Assessing the Vulnerability of Fish Stocks to Climate Change

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Outline

Vulnerability assessment methodology

1. Goals and objectives
2. Background and overview
3. Products and uses
4. Methodology
5. Attribute definitions
6. Stock profiles
7. Scoring procedure

Project Goal and Objectives

Goal: Produce a practical and efficient tool for assessing the vulnerability of a wide range of fish stocks* to a changing climate.

Objectives:

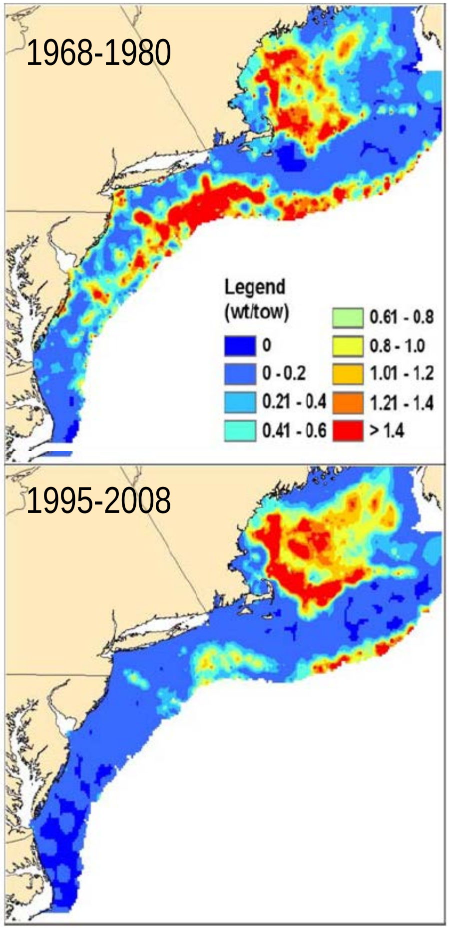
1. Develop relative vulnerability rankings across stocks
2. Determine attributes/factors driving vulnerability
3. Identify data quality and data gaps

*Methodology can be applied at the stock or species level

What's the issue?

- *Already observing impacts* of climate change on fish stocks.
- *Not clear which stocks are most vulnerable* to continued changes in climate/ocean systems.
- *Information on fish stock vulnerability useful* in shaping science and management efforts.
- *Increasing interest and drivers* for assessing climate vulnerability (e.g., NOP, E.O.13514, E.O. 13653, Judicial rulings)
- *Lack of methods* for assessing vulnerability of fish stocks in changing climate.

Distributional shift of Red Hake

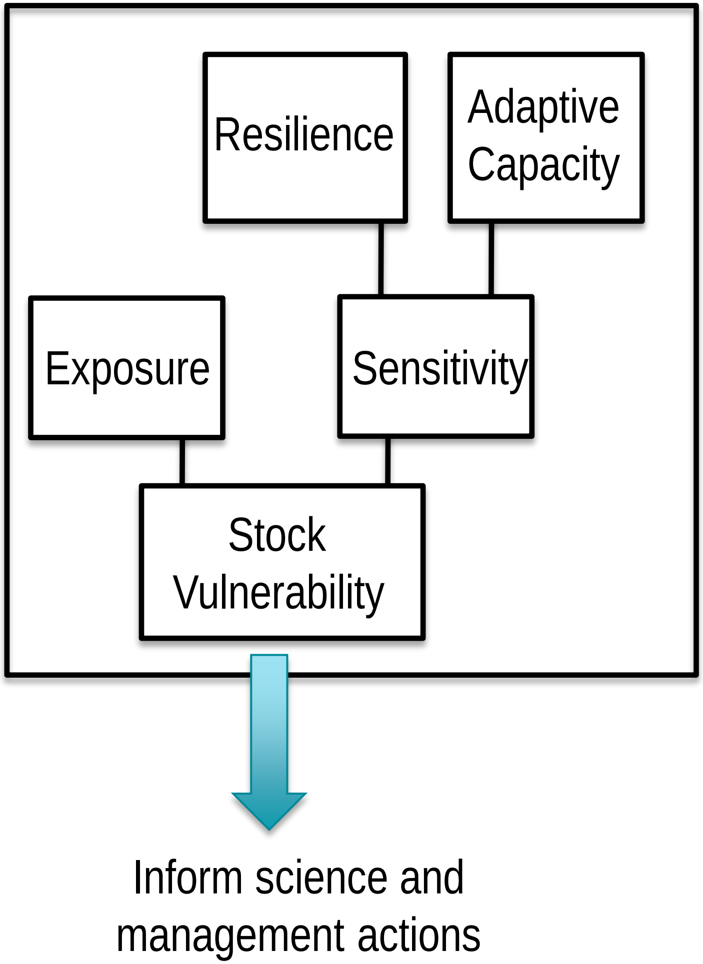


Nye et al. (2009)

Why Vulnerability Assessments?

Vulnerability assessments:

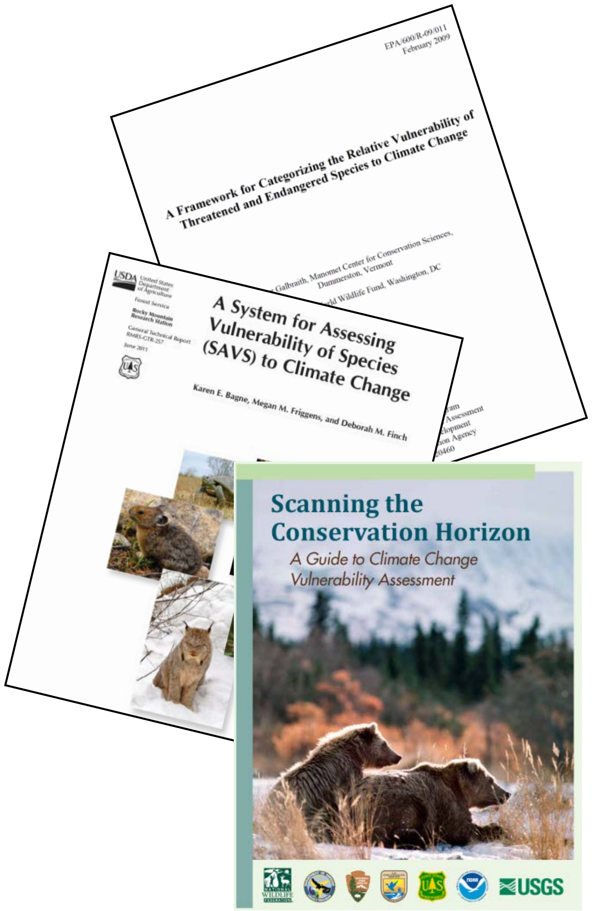
- Identify ***which*** species are at risk
- Help identify ***why*** species are at risk
- Used to ***inform*** science priorities and management considerations.



What do we mean by vulnerability?

- Vulnerability = risk of ***changes in stock abundance or productivity*** *in a changing climate*.
- Stocks with ability to shift distributions in a changing climate may receive a “low vulnerability” ranking.
- Subset of the attributes may be useful in identifying stocks that possess the ***ability to shift distributions***.

Examples from the Terrestrial Environment



Example Vulnerability Assessments Include:

- U.S. EPA's Threatened and Endangered Species Vulnerability Framework
- USDA System for Assessing Vulnerability of Species
- Climate Change Vulnerability Index for Species in Nevada (Nature Serve)
- Scanning the Conservation Horizon is a inter-agency guide to climate vulnerability assessments.

Methodology Development

2011

- *Developed initial outline* based on existing methodologies.
- *Established NMFS expert group* and held workshop to draft methodology (reps from each Science center and NMFS regional office)

2012

- *Completed draft definitions* of sensitivity attributes with expert group review
- *Completed 3 pilot tests* of biological methods (internal, New England (NE) and Caribbean)

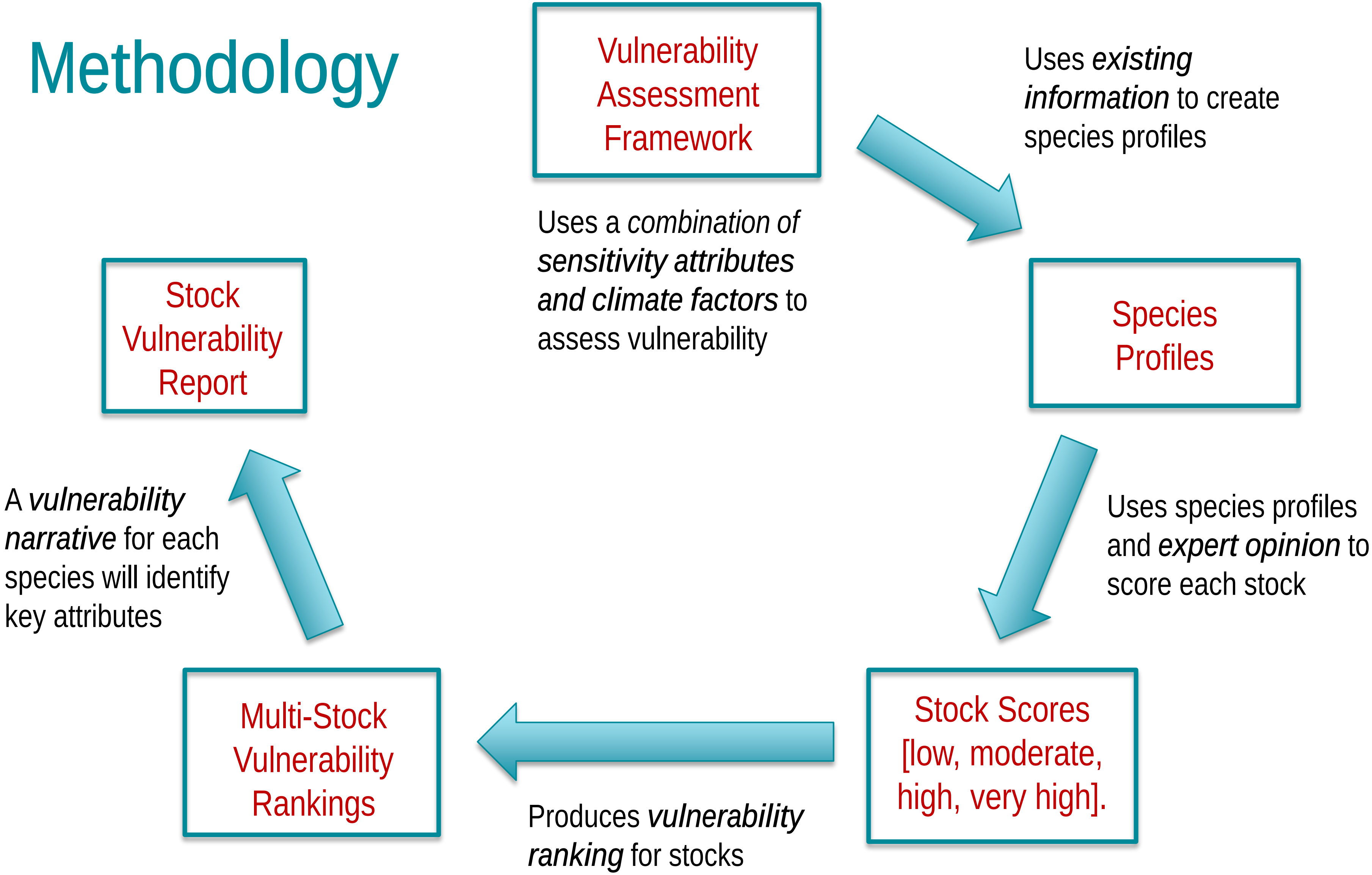
2013

- *Revised sensitivity and exposure attributes*, completed web database etc
- *Finalized methodology*

2014

- Spring – *Completed assessment* of 79 NE and Mid Atlantic species
- Summer/Fall - *Submit papers* on methodology and NE implementation

Methodology



Expected Products

- An **index of relative vulnerability** across stocks.
- **Information on the key attributes** behind the vulnerability score of each stock.
- **Identification of the major data gaps.**
- Completed stock profiles and climate projections available for other projects.

Species	Vulnerability
Sleepyfish	Very High
Plantfish	
Alligatorfish	
Popfish	
Spotfish	High
Pencilfish	
Orangefish	
Hiddenfish	
Rightfish	
Spiderfish	
Chocolatefish	Moderate
Flowerfish	
Lemonfish	
Lightfish	
Wrongfish	Low
Greenfish	
Ostrichfish	
Candyfish	
Picklefish	
Redtoefish	

Potential Uses

Science:

- Identify stocks that can benefit from incorporating environmental variability into stock assessments
- Identify gaps in information for use in shaping research priorities
- Identify stocks that could benefit from increased monitoring to better quantify when expected climate impacts occur

Management:

- Inform management decisions about catch amounts, and rebuilding plans
- Provide information for use in EIS's, BiOps and other decision making documents
- Identify potential management actions that might reduce vulnerability and increase stock resilience in a changing climate

Methodology

Stock Vulnerability

Exposure

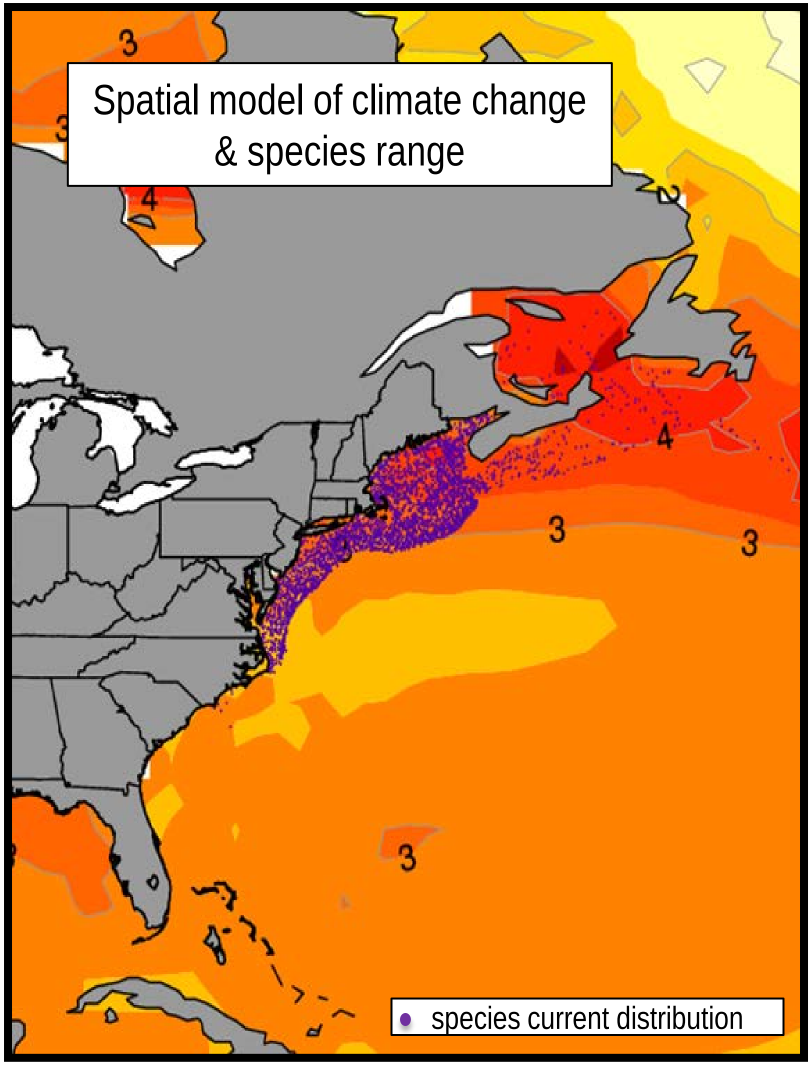
- Sea surface temperature
- Air temperature
- Salinity
- Ocean acidification (pH)
- Precipitation
- Currents
- Sea level rise

*** Exposure factors will vary depending on the region*

Sensitivity

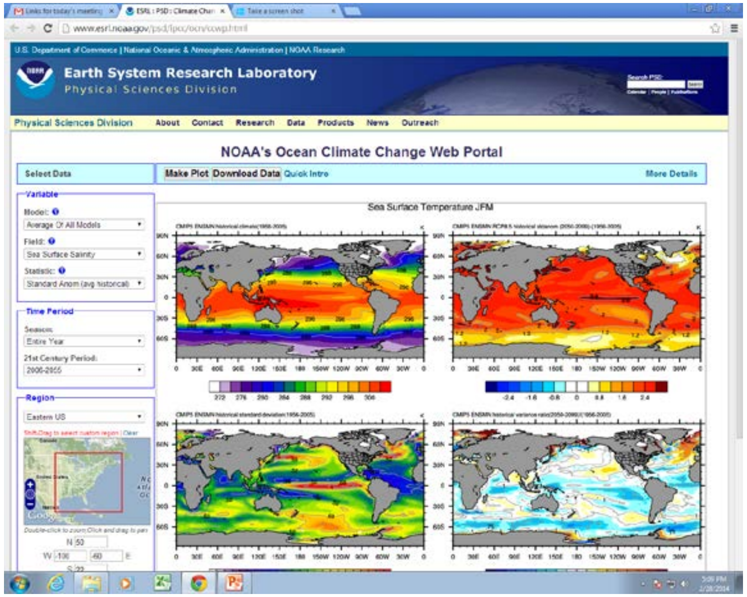
- Habitat Specificity
- Prey Specificity
- Sensitivity to Ocean Acidification
- Sensitivity to Temperature
- Stock Size/Status
- Other Stressors
- Adult Mobility
- Spawning Cycle
- Complexity in Reproductive Strategy
- Early Life History Survival and Settlement Requirements
- Population Growth Rate
- Dispersal of Early Life Stages

Exposure



- Defined as how much climate related change a stock is likely to experience
- Quantified as the spatial overlap between a stocks' current distribution and the expected climate change
- Mean change is related to current variability (Z-score)
- Changes in variability are measured with an F-test (future variability/current variability)

OAR website on expected climate change



- Interaction with OAR resulted in web product created to meet the needs of our methodology.
- Thanks to Jamie Scott, Mike Alexander and Jon Hare.

http://www.esrl.noaa.gov/psd/ipcc/ocn/ccwp.html

Sensitivity

Definition: Biological attributes believed to be indicative of the stock's response to climate change. They include the stock's resilience and its adaptive capacity[1]

12 attributes relate to current life history characteristics:

- Habitat Specificity
- Prey Specificity
- Sensitivity to Ocean Acidification
- Sensitivity to Temperature
- Stock Size/Status
- Other Stressors
- Adult Mobility
- Spawning Cycle
- Complexity in Reproductive Strategy
- Early Life History Survival and Settlement Requirements
- Population Growth Rate
- Dispersal of Early Life Stages

[1] Williams et al. 2008

Attribute Definition Document

Specific definitions and bins are available on request for each of the sensitivity attributes. Example provided below (in very small print)

Goal: To determine if the stock is a prey generalist or a prey specialist.

Relationship to climate change: Understanding how reliant a stock is on specific prey species could predict its ability to persist as the climate changes.

Background: Impacts extend beyond the stock in question to include species within its food web.

How to use expert opinion: Please account for ontogenetic shifts in diet; however, limit your response to the juvenile and adult life stages as larvae are considered elsewhere.

Prey Specificity Bins:

Low: The stock eats a large variety of prey.

Moderate: The stock can feed on a wide variety of prey, but are restricted to a limited number (~3) of prey types (copepods, krill, forage fish, etc).

High: The stock is partial to a single prey type. It is able to switch to a different prey type, but this may negatively impact fitness.

Very High: The stock is a specialist, and is unable to switch to alternative prey.

Stock Profiles

Purpose: Synthesize key information for each stock for use by experts in scoring attributes. Template is available on request.

Species Profile for Vulnerability Assessment to Climate Change

Species Name: Tilefish (*Lopholatilus chamaeleonticeps*)

Stock Name: Mid Atlantic Bight & south of Cape Hatteras

ATTRIBUTE	DATA	SOURCE	DATA QUALITY SCORE
Habitat specificity - To determine on a relative scale if the stock is a habitat generalist or a habitat specialist while incorporating information on the type and abundance of key habitats			
What are the habitat requirements for juveniles? (e.g. What types of habitat does the stock utilize? Is the species a specialist or a generalist? Does it utilize a physical or biological habitat? Is the habitat rare or abundant? Is the habitat disturbed?)	Much of below applies to juveniles as well as sdults. Juveniles often occupy simple vertical shaft burrows in semi-lithified clay. Lobster pots, red crab traps, ship wrecks and other artificial structures have also been used by tilefish. Steimle et al (1999) suggest that juveniles are more tolerant of low temperatures than adults, which could help recruits survive in marginal habitat conditions. Depth range has been found to be 90-264 m, wit most < 170m and at a maximum of 366 m.	Able et al. 1982; Steimle et al., 1999; Reid et al. 1999;	3
Prey specificity - To determine on a relative scale if the stock is a prey generalist or a prey specialist while incorporating information on the type and abundance of key prey types.			
What species/types of food do juveniles of this species eat? (e.g. Is the stock a detritivore, herbivore, or omnivore at this life stage? Does the stock show a strong preference for a particular prey type? If it's preferred prey is unavailable is there evidence that it can expand its diet?)	Post-larval tilefish have eat benthic organisms, such as crabs (spider, galatheids, pagurids) conger eels, Atlantic hagfish, bivalve mollusks, polychaetes, holothurians, and sea anemones. They also eat near-bottom or pelagic prey such as salps, squid, hyperiid amphipods, small spiny dogfish, Atlantic mackerel, Atlantic herring, and silver hake. Human trash (potato peels, meat bones, and shiny hardware) were also eaten. Freeman and Turner (1977) reported that juveniles ate more echinoderms and mollusks than larger tilefish.	Linton (1901); Bigelow and Schroeder (1953); Freeman and Turner (1977); Collins 1884; Steimle et al., 1999;	3

5 Point Tally Scoring System

- The scoring for each attribute is done by the experts assigning 5 tallies within the 4 scoring bins
- This gives experts the ability to express uncertainty in their score

- Example:

Low uncertainty scenario			
Low	Moderate	High	Very High
	5		

Moderate uncertainty scenario			
Low	Moderate	High	Very High
		3	2

High uncertainty scenario			
Low	Moderate	High	Very High
1	1	2	1

Data Quality Score

- Data quality is different than uncertainty; however, they can be related
- This score will be used to identify data gaps

Data Quality Score	Description
3	**Adequate Data.** The score is based on data which have been observed, modeled or empirically measured for the species or stock in question and comes a from reputable source.
2	**Limited Data.** The score is based on data which has a higher degree of uncertainty. The data used to score the attribute may be based on related or similar species, come from outside the study area, or the reliability of the source may be limited.
1	**Expert Judgment.** The attribute score reflects the expert judgment of the reviewer and is based on their general knowledge of the species, or other related species, and their relative role in the ecosystem.
0	**No Data.** No information to base an attribute score on. Very little is known about the species or related species and there is no basis for forming an expert opinion (use judiciously).

Sensitivity and Exposure Scoring Rubric

- Step 1 – Attribute Score
  - Weighted average of all experts "tallies"

	Scoring Bin			
	Low	**Moderate**	**High**	**Very High**
	1	**2**	**3**	**4**
Habitat Specificity	**1**	**6**	**13**	**5**

5 experts = 25 "tallies"

Attribute Score = ((1*1)+(2*6)+(3*13)+(4*5))/25 = 2.88

Sensitivity and Exposure Scoring Rubric

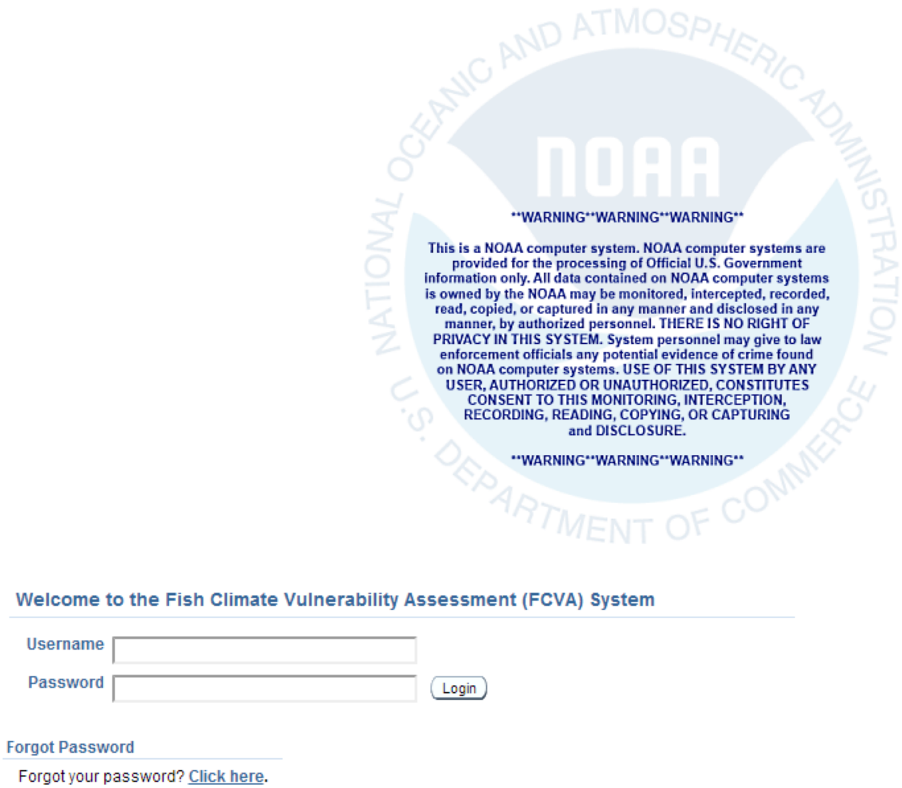
- Step 2 – Component Score (Sensitivity/Exposure)
  - 12 Sensitivity Attributes – 12 Exposure Factors
    - Very high = 3 or more attribute scores ≥ 3.5
    - High = 2 or more attribute scores ≥ 3.0
    - Medium = 2 or more attribute scores ≥ 2.5
    - Low = less than 2 attributes scores ≥ 2.5

Step 3 – Vulnerability Scoring Rubric

Vulnerability

Sensitivity \ Exposure	Low	Moderate	High	Very High
Very High	Moderate	High	Very High	Very High
High	Low	Moderate	High	Very High
Moderate	Low	Moderate	Moderate	High
Low	Low	Low	Low	Moderate

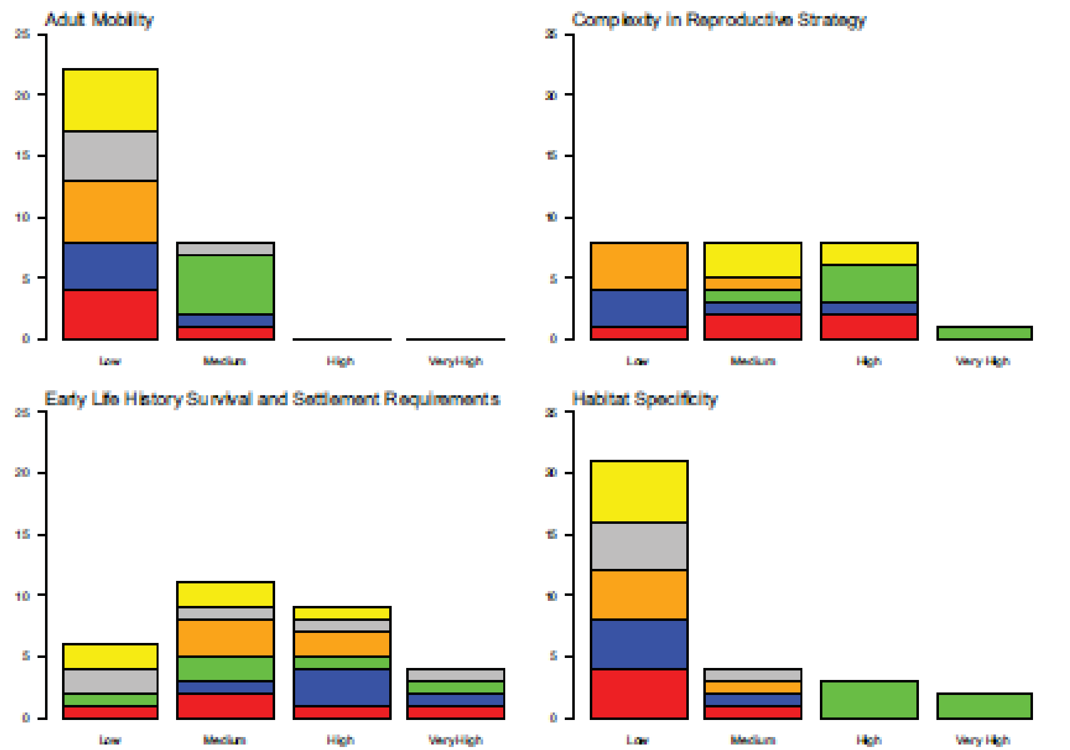
Web Enabled Database



**Need to contact NMFS for access

Scoring Process

- Experts score assigned stocks individually prior to workshop
- Experts compare and discuss preliminary scores at workshop.
- Experts can adjust their scores if needed



Each color represents the 5 tallies for one expert

Vulnerability Narratives

Anguilla rostrata	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Stock Status (Status)	2.7	1.0	
Other Stressors (Other)	2.8	1.7	
Population Growth Rate (Pop Growth)	2.8	1.8	
Spawning Cycle (Spawning)	2.5	2.2	
Complexity in Reproduction (Repr Complx)	2.7	1.9	
Early Life History Requirements (ELH)	2.6	1.2	
Sensitivity to Ocean Acidification (OA)	1.1	2.0	
Prey Specialization (Prey)	1.1	3.0	
Habitat Specialization (Hab)	2.6	3.0	
Sensitivity to Temperature (Sens Temp)	1.3	3.0	
Adult Mobility (Adult Mobil)	1.2	3.0	
Dispersal & Early Life History (Dispersal)	1.1	2.6	
Sensitivity Score	Moderate		
Sea Surface Temperature (SST)	4.0	3.0	
Var. in Sea Surface Temperature (Var SST)	1.0	3.0	
Salinity (Salinity)	1.6	3.0	
Var. Salinity (Var Sal)	1.2	3.0	
Air Temperature (Air Temp)	4.0	3.0	
Var. Air Temperature (Var Air Temp)	1.0	3.0	
Precipitation (Precip)	1.3	3.0	
Var. in Precipitation (Var Precip)	1.4	3.0	
Ocean Acidification (OA)	4.0	2.0	
Var. in OA (Var OA)	1.0	2.2	
Currents (Currents)	2.4	1.0	
Sea Level Rise (Sea Level)	0.0	0.0	
Exposure Score	Very High		
Overall Vulnerability Rank	High		

Low
Moderate
High
Very High

American eel:
Because this species is a generalist and can adjust easily to a variety of habitats and prey, it should be more resilient as the climate changes. However, since the entire species spawns in the Sargasso sea, and larvae drift and eat with the currents for months, climate change impacts on these life stages are not well understood.
In addition, stressors on the species are high. Much of the eel's habitat is impacted by freshwater dams, and an introduced parasite has become prevalent in most populations.

NE/MA Assessment

- In March, 2014, an assessment was completed on all NEFMC, MAFMC, and ASMFC managed species
- Results should be ready for publication in 2014

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