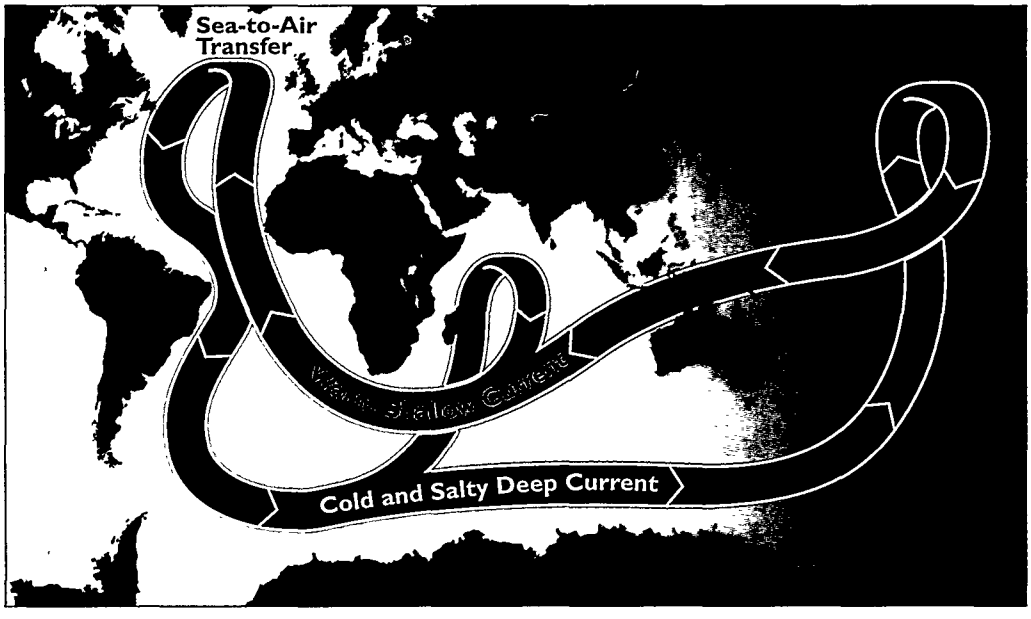
their likely effects on the climate, and to evaluate the resulting biological and economic impacts.

THE DYNAMIC OCEAN

Perhaps even more deeply mysterious than atmospheric dynamics are the workings of the oceans. From the earliest days of atmospheric testing, the AEC sought to understand the fate of radioactive fallout over Pacific waters. But the agency's interest was greatly heightened in 1954, when a Japanese fishing boat and its cargo of fish were contaminated following a Pacific Ocean nuclear test. Suddenly, the sea and its denizens were subjects of intense inquiry. Ensuing AEC support for oceanic research reaped unexpected rewards.

One of the pioneers was Wallace Broecker, of Columbia University's Lamont-Doherty Geological Observatory (now the Lamont-Doherty Earth Observatory). Soon after the 1954 incident, he began using natural and bomb-generated radionuclides as "clocks" to study ocean dynamics. By measuring the ratios of carbon isotopes, for example, he found that, whereas the average CO_2 molecule remains in the atmosphere for seven years, bottom water in the Pacific Ocean turns over only once every thousand years. His analyses of CO_2 absorption by the oceans also provided new data on the fate of atmospheric CO_2 more than a decade before it would become an important climate change issue. Broecker's methods were seminal: Distributions of stable and radioactive isotopes were subsequently used to measure the accumulation rates of deep-sea sediments and to develop the first records of climate change in the past. Broecker also turned to radionuclides as tracers. Using strontium-90 from fallout, for example, he was able to define the Atlantic Ocean "conveyor belt" that operates between Greenland and the equatorial tropics. In 1996, in part for work supported by the AEC, he was awarded the Presidential Medal of Science.

In the seventies, increasing attention turned to the ocean margins. Fallout from past decades was washing into lakes and rivers, then moving downstream into coastal waters. Toxic chemicals followed a similar path. At the same time, nuclear



A GLOBAL CONVEYOR BELT The connectedness of the world's oceans is suggested by this schematic depiction of the "great ocean conveyor." Evaporation in the North Atlantic and transfer of the vapor to the Pacific leaves behind saltier water, which then sinks and drives the cold deep current. The warm surface current has a direct impact on world weather, accounting, for example, for Northern Europe's relatively mild winters. Many of the details of this global conveyor were revealed by early AEC-sponsored research.

1962 Radiotracers were used by Oregon State scientists to show that fecal pellets produced by marine organisms are the major vector for transporting substances from the ocean surface to deep water.

1963 Cecil Leith at Livermore developed one of the first atmospheric general circulation models, providing the foundation for future global change calculations and global weather predictions.

1967 Oak Ridge began a major effort to understand the thermal effects of nuclear power plants. Aquatic ecology programs at Oak Ridge, Hanford, and Savannah River would expand dramatically in the seventies, in response to the National Environmental Policy Act. The research would reveal few adverse effects of thermal discharges into aquatic ecosystems.

1968 Two permanent sites were set aside for long-term ecological research: 120 square miles of sagebrush desert near Richland, Washington, and 100 acres of prairie forest border at Argonne. Field work was inaugurated at both sites.