Water Temperature Effects on Fisheries and their Habitats in Tidal Bay Waters and Management Considerations

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About the NOAA Climate Vulnerability Species Assessment

Climate Vulnerability Assessment Process

1. Scoping and Planning
- Define Study Area
- Identify Species to Include
- Define Climate Exposure Factors
- Define Sensitivity Attributes
- Identify Participants

2. Assessment Preparation
- Species Profiles
- Climate Projections
- Species Distributions

3. Scoring
- Climate Exposure
- Sensitivity Attributes
- Expert Certainty
- Directional Effect
- Data Quality

4. Analyses
- Estimate of Overall Vulnerability
- Certainty in Vulnerability
- Potential for Distribution Shift
- Importance of Climate Exposure Factors and Sensitivity Attributes
- Functional Group Evaluation
- Species Narratives

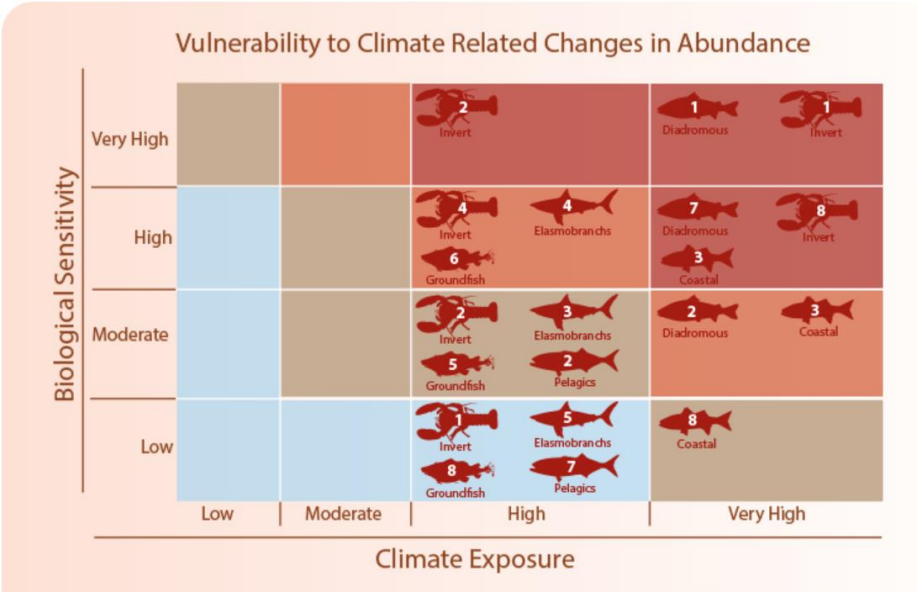
Overall Vulnerability Rank = Very High

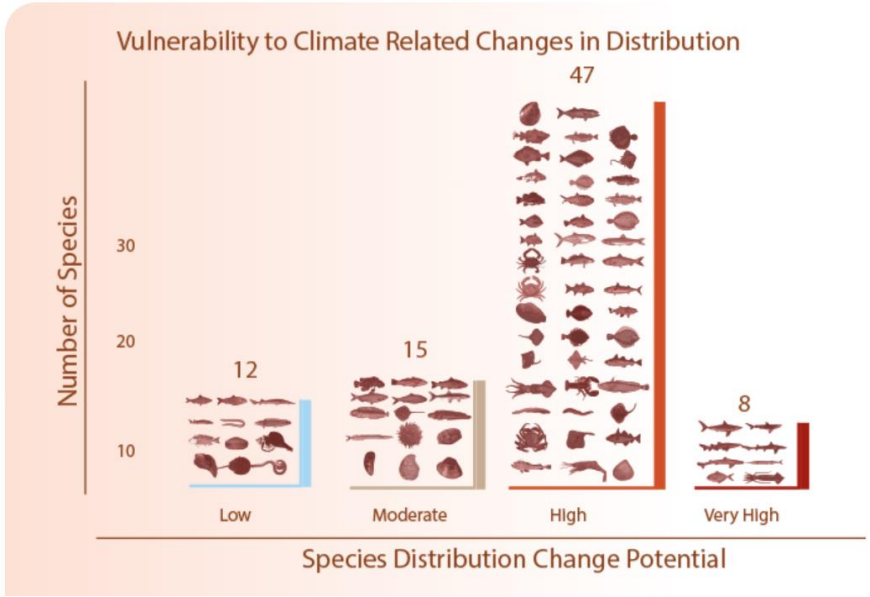
Biological Sensitivity = High
Climate Exposure = Very High
Data Quality = 92% of scores ≥ 2

	Callinectes sapidus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Stock Status	2.8	2.0	
	Other Stressors	3.0	2.4	
	Population Growth Rate	1.2	3.0	
	Spawning Cycle	2.2	3.0	
	Complexity in Reproduction	3.0	2.8	
	Early Life History Requirements	2.8	2.8	
	Sensitivity to Ocean Acidification	1.6	2.6	
	Prey Specialization	1.1	2.8	
	Habitat Specialization	2.4	3.0	
	Sensitivity to Temperature	1.6	3.0	
	Adult Mobility	1.7	2.8	
	Dispersal & Early Life History	1.6	3.0	
	Sensitivity Score	High		
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	1.3	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	2.7	1.5	
	Exposure Score	Very High		
	Overall Vulnerability Rank	Very High		

Low
Moderate
High
Very High

Vulnerability in Abundance and Distribution





Blue Crab

- Climate Vulnerability: Very High
- Temperature Sensitivity: Moderate
- Anticipated Distributional Shifts:
  - Neutral, but with a moderate degree of uncertainty (66-90% certainty in expert scores).
  - Warming may lead to increased productivity and northward shifts in the region, both of which would represent positive effects of climate change
- Temperature Impacts:
  - Warmer winters should lead to higher survival and increases in population productivity
  - Predation and cannibalism on juveniles is also higher during warm seasons; therefore the juvenile portion of the population might also be negatively impacted by the extended warm temperatures predicted. (MD Sea Grant EBFM)
- Key Habitats of Interest:
  - Estuarine SAV, estuarine marsh, estuarine water column

Eastern Oyster

- Climate Vulnerability: Very High
- Temperature Sensitivity: Low
- Anticipated Distributional Shifts:
  - The effect of climate change on Eastern Oyster on the Northeast U.S. Shelf is very likely to be negative
- Key Temperature Information:
  - Larvae do not tolerate high temperatures and have a narrower salinity tolerance range than adults (Sellers and Stanley, 1984; EOBRT, 2007).
- Key Habitats of Interest:
  - Estuarine shellfish reef, estuarine water column

Striped Bass

- Climate Vulnerability: Very High
- Temperature Sensitivity: Low/Moderate
- Anticipated Distributional Shifts:
  - Increasing temperatures could reduce habitat in the southern part of the Northeast U.S. Shelf while increasing habitat in the northern portions.

- Key Temperature Information:
  - Increasing summer temperatures result in a reduction of habitat in Chesapeake Bay. (Coutant and Benson, 1990)
  - ”Warming of the Chesapeake Bay will likely result in a more rapid spring to summer transition, and a reduction of the period when temperatures are most favorable for larval survival” (Secour and Houde, 1995)
  - Winter warming could also promote year-round residency, and reduce overwinter juvenile mortality leading to increased pressure on the forage species targeted by striped bass. (MD Sea Grant EBFM)

- Key Habitats of Interest:
  - Estuarine shellfish reef, estuarine water column

Summer Flounder

- Climate Vulnerability: Moderate
- Temperature Sensitivity: Low
- Anticipated Distributional Shifts:
  - The effect of climate change on Summer Flounder on the Northeast U.S. Shelf is estimated to be neutral but with high uncertainty (<66% certainty in expert scores).

- Key Temperature Information:
  - Recent changes in Summer Flounder distribution also have been identified and linked to climate (Pinsky et al 2013), but Bell et al. (2014) presented evidence that changes in Summer Flounder distribution were linked to reductions in fishing and expanding population rather than changes in temperature. Murawski (1993) also documented changes in Summer Flounder distribution related to abundance and not temperature.

- Key Habitats of Interest:
  - Estuarine SAV, marsh, water column

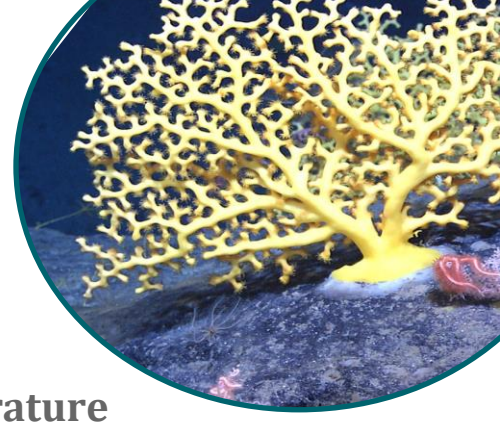
Forage Species (Pelagic Finfish)

- Bay anchovy
  - Climate Vulnerability: Low
  - Temperature Sensitivity: Low
  - Anticipated Distributional Shifts:
    - The effect of climate change on **anchovies** on the Northeast U.S. Shelf is very likely to be positive (>95% certainty in expert scores). As warming continues more habitat in the Northeast U.S. is expected to become available.

- Atlantic Menhaden
  - Climate Vulnerability: Low
  - Temperature Sensitivity: Moderate
  - Anticipated Distributional Shifts:
    - The effect of climate change on **Atlantic Menhaden** on the Northeast U.S. Shelf is very likely to be positive (90-95% certainty in expert scores). Recruitment will likely increase as temperature warm and more spawning occurs in the region.

- Key Temperature Information:
  - Rising temperatures have had a negligible impact on anchovy and menhaden stocks in recent years. There are fair assumptions that increasing temperatures will increase distribution further northward.
  - The rate of springtime warming, i.e. how quickly water temperatures rise in the spring, is a primary driver of forage fish abundance. Faster (earlier) springtime warming leads to decreased abundance of forage fishes.
- Key Habitats of Interest:
  - Estuarine water column

Habitat Climate Vulnerability Assessment



Sensitivity

- Habitat condition
- Habitat fragmentation
- Distribution/range
- Ability to spread or disperse
- Resilience
- Resistance
- **Changes in abiotic factors**
- Non-climate stressors
- Critical ecological linkages

Exposure

- **Sea surface temperature**
- **Bottom temperature**
- **Air temperature**
- **Stream temperature**
- Salinity (surface & bottom)
- pH
- Precipitation
- Streamflow
- Sea level rise

Habitat Vulnerability

Salt Marsh

Habitat Name (Vulnerability Rank)	Species	Importance of habitat by life stage (ACFHP)				Species Vulnerability Rank (FCVA)
		Eggs/Larva	Juvenile/YOY	Adult	Spawning Adult	
Estuarine Emergent Wetland (Very High)	Striped bass		Moderate	Moderate		Very high
	Blue crab		High	High		Very high
	Summer flounder		High	Moderate		Moderate
	Winter flounder	High	Moderate		High	Very high

- Increase in temperature may lead to increased photosynthetic rates, plant biomass, production of soil organic matter, changes in salt marsh community composition
- Increased temperature may influence the marsh platform (changing decay rate)
- Invasive marsh species may benefit from increasing temperatures

Submerged Aquatic Vegetation

Habitat Name (Vulnerability Rank)	Species	Importance of habitat by life stage (ACFHP)				Species Vulnerability Rank (FCVA)
		Eggs/Larva	Juvenile/YOY	Adult	Spawning Adult	
Estuarine submerged aquatic vegetation (High)	Striped bass		Moderate	Moderate		Very high
	Black sea bass		High			High
	Blue crab	Very high	Very high			Very high
	Summer flounder		High	Moderate		Moderate

- Increased water temperature may decrease productivity and distribution of eelgrass (primary production reduced above 23℃, growth reduced above 25℃)
- May impact timing of flowering and seed production
- Greater survival of invasive species with negative impacts on SAV
- Meadows with higher genetic diversity proven more resilient to extended heat waves

Shellfish Reef

Habitat Name (Vulnerability Rank)	Species	Importance of habitat by life stage (ACFHP)				Species Vulnerability Rank (FCVA)
		Eggs/Larva	Juvenile/YOY	Adult	Spawning Adult	
Estuarine intertidal shellfish reef (Very High)	Black sea bass		High	High		High
	Blue crab	Moderate	Moderate	Moderate		Very high
	Summer flounder		Moderate			Moderate
	Menhaden			Low		Moderate
Estuarine subtidal shellfish reef (High)						

- Oyster growth/reproduction rates peak 20-30℃, can live in temperatures up to 36℃
- Possible that max temperature thresholds for one or more life stages may be exceeded by end of the century
- Warming air/water temperatures can increase susceptibility to disease, parasites, predation
- Hypoxia due to warming coupled with eutrophication

Existing Information Gaps

- Need for finer resolution (bay-specific) models and spatial products (habitat impacts, climate change, etc.)
- Better quantifying links between climate change/temperature increases and species decline
- Identifying species-specific temperature thresholds

Science to Management Approaches

- Climate Science Strategy
- Ecosystem Based Fisheries Management Roadmap