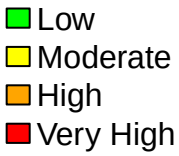
Atlantic Salmon − *Salmo salar*

Overall Vulnerability Rank = Very High

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

	Salmo salar	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Stock Status	3.8	2.4	
	Other Stressors	3.4	2.9	
	Population Growth Rate	1.8	2.4	
	Spawning Cycle	3.5	3.0	
	Complexity in Reproduction	3.5	3.0	
	Early Life History Requirements	3.6	3.0	
	Sensitivity to Ocean Acidification	1.5	1.8	
	Prey Specialization	2.0	2.8	
	Habitat Specialization	2.8	3.0	
	Sensitivity to Temperature	2.8	3.0	
	Adult Mobility	1.5	3.0	
	Dispersal & Early Life History	3.6	3.0	
	Sensitivity Score	Very High		
Exposure variables	Sea Surface Temperature	4.0	3.0	
	Variability in Sea Surface Temperature	1.0	3.0	
	Salinity	1.0	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	2.2	1.0	
	Sea Level Rise	2.8	1.5	
	Exposure Score	Very High		
	Overall Vulnerability Rank	Very High		



Atlantic Salmon (*Salmo salar*)

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). Atlantic Salmon are anadromous, spawning in freshwater, developing in freshwater and estuarine habitats, feeding as adults in marine habitats.

Biological Sensitivity: **Very High**. Five sensitivity attributes scored above 3.5: Stock Status (3.8), Early Life History Requirements (3.6), Dispersal and Early Life History (3.6), Spawning Cycle (3.5), and Complexity in Reproduction (3.5). Atlantic Salmon are diadromous and iteroparous, but few fish survive to repeat spawn. The Gulf of Maine Distinct Population Segment was listed as endangered under the endangered species act in 2000 (FR, 2000). Adults return to natal rivers and spawn in gravel habitats in the fall. Benthic eggs incubate through the winter and larvae are relatively large and dispersal is limited.

Distributional Vulnerability Rank: **Moderate** (87% certainty from bootstrap analysis). Atlantic Salmon have a relatively high degree of spawning fidelity, which limits the ability of the species to shift distribution (Stabell 1984). However, a low degree of straying has been identified (Martin et al., 2012).

Directional Effect in the Northeast U.S. Shelf: The effect of climate change on Atlantic Salmon in the Northeast U.S. Shelf Ecosystem is very likely to be negative (>95% certainty in expert scores). Warming will change freshwater and marine habitats and potentially effect the phenology of Atlantic Salmon migration. Ocean acidification could also affect olfaction, which Atlantic Salmon use for natal homing.

Data Quality: 88% of the data quality scores were 2 or greater indicate that data quality is moderate.

Climate Effects on Abundance and Distribution: In a review, Jonsson and Josson (2009) concluded that the thermal niche of Atlantic Salmon will likely shift northward causing decreased production and possibly extinction at the southern end of the range. The Northeast U.S. Shelf Ecosystem represents the southern extent of the range of Atlantic Salmon in the Northwest Atlantic Ocean. In a more recent review, Friedland et al. (2014) found that declines in post-smolt survival were associated with ocean warming. Friedland et al. (2014) hypothesized that in the Northwest Atlantic, the decline in survival was a result of early ocean migration by post-smolts. Similarly, Mills et al. (2013) suggested that poor trophic conditions, likely due to climate-driven environmental factors, and warmer ocean temperatures are constraining the productivity and recovery of Atlantic Salmon in the Northwest Atlantic. Thus, there is ample evidence that climate change and long-term climate variability will reduce the productivity of Atlantic Salmon in the Northeast U.S. Shelf Ecosystem.

Life History Synopsis**:** Atlantic Salmon is an anadromous species found in rivers and along the coast of both sides of the north Atlantic. Once common from Long Island Sound to northeastern Labrador in the western Atlantic, the distribution of Atlantic Salmon on both sides of the Atlantic has been greatly reduced due to human activity and habitat degradation (Kocik and Friedland, 2002; Fay et al., 2006). Atlantic Salmon are sexually mature after 1-3 years at sea, but the spawning population is predominantly made up of fish that have experienced 2 winters at sea (Kocik and Friedland, 2002; USASAC, 2004). Starting in spring, Atlantic Salmon return to their natal river; the homing instinct is very strong with >90% site fidelity (NRC, 2003; USASAC, 2004). Spawning occurs from October – November (Fay et al., 2006). Females lay eggs in shallow gravel nests, called redds; bury the eggs under gravel after

fertilization; then return to the ocean or overwinter in the river (Fay et al., 2006). Atlantic Salmon are iteroperous, but very few survive to repeat spawn (Kocik and Friedland, 2002; USASAC, 2004). Eggs incubate in the nest for approximately 6 months before hatching in the spring (Fay et al., 2006). The newly hatched alevin, remain buried in the nest till their yolk is absorbed (3 – 6 weeks), then emerge as independently feeding fry (Fay et al., 2006). Fry prefer shallow, low velocity, gravel substrate and feed opportunistically on zooplankton (Nislow et al., 1999). Once fry develop vertical bars of pigment, they are referred to as parr, which remain in the river for 1-3 years (Kocik and Friedland, 2002; USASAC, 2004). Parr consume invertebrates, such as larval insects and molluscs, and small fish (Scott and Crossman, 1973; Baum, 1997; Nislow et al., 1999). American Eel and Brook Trout are the main predators of young Atlantic Salmon (Fay et al., 2006). Parr mature, changing physiologically, into smolts, which enter salt water in spring and continue to mature, now called postsmolts, for 1-3 years in the ocean before becoming sexually mature (Fay et al., 2006). Oceanic postsmolts are opportunistic, surface feeders consuming invertebrates, insects, amphipods, euphausiids, gammarids, and fishes (Kocik and Friedland, 2002). Opportunistic predators, such as gadids, Silver Hake, and several sea birds, include postsmolt Atlantic Salmon in their diet (Kocik and Friedland, 2002). Atlantic Salmon mature to adulthood in ocean waters north of Newfoundland (Kocik and Friedland, 2002). Fish are the primary prey of adults, including Atlantic Herring, Capelin, small Atlantic Mackerel, Haddock, and some flatfishes (Kocik and Friedland, 2002; Mills et al., 2013). As adults, the only threats come from large fish such as tuna, Swordfish, large sharks, and seals (Kocik and Friedland, 2002). The U.S. Fish and Wildlife Service and National Marine Fisheries Service list several Atlantic Salmon populations as endangered distinct population segments under the federal Endangered Species Act since 2000 (FR, 2000; 2009; NRC, 2004). Farming of Atlantic Salmon has alleviated the fishing pressure on wild Atlantic Salmon populations, but may also have negative effects on the wild population by introducing disease and through genetic interactions (Kocik and Friedland, 2002).

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