

Evidence for Loss of Resilience in a Pacific Herring Stock

Ashleen J. Benson

Sean P. Cox

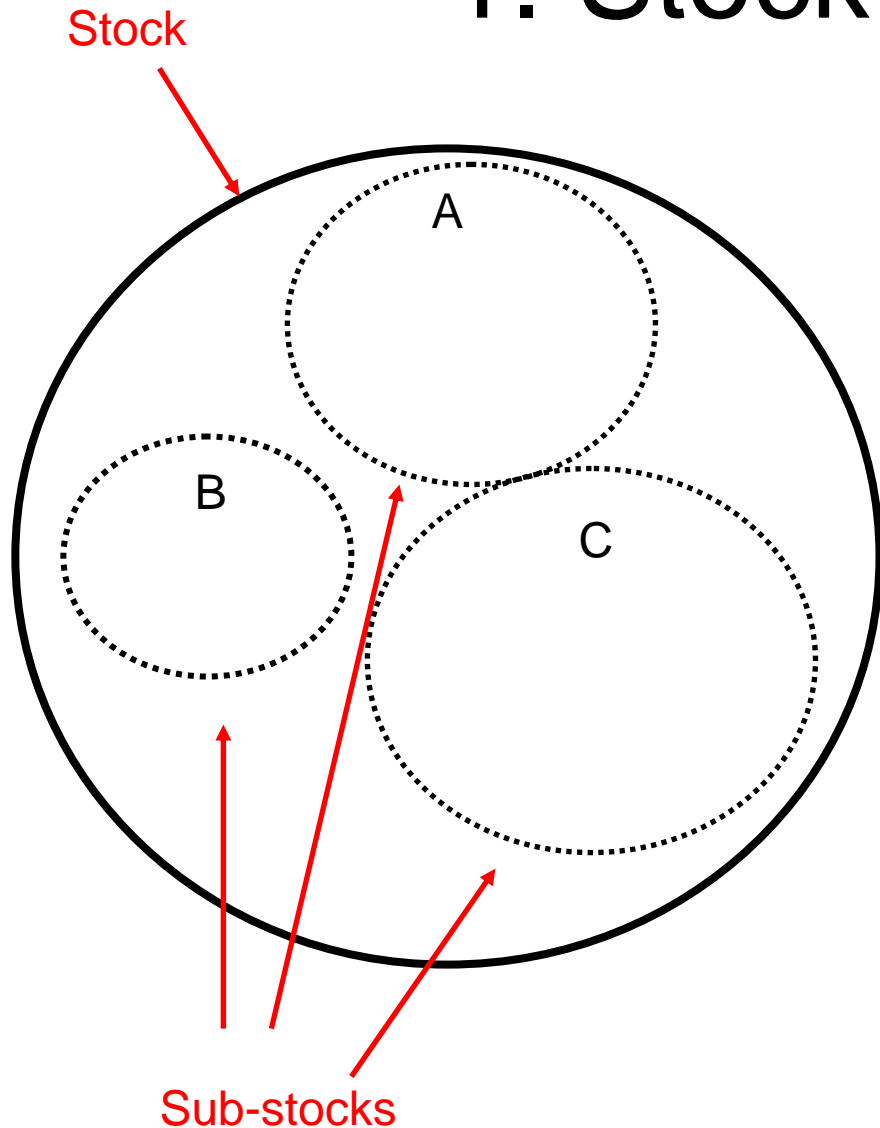
Aaron Springford

Fisheries Research Group
School of Resource and Environmental Management
Simon Fraser University



Theory

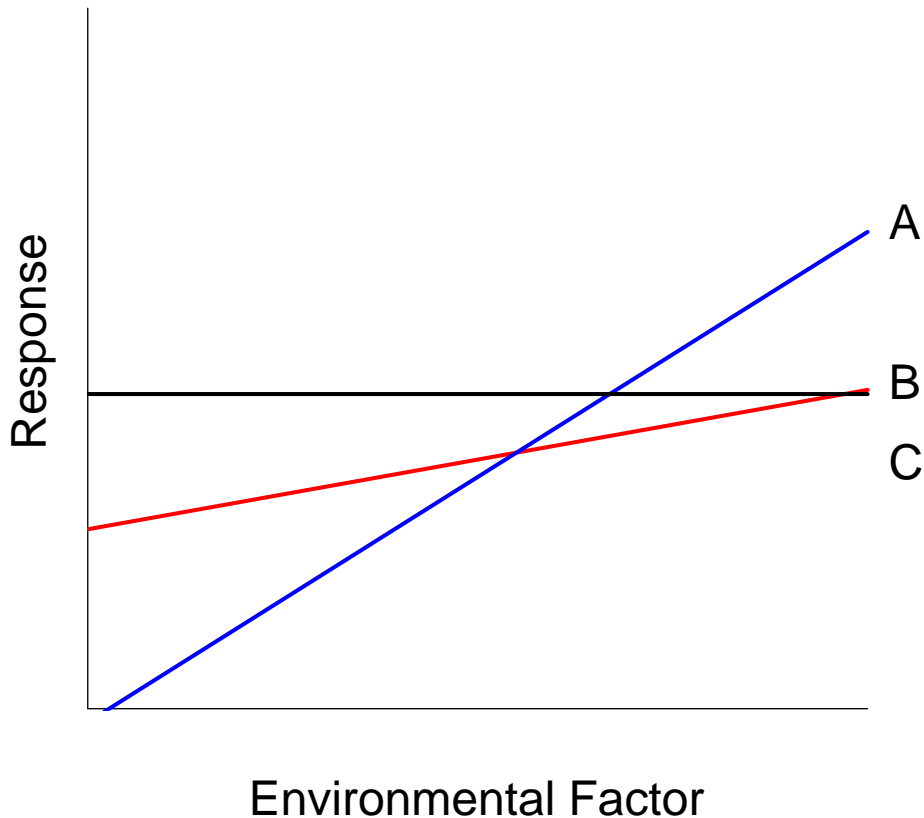
1. Stock concept



“[a “stock”] describes characteristics of semi-discrete groups of fish with some definable attributes which are of interest to fishery managers.”

Begg et al. (1999). Fish. Res. 43:1-8

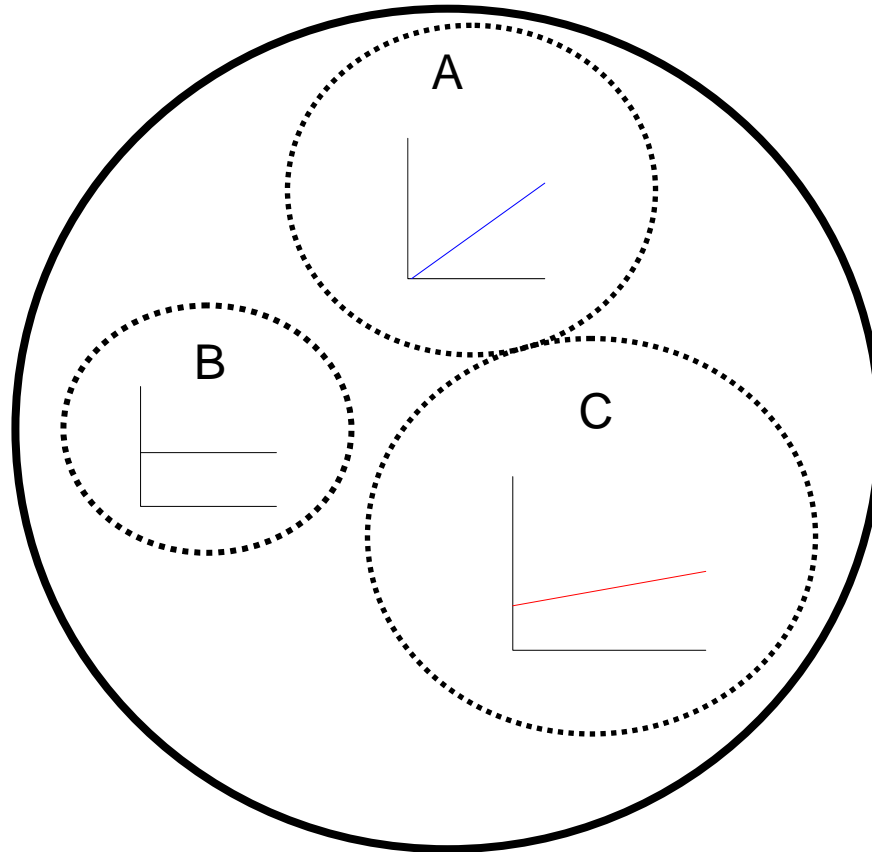
2. Response Diversity



Diverse responses to environmental forcing among species contributing to the same ecosystem function

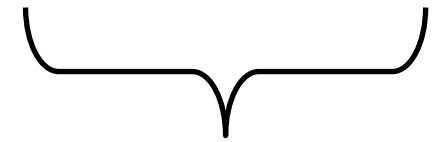
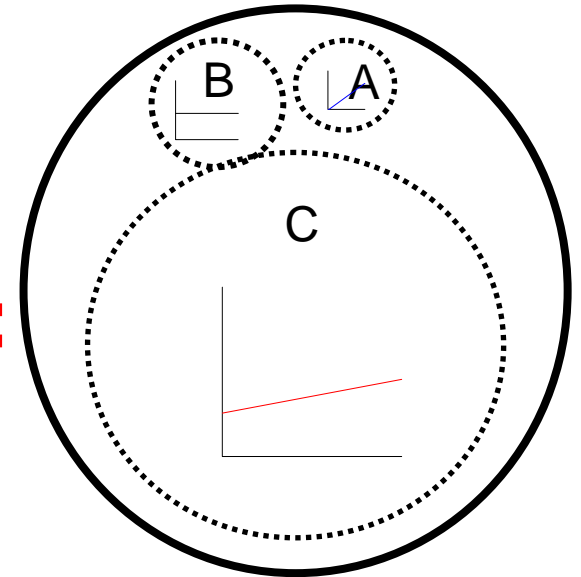
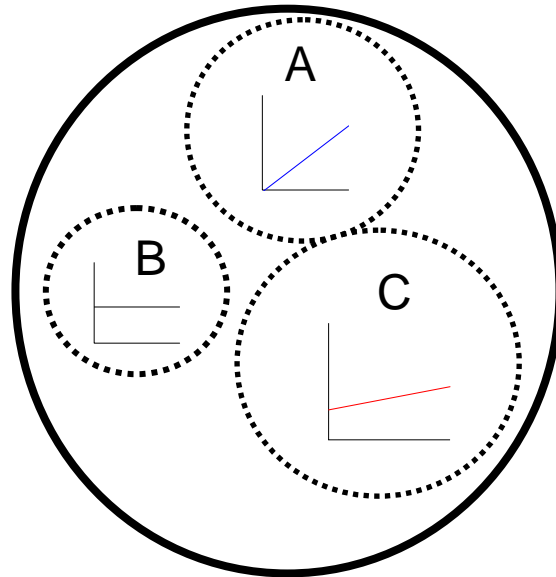
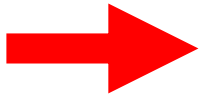
Elmqvist et al. 2003 Front. Ecol 1:484-494

Within-stock diversity



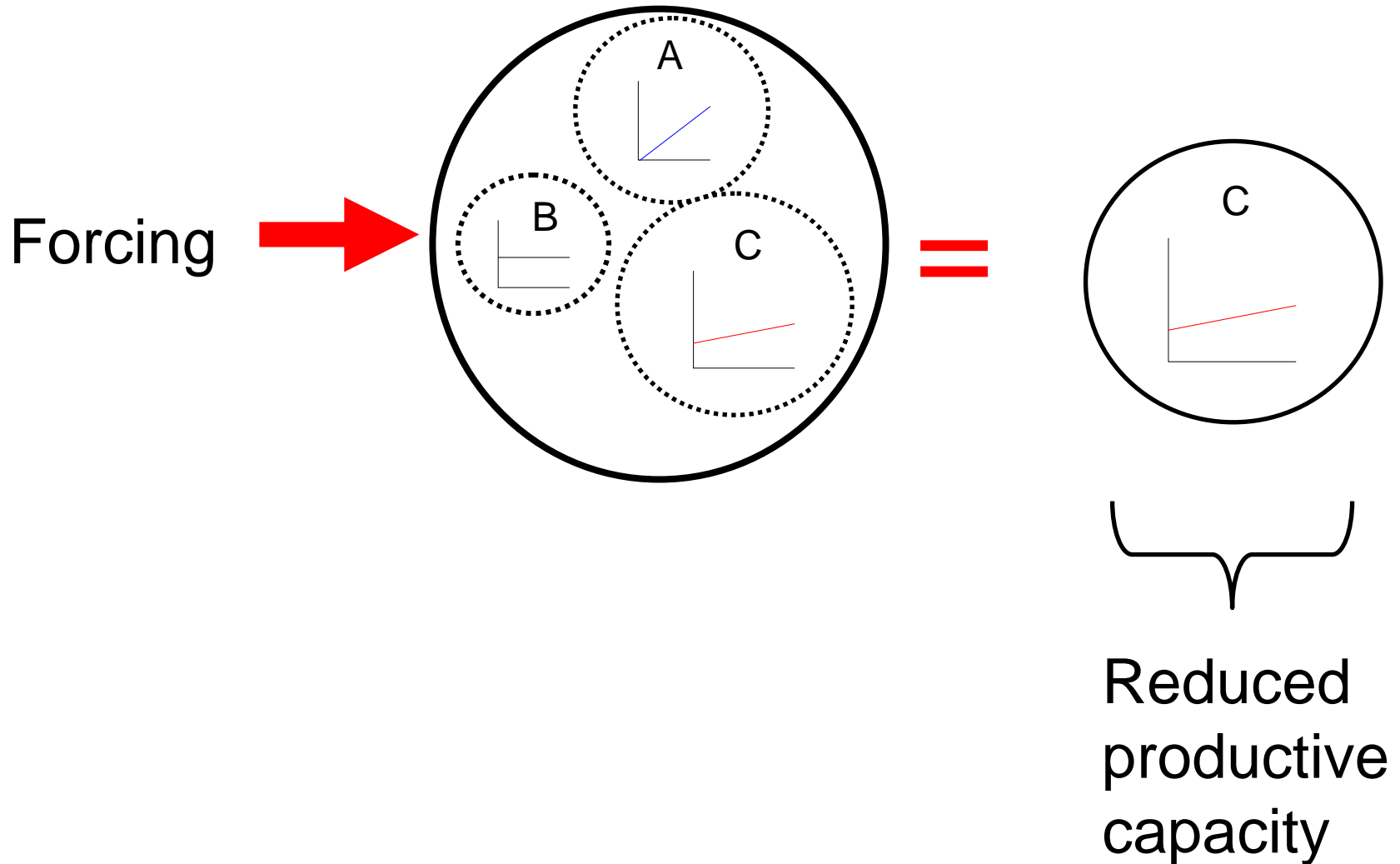
Resilience

Forcing



No change
in productive
capacity

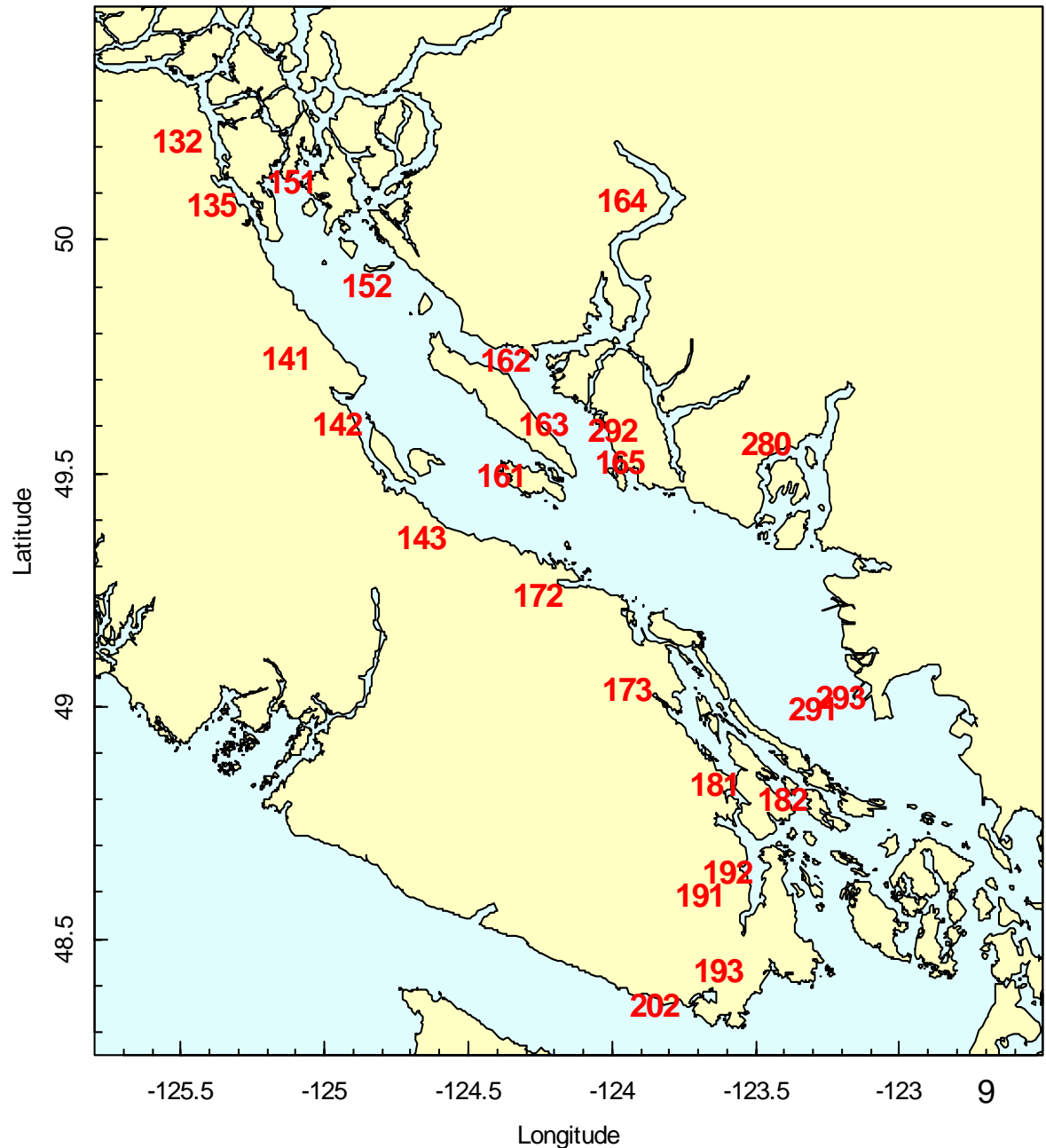
Loss of Resilience



Application

Strait of Georgia herring

spawn sections



Research Question

- Is there evidence of change in the resilience of Strait of Georgia herring stock(s)

Research Approach

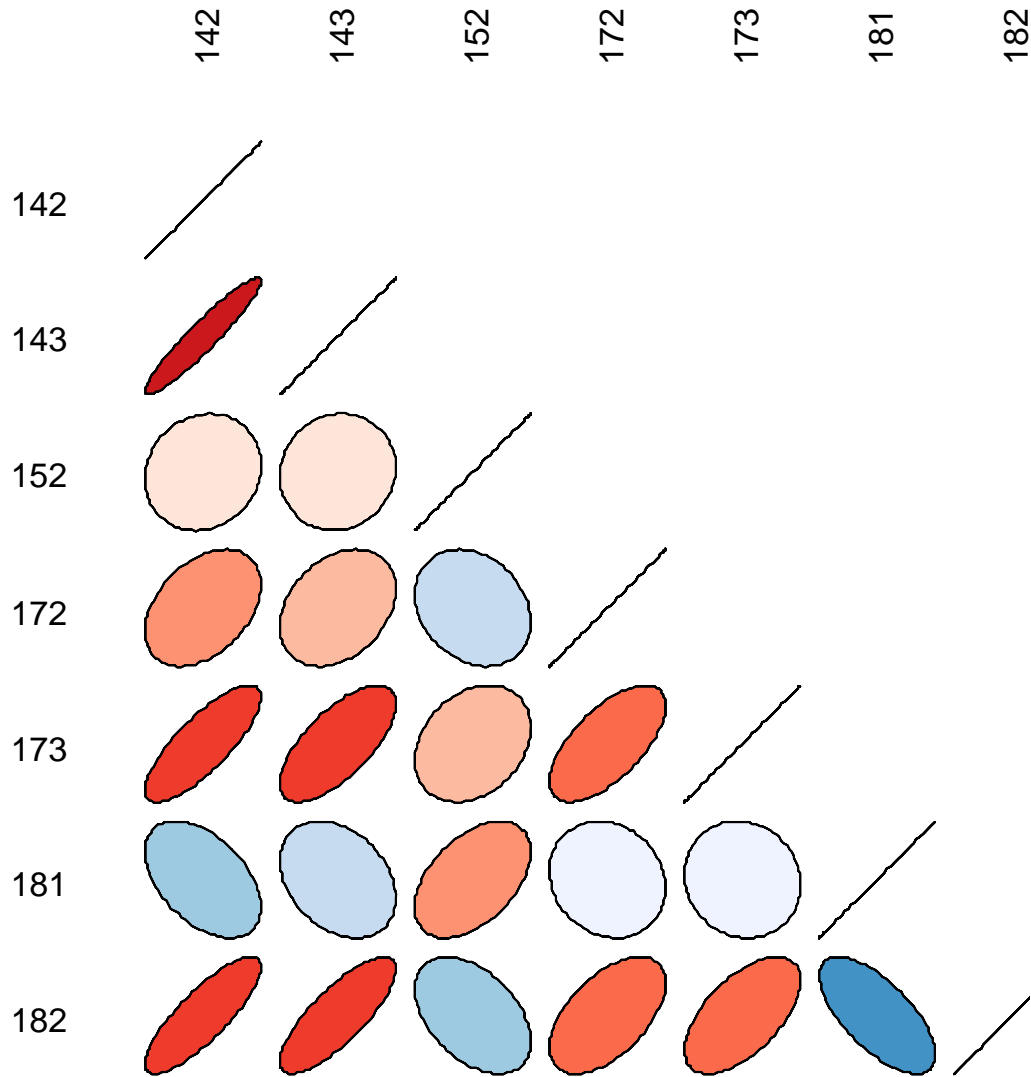
- Examine existing data
 - 1) Evidence of response diversity
 - 2) Changes in response diversity

Analysis

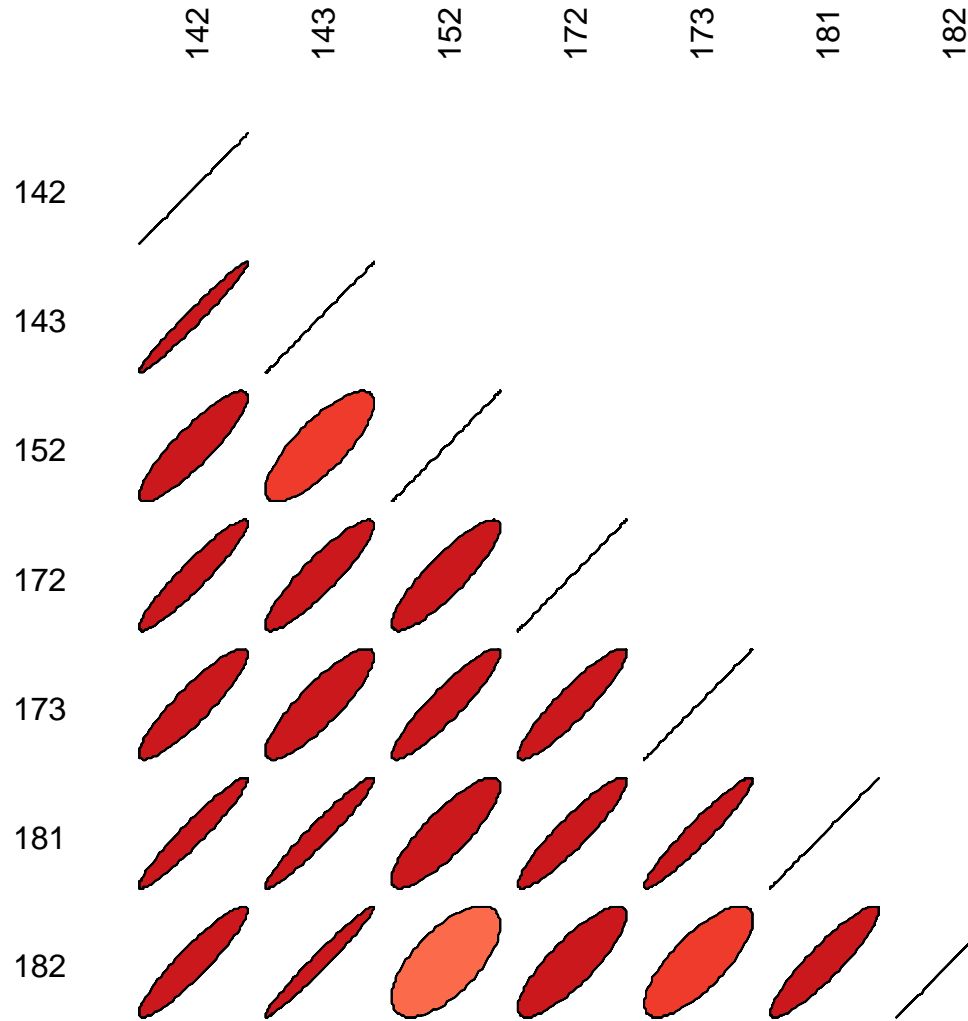
Evidence of response diversity

1. Spatial variability in recruitment patterns?

Age 3 recruitment 1975-2006

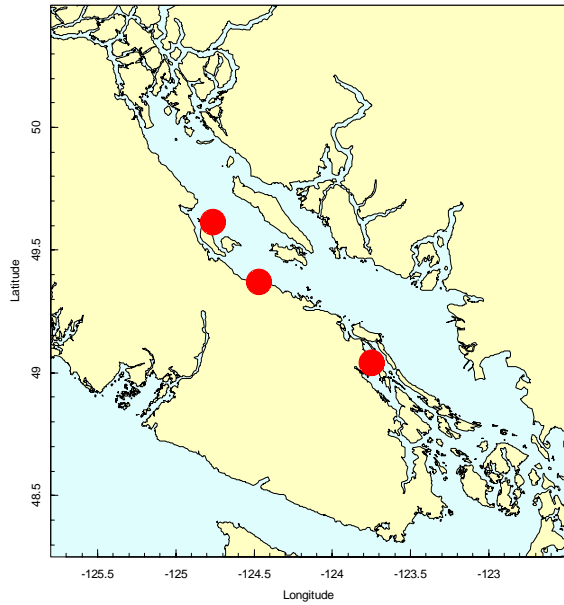
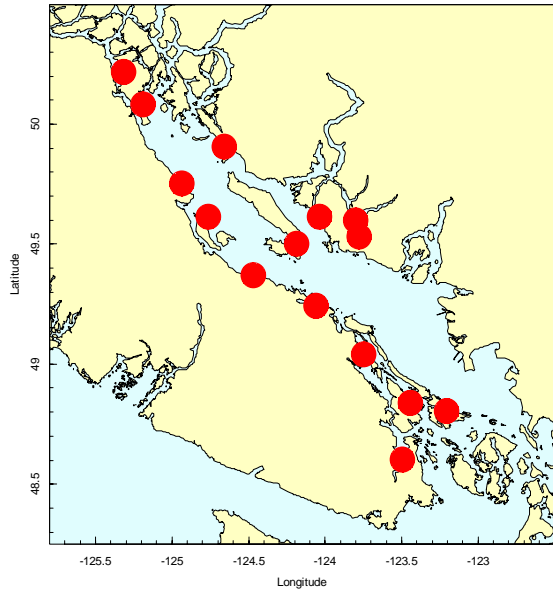


Age 4 recruitment 1975-2006

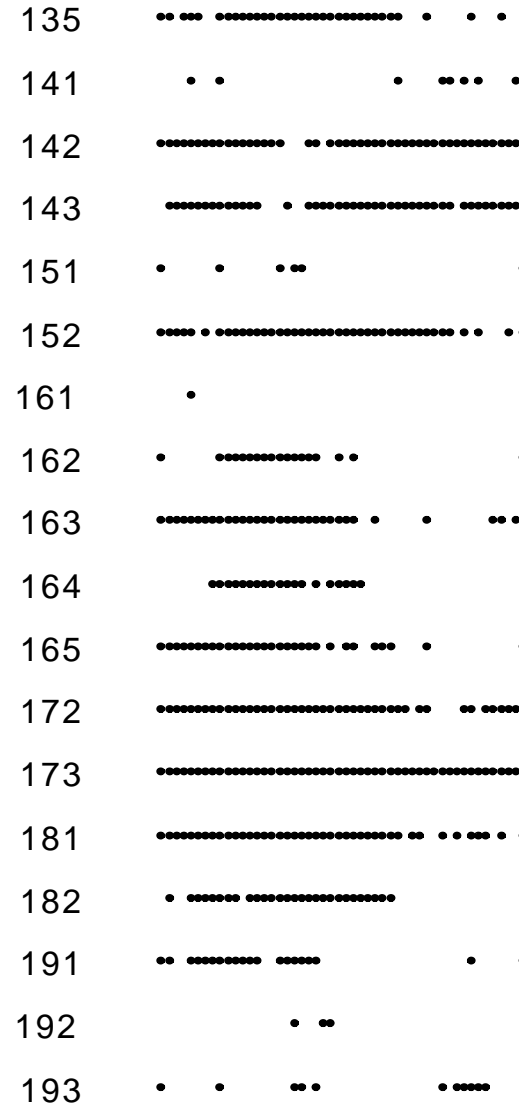
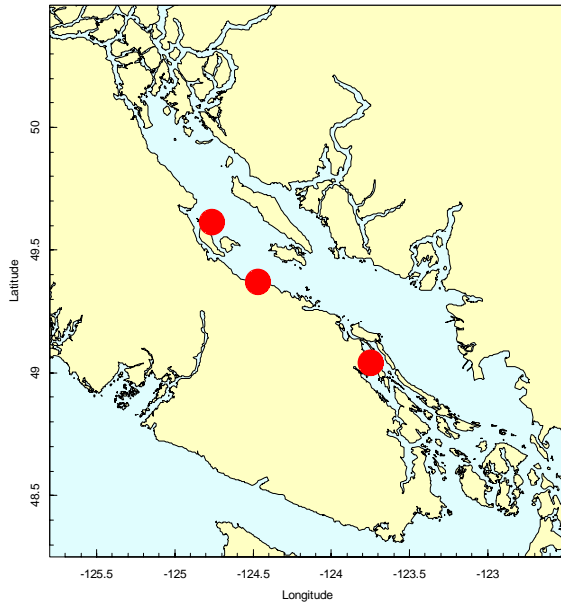
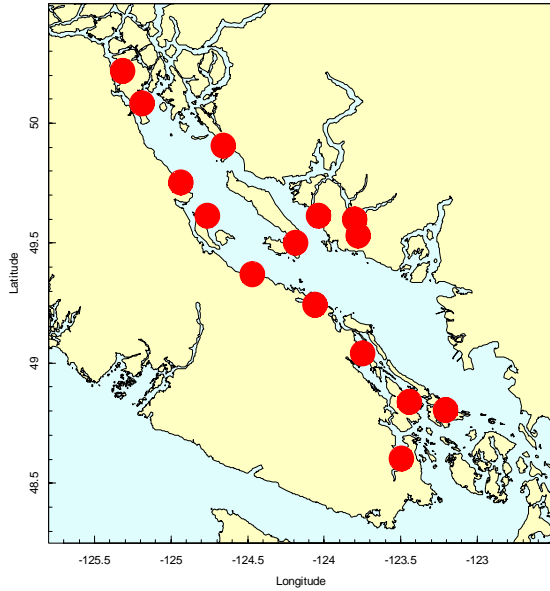


Evidence of response diversity

1. Spatial variability in recruitment patterns?
2. Spatial variability in spawning location?

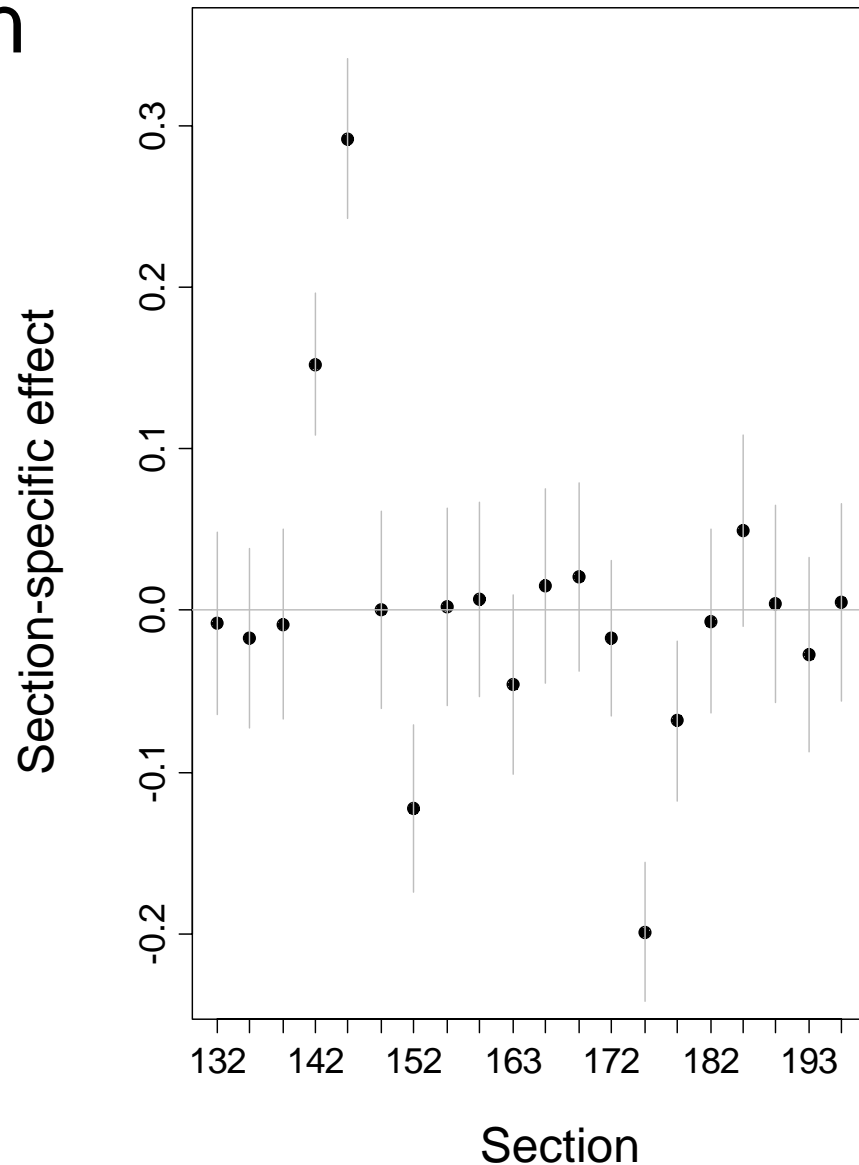


Spawn events 1951-2005



Generalized linear mixed effect model: Probability of spawn

- Biomass
- SST
- Fish size
- **Section**

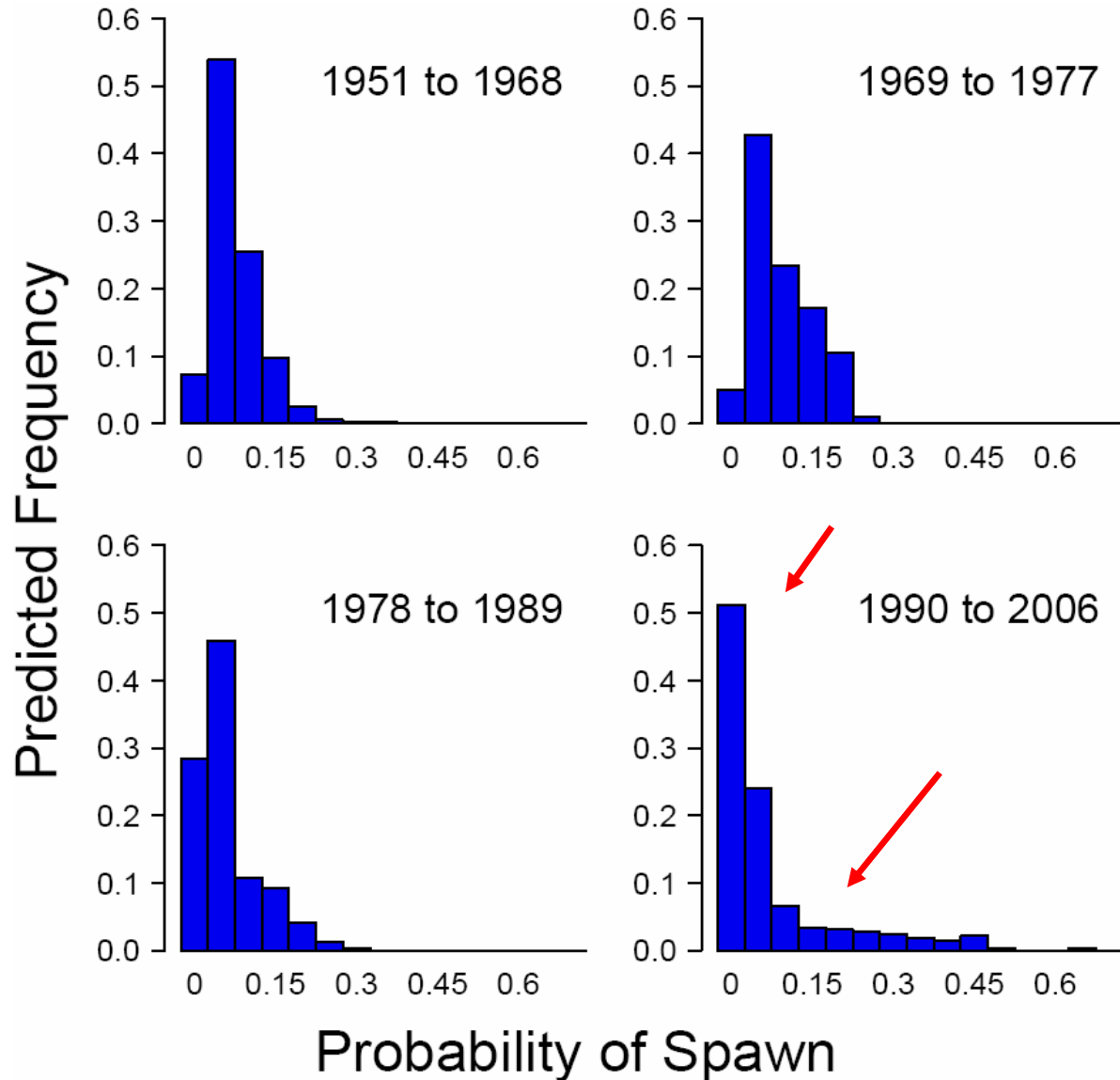


Changes in response diversity

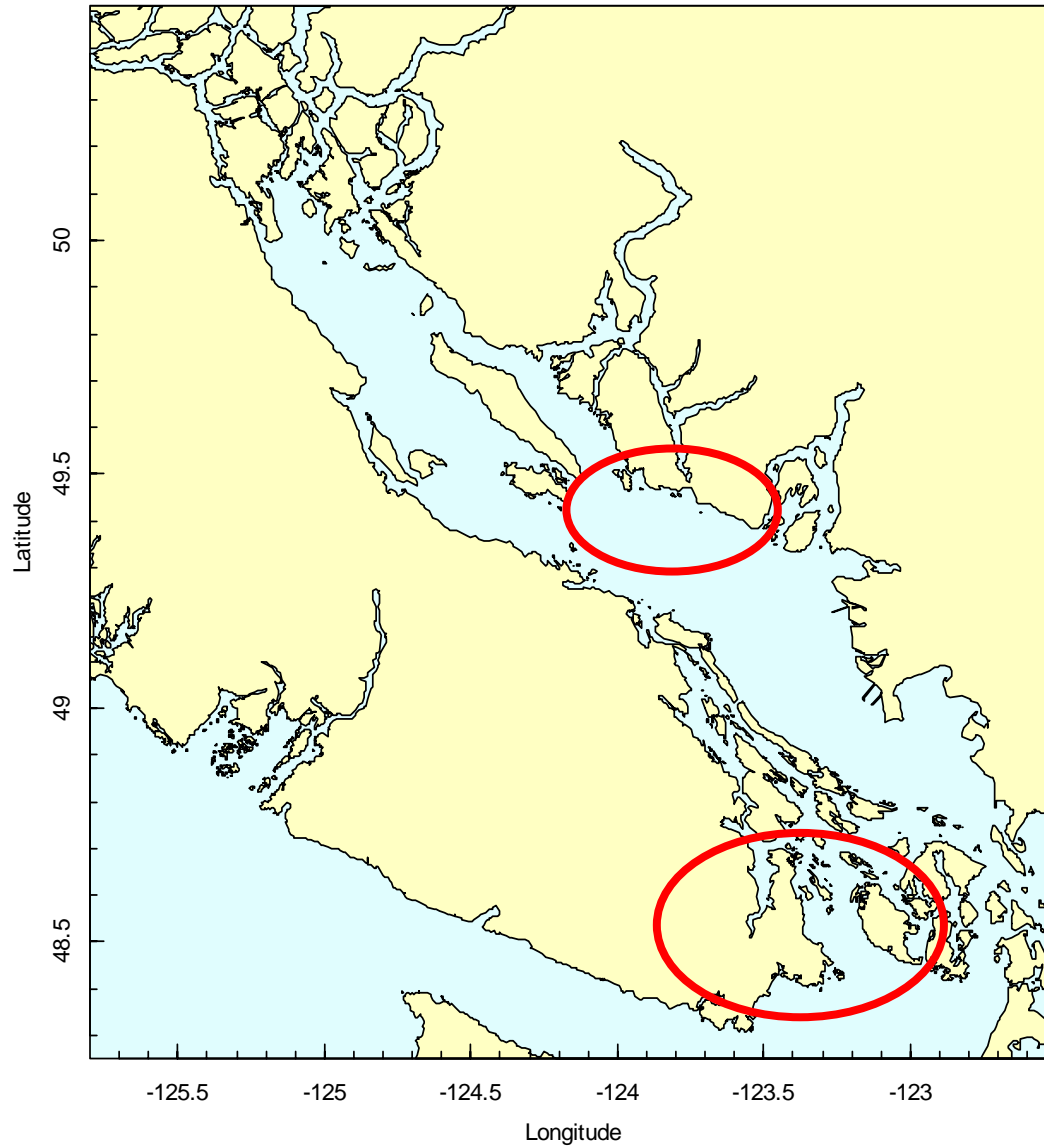
1. Temporal variability in probability of spawn

Bayesian spatial model: Probability of spawn

- Biomass
- SST
- Fish size
- **Section**

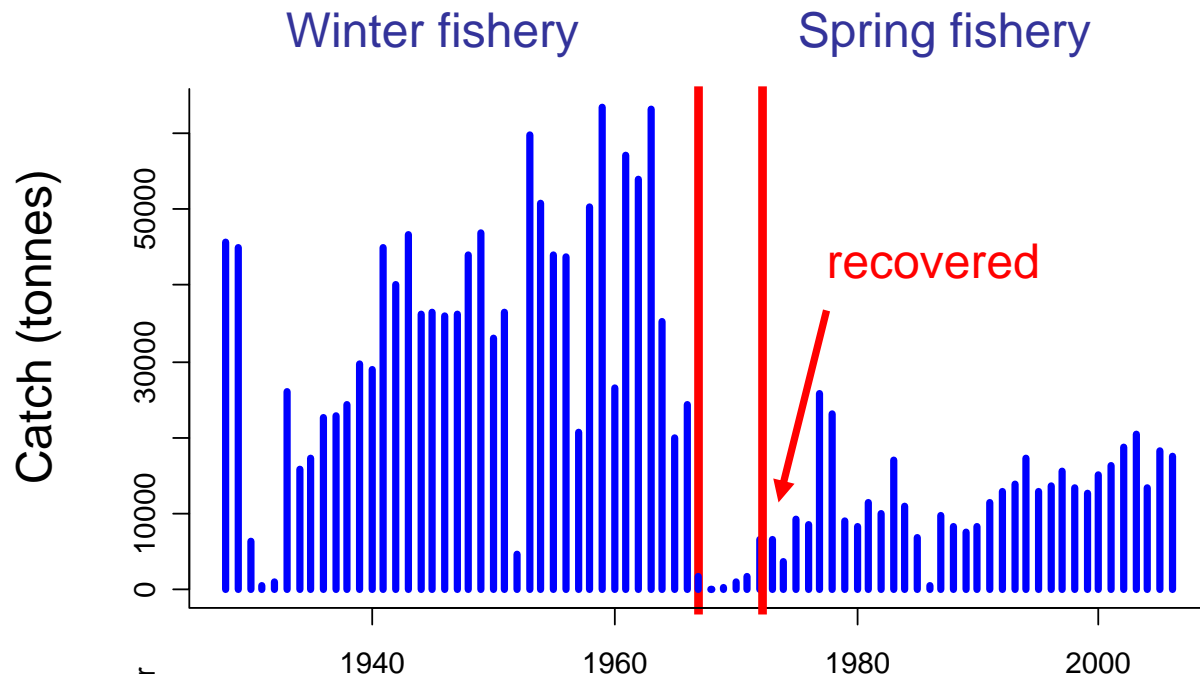


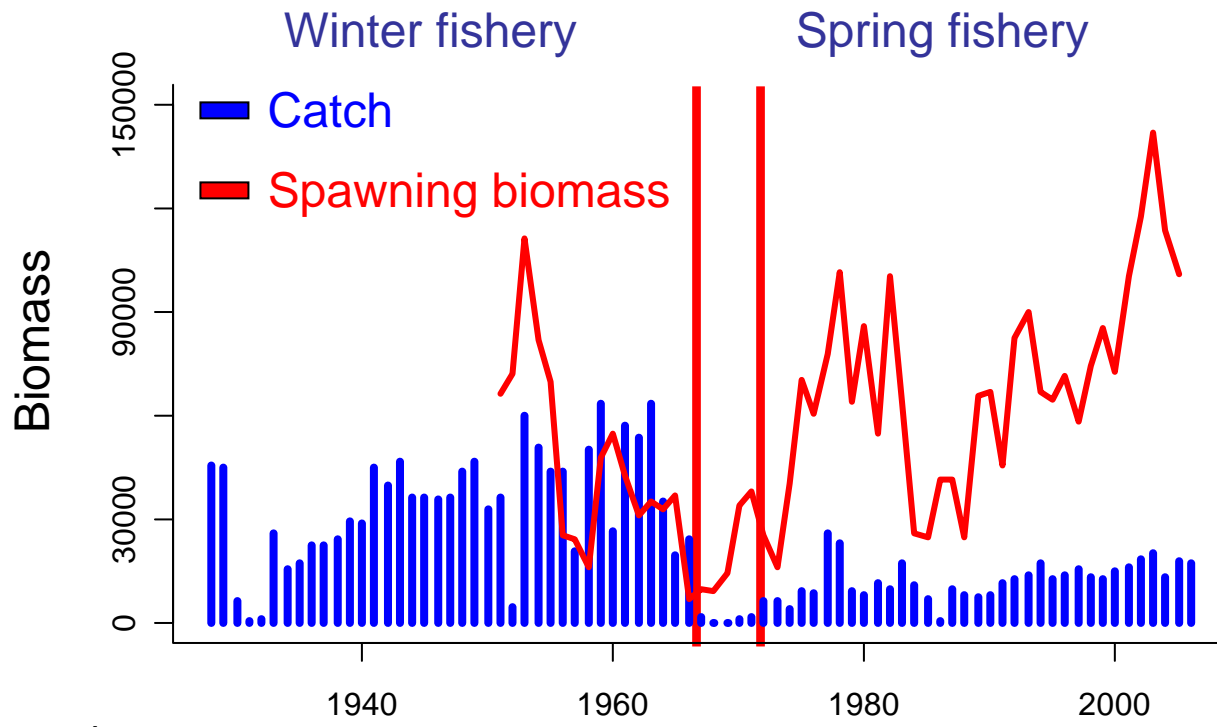
Areas with decreased probability of spawn

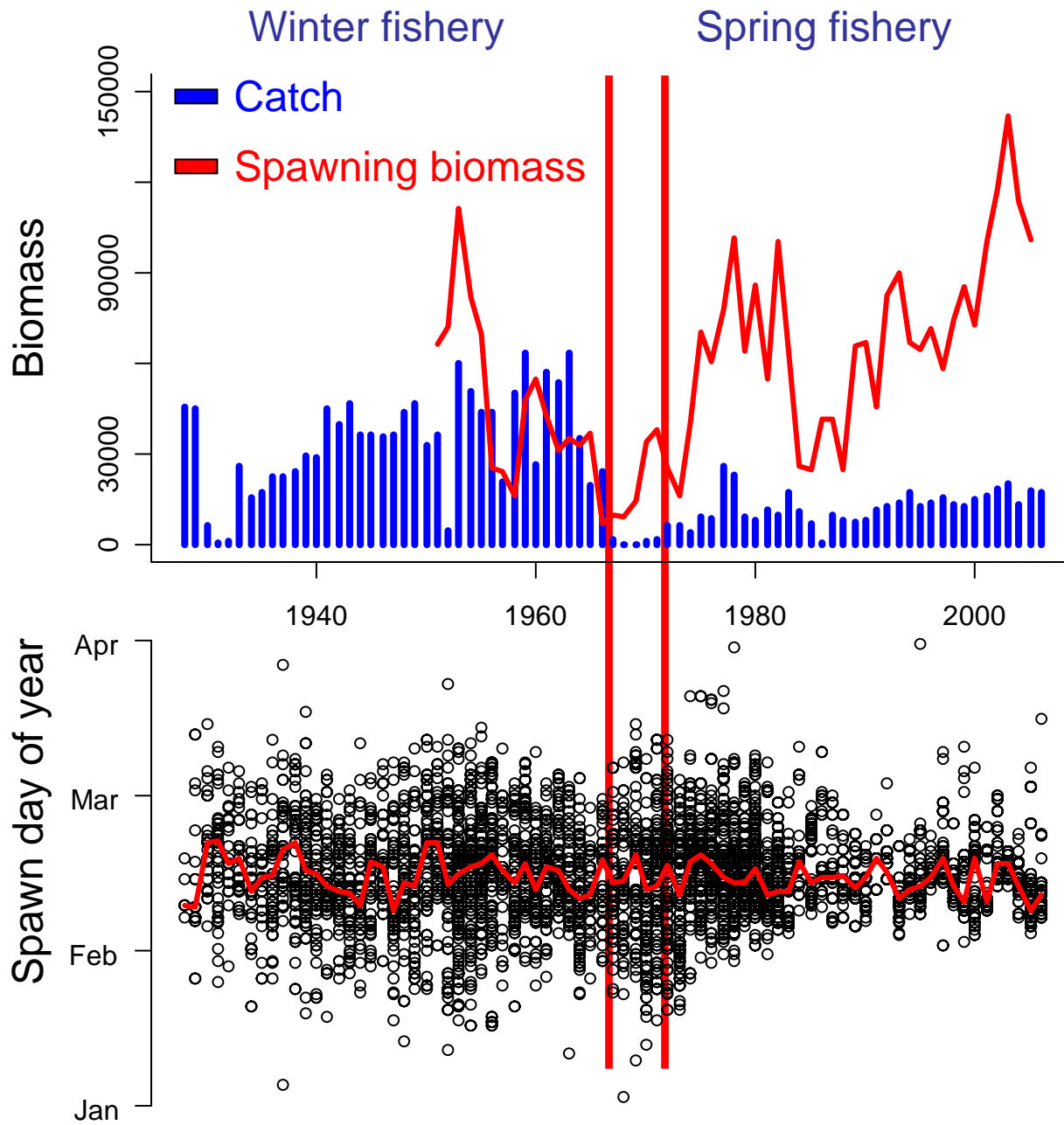


Changes in response diversity

1. Variability in the probability of spawn
2. Variability in the date of spawning

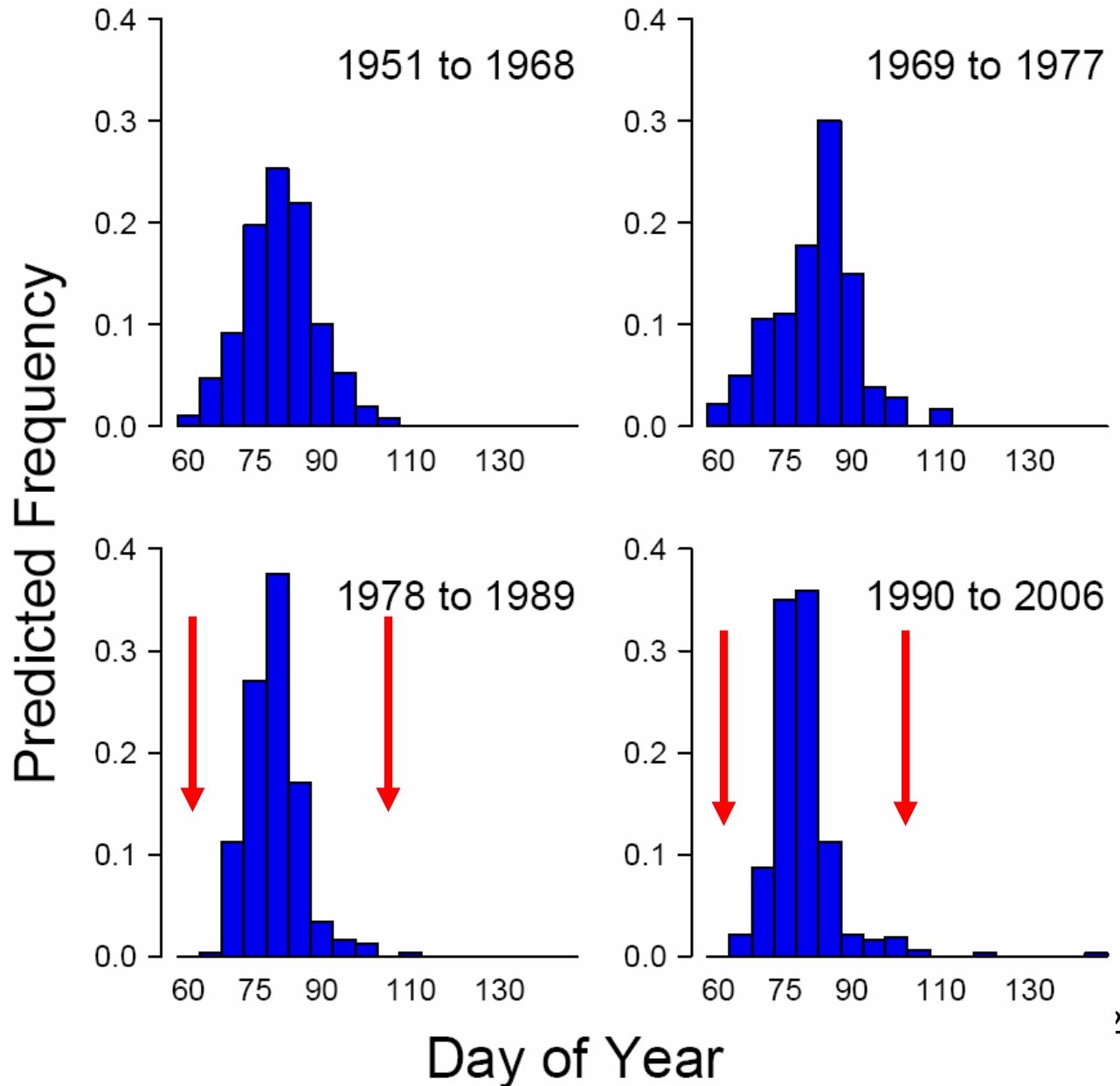






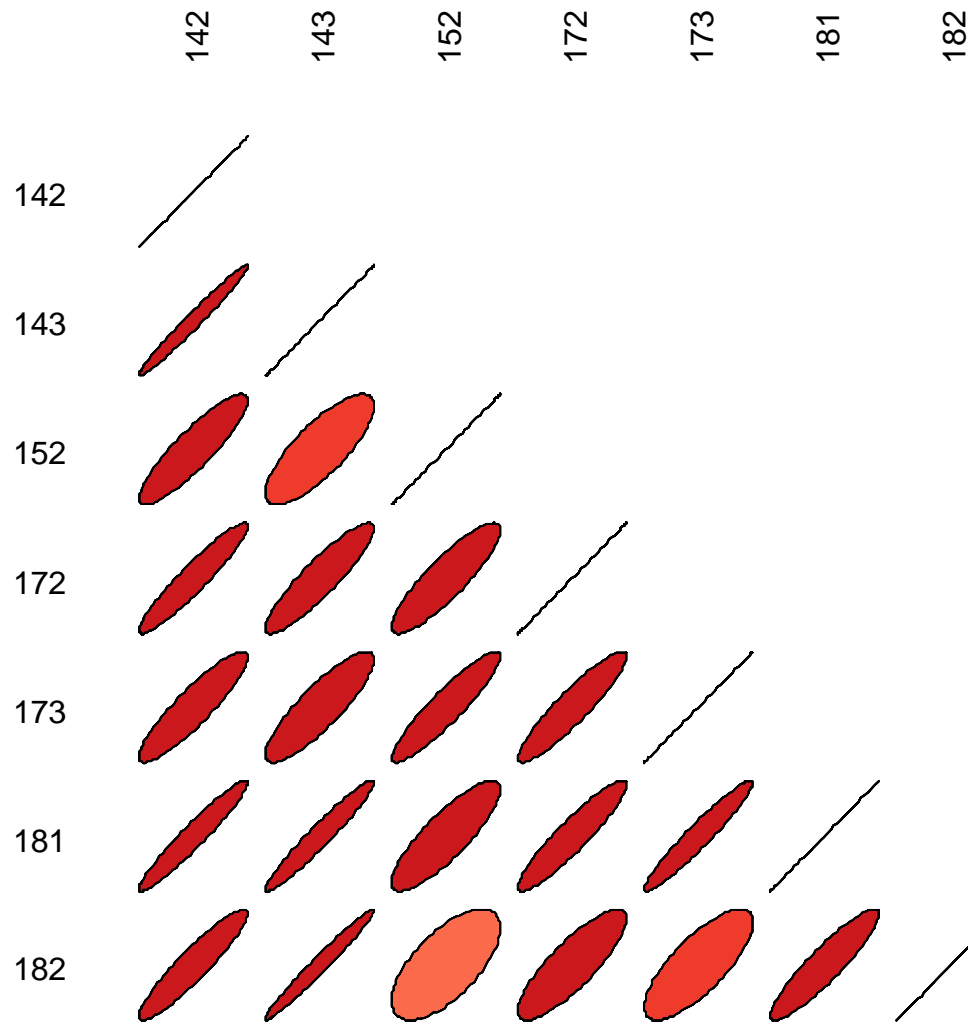
Bayesian spatial model: Date of spawn

- Biomass
- SST
- Fish size
- Section



Age 4 recruitment

1975-2006



Observations and Management Implications

- there has been a loss of response diversity in Strait of Georgia herring
- Strait of Georgia herring may now be more sensitive to external perturbations than they once were

- Risk inversely related to resilience in stock aggregates
 - Highly uncertain response to future environmental conditions
 - Past recovery rates may be poor predictor of future
- Robust management strategy
 - Maintain (or enhance?) within stock diversity
 - Maintain aggregate production

Acknowledgements

- Herring Conservation and Research Society (HCRS)
- Jake Schweigert, DFO
- Bill de la Mare, CSIRO
- NSERC
- Fisheries Research Group, SFU