Atlantic Croaker − *Micropogonias undulatus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 88% of scores ≥ 2

	Micropogonias undulatus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Stock Status	1.9	1.6	
	Other Stressors	2.2	2.4	
	Population Growth Rate	1.7	2.4	
	Spawning Cycle	1.8	3.0	
	Complexity in Reproduction	2.1	2.6	
	Early Life History Requirements	3.0	2.7	
	Sensitivity to Ocean Acidification	1.6	2.0	
	Prey Specialization	1.3	3.0	
	Habitat Specialization	2.0	3.0	
	Sensitivity to Temperature	1.4	3.0	
	Adult Mobility	1.5	2.6	
	Dispersal & Early Life History	1.8	2.6	
	Sensitivity Score	Low		
Exposure variables	Sea Surface Temperature	4.0	3.0	
	Variability in Sea Surface Temperature	1.0	3.0	
	Salinity	2.8	3.0	
	Variability Salinity	1.2	3.0	
	Air Temperature	4.0	3.0	
	Variability Air Temperature	1.0	3.0	
	Precipitation	1.2	3.0	
	Variability in Precipitation	1.3	3.0	
	Ocean Acidification	4.0	2.0	
	Variability in Ocean Acidification	1.0	2.2	
	Currents	2.0	1.0	
	Sea Level Rise	2.5	1.5	
	Exposure Score	Very High		
	Overall Vulnerability Rank	Moderate		

Low
Moderate
High
Very High

Atlantic Croaker (*Micropogonias undulatus*)

Overall Climate Vulnerability Rank: **Moderate** (98% certainty from bootstrap analysis).

Climate Exposure: **Very High**. Three exposure factors contributed to this score: Ocean Surface Temperature (4.0), Ocean Acidification (4.0) and Air Temperature (4.0). Exposure to all three factors occur during all life stages. Atlantic Croaker spawn on the shelf, juveniles use estuarine nurseries, and adults make seasonal migrations to feed in estuarine and coastal areas.

Biological Sensitivity: **Low**. Only one sensitivity attribute scored above 2.5: Early Life History Requirements (3.0). Atlantic Croaker exhibit an obligate estuarine-dependent life cycle, using estuaries during the late larval and juvenile stages (Able 2005).

Distributional Vulnerability Rank: **High** (98% certainty from bootstrap analysis). Two attributes indicated vulnerability to distribution shift. Atlantic Croaker larvae are widely dispersed after spawning and adults make north-south seasonal migrations along the Northeast U.S. Shelf.

Directional Effect in the Northeast U.S. Shelf: The effect of climate change on Atlantic Croaker on the Northeast U.S. Shelf is very likely to be positive (>95% certainty in expert scores). Recruitment will likely increase as winters become warmer and the adult distribution will likely extend northwards. The effect of ocean acidification over the next 30 years is likely to be minimal.

Data Quality: 88% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution: Climate effects have been identified on both productivity and distribution of Atlantic Croaker. Hare and Able (2007) proposed that over-winter mortality of young-of-the-year in estuarine nursery habitats was a major contributor to recruitment variability. Hare et al. (2010) projected that as climate warmed, recruitment increased leading to higher population abundances. Hare et al. (2010) also projected northward expansion of the population, largely owing to increase in population abundance, but also directly related to warming temperatures. Diamond et al. (2013) indicated that warming temperatures would have a large positive effect on Atlantic Croaker in the region, but that increased variability in salinity, increased offshore transport, and sea-level rise would have negative effects. Munyandorero (2014) used a biomass dynamic model and found equivocal support for climate effects on Atlantic Croaker population dynamics and recommended continue monitoring and modeling of the population and the environment.

Life History Synopsis**:** Atlantic Croaker is an estuarine-dependent, coastal species occurring from Cape Cod, Massachusetts, through the Gulf of Mexico (Able and Fahay, 2010). There is no genetic differentiation among populations along the Atlantic coast, but the Atlantic and Gulf of Mexico populations are discrete (Able and Fahay, 2010). Maturity may be reached at the end of the first year and most fish are mature by the third year of life (Barbieri et al., 1994). Adult Atlantic Croaker migrate from coastal areas to the continental shelf to spawn in early fall through winter (Able and Fahay, 1998, 2010). Eggs and larvae are pelagic and rely on fall winds for transportation across the shelf (Able and Fahay, 2010). Larvae are selective feeders consuming zooplankton such as tintinnids, pteropods, and pelecypods (Govoni et al., 1986; Able and Fahay, 2010). A few weeks after spawning, late stage larvae ingress into estuarine and freshwater nursery habitat along the mid Atlantic coast during early fall – winter (Able and Fahay, 2010). Juvenile Atlantic Croaker overwinter in deep areas estuaries and tributaries typically near grassbeds and mud flats (Able and Fahay, 2010). The northern extent of

suitable nursery habitat is limited by winter temperature < 3 ^{o}C (Able and Fahay, 2010). While in estuaries, juveniles consume demersal prey such as polychaetes, copepods, mysids and detritus (Able and Fahay, 2010). Striped Bass can be a major predator of juvenile Atlantic Croaker (Able and Fahay, 2010). Juveniles egress from the estuaries the next fall, and follow adults offshore (Able and Fahay, 2010). Adults are common inshore demersal fish over mud and sandy mud in spring and summer, but move offshore and south along the continental shelf to spawn and overwinter in late fall through winter (Able and Fahay, 2010). Benthic macroinvertebrates such as crustaceans, polychaetes, molluscs, and fish are common prey for adult Atlantic Croaker (Able and Fahay, 2010). Atlantic Croaker is managed under the Atlantic States Marine Fisheries Commission Interstate Fishery Management Plan for Atlantic Croaker (2005) and Addendum I (2011; ASMFC, 2011). Atlantic roaker is not experiencing overfishing and biomass estimates are increasing for the Atlantic stock (ASMFC, 2010).

Literature Cited:

Able KW. A re-examination of fish estuarine dependence: evidence for connectivity between estuarine and ocean habitats. Estuar Coast Shelf Sci. 2005; 64(1), 5-17. doi:10.1016/j.ecss.2005.02.002

Able KW, Fahay MP. The first year in the life of estuarine fishes in the middle Atlantic bight. Brunswick: Rutgers University Press; 1998. 342 p.

Able KW, Fahay MP. Ecology of estuarine fishes: temperate waters of the western North Atlantic. Baltimore: The Johns Hopkins University Press; 2010. 566p.

Atlantic States Marine Fisheries Commission (ASMFC). 2010. Atlantic croaker 2010 benchmark stock assessment. Washington (DC): ASMFC. 366p. Accessed online (May 2014): http://www.asmfc.org/uploads/file//5282798aatlanticCroaker2010BenchmarkStockAssessment.pdf

Atlantic States Marine Fisheries Commission (ASMFC). 2011. Addendum I to amendment 1 to the Atlantic croaker fishery management plan. Washington (DC): ASMFC. 7p. Accessed online (May 2014): http://www.asmfc.org/uploads/file/croakerAddendumI.pdf

Barbieri LR; Chittenden, Jr. ME; Lowerre-Barbieri SK. Maturity, spawning, and ovarian cycle of Atlantic croaker, *Micropogonias undulatus*, in the Chesapeake Bay and adjacent coastal waters. Fish Bull. 1994; 92: 671-685. Available: http://fishbull.noaa.gov/924/barbieri.pdf

Diamond SL, Murphy CA, Rose KA. Simulating the effects of global climate change on Atlantic croaker population dynamics in the mid-Atlantic Region. Ecol Modell. 2013; 264, 98-114. doi:10.1016/j.ecolmodel.2013.05.001

Govoni, J. J.; P. B. Ortner; F. Al-Yamani; L. C. Hill. 1986. Selective feeding of spot, *Leiostomus xanthurus*, and Atlantic croaker, *Micropogonias undulatus*, larvae in the northern Gulf of Mexico. Mar. Ecol. Prog. Ser. 28: 175-183.

Hare JA, Able KW. Mechanistic links between climate and fisheries along the east coast of the United States: explaining population outbursts of Atlantic croaker (*Micropogonias undulatus*). Fish Oceanogr, 2007; 16(1), 31-45. doi: 10.1111/j.1365-2419.2006.00407.x

Hare JA, Alexander MA, Fogarty MJ, Williams EH, Scott JD. (2010). Forecasting the dynamics of a coastal fishery species using a coupled climate-population model. Ecol Appl. 2010; 20(2), 452-464. doi: 10.1890/08-1863.1

Munyandorero J. In search of climate effects on Atlantic Croaker (*Micropogonias undulatus*) stock off the U.S. Atlantic coast with Bayesian state-space biomass dynamic models. Fish Bull. 2014; 112:49-70. doi: 10.7755/FB.112.1.4