Ecosystem and Socioeconomic Profiles in the Northeast

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Presentation to the MAFMC SSC

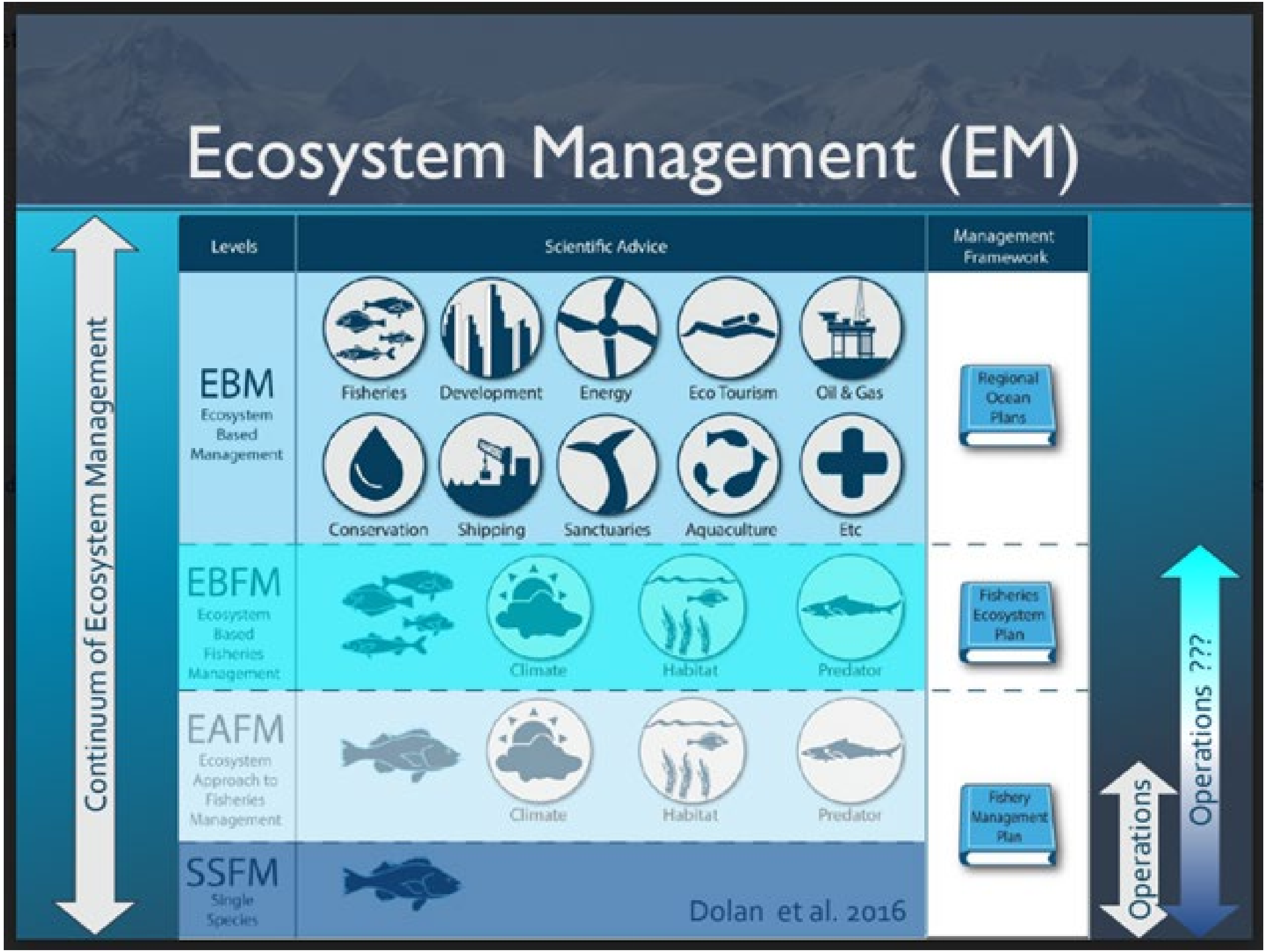
May 10, 2022

Outline

- Ecosystem and socioeconomic information in fisheries management
- The ecosystem and socioeconomic profile (ESP) framework
- Alaska Ecosystem and Socioeconomic Profiles
- Northeast Ecosystem and Socioeconomic Profiles
  - Overview
  - Bluefish
  - Black sea bass
  - Next steps
- Discussion

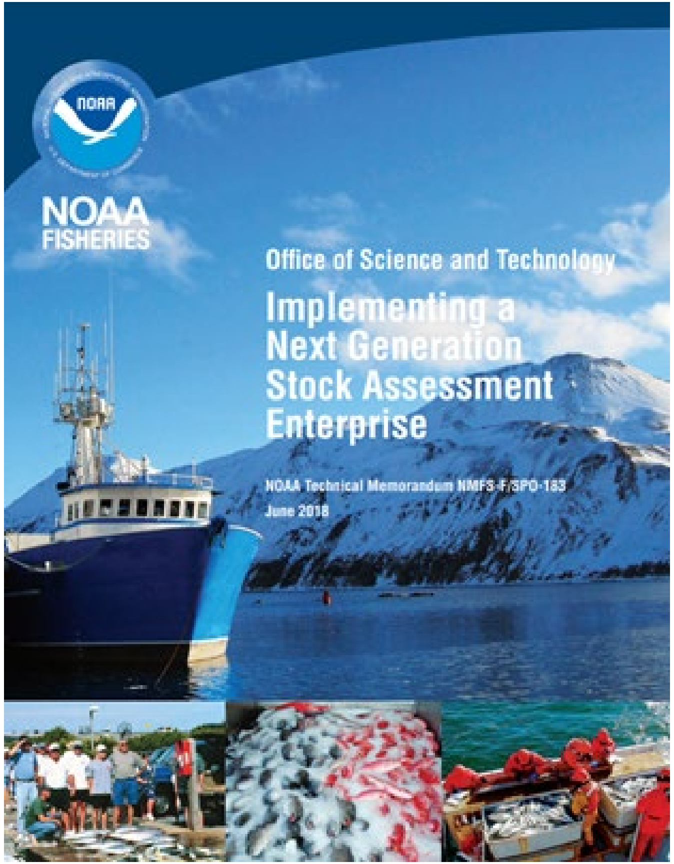
The need for ecosystem and socioeconomic information

- The Times They Are a-Changin':
  - Population processes (e.g., productivity changes, natural mortality, and distribution)
  - Physical processes (e.g., circulation patterns and bottom temperatures)
  - Social and economic drivers, and ocean uses
- Precision and accuracy of assessment models, biological reference points, and harvest control rules may be adversely affected (see Next-Generation Stock Assessment Enterprise NMFS 2018)
- There are ongoing efforts to provide more holistic single-species advice
- Can we come up with a framework to consistently incorporate additional info into the process?



Dolan et al. 2016 Slide from Kalei Shotwell

“Next-generation” stock assessment



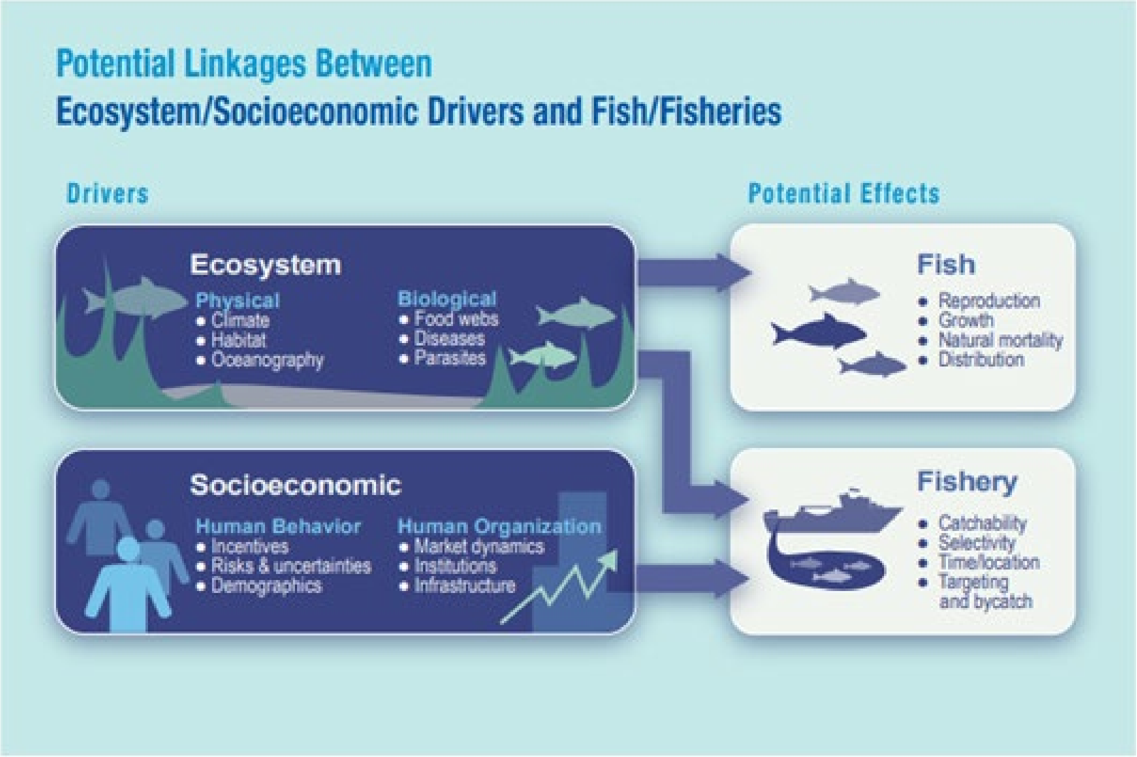


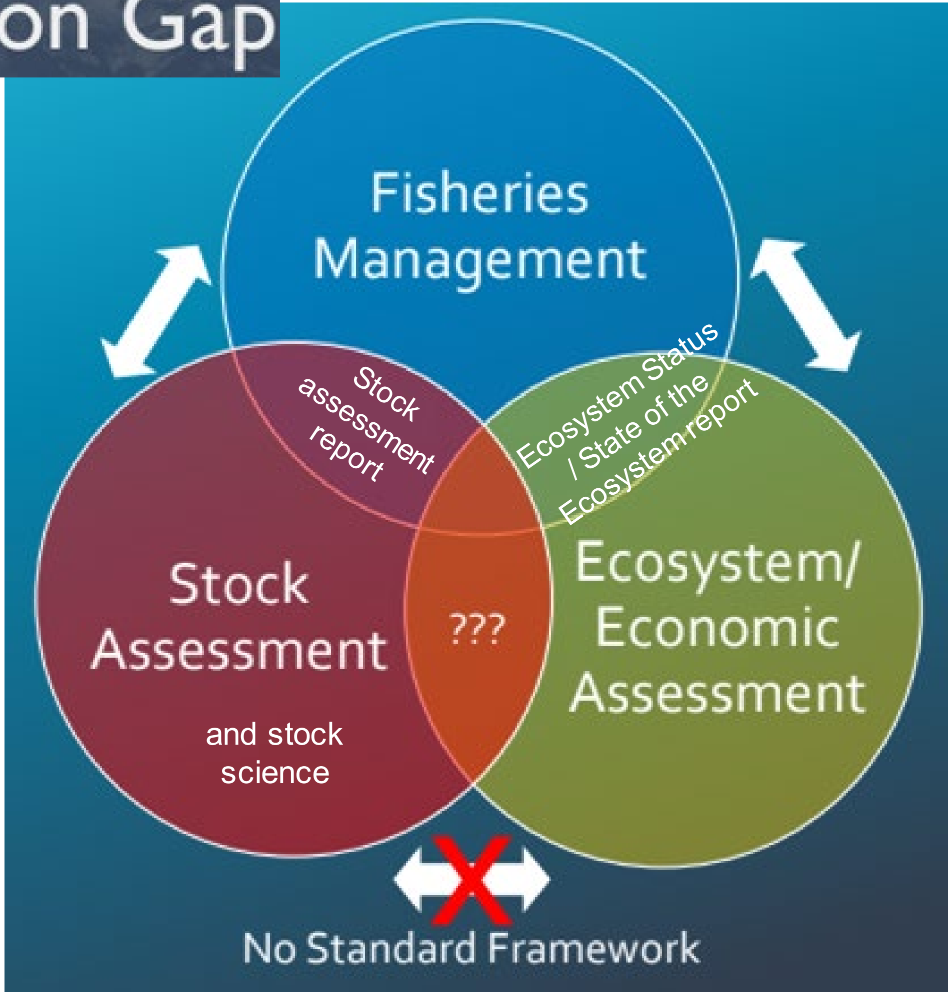
Figure 8.1 Ecosystem and socioeconomic processes affecting fish and fisheries.

“Next-generation” stock assessment

Box 8.1 Considerations when expanding the scope of a stock assessment to include ecosystem or socioeconomic factors.

1. Based on the stock's value, status, and biology, is there an incentive to expand its assessment to include ecosystem or socioeconomic factors?
2. Is there evidence to suggest that stock or fishery dynamics are tightly coupled with some variable ecosystem or socioeconomic feature?
3. Are data available to model this relationship within the assessment framework?
4. Can ecosystem or socioeconomic dynamics be incorporated in a way that maintains a manageable assessment model?
5. Can the relationships among stock, fishery, and ecosystem or socioeconomic dynamics be forecasted with at least a moderate degree of certainty?

Communication Gap

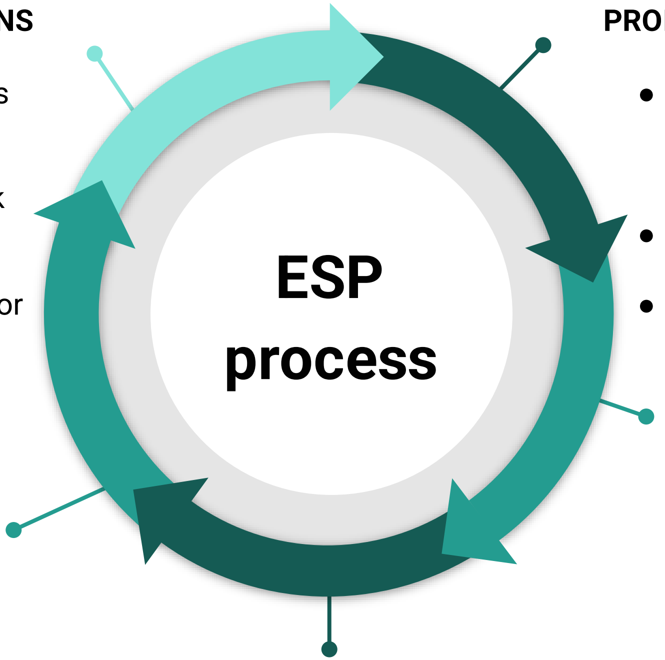


Slide from Kalei Shotwell

Ecosystem and Socioeconomic Profile (ESP) framework

ESP objectives

- Leverage existing information and knowledge pathways
- Incorporate a broad range of information
- Facilitate interpretation and use in management with a standardized framework and standardized visuals
- Improve transparency and reproducibility



PROBLEM STATEMENT

- Identify problems from previous assessments/benchmarks ("top-down")
- Gather and summarize existing literature ("bottom-up")
- Use repeatable, well-documented methods

CONCEPTUAL MODEL

- Identify important processes and linkages
- Can develop multiple conceptual models; for example, life history, human dimensions, and stock assessment process

INDICATOR DEVELOPMENT

- Indicators of a pressure, mechanism, and/or outcome
- Can be simple or complex
- Can add and evaluate indicators iteratively

INDICATOR ANALYSIS

- Determine indicator status
- Determine indicator importance
- Modeling/predictions

SUMMARY & RECOMMENDATIONS

- Provide a general recommendation as to whether the system is overall “favorable” or “unfavorable”
- Could link to assessment through risk table approach
- Recommendations for model assumptions, parameterization, and/or covariates

Problem statement identification

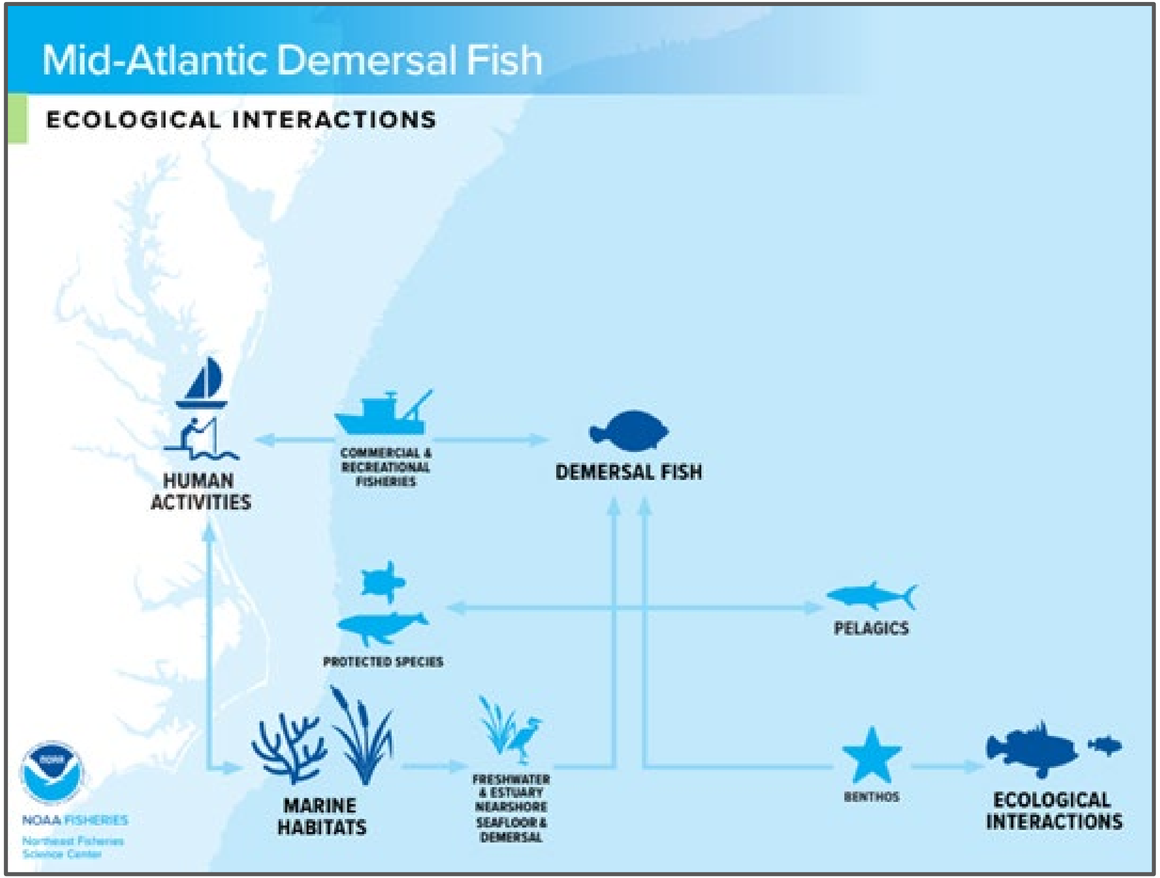
- Need a clear understanding of what is going on with the stock/ species/ management.
- Develop goals and deliverables to ensure the process goes smoothly
- The ESP may target a specific question or questions based on the life history, assessment, and management of the stock
- Develop a problem statement using previous assessment reports, research recommendations, subject matter experts, and literature review

Topic review for problem statement creation

- Review prior years' assessment documents and Essential Fish Habitat documents
- Systematic literature review (NOAA Central Library)
  - Reduce bias in literature search
  - Increase efficiency
- On-ramp to incorporate academic research

Conceptual models

- Qualitative outline of important linkages in the system
  - Understand bottlenecks
  - Organize important information
  - Begin to understand mechanisms
  - Identify testable hypotheses
- Multiple models possible:
  - Ecosystem model
  - Socioeconomic model
  - Linked model



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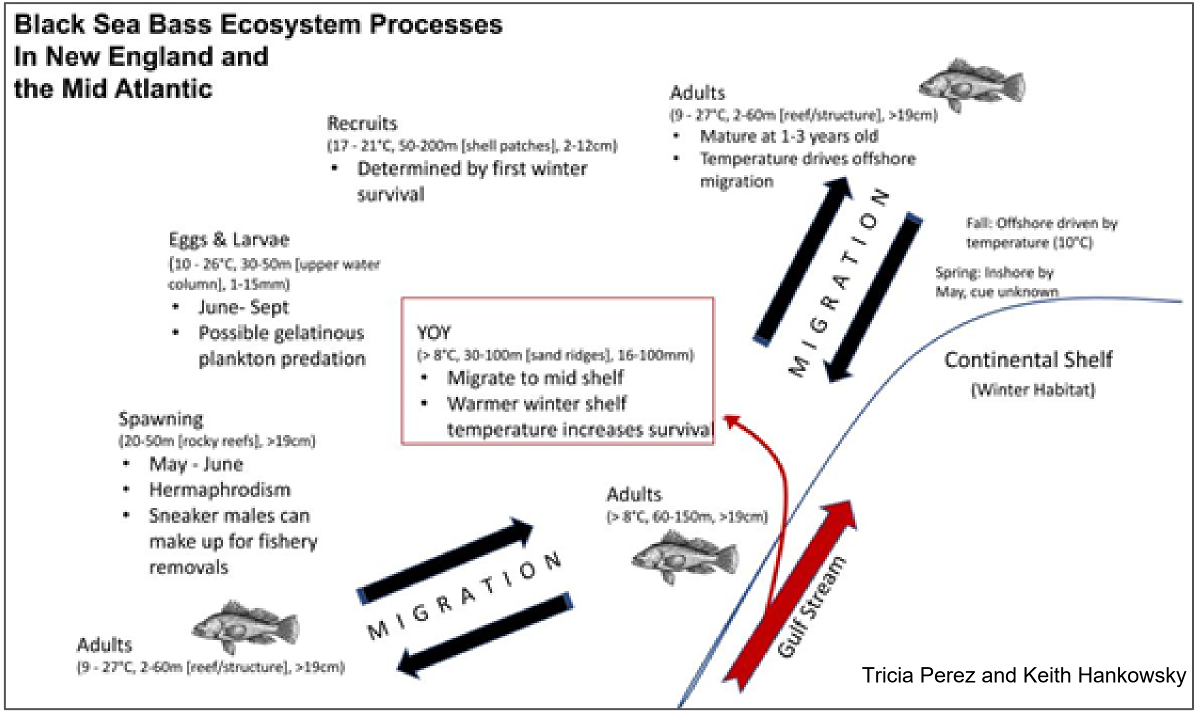


Tricia Perez and Keith Hankowsky

Indicator development

- Indicators are a proxy for reality (truth)
    - In most cases, we can't measure true quantities and mechanisms
    - Indicators can give us an approximation of reality
- They can be simple or complex
- We may not know the complete mechanism, but we can make simplifications and approximations to link current ecosystem and socioeconomic change to near-term change in stock status.

PRESSURE
ECOSYSTEM AND SOCIOECONOMIC CHANGE

- Temperature
- Ocean acidification
- Heatwaves
- Salinity

MECHANISM

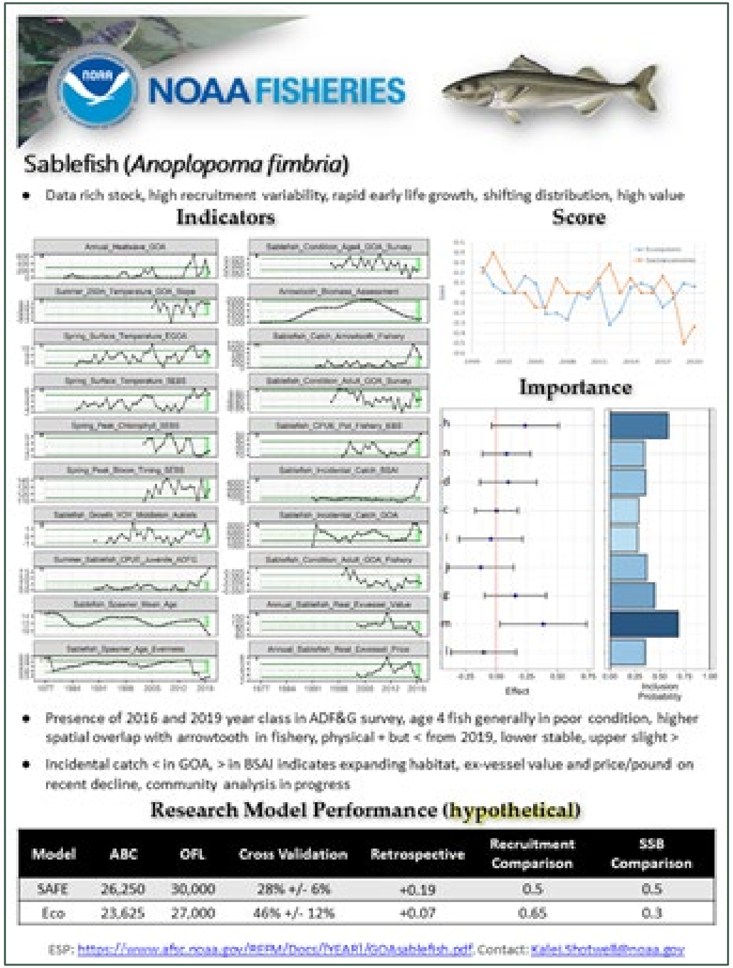
- Match/mismatch of predators/prey, reproduction
- Condition
- Ocean circulation
- Response to environmental cues

RESULT
CHANGE IN STOCK STATUS

- Number of recruits
- Spawning stock biomass
- Changes in length, age composition

Indicator analysis

- Trends over time
- Correlation with stock performance
- Bayesian Adaptive Sampling to determine covariate importance
- Modeling/prediction
- Opportunities to partner with academic researchers



NOAA FISHERIES

Sablefish (*Anoplopoma fimbria*)

- Data rich stock, high recruitment variability, rapid early life growth, shifting distribution, high value

- Presence of 2016 and 2019 year class in ADF&G survey, age 4 fish generally in poor condition, higher spatial overlap with arrowtooth in fishery, physical + but < from 2019, lower stable, upper slight >
- Incidental catch < in GOA, > in BSAI indicates expanding habitat, ex-vessel value and price/pound on recent decline, community analysis in progress

Research Model Performance (hypothetical)

Model	ABC	OFL	Cross Validation	Retrospective	Recruitment Comparison	SSB Comparison
SAFE	26,250	30,000	28% +/- 6%	+0.19	0.5	0.5
Eco	23,625	27,000	46% +/- 12%	+0.07	0.65	0.3

ESP: https://www.afsc.noaa.gov/REFM/Docs/[YEAR]/GOAsablefish.pdf, Contact: Kalei.Shotwell@noaa.gov

Summary and recommendations

Ecosystem Considerations

- Condition of the 2014 year-class is poor when compared to the relatively good condition of age-4 fish in previously high recruitment years and this is accompanied by a drop of 2014 year class recruitment strength in the most recent model recruitment estimates
- Body condition of the overall population on slope habitat has been decreasing since 2015 and may impact young sablefish arriving in already poor condition
- Overall, physical, YOY, and early juvenile indicators were generally good for sablefish while juvenile and adult indicators were generally average to poor.

It is important to consider the causal mechanisms for shifting condition of pre-spawning sablefish in both the survey and the fishery and the potential impact on spawning potential… a more detailed synthesis on gut content could be developed to better evaluate the condition indices, …potentially to generate time-series indicators of stomach fullness or energy content per individual sablefish biomass. These would help illuminate inference about competition and predation…

2021 STATE OF THE ECOSYSTEM | New England

Risks to Meeting Fishery Management Objectives

Climate and Ecosystem Productivity Risks

Climate change, most notably ocean warming, continues in the New England and is affecting the ecosystem in various ways:

- Ocean warming and changes in major currents continue.
- Frequent marine heatwaves occurred, with Georges Bank experiencing the warmest event on record at 4.3 degrees above average.
- We continue to observe little to no Labrador Slope Water entering the Gulf of Maine.
- Several biological diversity metrics are above average.
- Primary production continues to be high. Years with large fall phytoplankton blooms, such as 2020, have been linked to large haddock recruitment events on Georges Bank.

Pathways for scientific advice

Inform uncertainty

Provide additional context

- Do recent data seem consistent with past observations?
- Is there anything happening that might affect the stock in ways that the assessment model can't capture?

Inform assessment model…

assumptions

- Is the model consistent with the stock's life history?
- Are major biological processes accounted for?

choices

- Are parameter values consistent with existing information?
  - For example, natural mortality, catchability
- Inform data conditioning

covariates

- Indicator time series directly included in a model (ex, Woods Hole Assessment Model)

ESPs and the fisheries management process

- Provide relevant ecosystem and socioeconomic information for fisheries management
  - Work with management bodies to identify on-ramps where ESP information can fill knowledge gaps
  - Work towards operational ecosystem approach to fisheries management (EAFM)
- Track changes in the system over time

Scientific advice through informing uncertainty

- Inform management complementary to the assessment model
- Could iteratively be expanded on and added to a more quantitative category
- Risk table approach

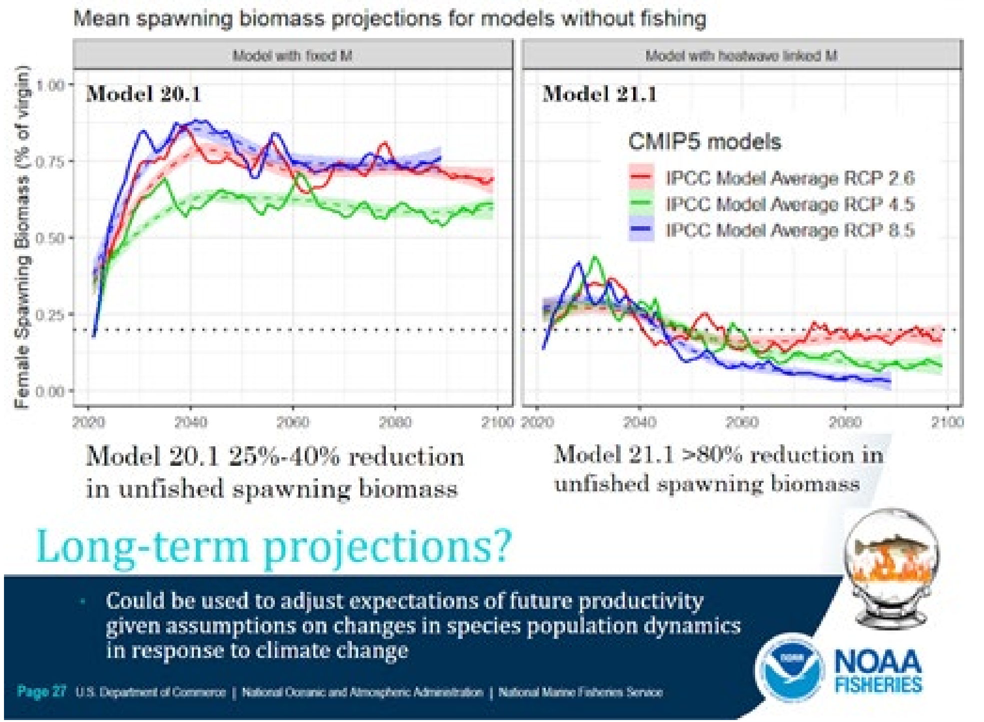
Table 1. Risk classification table for assessment, population dynamics, and environmental/ecosystem considerations.

	Assessment-related considerations	Population dynamics considerations	Environmental/ecosystem considerations
Level 1: Normal	Typical to moderately increased uncertainty; minor unresolved issues in assessment.	Stock trends are typical for the stock; recent recruitment is within normal range.	No apparent environmental/ecosystem concerns.
Level 2: Substantially increased concerns	Substantially increased assessment uncertainty or unresolved issues.	Stock trends are unusual; abundance increasing or decreasing faster than has been seen recently, or recruitment pattern is atypical.	Some indicators showing an adverse signals but the pattern is not consistent across all indicators.
Level 3: Major Concern	Major problems with the stock assessment; very poor fits to data; high level of uncertainty; strong retrospective bias.	Stock trends are highly unusual; very rapid changes in stock abundance, or highly atypical recruitment patterns.	Multiple indicators showing consistent adverse signals a) across the same trophic level, and/or b) up or down trophic levels (i.e., predators and prey of stock)
Level 4: Extreme concern	Severe problems with the stock assessment; severe retrospective bias. Assessment considered unreliable.	Stock trends are unprecedented. More rapid changes in stock abundance than have ever been seen previously, or a very long stretch of poor recruitment compared to previous patterns.	Extreme anomalies in multiple ecosystem indicators that are highly likely to impact the stock. Potential for cascading effects on other ecosystem components.

Dorn and Zador, 2020

Scientific advice through the assessment model

- ESPs can support and inform assessment model decisions
- Inform model assumptions
  - Support the choice of model for the stock
- Inform model parameterization
  - Support decisions to timeblock parameters such as maturity and length-weight keys
  - Provide contextual information to set values of parameters such as natural mortality
- Contribute to model covariates
  - Directly include indicator as a covariate (e.g., Woods Hole Assessment Model; WHAM)



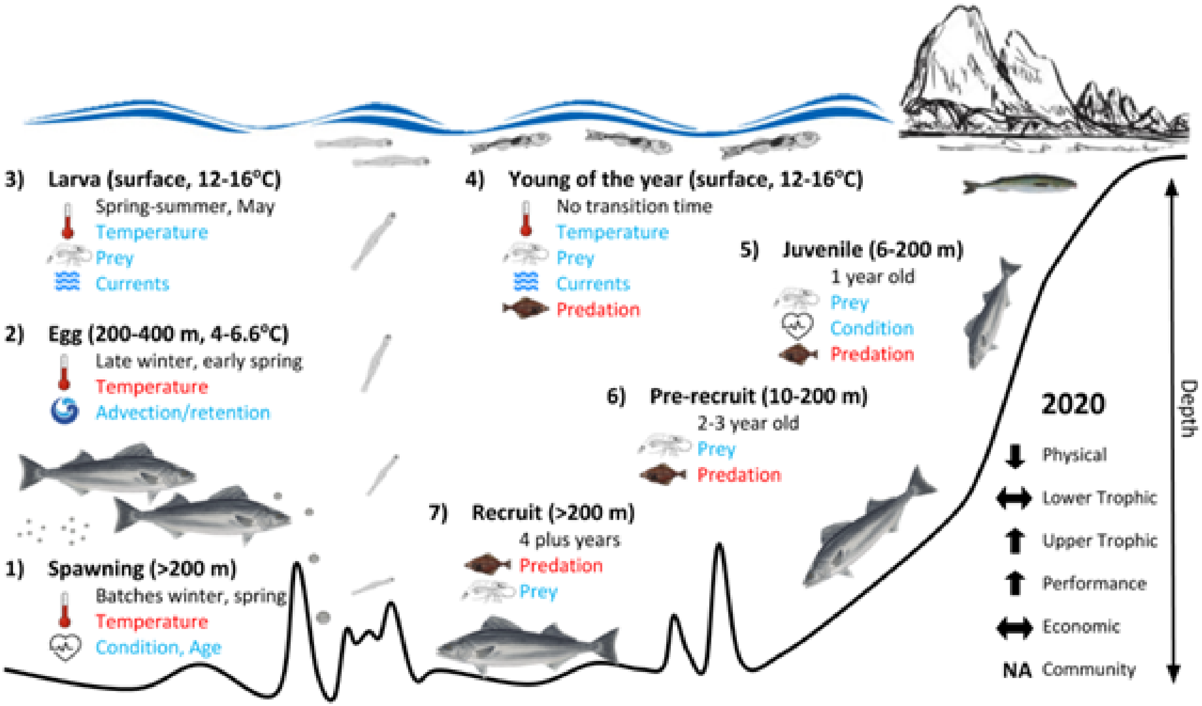
Steven Barbeaux, Alaska ESP workshop, March 2021

Ecosystem and Socioeconomic Profiles in Alaska

ESP implementation in Alaska

Stock	Year initiated	Full ESP	Partial update	Report card
Sablefish	2017	2017 - 2019	2020	2021
Gulf of Alaska Pollock	2019	2019	2020	2021
EBS Pacific Cod	2020	2021		2021
GOA Pacific Cod	2020	2021		2021
St Matthew Blue King Crab	2019	2019	2020	
Bristol Bay Red King Crab	2020	2020		2021
Bering Sea Snow Crab	2021	2022		

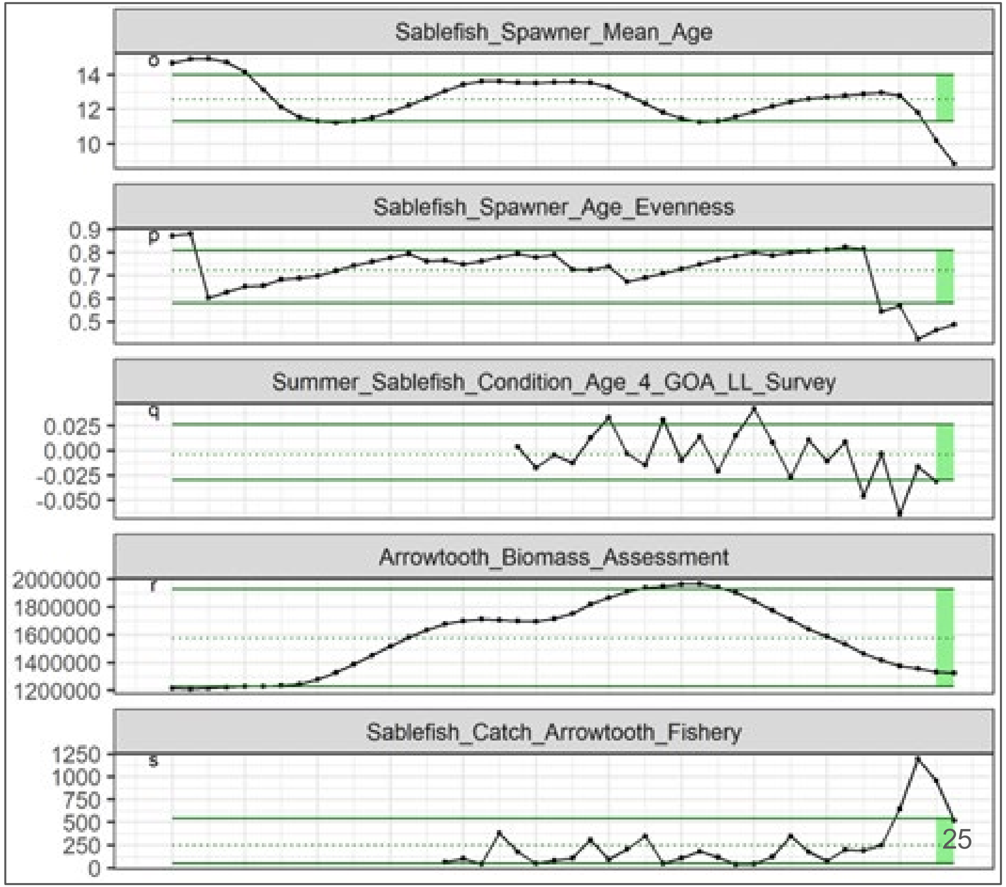
Sablefish



Appendix Figure 3C.1: Life history conceptual model for sablefish summarizing ecological information and key ecosystem processes affecting survival by life history stage. Red text means increases in process negatively affect survival, while blue text means increases in process positively affect survival. Trend of current year value compared to last year's value depicted with arrows on the left. NA means no indicators for that category.

Sablefish indicators and recent trends

- **Mean age of spawners** and **age evenness** continue to **decrease** suggesting higher reliance on the recent large 2014 and 2016 year-classes in the female spawning biomass
- **Condition** of the 2011, 2013-2015 year-classes is **poor** when compared to the relatively good condition of age-4 fish in previously high recruitment years
- **Spatial overlap** between sablefish migrating to adult slope habitat and the arrowtooth flounder population may have **increased**, based on continued recent large increases in incidental catch in the arrowtooth flounder fishery and may imply potentially **higher competition and predation**



Indicator category	Indicator	2017 Status	2018 Status	2019 Status	2020 Status	2021 Status
Physical	Annual Heatwave GOA Model	neutral	neutral	*high*	neutral	neutral
	Spring Temperature Surface EGOA Satellite	neutral	neutral	*high*	neutral	neutral
	Spring Temperature Surface SEBS Satellite	neutral	*high*	*high*	*high*	neutral
	Summer Temperature 250m GOA Survey	neutral	neutral	neutral	neutral	neutral
Lower Trophic	Spring Chlorophyll a Biomass EGOA Satellite	neutral	neutral	neutral	**low**	neutral
	Spring Chlorophyll a Biomass SEBS Satellite	**low**	neutral	**low**	neutral	neutral
	Spring Chlorophyll a Peak EGOA Satellite	neutral	*low*	neutral	*low*	neutral
	Spring Chlorophyll a Peak SEBS Satellite	*low*	**high**	neutral	neutral	neutral
	Annual Copepod Community Size EGOA Survey	neutral	**low**	**low**	neutral	NA
	Annual Copepod Community Size WGOA Survey	neutral	**low**	*high*	neutral	NA
	Summer Euphausiid Abundance Kodiak Survey	**low**	NA	neutral	NA	NA
	Annual Sablefish Growth YOY Middleton Survey	neutral	neutral	*high*	neutral	neutral

Acceptable Biological Catch considerations in the main assessment

- The estimate of the 2014 **year class strength declined** 68% from the 2017 to 2020 assessment models, while the 2016 year class was downgraded by 25% from the 2019 assessment; declines of this magnitude illustrate the uncertainty in these early recruitment estimates.
- Age-4 body condition of the 2014 year class was below average and lower than for previous large year classes in the early 2000s; **poor condition could lead to reduced survival and delayed maturity**.
- Fits to abundance and biomass indices are poor for recent years, particularly fishery CPUE and the GOA trawl survey, due to the **model overstating population growth** compared to what is indicated in the observed indices.
- Another **marine heat wave** formed in 2018, which may have been beneficial for sablefish juveniles in the 2014 – 2017 year classes, but it is unknown how it will affect movement, survival, growth, and maturity of late-stage juveniles and recently matured adult fish

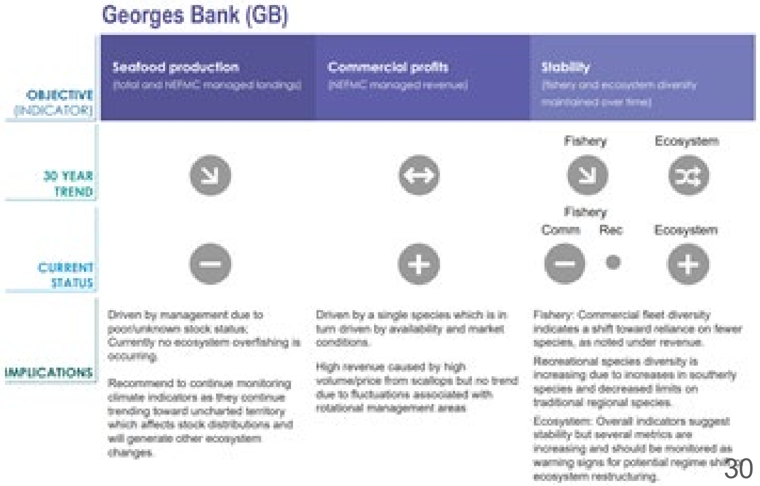
Sablefish catch recommendation

“Recommending an **ABC lower than the maximum** should result in more of the 2014, 2016, and 2017 year classes entering into the spawning biomass and becoming more valuable to the fishery. **This precautionary ABC recommendation buffers for uncertainty** until there are more observations of these potentially large year classes.”

Ecosystem and Socioeconomic Profiles in the Northeast

State of the Ecosystem Report

- Annual report for the Mid-Atlantic and New England Fisheries Management Councils
- Summary of ecosystem indicators relevant to fisheries management and objectives
- ESPs will extend SOE information to inform single-stock advice



Northeast ESP NEFSC workshop - August 2021

- Discussed the need for ESPs in the Northeast and what an ESP product might look like here
- Uncertainty in ecosystem conditions
  - Climate change: impacts to distribution, changes/breakdowns in ecosystem linkages, productivity (recruitment), natural mortality
  - Species interactions: trophic dynamics
  - Accurate estimates: catch, discards
  - Overlap with protected species
- Uncertainty in socioeconomic considerations
  - Human adaptation: changes in utilization, attainment, falling engagement
  - Need for broader market considerations: impacts of international markets, economic reference points in addition to biological, gear and targeting changes, allocation vs market demand

ESP purpose and deliverables

- Integrate ecosystem and socioeconomic factors into fisheries decision-making
- Develop a flexible, standardized framework
  - Leverage existing data and workflows
  - Work within existing processes (i.e., NRCC Assessment Process)
  - Provide supplemental information
  - Inform stock assessments and science advice
  - Monitor and test indicators for performance through time

Mid Atlantic OFL CV risk table

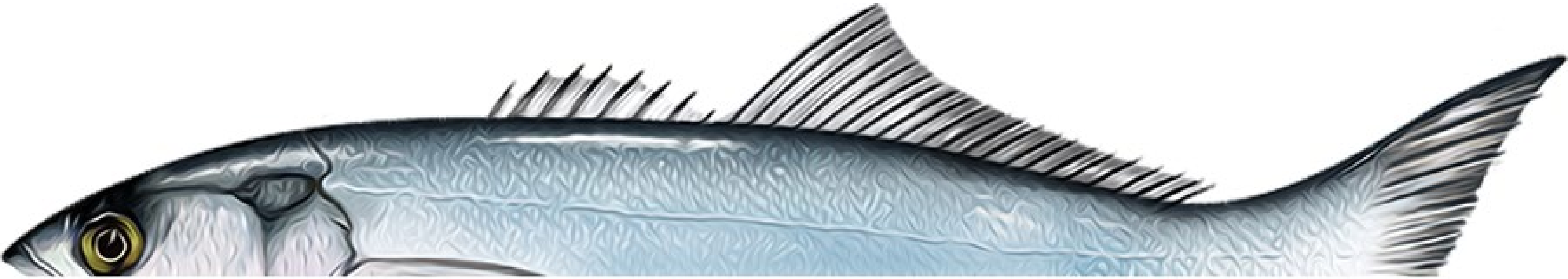
Decision Criteria	Default OFL CV=60%	Default OFL CV=100%	Default OFL CV=150%
Ecosystem factors accounted	Assessment considered habitat and ecosystem effects on stock productivity, distribution, mortality and quantitatively included appropriate factors reducing uncertainty in short term predictions. Evidence outside the assessment suggests that ecosystem productivity and habitat quality are stable. Comparable species in the region have synchronous production characteristics and stable short-term predictions. Climate vulnerability analysis suggests low risk of change in productivity due to changing climate.	Assessment considered habitat/ecosystem factors but did not demonstrate either reduced or inflated short-term prediction uncertainty based on these factors. Evidence outside the assessment suggests that ecosystem productivity and habitat quality are variable, with mixed productivity and uncertainty signals among comparable species in the region. Climate vulnerability analysis suggests moderate risk of change in productivity from changing climate.	Assessment either demonstrated that including appropriate ecosystem/habitat factors increases short-term prediction uncertainty, or did not consider habitat and ecosystem factors. Evidence outside the assessment suggests that ecosystem productivity and habitat quality are variable and degrading. Comparable species in the region have high uncertainty in short term predictions. Climate vulnerability analysis suggests high risk of changing productivity from changing climate.

Northeast ESP stocks

- Currently testing some ESPs coupled with research track assessments
  - Bluefish, black sea bass, cod
- Also working on mackerel through the management track assessment
- Future ESPs will be shaped by lessons learned in these preliminary ESPs

	Comprehensive ecosystem/ socioeconomic understanding	Uncertainty in ecosystem/ socioeconomic systems
Low ecosystem-related scientific uncertainty in the assessment		Bluefish
High ecosystem-related scientific uncertainty in the assessment		Black sea bass Mackerel Cod

Bluefish



Bluefish ESP timeline

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<tr><th colspan="6">2021</th><th colspan="5">2022</th></tr>
<tr><th>July</th><th>August</th><th>September</th><th>October</th><th>November</th><th>December</th><th>January</th><th>February</th><th>March</th><th>April</th><th>May</th></tr>
<tr><td>First WG meeting</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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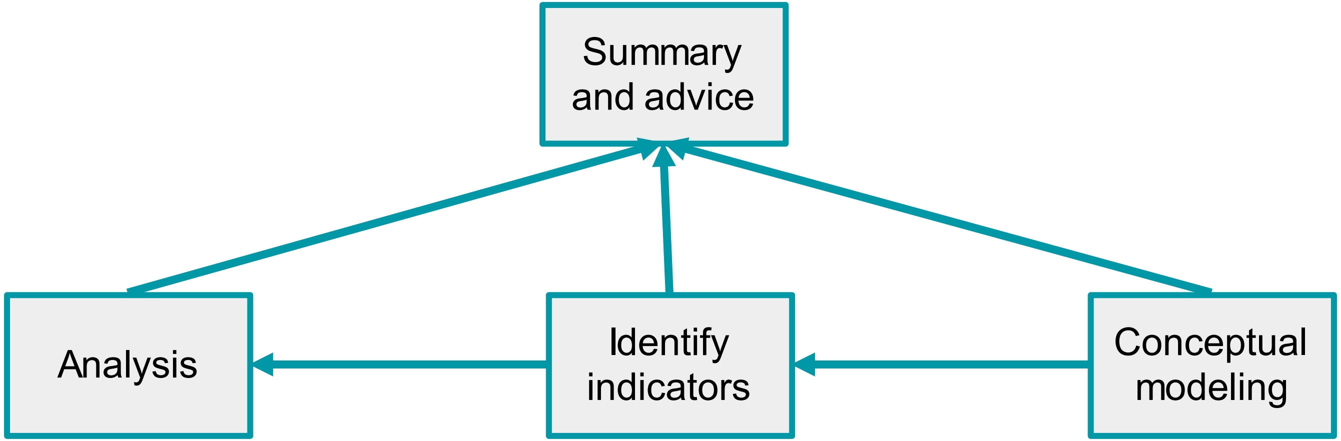
Bluefish ESP goals

- TOR 1: Ecosystem & climate influences on stock
- TOR 7: Research recommendations
- TOR 9: Additional analyses



Literature review and conceptual model

- 368 total papers reviewed from Web of Science queries
  - 154 relevant papers reviewed in depth
- Life history conceptual model: for each life stage, characterize habitat & distribution, phenology, age/length/growth, energetics, diet, and predators & competitors

detailed summary	region	summary	Article Title	Authors	Publication Year
Gonadosomatic indices and larval abundance and distribution (MarMAP) suggest continuous spawning in bluefish. Oceanographic model predicts that larvae from the middle of the spawning season do not recruit, giving bimodal recruitment peaks.	Western Atlantic	bluefish gonadosomatic index and spawning timing	ECOLOGICAL AND EVOLUTIONARY IMPLICATIONS OF THE LARVAL TRANSPORT AND REPRODUCTIVE STRATEGY OF BLUEFISH POMATOMUS-SALTATRIX	HARE, JA; COWEN, RK	1993
Description of otolith microstructure					
Bluefish occurence significantly dec But no change in bluefish length wi					

Estuarine juvenile

Habitat and distribution

Spring and summer cohorts had low spatial overlap in the estuary.	Stormer and Juanes 2017
Bluefish occurrence was significantly lower when dissolved oxygen was below 2mg/L. There was no relationship between bluefish length and dissolved oxygen concentration.	Howell and Simpson 1994

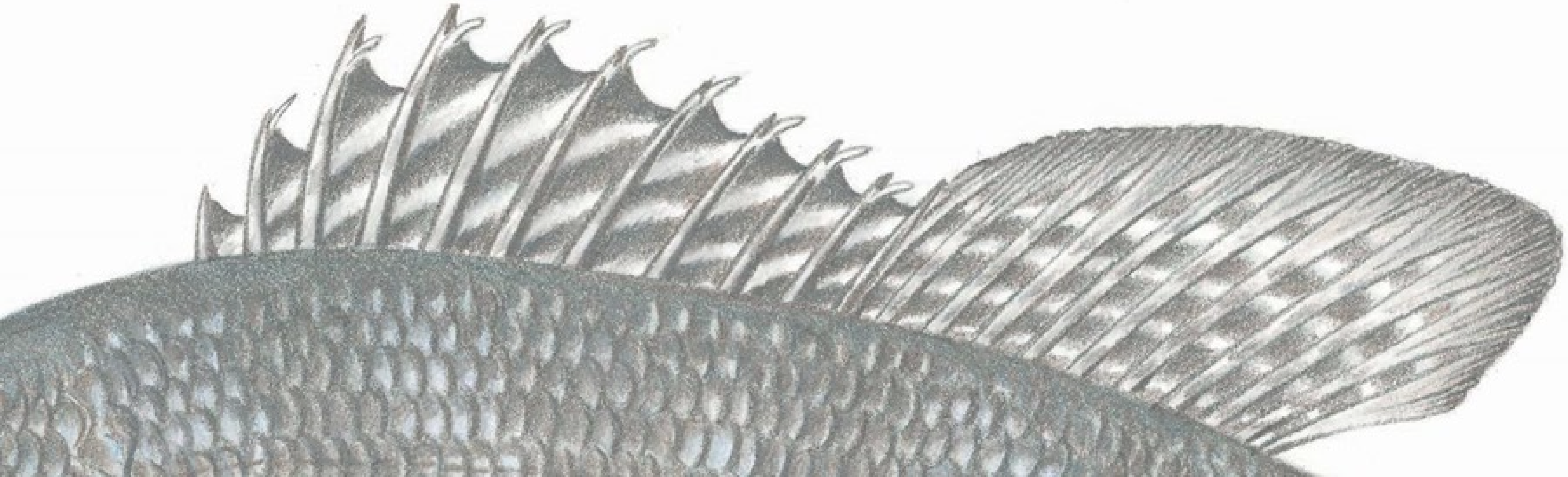
Socioeconomic considerations

- Large recreational fishery
  - Mix of subsistence and for-hire fishing
- Provide socioeconomic context that can be used to better understand the fishery and monitor changes over time
- Identify data gaps and future research that would help understand the system

Indicator development

- Identify indicators and document reasoning
  - Include specific units, geography, and time scale
  - Document connection to bluefish and references supporting that connection
  - Document how the indicator could be used to inform the model and/or management advice
- Select indicators to pursue
  - Assess indicator feasibility based on data availability, data quality, effort needed, and theoretical basis
  - Indicator scorecard survey sent to working group members
    - Help summarize indicator strengths/weaknesses
    - Prioritize indicator development
    - Contribute to recommendations for future research
- Create indicators with reproducible data pulls and scripts in R
  - Facilitate updates for future bluefish assessments
  - Methods can be applied to other stocks with minimal changes

Black sea bass



Background

- Ecosystem considerations highlighted in initial working group discussions
    - Prior research recommendations, stock assessment history
- Literature review
    - 179 citations collected from Web of Science with environmental focused query
        - 57 relevant citations divided by region and laboratory categories
- Synthesize findings into two types of conceptual model
    - “Top-down”: identify scientific uncertainties
        - Stock assessment conceptual model to identify stock assessment inputs that may be affected by ecosystem influences
    - “Bottom-up”
        - Life history conceptual model
            - Environmental conditions and drivers on life stage linkages
        - Identify hypotheses of mechanisms

Stock assessment conceptual model

- Identification of environmental influences on:
  - Recruitment
  - Natural mortality
  - Distribution and Habitat Use
  - Growth and Maturity

Environmental Impacts on	Notes	References
Recruitment	1. 100% mortality when winter temperatures decreased below 2-3 °C 2. 6°C Feeding stops and is the lethal temperature for C. striata, with short exposures to 5 °C proving lethal even when returned to nominal temps a. Interaction with osmoregulation at lower salinity, lower temps were better tolerated. 3. North Atlantic Oscillation index Correlated with age-0 CPUE but not age-1 4. Strong recruitment correlated with the warmest years, higher salinity and lowest slope water volume	1. Hales & Able 2001 2. Younes et al 2020 3. Peters, & Chigbu 2016 4. Miller et al 2016

Topic & Literature Review Outcomes

- Identify intersection of assessment model needs ("top-down") and issues raised from Literature ("bottom-up")
  - Top-down: Synthesize a set of science issues to focus indicator development and selection
  - Bottom-up: provide basis to develop suitable indicators
- Priority problems/issues that could help improve the assessment model
  - Early life stage survival
  - Migration/Stock mixing
  - Natural mortality

Next steps

- Atlantic cod ESP (*in progress* research track, 2023)
- Atlantic mackerel ESP (*in progress* management track, 2023)
- ESP workshop (Jan-Feb 2023)
    - Need SSC participation!
    - Post mortem of bluefish and black sea bass ESP processes
        - Discuss lessons learned
    - Map a plan forward
- Yellowtail flounder ESP (research track, 2024)
- Goldline tilefish ESP (research track, 2024)
- …?

Discussion questions

- How do you see the ESP being used within the context of SSC decision making?
  - What info is needed to "operationalize" ecosystem information?
  - How to balance stock specific vs generic indicators and methods?
  - What kind of documentation/supporting info would the SSC want to see in order to use an indicator to inform their processes?
- How to prioritize stocks for ESPs?
- How do you see the ESP fitting in to the stock assessment process?
  - Would the ESP be most useful as a part of the RT assessment, or as its own document?
  - How can periodic ESP updates be presented? Ex, Alaska provides report card updates for stocks that have ESPs.

Please email: scott.large@noaa.gov any additional ideas or feedback!

Resources

- Presentations by Kalei Shotwell (AFSC)
  - Slides from NOAA Central Library webinar - October 2020
  - Webinar recording - October 2020
  - Slides from presentation to NEFSC - August 2021
  - Presentation recording - August 2021

Northeast information

- State of the Ecosystem Reports
  - Mid Atlantic
  - New England

Alaska information

- 2021 Alaska ESP report cards
  - Bristol Bay Red King Crab
  - Alaska Sablefish
  - GOA Pacific cod
  - EBS Pacific cod
  - GOA Pollock
- 2021 Gulf of Alaska Pacific Cod Stock Assessment
  - Includes a discussion of potential future alternative models and associated indicators (Appendix 2.8)
- Past year ESPs
  - Sablefish 2018
  - Sablefish 2019
  - Pollock 2019
  - Blue king crab 2019

Extra slides

Report outline

- Background
  - Life history (conceptual model information)
  - Stock assessment history and description of parameters, assumptions, and considerations
  - Human dimensions
- Indicator analysis
  - Indicator selection
  - Methods (data sources & analyses)
  - Results
- Summary and recommendations