Blue Mussel − *Mytilus edulis*

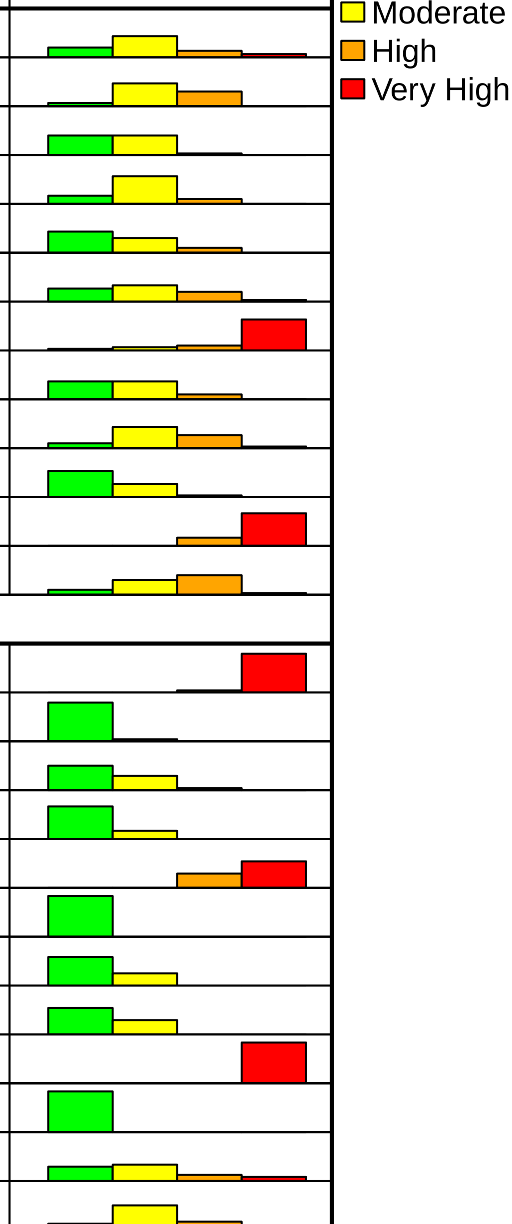
Overall Vulnerability Rank = Very High

Biological Sensitivity = High

Climate Exposure = Very High

Data Quality = 88% of scores ≥ 2

	Mytilus edulis	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Stock Status	2.1	0.8	
	Other Stressors	2.3	2.0	
	Population Growth Rate	1.6	2.1	
	Spawning Cycle	1.9	2.7	
	Complexity in Reproduction	1.6	2.8	
	Early Life History Requirements	2.0	2.8	
	Sensitivity to Ocean Acidification	3.6	2.2	
	Prey Specialization	1.7	3.0	
	Habitat Specialization	2.3	3.0	
	Sensitivity to Temperature	1.4	2.9	
	Adult Mobility	3.8	3.0	
	Dispersal & Early Life History	2.4	2.8	
	Sensitivity Score	High		
Exposure variables	Sea Surface Temperature	4.0	3.0	
	Variability in Sea Surface Temperature	1.0	3.0	
	Salinity	1.4	3.0	
	Variability Salinity	1.2	3.0	
	Air Temperature	3.6	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	2.1	1.5	
	Exposure Score	Very High		
Overall Vulnerability Rank		Very High		



Blue Mussel (*Mytilus edulis*)

Overall Climate Vulnerability Rank: **Very High** (95% certainty from bootstrap analysis).

Climate Exposure: **Very High**. Three exposure factors contributed to this score: Ocean Surface Temperature (4.0), Air Temperature (3.6) and Ocean Acidification (4.0). Blue Mussels use intertidal, nearshore and marine habitats through their life cycle.

Biological Sensitivity: **High**. Two sensitivity attributes scored above 3.0: Sensitivity to Ocean Acidification (3.6) and Adult Mobility (3.8). Adults have a calcium carbonate shell and are sessile.

Distributional Vulnerability Rank: **Moderate** (61% certainty from bootstrap analysis).

Directional Effect in the Northeast U.S. Shelf: The effect of climate change on Blue Mussel on the Northeast U.S. Shelf is very likely to be negative (>95% certainty in expert scores). Ocean acidification will likely negatively impact molluscs, including Blue Mussel. Warming may cause continued shifts northward and may reduce productivity in the southern part of the ecosystem.

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

Climate Effects on Abundance and Distribution: Blue Mussel are sensitive to heat shock, and along the East Coast of the U.S. large mortality events are associated with high summer temperatures; as a result, distributions have contracted ~350 km to the north since 1960 (Jones et al., 2010). Blue Mussel have also been found recently in the Arctic and this northward range extension was associated with warming temperature and change in circulation patterns (Berge et al., 2005). Blue Mussel adults exhibited no trend in calcification rate in response to changing aragonite saturation state (Ries et al., 2009) and in naturally low pH systems, adult shell growth is similar to control sites. However, shell growth of Blue Mussel larvae is lower at lower pHs (Gazeau et al., 2010). These results point to the complexity of understanding the effect of ocean acidification on marine species.

Life History Synopsis**:** Blue Mussel is a boreo-temperate, semi-sessile, epibenthic bivalve species found in the Arctic, North Pacific, and North Atlantic Oceans. In the western North Atlantic, Blue Mussels are found from Labrador to Cape Hatteras, North Carolina (Newell, 1989). Generally dioecious, although there have been examples of hermaphrodites, Blue Mussel mature at age 1 but can delay maturity if growing conditions have been poor (Newell, 1989). The timing of the reproductive cycle depends on food availability and environmental conditions, so spawning usually occurs in spring and summer, but is actually quite variable in areas where phytoplankton availability is less predictable (Newell, 1989). Spawning can be postponed at any point during gametogenesis if conditions are not right for survival of the larvae or the adult is under stress (Newell, 1989). Fertilization occurs in the water column where males release gametes first, triggering egg release (Newell, 1989). Spawning occurs in either two large batches or a slow dribble, and hundreds of thousands of eggs are produced (Newell, 1989). Eggs hatch in 5 hours post fertilization in 18^{o}C water (Newell, 1989). A ciliated embryo emerges from the egg and develops into the trochophore larvae within 24 hours (Newell, 1989). Trochophore larvae are ciliated and motile, but non-feeding (Newell, 1989). The veliger larval stage lasts up to 35 days and is characterized by the use of a ciliated velum to feed and for locomotion (Newell, 1989). This stage is characterized by the development of the shell, pigmented eyespots, and the foot (Newell, 1989). The veliger larva can move vertically in the water column in response to salinity and may use vertical distribution and currents to move horizontally (Newell, 1989). During these pelagic stages, grazing predators such as jellyfish and larval and adult fishes regularly consume larval Blue Mussels (Newell, 1989). The final larval stage, the pediveliger, uses the foot to explore for filamentous substrate (such as algae or hydroids) suitable for attachment, then hangs on and transforms into the juvenile form; this early attached life stage is known as plantigrade (Newell, 1989). Juvenile Blue Mussels remain attached to filamentous substrate until 1-1.5 mm shell length is reached (Newell, 1989). After detachment, the Blue Mussel drifts near the bottom until it finds other Blue Mussels, and then reattaches with byssal threads to the substrate or other Blue Mussel shells (Newell, 1989). Only strong predators able to break hard shells consume Blue Mussels, including large starfish, crustaceans, and some birds (Newell, 1989). Adult Blue Mussels occur from the coastal ocean to polyhaline and mesohaline estuarine environments, but can also colonize deeper and cooler waters as far south as Charleston, South Carolina (Newell, 1989). Blue Mussels anchor to the substrate or to other Blue Mussel shells with byssal thread secreted from the foot, but can adjust their position by shortening, lengthening, or replacing byssal threads (Newell, 1989). This species can tolerate a range of temperature, salinity, wave action, and air exposure, the upper and lower limits of which are influenced by previous exposure (e.g., estuarine populations can tolerate lower salinity water than oceanic populations) and have been shown capable of adapting phenotypically to changes in predation pressure (Newell, 1989; Leonard et al., 1999). Mussels are suspension feeders, primarily of phytoplankton, but detritus and attached bacteria may also be digested (Newell, 1989). Birds, crustaceans, starfish, and various fish including Tautog and Cunner are common predators (Newell, 1989). Since most Blue Mussel predators are marine species, the estuaries may provide a refuge (Newell, 1989). Blue Mussels are particularly well suited for mariculture, and have been farmed for decades in Europe, and are increasingly farmed in Canada and the United States (FAO, 2015; GARFO, 2014).

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