Future recruitment of Bering Sea walleye pollock: (1) retrospective patterns & uncertainty

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Goals

- Quantify impacts of climate variability on the recruitment of walleye pollock in the eastern Bering Sea
- Project future recruitment and population trends under possible warming scenarios

General approach

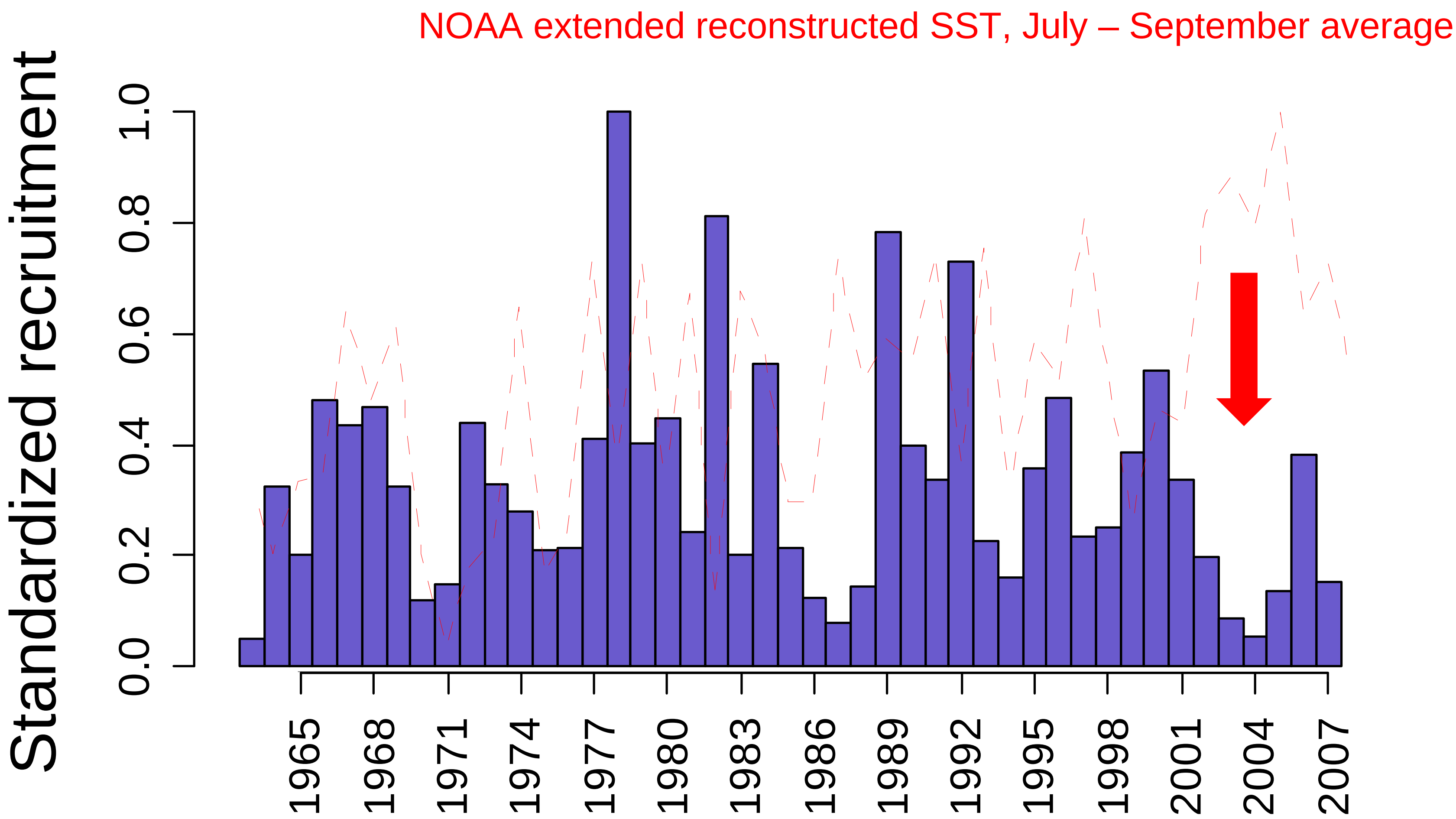
(Hollowed et al 2009, Hare et al 2010)

1. Identify likely mechanisms driving recruitment
2. Develop robust empirical relationships
   – R as function of relevant indictors variable(s)
3. Generate future scenarios for indicators based on IPCC model projections (downscaling)

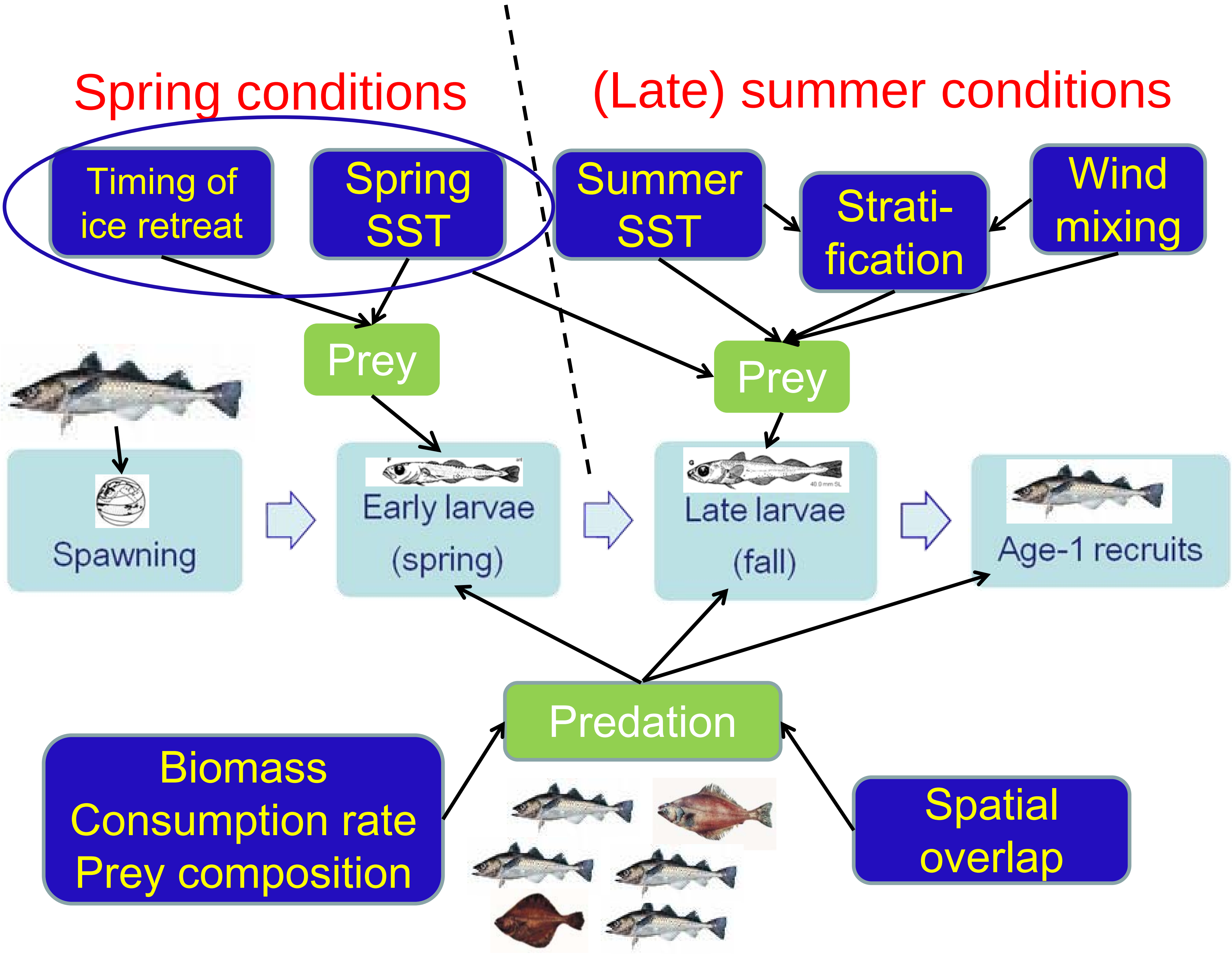
   → Nick Bond (next talk)
4. Simulate possible population trajectories of pollock under various warming scenarios and different harvest control rules

Simple alternative to full end-to-end model for predicting responses of individual species

Walleye pollock recruitment



Recruitment estimates from Ianelli et al (2009)

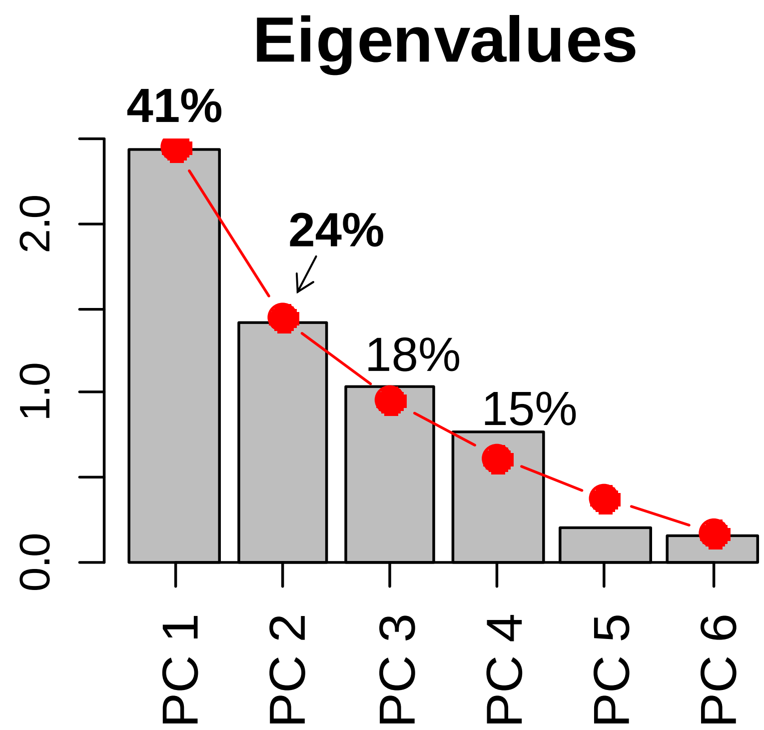

Spring conditions
(Late) summer conditions
Timing of ice retreat
Spring SST
Summer SST
Strati-fication
Wind mixing
Prey
Prey
Spawning
Early larvae (spring)
Late larvae (fall)
Age-1 recruits
Predation
Biomass
Consumption rate
Prey composition
Spatial overlap

BEST-BSIERP Bering Sea Project

Principle Components Analysis

Variables:

- Timing of ice retreat
- Spring transition
- Late summer SST
- Summer wind mixing
- Water column stability
- Predation pressure



→ Four significant modes

→ Recruitment significantly related to PC 1 and PC 3

PC 1: warm vs. cold

PC 2: windy vs. calm (stratified)

PC 3: low vs. high predation

PC 4: late spring / warm summer

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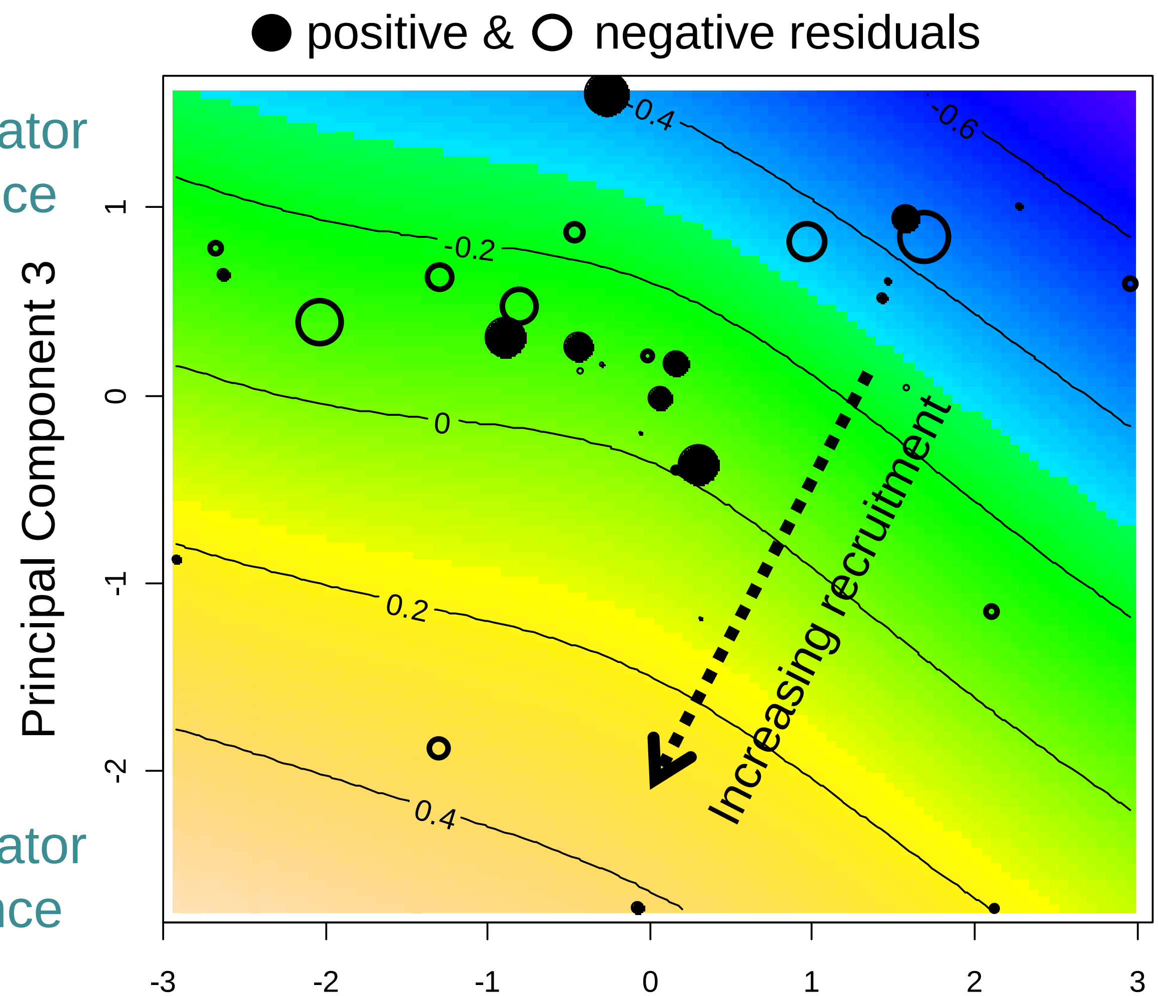
Modeled log-recruitment (1977-2007)

High predator abundance

$R^2 = 0.54$
$P < 0.0001$

Low predator abundance



Late ice out
Cold summer

Early ice out
Warm summer

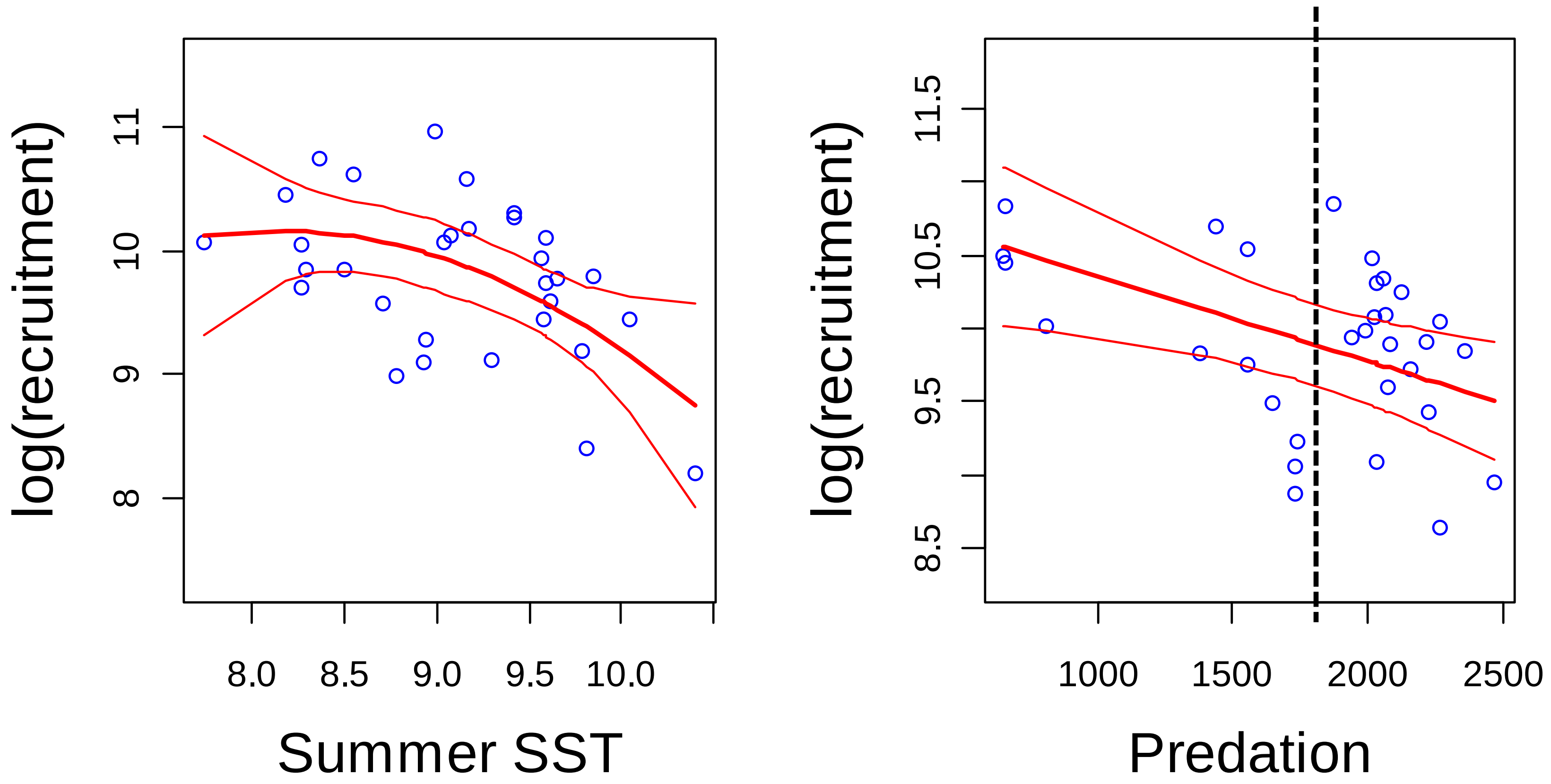
Simplifying model for projections

Two main gradients:

- PC 1: Warm vs. cold (spring & summer)
  - Importance of spring vs. summer conditions?
  - Comparison of models & correlations suggest that late summer SSTs are more important (SST effects only significant for July – Sept.)
    → Use late summer SST for projections!

- PC 3: Predation
  - Use index of predation instead of PC3!

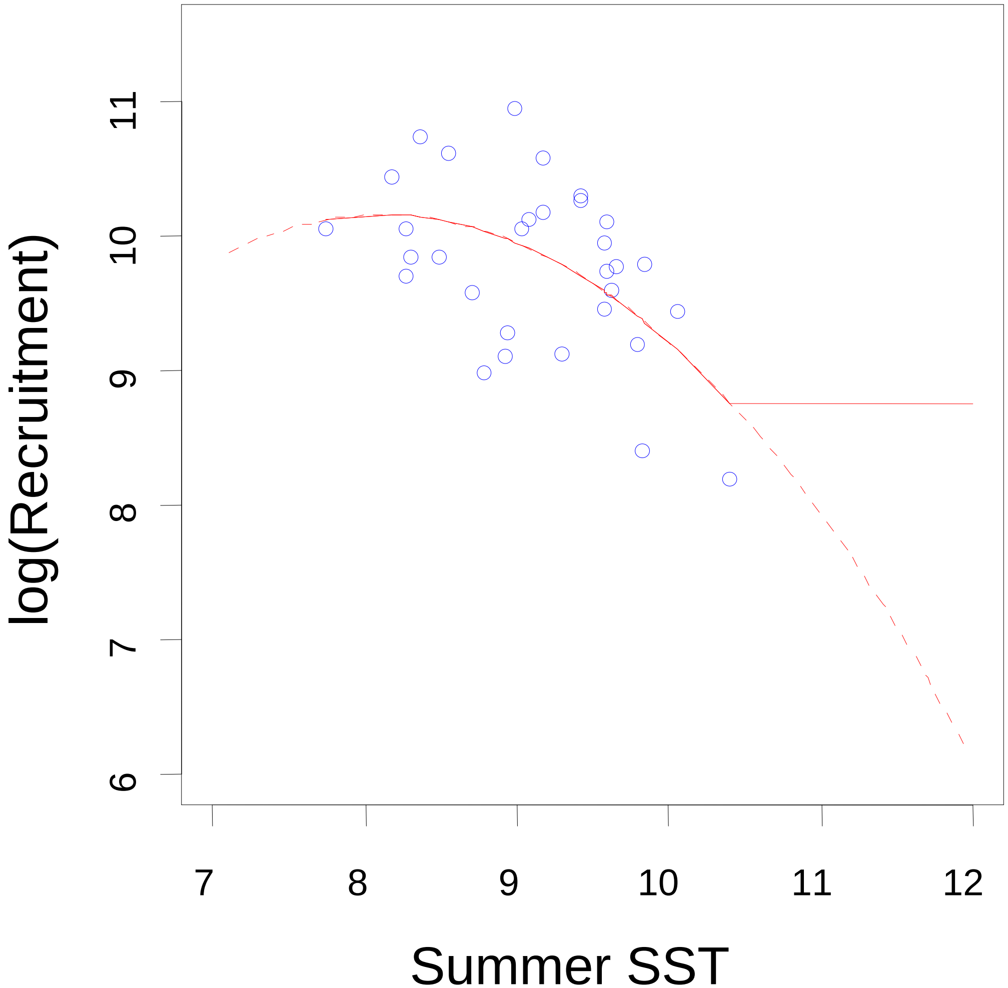
Estimated effects of SST and predation on recruitment



$R^2 = 0.44$

$P = 0.001$

Problem: projected SSTs extend beyond range of historical data

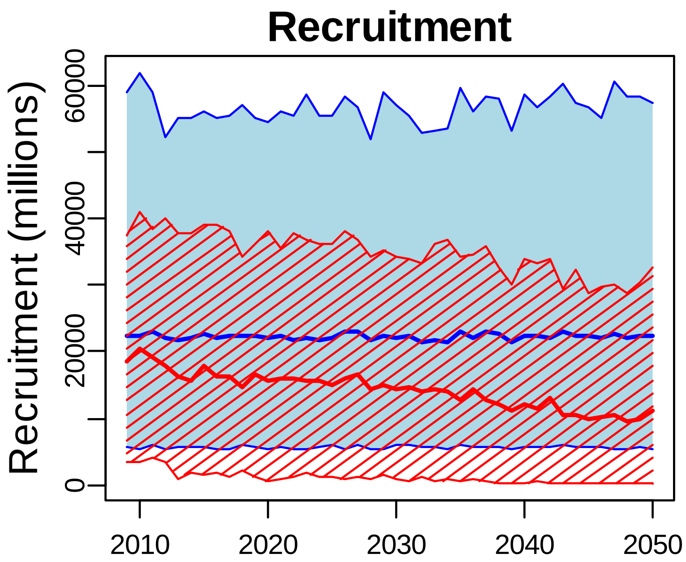


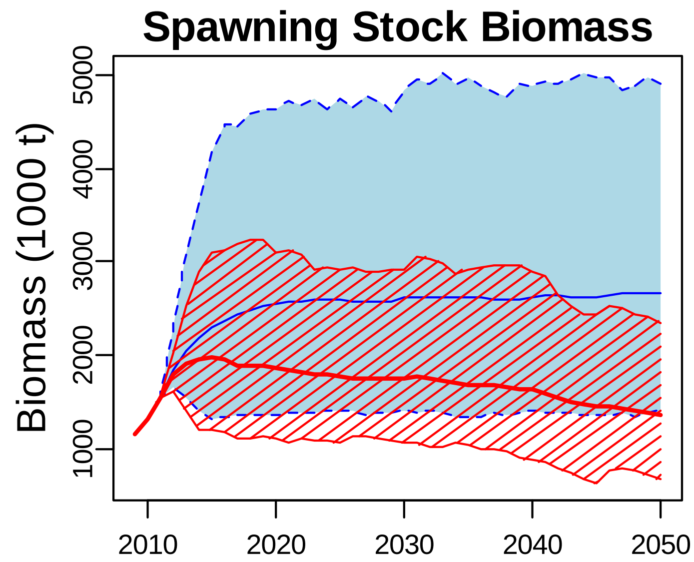
Projections

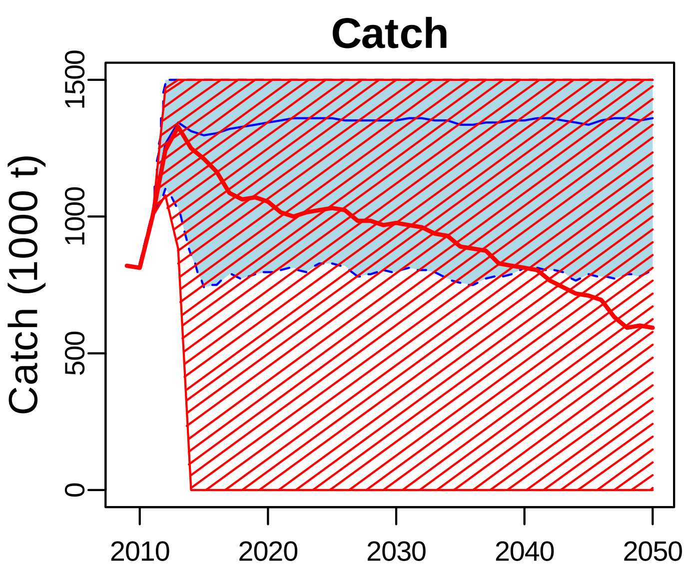
- Project population forward through 2050 starting with numbers-at-age and parameters from 2009 assessment (fixed parameters)
- Scenario 1: Current harvest control rule
  - Catch capped at 1.5 million tons
  - No fishing if B < 20% of unfished biomass
- Scenario 2: No fishing

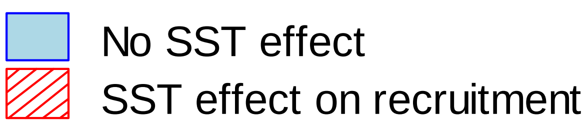
- Recruitment scenarios:
  1. random R from historical estimates (1977-2008)
  2. predicted R from SST-recruitment relationship using summer SSTs estimated from IPCC scenarios

Scenario 1 (current control rule): With and without SST effect







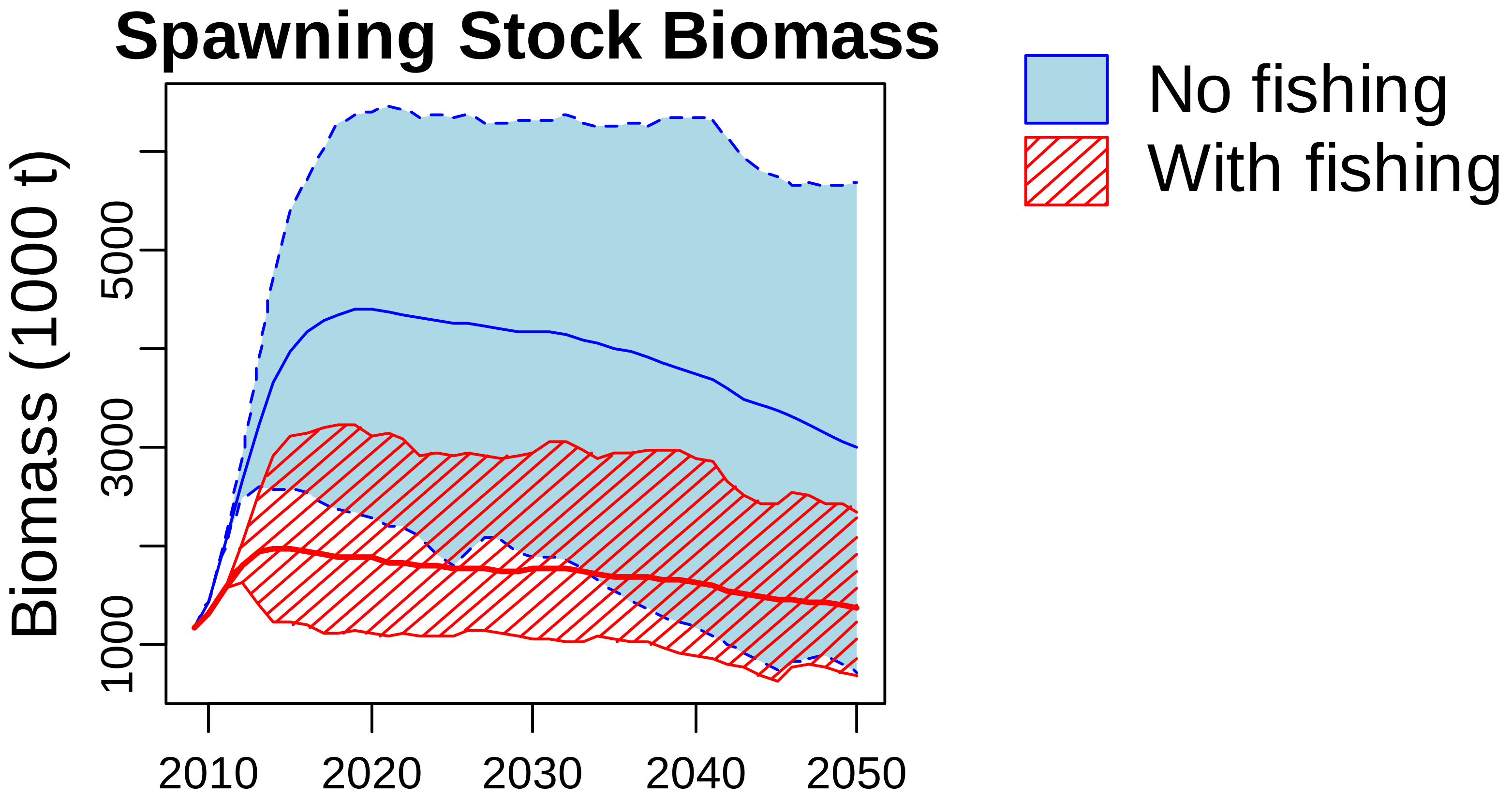


90% simulation envelopes

SST effect on future biomass:

Scenario 1 (fishing with current harvest control rule)

vs. Scenario 2 (no fishing)



Conclusions

- Simple empirical relationship, combined with SST projections estimated from IPCC model output, allow more realistic projections of future pollock dynamics for management strategy evaluations
- Large uncertainties in future trajectories arise from uncertainty in SST
- Given current understanding of pollock dynamics, pollock abundance is likely to decline in the future under any fishing scenario and catches will be highly variable under current harvest control rule

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