Linking recruitment synchrony to environmental variability

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Recruitment Synchrony

- Synchrony in Northeast Pacific marine fish recruitment (Hollowed et al., 1987; Mueter et al., 2007)
- Ecosystem-wide associations between environmental and biological variability (Hare and Mantua, 2000)
Hypothesis

_Synchronous production dynamics_ of stocks within and across ecosystems are due to _shared sensitivity to common environmental drivers_.
Approach

Growth

Recruitment

1. Evaluate synchrony within ecosystems
2. Identify stocks with similar susceptibility to environmental processes
3. Identify important environmental processes
4. Modeling
Recruitment Data

- California Current
- Gulf of Alaska
- Eastern Bering Sea & Aleutian Islands

(14 stocks)
(14 stocks)
(24 stocks)
Recruitment Data

- California Current (24 stocks)
- Gulf of Alaska (14 stocks)
- Eastern Bering Sea & Aleutian Islands (14 stocks)
Recruitment Data

- Removed effects of spawner biomass
- Used stock-recruitment residuals for all analyses

GOA arrowtooth flounder Beverton-Holt model fit
Recruitment Synchrony

- Synchrony in extreme recruitment events
- Correlation in recruitment between stocks

![Diagram showing recruitment synchrony across different fish species and years from 1950 to 2010. The diagram highlights the highest 25% and lowest 25% recruitment years for various species, with a particular focus on the high years of 1998-2000.]
Bayesian Hierarchical Modeling

- Data rich stocks inform data poor stock
- Modeled recruitment as a linear function of environmental variables
Slope Parameter

Graph showing the relationship between Recruitment and Environmental variable.
Slope Parameter

Recruitment vs Environmental variable

Group-level distribution
Slope Parameter

- Recruitment vs. Environmental variable

- Group-level distribution

- Ecosystem-level distribution
Stock Grouping

- Early life history information
- GOA: 4 groups
Cross-shelf transport group

- Arrowtooth flounder
- Dover sole
- Pacific halibut
- Rex sole
- Sablefish
Retention group

- Walleye pollock
- Pacific cod
- Flathead sole
Coastal group

- Seymour Canal Pacific herring
- Sitka Sound Pacific herring
Parental investment group

- Dusky rockfish
- Northern rockfish
- Pacific ocean perch
- Rougheyeye & blackspotted rockfish
Environmental Variables
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• GOA
  – Sea surface temperature (SST)
  – Upwelling
  – Freshwater discharge
  – Sea surface height (SSH)
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• GOA
  – Sea surface temperature (SST)
  – Upwelling
  – Freshwater discharge
  – Sea surface height (SSH)

• Data for each variable across many locations and times
Environmental Variables

- Principal component analysis to explain a large portion of the variance as a smaller number of uncorrelated time series
8 models

Model selection (DIC)

Best model
GOA Best Model: Sea Surface Height

- Ecosystem-level median
- Group-level median
- Stock-level median
- 95% credible interval

PC1: Positive coastal SSH anomalies
PC2: Negative offshore SSH anomalies

Gulf of Alaska
- Cross-shelf transport
  - Arrowtooth flounder
  - Dover sole
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  - Sablefish

Retention
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Parental investment
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Parameter

-6.0 -2.0 0.2 0.4 0.6 -6.0 -2.0 0.0 0.2 0.4 0.6
GOA Best Model: Sea Surface Height

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- **Group-level median**
- **Stock-level median**
- **95% credible interval**

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Parameter

\(-0.6 \quad -0.2 \quad 0.2 \quad 0.4 \quad 0.6 \quad -0.6 \quad -0.2 \quad 0.0 \quad 0.2 \quad 0.4 \quad 0.6\)
GOA Sea Surface Height Model Fits

**Flathead sole**

- Stock-recruitment residuals
- Year: 1960 to 2000

**Sablefish**

- Year: 1960 to 2000
California Current

- Best model: sea level
- High recruitment associated with:
  - High upwelling the year of spawning
  - Low upwelling the year before spawning
Eastern Bering Sea and Aleutian Islands

- Best model: all environmental variables considered
- Not simple to separate out the driving processes
Evaluating Stock Grouping

• Tested best model without separate groups
  – Support for grouped model in the BSAI, support not as strong in the GOA and CC
• Other grouping structures may improve the fit
  – More early life history information
Conclusions

• Synchrony in Northeast Pacific recruitment
  – Use methods that draw strength from this synchrony
• Some evidence for similar environmental influences within defined groups
• Environmental variables showed common influence on recruitment for several stocks
  – GOA: sea surface height
  – CC: sea level
Thanks!

Fisheries and the Environment (FATE)