Gulf of Alaska Arrowtooth Flounder Ecosystem and Socioeconomic Profile (ESP) Full Report

Kalei Shotwell, Jennifer Bigman, Russel Dame

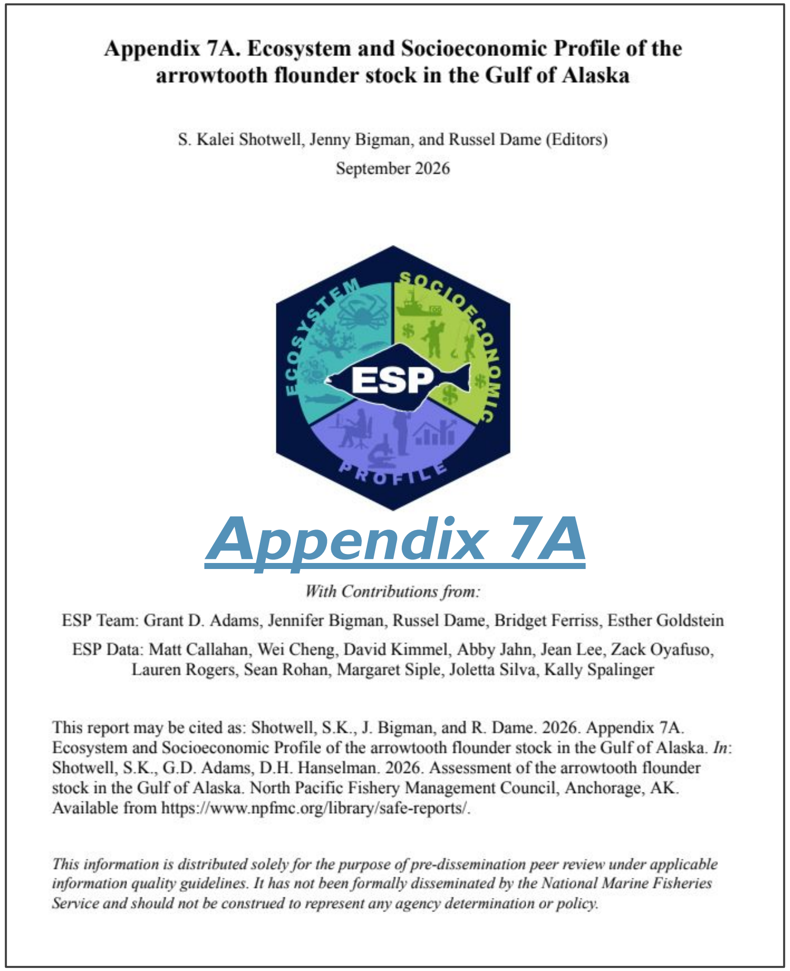


ESP Team and Contributors: Matt Callahan, Wei Cheng, Bridget Ferriss, Esther Goldstein, David Kimmel, Abby Jahn, Jean Lee, Zack Oyafuso, Lauren Rogers, Sean Rohan, Margaret Siple, Joletta Silva, Kally Spalinger

September 2026, Presentation to the Groundfish Plan Team

Overview

- Appendix 7A in SAFE Report
  - Recommended in 2016 (GOA-IERP), initiated in 2024, draft full in 2025
  - References Estimation example in Bigman et al., *in review*, available on preprint
- Justification
  - High biomass and important ecosystem role as GOA predator
  - Classified as data-rich stock
  - GOA Plan Team recommended exploring recruitment and environmental trends



Appendix 7A. Ecosystem and Socioeconomic Profile of the arrowtooth flounder stock in the Gulf of Alaska

S. Kalei Shotwell, Jenny Bigman, and Russel Dame (Editors)

September 2026

Appendix 7A

With Contributions from:

ESP Team: Grant D. Adams, Jennifer Bigman, Russel Dame, Bridget Ferriss, Esther Goldstein

ESP Data: Matt Callahan, Wei Cheng, David Kimmel, Abby Jahn, Jean Lee, Zack Oyafuso, Lauren Rogers, Sean Rohan, Margaret Siple, Joletta Silva, Kally Spalinger

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SSC/PT Recommendations - Summary

- Overall
  - PT: Recommended synthesizing contextual indicators by developing a multi-variate indicator to measure current year relative to historical conditions.
  - SSC: The SSC recognized progress with DSEM through RCEATTLE and encourages continued exploration of applications to additional stocks and supports efforts to create structured pathways for including environmental covariates in assessment models.
- Stock-specific
  - PT recommended the AFSC expert group develop proposed guidance for how to evaluate DSEM fits and how this effort can best be used in a management context. SSC supports ESP team categorizing indicators as predictive, contextual, monitoring.

Timeline: External (Level 3) ESP-DSEM

2016

Plan Team Requests ESP

After the prototype sablefish ESP, the Plan Team recommended producing ESPs for the other focal species of the GOA-IERP

2019

PT/SSC Requests Recruitment and ESP

During the 2019 GOA arrowtooth SAFE, PT/SSC comments included investigating declining recruitment trends inclusive of generating an ESP.

2024

Arrowtooth ESP Mini

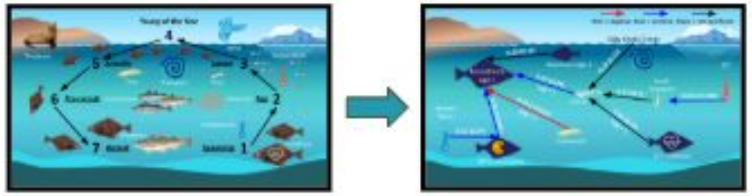
First draft of an ESP mini report with standard suite of indicators for the GOA arrowtooth prior to ESP team creation.

2025

Causal Model Development

ESP Team and subject matter experts from AFSC and other agencies begin development of ESP, mechanism table, directed acyclic graphs or DAGs, and running *dsem*

Sept 2025



Draft Full ESP

Report and presentation to GOA Plan Team of draft full ESP and simplified external DSEM with preliminary results

Sept 2026

DSEM Cookbook paper submitted and full ESP

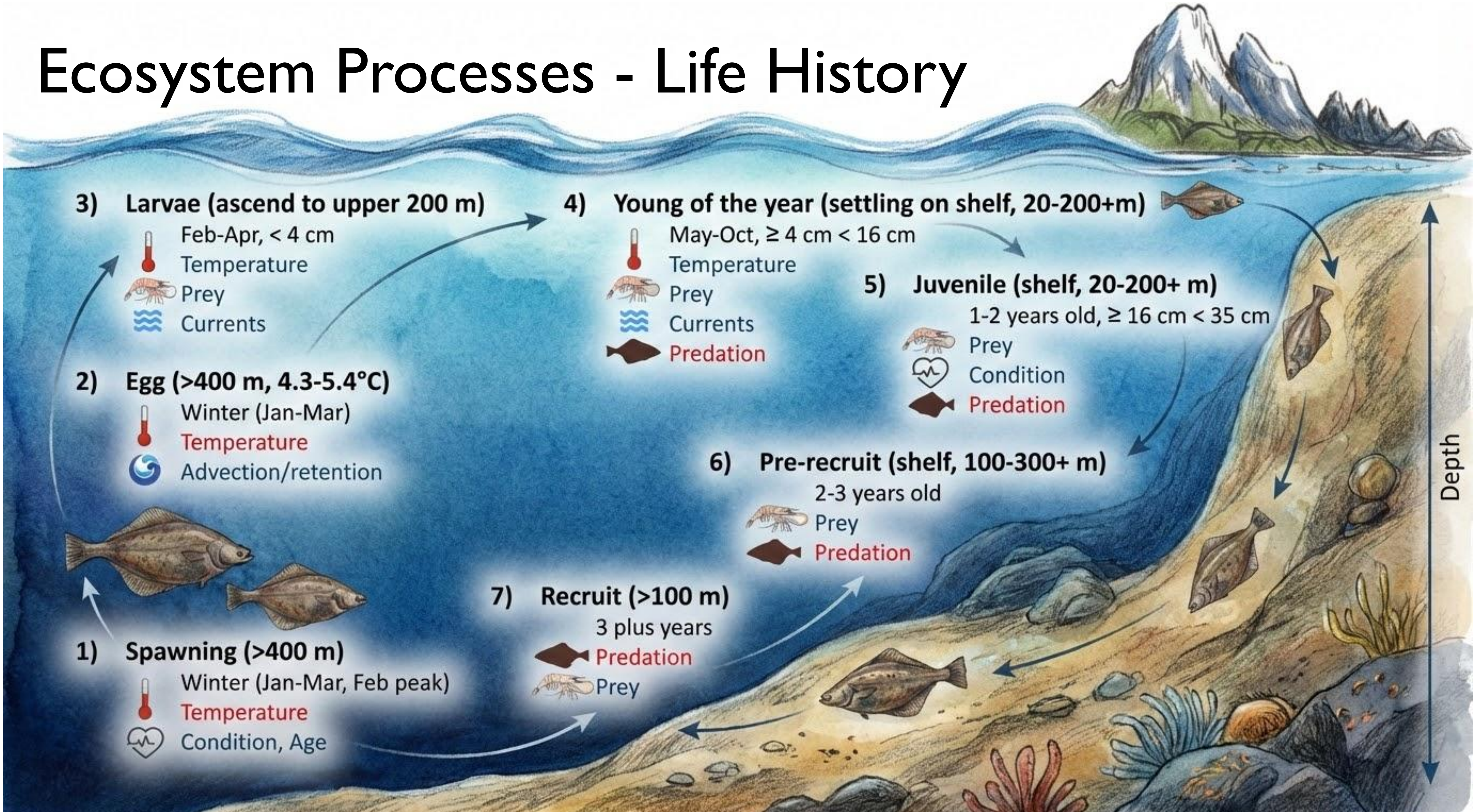
Manuscript on DSEM applications submitted for review in Fish and Fisheries, includes GOA arrowtooth example. DSEM integrated RCEATTLE proposed as **research model** for future GOA arrowtooth assessments.

ESP Team

Roles & Responsibilities

- Stock assessment lead author
- Ecosystem and economic status report representatives
- Subject matter experts on arrowtooth flounder ecology
- Statistical analyst for DSEM
- Facilitator / editor of ESP report

Ecosystem Processes - Life History

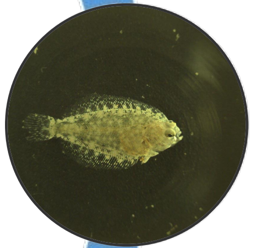


Ecosystem Indicators

Ecosystem Indicators

Larvae to YOY

1. Spring sea surface temperature (satellite), -
2. Spring east/west eddy kinetic energy (2, satellite), +
3. Spring arrowtooth larvae (EcoFOCI), +
4. Spring/Summer larval/YOY prey (2, EcoFOCI), -
5. Summer/Fall YOY Prey (MACE), +



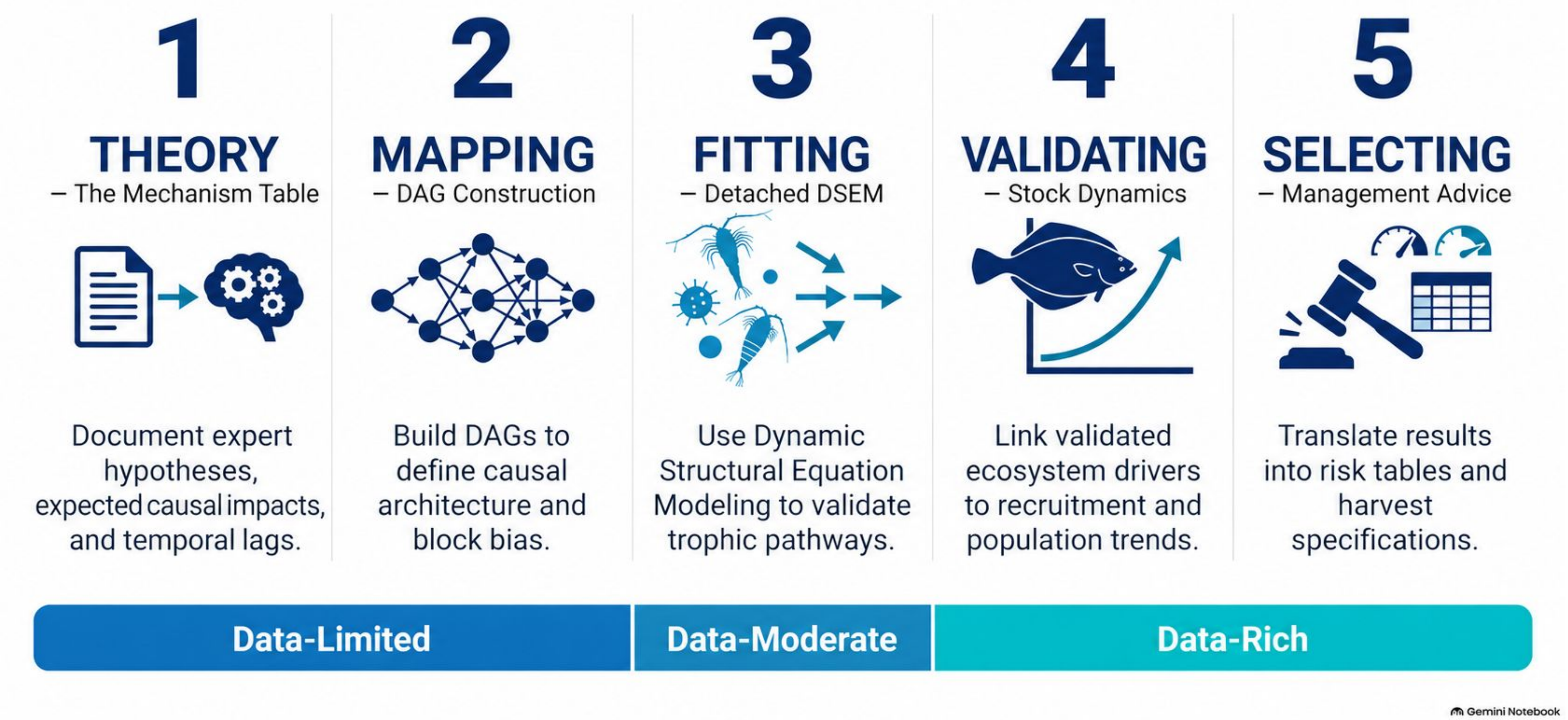
Juvenile

6. Age-1 ♀/♂ predation mortality (2, Rceattle), -
7. Age-1 arrowtooth (ADF&G nearshore), +
8. Juvenile arrowtooth condition (trawl survey), +

Adult

9. Adult arrowtooth CPUE (ADF&G nearshore), +
10. Biomass consumed arrowtooth (Rceattle), -
11. Bottom temperature (trawl survey), -
12. Area occupied (VAST), <>
13. Center of biomass east/north (2, VAST), <>
14. Adult arrowtooth condition (trawl survey), +
15. Arrowtooth ration (Rceattle), -

ESP-DSEM Workflow

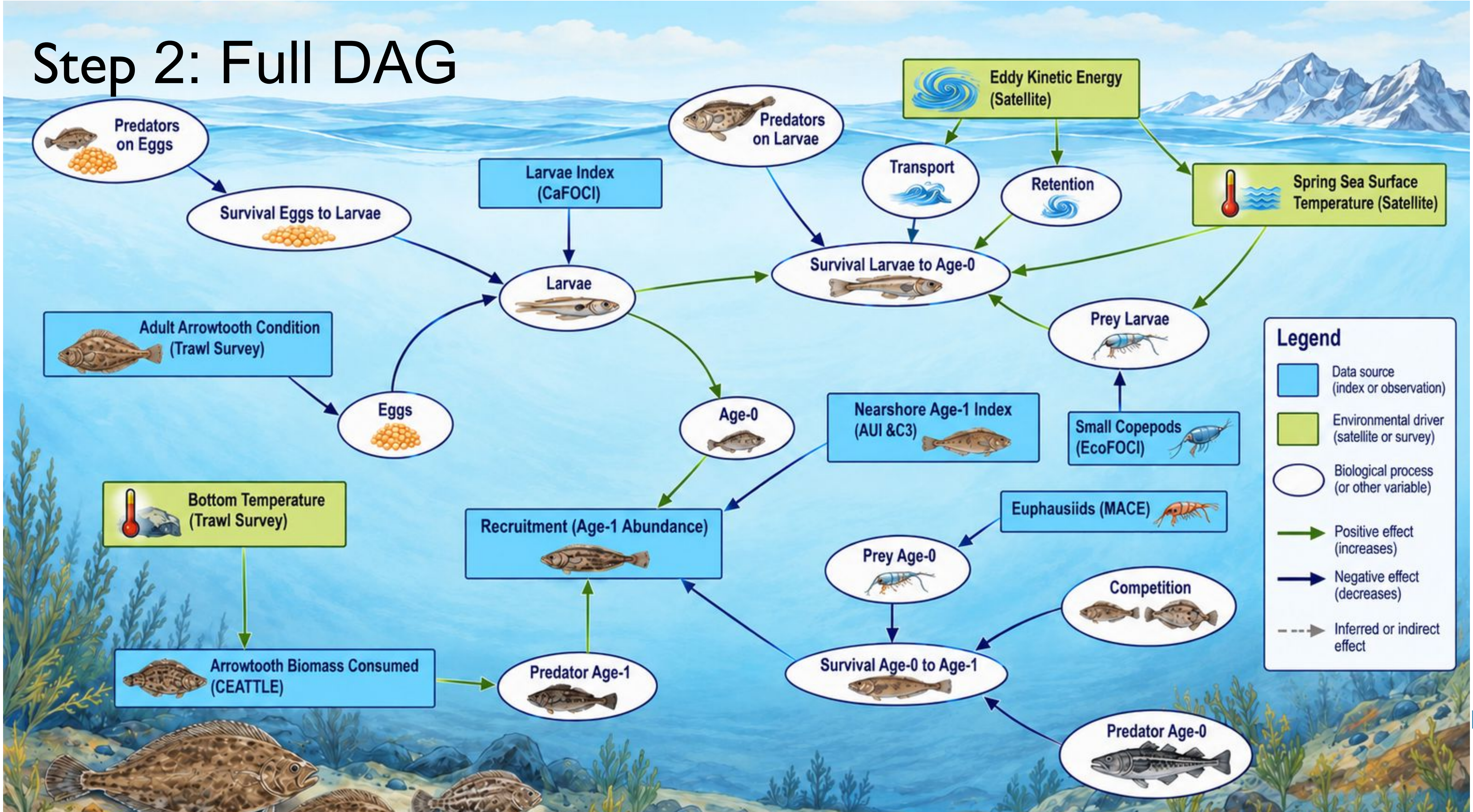


Step 1: Mechanism Table

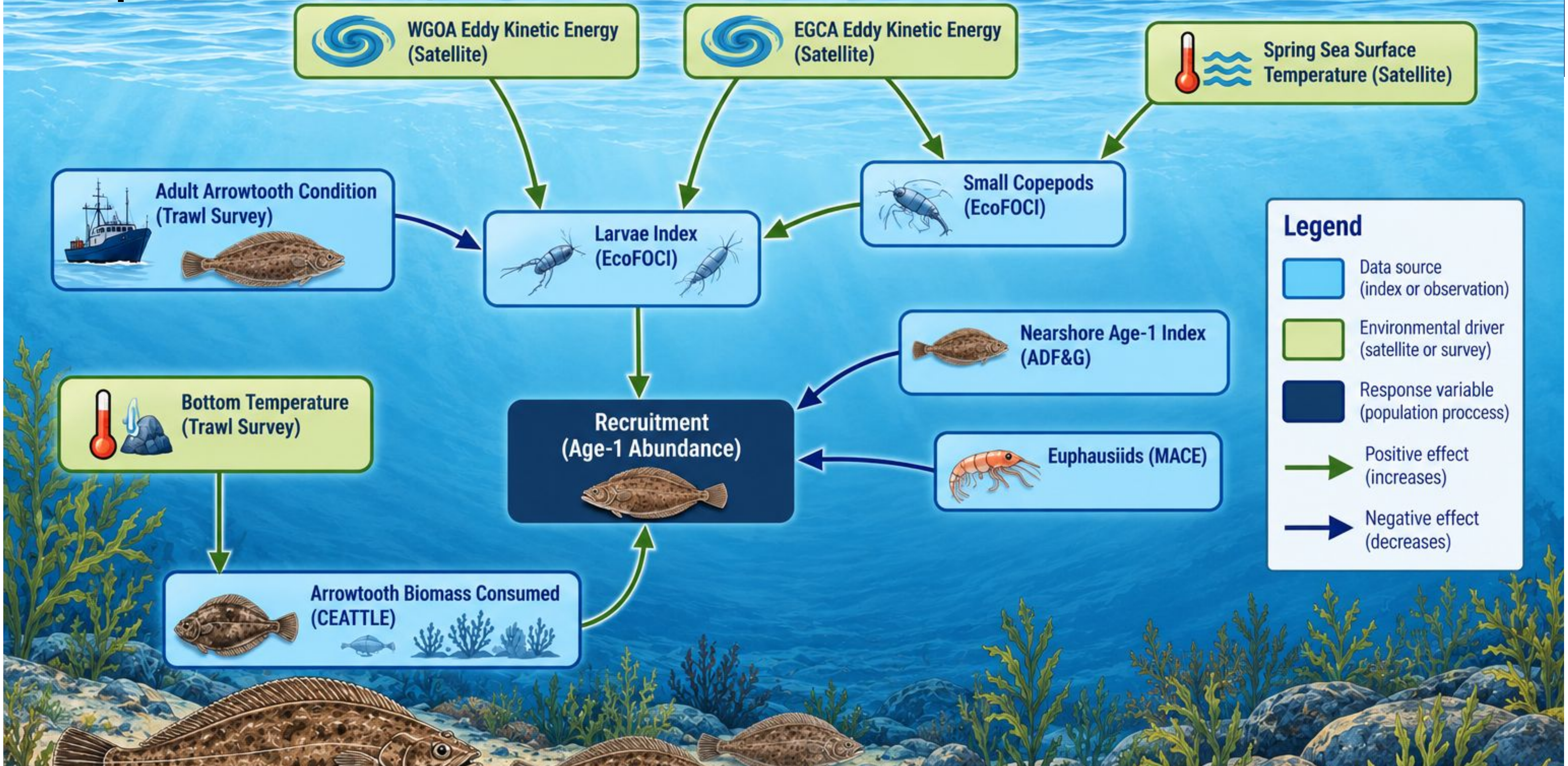
Stage	Habitat & Distribution	Phenology	Age, Length, Growth	Energetics	Diet	Predators & Competitors
Spawning	Deep, shelf edge, mesopelagic, troughs, canyons, slope (≥300 m, most ≥400 m)(5,13)	Jan-Apr, peak mid-January, 17 wks(13,20,21)	1st mature: 6 yr 50%: 10-11 yr, 47♀/42♂ cm(22)	Oviparous, high fecundity (0.25-2.22·10⁶ eggs)(13); 4.2-5.4°C(5)	Fish > 40 cm: pollock, herring, capelin, shrimp, euphausiids (18,22)	P: Pacific cod, halibut, Steller sea lions, sharks, fisheries(22); C: shelf groundfish(22)
Egg	Shelf edge, slope (most ≥400 m)(5); mesopelagic, troughs, canyons(13)	Incubation 15-20 days(5); peak egg - peak larval 4 wks(20)	Egg size: 1.58-1.98 mm, larger egg size(20, RACE)	Incubation temp is 4.3-5.4 °C	Extended lipid reserves(21); yolk is homogenous	
Larvae	Shelf edge, slope (early stage ≥400m, late stage 50(16)-200 m), mesopelagic, troughs, canyons (5,13)	Jan-Aug(6,16,21); peak mid-Feb, extended, 26 wks(20)	3.9-26 mm SL, ascend as yolk-sac larvae(5,13); slow growth Jan-Apr		Possibly lipid-rich, deep water, oceanic copepod eggs and nauplii(21)	P: Pacific ocean perch (infrequent), other fishes(18); C: share larval period with Pacific halibut(13)
YOY	Shelf, nearshore, coastal areas (6,13)		26-40 mm FL(6,13)	No relation size and energy density	Large/small copepods	P: Adult arrowtooth flounder, pollock, cod(17)
Juvenile	Shelf, nearshore (6-200+ m), near bays, straits, coastal areas, mixed mud, sand, not gravel, near rocky(1,2,3,4,8,12,14)	Settlement timing September(6)	ages 0-2 yrs (40-211 mm)(4,6,7); 0-1yr roughly 20 cm(22)	5-9.5°C and 32-33 ppt (temp preference < with age)(1,2,3)	mysids, cumaceans, euphausiids, other crustaceans(1,19)	P: Adult arrowtooth flounder, pollock, cod, halibut, sablefish (17,22)
Pre-recruit	Nearshore, shelf (100-200+ m)(14); near bays, straits, coastal areas, mixed mud and sand, near rocky(1,2,12)		age-2+ (200-390 mm)(9); females mature as young as age-3 (>400 mm)(10) deeper depth with age	Energy density > with length prior to maturity	euphausiids, pollock, capelin, shrimp, (9,17,19,22)	P: Adult arrowtooth flounder, cod, sablefish, halibut (17,22)
Adult	Abundant, 20-800m, most 100-300m, mesopelagic, troughs, canyons, shelf/slope(22)	First recruit to survey and fishery age 3, length 40 cm(22)	Max: 23yr, 79♀/40-63♂cm Average: 10 yrs, L_inf: 81.9♀/49.7♂ cm, K: 0.102♀, 0.236♂ (22)		Fish 15-30cm: shrimp, capelin, euphausiids, misc fish, herring(18,22)	P: Pacific cod, halibut, Steller sea lions, sharks, fisheries(22); C: shelf groundfish(22)

Link	Description	Hypothesized Direction / Lag	Confidence
Temperature to predation	Higher temperatures increase metabolism and then consumption (Holsman and Aydin, 2015).	Positive / 0	High
Euphausiids to age-1 recruitment	Euphausiids are a common prey of age-1 arrowtooth (Paul et al., 1999, Doyle et al., 2018).	Positive / 1	Medium
Temperature to small calanoid copepods	Marine heatwave influences the size (warm = more small copepods) and abundance of the copepod community (low large copepods in spring; Kimmel et al., 2023).	Positive / 0	High
Small calanoid copepods to larval abundance	Trophic modeling studies suggest biomass of arrowtooth flounder may be strongly influenced by changes in bottom-up production in plankton; fish < 200 mm eat zooplankton (Aydin et al., 2007; Doyle et al., 2018).	Negative / 0	Medium
Eddy kinetic energy (eke) in eastern GOA to larval abundance	More eddy kinetic energy (EKE) in the eastern GOA increases retention farther away from suitably nursery habitat resulting in lower overwinter survival (Goldstein et al., 2020).	Negative / 0	Medium
Eddy kinetic energy (eke) in western GOA to larval abundance	More eddy kinetic energy (EKE) in western GOA increases retention near more suitable nursery habitat resulting in higher overwinter survival (Goldstein et al., 2020).	Positive / 0	Medium
Adult condition to larval abundance	More energy reserves (Rohan et al., 2023) can be allocated to spawning and eggs/larvae would have more lipid reserves providing resilience from increased temperatures	Positive / 1	Medium
Larval abundance to age-1 recruitment	Larval CPUE reflects reproductive output and early life stage mortality and can be an early indicator of recruitment (Rogers et al., 2023)	Positive / 1	Medium/ Low
Nearshore age-1 to age-1 recruitment	The abundance of age-1 fish in ADFG nearshore survey (Spalinger et al., 2023) relates to the abundance of age-1 recruits	Positive / 0	Medium/ High
Predation to recruitment	Pacific cod and halibut represent the highest proportion of predation on > 30 mm arrowtooth flounder; cannibalism on the individuals 30-299 mm (Doyle et al., 2018, Adams et al., 2022).	Negative / 0	Medium/ Low

Step 2: Full DAG



Step 3ish: Simplified DAG



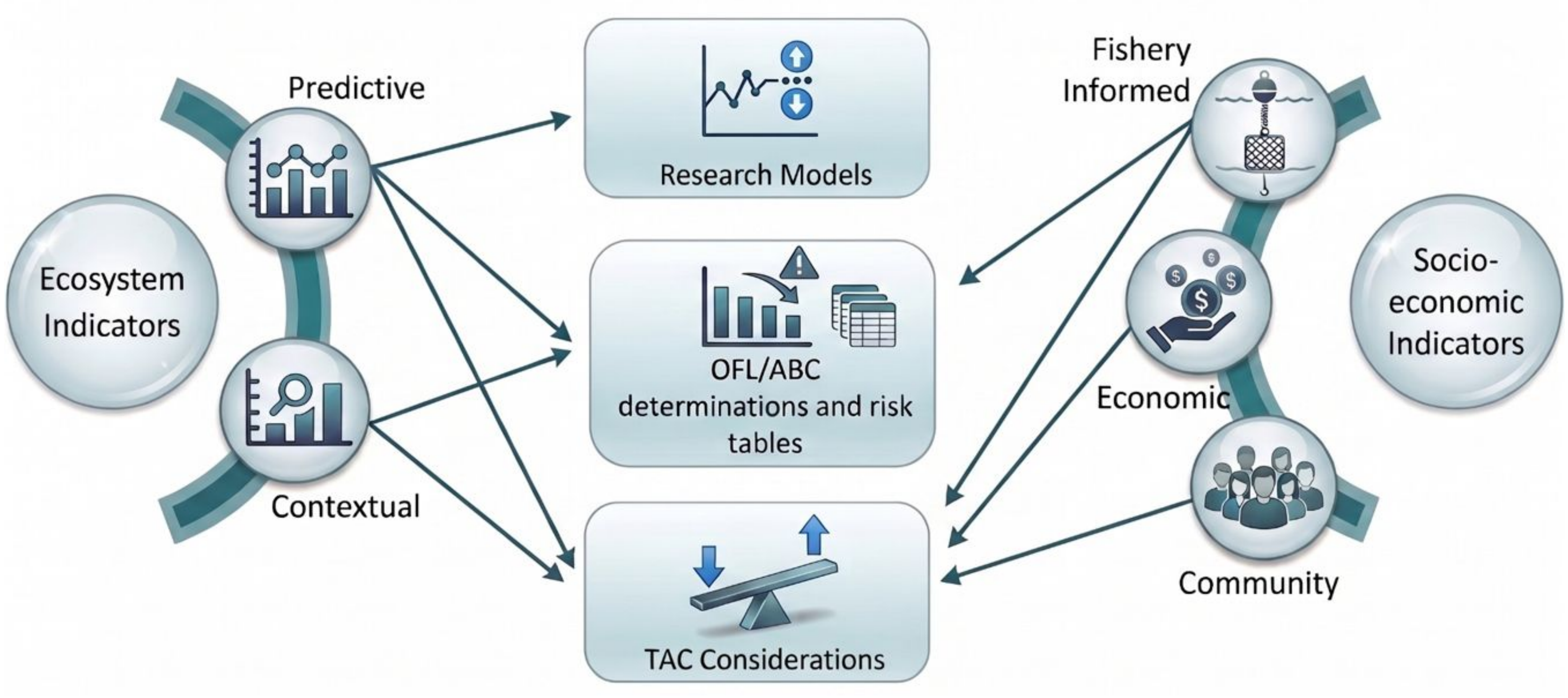
Step 4: Validating Models

Model	AIC	ΔAIC	$\sigma_{R,\ unexplained}$	% reduction in unexplained variation
structural	852.5	0	0.420	82%
regression	855.3	2.7	0.416	83%
AR1	858.7	6.2	0.716	49%
IID	888.4	35.9	1.000	0%

Step 5: Results Table

Link	Data from ESP (Indicator Title)	Estimate (P-value)	Relationship Change	Improvement Suggestions
Temperature to predation	Summer Bottom Temperature	0.17 (0.04)	None	Match bottom temperature to period of predation on age-1 arrowtooth with MOM6
Euphausiids to age-1 recruitment	Summer/Fall YOY Prey	-0.57 (<0.001)	Positive to Negative	Longer time series during YOY pelagic existence, e.g., EcoFOCI fall euphausiids time series
Temperature to small calanoid copepods	Spring Sea Surface Temperature	0.48 (<0.001)	None	More refined spatial match to pelagic arrowtooth larvae
Small copepods to larval abundance	Spring Larval Prey	-0.14 (0.38)	None	Determine actual prey size for arrowtooth larvae in late spring from diet samples, could switch to large copepod time series
Eddy kinetic energy (eke) in western GOA to larval abundance	WGOA Spring Eddy Kinetic Energy	0.13 (0.46)	None	Determine if entrainment leads to higher prey or being swept out of system, refine to connectivity metrics from individual based models or cross-shelf currents

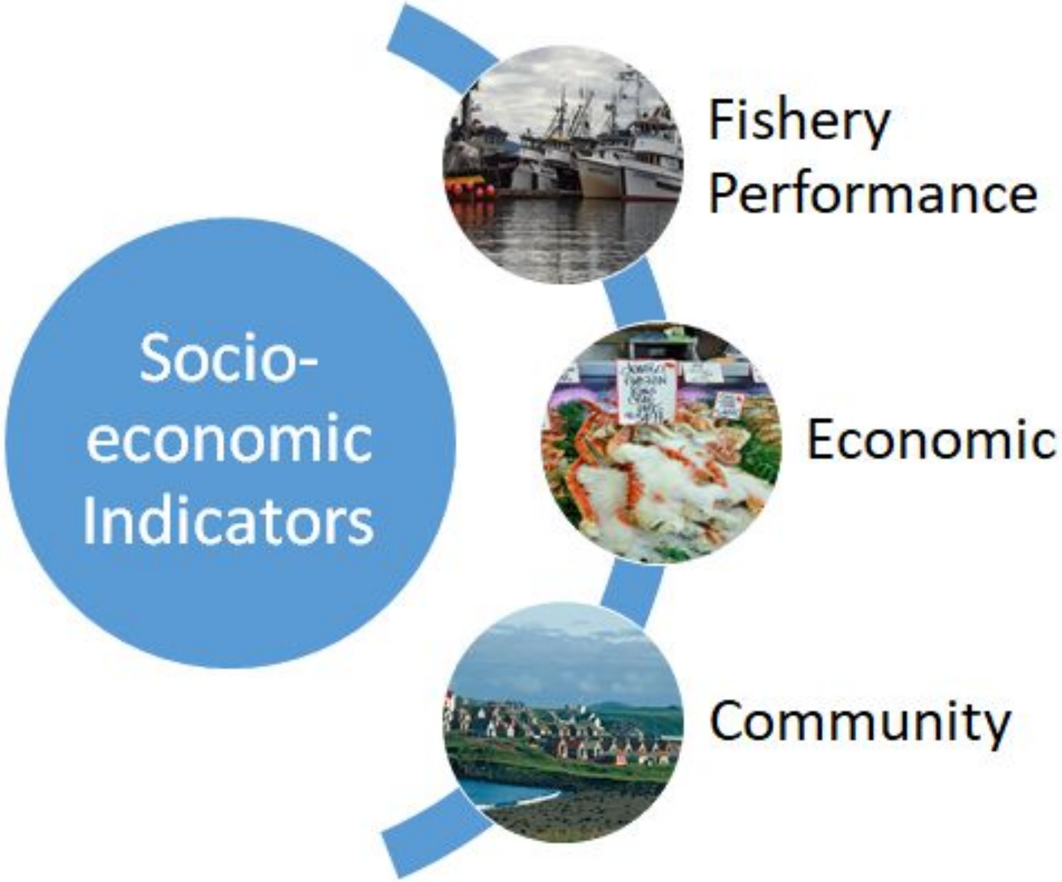
Ecosystem Indicator Categorization



Step 5: Status Table

Indicator Category	Indicator Title	2021 Status	2022 Status	2023 Status	2024 Status	2025 Status
Predictive	Spring Sea Surface Temperature	neutral	neutral	neutral	neutral	*high*
	Spring Arrowtooth Larvae	neutral	NA	neutral	NA	**low**
	Summer/Fall YOY Prey	NA	NA	NA	NA	NA
	Arrowtooth Biomass Consumed	neutral	neutral	neutral	neutral	neutral
Contextual	Spring Eddy Kinetic Energy East GOA	neutral	neutral	neutral	neutral	neutral
	Spring Eddy Kinetic Energy West GOA	*high*	neutral	neutral	*high*	neutral
	Spring Larval Prey	neutral	NA	neutral	NA	NA
	Female Predation Mortality Age1	*low*	neutral	neutral	neutral	neutral
	Male Predation Mortality Age1	*low*	neutral	neutral	neutral	neutral
	Small Arrowtooth ADF&G	neutral	neutral	neutral	**low**	neutral
	Juvenile Arrowtooth Condition	neutral	NA	neutral	NA	neutral
	Arrowtooth CPUE ADF&G	neutral	neutral	neutral	neutral	neutral
	Summer Bottom Temperature	neutral	NA	neutral	NA	neutral
	Arrowtooth Area Occupied	*high*	NA	neutral	NA	neutral
	Arrowtooth Center of Biomass East	**low**	NA	neutral	NA	neutral
	Arrowtooth Center of Biomass North	**low**	NA	neutral	NA	neutral
	Adult Arrowtooth Condition	neutral	NA	neutral	NA	neutral
Monitoring	Summer YOY Prey	NA	NA	neutral	NA	NA
	Arrowtooth Ration	**low**	neutral	neutral	neutral	neutral

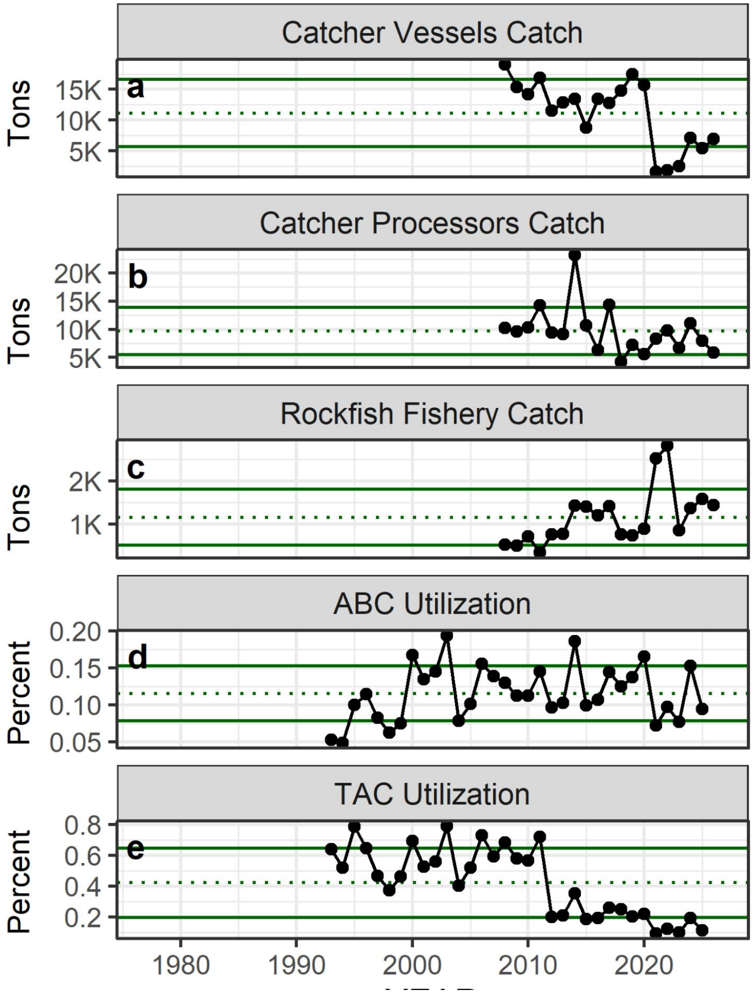
Socioeconomic Indicators*



1. Catch from catcher vessels
2. Catch from catcher processors
3. Non-target catch in rockfish fishery
4. ABC Utilization
5. TAC Utilization
6. Ex-vessel value
7. Ex-vessel price per pound
8. Revenue per unit effort

* Delayed due to staffing capacity shortage

Fishery-Informed Indicators



- Catcher vessel shifted in 2020 to lowest arrowtooth catch of the time series and remains low implying change in fleet behavior
- Catcher processor catch more variable, slightly increasing since low in 2018, implying a redistribution of arrowtooth
- Rapid changes of a non-target catch may imply a shifting distribution into non-preferred habitat and could increase competition/predation.
- ABC utilization variable but generally below 20%, increasing until 2020, and low now
- TAC utilization shifted from high period in 2012 and has remained low, TACs were much smaller (more than half) prior to 2012

Socioeconomic Status Table

Indicator category	Indicator	2021 Status	2022 Status	2023 Status	2024 Status	2025 Status
Fishery Informed	Catch Catcher Vessels	low	low	low	neutral	low
	Catch Catcher Processors	neutral	neutral	neutral	neutral	neutral
	Non-Target Catch Rockfish Fishery	high	high	neutral	neutral	neutral
	ABC Utilization	low	neutral	low	high	neutral
	TAC Utilization	low	low	low	low	low

Future Plans

1) Explore DSEM models then integrate to Rceattle
   - Meet with ESP Team, review DAGs again, identify new indicators, run a detached DSEM, determine any new models to test
   - Once determined models then add to DSEM branch of Rceattle, and use recommended operational model as starting point
2) Re-organize indicators based on results and provide summary
   - Use predictive, contextual, monitoring categories
   - Coordinate with ESR to create risk table template of highlights
   - Identify options for how to use these results (e.g., projections)

Gulf of Alaska Arrowtooth Flounder Operational Full Assessment

Kalei Shotwell, Grant Adams, Dana Hanselman

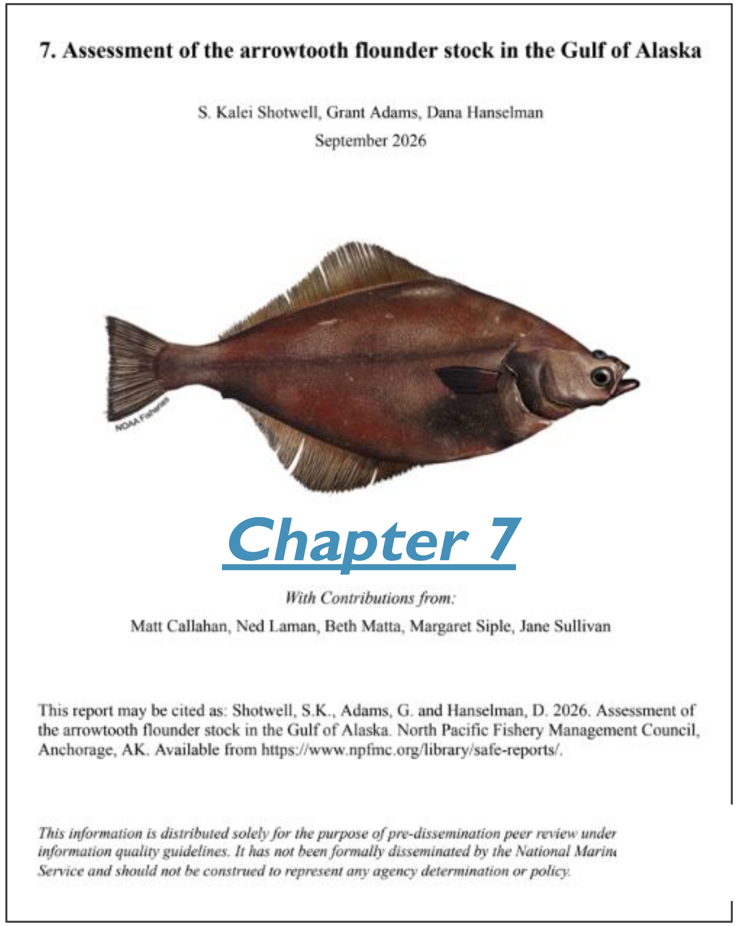


Contributors: Ned Laman, Beth Matta, Margaret Siple, Jane Sullivan

September 2025, Presentation to the Groundfish Plan Team

Background

- Arrowtooth Flounder (*Atheresthes stomias*, ATF)
- Area: Gulf of Alaska (GOA)
- Tier/Cycle: 3a on four year cycle from prioritization
- Platform: Rceattle (Climate-Enhanced, Age-based model with Temperature-specific Trophic Linkages and Energetics)
- Provided model bridging and alternatives in Sept 2024 and data update in Sept 2025
- Approved by Plan Team/SSC (pg. 4, pg.34) in Oct 2024 and by Plan Team/SSC (pg. 4, pg. 40) in Oct 2025


7. Assessment of the arrowtooth flounder stock in the Gulf of Alaska

S. Kalei Shotwell, Grant Adams, Dana Hanselman

September 2026

Chapter 7

With Contributions from:

Matt Callahan, Ned Laman, Beth Matta, Margaret Siple, Jane Sullivan

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Plan Team or SSC Recommendations

- Collection of recommendations since 2019 from PT and SSC
- Recommend investigation of the following elements:
  - Recent lower recruitment trends and relationship to environmental conditions in the GOA, including the development of an ESP
  - Lack of fit in female survey age and fishery length compositions, including interactions between female natural mortality and selectivity
  - Incorporation of predation mortality estimates from the GOA CEATTLE model
  - Update growth and age-length conversion matrices

Goals of Bridge and Data Document

Begin to address the PT/SSC recommendations by:

1. Updating the current ADMB model to TMB to potentially improve parameter estimation
2. Accounting for both the impacts of cannibalism and fishery removals in the population dynamics assessment model used for GOA ATF
3. Updating as much of the data as we can in the model
4. Create an ESP and begin to explore recent lower recruitment trends

We did these over the last two years and they were approved!

Data Table

Source	Data	Years
AFSC GOA bottom trawl survey	Survey biomass and standard error	1993,1996,1999,2001,2003,2005,2007,2009 2011,2013,2015,2017,2019,2021,**2023,2025**
	Age Composition	1993,1996,1999,2001,2003,2005,2007,2009 2011,2013,2015,2017,2019, **2021,2023 2025**
U.S. fisheries	Catch Biomass	1977-2021, **2022-2026**
	Length composition	1991-2020, **2021-2025**

*Note catch is current up to 8/22/2026

Data Improvements - approved in September 2025

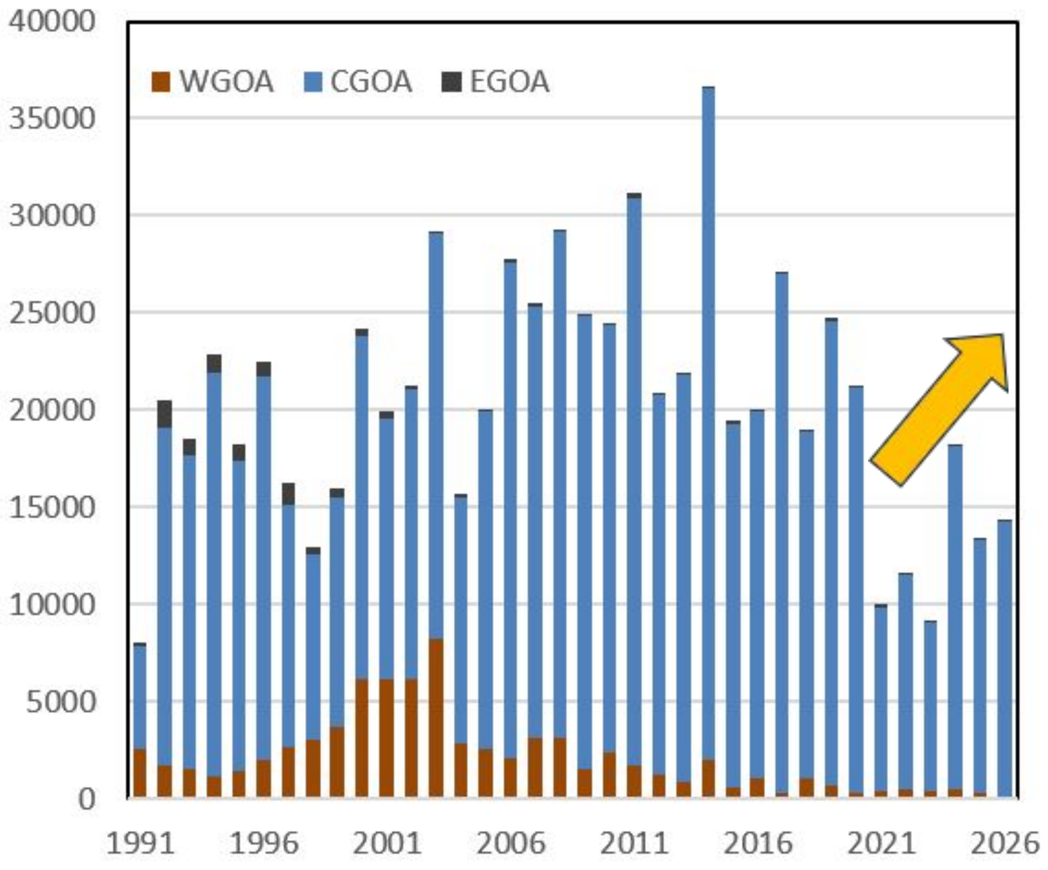
- Input Data
  - New catch, fishery length compositions, survey biomass, age compositions
  - Removed trawl survey and age compositions from non-standardized surveys and years with low confidence in arrowtooth identification (pre-1992)
  - Removed fishery length compositions prior to Observer Program (pre-1991) and years with lower sample sizes (<300 samples)
- Transition matrices
  - Changed fishery length composition bins to match the observed length distribution, also updated the length@age transition matrices and growth curves
  - Updated weight@age and age error with GOA data and provided a sensitivity to the age error matrix calculation (empirical versus modeled)

New Data since September 2025

- Input Data
  - New catch through 2026 and new fishery length composition for 2025
  - New survey biomass and age compositions for 2025
- Updated Auxiliary Data
  - ADF&G large-mesh bottom trawl survey index and length compositions
  - AFSC longline survey index and length compositions

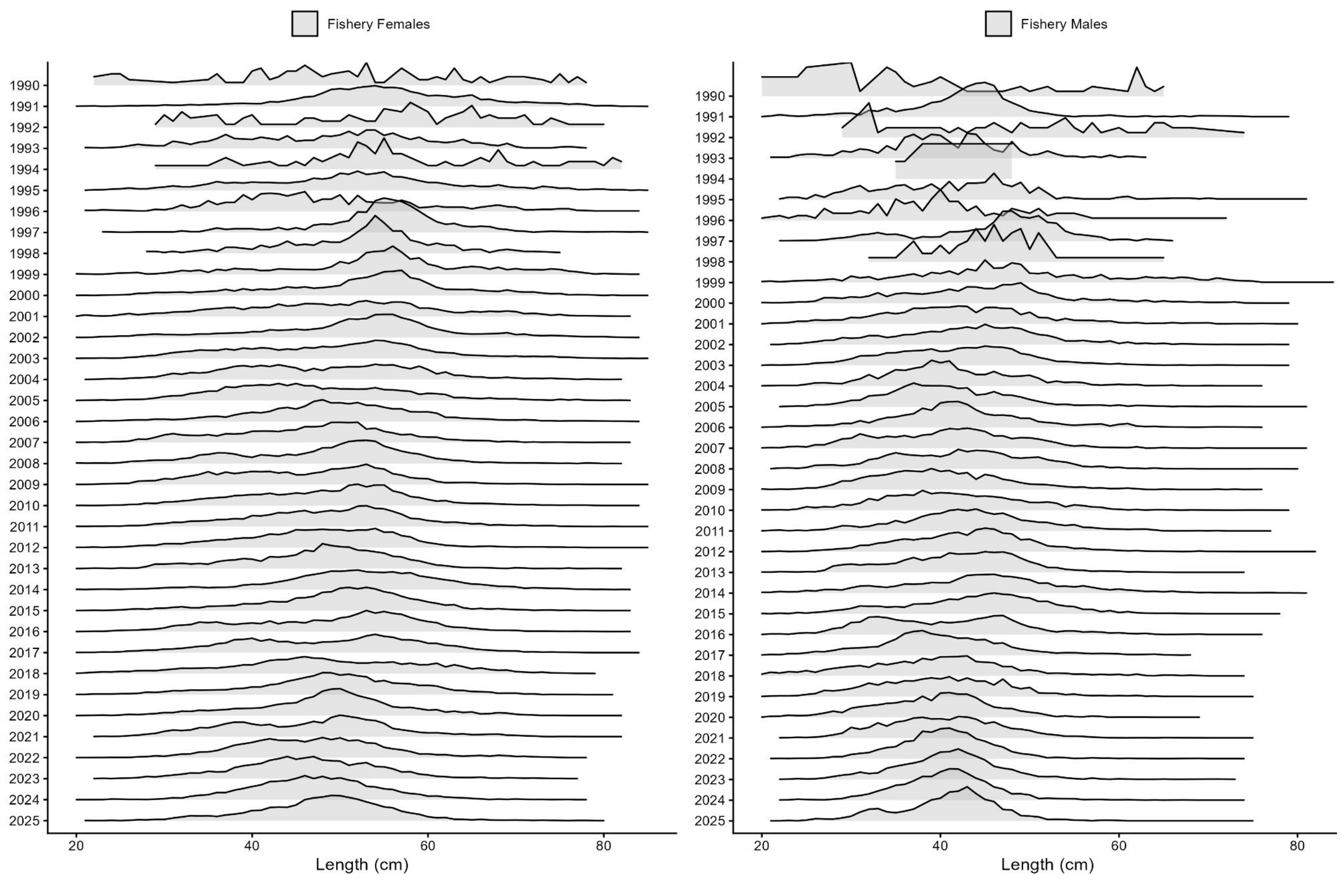
Fishery Catch Data

- Trends (data thru 8/22/2026)
  - Majority in the CGOA, and WGOA been < since mid 2000s
  - Decrease in catch in 2021 by 53%
  - Increase last few years by 43%
- Ratio catch/ABC is 11%
- ESP: Catcher processors catch near time series low



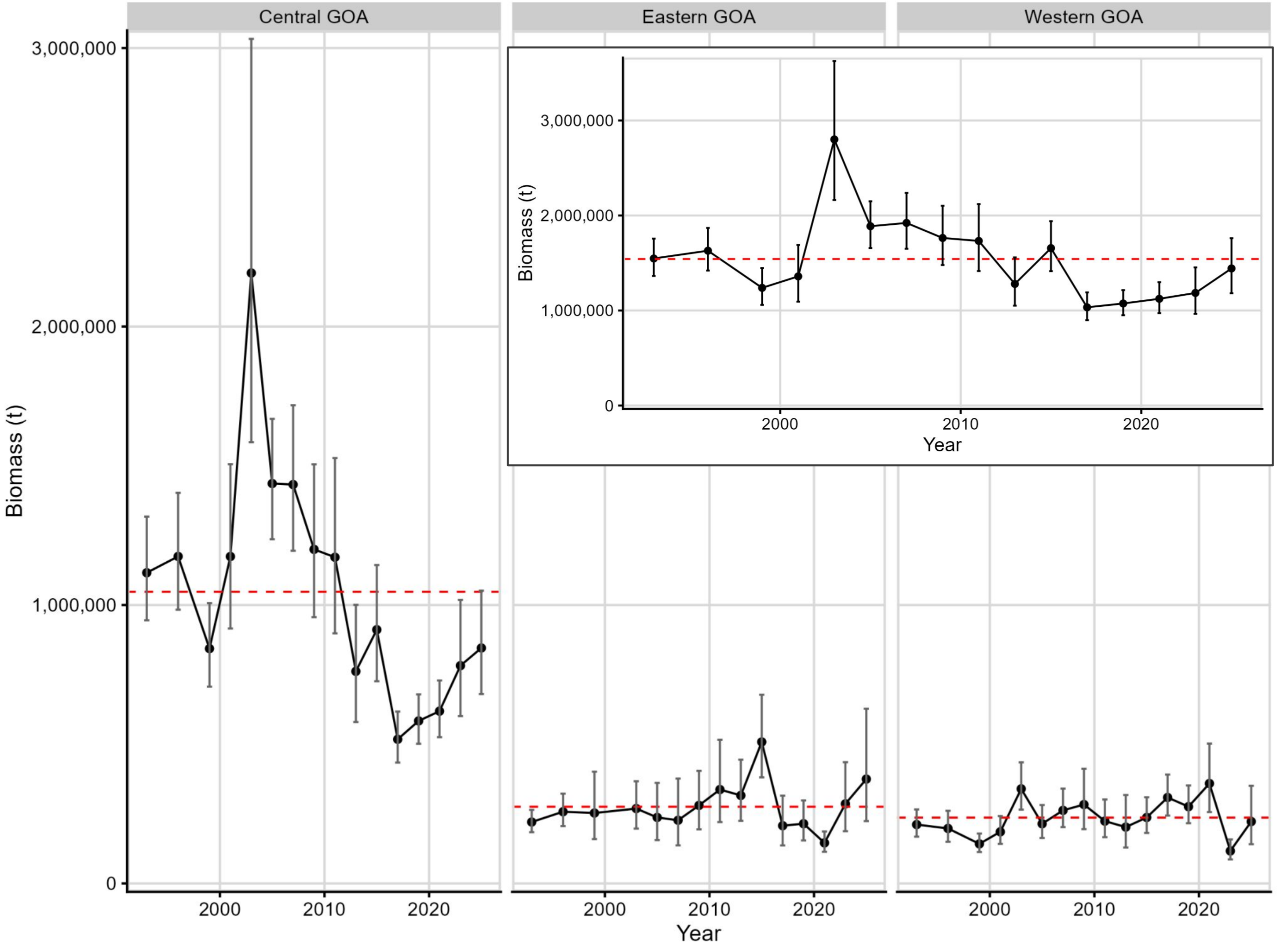
Fishery Composition Data

- Otolith samples generally low, deprioritized for ageing
- Length data available since 1990 to last full year, removed if low sample size
  - Median is 46 cm (females = 49, males = 42)
  - No clear directional trend, but larger females in 1990s
  - Kamchatka flounder not identified until 2008



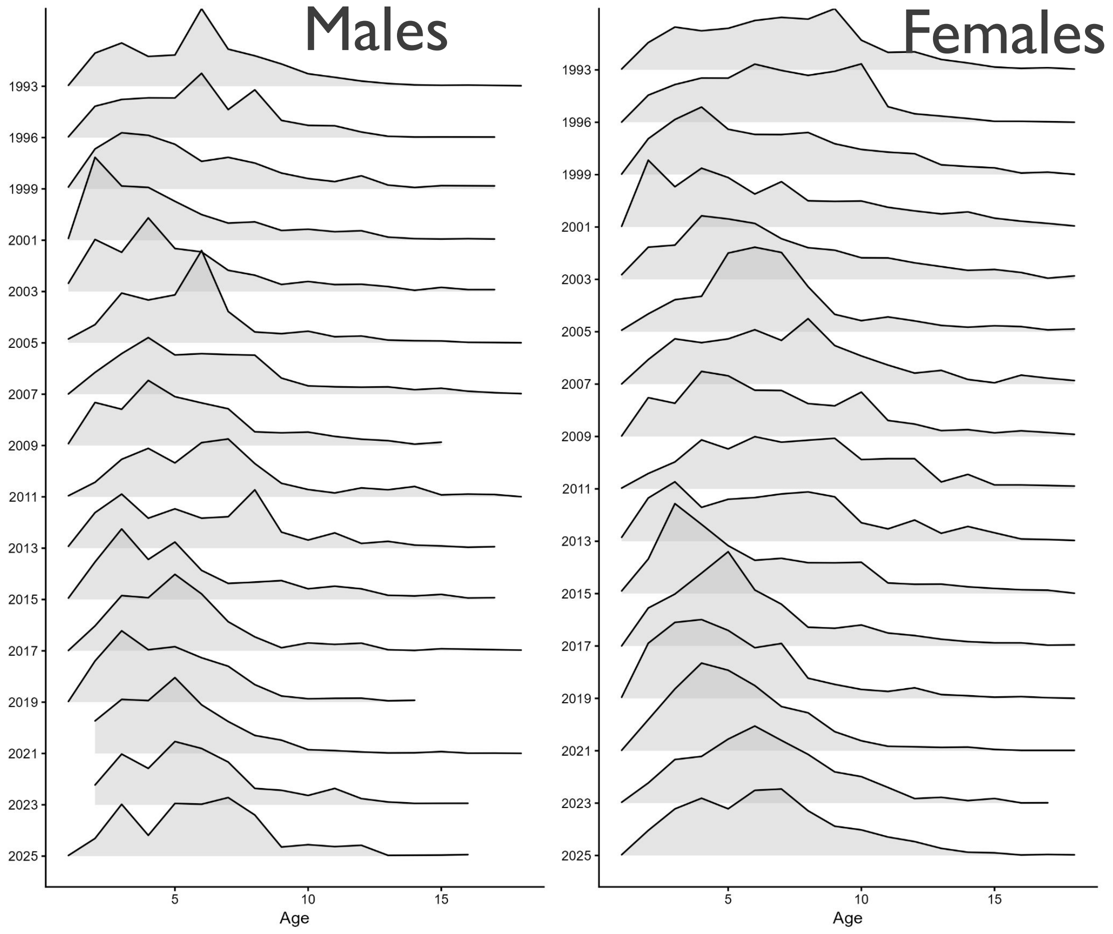
Bottom Trawl Survey Index

- Triennial 1993-1999, biennial 2001-present
  - No sampling in EGOA in 2001 (avg of previous 3 surveys to estimate)
  - Increased to high point in 2003 then decreased to low in 2017, increasing slowly to average in 2025 survey
  - Highest in CGOA, similar low biomass in E & WGOA



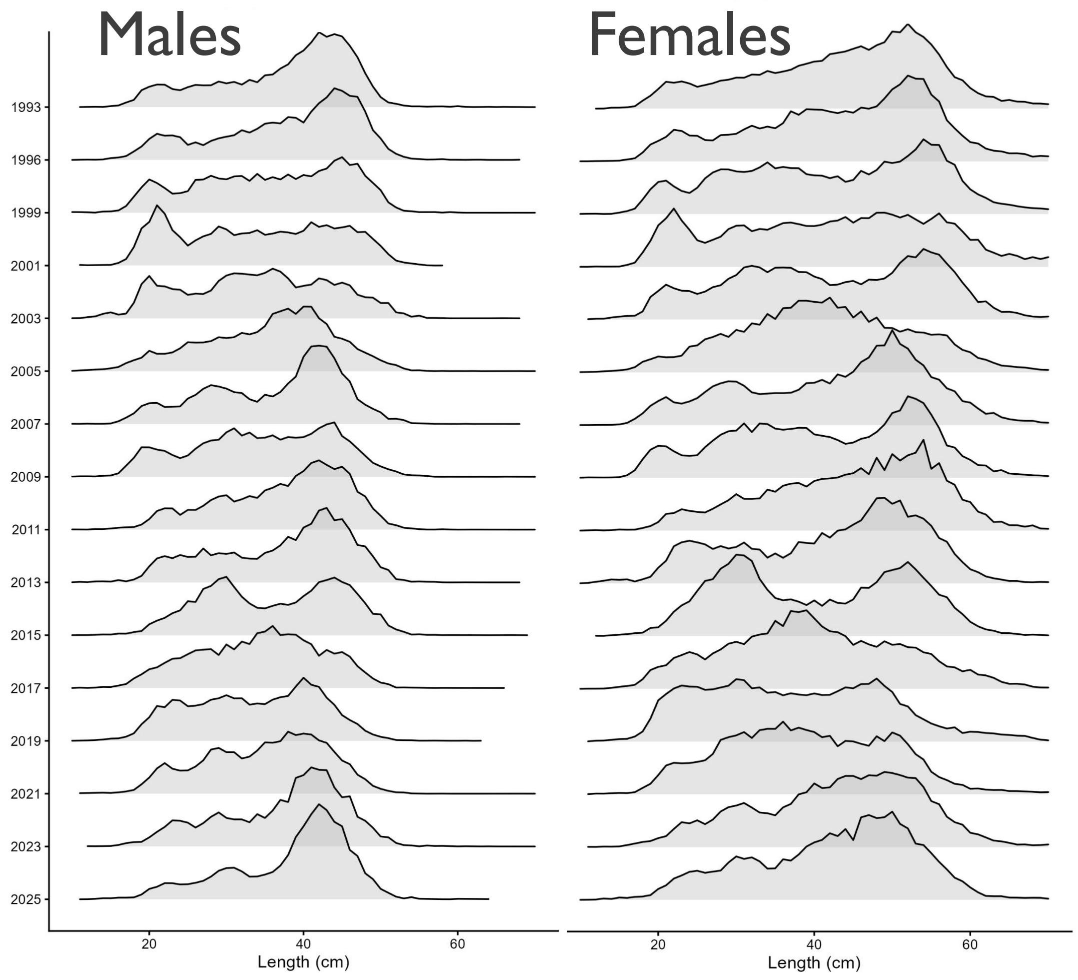
Bottom Trawl Survey Composition Data - Age

- Age data available for all surveys since 1993
  - Median age is 11 (females = 11, males = 10)
  - Ages for both males and females more spread out prior to 2015 survey
- Prioritized 2025 GOA ages, and thank AGP for them!!!



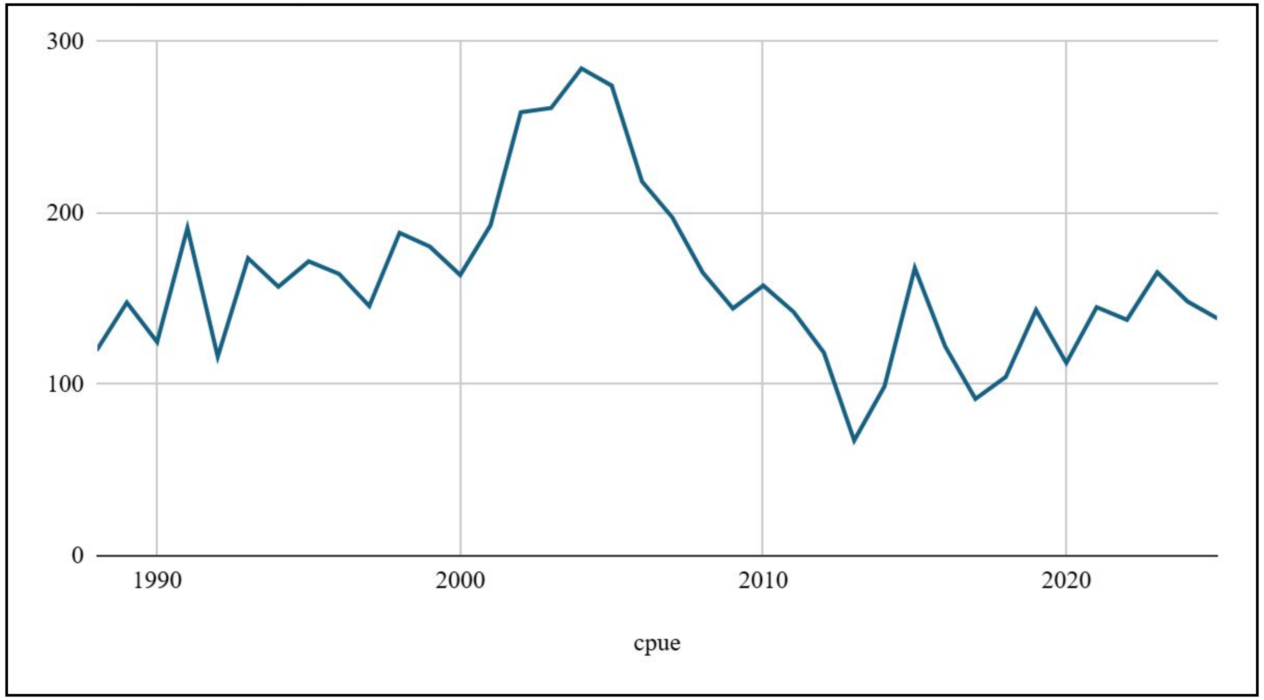
Bottom Trawl Survey Composition Data - Length

- Length data available for all surveys since 1993
- Length data not used when age data available
  - Median length is 40 cm (females = 46, males = 35)
  - No long term trends, females larger than males
  - Larger fish for both often sampled in EGOA



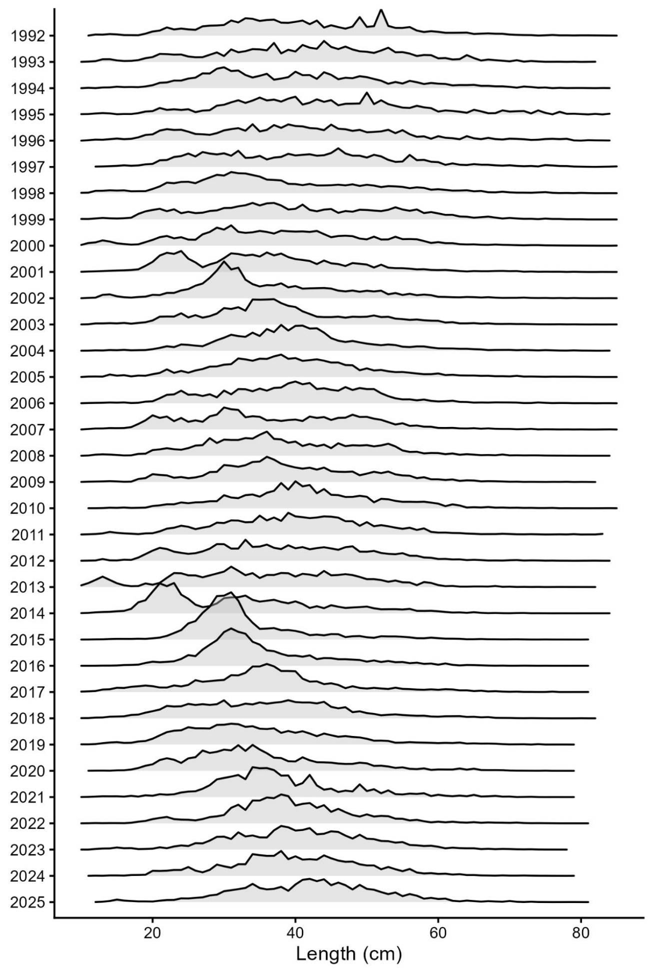
ADF&G Bottom Trawl Survey Index

- Large-mesh trawl in GOA
  - Reported in ESP to track the nearshore habitat, available annually since 1988
  - CPUE increased until mid 2000s then dropped to time series low in 2013, slowly increased to 2025
  - Similar trajectory to AFSC bottom trawl, earlier recovery



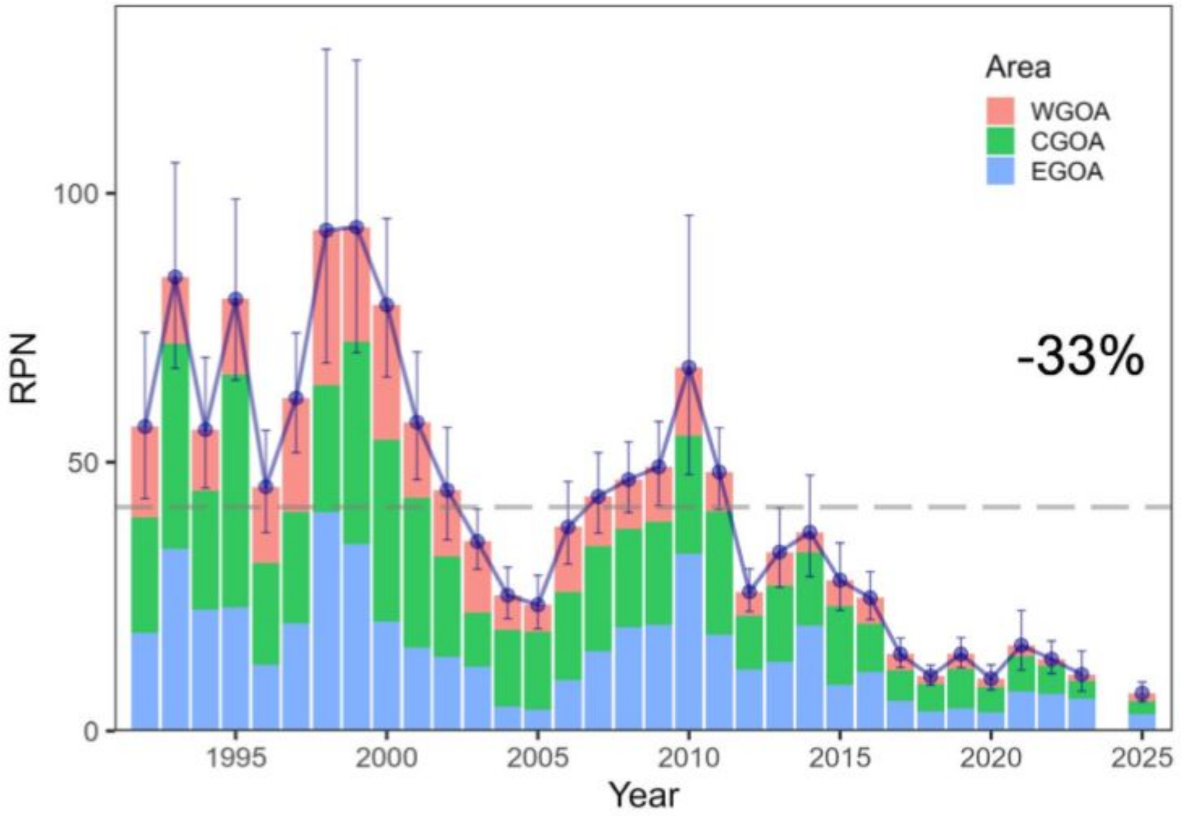
ADF&G Bottom Trawl Composition Data - Length

- Length data available for all surveys since 1992
- Representative of population in nearshore habitat
  - Median length is 37 cm (not sexed), similar to the bottom trawl survey
  - Some cohorts well tracked, such as 2001 and 2013



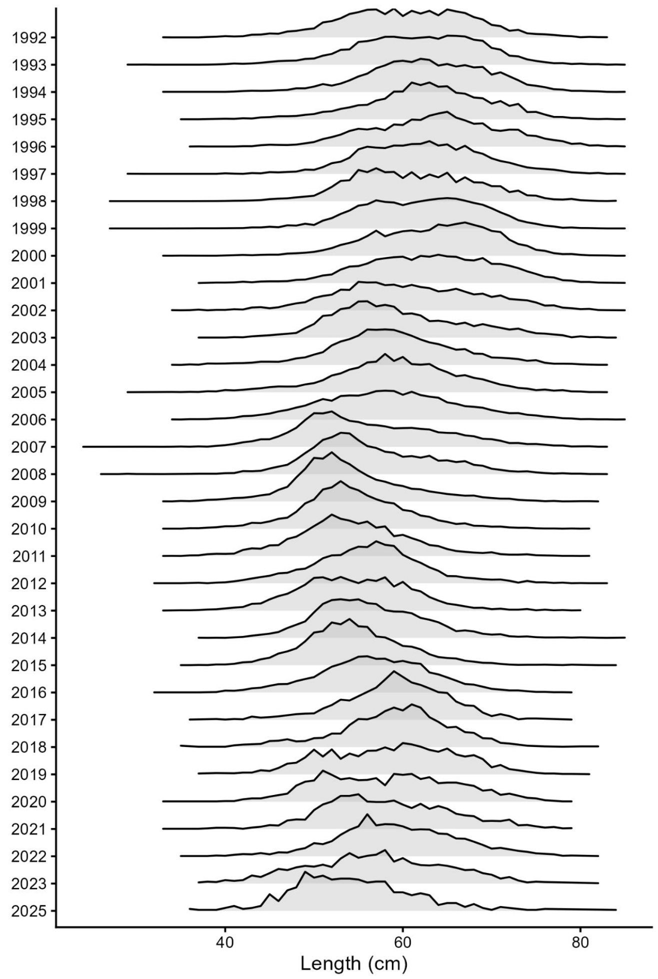
AFSC Longline Survey Index

- Longline survey in GOA
  - Available annually since 1992 until 2023, then biennial
  - Relative population numbers for arrowtooth/Kamchatka (separated in 2019) in slope habitat, mostly in C/EGOA
  - Does not account for hook competition with sablefish

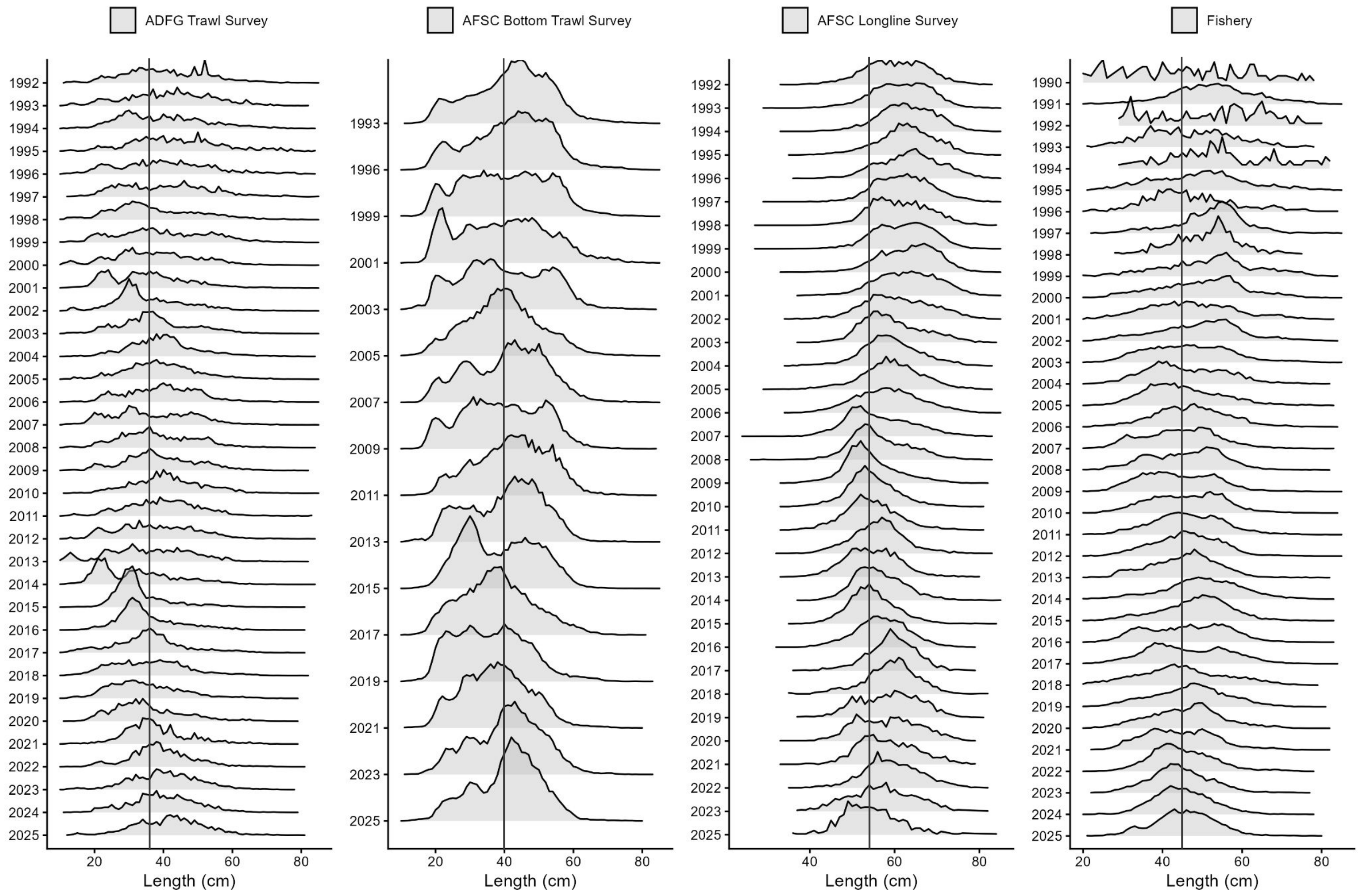


Auxiliary Composition Data - Longline Length

- Length data available for all surveys since 1992, no survey 2024
- Representative of population in shelf/slope habitat
  - Median length is 59 cm (not sexed)
  - Larger sizes through mid-2000s, then shift to small sizes until 2017, lower sample sizes after this
  - Lower samples sizes in recent years possibly due to lower population or hook competition with large recruits of sablefish



Comparison of Length Compositions



Analytical Approach

- Platform: Rceattle for Climate-Enhanced, Age-based model with Temperature-specific Trophic Linkages and Energetics in R
  - From Holsman et al., 2016 and expanded for groundfish in the GOA using TMB by Adams et al., 2022
  - Links single-species age-structured models through predation mortality
  - Conditioned on the temperature-dependent bioenergetic demand and diet-based prey-selectivity patterns of predators
  - Can be run in single-species mode or multi-species mode
- Data: uses the same inputs as the ADMB operational assessment
  - Addition of diet and bioenergetics from AFSC stomach sampling program and bottom temperature data from Climate Forecast System Reanalysis (Hulson et al., 2023)

Alternative Models

1. Model 25.0_old: single-species TMB based Rceattle model with data improvements that fixes sex-specific M (females = 0.2 and males = 0.35) and treats annual recruitment as random effects, uses data presented in September 2025. **BASE with old data**.

2. Model 25.0: Model 25.0_old that uses data up through the present. **BASE with new data**.

3. Model 25.1: Model 25.0 but estimates sex-specific M instead of fixing M. **Alternative model to evaluate**.

Research Models (from ESP)

1. Multi-species TMB based Rceattle model that estimates total mortality for pollock, Pacific cod, Pacific halibut, and arrowtooth flounder, fit to data from five fisheries and seven survey between 1977 and last full assessment for the stocks in the model), predation mortality derived by bioenergetics-based consumption and diet data, and treats annual recruitment as random effects (Adams et al., 2022)
2. ESP-DSEM external model on recruitment that uses the simplified structural model to predict recruitment estimates from the last accepted arrowtooth model (25.0_old). (Bigman et al., *in review*, preprint available)

Results - Model Evaluation Summary (25.0 vs 25.1)

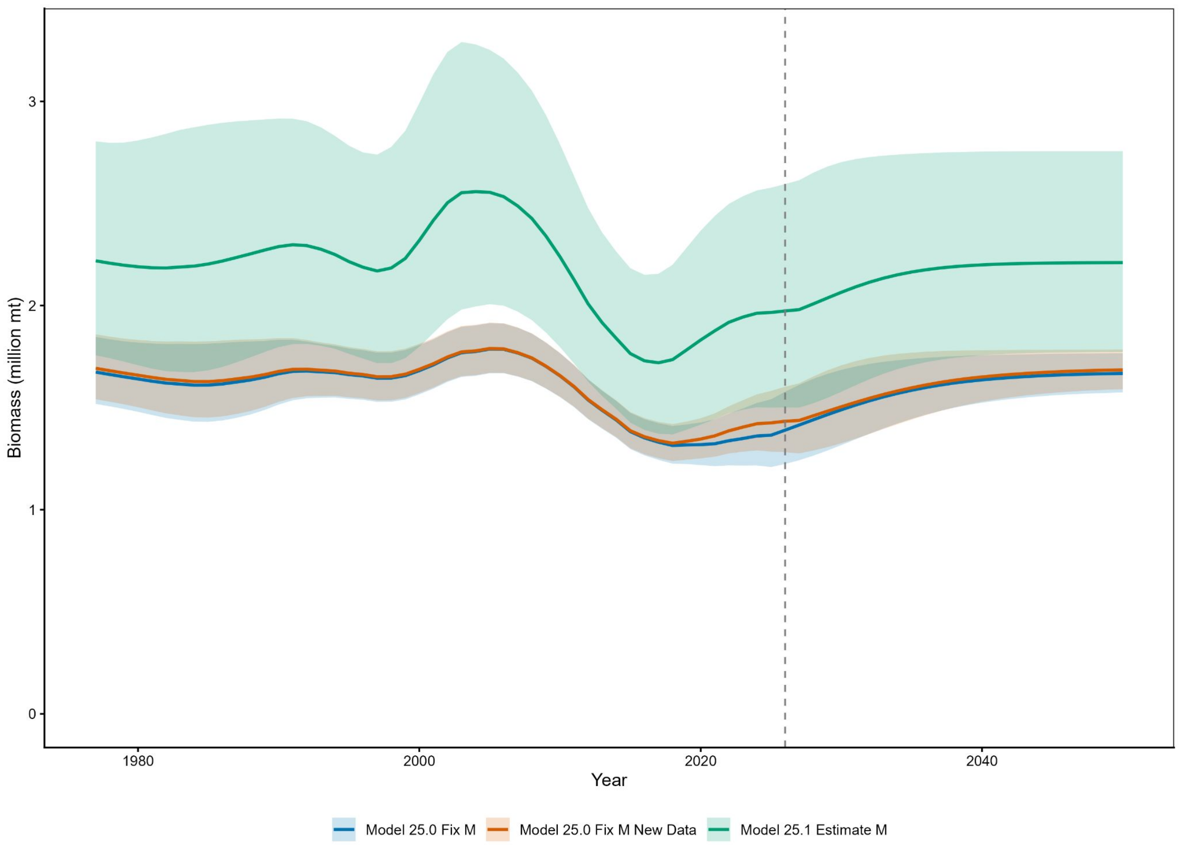
- Both models achieved verified convergence with an invertible Hessian matrix and small maximum gradient components
- Biomass and recruitment trends are similar between models, Model 25.1 causes a dramatic rescaling of population scale
- To balance higher mortality rates from Model 25.1 (M_{female} = 0.330 (65% increase) and M_{male} = 0.407 (16% increase), estimated mean recruitment increases more than 3-fold
- Model 25.1 projects a 38% higher total biomass in 2027 due to rapid population turnover, and a subsequent decrease in SSB by 19% because fewer fish survive to older spawning ages under higher *M*

Parameter Estimates Comparison

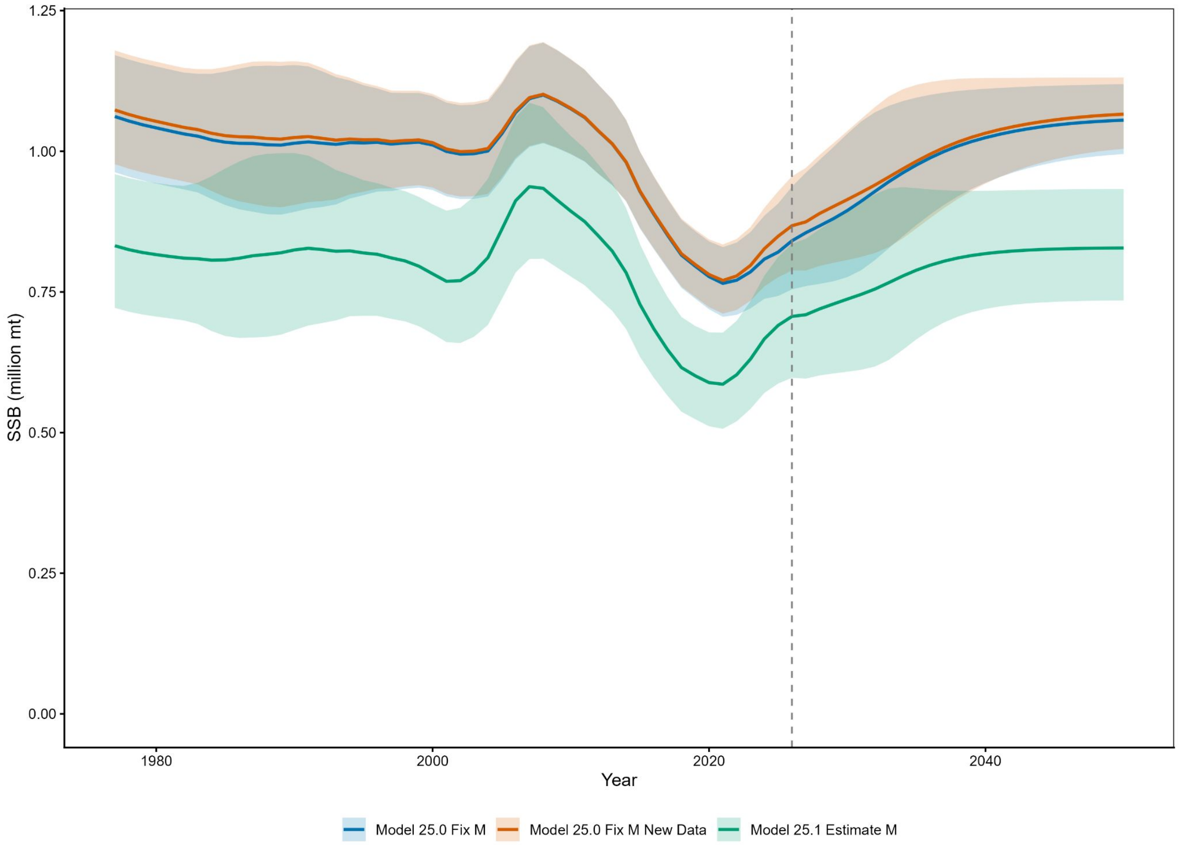
Estimates	Model 25.0_old	Model 25.0	Model 25.1
q-trawl	1	1	1
Mean Recruitment (thousand)	735,190	743,237	2,503,196
Recruitment Variability (σ_r)	0.290	0.281	0.276
Natural Mortality (M) female	0.20 (fixed)	0.20 (fixed)	0.330
Natural Mortality (M) male	0.35 (fixed)	0.35 (fixed)	0.407
2027 total biomass (t)		1,437,490	1,980,340
2027 spawning biomass (t)		874,501	709,459
$B_{100\%}$ (t)		1,073,870	829,454
$B_{40\%}$ (t)		429,548	331,781

Model Comparison

Total Biomass

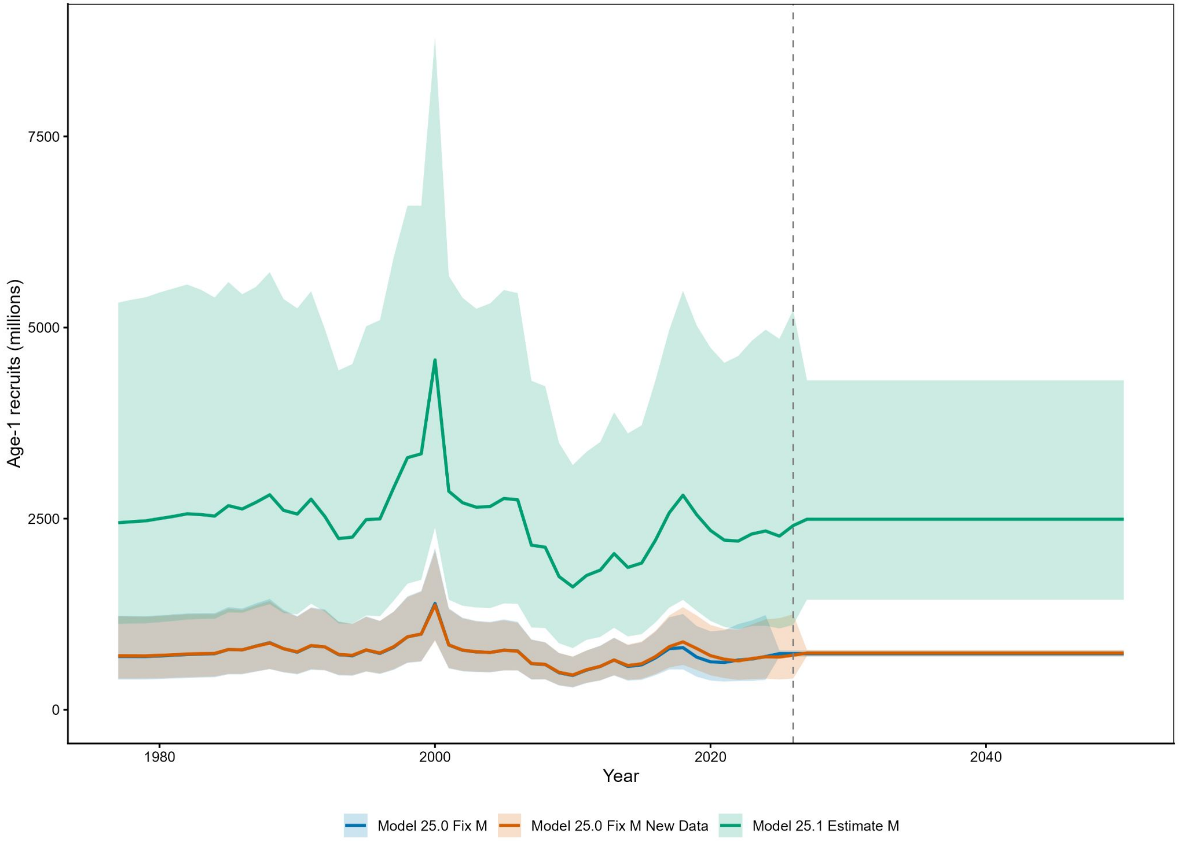


Spawning Stock Biomass

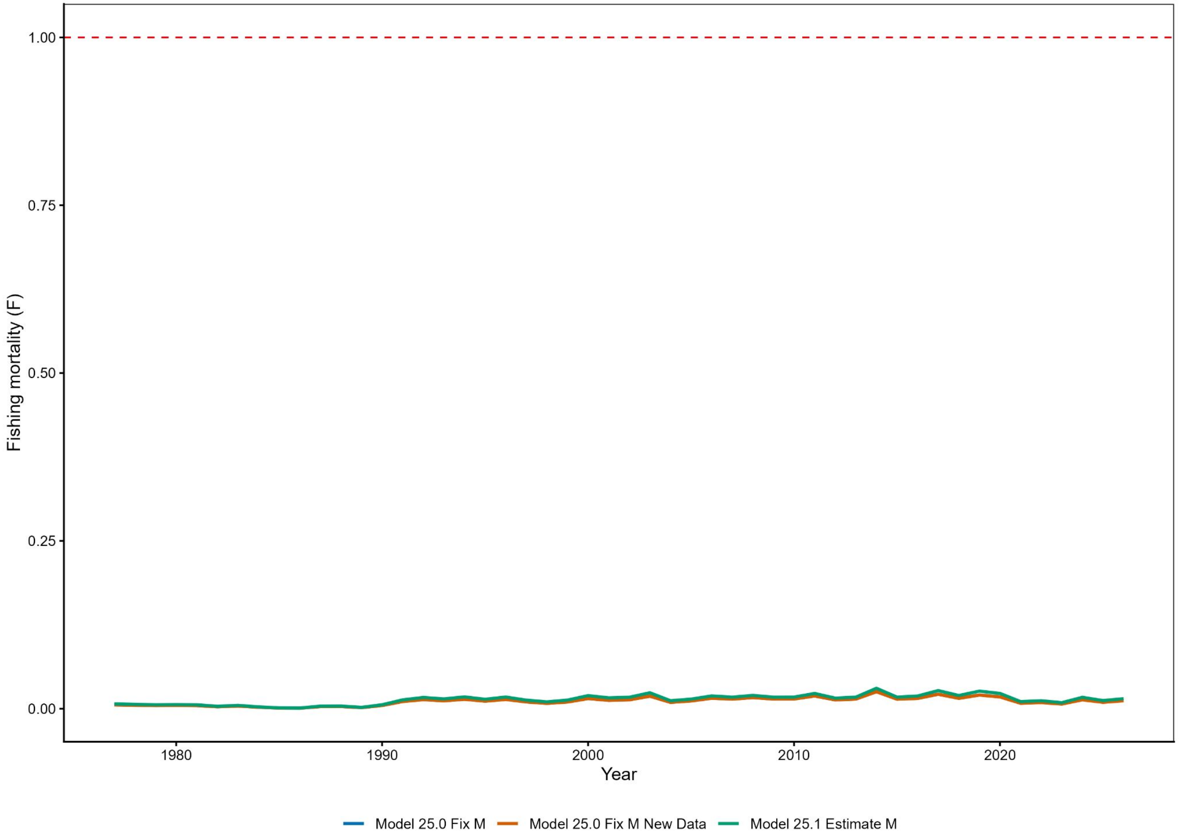


Model Comparison

Recruitment

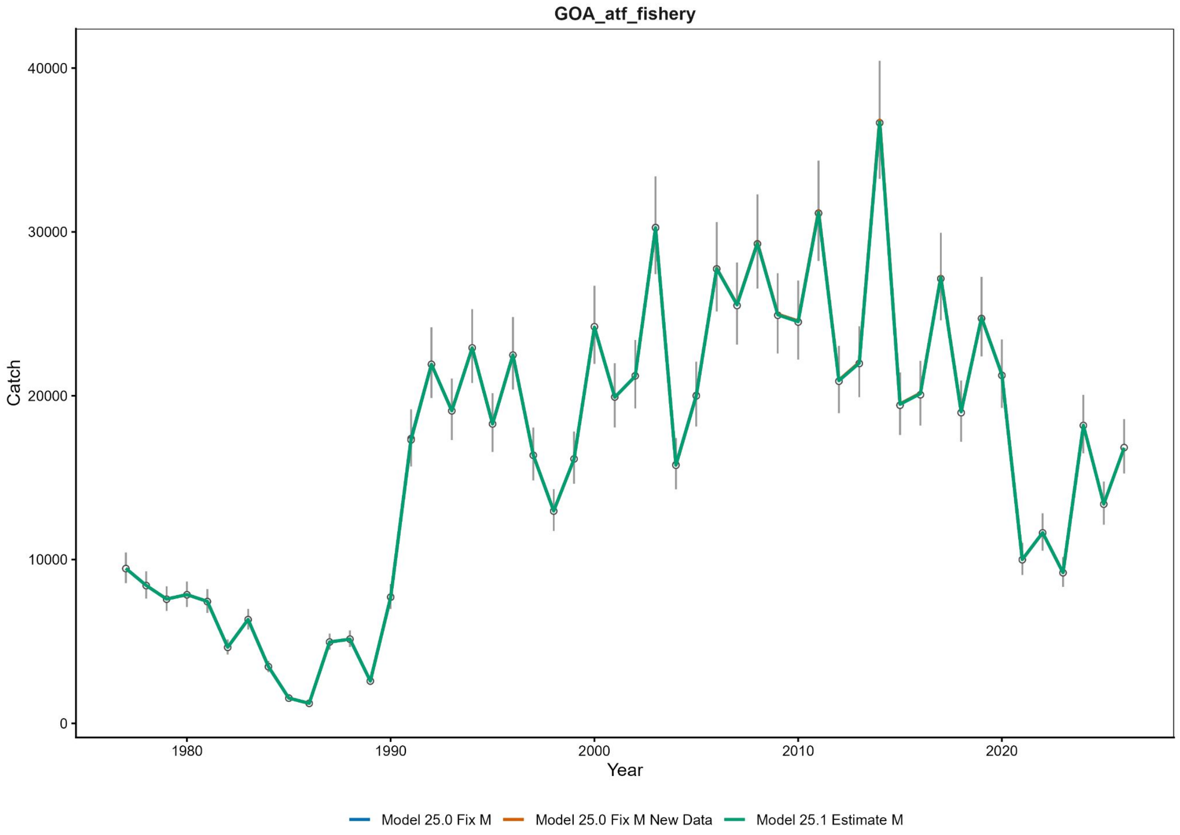


Fishing Mortality

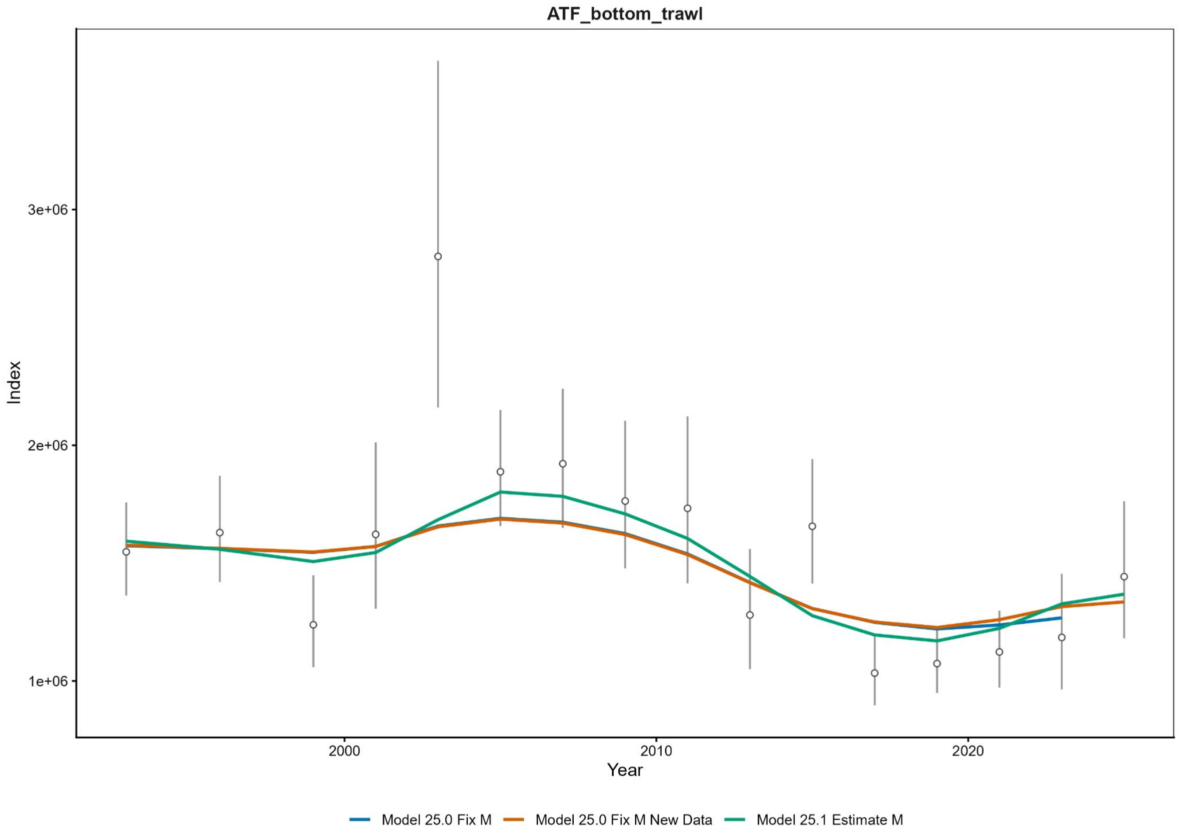


Model Comparison

Catch

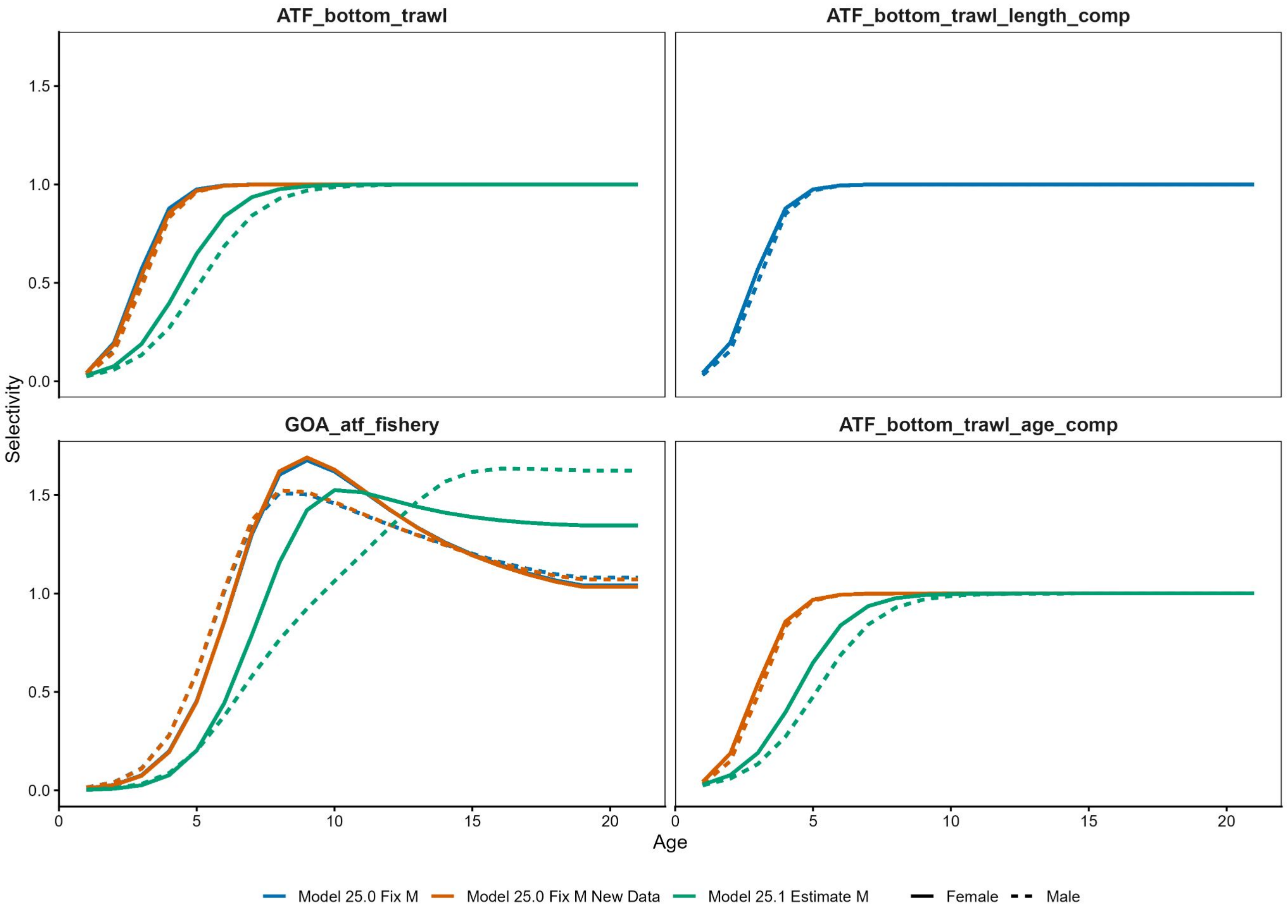


Survey Index



Model Comparison

- Model 25.0: fishery selectivity is dome-shaped for both sexes, suggesting older fish present but fishery not capturing them
- Model 25.1: higher female *M* makes female fishery selectivity an asymptotic curve, suggesting that older females die rather than escaping the gear



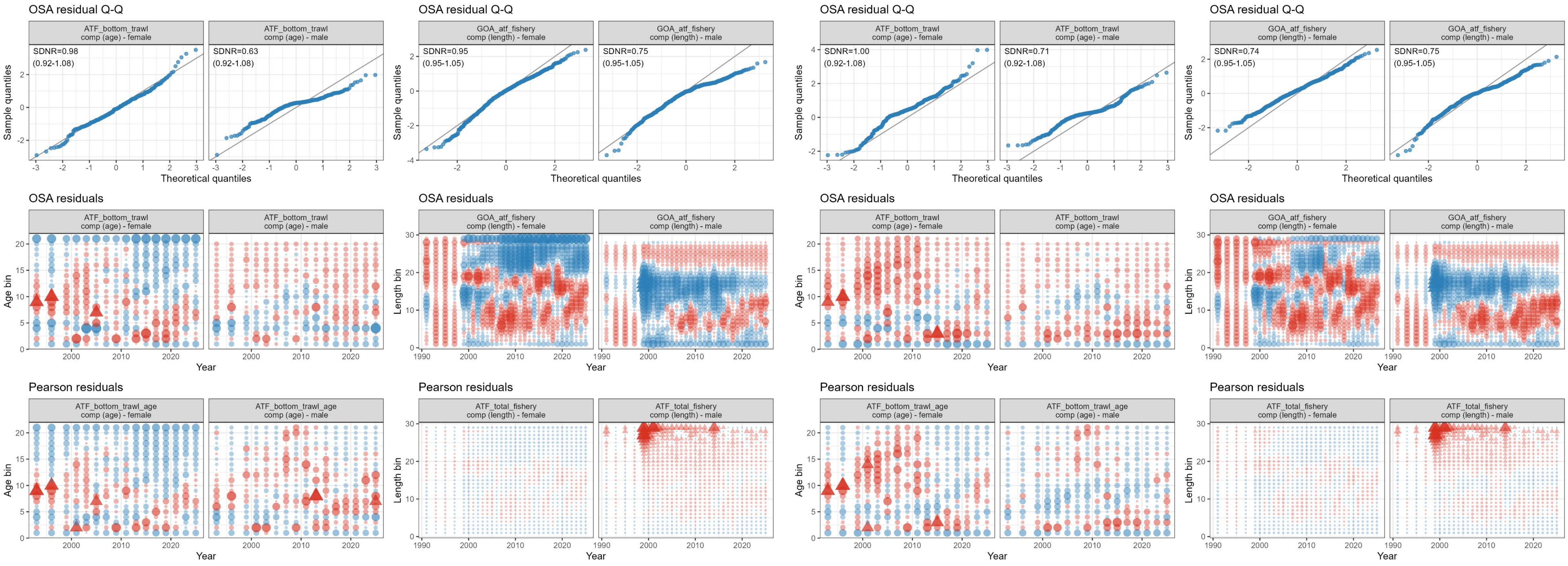
Results - Model Diagnostics Summary (25.0 vs 25.1)

- One-Step-Ahead (OSA) residuals show well-behaved residuals for both models, eliminating false misspecification flags from Pearson residuals
- Model 25.0 exhibits global convergence stability (100% of perturbed jitter runs returned to the exact same global minimum). Model 25.1 exhibits structural instability characterized by separate biomass trajectories and multiple local likelihood minima
- Model 25.0 achieved highly precise, unbiased parameter recovery, while Model 25.1 displays wider confidence intervals and mild estimation bias due to parameter trade-offs between M and selectivity

Model Diagnostics - OSA Residuals

Model 25.0

Model 25.1



Why Not Model 25.1

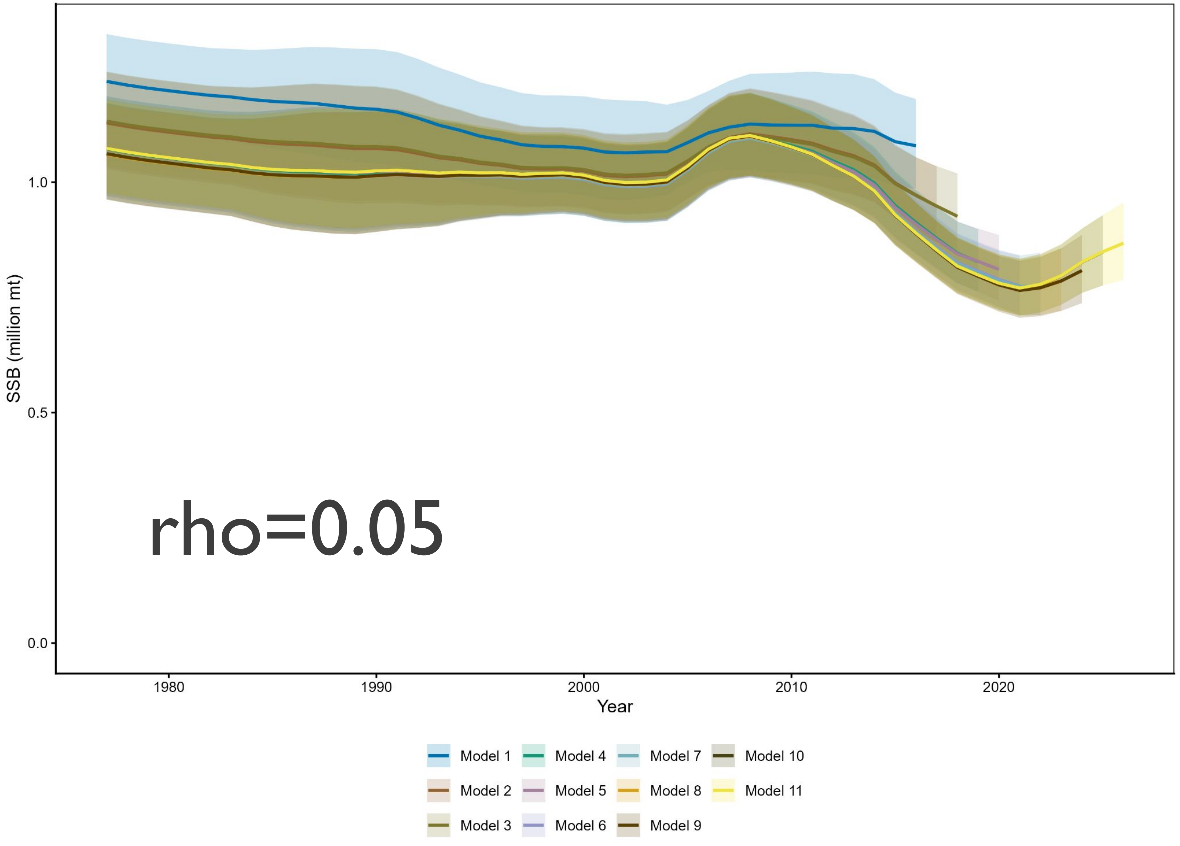
- **Biologically implausible *M*:** adult natural mortality rate of 0.33–0.41 is unrealistically high for adult flatfish and this contradicts an empirical catch-curve analysis of bottom trawl survey specimen data (ages 6+) estimates total mortality (Z) at 0.22 for females and 0.28 for males
- **We still observe old fish**: if adult *M* were actually near 0.33–0.41, the population would die off rapidly, and older fish would be mostly absent, but we routinely observe older age classes in the surveys
- **Extreme population rescaling**: to offset the high natural mortality estimated in Model 25.1, the model inflates mean recruitment more than 3-fold, artificially increasing total biomass and decreasing SSB

Author Preferred Model 25.0

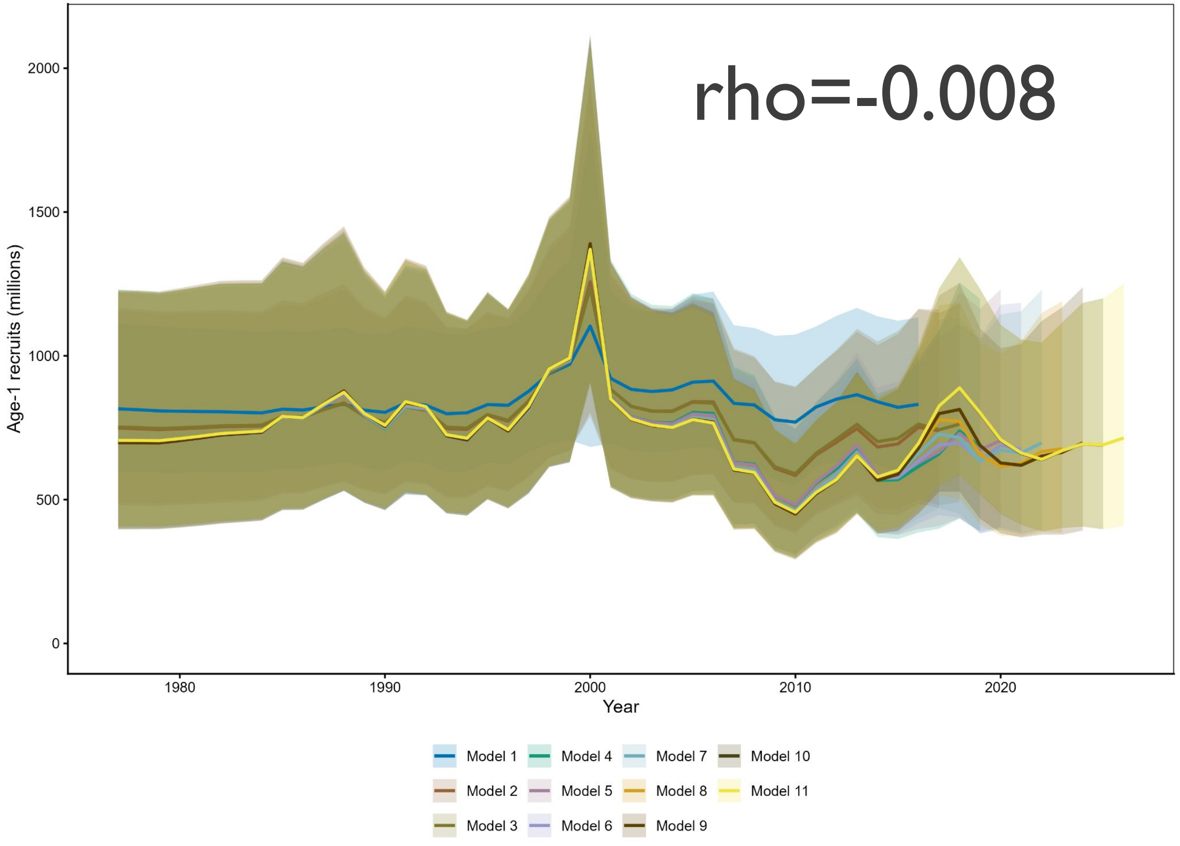
- Provides stable, biologically plausible population trajectories, avoids artificial population rescaling, and exhibits better estimation performance across jitter and self-test diagnostics
- Has well-behaved OSA residuals bounded within standard expectations and exhibits weaker temporal "blocking" in female bottom-trawl survey age compositions
- Retrospective Mohn's ρ statistics were small overall at 0.036, 0.050, and -0.008 for total biomass, spawning biomass, and recruitment, respectively for Model 25.0

Retrospectives Model 25.0

SSB

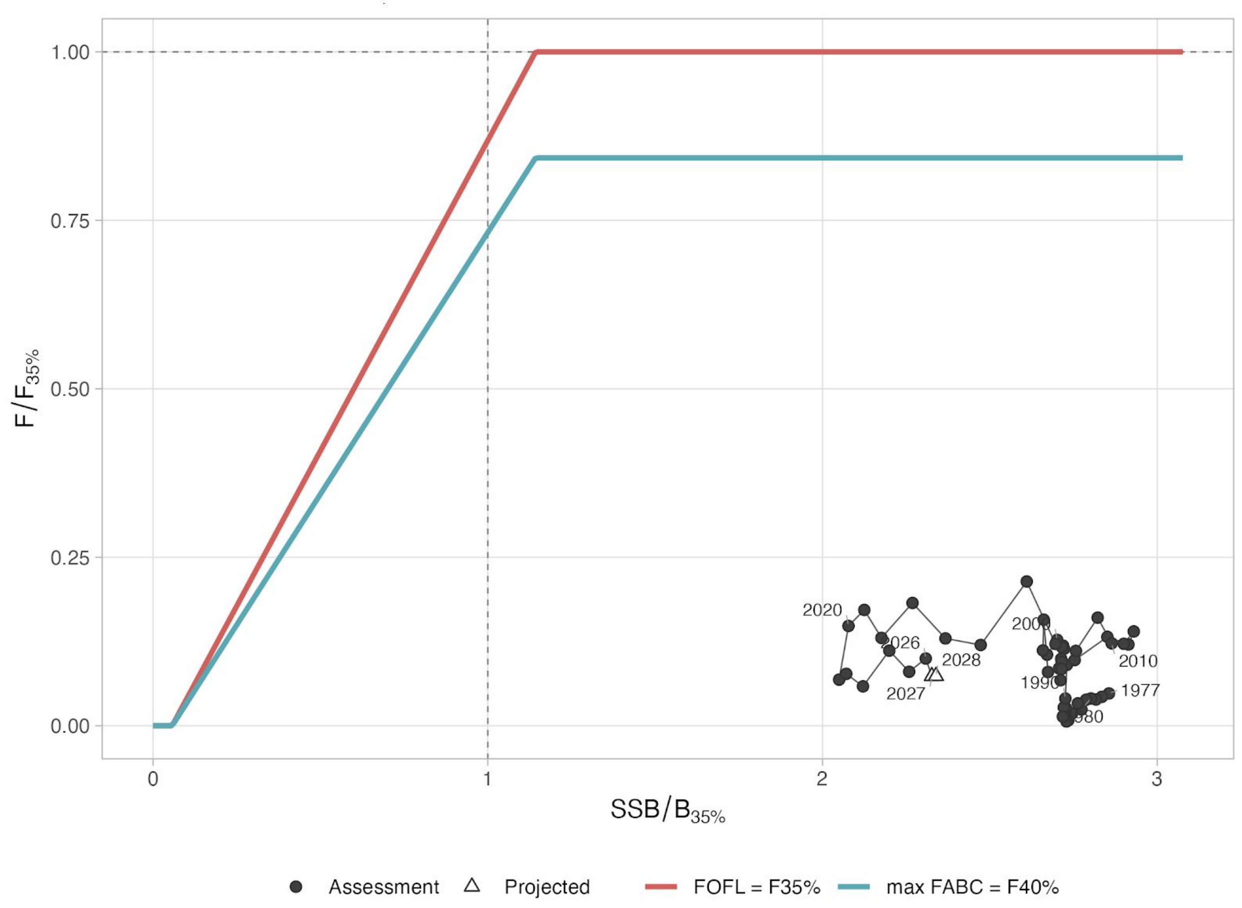


Recruitment



Phase Plane

- SSB is above B40%
- Stock is lightly exploited relative to reference points and trend expected to continue through 2028



Risk Table

Assessment-related Considerations	Population Dynamics Considerations	Ecosystem Considerations	Fishery-informed Stock Considerations
Level #: 1	**Level #:** 1	**Level #:** 1	**Level #:** 1
Unresolved structural uncertainty between *M* and selectivity, evaluate this in future and consider estimating M for younger ages (multispecies model). Model 25.0 has good convergence, reasonable diagnostics, little effect due to retrospective bias	Predictive indicators from ESP suggest average to higher survival of the 2024 age-0 year class, but 2025 was potentially a low survival year for age-0 arrowtooth flounder (due to high sea surface temperatures, low larval abundance, and poor prey conditions)	The adult population experienced ~ avg environmental conditions with moderate prey resources in 2026 (limited reporting). El Niño conditions in 2027 are not expected to impact adult survival at the population level, but distribution shifts may occur. Area occupied expanded and pop moved southwest	Stock is underutilized with average percent ABC at 12% from ESP indicators, fishery performance indicators not showing unusual trends or changes in fishery

Summary Table

- The stock is not being subject to overfishing, is not currently overfished, nor is it approaching a condition of being overfished
- ABC = 134,083
- OFL = 157,261

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2026	2027	2027*	2028*
M (natural mortality – female, male)	0.2, 0.35	0.2, 0.35	0.2, 0.35	0.2, 0.35
Tier	3a	3a	3a	3a
Projected total (age 1+) biomass (t)	1,316,560	1,341,280	1,437,490	1,447,782
Projected female spawning biomass (t)				
Estimate	699,407	696,032	874,501	879,111
$B_{100\%}$	1,018,700	1,018,700	1,073,870	1,073,870
$B_{40\%}$	407,478	407,478	429,548	429,54[illegible]
$B_{35\%}$	356,544	356,544	375,855	375,855
F_{OFL}	0.225	0.225	0.1179	0.1179
$maxF_{ABC}$	0.185	0.185	0.0994	0.0994
F_{ABC}	0.185	0.185	0.0994	0.0994
OFL (t)	143,347	143,347	**157,261**	157,060
*max*ABC (t)	119,985	119,985	134,083	133,901
ABC (t)	119,985	119,985	**134,083**	133,901
	As determined *last* year for:		As determined *this* year for:	
Status	2024	2025	2025	2026
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

*Projections are based on an estimated catch of 16,835 t for 2026 and estimates of 12,409 t and 12,409 t used in place of maximum permissible ABC for 2027 and 2028.

Apportionment

	Western	Central	West Yakutat	East Yakutat/SE	Total
2021 Area Apportionment	28.1%	57.1%	5.6%	9.2%	100%
2026 ABC (t)	33,716	68,511	6,719	11,039	119,985
2027 ABC (t)	33,716	68,511	6,719	11,039	119,985
2026 Area Apportionment	19.1%	59.9%	7.23%	13.80%	100%
2027 ABC (t)	25,572	80,318	9,692	18,501	134,083
2028 ABC (t)	25,537	80,20	9,679	18,476	133,901

Future Research

1) Investigate options to integrate additional survey datasets that sample different portions of the stock (ADF&G or longline survey)
2) Evaluate alternative survey and fishery selectivity structures, examine potential bottom-temperature relationships with catchability, and test age-varying natural mortality in Rceattle
3) Re-evaluate fishery length composition weights, explore Dirichlet-multinomial to estimate effective sample sizes, and incorporate upcoming standardized software tools to calculate Input Sample Sizes (ISS)
4) Update multispecies and ESP-DSEM models alongside the operational assessment to inform the risk tables, and potentially integrate environmental drivers directly into harvest projections during off-cycle assessment years

Thank You!

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