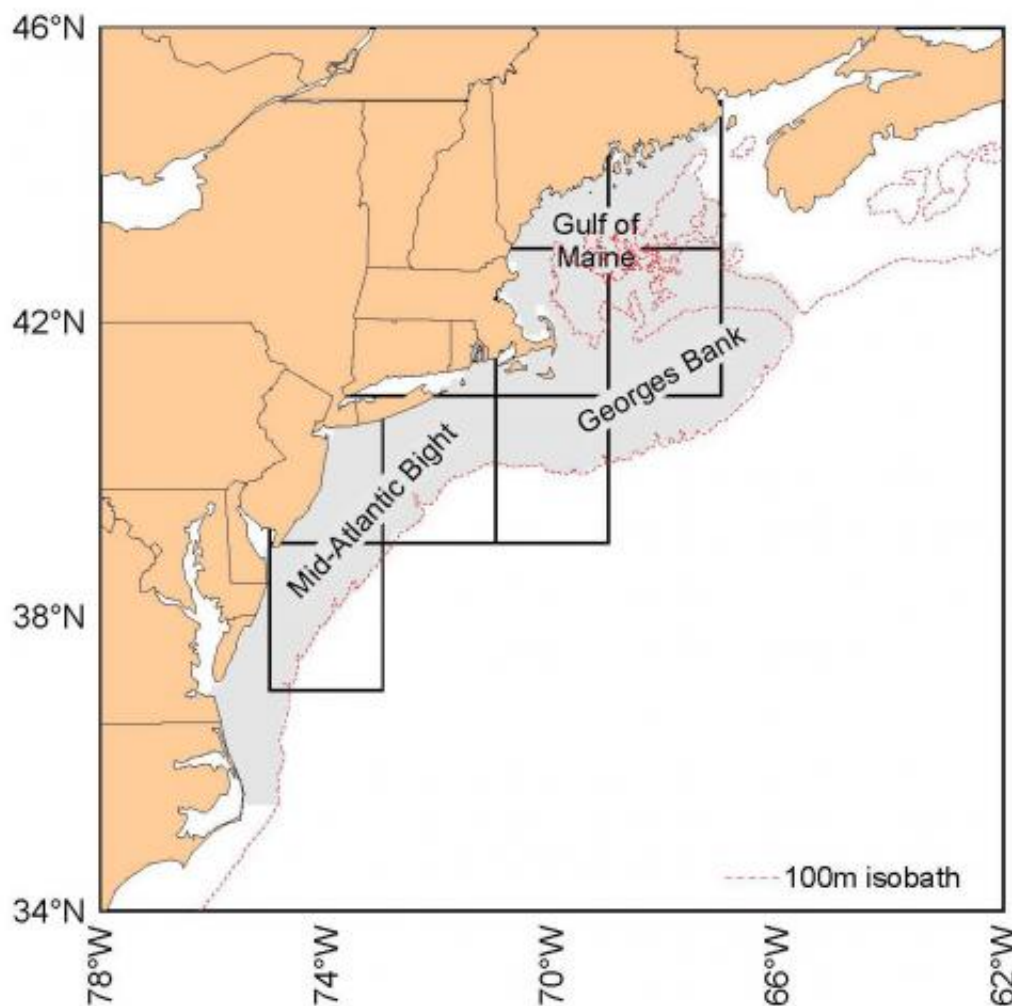


Changing ocean temperatures, circulation patterns affecting young Atlantic cod food supply

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Eight boxes represent index areas for long-term sea surface temperature (SST) trends for the Northeast Shelf ecosystem; annual mean, minimum, and maximum

SST for the period 1854-2011 was calculated for the index area. The grey shaded area of the Northeast Shelf was used in the calculation of thermal habitat distribution for the ecosystem. Credit: Kevin Friedland, NEFSC/NOAA

Changing ocean water temperatures and circulation patterns have profoundly affected key Northeast U.S. Continental Shelf zooplankton species in recent decades, and may be influencing the recovery of Atlantic cod and other fish stocks in the region.

NOAA researcher Kevin Friedland and colleagues looked at the distribution and abundance of important zooplankton species, sea surface water temperatures, and [cod](#) abundance. They found that zooplankton species critical for the survival of Atlantic cod larvae have declined in abundance in the same areas where Atlantic cod stocks have struggled to rebuild after an extended period of overfishing.

"Temperature is a governing factor in the growth, reproduction and distribution of [marine organisms](#). Shifting temperature distributions, whether triggered by natural or human factors, can cause the redistribution of plankton communities on regional and basin-wide scales," said Friedland, lead author on the study and a scientist at NOAA's [Northeast Fisheries Science](#) Center (NEFSC).

The change in thermal habitats has had biological consequences on multiple levels in the food chain, according to the study in press in the journal *Progress in Oceanography* (available [online](#)).

"The geographic and depth distributions of fish and shellfish populations can also change based on their preferred thermal habitats. Future changes in thermal conditions are expected to lead to further shifts in the distributional ranges of species by, in many cases, the loss and gain of

local populations," said Friedland.

Friedland and his colleagues found that ocean water temperatures of the Northeast [Continental Shelf](#) have increased in recent decades, but these changes have not been uniform over the entire ecosystem. Warm water habitats (16 to 27 C, 60 to 80 F) have increased and cool water habitats (5 to 15 C, 41 to 59 F), historically the core habitats in the ecosystem, have declined; however, the coldest habitats in the ecosystem (1-4 C, 34-39 F) have either stayed the same or increased slightly during the study period 1982-2011. This discontinuity is attributed to changes in circulation in the northern Gulf of Maine associated with the Labrador Current.



Larval cod. Image courtesy Wes Pratt, NOAA

Atlantic cod off the Northeast U.S. are managed as two stock units, the more northerly in the Gulf of Maine and the more southerly on and around Georges Bank. There are upward of ten known spawning populations within these two stocks, and the very young fish that they produce are found in specific larval development areas. Two zooplankton species that serve as food for Atlantic cod (*Gadus morhua*) larvae are *Pseudocalanus* spp, and *Centropages typicus*. The former is

associated with winter-spawning cod, and the latter with spring-spawning cod.

The researchers developed indices of zooplankton and cod abundance in six index areas, relating larval feeding and development areas to associated areas where adults reside. They found that *Pseudocalanus* spp has declined in abundance on parts of Georges Bank and in the eastern Gulf of Maine, areas where cod have been less abundant in recent years. *Centropages typicus* declined in abundance in the eastern Gulf of Maine as well. The areas where these zooplankton species have declined are spatially discrete and are related to the change in core thermal habitat of the ecosystem.

The abundance of zooplankton species is measured by the NEFSC's Ecosystem Monitoring Program (EcoMon), which conducts shelf-wide bimonthly surveys of the ecosystem. Data and observations from the NEFSC's spring bottom trawl surveys were also analyzed.

Although the researchers concentrated on [Atlantic cod](#) recruitment success and population trends, many of the zooplankton species examined are important as prey for early life stages of other fish species and marine mammals. These zooplankton [species](#) are important within the Northeast Shelf ecosystem, and can serve as model organisms to test the effect of thermal habitat on changes within the food web.

An Ecosystem Advisory issued by the NEFSC on April 25, 2013 provides additional information related to the Northeast Shelf ecosystem, notably a description of the extreme warming that occurred on the Shelf during 2012 and the associated shifts in thermal habitat.

Provided by NOAA Headquarters

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