# Northwest Atlantic Ocean Ecosystems Experiencing Large Climate-Related Changes

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[ 摘要 ] February 22, 2007. Ecosystems along the continental shelf waters of the Northwest Atlantic Ocean--from the Labrador Sea south of Greenland all the way to North Carolina--are experiencing large, rapid changes, report oceanographers funded by the National Science Foundation (NSF) in the Feb. 23, 2007, issue of the journal Science.
[ 关键词 ] Ecosystems;phytoplankton;biological oceanography

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are experiencing large, rapid changes, report oceanographers funded by the National Science Foundation (NSF) in the Feb. 23, 2007, issue of the journal Science.

While some scientists have pointed to the decline of cod from overfishing as the main reason for the shifting ecosystems, the paper emphasizes that climate change is also playing a big role.

"It is becoming increasingly clear that Northwest Atlantic ecosystems are being affected by climate forcing from the bottom up and overfishing from the top down," said Charles Greene, an oceanographer at Cornell University in Ithaca, N.Y. and lead author of the Science paper. "Predicting the fate of these ecosystems will be one of oceanography's grand challenges for the 21st century."

Most scientists believe humans are warming the planet by burning fossil fuels and changing land surfaces. Early signs of this warming have appeared in the Arctic. Since the late 1980s, scientists have noticed that pulses of fresh water from increased precipitation and melting of ice on land and sea in the Arctic have flowed into the North Atlantic Ocean and made the water less salty.

At the same time, climate-
driven shifts in Arctic wind patterns have redirected ocean currents. The combination of these processes has led to a freshening of the seawater along the North Atlantic shelf.

"Long time-series measurements, as well as research on large-
scale ocean processes, are the key to improving our understanding of ecosystem shifts," says Mary Elena-
Carr, program director in NSF's biological oceanography program. "This study brings together the important components: the atmosphere, freshwater flow, changes in currents and biological responses, all necessary to predicting future ecosystem responses to climate change."

Under normal conditions in summer months a warmer, less salty layer of water floats on the surface (warmer, less salty water is also less dense and lighter). This surface layer is known as a "mixed" layer, because wind
-driven turbulence mixes the water and creates a uniform temperature, salinity and density to depths that can range from 25 to 200 meters.

Similar to the flow of heating and cooling wax in a lava lamp, when the air temperature cools during autumn, temperature and density differences lessen between the surface mixed layer and the cooler, saltier waters below. As the density differences get smaller, mixing between the layers typically increases and the surface mixed layer deepens.

But Greene cites recent scientific studies that reveal the influx of fresh water from Arctic climate change is keeping the mixed layer buoyant, inhibiting its rapid deepening during autumn. A gradual rather than rapid deepening of the mixed layer has impacted the seasonal cycles of phytoplankton (tiny floating plants), zooplankton (tiny animals like copepods) and fish populations that live near the surface.

Normally, when the mixed layer deepens rapidly during autumn, phytoplankton numbers decline because they spend less time near the surface where they are exposed to the light necessary for growth. But with the mixed layer remaining relatively shallow, phytoplankton populations stay abundant throughout the fall. In turn, zooplankton that feed on phytoplankton have increased in number during the fall through the early winter. Herring populations also rose d

Greene's paper also cites a link between the collapse of cod fisheries in the early 1990s and an increase in bottom-
living species such as snow crabs and shrimp, which cod prey upon. Without cod, other animals that live in the water column and feed on zooplankton, including herring, may have increased.

While the herring story is still unclear, the authors contend that the crash of cod populations does not explain why phytoplankton and zooplankton populations at the base of the food chain have risen during autumn.

"We suggest that, with or without the collapse of cod, a bottom-up, climate-
driven regime shift would have taken place in the Northwest Atlantic during the 1990s," Greene said.



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