INTERNATIONAL 2007–2008 POLAR YEAR

International Polar Day - Polar Oceans

Cooling and sinking processes in polar oceans and circulation of polar waters throughout the global deep ocean exert a powerful control on the Earth's climate. The polar oceans also play very important roles in the global carbon cycle, removing carbon dioxide from the atmosphere through chemical and biological processes. Polar oceans support globally-important fisheries and ice-dependent polar birds and mammals, including polar bears in the Arctic and penguins in the Antarctic. All of these important polar ocean functions have a critical relationship with sea ice; changes in the integrated polar ocean - ice system thus have far-reaching impacts.

A deep cold ocean

Cooling and freezing processes in polar regions produce cold salty water that sinks to become the bottom water of the world's oceans. Through these cooling and sinking processes, and through circulation of the dense waters throughout the deep ocean, the oceans exert a powerful control on the Earth's climate. The cooling and freezing processes extract heat and freshwater from the ocean and leave a colder and, most important, saltier and more dense seawater. In both the Arctic and the Antarctic the total production of deep cold water depends on the temperature and salinity properties of source waters, on freshwater inputs from ice melt or river runoff, and on the timing and intensity of heat transfer from ocean to atmosphere; the actual production may occur sporadically, particularly in coastal polynyas between frozen land and offshore sea ice. Small changes in the volume of the inputs, in the heat or freshwater balances, or in the mixing of the dense cold water with less dense water can affect the formation of bottom water and therefore the global ocean circulation. Pulses in bottom water production, or pulses of freshwater that disrupt bottom water production, in one or both hemispheres, may provide mechanisms for relatively rapid shifts in climate.

Chemical and biological pumps

Approximately one-third of the carbon dioxide emitted by human and natural activities goes into the oceans. Polar oceans play very important roles in this carbon cycle. Carbon dioxide becomes more soluble in colder water, so cold polar water takes CO2 from the atmosphere, carries it downward during the production of bottom water, and transports it slowly through the deep global ocean, forming a chemical CO2 pump. A polar biological pump occurs when ocean phytoplankton grow quickly during the polar summer. These microscopic plants pull CO2 from the atmosphere; a portion of this plant carbon sinks to ocean sediments. The polar biological pump depends strongly on the abundance of major nutrients such as nitrogen and phosphorus, on the availability of essential micronutrients such as iron or zinc, and on the presence or absence of sea ice. Measurements of these nutrients and other chemical tracers provide information about the rates of bottom water production, the routes of deep ocean circulation, and the efficiencies of the chemical and biological pumps. Increasing acidification of the ocean as a consequence of decades of enhanced CO2 uptake may have acute impacts in polar regions. Stimulating the polar biological pump through experiments like artificial fertilization will first require a much better understanding of polar marine ecosystems.

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Polar ocean ecosystems: sea ice to sea floor

The organisms of the polar oceans, from microbes to mammals, have developed a remarkable array of adaptations to very cold water, long seasons of dark alternating with seasons of continuous light and high UV irradiation, and the presence of sea ice. Major components of polar ocean ecosystems, including microbial populations, gelatinous zooplankton, and organisms of the slopes and deep-sea abyssal plains, remain largely unknown; the microbial populations (including protozoans, bacteria, and viruses) undoubtedly play important roles in carbon and nutrient cycling and ecosystem dynamics. The polar oceans support globally-important fisheries and the ice-dependent polar birds and mammals: whales (including beluga and narwhal), seals, walruses and polar bears in the Arctic, penguins in the Antarctic. Many of these species show their highest abundance in marginal ice zones and polynyas; the sea floors under these zones contain a high abundance and rich diversity of organisms. The exquisite physiological and behavioral adaptations of many organisms to subzero water temperatures make them highly sensitive to slight changes in temperature or salinity; other polar organisms have evolved in cold waters around Antarctica and then radiated to other deep cold water regions of the planet. At an ecosystem level, the timing and location of sea ice determines both the growth and abundance of prey organisms and the access and reproductive success of predators. Humans have exploited the polar oceans for commercial purposes for nearly 200 years, with profound impacts on the ecosystems. Recently, global pollutants have accumulated in polar marine ecosystems, particularly in the Arctic and in important local food organisms. We can predict further changes in polar oceanic ecosystems as waters warm, as sub-polar water masses and sub-polar organisms intrude, and as sea ice retreats. The current and traditional knowledge of northern people contributes greatly to our understanding of Arctic marine ecosystems.

Paleoclimate and sea level

Ocean sediments provide long records of ocean circulation and climate. Ocean sediment cores from around the Antarctic and from the central Arctic basins record the initial formation of polar ice sheets, global cycles of glaciation and deglaciation, and the onset and intensity of bottom water formation and deep ocean circulation. Sediments beneath present-day ice shelves and sea ice carry records of the periodic advance and retreat of those systems. Ocean sediments in coastal regions contain important evidence of recent glaciation on adjoining land masses and of past sea levels. Oceanographers monitor present-day sea level in polar regions to understand spatial patterns of long term sea level rise due to ocean warming and melting of land ice and local patterns of coastal erosion.

Tools of polar oceanography

The tools of polar oceanography include: satellites to measure sea height, surface waves, sea ice extent and ocean colour (an indication of oceanic biomass); ship-based, ice-tethered and free drifting sensors for temperature and salinity; ultra-clean automated samplers for ocean trace elements; and advanced data assimilation models. Biologists use powerful genetic and molecular tools to determine the biodiversity and functional capabilities of key groups. To reach difficult areas within and under sea ice, polar oceanographers use acoustically-tracked sub-ice drifters, 'smart' automated gliders, and sensor tags on deep-diving marine mammals; the mammals often forage in interesting regions of high oceanic productivity.

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