Body condition as a shared response to environmental conditions in a demersal fish assemblage

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Photo credit: Darienne Lancaster

Changes in abundance distributions are often correlated with climate, but we often don't know the mechanism…

- *Movement*
- *Growth*
- *Recruitment*

Could changes in fish body size provide any clues?

Investigating changes in fish condition

1. Calculate Le Cren’s relative condition factors
2. Split specimens and catch by sex and maturity class
3. Estimate spatiotemporal biomass density
4. Estimate spatiotemporal condition
5. Calculate annual indices of condition
6. Identify common trends
7. Test for environmental correlates

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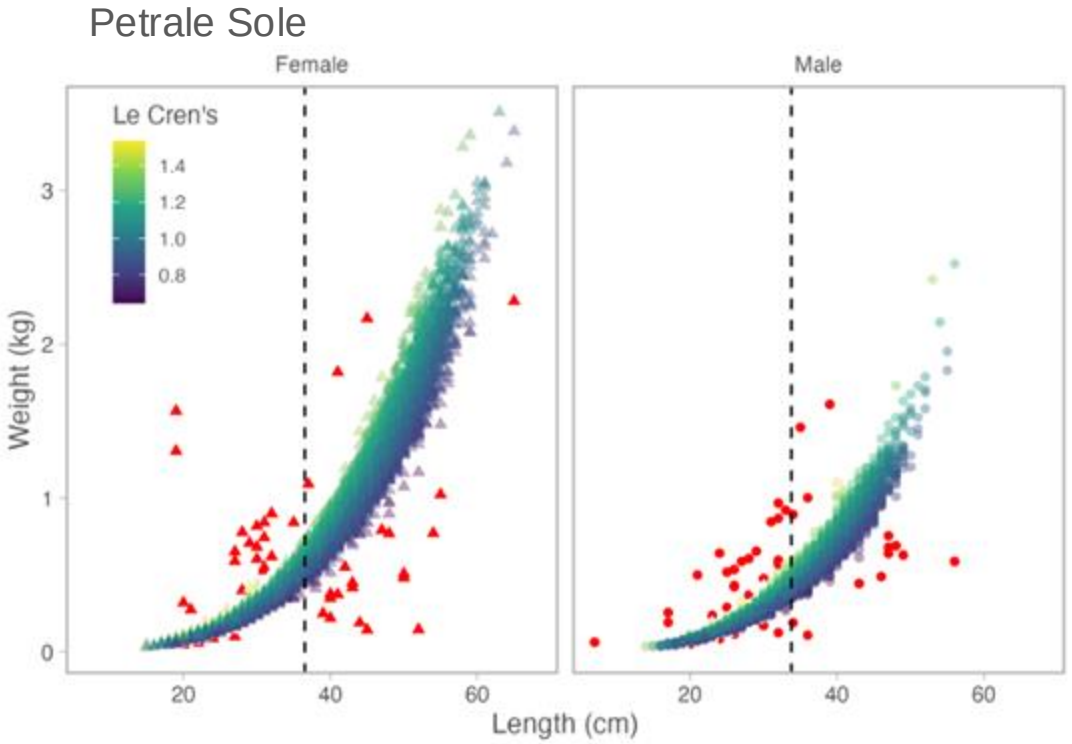
Assemblage-level
(across species, within class)

1. Fish body condition

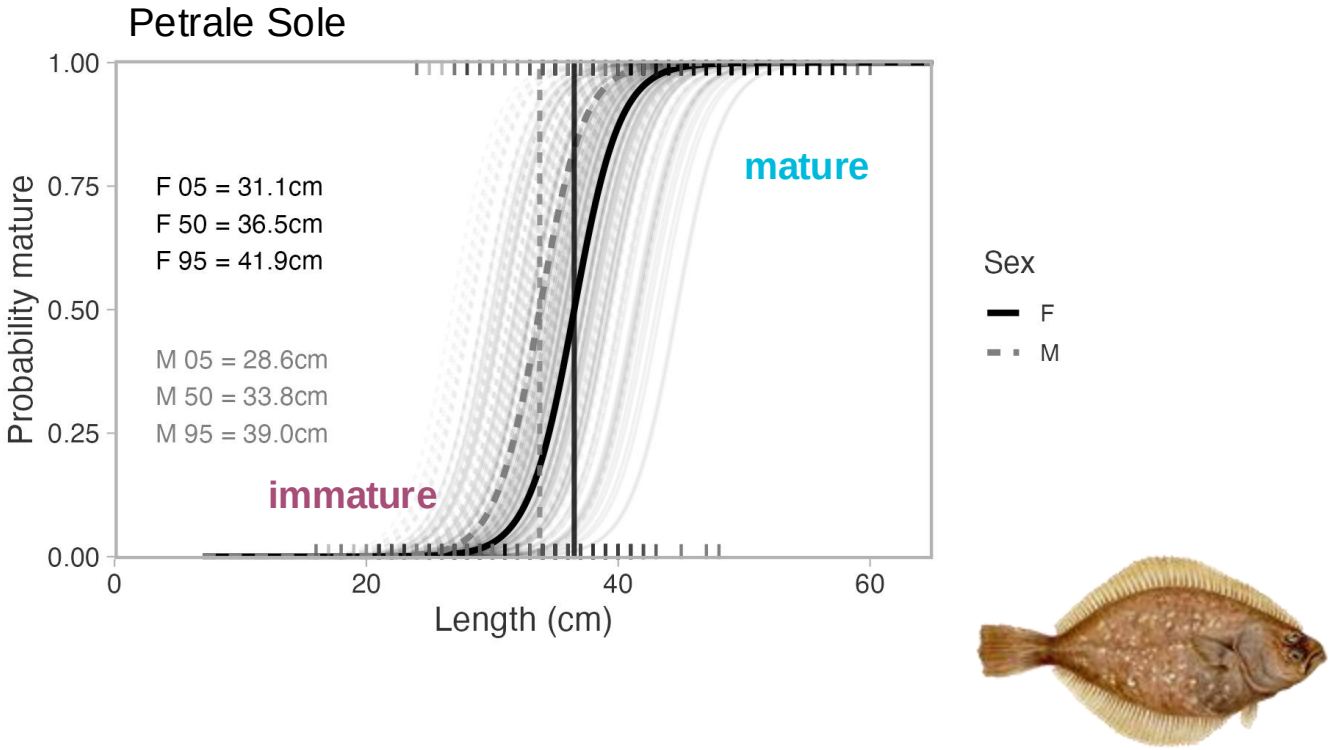
Le Cren's condition factor is the ratio of observed weight to predicted weight-at-length:

$$\frac{Weight}{a(Length)^b}$$

**Likely sensitive to reproductive state, especially in females*



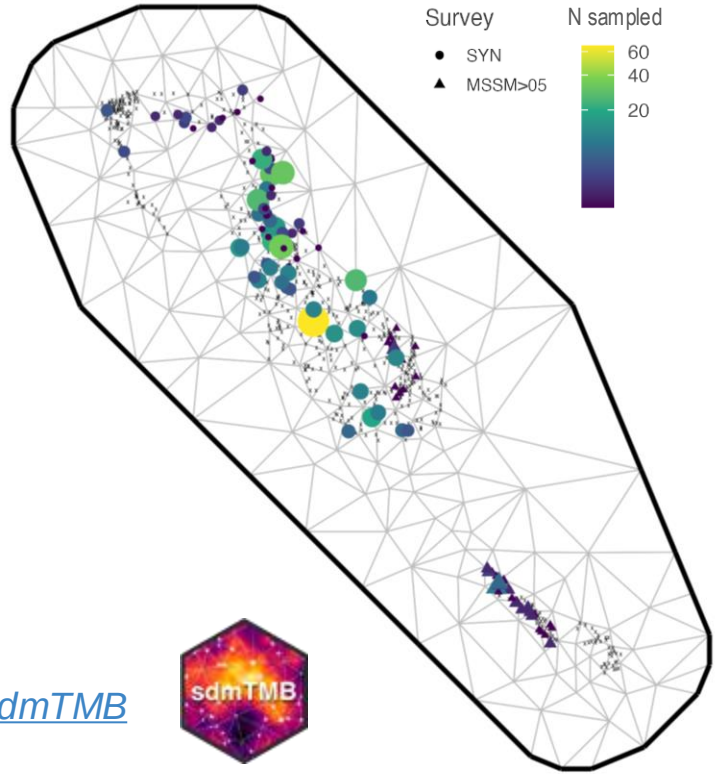
2. Split specimens & catch by length at 50% mature



3 & 4. Spatiotemporal model configurations

- Random-walk on spatiotemporal fields help bridge inconsistent spatial coverage between years
- Survey factor for differences in population sampled by different gear
- Day of year for seasonal changes
- Depth included in density models, not in condition models

Tow locations and Petrale samples in 2007 overlaid on an SPDE mesh



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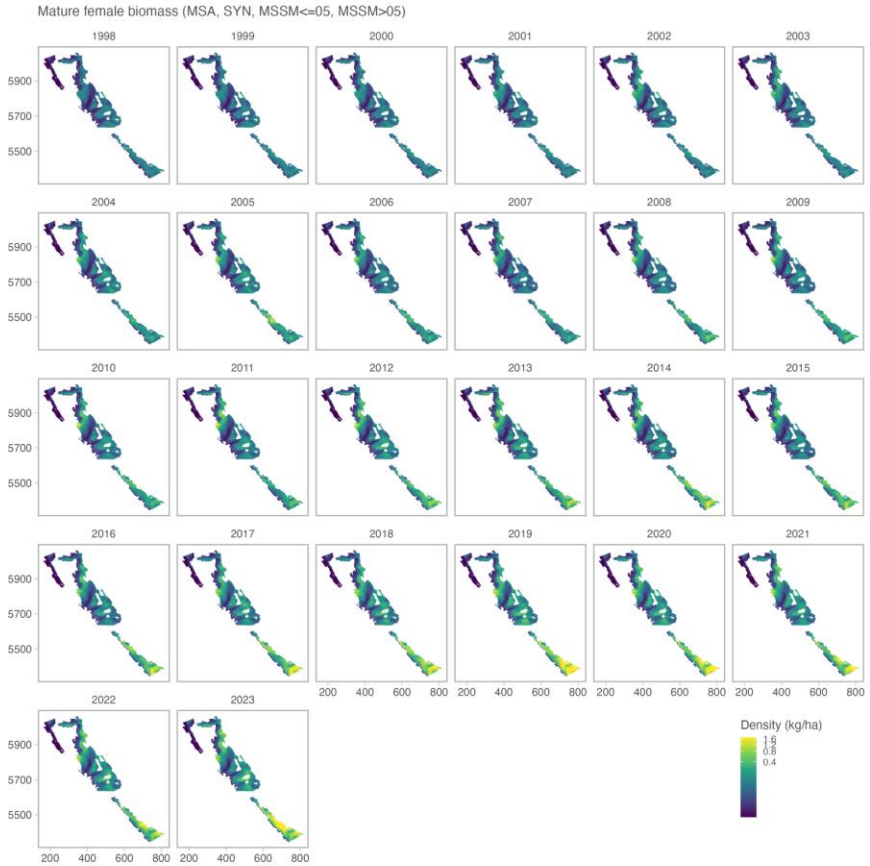
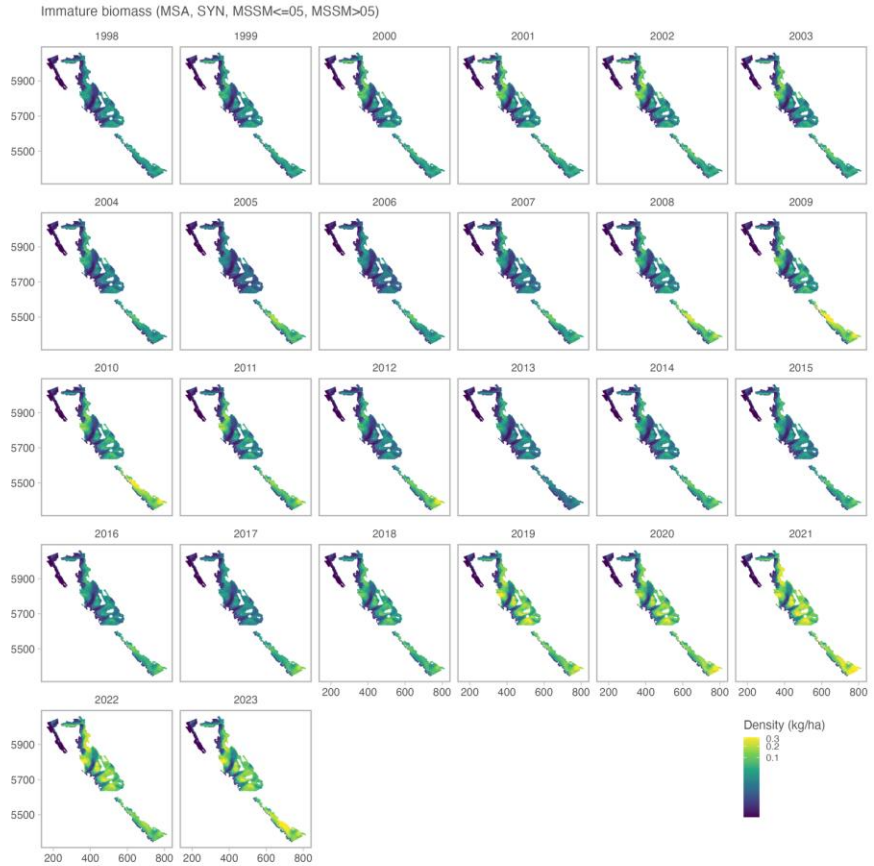
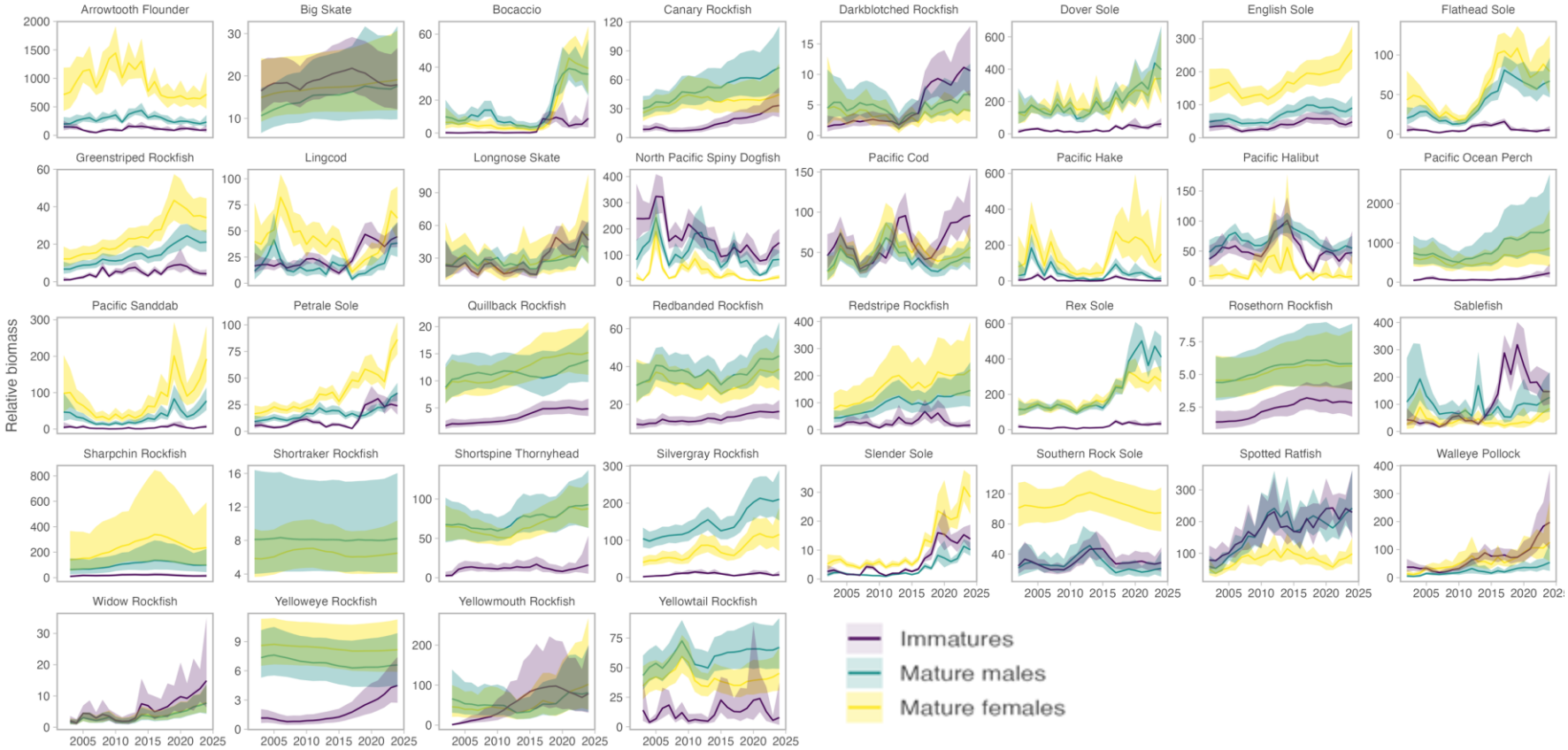
3. Maturity-specific spatiotemporal biomass predictions

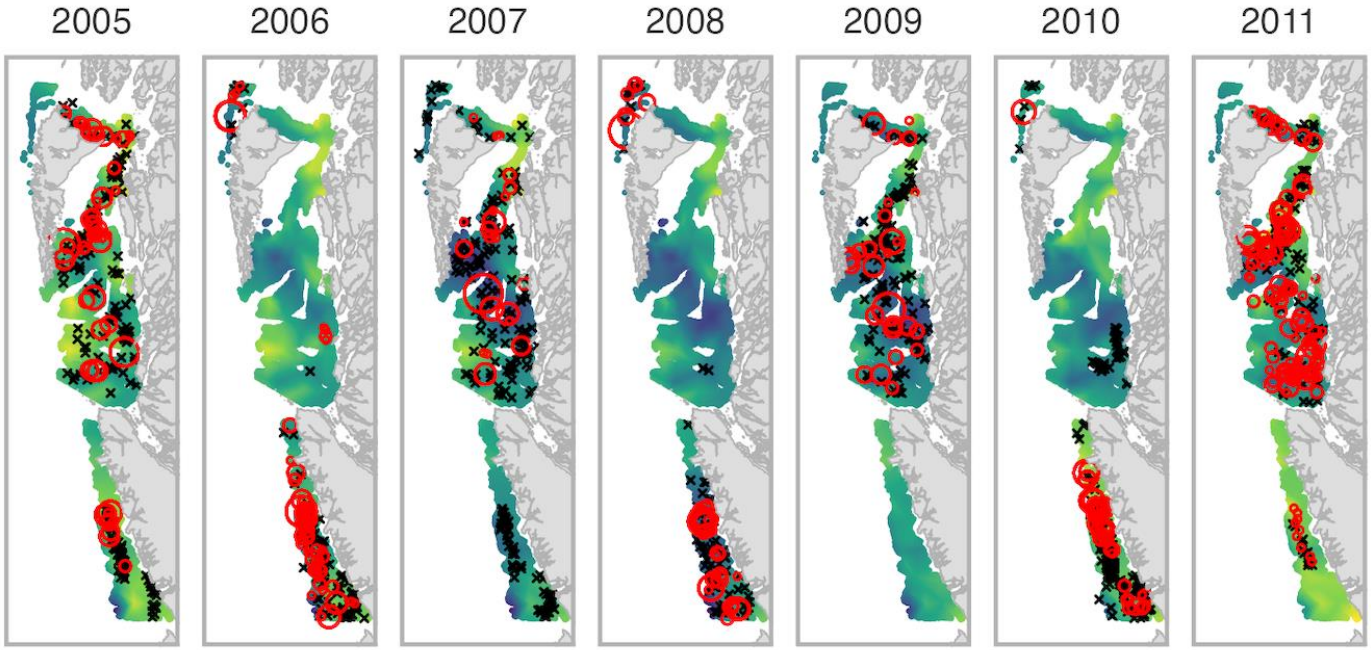




3. Maturity-specific biomass indices



4. Spatiotemporal fish condition models



Condition factor

1.05
1.00
0.95
0.90

x – species caught but no measurements

○ – condition measurements

4. When to adjust for density-dependence?

Condition factor ~ survey + day of year + ***local density*** *+ RW spatiotemporal random fields*

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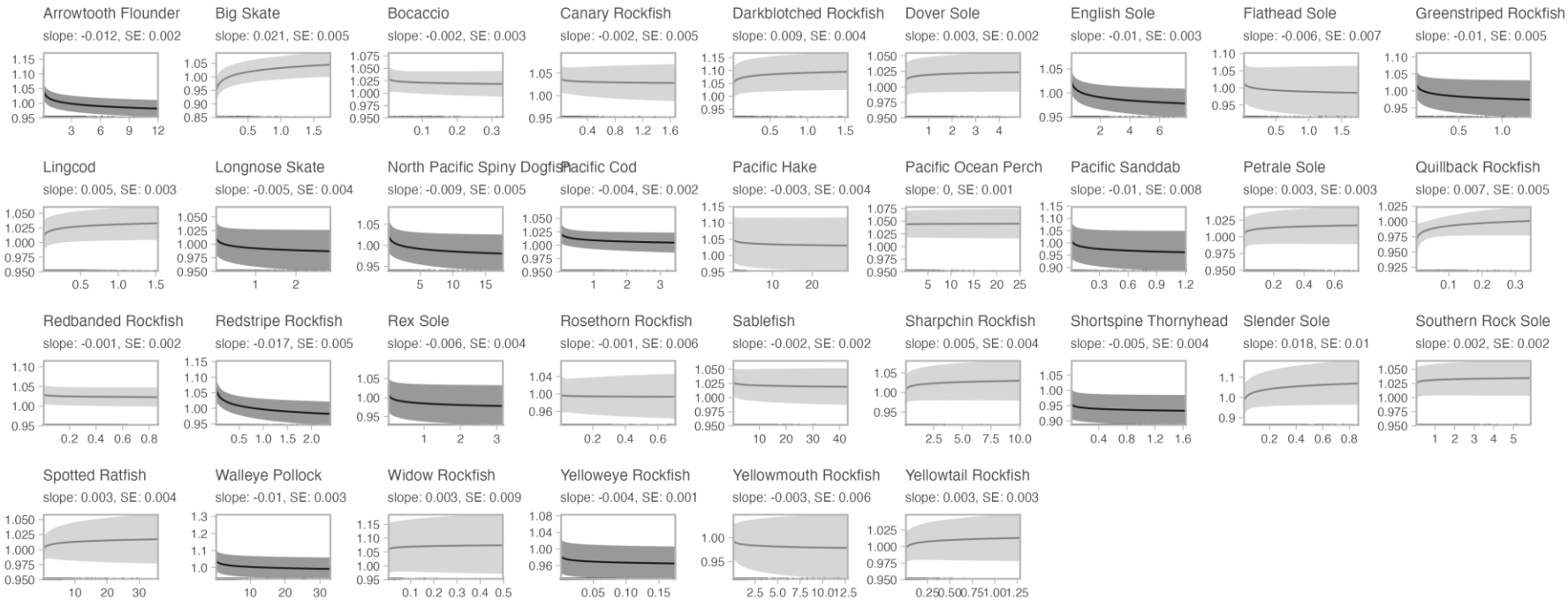


4. When to adjust for density-dependence?

Condition factor ~ survey + day of year + ***local density*** *+ RW spatiotemporal random fields*

- When density effect was negative – exclude density-dependence (adjusted)
  - Predictions generated for mean local densities across years

4. When to adjust for density-dependence?

*Condition factor ~ survey + day of year + **local density** + RW spatiotemporal random fields*

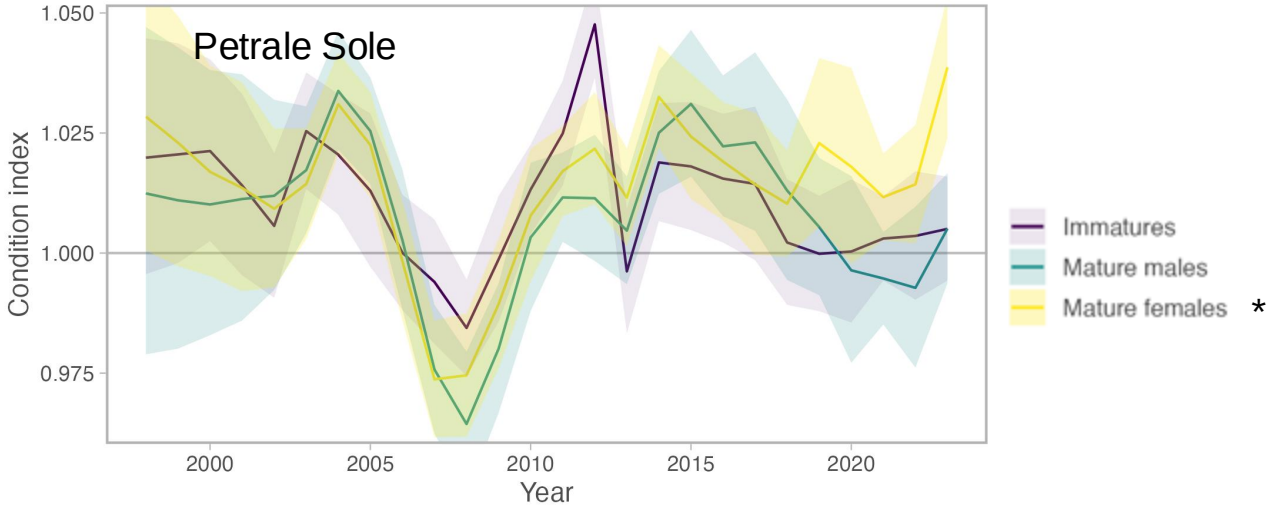
- When density effect was negative – exclude density-dependence (adjusted)
  - Predictions generated for mean local densities across years

- When density effect was positive or neutral – density-agnostic (not adjusted)
  - Rerun model without density covariate

Condition factor ~ survey + day of year + RW spatiotemporal random fields

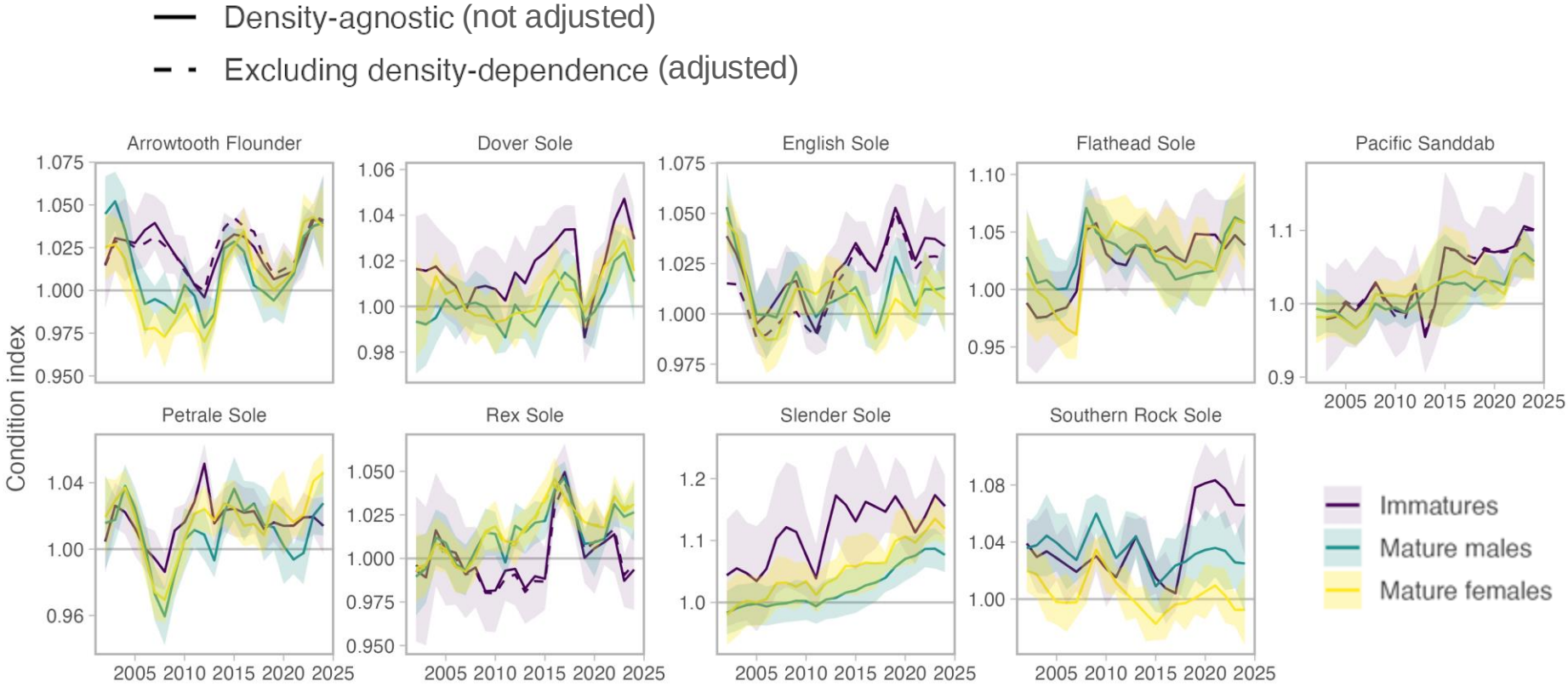
5. Generate annual condition indices

- Multiply each spatial estimate of fish condition by the proportion of that year's biomass predicted to have occurred at that location
- Sum these weighted estimates to create an annual index of average body condition

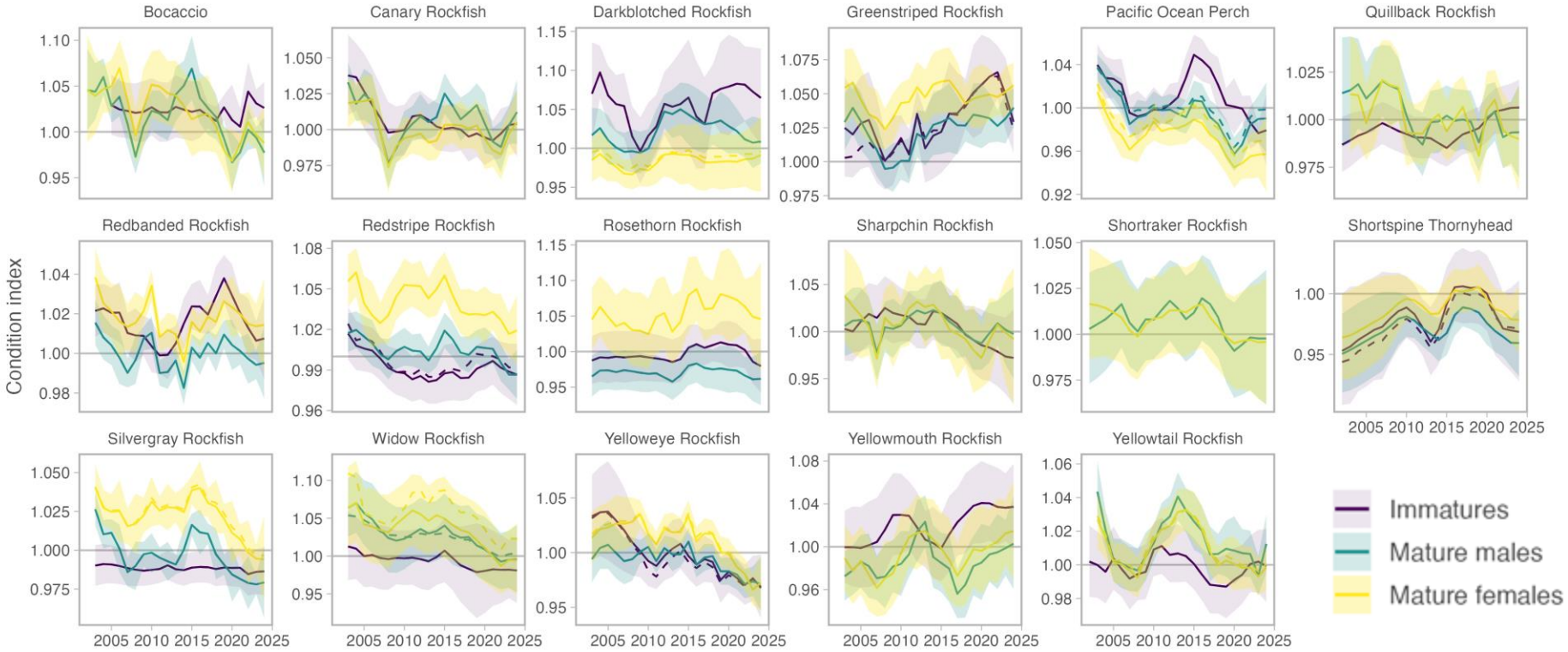


* Could be related to reproductive state?

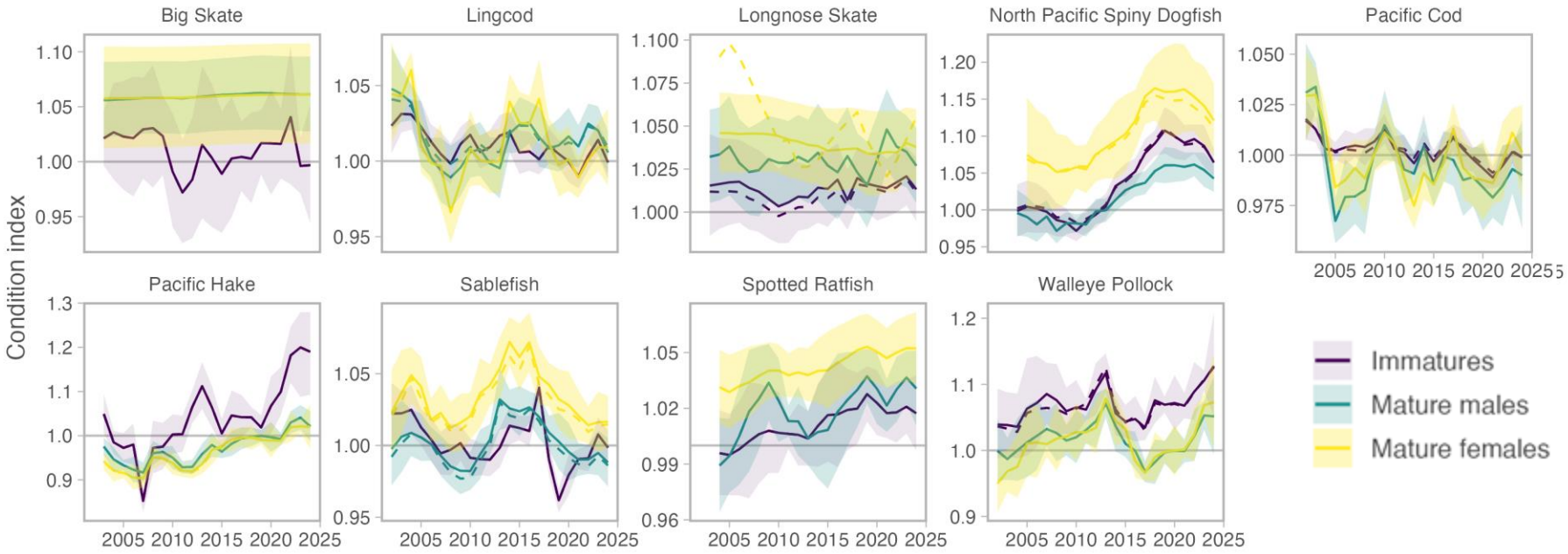
5. Flatfish condition indices



5. Rockfish condition indices

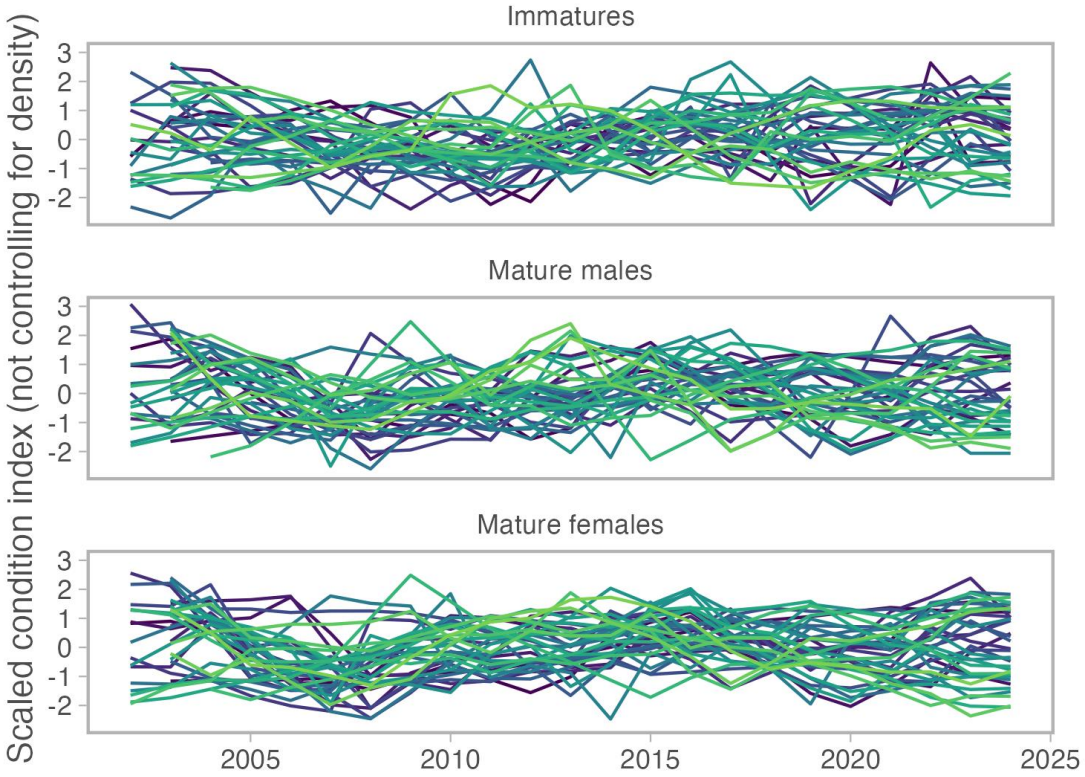


5. Other condition indices



6. Bayesian Dynamic Factor Analysis (DFA)

Looks for common trends among species (*Ward et al. 2019 in The R Journal)*



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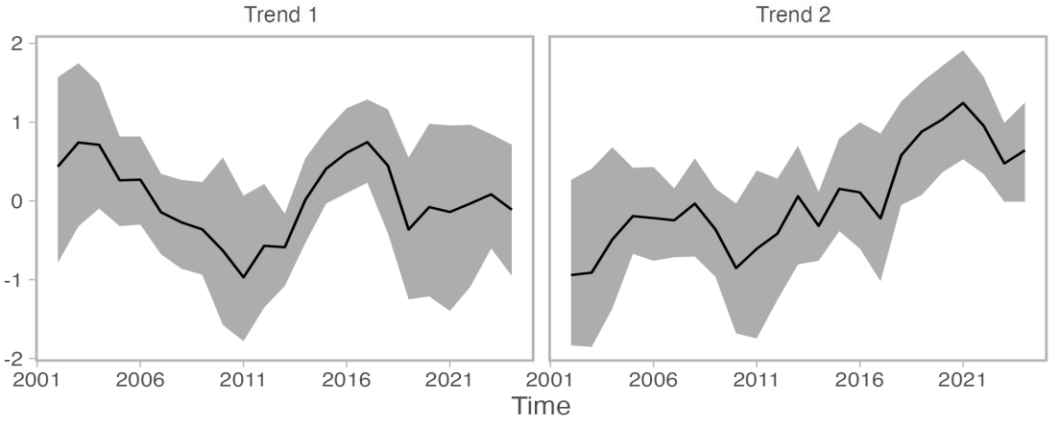
6. Common trends: immature condition *(not adjusted)*

Species condition index ~ Trend1 x Loading1 + Trend2 x Loading2 + Noise



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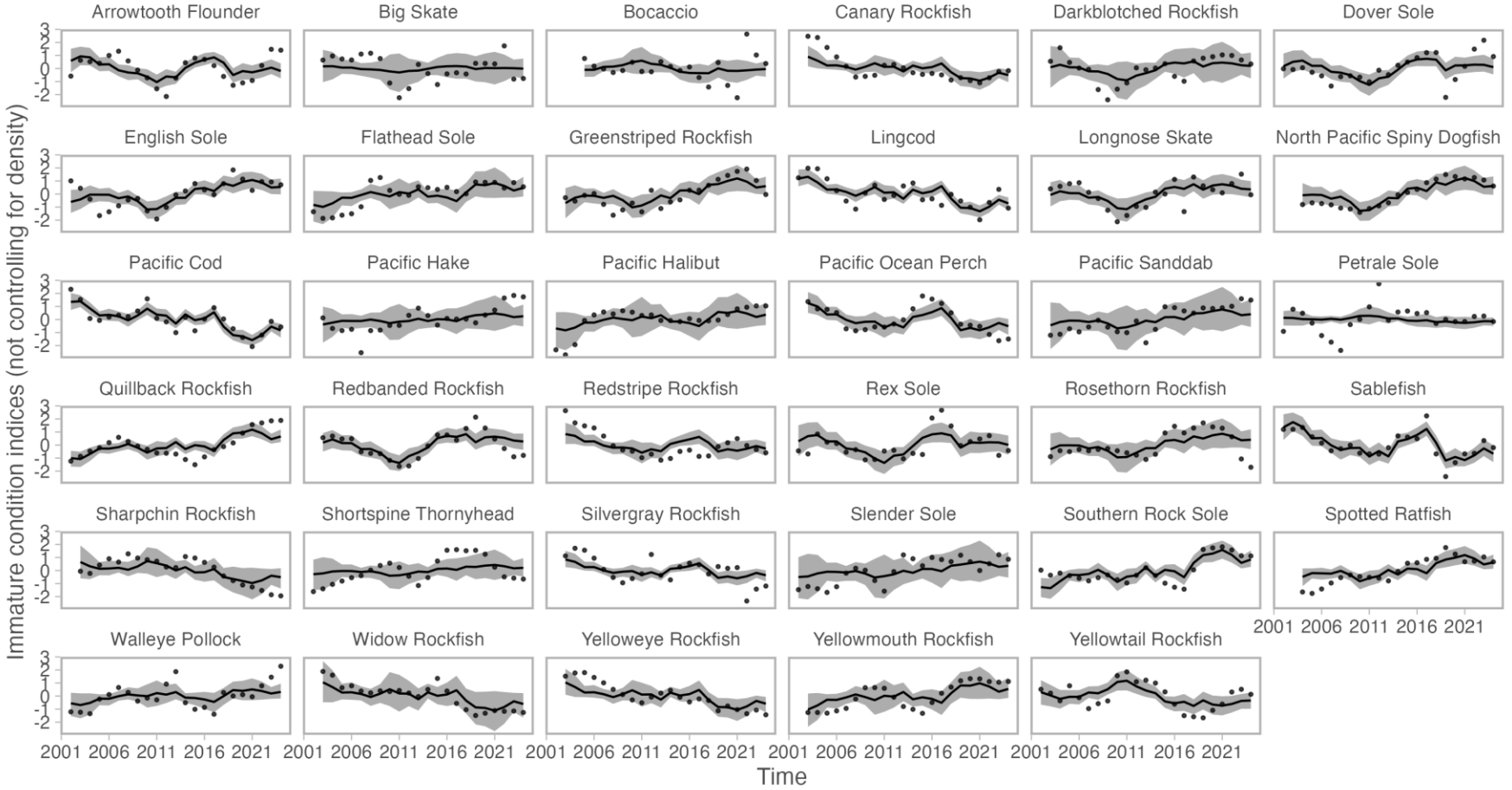
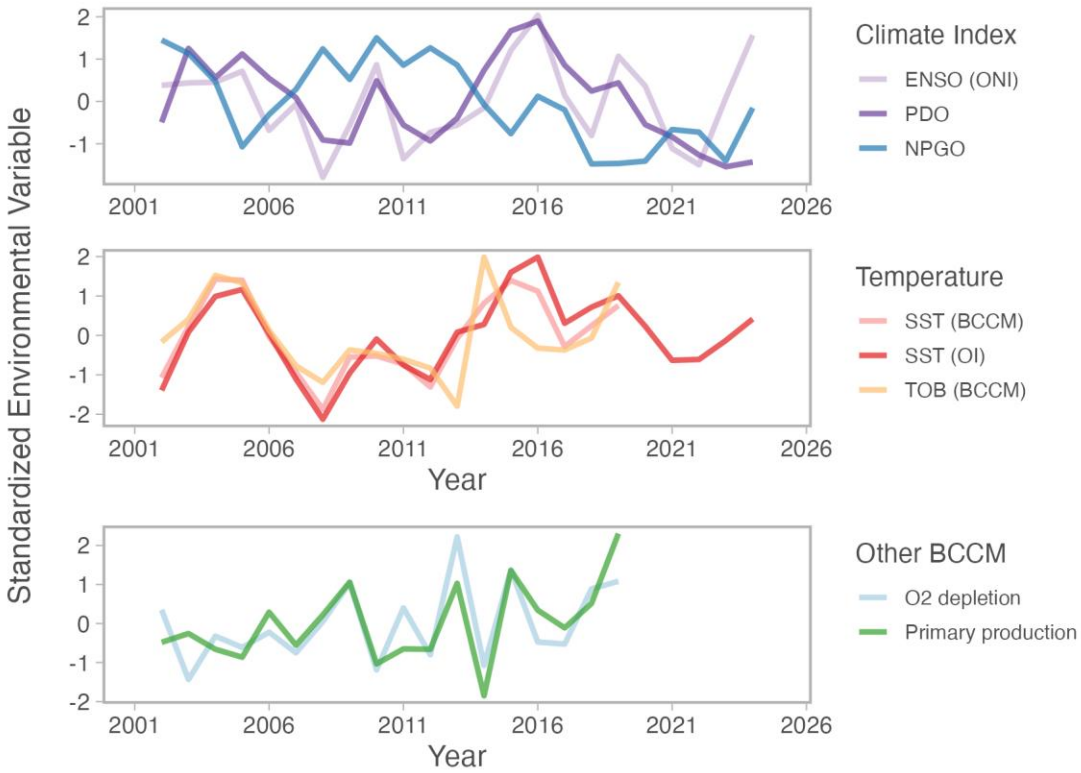
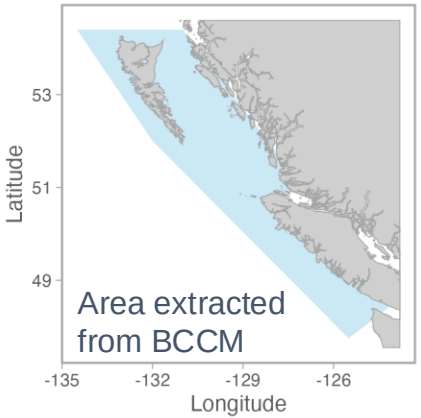


7. Environmental variables



Assess correlations using post-hoc tests that propagate uncertainty (*Litzow et al. 2020 in Prog Oceanogr*)

BCCM coupled physical-biogeochemical ROMS model (*Peña et al. 2019*)



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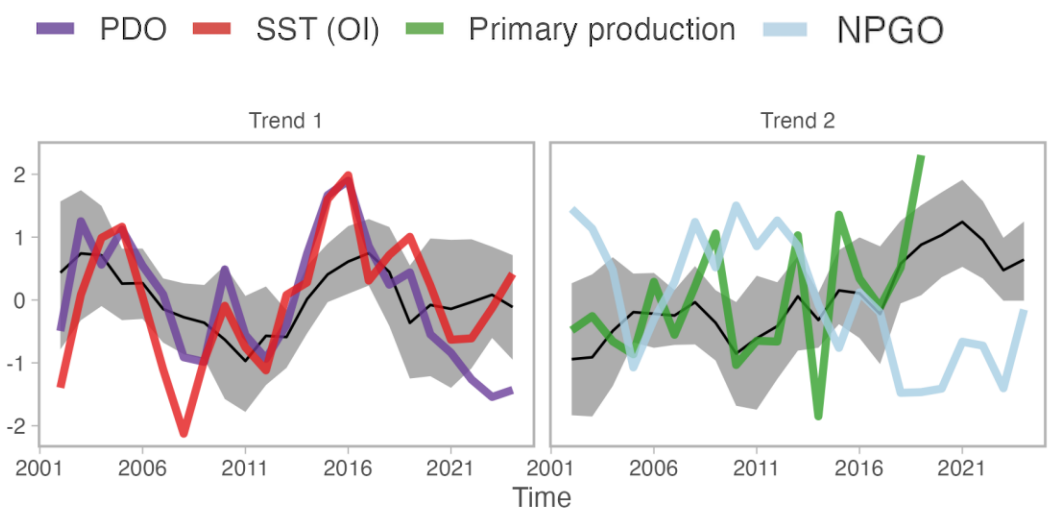

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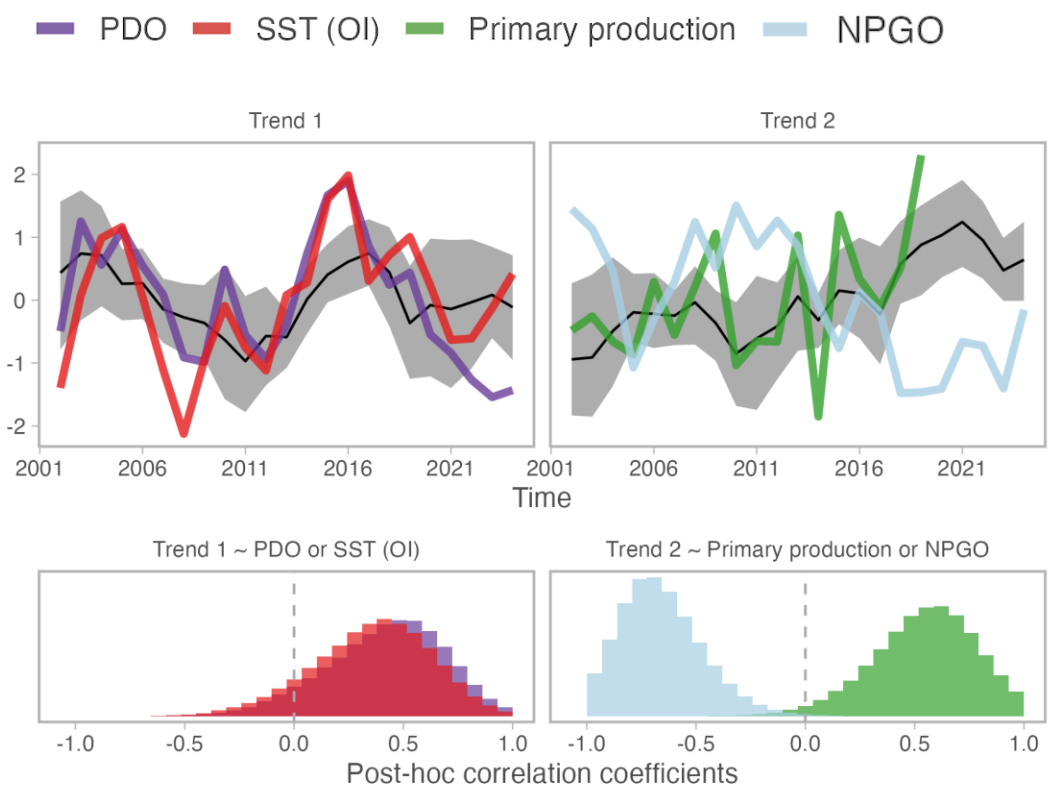

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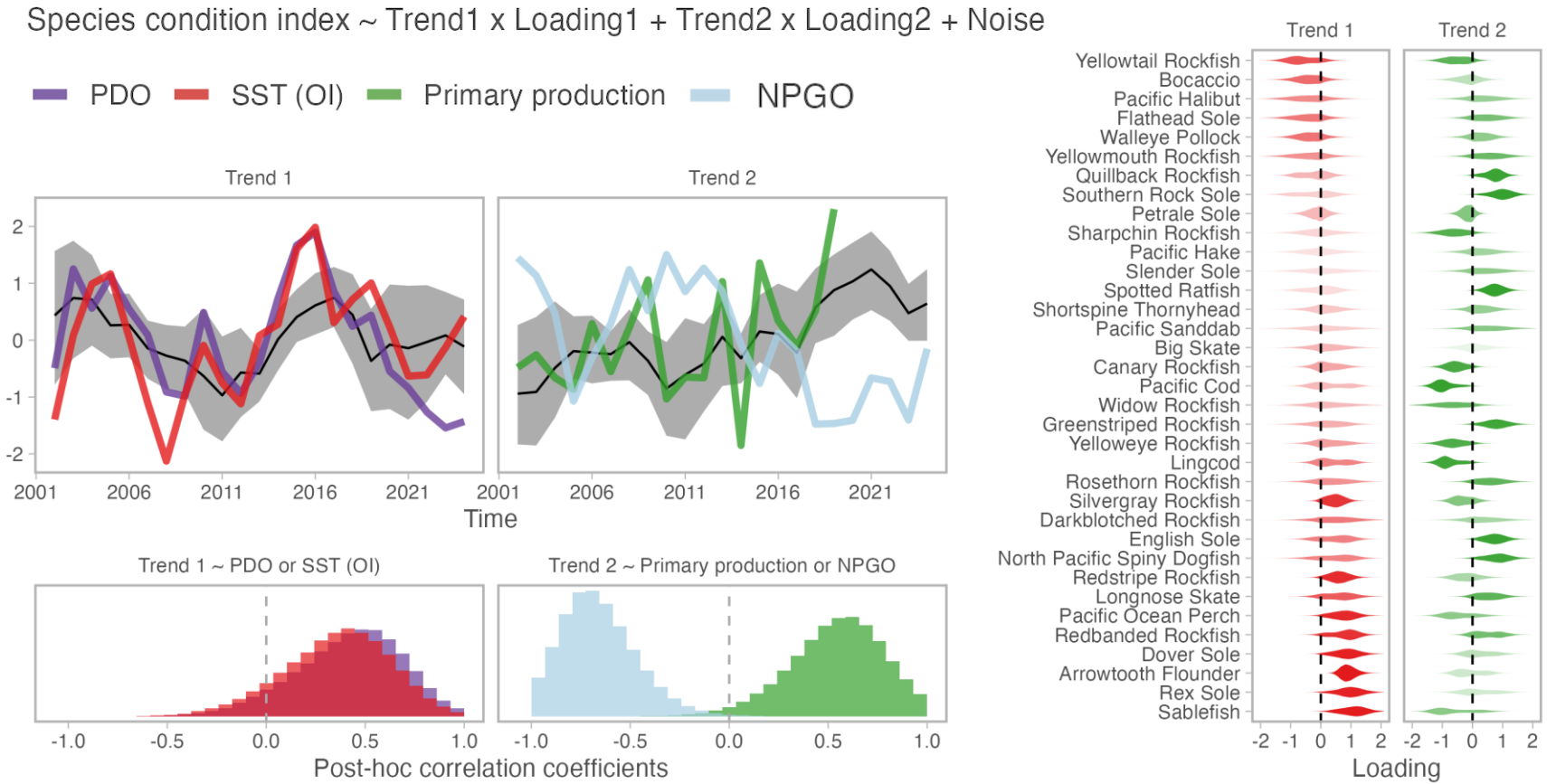
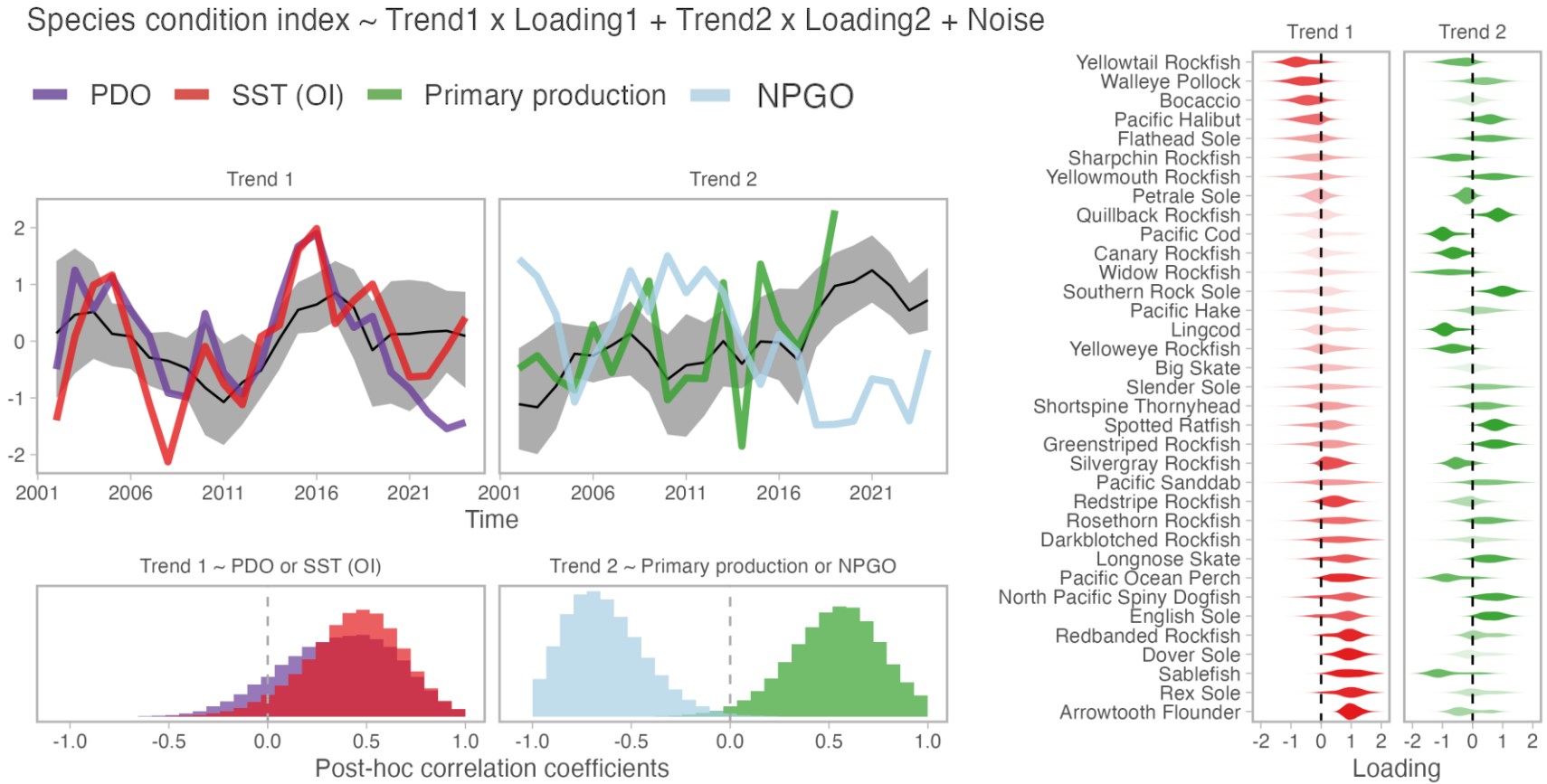
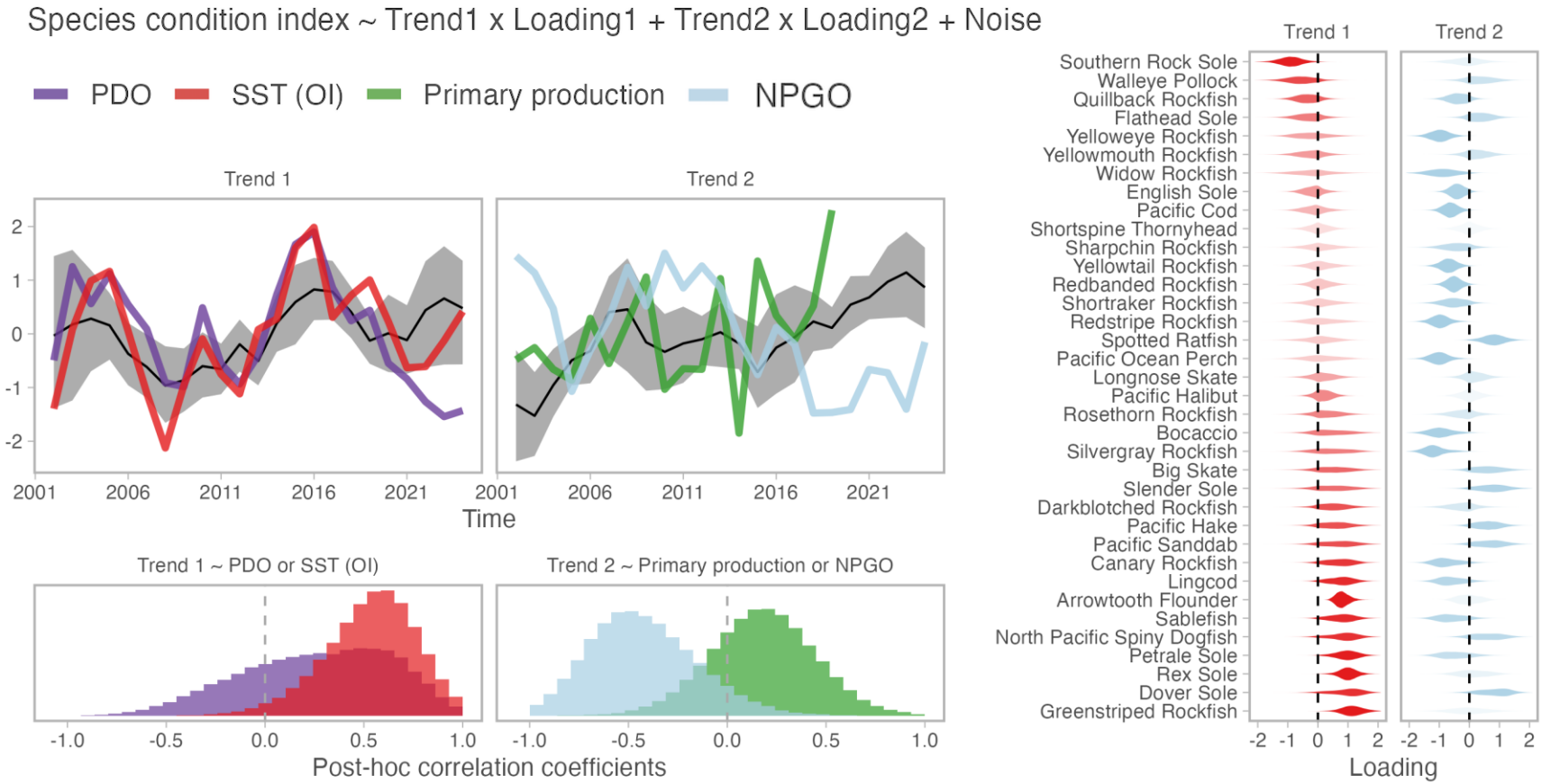


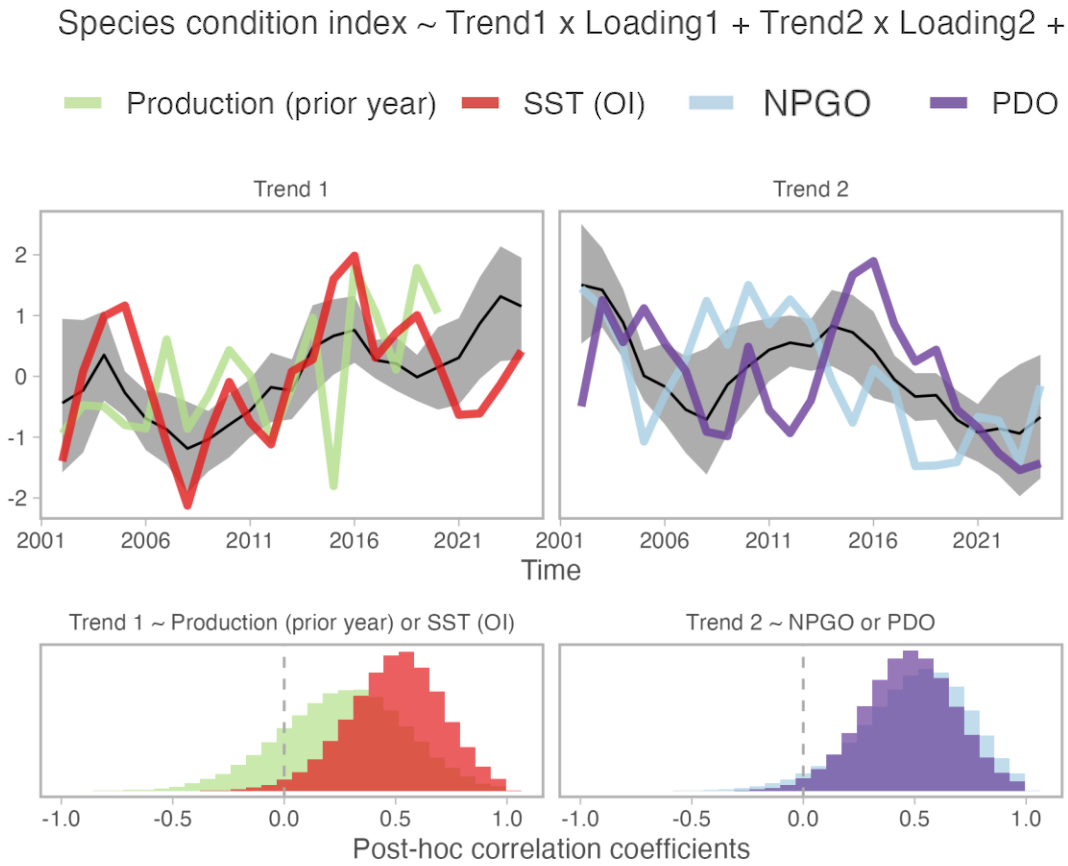
7. Common trends: immature condition *(adjusted)*

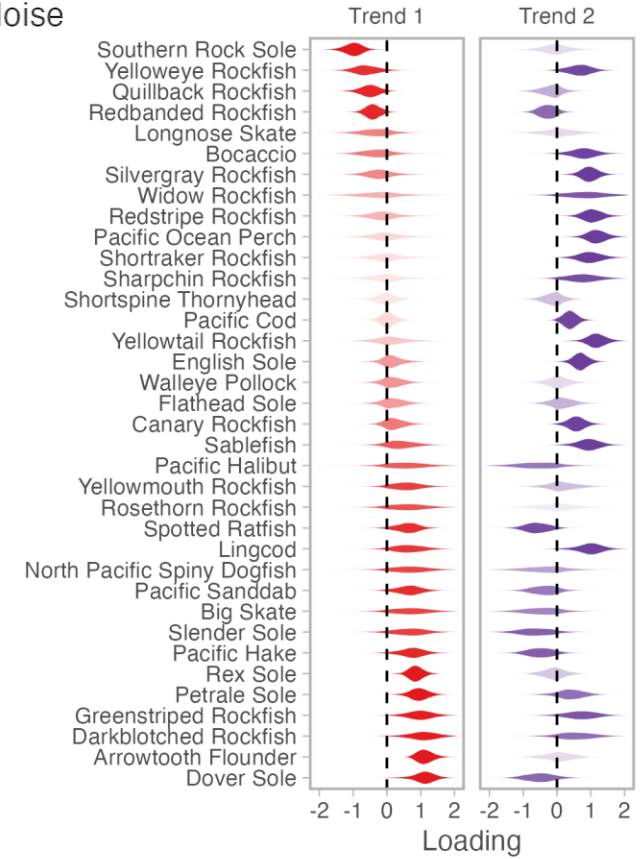


7. Common trends: mature male condition *(adjusted)*



7. Common trends: mature ***female**** condition *(adjusted)*

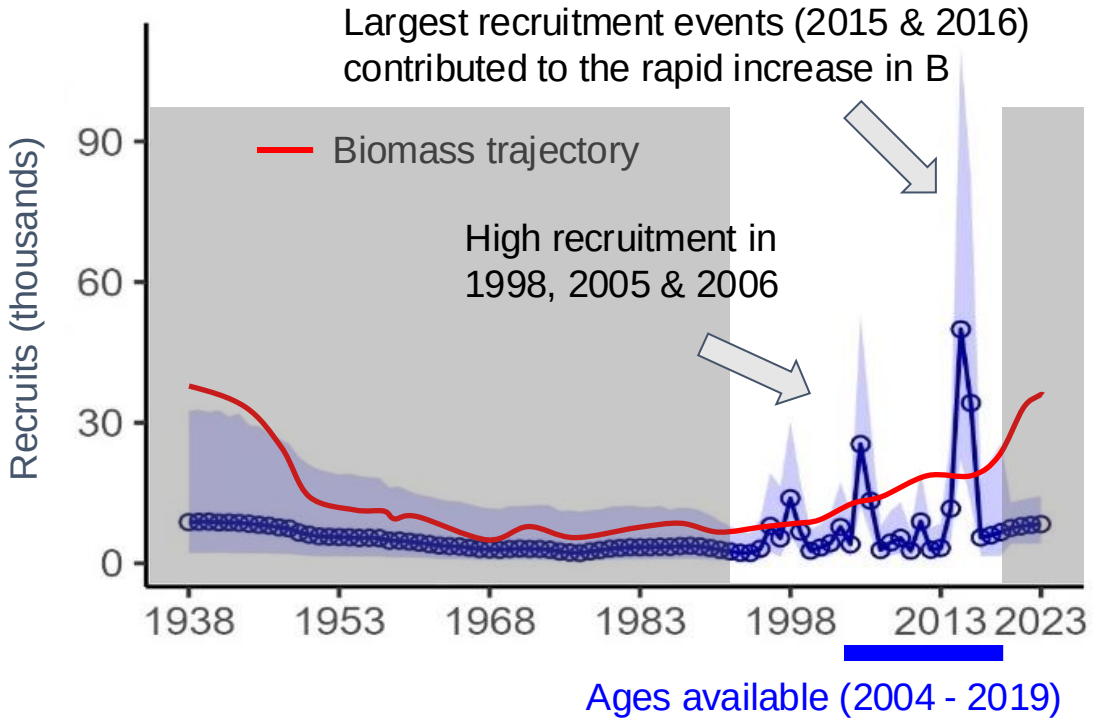




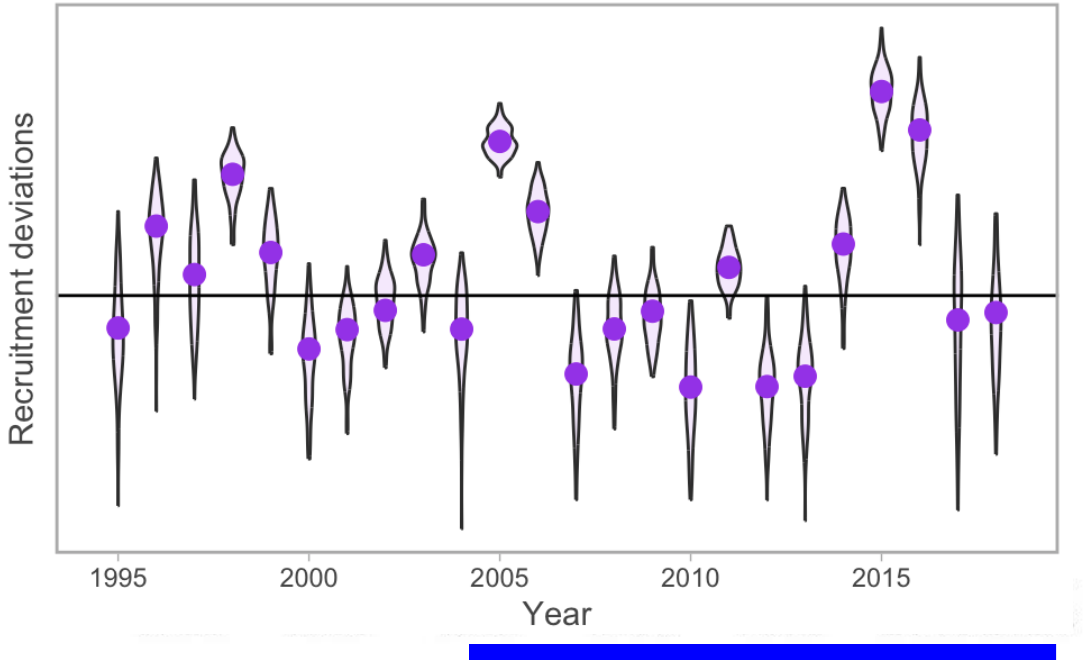
But do these changes matter…

Assessment of Petrale Sole in British Columbia in 2024

By Mackenzie Mazur, Kendra Holt, Nick Fisch, Philina English



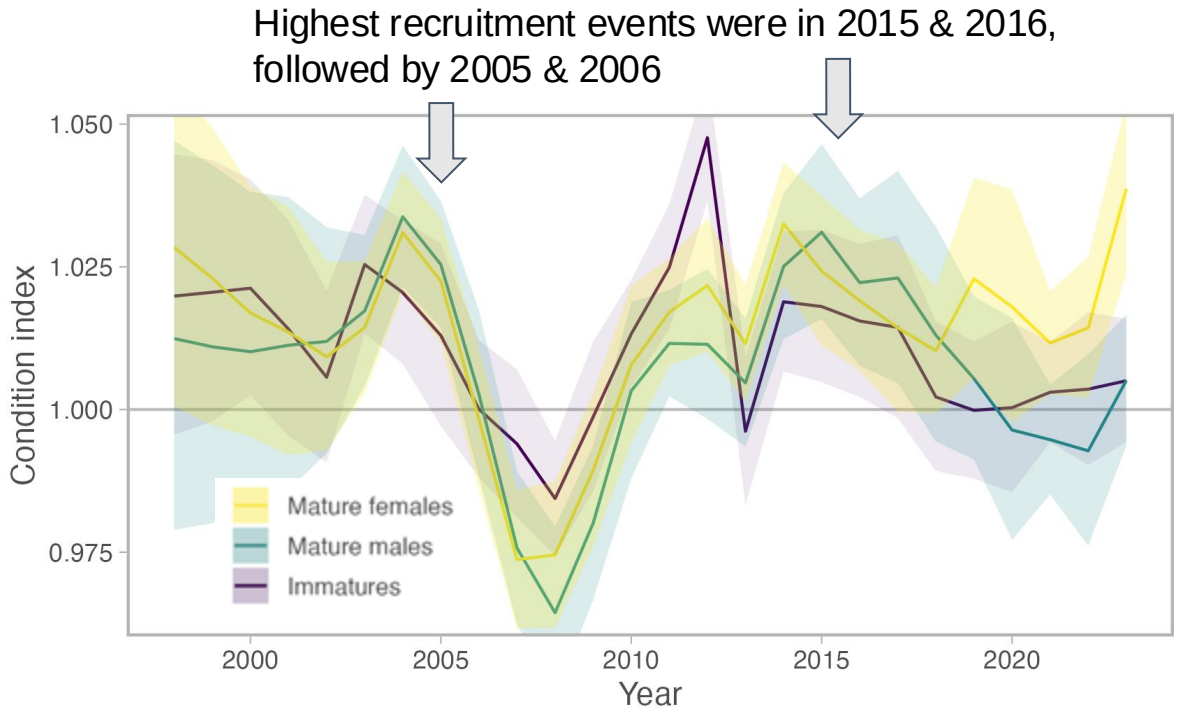
Recruitment deviations with uncertainty



Ages available (2004 - 2019)

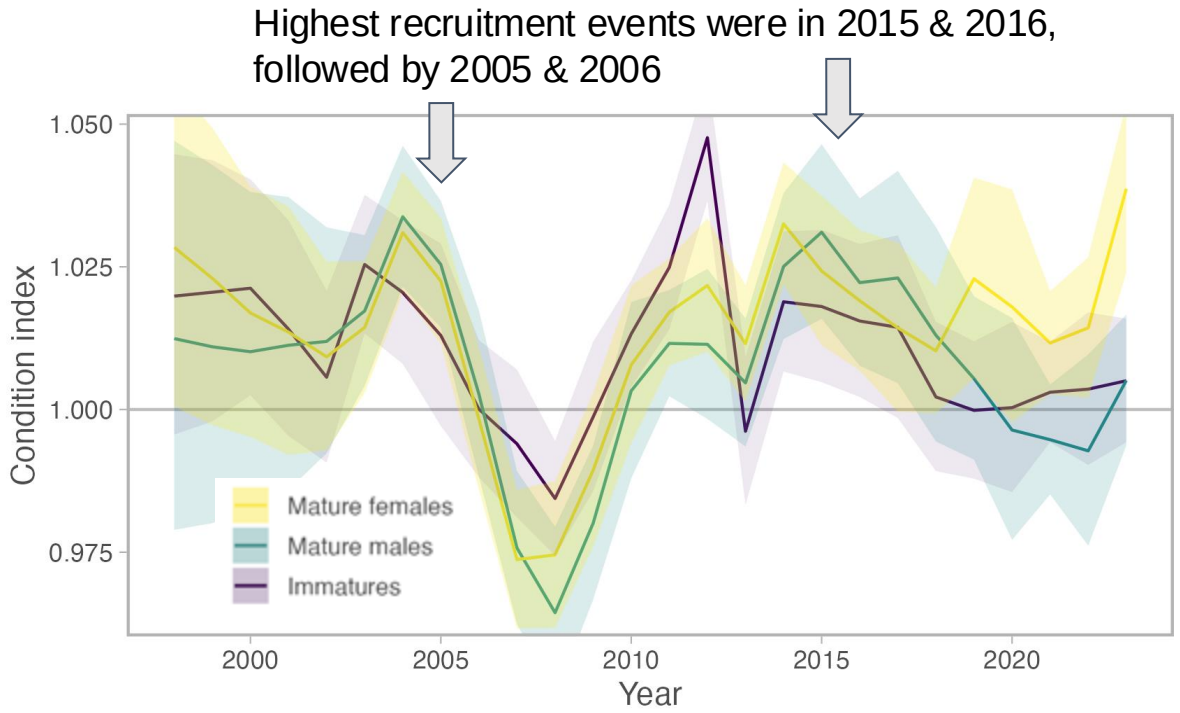
100 MCMC samples of recruitment deviations for 1995 to 2018

Body condition indices with uncertainty



100 posterior samples of condition index values for 1998 to 2023

Body condition indices with uncertainty

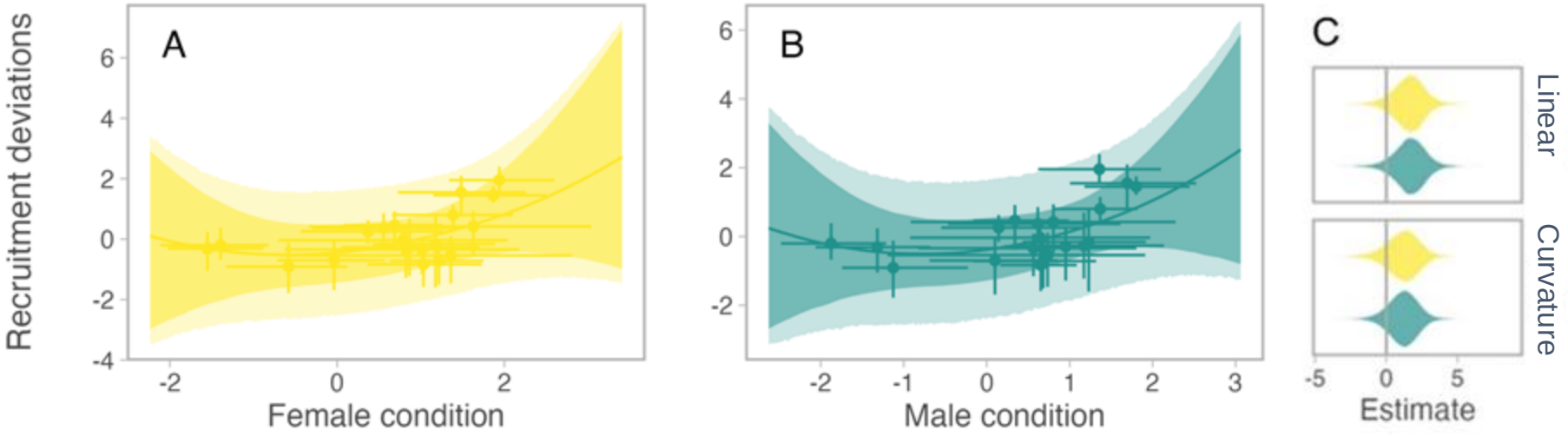


100 posterior samples of condition index values for 1998 to 2023

↓

Paired with next year's recruitment deviations for 100 Bayesian time-series regressions with AR1 correlation structure

Is recruitment related to prior year's mature body condition?



(in SDs from the mean of each time series)

95% CI for predicted relationship (dark) and predicted observations (lighter) (A, B) and coefficient densities (C) from combined posteriors of 100 time-series regressions (one for each pair of sample estimates

Next steps…

- Investigate relationships with recruitment and environmental variables for other species
- Incorporate local environment directly into spatial condition models
- Link results management advice
  - Incorporate empirical weight-at-age into assessments (*Kuriyama et al. 2016*)
  - Management strategy evaluation
  - Climate conditioned risk analysis (*Duplisea et al. 2021*)

Questions or suggestions?

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Photo credit: Darienne Lancaster