Atlantic Highly Migratory Species Climate Vulnerability Assessment

HMS Advisory Panel Meeting

September 8, 2022
Administrative Interest in Climate Change

• National Climate Task Force
• Climate Resilience Funding - Building Resilient Infrastructure and Communities (BRIC), Flood Mitigation Assistance, Inflation Reduction Act, Bipartisan Infrastructure Law, Justice40 Initiative, etc.
• E.O. 14008, “Tackling the Climate Crisis at Home and Abroad” (January 27, 2021) – also E.O. 14057, 13990, 13985, 12898
• EPA Guidance on Incorporating Climate Change and Environmental Justice in NEPA (April 26, 2022)
• Executive Action on Climate to Address Extreme Heat and Offshore Wind (July 20, 2022)
NOAA Fisheries Climate Science Strategy

• Published in 2015
• Increase the production, delivery, and use of climate-related information needed to fulfill NOAA Fisheries mandates.
• Implemented through regional action plans (RAPs) that identify priority needs and actions.
NOAA Fisheries
Climate
Ecosystems and Fisheries Initiative

https://bit.ly/3R5hV6n
HMS Engagement with Ongoing Climate Initiatives

• Climate Regional Action Plans
  o Southeast
  o Northeast
• East Coast Climate Change Scenario Planning
• Northeast State of the Ecosystem Reports
• Atlantic HMS Ecosystem Based Fishery Management (EBFM) Plan Implementation
• Climate Vulnerability Assessments (CVAs): fish species, habitats, protected resources, fishing communities
Climate Vulnerability Assessments

- Widely used in terrestrial systems, but until recently only a few examples from marine systems
- Uses currently existing knowledge and expert opinion
- Uses quantitative data when available, and qualitative information when data are lacking

**Exposure**
- Sea surface temperature
- Air temperature
- Salinity
- Ocean acidification
- Precipitation
- Currents
- Sea level rise

**Sensitivity**
- Early life stage dispersal, survival, settlement
- Habitat and prey specificity
- Adult mobility
- pH and thermal preferences
- Population Growth Rate
- Stock Size/Status

**Species Vulnerability**

**Inform science and management actions**
Existing Fish Stock CVAs

- **Northeast** – completed 2016
- Pacific salmon – completed July 2019
- Bering Sea – completed September 2019
- Pacific Islands – completed 2022
- **South Atlantic** – in progress
- **Gulf of Mexico** – in progress
- West Coast – in progress
Existing Fish Stock CVAs

- Northeast
- South Atlantic
- Gulf of Mexico

Dusky
Porbeagle
Sand Tiger
Smooth Dogfish

n = 4 Atlantic HMS
Existing Fish Stock CVAs

- Northeast
- South Atlantic
- Gulf of Mexico

Dusky
Sandbar
Bonnethead
Sand Tiger
Atlantic Sharpnose

n = 5 Atlantic HMS
Existing Fish Stock CVAs

- Northeast
- South Atlantic
- Gulf of Mexico

Atlantic Sharpnose
Blacknose
Blacktip
Bonnethead
Great Hammerhead
Scalloped Hammerhead
Lemon
Nurse
Sandbar
Tiger
Dusky
Finetooth

n = 12 Atlantic HMS
Existing Fish Stock CVAs

- Northeast
- South Atlantic
- Gulf of Mexico
- Need a more comprehensive HMS CVA
  - Include all sharks over full range in EEZ, if appropriate
  - Add tunas, billfish, swordfish
  - Add U.S. Caribbean
Erauskin-Extramiana et al. 2019

• Analyzed global distribution of tuna species and associated habitats between 1958-2004
• Suitable habitat for 20 of 22 analyzed stocks has shifted poleward
• Habitat distribution limits have shifted 6.5km/decade in the northern hemisphere
• Significant northward trend for Western Atlantic BFT and West Atlantic Skipjack Tuna habitats
• Poleward shift in mean location of all albacore tuna stock habitats
• 20% of latitudinal change related to climate indices (e.g., North Atlantic oscillation)
Climate Change Impacts on Atlantic HMS

Adapted from Erauskin-Extramiana et al. 2019
Climate Change Impacts on Atlantic HMS

Adapted from Erauskin-Extramiana et al. 2019
How are CVAs Conducted?

- **Project Scoping**: Oct – Dec 2022
- **Climate Change Exposure**: Jul 2022 – Mar 2023
- **Assessment, Outputs**: July 2023 – July 2024

- **Info gathering**: essential fish habitat
  - Dec 2022 – Jan 2023

- **Info gathering**: species life history
  - Apr – July 2023

- **Sensitivity Scoring**
Project Scoping & Core Team

HMS leading with support from Office of Science and Technology, Science Centers, Regional Offices

Defining our CVA

- Data sources (Essential Fish Habitat (EFH))
- Spatial boundaries (US EEZ or entire NW Atlantic?)
- Temporal scale (gradients, end of century)
- Exposure factors (temp, chemistry, more)
- Selecting experts
Information Gathering:

Species-specific profiles

• Summary of life history characteristics
• Inform expert scoring of vulnerability attributes
• Leverage existing efforts
  o EFH 5-Year Review
Climate Change Exposure
Jul 2022 – Mar 2023

EFH for Adult Swordfish

Projecting sea surface temperature anomaly

2017 EFH

Exposure
Sensitivity Scoring:

Multi-step process involving experts

• Training/orientation webinar
• Experts rank vulnerability individually
• Workshop to discuss scores
• Opportunity to re-rank
Project Outcomes: Species Narratives

- Critical communication tool
- Show overall vulnerability, exposure and sensitivity scores
- Can be used to summarize a lot of other information – distribution of tallies, data quality scores, uncertainty in scores, potential for distribution change, directional effect (e.g., Hare et al. 2016)
- Summary of identified climate effects on species
- Synopsis of life history
### Dusky Shark - Carcharhinus obscurus

**Overall Vulnerability Rank = High**

**Biological Sensitivity = High**

**Climate Exposure = High**

**Data Quality = 88% of scores ≥ 2**

#### Table: Carcharhinus obscurus

<table>
<thead>
<tr>
<th>Sensitivity Attributes</th>
<th>Expert Scores</th>
<th>Data Quality</th>
<th>Expert Scores Plots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock Status</td>
<td>3.9</td>
<td>2.4</td>
<td>Low</td>
</tr>
<tr>
<td>Other Stressors</td>
<td>1.8</td>
<td>2.2</td>
<td>Moderate</td>
</tr>
<tr>
<td>Population Growth Rate</td>
<td>4.0</td>
<td>3.0</td>
<td>High</td>
</tr>
<tr>
<td>Spawning Cycle</td>
<td>2.2</td>
<td>2.2</td>
<td>Very High</td>
</tr>
<tr>
<td>Complexity in Reproduction</td>
<td>1.5</td>
<td>1.2</td>
<td>High</td>
</tr>
<tr>
<td>Early Life History Requirements</td>
<td>1.0</td>
<td>2.6</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Sensitivity to Ocean Acidification</td>
<td>1.0</td>
<td>2.6</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Prey Specialization</td>
<td>1.1</td>
<td>2.8</td>
<td>High</td>
</tr>
<tr>
<td>Habitat Specialization</td>
<td>1.1</td>
<td>3.0</td>
<td>Very High</td>
</tr>
<tr>
<td>Sensitivity to Temperature</td>
<td>1.1</td>
<td>3.0</td>
<td>Very High</td>
</tr>
<tr>
<td>Adult Mobility</td>
<td>1.0</td>
<td>3.0</td>
<td>Very High</td>
</tr>
<tr>
<td>Dispersal &amp; Early Life History</td>
<td>1.2</td>
<td>3.0</td>
<td>Very High</td>
</tr>
</tbody>
</table>

**Sensitivity Score: High**

- **Sea Surface Temperature**: 3.9 (3.0)
- **Variability in Sea Surface Temperature**: 1.0 (3.0)
- **Salinity**: 2.8 (3.0)
- **Variability in Salinity**: 1.2 (3.0)
- **Air Temperature**: 1.0 (3.0)
- **Variability in Air Temperature**: 1.0 (3.0)
- **Precipitation**: 1.0 (3.0)
- **Variability in Precipitation**: 1.0 (3.0)
- **Ocean Acidification**: 4.0 (2.0)
- **Variability in Ocean Acidification**: 1.0 (2.2)
- **Currents**: 2.1 (1.0)
- **Sea Level Rise**: 1.1 (1.5)

**Exposure Score: High**

**Overall Vulnerability Rank: High**

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**Dusky Shark (Carcharhinus obscurus)**

- **Overall Climate Vulnerability Rank: High** (100% certainty from bootstrap analysis).

- **Climate Exposure**: High. Two exposure factors contributed to this score: Ocean Surface Temperature (3.9) and Ocean Acidification (4.0). Dusky Shark is pelagic and complete their life cycle in marine habitats.

- **Biological Sensitivity**: High. Two attributes scored above 3.0: Population Growth Rate (4.0) and Stock Status (3.9). Dusky Shark have low population growth rates (Cortés 1998). Dusky Shark is listed as vulnerable by the IUCN owing to low population abundance (http://www.iucnredlist.org/details/385270). Dusky Shark is identified as a Species of Concern in the Western Atlantic by the U.S. (http://www.nmfs.noaa.gov/pr/pdfs/species/duskyshark_detailed.pdf).

- **Distributional Vulnerability Rank: Very High** (99% certainty from bootstrap analysis). Dusky Shark are habitat generalists and highly mobile. In addition, Dusky Shark are a placental, viviparous species and do not have a larval stage.

- **Directional Effect in the Northeast U.S. Shelf**: The effect of climate change on Dusky Shark is very likely to be neutral (>95% certainty in expert scores). Dusky Shark is a highly mobile temperate shark. There is very little information available that suggests negative or positive effects of climate change.

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

- **Climate Effects on Abundance and Distribution**: There is very little information on the effect of climate change on Dusky Shark. Chin et al. (2010) conducted a vulnerability assessment of sharks and rays on Australia’s Great Barrier Reef (GBR) identifying similar factors for use in their vulnerability assessment, and ranked the level of exposure and sensitivity to these factors using current knowledge and expert opinion based on a 3 point scale (low, moderate, and high). Dusky shark exposure rankings were highly influenced by water temperature but sensitivity to this factor was ranked low for GBR sharks. Although the population growth rate was taken into account in the GBR study, little is known about the population status of sharks in this area (Chin et al. 2010, McAuley et al., 2012). GBR Dusky Sharks were assessed a low vulnerability ranking with respect to climate change.

- **Life History Synopsis**: Dusky Shark is a large, coastal, migratory, warm-temperate shark species found from southern New England to the Caribbean and the Gulf of Mexico to southern Brazil (SEADAR, 2011). Males of the species reach 50% maturity at 231 cm fork length (FL) (17.4 years); females are slightly larger (234 cm FL) and 17.6 years at 50% maturity (Natalson et al.; 1995, Natalson et al., 2013). Dusky Sharks are viviparous with an 18-month gestation period and around 7 pups per litter (Castro 2009; Romine et al. 2009). Young Dusky Sharks are large at birth, 90-100 cm total length, and occur in warm-temperate, nearshore areas with sand or rocky bottoms (Branstetter, 2002; McCandless et al., 2007). Rarely, juveniles may enter estuarine habitats, but generally avoid areas of low salinity (McCandless et al., 2007). Adult Dusky Sharks seasonally migrate great distances between New England and the Gulf of Mexico (Branstetter, 2002, Kohler et al. 1998). The diet of Dusky Sharks includes several species of teleosts, elasmobranchs, crustaceans, and squid (Branstetter, 2002). The Atlantic States Marine Fisheries Commission manages Dusky Sharks through an interstate fishery management plan and NMFS manages them as part of the Consolidated Atlantic Highly Migratory Species Fishery Management Plan (ASMFC 2008; NMFS 2006). Based on the last northwest Atlantic stock assessment, Dusky Sharks are...
Northeast Species Vulnerability

Atlantic HMS:
- Dusky
- Porbeagle
- Sand Tiger
- Smooth Dogfish

Vulnerability
- Very High
- High
- Moderate
- Low

Climate Change Exposure

Adapted from Hare et al. 2016
Project Outcomes: Species Narratives, Website, Manuscript

NEFSC CVA website

PLOS ONE

RESEARCH ARTICLE
Assessing the vulnerability of marine life to climate change in the Pacific Islands region

Jonatha Gillen, 1, 2, 3, Donald R. Kobayashi, 2, 3, Gabriela N. M. Moku, 1, 2, Jacob Auer, 1, 2, Charles Bricker, 1, 2, Mark Fisher, 1, 2, Mark A. Hixon, 1, 2, Melanie Hutchins, 1, 2, Bruce C. Murray, 1, 2, Joseph M. O’Malley, 1, 2, Kailor Seu, 1, 2, Molly Scott, 1, 2, Rob Telesco, 1, 2, Michael Tolison, 1, 2, Phoebe A. Woodward-Jenkins, 1, 2, Shyamaa K. Warri, 1, 2, Mark Nelson, 1, 2


OPEN ACCESS

Author summary: We used a model and field data from the tropical Pacific Islands to assess the vulnerability of marine life to climate change. Our model predicted that warming will lead to significant declines in species diversity, with the greatest impacts in the eastern tropical Pacific. Our findings highlight the need for targeted conservation efforts to protect vulnerable species in the region.

NEFSC CVA website
Results: Inform science and management initiatives

- Inform management decisions to increase stock resilience
- Provide information for use in decision making documents
  - NEPA documents - Environmental Impact Statements, Environmental Assessments
  - Biological opinions
  - Risk assessments
  - Cumulative impacts analyses
  - Ecosystem status reports
- Combine with social and economic data to build vulnerability assessments for fishing communities
- Climate change scenario planning exercises
Inform science and management initiatives

• Restoration planning
• EFH non-fishing impacts analyses
• High-level strategic planning
• Identify information gaps and help set research priorities
• Identify stocks that could benefit from increased monitoring
• Provide information that could be useful for stock assessments
Next Steps / Timeline

- **Project Scoping**
  - Oct – Dec 2022

- **Climate Change Exposure**
  - Jul 2022 – Mar 2023

- **Assessment, Outputs**
  - July 2023 – July 2024

**Info gathering:**
- Essential fish habitat
  - Dec 2022 – Jan 2023

- Species life history
  - Apr – July 2023

Targeted milestones in progress or completed by Spring 2023 AP meeting (estimated)
Questions?

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Peter Cooper, peter.cooper@noaa.gov

Read more about NOAA Climate Vulnerability Resources
BACKUP SLIDES
### SATL Species Vulnerability

<table>
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<th>Expos</th>
<th>Very High</th>
<th>High</th>
<th>Moderate</th>
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<tbody>
<tr>
<td>Low</td>
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<td>Moderate</td>
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</tr>
<tr>
<td>Very High</td>
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</table>

#### Atlantic HIMS:
- **Dusky**
- **Sandbar**
- **Sand Tiger**
- **Bonnethead**
- **Atlantic Sharpnose**

**Bold**: probability score is one vulnerability rank higher

**Italics**: probability score is one vulnerability rank lower

***: Bootstrap analysis found greatest probability of outcomes one rank lower than categorical rank

****: Bootstrap analysis found greatest probability of outcomes one rank higher than categorical rank
## GOM Species Vulnerability

<table>
<thead>
<tr>
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<th>Exposure</th>
<th>Very High</th>
<th>High</th>
<th>Moderate</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gulf Sturgeon</td>
<td>Scalloped Hammerhead shark</td>
<td>Eastern oyster</td>
<td>Warsaw grouper</td>
<td>Speckled trout</td>
<td>Yellowfin tuna</td>
</tr>
<tr>
<td>Great Hammerhead shark</td>
<td>Gulf shark</td>
<td>Smallmouth bass</td>
<td>Gag grouper</td>
<td>Resou, grouper, Blackfin, Yellowfin tuna</td>
<td></td>
</tr>
<tr>
<td>Goliath grouper</td>
<td>Yellowedge grouper</td>
<td>Scalloped hammerhead shark</td>
<td>Channel catfish</td>
<td>Red snapper, Snook</td>
<td></td>
</tr>
</tbody>
</table>

### Atlantic HMS:
- Dusky
- Scalloped Hammerhead
- Great Hammerhead
- Sandbar
- Lemon
- Tiger
- Finetooth
- Blacktip
- Bonnethead
- Blacknose
- Nurse
- Atlantic Sharpnose