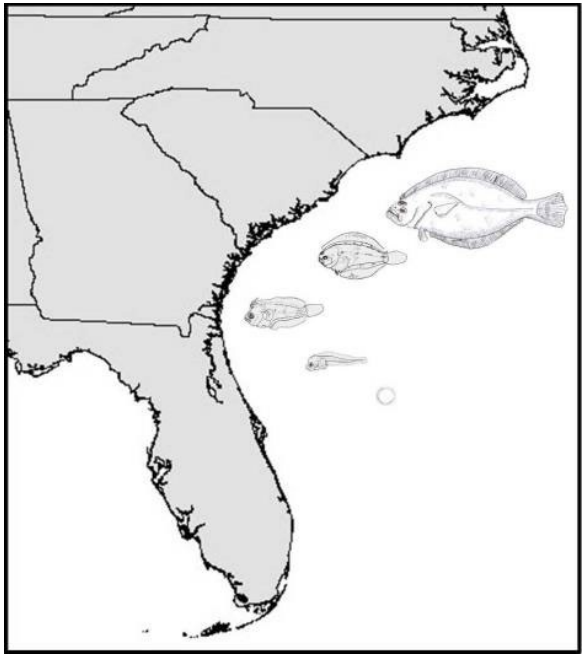
Key aspects of southern flounder life history: identifying knowledge gaps and potential effects on stock dynamics



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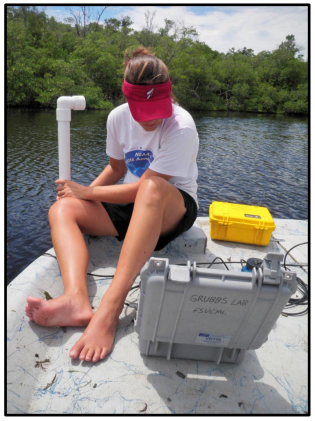

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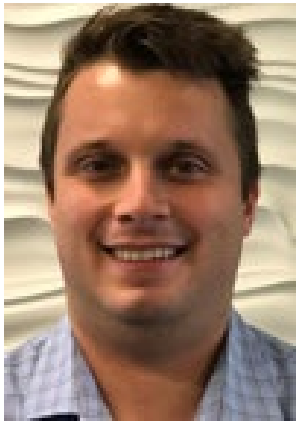
GMFMC



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NC COASTAL RECREATIONAL FISHING LICENSE

NORTH CAROLINA MARINE FISHERIES

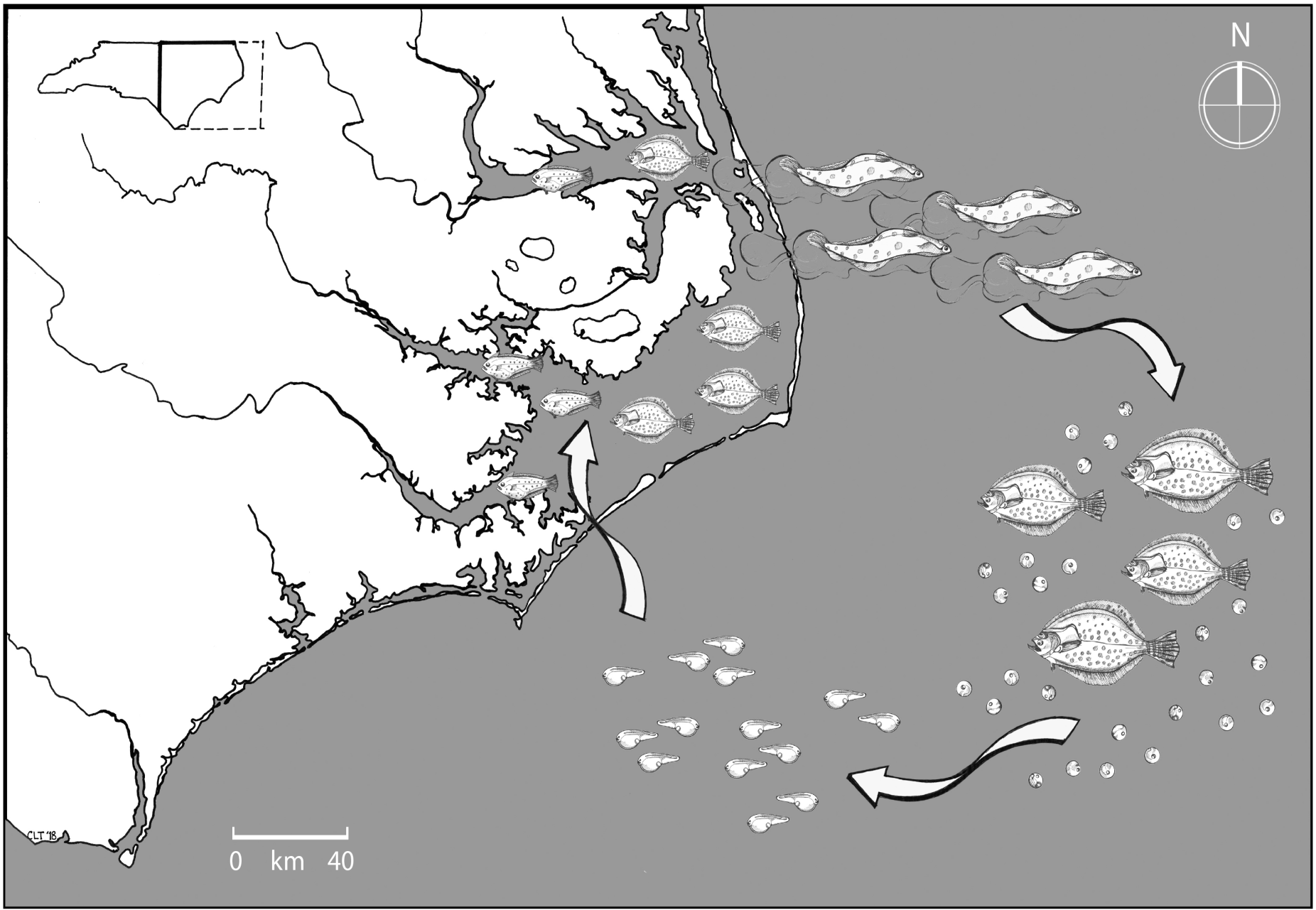
Sea Grant North Carolina

UNCW

Southern flounder - species range

Distributed along the southeast Atlantic coast and throughout the northern Gulf of Mexico

Southern flounder life history



Offshore spawning locations

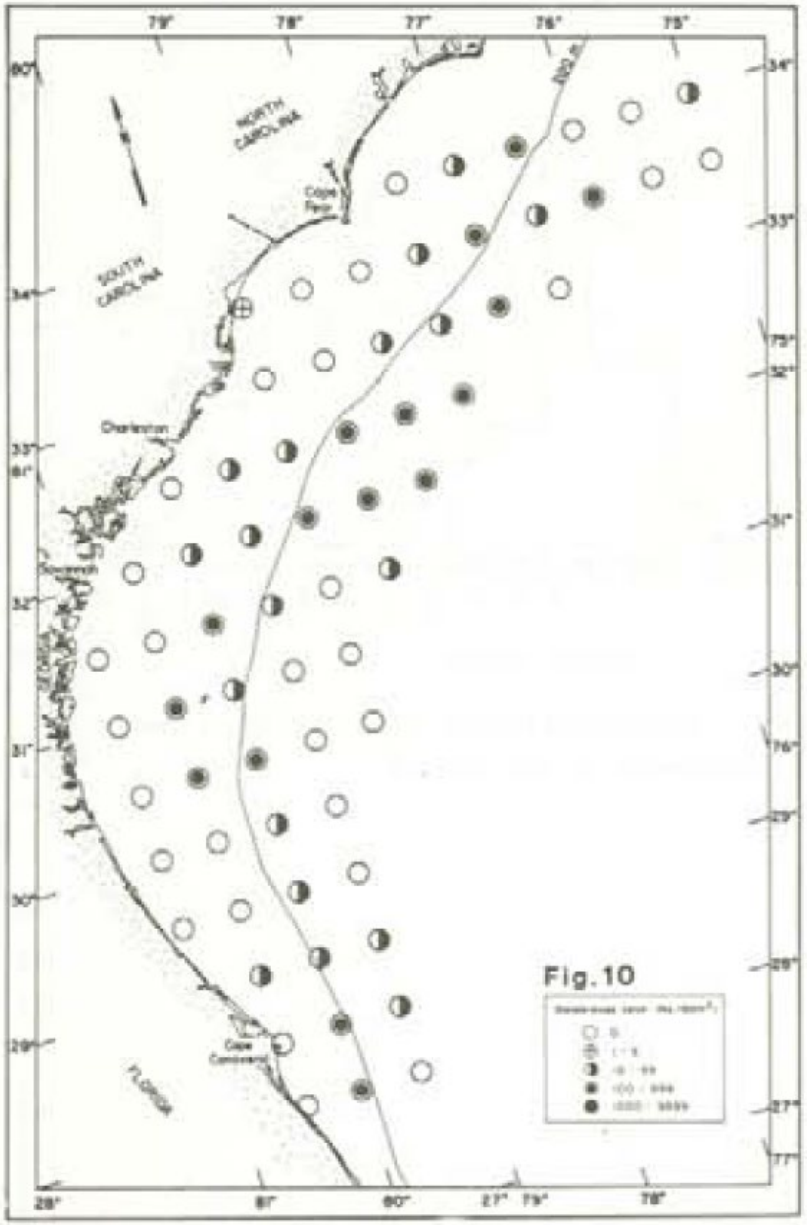
Ichthyoplankton surveys

1) Winter 1965-66
   - NC shelf: Dec-Feb
   - Paralichthys spp. peak in Dec and Jan over outer half of the shelf

2) Winter 1973
   - South Atlantic Bight: Feb-Mar
   - All stations with > 100/m^3 of Bothids occurred at > 40 m depth

3) Winter 1979-80
   - NC shelf: Nov - Mar
   - Paralichthys spp. occurred over mid and outer shelf Dec-Mar (Feb peak)

4) Winter 1991-1999
   - NC shelf: Dec – Feb
   - Paralichthys spp. distibuted across shelf with smallest larval sizes at outer shelf



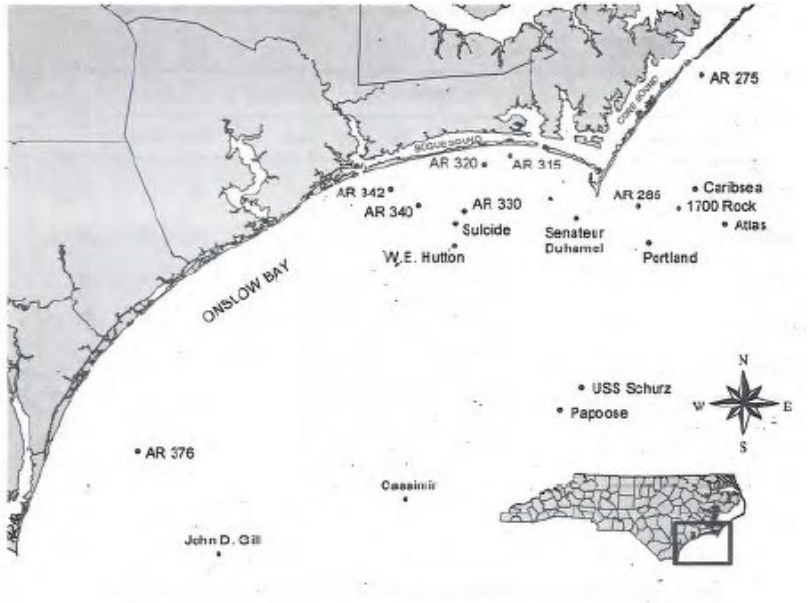
Smith et al. 1975; Powles and Stender 1976; Powell and Robbins 1994; Walsh 2007

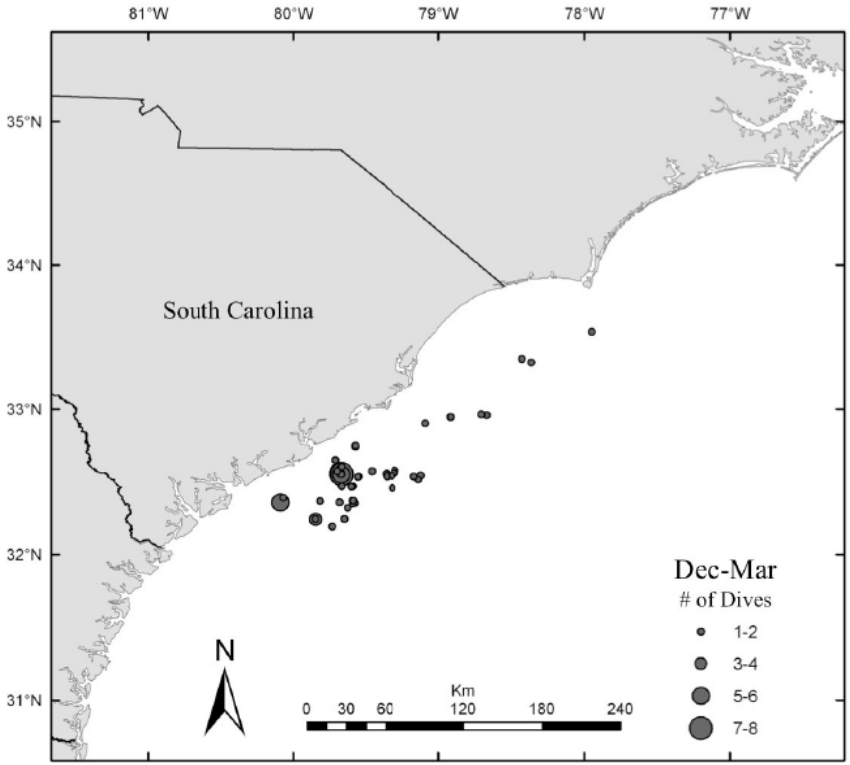
Offshore spawning locations

SE Shelf diving surveys

1) NC shelf: 2000-2004
   - <130 ft. depths
   - Fish observed staging along shoals in Fall
   - Only 7 southern flounder captured in winter

2) SC shelf: 2007-2010
   - Most dives < 40m depths
   - No *P. lethostigma* captured during Dec-Mar despite 91 dives





Offshore spawning locations

SE

1)

Offshore spawning areas remain uncertain

2)

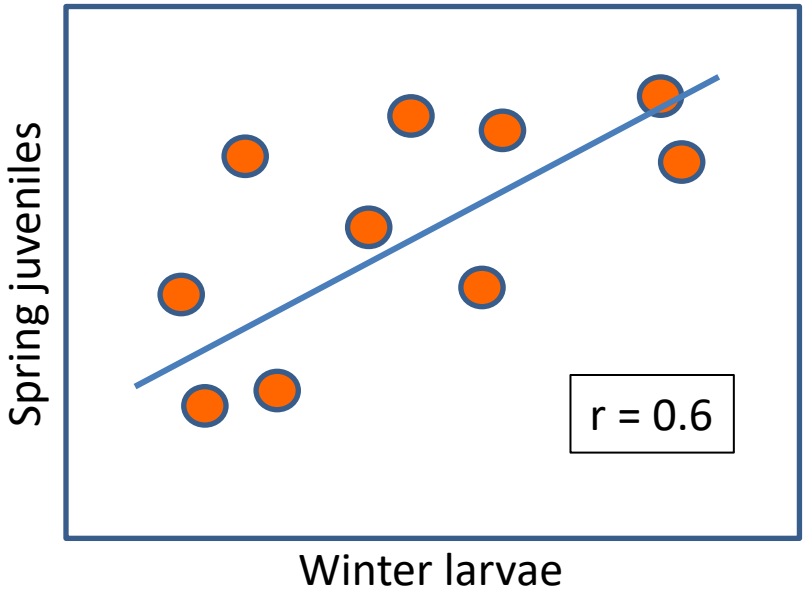
during Dec-Mar despite 91 dives

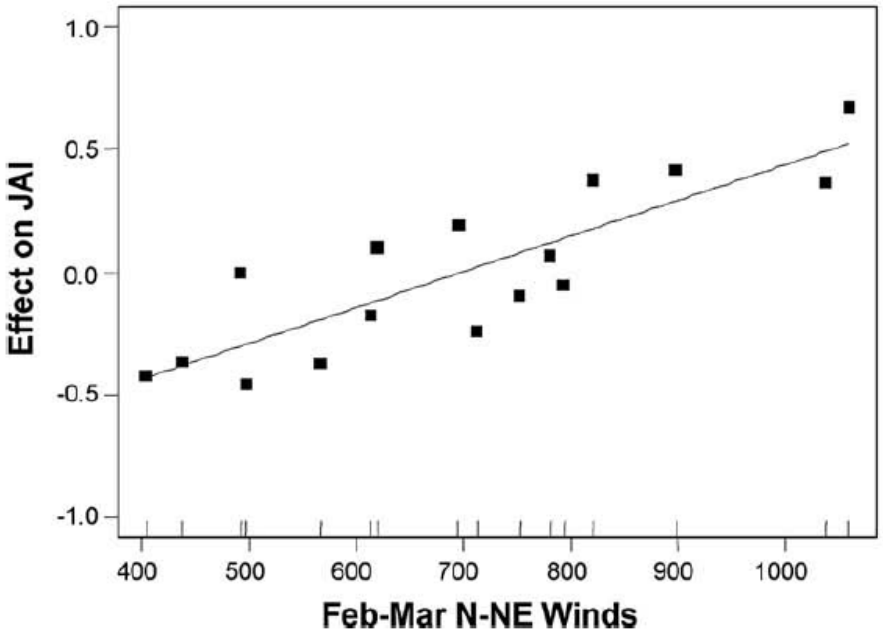
Larval transport/juvenile recruitment

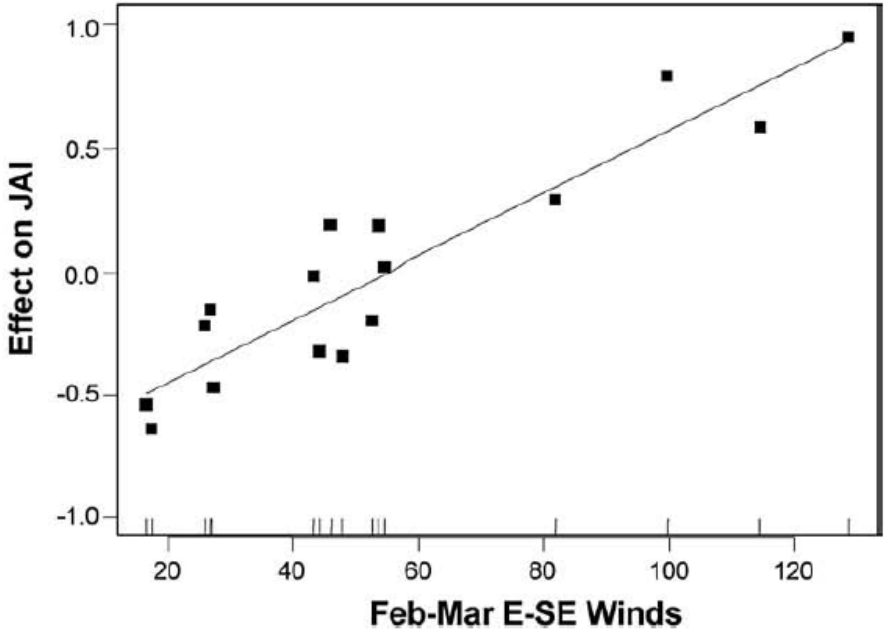
1) Winter winds promote southern flounder recruitment

2) Positive association between winter larvae and spring juvenile cpue

Taylor et al. 2009, 2010





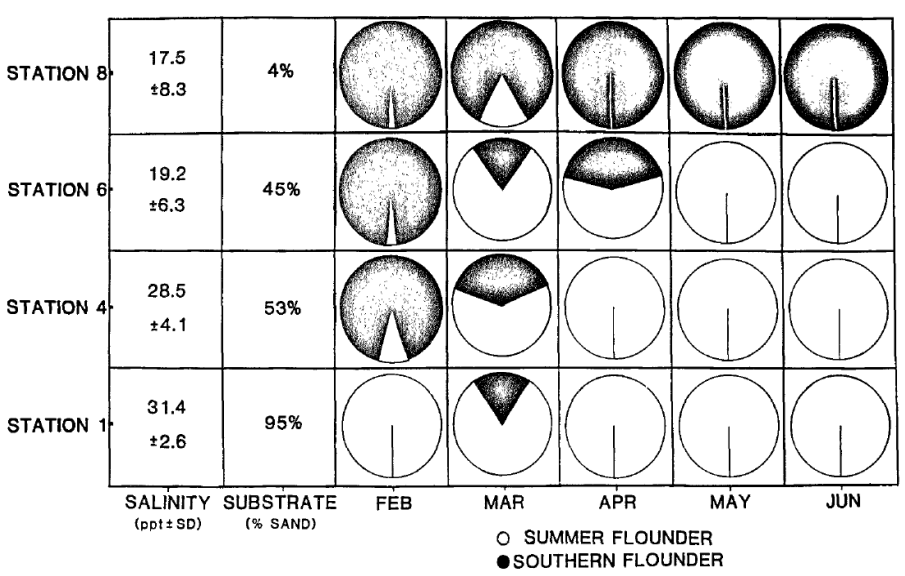


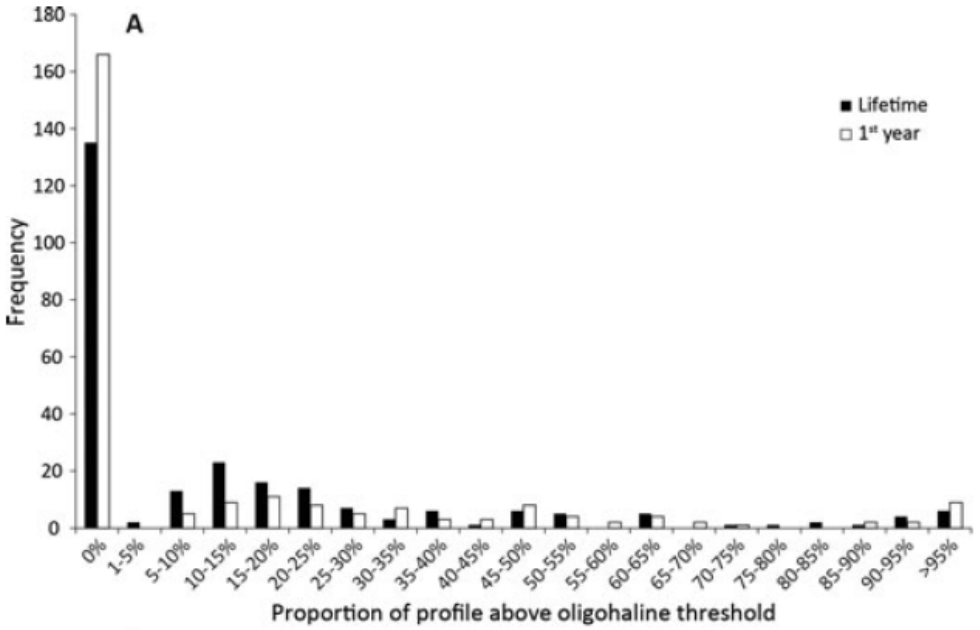
Juvenile settlement/habitat effects

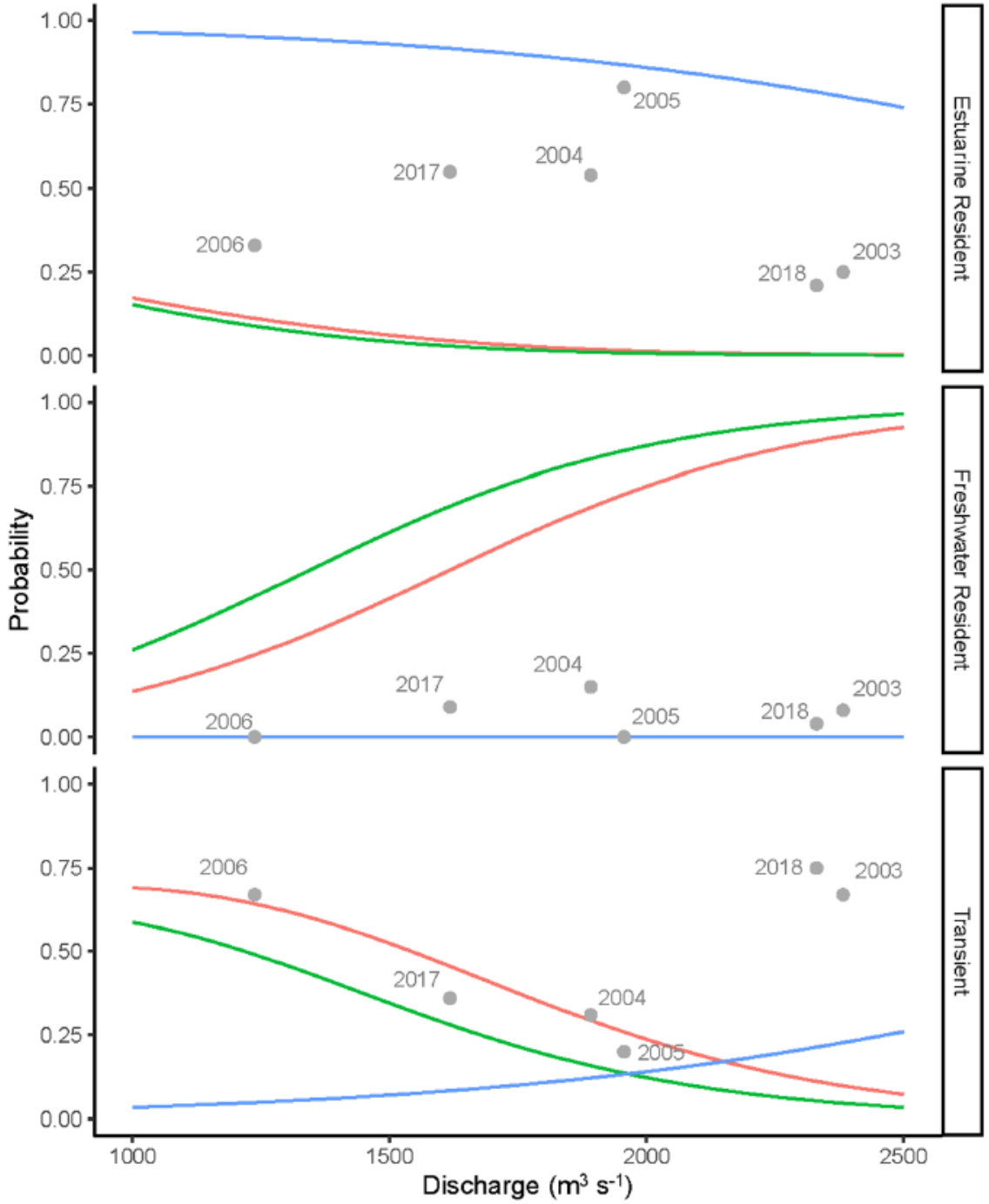
1) Settlement concentrated in oligohaline (salinity < 5 ppt) habitats with age/size shift to mesohaline habitats

2) Potential for low salinity contingents

Burke et al. 1991,Spidel 2009, Farmer et al. 2013 , Nims and Walter 2014







Juvenile settlement/habitat effects

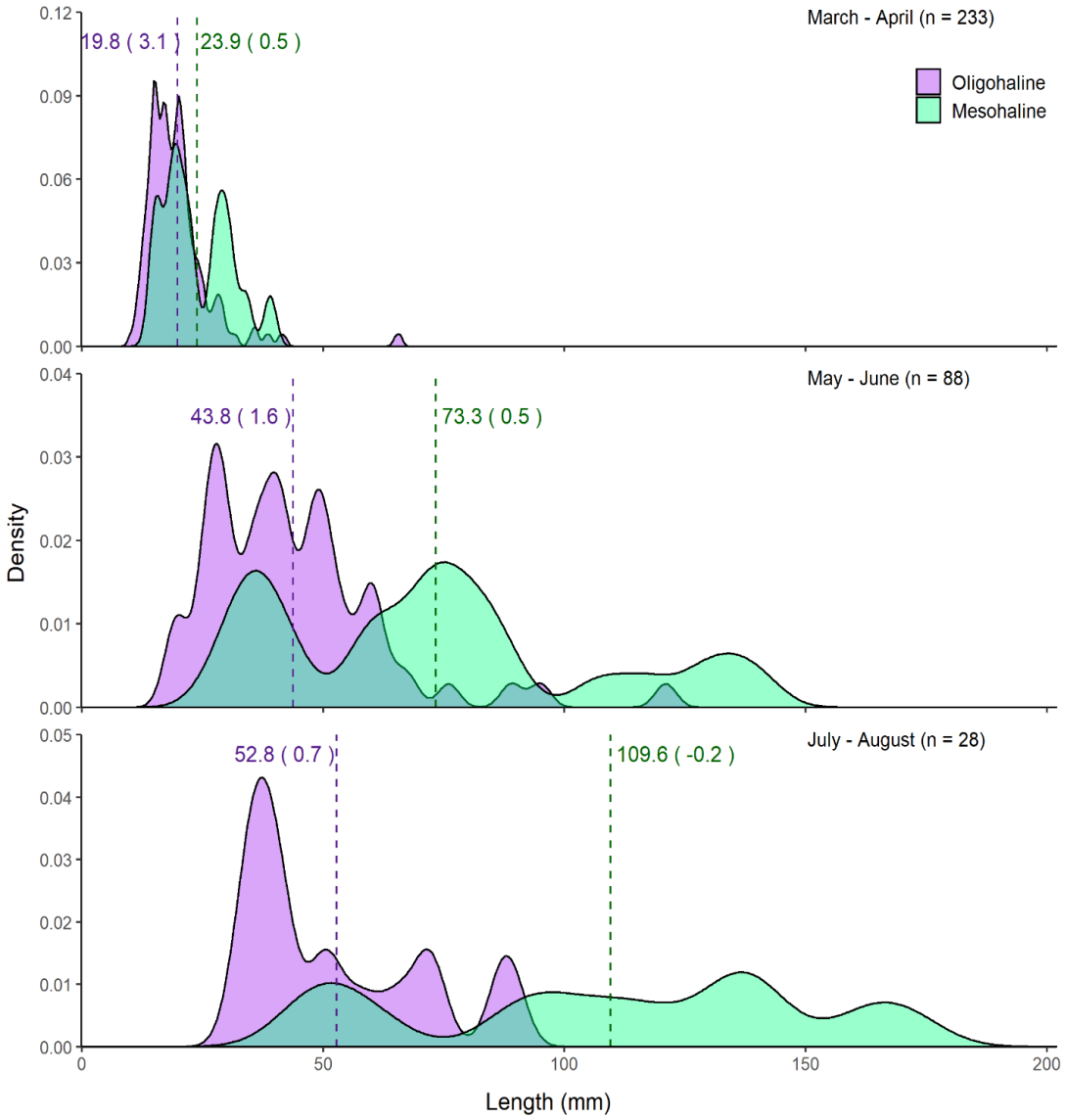
- Evidence for freshwater contingents
- Variable contributions to fishery landings and adult stock

Chrisp et al. 2023

Juvenile settlement/habitat effects

1) Potential impacts of habitat on flounder growth/mortality

- Reduced juvenile growth in oligohaline habitats
- Osmoregulatory costs of low salinity
- Delayed shift to piscivorous feeding

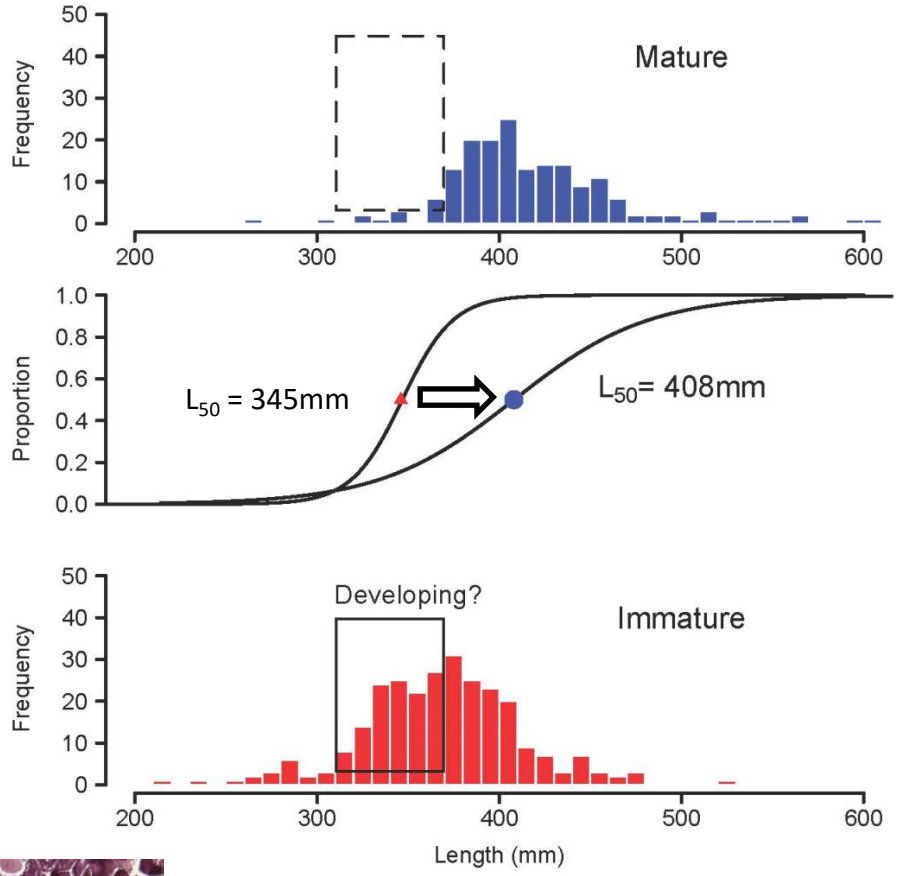


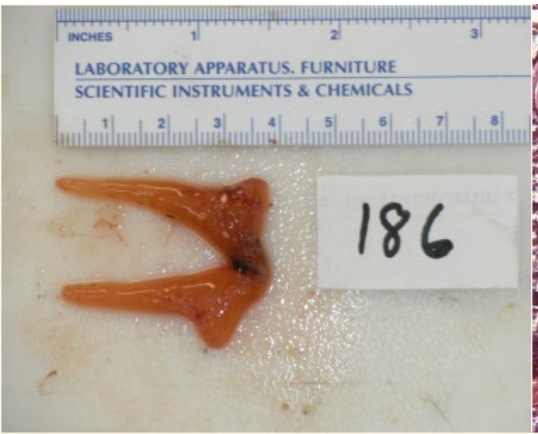
Juvenile settlement/habitat effects

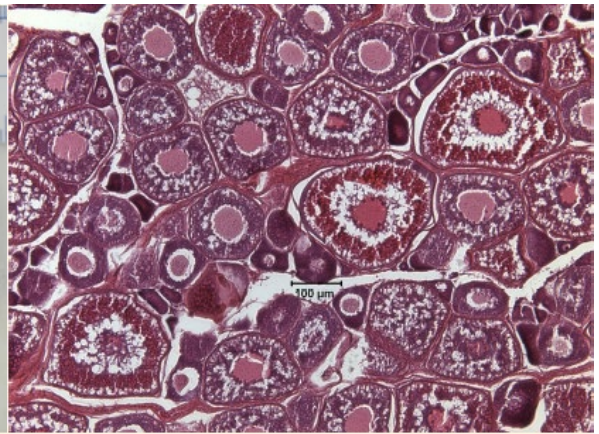
1) **Juvenile recruitment linked to local wind patterns**
   - Conditions necessary for hatching and larval survival?
2) **Implications for stock dynamics of post-settlement contingents?**

Maturity schedule

- Previous estimates based on macroscopic traits
- Histological analysis of NC fish predicted later shift to maturity



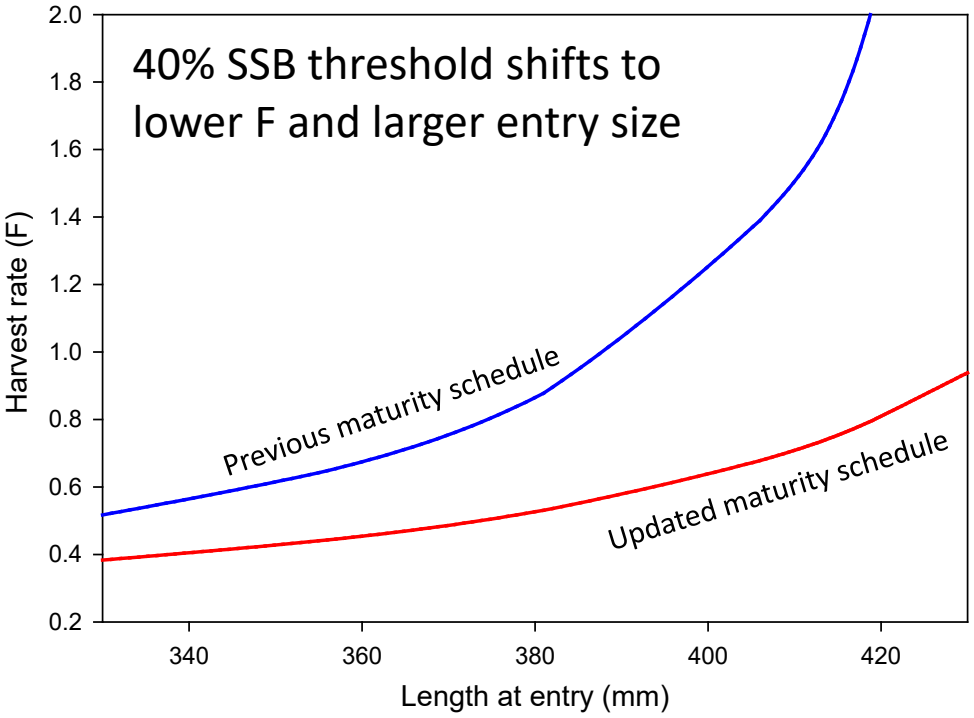


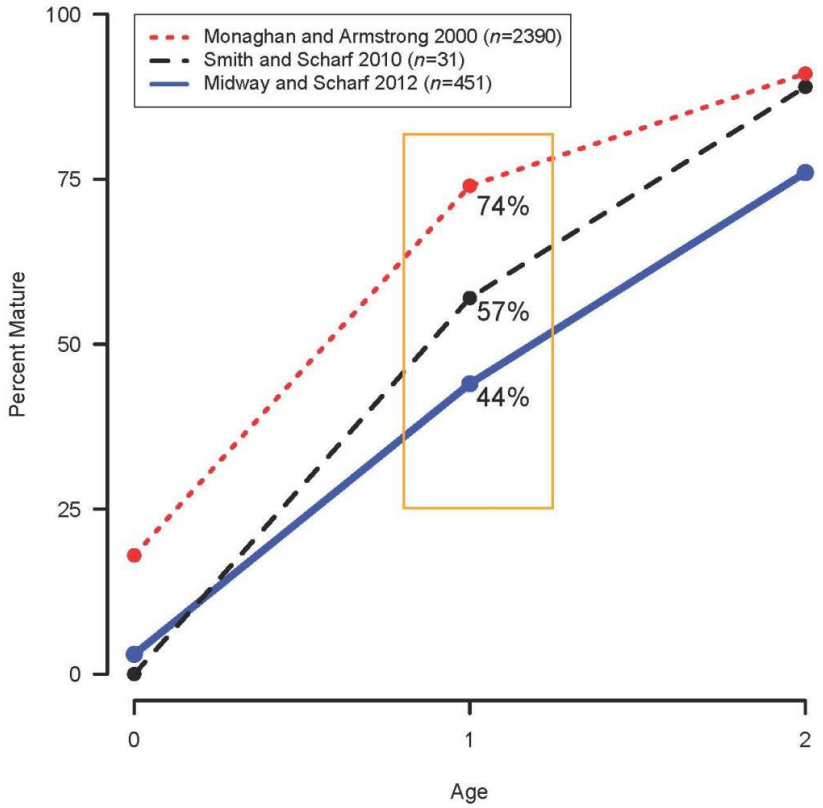


Midway and Scharf 2012

Impacts of shift in maturity schedule

- Much lower fraction of the harvest was mature
- Reduced contribution to spawning and future recruitment

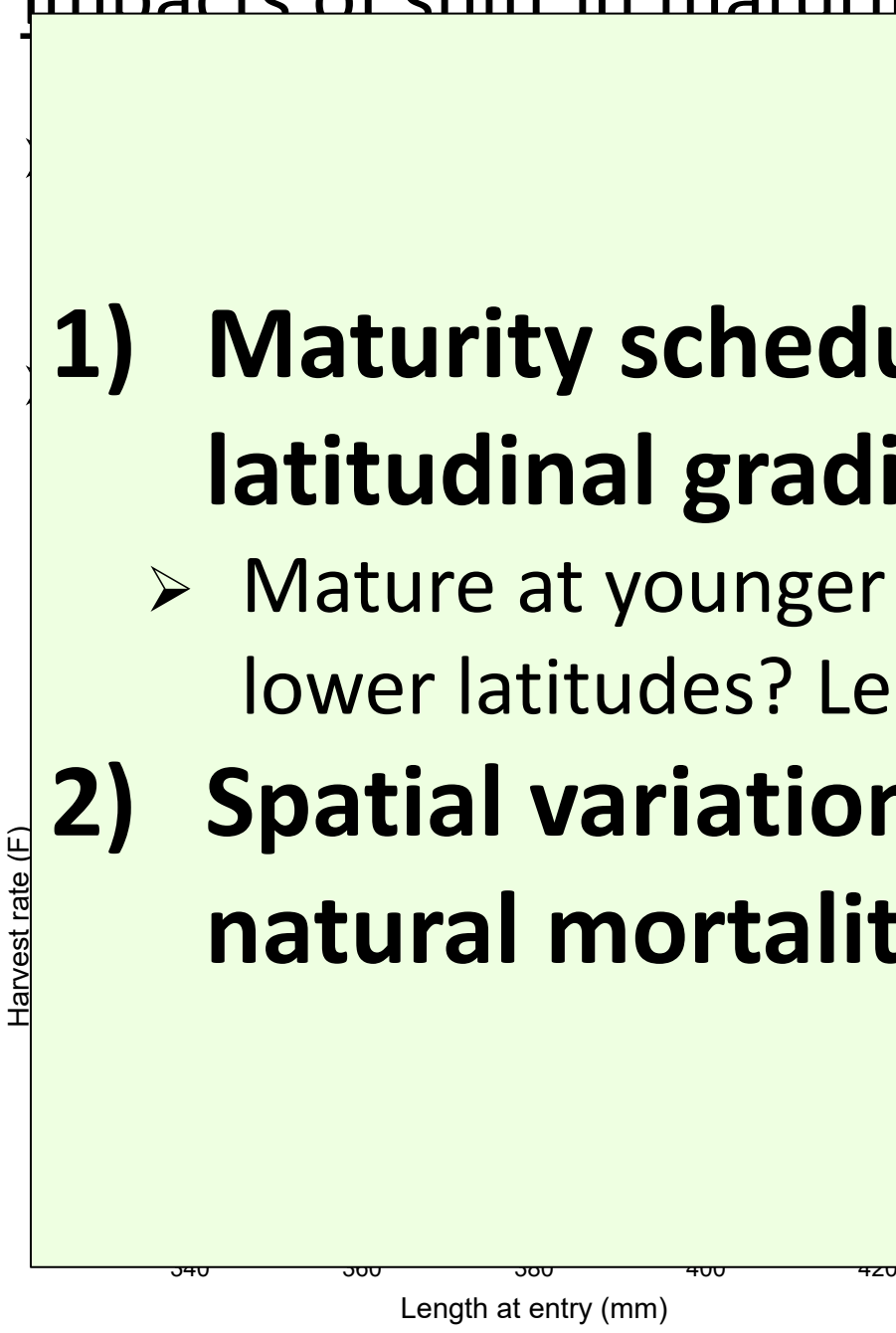




Midway and Scharf 2012

Impacts of shift in maturity schedule

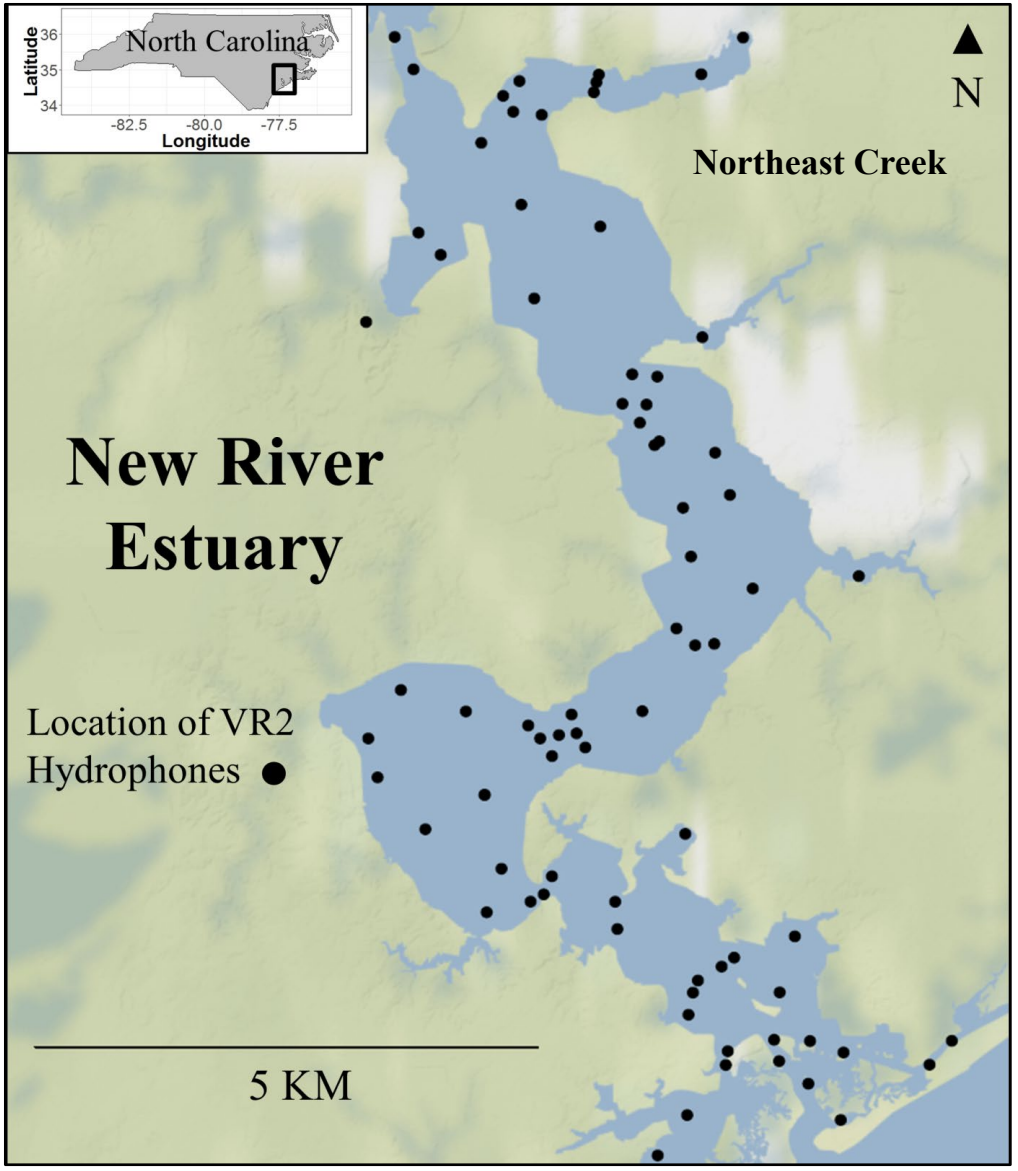
1) **Maturity schedules may display latitudinal gradient**
   - Mature at younger ages and smaller sizes at lower latitudes? Less size dependence?
2) **Spatial variation in growth and natural mortality?**



Midway and Scharf 2012

Estuarine habitat use and migration dynamics

- Monitored habitat use and movements of electronically tagged fish
- Multiple spatial and temporal scales
- Modeled influence of environmental features on behavior



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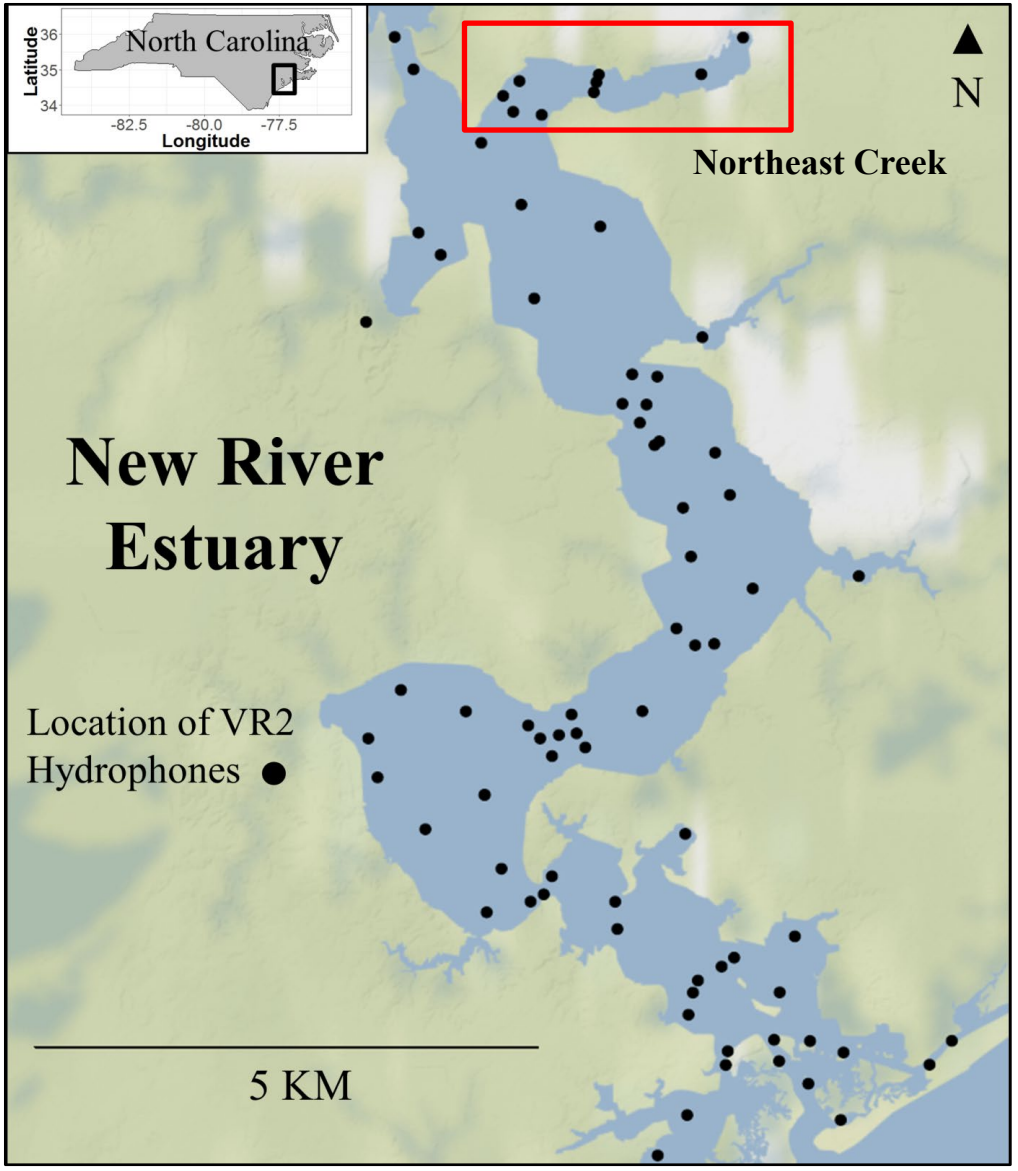

Estuarine habitat use and migration dynamics

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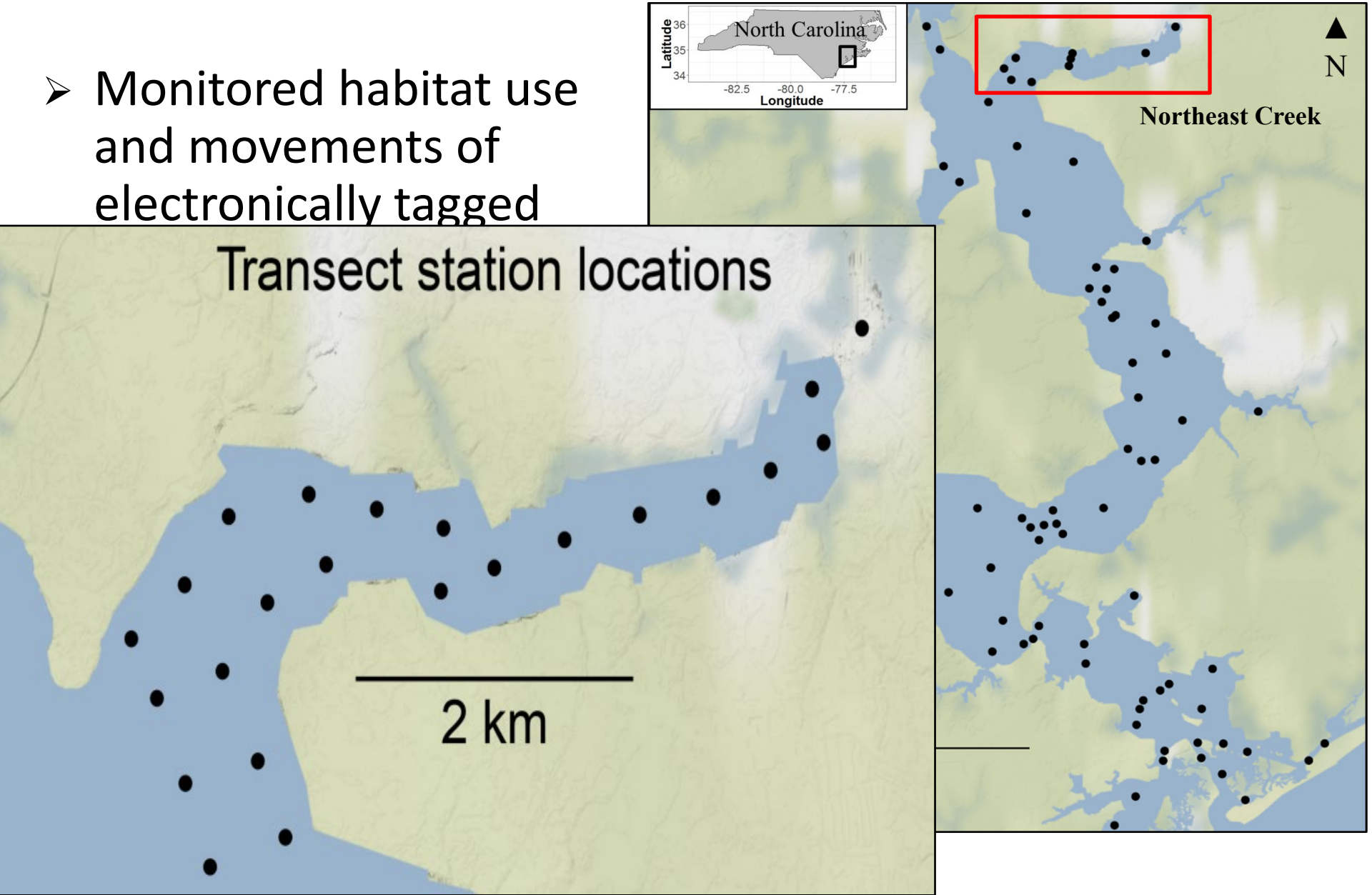
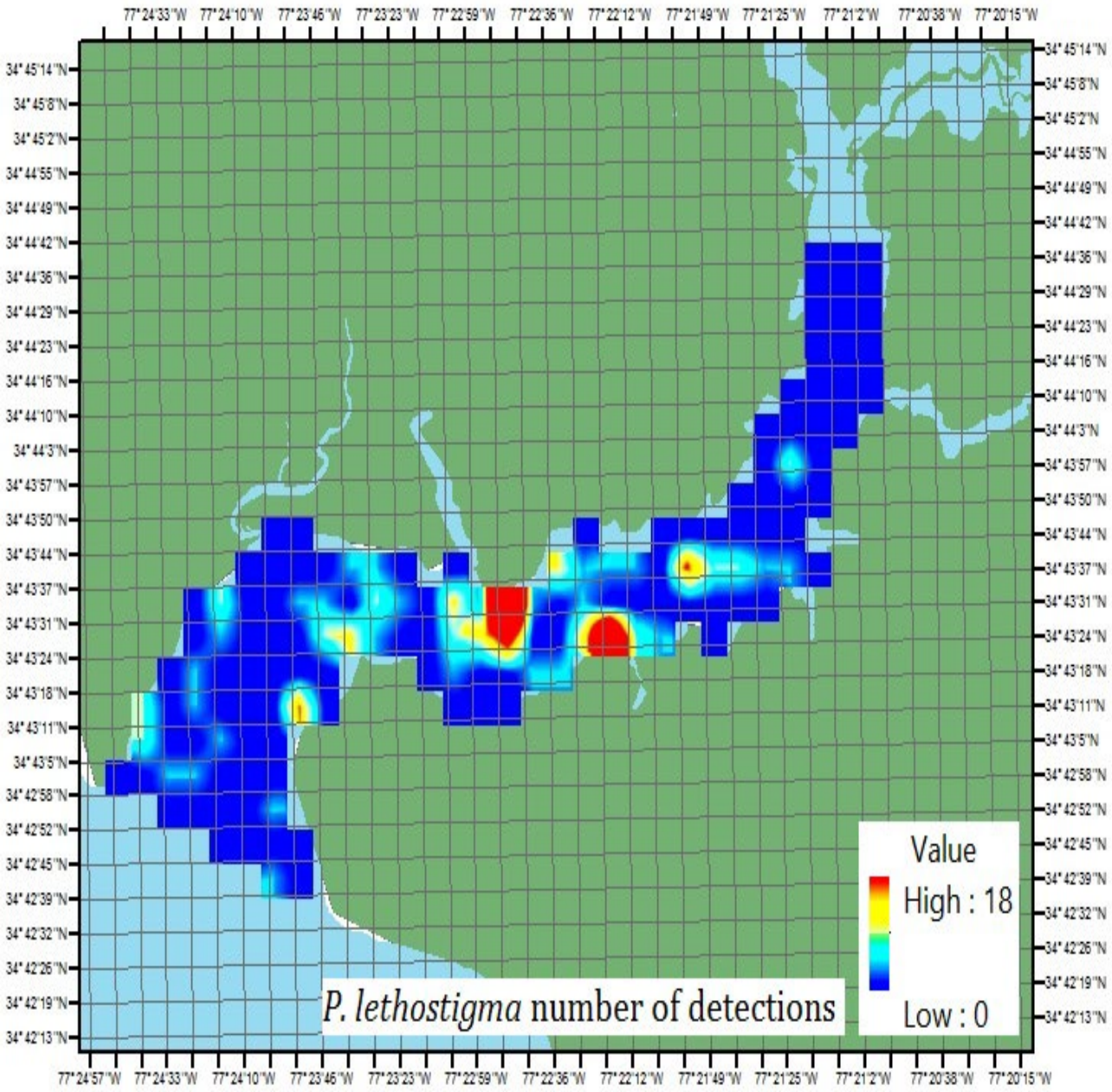




Flounder habitat use

Consistent areas of aggregation for several months

Individual movement

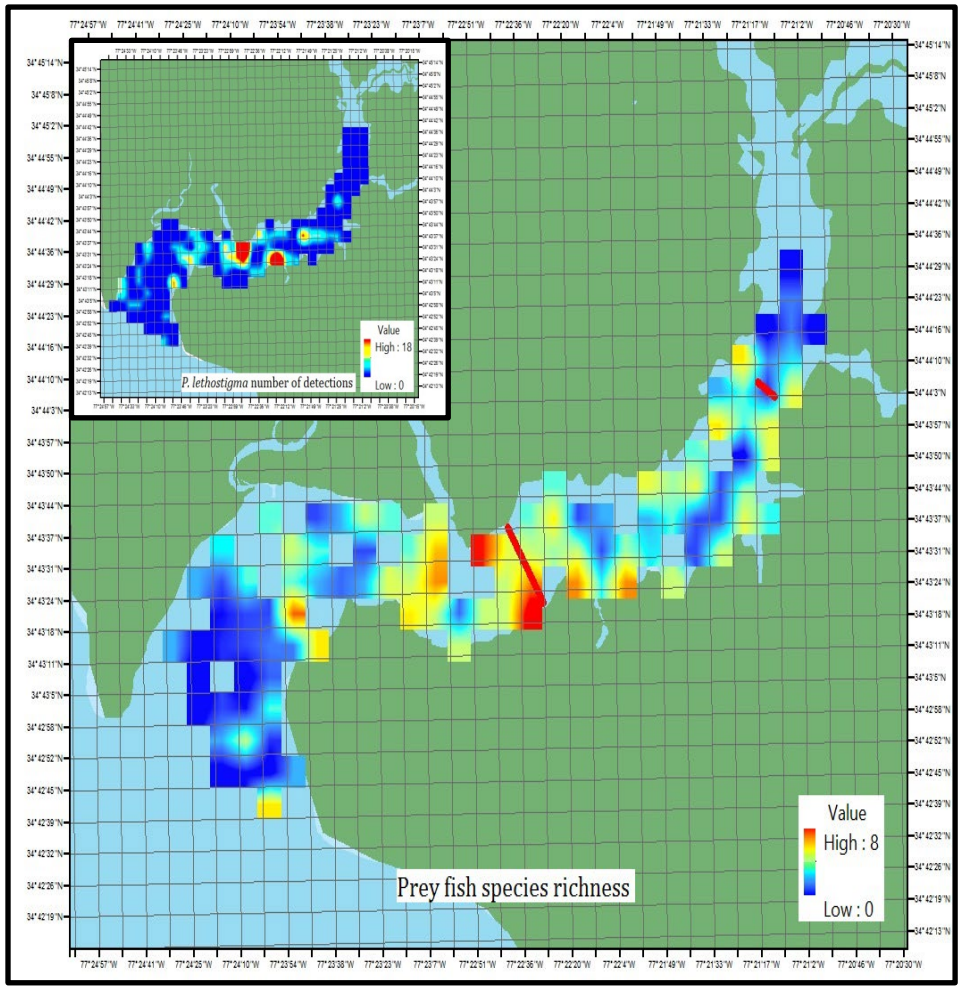
Flounder displayed low activity throughout the summer and early fall

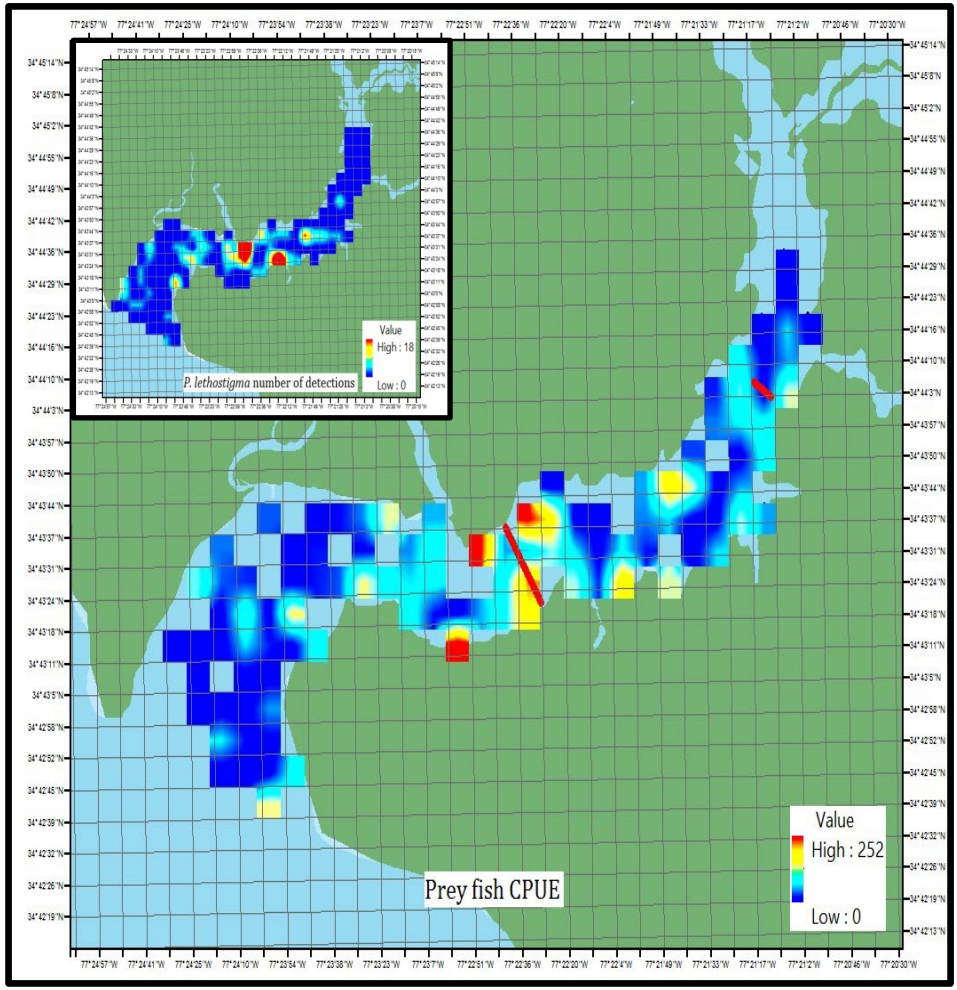
Many individuals remained within 1km x 1km spaces for >100 days

Hollensead, Messenger, & Scharf in prep

Habitat associations

Flounder were strongly associated with areas of high prey fish diversity and abundance

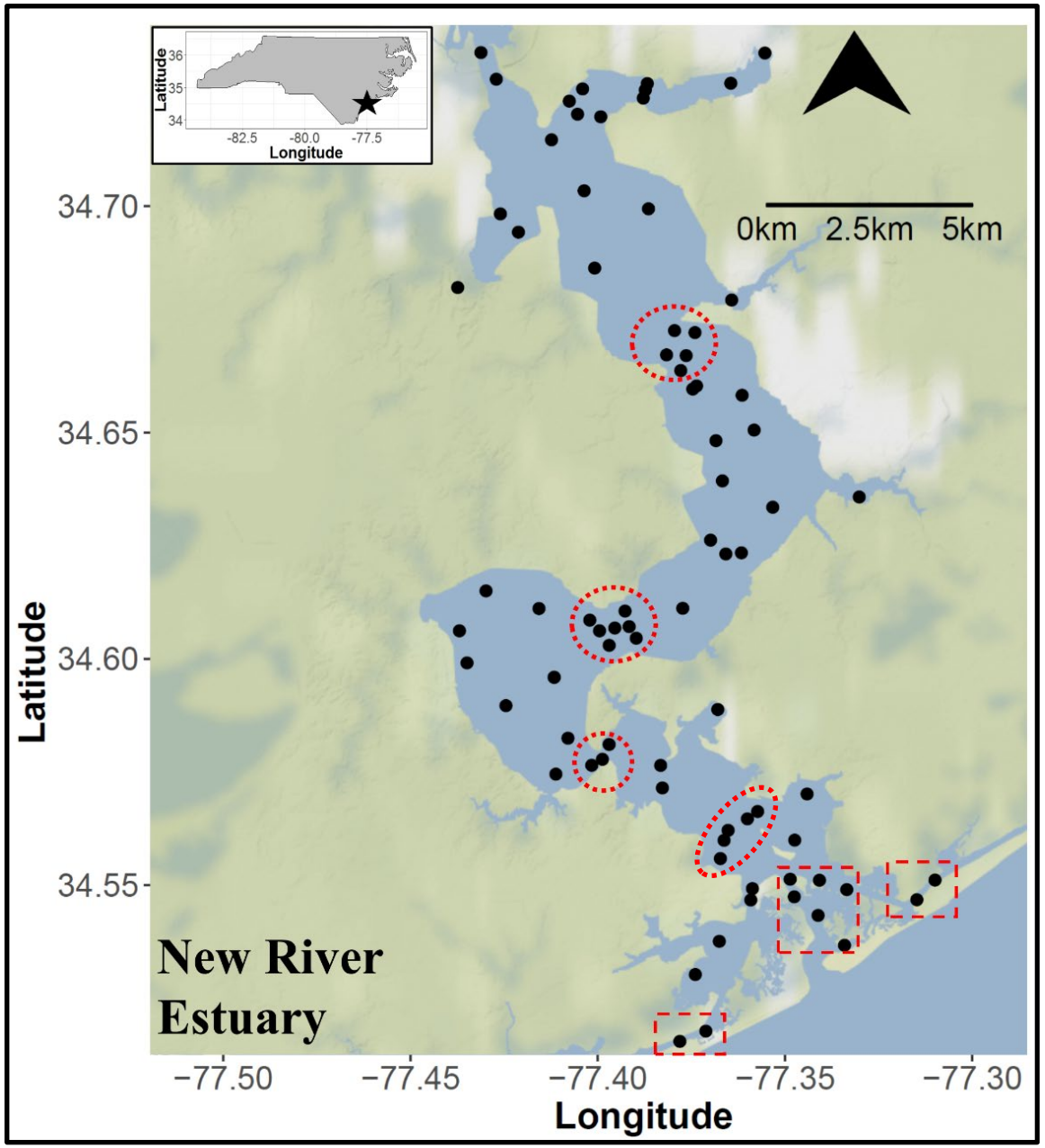




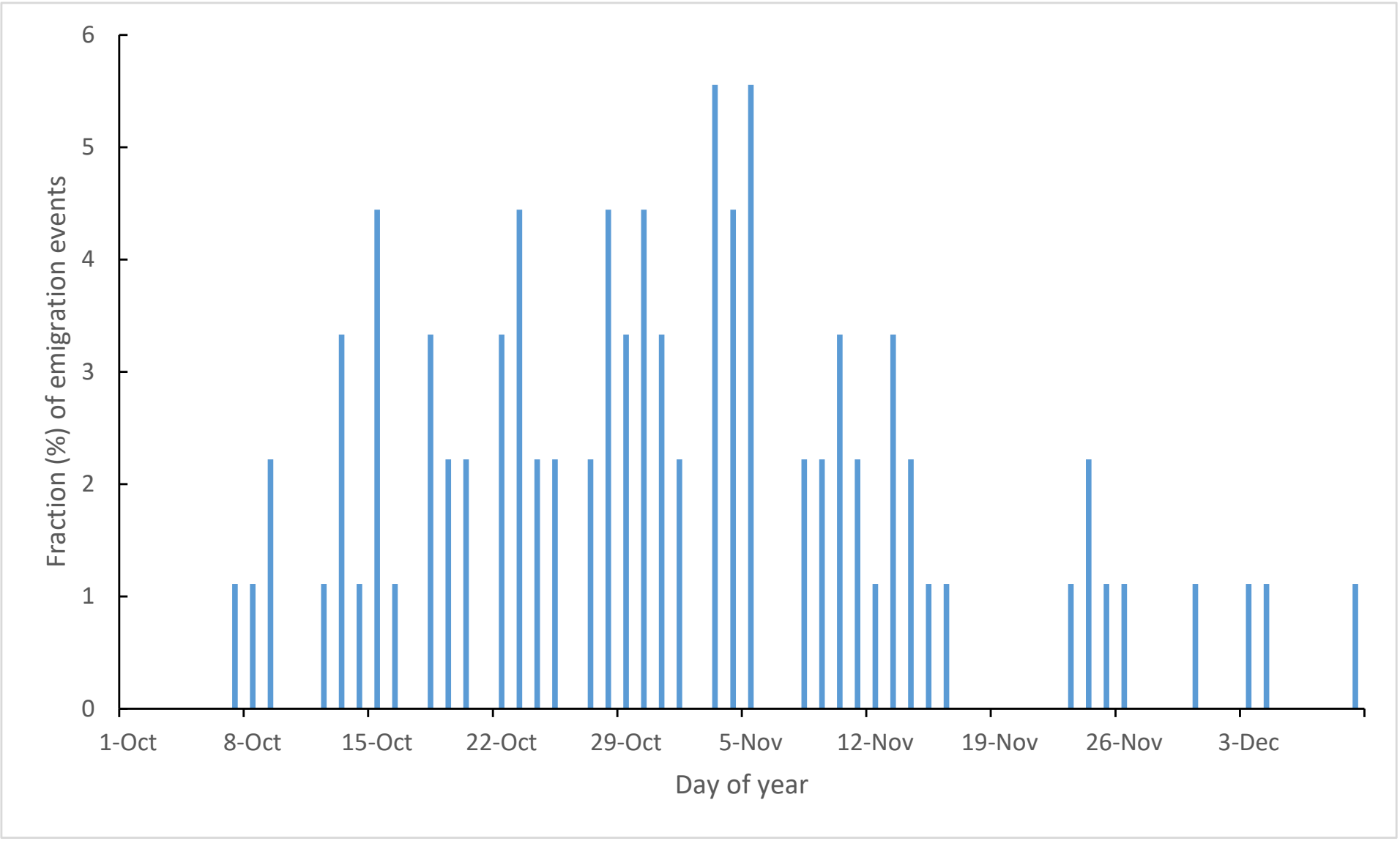
Hollensead, Messenger, & Scharf in prep

Detecting migration events

- Natural migration corridors
- Multiple hydrophones to build redundancy
- Estimation of detection efficiency

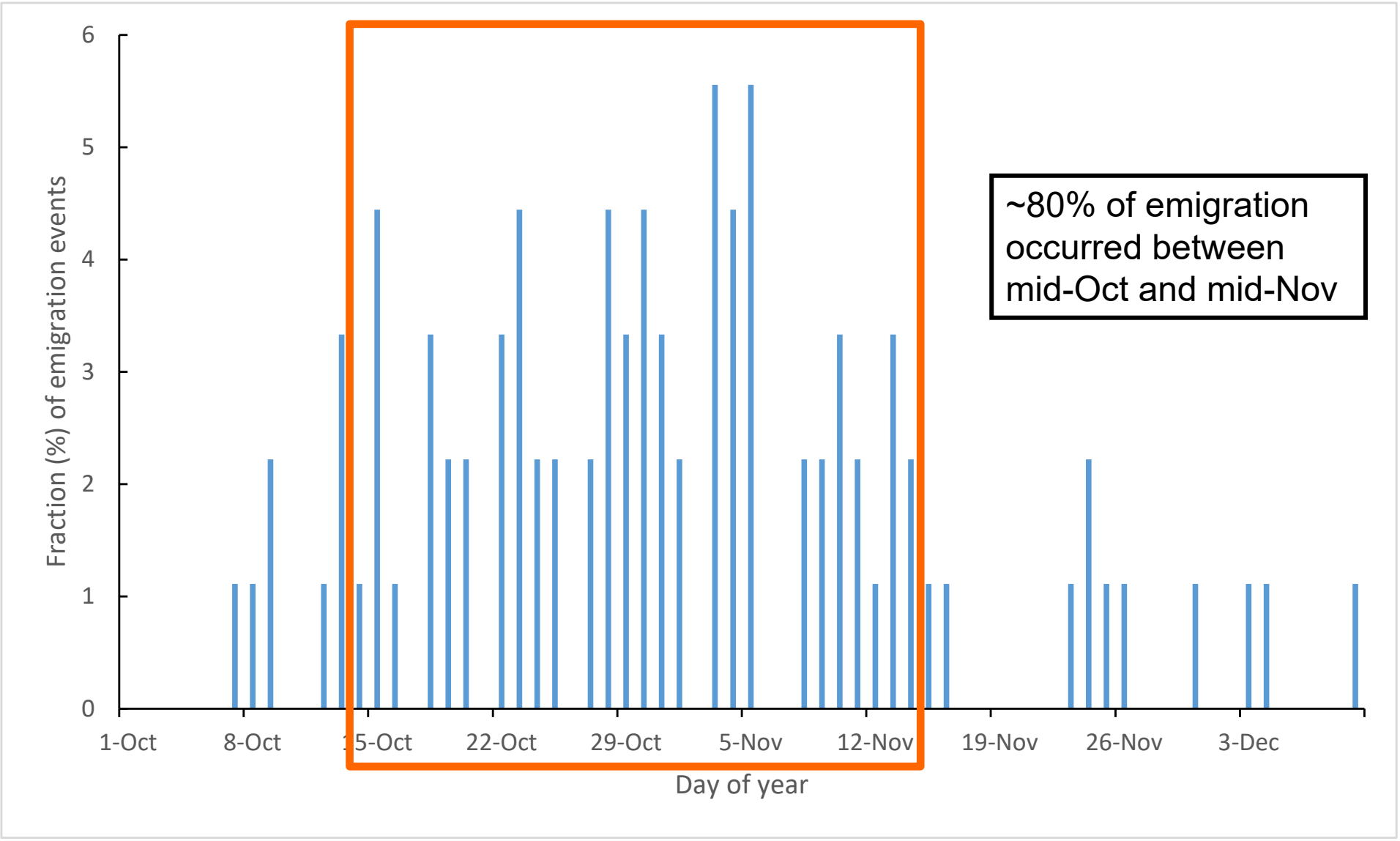


Estuarine emigration timing = consistent and predictable



Hollensead, White, & Scharf in prep

Estuarine emigration timing = consistent and predictable



Hollensead, White, & Scharf in prep

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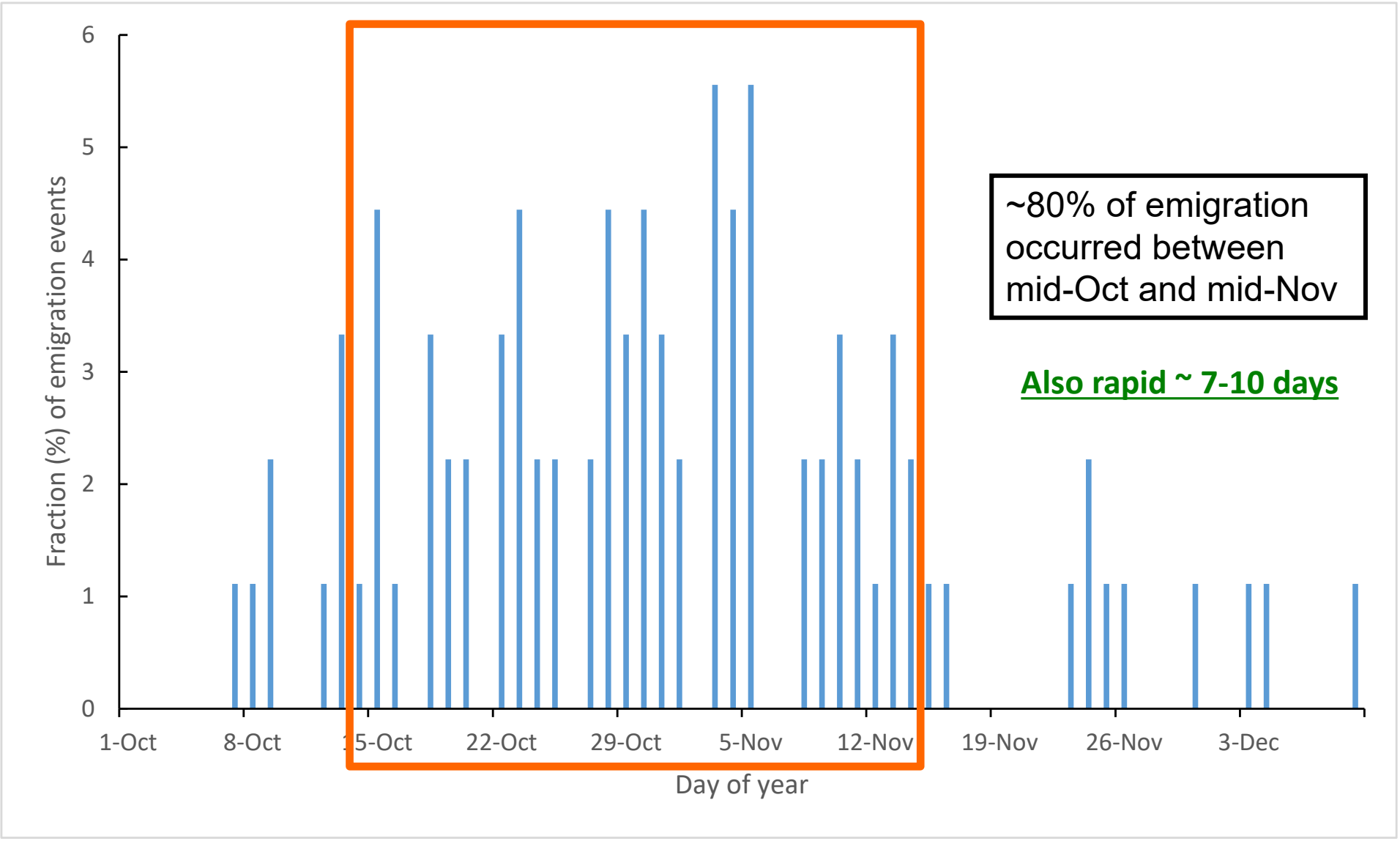
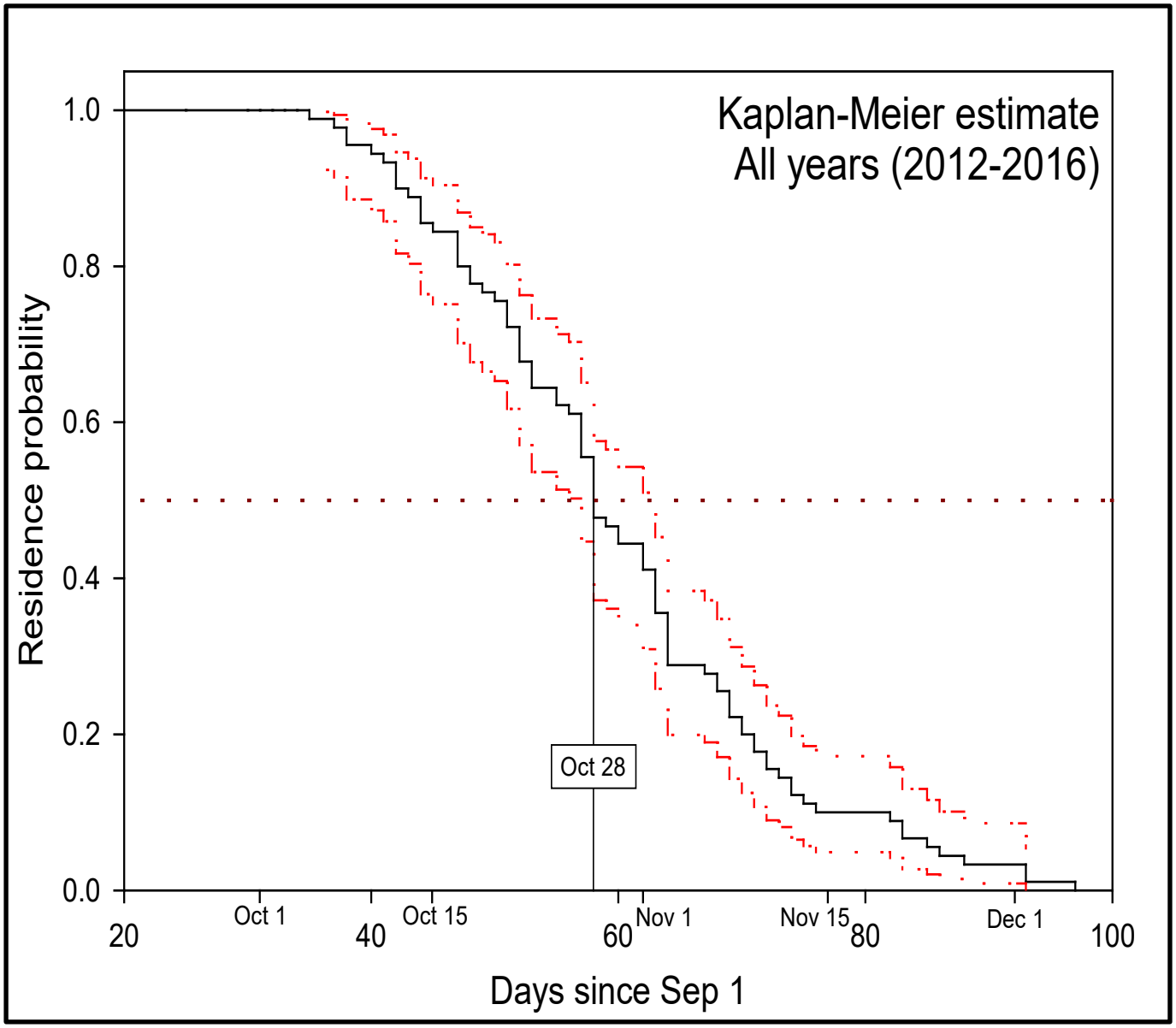


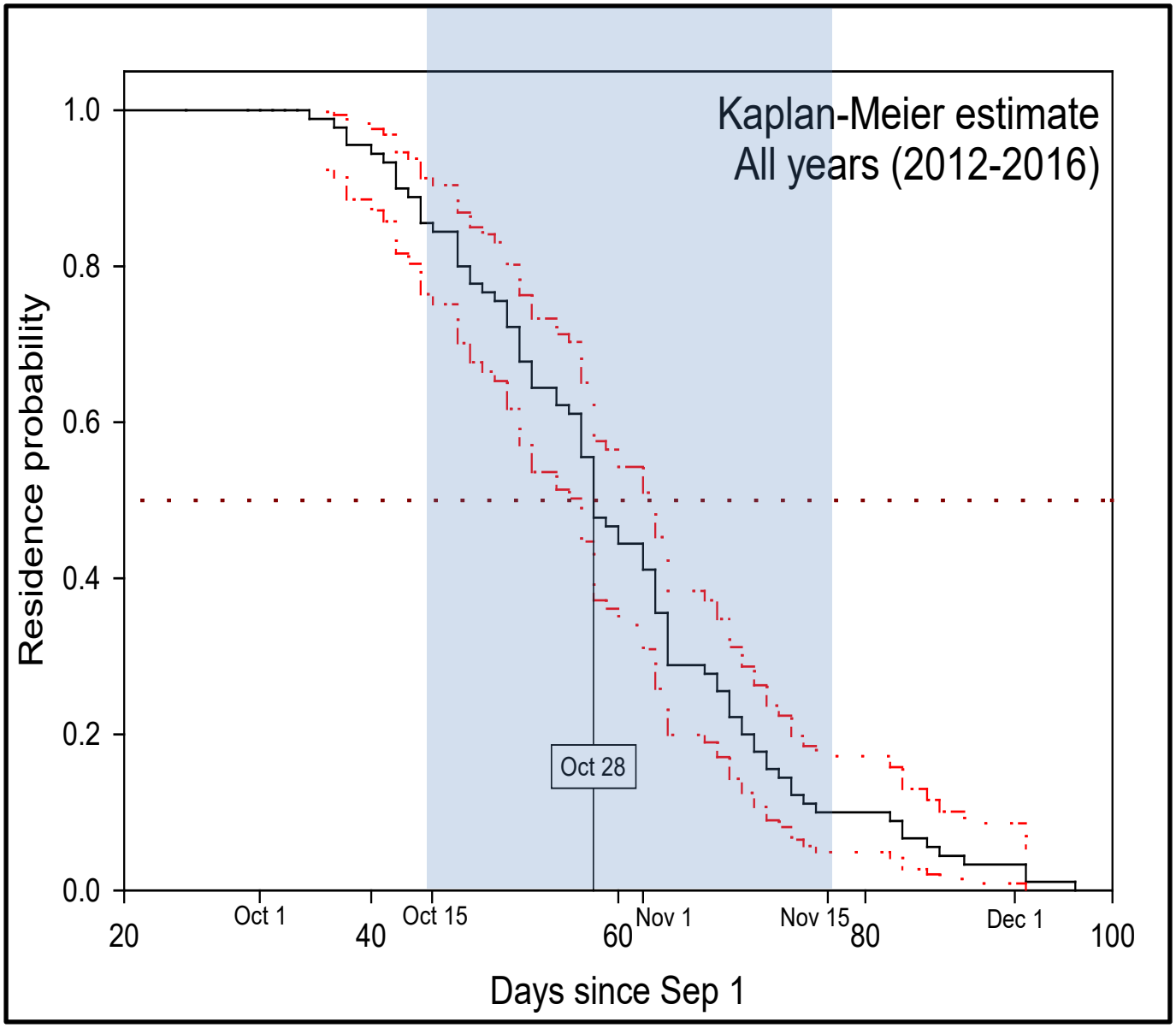
Hollensead, White, & Scharf in prep

Southern flounder emigration timing



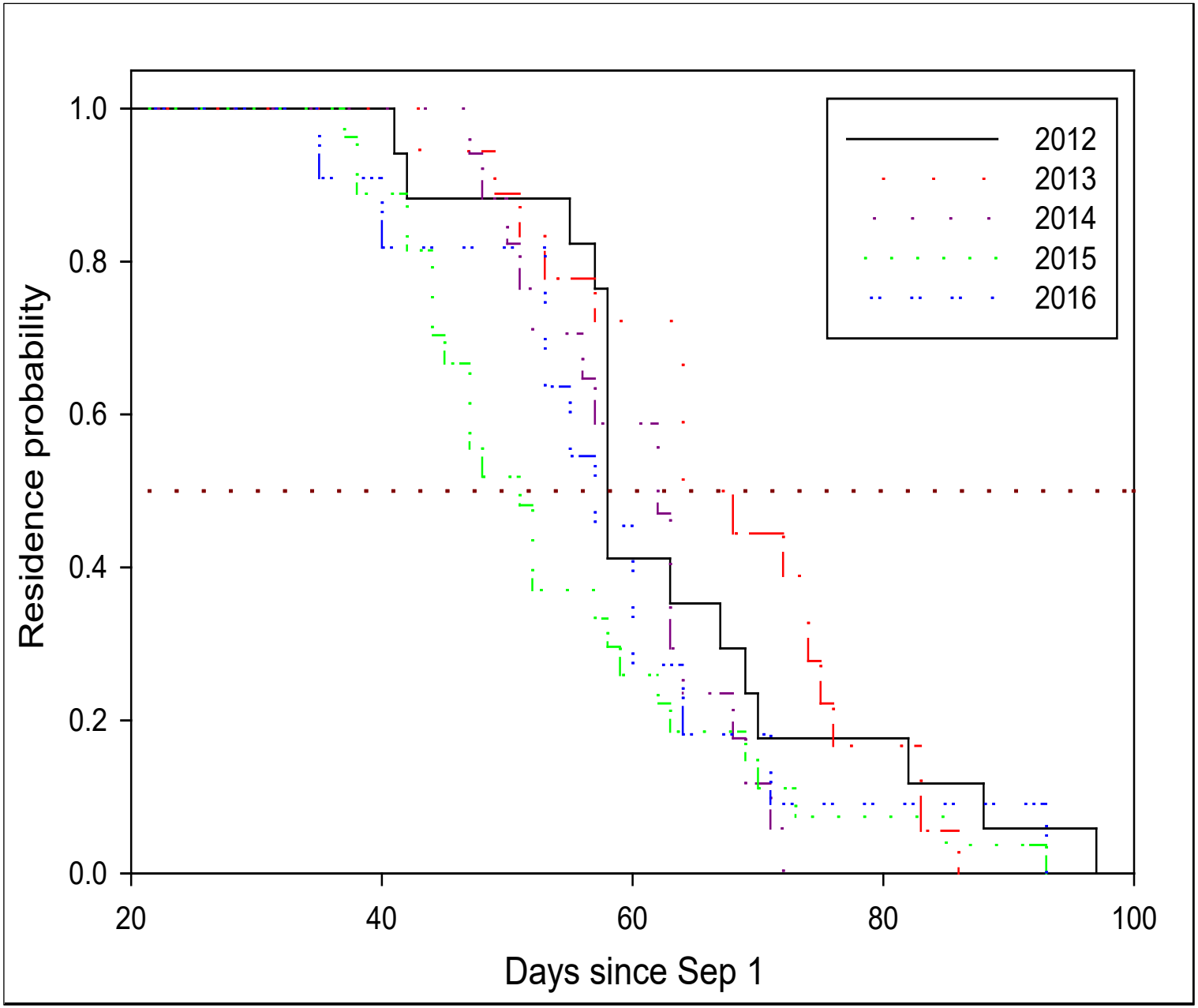
Hollensead, White, & Scharf in prep

Southern flounder emigration timing



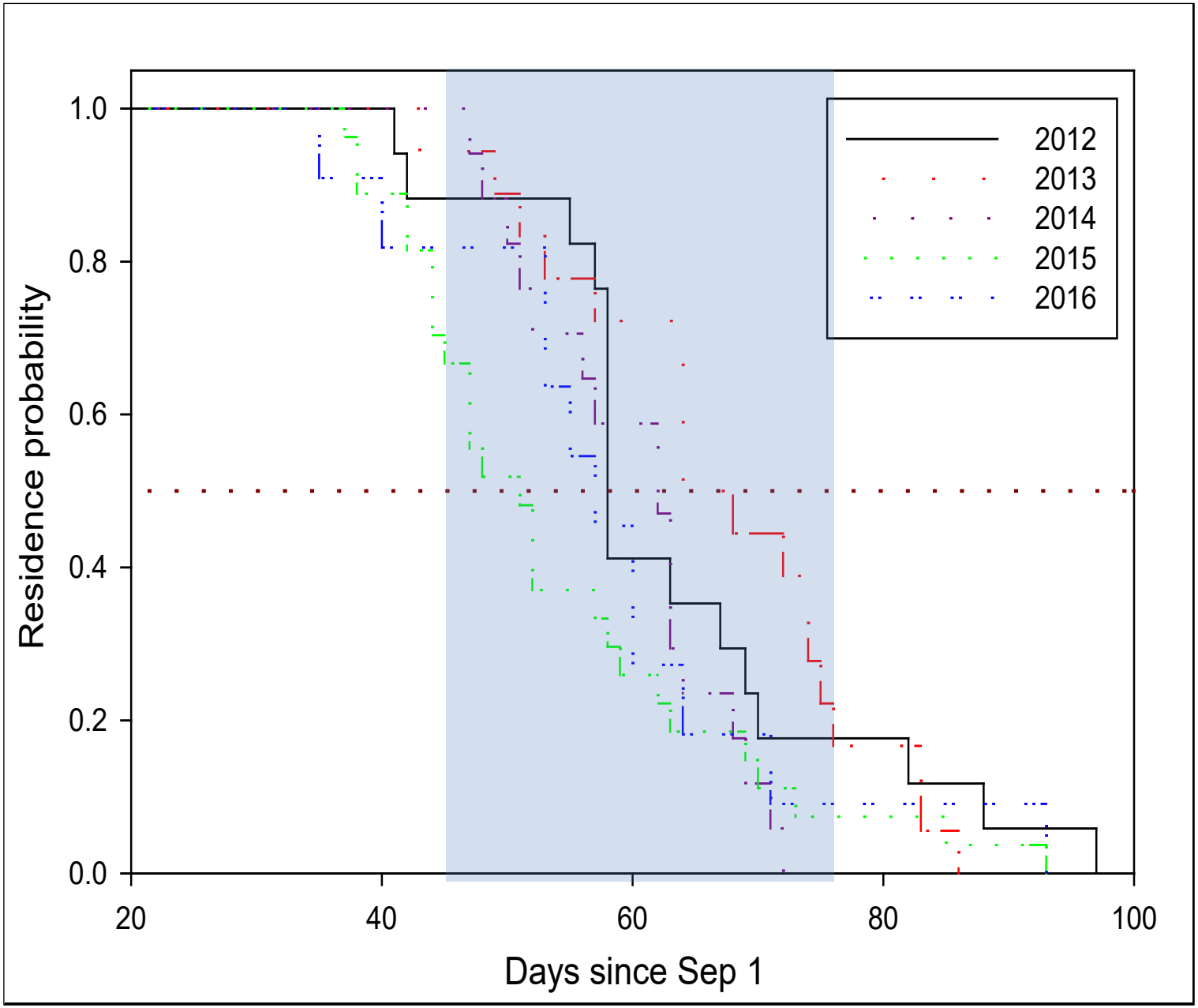
Hollensead, White, & Scharf in prep

Interannual variation in emigration timing



Hollensead, White, & Scharf in prep

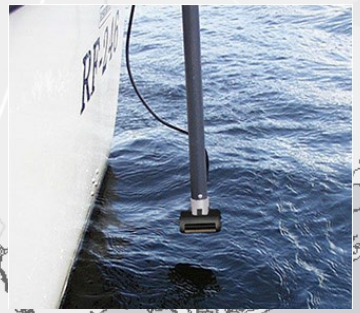
Interannual variation in emigration timing

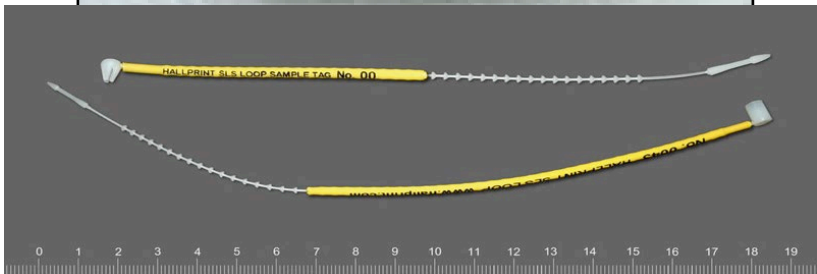


Hollensead, White, & Scharf in prep

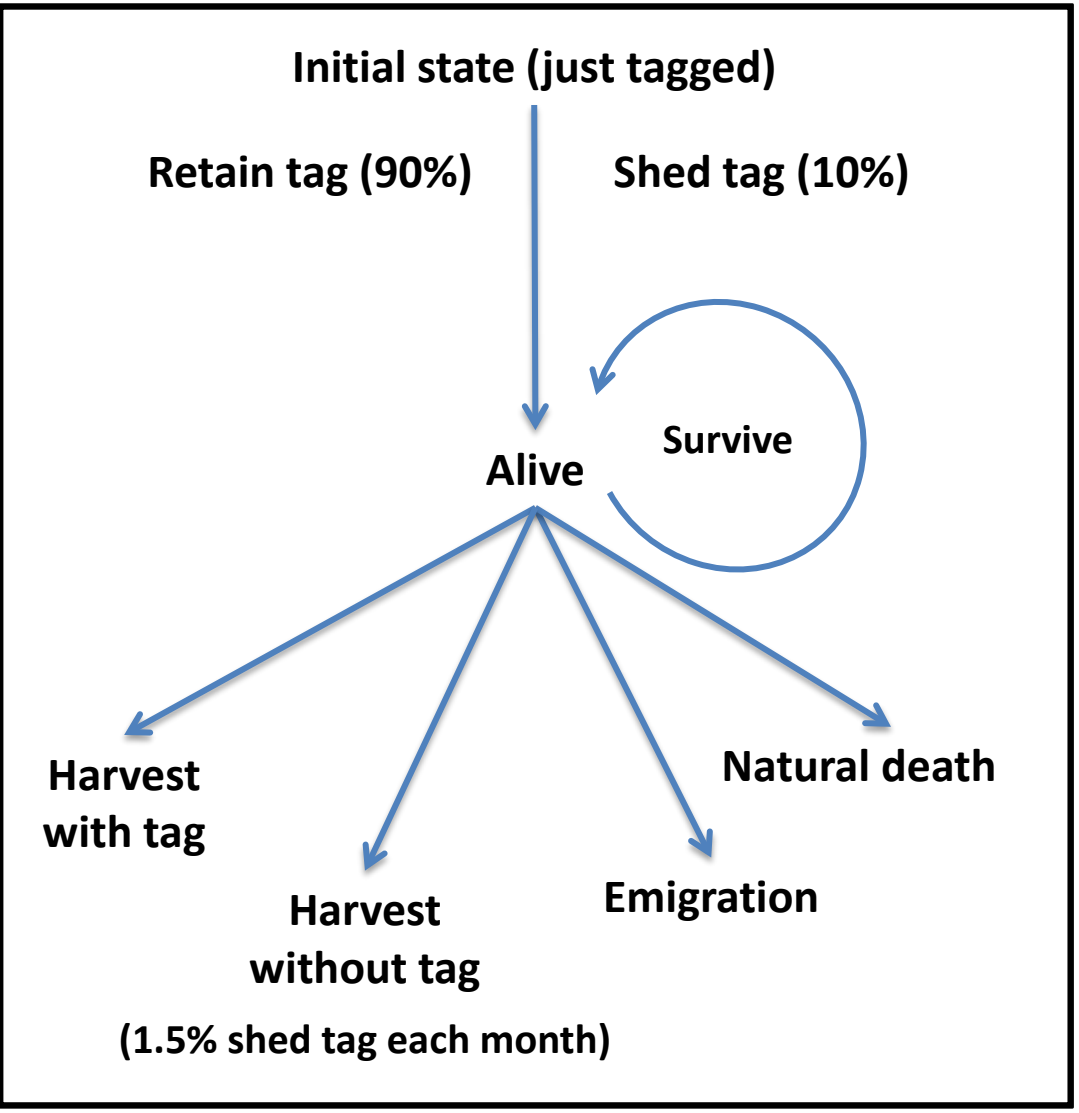
Fates of southern flounder in NC waters

- Tracked 3 annual cohorts (2014 – 2016)
- Acoustic tracking
  - Single estuary
- Conventional tagging
  - statewide



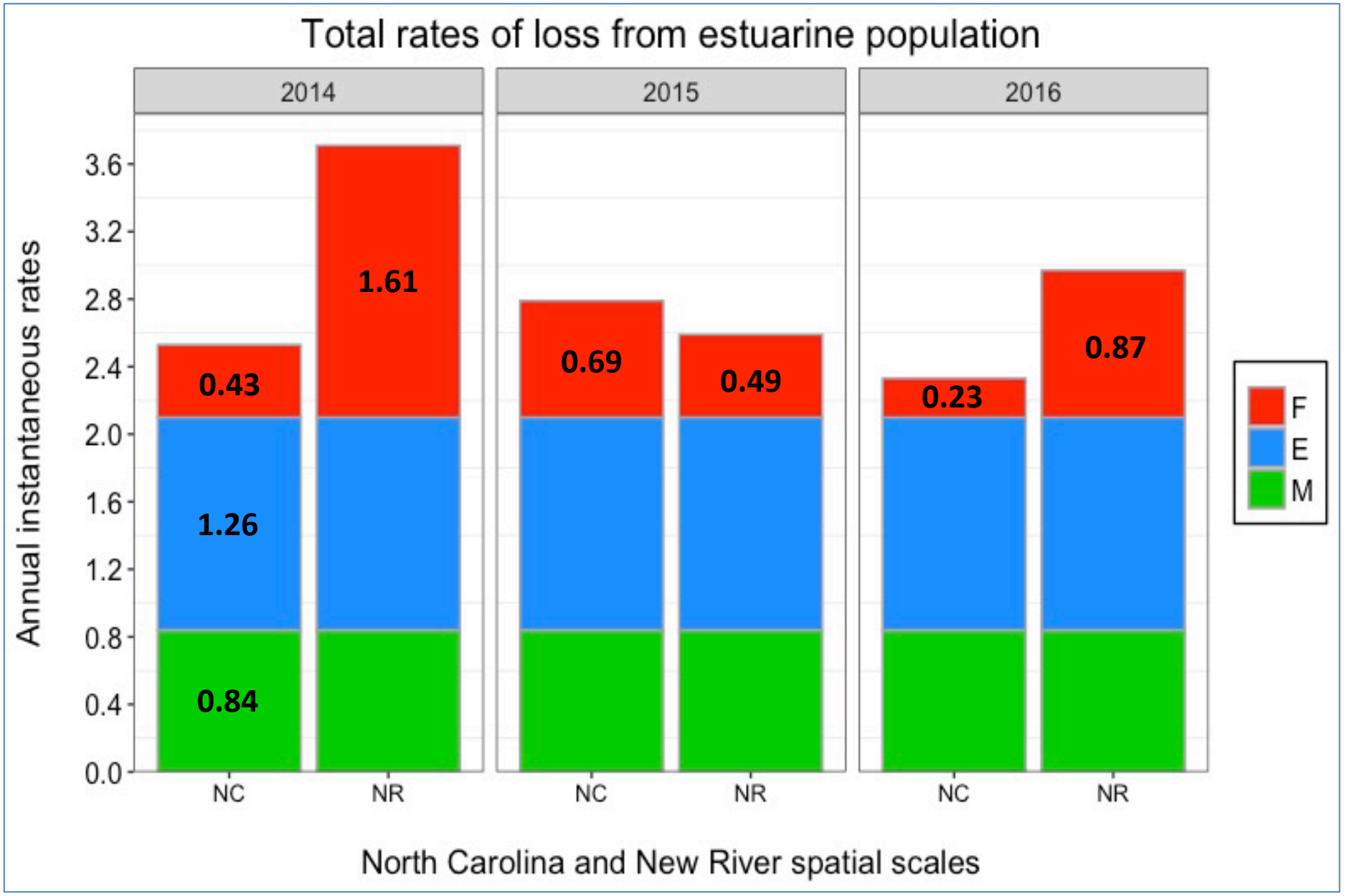


Multistate capture-recapture model



- Monthly time-step:
  Jul 2014 – Dec 2016
- Double tagging + high reward tags
- Assumed 100% detection of harvest (F) and emigration (E)
- Estimated instantaneous rates of F, M, E as separate components of loss

Scheffel, Hightower, Buckel, Krause & Scharf 2020



Scheffel, Hightower, Buckel, Krause & Scharf 2020

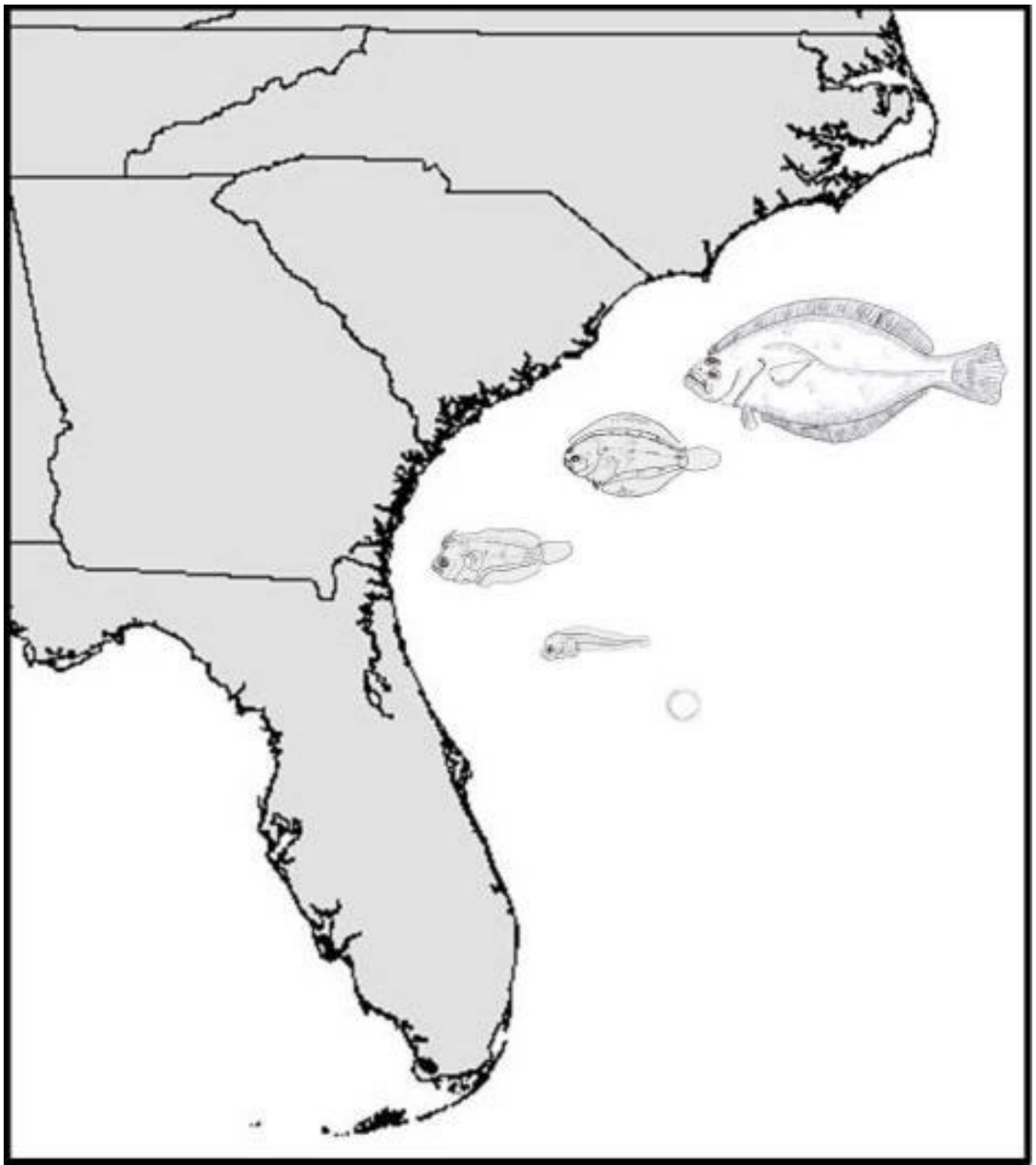
1) **Limited estuarine movements paired with rapid and extensive migration with consistent timing**

2) **Emigration accounts for large fraction of total loss from inshore waters**

3) **Sources and size-dependence of natural mortality?**

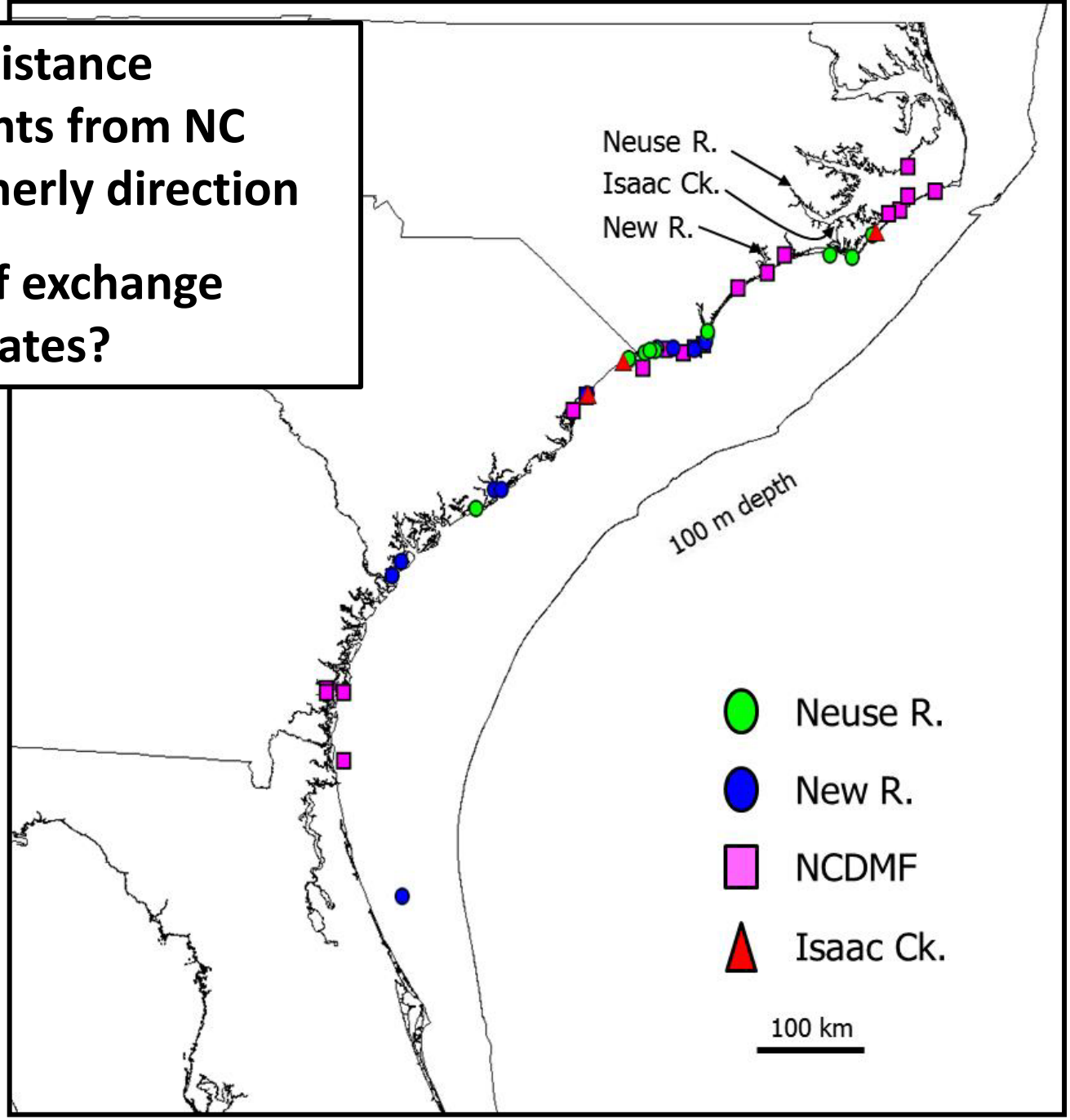
Scheffel, Hightower, Bacher, Krause & Scharf 2020

Extent and spatial scale of stock mixing in the ocean



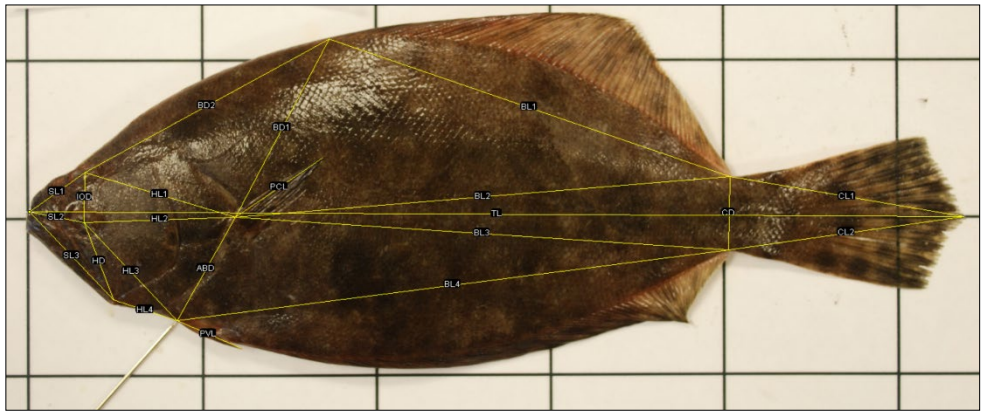
All long distance movements from NC in a southerly direction

Degree of exchange among states?



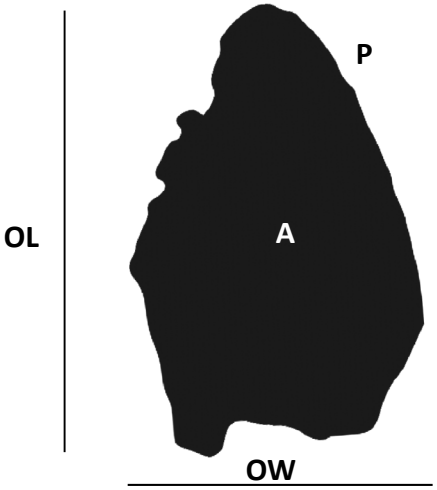
Craig, Smith, Scharf & Monaghan 2015

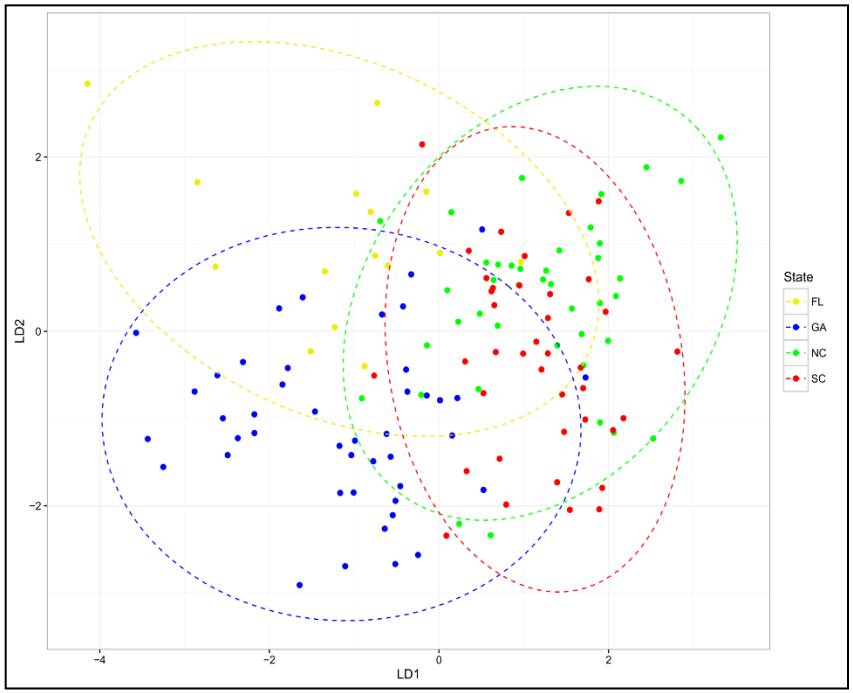
Otolith and whole body morphometrics



Low reclassification success

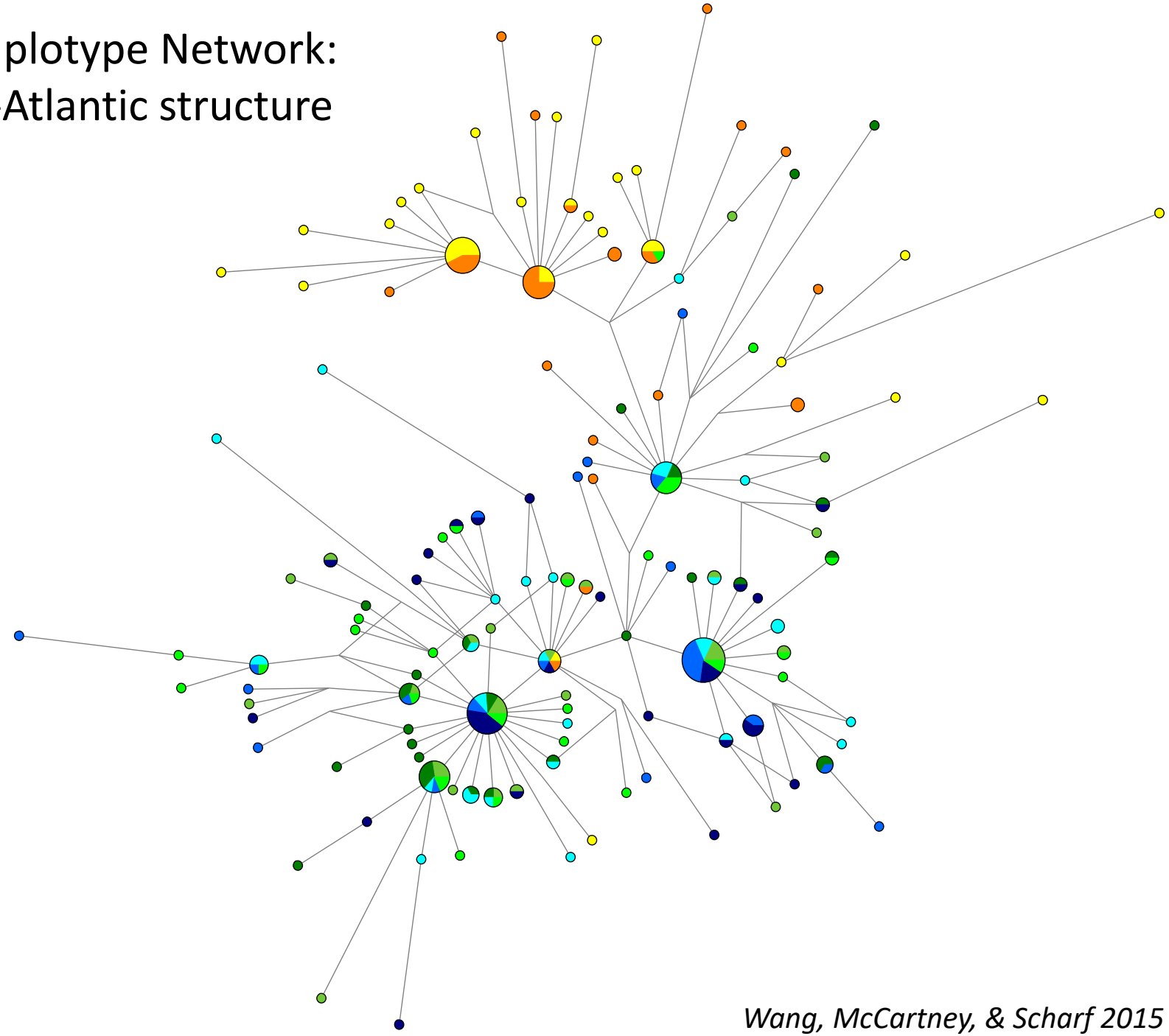
Stock mixing in the US South Atlantic





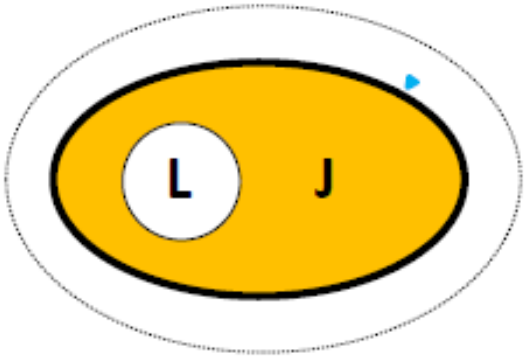
Midway, Cadrin, & Scharf 2014
Wiese 2016

mtDNA Haplotype Network:
No within-Atlantic structure



Wang, McCartney, & Scharf 2015

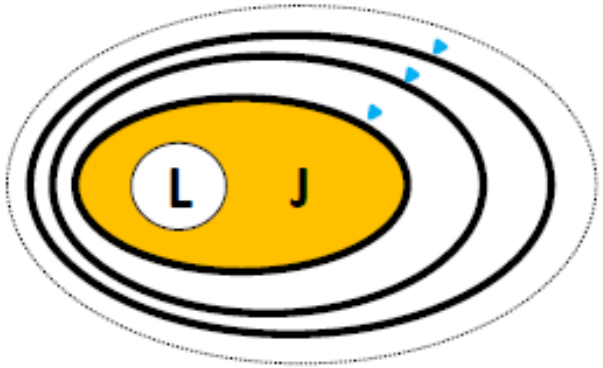
1. Nursery atlas of otolith chemical signatures



Pre-migration:

2011 year class – 1 year olds

2. Assigning adults to estuaries of origin

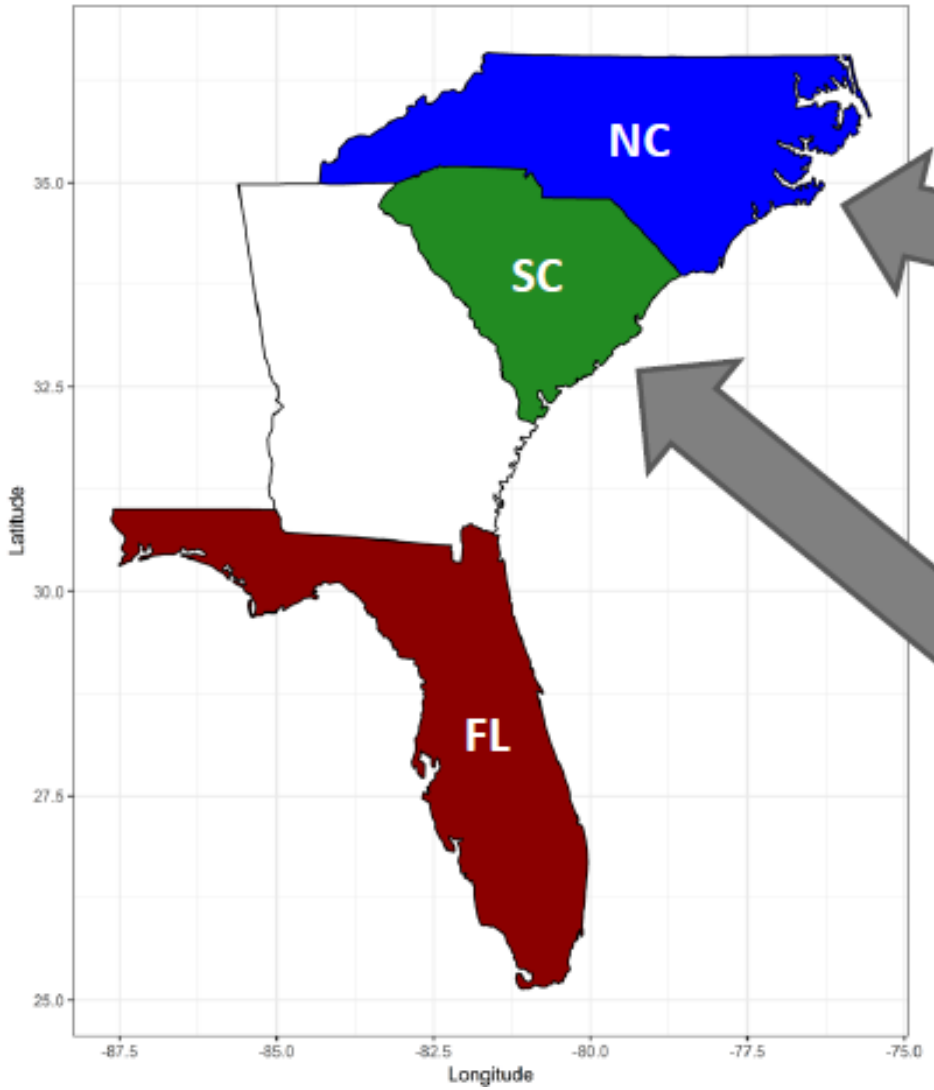


Post-migration:

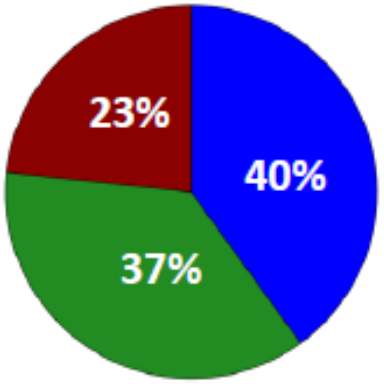
2011 year class – 3+ year olds

L	Larval core
J	Juvenile

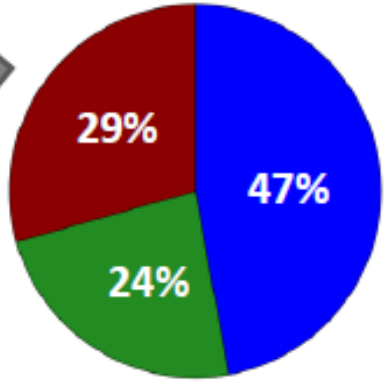
Predicted nursery origins suggest the potential for movement among states



Nursery origins



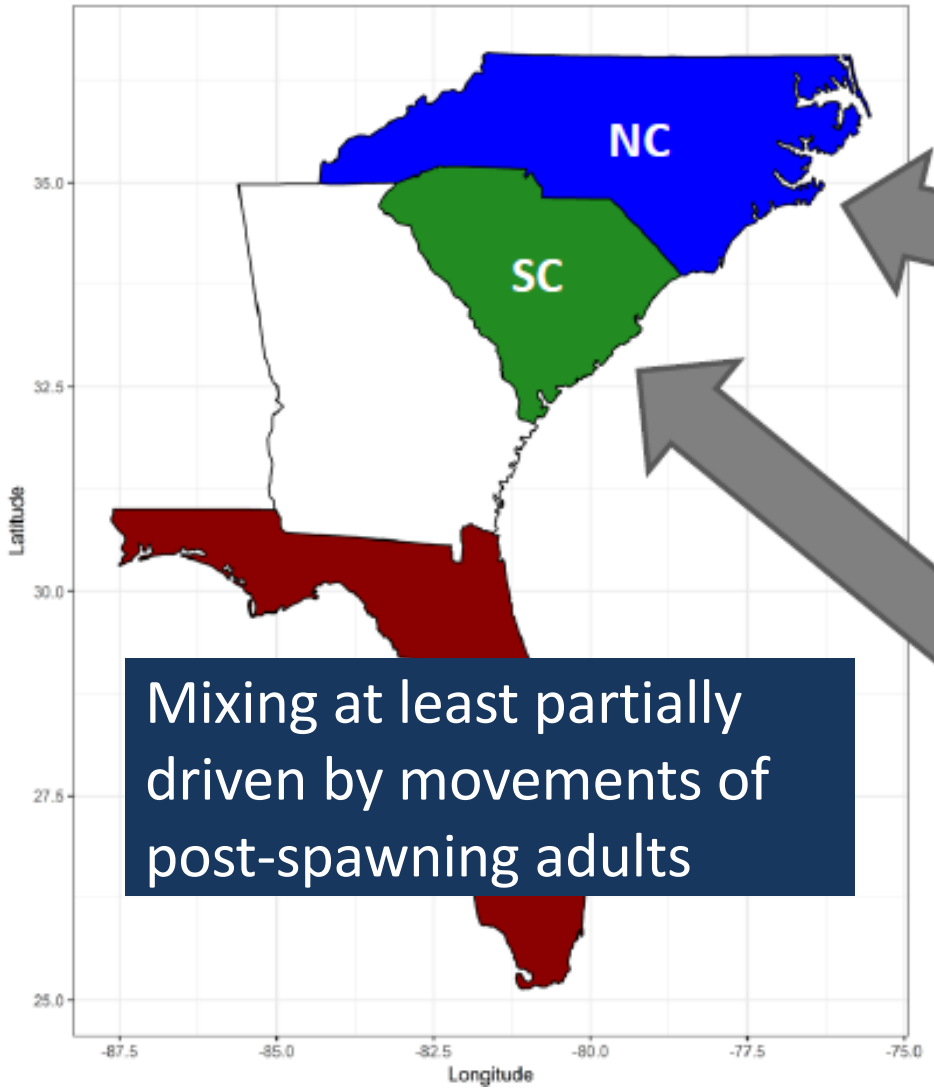
NC-captured adults



SC-captured adults

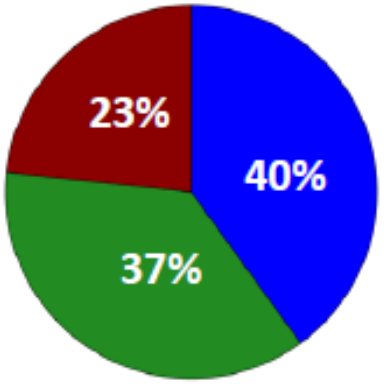
Wang, White, Arnott, & Scharf 2018

Predicted nursery origins suggest the potential for movement among states

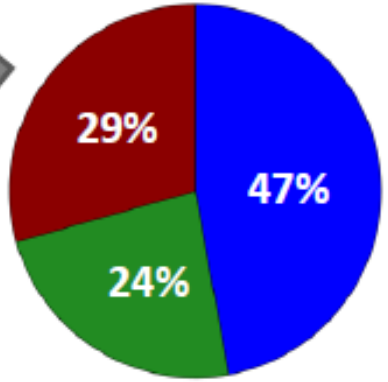


Mixing at least partially driven by movements of post-spawning adults

Nursery origins



NC-captured adults

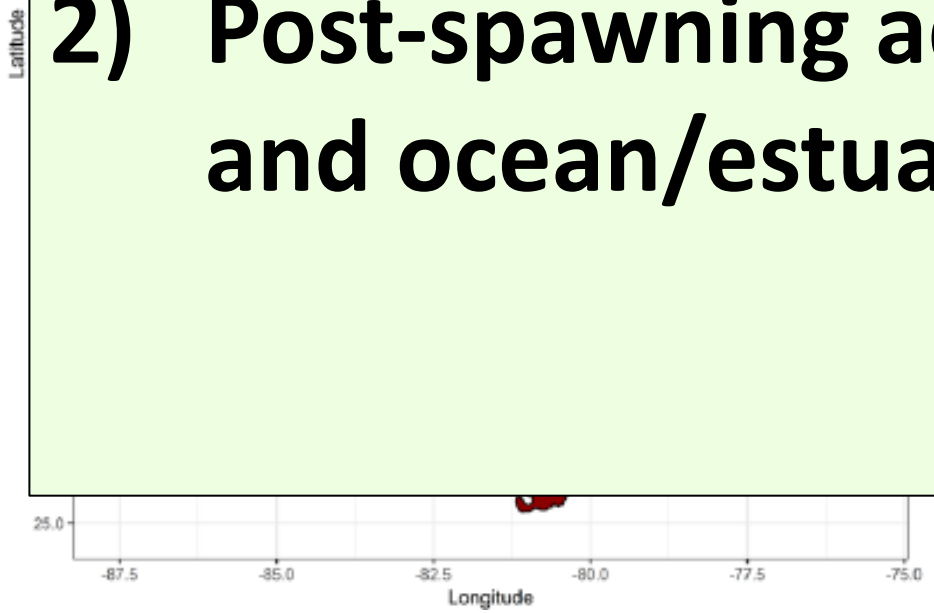


SC-captured adults

Wang, White, Arnott, & Scharf 2018

1) Cumulative evidence indicates extensive broad-scale mixing

2) Post-spawning adult movements and ocean/estuarine habitat use?



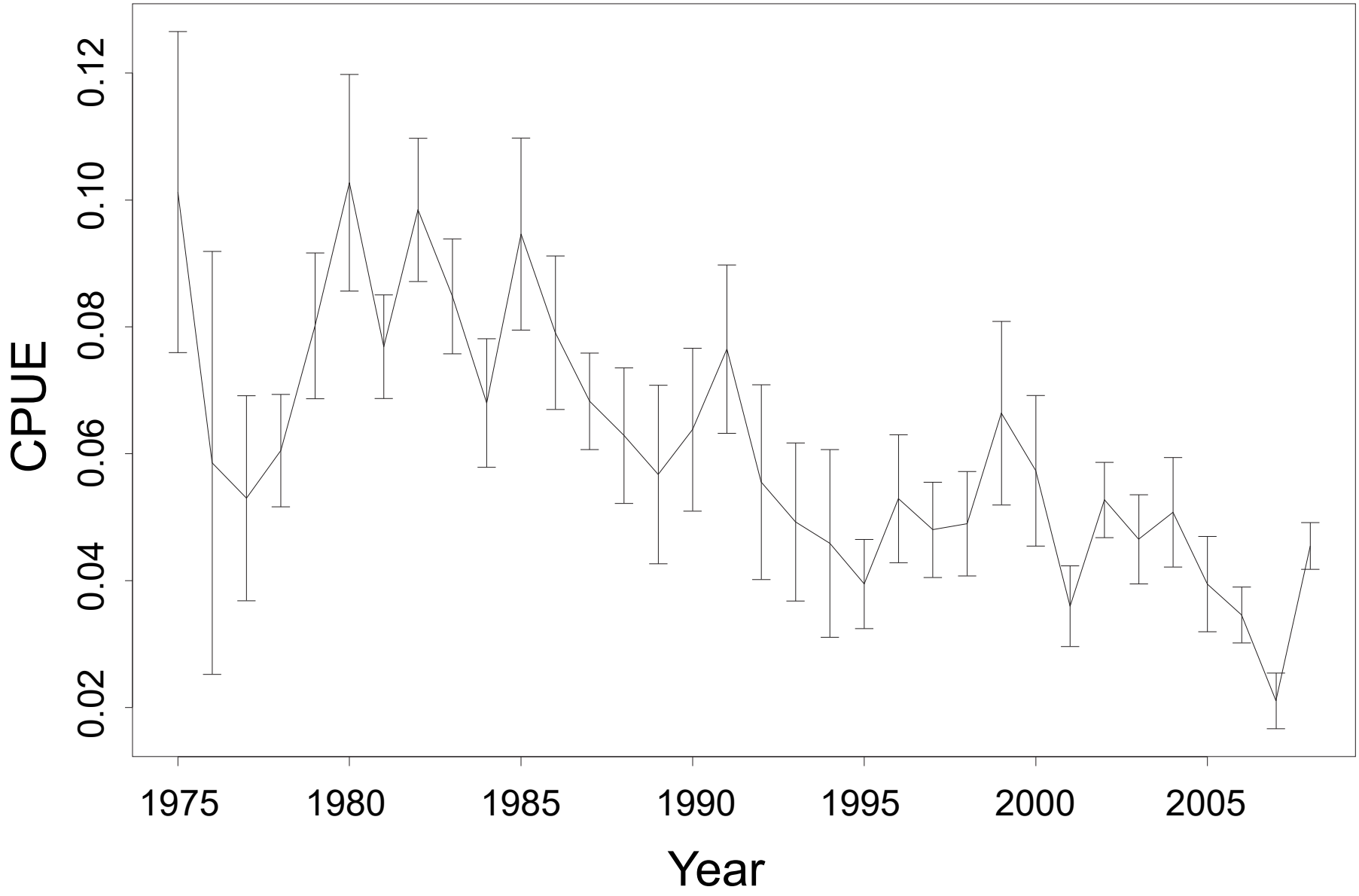
Wang, White, Arnott, & Scharf 2018

Stock dynamics of southern flounder

Outstanding questions

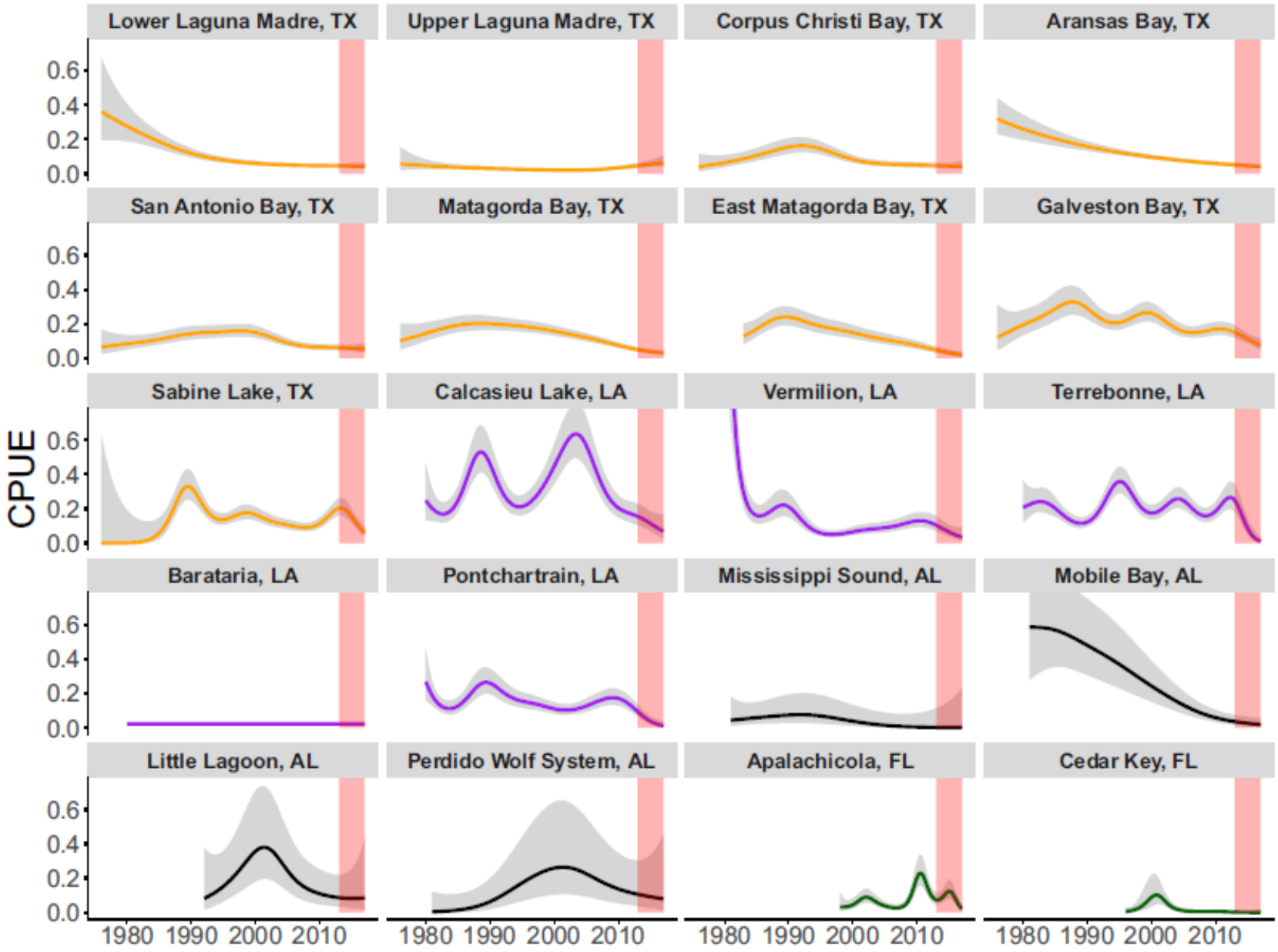
1) Offshore spawning locations
2) Conditions supporting larval success and transport
3) Impacts of estuarine settlement dynamics and contingents
4) Spatial scaling of life history traits
5) Dynamics of juvenile/sub-adult natural mortality
6) Extent of stock mixing and habitat use of post-spawn adults

Adult southern flounder abundance along the Texas coast



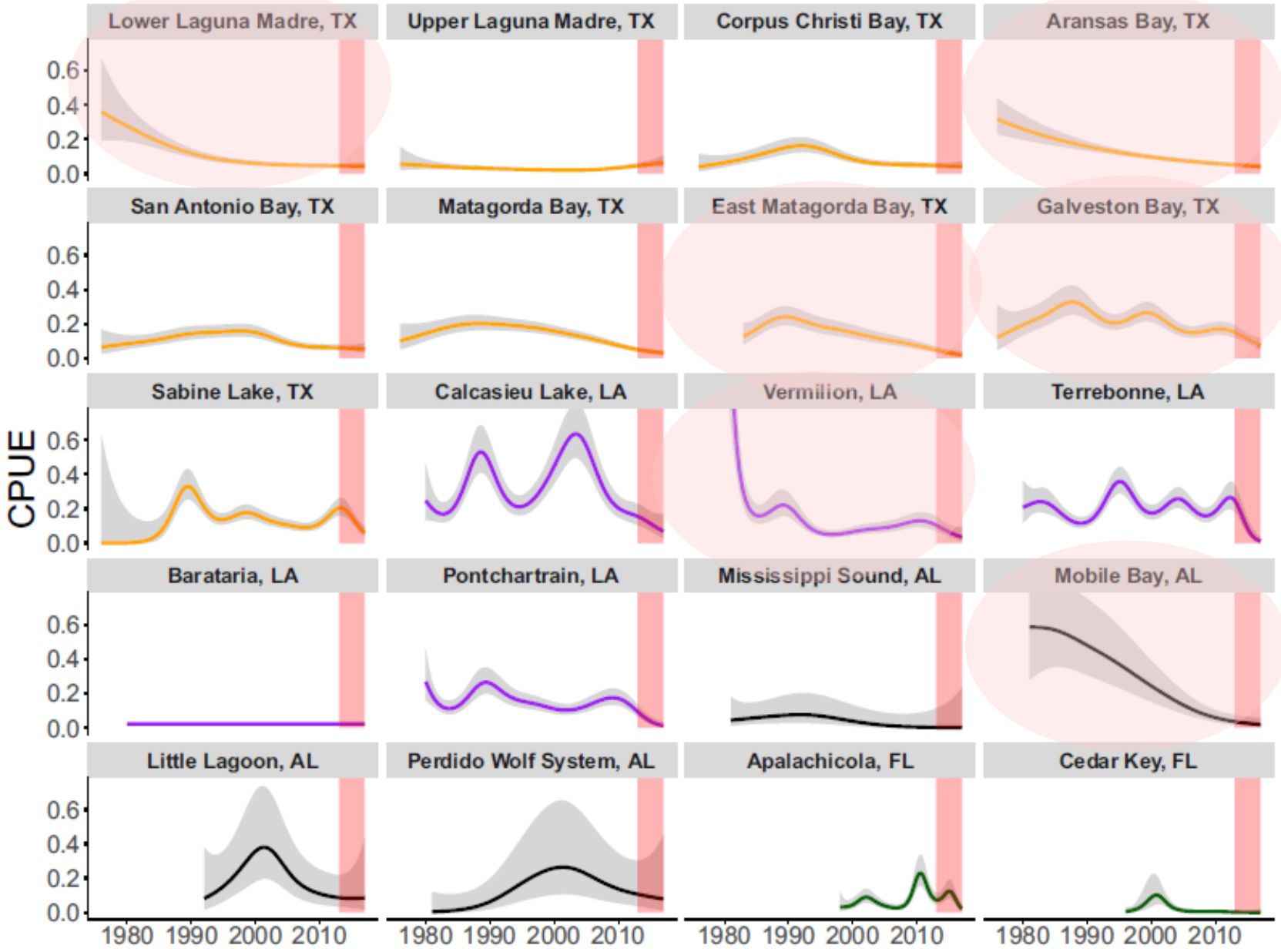
Reproduced from Froeschke et al. 2011

Juvenile southern flounder abundance in Gulf coast estuaries



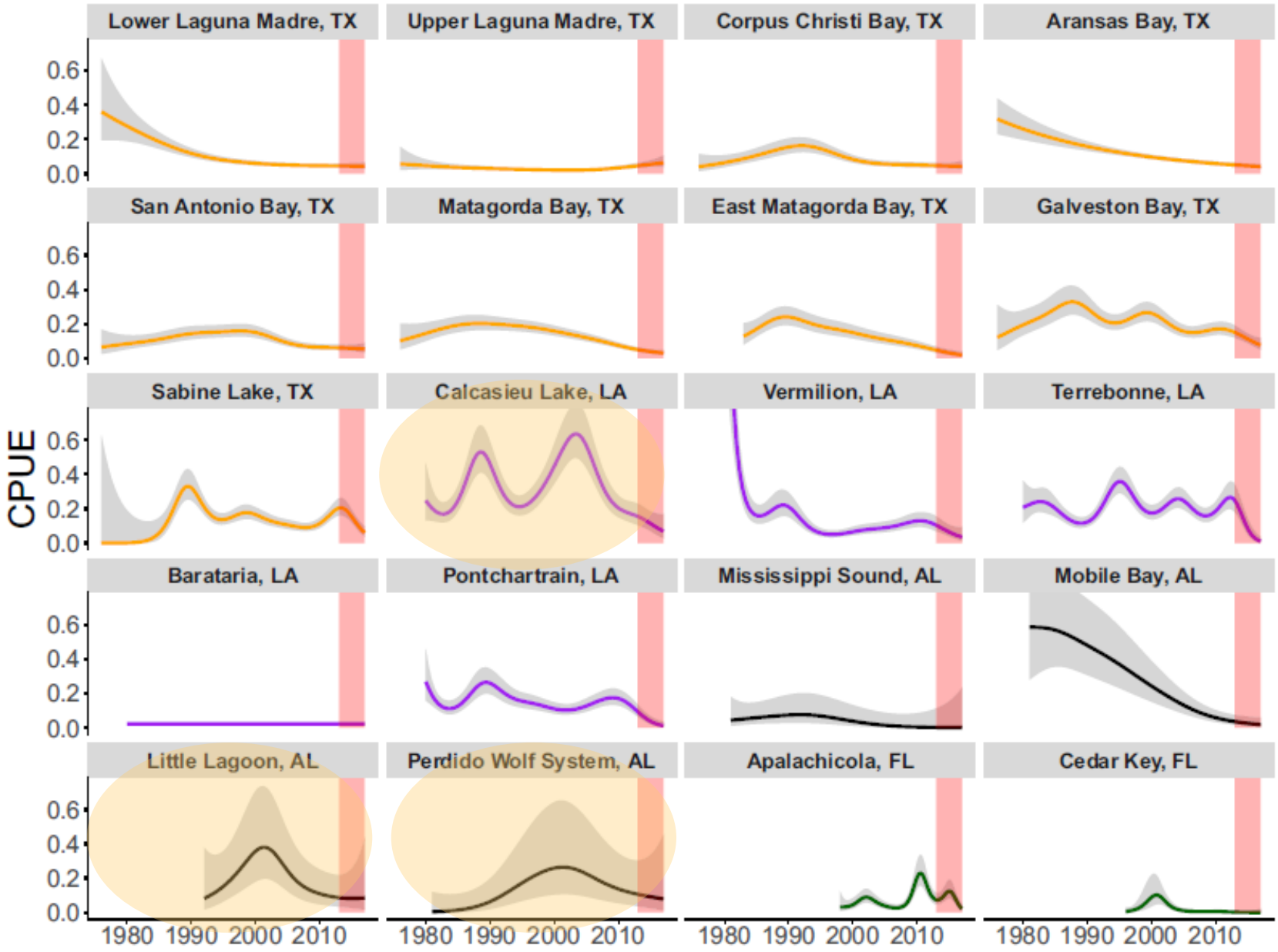
Erickson et al. 2021

Juvenile southern flounder abundance in Gulf coast estuaries



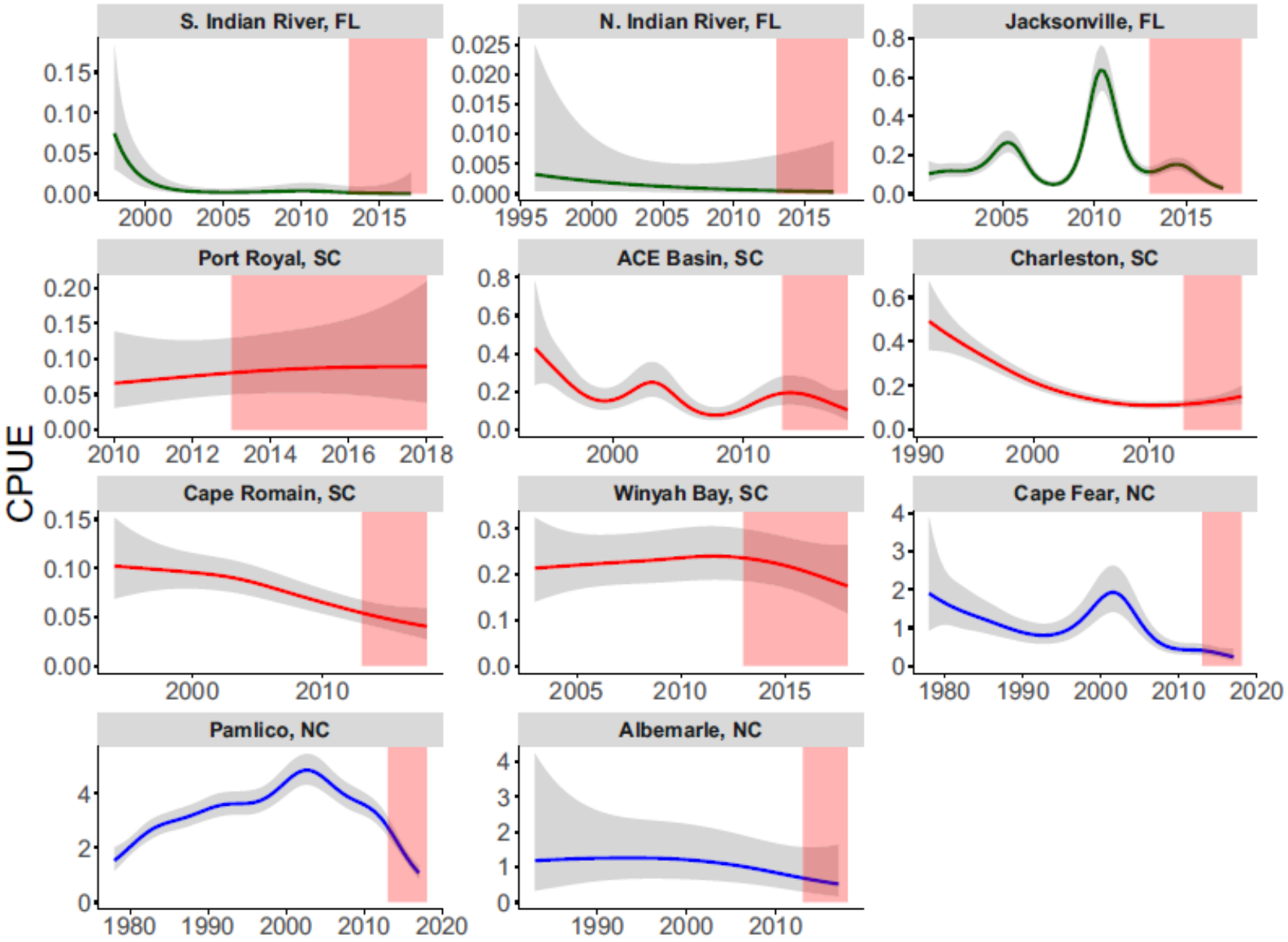
Erickson et al. 2021

Juvenile southern flounder abundance in Gulf coast estuaries



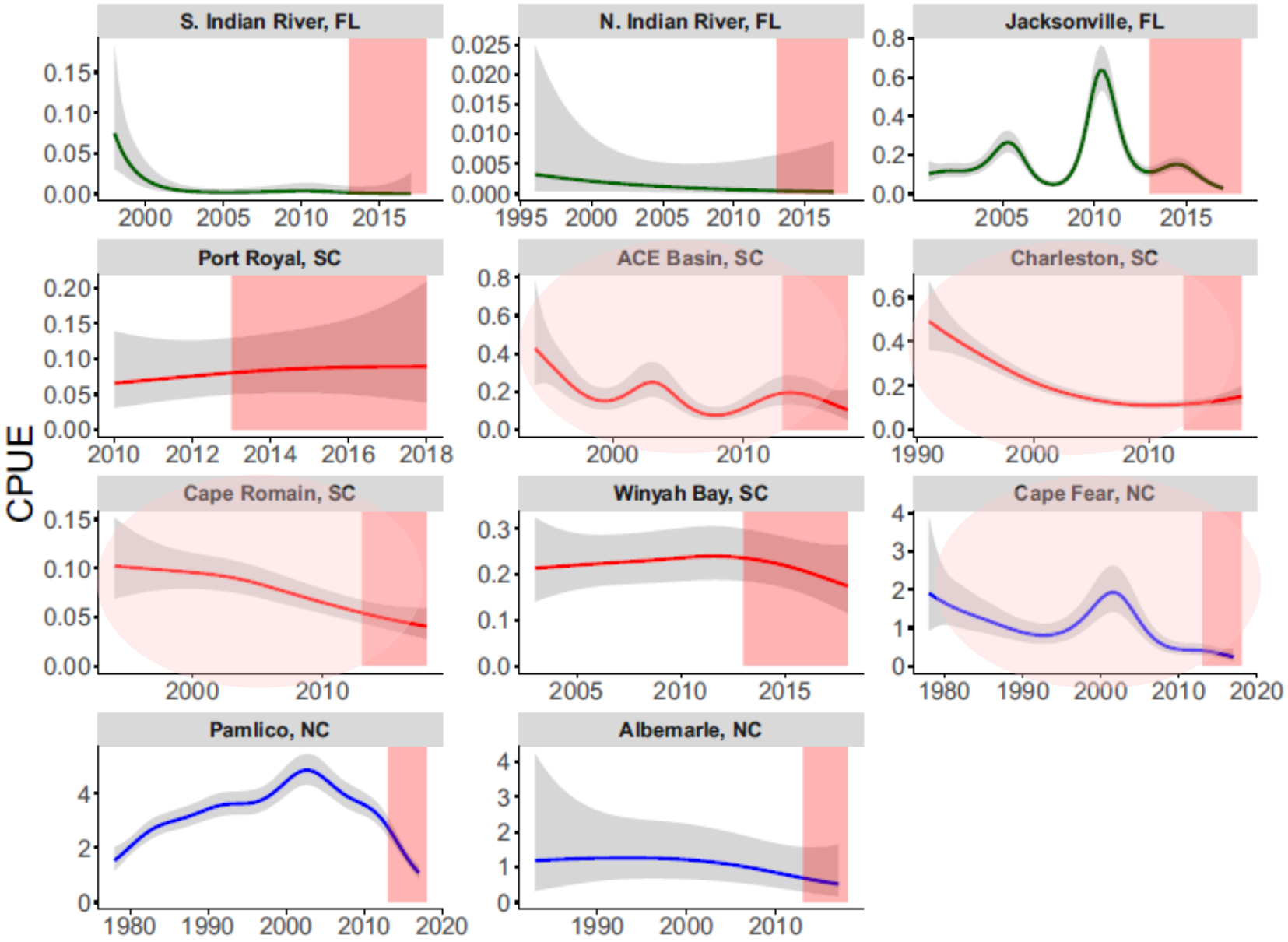
Erickson et al. 2021

Juvenile southern flounder abundance in Atlantic coast estuaries



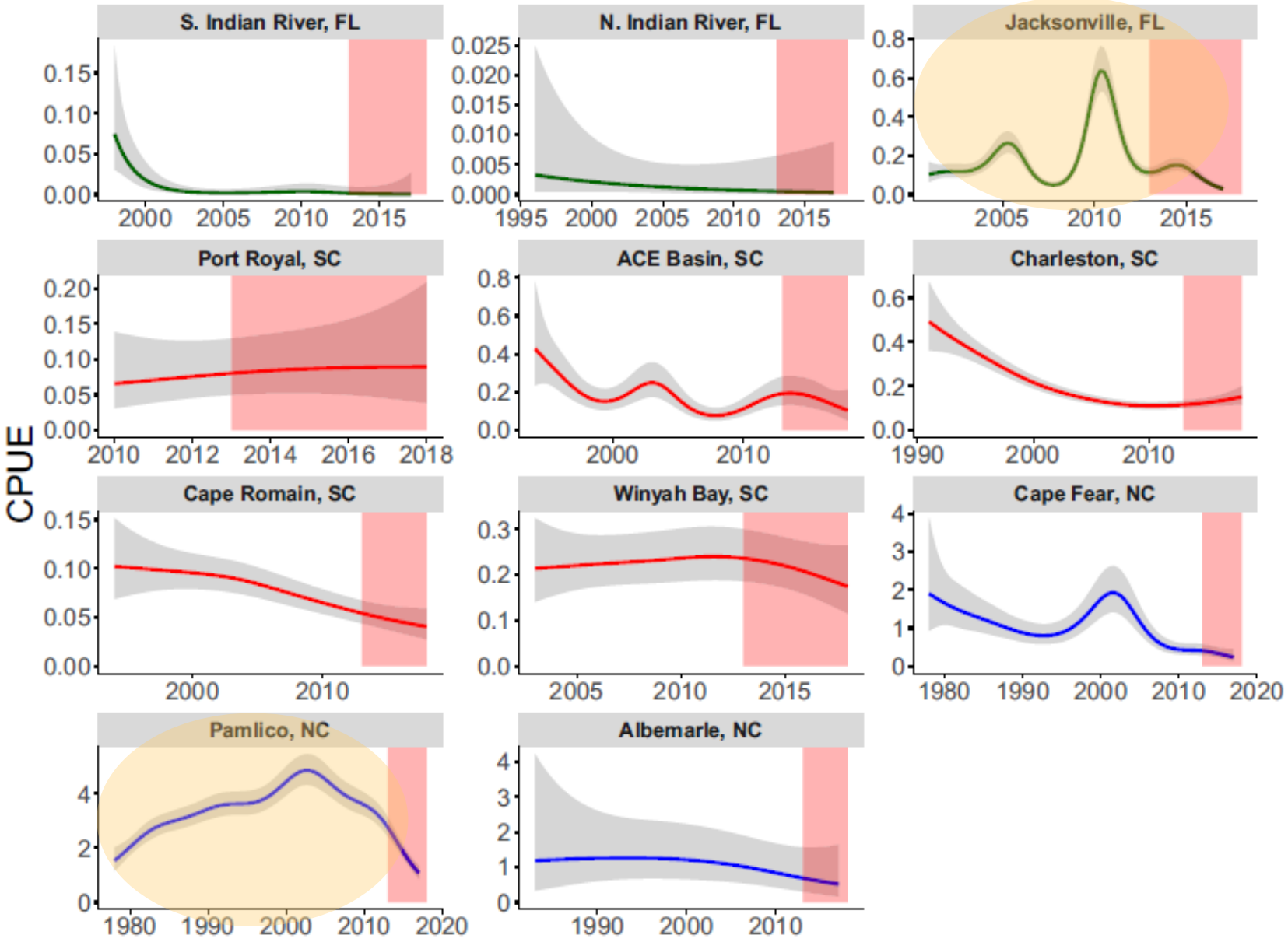
Erickson et al. 2021

Juvenile southern flounder abundance in Atlantic coast estuaries



Erickson et al. 2021

Juvenile southern flounder abundance in Atlantic coast estuaries



Erickson et al. 2021

1) **Range-wide declines in recruitment (NC to TX)**

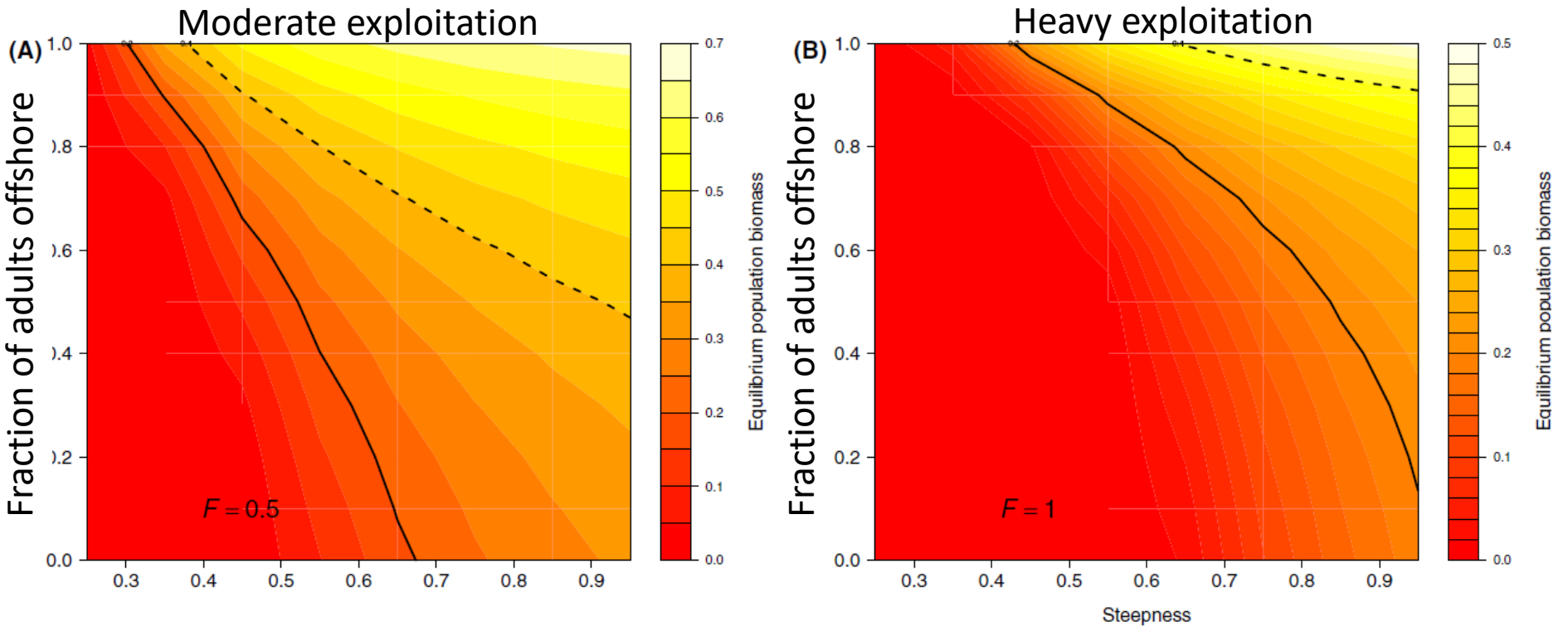
2) **Impacts of warming coastal ocean temperatures on egg/larval stages, estuarine development, and sex ratios?**

Erickson et al. 2021

Questions?

Post-spawning adult habitat use

- With heavy exploitation (F ≥ 1.0), meeting biomass targets require both high recruitment and almost completely cryptic adult biomass
- With moderate exploitation (F = 0.5), biomass targets can be achieved with a larger fraction of adults exposed to harvest and more typical recruitment



Midway, White & Scharf 2018