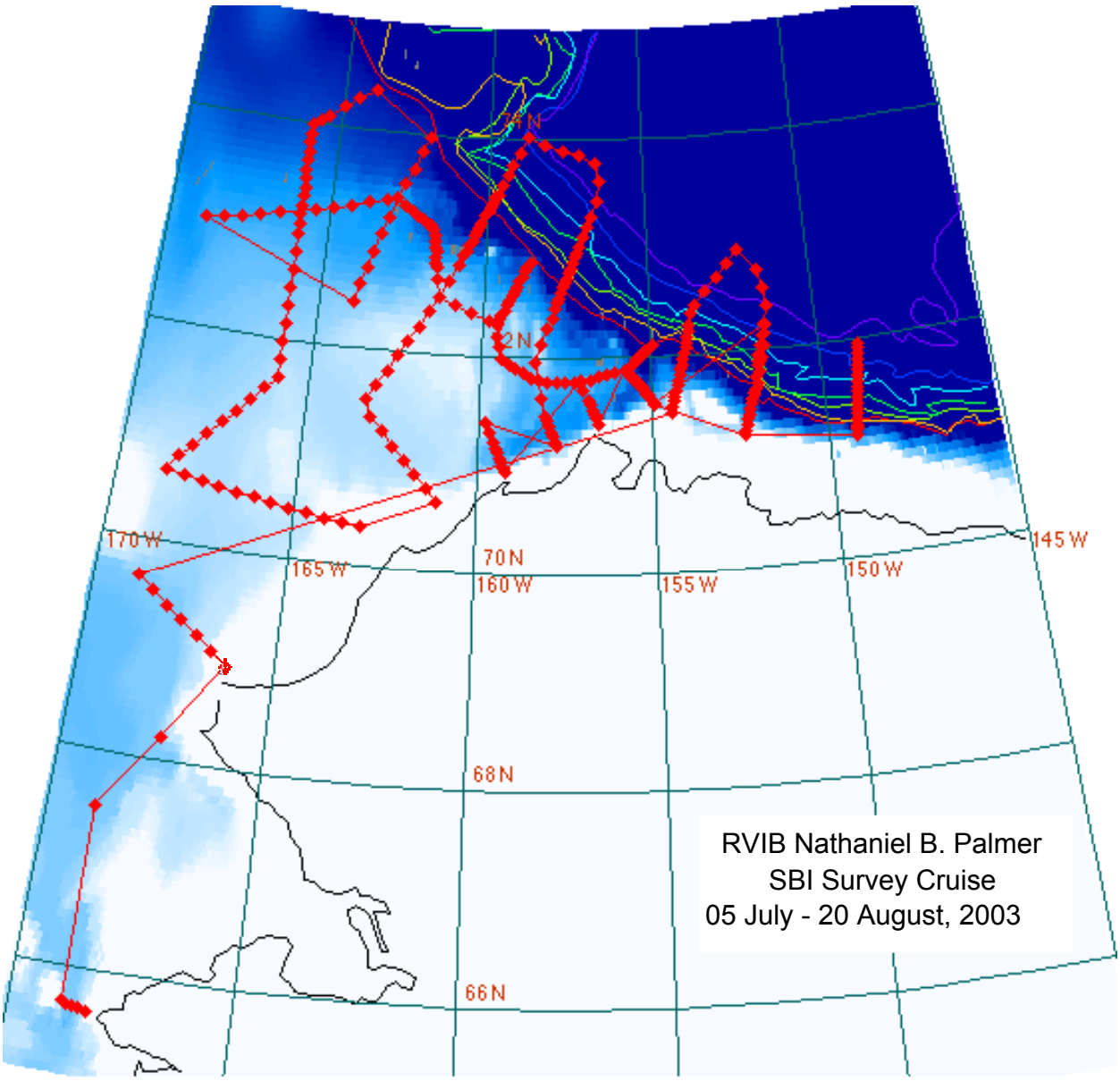
Cruise Report - SBI Survey Cruise
RVIB Nathaniel B. Palmer
05 July - 20 August 2003
Dutch Harbor to Barrow, Alaska



Map caption: A colored line joins consecutive stations. From it one may discern that two sections of stations were repeated during the cruise, one near the mouth of Barrow Canyon and the other on the section near 152°W. The shaded bathymetry is drawn from the ETOPO-5 bathymetric database with blue shading chosen to emphasize bottom depth variations nonlinearly between 35 and 500 meters. The coastline and colored isobaths - 500, 1000, 1500, 2000, 2500, 3000, and 3500 meters - were taken from the isobath database prepared by Professor Joseph Reid, UCSD/SIO.

Purpose of the Cruise

The Arctic Shelf-Basin Interactions (SBI) project focuses on shelf, shelf break and upper slope water mass and ecosystem modifications, material fluxes and biogeochemical cycles on the outer shelf and slope of Chukchi and Beaufort seas. This is the region where it is believed that key processes control water mass exchange and biogeochemical cycles, and where the greatest responses to climate changes are expected to occur. The primary scientific goal of the SBI 2003 Survey cruise was to carry out a CTD/lADCP/O_2/nutrient/chl-a survey of the US SBI Phase 2 Field Program study region. It was planned that the survey include high-resolution sections across key regions, cover the entire SBI study area more comprehensively than feasible during other SBI cruises, and repeat one or more of the intensely-sampled sections during the cruise. The cruise was one of eight during 2002-2004 planned for the Western Arctic Shelf-Basin Interactions Phase II Field Program (SBI), and was intended to be the only survey-type cruise of that program.

Note:

CTD	Conductivity/Temperature/'Depth'(pressure) measurement device
lADCP	lowered Acoustic Doppler Current Profiler
O_2	dissolved oxygen
nutrient	silicate, phosphate, nitrate, nitrite, ammonia, urea
chl-a	chlorophyll-a and other related phyto pigments

Pre-Cruise Advisory Planning

Prior to the cruise the SBI Advisory Committee issued the following priorities for the cruise:

1. Occupation of the four shelf-basin sections made during the 2002 process cruises, with close station spacing in the bathymetric zones sampled closely during the 2002 mooring cruise.

2. Reoccupation during the survey cruise (two occupations during the cruise) of as many of the four 2002 shelf-basin sections as feasible. Close spacing on the second occupation if feasible.

3. Occupation of cross-canyon Barrow Canyon sections, including reoccupation during the cruise.

4. Occupation of SBI stations and lines from Bering Strait to just north of 70°N.

5. Occupation of a Beaufort shelf-slope section east of the 2002 sections.

6. Occupation of a meridional section in the western portion of the SBI study area along the longitude where the 2002 mooring cruise carried out a high-resolution section.

7. If time, extending sections, for example extending the shelf-basin sections deeper into the Arctic Ocean interior than was possible in 2002.

The SBI Advisory Committee set lower priority to (a) carrying out a meridional section on the far west boundary of the SBI study area (e.g., just east of the treaty line), or (b) carrying out a section along the northern boundary of the SBI study area.

The SBI Science Team chose early/mid-June through July 2003 as the optimum time for the SBI survey cruise, based on overall SBI objectives. The SBI Survey cruise was scheduled on the Antarctic research vessel Nathaniel B. Palmer due to a lack of availability of suitable Arctic-based icebreaking vessels in that time frame. Consultants advised NSF and ECO regarding the ship's ice capabilities versus expected early-mid summer ice conditions in the SBI study region. Their advice was to delay the cruise somewhat to a time with more open areas and larger leads, specifically more navigation room around multi-year floes and chunks.

Acknowledgements

All hands, whether from Edison Chouest Offshore, Raytheon Polar Services, or the nine institutions comprising the scientific party, showed outstanding teamwork and professionalism, working together superbly to bring about this achievement. It is a pleasure to acknowledge and thank the National Science Foundation Office of Polar Programs, not only for the fiscal and logistics support which made this expedition possible, but equally for the continuing advice and encouragement received from our program managers.

If one person were to be singled out for praise - among the many who deserve praise - it would be nutrient analyst Susan Becker (UCSD/SIO). Not only did she cope with a higher daily sample load than usual (the cruise was planned for two nutrient analysts but one was unable to participate), and accomplish this with a 6-channel autoanalyzer significantly more complex and troublesome than the usual 4-channel machine, but she did this while maintaining a standard of data quality that was second to none, period. All on board were continually impressed with her dedication, perseverance, and expertise.

Science Team Personnel

Bruce Andrews	Prism Helicopters	helicopter pilot
Bob Anthony	Prism Helicopters	helicopter mechanic
Craig Aumack	UofTexas	CTD operator, stable isotopes (student)
Susan Becker	UCSD/SIO	nutrient analyst
John Bengtson	NOAA	marine mammal studies

Marie-Claude Beaupre	UCSD/SIO	data processing, chemistry
Jerry Bucher	RPSC	electronics technician
John Calderwood	UCSD/SIO	oxygen analyses, marine/electronics tech
Mike Cameron	NOAA	marine mammal studies
Emily Constantine	RPSC	marine technician
Jesse Doren	RPSC	marine technician
Paul Ellis	UCSD/SIO	oxygen analyses, marine tech
Brent Evers	RPSC	electronics technincian
Kathleen Gavahan	RPSC	computer/network technician
Eric Hutt	RPSC	marine science technician
Eric Johnson	Earth & Space Resources	CTD operator, lowered ADCP
Luther Leavitt, Jr.	Barrow, AK	community participant
Leopoldo Llinàs	UofMiami	CTD operator, plankton tows (student)
Jeremy Mathis	UofMiami	CTD operator, particulate and dissolved organic matter (student)
Charles Menadelook	Little Diomede, AK	community participant
Stephanie Moreland	UofAlaska	pigments
Karl Newyear	RPSC	Marine Projects Coordinator
Robert Palomares	UCSD/SIO	electronic technician, salinity analyes
Jim Rogers	Polson School District, Polson, Montana	Teachers Experiencing the Arctic and Antarctic, sample cop
Kristin Sanborn	UCSD/SIO	data processing
Heather Smith	UofWashington	marine mammal studies (student)
Dean Stockwell	UofAlaska	pigments
James Swift	UCSD/SIO	Chief Scientist
Jim Waters	RPSC	computer/network technician
Jenny White	RPSC	marine technician

Edison Chouest Offshore Personnel

Joe Borkowski III	Captain
Vladimir Repin	Ice Consultant / Navigator
Mike Watson	Chief Mate
Jay Bouzigard	2nd Mate
Robert Potter	3rd Mate
Dave Munroe	Chief Engineer
Johnny Pierce	Chief Engineer
Robert Morris	1st Engineer
Edward Forbes	2nd Engineer
Gerald Tompsett	2nd Engineer
Fredy Dela Cruz	3rd Engineer

Victor Maskey	Oiler
Rolly Rogando	Oiler
Doyle Lee	Oiler
David Cooley	Oiler
Tim Kennedy	Cadet
Ric Tamayo	Deck / Winch Operator
Enrque Alvezo	Deck / Winch Operator
Danilo Plaza	Deck / Winch Operator
Ronald Mack	Deck
Marcelo Mera	Deck
Lorenzo Sandoval	Deck
George Rayford	Deck
Ernest Stelly	Chief Steward
Mark Stone	Chief Steward
Jody Keown	Galleyhand
Alejandra Monje	Galleyhand

Narrative

Most SBI equipment was loaded during the Palmer's pre-cruise port stop in Honolulu, although items were also loaded in Dutch Harbor, Alaska. All members of the scientific party reached the Palmer in Dutch Harbor before departure on 05 July, although many of the group experienced air travel delays of one or two days due to flight cancellations (low ceilings at Dutch Harbor), and so the vessel's departure was delayed about eight hours - into the early evening - to allow those who finally made flights that day to join the ship.

The ship departed Dutch Harbor in excellent weather, and the weather remained excellent during the two and one half day run north to Nome, Alaska. During that time the science party carried out safety and emergency training, brought equipment to final readiness, organized the watch teams, and carried out a CTD/rosette wet test cast. In Nome the Palmer was joined by the helicopter, pilot, and mechanic who were intended to support ice reconnaissance, a marine mammal observation program, and ferrying the science party ashore at the end of the cruise.

The SBI science program began early on the morning of 09 July with a five-station CTD/hydrographic section across US waters in Bering Strait. The stations went well, the only problem of note being a hydraulic failure on the starboard A-frame which cancelled the first of three planned bongo net tows on the section, but that program was soon back in action. Ceilings lowered and fog increased late that morning, making weather unsuitable for flying, so friends of Community Participant Charles Menadelook brought him out to the ship by small boat from his home on Little Diomede Island, after which the Palmer began its steam north to the primary SBI study region over the shelf-slope-basin transition zone.

On 09 July 2003 at 1934 Alaska Time the distinguished Antarctic research vessel RVIB Nathaniel B. Palmer crossed 66 deg 33 min North Latitude, and thus became, for at least one cruise, an Arctic research vessel. One short section across US waters in the southern Chukchi Sea and two other stations were completed during the steam north.

The first high resolution CTD/hydrographic section across the Alaskan continental slope and into the Arctic Ocean interior northeast of Barrow began on 12 July. Stations were only 3 miles apart for much of the section. This provided a finely detailed, coherent view of the variations across the shelf and continental slope. Over the slope concentrations of chlorophyll and dissolved oxygen were high in the biologically active layer and there were strong lateral gradients in nutrients, with appreciable concentrations of nitrite, ammonia, and urea. This contrasted with the basin interior, where the concentrations of these nutrients were very low. There, the underside of the sea ice appeared relatively clean, contributing to the impression of reduced biological activity in the upper layer, compared to the slope region.

Because this was first penetration of the Arctic ice pack by the Palmer, there was much interest in the ship's performance. As it turned out, the ice was mostly broken and loose, with many leads and sometimes considerable areas of open water. Hence the Palmer very rarely experienced any significant impediments to progress, both during this first section and later during the expedition. Ice performance forecasts provided pre-cruise had been based largely on a 1983 statistical compilation. It is the Chief Scientist's opinion that there may have been in the last few years a change in the character of the ice cover on this region from a permanent, multi-year pack ice cover to a more nearly seasonal ice cover, dominated almost to exclusion by first-year ice. This is based, however, on anecdotes from recent cruises and local observers, and even if it is the case, it may represent an anomaly rather than a trend.

The ship returned to the shelf along a second high-resolution section. Both sections were east of Barrow Canyon, the principal bathymetric cut from the deep ocean into the Chukchi shelf in US waters. Because both shelf-basin sections showed a narrow band of high-oxygen water throughout most of the water column, sited over the same isobath, and because other measured characteristics were also distinctive in this zone, this heightened interest in the subsequent oceanographic survey of Barrow Canyon with four high-resolution cross-canyon sections. The first was across the mouth of the canyon, and the second, occupied one tidal cycle later, was approximately 50 km up-canyon, with the other two sections each an additional 50 km up-canyon. Indeed, these proved to be interesting sections from an oceanographic standpoint, each clearly exhibiting zones of water similar to the distinctive waters seen a few days earlier over the Beaufort Slope, the inference being that all six sections had crossed the core of the 2003 version of the Barrow Canyon early summer outflow. There were also hints that the canyon sections crossed shelf outflow water entering the upper reaches of Barrow Canyon on the west side, and then being pushed over to the east side (by rotational effects).

Flying weather had for the most part not been favorable during the first two shelf-basin transects, but near the end of the second transect a change of weather provided fine flying conditions. The marine mammal group completed seven aerial surveys with the helicopter over ice habitats in the basin and shelf zones. They encountered low densities of ringed and bearded seals, with higher densities of bearded seals over the shelf in the marginal ice zone. They also observed numerous groups of walrus at the ice edge, and spotted beluga whales near the shelf slope. Then the weather turned foggy again.

The original plan had been to set Charles Menadelook off at Barrow after 3-5 days aboard but it was not convenient to do so at the time and thus he was aboard 9 days. Finally good flying conditions coincided with proximity to Barrow, and the helicopter flew him ashore and returned with Community Participant Luther Leavitt, Jr., from Barrow. The Palmer was just offshore of Barrow at the same time that the Sir Wilfrid Laurier was disembarking a science party including Jackie Grebmeier of the SBI Advisory Committee.

Meanwhile, after a short crossing of the shelf near Barrow Canyon, the cruise continued with another pair of high-resolution shelf-slope-basin sections, this time west of Barrow Canyon, first doing the eastern member of the pair and then the western section. As the of this section pair progressed and the daily data updates were assembled, it became clear that on the eastern section a trio of eddies had been crossed, two of which had distinctive halocline cold, high-oxygen cores.

It is worthwhile mentioning that the LADCP program had been off to a slow start on this cruise regarding interpretation due to problems with the software used to process the data. But about the time the first of the west-of-Barrow-Canyon sections were being run, LADCP plots were coming available. These showed a velocity structure to the eddies which extended laterally well past the cold-core signature. In fact, some of the highest velocities were in an outer layer which was high in nutrients and low on oxygen, giving rise to speculation that the core and edge waters had split from a source region as a unit.

On the first of the western pair of sections there were no obvious signs of upper slope water property structures similar to those that had led to the Barrow Canyon outflow, i.e. there were at first no obvious signatures of a similar outflow from Herald Valley, a canyon in the shelf nominally upstream from the section. There was then a growing realization that while this was true, there had been a second distinctive water type in Barrow Canyon on its west side, low in oxygen and high in nutrients. This water was not seen on the eastern member of the pair of shelf-slope-basin sections west of Barrow Canyon but was clear on the western member of the pair. This observation of water to the west of Barrow Canyon nearly the same as water in Barrow Canyon, but apparently separated by a zone where that water type was not found, later became an important element in the planning of the final third of the expedition.

The next planned activity for the cruise was a shelf survey to map out whatever regional property variations occurred there. The depth of the shelf is about 50 meters, so casts were short and survey progress was usually rapid.

It should be mentioned that the marine mammal program was impacted by unsuitable flying weather but the team felt that they were proceeding well despite intermittent foggy days. During aerial survey flights over ice habitats in the basin and shelf zones they encountered low densities of ringed and bearded seals, with higher densities of bearded seals over the shelf in the marginal ice zone. Numerous groups of walrus were also observed at the ice edge, and beluga whales were spotted during the surveys near the slope of the continental shelf.

During all four excursions well into the Canada Basin none of the predicted multiyear ice was observed. Ice concentrations were sometimes high, but the ice was first-year ice with no large or consolidated floes. Most of the ice was rotten and in apparent melt, although nearer the ice edge on the Chukchi shelf there was a band of heavier ice, mostly pieces of pressure ridge and jumbled ice, that presented a much different appearance. But in the far north, as over most of the area, there were substantial open areas, some so large that ice was difficult to see in some directions. This is similar, if not even more open conditions, to ice observations made from the Polar Star during the 2002 Chukchi Borderlands field program.

The bongo net tow program decreased its frequency of casts mid-way through the cruise because good catch success earlier in the cruise was using up preservatives and sample jars faster than expected.

On 28 July it was necessary to reterminate the CTD wire: During a cast there was an unidentified error but with the bottom contact switch suspected even though the rosette was 1250 meters above the bottom. After aborting the cast and inspecting, the cast was begun again but an identical error occurred. On the third try, the cast worked OK until the deck unit lost power on the up cast. Eventually it was determined there was an electrical arc between two pins on a data cable which disabled the main CTD underwater unit (the 'fish') and possibly blew a fuse in the deck box. In short order the central CTD underwater unit was installed, along with two new sensor cables, and the wire was reterminated. The casts following this procedure were problem-free.

At the completion of one of the shelf sections of CTD casts and bongo net tows, the vessel was a few miles off the Alaskan coast, southwest of Wainwright. This afforded an opportunity to fly the second Community Participant, Luther Leavitt, Jr., back to Barrow some 75 miles away. His stay on board turned out to be 12 days, instead of the 3-5 planned, due to the sparse coincidence of proximity to Alaska with flying weather. For that matter the weather was a bit foggy for the return flight, but the expert crew from Prism Helicopters took all necessary precautions and made the trip safely.

The next shelf section took the vessel west, closer to Russian waters, into an area anticipated to be a source region for water similar to the low oxygen, high nutrient

Barrow Canyon water. Indeed, that turned out to be the case, temporarily deepening the mystery attending to the path the water would take if it were to reach a Barrow Canyon without crossing the first of the shelf-slope-basin sections west of Barrow Canyon.

On 02 August there was radio contact with the Xue Long, a Chinese vessel conducting SBI-like research in the area. The vessel was actually quite close by, but heavy fog made sighting impossible.

From the individual CTD profiles from the shelf survey, the larger spatial structure of the property distributions was not always apparent. Sometimes there were three or more layers at a shelf station, and when the individual profiles were combined into the long sections which formed the survey, meaningful patterns came clear. It was possible to trace a Bering Strait component with an unusual nutrient signature, to locate a shelf region where the near-bottom waters are very high in nutrients, to uncover transition zones where the chlorophyll maximum shifted significantly in the vertical, and to identify areas where shelf waters might break into the slope region.

On 04 August the Palmer reached the highest latitude for the cruise, and also completed the top priority aspects of the cruise, with two weeks of sampling time remaining. A plan was devised for the remainder of the science time which permitted reoccupation of two sections done earlier during the cruise and conduct a survey of the outer Chukchi shelf, a survey which it was hoped would identify better the sources and pathways of the low oxygen, high nutrient shelf bottom water. The outer shelf section included a section along the shelf edge, including closely-spaced stations across the mouth of Herald Valley, and two spur sections over the slope into the Canada Basin. The hydrographic data defined a likely path for the high-nutrient shelf bottom water around subtle bathymetric features into Barrow Canyon, a path that bypassed the first of the long shelf-slope-basin sections west of the canyon. The lowered-ADCP data revealed a shelf edge flow supporting these inferences. The earlier deep basin observations of high-nutrient outer reaches on cold core eddies may indicate one mechanism which could move these waters away from the slope into the basin interiors.

Next came a reoccupation of the section of stations across the mouth of Barrow Canyon, followed by a repeat of the section of stations east of Barrow Canyon, both in the vicinity of SBI moored arrays.

The sampling program for the cruise concluded with a section of stations from the Beaufort shelf to the deep Canada Basin, east of any yet done for the SBI program. When this section began the ship was in open water while the winds rose and were sustained to over 25-30 knots. The ship handled well in the developing swell, and other than some wave slop wetting down the Baltic Room there were no untoward incidents. By the time the section was completed, early on 17 August, the weather had improved and the seas were slowly dying. Surface salinities were low at the easternmost locations, perhaps due in part to presence of Mackenzie River water as well as summer ice melt. There was a surprise oceanographic feature seen at the final stations over the

Canada Basin: a strong westward flow of water with nearly identical properties to those over the Beaufort slope.

During the last three days of the cruise, samples were analyzed, data were processed, science equipment was packed and secured, the laboratories were cleaned, and other final business of a research expedition was completed. The CTD/rosette and most other data which were the prime product of the cruise were prepared for posting at the SBI website hosted by JOSS, so that SBI investigators could begin working with what the sea team provided.

The primary and secondary CTD temperature and conductivity sensors remained in use throughout the cruise. Near the end of the cruise, as the final section was being completed, the oxygen sensor failed. Its replacement was a little slow to settle in, causing a loss of CTD oxygen sensor data in the upper layer at two stations. But the deeper oxygens fit quite well with those from the previous oxygen sensor.

A realtively frequent problem with the CTD data in some regions was apparent ingestion of biological debris (or, by observation, entire organisms such as jellyfish) into the CTD pumps and sensors. Sometimes this cleared rapidly, but at other times it was necessary to haul the package out of the water and flush out the sensors. Another ongoing problem was modulo noise errors, sometimes 0-3 per cast but occasionally much more often. An investigation of the severity and effect of these errors is planned after the cruise. It was, however, possible to process all CTD data except for a very few severely impacted groups of CTD data scans.

262 stations were planned, an optimistic number which assumed good progress in the ice and few problems with equipment. The final tally was 329 CTD stations and 90 vertical bongo net tows completed, evidence partly of the easy ice conditions but mostly of outstanding teamwork and professionalism.

Three graduate students were funded by NSF to participate at sea. They not only ran CTD and bongo tow casts, but also helped with sampling, carried out research programs of their own (and of their advisors), and worked up property-property plots and vertical sections comparing the 2003 data to data from the three 2002 SBI cruises, and excellent plots of the ship's underway data.

The lowered-ADCP was a very useful adjunct to the CTD profiles. The ship's hull-mounted ADCP did not perform acceptably in shallow water (a known and expected problem) and so the LADCP velocity profiles were the only velocity measurements during approximately one-half the cruise. The velocity profiles show features which fit well with the hydrography across each section, and there were substantive velocity features geographically consistent between sections.

The marine mammal surveys produced good results, although unfavorable weather limited use of the helicopter. Across the study area, the team observed lower densities of seals than expected, presumably due to declining haulout rates following the annual

molting period. Consistently high densities of walrus were observed hauled out on a band of ice just inside the outer fringe of the marginal ice zone.

Cruise participants were treated to frequent wildlife sightings: bald eagles and puffins in Dutch Harbor, polar bears, walrus, and seals in the pack ice, and whales as well as various species of sea birds. This and views of the ever-changing ice added welcome reprieve from the sometimes unending-seeming sequence of stations.

The SBI Survey cruise was also host to Jim Rogers, a high school teacher from Polson in northwestern Montana (and an avid birder), supported by the NSF's Teachers Experiencing the Antarctic and Arctic program. He stood watch (as sample cop) and participated in the overall program. He made a verified sighting of an Ivory Gull during this trip, a species that breeds in eastern Arctic Canada but is rarely found near Alaska. His URL <http://tea.rice.edu/tea_jrogersfrontpage.html> includes logs and photos about life and work aboard the Palmer and the people who participated in this cruise.

The first steps of the trek home for the scientific party commenced from Barrow, which was hosting a conference that completely filled the town. But the same flights which brought the conferees to Barrow had plenty of empty seats heading south. Personnel, luggage, and cargo were disembarked via helicopter flights during 18-20 August as the Palmer stood offshore.

RVIB Palmer returned to Dutch Harbor, and then sailed on to Honolulu, where most SBI equipment was unloaded, finally heading to port in New Zealand.

Overview of Science Programs

CTD measurements

There was at least one (almost always only one) CTD/rosette cast at each SBI station, using USAP-owned SeaBird 911+ CTDs. There was a dissolved oxygen sensor on the CTD. Although the O2 data were not processed, availability of the O2 traces during the down cast was of great assistance with guiding bottle sampling in these waters. Also, the unprocessed CTD oxygen profiles were useful in assessing the bottle oxygen measurements. In addition to the P, C, T, and O2 data from the CTD, there were transmissometer, fluorometer, Haardt fluorometer, and PAR sensor data from the SeaBird. The Palmer's CTDs were used, augmented with some ODF and SBI sensors. ODF calibrated the pressure sensors in advance of the cruise.

The investigator for the Haardt fluorometer is Dr. Ron Benner (University of South Carolina; benner@biol.sc.edu; 803-777-9561). He was not on the cruise. ODF looked after this instrument.

There was a lowered-ADCP on the rosette. The PI supplying the lowered ADCP was Dr. Robert Pickart (WHOI; rpickart@whoi.edu; 508-289-2858). The person responsible

for the lowered ADCP and hull-mounted ADCP data during the cruise was Dr. Eric Johnson (Earth and Space Research; ejohnson@esr.org; 206-726-0501 ext.12).

The CTD was mounted on an RPSC 24-place rosette frame, with SeaBird pylon, and outfitted with 24 10-liter ODF-constructed bottles owned by RPSC. ODF will supplies a Simrad xxxxxx altimeter as part of the underwater package.

The RPSC CTD contacts were Karl Newyear (NewyeaKa@usap.gov) and Paul Olsgaard (OlsgaaPa@usap.gov). ODF CTD contacts were Robert Palomares (ET; rpalomares@ucsd.edu; 858-534-1907), Kristin Sanborn (data processing; kris@odf.ucsd.edu; 858-534-1903), and Marie Beaupre (data processing; marie@odf.ucsd.edu; 858-534-1906).

*bottle sampling depth*s

Bottle sampling depths on this cruise were focused on obtaining samples from cores of principal water masses, well-mixed layers, 20-meter or less bottle spacing through the halocline, primary extrema of T/S/O2, and near-bottom. Standard sampling depths applied to a degree.:

salinity

The CTD exhibited stable conductivity behavior, and thus primary salinities came from processed CTD data. Salinity samples were drawn and analyzed to calibrate the CTD. This ranged from a minimum of 2 samples to a maximum of about 12. ODF used the Palmer's Autosal.

oxygen

A dissolved oxygen value was obtained from each level sampled with the rosette. There were 3422 oxygen analyses. ODF supplied the equipment and personnel for dissolved oxygen analyses. The primary contact is Susan Becker (SIO/ODF; susan@odf.ucsd.edu; 858-534-9831).

nutrients

A 6-channel suite of nutrient values was acquired from each level sampled with the rosette. The total was 3422 nutrient analyses. ODF supplied the equipment and all chemicals. The primary contact is Susan Becker (SIO/ODF; susan@odf.ucsd.edu; 858-534-9831).

chl-a and other pigments

Samples for pigment analyses were drawn from a subset of the rosette bottles and analyzed on board by a two person team from the University of Alaska, Fairbanks. The primary contact is Dr. Dean Stockwell (dean@ims.uaf.edu; 907-474-5556).

DOM sampling

Samples were drawn, frozen, and stored for Dissolved Organic Matter for return to shore. Equipment, any chemicals, and one person will be provided by the University of Miami (Jeremy Mathis; jtmathis@hotmail.com). Freezer storage space is required for the samples. The pre-cruise contact is Dr. Dennis Hansell (University of Miami; dhansell@rsmas.miami.edu; 305-361-4078).

18O/16O sampling

Sampling containers were provided for oxygen-18 samples. The requested samples were collected and returned to shore for analyses. The data contact is Dr. Lee Cooper (lcooper1@utk.edu; 865-974-2990; fax 865-974-7896).

plankton tows

A total of 90 vertical bongo tows were completed aboard the 2003 SBI cruise. Of these, 12 tows were to depths of 1000 meters while the rest were to depths of 100 meters or shallower. These tows resulted in 180 preserved zooplankton samples along the arctic coast in two distinct size fractionations (>335 μm and >153 μm). Another 150-160 samples were preserved for molecular analysis. Dry weight percentage at three different size ranges (>1050 μm, 1050>x>550 μm, and 550>x>202 μm) was also calculated at 80 sites from both fractionations. The data contacts are Dr. Sharon Smith (University of Miami; ssmith@rsmas.miami.edu; 305-361-4177) and Leopoldo Llinás (University of Miami; lllinas@rsmas.miami.edu; 305-361-4702).

stable isotopes

Over 400 samples were taken for isotopic analysis ($\delta^{13}C$ and $\delta^{15}N$). Of these, 180 were organic particulate (POM) samples. The rest were a variety of zooplankton collected from individual bongo tows including the copepods *Calanus glacialis*, *Calanus hyperboreus*, *Metrida longa*, and *Paraeuchaeta novergeica*. The data contact is Dr. Ken Dunton, University of Texas, dunton@utmsi.utexas.edu.

The plankton and stable isotope teams note that the number of sampling locations and opportunities far exceeded their expectations. As such, the 2003 summer cruise aboard RVIB Palmer was considered a huge success by both the zooplankton ecology and marine botany representatives.

underway systems

Multibeam sonar data was acquired. A display available in the vicinity of the CTD operator, and the multibeam data were recorded (without post-processing), and the data provided to JOSS.

An underway measurement suite including centerline depth to bottom, seawater temperature & salinity, fluorometry, ADCP, standard meteorological parameters, position, time, ship speed/heading/etc., and other routine parameters was carried out by RPSC technicians.

TEA

Jim Rogers, a science teacher from Polson, Montana, was on board experiencing oceanographic field research first hand as part of NSF's Teachers Experiencing the Antarctic and Arctic program. He stood watch as a sample cop, and worked on other TEA activities. Contact information: phone 406-883-3611; jrogers@polson.k12.mt.us.

JOSS

The cruise wassupported ashore by the SBI team at the Joint Office for Science Support at UCAR. This included data catalogs, data distribution, cruise maps, cruise reports, etc. Contact: Jim Moore, JOSS; jmoore@ucar.edu; 303-497-8635.

marine mammal survey

Marine mammal surveys were carried out transparent to the CTD survey program on a not-to-interfere basis. The primary marine mammal program was helicopter-borne sweeps on specified tracks with a team of two observers. Contact: John Bengtson, NOAA; john.bengtson@noaa.gov; 206-526-4016.

Raytheon Polar Service Corporation (RPSC)

There were 9 RPSC technicians on the cruise, each working 12-hour shifts: one Marine Projects Coordinator (MPC), one marine science technician, 3 marine technicians, two network/computer techs, and two electronics techs.

RPSC techs supervised rosette launch and recovery.

RPSC techs handled underway data logging, including systems maintenance and routine review of data for reasonableness.

RPSC techs carried out multibeam sonar data logging, including system maintenance and routine oversight of data for reasonableness.

Network assistance and email was handled by the RPSC techs.

Hazmat laboratory wastes were collected in RPSC-provided containers. RPSC handled the paperwork.

Reports from the Science Teams

CTDO/salinity/oxygen/nutrients (UCSD Scripps Institution of Oceanography*)*

(report not yet received)

LADCP Data Collection Summary (Earth and Space Research)

The Lowered Acoustic Doppler Current Profilers were deployed and returned data from all 329 stations of the RVIB Nathaniel B. Palmer's 2003 SBI cruise. The first 44 stations were compromised by compass errors in the downward looking instrument, apparently due to a coil of power leads secured to the rosette framework nearby. This problem has been corrected in the data processing by rotating to the upper instrument's compass which was not significantly affected. Of the 329 stations 316 have been successfully processed and made available in Matlab format as vertical profiles of velocity. Of the 13 stations not yet successfully processed 6 consist of upward-looking data only, and cannot be processed without further software modifications. The other seven unprocessed stations consist of data taken in shallow water using instrument settings optimized for deeper water. These stations should be recoverable with more robust processing software, though vertical resolution is likely to be poor.

The data itself are very robust except were shallow water limited the range and duration of data gathering. Tidal amplitudes appear to be small in that no obvious tidal signal has been discerned, consistent with expectations reported from tide models. The outstanding features (Fig. 1) include strong flow down Barrow Canyon during the earlier part of the cruise (Fig. 2) with some evidence of water feeding into it from the surrounding shelf; strong eastward flow along the shelf edge east of Barrow canyon, evidently a continuation of its outflow (Fig. 3); a lesser outflow from Harold Valley to the west: and seaward of these a consistent westward flow along the outer shelf edge, particularly massive in the last, eastern-most section (Fig. 4). Beyond this westward flow there is abundant evidence of eddies that were not fully resolved by the sampling scheme. Velocity in the aforementioned major features ranges from 30 to 110 cm/s. Over the shelf smaller, more confused velocities prevailed. Their significance is not yet apparent, and they certainly contain aliased time and space variability. Nevertheless it is possible that in conjunction with the hydrography they may yet prove useful in outlining some general sense of water mass movement across the shelf.

Technically the only result worth mentioning is that shallow water results were much improved by restricting the instruments to only twelve 5 m bins, lengthening the ping interval to 1.5 sec, and switching to broadband mode to enhance data reliability at shorter ranges.

Chlorophyll-a and other pigments (University of Alaska, Fairbanks*)*

(report not yet received)

DOM sampling (University of Miami)

There were two main University of Miami organic biogeochemistry laboratory objectives for the 2003 SBI Survey Cruise. The main objective was to obtain high-resolution sampling of the East of Barrow Canyon transect. Prior years' sampling of this line revealed the possible presence of eddies. These eddies could be a mechanism for influx of carbon and nitrogen into the deep basin. The second objective of the cruise was to sample the bottom waters of the shelf itself to identify a relationship between sediment character and DOM concentrations.

Sampling for organic matter during the cruise (dissolved organic carbon and nitrogen, DOC and DON; and particulate organic carbon and nitrogen, POC and PON) had two aims. First, DOM samples were taken as a survey of the shelf bottom waters in an effort to determine the relationship between sediment/benthos characteristics and DOM release from the sediments (using bottom water DOM concentrations as an index for release). In previous work (2002 field season) we found that near bottom DOM was occasionally elevated, with indications that the most productive waters (in the western shelf) and the Alaskan Coastal waters overlaid these zones. Areas overlain by Bering Shelf water did not exhibit elevated values of bottom water DOM. Unfortunately, sampling then was not adequate to determine if there was a true causative relationship between sediment character (e.g., POM input, benthic richness, sediment composition, bottom water nutrient concentrations) and DOM concentrations in the overlying water. The present survey was designed to sample the full range of benthic types found in the region, from the inner shelf to the shelf break, from high productive to biologically impoverished. DOM concentrations will be compared to literature assessments of sediment/benthos distributions on the Chukchi Shelf.

Second, DOM and POM samples were collected from the upper 250 m of the densely sampled East of Barrow Canyon (EBC) line. This line crosses a region of eddy formation, and we seek to evaluate the role of these eddies in transporting organic matter from the shelf/shelf break region into the Arctic Basin. This survey was done with the hope that an eddy would be present at the time of sampling and that we could begin the assessment of transport by this mechanism. Figure I illustrates the resolution of sampling on the EBC line, which included stations 38 to 59. We collected 229 DOM and 229 POM samples on the EBC line. The POM samples were collected by vacuum filtration of 500-1000 mL of water onto GF/F filters. These samples will take on greater importance if an eddy was indeed present during occupation of the line. If not, their priority for analysis will be reduced.

In the bottom water survey, we took 243 samples for DOM analysis. These samples were collected by gravity filtration through GF/F filters held by in-line filter holders. The

DOC and DON analyses will be done by high temperature combustion at the University of Miami during the next few months.

(Insert Jeremy's figure here)

18O/16O sampling (University of Tennessee, Knoxville)

(report not yet received)

Zooplankton Distribution and Abundance in the Chukchi and Beaufort Seas (University of Miami)

Leopoldo Llinás, Research Assistant (lllinas@rsmas.miami.edu)

The purpose of this project is to determine which species of copepods are transported off the Chukchi and Beaufort shelves and the physical processes associated with that transport. Our research also aims at documenting the vertical distribution of copepods in the Chukchi and Beaufort Seas.

We conducted over 80 bongo net tows including eleven 0-1000m bongo net tows. Sampling was carried out every third CTD/hydrographic station with emphasis along the track covering portions of the Chukchi and Beaufort shelves similar to the track followed during the SBI Summer Cruise 2002: HLY-02-03 where forty-five stations were occupied and fifty-two Bongo tows were completed. Other areas sampled with a lower resolution include the Chukchi shelf where Bongos with depths up to 50 meters were conducted, and a final section east of the previous 2002 sections.

Portions of each sample were split on board. For taxonomical analysis, 50% of each sample was preserved in 4% buffered formalin solution. For bulk biomass estimates, 20% was filtered for different size meshes (>1050□m, 1050-560□m, and 560-202□m) and dried at 60ºC. For molecular analysis, another 20% was preserved in ethanol. The remaining 10% was given to Craig Aumack. Aumack will measure the isotopic ratios of Carbon 12 and Nitrogen 14 on the large-bodied zooplankton to identify the source (ice algae, diatoms) of the carbon and nitrogen.

Few problems occurred while towing the Bongo nets. At station 001, the planned Bongo was cancelled due to a hydraulic failure of the A-frame on the aft deck. After the five-station section in Bering Strait, time constrains required for the Raytheon Polar Services Company science support team to take over the Bongo collection for the rest of the cruise, an assignment our team was very grateful for. Later on, while rinsing the nets on board at station 204, the occurrence of strong winds (> 40 mph) flailed the nets and broke the shackle of a cod-end against the deck floor.

In general, deep tows (0-1000m) contained the copepods *Paraeuchaeta sp.* and *Metrida sp.*, while on the 0-100m the large-bodied zooplankton was dominated by *Calanus hyperboreus*, *C. glacialis* and chaetognatha. Preserved samples will be analyzed for taxonomy and abundance at the Rosenstiel School of Marine and Atmospheric Sciences, and Bongo net data will result in a qualitative record of the vertical distribution of copepods in the Arctic Basin. In the future, to obtain a quantitative knowledge of the vertical distributions of zooplankton we expect to use a vertically hauled opening-closing net system.

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Stable isotopes (University of Texas)

A total of 90 vertical bongo tows were completed aboard the 2003 SBI cruise. Of these, 12 tows were to depths of 1000 m. while the rest were to depths of 100 m. or shallower. These tows resulted in 180 preserved zooplankton samples along the arctic coast in two distinct size fractionations (>335 □m and >153 □m). Another 150-160 samples were preserved for molecular analysis. Dry weight percentage at three different size ranges (>1050 □m, 1050>x>550 □m, and 550>x>202 □m) was also calculated at 80 sites from both fractionations.

Over 400 samples were taken for isotopic analysis (□^{13}C and □^{15}N). Of these, 180 were organic particulate (POM) samples. The rest were a variety of zooplankton collected from individual bongo tows including the copepods *Calanus glacialis*, *Calanus hyperboreus*, *Metrida longa*, and *Paraeuchaeta novergeica*. The magnitude of sampling locations and sampling opportunity far exceeded expectations. As such, the 2003 summer cruise aboard the R/V Palmer was considered a huge success by both the zooplankton ecology and marine botany representatives.

Marine mammal distribution in the Chukchi and Beaufort Seas

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Background

The shelf, slope, and basin zones of the western arctic provide productive habitats for polar marine mammals. Determining the seasonal patterns of marine mammal abundance and distribution is key to understanding the ecological interactions involving these apex predators and the ecosystem "hotspots" where they are often found. Different marine mammal species integrate the environment across variable spatial and temporal scales, with the composite result reflecting oceanographic primary and secondary productivity derived from transport processes and mesoscale oceanographic features. During the 2003 SBI survey cruise, although abundance and distribution data on all marine mammal species observed was recorded, our main focus was on two species of seals in the sea ice zone: bearded seals (benthic foragers), and ringed seals (fish and crustacean predators). Our principal research objectives were to determine marine mammal distribution, relative abundance and habitat associations via visual surveys, and to relate these patterns to measures of mesoscale oceanographic structure and potential prey availability.

Ringed seals are small phocids (adults are typically 1.3 – 1.5 meters in length) found throughout the arctic in areas of seasonal sea ice as well as within the permanent polar ice cap (Smith 1987, Kelly 1988, Ramsay and Farley 1996, Reeves 1998). In the Chukchi and Beaufort Seas, ringed seals haul out in highest densities in shorefast ice during the May-June molting season, immediately following the March-April pupping season (Johnson *et al*. 1966, Burns and Harbo 1972, Frost *et al*. 1988, 1997, 1998, 1999, Bengtson *et al*. 2000). It is often assumed that the May-June distribution of seals reflects their winter-long distribution in the shorefast ice, although ringed seals may begin to disperse from their wintering grounds during May-June (Kingsley 1991). Little is known about the distribution of ringed seals during the 'open water' season, July-October, but ringed seals have been seen both hauled out on pack ice and foraging in open water some distance away from the nearest sea ice (Smith 1987). Whether ringed seals foraging in open water commute from ice edge haulouts or forage in open water all summer long without hauling out is currently unknown. Ringed seals migrate north and south with the retreat and advance of the sea ice edge, but some seals in areas of seasonal shorefast sea ice may be sedentary (Burns 1970; Smith 1987). In addition to ice-associated migrations, ringed seals can also travel long distances east or west (> 2000 km), particularly young seals (Smith 1987, Kapel *et al.* 1998). Ringed seals in the SBI study area reportedly prey primarily upon arctic cod during the winter (November-April) and upon pelagic, benthic, and sympagic (ice-associated) macrozooplankton during spring and summer (Lowry *et al*. 1980b). Ringed seals feed less frequently and lose weight during March-June when their behavior is constrained by breeding, pupping, and molting (Lowry *et al.* 1980b). They increase their food intake in late summer or autumn, when locally dense concentrations of prey appear to be important (Lowry *et al.* 1980b).

Bearded seals inhabit circumpolar arctic and subarctic waters in relatively shallow water depths that are seasonally ice-covered (Stirling *et al*. 1982, Kingsley *et al.* 1985). The distribution of bearded seals appears to be strongly influenced by water depth and prey biomass (Kelly 1988b). Bearded seals feed at depths less than 200 m (Burns *et al*. 1981, Stirling *et al*. 1982, Kingsley *et al*. 1985). In Alaska, bearded seals are distributed over the ice-covered continental shelves of the Bering, Chukchi, and Beaufort seas (Burns 1981b). In the Bering and Chukchi seas, the majority of bearded seals move south with the seasonally advancing ice in winter, and north with the retreating sea ice in spring. Bearded seals are benthic feeders, consuming clams, shrimp, crabs, benthic invertebrates, and fish (Johnson *et al*. 1966, Burns 1967, Lowry *et al*. 1980a). Of these items, clams, shrimp and crabs appear to be the most important prey species in the Bering and Chukchi Seas (Lowry *et al*. 1980a). In the Beaufort Sea, crabs and shrimp appear to be primary prey items, though clams are important prey species in August, and arctic cod is a primary prey species in November and February.

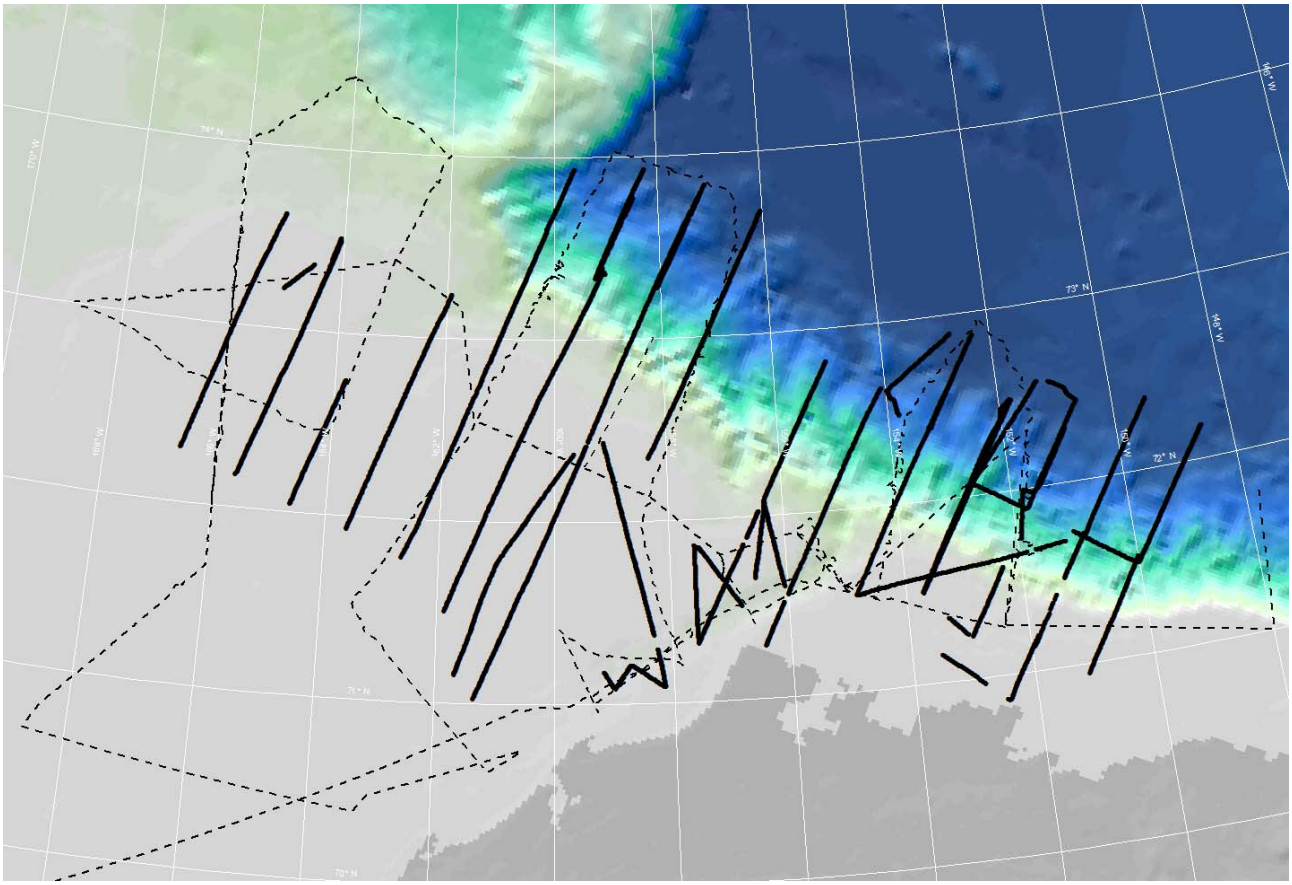

Figure 1. Distribution of aerial surveys for marine mammals in the SBI study area (July – August 2003). Thick solid lines show locations of "on effort" line transect sampling; thin dashed line shows the cruise track of the R/V *N.B. Palmer*.

Survey protocols

Pinniped aerial surveys were flown at a speed of approximately 100-170 km/h (60-100 knots) at 90 m (300 ft) during mid-day (2 hours either side of local solar noon) when the greatest proportion of seals were expected to be hauled out. As conditions allowed, helicopter survey tracks were set out perpendicular to bathymetric and sea ice gradients (Figure 1). An observer positioned at each window on the right and left sides of the aircraft counted seals seen during each flight. Data were recorded by audio/video recorder and later transcribed to computer files. Perpendicular distances of seals from the survey line were estimated by sighting along six fixed 10^{o} vertical angles (0^{o}-60^{o} from the horizon in 10^{o} increments) on a plexiglass strip attached to the helicopter's window. The perpendicular distance intervals were computed from the helicopter's altitude and the assigned angle category. The area beneath the aircraft (60^{o}- 90^{o}) was not visible to the observers, so this survey strip was monitored by a downward-looking digital video recorder mounted inside the helicopter behind the lower plexiglass window near the foot rest of the co-pilot's seat. These data provide information on sea ice characteristics as well as an independent record of seal densities.

When weather conditions were not suitable for flying, surveys were conducted from the Palmer's ice tower as the ship moved through the pack ice. Shipboard surveys of pinnipeds were conducted between 1000 and 1600 hours local solar time whenever the ship was transiting through ice capable of supporting a seal's weight. Survey effort outside of this time window was of limited usefulness because very few seals haul out then. Routine survey data collection included pinniped sightings, location, ice classification, and visibility conditions.

Preliminary results

The R/V *N.B. Palmer* proved to be an efficient platform from which to conduct surveys of this type, and the helicopter flights had virtually no impact upon the other science missions. Despite foggy weather during most of the cruise, approximately 3,655 km (2,193 nm) of linear transects of sea ice habitat were surveyed during 18 helicopter flights (Figure 1, Table 1). Six species of marine mammals were seen: 4100 walrus, 48 ringed seals, 16 bearded seals, 3 gray whales, 24 beluga whales, and 6 polar bears. Shipboard surveys yielded sightings of 310 walrus, 33 bearded seals, 5 ringed seals, and 6 polar bears. Density estimates based on these tallies and their relationships to environmental features await further data processing and analysis.

Across the study area, lower densities of ringed and bearded seals than expected were observed, presumably due to declining haulout rates following the seals' annual molting period. Consistently high densities of walrus were observed hauled out on bands of ice just inside the outer fringe of the marginal ice zone, where several thousands of walrus were seen in relatively localized areas. Relatively high densities of bearded seals were encountered on the continental shelf in the western portion of the study area, presumably in a zone where the benthic

productivity is high. We are eager to compare these results with relevant findings from other SBI investigators.

Table 1. Aerial survey flights for marine mammals during the July – August SBI survey cruise, 2003.

Date	Event no.	Survey time (h)	Survey distance (nm)
14-Jul-03	1	0.8	70.0
17-Jul-03	2	1.3	106.6
17-Jul-03	3	1.5	120.9
19-Jul-03	4	1.3	122.7
19-Jul-03	5	1.8	147.9
20-Jul-03	6	1.8	148.7
20-Jul-03	7	1.6	141.5
28-Jul-03	8	1.1	70.6
5-Aug-03	9	1.5	128.6
5-Aug-03	10	1.8	167.8
6-Aug-03	11	0.3	22.4
7-Aug-03	12	1.7	137.6
7-Aug-03	13	1.5	148.2
8-Aug-03	14	2.0	172.2
8-Aug-03	15	2.1	181.5
8-Aug-03	16	1.2	104.7
13-Aug-03	17	1.5	140.8
13-Aug-03	18	0.6	59.8
	Totals	25.3	2,192.5

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Raytheon Polar Service Corporation (RPSC)

RPSC Cruise Support
Cruise NBP 03-4A
5 July – 20 August 2003

General
Raytheon Polar Services Company (RPSC) is contracted by the National Science Foundation (NSF) to provide logistical and technical support and infrastructure for the United States Antarctic Program (USAP). Through this mandate, RPSC charters the RVIB Nathaniel B. Palmer (NBP) from Edison Chouest Offshore, Inc. (ECO). RPSC and ECO work together to provide a safe, comfortable, and productive living and working environment for NSF-funded science projects. An unusual series of events prevented the US and Canadian Coast Guards from providing a platform for the 2003 SBI Survey cruise, while at the same time the NBP had a long open period in her schedule because contractually required major upgrades were completed, tested, and accepted ahead of schedule.

The Nathaniel B. Palmer completed a maintenance period in Lyttelton, New Zealand at the end of the 2002-03 austral summer season, then left port on 23 May 2003 to transit north to support the SBI program. Scientific cargo was onloaded during a port call in Honolulu, Hawaii from 11 to 24 June 2003. During this time, Rob Palomares representing the Scripps Institution of Oceanography, Shipboard Technical Support, Oceanographic Data Facility (SIO/STS/ODF) visited the ship to account for all cargo items and to inspect several on-board systems. The vessel continued on to Dutch Harbor, Alaska with a 2 July 2003 arrival. Some remaining cargo items plus fuel and

fresh food were onloaded to the NBP, scientists embarked onto the ship, and laboratory setup began. The ship sailed from Dutch Harbor on 5 July 2003 to begin cruise NBP 03-4A.

Prior to beginning the primary survey portion of the cruise, the NBP arrived offshore of Nome, Alaska on 8 July 2003 where a helicopter and crew joined our complement. During the planning process, NSF identified the need for a helicopter to 1.) allow for ice reconnaissance, 2.) assist in passenger offload at Barrow, Alaska at the conclusion of the cruise, and 3.) to support aerial surveys of marine mammals for a funded component of the SBI project. Working through the US Dept. of the Interior's Office of Aircraft Services (OAS), NSF contracted with Prism Helicopters, Inc. for such support. RPSC made arrangements for shipboard support of the aircraft crew including aviation grade fuel and training of passengers in safety and operational matters related to the helicopter. RPSC was delegated to oversee Prism's contract, including properly accounting for flight hours and aircraft availability. In practice, ice conditions did not warrant reconnaissance flights. Two flights were undertaken to transfer community participants to/from shore, exchange of scientific crews and cargo in Barrow required several hours of flight time, while the remainder of the flights were for marine mammal surveys. At total of 51.2 hours of flight time were completed in association with this cruise (not counting offload of passengers at Barrow).

RPSC maintains and logs data from several underway systems including: ship's position, heading, speed, pitch and roll, multibeam sonar, meteorology (air temperature and humidity, wind speed and direction, barometric pressure), upward-looking radiometers (PSP, PIR, PAR), and surface seawater properties (temperature, salinity, transmissivity, fluorometry). For this cruise, RPSC also provided a full CTD system including 24 –10 liter niskin bottles and rosette, SeaBird 911 CTD fish, primary and secondary temperature, salinity, and dissolved oxygen sensors (all from SeaBird), PAR sensor, Chelsea and Wet Labs fluorometers, and a Wet Labs transmissometer. These were supplemented by a lowered ADCP, Simrad altimeter, and Haardt fluorometer provided by the scientists. In addition, RPSC maintains several NSF-funded science of opportunity systems, described below, which are included in the end of cruise data report provided to the science party. These systems are standardized throughout the USAP but can be reconfigured at the science party's request. The purpose of this underway data is to provide science groups with a set of standard measurements for use in interpreting other data specific to the project.

A list of specific makes and models of sensors used during this cruise are included in the end of cruise data report. Pre- and post-cruise sensor calibrations will be provided as available.

Other support provided by RPSC includes the following:
- Computer services including maintenance of the shipboard LAN, printer services, daily backups, disk space management, logging of the underway data described above, end of cruise data distribution of underway data, and email support for all cruise participants including the TEA (Teacher Experiencing the Arctic).

- Provision of general laboratory equipment such as dissecting microscopes and camera system, autosal salinometer, fume hoods, filtration rigs with pumps, and other miscellaneous laboratory materials.
- Deployment and recovery of the CTD rosette and the bongo nets provided by the scientists.
- Collection, documentation, and disposal of all laboratory-generated hazardous waste according the USAP protocols.
- Overseeing the contract for helicopter support from Prism Helicopters, Inc. as negotiated by the US Department of the Interior's Office of Aircraft Services and the NSF.
- Operation of the TeraScan remote-sensing system and coordination of Radarsat SAR imagery from the National Ice Center via an agreement between the NSF and the Canadian Space Agency.

Problems
All systems were generally problem-free throughout cruise NBP 03-4A, though there were minor items of note, some related to water depth.

First, the Simrad EM120 multibeam sonar system collected much more data than is normally the case, leading to difficulties in archiving (i.e. data filled up backup tapes). This is because the ping rate is inversely proportional to water depth and a large portion of this cruise occurred in quite shallow water (<100 meters). The system does not allow the ping rate to be manually changed. Therefore, multibeam data was subdivided into smaller sections to permit recording on several tapes without truncating the data. No data was lost or compromised because of this, but it was a minor annoyance.

Secondly, the hull-mounted ADCP system sometimes had difficulty in calculating the ship's speed through the water because it was hearing acoustic reflections from the bottom and/or multiple reflections from the surface and bottom. Occasionally, the ship's speed as calculated by GPS differed from that calculated by the ADCP by more than 5 knots. While one system outputs speed over ground and the other gives speed through the water, this difference was much greater than local oceanic currents or ship's drift due to wind. This is a recognized problem in data integrity, but there is no easy solution.

The EM120 multibeam crashed twice. The first time was prior to reaching Nome and prior to the start of science data collection. On 7 August 2003, it was down for 41 minutes. The cause of this crash is unknown.

The computer that logs underway data crashed twice. On 3 August 2003, 10 minutes of data were lost. On 6 August 2003, 20 minutes of data were lost. RPSC is continuing to investigate the cause of such instabilities and to remedy the situation.

The slip ring on the CTD winch was swapped out with a spare approximately midway through the cruise because an unacceptable number of modulo errors were observed on casts. The CTD fish suffered an electrical short of unknown cause, also

approximately midway through the cruise. A spare unit was installed and the damaged fish will be returned to the manufacturer for repair. During this short interruption in the survey, the electromechanical CTD cable was reterminated. No further problems were encountered after these minor repairs.

Science of Opportunity

There are several permanently installed science of opportunity systems on board the NBP that were operated during this cruise. All data collected from these systems will be included in the cruise-end data report provided to the science party. RPSC personnel monitored these systems as part of their normal duties.

Gravity Meter: This system requires very little maintenance and experienced no problems during cruise NBP 03-4A. As part of the normal upkeep of the gravimeter, a gravity tie was performed in Dutch Harbor prior to the cruise and another will be done immediately afterward. The gravimeter occupies a small room in the Aft Dry Lab and is part of the NSF equipment pool. There is no PI responsible for data collection.

Hull-mounted ADCP: This system is not science of opportunity in the purest sense of the term, since it is an important component of the SBI program and it was slightly reconfigured to SBI's specifications. Dr. Eric Firing of the University of Hawaii is the cognizant PI for this program, and questions about data quality, format, etc. can be directed to him at efiring@hawaii.edu or 808-956-7894.

pCO_2: This system measures the concentration of carbon dioxide dissolved in the surface seawater, as a tool for determining the overall carbon exchange between the ocean and atmosphere. Measurements are calibrated against standard gasses provided by Lamont-Doherty Earth Observatory. The PI in charge of this system is Dr. Colm Sweeney (csweeney@splash.princeton.edu, 609-258-6619, 609-258-2850 (fax)), assisted by Tim Newberger (tnewberg@ldeo.columbia.edu, 845-365-8790).