Using environmental data to inform spatial stock assessment assumptions in Stock Synthesis

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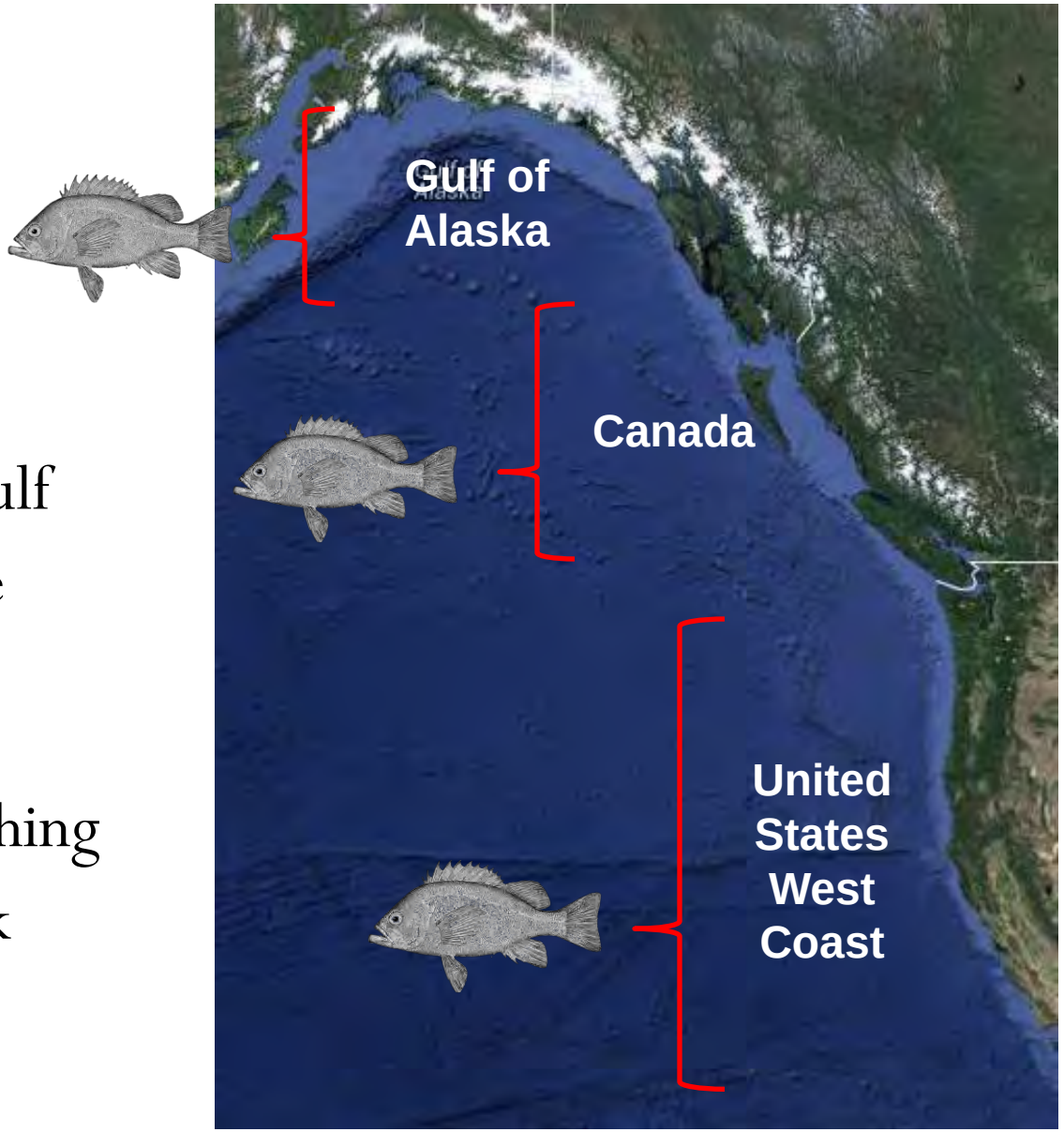
Current US Assessments

- Assume a large spatial scale
- E.g. West Coast stock, Canadian stock and Gulf of Alaska stock for one species
- Possible risk of overfishing or underutilizing stock sub-units



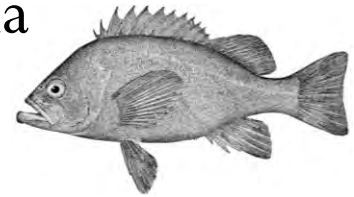
Spatial Structure Example

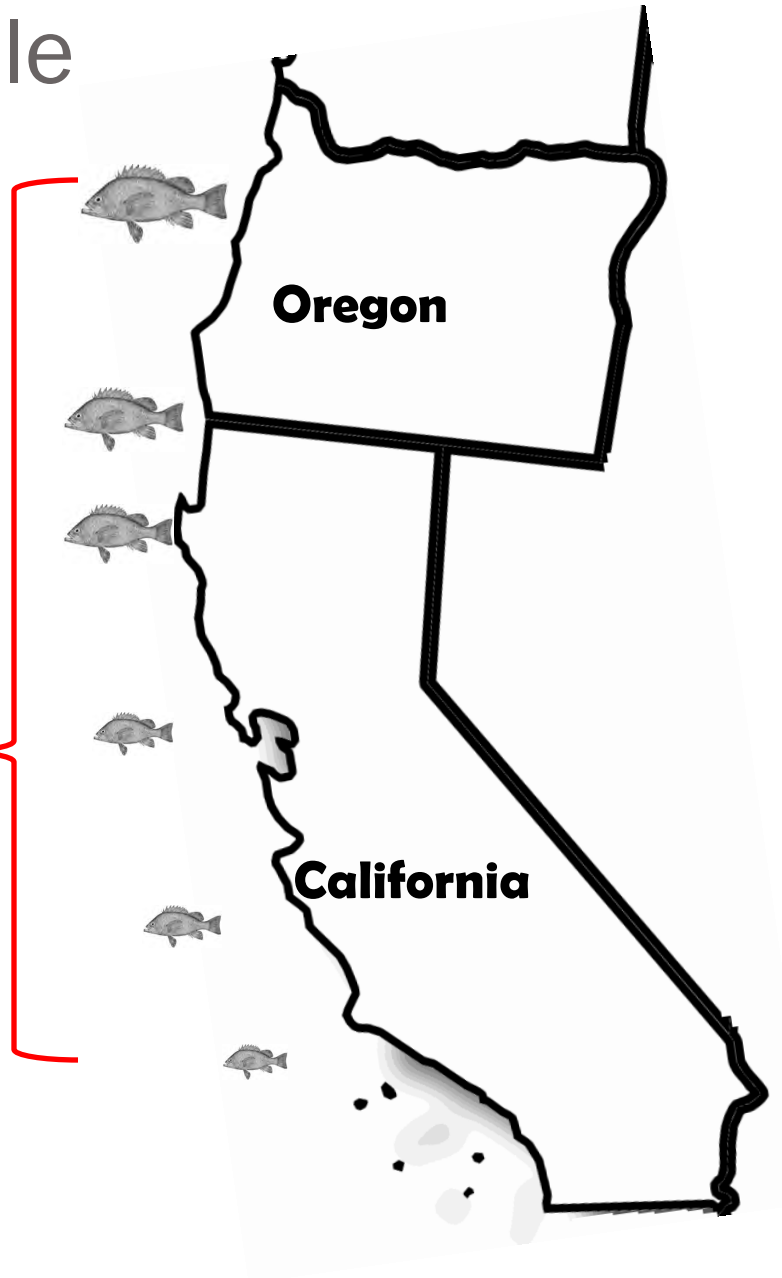
- Black rockfish (*Sebastes melanops*) Stock Assessment Area:

  Cape Falcon, Oregon and North of Point Peidras Blancas California

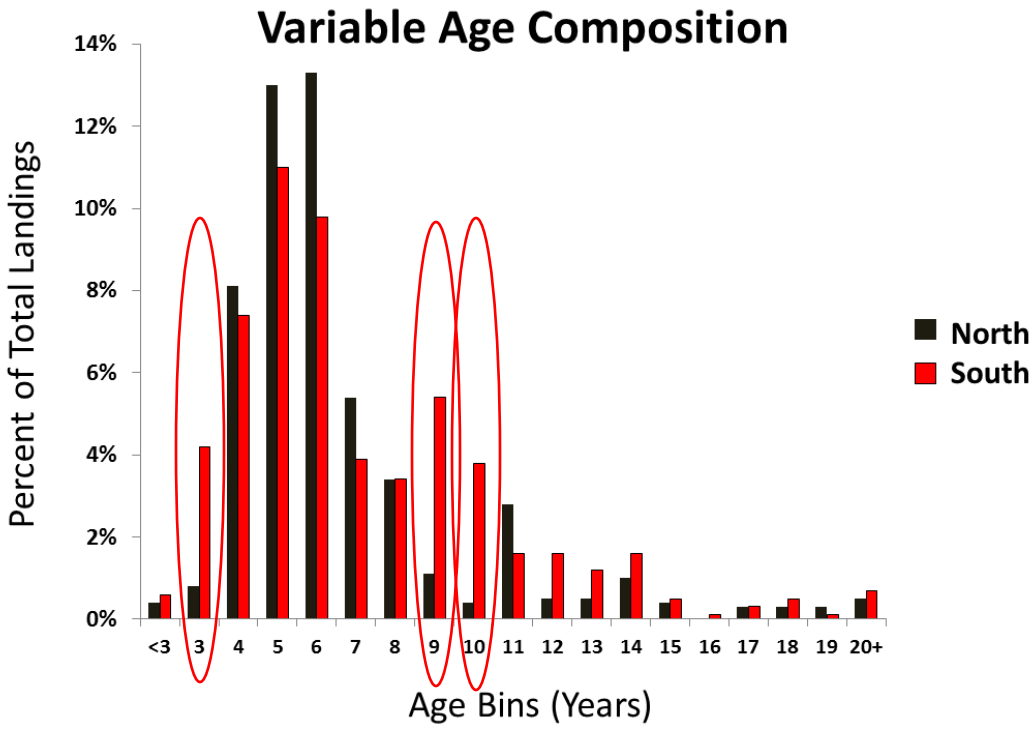
- Stock sub-units

  Can differ in magnitude, exploitation and management histories





Spatially Structured Data Example



- Attempted spatial assessment model for black rockfish status in 2007 failed
  - Results sensitive to parameter changes
- Lack of data to distribute recruiting fish to different areas
- Recruitment
  - Pelagic, juvenile fish move to and settle in the near shore habitat

Sampson, D. B. (2007). "The status of black rockfish off Oregon and California in 2007." Pacific Fishery Management Council, Portland, OR.

Research Goals

- What information is needed to provide reliable spatially structured stock assessment results?
- What are the consequences (if any) of not having that information?
- What are the consequences of different assumptions regarding spatial structure and environmental influences?
- Today's focus:
  - The influence of an **ENVIRONMENTAL FACTOR** driving the spatial distribution of recruitment

Monte Carlo Simulation Approach

Create an Operating Model

- Manipulate a simulated stock which is age and spatially structured

Generate Data Needed for Stock Assessments

- Based on experimental treatments and known parameters
- Replicated multiple times

Analyze the Generated Data

- Use a stock assessment program to estimate stock status and other relevant quantities

Compare

- Estimates vs. known values used in the operating model

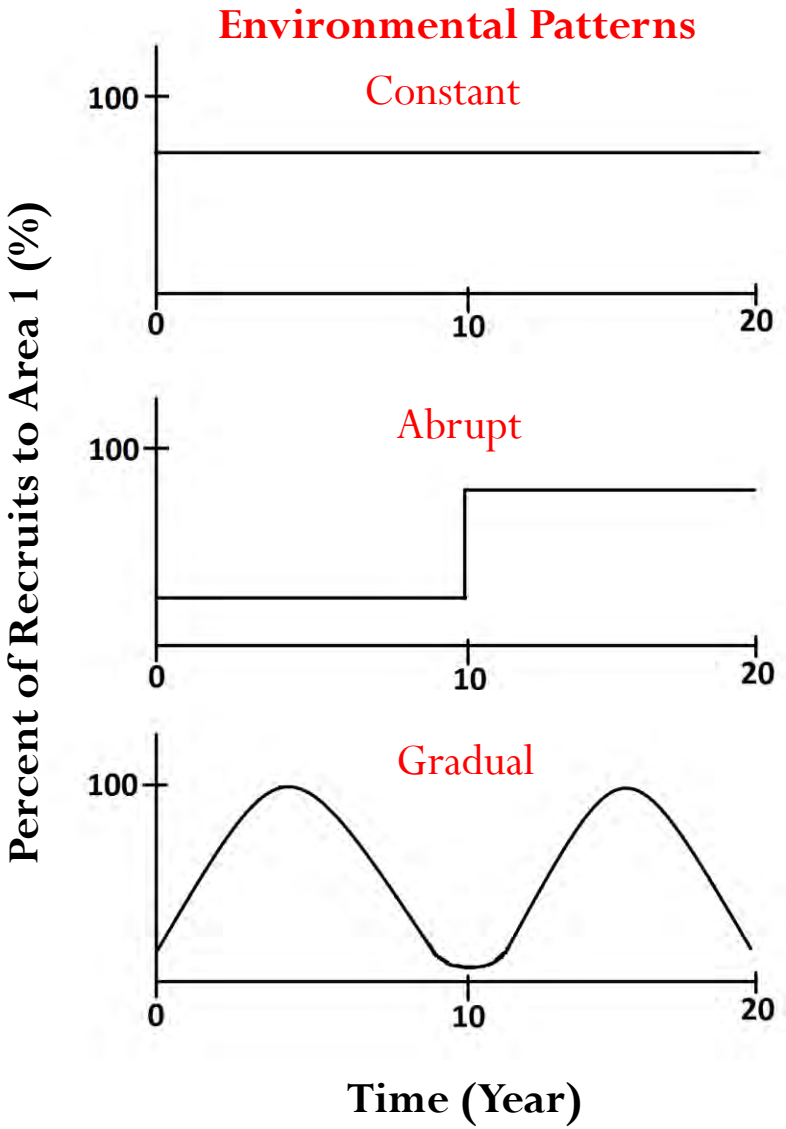
Operating Model

- Long lived species (similar to black rockfish)
- Age and spatially structured
- 2 areas, no movement of fish after settlement
- Pooled spawning biomass
- Identical in all aspects except:
  - Fishery selectivity (Age specific fishing mortality)
  - Percentage of recruits being distributed to each of the areas
- Recruitment to areas *(%Recruit)* driven by a simulated environment (3 temporal patterns)

Operating Model:

Environmental patterns influencing *%Recruit*

- Pooled Spawning Biomass
- Percent to Area 1
- Remainder to Area 2
- 3 Simulated scenarios
  - Constant
  - Abrupt
  - Gradual



Generate Data:

Microsoft Excel data generator

Data Needed for Stock Assessments

- Catch history
- Survey and fishery age composition
- Weight at Age data
- Survey biomass Index
- Catch per unit effort for the fishery

Monte Carlo replicates

- Include sampling variability in generated data
- Variability in annual recruitment
- Variability in environmental influence on percent recruitment

Analyze

Generated Data

Stock Synthesis (SS)

- Age structured assessment tool used to estimate stock status
- Used for majority of US West Coast Groundfish Assessments

Synthesis controls

- Estimate : Initial recruitment, recruitment deviations, growth and selection parameters
- Fix : Natural mortality and Steepness parameters

Methot, R. D. and C. R. Wetzel (2013). "Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management." Fisheries Research **142(0): 86-99.**

Analyze

Generated Data

Treatments:

- Spatial Assumptions (Future work)
- Survey data
  - Data provided to SS or not?
- Fix or estimate the environmental influence (link)
  - $P_{yr} = P + \exp(Env\_link * Env\_Factor_{yr})$
  - P = Percent Recruitment parameter
  - Env_link = 0
  - Env_link = 1
  - Env_link = Estimated by SS

Analyze

Generated Data

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Compare

Estimates and operating model values

Biological reference points

Relative Bias, overall and by-area

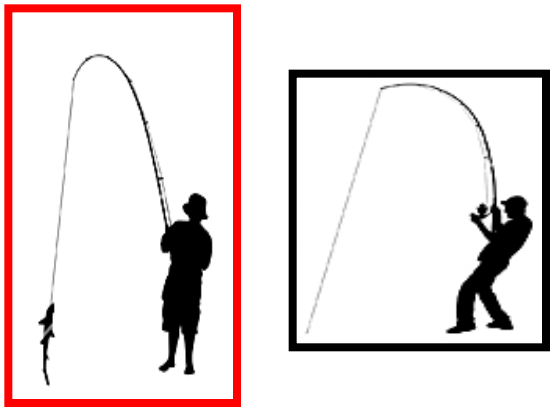
- Spawning Stock Biomass$_{current}$ (SSB)
- SSB$_{virgin}$
- Depletion (SSB$_{current}$/SSB$_{virgin}$)
  - "X" % Depletion = "X" % of Virgin SSB remaining

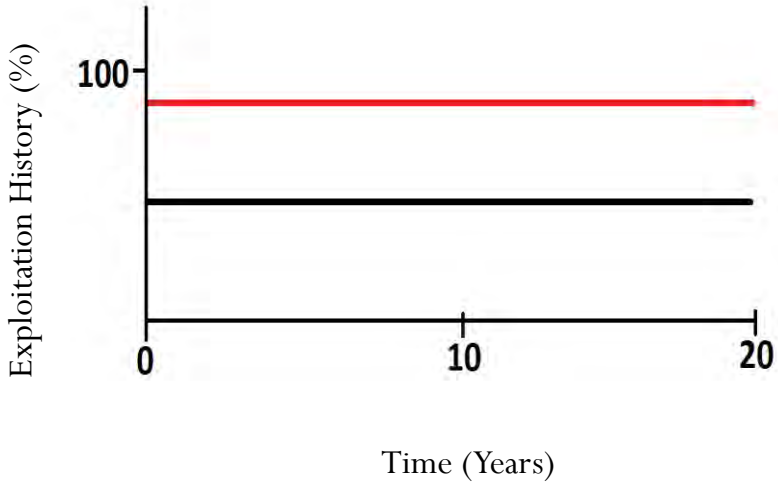
Estimate the strength of the environmental link

- $P_{yr} = P + \exp(\textbf{Env\_link} * Env\_Factor_{yr})$
- Does bias improve?

Treatments Considered Today

- 2 areas and 2 fleets
- Constant but differential levels of exploitation
- Survey data are available

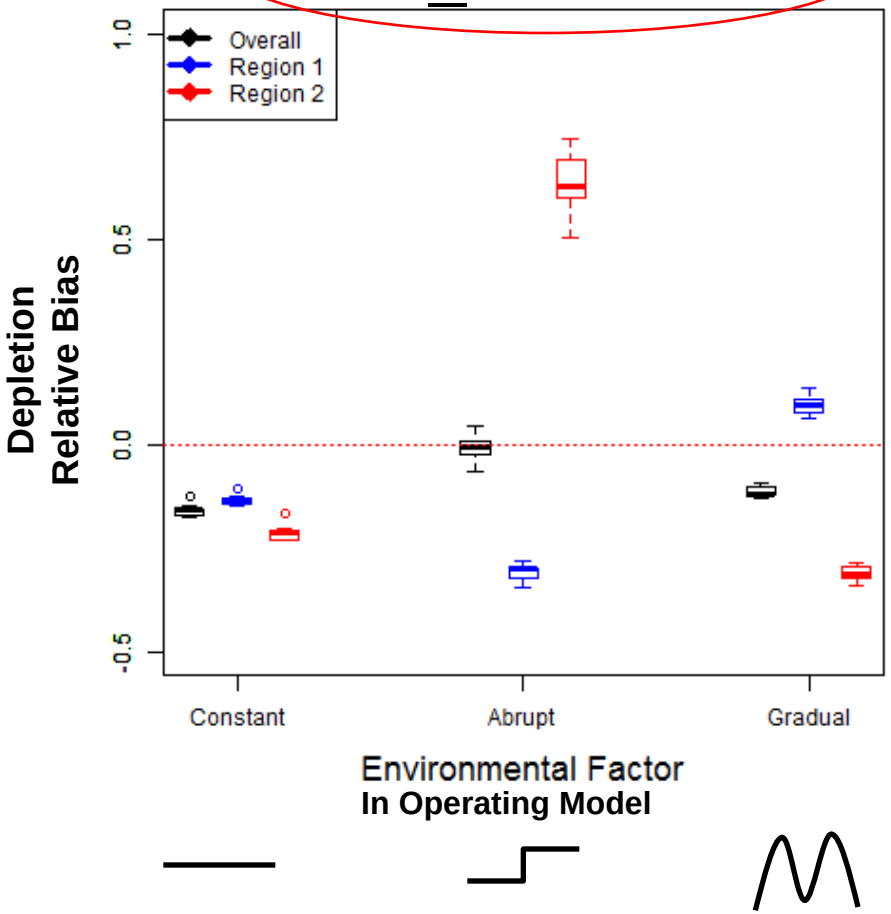




Does using an environmental factor reduce bias?

$$P_{yr} = P + \exp(\text{Env\_link} * \text{Env\_Factor}_{yr})$$

Env_Link = 1



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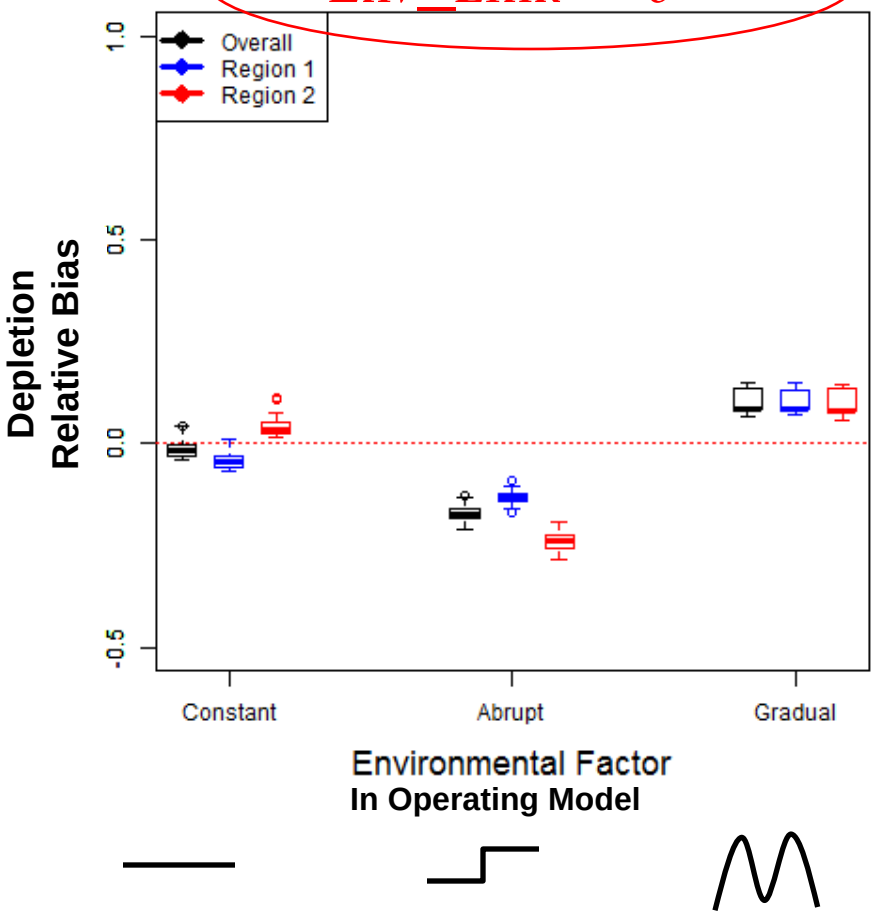

Bias differs based on pattern of the environmental factor

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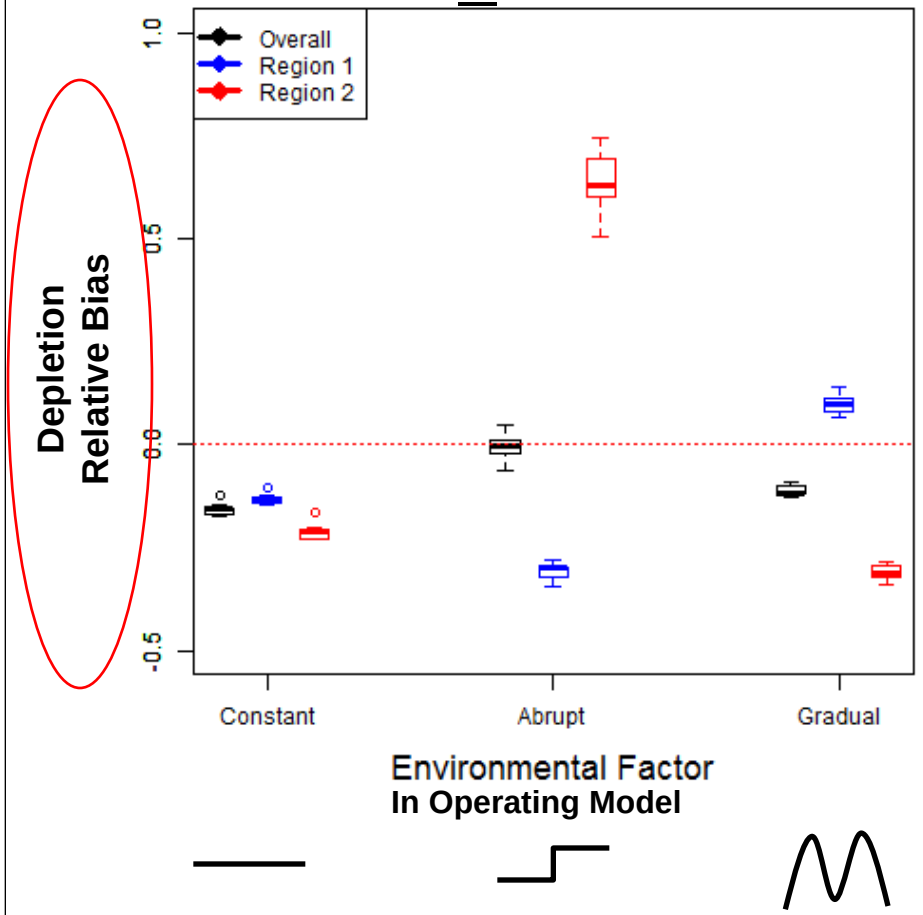

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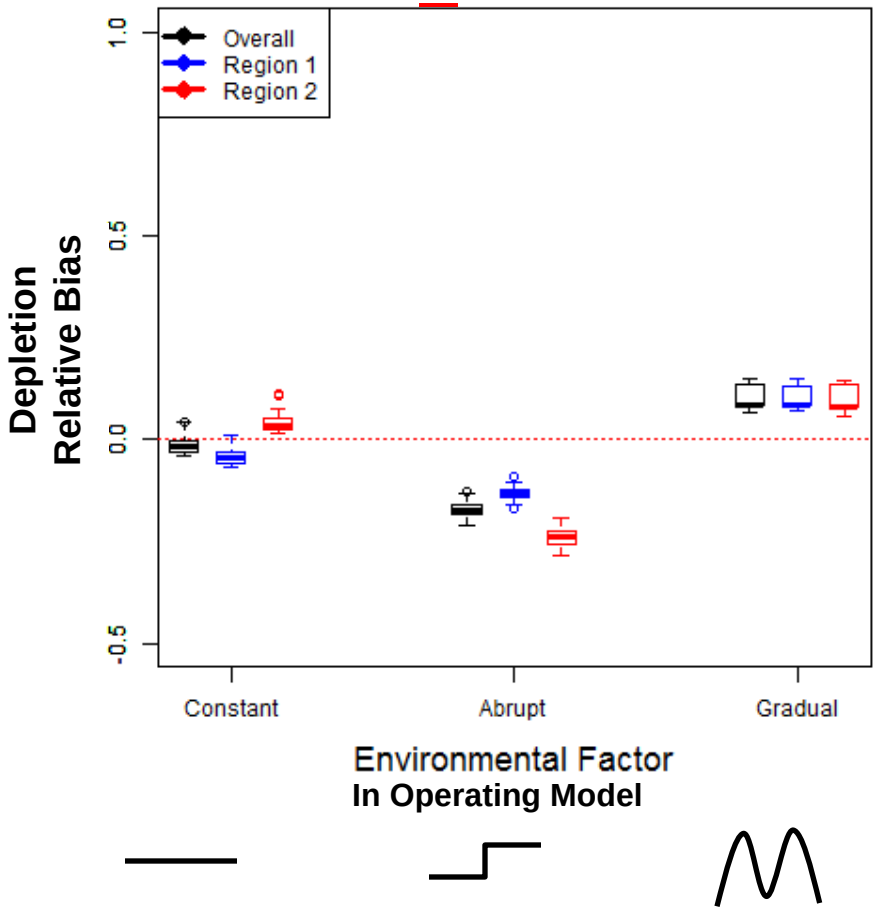

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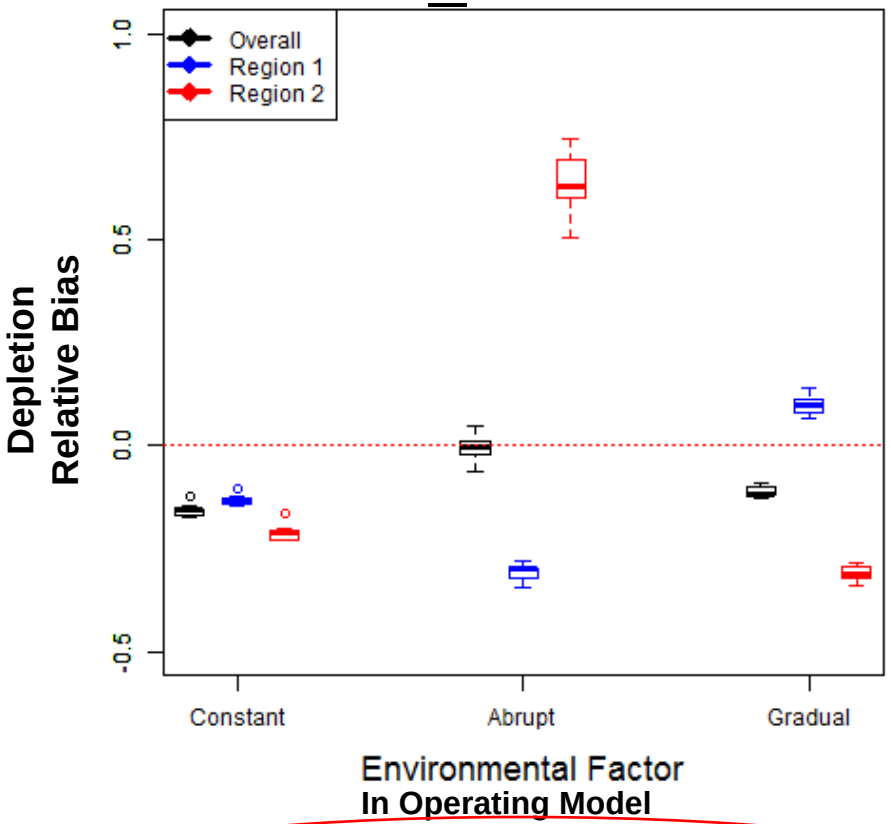

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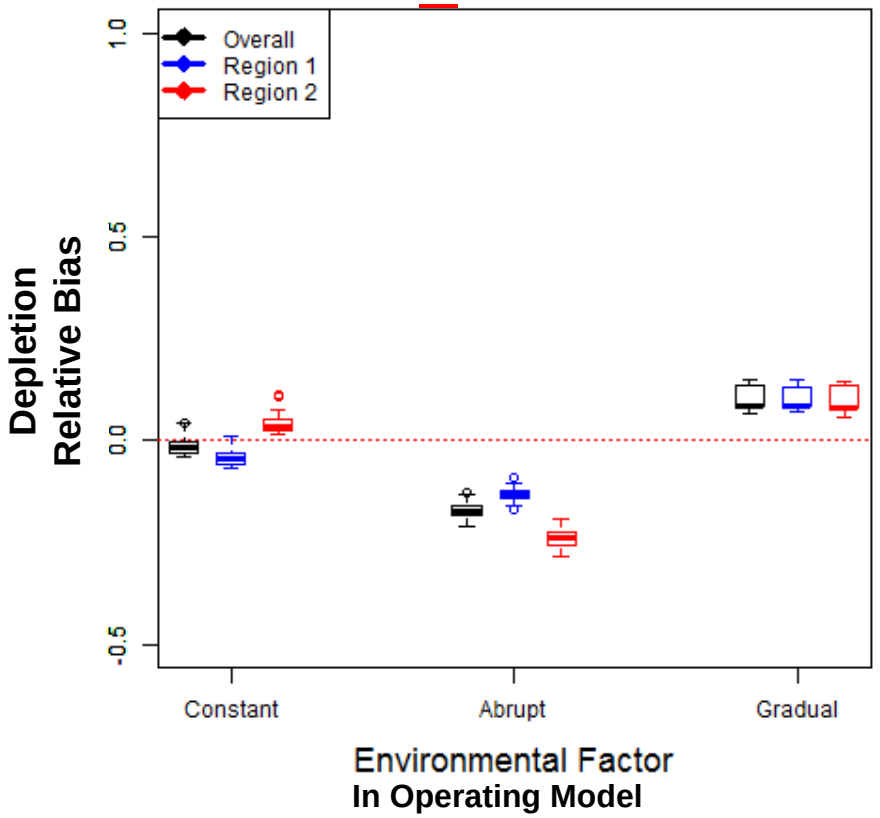

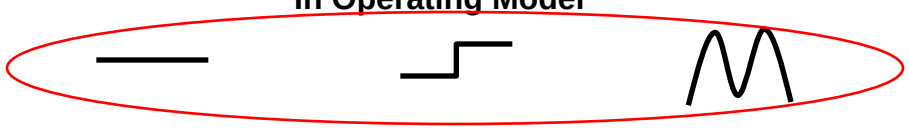

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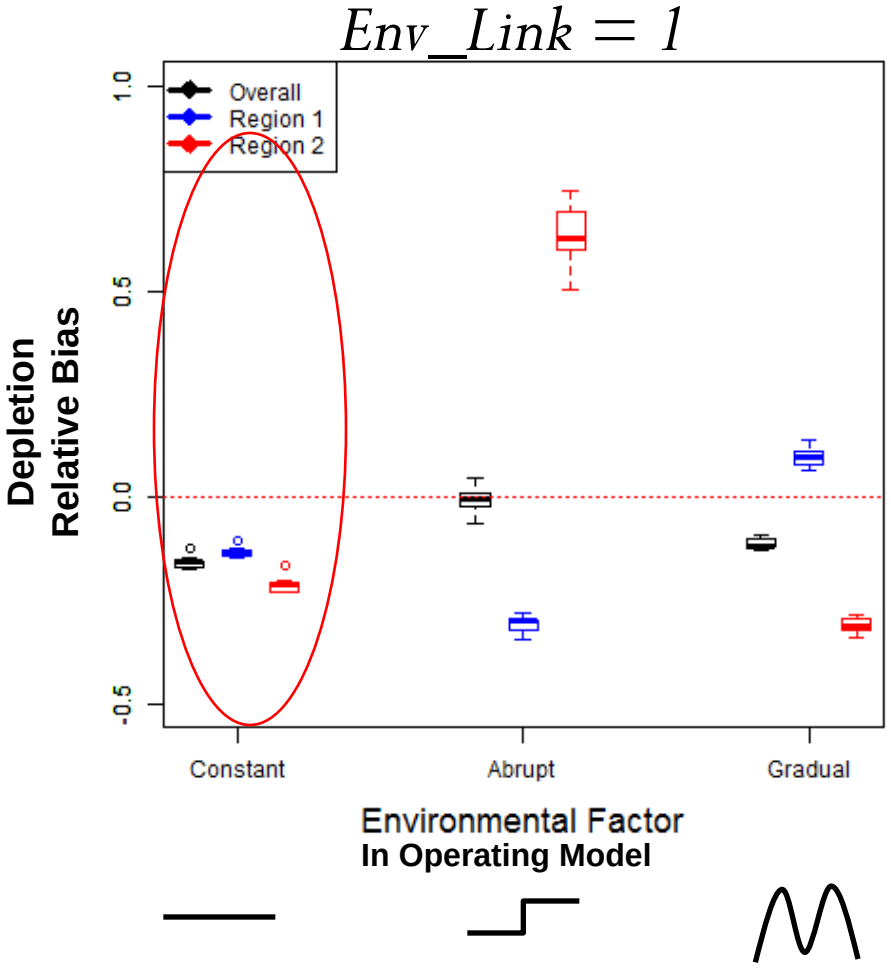

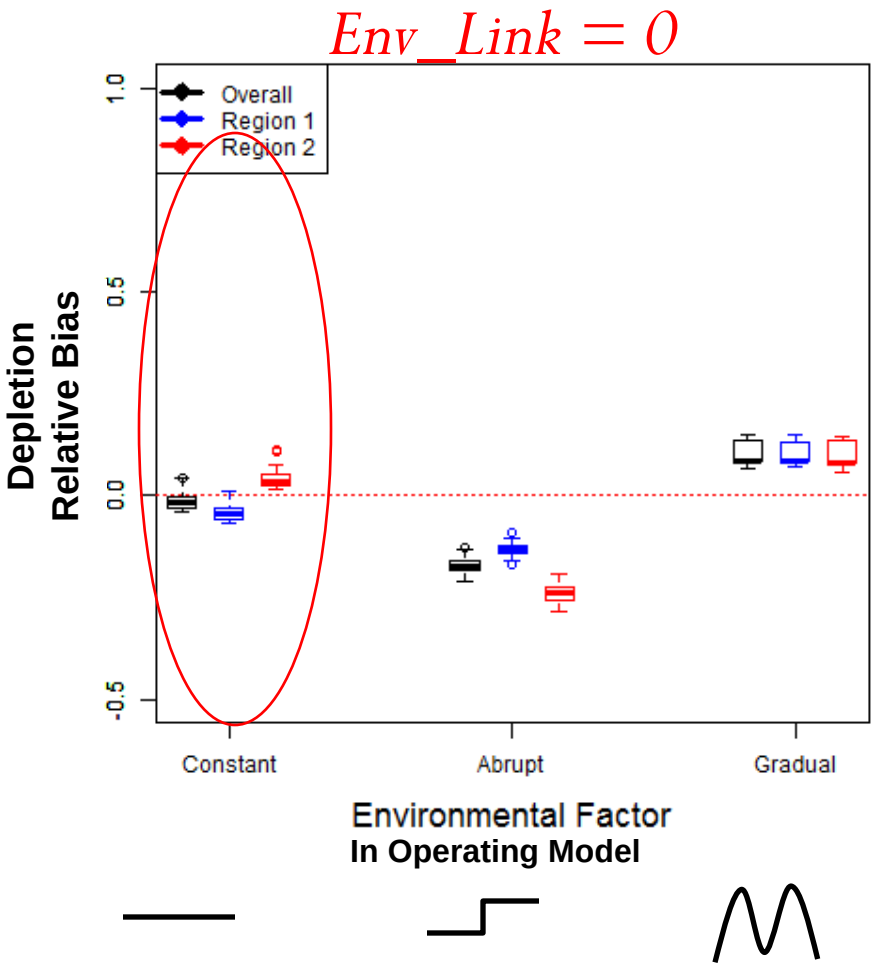

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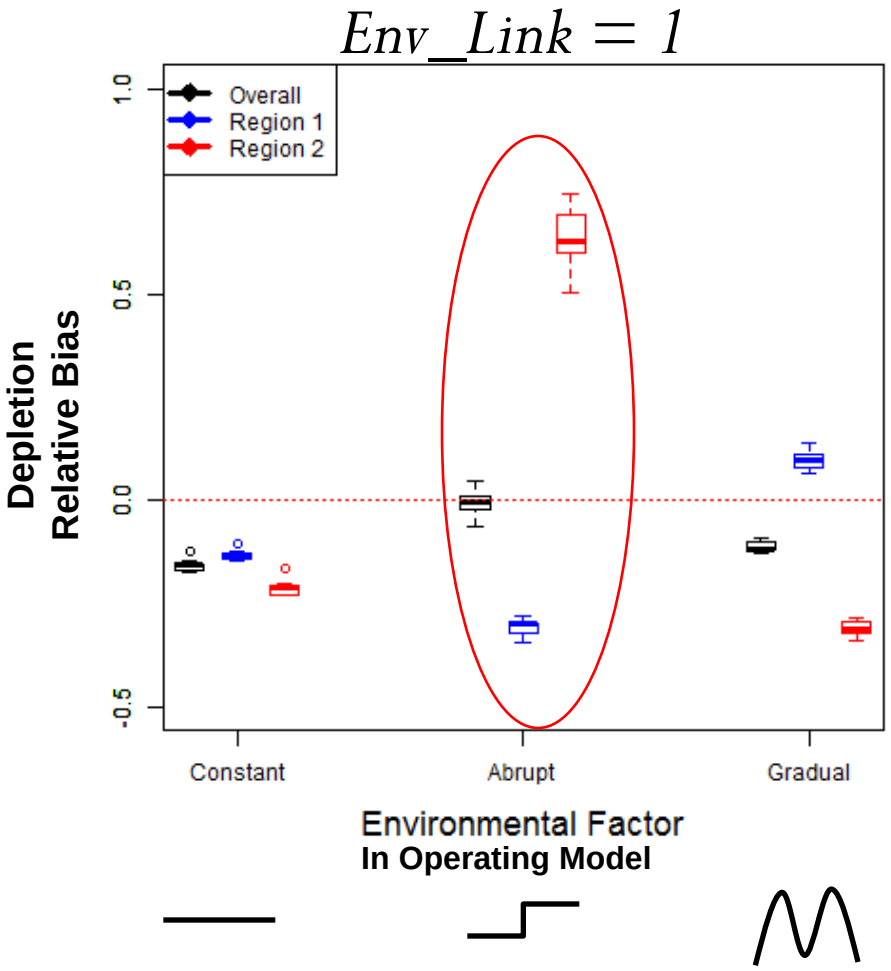

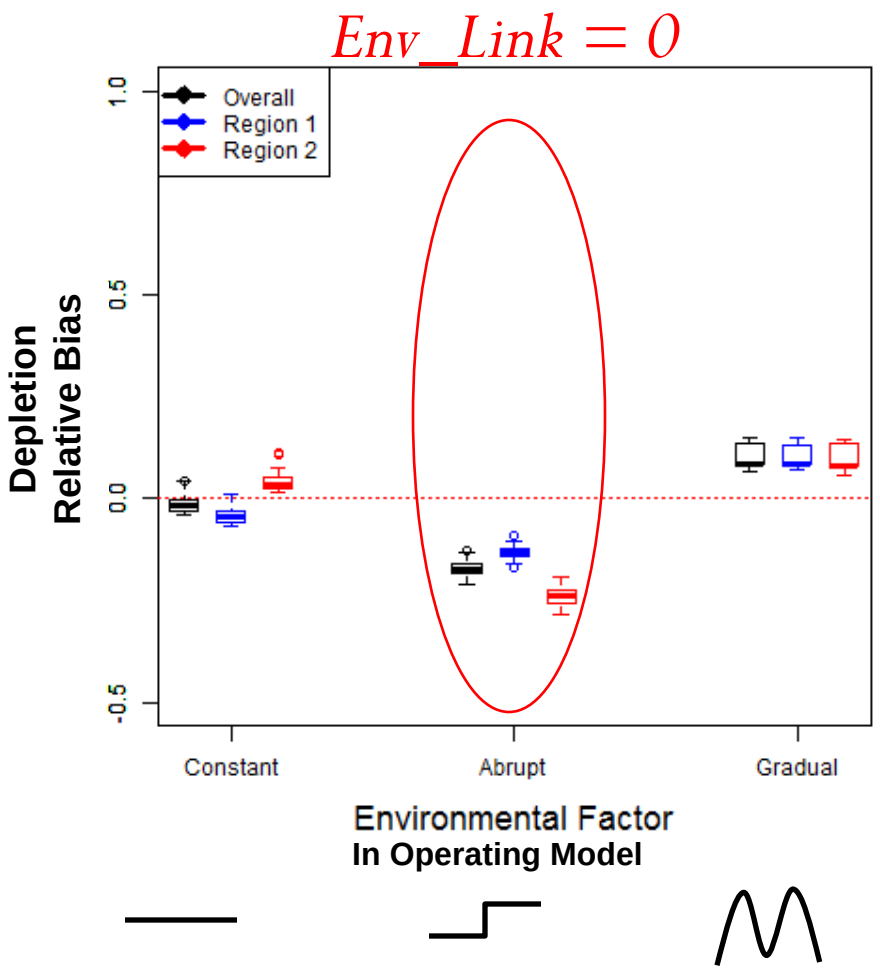

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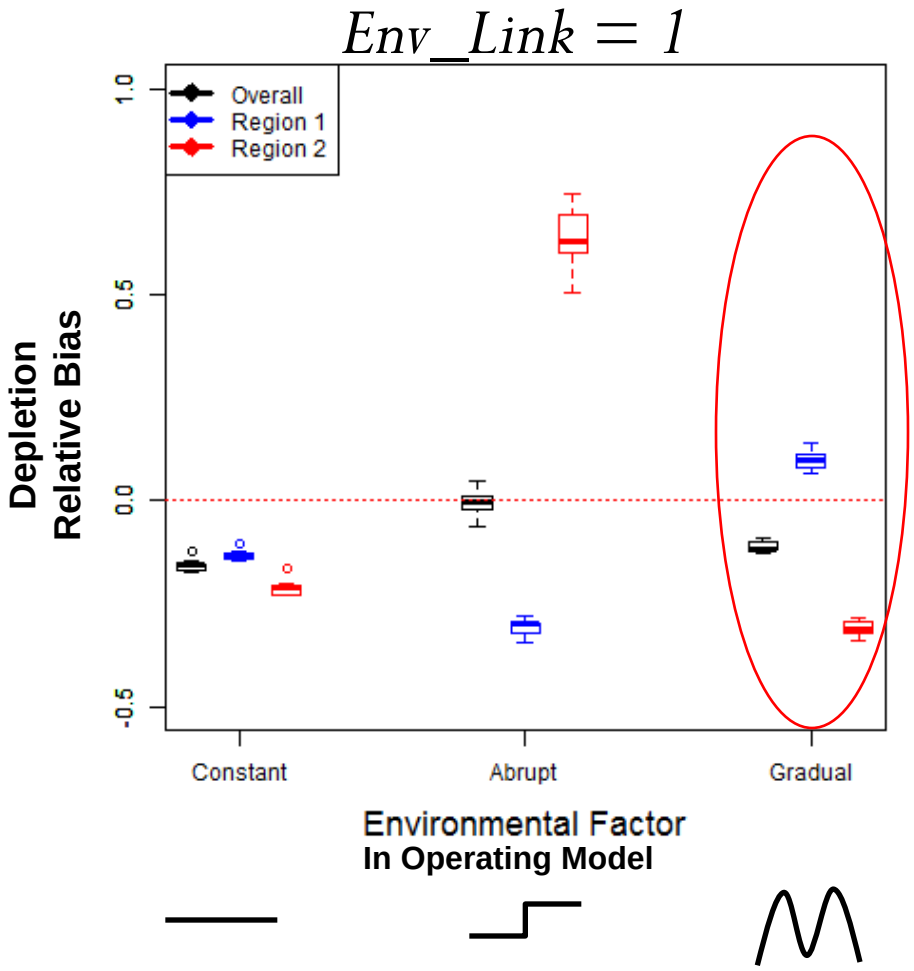

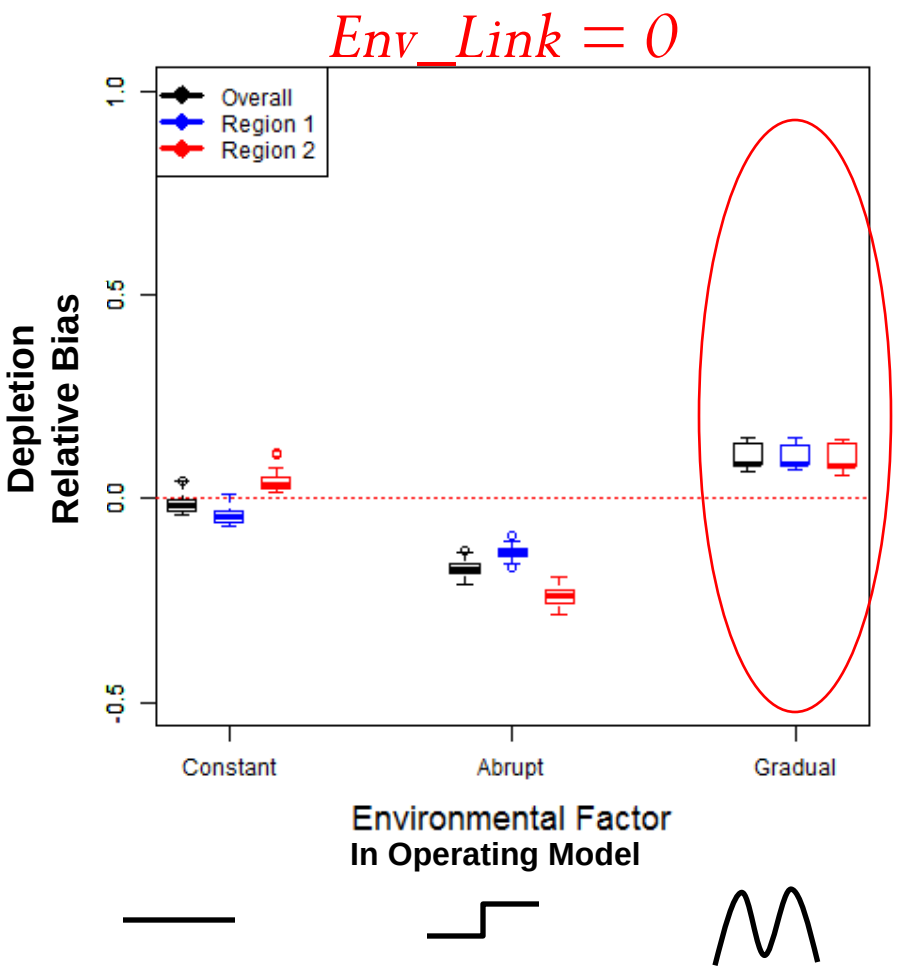

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Does bias differ when we estimate Environmental influence?

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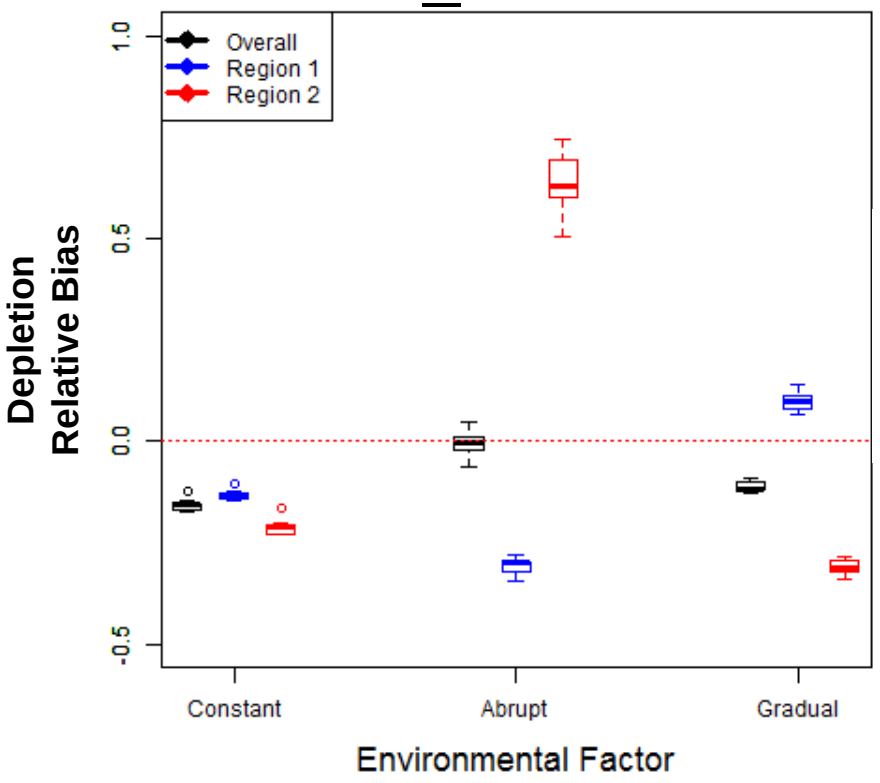
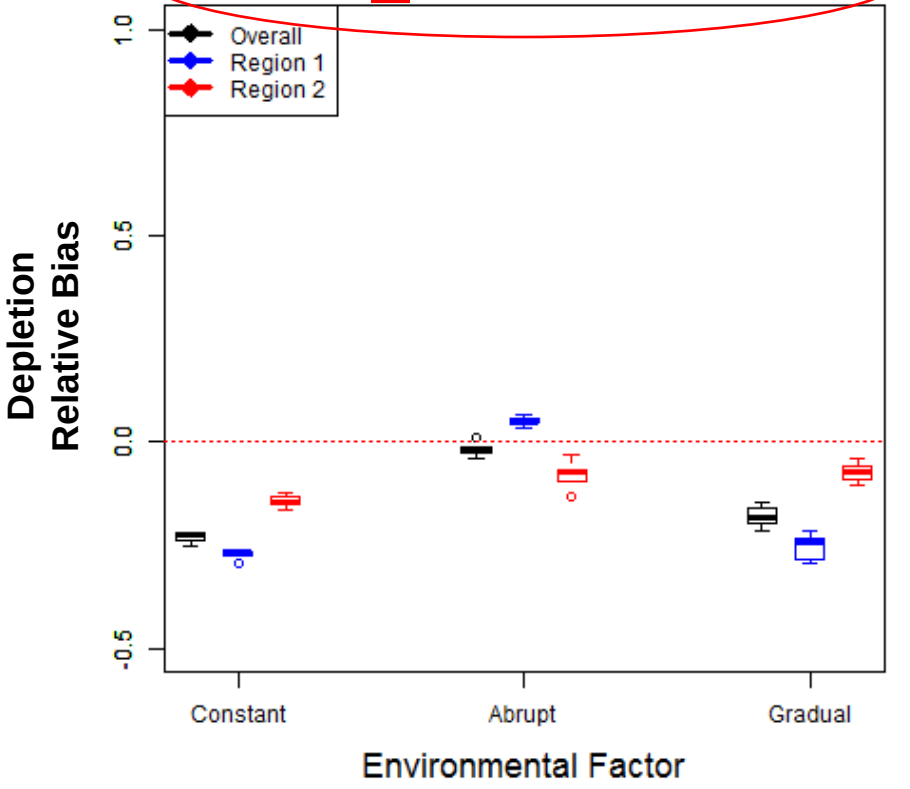


Env_link = Estimated



Bias decreases when SS is allowed to estimate environmental influence for specific patterns

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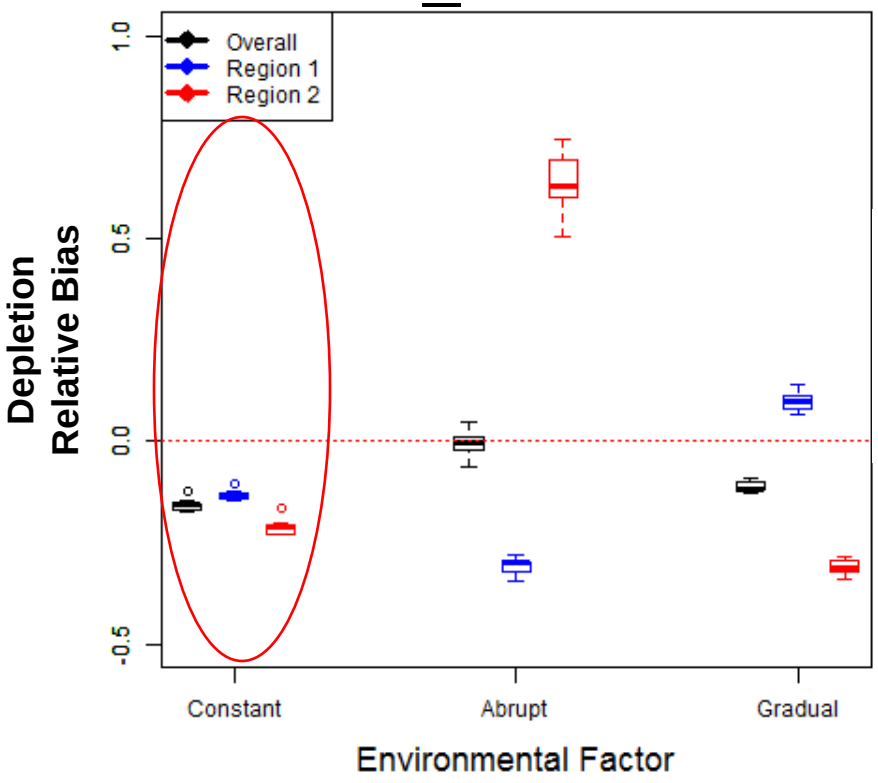

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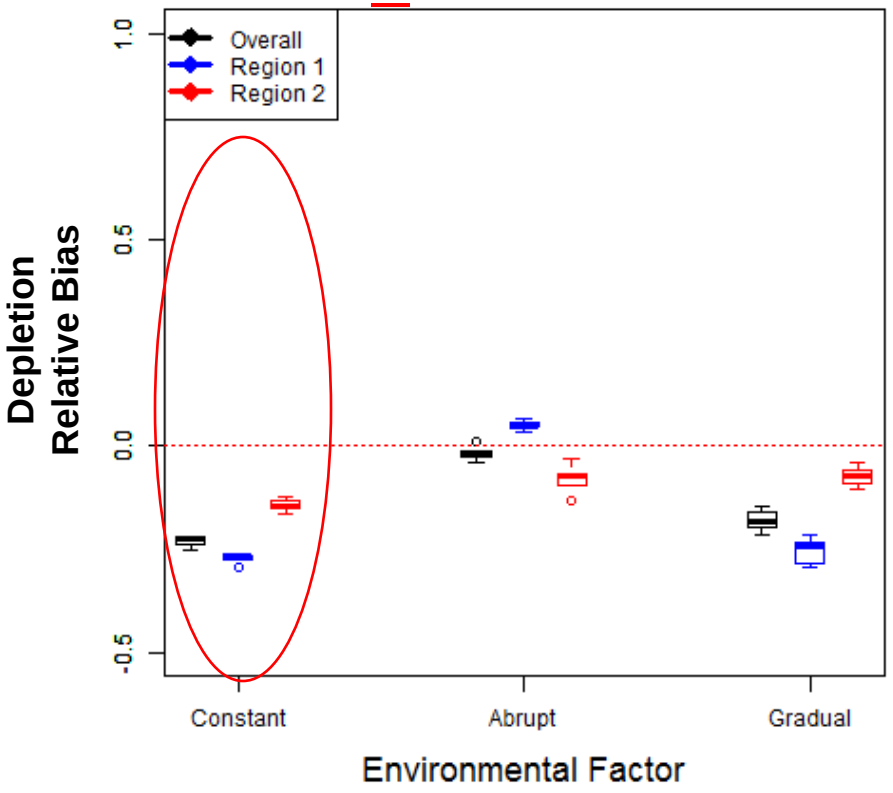

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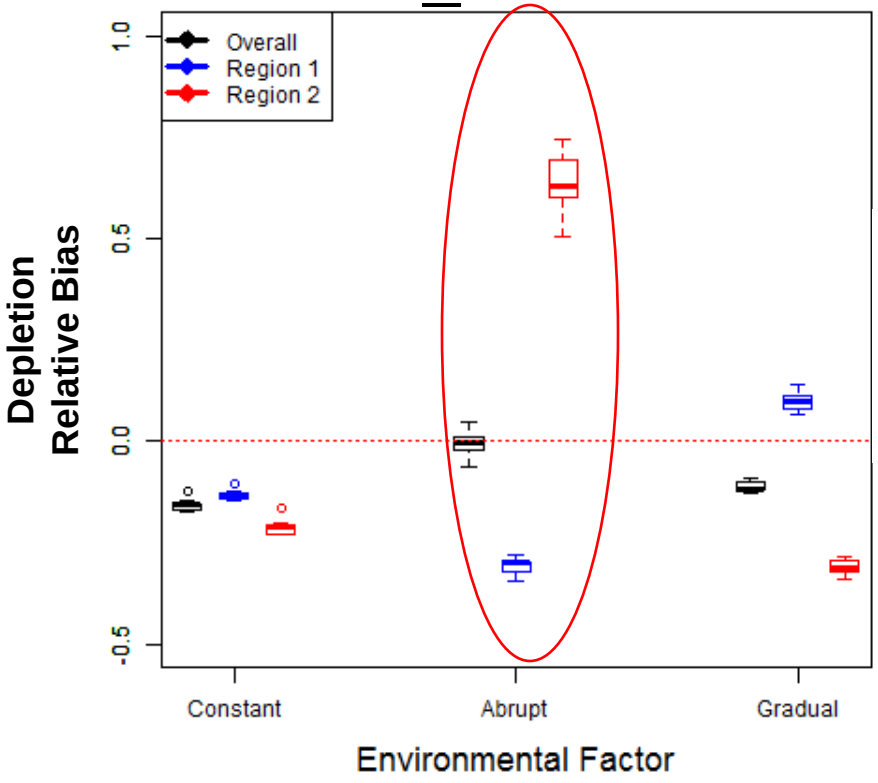

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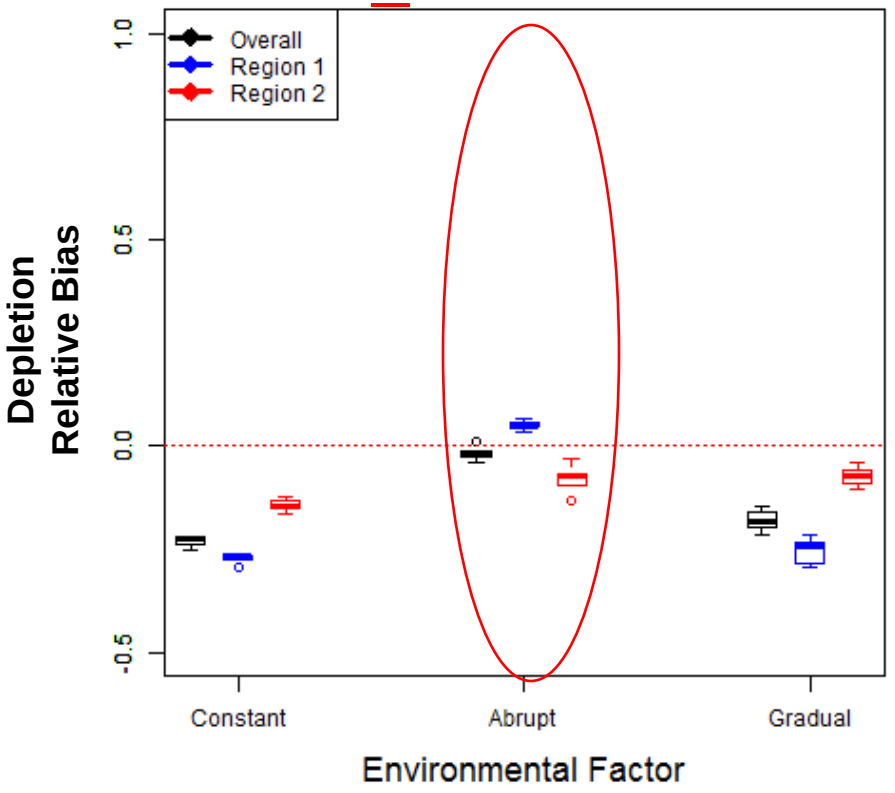

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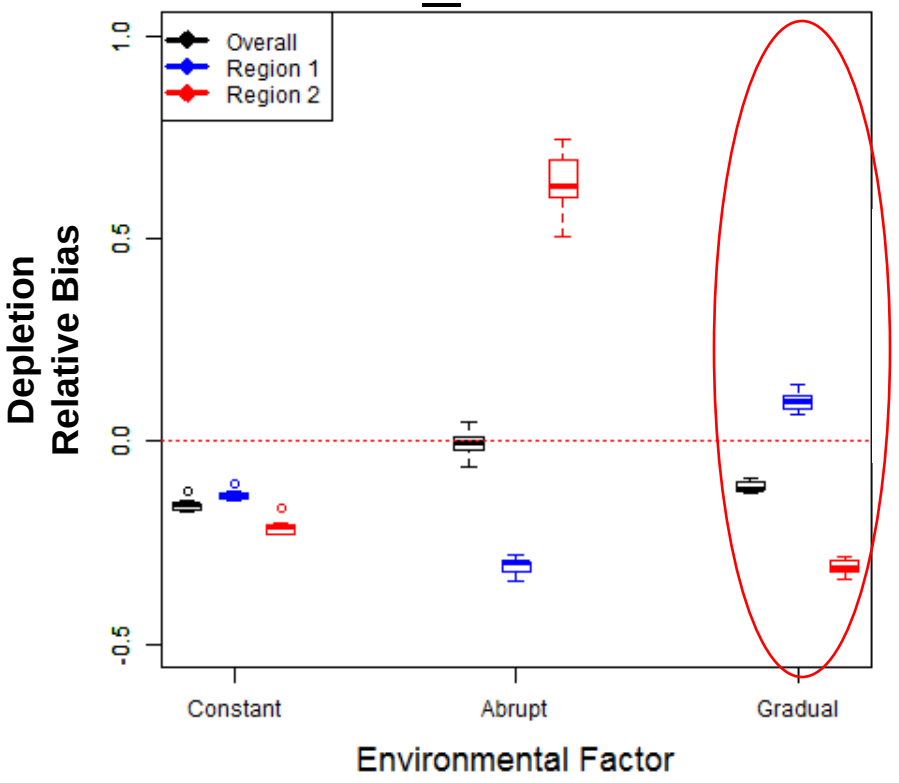

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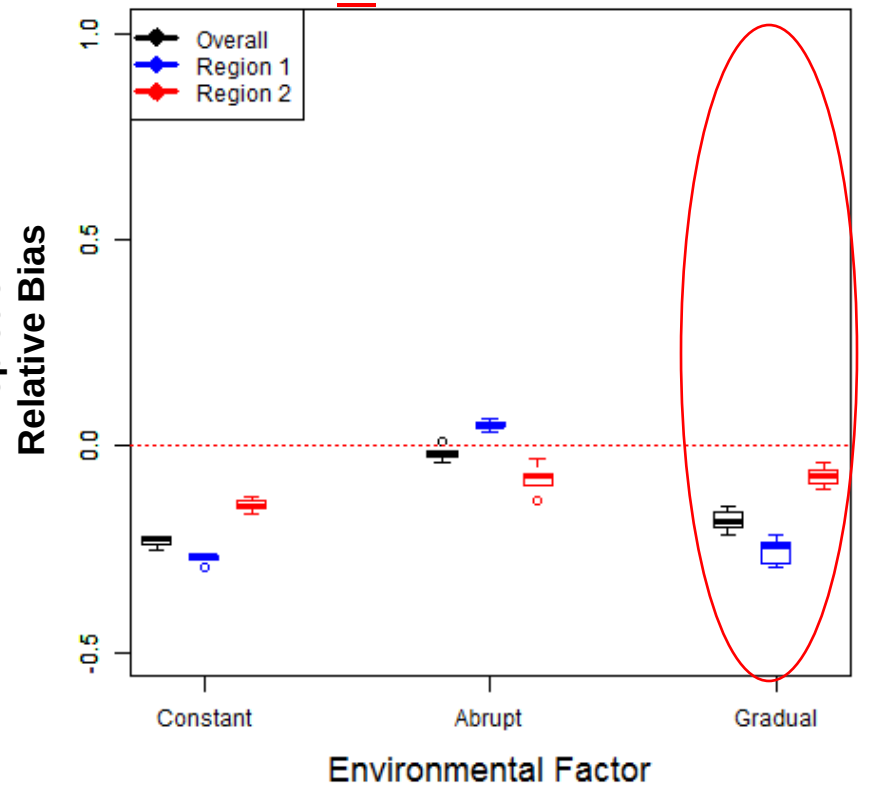

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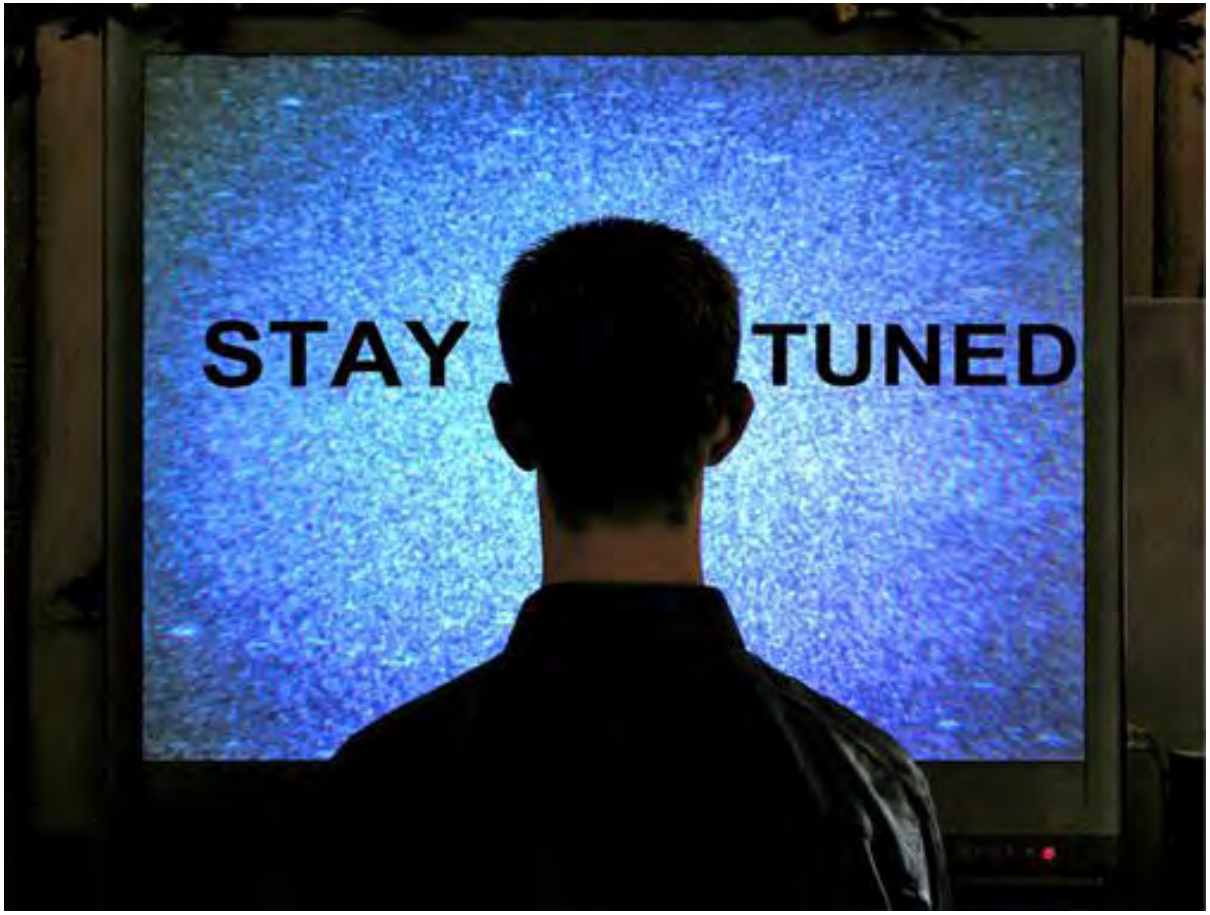
Discussion

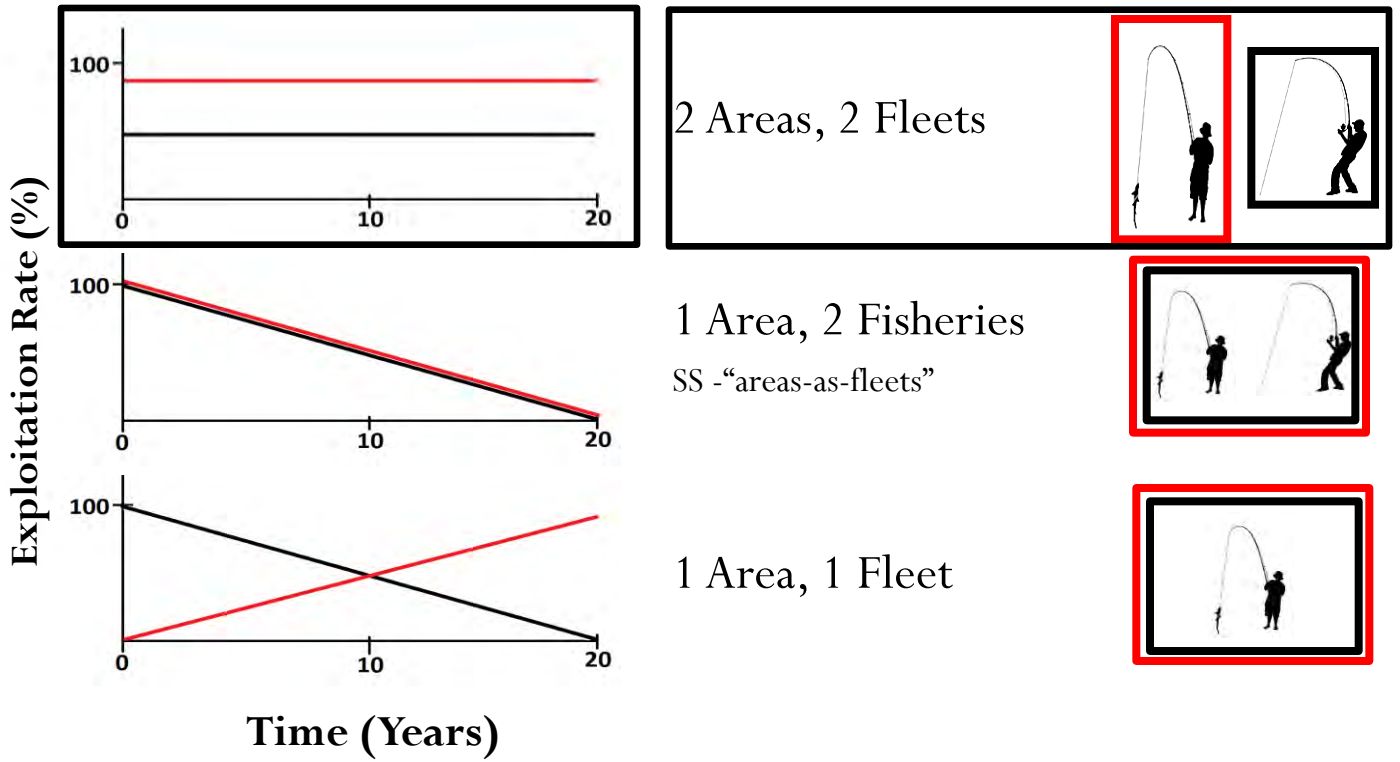
- Preliminary!
  - Under SOME conditions, YES, environmental data may help with the distribution of recruits and estimation of reference points
  - What are those conditions? "Abrupt" environmental change
- Explore reasons for difference in "Abrupt" vs. others
- Increased intensity of environmental influence on recruitment may provide more information for the estimation process

Future Work: Are there consequences for misinterpreting spatial structure in our estimation assumptions?



Future work & Implications

- Scenarios not shown will influence results



- A base spatial model to test assumptions for estimating recruit distribution

- Better understanding of the importance of environmental data influence on stock assessment results

Acknowledgements

- Dr. David Sampson
- Dr. Jessica Miller
- Dr. Andi Stephens
- Dr. Alix Gitelman

- Oregon State University Department of Fisheries and Wildlife

- Hatfield Marine Science Center of Oregon State University

- NOAA Living Marine Resources Cooperative Science Center

- Mom

Questions, Comments, Concerns