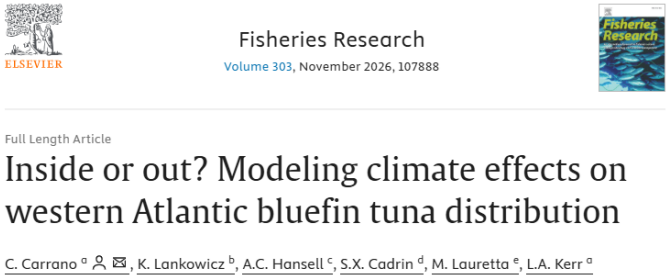
Inside or out? Modeling transboundary connectivity and availability shifts in western Atlantic bluefin tuna

Cole Carrano, Katie Lankowicz, Alex Hansell, Steve Cadrin, Matt Lauretta, Lisa Kerr



Fisheries Research
Volume 303, November 2026, 107888

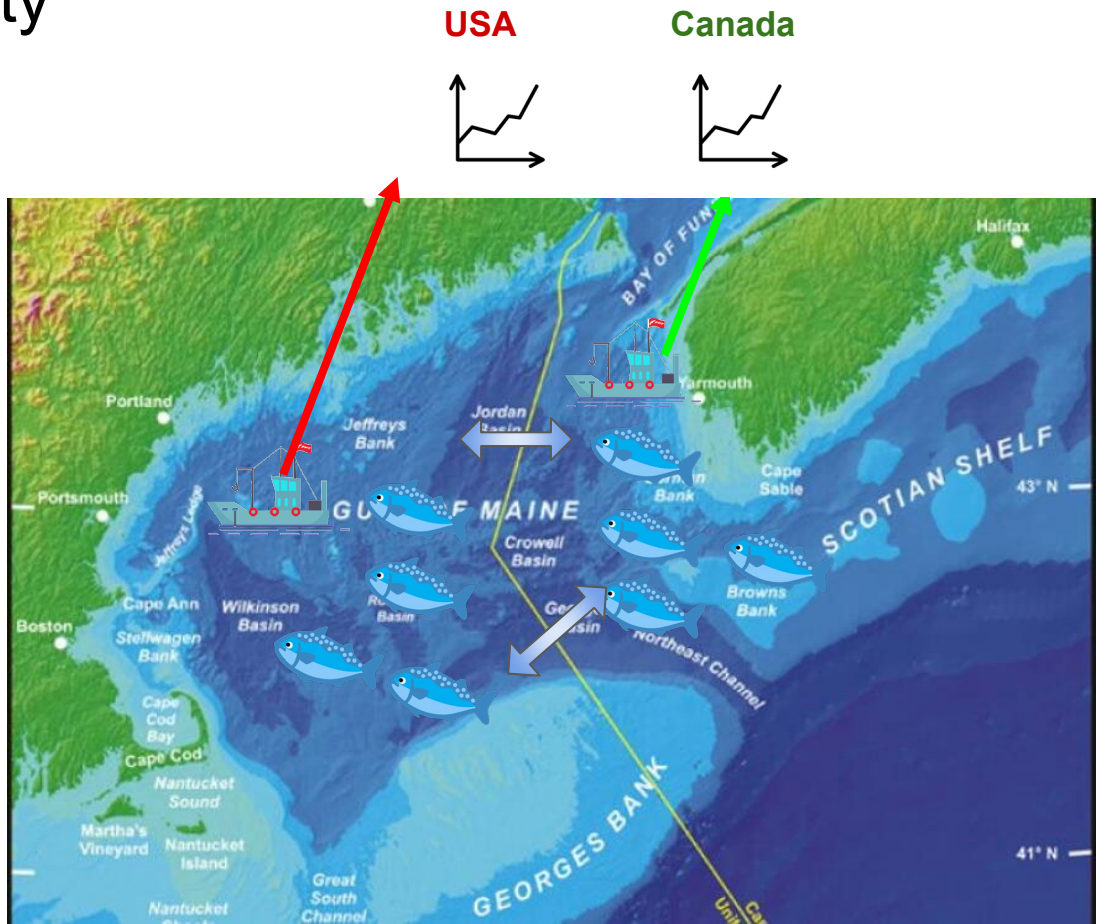
Full Length Article

Inside or out? Modeling climate effects on western Atlantic bluefin tuna distribution

C. Carrano [a], K. Lankowicz [b], A.C. Hansell [c], S.X. Cadrin [d], M. Lauretta [e], L.A. Kerr [a]

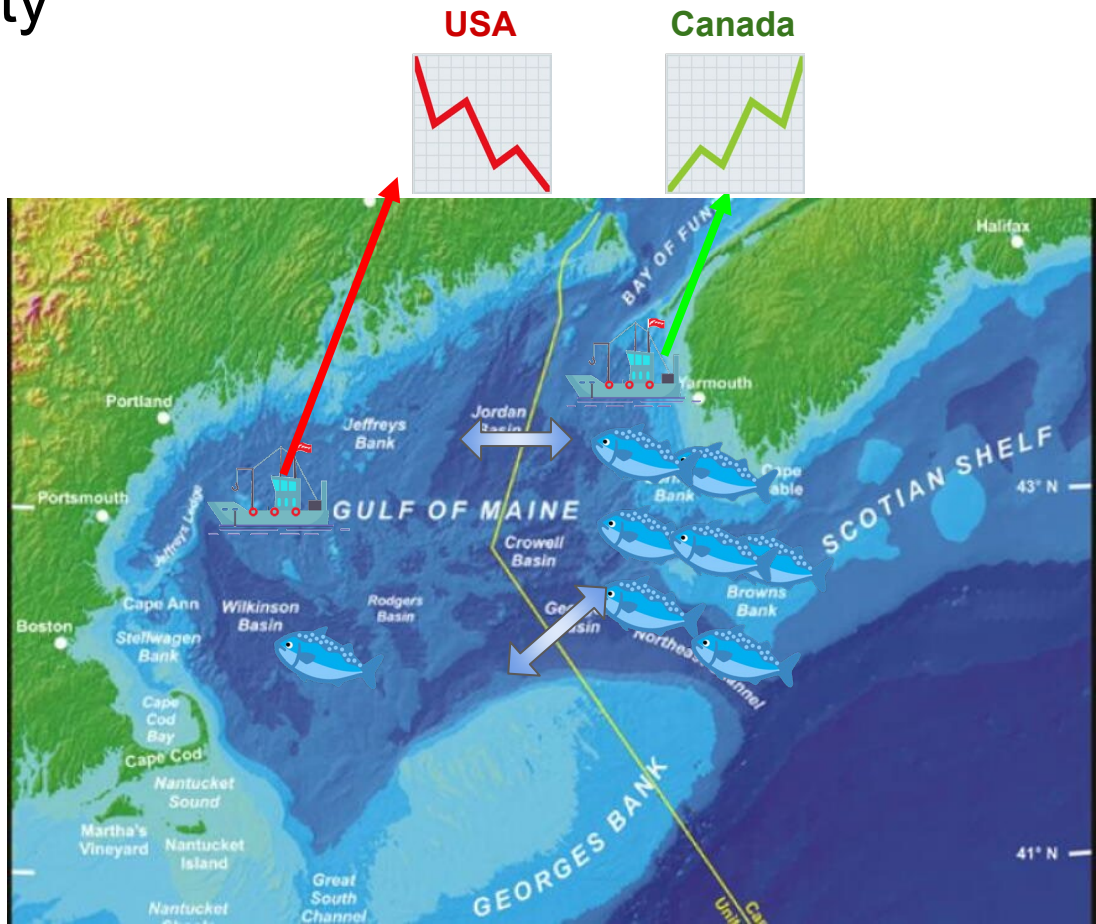
Importance of Connectivity

- **A single continuous population across jurisdictional boundaries with shared stock-wide dynamics**
- **Regional surveys measure relative abundance**



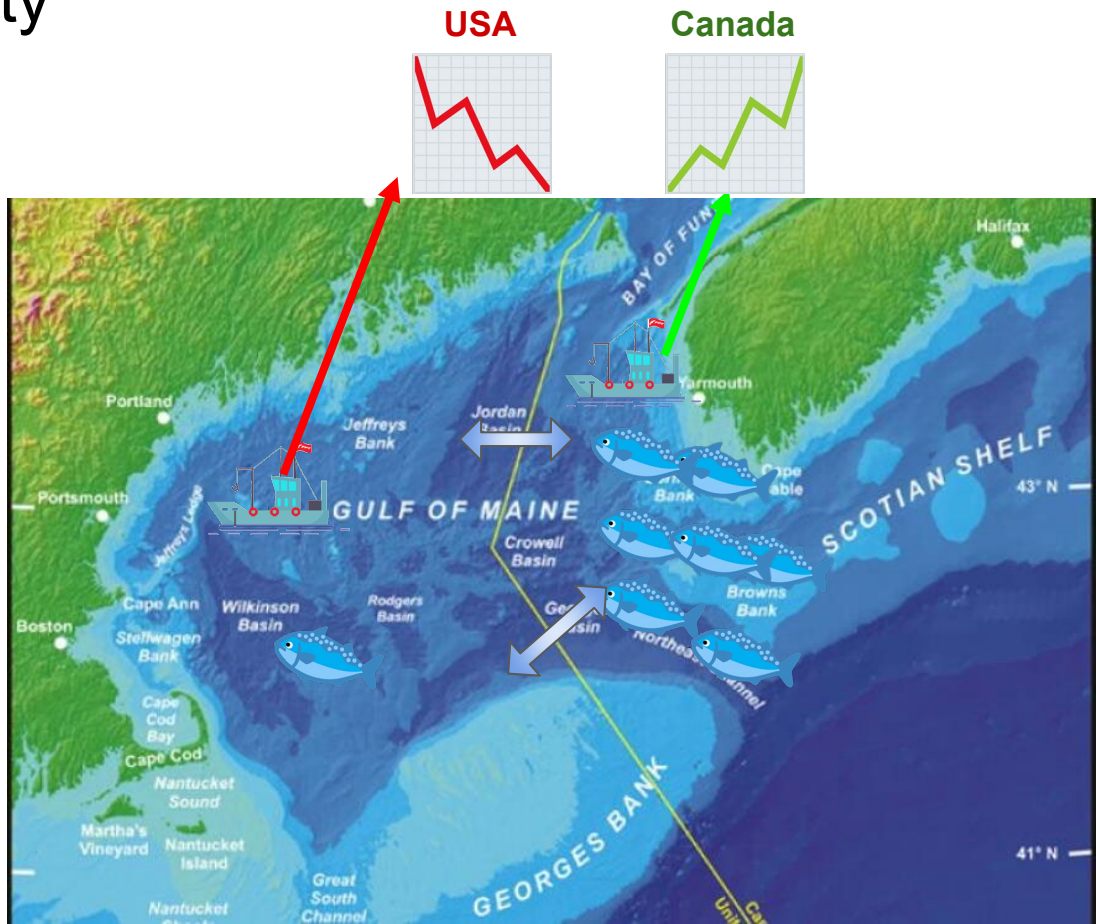
Importance of Connectivity

- A connected population exists across jurisdictional boundaries
- Regional surveys measure relative abundance
- **Fish move! Regional surveys reflect the change in perceived abundance**
    - **Indices now conflict**



Importance of Connectivity

- A connected population exists across jurisdictional boundaries
- Regional surveys measure relative abundance
- Fish move! Regional surveys reflect the change in perceived abundance
    - Indices now conflict
- **The reason for perceived abundance change is unidentifiable without an understanding of the whole stock across both regions**
    - **This issue is exaggerated for highly mobile stocks where movement is increased**

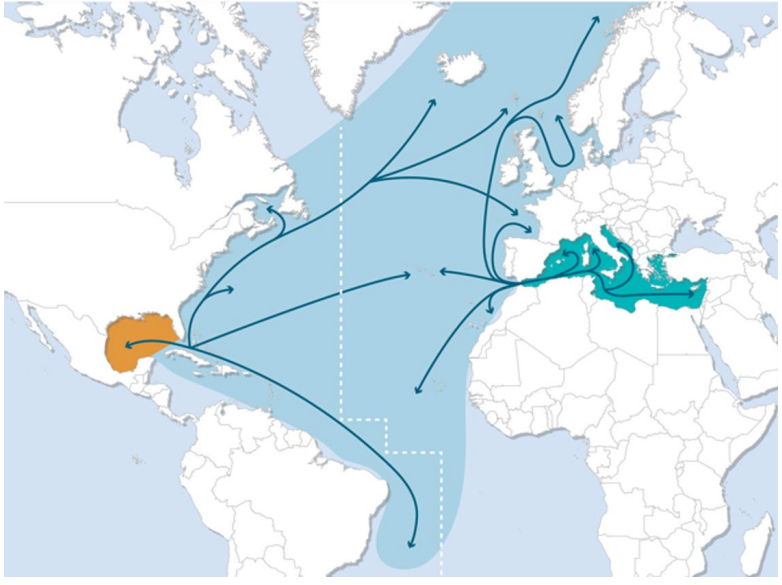


Background



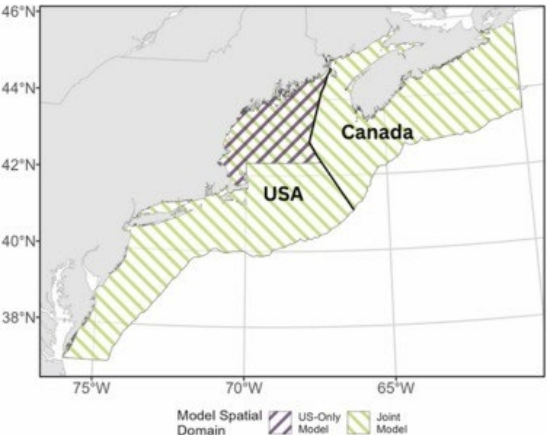
Atlantic bluefin tuna (*Thunnus thynnus*)

- High value global commercial and recreational fishery
- Highly migratory, ICCAT manages as two stocks (East/West)

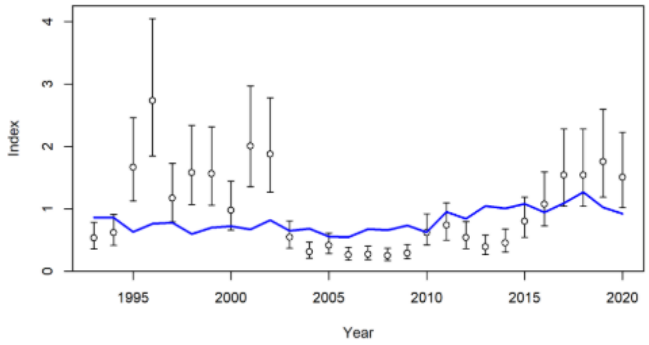


Western Atlantic bluefin tuna

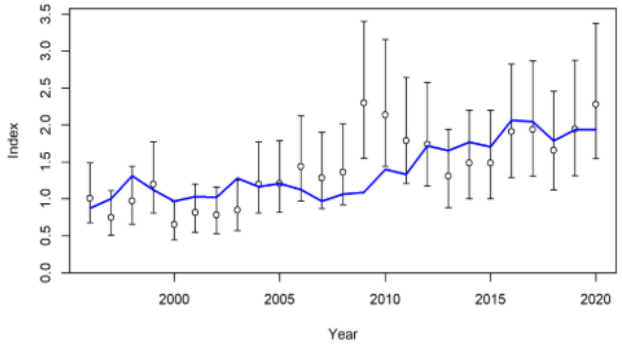
- Inhabit rich waters of Gulf of Maine and Canada late spring-fall
- Last WBFT assessment was 2021 (Stock Synthesis)
  - Uses several indices (fishery dependent and independent) from US and Canadian waters, but some indices conflict
  - Hypothesized climate driven distribution shifts



US Rod and Reel
>177cm



Canada Southwest
Nova Scotia



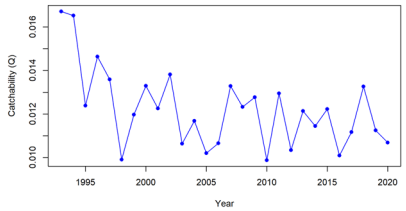
Problem:
Environmentally driven distribution shifts cause difficulty tracking stock abundance with regional surveys

Current ICCAT approach

Inside:
Use environmental index to modulate catchability of regional indices within assessment model

Outside:
Use transboundary spatiotemporal index to account for environmentally driven shifts external to the assessment

Stock Synthesis

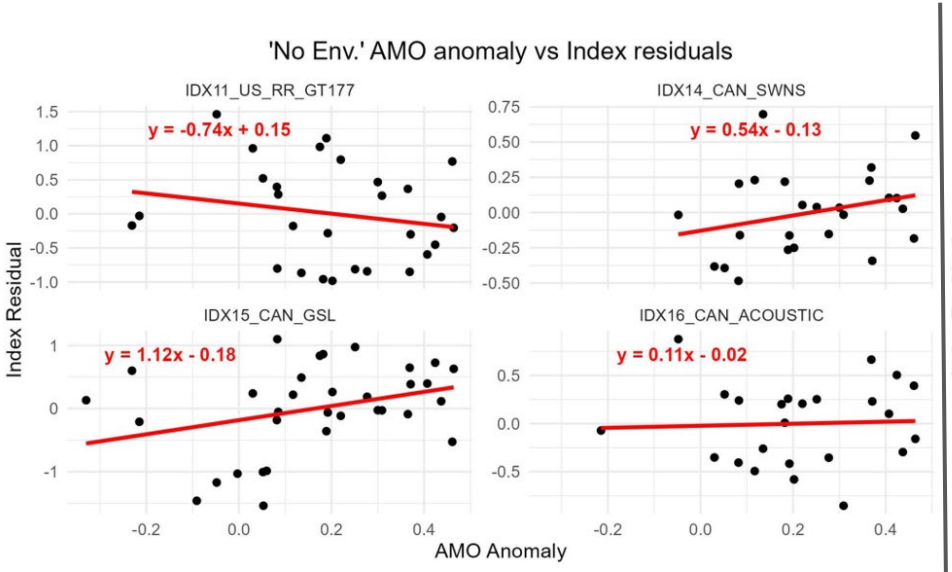


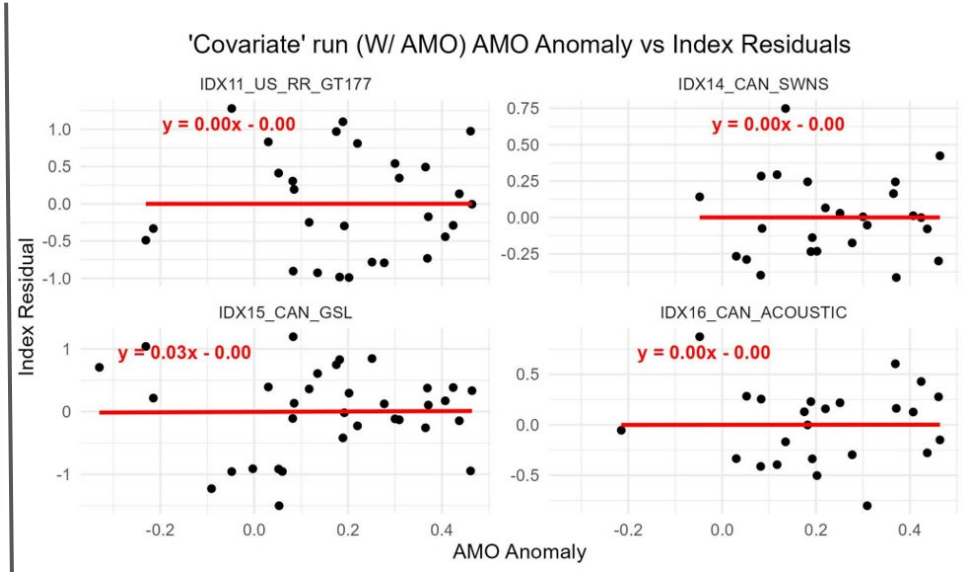
Vector Autoregressive Spatio-Temporal Model (VAST)



Inside: 2021 Western bluefin assessment

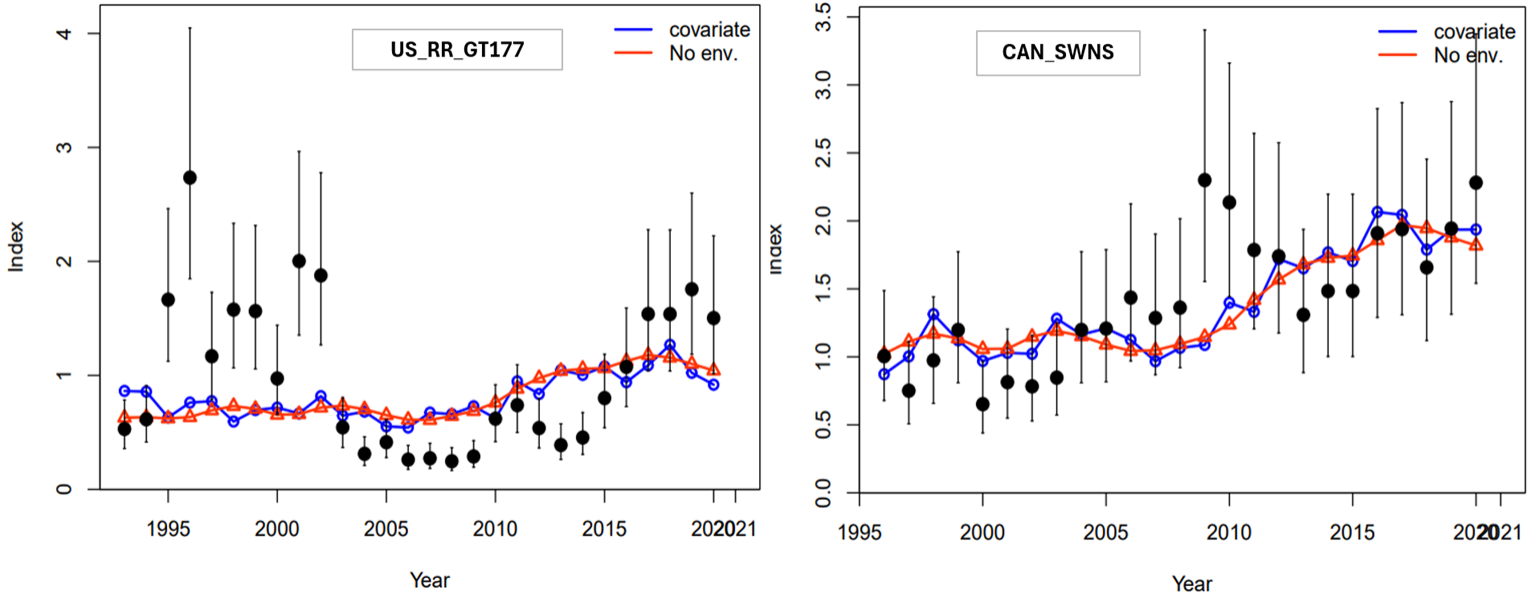
- Accounted for conflicting indices by using time series of Atlantic Multidecadal Oscillation (AMO) to modulate catchability for four affected indices of abundance





Inside: 2021 Western bluefin assessment

- Accounted for conflicting indices by using time series of Atlantic Multidecadal Oscillation (AMO) to modulate catchability for four affected indices of abundance

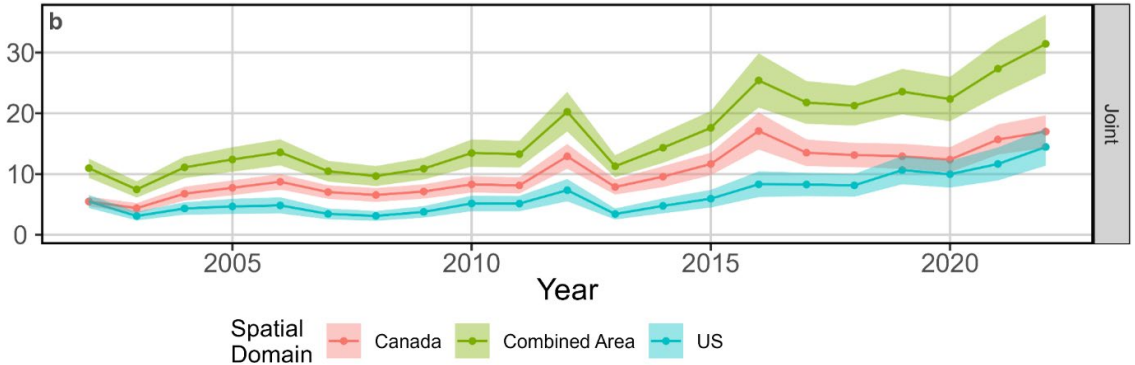


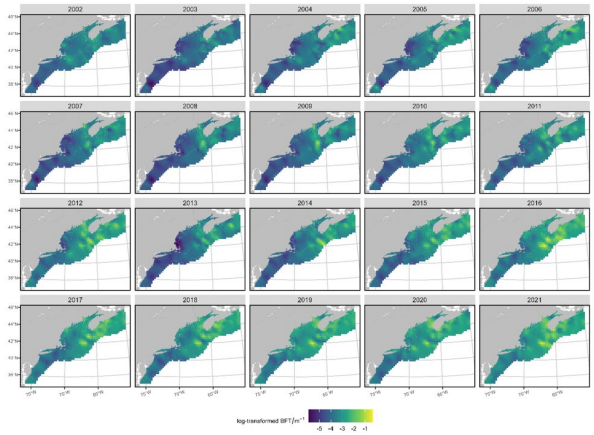
Dr. Katie Lankowicz
klankowicz@gmri.org



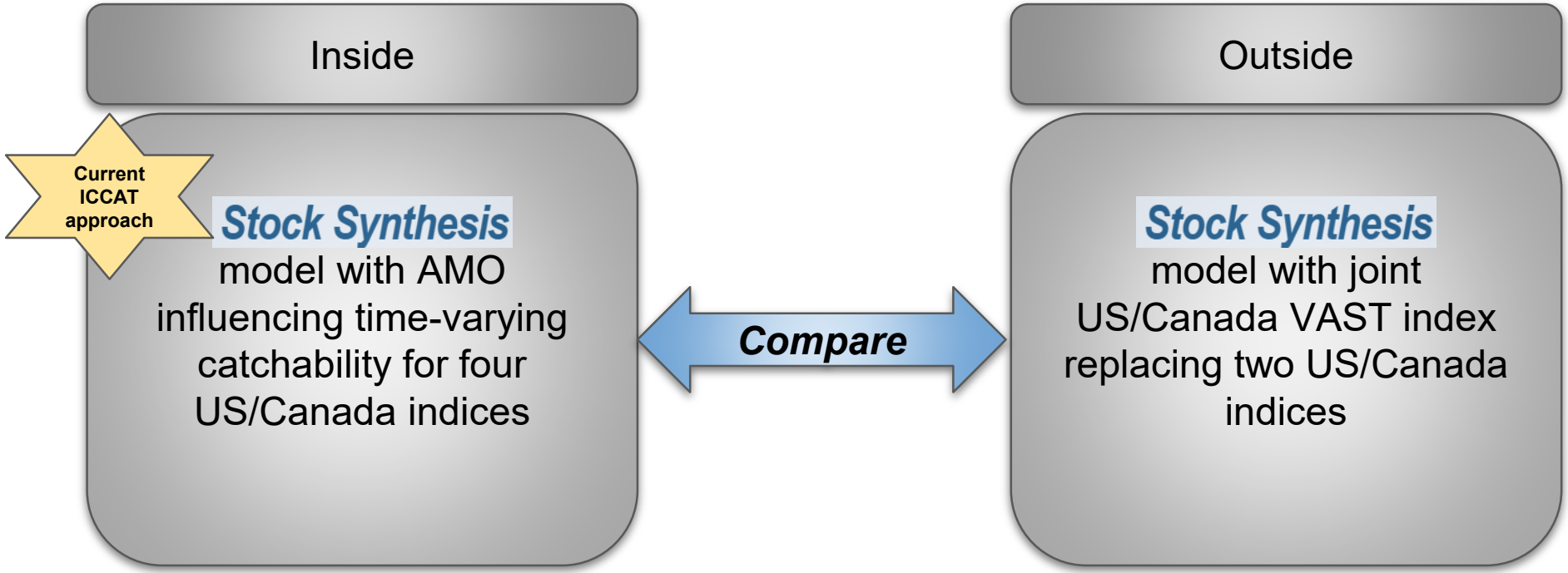
Outside: Vector Autoregressive Spatio-Temporal (VAST)

- VAST: Implements *delta-generalized linear mixed models (delta-GLMM)*
  - Spatio-temporal variation
  - Environmental covariates
- Joint US/Canada- landings from Large Pelagic Survey and Southwest Nova Scotia commercial catch from Virginia through Nova Scotia
  - Covariates: SST, depth, AMO

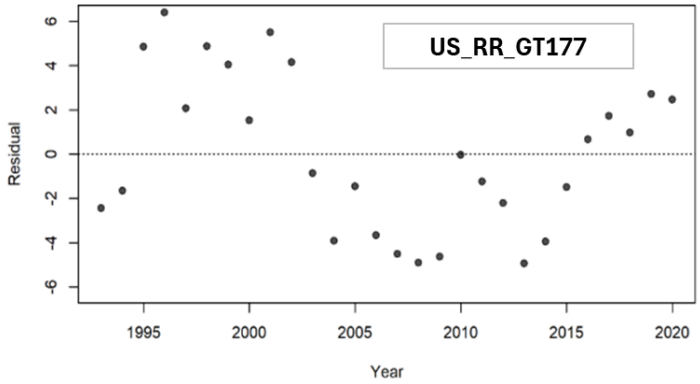


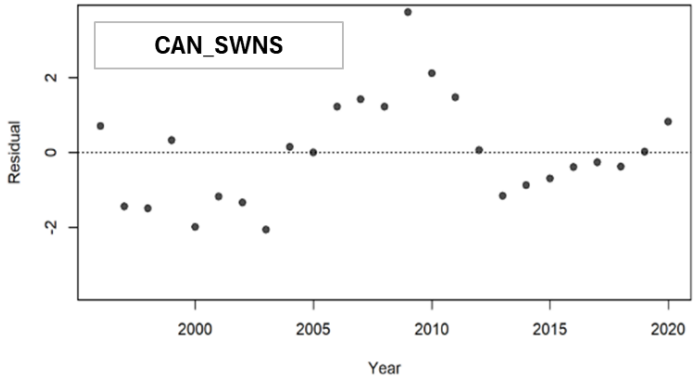


Methods

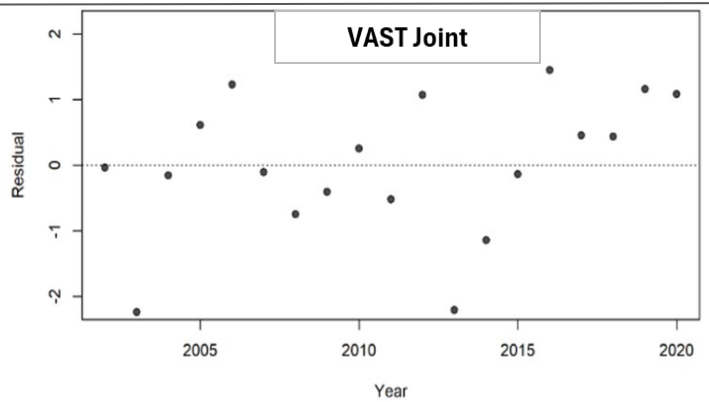

Inside
Outside
Current ICCAT approach
Stock Synthesis
model with AMO influencing time-varying catchability for four US/Canada indices
Compare
Stock Synthesis
model with joint US/Canada VAST index replacing two US/Canada indices

Comparing Index Fits (Stock Synthesis)





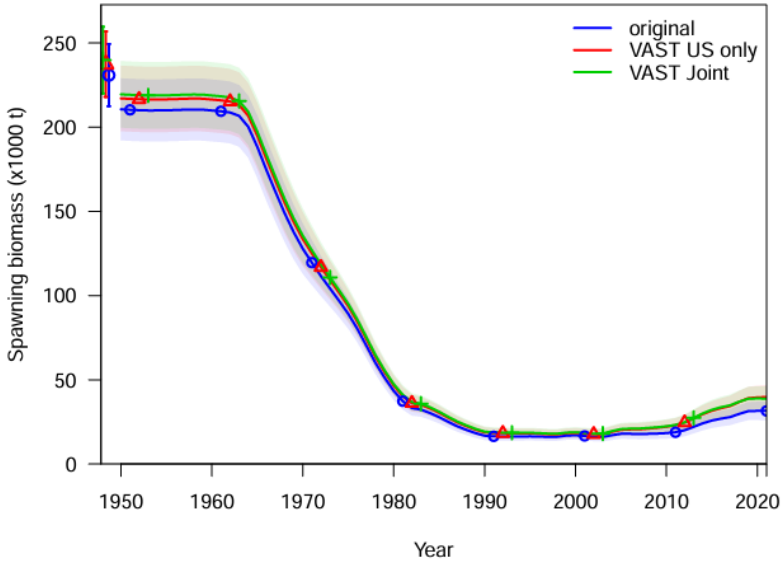
"Inside" Model (2021 assessment)

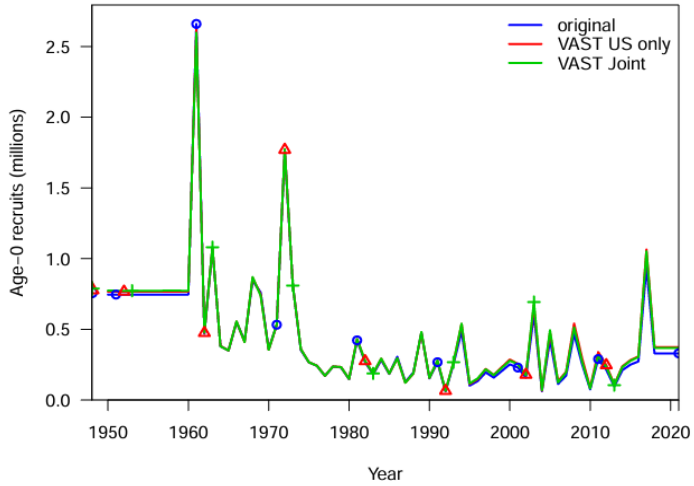


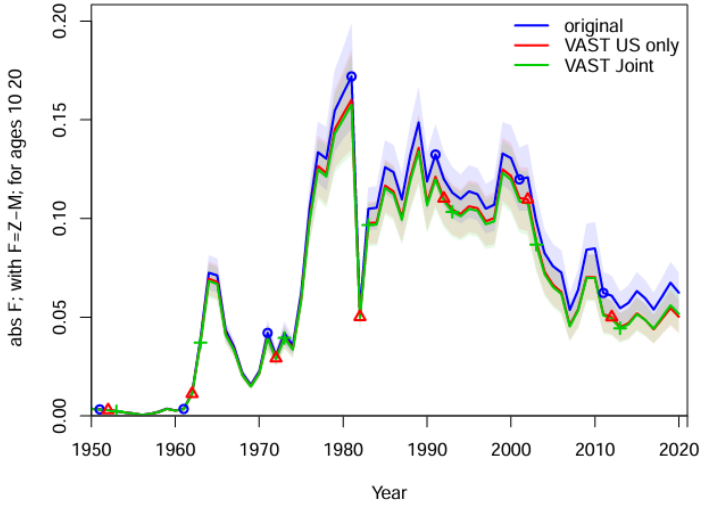
"Outside" Model (w/ VAST Index)

- VAST index (bottom row) has improved residuals

Assessment Model Comparisons







Comparison Takeaways:

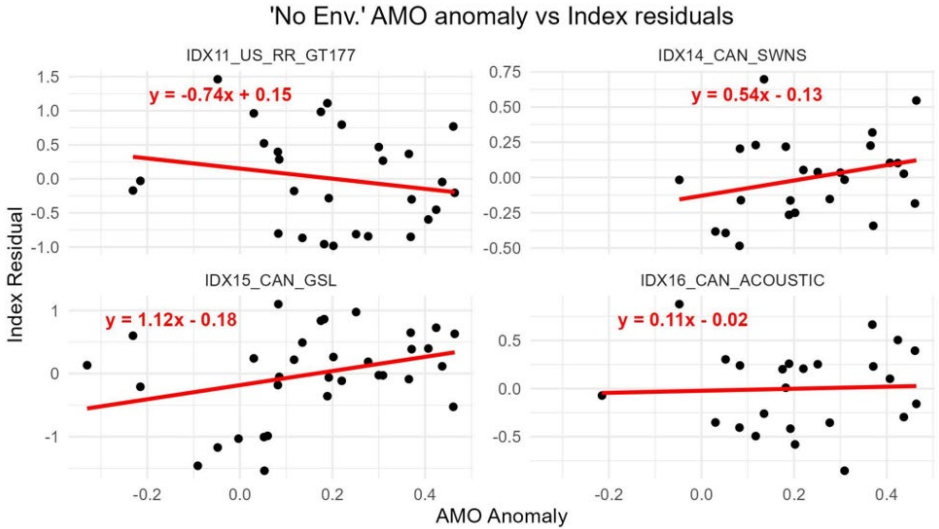
- Model fits VAST index better (smaller residuals, lower RMSE)
- Comparable trends in SSB, F, Recruitment

Key Advantages of External Standardization

- Uses a continuous, transboundary scale to assess the stock without artificial jurisdictional boundaries
- Uses environmental data at a fundamentally different scale
  - Finer resolution and can distinguish between effects on distribution and abundance (density)
- Reduces assessment complexity and potential parameter confounding (between catchability, recruitment, selectivity, and/or natural mortality)

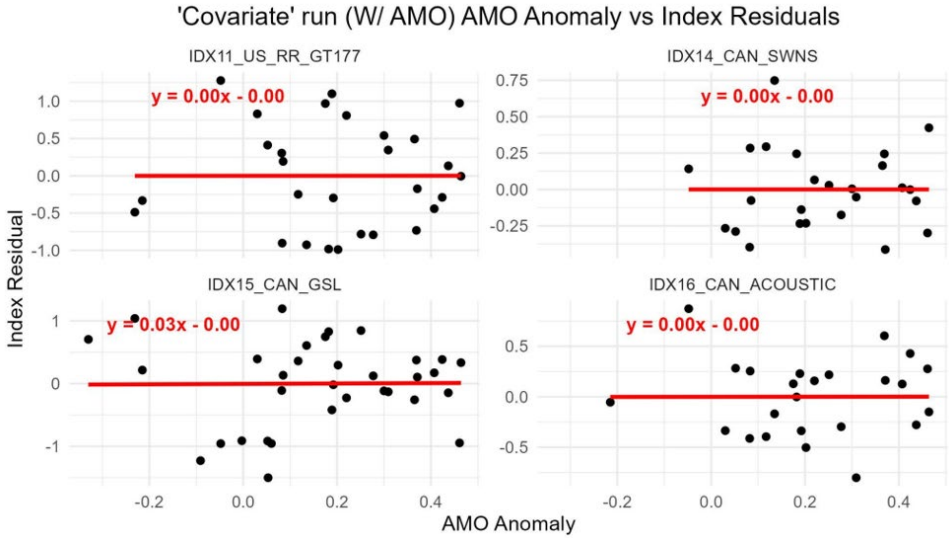
Summary

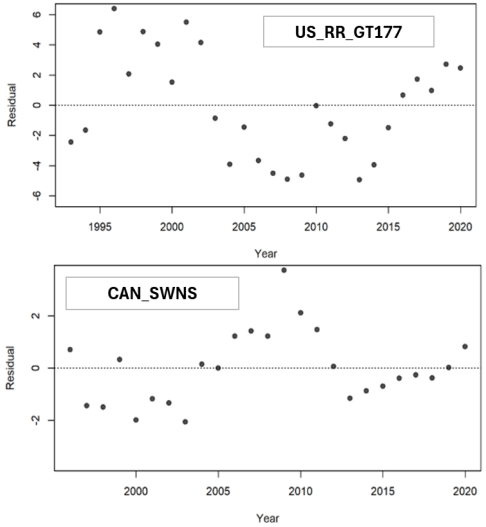
- Environmentally driven changes in bluefin tuna distribution cause difficulties in stock assessments which assume stationary catchability



Summary

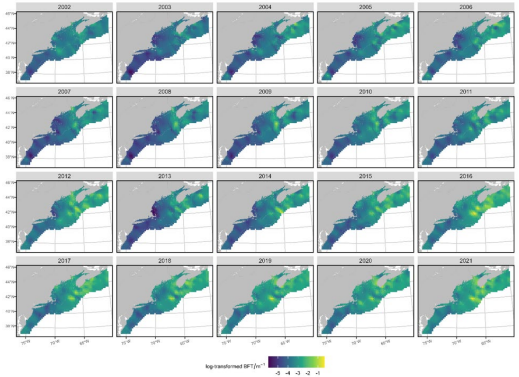
- Environmentally driven changes in bluefin tuna distribution cause difficulties in stock assessments which assume stationary catchability
- Adding an environmental covariate to inform time-varying catchability solves this issue, but non-random residual patterns remain





Summary

- Environmentally driven changes in bluefin tuna distribution cause difficulties in stock assessments which assume stationary catchability
- Adding an environmental covariate in the assessment to inform time-varying catchability solves this issue, but non-random residual patterns remain
- An assessment model with an externally standardized spatiotemporal index presents similar or improved diagnostics, and offers several key advantages



Conclusions/Recommendations

- External standardization captures environmental shifts without increasing assessment complexity or parameter confounding.
- Accounting for transboundary movement resolves conflicting regional trends and supports joint management.
- We recommend utilizing spatiotemporal models (e.g., VAST) when sufficient data are available, ensuring environmental mechanisms are evaluated externally before assessment integration

Acknowledgements

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Funding: NOAA Bluefin Tuna Research Program

Additional thanks to: Alex Hanke, Sosthène Akia, Walt Golet

