The Arctic in Rapid Transition (ART) Initiative: Integrating Priorities for Arctic Marine Science Over the Next Decade

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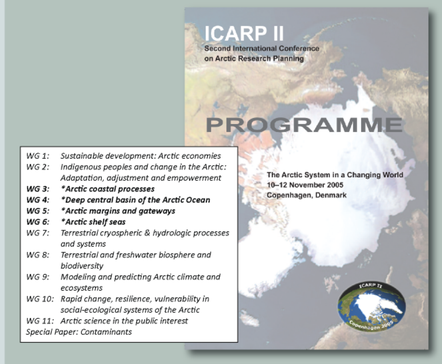
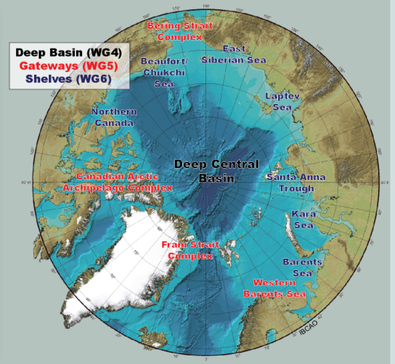
www.aosb.org/art.html

1) Background of the ART Initiative:

The Arctic is undergoing rapid environmental and economic transformations. Recent climate warming, which is simplifying access to oil and gas resources, enabling trans-Arctic shipping, and shifting the distribution of harvestable resources, has brought the Arctic Ocean to the top of national and international political agendas. Scientific knowledge of the present status of the Arctic Ocean and a process-based understanding of the mechanisms of change are required to make useful predictions of future conditions throughout the Arctic region. In turn, these predictions are urgently needed to plan for the consequences of climate change.

A step towards improving our capacity to predict future Arctic change was undertaken with the Second International Conference on Arctic Research Planning (ICARP II) meetings in 2005 and 2006 (www.icarp.dk), which brought together scientists, policymakers, research managers, Arctic residents, and other stakeholders interested in the future of the Arctic region. As the ICARP II process came to a close, the Arctic in Rapid Transition (ART) Initiative developed out of an effort to synthesize the several resulting ICARP II science plans specific to the Arctic marine environment (WG3: Arctic coastal processes, WG4: Deep central basin of the Arctic Ocean, WG5: Arctic margins and gateways, and WG6: Arctic shelf seas).



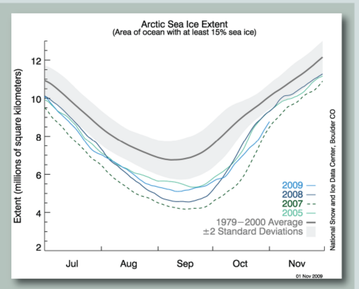


In sum, the ART Initiative is an integrative, international, interdisciplinary, long-term pan-Arctic program to study changes and feedbacks among the physical and biogeochemical components of the Arctic Ocean and their ultimate impacts on biological productivity. Furthermore, the ART process has been unique, in large part because the ART Steering Group is comprised almost entirely of early career scientists.

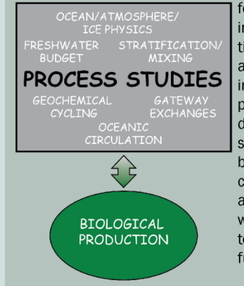
2) Science Goals of the ART Initiative:

The Arctic Ocean is now in a state of rapid transition with tremendous economic, social and environmental consequences. This is best exemplified by the marked reduction in sea-ice cover witnessed in instrumental records over the last 30 years. To further our understanding of the Arctic Ocean system, the ART Initiative is an international, interdisciplinary science program for the Arctic Ocean integrating past, present, and future.

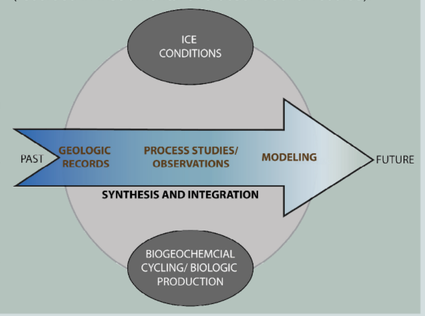
International: An important aspect of ART is to help bridge processes and ecosystem responses over a broad geographic range, including across international boundaries, shelves, margins, and the central Arctic Ocean. All of these regions are experiencing profound physical and biological change in response to recent climate warming.



Integrating Past, Present, and Future: ART focuses on integrating data on past and present transitional states of the Arctic Ocean that can be used synergistically with ongoing monitoring, observing and modeling efforts, to better assess future changes. Specific aims are to develop process oriented perspectives on sea-ice variability and biological productivity that merge knowledge on centennial through millennial timescales (acquired from geologic records) with decadal through seasonal variations (recorded in instrumental and observational records).



Interdisciplinary: Inabilities to predict the response of sea-ice cover in the Arctic arise from uncertainties in complex feedback processes, forcing mechanisms and initial boundary conditions of the ice-ocean-atmosphere system. The interdisciplinary approach of ART focuses on developing links between sea ice and its physical, biological, and geochemical feedback processes and forcing mechanisms, which provides a means to improve forecasts of future sea-ice conditions.



4) Key ART Scientific Questions:

Three major ART scientific questions (and multiple sub-questions) have emerged, centered around (i) sea ice variability; (ii) land-ocean interactions; and (iii) ecosystem responses. These major questions will guide the overall direction of the ART Science and Implementation Plan.

I. How were past transitions in sea ice connected to energy flows, carbon cycling, biological diversity and productivity, and how do these compare to present and projected shifts?
- *(a) How can the calibration of proxy data from marine sediments be improved through coupling with sea ice models and direct observations?*
- *(b) What were the principal forcing mechanisms responsible for regional variations in sea ice cover and biological productivity during past environmental transitions?*
- *(c) How do patterns of sea ice reduction forced by elevated greenhouse gas concentrations differ from those driven by changes in solar forcing?*
- *(d) To what extent are transitions in sea ice affecting Arctic Ocean habitats by impacting the size of the seasonal ice zone, increasing light availability and ocean temperature, and altering regional patterns of stratification and nutrient entrainment?*

II. How will biogeochemical cycling in the Arctic Ocean respond to transitions in terrestrial, gateway and shelf-basin exchanges?
- *(a) How will a modified hydrological cycle and changes in coastal physical conditions affect the delivery and transport pathways of fresh water and particulate and dissolved materials across the terrestrial-marine interface?*
- *(b) How does the transition to a warmer climate affect the lateral and vertical distribution of water masses in the Arctic Ocean and what is the potential impact on the ecosystems of continental shelves?*
- *(c) How is the shelf-basin exchange of heat, salt and matter (particulate and dissolved) affected by ongoing alterations of the Arctic environment?*

III. How do Arctic Ocean organisms and ecosystems respond to changes in temperature, vertical stratification, seasonal ice zones, and pH associated with current environmental transitions?
- *(a) Are there regional differences in how primary production is responding to changes in physical drivers across the Arctic?*
- *(b) What are the tolerance limits of key organisms and how do changes in environmental conditions affect the composition and structure of Arctic food webs, and what are the consequences for productivity and harvestable resources?*
- *(c) Is the relative impact from pelagic consumers on primary production and biogeochemical cycling different among Arctic regions and how will environmental transitions affect the timing and spatial variability of pelagic-benthic interactions?*
- *(d) How can changes in distribution and abundance of higher trophic level species and increased human presence in the Arctic induce trophic cascades in the ecosystems?*
- *(e) How will changes in the functioning of food webs impact net heterotrophic/autotrophic processes and will they shift the source/sink potential for atmospheric CO_2 in the Arctic?*

3) ART Initiation Workshop in Fairbanks, Alaska (7-9 November 2009):

The first ART workshop was held at the International Arctic Research Center (IARC) in Fairbanks, Alaska in November 2009 with 58 participants from 9 countries. Over half of the participants were early career scientists or students. The workshop began with six keynote speakers from various disciplines:

*(1) **Large Scale Processes and Changes in the Ecosystem:** Paul Wassmann (University of Tromsø)*
*(2) **Sea Ice:** Hajo Eicken (University of Alaska Fairbanks)*
*(3) **Paleo-oceanography:** Matthias Forwick (University of Tromsø)*
*(4) **Atmosphere:** John Walsh (University of Alaska Fairbanks)*
*(5) **Ocean Circulation and Processes:** Wieslaw Maslowski (Naval Postgraduate School)*
*(6) **Land-Ocean Interface:** Paul Overduin (Alfred Wegener Institute)*

The keynote presentations set the stage for the working group meetings that took place for most of the first and second days. Discussions were centered around three major foci: (i) sea ice variability; (ii) land-ocean interactions; and (iii) ecosystem responses. The final day of the workshop was spent in plenary, where each working group reported to the full workshop on the results of their discussions. In addition, a marine roundtable panel of experts was convened on the final day of the workshop to talk about the specific processes of developing an ART Science and Implementation Plan.

The ART workshop was sponsored by the US National Science Foundation, AOSB/IASC, the International Arctic Research Center, the Research Council of Norway, the Department of Fisheries and Oceans Canada, the Association of Polar Early Career Scientists, and IFM-GEOMAR. Special thanks to Sara Bowden (AOSB) for her support with the ART process.

5) ART Science and Implementation Plan:

The goal of the forthcoming ART Science and Implementation Plan is to integrate, update, and develop priorities for Arctic Marine Science over the next decade. More specifically, our focus within the ART Initiative is to bridge gaps in knowledge not only across disciplinary boundaries (e.g., biology, geochemistry, geology, meteorology, physical oceanography), but also across geographic (e.g., international boundaries, shelves, margins, and the central Arctic Ocean) and temporal (e.g., paleo/geologic records, current process observations, and future modeling studies) boundaries as well. The approach of the ART Initiative will provide a means to better understand and predict change in the Arctic Ocean system, with a particular focus on the ultimate consequences for biological productivity.

The ART Science Plan is currently in its drafting stages and the ART Steering Group/Writing Team is planning to complete a full draft by April 2010. On April 15, 2010, the ART Science Plan will be presented to the Arctic Ocean Sciences Board (AOSB) at the Arctic Science Summit Week in Nuuk, Greenland. A workshop for the drafting of the Implementation Plan is scheduled for Fall 2010.

For more information and updates regarding the ART Initiative, please visit www.aosb.org/art.html.