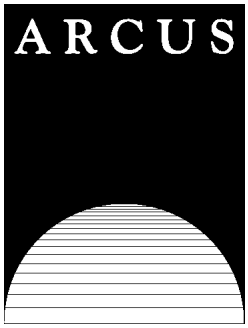
Marine Science in the Arctic: A Strategy

A Report from the Arctic Research Community to the National Science Foundation

Dennis Darby, Old Dominion University
Kelly Falkner, Oregon State University
Greg Flato, University of Victoria
Jackie Grebmeier, University of Tennessee
Chris Measures, University of Hawaii
John Walsh, University of Illinois
Knut Aagaard, University of Washington, Chair

Published by
The Arctic Research Consortium of the United States

This material is based upon work supported by the National Science Foundation under Cooperative Agreement #OPP-9727899. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of NSF.



Published by the Arctic Research Consortium of the United States (ARCUS) • 600 University Avenue, Suite 1 • Fairbanks, AK 99709 • phone: (907) 474-1600 • fax: (907)474-1604 • e-mail: arcus@arcus.org • http://www.arcus.org/

This work may be cited as:
Aagaard, K., D. Darby, K. Falkner, G. Flato, J. Grebmeier, C. Measures, and J. Walsh, 1999. *Marine Science in the Arctic: A Strategy.* Arctic Research Consortium of the United States (ARCUS). Fairbanks, AK. 84 pp.

Foreword

Following the recommendations of a planning group convened by the National Science Foundation in January 1997, the foundation asked the research community for advice and guidance in its long-term planning efforts by preparing a strategic plan for arctic marine sciences. The intent was to provide a grass-roots vision of the next decade of research in the marine Arctic. At the behest of the foundation, and again following the 1997 planning group recommendations, a seven-member working group was appointed through the Arctic Research Consortium of the United States (ARCUS) to develop, in concert with the broader community, the document presented here. A total of three drafts were prepared, and extensive contributions and commentaries from the research community and other interested parties were solicited and received during the entire process.

Much of the work in developing and producing this plan devolved upon Sue Mitchell and Wendy Warnick of ARCUS, and on Clara Jodwalis of the University of Alaska Fairbanks. The working group thanks them warmly!

Dennis Darby, Old Dominion University
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Summary

Scientific Issues

The marine Arctic has been an integral part of the history of our planet over the past 130 million years and it contributes significantly to the present functioning of the earth and its life. In the Arctic we see signs of variability that suggest the future of the planet may be different from the present and the recent past, for the marine Arctic is intimately involved in global climate and in the earth's great biogeochemical cycles. An adequate understanding of the past and the present Arctic, and of the processes that shape it, is key to predicting the future of this unique region and its impact on society, including its health and commerce.

The National Science Foundation has asked the research community for advice and guidance on how best to deal with these issues of national importance by preparing a strategic plan for basic research in the arctic marine sciences. The emphasis is on major research needs over the next decade, and the perspective is that of the entire marine Arctic viewed in a global context. While this plan is focused on basic research, the applications and benefits of such research are often immediate, and they include matters of special importance to those who live and work in the Arctic.

We consider it likely that much of the scientific research in the marine Arctic during the coming decade will be dominated by five themes, and we believe that the National Science Foundation must be prepared to support that research in an expanded and cohesive program. These five research themes are stated below, together with an explanatory statement and representative major questions that need to be addressed within each theme. Subsequent sections of this strategic plan address each theme in detail.

1. The Arctic in Global Climate

The Arctic is the northern hemisphere heat sink for the earth, and it plays a formative role in both the atmospheric and oceanic circulations.

Is the ice cover stable? Under global warming, are the net radiative feedback effects in the Arctic positive or negative? How does the Arctic modulate the global ocean circulation, e.g., *through its role in the water cycle? Is the Arctic a source or a sink for radiatively active (greenhouse) gases?*

2. Recent Variability and Change in the Arctic

The past decade has seen remarkable changes in the marine Arctic, but we do not know whether these represent temporary perturbations, long-term trends, or new equilibria.

Do recent decreases in ice extent and upper-ocean stratification signal a different sea ice regime? Are anthropogenic (human-caused) signals detectable against the natural variability of the Arctic? What measurements are needed to observe the continuing evolution of the arctic system? How do we acquire a long-term predictive capability?

3. History of the Arctic Ocean

The Arctic Ocean presents the largest gap in the world geologic record, limiting our ability to construct both global tectonic and paleoclimatic models. This gap also limits our ability to exploit the resources of the arctic shelves.

How was the Polar Basin formed? Where are the plate boundaries in the Canada Basin? How does the Gakkel Ridge, the slowest spreading ridge in the world ocean, differ chemically and structurally from other mid-ocean ridges? What does the marine Cenozoic sediment record tell us of past glacial-interglacial transitions, and how does the sediment record compare with the ice-sheet record and the abrupt changes it implies? When did sea ice first appear in the Polar Basin?

4. Biogeochemical Cycles

The global cycles of a variety of materials fundamental to life and to the state of the atmosphere may to a significant extent depend on arctic marine processes.

What is the role of the vast arctic continental shelves in the global cycling of carbon, nitrogen, silicon, and other materials? To what extent does production of biogenic gases within the Arctic contribute to the state of the present global atmosphere? How have changes to the unique arctic environment affected major global biogeochemical cycles, and how might future changes affect those cycles?

5. Health of the Arctic Ecosystem

The arctic ecosystem is adapted to an extreme environment with large seasonal forcing. The system is likely to be severely stressed by changing ice and water conditions, an increase in contaminants, and possibly increased UV radiation.

What is the present productivity of the marine Arctic? Why are there such large variations in the higher trophic levels? To what extent are persistent organic contaminants being sequestered in the arctic food web? How will life on the shelves respond to a changing environment?

Recommendations

Understanding the past and present Arctic is essential to predicting its future and to evaluating the global effects of changes in this unique region.

We therefore recommend that the National Science Foundation:

- Expand support of basic research on the arctic marine system, with particular emphasis on improving predictive capabilities. This emphasis should include both global and regional perspectives, with application to local problems and opportunities.
- Immediately pursue international cooperative agreements for planning and supporting arctic marine science. Canada is a natural first partner with which to initially develop such systematic and sustained cooperation.
- Facilitate scientific access to the Russian exclusive economic zone and continental shelves through a high-level bilateral agreement with Russia.

We further recommend that the National Science Foundation:

- Initiate a program to acquire marine environmental time series, including establishing a marine Environmental Observatory in the Arctic and a set of strategically located repeat hydrographic sections.
- Undertake a program of giant piston coring and support the expansion of International Ocean Drilling Program efforts in the Arctic Ocean.
- Support continued seafloor mapping and integrated geophysical measurements by submarines and other appropriate means.

The National Science Foundation should therefore:

- Initiate a sustained effort to develop instrumentation and measurement techniques suitable for ice-covered seas.
- Seek release from the petroleum industry of geophysical and coring data from the continental shelves.
- Ensure scientific control of expeditionary planning, scheduling, and scientific operation of the *Healy,* in the manner of University National Oceanographic Laboratory System (UNOLS) vessels.
- Use a balanced and complementary logistical system that includes ice breakers, smaller coastal vessels, aircraft, shore support stations, and submarines where feasible.
- Evaluate the logistical needs of arctic research every three to five years. Included in such an evaluation should be the need for a smaller vessel suitable for work in the marginal ice zone.