Using climate data to improve sablefish assessment model projections

Melissa Haltuch

SCS7

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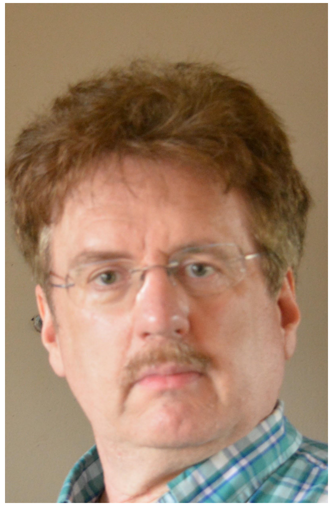
The whole is greater than the sum of its parts ~Aristotle

Maia Kapur

Lee Qi

Kelli Johnson

Nick Tolimieri



John Wallace

Mike Jacox

Meeting NMFS core science needs

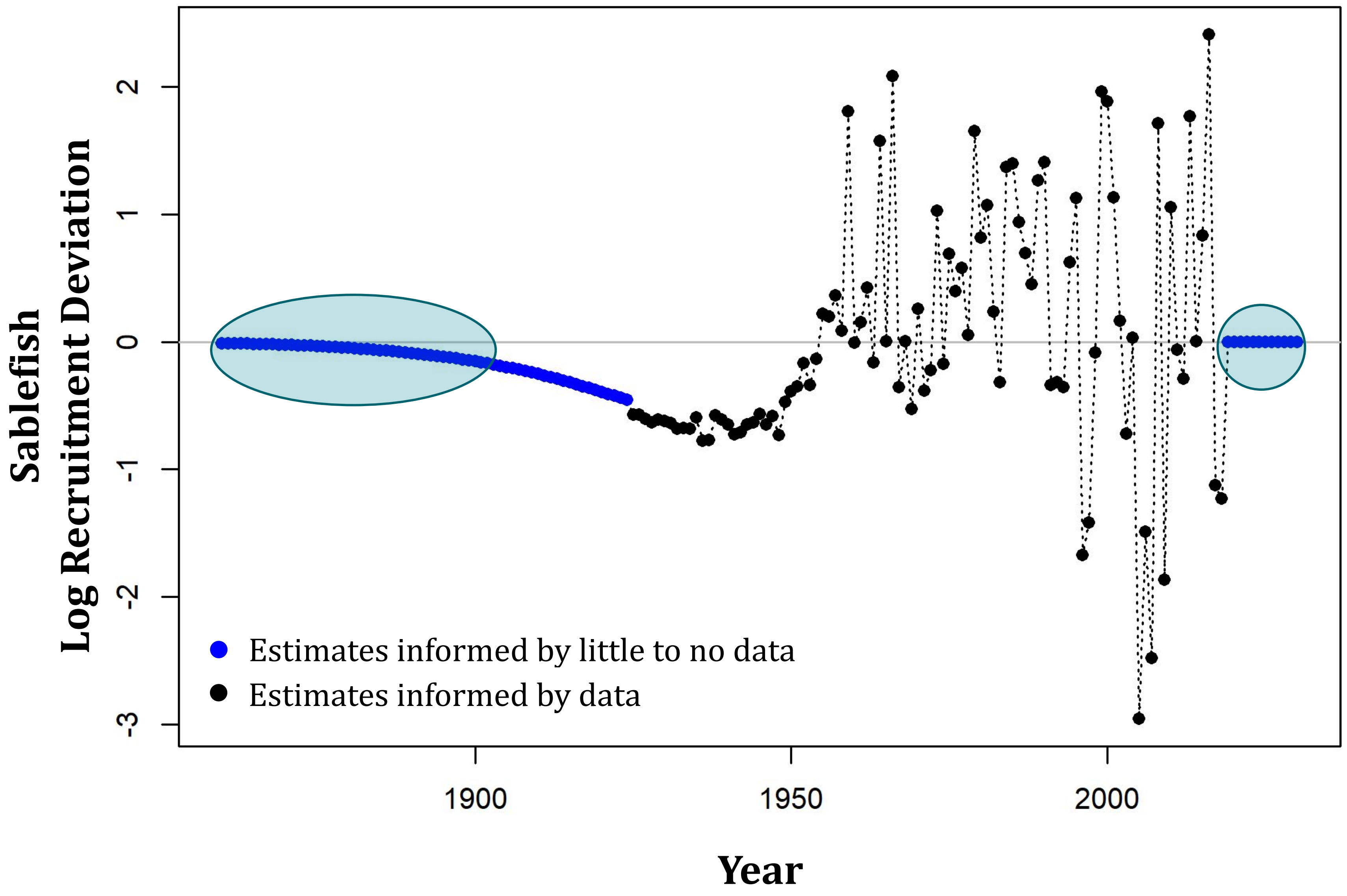
Core science needs

- Stock assessments are the scientific foundation of successful and sustainable fishery harvest management
- Measure the impact of fishing
- Project sustainable harvest levels
  - Using the long-term average number of age-x fish entering a population annually (recruitment)

How to improve estimates of recent recruitment not yet informed by data AND recruitment forecasts in the absence of annual stock assessments?

- Use climate drivers to inform recruitment
- Commercially valuable, high attainment groundfish stocks

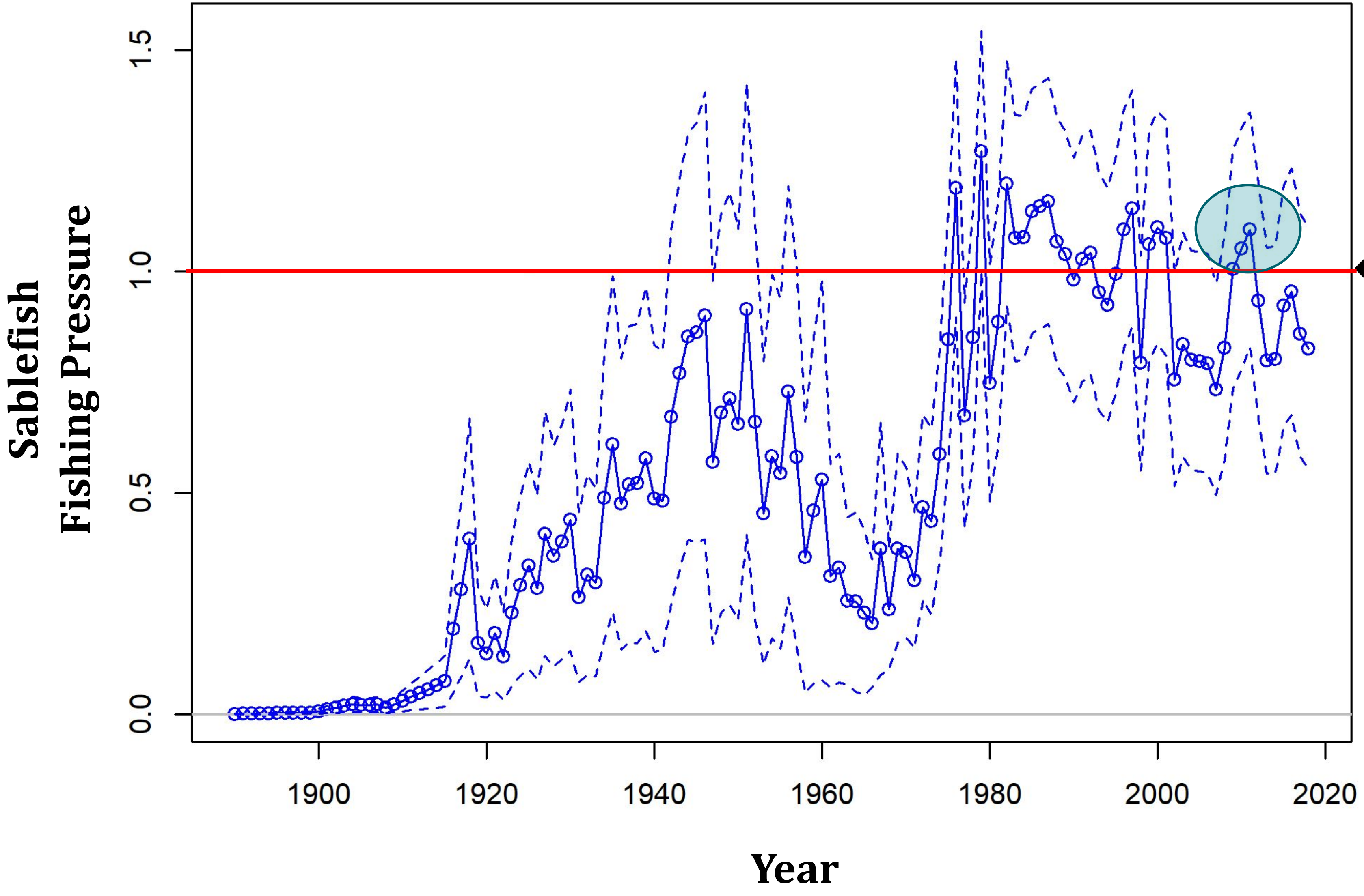
What is average recruitment?



Recruitment Deviation - model estimates of the annual recruitment variation as a random deviate from a stationary functional relationship between spawners and subsequent recruitment.

In this case, the Beverton-Holt stock-recruitment relationship.

Problem: Recruitment is seldom average, leading to retrospectively fishing higher or lower than the target

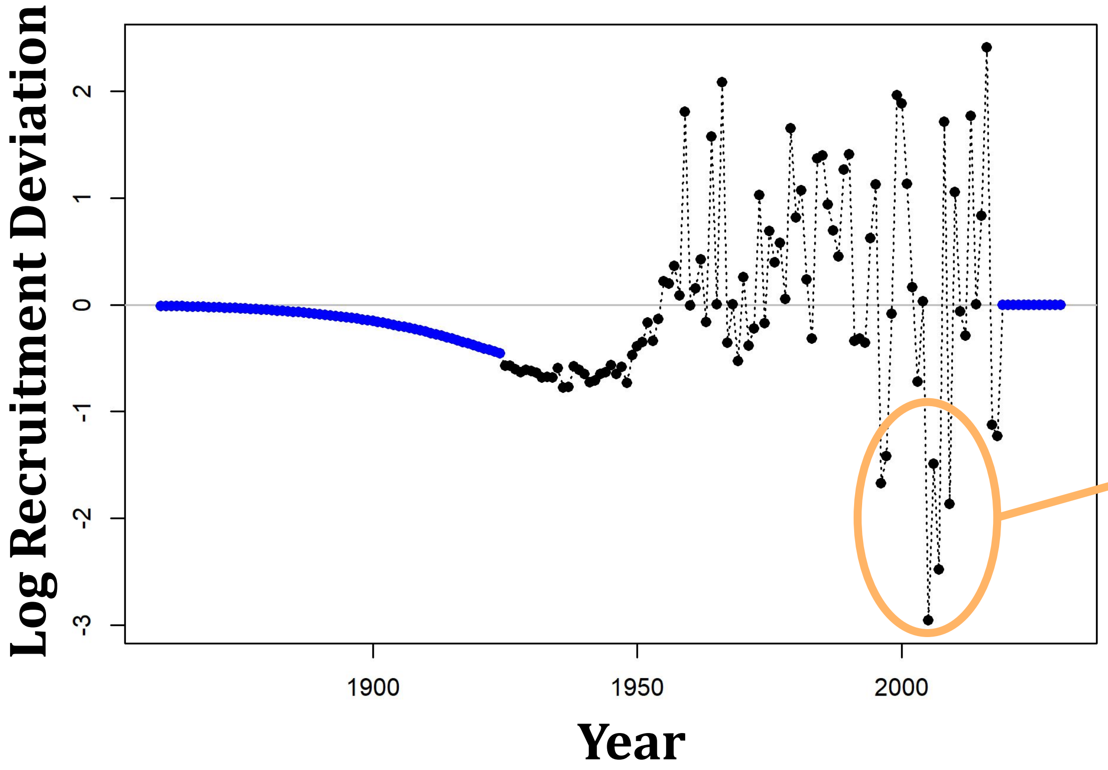


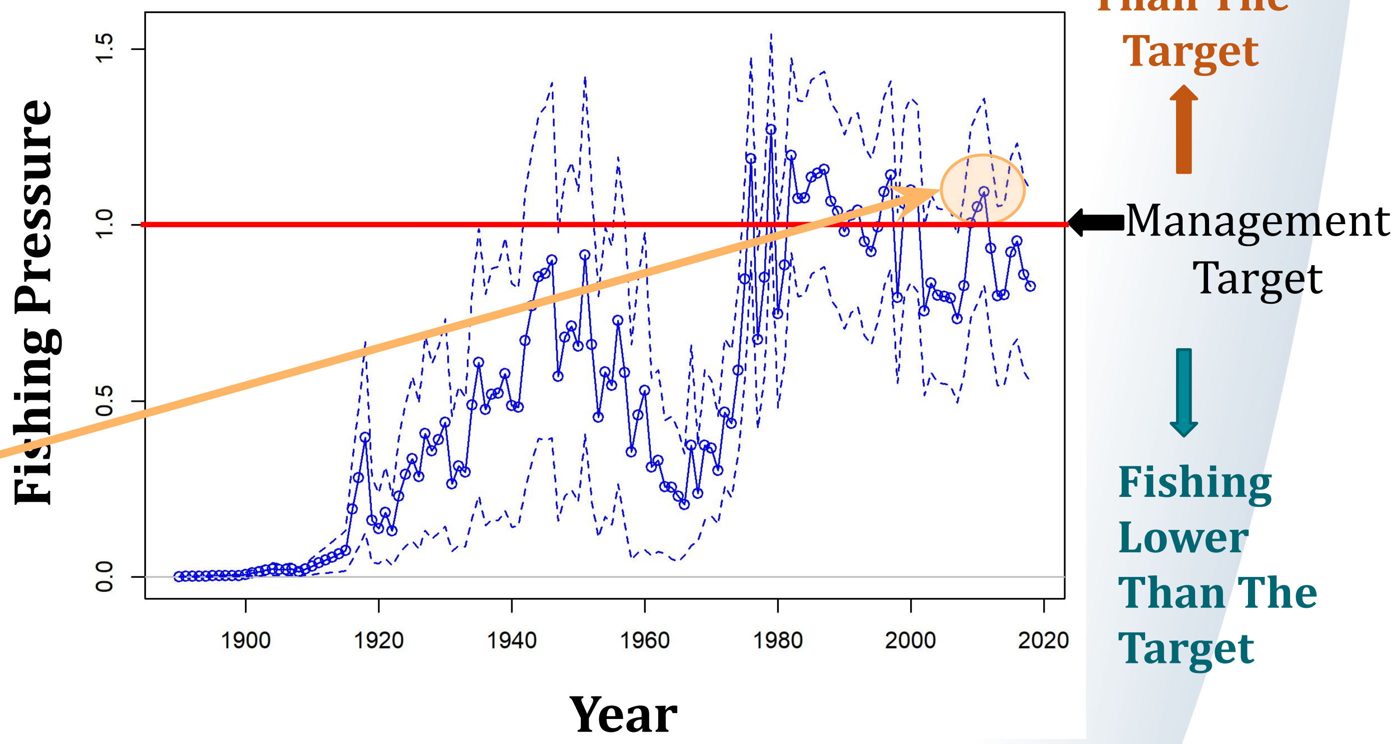
Fishing Higher Than The Target

Management Target

Fishing Lower Than The Target

Problem: recruitment is seldom average, leading to retrospectively fishing higher or lower than the target





Imperfect knowledge of poor/large recruitments contributes to subsequent higher/lower-than-target harvests

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Why focus on sablefish?

Substantial research investment during past 10-20 years

- Previous research identified recruitment – sea-level relationship
  - Proxy for late pelagic larval feeding conditions
- Sea-level considered in assessments since mid-2000s

Economically important choke species

Decades of stock decline until recently

Assessments with climate drivers could be extended to…

- Inform recruitment in absence of survey data
- Use short-term oceanographic forecasts to inform future recruitment

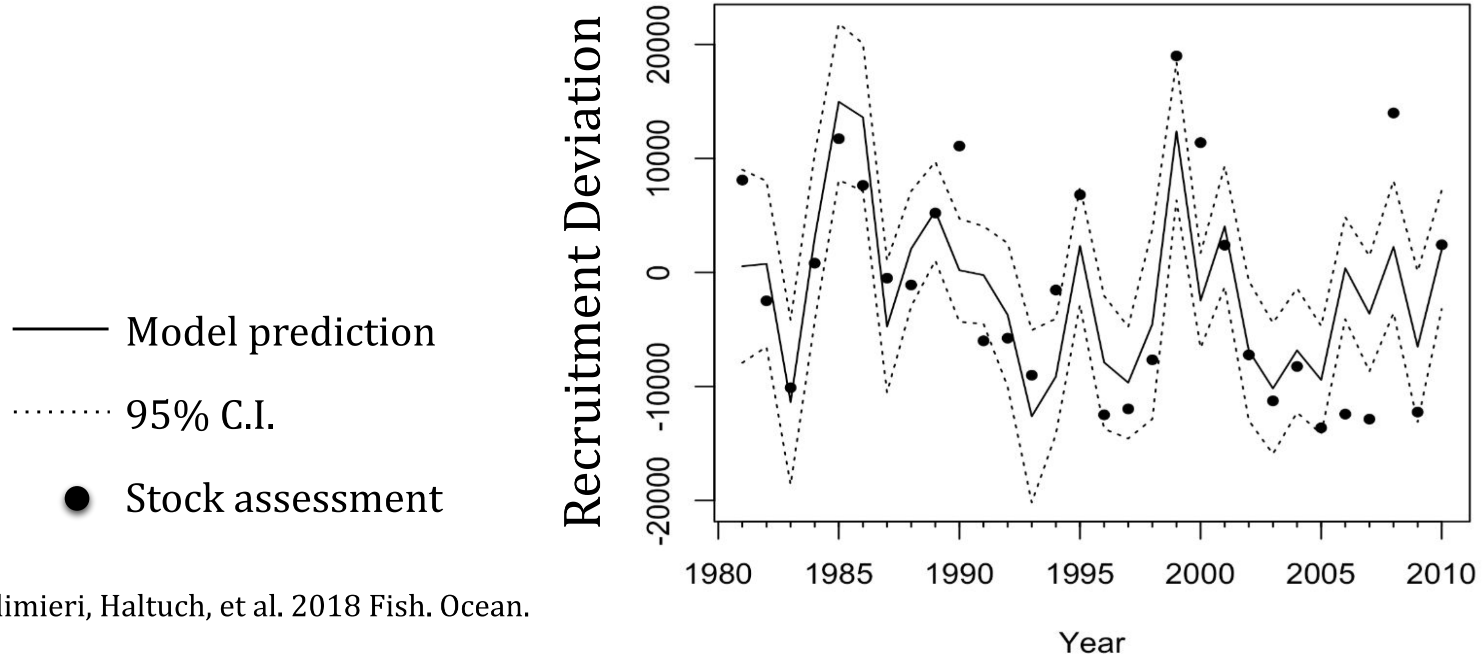
Mechanistic Drivers of Sablefish recruitment

Develop conceptual life-history model

Spatio-temporal specific ROMS: 1980 – 2010 (C. Edwards, UCSC)

GLMs Explain ~57% of the sablefish recruitment variability

Predict Recruitment deviations



Tolimieri, Haltuch, et al. 2018 Fish. Ocean.

Female preconditioning (50-1200 m)
(-) Degree Days
Cold water =
Higher productivity +
lower metabolic costs

Eggs (300-825 m)
(+) Cross-Shelf Transport
On-shore transport =
Higher larval settlement
(+) DD
Warm water =
faster development

Yolk-sack (1000–1200 m)
(+) Long-shore Transport
Northerly transport =
Better feeding conditions

Pelagic larvae (surface waters)
(-) Degree Days
Cold water =
Higher productivity + better feeding

Sablefish recruitment research

Mechanistic ROMs based modeling

Better explains recruitment variability

Supports the early hypothesis that northern sea level is important and indicative of late life-stage feeding conditions

Female Preconditioning		**Eggs**		**Yolk-sack Larvae**		**Pelagic larvae (surface waters)**
(-) Cold water = Higher productivity + lower metabolic costs	→	(+) Cross-Shore Transport = Higher larval settlement (+) Warm water = faster development	→	(+) Long-Shore Transport Northerly transport = Better feeding conditions	→	(-) Degree Days Cold water = Higher productivity + better feeding

Spatial modeling of survey age-0 sablefish

Northern sea-level conditions are most important for recruitment success

Southern recruitment failures suggest region wide poor recruitment

Tolimieri, Wallace, Haltuch, 2020 PLOS One

Next generation **tactical** models: research to application

A Challenge!

ROMs model outputs were not available on an operational timeline.

If funded, CEFI will help remedy this problem.

Science in support of EBFM:
Sea-level in the 2021 sablefish stock assessment

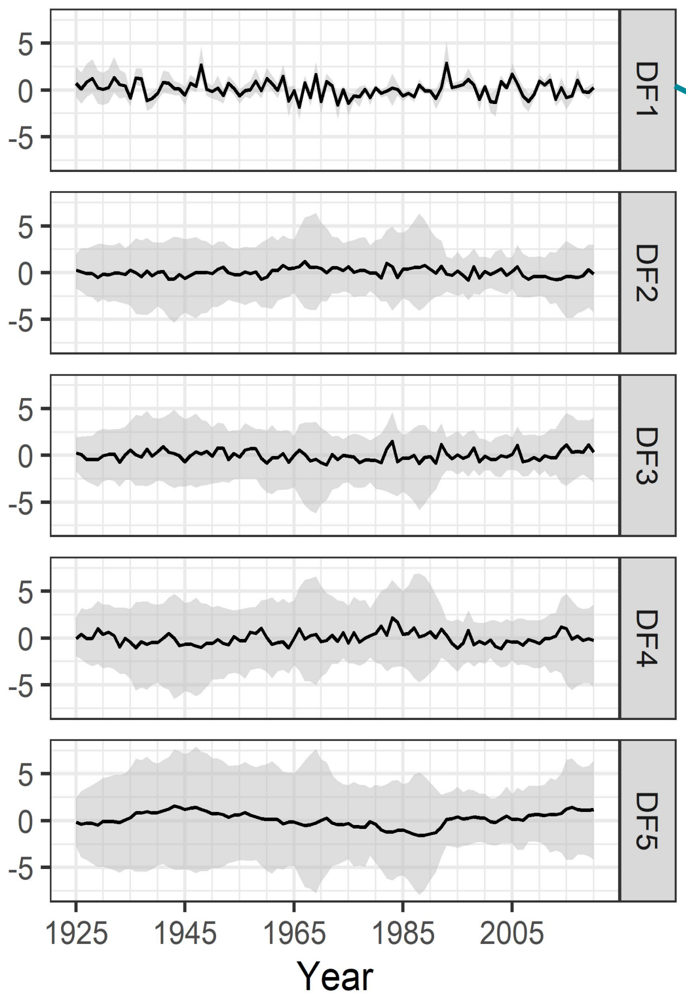
Reanalysis of sea-level

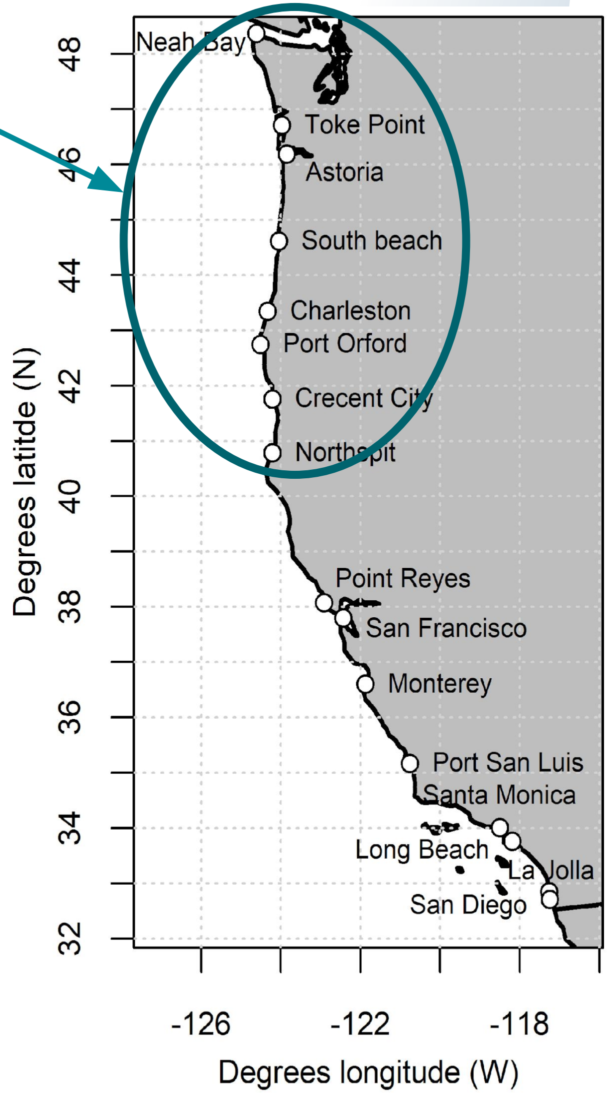
- 16 long time series of tide-gauge data
- Dynamic Factor Analysis
  - 5 Shared trends

Modeled recruitment deviations

~ 5 dynamic factors

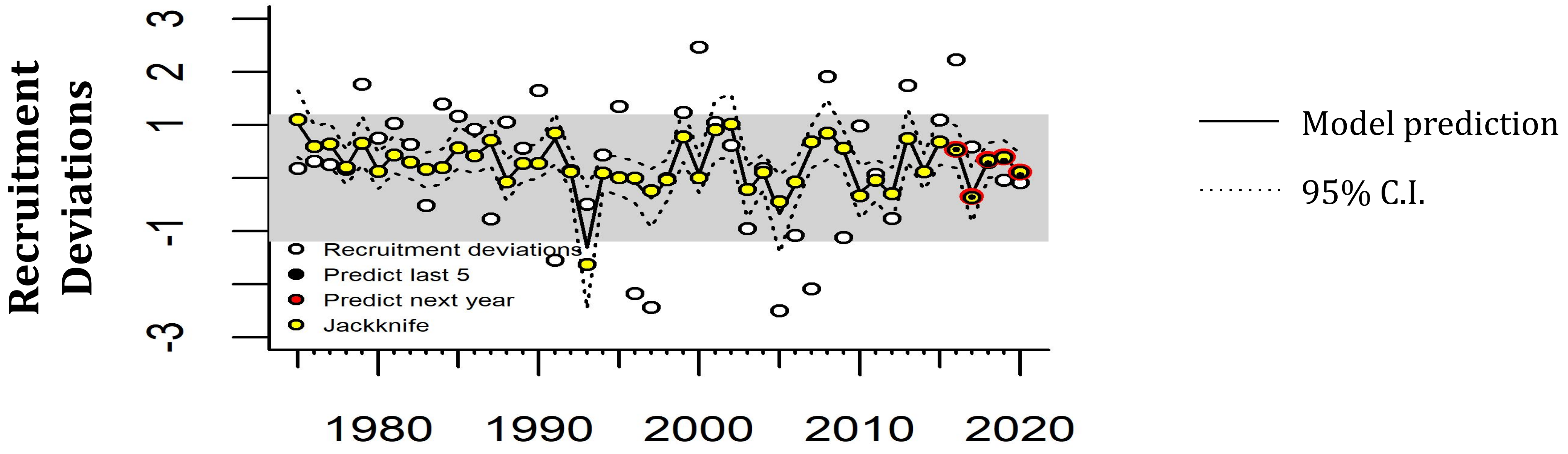
- Lots of model testing
- Evaluated in stock assessment model





Tolimieri and Haltuch, In Review

Science in support of EBFM:
Sea-level in the 2021 sablefish stock assessment



Best-fit model - Recruitment deviation ~ DF1

R^2 = 0.15, 1975-2020; R^2 = 0.28, 2003-2020

DF1 was negatively correlated with northern sea level

Continued support for northern sea level as indicator of late life-stage feeding conditions

Tolimieri and Haltuch, In Review

Science in support of EBFM: Sea-level in the 2021 sablefish stock assessment

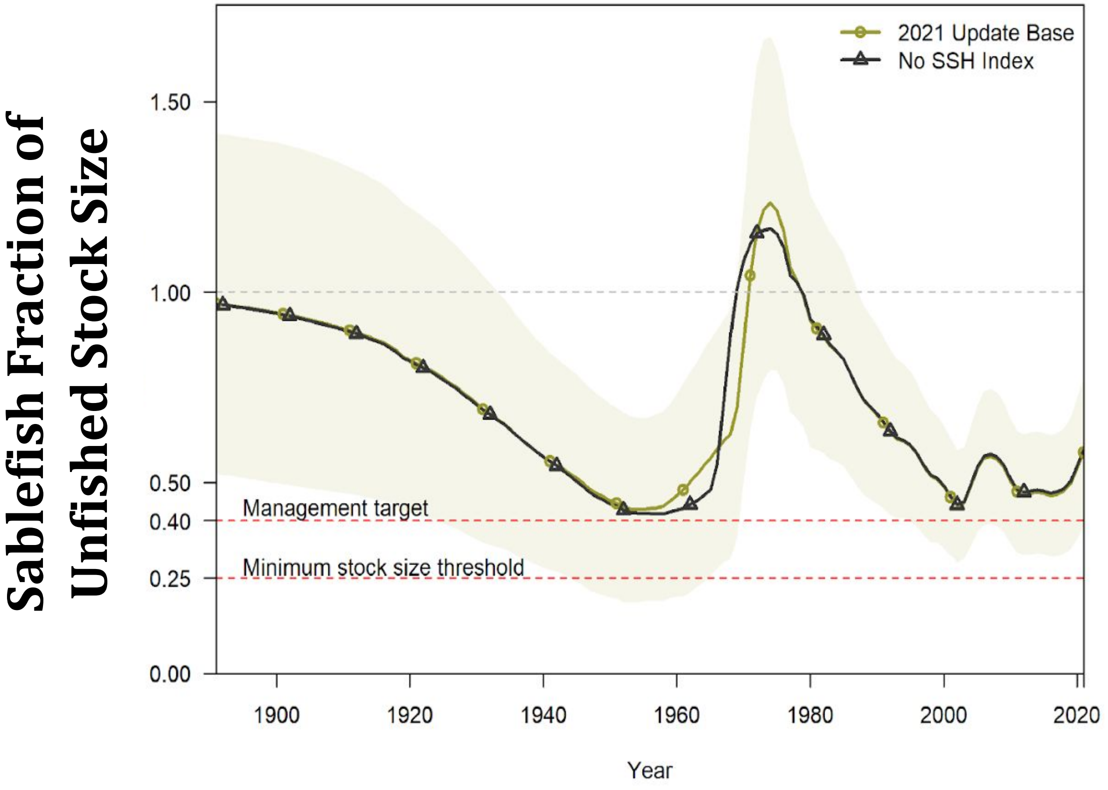
Sea-level DF1 in assessment

Limited influence on historical trends

- Survey and sea-level data agree with respect to recruitment strength

Potential for now-cast and short-term forecast

Stock projections including catch and climate could improve on average recruitment assumptions



Haltuch, Johnson, et al. 2019

Kapur et al. 2021

Next generation **tactical** models: research to application

Goal: To show that environment-based recruitment indices have the potential to provide fishery managers with improved leading recruitment information.

2021 model update Kapur et al. 2021

Retrospective model runs to evaluate potential forecast skill

How can sea level inform recruitment in the absence of survey and fishery data?

Two 10-year hindcasts from 2011 -2020

- Removed all fishery and survey data except catch
- Removed all fishery and survey data except catch and sea level index of age-0 recruitment

Compared 10-year hindcasts to the 2021 update assessment, which represents the 'true' state given all available data.

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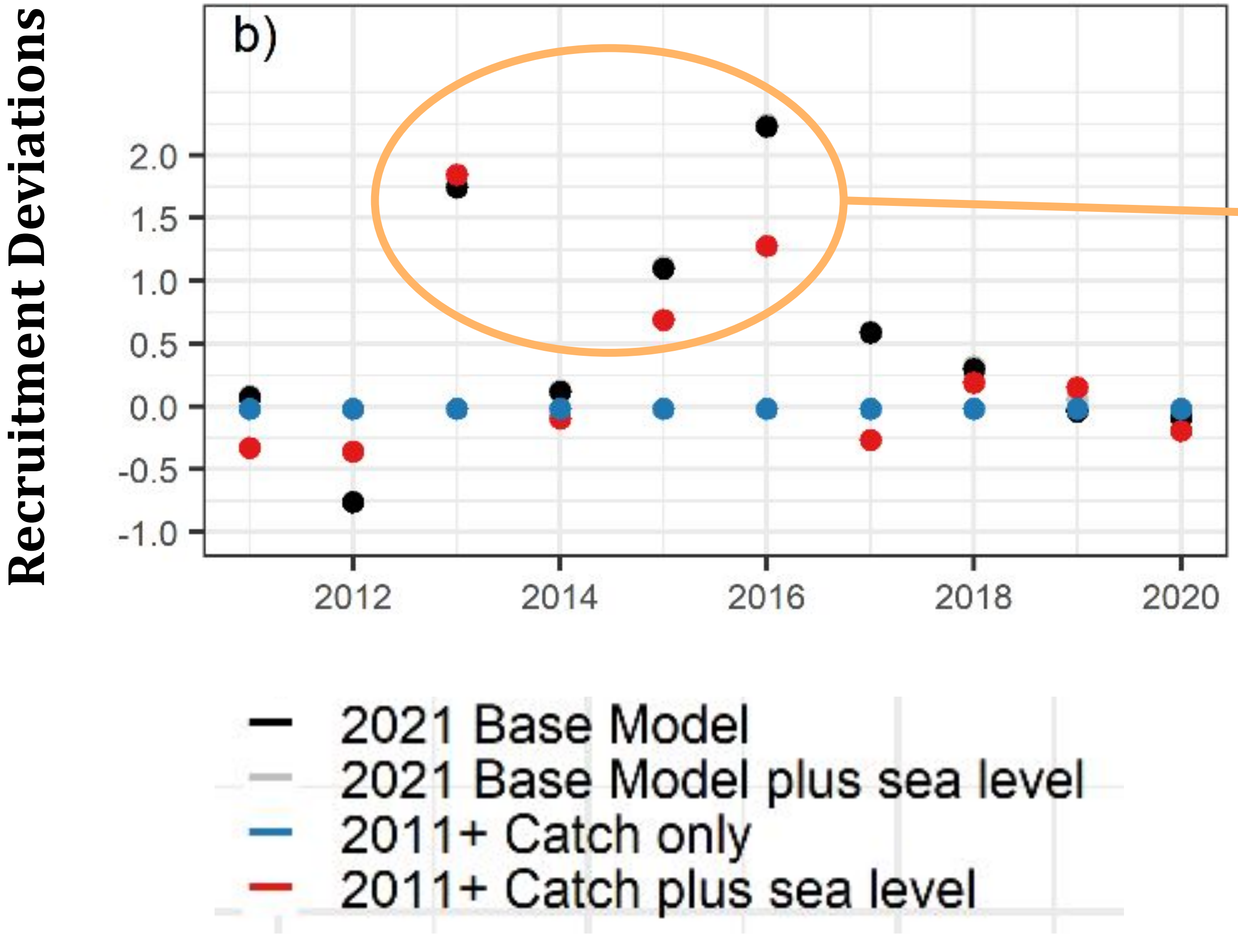
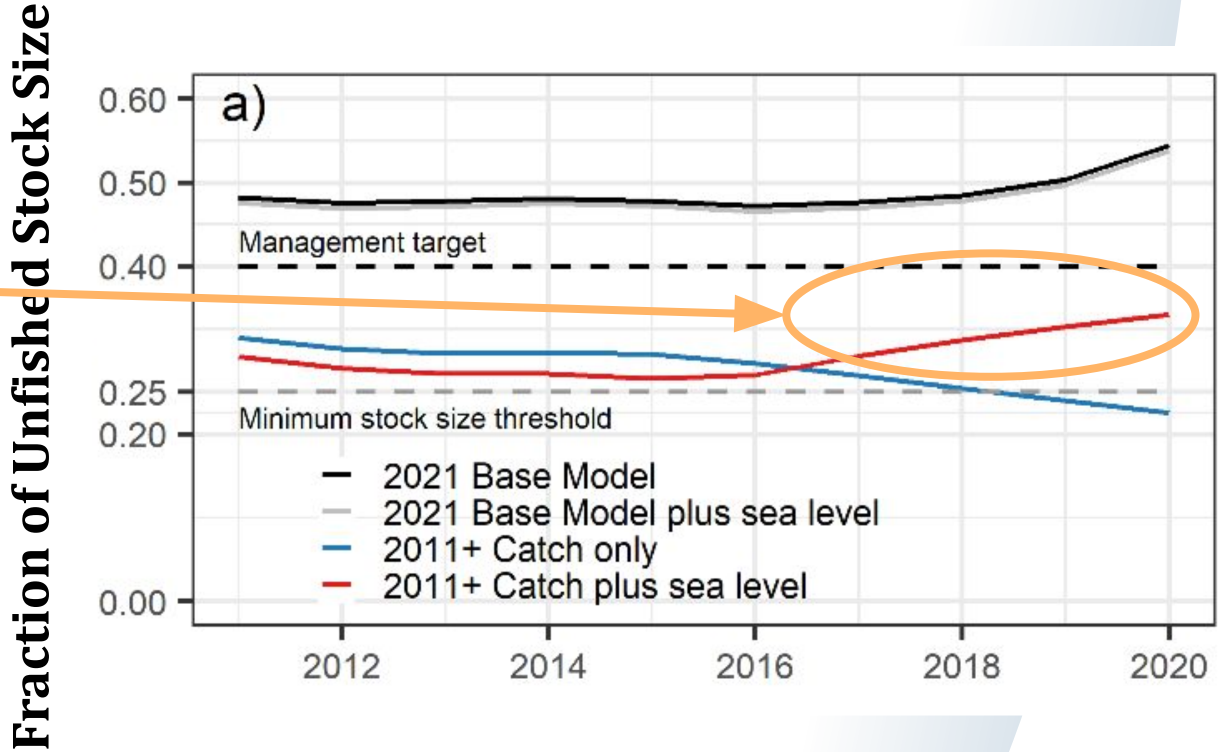
Next generation **tactical** models: research to application





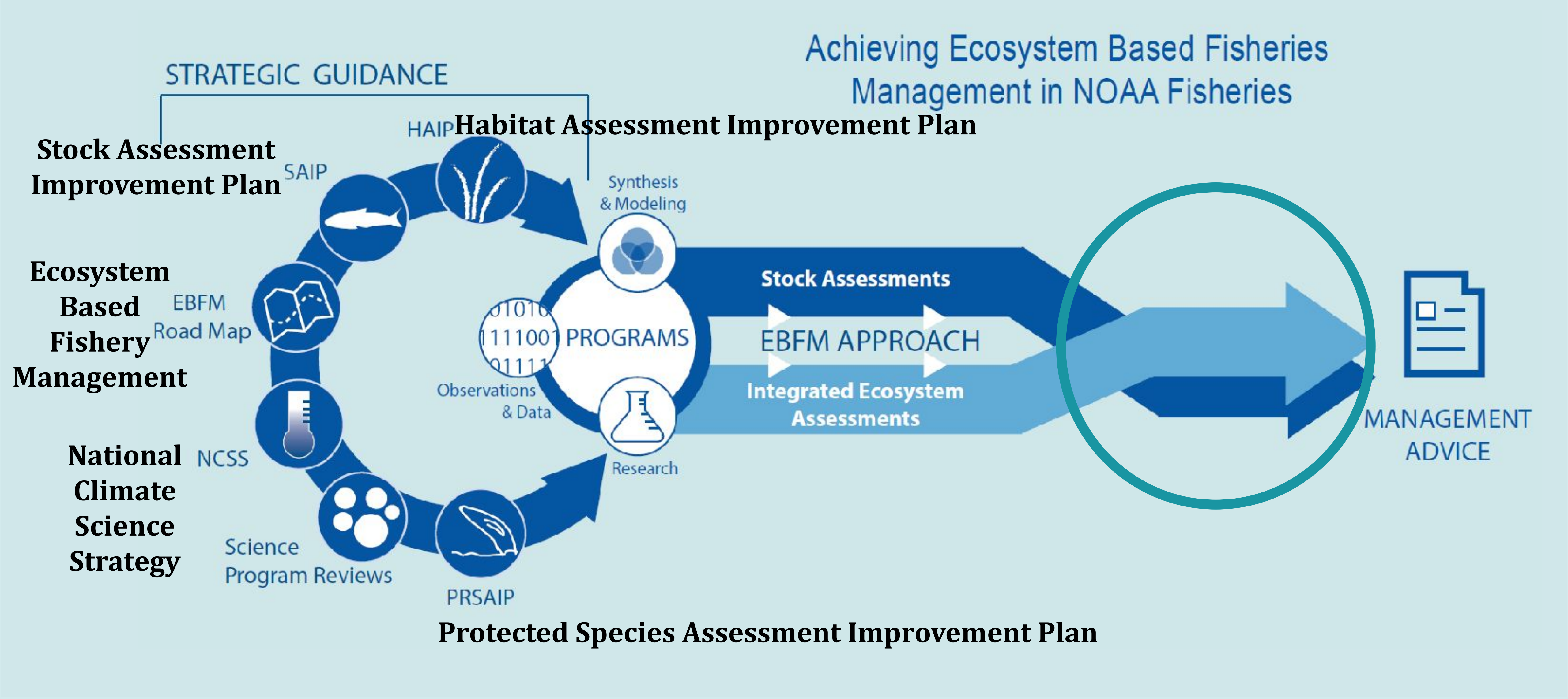
Next generation **tactical** models: research to application

Over the last 10 years sea level tends to underestimate recruitment deviations but is an improvement over average recruitment assumptions.

Evidence supports using catch and sea level forecasts for advice.

Co-developed a mechanism to incorporate climate data (+ catches) into tactical forecasts for the Pacific Fishery Management Council.

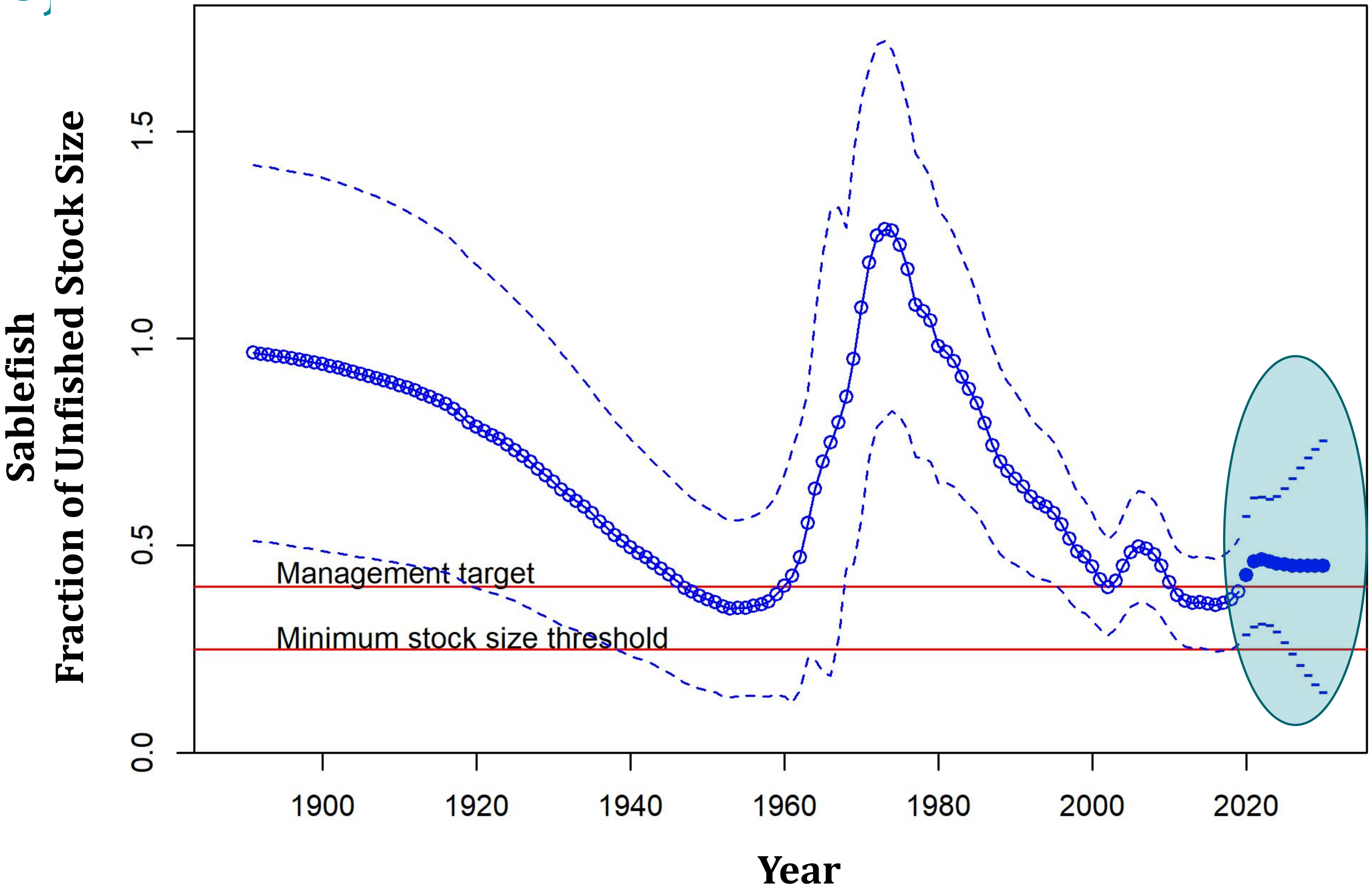
A sablefish story: Ecosystem considerations in stock assessment



Thank you for listening!

For more information contact: **melissa.haltuch@noaa.gov**

How does average recruitment impact stock projections?



Science in support of EBFM: Sea-level in the 2019 sablefish stock assessment

Sea-level DF1 in assessment

Limited influence on historical trends

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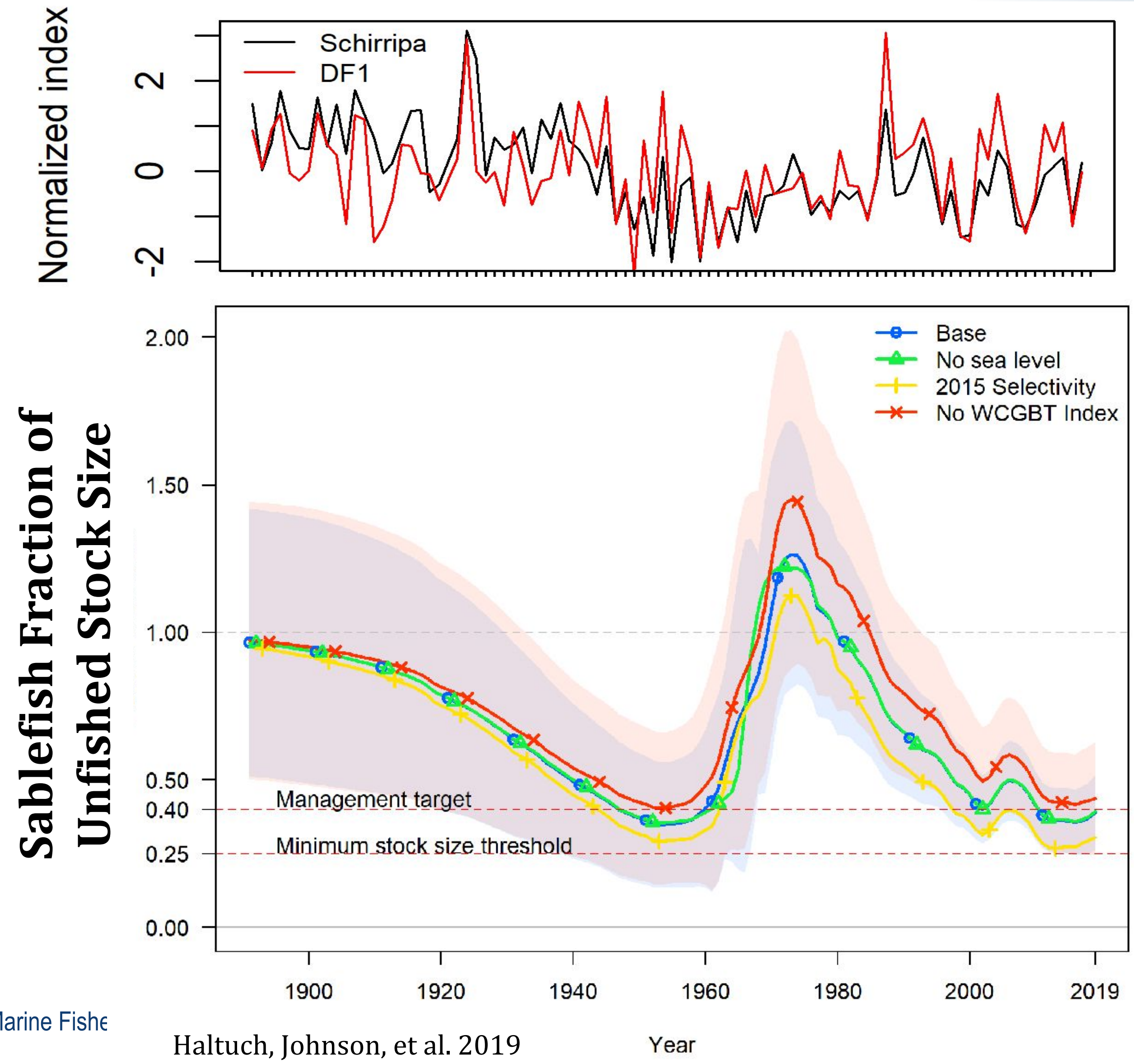
Potential for short-term forecast

Stock projections including catch and climate could improve on average recruitment projections



Haltuch, Johnson, et al. 2019

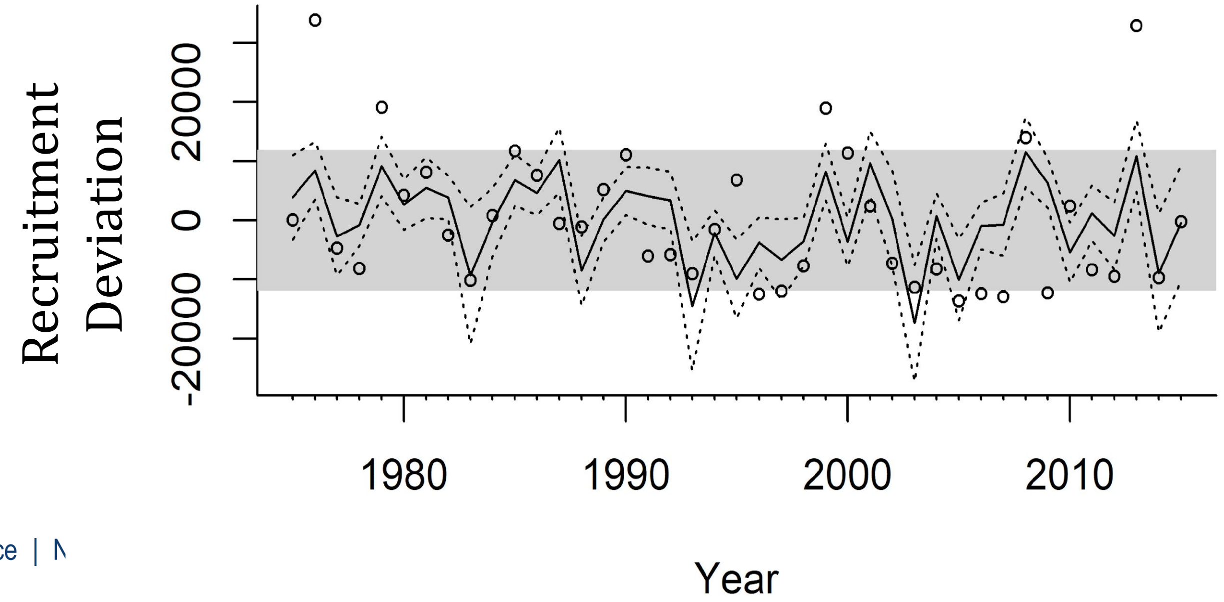
Science in support of EBFM: Sea-level in the 2019 sablefish stock assessment

Best-fit model ($R^2 = 0.35$):

Recruitment deviation ~ DF1 + DF3 +$DF3^2$

DF1 - Negative correlation with northern SL

DF3 - Positive correlation with southern SL

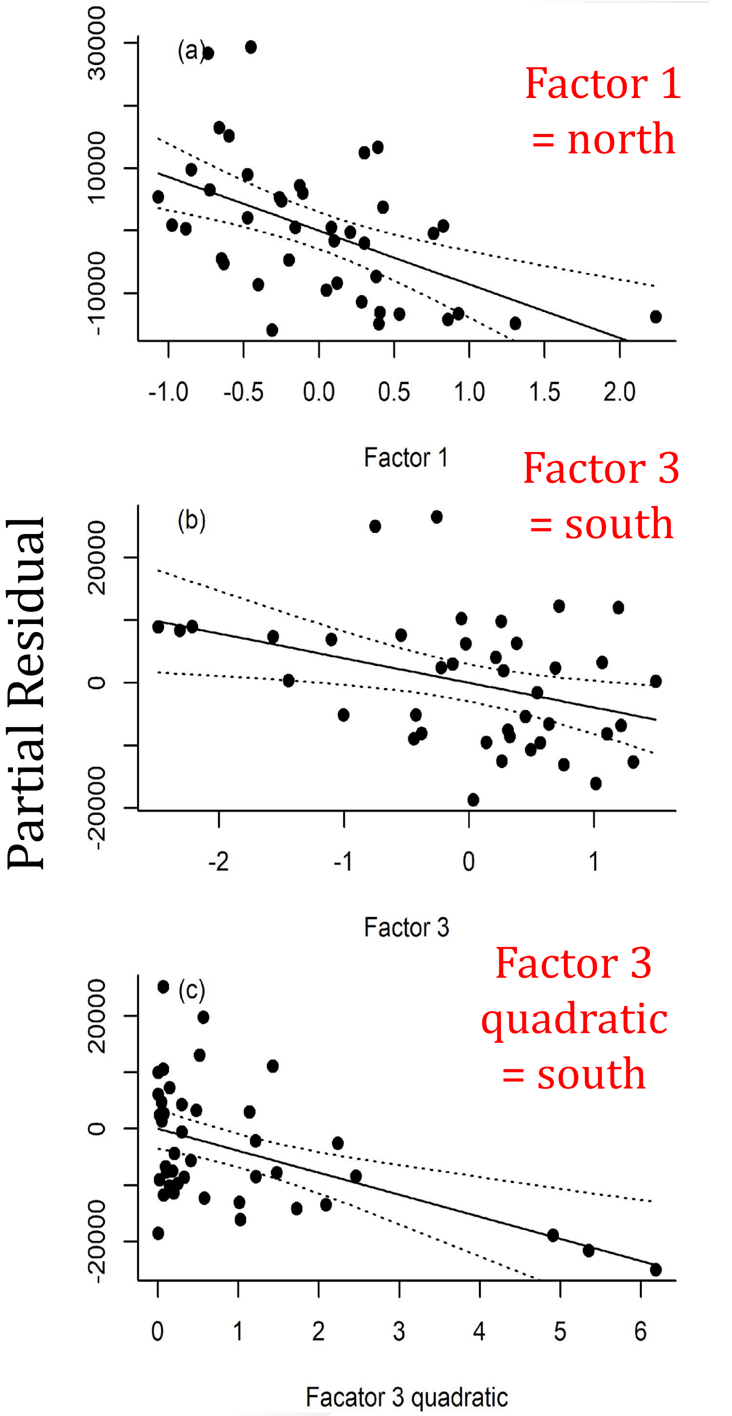


Model prediction

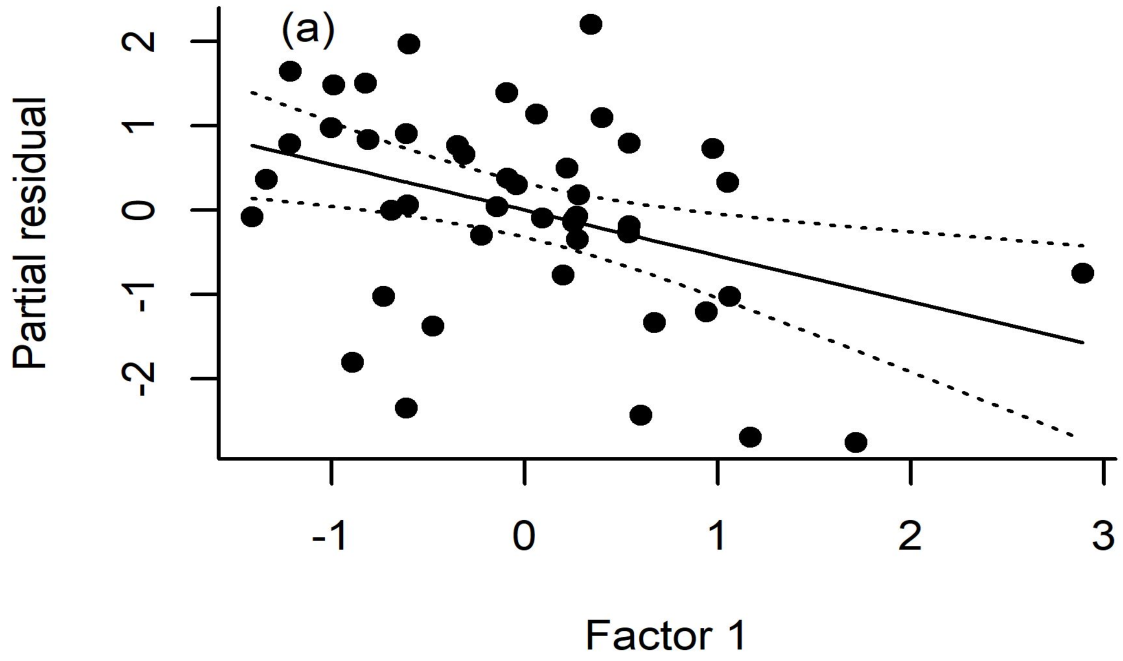
95% C.L.

Stock assessment

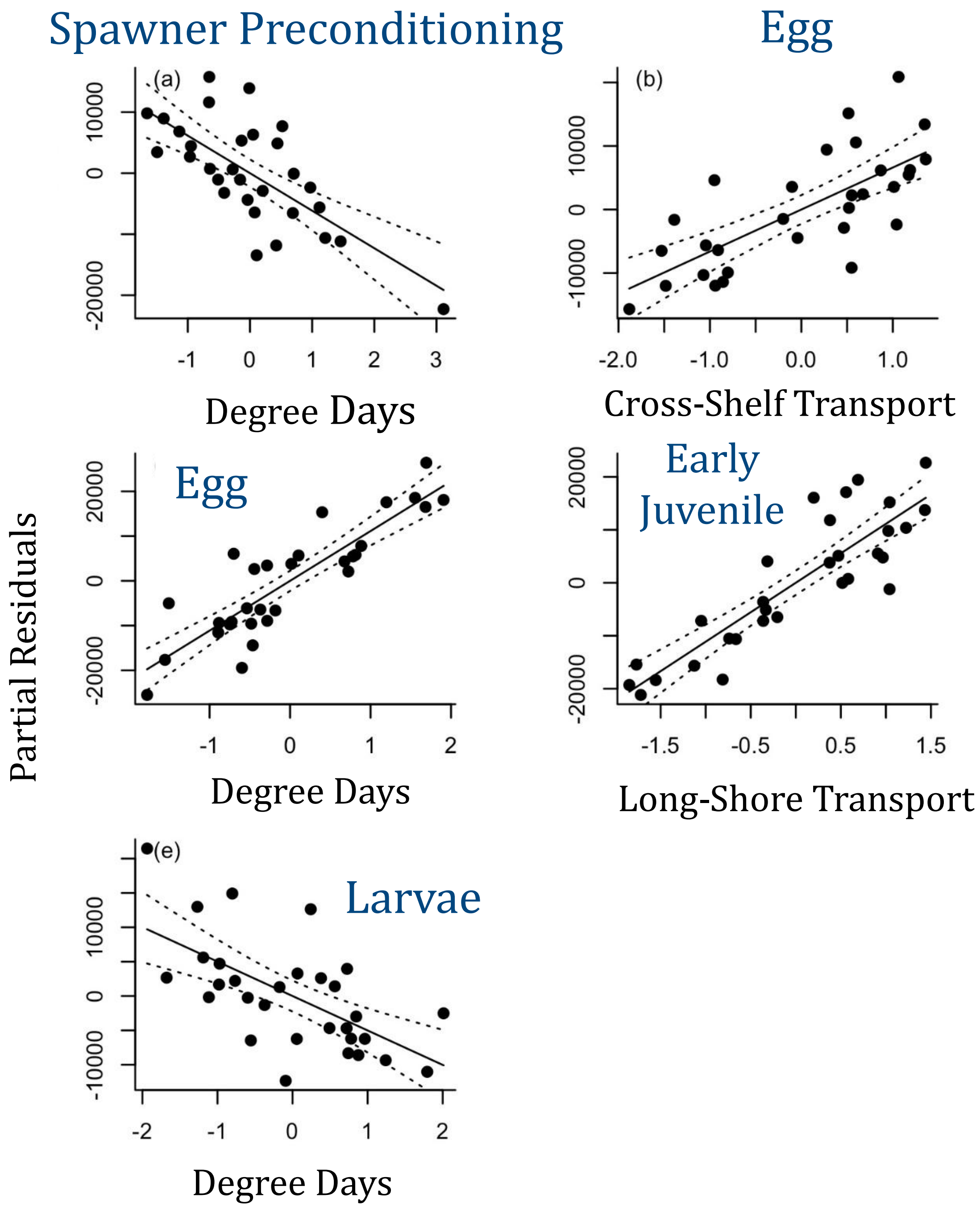
Tolimieri and Haltuch, In Prep.



Revised factor 1 North, 2021 update



Sablefish recruitment relationships



Best practices towards creating climate ready fisheries

Lessons learned

Build interdisciplinary science teams.

Communicate clearly and often with fishery management bodies.

Co-develop the management and decision-making frameworks that will use the scientific products and advice.

High priority needs

A strong foundation, and long time series, of basic biological and environmental data collections, and oceanographic model outputs to support mechanistic research.

Need time and buy-in from researchers beyond those that are directly involved in producing scientific products for management advice.

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