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Arctic Seas: Currents of Change, An International Symposium

DAVID J. ST. AUBIN[1]

The International Year of the Ocean (IYO), declared for 1998 by UNESCO and the Intergovernmental Oceanographic Commission (IOC), was a call to the world to examine the state of the planet's oceans, evaluate our collective impact on these critical environments, and take steps to protect them to ensure the quality of life for future generations. While the initiative was successful in rallying the attention of a large segment of the population, interest in the Arctic seas was disproportionately low compared with that in areas with large human coastal populations.

To redress this imbalance, a symposium was held on 21–24 October 1998 in Mystic, Connecticut, USA, convened by the Sea Research Foundation and Mystic Aquarium, to bring attention to the issues, both scientific and sociopolitical, that bear on the status and future of the Arctic Ocean and adjacent waters. The IOC endorsed the symposium as an event in support of the IYO initiative. The papers comprising this special issue of *Arctic* represent some of the scientific program presented over those three days.

Contributors were challenged to present their information in the context of changing conditions that are at the forefront of our thinking. Views on global climate change reported almost daily by the media typically focus on more southerly latitudes, with the poles seen as distant, unchanging fixtures on the stage. However, the constancy of the Arctic seas exists only in the minds of those unfamiliar with their vagaries, both short- and long-term. Frozen seascapes may give the impression of an intransigent environment, but more penetrating examination reveals a dynamic system, one that is shaped by the interaction of a complex set of physical forces that are variable in themselves. As we continue to learn of the basic make-up of the Arctic marine environment, we observe and project changes there that will have important local and global repercussions (Anon., 1999). Some of these changes are slow and inexorable; others show a quickening pace, spurred perhaps by global climatological events, including those accelerated by human activities.

These changes can be viewed at many different levels—and often in isolation from proximate causes or impacts. The Symposium attempted to span a broad range of perspectives, emphasizing the connections among the physical, biological, and sociopolitical facets of these issues. Participants represented the fields of climatology, physical oceanography, archaeology, marine biology, toxicology, ecology, and social anthropology, a novel blend that reflected the complexity and interrelationship of the questions under consideration. The multidisciplinary approach prompted constructive exchanges among participants and may help foster unanticipated collaborations that will advance our collective understanding of this environment.

The program consisted of five thematic sessions: Climate, Ice, and Ocean; Productivity; Ecology of Marine Mammals; Contaminants; and Human Resources and Development. The thematic undercurrent linking these topics was the examination of changing conditions in the Arctic seas. Change in itself is not necessarily alarming. It shapes the diversity of life on this planet and gives us insight into the balance of natural processes. But what can we predict about the consequences of the changes we are observing? Are the changes due to human presence and activity, local or more distant? And are their consequences something that we must attempt to redress?

G.L. Holland, Chair of the IOC, opened the conference by emphasizing the global and strategic importance of the Arctic Ocean, which has access to two major oceans and separates two continents, while bridging Eastern and Western societies. Warming trends can only lead to further exploitation of this region and increased competition for strategic advantages there. In the past, political conditions restricted international collaborations in Arctic marine science, and much of the effort supporting military objectives was classified. The warming political climate comes at an opportune time for research, though limited economic resources in Russia will constrain the level of such activity, at least in the near term. Efforts to foster regional cooperation in Arctic research date back to 1879, when the International Polar Commission was founded, but have been at the mercy of fluctuating governmental support throughout the last century. More recently, issues of

[1] Mystic Aquarium, 55 Coogan Boulevard, Mystic, Connecticut. 06355-1997, U.S.A.; dstaubin@mysticaquarium.org

international Arctic research have been addressed by nongovernmental organizations such as the Arctic Ocean Science Board (1984), the International Arctic Science Committee (1990), and the European Polar Board (1995). Despite the existence of these international agencies and the many national polar programs within the member countries, the database on the Arctic Ocean and associated waters remains small. Critical gaps exist, challenging those who would model the changing conditions that lie ahead.

A century after Nansen began his historic scientific expedition on board the *Fram*, the SCICEX cruise of the SSN *Pargo* revealed the shifting boundary between eastern and western halocline types in the Arctic and attendant changes in the temperature and thickness of the various water masses (Morison et al., 2000). Building on this and other cruises earlier in the decade was the recently completed SHEBA/JOIS project (Surface Heat Budget in the Arctic, and Joint Ocean Ice Studies), involving a multinational team of over 100 researchers on a tandem of Canadian icebreakers, one of which overwintered in the Beaufort Sea (Welch, 1998; Perovich et al., 1999). D. Perovich, Chief Scientist for SHEBA, and F. McLaughlin, one of the Chief Scientists for JOIS, reported that the warm winter of 1997–98 followed by the long summer of 1998 returned a surprising set of climatological and oceanographic data that continue to be examined. Preliminary analysis of findings presented by C. Ashjian, Woods Hole Oceanographic Institution, revealed unexpectedly high productivity in the Beaufort Sea, a possible consequence of the warmer conditions. At the same time, it was emphasized that while some Arctic regions are warmer, others have cooled (Overpeck et al., 1997), making generalizations across the Arctic tenuous at best. Productivity in the Bering Sea may in fact have declined over the past 30 years, judging from stable isotope ratios in tissues such as baleen, from which a longitudinal nutritional record can be gleaned (Schell, 2000).

Mapping the distribution of ice, as an index of past and present conditions, is an important prerequisite for developing models of future developments in ice cover. The multidisciplinary symposium presented a unique opportunity to contrast strikingly different approaches to this task. With the advent and refinement of sophisticated satellite-based sensors, detailed maps are possible, and have allowed analysis of an 18-year record of Arctic sea ice variability (Parkinson, 1992, 2000). Nevertheless, the time scale of more enduring trends in climate is much greater, necessitating the use of historical and proxy records to evaluate these longer-term developments. Fishing records in Iceland span four centuries and clearly note when unusual incursions of ice occurred along the south coast (Ogilvie and Jónsdóttir, 2000). Examining the archaeological record, Woollett et al. (2000) and Sophia Perdikaris, City University of New York, demonstrated how evidence of human fishing and hunting practices might allow speculation on prey availability and, by inference, climatological conditions. Savelle et al.'s (2000) analysis of stranded remains of bowhead whales in the Canadian Arctic Archipelago reaches even further back in time to describe a pattern of ice distribution over a 10 000-year span. These records serve as a reminder of the dynamic state of this environment and underscore the difficulty in interpreting highly variable interannual changes in parameters such as ice drift, as discussed at the symposium by I. Appel, Raytheon Co. The greatest challenge is to distinguish between anomalies and trends.

The albedo feedback effect (Rind et al., 1995; Washington and Meehl, 1996) and the thermohaline loop (Aagaard and Carmack, 1989) feature prominently in models of global climate change and recognize the important role played by Arctic seas. A major objective of the SHEBA and JOIS projects was to fill important gaps in our data necessary to develop climatic models. Though the advantages of remote sensing equipment are undeniable, projects such as these underscore the need for dedicated field studies to obtain samples and conduct experiments not readily performed in any other way. It continues to be apparent how much there is to learn of the physical (Macdonald, 2000) and biological (Chiperzak et al., 1995) characteristics of the Arctic seas.

In the first half of the 20th century, the Arctic warmed 1.2 ºC, more than did the entire Northern Hemisphere. Though some areas have recently cooled, this trend has had important regional implications, accelerating melting of the Arctic pack and permafrost. Presently, the most dramatic changes are being observed in the Siberian Arctic (Parkinson, 2000). Increased discharges from major rivers there have increased the number of open-water days, culminating in September 1995 with the absence of ice along the entire Russian coast. Enhanced access to the Northeast Passage may be good for commerce and development (Brigham, 1997), but it has important implications for marine life exposed to noise, disturbance, and an increased risk of maritime accidents.

In addition to its influence on ice and oceanic stratification, river outflow is responsible for transporting a growing load of dissolved organic matter released from thawing permafrost. The observation that this material may protect aquatic organisms from harmful UV radiation penetrating an increasingly discontinuous polar ozone layer is small compensation for the profound effects that increased runoff will have on the character of the Arctic basins (Gibson et al., 2000). Already an avenue for delivering contaminants, river outflow will potentially increase its burden with the expansion of poorly regulated development in warming northern territories.

Warming trends have important implications for Arctic marine life. The aforementioned increases in productivity will pulse through the food chain, perhaps to the benefit of top-level predators such as seals, whales, and polar bears. Yet the outcome of warming trends may not necessarily be favorable to these organisms (Tynan and DeMaster, 1997). Ice represents an essential hunting platform for polar bears, and long-term studies in Hudson Bay have shown how the timing of polar bear movements to shore in spring relates to breakup (Stirling et al., 1999). The condition and survival of ringed seal pups are adversely affected by unstable ice conditions in their breeding habitat (Harwood et al., 2000). Migration behavior and distribution of beluga, gray, and bowhead whales are correlated with ice conditions at specific times of the year, and preferences for certain habitat types could lead to displacement from current migration corridors (Moore, 2000; Moore et al., 2000). For bowheads and others exploiting patchily distributed food resources, shifting winds and currents could force changes in established patterns of habitat use (Finley et al., 1999). While Arctic marine mammals have contended with drastic changes in their habitat over millennial time scales, the concern is that the current rate of change is faster than ever, and may outstrip the animals' ability to adapt. Season-long climatic perturbations such as El Niño have shown their devastating effects on marine life, and D. Schell (University of Alaska) has speculated, on the basis of trends in stable isotope enrichment, that decreased productivity in the Bering Sea may have contributed to the precipitous decline in the population of Steller sea lions.

Sea ice distribution also plays an important role in the ecology of a number of species of marine birds (Hunt, 1991). Some have rather specialized reproductive and ecological strategies and lack the flexibility to quickly adapt to changing conditions. Those that rely on productive waters close to suitable nesting habitat may have diminished reproductive success if foraging trips take adults too far from their nests. Terns and auks are already in decline. They may not withstand the combined effects of climatic change and the increased environmental contamination from industrialization and maritime traffic accidents.

The Arctic has been recognized for some time as a sink for contaminants transported from remote industrial, agricultural, and urban sources by atmospheric processes (Wania and Mackay, 1993). The accumulating burden of pollutants, coupled with the cavalier attitude of many nations in using the Arctic to dispose of chemical and radionuclide wastes, will tarnish the pristine aura of the Arctic for decades, if not longer (MacDonald et al., 2000). Entrapment in ice and sediments represents a mechanism for redistribution of radioactive contaminants (Dethleff et al., 1998; Landa et al., 1998; Valette-Silver et al., 1999). Careful monitoring of organochlorine concentrations in marine biota has revealed downward trends in some constituents, such as the DDT group and some PCB congeners, but not in others, e.g., chlordanes and nonachlor (Addison and Smith, 1998). To date, there has been little focus on endocrine disrupters, though some recent findings in polar bears hint at their occurrence in, and possible impact on, Arctic species (Wiig et al., 1998). Health-related concerns associated with tissue burdens of contaminants extend to the indigenous human population subsisting on Arctic wildlife (Inkret et al., in press). National boards of health have been forced to address questions of food safety, balanced against the inadequacy of substitutes and the cultural importance of maintaining traditional lifestyles and customs.

The face of the Arctic is also changing in response to increasing development, resource exploitation, and recreational use by ecotourists. Some areas need complete protection, while in others managed development is the key (Pagnan, 2000). In the past, protection has come at a price for some, as when the Hoonah Tlingit people of Alaska were displaced with the designation of Glacier Bay as a National Monument (J. Snyder, University of Denver). Indigenous people are not likely to be subjected to such extreme measures in areas where they now have greater autonomy and jurisdiction over land use, such as in the newly formed Canadian territory of Nunavut. Still, Native society, which is already under considerable pressure to adapt to socioeconomic forces, may also have to contend with climatological events that represent a further challenge to the maintenance of a traditional lifestyle. "Voices of the Bay," a compilation of aboriginal perspectives,

reflects the enhanced sensitivity of Inuit and Cree to the changing conditions in Hudson Bay (Fleming et al., 1997).

THE FUTURE

As distant as they might be from most of the Northern Hemisphere's population, the Arctic seas cannot be viewed as disconnected from global processes. Climate change in either region affects conditions in the other; industrial activity here produces chemicals that are transported far to the north; and migrations of birds and sea mammals provide biological connections as well. Northern development is financed and stimulated by commercial interests in the south, largely aimed at the recovery of natural resources that are needed by southern society. More and more southern ecotourists are finding their way northward to experience the wildlife and landscape firsthand.

It is critical that research efforts continue so that better decisions can be made about the future of this environment. Governments need to be reminded of the need to fund Arctic research, particularly long-term projects, and to heed the messages that are brought home. Industry and commerce must be guided to tap the richness of the Arctic without damaging sensitive resources. It is our responsibility to use the knowledge that we have about the Arctic seas to promote awareness among those whose actions may determine the direction of change.

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