Scientists link climate change and Atlantic croaker fishery

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A new climate-population model developed by NOAA scientists to study rising ocean temperatures and fishing rates on one East Coast fish population could also forecast the impact of climate change and fishing on other fisheries. The model is one of the first to directly link a specific fish stock with climate change.

In a paper in the March 2010 issue of the journal *Ecology Applications* published online today by the Ecological Society of America, NOAA researchers forecast the future of the Atlantic croaker fishery in the mid-Atlantic under various climate and fishing scenarios. Atlantic croaker (Micropogonias undulatus) is a coastal marine fish inhabiting the east coast of the United States with an $8 million annual commercial fishery. Previous studies have shown a strong link between croaker abundance and winter temperatures.

"Some fish populations will increase and others decrease as a result of climate change," said lead author Jon Hare of the Northeast Fisheries Science Center (NEFSC) laboratory in Narragansett, R.I. "Our results demonstrate that climate effects on fisheries must be identified andunderstood, included in the scientific advice to managers, and factored into fishery management plans if sustainable exploitation is to be achieved."

For various temperature and fish population scenarios over the next 90 years to 2100, the researchers forecast that at current levels of fishing, the spawning population of Atlantic croaker would increase between 60 and 100%, the center of the population would shift 50 to 100 kilometers (roughly 30 to 65 miles) northward, and the maximum sustainable yield would increase 30 to 100%.

With ocean temperatures expected to increase through the 21st century, the researchers developed the population model for Atlantic croaker based on the hypothesis that recruitment, or survival of juveniles to adulthood, is determined by winter water temperature. Atlantic croaker spawn in the coastal ocean and larvae enter estuaries in Delaware Bay, Chesapeake Bay, and Pamlico Sound 30 to 60 days after hatching. Juveniles spend their first winter in these estuarine nursery habitats. Temperature during this winter period is very important to juvenile survival.

Temperature forecasts were obtained from 14 General Circulation Models (GCMs) used by the Intergovermental Panel on Climate Change (IPCC) to simulate three carbon dioxide emission scenarios through 2100: atmospheric carbon dioxide fixed at 350 , 550 and 720 parts per million (ppm). By comparison, the atmospheric concentration of carbon dioxide in February 2010 was 389.91ppm.

Hare and colleagues from NOAA's Northeast and Southeast Fisheries Science Centers, in collaboration with climate modelers from NOAA's Earth System Research Laboratory in Boulder, Colo., linked the Atlantic croaker population model with forecasts of minimum winter temperature from the 14 GCMs. These linked modeling efforts provided estimates of the abundance, distribution, and yield of the Atlantic croaker population under different climate change scenarios and different fishing rates.

With increasing minimum winter temperatures, the NOAA model predicted that Atlantic croaker abundance will increase. Higher temperatures result in higher recruitment, which leads to a larger spawning stock. At current levels of fishing mortality, all 14 GCM models and all climate scenarios predicted higher population abundances than observed since the early 1970's, when estimates of spawning stock were first developed. Even at higher fishing mortality rates, the models and climate scenarios predicted higher populations than observed in the past.

"Although our model does not include all potential environmental complexities, the recruitment hypothesis on which it is based is supported by both laboratory and field work, and is consistent with current fishery population models," Hare said. "The modeling work represents one of the first attempts to link a group of general circulation models to fish population models. The outputs from 14 GCM models are all consistent, so we have confidence in our long-term forecasts."

This approach could be used for other species where an environmental link to population dynamics is established.

"Most stock assessments that inform fishery management decisions do not include the effect of a changing environment because they are conducted annually or every few years and do not provide a long-term view," said Hare. "Understanding and quantifying the effect of climate change on populations, in combination with the effect of exploitation, is a major challenge to rebuilding and maintaining sustainable fisheries in the coming decades."

Another challenge is developing climate models that forecast on shorter timer scales than the current 50 to100 years.

"Fishery management does not operate on these long time scales, and shorter-term forecasts are required," Hare said. "In the future, a range of climate forecasts that include both the effects of fishing and climate on fish populations over time intervals of 5 to 20 years, 20 to 50 years and

50 to 100 years could be provided. These kinds of coupled models will help provide the best scientific advice for managing fisheries under changing climate conditions in the future."

Provided by NOAA