

Spotlight on Atlantic Cod and Atlantic Croaker
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Here we examine two Northeast species, Atlantic cod (*Gadus morhua*) and Atlantic croaker¹ (*Micropogonias undulatus*). In the northeastern US, cod (primarily found in New England (ME-CT)) is likely to experience negative impacts from climate change, while croaker (primarily found in the Mid-Atlantic (NY-VA)) is likely to experience positive impacts. We discuss some of the potential and likely social and economic impacts resulting from the climate change impacts to these two species.

Atlantic cod are managed by the New England Fisheries Management Council (NEFMC) as part of a complex of groundfish². Off the US coast, cod can be found from the Gulf of Maine down to the Mid-Atlantic Bight, though most are found north of 40°N (Fogarty *et al.* 2008). Cod are generally landed from eastern Long Island, NY through northern Maine, though the largest landings are in New England. In November 2011 the Gulf of Maine cod stock assessment underwent a peer review by a team of independent scientists. The preliminary results indicate



Figure 1. The crew aboard the head boat Yankee Captain out of Gloucester filleting Atlantic Cod after a fishing trip to Georges Bank.

http://www.nmfs.noaa.gov/fishwatch/species/atlantic_cod.htm

¹ Atlantic croaker is sometimes called Drum, but Spot is also called Drum so care must be taken to avoid confusion. For that reason we refer only to Atlantic croaker (or croaker) in this report.

² Other species in the complex are: Winter Flounder (Blackback, Lemon Sole; *Pleuronectes americanus*), Dab (American Plaice; *Hippoglossoides platessoides*), Haddock (*Melanogrammus aeglefinus*), Ocean Pout (*Macrozoarces americanus*), Pollock (*Pollachius virens*), Redfish (*Sebastes fasciatus*), Red Hake (Ling; *Urophycis chuss*), Silver Hake (Whiting; *Merluccius bilinearis*), Windowpane Flounder (Sand Flounder; *Scophthalmus aquosus*), Witch Flounder (Gray Sole; *Glyptocephalus cynoglossus*), Yellowtail Flounder (*Limanda ferruginea*) and Atlantic wolffish (*Anarhichas lupus*).

that the stock is overfished and overfishing is occurring and that it will not rebuild by the existing 2014 deadline (NMFS 2012). This may require more stringent regulation of that stock. Georges Bank cod are in better condition, but still heavily regulated. The vast majority of groundfish caught commercially are currently regulated primarily under a system of cooperative-like groups called “Sectors” that are assigned portions of the Annual Catch Limit (ACL); a small portion are regulated under an effort control system based on Days-at-Sea (DAS). Recreational regulations include minimum size and bag limits.³

In 2009 (NMFS 2010), cod and haddock accounted for \$36.6 million and 30.8 million pounds of commercial landings in New England. Of this, 92.1% was landed in Massachusetts, 7.3% in New Hampshire and 0.6% in Maine. Maine had a much larger cod fishery until the last 5-10 years, when increasingly stringent groundfish regulations and large Atlantic lobster (*Homarus americanus*) biomass have led many fishermen who once fished part of the year on lobster, part on cod and part on Northern shrimp (*Pandalus borealis*) to move almost exclusively to lobster. Total cod plus haddock value was only 4.7% of all landed value in New England in 2009 and 4.8% of landed pounds. Cod is also an important recreational fishing species; in 2009 (NMFS 2010) 483,000 codfish were harvested by anglers in New England (with an additional 1.1 million cod captured but then released). As with the commercial fishery, MA had the largest recreational cod fishery, with 70% of codfish (26% kept and 74% released), followed by New Hampshire with 24% (38% kept and 62% released), and then Maine with 6% (45% kept and 55% released). The high level of kept fish in Maine may indicate that cod is playing a subsistence as well as a recreational role. Steinback et al. (2009) found that 28% of Northeast anglers fish for reasons other than recreation, such as food or income. - though only 3% fish mostly for food or income

In 2009, the New England seafood industry generated \$10.1 billion in sales, and Massachusetts alone generated 78,000 jobs (NMFS 2010:50). Employment impacts from recreational fishing were highest in Connecticut (over 5,200 full- and part-time jobs), followed by Massachusetts (5,000 jobs), and Maine (2,000 jobs) (NMFS 2010:52).

Cod also has a strong cultural and symbolic value. The large schools of cod discovered by John Cabot in 1497 motivated the migration of many fishermen to the Northeast, “including the Norwegians, the Portuguese, the British, and the French – ethnicities still represented in today’s fishing communities” (NMFS 2009:27). “The cod fisheries helped feed Europe’s industrial revolution, and were an important part of the 17th through early 19th century’s trade route between Africa, the Caribbean, North America, and Europe” (NMFS 2009:26, re.

³ See <http://nefmc.org/nemulti/index.html> for more information on management issues.



Figure 2. Gloucester, MA Stern Trawler

<http://www.photolib.noaa.gov/htmls/fish0533.htm>

Kurlansky 1997). It is no wonder, then, that a statue of the Sacred Cod has adorned the Massachusetts Statehouse rotunda since the 1700s. The current Sacred Cod, dating to 1784, is the third; the first was destroyed in a fire and the second during the Revolutionary War (Massachusetts 1895). The Sacred Cod is of such importance as a current cultural icon that it is featured in a coloring book for children available on the state website (Anon. n.d.).

Cod are very sensitive to increases in temperature and are expected to be strongly impacted by expected ocean temperature increases (Fogarty et al. 2008, see Fig. 2 in section on Northeast U.S. Continental Shelf Ecosystem), though the level of impacts varies by the level of increased CO₂ emissions. There is also some concern that cod prey species may not move in synch with cod, creating further difficulties for cod in the Northeast Region (Murawski 1993). If cod move north, likely of Georges Bank and potentially even completely out of the Gulf of Maine (re. Fogarty et al. 2008), then commercial fishermen will need to substitute other species since they cannot follow the cod north into Canadian waters. Changing species can sometimes mean changing gear (often expensive) and/or learning new fishing grounds and species' habits. Fishermen often rely on social networks for information-sharing while fishing (e.g., Palmer 1990, 1991, St. Martin and Hall-Arber 2008:167, Holland et al. 2010:3, Kitts et al 2007). Changing species may mean needing to cultivate new networks. If fishermen switch to species whose range extends further south, this can mean longer trips or relocating their home base, either of which has effects on families and communities. Fishermen often choose day versus trip fishing based on family considerations (Maurstad 2000). Where trips are longer, household dynamics change, affecting time with spouse and children and ability to participate in community and school events. Where households re-locate, family as well as fishermen social networks are lost, and part of a community's economic base disappears (though the communities of destination gain). See Fowler and Etchegary (2008) for a fuller discussion of the social and economic impacts on communities of out-migration, especially in rural areas (re. Lal et al. 2011).

Gentrification is already creating pressure on small fishing communities (Colburn and Jepson Under review, NMFS 2009), making coastal property less affordable, and any climate change related loss of fishing households could exacerbate this trend. The four Northeast fishing communities currently most vulnerable to gentrification are Chatham, MA; Barnegat Light/Long Beach, NJ; Cape May, NJ and Montauk, NY (Colburn and Jepson Under Review). The exact degree or even direction of economic impacts for commercial fishermen, however, depends on which specific climate scenario results, as well as on other factors affecting prices and other market factors at that point in time (re. Markowski 1999).

Recreational fishermen will largely change target species, with unclear economic impacts, as many aspects of the recreational fishing experience are unrelated to specific species (re. Fedler and Ditton 1994). In their study of freshwater sportfishing in the northeastern United States, for example, Pendleton and Mendelsohn (1998) found that a doubling of atmospheric carbon dioxide could lead to between a \$4.6 million loss and a \$20.5 million net benefit for the region. Subsistence fishermen generally fish a wider range of species than those fishing for pure



Figure 3. 2007 State Record Croaker, Portsmouth, VA
http://www.mrc.state.va.us/vswft/state_records/state-record-croaker_08-22-07.shtm

recreation⁴ so would likely be able to adapt, provided enough species remain accessible. But to the extent multiple species become unavailable these fishermen may experience negative nutritional consequences, especially since they are also statistically more likely to collect non-fish marine resources, such as shellfish (which are expected to be heavily impacted by increasing ocean acidification), squid, seaweed or kelp (Steinback et al. 2009).

Even where climate change has a positive effect on a species, there are

social and economic impacts. Atlantic croaker are managed by the Atlantic States Marine Fisheries Commission (ASMFC). They are found from the Gulf of Maine to Argentina (ASMFC 2011), but in the Northeast their primary range is from Hudson Canyon (off the coasts of New York and New Jersey) south to Cape Hatteras, North Carolina (Hare et al. 2010:456). Croaker are not currently experiencing overfishing, according to a 2010 peer-reviewed stock assessment (ASMFC 2011). Spawning stock biomass (SSB) estimates have exhibited a cyclical trend, based on environmental conditions (ASMFC 2007), and as of 2010 croaker was coming off a peak and moving into a low biomass status (ASMFC 2012). The ASMFC has no specific harvest restrictions, though it encourages states with existing restrictions to maintain them⁵. It does, however, have a set of assessment triggers to monitor the status of the stock (ASMFC 2011).

In 2009, the Mid-Atlantic Region's seafood industry generated \$14.6 billion in sales, and New York alone generated 44,000 jobs with New Jersey generating another 38,000 (NMFS 2010:78). Employment impacts from recreational fishing were highest in New Jersey (over 8,500 full- and part-time jobs), followed by Maryland (5,700 jobs), and Virginia (5,200 jobs) (NMFS 2010:79). The commercial croaker fishery in 2009 was primarily located in Maryland (\$444 thousand and 597 thousand pounds) and Virginia (\$4.3 million and 9.2 million lbs). Croaker is not one of the top commercial species, representing only 0.7% of total Mid-Atlantic landings revenue and 2% of Mid-Atlantic landed pounds. It is, however, one of the key recreational species, with 15 million fish caught, second only to summer flounder (*Paralichthys dentatus*). Virginia accounts for 81% of all recreational croaker (43% kept and 57% released), followed by Maryland with 12% (57% kept and 43% released) and then Delaware with 6% (45% kept and 55% released).

⁴ Steinback, Scott, Kristy Wallmo and Patricia M. Clay. 2007. Assessing Subsistence On A Regional Scale For The Northeast U.S. Presented at the American Anthropological Association annual meeting. November. Washington, DC.

⁵ See <http://www.asmfc.org/speciesDocuments/southAtlanticSpecies/atlanticcroaker/stateregs.pdf> for a list of state regulations.

Croaker are more than sources of economic wealth; they are part of the traditional annual round for commercial gillnetters (McCay et al. 2006), and are commonly caught in the Virginia Saltwater Fishing Tournament (re. time series of croaker lengths in Barbieri et al. 1994:10). Tournament fishermen are a subset of recreational fishing more generally (Loomis and Ditton 1987), and this constitutes a particular sub-culture. In addition, croaker are one of the three Mid-Atlantic recreational species that experience high levels of harvest, with 45% of fish kept. As with cod in Maine, this may indicate subsistence use. McCay et al. (2006, p. 12 in the Wachapreague profile) specifically note subsistence-like behavior in relation to croaker in Wachapreague, VA. Similarly, in Indian River, Delaware, croaker, sea bass and summer flounder have “been the mainstay” for party boats (p. 17 in Delaware profile). Holland and Ditton (1992:31) affirm that party and charter boat fishing is more catch oriented than other types of recreational fishing. There may also be a relationship to tournament fishing in the catch levels; Loomis and Ditton (1987) found that tournament fishermen are more catch-oriented than the “average” recreational fisherman. They are also more focused on the sport and challenge aspects (Falk et al. 1989).

Hare et al. (2010:452) estimate that as ocean temperatures warm, “[a]t current levels of fishing, the average (2010–2100) spawning biomass of the population is forecast to increase by 60–100%. Similarly, the center of the population is forecast to shift 50–100 km northward. A yield analysis, which is used to calculate benchmarks for fishery management, indicates that the maximum sustainable yield will increase by 30–100%.” (See Fig. 3 in section on Northeast U.S. Continental Shelf Ecosystem.) With rising ocean temperatures, the fishery is expected to extend into southern New England (i.e., Connecticut, Rhode Island, and Massachusetts). Montane and Austin (2005) also found that hurricanes (predicted to increase under some scenarios of global warming) coincide with spikes in juvenile croaker recruitment.

Commercial fishermen at the southern end of the range might need to switch species, fish farther from home (meaning longer trips or moving their households) – with the negative impacts noted above. But fishermen further north would gain a new species with a high biomass, potentially raising the importance of croaker as a commercial species. With regard to recreational fishing, Carter and Letson (2009) found that climate activity (e.g., ENSO) had a moderate influence on the headboat fishery for red snapper in the Gulf of Mexico. Further, Mendelsohn and Markowski (1999) and Loomis and Crespi (1999) note that recreational fishing and boating activities may significantly increase with warming, and thus the effects of warming on recreational fishing are likely to be beneficial. Tournament fishermen would be able to switch species – though a certain amount of species specialization may lower angler satisfaction during a transition period. Subsistence-type fishermen at the southern end of the range may experience some negative nutritional impacts as croaker move north, but are likely to find acceptable substitutes; the exception to this positive scenario would come from the loss of croaker in combination with local shellfish, expected to decrease due to increasing acidification.

Research at the NMFS Northeast Fisheries Science Center continues to investigate the effects of climate change (both temperature and acidification) on the many marine species in the NEUS. Social and economic indicators of human community vulnerability and resilience, fishery

performance, and ecosystem function are under development as well, and should help to flesh out some of these impacts in the Northeast over time.

Some species will thrive in the NEUS under climate change, and some will largely leave the region. Either case can have positive or negative social and economic benefits, as those who depend on them for income, way of life, sport or food adjust their activities to meet the changed ecological circumstances. It is important to remember that in all cases different individuals and different groups (vessel sizes, fisheries, port communities, motivations for fishing) will have different options available and different pre-existing levels of resilience and vulnerability. Further, resilience and vulnerability will be based on a broader context than simply fisheries, including issues of loss of infrastructure or whole communities due to sea level rise, changing local agricultural patterns affecting community cultural and economic health, and impacts in markets outside the Northeast and the U.S. Until more research is completed (biological, sociocultural and economic) predicting definitive outcomes will remain a challenge.

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