Department of Homeland Security

U.S. Coast Guard

DHS supports Arctic research through the U.S. Coast Guard, which operates polar icebreakers as national polar research assets for Arctic oceanographic expeditions of both government and nongovernment researchers.

Icebreakers

The Coast Guard supports Arctic research through its operation of three polar icebreakers, USCGC *Polar Sea* and USCGC *Polar Star*, which serve as high-latitude research platforms in both the Arctic and Antarctic, and the new polar icebreaker USCGC *Healy*, which started Arctic science cruises in 2001. Support of Arctic research by the U.S. Coast Guard dates back to the 1880s, when voyages on revenue cutters were made by scientists, including the renowned naturalist John Muir on the Revenue Cutter *Corwin* in 1881 and others on the Revenue Cutter *Bear* commanded by Captain Michael Healy in the 1880s and 1890s. Arctic research aboard Coast Guard icebreakers intensified in the late 1960s and early 1970s, when the prospect of increased oil and gas exploration in the Alaskan Arctic required ecological baseline surveys in the Chukchi and Beaufort Seas. The Coast Guard icebreakers *Northwind*, *Burton Island*, and *Glacier* supported these cruises. In the 1980s these vessels were decommissioned as the Polar-class icebreakers joined the fleet.

Polar-Class Icebreakers

The two Polar-class icebreakers were designed to carry out a range of missions in the Arctic, including escorting non-icebreaking vessels through the ice, resupplying military and research bases, and supporting scientific operations. In recent years the role of the Polar-class vessels in research has expanded as more complex projects and larger science teams placed added requirements on these ships. This led to a major upgrade of their capabilities in 1987 through the Polar Science Upgrade Project, a five-year program to enhance the scientific support capabilities of these vessels. Laboratories and living areas were expanded to allow up to 32 scientists and technicians to embark on scientific cruises. Upgraded oceanographic winches, new cargo and science gear handling systems, expanded lab spaces, new oceanographic instrumentation, and new communications and satellite data acquisition systems significantly improved the research capabilities of the Polar-class vessels.

Since 2001, severe Antarctic ice conditions have critically reduced the service life of the *Polar Sea* and *Polar Star*. The condition of *Polar Star* and *Polar Sea* will pose a challenge to the Coast Guard and stakeholders in the U.S. polar research program.

	Funding (thousands)	
	FY 04	FY 05
Arctic Science/Logistics Support	21,691	16,800
Extramural Science Support	30	38
Total	21,721	16,838

USCGC Healy

To meet the expanding needs of the future, the Coast Guard commissioned a new research platform designed primarily for Arctic science, though capable of work in the Antarctic as well. The new vessel, USCGC *Healy*, was built by Avondale Industries in New Orleans, Louisiana. *Healy* is 420 ft long, has a beam of 82 ft, and displaces 16,000 long tons. The maximum speed is 17 knots, with a range of 16,000 nautical miles at 12.5 knots. *Healy*'s primary mission is to function as a world-class high-latitude research platform. *Healy* is able to conduct scientific operations during all seasons in the Arctic, including wintering over for planned missions.

The scientific support capabilities of *Healy* substantially surpass those provided by the Polar-class icebreakers. The ship is able to accommo-

date 35 scientists on a routine basis and provide surge accommodations for up to 50. Over 5,000 square feet of science lab and support space is provided, including a main science lab, a wet science lab, a biological and chemical analysis lab, an electronics lab, a meteorology lab, and a photography lab. In addition *Healy* has five hydraulically operated cranes, two oceanographic winches, and a double-drum core/trawl winch. It also provides over 4,000 square feet of open deck space and 20,000 cubic feet of scientific storage space in three cargo holds. Installed bathymetric and oceanographic instrumentation includes a bottom

USCGC Healy *enters the ice for the first time, April 2000.*

profiling system, a Seabeam bottom mapping sonar system, a data acquisition unit, and an acoustic Doppler current profiler. Lab spaces are equipped with a science data network providing 120 dual fiber-optic-connected Ethernet ports throughout the science spaces for real-time data transfer between data processors, workstations, and printers. In addition there is a dedicated Inmarsat-B with high-speed data transmission and e-mail capabilities for scientists.

After delivery on 9 November 1999 by Litton-Avondale Industries, *Healy* underwent a period of fitting-out availability and propulsion system repairs. The ship departed New Orleans on 26 January 2000 to conduct machinery, hull, and science suite testing. Initial warm-water trials were completed in March. Ice trials were conducted from April to June in Baffin Bay in the eastern Arctic. *Healy* performed well, with icebreaking performance exceeding design requirements of 3.0 knots through 4.5 ft of ice. The maximum thickness of unbroken level ice encountered was 5.5 ft, which *Healy* transited at a continuous speed of 2.6 knots. Ice ridges of 45 ft were broken through in three rams. *Healy* transited the Northwest Passage in July and arrived at Seattle on 9 August. The ship was commissioned on 21 August 2000.

During the first science cruises in 2001, *Healy* conducted successful cruises in the eastern Arctic Ocean, including the North Pole.

Arctic Research Cruises

The Coast Guard's major Arctic research efforts supported during the past two years were the Arctic West Summer (AWS) Cruises aboard *Healy* in 2004 and the Arctic West and East Summer (AWES) Cruises aboard *Healy* in 2005.

USCGC Healy *2004*

On 27 April *Healy* sailed for the six-month AWS 2004 mission to support three multidisciplinary projects: the National Tsunami Hazard Mitigation Program, the Western Arctic Shelf Basin Interactions (SBI) project, and the NOAA Ocean Floor Mapping project.

National Tsunami Hazard Mitigation Program. As part of the U.S. National Tsunami Hazard Mitigation Program, the Deep Ocean Assessment and Reporting of Tsunamis (DART) Project is an ongoing effort to maintain and improve the capability for the early detection and real-time reporting of tsunamis in the open ocean. A DART station consists of an anchored seafloor-bottom pressure recorder and a companion moored surface buoy for real-time communications. An acoustic link transmits from the bottom pressure recorder on the seafloor to the surface buoy. The data are then relayed via a satellite link to ground stations, which demodulate the signals for immediate dissemination to several sites, including NOAA's Tsunami Warning Centers. More information is available at the NOAA tsunami website (www.tsunami.noaa.gov).

During this mission (27 June–4 July), led by Shannon McArthur of NOAA, three DART stations off the coast of Alaska were serviced. Institutions participating included the NOAA National Data Buoy Center, the Lamont–Doherty Earth Observatory, and Science Applications International Corporation.

SBI 2004 Processing Cruises. The SBI project is a multi-year, interdisciplinary program to investigate the impact of global change on physical, biological, and geochemical processes over the Chukchi and Beaufort Sea shelf basin regions in the western Arctic Ocean. The SBI project is jointly sponsored by the National Science Foundation and the Office of Naval Research and consists of 14 ongoing research projects. More information is available at the SBI website (sbi.utk.edu).

There were two SBI processing cruises on *Healy* in 2004: the SBI 2004 May/June Processing Cruise (15 May–23 June), led by Jackie Grebmeier of the University of Tennessee Knoxville, and the SBI 2004 July/August Processing Cruise (18 July–26 August), led by Lee Cooper of the University of Tennessee Knoxville. During these cruises a wide variety of interdisciplinary research projects participated, ranging from hydrographic measurements to biological studies of various trophic levels.

Physical, biogeochemical, and biological measurements were made in the Bering Strait and over the shelf, slope, and basin of the Chukchi and Beaufort Seas using a variety of sampling devices. Subsamples from four CTD (conductivity, temperature, depth)/rosette casts were used for measuring primary production, chlorophyll content, nutrients, particulate carbon, inorganic carbon, biomarkers, microzooplankton, and radioisotopes. Various nets were used to collect zooplankton for both population and experimental purposes. Benthic grabs and cores were used to collect benthic fauna and sediment samples for population, community structure, food web, and metabolism studies. Acoustic Doppler current profiler data were obtained with both a 75-kHz phased-array system and a 153-kHz discrete-array system. Scientists were lowered to the ice to collect ice cores and make in situ measurements of the ice. Marine mammal surveys were conducted from the bridge. Helicopters were used for sampling of the Colville River Delta, small boat operations in support of experimental floating sediment trap deployments, ice reconnaissance, and observing and photographing marine mammals.

The institutions participating included the University of Tennessee Knoxville, the University of Alaska Fairbanks, the Woods Hole Oceanographic Institution, the University of Washington, the Scripps Institution of Oceanography, the University of Maryland, the University of Delaware, the Lamont–Doherty Earth Observatory, the University of Rhode Island, the Canadian Department of Fisheries and Oceans, the University of South Carolina, Old Dominion University, the University of Texas, Hokkaido University, the University of Miami, the Bermuda Biological Station for Research, the University Corporation for Atmospheric Research, Oregon State University, the Alaska Eskimo Whaling Commission, Bigelow Laboratory for Ocean Science, Tenino High School (Tenino, Washington), and Newman High School (Wausau, Wisconsin).

SBI 2004 Mooring Cruise. From 2 September to 1 October, Robert Pickett of the Woods Hole Oceanographic Institution led a cruise in support of the SBI project. During the main effort, 12 moorings deployed by *Healy* in 2003 (to measure temperature, conductivity, and currents) were recovered. Two acoustical recording platforms were also recovered. The cruise collected other data, including 157 CTD stations and water sampling at 117 of these stations. A study of the boundary current running on the slope to the north was conducted using XBTs (expandable bathythermographs) to define the current, plus CDTs, VPRs (video plankton recorders), and net tows for further analysis.

Institutions participating included the University of Alaska Fairbanks, the Woods Hole Oceanographic Institute, the University of Washington, the Scripps Institution of Oceanography, the University of Delaware, the Lamont–Doherty Earth Observatory, the University of Miami, the University of Rhode Island, and the University of Cadiz.

NOAA Ocean Floor Mapping. The primary purpose of this leg was to continue mapping the seafloor north of Alaska for use in future Exclusive Economic Zone (EEZ) claims, an effort that NOAA began on a *Healy* cruise in September 2003. Under Article 76 of the U.N. Convention on the Law of the Sea, a country may claim rights to the seafloor beyond the normal EEZ limit. One of the key pieces of evidence to support a claim is the location of the 2,500-meter depth contour and the foot of the continental slope. Although the U.S. has not ratified the convention, it is gathering data to support future claims. While the U.S. has made significant progress in temperate zones, this is only our second Law of the Sea bottom mapping survey for the Arctic Ocean.

During the 20-day cruise (6–26 October) led by Chief Scientist Larry Mayer of the University of New Hampshire, *Healy* ran 6,700 km of tracklines and completed most of the mapping of the 2,500-m isobath begun on *Healy* in 2003, as well as a survey of the "foot of the slope" over a segment of the continental margin east of Barrow, Alaska. The survey also revealed a complex margin with drift deposits, suggesting contour currents that are cut by numerous canyons.

Institutions included the University of New Hampshire, the Lamont–Doherty Earth Observatory, NOAA, and the Danish Hydrographic Agency.

USCGC Healy, *2005*

From 1 June to 28 November 2005, *Healy* completed three missions in support of Arctic research. The first and third missions of AWES-05 were NSF funded and focused on coring and col-

lecting geophysical transect data with a towed seismic source and receiving streamer. The second cruise, funded by NOAA Ocean Exploration, focused on cataloging the biomass of Arctic marine species.

Canada Basin Coring. The purpose of this two-week mission (13–26 June), led by Chief Scientist Dennis Darby of Old Dominion University, was to obtain expanded sections of Holocene and older sediment from the North American continental slope between Barrow and the Northwind Ridge. Multibeam sonar and 3.5-kHz seismic profiles were used to locate cores in areas of high sediment accumulation. *Healy* completed eight successful jumbo piston cores (JPCs), six multicores, six vertical plankton tows, and two CTD casts. The JPC deployments produced over 100 meters of sediment samples. Helicopters conducted seven ice reconnaissance sorties in search of "dirty ice," ice infused with sediment. During four flights, the helicopters landed so that the scientific party member could collect samples. Seven dirty ice samples were collected

Scientists were from Old Dominion University, the University of New Hampshire, Ohio State University, the University of Hawaii, the Desert Research Institute, Kent State University, Université de Quebec, Oregon State University, Kings Fork High School (Suffolk, Virginia), Science Applications Research International Incorporated, Johns Hopkins University, the Lamont–Doherty Earth Observatory, and the University Corporation for Atmospheric Research. This project was funded by the National Science Foundation

NOAA Ocean Exploration. During the 30-day (27 June–26 July) NOAA Ocean Exploration cruise, Rolf Gradinger of the University of Alaska Fairbanks led an international team of scientists from the U.S., Canada, China, and Russia in exploration of the Canada Basin. The major objective was to improve the inventory of life in the Canada Basin as part of the worldwide Census of Marine Life study. Sample stations were designated along the slope and within the deep basin and included studies of biota in the sea ice, water column, and seafloor. Each of the 14 stations was projected to last 24 hours and would encompass CTD casts, plankton net tows, ice team deployments, divers, pelagic and benthic ROV (remotely operated vehicle) deployments, box cores, and a towed camera platform. At each station, divers collected ctenopheres, amphipods, and Arctic cod and took video images of the under-ice surface. Near the end of the mission, several media personnel came onboard to document the discoveries and daily operations. Scientists discovered new species of pelagic and benthic organisms and determined range extensions for some known species.

Institutions involved in this effort included the University of Alaska Fairbanks, the Polar Research Institute of China, Texas A & M University, the Zoological Institute of St. Petersburg, the Harbor Branch Oceanographic Institution, California State University at Monterey Bay, Western Washington University, the P.P. Shirshov Institute, Barrow High School (Barrow, Alaska), NOAA, Deep Sea Systems, the National Ice Center, the Lamont–Doherty Earth Observatory, the University of Hawaii, Census of Marine Life, Blue Land Media, National Public Radio, ABC News, and *The New York Times*.

Healy–Oden Trans-Arctic Expedition. The Healy–Oden Trans-Arctic Expedition 2005 involved the joint crossing of the central Arctic Ocean by *Healy* and the Swedish icebreaker *Oden*. Anders Karqvist of the Swedish Polar Research Secretariat and James Swift of the Scripps Institution of Oceanography led the planning for the physical oceanographic projects, and Dennis Darby and Bernard Coakley, co-Chief Scientists for *Healy*, led the planning for the coring and geophysics projects.

Scientists were from Old Dominion University, the University of Alaska Fairbanks, Ohio State University, the University of Bergen, Stockholm University, the Desert Research Institute, Texas A & M University, the Scripps Institution of Oceanography, the U.S. Army Cold Regions Research and Engineering Laboratory, the University of Washington, Thor Heyerdahl High School (Larvik, Norway), the U.S. Arctic Research Commission, Alta High School (Alta, Norway), Uppsala University, Universite de Quebec, the Bergen School of Engineering, the Japan Agency for Marine–Earth Science and Technology, the Canadian Coast Guard, the University of Oslo, LGL Ltd, the Barrow Arctic Science Consortium, the Lamont–Doherty Earth Observatory, the Swedish Polar Research Secretariat, Vibackeskolan (Sundsvall, Sweden), Homer Hanna High School (Brownsville, Texas), Oregon State University, the Hawaii Mapping Research Group, and the University of New Hampshire. U.S. researchers were supported by the National Science Foundation.

International Ice Patrol

The Coast Guard International Ice Patrol (IIP), located in Groton, Connecticut, participated in

two research programs, one an iceberg detection study using satellite-borne radar systems and the other a cooperative research program with the Canadian Ice Service (CIS) to test the accuracy of iceberg drift models, including one recently developed by CIS. Although this research occurred south of the Arctic Circle, it has direct relevance to high-latitude navigation and is an integral part of the Coast Guard's Marine Science Program.

The iceberg detection research is part of Polar View, a satellite remote-sensing program that is supported by the European Space Agency (ESA) and the European Commission, with participation by the Canadian Space Agency. C-CORE, a global research and development corporation located in St. John's, Newfoundland, is the prime contractor of the Polar View team. IIP is participating as an end user. C-CORE provides IIP the locations of icebergs and ships obtained from the analysis of images by the synthetic aperture radar on two satellites, Canada's RADARSAT-1 and the European Space Agency's ENVISAT. During 2004 and 2005, IIP compared the satellite observations with observations from other sources, including IIP's aerial reconnaissance.

The second program is a joint IIP and CIS effort to evaluate the accuracy of the operational iceberg drift model used by the two organizations and a new model created by CIS. As part of this research, IIP plans to deploy ice beacons by aircraft onto icebergs. The observed iceberg movement will be compared to the model predictions.