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Recruitment predictions we *can* make

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Background information:

Striped Bass (*Morone saxatilis*)

- Anadromous fish
- Spawns in 7 Chesapeake Bay tributaries April-May

Best conditions for juvenile survival:

- Moderate river flow (Rufilson 1990)
- 15-20 °C (Secor & Houde 1995)
- Stable temperatures (Coutant & Cox 1981)

Methods:

- Study from 1985-2018, March 30–May 15 season
- River flow daily averages, ft^3/sec (USGS)
- Daily temperature in °C (various sources)
- Juvenile index: relative year-class strength

Sufficient conditions for poor recruitment: Low river flow or high temperatures

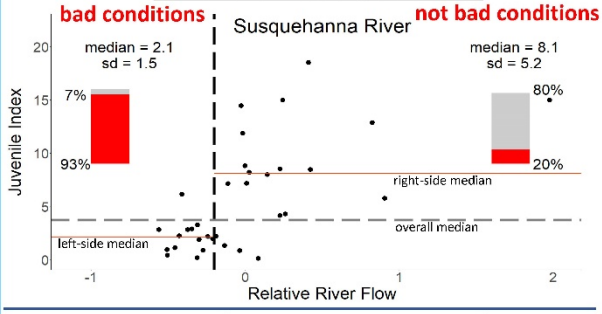
Hypothesis:

We can predict **poor** recruitment, not good

3 metrics describe recruitment

1. Median juvenile index
2. Std. deviation (variability)
3. Proportion of years with poor recruitment

River flow as a predictor

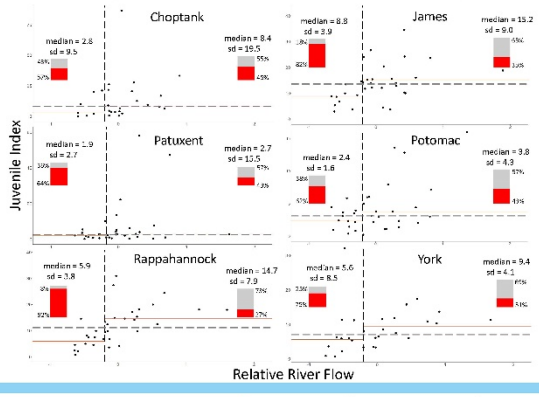


High Pr(poor recruit) — Lower median — Lower variation

VS.

Recruitment poor **OR** good — Higher median — Higher variation

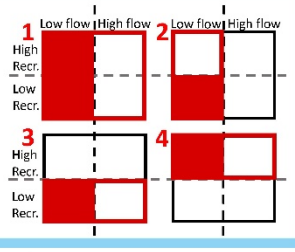
6 other rivers, same story



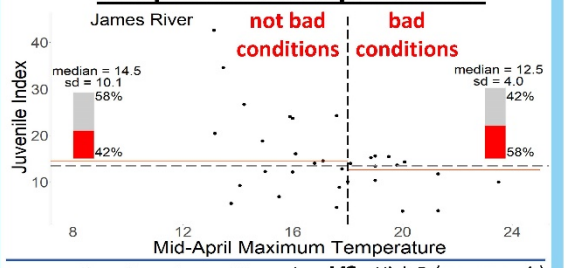
Key questions:

1. How often can we make a prediction of poor recruitment? (How often is flow low?)
2. How often are we correct when we predict?
3. What percent of poor recruitment can we predict?
4. What's the chance of falsely predicting poor recruitment given that it's good?

Answers (rivers combined)	
1.	36%
2.	75%
3.	54%
4.	21%



Temperature as a predictor…



Recruitment poor **OR** good — Higher median — Higher variation

VS.

High Pr(poor recruit) — Lower median — Lower variation

…but it's not as strong a predictor as river flow

Conclusions:

- Can use low flow to predict some poor recruitment
- High temperature also predicts, but not as well
- With time (experience) we can add more predictors
- Can't predict recruitment when conditions normal
- DON'T try to predict STRONG year classes, predict weak ones

Implications for climate change:

- Expect changes in recruitment as climate changes
- Forecasting negative effects of climate change on recruitment is easier than forecasting positive ones

Recruitment predictions we can make, and their significance under changing climate

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Abstract
Understanding what causes large year classes, and developing the ability to predict good recruitment, has been called the holy grail of fisheries science, the last great unanswered question. We propose it is easier to predict bad recruitment than good because all that's needed is to identify sufficient conditions for bad recruitment. For example, in seven stocks of striped bass (*Morone saxatilis*) in tributaries of Chesapeake Bay, low spring river flow reliably predicts poor recruitment: mean recruitment and standard deviation of recruitment are lower when river flow is low than when it's high. Additional cases of poor recruitment can be predicted if unfavorable temperature conditions are identified. Thus, to get poor recruitment, it's sufficient to have an environmental condition be lethal over a large enough temporal-spatial window. In contrast, to get good recruitment, it is necessary to have all environmental conditions be favorable to survival. Uncertainty in the stock assessment, and risk of management actions, are reduced by improving the ability to predict recruitment – in this case poor recruitment. Risks associated with specific management options, e.g., quotas, are generally evaluated by simulating possible values of recruitment. This simulation can be made conditional on whether or not unfavorable conditions for recruitment have been observed. The benefits of conditioning on climate variables depends on how likely are unfavorable conditions. Climatic changes leading to identifiable environmental variables becoming more frequently unfavorable can allow for reliable predictions of (some) poor recruitment. The converse is not true: favorability of some variables does not guarantee good recruitment.

Keywords:
lethal conditions, year class strength, uncertainty, risk, sufficient conditions, necessary conditions, river flow

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