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Incorporating Population Connectivity into Operating Models for Pacific Marine Invertebrates

Case Study: Pacific Geoduck (*Panopea generosa*)

Mackenzie Mazur, Sarah de Mendonça, Anna Tigano, Christine Hansen, Erin Porszt, and Dominique Bureau

Pacific Biological Station, Fisheries and Oceans Canada

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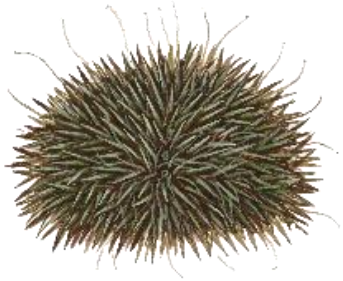
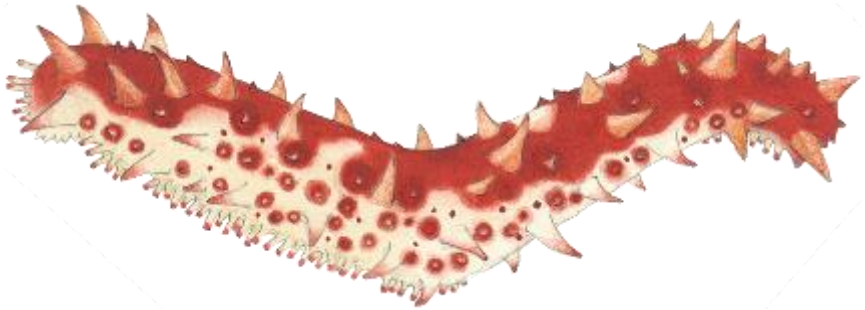





Population and genomic connectivity for management and conservation



Sarah de Mendonça

Larval dispersal simulations

↓

Biophysical connectivity

Whole genome data

↓

Genetic connectivity



Anna Tigano

This presentation →

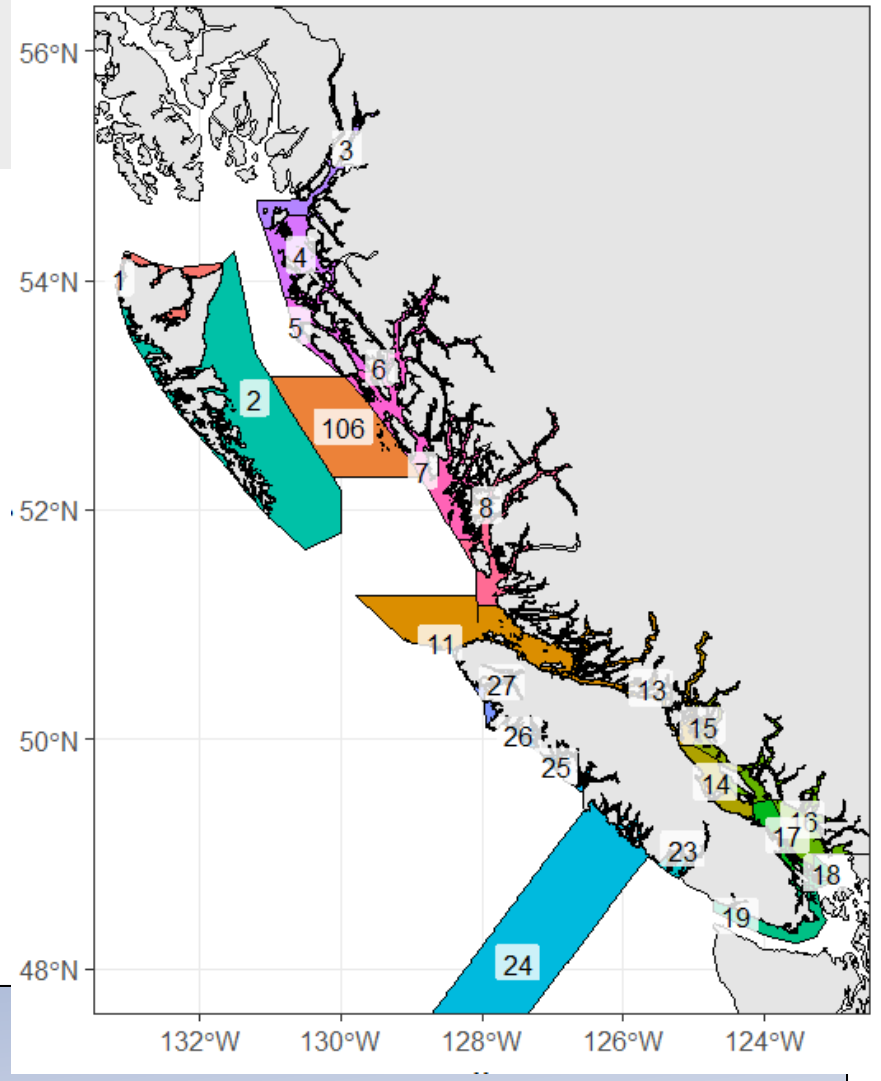
Fishery management operating model

Objective

Motivation

- Connectivity influences recruitment and stock structure.
- Yet connectivity is rarely represented explicitly in fisheries operating models.

Objective: Develop and evaluate connectivity-informed operating models

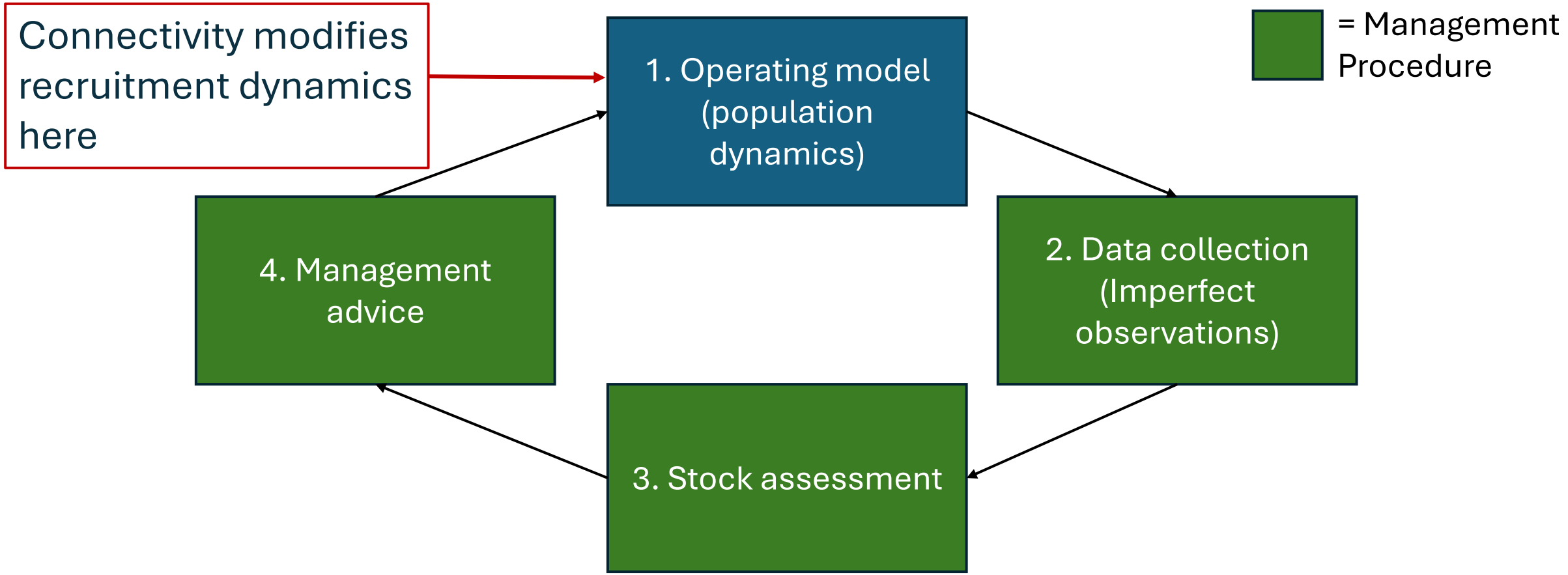


Research Question

Does incorporating connectivity change projected stock dynamics or management performance?

Management Strategy Evaluation (MSE)

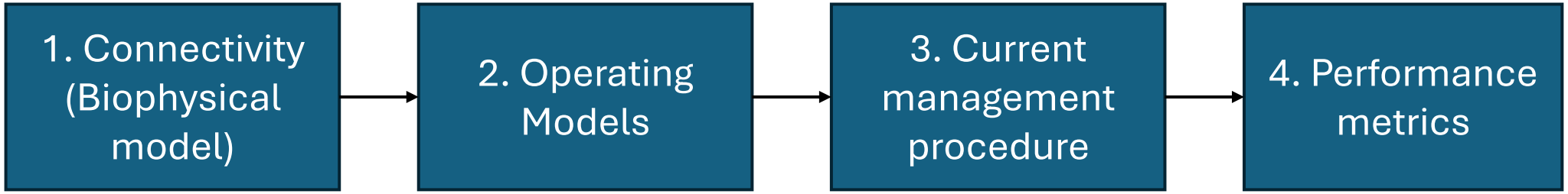
MSE simulates the fishery-management feedback loop.



In this study, only the operating model changes between scenarios. The management procedure remains identical.

Evaluating Alternative Connectivity Scenarios

Scenario	Assumption
Connected	Recruitment influenced by biophysical connectivity results
Self-recruiting	Recruitment produced locally



Question: Does incorporating connectivity alter projected stock dynamics relative to self-recruitment?

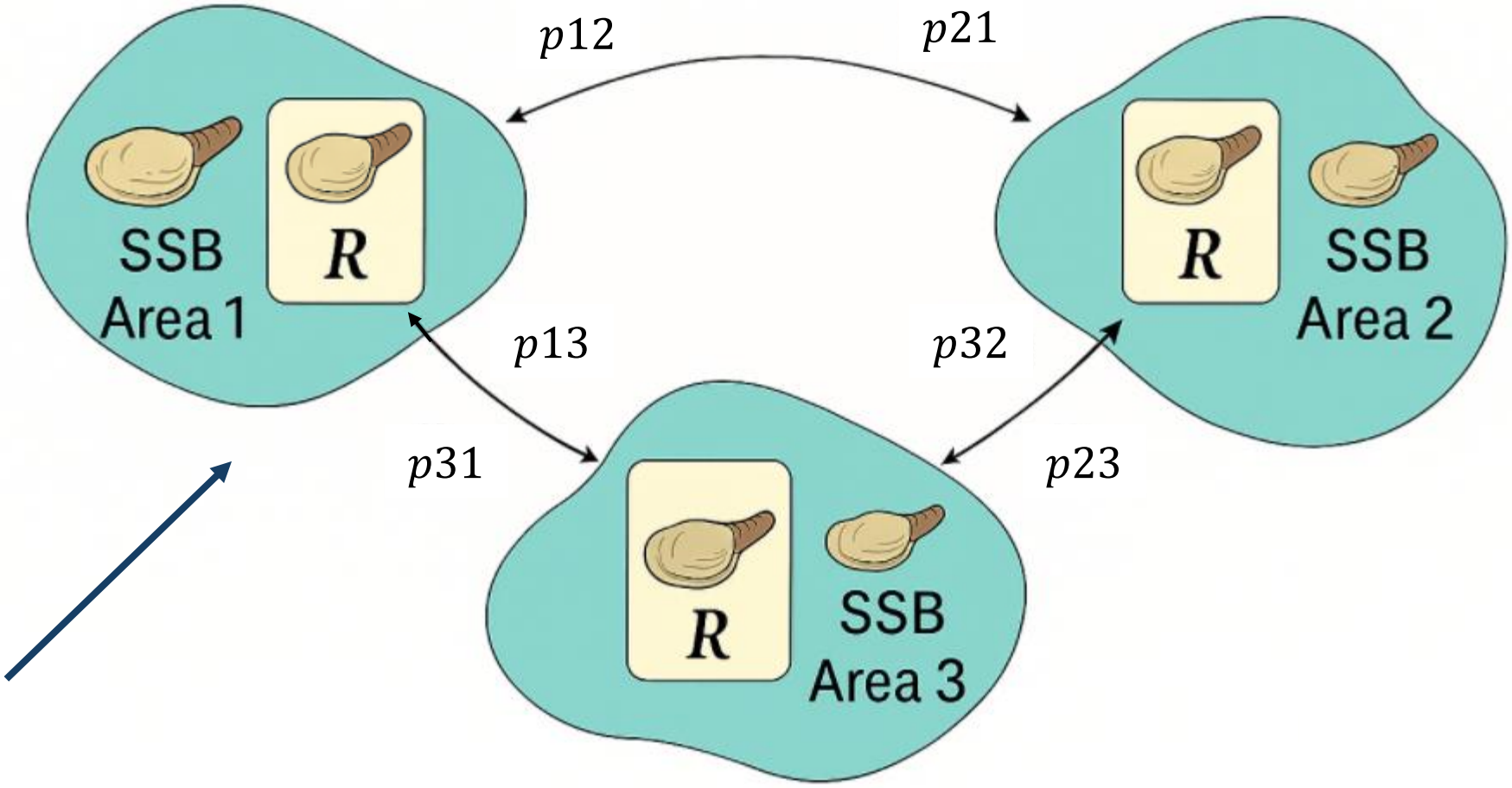
Incorporating Connectivity

Self-Recruiting:
Local recruitment only

$$R_i = f(SSB_i)$$

Connected:
Recruitment influenced by SSB from multiple areas

$$\boldsymbol{R_i = f(\sum_j p_{ij} SSB_j)}$$



pij: probability that larvae spawned in area j move to area i

Illustration shown for 3 areas; model implementation includes 22 areas.

Operating Model and Projections Configuration

Operating Models

- 22 areas
- Informed by catch, survey, and age data
- Area-specific growth
- Natural mortality: 0.016 – 0.036 (Zhang & Hand 2007)
- Steepness: 0.4 to 1
- 100 simulations per scenario

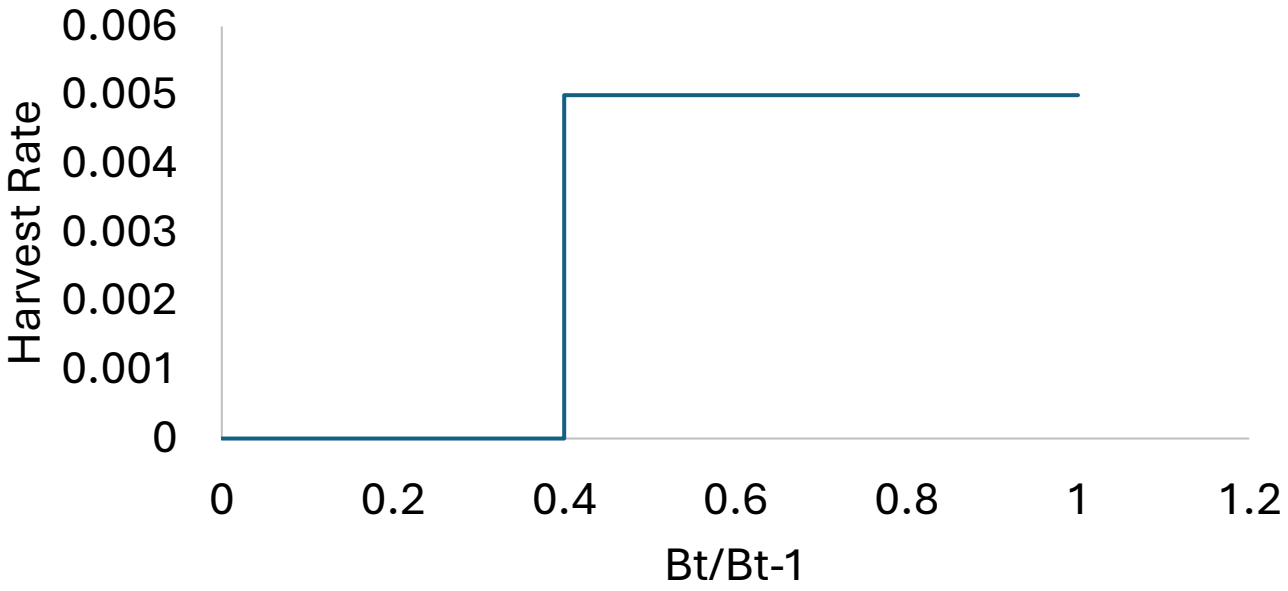
openMSE
www.openmse.com

Projections

- 20-year projections (2025- 2045)
- Annual management updates

Management Procedure

$$HR = \begin{cases} 0.005, \frac{B_t}{B_{t-1}} \geq 0.4 \\ 0, \frac{B_t}{B_{t-1}} < 0.4 \end{cases}$$



Same management procedure applied under both connectivity scenarios.

Research Question

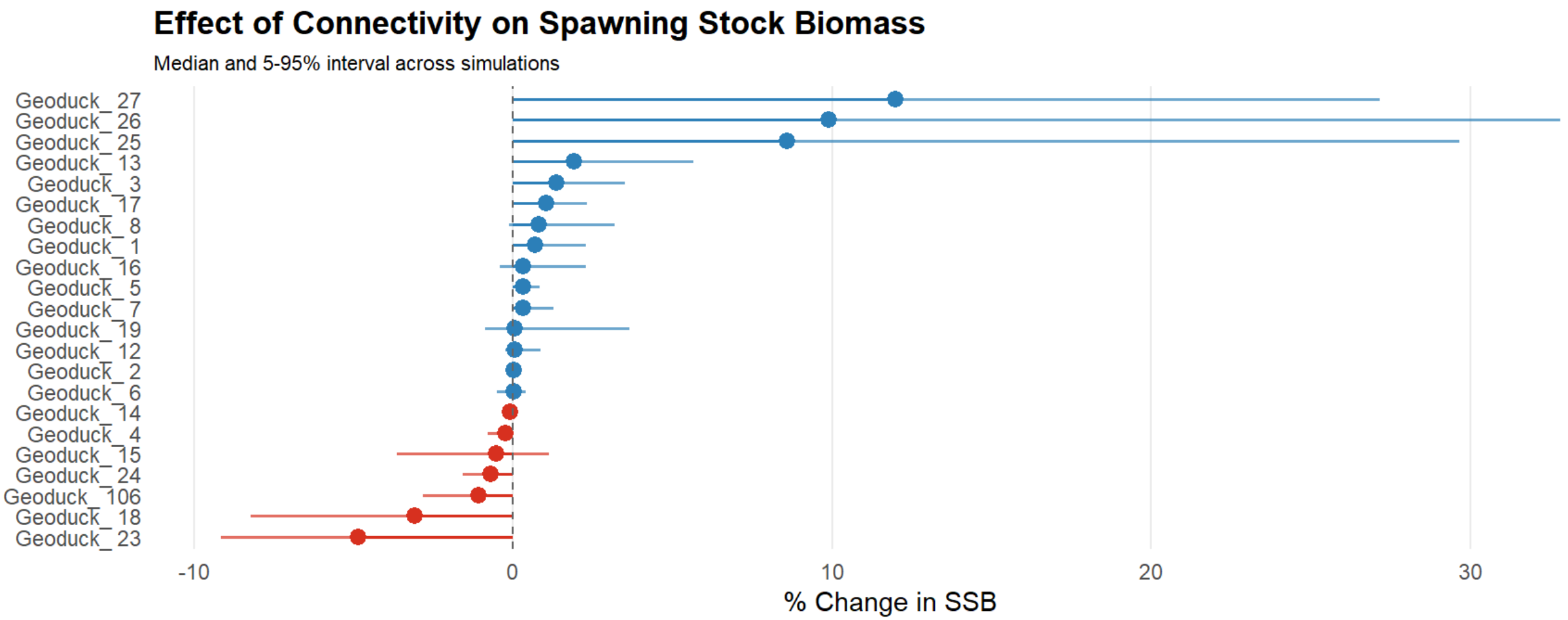
Does incorporating connectivity change projected stock dynamics or management performance?

Preliminary Results: Connectivity redistributes recruitment among areas.



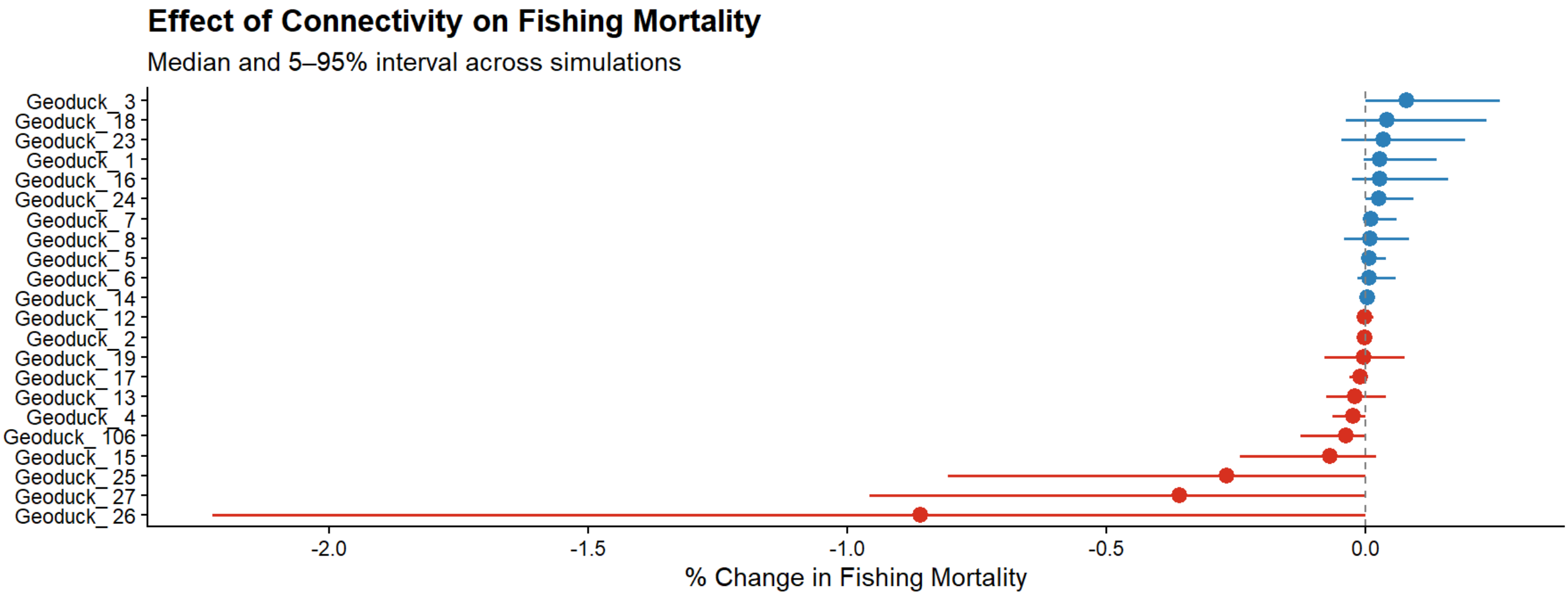
- Connectivity redistributes recruitment, but the magnitude is generally moderate.
- Largest gains exceed largest losses.
- Responses are uncertain but generally directionally consistent.

Preliminary Results: Small recruitment differences accumulate into larger biomass differences.



- Connectivity effects are highly area-specific.
- Effects on SSB are larger than the effects on recruitment.
- Accumulated recruitment differences lead to larger biomass changes.

Preliminary Results: Connectivity has little influence on fishing mortality.



- Connectivity has minimal effects on fishing mortality (< ~2% across all areas).
- Recruitment and SSB are more sensitive to connectivity than fishing mortality.
- The management procedure resulted in little impact on fishing mortality.

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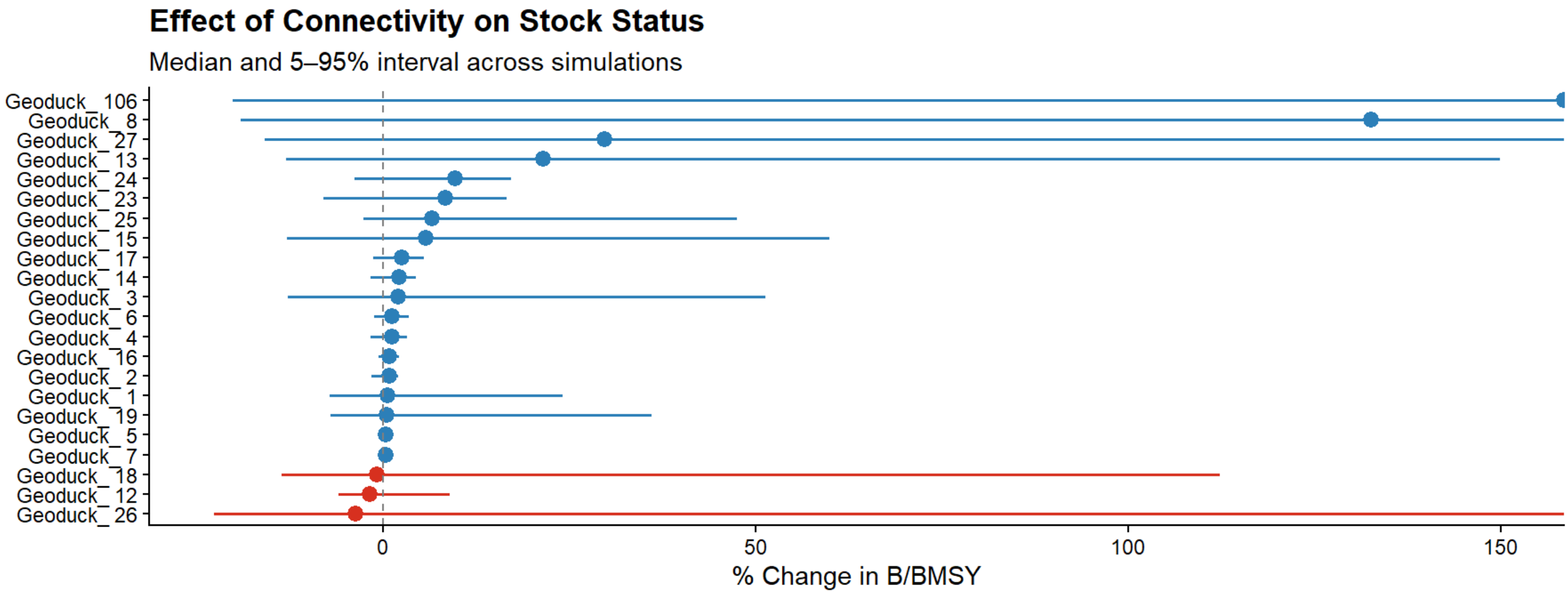
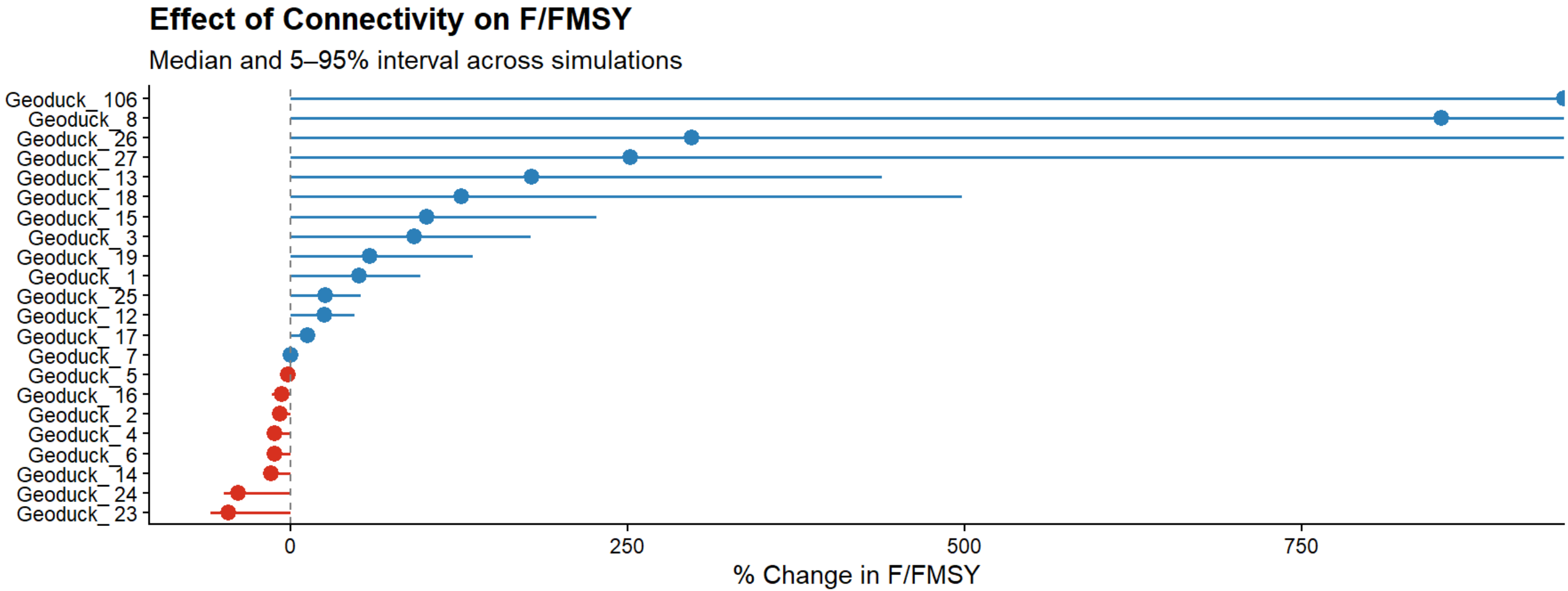
Preliminary Results: Connectivity can alter stock status through changes in biomass and productivity.



- Connectivity can substantially alter stock status (B/BMSY) in some areas.
- Changes in B/BMSY reflect changes in both spawning biomass (B) and the estimated reference point (BMSY).
- Connectivity changes productivity and biomass, both of which affect B/BMSY.

Preliminary Results: Connectivity primarily affects productivity rather than realized fishing mortality.



- Changes in F/FMSY arise from changes in both fishing mortality and the estimated reference point.
- Connectivity appears to have a much larger effect on FMSY than on F itself.
- Changes in productivity influence fishing mortality relative to FMSY.

Conclusions and Next Steps

Main Findings

- Connectivity can redistribute recruitment among areas.
- Recruitment differences can accumulate into substantial biomass differences.
- Connectivity can alter stock status and reference points.

Future Work

- Integrate genomic connectivity results
- Explore other connectivity scenarios (2017, 2021)
- Develop connectivity-informed operating models for Green Sea Urchin and Giant Red Sea Cucumber
- Use genomic offset to develop alternative OMs

mackenzie.mazur@dfo-mpo.gc.ca

Thank You

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CANADA BIOGENOME PROJECT

Berkeley UNIVERSITY OF CALIFORNIA

Integrative Biology

PSCHA Pacific Sea Cucumber Harvesters Association

GEODUCK underwater harvesters association

UCSB UNIVERSITY OF CALIFORNIA SANTA BARBARA

bluematter

ERI Earth Research Institute

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