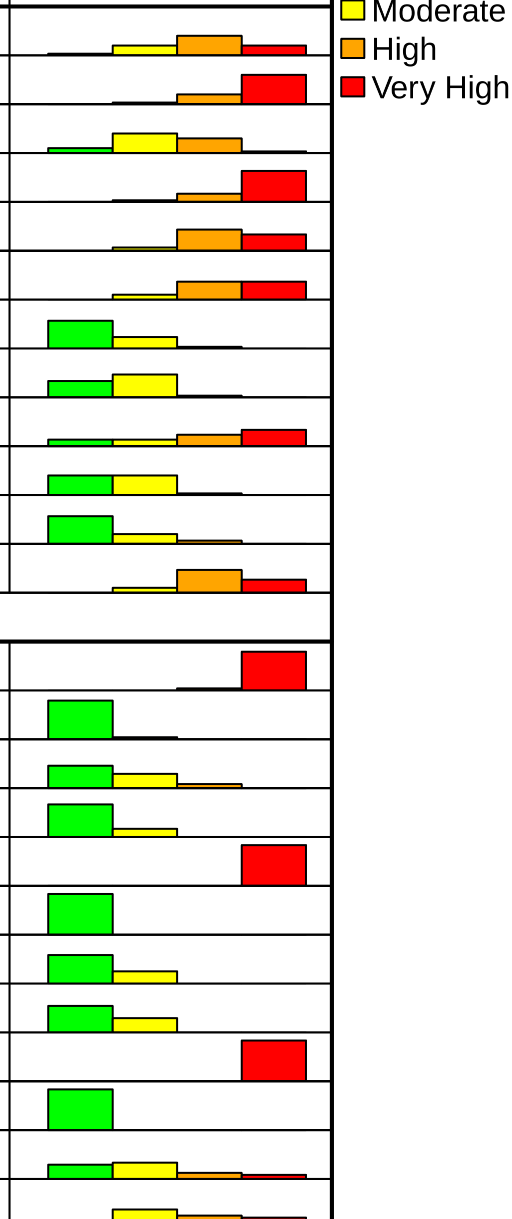
American Shad − *Alosa sapidissima*

Overall Vulnerability Rank = Very High

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

Alosa sapidissima		Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Stock Status	2.9	1.4	
	Other Stressors	3.7	2.0	
	Population Growth Rate	2.3	2.0	
	Spawning Cycle	3.7	2.8	
	Complexity in Reproduction	3.3	2.8	
	Early Life History Requirements	3.3	2.8	
	Sensitivity to Ocean Acidification	1.4	2.0	
	Prey Specialization	1.6	2.5	
	Habitat Specialization	2.9	2.6	
	Sensitivity to Temperature	1.6	3.0	
	Adult Mobility	1.4	2.8	
	Dispersal & Early Life History	3.2	3.0	
	Sensitivity Score	High		
Exposure variables	Sea Surface Temperature	4.0	3.0	
	Variability in Sea Surface Temperature	1.0	3.0	
	Salinity	1.6	3.0	
	Variability Salinity	1.2	3.0	
	Air Temperature	4.0	3.0	
	Variability Air Temperature	1.0	3.0	
	Precipitation	1.3	3.0	
	Variability in Precipitation	1.4	3.0	
	Ocean Acidification	4.0	2.0	
	Variability in Ocean Acidification	1.0	2.2	
	Currents	2.0	1.0	
	Sea Level Rise	2.8	1.5	
	Exposure Score	Very High		
Overall Vulnerability Rank		Very High		



American Shad (*Alosa sapidissima*)

Overall Climate Vulnerability Rank: **Very High** (100% 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). American Shad are anadromous, spawning in freshwater, developing in freshwater and estuarine habitats, feeding as adults in marine habitats.

Biological Sensitivity: **High**. Five sensitivity attributes scored above 3.0: Other Stressors (3.7), Spawning Cycle (3.7), Early Life History Requirements (3.3), Complexity in Reproduction (3.3), and Dispersal and Early Life History (3.2). American Shad are diadromous and exposed to a number of other stressors including habitat destruction, blockage to spawning habitats, and contaminants (Limburg and Waldman, 2009). Spawning time varies latitudinally and is linked to spring warming (Munroe, 2002). Eggs and larvae inhabit freshwaters and then juveniles move to estuarine and ocean waters. Dispersal of eggs and larvae is limited.

Distributional Vulnerability Rank: **Low** (97% certainty from bootstrap analysis). American Shad have a relatively high degree of spawning fidelity, limiting the ability of the species to shift distribution. Fidelity to the river system is high; fidelity to specific tributaries is lower (Walther et al., 2008).

Directional Effect in the Northeast U.S. Shelf: The effect of climate change on American Shad is estimated to be negative, but this estimate has a high degree of uncertainty (<66% certainty in expert scores). American Shad is distributed to Florida, so northward range shifts will likely move American Shad into the Northeast U.S. Shelf. However, changes in rivers from increased precipitation and warming will likely cause decreases in productivity particularly in the southern portion of the Northeast U.S. shelf. 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 indicate that data quality is moderate.

Climate Effects on Abundance and Distribution: A number of studies indicate climate effects on American Shad productivity. Crecco et al. (1986) found that spring river flows affected subsequent recruitment. Castro-Santos and Letcher (2010) developed a simulation model of up-stream migration and spawning and concluded that behavior, physiology, and energetics strongly affected both the distribution of spawning effort and survival to the marine environment. Leach and Houde (1998) found that larval growth and survival is related to temperature. Leggett and Carscadden (1978) concluded that the thermal regime of the home river was the principal factor influencing reproductive strategy in American Shad. These studies indicate that climate effects (e.g., streamflow, temperature) will impact the ecology and productivity of American Shad along the East Coast. Distribution in the marine stage has also changed substantially over the past several decades and a link to climate has been suggested (Nye et al., 2009). The impact of the interaction between distribution changes in the marine phase and strong natal homing is not clear.

Life History Synopsis**:** American Shad is an anadromous, migratory, pelagic, schooling species ranging from southern Labrador to northern Florida with some introductions along the United States Pacific coast (Munroe, 2002; Able and Fahay, 2010). The center of abundance is in the highly urbanized and disturbed section of North America from Connecticut to North Carolina (Able and Fahay, 2010). American Shad take 3-6 years to reach sexual maturity, most of which is spent in the ocean (Able and

Fahay, 2010; ASMFC, 2007). American Shad are semelparous south of Cape Hatteras, but increasing rates of iteroparity occur at increasing latitude (Munroe, 2002). American Shad return to natal rivers in dense schools to batch spawn, a process determined by river temperature and usually occurring in spring (Munroe, 2002; Able and Fahay, 2010). The beginning and cessation of spawning is cued by temperature (12-20 ^oC; Able and Fahay, 2010) and usually occurs well upstream when not impeded by dams (Munroe, 2002). Eggs sink within several meters of the spawning site and often get lodged in bottom substrate (Munroe, 2002). Larvae are planktonic for approximately one month before metamorphosing and feed opportunistically on zooplankton such as copepods, euphausiids, and insect larvae (Munroe, 2002; Able and Fahay, 2010). Juveniles mature in the estuary, feeding on zooplankton (copepods, cladocerans, and insect larvae; Munroe, 2002; Able and Fahay, 2010). Migration to the marine environment is size (75-125 mm) and temperature dependent, with young American Shad emerging from the estuary from late fall to spring (Munroe, 2002; Able and Fahay, 2010). Overwintering usually occurs near the mouth of the parent river (Munroe, 2002). Adult American Shad occur across the continental shelf with seasonal patterns in along-shelf, cross-shelf, and depth distributions (north and deep in fall, south and deep in winter, widely distributed in spring and summer; Munroe, 2002; Able and Fahay, 2010). Adults are opportunistic feeders on zooplankton (copepods, mysids), but consume much less during the spawning run (Munroe, 2002; Able and Fahay, 2010). Many predators consume American Shad, such as Bluefish and Sea Lamprey in rivers and Spiny Dogfish and seals at sea (Munroe, 2002; Able and Fahay, 2010). American Shad are considered fully exploited due to low population sizes caused by fishing and habitat destruction (ASMFC, 2007). Major efforts to improve access to and to restore spawning grounds are helping (Munroe, 2002), but the stocks in general remain depleted (ASMFC, 2014). American Shad are managed by the Atlantic States Marine Fisheries Commission to reduce overfishing and habitat destruction (ASMFC, 2014).

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