Cruise Report

Bering Ecosystem Study/Bering Sea Integrated Ecosystem Research Program

R/V Thomas G. Thompson TN250

June 16 – July 13, 2010

Prepared by David Shull, Chief Scientist, and the scientists of TN250

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

Note: All data and summaries in this report are preliminary unpublished data subject to revision or correction with intellectual property reserved to the scientist contributing to the report.

Overview

The overall objective of TN250 was to examine organic matter production and fate during the time-period following the spring bloom in the Bering Sea and their relationship to lower trophic levels and benthos. Eleven research groups were supported on TN250 and 34 science members participated including a marine science technician intern and a free-lance writer. The objectives of the individual projects included: the survey of hydrographic conditions; assessment of primary productivity via ^{14}C, ^{13}C, and ^{15}N incubations; quantification of carbon flux via ^{234}Th and sediment traps; determination of a water-column nitrogen budget; assessment of food sources and fates via stable isotope analysis; examination of the distribution, energetics, and grazing rates of micro-, meso- and macrozooplankton including fish larvae; assessment of the effects of benthic macrofauna on nutrient cycling; observation of seabirds in relation to Bering Sea hydrography. Data management was carried out by John Wasinger of UCAR. The basic cruise plan included a large scale survey using CTD and plankton nets along nine mostly east-west transects and one north-south transect along the 70-m isobath and daily productivity stations, where more detailed sampling occurred. The mission began at 2300 on June 16, 2010 and we returned to port at 1600 on July 13, 2010.

The cruise began by sampling along the UAP (upper Alaskan Peninsula) transect (Fig. 1). We then zig-zagged north along the Bering Shelf toward St. Lawrence Island. After the UAP, we completed the CN, CNN, NP, SB, P14N, W, and MN lines. After MN, we completed a new transect, ML, which connected the western end of the MN with the eastern end of the SL transect. After completing the SL transect, we sampled a new transect, BN, which took us north of the SL line into a region influenced by the Saint Lawrence Island polynya. We then sampled the 70-m line from north to south and four stations within Unimak Pass before returning to port. Sediment traps were deployed near the western ends of the CN, NP, P14N, and MN lines at water depths of approximately 200 m. These were recovered after deployment times of roughly 16 to 24 hours. By the end of the cruise we had sampled 209 stations; all but three included a CTD cast. Station water depths ranged from 18 m to 3460 m. During the cruise, we conducted underway sampling of the surface water for temperature, salinity, and fluorescence, water

velocity, and seafloor topography from Multibeam and underway observations of marine mammal and bird distributions. We maintained three additional underway sampling sensors; a flow cytometer, a pCO_2 sampler, and an ISUS nitrate sensor.

A gale with 35-kt winds forced us to cancel some activities such as MOCNESS and multicore for approximately three days. However, we sampled continually for the most part. We dropped off one member of the science party as we passed by St. Paul Island on 25 June. As we were finishing the 70-m line, a Thomas G Thompson crew member learned of a family emergency and requested to depart the ship in Dutch Harbor. The only flight available within a reasonable time frame was on the evening of 13 July; we were scheduled to return in the morning of 14 July. After obtaining permission from NSF, we returned to port approximately 14 hours ahead of schedule so that the crew member could fly home. This decision did not negatively impact the scientific mission because we had already completed all of the objectives outlined in the cruise plan, we had experienced no major delays during the cruise, and we had started the mission eight hours earlier than specified in the cruise plan (2300 16 June instead of 0700 17 June). Returning to port early also gave us more time in Dutch Harbor to offload gear prior to the R/V Thompson's transit back to Seattle.

John Wasinger from EOL maintained the Mapserver and Field Catalog. The Field catalog includes the event log, CTD data, station sheets, and plots of underway data. The Mapserver was useful for cruise planning as it enabled one to examine relationships between satellite data and the cruise track and it also allowed the scientists to keep track of the ship on and between stations.

We had on board four laboratory vans and three storage vans. The storage vans enabled us to keep all of the cargo for both BEST cruises (TN249 and TN250) on board rather than storing cargo or empty shipping crates in Dutch Harbor. Two of the laboratory vans were supplied by the University of Washington and two were part of the UNOLS van pool, with one of the latter two being the OPP Arctic General Purpose Van. The laboratory vans included a radiation van for C-14 work, a stable isotope van used for C-13 and N-15 inoculations, a general purpose van that we are used for chlorophyll measurements, and a cold van for sediment flux experiments. We also had four water baths on deck plumbed with ambient seawater and furnished with electricity.

One persistent problem during the previous cruise was leaky 30-L water bottles. The 30-L General Oceanics bottles that were purchased for this cruise leaked badly during the previous cruise, TN249. We fixed the leaks before the start of TN250 by increasing the spring tension. However, this made the bottles difficult to cock and damaged the o-ring seals. Midway through the cruise the bottles began leaking again and we discovered some chips in the bottles. We replaced the leaking bottles with older spare 30-L bottles that we had on board. This reduced the problems with leaks. Bottles were nevertheless checked for leaks immediately when the CTD and carousel were retrieved. Badly leaking bottles were not sampled to guarantee the integrity of all bottle data collected on this cruise.

More details about day-to-day activities that occurred during the cruise can be found in the Chief Scientist's web log at http://bsierp.nprb.org/fieldwork/2010/thompson02.html.

Acknowledgements

This project was done with financial and logistical support from the National Science Foundation and the North Pacific Research Board. The hard work and enthusiasm of the Captain and crew of the R/V Thomas G. Thompson made this work possible and enjoyable. They helped us to repair equipment that had been damaged during a gale and provided consistent support for our work. Our marine technicians, Jim Lovin and Ken Feldman, were exceptional. Jim had never been on the Thompson before and Ken had sailed on her just once. Nevertheless, they rapidly familiarized themselves with shipboard operations and were able to help us to conduct our work smoothly and safely. In addition to running deck operations, Jim maintained and, when necessary, repaired the CTD and MOCNESS. His expertise with cable terminations was particularly valuable. Ken also worked on deck and was responsible for maintaining underway data acquisition, networking and computer systems. Marine technician intern Russel Rejda and new marine technician Kasey Canfield were dedicated assistants to our lead marine techs. Overall the crew of the R/V Thompson and our marine technicians helped to set a friendly, cooperative tone that made our time at sea productive and pleasurable.

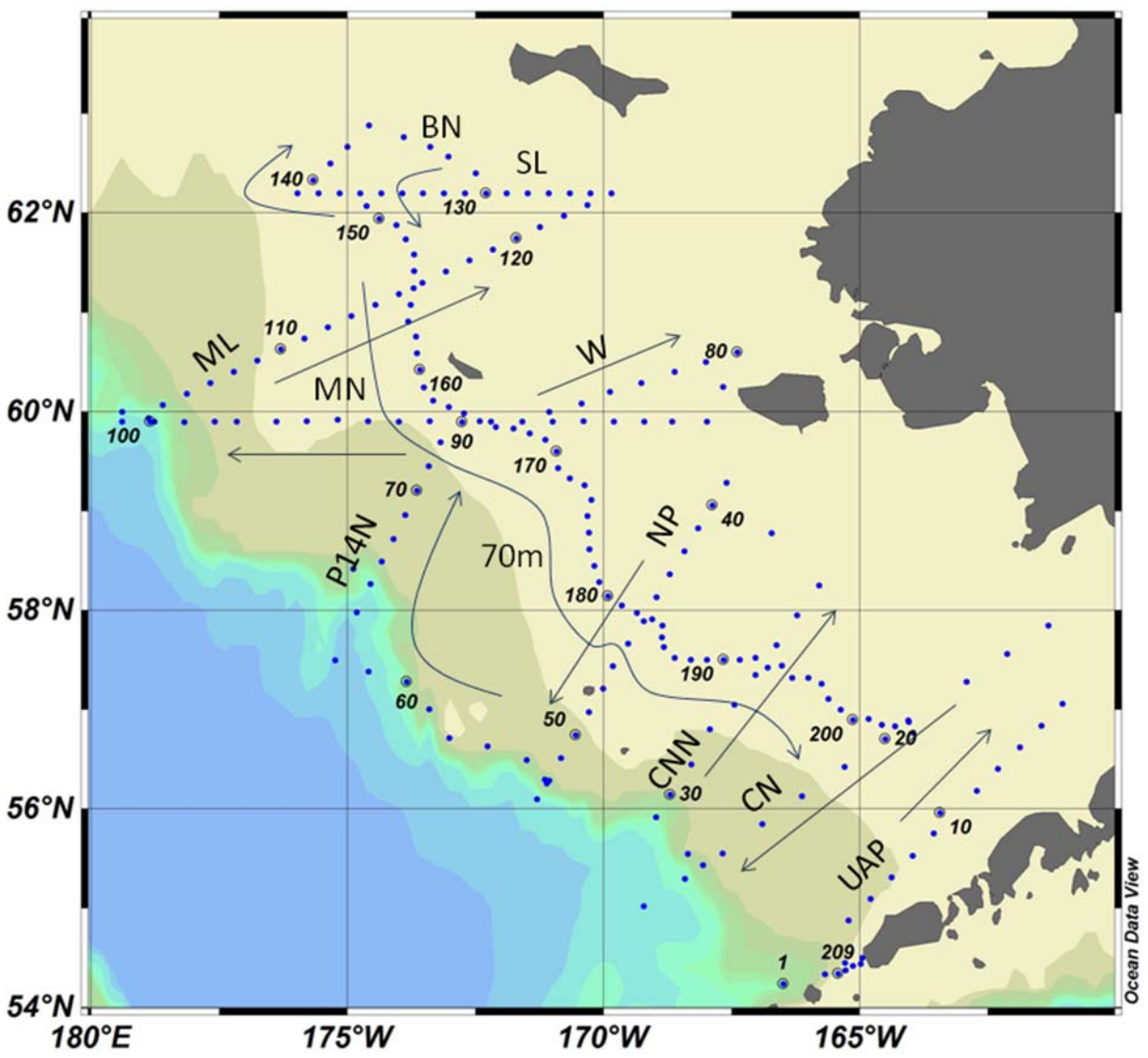


Figure 1. Cruise track and sampling locations. Nine cross-shelf transects (UAP, CN,CNN, NP, P14, MN, ML and SL) are noted as well as the SB and BN sampling lines and the 70 m isobath line (70m). The first and last stations are labeled along with every tenth station. Arrows indicate the direction of travel.

INDIVIDUAL PROJECT REPORTS

Note that tables and figures are numbered sequentially within each project but not within the document.

A Service Proposal to Examine Impacts of Sea-ice on The Hydrographic Structure and Nutrients Over the Eastern Bering Sea Shelf

PIs: Terry Whitledge (UAF), Rolf Sonnerup (UW), Phyllis Stabeno (NOAA)

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), Dean Stockwell (UAF), Rolf Sonnerup (UW)
On-board team members: Nancy Kachel[1], David Kachel[2], Dean Stockwell[3], Fred Menzia[2], Eric Wisegarver[2], Jessica Cross[3]

[1]University of Washington Joint Institute for the Study of Atmospheres and Oceans
[2]NOAA/Pacific Marine Environmental Laboratory
[3]University of Alaska, Fairbanks

The BEST Hydrographic Group conducted CTD casts and hydrographic sampling, coordinated the water collection activities of the other PI groups, and maintained and took calibration samples for several underway sampling systems attached to the ship's flow-through seawater system.

1. CTD Measurements and Sampling

The hydrographic group completed 242 CTD casts at 206 oceanographic stations. The CTD was a Sea Bird Electronics SBE 911 plus with dual temperature and conductivity sensors. It carried dual SBE 43 oxygen sensors, a Chelsea/SeaTech/WetLabs CStar optical transmissometer, a WetLabs ECO-AFL/FL fluorometer, a Biospherical/LICOR PAR sensor and a Benthos 916 altimeter. Standard CTD casts included nutrient samples from up to 12 thirty-liter Niskin bottles, one or more Winkler oxygen samples for calibration of the oxygen sensors, three or more ^{18}O samples on major transects for Tom Weingartner of the University of Alaska Fairbanks (UAF), and three to ten Total Alkalinity/Dissolved Inorganic Carbon (TA/DIC) and Dissolved Organic Carbon (DOC) samples. Total chlorophyll samples were taken from bottles at the surface, 10m, 20m, 30m, 40m and 50m. At approximately one-third of the stations samples were taken out of the same Niskin bottles for fractionated analysis. Extra nutrient samples were analyzed from bottles used for biological experiments at the request of scientists on the cruise. At

deep stations, samples for Winkler oxygen, DIC/Alkalinity, and nutrient analyses were taken at each depth sampled below 100m. Table 1 summarizes the sampling. Fred Menzia titrated the oxygen samples using the Winkler method. Eric Wisegarver analyzed nutrient samples.

Table 1. Sampling by Hydrographic Group

Hydrographic Stations	206
CTD casts	242
Nutrient Samples Analyzed	~1900
Winkler Oxygen Samples	235
DOC Samples	~150
TA/DIC Samples	300
Total Chlorophyll Samples	1600
Fractionated Chlorophyll Samples	550
Salinity Samples	112
Underway Samples	
Nutrient Samples	40
Total Chlorophyll Samples	40
Salinity Samples	40

a. Total and Fractionated Chlorophyll

We collected samples from 6 depths at each station, filtered them through GFF filters and froze them at –80°C for analysis ashore. At approximately one-third of the stations, another set of samples of the same volume was collected from the same Niskins. These were filtered through 5-µm membrane filters, then the GFF filters. Both fractions were then frozen at –80°C for chlorophyll analysis ashore after the cruise.

b. 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 analysis protocols for the WOCE hydrographic program as set forth in the manual by L.I. Gordon, et al. (2000). Approximately 1900 samples from CTD casts were analyzed for phosphate (PO_4^-), nitrate (NO_3^-), nitrite (NO_2^-), orthosilicic acid (H_4SiO_4), and ammonium (NH_4^+).

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 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. The overall precision of the analysis was within 1% of full range.

c. 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 100m. On the shelf, samples were usually collected in the upper layer or in the bottom mixed layer. End point determinations of the Winkler titration were determined poteniometrically. Thiosulfate was standardized for each batch of sample titrations, and blanks were measured periodically during the cruise.

d. 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^3 of headspace 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.

2. Underway Seawater System

The ship's underway seawater flow-through analysis system collects temperature, salinity, and fluorescence through a typical TSG system. Calibration samples were taken 1-2 times daily from the flow-through seawater line and analyzed for chlorophyll concentration and salinity. Ned Cokelet from PMEL 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). This system gives one new nitrate value every five minutes based on spectrophotometric analysis. Calibrations were periodically performed by sampling the underway seawater line to analyze nitrate.

For Both TN249 and TN250 members of Richard Feely's research team from NOAA/PMEL installed a GO 8050 Underway pCO2 system that collects real time pCO2 measurements from seawater and air. This system was periodically calibrated by the measurement of gas standards. In addition, Ginger Armbrust's technicians from University of Washington installed a SeaFlow flow-cytometer in the underway seawater system, hopefully to become a permanent installation on the Thompson. In concept, the SeaFlow system will provide oceanographers with a real-time display of the evolution of phytoplankton populations. This evolution occurs both over time, as most phytoplankton exhibit a diurnal cycle, and space due to either ship movement or water currents. Future development of the SeaFlow processing code will include automated population tracking and a real-time display of concentration.

Jessica Cross, a UAF graduate student and member of the Hydro Team, tended all four of the underway installations throughout the cruise, completing daily and advanced maintenance, as well as collecting calibration samples as needed.

To our knowledge, continuous flow-through pCO2 data has never been collected on the Bering shelf, and these cruises provide an opportunity to establish baseline measurements over a broad area of this shelf. By taking continuous surface samples, transitions between areas differing in productivity or phytoplankton species composition can all be mapped. Furthermore,

development of a permanent flow-through installation on the R/V Thompson provides a unique opportunity in data collection and management for the University of Washington and the BEST program.

3. Problems

The new 30-liter Niskin bottles presented scientific challenges throughout the entire cruise. David Shull and the marine technicians worked on them in Dutch Harbor, tightening the springs. Initially, they worked pretty well, but as time went recurrent leaks led to the tension being repeatedly increased, and the O-rings replaced. Sometimes they leaked as they were pulled out of the water and sometimes they leaked only after cracking the pressure valve, meaning they were not gas-tight. By July1, the increased tension was causing cracking and chipping around of the lower rims of the bottles themselves. The technique devised to protect the bottles during the process of cocking the bottles proved to be extremely arduous, such that two of the strongest members of the science party were needed to cock the bottom of each bottle. After one of the springs broke we realized that our technique posed risks for injury. At that same time we experienced failure of the Niskins to close when fired, which was diagnosed as a consequence of the excess tension on the lanyards. Therefore, we replaced the new General Oceanic bottles with nine older Niskins that had been refurbished and brought as spares. They worked much better.

In addition to the problems with bottles, at various times the CTD was reterminated, a vent was unclogged, both pumps replaced, and the electronic cable to the pumps replaced.
Also, stations on the southern half of the middle shelf experienced problems due to jellyfish, which would obstruct the sensors, especially on the upcast.

Note that with the sensor intake approximately 1.5m below the center of the Niskins, comparison of water properties measured from the bottles with electonic data will be less precise than usual for variables like chlorophyll, which often occurred in narrow bands in the vertical.

The quality of the electronic data from the sensors on the CTD package configured with those 30L Niskins could be seen to be affected by their presence of the larger than usual bottles. Performing quality control on this data set probably will take more time than usual. We will compare the data collected with that on the NOAAShip Oscar Dyson from the middle shelf in July to assist our effort to quality control the final data set.

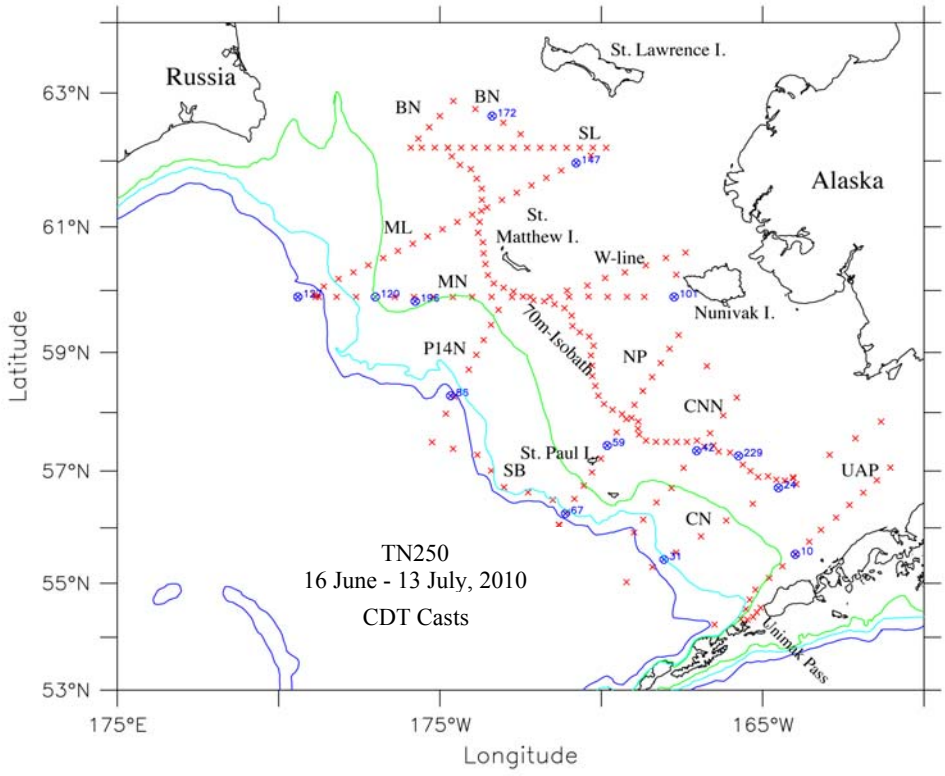


Figure 1. Locations of CTD casts on TN250. Full production casts are shown in blue.

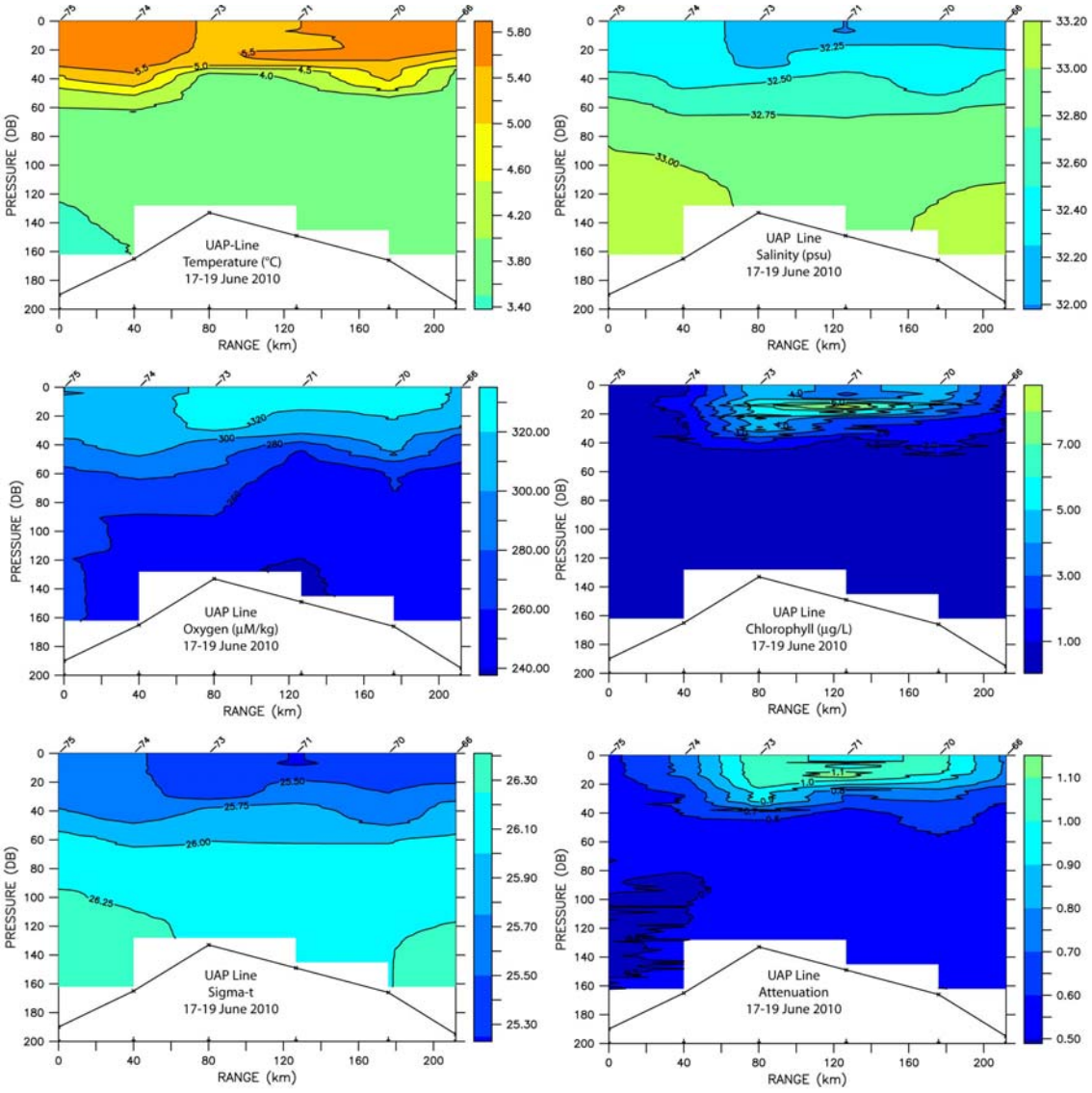


Figure 2. Water temperature, salinity, oxygen concentration, chlorophyll, sigma-t and light attenuation along the UAP transect from Unimak Pass toward Bristol Bay near the Alaska Peninsula. These measurements are preliminary and may change after further analysis.

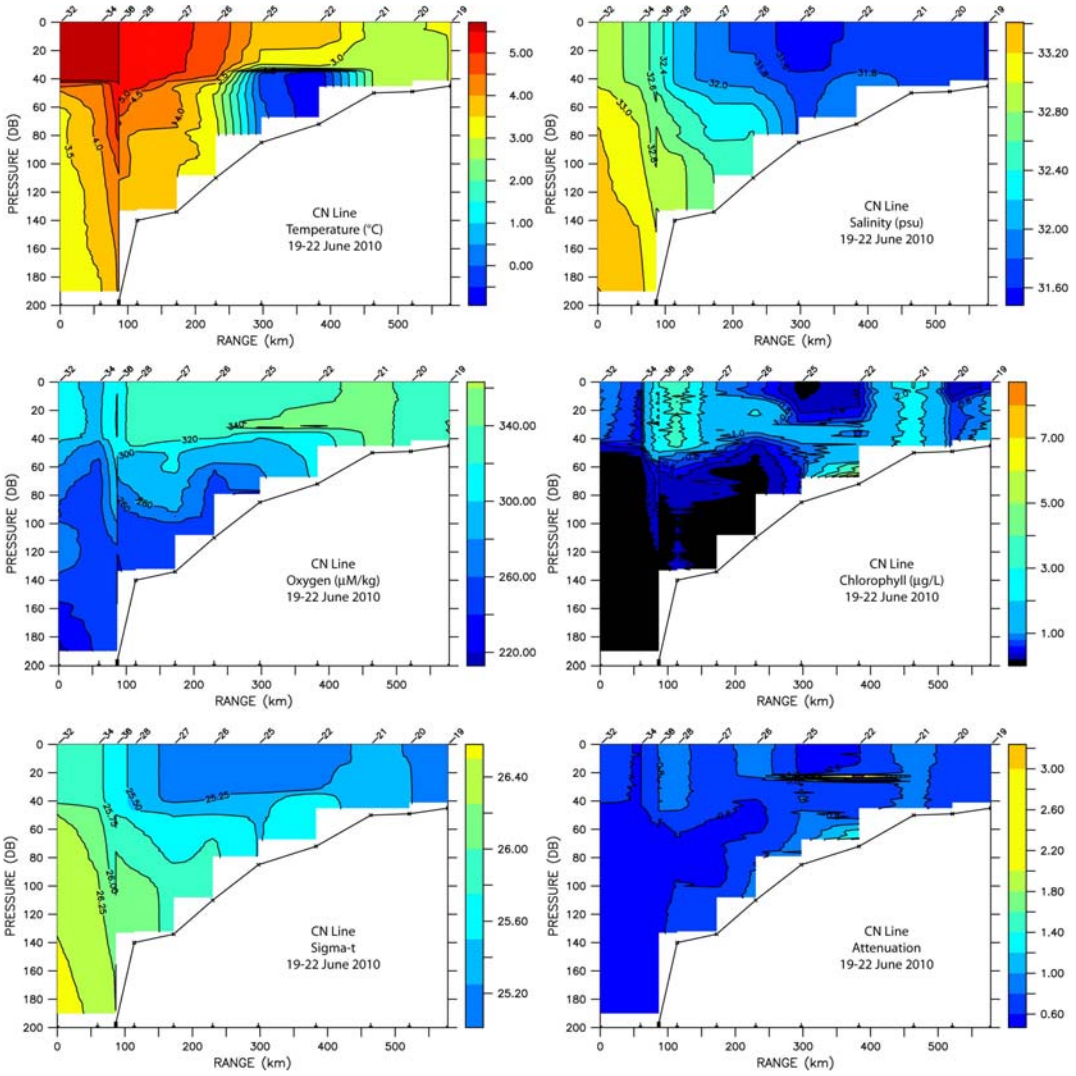


Figure 3. Water temperature, salinity, oxygen concentration, chlorophyll, sigma-t and light attenuation along the CN (Cape Newenham) transect. This line is approximately at the location of the historical PROBES/SEBSCC transect. These measurements are preliminary and may change after further analysis.

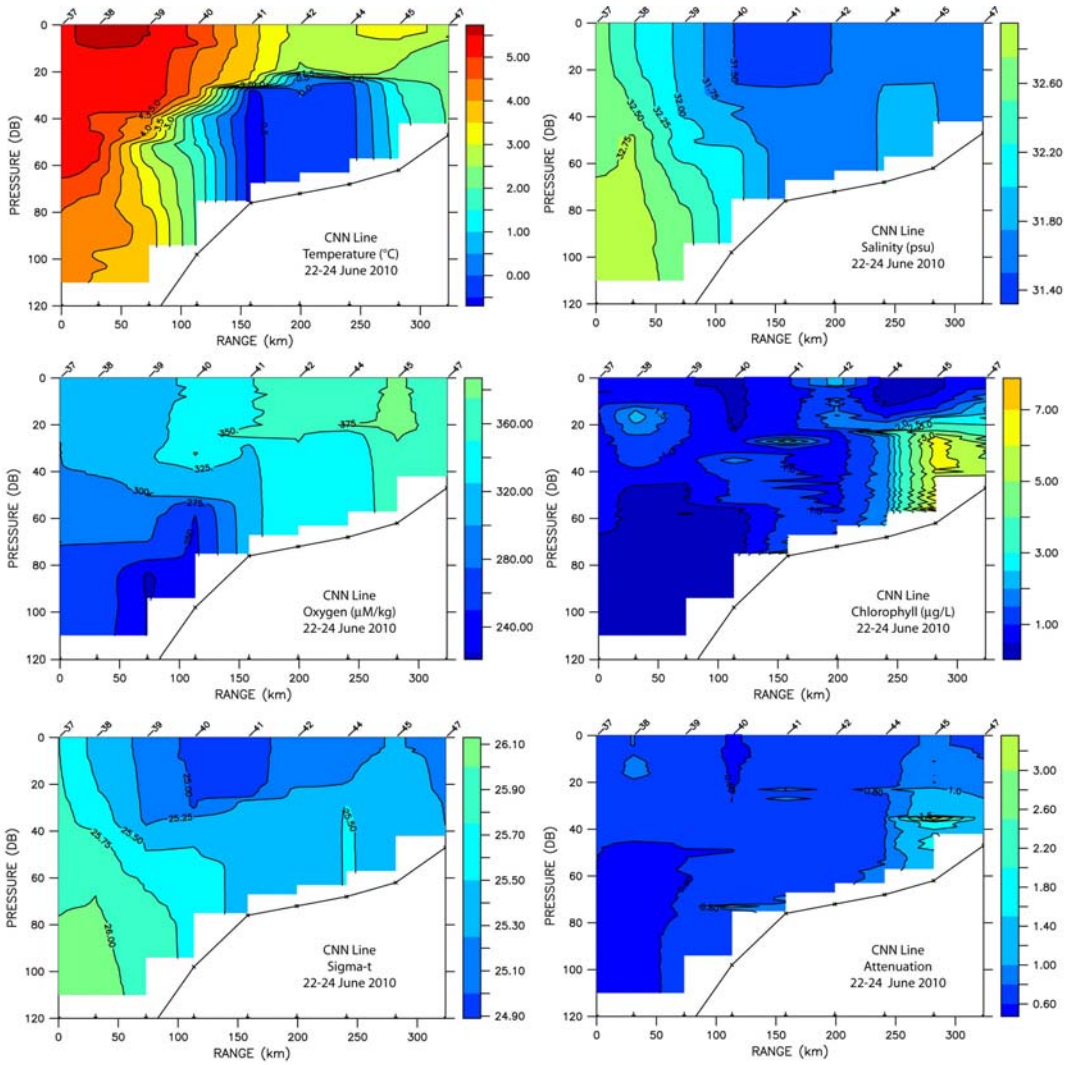


Figure 4. Water temperature, salinity, oxygen concentration, chlorophyll, sigma-t and light attenuation along the CNN (Cape Newenham North) transect. These measurements are preliminary and may change after further

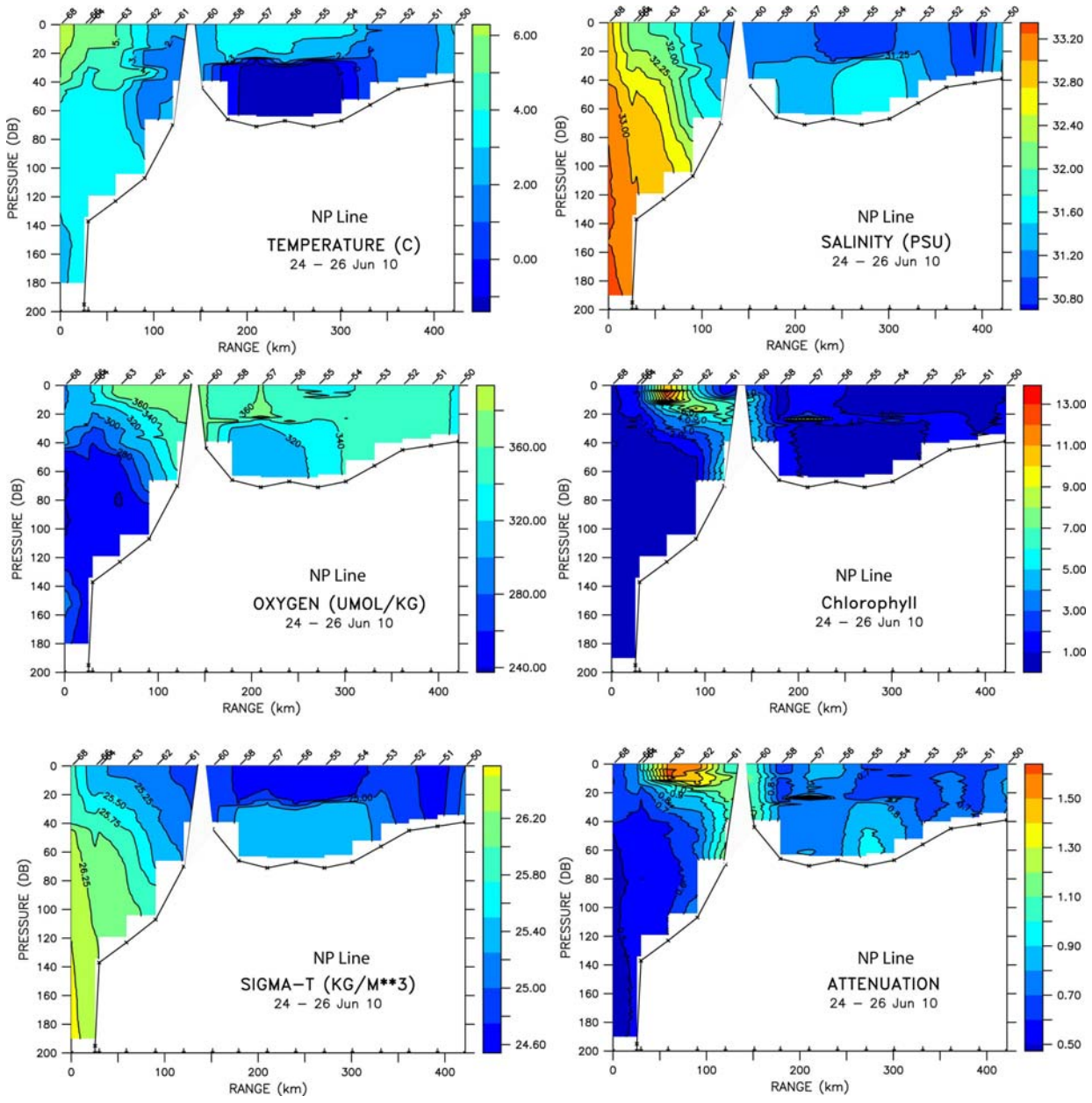


Figure 4. Water temperature, salinity, oxygen concentration, chlorophyll, sigma-t and light attenuation along the NP (Nunivak-Pribilof) transect. These measurements are preliminary and may change after further analysis.

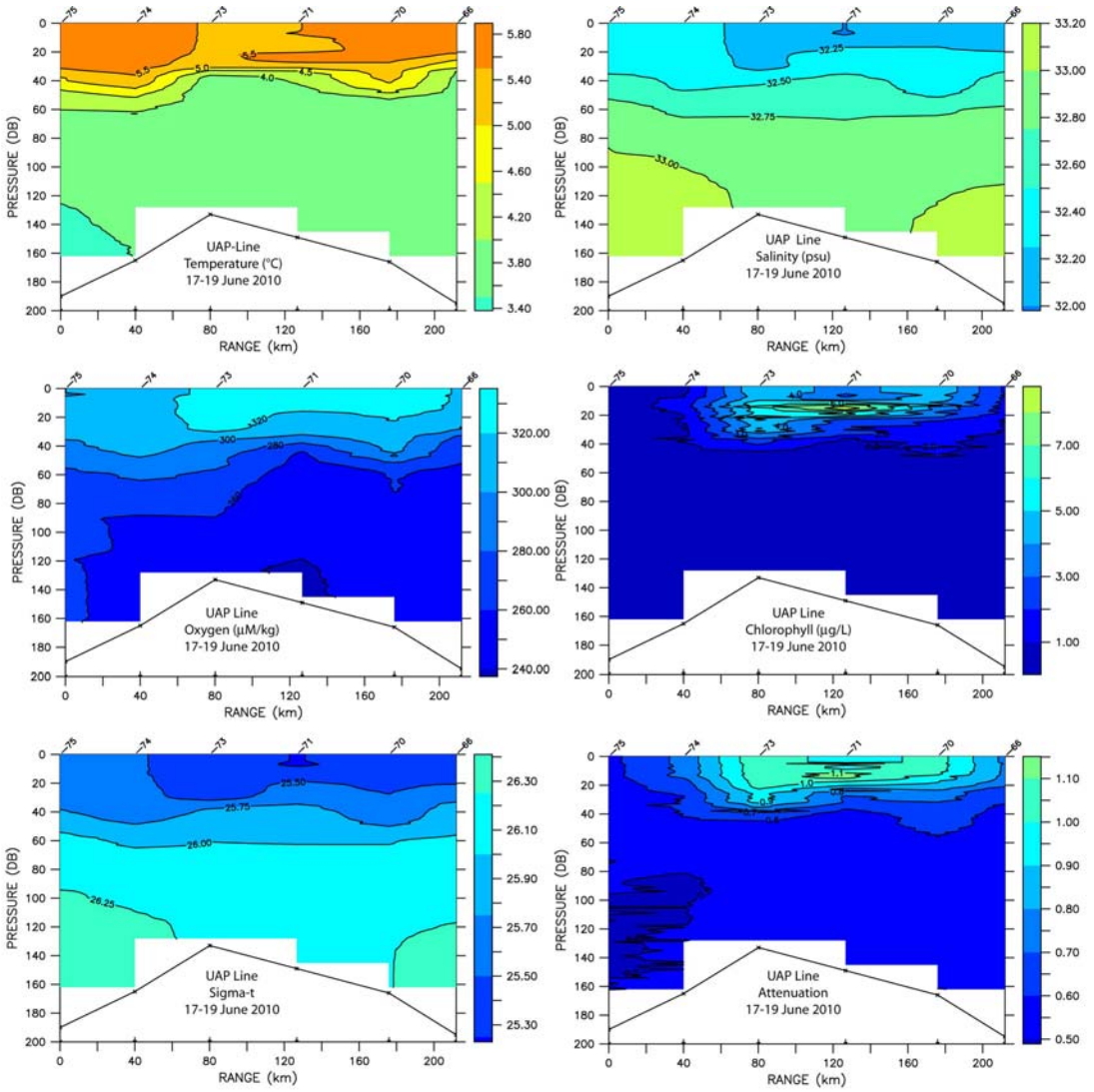


Figure 5. Water temperature, salinity, oxygen concentration, chlorophyll, sigma-t and light attenuation along the SB (Shelf Break) transect. These measurements are preliminary and may change after further analysis.

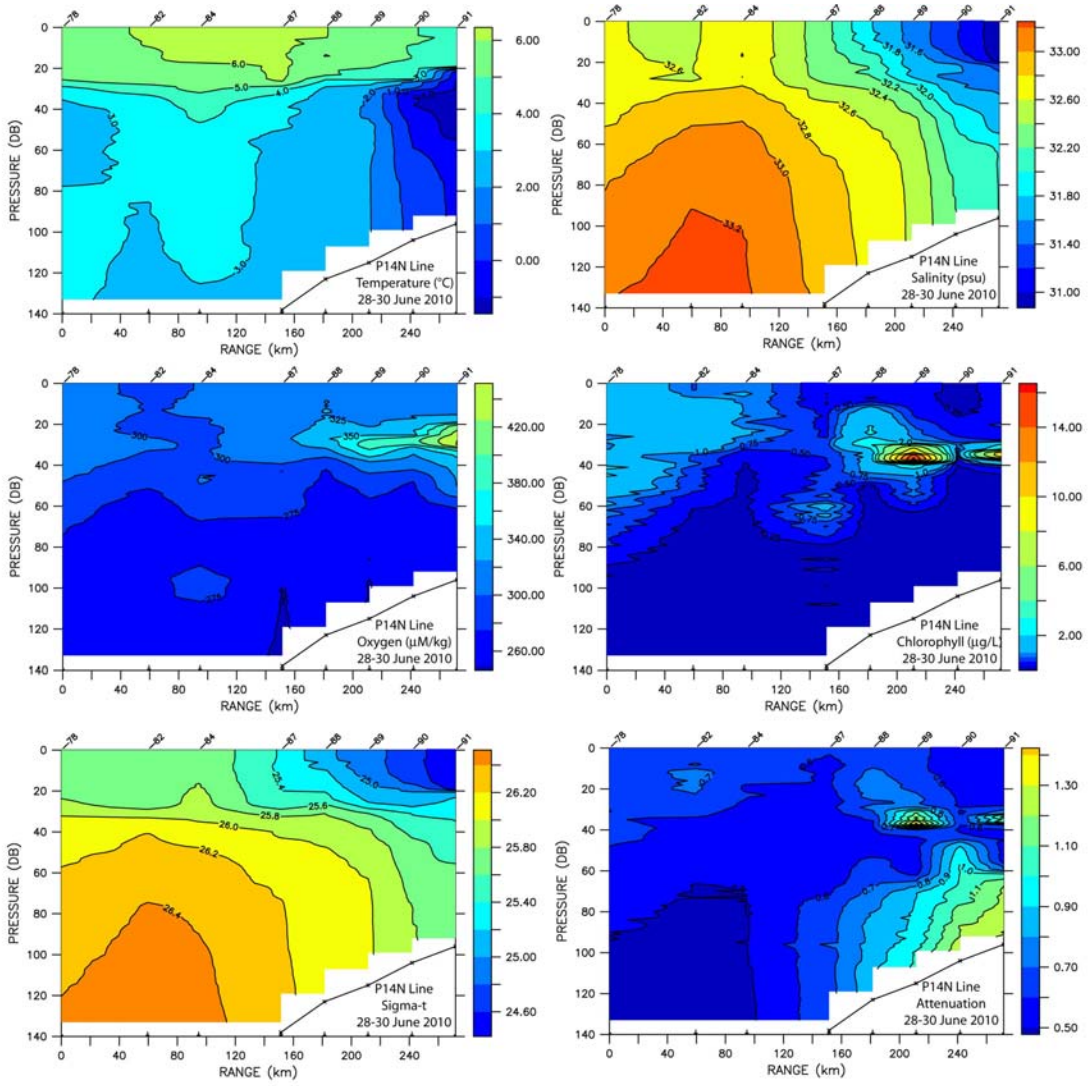


Figure 6. Water temperature, salinity, oxygen concentration, chlorophyll, sigma-t, and light attenuation along the P14N line (established as part of WOCE). These measurements are preliminary and may change after further analysis. Our results at the deep stations will be compared to chemistry results found during that program.

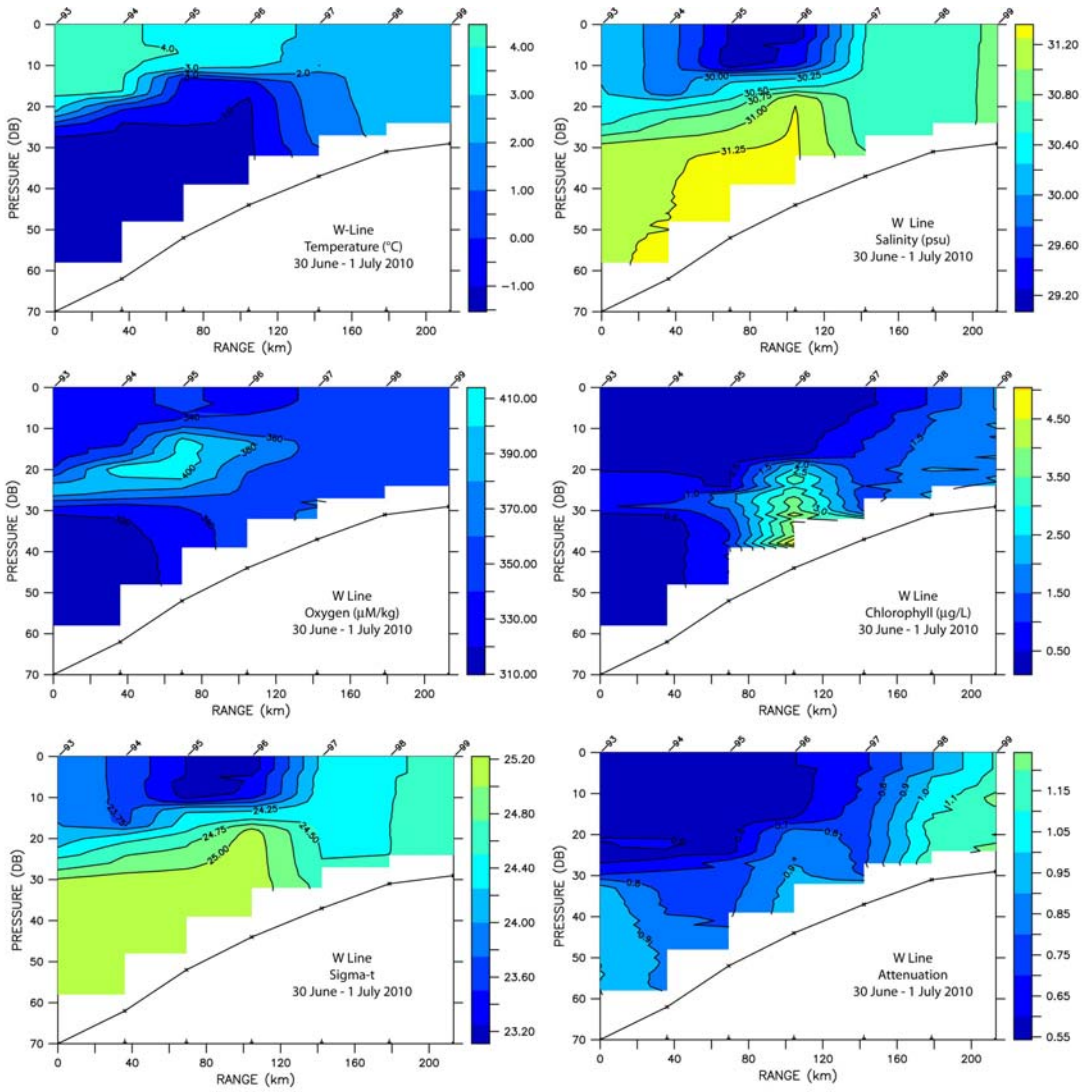


Figure 7. Water temperature, salinity, oxygen concentration, chlorophyll, sigma-t, and light attenuation along the W line (Tom Weingartner's transect). These measurements are preliminary and may change after further analysis.

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 (BIO)
On board team members: Roger P. Kelly (URI), Matt Baumann (URI), and Jonathan Whitefield (BIOS), Jason Pavlich (ARMADA Teacher at Sea, Red Hook HS, NY))

This project, part of a collaborative effort between BIOS and URI, addresses the question of whether climate-driven inter-annual 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 marginal-ice-zone (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.*

1. 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. Water column samples for U-238 analysis are also being collected to evaluate the U-Salinity relationship.

This year only surface tethered sediment traps will be used to collect sinking particles from the water column. As of 7/13/10, we have conducted 4 deployments and recoveries. In addition to ^{234}Th, trap samples will be analyzed for organic and inorganic CHN, particulate biogenic silica and phosphorus and pigments (where sufficient sample mass is collected).

Samples for suspended POC have been collected at most stations with corresponding water column Th-234 measurements. This has been done in an effort to establish a relationship between sinking material (trap POC) and suspended material. In addition to POC, these samples will be analyzed for stable C and N ratios.

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

The table below summarizes samples collected from June 16 to July 13, 2010, on TN250.

Station	WC Th-234	WC POC/Stable Carbon	WC U-238	Sediment Th-234	Drifting Sed. Traps
8-UAP5	X	X			
15-UAP2		X		X	
20-CN8	X	X		X	X
25-CN17	X	X			
26-CN20	X		X	X	
31-CNN7				X	
34-CNN4	X				
47-NP9	X	X			
53-TD2	X	X		X	X
54-NP15	X		X	X	
55-TR2				X	
58-SB5					
62-P14N-10	X		X		
63-P14N-7	X	X			X
67-TR3				X	

74-W3				X	
82-MN1	X	X			
83-MN2				X	
85-MN4		X			
87-MN6		X			
88-MN7		X			
89-MN8		X			
90-MN9		X			
91-MN10	X	X		X	
92-MN11		X			
93-MN12		X			
94-MN13		X			
95-MN14		X			
96-MN15		X			
97-MN16	X	X		X	
98-MN17		X			
99-MN18		X			
100-TD4	X				X
102-MN20	X	X		X	
103-TM4				X	
112-ML13				X	
122-ML3	X	X		X	
134-SL11				X	
145-BN3	X	X		X	
155-70M51				X	
167-70M39	X	X			
197-70M9	X	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.

2. Lomas component

The primary goal of this project is quantify rates of primary production and who are the primary producers. We collected samples from a full light profile (7 depths), and using ^{14}C to

quantify primary production in on-deck incubators. At each of these stations we also collected samples for a detailed analysis of phytoplankton community composition. This was done in several ways. Samples were 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 were also collected for 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 on the cruise as well as modelers as we try to understand carbon flow in the first few trophic levels. Samples from all depths were 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. Lastly, we collected samples for suspended biogenic silica which is a proxy for diatoms and another means to assess phytoplankton composition. At other stations we also collected samples for suspended particulate organic carbon, nitrogen and phosphorus to help understand variability in environmental stoichiometry.

The table below summarizes the samples collected between June 16 and July 13 2010, on TN250. Samples collected are listed as yes (Y) or the number of depths sampled, and no (N) if no sample was collected.

Station No.	Station Name	s-f Chla	s-f HPLC pigments	Pico-/Nano-plankton	Micro-plankton	Primary Production	Biogenic Silica
1	U1	4	N	4	N	N	4
8	UAP5	7	7	7	4	Y	7
15	UAP2	4	N	4	N	N	4
20	CN8	7	7	7	4	Y	7
25	CN17	7	7	7	4	Y	7
29	CNN9	4	N	4	N	N	4
34	CNN4	7	7	7	4	Y	7
39	NP1	4	N	4	N	N	4
47	NP9	7	7	7	4	Y	7
53	TD2	6	6	6	4	Y	6

58	SB5	4	N	4	N	N	4
63	P14N-7	4	N	4	N	N	4
67	TR3	7	7	7	4	Y	7
74	W7	4	N	4	N	N	4
82	MN1	7	7	7	4	Y	7
90	MN9	4	N	4	N	N	4
97	MN16	7	7	7	4	Y	7
103	TR4	7	7	7	4	Y	7
112	ML13	4	N	4	N	N	4
122	ML3	7	7	7	4	Y	7
134	SL11	4	N	4	N	N	4
145	BN3	7	7	7	4	Y	7
155	70M51	4	N	4	N	N	4
167	70M38	7	7	7	N	Y	7
181	70M25	4	N	4	N	N	4
197	70M9	7	7	7	N	Y	7

Results to date

To date, we have run only 1 primary production profile due to failure of the scintillation counter. We have run all of the collected chlorophyll-*a* samples to date but have not yet analyzed the results. The remaining samples will be processed and analyzed post-cruise.

Sea Ice Algae, a Major Food Source for Herbivorous Plankton and Benthos in the Eastern Bering Sea

PIs: Rolf Gradinger, Bodil Bluhm, Katrin Iken (UAF)
On board team member: Sean Brennan

Project goals

The goal of the Iken group's research is to track the relative importance of phytoplankton primary production and the primary production associated with sea ice – sea ice algae - in the Bering Sea food web. Our objectives include the collection of pelagic and benthic organisms within this food web for bulk sable isotope analyses and compound specific stable isotope analyses of fatty acids to isotopically differentiate dietary inputs (phytoplankton vs. sea ice algae) and identify organism trophic levels as energy moves through the food web.

Methods employed

At each target station water is collected by a CTD cast, zooplankton are collected via the drove net from the MOCNESS and benthic invertebrates are collected using a Van Veen grab. All collected samples are stored frozen (or, dried for bulk isotope measurements of pelagic and benthic invertebrates) until later analysis at the Alaska Stable Isotope Facility in Fairbanks, AK.

(1) Phytoplankton: At each target station six liters of water is collected at the chlorophyll maximum from 30-L bottles on the CTD carousel, filtered and frozen for later analysis. The six liters include three replicates for bulk isotopic measurements of POM; and three replicates for fatty acid compound specific stable isotope measurements for POM.

(2) Zooplankton: At each target station zooplankton are collected via the MOCNESS. The catch is sorted to species and stored for later analysis. Samples are collected such that there are three replicates for bulk isotopic measurements and two replicates for fatty acid compound specific stable isotope measurements. Each species sampled also has an accompanying voucher to verify identification. Thus, only the species abundant enough to satisfy the replicates and voucher quantities in each sample are collected for analysis.

(3) Benthos: At each target station benthic invertebrates are collected using a Van Veen grab. Three replicate grabs are taken at each station. In addition POM and chlorophyll samples are collected from the sediment surface of each grab. Benthic invertebrates are sorted to the lowest practical taxonomic level and stored for later analysis (three replicates for bulk isotope measurements; and two replicates for fatty acid compound specific measurements). Only species abundant enough to satisfy the replicates and voucher quantities in each sample are collected for analysis.

TN250 Completed stations list

Table 1. Sampling station summary during the 2010 Thompson BEST cruise (TN250). Numbers represent samples (incl. replicates) collected within each category. FAME samples are for fatty acid stable isotope analysis.

St. name	#	Lat (N)	Long (W)	Date	Depth (m)	water POM	Zoop	Benthos	sed Chl	sed POM	FAME
UAP3	10	55 57.77	163 11.43	18-Jun-10	89	3	6	11	3	3	15
CN4	18	57 16.74	162 55.40	19-Jun-10	50	3	8	18	3	3	21
CNN5	33	57 3.10	167 26.96	23-Jun-10	70	3	12	15	3	3	21
NP1	39	59 17.07	167 36.15	24-Jun-10	39	3	7	18	3	3	20
NP7	45	57 53.32	169 13.39	24-Jun-10	67	3	9	26	3	3	28
TD2	53	56 15.27	171 06.58	26-Jun-10	189	3	15	11	3	3	21
SB7	60	57 16.74	173 50.43	27-Jun-10	191	3	9	16	3	3	21
P14N4	69	58 57.62	173 52.36	29-Jun-10	123	3	19	18	3	3	30
MN3	84	59 54.03	169 12.13	1-Jul-10	47	3	7	15	3	3	18
MN13	94	59 54.01	175 11.97	2-Jul-10	118	3	13	18	3	3	23
MN18	99	59 54.02	178 11.98	3-Jul-10	142	3	15	22	3	3	27
SL1	124	62 11.99	169 50.96	6-Jul-10	41	3	10	31	3	3	30
SL9	132	62 12.01	173 06.97	6-Jul-10	60	3	12	31	3	3	34
SL16	139	62 12.02	175 54.28	7-Jul-10	90	3	13	25	3	3	28
BN3	145	62 40.01	173 23.00	8-Jul-10	68	3	11	25	3	3	30
					Total	**45**	**166**	**300**	**45**	**45**	**367**

Samples

Sampling of repeat stations from previous years occurred during the entire cruise. A sample summary is given in Table 1. Samples will be further processed back at the University of Alaska, Fairbanks. Pelagic samples collected were mostly copepods and euphausiids; benthic samples collected were mostly polychaetes, bivalves and amphipods (see Figure 1 for examples).

Figure 1. (left to right, top): large gammarid amphipod from station BN3 near St. Lawrence Is. (photo: Diane Stoecker); *Thysanoessa rashii* (many stations); *Calanus marshallae* (many stations); **(bottom):** *Nuculana radiata* (many northern stations); Maldanid polychaetes (most stations); *Lumbrinereis* sp. (many stations).

Assessment of mesozooplankton population and biomass in the eastern Bering Sea for spring and summer of 2008, 2009 and 2010.

PIs: Ken Coyle and Alexei Pinchuk (UAF)
On-board team member: Alexei Pinchuk

The primary task of the mesozooplankton component was to assess the abundance, biomass and species composition of the mesozooplankton on the shelf-break, 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 71 CalVET samples were taken at CTD stations along main transect lines across the shelf covering all shelf domains (Fig. 1A). Total of 90 depth-stratified MOCNESS tows were done at selected locations (Fig.1A) covering all shelf domains. MOCNESS collections were done in cooperation with BSIERP Ichtyoplankton Component.

The small mesozooplankton were sampled with a 25 cm CalVET (CalCOFI Vertical Egg Tow) net equipped with 0.15-mm mesh nets (Fig. 1 B). 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^2 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. Fish larvae will be removed and transferred to BSIERP Ichtyoplankton Component for further identification and morphometrics. 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. The data will be entered into a MS ACCESS database and submitted to BEST-BSIERP Data Management.

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*, *Euphausia pacifica* and *Thysanoessa longipes* were observed offshore on the outer shelf and along the shelf break (over 200m). *Metridia pacifica* and *Thysanoessa inermis* were particulary abundant on the outer shelf (between 200m and 100 m). *Calanus marschallae* and *Thysanoessa raschii* were common on the middle shelf, while *Sagitta elegans* and small copepod *Pseudocalanus* spp. were abundant in all domains. Substantial numbers of cold-water hyperiid *Themisto libellula* were recorded on the northern middle shelf and on some outer shelf stations. Large numbers of scyphozoan jellyfish *Chrysaora melanaster* 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* apparently had nearly finished reproduction on the southern middle and inner shelf as indicated by the lower number of gravid females in comparison to the earlier cruise. No spermatophore-bearing *Thysanoessa inermis* were observed, which indicates the end of their reproduction season. Total of 2 gravid *T. raschii* females were incubated at ambient temperature over two days. Total of 300 nauplii were set for rearing at 10^{o}C.

T

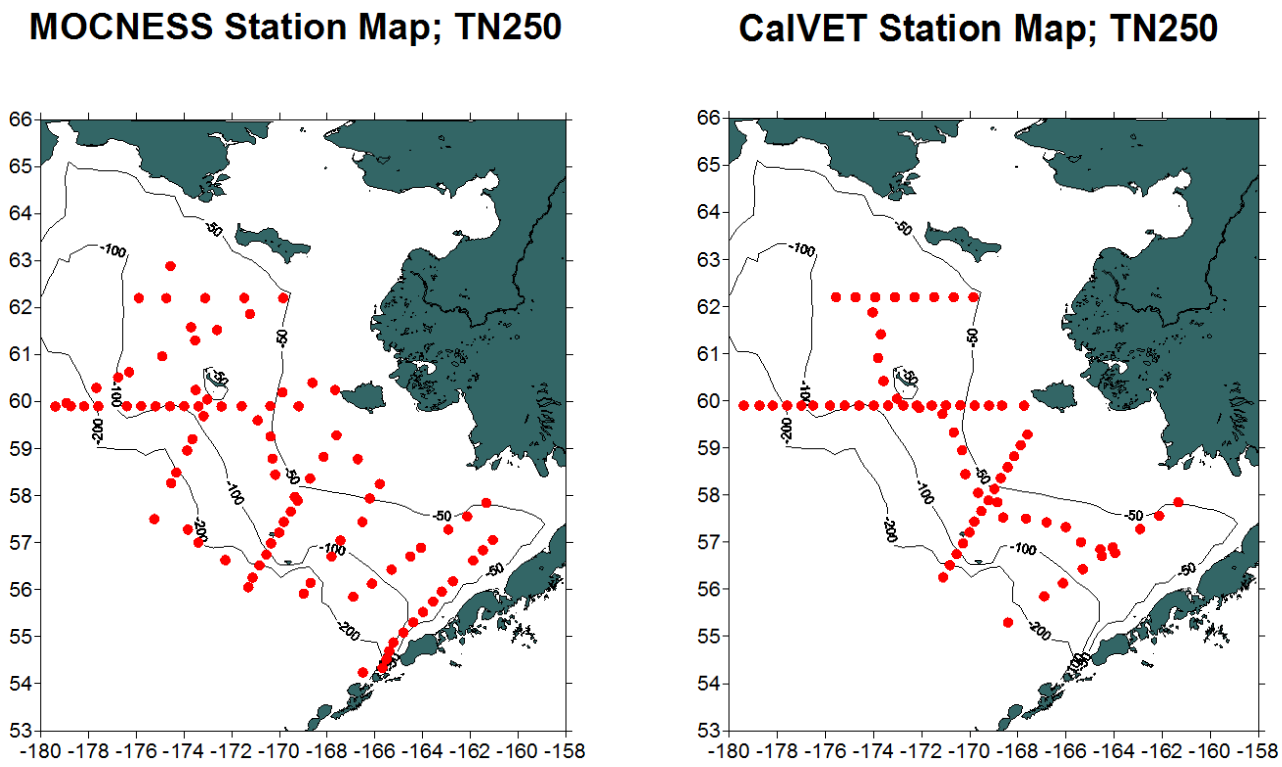


Figure 1. A. Locations of MOCNESS stations. B. Locations of CALVET stations.

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: Jessica Faux (UM), Megan Bernhardt (UW), and Tracy Shaw (OSU)

The overall 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 of collected larvae to allow calibration of the lipofuscin aging method when eggs can be collected in the field.

Lipid composition of water column particles

Grazing Experiments - Determination of Euphausiid of Diet History and Food Source Preferences from Lipids

A central goal of this project is to link grazing rates for euphausiids on natural and amended food sources with detailed lipid analysis of animals and their diets. The grazing experiment setup is detailed in the report from Lessard and provides animals for analysis. For lipid characterization of food resources and tracking of consumption, water is taken from designated Niskin bottles at the beginning of each grazing experiment (T_0) and filtered through combusted GF/F filters for carbon and lipid biomarkers to characterize the algal and detrital food available to krill. (Refer to Table 1 for grazing experiment water column samples.) Krill used for

grazing experiments are transferred (T_0) directly from the bongo cast into either ambient seawater or 0.2µm filtered sea water. The subsets of animals are placed in filtered seawater for 24 hours allow gut clearing of any prior consumption before analysis and comparison with fed animals. At the end of the incubation, the krill are removed from the bottles, sorted by species and sized, and then immediately frozen at -80ºC. (Refer to the Lessard report for details on experimental set up for grazing.) Frozen samples will be returned to the laboratory for detailed lipid analysis via GC-FID and GC-MS. (Refer to Table 1 for euphausiid collection logs).

Two extended starvation experiments were begun at the start of TN249 and have run throughout TN250. Time points continued to be taken until near the end of TN250. During TN250 four time points were taken for the first experiment and three for the second. A third extended starvation experiment featuring adult *T. raschii* was begun during TN250. The euphausiids were collected from station CN6, #19. After six days, a pulse of food collected from station NP8 was added; water samples were taken for future lab-based analysis. Euphausiids from five time points have been stored for later analysis.

Individual euphausiids of multiple species were also collected for lipid, calorie, carbon, and nitrogen analysis. Excess krill from a net tow were separated by species and placed into 2mm length increments. The composite samples were frozen in cryogenic vials in the -80ºC freezer for later lab analysis.

Growth Experiments for the Determination of Euphausiid Age

Four growth experiments have been completed and stored for future laboratory age analysis. These growth experiments include animals of a range of sizes and native species, with a focus on *Thysanoessa inermis* and *Thysanoessa raschii*, to provide estimates of lipofuscin indices for field animals of differing ages. After the collection of eggs, Alexei Pinchuk will conduct spawning experiments to provide larval animals of known age. These animals will be used in long term rearing experiments to calibrate ages for the field specimen that have been analyzed.

Organic Biomarkers in Particles verses Trap Material and Surface Sediments

To compare the suite of lipid markers in suspended verses sinking material, aliquots from Moran group sediment traps were filtered onto 25mm combusted GF/Fs and 47mm

polycarbonate filters. Trap samples were obtained in parallel with corresponding depths by CTD for particles and sediment from the same station when possible. (Refer to Tables 2 and 3 for sample location and designation). Additional surface sediments were obtained from extra multicore samples collected by the Shull group.

Cyanobacteria Detection and Lipid Biomarkers (BHPs)

At several stations, samples of water initially pre-filtered at the 3μm level, were pulled through 0.4μm polycarbonate filters and stored for initial attempts to examine cyanobacterial cells and provide samples for genomic analysis. The remaining water from these samples was pulled through 0.7μm glass fiber filters to analyze for BHPs (bacterial hopanoid polyols) to search for specialized bacterial cellular markers. (Refer to Table 4 for sample location and designations.)

Table 1: Water Collections and Euphausiid Sample Collections for Grazing Experiments as of 7/12/10.

Experiment Type and No.	Station, #	T_0 filter date	CTD Cast	Niskins	# krill composited	Dominant species
Grazing Experiment 1	UAP-6, #7	6/18/10	9	11	18	*T. raschii*
Grazing Experiment 2	CN-6, #19	6/20/10	22	9	22	*T. raschii*
Grazing Experiment 3	CN-16, #24	6/21/10	29	5	21	*T.longipes*
Grazing Experiment 4	CNN-5, #33	6/23/10	41	8	22	*T. raschii*
Grazing Experiment 5	NP-8, #46	6/25/10	57	5	25	*T. raschii*
Grazing Experiment 6	P14N-10, #62	6/28/10	79	3	22	*T. longipes*
Grazing Experiment 7	P14N-1, #72	6/30/10	91	4	42	*T. raschii*
Grazing Experiment 8	MN7, #88	7/2/10	109	9	30	*T. raschii*
Grazing Experiment 9	MN2, #102	7/4/10	127	5	24	*T. longipes*
Grazing Experiment 10	70m41, #165	7/10/10	193	8	26	*T. raschii*
Grazing Experiment 11	70m28, #178	7/11/10	208	8	20	*T. raschii*
Long term starvation #3	NP-8, #46	6/25/10	57	5	continuous	*T. raschii*
All filters frozen in the -80ºC freezer immediately after collection						

Table 2: Sediment Trap and CTD Collection Log as of 7/12/10 with thanks to the Moran group.

Sample Type	Date	Station	Experimental Details
Water Colum for sediment traps	6/21/2010	CN-17, #25	100m sampling depths, cast 31, Niskins 5
			60m sampling depth, cast 31, Niskins 4
			40m sampling depth, cast 31, Niskins 3
			23m sampling depth, cast 31, Niskin 2
Sediment trap samples - recovery	6/22/2010	TR-1, #300	Sediment trap @ 25m
			Sediment trap @ 40m
			Sediment trap @ 50m
			Sediment trap @ 100m
Water Colum for sediment traps	6/26/2010	TD-2, #53	14m sampling depth, cast 66, Niskin 7
			40m sampling depth, cast 66, Niskin 4
			60m sampling depth, cast 66, Niskin 3
			100m sampling depth, cast 66, Niskin 2
Sediment trap samples - recovery	6/27/2010	TR-2, #55	Sediment trap @ 25m
			Sediment trap @ 40m
			Sediment trap @ 50m
			Sediment trap @ 60m
			Sediment trap @ 100m
Water Colum for sediment traps	6/28/2010	P14N-7, #63	40m sampling depth, cast 81, Niskin 7
			60m sampling depth, cast 81, Niskin 5
			100m sampling depth, cast 81, Niskin 3
Sediment trap samples - recovery	6/29/2010	TR-3, #67	Sediment trap @ 25m
			Sediment trap @ 40m
			Sediment trap @ 50m
			Sediment trap @ 60m
			Sediment trap @ 100m
Water Colum for sediment traps	7/3/2010	TD-4, #100	40m sampling depth, cast 123, Niskin 8
			60m sampling depth, cast 123, Niskin 6
			100m sampling depth, cast 123, Niskin 4
Sediment trap samples - recovery	7/4/2010	TR-4, #105	Sediment trap @ 25m
			Sediment trap @ 40m
			Sediment trap @ 50m
			Sediment trap @ 60m
			Sediment trap @ 100m

Note: All filter samples were frozen at -80ºC after collection

Table 3: Sediment Collection Log as of 7/12/10

Date	Station	Stn #	# Cores	Surface/Down Core/Whole Core	Increments (cm)	Range (cm)
6/26/2010	TR-2(core)	55	1	Surface	1	0-2
6/29/2010	TR-3	67	1	Surface	1	0-2
7/4/2010	TM4	103	1	Surface	1	0-2
7/7/2010	SL11	134	1	Down core	1	0-15
7/7/2010	SL16	138	1	Down core	1	0-26

Note: All sediment samples were sliced, placed in IChem jars and frozen at -80ºC after collection

Table 4: Cyanobacterial Detection and BHPs Collection Log as of 7/12/10.

Sample Type	Station, #	Filter date	CTD Cast	Niskins	Depth	Pre-filtered
Cyano & BHP	NP-8, #46	6/25/10	57	4	30m	Yes
Cyano & BHP	P14N-6, #66	6/29/10	86	5	40m	Yes
Cyano & BHP	P14N-1, #72	6/30/10	91	3	40m	Yes
Cyano & BHP	MN10, #91	7/2/10	113	3	40m	Yes
Cyano & BHP	MN12, #93	7/2/10	115	5	40m	Yes
Cyano & BHP	MN15, #96	7/3/10	118	6	40m	Yes
Cyano & BHP	ML20, #104	7/4/10	129	6	40m	Yes
Cyano & BHP	ML15, #110	7/5/10	134	3	40m	Yes
Cyano & BHP	SL15, #138	7/7/10	164	4	40m	Yes
Cyano & BHP	SL16, #139	7/7/10	165	4	45m	Yes

Note: All filter samples were frozen at -80ºC after collection

Denitrification and Global Change in Bering Sea shelf sediments

PIs: Allan Devol (UW) and David Shull (WWU)
On-board team members: David Shull, Greg Brusseau, Rachel Allison, Colin Smith

Research objectives:

- Determine the rates of organic-matter (OM) oxidation in Bering Shelf and slope sediments as an indicator of variation in OM supply.
- Determine the relationship between rates of bioirrigation and rates of denitrification and nutrient regeneration in Bering Sea sediments.
- Examine how variation in rates of bioturbation affects organic-matter degradation pathways
- Estimate variation in OM input to the sediment from pigment profiles and measurements of bioturbation rate

Our work focused on collecting sediment cores for measurement of gas and nutrient fluxes, dissolved oxygen, dissolved nutrient profiles, phytoplankton pigments, $^{234}Th/^{238}U$ disequilibrium in sediments, and benthic community structure. Excess ^{234}Th profiles will be used to examine how rates of particle bioturbation vary across the Bering Shelf. These bioturbation rates will allow us to model rates of pigment degradation in shelf sediments. Pigment degradation rates, when compared to pigment:OM ratios determined from sediment traps (from the Moran/Lomas research group) will allow us to assess variation in particulate organic matter input to shelf sediments.

Core samples

Twenty sites were sampled in Spring 2009 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 ten. Cores were processed on deck and, depending upon the number of usable cores recovered, were generally allocated as follows:

3 flux cores (incubated for ca. 5d and overlying water sampled for, N_2/Ar, O_2/Ar, O_2 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 (NH_4^+, NO_2^-, NO_3^-) 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, ^{210}Pb) and sediment porosity

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

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

Table 1. Multicore sample locations and measurements from TN250

Coring station information					Measurements						
Stn	Date	Latitude	Longitude	Depth (m)	[O2]pw	Flux	Squeeze	[Nut]pw	^{234}Th	Pigments	Benthos
1	6/17/2010	54 ° 14.2'	166 ° 29.5'	1098	X	X	X	X	X	X	X
8	6/18/2010	55 ° 31.5'	163 ° 58.3'	92	X	X	X	X	X	X	X
15	6/19/2010	57 ° 3.5'	161 ° 2.5'	71	X	X	X	X	X	X	X
20	6/20/2010	56 ° 42.4'	164 ° 30.5'	76	X	X	X	X	X	X	X
31	6/22/2010	56 ° 30'	168 ° 17.2'	127	X	X	X	X	X	X	X
34	6/23/2010	57 ° 21'	167 ° 2.6'	72	X	X	X	X	X	X	X
39	6/24/2010	59 ° 17'	167 ° 37'	40	X	X	X	X	X	X	X
47	6/25/2010	57 ° 26.6'	169 ° 50'	68	X	X	X	X	X	X	X
54	6/26/2010	56 ° 3.2'	171 ° 19'	2788	X	X	X	X	X	X	X
55	6/26/2010	56 ° 18'	171 ° 15'	145					X	X	
58	6/27/2010	56 ° 43'	173 ° 1'	130	X	X	X	X	X	X	X
67	6/29/2010	58 ° 17'	174 ° 40'	2372		X		X	X	X	X
74	6/30/2010	59 ° 60'	171 ° 3.6'	70	X	X	X	X	X	X	X
83	7/1/2010	59 ° 54'	168 ° 39.8'	40	X	X	X	X	X	X	X
91	7/2/2010	59 ° 54'	173 ° 24'	86	X	X	X	X	X	X	X
97	7/3/2010	59 ° 54'	176 ° 60'	136	X	X	X	X	X	X	X
102	7/4/2010	59 ° 54'	179 ° 24'	2705	X	X	X	X	X	X	X
103	7/4/2010	59 ° 56.1'	178 ° 49.8'	149	X	X	X	X	X	X	X
112	7/5/2010	60 ° 51'	175 ° 22.9'	104	X	X	X	X	X	X	X
122	7/6/2010	61 ° 58.2'	170 ° 46.8'	50	X	X	X	X	X	X	X
134	7/7/2010	62 ° 12'	173 ° 56'	64	X	X	X	X	X	X	X
145	7/8/2010	62 ° 40'	173 ° 23'	66	X	X	X	X	X	X	X
155	7/9/2010	61 ° 14.7'	173 ° 43'	74	X	X	X	X	X	X	X

Also cored unsuccessfully at stations 26, 62, and 90

Gas flux data from the MIMS have not yet been analyzed. The spatial pattern in sedimentary oxygen consumption measured by optode indicate higher rates of oxygen uptake in shallow water and near the St. Lawrence Island polynya (Fig. 1).

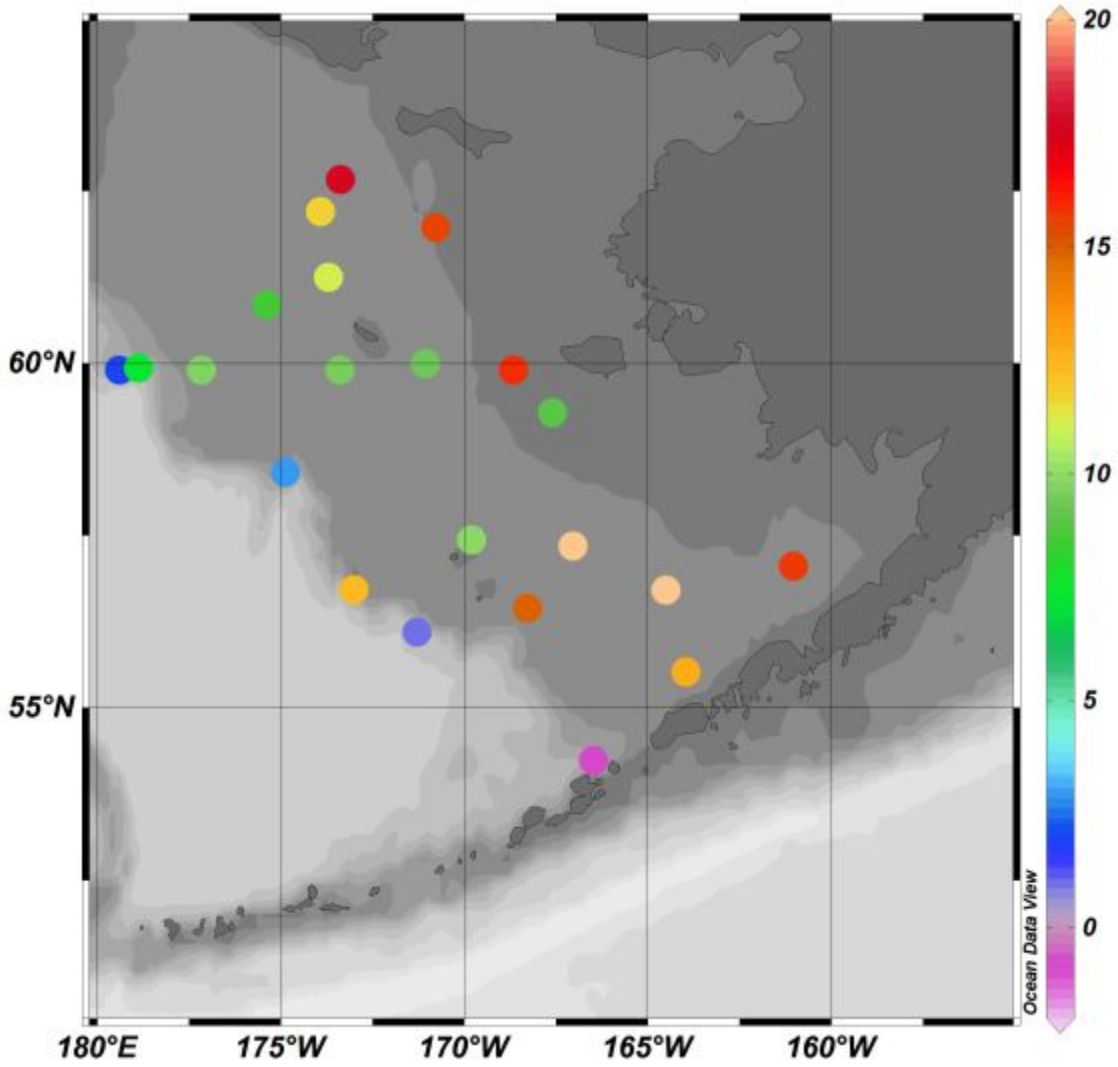


Figure 1. Oxygen consumption rates from flux core experiments (mmole O_2 m^{-2} d^{-1}). Oxygen concentrations determined by optode. Fluxes of nutrients and ^{234}Th profiles were also collected at these stations.

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

PIs: Raymond Sambrotto, Daniel Sigman
On-board team member: Kali McKee

This project measures new (nitrate) and regenerated nitrogen production directly with tracer incubation measurements in the eastern Bering Sea shelf. New production is indicative of the total amount of organic material available for higher levels of the food chain and the ratio of new to total nitrogen production (the co-ratio) indicates the degree to which production is linked to grazing within the water column. This ecological information will be used to characterize the partitioning of primary production between water column and bottom-dwelling consumers and how this changes with conditions on the shelf.

We have been measuring the natural isotopic ratios of both the nitrate supply (both $^{15}N/^{14}N$ and $^{18}O/^{16}O$) and the forms of nitrogen produced (the $^{15}N/^{14}N$ of suspended and sinking particles, dissolved organic N and ammonium). These measurements provide a passive isotope approach that will reflect the intensity of nitrate assimilation and provide a new constraint on shelf new production. We have also conducted tracer incubation measurements using $^{15}NO_3$, $^{15}NH_4$, ^{13}C, and ^{15}N-urea. Incubation experiments last from four to twenty-four hours depending upon the original in-situ concentrations of the nutrients. Water for these samples is collected at seven different light depths (100%, 55%, 30%, 17%, 9%, 5%, and 1.5%). Phytoplankton identifications are also made at the 55% and 5% light depths when relevant.

We have collected samples for urea, DON (dissolved organic nitrogen), and DOP (dissolved organic phosphorus) profiles. These samples will be analyzed using colorimetric methods; the urea samples are analyzed over the course of the cruise, while the DON/P samples will be analyzed back at Lamont using a SEAL AA3 autoanalyzer.

Activity Log:

Station Number	Station	Cast	$^{15}NO_3$/ $^{13}CO_3$ Uptake	$^{15}NH_4$ Uptake	Urea Uptake	Particles	DON Profile	Urea Wat. Col. Profile	Core Top Water	Phytoplankton ID
3	U3	5				√	√	√		
8	UAP5	10	√	√		√	√	√	√	
8	UAP5	11				√	√	√		
11	UAP2	14				√	√	√		

15	UAP-2	N/A							√	
16	CN0	19				√	√	√		
17	CN2	20				√	√	√		
20	CN8	23				√	√	√	√	
20	CN8	24	√	√		√	√	√		√
22	CN12	26				√	√	√		
25	CN17	30				√	√	√		
25	CN17	31	√	√		√	√	√		
29	CNN9	37				√	√	√		
31	CNN7	39				√	√	√	√	
34	CNN4	42	√	√		√	√	√	√	√
34	CNN4	43				√	√	√		
39	NP1	49	√	√	√	√	√	√	√	
39	NP1	50				√	√	√		
41	NP3	52				√	√	√		
43	NP5	54				√	√	√		
47	NP9	58				√	√	√	√	
47	NP9	59	√	√	√	√	√	√		√
50	NP12	62				√	√	√		
53	TD2	67	√	√	√	√	√	√		
54	TR2	N/A							√	
58	SB5	72				√	√	√	√	
58	SB5	73	√	√	√	√	√	√		√
60	SB7	75				√	√	√		
67	TR3	86	√	√	√	√	√	√		√
68	P14 5	87				√	√	√		
69	P14 4	88				√	√	√		
73	70m 40	92	√	√	√	√	√	√		
74	W7=XB 7	93				√	√	√	√	
75	W6=XB 6	94				√	√	√		
77	W4=XB 4	96				√	√	√		
82	MN1	102	√	√	√	√	√	√		
83	MN2	N/A							√	
84	MN3	104				√	√	√		
86	MN5	106				√	√	√		
90	MN9	111	√	√	√	√	√	√		√
91	MN10	113				√	√	√	√	

92	MN11	114				√	√	√		
93	MN12	115				√	√	√		
97	MN16	119				√	√	√	√	
97	MN16	120	√	√	√	√	√	√		√
99	MN18	122				√	√	√		
102		N/A							√	
103	TM4	128	√	√	√	√	√	√	√	
106	ML19	130				√	√	√		
112	ML13	136	√	√	√	√	√	√	√	√
114	ML11	139				√	√	√		
116	ML9	141				√	√	√		
122	ML3	147	√	√	√	√	√	√		
124	SL1	149				√	√	√		
125	SL2	150				√	√	√		
127	SL4	152				√	√	√		
134	SL11	160	√	√		√	√	√	√	√
136	SL13	162				√	√	√		√
139	SL16	165				√	√	√		√
145	BN3	172	√	√		√	√	√	√	√
148	70m 58	175				√	√	√		
155	70m 51	N/A							√	
157	70m 49	185				√	√	√		
160	70m 46	188				√	√	√		
167	70m 39	196	√	√		√	√	√		√
173	70m 33	202				√	√	√		
181	70m 25	212	√	√		√	√	√		√

The effect of environmental factors on distribution, abundance, and energy density of late larval and early juvenile stages of walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), and arrowtooth flounder (*Atheresthes stomias*)

On-board team members: Elizabeth Siddon, Wesley Strasburger, Lorelei Smith

Statement of Objectives

Our main objectives are to (1) characterize the larval/early juvenile summer fish assemblages in the eastern Bering Sea, (2) determine the effect of environmental factors on the abundance, distribution, and composition of ichthyoplankton, and (3) examine the energy density of larval and early juvenile stages of three target species: walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), and arrowtooth flounder (*Atheresthes stomias*). Our participation on this research cruise was supported by the North Pacific Research Board's Bering Sea Integrated Ecosystem Research Program (BSIERP). Our data will contribute to the collaborative effort of improving the understanding of the effects of climate variability on spatial and temporal variability in abundance, distribution, and condition of the early life stages of these three target fish species in the eastern Bering Sea. Ultimately, these data will allow for the better prediction of transport pathways of early life stages and of production of the three target taxa under changing climatic conditions in the eastern Bering Sea.

Field Methods

Sampling was conducted in collaboration with Alexei Pinchuk, University of Alaska Fairbanks, Seward Marine Center. We sampled ichthyoplankton using a $1m^2$ MOCNESS (Multiple Opening Closing Net and Environmental Sensing System) equipped with nine 500-µm mesh nets. In addition, the MOCNESS is equipped with sensors for temperature, conductivity, and fluorescence, thus recording data to characterize the sampled water column. Sampling was conducted obliquely in 20-m increments from 100 m depth (or 15 m above the substratum) to the surface. After retrieval of the gear, all nets were carefully rinsed, codends were detached, and samples were preserved in 10% formalin seawater. Samples will be brought to the lab for further identification and quantification. In addition, the contents of the drogue net of the MOCNESS were examined on board the R/V Thomas G. Thompson and all larval and early juvenile fishes, as well as the main zooplankton taxa, were removed for identification. Early life stages of target

taxa were counted (Table 1) and frozen at -80ºC for further analysis of energy density at NOAA Fisheries, Auke Bay Laboratories, Juneau, AK.

During TN250, a total of 90 stations on 12 transects were sampled (Table 1; Fig. 1), providing a large spatial coverage of data on ichthyoplankton assemblages from the eastern Bering Sea. The examination of the drogue net of the MOCNESS resulted in the collection of early life stages of all target taxa. A total of 256 *T. chalcogramma*, 3 *G. macrocephalus*, and 28 *Atheresthes* spp. as well as 296 *Sebastes* spp. have been frozen for future analysis of energy density.

Highest abundances of walleye pollock (*T. chalcogramma*) were observed in Unimak Pass and along the Alaska Peninsula, as well as within the outer domain along the MN line at 60°N; very few were collected at stations near the Pribilof Islands. *Theragra chalcogramma* were largely collected at stations with water depths >75m as well as stations beyond the shelf break (>150m water depth) (Fig. 2a). Pacific cod (*G. macrocephalus*) were rare and collected at stations near Unimak Pass only (Fig. 2b). *Atheresthes* spp. were collected predominantly in the outer domain (>100m water depth) and beyond the shelf break (>200 m) (Fig. 2c). *Sebastes* spp. were also collected at stations within the outer domain and beyond the shelf break (Fig. 2d). Future lab analysis will provide data on the horizontal and vertical distribution, size, and condition of early life stages of the target fish taxa.

Table 1. Summary of MOCNESS samples collected during TN250 and the number of specimens frozen for further bioenergetics analysis.

Station	MOC #	Latitude	Longitude	Walleye pollock	Pacific cod	*Atheresthes* spp.	*Sebastes* spp.
UP1	1	54.2383	-166.501	3	2	2	42
UP2	2	54.3366	-165.6833	3	0	1	12
UP3	3	54.5236	-165.5123	0	0	0	3
UP4	4	54.6914	-165.3933	3	0	3	0
UAP8	5	54.8781	-165.221	14	1	4	28
UAP6	7	55.3072	-164.3921	3	0	0	1
UAP5	8	55.5226	-163.9776	20	0	0	0
UAP4	9	55.7495	-163.5536	21	0	0	0
UAP3	10	55.96	-163.1915	20	0	0	0
UAP2	11	56.1789	-162.7254	16	0	0	0
UAP0	12	56.6191	-161.87582	1	0	0	0
UAP-1	13	56.8379	-161.4601	0	0	0	0
UAP-2	14	57.056	-161.0515	0	0	0	0
CN0	15	57.845	-161.3274	0	0	0	0

CN2	16	57.5607	-162.1274	0	0	0	0
CN4	17	57.2782	-162.9192	0	0	0	0
CN6	18	56.8917	-164.0637	0	0	0	0
CN8	19	56.7067	-164.5089	0	0	0	0
CN10	20	56.4256	-165.3033	0	0	0	0
CN12	21	56.1285	-166.1238	4	0	0	0
CN14	22	55.8479	-166.906	0	0	0	1
CNN9	23	55.9155	-168.9803	1	0	0	14
CNN8	24	56.1438	-168.6953	0	0	2	13
CNN6	25	56.7036	-167.8157	2	0	0	0
CNN5	26	57.0495	-167.4434	0	0	0	0
CNN2	27	57.9384	-166.2124	0	0	0	0
CNN1	28	58.248	-165.7932	0	0	0	0
X3	29	58.7751	-166.7144	0	0	0	0
NP1	30	59.2846	-167.6065	0	0	0	0
NP3	31	58.8251	-168.1518	0	0	0	0
NP5	32	58.3622	-168.7173	0	0	0	0
NP7	33	57.8925	-169.2325	0	0	0	0
NP8	34	57.6633	-169.5262	0	0	0	0
NP9	35	57.4398	-169.8195	0	0	0	0
NP10	36	57.2135	-170.0147	1	0	0	0
NP11	37	56.987	-170.3556	0	0	0	0
NP12	38	56.7446	-170.5502	1	0	0	0
NP13	39	56.5137	-170.8382	0	0	0	31
TD2	40	56.2581	-171.1241	1	0	0	7
NP15	41	56.0509	-171.3025	0	0	0	4
SB4	42	56.6284	-172.2685	7	0	2	29
SB6	43	57.0022	-173.4068	0	0	5	45
SB7	44	57.2775	-173.8398	0	0	5	18
P14-10	45	57.4996	-175.2516	0	0	0	0
P14-7	46	58.2653	-174.5427	1	0	0	11
P14-6	47	58.4901	-174.3262	0	0	0	6
P14-4	48	58.9573	-173.8704	10	0	1	7
P14-3	49	59.2022	-173.6476	36	0	3	23
P14-1	50	59.6909	-173.1833	0	0	0	1
W5	51	60.1965	-169.8743	0	0	0	0
W3	52	60.4114	-168.5329	0	0	0	0
NI	53	60.2472	-167.6714	0	0	0	0
MN3	54	59.9	-169.662	0	0	0	0
MN5	55	59.9051	-170.3886	0	0	0	0
MN7	56	59.9017	-171.586	0	0	0	0
MN10	57	59.9014	-173.3974	0	0	0	0
MN11	58	59.9022	-173.9983	44	0	0	0
MN12	59	59.902	-174.5937	24	0	0	0
MN13	60	59.9013	-175.1978	7	0	0	0
MN14	61	59.9043	-175.8017	11	0	0	0
MN15	62	59.9014	-176.405	2	0	0	0
MN17	63	59.9005	-177.5971	0	0	0	0
MN18	64	59.9016	-178.199	0	0	0	0

MN19	65	59.9018	-178.7514	0	0	0	0
MN20	66	59.896	-179.3952	0	0	0	0
TR4	67	59.9717	-178.9375	0	0	0	0
ML18	68	60.2924	-177.6823	0	0	0	0
ML16	69	60.5149	-176.7668	0	0	0	0
ML15	70	60.626	-176.3	0	0	0	0
ML12	71	60.9638	-174.9162	0	0	0	0
ML9	72	61.3009	-173.5369	0	0	0	0
ML7	73	61.5244	-172.6189	0	0	0	0
ML4	74	61.8621	-171.2384	0	0	0	0
SL1	75	62.2036	-169.8469	0	0	0	0
SL5	76	62.2037	-171.4828	0	0	0	0
SL9	77	62.1999	-173.1198	0	0	0	0
SL13	78	62.2001	-174.746	0	0	0	0
SL16	79	62.1992	-175.8969	0	0	0	0
BN5	80	62.8835	-174.5724	0	0	0	0
70m-53	81	61.5831	-173.709	0	0	0	0
70m-45	82	60.2483	-173.5134	0	0	0	0
70m-43	83	60.047	-173.0265	0	0	0	0
70m-36	85	59.6014	-170.9157	0	0	0	0
70m-33	86	59.2574	-170.3746	0	0	0	0
70m-30	87	58.7853	-170.2902	0	0	0	0
70m-30	88	58.4439	-170.1782	0	0	0	0
70m-24	89	57.9757	-169.3598	0	0	0	0
70m-12	90	57.4405	-166.5266	0	0	0	0

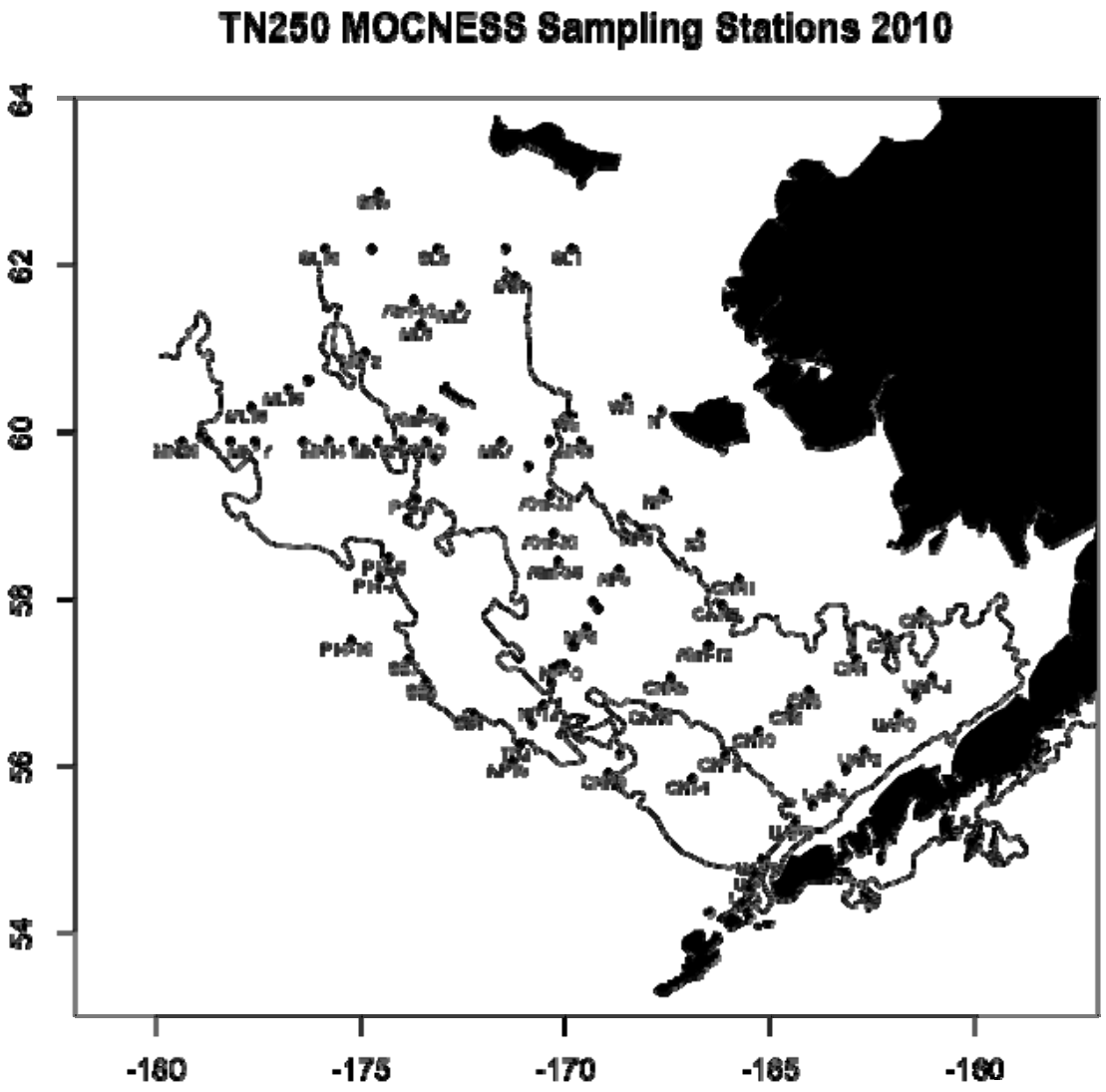


Figure 1. Map showing stations at which MOCNESS sampling was conducted during research cruise TN250 aboard R/V Thomas G. Thompson. Selected station names are plotted for orientation. The 50m, 100m, and 200m isobaths are shown.

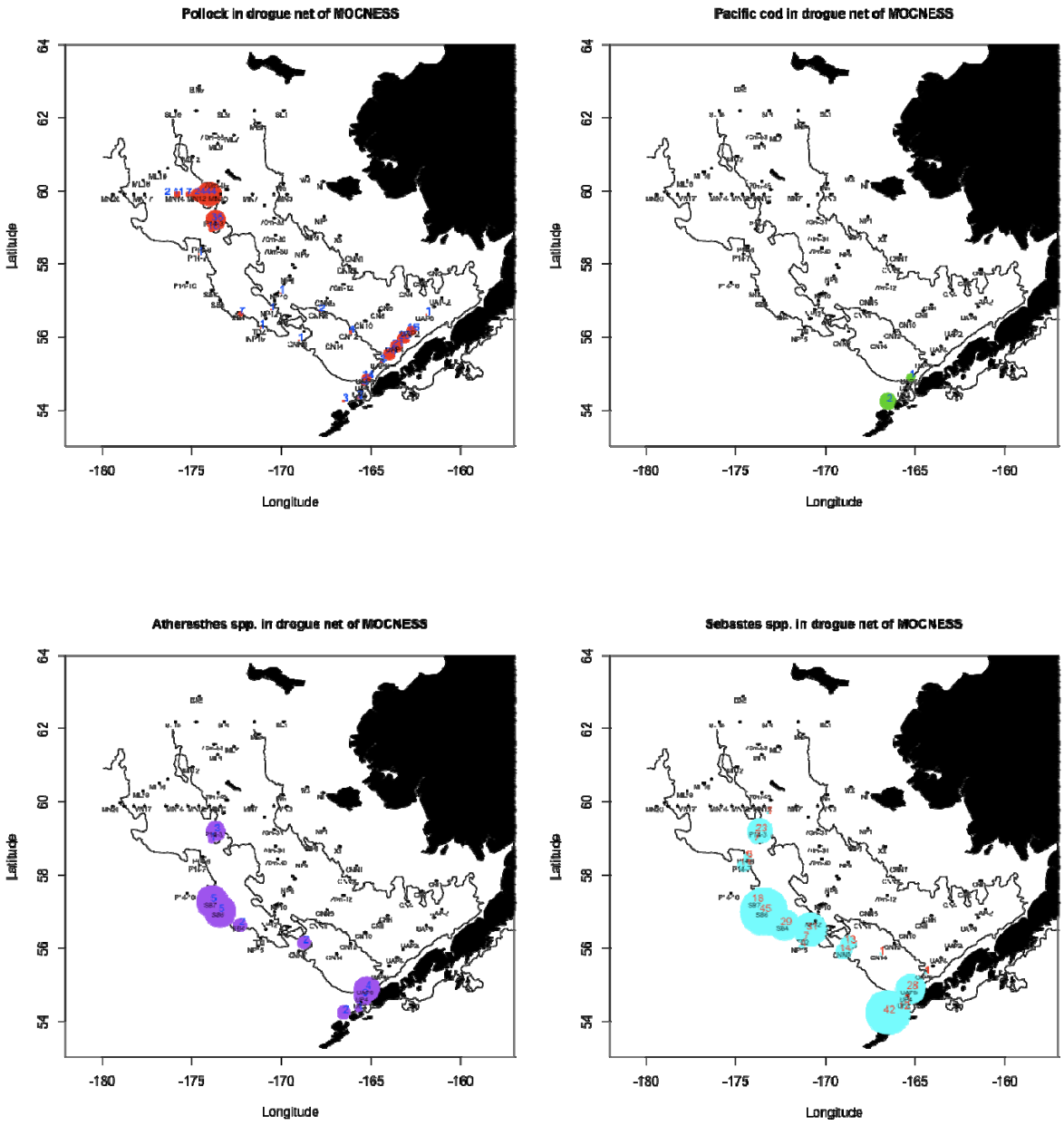


Figure 2. Maps showing preliminary counts of target taxa (walleye pollock [upper left], Pacific cod [upper right], and *Atheresthes* spp. [lower left]), and well as *Sebastes* spp. [lower right] collected in the drogue net of the MOCNESS.

Microzooplankton abundance, biomass and grazing impact on phytoplankton during summer in the eastern Bering Sea

PI: Diane Stoecker
On-board team members: Diane Stoecker and Allison Weigel

Project Objectives for cruise

1. Obtain samples for determination of microzooplankton (MZ) abundance, biomass and composition in the mixed layer and chlorophyll maximum layer (if present).

2. Estimate the grazing impact of microzooplankton on phytoplankton in the mixed and chlorophyll max layers (2 point dilution experiments).

Cruise Activities

Water samples were collected on "Prod" and some regular CTD casts from the mixed layer and/or chlorophyll maximum layer and preserved with 5% acid Lugol's solution (Table 1). Non-"Prod" cast sampling was focused on the CN, NP, MN and SL lines. The preserved samples will be shipped to Horn Point Laboratories for enumeration of the larger (>20 micron) microzooplankton (MZ) in selected samples. In addition, some 2- ml samples were observed onboard to characterize the phytoplankton and microzooplankton communities. This information will be useful in identifying MZ when the samples are counted in the laboratory and in characterizing microphytoplankton assemblages.

Microscopic observations of selected samples revealed that small phytoplankton were dominant in most mixed layer and some chlorophyll maximum samples. Large centric diatoms were only abundant in some subsurface chlorophyll maxima. *Phaeocystis* was not abundant compared to summer 2008 and summer 2009 cruises. MZ were extremely abundant in some samples, with both MZ grazers and predators common, indicating a complex microbial food web. However, in some, but not all, chlorophyll maximum samples MZ were relatively sparse.

Table 1. MZ sampling on TN250

Date	Sta	Depth
6/18/10	UAP-5	5m
		45m
6/18/10	UAP-4	20m
		30m
6-19-10	UAP-2	3m
6-19-10	CN-0	20m
6-19-10	CN-2	20m
6-19-10	CN-4	10m

6-20-10	CN-6	20m, 70m
6-20-10	CN-8	7m, 30m
6-20-10	CN-10	10m, 30m
6-20-10	CN-12	10m, 20m
6-2-/10	CN-14	10m
6/21/10	CN-16	20m, 50m
6/21/10	CN-17	3m
6/21/10	CN-20	20m
6/23/10	CNN-4	5m
6/24/10	NP-1	4m, 17m
6/24/10	NP-2	20m
6/24/10	NP-3	10m
6/24/10	NP-4	10m
6/24/10	NP-5	10m, 25m
6/24/10	NP-6	10m, 25m
6/24/10	NP-7	10m, 26m
6/25/10	NP-8	10m, 24m
6/25/10	NP-9	6m, 26-28m
6/25/10	NP-10	10m
6/25/10	NP-11	Om, 20m
6/25/10	NP-12	15m, 40m
6/25/10	NP-13	3m, 40m
6/25/10	NP-14	10m
6/26/10	TD2	4m
6/26/10	NP-15	10m, 40m
6/27/10	SB5	10m
6/27/10	SB5	4m
6/28/10	P14N-10	10m
6/30/10	70m-40	5m
7/1/10	MN-1	5m
7/1/10	MN-2	0m, 20m
7/1/10	MN-3	10m, 20m
7/1/10	MN-5	10m, 24m
7/2/10	MN-7	10m, 27m
7/2/10	MN-8	10m, 30m
7/2/10	MN-9	5m, 24m
7/2/10	MN-10	10m, 34m
7/2/10	MN-11	10m, 34m
7/2/10	MN-12	10m, 35m
7/2/10	MN-13	10m, 32m
7/3/10	MN-14	10m, 40m
7/3/10	MN-15	18m, 30m
7/3/10	MN-16	10m, 32m
7/3/10	MN-16	7m
7/3/10	MN-17	10m, 30m

7/3/10	MN-18	26m
7/3/10	MN-19	10m, 30m
7/4/10	TM 4	6m, 35m
7/5/10	ML 13	3m, 37-38m
7/6/10	ML 3	7m, 33m
7/6/10	SL-1	10m, 30m
7/6/10	SL-2	10m, 30m
7/6/10	SL-3	10m, 30m
7/6/10	SL-4	10m, 27m
7/6/10	SL-6	10m, 30m
7/7/10	SL-9	0m, 36m
7/7/10	SL-11	6m, 30m, 33m
7/7/10	SL-13	10m , 20m
7/7/10	SL-14	10m, 27m
7/7/10	SL-15	10m, 36m
7/7/10	SL-16	10m, 40m
7/8/10	BN 3	5m, 30m
7/8/10	BN 1	10m, 30m
7/8/10	70m-58	10m, 27m
7/9/10	70m-51	6m, 37m
7/9/10	70m-50	36-38m
7/9/10	70m-45	10m, 20m
7/10/10	70m-39	5m, 28m
7/10/10	70m-31	10m
7/11/10	70m-25	3m, 28m
7/11/10	70m-20	10m, 25m
7/12/10	70m-9	10m, 24m
7/12/10	70m-6	10m, 22m
7/12/10	70m-1?	

Two point dilution grazing experiments were conducted to estimate grazing rates of microzooplankton assemblages on phytoplankton. Water was prescreened thru a 200 micron mesh to remove mesozooplankton. Water for experiments was usually collected in the mixed layer (ML) at the depth corresponding to 55% surface irradiance (55% I_o) and the triplicate bottles screened to mimic this light level and incubated on deck at close to ambient sea surface temperatures. Usually we ran parallel incubations without (-) and with (N+P) addition of nutrients (5 micromoles N as $NaNO_3$ & 0.3 micromoles of P as Na_2HPO_4). In several experiments, we did incubations of water from the mixed layer and from the chlorophyll maximum layer (CM). ML experiments correspond to sample depths $\leq$10m in Table 2. CM experiments corresponded to sample depths between 26 and 35m (Table 2). No nutrients were

added to ML vs. CM experiments. We also ran experiments to test for the effects of dense or dying blooms on the quality of dilution water for phytoplankton growth (data not shown)

Preliminary results are shown in Table 2. Microzooplankton grazing coefficients in the ML ranged from ~0 to 0.95 d^{-1} with an average for the no added nutrients treatments of 0.27 d^{-1}. In 7 of 20 ML experiments without added nutrients, grazing coefficients exceeded estimated phytoplankton growth at 55% I_o. In 75% of the ML experiments, grazing accounted for 50% or more of estimated phytoplankton growth. In some ML experiments, addition of N and P stimulated phytoplankton growth, but not necessarily microzooplankton grazing; nutrient addition appeared to inhibit grazing in some experiments**.** MZ grazing was important in the CM layer, with an average grazing coefficient of 0.28 d^{-1}.

Table 2. Summary of Dilution Experiments, preliminary data:

Exp	Date	Sta	Water Temp (°C)	Sample Depth (m)	<200 µm Chl. (µg/l)	<200 µm Chl (%<20 µm)	Nutrient addition	Grazing coeff. (g/d)
1	6/18/2010	UAP-5	5.4	5	0.90	78	-	0.19
2	6/19/2010	UAP-2	4.2	3	0.59	94	-	0.02
							N+P	0.09
3	6/20/2010	CN 8	3.7	7	0.32	90	-	0.30
							N+P	0.22
4	6/21/2010	CN 17	3.8	3	0.96	76	-	0.41
							N+P	0.32
5	6/23/2010	CNN 4	2.8	5	0.63	63	-	0.19
							N+P	0.01
6	6/24/2010	NP 1	3.2	4	0.28	73	-	0.22
							N+P	0.25
7	6/25/2010	NP 9	4	6	0.13	85	-	0.31
			3*	26	0.49	86	-	0.29
8	6/26/2010	TD2	6	4	.97	77	-	0.24
							N+P	0.45
9	6/27/2010	SB5	5	4	1.14	>99	-	0.26
							N+P	0.14

10	6/28/2010	P14N-10	6	10	0.50	>99	-	0.29
							N+P	0.33
11	6/29/2010	TR3	6.4	5	0.44	89	-	0.32
							N+P	0.27
12	6/30/10	70m-40	4.6	**5**	.14	81	-	0.13
							N+P	0.42
13	7/1/10	MN-1	3.5	5	0.63	73	-	0.20
							N+P	0.15
14	7/2/10	MN-9	5.3	5	0.13	98	-	0.33
							N+P	0.14
15	7/3/10	MN-16	5.5	7	0.12	85	-	0.26
							N+P	0.23
16	7/3/10	MN-18	1.5**	26	1.21	81	-	0.18
17	7/4/10	TM4	1.5**	35	0.65	92	-	0.15
18	7/5/10	ML-13	6.2	3	0.11	68	-	0.08
			-1.0***	35	5.36	32	-	0.14
19	7/6/10	ML-3	5.4	7	0.10	67	-	~0
20	7/7/10	SL-11	5.8	6	0.30	44	-	0.95
			-1.0***	33	1.08		-	0.07
21	7/8/10	BN-3	5.8	5	0.10	78	-	0.31
			-1***	30	0.85	86	-	0.21
22	7/9/10	70m-51	6.1	6	0.18	93	-	0.40
23	7/10/10	70m-39	6.1	5	INC			
			-1***	28				
24	7/11/10	70m-25	6.8	3	INC			
			-1***	28				

***incubated at 55% I_o on deck**
****incubated in cold room (~4^o C) in dark**
*****incubated on ice in dark**
INC-sample and data analyses incomplete to date.

North Pacific Pelagic Seabird Observer Program

PIs: Kathy Kuletz and David Irons (USFWS)
On-board team members: Brian Hoover, Sarah Jennings

The 2010 Summer BEST II cruise departed from Dutch Harbor on July 16th and arrived back at Dutch Harbor on July 13th, constituting 26 full days at sea. Seabird surveys began on June 17th, and continued until the morning of July 13th. Our primary objectives were to identify seabird species at sea, and to document their abundance and behavior patterns. The study area encompassed regions within the central, eastern, and northern Bering Sea. Several distinct habitats were surveyed during the cruise, such as Unimak Pass, Bristol Bay, the 300m shelf break, and coastal areas surrounding St. Lawrence, St. Matthews, and the Pribilof Islands.

Seabird surveys were only conducted while the vessel was moving, typically when transiting between oceanographic stations. We used strip-transect methodology. A trained observer surveyed from the port side bridge, and recorded seabirds sighted within 300 meters and within a 90° arc. All birds and marine mammals observed on the water were recorded, while flying birds were only counted during timed intervals in a "snapshot" fashion. We recorded observations into 100-meter distance bins, and also noted their number and behavior (water, scan, flying, foraging, on ice) for each record. Rare birds or large flocks that were sighted outside the 300m detection threshold were recorded as "Bin 9" sightings. Seabirds were identified to species whenever possible, or to the lowest taxonomic resolution. Albatross were specifically recorded in a distance-sampling format, with their distance and angle from the boat recorded at the time of first sighting.

Environmental criteria such as sea state, glare, ice cover and cloud cover are continually recorded while surveying, and surveys are paused during heavy fog or snow. Sightings are recorded into a GPS-integrated laptop using the survey software program DLog3.

Results

- 137 total surveys
- 153.2 hours surveyed

On average, we conducted 5.3 surveys a day, comprising 5.8 total hours/day. Surveys were typically attempted between 800 and 2300 (AST), but the regimented cruise schedule and

inclement weather limited surveys to an opportunistic basis. We were unable to survey for two separate days (June 21, 25) while we remained stationary at oceanographic stations during daylight hours. We were also unable to survey during several occasions when dense fog hampered visibility conditions, sometimes lasting for hours (or days!).

Seabird abundance is presented in Table 1. Dark shearwater *spp.* represent the majority of birds sighted (49%), as these species occur in large feeding aggregations of several thousand individuals. Shearwater sightings were spatially clustered, however, and were only observed in 12% of all transects surveyed. Large foraging flocks of shearwaters were particularly noted near Unimak Pass and in northern Bristol Bay. Murre *spp.* and kittiwake *spp.* were also frequently observed and are BSIERP species of interest, as they breed colonially in the Bering Sea and are common predators of euphausiids and juvenile fish. Both species were recorded throughout the study area, although murres were less frequently observed along the shelf break, and were recorded at highest densities near islands and nearshore habitats.

Several rare or unusual seabird species were recorded. Twenty Laysan Albatross (*Phoebastria immutabilis*), one Black-footed Albatross (*Phoebastria nigripes*), and two juvenile Short-tailed Albatross (*Phoebastria albatrus)* were observed during the cruise. Albatross were typically sighted along deep-water shelf breaks, and both Short-tailed Albatross sightings occurred south of Pribilof Canyon along the 300m break. Other unusual sightings included two Mottled Petrels (*Pterodroma inexpectada*) northwest of St. Paul, and a single Dovekie (*Alle alle*) sighted within 5 miles of St. Matthews Island on July 9th.

Marine mammals were also recorded during surveys. While we never encountered sea ice, an immature or female walrus was observed on June 29th near St. Matthew Island, and several Ringed Seals were also seen in the area. A solitary sea otter was observed on June 19th in northern Bristol Bay. The majority of large whales sighted were Fin or Humpback Whales, however a probable Blue Whale was observed on June 17th north of Unimak Pass. The largest concentration of whales observed was 9-15 Fin Whales over Zhoudang Canyon, although we were not actively surveying at the time and these individuals were not recorded in our survey data.

There were few noteworthy incidents. Light gale conditions on June 21 created sea states of Beaufort 5-6, and surveying was halted when it became too difficult to detect birds on the water. The weather was otherwise flat and overcast most days, providing reasonable survey conditions.

On July 9th, the NOAA vessel Oscar Dyson passed within 3 miles of the Thompson, just east of St. Matthews. As the Dyson also carried a bird observer team, overlapping surveys may cause problems if both survey teams recorded the same birds. Double-counting is unlikely, however, as the boats were a reasonable distance apart.

Table 1: Seabird Count

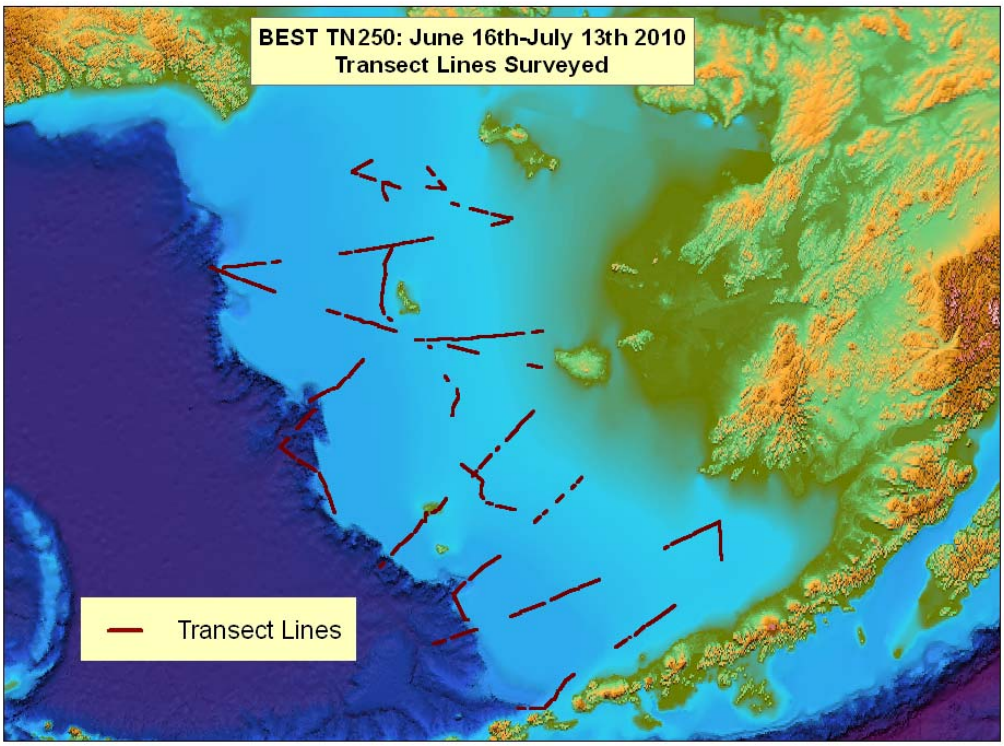
Species	within 300m	% total	Bin 9
Black-footed Albatross	0	*0*	*1*
Laysan Albatross	7	*<0.1*	*13*
Short-tailed Albatross	1	*<0.1*	*1*
Short-tailed Shearwater	740	*6.9*	
Sooty Shearwater	2	*<0.1*	
Unknown dark Shearwater	4542	*42.2*	*10134*
Northern Fulmar	1435	*13.3*	*415*
Fork-tailed Storm Petrel	677	*6.3*	*87*
Leach's Storm-Petrel	2	*<0.1*	
Mottled Petrel	1	*<0.1*	*1*
Pelagic Red-faced Cormorant	0	*0*	*1*
Pelagic Cormorant	5	*<0.1*	
Arctic Tern	3	*<0.1*	
Unknown Tern	5	*<0.1*	
Long-tailed Jaeger	1	*<0.1*	*12*
Parasitic Jaeger	3	*<0.1*	*1*
Pomarine Jaeger	2	*<0.1*	
Unknown Jaeger	3	*<0.1*	
Red-legged Kittiwake	46	*0.4*	*2*
Black-legged Kittiwake	325	*3.0*	
Herring Gull	2	*<0.1*	
Slaty-backed Gull	1	*<0.1*	
Glaucous Gull	3	*<0.1*	
Glaucous-winged Gull	5	*<0.1*	
Unknown Gull	2	*<0.1*	
Ancient Murrelet	15	*0.1*	
Brachyramphus Murrelet	1	*<0.1*	
Cassin's Auklet	1	*<0.1*	
Crested Auklet	13	*<0.1*	*25*
Least Auklet	115	*1.1*	
Parakeet Auklet	80	*0.7*	*10*
Unknown Small Dark Alcid	6	*<0.1*	
Dovekie	0	*0*	*1*
Pigeon Guillemot	7	*<0.1*	*3*
Thick-billed Murre	1503	*14.0*	*16*

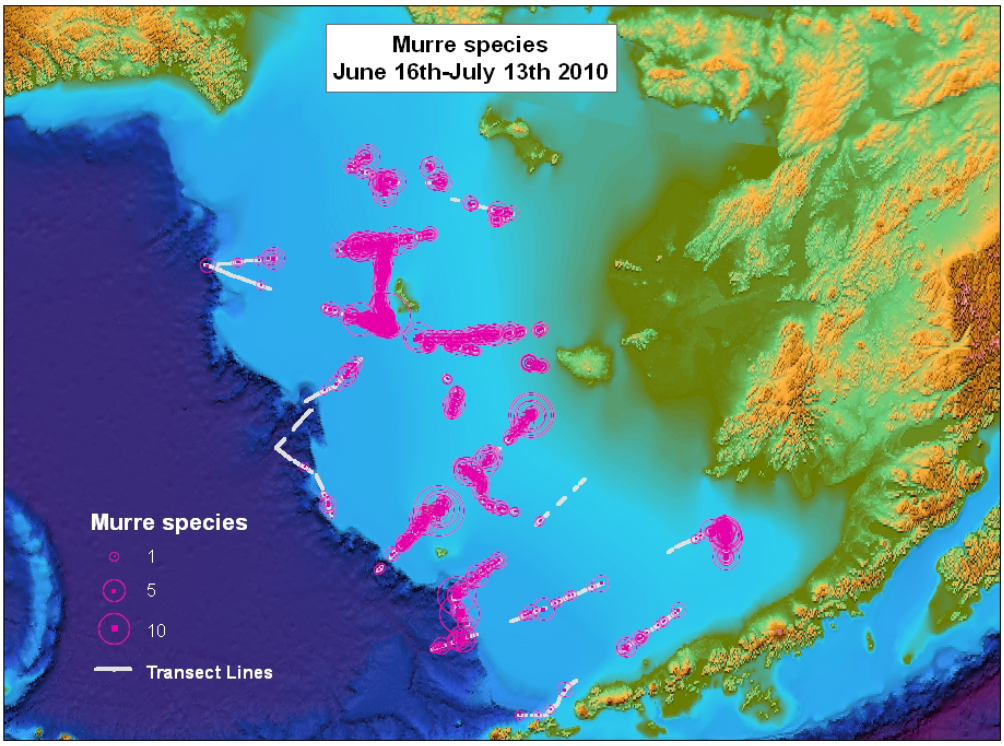
Common Murre	623	*5.8*	
Unknown Murre	207	*1.9*	
Tufted Puffin	222	*2.1*	
Horned Puffin	62	*0.6*	
Red-necked Phalarope	1	*<0.1*	
Red Phalarope	89	*0.8*	*11*
Harlequin Duck	4	*<0.1*	
Unknown Eider	4	*<0.1*	
TOTAL	**10767**	***100%***	***10735***

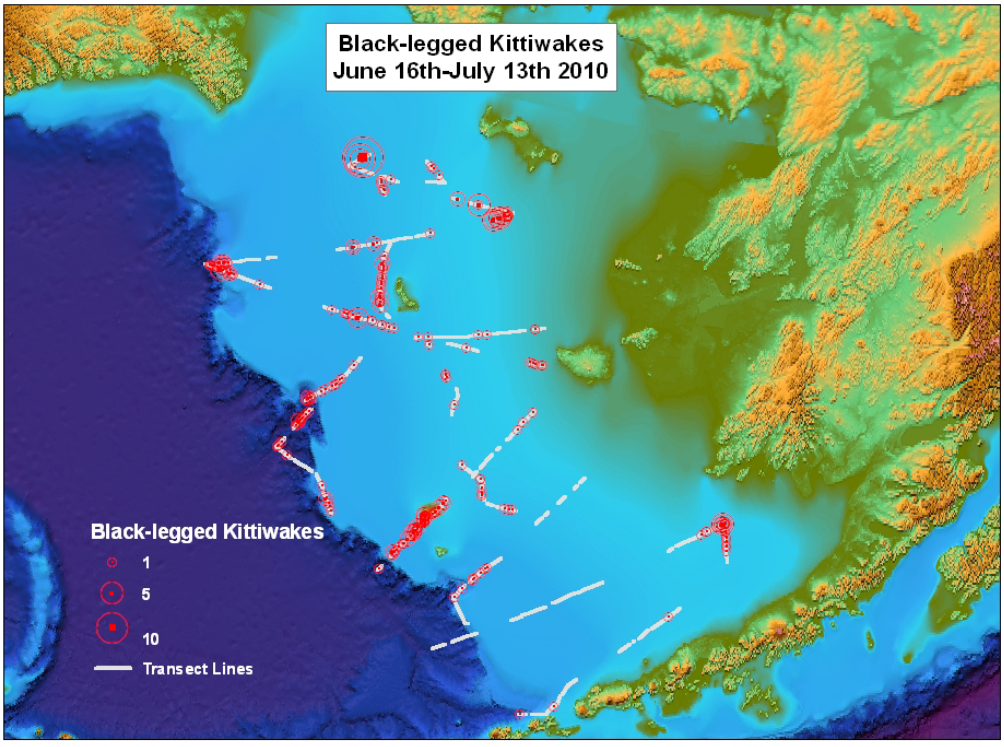
Table 2: Marine Mammal Count

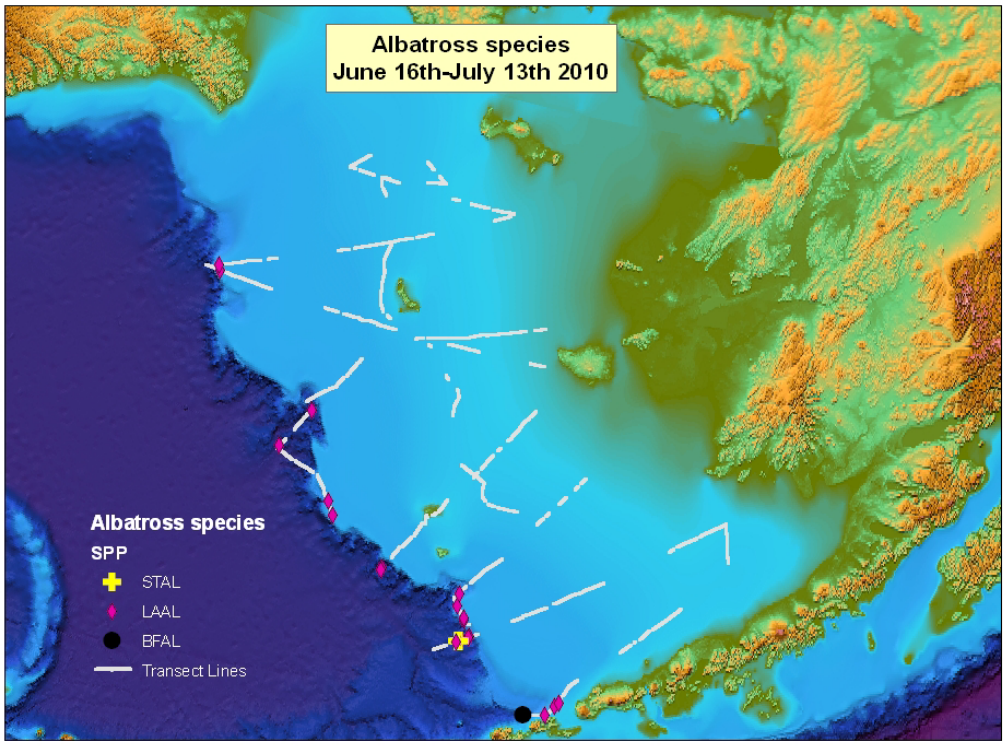
Species	Within 300m	Total %	Bin 9
Humpback Whale	2	6.3	7
Minke Whale	3	9.4	
Fin Whale			7
Unknown Whale	4	12.5	8
Dall's Porpoise	16	50	33
Unknown Porpoise	1	3.1	2
Northern Fur Seal	3	9.4	4
Ringed Seal	1	3.1	
Unknown Pinniped	1	3.1	
Sea Otter			1
Unknown Marine Mammal	1	3.1	
TOTAL	**32**	**100%**	**62**

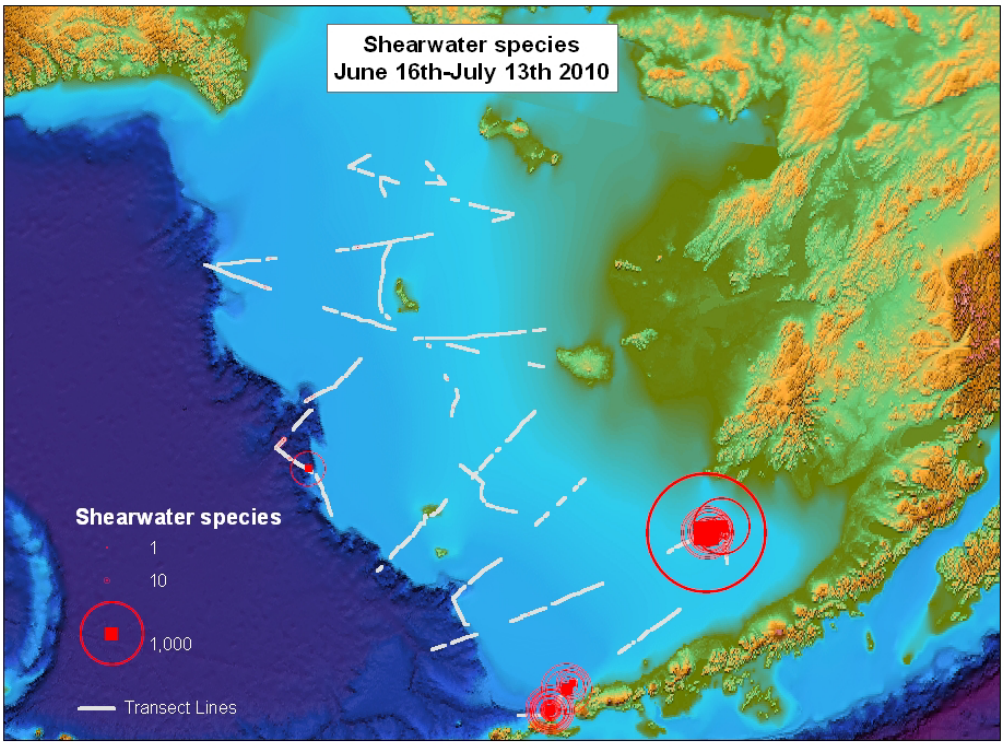
Figures. The following figures illustrate the regions surveyed, and the observed abundance of the major bird and marine mammal species.

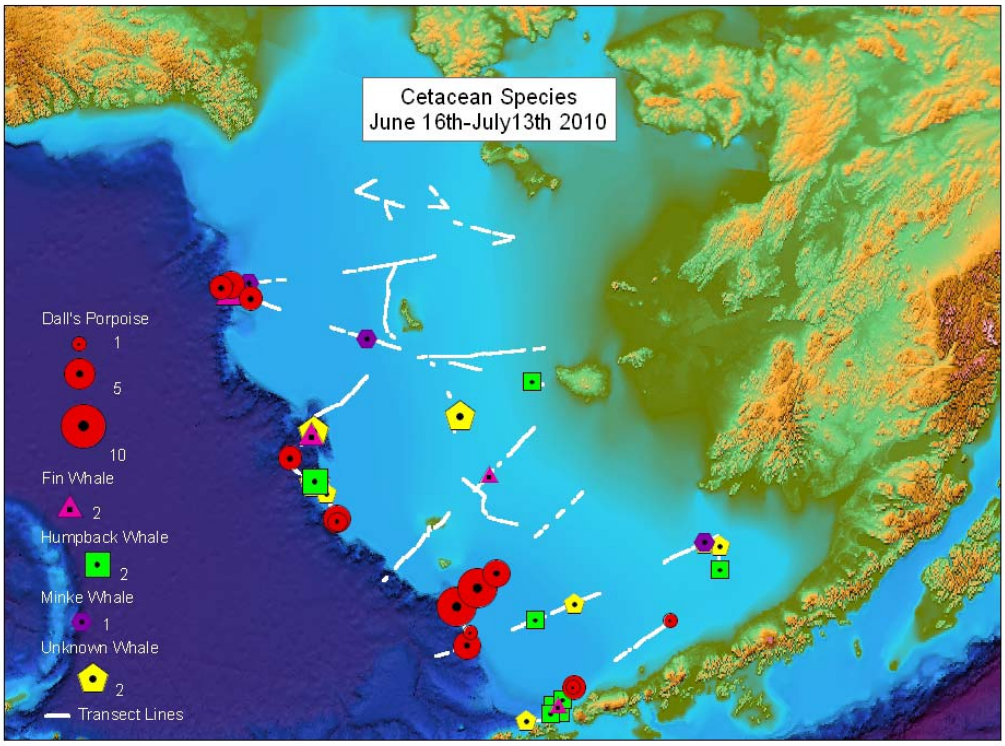


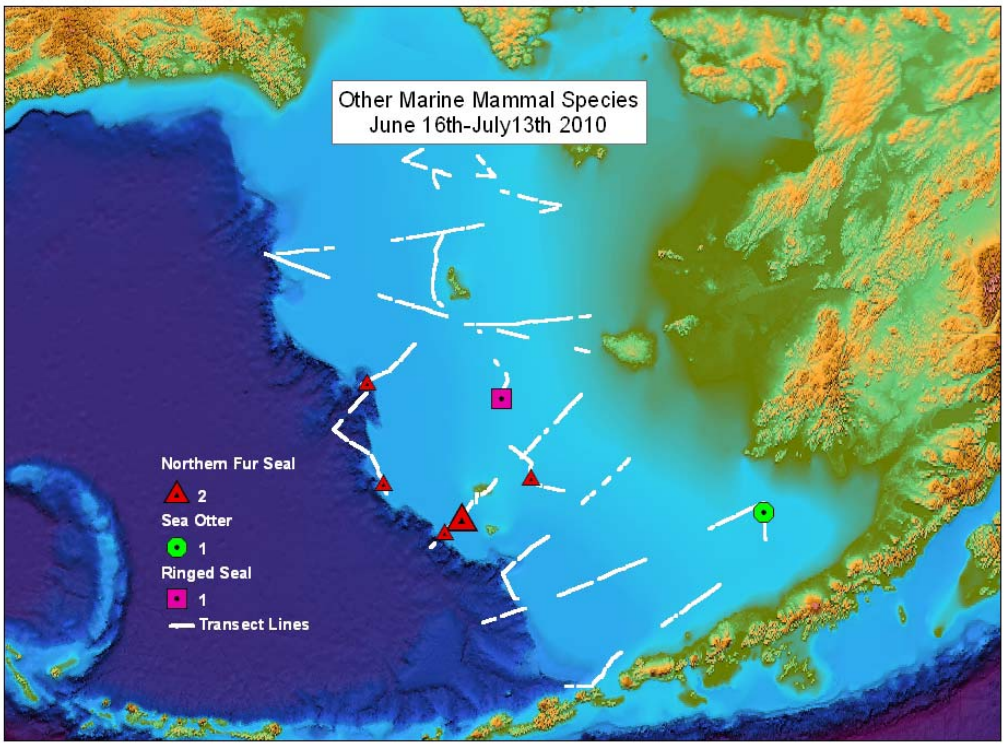

Murre species
June 16th-July 13th 2010
Murre species
1
5
10
Transect Lines


Black-legged Kittiwakes
June 16th-July 13th 2010
Black-legged Kittiwakes
1
5
10
Transect Lines


Albatross species
June 16th-July 13th 2010
Albatross species
SPP
STAL
LAAL
BFAL
Transect Lines


Shearwater species
June 16th-July 13th 2010
Shearwater species
1
10
1,000
Transect Lines


Cetacean Species
June 16th-July13th 2010
Dall's Porpoise
1
5
10
Fin Whale
2
Humpback Whale
2
Minke Whale
1
Unknown Whale
2
Transect Lines


Other Marine Mammal Species
June 16th-July13th 2010
Northern Fur Seal
2
Sea Otter
1
Ringed Seal
1
Transect Lines

Bering Ecosystem Study Data Management Support

PIs: Jim Moore, Greg Stossmeister, Steve Williams (NCAR/EOL)

On-board team member: John Wasinger

The online field catalog and Mapserver were installed and run aboard ship, accessible via the internal ship network. Archives of previous BEST cruises were available for easy reference and station/track comparison. Both systems were built for continued operations during TN250. The catalog included the event log, reports and plans, underway plots from ship data and preliminary CTD transect plots from PMEL personnel, CTD data files and logsheets from the ship and PMEL, and data downloaded from the Internet including satellite images and ice and weather forecasts. The event log contains a record of all science events during the cruise. The mapserver displayed real-time ship data, including the track, fluorescence, sea surface temperature, and salinity.

During the cruise, Wasinger spent the majority of his time reprocessing CTD data that he found to be incorrect. Reprocessing involved internal file name changes and file renames prior to re-rendering of the plots and log PDFs. He wrote an application to generate a rainbow spectrum to be used when scale range changes were requested to fluorescence, temperature, and nitrate track plots. The source code for this application is ~/bin/tools/spectrum_map.cc. He fixed a bug in the automation process that provides satellite chlorophyll-a overlays. These overlays were spectrally rendered in a logarithmic scale. The received fluorescence that should match the Chlorophyll-a was rendered in a linear scale. Since fluorescence is a raw measured value we decided to leave it displayed as such. Bird observation, nutrient, and bottle file xls spreadsheets were collected as well as paper copies of the ships log. The 'Sea Surface Temperature Entry' sensor was in inadvertently disconnected from Saint Paul Island till the start of the Benthos Nitrate line.

The full catalog will be hosted at NCAR/EOL:
http://catalog.eol.ucar.edu/best_tn250

NCAR/EOL will also host the full suite of mapserver plots:
http://mapserver.eol.ucar.edu/bestcruises

Appendix A. Science Party

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Appendix B. R/V Thomas G Thompson crew

Name	Title
John Wilson	Master
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Eric Haroldson	2nd Mate
David Vanderhoek	3rd Mate
Pamela Blusk	AB
Dana Africa	AB
Zeke Machado	AB
Frank Spetla	AB
Michael Hansen	AB
Matthew Ursin	AB
Kyle Piety	OS
Paul Morrissey	Chief Engineer
James Swanton	1st Asst. Engineer
Christina Agular	2nd Asst. Engineer
Dominic Castner	3rd Asst. Engineer
Nick Ridgeway	3rd Asst. Engineer (extra)
Craig Sandvigen	Oiler
Chris Schneider	Oiler
Russel Rowley	Oiler
Larry Nelson	Wiper
Dan McBriar	Chief Steward
Steve Sniezak	2nd Cook
Terrence Singerline	Mess Attendant