Predicting poor recruitment in striped bass from environmental conditions

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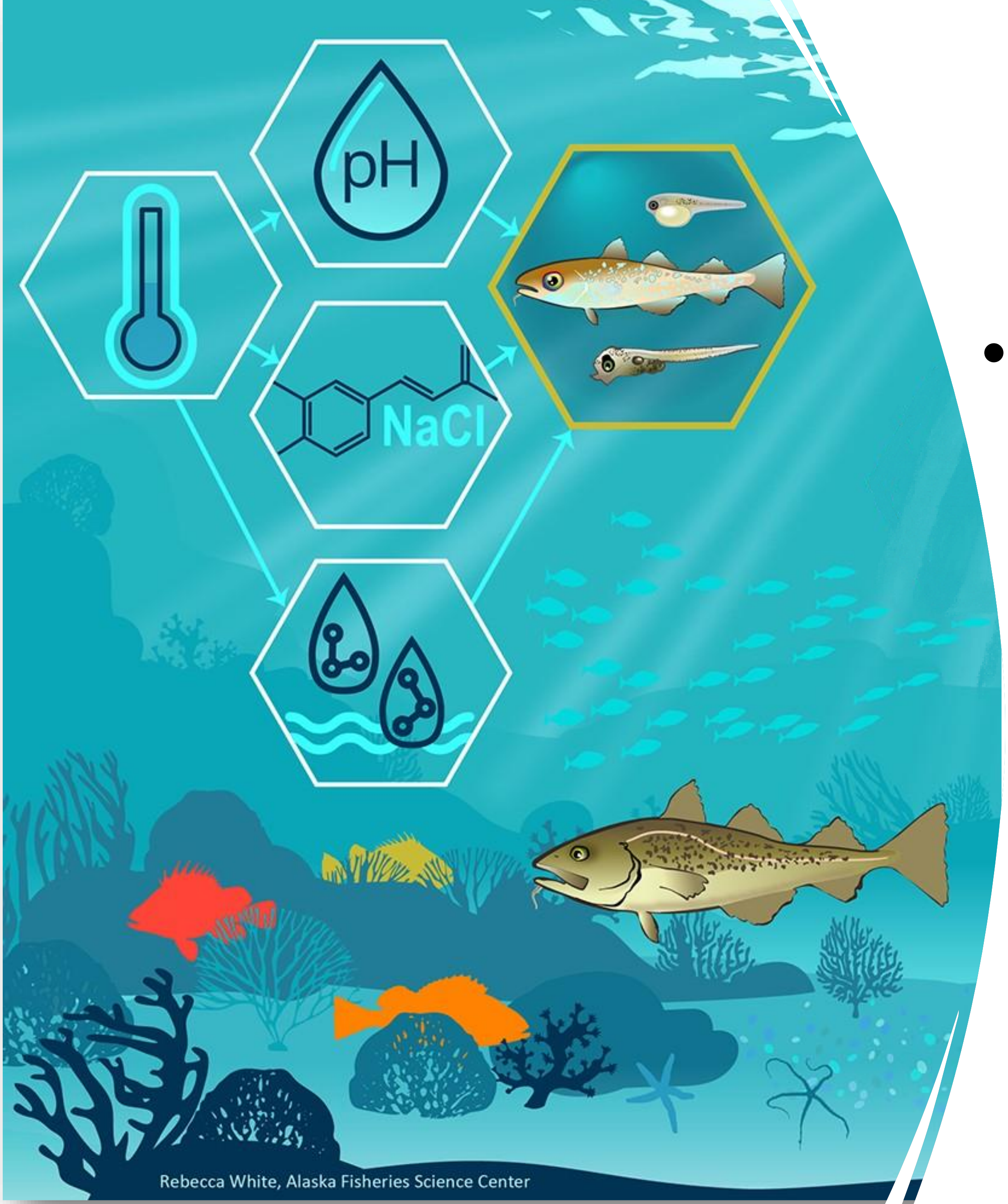


Recruitment & the environment

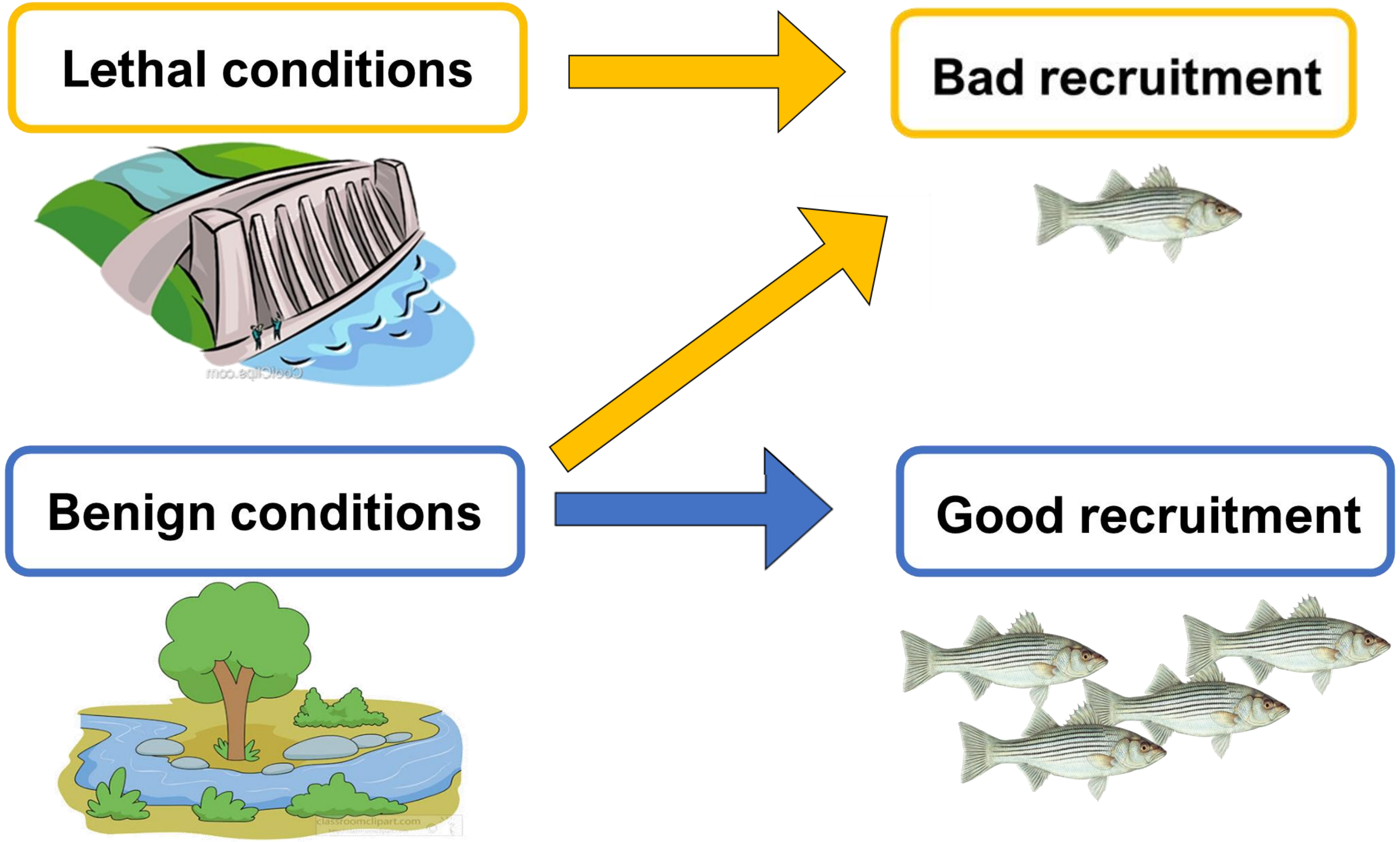
- Recruitment linked to environmental conditions BUT:
  - Highly uncertain relationships
  - Often fail with additional years of data
  - Add little improvement to recruitment predictions

Poor-recruitment paradigm:

Predicting *poor* recruitment is easier than predicting good recruitment

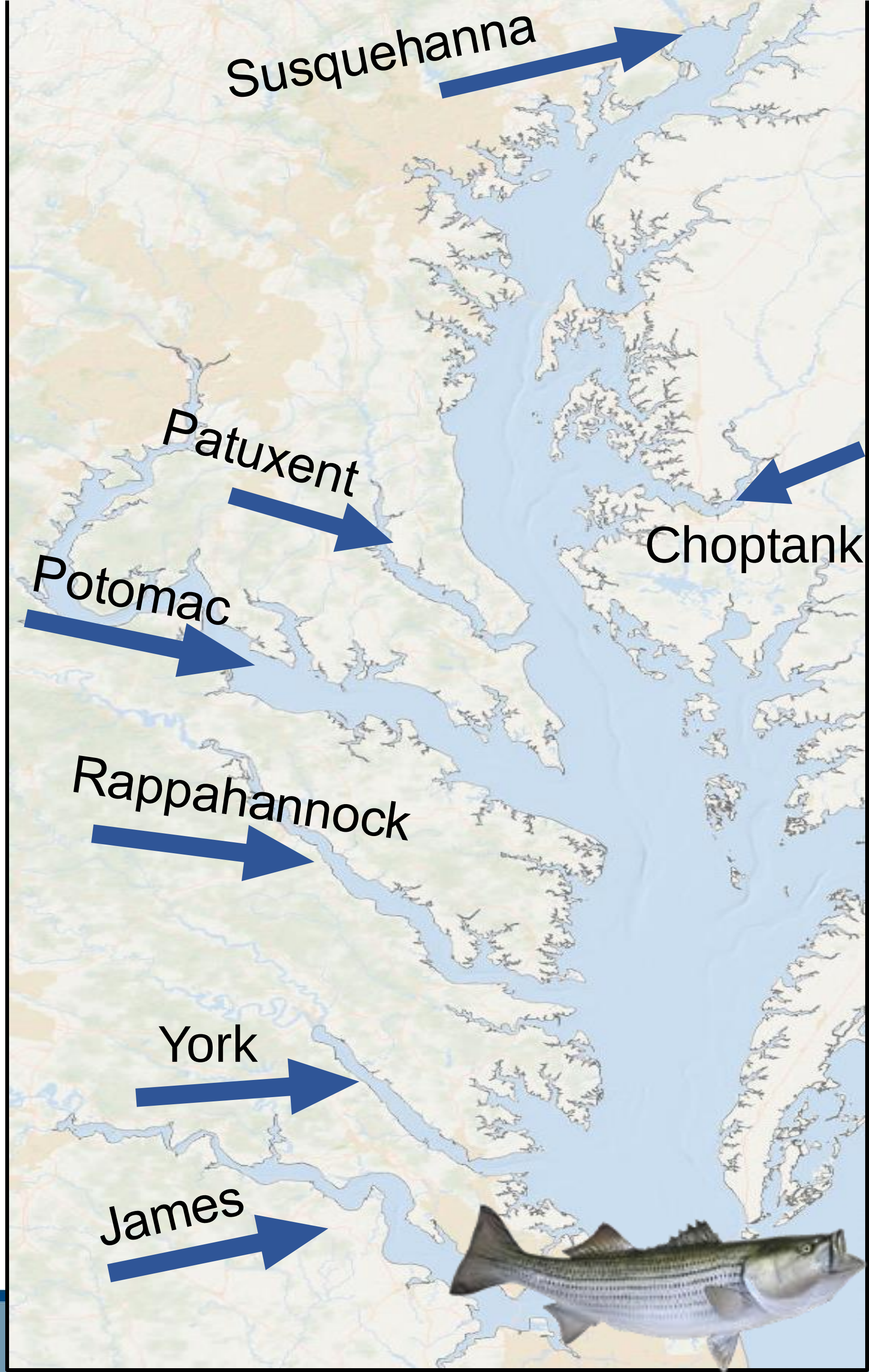
Poor recruitment requires only one extreme environmental condition

Converse not necessarily true… favorable conditions ≠ good recruitment



Applying to striped bass...

- 7 major tributaries of Chesapeake Bay
  - Recruitment:
    - Annual age-0 juvenile abundance index
  - Environment:
    - Annual mean spring river discharge (ft^3/s)
    - Average of daily river discharges for period 30 March – 15 May
- Data from 1985 – 2023
  - Chosen to avoid confounding with low stock
  - Historic data (1967-1984) for 3 VA rivers also analyzed separately



Poor-recruitment Paradigm methodology

Define "Extreme" environment conditions:

= lowest 1/3 of river discharge observations

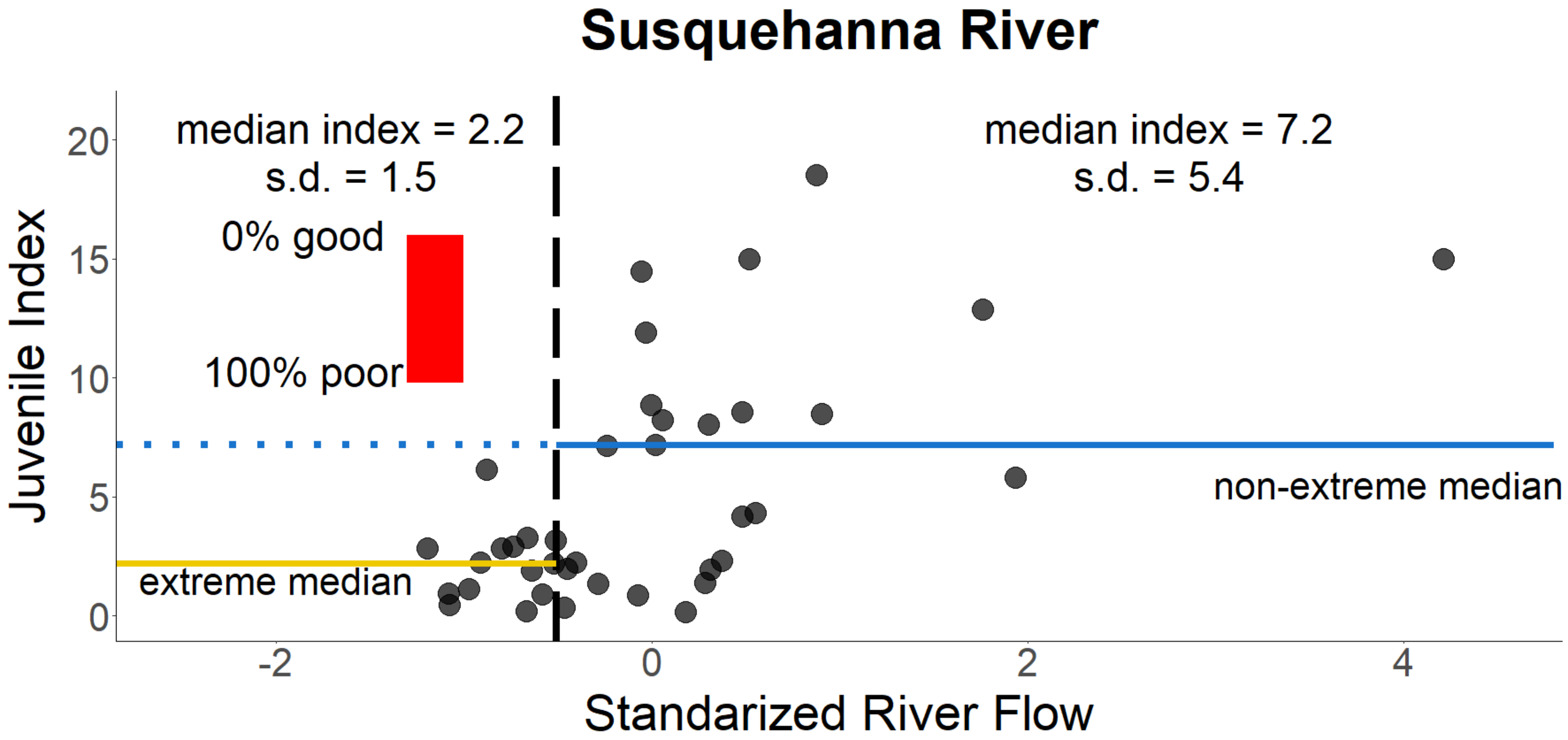
Characterize recruitment patterns:

- **Median recruitment**
- **Standard deviation**
- **Proportion of years with bad recruitment**

Comparing "extreme" to non-extreme" we expect:

- **Reduction in recruitment**
- **Lower std. dev**
- **> 50% poor recruitment under extreme conditions**

Paradigm results for Chesapeake striped bass:



During extreme conditions:

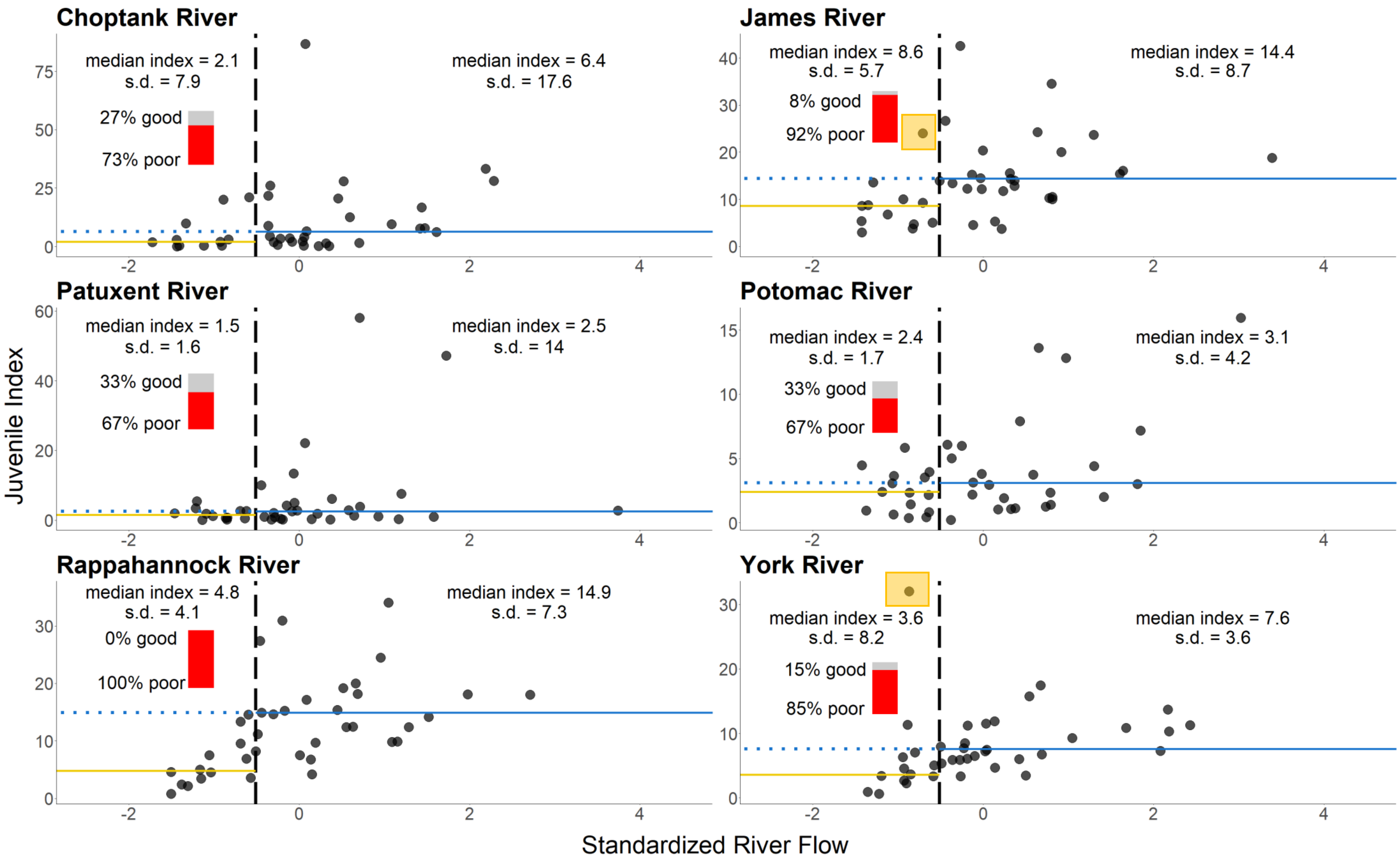
- **Recruitment is lower**
- **Std. Dev. is lower**
- **Propr. of years with bad recruitment is high**

extreme conditions

non-extreme conditions

Extreme conditions (left):

- **Recruitment always lower**
- **Std. Dev. lower**
- **Large # years with bad recruitment**
- **Large recruitment only ever seen twice across all rivers**



River	Choptank	James	Patuxent	Potomac	Rappahannock	Susquehanna	York
% reduction median recruitment	67.2%	40.3%	40.0%	22.6%	67.8%	69.4%	52.6%

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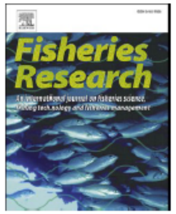

Evaluating a possible new paradigm for recruitment dynamics: predicting poor recruitment for striped bass (*Morone saxatilis*) from an environmental variable

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A R T I C L E I N F O

Handled by A.E. Punt

Keywords:
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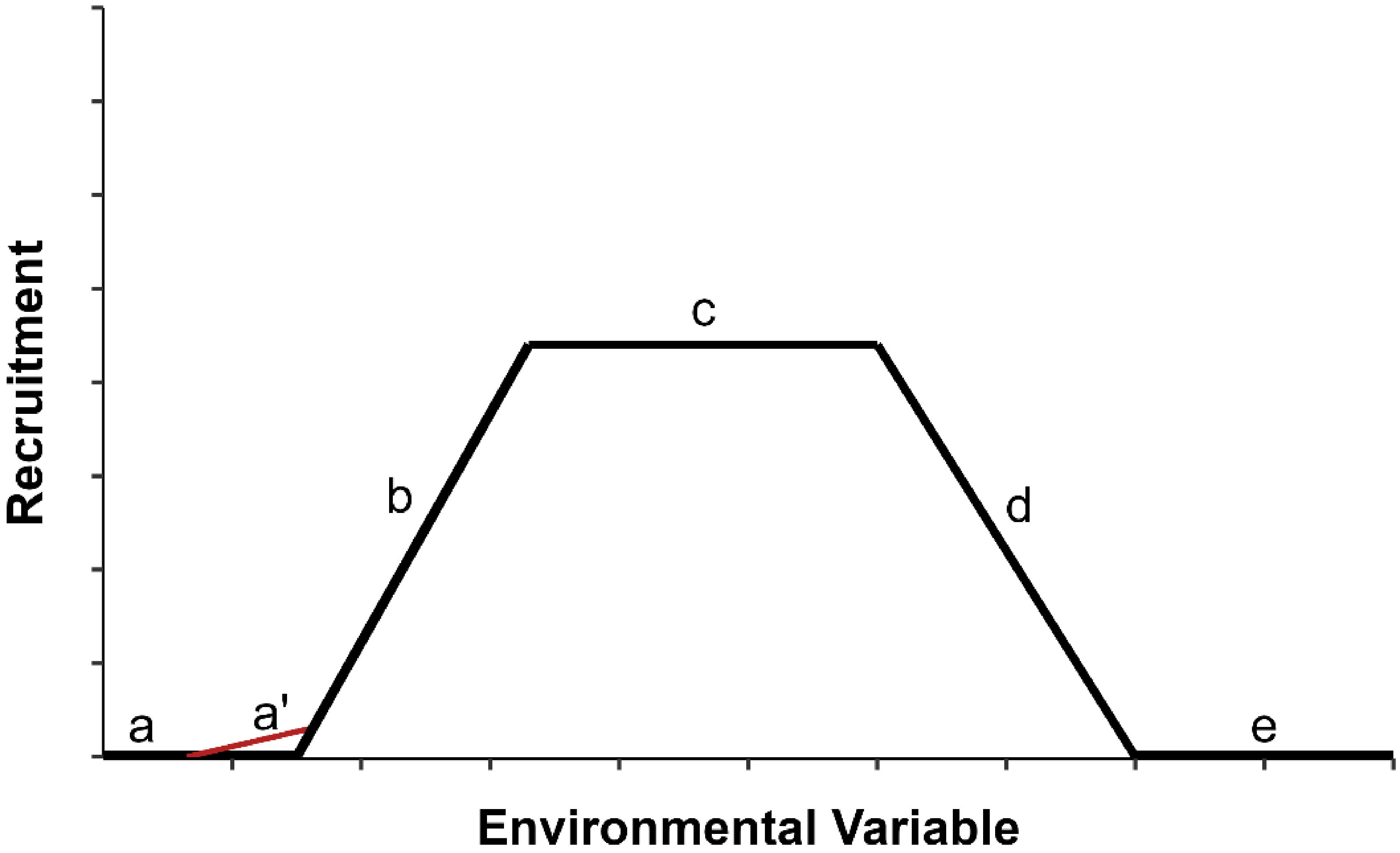
Population dynamics
Recruitment prediction
Stock projections
Year class strength
Striped bass
River discharge

A B S T R A C T

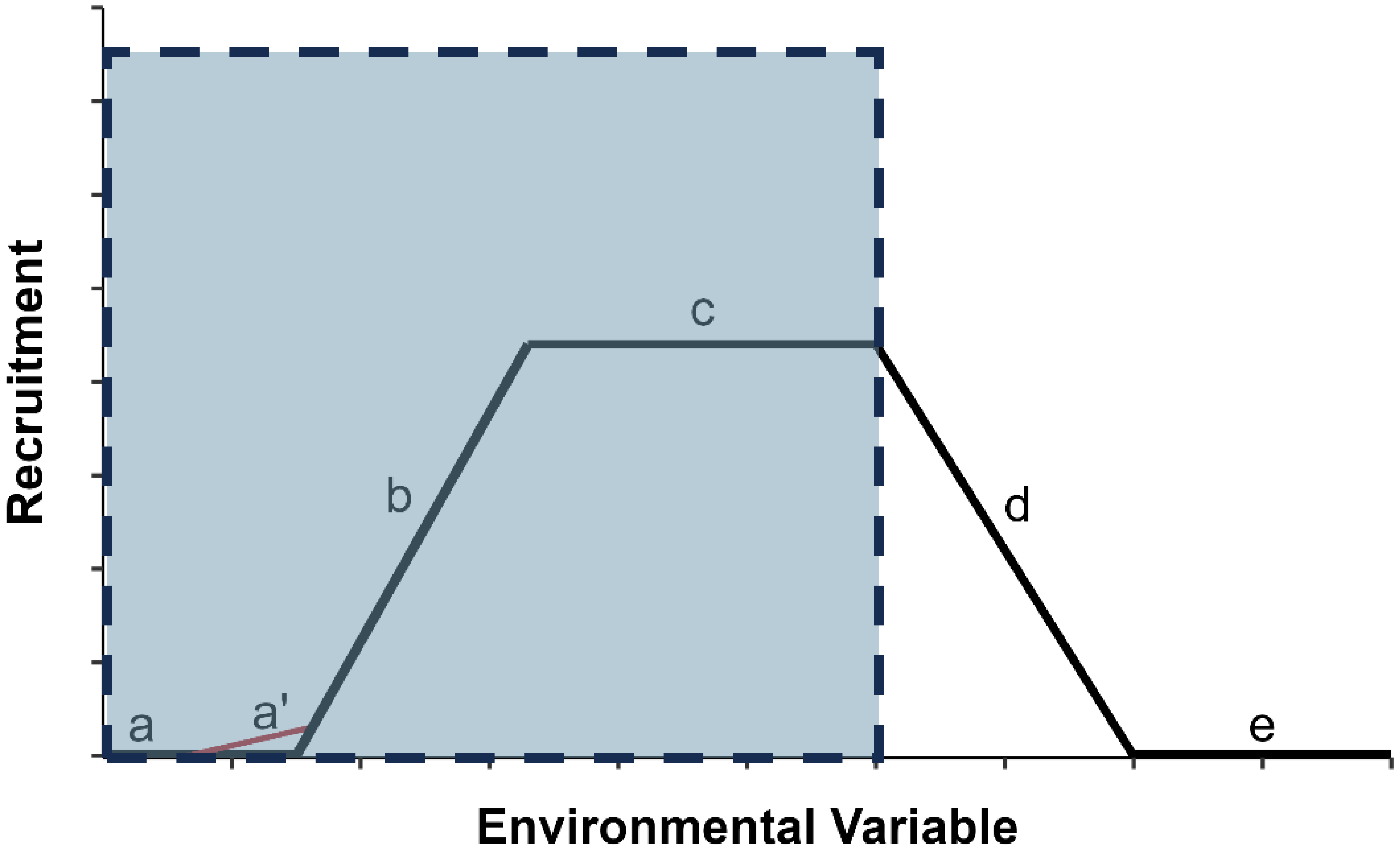
Understanding what causes large year classes and predicting them has been called the holy grail of fisheries science, one of the last great unanswered questions. Recruitment prediction, or forecasting, is an important component for setting fishery catch limits. We propose a new approach, called the “poor-recruitment paradigm”, for predicting recruitment using environmental variables. This approach hypothesizes that it is easier to predict poor recruitment rather than good recruitment because an environmental variable affects recruitment only when its value is extreme (lethal); otherwise, the variable may be benign and not influence recruitment. Thus, good recruitment necessitates all environmental conditions not be harmful and for some to be especially favorable; poor recruitment, however, requires only one environmental variable to be extreme.

This idea was evaluated using recruitment and river discharge data for striped bass (*Morone saxatilis*) from seven major spawning tributaries of Chesapeake Bay. Low spring river discharge reliably resulted in poor recruitment of striped bass. Specifically, in all rivers, median recruitment and standard deviation of recruitment were lower when spring river discharge was low compared to when it was average or high; additionally, the proportion of years with poor recruitment was higher in years of low discharge than in years of average to high discharge. The consistent predictability of poor recruitment has the potential to improve stock projections, and therefore, has the potential to improve catch advice.

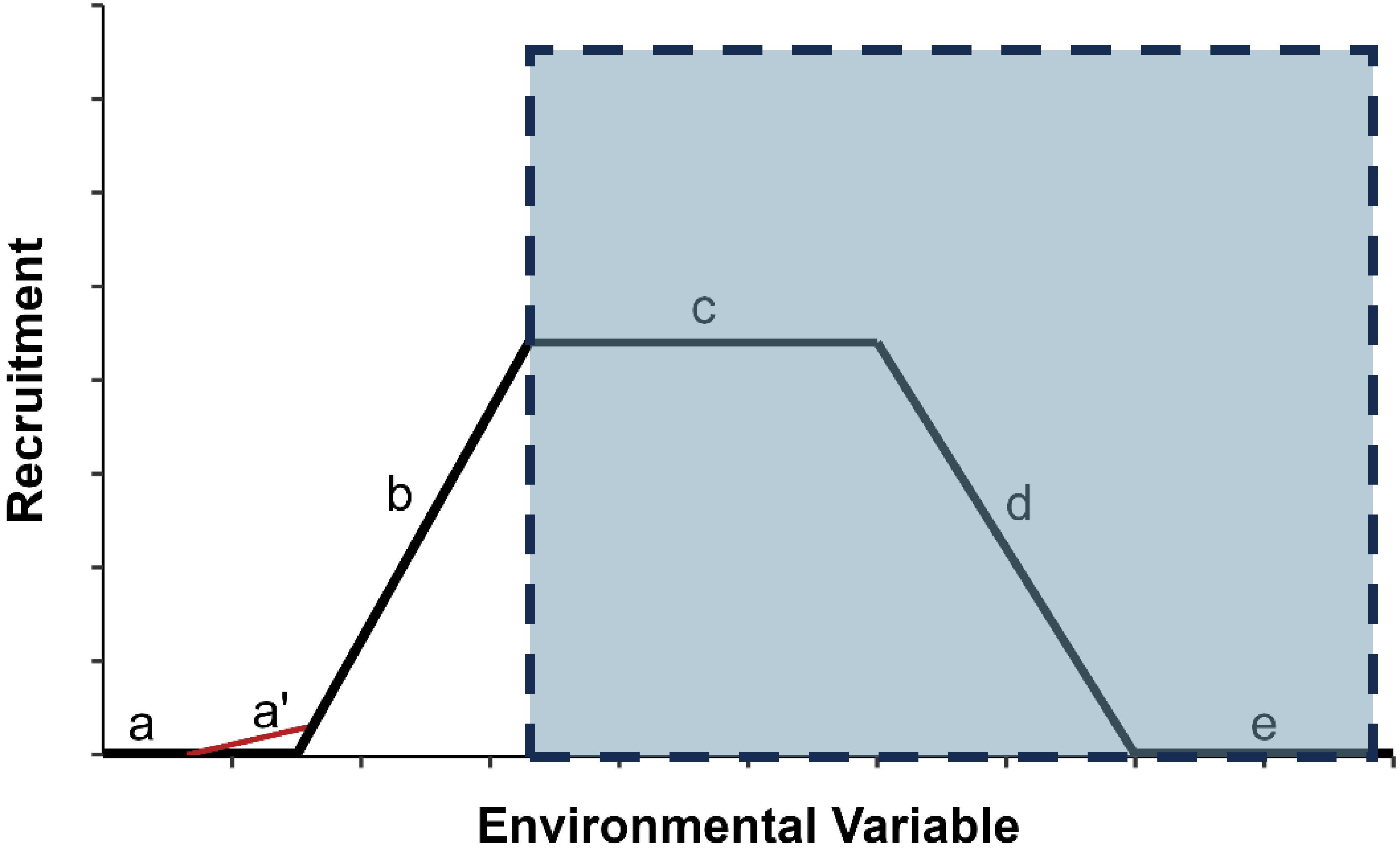
Modeling the poor-recruitment paradigm



Modeling the poor-recruitment paradigm

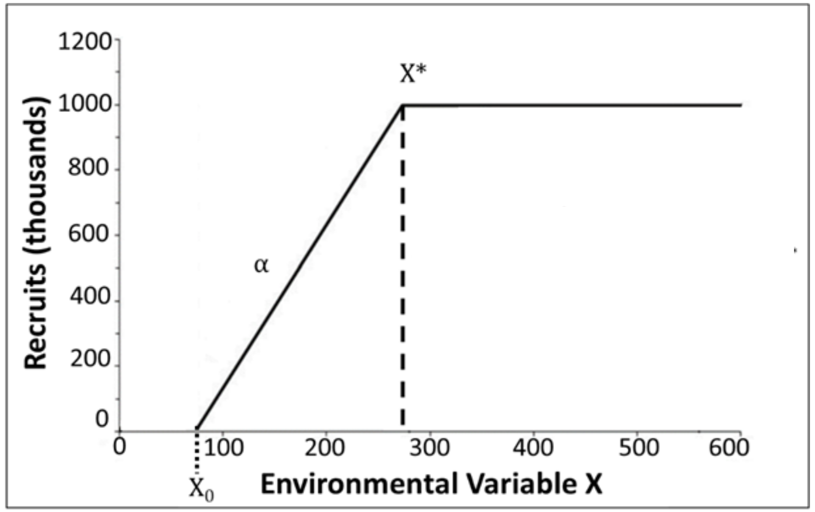


Modeling the poor-recruitment paradigm



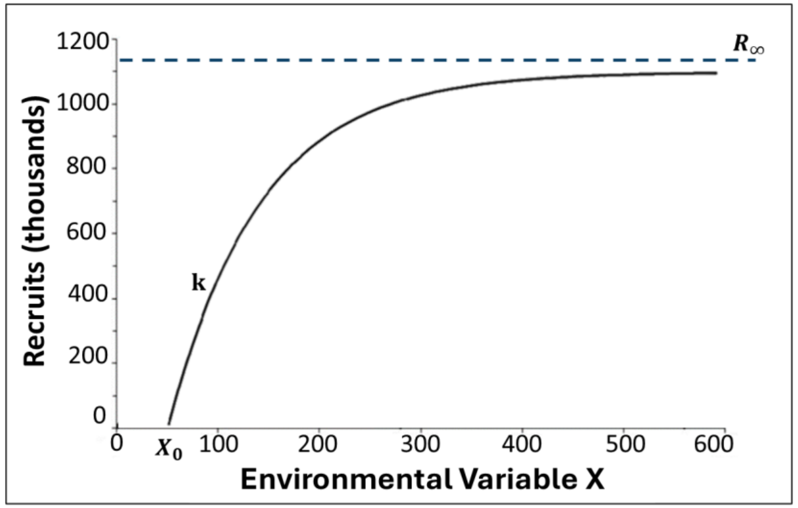
Proposed models for predicting recruitment

Hockey Stick



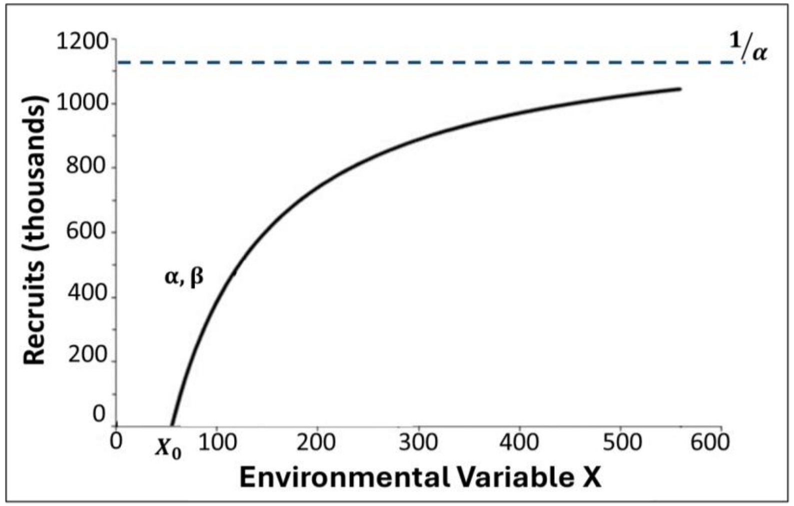
$$Recruitment = \begin{cases} 0 & X \leq X_0 \\ \alpha(X - X_0) & X_0 < X < X^* \\ \alpha X^* = R^* & X \geq X^* \end{cases}$$

von Bertalanffy



$$= R_\infty \left(1 - e^{-k(X - X_0)}\right)$$

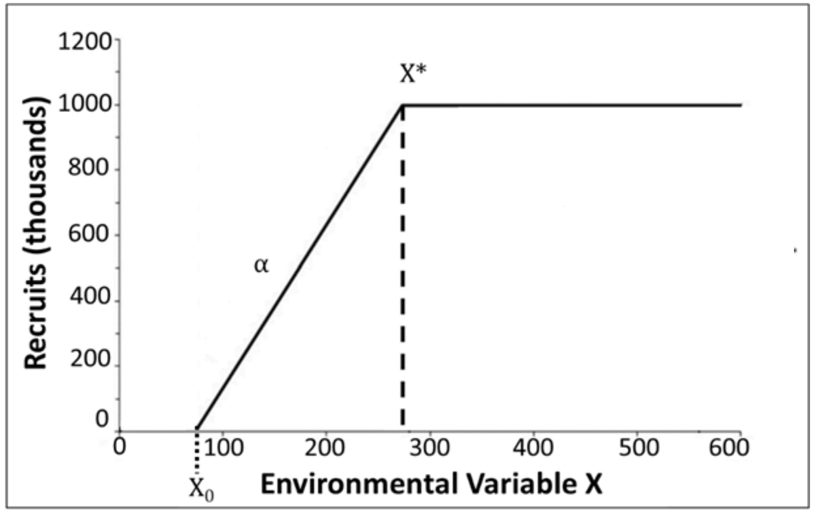
Modified Beverton-Holt



$$= \frac{(X - X_0)}{\alpha(X - X_0) + \beta}$$

Proposed models for predicting poor recruitment

Hockey Stick

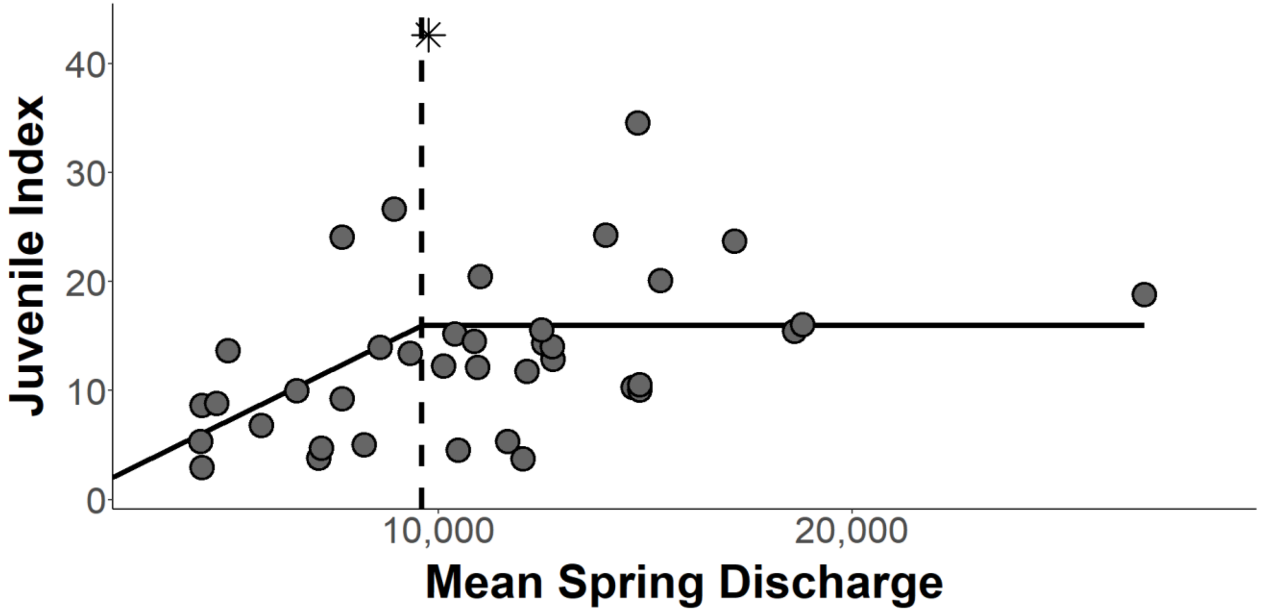


$$Recruitment = \begin{cases} 0 & X \le X_0 \\ \alpha(X - X_0) & X_0 < X < X^* \\ \alpha X^* = R^* & X \ge X^* \end{cases}$$

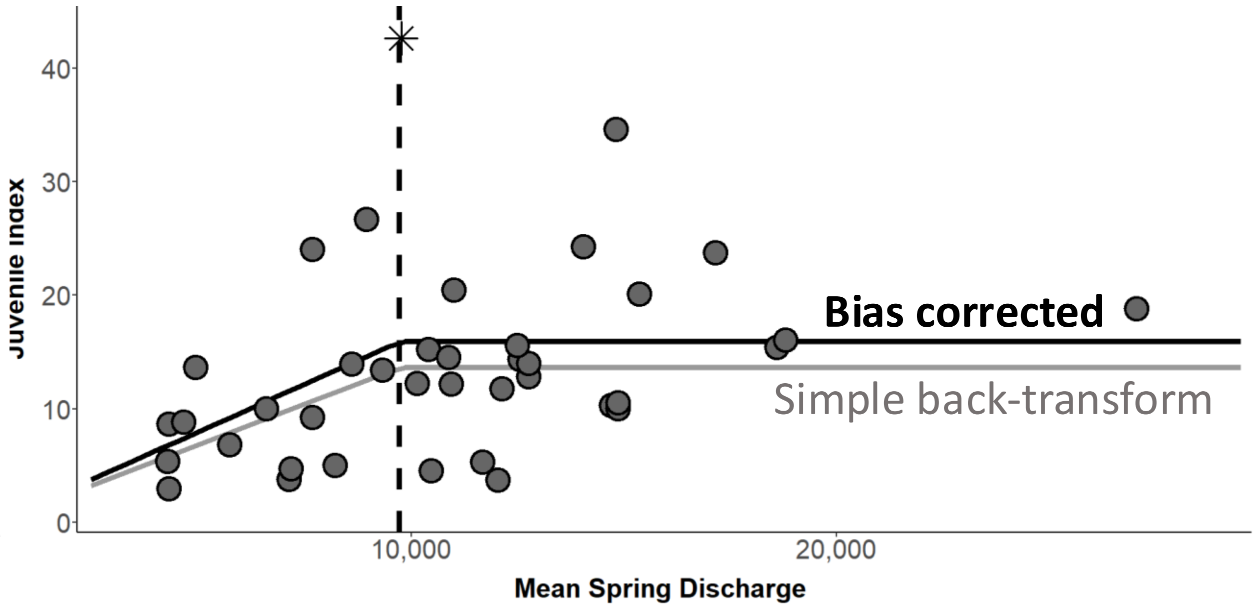
For striped bass data, smooth models have more issues with:

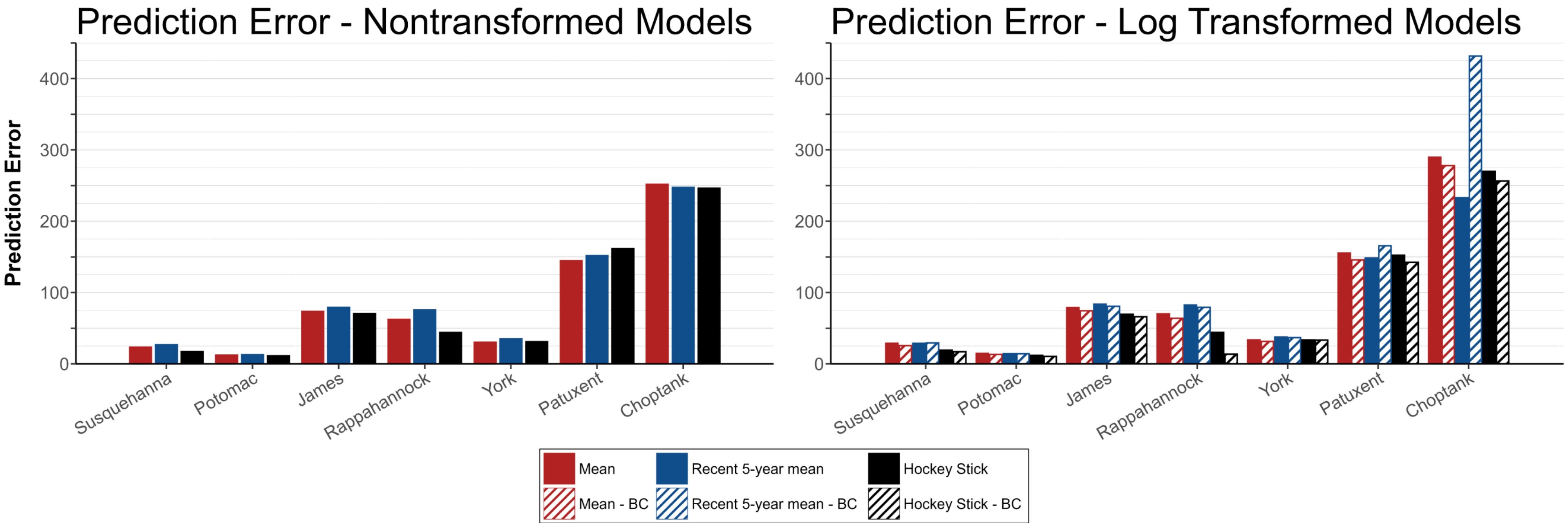
- Convergence
- "Nonsensical" parameter estimates

James River
(non-transformed model)

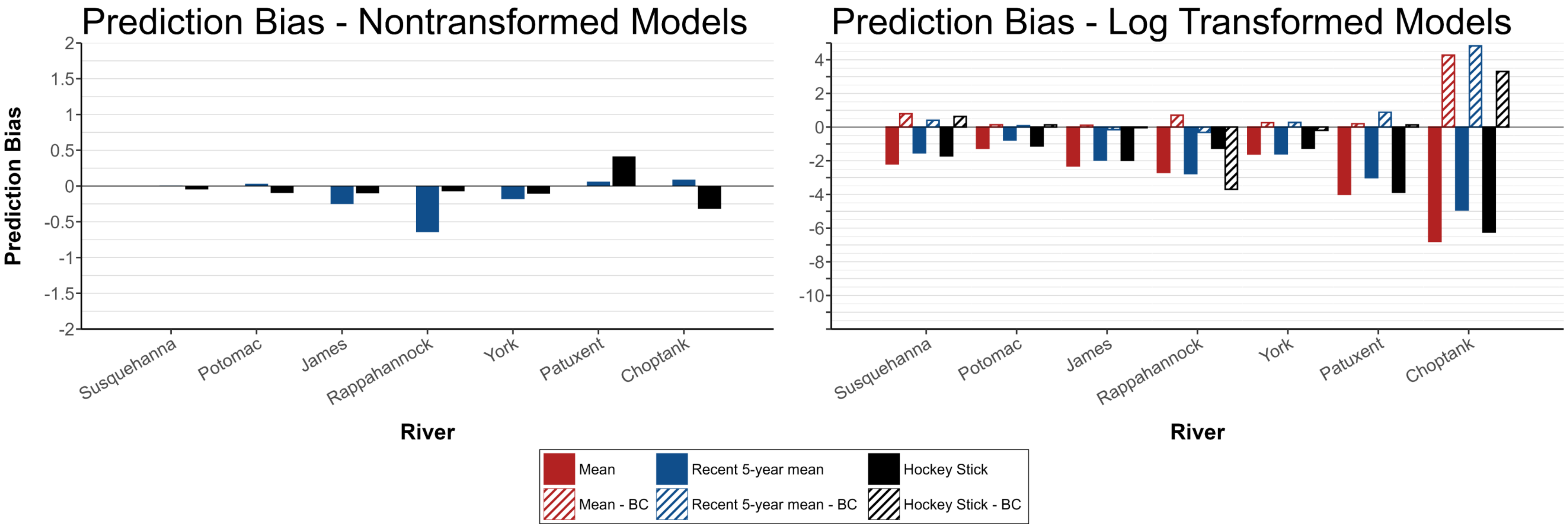


James River
(log-transformed model)





Prediction Error - Nontransformed Models
Prediction Error - Log Transformed Models
Prediction Error
0
100
200
300
400
Susquehanna
Potomac
James
Rappahannock
York
Patuxent
Choptank
Mean
Recent 5-year mean
Hockey Stick
Mean - BC
Recent 5-year mean - BC
Hockey Stick - BC



Prediction Bias - Nontransformed Models
Prediction Bias - Log Transformed Models
Prediction Bias
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
4
2
0
-2
-4
-6
-8
-10
Susquehanna
Potomac
James
Rappahannock
York
Patuxent
Choptank
River
Mean
Recent 5-year mean
Hockey Stick
Mean - BC
Recent 5-year mean - BC
Hockey Stick - BC

Conclusions:

- Poor-recruitment easier to predict (than good) for Chesapeake striped bass
- Low river discharge --> 20 – 70 % reduction in recruitment
- Can provide way to judge credibility of a juvenile abundance index value
- Hockey stick reasonable for striped bass recruitment
    - (Smooth models can perform similar to hockey stick if well-behaved)

Contact Information

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