THE ARCTIC OCEAN: TOWARDS A SYNTHESIS

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The North Atlantic and the Nordic Seas are, together with the Southern Ocean, parts of the global thermohaline circulation. Of the Gulf Stream, which on average represents a flux of 37 Sv where it leaves North America, about 22 Sv, known as the North Atlantic Current, flows northeast[1]. This current splits south of Iceland, forming one branch of 12 Sv that flows towards the Labrador Sea and another branch of 10 Sv (the Norwegian Atlantic Current), which flows into the Nordic Seas. Of the latter, an average of 3.3 Sv reaches the North Polar Basin, mainly via the Barents Sea. Although most of this water returns along the transpolar course, a small fraction may reach the Chukchi and Beaufort Seas[2-5]. The Bering Strait and Canadian and Siberian rivers furnish about 1 Sv[6,7].

On average, 11 Sv of cold water flows out of the Nordic Seas and into the North Atlantic; of this the East Greenland surface current represents about 4 Sv, the rest is North Atlantic Deep Water[8] (NADW). The 7 Sv of NADW consists of deep water leaving the North Polar Basin and water formed by deep convection in the Greenland Sea[9,10].

In addition, the Labrador Sea produces on average 11 Sv of intermediate Labrador Sea Water[11] (LSW). Most of this water spreads northwards and eastwards; the fraction that reaches as far as Bermuda may need about 10 years to reach west of Ireland. While on its way, LSW is brought to the surface every winter, leaving a temperature imprint on the surface water and the atmosphere (the "North Atlantic Climate Memory[12]) and thus having a regional climate effect

Average fluxes mask pronounced interannual and seasonal variations. These can be related to the North Atlantic Oscillation[13,14] (NAO, or its circumpolar sibling, the Arctic Oscillation, AO).

When the NAO index (usually given as the normalized pressure difference between Lisbon and Iceland) is strongly positive, the northern jet stream and its associated storm track have a northern course which generate a narrow but fast Norwegian Atlantic Current which efficiently reaches the eastern half of the North Polar Basin. This causes large-scale melting of sea ice[15]. The winds also force Polar water, including the Siberian river plumes, towards the Bering Strait, raising the sealevel there. This, and a high incidence of intense "Aleutian Lows" for a positive AO index diminishes the transport of Bering Sea Water into the North Polar Basin.

When the NAO index is positive, the cold low-salinity water that flows south through the Fram Strait is forced by the winds towards the Norwegian Sea while the export of this water to the Labrador Sea is diminished. Thus the Arctic Front is shifted eastwards. The low-salinity layer strongly reduces deep-water formation in the Greenland Sea whereas deep-water formation in the Labrador Sea is intensified due to the low incidence of this water and cooling due to high evaporation along the storm track.

During a strongly negative NAO index, the storm track has a southerly course and the Norwegian Atlantic Current is broad and slow, resulting in little transport into the North Polar Basin. Siberian river water occupies the area from the Laptev Sea to the Kara Sea. The sea level near the

Bering Strait is low and the "Aleutian Low" is likely to be weak, thus the flow of Pacific water through the Bering Strit is large. A high-pressure keeps the low-salinity water away from the area of deep convection in the Greenland Sea, causing efficient production of deep water. The production of LSW, however, is small because of large export of low-salinity water from the Greenland Sea to the Labrador Sea.

Also the volume of multiyear sea-ice is closely related to NAO. In periods of positive NAO index, melting and export of sea ice proceed at high rates[16]. In periods with negative NAO index, the high incidence of freshwater and the low incidence of Atlantic Water along the Laptev and Kara shelves promote production of sea ice while little is exported through the Fram Strait, thus there is an ice build-up in the Nrth Polar Basin.

In spite of large interannual NAO variations, the export of NADW varies relatively little, small production in the Greenland Sea may be accompanied by high production in the North Polar Basin (positive NAO index) and vice versa. Moreover, the northward transport of Atlantic Water varies little except fpr the Irminger Current between Greenland and Iceland. Thus a positive NAO index above all is characterized by enhanced circulation inside the Nordic Seas and the North Polar Basin. Because of the circulation pattern, temperature anomalies in the Barents Sea can be traced in the Labrador Sea about 8 years later[17]. Thus successful recruitment of capelin and cod stocks, which is reated to warm anomalies, tend to occur in different periods east and west of the Arctic Front.

The NAO index seems to form 3-5 year groups of similar index; moreover, the 11-year solar cycle is evident both in SST and, above all, in the volume of Polar Basin sea ice and its rate of export. There is also a 65-year cycle which may be associated with major shifts in commercial fisheries[18]. A long-term trend is also evident in the Polar Basin sea-ice volume, at present being 27 million km^3, as in the mid 1950s, whereas it reached peaks of about 33 million km^3 in 1966, 1976 and 1987[19].

The NAO winter index has shown no trend for the last 200 years, but in the past 50 years the summer index has become increasingly negative (Cook et al. 1997). Both in the Bering and Barents Seas, the 18-year Saros cycle is evident[20].

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