Integrating Ecosystem and Climate Influences on Dynamics of New England Stocks into Stock Assessment

Lisa Kerr-NEFMC SSC

Scientific Coordination Subcommittee Meeting

Sitka, Alaska

August 15, 2022

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Science. Education. Community.

Roadmap

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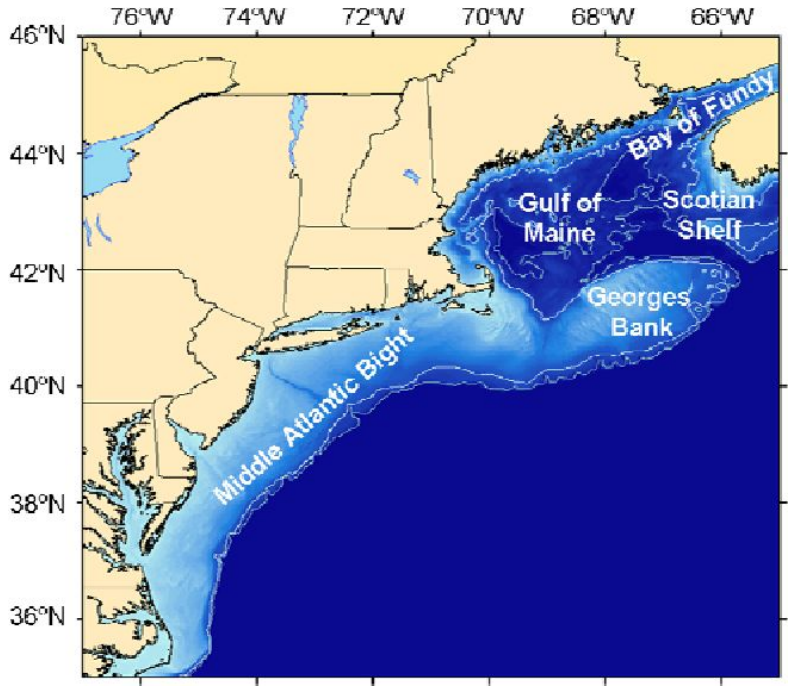
- Overview of new stock assessment process.
- Adoption of new assessment models in the region.
- Progress on integration of ecosystem and climate impacts in stock assessment.
  - Case study: American plaice



New England Fishery Management Council

New Stock Assessment Process

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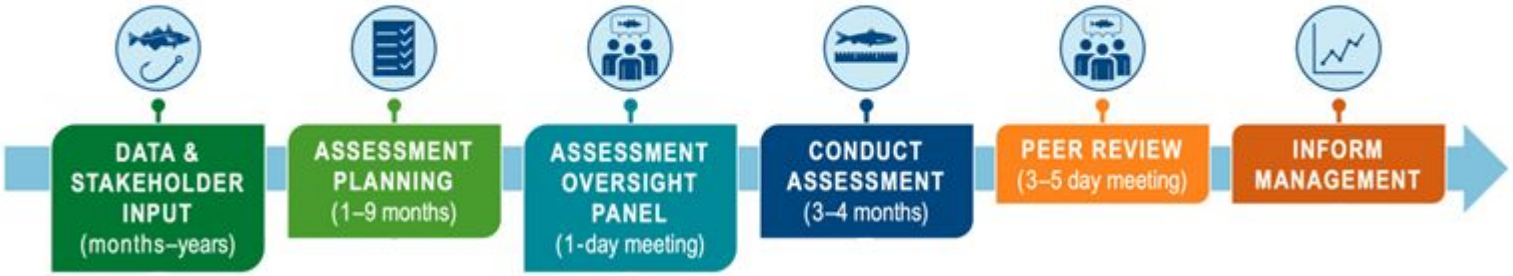
RESEARCH TRACK STOCK ASSESSMENTS

MANAGEMENT TRACK STOCK ASSESSMENTS



Research Track Stock Assessments

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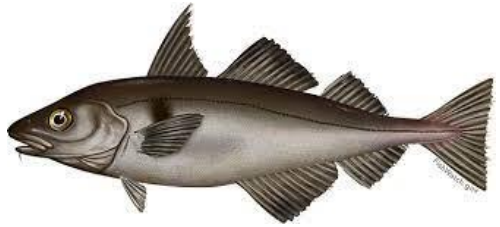
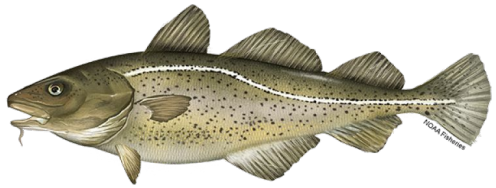
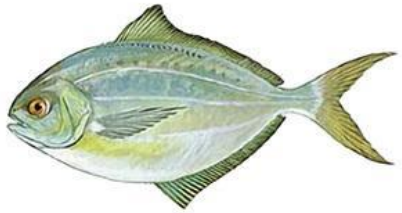
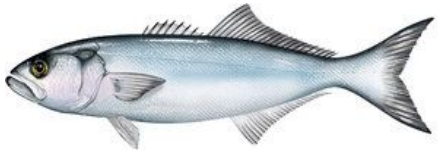
- **Thematic**
  - Index-Based Methods and Control Rules
  - Applying State Space Models
- **New England**
  - Red Hake Stock Structure
  - Haddock
  - American Plaice
  - Atlantic Cod
  - Yellowtail flounder
- **Mid-Atlantic**
  - Illex
  - Butterfish
  - Bluefish
  - Spiny Dogfish
  - Black sea bass
  - Golden tilefish


Research Track Stock Assessments

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ToR 1. Identify relevant **ecosystem and climate influences** on stock dynamics. Consider findings, as appropriate, in addressing other TORs

ToR 2. Estimate **catch** from all sources including landings and discards.

ToR 3. Identify the appropriate **survey data** to be used in the assessment.

ToR 4. Use appropriate **assessment approach** to estimate annual F, R, SSB.

ToR 6. Define appropriate methods for producing **projections**…

ToR 5. Update or redefine **status determination criteria.**

ToR 7. Review, evaluate, and report on the status of **research recommendations…**

ToR 8. Develop a **backup assessment** approach…

Consideration of New Model Types

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Virtual population analysis

Statistical catch at age

State Space Models

State Space Models

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- State-space models have been used internationally and application is on the increase in the US.
- Capacity to account for observation and process error.
- Well suited to statistical testing of whether inclusion of a parameter in the model is justified.

Woods Hole Assessment Model (WHAM): an R + TMB package to run state-space age-structured stock assessment models.

Tim Miller

WHAM: A research and management tool designed for:

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Required

Single-species stock assessment

Age-structured population data

Traditional assessments

Optional

Unexplained temporal variation in some stock attributes (**random effects**)

Clear, **mechanistic hypothesis** that an environmental variable(s) drives a demographic and observational process(es) (**environmental covariates)**

WHAM/State-space

Source: T. Miller

WHAM Options

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Random effects account for variability without a mechanistic link

- Recruitment (year)
- Interannual transitions in abundance at age (“survival”) (year, age)
- Natural mortality (year, age)
- Selectivity (fishery or index) (year, age)
- Catchability (year)
- Hidden (imperfectly observed) environmental/climate variables (year)

Environmental covariates can be linked with :

- Recruitment
- Natural Mortality
- Catchability
- Multiple effects (Recruitment, M, catchability) are possible

https://timjmiller.github.io/wham

Source: T. Miller

Research Track: Applying State Space Modeling

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Applying State Space Models

The purpose of this research track is to explore the application and use of state-space models across a wide range of stocks in the Greater Atlantic Region.

Meeting | New England/Mid-Atlantic

ToR 3: Develop guidelines for including ecosystem and environmental effects in assessment models and how to treat them for generating biological reference points and scientific advice.

Integrate ecosystem and climate influences on stock dynamics

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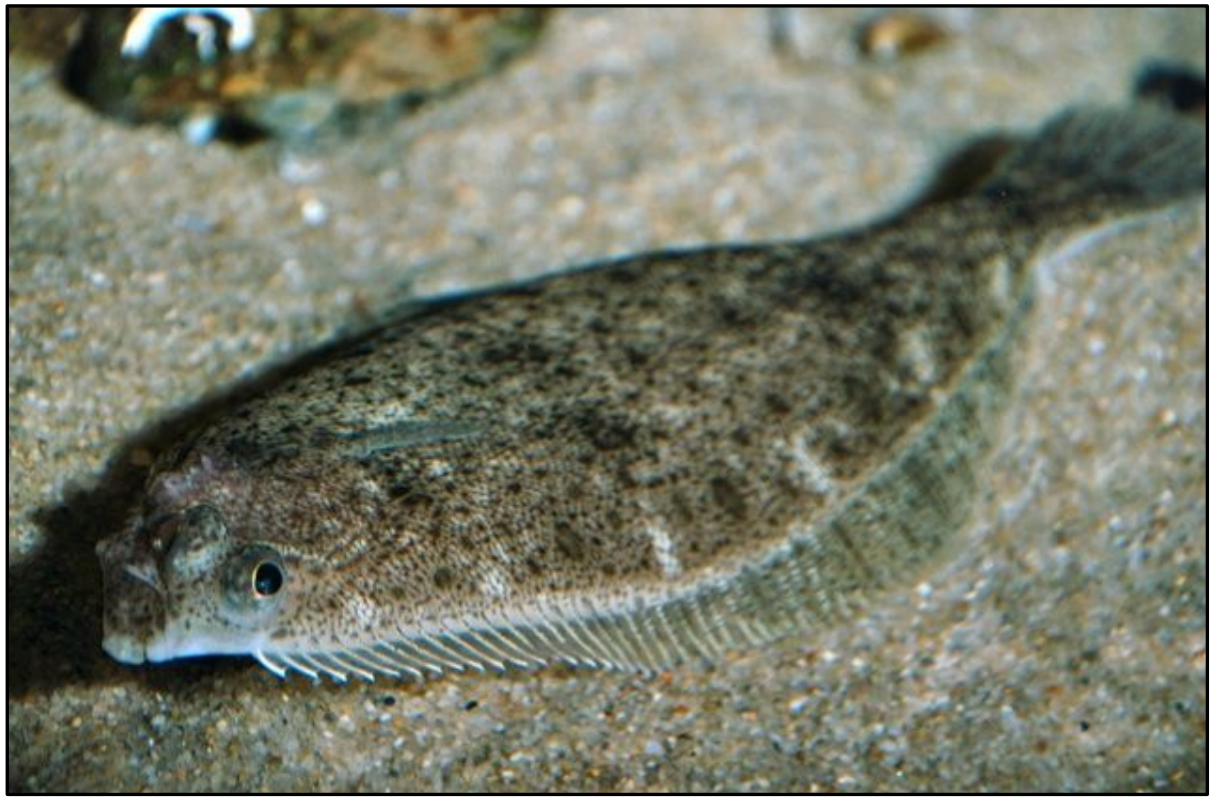
Case Study: American Plaice



ToR 1 Contributors: Lisa Kerr, Jaime Behan, Amanda Hart, Alex Hansell, Tyler Pavlowich, Steve Cadrin, Tim Miller

Identify and integrate ecosystem and climate influences on stock dynamics.

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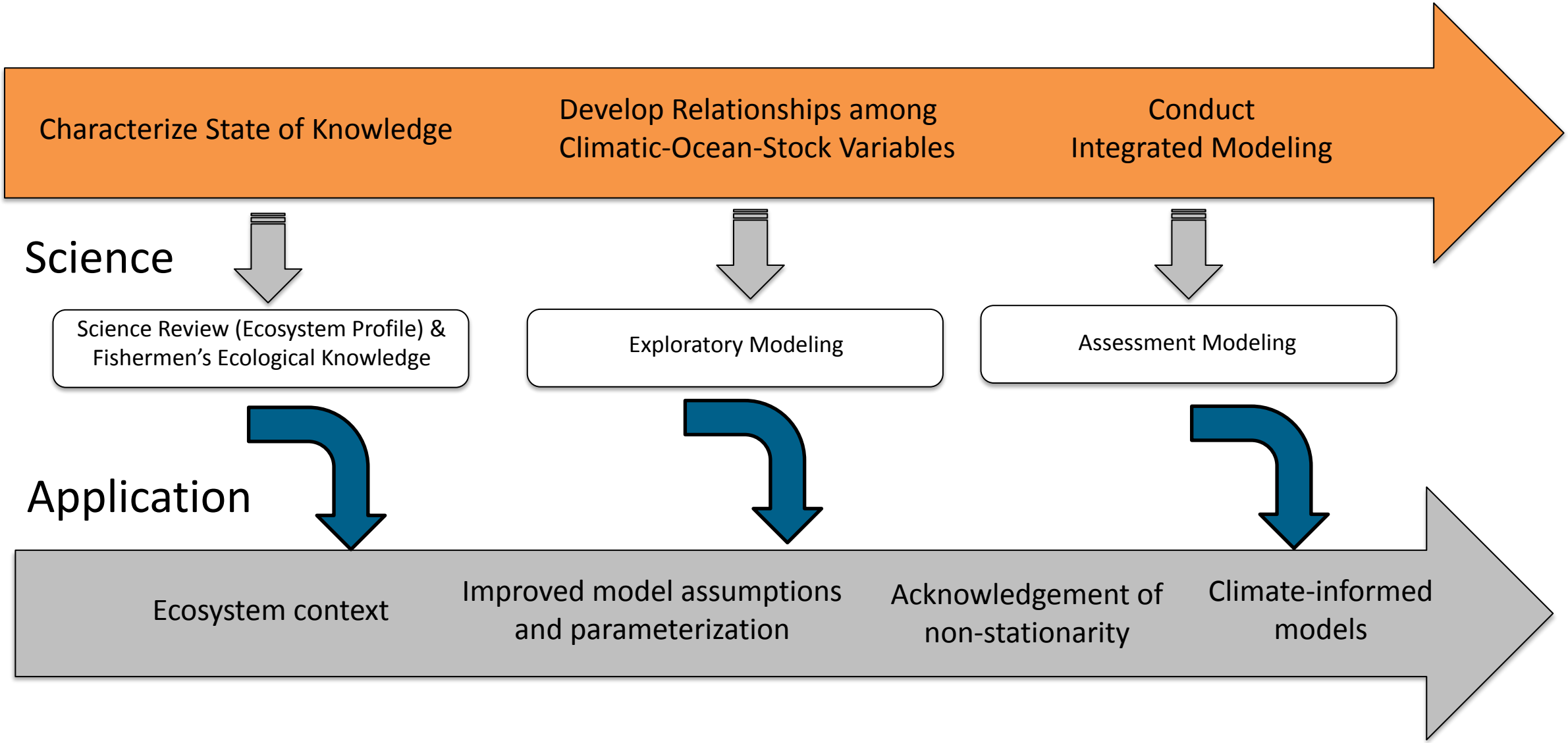

Ecosystem Profile of American Plaice

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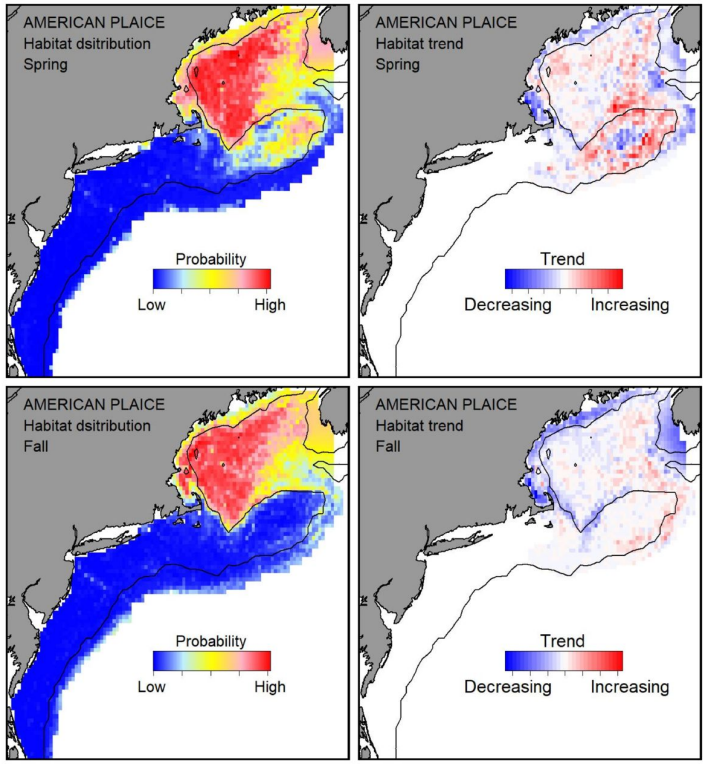
Conducted a review of the best available science on ecosystem and climate influences on stock dynamics of American plaice.



Ecosystem Profile of American Plaice

1. Distribution and Habitat Use
2. Recruitment
3. Growth and Maturity
4. Natural Mortality

- Reviewed literature published 1918-2021
- Primary research areas: Gulf of Maine & Georges Bank
  - Also included lit from Scotian Shelf, Grand Bank, Gulf of St. Lawrence regions

Lead: J. Behan

Fishermen's Ecological Knowledge

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Solicited feedback from stakeholders to identify key ecosystem and climate influences on the stock and changes in fleet behavior in response to changing ocean conditions.

Stakeholder Meetings: September 24th, 2021 - November 3rd, 2021 (Gloucester, MA - Portland, ME)

Summary of Fishermen's Feedback:

Impacts from Management	● Declining catch of plaice is not reflective of declining biomass ○ due to increasing regulatory measures that have prevented targeting the stock in specific areas at specific times of the year. ● Decreased Otter trawling from implementation of annual catch limit. ○ resulted in increased fixed gear (lobster traps) in areas traditionally trawled ○ Led to less available trawlable areas ● Increased minimum mesh size regulations impacted ability to catch plaice.
Distribution Changes & Catch Rates	● **Plaice traditionally came inshore in spring, but are now not caught inshore.** ● Plaice abundance, size at age have been impacted by changes in water temperature. ● Suggested examining CPUE indices for plaice may be useful to consider in the research track assessment.
Survey Catches	● Fishery-independent surveys have low sampling intensity. ○ NEFSC and MA DMF trawl surveys cannot adequately sample inshore areas due to fixed gear ○ The NEFSC survey gear is not effective for catching flatfish species and there is low survey catch efficiency for plaice and other flounder species.

Lead: T. Pavlowitch

Exploratory Modeling: American Plaice Stock Dynamics

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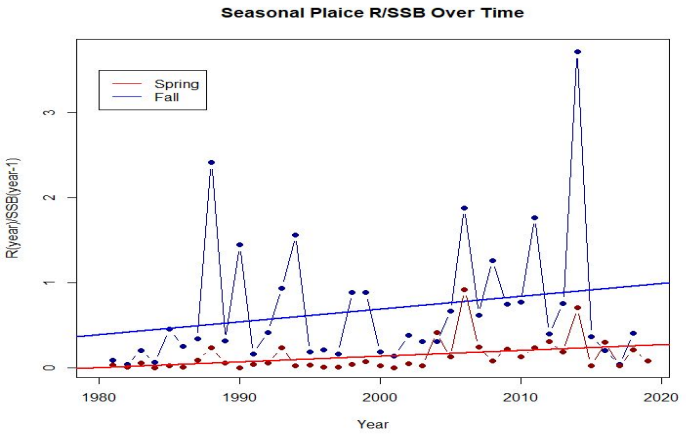
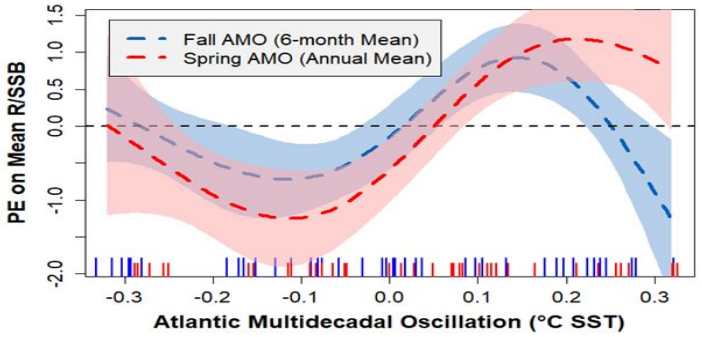
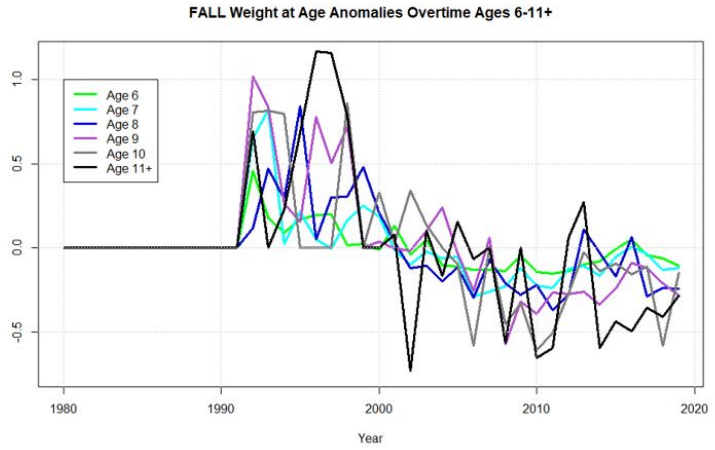
Informed by the science review and fishermen's ecological knowledge, we conducted exploratory modeling to examine the relationship between American plaice stock dynamics and ocean climate variables.

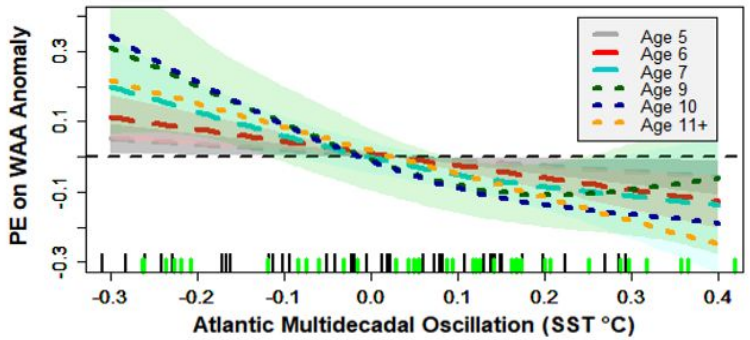
Increased Recruitment



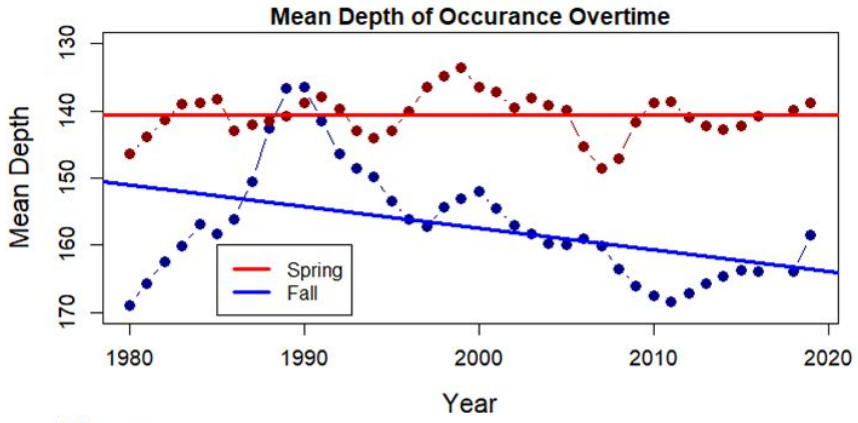


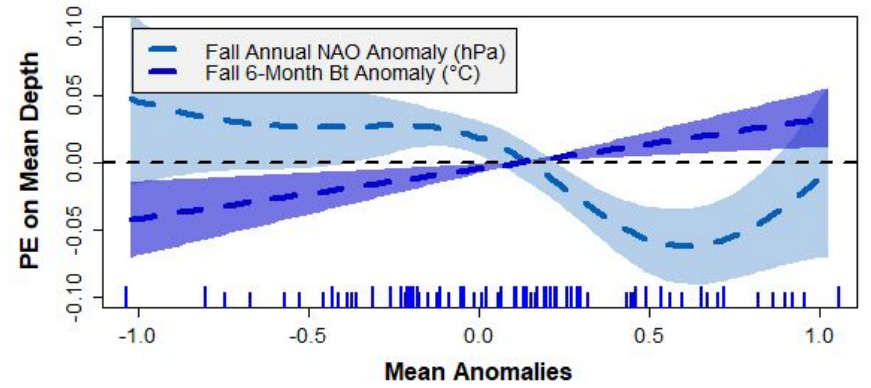
Decreased Weight-at-Age





Shift to Deeper Water





Lead: J. Behan

Application to Survey Data

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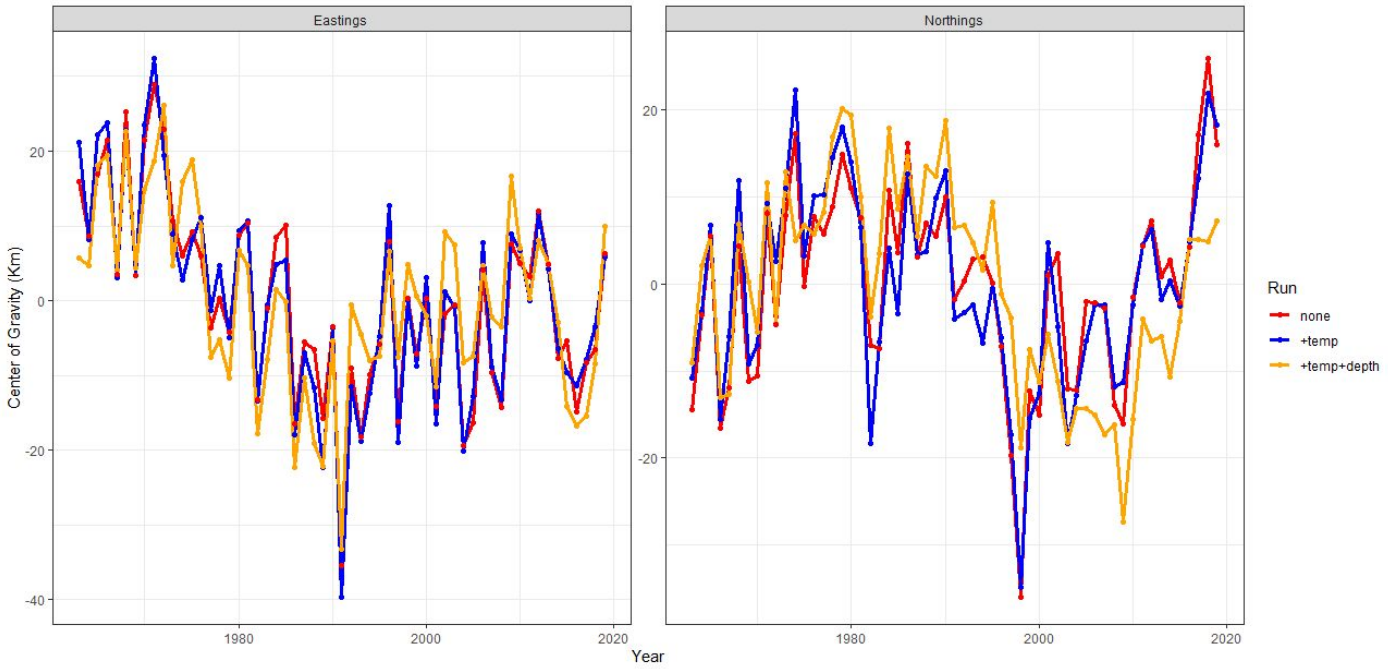
- Evaluated whether inclusion of environmental covariates (temperature) in a spatio-temporal model (VAST) improves model fit.
- **Outcome:** Temperature did not improve model fit.

Spatio-temporal Distribution of American Plaice (VAST)



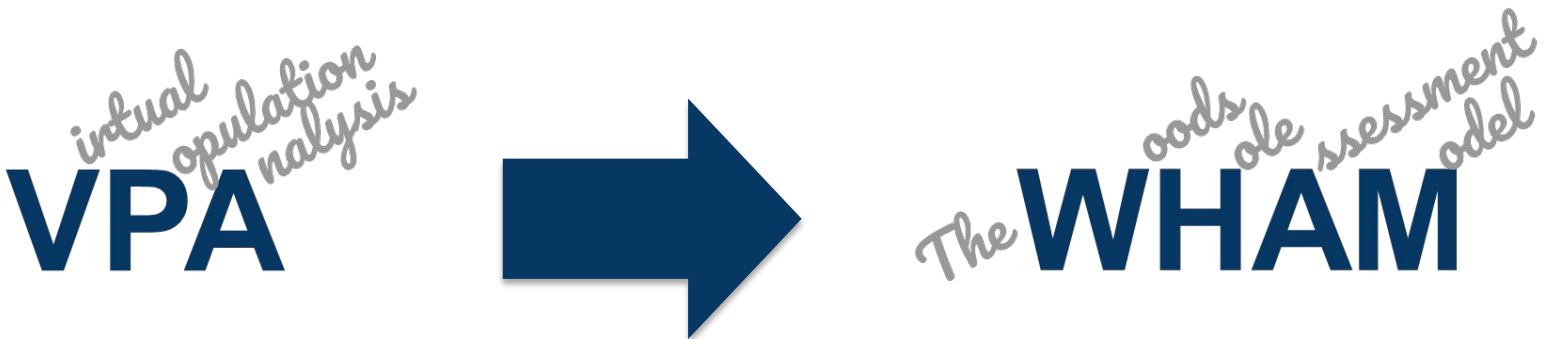
Lead: A. Hansell

Application to Assessment Modeling

- Evaluated whether inclusion of time-varying processes or links to environmental covariates improved assessment model performance.

Outcome:

- Transitioned from VPA to WHAM which provides potential for integration of time-varying processes and climate covariates.
- Random effects were included which allowed for time varying survival and fishery selectivity.
- Environmental covariates may improve model performance (catchability, recruitment), diagnostic issues and time constraints prevented conclusions.



Lead: A. Hart

Criteria and Diagnostics

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- Diagnostics for acceptance of time-varying process (random effects) an environmental covariate into an assessment
  - Comparisons of models w/wout random effect or environmental link
  - Detectable improvement in model fits?
    - AIC
    - One-step ahead residuals
    - Mohn's rho
- Examination of relationship with key process
  - Extra parameter estimated in WHAM to describe magnitude & direction of relationship
  - Comparison to relationship estimated outside of assessment.
- Demonstration of forecasting skill
  - Mean absolute scaled error (MASE) to evaluate prediction skill of model.
- Process for verification of relationship over time
  - Relationships will be reevaluated through management track process.

Application to Biological Reference Points and Projections

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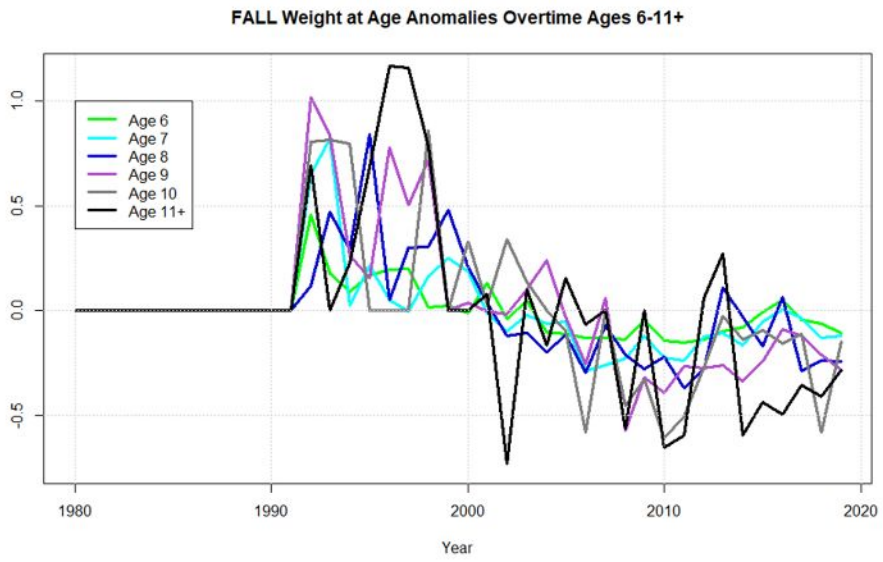
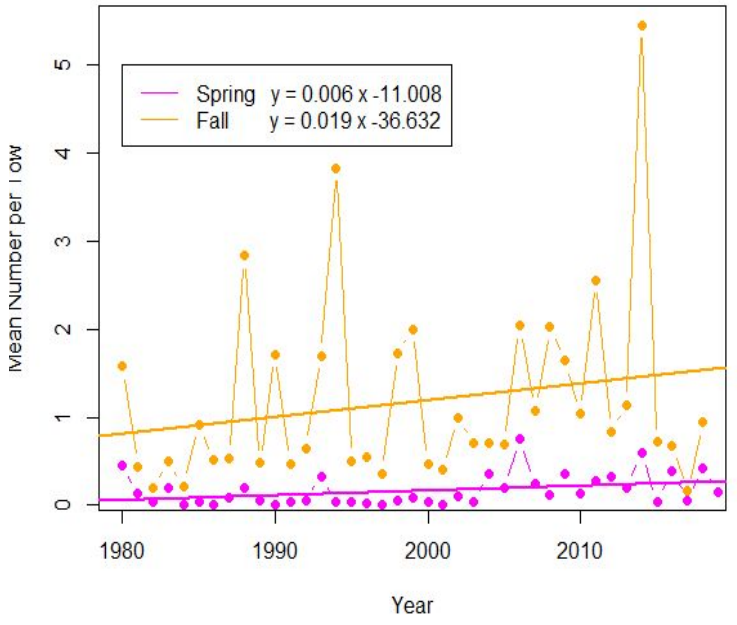
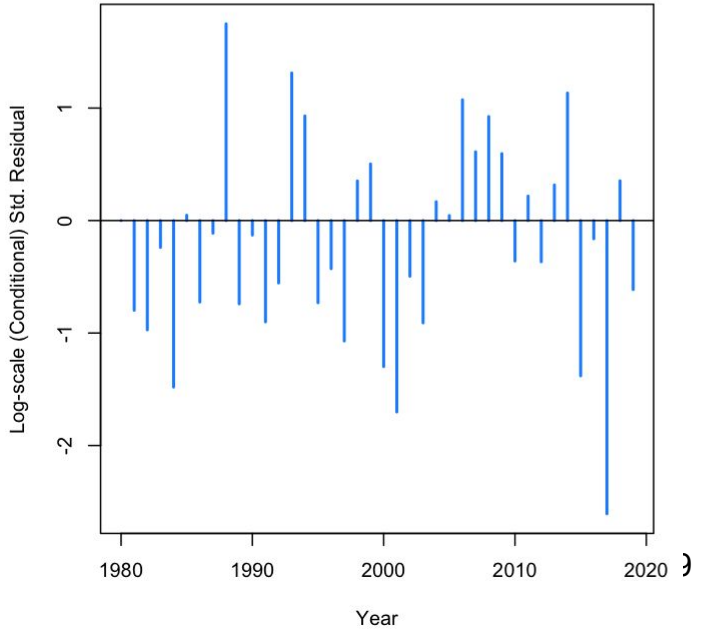
- Evaluated whether alternative stanzas of recruitment and growth should be used to inform estimation of biological reference points and projections.
- **Outcome:** Weight-at-age from most recent time period were used. However, the full time series of recruitment was used to inform future expectations of plaice productivity



Age 1 Plaice Catch per unit Effort



Recruitment Deviations: WHAM Model (29-F)



American Plaice Case Study Summary

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- **Characterized state of knowledge** of ecosystem and climate influences on American plaice stock dynamics.
- Identified **promising mechanistic relationships** between climate drivers and stock dynamics.
- Demonstrated **WHAM's flexibility** to account for environmental influence on stock dynamics and incorporated time varying survival.
- Runs including environmental covariates are valuable **precedent for future updates** in management track processes.

Summary

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- Application of new stock assessment process is underway
  - Research Track—Management Track Process.
- New state space assessment model is being adopted in the region.
  - Atlantic butterfish
  - Georges Bank haddock
  - Eastern Georges Bank haddock
- Progress on integration of ecosystem and climate impacts in the context of stock assessment
  - Haddock
  - Atlantic cod
  - Yellowtail flounder

Questions: lkerr@gmri.org