XI-29 Arctic Ocean: LME #64

I. Belkin, M.C. Aquarone and S. Adams

The Arctic Ocean LME is centred on the North Pole and is bordered by the landmasses of Eurasia, North America and Greenland, or more precisely, by the LMEs adjacent to these landmasses (except for the Canadian Arctic Archipelago, see Figure XI-29.1). It covers over 6 million km^2, of which 2% is protected, and contains 0.2% of the world's sea mounts (Sea Around Us 2007). Three prominent ridges (Alpha Mendeleev Ridge, Lomonossov Ridge and Gakkel Ridge) divide the Arctic basin into four sub-basins. The LME lies within the domain of the North Atlantic Oscillation. It has a perennial ice cover that extends seasonally between 60° N and 75° N latitude. Ice cover reduces energy exchange with the atmosphere, which results in reduced precipitation and cold temperatures. The LME is subject to rapid climate change with the ice cover shrinking in thickness and extent. The National Aeronautics and Space Administration (NASA) reported on 13 September 2006 that, in 2005-2006, the winter ice maximum was about 6% smaller than the average amount over the past 26 years (NASA 2006). The sea ice extent in September 2007 was about 20-25% below the long-term mean. Additional reports pertaining to the Arctic Ocean LME are found in UNEP (2004,2005).

I. Productivity

The continental shelf is 100-200 km wide north of Alaska. In Siberia, it can extend to over 1,600 km in some areas. In winter, the ice pack more than doubles in size, extending to the encircling landmasses. Water masses typically circulate cyclonically but the circulation patterns are complex and variable. For more information concerning the movement of sea ice in this LME, see NASA (1992). NOAA's State of the Arctic Report is available in PDF format at www.pmel.noaa.gov/. Low temperatures, ice cover and extreme seasonal variations in light conditions are some of the physical characteristics that slow down biological processes, limit the productivity of Arctic ecosystems and make them more vulnerable to contaminants.

The Arctic Ocean primary production strongly depends on the ocean's sea ice cover (SIC). Over the last decade, the Arctic SIC extent and thickness decreased dramatically. The SIC area in 2007 and 2008 was 20-25% smaller than ever before. As the SIC shrinks, the open water area (OWA) increases, accompanied by increase in primary production. Since 1998, the Arctic OWA has increased at the rate of 0.07 × 10^6 km^2 year^{-1}, resulting in elevated rates of annual primary production in most recent years, with a 9-year peak in 2006 and the average pan-Arctic primary production of 419 ± 33 Tg C a^{-1} in 1998–2006 (Pabi et al., 2008). The observed interannual variability of the SIC is believed to be a major factor explaining year-to-year differences in primary production, whereas SST changes (related to the Arctic Oscillation) and incident irradiance are considered to be minor factors (Pabi et al., 2008). The total production for the deep central Arctic Ocean is estimated to exceed 50 Tg C a^{-1} (Sakshaug, 2003).

According to Bluhm and Gradinger (2008), the seven core marine mammals of the Arctic are: bowhead whale (*Balaena mysticetus*), beluga (belukha) whale (*Delphinapterus leucas*), narwhal (*Monodon monoceros*), walrus (*Odobenus rosmarus*), bearded seal (*Erignathus barbatus*), ringed seal (*Phoca hispida*), and polar bear (*Ursus maritimus*) Fish fauna is not well studied partly because of the lack of commercial fishery. Among 60 fish species found in the Russian sector of the Arctic are Arctic cisco, European cisco, muksun (*Coregonus muksun*), Atlantic whitefish (*Coregonus huntsmani*), Arctic char, navaga (*Eleginus nawaga*) and sheefish (*Stenodus leucichthys*). Arctic cod are the main consumers of plankton in the Arctic seas. A bathymetric map is available at www.ngdc.noaa.gov/

Oceanic Fronts (Belkin et al. 2009)(Figure XI-29.1): Observations of fronts in the open Arctic Ocean are hampered by perennial ice cover that prevents satellite remote sensing of fronts in the Arctic Basin. Hydrographic surface and subsurface data collected from surface vessels, ice drifting stations and submarine revealed a major front in the central Arctic that separates Atlantic waters from Pacific waters. Until the mid-1990s, this front was located over the Lomonosov Ridge (LRF). Observations from the late 1990s and early 2000s have documented a major shift of this front that occurred around 1995. Since then, the front ran along Mendeleyev-Alpha Ridge (MARF). It is unclear yet if the front will shift back in the future and if such shifts occurred in the past. In the Nordic Seas, the water-mass Arctic Front (AF) separates the Greenland and Norwegian Seas, while the East Greenland Current Front (EGCF) is a shelf-slope front.

Figure XI-29.1. Fronts of the Arctic Ocean LME. Acronyms: AF, Arctic Front; LRF, Lomonosov Ridge Front; MARF, Mendeleyev-Alpha Ridge Front. Yellow line, LME boundary. After Belkin et al. (2009).

Arctic Ocean LME, Sea Surface Temperature:
Linear SST trend since 1957: NA°C.
Linear SST trend since 1982: NA°C.

This LME has been excluded from the analysis (after Belkin, 2009) since it is covered by sea ice almost year round, therefore SST data are deemed severely contaminated by the sea ice presence.

II. Fish and Fisheries

The Arctic Ocean LME, along with its surrounding LMEs is unique in that the melting and freezing of ice creates rich habitats close to the sunlit surface. The wide continental shelves provide large shallow areas, where freshwater from north-flowing rivers creates estuarine conditions. There is a limited number of true Arctic species of commercial importance. Arctic charr (*Salvelinus alpinus*) occurs throughout the Canadian Arctic, and have been sighted farther north than any other fish species. In the summer, many stocks of Arctic charr migrate to the sea, where they have a larger resource base to exploit and thus are able to grow faster. While at sea, they feed on crustaceans and small fish. Before winter, these migrants return to the rivers and lakes. Under extreme winter conditions, they hardly feed at all. Sea mammals abound and are still exploited. However, the Arctic LME does include waters seasonally ice-free and regularly commercially fished, both in the Northwest Atlantic (including Davis Strait and Baffin Bay) and in the Northeast Atlantic (waters north of Iceland and towards Svalbard). Thus, reported landings in the Arctic Sea LME (Figure XI-29.2) are dominated by catches taken in the Atlantic waters. These reported landings show a series of peaks and troughs (Figure XI-29.2). From the 1950s to early 1970s, the catch was dominated by ocean perch and thereafter by capelin. The highest catch of about half a million tonnes, consisting mainly of capelin, was obtained in 1996.

Only scattered reports are available for the coastal areas around the Arctic Archipelago off the coastline of Canada bordering the Arctic Sea LME. This coastal region of the Arctic Ocean has provisionally been designated as LME 65 (PAME 2007) in Figure XI-29.1. Booth & Watts (2007) have verified the catches from these areas, as reported by the Canadian Department of Fisheries and Oceans, from the bottom up, i.e., based on the size of the human populations in coastal communities, and their seafood consumption patterns. The resultant estimates of catches, which peaked at over 2,500 t in 1960 (driven by feed requirements for sled-dogs subsequently replaced by the snowmobile as the major form of transport) before declining to around 600-700 t per year in recent years, are small compared to the reported landings for the current Arctic LME. Nevertheless, these catches are significant in terms of true arctic fisheries, and will form the predominant catches for the anticipated new Arctic Archipelago LME. These data for the new Arctic Archipelago LME can be found at www.seaaroundus.org.

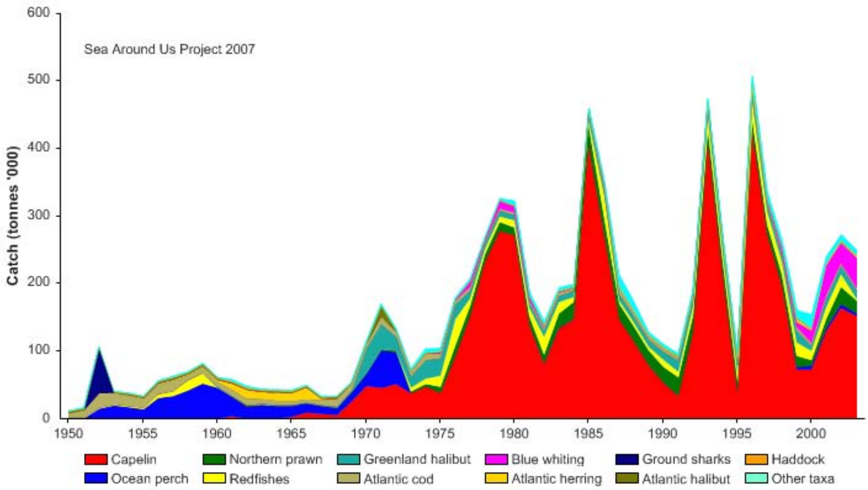

Figure XI-29.2. Total reported landings in the Arctic Ocean LME by species (Sea Around Us 2007).

III. Pollution and Ecosystem Health

Being away from immediate sources of pollution and shipping and fishing activities, the Arctic Ocean LME is relatively clean and has intact or slightly disturbed ecosystems (Lystsov 2006).

The Arctic Ocean is a sink for global pollution because of the flow of oceanic and atmospheric currents. It is a fragile ecosystem threatened by land-based sources of pollution, particularly POPs and heavy metals (Lystsov 2006), shipping, dumping and the exploitation of offshore hydrocarbon. The Alfred Wegener Institute for Polar and Marine Research observed in 2006, the highest air pollution on record since measurements began in 1991. The orange-brown ‘Arctic Haze’ over the west coast of Svalbard contained up to fifty micrograms aerosol per cubic metre air in Ny-Alesund—values usually measured during rush hour in cities and 2.5 times the concentrations measured there in spring 2000. Increased warming is expected and climatic variability has already had a significant impact on this LME (AWI 2006). A State of the Arctic Environment Report is available at www.amap.no /assess/soaer-cn.htm. Ocean currents transport contaminants into the Arctic Ocean. The main inflow of water is via the Norwegian Current into the Barents and Kara seas, and via the West Spitsbergen Current through Fram Strait into the Arctic Ocean. Persistent contaminants bioaccumulate in plants and animals and their food webs. Fat, or the ability to gather and store energy as a means of survival during the dark and cold winter, plays an important role in animal metabolism in the Arctic. Fat increases biomagnification of fat-soluble contaminants, which is accentuated in many Arctic animals by their long lives. Airborne pollutants can be deposited on sea ice, which then melts and releases its pollutant load to the ocean surface waters (see Pfirman *et al*. 1995 and 1999). Arctic deep water has an extremely long residence time. Part of the legacy of the Cold War is environmental contamination, mostly from nuclear tests at Novaya Zemlya but also from nuclear processing plants such as Windscale/Sellafield, with chemical and radioactive contaminants (such as iodine, caesium, plutonium and other radioactive isotopes) working their way into the Arctic food chain. People who rely on marine systems for food resources are at risk.

Endangered marine species include walruses and whales. Fragile Arctic ecosystems are slow to change and slow to recover from disruptions or a thinning polar icepack. On 15 May 2006 the *Guardian* reported record amounts of the Arctic ocean failed to freeze during the recent winter, and that the sea ice reached an all-time low in March, down some 300,000 square kilometres from 2005 and said that if the cycle continues, the recovery of ice in winter will no longer be sufficient to compensate for increased melting in the summer. The low-lying Arctic coasts of western Canada are particularly sensitive to sea-level rise. Coastal erosion and retreat as a result of the thawing of ice-rich permafrost are threatening communities, heritage sites, and oil and gas facilities.

IV. Socioeconomic Conditions

The Arctic Circle of 80° N Latitude encompasses parts of Sweden, Finland, Greenland, Canada, Russia, the USA (Alaska), the Sverdrup Islands and the Svalbard (Spitsbergen, Norway). Human settlement consists of small communities, nomadic groups of indigenous people, and larger communities residing around a harbour, a factory or a mineral resource. The Arctic coastal areas are among the most sparsely populated in the world. The region is facing huge socioeconomic challenges and change. All communities are dependent on the natural resources of this remote and harsh region. Hunting and fishing are traditional sources of livelihood. In former times, fur seals and whales were the object of a major trade. Indigenous groups number 1.5 million out of a total Arctic population of 10 million. These indigenous groups have shown resilience and an ability to survive changes in resource availability, but may be less well equipped to cope with the combined impacts of climate change and globalisation. Ice and fish are critical to the traditional lifestyle of the indigenous populations. As Achim Steiner, Executive Director of the UN Environment Programme (UNEP), recently said: “The costs of climate change are already being paid by the peoples and communities of the Arctic” (Science Daily, April 11, 2007).

The Arctic economy is a mixture of formal economies (commercial harvesting of fish, oil and natural gas and mineral extraction, forestry, and tourism) and informal subsistence economies (the harvesting of natural renewable resources such as seals and whales, with seals, for instance, providing food, heat, light and clothing). Increasingly, the overall economy is tied to distant markets. For example, in Alaska, gross income from tourism is US$1.4 billion. Technological advances and climatic change threaten the tradition of utilising the environment and its renewable resources for survival. The subsistence economy enters into conflict with the expanded use of natural resources such as oil, gas, metals and minerals. The growth of tourism will lead to new and more frequently used navigation routes.

V. Governance

Sweden, Finland, Greenland, Canada, Russia, the U.S. (Alaska), and Norway (Svalbard-Spitsbergen) border the Arctic Ocean LME. Russia has the longest coastline, encompassing five adjacent LMEs (Barents, Kara, Laptev, East Siberian and Chukchi Sea LMEs). Regional governance is important because of the unique character of this LME. While the Arctic is made up of several large seas, it is essentially a semi-enclosed ocean shared by the surrounding countries. The fragility of the Arctic Ocean calls for reinforced efforts among neighbouring states. The Arctic Region has an independent Regional Seas Programme that has not been established under UNEP, although it participates in the global meetings of the Regional Seas, shares experiences and exchanges policy advice and support to the developing Regional Seas Programmes.

In 1991, the Arctic countries adopted an Arctic Environmental Protection Strategy. In 1996, the Arctic Foreign Ministers agreed to the Ottawa Declaration. The Arctic Council was founded as an intergovernmental forum for cooperation among national governments and six Arctic indigenous organisations. In 2000, the Council agreed on a strategic framework for sustainable development and its economic, social and cultural aspects. The Arctic Monitoring and Assessment Programme (AMAP) presented a comprehensive report on the state of the Arctic environment in 1998 (www.amap.no/). The Programme for the Conservation of Arctic Flora and Fauna has finalised an overview report on biodiversity and conservation in the Arctic, including its marine areas. The Arctic Council is also engaged in work aimed at enhancing environmental safety in connection with the transportation of oil and gas. An expert group on Emergency, Prevention, Preparedness and Response (EPPR) has prepared a circumpolar map of resources at risk from oil spills in the Arctic. Also a Working Group of the Arctic Council, the Protection of the Arctic Marine Environment (PAME) has prepared a regional action plan for the control of land-based sources of Arctic marine pollution. Climate variability and change will pose challenges to the future prospects of humans and of nature in the Arctic. To help address these challenges, the Arctic Council has adopted a new project on Climate Impact Assessment in the Arctic (ACIA).

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