OXYGEN, NUTRIENT, AND SALINITY ANALYSES IN THE EASTERN ARCTIC OCEAN

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LONG TERM GOALS

The long-term research goals are to examine and understand the interactions of the high-latitude oceans with the other oceans, especially with regard to the formation and circulation of the intermediate and deep waters and the propagation into the oceans of the effects of environmental fluctuations.

OBJECTIVES

The objectives of this program are to acquire and analyze data to study the origin and circulation of the intermediate and deep waters of the Arctic Ocean and nearby seas. Goals include determining the surface-to-bottom distributions and sources of the physical and chemical characteristics In this case dissolved oxygen in particular), the location, origin, and structure of subsurface boundary currents, and to contribute to studies of the response of the regimes to environmental forcing.

APPROACH

The measurement phase of this program was built around multi-basin sections of surface-to-bottom CTD/hydrographic profiles with horizontal and vertical resolution, data breadth and quality similar to those of the WOCE Hydrographic Program, in this case beginning across the mouth of the St. Anna and Voronin Troughs in the northern Kara Sea, then heading across the eastern ends of the Nansen and Amundsen Basins, across Lomonosov Ridge to the Makarov Basin, and finally with short sections across the Lomonosov Ridge and the Siberian continental shelves flanking both sides of the Lomonosov Ridge. This program funded CTD, salinity, and oxygen measurements at 104 stations by technicians from the Scripps Oceanographic Data Facility (ODF). CTD work was carried out in close collaboration with Robin Muench and Ursula Schauer. The data analyses extend, test, and refine earlier conceptual models of the thermohaline circulation of the Arctic domains using the new data as well as other recent reference-quality surface-to-bottom CTD, hydrographic, and tracer data.

ACCOMPLISHMENTS

Data from the PFS *Polarstern* ARK XII cruise at the end of FY96 have been distributed to co-investigators and used in reports and presentations. These are now forming the basis for additional papers and presentations in preparation by Swift, Jones, Muench, Schauer, and other

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co-investigators. These data have been compared to gridded historical data and a manuscript by Swift, Morison, and Muench discussing the differences is in final preparation. A paper discussing sources of upper layer water, including ARK XII data, has been submitted. Several additional manuscripts based my ONR- and NSF-supported Arctic research are in various stages of publication. Final data from earlier cruises are publicly available.

SCIENTIFIC/TECHNICAL RESULTS

Recent results show that the inflow into the Canadian Basin from the Eurasian Basin consists largely of well-ventilated water from above 1500 m with a significant component of shelf water most likely originating in the Barents, Kara, and/or Laptev Seas. There is evidence of this to varying degree at all levels of the Makarov Basin below the halocline, including the deepest waters at the boundaries. The Canada Basin is connected to this ventilation source by the extension of the boundary flow winding along the steep topography of the Mendeleyev Ridge and the Chukchi Plateau where, over complex topography, water properties spread away from the boundary flow . The Chukchi-Mendeleyev boundary region may therefore be a source from which these waters spread into more central regions of the Canadian Basin. In the Canada Basin the Chukchi Sea plays a special additional role in adding cold, high silicate concentration waters to the halocline and perhaps to deeper levels of the water column. The Makarov Basin does not appear directly connected to the high silicate source in the Chukchi Sea.

The Makarov Basin halocline characteristics in 1994 differed substantially from pre-1991 depictions in that the halocline silicate maximum over the central Makarov Basin was essentially absent. This is further evidence of the continuing displacement of the upper (S ˜ 33.1) halocline water from the Chukchi-East Siberian Sea region by water from the Eurasian Basin, as observed by other investigators.

Atlantic layer characteristics in 1994 in the Canadian Basin differed from previous general depictions, particularly in the temperature of the Chukchi-Mendeleyev boundary waters, which were at least 0.2 °C warmer than indicated in the work based on data through the 1970s. This is likely the result of reduced cooling in the Norwegian Sea during winters with a high North Atlantic Oscillation index.

The observation in the Makarov Basin in 1994 of what is probably an eddy or bolus associated with the inflowing water from the Eurasian Basin together with other observations suggests that such features provide a mechanism for transport of anomalous properties into the central Arctic and create property gradients or fronts in both intermediate and deep waters.

The Atlantic and Pacific oceans provide source waters for the Arctic Ocean which can be distinguished by their differing nitrate and phosphate concentration relationships, with Pacific water having higher phosphate concentrations relative to those of nitrate. Using these relationships, one can estimate the amount of Atlantic and Pacific waters as well as the amount of freshwater in the surface layer (top 30 m) of the Arctic Ocean. Deduction of the pathways of Pacific and Atlantic source waters in the surface layer suggests that the flow within the Arctic Ocean surface layer differs substantially from ice drift, especially near the North American and European boundaries of the Polar Basin.

IMPACT FOR SCIENCE

This program supplied reference-quality temperature, salinity, oxygen, and nutrient data (and calculated densities) from a previously unsampled region of the Arctic Ocean. Via the

associated data analyses, we should gain a much-improved understanding of the pathways and time scales associated with the circulation over the Arctic basins.

TRANSITIONS

RELATED PROJECTS

This project continues the study of the water masses and circulation of the Arctic Ocean and nearby seas carried out with NSF and ONR support over several years. This project was jointly (50%) funded with NSF. It is strongly related to ARCSS OAII goals and plans, and to the ONR ANWAP program.

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