# Cruise Report
# Bering Ecosystem Study-Bering Sea Integrated Research Program
# *USCGC Healy* Cruise HLY0902
# April 3 – May 12, 2009
# Dutch Harbor, AK – Dutch Harbor, AK

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Photo by Chris Linder, WHOI

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**Acknowledgements**

We gratefully acknowledge the Captain, Officers, and Crew of the USCGC Healy for their invaluable support during the cruise. We are especially thankful to EMCM Curt Podhora who worked on many aspects of the science equipment (van heat, incubator temperatures) and repaired a centrifuge that had failed and that was important to the work of one of our groups. We also are grateful to LCDR Doug Petrusa, LT Oscar Galvez, and LTJG Bryson Jacobs from the engineering department and to the Marine Science Technicians, especially MST2 Tom Kruger, for their ready cooperation, assistance and hard work in trouble shooting the science seawater system and installing the ballast water option of supplying incubation water to the water baths on the bow. Many thanks to the Marine Science Technicians MSTC Mark Rieg, MST1 Rich Layman, BM1 Ray Mendoza, MST2 Tom Kruger, and MST3 Marshall Chaidez who worked tirelessly on our behalf. Thanks to the Healy Science Support Team (David Hasilev, Scott, Hiller, Brandi Murphy, Chip Maxwell, and Steve Roberts) for keeping the science and computer systems running. Steve Roberts (LDEO Science Support) also has been invaluable in monitoring and optimizing the use of the ballast water system. Thanks to the bridge crews and to the small boat crews for their excellent piloting during science operations.


Photo by Chris Linder, Woods Hole Oceanographic Institution

Figure 1. Group shot of science and Healy crew on Healy helicopter deck.

Note: All data and summaries in this report are preliminary unpublished data subject to revision or correction with intellectual property reserved to the scientist contributing to the report. Please contact the individual scientist responsible for each section (see Appendix 2 for contact information) for additional information.

**Overview**

The overall objective of this cruise is 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, including one NSF IPY Educational Program, are supported on cruise HLY0902 on board the USCGC Healy in the Bering Sea during the period of April 3 – May 12, 2009. Forty-one science party members are on board.

We surveyed across four major east-west cross-shelf transects – the CN (southernmost), the NP (second from the south), the MN (third from the south), and the SL (northernmost) lines (Figure 1), in a water column phytoplankton bloom, and along the 70 m isobath. We conducted 172 stations at which 233 CTD casts, 98 CalVet net tows, 11 MOCNESS net tows, 53 Bongo Net tows, 64 Ring Net tows, 61 Video Plankton Recorder casts, 60 Van Veen grabs, 59 Multicore drops, 1 XBT, and 1 ice net were done. 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. More intensive sampling occurredd usually every other day at eighteen "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. Bongo tows to collect krill for grazing, growth, and reproduction experiments and chemical analyses were conducted almost nightly. Five sediment trap deployments were conducted, most in the phytoplankton bloom.

The first portion of the cruise also supported frequent ice sampling through long (6-8 hour) and short (2 hour) ice stations. Usually, a long ice station was conducted every other day in conjunction with the process stations while the short ice stations occasionally were conducted on other day. Up to seven groups participated in the on-ice deployments. In addition to sampling sea ice properties and biota, the Iken and Moran/Kelly groups worked together to deploy under-ice sediment traps. Ice stations were less frequent during the second portion of the cruise because ice conditions were deteriorating to an extent where suitable ice could not be found or because we were working in open water.

We were able to conduct 5 consecutive days of sampling in a phytoplankton bloom that developed on the shelf to the SW of St. Matthews Island (Figure 2). We returned to sample this bloom again during our transit south along the 70 m isobath line.

Underway sampling of the surface water for temperature, salinity fluorescence, oxygen, and other chemical parameters, water velocity, gravity, and seafloor topography from SeaBeam and underway observations of marine mammal and bird distributions and sea ice extent and type also have been conducted.

During the period of the cruise so far, the ice edge retreated to the N significantly. Biological activity in the water column was quite low except for in the phytoplankton bloom, in contrast to that of the sea ice that supported a bloom of ice algae and the organisms that utilize the algae. The highest biological activity outside of the phytoplankton bloom was observed along the SL line to the south of the St. Lawrence Island Polynya.

Janet Scannell from EOL has 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. Steve Roberts has been serving satellite imagery, underway data, and ship location through the map server.

Outreach activities for the cruise to date include at least four on-line web logs[1], including those of the Polar Discovery Project and the Polar Trec Teacher, teleconferences between science party personnel and the general public at museums through the Polar Discovery project, and other outreach through Polar Discovery. The Chief Scientist has been sending daily reports of ship position, activities, weather, ice conditions, and marine mammal and oceanographic conditions to the communities of Gambell and Savoonga. Our contacts there have been very enthusiastic about the reports and Branson Tungiyan says “I-gam-si-qa-yug-vi-kam-ken” ("I thank you", in St. Lawrence Island Yupik).

[1]Web Sites
www.polardiscovery.whoi.edu
www.polartrec.com/spring-plankton-and-changing-ice-cover
http://bsierp/nprb.org/
http://www.ecofoci.noaa.gov/cruiseWeb/ice09/

As was the situation in 2008, underway sampling using the flow-through seawater system was compromised because the system periodically became clogged with ice. 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). We had the good fortune to be in heavy ice during several days when the air temperature was above freezing, thus preventing freezing of seawater in the hoses that supply ambient water to the water baths. Because the water could not freeze in the hoses, we were able to conclude that freezing of the inflow water to the water baths resulted from sea ice being ingested by the science seawater system rather than from in-situ freezing. Prior to the cruise, the Coast Guard also installed improved seawater distribution manifolds with substantive heat tape and insulated wooden shelters around the manifolds to prevent freezing and this worked to the extent that we never experienced a freeze-up of the manifolds. However, we still experienced freeze-up of both seawater flowing aft to the science sensors to the ambient seawater supply in the labs and

on the aft deck as well as seawater flowing forward to supply cooling water to the on-deck water baths as a result of ingestion of sea ice by the science seawater system.

We instituted the ballast water system of supplying seawater to the water baths. The Coast Guard had anticipated this occurrence and had procured the necessary hardware to accomplish this. Under this system, ambient seawater is pumped into the forward ballast tank using the science seawater system while the ship is at station (because ice is not pressed into the science seawater intake while the ship is moving. Water is then pumped from the ballast tank to the water baths. This reduces the flow demand on the science seawater system and ice separator while the ship is underway and prevents blockage of the underway science system by ice. Filling the tank has become routine, with the chief scientists working together with LDEO science support and the engineers to monitor water levels and to coordinate filling (the Chief Scientist has become very proficient at fire hose connections and drainage). The system operated extremely well, with water temperatures from the tank consistently less than -1 deg. C., until 4 days ago when ambient air temperatures increased above freezing and ballast water temperatures warming to ~-0.8 deg. C or just at the limit of the required temperature (within 1 degree of ambient; ambient was -1.8 deg. C). The temperature of seawater entering the tank was -1.6° to-1.8°C, corresponding extremely well with the external seawater temperature. Temperature inside the tank (measured with a temperature logger) was -1.2°C. We are working with the engineers to determine the source of the apparent warming between the ballast water tank and the tank outflow/water bath inflow. As the cruise continued, warming of ambient water in the ballast tank or in the hoses increased with the warmer air temperatures experienced during starting in mid-April. It is clear that the ballast water solution is effective during extremely cold environmental conditions but that once air temperatures increase, warming of the water stored there and delivered to the water baths on deck will occur (see Appendix I).

Because of the warming air and warming ballast water temperatures, we increasingly utilized the science seawater system to deliver cooling water to the on-deck water baths. This of necessity compromised the quality of some of the underway data and occasionally required us to choose between underway sensor data and cooling water for the experiments in the on-deck water baths (the latter always won). In the milder ice conditions of mid-late April, clogging of the science seawater system by ice was much less of a problem, likely because the ship was able to simply push the ice away rather than breaking through a compressed ice field. However, the science seawater system did clog completely during transit of some especially heavy ice in the northern portion of the study area in early May. Steve Roberts and Scott Hiller were able to devise a system to flush the ice out of the science seawater system by pushing either cold or hot fresh water through the system from the biochem lab. This was quite effective and was used twice to clear the system. Luckily, the experiments did not appear to be compromised by the temporary blockage of the science seawater system.

Although we started the cruise with two vans that had questionable heat because of heater damage in transit or heater failure, we have been able to heat those vans adequately using space heaters, some purchased in Dutch Harbor after the new HVAC unit for the rad van arrived inoperable. The liquid scintillation counter supplied in the radiation van also apparently sustained damage when the van door was breached and seawater entered the van during the

crossing of the Gulf of Alaska. Fortunately, Mike Lomas had arranged to borrow the URI portable LSC for the trip and that instrument is working satisfactorily.

Synopses of individual projects, contributed by the scientists, follow. Table and figure numbering is unique to each section rather than sequential through this document.

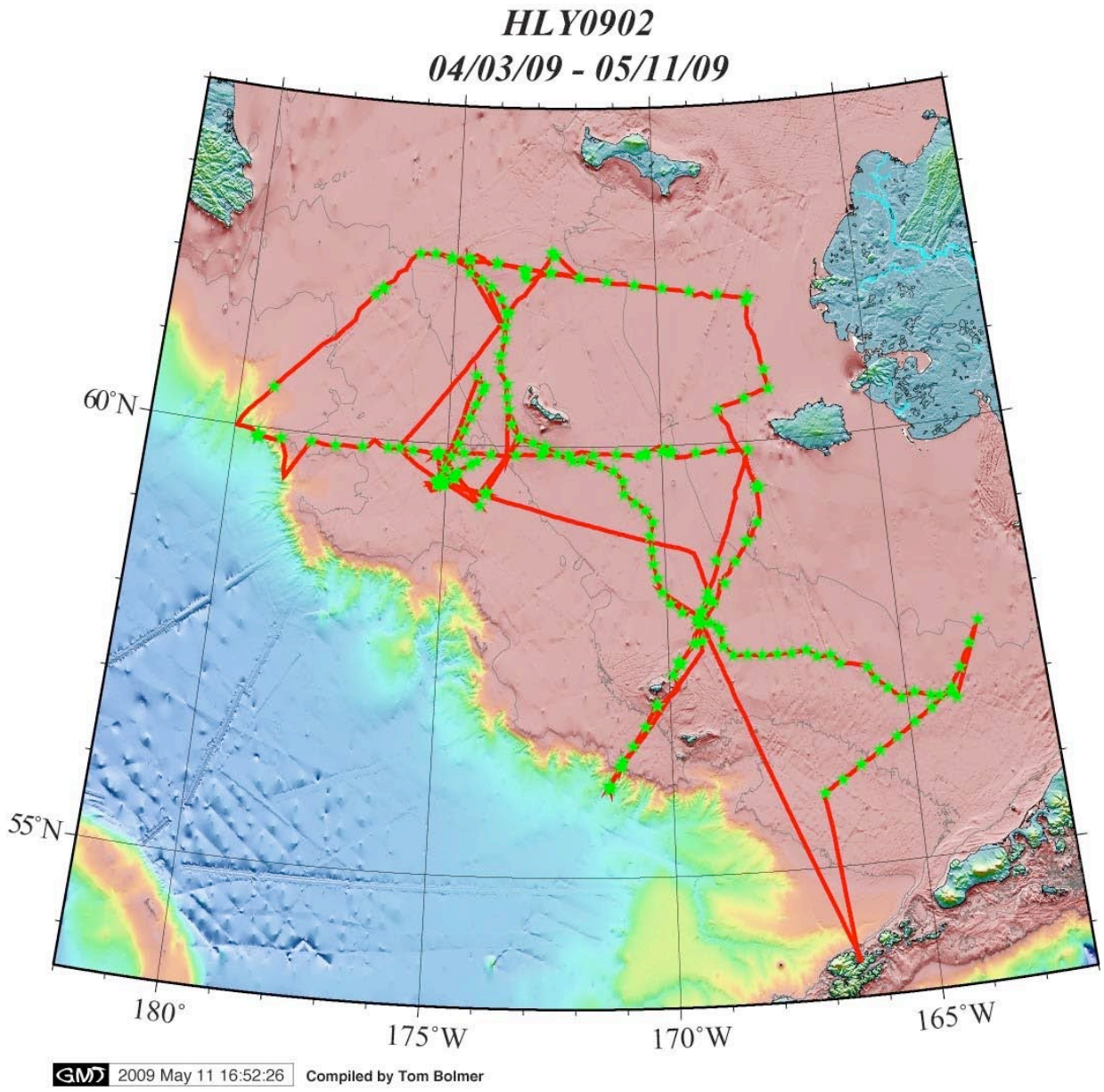



Figure 1. Cruise track of USCGC Healy during HLY0902, April 3 – 24, 2009. Green symbols indicate locations where CTD casts were conducted. The red line indicates the track of the ship.

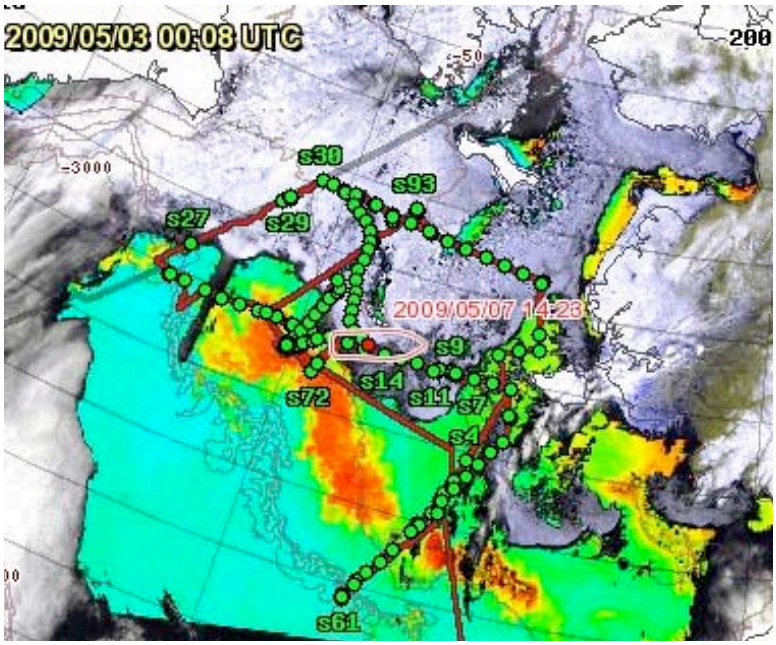



Figure 2. Ice cover (AVHRR) and ocean color (MODIS) at the beginning of May, showing the intense phytoplankton bloom on the shelf. Sampling locations of Healy are shown as the green symbols. Healy had completed sampling for the second time and was resuming sampling along the 70 m line when this image was made using the on board Map Server program.

## A Service Proposal to Examine Impacts of Sea-ice on The Hydrographic Structure and Nutrients Over the Eastern Bering Sea Shelf and A Service Proposal to Examine Impacts of Sea-Ice on the Distribution of Chlorophyll-*a* over the Eastern Bering Sea Shelf.

PIs: Terry Whitledge (UAF), Rolf Sonnerup (UW), Phyllis Stabeno (NOAA), Dean Stockwell (UAF), Calvin Mordy (UW)
On-Board Team Members: Edward D. (Ned) Cokelet (NOAA), Nancy Kachel (UW), David Kachel (NOAA), Calvin Mordy, Daniel Naber (UAF), and Jessica Cross (UAF)

The BEST Hydrographic Group conducted 233 CTD casts at 172 oceanographic stations. The CTD was a Sea Bird Electronics SBE 911 plus with dual temperature and conductivity sensors. It carried an auxiliary SBE 35 temperature sensor, a WETLabs optical transmissiometer, a Chelsea Aqua Tracker fluorometer, a Biospherical QSP2300 PAR sensor and a Benthos 916 altimeter. The group conducted CTD casts which included nutrient samples from up to twelve 30-liter Niskin bottles, two or more Winkler oxygen samples for calibration of the CTD oxygen sensor, three or more $O^{18}$ samples for Tom Weingartner of the University of Alaska Fairbanks (UAF), and three to ten Total Alkalinity/Dissolved Inorganic Carbon (TA/DIC) and Total Organic Carbon (TOC) samples. Table 1 summarizes the sampling. Scott Hiller and Brandi Murphy, Scripps Institution of Oceanography, operated the CTD console during the cruise and analyzed salinity samples for calibration.

Table 1. Sampling by the Hydrographic Group, 3 April-11 May 2009

| **Hydrographic Stations** | 172 |
|---|---|
| CTD casts | 233 |
| Nutrient Samples Analyzed | 1547 |
| Winkler Oxygen Samples | 368 |
| DOC Samples | 307 |
| TA/DIC Samples | 307 |
| $O^{18}$ Samples | 368 |
| Total Chlorophyll Samples | 1078 |
| Fractionated Chlorophyll Samples | 258 |
| | |
| **Underway Samples** | |
| Nutrient Samples | 56 |
| Winkler Oxygen Samples | 54 |
| Total Chlorophyll Samples | 54 |
| | |
| **Ice Station Samples Analyzed** | |
| Nutrient Samples for Iken | 165 |
| Ice Stations Visited by Hydro | 9 |
| Nutrient Samples for Hydro | 105 |
| Winkler Oxygen Samples | 10 |
| Total Chlorophyll Samples | 120 |

**Chlorophyll Measurements**

The Hydro Group collected 1078 total chlorophyll samples and 258 fractionated chlorophyll samples. Water samples were drawn from the Niskin bottles of each CTD cast in 289 ml bottles, except at times of high chlorophyll content when 137 ml bottles were used. Total chlorophyll samples were filtered through 25-mm diameter, 0.7 micron mesh GFF filters. Fractionated samples were filtered through 47-mm diameter, 5 micron mesh track-etched membrane filters. Each filter was folded, placed in plastic vial or folded in aluminum foil, labeled and placed in the -80-degree freezer for transportation to PMEL and later acetone extraction and analysis.

The CTD's Chelsea Instruments Mk III Aquatracka fluorometer was field-calibrated during the cruise against a subset of total chlorophyll determinations from Drs. Lomas and Lessard. Figure 1 shows a linear least-squares fit of the discrete chlorophyll-a concentrations on the abscissa and the CTD chlorophyll concentration on the ordinate based upon the Chelsea factory calibration of 6 March 2007. (Chelsea warns users that their factory calibration may not be appropriate for the species or area being studied and recommends that users do their own field calibration.) The fluorometer's voltage and chlorophyll-a concentrations were read from the Sea Bird CTD bottle files, a line of which is generated each time the CTD rosette trips a bottle. In Figure 1, Lomas' s points are in black, Lessard's are in purple, a line of slope 1 is black dashed, and the linear least squares fit line is solid green.

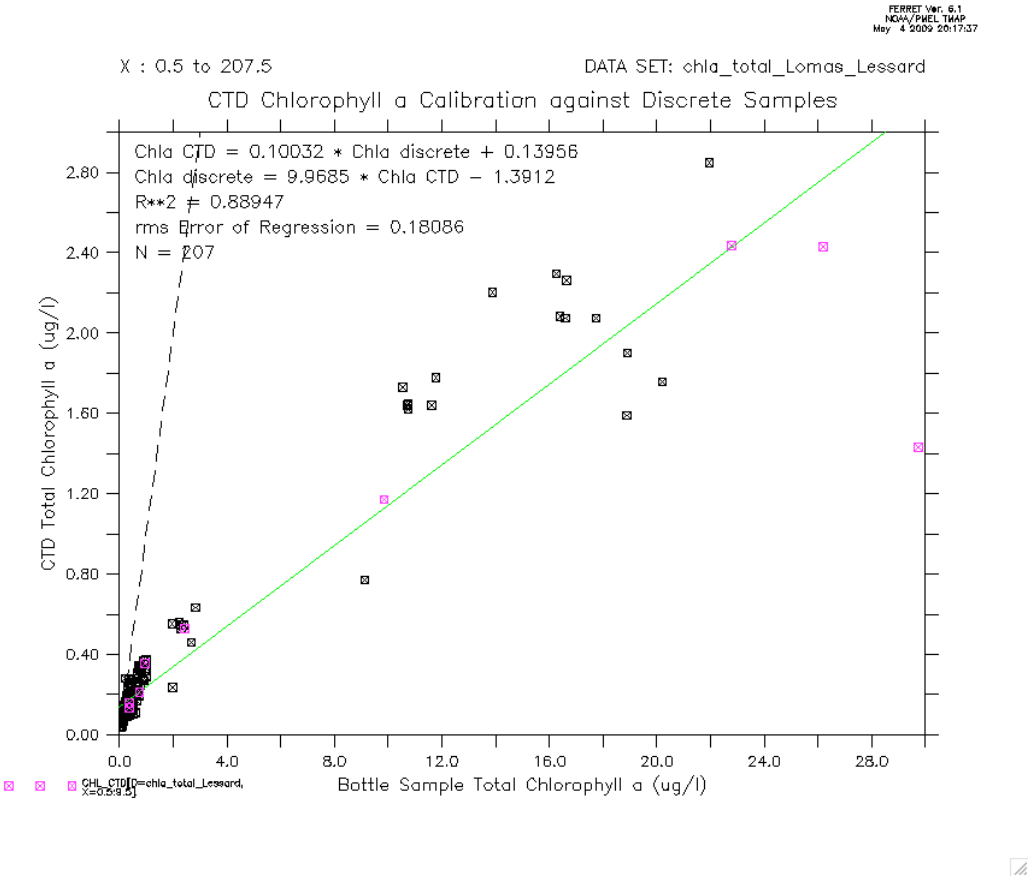



Figure 1. Linear least-squares-fit field calibration of the CTD fluorometer.

From the diagram, one can see that the Chelsea "calibration" underestimates the chlorophyll-a concentration by about a factor of 10. The equation of the fit and the inverse equation are shown on the diagram. To use the new "calibration" one would multiply the Chlesea chlorophyll-a concentration by 9.9685 and subtract 1.3912 μg/l. The rms error of the fit is 0.18086. Scaling this by the inverse formula implies an rms error in the newly scaled chlorophyll-a concentrations of about 1.8 μg/l.

Mike Lomas reported that his results from last year implied a scaling factor of about 5 then, so the fluorometer may have lost sensitivity with age. Scott Hiller will send the fluorometer back to Chelsea at the end of the field season and for a calibration before they disassemble it and another after they refurbish it. That will give some idea if the fluorometer has degraded.

At mid-cruise we decided to rescale all the CTD chlorophyll values by the new field scaling. This was done to all the CTD data files from the cruise.

**Nutrient Measurements**

Nutrient samples were collected from the Niskin bottles in acid-washed 35-ml polyethylene bottles after three complete seawater rinses and typically analyzed within 12 hours of sample collection. Nutrients were analyzed with a continuous flow analyzer (CFA) using the standard and analysis protocols for the WOCE hydrographic program as set forth in the manual by L.I. Gordon, et al (2000). Approximately 1547 samples from CTD casts were analyzed for phosphate ($PO_4^{3-}$), nitrate ($NO_3^-$), nitrite ($NO_2^-$), orthosilicic acid ($H_4SiO_4$), and ammonium ($NH_4^+$). Approximately 165 nutrient samples from ice cores and brine were analyzed for Katrin Iken's group and 105 for the Hydro team (Table 1).

A mixed stock standard consisting of silicic acid, phosphate and nitrate was prepared at PMEL by dissolving high purity standard materials ($KNO_3$, $KH_2PO_4$ and $Na_2SiF_6$) in deionized water using a two-step dilution for phosphate and nitrate. This standard was stored at room temperature. Nitrite and ammonium stock standards were prepared about every 10 days by dissolving in distilled water, and these standards were stored in the refrigerator. Working standards were freshly made at each day by diluting the stock solutions in low nutrient seawater. The low nutrient seawater used for the preparation of working standards, determination of blank, and wash between samples was filtered seawater obtained from low-nutrient Pacific surface waters.

A typical analytical run consisted of distilled water blanks, standard blanks, working standards, a standard from the previous run, samples, replicates, and working standards, and standard and distilled water blanks. Four replicates were usually measured on each run, plus any samples with questionable peaks, and the overall precision of the analysis was within 1% of full range.

**Oxygen Measurements**
Winkler titrations were conducted according to WOCE protocols. On each cast, the number of samples and the depths sampled were dependent on the oxygen profile from the CTD. In deep water, samples were typically collected at every depth below 100 m. On the shelf, samples were usually collected in the upper layer, and in the bottom layer. End point determinations of the Winker titration were determined poteniometrically. Thiosulfate was standardized for each batch of sample titrations, and blanks were measured periodically during the cruise. Several samples were collected from brine wells at the ice station to verify Optode measurements collected there.

**TA/DIC and TOC Sampling**
The sampling protocol for the TA/DIC sampling was as follows: Samples were drawn into pre-combusted, acid-washed borosilicate glass bottles immediately after oxygen sampling directly from the Niskin bottles using tubing to reduce the amount of bubbles entrained in the sample. The bottles were rinsed three times and then filled almost full. Approximately one cm of head space was allowed for gas expansion. After the bottle was filled, it was injected with 200 µl of saturated aqueous mercuric chloride to stop biological activity in the sample. The lid was screwed on as tightly as possible, and the bottle shaken to mix in the mercuric chloride solution. Sample bottles were labeled with the station number, cast number and Niskin bottle number.

The sampling protocol for the TOC sampling was as follows: The plastic bottles were rinsed three times from the Niskin and then filled about 90% full. The caps were screwed on tight, labeled the same as the DIC samples and placed in a -20$^{o}$ C freezer for the duration of the cruise. Both TA/DIC and TOC samples will be transported to the University of Alaska, Fairbanks for analysis following the cruise.

**$O^{18}$ Sampling**
The sampling protocol for $O^{18}$ was as follows: 20 ml glass vials were triple rinsed from the Niskin bottle, using tubing. When the bottle was full the tubing was slowly pulled out and pinched off to not introduce air bubbles into the vial and to leave a meniscus on the top. The vial was capped and checked to ensure no air was in the vial when sealed. After the water in the vial reached room temperature the cap was checked for looseness, tightened, and then wrapped with parafilm.

**Underway Seawater System**
Ned Cokelet arranged for the underway seawater sampling system to be augmented for this cruise by adding a Satlantic ISUS nitrate meter (on loan from Lisa Eisner, NOAA Auke Bay Laboratory). Scott Hiller set up the instruments. Seawater samples were collected from the system and analyzed for dissolved oxygen, nitrate and chlorophyll concentration for calibration.

**Ice Station Sampling**

The Hydrographic Group sampled at 9 ice stations. We recorded the position, snow thickness, air and snow temperatures, and freeboard. We collected one ice core for ice and snow thickness and temperature profile measurements, a second core for salinity, nutrient and chlorophyll analyses, a third core for $O^{18}$ analyses and occasionally more cores for ice algae samples for Drs. Lessard and Shull. Each core was photographed and described during a visual inspection prior to sampling. PAR measurements were recorded both above and below the ice in one of our core holes and in the CTD hole augured by Iken's group. Ice wells were augured to 20, 40, 60,… cm depths, as the ice thickness would allow. These filled with brine that was sampled for temperature, salinity, nutrients, chlorophyll and sometimes dissolved oxygen via the Winkler technique. Also an Aanderaa Optode was placed in one ice well with a corresponding Optode in the air in an upturned bucket above to measure the oxygen saturation, or in two adjoining ice wells. Upon our return to the ship, 1000 ml of filtered seawater were added to each chlorophyll core section to melt the ice without it becoming too fresh. Ice core segments thawed in the dark and sampled as soon as they melted, or stored in the refrigerator until sampling could take place. Brine salinity samples were diluted 1:1 or 3:1 (fresh:salt) with distilled water later analysis on the ship's salinometer.

**Typical Results**

Figures 2-6 show the water temperature, salinity, nitrate, chlorophyll and oxygen concentrations as measured by the underway seawater sampling system. Also shown are the CTD cast numbers and the CTD transect locations. The underway nitrate and oxygen values will be calibrated against discrete samples taken and analyzed during the cruise. These measurements are preliminary and may change after further analysis.

Figures 7-46 show the water temperature, salinity and density (sigma-t) and the chlorophyll, oxygen, nitrate, phosphate and silicate concentrations for the MN, SL, W, NP and 70-m transects. In each plot, the green line is the euphotic depth defined as the depth at which the total photosynthetically available radiation (PAR) first reaches 1% of the downwelling PAR measured on the ship's mast. The green line is solid where it connects contiguous computed depths and dashed when it passes beneath nighttime CTD casts for which the euphotic depth is indeterminate because the surface light level vanishes. The black line is the mixed layer where the sigma-t difference from the surface equals 0.125 $kg/m^3$. White isolines on the salinity sections show density (sigma-t) values. White isolines on the chlorophyll sections show oxygen saturation values. These measurements are preliminary and may change after further analysis.

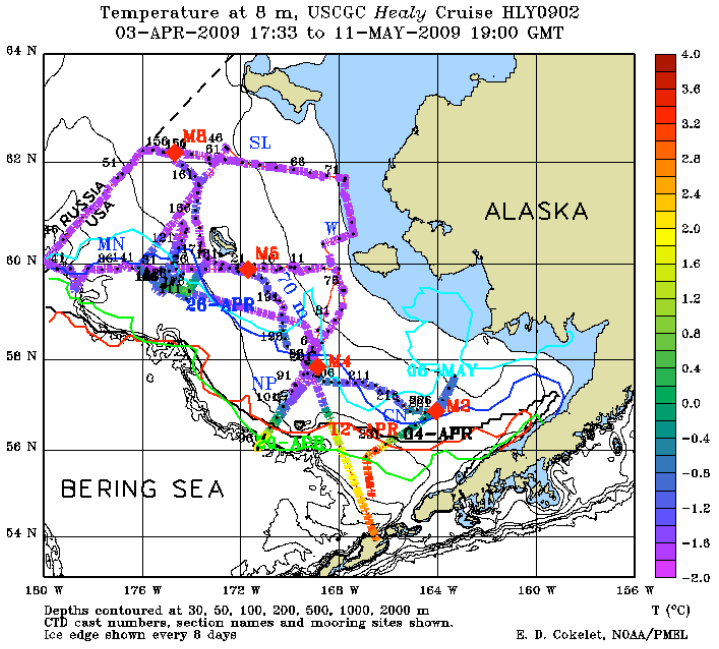



Figure 2. Water temperature at 8 m depth measured by the underway seawater sampling system.

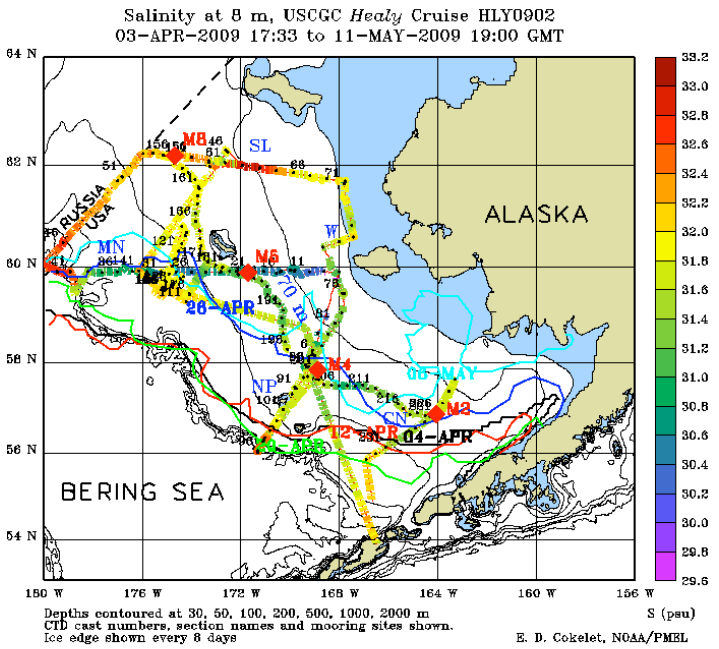



Figure 3. Salinity at 8 m depth measured by the underway seawater sampling system.

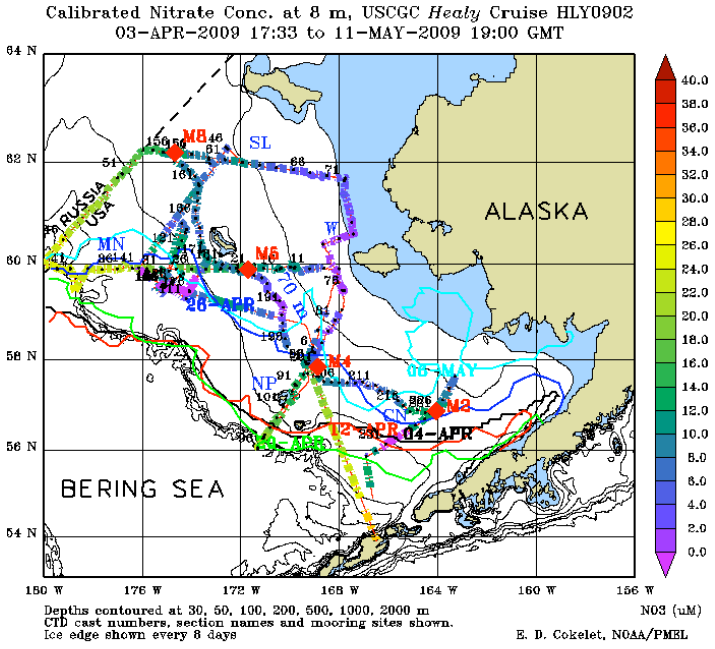



Figure 4. Calibrated dissolved nitrate concentration at 8 m depth measured by the underway seawater sampling system.

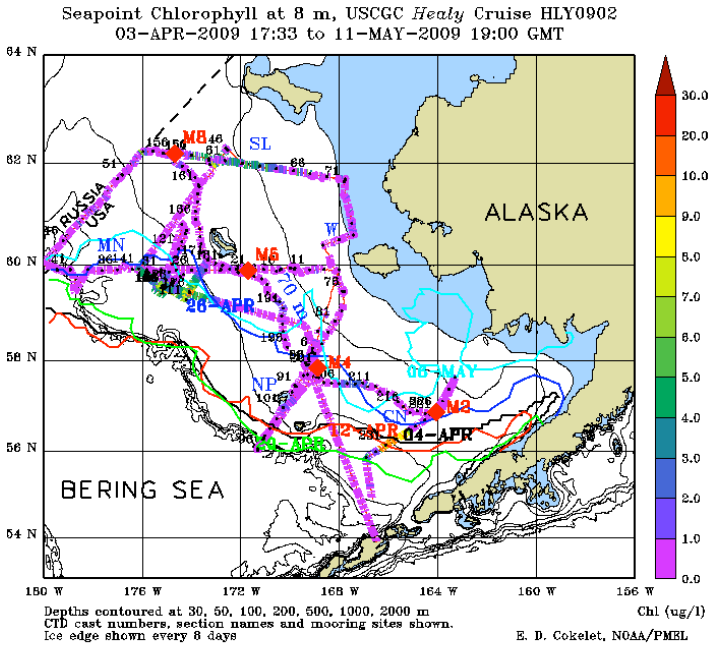



Figure 5. Uncalibrated chlorophyll concentration at 8 m depth measured by the underway seawater sampling system.

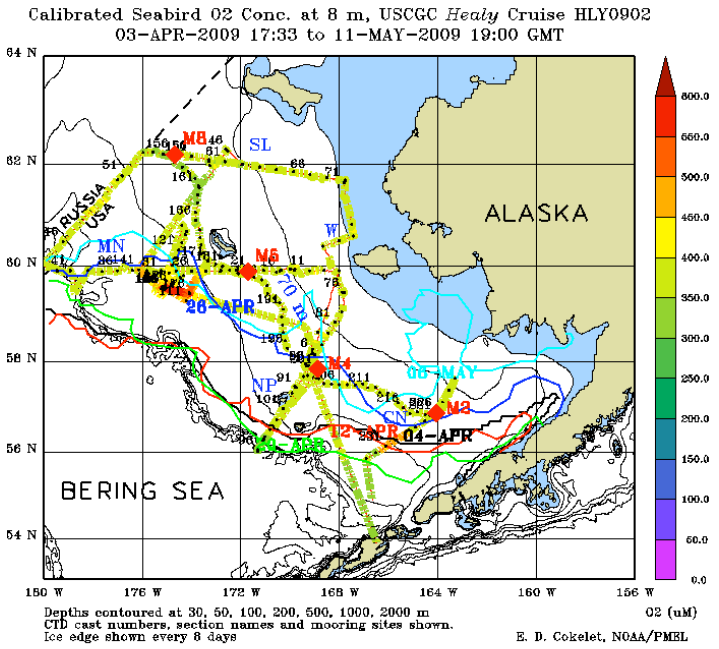



Figure 6. Calibrated dissolved oxygen concentration at 8 m depth measured by the underway seawater sampling system.

## Transects of Water Properties along the MN Line

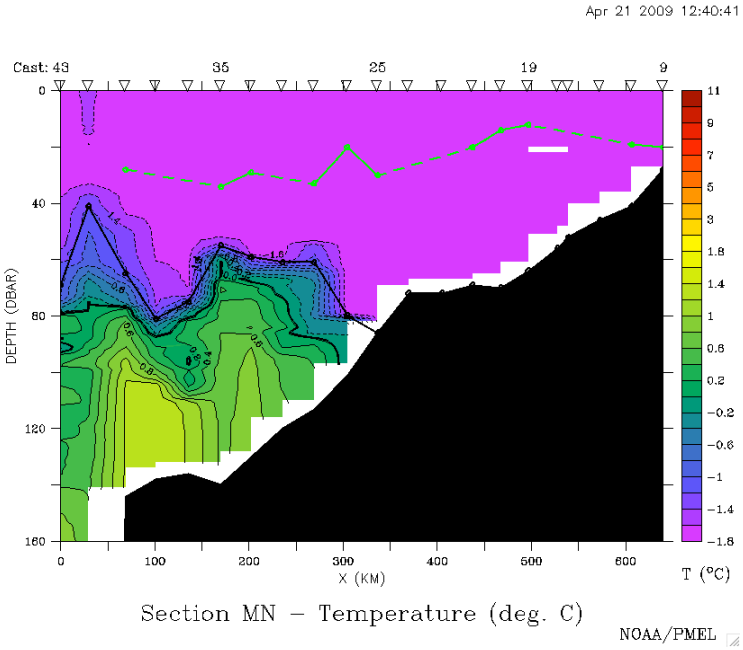



Figure 7. Water temperature along the MN transect.

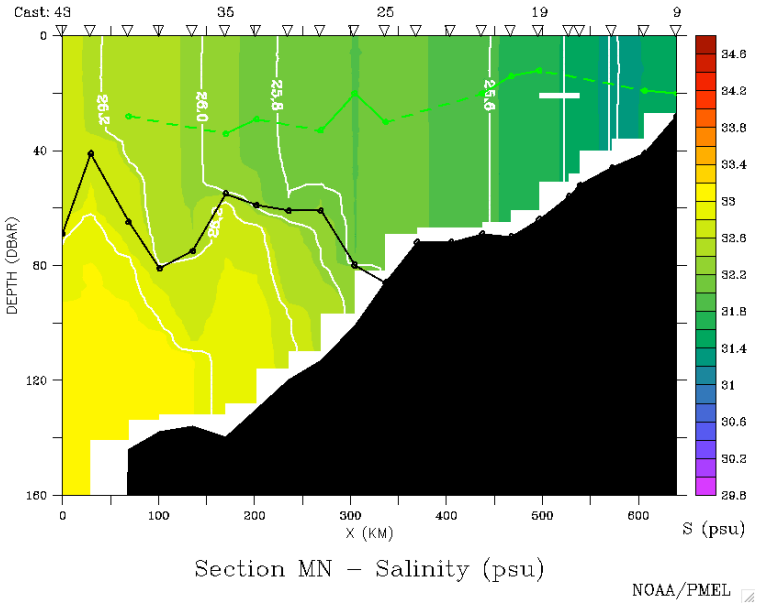



Figure 8. Salinity along the MN transect.

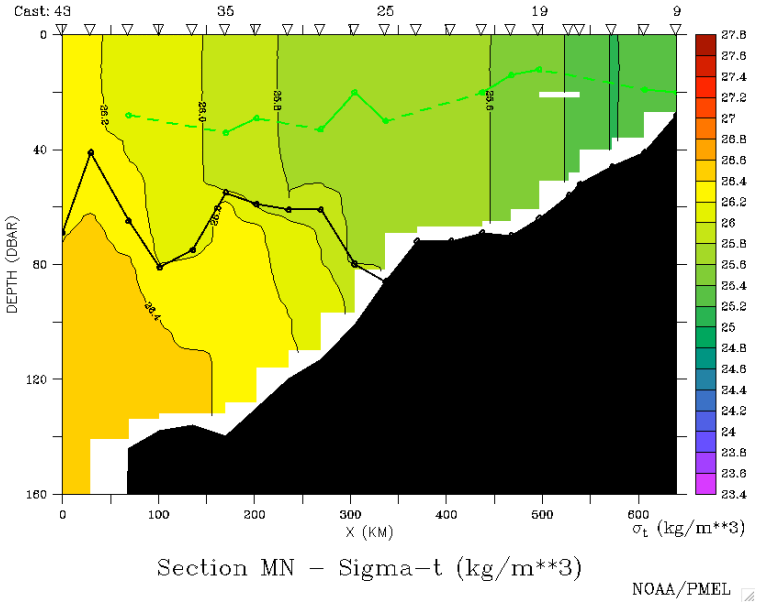



Figure 9. Sigma-t density along the MN transect.

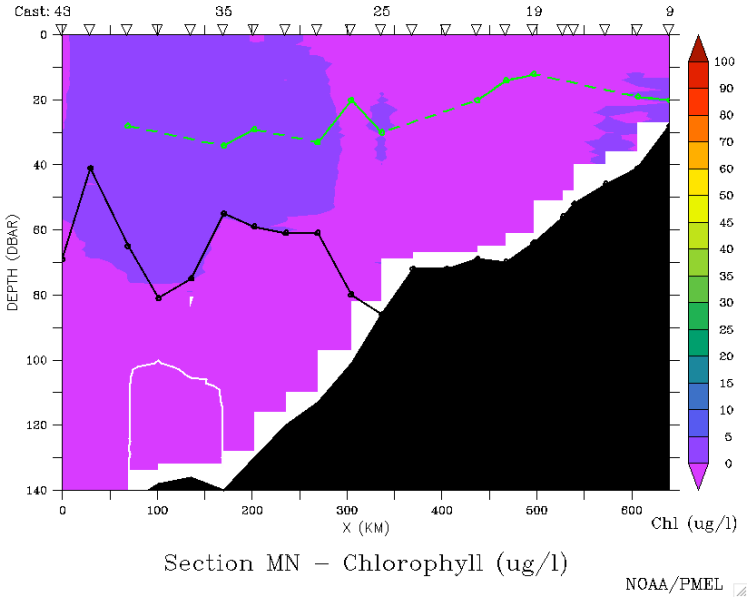



Figure 10. Chlorophyll concentration along the MN transect.

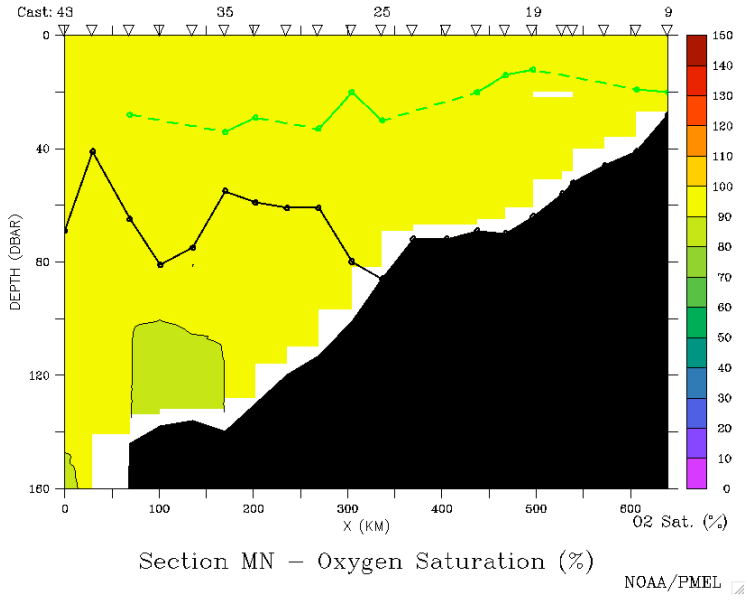



Figure 11. Dissolved oxygen saturation along the MN transect.

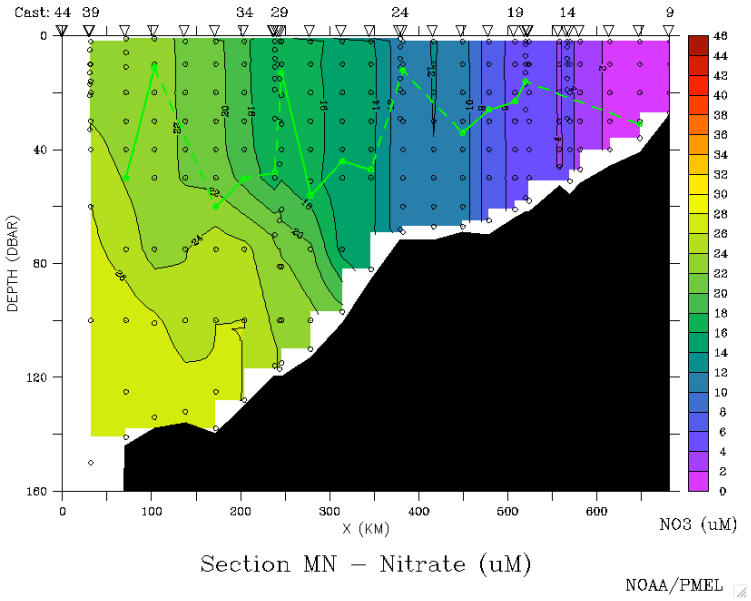



Figure 12. Nitrate along the MN transect.

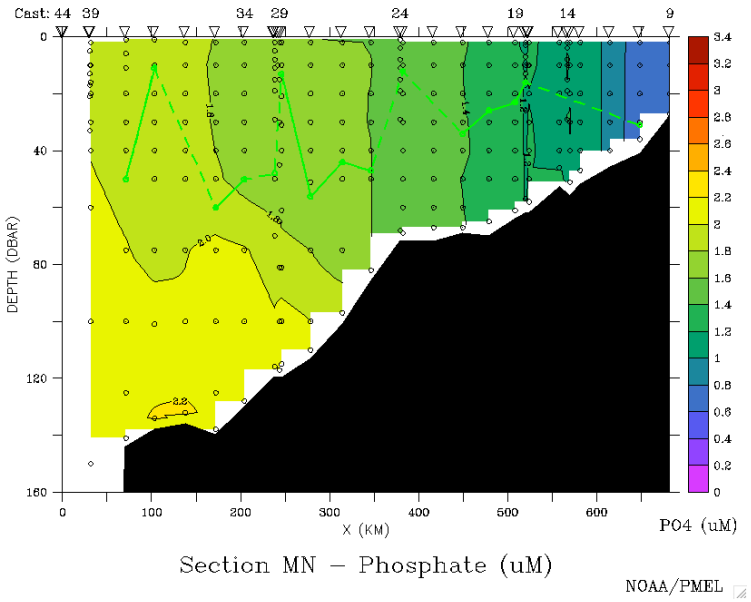



Figure 13. Phosphate along the MN transect.

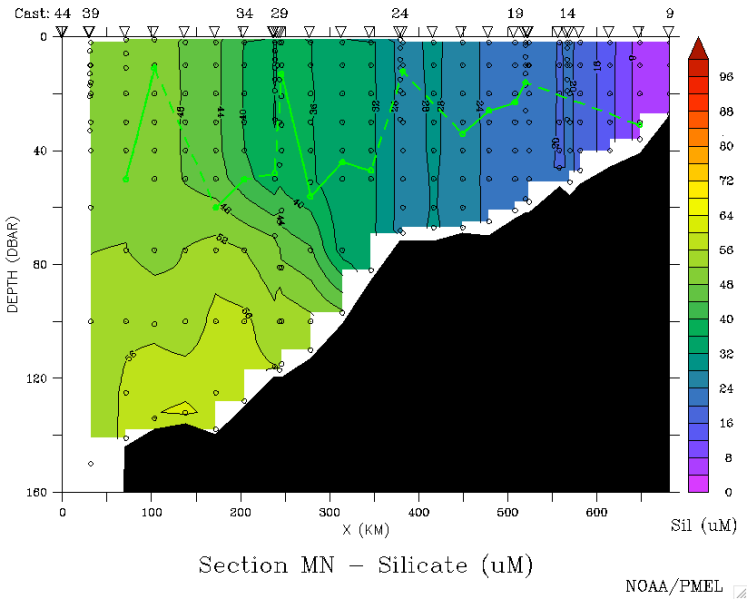



Figure 14. Silicate along the MN transect.

## Transects of Water Properties along the SL Line

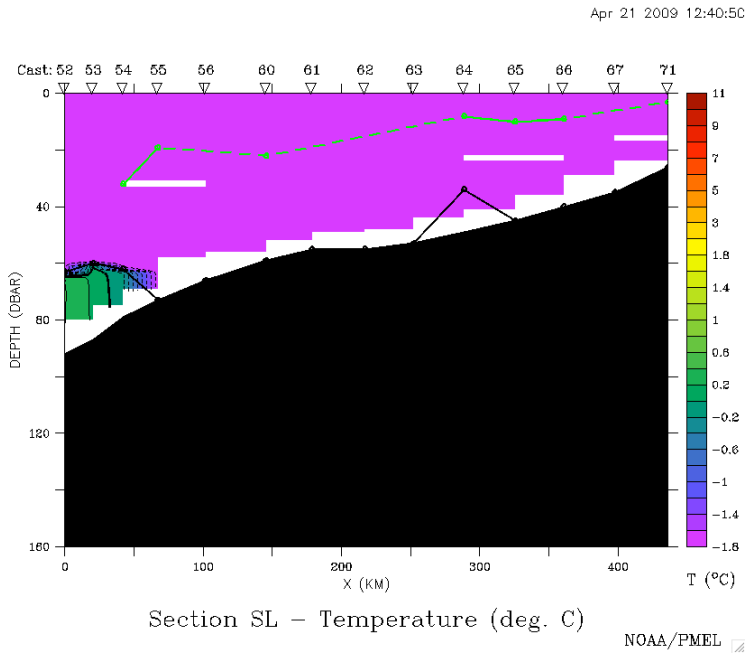



Figure 15. Water temperature along the SL transect.

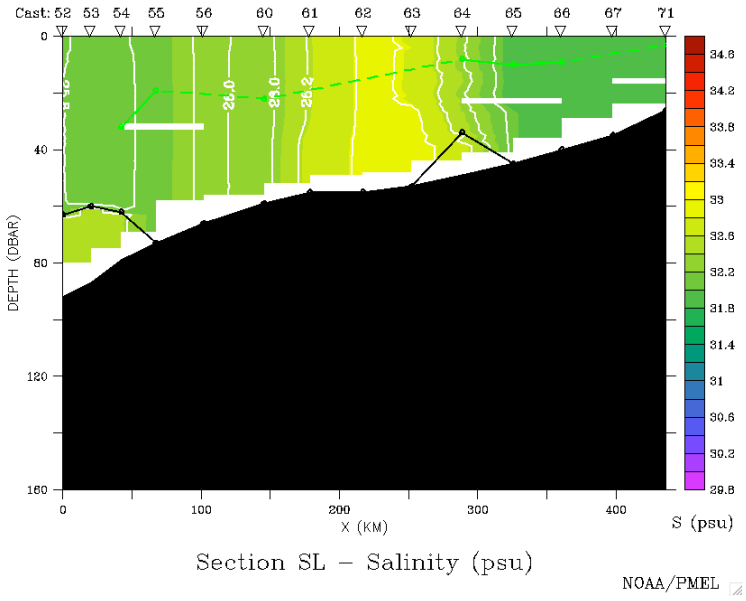



Figure 16. Salinity along the SL transect.

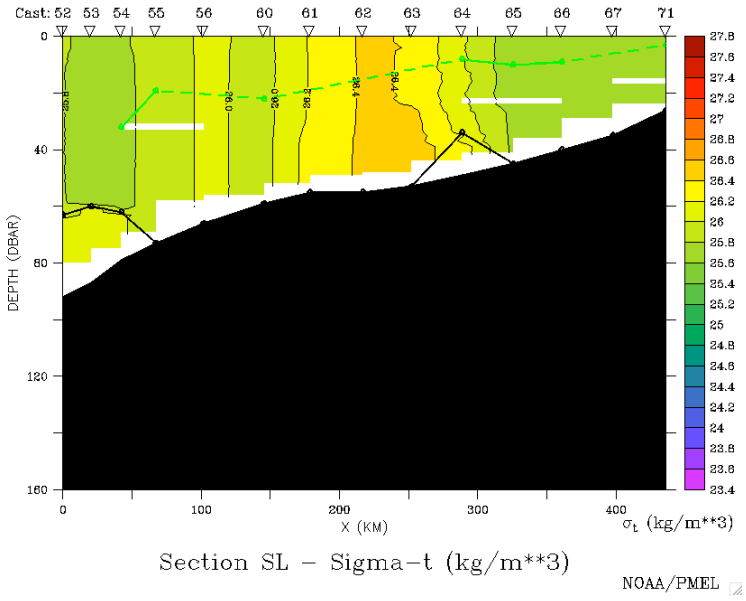



Figure 17. Sigma-t density along the SL transect.

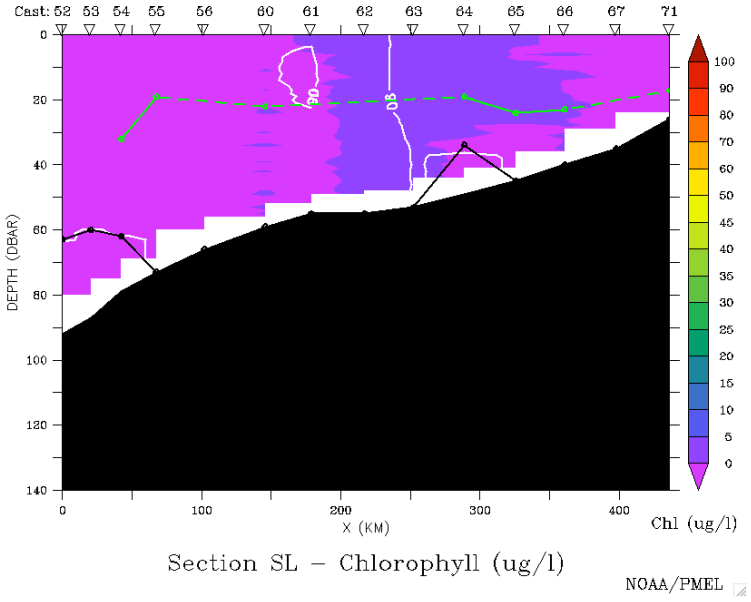



Figure 18. Chlorophyll concentration along the SL transect.

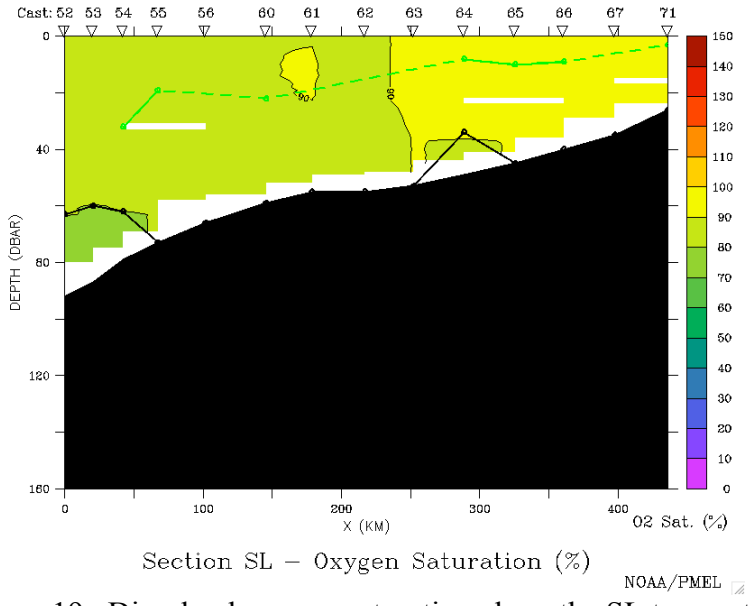



Figure 19. Dissolved oxygen saturation along the SL transect.

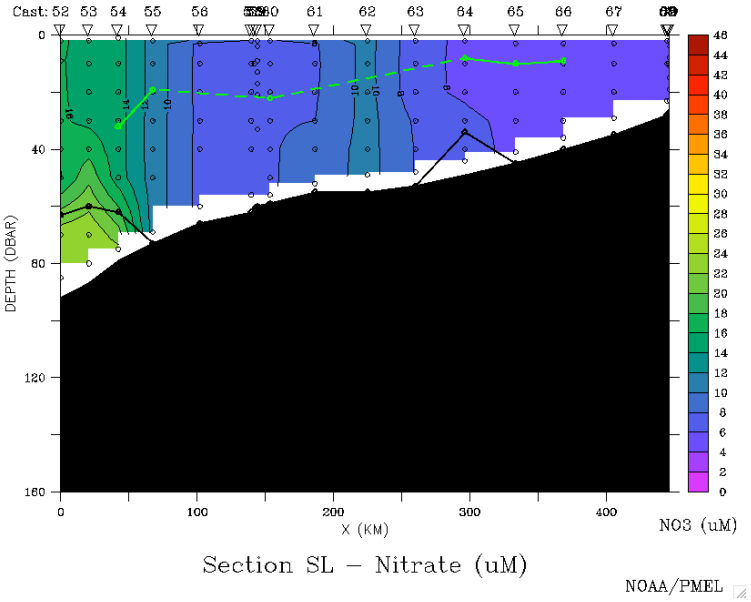



Figure 20. Nitrate along the SL transect.

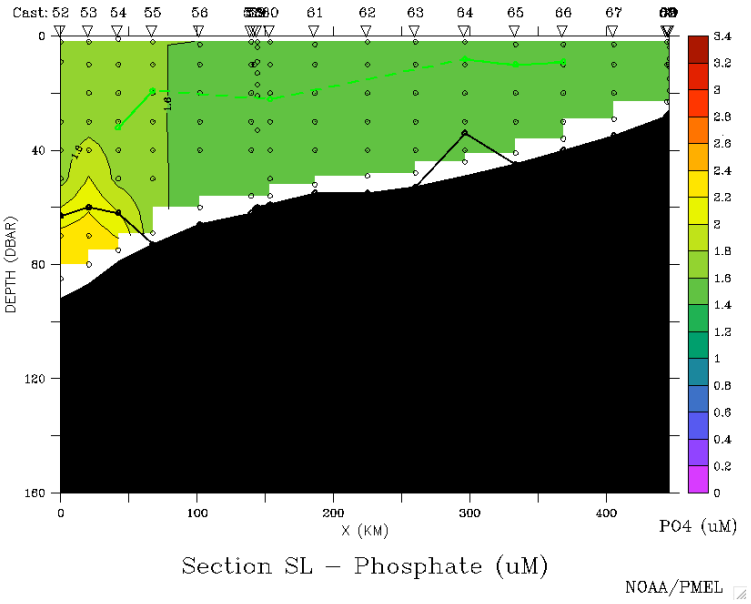



Figure 21. Phosphate along the SL transect.

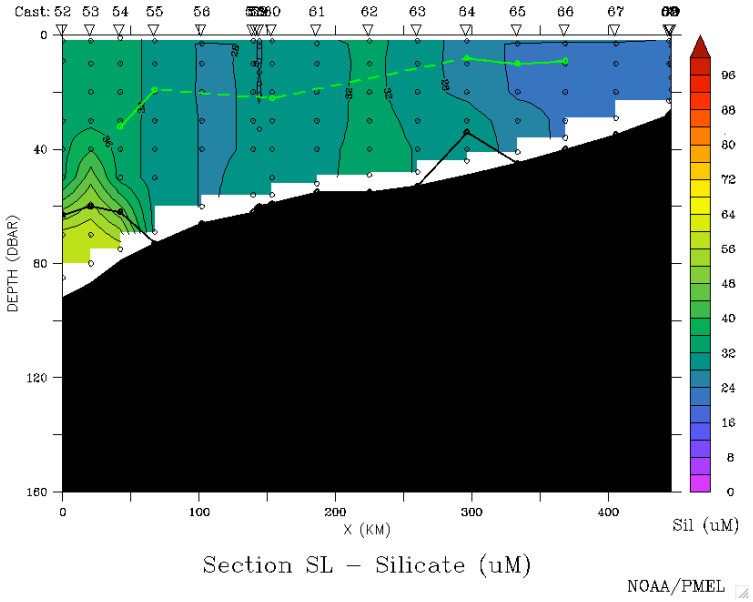



Figure 22. Silicate along the SL transect.

## Transects of Water Properties along the W Line

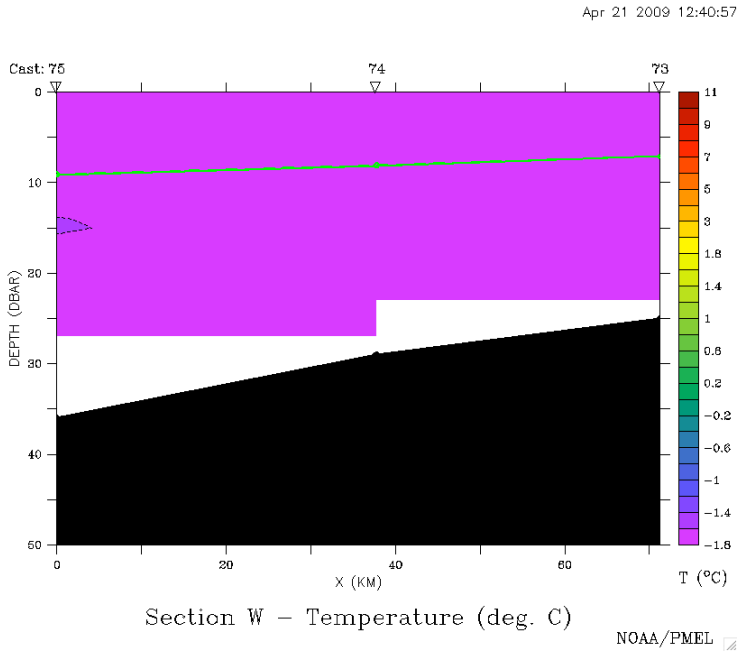



Figure 23. Water temperature along the W transect.

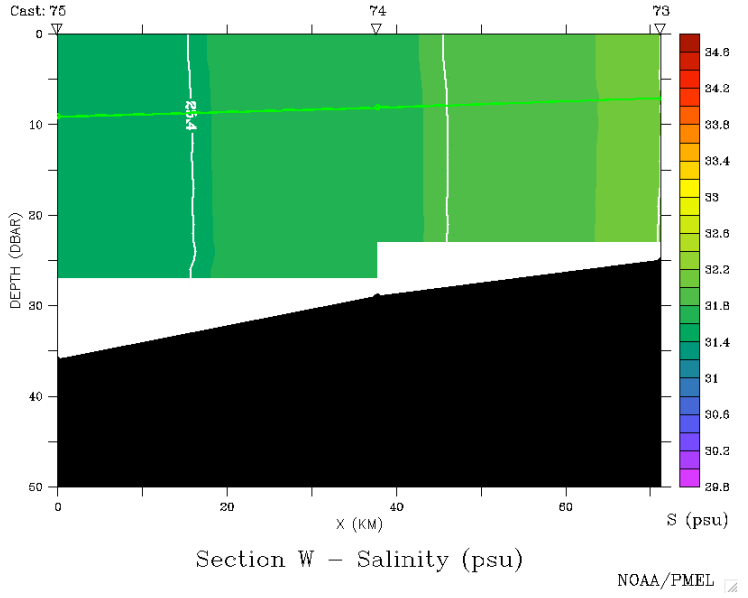



Figure 24. Salinity along the W transect.

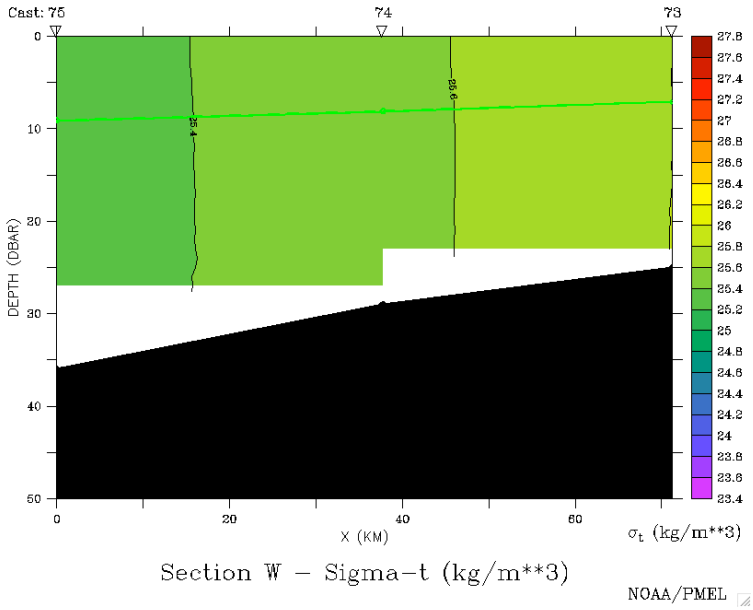



Figure 25. Sigma-t density along the W transect.

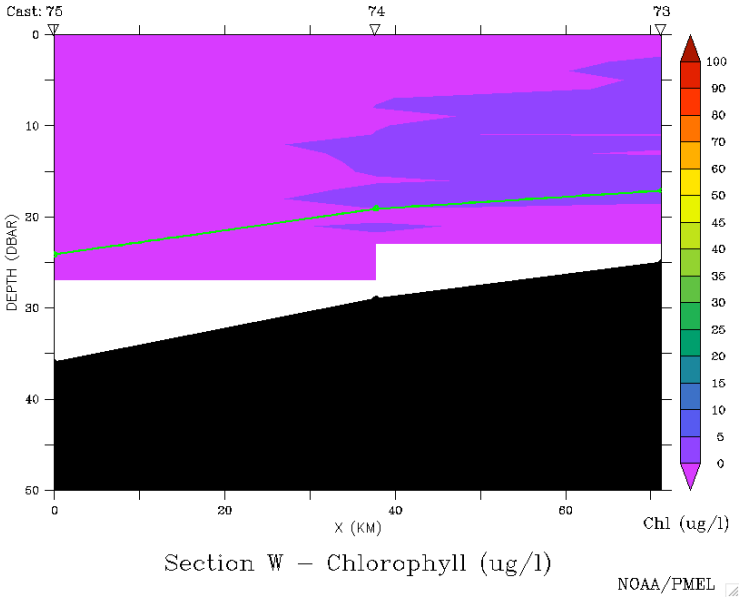



Figure 26. Chlorophyll concentration along the W transect.

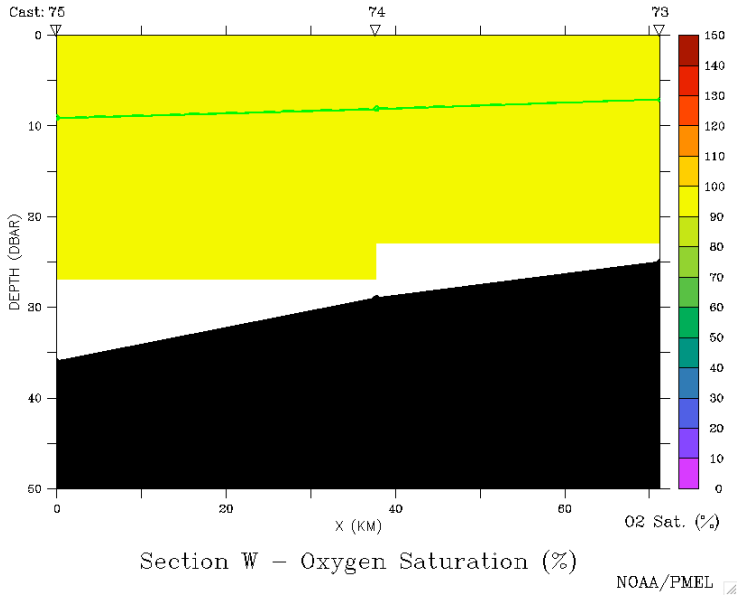



Figure 27. Dissolved oxygen saturation along the W transect.

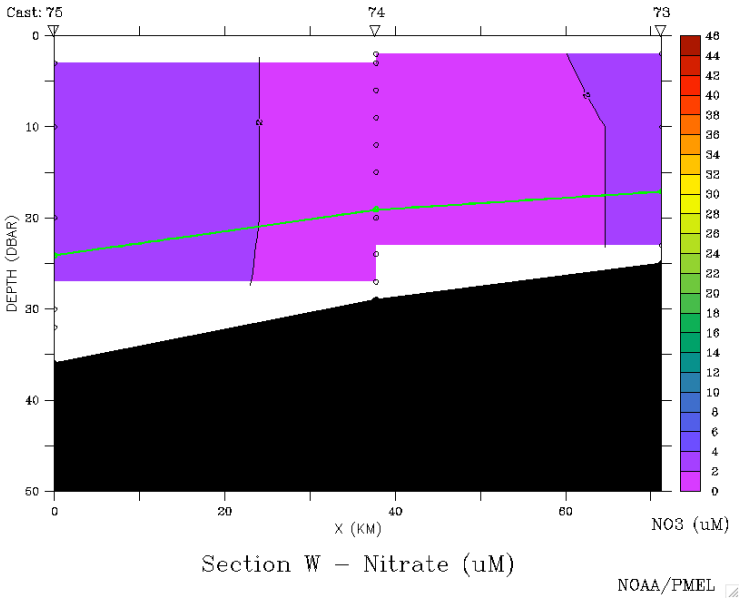



Figure 28. Nitrate along the W transect.

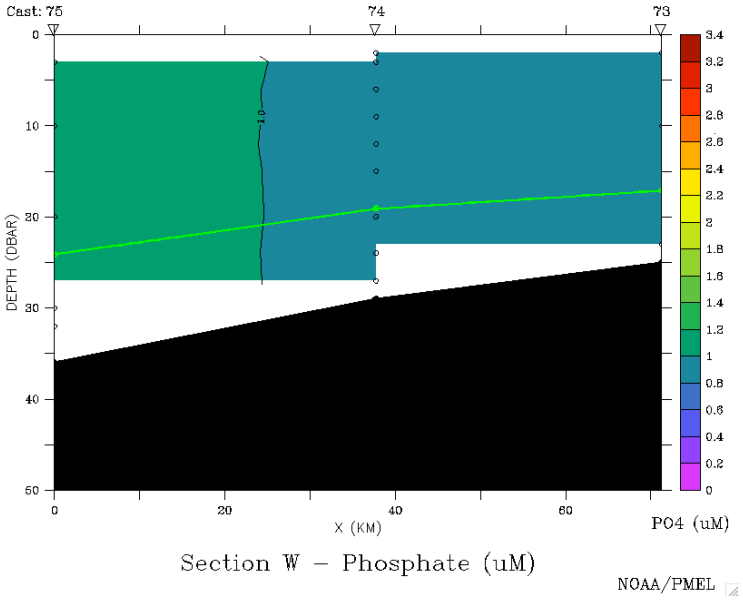



Figure 29. Phosphate along the W transect.

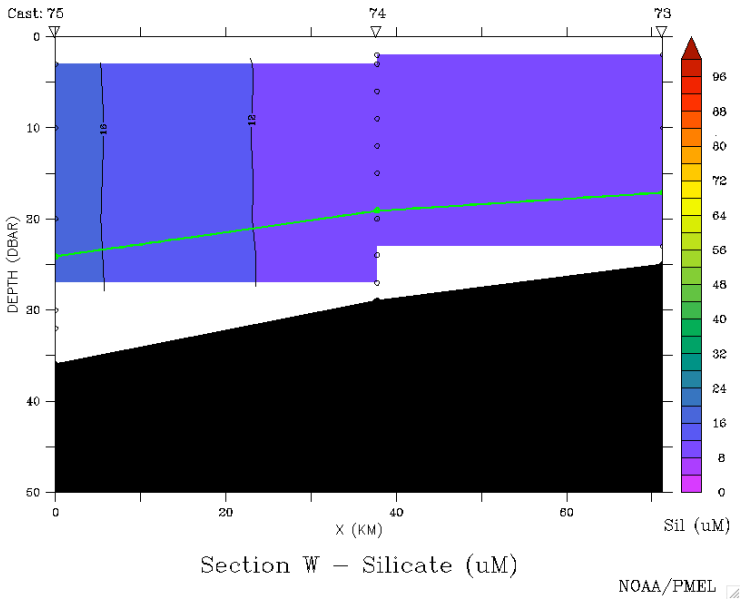



Figure 30. Silicate along the W transect.

## Transects of Water Properties along the NP Line

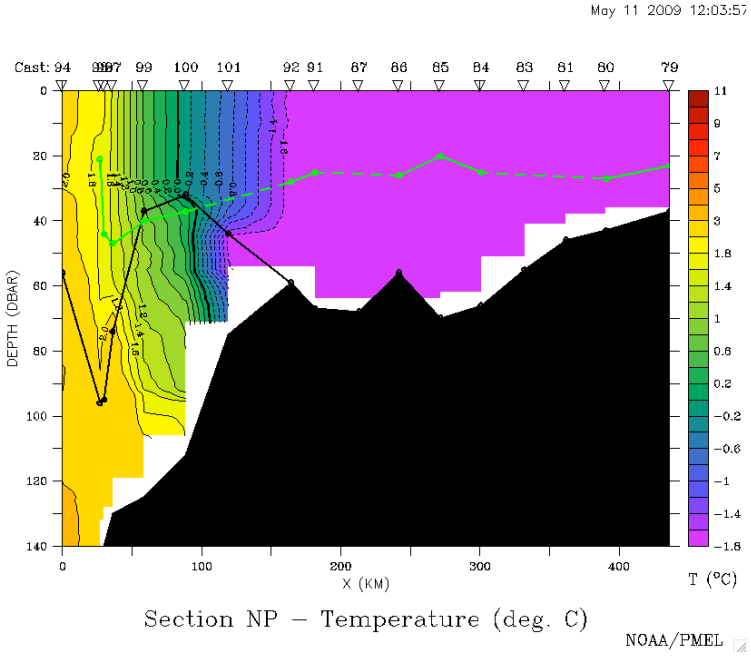



Figure 31. Water temperature along the NP transect.

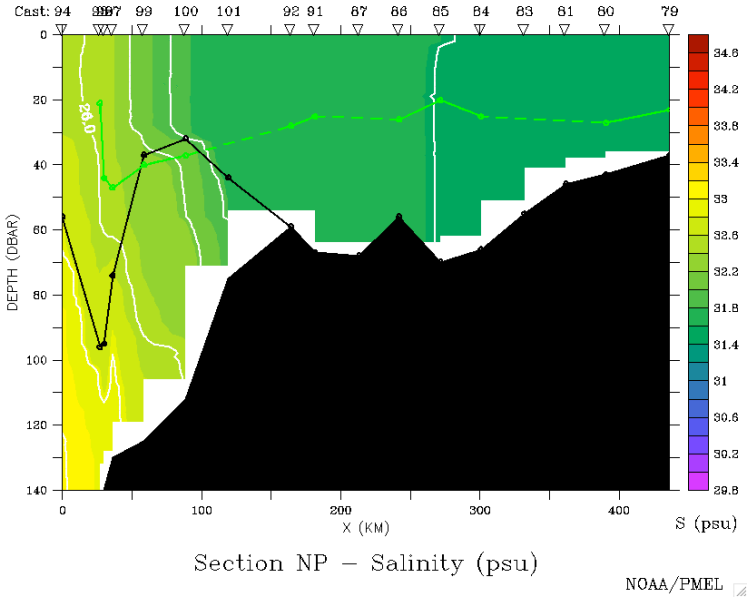



Figure 32. Salinity along the NP transect.

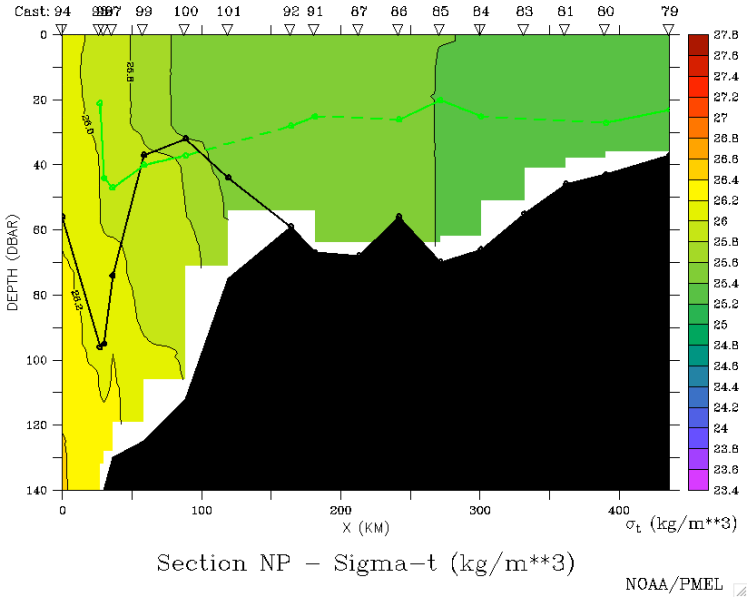



Figure 33. Sigma-t density along the NP transect.

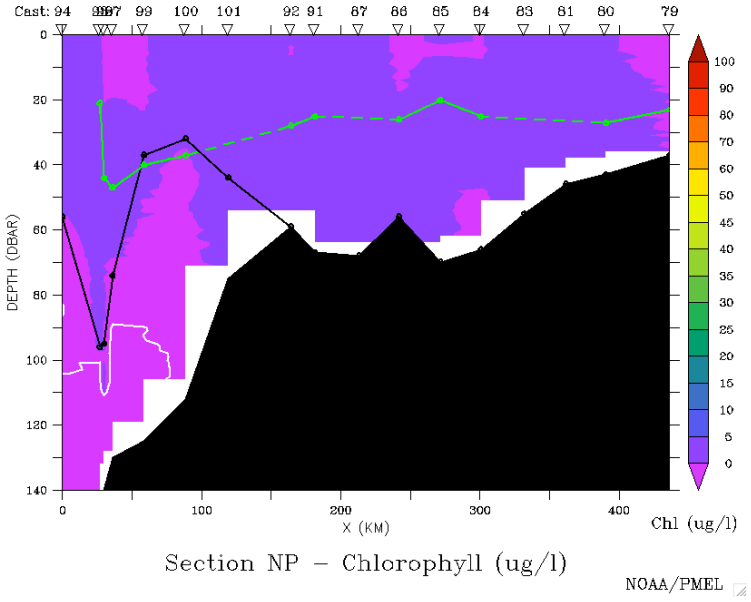



Figure 34. Chlorophyll concentration along the NP transect.

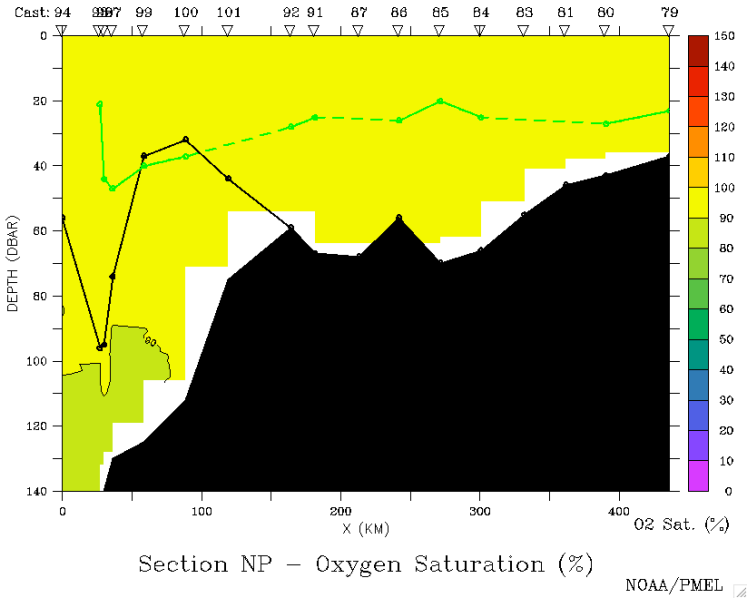



Figure 35. Dissolved oxygen saturation along the NP transect.

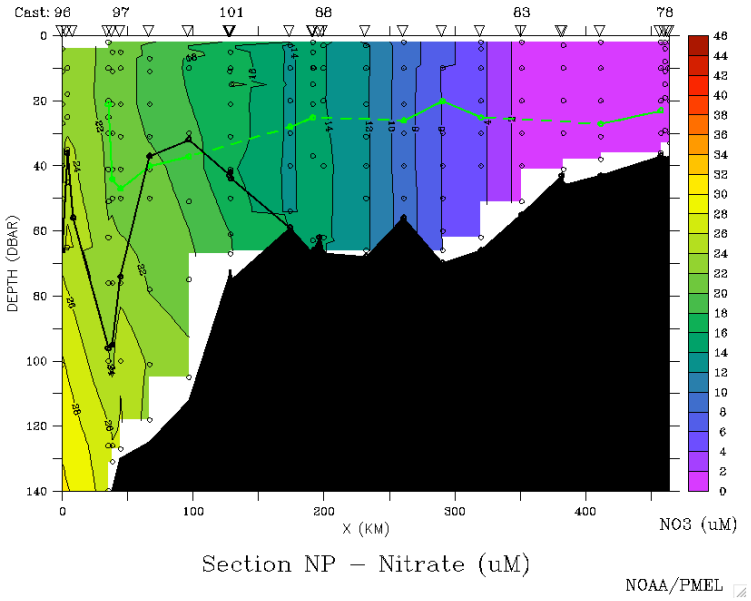



Figure 36. Nitrate along the NP transect.

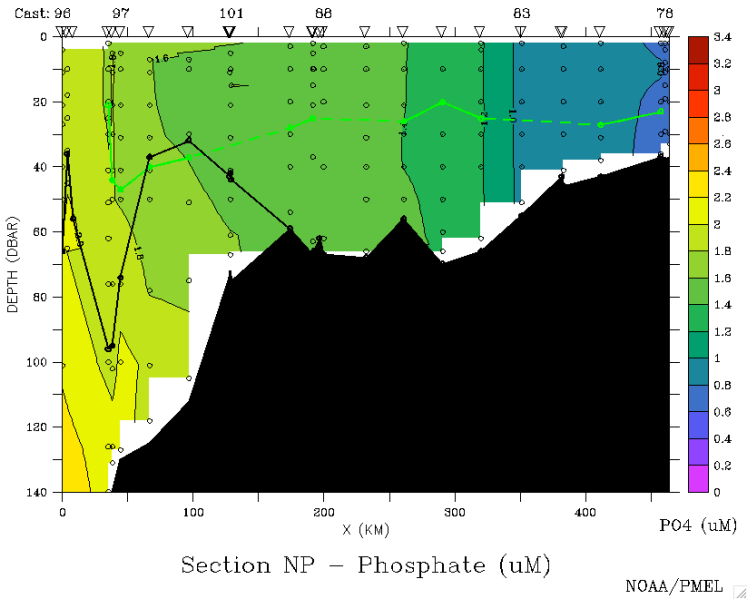



Figure 37. Phosphate along the NP transect.

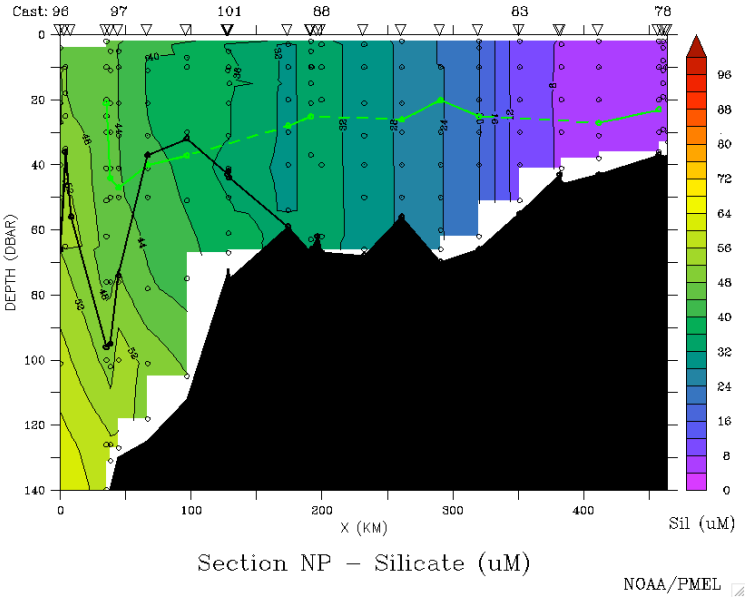



Figure 38. Silicate along the NP transect.

## Transects of Water Properties along the 70 Meter Line

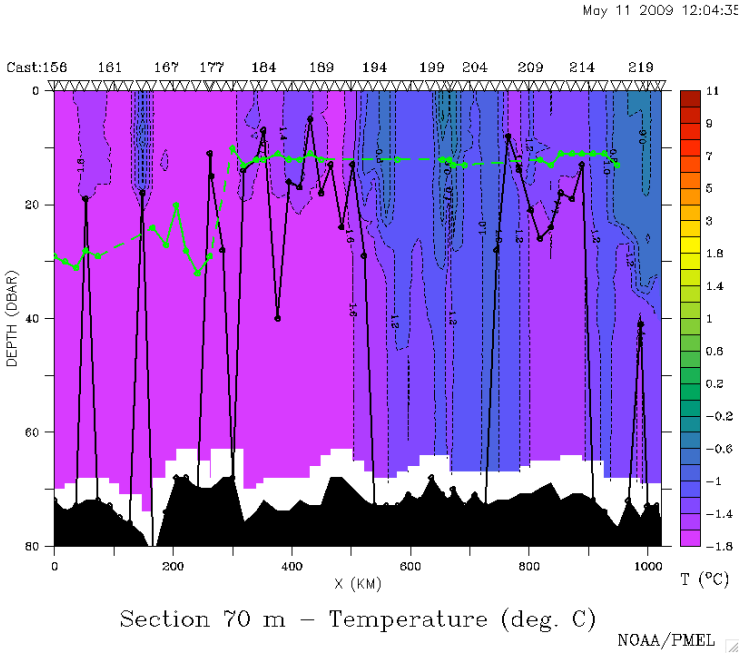



Figure 39. Water temperature along the 70-m transect.

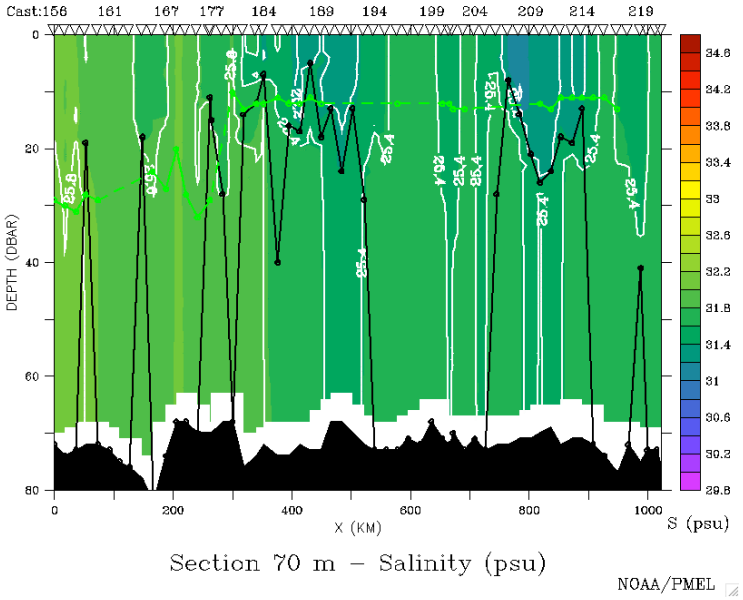



Figure 40. Salinity along the 70-m transect.

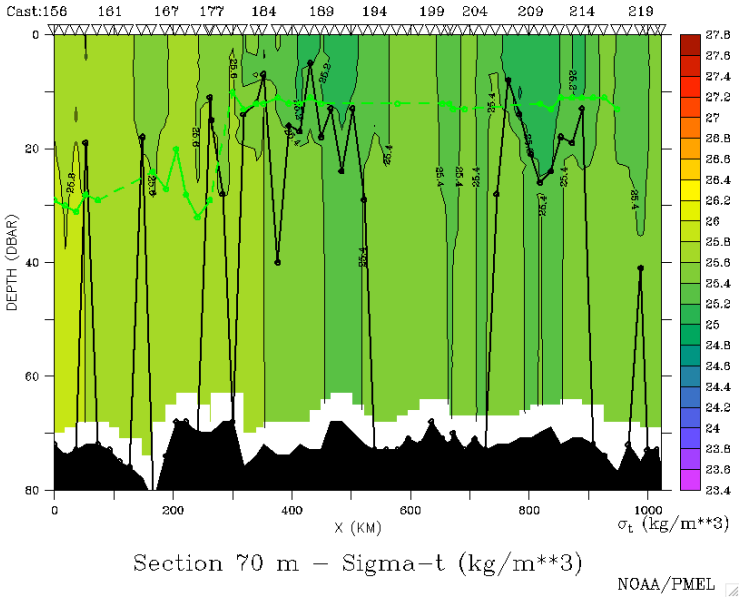



Figure 41. Sigma-t density along the 70-m transect.

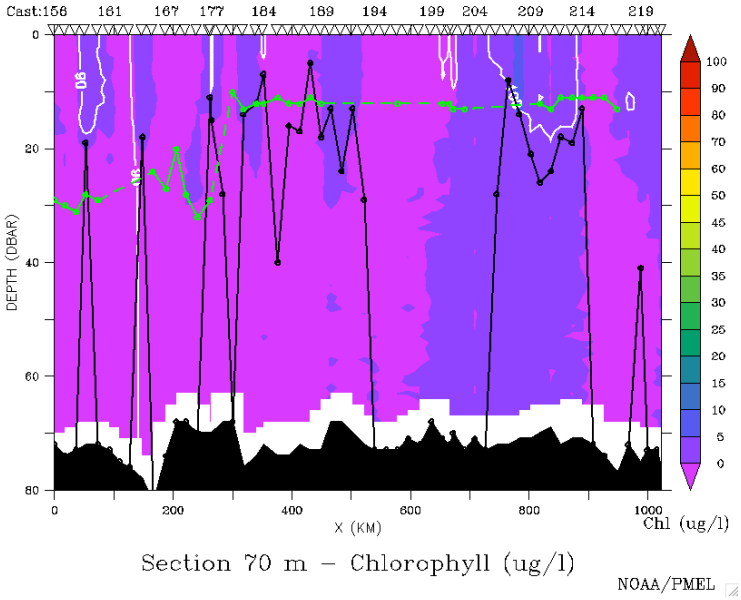



Figure 42. Chlorophyll concentration along the 70-m transect.

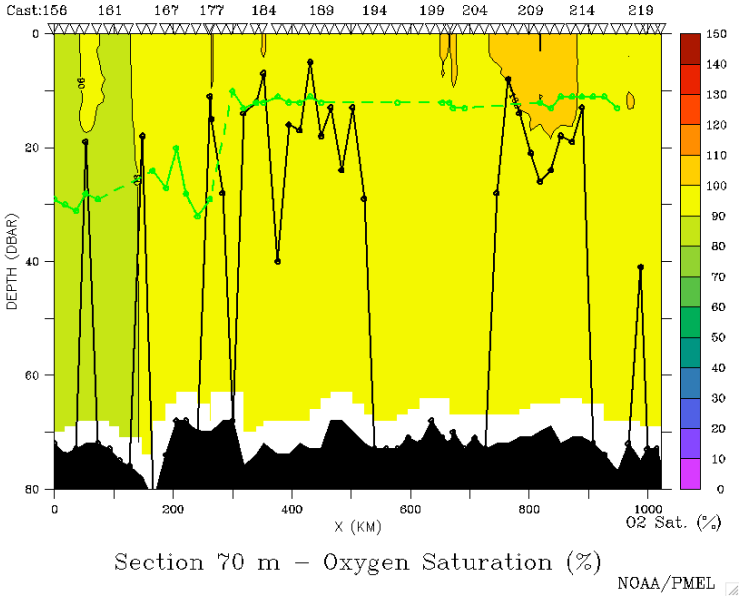



Figure 43. Dissolved oxygen saturation along the 70-m transect.

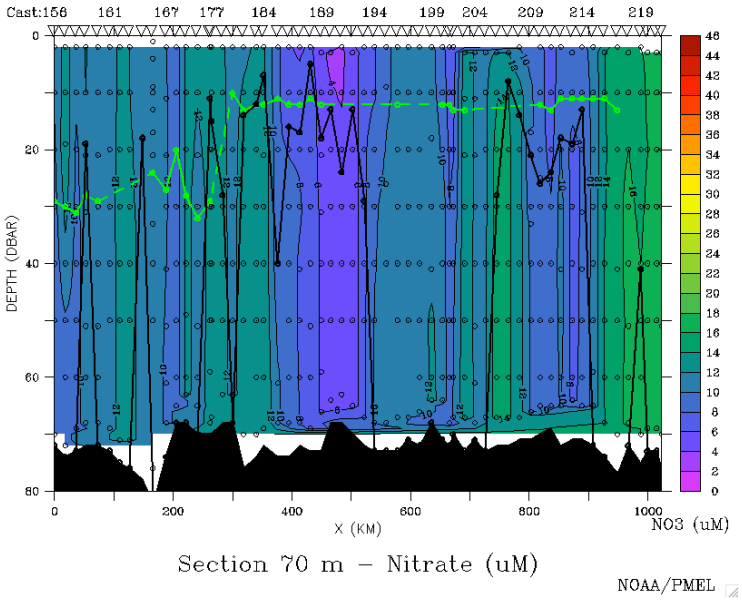



Figure 44. Nitrate along the 70-m transect.

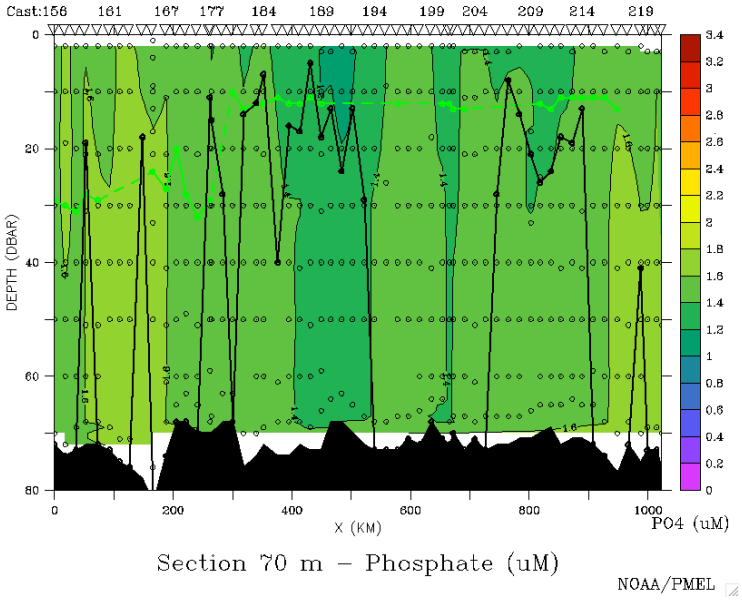



Figure 45. Phosphate along the 70-m transect.

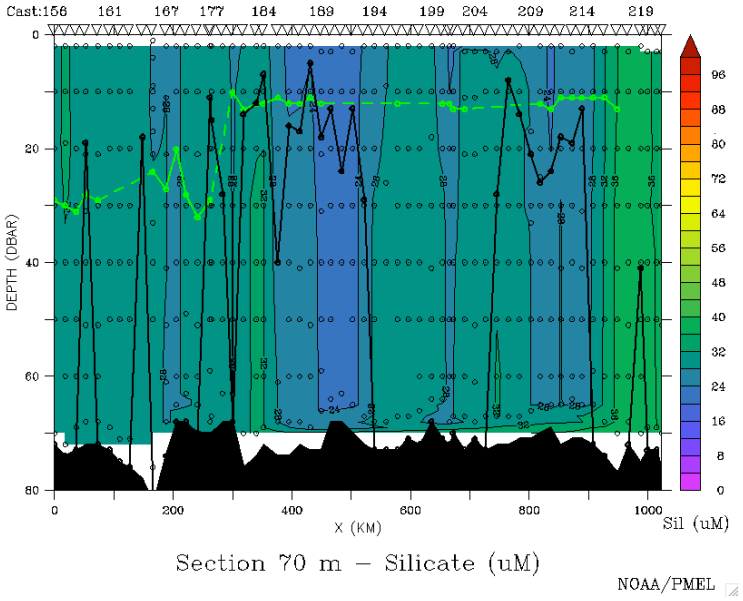



Figure 46. Silicate along the 70-m transect.

## The Impact of Changes in Sea Ice on Primary Production, Phytoplankton Community Structure, and Export in the Eastern Bering Sea

PIs: Brad Moran (URI) and Mike Lomas (BIOS)
On-Board Team Members: Roger P. Kelly (URI), Mike Lomas, and Doug Bell (BIOS)

This project, part of a collaborative effort between BIOS and URI, addresses the question of whether climate-driven interannual variability in sea ice extent alters the magnitude of gross and net primary production, its autotrophic community structure, and subsequently the partitioning of primary production carbon between carbon export to the benthos and DOC within the water column. The broader project objectives are to:

1. *Quantify the magnitude and regional variability of gross primary production and net community production in MIZ and open-water blooms associated with seasonal and interannual changes in sea ice extent.*

2. *Quantify the main floristic patterns (using a diversity of chemotaxonomic methods) and autotrophic cell size distributions in MIZ and open-water blooms.*

3. *Quantify the export flux of organic carbon associated with MIZ and open-water blooms in deeper waters (outer-shelf/slope), and link carbon export to primary production and benthic oxygen utilization to assess the efficiency of pelagic-benthic coupling associated with seasonal and interannual changes in sea ice extent.*

**A. Moran Component:**

The primary goals of this project are to quantify and characterize the material sinking through the water column and its accumulation in the sediments of the Bering Sea. The sinking particulate flux will be evaluated using $^{234}$Th, a tracer of particle export, and analysis of material collected in sediment traps. Thorium-234 samples are collected from the CTD-rosette at the standard depths determined by the hydro team. These 4L samples are treated with reagents (25% ammonium hydroxide, 0.2 M potassium permanganate, 1.0 M manganese chloride) to produce a manganese dioxide precipitate, which quantitatively scavenges thorium. This precipitate is collected on a filter, which is analyzed at sea for $^{234}$Th using a RISO GM-25-5 beta counter.

Two types of sediment traps will be used to collect sinking particles from the water column. One type used has been ice-anchored traps, in conjunction with the Iken/Gradinger group. At all long ice stations, sediment traps have been deployed at 5 and 20m depths. At shallow stations, replicate trap strings have been deployed. At deeper stations, longer trap strings have been deployed to characterize the evolution of ice-generated particles as they descend to the sediments. In open water, drifting sediment trap deployments were conducted at 3 different locations totaling 5 deployments. In addition to $^{234}$Th, trap samples will be analyzed for organic and inorganic CHN, pigments, microscopy (Lessard), and particulate proteins (Harvey) (where sufficient sample mass is collected).

In addition to water column $^{234}$Th, sediment $^{234}$Th is being measured at sea on samples collected by the Shull group. These measurements will be used to quantify the accumulation of $^{234}$Th as well as bioturbation rates in marine sediment. In an effort to create a $^{234}$Th budget, water column $^{234}$Th profiles have been collected in places where sediment samples have been collected.

The table below summarizes the samples collected between April 3rd and May 5th 2009, on HLY0902.

| Station No. | Station Name | Date | 234Th | Ice Traps | Drifting Traps |
|---|---|---|---|---|---|
| 1 | NP7 | 090404 | X | | |
| 2 | NP6.5 | 090405 | X | | |
| 3 | I/P1 | 090405 | | X | |
| 9 | MN4.5 | 090407 | X | X | |
| 10 | MN5 | 090408 | X | | |
| 14 | MN8 | 090409 | X | | |
| 19 | MN13 | 090410 | X | | |
| 22 | MN16 | 090411 | X | | |
| 25 | MN19 | 090412 | X | | |
| 26 | MN20 | 090412 | X | | |
| 29 | MN-SL4 | 090414 | X | X | |
| 32 | SL12 | 090415 | X | | |
| 35 | SL9 | 090416 | X | X | |
| 45 | SL1 | 090418 | X | X | |
| 50 | NP1 | 090420 | X | X | |
| 54 | NP5 | 090421 | X | | |

| Station No. | Station Name | Date | 234Th | Ice Traps | Drifting Traps |
|---|---|---|---|---|---|
| 58 | NP9 | 090422 | X | | |
| 60 | ST1 | 090422 | X | | X |
| 61 | NP15 | 090422 | X | | |
| 66 | NP11 | 090424 | X | | |
| 69 | BL1 | 090426 | X | | |
| 70 | BL2 | 090426 | | | X |
| 73 | BL4 | 090427 | X | | |
| 85 | BL15 | 090429 | X | | XX |
| 92 | MN-SL5 | 090501 | X | X | |
| 93 | BN1 | 090502 | X | X | |
| 98 | SL12 | 090504 | X | | |
| 115 | BL21 | 090506 | X | | X |
| 120 | 70M42 | 090507 | X | | |

**Results to date:**

Although $^{234}$Th is being measured at sea, it is necessary to count the samples monthly over the life-time of $^{234}$Th (140 days) before a precise value is known for any sample. As of this time it is impossible to evaluate any results from this component of the study.

**B. Lomas component:**

The primary goal of this project is quantify rates of primary production and who are the primary producers. In conjunction with the Sambrotto group we are collecting samples from a full light profile (7 depths), and using $^{14}$C to quantify primary production in on-deck incubators. At each of these process stations we also collect samples for a detailed analysis of phytoplankton community composition. This is done in several ways. Samples are collected for flow cytometric analysis to quantify the pico- (<2µm) and nano-(<20µm) sized phytoplankton as well as heterotrophic bacteria. These groups are dominated by marine *Synechococcus* (pico-) and cryptophytes (nano-), although there are at least 2-3 other eukaryotic populations of nano-phytoplankton present. Samples are also collected microscopic analysis of micro-phytoplankton. These direct counts (by flow cytometry and microscopy) of specific phytoplankton groups are ultimately converted to carbon/population values. This information is critical for both the other biologists (e.g., M-MFW gang) on the cruise as well as modelers as we try to understand carbon flow in the first few ecosystem trophic levels. Lastly, samples from all depths are collected for size-fractionated (whole and >5µm) chlorophyll a and HPLC pigment analysis. HPLC pigment profiles will be processed to assess the relative abundance of pico-, nano- and micro-phytoplankton abundances for comparison with other analyses.

At the non-process stations we are also collecting samples for pico- and nano-phytoplankton analyses to survey the abundance of these organisms underneath the ice in the eastern Bering Sea. Information on sea ice micro-phytoplankton (primarily diatoms) is abundant in the literature and also collected by the Gradinger and Iken group on this cruise. However, little is known about the abundance of pico- and nano-phytoplankton underneath the

ice. Data from HLY0802 suggest they are in general abundant (>$10^3$ cells $ml^{-1}$) but have the highest abundance under the ice (compared to at the ice edge) where *in situ* light is lowest.

The table below summarizes the samples collected between April 3rd and 21st 2009, on HLY0902. Samples collected are listed as yes (Y) or no (N) and the number of depths sampled in parentheses.

| Station No. | Station Name | Date | s-f Chla | s-f HPLC pigments | Pico-/Nano-plankton | Micro-plankton | Primary Production |
|---|---|---|---|---|---|---|---|
| 1 | NP7 | 090404 | Y(4) | N | Y(4) | Y(4) | N |
| 2 | NP6.5 | 090405 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 5 | MN1 | 090406 | Y(4) | N | Y(4) | N | N |
| 6 | MN2 | 090406 | Y(4) | N | Y(4) | N | N |
| 9 | MN4.5 | 090407 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 10 | MN5 | 090408 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 12 | MN6 | 090408 | Y(4) | N | Y(4) | N | N |
| 13 | MN7 | 090408 | Y(4) | N | Y(4) | N | N |
| 15 | MN9 | 090409 | Y(4) | N | Y(4) | N | N |
| 17 | MN11 | 090409 | Y(5) | N | Y(5) | N | N |
| 18 | MN12 | 090409 | Y(5) | N | Y(5) | N | N |
| 19 | MN13 | 090410 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 20 | MN14 | 090410 | Y(4) | N | Y(4) | N | N |
| 24 | MN18 | 090411 | Y(5) | N | Y(5) | N | N |
| 25 | MN19 | 090412 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 26 | MN20 | 090412 | Y(5) | N | Y(5) | N | N |
| 27 | MN-SL2 | 090413 | Y(4) | N | Y(4) | N | Y(7) |
| 29 | MN-SL4 | 090414 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 32 | SL12 | 090415 | Y(4) | N | Y(4) | N | Y(7) |
| 35 | SL9 | 090416 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 39 | SL6 | 090417 | Y(4) | N | Y(4) | N | Y(7) |
| 42 | SL3 | 090417 | Y(4) | N | Y(4) | N | Y(7) |
| 45 | SL1 | 090418 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 47 | W1 | 090419 | Y(3) | N | Y(3) | N | N |
| 49 | W3 | 090419 | Y(3) | N | Y(3) | N | N |
| 50 | NP1 | 090420 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 51 | NP2 | 090420 | Y(4) | N | Y(4) | Y(4) | N |
| 54 | NP5 | 090421 | Y(4) | N | Y(4) | Y(4) | N |
| 55 | NP6 | 090421 | Y(4) | N | Y(4) | Y(4) | N |
| 56 | NP7 | 090421 | Y(4) | N | Y(4) | Y(4) | N |
| 57 | NP8 | 090421 | Y(4) | N | Y(4) | Y(4) | N |
| 58 | NP9 | 090422 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 59 | NP10 | 090422 | Y(4) | N | Y(4) | Y(4) | N |
| 60 | ST1 | 090422 | Y(5) | Y(5) | Y(5) | Y(4) | Y(5) |
| 62 | ST1-R | 090423 | Y(4) | N | Y(4) | Y(4) | N |

| Station No. | Station Name | Date | s-f Chla | s-f HPLC pigments | Pico-/Nano-plankton | Micro-plankton | Primary Production |
|---|---|---|---|---|---|---|---|
| 66 | NP11 | 090424 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 69 | BL1 | 090426 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 70 | ST2-R | 090426 | Y(4) | N | Y(4) | Y(4) | N |
| 73 | BL4 | 090427 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 85 | BL15 | 090429 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 90 | BL20 | 090430 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 93 | BN1 | 090502 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 98 | SL12 | 090504 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 100 | SL11 | 090504 | Y(4) | N | Y(4) | Y(4) | N |
| 115 | BL21 | 090506 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |
| 116 | BL15 | 090506 | Y(4) | N | Y(4) | Y(4) | N |
| 120 | 70M44 | 090507 | Y(7) | Y(7) | Y(7) | Y(4) | Y(7) |

**Results to Date:**

We've completed the analysis of extracted chlorophyll's (Chla) for the three main lines; the MN (Figure A), the SL (Figure B) and the NP (Figure C). Generally, Chla has been low (<1ug $L^{-1}$) with the >5um Chla comprising roughly 50% of the total. Two notable exceptions were the 'bloom' in the middle of the SL line where >5um Chla was nearly 100% of the total. This is very likely due to sea-ice algae 'melting out' of the bottom of the ice and entering the water column. The second, near St. Paul Island, there was a significant increase in Chla in the open water region that was entirely due to large diatoms (Figure C).

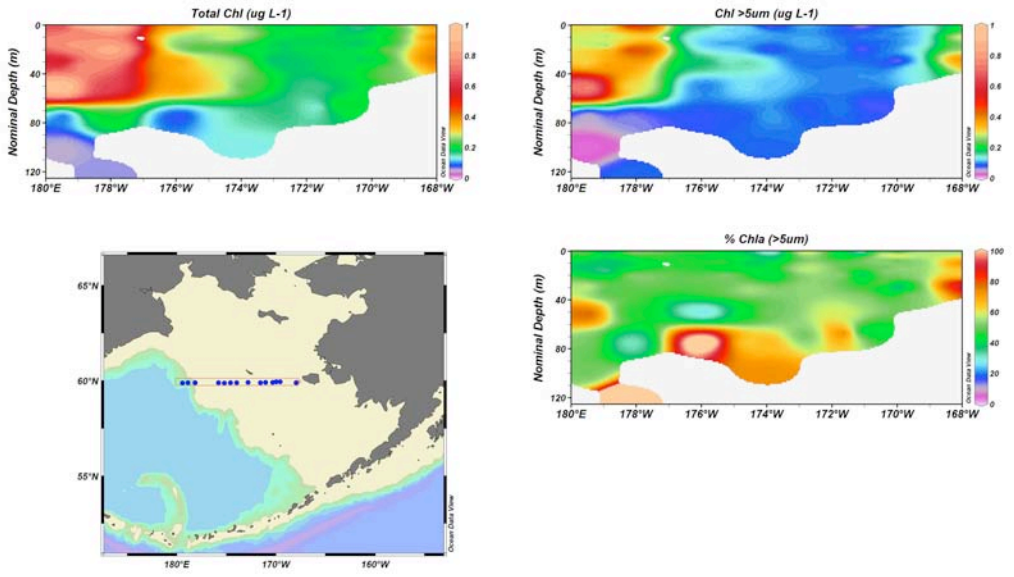



**Figure A.** Section plots of whole and >5um extracted Chla concentrations and >5um Chla a percentage of the whole along the MN line during HLY0902.

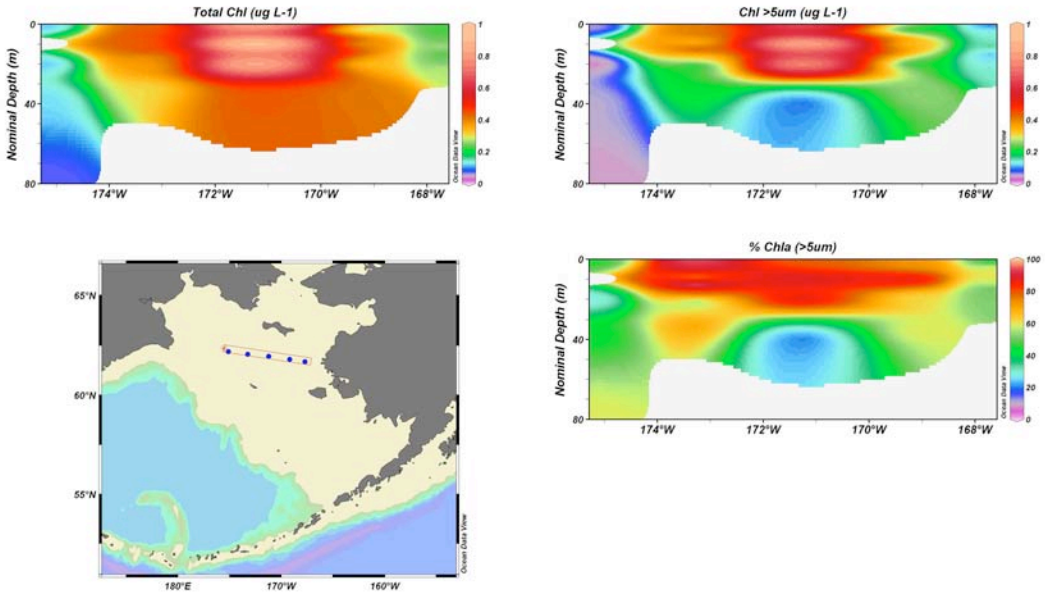



**Figure B.** Section plots of whole and >5um extracted Chla concentrations and >5um Chla a percentage of the whole along the SL line during HLY0902.

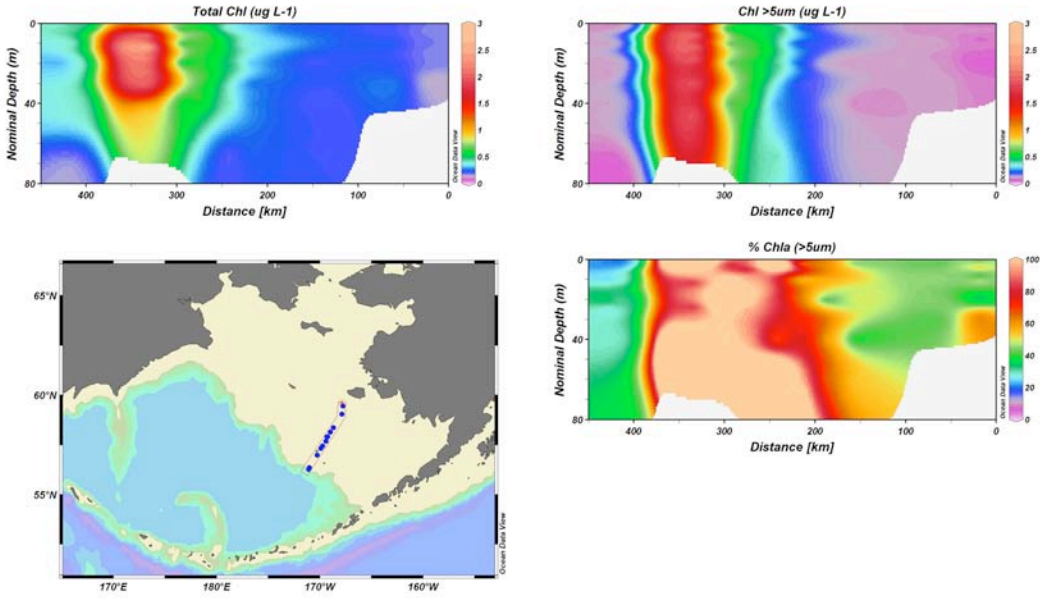



**Figure C.** Section plots of whole and >5um extracted Chla concentrations and >5um Chla a percentage of the whole along the NP line during HLY0902.

Potential rates of primary production were generally very low likely due to both the overall low biomass and slow physiological growth rates of resident cells due to prolonged periods of low light under the ice (Figure D). There is a consistent covariance of primary production and average euphotic zone Chla concentration suggesting that the station-to-station variability is due to changes in biomass alone.

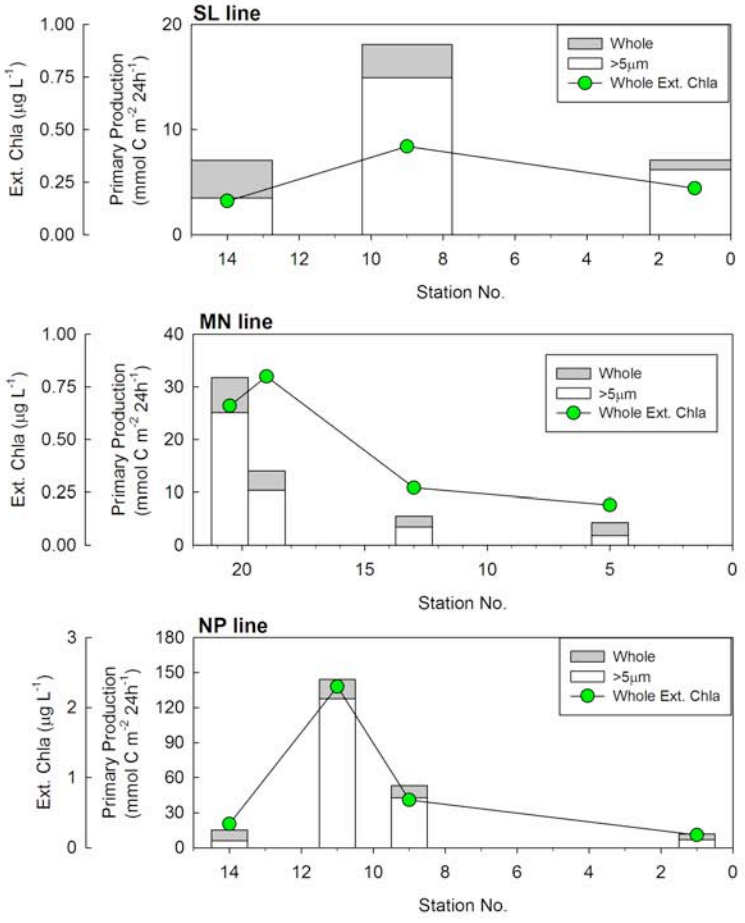



**Figure D.** Transect plots of primary production by the whole and >5um communities. Overlain is the mean euphotic zone Chla concentration for each station.

Our bloom time-series (Figure E) showed that while we started sampling after the initiation of the bloom it was clearly still in the growth phase showing consistently increasing Chla concentrations and integrated primary production over the course of the 11 days that it was sampled.

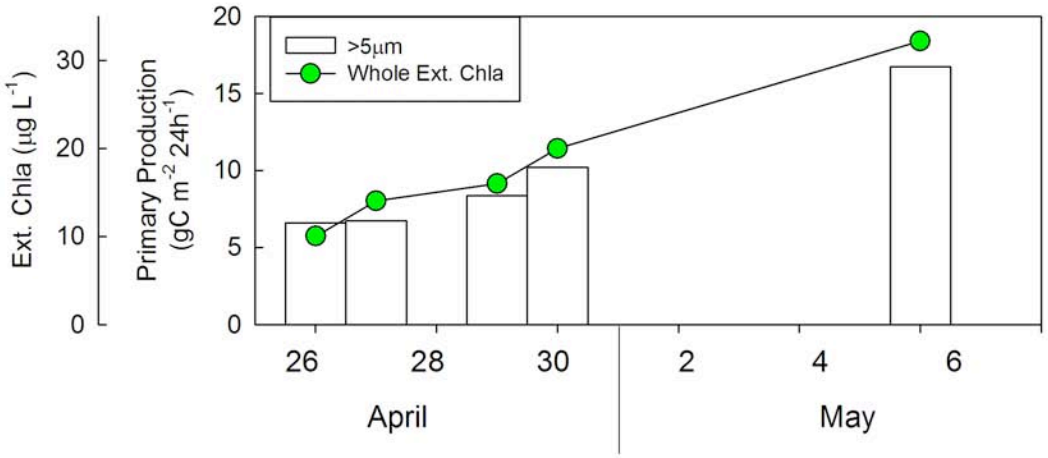



**Figure E.** Time-series of the Bloom Stations showing increasing Chla completely attributable to >5um cells, and a corresponding increase in euphotic zone integrated primary production.

## Nitrogen supply for new production and its relation to climatic conditions on the eastern Bering Sea Shelf

PIs: Raymond Sambrotto (LDEO) and Daniel Sigman (Princeton)
On-Board Team Members: Didier Burdloff (LDEO) and Kris Swenson (LDEO)

### Summary

The principal goal of our group was to access the primary productivity of the Bering Sea by taking 15N & 13C 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, preserved samples taken for phytoplankton identification, samples taken for Dissolved Organic Nitrogen and Phosphate, as well as Nitrification activity in deep water column. 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. Another component of our sampling station involved natural abundance ä15N and ä18O of nitrate, and ä15N of the total dissolved nitrogen (TDN=Nitrate +DON + ammonium, if present) to construct a nitrogen budget of the eastern shelf of the Bering Sea. The corresponding activity consisted of collecting samples in the water column ranging from under-ice “winter” water column to the winter ice

floe edges. Normally, in a well -mixed under-ice water column 2 or 3 depths were sampled. At the sites with 2 or 3 layer present, 6-10 samples were collected. At selected stations (Table 1), 60 ml of sea water collected from selected depths of the CTD casts was filtered through 0.2 micron membrane filters. Filtered sea waters were frozen at -20 C for subsequent isotopic analysis. Isotopic analysis will be run in the laboratory of D. Sigman at Princeton University.

The procedures and the stations at which they were performed can be seen in Table I.

**Results and Conclusions:**

In this cruise, we successfully completed on-deck incubations at all designated productivity process stations, and performed in-situ incubations at six of them. Our other sampling procedures listed above were all performed at spatially designated short and long stations.

The frigid conditions that were experienced early in the cruise made it difficult to keep the incubators running all the time, despite attempts at insulating and heating the connections and hoses that allowed the water to reach and drain from the incubators. With assistance from crew members and fellow scientists, we seem to have resolved the problems. A switch to water from the ship's ballast tank has helped, as the science seawater system contained a high volume of ice at times, which froze the manifolds, and thus froze the rest of our incubation setup.
The conditions on the ice made it possible for our in-situ incubations to take place, and we collected six nice profiles, which will undergo isotopic analysis upon return to Lamont.

We have reached our sampling goals for this cruise,and we look forward to get 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.

Table 1. Summary of collections by station and cast for the entire cruise.

| STN | CTD | $^{15}N03/^{13}CO3$ Uptake | $^{15}N03/^{13}CO3$ Uptake *in situ* | $^{15}NH4$ Uptake | $^{15}N$ Urea Uptake | Nitrification Exp. | $^{15}N03$ in water | Particles in water | DON/P Profile | Urea Wat. Col. Profile | Phytoplankton ID |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1- NP7 | 1 | | | | | | X | X | X | X | |
| 3 | 6 | X | | X | | | | X | | | |
| 4 BC-1 | 8 | X | | X | | | | | | | |
| 5 MN-1 | 9 | | | | | | X | X | X | X | |
| 9 MN-4.5 | 14 | | X | | | X | X | X | X | | |
| 10 MN-5 | 18 | X | | X | | | | | | | |
| 12 MN-6 | 20 | | | | | | | X | X | X | |
| 13 MN-7 | 21 | | | | | | | | | X | |
| 15 MN-9 | 24 | X | | X | | | | | | | X |
| 17 MN-11 | 26 | | | | | | | X | X | X | |
| 19 MN-13 | 32 | X | | X | | | X | X | X | X | X |
| 24 MN-18 | 38 | X | | | | | X | X | X | X | |
| 25 MN-19 | 42 | X | | X | | X | | X | X | X | |
| 26 MN-20 | 44 | | | | | | | X | X | X | |
| 27 MN-SL2 | 46 | X | | X | | | | | | | X |
| 29 SL-14 | 50 | X | X | | | | | X | X | X | |
| 32 SL-12 | 54 | | | | | | X | X | X | X | |
| 34 SL-10 | 56 | | | | | | | X | X | X | |
| 35 SL-9 | 59 | X | | X | | | | | | | X |
| 36 SL-8 | 61 | | | | | | | X | X | X | |
| 40 SL-5 | 64 | | | | | | X | X | X | X | |
| 42 SL-3 | 66 | | | | | | | X | X | X | |
| 45 SL-1 | 70 | X | X | | | | | | | | X |
| 48 W-2 | 74 | X | | X | | | | X | X | X | |
| 50 NP-1 | 78 | X | X | | | | | X | X | X | |
| 51 NP-2 | 80 | | | | | | | X | X | X | |
| 54 NP-5 | 84 | X | | | X | | X | X | X | X | |
| 56 NP-7 | 86 | | | | | | | X | X | X | |
| 58 NP-9 | 91 | X | | X | | X | | X | X | X | X |
| 61 NP-15 | 95 | X | | X | | X | X | X | X | X | |
| 65 NP-12 | 100 | | | | | | | X | X | X | |
| 66 NP-11 | 104 | X | | X | | | | X | X | X | X |
| 69 BL-1 | 107 | X | | X | | | | X | X | X | |
| 73 BL-4 | 115 | X | | X | | | X | X | X | X | |
| 78 BL-9 | 120 | | | | | | | X | X | X | |
| 85 BL-15 | 130 | X | | X | | | X | X | X | X | X |
| 88 BL-18 | 134 | | | | | | | X | X | X | |
| 90 BL-20 | 140 | X | | X | X | X | X | X | X | X | |
| 92 MN-SL5 | 142 | X | X | | | | | X | X | X | |
| 93 BN-1 | 146 | X | X | | | | X | X | X | X | X |
| 96 SL-9 | 150 | | | | | | | X | X | X | |
| 98 SL-12 | 155 | X | | X | | | X | X | X | X | X |
| 100 70M-58 | 156 | | | | | | | X | X | X | |
| 109 70M-49 | 166 | X | | X | | | | X | X | X | X |
| 113 70M-45 | 170 | | | | | | | X | X | X | |
| 115 BL-21 | 174 | X | | X | X | | X | X | X | X | |
| 120 70M-42 | 180 | X | | X | | | | X | X | X | |
| 124 70M-38 | 185 | | | | | | | X | X | X | |
| 134 70M-28 | 195 | | | | | | X | X | X | X | |
| 148 70M-14 | 209 | X | | X | | | X | X | X | X | X |

Representative plots of the Urea distribution in the water column along the MN, SL, NP and BL transects are shown in figure 1-4.

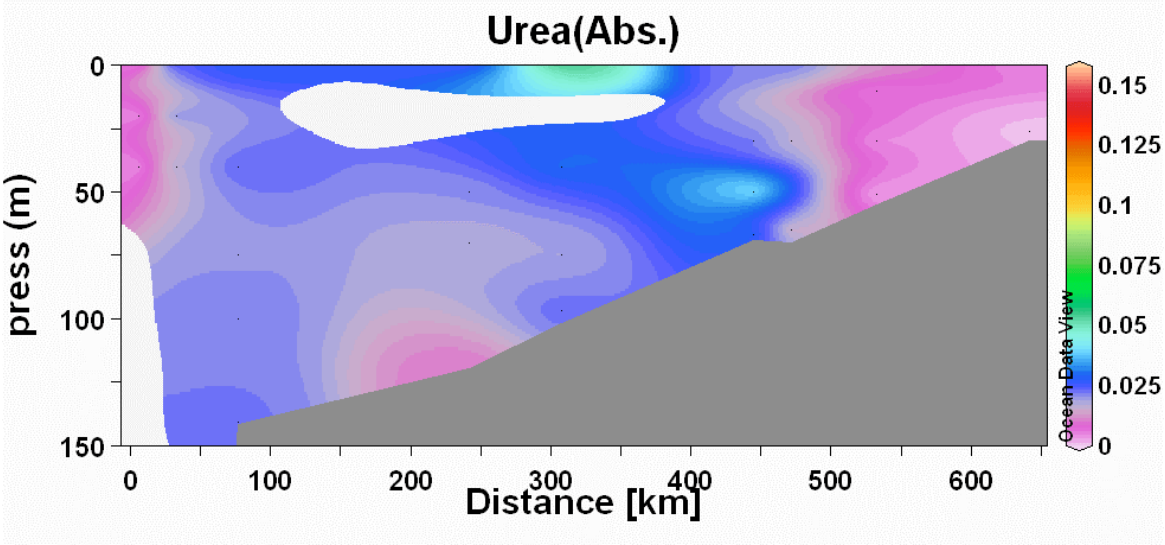



Fig 1. Urea (Absorbance Unit) on the MN (St Matthews-Nunivak) transect.

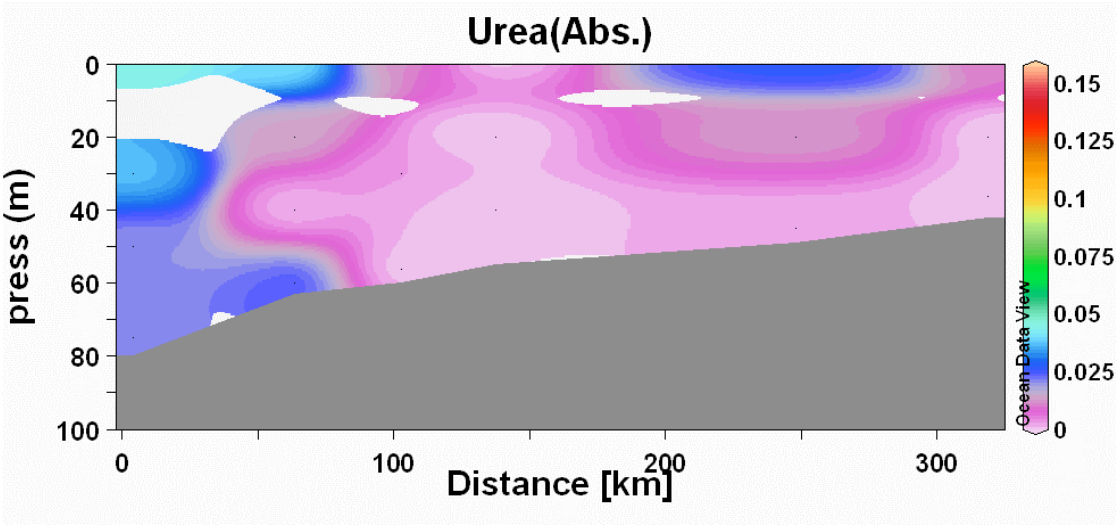



Fig 2. Urea (Absorbance Unit) on the SL (St Lawrence) transect.

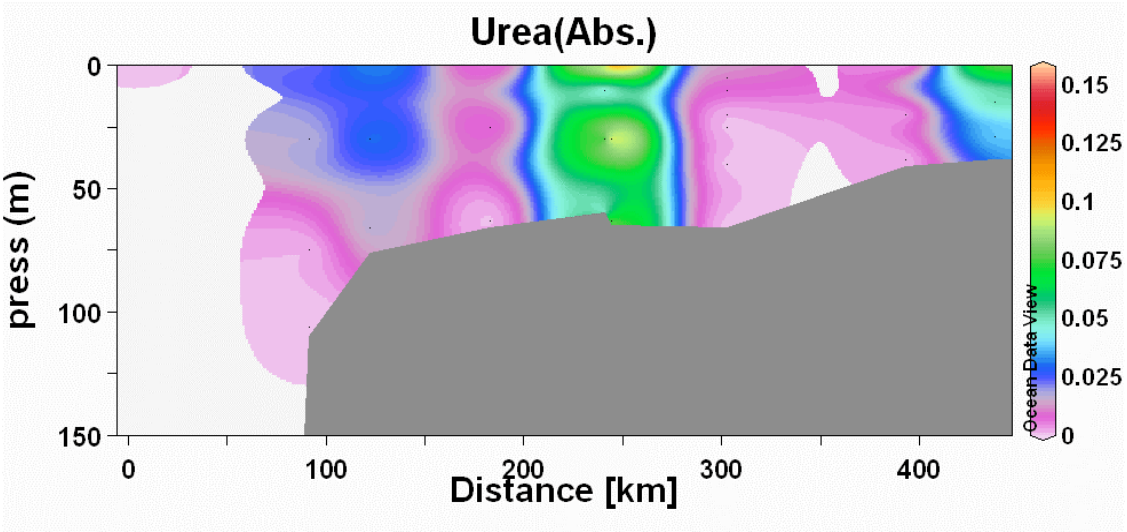



Fig 3. Urea (Absorbance Unit) on the NP (Nunivak-St. Paul) transect.

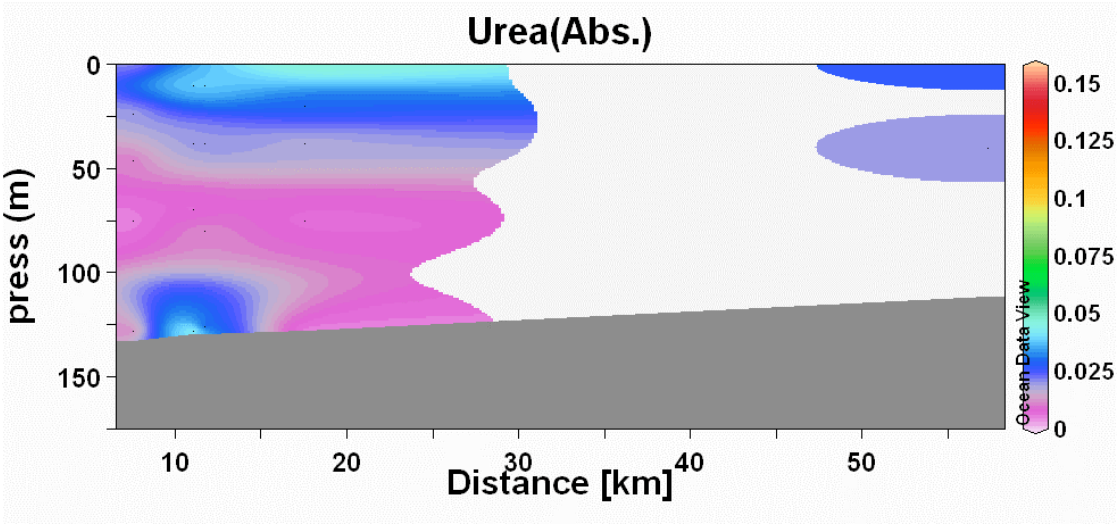



Fig 4. Urea (Absorbance Unit) on the BL (phytoplanktonic Bloom area) transect.

## Mesozooplankton-Microbial Food Web Interactions in a Climatically Changing Sea Ice Environment.

PIs: Evelyn Sherr (OSU), Barry Sherr (OSU), Robert Campbell (URI), Carin Ashjian (WHOI)
On-Board Team Members: Carin Ashjian, Phil Alatalo (WHOI), Celia Ross (OSU), Julie Arrington (OSU), Celia Gelfman (URI), Donna Van Keuren (URI)

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

Barry and Evelyn Sherr, Celia Ross, Julie Arrington

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. We are 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, 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.

Our group completed 16 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 in 9 of the incubations. Three experiments (1, 7, 9) were incubated at 30% of ambient light and four (10, 11, 12, 13) were incubated at 10%. We incubated our 10% diluted water samples on the Ashjian/Campbell plankton wheel (Figure 1) except for the first experiment which used our incubator.

Growth rates of algae were determined by change in chlorophyll-a concentrations from the initial to final times of the incubations. The results (Table 1) suggested grazing mortality in twelve experiments with significant grazing in six of those experiments. Phytoplankton growth rates in the 10% diluted water treatments varied from negligible to about 0.454 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.

Sampling in the first half 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 confirmed that the phytoplankton stocks in the water are either very small cells which most mesozooplankton likely cannot utilize as food, or large and chain-forming diatoms which appear to be primarily sloughed off from the overlying ice.

Microscopic 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 2. 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.

We have also collected profile samples for analysis of microzooplankton abundance and flow cytometric analyses of phytoplankton in the upper water column from depths sampled for primary production at 18 stations. 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.

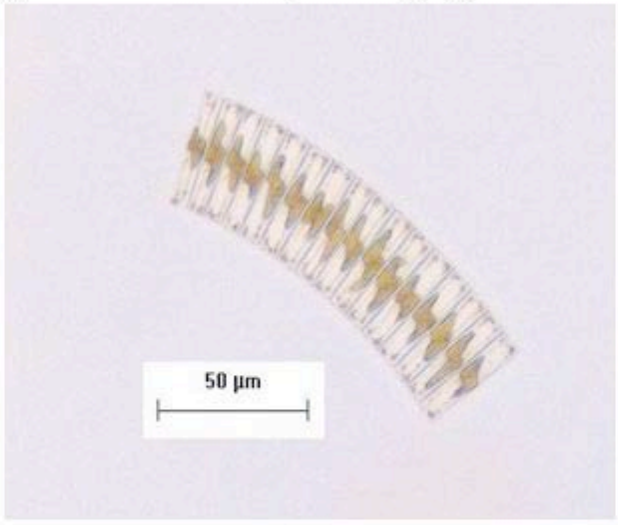
**Table 1. Results of dilution experiments. Microzooplankton grazing rate is calculated as the difference between the 10% diluted water growth rate and the whole water growth rate. Negative values (in bold) for micro-zooplankton grazing rate indicate microzooplankton grazing losses for algae in the water. Values close to 0 or positive indicate net growth of algae and no apparent microzooplankton grazing. There has been an indication of significant microzooplankton grazing at the six out of the sixteen stations sampled.**

| Exp | Date | Site | Sample Depth, (m) | To WW chl-a, ug/liter | 10% diluted water growth rate, 1/day | | Whole water growth rate, 1/day | | Microzoo grazing rate, 1/day |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Mean | mean | std dev | mean | std dev | |
| 1 | 4/8/09 | MN-5 | 10 | 0.252 | -0.242 | 0.132 | 0 | 0.034 | .242 |
| 2 | 4/10/09 | MN-13 | 20 | 0.351 | -0.044 | 0.063 | 0.091 | 0.025 | 0.135 |
| 3 | 4/12/09 | MN-19 | 25 | 0.889 | 0.204 | 0.056 | 0.248 | 0.015 | 0.044 |
| 4 | 4/14/09 | MN- SL4 | 10 | 0.237 | -0.077 | 0.033 | -0.043 | 0.026 | 0.034 |
| 5 | 4/16/09 | SL-9 | 10 | 0.497 | 0.256 | 0.145 | 0.173 | 0.043 | **-0.083** |
| 6 | 4/18/09 | SL-1 | 10 | 0.341 | 0.092 | 0.024 | 0.023 | 0.019 | **-0.069** |
| 7 | 4/20/09 | NP-1 | 10 | 0.272 | -0.068 | 0.046 | -0.095 | 0.071 | **-0.027** |
| 8 | 4/22/09 | NP-9 | 10 | 1.06 | 0.147 | .111 | 0.117 | .061 | **-0.030** |
| 9 | 4/24/09 | NP-11 | 10 | 2.853 | 0.426 | 0.137 | 0.410 | .009 | **-0.015** |
| 10 | 4/26/09 | BL-1 | 7 | 10.256 | 0.371 | 0.034 | 0.246 | .003 | **-0.125** |
| 11 | 4/27/09 | BL-4 | 7 | 23.600 | 0.254 | 0.025 | 0.123 | .053 | **-0.131** |
| 12 | 4/29/09 | BL-15 | 5 | 20.930 | 0.454 | 0.025 | 0.302 | 0.023 | **-0.153** |
| 13 | 4/30/09 | BL-20 | 5 | 21.389 | 0.264 | 0.047 | 0.200 | 0.019 | **-0.064** |
| 14 | 5/2/09 | BN-1 | 10 | 1.900 | 0.255 | 0.045 | 0.400 | 0.101 | **-0.145** |
| 15 | 5/4/09 | SL-12 | 10 | 0.602 | 0.332 | 0.025 | 0.087 | 0.023 | **-0.244** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 5/6/09 | BL-21 | 15 | 37.459 | | 0.140 | 0.051 | 0.016 | 0.052 | **-0.123** |


Figure 1. 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

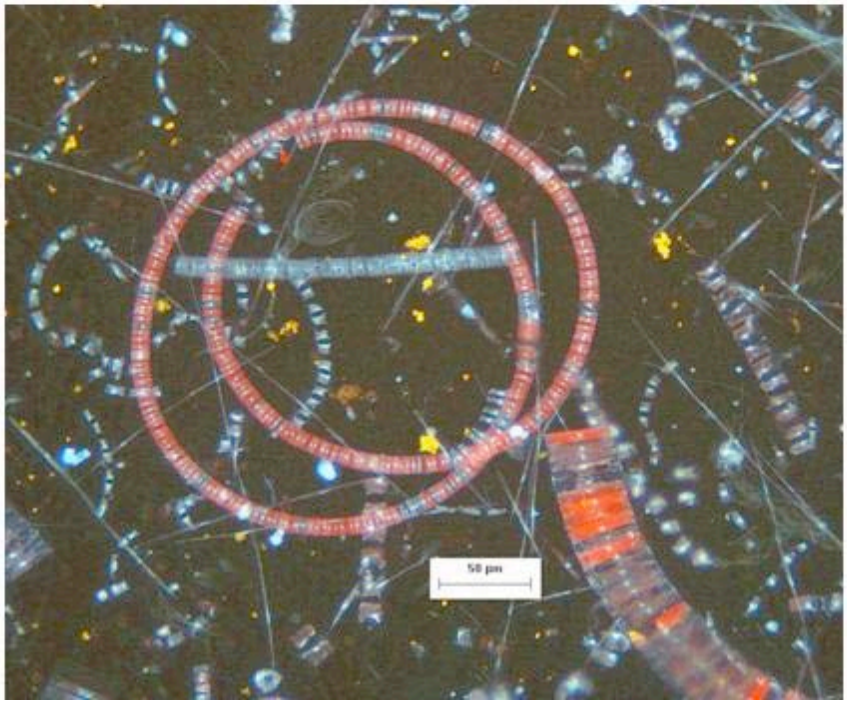


Figure 2. Examples of sea ice algae imaged by top: light microscopy after fixation with acid Lugol solution, and bottom: epifluorescence microscopy after fixation with formalin and staining with a blue-fluorescing dye that shows the nucleus and cytoplasm of

individual cells.

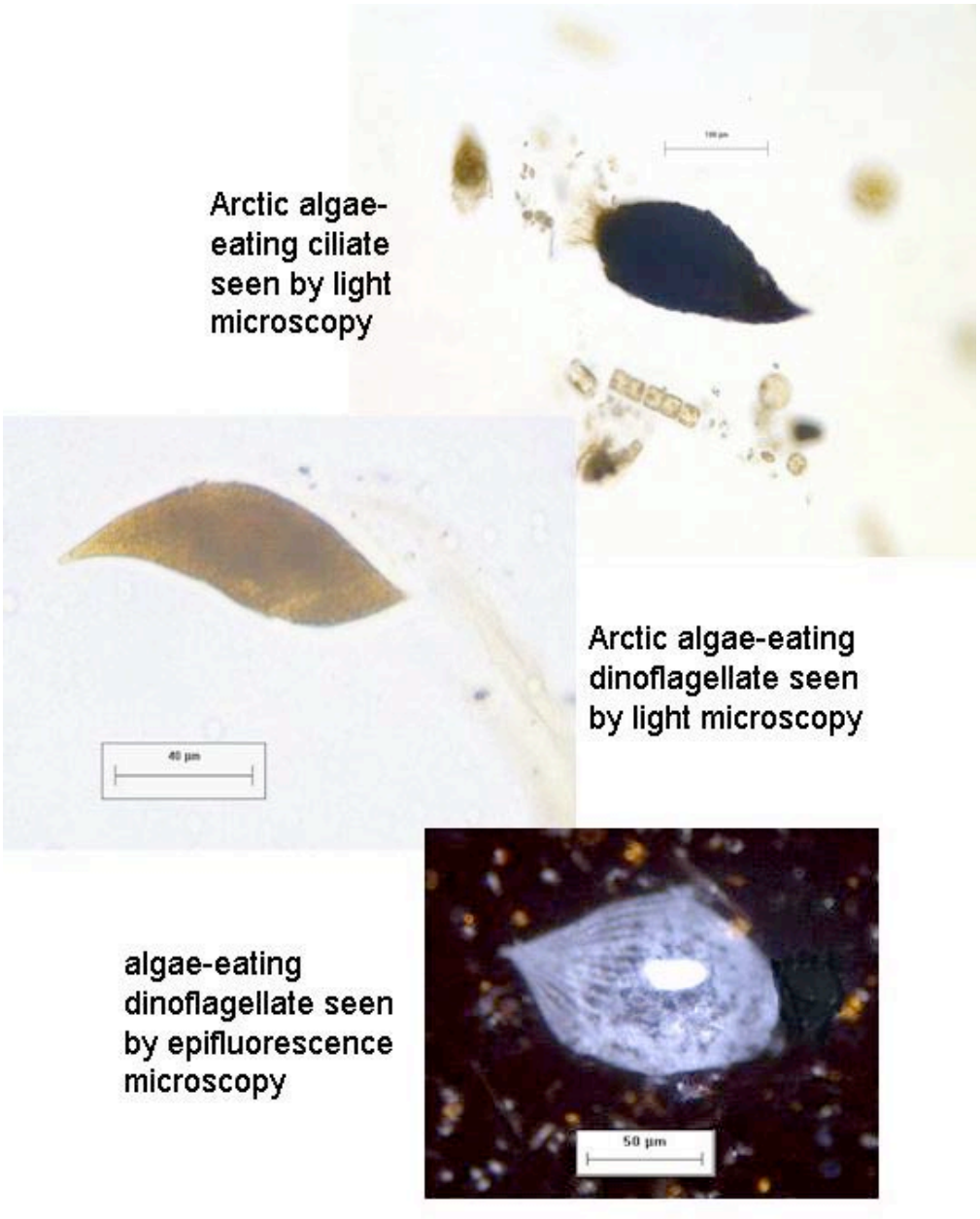



Figure 3. Examples of herbivorous protists in the microzooplankton seen in the Arctic Ocean. Similar protists have been observed during this cruise. Heterotrophic dinoflagellates known to ingest large sized diatoms appear to be especially abundant in our samples.

## B. Mesozooplankton Feeding and Reproduction

Carin Ashjian, Philip Alatalo, Celia Gelfman, 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 18 feeding experiments using the dominant zooplankton species/taxa at the process stations were conducted. The inshore plankton community was dominated by *Calanus marshallae/glacialis* and *Pseudocalanus* spp., with the mid-shelf dominated by *C. marshallae, Metridia longa,* and *Pseudocalanus* spp., and the outer shelf dominated by *Neocalanus cristatus* and *N. plumchrus, Eucalanus bungii bungii,* Krill have been present across the shelf, with *Thysanoessa raschii* dominant inshore and *T. longipes* and *T. inermis* more important offshore. The experiments have been comprised of 3 dominant copepod species (*Calanus marshallae/glacialis*, *Pseudocalanus* spp., and *Metridia pacifica*) and 1 dominant euphausiid (*T. raschii*) species, although grazing measurements with the copepods *E. bungii bungii, N. cristatus*, and *N. plumchrus* also were obtained when those species were abundant. Chlorophyll concentrations have been quite low (<0.2 µg chl a/l) at process stations under the ice with concomitant low grazing on chlorophyll at those stations. Grazing rates were substantially higher at stations with higher chlorophyll concentrations and also on ambient water enriched with ice algae. Highest grazing rates were obtained during our sampling of a water column bloom in early May. Samples to estimate feeding on microzooplankton and phytoplankton/ice algae taxa will be analyzed in the laboratory.

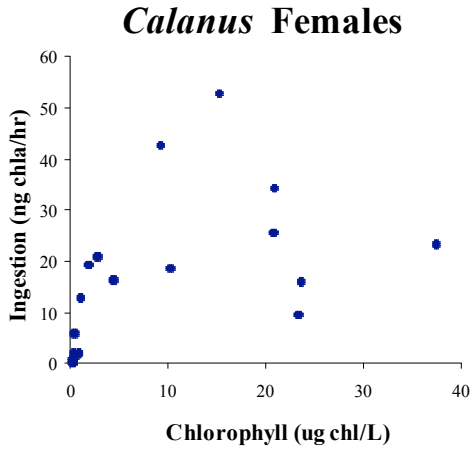



Figure 1. Grazing rate of *Calanus* females as a function of ambient water column chlorophyll concentration.

Egg production experiments were conducted with the dominant copepod species at selected stations. A total of 26 measurements were made for *Calanus*, 7 for *M. pacifica,* one for *E. bungii bungii,* and 9 for *Pseudocalanus* spp. Reproduction was initially low for *Calanus marshallae/glacialis* but increased over the course of the cruise to very high rates especially in the phytoplankton bloom. Egg production rates increased with increasing ambient chlorophyll

concentration and reached a maximum of 40-50 eggs $^{-F\ -day}$ at 10 µg chl/L. These high rates are probably at or near maximum for this species at these temperatures. Egg production in this species may be fueled by feeding on ice algae at the ice/water interface, by lipid reserves, or by feeding on water column phytoplankton. The ability of this species to reproduce using lipid reserves is being investigated during long-term egg production experiments. Reproduction of *Pseudocalanus* spp. and *Metridia pacifica* was low at most stations. No reproduction was observed for *Eucalanus bungii bungii*.

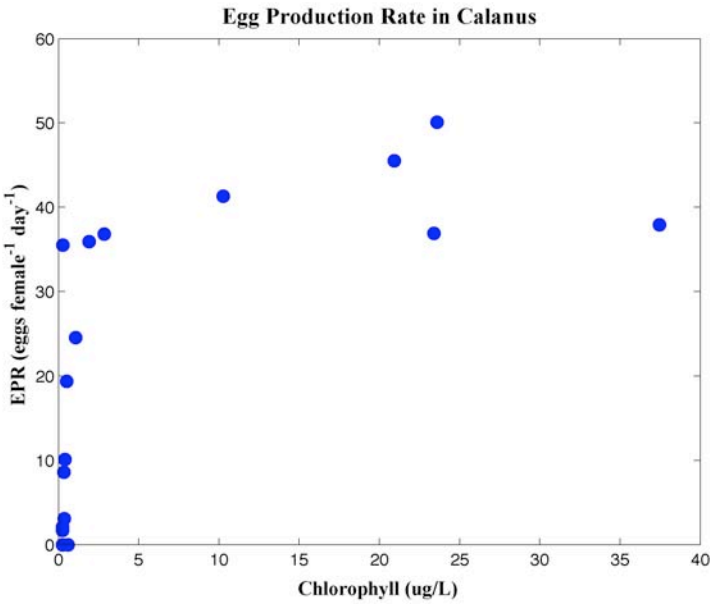



Figure 2. Egg production rate as a function of ambient water column chlorophyll concentration for *Calanus*.

Samples have also been collected for morphometrics, carbon and nitrogen, RNA/DNA, and genetic sequencing at process and selected stations.

Table 1. Summary of zooplankton experiments and measurements by station. All animals used in these experiments were photographed for morphometric measurements. CHN=Animals picked for carbon and nitrogen content determination, RNA/DNA = animals picked for the ratio of RNA to DNA, a measure of metabolic activity; Cal=Calanus; Pcal=Pseudocalanus; Met=Metridia; Eucal=Eucalanus; Gen.=animals picked for genetic sequencing for species differentiation and population studies; Graz=Grazing Experiment; Bongo=Bongo tows conducted to quantify zooplankton abundance.

| Station Name | Station | Date | Cal EPR | Pcal EPR | Met EPR | Eucal EPR | CHN | RNA/ DNA | Gen. | Graz. | Bongo |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ice #1 | 3 | 4/5/09 | x | | | | | x | x | GE1 | x |
| MN4.5 | 9 | 4/7/09 | x | x | | | x | x | x | | |
| MN5 | 10 | 4/8/09 | x | x | | | x | x | | GE2 | x |
| MN9 | 15 | 4/9/09 | x | | | | x | x | | | |
| MN13 | 19 | 4/10/09 | x | | x | | | x | | GE3 | x |
| MN18 | 24 | 4/11/09 | | | x | | | | | | |
| MN19 | 25 | 4/12/09 | | | | x | x | | x | GE4 | x |
| MN-SL2 | 27 | 4/13/09 | | | | | | | x | | |
| MN-SL4 | 29 | 4/14/09 | x | x | x | | x | x | x | GE5 | x |
| SL12 | 32 | 4/15/09 | x | x | | | | x | x | | |
| SL9 | 35 | 4/16/09 | x | x | x | | x | x | | GE6 | x |
| SL6 | 39 | 4/17/09 | x | | | | | x | x | | |
| SL1 | 45 | 4/18/09 | x | x | | | x | x | x | GE7 | x |
| W1 | 47 | 4/19/09 | x | x | | | | x | x | | |
| NP1 | 50 | 4/20/09 | x | x | | | x | x | x | GE8 | x |
| NP9 | 58 | 4/22/09 | x | x | | | x | x | x | GE9 | x |
| NP11 | 66 | 4/24/09 | x | | | | x | x | | GE10 | x |
| BL1 | 69 | 4/26/09 | x | | | | x | x | x | GE11 | x |
| BL4 | 73 | 4/27/09 | x | x | x | | x | x | | GE12 | x |
| ICE#3 | 83 | 4/28/09 | x | | | | | x | x | | |
| BL15 | 85 | 4/29/09 | x | x | x | | x | x | | GE13 | x |
| BL20 | 90 | 4/30/09 | x | x | | | | x | | GE14 | x |
| MN 14.5 | 91 | 4/30/09 | | | | | | | x | | |
| MN-SL4 | 92 | 5/1/09 | x | x | | | | x | x | | |
| BN1 | 94 | 5/2/09 | x | x | | | x | x | x | GE15 | x |
| SL12 | 98 | 5/4/09 | x | x | x | | x | x | x | GE16 | x |
| 70M47 | 111 | 5/5/09 | x | | | | | x | | | |
| BL21 | 115 | 5/6/09 | x | x | | | x | x | | GE17 | x |
| 70M42 | 120 | 5/7/09 | x | x | | | x | x | x | GE18 | x |
| 70M47 | 134 | 5/8/09 | x | | | | | x | x | | |
| | | **TOTAL** | **26** | **17** | **7** | **1** | **1437** | **999** | **~950** | **18** | **18** |

**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 is being described using a self-contained Video Plankton Recorder (see Ashjian et al., 2004 for more information on the instrument). Casts were 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. Sixty one casts were conducted across the NP, MN, and SL lines and in the phytoplankton bloom that was studied in early May. Casual viewing of the data has been conducted but only limited progress has been made on image identification because of our intense work schedule. However, the diatom chains of the phytoplankton bloom were clearly visible in the images. Complete analysis will be conducted in the laboratory following the cruise.

Figure 3. Philip Alatalo (L, WHOI) and Marine Science Officer LTJG Stephan Elliott (R, USCG) deploy the Video Plankton Recorder during HLY0802.

Figure 4. Phytoplankton chains observed by the VPR during the water column bloom in early May.

## Mesozooplankton Distribution and Abundance/Krill Egg Production and Rearing

PIs: Ken Coyle (UAF) and Alexei Pinchuk (UAF)
On Board Team Member: Alexei Pinchuk

The primary task of this mesozooplankton component was to assess the abundance, biomass and species composition of the mesozooplankton on the shelf-break, middle and inner shelf 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 92 CalVET samples were taken at all CTD stations along all transect lines across the shelf and on every third station along 70 m isobath line. Heavy ice conditions allowed for 10 stratified MOCNESS tows in ice-free waters.

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.

The large mesozooplankton component was intended to be sampled with 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 planned to be consistently taken in 20 m depth increments from the bottom to the surface.

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, chaetognats, gelatinous zooplankton and, at some stations, euphausiids. Oceanic Neocalanus spp., *Eucalanus bungii* and T*hysanoessa longipes* were observed on the offshore end of MN transect 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. Large numbers of scyphozoan jellyfish were observed on the southeastern middle shelf over 100 m – 50 m depth range. A detailed assessment of zooplankton abundance, biomass and distribution will be made after the samples have been processed.

The primary task of krill egg production and rearing component was to assess reproductive status of krill population, timing of reproduction, number of eggs released, hatching success under laboratory conditions, and to establish a krill culture of known age to aid work on the biology and ageing of euphausiids performed by Harvey/Lessard.

Visual assessment of live krill catches done by Lessard/Harvey group revealed that populations of *Thysanoessa raschii* had not yet started their reproduction on the middle and inner shelf covered with ice. In contrast, substantial numbers of spawning *Thysanoessa inermis* were observed on the outer end of MN line near the ice edge. Total of 29 (out of 35) gravid females incubated at ambient temperature over two days produced 6, 586 eggs. Brood size varied from 5 to 913 eggs, and the average brood size was 245±75 (95% CI) eggs female$^{-1}$. We suspect the smallest broods represented females that had partially released eggs prior to incubation. Hatching success was low (~20%) with many eggs appearing non-viable or undergoing abnormal development. Total of 1,000 nauplii were set for rearing at 5$^{o}$C.

**The Trophic Role of Euphausiids in the eastern Bering Sea: Ecosystem Responses to Changing Sea-Ice Conditions**
PIs: Rodger Harvey (UMaryland) and Evelyn Lessard (UW)

On-Board Team Members: Rodger Harvey, Evelyn Lessard, Megan Bernhardt (UW), Virginia Endel (UW), and Tracy Shaw (NOAA)

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 euphausiid diet history, prey selection, ingestion rates and nutritional condition 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 the 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. Krill collections, feeding experiments and microplankton/ice prey distributions

Evelyn Lessard, Megan Bernhardt, Tracy Shaw and Virginia Engel

### Euphausiid collections: Bongo tows

We performed 34 Bongo tows (Table 1) 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 also took quantitative Bongo tows for assessing euphausiid species and biomass at selected ice-covered stations.

### Euphausiid feeding experiments

We have performed 21 feeding experiments (Table 2) under varying ice cover and in open water. For the feeding experiments, we captured live euphausiids with a Bongo net and added known numbers and species to bottles filled with seawater and incubated them for 24h on a rotating wheel in a flowing seawater incubator under ambient temperature and light conditions. The prey for each experiment were either 1) unaltered seawater plankton and particles, 2)ice protists (algae and heterotrophs) from ice cores that had been gently melted into seawater 3) seawater supplemented with ice protists or 4) seawater supplemented with >10 um concentrated plankton. Shipboard, an index of 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 to determine taxa and carbon-specific grazing rates and indices of prey selection.

### Euphausiid Growth experiments

We have performed 8 growth experiments assessing instantaneous growth rates ca 250 euphausiids We provided >400 animals with species and size determinations, from the feeding and growth experiments, to Harvey for lipid profiles and lipofuscin content (below).

**Protist cell isolations and culturing**

Graduate student Gigi Engel isolated ca. ten different species from several protist taxa (diatoms, ciliates and heterotrophic dinoflagellates) from water column and ice samples. The phototrophs are being incubated in f/2 media and the phagotrophs are being incubated in media with prey that were cultured from the study area last year (cryptophytes and diatoms). Several isolates are showing growth. Enrichment cultures were also started that will be brought back to the lab for further isolations and culturing. Lipid profiles will be determined on successful phagotrophic cultures to identify biomarkers that can be used to trace ingestion.

**Some preliminary observations and findings**

We were able to do a number of feeding experiments under widely varying conditions with *T.raschii*, as this species dominates inshore, where we spent much of our of time. In our more offshore stations, we were able to assess feeding by *T.inermis* and *T.longipes*. There were much larger numbers of small size (juvenile) krill this year than last, suggesting that the final spawning last year occurred later and that juveniles, rather than adults, overwintered. Also of note, while we did not encounter any spawning krill last year on the spring cruise, *T. inermis* were spawning on the outer shelf near the ice edge. We will be interested to see if the different age distribution early in the year has any effect on recruitment and will assess if differences in prey availability and feeding habits led to the difference in timing of reproduction between the two years.

The FlowCAM, an instrument that can image and enumerate live plankton samples, proved to be an invaluable tool for assessing plankton and ice and plankton community composition in real time as we progressed from the heavy ice-covered waters to the open water, and in our search for the open water spring bloom. It provided quick information on the prey field that aided us in choosing station locations and designing experiments. During the first half of the cruise, the ice biota was dominated by the usual suspects (mainly pennates including *Pleurosigma/Gyrosigma*, *Navicula*, *Nitzschia frigida*,, *Fragillariopsis*). Some heterotrophic protists were also present in the ice (ciliates, heterotrophic dinoflagellates and other flagellates). As the season progressed, sloughing off the ice algal species was apparent in the water column and heterotrophic protists increased. During our search for the open water bloom, we were able to quickly see that the dominant diatoms in the water column were mainly centric (first dominated by the very large *Porosira glacialis*, then several *Thalassiosira* species); though ice algae were also present, they did not thrive in the water column.

**Table 1. Locations and conditions for euphausiid collections with Bongo nets for feeding and growth (IGR) experiments and lipid and carbon analyses**

| Station # | Station Name | Ca st # | Latitude (decimal) | Longitude (decimal) | Date (local) | Time (local) | Tow Type | Station Depth | Light Level | Surface temp (ºC) | Surface chl (µg/l) | Salinity | Air temp (ºC) | Feeding expt | IGR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | NP6.5 | 1 | 58.0574 | 169.2438 | 4/5/09 | 0145 | vertical | 67 | Dark | -1.69 | 0.3 | 31.03 | -2.3 | | |
| 4 | BC-1 | 2 | 58.6183 | 168.8417 | 4/5/09 | 2331 | vertical | 63 | Dark | -1.65 | 0.4 | | 0.4 | 1 | |
| 4 | BC-1 | 3 | 58.6183 | 168.8417 | 4/6/09 | 0005 | vertical | 63 | Dark | -1.65 | 0.4 | | 0.4 | 1 | |
| 7 | MN3 | 4 | 59.8970 | 169.2045 | 4/7/09 | 0016 | vertical | 47 | Dark | -1.61 | 0.3 | 30.32 | -4.9 | | |
| 10 | MN5 | 5 | 59.9002 | 170.3972 | 4/8/09 | 0231 | vertical | 64 | Dark | -1.68 | 0.3 | 30.74 | -7 | | 19 |
| 14 | MN8 | 6 | 59.9093 | 172.1285 | 4/9/09 | 0239 | vertical | 70 | Dark | -1.7 | 0.5 | 30.73 | -7.5 | | |
| 14 | MN8 | 7 | 58.9078 | 172.1647 | 4/9/09 | 0252 | vertical | 70 | Dark | -1.69 | 0.2 | 30.66 | -7.1 | | |
| 19 | MN13 | 8 | 59.8739 | 175.2119 | 4/10/09 | 0250 | vertical | 123 | Dark | -1.65 | 0.3 | 30.4 | -11.6 | 2 | |
| 22 | MN16 | 9 | 59.8878 | 176.9897 | 4/11/09 | 0117 | vertical | 140 | Dark | -1.66 | 0.3 | 32.29 | -13.2 | | |
| 23 | MN17 | 10 | 59.8969 | 177.6009 | 4/11/09 | 0448 | vertical | 142 | Dark | -1.65 | 0.4 | 31.04 | -13 | | |
| 25 | MN19 | 11 | 59.8995 | 178.9100 | 4/12/09 | 0047 | oblique | 650 | Dark | -1.53 | 0.7 | 32.56 | -10.1 | 3 | |
| 26 | MN20 | 12 | 59.8980 | 179.4126 | 4/13/09 | 0021 | oblique | 2734 | Twilight | -1.57 | 0.4 | 32.62 | -8.2 | 4 | 20 |
| 28 | MN-SL3 | 13 | 61.6933 | 176.9962 | 4/14/09 | 0219 | vertical | 117 | Dark | -1.68 | 0.3 | 32.08 | -10.8 | | |
| 30 | SL14 | 14 | 62.2165 | 175.9526 | 4/15/09 | 0141 | vertical | 93 | Dark | -1.67 | 0.5 | 32.11 | -12.5 | 5 | |
| 34 | SL10 | 15 | 62.1558 | 173.9981 | 4/16/09 | 0124 | vertical | 63 | Dark | -1.63 | 1 | 32.31 | -9.2 | 6 | |
| 37 | SL7.5 | 16 | 62.0051 | 172.0449 | 4/17/09 | 0210 | vertical | 53 | Dark | -1.76 | 0.5 | 32.87 | -4.6 | | |
| 44 | SL1.3 | 17 | 61.6941 | 167.9718 | 4/18/09 | 0244 | vertical | 29 | Dark | -1.67 | 0.4 | 31.95 | -3.8 | | |
| 46 | SL-W1 | 18 | 60.8283 | 167.4841 | 4/19/09 | 0217 | vertical | 24 | Dark | -1.67 | 0.4 | 31.43 | -8.7 | 7 | |
| 50 | NP1 | 19 | 59.4479 | 167.7978 | 4/20/09 | 0215 | oblique | 38 | Dark | -1.64 | 0.3 | 31.42 | -6.3 | 8 | 21 |
| 52 | NP3 | 20 | 58.8335 | 168.1639 | 4/21/09 | 0103 | oblique | 46 | Dark | -1.64 | 0.4 | 31.27 | -4.5 | 9 | |
| 58 | NP9 | 21 | 57.4488 | 169.7773 | 4/22/09 | 0213 | oblique | 66 | Dark | -1.61 | .0.6 | 31.74 | -0.2 | 10 | |
| 61 | NP15 | 22 | 56.0364 | 171.2861 | 4/23/09 | 0103 | oblique | 2804 | Dark | 2.24 | 0.4 | 32.55 | 2.6 | 11 | 22 |
| 66 | NP11 | 23 | 56.9705 | 170.2783 | 4/24/09 | 0220 | oblique | 76 | Dark | -0.27 | 1.2 | 31.63 | 1 | 12 | |
| 68 | AS1 | 24 | 58.1781 | 169.0879 | 4/25/09 | 0221 | vertical | 73 | Dark | -1.67 | 0.3 | 31.55 | 0.7 | | 23 |
| 69 | BL1 | 25 | 59.5488 | 175.2178 | 4/26/09 | 0513 | oblique | 135 | Dark | -1.25 | 2.6 | 32.03 | 0.1 | 13 | |
| 73 | BL4 | 26 | 59.5433 | 175.0277 | 4/27/09 | 0203 | oblique | 133 | Dark | -1.21 | 6.5 | 32.07 | -0.8 | 14 | 24 |
| 85 | BL15 | 27 | 59.5446 | 175.1414 | 4/29/09 | 0156 | oblique | 135 | Dark | -1.04 | 5.5 | 32.05 | -0.6 | 15 | |
| 90 | BL20 | 28 | 59.5418 | 175.1199 | 4/30/09 | 0103 | oblique | 135 | Dark | -0.84 | 7.4 | 32.07 | -1.4 | 16 | |
| 91 | MN14.5 | 29 | 59.9037 | 176.1280 | 4/30/09 | 1513 | oblique | 141 | Day | -0.61 | 4.8 | 32.25 | -0.6 | 17 | |
| 93 | BN1 | 30 | 62.2510 | 172.5169 | 5/2/09 | 0148 | vertical | 58 | Dark | -1.67 | 1.2 | 31.93 | -2.1 | | |
| 95 | SL8 | 31 | 62.0550 | 172.6303 | 5/3/09 | 0244 | vertical | 53 | Dark | -1.65 | 1.1 | 31.82 | -2.8 | 18 | |
| 98 | SL12 | 32 | 62.1854 | 175.1517 | 5/4/09 | 0147 | vertical | 81 | Dark | -1.56 | 0.5 | 31.95 | -3 | 19 | 25 |
| 115 | BL21 | 33 | 59.4661 | 174.0546 | 5/6/09 | 0209 | oblique | 116 | Dark | -0.03 | 7.2 | 31.77 | -1.4 | 20 | 26 |
| 118 | 70M44 | 34 | 60.0996 | 173.3165 | 5/7/09 | 0224 | oblique | 74 | Dark | -1.61 | 0.7 | 31.53 | 0.3 | 21 | |

**Table 2. Euphausiid feeding experiments. Collection location, initial chlorophyll levels, and species.**

| Expt # | Station Name | CTD | Latitude | Longitude | Date (local) | Time (local) | Depth | Temp | Salinity | + Ice Algae | Total Chlor | >5 µm Chlor | <5µm Chlor | Euphausiid spp. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BC1 | 8 | 58 37.74 N | 168 51.73 W | 04/06/09 | 0035 | 6m | -1.71 | 31.56 | Yes | 1.56 | 1.30 | 0.26 | *T. raschii* |
| 2 | MN13 | 29 | 59 52.46 N | 175 12.68 W | 04/10/09 | 0320 | 6m | -1.71 | 32.047 | No | 0.35 | 0.13 | 0.22 | *T. raschii* |
| 3 | MN19 | 40 | 59 54.29 N | 178 54.21 W | 04/12/09 | 0058 | 7m | -1.61 | 32.58 | No | 0.94 | 0.55 | 0.40 | *T.longipes/T. inermis* |
| 4 | MN20 | 45 | 59 54.64 N | 179 26.93 W | 04/13/09 | 0042 | 10m | -1.68 | 32.62 | No | 0.74 | 0.44 | 0.30 | *T. inermis* |
| 5 | SL14 | 52 | 62 13.17 N | 175 56.91 W | 04/15/09 | 0205 | 9m | -1.70 | 32.08 | Yes | 6.74 | 6.58 | 0.16 | *T. raschii* |
| 6 | SL10 | 56 | 62 09.42 N | 173 59.67 W | 04/16/09 | 0149 | 10m | -1.73 | 32.37 | Yes | 7.82 | 7.65 | 0.17 | *T. raschii* |
| 7 | SL-W1 | 72 | 60 49.85 N | 167 28.93 W | 04/19/09 | 0232 | 10m | -1.70 | 31.45 | Yes | 3.49 | 3.22 | 0.27 | *T. raschii* |
| 8 | NP1 | 76 | 59 27.26 N | 167 48.63 W | 04/20/09 | 0240 | 10m | -1.65 | 31.47 | Yes/No | 2.47 | 2.28 | 0.19 | *T. raschii* |
| 9 | NP3 | 82 | 58 50.51 N | 168 09.41 W | 04/21/09 | 0122 | 10m | -1.66 | 31.44 | Yes | 0.75 | 0.51 | 0.24 | *T. raschii* |
| 10 | NP9 | 89 | 57 28.25 N | 169 47.30 W | 04/22/09 | 0233 | 10m | -1.70 | 31.77 | Yes | | | | |
| 11 | NP15 | 95 | 56 01.08 N | 171 17.62W | 04/23/09 | 0143 | 18m | 2.23 | 32.64 | Yes | 0.59 | 0.23 | 0.36 | Mix of 3 spp |
| 12 | NP11 | 101 | 56 58.26 N | 170 16.64W | 04/24/09 | 0148 | 14m | -0.75 | 31.63 | No | 2.43 | 2.23 | 0.20 | T. raschii |
| 13 | BL1 | 106 | 59 31.73 N | 175 12.18 W | 04/26/09 | 0708 | 7m | -1.27 | 32.04 | No | 9.85 | 9.54 | 0.32 | T. raschii |
| 14 | BL4 | 113 | 59 32.94 N | 175 02.78 W | 04/27/09 | 0237 | 6m | -1.17 | 32.09 | No | 22.77 | 22.50 | 0.27 | T. raschii |
| 15 | BL15 | 128 | 59 32.94 N | 175 05.17 W | 04/29/09 | 0301 | 5m | -0.9 | 32.07 | No | 26.18 | 25.80 | 0.38 | T. raschii |
| 16 | BL20 | 138 | 59 32.30 N | 175 07.18 W | 04/30/09 | 0210 | 3m | -0.99 | 32.09 | No | 29.73 | 29.54 | 0.19 | T. raschii |
| 17 | MN14.5 | 141 | 59 55.23 N | 176 07.20 W | 04/30/09 | 1549 | 4m | -0.79 | 32.95 | No | 31.36 | 31.01 | 0.35 | T. inermis/T. raschii |
| 18 | SL8 | 149 | 62 03.48 N | 172 38.07 W | 05/03/09 | 0257 | 7m | -1.67 | 31.94 | No | 1.50 | 1.37 | 0.13 | T. raschii |
| 19 | SL12 | 153 | 62 11.02 N | 175 09.04 W | 05/04/09 | 0215 | 10m | -1.60 | 31.98 | Yes/No | 8.44/1.04 | 8.01/0.63 | 0.42/0.41 | T. raschii |

| Expt # | Station Name | CTD | Latitude | Longitude | Date (local) | Time (local) | Depth | Temp | Salinity | + Ice Algae | Total Chlor | >5 µm Chlor | <5µm Chlor | Euphausiid spp. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | BL21 | 172 | 59 27.35 N | 174 04.34 W | 05/06/09 | 0246 | 3m | 0.24 | 31.81 | No | 26.26 | 26.02 | 0.24 | T. raschii |
| 21 | 70M44 | 177 | 60 06.15 N | 173 19.88 W | 05/07/09 | 0243 | 7m | -1.66 | 31.62 | No | 0.91 | 0.61 | 0.3 | T. raschii |

## B. Lipid composition of water column particles and krill

Rodger Harvey and Rachel Pleuthner

To determine diet history of euphausiids, a series of experiments have been run to examine impacts of different diets and starvation on euphausiid lipid composition. At each collection point water column particles have been collected concurrently to characterize the lipid composition of potential prey fields.

### Water Column particles and Feeding Experiments

Feeding experiment setup is detailed above. For characterization, of food resources and tracking of consumption via lipid analysis, water was taken from a designated Niskin bottle at the beginning of each grazing experiment ($T_0$) and filtered through combusted GF/F filters for carbon and detailed lipid analysis to characterize the algal and detrital food available to krill. Krill are sampled ($T_0$) directly from the bongo cast, if quantities allow.

For comparison of suspended material used as animal food resources verses sinking material, aliquots of material collected by the Moran Team (Pat Kelly) sediment traps were provided for analysis. Samples present in brine were filtered onto 25mm combusted GF/Fs and matched at depths where suspended material was collected by Niskin bottle for lipid signatures of likely food. (Refer to Table 4 for Sample Location and Designation).

At the conclusion of each grazing experiment, the animals were either sacrificed or frozen for future lipid analysis. (Refer to Table 2 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 was determined via flow-through fluorescence using an Agilent HPLC. The rest of each euphausiid was frozen in the -70ºC chest freezer for future lipid analysis.

Four extended grazing experiments were performed. The latter two of these experiments were short, spanning 36 hours at the most and were kept in filtered sea water for the duration of the experiment. The animals from the first two experiments were collected from two different stations, given a week long fasting period in which they are incubated in filtered sea water, a food source is then introduced into the system for a predetermined period of time, and the euphausiids are returned to filtered sea water for a week. Samples are taken at various time points including $T_0$ (straight from the water column); day 3, day 7, etc. (Refer to Table 2 for animal storage).

### Experimental Animals for Determination of Age in Bering Sea Euphausiids

Eight growth experiments were completed by Tracy Shaw. Preliminary lipofuscin analysis has been completed for the first five; the last two were not used for LF Index

numbers due to a shortage of supplies. These experiments include animals of a range of sizes and species –mostly *Thysanoessa raschii* and *Thysanoessa inermis* - to provide a first estimate of lipofuscin indices for field animals of differing ages. (Refer to Table 3.) After the collection of eggs, Alexei Pinchuk will conduct growth experiments spanning 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 HLY0802 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 samples of krill neural tissue. That scan allowed for a qualitative identification of lipofuscin, and will be used to measure lipofuscin content in euphausiids for the duration of the cruise. A calibration curve using quinine sulfate serves as a proxy for quantitative measures of fluorescence intensity to be performed for each run.

Part B
For protein analysis, tryptophan fluorescence is 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.

Analysis is performed for every krill sample with the primary source being growth experiments. Thus far, the dominant euphausiid species throughout most of these experiments has been *T. raschii*.

Table 1: Water Sample Collection for Experiments

| Experiment Type and No. | Station, # | $T_0$ filtration date | CTD Cast |
|---|---|---|---|
| Grazing Experiment #1 | BC-1, #4 | 4/6/2009 | 8 |
| Grazing Experiment #2 | MN-13, #19 | 4/10/2009 | 29 |
| Grazing Experiment #3 | MN-19, #25 | 4/12/2009 | 40 |
| Grazing Experiment #4 | MN-20, #26 | 4/13/2009 | 45 |
| Grazing Experiment #5 | SL-14, #30 | 4/15/2009 | 52 |
| Grazing Experiment #6 | SL-10, #34 | 4/16/2009 | 56 |
| Grazing Experiment #7 | SL-W1, #46 | 4/19/2009 | 72 |
| Grazing Experiment #8 | NP-1, #50 | 4/20/2009 | 76 |
| Grazing Experiment #9 | NP-3, #52 | 4/21/2009 | 82 |
| Grazing Experiment #10 | NP-9, #58 | 4/22/2009 | 89 |
| Grazing Experiment #11 | NP-15, 61 | 4/23/2009 | 95 |
| Grazing Experiment #12 | NP-11, 66 | 4/24/2009 | 101 |
| Grazing Experiment #13 | BL-1, 69 | 4/26/2009 | 106 |

| Experiment Type and No. | Station, # | $T_0$ filtration date | CTD Cast |
|---|---|---|---|
| Grazing Experiment #14 | BL-4, 73 | 4/27/2009 | 114 |
| Grazing Experiment #15 | BL-14, 85 | 4/29/2009 | 128 |
| Grazing Experiment #16 | BL-20, #90 | 4/30/2009 | 138 |
| Grazing Experiment #17 | MN14.5, #91 | 5/1/2009 | 141 |
| Grazing Experiment #18 | SL-8, #95 | 5/2/2009 | 149 |
| Grazing Experiment #19 | SL-12, #98 | 5/4/2009 | 153 |
| Grazing Experiment #20 | BL-21, #115 | 5/6/2009 | 172 |
| Grazing Experiment #21 | 70M44, #118 | 5/7/2009 | 177 |
| | | | |
| *All filters frozen in -70 immediately following filtration | | | |

Table 2: Euphausiid Sample Log

| Experiment No./Type | No. Krill in Storage | No. Lipofuscin Index Krill | Beginning of Krill Eye Lipofuscin Analysis | Whole Samples Frozen | Storage date |
|---|---|---|---|---|---|
| Grazing Experiment #1 | 24 | 24 | 4/8/2009 | No | 4/7/2009 |
| Grazing Experiment #2 | 24 | 24 | 4/12/2009 | No | 4/11/2009 |
| Grazing Experiment #3 | 29 | 0 | N/A | Yes | 4/13/2009 |
| Grazing Experiment #4 | 22 | 0 | N/A | Yes | 4/14/2009 |
| Grazing Experiment #5 | 13 | 0 | N/A | Yes | 4/16/2009 |
| Grazing Experiment #6 | 48 | 0 | N/A | Yes | 4/17/2009 |
| Grazing Experiment #7 | 32 | 0 | N/A | Yes | 4/20/2009 |
| Grazing Experiment #8 | 30 | 0 | N/A | Yes | 4/21/2009 |
| Grazing Experiment #9 | 34 | 0 | N/A | Yes | 4/22/2009 |
| Grazing Experiment #10 | 25 | 0 | N/A | Yes | 4/23/2009 |
| Grazing Experiment #11 | 17 | 0 | N/A | Yes | 4/24/2009 |
| Grazing Experiment #12 | 32 | 0 | N/A | Yes | 4/25/2009 |
| Grazing Experiment #13 | 51 | 0 | N/A | Yes | 4/27/2009 |
| Grazing Experiment #14 | 48 | 0 | N/A | Yes | 4/28/2009 |
| Grazing Experiment #15 | 61 | 0 | N/A | Yes | 4/30/2009 |
| Grazing Experiment #16 | 62 | 0 | N/A | Yes | 5/1/2009 |
| Grazing Experiment #17 | 58 | 0 | N/A | Yes | 5/2/2009 |
| Grazing Experiment #18 | 77 | 0 | N/A | Yes | 5/4/2009 |
| Grazing Experiment #19 | 31 | 0 | N/A | Yes | 5/5/2009 |
| Grazing Experiment #20 | 70 | 0 | N/A | Yes | 5/7/2009 |
| Grazing Experiment #21 | 50 | 0 | N/A | Yes | 5/8/2009 |
| | | | | | |
| Extended Grazing Ex #1 | 53 total | 0 | N/A | Yes | Continual |
| Extended Grazing Ex #2 | 86 total | 0 | N/A | Yes | Continual |
| Extended Grazing Ex #3 | 13 | 0 | N/A | Yes | 4/14/2009 |
| Extended Grazing Ex #4 | 40 | 0 | N/A | Yes | 4/26/2009 |
| | | | | | |

| Experiment No./Type | No. Krill in Storage | No. Lipofuscin Index Krill | Beginning of Krill Eye Lipofuscin Analysis | Whole Samples Frozen | Storage date |
|---|---|---|---|---|---|
| Growth Experiment #19 | 74 | 73 | 4/12/2009 | No | 4/10/2009 |
| Growth Experiment #20 | 60 | 57 | 4/16-17/2009 | No | 4/15/2009 |
| Growth Experiment #21 | 60 | 60 | 4/24/2009 | No | 4/22/2009 |
| Growth Experiment #22 | 60 | 58 | 4/27/2009 | No | 4/25/2009 |
| Growth Experiment #23 | 60 | 60 | 4/29/2009 | No | 4/27/2009 |
| Growth Experiment #24 | 60 | 52 | 5/1/2009 | No | 4/29/2009 |
| Growth Experiment #25 | 57 | 0 | N/A | Yes | 5/6/2009 |
| Growth Experiment #26 | 59 | 0 | N/A | Yes | 5/8/2009 |
| | | | | | |
| Extra T. inermis females | N/A | 10 | 4/16-17/2009 | No | 4/15/2009 |
| NP-3, Fill-in-the-gap LF krill | N/A | 20 | 4/22/2009 | No | 4/21/2009 |
| MN-14.5, Fill-in-the-gap LF krill | N/A | 27 | 5/2/2009 | No | 5/2/2009 |
| | | | | | |
| Sample Type | # krill, body length (mm) | Species | No. Lipofuscin Index Krill | Whole Krill Frozen? | Date Stored |
| Lab Carbon Measurements | 4 | *T. raschii* | 0 | Yes | 4/10/2009 |
| Lab Carbon Measurements | 26, 8-10mm | *T. inermis* | 0 | Yes | 4/11/2009 |
| Lab Carbon Measurements | 43, 10-12mm | *T. inermis* | 0 | Yes | 4/11/2009 |
| Lab Carbon Measurements | 20, 12-14mm | *T. inermis* | 0 | Yes | 4/16/2009 |
| Lab Carbon Measurements | 2, 10-14mm | *T. inermis* | 0 | Yes | 4/16/2009 |
| Lab Carbon Measurements | 6, 16-22mm | *T. inermis* | 0 | Yes | 4/16/2009 |
| Lab Carbon Measurements | 7, 12-14mm | *T. raschii* | 0 | Yes | 4/26/2009 |
| Lab Carbon Measurements | 4, 16-18mm | *T. raschii* | 0 | Yes | 4/26/2009 |
| Lab Carbon Measurements | 21, 18-20mm | *T. raschii* | 0 | Yes | 4/26/2009 |
| Lab Carbon Measurements | 8, 20-22mm | *T. raschii* | 0 | Yes | 4/26/2009 |

Table 3: HPLC Lipofuscin Run Log

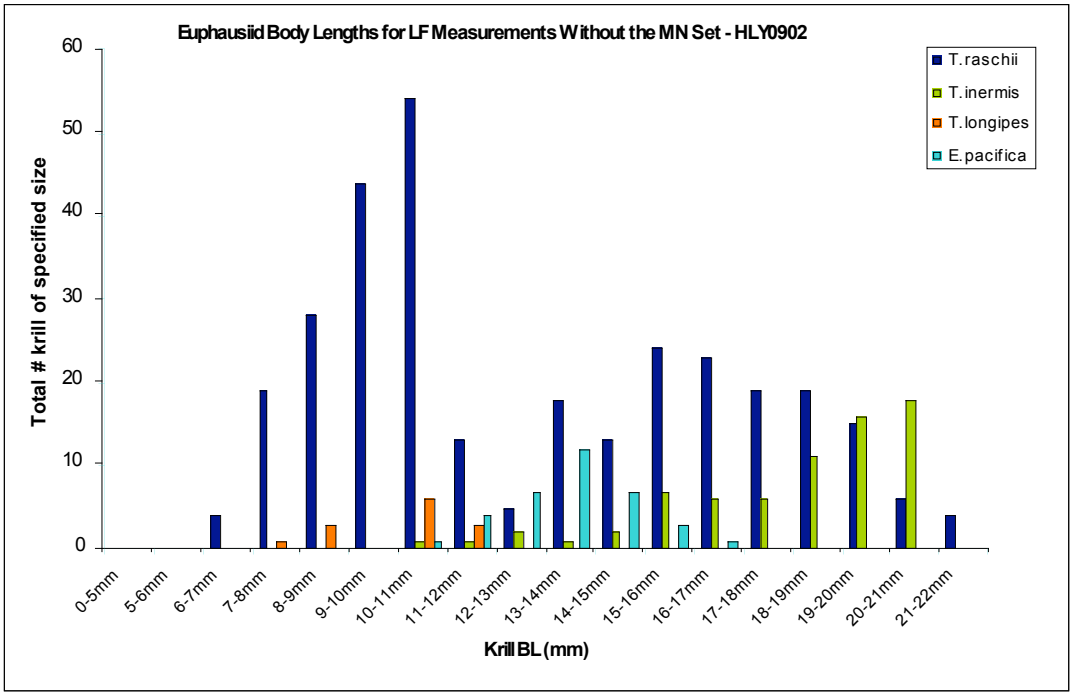
| Experiment No. | No. Krill in Expt. | No. Krill Analyzed | Krill Eye Lipofuscin Analysis | Krill Eye Protein Quantification | Composite Samples Frozen | Storage date |
|---|---|---|---|---|---|---|
| Grazing Experiment #1 | 25 | 24 | 4/8/2009 | 4/8/2009 | Yes | 4/7/2009 |
| Grazing Experiment #2 | 24 | 24 | 4/12/2009 | 4/12/2009 | Yes | 4/11/2009 |
| | | | | | | |
| Growth Experiment #19 | 74 | 73 | 4/12/2009 | 4/12/2009 | Yes | 4/10/2009 |
| Growth Experiment #20 | 60 | 57 | 4/16/2009 | 4/16-17/2009 | Yes | 4/15/2009 |
| Growth Experiment #21 | 60 | 60 | 4/23/2009 | 4/24/2009 | Yes | 4/22/2009 |
| Growth Experiment #22 | 60 | 58 | 4/26/2009 | 4/27/2009 | Yes | 4/25/2009 |
| Growth Experiment #23 | 60 | 60 | 4/28/2009 | 4/29/2009 | Yes | 4/27/2009 |
| Growth Experiment #24 | 60 | 52 | 4/30/2009 | 5/1/2009 | Yes | 4/29/2009 |
| | | | | | | |
| Extra T. inermis females | 10 | 10 | 4/16-17/2009 | 4/16-17/2009 | Yes | 4/15/2009 |
| NP-3, Fill-in-the-gap krill | 20 | 20 | 4/22/2009 | 4/22/2009 | Yes | 4/21/2009 |
| MN14.5, Fill-in-the-gap krill | 27 | 27 | 5/2/2009 | 5/3/2009 | Yes | 5/2/2009 |

Table 4: Sediment Trap and CTD Collection Log

| **Expt/Type** | **Date** | **Station** | **# Filter(s) & Vol(s)** | **Experimental Details** |
|---|---|---|---|---|
| Sed Traps | 4/29/2009 | BL-15, #85 | 1 (100mL) | Sediment Trap, 25m, 12hr daytime deployment |
| Sed Traps | 4/29/2009 | BL-15, #85 | 1 (100mL) | Sediment Trap, 40m, 12hr daytime deployment |
| Sed Traps | 4/29/2009 | BL-15, #85 | 1 (100mL) | Sediment Trap, 50m, 12hr daytime deployment |
| Sed Traps | 4/29/2009 | BL-15, #85 | 1 (100mL) | Sediment Trap, 60m, 12hr daytime deployment |
| Sed Traps | 4/29/2009 | BL-15, #85 | 1 (100mL) | Sediment Trap, 100m, 12hr daytime deployment |

| Expt/Type | Date | Station | # Filter(s) & Vol(s) | Experimental Details |
|---|---|---|---|---|
| Sed Traps | 4/30/2009 | BL-15-1, #85.5 | 1 (100mL) | Sediment Trap, 25m, 12hr nighttime deployment |
| Sed Traps | 4/30/2009 | BL-15-1, #85.5 | 1 (100mL) | Sediment Trap, 40m, 12hr nighttime deployment |
| Sed Traps | 4/30/2009 | BL-15-1, #85.5 | 1 (100mL) | Sediment Trap, 50m, 12hr nighttime deployment |
| Sed Traps | 4/30/2009 | BL-15-1, #85.5 | 1 (100mL) | Sediment Trap, 60m, 12hr nighttime deployment |
| Sed Traps | 4/30/2009 | BL-15-1, #85.5 | 1 (100mL) | Sediment Trap, 100m, 12hr nighttime deployment |
| Water Column | 4/30/2009 | MN14.5, #91 | 3 (0.8L ea) | WC samples from 100m, ~ Sed Trap recovery time, Niskin 2, CTD: 141 |
| Water Column | 4/30/2009 | MN14.5, #91 | 1 (14.5L) | WC samples from 100m, ~ Sed Trap recovery time, Niskin 2, CTD: 141 |
| Water Column | 4/30/2009 | MN14.5, #91 | 3 (0.8L ea) | WC samples from 50m, ~ Sed Trap recovery time, Niskin 3, CTD: 141 |
| Water Column | 4/30/2009 | MN14.5, #91 | 1 (16.0L) | WC samples from 50m, ~ Sed Trap recovery time, Niskin 3, CTD: 141 |
| Water Column | 4/30/2009 | MN14.5, #91 | 3 (0.5L ea) | WC samples from 4m, ~ Sed Trap recovery time, Niskin 8, CTD: 141 |
| Water Column | 4/30/2009 | MN14.5, #91 | 1 (5.4L) | WC samples from 4m, ~ Sed Trap recovery time, Niskin 8, CTD: 141 |
| | | | | |
| Water - Bloom | 5/6/2009 | BL-21, #115 | 2 (0.5L ea) | WC samples from 20m -- Niskin 6 Chl Max, CTD: 172 |
| Water - Bloom | 5/6/2009 | BL-21, #115 | 2 (5.0, 4.5L) | WC samples from 20m -- Niskin 6, Chl Max, CTD: 172 |
| Water - Bloom | 5/6/2009 | BL-21, #115 | 2 (0.49, 0.51L) | WC samples from 50m -- Niskin 3, CTD: 172 |
| Water - Bloom | 5/6/2009 | BL-21, #115 | 2 (6.1, 7.5L) | WC samples from 50m -- Niskin 3, CTD: 172 |
| Water - Bloom | 5/6/2009 | BL-21, #115 | 2 (0.5L ea) | WC samples from 100m -- Niskin 1, CTD: 172 |
| Water - Bloom | 5/6/2009 | BL-21, #115 | 2 (8.5, 5.5L) | WC samples from 100m -- Niskin 1, CTD: 172 |
| Sed Traps | 5/6/2009 | BL-21, #115 | 1 (97mL) | Sediment Trap, 25m, 12hr daytime deployment |
| Sed Traps | 5/6/2009 | BL-21, #115 | 1 (100mL) | Sediment Trap, 40m, 12hr daytime deployment |
| Sed Traps | 5/6/2009 | BL-21, #115 | 1 (150mL) | Sediment Trap, 50m, 12hr daytime deployment |
| Sed Traps | 5/6/2009 | BL-21, #115 | 1 (150mL) | Sediment Trap, 60m, 12hr daytime deployment |
| Sed Traps | 5/6/2009 | BL-21, #115 | 1 (150mL) | Sediment Trap, 100m, 12hr daytime deployment |

Figure 1: Frequency chart of body lengths for all euphausiid lipofuscin measurements - HLY0902




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

PIs: Katrin Iken (UAF), Rolf Gradinger (UAF), Bodil Bluhm (UAF)
On-Board Team Members: Katrin Iken, Heloise Chenelot (UAF) and Jared Weems (UAF)

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. We use qualitative and quantitative observations of ice-produced matter as well as stable isotope analysis to elucidate food web structure. In addition, we are collecting samples for fatty-acid specific (FAME) analysis of stable isotopes to further identify ice diatom contributions to consumer diets. A graduate student (J. Weems) is also conducting feeding experiments with clams and euphausids with isotopically labeled food sources to determine isotopic turnover times, which will allow us to interpret isotope data from field collections.

During HLY0902 we collected sea ice (15 stations, 6 of these were short and 8 were long ice stations), CTD water, plankton and benthic (21 stations) samples (Table 1).

**Table 1: Overview of sampling events**

| Sta # | St name | Date | Depth | POM | Plankton | Benthos | Ice |
|---|---|---|---|---|---|---|---|
| 1 | NP7 | 4-Apr-09 | 72 | X | — | X | — |
| 3 | St. 3 | 5-Apr-09 | 69 | X | X | X | X |
| 9 | MN 4.5 | 7-Apr-09 | 56 | X | X | X | X |
| 10 | MN5 | 8-Apr-09 | 62 | X | X | X | X |
| 19 | MN13 | 10-Apr-09 | 120 | X | X | X | — |
| 24 | MN18 | 11-Apr-09 | 144 | X | X | — | X |
| 25 | MN19 | 12-Apr-09 | 504 | X | X | — | X |
| 29 | St.29 | 14-Apr-09 | 113 | X | X | X | X |
| 32 | SL12 | 15-Apr-09 | 80 | X | X | X | — |
| 35 | SL9 | 16-Apr-09 | 62 | X | X | X | X |
| 45 | SL1 | 18-Apr-09 | 28 | X | X | X | X |
| 50 | NP1 | 20-Apr-09 | 35 | X | X | X | X |
| 58 | NP9 | 22-Apr-09 | 66 | X | X | X | — |
| 66 | NP11 | 24-Apr-09 | 72 | X | X | X | — |
| 69 | BL1 | 26-Apr-09 | 133 | X | X | X | — |
| 83 | Ice #2 | 28-Apr-09 | 90 | X | X | X | X |
| 85 | BL15 | 29-Apr-09 | 133 | X | X | X | — |
| 90 | BL20 | 30-Apr-09 | 135 | X | — | — | — |
|  | Ice MN- |  |  | X | X | X | X |
| 92 | SL5 | 1-May-09 | 72 |  |  |  |  |
| 93 | BN1 | 2-May-09 | 59 | X | X | X | X |
| 96 | SL9/2 | 3-May-09 | 60 | — | — | — | X |
| 98 | SL12/2 | 4-May-09 | 80 | X | X | X | — |
| 99 | Ice #4 | 4-May-09 | 70 | — | — | — | X |
| 109 | 70M49 | 5-May-09 | 79 | — | — | — | X |
| 115 | BL21 | 6-May-09 | 115 | X | X | — | — |
| 116 | BL15/2 | 6-May-09 | 133 | X | — | X | — |

**Table 2: Ice-sampling activity details**

| St name | Date | Duration | Chl, POM, community | Under-ice CTD | Sediment traps | *in situ* incubations | Video |
|---|---|---|---|---|---|---|---|
| St. 3 | 5-Apr-09 | Long | X | X | X | X | X |
| MN 4.5 | 7-Apr-09 | Long | X | X | X | X | X |
| MN5 | 8-Apr-09 | Short | X | - | - | - | - |
| MN18 | 11-Apr-09 | Short (man basket) | X | - | - | - | - |
| MN19 | 12-Apr-09 | Short (small boat) | X | - | - | - | - |
| St.28 | 14-Apr-09 | Long | X | X | X | X | X |
| SL9 | 16-Apr-09 | Long | X | X | X | X | X |
| SL1 | 18-Apr-09 | Long | X | X | X | - | X |
| NP1 | 20-Apr-09 | Long | X | X | X | X | X |
| Ice #2 | 28-Apr-09 | Short (man basket) | X | - | - | - | - |

| St name | Date | Duration | Chl, POM, community | Under-ice CTD | Sediment traps | *in situ* incubations | Video |
|---|---|---|---|---|---|---|---|
| Ice MN-SL5 | 1-May-09 | Long | X | X | X | X | X |
| BN1 | 2-May-09 | Long | X | - | X | X | - |
| SL9/2 | 3-May-09 | Short | X | X | - | - | - |
| Ice #4 | 4-May-09 | Short (man basket) | X | - | - | - | - |
| 70M49 | 5-May-09 | Short (man basket) | X | - | - | - | - |

**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 8 stations. At all stations, the under-ice CTD measurements showed a well-mixed and homogenous water column structure.

**Sea ice sampling**

Ice cores for algal pigment, meiofauna species composition and C and N stable isotope ratios were collected at 15 stations. The ice varied in thickness across stations between 40 cm and 165 cm. On average, ice thickness was greater than in 2008 at the same time of year and sea ice contained significant amounts of sediments even at locations removed from the nearshore areas. Ice cores were partitioned into 1 to 10cm long sections (0-1, 1-2, 2-5, 5-20, 10-20, etc) and melted in the dark at 4°C partially with addition of filtered seawater. After complete melt, samples of three cores were filtered onto GF/F filters and frozen for further analysis at the home lab for chlorophyll and POM content. Nutrient concentrations in the ice segments were determined in one core per station by the BEST nutrient service team (C. Mordy). Three additional cores per station were sieved through 20µm gaze and the retained meiofauna was counted alive under a dissecting scope. Overall, meiofauna counts were low, and dominant taxa were rotifers with occasional nematodes, turbellarians, trochophore larvae and harpacticoid copepods. At one location (St. 70M49) one core contained what likely is a scyphozoan polyp (see picture below). Cnidarians are uncommon in sea ice and hydroids have only been described recently by our group (*Sympagohydra tuuli*). To the best of our knowledge the polyp found in the Bering Sea sample is the first record of a scyphozoan polyp inhabiting ice.

***H. Chenelot (UAF) takes an ice core in thick sea ice. If sea ice thickness exceeds core length, an extension has to be added to the corer.***

***Sediment inclusions in sea ice.***

***Scyphozoan polyp found in sea ice.***

### *In situ* incubations and sediment trap deployments

Ice algal primary productivity and N-uptake were determined with *in situ* incubations (4-5 h) at seven locations. Ice algal samples were incubated just at the ice-water interface,

water samples (from 5 m depth) at 5 m with additions of stable isotope trace amounts of 13C and 15N.

Sediment traps were deployed through holes in the sea ice at eight locations for 5 hours in 5 and 20 m depth. At five locations (St. 3, MN4.5, SL1, NP1, BN1) two sets of these traps were deployed together with Roger Kelley. At three locations, one set of traps was deployed at 5, 20, 35, 50 and 65 m (St. 29) and at 5, 20, 35 and 50 m (SL9, Ice MN-SL5). Collected material was processed to be analyzed for algal pigment content, particle analysis, and POC/PON concentrations as well as for Thorium measurements of particle flux. Owing to the large sediment content in sea ice, traps usually contained a large amount of sediment, as well as live ice algae, fecal pellets and detritus. At ice locations sampled later in the cruise (Ice MN-SL5, BN1), significant amounts of ice algae and green fecal pellets were also found in the traps, indicating release and use of ice-produced materials at those locations.

**Under-ice video observations**

A B/W video camera was lowered through a core hole and connected to a mini-DV camcorder at seven locations. One to two hours 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. Video recordings show particle movement and on April 14 (St. 28), some euphausiids (*Thysanoessa rashii*) were observed below the ice. This was the only krill observation during this cruise, while krill was observed multiple times and at several locations during 2008.

**Ice observations**

Ice observations were occasionally conducted during daylight hours, while the ship was in transit, other work permitting. No observations were done during the dark night period. The observations together with two digital images per observation were logged on the Healy ice observational sheet and are available on the Healy 0902 event catalog.

**CTD water sampling**

CTD water was sampled at 23 stations. At all stations, water from ~10m depth or the chlorophyll max layer was filtered onto pre-combusted GF/F filters and frozen for later C and N stable isotope analysis of POM, onto GF/F filters for chlorophyll analysis and onto pre-combusted GF/C filters for fatty-acid (FAME) specific stable isotope analysis. FAME filters were stored frozen in 2 ml chloroform. All samples are kept frozen until further processing at our home lab.

**Plankton sampling**

Plankton samples were collected with a 333 um ring net (vertical haul) at 13 stations. Typically, hauls were down to 10 m above bottom, except for at very shallow stations, where the entire water column was sampled, or at stations deeper than 150 m, where only

the upper 150 m were sampled. 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*, *Eucalanus bungi*), euphausids (mainly *Thysanoessa rashii,* some *T. inermis*), and chaetognaths (*Sagitta elegans*). At Sts. BL20 and BN1 we also observed several individuals of *Lumbrineris* sp (Polychaeta) in the water column, which typically have a benthic lifestyle. Samples for later C and N stable isotope analysis are dried on board while samples for FAME analysis are stored frozen.

**Benthos sampling**

For benthos, three van Veen grabs per station were collected at 19 stations and replicate surface sediment samples taken for chlorophyll, POM (stable isotope) and FAME measurements. The remaining parts of the grab sediments were sieved over 1 mm and biota sorted immediately for stable isotope analyses. Main target groups were mollusks (e.g. *Yoldia hyperborea*, *Macoma calcarea, Cylichna alba*), polychaetes (Maldanidae, Lumbrineridae, *Glycinde wireni*, *Leithoscoloplos pugettensis*, *Barantolla americana*), amphipods (incl. *Byblis* spp., *Ampelisca* spp., *Protomedia* spp., and *Harpinia* spp), 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. FAME stable isotope samples are kept frozen until further processing.

***J. Weems (left) and H. Chenelot (right, both UAF) take surface sediment samples from a van Veen grab***.

**Feeding experiments to determine isotope turnover rates**

Turnover experiments with clams (*Nuculana radiata*) began previous to HLY0902, with a collection site southwest of St. Lawrence Island on the HLY0901 cruise (18 March

2009). Three hundred clams were collected and divided into three treatments: 1. regular ice algal-based diet, 2. ice algal-based diet enriched with $^{13}C$ and $^{15}N$, 3. starvation (no food addition). An additional 50 clams were also kept to provide an initial baseline to which all treatments will be isotopically compared. Food supplies were prepared at UAF and stored on board frozen. Clams were individually kept at constant temperature. Clams of treatment 1 and 2 were fed every three days with their respective food source, and water in all clam treatments was changed every three days. At regular intervals over a 42 day experimental period, individuals were removed and kept frozen for later isotopic analysis so that enrichment in bulk tissue and in isolated lipids due to isotopically different food sources can be analyzed. In addition, two pilot experiments with krill (*Thysanoessa inermis* and *T. raschii*) involving the same treatment types described above were conducted to establish proper long-term maintenance conditions for such turnover experiments with krill to be done during the BEST 2009 summer cruise.

## Denitrification and Global Change in Bering Sea Shelf Sediments

PIs: Alan Devol (UW) and David Shull (WWU)
On-Board Team Members: David Shull, Heather Whitney (UW), and Maggie Esch (WWU)

The primary goal of the benthic biogeochemistry group is 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. A secondary goal during the next two cruises will be to quantify particle bioturbation rates and address the question of how organic-matter degradation rates and pathways vary with bioturbation. We are examining the kinetics of organic-matter degradation and ammonification by incubating aliquots of sediment from different depths under anoxic conditions. 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 via under-ice microelectrode profiles of oxygen.

### Core samples

We sampled twenty stations 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 generally averaged approximately eleven. 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 and overlying water sampled for, N2/Ar, O2/Ar, O2 by optode, nitrate, nitrite, ammonium, phosphate, and silicate). Following flux measurements, these were frozen for later CT-scanning of burrow distributions

1 squeeze core

Profiles of dissolved oxygen measured by microelectrode and by optode
Profiles of dissolved nutrients (nitrate, nitrite) by whole-core squeezing

2 section cores cut at 0.5- 1-cm intervals and centrifuged for pore-water nutrients, nitrate, nitrite, ammonium, phosphate, silicate to 20 cm. Remaining sediment reserved for measurements of solid-phase elements (Fe, Mn, Al, C, N, Pb-210)

1 core sectioned at 0.5- to 1-cm intervals for measurement of Th-234/U-238 disequilibrium and chloropigments as bioturbation and organic-matter tracers.

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

4 cores sectioned and combined into 0-1cm, 1-2cm, 3-4cm, and 6-7cm depth sections and incubated in glass vials for up to three weeks at near-*in situ* temperature.

**Sea Ice surveys**

At three ice stations, a mini ROV was deployed and used to survey ice algae, dissolved oxygen and krill observable under the ice. At one station, we collected a microelectrode profile of dissolved oxygen within the diffusive sub layer under the ice for determination of ice algal productivity. At other stations we compared video of ice algae to chlorophyll-a concentration.

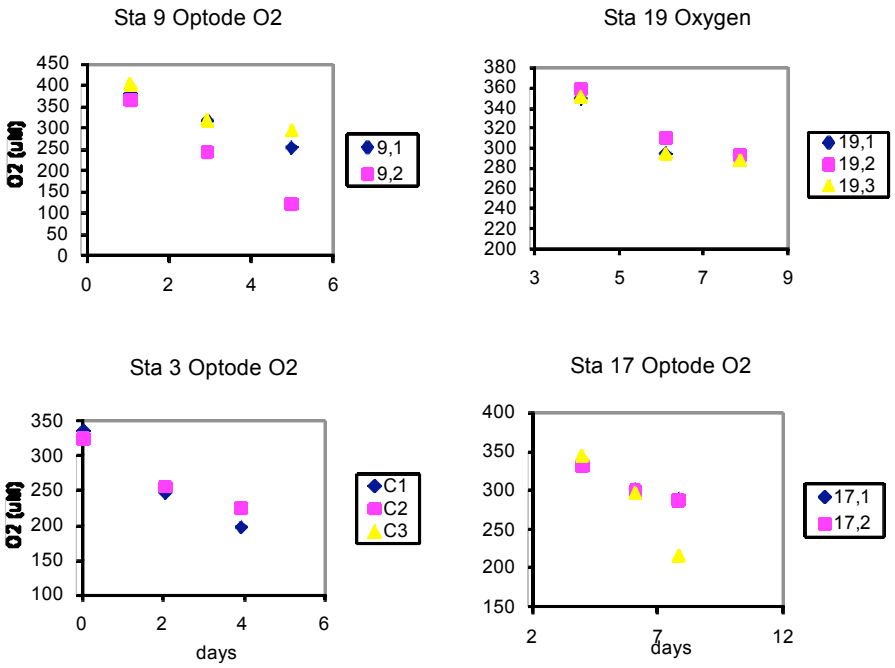
**Initial results**

**Multicore locations**

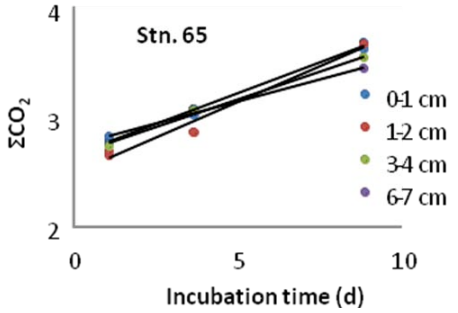
| Coring station information | | | | | Measurements | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stn No. | Stn name | Date | Latitude | Longitude | Depth (m) | [O2]pw | Flux | [Nut]pw | 234Th | Benthos | Anox Inc |
| 3 | Ice Proc. | 4/5/2009 | 58º 12.7' N | 169º 7.0' W | 72 | X | X | X | X | X | |
| 9 | MN 4/5 | 4/7/2009 | 59º 57.7' N | 169º 53.7' W | 55 | X | X | X | X | X | X |
| 17 | MN 11 | 4/9/2009 | 59º 54.2' N | 173º 59.7' W | 104 | X | X | X | X | X | X |
| 19 | MN 13 | 4/10/2009 | 59º 51.5' N | 175º 13.3' W | 120 | X | X | X | X | X | X |
| 25 | MN 19 | 4/12/2009 | 59º 53.6' N | 178º 54.2' W | 705 | X | X | X | X | X | |
| 26 | MN 20 | 4/12/2009 | 59º 55.1' N | 179º 27.2' W | 2714 | X | X | X | X | X | X |
| 32 | SL 12 | 4/16/2009 | 62º 11.9' N | 175º 8.4' W | 81 | X | X | X | X | X | X |
| 35 | SL 9 | 4/16/2009 | 61º 57.8' N | 173º 14.4' W | 62 | X | X | X | X | X | |
| 39 | SL 6 | 4/17/2009 | 61º 56.2' N | 171º 13' W | 53 | X | X | X | X | X | X |
| 54 | NP-5 | 4/21/2009 | 58º 22' N | 168º 43.5' W | 68 | X | X | X | X | X | |
| 58 | NP-9 | 4/22/2009 | 57º 27' N | 169º 46' W | 68 | X | X | X | X | X | |
| 65 | NP-12 | 4/23/2009 | 56º 43.4' N | 170º 8' W | 109 | X | X | X | X | X | X |
| 69 | BL-1 | 4/26/2009 | 59º 33.8' N | 175º 12' W | 133 | X | X | X | X | X | X |
| 73 | BL-4 | 4/27/2008 | 59º 35.4' N | 175º 4.4' W | 129 | X | X | X | X | X | X |
| 83 | ICE-1 | 4/28/2009 | 60º 48.63' N | 174º 23.3' W | 91 | X | X | X | X | X | X |
| 90 | BL-20 | 4/30/2009 | 59º 32.8' N | 175º 8.95' W | 133 | X | X | X | X | X | X |
| 92 | MN-SL5 | 5/1/2009 | 61º 34.3' N | 173º 42.8' W | 72 | X | X | X | X | X | X |
| 93 | BN-1 | 5/2/2009 | 62º 15.8' N | 172º 31.1' W | 57 | X | X | X | X | X | X |
| 98 | SL-12 | 5/4/2009 | 62º10.9' N | 175º 8.8' W | 80 | X | X | X | X | X | X |
| 116 | BL-15 | 5/6/2009 | 59º 33.7' N | 175º 9.2' | W 130 | X | X | X | X | X | X |

Attempted to core at other locations but were unsuccessful at collecting undisturbed sediment (Stns 1, 12, 13, 61)

**Examples of oxygen consumption from stations occupied early in the cruise**




**Example of total $CO_2$ production at different depths from sediment incubations**




## Seabird and Marine Mammal Surveys Aboard HLY0902 (April 4 – May 11, 2009)

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**Project:**

As part of the HLY0902 cruise, we surveyed marine birds and mammals in conjunction with the spring 2009 BEST cruise aboard the USCGC Healy on April 4 – May 11, 2009. The collected 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. One observer scanned the water ahead of the ship using hand-held 10x 42 binoculars and recorded all birds and mammals within a 300-m arc, extending $90^0$ from the bow to the beam. We also noted the animals behavior (flying, on water, on ice, feeding). 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.

Observations were directly entered into a GPS interfaced laptop computer using the DLOG2 program (Ford Ecological Consultants, Inc.). Location data were also automatically written to the program 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:**
Between April 4 and May 11, 2009, we surveyed 175 transects totaling 4,173 km. During this time we recorded a total of 11,258 birds belonging to 29 species (Table 1). The majority of birds observed were Common and Thick-billed Murres (*Uria* spp.) which comprised 63 % of the on-transect bird observations. A large number of murres were observed in forage flocks on April 20, just west of Nunivak Island, and then in smaller groups south of St. Matthew Island (Figure 1). Other species of interest observed included: Black Guillemot, Common Eider, Ivory Gull, Kittlitz's Murrelet, Laysan Albatross, Red-legged Kittiwake, and Ross's Gull (Figure 2).

We observed a total of 1,940 mammals during the survey (Table 2), including four species of seals: Bearded Seal, Ribbon Seal, Ringed Seal, and Spotted Seal. Spotted Seals were the most abundant seal species observed, and the most widely distributed seal throughout the survey area (Figure 3). Many of the seals observed during the early part of the cruise had pups with them on the ice. Pacific Walrus were the most abundant marine mammals recorded. Walrus were observed throughout the survey area, but the majority of the walrus were in several large groups on April 5, northeast of St. Paul Island (Figure 4).

**Table 1. On transect seabird observations during HLY0902 (April 4 – May 11, 2009)**

| Species | No. |
|---|---|
| Black Guillemot | 35 |
| Black-legged Kittiwake | 1053 |
| Brachyramphus Spp. | 2 |
| Common Eider | 3 |
| Common Murre | 795 |

| Species | No. |
|---|---|
| Pelagic/Red-faced Cormorant | 68 |
| Red-faced Cormorant | 6 |
| Red-legged Kittiwake | 6 |
| Ross's Gull | 7 |
| Sabine's Gull | 1 |

| Species | No. |
|---|---|
| Fork-tailed Storm-petrel | 7 |
| Glaucous Gull | 810 |
| Glaucous-winged Gull | 84 |
| Harlequin Duck | 5 |
| Herring Gull | 21 |
| Ivory Gull | 39 |
| Kittlitz's Murrelet | 4 |
| Laysan Albatross | 9 |
| Least Auklet | 15 |
| Mew Gull | 1 |
| McKay's bunting | 7 |
| Northern Fulmar | 578 |
| Northern Pintail | 12 |
| Parakeet Auklet | 15 |
| Passerine Spp. | 2 |
| Pelagic Cormorant | 73 |
| Pigeon Guillemot | 12 |
| Slaty-backed Gull | 9 |
| Snow Bunting | 1 |
| Sooty Shearwater | 152 |
| Thick-billed Murre | 4245 |
| Tufted Puffin | 70 |
| Unid. Alcid | 40 |
| Unid. Auklet | 4 |
| Unid. Bird | 4 |
| Unid. Dark Shearwater | 730 |
| Unid. Duck | 2 |
| Unid. Eider | 1 |
| Unid. Guillemot | 13 |
| Unid. Gull | 147 |
| Unid. Kittiwake | 33 |
| Unid. Murre | 2123 |
| Unid. Procellariiformes | 13 |
| Unid. Puffin | 1 |
| total | 11,258 |

**Table 2. Total mammal observations during HLY0902 (April 4 – May 11, 2009)**

| Species | No. |
|---|---|
| Bearded Seal | 200 |
| Dall's Porpoise | 14 |
| Fin Whale | 3 |
| Gray Whale | 4 |
| Harbor Porpoise | 59 |
| Killer Whale | 17 |
| Minke Whale | 3 |
| Ribbon Seal | 117 |
| Ringed Seal | 12 |
| Spotted Seal | 349 |
| Steller Sea lion | 10 |
| Pacific Walrus | 957 |
| Unid. Pinniped | 13 |
| Unid. Seal | 176 |
| Unid. Whale | 6 |
| total | 1,940 |

**Figure 1. Murre species distribution aboard HLY0902 (April 4 – May 11, 2009)**

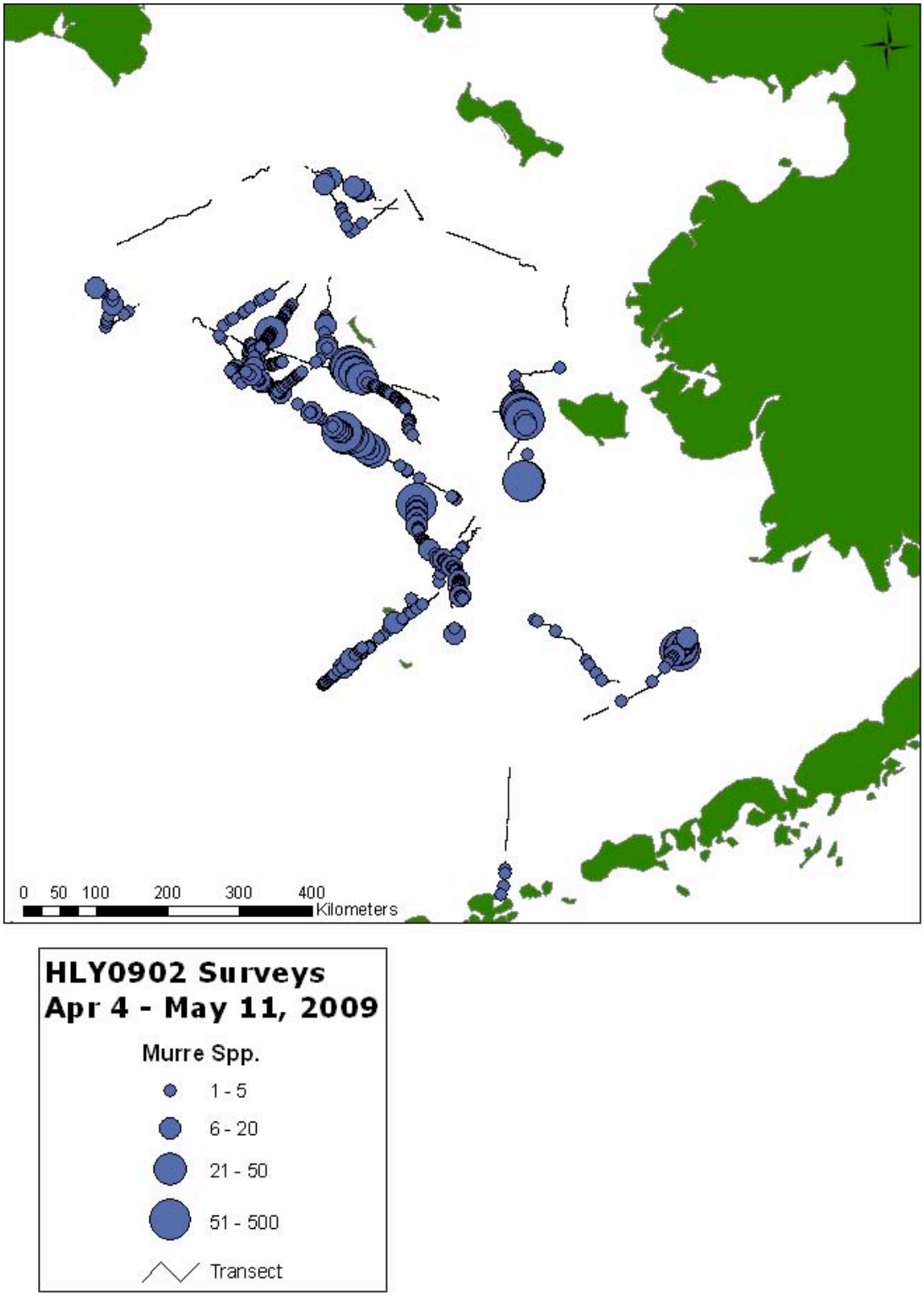
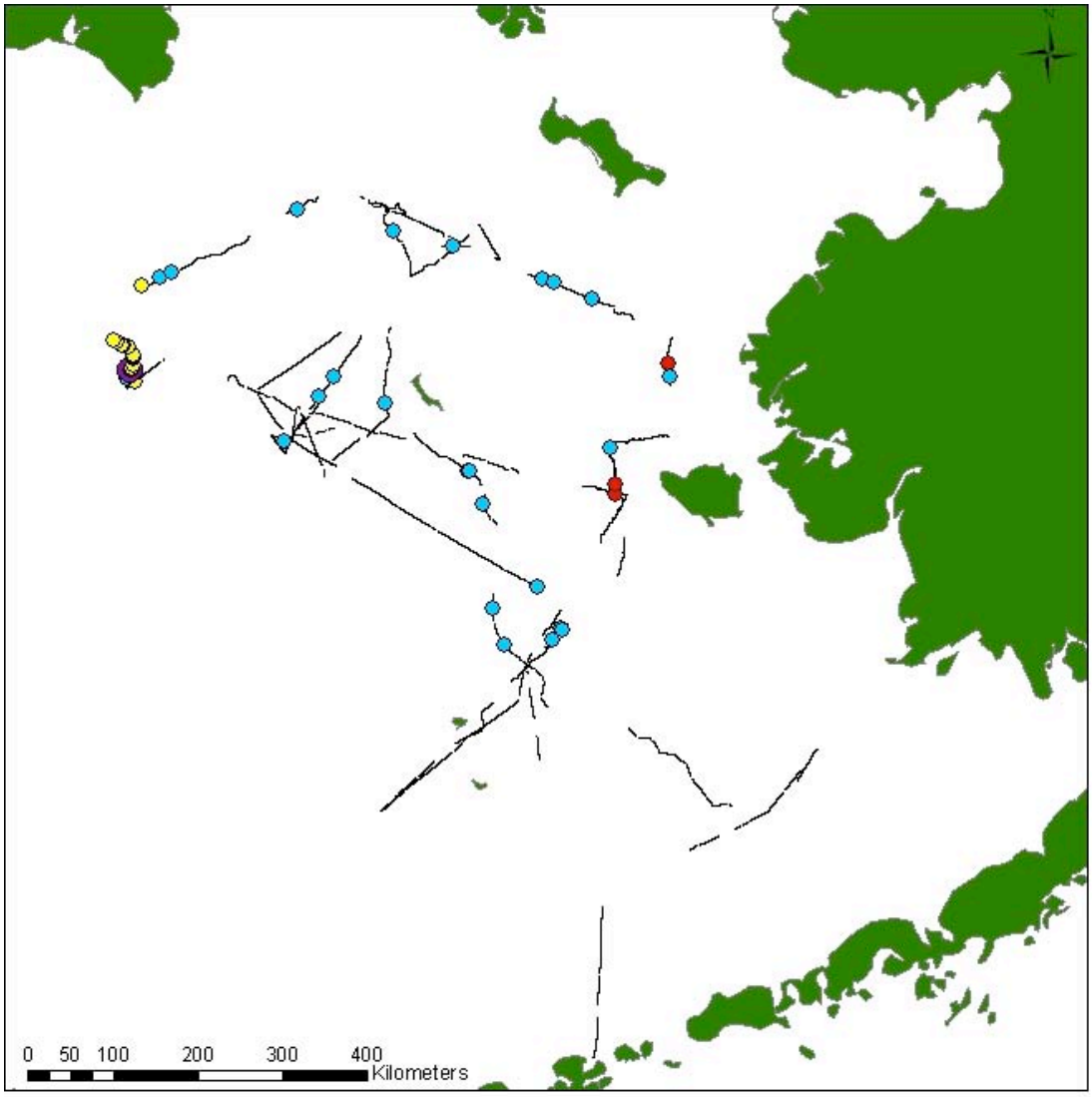


**Figure 2. Marine bird distribution aboard HLY0902 (April 4 – May 11, 2009)**



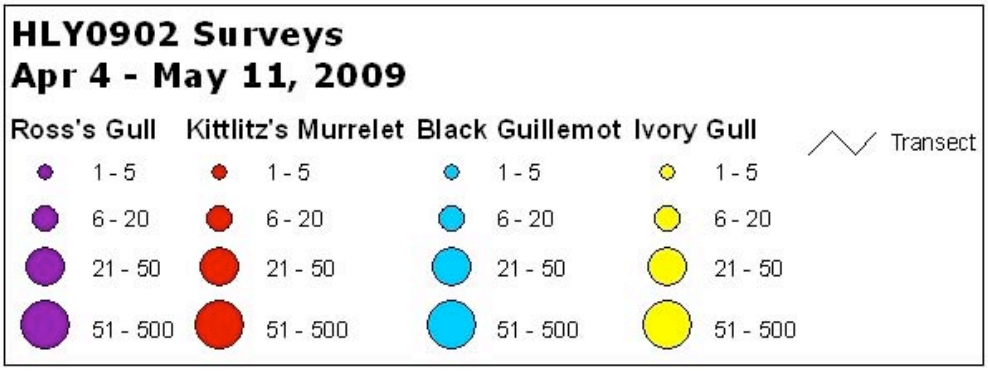



**Figure 3. Ice Seal distribution aboard HLY0902 (April 4 – May 11, 2009)**

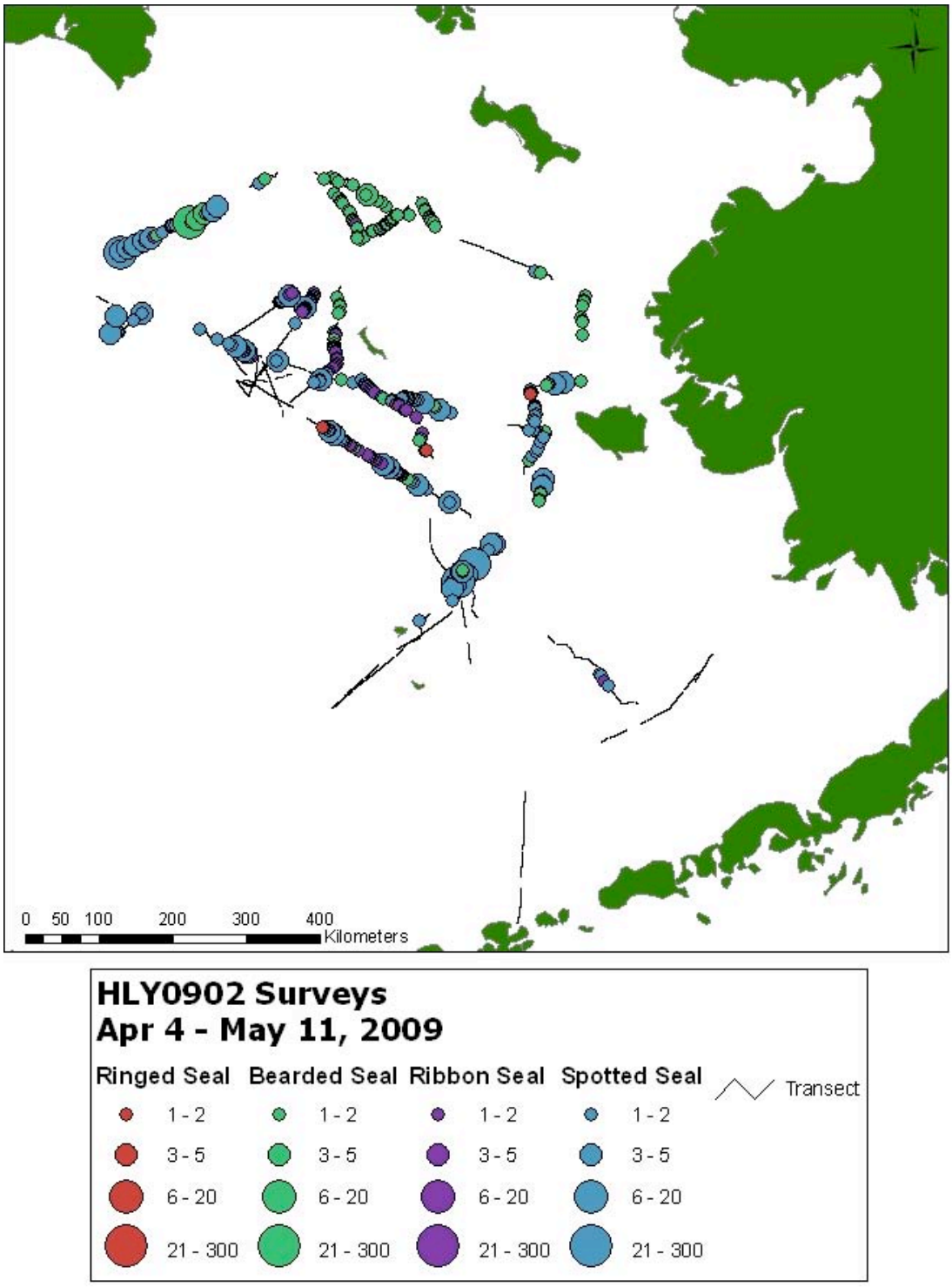
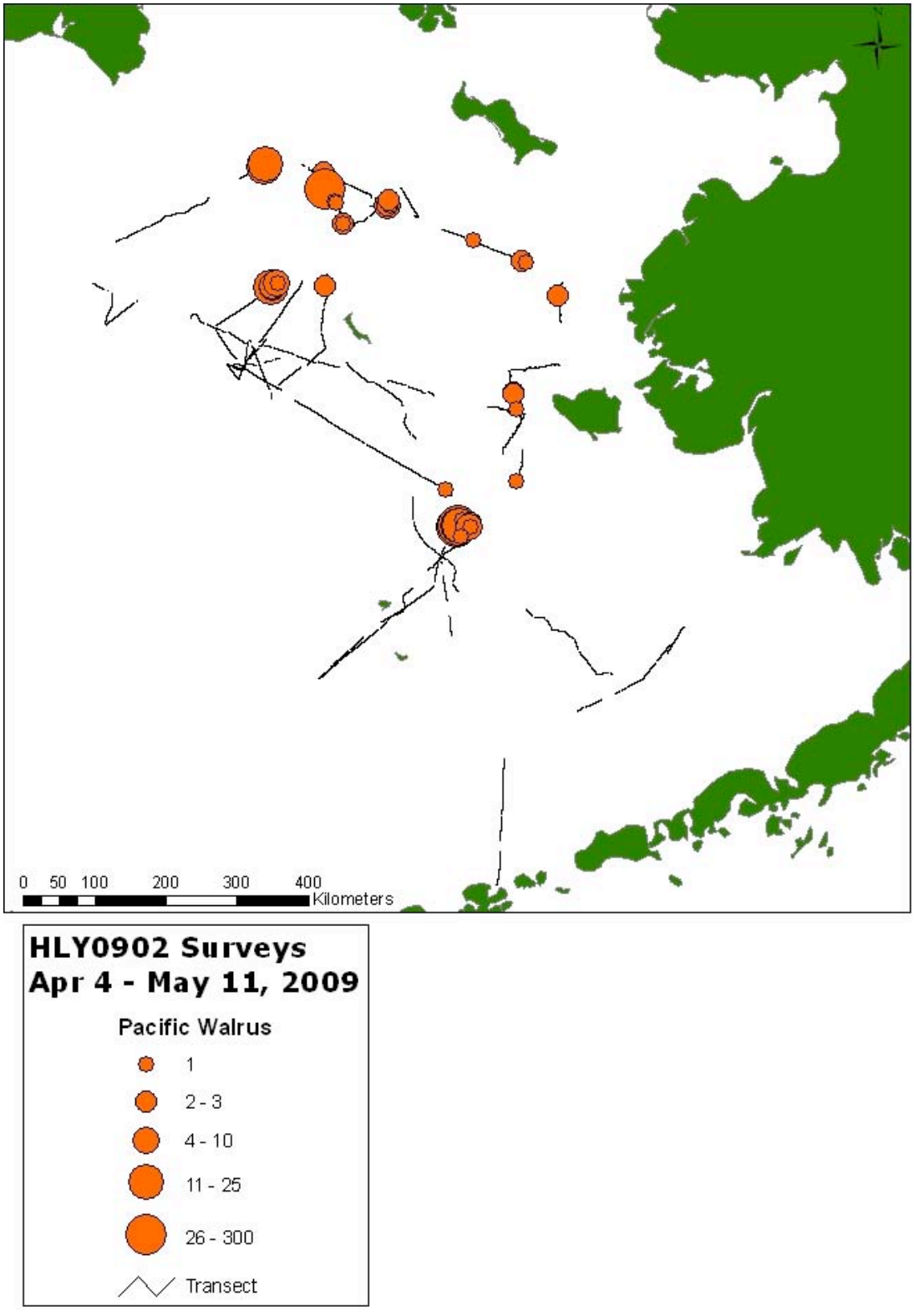


**Figure 4. Walrus distribution aboard HLY0902 (April 4 – May 11, 2009)**



## IPY: Collaborative Research: Live from the Poles; A Multimedia Educational Experience

PI: Chris Linder (WHOI)

On-Board Team Members: Chris Linder (WHOI), Helen Fields

The Live from the Poles media team produced the following online products during the expedition:

**Table 1. Online Products**

| Online product | URL |
|---|---|
| 40 daily stories for the Polar Discovery website from April 3 to May 12 (writing by Helen Fields, photographs by Chris Linder) | http://polardiscovery.whoi.edu |
| 5 blogs for ScientificAmerican.com's "60 Second Science" website (writing by Helen Fields, photographs by Chris Linder) | http://www.scientificamerican.com/blog/60-seconds-in-bering-sea |
| 5 blogs for the liveBooks photography website (writing & photographs by Chris Linder) | http://blog.livebooks.com/category/contributors/chris-linder |
| Excerpts from Polar Discovery essays posted to The Discovery Channel's Earth Live website plus audio interviews with Carin Ashjian, Liz Labunski, Helen Fields, and Chris Linder | http://blogs.discovery.com/earth-live-bering-sea/ |
| Twitter: as of May 10, 2009 we wrote 213 updates and have 127 followers | http://twitter.com/WHOIExpeditions |
| Interview with Helen Fields on Smithsonian Magazine's Surprising Science blog | http://blogs.smithsonianmag.com/science/2009/04/28/connected-even-on-a-ship-in-the-arctic/ |

**Table 2. Polar Discovery website Visitor Statistics from April 1 through May 6**

| | |
|---|---|
| Total Visits | 27,226 |
| Average Visits per day | 756 |
| Visitors who visited more than once | 1.57 |
| Visit duration | 00:7:53 |

**Table 3. Polar Discovery website Top Page Hits from April 1 through May 6**

| | |
|---|---|
| Polar Discovery :: Expedition 5 Journals : Today on the Ice | 5,489 |
| Polar Discovery :: Home | 5,763 |
| Polar Discovery : Expedition 5 to the Bering Sea :: Home | 4,976 |
| Polar Discovery :: Arctic Ecosystem | 2,863 |
| Polar Discovery :: Comparing the Poles :: Climate | 1,787 |
| Polar Discovery :: Arctic Location and Geography | 965 |
| Polar Discovery :: Expedition 5 Journal Day 1 | 970 |
| Polar Discovery :: Antarctica :: Location and Geography | 900 |
| Polar Discovery :: Expedition 5 :: Meet the Research Teams | 874 |
| Polar Discovery :: Where are We? Expedition 5 Google Map | 869 |

**Table 4. Polar Discovery website Top Level Domain Types from April 1 through May 6**

| **Top Level Domain Types** | **Visits** | **Percent Total** | **Page Hits** |
|---|---|---|---|
| Network | 8,626 | 31.68% | 91,905 |
| Commercial | 7,405 | 27.20% | 41,657 |
| Unresolved IP Address | 5,334 | 19.59% | 41,102 |
| Education | 2,559 | 9.40% | 28,825 |
| Unknown | 1,969 | 7.23% | 13,236 |
| Organization | 838 | 3.08% | 6,743 |
| Government | 269 | 0.99% | 2,615 |

**Table 5. Live Talks**

| Institution | Date | Audience | Speakers |
|---|---|---|---|
| 1. Smithsonian Environmental Research Center<br>Edgewater, MD | 4/15 | General public | Dr. Rodger Harvey |
| 2. Carnegie Museum of Natural History<br>Pittsburgh, PA | 4/20 | Docents | Dr. Evelyn Lessard, Helen Fields |
| 3. Woods Hole Oceanographic Institution Exhibit Center<br>Woods | 4/22 | Exhibit Center Volunteers | Dr. Carin Ashjian |
| 4. Museum of Science<br>Boston, MA | 4/30 | General public | Dr. Carin Ashjian, Helen Fields |
| 5. liveBooks webinar<br>Online | 5/5 | General public | Chris Linder |
| 6. Pacific Science Center<br>Seattle, WA | 5/9 | Discovery Corps docents | Dr. David Shull, Brandi Murphy, Helen Fields |

## Bering Ecosystem Study Data Management Support

PIs: Jim Moore (NCAR) and Greg Stossmeister (NCAR)
On-Board Team Member: Janet Scannell (NCAR)

The online field catalog is fully populated with data, from the HLY0902 cruise, accessible to all on board the USCGC Healy. This data includes underway plots, such as sea surface temperature, salinity, and fluorescence; a station summary page and an event log of all the science events taking place, including maps of all of the stations; the preliminary CTD data including transect plots showing nutrients and other values, such as chlorophyll and oxygen saturation; ice observations from both HLY0901 and HLY0902 cruises; the chief scientist reports and the teacher's journals; DMSP and NOAA satellite imagery for the Bering Sea; as well as various surface and sonar plots from the underway systems, and web camera images taken from the bow of the ship, which also show ice conditions. Figure 1 shows the station summary page for the first part of the HLY0902 cruise.

The entire field catalog will be transferred to a server at NCAR/EOL in Boulder. Colorado where it will be accessible through the BEST project web site at NCAR/EOL located at http://www.eol.ucar.edu/projects/best. All of the underway data and PI data

sets from this cruise will be added to the permanent archive of the BEST data also available through the same web site.


**STATION SUMMARY**

| STATION NO. | STATION ID | CRUISE PHASE | MAP | DATE | TIME(UTC) | LATITUDE(N) | LONGITUDE(W) | DEPTH (m) | DURATION (hr) | EVENT LOGS |
|---|---|---|---|---|---|---|---|---|---|---|
| HLY0902-001 | NP7 | NP plots | Map | 2009/04/05 | 03:02 | 57.90267 | 169.31700 | 66 | 3.22 | html, csv |
| HLY0902-002 | NP6.5 | | Map | 2009/04/05 | 09:13 | 58.03806 | 169.22800 | 67 | 0.92 | html, csv |
| HLY0902-003 | ICE/PROCESS 1 | | Map | 2009/04/05 | 12:36 | 58.17074 | 169.10020 | 69 | 13.63 | html, csv |
| HLY0902-004 | BC1 | BC | Map | 2009/04/06 | 07:32 | 58.6182 | 168.8417 | 69 | 1.27 | html, csv |
| HLY0902-005 | MN1 | MN map plots | Map | 2009/04/06 | 23:31 | 59.90022 | 167.99700 | 28 | 0.40 | html, csv |
| HLY0902-006 | MN2 | | Map | 2009/04/07 | 03:40 | 59.90741 | 168.59660 | 41 | 0.78 | html, csv |
| HLY0902-007 | MN3 | | Map | 2009/04/07 | 07:36 | 59.89942 | 169.19930 | 46 | 0.83 | html, csv |
| HLY0902-008 | MN4 | | Map | 2009/04/07 | 12:20 | 59.90372 | 169.79600 | 52 | 0.57 | html, csv |
| HLY0902-009 | MN4.5 | | Map | 2009/04/07 | 14:36 | 59.93499 | 169.99310 | 56 | 15.45 | html, csv |
| HLY0902-010 | MN5 | | Map | 2009/04/08 | 10:20 | 59.90012 | 170.3972 | 62 | 5.83 | html, csv |
| HLY0902-011 | ICE 2 | | Map | 2009/04/08 | 19:05 | 59.8968 | 170.5407 | 64 | 2.38 | html, csv |
| HLY0902-012 | MN6 | MN map plots | Map | 2009/04/09 | 00:21 | 59.91145 | 171.05920 | 70 | 1.12 | html, csv |
| HLY0902-013 | MN7 | | Map | 2009/04/09 | 04:28 | 59.90039 | 171.59520 | 69 | 2.10 | html, csv |
| HLY0902-014 | MN8 | | Map | 2009/04/09 | 10:23 | 59.90979 | 172.1457 | 72 | 1.32 | html, csv |
| HLY0902-015 | MN9 | | Map | 2009/04/09 | 15:01 | 59.90612 | 172.79520 | 72 | 1.42 | html, csv |
| HLY0902-016 | MN10 | | Map | 2009/04/09 | 19:24 | 59.89843 | 173.40490 | 86 | 1.40 | html, csv |
| HLY0902-017 | MN11 | | Map | 2009/04/09 | 23:02 | 59.89337 | 173.97820 | 101 | 2.20 | html, csv |
| HLY0902-018 | MN12 | | Map | 2009/04/10 | 04:56 | 59.90060 | 174.61200 | 113 | 0.72 | html, csv |
| HLY0902-019 | MN13 | | Map | 2009/04/10 | 09:26 | 59.89907 | 175.20180 | 120 | 10.60 | html, csv |
| HLY0902-020 | MN14 | | Map | 2009/04/11 | 00:03 | 59.90339 | 175.80530 | 130 | 0.63 | html, csv |
| HLY0902-021 | MN15 | | Map | 2009/04/11 | 03:28 | 59.90995 | 176.38380 | 140 | 0.68 | html, csv |
| HLY0902-022 | MN16 | | Map | 2009/04/11 | 08:14 | 59.89934 | 176.99300 | 136 | 1.22 | html, csv |
| HLY0902-023 | MN17 | | Map | 2009/04/11 | 12:48 | 59.8969 | 177.6008 | 136 | 1.28 | html, csv |
| HLY0902-024 | MN18 | | Map | 2009/04/11 | 17:12 | 59.90531 | 178.19190 | 144 | 5.80 | html, csv |
| HLY0902-025 | MN19 | | Map | 2009/04/12 | 07:14 | 59.90162 | 178.89830 | 490 | 13.27 | html, csv |
| HLY0902-026 | MN20 | | Map | 2009/04/12 | 22:12 | 59.90228 | 179.42250 | 2700 | 10.68 | html, csv |

Figure 1 - Station summary page from the HLY0902 field catalog for the first part of the HLY0902 cruise.

## CTD Operations – Science Seawater Sensors – Meteorological Sensors
## Scripps Institution of Oceanography

Scott Hiller

### CTD Operations

Data Set overview

233 CTD Casts on 172 stations were completed. Cast depth range was 30-2800 meters and water samples were taken from each cast. See Table 1 for StationCast log.

Instrumentation

CTD casts were performed with a rosette system consisting of a 12-place rosette frame with 30 liter bottles and a 12-place SBE-32 Carousel pylon. Underwater electronic components consisted of:

- Sea-Bird Electronics, Inc. (SBE) 911plus CTD
- WETLabs C-Star transmissometer with a 25cm path length and 660nm wavelength
- Biospherical Instruments, Inc. Photosynthetically Active Radiation (PAR) sensor
- Chelsea MkIII Aquatrack fluorometer
- Benthos, PSA-916, 1-100 meter altimeter

The CTD utilized redundant temperature and conductivity sensors, along with a SBE-43 dissolved oxygen sensor, plumbed to the primary temperature and conductivity sensors. The PAR sensor was located at the top of the rosette. The surface PAR sensor was located atop the helicopter shack.

This instrument package provided pressure, dual temperature and dual conductivity channels as well as light transmissivity and fluorometric signals at a sample rate of 24 scans per second.

The bottles on the rosette were General Oceanic 30 liter bottles. The bottles were equipped with internal nylon coated springs and silicone o-rings which are used to minimize toxicity to the sample. Bottle numbering is 1 to 12 with 1 tripped first usually at the deepest sampling level and 12 tripped last at the shallowest sampling level. The rosette system was suspended from a standard UNOLS 3 conductor 0.322" electromechanical cable.

CTD Data Acquisition

The CTD 911plus was operated generally as suggested in the Sea-Bird CTD Operating and Repair Manual, which contains a description of the system, its operation and functions. The Seasoft acquisition program as described in the CTD Data Acquisition Software Manual provided a real-time graphical display of selected parameters adequate to monitor CTD performance and information for the selection of bottle-tripping depths. Raw data from the CTD were archived on the PC's hard disk at the full 24 Hz sampling rate. Seasave data acquisition software used for this cruise was version 7.18c.

A CTD Station Sheet form was filled in for each deployment, providing a record of times, positions, bottom depth, bottle sampling depths, and every attempt to trip a bottle, as well as any pertinent comments. The CTD stations sheet also served as a Sample Log

sheet for people taking water samples. Each CTD station sheet was scanned and filed with the archived data as a .pdf file.

CTD Data Processing

Pressure
The CTD pressure sensor was calibrated in Dec 2008.

Temperature
The temperature sensors were calibrated in Dec 2008. The dual temperature sensors were monitored during the cruise and exhibited good agreement. It appears that no additional corrections need to be applied. A post-cruise calibration will be performed.

Conductivity
The conductivity sensors were calibrated in Dec 2008. Corrected CTD pressure and temperature values were used with bottle salinities to back-calculate bottle conductivities. Comparison of these bottle values with the CTD primary and secondary conductivity values indicated a small constant offset. The secondary conductivity sensor (C2) exhibited a smaller offset for the cruise and this sensor should be used at the primary sensor when reporting data from this cruise. C1 offset for the cruise, as compared to bottle salinities was 0.0032 mS/cm, whereas C2 offset for the cruise was 0.0020 mS/cm. A post-cruise calibration of these sensors will be performed.

Sea-Bird Seasoft CTD processing software was employed. The processing programs are outlined below. A more complete description may be found in the Sea-Bird Software Manual which is available from the Sea-Bird website (www.seabird.com).
The sequence of programs that were run in processing CTD data from this cruise are as follows:

- *DATCNV* - Converts data from raw frequencies and voltages to corrected engineering units
- *WILDEDIT* - Eliminates large spikes
- *FILTER* – A low pass filter to smooth pressure for LOOPEDIT
- *LOOPEDIT* - Marks scans where velocity is less than selected value to avoid pressure reversals from ship roll, or during bottle flushing.
- *DERIVE* - Computes calculated parameters
- *BOTTLESUM* – Creates a bottle trip summary file
- *BINAVG* - Average data into desired pressure bins

After processing, preliminary CTD data was copied to a network server for archival and science party access. Data processing was preformed immediately after the completion of each CTD cast.

**TABLE 1.**

USCGC Healy - HLY0902 - CTD Cast log

1 - Station/Cast Number
2 - Station Name
3 - GMT Date
4 - GMT Time
5 - Latitude
6 - Longitude
7 - CTD max depth (meters)
8 - Bottom Depth (Seabeam)
9 - Seasave CTD data (first good scan number)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 001001 | NP7 | Apr 05 2009 | 02:55:41 | 57 54.16 N | 169 18.90 W | 61 | 67 | 4500 |
| 002002 | NP6.5 | Apr 05 2009 | 09:13:49 | 58 02.31 N | 169 13.67 W | 64 | 67 | 840 |
| 002003 | NP6.5 | Apr 05 2009 | 10:00:14 | 58 03.23 N | 169 14.49 W | 64 | 67 | 2802 |
| 003004 | Ice Proc | Apr 05 2009 | 12:37:12 | 58 10.28 N | 169 05.97 W | 66 | 70 | 300 |
| 003005 | Ice Proc | Apr 05 2009 | 13:40:24 | 58 10.91 N | 169 05.52 W | 66 | 70 | 313 |
| 003006 | Ice Proc | Apr 05 2009 | 16:10:54 | 58 11.41 N | 169 04.72 W | 65 | 70 | 800 |
| 003007 | Ice Proc | Apr 06 2009 | 02:05:25 | 58 16.04 N | 169 05.01 W | 64 | 70 | 260 |
| 004008 | BC1 | Apr 06 2009 | 08:36:13 | 58 37.76 N | 168 51.71 W | 57 | 60 | 1081 |
| 005009 | MN1 | Apr 06 2009 | 23:30:52 | 59 53.99 N | 167 59.76 W | 26 | 30 | 240 |
| 006010 | MN2 | Apr 07 2009 | 03:40:06 | 59 54.41 N | 168 35.82 W | 35 | 41 | 140 |
| 007011 | MN3 | Apr 07 2009 | 07:36:07 | 59 53.94 N | 169 11.92 W | 40 | 45 | 865 |
| 008012 | MN4 | Apr 07 2009 | 12:19:45 | 59 54.21 N | 169 47.70 W | 47 | 50 | 1417 |
| 009013 | MN4.5 | Apr 07 2009 | 14:36:45 | 59 56.11 N | 169 59.54 W | 51 | 55 | 361 |
| 009014 | MN4.5 | Apr 07 2009 | 16:26:29 | 59 56.28 N | 169 57.05 W | 50 | 55 | 553 |
| 009015 | MN4.5 | Apr 08 2009 | 05:56:31 | 59 56.25 N | 169 47.64 W | 46 | 55 | 240 |
| 010016 | MN5 | Apr 08 2009 | 11:15:44 | 59 53.70 N | 170 24.00 W | 54 | 58 | 1201 |
| 010017 | MN5 | Apr 08 2009 | 13:30:29 | 59 54.08 N | 170 23.41 W | 57 | 60 | 4625 |
| 010018 | MN5 | Apr 08 2009 | 15:59:44 | 59 54.69 N | 170 20.86 W | 57 | 62 | 841 |
| 011019 | Ice Sta2 | Apr 08 2009 | 21:19:42 | 59 52.77 N | 170 32.34 W | 60 | 64 | 740 |
| 012020 | MN6 | Apr 09 2009 | 00:20:50 | 59 54.67 N | 171 03.59 W | 65 | 70 | 120 |
| 013021 | MN7 | Apr 09 2009 | 04:26:55 | 59 54.03 N | 171 35.76 W | 67 | 69 | 200 |

```
014022  MN8      Apr 09 2009 11:18:17  59 54.36 N 172 10.71 W   67   72
313
015023  MN9      Apr 09 2009 15:01:29  59 54.38 N 172 47.75 W   69   72
337
015024  MN9      Apr 09 2009 16:16:50  59 54.49 N 172 48.93 W   68   72
505
016025  MN10     Apr 09 2009 19:24:04  59 53.92 N 173 24.32 W   81   85
505
017026  MN11     Apr 09 2009 23:01:42  59 53.61 N 173 58.73 W   97  102
260
018027  MN12     Apr 10 2009 04:56:21  59 54.03 N 174 36.77 W  107  112
180
019028  MN13     Apr 10 2009 09:25:51  59 53.92 N 175 12.14 W  114  120
481
019029  MN13     Apr 10 2009 11:22:16  59 52.43 N 175 12.71 W  115  120
313
019030  MN13     Apr 10 2009 13:30:51  59 52.01 N 175 15.40 W  114  120
313
019031  MN13     Apr 10 2009 16:08:00  59 52.32 N 175 12.58 W  115  120
409
019032  MN13     Apr 10 2009 16:40:29  59 52.17 N 175 12.60 W  115  120
457
019033  MN13     Apr 10 2009 17:47:49  59 51.95 N 175 13.13 W   30  120
505
020034  MN14     Apr 11 2009 00:02:14  59 54.18 N 175 48.32 W  126  131
220
021035  MN15     Apr 11 2009 03:27:48  59 54.59 N 176 23.08 W  132  138
160
022036  MN16     Apr 11 2009 08:13:44  59 53.96 N 176 59.63 W  135  140
409
023037  MN17     Apr 11 2009 13:20:27  59 53.18 N 177 36.99 W  130  137
289
024038  MN18     Apr 11 2009 17:12:52  59 54.31 N 178 11.56 W  136  142
409
025039  MN19     Apr 12 2009 07:13:52  59 54.11 N 178 53.94 W  425  435
260
025040  MN19     Apr 12 2009 08:58:24  59 54.31 N 178 54.23 W   60  390
505
025041  MN19     Apr 12 2009 13:32:21  59 54.06 N 178 54.22 W   60  500
217
025042  MN19     Apr 12 2009 16:20:35  59 54.35 N 178 54.40 W   99  390
145
026043  MN20     Apr 12 2009 22:11:13  59 54.16 N 179 25.35 W  268 2690
130
026044  MN20     Apr 13 2009 01:25:57  59 53.07 N 179 26.31 W  298  740
220
026045  MN20     Apr 13 2009 08:41:52  59 54.65 N 179 26.96 W  100 2690
217
027046  MN-SL2   Apr 13 2009 16:32:35  60 29.37 N 179 12.05 W  100 1005
841
028047  MN-SL3   Apr 14 2009 10:54:43  61 41.76 N 176 59.19 W  107  117
313
029048  MN-SL4   Apr 14 2009 13:20:07  61 46.87 N 176 47.70 W  105  113
313
029049  MN-SL4   Apr 14 2009 14:29:01  61 46.62 N 176 47.34 W   40  111
241
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029050  MN-SL4   Apr 14 2009 16:32:23  61 46.19 N 176 47.35 W  106  111
337
029051  MN-SL4   Apr 15 2009 02:13:35  61 46.84 N 176 48.62 W  106  118
120
030052  SL14     Apr 15 2009 10:05:31  62 13.17 N 175 56.85 W   84   92
145
031053  SL13     Apr 15 2009 14:46:43  62 13.65 N 175 33.20 W   79   84
145
032054  SL12     Apr 15 2009 20:54:10  62 11.55 N 175 08.43 W   75   80
370
033055  SL11     Apr 16 2009 02:44:44  62 11.10 N 174 39.28 W   69   73
300
034056  SL10     Apr 16 2009 09:49:30  62 09.39 N 173 59.69 W   59   63
337
035057  SL9      Apr 16 2009 14:03:20  62 05.36 N 173 16.89 W   55   60
147
035058  SL9      Apr 16 2009 15:11:59  62 04.59 N 173 16.50 W   55   60
193
035059  SL9      Apr 16 2009 16:33:09  62 03.61 N 173 16.35 W   53   61
433
035060  SL9      Apr 17 2009 01:36:26  61 58.70 N 173 14.69 W   56   60
200
036061  SL8      Apr 17 2009 06:38:34  62 02.55 N 172 37.47 W   51   55
180
038062  SL7      Apr 17 2009 11:25:04  61 59.67 N 171 53.90 W   49   53
313
039063  SL6      Apr 17 2009 15:28:56  61 56.77 N 171 13.74 W   47   52
240
040064  SL5      Apr 17 2009 20:22:52  61 53.83 N 170 32.63 W   44   49
180
041065  SL4      Apr 18 2009 00:20:36  61 51.14 N 169 50.60 W   41   44
150
042066  SL3      Apr 18 2009 03:29:34  61 48.25 N 169 10.95 W   36   42
300
043067  SL2      Apr 18 2009 08:00:14  61 44.92 N 168 29.43 W   29   40
289
045068  SL1      Apr 18 2009 13:57:09  61 42.07 N 167 45.23 W   23   27
137
045069  SL1      Apr 18 2009 14:51:22  61 41.84 N 167 44.51 W   22   27
289
045070  SL1      Apr 18 2009 16:09:09  61 41.44 N 167 43.93 W   22   28
169
045071  SL1      Apr 18 2009 23:12:11  61 38.86 N 167 47.59 W   24   26
320
046072  SL-W1    Apr 19 2009 10:32:29  60 49.85 N 167 28.93 W   20   25
121
047073  W1       Apr 19 2009 16:24:31  60 35.87 N 167 24.74 W   23   25
121
048074  W2       Apr 19 2009 20:53:28  60 30.46 N 167 59.83 W   26   28
120
049075  W3       Apr 20 2009 00:28:21  60 23.71 N 168 38.85 W   32   35
360
050076  NP1      Apr 20 2009 10:39:43  59 27.25 N 167 48.57 W   33   38
241
050077  NP1      Apr 20 2009 14:34:56  59 27.45 N 167 47.13 W   33   38
169
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050078  NP1      Apr 20 2009 16:00:13  59 27.14 N 167 48.42 W   33   38
265
050079  NP1      Apr 21 2009 02:15:12  59 27.71 N 167 51.99 W   35   38
140
051080  NP2      Apr 21 2009 05:53:30  59 02.99 N 167 53.33 W   38   41
130
052081  NP3      Apr 21 2009 08:13:24  58 49.87 N 168 09.37 W   41   45
121
052082  NP3      Apr 21 2009 09:22:18  58 50.53 N 168 09.38 W   40   46
147
053083  NP4      Apr 21 2009 12:29:04  58 36.54 N 168 26.47 W   51   55
217
054084  NP5      Apr 21 2009 17:23:23  58 21.76 N 168 42.11 W   61   66
361
055085  NP6      Apr 21 2009 23:27:39  58 08.54 N 168 58.51 W   66   70
100
056086  NP7      Apr 22 2009 02:51:56  57 54.82 N 169 14.26 W   63   65
180
057087  NP8      Apr 22 2009 06:36:21  57 40.60 N 169 26.04 W   66   68
220
058088  NP9      Apr 22 2009 09:39:31  57 27.01 N 169 46.69 W   63   66
217
058089  NP9      Apr 22 2009 10:33:56  57 28.28 N 169 47.25 W   63   66
193
058090  NP9      Apr 22 2009 15:18:47  57 26.44 N 169 44.69 W   61   66
169
058091  NP9      Apr 22 2009 16:04:54  57 26.82 N 169 44.49 W   63   66
505
059092  NP10     Apr 22 2009 18:50:00  57 19.33 N 169 54.53 W   54   58
265
060093  STD1     Apr 23 2009 04:17:56  56 15.95 N 171 04.53 W  138  144
140
061094  NP15     Apr 23 2009 06:13:19  56 03.58 N 171 17.92 W 2740 2750
200
061095  NP15     Apr 23 2009 09:43:08  56 01.05 N 171 17.64 W  100 2800
1249
061096  NP15     Apr 23 2009 10:53:09  56 03.14 N 171 18.11 W  403 2800
1033
062097  NP13.5   Apr 23 2009 23:08:58  56 20.73 N 171 01.22 W  127  130
260
063098  NP14     Apr 24 2009 00:08:19  56 17.45 N 171 03.10 W  131  135
200
064099  NP13     Apr 24 2009 02:48:11  56 30.44 N 170 48.64 W  117  123
200
065100  NP12     Apr 24 2009 05:39:50  56 43.73 N 170 31.71 W  105  110
120
066101  NP11     Apr 24 2009 09:47:43  56 58.23 N 170 16.63 W   70   76
337
066102  NP11     Apr 24 2009 12:04:15  56 58.60 N 170 16.83 W   68   73
289
066103  NP11     Apr 24 2009 14:38:07  56 58.47 N 170 16.40 W   66   73
97
066104  NP11     Apr 24 2009 16:06:46  56 58.33 N 170 16.16 W   68   73
145
067105  OR1      Apr 24 2009 22:20:43  57 41.99 N 169 15.89 W   66   69
130
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069106  BL1      Apr 26 2009 15:08:22  59 31.74 N 175 12.14 W  127  133
553
069107  BL1      Apr 26 2009 16:03:06  59 32.94 N 175 11.29 W  126  133
865
069108  BL1      Apr 26 2009 17:05:39  59 34.11 N 175 11.70 W  126  133
553
070109  BL2      Apr 26 2009 22:12:50  59 30.65 N 175 05.10 W  126  130
180
071110  MN13     Apr 27 2009 00:46:37  59 54.18 N 175 12.23 W  114  120
150
072111  BL3      Apr 27 2009 06:11:50  59 17.43 N 174 12.30 W  114  116
200
073112  BL4      Apr 27 2009 09:38:48  59 32.59 N 175 01.67 W  123  128
121
073113  BL4      Apr 27 2009 10:37:34  59 32.92 N 175 02.82 W  123  128
121
073114  BL4      Apr 27 2009 14:54:49  59 32.40 N 175 04.61 W  124  128
241
073115  BL4      Apr 27 2009 16:04:10  59 32.15 N 175 03.57 W  124  130
193
074116  BL5      Apr 27 2009 23:03:43  59 32.63 N 175 09.25 W  126  130
200
075117  BL6      Apr 28 2009 00:32:38  59 42.27 N 175 01.61 W  119  124
200
076118  BL7      Apr 28 2009 01:57:47  59 51.33 N 174 54.26 W  112  116
210
077119  BL8      Apr 28 2009 03:27:47  60 00.64 N 174 45.98 W  105  110
160
078120  BL9      Apr 28 2009 04:58:15  60 09.90 N 174 38.32 W  101  120
140
079121  BL10     Apr 28 2009 06:21:52  60 19.16 N 174 30.48 W   96  102
280
080122  BL11     Apr 28 2009 08:06:53  60 28.47 N 174 22.67 W   90   98
241
081123  BL12     Apr 28 2009 10:16:39  60 37.55 N 174 14.34 W   85   91
73
082124  BL13     Apr 28 2009 11:29:36  60 41.60 N 174 11.00 W   83   90
385
083125  ICE3     Apr 28 2009 20:31:41  60 48.78 N 174 23.02 W   84   91
220
084126  BL14     Apr 29 2009 07:22:09  59 35.90 N 174 48.28 W   18  123
265
085127  BL15     Apr 29 2009 09:27:00  59 32.65 N 175 08.49 W   26  130
361
085128  BL15     Apr 29 2009 11:01:42  59 32.96 N 175 05.16 W   25  129
145
085129  BL15     Apr 29 2009 12:42:40  59 33.02 N 175 05.42 W   25  130
241
085130  BL15     Apr 29 2009 15:57:01  59 34.51 N 175 05.73 W   25  130
337
085131  BL15     Apr 29 2009 17:05:38  59 35.06 N 175 07.51 W   25  130
193
086132  BL16     Apr 29 2009 21:11:52  59 38.13 N 174 48.99 W  117  124
120
087133  BL17     Apr 29 2009 22:25:40  59 40.43 N 174 43.79 W  115  120
120
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088134  BL18     Apr 29 2009 23:56:39  59 45.68 N 174 27.09 W  107  112
190
089135  BL19     Apr 30 2009 00:52:10  59 48.30 N 174 18.60 W  105  109
280
090136  BL20     Apr 30 2009 07:51:26  59 31.56 N 175 07.64 W  127  130
193
090137  BL20     Apr 30 2009 09:46:59  59 32.09 N 175 07.34 W  126  130
457
090138  BL20     Apr 30 2009 10:02:08  59 32.22 N 175 07.21 W   49  130
553
090139  BL20     Apr 30 2009 14:20:38  59 32.77 N 175 08.61 W  126  130
313
090140  BL20     Apr 30 2009 15:41:30  59 32.37 N 175 07.80 W  125  130
457
091141  MN14.5   Apr 30 2009 23:39:57  59 55.24 N 176 07.21 W  132  137
3400
092142  MN-SL5   May 01 2009 16:05:04  61 33.03 N 173 39.85 W   68   73
673
092143  MN-SL5   May 02 2009 00:12:10  61 34.78 N 173 42.33 W   69   73
160
093144  BN1      May 02 2009 09:20:27  62 14.98 N 172 30.87 W   51   57
289
093145  BN1      May 02 2009 14:08:30  62 15.30 N 172 32.69 W   52   59
337
093146  BN1      May 02 2009 15:30:43  62 15.13 N 172 31.77 W   52   59
637
093147  BN1      May 03 2009 01:52:05  62 17.44 N 172 36.11 W   53   58
180
094148  SL7      May 03 2009 06:42:55  61 59.67 N 171 55.39 W   51   55
220
095149  SL8      May 03 2009 10:56:57  62 03.47 N 172 38.12 W   51   55
637
096150  SL9      May 03 2009 23:56:37  62 03.48 N 173 17.32 W   56   60
130
097151  SL10     May 04 2009 03:33:45  62 08.69 N 173 58.41 W   60   65
90
098152  SL12     May 04 2009 09:27:49  62 11.16 N 175 09.15 W   74   79
1009
098153  SL12     May 04 2009 10:14:40  62 10.99 N 175 09.04 W   74   79
169
098154  SL12     May 04 2009 14:20:21  62 10.93 N 175 07.86 W   74   79
217
098155  SL12     May 04 2009 15:34:14  62 10.79 N 175 07.02 W   74   79
289
100156  70M58    May 04 2009 22:05:01  62 11.28 N 174 44.12 W   69   73
320
101157  70M57    May 05 2009 00:06:49  62 01.71 N 174 39.86 W   71   73
210
102158  70M56    May 05 2009 01:46:29  61 56.68 N 174 21.91 W   68   73
120
103159  70M55    May 05 2009 03:17:10  61 51.81 N 174 06.72 W   68   73
420
104160  70M54    May 05 2009 05:40:26  61 43.54 N 173 51.00 W   67   73
220
105161  70M53    May 05 2009 07:47:35  61 33.54 N 173 42.45 W   69   72
265
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106162  70M52    May 05 2009 09:30:46  61 24.67 N 173 44.14 W   71   75
361
107163  70M51    May 05 2009 11:52:28  61 15.38 N 173 44.40 W   70   75
241
108164  70M50    May 05 2009 14:23:10  61 04.03 N 173 49.85 W   74   79
649
108165  70M50    May 05 2009 14:36:22  61 03.95 N 173 49.73 W   73   79
1561
109166  70M49    May 05 2009 18:37:07  60 54.49 N 173 49.15 W   76   81
1105
110167  70M48    May 05 2009 21:10:00  60 43.65 N 173 38.90 W   67   72
670
111168  70M47    May 05 2009 23:03:52  60 34.27 N 173 38.48 W   64   67
260
112169  70M46    May 06 2009 01:05:52  60 25.71 N 173 35.76 W   62   65
120
113170  70M45    May 06 2009 03:03:37  60 15.44 N 173 30.86 W   65   68
400
114171  70M44    May 06 2009 04:54:25  60 05.85 N 173 18.87 W   67   70
390
115172  BL21     May 06 2009 10:46:04  59 27.32 N 174 04.33 W   09  115
385
115173  BL21     May 06 2009 14:29:18  59 25.99 N 174 04.56 W   09  115
505
115174  BL21     May 06 2009 15:11:42  59 25.91 N 174 03.87 W   09  115
577
116175  BL15     May 06 2009 21:19:03  59 32.68 N 175 08.65 W  127  130
1000
117176  BL21     May 07 2009 02:25:51  59 26.08 N 174 04.23 W  109  115
525
118177  70M44    May 07 2009 10:42:36  60 06.17 N 173 19.89 W   67   71
337
119178  70M43    May 07 2009 12:33:11  60 02.73 N 173 00.51 W   62   67
457
120179  70M42    May 07 2009 14:47:36  59 59.14 N 172 44.50 W   63   67
409
120180  70M42    May 07 2009 15:34:42  59 59.47 N 172 44.20 W   62   67
458
120181  70M42    May 07 2009 16:27:24  59 59.79 N 172 43.47 W   62   67
505
121182  70M41    May 07 2009 18:22:36  59 54.81 N 172 26.32 W   69   72
481
122183  70M40    May 07 2009 20:23:47  59 50.23 N 172 04.48 W   70   75
300
123184  70M39    May 07 2009 21:50:39  59 50.39 N 171 51.20 W   69   72
280
124185  70M38    May 08 2009 00:05:12  59 46.49 N 171 26.85 W   67   72
140
125186  70M37    May 08 2009 01:46:29  59 42.87 N 171 08.18 W   68   70
320
126187  70M36    May 08 2009 03:25:59  59 35.65 N 170 54.79 W   67   72
910
127188  70M35    May 08 2009 05:04:30  59 26.17 N 170 53.97 W   68   72
110
128189  70M34    May 08 2009 06:28:44  59 20.08 N 170 38.71 W   66   70
320
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129190 70M33 May 08 2009 08:02:31 59 14.74 N 170 24.74 W 63 68
457
130191 70M32 May 08 2009 09:33:48 59 06.45 N 170 14.95 W 63 67
457
131192 70M31 May 08 2009 11:31:43 58 56.93 N 170 19.73 W 65 70
889
132193 70M30 May 08 2009 13:29:07 58 46.40 N 170 17.42 W 66 70
145
133194 70M29 May 08 2009 15:01:53 58 37.05 N 170 16.38 W 67 70
505
134195 70M28 May 08 2009 16:27:04 58 26.77 N 170 11.22 W 68 74
649
135196 70M27 May 08 2009 18:03:15 58 17.02 N 170 05.47 W 67 72
313
136197 70M26 May 08 2009 19:17:36 58 08.82 N 169 55.06 W 67 70
420
137198 70M25 May 08 2009 20:31:46 58 02.50 N 169 40.21 W 65 68
380
138199 70M24 May 08 2009 23:24:14 57 57.56 N 169 21.74 W 63 67
560
139200 70M23 May 09 2009 00:47:50 57 54.28 N 169 03.83 W 63 67
550
140201 70M22 May 09 2009 03:26:29 57 50.96 N 168 53.60 W 68 70
310
141202 70M21 May 09 2009 04:22:17 57 47.77 N 168 50.12 W 66 70
100
142203 70M20 May 09 2009 05:48:36 57 37.84 N 168 49.04 W 67 70
1000
143204 70M19 May 09 2009 07:03:25 57 31.33 N 168 36.34 W 67 65
450
144205 70M18 May 09 2009 08:23:03 57 31.15 N 168 18.22 W 67 71
385
145206 70M17 May 09 2009 10:20:11 57 29.99 N 167 59.38 W 66 72
505
146207 70M16 May 09 2009 12:10:11 57 30.05 N 167 39.54 W 66 71
745
147208 70M15 May 09 2009 14:04:42 57 29.87 N 167 20.89 W 67 72
409
148209 70M14 May 09 2009 15:48:10 57 31.24 N 167 01.97 W 66 70
433
149210 70M13 May 09 2009 17:01:16 57 26.10 N 166 49.22 W 65 68
529
150211 70M12 May 09 2009 18:16:45 57 26.49 N 166 31.10 W 65 68
385
151212 70M11 May 09 2009 19:33:41 57 19.74 N 166 20.28 W 64 70
740
152213 70M10 May 09 2009 21:02:03 57 19.23 N 166 00.42 W 64 67
1300
153214 70M9 May 09 2009 22:24:29 57 15.57 N 165 45.47 W 64 69
2390
154215 70M8 May 10 2009 00:24:43 57 06.53 N 165 36.73 W 65 69
600
155216 70M7 May 10 2009 02:12:57 56 59.69 N 165 22.78 W 67 70
1020
156217 70M6 May 10 2009 04:19:42 56 51.53 N 165 07.22 W 70 74
620

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157218  70M5     May 10 2009 06:03:31  56 54.55 N 164 49.58 W   68   72
700
158219  70M4     May 10 2009 07:51:57  56 50.97 N 164 30.00 W   70   74
505
159220  70M3     May 10 2009 09:01:03  56 49.75 N 164 18.91 W   68   73
193
160221  70M2     May 10 2009 11:15:33  56 50.50 N 164 04.17 W   69   73
793
161222  70M1     May 10 2009 12:39:05  56 47.16 N 163 57.48 W   69   73
2121
162223  CN3      May 10 2009 18:11:05  57 38.34 N 163 16.74 W   43   48
145
163224  CN4      May 10 2009 20:15:03  57 22.98 N 163 32.17 W   49   54
480
164225  CN5      May 10 2009 22:07:01  57 07.37 N 163 48.17 W   61   66
600
165226  CN7      May 10 2009 23:50:47  56 54.18 N 164 02.72 W   65   70
2200
166227  CN8      May 11 2009 01:55:06  56 42.31 N 164 30.74 W   70   74
600
167228  CN9      May 11 2009 03:42:34  56 33.87 N 164 54.12 W   73   77
510
168229  CN10     May 11 2009 05:46:01  56 25.48 N 165 17.74 W   80   84
620
169230  CN11     May 11 2009 07:42:35  56 16.89 N 165 41.61 W   87   92
2521
170231  CN12     May 11 2009 09:50:01  56 08.49 N 166 06.13 W   04  109
1681
171232  CN13     May 11 2009 12:11:13  55 59.49 N 166 30.70 W   23  129
673
172233  CN14     May 11 2009 13:55:39  55 51.24 N 166 53.92 W   30  136
313
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**Science Seawater Sensors**

Instrumentation

The Science Seawater system was used for the entire length of this cruise. The system was turned on after leaving Dutch Harbor on April 4, 2009 and remained on until reaching port in Dutch Harbor on May 11, 2009.

The system sensors used for this cruise consisted of:

- Seabird Thermosalinograph (TSG), model SBE-45, ser. 0215 and ser. 0228
- Seabird Oxygen sensor, model SBE-43, ser. 1333
- Seapoint Fluorometer, ser. SCF2957
- SeaMetrics flowmeter, ser. 60012089621
- Seabird Hull Temperature Sensor, model SBE-3S, ser. 4063

Data from these sensors was passed to the shipboard NOAA SCS (Scientific Computer System) where it was checked and archived. Data was also transmitted once a day to the Shipboard Automated Meteorological and Oceanographic System (SAMOS) where it is also checked and archived. http://samos.coaps.fsu.edu

Problems and/or Procedural changes
On April 12, 2009 the TSG, serial #0215, was replaced with a newly calibrated TSG, serial #0228. TSG #0215 was showing too much drift and erratic data. The reason for a sudden drift in data output is unknown. The new TSG, #0228, has been preforming well. On several occasions during the cruise ice was ingested into the science seawater system which resulted in no seawater flow until the ice could be cleared. The flowmeter data should be used as an indicator of when water was flowing through the sensors, subsequently allowing the sensors to produce valid data.
Check samples were taken daily from the TSG and run on the shipboard salinometer (Guildline Autosal 8400B).

**Meteorological Sensors**

Instrumentation
The Shipboard Meteorological sensor suite consists of numerous sensors located on the forward bow Jackstaff, above the Bridge and above the HCO (Helo control tower). The data from these sensors was also passed to the shipboard NOAA SCS (Scientific Computer System) where it was checked and archived. Data was transmitted once a day to the Shipboard Automated Meteorological and Oceanographic System (SAMOS) where it is also checked and archived. http://samos.coaps.fsu.edu
The system sensors used for this cruise consisted of:

Foward Jackstaff (Bow) sensors
- RM Young Air Temperature
- RM Young heated ultrasonic Anemometer

Bridge Sensors
- RM Young Air Temperature
- RM Young heated ultrasonic Anemometer
- RM Young Humidity
- RM Young Barometric pressure

HCO Sensors
- Paroscientific MET-3A (Air T, Baro, Humidity)
- RM Young heated ultrasonic Anemometer
- RM Young Precipitation
- Biospherical QSR-2200, Surface PAR
- Eppley PIR (LWR)
- Eppley PSP (SWR)

| Primary Instrument Metadata | | Vessel Name | | | USCGC HEALY – NEPP (WAGB20) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Logging System Name* | | NOAA – SCS | | | | | | *System Version* | | | 4.2.0 | | | |
| **Wind direction convention (to/from)** | | From | | **Anemometer zero-line reference (deg)** | | | | zero | | | **Pressure adjusted to sea level (yes/no)** | | NO | |
| **Parameter** | ***Designator for SAMOS*** | ***Instrument*** | | | **Distance (nearest 0.1 m)** | | | | ***Data Averaging*** | | | | | |
| | | **Location** | **Make and Model** | **Units** | **From bow** | **-P/S from center line** | **Height /depth** | **Measured/ Calculated** | **Spot vs. Avg. Value** | **Value Time Center** | **Length (sec)** | **Sampling rate (Hz)** | **Data precision (decimal)** | **Calibration date** |
| **Time** | YMD:HMS | | | | | | | | | | | | | **(YYMMDD)** |
| **Latitude** | LA | | Applanix MV4 | Deg | 34.3 | 0 | -.8 | Measured | Avg. | end | 60 | 1 | 5 | N/A |
| **Longitude** | LO | | Applanix MV4 | Deg | 34.3 | 0 | -.8 | Measured | Avg | end | 60 | 1 | 5 | N/A |
| **Course over ground** | CR | | Applanix MV4 | Deg | 34.3 | 0 | -.8 | Measured | Avg | end | 60 | 1 | 1 | N/A |
| **Heading** | GY | | Sperry | Deg | 33.3 | 0 | 18.8 | Measured | Avg | end | 60 | .5 | 3 | N/A |
| **POS-MV Heading** | SH | | Applanix MV4 | Deg | 34.3 | 0 | -.8 | Measured | Avg | end | 60 | 1 | 1 | N/A |
| **Speed over ground** | SP | | Applanix MV4 | KTS | 34.3 | 0 | -.8 | Measured | Avg | end | 60 | 1 | 1 | N/A |
| **Water Spd Fore - Aft** | SL | | Sperry | KTS | 50.8 | 0.8 | -10 | Measured | Avg | end | 60 | 2 | 2 | |
| **Water Spd Port - Stbd** | SX | | Sperry | KTS | 50.8 | 0.8 | -10 | Measured | Avg | end | 60 | 2 | 2 | |
| **Depth to Surface** | BT | | Seabeam 2112 | Meters | 46.2 | 0.8 | -10 | Measured | Avg | end | 60 | variable | | |
| **Pitch** | VP | | Applanix MV4 | Deg | 34.3 | 0 | -.8 | Measured | Avg | end | 60 | 1 | | |
| **Roll** | VR | | Applanix MV4 | Deg | 34.3 | 0 | -.8 | Measured | Avg | end | 60 | 1 | | |
| **Heave** | VH | | Applanix MV4 | Deg | 34.3 | 0 | -.8 | Measured | Avg | end | 60 | 1 | | |
| **Wind – relative dir** | WD | Yard arm Port | RM Young 0901 | Deg | 40.9 | -5.0 | 30.9 | Measured | Avg | end | 60 | 1 | 0 | 070307 |
| **Wind – relative dir** | WD1 | Yard arm Stbd | RM Young 0901 | Deg | 40.9 | 5.0 | 30.9 | Measured | Avg | end | 60 | 1 | 0 | 070206 |
| **Wind – relative dir** | WD2 | Bow Mast | RM Young 85004 | Deg | 0 | 0 | 25.5 | Measured | Avg | end | 60 | 1 | 0 | 081210 |
| **Wind – relative dir** | WD3 | Yard arm Stbd | RM Young 85004 | Deg | 40.9 | 3.5 | 30.9 | Measured | Avg | end | 60 | 1 | 0 | 081210 |
| **Wind – relative dir** | WD4 | Aft HCO | RM Young 85004 | Deg | 93.0 | 3.0 | 24.5 | Measured | Avg | end | 60 | 1 | 0 | 081210 |
| **Wind – true dir** | TI | Yard arm Port | RM Young 0901 | Deg | 40.9 | -5.0 | 30.9 | Calculated | Avg | end | 60 | 1 | 0 | 070307 |
| **Wind – true dir** | TI1 | Yard arm Stbd | RM Young 0901 | Deg | 40.9 | 5.0 | 30.9 | Calculated | Avg | end | 60 | 1 | 0 | 070206 |
| **Wind – true dir** | TI2 | Bow Mast | RM Young 85004 | Deg | 0 | 0 | 25.5 | Calculated | Avg | end | 60 | 1 | 0 | 081210 |

| Primary Instrument Metadata | | Vessel Name | | | USCGC HEALY – NEPP (WAGB20) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Logging System Name* | | NOAA – SCS | | | | | | *System Version* | | | 4.2.0 | | | |
| **Wind direction convention (to/from)** | | From | | **Anemometer zero-line reference (deg)** | | | | | zero | | **Pressure adjusted to sea level (yes/no)** | | NO | |
| | *Designator* | *Instrument* | | | **Distance (nearest 0.1 m)** | | | | *Data Averaging* | | | | | |
| **Parameter** | *for SAMOS* | **Location** | **Make and Model** | **Units** | **From bow** | **-P/S from center line** | **Height /depth** | **Measured/ Calculated** | **Spot vs. Avg. Value** | **Value Time Center** | **Length (sec)** | **Sampling rate (Hz)** | **Data precision (decimal)** | **Calibration date** |
| **Time** | YMD:HMS | | | | | | | | | | | | | **(YYMMDD)** |
| **Wind – true dir** | TI3 | Yard arm Stbd | RM Young 85004 | Deg | 40.9 | 3.5 | 30.9 | Calculated | Avg | end | 60 | 1 | 0 | 081210 |
| **Wind – true dir** | TI4 | Aft HCO | RM Young 85004 | Deg | 93.0 | 3.0 | 24.5 | Calculated | Avg | end | 60 | 1 | 0 | 081210 |
| **Wind – relative speed** | WS | Yard arm Port | RM Young 0901 | Knots | 40.9 | -5.0 | 30.9 | Measured | Avg | end | 60 | 1 | 0 | 070307 |
| **Wind – relative speed** | WS1 | Yard arm Stbd | RM Young 0901 | Knots | 40.9 | 5.0 | 30.9 | Measured | Avg | end | 60 | 1 | 0 | 070206 |
| **Wind – relative speed** | WS2 | Bow Mast | RM Young 85004 | M/S | 0 | 0 | 25.5 | Measured | Avg | end | 60 | 1 | 0 | 081210 |
| **Wind – relative speed** | WS3 | Yard arm Stbd | RM Young 85004 | M/S | 40.9 | 3.5 | 30.9 | Measured | Avg | end | 60 | 1 | 0 | 081210 |
| **Wind – relative speed** | WS4 | Aft HCO | RM Young 85004 | M/S | 93.0 | 3.0 | 24.5 | Measured | Avg | end | 60 | 1 | 0 | 081210 |
| **Wind – true speed** | TS | Yard arm Port | RM Young 0901 | Knots | 40.9 | -5.0 | 30.9 | Calculated | Avg | end | 60 | 1 | 0 | 070307 |
| **Wind – true speed** | TS1 | Yard arm Stbd | RM Young 0901 | Knots | 40.9 | 5.0 | 30.9 | Calculated | Avg | end | 60 | 1 | 0 | 070206 |
| **Wind – true speed** | TS2 | Bow Mast | RM Young 85004 | M/S | 0 | 0 | 25.5 | Calculated | Avg | end | 60 | 1 | 0 | 081210 |
| **Wind – true speed** | TS3 | Yard arm Stbd | RM Young 85004 | M/S | 40.9 | 3.5 | 30.9 | Calculated | Avg | end | 60 | 1 | 0 | 081210 |
| **Wind – true speed** | TS4 | Aft HCO | RM Young 85004 | M/S | 93.0 | 3.0 | 24.5 | Calculated | Avg | end | 60 | 1 | 0 | 081210 |
| **Air temperature** | AT | Bow Mast | RM Young 41342LC | Deg C. | 0 | 0 | 25.5 | Measured | Avg | end | 60 | .33 | 2 | 081223 |
| **Air temperature** | AT1 | Bridge Stbd | RM Young 41382VC | Deg C. | 34.8 | 12.5 | 21.7 | Measured | Avg | end | 60 | .33 | 2 | 081223 |
| **Air Temperature** | AT2 | Aft HCO | Paroscientific MET3A | Deg C. | 93.0 | 3.0 | 24.5 | Measured | Avg | end | 60 | 1 | 2 | 081223 |
| **Barometric pressure** | BP | Bridge Stbd | RM Young 61201 | mbars | 34.8 | 12.5 | 21.7 | Measured | Avg | end | 60 | .33 | 2 | 081223 |
| **Barometric pressure** | BP1 | Aft HCO | Paroscientific MET3A | mbars | 93.0 | 3.0 | 24.5 | Measured | Avg | end | 60 | .33 | 2 | 081223 |
| **Relative humidity** | RH | Bridge Stbd | RM Young 41382VC | % | 34.8 | 12.5 | 21.7 | Measured | Avg | end | 60 | .33 | 0 | 081223 |
| **Relative humidity** | RH1 | Aft HCO | Paroscientific MET3A | % | 93.0 | 3.0 | 24.5 | Measured | Avg | end | 60 | 1 | 2 | 081223 |
| **Precipitation** | PR | Aft HCO | RM Young 50202 | mm | 93.0 | 3.0 | 24.5 | Measured | Avg | end | 60 | 1 | 2 | 090110 |
| **Longwave radiation** | LW | Aft HCO | Eppley Labs PIR | W/M^2 | 90.2 | 1 | 24.8 | Measured | Spot | end | 60 | 1 | 2 | 081113 |
| **Longwave radiation** | LD | Aft HCO | Eppley Labs PIR | Deg K | 90.2 | 1 | 24.8 | Measured | Spot | end | 60 | 1 | 2 | 081113 |

| Primary Instrument Metadata | | Vessel Name | | | USCGC HEALY – NEPP (WAGB20) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Logging System Name* | | NOAA – SCS | | | | | | *System Version* | | | 4.2.0 | | | |
| **Wind direction convention (to/from)** | | From | | **Anemometer zero-line reference (deg)** | | | | zero | | | **Pressure adjusted to sea level (yes/no)** | | NO | |
| **Parameter** | ***Designator for SAMOS*** | ***Instrument*** | | | **Distance (nearest 0.1 m)** | | | | ***Data Averaging*** | | | | | |
| | | **Location** | **Make and Model** | **Units** | **From bow** | **-P/S from center line** | **Height /depth** | **Measured/ Calculated** | **Spot vs. Avg. Value** | **Value Time Center** | **Length (sec)** | **Sampling rate (Hz)** | **Data precision (decimal)** | **Calibration date** |
| **Time** | YMD:HMS | | | | | | | | | | | | | **(YYMMDD)** |
| **Longwave radiation** | LB | Aft HCO | Eppley Labs PIR | Deg K | 90.2 | 1 | 24.8 | Measured | Spot | end | 60 | 1 | 2 | 081113 |
| **Photosynthetically Active Radiation** | PA | Aft HCO | Biospherical QSR-2200 | uE/sec/M^2 | 90.2 | 1 | 24.8 | Measured | Spot | end | 60 | 1 | 4 | 081210 |
| **Shortwave radiation** | SW | Aft HCO | Eppley Labs PSP | W/M^2 | 90.2 | -1.5 | 24.8 | Measured | Spot | end | 60 | 1 | 2 | 081113 |
| **Salinity** | SA | Bio-Chem Lab | Seabird SBE45 | PSU | 85.6 | -12.5 | -8.1 | Measured | Avg | end | 60 | .17 | 3 | 090123 |
| **Conductivity** | TC | Bio-Chem Lab | Seabird SBE45 | mS/cm | 85.6 | -12.5 | -8.1 | Measured | Avg | end | 60 | .17 | 3 | 090123 |
| **TSG Temperature** | TT | Bio-Chem Lab | Seabird SBE45 | Deg C | 85.6 | -12.5 | -8.1 | Measured | Avg | end | 60 | .17 | 3 | 090123 |
| **Sea Surface Temp** | ST | Engine Room bilge | Seabird SBE3S | Deg C | 85.6 | -12.5 | -8.1 | Measured | Avg | end | 60 | .17 | 3 | 081213 |
| **Fluorometer** | FL | Bio-Chem Lab | Seapoint SCF | ug/l | 85.6 | -12.5 | -8.1 | Measured | Avg | end | 60 | .17 | 3 | 071215 |
| **Oxygen** | OX | Bio-Chem Lab | Seabird SBE43 | Ml/l | 85.6 | -12.5 | -8.1 | Measured | Avg | end | 60 | 1 | 3 | 090122 |
| **TSG flowmeter** | FI | Bio-Chem Lab | Flocat C-ES45 | L/min. | 85.6 | -12.5 | -8.1 | Measured | Avg | end | 60 | 1 | 2 | 080107 |

## A Summary of the LDEO Science Support Activities on HLY0902

Steve Roberts (UCAR) and Chip Maxwell (UMiami)
Prepared by Steve Roberts

This is a brief summary of the performance of the Underway Science systems during the research cruise HLY0902 on the USCGC Healy, 04/01/09 – 05/12/09 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 HLY0902 has additional information.

**Acoustic Data**

**SeaBeam 2112 Multibeam Sonar**

The SeaBeam worked well for this leg. Frequent CTD's allowed us to keep the sound velocity profile valid. However, much of the cruise was in shallow water (less than 100 meters deep) and in ice. 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.

During the transit from Seattle and early into the HLY0901 science leg, the Bridge VMS experienced several lengthy episodes when the NMEA time message used by the Seabeam for it's timing became delayed. When this happens the multibeam data becomes corrupted and can note be corrected. In light of the increased instability of the VMS spent a far amount of time implementing an alternate source for the NMEA message input from the POS/MV during the previous science leg and into the beginning of this science leg.

**Knudsen 320BR Sub-Bottom Profiler**

The Knudsen was run in the Low Frequency "CHIRP" (3 - 6 KHz) mode for most of the cruise. The Knudsen was run in pinger mode on several occasions to support deep multi-cores. These data look good. However the heave correction input does not appear to be working as well as it should be and needs to be looked into.

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.

**ADCP 75**

The ADCP 75 was operated for the whole leg. During the cruise VMDAS was upgraded from 1.44 to 1.46.

**ADCP150**

The ADCP 150 was operated for the whole leg. On several occasions both the short term and long term averages stopped updating for unknown reasons. RDI was contacted and they recommended upgrading our version of VMDAS. So Chip upgraded VMDAS from version 1.45 to 1.46. However problem still occurred after this upgrade so debugging is still required.

**Navigation**
**POS/MV-320**
The POSMV recorded the ship's position, heading, pitch and roll with no know issues during the cruise. It was noted that DGPS was utilized by the POS/MV for only a portion of the cruise.

**Ashtech ADU5**
The ADU5 operated well except for the occasional events where the receiver stopped producing heading and attitude data even though the data streams remained active and requires a reset. Be sure to check the ELOG entries if you are using this data.

**Sperry Gyro Compasses**
Two new Sperry Gyroscopes were added to the Healy in 2007 to replace the old Sperry MK27s. 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. It should be noted that there was a marked improvement with the MK39 compared to last year even with the speed input from the Doppler speed log turned off.

**Sea Water Flow Through data**
**Uncontaminated Sea Water**
Tests were conducted during the prior cruise (HLY0901) while in heavy ice to better understand the behavior system in terms of water flow and ice ingestion. The evidence seemed to indicate that the system can only support a low volume of flow to the TSG in the biochem lab. Otherwise ice will begin to get past the ice separator. Near the start of this cruise when the ship was already in the ice several incubators were hooked up to the science seawater system and started drawing large amounts of water via the port and starboard manifolds on the bow. The system immediately began ingesting ice and eventually water stopped flowing to the biochem lab to the tsg. Even though the outside air temperature was above freezing even the hoses supplying the incubators eventually clogged with ice. So the scientist switched over to using the forward ballast as the source of water for their incubators and the science seawater system was used to fill this tank only when the ship was stopped. Various schemes were tried to maximize the flow of water to the tank. Part way into the cruise to save time and not sit in one spot for several hours while filling the tank we would instead allow the ship to continue transiting but shut down the flow to the tsg to prevent ice from clogging that section of the system

Observations of the system pumps indicate that if ss3 is operated at about 10% or less of ss2 which translates into about 22 gpm then no ice will get past the ice separator. Typical setting used while in the ice were:

ss2:55%
ss3 45-47%

It appears that changing the pumping volume of ss4 which drains the sea chest did not have much of a noticeable effect on the effectiveness of ice removal. If higher settings for ss2 are used then a corresponding increase in ss3 is required to prevent ice from getting into the science sea water.

See ELOG for more information.

**Thermosalinographs**

The TSGs in the Biochem Lab appeared to have failed sometime during the cruises so data during this time is probably unusable. Scott Hiller swapped it with a replacement unit. Also please see the issues with the uncontaminated sea water system above. Be sure to look in the ELOG for timing of these problems and outages.

**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. Please see the issues with the uncontaminated sea water system above since these instruments are impacted by the lack of water flow due to ice blockages

**Meteorological Sensors**

Three Ultrasonic wind sensors were operated in addition to the ship's 2 existing sensors. These sensors operated satisfactorily for the leg. Care should be taken when using the HCO shack and Bow Jackstaff data since these data seem to be affected by the ship's deck house and the wind direction.

**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. Included in this activity was the monitoring, downloading and processing of near real-time MODIS chlorophyll imagery and SAR imagery from NIC. Made major enhancement of Bering Sea bathymetry using historical Healy multibeam data.

**Gravity**

The Two Bell BGM-3 marine gravity meters in IC/Gyro were monitored. Both instruments experienced gyro motor failures during the cruise at separate times. The instruments were restored to operational mode after replacing the defective motors Care should be taken when using this data. Installed a web camera in ICGyro to allow better monitoring of instruments.

**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 USB disk containing all the underway data along with various documentation was 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. Also used this laptop to reprocess imagery to generate a Quicktime movie of the Bering Sea region for use by the scientists. Since we were operating in the Fairbanks, Alaska station range circle all DMSP data was collected in unencrypted mode. There have been periods when data quality became highly degraded .Attempts to debug this yielded no obvious causes.

**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 on shore. Added gps postion to the EXIF image tags at the request of shore-side users.

## Appendix I: Science Seawater Ballast Reservoir System Instructions

LTJG Bryson Jacobs with C. Ashjian and S. Roberts

### INTRODUCTION

In conditions of heavy icebreaking that inhibit the use of the Science Seawater System for high-demand equipment, such as water baths and incubators on the weather decks, the Forepeak Ballast Tank (3-E-0-W) can be used as a reservoir for near-ambient temperature seawater. Directions for installing the water-delivery apparatus are available as Appendix A.[1] In ideal conditions the apparatus can be constructed in one working day. However, manning constraints, poor weather, and conflicting operations caused construction to stretch to four days during AWS09.

Planning and open communication with the science community, namely the Chief Scientist and the Science Technician(s), are crucial for smooth operation of this less-than-perfect system. The limitations of both the installed SSW system and the Forepeak Reservoir system must be understood to prevent friction between the two communities. Remember, we are all here to complete scientific experiments to the best of our ability!

### EVALUATING THE NEED

Past experience has proven that when faced with heavy ice conditions, HEALY's installed SSW system cannot extricate ice fragments quickly enough to provide liquid water to aft water monitoring devices AND equipment demanding high flow rates while the ship is making way. The high flow demand causes the fragments to congest the pipes, essentially clogging the whole system. Warm temperatures early in the AWS09 second cruise precluded freezing of water in input hoses, thus clearly identifying ice ingested into the seawater system through the science seawater intake as the cause of clogging on the bow. If high-flow devices such as incubators are deemed critical to the science mission, currently the only recourse is to use the Forepeak Reservoir system as long as prolonged icebreaking is taking place.

However the use of the Forepeak Reservoir appears to be limited to cold weather use. Under conditions where the external air temperatures approach or exceed the freezing point combined with plenty of sunlight will result in the inability of keeping the reservoir water at the required minimum temperature. Such conditions were encountered during the latter part of the AWS0902 cruise (late April-early May). At this time there appears to be no solution to meeting the needs of the scientist in conditions of heavy ice but mild weather conditions.

[1] One recommended change to these is to relocate Flange 2 to the port side of the Foc'sle and draw SSW from the port-side fitting to be discharged to the tank through Cover 2 on the port side of the Fwd Deck Machinery space.

## INSTALLATION

The directions within Appendix A should be used as the primary guidelines, but are not infallible- plenty of room exists for further ingenuity and modifications. Two to three people, typically a junior officer, an Auxiliary MK, and an EM are required to: 1) meet with the chief scientist to discuss science needs and the capabilities/limitations of HEALY's systems; 2) construct all required piping, hoses, and deck fittings; and 3) ensure pump is electrically wired and connected to the power grid. Once installed, an OPTEST should be done to ensure the pump energizes and provides flow to both standpipes.

## OPERATION

The operation of the system underwent much iteration during AWS09 to maximize efficiency and preserve near-ambient temperatures (the Number One concern for successful experiments). The following are the constraints encountered and/or imposed for safe and effective operation:

1) The submerged well pump provides 14 to 16 gallons per minute (900 GPH) to the standpipes.
2) The SSW system can be throttled by manipulating the SSW Pumps and the valve in the Foc'sle vestibule to provide a maximum flow of 130 GPM (7,800 GPH) to fill the Forepeak tank.
3) The Forepeak tank low suction level for the pump is assumed to be 15,000 gallons as indicated by the electronic TLI on MPCMS.
4) The maximum fill level for AWS09 was limited to no more than 50,000 gallons to preserve acceptable trim and stability for the ship. This level is specific to loading conditions and could be raised depending on the amount of fuel and ballast water being stored onboard.
5) Once started, the pump should continue running to prevent seizure and also the formation of ice in the standpipes.
6) Upon the conclusion of a fill cycle, the 2.5" fire hose on the weather deck shall be drained of all water by disconnecting it at both fittings and forcing the water out to prevent ice clogs.
7) The maximum allowable temperature deviation of the reservoir water from the ambient seawater should be 1°C, or whatever is deemed acceptable by the Chief Scientist.
8) Changes in the flow volume and pressure of science sea water resulting from the adjustments to pumps and from the diversion of a large volume to the forward ballast tank during filling can significantly impact the underway science seawater sensor system, presently located in the biochem lab. Coordination with science support personnel prior to filling also is necessary to maintain the quality of the underway sensor data.

Since high flow cannot occur when HEALY is making way in ice, the best time to fill the Forepeak reservoir is during long science stations and on-ice deployments. When filled to 50,000 gallons, the tank typically lasts 36 hours until the low level is met. Some data suggest that 30,000 gallons may be an appropriate volume since heating inside the tank is minimized due to the shorter residence time (~15 hours) (see SBI reports). Coordination by the Chief Scientist for at least one longer science station per day should be more than adequate to ensure the tank level remains within its acceptable range. The most effective SSW pump configuration to rapidly fill the tank found during AWS09 was as follows:

1) SSW Pump 3 set to speed "1."
2) SSW Pump 2 throttled to provide 60 psi of system pressure (typically between speeds "75" to "84")
3) SSW Pump 4 set to speed "25."

Once the tank is filled to the desired level, the configuration should be brought back to a more-standard setting with the fill valve in the Foc'sle vestibule closed. Observations seem to indicate that keeping the difference in speed between pumps 2 & 3 at about 10 or less will result in little or no ice getting into the SSW system while underway in heavy ice conditions. This translates into a maximum SSW flow of about 20 gpm. Typical pump settings that were used successfully are 55% for pump 2 and 45% for pump 3. The effectiveness of pump 4 at various settings was not apparent so a value of 25% was typically used

A procedure was developed to monitor ballast water volume and temperature and to coordinate filling steps between engineering, science, and science support.

1) Engineering contacts science point persons, who for AWS09 were the chief scientists, when ballast tank water volume nears 15,000 gallons during drawdown. Alternatively, science point person contacts main control periodically to monitor volume of water in ballast tank (both occurred during AWS09). This permits the science point person to coordinate filling time with on-station periods
2) Science point person contacts science support personnel to a) notify them that the ballast water tanks will be filled and b) to alert them that they will shortly need to go adjust pumps in main control.
3) Science point person, or representative, opens science seawater valve on foc'sle and starts filling process.
4) Science support personnel makes recommendations to the engineering watch to adjusts science seawater system pumps to increase volume flow to the bow.
5) Science support personnel monitor underway science seawater sensors and system to maintain appropriate volume flow through sensors.
6) Engineering notifies science point person when desired ballast tank volume has been achieved.

7) Science support personnel coordinate with the engineering watch to turn down science seawater pumps. Science point person or designated representative turns off science seawater at bow and drains fire hose (as above).

## CONCLUSION

The heuristic approach to this system evolved continuously to attain an acceptable balance of temperature preservation, tank level management, and science station scheduling. If the HEALY science party continues to conduct experiments requiring high flow of the SSW system, permanent engineering changes may need to be made to optimize the Forepeak Reservoir system. These will include installing insulated pipes from the tank to the standpipes and extra piping of the SSW system to allow the Forepeak Tank to be filled without the need for fire hoses. Another option to explore may be the use of a closed-loop system in which a cooling medium is circulated from a tank, through a heat pump, to the incubators, and back to the tank. This would prevent the need for frequent and lengthy science stations to refill the tank.

Appendix A.

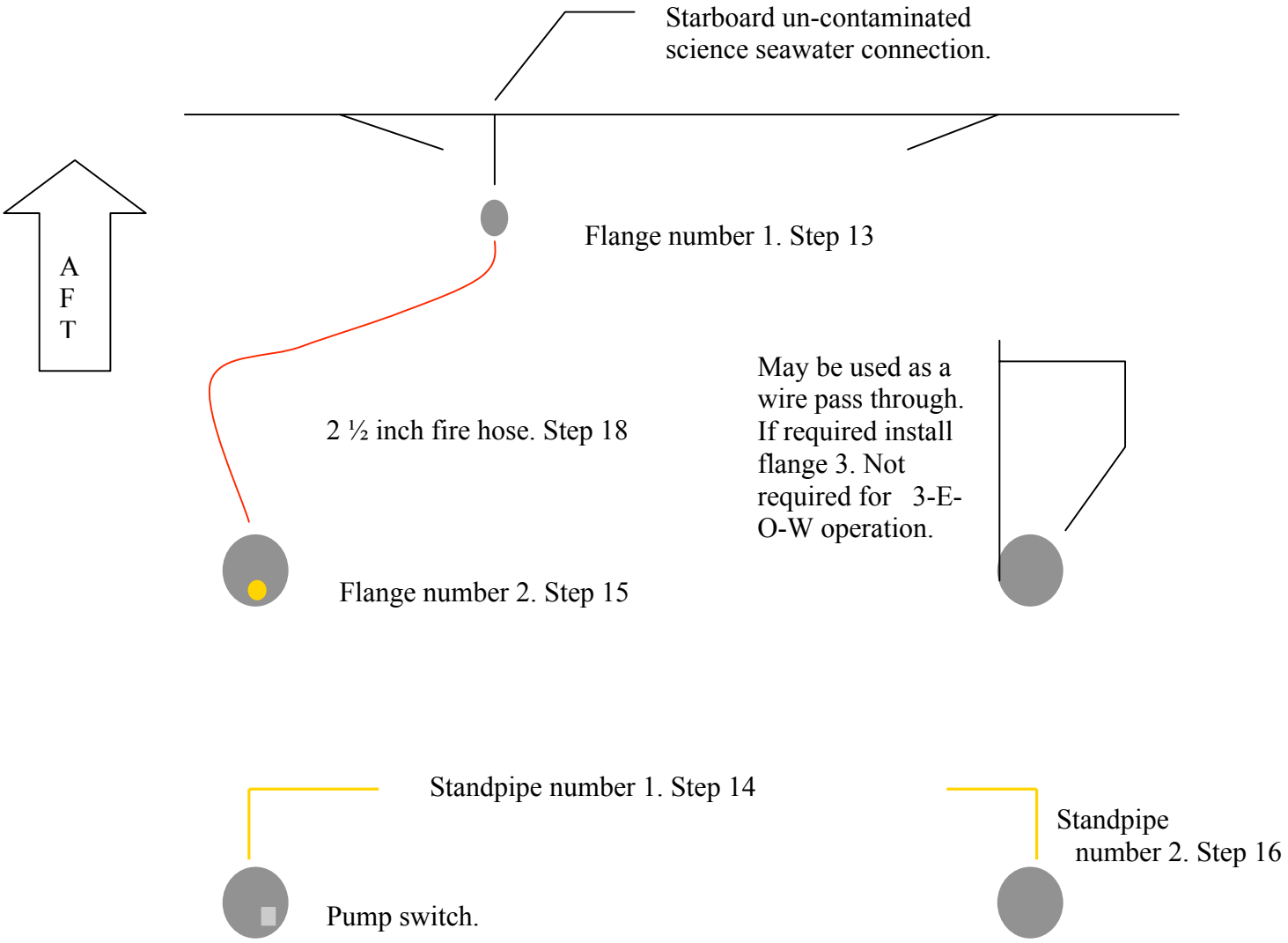
Installing the sump pump in the 3-E-O-W ballast tank can provide ambient water to the foc'sle incubator experiments. These experiments where completed during AWS-02. A complete over view of the first system using AOP's can be found as appendix E to the AWS-02 cruise report. The improved system as described hear was installed and used during AWS-04 with no problems. This can be beneficial when Science Sea Water is freezing up in the piping. All required equipment is located in Cargo 1 in a foot locker port side in the overhead.

Required items:

| **Sump pump** | **Pump controller** | **Transformer** |
|---|---|---|
| **2 each stand pipes** | **2 each flanges** | **2 each special covers** |
| **Assorted clamps and brackets** | 2 each 1 ½ inch fire hose | 2 each 2 ½ inch fire hose |

Bold-faced items are located in this box along with all mounting hardware.

Figure 1. Simple line drawing of required items on the foc'sle.




Required on foc'sle:
Flange number 1
Flange number 2
2 ½ inch fire hose
Standpipe number 1
Standpipe number 2

## Appendix 2. Science Party Members

| Name | Institution | Email |
|---|---|---|
| Carin Ashjian | Woods Hole Oceanographic Institution | cashjian@whoi.edu |
| Philip Alatalo | Woods Hole Oceanographic Institution | alatalo@whoi.edu |
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## Appendix III. Ship's Crew and TAD

Adams, Ivan ET3
Alley, Tysin FS3
Angelo, James YNC
Appleberry, Jason LT
Ayers, Silas LT
Baldwin, Robin FS3
Bateman, Dale CDR
Beasley, Corey HSCS
Beebe, Brandon FN
Beringer, Mike ETC
Braddock, Amelia SN
Brogan, John MKC
Brown, Betty MK3
Buford, Aimee BM2
Chaidez Marshall MST3
Coates, Brittney FN
Cooler, Jessica SA
Coombe, Jeffrey MK2
Dabe, Jeffre IT1
Davis, Jonathon ET2
Dolton, Peter ENS
Dowd, Robert SN
Dull, Steven FS2
Dunning, Lara BM2
Fernandez, Chelsey SN
Ford, Angela SN
Galvez, Oscar LT
Glenzer, William BM1
Gray, Deidre SN
Gregg, Tony ENS
Griffin, Bobby SK2
Hamilton, H. Mark FS3
Harbinsky, Mark ET2
Harris, Daniel SK1
Hassilev, Dave
Howard, Daniel DC3
Huneycutt, Gaines BM1
Hurtado, Daniell EM1
Imgarten, Christopher DC1
Irwin, Paul EM2
Jacobs, Bryson LTJG
Jones, Greg MKCS
Kidd, Wayne BMC
Kimmel, Patrick BM3
Kriekel, Lindsey BM3
Kruger, Thomas MST2
Ladd, Donald EM2
Leisure, Jeremy KS3
Lambert, Douglas MKC
Layman, Rich MST1
Liebrecht, Brian ET1
Lyons, Sean CWO3
Manangen, Sorjen OSC
Marsden, George DCC
McNally, Terence SK1
Mendoza, Raymond MS1
Merten, James BM3
Miller, Valerie CWO2
Miozzi, Michael FN
Murphy, Nicholas MK1
Murray, Justin SN
Myatt, Lisa ENS
Olson, James EM3
O'Sullivan, Brandon MK2
Passalacqua, Joseph ETCM
Petrusa, Douglas LCDR
Podhora, Curtis EMCM
Powell, Greory ET3
Qichocho, Robert MK1
Redd, Davion DC2
Rieg, Mark MSTC
Rodermund, Michael SA
Rose, John CWO
Roy, Evan BM3
Rudibaugh, Kenneth MK1
Schendorf, Tara ENS
Shaffer, Hans EM1
Smith, Corey MK2
Sommer, Frederick CAPT
Sterling, Wendy MK2
Stein, Kelsey FN
Stewart, Jeffrey CDR
Swanson, Shawn ET1
Thomas, Tasha LTJG
Von Kauffmann, Daniel ET1
Whiting, Allan MK1
Williams, Tony FSCS
Wilson, Thomas BMCM
Yeckley, Andy BM2
Zitting, Arrene FS1

**Appendix IV. Operations Plan**

# USCGC Healy HLY0902 Operations Plan
# April 3 – May 12 2009

Carin Ashjian, Chief Scientist
Evelyn Lessard, Co-Chief Scientist

## General

**Mid-Rats:** A large number of the science party will require mid-rats. We anticipate that 14 people will be permanently on either the midnight-noon-midnight watches or ~7PM to ~7AM watch and will require mid-rats daily. Seven (7) people will have no watch schedule and will work whenever required. Twenty-one (21) people will be primarily working during the day but may also occasionally work at night. (42 total)

## Types of Stations and Activities at Each:

Note, the following is an estimate of the activities at each station type. The actual planned activities may deviate from this estimate. In addition, if the deployment fails (e.g., multicore gets no mud), additional deployments may be necessary.

### 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 at 30 m/min wire speed and a Calvet Net tow from the 3/8" wire off of the stern to 10 m off of the bottom 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.

List of Activities at Regular Short Station (not in order):
CTD Cast – Hydro Group
VPR Cast – Ashjian/Alatalo
Calvet Net Tow - Pinchuk
(CTD cast for Prod water; ~every other day and only 1/day)

### 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 at 10 m/min wire speed. Ashjian PI.

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 using towed bongo nets (TBONGO) from the 3/8" wire off of the stern to collect krill at night. The ship should be moving gently forward (~1 knot) during this tow. Lessard/Harvey PI.

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 (3-4) from starboard A-Frame– Hydro Team
- VPR cast (1) from stern A-frame, 3/8" wire – Ashjian/Alatalo
- Plankton ring net tows (2-3) from stern A-frame, 3/8" wire –Ashjian/Iken
- Vertical Bongo Net Tows (1-2), 3/8" wire, same time period as plankton ring net tows –Ashjian
- Calvet net tow (1) from the stern A-frame, 3/8" wire –Pinchuk
- Towed Bongo Net tows (2-3), 3/8" wire, at night – Lessard/Harvey
- Multinet or MOCNESS net tow (1) from stern A-frame, 0.68" conducting, when ice permits – Pinchuk
- Van Veen grabs from the stern A-frame, 3/8" wire – Iken team
- Multicore (2) from stern A-frame, 9/16" wire – Devol/Shull

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

- On-ice sampling and deployment of shallow sub-ice sediment traps (see below for description of on-ice operations)
- Deployment of deep sediment traps anchored to ice edge (Moran/Kelly; see below)
- ROV surveys under ice deployed from ice-Shull
- If necessary, small boat work to access ice- Iken/Kelly

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

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

At 5-6 Open Water Stations:

- Van Veen Grab sampling from stern A-frame, 3/8" wire, 3 replicates – Iken 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 in (1).

Vertical ring net tows (VNET) are conducted as described above in (2).

Towed Bongo Nets (TBONGO) are conducted as described above in (3).

Vertical Bongo Tows (VBONGO) are conducted 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 at 60 m/min wire speed.

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 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 from the PI groups of Iken et al., Devol/Shull, Lessard/Harvey, Sambrotto, Moran/Kelly, Linder, and Hydro will be deployed onto the ice with equipment to begin the ice work (see more complete description below). The Kelly et al. team will deploy deep sediment traps from the ship to be anchored to the ice edge when the water is sufficiently deep (>200m). The scientists will remain on the ice for up to 6 hours; during the first half of the cruise, a smaller team (Iken and Sambrotto groups) will need to return to the ice ~6-8 hours after the deployment of sediment traps hanging below the ice surface and to terminate under-ice incubations of water. 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. 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). A CTD cast likely will be conducted at the end of the ice station. When possible, sampling from the ship will be conducted concurrently with the ice station work. No benthic work can be done while the sediment traps are deployed.

**5) Short station plus short ice station (when in ice)**

Short ice stations will be conducted on the days between long ice stations. These stations will be similar to the long ice stations except that no sediment traps or under-ice incubations will be done.

**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.

Iken: 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 Iken 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 and a small table near the front of the bridge on the port side on which to install her laptop (T. Thomas says that a suitable table is present in the met lab and was used for this purpose during the summer cruise). Iken et al. requires access to a science data network computer and a surface on which to install their laptop (the map table towards the rear of the bridge on the port side worked well last year).

**3) Open-Water Deep Sediment Trap Deployment (Moran/Kelly)**

**Operational Plan**

**Number of sediment trap stations**
We anticipate at least 5 deep sediment trap stations as part of the BEST spring cruise. Deep traps consist of a trap line (3/8" dia. spectra single braid, 2 ¼" wide swivels) 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 18-24 hours.

**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.
(a) Load 100 ft leader and 110 m trap line on winch or capstan. Leader will be connected to the trap line with a spring link clip (carabiner).
(b) A snatch block will be secured on deck in-line with A-frame block (capstan only).
(c) The trap line will be passed through the A-frame block.
(d) Ballast, sub-surface, surface and spar buoys will be placed on fantail where they can be accessed.

*On station* – The Healy's bow should be directed into the wind/current/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 lbs) will be secured to the bottom eye of the 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.

(3) Sediment trap deployment
(a) Using the winch/capstan to control payout and A-frame to control the position of the line, the trap ballast will be lifted and passed over the transom life lines. If sea conditions require, a tagline may be used to stabilize the load.
(b) The ballast will be lowered to the first trap stop and the A-frame will be brought in-board. The first crosspiece will be attached to the line and the first set of tubes inserted into the crosspiece, then the A-frame will be put out-board, and the traps lowered into the water. The traps will be attached in this manner until all 5 stops are completed.
(c) Following the last set of traps, 2 sets of sub-surface buoy strings will be attached to the downline.
(d) After the shock cord and back-up trap line pass through the A-frame block and the trap top eye is at working height (a few feet above the deck), it will be necessary to remove all lifelines. The array will then be secured to the vessel with a tagline and lowered to the deck. This tagline will be secured to the deck via an eyebolt, pass through the tag eye of the downline, and be secured to a deck cleat.
(e) The surface buoy string will be attached to the trap top eye with a shackle.
(f) The leader from the winch/capstan will be fitted with a quick-release (supplied by the ship?), which will then be attached to the bridle of the spar buoy.

(4) Sediment trap release

(a) 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.
(b) The buoy string will be lowered over the transom while the spar is lifted by the A-frame and transferred overboard.
(c) The tagline to the top-eye will be paid-out simultaneously as (b).
(d) Once the spar is lowered to the water and the buoys are determined not to be fouled, the tagline will be pulled through the eye.
(e) When the tag line is clear of the eye, the quick release will be triggered, allowing the traps to drift freely.

(5) Sediment Trap Tracking

The position (lat and long) of the sediment trap will be determined from the ARGOS transmitter on the spar buoy. The positions will be relayed every 2-4 hours via email (the frequency may be limited by the ships email transfer rate?). This proved very robust in the summer 2008 deployments, though fog and swell did limit transmissions from the buoy at times. 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. After sighting the traps, they will be recovered using a small-boat assist.

*Small-boat Assist*

a) The deck will be prepared by flaking (faking) out the entire 100ft leader onto the deck and passing the working end through the appropriate blocks. The working end will have a clip on it. The eye and block for securing the taglines will also be in place on the deck.
b) The Healy will determine the direction the traps are drifting (note this will be dependent on the current, not the wind), and launch a small boat according to the conditions.
c) The small boat will motor to the traps, and disconnect the first buoy from the rest of the buoy line when the Healy is nearly in position (step d). The spar and two surface buoys will be left to drift until the traps are on deck.
d) During step (c), the Healy will move it's stern to within 100 ft of the sediment traps. With bridge permission, the leader will be passed to the small boat using a heaving line. The small boat will then tow the leader to the first buoy and clip it in.
e) The winch/capstan will slowly haul in the traps. The small boat will tend the free-floating spar and prepare to recover any man-overboard.
f) The lifelines will then be lowered, and the traps will be hauled up to the deck using the winch/capstan, and then secured through the top-eye using a tagline. The leader will then be removed from the first buoy, and clipped to the top eye.
f) The first buoy will be removed from the down line and cleared from the deck.
g) The traps will be recovered using the reverse of the deployment procedure until the ballast is brought on deck (steps 3 a-d).

h) The small boat will disconnect the second and third buoys from the spar and take them aboard (if room allows). The small boat brings the spar near the transom of the Healy.
i) Once the traps are completely on deck, the ballast is removed from the end of the trap line, and a clip placed in the bottom eye.
j) The clip is then passed to the small boat using a heaving line, and connected to the bridle of the spar. The spar is then lifted out of the water using the winch/capstan and placed on deck using the A-frame.
k) Healy recovers the small boat with second and third buoys aboard.

**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.

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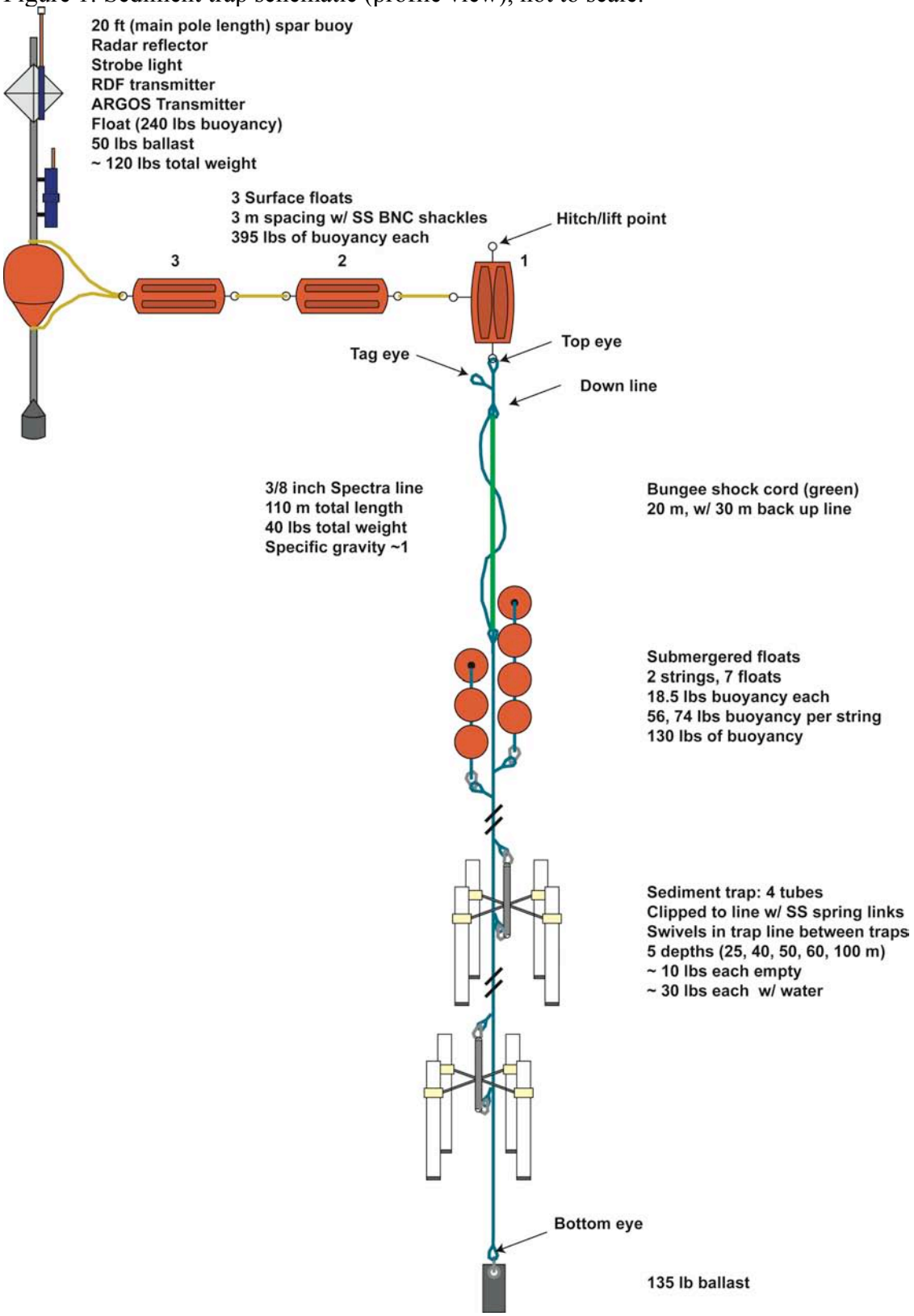
Figure 1: Sediment trap schematic (profile view), not to scale.



## 4) Ice Station Detailed Operational Plan

**Teams Working on the Ice**
Iken (3-4 people)
Moran/Kelly (1-2 people, only for Moran/Kelly sediment trap deployments, see below)
Shull (2 people)
Hydro (2 people)
Lessard/Harvey (1-2 people)
Linder (2 people, usually in conjunction with one of the teams and in close coordination with all)
Sambrotto (2 people)

**Number of off-ship ice coring sorties (ice stations)**
"Long Ice Stations" (6-8 hours) will be conduced every other day, depending on ice conditions (snow and ice thickness, dimensions of the ice floe, weather) and progress of work. 'Short Ice Stations" (2-3 hours) will be conducted on days alternating with long ice stations, again dependent on the above conditions. When possible, stations can be conducted *in parallel* to the water column sampling activities when ice conditions and ship position permit. Benthic sampling must occur after ice station sampling has concluded.

**Number of Moran/Kelly Trap Deployments in Conjunction with On-Ice Deployments**
We anticipate at least 5 deep sediment trap stations as part of HLY-09-02 (not to be confused with the Gradinger ice sediment trap). Stations will be limited to shelf-slope locations with water depths greater than 200 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.

**Planning Meeting**
A planning meeting will be held early in the cruise, before reaching ice, to review the order of operations at the ice station and the locations of each groups' sampling. All teams will be expected to attend.

**Operational procedure of typical ice station – On-Ice:**

(1) Notification and Selection of ice floe to be sampled

K. Iken will be notified 40 min prior to arrival at selected position. Iken together with ship officers and bosun will select a suitable ice floe for the sea ice research. Shull, Sambrotto, Hydro/PMEL, and Lessard/Harvey teams will sample ice floes selected by Iken.

P. Kelly notified 40 min. prior to arrival at ice station where he will deploy sediment traps (see below).

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

(2) Safety briefing

Prior to be EACH deployment on ice a safety briefing will be held for final approval by the ship's command. At deep stations, this will include discussions of the deployment of the deep sediment traps (Moran/Kelly – see below). A polar bear watch will be identified by the CG. All members of all science teams will attend.

(3) Foredeck set-up
Prior to deploying the brow, appropriate measures (e.g., hose bridge) shall be taken to insure the safety of the hoses and wires servicing the water baths on the bow.

(4) Transfer of equipment and personnel

- *Personnel:*
Iken 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).
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 Iken's time on the ice (Lessard/Harvey will join the Iken 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).
Linder Team: 1-2 people, in conjunction with one of the teams
Moran/Kelly – see below

- *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. If possible, some equipment should be lowered to the ice rather than being slid down the brow, since the surface of the brow is eroding the integrity of the surface of the equipment (e.g., sleds).

Iken Team:
- 1 ice auger (4 ft long, 20 lbs),
- 1 electric generator (3x2x2 ft, 50 lbs)
- 1 sled with: 1 action packer containing biological sampling and measuring devices, (ca 15 lbs), 1 action packer with coring equipment (ca. 20 lbs)
- 1 sled with : 3 coolers (4x2x3 ft, 70 lbs full), 1 sample box (2x2x2 ft, 30 lbs full)
- 1 sled with: 2 sediment traps with floatation and mounting equipment and weights (4x3x2 ft, 30lbs), 1 ice corer (4 ft long, 30 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 50 lbs.)
-1 ice corer (about 20 lbs.)
- 2 sleds

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), lowered onto ice rather than slid down the ramp

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.)

Linder Team: Cameras (hand carry)

Moran/Kelly – see below

(5) Work on ice

Iken Team:
The progression of a typical ice station is as follows:
a) select final sampling location on ice
b) drill holes with auger: one for CTD and water sampler, one hole for video camera, one for primary production experiment, four in a row for sediment trap deployment
b) take six ice cores (one for total length, temperature along total length, and complete sectioning; five cores as replicates for bottom slices for biological and physical measurements on board)
c) deploy primary productivity incubation (for four hours)

d) deploy sediment traps (about 20 m 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; sediment trap needs to be deployed for about 5 h.
e) collect water and ice samples
f) make snow measurement transect (50x50 m around the sampling area)
g) take ice cores for other working groups interested in ice samples

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 5 h incubation time return to site 1 and recover primary productivity incubation and sediment traps (ca. 20 min on ice) – return to ship.

Shull Team:
a) select final sampling location on ice based on Iken's assessment
b) create opening for ROV with ice drill
c) calibrate microelectrode probe with water from station
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).
f) if feasible, collect two ice cores and sample for chlorophyll and ice algae identification
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
i. drill a large hole ( 3 together) then lower a SeaCat through the hole to ~20m depth

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 Iken, 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 Iken.

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

Linder Team: Photography and documentation. Assist PI teams with sampling described above.

Moran/Kelly – see below

(6) Additional requests for support from ship

(a) Equipment

Iken:
- 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, 2005 and 2008.
Shull: Request the use of a Healy sled for moving equipment on the ice (if available).
PMEL Team: as per Iken. PMEL group has own hand-held radio.
Lessard/Harvey: Same equipment as Iken.
Sambrotto: radio communication (hand-helds) for communication with ship (1 radio on the ice).

(b) Polar bear watch
We 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.

**5) Operational procedure for Moran/Kelly sediment trap deployment at ice stations (Moran/Kelly)**

**Number of off-ship shallow sediment trap sorties (ice stations)**
We anticipate at least 5 shallow ice-bound sediment trap stations as part of HLY-09-02 to be sampled in conjunction with K. Iken and R. Gradinger. Stations will be limited to

shelf locations with water depths in the range of 30 – 200m, and deployments will last approximately 6 hours.

(1) Selection of ice floe to be sampled
We ask that R. Kelly be notified 40 min prior to arrival at selected position. Ice suitable for R. Gradinger/ K. Iken will be suitable for this research as well.

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

(3) Personnel and Equipment transfer
4-6 people will be transferred to the ice deploy the sediment traps (this includes 3-4 participants from K. Iken's group, and 1-2 participants from the Moran group). Trap configuration will vary depending on water depth. At shallow stations (13-80 m depth), several trap lines with 2 -3 traps apiece will be deployed. At deeper stations (80 – 200 m depth), a single trap line with as many as 5 traps may be deployed. Equipment transferred will include trap tubes (1 tote), trap line, brackets, and ballast (2-3 totes), and crossbars to support the traps. In addition, a gas-powered ice-auger provided by K. Iken will be used to create holes large enough to deploy the traps

(4) Sediment trap deployment/recovery
At the start of each station, shallow sediment traps will be deployed through the ice by hand. Holes will be augered through the ice ~50m from other ice-science activities to avoid contamination. Briefly, ballast will be lowered until the trap stop is reached, two tubes will be loaded onto the trap brackets, and the traps will be lowered until the next bracket is reached. After the final tubes are installed, the top eye of the trap line will be secured to the ice crossbar to stop the traps from sinking. The traps will remain in the water for 6 hours, and then be recovered by the reverse of the deployment procedure.

(5) Personnel and Equipment transfer
After trap deployment, the ice personnel will then be returned to the Healy when all other ice work is completed. After a period of approximately 6 hours from deployment, they will return to the ice to recover the sediment traps. At this time, the gear will also be returned to the ship.

**Additional requests for support from ship**
**(1) Small Boat Use**
In the event of major ice floe breakup, it may be necessary to use a small boat to recover the sediment traps.

**(2) 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.

Please note, that this description does not include additional ice research being proposed by other research teams.

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## 6) Other Operational Considerations

A) Moorings:

We will be working near four NOAA moorings. The positions are listed below. There are additional moorings within 1 nm of NOAA mooring M2 so we should maintain an ~2 nm minimum distance from M2.

NOAA Mooring Positions:
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

We also will be working near the Weingartner moorings deployed last summer in July by Healy. We will sample along the "W" line. The positions of the moorings are listed below. Weingartner would like us to sample 1 mile from the moorings.

Weingartner Mooring Positions:

| Mooring | Longitude (W) | Latitude (N) | Depth (m) |
|---|---|---|---|
| N55 | 171 58.488 | 61 57.717 | 54.4 |
| N40 | 169 16.722 | 61 48.328 | 40.3 |
| N25 | 167 27.112 | 61 42.006 | 25.6 |
| C55 | 170 5.367 | 60 10.316 | 54.91 |
| C40 | 169 1.266 | 60 20.204 | 40.5 |
| C25 | 167 20.257 | 60 40.959 | 24.9 |
| S55 | 168 23.646 | 58 35.378 | 55.3 |
| S40 | 167 58.94 | 59 8.175 | 42 |
| S25 | 167 46.885 | 59 51.088 | 26.2 |

B) Communication with local communities

We will communicate the ship's position, planned positions for the 2-3 days, and scientific and meteorological observations to Gambell and Savoonga on St. Lawrence Island nightly (and potentially other local communities). Ashjian will take the lead on this but needs input from OPS in the form of a map of the ship's location that includes SLI and projected area of operations for the next few days (same as for 2008). The transfer of the map should occur by e-mail but we may have to resort to usb-net. The purpose of this communication is to minimize any potential disturbance by the ship to local community subsistence hunting.

C) Polar Discovery and Polartrec Communication Needs:

Both Linder and Welch will be conducting teleconferences during the cruise. Linder will need to make 8-10 conference phone calls of 20-45 minute duration. Welch will need to conduct a 1 hour conference phone call and up to 10 10-minute calls. Either the Iridium or the Inmarsat should do as long as the phone connection remains intact (last year we had a terrible time using the Iridium phone for the PolarTrec hour long call).