Goals for SBI Phase 3: Synthesis and Modeling

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An increasing body of research indicates that climate change will significantly impact the physical and biological linkages between the Arctic shelves and adjacent ocean basins. In 1998 the National Science Foundation (NSF) and the Office of Naval Research (ONR) responded to the need for better fundamental information of these linkages through support for an interdisciplinary global change research study, the Western Arctic Shelf-Basin Interactions (SBI) program. Initiated within NSF's Arctic System Science Program, the goal of SBI is to improve our understanding of the impacts of global change on the physical and biogeochemical connections among the continental shelves, slopes, and deep basins of the western Arctic. The SBI field activities have centered on the outer shelf, shelf break and upper slope, where key processes control sea ice cover, water mass exchange and biogeochemical cycles, and where rapid and significant responses to climate change have already occurred. A brief summary of the SBI project development and highlights to date are presented in the attached Editorial for the first SBI Special Issue in Deep-Sea Research II that will have a December 2005 publication data (Appendix A: file SBIDSREditorial.pdf).

The SBI project is progressing in three phases over a 10-year period, outlined below:

- Phase 1 (1998-2001; completed): Analysis and synthesis of historical data (climate variability, physical and biological oceanography, and ecosystem structure and function), opportunistic field investigations, and modeling of specific regions and processes.
- Phase 2 (2002-2006; ongoing): A multi-year field program in the Bering Strait region and over the outer shelf and slope in the Chukchi and Beaufort seas, complemented by biophysical modeling, has allowed integrated studies and initial synthesis of several elements of oceanographic and biological processes across Arctic shelves, slopes, and basins.
- Phase 3 (2007-2009; upcoming): A final phase will focus on the synthesis and integration of a wide range of data into conceptual and numerical models in order to facilitate improved understanding of the Pan Arctic System and to advance predictive capability of impacts of climate change on shelf-basin interactions.

Within the SBI science plan, Phase 3 synthesis was envisioned to focus on two objectives: 1) assessments of global change effects on the biological, chemical and physical processes in the Arctic, and 2) determining global change impacts on overall carbon/nitrogen cycles and the combined effects on the yield and structure of the higher trophic levels, including human populations in the Arctic. Studies would investigate the consequences of global change for the Arctic shelf and basin ecosystem through pan-Arctic models. Such models would include embedded regional submodels, and would have utility in exploring "what-if" scenarios related to global change. Within the proposed Phase 3 synthesis and modeling phase there is a need to evaluate and integrate the field results collected as part of SBI with other western Arctic studies and then expand these studies to a pan-Arctic assessment of other shelves and basins. Together, these activities would advance predictive capabilities concerning both positive and negative impacts and feedbacks of polar change to processes at lower latitudes.

The Pacific sector of the Arctic is a major gateway from the perspective of ocean water mass

exchange, sea ice formation and transport, freshwater, and nutrient fluxes, atmospheric fluxes of heat and moisture, as well as fluxes of organisms and carbon through large seasonal migrations in the ocean and the air. Because the Beaufort and Chukchi Seas are linked to the rest of the Arctic Ocean through the prevailing circulation patterns (also subject to variability) SBI Phase 3 studies would evaluate how different fluxes interact in concert with high and low latitude climate variability and change. Currently we see the greatest change in Arctic sea ice extent and thickness in the western Amerasian Arctic, with intriguing evidence identified during the SHEBA (Surface Heat Budget of the Arctic Ocean) program that much of this change is linked to heat input from the Bering Sea into the western Arctic. The relative contribution of oceanic (thermodynamic) versus atmospheric (dynamic) forcing to changes in ice cover is yet to be explained and is important to understanding how these changes affect Arctic ecosystems. Relevant questions might include: Will continued global warming lead to gradual proportional shifts in atmospheric, ocean, and ecosystem processes, or will threshold dynamics result in dramatic mode-shifts in the Arctic System? Are there feedback processes that can stabilize or reverse recently observed trends? Because SBI Phase 3 will be coincident with the planning and implementation of SEARCH (Study of Environmental Arctic Change), ISAC (International Study of Arctic Change) and IPY (International Polar Year, 2007-2009), SBI synthesis efforts will be both timely in productivity and scope.

Integration and synthesis of SBI observations into a pan-Arctic perspective in Phase 3 will provide a significant legacy and contribute profoundly to ARCSS synthesis efforts. SBI Phase 3 will necessarily combine datasets from other projects to produce new synergistic datasets that will powerfully contribute to regional and pan-Arctic environmental change assessments. Some likely unresolved questions that might be addressed in the SBI Phase 3 Announcement of Opportunity (AO) include:

- Integration of carbon exchange currencies within the sequence: production, transport and fate from marine, freshwater and sea ice. For example, interdisciplinary integration of results from both national and international projects might include SBI, the Freshwater Initiative, JWACS (Joint Western Arctic Climate Study), CASES (Canadian Arctic Shelf Exchange Study), CHINARC (Chinese-American-Canadian-Asian studies in the Arctic), RUSALCA (Russian-American Long-term Census of Marine Life), ASOF (Arctic-Subarctic Ocean Flux study), Russia-German Laptev Sea project, CABANERA (Carbon Flux and Ecosystem Feedback in the Northern Barents Sea in an Era of Climate Change), etc.

- Synthesis of past 50-100 years of oceanographic and sea ice conditions in the western Arctic Ocean to identify linkages between the Pacific discharge and the Arctic, and allow prediction of the effects of changes in Pacific discharge on climate, ecosystem, and ocean-human interactions

- Coupled biochemical/physical modeling of the western Arctic Ocean ecosystem at seasonal to interdecadal scales

- Predictive scales of variability of Pacific Water inflow (heat, freshwater/salt and volume) at seasonal to interannual/decadal scales, which may be critical to the reduction of sea ice

cover in the western Arctic Ocean in the recent years

- Realistic representation of the mean circulation of the Chukchi and Beaufort seas suitable for data validation for forcing of biochemical models

- Prediction of the effects of scenarios of Arctic climate change and carbon sequestration on the western Arctic Ocean ecosystem

- Coordinated studies focused on the synthesis and predictability of the Pan-Arctic ecosystem in collaboration with SEARCH and ISAC objectives, and

- Continued outreach and education, including incorporating local arctic residents into observational activities and data analysis as well as the development of interdisciplinary graduate education programs to instill a systems approach for polar research studies and training.

In order to meet our objectives for a SBI Phase 3 start in 2007, we have developed the following draft timeline for SBI and open community meetings, SBI and ARCSS Advisory Committee meetings, and development of the SBI Phase 3 AO and release.

SBI Phase 3 Timeline

2005
- October: input from ARCSS Committee on SBI Phase 3 objectives and planning
- November: SBI PI eTown meeting for Phase 3 discussions
- December: publication release of first SBI special issue in Deep-Sea Research II

2006
- January: open community eTown meeting for SBI Phase 3 planning discussions
- February: open evening session at AGU/ASLO/TOS Oceans meeting for SBI Phase 3 discussions, with subsequent discussions at SBI PI meeting
- March: SBI Advisory Committee meeting in Wash. DC for focused Phase 3 AO discussions with NSF
- March/April: SBI Phase 3 presentation to ARCSS Committee
- May: finalize SBI Phase 3 AO, start through NSF system
- July: release Phase 3 AO
- October: Phase 3 proposal deadline

2007
- March: SBI Phase 3 (2007-2009) funding, coincident with start of IPY

In conclusion, the objectives for the integration and synthesis activities for SBI Phase 3 will be focused and refined through the science community process over the next 3-4 months in the spirit of the synthesis mode of the current ARCSS program. In this light, SBI Phase 3 activities will provide a valuable contribution to activities within ARCSS to understand the systems dynamics of the Arctic.