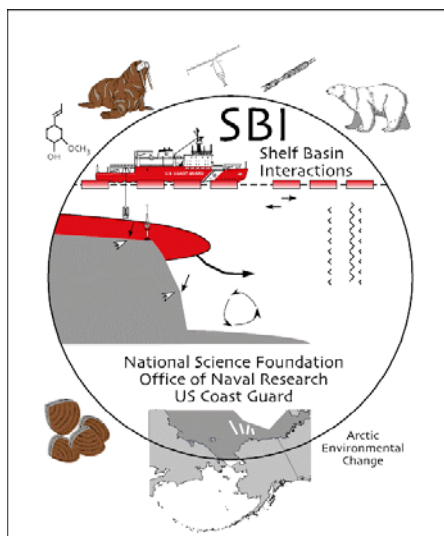


2002 FIELD SEASON FOR THE SHELF-BASIN INTERACTIONS (SBI) PROJECT



The field phase of the Western Arctic Shelf-Basin Interactions (SBI) project completed four successful scientific missions in 2002 to the Arctic using three vessels: the USCGC *Healy* (5 May -15 June and 17 July-26 August), the USCGC *Polar Star* (15 July-13 August) and the RV *Alpha Helix* (20-29 June). Up to 39 scientists from nineteen institutions in the United States, Bermuda, Canada, and Europe participated in this interdisciplinary scientific endeavor during any one cruise, depending on the ship and its objectives. During the field program the SBI project applied a broad array of physical, biogeochemical and biological measurements from May through September (and year-round with the moorings), which are almost unprecedented in scope for the Arctic. This second phase of the SBI project (2002-2006) took place in the Bering Strait region and over the outer shelf, shelf break and upper slope of the Chukchi and Beaufort seas, and is comprised of 40 Principal Investigators within 14 integrated projects.

The goal of the SBI global change project is to investigate the production, transformation and fate of carbon at the shelf-slope interface in the Arctic as a prelude to understanding the impacts of a potential warming of the Arctic. The SBI project is funded through the National Science Foundation and the Office of Naval Research. Thirty to fifty stations were occupied each cruise on the Chukchi Sea shelf (Herald Valley [HV] region), the Chukchi outer shelf to Arctic Basin lines (West Hanna Shoal [WHS] and East Hanna Shoal [EHS] regions), the Barrow Canyon (BC) region, East Barrow (EB) region, and stations near the Alaska coastline (Figure 2). Cruise reports for all 4 cruises are linked to the SBI website: <http://utk-biogw.bio.utk.edu/SBI.nsf>. The following synopsis outlines the four SBI cruises, with some preliminary results.

The spring cruise on the new USCGC *Healy* icebreaker was the first interdisciplinary research cruise to this region by a science vessel at this time of year. During both the spring and summer process cruises, a CTD (conductivity-temperature-depth/rosette system) was used for collecting physical and hydrochemical samples. Subsamples from multiple CTD/rosette casts were used for primary production, chlorophyll content, nutrients, particulate carbon, inorganic carbon, biomarkers, microzooplankton, and radioisotopes. Various nets (vertical, bongo) were used to collect size fractions of micro-macro- and meso-zooplankton for both population and experimental purposes. Benthic grabs and cores were used to collect benthic fauna and sediment samples for population, community structure, food web, chemistry and metabolism studies. In-situ pumps were also used to measure the activities of the particle-reactive radionuclide thorium-234. Preliminary findings indicate that the study area had a thinner ice thickness than expected for the spring period, with areas of heavy ice located in historically heavy ice areas. A notable finding was the high sediment content of first year ice during both the spring and summer cruise, which can have a direct impact on both the melting of the sea ice as well as primary production in the ice layers and the water underlying it. Biochemical products were observed transiting off the shelf to the deep basin during all cruises.

The SBI Bering Strait mooring cruise on the RV *Alpha Helix* deployed three moorings in Bering Strait during June to investigate hydrographic and flow properties of Pacific-origin water transiting northward through Bering Strait. Instruments deployed included hydrographic sensors, nutrient samplers, optical instruments, upward looking sonar and upward looking ADCP, and the cruise included both hydrographic and ADCP surveys. This project acts as a upstream boundary condition for the SBI project as well as provides a long time series measurement of three moorings that have been maintained in Bering Strait for

the last decade. The Chukchi/Beaufort mooring cruise on the USCGC *Polar Star* deployed three moorings as part of the Chukchi Outflow Mooring Array in the Chukchi Sea, including sensors to measure ocean physics, optical and biochemical parameters. The Beaufort Shelf Mooring Array was deployed as a tightly spaced (3-5 km spacing) line of 8 moorings across the Beaufort continental slope east of Barrow, Alaska, with profiling instrumentation. In a joint effort with NOAA fisheries and Scripps Institution of Oceanography, an Acoustic Recording

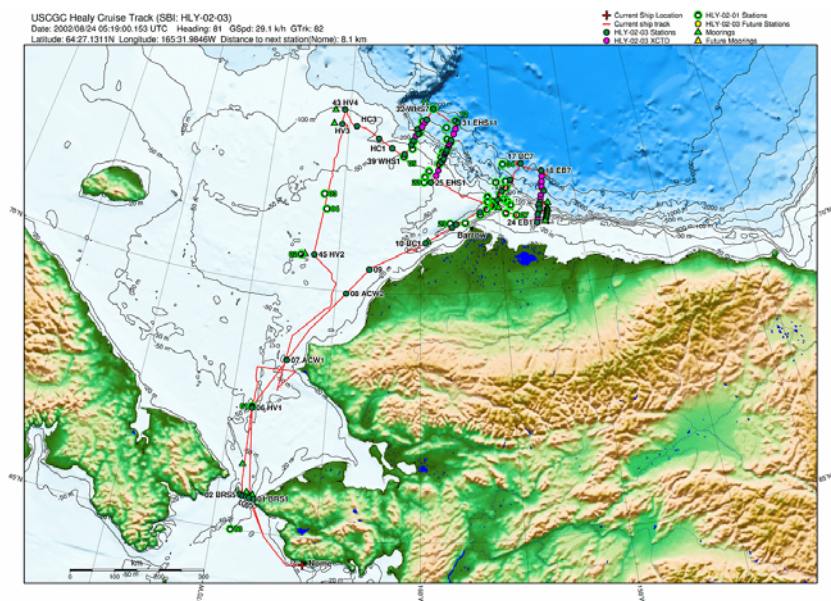


Figure 1. Station location for the SBI 2002 process cruises and locations of the SBI mooring network.

Package was deployed along the shallow Beaufort slope to record sounds of passing marine mammals. Finally, an intense hydrographic sampling around each mooring deployment, and within Barrow Canyon, was completed during the cruise. Preliminary data on the origin and fate of the shelf edge boundary currents indicate the outer shelf of the Herald Valley outflow site is filled with cold, dense Pacific-origin winter water as it flows eastward, forming a shelfbreak jet. The bottom water in this region has high turbidity, likely due to sediments drawn into this water mass as it crosses the shelf. Small lenses of water observed at the shelf edge are likely the beginnings of eddies and a fully-developed subsurface anti-cyclonic, eddy comprised of cold, turbid, Pacific-origin winter water was observed on the eastern transect of the study region (East Barrow, EB line). This is the same type of eddy that has been observed repeatedly throughout the interior of the Canada Basin, a result that suggests that these eddies emanate from the shelf-edge boundary current. The results of the mooring cruise indicate the western Arctic boundary current system is an "eddy factory", and SBI scientists are investigating why this shelf edge system is so wildly unstable. Eddy formation is obviously of critical importance for shelf-basin flux and the ventilation of the interior Arctic. Further information on these cruise can be found on the SBI website as well as at <http://www.whoi.edu/arcticedge>.

During the summer SBI process cruise all transects were occupied due to the low ice cover in the study region for this time of year. Primary production was either occurring or at the end of its bloom period. In contrast with the spring SBI cruise when several stations had surface nitrate concentrations in excess of 10 micromolar (pre-bloom conditions), surface nutrient concentrations were low during the summer cruise, with highest water column chlorophyll near the bottom, suggesting post-bloom conditions. Microscopic analyses of phytoplankton supported these post-bloom conditions throughout the study region during the summer cruise. Both bacteria and bacterivorous flagellates were common in the upper water column, whereas there were many occurrences of a deeper chlorophyll maximum layer of large diatoms. The accumulation and decay of diatoms suggests that plankton grazers are not able to consume most of the spring bloom, and that instead the bulk of the bloom is decomposed by heterotrophic

microbes or sinks to the benthos. A variety of sediment processes indicate patterns of sediment focusing and recycling in the SBI study region. High sediment oxygen uptake and nutrient flux (an indication of carbon supply), along with denitrification, occurs on the shelves. A regular pattern of high to low rates were observed from shelf to deep basin. Both radioisotope and sediment tracer studies indicate that phytodetritus is rapidly deposited to depths as great as 1000 m along the East Barrow and Barrow Canyon transect lines since the time of the spring cruise. It is notable that higher sediment uptake rates occurred at deeper depths in Barrow Canyon than the other transect lines, which are likely due to a focusing of organic carbon down the axis of the canyon. Benthic macrofaunal populations also follow the trend in carbon deposition to the benthos. Shallow oxygen penetration depths in sediments in Barrow Canyon sections suggest sediment focusing and off shelf carbon transport in the Barrow Canyon area. In contrast, the East Hanna shoal section to the east of BC had deep oxygen penetration depths, likely a reflecting of low relative productivity and consequently carbon rain rate to the sediments.

Modification of waters over the shelf and transport of biogenic signals from the shelf to the basin were observed during all cross-shelf sections for every SBI cruise on the main transects. It is notable that when comparing spring vs. summer data from the same hydrographic sections we see an increase of 5 to 10 micromolar in maximum silicate concentrations in the plume originating over the shelf in Barrow Canyon (Fig. 3 a, b) as well as pulses of ammonium moving off the shelf to the deep basin (Fig. 3 c, d). This observation suggests fairly rapid settling and re-mineralization of diatoms produced by the spring bloom over the shelf. By the time of the summer SBI process cruise, most of the water column production had settled to downwards in the water column and undergone transformation in the water and sediments. Maxima in other variables had a tendency to peak offshore and to intersect the shelf break instead of the more shallow portions of the shelf.

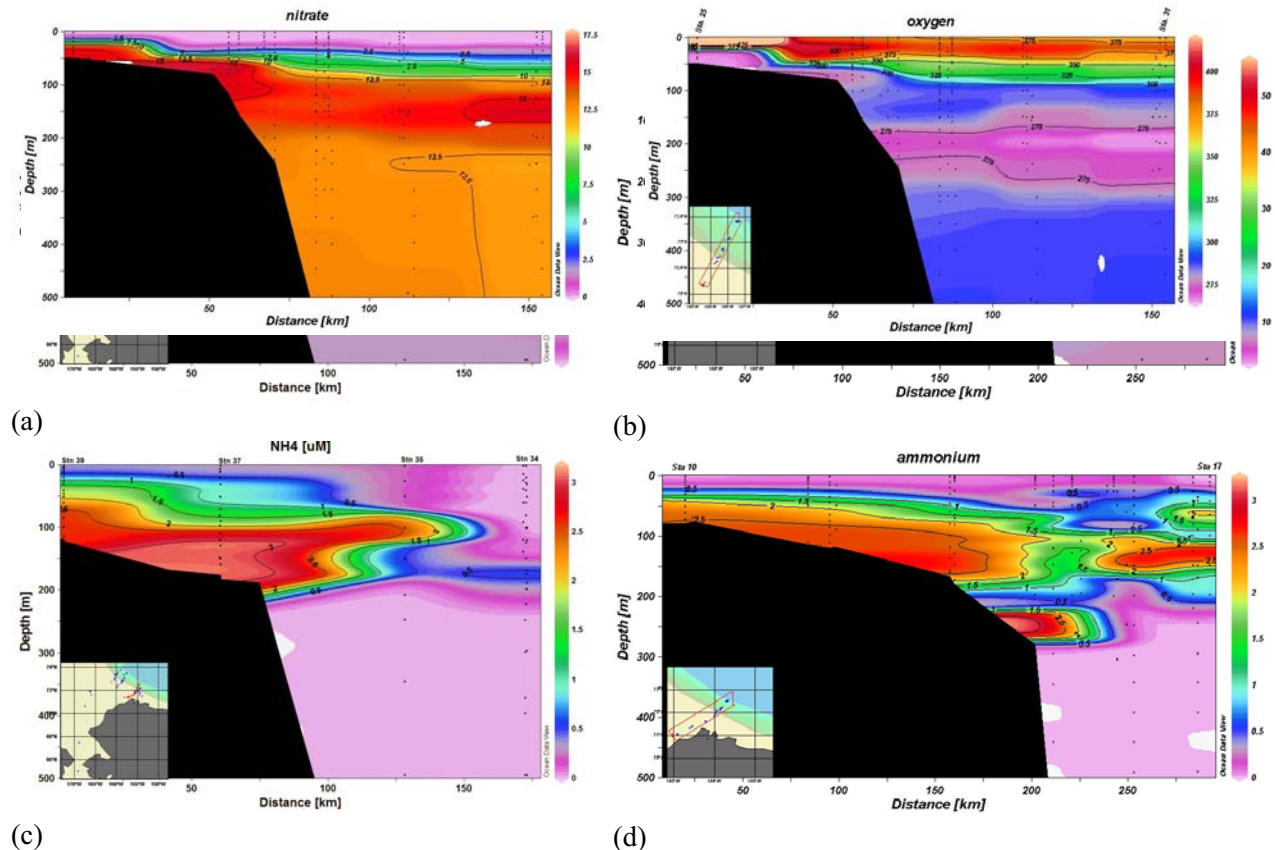


Figure 2. Nutrient concentrations along the Barrow Canyon line for silicate in spring (a) and summer (b) as well as ammonium in spring (c) and summer (d) as part of the SBI field project in 2002.

In support of the SBI field program, the Joint Office of Science Support (JOSS) group maintained a shipboard field catalog during both process cruises on the Healy that provided real-time data to scientists on the ship and select data was also made available to onshore PIs to follow the progress of the cruise. Field products includes satellite images, ship tracking, weather, CTD data from the hydrographic group as well as associated bottle data, and shipboard event logs. The SBI field catalog (with maps and event information at sea) can be found on the webpage: <http://www.joss.ucar.edu/sbi/catalog/>.

Full details on the SBI project, the field cruise program and results to date can be found on the SBI webpage: <http://utk-biogw.bio.utk.edu/SBI.nsf> and associated links on that web site. In addition to the research information available through the JOSS and SBI websites, additional public outreach was provided to explain our research program during the summer cruises. A broadcast crew from CBS News, a reporter from USA Today, and a reporter from the Associated Press were aboard the USCGC Healy during the summer cruise transit of Barrow Canyon. Interviews were also provided to a reporter for the Nome Nugget prior to the USCGC Healy leaving port and to KBRW-AM/FM, a National Public Radio affiliate in Barrow that broadcasts across the North Slope Borough using the INMARSAT telephone capabilities during the cruise. Several articles from USA Today are already available at: <http://www.usatoday.com/weather/antarac/acoldsci.htm>. A news story was released at the end of August on the Associated Press wire and appeared in a number of newspapers, including the Baltimore Sun, Orlando Sentinel, Fresno Bee, and Juneau Empire. CBS News broadcast three stories on August 28, 29, 31, 2002 on their national evening news program, and are planning a longer piece on the Sunday morning program as well as in a documentary format. Some of the content of these news pieces is available via the SBI website.

A valuable addition to our research program was the participation during the summer SBI process cruise of Ms. Betty Carvellas, a Vermont high school teacher provided daily updates on research and ship operations, including spotlights on individual research groups, explained in layperson's terms. These daily updates are accessible through the Teachers Experiencing the Antarctic and the Arctic web site (<http://tea.rice.edu>, specifically http://tea.rice.edu/tea_carvellasfrontpage.html). While aboard the cruise, she also served as a team member with the group investigating "Water/sediment tracers, sediment metabolism and benthic community structure." Outreach activities during the cruise included a tour of the Healy for students from the Anvil City Science Academy (a public magnet school in Nome) while the ship was anchored off Nome. Also during the cruise INMARSAT telephone -aided Powerpoint presentations were made of cruise activities to a district-wide teachers-in service at Essex High School, and to a public forum at the Burnham Library, both in Colchester, Vermont.

Plans for the 2003 SBI field season include a March helicopter survey and field sampling project, participation by some SBI PIs in an April ice camp sponsored by the Office of Naval Research, the June Bering Strait mooring project, a July-August hydrographic and sampling survey cruise, and a September mooring cruise. The 2004 field season will proceed with four cruises similar to that undertaken in 2004 to provide both interannual comparison of processes in the SBI sampling region. The final SBI mooring retrieval will occur this year. Phase II of SBI will continue through 2006 with data synthesis. The final SBI Phase III (2007-2009) will focus on development of Pan Arctic models suitable for simulating scenarios of the impacts of climate change on shelf-basin interactions.

This article was written on behalf of all the SBI Phase II participants who are acknowledged for providing many of the concepts and results outlined in this article. Further information on the overall SBI project can be found on the SBI website: <http://utk-biogw.bio.utk.edu/SBI.nsf> or by contacting Jackie Grebmeier, Director and SBI Project Chief Scientist, Marine Biogeochemistry and Ecology Group, Department of Ecology and Evolutionary Biology, The University of Tennessee, 10515 Research Drive, Suite 100, Bldg A, Knoxville, TN 37932; ph. 865-974-2592, fax 865-974-7896; email: jgrebmei@utk.edu.