

Ecosystem & Socioeconomic Profile (ESP) & Dynamic Structural Equation Model (DSEM) Update

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September 2025, Presentation to the Groundfish Plan Team



Outline

National ESPs

Workshop and recent products, data modernization and Openscapes project

Alaska ESPs

Table of reports, PT/SSC recommendations overall and stock-specific, Alaska website

New Decision
Workflow

Proposal for improving ecosystem indicator workflow and streamlining communication

New Indicator
Analysis

Causal modeling as extension of the ESP process and integration into stock assessment models

National ESP Team Progress 2025

- March Hybrid Workshop
 - Day 1 and 2: Answering what are ESPs and how to conduct them
 - Day 3: Website, comms plan
- National ESP Team [Seminar](#)
- Minimum specifications templates and National onboarding guide
- 2025 Openscapes Cohort to automate ESP report templates



Alaska ESP Reports

Stock	Initiated	Full	Update*	Report card*
Sablefish	2017	2017 - <u>2019</u>	<u>2020</u> , 2025	<u>2021</u> , <u>2022</u> , <u>2023</u> , <u>2024</u> , 2025
Gulf of Alaska Pollock	2019	<u>2019</u>	<u>2020</u> , 2025	<u>2021</u> , <u>2022</u> , <u>2023</u> , <u>2024</u> , 2025
EBS Pacific Cod	2020	<u>2021</u>	2025	<u>2021</u> , <u>2022</u> , <u>2023</u> , <u>2024</u> , 2025
GOA Pacific Cod	2020	<u>2021</u>	2025	<u>2021</u> , <u>2022</u> , <u>2023</u> , <u>2024</u> , 2025
St Matthew Blue King Crab	2019	<u>2019</u>	<u>2020</u>	<u>2022</u>
Bristol Bay Red King Crab	2020	<u>2020</u>	<u>2025</u>	<u>2021</u> , <u>2022</u> , <u>2023</u> , <u>2024</u> , <u>2025</u>
Bering Sea Snow Crab	2021	<u>2022</u>	<u>2025</u>	<u>2023</u> , <u>2024</u> , <u>2025</u>
Bering Sea Tanner Crab	2024	<u>2025</u>		
GOA Arrowtooth Flounder	2024	2025 (draft)		
BSAI Atka Mackerel	<u>2025</u>	2026		* 2025 new format

SSC/PT Recommendations - Summary

- Overall (34 pages of minutes on ESPs for 2024-2025!!!)
 - PT: Coordinate ESP and CEATTLE authors to avoid duplication
 - SSC: Support flexibility in tailoring socioeconomic indicators and awaiting discussion group, provisionally support new approach to categorize ESP indicators (pending review)
- Stock-specific (see specifics in Extra Slides):
 - Sablefish: PT: standardize size grades, SSC: expand small community narrative
 - GOA Pollock: PT/SSC: develop Chinook bycatch indicators, SSC: nearshore datasets for euphausiid index, commends pathway development through DSEM
 - Pacific cod: PT: encouraged AI stock to leverage other cod ESPs, SSC: support developing socioeconomic indicators for fishery performance/community categories
 - BSAI Atka Mackerel: PT/SSC support developing ESP for this stock



Alaska ESP Website (In Progress)

The screenshot displays the Alaska ESP Website interface. At the top, the URL <https://akesp.psmfc.org> is visible, along with navigation links for "News", "Tools", and "About". A dark navigation menu on the left contains the following items:

- Home (Home icon)
- Stocks (Anchor icon)
- Data (soon) (Data icon)
- Resources (Folder icon)

The main content area features a circular logo with a fish in the center, labeled "ESP". The logo is divided into four quadrants: "ECOSYSTEM" (top-left), "SOCIOECONOMIC" (top-right), "PROFILE" (bottom), and "DATA" (bottom-left). Below the logo, the text "Alaska Fisheries Science Center" and "Ecosystem and Socioeconomic Profiles" is displayed over a background image of a glacier.

Decision Pathways

Qualitative: "Outside the model"

SSC

- Acceptable Biological Catch (ABC; e.g., risk tables, uncertainty criteria)
- Rebuilding plans

Council

- Total Allowable Catch (TAC) decisions
- Setting harvest control rules
- Rebuilding plans

Research

- Survey planning
- Research priorities
- Requests for proposals

Quantitative: "In the model"

Assumptions

- Mechanistic linkages
- Consistency with stock life history
- Biological realism

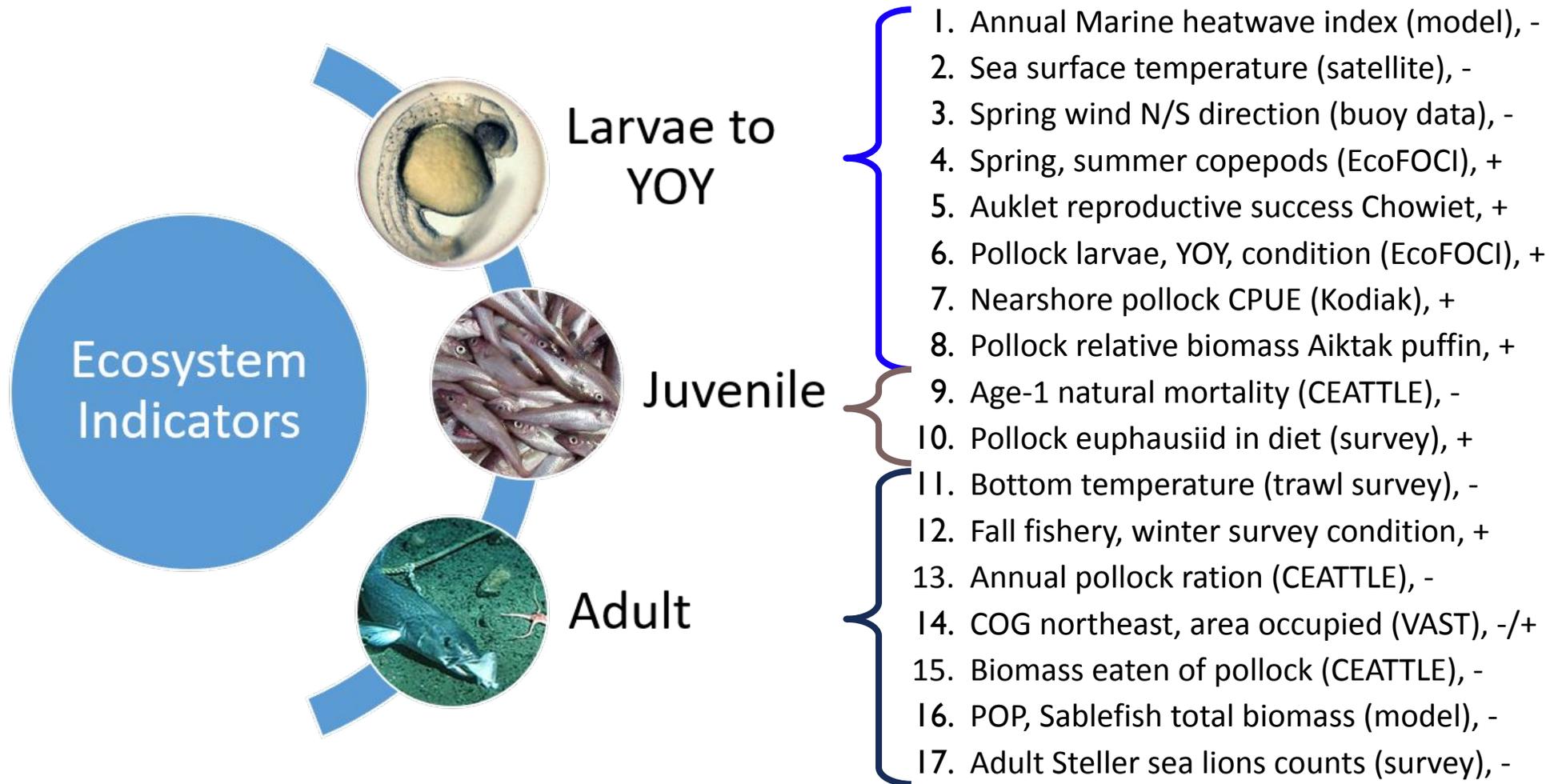
Choices

- Inform data conditioning
- Time blocks
- Parameter values consistent with existing info

Covariates

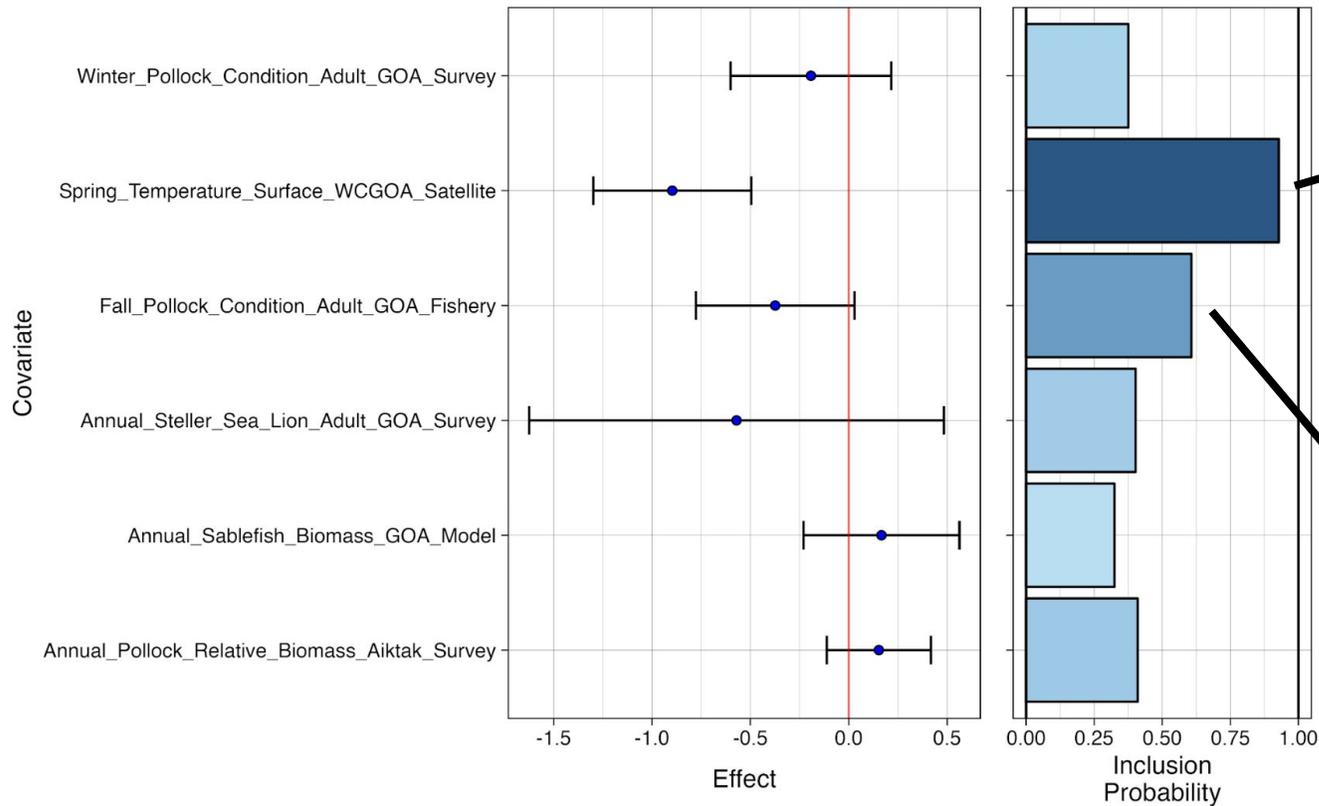
- Indicator time series directly included in model (e.g., Rceattle, WHAM)

Current Indicator Organization



Current Indicator Importance

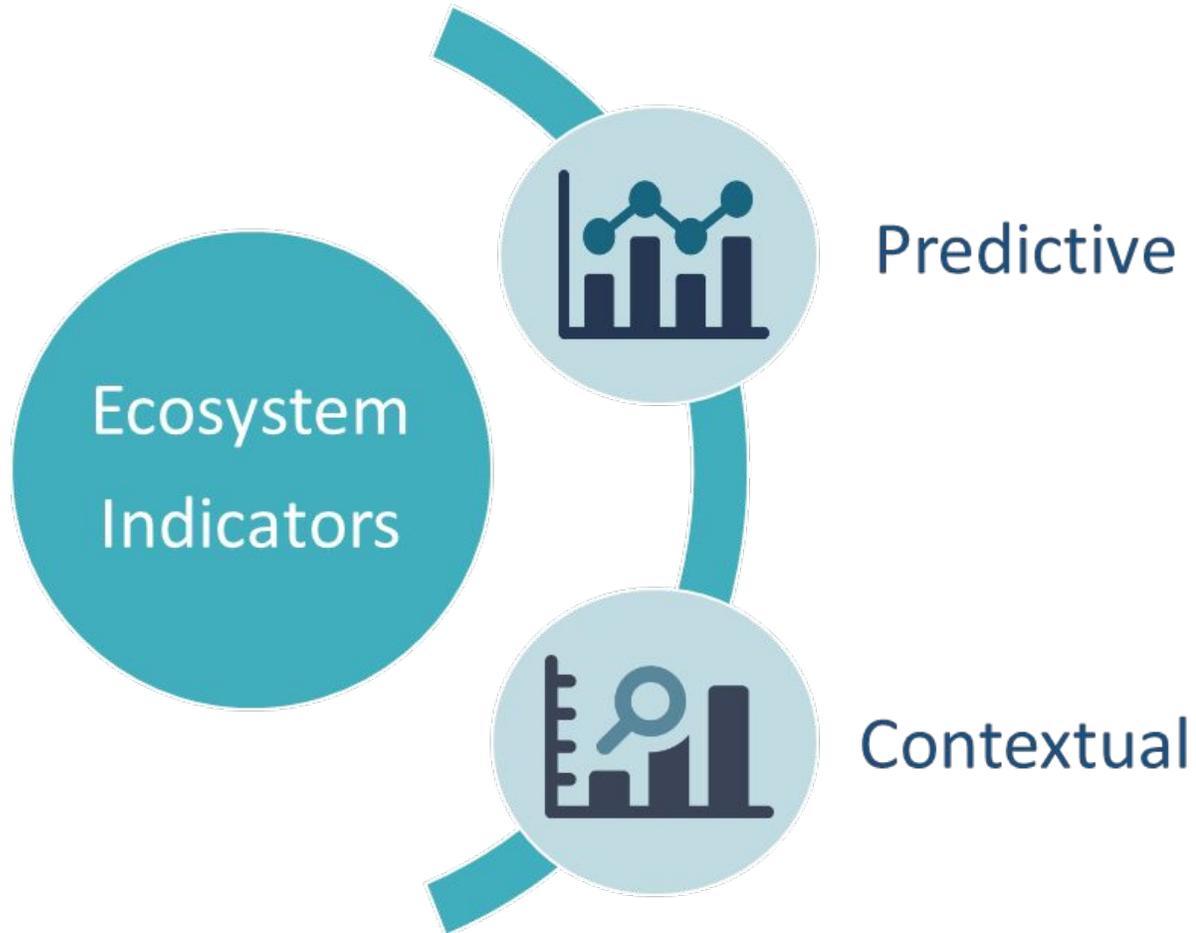
Importance Result



Status Table

Indicator category	Indicator	2020 Status	2021 Status	2022 Status	2023 Status	2024 Status
Larval to YOY	Annual Heatwave CGOA Model	neutral	neutral	neutral	neutral	neutral
	* Spring Temperature Surface WCGOA Satellite	neutral	neutral	neutral	neutral	neutral
	Spring Wind NS Direction	neutral	low	neutral	neutral	neutral
	Spring Small Copepod Abundance Shelikof Survey	NA	neutral	NA	neutral	NA
	Summer Large Copepod Abundance Shelikof Survey	NA	NA	NA	neutral	NA
	Annual Auklet Reproductive Success Chowiet Survey	NA	neutral	neutral	neutral	high
	Spring Pollock CPUE Larvae Shelikof Survey	NA	neutral	NA	neutral	NA
	Summer Pollock CPUE YOY Shelikof Survey	NA	NA	NA	neutral	NA
	Summer Pollock Condition YOY Shelikof Survey	NA	NA	NA	low	NA
	Summer Pollock CPUE YOY Nearshore Kodiak Survey	neutral	neutral	neutral	neutral	high
Juvenile	Annual Pollock Relative Biomass Aiktak Survey	NA	neutral	neutral	low	neutral
	Pollock Predation Mortality Age1 GOA Model	neutral	neutral	neutral	neutral	neutral
	Summer Pollock Euphausiid Diet Juvenile GOA Survey	NA	neutral	NA	neutral	NA
Adult	Summer Temperature Bottom GOA Survey	NA	neutral	NA	neutral	NA
	* Fall Pollock Condition Adult GOA Fishery	neutral	neutral	neutral	neutral	NA
	Winter Pollock Condition Adult GOA Survey	neutral	neutral	low	neutral	neutral
	Annual Ration Pollock GOA Model	neutral	neutral	neutral	neutral	neutral

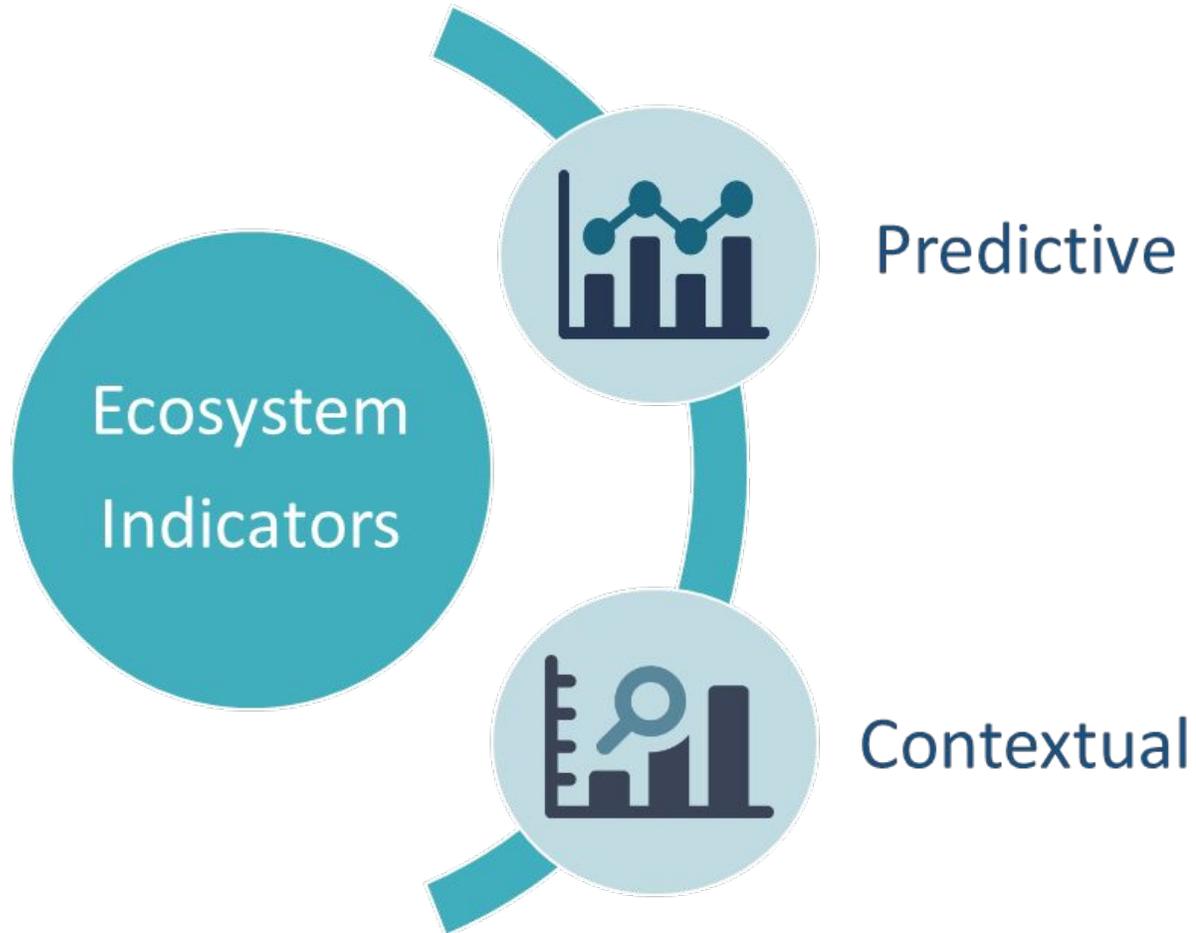
Proposed Solution



Proposing a new ESP ecosystem indicator workflow and communication pathway to:

- Develop criteria that categorize ecosystem indicators as predictive or contextual
- Improves communication of indicator importance and intent by highlighting indicators that demonstrate robust statistical relationships with stock
- Reduces information overload from uninformative indicators

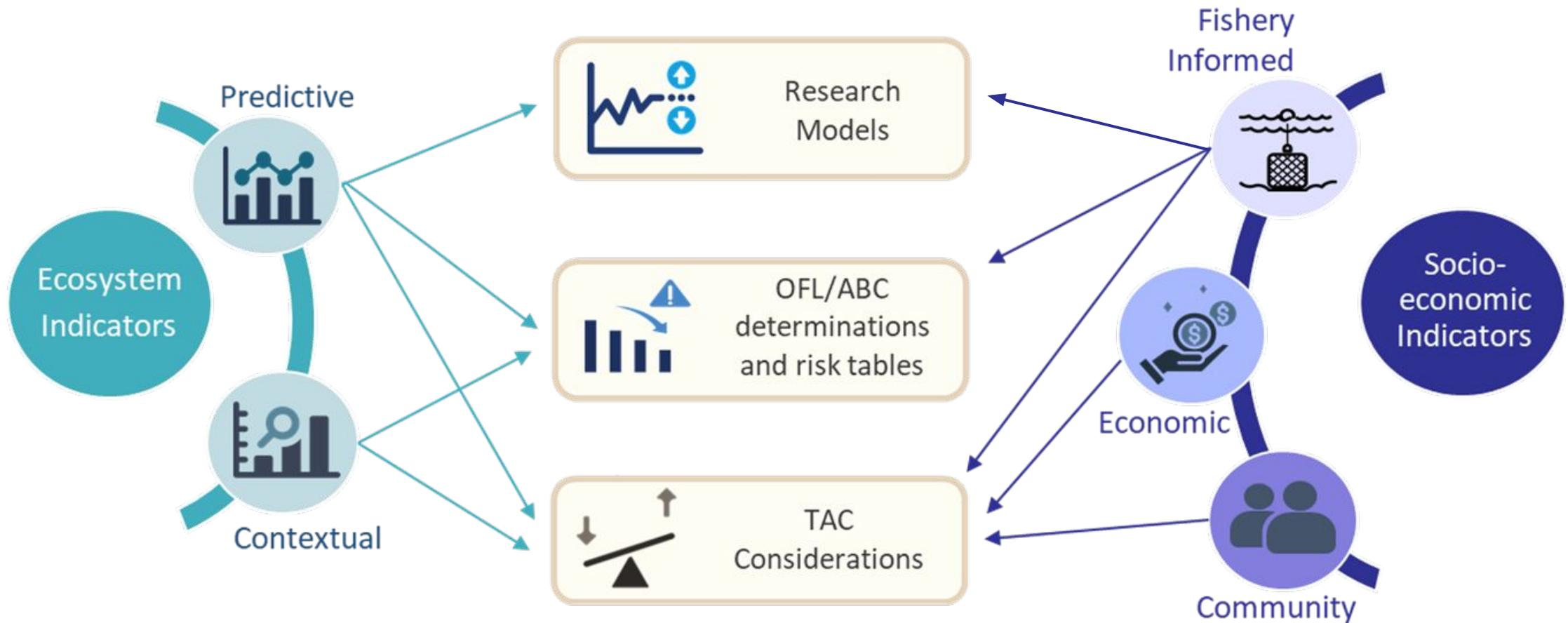
Proposed Solution



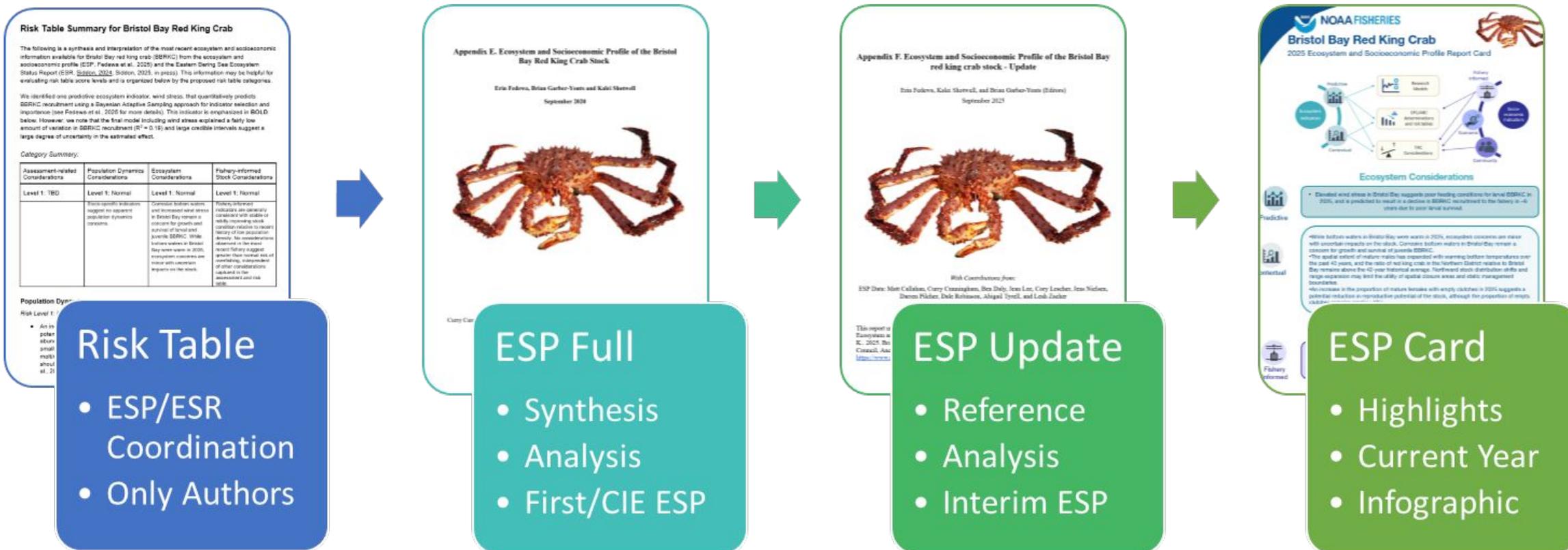
Statistically-significant relationship between an environmental or ecological observations and a population process (e.g., recruitment)

Do not provide a quantitative prediction, but are considered useful to highlight potential red flags, provide information on stock status or health, or help to inform a management concern or risk table category

Indicator Pathways to Decisions

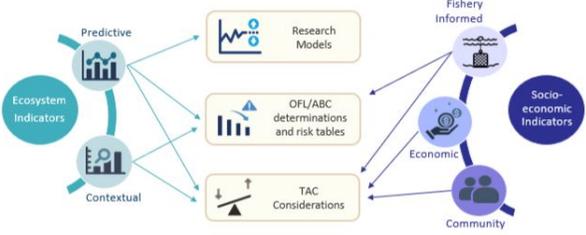


Templates for Streamlining Communication



Report Cards - Closer Look

NOAA FISHERIES
Bristol Bay Red King Crab
 2025 Ecosystem and Socioeconomic Profile (ESP) Report Card

Ecosystem Considerations

- Elevated wind stress in Bristol Bay suggests **poor feeding conditions** for larval red king crab in 2025, and is predicted to result in a decline in recruitment to the fishery in ~6 to 8 years due to poor larval survival.
- Bristol Bay was considerably warmer than the last four years, and corrosive bottom waters remain a concern for growth and survival of juvenile red king crab. Overall, **ecosystem concerns are minor** with uncertain impacts on the stock.
- The spatial extent of mature males has expanded with warming bottom temperatures over the past 40 years, and the ratio of red king crab in the Northern District relative to Bristol Bay remains above the 42-year historical average. **Northward stock distribution shifts and range expansion** may limit the utility of spatial closure areas and static management boundaries.
- An increase in the proportion of mature females with empty clutches in 2025 suggests a **potential reduction in reproductive potential** of the stock, although the proportion of empty clutches remains small (< 4%)

Socioeconomic Considerations

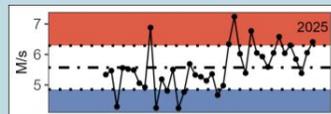
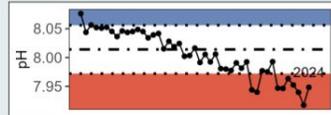
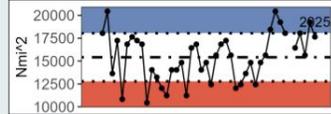
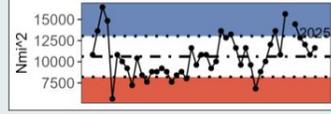
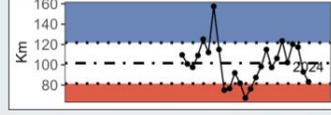
- Fishery-informed indicators are generally consistent with **stable or mildly improving stock condition** relative to the recent history of low population density.
- Crab vessel captain observations on fishing conditions in the 2024/25 Bristol Bay red king crab fishery are consistent with **high fishery CPUE**.

Predictive
Contextual
Fishery Informed

NOAA FISHERIES
Bristol Bay Red King Crab ESP Report Card



Ecosystem Indicators

Indicator	Status	Trend
Summer Wind Stress	Above long-term mean	
Spring pH	Below long-term mean	
BBRKC Mature Male Area Occupied	Near long-term mean	
BBRKC Mature Female Area Occupied	Near long-term mean	
Fishery Catch Distance from Shore	Near long-term mean	

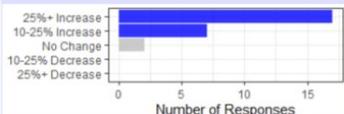
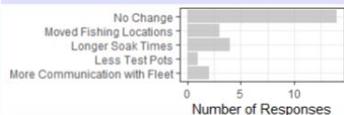
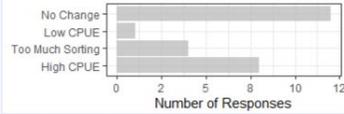
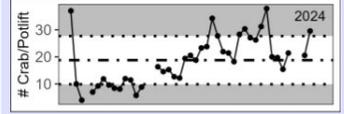
Predictive
Contextual

Most recent year indicator status indicates good conditions, average conditions, or poor conditions for the stock

NOAA FISHERIES
Bristol Bay Red King Crab ESP Report Card



Socioeconomic Indicators

Indicator	2025 Status	Trend
Skipper Survey: Perceived Abundance of Legal Males	Increase in perceived abundance	
Skipper Survey: Changes in Fishing Behavior	Minor changes in behavior	
Skipper Survey: Motivation for Changes in Fishing Behavior	Minor changes in behavior	
Fishery CPUE	Above long-term average	
Annual Incidental Catch	Near long-term average	

Fishery Informed

Current Indicator Analysis Methods

- Multiple statistical methods available (Oke et al., *in review*)
- Only use Bayesian Adaptive Sampling (BAS) in groundfish ESPs to date, but sensitivity to missing data and length of time series
- Other regression methods may overcome some BAS limitations but still issues with these approaches (Champagnat et al., [accepted](#), Sullivan et al., [seminar](#))
 - Ecosystems are complicated and variables are not all independent
 - Correlations, confounding among predictors can lead to biased estimates

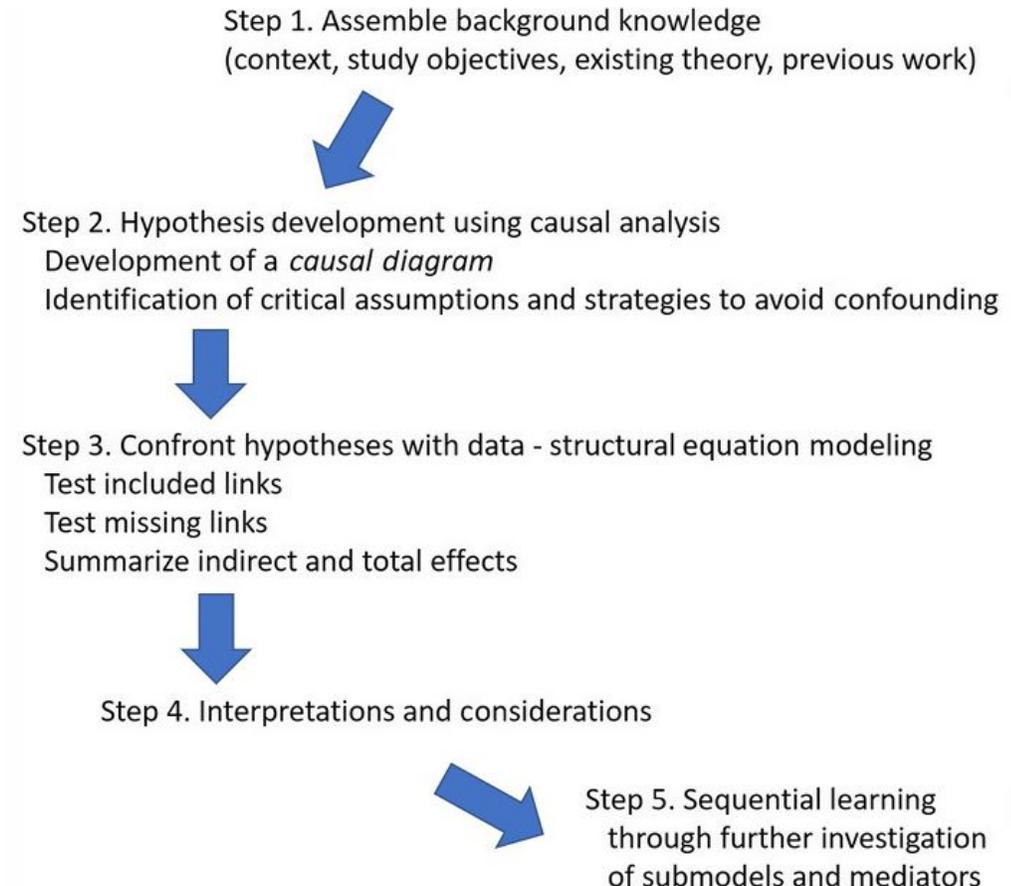


Causal Analysis

“Alternatively, causal modeling can extend the regression paradigm by translating a scientist’s ideas about data-generating mechanisms into a set of observational expectations“

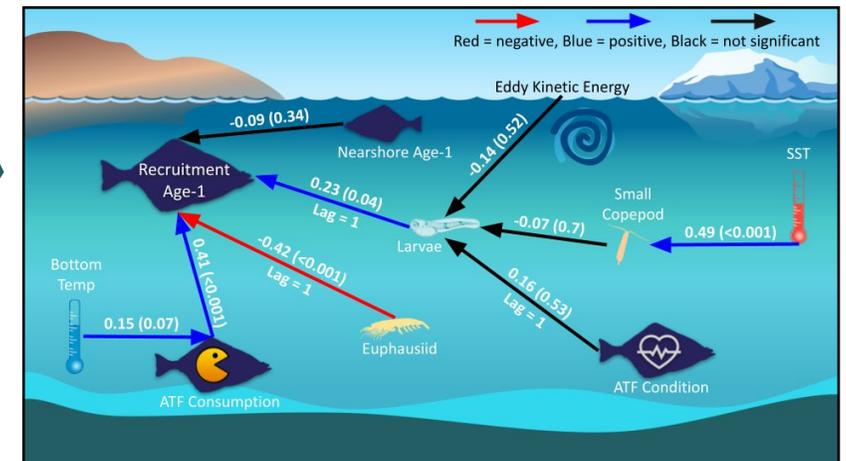
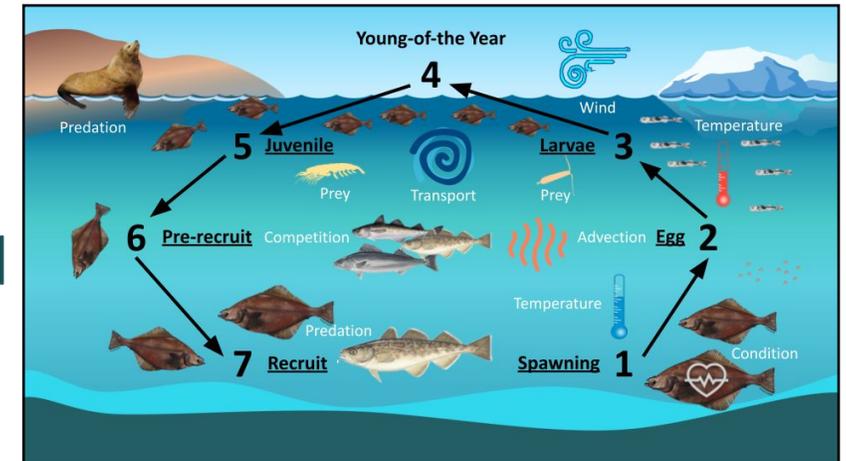
(Grace and Irvine 2020)

For ESP process, varied experts can pool knowledge, and causal diagrams make assumptions transparent and easier to discuss and review. The **focus is on the science**, not the statistics.



Causal Workflow in ESPs

1. Start with ESP synthesis, conceptual model, and indicator suite (example top right)
2. Create causal diagram or Directed Acyclic Graph (DAG) (example bottom right)
 - Use synthesis and any established relationships from ESP to develop mechanism table
 - Make DAG based off relationships defined in mechanism table (use [Daggity](#) or similar)
3. Use Dynamic Structural Equation Model (DSEM, [Thorson et al., 2024](#)) for estimation
 - Test multiple models (full, simple, AR1, IID), evaluate relationships, select best model
4. Review results with ESP Teams and iterate



A Step Further - Integrated DSEM

- Benefits of embedding DSEM in a stock assessment model
 - Improved accounting of uncertainty, model selection, and validation
 - Works for any time-varying population parameter
 - Projections can drive stock productivity for management goals
- First example GOA pollock model ([Champagnat et al., accepted](#))
 - Develop a series of reasonable DAGs with ESP experts
 - Embedded DSEM code within GOA pollock stock assessment model
 - Moderate DAG best, 69% reduction of unexplained recruitment variability
- Now expanded to AFSC's state-space model (Rceattle)

RCEATTLE Overview

- Developed from ADMB CEATTLE ([Holsman et al., 2016](#))
- TMB code-base for state-space age structured modelling
 - Random effects for R, M, Q, and selectivity, flexible in the number of species, sexes, fleets, ages, and lengths
 - Standardized diagnostic and trend plots, can easily assess performance via diagnostics, fit, simulation, and MSE
 - Single-species or optional multi-species predation mortality
 - Flexible specification of HCRs and BRPs
- 9 groundfish stocks code base is developed and exactly/closely match operational model, 4 more approximation but could get better

RCEATTLE + DSEM Branch (Summer 2025)

- Expanded in 2025 to link recruitment to covariates via DSEM
- Scalable from simple model to large DAG
- Can link covariate to recruitment via DSEM interface

```
sem = "  
  # link,           , lag, param name, start_value  
  SST -> SST       , 1  , AR1_SST   , 0  
  SST -> recdevs1  , 1  , SST_to_R , 0  
  recdevs1 <-> recdevs1, 0  , sigmaR1  , 1  
"  
model <- Rceattle::fit_mod(data_list = GOApollock,  
                           dsem = build_DSEM(  
                             sem = sem  
                           ))
```

Next Steps

- **ESPs are powerful tools** to help advance ecosystem-based fisheries management and **we propose a causal extension** to this process
- New categories for ecosystem indicators and standardized templates **improve workflow and streamline communication**
- Next Steps:
 - Pending Plan Team and SSC feedback, apply new categories and templates for existing groundfish ESPs (Nov 2025)
 - Evaluate integrated Rceattle+DSEM for GOA Arrowtooth flounder ESP (Nov 2025) and BSAI Atka mackerel (Nov 2026) and discuss options for use in decisions (preview this week!)



Discussion

- 1) Are the new predictive and contextual categories helpful for improving communication? Thoughts on revisions or additions to the definitions?
- 2) Are the new templates (risk table, full, update, report card infographic) useful? Any feedback on the format or suggestions for improvement?
- 3) Any concerns on including causal modeling in the ESP process? Any feedback on using DSEM for evaluating indicators performance? Additional ideas?

Thank You!



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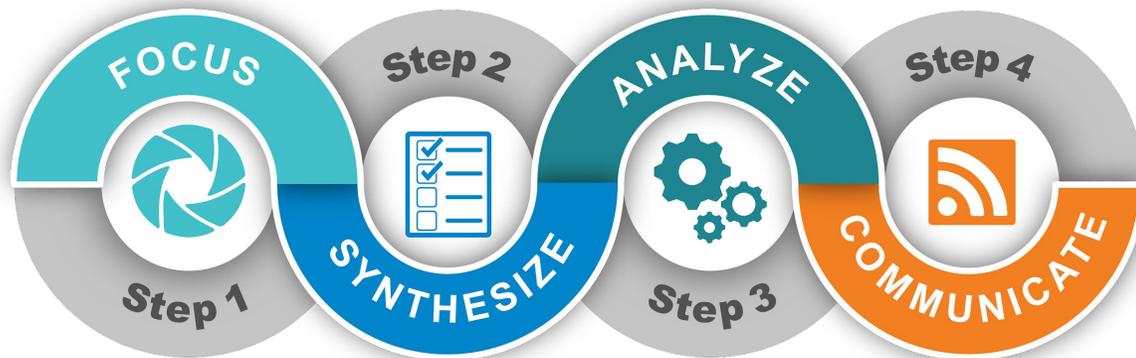


Extra Slides Below

ESP Definition

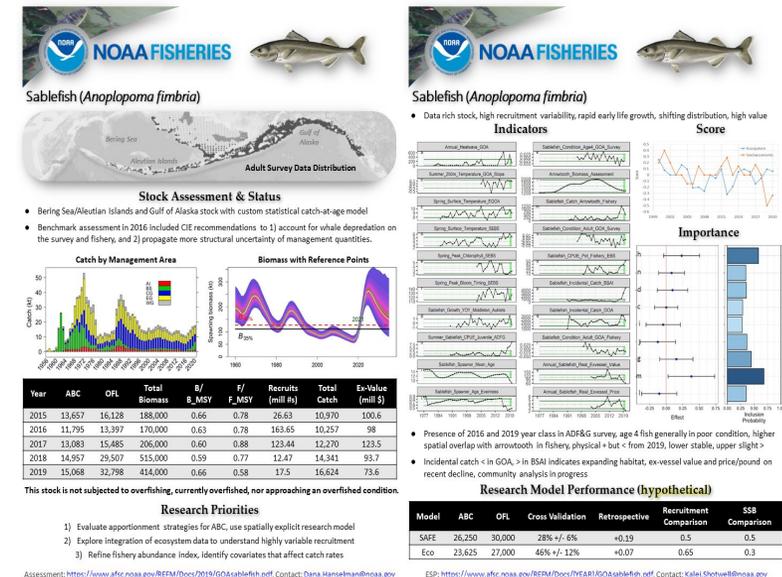
Process

Important ecosystem and socioeconomic indicators are identified and analyzed at the stock level



Product

Supplemental report that synthesizes the results of the indicator analysis and communicates drivers of stock dynamics



National ESP History



Alaska ESPs (16 stocks requested, 8 complete full, 2 under review)



Pacific Islands ESPs (2 stocks requested, 1 complete)



Northeast ESPs (15 stocks requested, 6 complete)



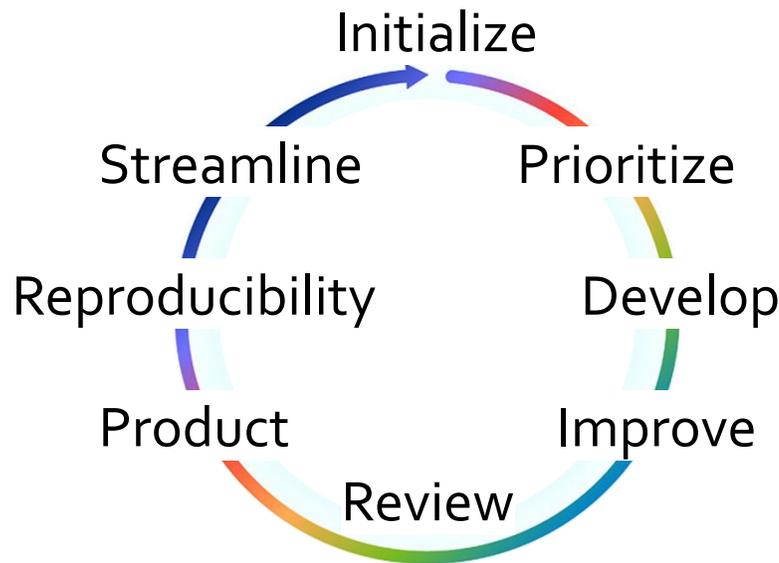
Northwest/Southwest (ESP-like reports)



Southeast (ESP-like report card)



National Initiative and Team



Recommendations - Overall

- 2024 October SSC: where to report indices from the ESR that could be useful for ESPs, make clear ESPs have multiple audiences, refer to fishery performance indicators by descriptive names (for informing ABC), local/traditional knowledge valuable info for current state of fishery socioeconomics (e.g., skipper surveys)
- 2024 November PT: CEATTLE authors coordinate with ESP teams to avoid duplication, develop Atka mackerel ESP
- 2024 December SSC: support for ESP data management system and R package, support developing Atka mackerel ESP, support flexibility in tailoring socioeconomic indicators to species, support scoping other data sources (e.g., RAM) as low-effort input to ESPs, support refining indicator units and developing profitability, social/distributional indicators
- 2025 June SSC: provisionally support new approach to categorize ESP indicators into predictive and contextual (pending review), more discussion on where to include economic, social, community info across range of products including ESPs

Recommendations - Sablefish



- 2024 September PT: standardize size grade and pricing across processors
- 2024 October SSC: develop narrative text to include small communities engaged in sablefish fishery, add value and harvest volume for trawl fisheries, consider developing average community diversification
- 2024 December SSC: further work on skip spawning possibly as index in ESP, consider formal inclusion of ADF&G juvenile index in the assessment, consider standardizing age-1 sablefish in the fishery index to total number of hauls, expand discussion of current graphics for community indicators

Recommendations - GOA Pollock



- 2024 November PT: consider developing Chinook bycatch indicators from an ecosystem context (e.g., hatchery production, marine survival), include socioeconomic indicators on impacts of 2024 shutdown of the fishery
- 2024 December SSC: consider nearshore datasets or acoustic data from trawl surveys to develop a euphausiid index, consider developing Chinook bycatch indicators, consider identifying most important indicator development and key data streams in data gaps section, commends authors on developing pathway for elevating ESR considerations to ESPs to inform management and then directly inform stock assessment parameters through DSEM

Recommendations - Pacific Cod



- 2024 November PT: encouraged author to work with ESP teams to leverage existing [Pacific cod] ESPs or develop AI Pacific cod ESP specifically
- 2024: December SSC: support to develop relevant socioeconomic indicators noting none are presented for fishery performance or community categories (e.g., % TAC, # vessels by gear), support using projections for CEATTLE indicators if most recent estimates not actionable
- 2024 December SSC (EBS Pacific cod): consider developing index of zooplankton from multiple data sources, spawning habitat index, CPUE-weighted temperature index, describe export market conditions