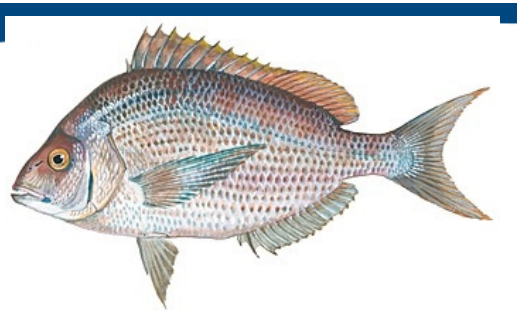
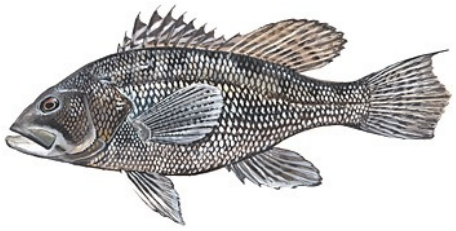
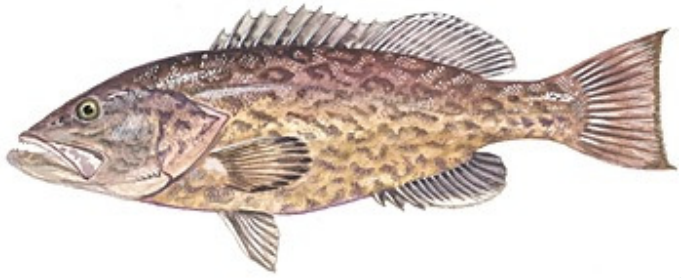




Low Recruitment in the South Atlantic: Workgroup Update

Kyle Shertzer, Kevin Craig, Ana Vaz

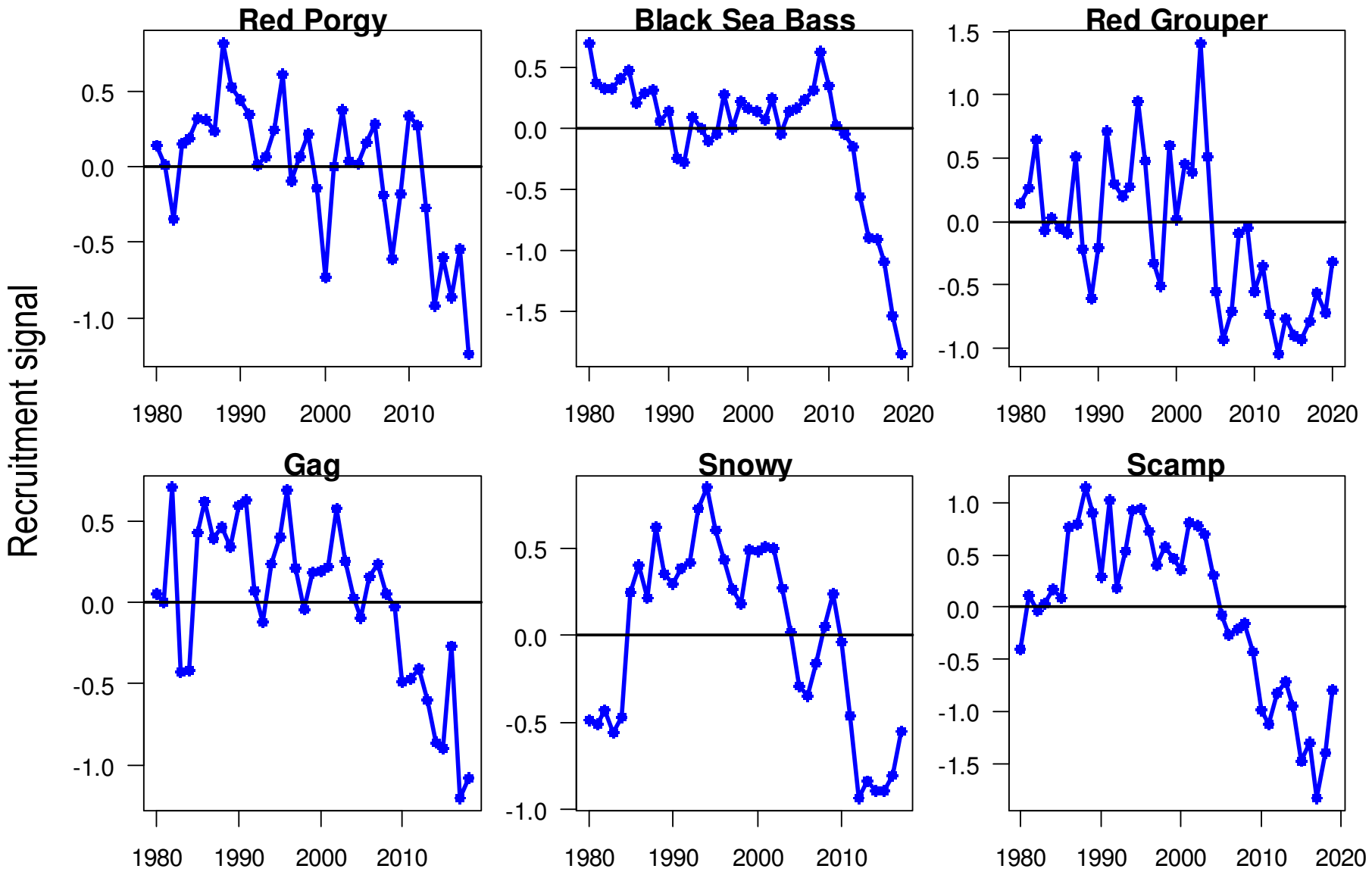
Contributors: Nate Bacheler, Nikolai Klibansky, Brendan Runde, Kaitlynn Wade, Erik Williams

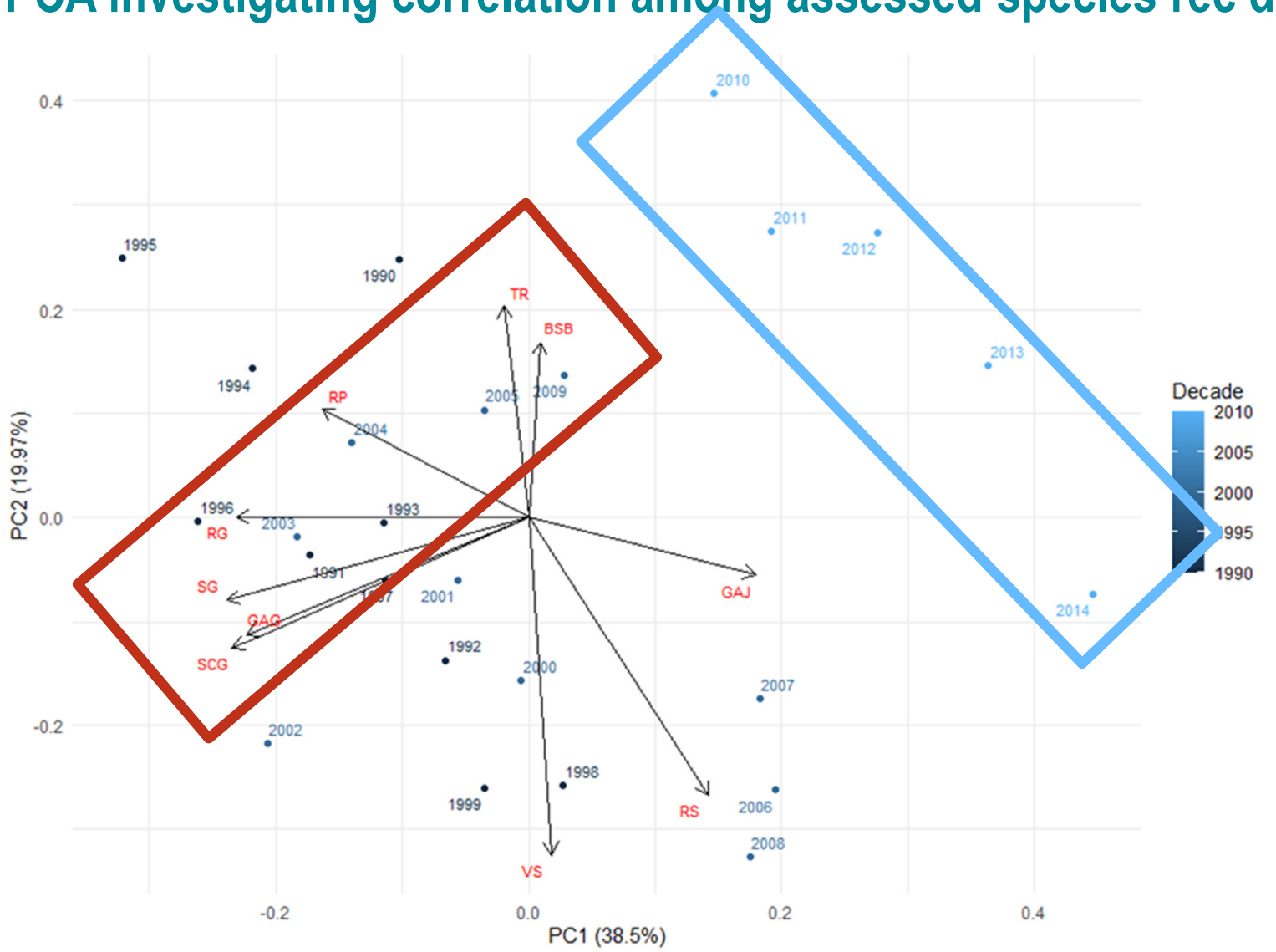

Evidence of recent poor recruitment in the SA

- Stock assessments: black sea bass, gag, scamp, red grouper, red porgy, snowy grouper
- SERFS trends reports: bank sea bass, knobbed porgy, sand perch, scup
- Peer-reviewed publications:
  - Scamp (*Bacheler & Ballenger 2018*)
  - Red porgy (*Bacheler et al. 2023*)
  - Multiple species (Wade et al. 2023)

Estimates of recruitment from stock assessments

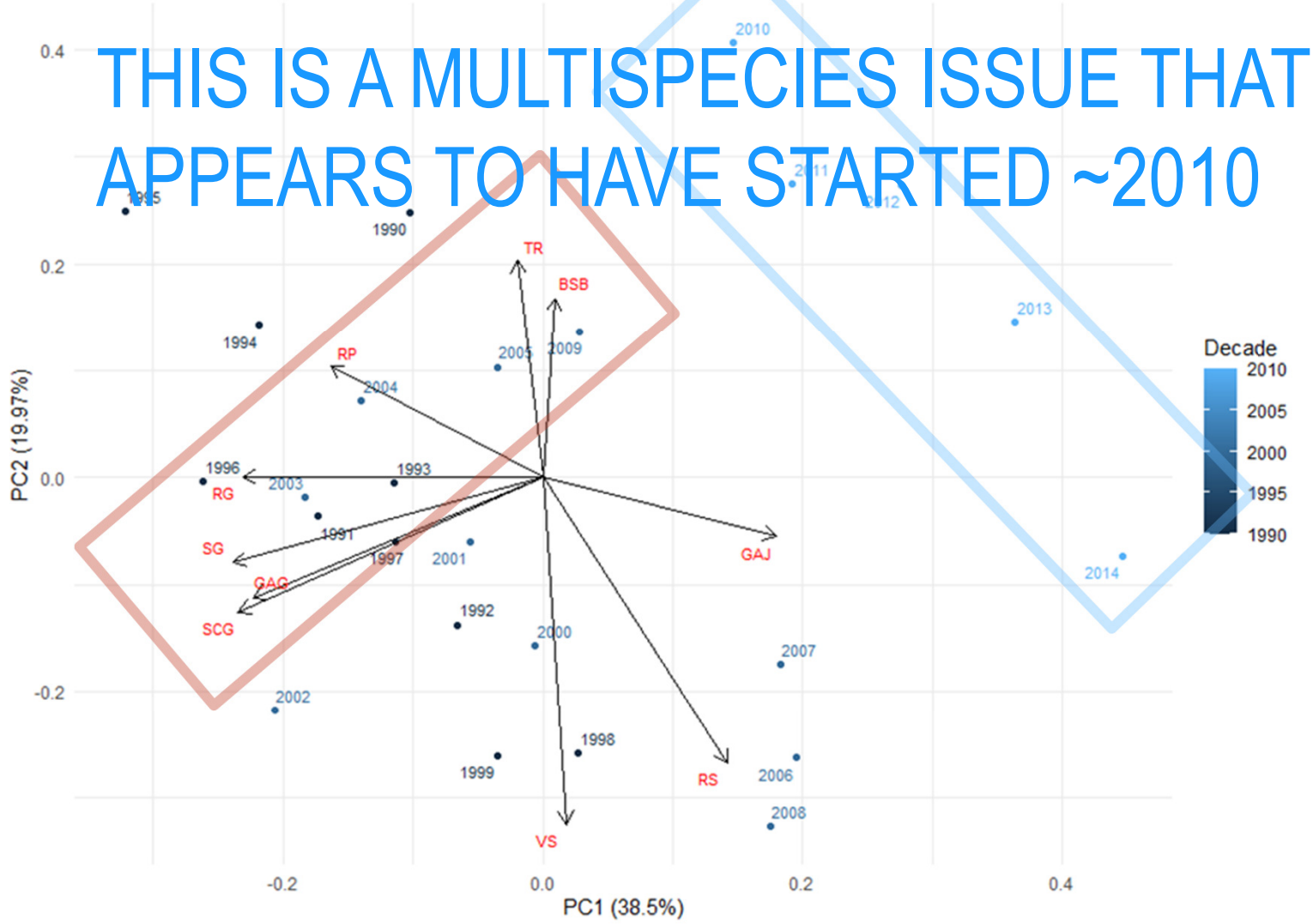


PCA investigating correlation among assessed species rec devs



PCA investigating correlation among assessed species rec devs

THIS IS A MULTISPECIES ISSUE THAT APPEARS TO HAVE STARTED ~2010



Hypotheses considered

- Sampling artifact
- Recruitment overfishing
- Sperm limitation of protogynous fishes
- Depredation
- Environmental effect

Hypotheses considered

- **Sampling artifact**
- Recruitment overfishing
- Sperm limitation of protogynous fishes
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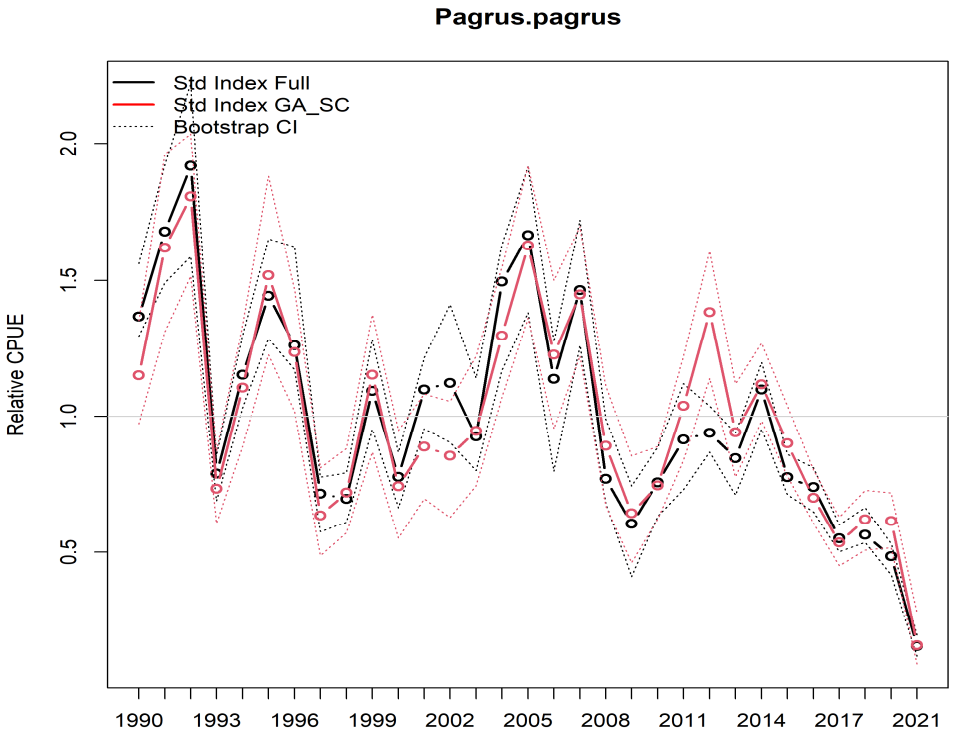
- Environmental effect

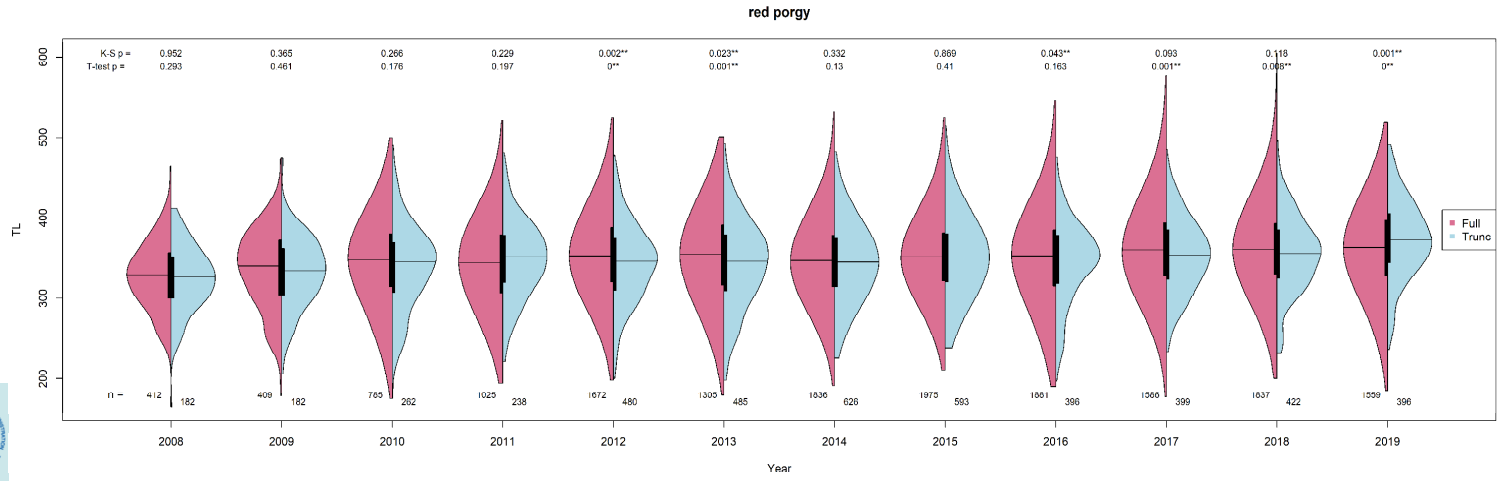
Sampling artifact

- SERFS sampling has expanded geographically over time
  - Could this create a false signal of decline in the index?
- Compared indices and lengths using all SERFS areas to those using restricted SERFS areas from before geographic expansion
- No evidence found; indices appear similar for most species (examples next slide)
- In addition, patterns in composition data are generally consistent with fishery dependent sources, which have not undergone geographic changes in sampling

Index and comps from full SERFS area and from original core areas

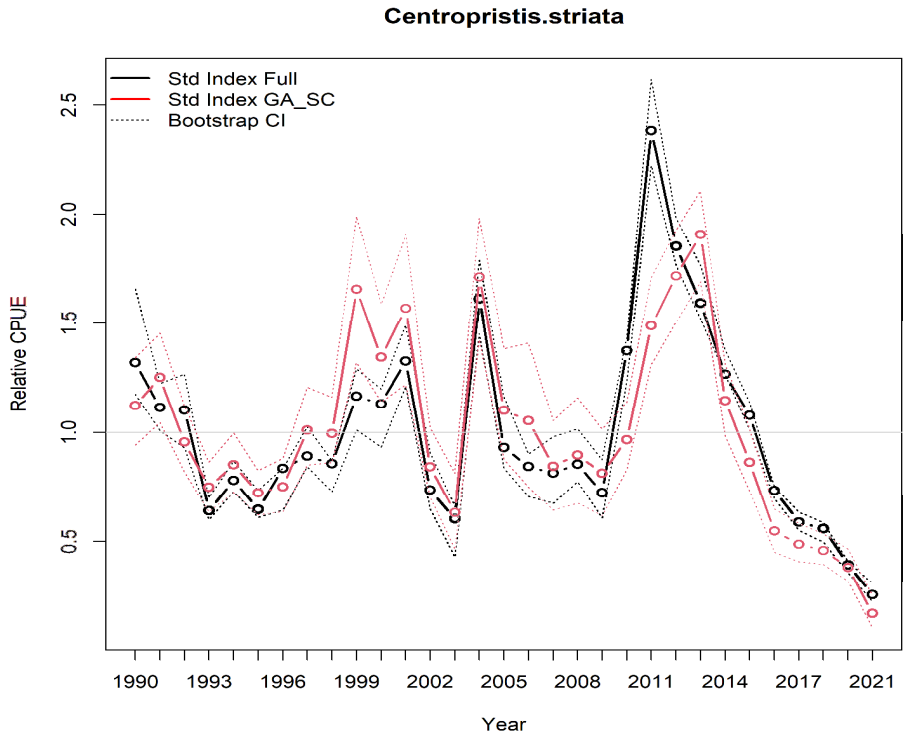
Red porgy

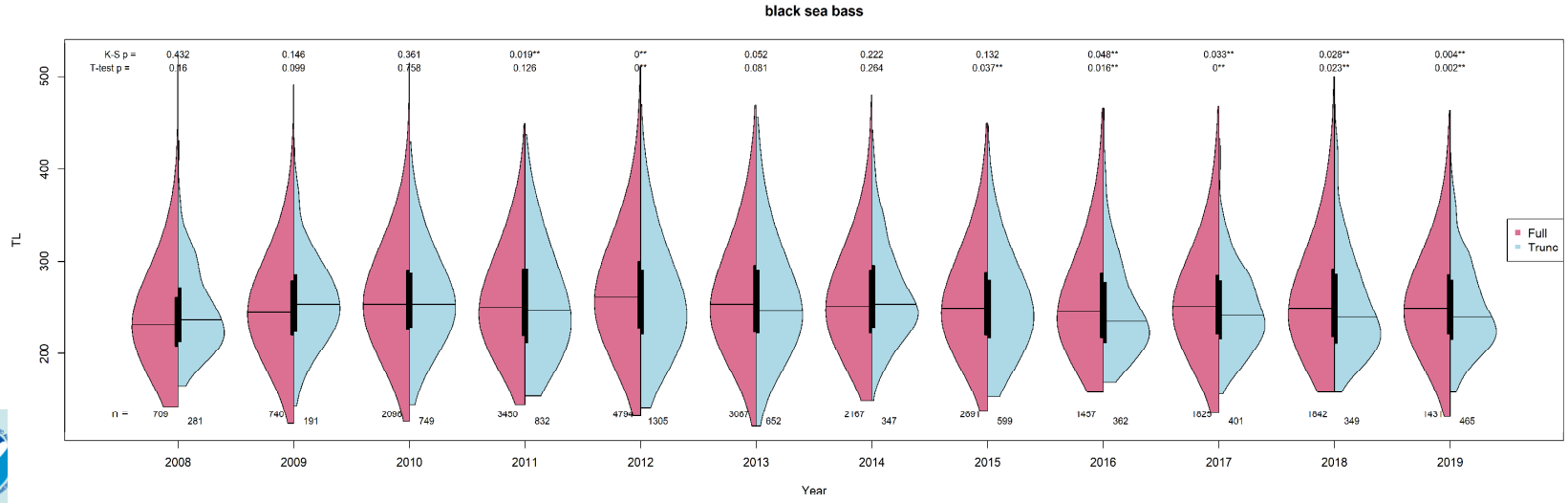




Index and comps from full SERFS area and from original core areas

Black sea bass





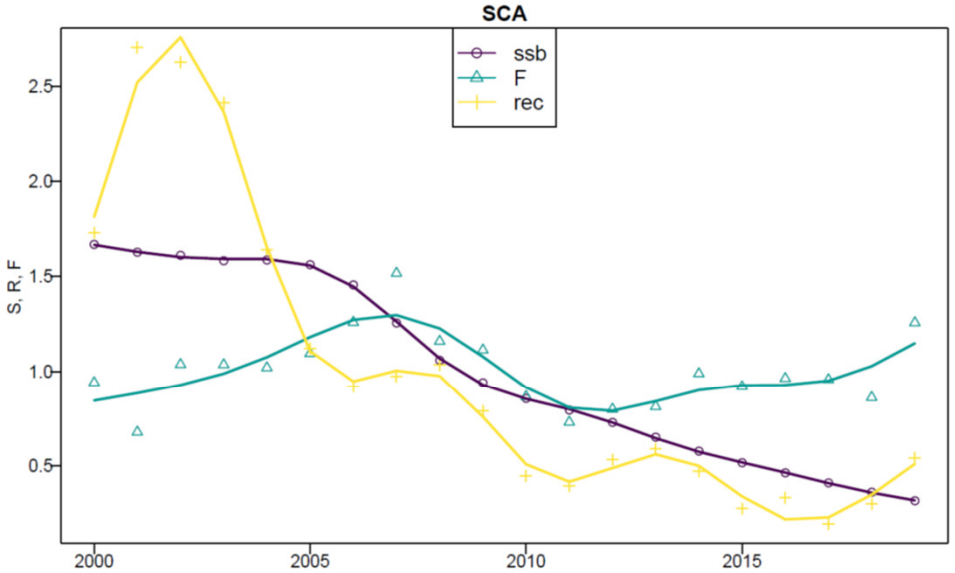
Hypotheses considered

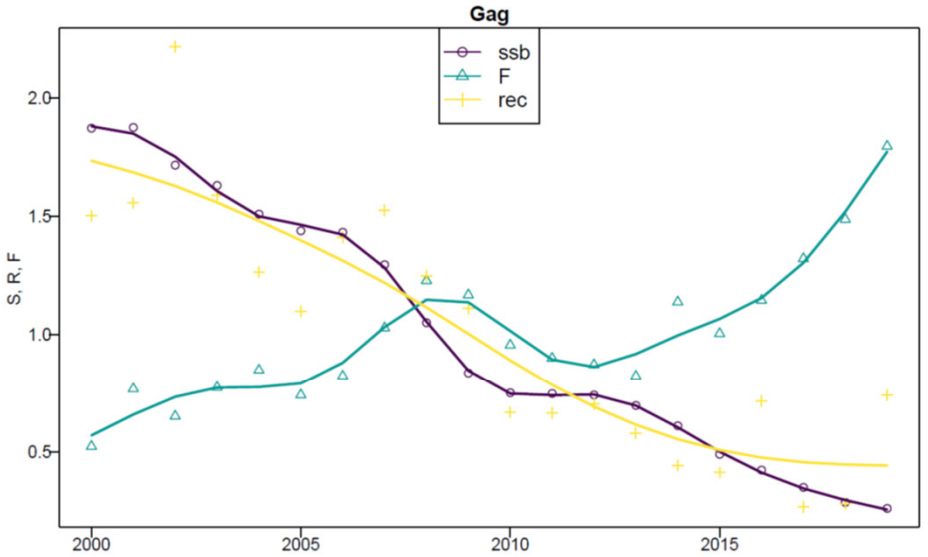
- Sampling artifact
- **Recruitment overfishing**
- Sperm limitation of protogynous fishes
- Depredation
- Environmental effect

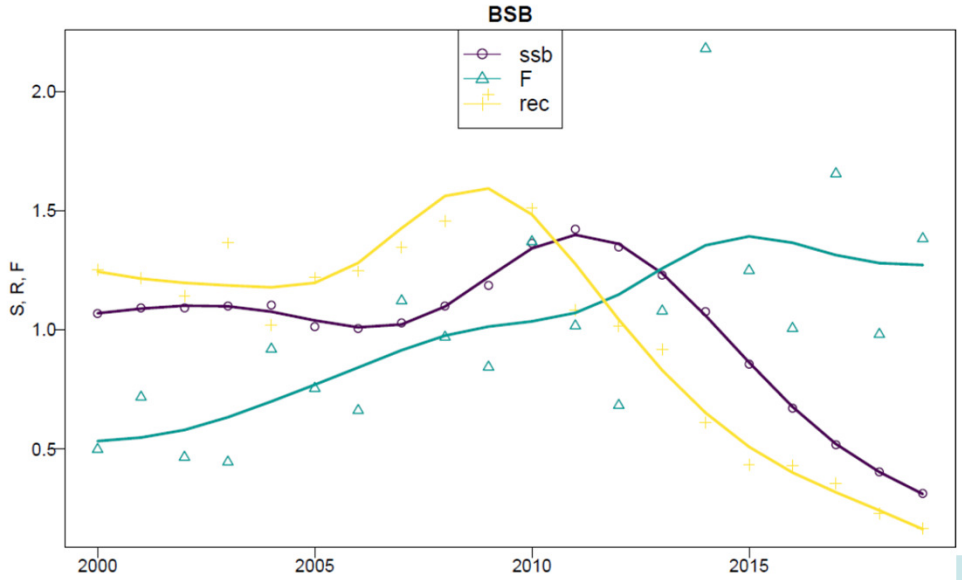
Recruitment overfishing

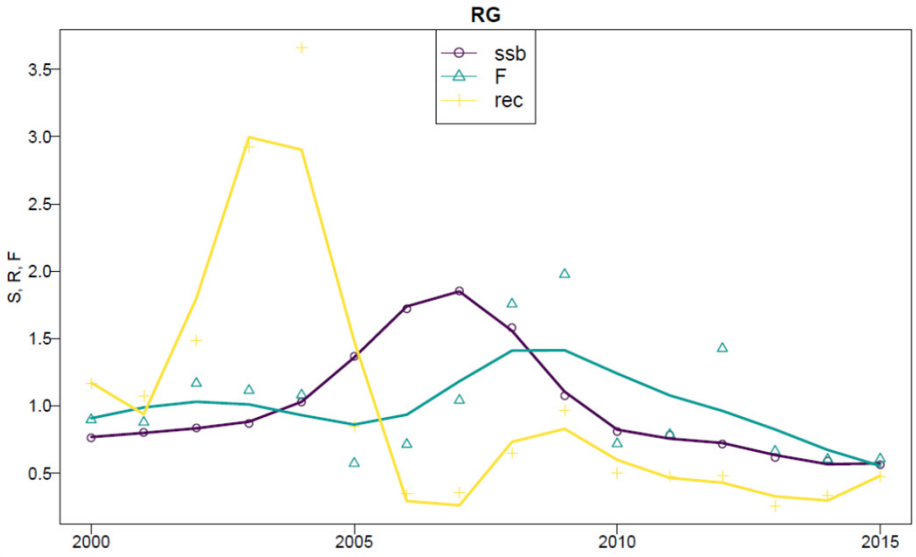
- ↑fishing → ↓spawners → ↓recruitment
- Implies an order of events
- Do we see that order in the assessment output?
- Investigated recruitment overfishing hypothesis with
  - Visual inspection of time series
  - Change point analysis
  - Derivative analysis
  - Recruits per spawner analysis
  - Evidence from SERFS

Recruitment overfishing – visual inspection









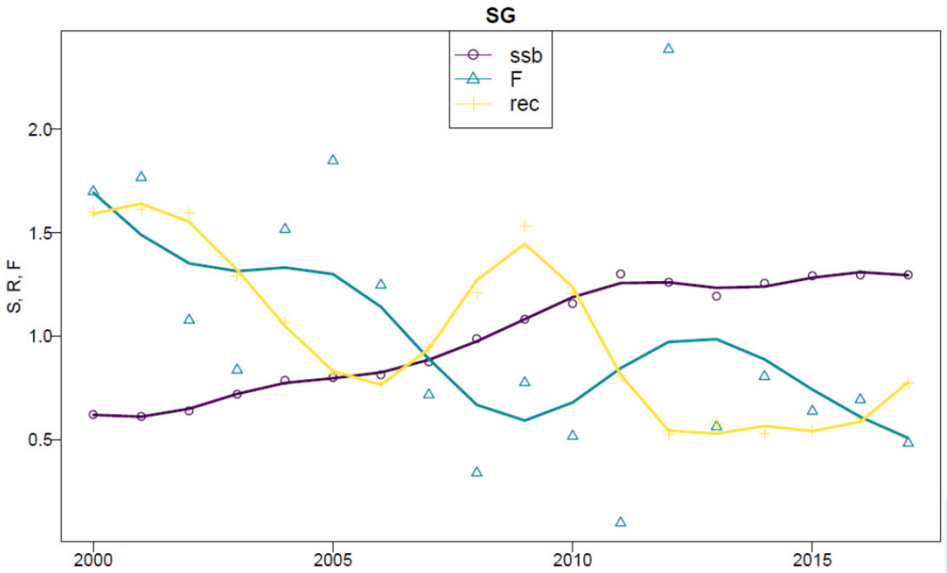
Recruitment overfishing – change point analysis

- Kaitlynn Wade (graduate intern) used simulation analyses to evaluate methods
  - Tree classification and linear regression change point (strucchange) were effective for identifying recruitment overfishing
  - Bayesian change point analysis was not
- Applied tree classification and strucchange to SA stocks

Recruitment overfishing – change point analysis

Stock	Change point in fishing	Change point in recruitment
Red porgy	2012.5	2012.5
Black sea bass	2011.5	2011.5
Red grouper	2009.5	2004.5
Gag	2013.5	2009.5
Snowy grouper	2006.5	2010.5
Scamp	2009.5	2004.5

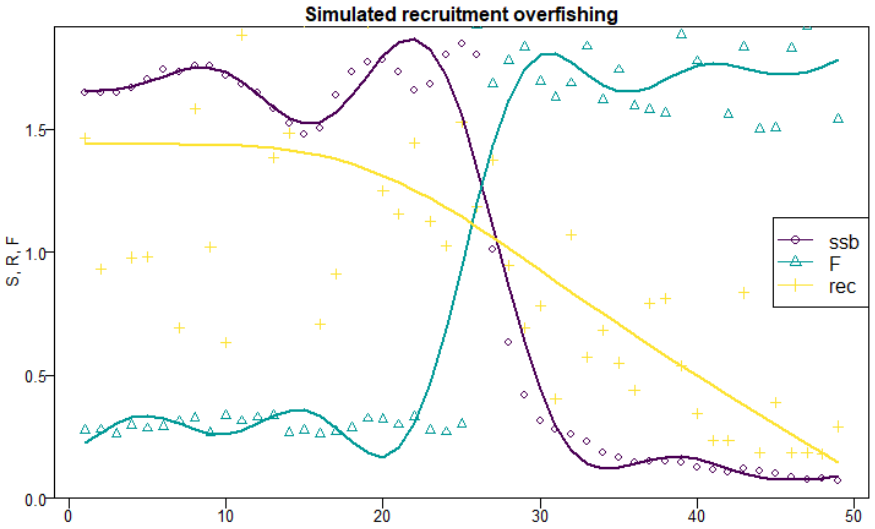
Note, both methods (Tree classification and strucchange) identified same years for each species

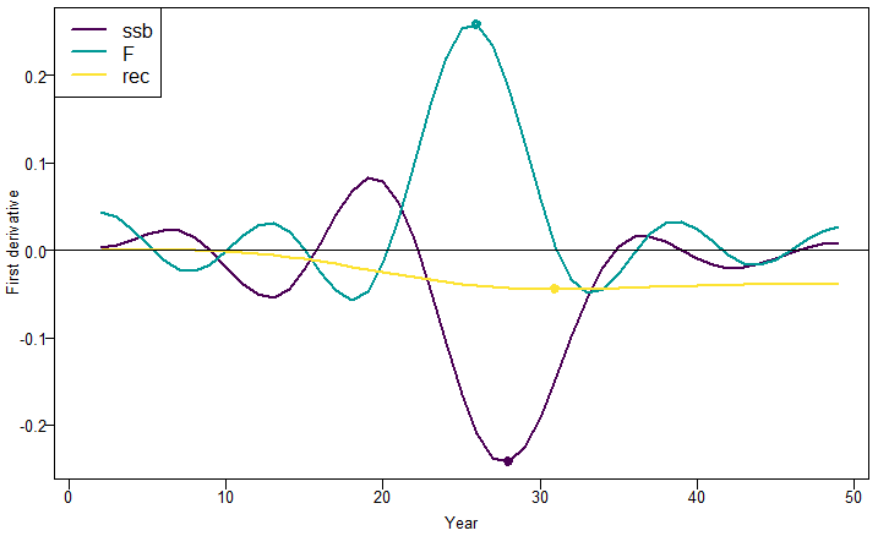


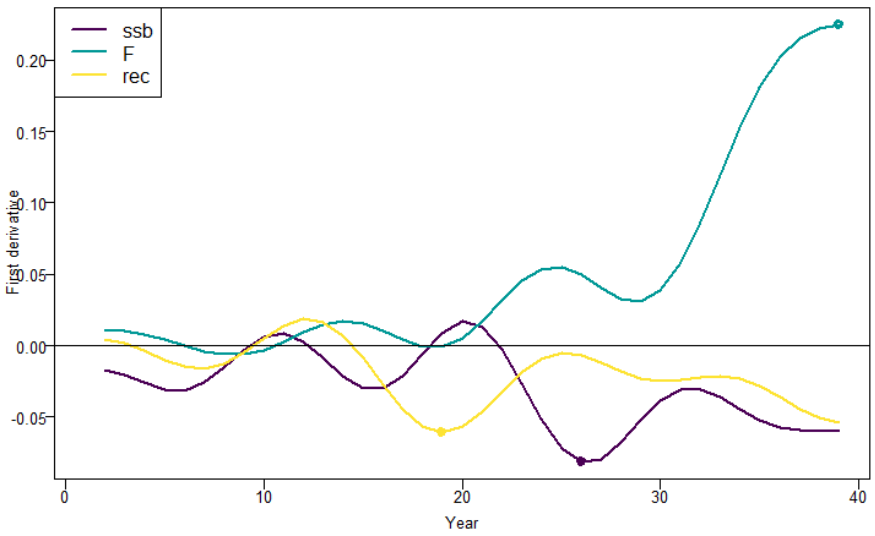
Snowy does NOT show recruitment overfishing: F and SSB go in the wrong direction

Recruitment overfishing – derivative analysis

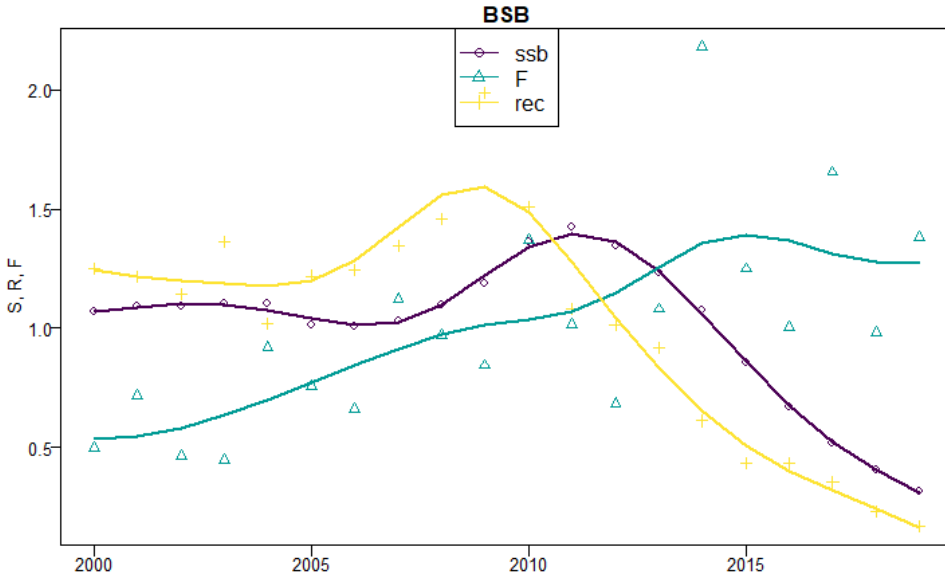
- Fit differentiable smoothers to SSB, F, and rec time series
- Evaluate locations of max gradient (F) and min gradients (SSB, rec)

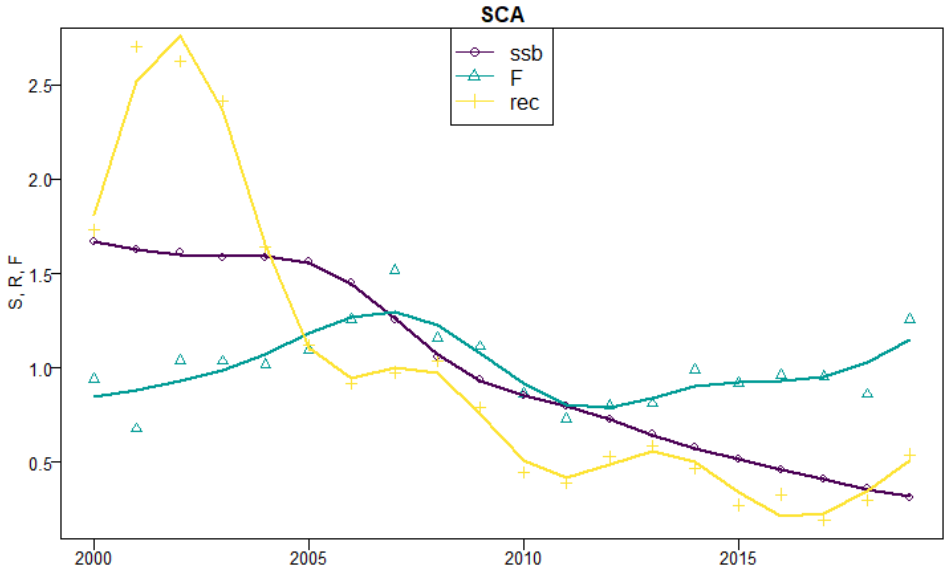


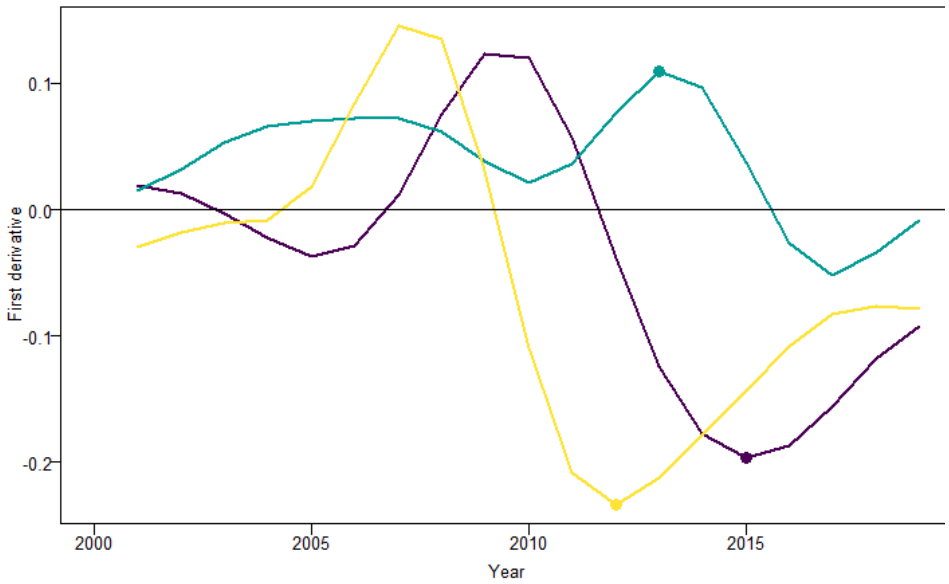


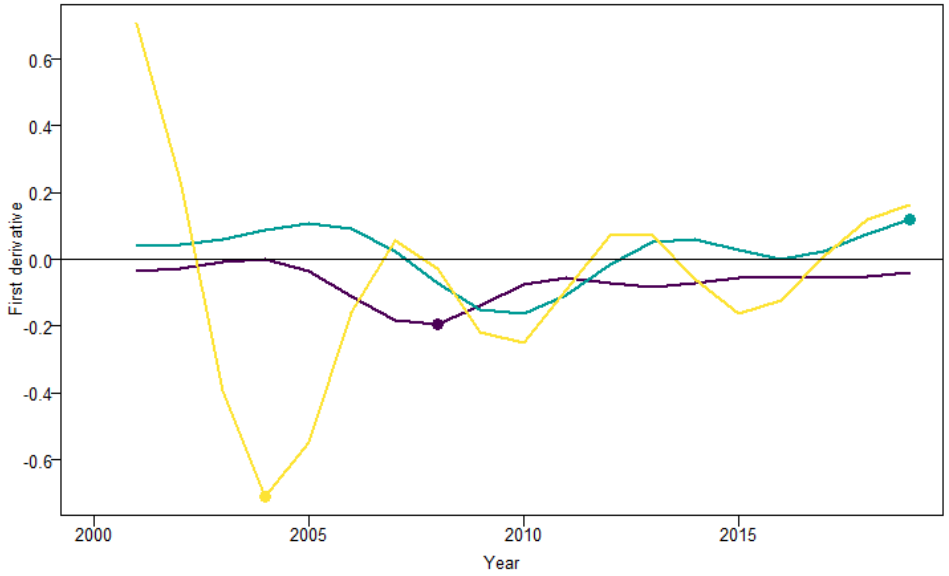


Recruitment overfishing – derivative analysis



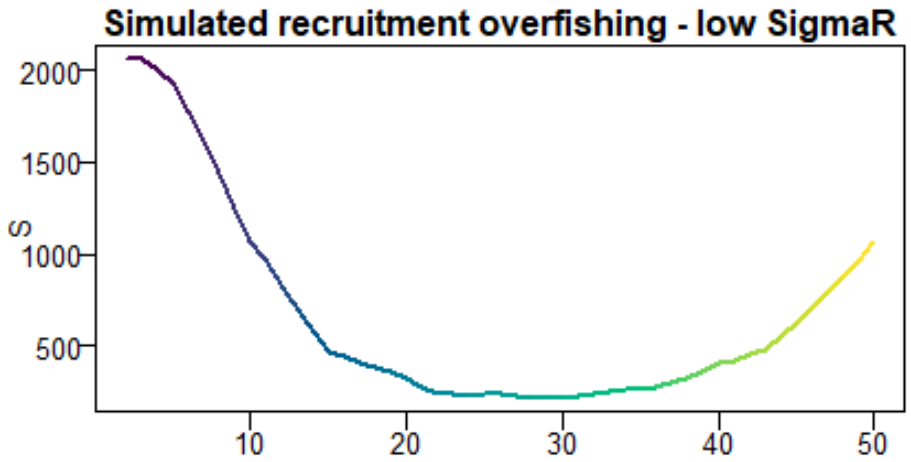


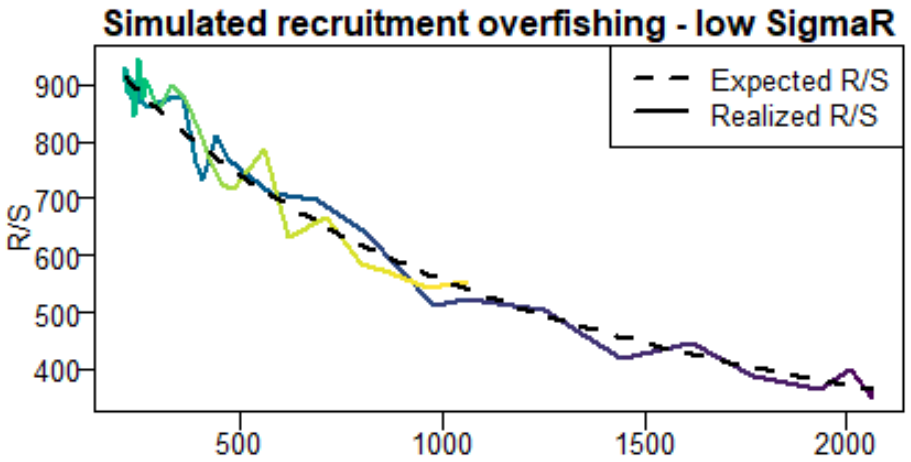


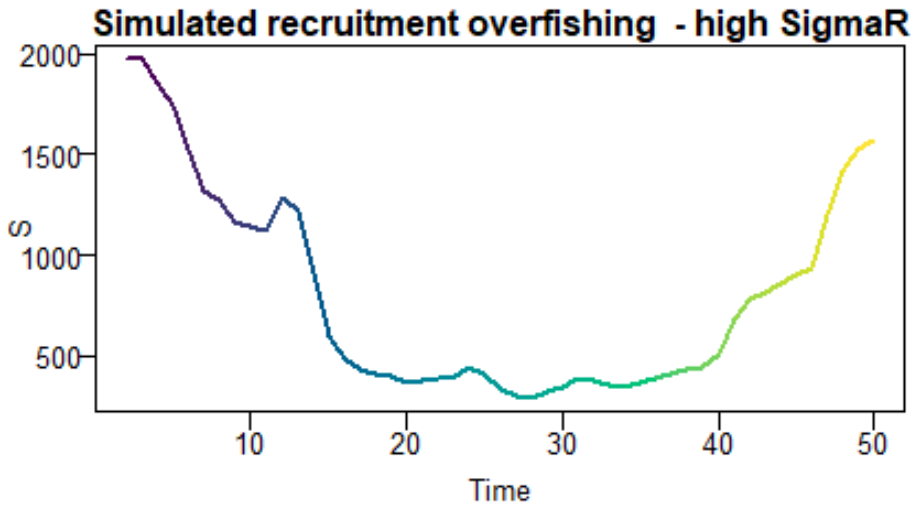


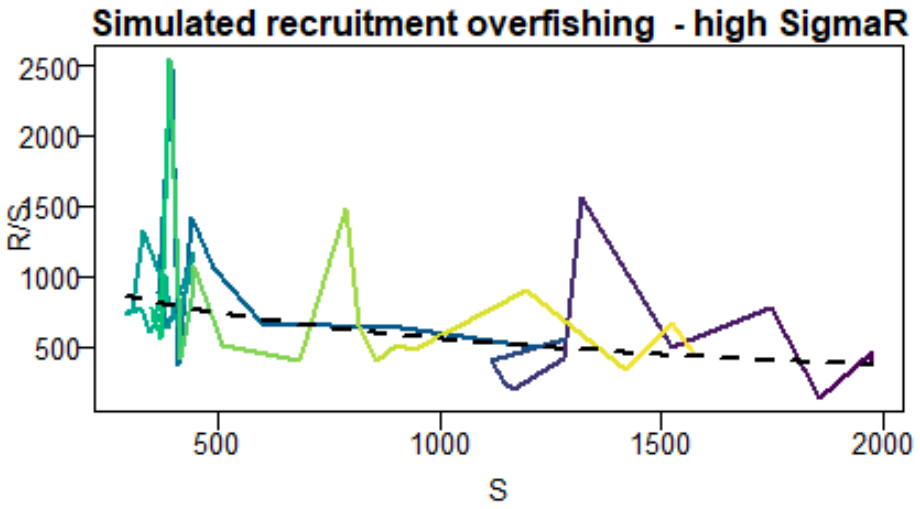
Recruitment overfishing – recruits per spawner

According to theory …



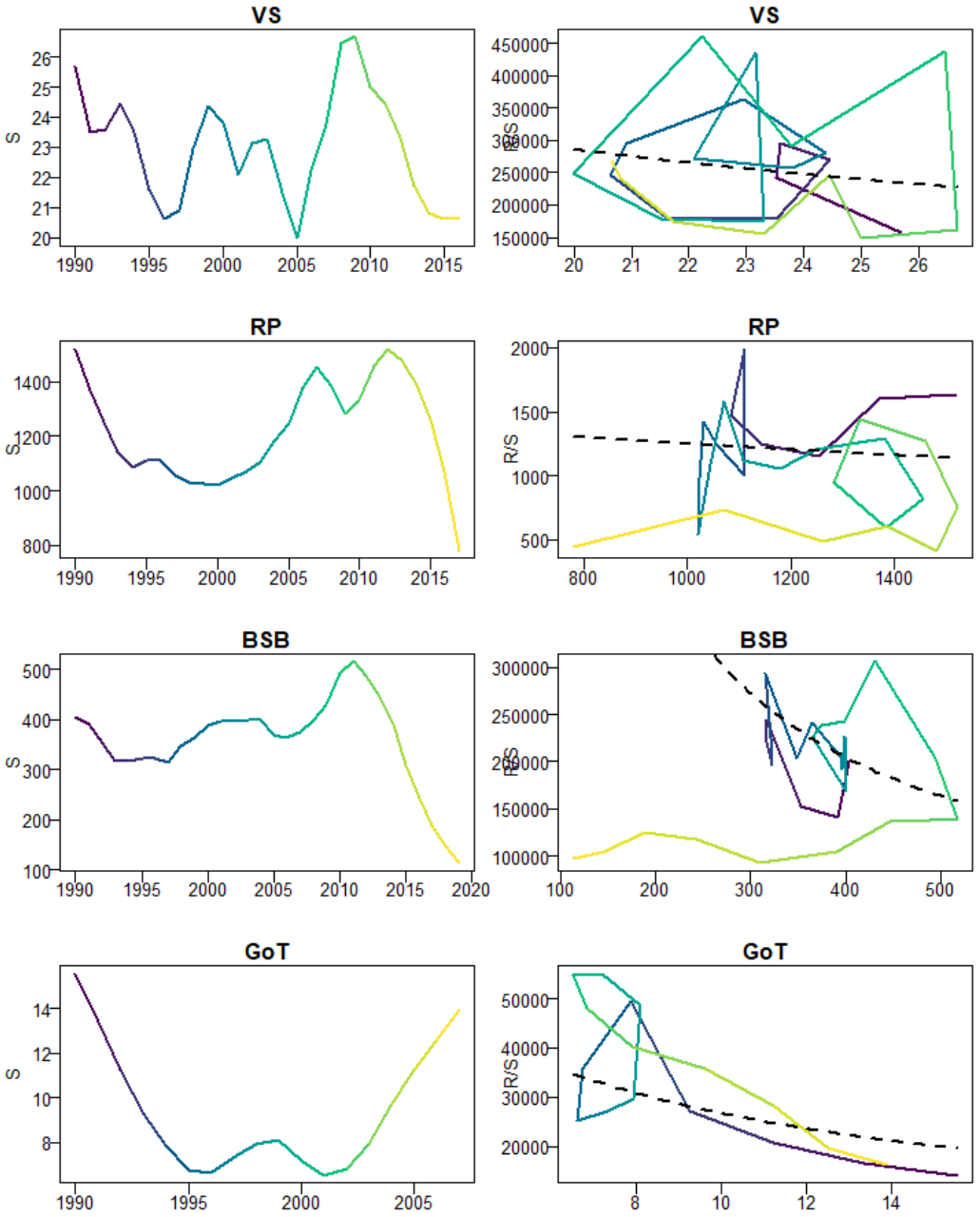






Recruitment overfishing – recruits per spawner

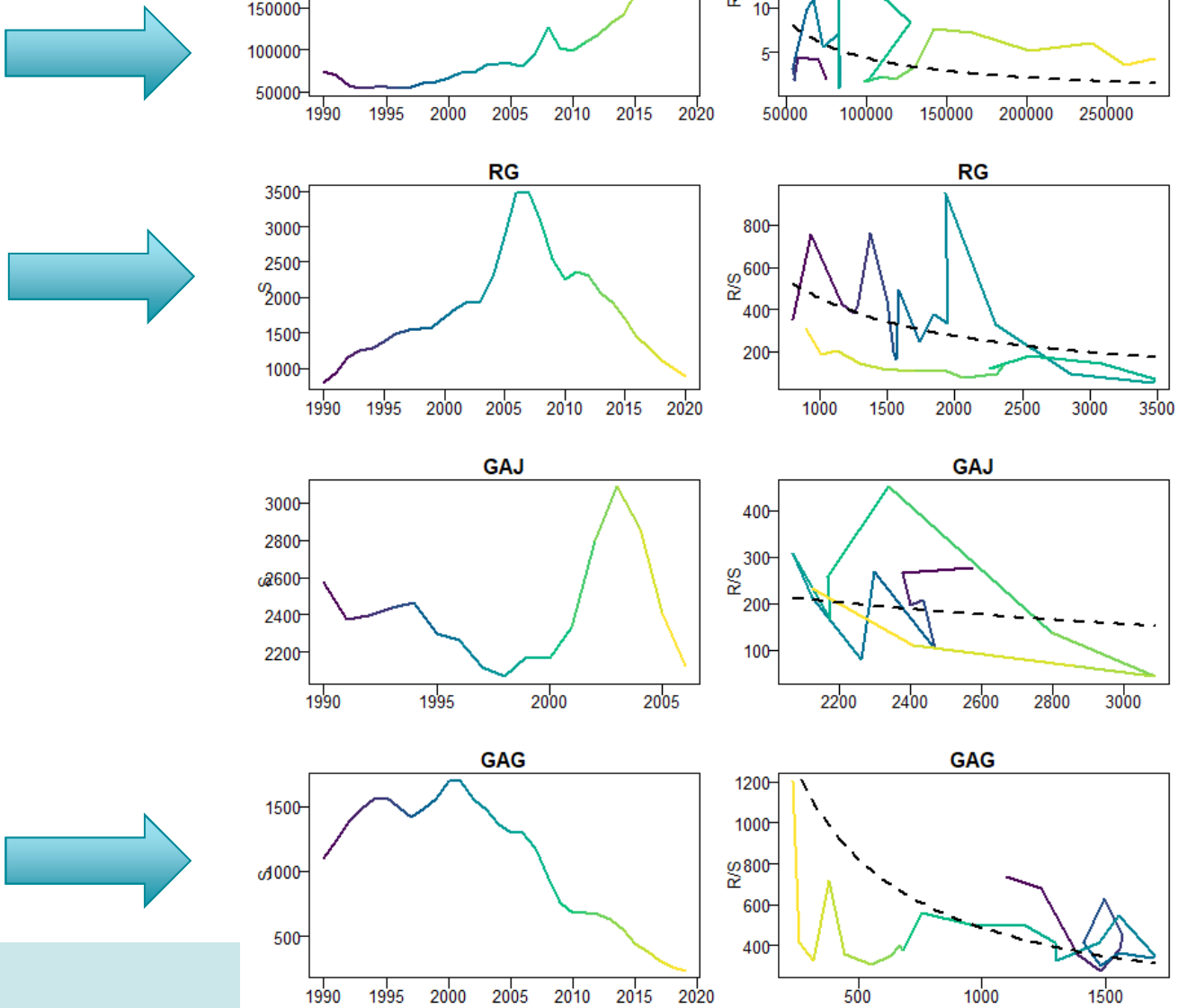
What assessments show…



NOAA FISHERIES

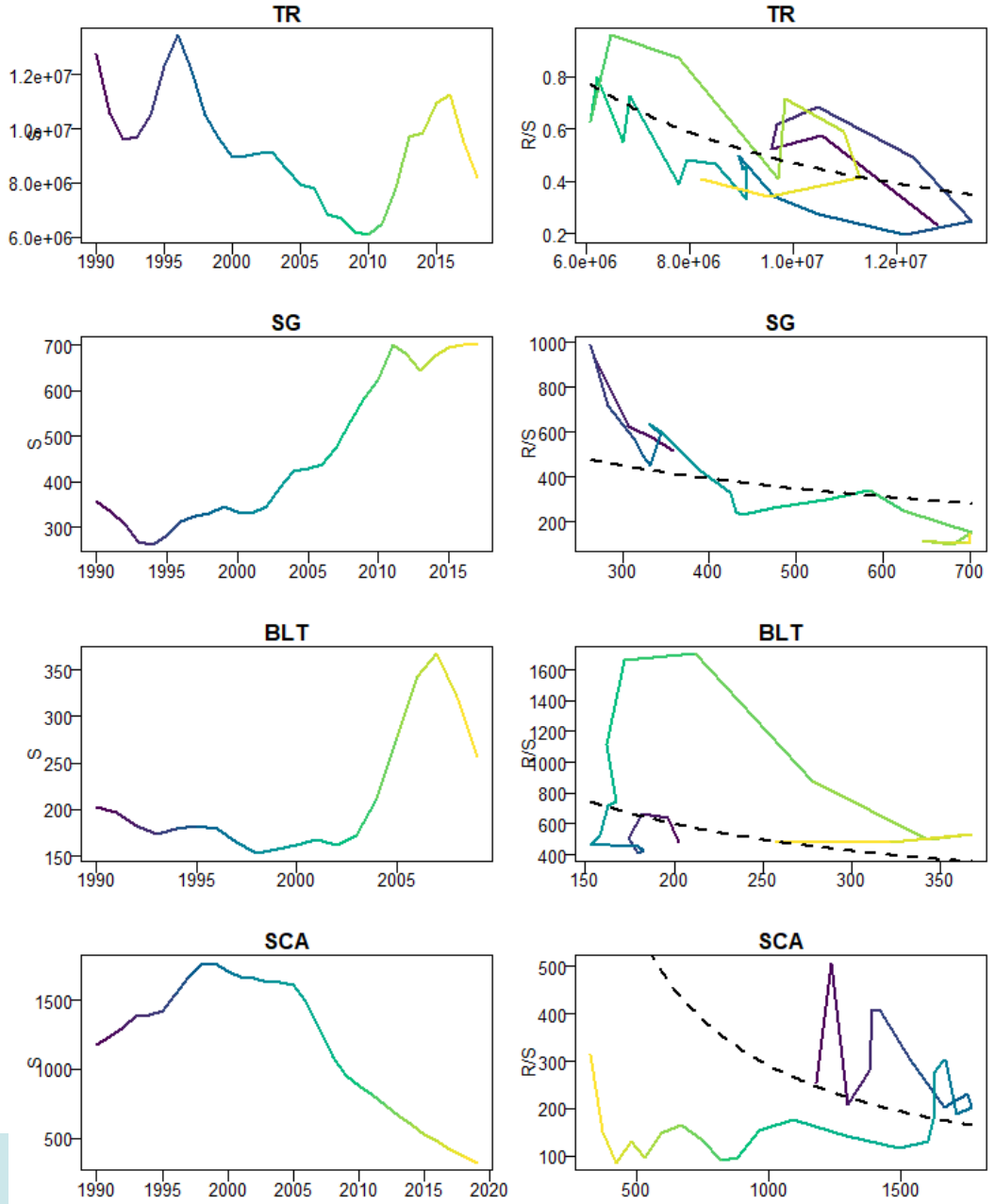
Recruitment overfishing – recruits per spawner

What assessments show…



Recruitment overfishing – recruits per spawner

What assessments show…

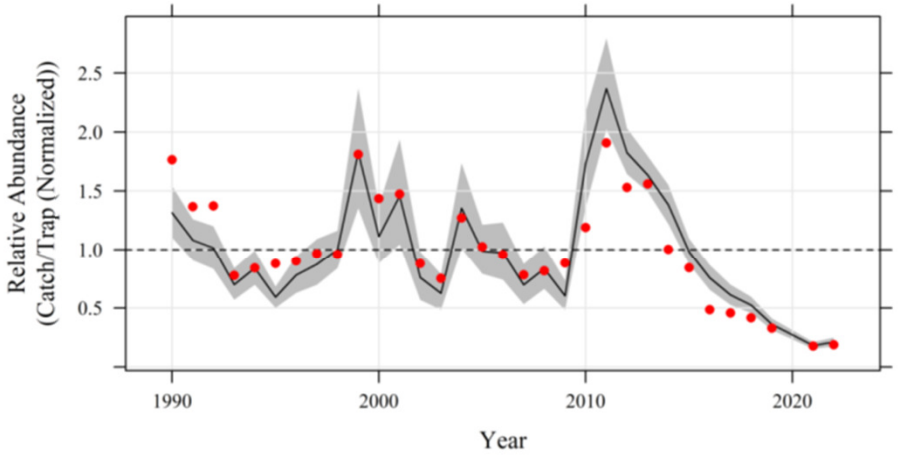


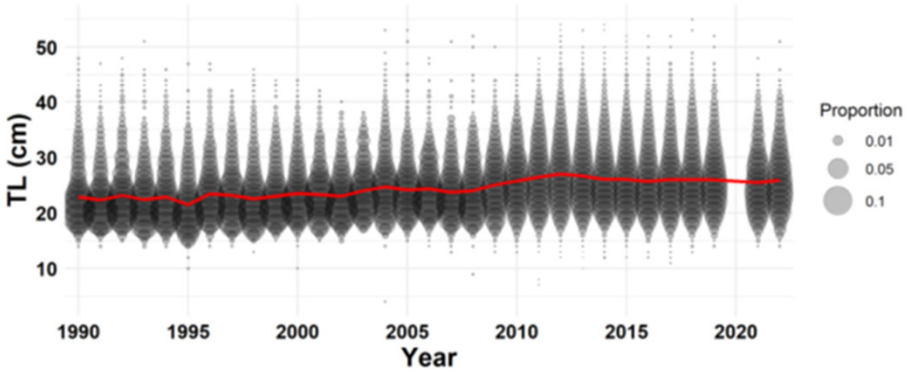
Recruitment overfishing – evidence from SERFS

- For declining stocks
  - Recruitment overfishing should coincide with decreases in mean size or age
  - Recruitment failure should show the opposite
- Examine Bubley et al. 2023. Trends in relative abundance of reef fishes in fishery-independent surveys in waters off the southeastern United States.

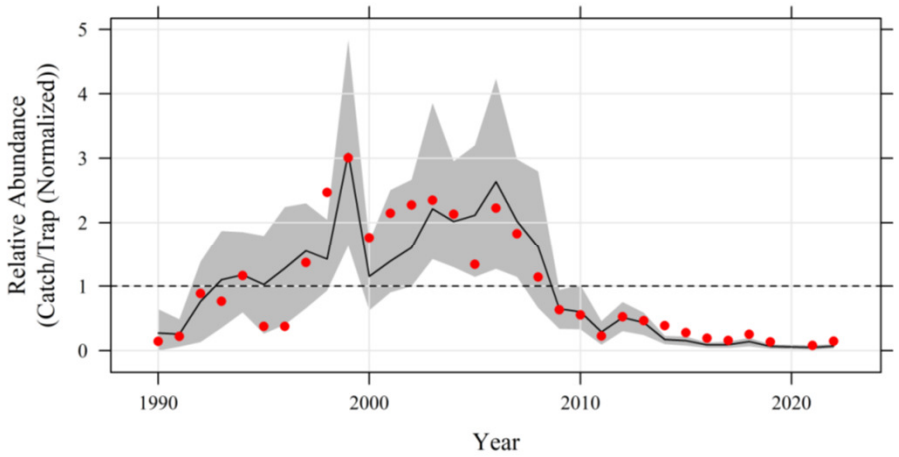
Recruitment overfishing – evidence from SERFS

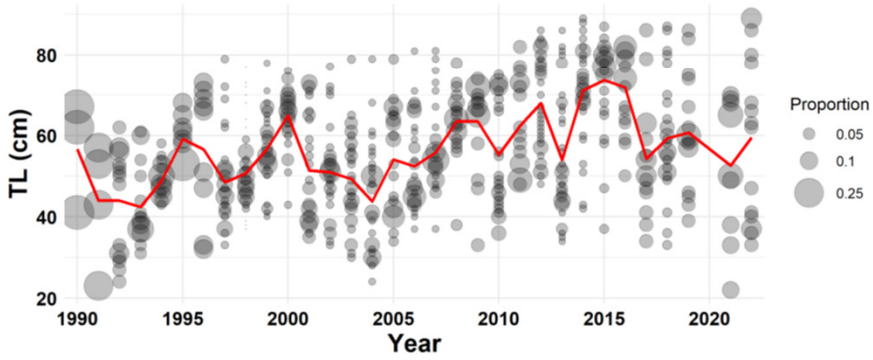
Black sea bass





Red grouper

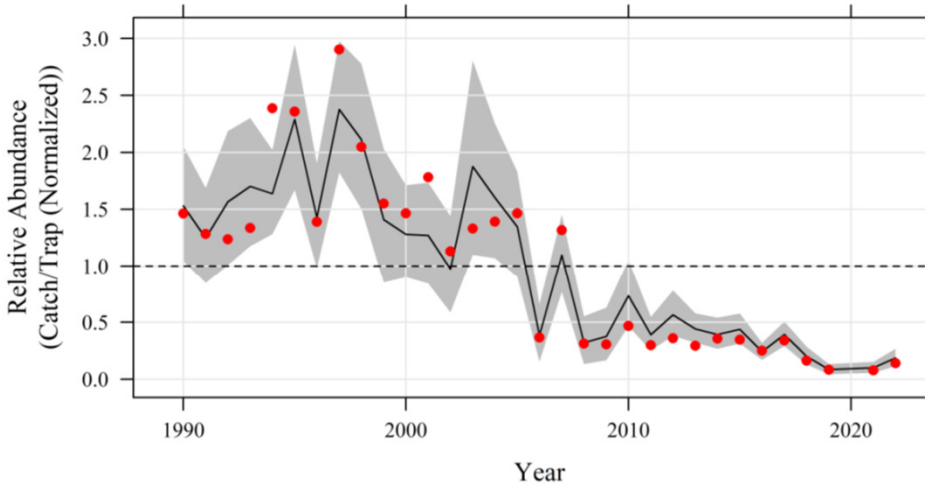


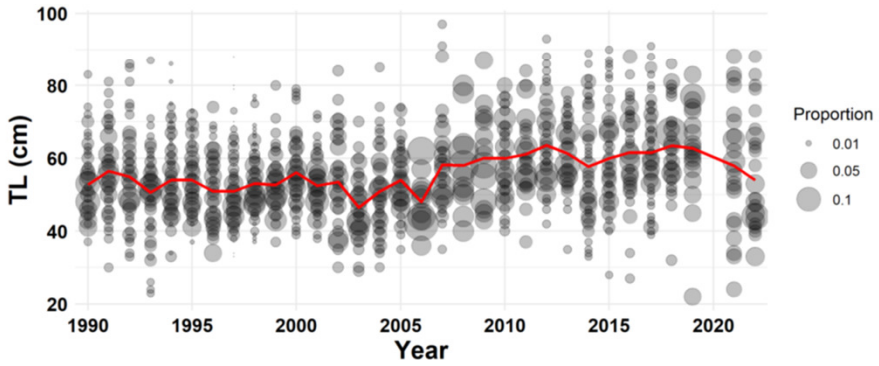


Bubley et al. 2023

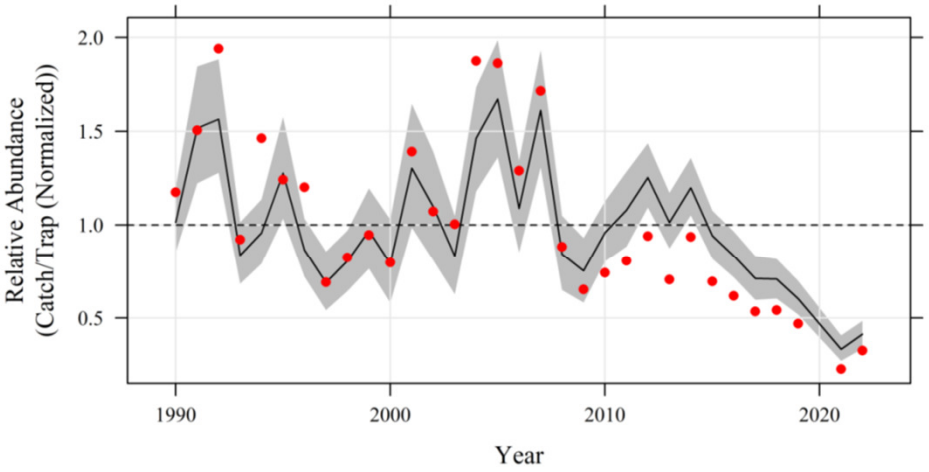
Recruitment overfishing – evidence from SERFS

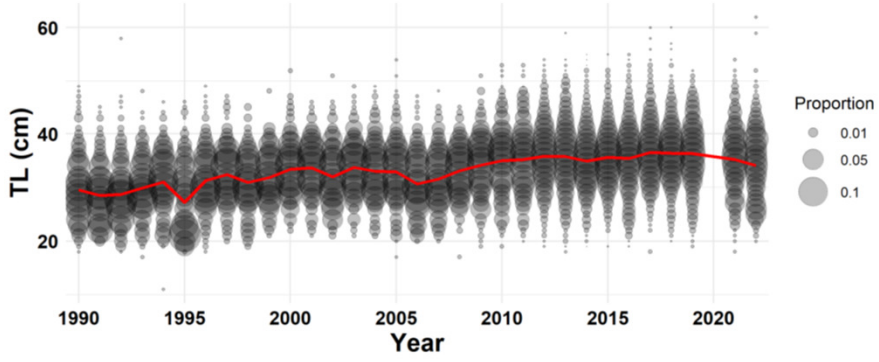
Scamp





Red porgy

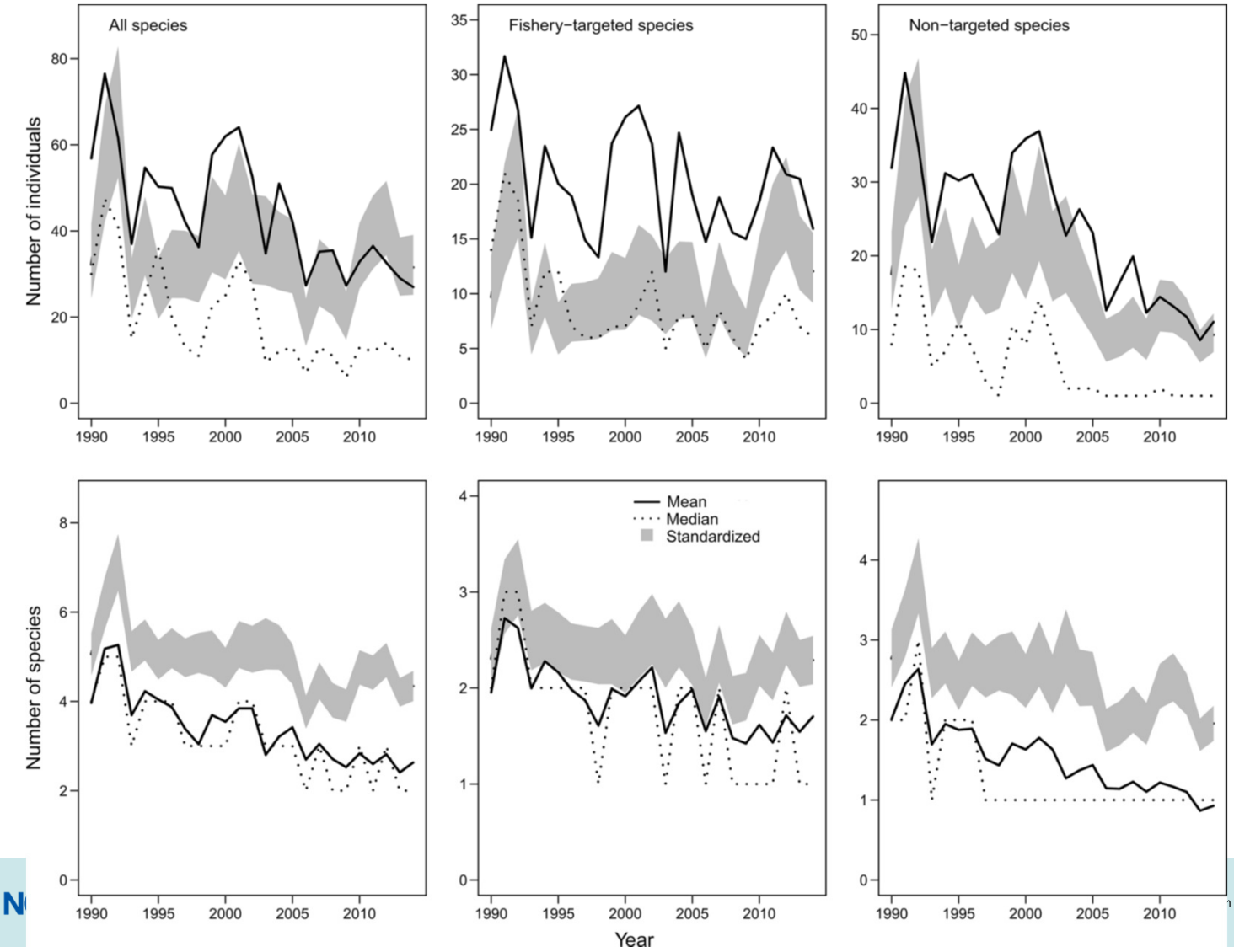




Bubley et al. 2023

Recruitment overfishing – evidence from SERFS

- Abundance declines are not restricted to fishery targeted stocks
- From Bacheler and Smart. 2016. Mar Biol 163:26



Hypotheses considered

- Sampling artifact
- Recruitment overfishing
- **Sperm limitation of protogynous fishes**
- Depredation
- Environmental effect

Sperm limitation?

- Most of the spp exhibiting low recruitment are protogynous
- However, the usual mechanism we think of is the following:

  ↑fishing → ↓males → ↓fertilized eggs
- This is a special case of recruitment overfishing, which we do not suspect is the culprit in the past 15 years

- We cannot rule out other potential mechanisms

Hypotheses considered

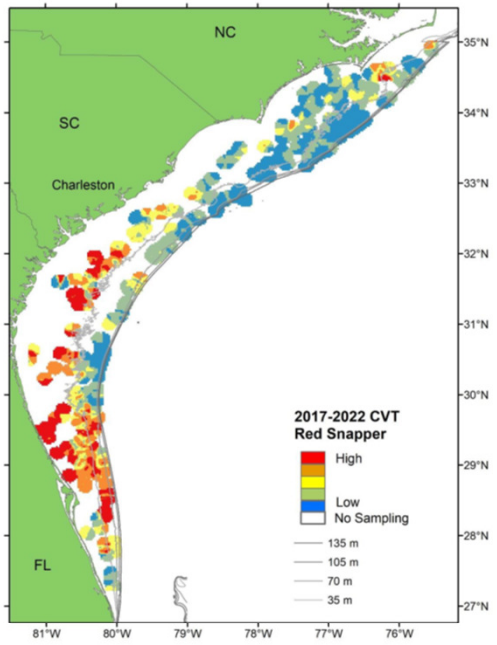
- Sampling artifact
- Recruitment overfishing
- Sperm limitation of protogynous fishes
- **Depredation**
- Environmental effect

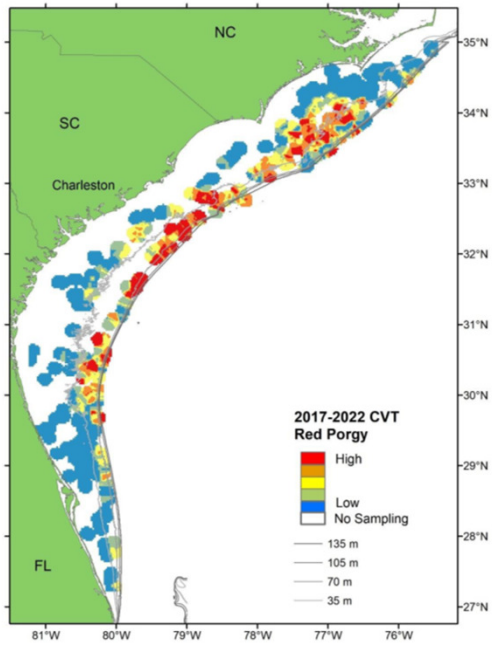
Depredation

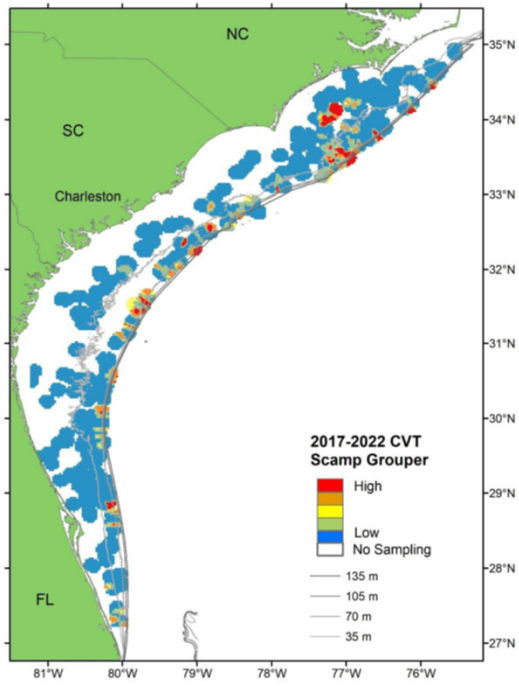
- Sharks? Red Snapper? Lionfish?
  - We do not have a good explanation for why generalist predators preferentially eat this suite of low-recruit species
  - Nor why they apparently avoid other species such as snappers, tomtate, and grunts, which have been generally increasing in abundance over the recent time period

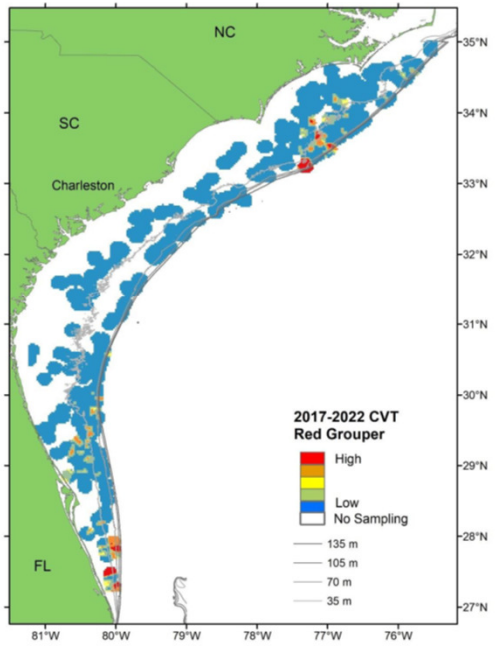
Red Snapper?

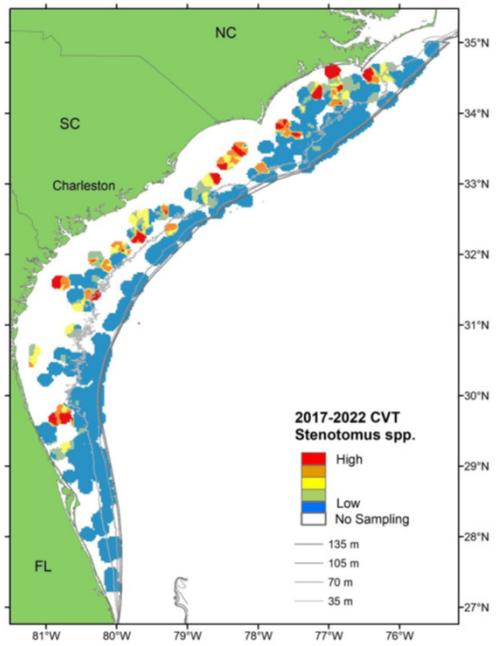
From Bubley et al.
2023 Trends report









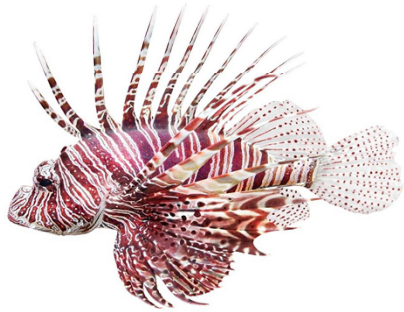


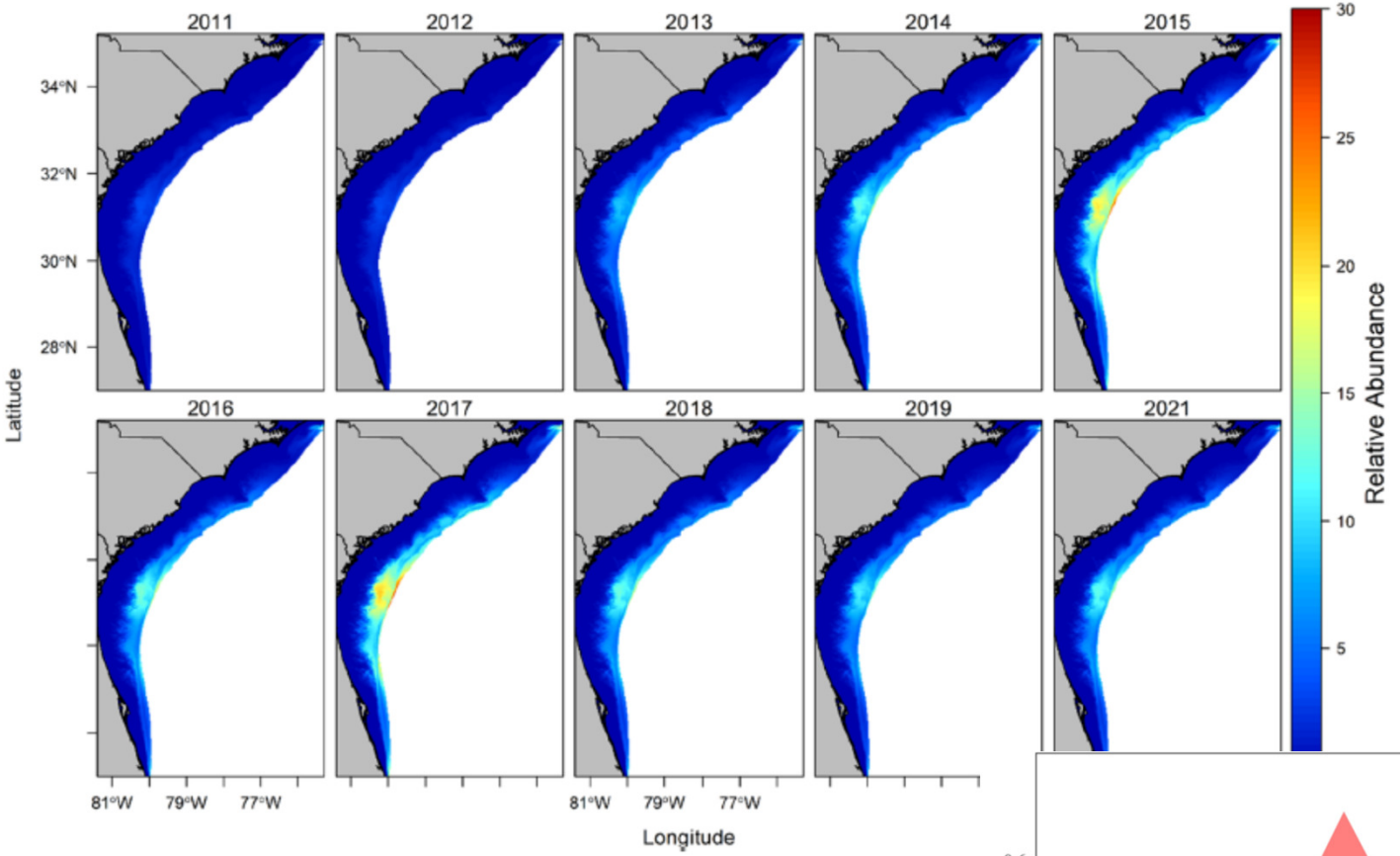
Red Snapper?

- Take-away points from Gentry et al. Ecopath with Ecosim Model
  - Red snapper is not likely to cause >5% decline in other species/groups
  - Red snapper is a generalist predator, switches prey according to availability, and has a diverse diet of fish, crustaceans, plankton, and other inverts.

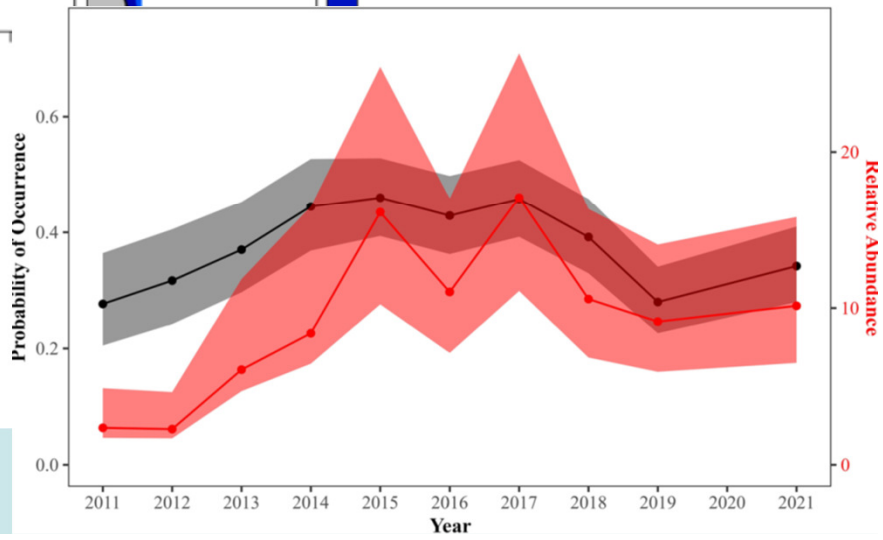
- (from presentation to SAFMC, December 2021)

Lionfish?





(Finch et al. 2024)



Hypotheses considered

- Sampling artifact
- Recruitment overfishing
- Sperm limitation of protogynous fishes
- Depredation
- **Environmental effect**

Recruitment drivers

- Applied methods from Sellinger et al. to SA stocks
- Sellinger et al. categorized stocks into three categories of recruitment drivers: SSB, environmental, edge (both).
- Based on correlations between SSB and recruits

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The robustness of our assumptions about recruitment: A re-examination of marine recruitment dynamics with additional data and novel methods

Emily L. Sellinger [a,*], Cody Szuwalski [b], André E. Punt [c]

Species	Classification
VS	Env
RP	Both
BSB	Both
GoTile	Env
RS	Env
RG	Env
GAJ	Env
GAG	Both
GTrig	Env
SG	Both
BlTile	Env
SCA	Both

Env = No significant zero lag

SSB = Significant zero lag; no significant neg lags

Both = Significant zero lag and neg lag

A clue?

XXX = peak spawning

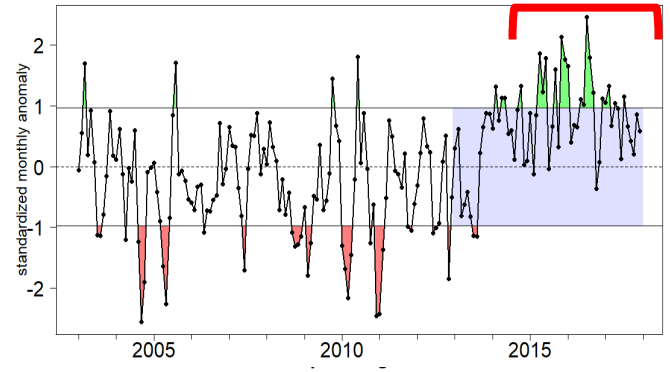
Abundance decrease, Evident low recruitment

Abundance increase, No signs of low recruitment

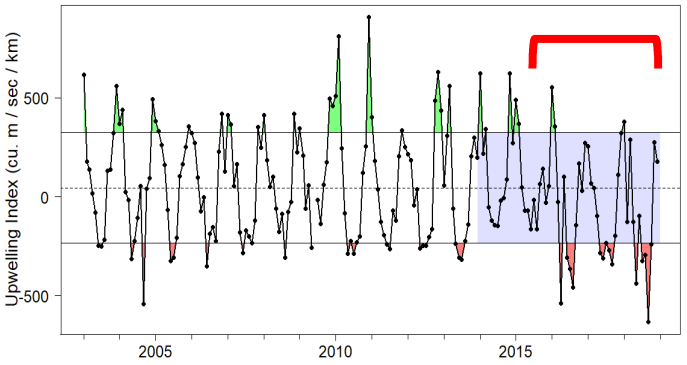
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Black sea bass		XXX	XXX	XXX								
Gag		XXX	XXX	XXX								
Stenotomous spp.		XXX	XXX									
Red grouper	XXX	XXX	XXX	XXX	XXX							
Red porgy	XXX	XXX	XXX								XXX	XXX
Scamp			XXX	XXX	XXX							
Sand perch					XXX	XXX	XXX					
Almaco jack							XXX					
Lane snapper						XXX	XXX	XXX				
Red snapper						XXX	XXX	XXX	XXX	XXX		
Vermilion snapper						XXX	XXX	XXX				
White grunt					XXX	XXX						
Mutton snapper					XXX	XXX	XXX					
Gray snapper						XXX	XXX					

Changing Ocean Conditions - ESR South Atlantic

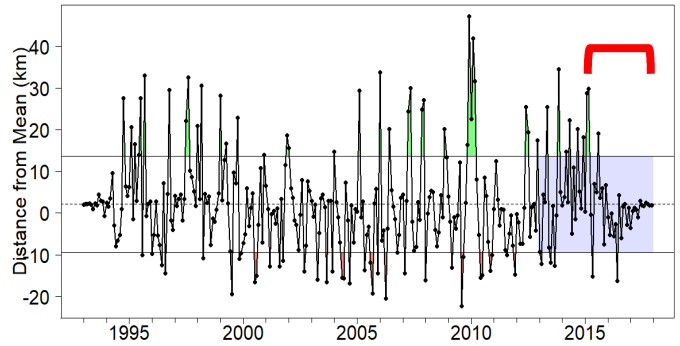
Increasing SST



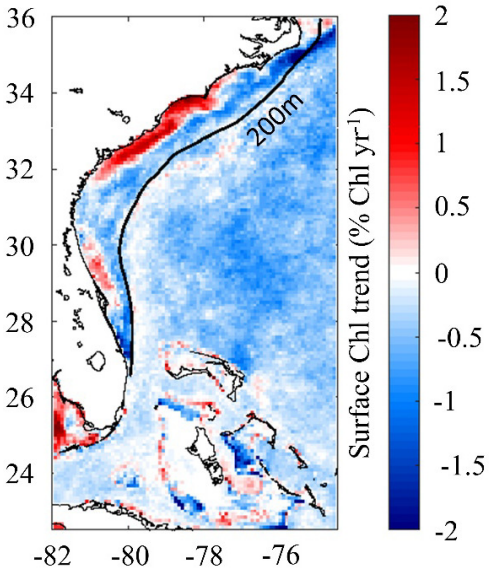
Decreasing upwelling intensity



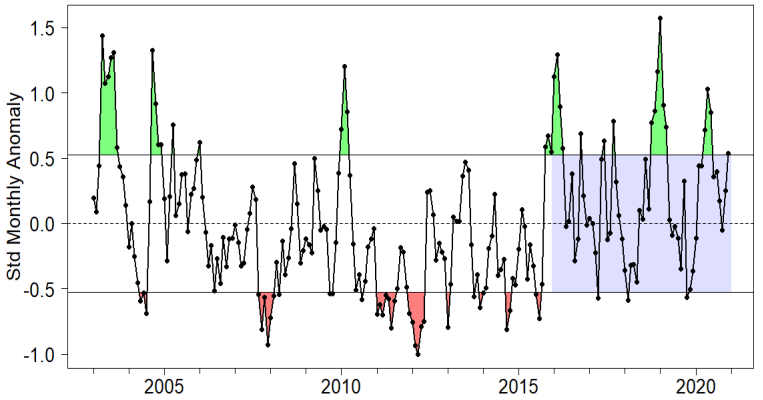
Gulf stream position: onshore



Nutrient dynamics



Chlorophyll-a (2003-2020)



4 km MODIS Aqua satellite imagery

(Craig et al., 2022)

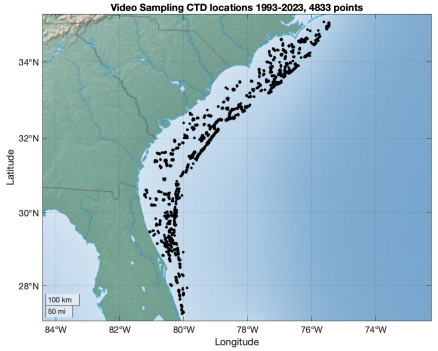
Environmental Drivers of Poor Recruitment (ongoing)

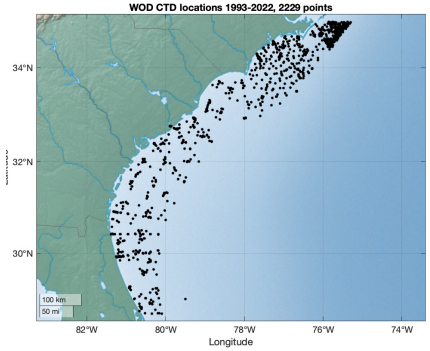
Goal: Investigate environmental drivers of poor recruitment

Two pronged approach:

1. Explore mechanistic explanations (eg., reduced productivity)
2. Explore spatial-temporal scales of variability from environmental drivers

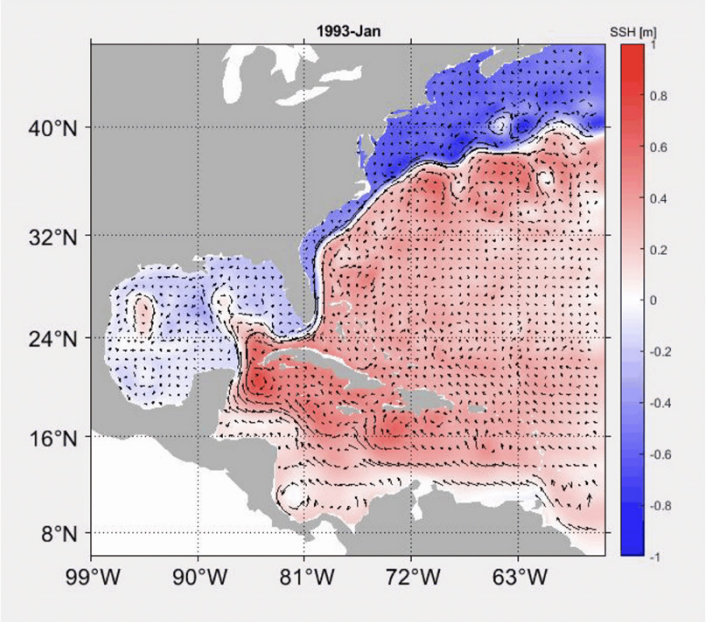
Data limitation: relative low coverage of sampling - oceanographic model output can help outcome this limitation





- eg. CTD casts from the World Ocean Database (WOD) and SERFIS/MARMAP surveys: 7062 data points across 30 years

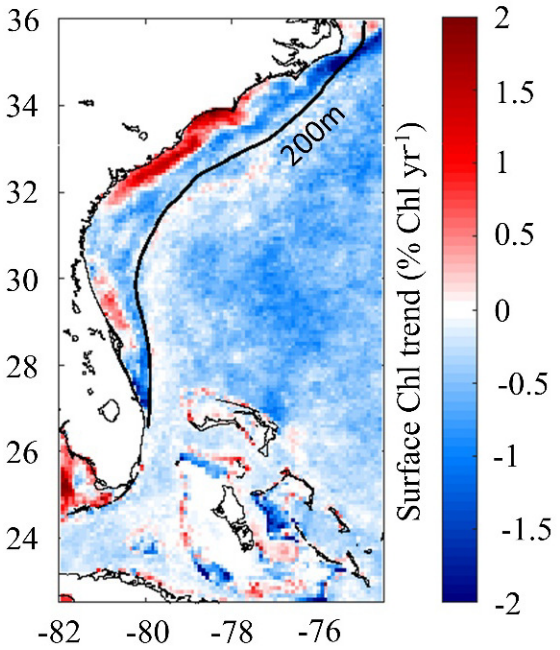
Data sources



Ruoying He, NCSU, unpub.

CNAPS: 30 years 3D oceanographic model (1993-2023, daily fields, 4km hor. resolution)

- **Sea surface temperature (SST)**
- **Sea surface height (SSH)**
- **Mixed layer depth**
- **Surface salinity**
- **Bottom temperature**

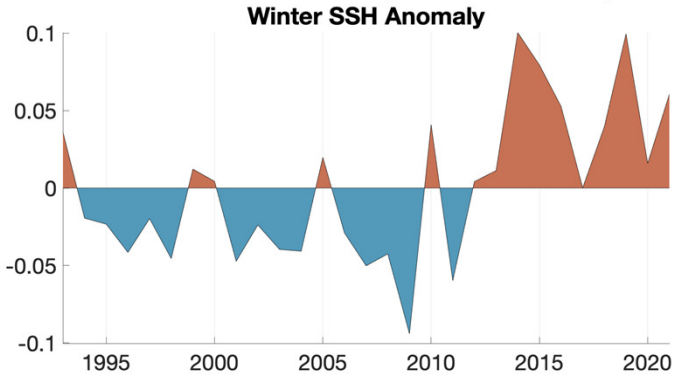


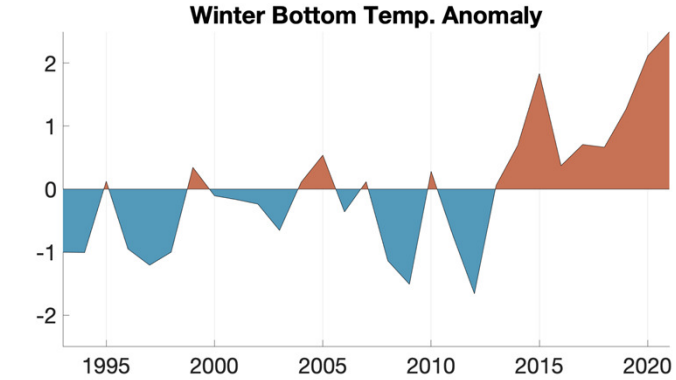
Chl-a as a proxy for primary productivity:

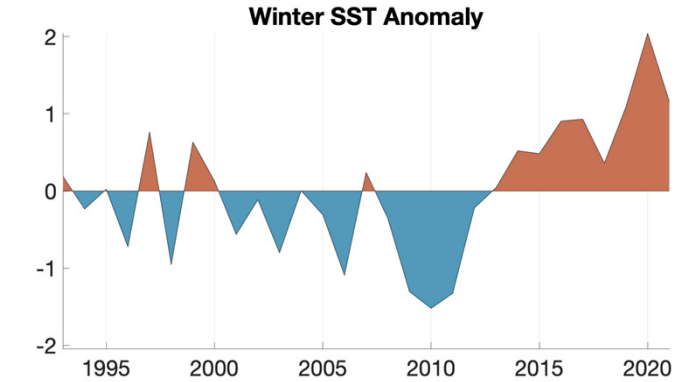
- Satellite Global Color from MODIS Aqua (2003-2022) and Copernicus-GlobColour (1998-2021)

- **Use products at seasonal scales**

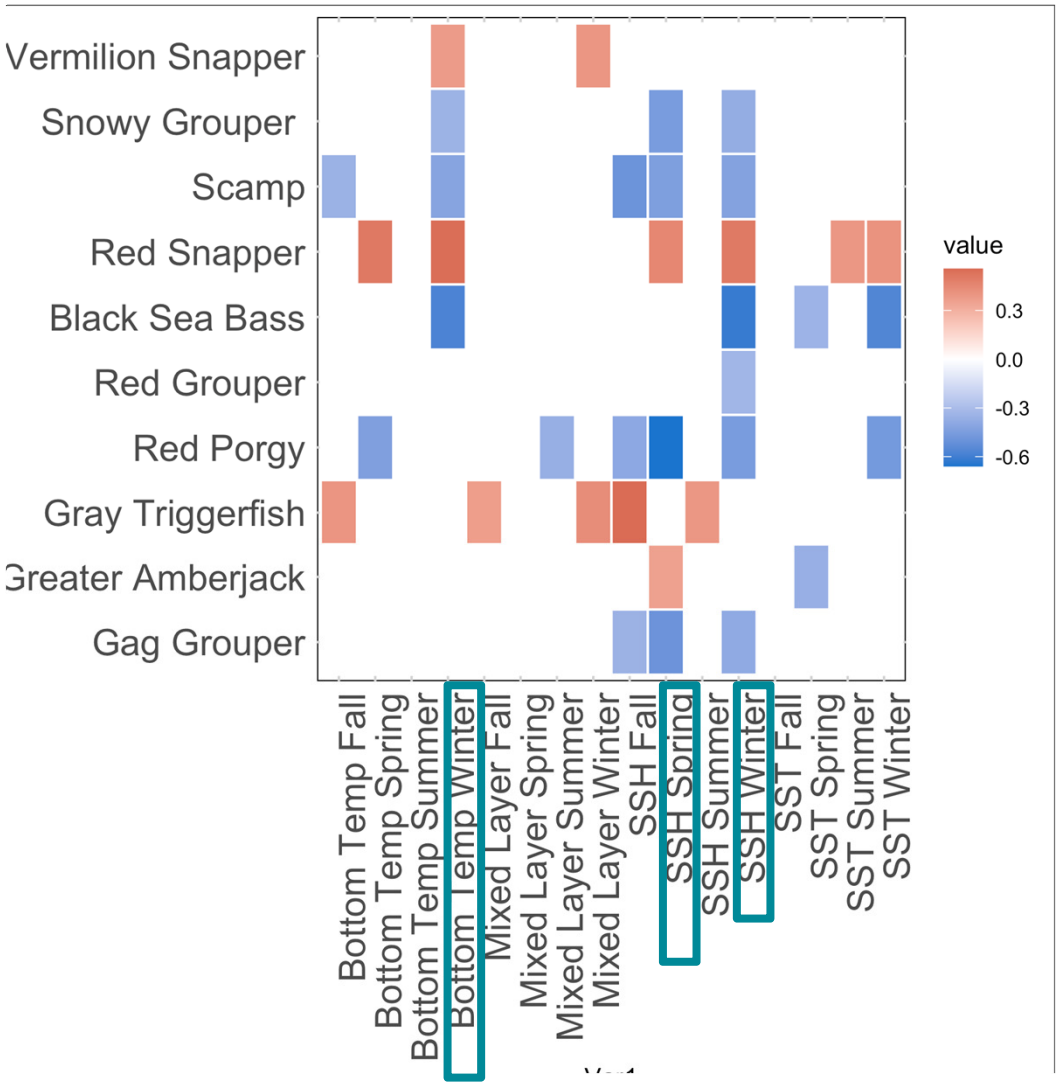
Anomalies (0-300m)



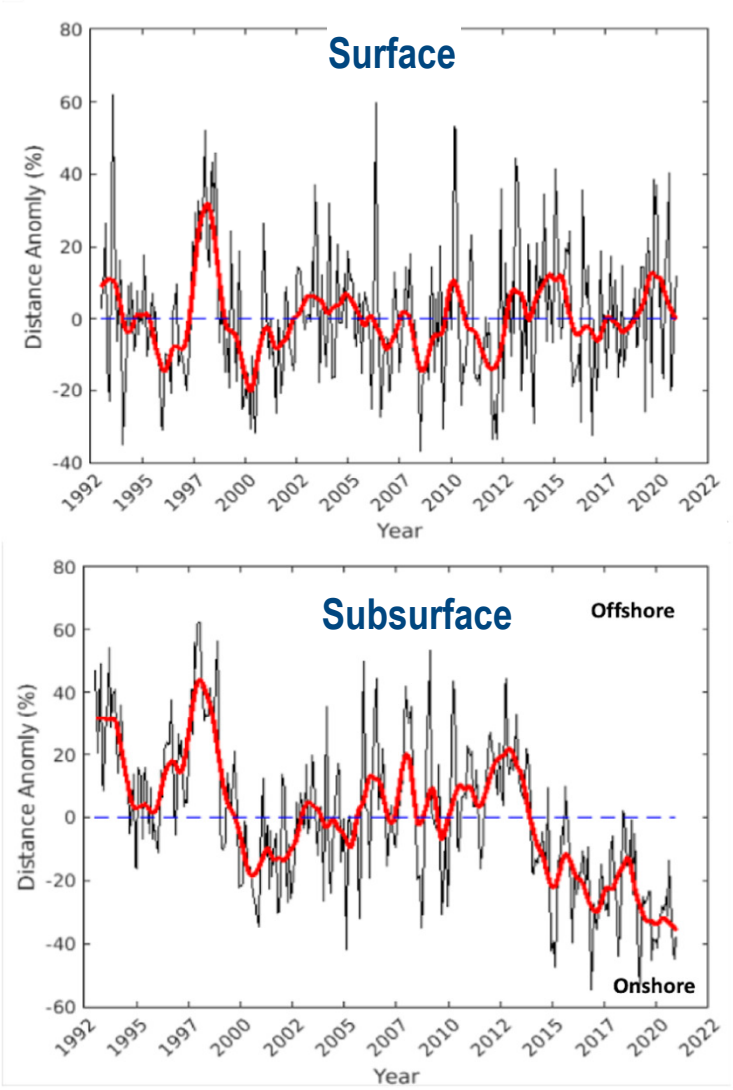


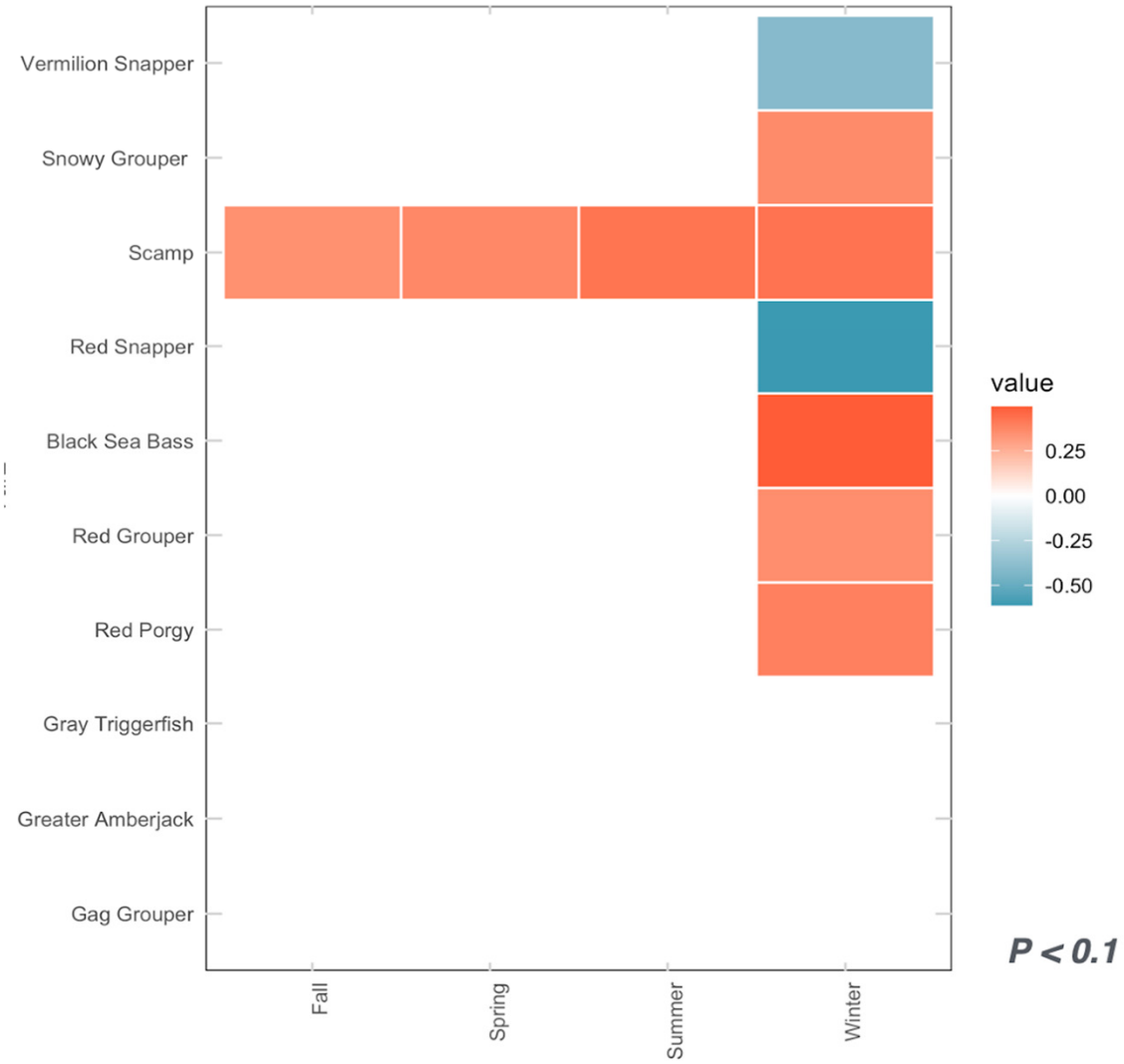


Correlations



Gulf Stream Position





(Shropshire and He., unpub.)

Discussion

- These results are still preliminary! No smoking gun yet on what's driving low recruitment.
- Did not find evidence for sampling artifacts, recruitment overfishing, effects of protogyny, depredation. Main focus now is on env drivers.
- Recruitment overfishing does not appear to be the primary driver of low recruitment in recent years
  - Could still play a role as a suppressant of recruitment
  - May have been an important driver earlier (1970s, 1980s) during declines in abundance of multiple snapper-grouper spp
- Environmental drivers: preliminary takeaways and next steps…

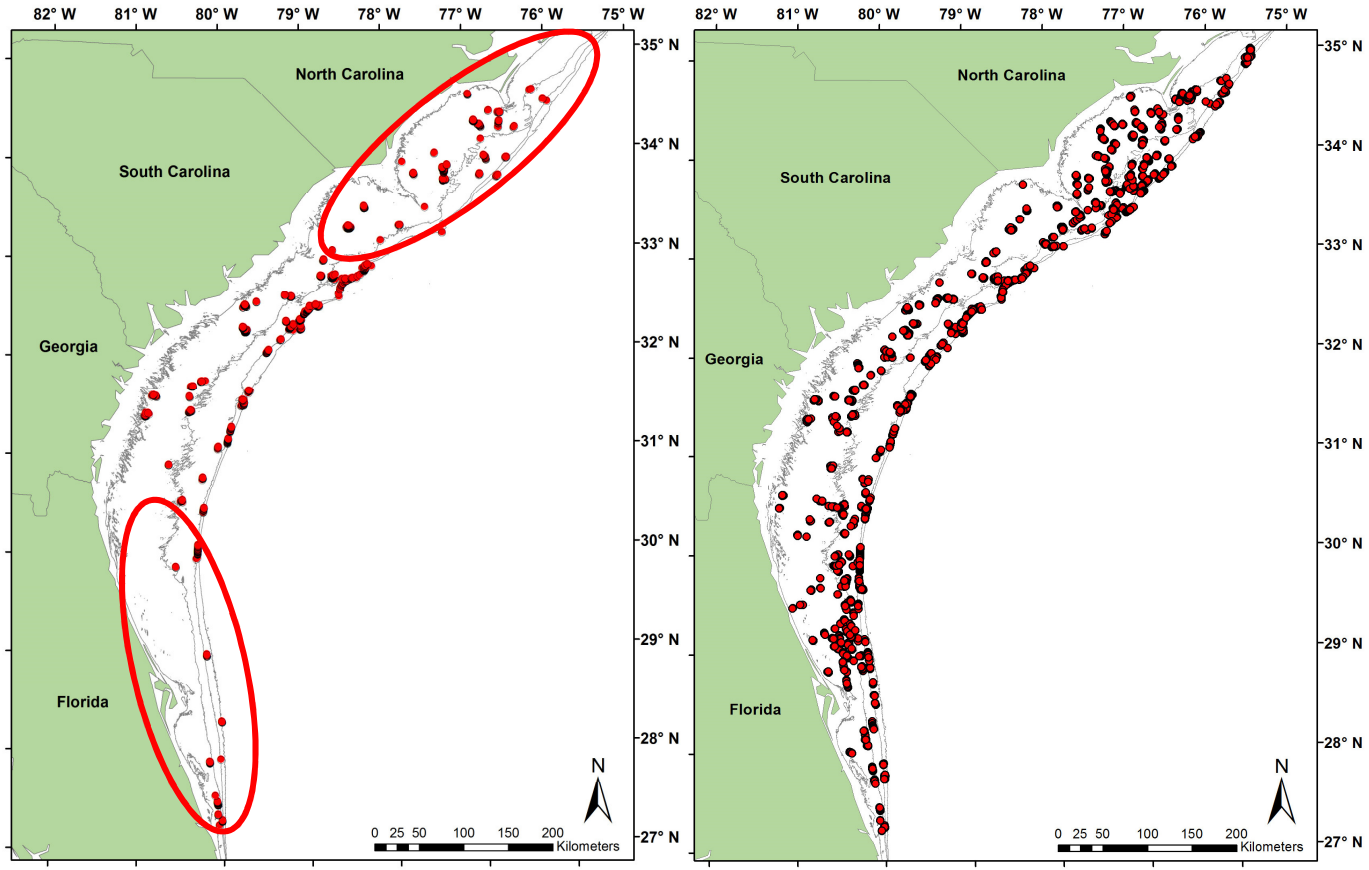
Environmental drivers

- Preliminary takeaways
  - Sig. correlation between Winter SSH, SST, and Bottom Temperature with recruitment deviations of several species.
  - Intrusions of Gulf Stream at depth appear more frequent - anomaly of GS distance at subsurface is sig. correlated with several species.

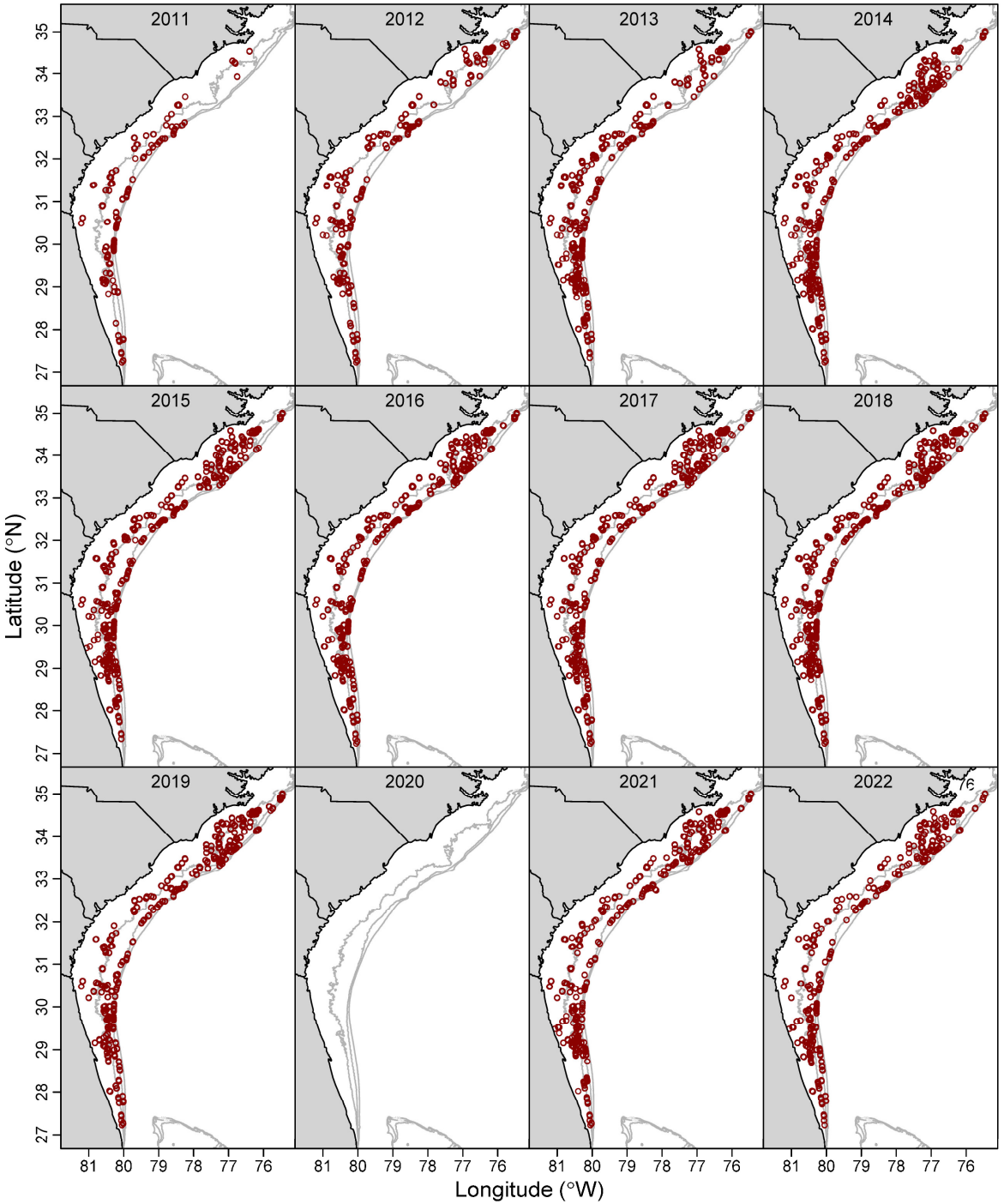
- Next steps
  - Explore relationships between recruitment, Gulf Stream deflection and Chl-a
  - Investigate the role of wind + stratification
    - Consider the roles of large scale upwelling vs. coastal
  - Consider combined effects of environmental covariates instead of individual variables.


Questions?
Discussion?
Suggestions?

SERFS survey expansion (2009 vs 2016)

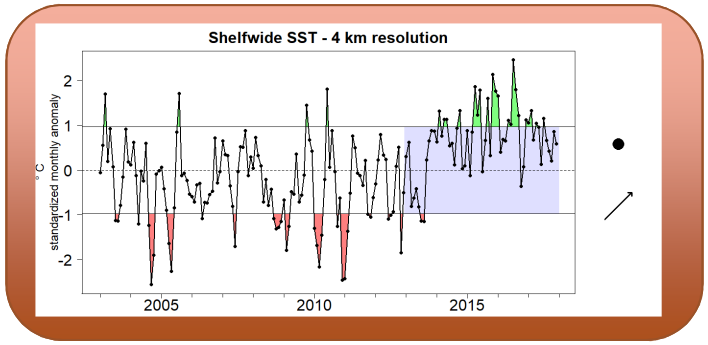


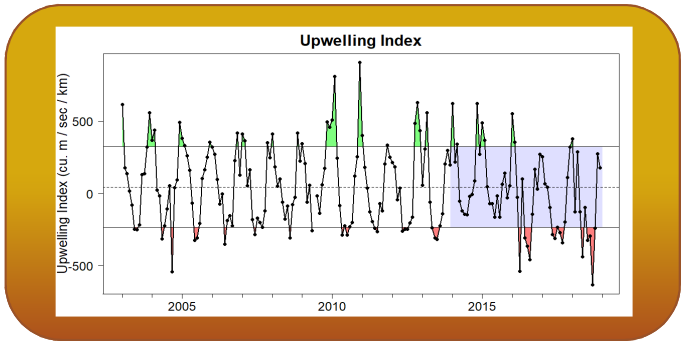
SERFS survey expansion 2011-2022

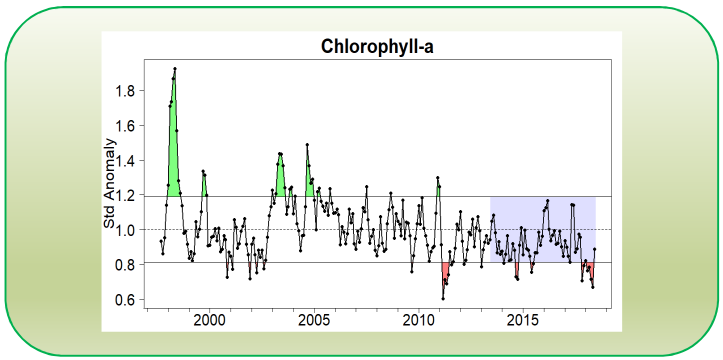


Three emerging themes in the US South Atlantic

Changing Ocean Conditions







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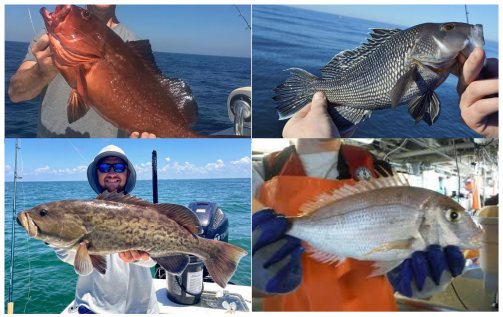
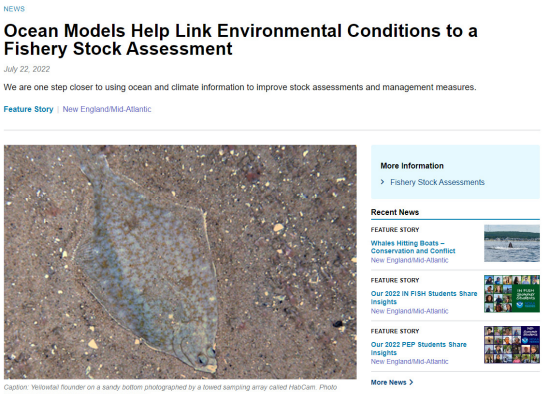
Recruitment declines



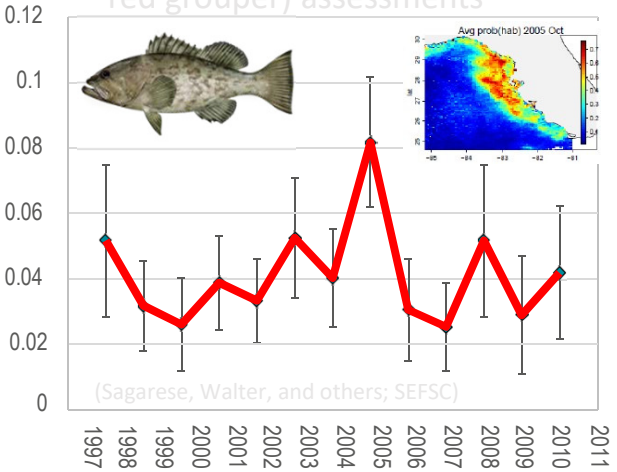
Ecosystem indicators & stock assessments



(du Pontavice, Saba, Miller, Stock; NEFSC)

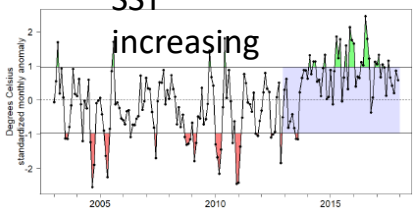
Cooler and more persistent 'cold pool' associated with lower yellowtail flounder recruitment

Red tides and Gulf grouper (gag, red grouper) assessments



(Sagarese, Walter, and others; SEFSC)

SST increasing



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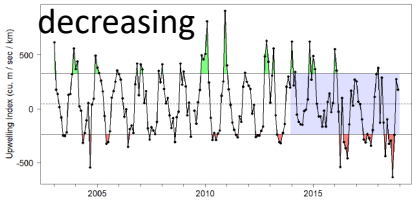
Nutrient Upwelling decreasing



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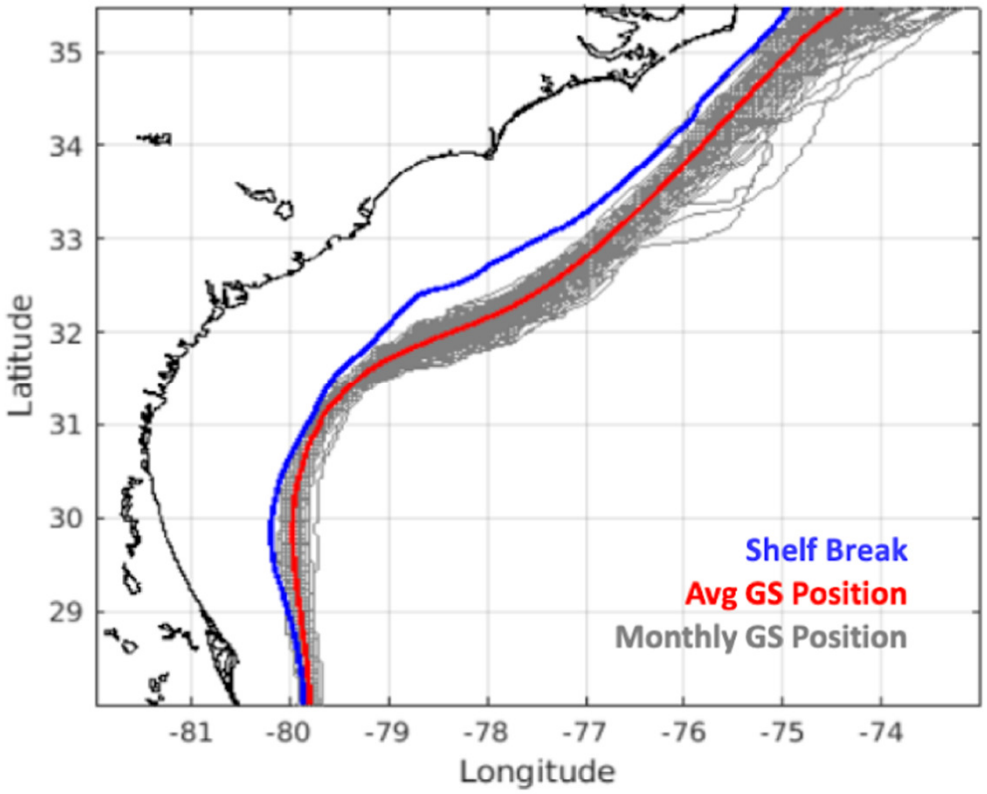
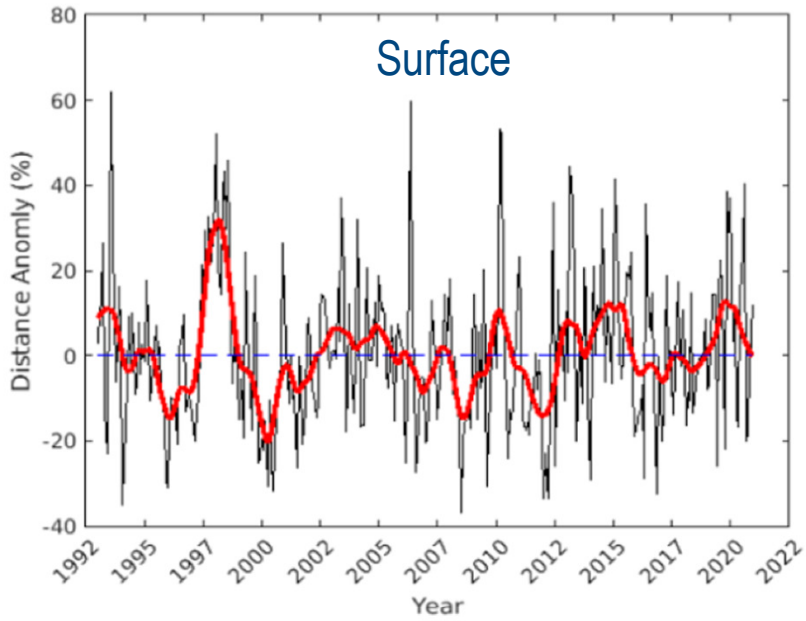
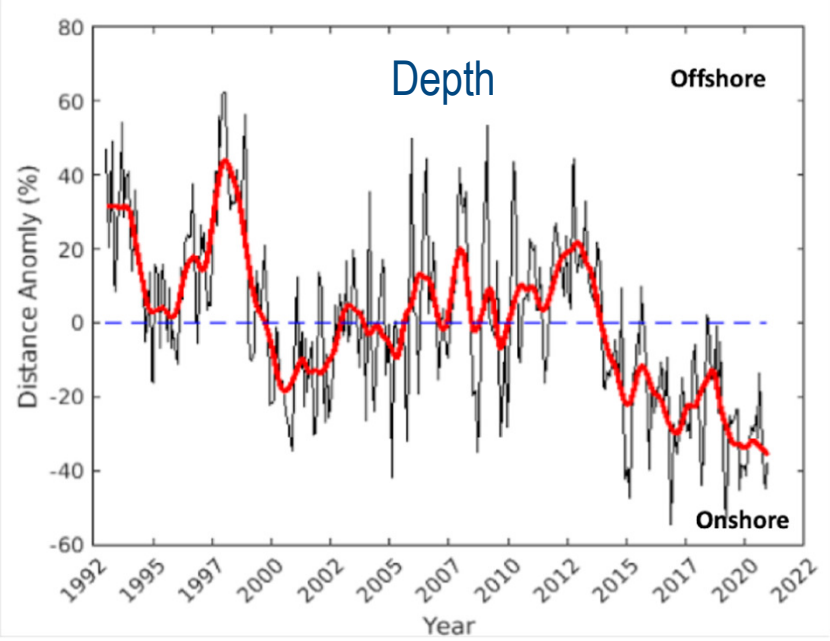
Recent recruitment declines

Upwelling Gulf Stream

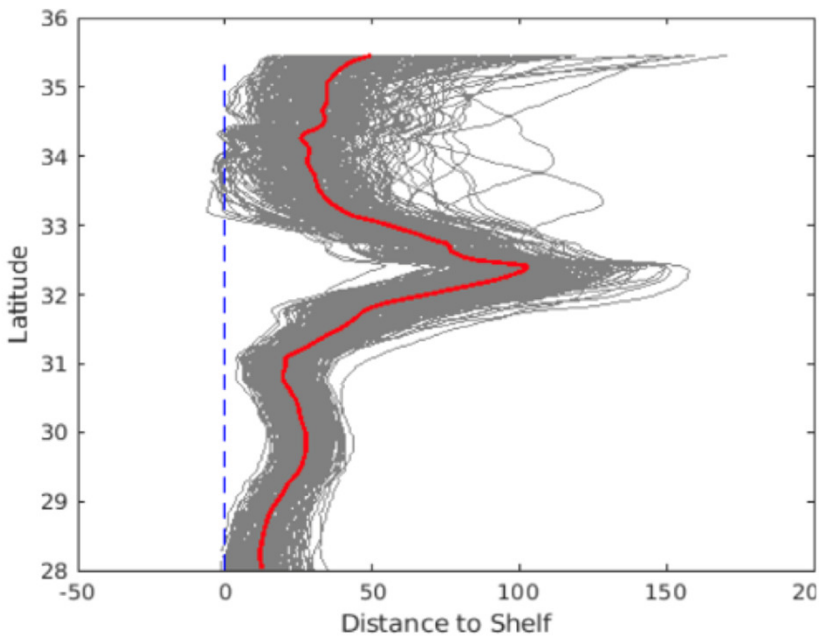


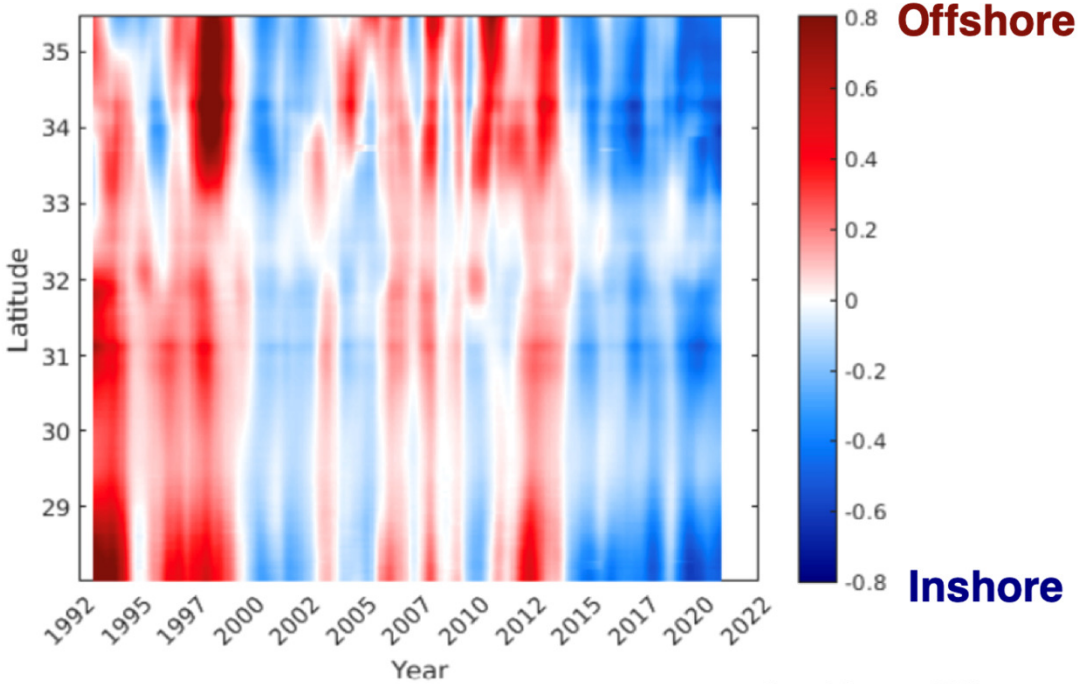




Upwelling at Depth

Given by the variability of the distance of the 18oC isotherm from the shelf break (200m isobath) when compared to the climatological position (long term mean)



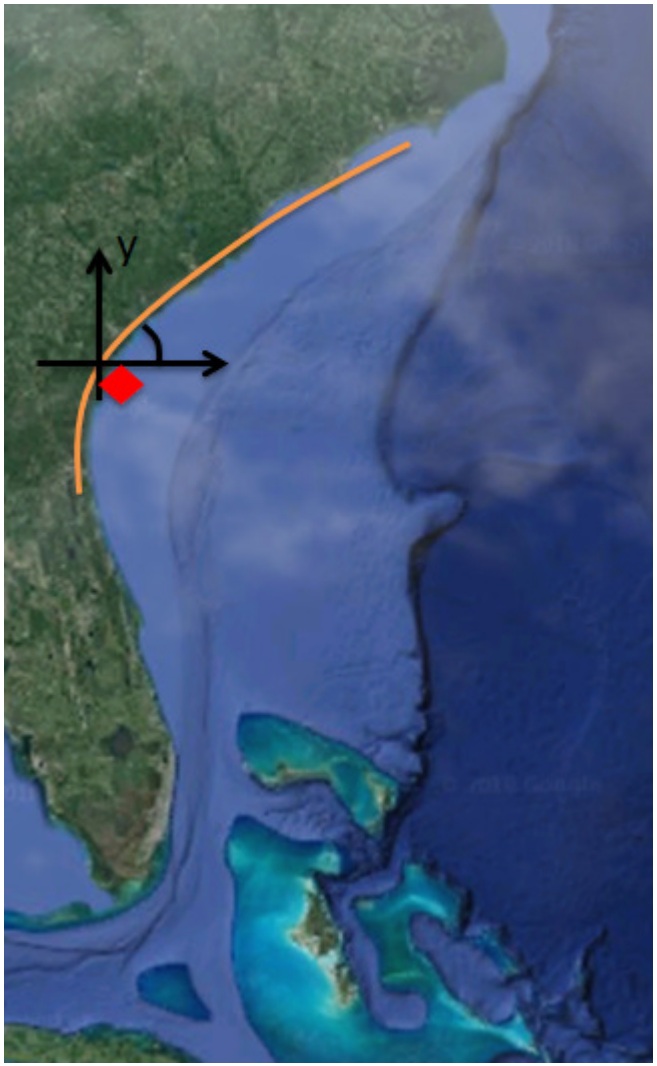


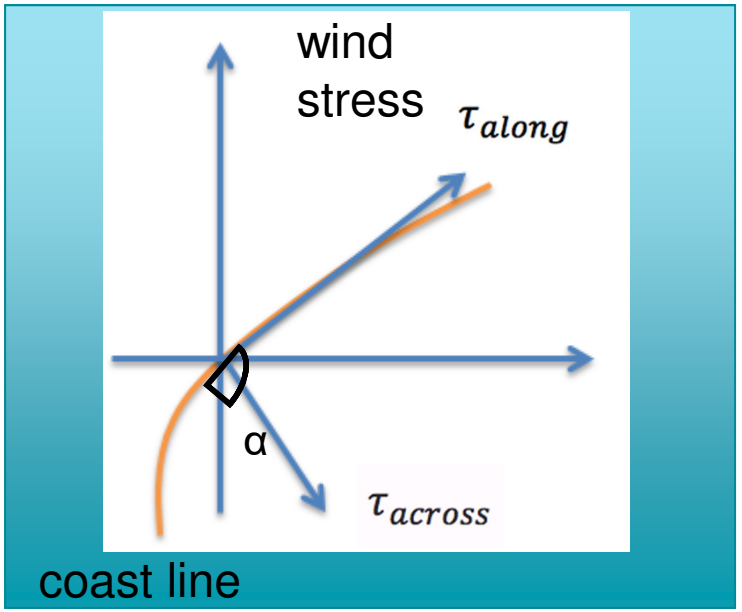
Note: 0.8 means 80% greater distance offshore than climatogy

Upwelling Index

$$UI = -\frac{\tau_{along}}{f \cdot \rho_w} 10^3$$

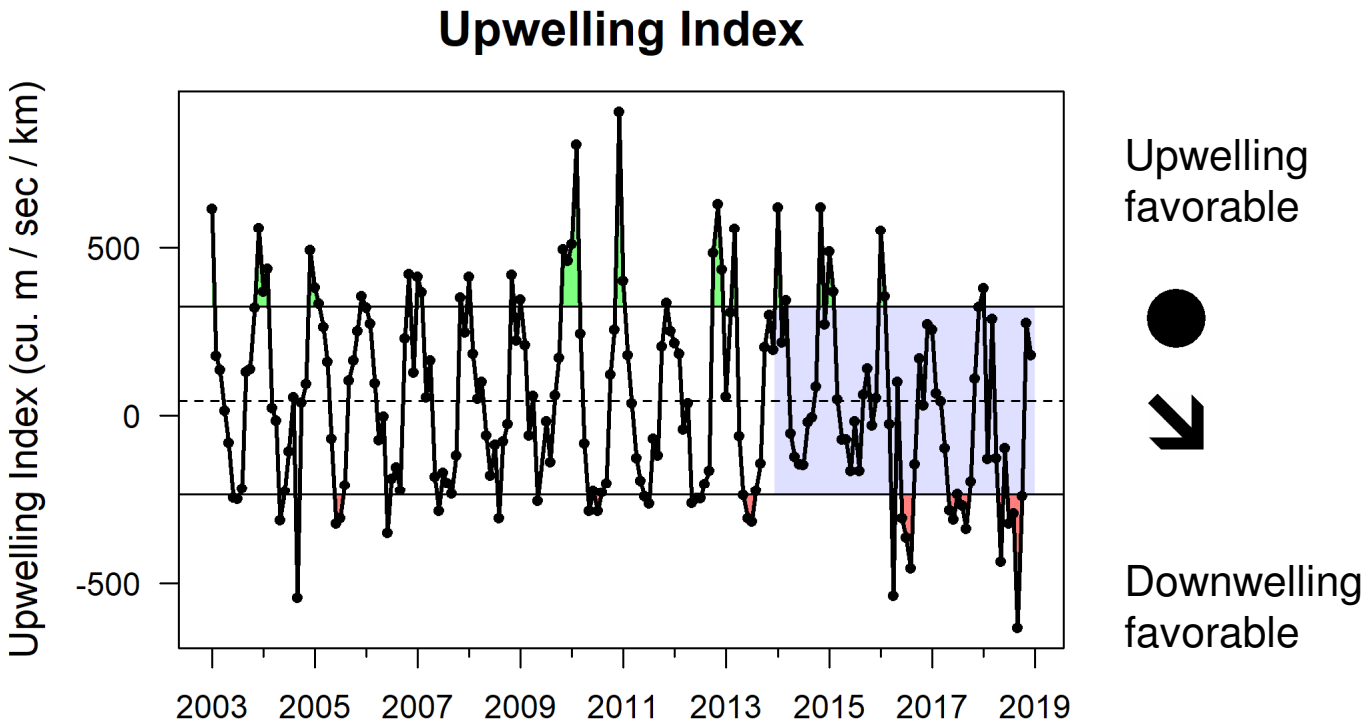
$$\tau_{along} = \rho_a \cdot C_d \cdot \sqrt{u^2 + v^2} \cdot v$$





- Gray's Reef Buoy Station (40 nm southeast of Savannah)

α = Angle of the coastline and the X axis
Tau = alongshore and cross shelf wind stress
ρ_a = Air density
ρ_w = Seawater density
C_d = Drag coefficient



- Monthly 2003 to 2018