

Interaction between Atlantic menhaden and striped bass in Chesapeake Bay: Implication for ecosystem-based fishery management

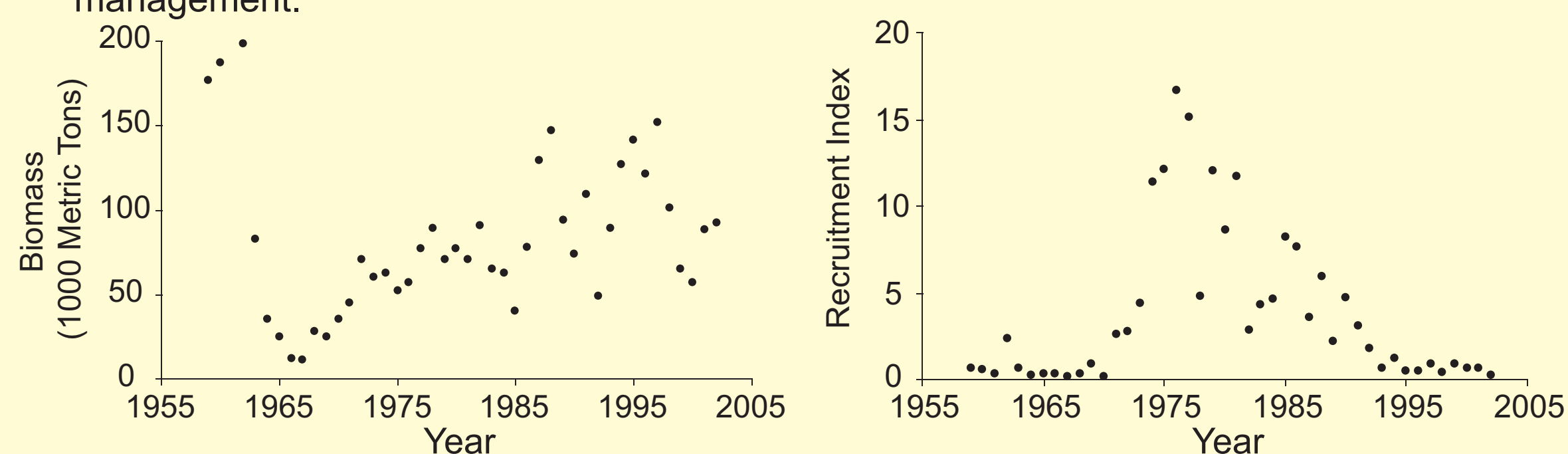
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Abstract

Atlantic menhaden (*Brevoortia tyrannus*) play an important role in Chesapeake Bay as a direct trophic link between primary production and striped bass (*Morone saxatilis*) and other sport and commercial fishes. Effective management of Atlantic menhaden in Chesapeake Bay may have a significant effect on fishery ecosystem management. Atlantic menhaden recruitment in Chesapeake Bay is 5-10 times lower now than in the 1980s. Because of numerous, simultaneous hydro-climatic variability and deteriorated habitat associated with enhanced nutrient inputs in Chesapeake Bay, the exact mechanisms responsible for the decline in Atlantic menhaden recruitment remain largely unclear. We found that biological interactions of striped bass predation superimposed on hydro-climatic forcing could be extremely detrimental to the recruitment variation of Atlantic menhaden in Chesapeake Bay. We incorporated the potential effects of striped bass predation into an Atlantic menhaden stock-recruitment Ricker model. This model not only provides an important tool in forecasting Atlantic menhaden recruitment and establishing the Atlantic menhaden harvest cap, but also assists in the development of an ecosystem-based fishery management plan in Chesapeake Bay.

Menhaden: High biomass – low recruitment

Atlantic menhaden (*B. tyrannus*) play an important role in Chesapeake Bay as a direct trophic link between primary production and striped bass (*M. saxatilis*). Atlantic coastwide menhaden spawning stock is reasonably healthy, but localized overfishing has been a concern. In contrast, Atlantic menhaden recruitment in Chesapeake Bay is 5 – 10 times lower now than in the 1980s. These factors are important for fisheries management.

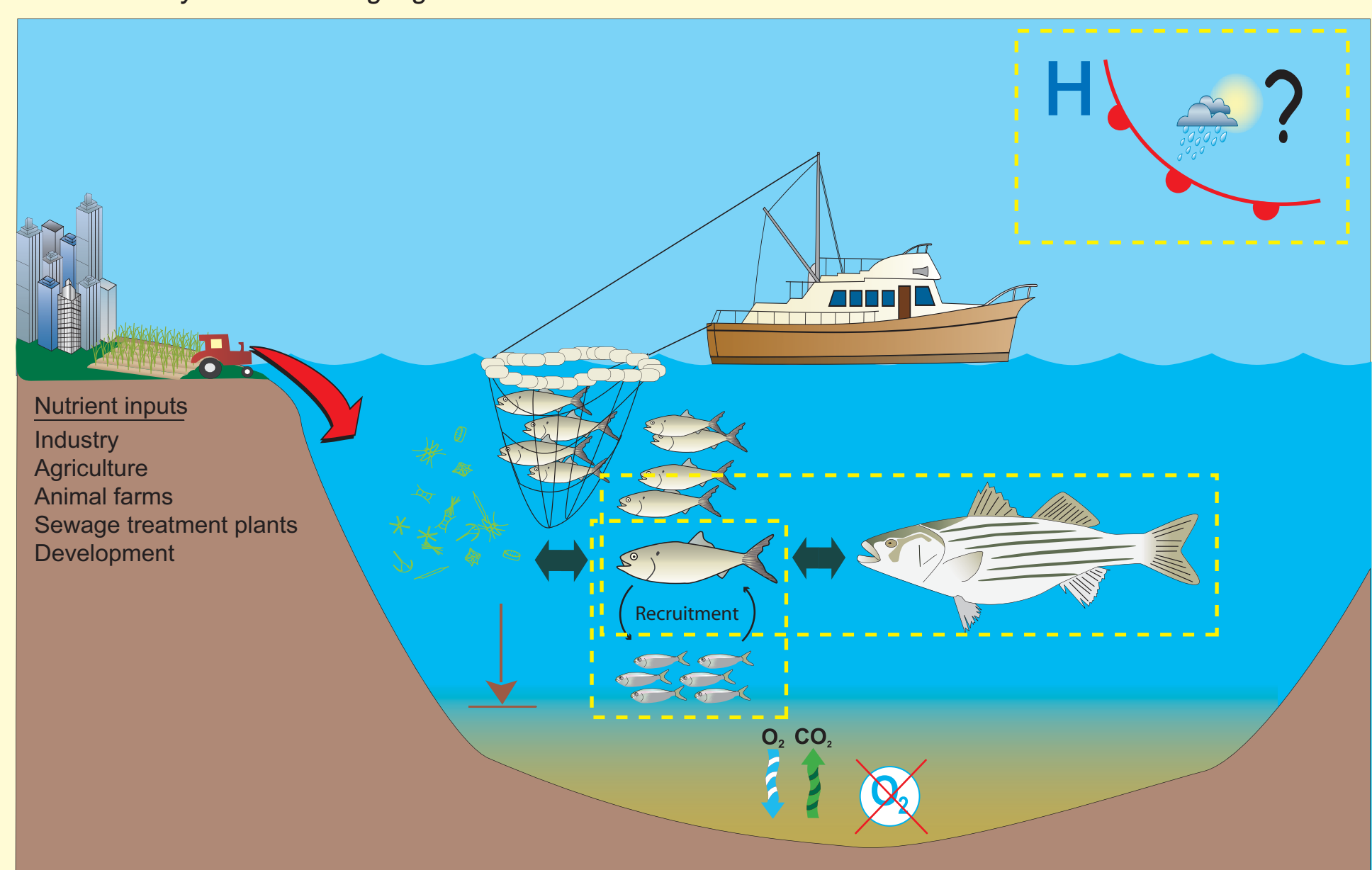


Menhaden spawning stock biomass along the Atlantic coast since the late 1950s.

Menhaden recruitment in Chesapeake Bay.

Ecosystem based fisheries management needed

Illustration of the key elements of menhaden ecosystem based fisheries management, with those areas addressed by this model highlighted with a dashed line.



Ecosystem-based fisheries management aims to manage fisheries in a manner that considers a variety of interactions with the fishery of interest.

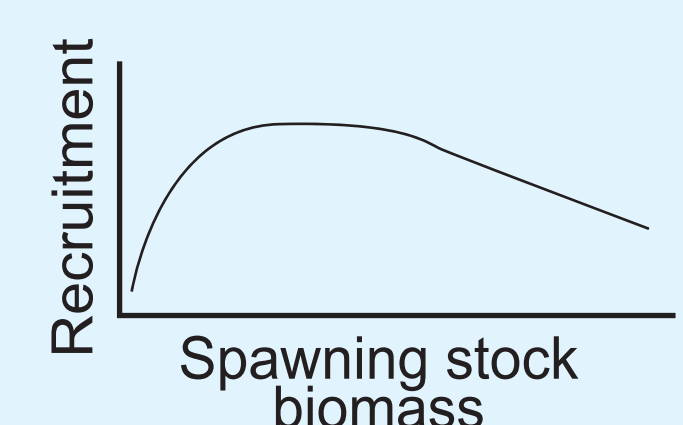
Ecosystem-based fisheries management is now strongly advocated and in some cases even mandated. Some of the main ecological interactions affecting menhaden biomass and recruitment are availability of food (plankton), level of predation from fish such as striped bass, and habitat quality such as dissolved oxygen, nutrient inputs, temperature, and weather pattern variability.

Striped bass biomass: a good predictor of menhaden recruitment

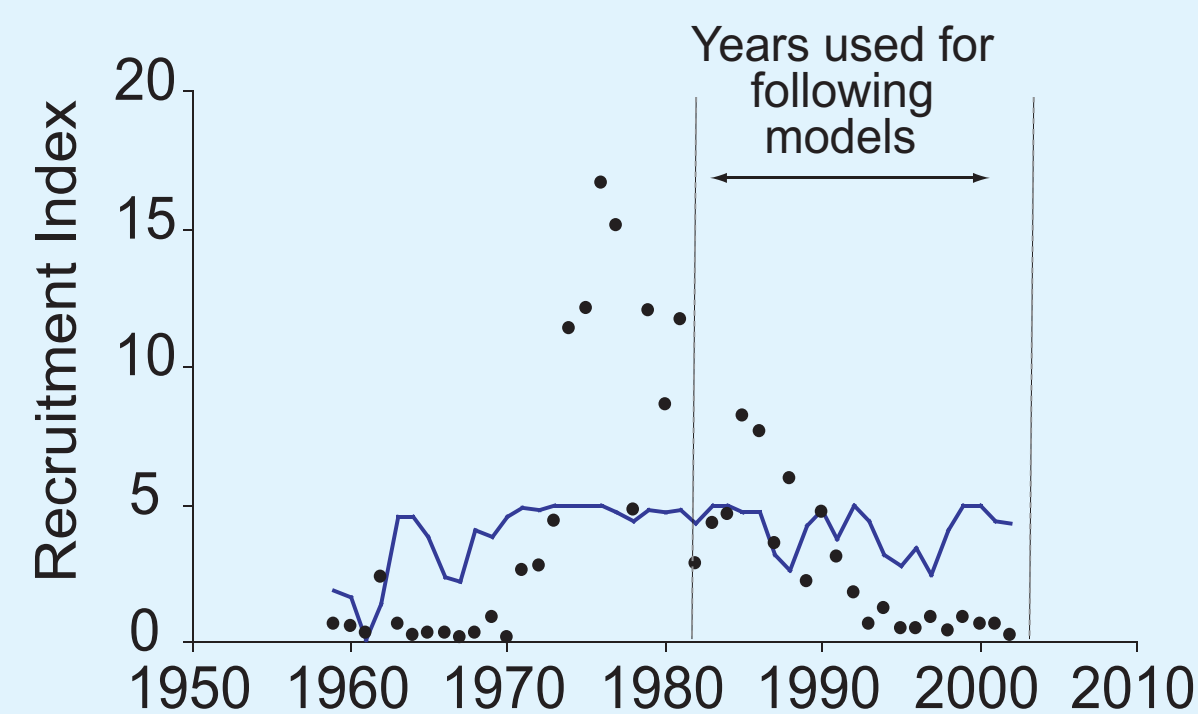
A stock-recruitment Ricker model that incorporates several environmental parameters and their interactions can be helpful for ecosystem-based fisheries management. A menhaden stock-recruitment Ricker model that incorporates striped bass biomass was found to be a good predictor of menhaden recruitment, with the potential to provide a good prediction of low to medium recruitment events.

Description of the model

Ricker curve only



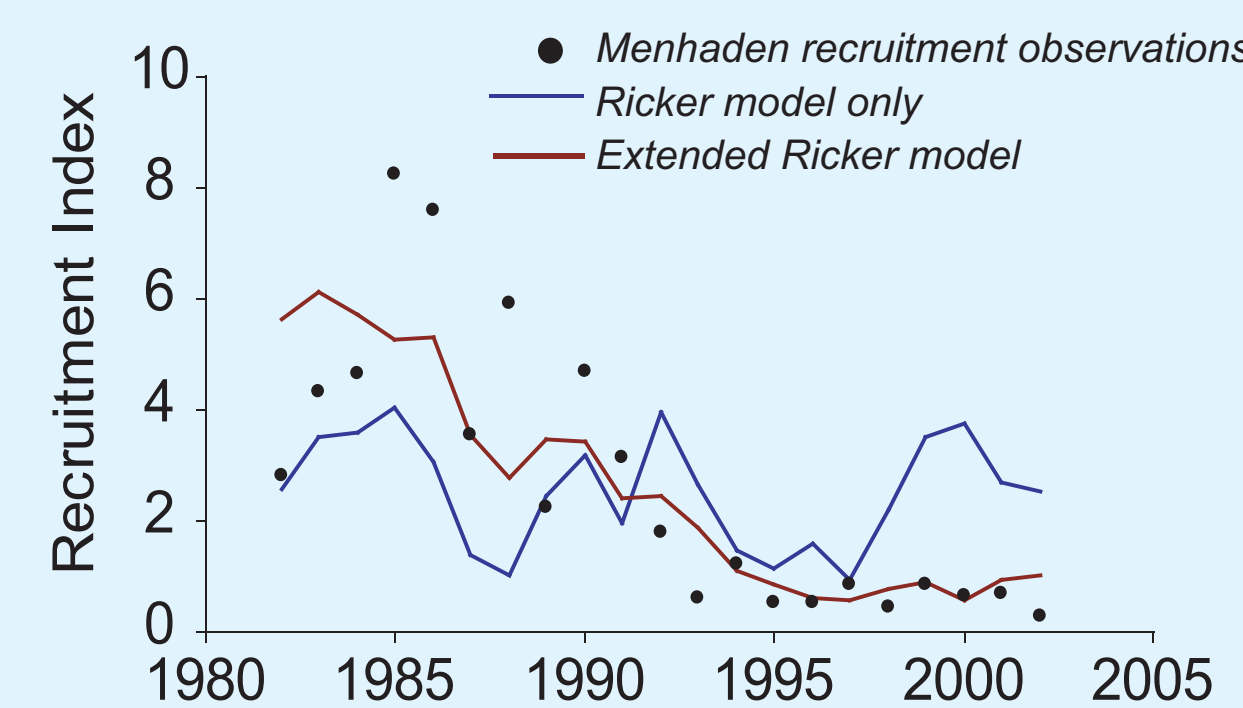
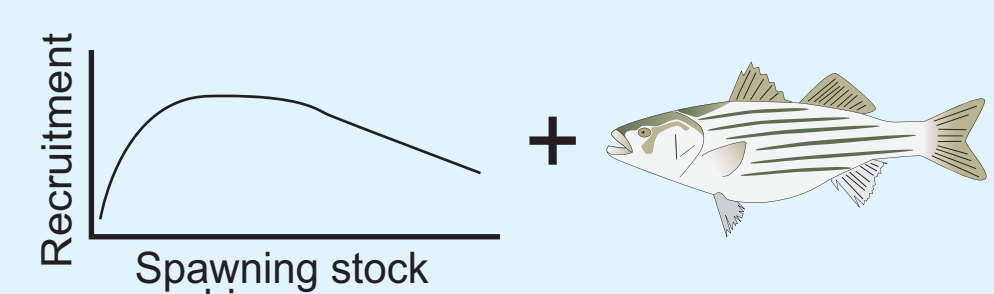
Model output



Interpretation of output

- Very poor at predicting menhaden recruitment
- Accounts for only 18% of menhaden recruitment variation

Ricker curve + striped bass biomass

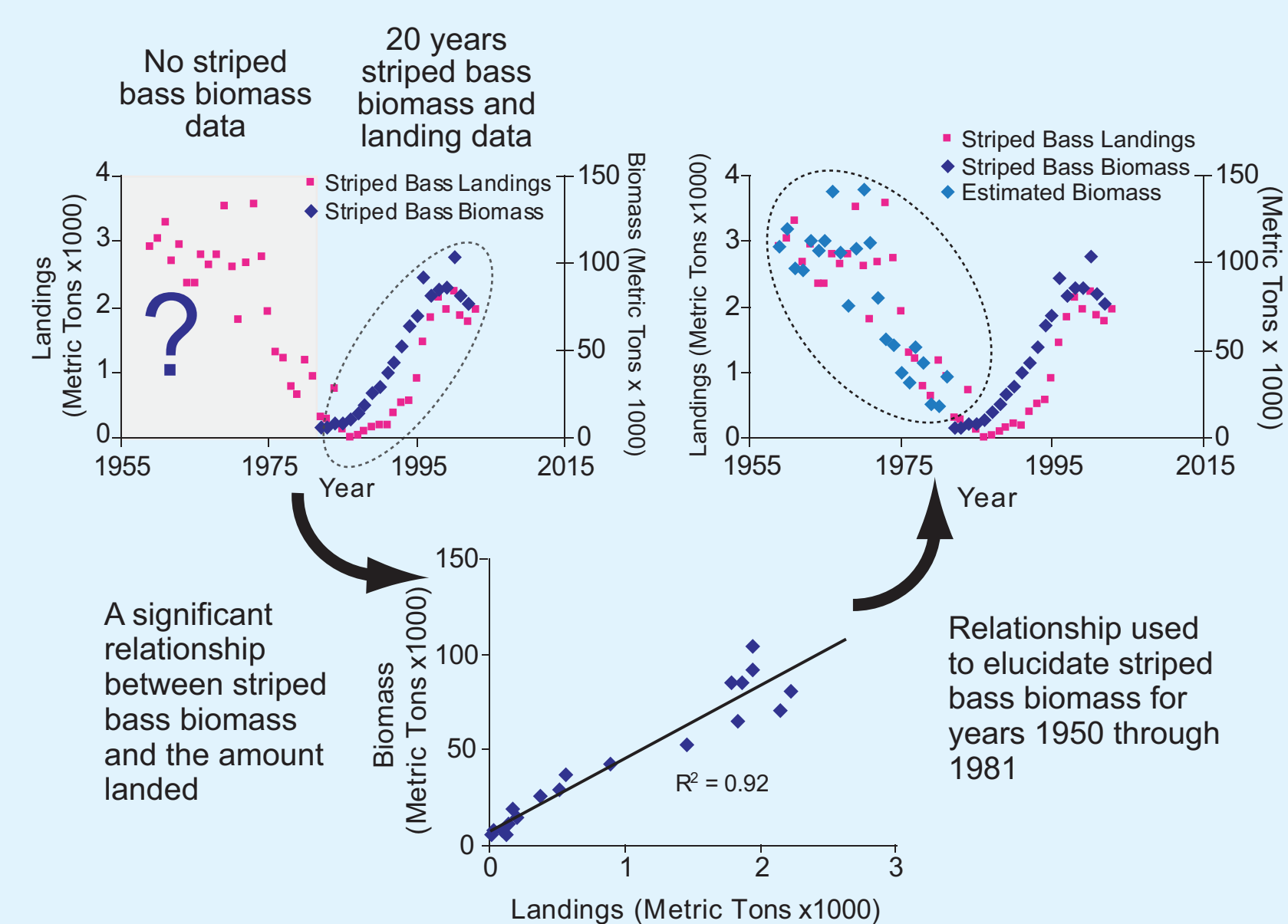


- Good at predicting small recruitment events
- Moderate at predicting big events
- Accounts for 64% of menhaden recruitment variation

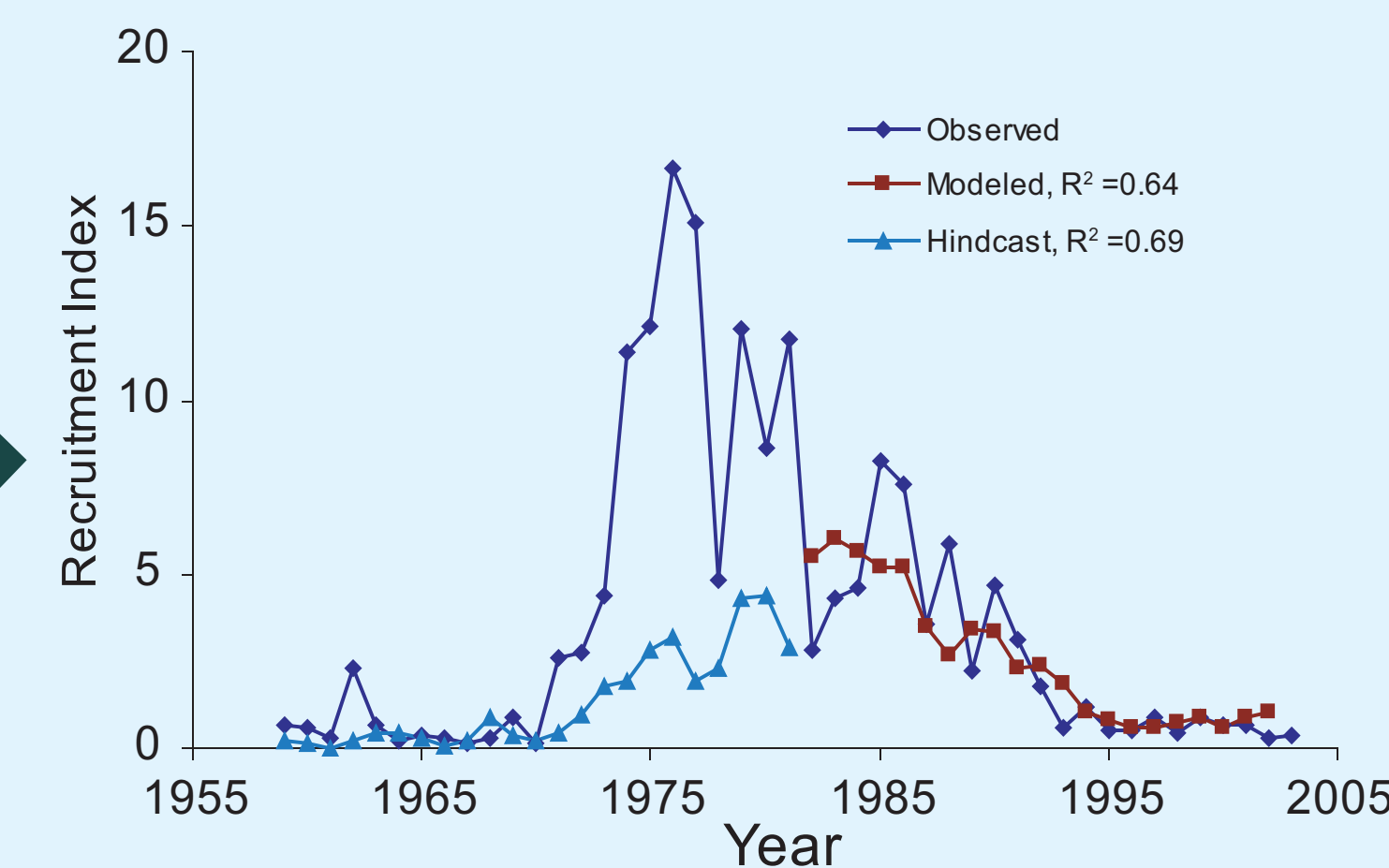
Outputs based on the standard and the extended menhaden stock-recruitment Ricker models.

Hindcast shows model reliable at predicting low recruitment levels

The menhaden-stock recruitment model that incorporates the striped bass biomass had good hindcast accuracy when compared to the historic menhaden recruitment data. Accuracy of the extended menhaden stock-recruitment Ricker model hindcasts was optimum in low recruitment years (1960s) and moderate in high recruitment years (1970s).



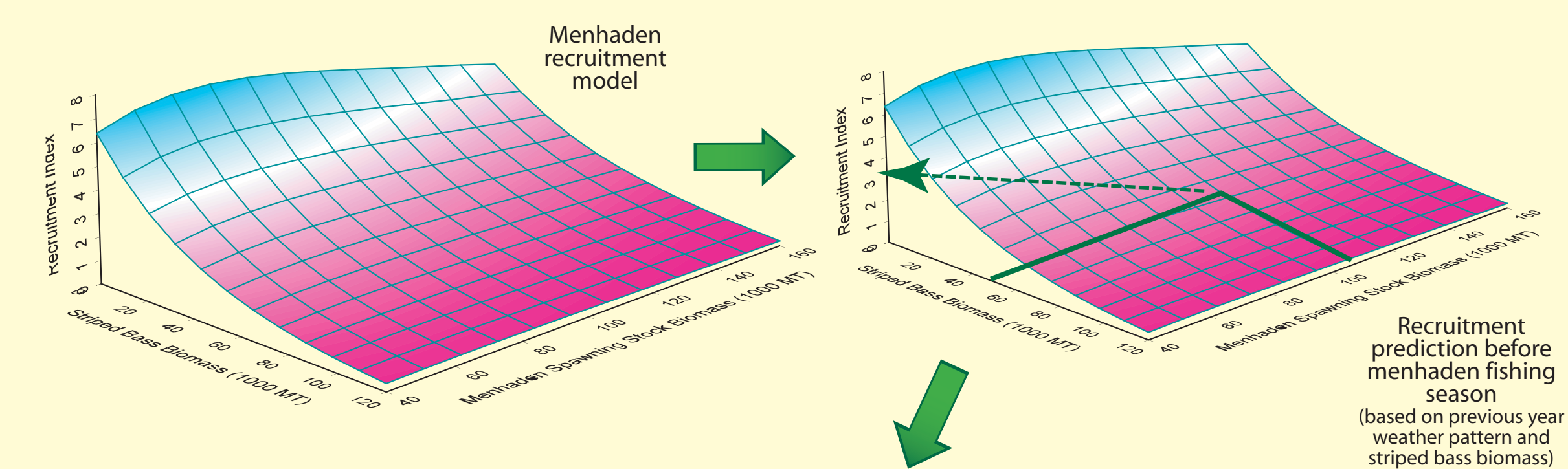
Method used to estimate striped bass biomass from 1955 to 1981.



Hindcast of menhaden recruitment in Chesapeake Bay based on the striped bass biomass model developed.

Application of the model to menhaden management

The model, which incorporates the potential effects of striped bass predation, will be a good start towards developing a model that predicts menhaden recruitment in Chesapeake Bay and that may be incorporated into an overall management plan for menhaden. In addition, we will adapt this modeling strategy for other fish species. Therefore, results from this research will greatly assist in the development of an ecosystem-based fisheries management plan in Chesapeake Bay.



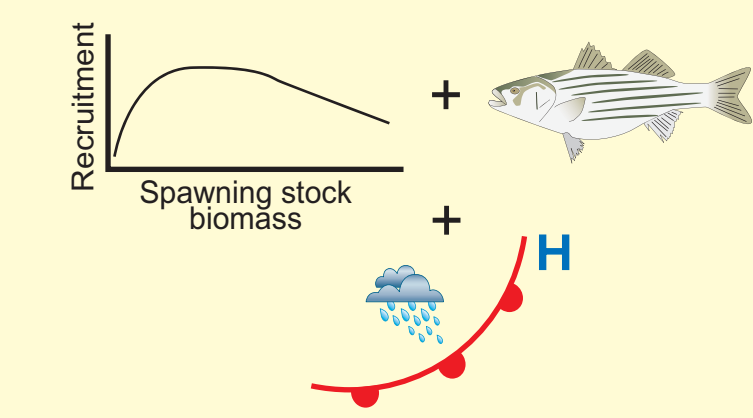
Incorporation of the model into menhaden fisheries management.

Ongoing research required to refine model

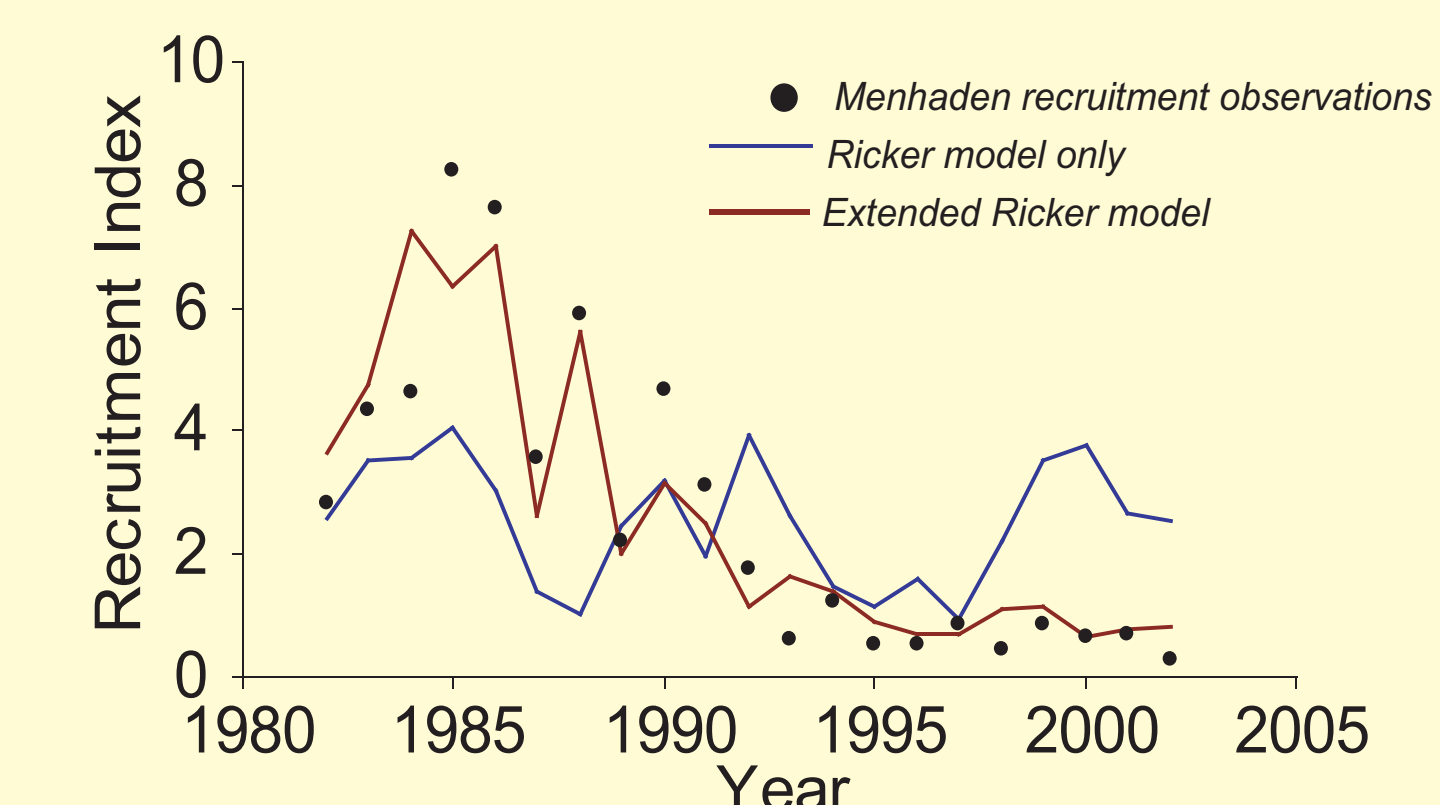
Accuracy of model fit and associated hindcasts were inconsistent when weather patterns were included in the model either alone or when combined with striped bass biomass. Because of this inconsistency, and because previous studies have shown a strong relationship between weather patterns and menhaden recruitment in the Bay, it is the aim of this project to investigate the discrepancies when weather patterns are included.

Description of the model

Ricker curve + striped bass biomass + weather



Model output



Output based on the extended menhaden stock-recruitment Ricker model that incorporates striped bass and weather.

Acknowledgements

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Menhaden recruitment data: Maryland Department of Natural Resources
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