Modeling Atlantic Menhaden recruitment in Chesapeake Bay: *Is the striped bass recovery a problem?*

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The problem: Menhaden population status

Sources: ASMFC & MD DNR
Evolution towards multispecies & ecosystem-based approaches
Evaluating potential role of striped bass recovery on menhaden recruitment
Menhaden & striped bass population status

Predation influence?

Striped bass recovery

Sources: ASMFC & MD DNR
Objective

Formally test the often-referenced role of striped bass predation on Atlantic Menhaden recruitment in Chesapeake Bay

Approach

1. Model definition
   - Menhaden Ricker Curve
   - Striped bass adult biomass (age ≥ 2 yrs) as a proxy for predation pressure

2. Evaluate model (goodness of fit)

3. Hindcast (model robustness?)
   - requires historic striped bass biomass data pre 1982 source: commercial landings as proxy

4. Evaluate Model sensitivity to parameter & biomass variability (e.g. input or parameter error)

\[ R = \alpha S e^{(-\beta S - \gamma P)} \]

External forcing parameter
Striped bass biomass: A good predictor of menhaden recruitment

Ricker model only

\[ R = \alpha S e^{(-\beta S)} \]

Ricker model + striped bass biomass

\[ R = \alpha S e^{(-\beta S - \gamma P)} \]
Autocorrelation

Recruitment index data

Model residuals: menhaden recruitment = SSB + striped bass biomass
Hindcasting: Need a proxy for the striped bass biomass predictor before 1982

Establish relationship: tight relationship between biomass and landings 3 years later

Used landings 3 year lag
As proxy for pre-1982 biomass’
Hindcast fit of menhaden recruitment

\[ R = \alpha S e^{-\beta S - \gamma P} \]

- Observed
- Model fit, \( r^2 = 0.64 \)
- Hindcast, \( r^2 = 0.69 \)
Projecting menhaden recruitment

Inputs: early year menhaden spawning stock & striped bass biomass
Output: fall menhaden recruitment index

\[ R = \alpha S e^{(-\beta S - \gamma P)} \]
Projecting 2006 menhaden recruitment

\[ R = \alpha S e^{-\beta S - \gamma P} \]

- Observed
- Model fit, \( r^2 = 0.64 \)
- Hindcast, \( r^2 = 0.69 \)
- Project

2006 projection?
Sensitivity of recruitment projection to menhaden spawning stock and striped bass biomass

\[ R = \alpha S e^{(-\beta S - \gamma P)} \]

Projecting fall menhaden recruitment based on early year menhaden spawning stock & striped bass biomass
Sensitivity of recruitment projection to model parameters

\[ R = \alpha S e^{(-\beta S - \gamma P)} \]

Upper 95% confidence intervals of \( \alpha \)

Model is sensitive to \( \gamma \) when \( \alpha \) is high

Model is not sensitive
Model improvement: uncertain relationship between menhaden seine survey data and actual recruitment (schooling species, whole-bay averaging, etc.)
Climate

- Industry
- Agriculture
- Animal farms
- Sewage treatment plants
- Development

- Feeding
- Young of the year
- Ages 1 - 2 years
- Age 2 years and above
- Eggs

Chesapeake EcoCheck
Assessing and forecasting ecosystem status

University of Maryland Center for Environmental Science
Next steps: Climate influence

Step 1: Test several climate patterns for correlation with menhaden recruitment.

Step 2: Incorporate Bermuda High climate pattern into ecosystem-based model.

Ricker model + striped bass biomass + climate

Model output

- Observed menhaden recruitment
- Ricker model only
- Ecosystem-based model (Ricker + predation/climate pattern)
There do seem to be positive relationships between menhaden recruitment and bottom-up (i.e. prey quality & quantity) variables.

Chlorophyll seems be better than annually integrated primary production in most of fits to date.

Data from Houde, Harding, and Annis 2006. Progress Report to NOAA Chesapeake Bay Office
Conclusions and management implications

The recovery of the striped bass population coincides with a prolonged decline in recruitment of menhaden in Chesapeake Bay.

Dietary data supports theories that a causal relationship is often alluded to in fisheries circles, however...

Before incorporating sensible theories into fisheries management, they must be formally tested.

This study supports the possibility that the striped bass recovery may be directly related to the apparent decline in menhaden recruitment over the last few decades.

Effective fisheries management requires models that acknowledge the many factors (in addition to spawning stock biomass) that influence recruitment...

more work is ongoing by these and other researchers...

• Climate-driven hydrographical variability
• Menhaden prey quality & quantity
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