



OCEAN & CLIMATE CHANGE INSTITUTE



JANUARY 2009 REPORT

Woods Hole Oceanographic Institution

Message from the OCCI Director

In recent years, sea ice melting in the Arctic has been one of the early signs that warming is having a significant effect on Earth's climate system. In 2007, sea ice cover was the lowest ever recorded and many scientists looked on with great anticipation to see what would happen to the ice in 2008. As it turned out, sea ice cover in 2008 was slightly larger than in 2007, but still well below average and smaller than predicted by many climate models.



Photo of Bill Curry by Tom Kleindinst, WHOI

Ocean circulation processes play a major role in the climate and sea ice changes we are observing, and understanding the causes and consequences of these changes is a major part of Ocean and Climate Change Institute activities. In 2008, the OCCI distributed about \$1.3M for the Arctic Research Initiative, our five-year focused research program studying the changes in Arctic climate and their impacts on the marine and surrounding terrestrial ecosystems. Combined with our Comer Science and Education Foundation research activities, the two-year total for this initiative is now about \$5M, enabling many WHOI researchers to participate in International Polar Year research activities.

Two research projects are highlighted in this issue. Michael Moore (Senior Research Specialist in Biology) is working with indigenous Alaskan whalers to study bowhead whales in preparation for the likelihood that decreased Arctic sea ice cover is going to increase commercial navigation of the Arctic and increase ship collisions with marine mammals.

Katherine Silverthorne (Physical Oceanography) is a graduate student supported by OCCI, and studies the development of "18 degree water" in the North Atlantic. This water mass plays a role in the complex interactions of the Gulf Stream and the atmosphere each winter and its

development has a large impact on North Atlantic climate.

This past year also saw several notable OCCI outreach activities with individuals from industry and government. In February, we participated in CERAWEEK 2008, a conference attended by leaders from the international energy industry, at the invitation of WHOI Corporation Member Jamey Rosenfield. At this meeting, we had the opportunity to showcase WHOI research and technology for the Arctic, a region of great interest to energy companies because of its resource potential. In July, we participated in a "Climate War Game" hosted by The Center for a New American Security, a non-profit headed by WHOI Corporation Member Kurt Campbell. The "war game" was a negotiation exercise in which individuals played the roles of future international leaders engaged in negotiations to stabilize climate. OCCI helped to produce a climate scenario that would be realistic yet severe enough to prompt cooperative action by future world leaders.

With the help of Mary-Louise Timmermans (Assistant Scientist in Physical Oceanography), OCCI hosted the International Symposium on Arctic Sea Ice and Climate at WHOI in November 2008, which convened a group of leading Arctic researchers to discuss the recent melting in the Arctic and to present preliminary observations from the 2008 field data collection season. As part of OCCI's outreach efforts, one of the participants, Jean Claude Gascard, an oceanographer at the Université Pierre et Marie Curie in Paris, France, presented a public lecture at Redfield Auditorium in Woods Hole. The lecture titled, "*Arctic Changes, Global Warming, Global Warning*," was well attended and stimulated much discussion.

Your generosity makes it possible for WHOI to remain competitive in its pursuit of federal resources, to act as an accurate source of information about the oceans, and to inform national policy discussions. We continue to be very grateful for your support of the Institution and the Ocean and Climate Change Institute.

—Bill Curry, Senior Scientist & Director

Bowhead Whales

Ice Retreat, and Millennia of Traditional Ecological Knowledge

Bowhead whales have been sustainably harvested by the Iñupiaq people for at least a millennium. They understand the whales intimately, and they have a deep knowledge of their biology and behavior. Because of my ongoing studies on the biology and human impact issues of the North Atlantic right whale, I was invited in 2003 to participate in a workshop focused on integrating right whale and bowhead whale research. Out of this workshop has grown an important set of collaborative and comparative approaches to the study of large marine mammals.



Jim Canavan, WHOI

Bowhead and right whales are closely related evolutionarily, and they have many similarities in morphology and behavior. One goal of our research is to compare and contrast right whale conservation issues with the likelihood of increased problems for bowhead whales as ice retreat opens up the North Slope region of Alaska to fishing and shipping interests. In discussing the issues of vessel collision, fishing gear entanglement facing right whales, and the potential for comparable bowhead issues in the future, I found the Iñupiaq very cognizant of the need to proactively learn about the risks, consequences and potential mitigation strategies.

We learned several techniques from the Iñupiaq whalers for large whale dissection that do not require heavy machinery. On the US east coast, we often handle large whales for forensic examination, often with no machinery. The Iñupiaq use a mechanical technique that involves many people pulling independently on the same piece of an animal—like a dog team pulling a sled. A few days after returning from Alaska in October 2007, I found myself working with Patagonian biologists examining a mass mortality of southern right whales on a very remote coast in Peninsular Valdés. Teaching local Argentinean

biologists useful Iñupiaq whale disassembly techniques was a special privilege.

While visiting the North Slope we were able to examine recently-killed bowhead whales. From these observations we learned that shoulder lesions observed in many museum specimens may be acquired from the severe stresses that muscles and tendons exert on flipper bones, as large whales swim and steer. Originally we had thought that these lesions, like others elsewhere in the skeleton were damage caused by the pressure changes that whales experience during deep diving. That these lesions may be stress-related is a new, important line of inquiry for our studies of large marine mammals.

As a result of this work and with additional support from the Arctic Research Initiative, a workshop on shipping and fishing activity in the Arctic will be held in Anchorage, in July of 2009. This workshop will bring key local, industry, state and federal representatives together with researchers to discuss the potential for increased impacts on marine mammals in the Bering, Chukchi and Beaufort Seas from intensifying fishing and shipping activities as Arctic ice recedes.

—Michael Moore, Biology Department



Whalers in Barrow, Alaska removing blubber from a bowhead whale taken during their fall hunt. Unlike the spring hunt which takes place with small skin boats on the sea ice, the fall hunt is an open water hunt in which harvested whales are hauled ashore for butchering—and easily accessible to biologists.

Eighteen Degree Water

A critical component of Earth's climate system



Although North Atlantic Subtropical Mode water (a large, mid-depth water mass found south of the Gulf Stream) was identified for the first time

over one hundred years ago, the processes which govern its origin are still unclear. North Atlantic Subtropical Mode water, also known as Eighteen Degree Water (EDW) because it is always 18 degrees Celsius, is thought to be formed when strong winter storms carry cold air across the warm Gulf Stream, pulling heat and moisture from the ocean, and creating a several hundred meter thick layer of cold and salty water on the surface. Subsequent spring and summer heating warms the surface again, but the chilled waters below the surface remain and expand laterally, suspended between warmer surface waters and the even colder deep waters. The lateral spreading means that Eighteen Degree Water produced in the Gulf Stream region can be traced in the Atlantic as far south as the Caribbean Sea.

Mode waters are large reservoirs of heat which are re-exposed annually to the atmosphere, allowing the conditions of one winter to continue to affect the atmosphere and ocean for several years to follow. Heat

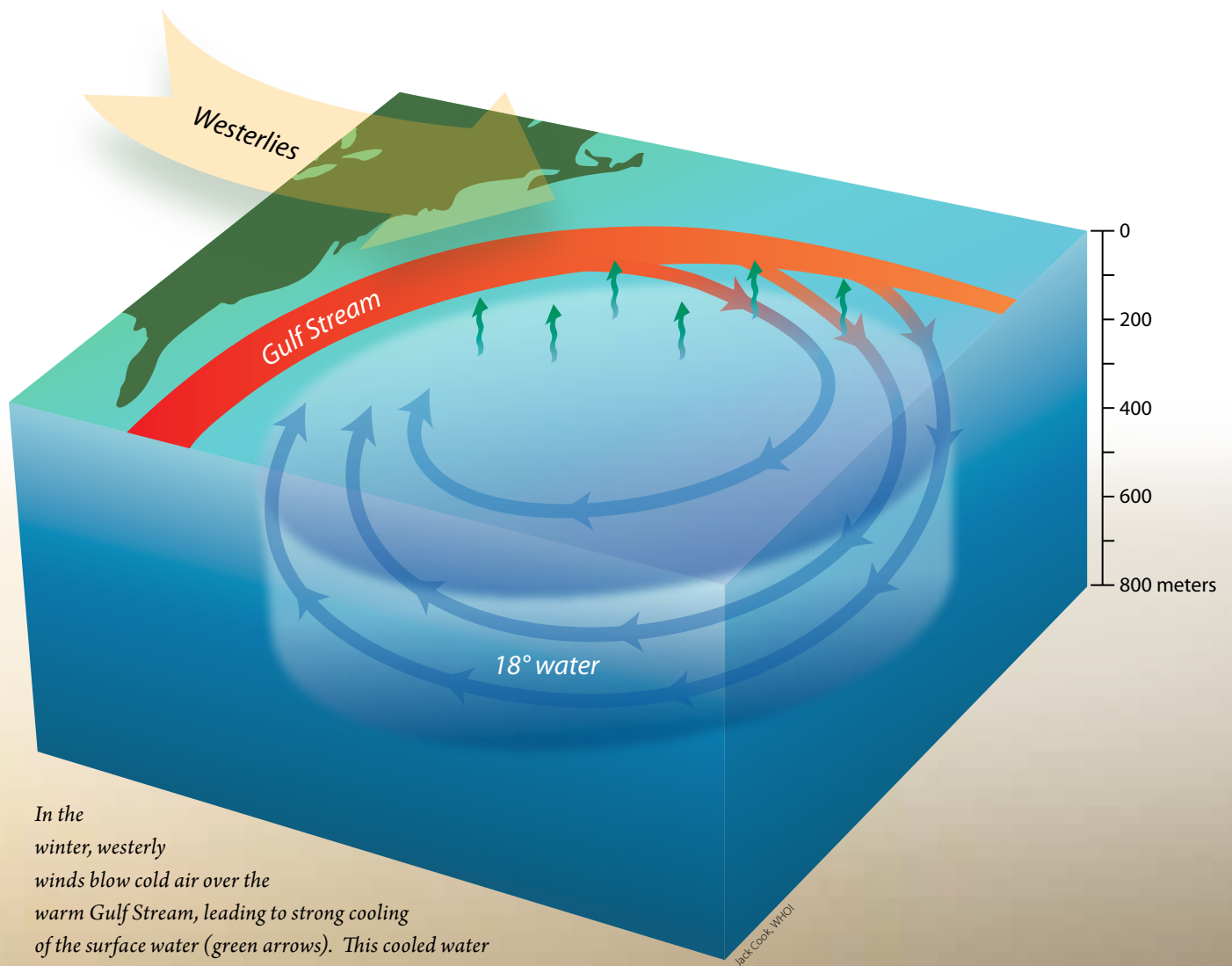
transfer from the ocean to the atmosphere over the Gulf Stream in winter (which produces the EDW) is among the largest in the world and of critical importance to Earth's climate system.

My research is part of a larger observational and modeling initiative known as CLIMODE (CLimate variability MOb water Dynamics Experiment), a program undertaken to investigate EDW properties and to provide insight into the relative importance of the processes which govern its formation and evolution. Previous studies have estimated the amount of EDW water formed in the wintertime by comparing observed meteorology with data retrieved from drifting floats. However, discrepancies between the indirect and direct estimates of EDW formation rates indicate that the process could involve large scale, lateral mixing in the turbulent Gulf Stream, rather than just simple air-sea interactions.

To evaluate this possibility, John Toole (my graduate advisor and a Senior Scientist in the Physical Oceanography Department) deployed two profiling floats which drifted in the Gulf Stream and measured upper ocean properties directly as wintertime storms passed above. With OCCI support, I have been analyzing those observations to understand how the upper ocean responded to the strong cooling and the winds that accompanied the storms. Moving forward, I plan to supplement the observation study with numerical modeling, another component of my doctoral thesis as an MIT/WHOI Joint Program student. This in-depth study of EDW characteristics should lead to significant improvements to global climate models and better prediction of future ocean conditions.

—Katherine Silverthorne,
Physical Oceanography Department

Sunset on the Oceanus during a CLIMODE project cruise to recover moorings.



In the winter, westerly winds blow cold air over the warm Gulf Stream, leading to strong cooling of the surface water (green arrows). This cooled water mass (18 degree water) sinks to depths of up to 500 meters, and is spread to the south and west by the large scale circulation of the North Atlantic Ocean.



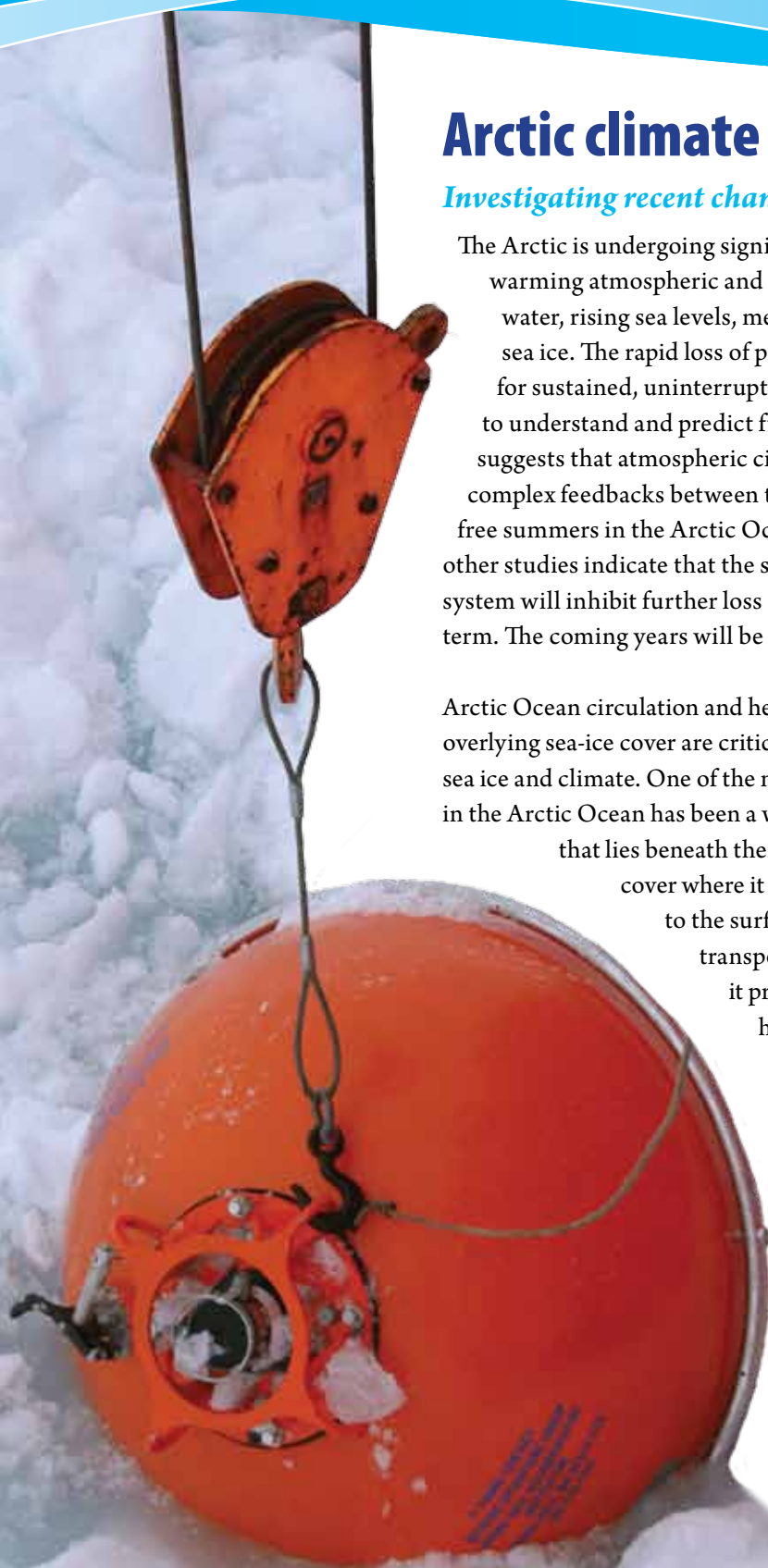
Arctic climate

Investigating recent changes to the Arctic system

The Arctic is undergoing significant climate changes that include warming atmospheric and ocean temperatures, freshening of sea water, rising sea levels, melting permafrost and the decline of sea ice. The rapid loss of permanent sea ice underscores the need for sustained, uninterrupted Arctic observations and analyses to understand and predict future Arctic changes. Some research suggests that atmospheric circulation, rising global temperatures and complex feedbacks between the sea ice and the ocean will lead to ice-free summers in the Arctic Ocean in as few as 10 years from now, while other studies indicate that the strong natural variability of the Arctic system will inhibit further loss of summer sea ice, at least in the near term. The coming years will be of great significance in Arctic research.

Arctic Ocean circulation and heat transport from the ocean to the overlying sea-ice cover are critical components in the delicate balance of sea ice and climate. One of the most significant recent changes to occur in the Arctic Ocean has been a warming of the Atlantic-derived water that lies beneath the surface waters. This warming affects ice cover where it is possible for the heat to be transported to the surface. Our observations of vertical heat transport in the central Canada Basin show that it provides only a small fraction of the total heat input to overlying waters, and that most of the ocean heat is derived from incoming solar radiation. Our ongoing analyses are aimed at understanding the fate of the warm waters entering the Arctic from the Pacific and Atlantic Oceans, and the complex relationships between Arctic Ocean heat and fresh water dynamics and atmospheric circulation patterns and thermodynamics.

—Mary-Louise Timmermans,
Physical Oceanography Department





Front row, left to right: Mary-Louise Timmermans, Jim Overland, Jean Claude Gascard, Seymour Laxon;
Behind Timmermans: Humfrey Melling;
Middle row, left to right: Tom Weingartner, Martin Miles, Carin Ashjian, Ron Kwok;
Back row, left to right: Ron Lindsay, Jennifer Francis, John Cassano, Don Perovich, Andrey Proshutinsky.

The Symposium on Arctic Sea Ice and Climate

With support from the Ocean and Climate Change Institute, sixteen scientists from the United States, Canada, France, Russia and the UK met in Woods Hole in November of 2008 to present their latest research in a symposium on Arctic Sea Ice and Climate. The timing for the symposium was notable—the second lowest minimum summer sea-ice extent on record was measured in September of 2008, with the extreme minimum set only the previous year. The presentations, which dealt with the most up-to-date understanding of the physical and biological parameters and mechanisms in a changing Arctic climate, were interspersed with extensive discussions on Arctic Climate. The general conclusion reached by participating scientists was that greenhouse gases were a factor in the recent major loss of summer sea ice, but that natural variability in atmospheric circulation patterns lead to a more rapid loss of sea ice than might have occurred under present warming conditions alone. Only time will tell whether a rapid acceleration in the pace of Arctic change will emerge.

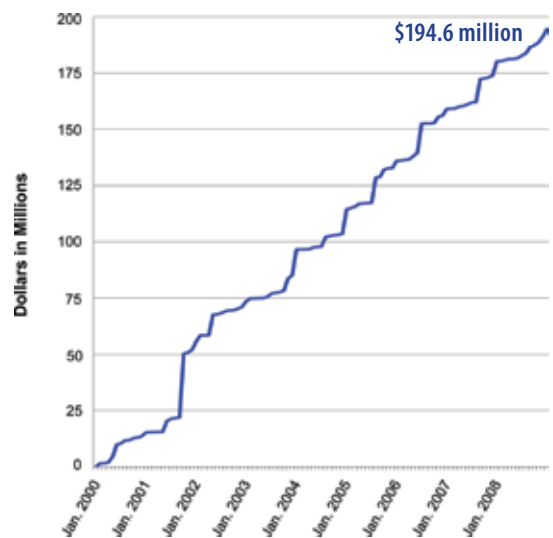
—Mary-Louise Timmermans

Financial update

WHOI's "Depth of Leadership Campaign" has officially come to a close. In 2008, we raised \$14.4 million, bringing our final total to \$194.6 million. During the course of the Campaign we built two new science laboratories, acquired a new coastal research vessel and established four ocean institutes focused on addressing areas of significant concern to the general public and policymakers. Many thanks to all who have contributed to the Campaign's success!

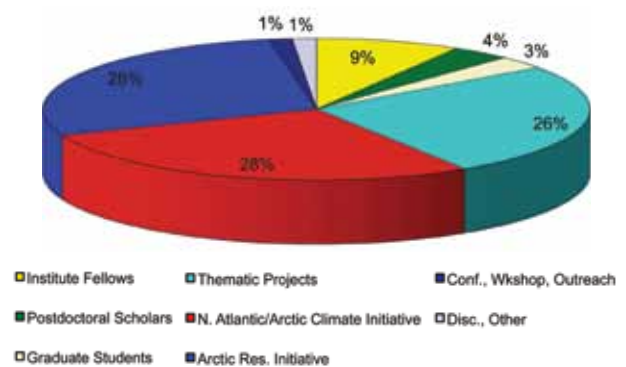
Campaign Funds Raised to Date: \$194,586,716

As of December 31, 2008



Between 2001 and 2008, the OCCI supported 111 Research Awards, 10 Institute Fellows, 7 Postdoctoral Scholars, and 3 Joint Program Students as well as a variety of workshops, seminars and outreach activities.

OCCI Spending 2001-2008: \$14,479,778





About the Ocean and Climate Change Institute

We are an institute without walls or permanent staff. We are dedicated to understanding the ocean's role in climate by devoting resources to interdisciplinary research teams, educating the next generation of ocean and climate researchers, and communicating the importance of ocean research to a variety of climate stakeholders including the government, corporations and the public at large.

OCEAN & CLIMATE CHANGE INSTITUTE

Woods Hole Oceanographic Institution

MS#22, 266 Woods Hole Road

Woods Hole, MA 02543

Director: Bill Curry wcurry@whoi.edu

Administrator: Andrew Daly adaly@whoi.edu

Front cover: Arches and caves shaped by the rapidly flowing water that drained a surface lake on the Greenland ice Sheet. Summer melting creates the lakes. Sudden cracking of the ice beneath the lakes causes them to drain away quickly. Back cover: Team members ride the crane down to an ice floe in the Arctic Ocean to deploy a mooring system for the Beaufort Gyre Experiment. Photos by Chris Linder, WHOI. Brochure design: Katherine Joyce, WHOI Graphic Services.