Sand Lances − *Ammodytes spp.*

Overall Vulnerability Rank = Moderate

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

	Ammodytes spp.	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Stock Status	1.7	1.2	
	Other Stressors	2.0	2.0	
	Population Growth Rate	1.4	2.8	
	Spawning Cycle	2.7	2.4	
	Complexity in Reproduction	1.7	2.2	
	Early Life History Requirements	2.3	2.0	
	Sensitivity to Ocean Acidification	1.4	2.4	
	Prey Specialization	1.3	2.5	
	Habitat Specialization	2.0	2.6	
	Sensitivity to Temperature	2.5	2.4	
	Adult Mobility	2.8	2.4	
	Dispersal & Early Life History	1.6	2.6	
	Sensitivity Score	Moderate		
Exposure variables	Sea Surface Temperature	4.0	3.0	
	Variability in Sea Surface Temperature	1.0	3.0	
	Salinity	1.8	3.0	
	Variability Salinity	1.2	3.0	
	Air Temperature	2.7	3.0	
	Variability Air Temperature	1.0	3.0	
	Precipitation	1.1	3.0	
	Variability in Precipitation	1.1	3.0	
	Ocean Acidification	4.0	2.0	
	Variability in Ocean Acidification	1.0	2.2	
	Currents	2.2	1.0	
	Sea Level Rise	2.7	1.5	
	Exposure Score	High		
	Overall Vulnerability Rank	Moderate		

Low
Moderate
High
Very High

Sand Lances (*Ammodytes americanus / Ammodytes dubius*)

Overall Climate Vulnerability Rank: **Moderate** (97% certainty from bootstrap analysis).

Climate Exposure: **High**. Two exposure factors contributed to this score: Ocean Surface Temperature (4.0) and Ocean Acidification (4.0). Exposure to ocean surface temperature and ocean acidification occurs during all life stages.

Biological Sensitivity: **Moderate**. The highest sensitivity attributes were Adult Mobility (2.8), Spawning Cycle (2.7), and Sensitivity to Temperature (2.5). Sand Lances are associated with sandy habitats where they seek shelter and overwinter in the sand (aestivation) (Wright et al., 2000). This association with sandy habitats limits adult mobility. Sand Lance spawn in a distinct season: late winter/early spring and the cycle of feeding, aestivation, and spawning is related to temperature (Tomiyama and Yanagibahi, 2004).

Distributional Vulnerability Rank: **Moderate** (45% certainty from bootstrap analysis). Only one attribute indicated vulnerability to distribution shift: Sand Lance have dispersive early life history stages. A shift in distribution is limited by restricted adult mobility, specific requirements of adults for sand habitats of specific grain sizes, and a moderate sensitivity in the timing of the life cycle to temperature.

Directional Effect in the Northeast U.S. Shelf: The effect of climate change on Sand Lance on the Northeast U.S. Shelf is estimated to be negative, but this estimate is uncertain (66-90% certainty in expert scores). Higher temperatures may decrease productivity and limit habitat availability for Sand Lance. But Sand Lance require specific habitat types defined by grained size creating uncertainty as to the effect of climate change on adult distributions.

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

Climate Effects on Abundance and Distribution: In the Northeast Atlantic, Sand Lances are identified as particularly at risk from climate change owing to the strict association with coarse sandy sediments; which in some regions represents limited habitat (Heath et al., 2012). Further, Arnott and Ruxton (2002) found a negative correlation between warmer sea temperatures and recruitment. Wanless et al. (2000) suggested that changing environmental conditions may have contributed to the long-term decline in size of age-0 in the North Sea. They hypothesize that changes in spawning time and or growth could have resulted in the decrease in size. These studies suggest a potential effect of climate change on population productivity. In the Northwest Atlantic, Richardson et al. (2014) documents an alternation between Atlantic Herring and Sand Lances; the cause of this alternation is uncertain.

Life History Synopsis**:** Sand Lance are schooling and burrowing fish species found along the Atlantic continental shelf. There are two species of Sand Lance in the northwest Atlantic from Greenland to Cape Hatteras, North Carolina, that are so morphologically similar that they are rarely identified to species (Nizinski, 2002). Sand Lance mature at 2 years of age, and spawn in late fall through early spring over sandy bottom across the shelf (Nizinski, 2002). The cross-shelf range of spawning habitat is likely species specific (an inshore species and an offshore species), but the exact spawning locations of either species are poorly known (Able and Fahay, 2010). Eggs are demersal and adhesive and probably have a long incubation period of 1-2 months (Nizinski, 2002). Inter-annual abundance of larvae entering New Jersey estuaries varied little over almost 2 decades of sampling (Able and Fahay, 2010). Larvae are widespread during winter and spring on the shelf and into estuaries consuming mostly phytoplankton

and copepods (Nizinski, 2002; Able and Fahay, 2010). Larvae begin schooling 3 months after hatching and are fully metamorphosed and begin burrowing after 4-5 months (Able and Fahay, 2010). As larvae mature they include a more diverse group of invertebrates in their diet, including copepods, crabs, cirripedes, bivalves, gastropods, cnidarians, mysid shrimp, decapod shrimp, cladocerans, phytoplankton, and occasional fish (Able and Fahay, 2010). Juvenile and adult Sand Lance burrow into sandy substrates of very shallow coastal to deep shelf waters (Able and Fahay, 2010). *Ammodytes americanus* usually occurs farther inshore and into estuaries than *A. dubius*, but there is considerable overlap and an obligatory association with sand habitat (Nizinski, 2002; Richardson et al., 2014). The primary predators of Sand Lance are terns, cormorant, and a variety of fishes, including: Little Skate, Monkfish (Goosefish), Atlantic Cod, Haddock, Atlantic Halibut, Silver Hake, Red Hake, Atlantic Salmon, Atlantic Mackerel, Striped Bass, Bluefish, Pollock, American Plaice, Yellowtail Flounder, and Gulf Stream Flounder (Nizinski, 2002). Sand Lance are not currently managed in United States waters, but oscillations between Sand Lance and Atlantic Herring abundance and their link to Atlantic Cod distributions may make them an important part of an ecosystem-based management plan (Richardson et al., 2014). Sand Lance are heavily exploited in other regions of the world (Furness 2002) but are not currently exploited in the Northeast U.S. Shelf.

Literature Cited:

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

Arnott SA, Ruxton GD. Sandeel recruitment in the North Sea: demographic, climatic and trophic effects. Mar Ecol Prog Ser. 2002; 238: 199-210. doi: 10.3354/meps238199

Furness RW. Management implications of interactions between fisheries and sandeel-dependent seabirds and seals in the North Sea. ICES J Mar Sci. 2002; 59(2): 261-269. doi: 10.1006/jmsc.2001.1155

Heath MR, Neat FC, Pinnegar JK, Reid DG, Sims DW, Wright PJ. Review of climate change impacts on marine fish and shellfish around the UK and Ireland. Aquatic Conservation: Marine and Freshwater Ecosystems, 2012; 22(3): 337-367. doi: 10.1002/aqc.2244

Nizinski MS. Sand Lances. Family Ammodytidae. In: B.B. Collette BB, Klein-MacPhee G, editors, Fishes of the Gulf of Maine, 3rd ed. Washington: Smithsonian Institution Press; 2002. pp. 496-505.

Richardson, DE, Palmer MC, Smith BE. The influence of forage fish abundance on the aggregation of Gulf of Maine Atlantic cod (*Gadus morhua*) and their catchability in the fishery. Can J Fish Aquat Sci. 2014; 71: 1349-1362. doi: 10.1139/cjfas-2013-0489

Tomiyama M, Yanagibashi S. Effect of temperature, age class, and growth on induction of aestivation in Japanese sandeel (*Ammodytes personatus*) in Ise Bay, central Japan. Fish Oceanogr. 2004; 13(2): 81-90. doi: 10.1046/j.1365-2419.2003.00272.x

Wanless S, Wright PJ, Harris MP, Elston DA. Evidence for decrease in size of lesser sandeels *Ammodytes marinus* in a North Sea aggregation over a 30-yr period. Mar Ecol Prog Ser. 2004; 279: 237-246. doi: 10.3354/meps279237

Wright PJ, Jensen H, Tuck I. The influence of sediment type on the distribution of the lesser sandeel, *Ammodytes marinus*. J Sea Res. 2000; 44(3): 243-256. doi: 10.1016/S1385-1101(00)00050-2