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
  • Seasonal surveys
- MDMF bottom trawl survey (1976-2017, coming soon)
- Spring & Fall
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

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

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)
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


2000 2001 2002 2003 2004 2005

2006 2007 2008 2009 2010 2011

Recruits in Spring
Center of gravity (Spring)
Fall change in center of gravity
Spring change in center of gravity
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?