Polar Icebreaker Roles and U.S. Future Needs: A Preliminary Assessment

Committee on the Assessment of U.S. Coast Guard Polar Icebreaker Roles and Future Needs

Polar Research Board
Division on Earth and Life Studies

Marine Board
Transportation Research Board

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Acknowledgments

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

Lawson Brigham, U.S. Arctic Research Commission, Anchorage, Alaska
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Although the reviewers listed above have provided constructive comments and suggestions, they were not asked to endorse the report's conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by George M. Hornberger, University of Virginia, and John B. Mooney, Jr., U.S. Navy (ret.). Appointed by the National Research Council, they was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring Committee and the institution.

Contents

Summary

At the request of Congress in PL 108-334, the U.S. Coast Guard (USCG) provided funds to the National Research Council of the National Academies to establish the Committee on the Assessment of U.S. Icebreaker Roles and Future Needs. The Committee's Statement of Task (Appendix A) charges it to provide a comprehensive assessment of the current and future roles of U.S. Coast Guard polar icebreakers in supporting U.S. operations in the Antarctic and the Arctic, including scenarios for continuing those operations and alternative approaches, the changes in roles and missions of polar icebreakers in the support of all national priorities in the polar regions, and potential changes in the roles of U.S. Coast Guard icebreakers in the Arctic that may develop due to environmental change. The Committee was asked to provide a brief interim report to highlight the most urgent and time-dependent issues, and this report fulfills that request. The Committee will provide a final report covering the full scope of its tasks and more detailed analysis in the late summer of 2006.

In this interim report, the Committee describes present and expected future uses of the polar icebreakers (POLAR STAR, POLAR SEA, and HEALY) with respect to relevant U.S. Coast Guard missions in the Antarctic and the Arctic, including national defense, homeland security, support of economic activity, law enforcement, search and rescue, environmental protection, and the support of and conduct of science, as part of an overall demand for icebreaking services. This report also addresses potential changes in the roles and missions of U.S. Coast Guard polar icebreakers in support of future marine operations in the Arctic that may develop due to environmental change. The Committee addresses what it believes are the most time-dependent issues for decisions makers, focusing in particular on the urgent, short-term need for reliable icebreaking support. Longer-term issues will be covered in detail in the Committee's final report.

The Committee appreciates the presentations and supplementary materials provided by the U.S. Coast Guard, National Science Foundation, Arctic Research Commission, Department of State, National Oceanic and Atmospheric Administration, and others in the marine transport and science communities. The Committee's findings and recommendations are based on its analysis of the materials and briefings received, and the Committee's expert judgment. The Committee members have expertise in ship design and operations, national defense, naval architecture, marine transport–shipping industry, polar ship technologies, icebreaker command and operations, science management, oceanography, glaciology, sea ice dynamics, paleoclimatology, and Antarctic policy.

Congressional staff and Office of Management and Budget (OMB) examiners spoke with the Committee and they indicated a need for management decisions regarding the polar icebreakers. The Committee was told that the findings and recommendations in this report could be useful for informing FY07 budget decisions. Although the Statement of Task does not request the Committee to make management recommendations, it explicitly instructs the Committee to provide materials for urgent decision making. The Committee believes that management recommendations are useful to both Congress and OMB to help in resolving the U.S. Coast Guard icebreaker issue for FY07 and until a long-term solution can be found. The Committee hopes that the interim findings and recommendations will inform decision making while it proceeds to carefully develop recommendations for a long-term solution. The Committee identifies four overarching issues for which findings and recommendations are made. These issues are icebreaking needs for the Antarctic and for the Arctic, the current status of the U.S. Polar Class (heavy) icebreakers, and managing the nation's icebreaking assets.

ICEBREAKING NEEDS IN THE ANTARCTIC

The need for icebreaking in the Antarctic is primarily a result of a succession of national policy statements and Presidential Decision Directives, which assert that the United States has strategic interests in the Antarctic related to foreign policy and security, environmental protection and scientific research. The United States asserts strategic interests in Antarctica through the year-round residence of American researchers at three permanent scientific stations. The presence of the South Pole Station, in particular, helps protect the U.S. position on sovereignty in Antarctica, providing for a unique research platform at a location that assures U.S. participation in the Antarctic Treaty system.

Despite some missions of opportunity, the primary use of U.S. heavy icebreakers (POLAR STAR and POLAR SEA), at present, is to break a channel into McMurdo Station to aid the re-supply that is critical to the continued functioning of both the McMurdo and South Pole Stations. By using an altered logistics strategy, the National Science Foundation (NSF) has determined that it may be possible to maintain operations at the McMurdo and South Pole Stations while occasionally skipping annual channel break-in and ship-borne portion of the McMurdo re-supply to avoid a break-in under extraordinarily heavy ice conditions. Nevertheless icebreaker support of the break-in to McMurdo Station is required for the foreseeable future. Based on these findings, the Committee recommends:

- **Recommendation #1**: The United States should reliably control (by ownership or other means) at least one heavy icebreaker that is available and capable of breaking a channel into McMurdo Station.

The Committee will investigate in the next several months how the icebreaker assets should be controlled to meet the nation's icebreaking needs, and recommendations will be provided in the final report.

ICEBREAKING NEEDS IN THE ARCTIC

Because of the geographic location of Alaska, the United States is an Arctic nation with significant geo-political, security, economic, and scientific interests in the Arctic, and U.S. interests must be protected in this region. The U.S. Coast Guard has the overarching missions of maritime safety, maritime security, national defense, and protection of natural resources in this

region where icebreaking capabilities are sometimes required. Although the HEALY is primarily devoted to fulfilling the U.S. Coast Guard mission to support scientific research, this ship is also available to support the overarching U.S. Coast Guard missions in the Arctic. If this ship is tasked to the Antarctic, as it was in 2002-2003, the federal icebreaker presence in arctic waters is reduced significantly.

In the winter, the entire Alaskan northern coast and a substantial portion of the Alaskan western coast is ice-covered. In the summer months, the Arctic sea ice margin retreats northward creating open waters around the entire Alaskan coastline for several weeks to several months. Arctic sea ice extent over the next several decades in early spring and late summer (shoulder seasons) is expected to be even further reduced, creating more broken ice along the Alaskan coastline. Greater spatial and temporal variability in sea ice extent and thickness throughout the Arctic is expected, which may influence the capability needed to break ice of differing thicknesses in certain regions of the Arctic.

Economic activity appears to be increasing and moving northward as a result of dramatic ice margin retreat over recent years. These economic activities involve fishing fleets, native Alaskan hunting and fishing expeditions, cruise ships, and increased interests in more northerly natural resource exploitation. Increased activity would imply a greater human presence in these regions, where risks are increasing due to changing ice edge environments and more broken ice in open waters. In addition, possible ratification of Article 76 of the U.N. Convention on the Law of the Sea would require extensive mapping of the U.S. continental shelf off the coast of Alaska, if the United States wishes to use the treaty to extend its economic zones and counter claims by other Arctic nations.

The potential increase in human activity in northern latitudes will likely increase the demand on the U. S. Coast Guard to have a greater presence in and around the ice margin to perform its security and law enforcement missions. Assuming that the U.S. Coast Guard is to continue to support scientific research in the Arctic as well, icebreaking capability is required, including occasional heavy icebreaking. The Committee recommends:

- **Recommendation #2**: The United States should maintain dedicated, year-round icebreaker capability for the Arctic to support national security interests as well as science.

CURRENT STATUS OF THE U.S. POLAR CLASS ICEBREAKERS

Ships with icebreaking capabilities are currently required for multiple missions in the Arctic and the Antarctic and likely in the future. The two existing heavy icebreakers, POLAR STAR and POLAR SEA, have operated in both polar regions for 29 and 28 years, respectively, and are near the ends of their design service lives. Both ships are inefficient to operate because they now require substantial and increasing maintenance efforts to keep vital ship systems operating, and their technological systems are becoming increasingly obsolete. These conditions are increasing the risk of operational failure and are placing national programs and missions at risk.

Currently, only one U.S. Coast Guard heavy icebreaker, the POLAR STAR, is capable of supporting the re-supply operation in Antarctica. The NSF and U.S. Coast Guard have identified funds for restoring POLAR SEA to interim operational capability by the fall of 2006. However, this is not a long-term solution because the age, condition, and expense of maintaining a Polar

Class, heavy icebreaker on a yearly basis puts the annual Antarctic re-supply at significant risk of failure. Providing an icebreaker capable of handling the rigorous ice conditions in McMurdo Sound is a critical problem in the short term, which the Committee has defined as the next 4 to 8 years. This is an optimistic estimate of the time required to either build a new ship(s) or extend the service life(ves) of the current ship(s). Although the HEALY is capable of supporting the McMurdo break-in, it is primarily tasked to support Arctic science, and its removal directly impacts Arctic missions. A reliable and fully operational HEALY is essential to successful executions of many science missions in the Arctic.

Since 2005, the NSF has twice negotiated a contract with a private company, the Far East Shipping Company (FESCO), to hire the Russian icebreaker ship, KRASIN, to break a channel to McMurdo Station. Contracting ships of other nations on *a year-by-year basis* is not a dependable long-term solution. Only a few icebreakers are capable of supporting this mission in a timely manner, and many of these ships have been contracted for the next several years due to emerging resource exploitation in northern latitudes. A long-term contract for icebreaking operations with an operator other than the U.S. Coast Guard is a viable option to be considered, although this arrangement may have long-term implications for U.S. control of icebreaking capabilities and the availability of icebreakers to the United States in the Arctic.

A short-term plan is needed to provide a bridge to a long-term solution. This long-term solution must ensure the integrity and operation of the icebreaking assets necessary to meet U.S. needs in both the Arctic and the Antarctic. Regardless of the ultimate long-term solution, full implementation will require on the order of 4 to 8 years. Based on these findings, the Committee recommends:

- **Recommendation #3**: In the short term, the required maintenance should be performed to make at least one Polar Class ship mission capable over the next 4 to 8 years.

MANAGING THE NATION'S ICEBREAKING ASSETS

Significant long-term maintenance of the heavy icebreakers has been deferred over the past several years. This, coupled with the lack of a plan for replacement or refurbishment of the nation's icebreaking ships, has put meeting national needs in the north and south (as outlined above) at risk.

Recently, OMB assigned budget authority for the U.S. Coast Guard polar icebreaking program to the NSF, and Congress sustained this action. Now the NSF has fiscal control over all direct costs associated with polar icebreaking program, including personnel, training, operation and maintenance costs. Under a Memorandum of Agreement (MOA) negotiated between the USCG and the NSF, the USCG must submit a yearly plan for the NSF approval. Although the MOA identifies funds for traditional U.S. Coast Guard missions (e.g., search and rescue, law and treaty enforcement), the cost of training for these USCG missions must be included in the plan and is therefore subject to approval by the NSF.

The immediate problem is that given the current mode of operation, activity is underfunded. Moving budget authority for the icebreaking program to the NSF does not address the base funding problem and increases the difficulty of management because management decisions related to the polar icebreakers are now spread across two agencies. Currently, the polar icebreakers are dual purpose ships, meeting both the NSF and the USCG mission

responsibilities. The U.S. Coast Guard reports that over 90 percent of the ship deployment time is in support of science primarily utilized by the NSF, although NOAA has recently used roughly 30 percent of available time on the HEALY. These ships, however, are necessary to support other U.S. Coast Guard traditional missions (e.g., national and homeland security, maritime safety, search and rescue), and these missions will increase in the future if human presence in the Arctic increases due to climate changes and emerging economic opportunities. The U.S. Coast Guard reports that limited budgets keep these ships in port unless other agencies provide deployment funds.

Having been given budget authority over the icebreaking program, the NSF is now fiscally responsible for missions outside its core mission and expertise. Without budget authority, the U.S. Coast Guard has been put in a situation in which it has the role of operating a ship for which it does not have full management control. Issues such as how to fund or choose among crew training alternatives for non-science missions is not fully under USCG control.

The Committee believes that the U.S. Coast Guard icebreaking mission transcends the support of science despite the fact that the majority of icebreaker usage at the current time is to support science. There remains a need for USCG operations to support its other missions, and this need may increase in the future in the Arctic. The Committee strongly believes that management responsibility should be aligned with management accountability and therefore recommends:

- **Recommendation #4**: In the short-term, the management of the U.S. polar icebreakers should reside with the U.S. Coast Guard, and it should have the appropriate operational and maintenance budget to fulfill U.S. Coast Guard missions that require icebreaking.

- **Recommendation #5**: In the short-term, the NSF should revert to being a user and should continue to negotiate financial agreements to pay for icebreaker services when U.S. Coast Guard ships are employed.

GOALS FOR THE COMMITTEE'S FINAL REPORT

Having identified both basic uses and needs for polar icebreakers and described how the roles and missions of these ships may change in response to changing environmental conditions in the Arctic, over the next several months the Committee will investigate the mix of icebreaking capabilities and numbers of icebreaking ships that are required to meet these needs over the *long-term*. The Committee will consider this mix in light of the multiple, divergent missions of the polar icebreakers, how the operational mode of the U.S. Antarctic Program might be modified to reduce dependence on icebreaking assets and the potential for increasing icebreaker needs in the Arctic. Specifically, the Committee will investigate whether multipurpose or single purpose assets are required to efficiently meet the nation's long-term icebreaking needs and identify a range of options to efficiently manage and operate these ships over the next several decades.

Although the Statement of Task charged the Committee to outline feasible scenarios for continuing icebreaking operations and identify those that seem most promising, the Committee determined that it was not feasible to conduct this analysis in the three months the Committee had to deliver this interim report. In the final report, the Committee will investigate the options for acquiring icebreaking capabilities, including, but not limited to, a full service life extension program for one or both existing heavy icebreaking ships, construction of one or more new ship(s), and alternate methods of meeting identified needs (e.g., use of ice-strengthened vessels,

hiring foreign vessels, and other options that do not use U.S. Coast Guard services). The Committee will specifically investigate the future needs for polar icebreaking to support national security issues, especially in light of the potential environmental and economic changes in the Arctic. The Committee will also review existing laws governing U.S. Coast Guard polar icebreaking operations and present recommended changes in these laws based upon potential missions and new operating regimes that seem most promising to meet the nation's long-term icebreaking needs.

The Committee wishes to emphasize that the issue before them is the viability and need for icebreaking capabilities to support U.S. needs in the polar regions. Although the Committee's Statement of Task emphasizes the U.S. Coast Guard role, and this role has been crucial in the past, it is uncertain whether the future will hold the same type of nearly exclusive emphasis on the U.S. Coast Guard to meet the nation's full polar icebreaking needs. The Committee will investigate a wide range of models to determine how to best meet the nation's needs for icebreaking and address this central issue in its final report. These findings and recommendations will be focused on providing direction for meeting the nation's long-term icebreaking needs for the next several decades.

1

Introduction

The United States has strong interests in the polar regions. In the Arctic there is the State of Alaska and geopolitical relations with the other Arctic nations in play. In the Antarctic there are obligations and leadership roles under the 1961 Antarctic Treaty buttressed by a stated national interest in shaping international policy regarding the Antarctic continent and its surrounding waters. Over the years, Presidential Decision Directives and other statements of national policy have reaffirmed the importance of a U.S. presence and leadership in scientific discovery and stewardship of the polar regions (PDD/NSC-26; 1984 PIRS; 1990 PRS). As clarified in a 1996 Presidential Decision Determination (PDD/NSC-26): "The achievement of United States interests … rests upon the year round presence in *Antarctica* maintained by the United States Antarctic Program (USAP), the program of scientific research and associated logistics funded and managed by the National Science Foundation."

With respect to the Arctic, the most recent National Security Council policy review of U.S. Arctic policy, undertaken in 1994, lists "national security and defense" as a principal interest in the Arctic, noting: "Fundamentally, we must ensure that the Arctic Ocean is treated like other oceans for purposes of sovereignty and jurisdictional claims and that these activities are in accord with the principles of the 1982 U.N. Law of the Sea Convention" (NSC-NSDD-90).

U.S. government assets, including ships available in the polar regions are necessary to the support of scientific research, logistics and supply activities, diplomatic missions related to U.S. strategic interests, environmental protection, search and rescue, economic interests, national defense readiness, homeland security readiness, maritime domain awareness, sovereignty and maritime mobility interests, and resource exploration and exploitation.

The U.S. Coast Guard, one of five armed services of the United States, was housed within the Department of Transportation until 2002, when it was transferred to the newly created U.S. Department of Homeland Security (DHS). The primary purpose of the U.S. Coast Guard is to protect the public, the environment, and U.S. economic interests. Section 888 of the Homeland Security Act of 2002, Preserving Coast Guard Mission Performance, identifies the following Coast Guard mission areas: law enforcement, marine pollution response, search and rescue, providing a U.S. presence, defense operations, and a unique mission in Ice Operations, which include diplomatic treaty activities and support for Department of Defense and civilian scientific research.

To fulfill its multiple missions, the U.S. Coast Guard has established five strategic goals, maritime mobility, national defense, maritime security, protection of natural resources, and maritime safety. Maritime mobility is defined as the facilitation of maritime commerce and elimination of interruptions and impediments to economical movement of goods and people, while maximizing recreational access to and enjoyment of the water. Polar icebreaking to facilitate maritime commerce, scientific exploration, and national security activities are included in the goal of maritime mobility. National defense encompasses the defense of the nation, enhancement of regional stability in support of the National Security Strategy, utilizing our unique and relevant maritime capabilities.

Under the goal of maritime security, the U.S. Coast Guard seeks to protect U.S. maritime borders from all intrusions by halting the flow of illegal drugs, migrants, and contraband into this country through maritime routes; prevention against incursions of the U.S. Exclusive Economic Zone (EEZ); and suppression of violations of federal law in the maritime region. The protection of natural resources involves elimination of environmental damage and natural resource degradation associated with maritime activities, including transportation, commercial fishing, and recreational boating. The maritime safety mission focuses on the elimination of deaths, injuries, and property damage associated with maritime transportation, fishing, and recreational boating.

Recent observations of the Arctic and the Antarctic indicate pronounced large-scale environmental change. Continuing support of U.S. interests in the polar regions under changing environmental conditions, especially with potential increases in strategic and commercial endeavors in the Arctic, may affect future demand for icebreaker services. The dramatic decrease in Arctic summer sea ice extent coincident with potential ecosystem changes are giving rise to increased scientific study in the Arctic. This decrease in sea ice extent is expected to increase commerce, military operations, and transit in the Arctic (Arctic Marine Transport Workshop, 2004), accelerating demand for access and support operations required by treaties, laws, and other internal and external U.S. policies.

Since 1965, the U.S. Coast Guard has been the sole federal agency responsible for providing national polar icebreaking capabilities. Whenever and wherever a U.S. Coast Guard ship is operating, it is available to perform one or more of its other missions as the situation requires, such as assisting national defense, search and rescue, maritime law enforcement, and marine environmental protection.

Although the U.S. Coast Guard ships encompass the full range of normal U.S. Coast Guard missions, in the Antarctic the primary mission of the two heavy icebreaking vessels, the POLAR STAR and the POLAR SEA, is to break open a channel in the ice to allow access to, and re-supply of McMurdo Research Station and, from there, the rest of continental Antarctica including South Pole Station. This logistic support is critical to the integrity of the U.S. Antarctic Program. In the Arctic, the newest U.S. Coast Guard icebreaker, the HEALY, is a specially designed dual purpose ship that breaks ice in direct support of scientific research. Users of the ship's time, such as the NSF and NOAA, have traditionally reimbursed some portion of the operational costs.

The U.S. Coast Guard missions support multiple governmental responsibilities and associated agencies, and these interests are overseen by multiple congressional Committees. This arrangement of decentralized stakeholders and oversight complicates authorization and appropriations for the maintenance, operation, and recapitalization of the ships that deliver these required icebreaking capabilities. Thus, we face a challenge today: the aging condition of the U.S. Coast Guard POLAR SEA and POLAR STAR requires that significant U.S. government

investment is needed to continue their service and/or to replace them. While there are many stakeholders and potential users directly and/or indirectly reliant on icebreaking capabilities in the Arctic and the Antarctic, the path or mechanism to rebuild these necessary capabilities is unclear.

In the fall of 2004, Congress passed PL 108-334, instructing the U.S. Coast Guard to request assistance on this issue from the National Academies. In response, the National Academies created the Committee on the Assessment of U.S. Coast Guard Polar Icebreaker Roles and Future Needs in June, 2005. The principal task of the Committee is to provide a comprehensive assessment of the current and future roles of U.S. Coast Guard polar icebreakers in supporting U.S. operations in the Antarctic and the Arctic (Appendix A). The Committee's goal is to look at past, current, and anticipated future needs for U.S. icebreaking capabilities, exploring different scenarios of operation, from continuation of current operations to innovative alternative approaches, and also to consider how the nation's need for icebreaking capabilities will change in the Arctic in the context of on-going and future environmental change.

The Committee will conduct its work in two phases. First, it will provide an interim report that presents the foundation materials needed for urgent decision making. Second, the Committee will produce a detailed report in the summer of 2006 with recommendations for future actions that meets the requirement for a comprehensive study that cannot be accomplished in the initial timeframe. Each of these reports will provide the information needed by Congress, the Office of Management and Budget, the U.S. Coast Guard, the National Science Foundation, and other relevant agencies (e.g., the U.S. Department of State, Department of Defense, National Oceanic and Atmospheric Administration) with responsibilities related to the U.S. presence in polar regions for the decision making process.

In this interim report, the Committee specifically focuses on Tasks 1a and 3 of its Statement of Task (Appendix A) and provides foundation materials needed for urgent decision making. Focusing on Task 1a, the Committee describes present uses of polar icebreakers with respect to the relevant missions in the Antarctic and the Arctic, including national defense, homeland security, support of economic activity, law enforcement, search and rescue, environmental protection, and the support of and conduct of science, as part of an overall demand for icebreaking services. In response to Task 3, the Committee describes potential changes in the roles and missions of U.S. Coast Guard polar icebreakers in support of future marine operations in the Arctic that may develop due to environmental change.

The Committee was told that the findings and recommendations in this report could be useful for informing FY07 budget decisions. Although the Statement of Task does not request the Committee to make management recommendations, it explicitly instructs the Committee to provide materials for urgent decision making. The Committee believes that management recommendations are useful to both Congress and OMB to help in resolving the U.S Coast Guard icebreaker issue for FY07 and until a long-term solution can be found.

2

Rationale for a Continued U.S. Icebreaking Capability

RATIONALE FOR A U.S. ANTARCTIC PRESENCE

Since the United States committed to a significant program of exploration and study of the Antarctic during the International Geophysical Year of 1957-1958 and subsequently signed the Antarctic Treaty of 1959, the nation has maintained an active presence in the region. Antarctica is governed by an international treaty which requires that governing countries conduct an active scientific program in the region. Currently, 28 nations are full members with voting rights. The U.S. Department of State represents the United States in the Antarctic Treaty process. Management of the United States Antarctic Program was assigned to the National Science Foundation by Presidential Memorandum 6646 (1982).

National policy directives have consistently reiterated the national importance of maintaining a visible presence and an active U.S. Antarctic Program in the region. U.S. interests were most recently articulated in a Presidential Decision Directive NSC (1994), which presented four objectives for U.S. policy in Antarctica:

1. Protecting the relatively unspoiled environment of Antarctica and its associated ecosystems.
2. Preserving and pursuing unique opportunities for scientific research to understand Antarctica and global physical and environmental systems.
3. Maintaining Antarctica as an area of international cooperation reserved exclusively for peaceful purposes.
4. Assuring the conservation and sustainable management of the living resources in the oceans surrounding Antarctica.

In 1996, the Committee on Fundamental Science of the President's National Science and Technology Council (NSTC) reviewed U.S. activities in the polar regions and confirmed that "the National Science Foundation has implemented U.S. policy in an effective manner" and that "the USAP research program is of very high quality" (U.S. Antarctic Program, Committee on Fundamental Science, NSTC [Appendix IV] April 1996). In 1997, an in-depth review of the U.S. Antarctic Program again confirmed the importance of a continued strong science program in the Antarctic and made recommendations for improvement (NSF, Report of the U.S. Antarctic Program External Panel, April 1997). In a recent briefing to this Committee, the Department of State once again stated that it is essential that the United States maintain an active and influential

presence in Antarctica, including but not limited to year-round operation of South Pole Station and other permanent stations.

The long-term cooperative management of Antarctica achieved under the Antarctic Treaty is a significant accomplishment, and the central role of science in this system cannot be overstated. Under the Treaty, the United States and other signatories are guaranteed freedom of scientific research and provided inspection rights to ensure compliance. The Treaty prohibits military activities and establishes a legal framework with provisions that defuse potential sovereignty disputes in Antarctica. The influential U.S. presence in Antarctica is principally a result of the operations of the U.S. Antarctic Program and its three year-round research stations: McMurdo Station, Palmer Station, and South Pole Station. This presence protects the U.S. stance on Antarctic sovereignty, secures the United States an influential role in the Treaty's decision-making system, and helps maintain the political and legal balance necessary for the success of the Treaty. While the United States does not claim territory in Antarctica, it does maintain the basis for a claim and it does not recognize the territorial claims made by seven other countries.

The U.S. national presence in the Antarctic is possible because of the logistical support of U.S. military forces that are charged to support the re-supply of the permanent science stations. The marine aspects of this mission were originally accomplished by the U.S. Navy and transferred to the U.S. Coast Guard in 1965. The U.S. Navy continued to provide air lift support to Operation Deep Freeze until the mid 1990s, when this task was transferred to the Air National Guard. The principal role of the U.S. Coast Guard has been to provide logistics support to the U.S. Antarctic Program by breaking a channel into McMurdo Sound to allow re-supply of the McMurdo and South Pole Stations. Icebreakers are a lifeline to and critical for the maintenance of U.S. Antarctic Program operations.

Until recently, the approach of using the two heavy icebreakers, sometimes together and sometimes separately depending on conditions, to open a channel for re-supply of the McMurdo and South Pole Stations has worked successfully.[1] But the deteriorating status of these ships now adds greater uncertainty and risk of failure for the operation. The NSF is concerned that the lack of reliable icebreaking support may make it increasingly difficult to maintain the permanent stations and associated science programs. According to comments from the representative of the Department of State assigned to Antarctic issues, if re-supply of South Pole Station is not successful, this would jeopardize the continued U.S. presence at the South Pole. There would be significant consequences because abandonment of that key site would create a vacuum in leadership and likely result in a scramble for control. The South Pole occupies an essential position at the apex of the areas that are claimed by seven countries that maintain territorial claims, and this would be a detriment to our position as well as to the stability of the Treaty system.

[1] Research needs at Palmer Station on the Antarctic Peninsula requires nearly year-round access. However, this area has more benign ice conditions and does not require heavy icebreaking for re-supply. Access is accomplished by the *Laurence M. Gould* and the *Nathaniel B. Palmer*, leased by the NSF's prime contractor, currently Raytheon Polar Services, from Edison Chouest Offshore. These ships are designed primarily as oceanographic research vessels but with enough ice breaking capability for the Antarctic Peninsula region.

RATIONALE FOR A U.S. ARCTIC PRESENCE

The United States is an Arctic nation, meaning that we—and seven other countries—have territory and citizens above 60 degrees north latitude. Thus, the nation has clear obligations to the population of Alaska as well as a range of international responsibilities, treaty obligations, and policy interests in the region. The United States is a founding signatory and member state of the Arctic Council, an intergovernmental forum for addressing issues and challenges shared by the Arctic states of Canada, Denmark (including Greenland and the Faeroe Islands), Finland, Iceland, Norway, the Russian Federation, Sweden, and the United States.

The most recent National Security Council policy review of U.S. Arctic policy, undertaken in 1994, lists "national security and defense" as one of the key principal interests in the Arctic. Typically, U.S. national security and foreign policy concerns center on sovereignty and jurisdictional issues and the Arctic Ocean is treated like other oceans for purposes of sovereignty and jurisdictional claims. These issues focus on freedom of access to ice-covered boundary areas as well as international straits and waterways in the Arctic, such as the Bering Strait and the Northwest Passage. In addition, obligations under international agreements, such as the U.S.-Denmark bilateral agreement regarding airbases in Greenland and the multilateral agreement concerning the North Atlantic Ice Patrol, must be fulfilled. At present, the re-supply of the U.S. Thule Air Force Base in Greenland is achieved through an agreement between the Canadian and U.S. coast guards. The Canadian Coast Guard is responsible for re-supplying the base in exchange for ice-breaking services provided by the U.S. Coast Guard in the western Arctic. Reciprocal support for Canadian icebreaking requirements is routinely offered. In practice, this has consisted mostly of joint science program support and operational support, such as the Surface Heat Budget of the Arctic Ocean (SHEBA) project.

Of special importance in the near term is the approaching enforcement of the 1982 U.N. Law of the Sea Convention. Since the seventeenth century, the oceans have been subject to a "freedom of the seas" doctrine, a principle limiting national rights and jurisdiction over the oceans to a narrow belt of sea surrounding a nation's coastline. The remainder of the seas was proclaimed free to all and belonging to none. But by the mid-twentieth century there was growing concern over the toll on coastal fish stock caused by long-distance fishing fleets, pollution from transport ships, and other demands, and in 1945 the United States extended its jurisdiction to include all natural resources on the continental shelf; other nations soon followed suit. As pressure on ocean resources increased, amplified by advances in technology, discussions began in 1973 that culminated in the 1982 adoption by the United Nations of a constitution for the seas, the U.N. Convention on the Law of the Sea (UNCLOS). The Convention covers many issues from navigational rights to the legal status of resources on the seabed.

UNCLOS entered into force on November 16, 1994, but without accession by the United States. Most of the 1982 Convention has been supported by U.S. Administrations beginning with President Reagan, but many industrialized nations had problems with some provisions related to deep seabed mining. However, changes have been made to address these issues, and the Convention is now seen as likely to be ratified by the U.S. Senate. Adhering nations are taking the steps required to extend their jurisdiction to claim territory beyond the current 200-mile exclusive economic zone by documenting the extent of their continental shelves through undersea mapping.

Asserting a national presence in the Arctic requires access to the region and icebreaker support is the preferred way of egress into ice-covered boundary areas. Although U.S. Navy submarines and U.S. Air Force aerial assets are present in the Arctic region, the U.S. Coast Guard

is the principal government agency that is capable of year-round operations in Arctic surface waters. The U.S. Coast Guard, through use of the HEALY and previously the Polar Class vessels (last used in 2002 for Arctic operations), is the main federal presence in the waters of this region. Although primarily devoted to oceanographic research, the HEALY is available for other missions ranging from national defense, law enforcement, search and rescue, and support of U.S. commerce (shipping, tourism, fishing, and resource exploration).

RATIONALE FOR U.S. SUPPORT OF ANTARCTIC AND ARCTIC SCIENCE

Research in the polar regions is relevant to U.S. national interests in many ways. According to information provided by the National Science Foundation, the Arctic and the Antarctic are premier natural laboratories whose extreme environments and geographically unique settings enable research on fundamental phenomena and processes not feasible elsewhere (NSF, 2005). In addition, the polar regions are tightly coupled to the global earth system. Research in the polar regions is conducted to advance our understanding of the earth and its systems (e.g., understanding global heat distribution in the oceans and the atmosphere), to explore new frontiers (e.g., the central Arctic Ocean and the Southern Ocean are the least studied regions of the earth's oceans), and to perform research that is best conducted in these cold, dry settings (e.g., the extremely dry atmosphere and high altitude of the South Pole make it the ideal location for astrophysical observations and study of the origins of the universe). Advances in polar research depend heavily on ships capable of operating in ice-covered regions, either as research platforms or as key components of the logistics chain that supports on-continent research (NSF, 2005).

The polar regions have a special role in research that is trying to better understand environmental change. Environmental changes occurring in the polar regions, and particularly in the Arctic, are unprecedented in times of modern observation. Satellite images show that the summer minimum extent (in September) of the Arctic sea ice cover has decreased over the last several decades, with a record minimum extent observed in 2005. From 1979 through 2001, the rate of decline in the extent of summer sea ice was slightly more than 6.5 percent per decade. The rate of decline for the 2002-2005 time period is approximately 8 percent per decade. During the last four years (2001-2005), Arctic ice extent was approximately 20 percent less than the average from 1978 through 2000. This decline in sea ice amounts to approximately 1.3 million square kilometers (500,000 square miles), an area equivalent to roughly twice the size of Texas (ACIA, 2005).

Some Alaskan coastal villages are relocating to inland sites because coastal erosion—accelerating due to ice retreat, permafrost melt, and increased storm activity—threatens buildings, roads, and major infrastructure. At the other end of the planet, some ice shelves in Antarctica are disintegrating, retreating, and/or thinning. The spectacular collapse of the Larsen B Ice Shelf, on the Antarctic Peninsula, caused an area roughly the size of Rhode Island to break into small icebergs in 2002. Glaciers in West Antarctica are shrinking at a rate substantially higher than observed in the 1990s (ACIA, 2005 report and references therein). The polar regions are central to many of the environmental issues of our time as these regions are expected to be more sensitive to a changing climate than lower latitudes. It has been demonstrated that in polar regions the magnitude of a global warming signal is amplified by ice-albedo feedback. In response, interest and scientific investigation in the polar regions to understand the cause and consequences of environmental change is greatly increasing as epitomized by the level of planning and participation and interest in the International Polar Year 2007-2008. Icebreakers

play a key role in supporting science, especially in the Arctic where the successful execution of many ocean- based science missions have relied upon the HEALY.

3

The U.S. Coast Guard Icebreaker Fleet

SHIP CLASSIFICATIONS

There are approximately 40 vessels classified as icebreakers currently operated by 12 countries including Argentina, Australia, Canada, China, Finland, Germany, Japan, Norway, Panama, Russia, Sweden, and the United States. Ice-strengthened vessels are also used by Canada, Chile, Russia, South Africa, the United Kingdom, and the United States. Icebreakers are classified and certified by only 10 of the more than 50 existing organizations worldwide that classify sea-going vessels. Despite this limited number of organizations, no standard classification for icebreakers exists as each organization has a unique classification system for these ships. Consequently, icebreakers operating on the world market have a wide-range of operational capabilities. Since 2002, Det Norkse Veritas (DNV), the American Bureau of Shipping (ABS), and Lloyd's Register (LR) have been collaborating to develop unified classification requirements (Helsinki Commission Ice EWG, 2003); and the International Association of Classification Societies (IACS) has been developing Unified Requirements for Polar Ships.

Although the *Polar Ice Operations Mission Analysis Report* (Booz Allen Hamilton, 2005) defined and employed the standard U.S. Coast Guard operational classifications of the types of polar-capable ships (i.e., heavy, medium, and light icebreakers, and ice-strengthened vessels), the Committee concluded that these operational classifications cannot be used to adequately describe and compare the performance of icebreakers in various environmental conditions. Thus, for the purpose of this interim report, the Committee will only use the operational classifications developed by the U.S. Coast Guard and the Office of Science and Technology Policy (OSTP). Heavy icebreakers are defined as ships that have icebreaking capability of 6 feet of ice continuously at 3 knots, and can back and ram through at least 20 feet of ice. Ice strengthened ships can break less than 3 feet of ice continuously at 3e knots and can back and ram through at least 3 feet of ice. Several important factors determine how well an icebreaker can accomplish its icebreaking mission: (1) propulsion power, which depends to some extent on the type of propulsion (e.g., diesel, diesel electric, nuclear), (2) momentum, which is calculated by multiplying the ship's displacement (weight) with the ship's speed while traversing ice-ridden waters, and (3) hull shape. To be categorized as a polar icebreaker by the U.S. Coast Guard, an icebreaker must have propulsion power greater than 10,000 horsepower and a minimum displacement of 6,000 tons (Booz Allen Hamilton, 2005).

DETERMINATION OF U.S. POLAR ICEBREAKING REQUIREMENTS

In 1984 the *United States Polar Icebreaker Requirements Study* was published. This interagency report (undertaken jointly by the U.S. Coast Guard, Department of Transportation, Maritime Administration, Department of Defense, National Science Foundation, National Oceanic and Atmospheric Administration, and Office of Management and Budget) assessed the long-term national needs for a polar icebreaking capability and icebreaking requirements, and recommended that four polar icebreakers would be required to meet national and program requirements through the year 2000.

In 1990 the Coast Guard, Department of Transportation, Department of Defense, National Science Foundation, and Office of Management and Budget prepared an updated report to the President on polar icebreaker requirements, as requested in section 23 of the Coast Guard Authorization Act of 1988 (Public Law 100-448) and in report language with the 1990 Department of Defense Appropriations Act (Public Law 101-165). This report reiterated that "As instruments of national policy and presence, icebreakers are necessary to meet the legitimate needs of national defense and security, to demonstrate the full range of national sovereignty, and to protect economic interests and to fulfill scientific research requirements" (1990, p. 7). However, it went on to say that two heavy icebreakers were capable of satisfying the defense requirements, but incapable of satisfying non-defense missions on a sustained basis. As noted in the report, the recommended number of icebreakers was determined more by budgetary constraints than by national and programmatic needs: the required allotment of operational days of an ice-capable ship was reduced by 50 percent based on the Government Accountability Office projected budget shortfalls. This adjustment, in essence, removed one heavy icebreaker from the national needs posture based solely on budget forecasts and without supporting operational analysis (Executive Office of the President, 1990; Booz Allen Hamilton 2005), reducing the assets required from 5.1 to 4.06 icebreakers. The 1990 Polar Icebreaker Requirements Report, however, failed to address the capability required of these icebreakers and equated an ice-strengthened research ship to a heavy icebreaker. As a result of these studies, the United States currently has three polar icebreakers, all under the command of the U.S. Coast Guard—the HEALY (commissioned in 2000), the POLAR SEA (commissioned in 1978), and the POLAR STAR (commissioned in 1976).

ROLES AND CAPABILITIES OF CURRENT U.S. ICEBREAKER FLEET

The HEALY is the most technologically advanced polar icebreaker, designed specifically as a dual purpose ship—a polar icebreaker/research vessel—to conduct regular U.S. Coast Guard missions and specifically to meet the needs of scientists working in the Arctic. The HEALY's performance tests (Sodhi et al., 2001) and practical experience has shown that the vessel is capable of operating successfully in challenging ice conditions beyond the "light" classification. The HEALY measures 420 feet long by 82 feet in beam and is powered by a 30,000 horsepower diesel electric propulsion plant; it has a displacement of approximately 16,000 tons; it is designed to break 4½ feet of ice at a continuous 3 knots, and can operate in temperatures as low as -50°F (Booz Allen Hamilton, 2005). Although the HEALY has been used in the Southern Ocean to supplement the POLAR SEA on one occasion, it is not designed to deal routinely with ice conditions in McMurdo Sound.

Since being launched, the HEALY has proven capable of supporting a wide range of research activities, providing more than 4,200 square feet of scientific laboratory space, numerous electronic sensor systems, oceanographic winches, and accommodations for up to 50 scientists. At a time when scientific interest in the Arctic Ocean basins and shelf areas is intensifying and commercial interests appear to be significantly increasing, the HEALY substantially enhances the U.S. Arctic research capabilities.

The HEALY is also a capable platform for supporting traditional U.S. Coast Guard and U.S. Department of Homeland Security missions in the polar regions, including logistics, search and rescue, ship escort, environmental protection, and enforcement of laws and treaties. This ship has performed well, overcoming some initial skepticism about whether such a dual use vessel could successfully meet diverse needs. Several federal agencies, beyond the National Science Foundation, utilize the HEALY, such as the National Oceanic and Atmospheric Administration, the United States Geological Survey and the United States Fish and Wildlife Service. A reliable and fully operational HEALY is essential to the successful execution of all missions of national interest in the Arctic, including the support of science.

The most powerful of the U.S. Coast Guard's icebreaker fleet are the two Polar Class icebreakers—the POLAR STAR and the POLAR SEA. They are classified as heavy icebreakers. The POLAR SEA and POLAR STAR were state-of-the-art in design, power, strength, and weight and incorporated many innovative features when built in the 1970s. They are each 399 feet in length by 83 feet in beam, and designed to break 6½ feet of ice at a continuous 3 knots. Two separate propulsion systems were built into the ships: 18,000 horsepower diesel-electric motors for "normal" icebreaking and 60,000 horsepower continuous (75,000 horsepower maximum) gas turbines for heavy ice conditions, such as continuous breaking of thick multi-year ice or backing and ramming operations in ridged ice.

The Polar Class icebreakers were designed with 30-year service lives, to support the McMurdo break-in and a variety of science and logistics missions in the Arctic. Although they were built with basic science facilities, POLAR SEA and POLAR STAR received substantial science upgrades in the late 1980s. Currently, each ship has five laboratories and accommodates up to 20 scientists and technicians, as well as cranes and work areas capable of supporting studies in geology, volcanology, oceanography, sea-ice physics, and other research topics. Each ship can carry seven portable science laboratories or containers on the deck.

All three U.S. Coast Guard polar icebreakers have flight decks and each is capable of sheltering two helicopters. These aircraft are essential for assessing ice conditions. Helicopter capabilities also support other missions such as logistical support, search and rescue, sea ice reconnaissance, and science operations. In a majority of the polar regions, aircraft operations off the deck of an icebreaker constitutes the only way in which the United States can project light, field-landing-capable air power. For example, virtually all air operations involving over-sea ice and over-water flight in the Antarctic require an icebreaker flight deck for launch and recovery.

In the past, the POLAR STAR and POLAR SEA have carried out a variety of traditional U.S. Coast Guard and science missions in the Antarctic and the Arctic. Then, a typical mission profile for each ship was to break the channel to McMurdo Station in one year, meanwhile supporting some marine science tasks as feasible, and, during the following year, focusing on Arctic missions. The other heavy icebreaker was used in the Antarctic in the successive years, so that each had a two-year cycle of polar missions. While en-route to Antarctica, these ships support some science missions such as tending automatic weather stations in the Pacific. In addition, these ships have supported scientific research on bird and penguin populations, the

marine biology and chemistry of the Ross Sea, and the fish populations at the sea ice margin and mapped the continental shelf in the Ross Sea.

In recent years, due to the deteriorated condition of these ships and the heavy ice conditions in McMurdo Sound, it has been necessary to restrict use of the icebreakers to support the McMurdo break-in. Currently, in the Antarctic the primary role of the heavy icebreakers is to support the U.S. Antarctic Program and scientific research community by breaking a channel through the sea ice to allow a fuel tanker and a cargo ship (with food and supplies) to off-load at McMurdo Research Station in the Ross Sea. McMurdo Station is the primary support hub for all U.S. activities in the interior of the continent, including South Pole Station.

CURRENT STATUS OF U.S. POLAR ICEBREAKERS

Both the POLAR SEA and POLAR STAR have been in service for 28 and 29 years, respectively, and are approaching the end of their design service lives. Necessary maintenance has been deferred on both polar icebreakers due to the lack of funding, and this has created major mission-readiness issues. Consequently, both ships are inefficient to operate because they now require substantial and increasing maintenance efforts to keep vital ship systems, such as the main propulsion motors, operating, and their technological systems are becoming increasingly obsolete. These conditions are increasing the risk of operational failure and are placing national programs and missions in the Arctic and the Antarctic at risk.

In 2002-2003, the POLAR STAR was not mission-capable, and severe ice conditions in the Ross Sea necessitated that the HEALY assist the POLAR SEA in the McMurdo channel clearing. Although shifting the HEALY to the Antarctic offered a one-time solution to the problem, it is not a long-term option. The use of the HEALY in the Antarctic during this time significantly impacted the science missions in the Arctic, as many science missions were postponed. Beyond the impact on Arctic science, U.S. Coast Guard personnel reported that the HEALY could not turn as effectively as required in the tight space near McMurdo Station.

In 2004-2005, unusually heavy ice conditions again necessitated use of two heavy icebreakers. At this time, the POLAR SEA was in dry dock and not mission-capable. The National Science Foundation was forced to contract the services of the Russian icebreaker KRASIN, operated by the Far East Shipping Company (FESCO). Currently, only one U.S. Coast Guard heavy icebreaker, the POLAR STAR, is capable of supporting the re-supply operation in Antarctica, but the NSF is concerned about the reliability of this ship. In a recent briefing, the NSF informed the Committee that an agreement had been reached with FESCO to hire the KRASIN to break the channel to McMurdo Station for the 2005-2006 re-supply mission and that the POLAR STAR will remain on "standby" in port in Seattle to assist the KRASIN if needed. The U.S. Coast Guard further informed the Committee that at the end of Deep Freeze '06, the POLAR STAR will be put it in "caretaker" status and the crew will be reduced from approximately 135 to 35 while it remains pier-side in Seattle. It will remain in this state indefinitely until a budget decision can be made to either properly repair it or possibly decommission it. Meanwhile, POLAR SEA will receive the minimum funding necessary to complete its repairs to make it mission-capable to support Deep Freeze '07.

In response to the deteriorating status of the heavy icebreakers, the National Science Foundation recently completed a study of modes of re-supply of the McMurdo and South Pole Stations, including alternatives with less reliance on Coast Guard icebreakers. This study (NSF, 2005) concluded that icebreaker support for the U.S. Antarctic re-supply would remain essential for the foreseeable future, but that alternative methodologies should be put into place to partly

ameliorate the effects of an occasional missed vessel-borne fuel and cargo delivery to McMurdo Station. One recommendation in the NSF sub-Committee report is to contract the required icebreaker support through other nations or private companies while performing the needed maintenance on the U.S. Coast Guard polar icebreakers, as a short-term bridge strategy. For the longer term, the NSF sub-Committee study recommends conduct of a detailed investigation of the costs and benefits of obtaining a new U.S. McMurdo break-in capable icebreaker through the U.S. Coast Guard, commercially, or other means.

Providing an icebreaker capable of handling the rigorous ice conditions in McMurdo Sound is a critical problem for the next 4 to 8 years, which is the minimum amount of time required to either build a new ship(s) or extend the service life of the current ship(s). While the HEALY is capable of supporting the McMurdo break-in, it is primarily tasked to support Arctic science. If this ship is used in the Antarctic, then Arctic science missions are directly impacted as was the case in 2002-2003. A reliable and fully operational HEALY is essential to successful executions of many science missions in the Arctic and under the current budget agreement the NSF will provide funds for the HEALY to continue operations in the Arctic.

Contracting ships of other nations on *a year-by-year basis* is not a dependable long-term solution. Only a few icebreakers are capable of supporting this mission in a timely manner, and many of these ships have been contracted for the next several years due to emerging resource exploitation in northern latitudes (Mikko Niini, Aker Technology, Inc., personal communication).

Due to rapidly aging mechanical systems, deferred routine and major maintenance due to reduced funding over recent years, and recent increased Antarctic operational requirements, both the POLAR SEA and POLAR STAR now require annual extensive, expensive repairs to enable readiness for sea. A regular and fully funded repair and maintenance schedule would only keep the ships mission-capable for several more years, but may provide a bridge to the long-term solution. Many of the experts and stakeholders who spoke to the Committee stated that the resolution of this funding dilemma to provide mission capable ships is an urgent problem that needs to be addressed before the long-term solution can be found.

MANAGING THE U.S. POLAR ICEBREAKERS

Until 2005, the U.S. Coast Guard has been responsible for operating and maintaining these ships. Budget base transfers in the 1970s and 1980s placed annual funding resources in the budgets of agencies with programs benefiting from icebreaker support in that era, including the Department of Defense, National Science Foundation, and Maritime Administration. Memoranda of Agreement implemented these budget transfers to the U.S. Coast Guard by providing for incremental reimbursement of deployment-related expenses (primarily fuel and other consumables).

Changes in programs and levels of user-agency funding resulted in the decommissioning of older icebreakers in the late 1980s, and some changes were made in the reimbursement formula, but the general concept of agencies “buying” operational icebreaker days continued until 2005. It should be noted that while the U.S. Coast Guard retained a budget base for icebreaker crews, maintenance, training, and other support to ensure the ships were ready for operations, it has not had identified budget funding to deploy icebreakers solely for its own mission responsibilities.

For fiscal year 2006, the President's budget, prepared by the Office of Management and Budget, transferred the budget authority for these ships to the National Science Foundation, while the Coast Guard was to retain custody of the three polar icebreakers and continue to operate and maintain this fleet. Congress enacted this one-time-transfer of $48 million from the U.S. Coast Guard to the National Science Foundation, which was intended to offset all direct costs associated with the polar icebreaking program, including personnel, training, operation and maintenance. These funds constitute the Coast Guard's entire non-capital budget for polar icebreakers. This amount, however, is essentially less than two-thirds of the $65-75 (Science, 2005) million that the U.S. Coast Guard estimates it will cost to maintain the ships. Congress finalized the transfer of funds in CONFERENCE REPORT (H. REPT. 109-272) between the House and Senate Appropriations Committees that are responsible for the NSF.

According to briefings received from the budget examiners from the Office of Management and Budget (October 7, 2005), this action was based on the fact that the vast majority of icebreaker ship time has been employed for scientific research. The availability and readiness of the polar icebreakers to address other national needs such as law enforcement, marine pollution response, search and rescue, providing a U.S. presence, and defense operations was not cited as a factor in the decision to transfer the ships to the NSF.

With this transfer, the NSF assumed control of the polar icebreaker program and a MOA between the USCG and the NSF regarding polar icebreaker support and reimbursement was established in August, 2005. The purpose of this MOA, provided to the Committee by the USCG, is to "implement the [then proposed] budget base transfer for use of the USCG icebreakers for scientific and operational support for all planned USCG operations for FY2006 and beyond."

Under the 2005 MOA, the NSF agrees to consider all national priorities and maintenance requirements when allocating the limited budget. In addition, the NSF will identify icebreaker mission needs for the succeeding fiscal year to the USCG. The MOA acknowledges that the "USCG has agreed to support Canadian logistical requests in the Western Arctic, scheduled on a situational basis, in accordance with an annual advanced planning process, to gain Canadian icebreaker support of U.S. facilities in the Eastern Arctic. If Canadian icebreaker resources are not available in the Eastern Arctic, USCG polar icebreaker resources may need to be reprioritized."

The responsibilities of the USCG under this agreement are scheduled on an annual basis by the NSF. The U.S. Coast Guard has agreed to provide support staff and services necessary to operate and maintain the polar icebreaker fleet and to inform the NSF of secondary polar icebreaker missions as they occur. These missions include the traditional USCG missions of the polar icebreakers (search and rescue, enforcement of laws and treaties) that were conducted as needed and funded from the base funding. Under this agreement, the U.S. Coast Guard will continue to perform these missions (as needed), and the NSF will continue to fund these missions from the program base that was transferred to the NSF in FY06. In addition, if a situation arises that requires long-term polar icebreaker involvement (major marine pollution or humanitarian relief efforts), then funding and scheduling impacts will be coordinated between the USCG and the NSF.

In the current budgeting scenario for FY06, USCG will prepare a "program plan" that outlines their needs for conducting readiness exercises or other training in support of science and the broader icebreaker missions, which will be reviewed by the NSF budget and operations personnel and subject matter experts (e.g., maritime engineers). USCG personnel will assist in the review as needed. Upon mutual agreement of the parties, the NSF will approve the plan and

provide USCG with a letter of intent documenting the amount of funding to be provided in the subsequent fiscal year.

IMPLICATIONS FOR NATIONAL INTERESTS

The transfer of budget authority for the polar icebreaking program from the USCG to the NSF has several implications for national interests in the polar regions. The United States is an Arctic nation, with national interests that must be protected at all times. National security and defense interests in the Arctic include the enhancement of regional stability by protecting the U.S. citizens in Alaska, our Arctic maritime borders, and the U.S. Exclusive Economic Zone. Economic interests include maritime commerce and protection of our natural resources and environment as well as the protection of our Exclusive Economic Zone from illegal activity.

Protection of these interests in the Arctic primarily falls to the U.S. Coast Guard Ice Operations, whose mission is to protect the public, the environment, and U.S. economic interests, through law enforcement, marine pollution response, search and rescue, providing a U.S. presence, defense operations, support for diplomatic treaty activities, support for the Department of Defense, and support for scientific research in the polar regions. Until recently, the U.S. Coast Guard had budget authority to oversee the polar icebreakers, which were used to fulfill these missions as needed. Although the majority of ship time for the U.S. Coast Guard icebreakers has been allocated to scientific research and logistics and funded by the scientific community, funding for crews and mission training were covered under the budget of the U.S. Coast Guard.

In the current budget situation, funding for all U.S. Coast Guard personnel and activities involving the polar icebreakers is under the control of the National Science Foundation. The core mission of the National Science Foundation is "to promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense." While the mission of the National Science Foundation does involve national defense, this is accomplished through funding scientific research that can be used in the defense of our nation and does not include participating in law enforcement or combat situations.

Under the current MOA between the NSF and the USCG regarding polar icebreaking, the USCG must develop a yearly plan that includes costs for personnel, ship maintenance, and mission training. While the MOA provides funding from the program base for the secondary missions, such as search and rescue and enforcement of laws and treaties, no specific funding is identified for mission training. Funds for all training activities including search and rescue as well as science operations, must be included in the plan that is subject to the NSF approval.

The immediate problem involving the polar icebreakers is that given the current mode of operation, activity is underfunded. Moving budget authority for the icebreaking program to the NSF does not address the base funding problem and increases the difficulty of management because management decisions related to the polar icebreakers are now spread across two agencies. Currently, the polar icebreakers are dual purpose ships, meeting both the NSF and the USCG mission responsibilities. The U.S. Coast Guard reports that over 90 percent of the ship deployment time is in support of science primarily utilized by the NSF, although NOAA has recently used roughly 30 percent of available time on the HEALY. These ships, however, are necessary to support other U.S. Coast Guard traditional missions (e.g., national and homeland security, maritime safety, search and rescue), and these missions will increase in the future if human presence in the Arctic increases due to climate changes and emerging economic

opportunities. The U.S. Coast Guard reports that limited budgets keep these ships in port unless other agencies provide deployment funds.

Having been given budget authority over the icebreaking program, the NSF is now fiscally responsible for missions outside its core mission and expertise. Without budget authority, the U.S. Coast Guard has been put in a situation in which it has the role of operating a ship for which it does not have full management control. Issues such as how to fund or choose among crew training alternatives for non-science missions is not fully under their control.

The Committee believes that the U.S. Coast Guard icebreaking mission transcends the support of science despite the fact that the majority of icebreaker usage at the current time is to support science. There remains a need for USCG operations to support its other missions, and this need may increase in the future in the Arctic. The Committee strongly believes that management responsibility should be aligned with management accountability.

4

Potential Influences on Future Needs for Icebreakers

CHANGES IN ARCTIC SEA ICE

It is uncertain what changes in Arctic sea ice will have on the need for icebreakers. The winter Arctic sea ice extends southward through the Bering Strait and into the northern Bering Sea so that the entire Alaskan northern coast and a substantial portion of the Alaskan western coast is ice-covered in winter. In the summer months, the Arctic sea ice margin retreats northward which creates open waters around the entire Alaskan coastline for several weeks to several months. Model projections of Arctic sea ice extent over the next several decades show that the early spring and late summer (shoulder seasons) sea ice cover is likely to be reduced. Northward retreat of the ice margin in early spring will create more broken ice along the Alaskan coastline as the sea ice begins to melt. These conditions will remain late into the summer until the ice margin begins to advance toward the south in response to cooling seasonal temperatures. These models also show greater spatial and temporal variability in sea ice extent and thickness throughout the Arctic, which may influence the capability needed to break ice of differing thicknesses in certain regions of the Arctic. Ice conditions may require occasional heavy icebreaking capabilities.

CHANGES IN HUMAN ACTIVITIES AND ECONOMIC CONSEQUENCES

As a result of a number of factors, including the dramatic ice margin retreat over recent years, economic activity appears to be moving northward. Anecdotal evidence suggests that some Arctic fishing fleets have already begun to follow the fish stocks that migrate northward as the ice edge retreats. For indigenous populations in the Arctic, including the Inupiaq and Yupik Eskimo of Alaska and the Inuit in the Canadian Arctic, sea ice retreat disrupts and significantly restricts their subsistence hunting and food-sharing life styles as many key species become less accessible due to northward migrations, or in the worst-case scenario become extinct (ACIA, 2005).

A workshop on marine transportation in the Arctic (Arctic Marine Transport Workshop, 2004) suggested that it is plausible to expect increased marine tourism as cruise ships venture further north following the retreat of the ice edge. There has also been an increase in oil and gas tanker traffic, particularly in the Siberian Arctic and Sub-Arctic (*New York Times*, 2005). It is also likely that resource exploration, recovery, and shipping activities will expand into previously inaccessible areas. Several companies have begun to explore the extensive oil and gas fields near

the Sakhalin Islands (Mikko Niini, Aker Arctic Technology, Inc., personal communication). These companies have begun to charter the majority of the existing icebreakers and ice-strengthened ships for the foreseeable future, which could create a scarcity of these types of ships available on the world market. In addition, many orders for double-acting tankers, ships that can both break ice and transport cargo, have been placed and demand is expected to grow (Mikko Niini, Aker Arctic Technology, Inc., personal communication).

Any increase in activity in the Arctic will almost assuredly create greater risks of environmental impact and the potential for human activities that push the limits of safety near the ice edge, especially in the shoulder seasons. These activities will increase the necessity to respond to accidents and create a greater need for law enforcement in ice margin areas, which will increase the need for ice-capable ships (ice-strengthened ships and icebreakers) in the Arctic. This increase in human activity in more northerly latitudes will most likely increase the demand on the U.S. Coast Guard to have a greater presence in and around the ice margin to perform its many safety, security, and law enforcement missions.

U.N. CONVENTION ON THE LAW OF THE SEA

Under the U.N. Convention on the Law of the Sea (UNCLOS), nations are claiming sovereignty over extended territories beyond the current 200 mile economic boundary. In the Arctic Ocean the possibility for conflict exists as boundaries of five nations—Canada, Denmark, Norway, Russia, and the United States—that have coasts on the Arctic Ocean, converge giving rise to the potential for disputed claims. For example, Russia adopted the treaty in 1997, and a claim filed four years later included nearly half the Arctic Ocean. The claim was rejected by the UNCLOS commission's technical panel, but a recent mapping expedition aboard the research vessel, AKADEMIK FEDOROV, to the North Pole may yield data that substantiates the Russian claim.

If the United States ratifies this law, it will have ten years to make a claim to extend its Exclusive Economic Zone (EEZ) borders as defined by the extent of the continental shelf off Alaska. One implication for science is that the Convention grants the coastal nation jurisdiction over marine scientific research conducted in its EEZ and its continental shelf and requires consent for conduct of such research. The implications for icebreaker capability are that adherence is likely to increase demands for a U.S. presence in an expanded EEZ. There are also requirements under the Convention for mapping in order to document claims. For the United States this would likely require use of the HEALY, which is currently the only U.S. icebreaker vessel with multibeam capability.

PLANS FOR OTHER ICE-CAPABLE RESEARCH SHIPS

Presentations to the Committee at the meeting on November 6, 2005, outlined that several plans for ice-capable research ships have been proposed in the U.S. and in other countries. These presentations underscored that there have been significant advances in icebreaking technologies since the polar icebreakers were built. The Antarctic Research Vessel Oversight Committee (ARVOC) serves in an advisory capacity to the National Science Foundation and for the past 3 years ARVOC has been engaged in an assessment and planning effort directed towards making recommendations to the NSF regarding future vessels and the possible construction of a new polar research icebreaker to replace the NATHANIEL B. PALMER. Such a new ship would

be designed to work farther into the ice than the NATHANIEL B. PALMER and would be able to reliably support year-round science operations in most of the Southern Ocean.

The Alaska Region Research Vessel is proposed to replace the 37-year old R/V *Alpha Helix* that is owned by the National Science Foundation. The ship is designed to operate in the coastal and open ocean waters of the Alaska region. Sufficient ice strengthening will allow it to work safely in moderate seasonal ice, operating over a longer period than formerly possible in the North Pacific Ocean; Gulf of Alaska; and the Bering; Chukchi; and Beaufort Seas. The design is based on science mission requirements developed by the University-National Oceanographic Laboratory System community.

While the AURORA BOREALIS is still in the planning stages, it is to be a dedicated European research icebreaker with a deep drilling capability. It is to be built as a joint European research vessel that will be used in the Arctic. This new icebreaker would be conceived as an optimized science platform, which would facilitate long international and interdisciplinary expeditions into the central Arctic Ocean during all seasons of the year. U.S. participation in this project is considered feasible by the European Consortium, but the topic has yet to be addressed in the United States.

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Findings and Recommendations

This Committee was asked to conduct its work in two phases, and this interim report provides information to highlight the most time dependent issues related to the roles and future needs of the icebreakers. Based on the first phase of its work, the Committee provides the following findings and recommendations. These findings and recommendations are based on the Committee's analysis of written materials provided to it, testimony from a variety of sources, and, in total, its judgment.

ICEBREAKING NEEDS IN THE ANTARCTIC

Findings

A succession of policy analyses and Presidential Decision Directives assert that the United States has strategic interests in the Antarctic related to foreign policy and security, environmental protection, and scientific research. The United States asserts strategic interests in Antarctica primarily through the year-round residence of American researchers at three permanent scientific stations. The presence of the South Pole Station, in particular, helps protect the U.S. position on sovereignty in Antarctica, providing for a unique research platform at a location that assures U.S. participation in the Antarctic Treaty system.

Despite some missions of opportunity, the primary use of U.S. heavy icebreakers, at present, is to break a channel into McMurdo Station to aid the re-supply that is critical to the continued functioning of both the McMurdo and the South Pole Stations. Ice conditions in McMurdo Sound, especially the severe conditions which have developed in recent years, require heavy icebreaking capability for the foreseeable future.

In the U.S. Antarctic Program's current mode of operation, annual break-in supported by a heavy icebreaker is mandatory for annual re-supply. To partially ameliorate the single point of failure this represents, the National Science Foundation has begun to explore logistics alternatives for Antarctic support including conservation, redirection, and expanded storage of fuel at McMurdo Station, as well as alternative ground and air fuel and cargo delivery to the McMurdo and South Pole Stations. By using an altered logistics strategy it may be possible to maintain operations at the McMurdo and South Pole Stations despite an occasional missed annual channel break-in and the ship-borne portion of the McMurdo re-supply resulting from a year with

extraordinarily heavy ice conditions. Icebreaker support of the break-in to McMurdo Station, however, would be required for successful re-supply for the foreseeable future.

Recommendation

- **Recommendation #1**: The United States should reliably control (by ownership or other means) at least one heavy icebreaker that is available and capable of breaking a channel into McMurdo Station.

The Committee will investigate in the next several months how the icebreaker assets should be controlled to meet the nation's icebreaking needs and recommendations will be provided in the final report.

ICEBREAKING NEEDS IN THE ARCTIC

Findings

Because of the geographic location of Alaska, the United States is an Arctic nation with significant geo-political, security, economic, and scientific interests in the Arctic, and U.S. interests must be protected in this region. It is the U.S. Coast Guard that has the overarching missions of maritime safety, maritime security, national defense, and protection of natural resources. Although the HEALY is primarily devoted to oceanographic research, this ship is available to support the overarching U.S. Coast Guard missions in the Arctic. If this ship is tasked to the Antarctic, as in 2002-2003, the main federal presence in Arctic waters is substantially reduced.

The winter Arctic sea ice extends southward through the Bering Strait and into the northern Bering Sea so that the entire Alaskan northern coast and a substantial portion of the Alaskan western coast is ice-covered in winter. In the summer months, the Arctic sea ice margin retreats northward, which creates open waters around the entire Alaskan coastline for several weeks to several months. Arctic sea ice extent over the next several decades in the shoulder seasons is expected to be reduced, creating more broken ice along the Alaskan coastline. Greater spatial and temporal variability in sea ice extent and thickness throughout the Arctic is expected, which may influence the capability needed to break ice of differing thicknesses in certain regions of the Arctic.

As a result of a number of factors, including the dramatic ice margin retreat over recent years, economic activity appears to be moving northward. This includes fishing fleets, native Alaskan hunting and fishing expeditions, cruise ships, and increased interests in more northerly natural resource exploitation. Any increase in more northerly economic activity will result in a greater human presence. The changing sea ice regime has also affected Native Alaskans' subsistence hunting activities, with increased risk due to unstable ice and more expansive open water.

Possible ratification of Article 76 of the U.N. Convention on the Law of the Sea will require extensive mapping of the U.S. continental shelf off the coast of Alaska, if the United States wishes to use the treaty to extend its economic zones and counter claims by other Arctic nations. Currently, the only U.S. polar icebreaker capable of acquiring this data is the HEALY.

This increase in human activity in more northerly latitudes will most likely increase the demand on the U.S. Coast Guard to have a greater presence in and around the ice margin to perform its many safety, security, and law enforcement missions. Assuming that the U.S. Coast Guard is to continue to support scientific research in the Arctic as well, icebreaking capability is required, including, occasional heavy icebreaking.

Recommendation

- **Recommendation #2**: The United States should maintain dedicated, year-round icebreaker capability for the Arctic to support national security interests as well as science.

CURRENT STATUS OF U.S. POLAR CLASS ICEBREAKERS

Findings

Ships with icebreaking capabilities are required for multiple missions in the Arctic and the Antarctic, certainly today and likely in the future. The two existing heavy icebreakers, POLAR STAR and POLAR SEA, have operated in both polar regions for 29 and 28 years, respectively and are near the ends of their operational design service lives. Both ships are inefficient to operate because they now require substantial and increasing maintenance efforts to keep vital ship systems operating, and their technological systems are becoming increasingly obsolescent. These conditions are increasing the risk of operational failure and are placing national programs and missions at risk.

Currently, only one U.S. Coast Guard heavy icebreaker, the POLAR STAR, is capable of supporting the re-supply operation in Antarctica. The NSF and the U.S. Coast Guard have identified funds for restoring POLAR SEA to interim operational capability by the fall of 2006, however this is not a long-term solution because the age, condition and expense of maintaining the heavy icebreakers on an yearly basis puts the annual Antarctic re-supply at significant risk of failure. Providing an icebreaker capable of handling the rigorous ice conditions in McMurdo Sound is a critical problem for the next 4 to 8 years, which is the minimum amount of time required to either build a new ship(s) or extend the service life(ves) of the current ship(s). While the HEALY is capable of supporting the McMurdo break-in, it is primarily tasked to support Arctic science. If this ship is used in the Antarctic, then Arctic science missions are directly impacted as was the case in 2002-2003. A reliable and fully operational HEALY is essential to successful executions of many science missions in the Arctic.

Since 2005, the NSF has twice negotiated a contract with FESCO to hire the KRASIN to break a channel to McMurdo Station. Testimony given to the Committee suggests that this may not be possible in the future as this ship may have a long-term contract to work in the Arctic. Contracting ships of other nations on *a year-by-year basis* is not a dependable long-term solution because only a few icebreakers are currently capable of supporting this mission in a timely manner and many of these ships have been contracted for the next several years. A long-term contract for icebreaking operations with an operator other than the U.S. Coast Guard is a viable option that must be considered, although this arrangement may have long-term implications for U.S. control of icebreaking capabilities and the availability of icebreakers to the United States in the Arctic.

A short-term solution must be devised that provides a bridge from the current situation to a long-term solution. Additionally, this long-term solution must ensure the integrity and

operation of the icebreaking assets necessary to meet U.S. needs in the Arctic and the Antarctic. Regardless of the ultimate long-term solution, full implementation will require at least 4 to 8 years.

Recommendation

- **Recommendation #3**: In the short term, the required maintenance should be performed to make at least one Polar Class ship mission capable over the next 4 to 8 years.

MANAGING THE NATION'S ICEBREAKING ASSETS

Findings

Significant, long-term maintenance of the heavy icebreakers has been deferred over the past several years. This, coupled with the lack of a plan for replacement or refurbishment of the nation's icebreaking ships, has put meeting national needs in the north and south (as outlined above) at risk.

Recently, OMB assigned budget authority for the U.S. Coast Guard polar icebreaking program to the NSF, and Congress sustained this action. Now the NSF has fiscal control over all direct costs associated with polar icebreaking program, including personnel, training, operation and maintenance costs. Under a MOA negotiated between the USCG and the NSF, the USCG must submit a yearly plan for the NSF approval. Although the MOA identifies funds for traditional U.S. Coast Guard missions, (e.g., search and rescue, law and treaty enforcement), the cost of training for these USCG missions must be included in the plan and is therefore subject to approval by the NSF.

The immediate problem is that given the current mode of operation, activity is underfunded. Moving budget authority for the icebreaking program to the NSF does not address the base funding problem, and increases the difficulty of management because management decisions related to the polar icebreakers are now spread across two agencies. Currently, the polar icebreakers are dual purpose ships, meeting both the NSF and the USCG mission responsibilities. The U.S. Coast Guard reports that over 90 percent of the ship deployment time is in support of science primarily utilized by the NSF, although NOAA has recently used roughly 30 percent of available time on the HEALY. These ships, however, are necessary to support other U.S. Coast Guard traditional missions (e.g., national and homeland security, maritime safety, search and rescue) and these missions will increase in the future if human presence in the Arctic increases due to climate changes and emerging economic opportunities. The U.S. Coast Guard reports that limited budgets keep these ships in port unless another agency provides deployment funds.

Having been given budget authority over the icebreaking program, the NSF is now fiscally responsible for missions outside its core mission and expertise. Without budget authority, the U.S. Coast Guard has been put in a situation in which it has the role of operating a ship for which it does not have full management control. Issues such as how to fund or choose among crew training alternatives for non-science missions are not fully under their control.

The Committee believes that the U.S. Coast Guard icebreaking mission transcends the support of science despite the fact that the majority of icebreaker usage at the current time is to support science. There remains a need for USCG operations to support its other missions and this

need may increase in the future in the Arctic. The Committee strongly believes that management responsibility should be aligned with management accountability and therefore recommends:

Recommendations

- **Recommendation #4**: In the short-term, the management of the U.S. polar icebreakers should reside with the U.S. Coast Guard, and it should have the appropriate operational and maintenance budget to fulfill U.S. Coast Guard missions that require icebreaking.

- **Recommendation #5**: In the short-term, the NSF should revert to being a user and should continue to negotiate financial agreements to pay for icebreaker services when U.S. Coast Guard ships are employed.

GOALS FOR THE COMMITTEE'S FINAL REPORT

In the Statement of Task, the Committee was charged to assess the roles of U. S. icebreakers in supporting United States operations in the Antarctic and the Arctic and provide an analysis of the overall demand for icebreaking services. Having identified the both basic uses and needs for polar icebreakers and described how the roles and missions of these ships may change in response to changing environmental conditions in the Arctic (Tasks 1a and 3), over the next several months, the Committee will investigate the mix of icebreaking capabilities and numbers of icebreaking ships that are required to meet these needs over the *long-term* (Tasks 1b and 1c). The Committee will consider this mix in light of the multiple, divergent missions of the polar icebreakers, how the operational mode of the U.S. Antarctic Program might be modified to reduce dependence on icebreaking assets and the potential for increasing icebreaker needs in the Arctic. Specifically, the Committee will investigate whether multipurpose or single purpose assets are required to efficiently meet the nation's long-term icebreaking needs and identify a range of options to efficiently manage and operate these ships over the next several decades.

Although the Statement of Task charged the Committee to outline feasible scenarios for continuing icebreaking operations and identify those that seem most promising, the Committee determined that it was not feasible to conduct this analysis in the three months the Committee had to deliver this interim report. The Committee will investigate the options for acquiring these capabilities (Task 2) including, but not limited to a full service life extension program for one or both existing heavy icebreaking ships, construction of one or more new ship(s), and alternate methods of meeting identified needs including use of ice-strengthened vessels, hiring foreign vessels, and other options that do not use U.S. Coast Guard services. The Committee will specifically investigate the future needs for polar icebreaking to support national security issues, especially in the light of the potential environmental changes in the Arctic. The Committee will also review existing laws governing U.S. Coast Guard polar icebreaking operations and present recommended changes in these laws based upon potential missions and new operating regimes that seem most promising to meet the nation's long-term icebreaking needs (Task 4).

In addition, the Committee wishes to emphasize that the issue before us is the viability and need for icebreaking capabilities to support U.S. needs in the polar regions. Although our statement of task emphasizes the U.S. Coast Guard role, and this role has been crucial in the past, it is uncertain whether the future will hold the same type of nearly exclusive emphasis on the U.S. Coast Guard to meet the nation's full polar icebreaking needs. Looking at how other nations meet their needs for icebreaking services, many rely on non-military operators as viable alternatives, with gains in efficiency of operation and improved continuity of staffing for this specialized

activity, and we will directly address this central issue in our final report. These findings and recommendations will be focused on providing direction for meeting the nation's long-term icebreaking needs for the next several decades.

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Appendix A

Statement of Task

Polar icebreakers are essential for the United States to conduct operations in the Antarctic and the Arctic regions. This study will provide a comprehensive assessment of the current and future roles of Coast Guard polar icebreakers in supporting U.S. operations in the Antarctic and the Arctic, including scenarios for continuing those operations and alternative approaches, the changes in roles and missions of polar icebreakers in the support of all national priorities in the polar regions, and potential changes in the roles of Coast Guard icebreakers in the Arctic that may develop due to environmental change. Specifically, this study will:

1. Assess the roles of U.S. Coast Guard icebreakers (heavy, medium, and light) in supporting U.S. operations in the Antarctic and the Arctic and provide an analysis of the overall demand for icebreaking services, including:

    a. Describe present uses of polar icebreakers with respect to the relevant missions in the Antarctic and the Arctic, including national defense, homeland security, support of economic activity, law enforcement, search and rescue, environmental protection, and the support of and conduct of science.

    b. Describe expected future needs for polar icebreakers, such as where and when the polar icebreakers will be expected to operate and what capabilities will be needed in order to accomplish all missions in the polar regions.

    c. Determine the approximate number and types of Coast Guard polar icebreakers needed in the future and when and where they might be expected to operate to meet national priority concerns in the polar regions.

2. Present and analyze a small number of feasible scenarios for continuing polar icebreaker operations in the polar regions, including service life extension of existing Coast Guard icebreakers, replacement of existing Coast Guard icebreakers, and alternate methods of meeting identified needs (e.g., re-supply of McMurdo Station and availability of platforms for marine research), including use of ice-strengthened vessels, foreign vessels, and other options that do not use Coast Guard services.

3. Describe potential changes in the roles and missions of Coast Guard polar icebreakers in support of future marine operations in the Arctic that may develop due to environmental change.

4. Review existing laws governing Coast Guard polar icebreaking operations and present recommended changes based upon potential missions and new operating regimes.

This study will be conducted in two phases. The Committee will deliver an interim report by November 30, 2005, that provides the foundation materials needed for urgent decision making. In addition it will deliver a final, detailed report in the summer of 2006 that meets the requirement for a comprehensive study, which cannot be accomplished in the initial timeframe. In phase one, the Committee will focus on conducting the demand analysis (Task 1) and outlining the nature of the feasible scenarios for continuing operations, including identification of those that seem most promising (starting on Task 2) for additional analysis. The potential for environmental change (Task 3) is one variable that will be considered when identifying promising scenarios, although details will be developed and provided in phase two.

Appendix B

Biographical Sketches of Committee Members

COMMITTEE MEMBERS

Anita K. Jones is a professor at the University of Virginia. She received her Ph.D. in Computer Science from Carnegie-Mellon University (CMU) in 1973. Dr. Jones left CMU as an associate professor when she co-founded Tartan Laboratories. She was vice-president of Tartan from 1981 to 1987. In 1988 she joined the University of Virginia as a professor and the chair of the Computer Science Department. From 1993-1997 Dr. Jones served at the U.S. Department of Defense where, as Director of Defense Research and Engineering, she oversaw the department's science and technology program, research laboratories, and the Defense Advanced Research Projects Agency. She received the U.S. Air Force Meritorious Civilian Service Award and a Distinguished Public Service Award. Dr. Jones served as vice chair of the National Science Board and co-chair of the Virginia Research and Technology Advisory Commission. She is a member of the Defense Science Board, the Charles Stark Draper Laboratory Corporation, and the National Research Council Advisory Council for Policy and Global Affairs and the MIT Corporation. She is a fellow of the Association for Computing Machinery and the Institute of Electrical and Electronics Engineers, and the author of 45 papers and two books. Dr. Jones is a member of the National Academy of Engineering.

Albert J. Baciocco, Jr. retired from the U.S. Navy in 1987 after 34 years of distinguished service, principally within the nuclear submarine force and directing the Department of the Navy research and technology development enterprise. He graduated from the U.S. Naval Academy in 1953 with a B.S. in engineering, and subsequently completed graduate level studies in nuclear engineering as part of his training for the naval nuclear propulsion program. He served as Chief of Naval Research from 1978 to 1981, and as the Director of Research, Development and Acquisition, the senior military Research, Development and Acquisition official in the Department of the Navy from 1983 to 1987. Upon retirement, he established The Baciocco Group, Inc., a technical and management consulting practice, and has since been engaged in a broad range of business and pro bono activities with industry, government, and academe, including memberships on the Naval Studies Board and the Army Science Board, and service on the Boards of Directors of several corporations, both public and private. He is a Trustee of the South Carolina Research Authority and serves as Director of the Foundation for Research Development at the Medical University of South Carolina. He is a member of Tau Beta Pi, a national engineering honor society and the recipient of an Honorary Doctorate in Engineering from Florida Atlantic University. Vice Admiral Baciocco is a Senior Fellow of the Potomac Institute for Policy Studies, Arlington, Virginia, and has been designated a lifetime National Associate of the National Academies by the Council of the National Academy of Sciences.

Julie Brigham-Grette is a professor in the Department of Geosciences at the University of Massachusetts, Amherst. Dr. Brigham-Grette received her Ph.D. from the University of Colorado's Institute for Arctic and Alpine Research. After post-doctoral research at the University of Bergen, Norway, and the University of Alberta, Canada, with the Canadian Geological Survey, she joined the faculty at the University of Massachusetts in the fall of 1987. Dr. Brigham-Grette has been conducting research in the Arctic for nearly 24 years, including eight field seasons in remote parts of northeast Russia since 1991, participating in both the science program as well as dealing with difficult logistics. Her research interests and experience span a broad spectrum dealing with arctic paleoclimate records and the Late Cenozoic evolution of the Arctic climate both on land and off shore, especially in the Bering Strait region. She was a member of the Arctic Logistics Task Force for the NSF Office of Polar Programs (OPP) 1996-1999 and 2000-2003, and was member of the OPP Office Advisory Council 2002-2004. She chaired the U.S. Scientific Delegation to Svalbard for Shared Norwegian/U.S. Scientific Collaborations and Logistical Platforms in 1999. Brigham-Grette is currently Chair of the International Geosphere/Biosphere Program's Science Steering Committee on Past Global Change (PAGES) with an international program office in Bern, Switzerland, and President of the American Quaternary Association. She also serves as one of two U.S. representatives to the International Continental Drilling Program.

Rita R. Colwell received her Ph.D. in Oceanography at the University of Washington. Dr. Colwell is the Chair of Canon U.S. Life Sciences, Inc., and Distinguished University Professor at the University of Maryland, College Park, and at the Johns Hopkins University Bloomberg School of Public Health. Dr. Colwell was the first woman to be named Director of the National Science Foundation, where she served with distinction from 1998 to 2004. In her capacity as the NSF Director, she served as Co-chair of the Committee on Science of the National Science and Technology Council. Dr. Colwell has held many advisory positions in the U.S. government, nonprofit science policy organizations, and private foundations, as well as in the international scientific research community and is a member of the American Philosophical Society, American Academy of Arts and Sciences, and National Academy of Sciences.

Hajo Eicken is Associate Professor at the Geophysical Institute and the Department of Geology and Geophysics at the University of Alaska, Fairbanks. Before joining the University of Alaska, Dr. Eicken was a senior scientist at the Alfred Wegener Institute where he was the head of a research group for sea ice physics and remote sensing. He received his Ph.D. in geophysics at the University of Bremen. Dr. Eicken's research interests include studies of the growth, evolution, and properties of sea ice in the Arctic and the Antarctic. He is particularly interested in determining how microscopic and macroscopic properties affect larger-scale sea-ice processes and their role in the climate system. Dr. Eicken has participated in several icebreaker expeditions in both hemispheres. He is serving on a number of national and international scientific and technical Committees.

Jeffrey M. Garrett served as the Commander of the 13th Coast Guard District for two years before he retired from the U.S. Coast Guard in August 2005 after 30 years of distinguished service, reaching 2-star flag rank in 2004. Upon graduating from the U.S. Coast Guard Academy in 1974, Garrett was assigned to the commissioning crew of U.S. Coast Guard POLAR STAR (WAGB 10) as Communications Officer and deck watch officer and again in both polar regions while on the POLAR STAR as Executive Officer. As Commanding Officer of U.S. Coast Guard POLAR SEA (WAGB 11) he completed three polar deployments to the Western Arctic and Antarctica. Garrett's shore assignments include watch officer duties at Vessel Traffic Service Prince William Sound in Valdez, Alaska; in the Ice Operations Division at U.S. Coast Guard

Headquarters; and as a program reviewer in the Programs Division at Headquarters. Garrett holds a Master of Science in Management degree from the Naval Postgraduate School. He was also a research fellow while attending the Industrial College of the Armed Forces (1992-1993), followed by a return to Headquarters as Assistant Chief of the Programs Division. He also served as Chief of Operations for the Pacific Area. Garrett became the first Commanding Officer of U.S. Coast Guard HEALY (WAGB-20), the nation's newest polar icebreaker and the Coast Guard's largest cutter, upon delivery of the ship in November 1999. He commanded HEALY through shakedown operations and ice trials in the Eastern Arctic in early 2000, followed by transit through Northwest Passage to homeport in Seattle. Following his work with the HEALY, Garret moved to Coast Guard Headquarters, where he served as the U.S. Coast Guard Director of Resources, responsible for the Coast Guard's budget, long-range planning and policy development. He managed execution of the Coast Guard's Operating Expense and Capital Asset appropriations and directed the performance program. Garrett's military awards include the Legion of Merit, Meritorious Service Medal (two awards), U.S. Coast Guard Commendation Medal (two awards), U.S. Coast Guard Achievement Medal (two awards), Unit Commendation, Meritorious Unit Commendation (two awards), Antarctic Service Medal (four awards), and Arctic Service Medal (five awards).

Jacqueline M. Grebmeier is a Research Professor and Project Director at the University of Tennessee, Knoxville. Her research interests include pelagic-benthic coupling, benthic carbon cycling, and benthic faunal population structure in the marine environment; understanding how water column processes influence biological productivity in Arctic waters and sediments; how materials are exchanged between the sea bed and overlying waters; and documenting longer-term trends in ecosystem health of Arctic continental shelves. Some of her research includes analyses of the importance of benthic organisms to higher levels of the Arctic food web, including walruses, gray whales, and diving sea ducks, and studies of radionuclide distributions of sediments and within the water column in the Arctic as a whole. Over the last 20 years she has participated in 33 oceanographic expeditions on both U.S. and foreign vessels, with over 500 days on icebreakers alone. She is a member of the Polar Research Board, served previously as a member of the U.S. Arctic Research Commission, and has contributed to coordinated international and national science planning efforts such as the International Polar Year and Shelf-Basin Interactions project. Dr. Grebmeier earned her Ph.D. in biological oceanography in 1987 from the University of Alaska, Fairbanks.

Mahlon C. Kennicutt II is the Director of Sustainable Development and Team Leader for the Sustainable Coastal Margins Program, Office of the Vice President for Research, at Texas A&M University. Dr. Kennicutt earned his Ph.D. in oceanography in 1980 from Texas A&M University. Dr. Kennicutt has worked as an oceanographer for 25 years, spent over 500 days at sea, including on various ships in Antarctica, and is familiar with the logistics operations at McMurdo Station as well as UNOLS ship operations. In addition, Dr. Kennicutt is a vice president of the Scientific Committee for Antarctic Research of the International Council for Science (ICSU), an international Committee that serves as the formal science advisor to the Antarctic Treaty Consultative Parties. In this role he is familiar with the Antarctic Treaty and especially its environmental protocols. As the U.S. Delegate to SCAR, he accompanies the U.S. Department of State delegation to Treaty meetings. As a scientist, his research interests include environmental monitoring; fate and effects of contaminants; environmental impacts of offshore energy exploration and exploitation; coordination of the social and physical sciences to address environmental issues; and all aspects of the sustainable development of coastal margins. He served on the NRC's Committee to Review the Oil Spill Recovery Institute and the Committee on Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope. Dr. Kennicutt is a member of various professional organizations including the American Geophysical

Union, the American Association for the Advancement of Science, and the American Society of Limnology and Oceanography.

Ronald K. Kiss is President Emeritus of Webb Institute, a private four-year college providing B.S. degrees in naval architecture and marine engineering. Prior to joining Webb Institute, he was vice president of SYNTEK assisting the U.S. Navy on the Joint Navy/Defense Advanced Research Projects Agency arsenal ship program and the Navy's aircraft carrier and surface combatant programs. He served as deputy assistant secretary of the Navy for ship programs in the Office of the Assistant Secretary of the Navy (Research, Development and Acquisition) and as executive director of Amphibious, Auxiliary, Mine and Sealift Directorate at Naval Sea Systems Command. Mr. Kiss spent nearly 20 years with the Maritime Administration, culminating as Acting Associate Administrator for Shipbuilding and Ship Operations. He holds a B.S. degree in naval architecture and marine engineering from Webb Institute, an M.S. in naval architecture from the University of California-Berkeley, and has participated in a number of postgraduate programs at institutions including Harvard University and the Massachusetts Institute of Technology.

Douglas R. MacAyeal is a professor in the Department of the Geophysical Sciences at the University of Chicago. Dr. MacAyeal's field efforts in Antarctica, including the Ross Ice Shelf and the Ross Sea, yield a range of physical models concerning the dynamics of large ice masses. His work in the past has focused on the processes of ice-stream flow and the nature of the subglacial boundary layer that facilitates ice-stream basal lubrication. These models of ice streams were subsequently built upon to determine the role of ice-stream surging in abrupt climate change of the North Atlantic. Dr. MacAyeal's current research interest involves the break-up of ice shelves and the subsequent transport of icebergs into the surrounding ocean. He received his Ph.D. from the Geophysical Fluid Dynamics Laboratory at Princeton University. Dr. MacAyeal has been the chief editor for the *Journal of Glaciology* and a member of the Committee of Advisors for the Office of Polar Programs at the National Science Foundation.

Robert C. North retired from active duty with the U.S. Coast Guard in April 2001. He is presently serving as the President of North Star Maritime, Inc., a marine industry consulting firm specializing in international and domestic maritime safety, security, and environmental protection regulatory issues. RAdm. North's U.S. Coast Guard career spanned nearly 35 years and culminated with service as the U.S. Coast Guard's Assistant Commandant for Marine Safety, Security and Environmental Protection where he directed national and international programs for commercial vessel safety, merchant mariner licensing and documentation, port safety and security, and waterways management. In that capacity, he led U.S. delegations to the International Maritime Organization and also served as a member of numerous classification society committees and the Sealift Committee of the National Defense Transportation Association. Previously, he served as Chief of Acquisition involving major systems such as the U.S. Coast Guard's newest polar icebreaker, the HEALY, and the replacement programs for the U.S. Coast Guard's buoy tender and patrol boat fleets. Earlier assignments included First Lieutenant and deck watch officer on the WESTWIND, a polar icebreaker involved in ice escort, resupply and search and rescue operations in the Arctic and Great Lakes regions. He is a graduate of the State University of New York Maritime College at Fort Schuyler and the U.S. Army War College, Carlisle, Pennsylvania.

Raymond J. Pierce obtained his Master Mariner (H.T.) certification in 1976, his Canadian Coast Guard Command in 1977, and his Masters Foreign Going certification in 1981. During this period he held positions of increasing responsibility on various Canadian Coast Guard ships operating in the Atlantic, Pacific, and Arctic Oceans. In 1979 he was promoted to the rank of

Commanding Officer, and later he was assigned to Headquarters as Superintendent, Operational Requirements and Polar Icebreaking. Captain Pierce has worked for BeauDril Ltd. as a shipmaster, port captain of arctic operations, marine superintendent, and manager. He was also active in the field of advanced navigation and electronic charting with Offshore Systems International of Vancouver. He was an advisor to and director of this emerging public company. After his work in the private sector Pierce rejoined the Canadian Coast Guard where he has served as Regional Director Ship Safety, Regional Director General of the Northern Central and Arctic Regions. Captain Pierce is currently Executive Director of Departmental Renewal at the Canadian Coast Guard.

Steven T. Scalzo is the Chief Operating Officer of Marine Resources Group, Inc., a holding and support company for investments in tug, barge, and ancillary marine service companies. Mr. Scalzo joined Foss Maritime, a subsidiary of Marine Resources Group, in 1975. He is a graduate of the United States Merchant Marine Academy and received a Master's degree in Law and Commerce from Gonzaga University. Mr. Scalzo is a past member of the National Research Council Marine Board and he is active in international, national, and local public policy, and legislative and regulatory issues affecting the safety of marine transportation, including service as past chairman of the U.S. Department of Transportation Towing Safety Advising Committee and the State of Washington Puget Sound Marine Safety Committee. He has also served as the Chairman of the American Waterway Operators, the tug and barge industry national trade association, and he is currently a Board member of the American Steamship Owners Mutual Protection and Indemnity Association, Inc. (the American Club), and the Coast Guard Foundation.

David G. St. Amand has over 28 years of maritime industry experience, the last 19 of which has been as a management consultant. He is an expert on the economics of petroleum shipping. St. Amand has conducted extensive analysis of the Alaskan North Slope tanker trade, as well as the U.S. coastwise petroleum products and foreign tanker trades. He has assisted many of the major oil companies on tanker and logistics matters. St. Amand developed the cost analysis of the double-hull requirement used by the U.S. Department of Transportation in the OPA-90 regulatory impact assessment (1997-1998). He has worked closely with tanker owner/operators and oil spill response contractors to ensure compliance with the requirements of OPA-90 and the U.S. Coast Guard. St. Amand was the project manager at Mercer Management Consulting for the development of vessel oil spill response plans for over 200 oil tankers with 35 different owner/operators. He has also conducted benchmarking "best practices" studies for oil majors examining chartering and operations issues involving tankers, barges, and marine terminals. In the course of his work, he has made voyages on tankers ranging in size from under 20k DWT to over 500k DWT, including tankers in all AFRA size categories. St. Amand also has experience consulting for the inland tug barge industry, having worked with inland operators on economic and operational issues. He developed the operating policy and procedures manuals for one of the largest inland operators. St. Amand assisted the American Waterways Operators (AWO) in developing its strategic plan AWO2000. He served as a member of the National Academy of Sciences (Marine Board) Committee examining the impact of the Oil Pollution Act of 1990 on the oil transportation industry. St. Amand also served on the Towing Safety Advisory Committee (TSAC), a Congressionally-mandated U.S. Coast Guard advisory Committee appointed by the U.S. Department of Transportation. Based on his TSAC work, he received a public service commendation for long-term assistance to the U.S. Coast Guard on regulatory and safety matters. He also received a Certificate of Merit from U.S. Coast Guard's Commandant Admiral Kramek (ret.). St. Amand holds a B.S. in Naval Architecture and Marine Engineering from Webb Institute and an M.B.A. from the Amos Tuck School of Business Administration at Dartmouth College. He is a member of the American Bureau of Shipping (ABS), Society of Naval

Architects and Marine Engineers (SNAME), and Council of Supply Chain Management Professionals (CSCMP).

James H. Swift is a research oceanographer and academic administrator at the University of California, San Diego Scripps Institution of Oceanography (SIO). He received his Ph.D. in physical oceanography from the University of Washington. Dr. Swift has been on 25 blue water and icebreaker expeditions in the Atlantic, Pacific, Arctic, and Southern Oceans. His primary scientific interests are Arctic water masses and circulation, the global thermohaline circulation, and ocean measurement and interpretation. Dr. Swift is scientific advisor to the SIO Oceanographic Data Facility and coordinator for academic institutions involved in the U.S. Global Ocean Carbon and Repeat Hydrography program. He is also director of the WOCE Hydrographic Program Office (now known also as the CLIVAR and Carbon Hydrographic Data Office). Dr. Swift was the founding chair of the University-National Oceanographic Laboratory System Arctic Icebreaker Coordinating Committee, which oversaw science-related aspects of the construction and testing of the research icebreaker U.S. Coast Guard HEALY, and whose long-term mission includes promoting a productive and successful working relationship between the U.S. Coast Guard and the science community using icebreakers. He now serves on the U.S. Antarctic Research Vessel Oversight Committee, is the chair of the National Science Foundation Office of Polar Programs Advisory Committee, and chairs their subCommittee on the McMurdo Antarctic Resupply which presently relies on icebreaker support.