THE ARCTIC OCEAN AND GLOBAL CHANGE

A Statement to the US Commission on Ocean Policy
by
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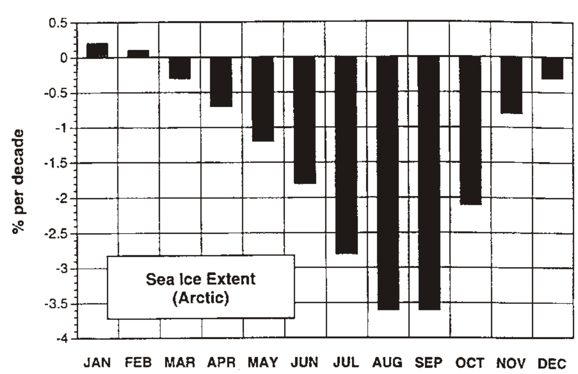
Chair, US Arctic Research Commission

The United States Arctic Research Commission is responsible for recommending Arctic research goals and objectives to the President and the Congress. In addition, we coordinate and encourage interagency cooperation in Arctic research, support improvements in Arctic research Logistics and in the collection and sharing of information concerning the Arctic. The interests of the Commission on Ocean Policy and the Arctic Research Commission meet in our common concern for research activities in the Arctic Ocean and the Bering Sea. For many years the Arctic Ocean and its adjacent seas have been our country's forgotten ocean. In "world wide" ocean study programs such as WOCE (the World Ocean Experiment) studies stopped at 60E North. But the Arctic Ocean has profound effects on the world's climate and in, in turn, profoundly affected by climate change. Even the US Navy has neglected the study of the Arctic even though it was for many years an important theater of operation. But the importance of the Arctic Ocean is emerging and with it the mandate for more extensive study. The pending legislation establishing an "integrated ocean and coastal observing system" (H.R. 4, Sect. 1315) requires the NORLC to employ "Ocean sensors for climate observations, including the ***Arctic Ocean and sub-polar seas***" (sub sect. (C), (2)) (emphasis added).

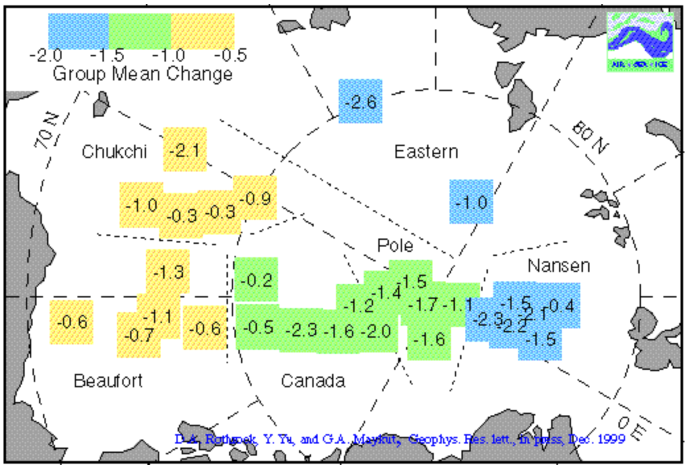
The Arctic Ocean occupies a unique position in the study of global environmental change. The boundary between ice and open water is the most visible climate boundary on the planet. This highly visible boundary marks a line where the annual cycle of warming and cooling leads to a boundary between liquid and solid water. This boundary is unlike any other climatic boundary on the planet. In both its visibility and its sensitivity to changes in climate regime.
The presence of sea ice and the changes in its abundance and distribution make the Arctic Ocean a unique and powerful indicator of climate change.



The rates of change of sea ice extent as a function of time of year. Summer areas are shrinking at the highest rates but winter extent is not changing.

CHANGES IN SEA ICE

The thickness and extent of sea ice in the Arctic is changing - has been changing for some time. The measurement of sea ice extent is a relatively simple task using satellite passive microwave sensors. These

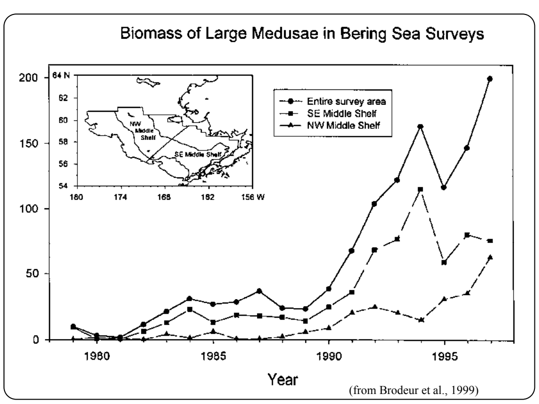


measurements indicate that Arctic Ocean Sea ice is decreasing its summer extent by as much as 3.5 percent per decade. Changes in the sea ice cover during the summer (when the sun rises relatively high in the sky) make for substantial changes in the heat balance of the region. Winter sea ice extent does not seem to vary in the same amount probably due to the formation of young thin ice everywhere during the winter which melts more rapidly during the warmer months.

Measurements of sea ice thickness using upward looking sonar from US Navy nuclear submarines show that the average thickness of sea ice has decreased over the last 30 to 40 years by as much as 2.6 meters per decade. The average loss of sea ice thickness from these measurements is roughly 40% over the last three decades. This reinforces the view that the abundance of thick, multi-year ice has suffered a substantial decrease.

BIOLOGICAL CHANGES

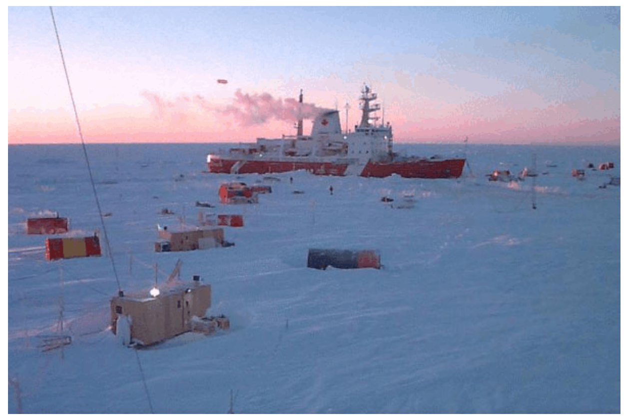
Changes in the location of the edge of the Arctic Ocean sea ice are significant in several ways. Walrus are bottom feeders. In order to feed their young, walrus need to be able to haul out on the ice edge in fairly close proximity to sea floor environments with sufficient food resources. As the ice edge moves these animals may find themselves isolated from either their feeding or haul out areas. This, of course will produce a stress on the walrus which may have harmful effects on their ability to survive in a rapidly changing environment. The endangered population on Steller Sea Lion in the Bering Sea has undergone very substantial reductions in their abundance. So to have sea otters in the same region. These populations appear to be responding to changes in their environment which may be compounded by human activity.



In addition to climate change effects on large and visible marine mammal, changes are occurring in lower trophic levels. Researchers in the Bering Sea have noted very substantial changes in some populations with the largest and most visible occurring in the abundance of *medusae* or jelly fish. This changes is mimicked in the Arctic Ocean as well. The reasons for this change and its association with other phenomena such as changes in nutrient and ice regimes is still unclear but it is clear that substantial changes are occurring.

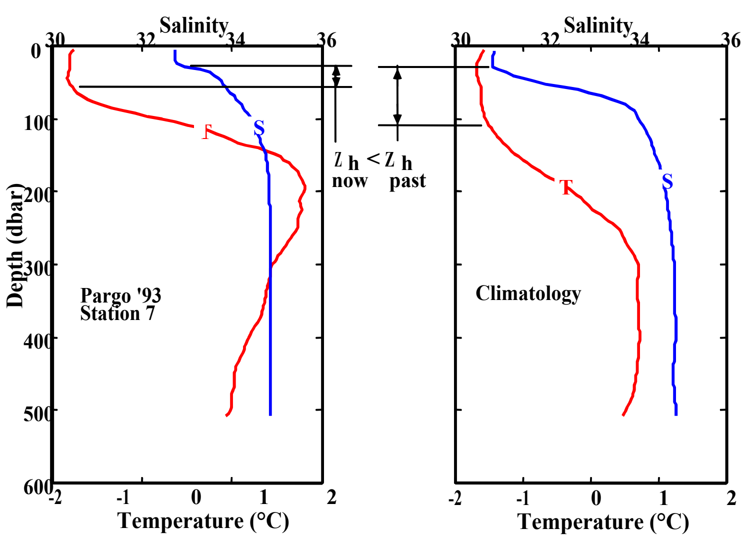
CHANGES IN ENERGY BALANCE

Changes in the location of the boundary between open water and sea ice govern important changes in heat transfer in the region. The albedo of snow covered sea ice is about 90% whereas the albedo of open ocean is less than 20%. Other phenomena complicate this simple view. In order to study the energy balance of the Arctic the National Science Foundation with collaborating programs at the Office of Naval Research, NASA and the Department of Energy undertook a year long study of the Surface Heat Budget of the Arctic (SHEBA) using a Canadian icebreaker frozen for a year in the sea ice in the Beaufort Sea. The principal purpose of this expedition was to understand the factors affecting heat transfer into and out of the Arctic Ocean in order to improve climate models which were deemed inadequate at the time.



The Canadian Coast Guard icebreaker DeGroseiller acting as the SHEBA camp

THE FRESH WATER BALANCE

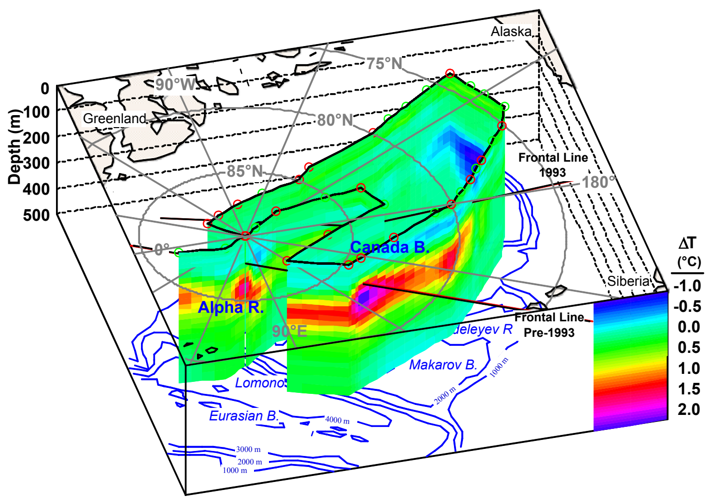


The decay of the cold halocline between the '50s and the '90s. Zh represents the thickness of the cold halocline

The potential feedback between climate change and the hydrological cycle may result in an increase in the supply of fresh water to the region. Freshening the surface water of the Arctic Ocean may have several important effects. First, it can lead to the production of more sea ice during the cold winter months. Second, it may suppress the formation of deep water by decreasing the density of the surface water. Third, the relatively colder fresher surface water in the Arctic protects the surface regime from the mixing in of the heat stored in warmer saltier layers just below the surface, a phenomenon known as the “cold halocline.” The warmer, saltier water below the cold halocline comes from the Atlantic Ocean *via* Fram Strait. This water contains sufficient heat to melt all of the sea ice in the Arctic Ocean. By suppressing vertical mixing the cold halocline protects the surface from the effects of changes in the inflow of Atlantic water. The cold halocline is eroding due to increases in the input of Atlantic water.

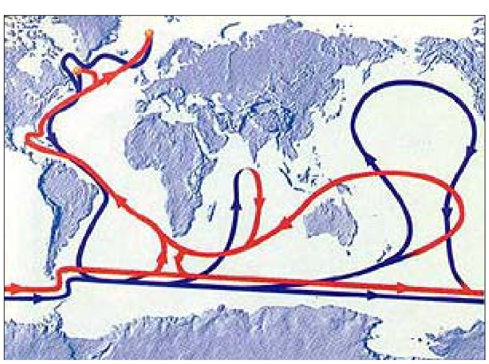
ARCTIC OCEAN CIRCULATION CHANGES

The most significant change in the circulation of the Arctic Ocean was only revealed in the last decade. The abundance of Atlantic water in the Arctic and the penetration of this water mass into the Arctic Ocean Basin has increased dramatically. Comparison of temperature measurements compiled before this decade with the results of measurements made both by icebreaker expeditions and Navy nuclear submarines show an increase of temperature in the core of this water mass of up to 2EC. At the same time, the front between this water and interior water has moved from the vicinity of the Lomonosov Ridge across the Makarov Basin to the Alpha-Mendeleev Ridge.



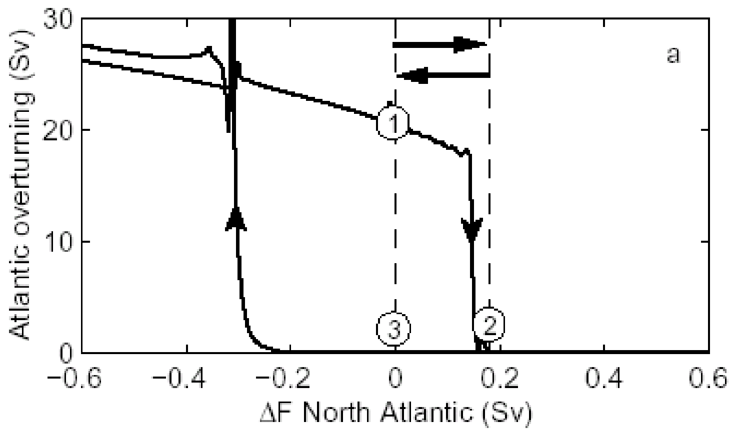
Changes in the temperature of sub-surface water in the “eastern” Arctic Ocean. The core of the Atlantic Water has warmed by 2EC and penetrated into the Makarov Basin

RAPID CLIMATE CHANGE



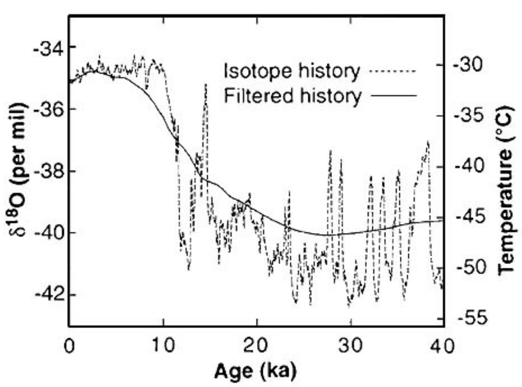
The Oceanic “Conveyor Belt” taking cold dense water (blue) from the Arctic regions throughout the deep ocean and returning warm surface water (red) to be altered again in the Arctic.

The deep circulation of the world ocean is sometimes characterized as the “conveyor belt.” Cold dense deep water is formed in the polar regions and circulates throughout the ocean basins. This cold water rises slowly preventing heat from reaching into the deep. The surface circulation returns warm surface water to the polar regions where it is again cooled to produce deep water. This system is driven in large part by processes occurring in the Arctic and its adjacent seas. Changes in the Arctic may affect the processes driving the conveyor belt.



This figure shows the results of model studies of the effect of changes in freshwater balance ()F) on Atlantic Overturning. An increase of fresh water from Point 1 to Point 2 results in a catastrophic shutdown of overturning. A change back leads to Point 3 indicating the difficulty in restarting the overturning.

Several studies have indicated that the formation of deep water in the Greenland Sea adjacent to the Arctic Ocean is sensitive to the freshwater balance of the region. An increase in the flux of fresh water may lead to a catastrophic shut down of the Atlantic overturning which, in turn, will have major effects around the world. Such a change would cause the flow of warm Atlantic water into the northern parts of the North Atlantic *via* the Gulf Stream to take a more southerly path and leave Scandinavia and Northern Europe with climates much like the of Newfoundland.



Temperature record derived from Oxygen isotope studies on the GISP II ice core from Greenland. Note the very rapid deglaciation at 12,000 years before present.

Such rapid changes are not unknown in the historical record. Isotope studies on ice cores from Greenland show that climate in the region can change with amazing rapidity, changing from fully glacial to interglacial in decades or less. No models come close to making serious predictions of rapid and substantial climate change but the potential is clearly present. These changes are dominated by processes associated with the Arctic where the modification of sea water density is the strongest.

All of the environmental changes discussed above are underway in the Arctic Ocean. Each has been observed in the field but much remains unknown about the Arctic climate system. Many of the changes already recognized may be part of episodic changes in atmospheric and oceanic circulation patterns. As an example, we know that the North Atlantic Oscillation (NAO) and the Arctic Oscillation (AO), decadal changes in atmospheric circulation with major effects in the Arctic have been in operation for many years. On the other hand, it is appears that the AO/NAO is changing and spending more time in the "warm" state of the oscillation. We do not know whether this is an integral and natural part of the AO/NAO system or is evidence of a regime shift. Even more mysterious is the question of what other states the system may take i.e., shifting from the current cold-warm oscillation to a warm-very warm oscillation with major, world-wide climate effects. Climate models do poorly at reproducing these variations. Grid scales are generally too small to give reasonable resolution in the Arctic and the parameterization of the physics involved is similarly elusive. The Arctic Research Commission has called upon the Interagency Arctic Research Policy Committee, chaired by the NSF, to bring together a coordinated, multi-agency research program to study this problem, to fill the inevitable research gaps, to avoid duplication and to improve on our ability to detect and eventually predict climate change phenomena in the Arctic. This program, now well underway, is called the Study of Environmental Arctic Change – SEARCH.

CURRENT RESEARCH PROGRAMS

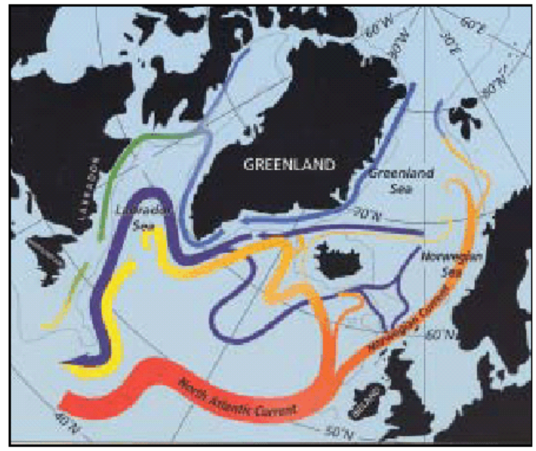
SEARCH. The principal climate change research program currently under way in the Arctic is the Interagency Study of Environmental Arctic Change (SEARCH) <http://psc.apl.washington.edu/search/index.html>. SEARCH is organized as an interagency coordinated program of study of environmental change both on land and at sea. Contributing Agencies include the Department of Agriculture, the Department of Defense, the Department of Energy, the Department of the Interior, the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, the National Aeronautics & Space Administration, the National Science Foundation and the Smithsonian Institute.

Scientists investigating the Arctic environment have collected significant new data in recent years because of improved access to the central Arctic Ocean, new technologies, and better agency and international cooperation. With these new data, researchers have noted unexpected changes in the Arctic. These include:

∃ lower sea-level atmospheric pressure
∃ increased air temperature over most of the Arctic, but lower temperatures over eastern North America and Greenland
∃ changed ocean circulation and rising coastal sea level
∃ warmer Atlantic waters penetrating farther in the Arctic Ocean
∃ reduced sea ice cover
∃ thawing permafrost

Through SEARCH, government agencies will cooperate to understand the full scope of the changes going on in the Arctic. Scientists will research exactly how the observed changes relate to the Arctic's natural variability and if the changes indicate the start of a major climate shift in the North.

Arctic Sub-Arctic Ocean Fluxes (ASOF). ASOF is an important program within SEARCH. Modern models of ocean circulation and climate are among the most advanced tools available to answer these issues. However, questions remain as to whether they yet deal adequately with the complexities of the ocean's thermohaline circulation and its many sources of variability. These controls on the Meridional Ocean Circulation (MOC, the "conveyor belt") are believed to include:



Schematic of the northern loop of the thermohaline circulation in the Northern North Atlantic. Warm, circulation in the Northern North Atlantic. Warm, salty subtropical waters pass north into Worthington's "Arctic Mediterranean", give up their heat and return as cold dense overflows crossing the Greenland-Scotland Ridge through the Denmark Strait and Faroe-Shetland Channel.

∃ the poleward flux of warm and salty Atlantic surface water,
∃ the freshwater & ice flux out of the Arctic,
∃ the speed and density of the deep overflows crossing the Greenland-Scotland Ridge,
∃ open-ocean convection,
∃ mixing near the ocean margins, including the sea surface,
∃ ice-ocean and atmosphere-ocean interactions, and freshwater input from the atmosphere and rivers.

These processes and transports are poorly observed and understood. We have no measurements of the freshwater flux between the Arctic Ocean and Atlantic by either of its two main pathways; we have new (from the European Community VEINS Project) measurements of the heat and salt flux to the Arctic Ocean, but not yet of its variability on any scale; we have a growing knowledge of the long-term variability of the hydrography of the dense overflows which "drive" the MOC, but only embryonic ideas as to their causes, etc; and our present observations of the MOC (in the North Atlantic or anywhere else) are insufficient to detect whether it is changing. Understandably then, we would take the view that these key mechanisms and processes are too crudely represented in the present generation of global climate models. It is the aim of ASOF to supply these missing observations. More specifically: to measure and model the variability of fluxes between the Arctic Ocean and the Atlantic Ocean with a view to implementing a longer-term system of critical measurements needed to understand the high-latitude ocean's steering role in decadal climate variability. Full details as to where, what, when and why can be found in the ASOF Science Plan or Implementation Plan at http://asof.npolar.no/.

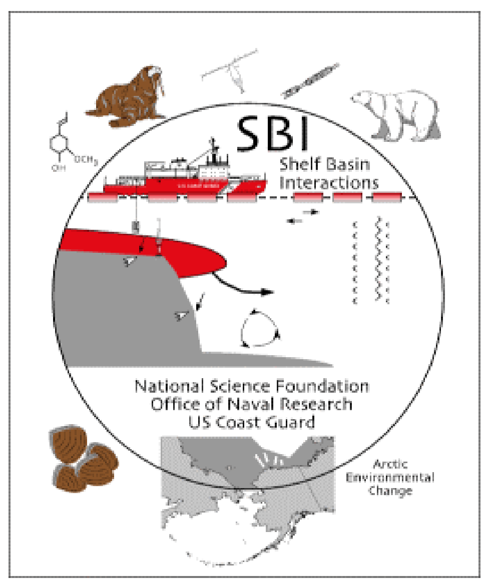
The North Pole Observatory. Beginning in spring 2000, an international research team supported by the National Science Foundation (NSF) has conducted annual expeditions each April to the North Pole to take the pulse of the Arctic Ocean and learn how the world's northernmost sea helps regulate global climate <http://psc.apl.washington.edu/northpole/>. The team establishes a group of un-manned scientific platforms, collectively called an observatory, to record data throughout the remainder of the year on everything from the salinity of the water to the thickness and temperature of the ice cover. With the experience gained from early versions of the Observatory, the number of research projects has begun to expand covering an even broader range of sciences. The Observatory offers opportunities for three types of measurements:

∃ Drifting data buoys reporting via satellite provide coverage over a wide geographic area by following the drift of the ice pack.

∃ Oceanographic moorings anchored to the ocean floor recording internally measure long-term time series at a single position beneath the ice.

∃ Aerial surveys of hydrographic casts profiling parameters from the surface become possible using the light aircraft used in the April mooring and buoy deployments.

For long-term observations, an automated station does the work of a manned camp, but at far less cost. The area around the North Pole is far from any landmass or observing stations. Even with the use of submarines and icebreakers it is difficult to obtain long-term measurements at the Pole. The Observatory will fill a hole in current observations of the Arctic and provide a set of data taken over a long period as a benchmark for the study of climate change.



The Western Arctic Shelf Basin Interactions Program. The Western Arctic Shelf-Basin Interactions (SBI) program has been developed to improve our knowledge and understanding of shelf-basin exchange and will lead to an enhanced predictive capability for global change impacts in the Arctic. The SBI program includes field and modeling studies directed at elucidating the underlying physical and biological, shelf and slope processes that influence the structure and functioning of the Arctic Ocean. The SBI program is being conducted in three phases:

∃ Phase 1 involves regional historical data analysis, opportunistic field investigations, and modeling.

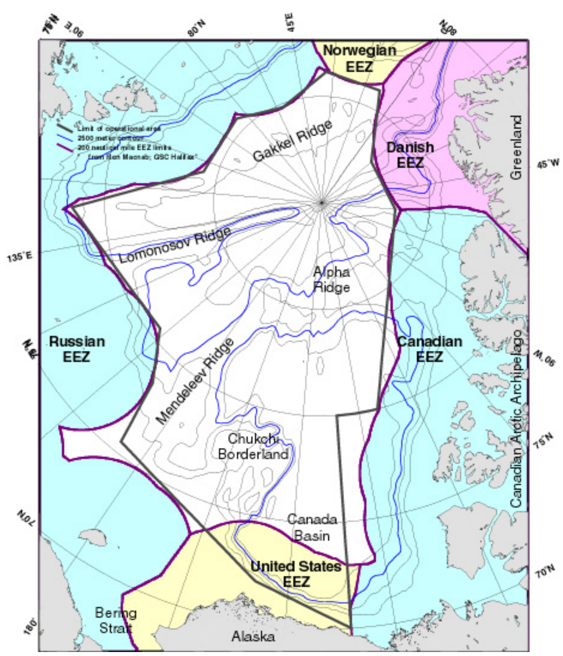
∃ Phase 2 constitutes the core regional field investigations in the Chukchi and Beaufort Seas, along with continued regional modeling efforts.

∃ Phase 3 will investigate global change ramifications on the ecosystems of the Arctic shelves and basin. This phase will involve development of a Pan-Arctic model (including embedded regional sub-models) suitable for exploring "what-if scenario" studies related to global change.

Phase 2, the field investigations phase, of SBI is under way now. The spring cruise (5 May - 15 June, 2002) has already been conducted and the summer cruise (15 July - 26 August, 2002) is currently underway aboard USCGC HEALY.

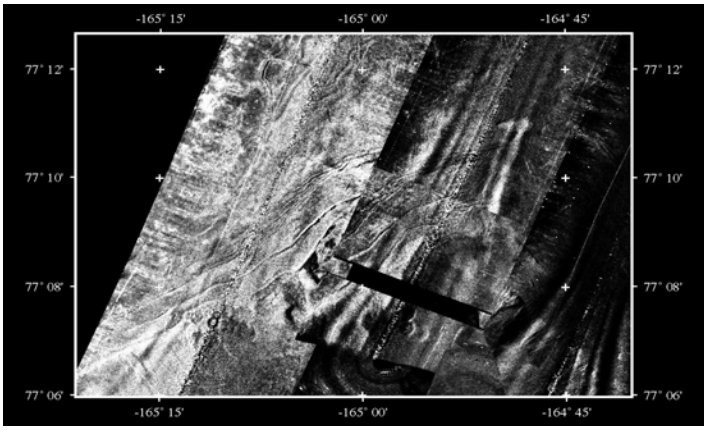
<u>The Arctic Environmental Observatory in the Bering Strait</u>. This project is funded by the National Science Foundation, is a cooperative research project involving scientists from the University of Tennessee, the Alaska Department of Fish and Game, and the University of Maryland. A permanent observatory has been installed on Little Diomede Island in the Bering Strait. Physical, chemical, and biological data will be collected automatically from water pumped into the school-based station from the depths of the Bering Strait. Some of the island residents will participate in the project by helping maintain the system and doing manual sampling. Local subsistence hunters will also collect marine mammals to be examined and cataloged as part of the long-term records for the site.

The settlement on Little Diomede, Site of the Observatory



The SCICEX Operating Area

<u>SCICEX</u>. In six cruises between 1993 and 1999 the Navy provided 211 days of research time covering more than 90,000 km of survey track. Changes in the Navy's submarine fleet due to the end of the Cold War have ended the opportunity for "dedicated" submarine cruises with civilian science riders and special instrument installations. Nevertheless, the SCICEX program continues at a reduced level.



A SCAMP Sidescan Sonar Image of Glacial Moraines on the Chukchi Rise

SCICEX investigators receive data and samples from “opportunity” cruises - several days of observing time using the standard instrumentation on the submarines during time available during Arctic Ocean cruises conducted for military purposes. The scientific community sets priorities for these cruises and the Navy endeavors to carry out as much of the high priority science as the submarine can accomplish in the available time. Unfortunately, no civilian science “riders” are allowed on these missions, nor are special instrument installations possible. The possibilities for future use of Navy nuclear submarines by civilian researchers are under continuing discussion. See below.

The dedicated cruises aboard Navy submarines allowed synoptic views of the Arctic Ocean for the first time. The submarine is capable of systematically surveying water mass properties, bottom topography and sampling for chemical and biological analyses with a rapidity and precision not attainable by any other platform. Ice cover inhibits measurements from aircraft or spacecraft and the difficulties of navigating in - rather than under - the Arctic sea ice makes icebreakers an inefficient platform for rapid exploration and regional surveys. While highly directed research cruises are vital in all oceans, they stand on a century or more of survey data in the temperate and tropical oceans. The Arctic Ocean is in almost every way a virtually an unknown place. Among the most exciting scientific instruments deployed on the USS HAWKBILL in 1998 and 1999 was the Sea floor Mapping and Characterization Pods (SCAMP) a bathymetric mapping and side scan sonar instrument. This instrument package included a SeaMarc™ interferometric sonar recording both bathymetry and backscatter information and a “chirp” sub-bottom profiling sonar for shallow stratigraphic investigations.

Recent discoveries using SCAMP include the imaging of glacial phenomena including iceberg scours, sub-glacial flutes and moraines at depths approaching 1000 meters. These features indicate floating ice shelves in the Arctic Ocean during past ice ages comparable to the modern ice shelves in the Antarctic. The Antarctic ice shelves are the source for the large tabular icebergs common in the Southern Ocean. Iceberg scour marks and erosion features at depths of 1000 meters on the Lomonosov Ridge clearly show that this phenomenon occurred in the Arctic as well. No current models of ice age climate in the Arctic produce or even consider major ice shelves in the Arctic during the

Pleistocene glacial events. Bathymetric measurements using SCAMP have more than doubled the database of soundings in the region.

FEDERAL FUNDING AGENCIES

The principal funding agencies for research in the Arctic Ocean are the National Science Foundation, the Office of Naval Research and NOAA. Although not broken down into terrestrial and marine categories, NSF Office of Polar Programs Arctic research funding has grown from around $17 million in FY '94 to over $60 million in the President's FY '03 budget request (but only a small part of the OPP funding was for Arctic Ocean research). This sounds like excellent news for Arctic research, but it is tempered other decreases. Funding for the ONR High Latitude Program has decreased from $30 million in FY '94 to $2.5 million in the current budget. NOAA funding for their Arctic Research Initiative has stayed between $1 million and $2 million over the same time period. Taking inflation into account the $48 million in these budgets in FY '94 and the $63 million in FY '03 are just about a wash for Arctic Research.

At NSF the budget for Arctic research activities has grown over this period from about 40% of that for Antarctic research to equality with the Antarctic research budget. In addition, a substantial supplement for Arctic logistics has made it possible for NSF-OPP Arctic Sciences to support extended operations aboard USCGC HEALY and the SCICEX submarine. Previously, logistics costs in the Arctic were paid from science funds. Motivated in part by the Arctic Research Commission's Report on Arctic Logistics, an increase of approximately $20 million in the NSF-OPP budget for Arctic Logistics was incorporated in the FY '00 budget.

Logistics funding for Arctic research at NSF remain substantially below those for Antarctic research but, with the exception of ship costs, logistics and facilities in Alaska and other parts of the Arctic are much more available than in the Antarctic. Many years ago the government issued a Presidential Decision Directive requiring that NSF maintain three research stations on the Antarctic continent at McMurdo Sound, the Palmer Peninsula and the South Pole. US facilities in the Arctic are on a much more modest scale.

Icing aboard USS Kirk, FF 1087

The Arctic Research Commission has recommended a substantial increase in the funding of the ONR High Latitude Program. The support of the Ocean Policy Commission for this suggestion would be most welcome. The abandonment of Arctic Ocean research by ONR flies in the face of the results of the Symposium on Navy Operations in an Ice Free Arctic supported by The Oceanographer of the Navy, the Navy/National Ice Center, ONR and the Arctic Research Commission. This meeting made it clear that the products of civilian research were essential for the Navy to accommodate to changes in the battle space environment which may be caused by global change on time scales comparable to those involved in Navy RDT&E and acquisition activities.

OCEAN RESEARCH FACILITIES

There are three important issues regarding the floating research platform needs in the Arctic Ocean. These are:

∃ the Coast Guard Icebreakers,
∃ the Alaska Area Research Vessel, and
∃ nuclear submarine capabilities.

The Coast Guard Icebreakers. The USCGC HEALY recently brought into service as the principal research icebreaker for the US Arctic Ocean research community is a sophisticated and highly effective ship. Recent users in 2001 and 2002 are full of praise for HEALY. But two interconnected issues arise about the Coast Guard icebreakers. The first is the timing of efforts to consider replacements for the two Polar Class ships POLAR SEA and POLAR STAR. These ships are now thirty years old. Since the design and construction of a major new research ship takes about ten years and since forty years is clearly a long life for any ship, the time to begin planning for the replacements for these ships is now. It may seem odd that this issue is brought before the Ocean Policy Commission by the Arctic Research Commission when the Arctic has just received an excellent new ship. But if POLAR SEA and POLAR STAR are not replaced in a timely fashion it will still be necessary to support the US Antarctic program, especially the annual resupply at McMurdo Sound and HEALY may be diverted from its role in the Arctic to provide this vital service with devastating effects on Arctic Ocean research. Although the Coast Guard's Deep Sea fleet renewal plan is still

USCGC HEALY (WAGB 20) in the ice

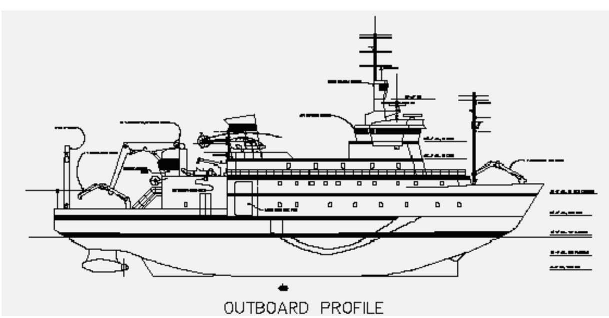
USCGC HEALY

formulating, it does not appear that there is consideration for new icebreakers in their plans.

The second problem arising is the question of the continuity and emphasis on icebreaker operations as the Coast Guard enters the new Department of Homeland Security. It remains uncertain whether or not the Coast Guard in its new home will want to continue to provide icebreaker support to science as a major function. In addition, Coast Guard operation of research vessels is at times viewed by the academic community with a somewhat jaundiced eye. Massive ship's crews verging on 100 people and an operating tempo of around 180 days away from homeport would certainly jeopardize the future of a UNOLS vessel which operates with a scientist to crew ratio of about 3 to 2 and schedules of more than 250 days at sea.

Given the necessity to consider the next generation of large icebreakers and questions about the Coast Guards priorities in its new governmental home, this is an excellent time for the careful consideration of new arrangements for the 21st century icebreaker fleet.

<u>The Alaska Area Research Vessel</u>. The highly capable polar icebreakers are not, however, the only ships needed. The Federal Oceanographic Fleet Coordinating Committee (FOFCC) plan <http://www.unols.org/fic/fofc_fleet_plan.html> includes two new vessels for work in the Arctic margins. The Alaska Area Research Vessel (AARV) is at the top of the FOFCC priority list and enjoys overwhelming support from the UNOLS community for its construction as the first of these new ships. This ship will be particularly important for research on fisheries in the Bering Sea with an emphasis on its ability to conduct important fisheries research throughout the year. You will hear more about these research needs from Jim Balsinger, Clarence Pautzke and Craig Dorman. The Arctic Research Commission strongly supports the early construction of the AARV.



Outboard Profile of the AARV

<u>Nuclear Submarine Capabilities</u>. From 1993 through 1999 the US Navy provided civilian researchers with the opportunity to use Navy nuclear fast attack submarines as research platforms. The six SCICEX dedicated cruises (there was no cruise in 1994) provided 211 days of research time in the Arctic covering more than 90,000 km of survey track. The data base on the Arctic Ocean produced as a result of the SCICEX dedicated cruises more than doubled our knowledge of the Arctic Ocean and its behavior. As a result of major reductions in the number of the Navy's nuclear fast attack submarines at the end of the Cold War, it is no longer possible for the Navy to provide the civilian

science community with dedicated cruises on which civilian scientists can ride the submarine and sophisticated instruments can be carried aboard for research purposes. Nevertheless, the Arctic Ocean research community has tasted the heady wine of submarine data collection at speeds up to 18 knots, enjoying virtually complete freedom to maneuver within the confines of the approved operating area, and they want more! How can data collection capabilities equivalent to that provided by the Navy in the SCICEX dedicated cruises be regained?

USS HAWKBILL (SSN 666) at the North Pole

There are several ways to achieve a “SCICEX like” data acquisition program. The first of these is to find a way to encourage the Navy to, once again, conduct dedicated cruises aboard Arctic capable Navy nuclear submarines. In order to do so the priorities given to the Navy submarine force must include Arctic survey work as a requirement. While ordinary circumstances are not likely to raise the priority of scientific research to this level, there are other motivating requirements such as Article 76 of the UN Convention on the Law of the Sea (See below).

The Navy is considering a successor to the nuclear research submarine NR-1. A workshop was held in 2000 to recommend scientific capabilities for a replacement and the nearly universal recommendation of the attendees was that the new submarine be capable of independent operation in the Arctic. If and when the Navy decides to replace NR-1 with a new (Arctic capable) research submarine, the capabilities of the SCICEX program will be restored.

Much of the value of the SCICEX dedicated cruises was in the rapid and systematic surveys conducted on such parameters as ice draft, water mass properties, bathymetry and gravity. Special studies including specialized ice thickness maps of sites re-occupied several times were also conducted. The submarine’s ability to respond to scientist’s on-scene recognition of anomalous features in the oceanographic realm (eddies, fronts, bottom anomalies) made the presence of science rider highly valuable. Nevertheless, the survey capabilities and some of the anomaly recognition activities could be duplicated by autonomous underwater vehicles (AUVs). The characteristics of a suitable Arctic Ocean Exploration AUV (AOE-AUV) are substantially different from any AUV currently in existence. The AOE-AUV should be capable of around 10,000 km of survey track during each deployment. This amounts to a speed slightly under four knots during a 60 day deployment. The vehicle will need an air independent power (AIP) system but these devices already exist in several forms. Perhaps the most challenging engineering problem is the development of sensing systems for such measurements as ice draft, bathymetry and gravity capable of operating independently and reliably for 60 day without the intervention of a support technician. Solving this problem will be a boon to all oceanographers as the requirement for technician time on all platforms could be substantially reduced if these instruments could be depended upon to operate throughout a cruise without the attention of a marine tech.

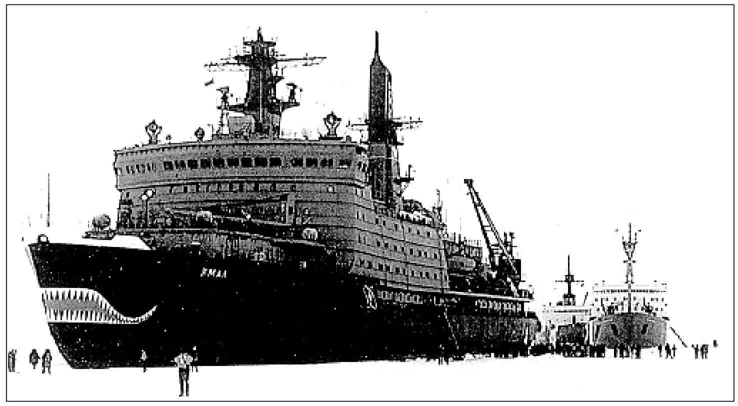
Another approach to the problem is to discuss opportunities with the Navies of other nations with under-ice capabilities. Both Great Britain and the Russian Federation operate nuclear submarines under the Arctic sea ice. Both Sweden and Germany have produced non-nuclear but AIP submarines capable of extended operation below the surface. The Arctic Research Commission continues to explore these developments with potential providers.

INTERNATIONAL COOPERATION

The Arctic Ocean is bordered by the US, Russia, Norway, Denmark/Greenland and Canada. The International Arctic Science Committee (IASC) is a non-governmental association of Arctic researchers. It includes these five and another 13 members including Great Britain, Germany, France, Japan and China. Because of its location the Arctic Ocean is a site for multinational research. The Arctic Ocean Studies Board is a government-to-government body which concerns itself specifically with Arctic Ocean research cooperation. AOSB Members are: Canada, Denmark, Finland, France, Germany, Iceland, Japan, The Netherlands, Norway, Poland, Russia, Sweden, Switzerland, the United Kingdom and the US. IASC and the AOSB work closely together and conduct their annual meetings together in order to support international coordination and multi-national program planning.

IASC has created a Forum of Arctic Research Operators (FARO). FARO is designed to bring together logistics and facilities providers to discuss operating procedures and to support resource sharing. These discussions include both land based logistics and research station use and ship schedule information. In addition, there is a special arrangement between the US Arctic Research Commission and the Canadian Polar Continental Shelf Program (CPCSP) for logistics sharing including icebreaker scheduling and joint use opportunities. Since the CPCSP is the principal provider of logistics support for Canadian researchers in their Arctic region, it also supports the logistics needs of US researchers working in the Canadian Arctic at cost.

Research aboard icebreakers in the high Arctic is generally carried out on two ship expeditions with ships from different countries. HEALY (USA), POLAR SEA (USA), LOUIS ST. LAURENT (Canada), POLARSTERN (Germany) and ODEN (Sweden) have, in various combinations conducted two ship expeditions to the high Arctic during the last decade. Even the Russian nuclear icebreakers have been used (although they have no research facilities) for their very high power and endurance levels and consequent ability to break very heavy ice while escorting the research icebreakers. All of these expeditions have included international science parties from several countries.



YAMAL (foreground) , POLAR SEA and LOUIS ST. LAURENT at the North Pole, 1994

ARCTIC COMMERCE

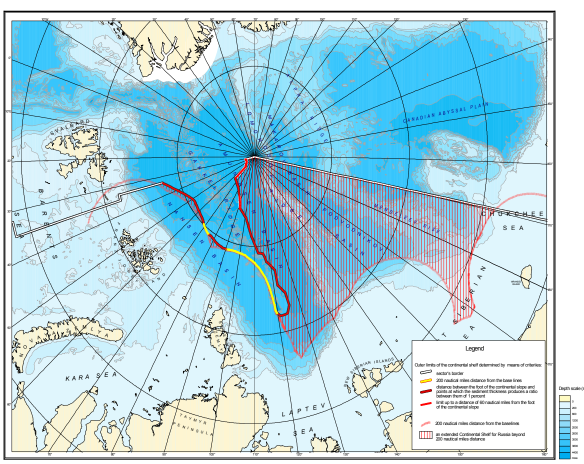
Climate change will change our view of commercial activities in the Arctic. Arctic commerce can be divided into transportation and resource exploitation activities. The effects on transportation in the Arctic will be profound for the 9 out of 10 people in the world who live on continents bordering the Arctic Ocean. Currently, transportation into the high Arctic is limited mostly to re-supply of various settlements and resource operations in the region. This transport by ship or barge is limited to a relatively short late summer season when open water along the North coasts of the mainland continents allows the penetration of ordinary shipping. The Northern Sea Route across Russia is a special case operated by the Russian government with icebreaker support from the Murmansk Shipping Company. The Northern Sea Route is subject to detailed regulations promulgated by the Northern Sea Route Authority. The Northwest Passage across the Canadian Arctic is governed by the Canadian Arctic Shipping Pollution Prevention Regulations. Both the Northern Sea Route and the Northwest Passage are considered by their regulating governments as internal waters requiring compliance with these regulations. The US government does not recognize these claims but maintains friendly relations with the two powers involved and does not defy their authority. The International Maritime Organization (IMO) is drafting a “Polar Code.” This code should govern high latitude shipping both North and South. Whether the IMO Polar Code will supplant or supercede the Canadian and Russian regulations remains undecided.

Climate change may substantially alter this regime. The distance from North Pacific to European ports *via* the Arctic is 40% shorter than the equivalent distances *via* either the

Panama or Suez canals. If warming in the Arctic leads to a substantial window of opportunity for trans-Arctic shipping for such cargoes as Japanese automobiles from Pacific ports to either Europe or the east coast of North America, we can expect a large increase in ship traffic through the region. Even without sea ice the Arctic Ocean is not a particularly hospitable place. Trading ice cover for weather typical of the winter North Atlantic or Pacific may not provide a tranquil setting for Trans-Arctic shipping. Nevertheless, the potential for these changes suggests that we should be better prepared for the future.

The natural resources of the Arctic are substantial. The largest lead-zinc mine in the world is the Red Dog mine in the Alaskan Arctic. The town of Bilibino in Arctic Russia exists to support gold mining in that area. Oil and gas in the Canadian, US and Russian Arctic is abundant and may become a principal source of energy for the developed world, particularly in the US. The European Union and Russia are currently collaborating on the development of petroleum resources in the Eastern Barents Sea to be transported in ice strengthened tankers (already under construction) to Murmansk for transshipment to large tankers for the trip to Europe. Canada has experimented with the transportation of oil south by tanker from the MacKenzie River delta. There can be little doubt that the enormous Russian continental shelf in the Arctic will be an oil-producing region in the future. As climate change reduces the difficulties associated with sea ice, major petroleum production development will expand. The potential for damage to the environment from these activities can only be understood by broadening our knowledge base through expanded research and by closely monitoring and exploring the mechanisms and processes of environmental change in the Arctic.

UNCLOS ARTICLE 76



The Russian Article 76 Claim in the Arctic

Under Article 76, of the UN Convention on the Law of the Sea (UNCLOS) State Parties (those who have acceded to the treaty) may submit claims to the sea floor beyond their current 200 mile exclusive economic zones (EEZs) which can be identified as extensions to their continental margins. These claims concern only the sea floor and soils, sediments and geological formations below the sea floor. Claims under Article 76 require survey data of various kinds supporting these claims as well as agreement on maritime boundaries between adjacent states. We expect that the Senate will eventually ratify UNCLOS. From the date of our accession to the Convention we will have ten years to submit our claim under Article 76.

Russia is a signatory to UNCLOS and has already submitted its claim under Article 76. This claim is currently being evaluated by the Commission on Extensions of the Continental Margin, established by UNCLOS and currently chaired by Russia. The Russian claim includes nearly 45 percent of the international area of the Arctic Ocean. US marine geologists who have reviewed the Russian claim at the invitation of the State Department are of the opinion that supporting data are sparse and of low quality and that the geological interpretation used to justify the Russian claim is not based on internationally accepted geological standards and practices. Nevertheless, the Russian claim covers almost 45% of the Arctic Ocean.

The United States has virtually NO DATA in the Arctic Ocean Basin on which to base a claim under UNCLOS Article 76. The United States appears to have a significant claim to in the Arctic which would include potential fossil fuel resources on the Chukchi Plateau and the Northwind Ridge north and east of the Bering Strait. If the Russian claim is approved, the provisions of UNCLOS, Section XIII, Article 246, will require that any nation desiring to conduct research on or below the sea bed obtain research clearance in the same way currently required for work insider the 200 mile EEZ. Russia rarely grants this clearance to US vessels. If/when the Russian claim is established, marine geological and geophysical research will be seriously affected in around 45 percent of the Arctic Ocean.

The United States can (and should) conduct a proper, comprehensive survey both to counter the Russian claim, and to set a fair, high quality, international standard for the survey data gathered to support Article 76 claims. The United States can get an early start on data collection even before acceding to the treaty. In addition, the possibility for international cooperation and the development of multiple claims exists. Norway (Svalbard) and Denmark (Greenland) are ready to invite a US Navy submarine into their EEZs as part of a program to collect and share data needed to submit their claims (a nuclear submarine is the platform most capable of collecting systematic survey data in the ice covered Arctic). Precedent exists in both nations from previous invitations. Numerous government officials in Canada are anxious to participate in a data sharing endeavor that will enable them to get started on their own claim. However there is not, at present, a consensus in Ottawa. Should Canada ultimately participate, there is also a possibility that a sufficiently credible and objective survey could be accomplished to resolve questions about the maritime boundary in the Arctic Ocean between the United States and Canada.

While the importance of the of a US claim under UNCLOS Article 76 is important to the US, a systematic and complete bathymetric and stratigraphic survey of the non-Russian portion of the Arctic Ocean will collaterally give researchers a comprehensive data base to study the current state and geologic, climatic and oceanographic history of the Arctic Ocean, adding to the dramatic revelations gained in 1998 and 1999 from surveys conducted by the SCICEX Program. The strategic/political priority for these surveys is what may drive them to completion, but their scientific value cannot be underestimated.

NATIONAL SECURITY

THE UNITED STATES IS AN ARCTIC NATION. We have many responsibilities and opportunities in the Arctic Ocean. The Arctic coastline of the United States is larger than the Coastline of any other state in the union except Florida and the combined Arctic Ocean and Bering Sea coastlines in the Arctic Research Commission's area of responsibility are roughly 25% of the entire coastline of the nation. The port of Dutch Harbor is the largest fishing port in the US in terms of dollar value landed and the Alaska fishery as a whole exceeds the dollar value of the rest of the country combined. In the Arctic we share maritime boundaries with both Canada and Russia. Resources in the circum-Arctic will grow in importance. Climate change will bring about important new activities in transportation and resource exploitation. Activities in Russia will involve US firms in joint ventures. Currently, the Arctic boundaries of the United States are virtually unguarded and the potential to penetrate the barriers erected for the security of the country are enormous. If the United States chooses not to be the dominant player in the Arctic Ocean we cede that ocean to whichever nation decides to exercise control.

RECOMMENDATIONS

The Arctic is changing more dramatically than any place else on the planet. These changes are occurring now and we must maintain and increase our research efforts in order to understand and to adapt to these changes. The Arctic Research Commission recommends to the Commission on Ocean Policy the following policy initiatives:

1. Restore the funding for the ONR High Latitude Program to the $10-$15 million per year range.

2. Ratify the United Nations Convention on the Law of the Sea and commence immediately a program of bathymetric surveys to meet the requirements of Article 76 on all the US coasts.

3. Restart the SCICEX dedicated cruises either as part of the above or as essential research activities on their own merits.

4. Commence planning for the replacement of the Polar Class icebreakers and review their operating mode.

5. Integrate Arctic Ocean research in the National Ocean Research Plan and the Integrated Ocean Observing System. Integrate Arctic Ocean planning in planning by all ocean research agencies.

6. Include Arctic Ocean studies in planning for the President's Climate Change initiative.

7. Follow the FOFCC Plan and build the AARV.

Given these important reasons for understanding the region and its changing and challenging environment the Arctic Research Commission asks that you -

DON'T FORGET THE ARCTIC!

22 August 2002

THE HONORABLE GEORGE B. NEWTON

Biographical Sketch

George Newton received a Bachelor of Science degree in Electrical Engineering from Brown University in 1958 and a Master of Science degree from Rennselaer Polytechnic Institute. He spent 24 years in the U.S. Navy, almost exclusively in submarines, including command of a nuclear attack submarine.

Since entering the business field in 1981, he has had almost continuous involvement with Arctic science, research, and development matters. Most notable has been his continuous participation in the U.S. Navy's Arctic Programs, in general, and the Submarine Arctic program, specifically. In 1990 he was appointed to then-Senator Albert Gore's *Ad Hoc* Sea Ice Data Committee, formed to analyze submarine Arctic sea ice profiles and tie statistical trends in ice mass to possible climate change. In 1992, President George Bush appointed him to a 4-year term as a member of the U.S. Arctic Research Commission. He was subsequently reappointed to second and third terms and elevated to the position of Chair. Long an advocate for using submarines in the Arctic for civilian research, he conceived and coordinated the initiation of the Submarine Science (SCICEX) program a unique cooperative effort between U.S. civilian science agencies and the operational Navy. The program enabled six dedicated science cruises (1998-1999) under sea ice that significantly changed the world's understanding of the Arctic Ocean.

Currently Mr. Newton works for Planning Systems, Inc. in Reston, VA, in addition to his chairmanship of the Arctic Research Commission. He is a member of the Arctic Institute of North America, the Naval Submarine League, and the Cosmos Club.

08/08/02