Projecting the effects of climate change on river herring in both freshwater and marine habitat

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Project overview

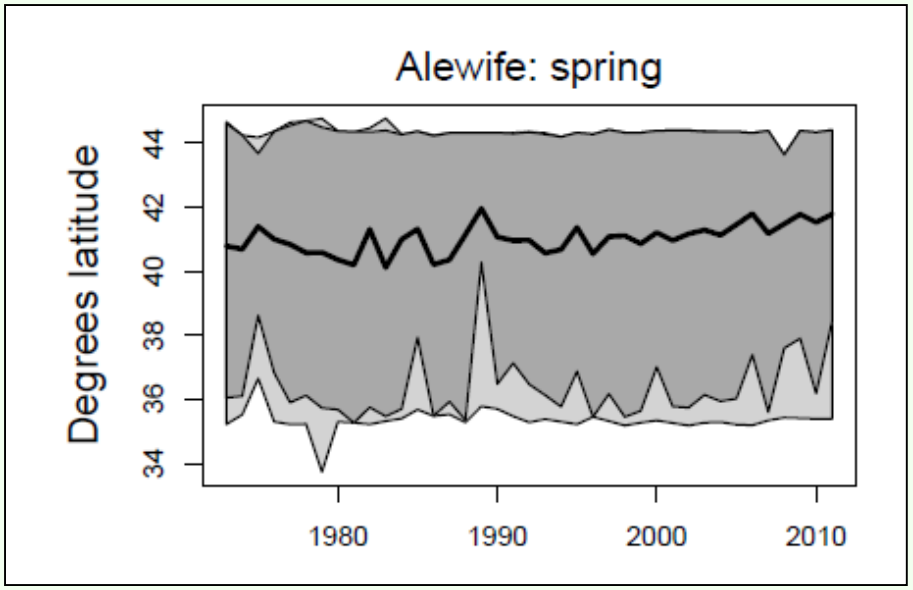
- River herring: anadromous life history
  - Susceptible to changes across multiple habitats
- Overall goal: evaluate/project effects of climate variability/change
  - Empirical relationships: abundance ~ environment
  - Climate models: future marine/fresh. habitat
  - Couple empirical & climate models: project effects on river herring

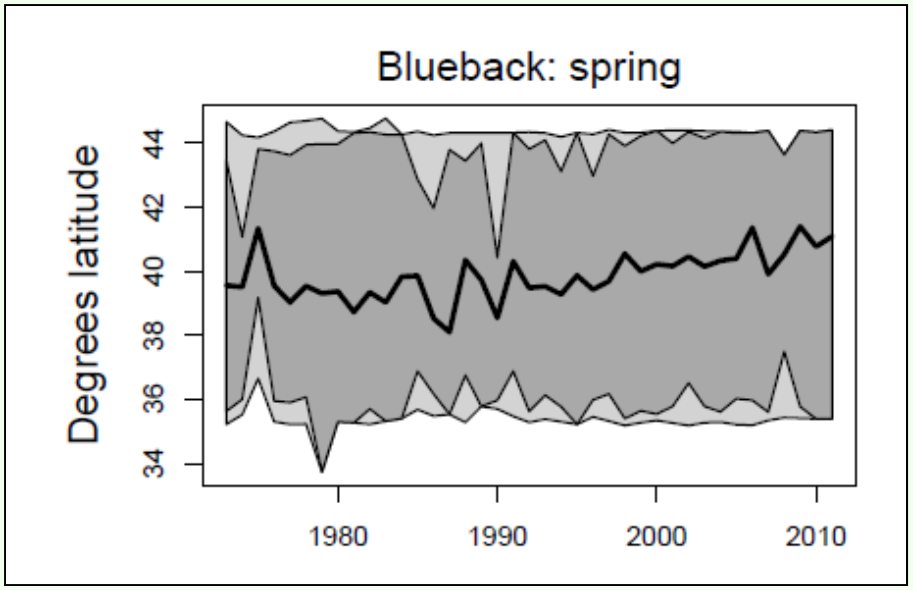
Analyses

- Focus: marine habitat (NEFSC trawl survey)
  - Seasons: spring & fall
  - Water temp: surface & bottom
  - Presence/absence, numbers, biomass
- Presentation
  - Spring survey (more robust)
  - Bottom temp. (explains more variability)
  - Numbers (relate to run counts)

NEFSC trawl survey data

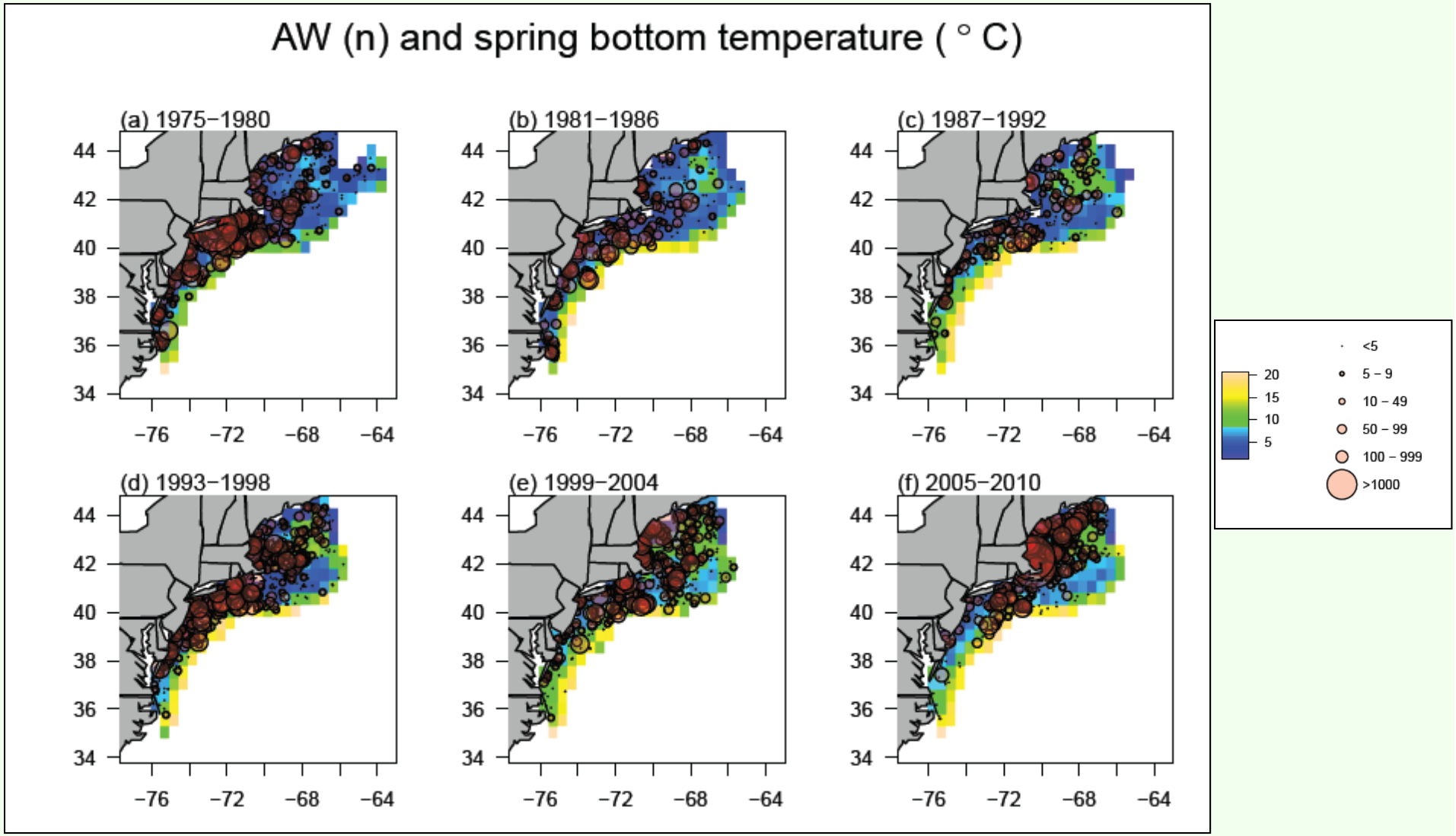
- Cannot detect northern expansion
- Increases in mean latitude: minimum est.



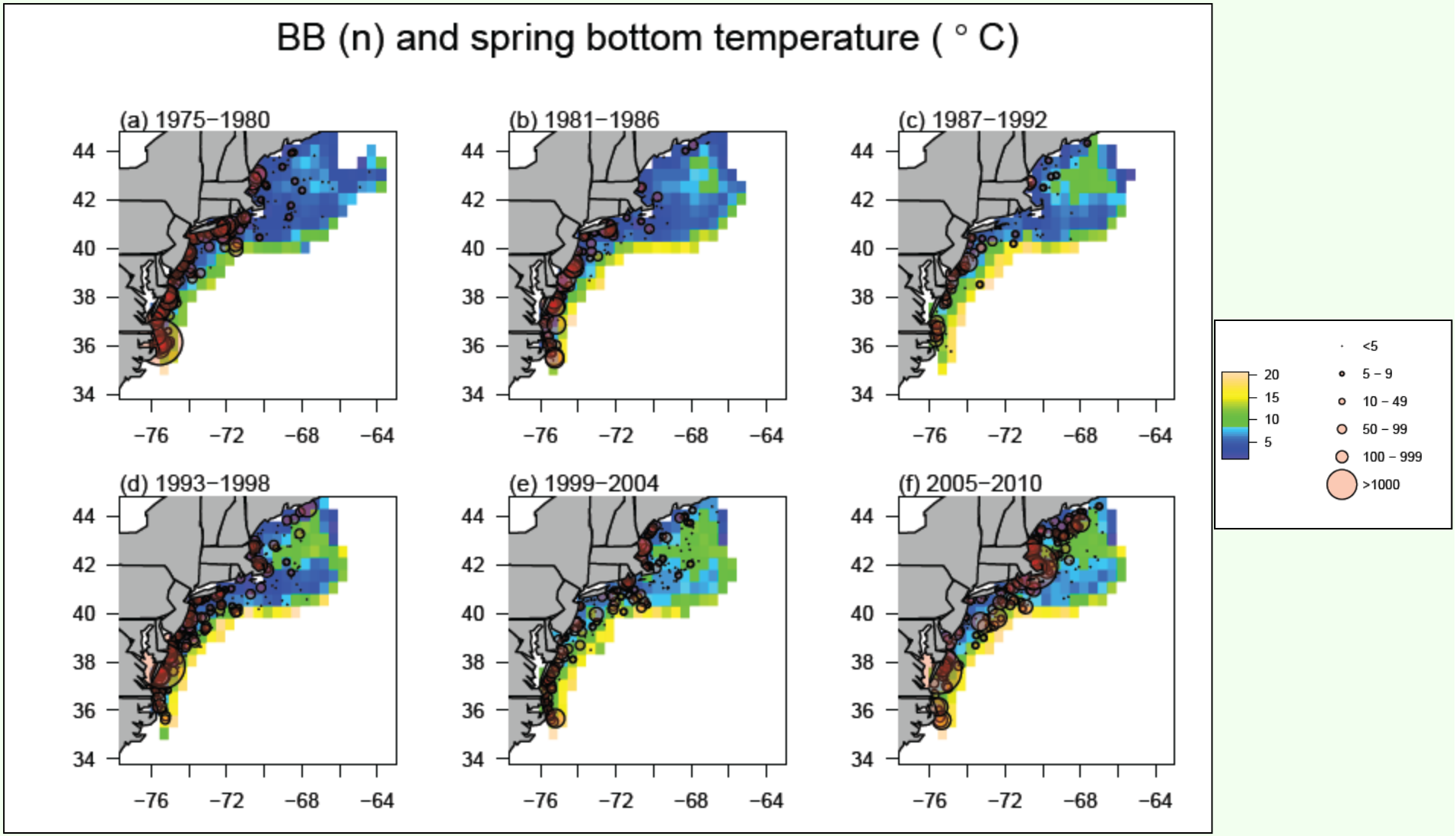


Survey range
Obs. spp. range
Mean spp. range

Historical catch trends



Historical catch trends



Historical catch trends

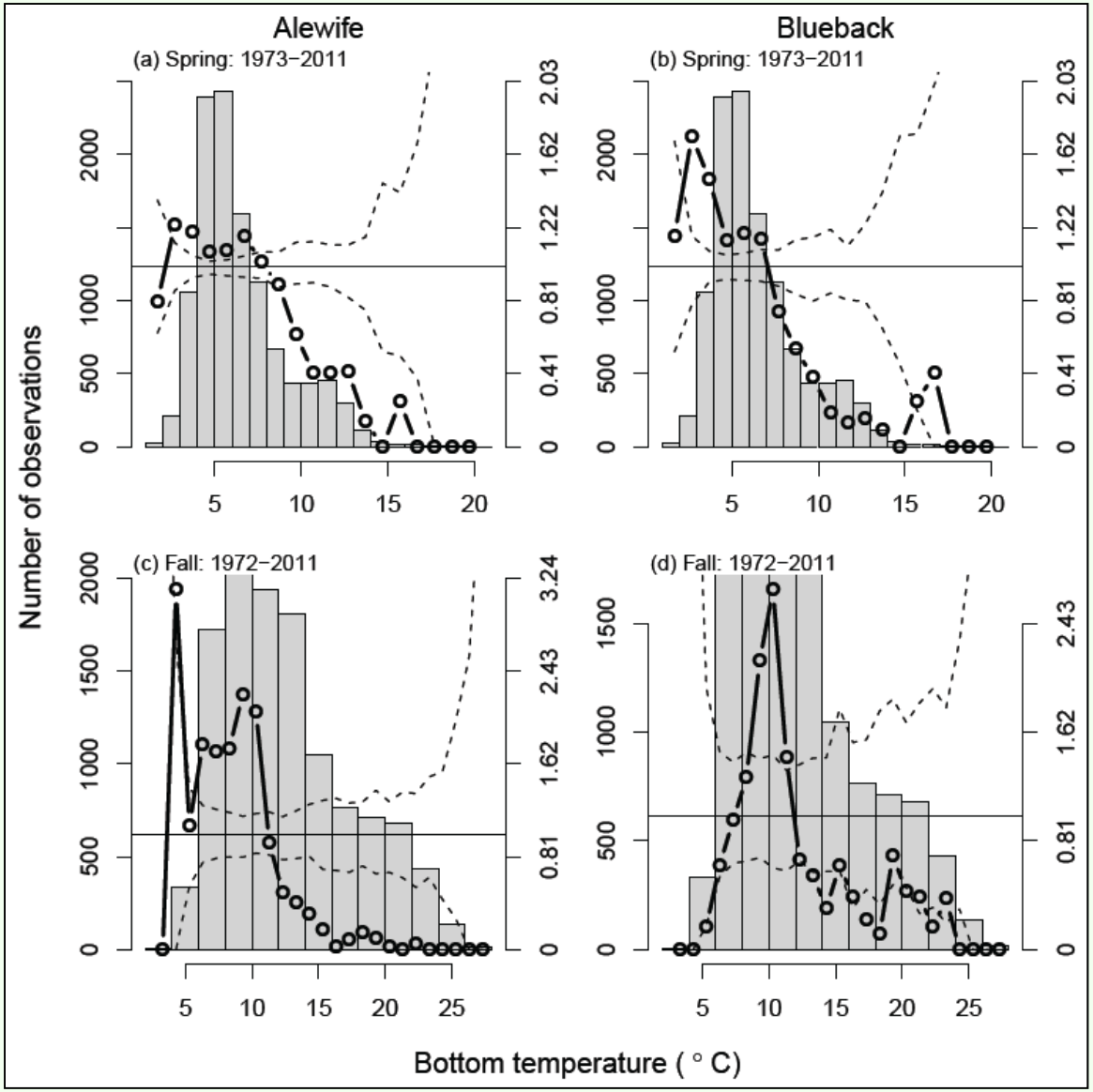
- Summary
  - AW & BB: similar patterns
  - Increasing frequency/abundance in survey
    - Follows survey indices
  - Migrating: north, east, deeper over time
    - Corroborated: linear models & Nye et al. (2009)
    - Suggest: lat. increase due to warming
- Discrepancy with rivers?

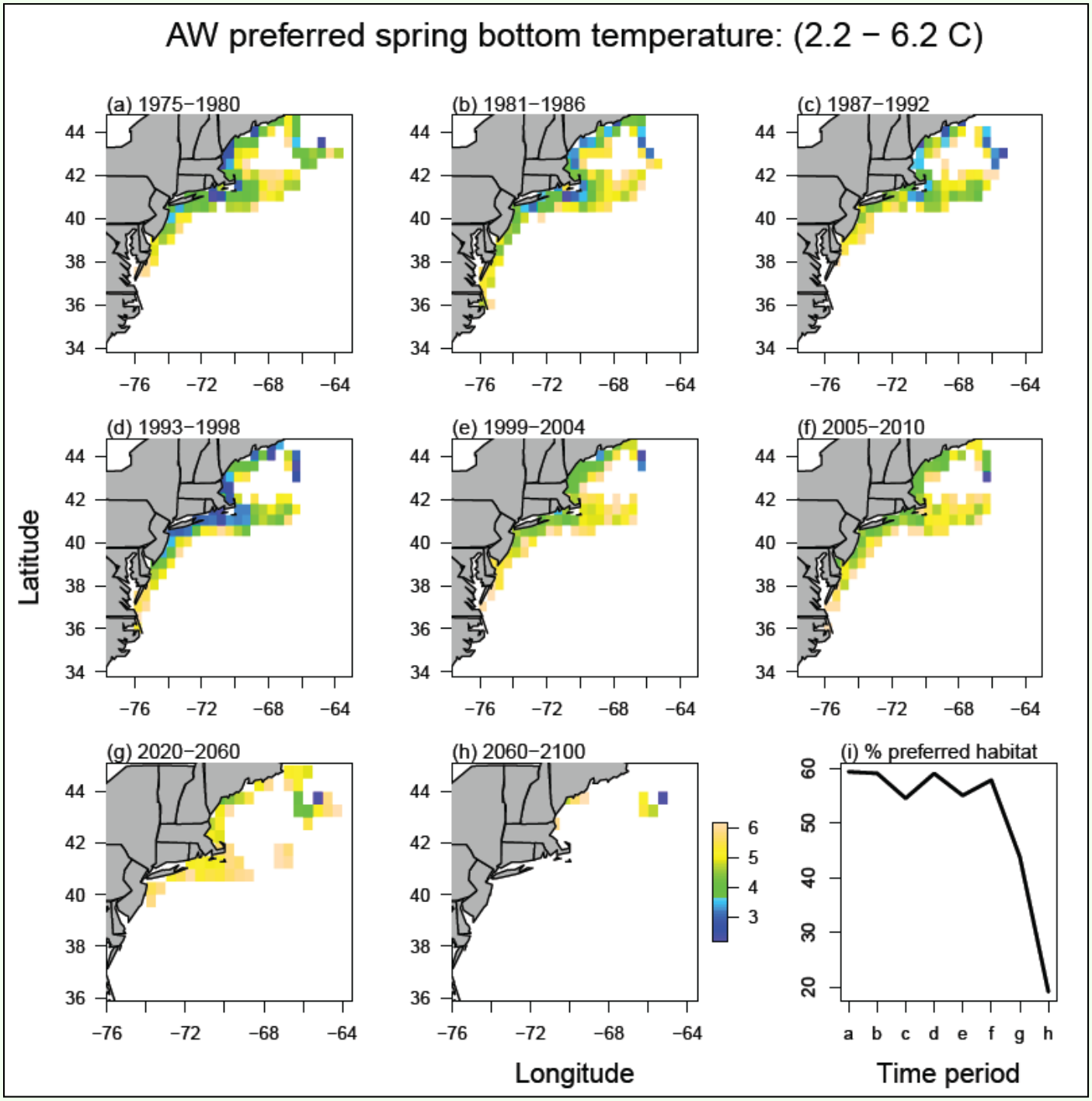
Thermal preferences

- Marine thermal preference
  - Not previously known
- Quotient analysis
  - Determine habitat preference/avoidance
  - Relative to sampling effort
  - Null hypothesis: even distribution
- Project future conditions (2 time periods)
  - 8 model ensemble, moderate emissions (A1B)
- Project preferred habitat in future

Thermal preferences

- Above dashed line
  - Significant preference
- Below dashed line
  - Significant avoidance
- Spring preference
  - 2.2 – 6.2 °C (AW & BB)
- Spawning (Ellis & Vokoun 2009)
  - 9 – 13 °C




AW preferred spring bottom temperature: (2.2 − 6.2 C)
(a) 1975−1980
(b) 1981−1986
(c) 1987−1992
(d) 1993−1998
(e) 1999−2004
(f) 2005−2010
(g) 2020−2060
(h) 2060−2100
(i) % preferred habitat
Latitude
Longitude
Time period
44
42
40
38
36
34
−76
−72
−68
−64
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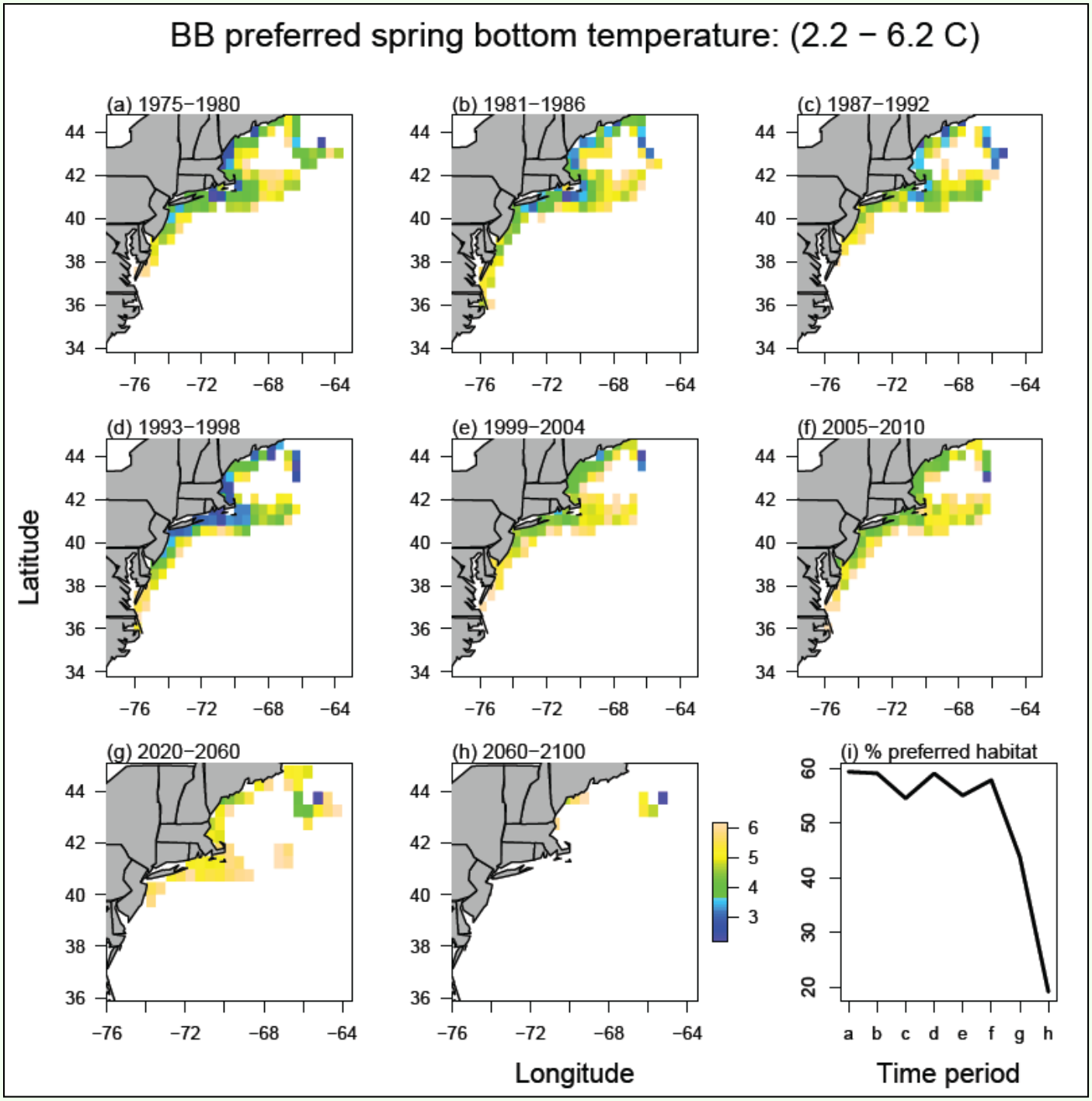
BB preferred spring bottom temperature: (2.2 − 6.2 C)
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Thermal preferences

- Summary
  - Preferred thermal habitat projected to substantially decrease in survey area (except for BB in fall)
  - Possible implications:
    - Migrate to remain in preferred habitat
    - Tolerate less ‘suitable’ habitat
    - Adapt to changing habitat
    - Negative impact on population

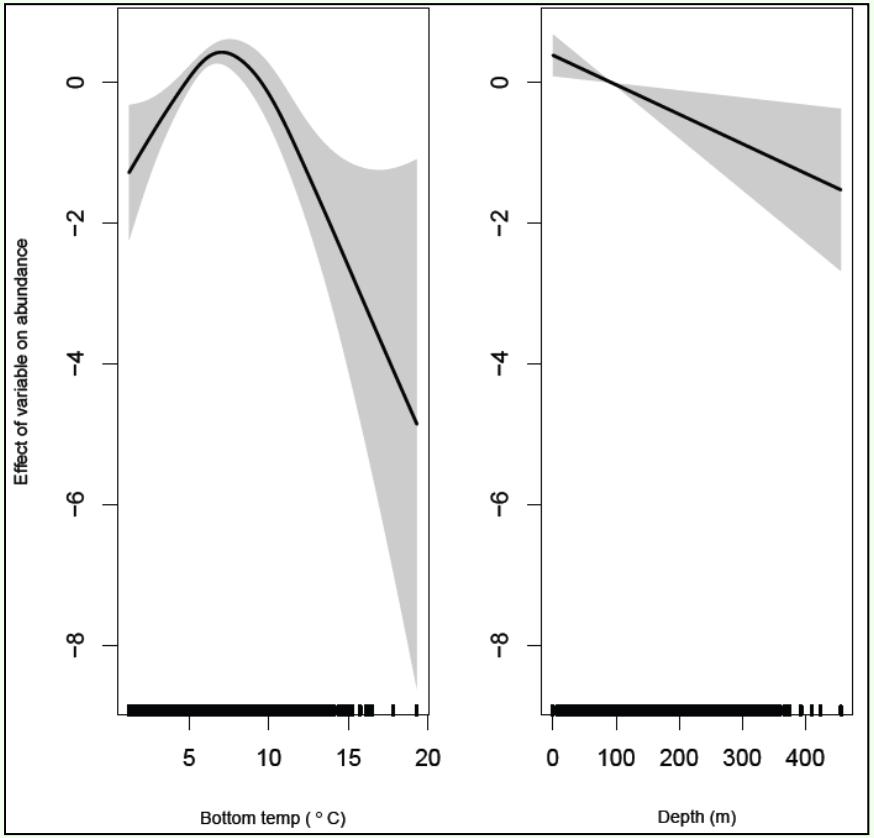
Abundance/habitat models

- Generalized Additive Models (GAMs)
  - Empirical relationship: N ~ time + space + temp
  - Accounts for nonlinearities and non-normality
    - Number: negative binomial error (log link)
    - Presence: binomial error (logit link)
  - Model selection: information theoretic (AIC)
    - Initial: surface vs. bottom temp
    - Final: several variables and interactions

Abundance/habitat models

- Alewife abundance: spring

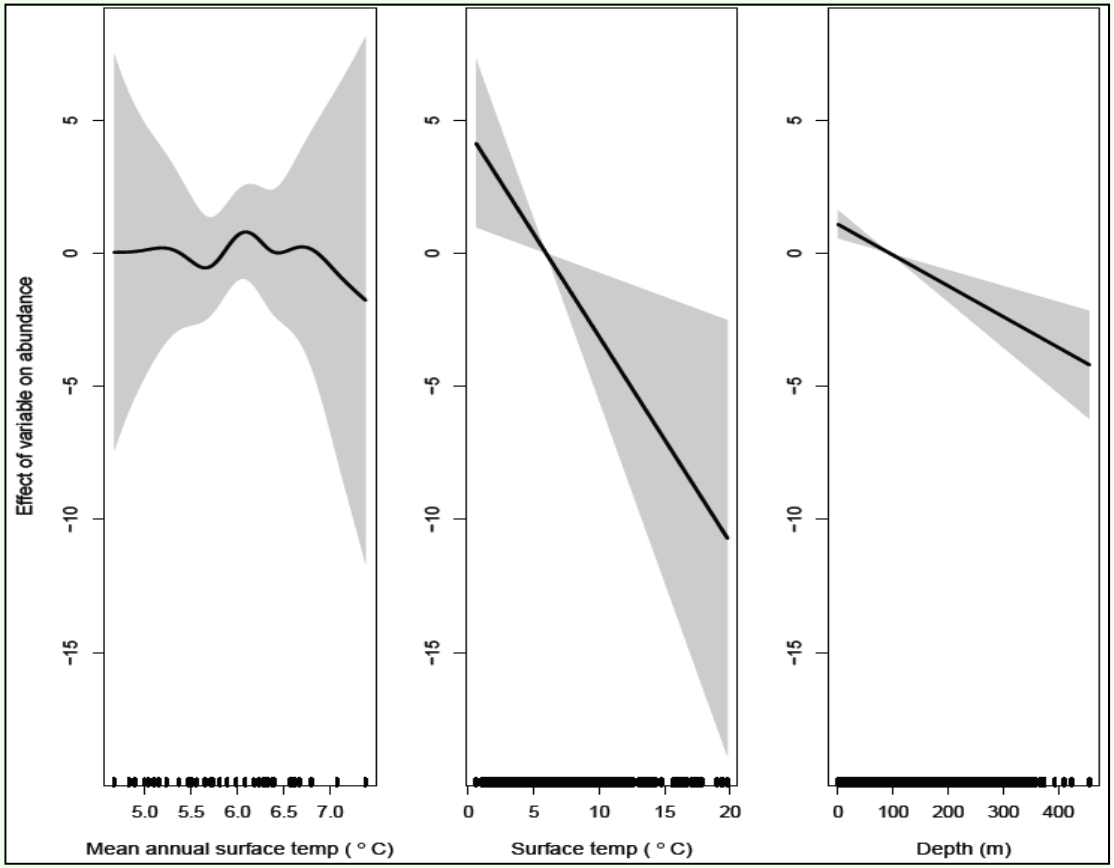
  Model: N ~ 6y + BT + Depth + Lon/Lat + BT*6y + Depth*6y



Abundance/habitat models

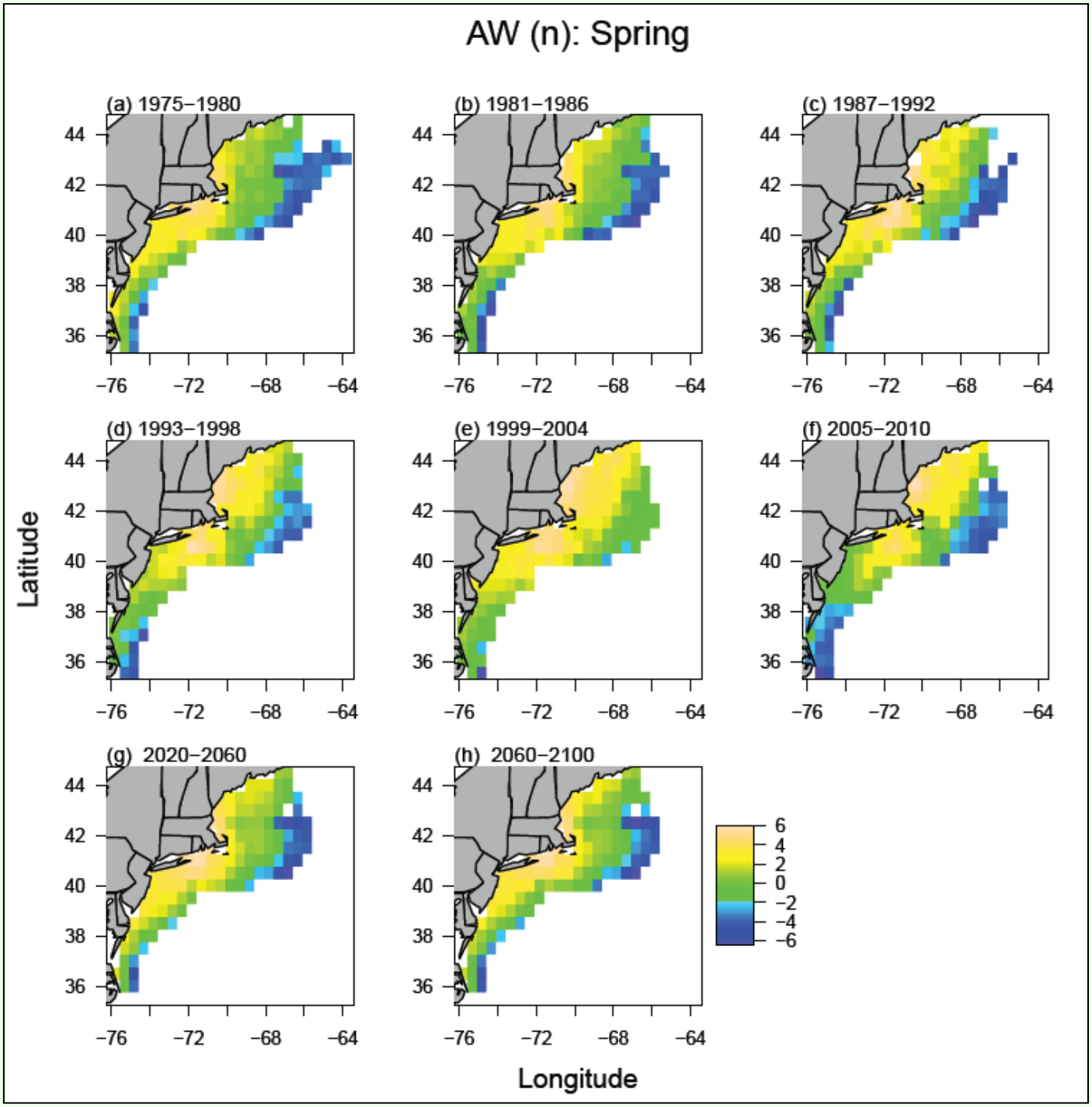
- Blueback abundance: spring

Model: N ~ 6y + MeanSST + SST+ Depth + Lon/Lat + MeanSST*6y + SST*6y + Depth*6y



Projected distribution/abundance

- Use GAM predictions & climate models
  - Future data
    - Survey data from 2005 – 2010
    - Climate model projections (2 time periods)
    - Project future distribution/abundance
  - Assumes
    - Survey/fishery/population dynamics
      - Fixed: 2005 – 2010
    - Temperature is only change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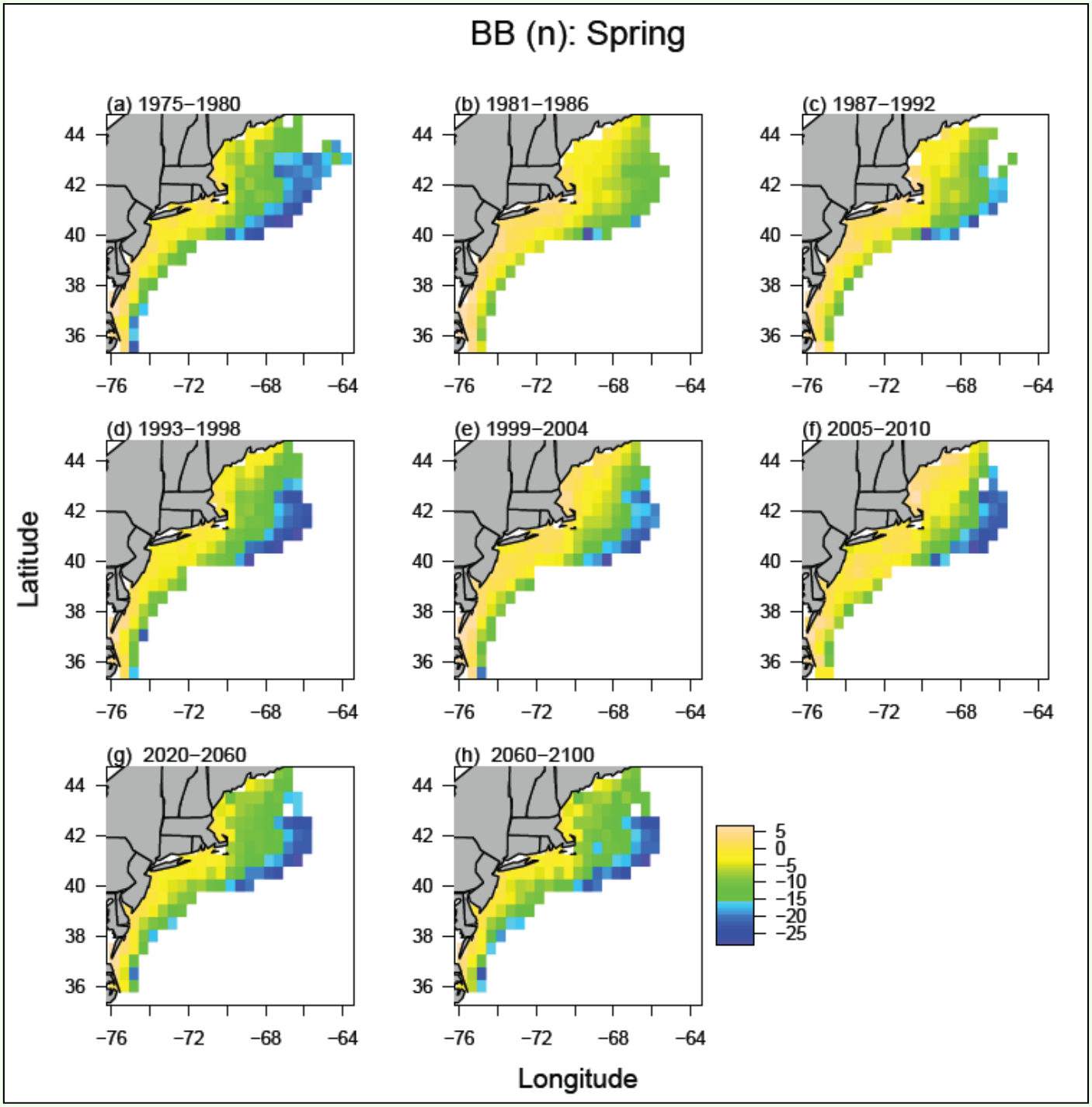
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−25

Summary

- River herring distributions are changing
  - North shift likely related to warming
- Marine thermal preferences described
- Future habitat and abundance
  - Significant temperature effects (GAMs & quotient)
- Considerations
  - Bottom trawl – pelagic species
  - Analysis limited to survey area/timing
  - Not population models: important dynamics not considered

Acknowledgments

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  - John Manderson
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