A seasonal spatio-temporal model of summer flounder on the Northeast shelf

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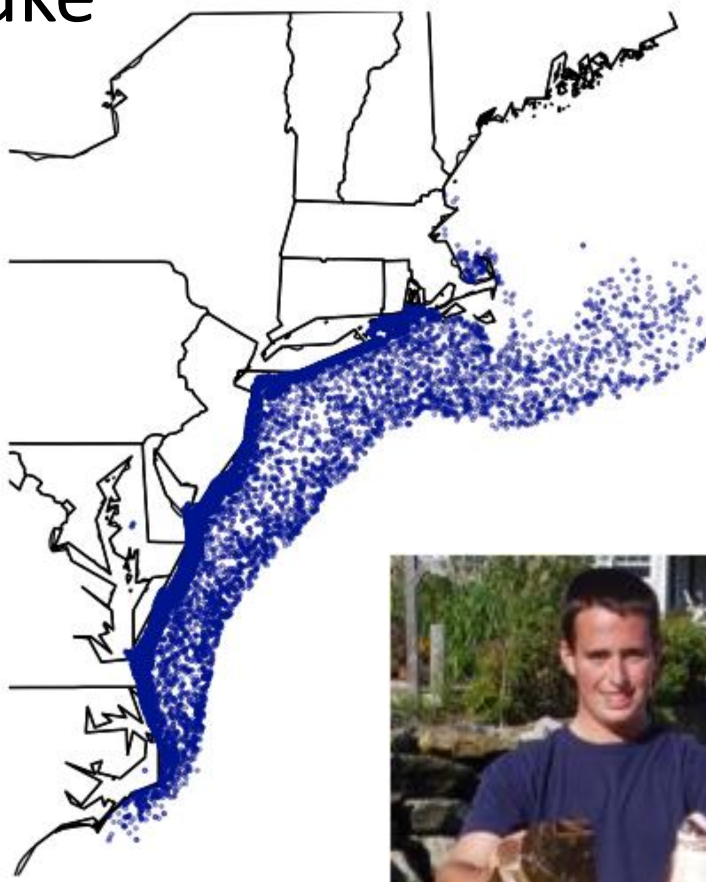
Summer flounder, a.k.a. fluke (*Paralichthys dentatus)*



- Most common recreationally caught flatfish on the East Coast
- Both commercial and recreational fishery is managed by state quota
- Allocation formulas are based on historical catch (and implicitly historical distribution)

credit: M. Terceiro, NMFS

2018 Summer flounder assessment

ToR 3: “Describe … the stock’s spatial distribution (for both juveniles and adults), including any changes over time. Describe factors related to productivity of the stock and any ecosystem factors influencing recruitment.”

Objectives

- Is the spatial distribution of the stock changing over time?
- Are there differences between recruits and spawners?
- Are observed changes driven by environmental covariates, size-structure, or something else?

Research approach

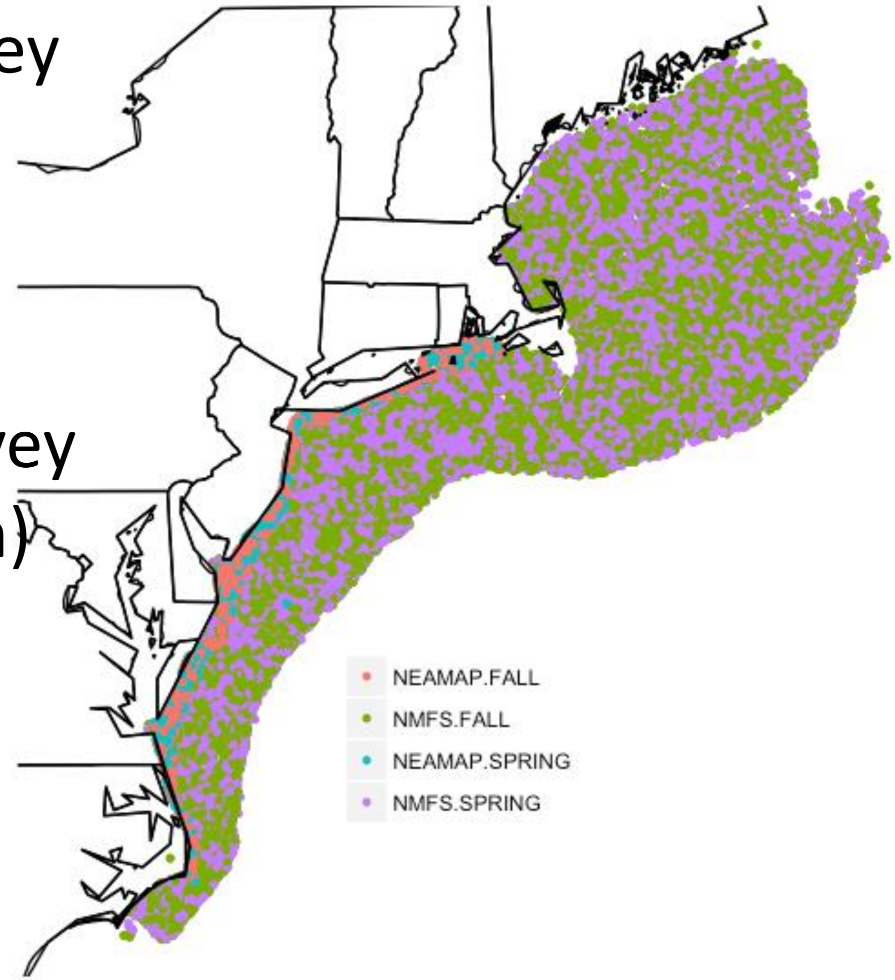
- Fit a spatio-temporal model (VAST) to state & federal bottom trawl survey data.

- Why choose VAST?
  - Combining multiple surveys
  - Size-structure
  - Environmental covariates
  - Unexplained variation
  - <u>Seasonal</u> surveys

Data

- NEFSC bottom trawl survey (1976-2017)
- NEAMAP bottom trawl survey (2007-2017)
- MDMF bottom trawl survey (1976-2017, coming soon)

- Spring & Fall



1970
1980
1990
2000
2010
NEAMAP.FALL
NMFS.FALL
NEAMAP.SPRING
NMFS.SPRING

Data

Define size categories as:

Recruits: ≤ 30cm

Spawners: ≥ 31cm

Individual weight was estimated using the an weight-length relationship (Wigley et al 2003):

$$\ln W = \ln a + b \ln L$$

Model structure

$$\log(n_i) = \omega_n(s_i, c_i) + \gamma_n(t_i, c_i) + \epsilon_n(s_i, c_i, t_i) + \sum_{k=1}^{n_k} \alpha_{k,c_i} x_k(s_i, t_i)$$

Model structure

$$\log(n_i) = \omega_n(s_i, c_i) + \gamma_n(t_i, c_i) + \epsilon_n(s_i, c_i, t_i) + \sum_{k=1}^{n_k} \alpha_{k,c_i} x_k(s_i, t_i)$$

$$+ \gamma_n(z_i, c_i) + \epsilon_n(s_i, c_i, z_i) + \sum_{k=1}^{n_k} \alpha_{k,c_i} x_k(s_i, z_i)$$

Season intercept

Seasonal spatio-temporal variation (GRF)

Seasonal covariate effect

Model structure

$$\log(n_i) = \omega_n(s_i, c_i) + \gamma_n(t_i, c_i) + \epsilon_n(s_i, c_i, t_i) + \sum_{k=1}^{n_k} \alpha_{k,c_i} x_k(s_i, t_i)$$

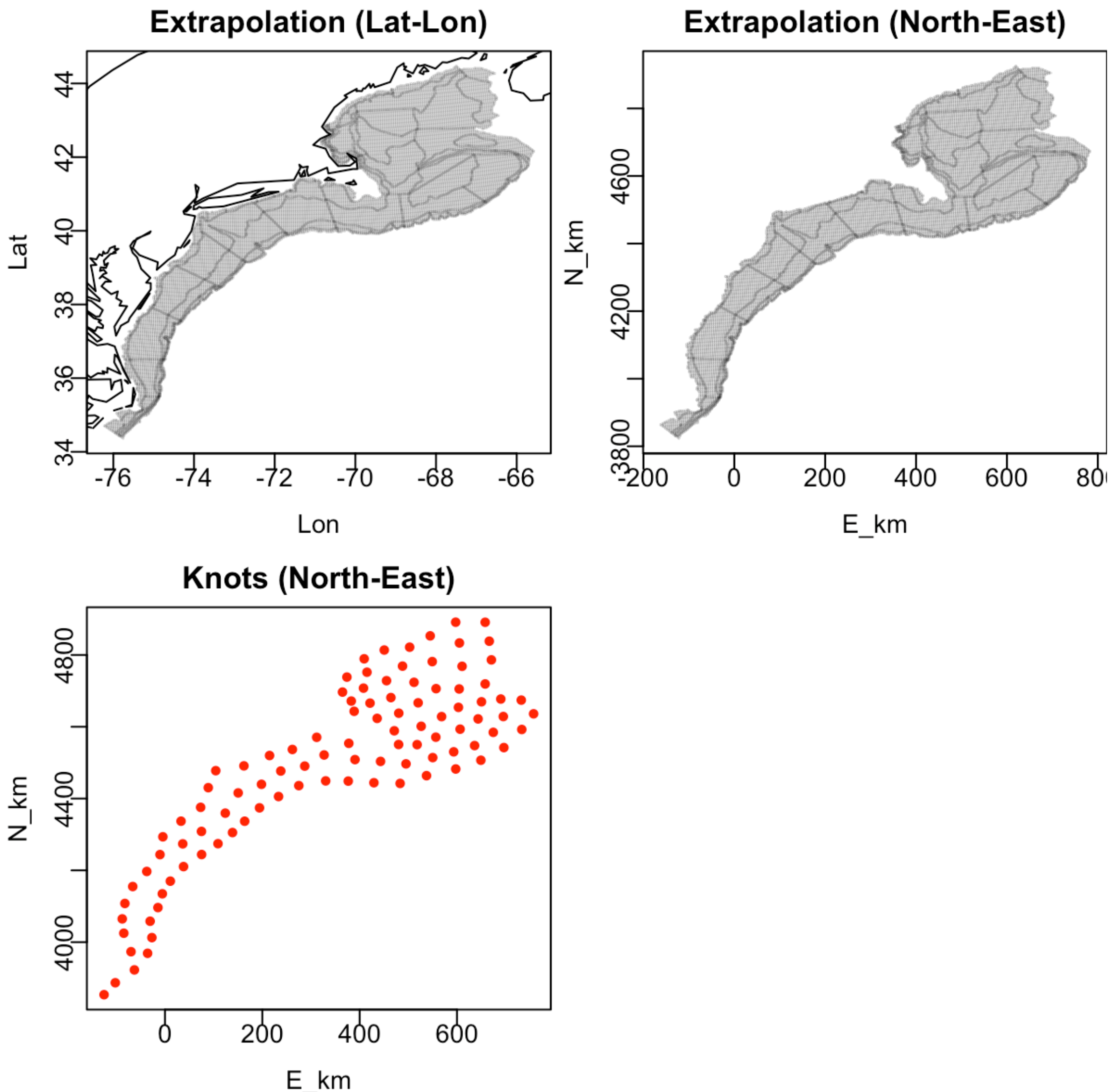
$$+ \gamma_n(z_i, c_i) + \epsilon_n(s_i, c_i, z_i) + \sum_{k=1}^{n_k} \alpha_{k,c_i} x_k(s_i, z_i)$$

Biomass per group

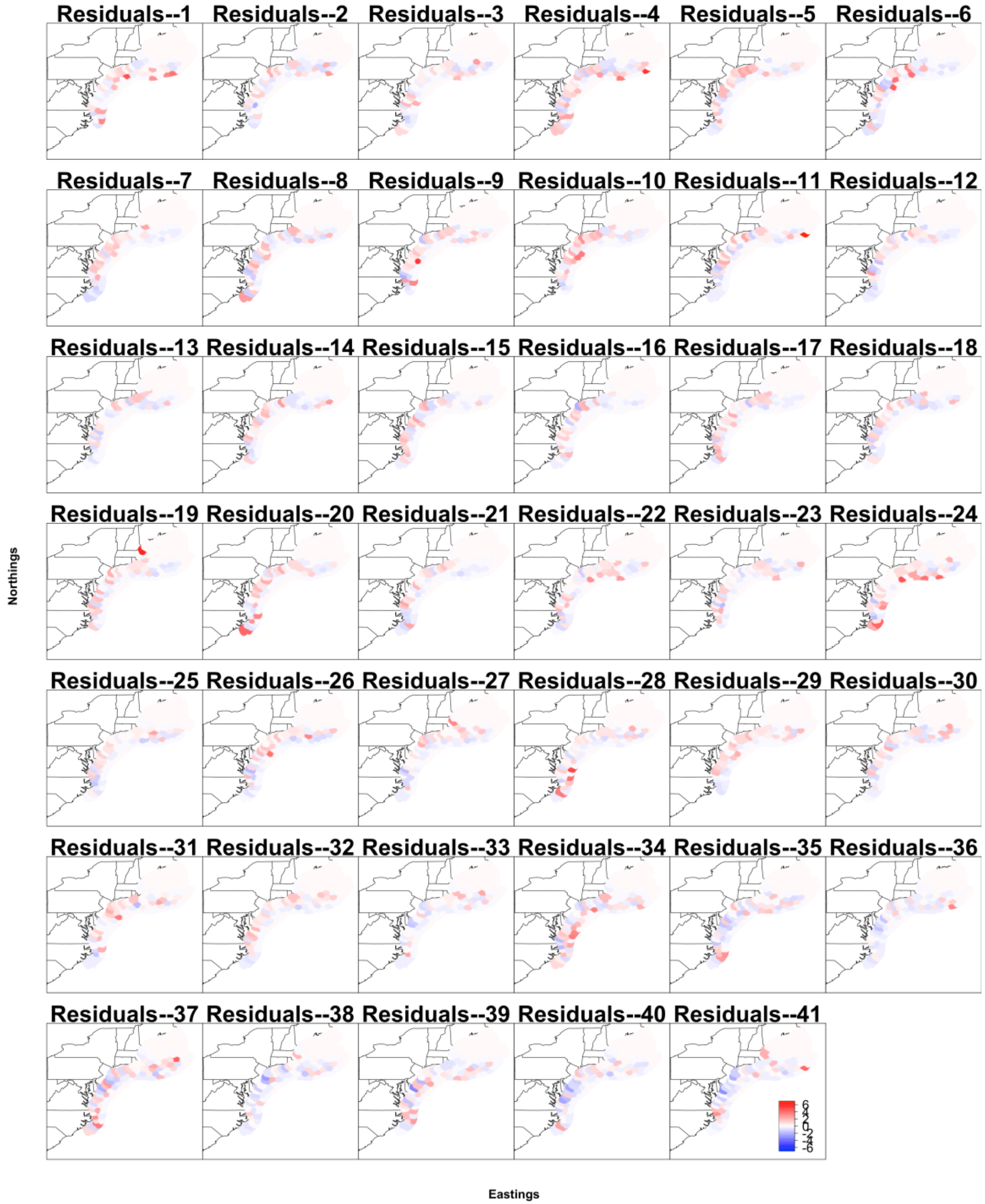
$$\log(w_i) = \omega_w(s_i, c_i) + \gamma_w(t_i, c_i) + \epsilon_w(s_i, c_i, t_i) + \sum_{k=1}^{n_k} \beta_{k,c_i} x_k(s_i, t_i)$$

$$+ \gamma_w(z_i, c_i) + \epsilon_w(s_i, c_i, z_i) + \sum_{k=1}^{n_k} \beta_{k,c_i} x_k(s_i, z_i)$$

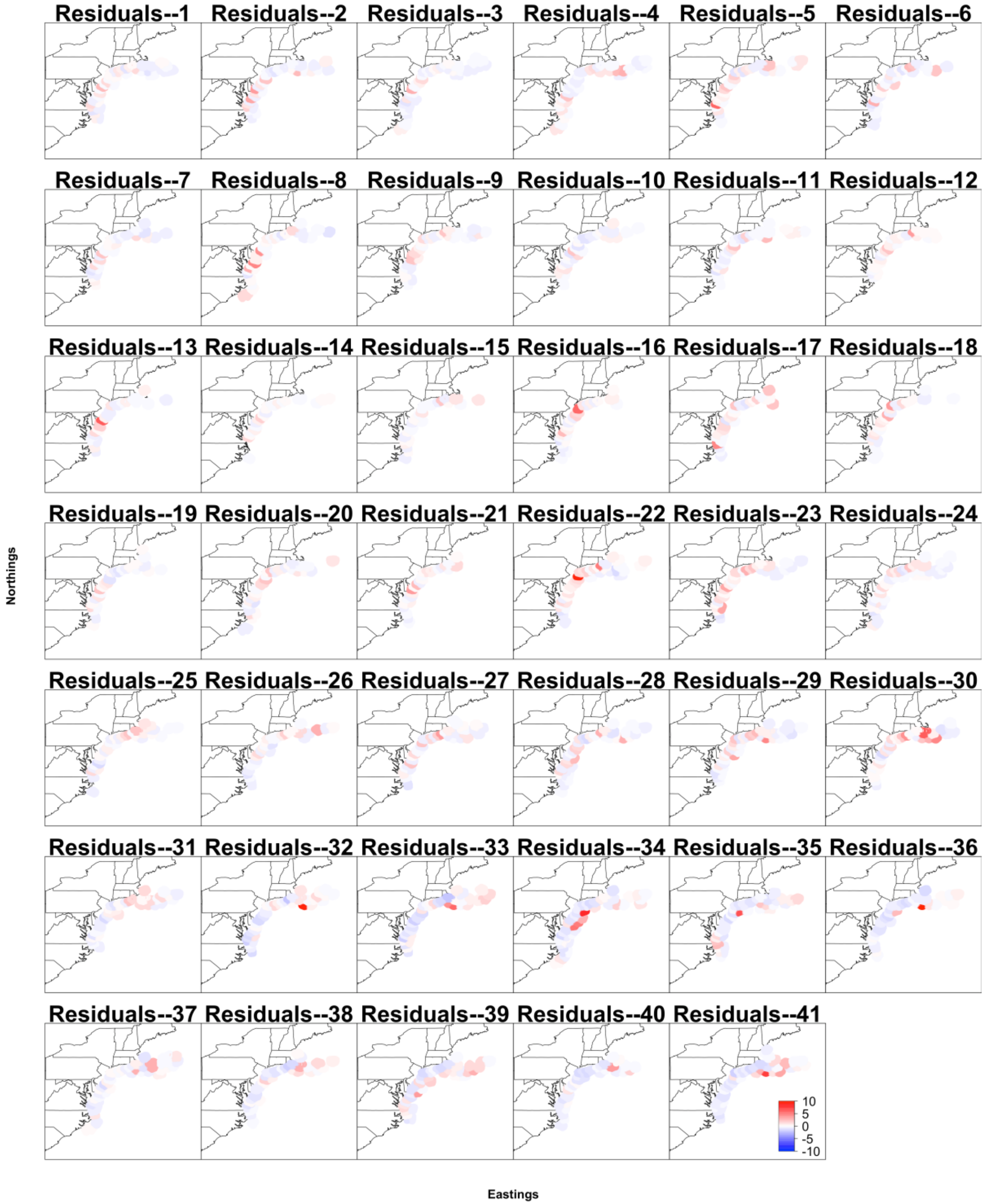
Model setup


Extrapolation (Lat-Lon)
Extrapolation (North-East)
Knots (North-East)
Lat
Lon
N_km
E_km
34
36
38
40
42
44
-76
-74
-72
-70
-68
-66
3800
4200
4600
-200
0
200
400
600
4000
4400
4800

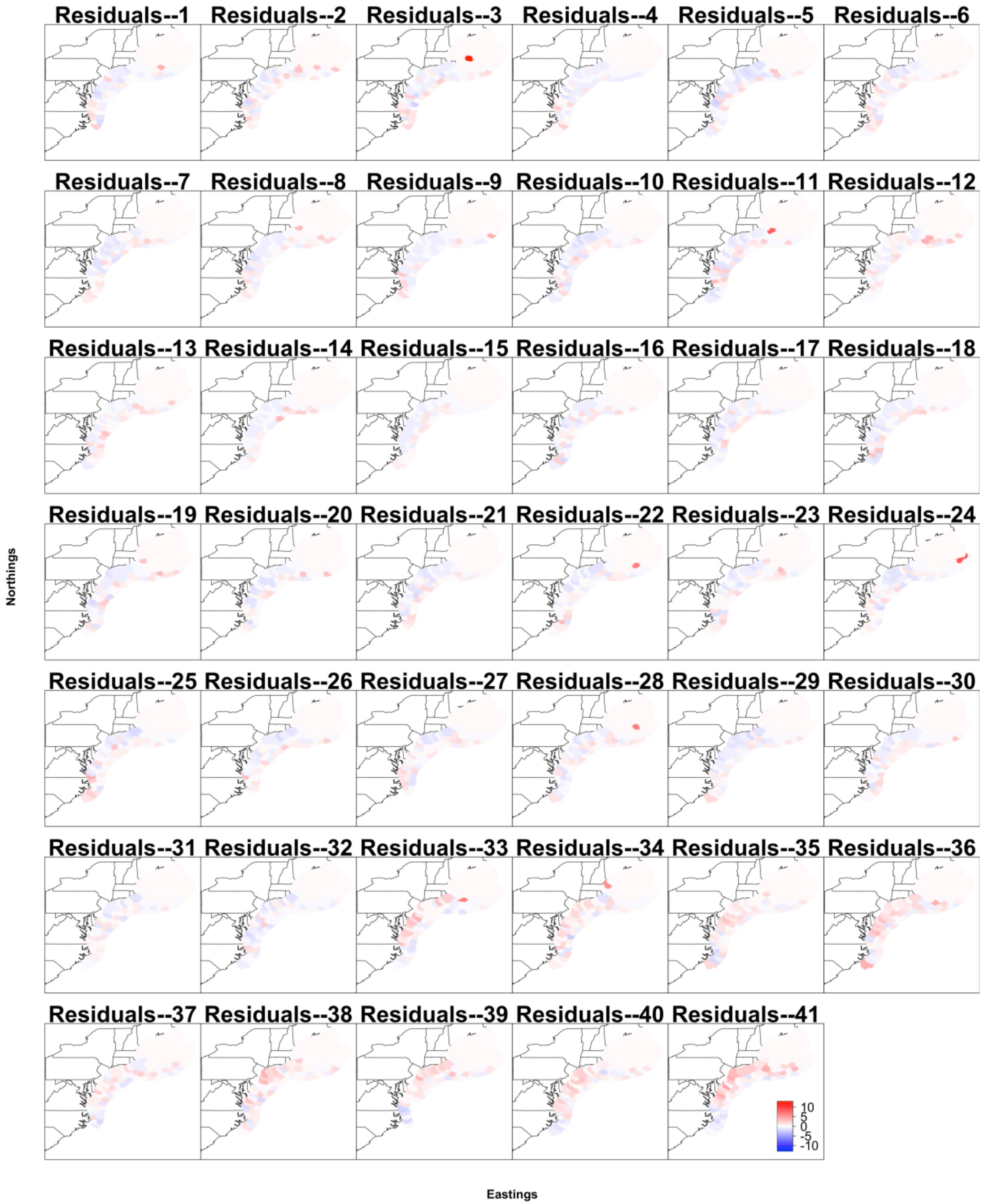
Fall encounter probability residuals



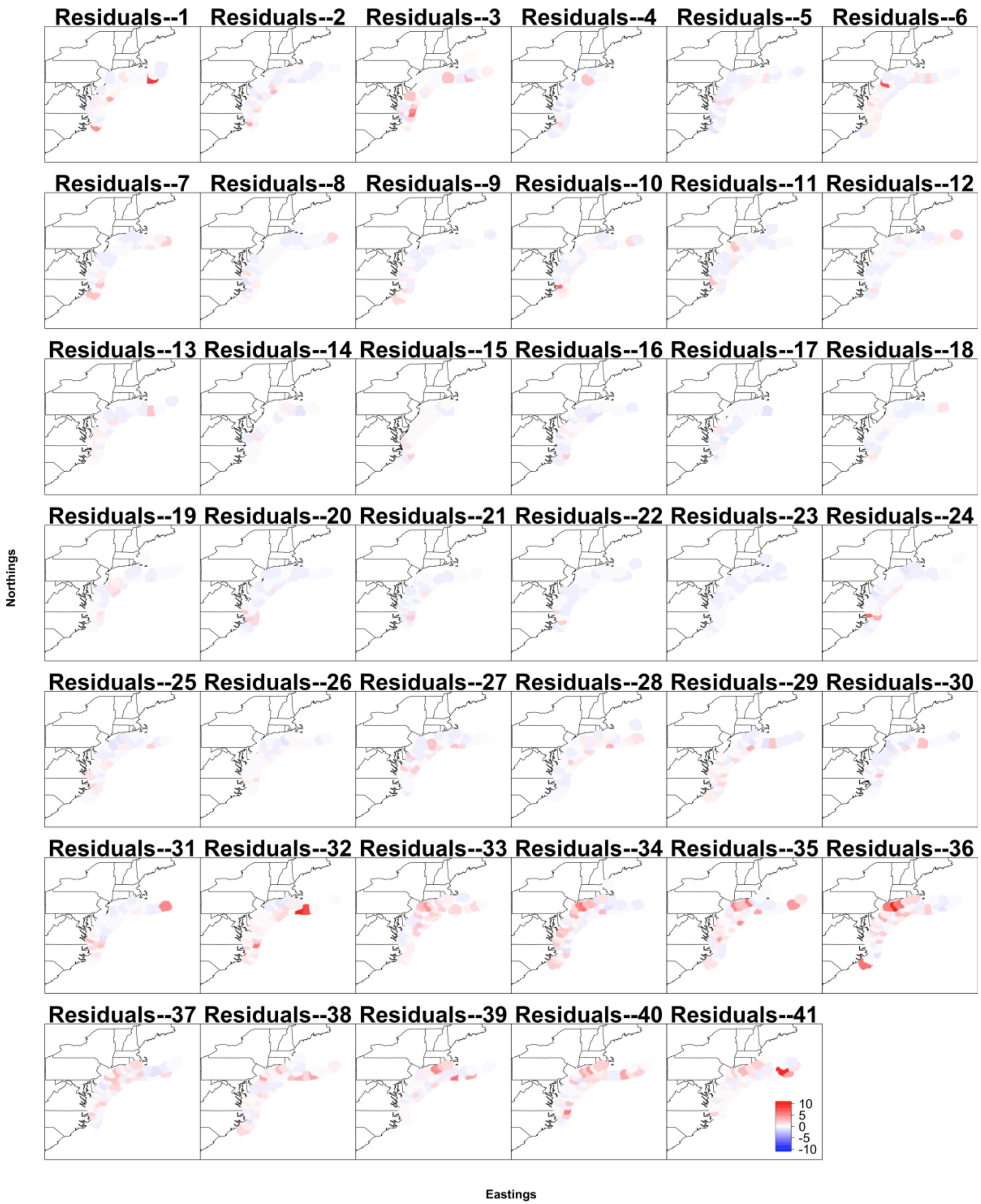
Fall catch rate residuals



Spring encounter probability residuals

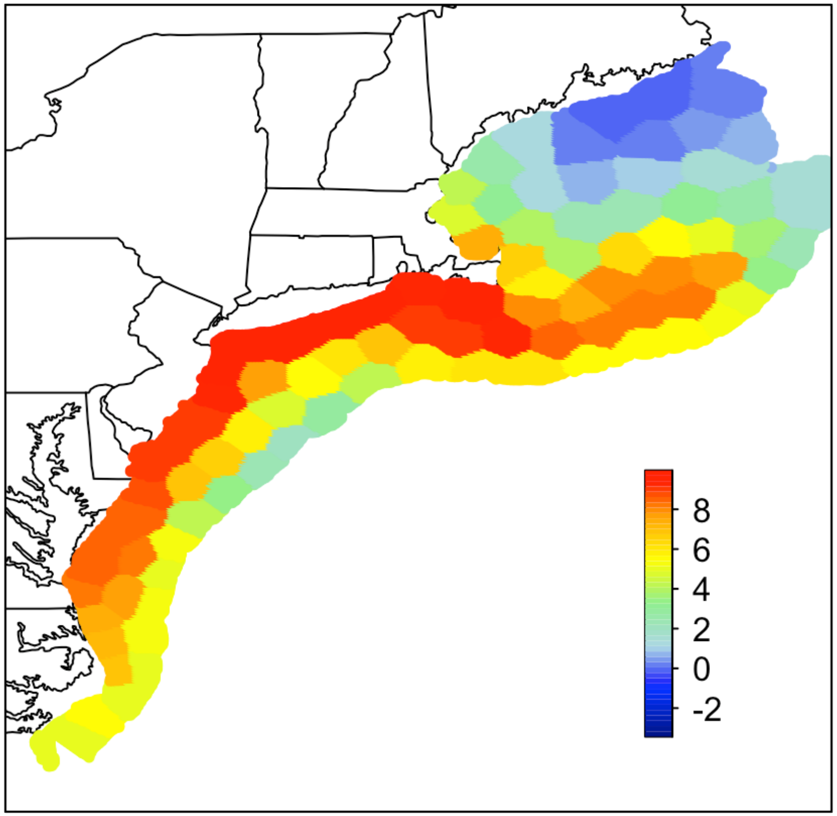


Spring catch rate residuals

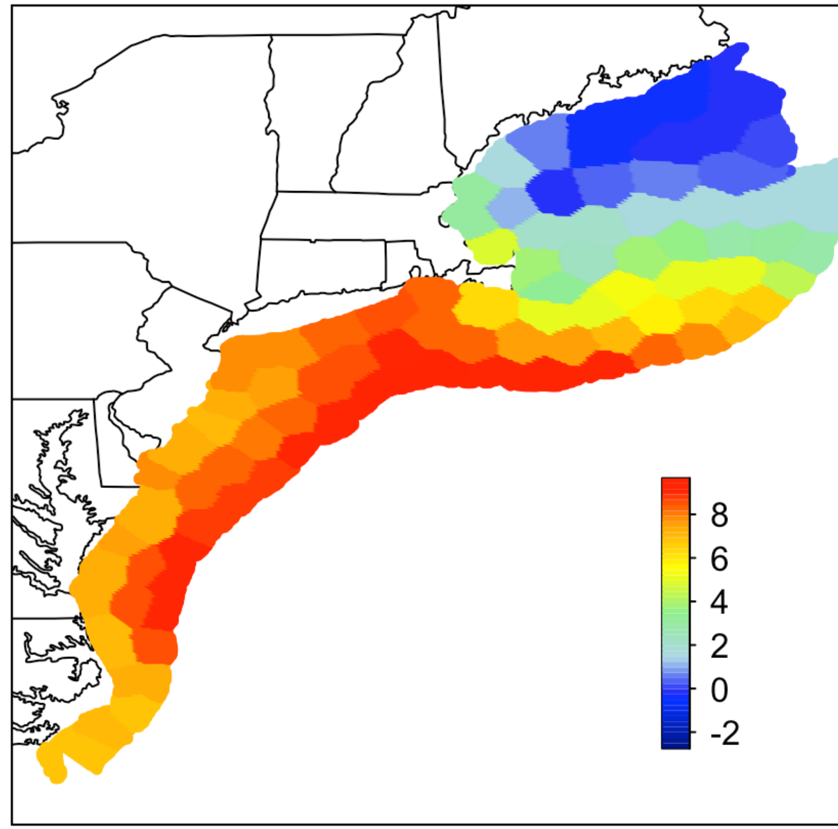


Seasonal patterns
Spawners

Fall

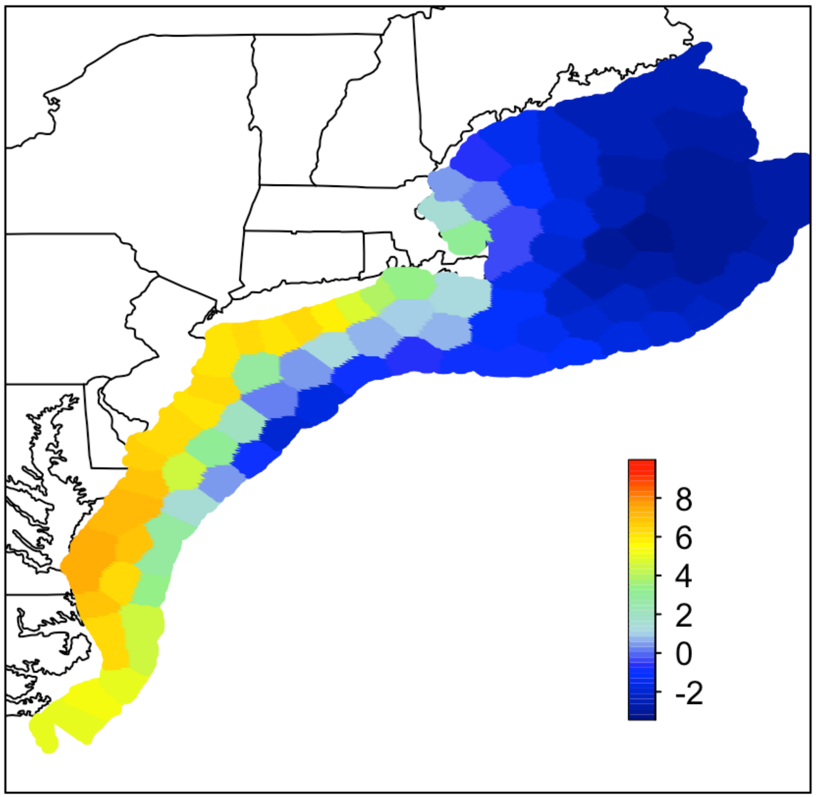


Spring

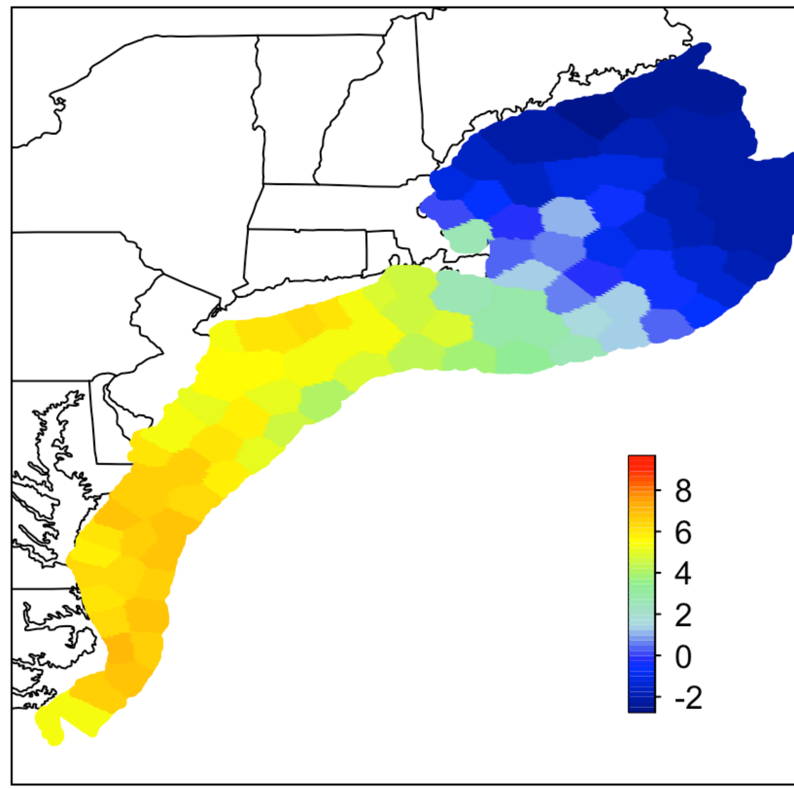


Seasonal patterns
Recruits

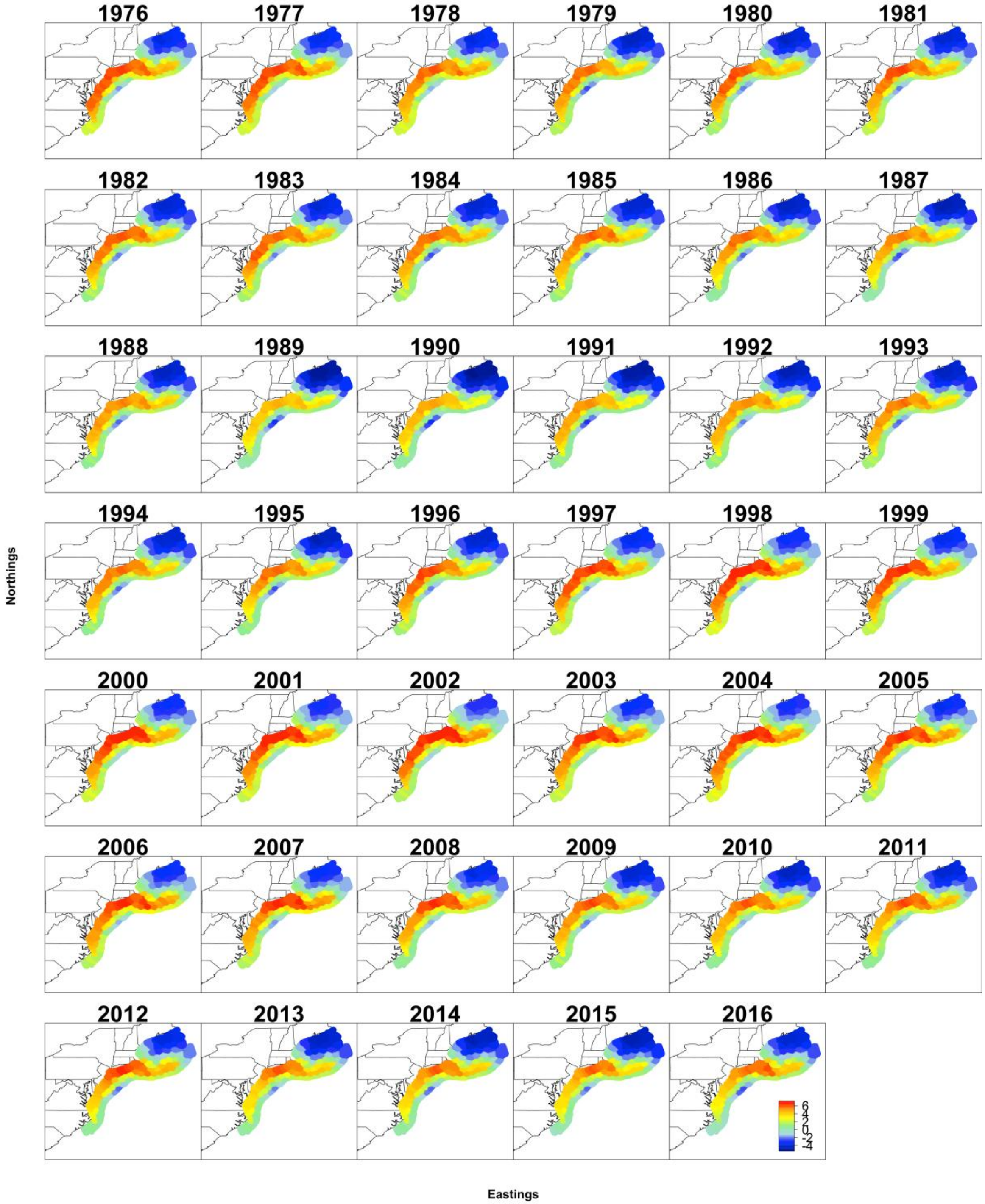
Fall



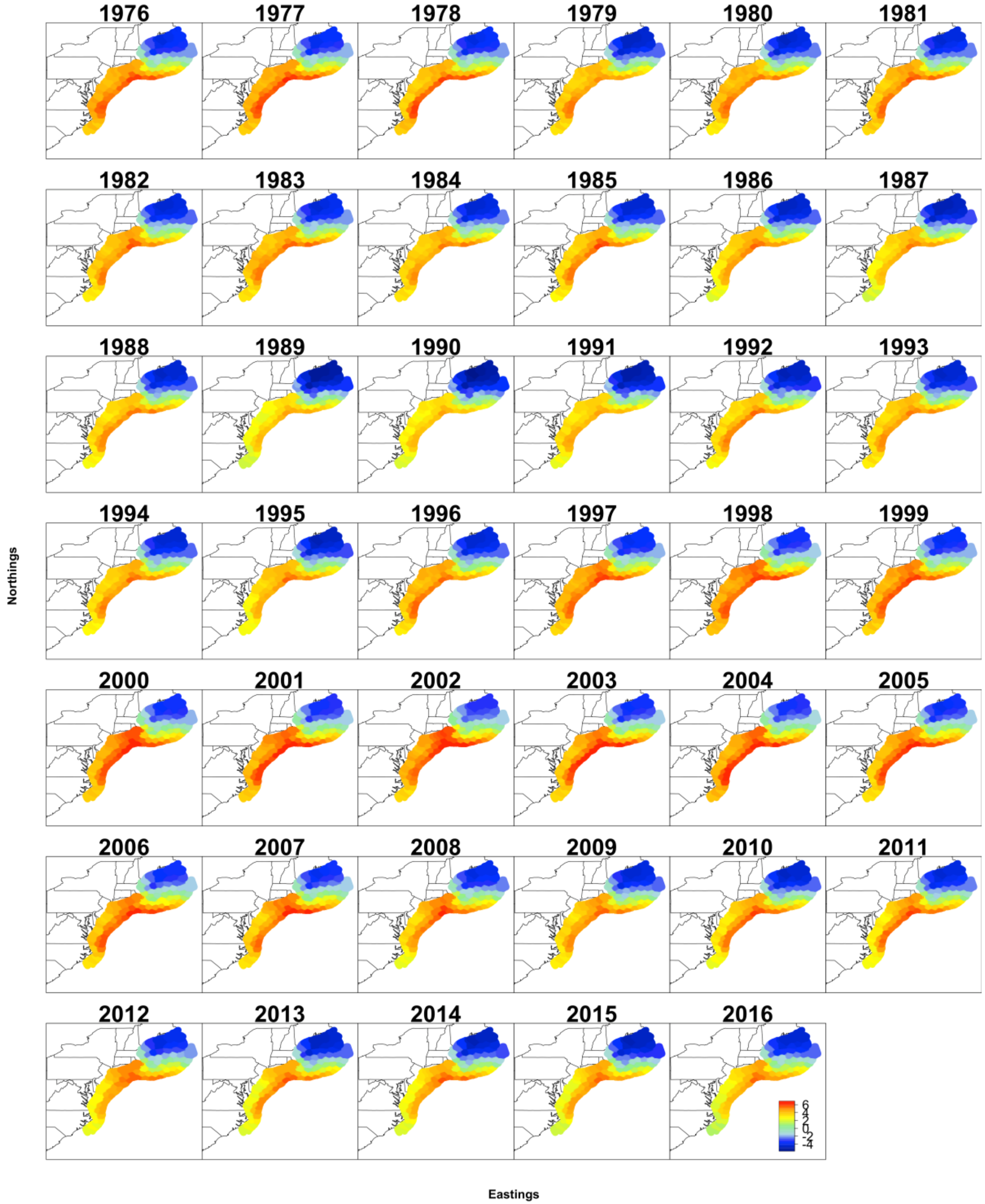
Spring



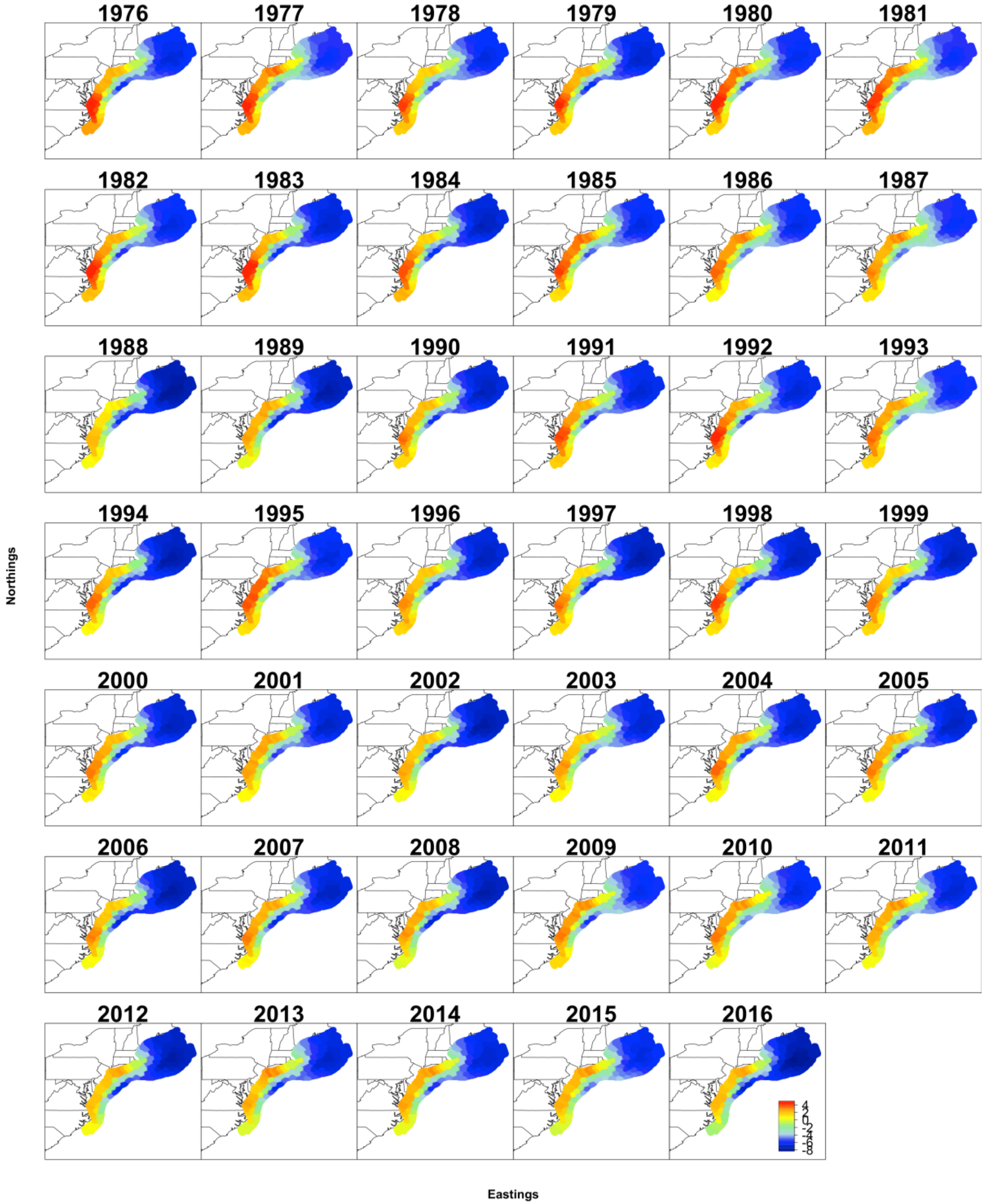
Spawners in Fall



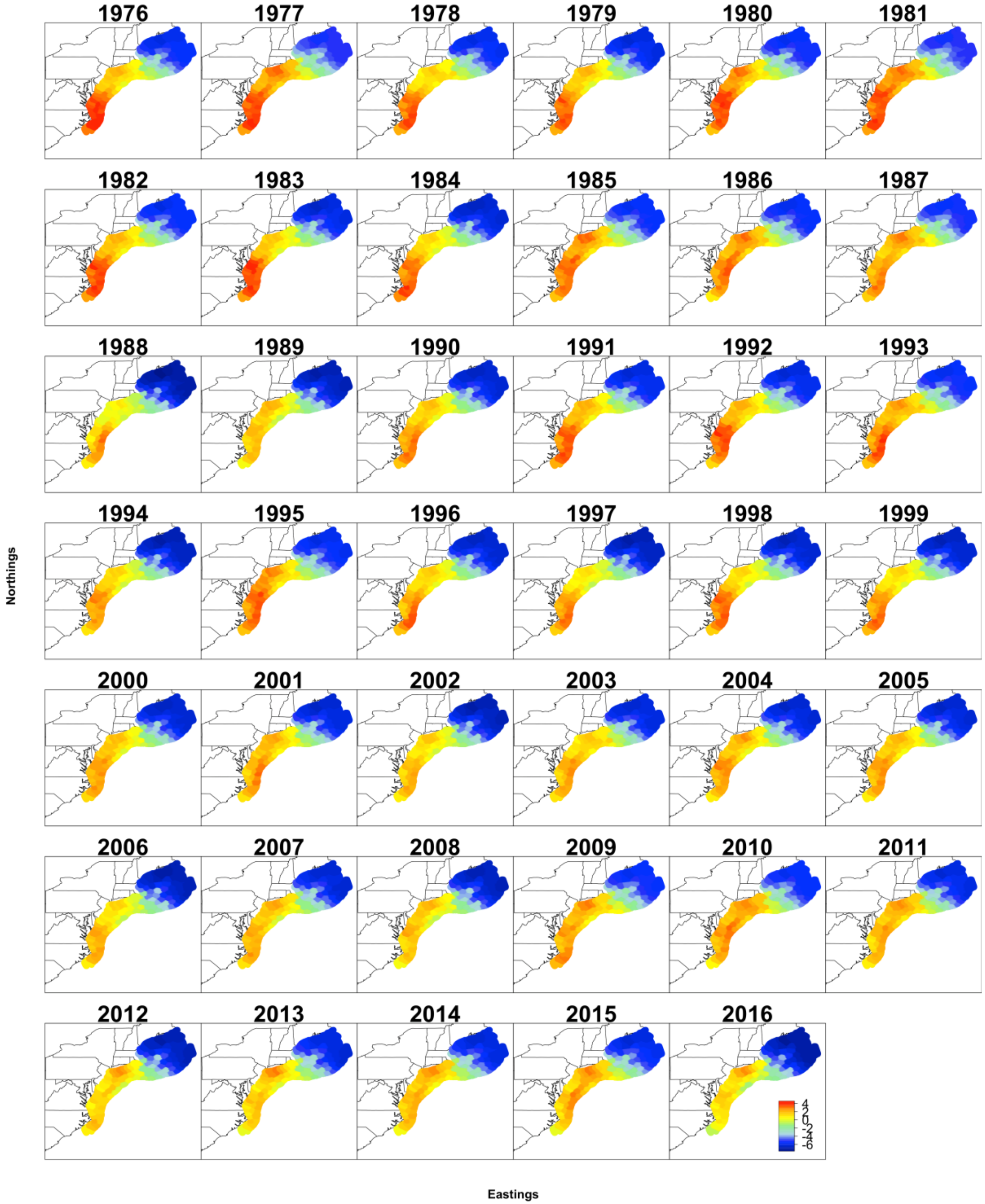
Spawners in Spring



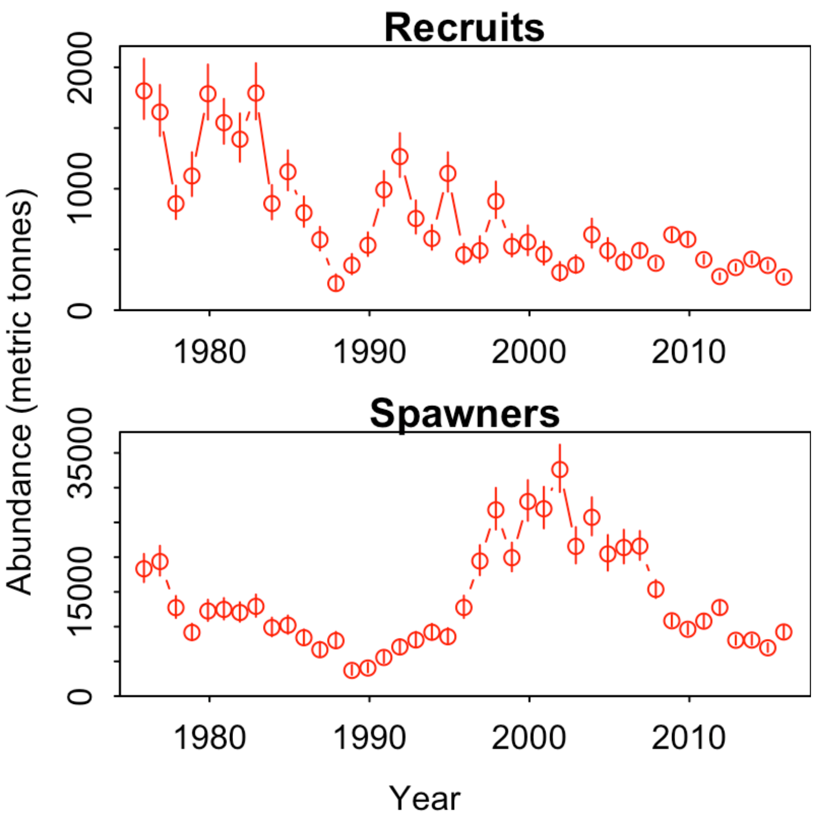
Recruits in Fall



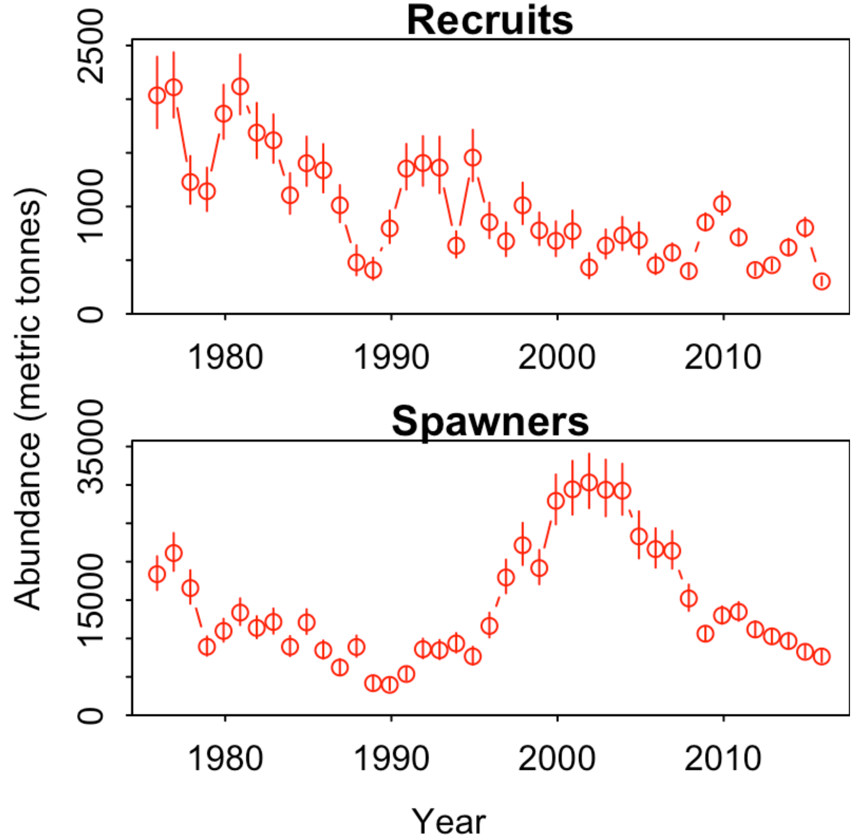
Recruits in Spring



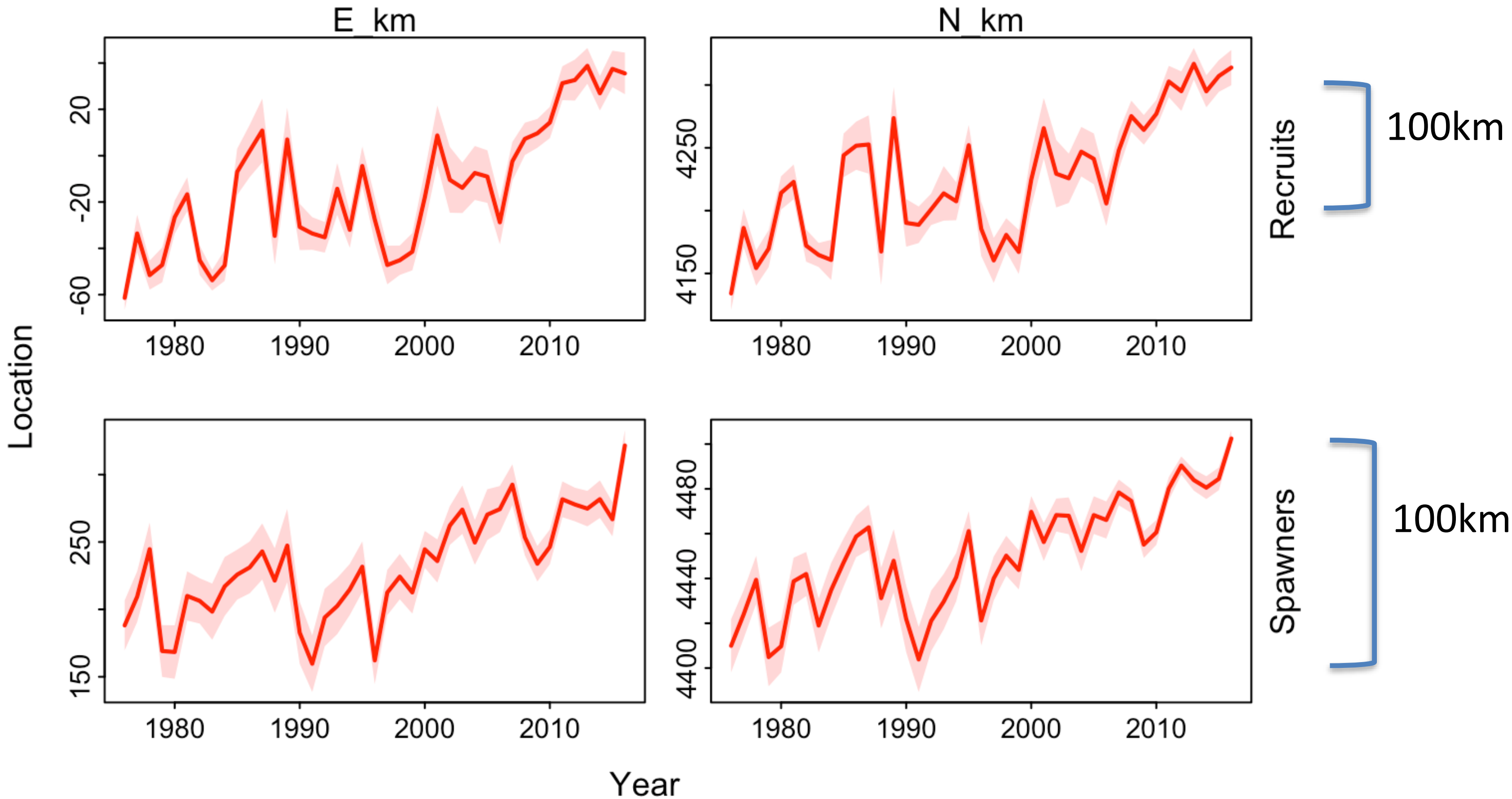
Fall


Recruits
Abundance (metric tonnes)
2000
1000
0
1980
1990
2000
2010
Spawners
35000
15000
0
Year

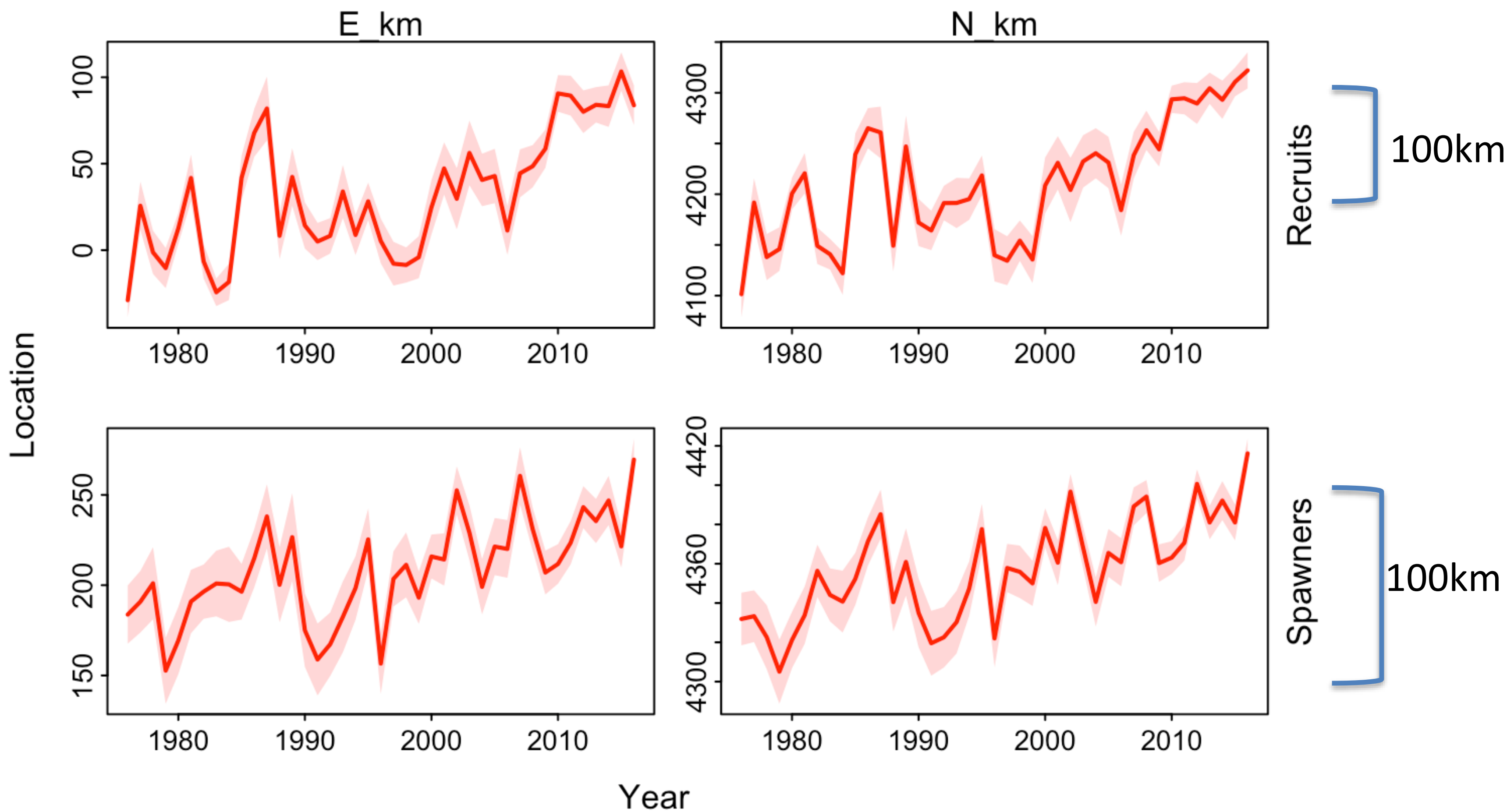
Spring


Recruits
Abundance (metric tonnes)
2500
1000
0
1980
1990
2000
2010
Spawners
35000
15000
0
Year

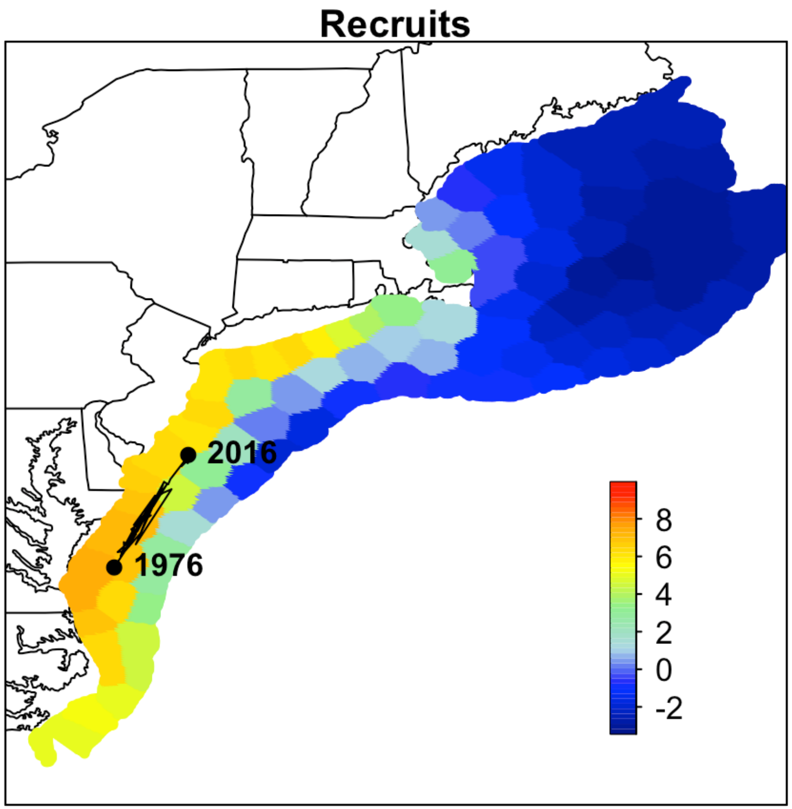
Center of gravity (Fall)

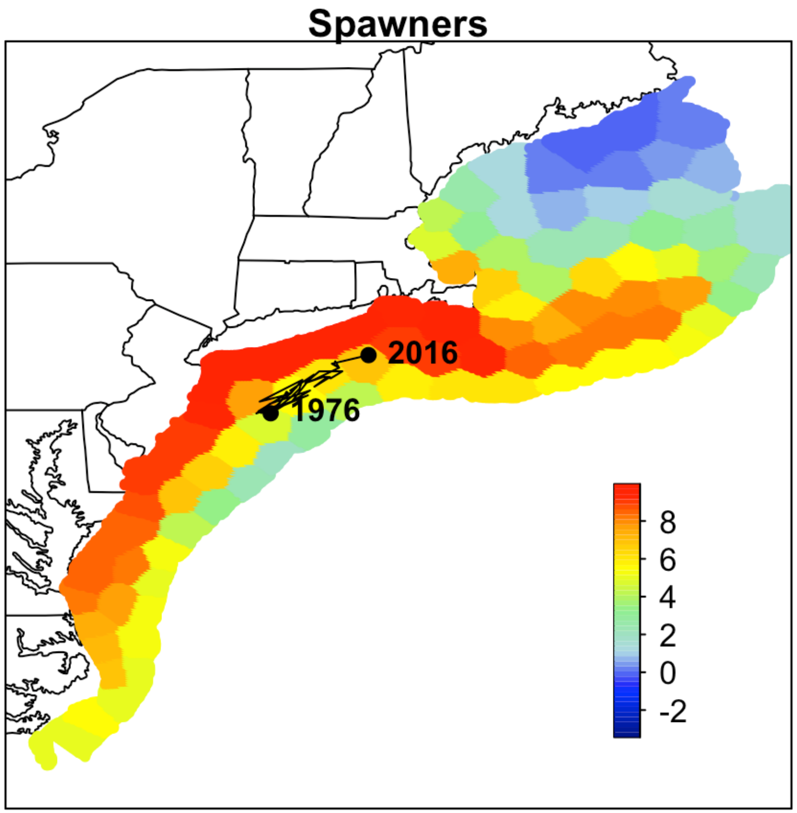


Center of gravity (Spring)

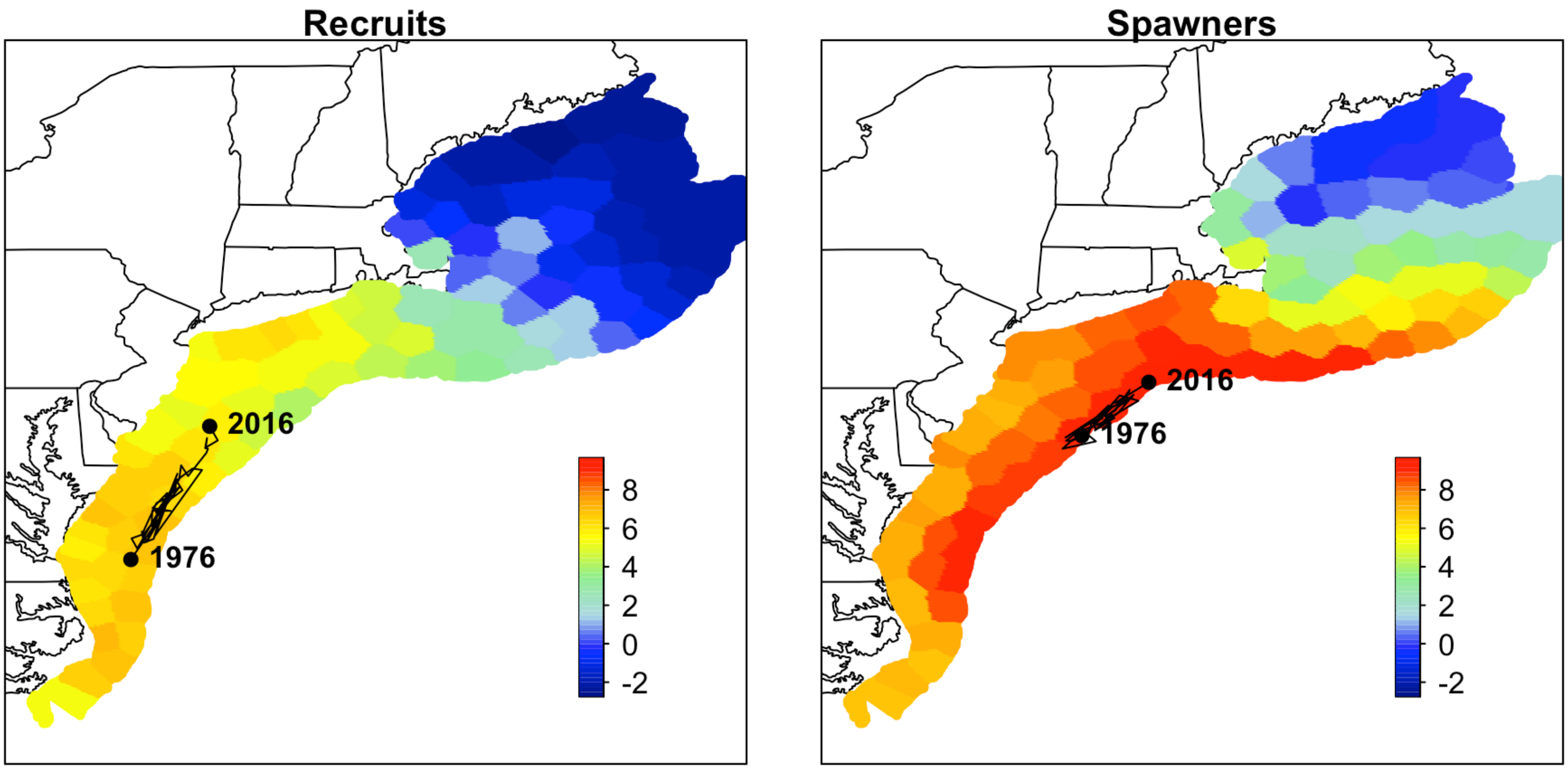


Fall change in center of gravity

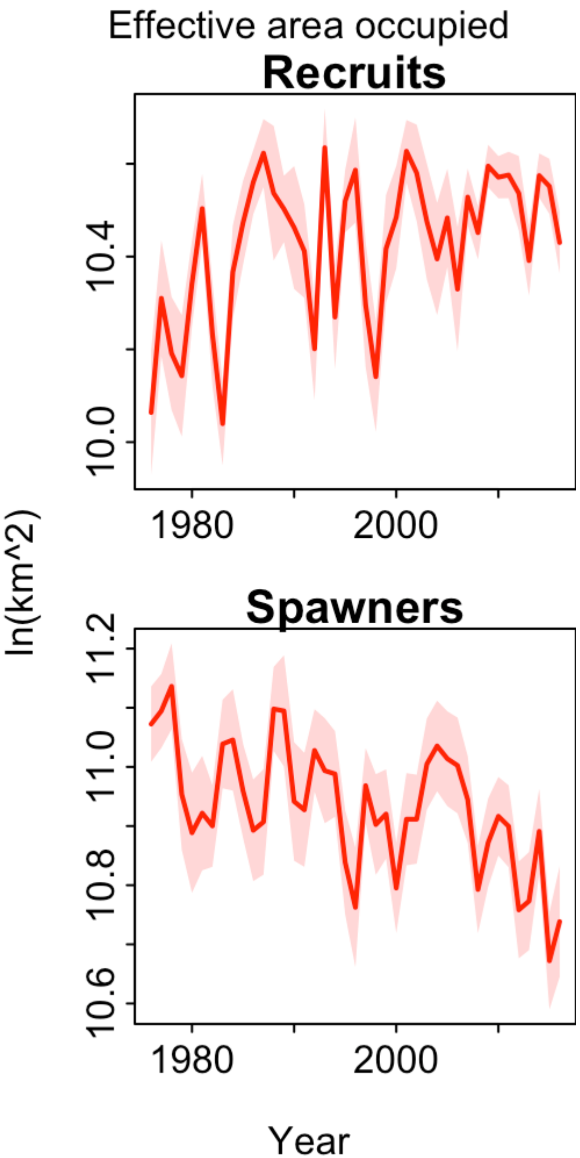




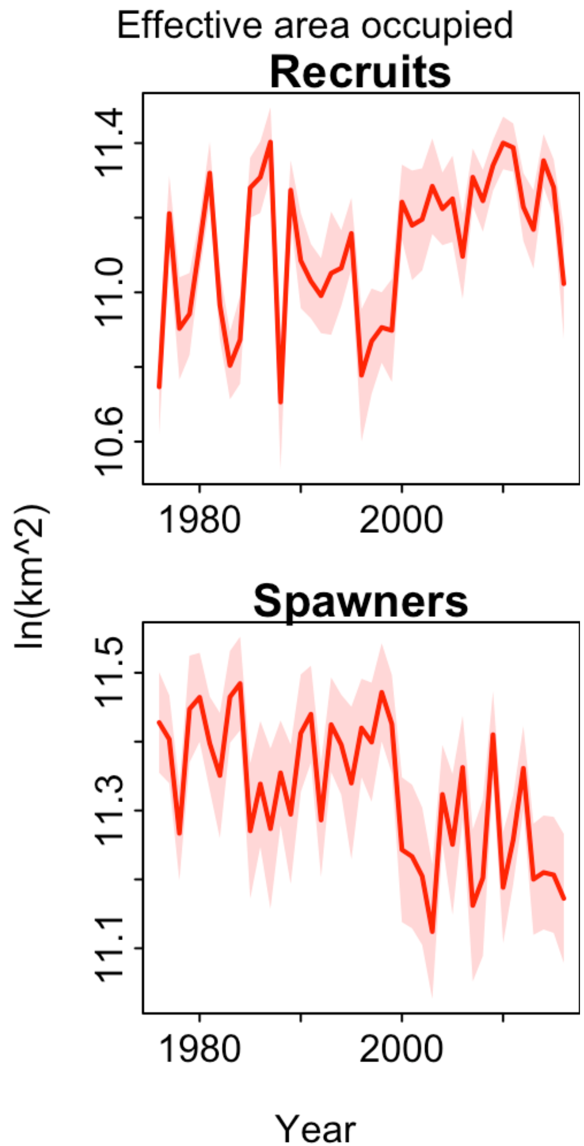
Spring change in center of gravity



Fall


Effective area occupied
Recruits
10.0
10.4
1980
2000
ln(km^2)
Spawners
10.6
10.8
11.0
11.2
1980
2000
Year

Spring


Effective area occupied
Recruits
10.6
11.0
11.4
1980
2000
ln(km^2)
Spawners
11.1
11.3
11.5
1980
2000
Year

Preliminary takeaways & next steps

- Consistent evidence of a northward shift in both seasons and size-classes.
- Does not seem to be driven by size-structure, or changes in total abundance.

- Next-- incorporate environmental covariates

Conceptual challenges

- Are we tracking the same fish in both seasons?
- Does it matter?
- Maybe not for a spatial model, but it might for a population model.

- Confounding between environmental covariates and exploitation patterns?