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### **Changes in forage fish abundance alter Atlantic cod distribution, affect success of the fishery**

A shift in the prey available to Atlantic cod in the Gulf of Maine that began nearly a decade ago contributed to the controversy that surrounded the 2011 assessment for this stock. A recent study of how this occurred may help fishery managers, scientists, and the industry understand and resolve apparent conflicts between assessment results and the experiences of the fishing industry.

When the dominant prey species of Atlantic cod changed from Atlantic herring to sand lance beginning in 2006, cod began to concentrate in a small area on Stellwagen Bank where they were easily caught by fishermen. The fishermen perceived the Gulf of Maine cod stock to be abundant in subsequent years as they reported increased ease in catching cod, yet the 2011 stock assessment concluded that the Gulf of Maine cod stock had not increased as expected and that fishing rates had been too high even though catches had not exceeded the quotas. Fishermen were skeptical, and the 2011 assessment conclusions were questioned and criticized.

Writing in the *Canadian Journal of Fisheries and Aquatic Sciences*, researchers from NOAA Fisheries' Northeast Fisheries Science Center (NEFSC) show how the fishermen's observations and the assessment results could both be accurate. Their findings reveal why fishermen targeting these cod would conclude the fish were abundant, and also illustrate how commercial catch-per-unit of effort can be a misleading indicator of stock abundance.

The NEFSC has been routinely monitoring the diet and distribution of cod and many other marine species since 1963 in an ecosystem survey of waters off the Northeast from Maine to North Carolina and eastward into Canadian waters. By collecting, analyzing, and documenting stomach contents of cod taken in the Gulf of Maine during this survey, the researchers can see what cod eat both seasonally and over time.

"Atlantic herring and sand lance are dominant prey for Atlantic cod in the Gulf of Maine. This long, standardized time series of data has been invaluable to our ability to both show and understand where and when predators and prey are distributed across the region," said David Richardson, an oceanographer at the NEFSC's Narragansett Laboratory in Rhode Island and lead author of the study. "When sand lance are abundant, they account for a high proportion of the diet of cod. Also, cod tend to be more aggregated when they are feeding on sand lance than when they are feeding on other prey."

An assessment is an examination of fishery stock conditions used to develop catch limits and other management measures. The 2011 assessment results were also controversial because the 2008 assessment had suggested an uptick in young fish that would grow the stock. Ultimately this growth in the population did not materialize, and the catch limits set based on the 2008 assessment were found to be too high.

“The sand lance-induced cod aggregations led to a number of challenges in evaluating population trends in Gulf of Maine cod,” Richardson said. “During the 2007 and 2008 spring bottom trawl surveys, extremely high catches of cod were recorded at individual stations on Stellwagen Bank, while the remainder of the stock area had low catch rates. At the same time, the fishing industry was experiencing high catch rates of cod in the same small area on Stellwagen bank. One of the main conclusions of this study is that the trends in cod abundance in this small region were not truly reflective of the overall resource at the time.”

Atlantic herring and sand lance have very different habitat and life history requirements that affect their distribution. Atlantic herring are migratory, shifting distribution in response to changing oceanographic conditions like temperature. Sand lance are burrowers, and have a nightly need to burrow into shallow sandy bottom, such as that found on Stellwagen Bank, an underwater plateau covering about 156 square miles located in the southwestern portion of the cod stock area.

“Data from the Northeast Fisheries Science Center survey and from the fishery both indicate that an increase in sand lance abundance resulted in cod aggregating in a small and predictable area on Stellwagen Bank where they were easily caught by fishermen,” Richardson said. “The cod were fished in a very small area, approximately 100 square miles, while the entire cod stock area on which the assessment was based is 20,255 square miles.”

Michael Palmer, an assessment scientist in the NEFSC’s Population Dynamics Branch at the Woods Hole Laboratory and a co-author of the study, said the concentration of cod and of the fishing fleet was significant. “Between 1994 and 2010 the number of fishing trips occurring in this small area increased by 191 percent, and the number of trips occurring outside this area declined by 46 percent.”

“This shift in the fishery distribution indicates a large influx of fishing effort into this small area during the same time period that sand lance was abundantly available to feeding cod,” said Palmer. By 2010, 45 percent of all Gulf of Maine cod landings came from this area, compared with 12 percent prior to 2005.

This dynamic is important not only for cod but also for other species, including whales that have been reported feeding on sand lance in the same area. “The change in the composition of the forage fish community in the Gulf of Maine may have driven distribution shifts, not only for Atlantic cod, but also for other predators feeding on the same set of prey species,” said Richardson.

In addition to Richardson and Palmer, study authors include fishery biologist Brian Smith, who studies the link between fish feeding and offshore benthic habitats and leads the NEFSC’s food web dynamics program.

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Canadian Journal of Fisheries and Aquatic Sciences:

<http://www.nrcresearchpress.com/doi/full/10.1139/cjfas-2013-0489#.U6nsNRCqRHY>

Atlantic Cod – Fishwatch:

[http://www.fishwatch.gov/seafood\\_profiles/species/cod/species\\_pages/atlantic\\_cod.htm](http://www.fishwatch.gov/seafood_profiles/species/cod/species_pages/atlantic_cod.htm)

Sand lance: [http://www.coastalstudies.org/what-we-do/stellwagen-bank/fish\\_bony.htm](http://www.coastalstudies.org/what-we-do/stellwagen-bank/fish_bony.htm)