Ecosystem Status Report: Gulf of Alaska 2025

Bridget Ferriss

Alaska Fisheries Science Center, NOAA Fisheries

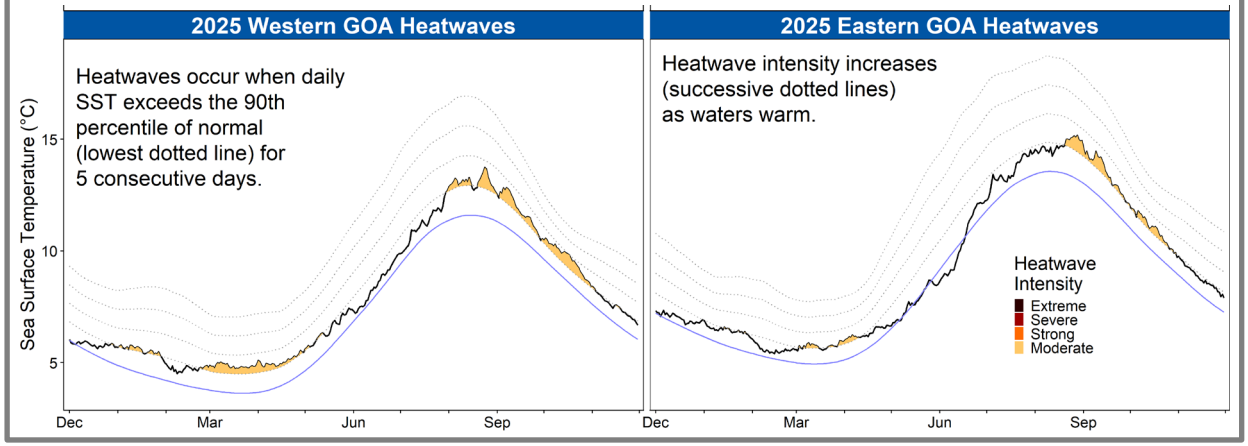
With contributions from:

Kelia Axler, Kerim Aydin, Brenda Ballachey, Lewis Barnett, Sonia Batten, Shaun Bell, Piper D. Bishop, James Bodkin, Nick Bond, Matt W. Callahan, Allison Carl, Reuben Cash, Shannon Cellan, Wei Cheng, Heather Coletti, Christina Conrath, Daniel Cushing, Seth Danielson, Isaiah Dela Cruz, Lauren Divine, Alexandra Dowlin, Sherri Dressel, Brie Drummond, Kelly Drummond, George Esslinger, Stacie Evans, Thomas Farrugia, Will Fennie, Emily Fergusson, Bridget Ferriss, Teresa Fish, Sarah Friedman, Christine Gabriele, Sarah Gaichas, Jeanette Gann, Tom Gelatt, Alicia Godersky, Scott Hatch, Claudine Hauri, Kyle Hebert, Gwenn Hennon, Tyler Hennon, Russell Hopcroft, Katrin Iken, Darin Jones, Robert Kaler, Parkes Kendrick, David Kimmel, Kim Kloecker, Brenda Konar, Gulce Kurtay, Elizabeth Labunski, Jesse Lamb, Kari Lanphier, Emily Lemagie, Mike Levine, Rosie Masui, Jackie McConnell, Sara Miller, Janet Neilson, Jens Nielsen, Ivonne Ortiz, Clare Ostle, Zack Oyafuso, Remi Pages, Kendrick Parkes, Melanie Paquin, John Piatt, Andrew Piston, Meredith Pochardt, Steven Porter, Bianca Prohaska, Maya Reda-Williams, Heather Renner, Patrick Ressler, Bruce Robson, Lauren Rogers, Sean Rohan, Nora Rojek, Joshua R. Russell, Kim Schuster, Margaret Siple, Adam Spear, William Stockhausen, Wesley Strasburger, Florence Sullivan, Robert Suryan, Katie Sweeney, Rick Thoman, James T. Thorson, Troy Thynes, Sarah Traiger, Chris Tran, C. Turner, Scott C. Vulstek, Andy Wall, Muyin Wang, Sophia Wassermann, Shannon Whelan, George A. Whitehouse, Carrie Worton, Bruce Wright, Stephani Zador

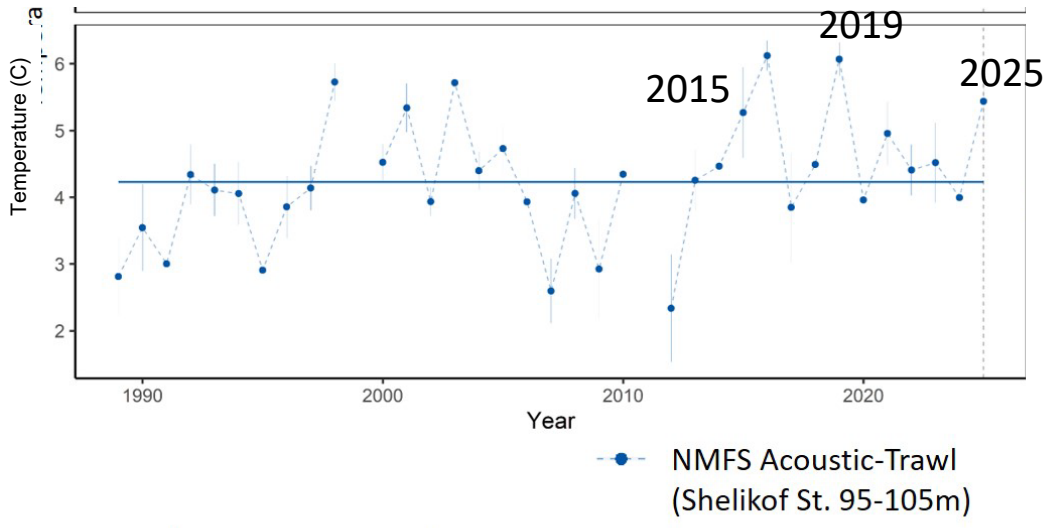
1. Warm throughout the year and water column

Jones, Callahan, Rohan, Kendrick, Lemagie

A. Sea Surface Temperature



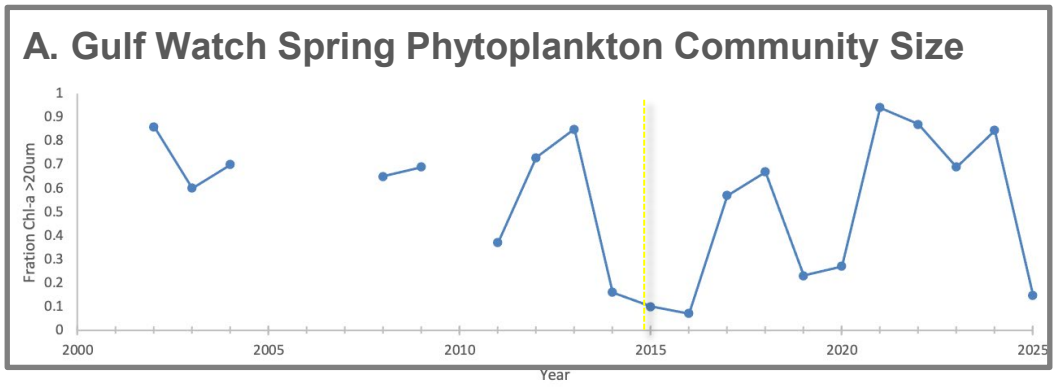
B. Winter Bottom Temperature, Shelikof Strait

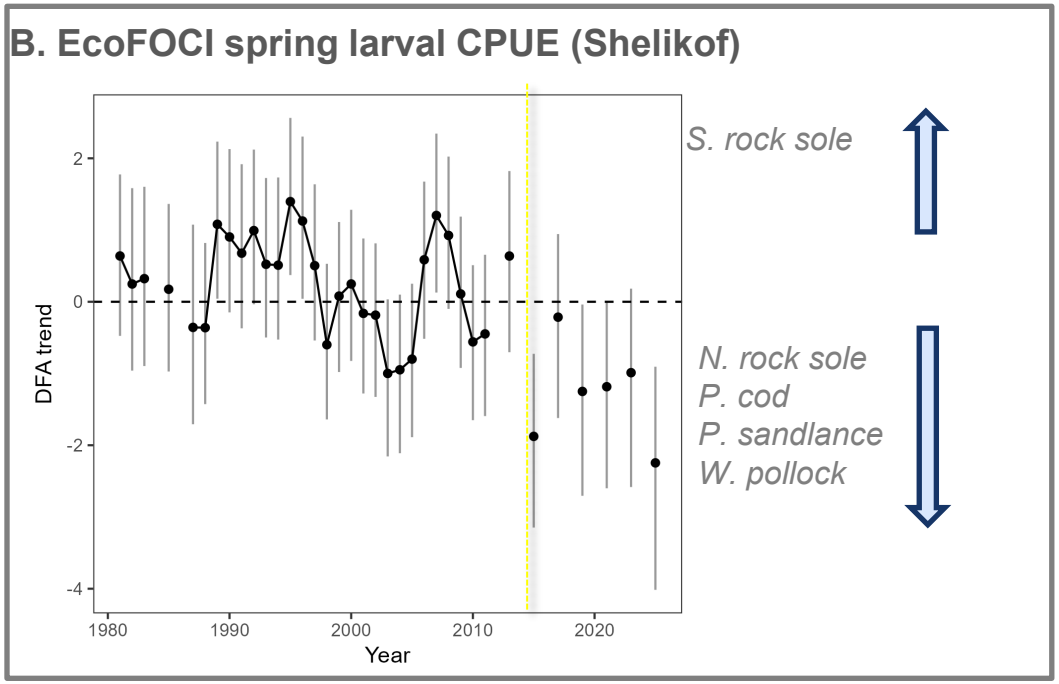


- At or near MHW conditions at surface winter, spring, fall
- Warm at depth on shelf (incl. winter & summer)
- Warm offshore in GOA
- Similarities to 2015

2. Similarities to 2014-2016 in reduced lower trophic productivity

Rogers et al., Hennon & Batten, Prohaska et al., Farrugia et al.

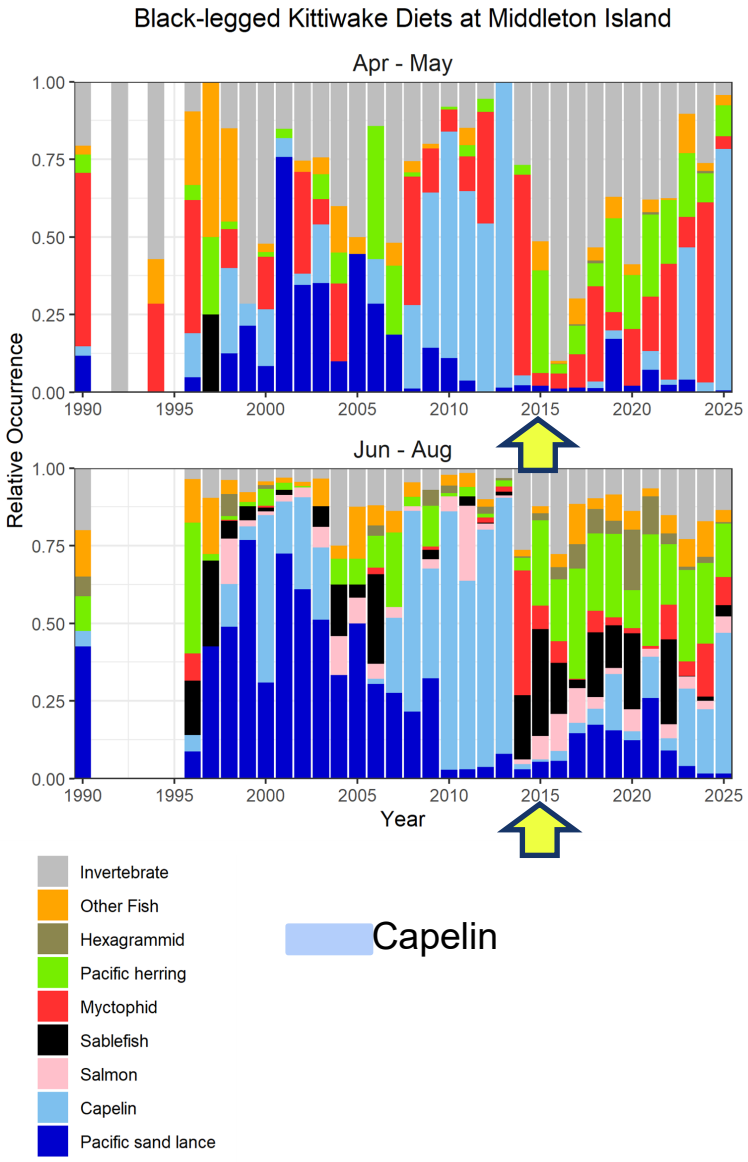




- **Phytoplankton** decline mean body size of community (*MHW Batten et al., 2018*)
- **Zooplankton** community shift to warm water species (*MHW McKinistry & Campbell 2018*)
- **HABs** increase (*MHW Vandersea et al., 2018*)
- **Larval groundfish** low CPUE (spring Shelikof EcoFOCI) (*MHW Rogers et al., 2020*)
- **Body condition** for zooplanktivorous groundfish reduced in summer
- Similar 2014-2016

3. Mixed upper trophic & ecosystem metrics

Prohaska et al., Gabriele et al., Whelan et al., Coletti et al., Drummond et al., Cushing, Dressel et al.

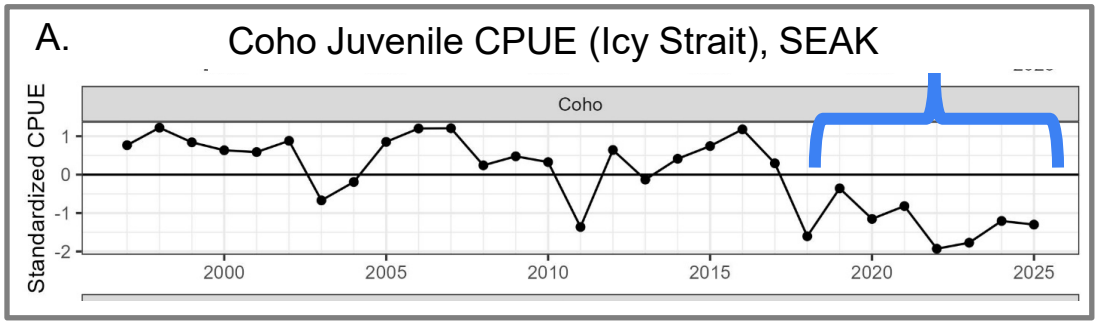


Same as 2014-2016?

- Groundfish summer body condition below average (exceptions) ✓
- Poor body condition for Glacier Bay adult female humpback whales (*MHW: Gabriele et al., 2022*) ✓
- ***Fucus*, sea stars** present and no **mussels** increase (no conversion of algal dominate to invert dominate) (*MHW Weitzman et al., 2021*) ✗
- **Capelin** & **herring** present in surface seabird diets, **sand lance** missing (*MHW: Arimitsu et al., 2021*) ✗
- **Seabird** average to above average reproductive success; no major die-offs; no shift to nearshore habitats (*MHW: Piatt et al., 2020*) ✗

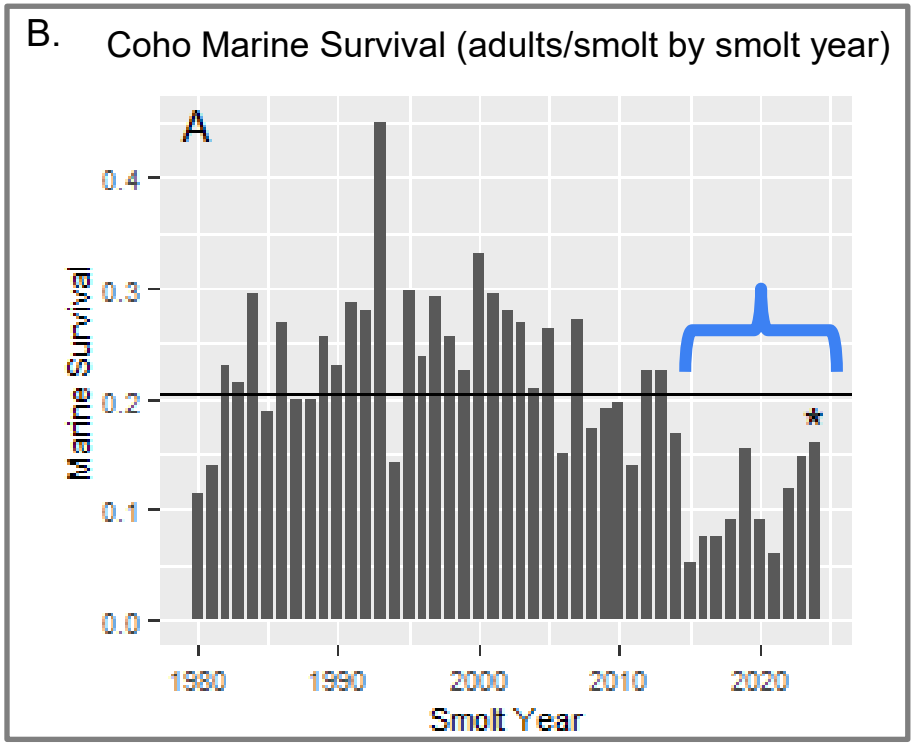
4. GOA Coho Salmon Multi-year Environmental Challenges

Whitehouse, Strasburger et al., Vulstek & Russell, Fergusson & Strasburger



Coho salmon returning in 2026

- Fall 2023-2024 freshwater
- Spring 2025 nearshore marine environment
- 2025-2026 central GOA



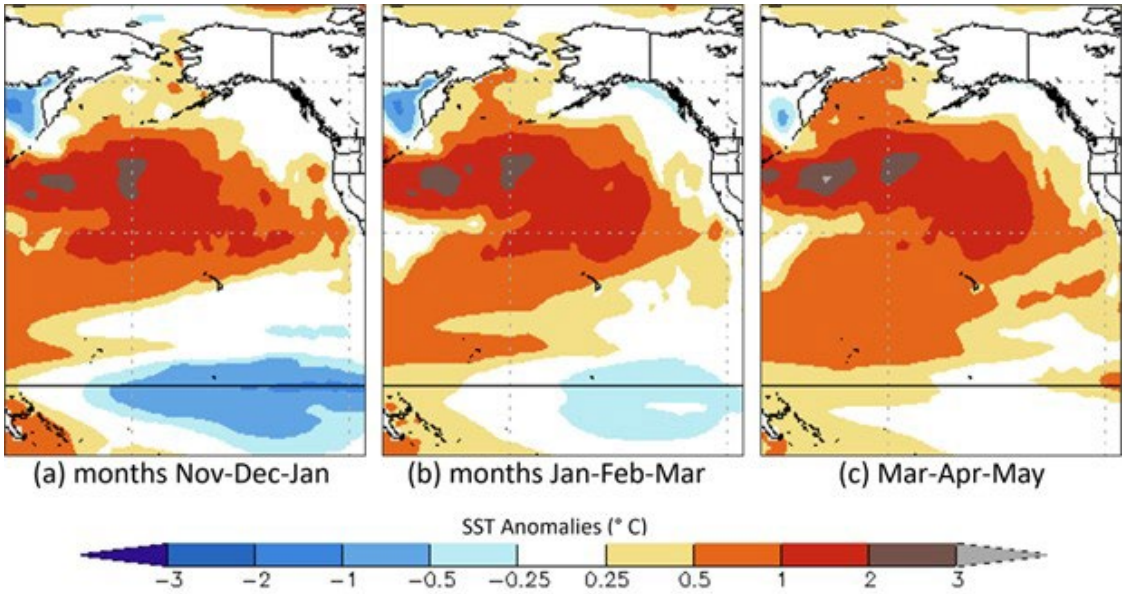
A. **Juv. coho salmon CPUE** in Icy Strait, SEAK, continued 8 year below-average

B. Preliminary **marine survival** indices of 2024 coho salmon in Auke Creek continued 11 year below-average, but increasing trend

5: Cooling in 2026 but residual heat?

E. Lemagie, S. Bell, N. Bond, T. Hennon

- National Multi-Model Ensemble predict average/cooler sea surface temperatures in winter/spring 2026 (baseline: 1991-2020)
- La Niña winter 2025/2026
- Concern over residual heat in the GOA water column and cumulative ecosystem impacts from 2025

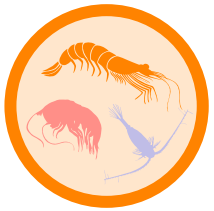


GOA 2025: Key Messages

[implications for P. cod]

1. Warm at surface and depth, winter, spring and fall

- [*winter spawning; egg/larval survival; incr. demand for prey*]

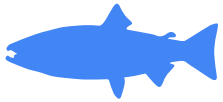


2. Similarities to 2014-2016 in reduced lower trophic level productivity

- [*less productive food web to directly and indirectly support cod prey]*

3. Mixed upper trophic & ecosystem metrics

- [*cod body condition below average but some prey base and upper trophic indicators ok]*



4. GOA coho salmon multi-year environmental challenges

5. Cooling in 2026 but concerns of residual heat & cumulative ecosystem effects

- [*elevated concerns of cumulative ecosystem response to warm year*]

Ecosystem & Socioeconomic Profile (ESP): Gulf of Alaska (GOA) Pacific Cod

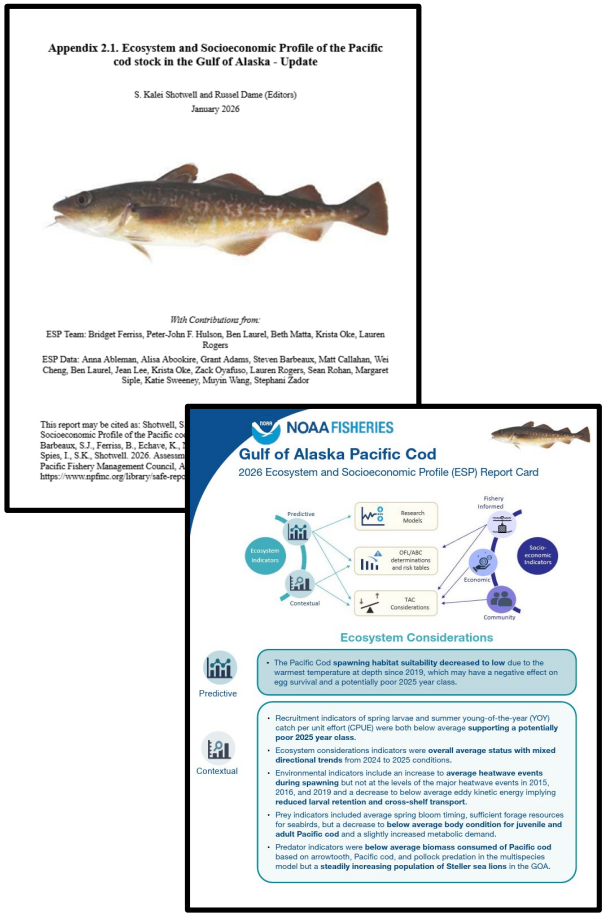
Kalei Shotwell & Russel Dame,
February 2026 SSC

ESP Team and Contributors:

Anna Ableman
Alisa Abookire
Grant Adams
Steven Barbeaux
Matt Callahan
Wei Cheng
Bridget Ferriss
Peter-John Hulson
Ben Laurel
Jean Lee
Beth Matta
Krista Oke
Zack Oyafuso
Lauren Rogers
Sean Rohan
Margaret Siple
Katie Sweeney
Muyin Wang
Stephani Zador

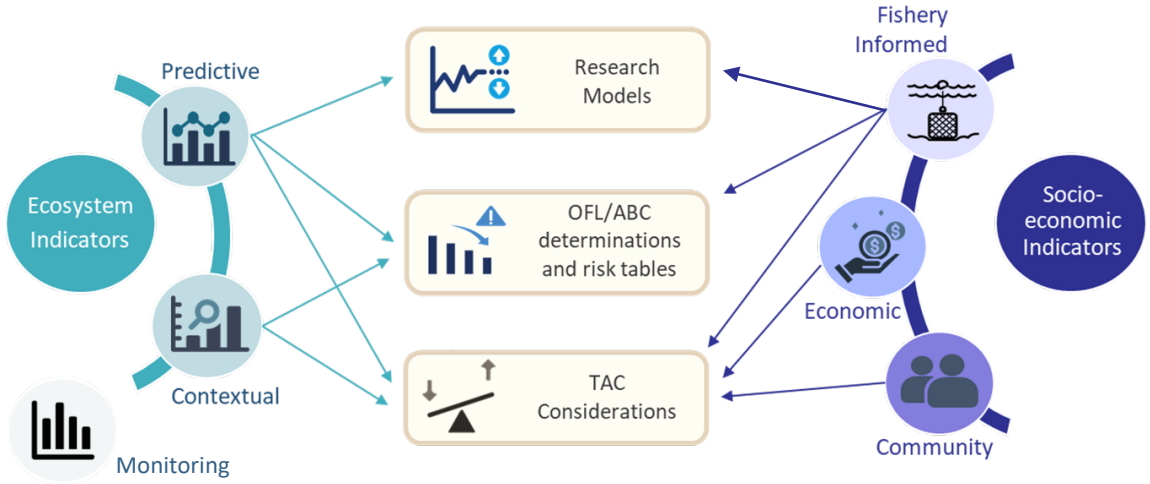
Overview

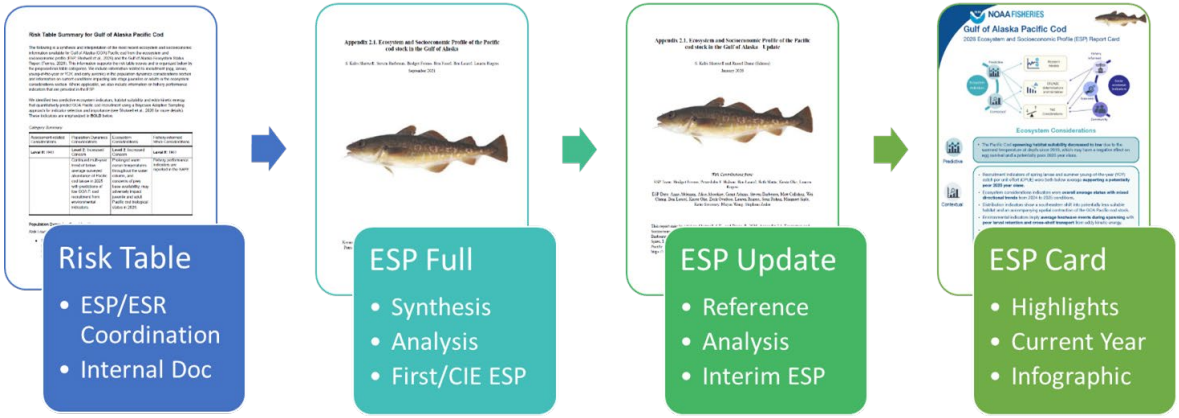
- Appendix 2.1 in GOA Pacific Cod SAFE Report
- New ESP categories and templates
- Review ecosystem indicator importance analysis
- Focus on indicators referenced in the risk table
- Future plans



New ESP Categories and Templates

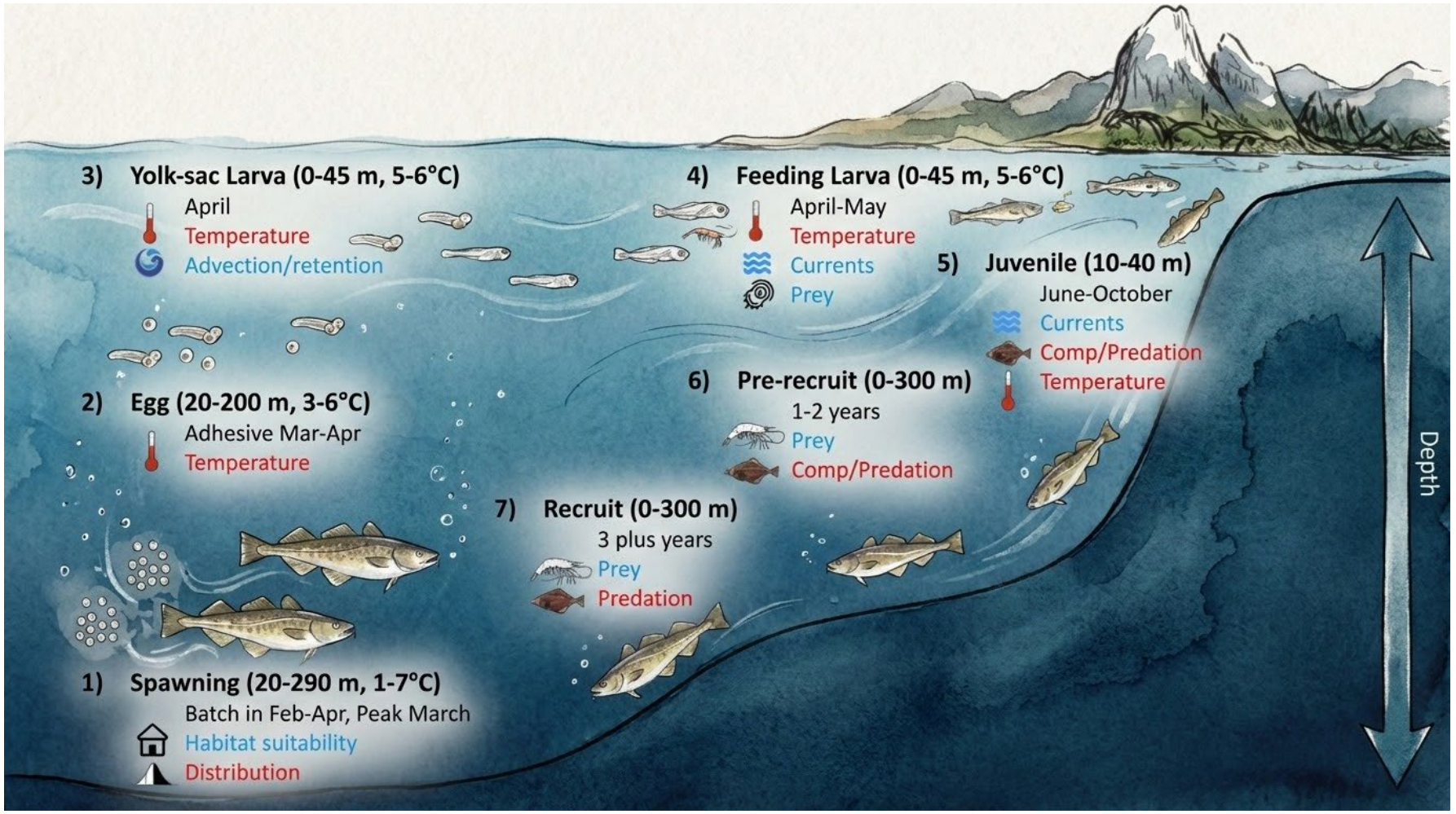
Established Indicator Categories for Decisions



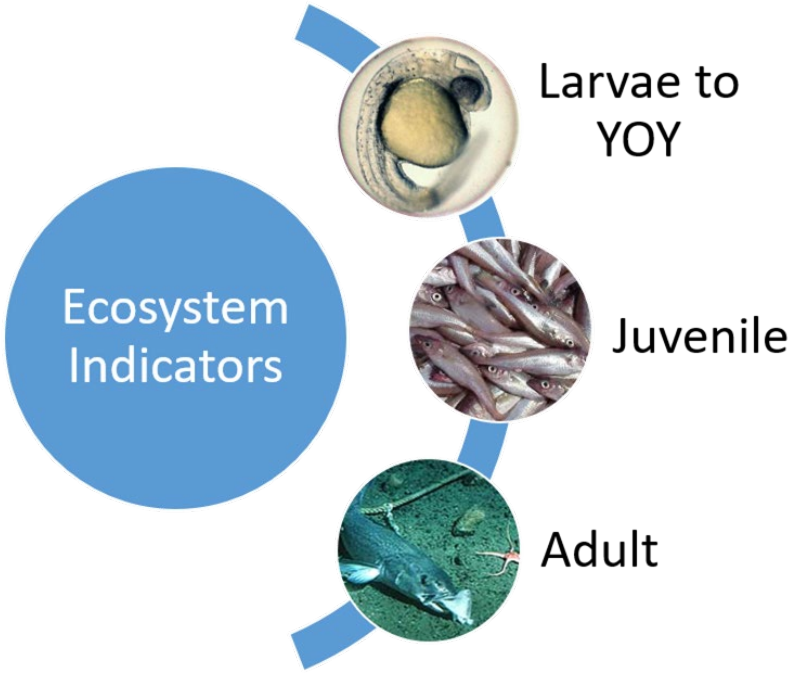


Created New Templates for Streamlining Communication

Pacific Cod Conceptual Model



Ecosystem Indicators

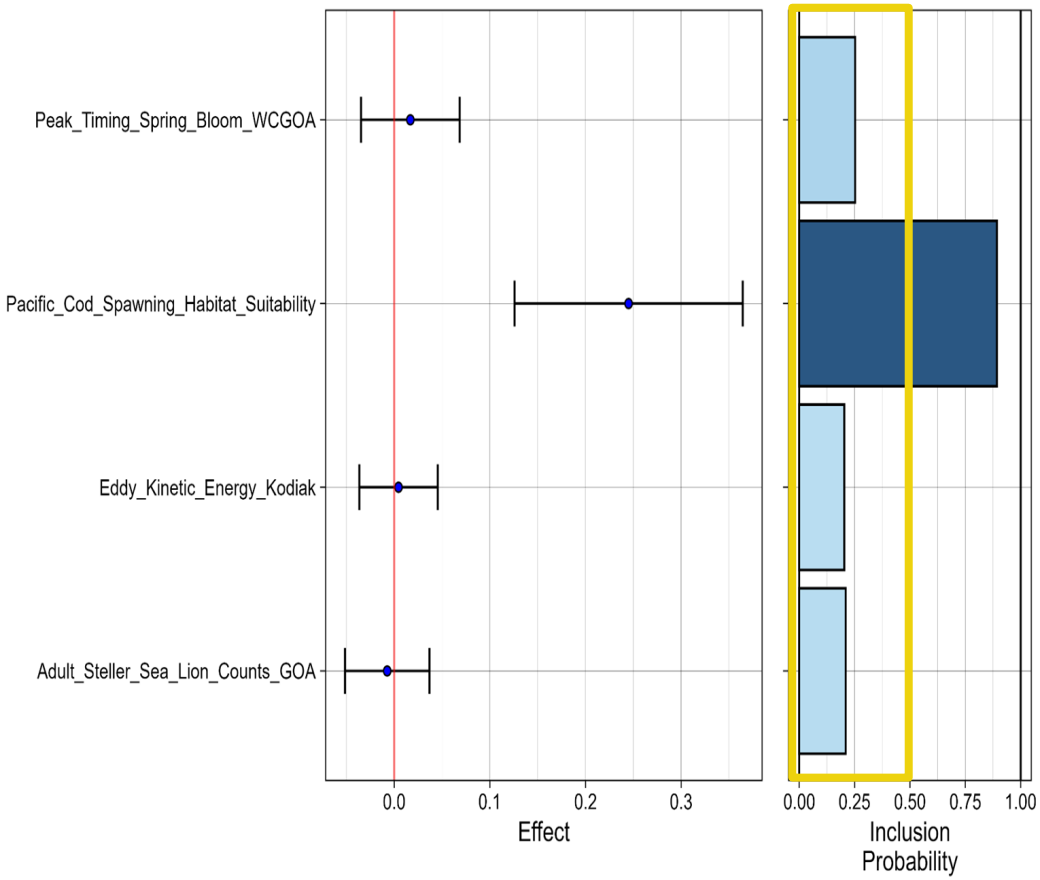


- Marine heatwave index spawning (OISST), -
- **Spawning habitat suitability (model), +**
- **Eddy kinetic energy Kodiak (CMEMS), +**
- **Peak timing spring bloom WCGOA (OC-CCI), +**
- Summer large copepods Shelikof (EcoFOCI), +
- Spring Pacific cod larvae Shelikof (EcoFOCI), +
- Murre reproductive success Chowiet (USFWS), +
- YOY Pacific cod CPUE WCGOA (Beach Seine), +
- Age-1 natural mortality (multisp. model), -
- Bottom temperature shelf (CFSR), -
- Juvenile condition (GAP), +
- Adult condition (GAP), +
- Annual Pacific cod ration (multisp. model), -
- Center of gravity, both North and East (GAP), -
- Area occupied (GAP), +
- Biomass eaten of Pacific cod (multisp. model), -
- **Adult Steller sea lion counts (MML), -**

Indicator Analysis - Importance Testing

One indicator with importance > 0.5:

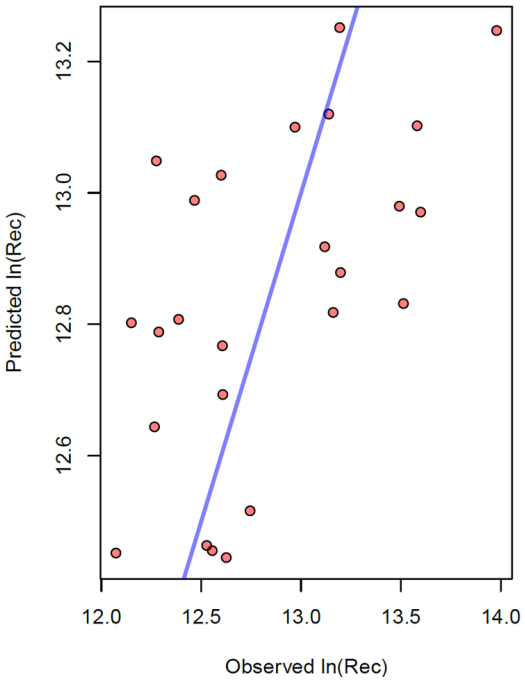
- Pacific Cod Spawning Habitat Suitability (0.89 probability)
- Positive effect, matches conceptual model
- Large CI on effect

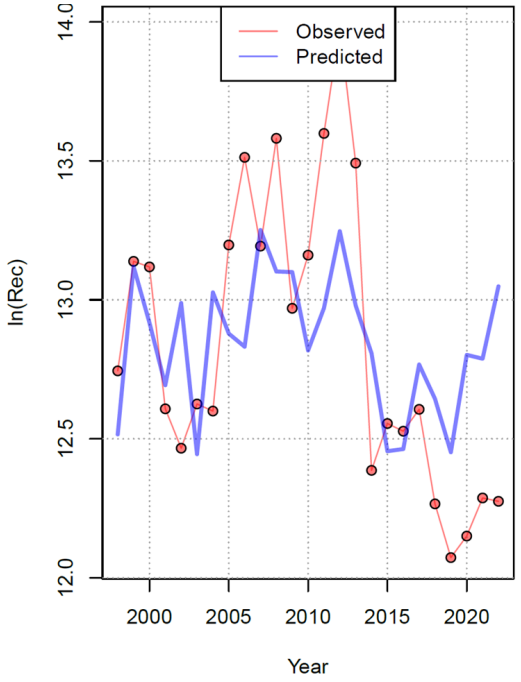


Indicator Analysis - Model

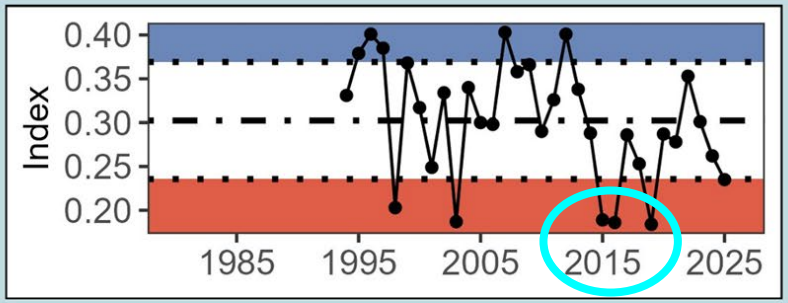
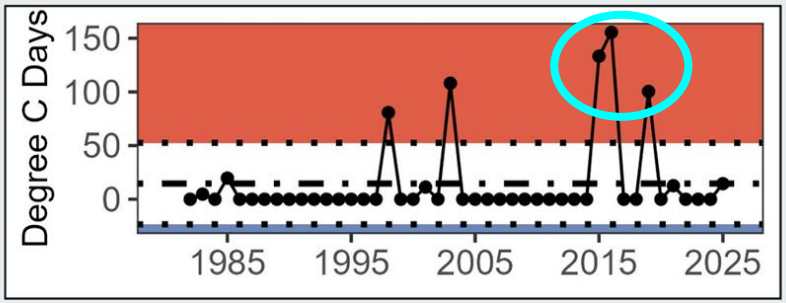
Final model explains moderate amount of variation in recruitment:

- $R^2 = 0.32$
- 1998-2022 year class
- Captures general pattern but not magnitude of variation



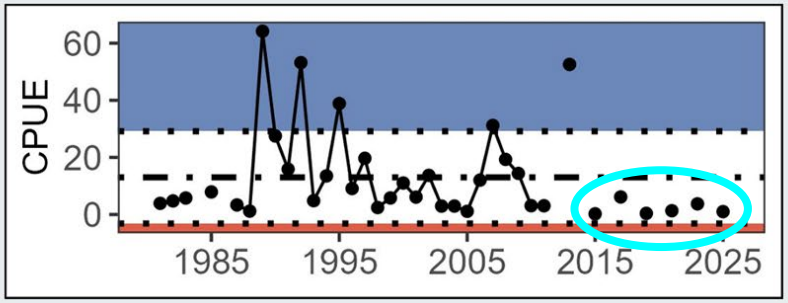
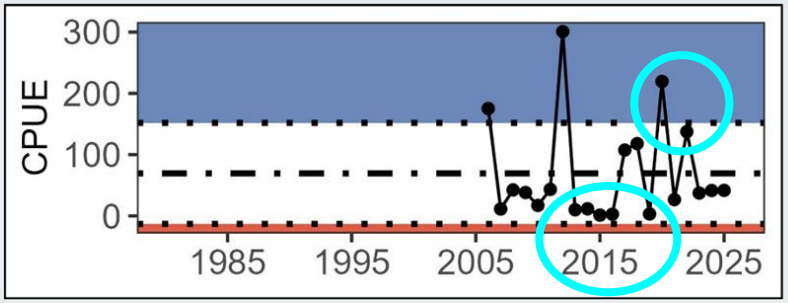


Report Card

	Indicator	Status	Trend
Predictive	**Pacific Cod Spawning Habitat Suitability**	Below long-term mean	
Contextual	**Heatwave During Spawning in GOA**	Near long-term mean	

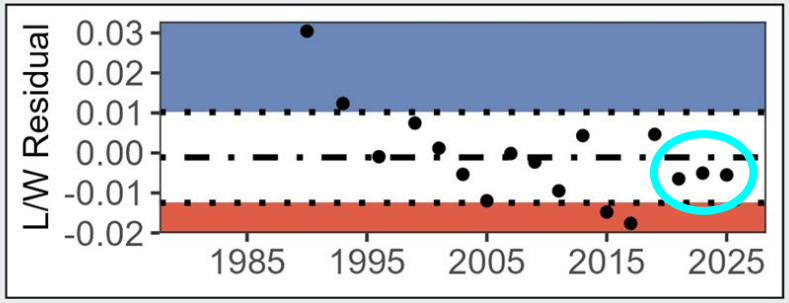
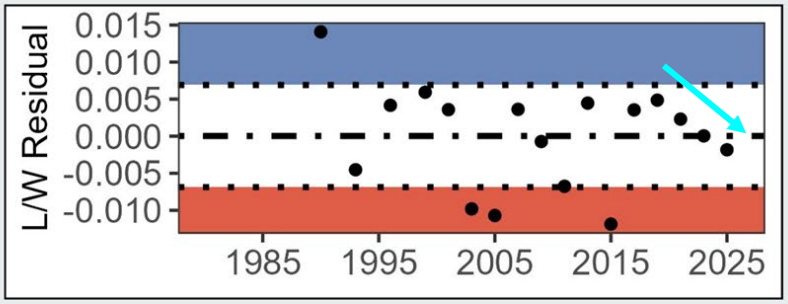
Report Card

Contextual

Indicator	Status	Trend
Spring Pacific Cod Larvae CPUE in Shelikof	Near long-term mean	
Summer Pacific Cod YOY CPUE in WCGOA	Near long-term mean	

Report Card

Contextual

Indicator	Status	Trend
Juvenile Pacific Cod Condition in GOA	Near long-term mean	
Adult Pacific Cod Condition in GOA	Near long-term mean	

REPORT CARD SUMMARY

PREDICTIVE

Spawning Habitat Suitability: DECREASED TO LOW

- Warmest temperature at depth since 2019, negative effect on egg survival, potentially poor 2025 year class

CONTEXTUAL

RECRUITMENT

- Spring larvae & summer YOY CPUE **below average**; potentially poor 2025 year class

ECOSYSTEM

- Overall average status: **mixed** directional trends from 2024 to 2025 conditions

ENVIRONMENTAL

- Increase to **average heatwave** events (below 2015/16/19 levels); **decrease** to below **average** eddy kinetic energy (reduced larval retention/transport).

PREY

- Average spring bloom, sufficient forage for seabrids; decrease to below average Pacific cod **body condition**, slightly increased metabolic demand

PREDATOR

- Below average biomass consumed of Pacific cod (arrowtooth, cod, pollock multispecies model); steadily increasing Steller sea lion lion population in GOA

Future Plans

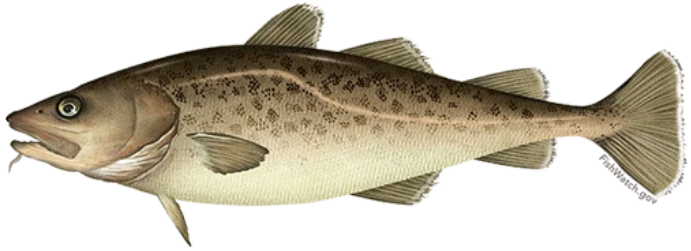
1) Request for information in 2026, use ESP data gaps and research priorities list, potentially contact leads of current research projects for input on updating indicators
2) Improvements to indicator monitoring analysis based on recent work with sablefish (Oke et al.) and GOA pollock (Champagnat et al.)
3) Monitor National ESP workshops and training opportunities to improve this ESP in the future

Questions?

Contact:

Kalei Shotwell, AFSC
Russel Dame, AFSC

kalei.shotwell@noaa.gov
russel.a.dame@noaa.gov



GOA PACIFIC COD

P. HULSON, S. BARBEAUX, B. FERRISS, K. ECHAVE, J. NIELSEN, S. MCDERMOTT, B. LAUREL, A. ABOOKIRE, INGRID SPIES, AND S. K. SHOTWELL

NOAA FISHERIES

February 2026, Presentation to the NPFMC SSC

ASSESSMENT OVERVIEW

- BLUF:
  - GOA Pacific cod: Tier 3b
  - 2025 estimated spawning biomass to be at $B_{34.3\%}$, projected in 2026 to be at $B_{33.1\%}$
  - 2026 recommended ABC is a 29% increase from 2025 ABC
  - Do not recommend reduction from maximum ABC

OPERATIONAL UPDATE ASSESSMENT

- 2025 GOA Pacific cod is an 'Operational Update' assessment:

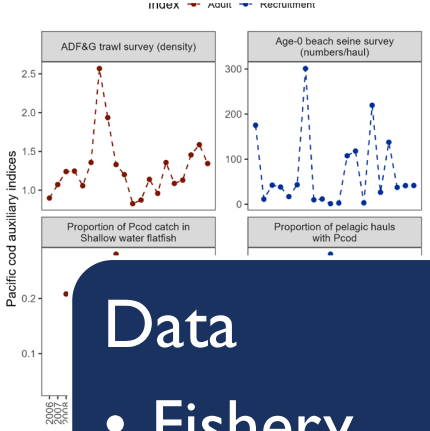
"An operational update assessment is conducted when updating the last full assessment model structure with current data, and maintains the accepted model configuration. This assessment type must carry forward the fundamental structure of the last operational full assessment reviewed and endorsed through the NPFMC review process. Therefore, the content presented in an operational update assessment can be considered an abbreviated version of the last operational full assessment, and the majority of sections that do not directly inform review bodies on making a management decision can be presented in a condensed form and referenced from the last operational full assessment." – Alaska Groundfish Stock Assessment Guidelines

- Distinct from an 'Operational Full' assessment within which alternative models are explored and recommended

OPERATIONAL UPDATE ASSESSMENT

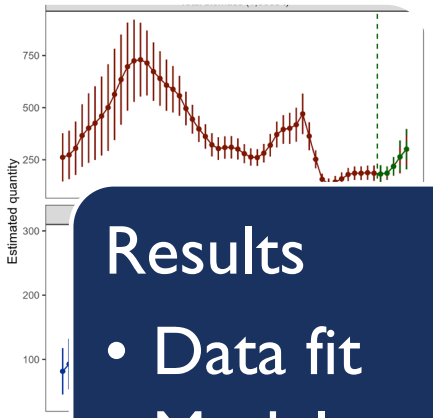
- 2025 GOA Pacific cod is an 'Operational Update' assessment:
- **Only new data through 2025 included, no model changes**
- Abbreviated SAFE document
  - Only sections that have been updated with new information since 2024 assessment included
  - Any missing sections (e.g., full Introduction) can be found in the 2024 SAFE
  - SSC/PT comments and responses not included, will be included and addressed in the next full assessment
  - SS3 model files, additional results, and diagnostics available electronically at this link

ASSESSMENT EVALUATION OUTLINE



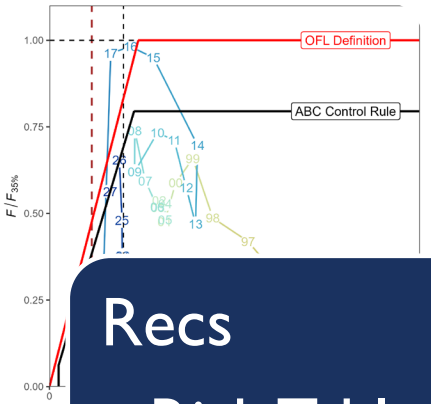
Data

- Fishery
- Survey
- Other



Results

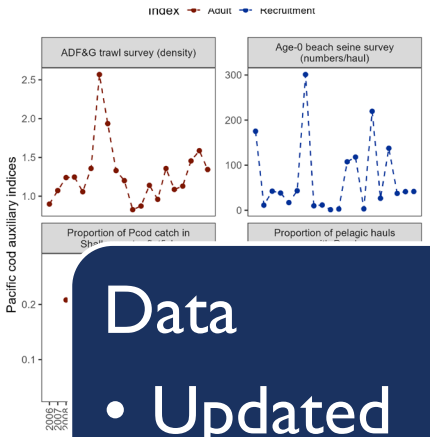
- Data fit
- Model evaluation
- Model estimates



Recs

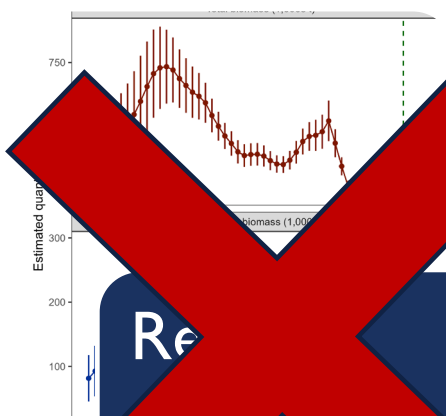
- Risk Table
- ABC/OFL
- BRD

ASSESSMENT EVALUATION OUTLINE



Data

- Updated
- Survey index context



Re

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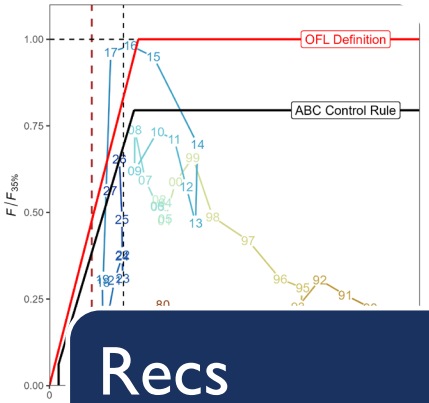
Model results

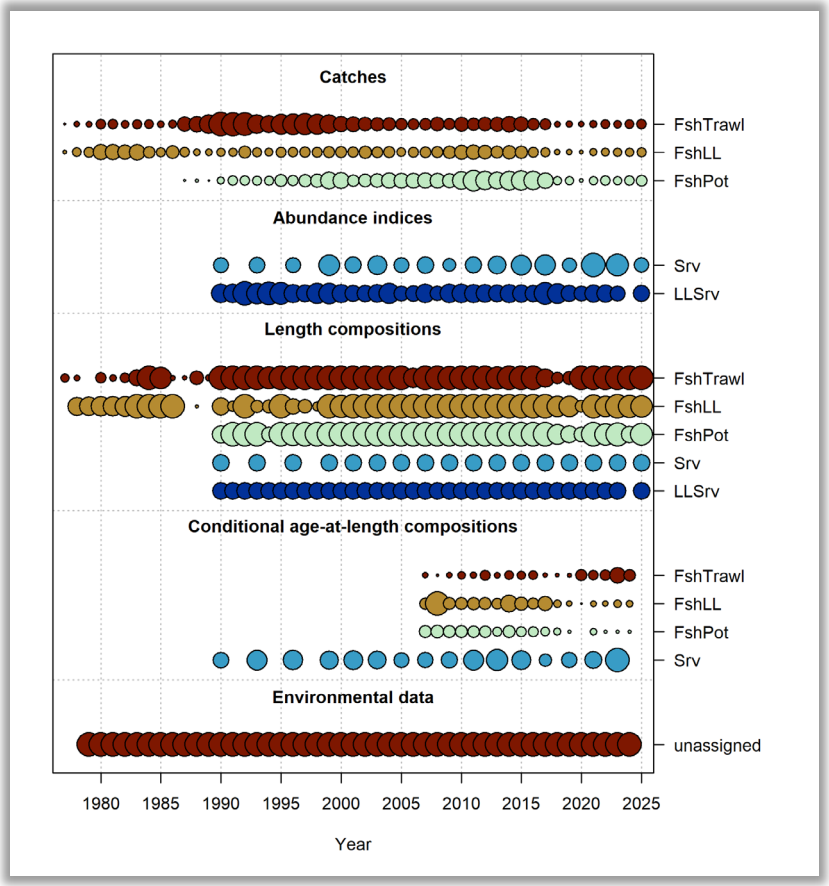


Recs

- Risk Table
- ABC/OFL

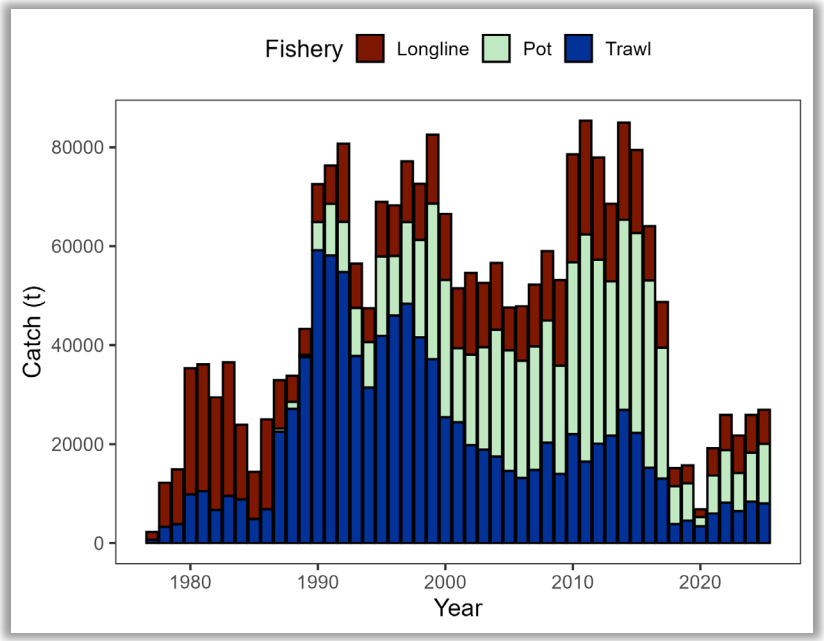
DATA OVERVIEW

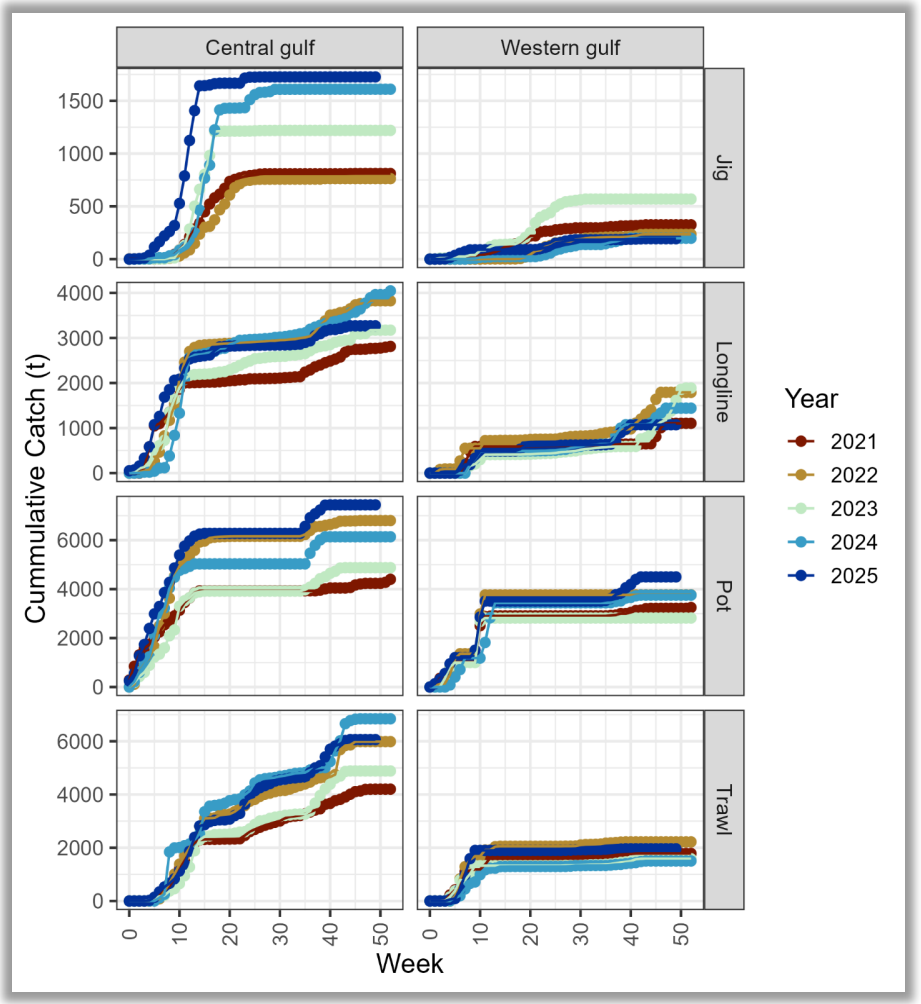
New Data	Years
Federal and state fishery catch, by gear type	2024, 2025
Federal and state fishery length composition, by gear type	2024, 2025
Federal fishery conditional age-at-length	2024
GOA AFSC bottom trawl survey abundance	2025
GOA AFSC bottom trawl survey length composition	2025
GOA AFSC longline survey Relative Population Numbers	2025
GOA AFSC longline survey length composition	2025



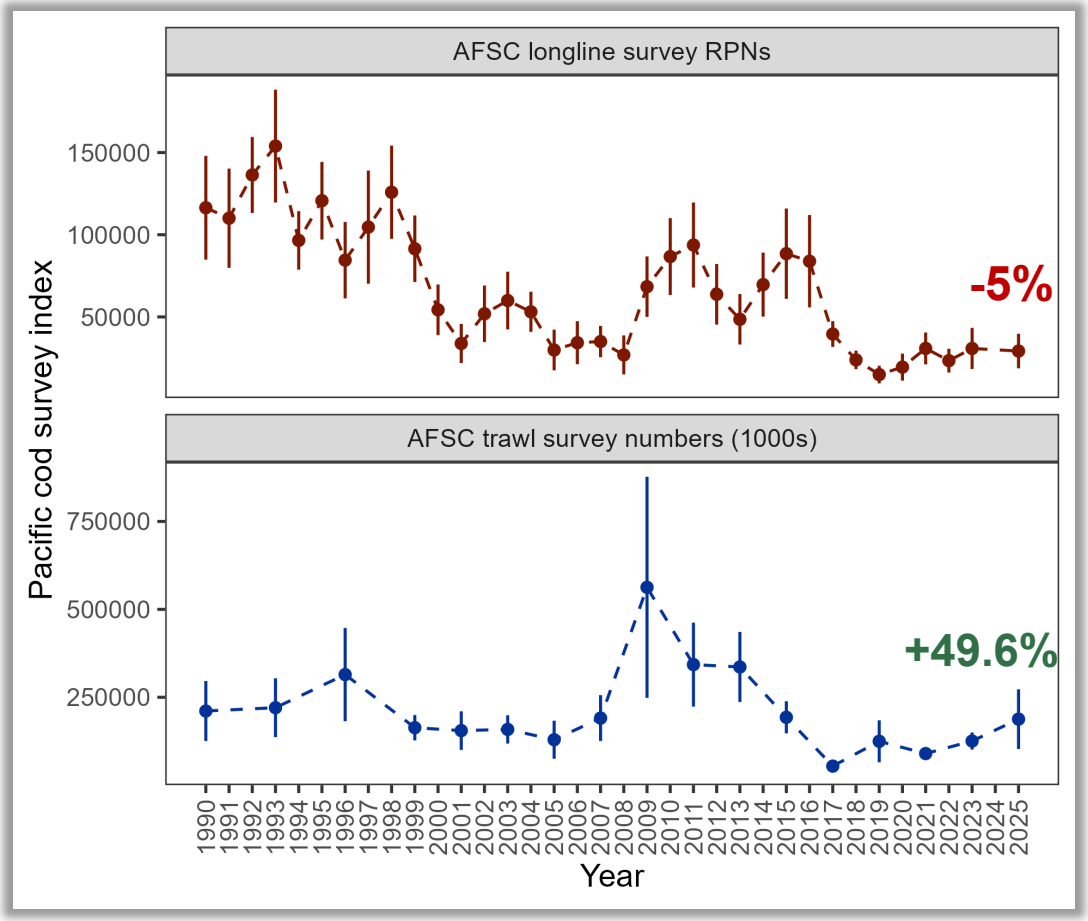
DATA - CATCH

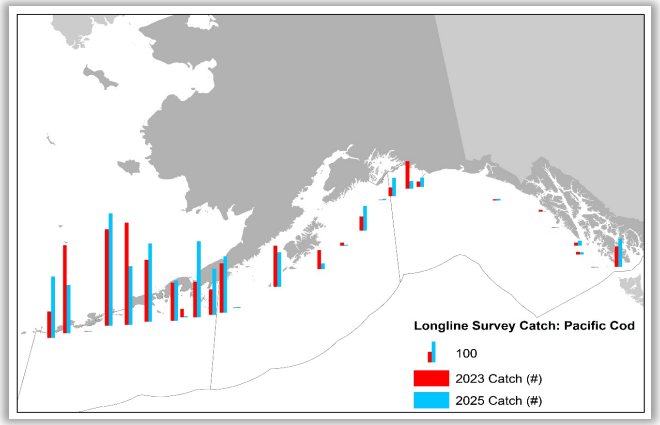
- Pot majority > LL > Trawl
- Nothing inconsistent in cumulative catch to previous years
- Catch through Dec 8, 2025

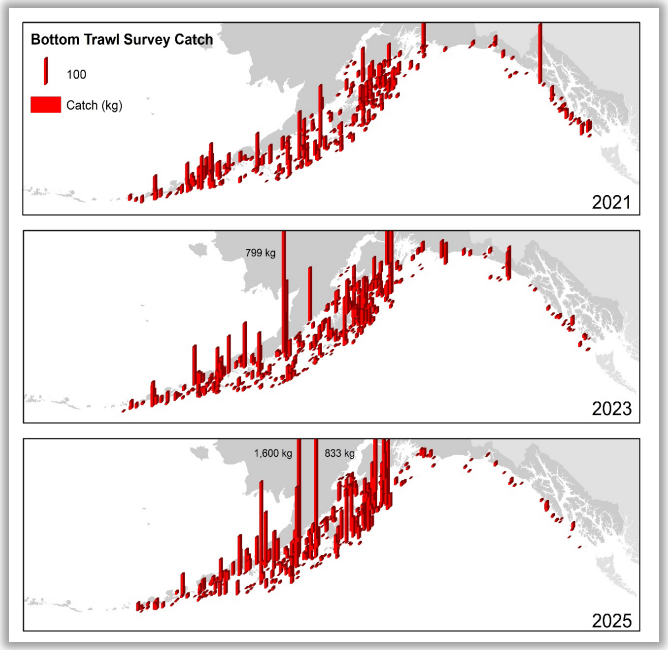




DATA – AFSC SURVEY INDICES





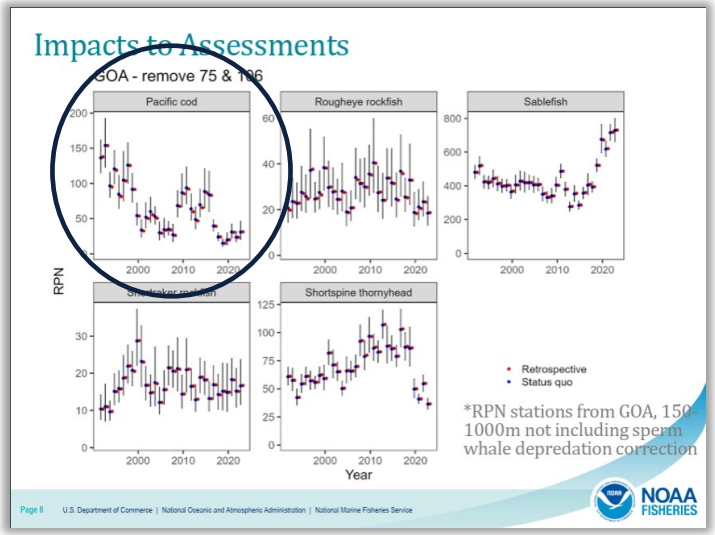


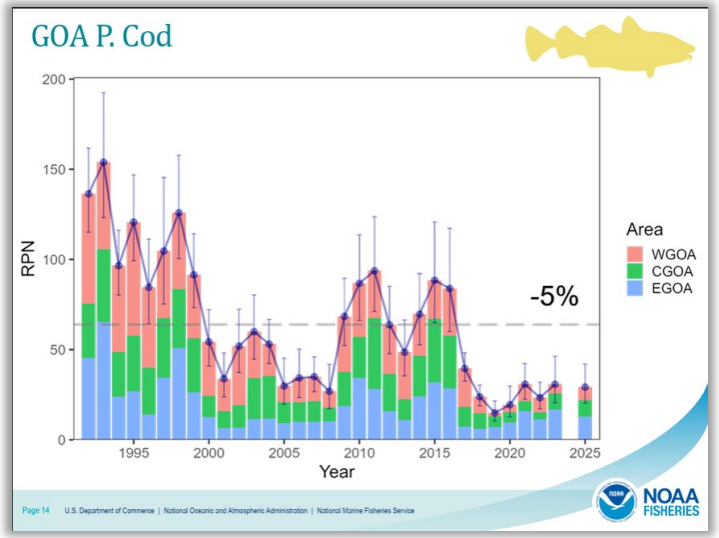
DATA – 2025 SURVEY CONTEXT

- Adding context to the survey results:
  1. Why was there an observed decline in longline survey RPNs that is inconsistent with trawl survey abundance?
  2. Was there an influence of the GOA bottom trawl survey restratification on 2025 results?

DATA – 2025 AFSC LONGLINE SURVEY

1. *Why was there an observed decline in longline survey RPNs?*
   - Not due to dropping stations in survey redesign





- Subregion change since 2023: WGOA **+40%**, CGOA **+4.8%**, EGOA **-23.6%**

- This decline in GOA-wide RPN due to EGOA

DATA – 2025 AFSC LONGLINE SURVEY

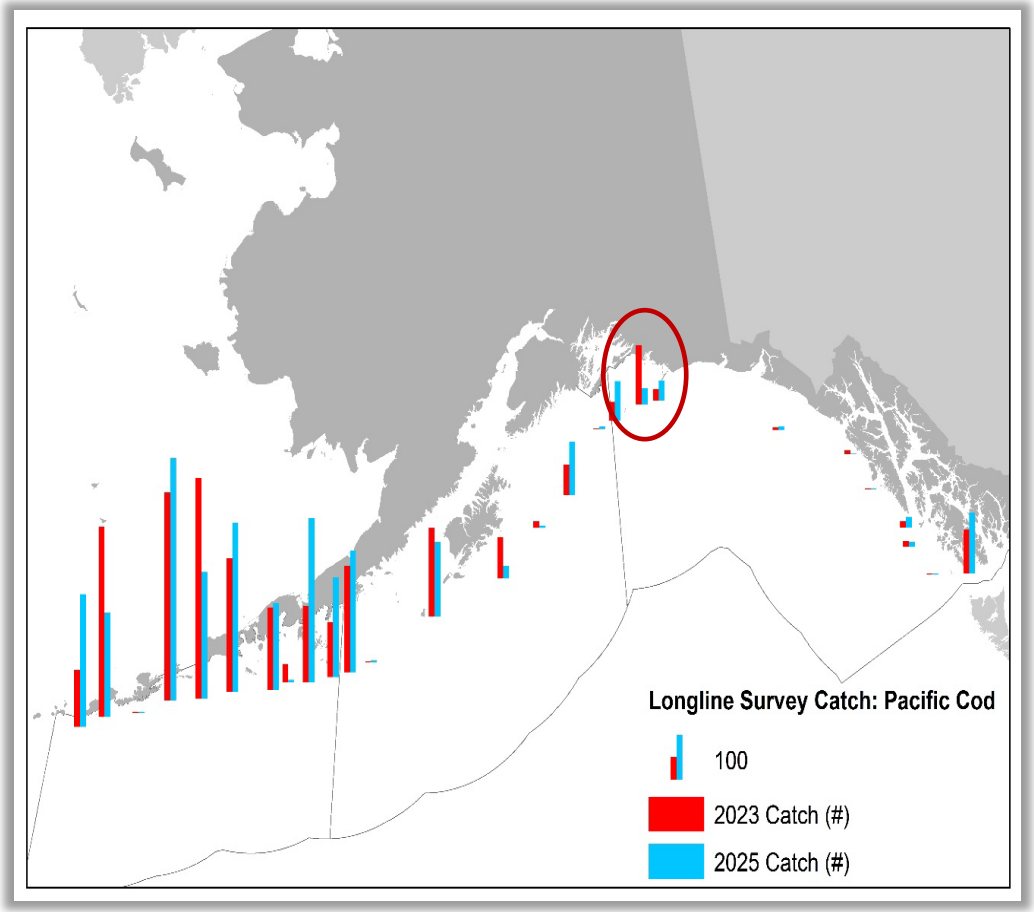
1. *Why was there an observed decline in longline survey RPNs?*
   - RPN calculation reminder: mean catch per hook (across skates within a strata) multiplied by stratum area size (stratum are 150m and deeper)
   - Drilling down into EGOA:
     - Why is the EGOA RPN so large in comparison to WGOA and CGOA?
     - What was the reason for the EGOA RPN decline?

DATA – 2025 AFSC LONGLINE SURVEY

- Drilling down into EGOA RPN: *Why so large?*
  - Since 2020 77% of cod in RPN index caught in 151-200m stratum (remainder caught in 201-300m stratum; *note:* 1.3x more cod caught in 101-150m compared to 151-200m)
  - Area size for 151-200m in EGOA 4x larger than WGOA and 3x larger than CGOA
  - Large area size has downstream effect on RPN resulting in >33% of GOA RPN within EGOA across time-series (*AFSC bottom trawl survey observes <5% of cod abundance in EGOA*)

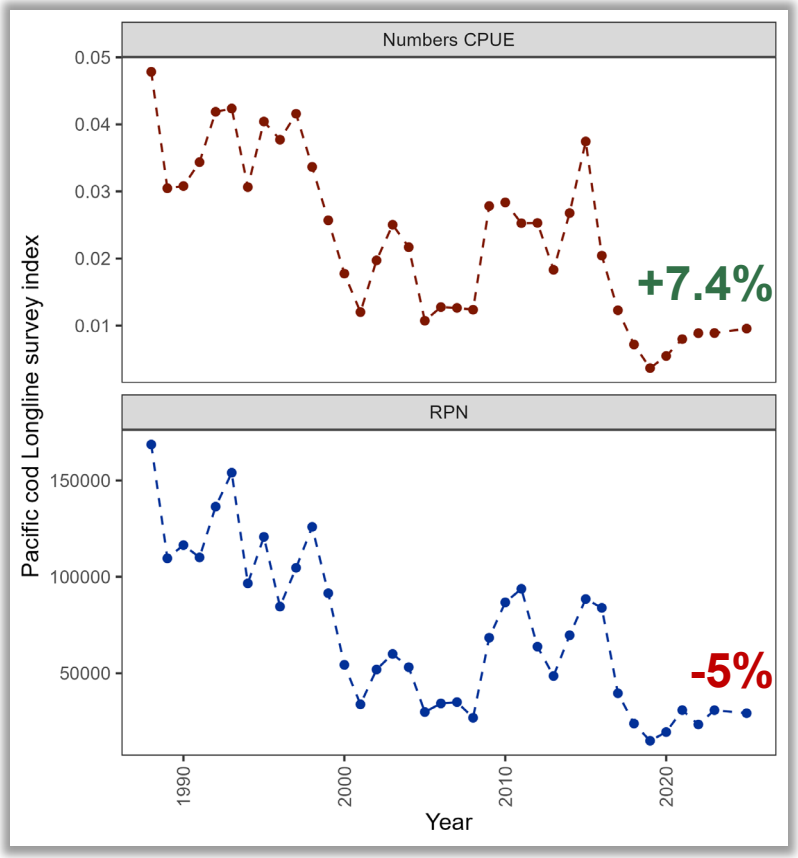
DATA – 2025 AFSC LONGLINE SURVEY

- Drilling down into EGOA:
  - Compared to 2023, only one station's catch of cod declined
  - #90: 2023 catch largest since 1993, 6.5x larger than avg since 2000



DATA – 2025 AFSC LONGLINE SURVEY

- Removing area size effect, numbers CPUE increased by more than 7%
- **Bottom line**: a single station from a subregion with disproportionate area size drove the decline in the RPN index



DATA – AFSC LONGLINE SURVEY

- The RPN index is *not wrong*, this is a result of the particular stratums we use for this index
- Prior to next full assessment we will be reevaluating how AFSC longline survey RPN index computed
- Update assessment: did **not** change the index used in the model

DATA – AFSC BOTTOM TRAWL SURVEY

2. Was there an influence of the GOA bottom trawl survey restratification on 2025 results?
   - Reminder: over the years PT/SSC has reviewed several presentations leading up to application in 2025 of GOA survey redesign, design has been extensively simulation tested
   - Final piece: using real data, what would happen if historical data collected following new survey design?
   - Appendix 2.2: with GAP (Zack Oyafuso and Stan Kotwicki) performed analysis in which historical stations were post-stratified into 2025 strata for GOA cod

DATA – AFSC BOTTOM TRAWL SURVEY

Using real data, what would happen if historical data collected following new survey design?

- Not a straight-forward question to answer
- Primary difficulty to overcome is that historical stations were chosen within a grid cell with selection probabilities based on old strata
- This means that you must reweight stations after post-stratifying into new strata so that old strata with higher number of stations don't 'overwhelm' old strata with lower number of stations upon combining within the new strata

DATA – AFSC BOTTOM TRAWL SURVEY

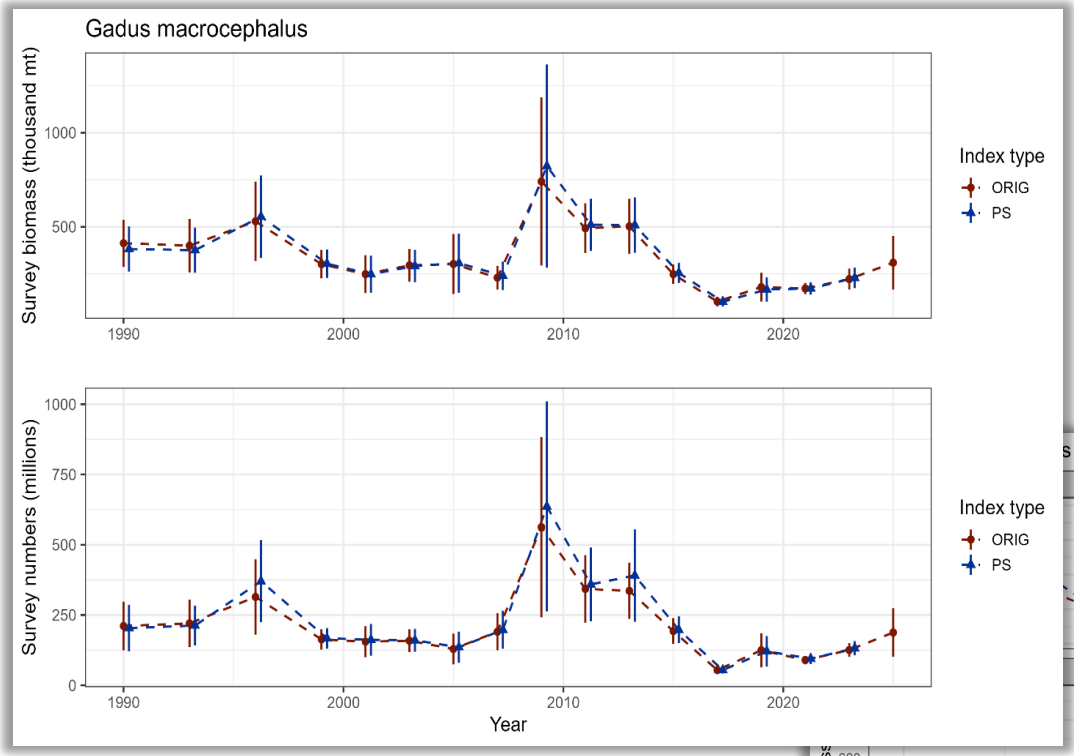
- Upon post-stratification within new strata, before you calculate design-based indices, you must re-weight to account for the new selection probabilities, otherwise you will introduce bias
  - Can think of the weight as being the inverse of the selection probability – the higher the selection probability in the original design the lower the weight, and visa versa
- The point: must account for this in post-stratifying samples so that we can determine whether the survey redesign has unintended consequences (i.e., bias) using real-world data

DATA – AFSC BOTTOM TRAWL SURVEY

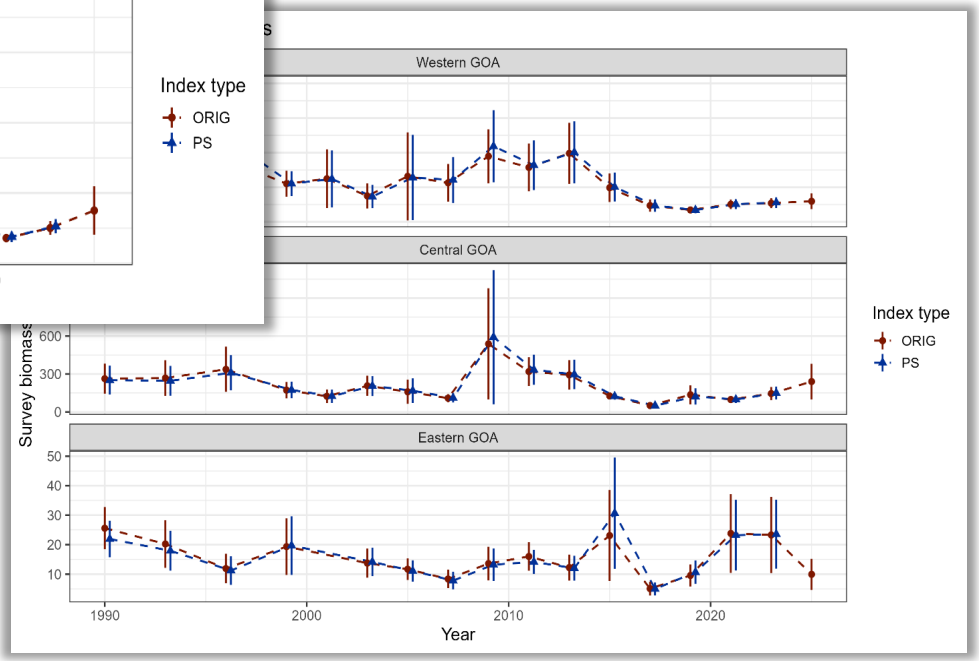
Using real data, what would happen if historical data collected following new survey design?

- Utilized survey R-package "Analysis of complex survey samples"
  - survey::postStratify() function follows Rao et al (2002 – analyzing survey data using post-stratification) with variance estimates following Valliant (1993), built upon Horvitz-Thompson estimator
- Steps taken in analysis:
  1. Reclassified historical stations within new 2025 stratum boundaries
  2. Computed selection probabilities and re-weighted station observations
  3. Compute design-based index

DATA – AFSC BOTTOM TRAWL SURVEY



- Results indicate minor differences between time-series, particularly since 2019



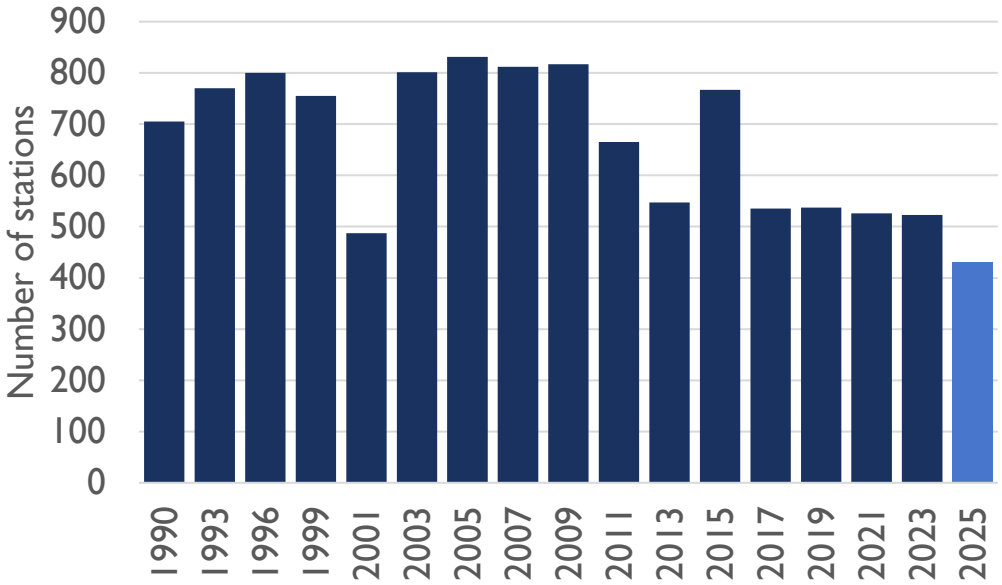
- CVs increase by 0.6% for biomass, 1.4% for numbers, on average

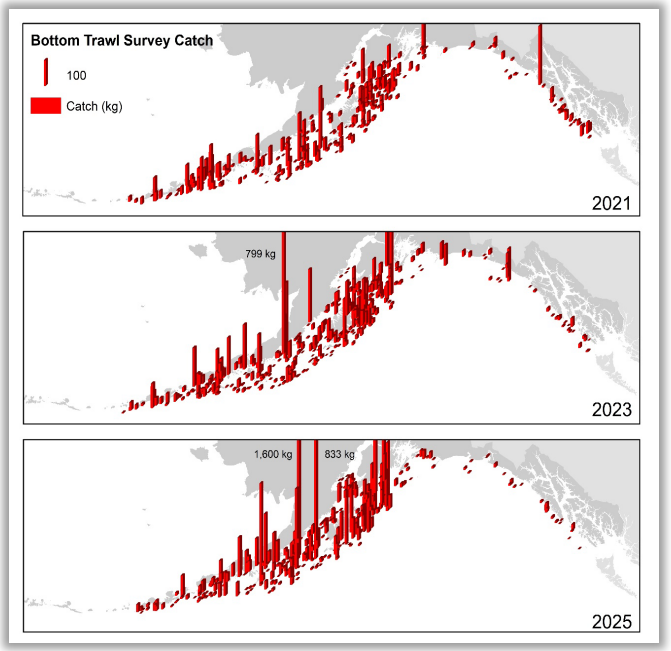
DATA – AFSC BOTTOM TRAWL SURVEY

2. Was there an influence of the GOA bottom trawl survey restratification on 2025 results? ***NO***
   - The results from the 2025 survey continue trends we have recently observed and estimates that are within historical ranges
   - This analysis was not intended to create a new time-series of historical data, rather, to compare and verify that the 2025 survey restratification did not have an unintended consequence on historical data
   - GOA cod is one of best test cases, impossible to disentangle effects of post-stratification with sampling variability for stocks that are more difficult to sample (i.e., rockfish)

DATA – AFSC BOTTOM TRAWL SURVEY

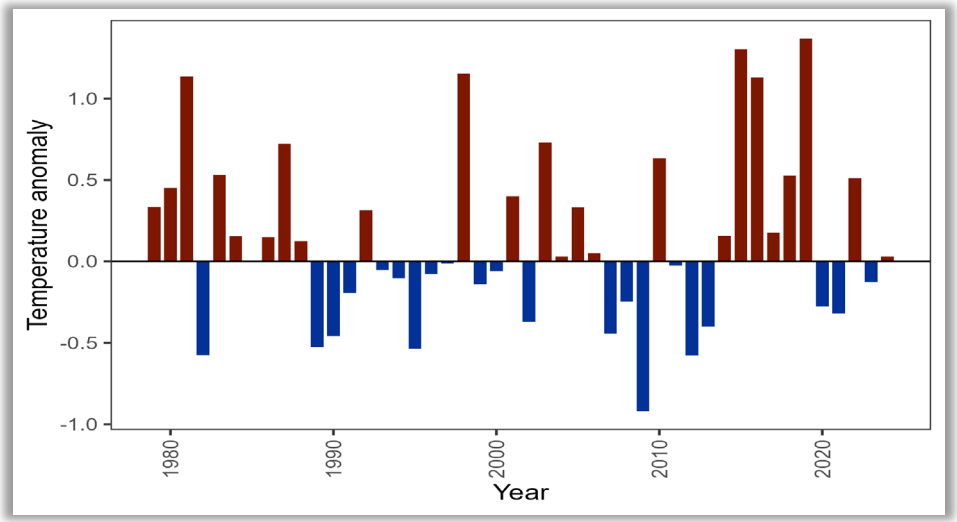
- 23% CV in 2025 AFSC bottom trawl survey index
  - Increase in catch variable across stations
  - Number of stations in 2025 fewest in survey since 1990
  - But, CV > 23% in 2019 and 2009

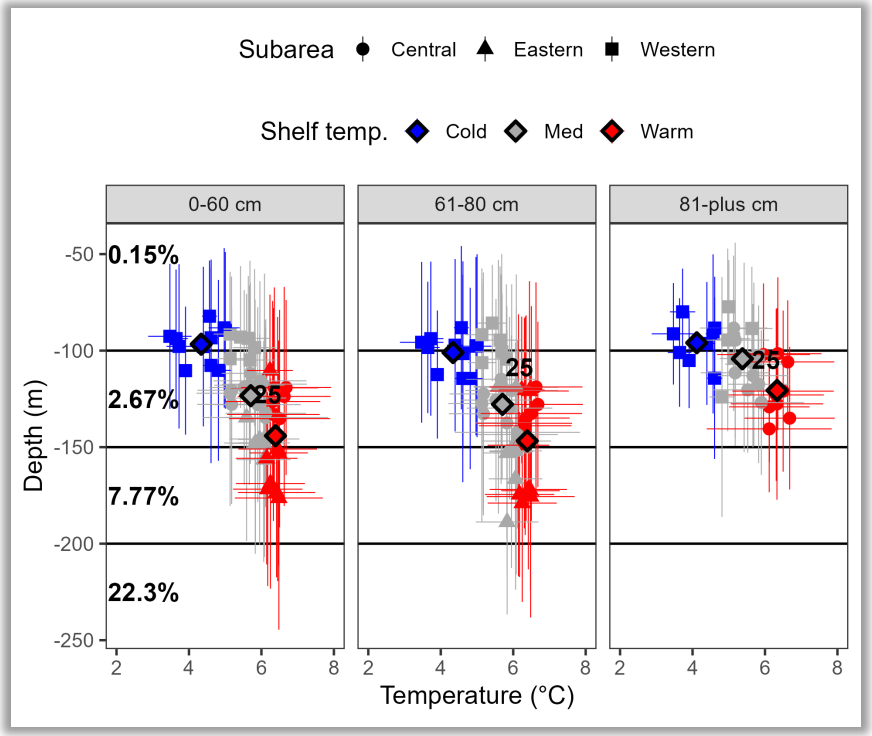




DATA – ENVIRONMENTAL

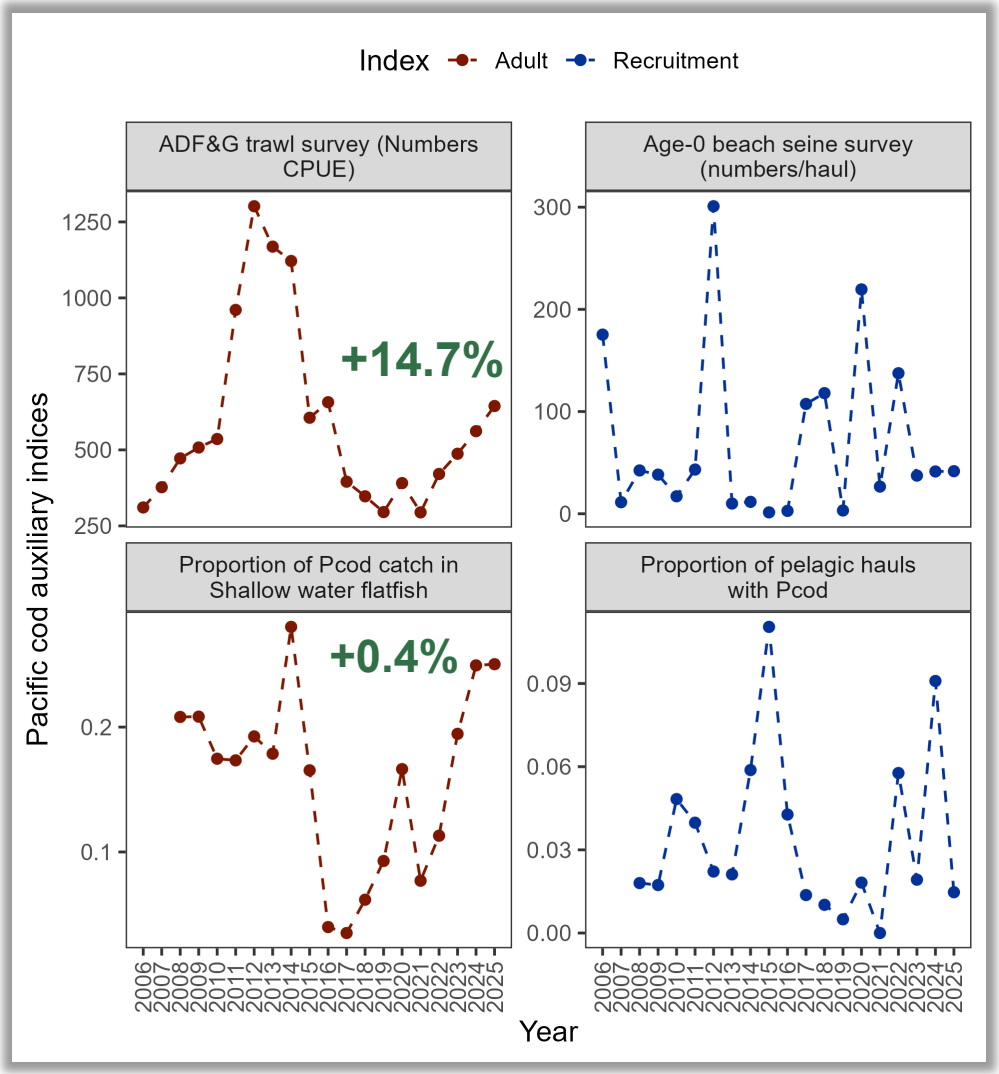
- 2025 CFSR not available – covariate not updated (new index will be used in next full assessment)
- Warmer bottom temps in bottom trawl survey associated with deeper depth on average





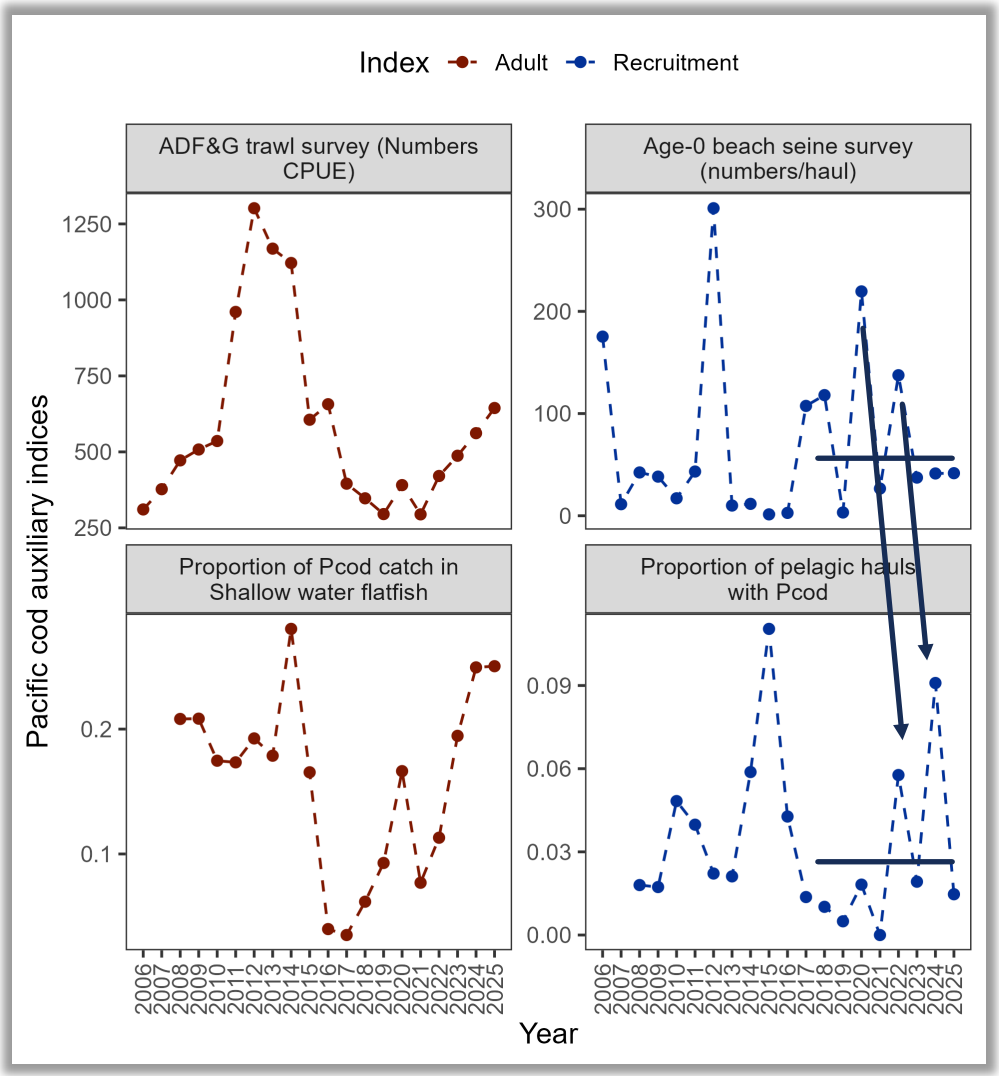
DATA – AUXILIARY INFORMATION

- Adult indices:
  - ADF&G Numbers CPUE increased
  - Proportion of cod in SWF catch stayed at >0.2

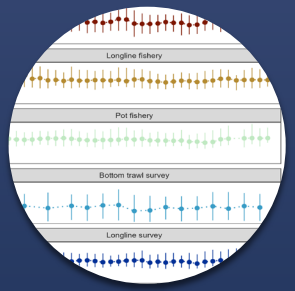


DATA – AUXILIARY INFORMATION

- Recruitment indices:
  - Beach seine 2023-2025 below average
  - 2025 below avg in pelagic hauls with cod (age-2)
- Both agree with above average 2020 and 2022 year classes

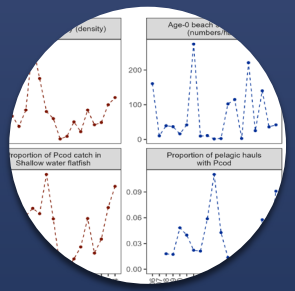


DATA – SUMMARY



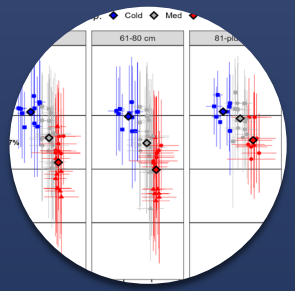
Catch trends:

- No red flags



Index trends:

- General trend is a continued increase in adult population



Environmental trends:

- 2025 warmer than average, cod deeper

- Risk table
- ABC/OFL recommendations

RISK TABLE

Risk table guiding principle: what are the risks, external to the stock assessment, to the recommended 2026 ABC?

Assessment-related Considerations	*Population Dynamics Considerations*	*Ecosystem Considerations*	*Fishery-informed Stock Considerations*
Level 1: Normal	**Level 1:** Normal	**Level 2:** Increased Concern	**Level 1:** Normal
Model 24.0 does not have a concerning retrospective pattern and fits the available data well	Stock continues to experience historically low spawning biomass coupled with below average recruitment	Prolonged warm ocean temperatures throughout the water column in 2025, and concerns of prey base availability, may adversely impact adult Pacific cod biological status in 2026.	Fishery performance indicators are consistent with previous years

RISK TABLE

- Changes from 2024:
- Pop'n dynamics considerations: historically low spawning biomass, below average recruitment, and below average spawning conditions in 2025 are cause for concern.
- However, our understanding of spawning biomass and recruitment comes from assessment model, which, by definition, includes these considerations in any ABC recommendations
- Below average spawning conditions in 2025 will likely lead to poor 2025 year-class, but, this has little effect on 2026 ABC
- While there remains concern over the pop'n dynamics of this stock, reduce the risk level to 1 because these risks are not external to the stock assessment

RISK TABLE

- Changes from 2024:
- Ecosystem considerations: warmer than average ocean conditions in 2025, decrease in adult body condition
- Change from risk level 1 to 2 increased concern

Should the 2026 ABC be reduced from maximum?

- Given our history with this stock, we must think critically about any recommendations that could have unintended impacts on the stock

RISK TABLE

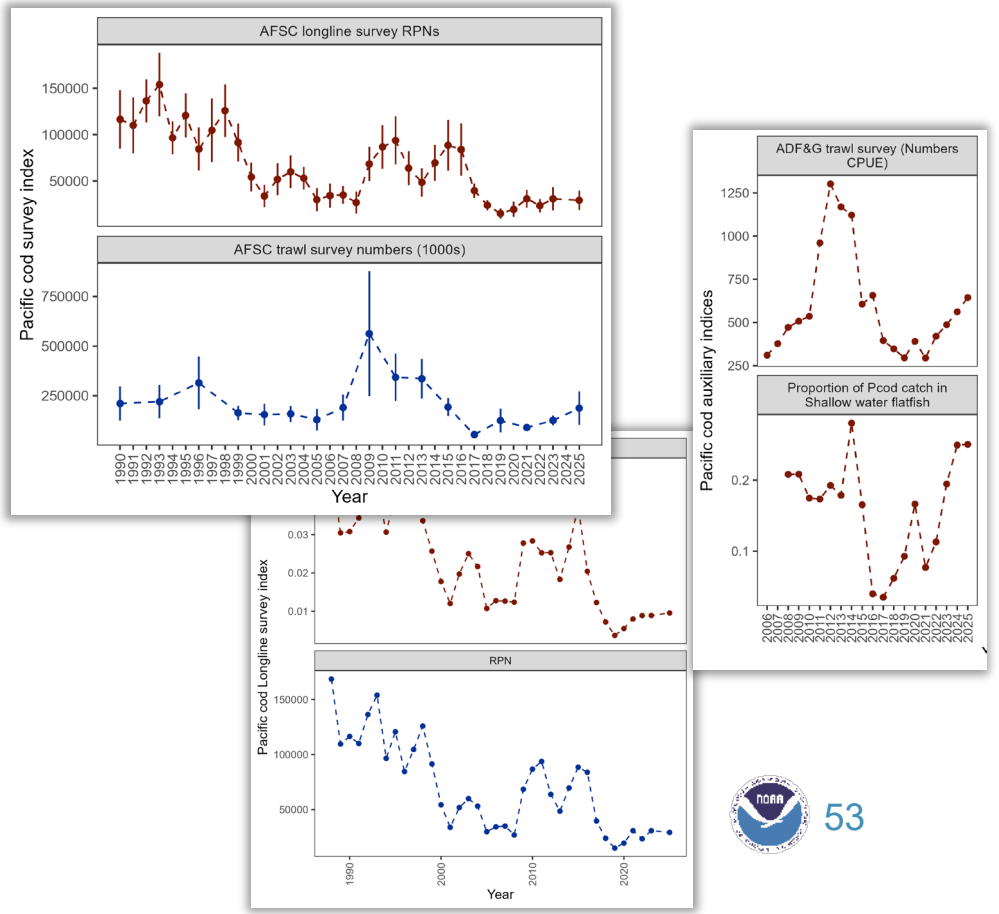
Should the 2026 ABC be reduced from maximum?

- Thinking through this question:
  - Data synthesis
  - Model evaluation
  - Projection considerations
  - Stock status and HCR
  - Have we been here before, and, what happened?

RISK TABLE

Should the 2026 ABC be reduced from maximum?

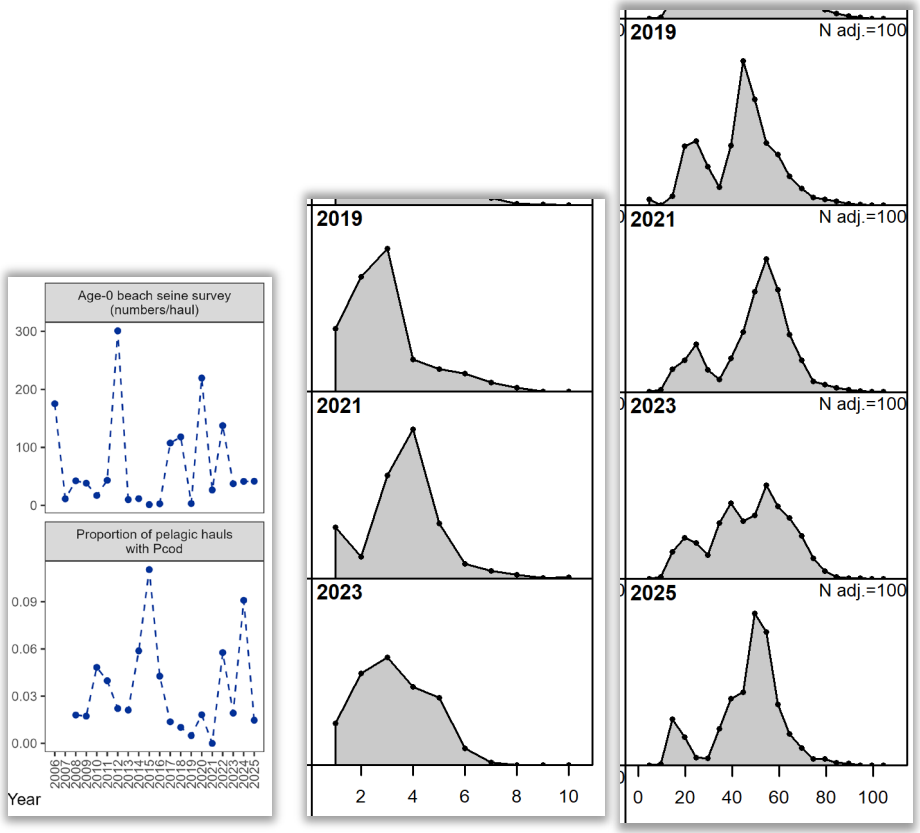
- Data synthesis:
  - Available population index data indicates an increase in the population since 2023/2024
  - AFSC longline survey exception, but, we've discussed why this result occurred, raw catch rates indicates slight increase



RISK TABLE

Should the 2026 ABC be reduced from maximum?

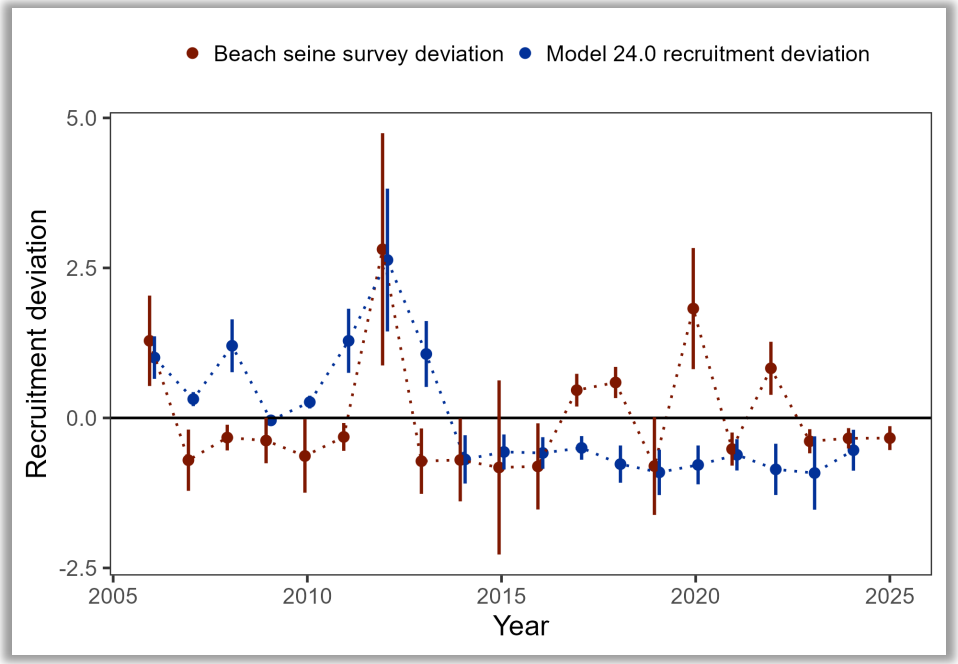
- Data synthesis:
  - Available AFSC trawl survey age and length composition consistently indicates age-1 – age-3 fish in population
  - Beach seine and pelagic catch indicate young fish in system, particularly 2020 & 2022 year classes



RISK TABLE

Should the 2026 ABC be reduced from maximum?

- Model evaluation:
  - Model continues to estimate below average recruitment, but, these estimates do not compare to available data well

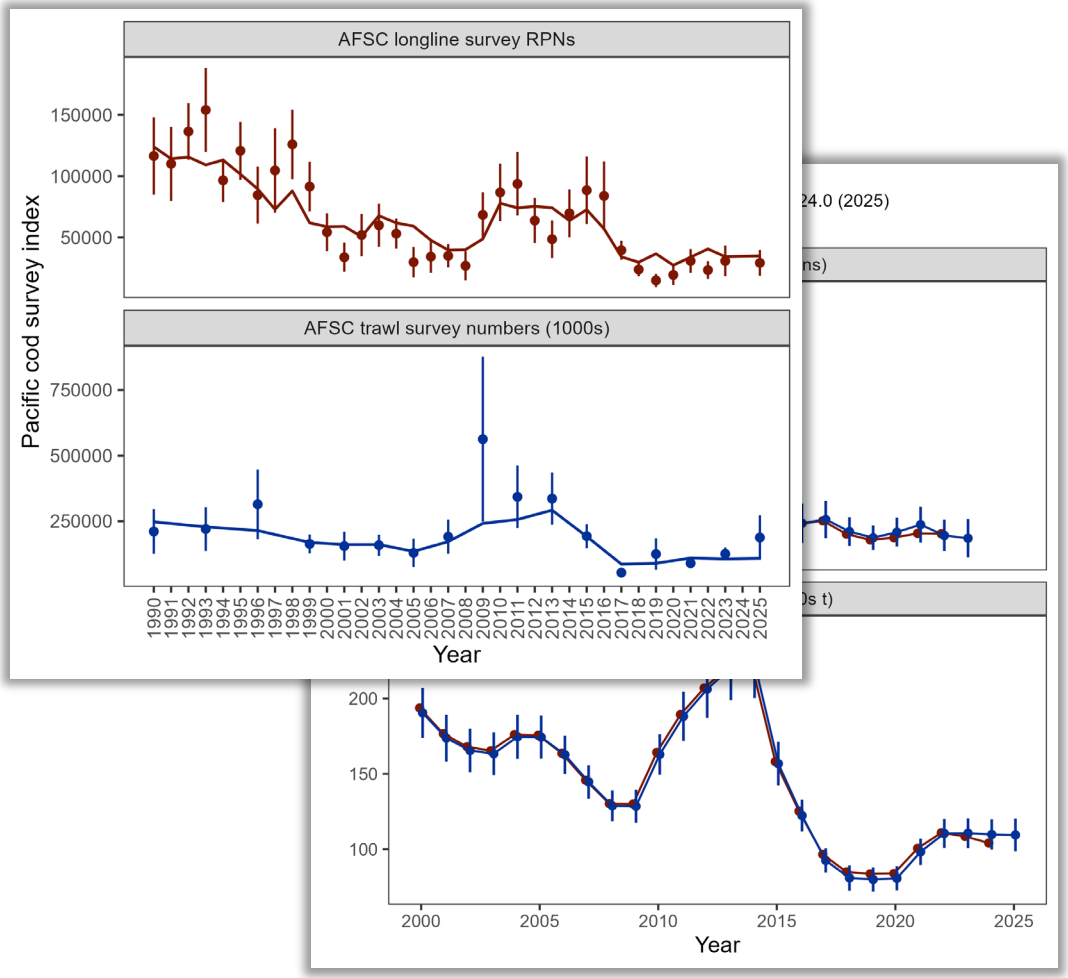


- There is a possibility that the model estimates are misrepresenting recruitment

RISK TABLE

Should the 2026 ABC be reduced from maximum?

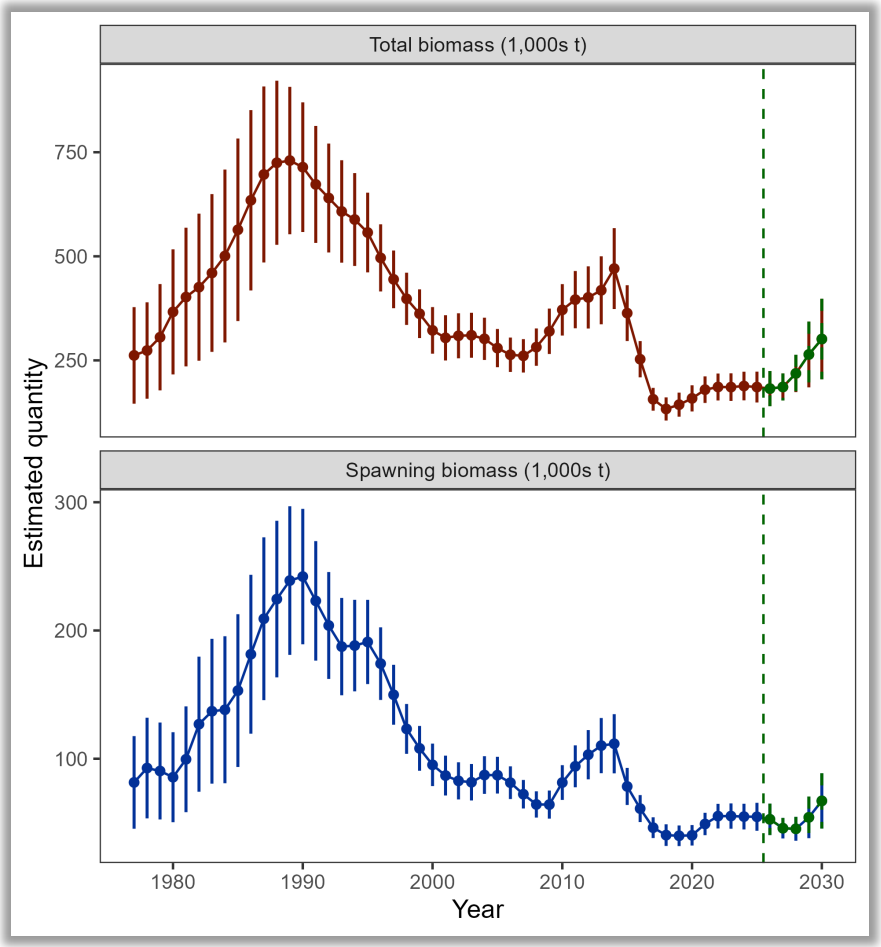
- Model evaluation:
  - Model does not reflect increase in available index data
  - The increase in 2025 from Model 24.0 is the result of stable pop'n estimates compared to decreasing trend estimated in 2024



RISK TABLE

Should the 2026 ABC be reduced from maximum?

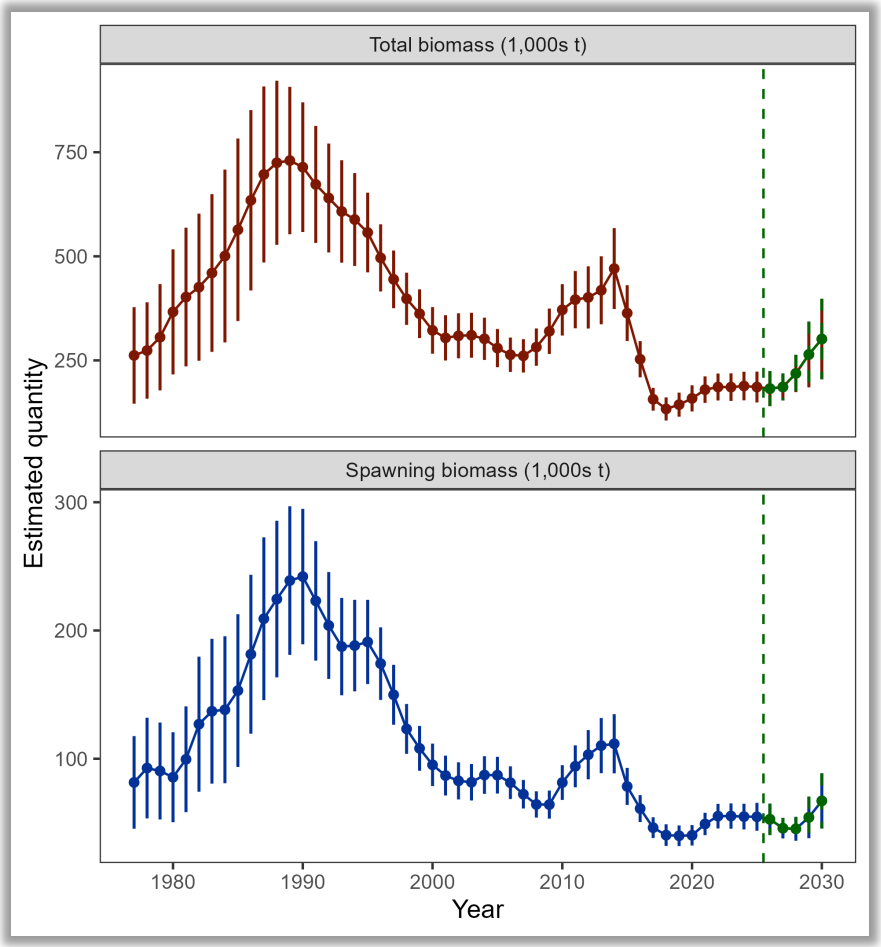
- Projection considerations:
  - Continue to note the average recruitment concern in projected biomass, when recent recruitment estimated to be below average since 2014; this potentially results in overly-optimistic long-term projections, but does not have large effect on 2026 ABC



RISK TABLE

Should the 2026 ABC be reduced from maximum?

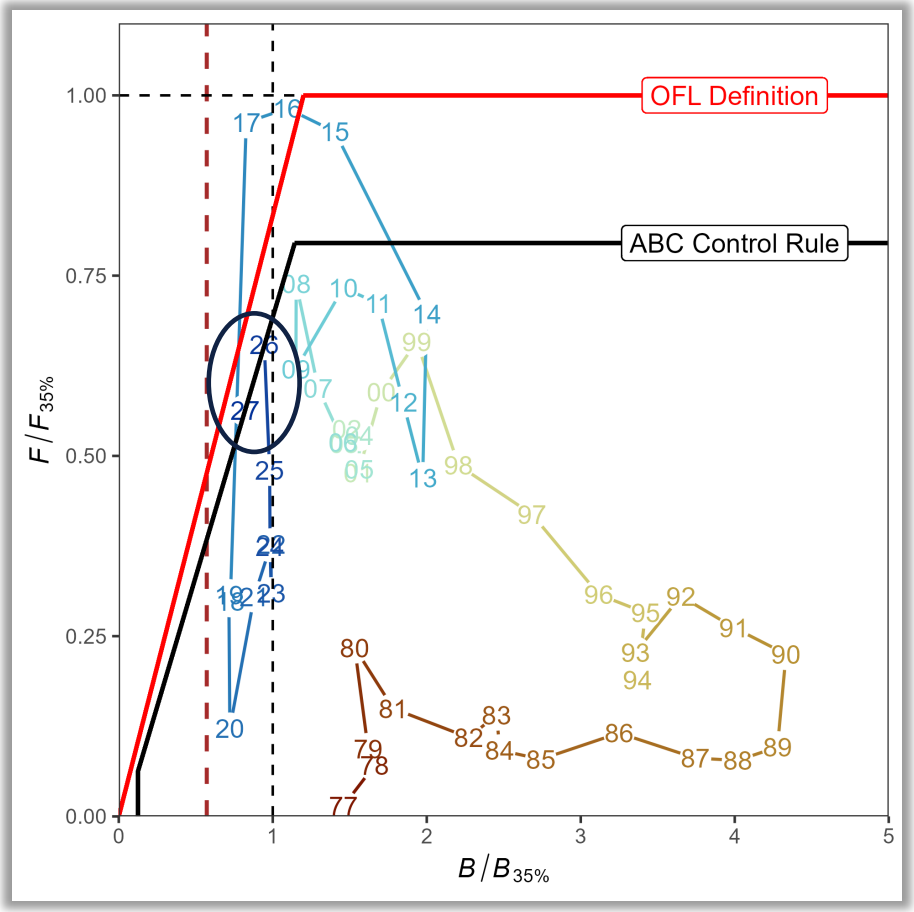
- Projection considerations:
  - Assumption of utilizing full ABC in terminal year of model for projections reduces 2026 recommended ABC by 5% as compared to using observed catch proportions since fishery closure in 2020



RISK TABLE

Should the 2026 ABC be reduced from maximum?

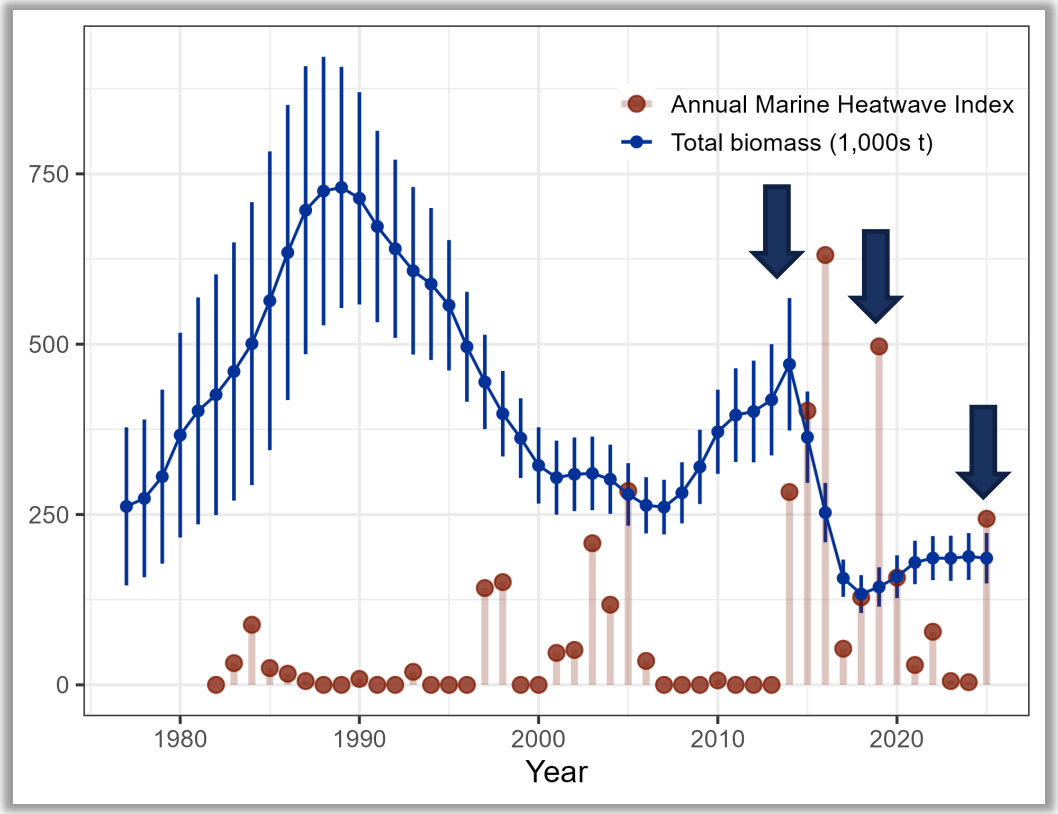
- Stock status and HCR:
  - Stock is currently in Tier 3b, on the ramp of the HCR
  - Based on the HCR and projected stock status, $F_{40\%}$ reduced by 18% to obtain 2026 F_{ABC}



RISK TABLE

Should the 2026 ABC be reduced from maximum?

- Have we been here before, and, what happened?
- Recognizing that no two years are exactly the same, highlight two recent years in which number of heatwave days similar to 2025: 2014 and 2019



RISK TABLE

Have we been here before, and, what happened?

- 2014: precipitated severe heatwave in 2015 and 2016, following which population collapses
- Model estimates from 2014/2015 much different than current model
  - Spawning biomass in 2014 250% larger than Model 24.0 2014 estimate
  - Adopted 2015 ABC 150% larger than recommended 2026 ABC
- Standardizing ABC as a proportion of total biomass and comparing between 2015 and 2026, recommended 2026 ABC 24% smaller than what was adopted in 2015
- Seasonality and selectivity is the primary difference between the model used in 2014 and Model 24.0

RISK TABLE

Have we been here before, and, what happened?

- 2019: Model recommendation in 2019 resulted in 2020 fishery closure
- After 2019, survey indices have increased, presumably reflecting advantageous conditions for cod population due to improvement in ecosystem conditions after 2019
- 2019 year-class estimated to be smallest in time-series, suspect that 2025 year-class could be of similar magnitude
- While a number of improvements to the model and data have been implemented since 2019, Model 24.0 is fundamentally the same model as used in 2019 to recommend the fishery closure (note: no additional buffers have been applied to recommended ABC since fishery closure)

RISK TABLE

Should the 2026 ABC be reduced from maximum?

- Summary: There are several aspects of the current stock assessment that mitigate risk, including catch assumptions in projections, stock status and the HCR, and model development over time
- But, do these serve to mitigate the risk identified for the 2026 ABC?
  - It is not clear to what extent increased risk highlighted in 2025 is mitigated by stock assessment
  - It remains unknown if environmental conditions in 2025 will persist into 2026, and whether they had significant impact on the GOA cod stock

RISK TABLE

Should the 2026 ABC be reduced from maximum?

- An additional buffer to the 2026 ABC could be considered, however,
  - There is no quantitative method available with clear objectives from which to derive the additional buffer, it remains a subjective decision
  - There is no understanding of any measurable risk reductions that have occurred due to buffers that have been implemented across stocks to inform the magnitude of buffers

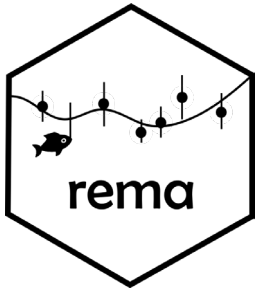
RISK TABLE

Should the 2026 ABC be reduced from maximum?

Taken together, a reduction from maximum ABC in 2026 is not recommended, while at the same time acknowledge the ***increased risk*** associated with this recommendation

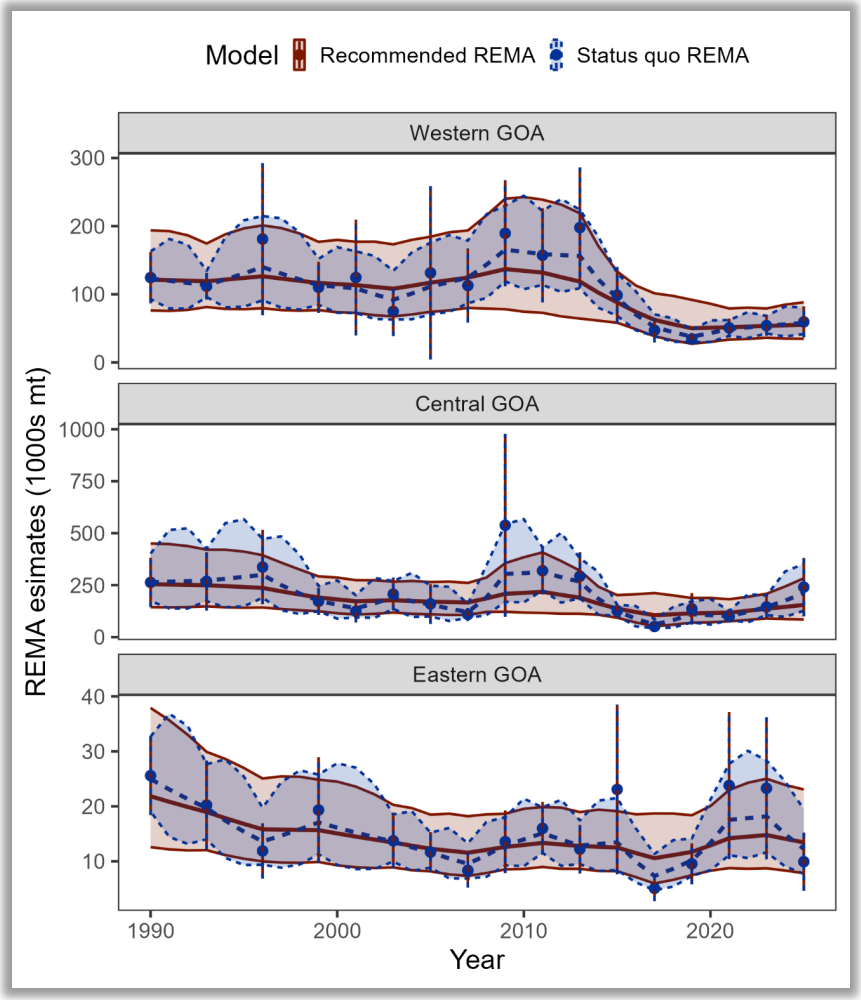
APPORTIONMENT

- Two REMA model configuration changes recommended for apportionment (BRD)
  1. Estimate single process error parameter across GOA subregions
  2. Estimate additional observation error parameter for GOA bottom trawl survey
- These REMA model configurations previous adopted for GOA Thornyhead stock complex (Echave et al. 2022, Siwicke et al. 2024)



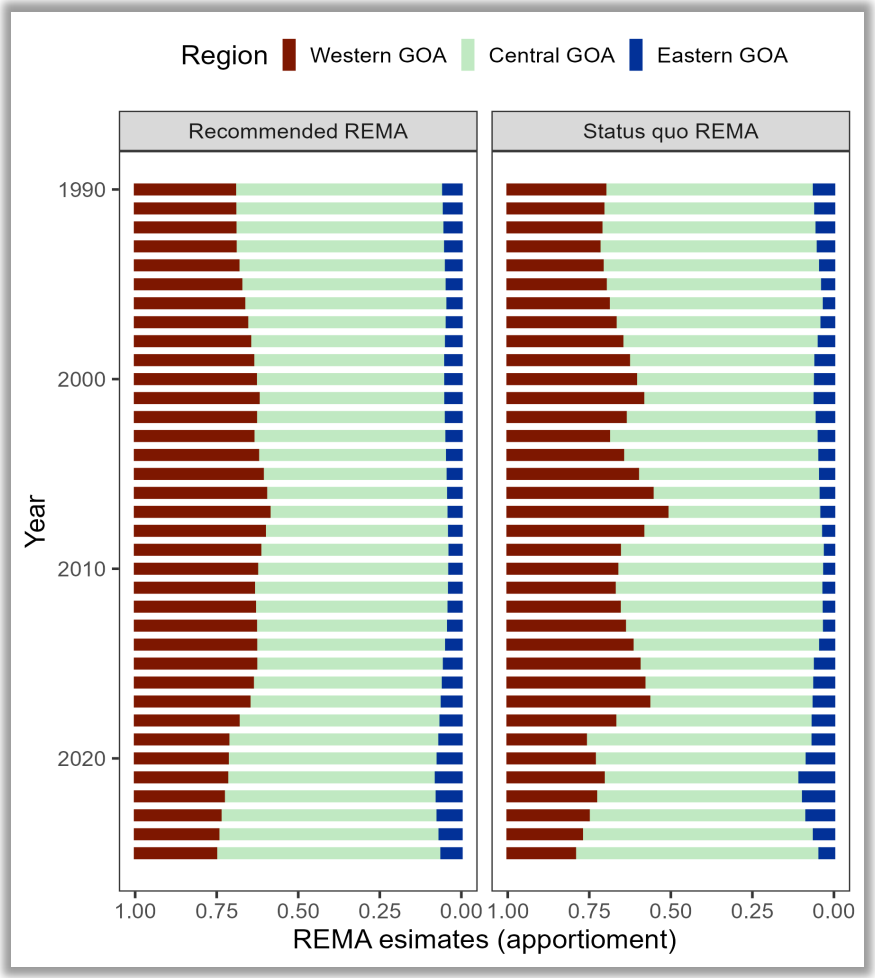
APPORTIONMENT

- Recommended REMA configuration changes serve to:
  1. Provide estimates of subregion biomass and uncertainty that is reflective of uncertainty and variability in survey estimates,
  2. Provide apportionment estimates that do not result in drastic and improbable shifts in distribution that are inconsistent with our understanding of cod life history and movement



APPORTIONMENT

- Recommended REMA configuration changes serve to:
  1. Smooth estimates of subregion biomass and uncertainty that is reflective of primary assessment model estimates of biomass,
  2. Provide apportionment estimates that do not result in drastic and improbable shifts in distribution that are inconsistent with our understanding of cod life history and movement

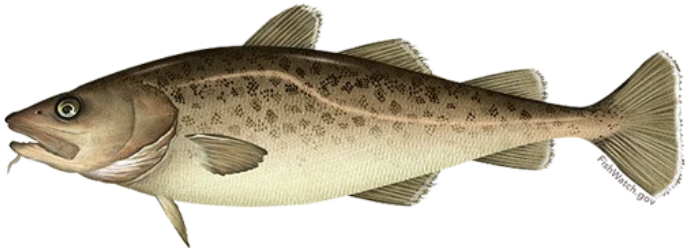


APPORTIONMENT

- Comparison among adopted apportionment from 2025, apportionment from status quo REMA model, and apportionment from recommended REMA model:

	Western	Central	Eastern	Total
Previous apportionment	27.1%	63.8%	9.1%	100%
2025 BRD	8,710	20,506	2,925	32,141
Status quo apportionment	20.6%	75.1%	4.3%	100%
2026 BRD	8,553	31,182	1,785	41,520
Recommended apportionment	24.8%	69.2%	6%	100%
2026 BRD	10,297	28,732	2,491	41,520

FUTURE MODEL DEVELOPMENT

- Harvest projection planned for fall 2026
- Planned model developments:
  - Re-evaluation of input data: Longline survey Index, composition data (with input sample size), Recruitment index, Environmental data
  - Re-evaluation of model assumptions: selectivity
  - Re-evaluation of modeling software: RTMB/TMB
  - Re-evaluation of stock vs assessment spatial structure: WGOA-EBS within spatial assessment

QUESTIONS?