18. Assessment of the Skate Stock Complex in the Bering Sea and Aleutian Islands

Cindy A. Tribuzio, Mary Elizabeth Matta, Steve Barbeaux

Alaska Fisheries Science Center

Matt Cheng

University of Alaska Fairbanks

November 2026

With Contributions from: Elizabeth Siddon and Ivonne Ortiz

This report may be cited as: Tribuzio, C.A., M.E. Matta, S. Barbeaux, and M. Cheng. 2026. Assessment of the skate stock complex in the Bering Sea and Aleutian Islands. North Pacific Fishery Management Council, Anchorage, AK. Available from https://www.npfmc.org/library/safe-reports/

Executive Summary

The Bering Sea and Aleutian Islands (BSAI) Skate Stock Complex is managed in aggregate, with a single set of harvest specifications applied to the entire complex. However, to generate the harvest recommendations the stock is divided into two units. Harvest recommendations for Alaska skate (*Arctoraja parmifera*, formerly *Bathyraja parmifera*), the most abundant skate species in the BSAI, are made using the results of an age-structured model and are managed under Tier 3. The remaining species (Other Skates) are managed under Tier 5 due to a lack of data. The Tier 3 and Tier 5 recommendations are combined to generate recommendations for the complex as a whole.

A number of issues surrounding the previously accepted Alaska skate Tier 3 model were raised during the September 2025 presentation to the Plan Team and SSC (Tribuzio et al. 2025). These issues included some estimated parameters hitting bounds as well as an over-reliance on limited data sets and several procedural errors in the model control file. For the 2027 harvest recommendations, we propose an updated model, Model 25.3, which addresses the issues from the previous model. Harvest recommendations using the Tier 4 and Tier 5 harvest control rules are provided in Appendix 18.A, for comparison. No changes have been made to the previously accepted Other Skates Tier 5 model.

BSAI skates are generally assessed on a biennial stock assessment schedule. An operational assessment is conducted in odd years, and in even years a harvest projection is produced. Due to staff changes after 2020 and the lapse in appropriations during the 2025 stock assessment cycle, the assessment cycle for BSAI skates has diverged from the typical biennial pattern. This report presents an operational full assessment for the BSAI Skate Stock Complex. The last operational update and full assessments occurred in 2023 (Tribuzio et al. 2023) and 2020 (Ormseth 2020), respectively (both available at https://www.npfmc.org/library/safe-reports/).

Summary of Changes in Assessment Inputs

Changes in the input data:

1. Catch data have been updated through October 5, 2026. Total catch for 2026 was estimated by the mean proportion of catch occurring after October 5 over the previous 5 years.

This information is distributed solely for the purpose of pre-dissemination peer review under applicable information quality guidelines. It has not been formally disseminated by the National Marine Fisheries Service and should not be construed to represent any agency determination or policy.

2. 2024 and 2026 Aleutian Islands (AI) and 2024-2026 EBS bottom trawl survey biomass data were included.
3. Survey length compositions from the 2024-2026 EBS shelf bottom trawl survey and fishery length compositions from 2024-2026 were included in the Alaska skate Tier 3 model.

Changes in assessment methodology:

The previous accepted Tier 3 Alaska skate model is Model 14.2d. Here we present the updated base model and one model alternative, both of which were introduced in September 2025.

- **Model 14.2d1:** This is the base model with a bridge to the newer version of Stock Synthesis (v3.30.23.2). Jitter was changed from 1% to 10%, maximum lambda phase was changed from 4 to 1, and a recruitment ramp adjustment was included to be consistent with best practices. These changes are not part of the model and more to improve optimization. They are reported here for transparency.
- **Model 25.3:** Growth was estimated outside of the assessment model (compared to Model 14.2d1 where growth is estimated internally). Selectivities of all three fleets were modified by fixing parameters that created non-convergence issues.

There were no changes to the previously accepted Tier 5 model for Other Skates (**Model 23.0 (*rema*)**).

Summary of Results

The harvest recommendations resulting from the author-recommended models, Model 25.3 for Alaska skate and Model 23.0 for the Other Skates, are listed in the tables below. The total current year catch of the BSAI skate stock complex is estimated as the sum of the total current year catch for each species identified in the NMFS Alaska Regional Office Catch Accounting System (CAS): Alaska, Aleutian, big, longnose, whiteblotched, and other skates. The total catch for each species is estimated as the sum of the catch through the data retrieval date, October 5, 2026, and the recent 5-year mean of catch occurring after that date. Projections are based on estimated catches of 17,205 t for 2026 and 24,266 t (5-yr mean total catch) used in place of maximum permissible ABC for 2027 and 2028. The catch estimates for the full complex are used in projections because ABCs are not set for the Alaska skate separately.

Alaska skate harvest recommendations (Model 25.3)				
	As estimated or specified *last* assessment for:		As estimated or recommended *this* year for:	
Quantity	2025	2026	2027*	2028*
M (natural mortality rate)	0.13	0.13	0.13	0.13
Tier	3a	3a	3a	3a
Projected total (age 0+) biomass (t)	436,238	425,822	376,985	368,228
Projected Female spawning biomass (t)	98,443	91,145	98,154	92,882
$B_{100\%}$	178,425	178,425	155,861	155,861
$B_{40\%}$	71,370	71,370	62,344	62,344
$B_{35\%}$	62,449	62,449	54,552	54,552
F_{OFL}	0.093	0.093	0.100	0.100
$maxF_{ABC}$	0.08	0.08	0.085	0.085
F_{ABC}	0.08	0.08	0.085	0.085
OFL (t)	30,941	30,140	27,074	26,633
maxABC (t)	26,665	25,975	23,366	23,367
ABC (t)	26,665	25,975	23,366	23,367
	As determined *last* assessment for:		As determined *this* year for:	
Status	2022	2023	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 estimated catches of 17,205 t for 2026 and 24,266 t (5-yr mean total catch) used in place of maximum permissible ABC for 2027 and 2028. The catch estimates for the full complex are used because ABCs are not set for the Alaska skate separately.

Other Skate harvest recommendations (Model 23.0)				
	As estimated or specified *last* assessment for:		As estimated or recommended *this* year for:	
Quantity	2025	2026	2027	2028
M (natural mortality rate)	0.10	0.10	0.10	0.10
Tier	5	5	5	5
Biomass (t)	131,446	131,446	130,627	130,627
F_{OFL}	0.10	0.10	0.10	0.10
$maxF_{ABC}$	0.075	0.075	0.075	0.075
F_{ABC}	0.075	0.075	0.075	0.075
OFL (t)	13,145	13,145	13,063	13,063
maxABC (t)	9,858	9,858	9,797	9,797
ABC (t)	9,858	9,858	9,797	9,797
	As determined *last* assessment for:		As determined *this* year for:	
Status	2022	2023	2025	2026
Overfishing	No	n/a	No	n/a

Aggregate BSAI Skate Harvest Recommendations				
	As estimated or specified *last* assessment for:		As estimated or recommended *this* year for:	
Quantity	2025	2026	2027	2028
OFL (t)	44,086	43,825	40,137	39,696
maxABC (t)	36,523	35,833	33,163	33,164
ABC (t)	36,523	35,833	33,163	33,164

Summaries for Plan Team

Area	Year	Age 0+ Biomass	OFL	ABC	TAC	Catch
BSAI	2025	584,499	44,086	36,523	27,646	21,735
BSAI	2026	569,197	43,285	35,833	27,646	17,205
BSAI	2027	507,612	40,137	33,163	n/a	n/a
BSAI	2028	498,855	39,696	33,164	n/a	n/a

Responses to SSC and Plan Team Comments

Comments on Assessments in General

"The SSC recommends that stock assessment authors explicitly track and communicate any survey changes that impact their assessments and how (if needed) they have accounted for those changes." (SSC October 2024)

Author Response: We have explicitly detailed all bottom trawl survey additions and changes across the eastern Bering Sea shelf, EBS slope, and Aleutian Islands regions.

Comments Specific to this Assessment

"The SSC suggests that it may be appropriate to update the stock structure template during the next full assessment, with a focus on Alaska skate, as was requested by the SSC in 2018." (SSC December 2020, 2022, 2023)

Author Response: We have completed a stock structure document, focused mainly on Alaska skate (Matta et al. 2026). It is available on the eAgenda for the November Joint Groundfish Plan Team meeting.

"…The leopard skate biomass in the AI continues to decline and the SSC reiterates its concern over the decline of this rare endemic species." (SSC December 2023)

Author Response: We discuss the leopard skate biomass decline in the new stock structure evaluation (Matta et al. 2026) and recommend continued/improved monitoring of this species in the AI. Survey catches are highly variable; previous discussions with RACE staff indicate that survey trawl gear and bottom habitat complexity may reduce survey catchability of skates in general in the AI. Currently, fishery catch data for Alaska skates and leopard skates is combined; therefore, it is not possible to track catch of leopard skates. We have initiated a collaborative research proposal and special project with the AFSC Fisheries Monitoring and Analysis (FMA) division to collect biological samples for genetic species verification and life history parameter estimation.

"The Team recommends the authors examine using a catchability that is tuned to temperature." (BSAI PT November 2023)

"The SSC concurs with the recommendation to explore using a catchability tuned to temperature." (SSC December 2023)

Author Response: Exploration of temperature-tuned catchability (q) is in progress. While we were unable to fully explore tuning catchability to temperature for this assessment, we highlight biomass trends with regard to the cold pool index in the Risk Table. We anticipate exploring this relationship further in future assessments.

"The SSC concurs with assessment authors' plans for future assessments including exploring updated natural mortality rates (M) for each of the Tier 5 Other Skate species." (SSC December 2023)

Author Response: The authors have an ongoing project to re-evaluate the natural mortality estimates for all elasmobranchs in the BSAI and GOA FMPs that have sufficient data.

"The Team thanked the authors for their investigation on the non-convergence issues and recommended the following models be brought forward for consideration in November: The current model 14_2d should be brought forward even though parameters were on bounds and it was not converged. The Team leaves it to the authors to decide if they would like to update this model with additional data. Model 25_2 or 25_3 with fixed selectivity parameters to ensure a converged Tier 3 model is available as an alternative. Tier 4 model, with sensitivities if available. Tier 5 model The Team agreed that priority should be on the Tier 4 and Tier 5 models." (BSAI PT October 2025)

"The SSC concurs with the GPT recommendation that the authors bring forward the base model (Model 14_2d) and Model 25_2 or Model 25_3 - at the authors' discretion, but in agreement with the authors' preference for Model 25_2 that uses catchability from Kotwicki and Weinberg (2005)" "The SSC also concurs with the GPT that Tier 4 (with selectivities if available) and Tier 5 model options be brought forward for consideration." (SSC October 2025)

Author Response: The base model (14.2d1) and Model 25.3 are brought forward in this assessment. The authors chose to postpone further development of Model 25.2 pending further investigation of catchability with respect to temperature, as noted in the above comment. While the author-recommended model is a Tier 3 model, we include Tier 4 and Tier 5 options for context. Details of those options, as well as associated harvest recommendation tables, are included in Appendix 18A.

"The SSC encourages consideration of collecting and ageing Alaska skate vertebrae when prioritizing fishery and survey sampling and determining age-reading priorities at the AFSC Age and Growth Lab." (SSC December 2023)

Author Response: Working with the FMA division, we initiated collections in 2025 and 2026 of Alaska skate vertebrae from fixed and trawl gear fisheries (over 500 specimens have been collected to date). Collection of vertebrae from the EBS bottom trawl survey is currently not feasible. The AFSC Age and Growth Program is under a severe staffing shortage, which compounds with the recent retirement of highly productive, experienced age readers. There is currently only one member of the program with skate ageing experience. It is unclear when they would have capacity to train readers to prepare and age skate vertebrae, which are among the most difficult structures to interpret. Skates are a lower-priority, time-consuming species to age, and, as capacity stands currently, ageing of skates would occur at the expense of other higher-priority stocks.

"The SSC recommends that the authors consider exploring a Bayesian framework to estimate growth parameters externally to better account for and quantify uncertainty in these parameters." (SSC December 2025)

Author Response: We focused on resolving non-convergence issues this assessment cycle. However, we intend to explore this suggestion in the future, particularly if it is possible to obtain new age data from recent collections mentioned above.

Introduction

The Alaska skate (*Arctoraja parmifera*, formerly known as *Bathyraja parmifera*) is the dominant species of skate in the BSAI Fishery Management Plan (FMP) area, accounting for over 86% of the skate biomass on the eastern Bering Sea (EBS) continental shelf (<200 m depth) in most years. This species is also found in the Aleutian Islands (AI), EBS slope (>200 m depth), and northern Bering Sea (NBS) habitat areas, where it is far less abundant.

The Other Skates group in the BSAI FMP consists of the following species: big skate (formerly known as *Raja binoculata*, now *Beringraja binoculata*; Ishihara et al. 2012), longnose skate (formerly *Raja rhina* and *Beringraja rhina*, now putatively *Caliraja rhina*; Ebert 2022), Aleutian skate (*Bathyraja aleutica*), Bering skate (*Bathyraja interrupta*), Commander skate (*Bathyraja lindbergi*), whiteblotched skate (*Bathyraja maculata*), butterfly skate (*Bathyraja mariposa*), whitebrow skate (*Bathyraja minispinosa*), leopard skate (*Arctoraja panthera*), mud skate (*Bathyraja taranetzi*), roughtail skate (*Bathyrara trachura*), Okhotsk skate (*Bathyraja violacea*), broad skate (*Amblyraja badia*), and deepsea skate (*Bathyraja abyssicola*). Additionally, the rare deepwater Pacific white skate (*Bathyraja spinosissima*) was recently identified for the first time in the Bering Sea (Orr et al. 2019).

The skate species compositions in the AI and EBS slope differ from each other and from the EBS shelf. In the AI, the most common species are Alaska, Aleutian, whiteblotched, leopard, mud, and big skates. Skate species diversity is greatest on the EBS slope, where Alaska, Aleutian, Bering, whiteblotched, mud, Commander, whitebrow, and roughtail skates have been observed consistently. After the Alaska skate, the next most common species on the EBS shelf are Aleutian, Bering, whiteblotched, mud, and big skates.

Life history

Skates generally have life history characteristics that can make them more vulnerable to overfishing, such as slow growth, late maturity, low fecundity, and moderate life spans (Hoenig and Gruber 1990; King and McFarlane 2003). Additionally, skates in Alaska, including the Alaska skate, utilize persistent, localized nursery areas along the interface between the continental shelf and slope of the EBS for egg deposition, with long incubation periods of at least 3.5 years (Hoff 2008; 2010; 2016). With the exception of big skates, which can have up to seven embryos per egg case (Howard 2017), skates only have one embryo per egg case. Alaska skates lay egg cases in pairs, with one embryo per case. The age at 50% maturity of Alaska skates is 10 years in females and 9 years in males (Matta and Gunderson 2007), and the maximum observed age is 26 years (Matta et al. 2017). The Alaska skate reproduces throughout the year, with a summer peak in egg deposition (Hoff 2008; Matta 2015). Annual fecundity is poorly estimated but thought to be low (between 20 and 100 egg cases per female per year) (Hoff 2007; Matta 2015). Life history parameters and depth distributions for members of the BSAI Skate Stock Complex are listed in Table 18.1.

Stock structure

A stock structure evaluation of the Alaska skate, with comments on observed population trends in the less dominant species of the complex, was completed this year as a supplement to this assessment at the request of the SSC (Matta et al. 2026). A stock structure evaluation of the Skate Stock Complex as a whole was previously completed in 2012. This year's evaluation noted apparent decreasing trends in

several members of the BSAI Skate Stock Complex, including Alaska and leopard skates. Recent genetic studies cited in the report suggest some level of stock structure in Alaska skates, with embryonic skates from different nursery areas in the EBS exhibiting significant pairwise genetic differences (Spies et al. 2021b). Additionally, there is evidence of a cryptic species (*Arctoraja c.f. parmifera*) near Pervenets Canyon in the EBS that is genetically but not morphologically distinguishable from the Alaska skate (Orr et al. 2011; Spies et al. 2011; Spies et al. 2021a). A limited number of tag-recapture data were also described in the stock structure evaluation report; these observations demonstrate that Alaska skates are capable of cross-shelf movements within the EBS.

Fishery and Management History

Fishery history

There is no directed fishing for skates in the BSAI, though some of the skate bycatch is retained (Table 18.2), reflecting market value. Directed fisheries for skates briefly occurred in federal and state waters in the Gulf of Alaska in 2003 and 2009-2010, respectively (Ormseth 2020).

Management units

To generate harvest recommendations, the BSAI Skate Stock Complex assessment is split into two units: 1) Alaska skate occurring on the EBS shelf and 2) Other Skates, which represent the remaining species in the complex, as well as Alaska skate in the Aleutian Islands and EBS slope. This separation is due to differences in spatial distribution, relative abundance, and information available for the various skate species in the BSAI FMP area. The Alaska skate is assessed as Tier 3, and Other Skates are assessed as Tier 5. Though Alaska skates and Other Skates are assessed separately, a single ABC and OFL (summed from results of the Tier 3 and Tier 5 models) is used to manage the BSAI Skate Stock Complex. There is currently no assessment of Alaska skate or Other Skates in the northern Bering Sea.

Management history

In 1998, the North Pacific Fishery Management Council (NPFMC) approved Amendment 63 to the BSAI FMP to reclassify skates (together with sharks, sculpins, and octopus) as target species. These stocks were assigned to the "Other Species" management category within the BSAI FMP and catches were reported in aggregate, with directed fishing for sharks and skates prohibited. Amendment 95 was approved by the NPFMC in 2009 to remove skates from the Other Species group, and beginning in 2011, skates were managed as the Skate Stock Complex (Table 18.3). In 2015, Amendment 104 designated six skate egg case nursery sites along the outer shelf of the Bering Sea, with a combined area of 82 nm^2, as Habitat Areas of Particular Concern (HAPCs). Though this action did not restrict fishing within the nursery HAPCs, it recognized the importance of these areas to skate stocks in the EBS.

Initially, harvest recommendations for the Other Species group were produced using Tier 6 criteria. Beginning in 2003, the skate component of the Other Species group was assessed as Tier 5 due to the availability of reliable estimates of biomass and natural mortality. Recognizing the potential for depletion of rare and endemic species, Alaska skate and Other Skates were assessed separately starting in 2006 using Tier 5 criteria, with a Tier 3 model used for Alaska skate since 2008. Major changes were made to the Alaska skate Tier 3 model in 2014, which has stood as the accepted model for providing catch advice since.

Current fishery

Within the BSAI, skates are caught primarily in the EBS, with a low level of relatively constant catch in the AI (Figure 18.1). Most of the catch occurs in longline fisheries targeting Pacific cod, with catch in the yellowfin sole trawl fishery being next most common (Figure 18.1).

There has been a northward shift in the spatial distribution of catch of skates in some years, both of Alaska skates and Other Skates based on observer sampling. Over the last 5 years, on average 80% of the skate catch in the EBS has occurred in fisheries targeting Pacific cod (Figure 18.1), and the northward shift or expansion in catch is likely reflective of a spatial shift in the directed Pacific cod fishery.

Updated catch, acceptable biological catch (ABC), overfishing limit (OFL), total allowable catch (TAC) and associated management measures are reported in Table 18.3. Total catch estimates for this operational assessment are provided for the two assessment units, Alaska skate and Other Skates, and shown in Table 18.4. Estimated discards for the BSAI skate stock complex by gear and FMP subarea are reported in Table 18.2.

Data

Data inputs utilized for the BSAI skate stock complex assessments are:

Source	Data Type	Years
NMFS EBS shelf bottom trawl	Survey biomass	1982–2026 (no survey in 2020)
NMFS EBS shelf bottom trawl	Length composition	2000–2026
NMFS EBS shelf bottom trawl	Length-at-age	2003, 2004*, 2007–2009, 2015
Catch Reconstruction	Fishery Catch	1954–1996
AKRO Blend Catch Estimation	Fishery Catch	1997–2002
AKRO Catch Accounting System	Fishery Catch	2003–2026
Groundfish Observer Program	Length composition	2009–2026
NMFS EBS slope bottom trawl	Survey biomass	2000, 2002, 2008, 2010, 2012, 2016
NMFS AI bottom trawl	Survey biomass	2000–2026 (biennial, no survey in 2020)

* The 2004 age samples (n = 28) are not included in the base model, Model 14.2d1, but are included in the author recommended alternative model, Model 25.3.

Fishery Data

There are a number of caveats to consider regarding the catch estimates in the BSAI Skate Stock Complex: 1) the historical catch reconstruction (1954-1996) is undocumented; 2) species group catches from 1997-2002 were estimated independently using the Blend Catch Estimation method (Gaichas 2002); and 3) species identification began improving in 2005.

Due to the large number of skate species in the complex and morphological similarities, identification of some skate species is challenging. Therefore, catch is sometimes reported as “unidentified skates”. Beginning in 2018, the unidentified skate catch was partitioned to species by a process that utilized observation rates, target fishery and area to inform the proportions (Ormseth 2018). The AFSC Fisheries Monitoring and Analysis division internalized this process in 2022, resulting in a decline in the proportion of unidentified skates in the total catch. The remaining portion of unidentified skates continues to be partitioned following the methods adopted by Ormseth (2018). Alaska skate is the predominant species

caught in the BSAI Skate Stock Complex, 87% by weight on average over the previous 5 years (Figure 18.1). Total annual catches of Alaska skates and the Other Skates are presented in Table 18.4

Fishery data for the Tier 3 Alaska skate models are grouped by gear type: longline and trawl. Estimated catch of Alaska skate in pot gear is minimal and therefore combined with trawl catch estimates. Catch of Alaska skate is predominantly in the EBS, 99% on average over the previous 5 years. Therefore, catch from the entire FMP is used in the Tier 3 model. Alaska skate catch by year and gear for Tier 3 models are reported in Table 18.5. Fishery length and age data available for the models by year and gear with input sample sizes are provided in Table 18.6 and shown in Figure 18.2. Fishery length composition input data are available at: AKskate_Lcomps2026.csv

Fishery data are not included in the Other Skate Tier 5 Model 23.0.

Survey Data

Table 18.7 and Figure 18.3 report the survey biomass estimates, with uncertainty, which are used in the Tier 3 models for Alaska skate and the Tier 5 models for Other Skates. Tier 3 models include the biomass estimates for Alaska skates from the EBS shelf survey. The northern Bering Sea survey is not included in the Tier 3 Alaska skate models; however, we have included those survey biomass estimates in Appendix 18B for reference. Reliable skate species identification in the survey is only available starting in 1999, therefore the EBS shelf survey biomass estimates for Alaska skate prior to 1999 are based on an extrapolation procedure defined in the 2020 assessment (Ormseth 2020): “For each survey prior to 1999, total skate biomass estimates were partitioned into Alaska skate and “other” skates based on the average proportion (0.95) of Alaska skate in the 1999-2019 surveys.”

Survey length sample sizes by year with input sample sizes are reported in Table 18.6. Survey length composition input data are available at: AKskate_Lcomps2026.csv

The Other Skates Model 23.0 includes the combined Other Skates biomass for each of the three surveys (Table 18.7). Species-specific survey biomass estimates for the dominant species in each survey, as well as the “minor” group, are provided in Appendix 18B. The leopard skate, which is endemic to the Aleutian Islands, was not formally identified as a separate species from the Alaska skate until 2010. Survey biomass estimates of Alaska skate prior to 2010 are portioned between the two species by the mean proportion of leopard skate from 2010 to present (Ormseth, 2020).

There are limited length-at-age data available for the model, all from the EBS shelf survey. The sample sizes and distribution across years for the length-at-age data included in Model 14.2d1 are shown in Table 18.6 and Figure 18.2. There has not been new age data available for the model since 2015. An additional 28 age samples from 2004 were added to the data set used to estimate growth externally for Model 25.3.

Other time series data used in the assessment

There are no other time series data incorporated into the Alaska skate Tier 3 or Other Skates Tier 5 assessment methods. As per guidelines, other sources of removals, e.g., survey or recreational removals, are reported in Appendix 18C.

Analytic Approach

General Model Structure

Here we present the accepted base model structures for both components of the BSAI Skate Stock Complex. Models are run separately for EBS Alaska skates (Tier 3) and the Other Skates sub-group (Tier 5).

Description of Base Model: Alaska Skate (Tier 3)

The age- and size-structured population dynamics base model for BSAI Alaska skate, Model 14.2d1, is run using the Stock Synthesis platform (SS3; technical details given in Methot and Wetzel 2013, Methot et al. 2020 and in the Stock Synthesis Virtual Lab). No major changes to the assessment approach have occurred since 2014. The current full assessment run of Model 14.2d1 retains the same assumptions as the original model. Because growth and maturity patterns are similar for males and females, only one sex is specified. Spawning is assumed to occur at the midpoint of the year. No informative priors were used. It was assumed that parameters did not vary with season or year (i.e., no time blocks) and were not influenced by environmental conditions (e.g., cold pool index). All parameters are listed in Table 18.8 and described in more detail below.

In 2023, the SSC accepted Model 14.2d as the base model after a bridging exercise that updated the SS3 version and incorporated minor changes to historical data. Model 14.2d1 was presented in September 2025 (Tribuzio et al. 2025) and accepted by the SSC as the new base model. The only change between Model 14.2d and Model 14.2d1 is the newer version of SS3. Following best practices, the jitter was changed from 1% to 10%, the maximum lambda phase from 4 to 1, and a recruitment ramp adjustment included to be consistent with best practices and improve optimization.

Description of Base Model: Other Skates (Tier 5)

The BSAI Other Skates subgroup is assessed under Tier 5, where OFL is equal to estimated biomass multiplied by an estimate of natural mortality (M). The current species groupings (i.e., dominant species and combined minor species for each survey) were established in 2020; however, the harvest recommendation model is run on the combined biomasses of Other Skates for each survey area. The reason for this is that all of the Other Skates species are assigned the same M value ($M = 0.1$), which makes running the models separately equivalent to running them together. To provide harvest advice for Tier 5 stocks, a random effects model was run using the *rema* package (Hulson et al. 2021, Sullivan et al., 2022). The *rema* framework was implemented in the 2023 assessment (Model 23.0), and there are no proposed model changes in this assessment.

The *rema* model was run for all skates combined (omitting Alaska skates on the EBS shelf survey) for each of the three bottom trawl surveys spanning the following time periods: EBS shelf (1999-2026), EBS slope (2002-2026), and AI (2000-2026). The model runs begin in 1999 due to concerns over accuracy of species identifications prior to then. Surveys on the EBS shelf have occurred with higher frequency (annually) than in the AI (generally biennially, with 12 observations) and EBS slope (6 observations, conducted sporadically). There were no surveys conducted in 2020 due to the global pandemic. The EBS slope, the region with the greatest skate diversity, has not been surveyed since 2016. The total BSAI Other Skate biomass used for harvest specifications is the sum of the *rema* estimated biomass for each year.

Parameters Estimated Outside the Assessment Model (Alaska skate)

Natural Mortality (M)

In the 2007 Alaska skate model, an M value of 0.13 was selected from a range of values estimated indirectly from other species-specific life history parameters (Alverson and Carney 1975, Rikhter and Efanov 1976, Pauly 1980, Hoenig 1983, Roff 1984, Charnov 1993, Jensen 1996, Gunderson 2003). The previous assessment author demonstrated that this value of M has consistently provided the best model fit, so we continue to fix M at 0.13. A likelihood profile over M was conducted and is included in the results section.

Length at Maturity

SS3 incorporates female maturity parameters into the model using the following equation:

$$\text{proportion mature} = \frac{1}{1 + e^{b(L - L_{50})}}$$

where L_{50} is the length at 50% maturity and b is a slope parameter. Maturity parameters were obtained from Matta (2006), where b = -0.548 and L_{50} = 93.28 cm TL. Maturity was estimated directly from paired length and maturity stage data as described in Matta and Gunderson (2007); maturity stage was assessed through macroscopic examination of the reproductive organs.

Ageing Error

A fixed ageing error matrix based on paired independent readings of skate vertebrae (Matta and Gunderson 2007) was included in the model. For each age, the standard deviation of the estimated age was calculated from at least two reads of each vertebra and incorporated into the model to account for variability in age determination.

Survey Catchability (q)

Survey catchability (q) was fixed at 1 as in previous Alaska skate assessment models. The EBS shelf survey appears to sample Alaska skates very reliably, with CVs on average 6%, over the last 5 years (Table 18.7). A likelihood profile over q was conducted and is included in the results section.

Weight at Length

The relationship of body weight to body length is described by a power function

$$W = a * TL^b$$

where W is weight in kg, TL is total length in cm, a is a scaling coefficient, and b is the allometric growth parameter, which describes the rate of growth in weight with respect to length. The a and b parameters were estimated from data obtained during an Alaska skate tagging project conducted aboard EBS shelf surveys 2008-2010 (O. Ormseth, unpublished data). Parameters were not significantly different between sexes, so data were combined. For sexes combined, a was estimated as 9.0 X 10^{-6} and b was estimated as 2.9617 (r^2 = 0.93, n = 1,515).

Stock-Recruit Parameters

The standard Tier 3 approach was followed in which no relationship was assumed between the stock and recruitment. Steepness was therefore fixed at 1.0 to create a mean level of recruitment. The σ_R value was fixed to a value of 0.4.

Parameter Estimates (Other Skates)

The only parameter used in the Tier 5 Other Skates model is M. Estimates of M for skates are highly uncertain and may vary among species. We applied the accepted conservative, complex-wide value of M = 0.10 that has been used in previous assessments of the BSAI Other Skates group.

Parameters Estimated Inside the Assessment Model (Alaska skate)

Growth parameters

Alaska skate length-at-age (LAA) observations are best fitted by the Gompertz growth model (Matta and Gunderson 2007). In line with previous assessments, the Schnute 4-parameter growth model (Schnute

1981) was used to approximate the Gompertz growth function in SS3. The Schnute model is formulated as

$$L(t) = [L_0^\gamma + (L_i nf^\gamma - L_0^\gamma)\frac{1 - e^{-\kappa(t-A_1)}}{1 - e^{-\kappa(A_2-A_1)}}]^{\frac{1}{\gamma}}$$

where $L(t)$ is length at age t, L_0 and L_{inf} are the length at ages A_1 and A_2, respectively, and κ and γ are parameters that control the shape of the growth curve. Ages A_1 and A_2 were fixed at 0 and 15, respectively. There was insufficient data to estimate A_2. The fixed value of 15 years was chosen because that is the age where growth appears to reach an asymptote in the available data. In SS3, κ is referred to as the von Bertalanffy k parameter and γ is referred to as the Richards coefficient. All growth parameters were estimated within the model based on paired length and age data from the eastern Bering Sea bottom trawl surveys in 2003, 2007-2009, and 2015, as were the two uncertainty parameters (CV of length-at-age at ages A_1 and A_2).

Length Selectivity

Selectivity at length was estimated separately for each fishery (trawl and longline) and the EBS shelf bottom trawl survey using a double-normal function with defined initial and final selectivity levels (Methot et al., 2020) where all parameters were estimated inside the model. The six parameters of the double-normal function are: p1 (the peak or ascending inflection size), p2 (the width of the plateau), p3 (the ascending width), p4 (the descending width), p5 (the selectivity at the first length bin), and p6 (the selectivity at the last length bin). The bounds were set to the default values listed in the SS3 documentation (Methot et al. 2020).

Stock-recruit Parameters

The natural log of unfished recruitment (*R0*) value was estimated inside the Alaska skate model. Recruitment deviations were also estimated assuming a lognormal distribution for 1950-2026. In SS3, each deviation is considered a separate parameter.

Initial Fishing Mortality

Initial fishing mortality in the longline and trawl fisheries was set to zero.

Description of Alternative Models

At the September 2025 BSAI Groundfish Plan Team meeting, the authors brought forward two alternative models, which were intended to address two major issues in Model 14.2d1: over-reliance on limited age data and non-convergence (Tribuzio et al. 2025). Models 25.2 and 25.3 estimate growth outside of the model and have fixed a number of the selectivity parameters. The only difference between Model 25.2 and 25.3 is that model 25.2 fixes q at 0.83. We do not bring forward Model 25.2 at this time because changing the catchability requires further investigation, as described in the Risk Table and Research Priorities sections of this assessment. The sections below describe Model 25.3 in greater detail and how that model addresses the two major issues in Model 14.2d1.

Over-reliance on Limited Data

The Alaska skate model utilizes age data as well as length data. There are limited age data available, with no new age data since 2015. The limited age data are all from the EBS shelf bottom trawl survey, and there are unlikely to be future collections from this fleet. The North Pacific Groundfish Observer Program began collecting Alaska skate vertebrae in 2025; however, there is no ability to begin ageing those structures at this time. In contrast, length data are abundant for fishery and survey fleets; these data are collected annually and will continue to be collected.

Model 14.2d1 estimates growth inside of the model, but growth parameters hit bounds. For Model 25.3, growth parameters were estimated separately using the Schnute model parameterized to approximate a Gompertz growth pattern as described in the SS3 manual (Methot et al. 2020).

The external growth function estimates four parameters (L_0, L_{inf}, κ, and b) with the following assumptions:

1. All of the age data are from the EBS shelf bottom trawl survey, and as such, all are collected in the months of June and July. Since SS3 estimates ages at the beginning of the year, all of the ages are adjusted by a factor to represent the fraction of the year between the beginning of the year and date of capture.

2. Nearly all of the aged Alaska skates were 20 years or less and 120 cm total length or less, with the exception of one individual that was aged 26 years and was 137 cm total length. This animal was genetically verified to be an Alaska skate. Both survey and fishery data include a small number of specimens up to 160 cm total length, though species identification was not independently confirmed for any of these individuals. Model 25.3 uses growth parameters fixed at the values estimated using the dataset including the 26-year individual.

3. A_1 was set equal to 0 and A_2 was set equal to 15. The A_2 parameter represents the mean age at which the population reaches L_{inf}. Data were insufficient to estimate this value, therefore it was fixed based on the mean size-at-age data.

The coefficients of variation of the length-at-age data at ages A_1 and A_2 were calculated and fixed in the control file (i.e., CV_young and CV_old). These CV_young and CV_old values are slightly different from what was shown in September 2025 and were re-specified and fixed at values similar to those resulting from Model 14.2d1.

A small set (n = 28) of ages collected during the 2004 EBS shelf survey were included in the external growth estimation procedure, which were not previously in the model.

Non-Convergence

Multiple selectivity parameters in Model 14.2d1 hit bounds or resulted in large parameter standard deviations, suggesting non-convergence.

Several selectivity scenarios were conducted to attempt to determine the best approach to solving the bounds and high standard deviations of the selectivity function parameters. When allowed to estimate more freely (i.e., essentially limitless bounds), the model tended to estimate unrealistic selectivity curves, including fully selected at all ages, all curves essentially logistic, or knife-edge declines to zero. Ultimately, the combination which resulted in reasonable fits and parameter estimates were double normal functions with the following:

- Fixing survey selectivity to be logistic (i.e., setting Size_DblN_end_logit = 0 so there is no descending curve)

- Fixing Size_DblN_start_logit = 0 for all fleets, so initial selectivity at length is 0 for all fleets.

- Fixing the Size_DblN_top_logit and Size_DblN_descend_se parameters for all fleets (acknowledging that these two parameters are meaningless when survey selectivity is fixed to be logistic). The value of the fixed parameters vary by fleet, but control the width of the top plateau and the rate, or steepness of the descent.

This resulted in Model 25.3 having three estimated parameters for both the trawl and longline fisheries (peak, ascending limb, and ending values) and two estimated parameters for the survey (peak and ascending limb).

Results

Alaska Skate (Tier 3)

Model Evaluation

Individual Model Goodness of Fit

Table 18.9 shows the model likelihoods for Models 14.2d1 and 25.3. Model 25.3 has fewer estimated parameters, but greater likelihoods. The fits to the survey index are similar between the two models (Figure 18.4).

Growth was only estimated in Model 14.2d1, and the mean length-at-age estimates are shown in Figure 18.5.

A comparison of the selectivity curves estimated for both models and all three fleets are shown in Figure 18.6. Model 14.2d1 was dome-shaped for all three fleets, however the descending limb and end point for the trawl fleet (Fleet 2) is nearly logistic. Model 25.3 has much more substantial declines on the descending limb for the longline (Fleet 1) and trawl fleets, while the survey (Fleet 3) selectivity is specified to be logistic. The dome pattern for the fisheries acknowledges that the largest individuals are either less available to the fleets or less susceptible to the gears that the fleets use. In contrast, the logistic survey selectivity assumes that the largest individuals are fully selected.

The different selectivity patterns result in different fits to the length composition data (Figure 18.7, Figure 18.8, and Figure 18.9). The observed length compositions of the survey and trawl fishery tend to be bi-modal, and the two models fit the smaller peak similarly. Model 25.3 tends to underestimate the larger peak more than Model 14.2d1. Model 25.3 does not capture the decline in the size distribution for the largest individuals. Similar to the survey size composition fit, Model 25.3 underestimates the peak of the size composition, but in the early years of the time series, Model 14.2d1 overestimates the size composition at the smallest sizes. The length composition data from the trawl fleet shows stronger bi-modal length distributions, and Model 25.3 overestimates the dip between the modes. Longline fishery length composition data is more unimodal and left-skewed, although the survey has a similar pattern from about 2015-2023 where there are more large fish. The trawl fishery data is similar but more truncated (2016-2019). Distributions of both fleets become almost unimodal during those years. The differences in fits to the length composition data resulting from Model 25.3 are likely due to the reduced number of parameters preventing the model from achieving a closer fit. While there are differences in the fit between models, the general form and fit are similar.

Both models show residual patterns in the One-Step Ahead (OSA) and Pearson residuals (Figure 18.10 and Figure 18.11). Model 14.2d1 may be overfitting the data and Model 25.3 may be a more statistically reasonable model due to the standard deviation of normalized residuals (SDNR) closer to 1. These results suggest future work should explore data-weighting. The OSA and Pearson residuals also provide some indication of length-based cohorts, particularly in the fits to the survey length composition data. The Alaska skate is a slow-growing species with moderate longevity. The survey residuals in Figure 18.10 and Figure 18.11 show a cohort of small animals right at the start of the time series, which are likely between 0 and 3 years old, with the cohort tracking through the entire time series. There appears to be a signal of another cohort of small individuals starting at about 2021. Due to the biology of the species, a length cohort could include multiple ages and therefore a represent a number of birthyears.

Retrospective Performance

A ten-year retrospective analysis was conducted for each model by sequential removal of all data for each year beginning with 2026 and ending with 2016. Retrospective performances of Models 14.2d1 and 25.3 in estimated spawning biomass and numbers of recruits are shown in Figure 18.12 and Figure 18.13, respectively. Model 25.3 has slightly negative Mohn's rho (ρ) of -0.140 for SSB, while Model 14.2d1 (ρ = 0.256) is positive and much larger.

We provide a comparison of the historical model run SSB results used for management advice in Figure 18.14, as a between-model retrospective evaluation. The 2014–2020 model runs scaled up and down as new data were added. The 2023 and current recommended model have similar fits in the recent time series with the only noticeable difference in the earliest years.

Parameter Estimates

A comparison of estimated parameters (excluding the recruitment deviations) is provided in Table 18.8. To achieve convergence, Model 25.3 fixes all of the growth parameters and certain selectivity parameters, as described in the Description of Alternative Models section. Of the remaining parameters in Model 25.3, none hit bounds and all were estimated to have low standard deviations and gradients. All of the parameters that were fixed in Model 25.3 were bounded or had high gradients in Model 14.2d1.

Likelihood Profiles

We conducted three likelihood profiles for Model 25.3 to explore conflicts in the data. Survey catchability (q) is fixed at 1 in the model. The likelihood profile over q suggests that a value < 1 would be more appropriate and is highly influenced by the length data (Figure 18.15). This is congruent with research suggesting that skates have a survey catchability < 1 (Kotwicki and Weinberg, 2005) and a topic we intend to explore further as discussed in the Research Priorities and Risk Table sections of this assessment. There is a data conflict between size-at-age data and the length data for q, which could stem from confounding availability and gear selectivity. The likelihood profile on M suggests no major data conflicts but does minimize at a value greater than the fixed M of 0.13 (Figure 18.16). The profile of log initial recruitment (LN(R0)) shows no data conflicts and minimizes at about the value estimated by the model (Figure 18.17).

Leave-One-Out

A leave-one-out analysis was explored for Model 25.3 and is shown in Figure 18.18. In this analysis, each length data source was dropped one at a time. Length selectivities were fixed to represent the length composition data set being left out. As data sources were removed, the model was stable with two exceptions. If survey length data were removed, the model scaled up across the time series, and if all length data were removed, the model was less stable. As length data are removed, the model relies more heavily on the recruitment deviations to account for changes in the survey index. There are no age data in Model 25.3 and the model is heavily reliant on length composition data.

Derived Quantities

Table 18.10 shows the key derived quantities for 2027 and 2028 resulting from Model 14.2d1 and Model 25.3, as well as the same quantities as specified for 2026 from the 2023 Operational Update assessment (Tribuzio et al. 2023) and the 2024 Harvest Projection (Tribuzio et al. 2024). There was no assessment conducted in 2025, therefore there are not previously specified values for 2027 available for comparison. The 2027 OFL and ABC from Model 14.2d1 are similar to what was specified for 2026, but the projection for 2028 suggests a steeper decline in the OFL and ABC. In contrast, Model 25.3 2027 OFL and ABC are lower than those for Model 14.2d1, but the projection is more optimistic with the 2028 OFL and ABC only declining slightly.

Choice of Model

The author's recommended model is Model 25.3. Most importantly, Model 25.3 achieves convergence based on the following criteria: all of the parameters were within the pre-specified bounds, maximum gradient components were less than $1e^{-4}$, and a positive-definite Hessian was achieved. Model 14.2d1 had many parameters which did not meet these criteria. Model 25.3 resulted in improved SDNR values for composition data and better retrospective performance than Model 14.2d1. The likelihood profiles over *q* and *M* suggest future avenues of research, but no diagnostics suggested significant concerns with the author's preferred model.

Time Series Results

Definitions

Biomass is shown as total (age 0+) biomass (metric tons; t) of all Alaska skates in the eastern Bering Sea population (Table 18.11), as total mature biomass (for both sexes; t) (Table 18.12), and as female spawning stock biomass (SSB, 1/2 of total spawning biomass, t). Recruitment is reported as the number (in thousands) of Alaska skates at age 0 (Table 18.13). The CV is included for spawning biomass and age-0 recruits.

Biomass time series

Time series of total biomass is reported in Table 18.11 and shown in Figure 18.19. Total mature biomass is reported in Table 18.12. Female spawning stock biomass and the Model 25.3 estimated reference points are shown in Figure 18.19. The model suggests that the Alaska skate population declined beginning in the 1960s, with the steepest decline during the 1970s. The population then rebounded dramatically during the 1980s, increasing until ~1995. It then declined slightly and began to increase in 2007. The 2026 model run suggests that total biomass has decreased since 2015 and spawning biomass has decreased since 2020.

Recruitment

Time series of age-0 recruitment are reported in Table 18.13 and Figure 18.20. The model suggests that a period of increased recruitment occurred between the years 1980-1984, with the highest level of recruitment in 1982. The model also estimates that recruitment increased during the 2000s, peaking in 2006, and declining until 2015. The model estimated a relatively large increase in recruitment between 2019 and 2020 with variable estimates since then. Model 25.3 estimates that the recent recruitment is close to, but slightly below, the long-term mean.

Exploitation rate

A time series of exploitation (catch/total biomass) is given in Table 18.14 and Figure 18.21. These rates suggest that skates experienced the greatest fishing pressure in the 1970s. Exploitation rates have been fairly stable (~0.04-0.05) since the 1990s.

Numbers at age

Model 25.3 indicates that the large year classes that occurred in the 1980s are gone from the population and that the moderately-sized year classes of the 2000s are beginning to show up in the older population (Figure 18.22). There appears to be an incoming cohort of young animals. Table results of numbers at age are available at: M25_3_NAA_2026

Phase-plane plot

The trajectory of relative spawning biomass vs. relative fishing mortality (Figure 18.23) reflects the high F and decrease in biomass during the 1970s, as well as the subsequent increase in biomass. In recent years

the relationship between the two variables has been consistent, with spawning biomass well above $B_{35\%}$ (Figure 18.19) and F well below $F_{35\%}$ (Figure 18.21).

Other Skates (Tier 5)

The time series of aggregated Other Skates biomass estimated by Model 23.0 are presented in Table 18.15 and Figure 18.24. The declining trend in the Aleutian Islands observed since the mid-2000s continued through the 2024 survey but increased slightly in the 2026 survey. The mid-2000s through 2024 decline was largely driven by general declines of leopard, Alaska, and Aleutian skate survey biomass estimates (Appendix 18B). Butterfly skates are considered a minor species; they had also been declining but increased in 2022. The EBS shelf survey biomass estimate for Other Skates has generally been trending upwards since 2004 and the 2026 estimate is greatest of the time series (Figure 18.24). There has been no EBS slope survey since 2016, thus the estimated biomass from that region is unchanged and is highly uncertain (Figure 18.24).

Projections and Harvest Recommendations

Amendment 56 Reference Points

This assessment using Model 25.3 provides reliable estimates of B_0, $B_{40\%}$, and fishing mortality rates corresponding to $F_{40\%}$ and $F_{35\%}$. Therefore, management recommendations are made under Tier 3 of the BSAI Groundfish Fishery Management Plan. Using Tier 3, ABC and OFL are set according to the following criteria:

3a) Stock status: $B/B_{40\%} > 1$

$F_{OFL} = F_{35\%}$

$F_{ABC} \leq F_{40\%}$

3b) Stock status: $0.05 < B/B_{40\%} < 1$

$F_{OFL} = F_{35\%}$ x $(B/B_{40\%} - 0.05) \times 1/0.95$

$F_{ABC} < F_{40\%}$ x $(B/B_{40\%} - 0.05) \times 1/0.95$

3c) Stock status: $B/B_{40\%} < 0.05$

$F_{OFL} = 0$

$F_{ABC} = 0$

The BSAI Other Skates are Tier 5, thus the $F_{OFL} = M$ and $F_{ABC} = F_{OF} * 0.75$.

Specification of OFL and Maximum Permissible ABC (Alaska skate)

The 2027 estimate of female spawning biomass for BSAI Alaska skates is 98,154 t. The estimate of $B_{40\%}$ is 62,344 t, so $B/B_{40\%}$ is 1.57 and 2027-2028 Alaska skate harvest levels can be assigned according to subtier 3a. Therefore, $F_{OFL} = F_{35\%} = 0.100$ and maximum $F_{ABC} = F_{40\%} = 0.085$. The corresponding 2027 OFL is 27,074 t and maximum allowable ABC is 23,366 t. For 2028, OFL is projected to be 26,633 t and maximum allowable ABC will be 23,367 t.

Standard Harvest Scenarios

A standard set of projections is required for each stock managed under Tiers 1, 2, or 3 of Amendment 56. This set of projections encompasses seven harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Policy Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). Results of the projection exercise are in Table 18.16, Table 18.17 and Figure 18.25. Projections with Model 25.3 were run using https://github.com/noaa-afsc/AK_Scenarios_For_SS.

For each scenario, the projections begin with the vector of 2026 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2027 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2026. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1000 times to obtain distributions of possible future stock sizes, fishing mortality rates, and catches.

Five of the seven standard scenarios that are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2027, are as follows ("max F_{ABC}" = maximum permissible F_{ABC} under Amendment 56) and results are shown in Table 18.16, Table 18.17 and Figure 18.25:

Scenario 1: In all future years, F is set equal to max F_{ABC}. (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TACs.)

Scenario 2: In all future years, F is set equal to a constant fraction of max F_{ABC}, where this fraction is equal to the ratio of the F_{ABC} value for 2027 recommended in the assessment to the max F_{ABC} for 2027. (Rationale: When F_{ABC} is set at a value below max F_{ABC}, it is often set at the value recommended in the stock assessment). For Alaska skates the recommended F_{ABC} is typically the max F_{ABC}, however the total catch is usually well below ABC (Table 18.3). Therefore, for Scenario 2 the catch in 2027 and 2028 is set equal to the estimate of 2026 total catch used in the model.

Scenario 3: In all future years, F is set equal to the 2022-2026 average F. (Rationale: For some stocks, TAC can be well below ABC, and recent average F may provide a better indicator of F_{TAC} than F_{ABC}.)

Scenario 4: In all future years, F is set equal to 50% of max F_{ABC}. (Rationale: This scenario provides a likely lower bound on F_{ABC} that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)

Scenario 5: In all future years, F is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether a stock is currently in an overfished condition or is approaching an overfished condition. These two scenarios are as follows (for Tier 3 stocks, the MSY level is defined as $B_{35\%}$):

Scenario 6: In all future years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be above its MSY level in 2027 and above its MSY level in 2041 under this scenario, then the stock is not overfished.)

Scenario 7: In 2027 and 2028, F is set equal to max F_{ABC}, and in all subsequent years, F is set equal to FOFL. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is expected to be above its MSY level in 2038 under this scenario, then the stock is not approaching an overfished condition.)

Specification of OFL and Maximum Permissible ABC (Other Skates)

Model	F_{OFL}	F_{ABC}	Combined B_{rema}	OFL	ABC
23.0	0.10	0.075	130,627	13,063	9,797

Risk Table and ABC Recommendation

Assessment Considerations

The preferred model for Alaska skate has a small negative retrospective bias and with each successive year added the estimated SSB decreases, suggesting the model has been slightly overestimating the population. The Alaska skate Tier 3 model is relatively simple and likely does not capture critical aspects of the population. In particular, survey catchability (q) is set equal to 1. The current approach is most conservative because reducing q will effectively scale up the survey biomass and resultant model outputs.

Survey catchability can be decomposed into availability and gear susceptibility, both of which likely interact for Alaska skates. Past BSAI Plan Team and SSC comments have suggested exploring tuning survey catchability to temperature. For this assessment, we conducted preliminary analyses comparing the EBS shelf survey biomass to the cold pool index (available at: coldpool). The EBS shelf survey biomass is significantly, negatively correlated with the cold pool index, specifically the extent of the 0 °C waters, r = -0.47 (-0.72 - -0.11, 95% Confidence Interval), but a similar relationship occurs with both the 1 and 2 °C indices (Figure 18.26). When the cold pool extent is larger, the EBS shelf survey biomass is lower (Figure 18.27). The change in biomass appears to be a rapid response without any time lag, and the stock likely shifts distribution in response to temperature.

Being a large bodied species, the Alaska skate likely has the capacity to move to warmer waters in response to the cold pool extent. The 2026 stock structure evaluation details the limited tagging data available (Matta et al. 2026). The tagging data demonstrate that Alaska skate are capable of cross-shelf movements. In contrast, none of the 27 recovered tags were recaptured outside of the EBS. Given the small sample size, that result does not preclude movements between the EBS and other management regions.

Research suggests that skates in general, and Alaska skate in particular, are less susceptible to the survey gear. Kotwicki and Weinberg (2005) conducted a study which estimated overall survey gear susceptibility for skates to be equal to 0.836 and that the susceptibility is a function of total length.

Model runs setting q = 0.836 were presented to the 2025 BSAI Groundfish Plan Team and the SSC. We did not bring forward those models this year because the interaction of availability and susceptibility needs further exploration.

The EBS Shelf Alaska skate model is a statistical-catch-at-age model. However, it is functionally a length model where lengths are converted to ages. While this is not uncommon, in the case of Alaska skate, the age data to inform the age/length key is limited and possibly outdated. There are only 1,255 ages available, over the years 2003, 2004, 2007-2009 and 2015. The model is assuming a static growth pattern, which may be an invalid assumption. Elasmobranchs are generally longer lived and growth patterns may be slower to respond to environmental changes, or they simply avoid less preferred temperatures. Regardless, the age data to inform the model is over 10 years old and the time since it was last updated is increasing.

There are outstanding assessment considerations for the Tier 5 Other Skates as well. The Other Skates component of the BSAI stock complex was established at the inception of the BSAI Skate Stock Complex, with all species lumped together by survey. Development of improved survey averaging and data-limited tools justify a re-examination of the approaches used for the Other Skates. First, based on the variability in life history (Table 18.1), it is unlikely that the assumption that all of the Other Skates have the same *M* is valid. Second, many life history and age/growth studies have been conducted in the last 20 years and that information may be useful for either improving *M* estimates for Tier 5, or even elevating some species to Tier 4. Lastly, the structure of the BSAI Skate Stock Complex can mask critical declines in some stocks, for example the Aleutian Islands leopard skate and Alaska skates (Appendix 18B). It is necessary to consider alternative assessment methods for the Tier 5 stocks to better track species-specific trends. Lastly, the lack of an EBS slope survey continues to increase concern over assessing stocks in that region.

For both the Alaska skate Tier 3 model and the Other Skates Tier 5 assessment approach, we rate the Assessment Considerations at Level 2.

Population Dynamics Considerations

The biomass of Alaska skates continues to decline. However, there appears to be a strong cohort developing, and projections suggest that the population is not at risk of becoming overfished, therefore there is not increased concern. The projections suggest continued declines in the SSB, but at a slower rate. There are likely facets of the population dynamics that are not understood, especially recruitment, hatching success, and movement of the stock. Because of these unknowns, the Population Dynamics Considerations for Alaska skate are rated Level 1.

The biomass of Other Skates overall is increased in both the AI and EBS shelf. While the Other Skates are assessed as a group, it is important to track trends in the individual species. In particular, leopard (an endemic species), Alaska, and Aleutian skates in the Aleutian Islands have been decreasing in recent years and continue to be below the long-term average. There is a greater level of uncertainty in the AI survey estimates for skates due to higher rugosity of the seafloor, untrawlable habitat, and trawl footrope design. The leopard skate was also only recently treated as a separate species from the Alaska skate; therefore the time series may be too short to draw any definitive conclusions about biomass trends. That said, the current survey biomass is 74% below the long-term average (Matta et al. 2026). It is not possible to evaluate the population dynamics of the EBS slope skate species, which is the most species-rich region for this stock complex. The lack of slope survey data continues to hamper evaluation of the stock complex in that region. Overall, the Other Skates are rated as Level 2 for Population Dynamics Considerations, due to the continued long-term declines in three species in the AI (Appendix 18B).

Environmental/Ecosystem considerations (contributed by Elizabeth Siddon and Ivonne Ortiz)

The following paragraphs summarize the Environmental/Ecosystem Considerations for the BSAI skates stock complex. A detailed evaluation is provided in Appendix 18D.

Proper evaluation of risk is difficult for a data-limited stock. However, based on available ecosystem information, the overall environmental and ecosystem-related risk for BSAI skates is evaluated as ‘Level 1 – Normal (no concern)’. In 2026, the eastern Bering Sea shelf experienced a sharp return to cool thermal conditions driven by late-winter north-to-south winds and sea ice expansion in March and April, producing a 2°C cold pool ~150% larger than in 2025.

Younger Skate Stages: All BSAI skate species are oviparous with temperature-sensitive embryonic development and prolonged egg incubation (~3.5 years for Alaska skate; Hoff 2008). The colder 2026 bottom temperatures may slightly extend egg incubation times over the EBS shelf, though temperatures remain within historical operational ranges with low vulnerability for Alaska skates (whereas long-term

gradual warming in the Aleutian Islands may slightly shorten incubation times). Young skates feed on benthic infauna and small epifaunal invertebrates; indirect indicators of prey resources are sufficient as benthic forager biomass increased in 2026 and motile epifauna biomass remains >1 SD above the long-term mean. While increased benthic forager biomass suggests a slight increase in potential competition for space and benthic prey, non-limiting food supplies mitigate competition concerns. Predation on early life stages - including neonate predation by Pacific cod and Pacific halibut - remains low because Pacific cod biomass is below its long-term mean and Pacific halibut biomass remains near historical lows.

Adult Skates: Late-stage juvenile and adult skates are demersal generalists distributed across the EBS shelf, slope, and Aleutian Islands. However, Alaska skates display an inverse relationship with cold pool extent, which may indicate a spatial shift in adult distribution to outside the standard survey area when the cold pool occupies a large portion of the shelf habitat. Adult Alaska skates consume a varied diet of fish (such as pollock and herring) and benthic invertebrates and benefit from strong benthic productivity. Competition for prey remains low to moderate, and adult skates experience minimal top-down predation pressure due to general declines in apex predators across the EBS.

Fishery Performance Considerations

Skates are not targeted, and the amount of harvest depends on skate abundance and the behavior of directed fisheries. Fishery Performance Considerations is rated as Level 1 for both components of the BSAI Skate Stock Complex.

Summary and ABC recommendation

Assessment-related Considerations	Population Dynamics Considerations	Environmental / Ecosystem Considerations	Fishery Performance Considerations
Level 2 for Alaska skates Level 2 for Other Skates	Level 1 for Alaska skates Level 2 for Other Skates	Level 1: no increased concerns	Level 1: no increased concerns

While there are increased concerns in the Assessment Considerations for both groups and in the Population Dynamics Considerations for the Other Skates, we feel that a further reduction in the ABC is not warranted. The EBS shelf Alaska skate model, while having elevated concerns, results in biomass levels that are well above target reference points at this time and the length composition data suggests a strong incoming cohort. While a reduction in ABC for the Other Skates may be warranted due to elevated concern in both the Assessment and Population Dynamics Considerations, a reduction in the ABC would be ineffective for the stocks of concern due to the single ABC and OFL for the complex, the dominance of the Alaska skate on the EBS shelf, and the non-target status of skates. Therefore, no reductions from maximum permissible ABC are recommended for the BSAI Skate Stock Complex.

Status Determination

The 2025 total BSAI Skate Stock Complex catch was 21,735 t (Table 18.3) and the OFL was 44,086 t, therefore the BSAI Skate Stock Complex was not subject to overfishing.

While the status determination is at the stock complex level, we provide the relative measures for the Alaska skate component of the BSAI Skate Stock Complex. The 2025 Alaska skate total catch estimate was 18,913 t, which is less than the 2025 OFL of 30,941 t and overfishing was not occurring. The projected 2027 female spawning stock biomass (98,154 t) is greater than $B_{35\%}$ (54,552 t); therefore the Alaska skate is not overfished. The projected SSB from Scenarios 6 (61,815 t) & 7 (62,258 t) indicate that the Alaska skate SSB will be above $B_{35\%}$ (54,552 t) in 2041, so Alaska skates are not currently in an

overfished condition and are not approaching an overfished condition. The F rate that would have produced a catch equal to the 2025 OFL being taken was 0.16, which is substantially greater than the observed F_{2025} of 0.066 (0.062-0.071, 95% confidence interval).

For the Tier 5 Other Skates, the 2025 OFL was 13,145 t and catch was 2,821 t, therefore overfishing did not occur. It is not possible to determine if Tier 5 stocks are approaching or are overfished.

Ecosystem Considerations

This section has been omitted in lieu of the detailed evaluation included in the risk table evaluation. See Appendix 18D for detailed description of the Ecosystem Considerations.

Data Gaps and Research Priorities

There are a number of high-priority data gaps and research priorities.

- *Limited age data.* The Alaska skate model relies on age estimates from a small number of aged samples collected between 2003 and 2015. Vertebrae are the only structure available for ageing this species and it requires specialized experience to conduct skate age reading. While age samples have been collected recently from the fishery, the Age and Growth Program does not have the capacity to age the samples.
- *Natural mortality.* Natural mortality for Alaska skate and the species in the Other Skates sub-complex has not been re-evaluated since the inception of the BSAI Skate Stock Complex assessment. Estimates of species-specific M need to be re-evaluated using recent methods and updated literature.
- *Survey indices in species-rich areas.* The EBS slope region is the most species-diverse region for skate species and has not been assessed since 2016. It is impossible to track trends in species that are only present or generally more dominant in the EBS slope.
- *Survey catchability.* For the Alaska skate Tier 3 model, there needs to be exploration of inclusion of the cold pool index. The species has the potential to change distribution in response to temperatures, and preliminary explorations of the relationship between the EBS shelf survey index and the cold pool index (Figure 18.26 and Figure 18.27) suggest a strong relationship. This relationship could impact the availability of the stock to the EBS shelf survey. Another consideration for survey catchability is that there is a demonstrated relationship between size and susceptibility to the gear (Kotwicki and Weinberg 2005), suggesting that larger animals are less susceptible to the gear and an overall $q < 1$.
- *Species identification.* Species identification is often a challenge for skate species. It is necessary to either improve at-sea observer species identification, particularly in the Aleutian Islands, or institute genetic identification to better track species-specific catch.
- *Life history research.* Life history research on many species of the BSAI Skate Stock Complex has been published and is now included in Table 18.1. However, critical life history research is lacking for priority species, such as the endemic leopard skate. For the Alaska skate Tier 3 model, the weight-at-length curve needs to be updated with expanded data.

Acknowledgments

We thank previous authors of the BSAI skate assessment for their contributions, especially Olav Ormseth and Sarah Gaichas. We gratefully acknowledge the following for their timely and efficient work in providing data and information for skate species: the Groundfish Assessment Program for AFSC bottom trawl survey estimates; the Alaska Regional Office (NMFS) for estimates of commercial catch; Bob

Ryzner, Rob Ames, Jean Lee, Matt Callahan and Neils Leuthold (AKFIN, Pacific States Marine Fisheries Commission) for a user-friendly portal to access Catch Accounting System data and multiple AFSC survey data sources; Ivonne Ortiz and Ebett Siddon (AFSC) for their contributions to the Ecosystem Considerations sections. Finally, we thank AFSC staff Jerry Hoff and Duane Stevenson for answering questions regarding species status and bottom trawl survey data and the Marine Ecology and Stock Assessment program for advice on resolving model issues.

Literature Cited

Ainsley, S.M. 2009. Age, growth and reproduction of the Bering skate, *Bathyraja interrupta* (Gill & Townsend, 1897), from the eastern Bering Sea and Gulf of Alaska. Moss Landing Marine Laboratories, California State University, Monterey Bay, CA.

Ainsley, S.M., D.A. Ebert, and G.M. Cailliet. 2011a. A comparison of reproductive parameters of the Bering skate, *Bathyraja interrupta*, from two Alaskan large marine ecosystems. Mar. Freshwater Res. 62(6):557-566.

Ainsley, S.M., D.A. Ebert, and G.M. Cailliet. 2011b. Age, growth, and maturity of the whitebrow skate, *Bathyraja minispinosa*, from the eastern Bering Sea. ICES J. Mar. Sci. 68(7):1426-1434.

Ainsley, S.M., D.A. Ebert, L.J. Natanson, and G.M. Cailliet. 2014. A comparison of age and growth of the Bering skate, *Bathyraja interrupta* (Gill and Townsend, 1897), from two Alaskan large marine ecosystems. Fish. Res. 154:17-25.

Alverson, D.L., and M.J. Carney. 1975. Graphic review of growth and decay of population cohorts. J Conseil 36(2):133-143.

Arrington, M.B. 2020. Growth and maturity of longnose skates (*Raja rhina*) along the North American West Coast. MS Thesis. University of Washington, Seattle, WA.

Charnov, E.L. 1993. Life history invariants: some explorations of symmetry in evolutionary ecology. Oxford University Press Inc., New York. 167 p.

Dulvy, N.K., Dyldin, Y.V., Ebert, D.A., Herman, K., Ishihara, H., Jeong, C.-H., Semba, Y., Tanaka, S., Volvenko, I.V., Walls, R.H.L. & Yamaguchi, A. 2020. *Bathyraja violacea*. The IUCN Red List of Threatened Species 2020: e.T161594A80676330. Available at https://dx.doi.org/10.2305/IUCN.UK.20203.RLTS.T161594A80676330.en

Ebert, D.A. 2003. Sharks, rays, and chimeras of California. University of California Press, Berkeley, CA, 285 pp.

Ebert, D.A. 2005. Reproductive biology of skates, *Bathyraja* (Ishiyama), along the eastern Bering Sea continental slope. J. Fish. Biol. 66(3):618-649.

Ebert, D.A. 2022. *Caliraja* gen. nov., a new skate genus (Rajiformes: Rajidae) from the eastern North Pacific. Revista de Biologia Marina y Oceanografia 57:271-275.

Ebert, D.A., W.D. Smith, and G.M. Cailliet. 2008. Reproductive biology of two commercially exploited skates, *Raja binoculata* and *R. rhina*, in the western Gulf of Alaska. Fish. Res. 94(1):48-57.

Ebert, D.A., Chiquillo, K.L.C, Crow, K.D. & Davis, C.D. 2016. *Amblyraja badia*. The IUCN Red List of Threatened Species 2016: e.T161452A80676476. Available at http://dx.doi.org/10.2305/IUCN.UK.20162.RLTS.T161452A80676476.en

Finucci, B. & Rohner, C.A. 2025. *Bathyraja spinosissima*. The IUCN Red List of Threatened Species 2025: e.T161486A124494104. Available at https://dx.doi.org/10.2305/IUCN.UK.20252.RLTS.T161486A124494104.en

Gaichas, S. K. 2002. Squid and other species in the Bering Sea and Aleutian Islands. In Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea and Aleutian Islands for 2003. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Gburski, C.M., S.K. Gaichas, and D.K. Kimura. 2007. Age and growth of big skate (*Raja binoculata*) and longnose skate (*R. rhina*) in the Gulf of Alaska. Environ. Biol. Fish. 80(2-3):337-349.

Gunderson, D.R., M. Zimmermann, D.G. Nichol, and K. Pearson. 2003. Indirect estimates of natural mortality rate for arrowtooth flounder (*Atheresthes stomias*) and darkblotched rockfish (*Sebastes crameri*). Fish. Bull. 101(1):175-182.

Haas, D.L. 2011. Age, growth, and reproduction of the Aleutian skate, *Bathyraja aleutica*, from Alaskan waters. MS Thesis. Moss Landing Marine Laboratories, California State University, Monterey Bay, CA.

Haas, D.L., D.A. Ebert, and G.M. Cailliet. 2016. Comparative age and growth of the Aleutian skate, *Bathyraja aleutica*, from the eastern Bering Sea and Gulf of Alaska. Environ. Biol. Fish. 99(11):813-828.

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. 81(4):898-903.

Hoenig, J. M. and S. H. Gruber. 1990. Life-history patterns in the elasmobranchs: Implications for fisheries management. Pages 1-16 in Pratt, H.L., Gruber, S.H., and Taniuchi, T. (eds.). Elasmobranchs as living resources: Advances in the biology, ecology, systematics, and the status of the fisheries. NOAA Tech. Report NMFS 90.

Hoff, G.R. 2007. Reproductive biology of the Alaska skate *Bathyraja parmifera*, with regard to nursery sites, embryo development, and predation. PhD Dissertation, University of Washington, Seattle, WA.

Hoff, G. R. 2008. A nursery site of the Alaska skate (*Bathyraja parmifera*) in the eastern Bering Sea. Fish. Bull. 106(3):233-244.

Hoff, G. R. 2010. Identification of skate nursery habitat in the eastern Bering Sea. Mar. Ecol. Prog. Ser. 403:243-254.

Hoff, G. R. 2016. Identification of multiple nursery habitats of skates in the eastern Bering Sea. J. Fish Biol. 88(5):1746-1757.

Howard MJ. 2017. Chapter 44: Fecundity, egg case sizes, and neonate morphometrics of big skate *Beringraja binoculata* (Girard, 1855). In The Elasmobranch Husbandry Manual II: Recent advances in the care of sharks and their relatives, In Smith M, Warmolts D, Thoney D, Hueter R, Murray M, Ezcurra J (eds). Ohio Biological Survey, INC, Columbus, pp 451-458, pp 504.

Hulson, P. J. F., K. B. Echave, P. D. Spencer, and J. N. Ianelli. 2021. Using multiple indices for biomass and apportionment estimation of Alaska groundfish stocks. U.S. Dep. Commer. NOAA Tech. Memo. NMFS-AFSC-414, 28 p. https://doi.org/10.25923/by6g-4s98

Ishihara, H., M. Treloar, P.H.F. Bor, H. Senou, and C.H. Jeong. 2012. The comparative morphology of skate egg capsules (Chondrichthyes: Elasmobranchii: Rajiformes). Bulletin of the Kanagawa Prefecture Museum of Natural History 41:9-25.

Jensen, A.L. 1996. Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. Can. J. Fish. Aquat. Sci. 53(4):820-822.

King, J. R. and G. A. McFarlane. 2003. Marine fish life history strategies: applications to fishery management. Fish. Manag. Ecol. 10(4):249-264.

Kotwicki, S., and K.L. Weinberg. 2005. Estimating capture probability of a survey bottom trawl for Bering Sea skates (*Bathyraja* spp.) and other fish. Alaska Fish. Res. Bull. 11(2):135-145.

Matta, M. E. 2015. Reproductive biology of the Alaska skate *Bathyraja parmifera*, with comments on an intersexual individual. J. Fish. Biol. 87(3):664-678.

Matta, M.E., and D.R. Gunderson. 2007. Age, growth, maturity, and mortality of the Alaska skate, *Bathyraja parmifera*, in the eastern Bering Sea. Environ. Biol. Fish. 80(2-3):309-323.

Matta, M. E., C. A. Tribuzio, D. A. Ebert, K. J. Goldman and C. M. Gburski. 2017. Age and growth of elasmobranchs and applications to fisheries management and conservation in the northeast Pacific Ocean. Pages 179-220 in Larson, S. & Lowry, D. (eds.). Northeast Pacific Shark Biology, Research and Conservation Part A. Oxford: Academic Press.

Matta, M.E., C.A. Tribuzio, I. Spies, D.E. Stevenson, and G.R. Hoff. 2026. Evaluation of Alaska skate stock structure in the Bering Sea and Aleutian Islands. North Pacific Fishery Management Council, Anchorage, AK. Available from https://meetings.npfmc.org/Meeting/Details/8165

Maurer, J.R.F. 2009. Life history of two Bering Sea slope skates: *Bathyraja lindbergi* and *B. maculata*. MS Thesis. California State University, Monterey Bay, CA.

Methot, R.D. and C.R. Wetzel. 2013. Stock Synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fisheries Research 142:86-99. https://doi.org/10.1016/j.fishres.2012.10.012

Methot, R. D., Jr., C. R. Wetzel, I. G. Taylor, and K. Doering. 2020. Stock Synthesis User Manual Version 3.30.15. U.S. Department of Commerce, NOAA Processed Report NMFS-NWFSC-PR-2020-05. https://doi.org/10.25923/5wpn-qt71

Ormseth, O. 2018. Improved catch estimation for individual species in the BSAI skate complex. September Groundfish Plan Team document. North Pacific Fishery Management Council. https://meetings.npfmc.org/CommentReview/DownloadFile?p=3f43bf6d-83e9-4d43-a00f-4d4beeb0f8a6.pdf&fileName=Improved%20BSAI%20skate%20catch%20estimation.pdf

Ormseth, O. 2020. 18. Assessment of the skate stock complex in the Bering Sea and Aleutian Islands. North Pacific Fishery Management Council, Anchorage, AK. Available from https://www.npfmc.org/library/safe-reports/

Orr, J.W., D.E. Stevenson, G.R. Hoff, I. Spies, and J.D. McEachran. 2011. *Bathyraja panthera*, a new species of skate (Rajidae: Arhynchobatinae) from the western Aleutian Islands, and resurrection of the subgenus *Arctoraja* Ishiyama. NOAA Prof. Paper NMFS 11.

Orr, J.W., D.E. Stevenson, G. Hanke, I.B. Spies, J.A. Boutillier, and G.R. Hoff. 2019. Range extensions and new records from Alaska and British Columbia for two skates, *Bathyraja spinosissima* and *Bathyraja microtrachys*. Northw. Nat. 100(1):37-47.

Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. J Conseil 39(2):175-192.

Provost, C.M. 2016. Age, growth, and sexual maturity of the deepsea skate *Bathyraja abyssicola*. MS Thesis, Alaska Pacific University.

Rikhter, V.A., and V.N. Efanov. 1976. On one of the approaches to estimation of natural mortality of fish populations. International Commission for the Northwest Atlantic Fisheries.

Roff, D.A. 1984. The evolution of life-history parameters in teleosts. Can. J. Fish. Aquat. Sci. 41(6):989-1000.

Spies, I.B., D.E. Stevenson, J.W. Orr, and G.R. Hoff. 2011. Molecular systematics of the skate subgenus *Arctoraja* (*Bathyraja*: Rajidae) and support for an undescribed species, the leopard skate, with comments on the phylogenetics of *Bathyraja*. Ichthyological Research 58(1):77-83.

Spies, I., J.W. Orr, D.E. Stevenson, P. Goddard, G.R. Hoff, J. Guthridge, and C.N. Rooper. 2021a. Genetic evidence from embryos suggests a new species of skate related to *Bathyraja parmifera* (Rajiformes: Arhynchobatidae) in the Bering Sea. Mar. Ecol. Prog. Ser. 670:155-166.

Spies, I., J.W. Orr, D.E. Stevenson, P. Goddard, G. Hoff, J. Guthridge, M. Hollowed, and C. Rooper. 2021b. Skate egg nursery areas support genetic diversity of Alaska and Aleutian skates in the Bering Sea. Mar. Ecol. Prog. Ser. 669:121-138.

Stevenson, D.E., J.W. Orr, G.R. Hoff, and J.D. McEachran. 2007. Field guide to sharks, skates, and ratfish of Alaska. Alaska Sea Grant College Program, University of Alaska Fairbanks.

Stewart, I. and A. Hicks, 2022. Assessment of the Pacific halibut (*Hippoglossus stenolepis*) stock at the end of 2021. International Pacific Halibut Commission, IPHC-2022-SA-01, available at https://www.iphc.int/uploads/pdf/sa/2022/iphc-2022-sa-01.pdf

Sullivan, J., C. Monnahan, P. Hulson, J. Ianelli, J. Thorson, and A. Havron. 2022a. REMA: a consensus version of the random effects model for ABC apportionment and Tier 4/5 assessments. Plan Team Report, Joint Groundfish Plan Teams, North Pacific Fishery Management Council. 605 W 4th Ave, Suite 306 Anchorage, AK 99501

Winton, M.V., L.J. Natanson, J. Kneebone, G.M. Cailliet, and D.A. Ebert. 2013. Life history of *Bathyraja trachura* from the eastern Bering Sea, with evidence of latitudinal variation in a deep-sea skate species. J Mar Biol Assoc UK 94(02):411-422.

Auxiliary Files

Alaska skate model history

Previous PT and SSC comments

All code and output for the models included in this assessment are available as listed below:

- Alaska skate Tier 3 model files
- Other skate Tier 5 model files

All code and output for the Appendix 18A model alternatives are available as listed below:

- Alaska skate Tier 4 model files
- Alaska skate Tier 5 model files

Tables

Table 18.1: Selected life history parameters and depth distributions of BSAI skate species. “UNK” indicates no information is available.

Species	Common Name	Max. Obs. Length (cm)	Max. Obs. Age (yr)	Age / Length at 50% Maturity	Depth Range (m)	Recent Synonyms	Sources
Amblyraja badia	Broad skate	99 (F) 95 (M)	UNK	86-93 cm (M)	846-2324	Roughshoulder skate	Ebert 2003, Ebert et al. 2016, Ebert unpubl. data
Arctoraja parmifera	Alaska skate	137 (F)	26 (F)	10 yr, 93 cm (F), 9 yr, 92 cm (M)	17-392	*Bathyraja parmifera*	Matta and Gunderson 2007, Matta et al. 2017, Stevenson et al. 2007
Bathyraja abyssicola	Deepsea skate	160 (F) 135 (M)	45 (F)	127 cm (F), 118 cm (M)	350-3000	—	Ebert 2003, Provost 2016, Ebert unpubl. data
Bathyraja aleutica	Aleutian skate	161	17 (F) 16 (M)	10 yr, 124 cm (F), 10 yr, 123 cm (M)	15-1602	—	Stevenson et al. 2007, Haas 2011, Haas et al. 2016
Bathyraja interrupta	Bering skate	86	21 (F) 18 (M)	13 yr, 72 cm (F), 11 yr, 70 cm (M)	26-1050	—	Stevenson et al. 2007, Ainsley 2009, Ainsley et al. 2011a, Ainsley et al. 2014
Bathyraja lindbergi	Commander skate	102	32 (F) 35 (M)	21 yr, 79 cm (F), 22 yr (M), 80 cm	126-1193	—	Stevenson et al. 2007, Maurer 2009
Bathyraja maculata	Whiteblotched skate	147	33 (F) 36 (M)	26 yr, 96 cm (F), 25 yr, 93 cm (M)	73-1193	—	Stevenson et al. 2007, Maurer 2009
Bathyraja mariposa	Butterfly skate	76	UNK	UNK	90-448	—	Stevenson et al. 2007
Bathyraja minispinosa	Whitebrow skate	92	37 (F) 35 (M)	24 yr, 67 cm (F), 23 yr, 70 cm (M)	150-1420	—	Stevenson et al. 2007, Ainsley et al. 2011b
Arctoraja panthera	Leopard skate	139	UNK	UNK	48-396	*Bathyraja panthera*	Stevenson et al. 2007
Bathyraja spinosissima	Pacific white skate	208	UNK	UNK	800-2938	—	Orr et al. 2019, Finucci and Rohner 2025
Bathyraja taranetzi	Mud skate	77	UNK	63 cm (F), 56 cm (M)	58-1054	—	Stevenson et al. 2007, Ebert et al. 2005
Bathyraja trachura	Roughtail skate	94	36 (F) 35 (M)	25 yr, 80 cm (F), 21 yr, 74 cm (M)	213-2550	—	Stevenson et al. 2007, Winton et al. 2013
Bathyraja violacea	Okhotsk skate	107	9 (F)	5-6 yr (F)	25-1100	—	Dulvy et al. 2020
Beringraja binoculata	Big skate	204 (244)	14 (F) 15 (M)	149 cm (F), 119 cm (M)	16-402	*Raja binoculata*	Stevenson et al. 2007, Gburksi et al. 2007, Ebert et al. 2008
Caliraja rhina	Longnose skate	144	24 (F) 25 (M)	12-13 yr, 113 cm (F), 10 yr, 102 cm (M)	9-1069	*Raja rhina, Beringraja rhina*	Stevenson et al. 2007, Gburksi et al. 2007, Ebert et al. 2008, Arrington 2020

Table 18.2: Estimated discard rates of skates in the eastern Bering Sea and Aleutian Islands. Data are provided by NMFS AKRO Catch Accounting System, queried through AKFIN on October 5, 2026.

	Aleutian Islands		Eastern Bering Sea	
Year	**Longline**	**Trawl**	**Longline**	**Trawl**
2003	80%	85%	53%	55%
2004	73%	91%	74%	61%
2005	87%	88%	66%	64%
2006	78%	79%	71%	65%
2007	51%	89%	72%	66%
2008	81%	64%	69%	57%
2009	69%	67%	75%	59%
2010	80%	60%	70%	57%
2011	93%	70%	80%	60%
2012	79%	51%	73%	66%
2013	83%	59%	72%	64%
2014	95%	54%	71%	64%
2015	84%	45%	73%	65%
2016	95%	38%	80%	60%
2017	89%	43%	72%	64%
2018	82%	47%	63%	49%
2019	74%	46%	52%	52%
2020	68%	56%	52%	58%
2021	66%	60%	53%	59%
2022	58%	75%	54%	71%
2023	100%	72%	47%	71%
2024	69%	84%	48%	53%
2025	33%	91%	53%	60%
2026	44%	92%	52%	60%

Table 18.3: Estimated catch (t) of the skate stock complex in the Bering Sea and Aleutian Islands (BSAI). The total BSAI skate catch is provided by the NMFS Alaska Regional Office in the Catch Accounting System, queried October 5, 2026. Catch data were incomplete for 2026, so the catch as of October 5, 2026 was expanded by a correction factor based on seasonal catch patterns from the last 5 years.

Year	Management Method	OFL	ABC	TAC	Total Complex Catch
1992	Other Species	27,200	27,200	20,000	16,962
1993	Other Species	26,600	26,600	26,600	12,226
1994	Other Species	141,000	27,500	26,390	14,223
1995	Other Species	136,000	27,600	20,000	14,892
1996	Other Species	137,000	27,600	20,125	12,643
1997	Other Species	138,000	25,800	25,800	17,747
1998	Other Species	134,000	25,800	25,800	19,318
1999	Other Species	129,000	32,860	32,860	14,080
2000	Other Species	71,500	31,360	31,360	18,877
2001	Other Species	69,000	33,600	26,500	20,570
2002	Other Species	78,900	39,100	30,825	21,279
2003	Other Species	81,100	43,300	32,309	21,143
2004	Other Species	81,150	46,810	27,205	22,329
2005	Other Species	87,920	53,860	29,000	23,084
2006	Other Species	89,404	58,882	29,000	20,250
2007	Other Species	91,700	68,800	37,355	18,623
2008	Other Species	104,000	78,100	50,000	21,677
2009	Other Species	80,800	63,700	50,000	20,595
2010	Other Species	88,200	61,100	50,000	17,706
2011	Skate Complex	37,800	31,500	16,500	23,828
2012	Skate Complex	39,100	32,600	24,700	24,790
2013	Skate Complex	45,800	38,800	24,000	26,991
2014	Skate Complex	41,849	35,383	26,000	27,484
2015	Skate Complex	49,575	41,658	25,700	28,227
2016	Skate Complex	50,215	42,134	26,000	29,166
2017	Skate Complex	49,063	41,144	26,000	31,863
2018	Skate Complex	46,668	39,082	27,000	31,157
2019	Skate Complex	51,152	42,714	26,000	20,157
2020	Skate Complex	49,792	41,543	16,313	19,248
2021	Skate Complex	49,297	41,257	18,000	20,029
2022	Skate Complex	47,790	39,958	30,000	29,236
2023	Skate Complex	46,220	38,605	27,441	26,010
2024	Skate Complex	45,574	37,808	30,519	27,146
2025	Skate Complex	44,086	36,523	27,646	21,735
2026	Skate Complex	43,285	35,833	27,646	17,205

Table 18.4: Time series of the estimated catch (t) for Alaska skate and Other skates. Catch estimates are provided by the NMFS Alaska Regional Office in the Catch Accounting System, queried October 5, 2026. Catch data were incomplete for 2026, so the catch as of October 5, 2026 was expanded by a correction factor based on seasonal catch patterns from the last 5 years.

Year	Alaska Skate	Other Skate	Total
2003	18,046	3,097	21,143
2004	17,546	4,783	22,329
2005	18,714	4,370	23,084
2006	16,551	3,699	20,250
2007	15,196	3,427	18,623
2008	15,567	6,110	21,677
2009	16,064	4,531	20,595
2010	13,631	4,075	17,706
2011	18,584	5,244	23,828
2012	19,398	5,392	24,790
2013	21,918	5,073	26,991
2014	21,392	6,092	27,484
2015	21,492	6,735	28,227
2016	23,338	5,828	29,166
2017	24,901	6,962	31,863
2018	24,778	6,379	31,157
2019	15,898	4,259	20,157
2020	15,726	3,522	19,248
2021	16,965	3,064	20,029
2022	26,024	3,212	29,236
2023	21,681	4,328	26,009
2024	24,021	3,125	27,146
2025	18,913	2,821	21,734
2026	15,410	1,795	17,205

Table 18.5: Reconstructed catch data used in the Alaska skate Tier 3 model, by year and gear type. Catch estimates from 2007-2026 are estimated following the methods described in Ormseth (2018). Data are provided by NMFS AKRO Catch Accounting System and the North Pacific Observer Program, queried through AKFIN on October 5, 2026. Catch data were incomplete for 2026, so the catch as of October 5, 2026 was expanded by a correction factor based on seasonal catch patterns from the last 5 years.

Year	Longline	Trawl	Year	Longline	Trawl	Year	Longline	Trawl
1954	0	0	1979	2,609	16,207	2004	16,308	3,892
1955	0	0	1980	4,578	12,310	2005	17,661	3,405
1956	0	0	1981	4,503	12,553	2006	14,907	3,347
1957	0	0	1982	2,349	6,437	2007	8,917	6,806
1958	8	61	1983	1,971	5,456	2008	10,368	5,580
1959	21	156	1984	1,072	2,995	2009	9,483	7,159
1960	0	0	1985	1,443	4,045	2010	7,953	5,678
1961	0	0	1986	1,301	3,675	2011	13,254	5,330
1962	0	0	1987	1,062	3,006	2012	14,310	5,087
1963	0	0	1988	1,443	4,287	2013	16,554	5,362
1964	43	304	1989	588	1,752	2014	17,479	3,912
1965	150	928	1990	688	2,009	2015	18,933	2,558
1966	130	924	1991	6,246	1,372	2016	20,893	2,446
1967	537	1,967	1992	12,586	2,815	2017	21,717	3,184
1968	1,539	9,252	1993	9,072	2,029	2018	20,459	4,320
1969	690	4,365	1994	10,554	2,361	2019	10,239	5,659
1970	1,220	6,502	1995	11,050	2,472	2020	11,387	4,338
1971	856	5,613	1996	9,381	2,098	2021	11,335	5,630
1972	1,377	4,916	1997	13,059	2,932	2022	21,217	4,805
1973	3,264	23,062	1998	14,100	3,178	2023	17,934	3,744
1974	3,700	24,994	1999	10,288	2,318	2024	20,583	3,438
1975	3,348	22,736	2000	13,362	3,055	2025	17,262	1,651
1976	1,702	10,897	2001	14,244	3,291	2026	13,296	2,115
1977	2,559	15,090	2002	15,943	3,571		—	—
1978	3,864	25,571	2003	15,580	3,693		—	—

Table 18.6: Alaska skate survey and fishery hauls sampled, number of lengths and vertebrae collected, number of vertebrae aged, and input sample sizes for Model 14.2d and 25.3. Input sample size is fixed at 200 for survey and the square root of the number of hauls for fishery. Survey length data are available from 2000 to present, and ages in 2003, 2007-2009 and 2015. There was no survey in 2020. Fishery length data are available since 2009, and there are no fishery ages.

	EBS Shelf Survey				Longline Fishery			Trawl Fishery		
Year	Hauls	Aged	Lengths	Input N	Hauls	Lengths	Input N	Hauls	Lengths	Input N
2000	352	—	2,135	200	—	—	—	—	—	—
2001	355	—	3,188	200	—	—	—	—	—	—
2002	355	—	2,669	200	—	—	—	—	—	—
2003	356	182	2,818	200	—	—	—	—	—	—
2004	355	28	4,180	200	—	—	—	—	—	—
2005	353	—	4,491	200	—	—	—	—	—	—
2006	356	—	4,759	200	—	—	—	—	—	—
2007	356	239	4,997	200	—	—	—	—	—	—
2008	355	156	4,131	200	—	—	—	—	—	—
2009	356	337	4,584	200	4,496	18,934	67	3,082	8,476	56
2010	356	—	3,610	200	4,255	16,972	65	3,752	9,633	61
2011	356	—	4,522	200	5,156	22,166	72	3,181	6,601	56
2012	356	—	3,704	200	5,934	26,462	77	2,495	5,338	50
2013	356	—	3,797	200	7,252	31,269	85	3,705	7,721	61
2014	356	—	3,576	200	7,594	32,481	87	2,925	6,025	54
2015	356	313	3,906	200	7,536	31,189	87	2,043	3,910	45
2016	356	—	4,246	200	6,448	27,892	80	2,040	4,134	45
2017	356	—	4,243	200	6,198	26,250	79	3,096	6,375	56
2018	356	—	4,593	200	4,445	20,254	67	5,152	11,758	72
2019	356	—	3,651	200	3,034	12,847	55	6,246	16,057	79
2020	—	—	—	—	2,374	10,627	49	4,333	10,646	66
2021	356	—	3,855	200	2,363	11,209	49	4,156	10,994	64
2022	356	—	3,783	200	2,729	12,895	52	3,749	8,757	61
2023	356	—	3,688	200	2,359	10,827	49	2,971	7,476	54
2024	330	—	3,171	200	2,889	13,119	54	2,394	5,491	49
2025	330	—	3,420	200	2,887	12,915	54	1,331	2,605	36
2026	330	—	2,804	200	1,354	6,288	37	1,225	2,800	35

Table 18.7: Survey biomass estimates time series as used in Model 14.2d1 and Model 25.3 (eastern Bering Sea, EBS, shelf Alaska skates) and Model 23.0 (all Other skates), from the NMFS EBS shelf, EBS slope and Aleutian Islands (AI) bottom trawl surveys. CV = coefficient of variation. No bottom trawl surveys were conducted in 2020 due to the coronavirus pandemic.

	EBS Shelf Alaska Skate		EBS Shelf Other Skates		EBS Slope Other Skates		Aleutian Islands Other Skates	
Year	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV
1982	155,270	0.11	—	—	—	—	—	—
1983	153,071	0.09	—	—	—	—	—	—
1984	176,930	0.08	—	—	—	—	—	—
1985	141,600	0.10	—	—	—	—	—	—
1986	237,480	0.15	—	—	—	—	—	—
1987	334,213	0.09	—	—	—	—	—	—
1988	344,633	0.13	—	—	—	—	—	—
1989	383,034	0.08	—	—	—	—	—	—
1990	451,562	0.11	—	—	—	—	—	—
1991	421,699	0.09	—	—	—	—	—	—
1992	369,457	0.09	—	—	—	—	—	—
1993	355,320	0.07	—	—	—	—	—	—
1994	366,898	0.08	—	—	—	—	—	—
1995	331,177	0.08	—	—	—	—	—	—
1996	378,855	0.06	—	—	—	—	—	—
1997	370,792	0.07	—	—	—	—	—	—
1998	335,943	0.05	—	—	—	—	—	—
1999	311,502	0.17	30,629	0.33	—	—	—	—
2000	298,846	0.06	24,602	0.21	—	—	29,219	0.09
2001	402,198	0.06	17,256	0.15	—	—	—	—
2002	347,129	0.07	18,333	0.15	69,473	0.49	34,465	0.11
2003	353,348	0.05	31,697	0.25	—	—	—	—
2004	401,879	0.05	14,083	0.12	33,380	0.08	53,225	0.16
2005	461,911	0.05	20,222	0.26	—	—	—	—
2006	424,220	0.05	17,924	0.16	—	—	54,213	0.12
2007	458,343	0.07	16,956	0.22	—	—	—	—
2008	347,043	0.06	19,218	0.22	36,459	0.08	—	—
2009	338,992	0.07	19,515	0.17	—	—	—	—
2010	352,472	0.06	17,683	0.17	35,563	0.12	51,942	0.11
2011	393,143	0.05	17,627	0.25	—	—	—	—
2012	352,004	0.06	16,163	0.15	59,936	0.10	35,405	0.12
2013	375,588	0.06	26,690	0.23	—	—	—	—
2014	393,099	0.05	24,061	0.18	—	—	42,904	0.12
2015	433,418	0.06	39,180	0.23	—	—	—	—
2016	531,725	0.04	36,811	0.19	49,208	0.11	27,767	0.14
2017	516,122	0.07	65,088	0.33	—	—	—	—
2018	526,964	0.05	63,847	0.22	—	—	29,489	0.14
2019	476,702	0.05	37,599	0.16	—	—	—	—
2021	452,379	0.05	45,116	0.17	—	—	—	—
2022	443,220	0.06	45,100	0.17	—	—	23,075	0.23
2023	406,760	0.08	80,777	0.27	—	—	—	—
2024	377,151	0.06	49,227	0.20	—	—	19,924	0.19
2025	367,627	0.05	54,780	0.23	—	—	—	—
2026	307,495	0.05	58,905	0.24	—	—	27,252	0.21

Table 18.8: Comparison of biological, growth, and size selectivity parameters, with standard deviations, between Model 14.2d1 and Model 25.3.

	Model 14.2d1		**Model 25.3**	
Parameter	**Estimate**	**StdDev**	**Estimate**	**StdDev**
L at Amin Fem GP 1	14.2908	0.3882	—	—
L at Amax Fem GP 1	101.7900	0.3173	—	—
VonBert K Fem GP 1	0.3757	0.0056	—	—
Richards Fem GP 1	-1.0000	0.0000	—	—
CV young Fem GP 1	0.3500	0.0002	—	—
CV old Fem GP 1	0.0500	0.0000	—	—
SR LN(R0)	10.0193	0.0221	10.0072	0.0204
Size DblN peak LGL(1)	91.2005	3.5087	89.8842	1.1888
Size DblN top logit LGL(1)	-1.0755	0.8097	—	—
Size DblN ascend se LGL(1)	6.9891	0.1525	6.8280	0.0722
Size DblN descend se LGL(1)	0.7595	7.2549	—	—
Size DblN start logit LGL(1)	-4.9987	0.0430	—	—
Size DblN end logit LGL(1)	1.3526	1.0948	-1.6182	0.5991
Size DblN peak TWL(2)	54.9263	3.9702	85.6907	1.4648
Size DblN top logit TWL(2)	1.7284	24.7343	—	—
Size DblN ascend se TWL(2)	6.1042	0.3213	7.6478	0.0955
Size DblN descend se TWL(2)	4.4888	98.3485	—	—
Size DblN start logit TWL(2)	-4.9972	0.0923	—	—
Size DblN end logit TWL(2)	5.9245	57.8677	-1.2223	0.5084
Size DblN peak SURV(3)	58.9480	1.7816	88.0519	2.8829
Size DblN top logit SURV(3)	0.5811	0.3141	—	—
Size DblN ascend se SURV(3)	6.3381	0.1304	7.8645	0.1037
Size DblN descend se SURV(3)	-0.0245	13.6910	—	—
Size DblN start logit SURV(3)	-4.9996	0.0151	—	—
Size DblN end logit SURV(3)	1.4899	0.8961	—	—

Table 18.9: Comparison of likelihoods and reference points between Model 14.2d1 and Model 25.3. RMSE is root mean square error; SDNR is standard deviation of normalized residuals.

Model Metric / Diagnostic	Model 14.2d1	Model 25.3
Active Parameters	102	86
Total Negative Log-Likelihood	356.287	575.707
Survey Index Likelihood	-21.993	95.419
Length Comp Likelihood	199.277	365.578
Recruitment Deviations Likelihood	6.172	24.236
ln(R0) Estimate	10.019	10.007
Survey Index RMSE	51,276.781	52,154.175
Survey Index SDNR	837,515.718	833,780.058
B100% (Female Spawning Biomass, t)	296,726	311,701
F35%	0.080	0.085

Table 18.10: Comparison of the model-derived quantities for the 2023 run of Model 14.2d, and the two models presented in this assessment: 14.2d1 and 25.3.

	As estimated in 2024	Model 14.2d1		Model 25.3		
Quantity	**2026**	**2027**	**2028**	**2027**	**2028**	**% Change (2026 to M25.3 2027)**
$B_{100\%}$	178,425	149,184	149,184	155,861	155,861	-13%
$B_{40\%}$	71,370	59,674	59,674	62,344	62,344	-13%
$B_{35\%}$	62,449	52,065	52,065	54,552	54,552	-13%
Female Spawning Biomass (t)	217,439	183,703	170,334	196,308	182,151	-10%
Relative Spawning Biomass	0.679	0.619	0.574	0.630	0.584	-7%
$F_{40\%}$	0.080	0.079	0.080	0.085	0.085	7%
$F_{35\%}$	0.093	0.093	0.091	0.100	0.100	7%
ABC (t)	25,975	24,615	25,067	23,366	23,367	-10%
OFL (t)	30,140	28,585	28,611	27,074	26,633	-10%

Table 18.11: Time series of total (age 0+) biomass (t) predicted by Model 14.2d1 and 25.3. CV = coefficient of variation. Estimates from the 2023 Model 14.2d run are included for comparison.

	Model 14.2d	Model 14.2d1		Model 25.3			Model 14.2d	Model 14.2d1		Model 25.3	
Year	Est.	Est.	CV	Est.	CV	Year	Est.	Est.	CV	Est.	CV
Unfished	544,933	506,385	0.023	523,645	0.020	1988	328,766	325,405	0.073	338,829	0.072
1950	544,814	506,324	0.030	523,314	0.020	1989	355,202	352,214	0.071	359,527	0.068
1951	544,555	506,184	0.030	522,806	0.020	1990	381,458	378,625	0.072	381,126	0.062
1952	544,038	505,895	0.030	522,056	0.020	1991	402,650	399,691	0.062	399,263	0.053
1953	543,084	505,346	0.030	520,985	0.020	1992	413,938	410,555	0.055	409,034	0.048
1954	541,477	504,399	0.030	519,506	0.020	1993	413,049	408,934	0.052	407,984	0.045
1955	539,011	502,911	0.030	517,536	0.020	1994	413,038	407,836	0.050	408,745	0.042
1956	535,554	500,780	0.030	515,002	0.020	1995	409,194	402,582	0.048	406,196	0.039
1957	531,090	497,968	0.030	511,861	0.020	1996	403,647	395,397	0.046	401,934	0.037
1958	525,721	494,508	0.030	508,103	0.020	1997	400,136	390,090	0.044	400,234	0.035
1959	519,556	490,411	0.033	503,690	0.024	1998	393,155	381,332	0.043	394,656	0.033
1960	512,755	485,736	0.038	498,642	0.029	1999	386,790	373,358	0.042	389,717	0.031
1961	505,775	480,853	0.046	493,314	0.036	2000	387,589	372,770	0.041	391,807	0.030
1962	498,568	475,653	0.054	487,603	0.044	2001	387,350	371,439	0.041	391,872	0.029
1963	491,218	470,184	0.061	481,574	0.052	2002	388,734	371,972	0.041	392,615	0.029
1964	483,776	464,477	0.068	475,283	0.059	2003	390,824	373,373	0.041	394,222	0.028
1965	475,925	458,217	0.072	468,434	0.064	2004	395,443	377,369	0.041	398,987	0.027
1966	467,315	451,062	0.076	460,698	0.069	2005	400,901	382,249	0.040	404,857	0.027
1967	458,729	443,794	0.079	452,886	0.072	2006	407,196	387,886	0.039	412,849	0.026
1968	448,741	435,014	0.081	443,587	0.075	2007	417,425	397,439	0.039	423,061	0.026
1969	430,697	418,162	0.084	426,146	0.078	2008	431,625	410,983	0.038	438,338	0.025
1970	418,756	407,236	0.085	414,765	0.080	2009	447,166	425,817	0.036	453,019	0.024
1971	404,530	393,959	0.087	401,056	0.081	2010	463,320	441,251	0.035	468,865	0.023
1972	392,025	382,303	0.087	389,049	0.082	2011	483,121	460,346	0.035	486,256	0.023
1973	380,211	371,256	0.088	377,745	0.082	2012	497,927	474,679	0.035	498,920	0.024
1974	349,225	341,210	0.092	347,288	0.086	2013	510,646	487,053	0.035	509,079	0.024
1975	317,230	310,092	0.096	315,945	0.091	2014	518,487	494,709	0.034	514,381	0.024
1976	289,368	282,968	0.101	288,958	0.095	2015	523,633	499,561	0.034	516,481	0.023
1977	276,434	270,511	0.103	277,234	0.097	2016	524,564	500,272	0.034	514,894	0.023
1978	259,985	254,499	0.105	262,599	0.099	2017	519,087	494,588	0.034	508,223	0.021
1979	233,718	228,698	0.111	239,152	0.104	2018	507,185	482,561	0.034	495,538	0.022
1980	220,318	215,540	0.113	229,768	0.107	2019	491,109	466,279	0.034	479,831	0.021
1981	211,765	207,077	0.114	226,246	0.108	2020	480,798	455,176	0.034	470,616	0.020
1982	206,605	201,931	0.114	226,086	0.108	2021	468,487	441,510	0.034	458,259	0.020
1983	213,535	208,805	0.110	236,506	0.104	2022	454,747	425,701	0.034	445,024	0.019
1984	226,391	221,675	0.104	251,117	0.099	2023	433,480	401,727	0.035	423,554	0.020
1985	247,422	242,841	0.096	271,499	0.092	2024	—	384,337	0.037	407,404	0.021
1986	271,545	267,281	0.087	292,590	0.085	2025	—	368,112	0.038	389,858	0.022
1987	299,234	295,407	0.079	315,273	0.078	2026	—	360,991	0.040	380,443	0.024

Table 18.12: Time series of spawning biomass (t) predicted by Model 14.2d1 and 25.3. CV = coefficient of variation. Estimates from the 2023 Model 14.2d run are included for comparison.

	Model 14.2d	Model 14.2d1		Model 25.3			Model 14.2d	Model 14.2d1		Model 25.3	
Year	Est.	Est.	CV	Est.	CV	Year	Est.	Est.	CV	Est.	CV
Unfished	320,052	296,726	0.022	311,701	0.020	1988	111,906	109,966	0.073	116,837	0.072
1950	320,052	296,726	0.030	311,701	0.020	1989	122,578	120,857	0.071	129,812	0.068
1951	320,052	296,726	0.030	311,701	0.020	1990	140,473	139,209	0.072	148,801	0.062
1952	320,052	296,726	0.030	311,701	0.020	1991	164,044	163,323	0.062	170,482	0.053
1953	320,052	296,726	0.030	311,701	0.020	1992	185,715	185,033	0.055	188,971	0.048
1954	320,052	296,726	0.030	311,701	0.020	1993	200,432	199,475	0.052	201,054	0.045
1955	320,052	296,726	0.030	311,701	0.020	1994	212,426	211,083	0.050	211,737	0.042
1956	320,052	296,726	0.030	311,701	0.020	1995	218,218	216,514	0.048	217,313	0.039
1957	320,052	296,726	0.030	311,701	0.020	1996	219,271	217,251	0.046	218,737	0.037
1958	320,052	296,726	0.030	311,701	0.020	1997	218,533	216,159	0.044	218,524	0.035
1959	318,796	295,944	0.033	310,876	0.024	1998	213,380	210,473	0.043	213,475	0.033
1960	316,604	294,573	0.038	309,516	0.029	1999	206,894	203,133	0.042	206,522	0.031
1961	313,678	292,786	0.046	307,747	0.036	2000	203,137	198,206	0.041	202,019	0.030
1962	310,102	290,558	0.054	305,471	0.044	2001	196,606	190,416	0.041	195,116	0.029
1963	306,111	288,002	0.061	302,759	0.052	2002	189,623	182,338	0.041	188,432	0.029
1964	301,899	285,210	0.068	299,711	0.059	2003	183,507	175,421	0.041	182,554	0.028
1965	297,363	282,024	0.072	296,190	0.064	2004	180,658	172,094	0.041	178,941	0.027
1966	292,323	278,237	0.076	292,006	0.069	2005	178,499	169,628	0.040	176,058	0.027
1967	287,283	274,342	0.079	287,683	0.072	2006	178,092	168,944	0.039	175,399	0.026
1968	281,305	269,411	0.081	282,275	0.075	2007	180,743	171,308	0.039	177,098	0.026
1969	270,067	259,172	0.084	271,357	0.078	2008	186,157	176,417	0.038	182,227	0.025
1970	262,528	252,535	0.085	264,094	0.080	2009	193,343	183,329	0.036	189,326	0.024
1971	253,333	244,176	0.087	255,054	0.081	2010	199,808	189,423	0.035	195,879	0.023
1972	245,042	236,642	0.087	246,869	0.082	2011	206,928	196,046	0.035	203,110	0.023
1973	236,976	229,263	0.088	238,864	0.082	2012	212,544	201,495	0.035	209,024	0.024
1974	216,505	209,506	0.092	218,113	0.086	2013	219,946	208,827	0.035	216,577	0.024
1975	194,973	188,723	0.096	196,172	0.091	2014	227,042	215,923	0.034	223,712	0.024
1976	175,632	170,129	0.101	176,414	0.095	2015	236,781	224,999	0.034	234,043	0.023
1977	165,241	160,388	0.103	165,765	0.097	2016	244,381	231,551	0.034	240,793	0.023
1978	152,380	148,092	0.105	152,662	0.099	2017	251,674	238,505	0.034	249,011	0.021
1979	133,286	129,515	0.111	133,339	0.104	2018	256,771	243,052	0.034	252,448	0.022
1980	121,383	118,065	0.113	121,295	0.107	2019	259,209	244,892	0.034	256,344	0.021
1981	111,378	108,460	0.114	111,255	0.108	2020	263,416	248,613	0.034	260,498	0.020
1982	102,321	99,725	0.114	102,384	0.108	2021	265,041	250,062	0.034	262,966	0.020
1983	98,782	96,418	0.110	99,042	0.104	2022	262,187	247,086	0.034	261,172	0.019
1984	97,064	94,847	0.104	97,687	0.099	2023	249,938	234,761	0.035	249,860	0.020
1985	98,220	96,083	0.096	99,292	0.092	2024	—	221,940	0.037	237,175	0.021
1986	100,286	98,200	0.087	102,150	0.085	2025	—	206,507	0.038	220,790	0.022
1987	104,566	102,529	0.079	107,668	0.078	2026	—	194,123	0.040	207,858	0.024

Table 18.13: Time series of recruits (millions) predicted by Model 14.2d1 and 25.3. CV = coefficient of variation. Estimates from the 2023 Model 14.2d run are included for comparison.

	Model 14.2d	Model 14.2d1		Model 25.3			Model 14.2d	Model 14.2d1		Model 25.3	
Year	Est.	Est.	CV	Est.	CV	Year	Est.	Est.	CV	Est.	CV
Unfished	24,102	22,456	0.022	22,185	0.020	1988	20,364	19,918	0.358	19,471	0.357
1950	20,752	20,557	0.388	20,110	0.386	1989	20,732	19,855	0.355	19,218	0.354
1951	20,547	20,345	0.386	19,882	0.384	1990	21,547	20,018	0.349	19,340	0.350
1952	20,322	20,113	0.384	19,635	0.382	1991	21,370	19,431	0.339	19,465	0.347
1953	20,075	19,862	0.381	19,368	0.379	1992	18,648	17,262	0.333	18,707	0.347
1954	19,806	19,592	0.379	19,081	0.377	1993	19,156	18,085	0.331	20,315	0.352
1955	19,517	19,302	0.376	18,774	0.374	1994	24,472	23,359	0.339	23,921	0.363
1956	19,206	18,994	0.374	18,450	0.371	1995	29,863	28,915	0.321	26,440	0.362
1957	18,878	18,670	0.371	18,112	0.368	1996	25,870	25,399	0.341	25,130	0.373
1958	18,534	18,333	0.368	17,762	0.365	1997	29,316	28,242	0.325	29,894	0.367
1959	18,179	17,986	0.364	17,405	0.361	1998	30,461	29,381	0.327	27,858	0.380
1960	17,817	17,634	0.361	17,046	0.358	1999	31,016	30,091	0.312	30,891	0.333
1961	17,452	17,280	0.358	16,688	0.355	2000	34,852	33,743	0.269	34,489	0.289
1962	17,088	16,930	0.354	16,340	0.351	2001	29,639	28,714	0.267	29,719	0.293
1963	16,728	16,586	0.351	16,016	0.348	2002	27,776	26,546	0.286	26,612	0.313
1964	16,379	16,251	0.348	15,709	0.345	2003	34,140	33,158	0.288	31,990	0.325
1965	16,048	15,929	0.345	15,423	0.342	2004	40,460	39,302	0.298	38,696	0.335
1966	15,744	15,628	0.342	15,160	0.339	2005	39,030	38,378	0.327	38,935	0.360
1967	15,468	15,361	0.339	14,917	0.336	2006	44,353	41,699	0.302	46,390	0.334
1968	15,207	15,123	0.336	14,681	0.334	2007	34,182	32,197	0.367	31,039	0.400
1969	14,966	14,904	0.334	14,484	0.332	2008	41,103	41,310	0.306	42,654	0.336
1970	14,730	14,681	0.332	14,318	0.330	2009	38,843	37,456	0.323	31,122	0.376
1971	14,520	14,461	0.330	14,208	0.329	2010	33,876	32,353	0.338	39,220	0.342
1972	14,364	14,281	0.328	14,186	0.329	2011	29,036	28,276	0.333	26,503	0.365
1973	14,281	14,183	0.327	14,254	0.329	2012	28,670	28,255	0.302	28,609	0.331
1974	14,347	14,242	0.327	14,542	0.331	2013	23,676	22,911	0.306	23,818	0.329
1975	14,648	14,530	0.329	15,177	0.336	2014	20,465	19,353	0.286	20,395	0.307
1976	15,329	15,185	0.334	16,356	0.345	2015	16,830	16,176	0.286	14,305	0.301
1977	16,574	16,412	0.344	18,267	0.360	2016	18,774	17,896	0.272	14,378	0.295
1978	18,729	18,570	0.360	21,320	0.383	2017	20,567	18,258	0.262	18,770	0.266
1979	22,400	22,262	0.387	26,030	0.420	2018	18,024	15,360	0.276	14,845	0.287
1980	28,538	28,460	0.436	32,542	0.471	2019	24,235	19,002	0.285	19,767	0.299
1981	38,284	38,407	0.516	37,618	0.507	2020	40,942	28,757	0.239	27,036	0.253
1982	43,197	43,515	0.540	36,301	0.497	2021	28,734	22,965	0.310	19,514	0.305
1983	33,424	33,309	0.480	28,595	0.440	2022	34,772	34,847	0.279	32,072	0.279
1984	26,494	26,384	0.419	24,833	0.408	2023	23,782	32,322	0.315	33,652	0.306
1985	22,731	22,668	0.388	22,136	0.385	2024	—	24,814	0.341	28,505	0.327
1986	20,910	20,850	0.371	20,415	0.370	2025	—	19,368	0.355	17,763	0.340
1987	20,337	20,172	0.363	19,597	0.361	2026	—	22,251	0.403	21,959	0.403

Table 18.14: Time series of exploitation rates (catch/total biomass) estimated by model 25.3.

Year	Longline	Trawl	Total F	Year	Longline	Trawl	Total F
1954	0.000	0.000	0.000	1991	0.020	0.004	0.024
1955	0.000	0.000	0.000	1992	0.039	0.008	0.047
1956	0.000	0.000	0.000	1993	0.028	0.006	0.034
1957	0.000	0.000	0.000	1994	0.033	0.007	0.040
1958	<0.001	<0.001	<0.001	1995	0.035	0.008	0.043
1959	<0.001	<0.001	<0.001	1996	0.030	0.007	0.037
1960	0.000	0.000	0.000	1997	0.043	0.010	0.053
1961	0.000	0.000	0.000	1998	0.048	0.011	0.059
1962	0.000	0.000	0.000	1999	0.036	0.008	0.043
1963	0.000	0.000	0.000	2000	0.047	0.010	0.057
1964	<0.001	0.001	0.001	2001	0.050	0.011	0.061
1965	<0.001	0.003	0.003	2002	0.056	0.012	0.068
1966	<0.001	0.003	0.003	2003	0.054	0.012	0.067
1967	0.002	0.006	0.007	2004	0.056	0.013	0.069
1968	0.005	0.028	0.033	2005	0.060	0.011	0.071
1969	0.002	0.014	0.016	2006	0.050	0.010	0.060
1970	0.004	0.021	0.025	2007	0.029	0.020	0.049
1971	0.003	0.019	0.022	2008	0.032	0.016	0.048
1972	0.005	0.017	0.022	2009	0.028	0.020	0.048
1973	0.012	0.084	0.096	2010	0.023	0.015	0.038
1974	0.014	0.100	0.115	2011	0.037	0.014	0.050
1975	0.014	0.100	0.115	2012	0.038	0.013	0.051
1976	0.008	0.051	0.059	2013	0.043	0.013	0.056
1977	0.013	0.075	0.088	2014	0.044	0.009	0.054
1978	0.021	0.138	0.159	2015	0.047	0.006	0.053
1979	0.015	0.094	0.110	2016	0.052	0.006	0.058
1980	0.029	0.075	0.103	2017	0.055	0.008	0.062
1981	0.029	0.077	0.107	2018	0.053	0.011	0.064
1982	0.015	0.039	0.054	2019	0.027	0.015	0.042
1983	0.012	0.031	0.043	2020	0.031	0.012	0.043
1984	0.006	0.015	0.022	2021	0.032	0.016	0.048
1985	0.008	0.019	0.027	2022	0.063	0.014	0.077
1986	0.006	0.016	0.022	2023	0.057	0.012	0.069
1987	0.005	0.012	0.016	2024	0.069	0.011	0.080
1988	0.006	0.015	0.021	2025	0.061	0.006	0.066
1989	0.002	0.006	0.008	2026	0.048	0.007	0.055
1990	0.002	0.006	0.009	—	—	—	—

Table 18.15: Aggregated biomass estimates for Other Skates from rema (Model 23.0) and exploitation rates. Alaska skates are not included in the eastern Bering Sea (EBS) Shelf rema model, but are included in the Aleutian Islands and EBS slope rema models. The 2023 total Other Skate biomass estimate was used for harvest recommendations. No survey was conducted in 2020. Species-specific rema model results are available for the dominant species in Appendix 18B. Detailed rema outputs with confidence intervals are available at: Tier5_output

Year	Aleutian Islands	EBS Shelf	EBS Slope	Total Biomass (t)	Catch (t)	Exploitation Rate
1999	—	23,418	—	23,418	—	—
2000	30,238	21,916	—	52,155	—	—
2001	32,837	19,170	—	52,007	—	—
2002	35,659	18,966	38,418	93,043	—	—
2003	41,012	19,571	36,239	96,821	3,097	0.032
2004	47,168	16,354	34,182	97,704	4,783	0.049
2005	49,494	17,552	34,776	101,821	4,370	0.043
2006	51,935	17,783	35,379	105,097	3,699	0.035
2007	51,116	17,863	35,993	104,972	3,427	0.033
2008	50,309	18,483	36,618	105,410	6,110	0.058
2009	49,516	18,726	37,766	106,008	4,531	0.043
2010	48,735	18,305	38,951	105,990	4,075	0.038
2011	43,371	18,451	46,157	107,980	5,244	0.049
2012	38,598	18,975	54,697	112,269	5,392	0.048
2013	38,916	23,275	53,448	115,638	5,073	0.044
2014	39,237	26,682	52,227	118,146	6,092	0.052
2015	34,570	33,255	51,034	118,859	6,735	0.057
2016	30,457	38,078	49,868	118,404	5,828	0.049
2017	29,688	44,655	49,868	124,212	6,962	0.056
2018	28,938	47,641	49,868	126,448	6,379	0.050
2019	27,629	43,043	49,868	120,541	4,259	0.035
2020	26,379	44,531	49,868	120,779	3,522	0.029
2021	25,185	46,071	49,868	121,125	3,064	0.025
2022	24,046	48,606	49,868	122,520	3,212	0.026
2023	23,330	54,736	49,868	127,934	4,328	0.034
2024	22,635	53,314	49,868	125,818	3,125	0.025
2025	23,688	54,657	49,868	128,213	2,821	0.022
2026	24,789	55,969	49,868	130,627	1,795	0.014

Table 18.16: Standard harvest scenarios projected through 2036 with resultant female spawning biomass (t) and full selection fishing mortality (*F*).

Year	scenario_1	scenario_2	scenario_3	scenario_4	scenario_5	scenario_6	scenario_7
				Female Spawning Biomass (t)			
2026	103,929	103,929	103,929	103,929	103,929	103,929	103,929
2027	98,154	98,154	98,154	98,154	98,154	98,154	98,154
2028	91,076	92,882	92,443	92,738	97,908	89,997	91,076
2029	86,125	89,558	88,713	89,284	99,474	84,106	86,125
2030	81,508	84,720	85,180	86,008	101,066	78,672	80,542
2031	79,587	82,619	84,314	85,410	105,587	75,971	77,720
2032	79,212	82,060	84,978	86,357	111,966	74,835	76,463
2033	79,196	81,838	85,964	87,630	118,860	74,095	75,594
2034	78,092	80,502	85,754	87,684	124,356	72,364	73,720
2035	77,175	79,340	85,642	87,821	129,788	70,895	72,104
2036	75,990	77,902	85,128	87,525	134,346	69,262	70,321
2037	74,590	76,250	84,256	86,836	137,930	67,524	68,434
2038	73,132	74,554	83,198	85,926	140,689	65,822	66,594
2039	71,758	72,960	82,120	84,966	142,854	64,276	64,923
2040	70,539	71,547	81,121	84,062	144,610	62,939	63,476
2041	69,496	70,336	80,240	83,256	146,080	61,815	62,258
				Fishing Mortality (F)			
2026	0.055	0.055	0.055	0.055	0.055	0.055	0.055
2027	0.085	0.062	0.068	0.064	0.000	0.100	0.085
2028	0.085	0.062	0.068	0.064	0.000	0.100	0.085
2029	0.085	0.085	0.068	0.064	0.000	0.100	0.100
2030	0.085	0.085	0.068	0.064	0.000	0.100	0.100
2031	0.085	0.085	0.068	0.064	0.000	0.100	0.100
2032	0.085	0.085	0.068	0.064	0.000	0.100	0.100
2033	0.085	0.085	0.068	0.064	0.000	0.100	0.100
2034	0.085	0.085	0.068	0.064	0.000	0.100	0.100
2035	0.085	0.085	0.068	0.064	0.000	0.100	0.100
2036	0.085	0.085	0.068	0.064	0.000	0.100	0.100
2037	0.085	0.085	0.068	0.064	0.000	0.100	0.100
2038	0.085	0.085	0.068	0.064	0.000	0.100	0.100
2039	0.085	0.085	0.068	0.064	0.000	0.100	0.100
2040	0.085	0.085	0.068	0.064	0.000	0.100	0.100
2041	0.085	0.085	0.068	0.064	0.000	0.099	0.099

Table 18.17: Table 18.16 (continued). Standard harvest scenarios projected through 2036 with resultant catch (t).

Year	scenario_1	scenario_2	scenario_3	scenario_4	scenario_5	scenario_6	scenario_7
				Catch (t)			
2026	15,411	15,411	15,411	15,411	15,411	15,411	15,411
2027	23,366	17,205	18,765	17,663	0	27,074	23,366
2028	22,985	17,205	18,690	17,643	0	26,366	22,984
2029	22,780	23,515	18,735	17,736	0	25,889	26,395
2030	22,629	23,298	18,805	17,853	0	25,496	25,954
2031	22,439	23,040	18,826	17,923	0	25,080	25,488
2032	22,169	22,700	18,762	17,909	0	24,599	24,956
2033	21,825	22,286	18,616	17,811	0	24,062	24,370
2034	21,444	21,838	18,415	17,654	0	23,512	23,772
2035	21,065	21,397	18,193	17,471	0	22,993	23,210
2036	20,718	20,995	17,976	17,287	0	22,532	22,711
2037	20,417	20,646	17,780	17,119	0	22,141	22,288
2038	20,163	20,352	17,611	16,973	0	21,818	21,938
2039	19,954	20,109	17,469	16,850	0	21,556	21,652
2040	19,784	19,911	17,352	16,747	0	21,344	21,422
2041	19,645	19,749	17,255	16,662	0	20,991	21,207

Figures

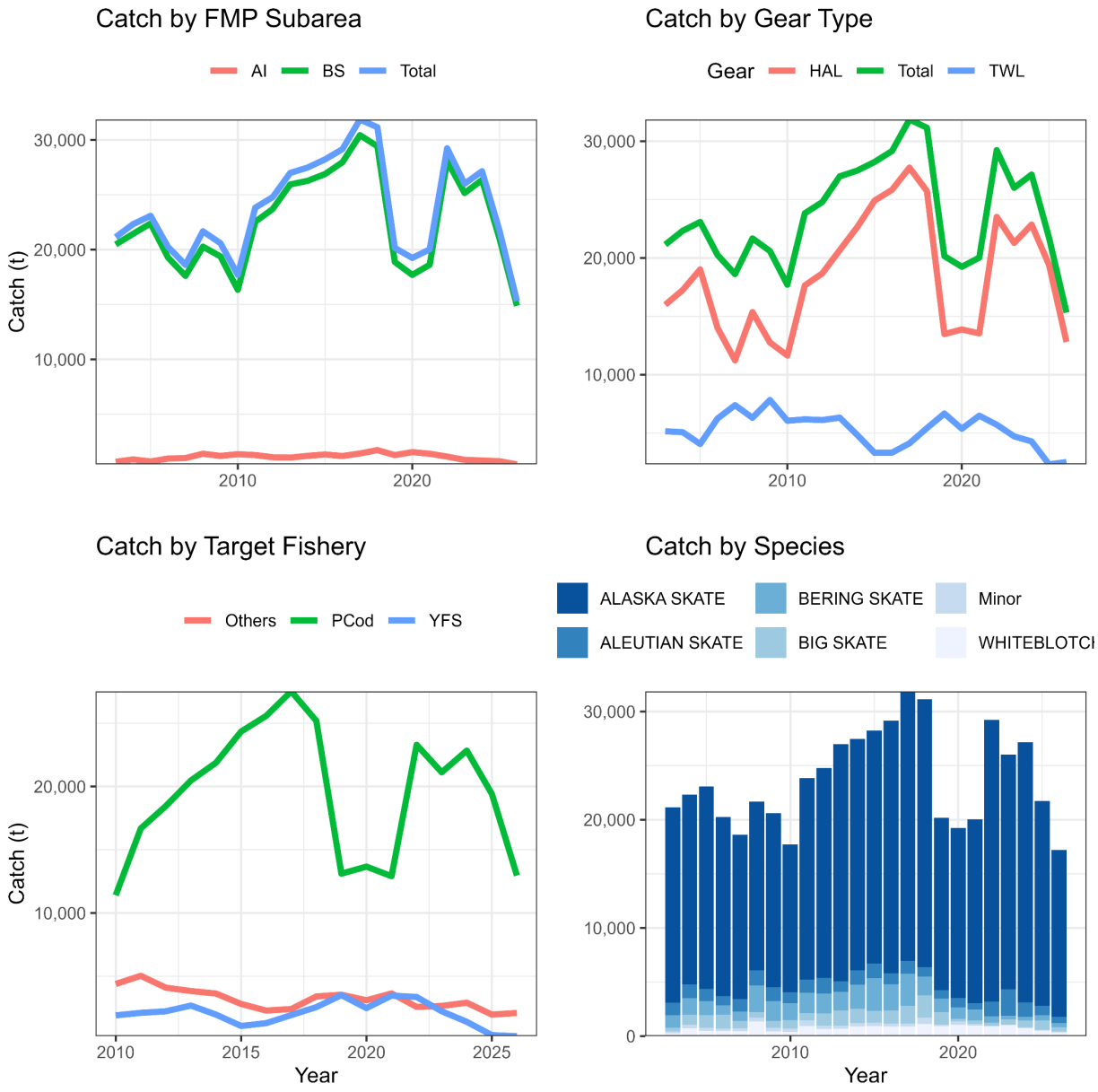


Figure 18.1: Total catch estimates of the Bering Sea/Aleutian Islands Skate Stock Complex. Top left: total catch by Fishery Management Plan sub-areas: Bering Sea (BS) and Aleutian Islands (AI). Top right: total catch by longline (HAL) and trawl (TWL) gear types. Bottom left: Catch of skates in the Pacific cod (PCod) and yellowfin sole (YFS) fisheries, all other target fisheries that catch skates are combined. Bottom right: species-specific catch, as estimated following Ormseth (2018), where unidentified skates are portioned by observed species compositions. Data are provided by NMFS AKRO Catch Accounting System and the North Pacific Observer Program, queried through AKFIN on October 5, 2026.

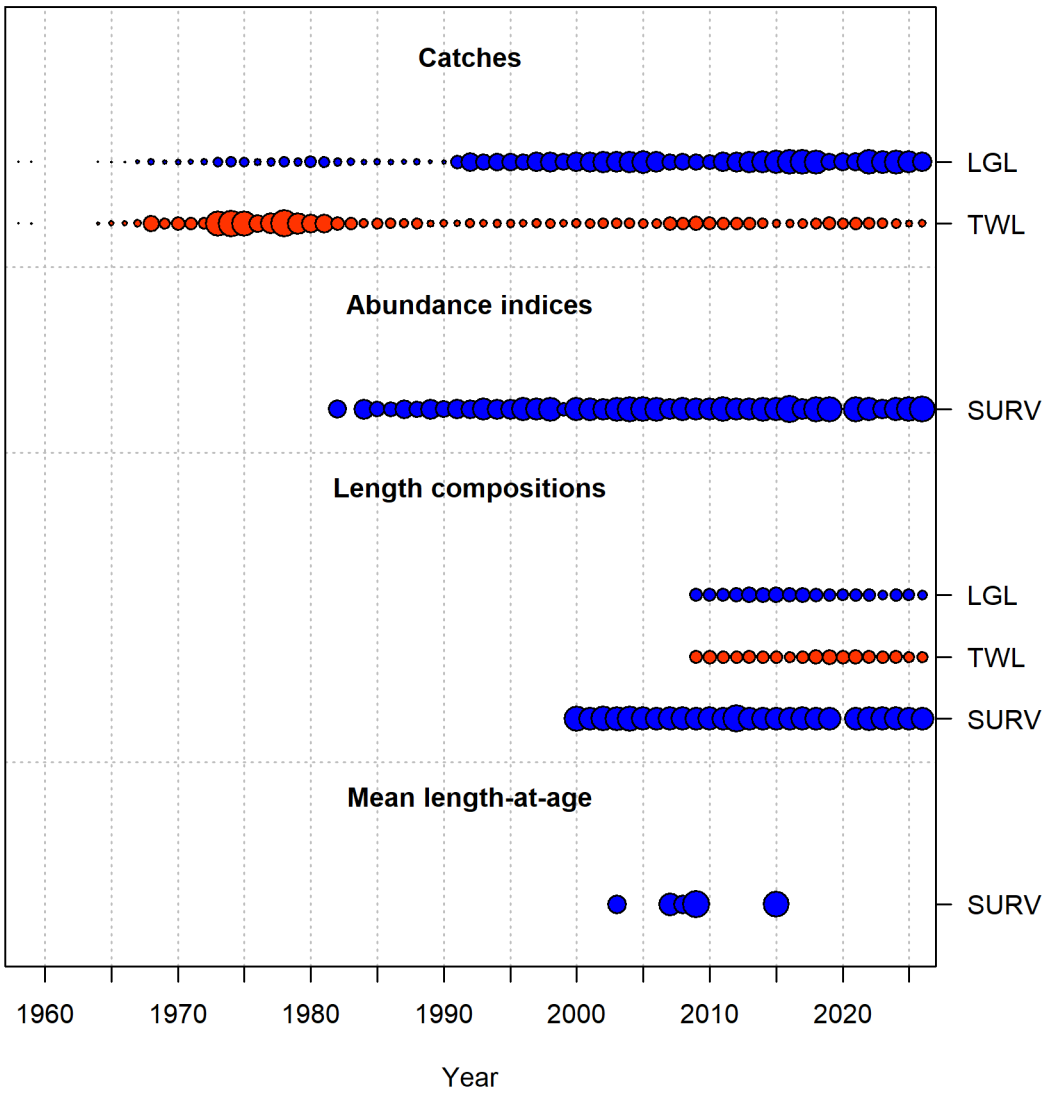


Figure 18.2: Data inputs for eastern Bering Sea Alaska skate Model 14.2d1 and Model 25.3. Dots indicate years in which data are available and the size of the dot is relative sample size or volume within that data category. The mean length-at-age data represent the age data used in Model 14.2d1 only, growth is estimated externally for Model 25.3 and the data used is described in the text.

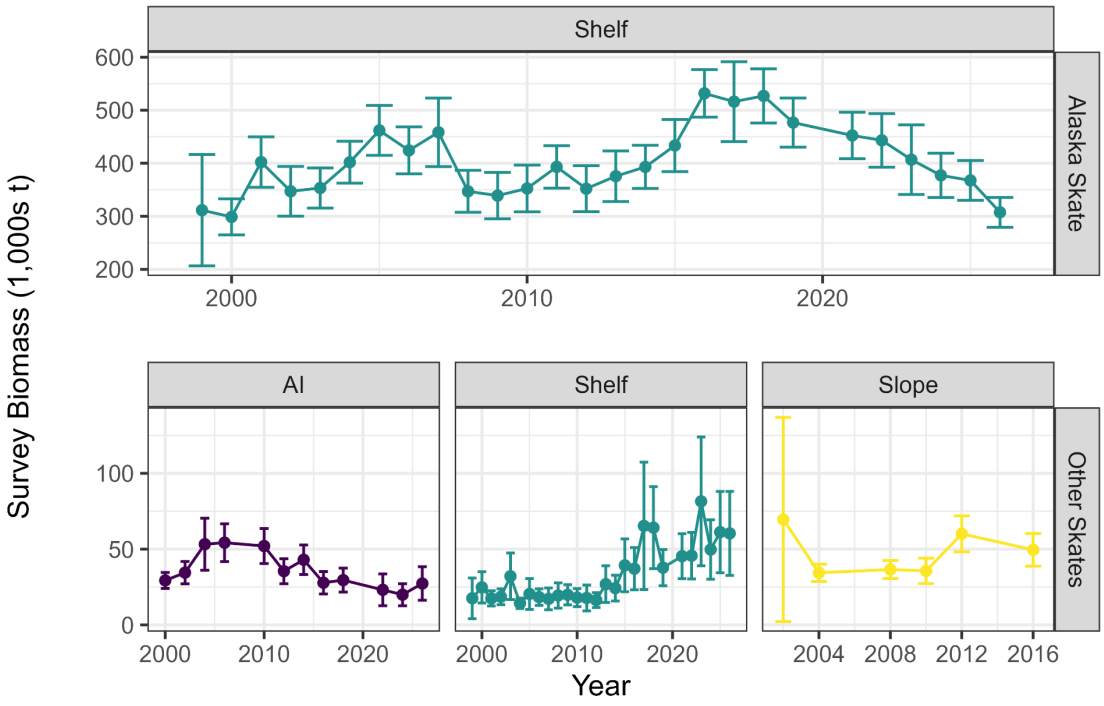


Figure 18.3: Alaska Fisheries Science Center Aleutian Island (AI), eastern Bering Sea shelf (EBS_SHELF) and EBS slope (EBS_SLOPE) survey design-based biomass estimates with 95% error bars for the Alaska skate and Other Skates components of the BSAI Skate Stock Complex.

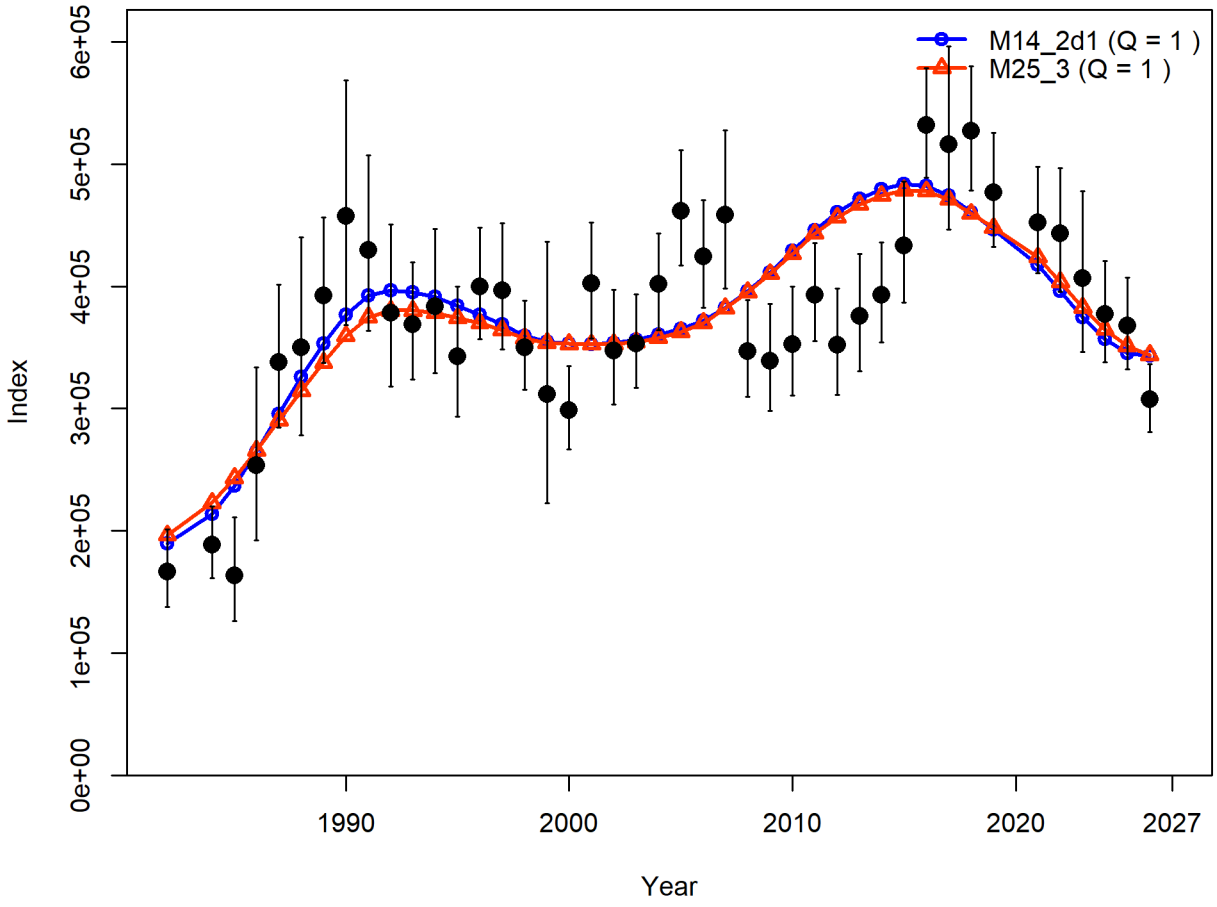


Figure 18.4: Models 14.2d1 and 25.3 fits to the eastern Bering Sea bottom trawl survey design-based biomass estimates for Alaska skate.

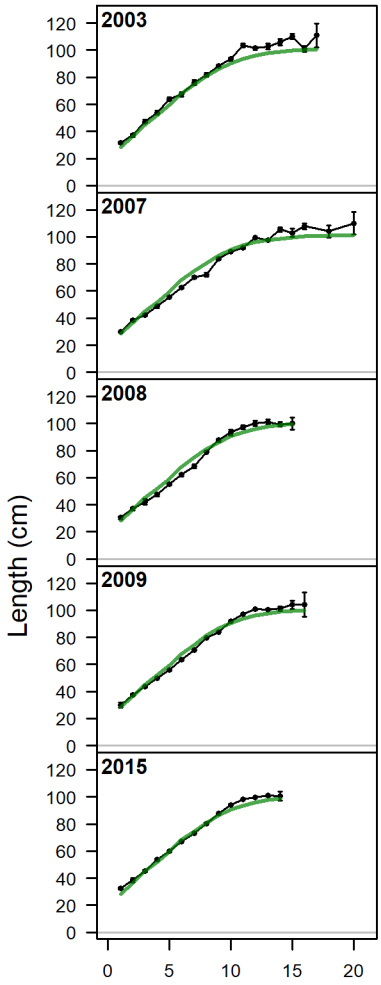


Figure 18.5: Mean length at age for Alaska skate with Model 14.2d1 model fits.

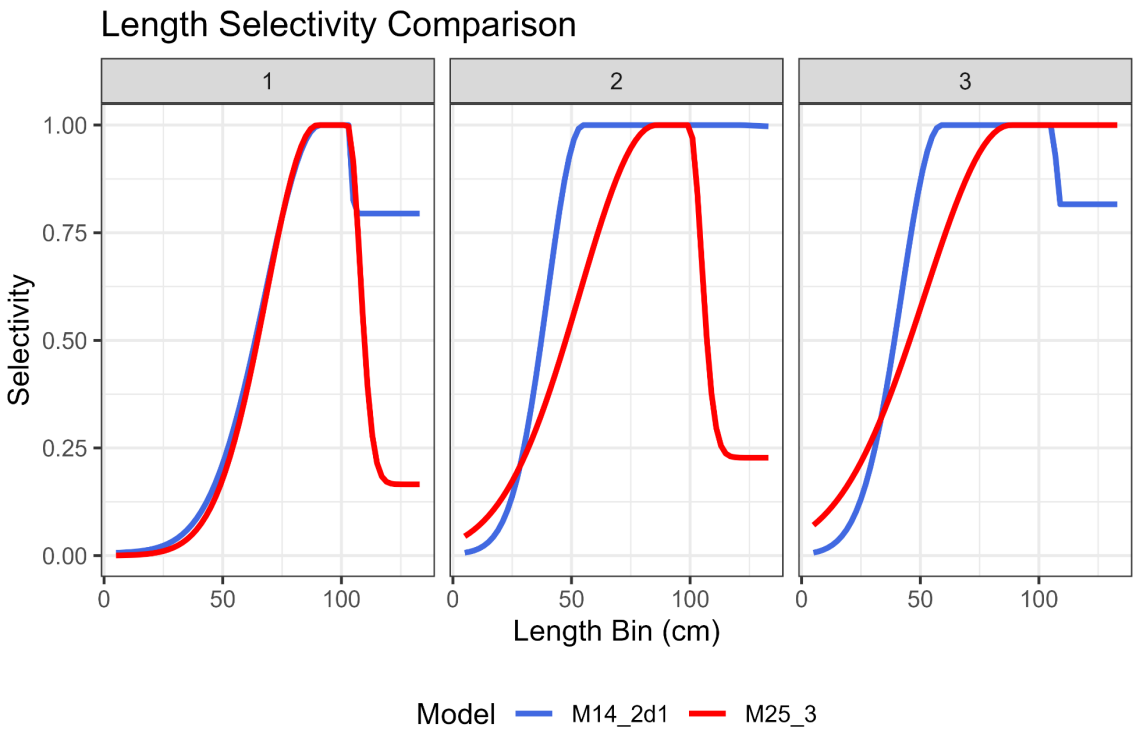


Figure 18.6: Survey selectivity curves for the three fleets in Alaska skate Models 14.2d1 and 25.3: longline (Fleet 1), trawl (Fleet 2), and survey (Fleet 3).

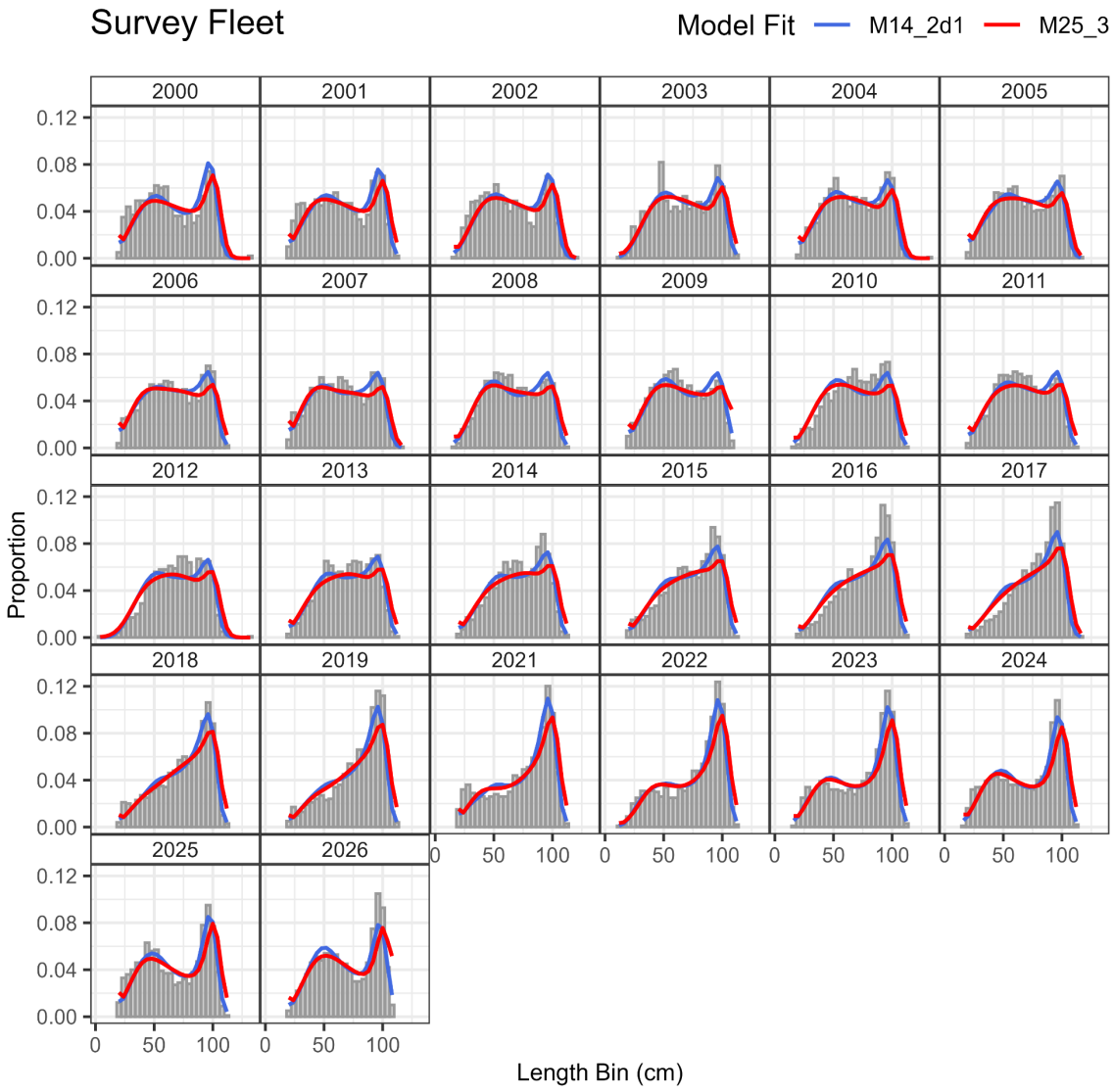


Figure 18.7: Alaska skate length compositions from the eastern Bering Sea bottom trawl survey with the Models 14.2d1 and 25.3 fits.

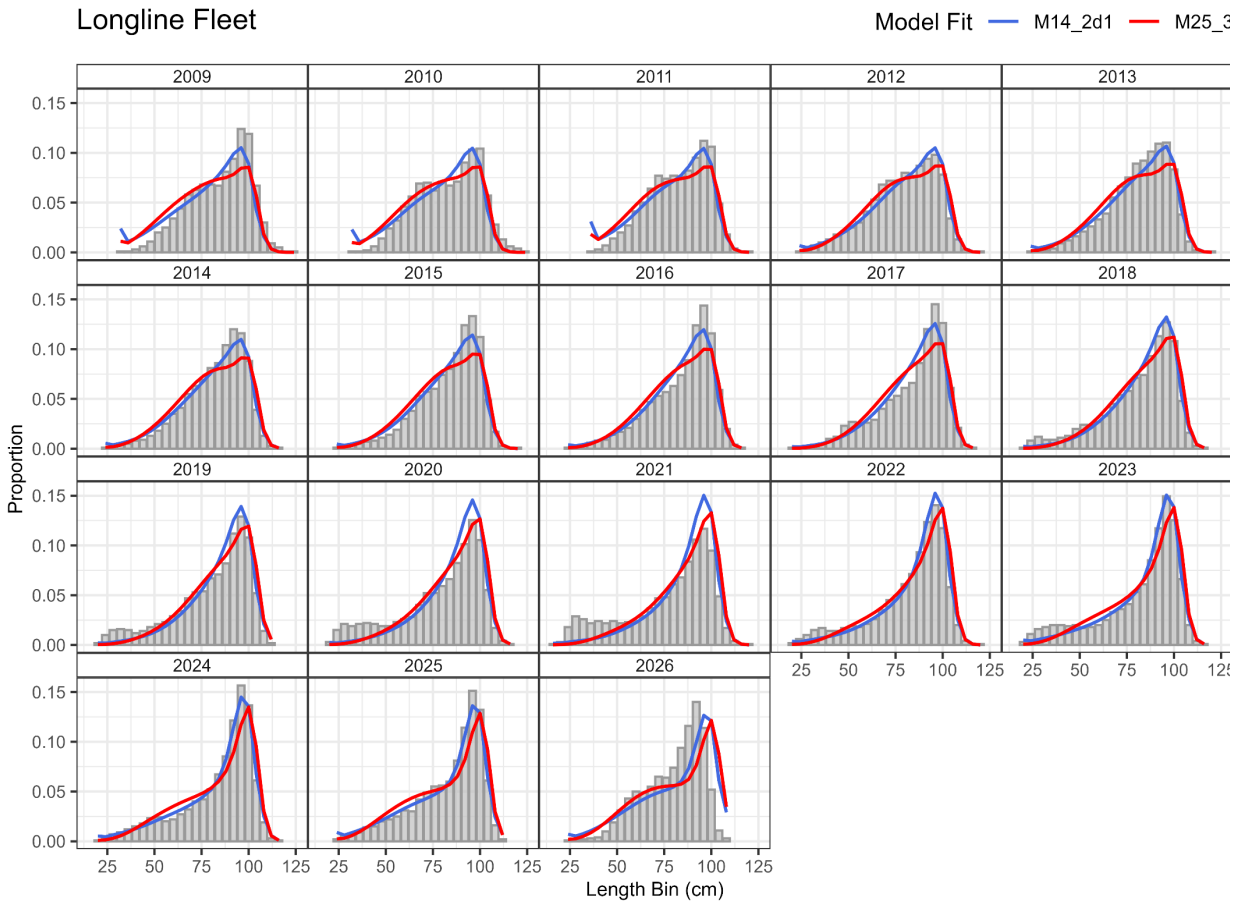


Figure 18.8: Alaska skate length compositions from longline fisheries data with the Model 14.2d1 and 25.3 fits.

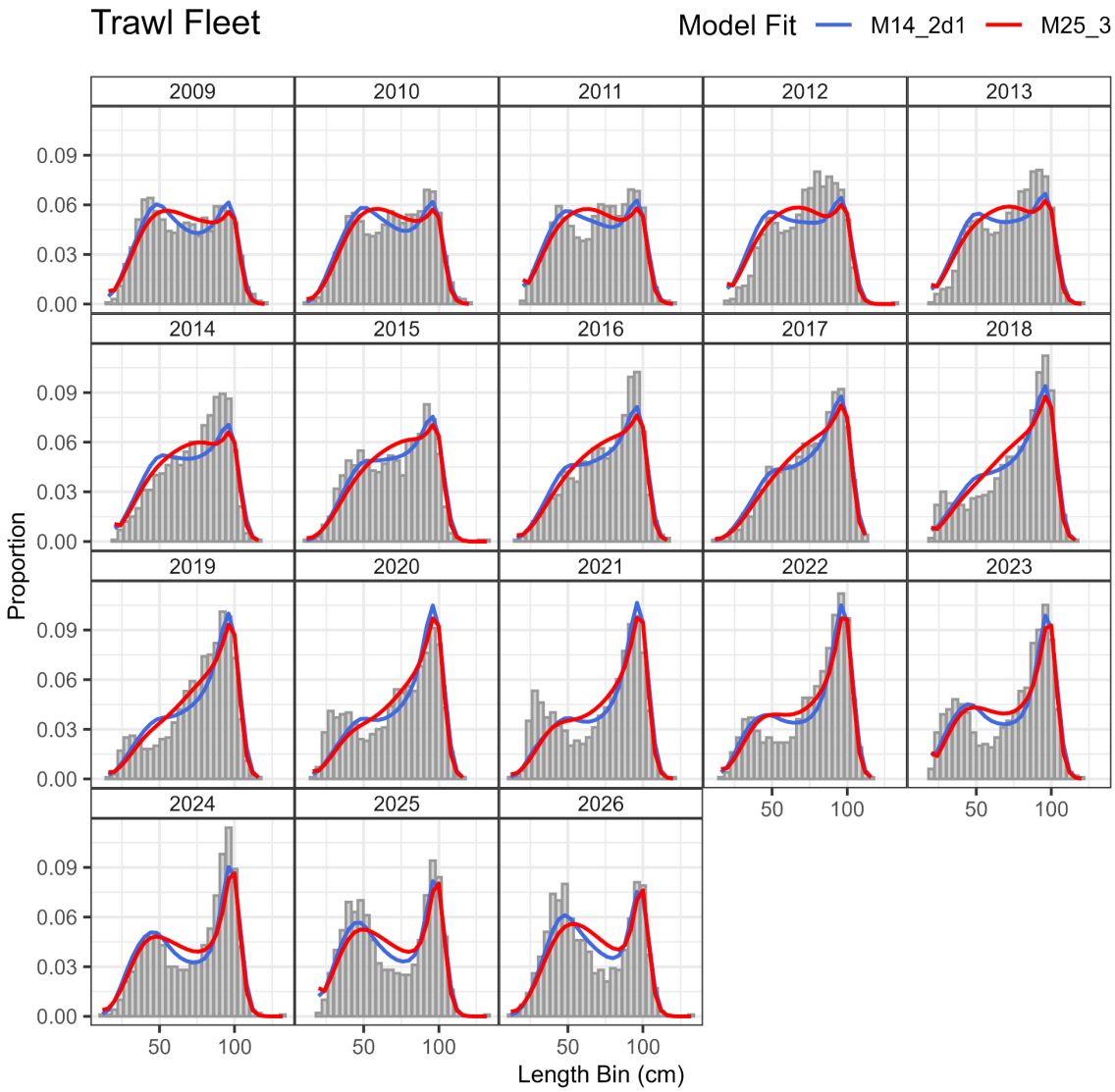


Figure 18.9: Alaska skate length compositions from trawl fisheries data with the Model 14.2d1 and 25.3 fits.

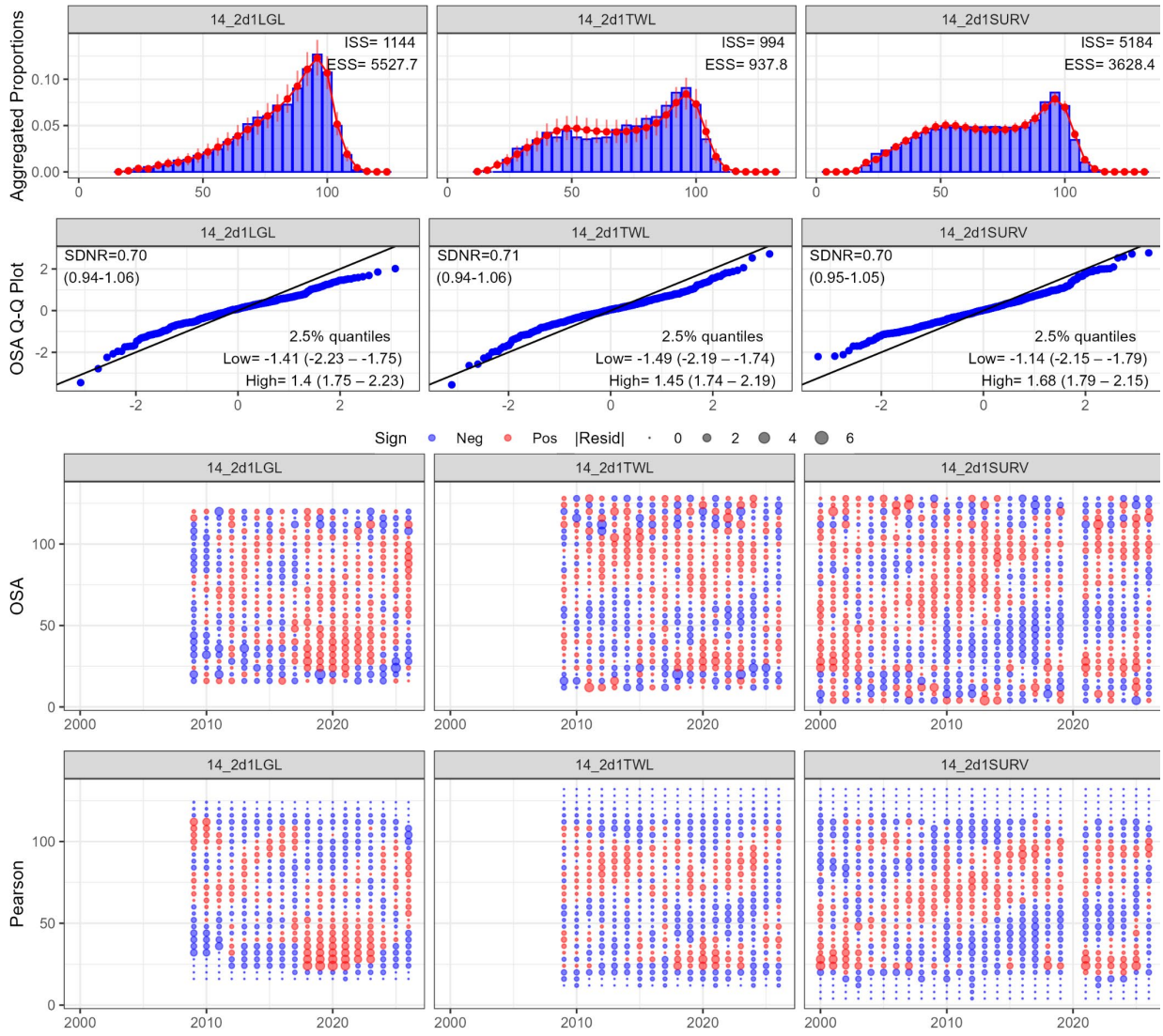


Figure 18.10: Pearson's and One-Step Ahead residuals for the Alaska skate Model 14.2d1 length composition model fits. The input sample size (ISS), effective sample sizes (ESS), and the standardized deviations of normalized residuals (SDNR) are shown for each fleet.

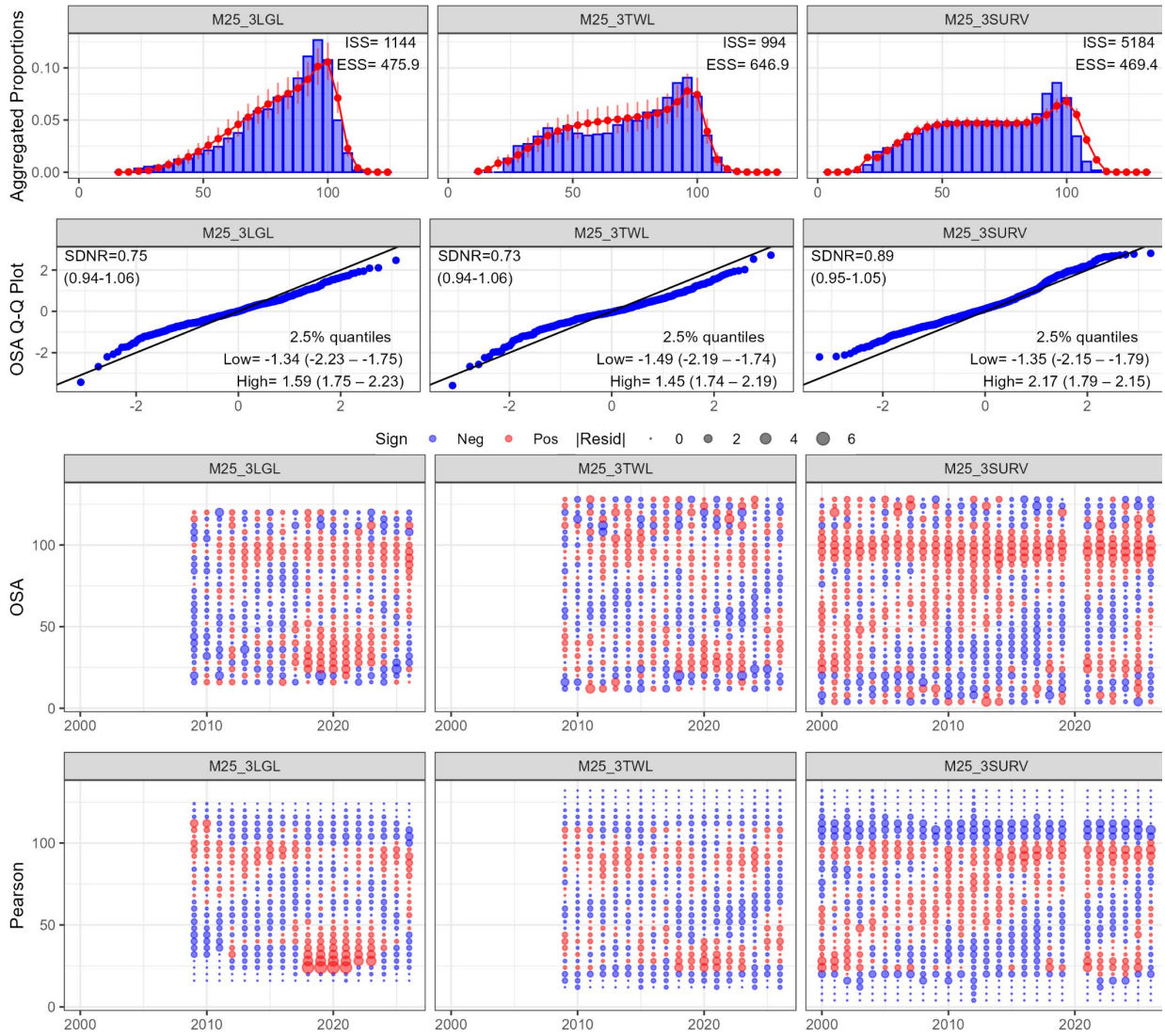


Figure 18.11: Pearson's and One-Step Ahead residuals for the Alaska skate Model 25.3 length composition model fits. The input sample size (ISS), effective sample sizes (ESS), and the standardized deviations of normalized residuals (SDNR) are shown for each fleet.

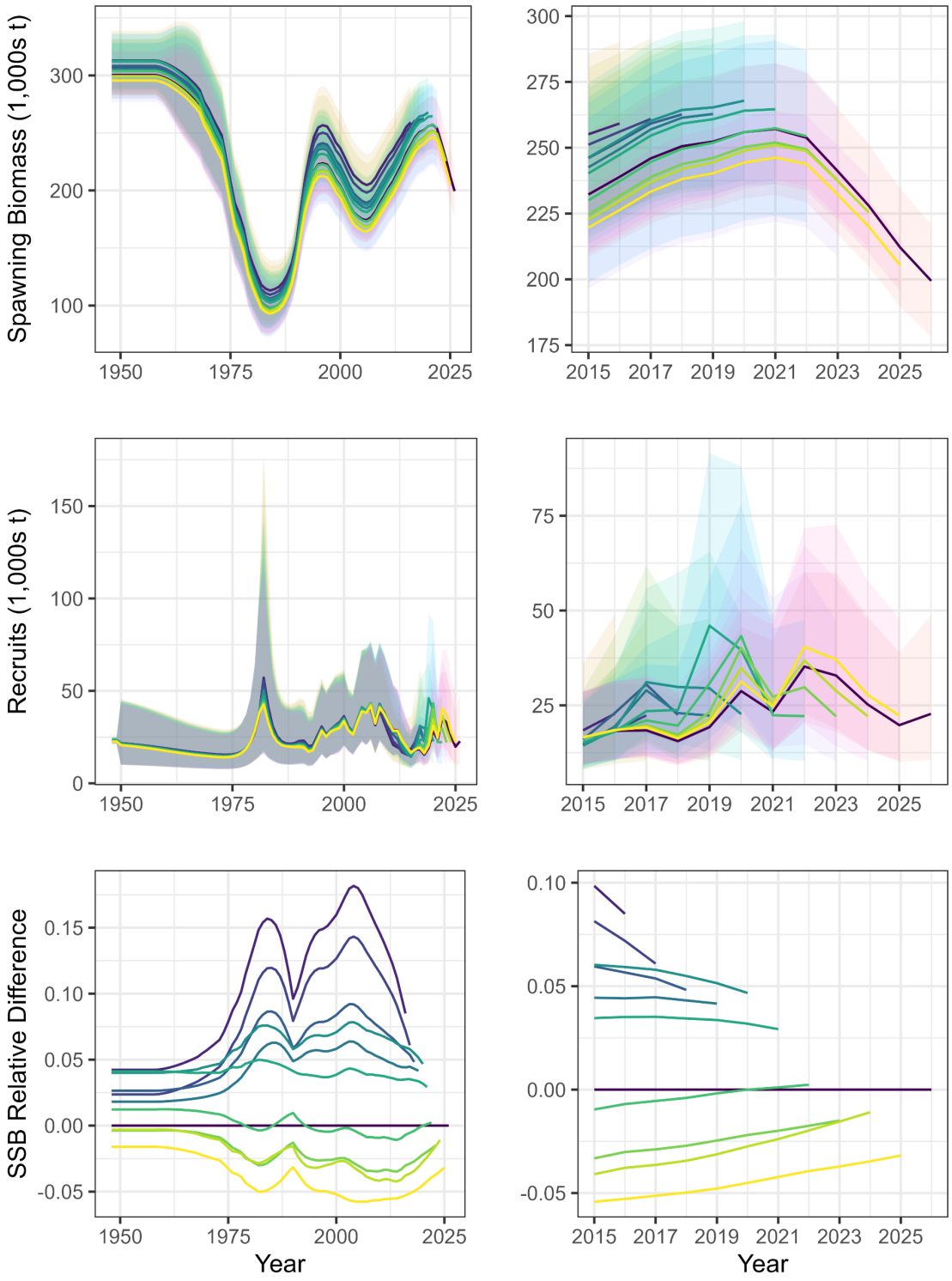


Figure 18.12: Within-model retrospective analysis, with uncertainty intervals, for Alaska skate Model 14.2d1. Left panels show entire model time series; right panels are zoomed in on the most recent years.

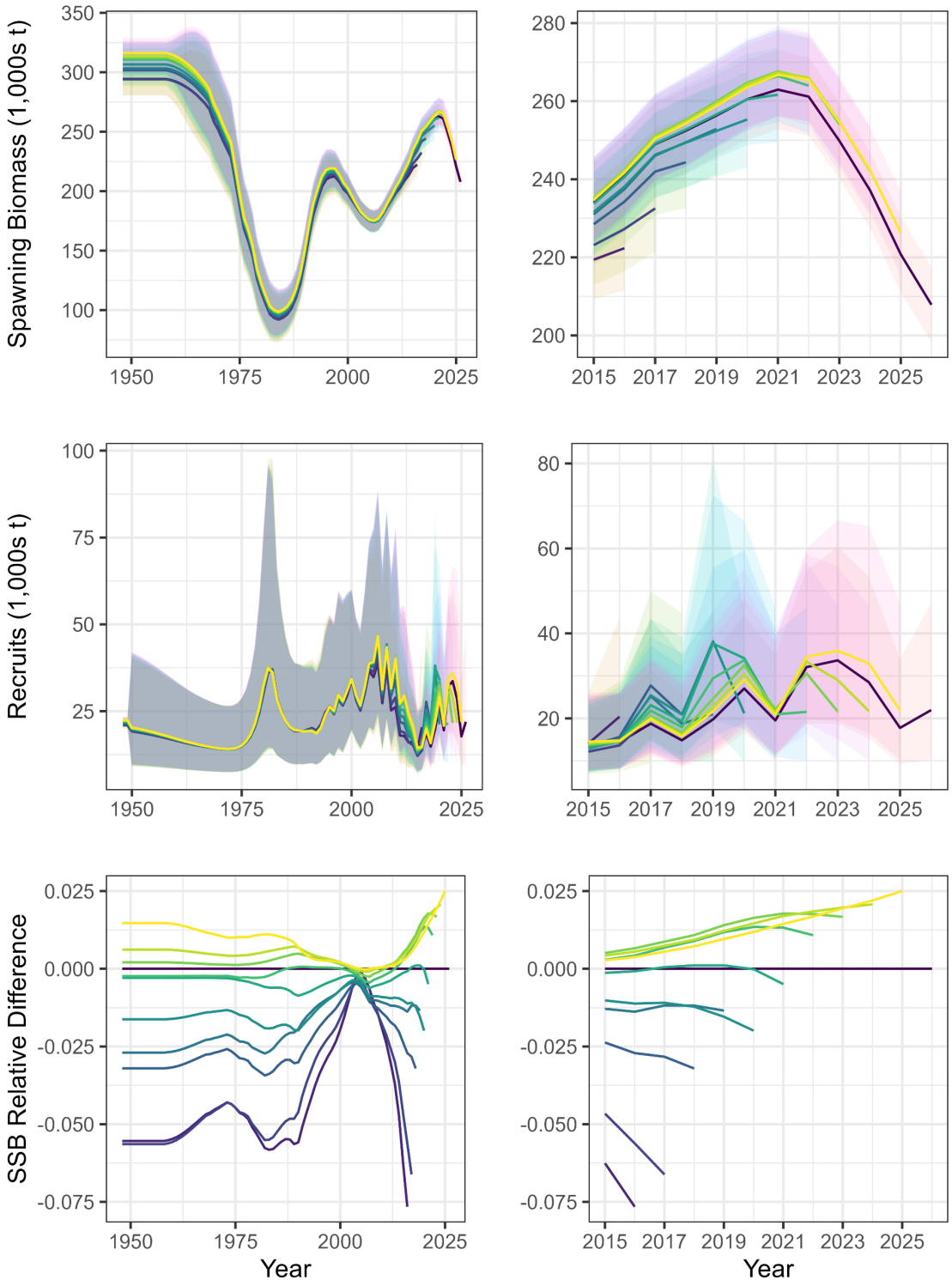


Figure 18.13: Within-model retrospective analysis, with uncertainty intervals, for Alaska skate Model 25.3. Left panels show entire model time series; right panels are zoomed in on the most recent years.

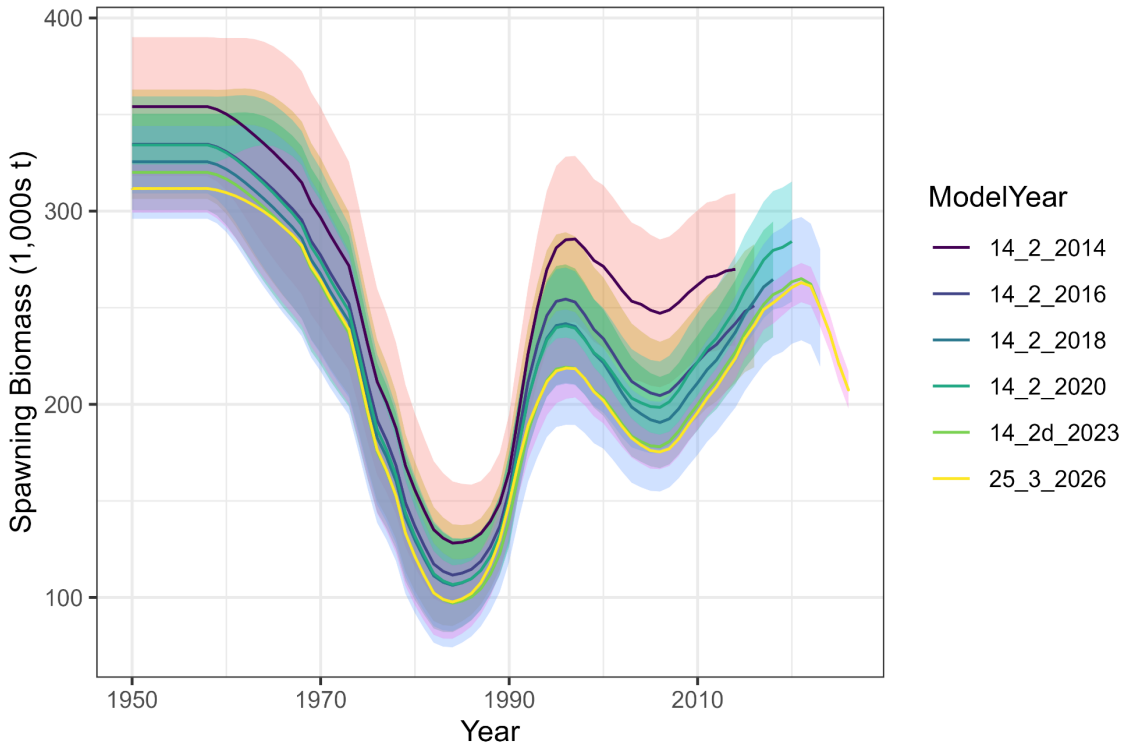


Figure 18.14: Between-model retrospective analysis showing spawning biomass, with uncertainty intervals, from every Alaska skate management model run since 2014 and the current author-recommended model, Model 25.3 (25_3_2026).

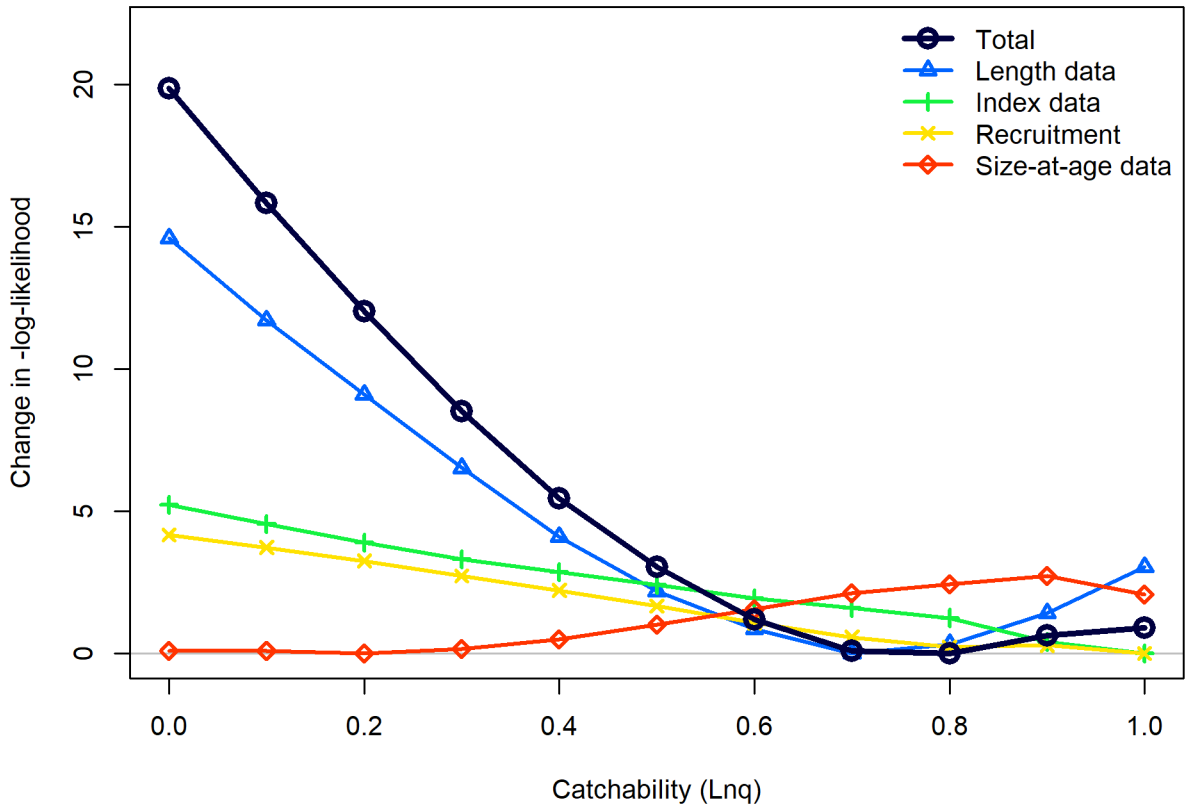


Figure 18.15: Likelihood profile over survey catchability (q) for Alaska skate Model 25.3.

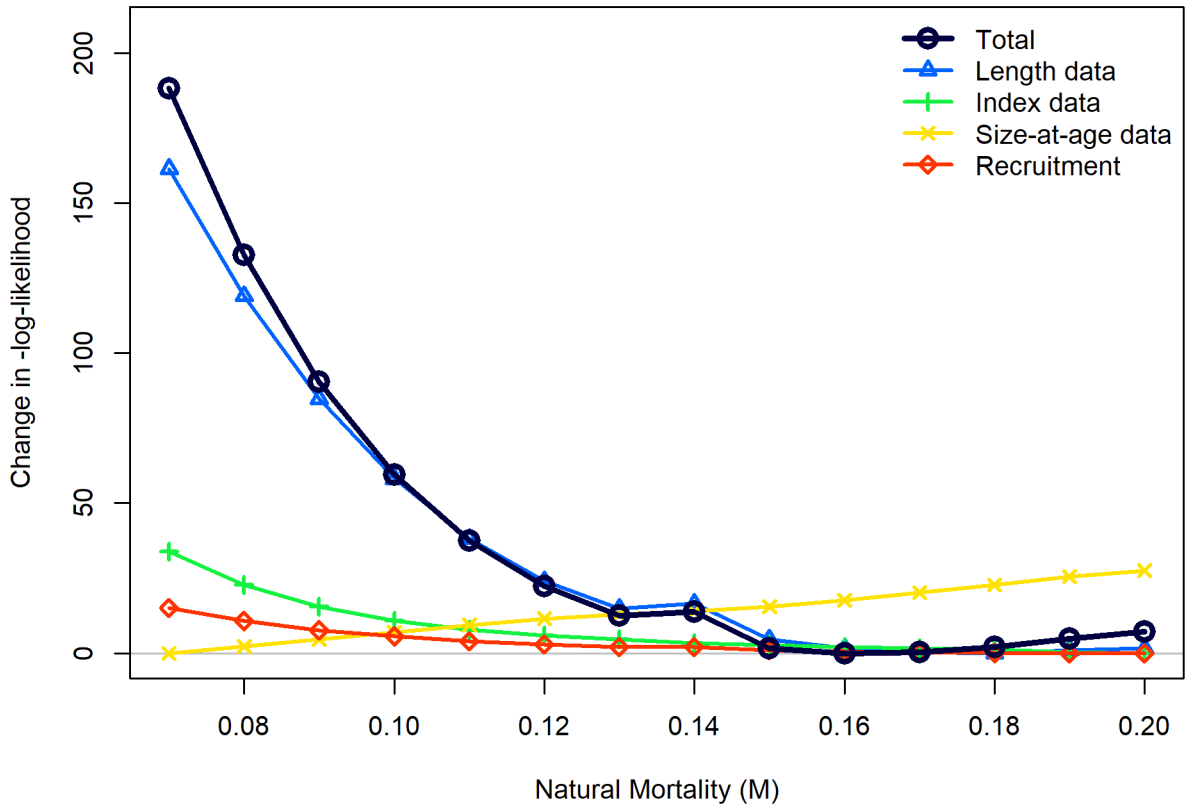


Figure 18.16: Likelihood profile over natural mortality (*M*) for Alaska skate Model 25.3.

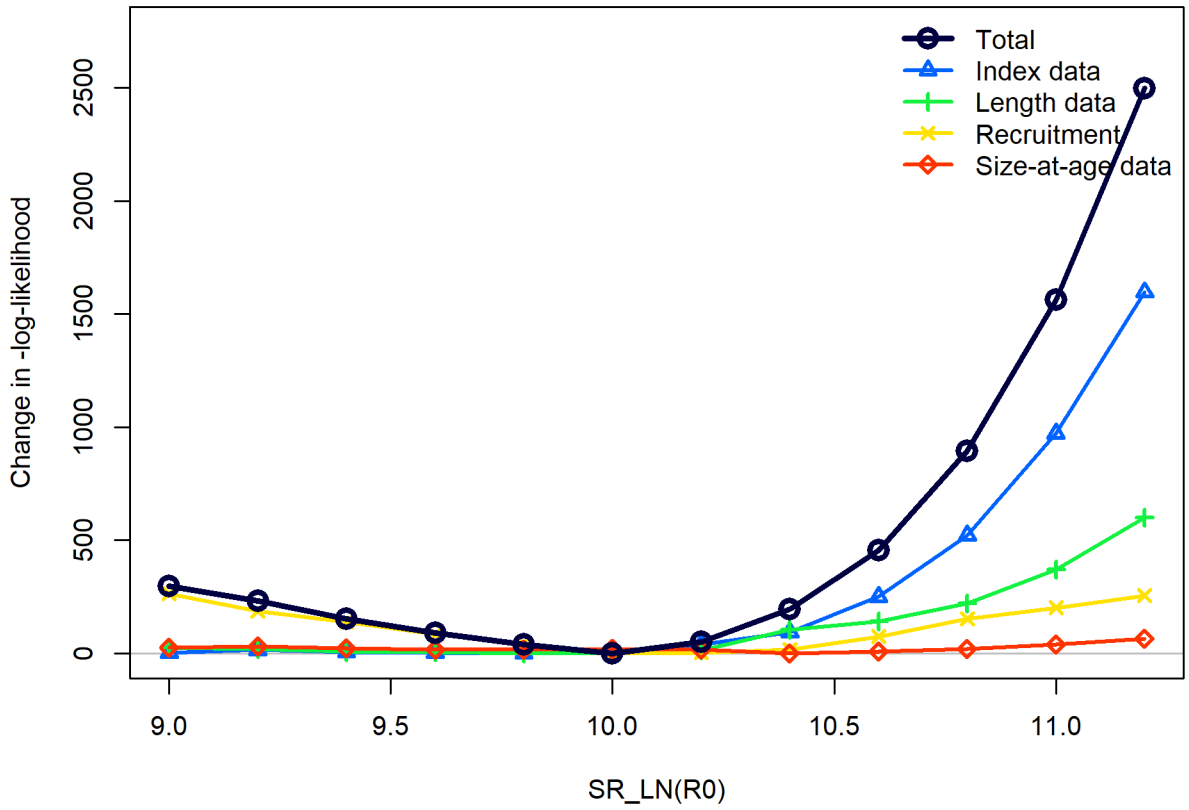


Figure 18.17: Likelihood profile over log of the initial recruitment (lnR0) for Alaska skate Model 25.3.

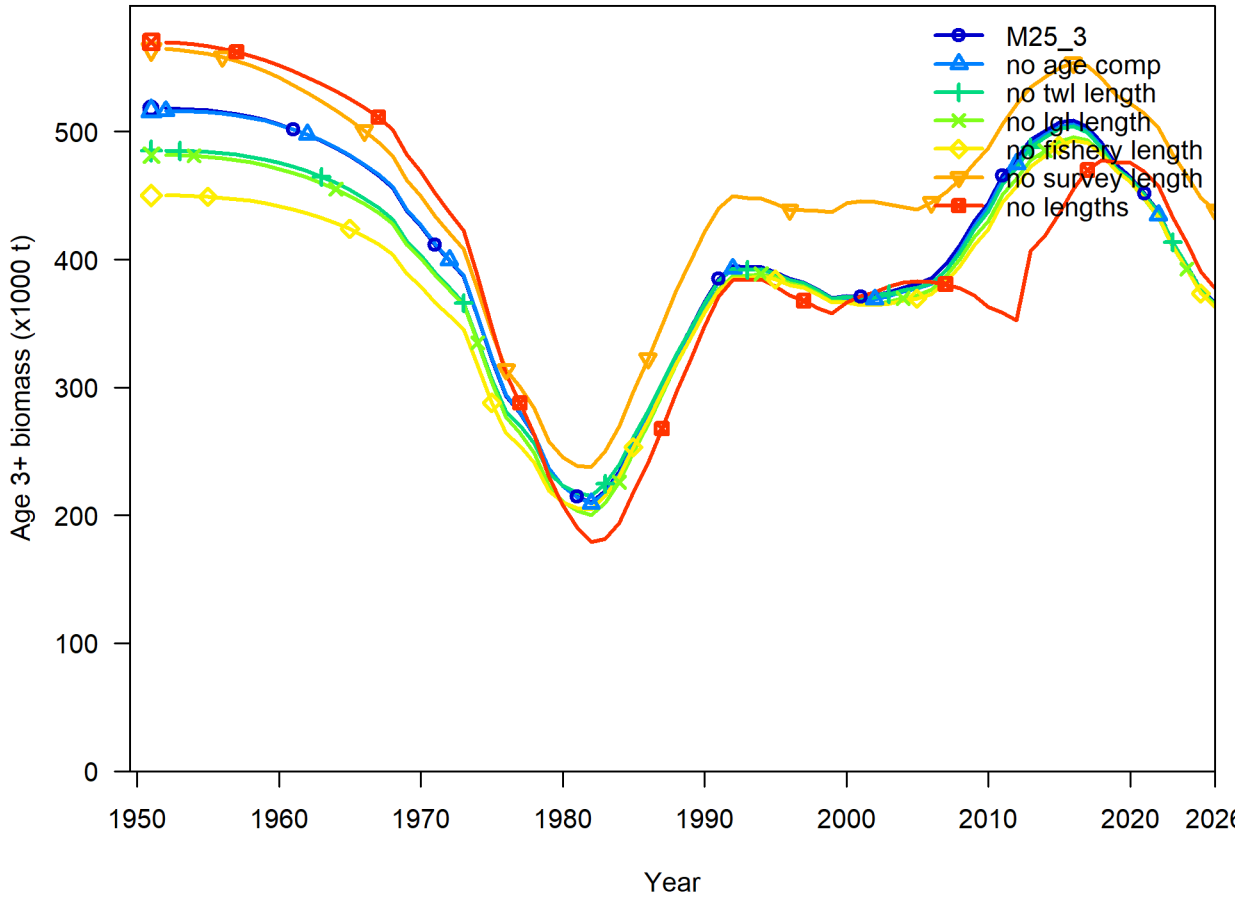


Figure 18.18: Leave-one-out analysis for Alaska skate Model 25.3.

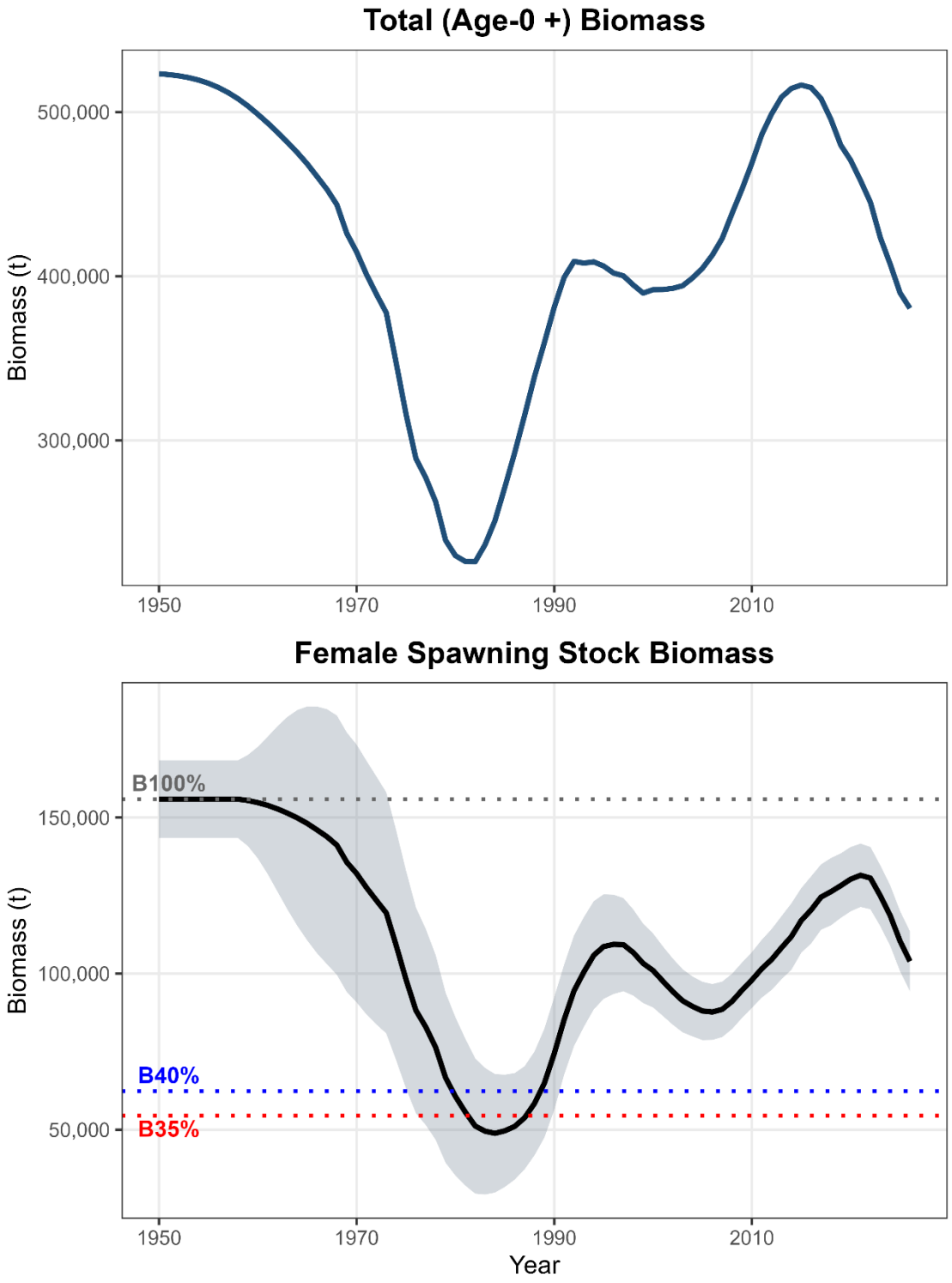


Figure 18.19: Alaska skate Model 25.3 estimated total biomass (age-0+, top panel) and female spawning stock biomass with 95% asymptotic intervals, with reference points shown as horizontal lines (bottom panel).

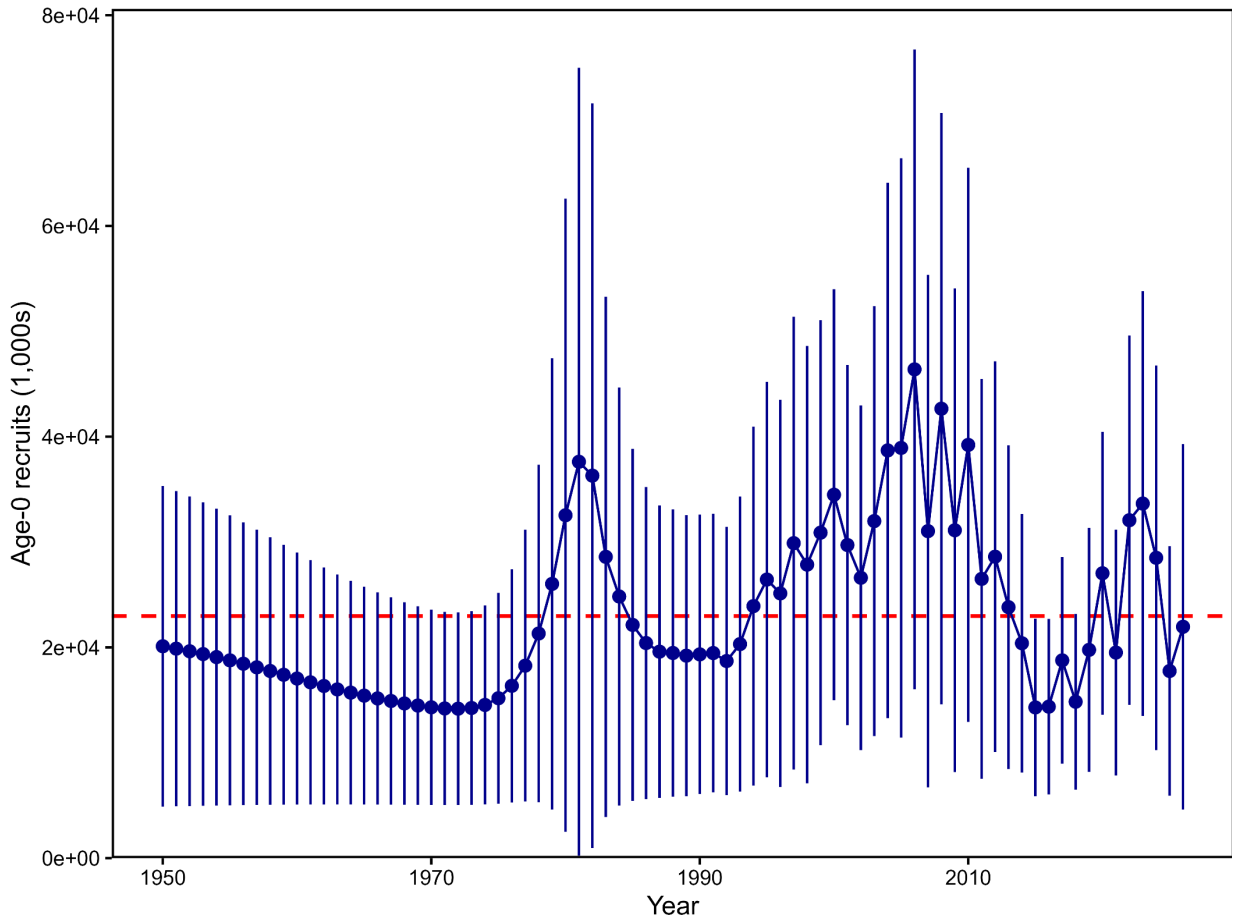


Figure 18.20: Alaska skate Model 25.3 estimates of recruitment with 95% confidence intervals.



Figure 18.21: Alaska skate Model 25.3 estimates of exploitation rate (*F*).

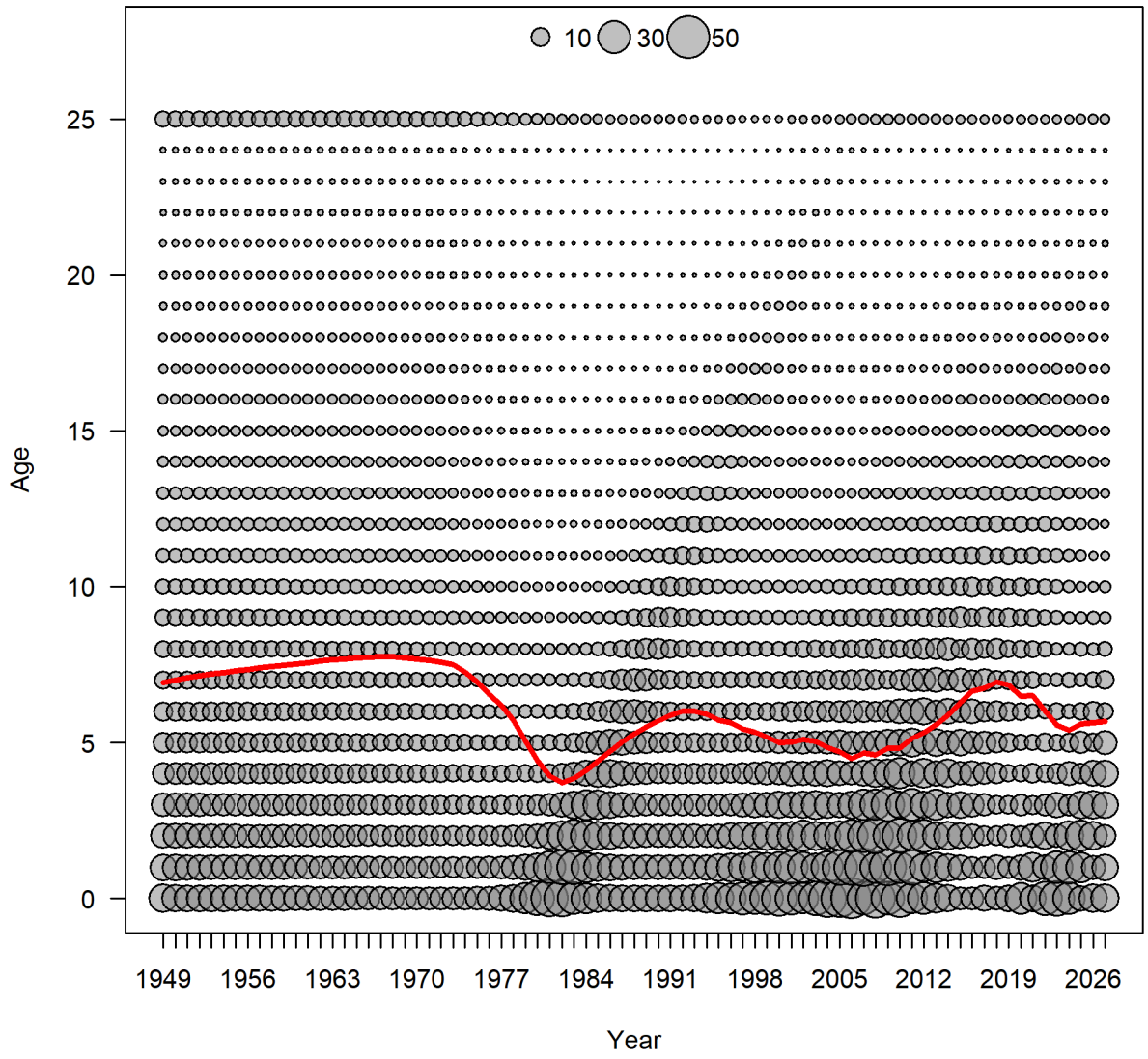


Figure 18.22: Alaska skate Model 25.3 estimated numbers at age. The red line is the average age of the population each year.

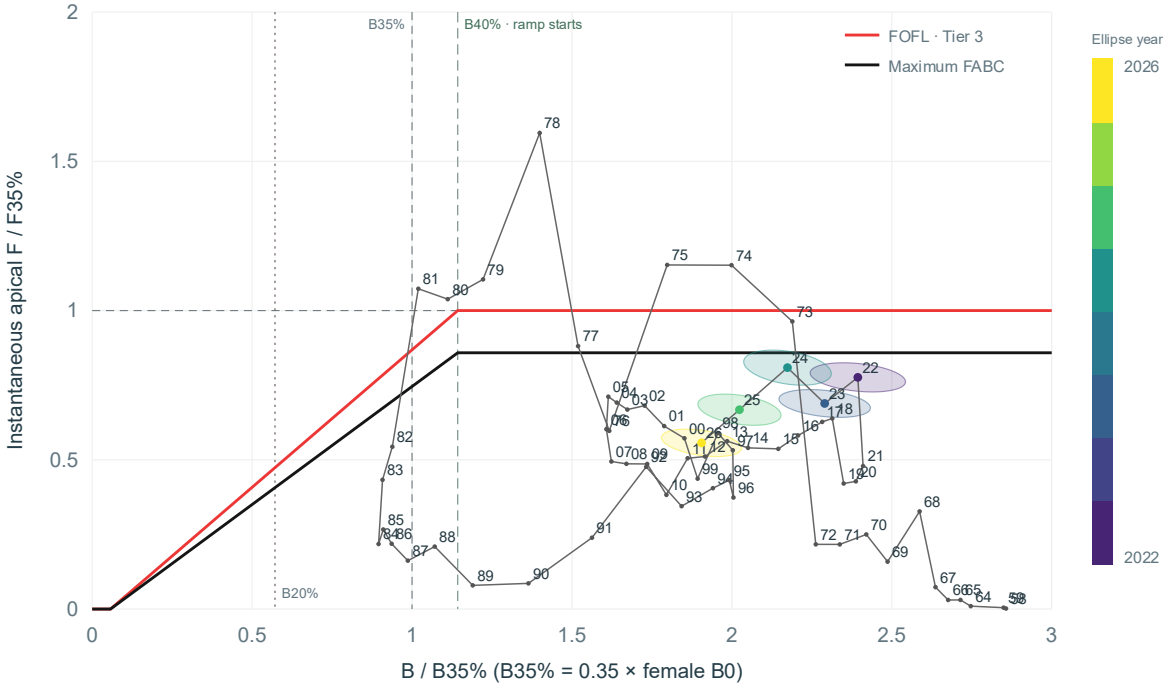


Figure 18.23: Alaska skate Model 25.3 phase plane plot with two years of forward projections included.

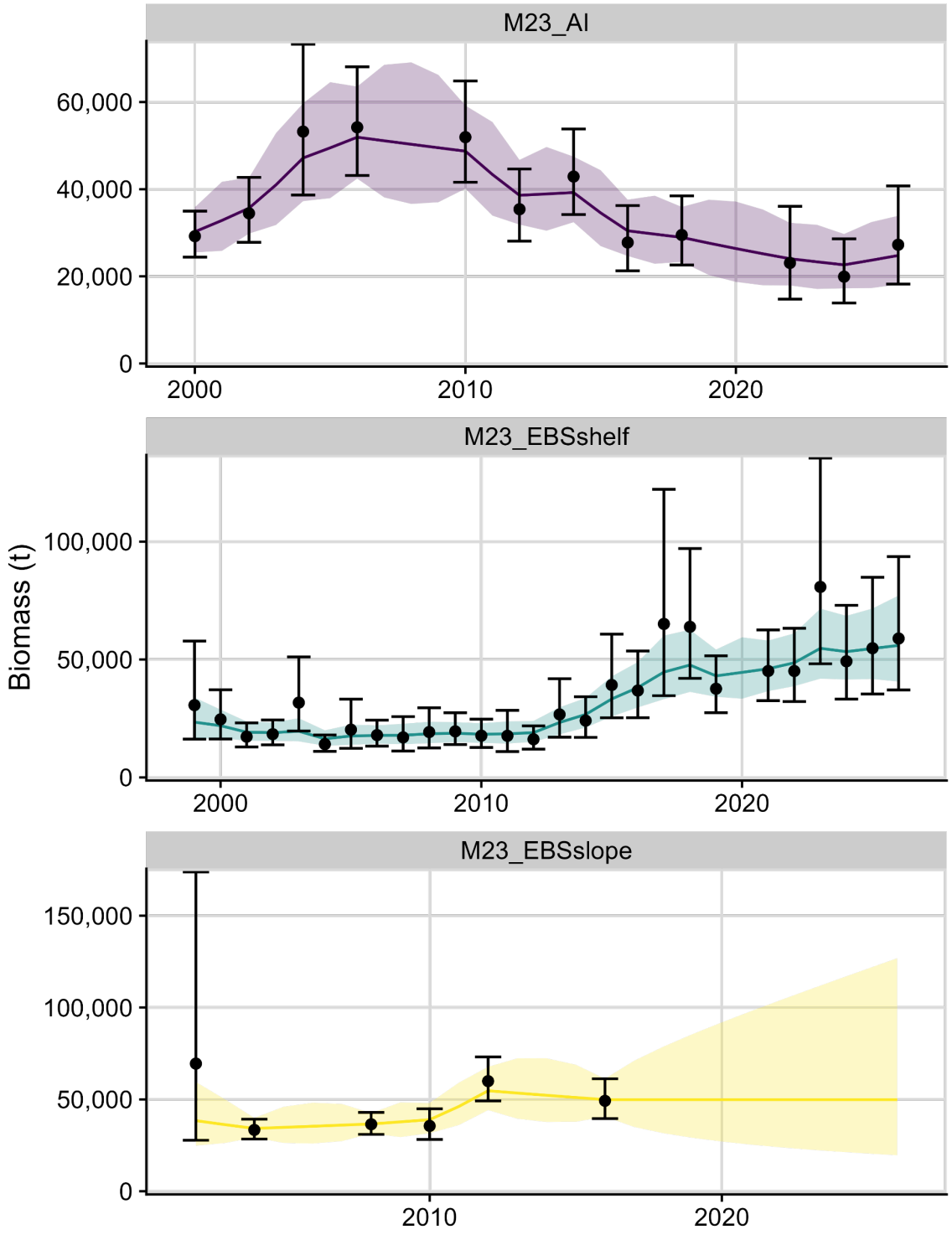


Figure 18.24: Model 23.0 Other Skates rema biomass estimates for the Aleutian Islands (AI), eastern Bering Sea shelf (EBSshelf) and EBS slope (EBSslope) surveys with the design-based biomass estimates and 95% confidence intervals. The EBS shelf estimates do not include Alaska skate, but that species is included in the AI and EBS slope.



Figure 18.25: Harvest projection scenarios for Alaska skate Model 25.3

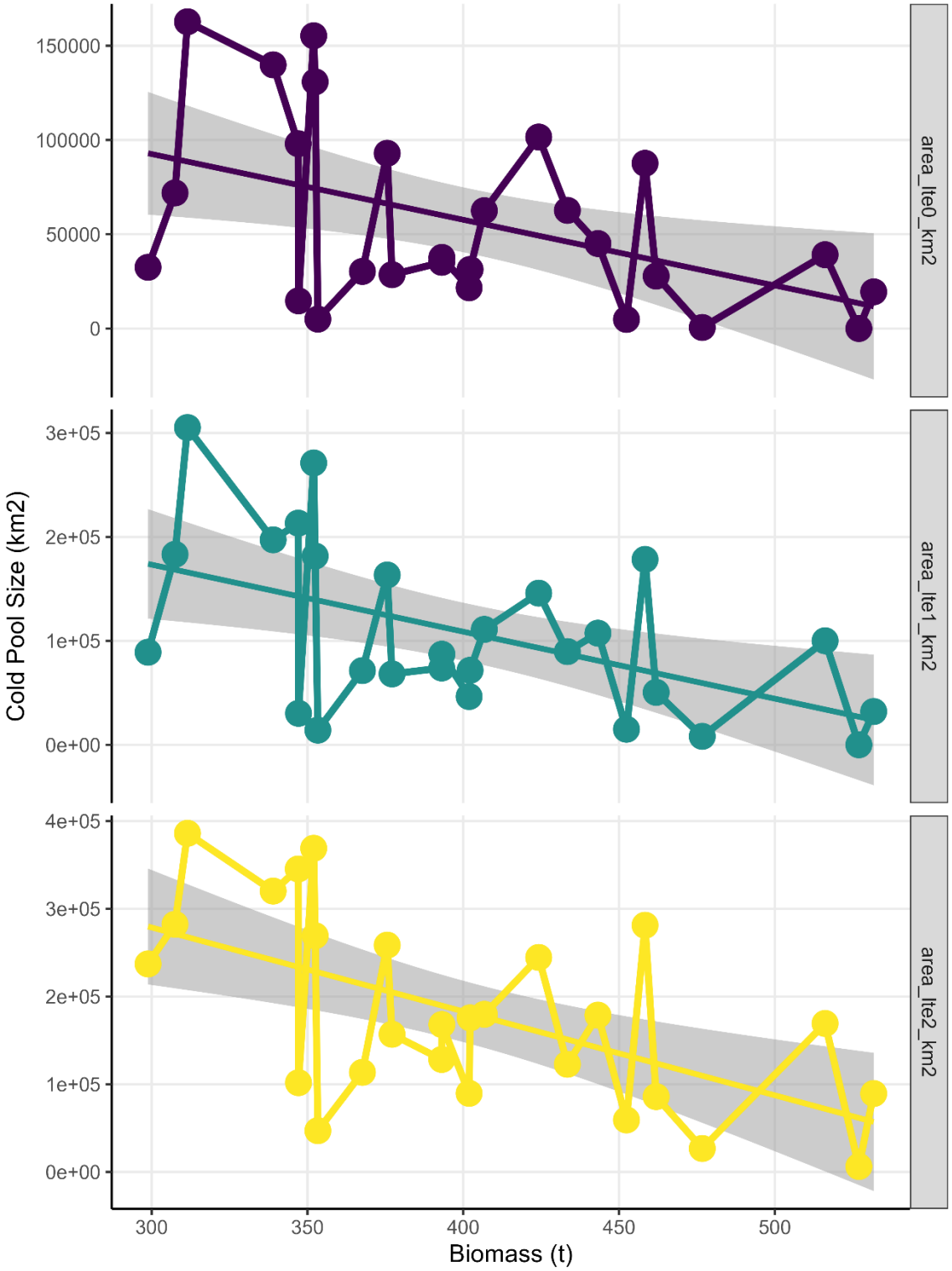


Figure 18.26: Trends in the cold pool index at 0 °C (top), 1 °C (middle) and 2 °C (bottom) compared to the EBS shelf survey biomass (in 1,000s of t) for Alaska skate. The line is the linear regression with confidence intervals.

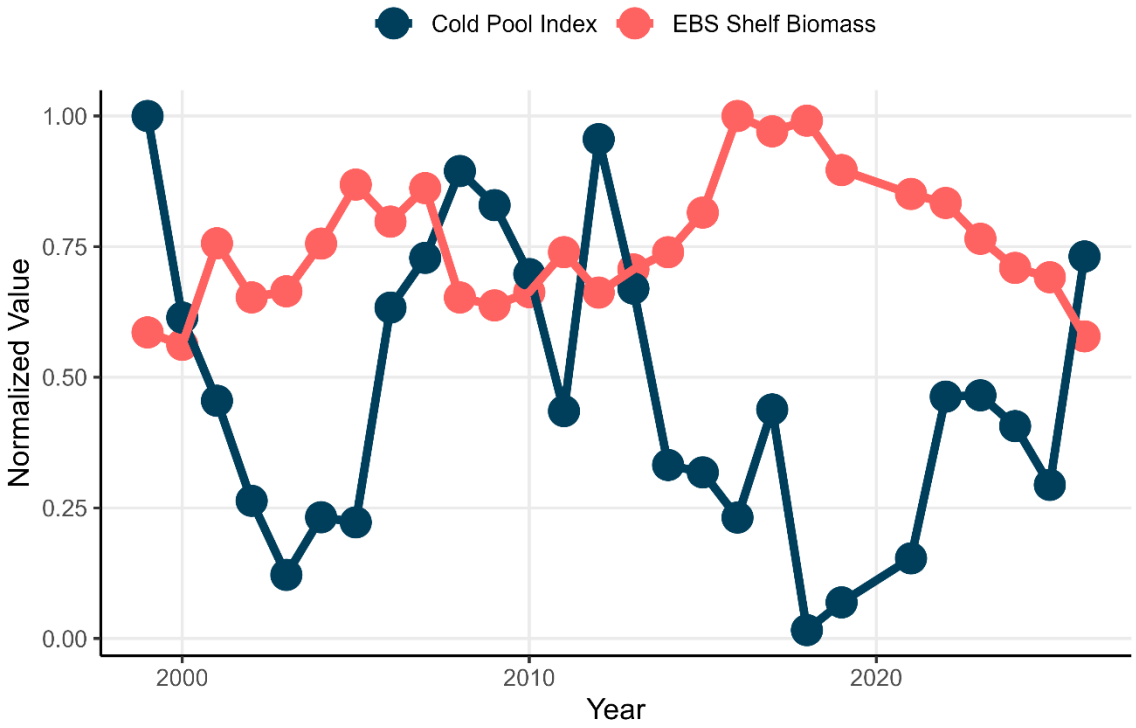


Figure 18.27: Time series of the cold pool index (area in km^2 of 2 °C water) and EBS shelf survey Alaska skate biomass (metric tons).

Appendix 18A. Alaska Skate Tier 4 and Tier 5 Alternatives

November 2026

This appendix provides a comparison to Tier 4 and Tier 5 options for the eastern Bering Sea (EBS) component of the Alaska skate stock. Due to the limited age data and challenges with the Tier 3 model convergence presented in September 2025, the authors suggested bringing forward the Tier 4 and Tier 5 alternatives for this operational full assessment. While the model convergence issues have been resolved and the authors do not currently recommend the Tier 4 or Tier 5 options, it is important to retain those options in context of the limited age data informing the Tier 3 model.

The same model approach, *rema*, used for the Other Skate subgroup of the BSAI Skate Stock Complex (Model 23.0) was used for the Tier 5 Alaska skate and is described in detail in the main body of this assessment. For the Tier 5 Alaska skate, M was set at 0.13, the same as the author-recommended Tier 3 Model 25.3 and the survey biomass with *rema* model output is shown in Figure 18A.1. The model was run with both combined and separate process errors, with no noticeable differences in the model outputs for the EBS shelf survey.

The Tier 4 model was implemented using the multiple fleet option in the *tier4tools* R package (Sullivan and Omori 2026). This approach was reviewed and is being brought forward in other Alaska groundfish Tier 4 stocks (e.g., GOA rougheye/blackspotted rockfish, Sullivan 2025). For the Tier 4 model for Alaska skates, M, growth, maturity and fecundity were fixed at the same values as used in Model 25.3. Selectivity-at-age curves for each fleet were used from the SS3 Model 25.3. The *tier4tools* package uses the proportion of catch by fleet to develop a composite selectivty curve. The mean proportion by gear over the recent 5-year period was used to develop the composite selectivity curve, with longline being 84% and trawl being 16% of the catch on average (Figure 18A.2). The F_{OFL} and F_{ABC} from the SPR analysis (Figure 18A.3) are then applied to the *rema* biomass for 2027 and 2028 (Figure 18A.1).

Table 18A.1 compares the estimated 2027 total (age-0+) biomass and harvest recommendations for EBS Alaska skate using the Tier 3, Tier 4 and Tier 5 approaches. Below we provide example executive summary tables for the Tier 4 (Table 18A.2) and Tier 5 (Table 18A.3).

Literature Cited

Sullivan, J. 2025. A proposed Tier 4 approach to the rougheye and blackspotted rockfish complex in the Gulf of Alaska. September GOA Groundfish Plan Team meeting. NPFMC, Anchorage, AK. Available at: https://meetings.npfmc.org/CommentReview/DownloadFile?p=3b546b93-bccc-4efb-af48-19804aff715e.pdf&fileName=GOA%20rougheye%20and%20blackspotted%20rockfish.pdf

Sullivan J., and Omori K 2026. tier4tools: Tier 4 Spawning Potential Ratio (SPR) reference points for NPFMC groundfish assessments. R package version 0.1.0.

Tables

Table 18A.1: Comparison of the 2027 harvest recommendations from the Tier 3 model (author recommended model 25.3) and the Tier 4 and Tier 5 approaches for the EBS component of the Alaska skate stock.

Quantity	3	4	5
Projected total (age 0+) biomass (t)	376,985	315,667	315,667
OFL (t)	27,517	38,827	41,037
ABC (t)	23,747	33,461	30,778
FOFL	0.099	0.123	0.130
FABC	0.085	0.106	0.098

Table 18A.2: Eastern Bering Sea Alaska skate Tier 4 harvest recommendation summary table.

	As estimated or specified last year for:		Tier 4 recommendation for:	
Quantity	**2025**	**2026**	**2027**	**2028**
M (natural mortality rate)	0.13	0.13	0.13	0.13
Tier	3a	3a	4	4
Projected total (age 0+) biomass (t)	436,238	425,822	315667	315667
Projected Female spawning biomass (t)			—	—
B100%	178,425	178,425	—	—
B40%	71,370	71,370	—	—
B35%	62,449	62,449	—	—
FOFL	0.093	0.093	0.123	0.123
maxFABC	0.08	0.08	0.106	0.106
FABC	0.08	0.08	0.106	0.106
OFL (t)	30,941	30,140	38827	38827
maxABC (t)	26,665	25,975	33461	33461
ABC (t)	26,665	25,975	33461	33461

Table 18A.3: Eastern Bering Sea Alaska skate Tier 5 harvest recommendation summary table.

	As estimated or specified last year for:		Tier 5 recommendation for:	
Quantity	**2025**	**2026**	**2027**	**2028**
M (natural mortality rate)	0.13	0.13	0.13	0.13
Tier	3a	3a	4	4
Projected total (age 0+) biomass (t)	436,238	425,822	315,667	315,667
Projected Female spawning biomass (t)			—	—
B100%	178,425	178,425	—	—
B40%	71,370	71,370	—	—
B35%	62,449	62,449	—	—
FOFL	0.093	0.093	0.130	0.130
maxFABC	0.08	0.08	0.098	0.098
FABC	0.08	0.08	0.098	0.098
OFL (t)	30,941	30,140	41,037	41,037
maxABC (t)	26,665	25,975	30,778	30,778
ABC (t)	26,665	25,975	30,778	30,778

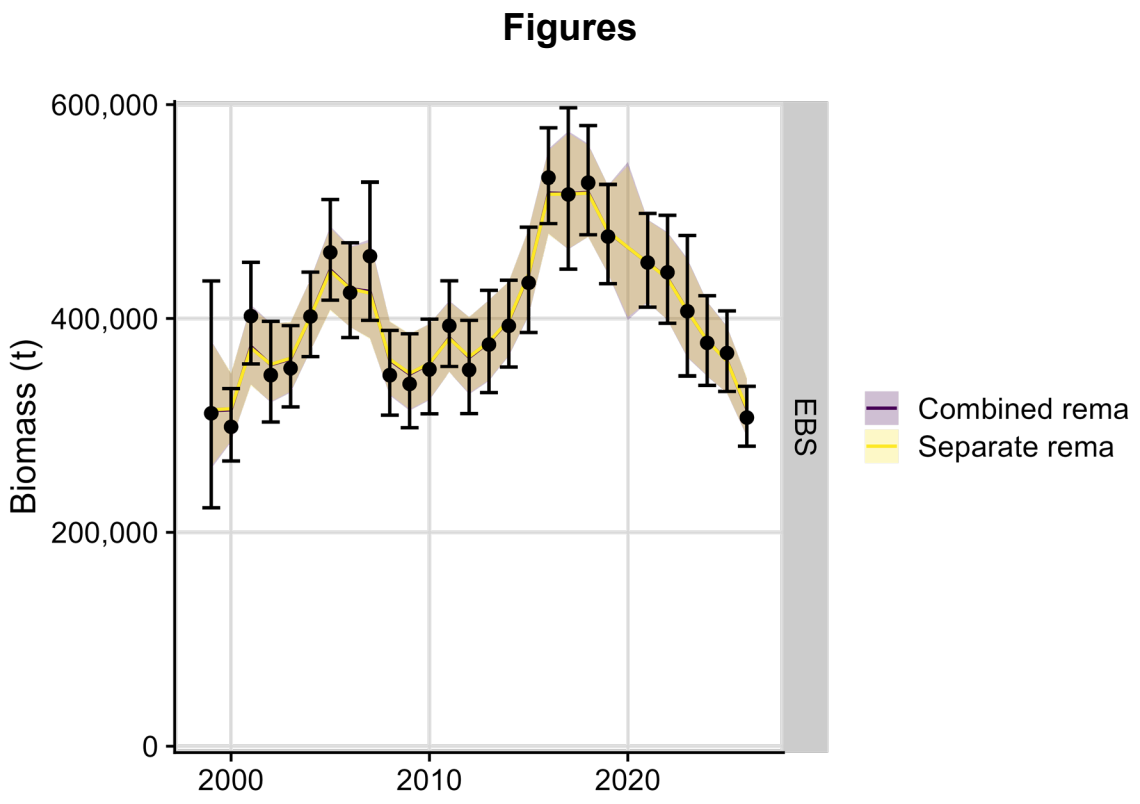


Figure 18A.1: Total exploitable biomass of Alaska skate for the EBS shelf based on the *rema* model averaging approach. The *rema* model was run twice, once with combined and once with separate process errors. Results of both runs are shown.

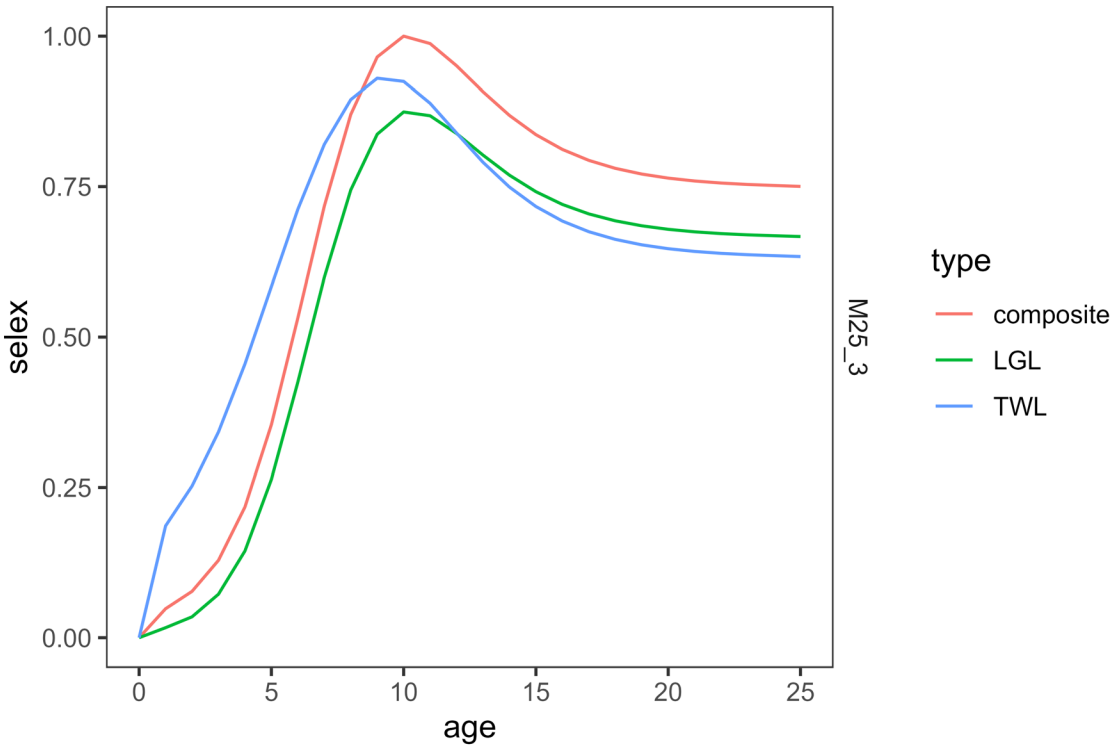


Figure 18A.2: Fleet-specific selectivity-at-age curves from the SS3 output from Alaska skate Tier 3 Model 25.3 with the composite selectivity curve created by the multiple fleet option in *tier4tools*. Fleets are longline (LGL) and trawl (TWL).

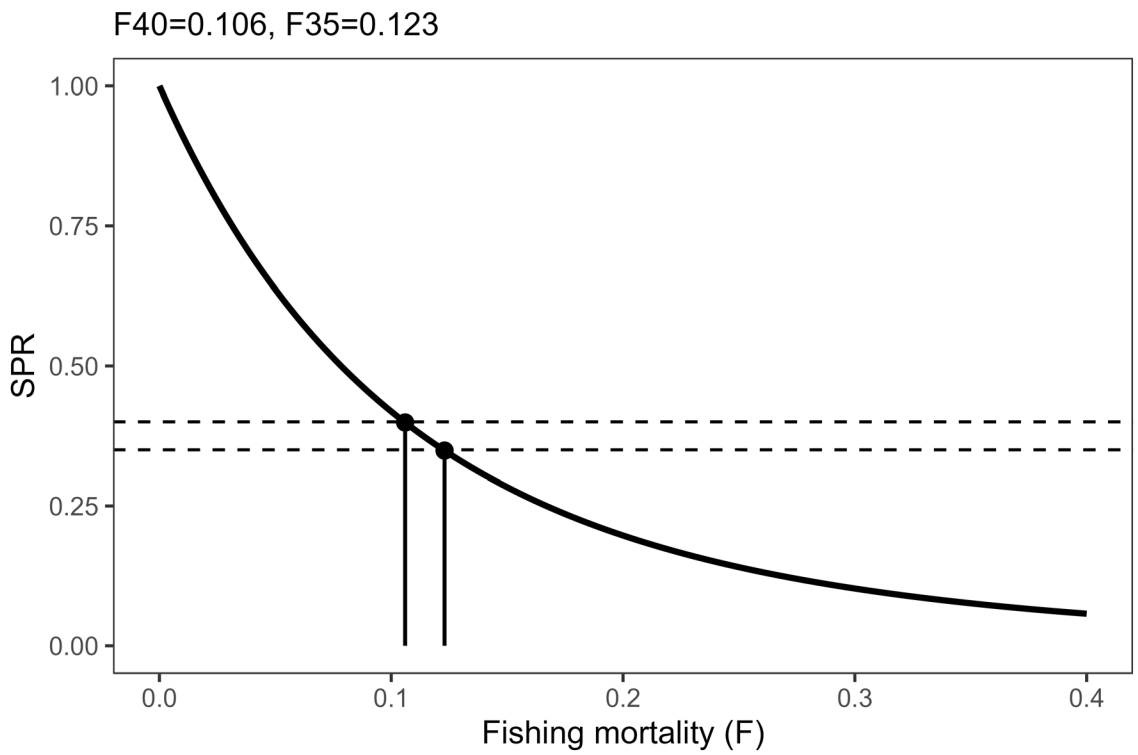


Figure 18A.3: Alaska skate spawning potential ratio as fishing mortality rate changes. The vertical lines represent the F_{OFL} and F_{ABC}.

Appendix 18B. Species-specific *rema* output

November 2026

There are many species within the Bering Sea and Aleutian Islands (BSAI) Skate Stock Complex, and the dominant species varies for each survey. Here we present the species-specific rema model output for the dominant species and combined minor species in each of the three surveys included in the Tier 5 BSAI Skate Stock Complex harvest recommendations. The dominant species, those with a combined biomass of 95% of the survey biomass, along with the grouped minor species for each survey are as follows:

Aleutian Islands Survey Species Groupings	
Dominant	**Minor**
Alaska	Butterfly
Aleutian	Commander
Bering	Longnose
Big	Mud
Leopard	Roughtail
Whiteblotched	Whitebrow
	Skate Unidentified
Eastern Bering Sea Shelf Survey Species Groupings	
Dominant	**Minor**
Aleutian	Longnose
Bering	Mud
Big	Okhotsk
	Whiteblotched
Eastern Bering Sea Slope Survey Species Groupings	
Dominant	**Minor**
Alaska	Deepsea
Aleutian	Longnose
Bering	Okhotsk
Commander	Skate Unidentified
Mud	
Roughtail	
Whiteblotched	
Whitebrow	

The species-specific Aleutian Islands, EBS shelf and EBS slope *rema* biomass trends are shown in Figure 18B.1, Figure 18B.2, and Figure 18B.3, respectively. A table of survey biomass, uncertainty and *rema* model outputs are available here: Species_specific_rema_output

The northern Bering Sea has only encountered Alaska skates and we include those biomass estimates here for information (Figure 18B.4). The northern Bering Sea tables of survey biomass, uncertainty and rema model outputs are available here: AKskate_NBS_rema_output

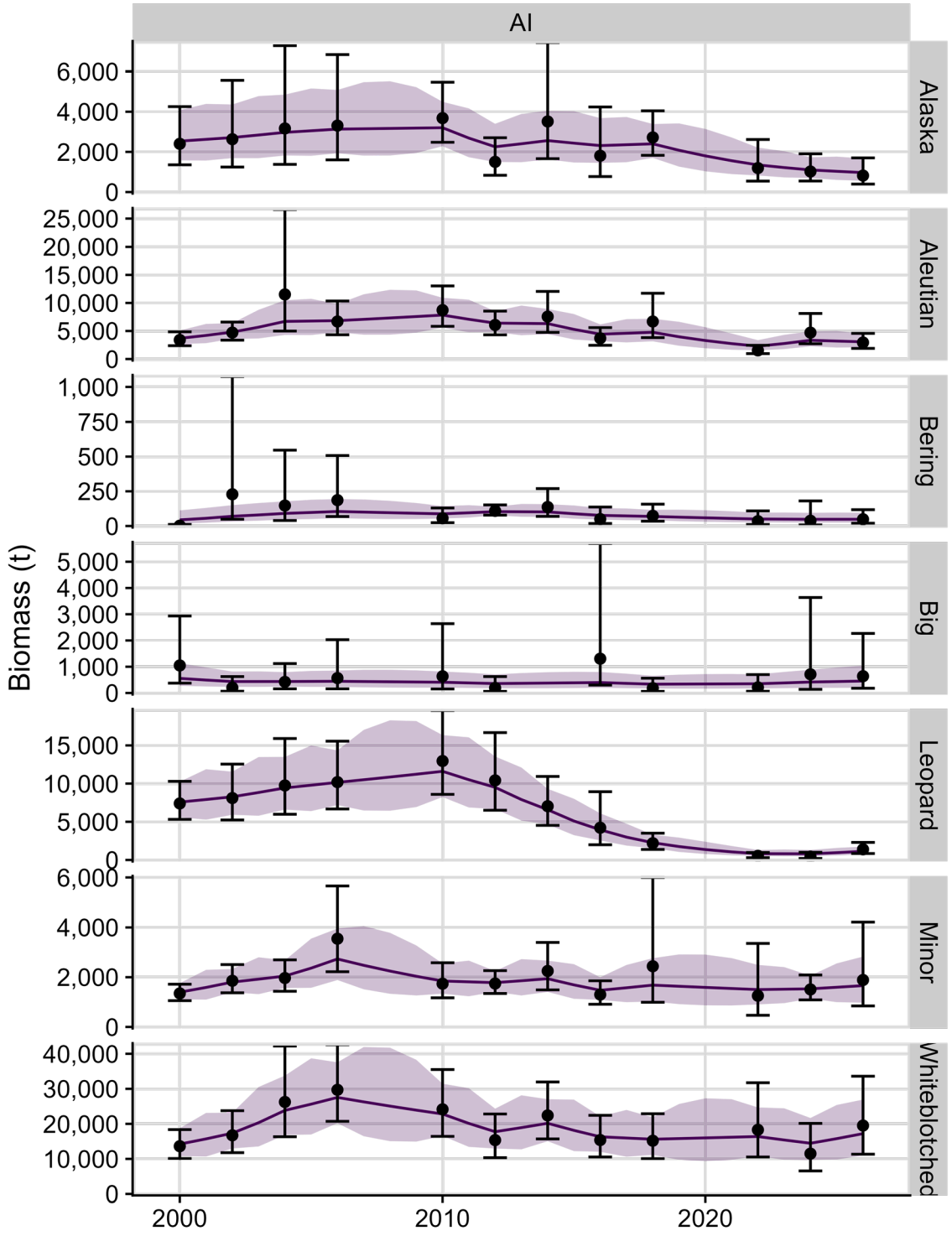


Figure 18B.1: Aleutian Islands species-specific survey estimates and rema model outputs.

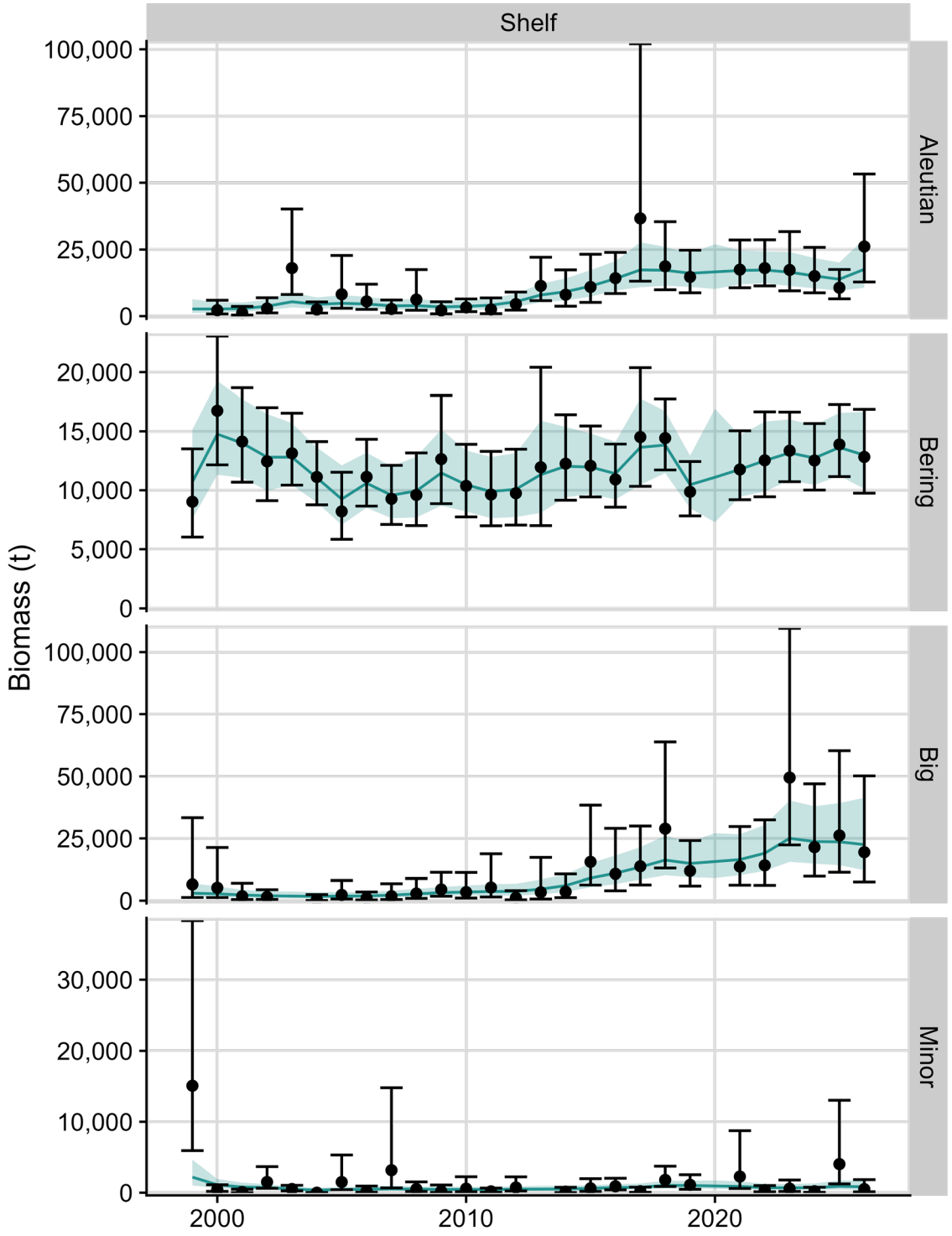


Figure 18B.2: EBS Shelf survey species-specific survey estimates and rema model outputs.

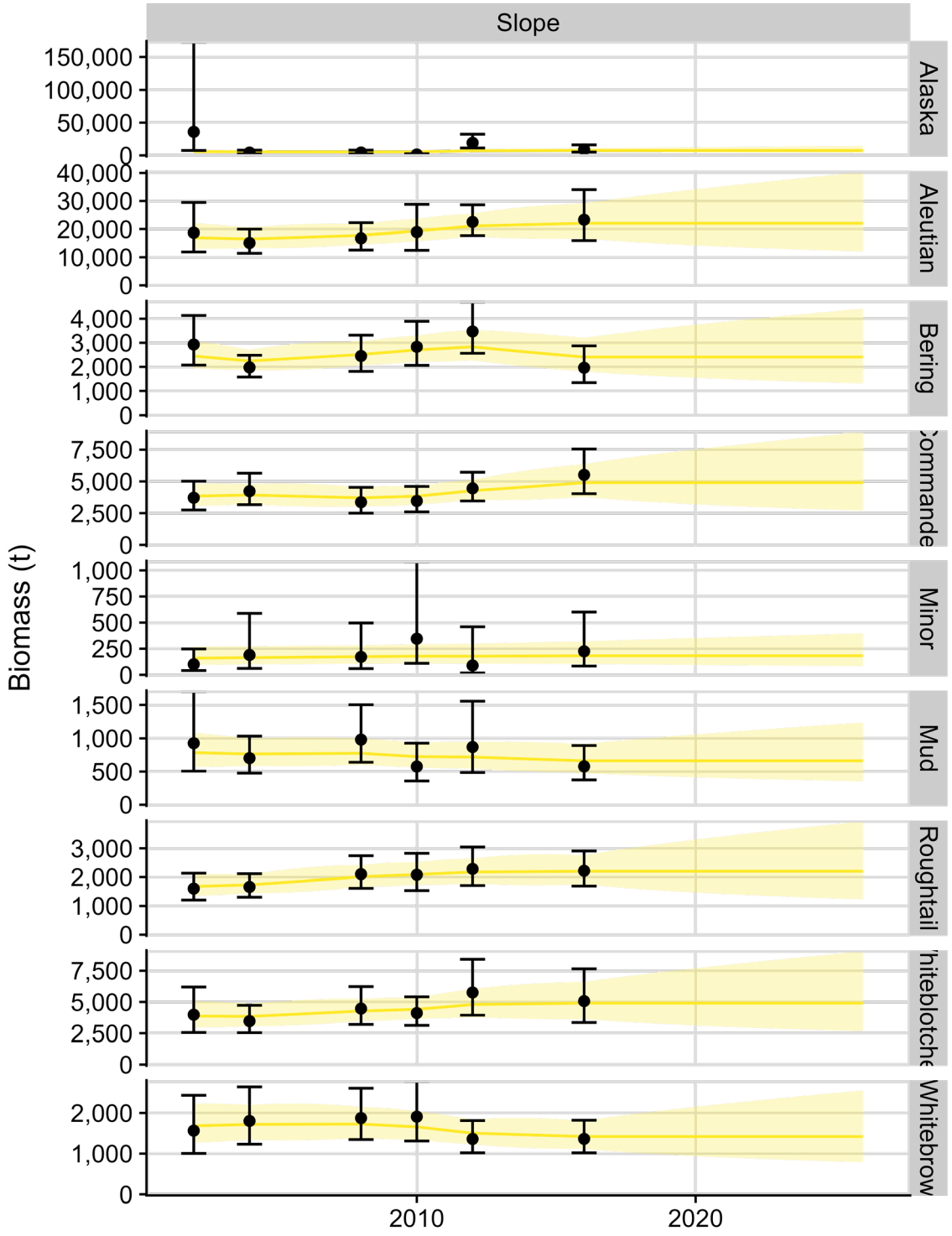


Figure 18B.3: EBS slope survey species-specific survey estimates and rema model outputs.

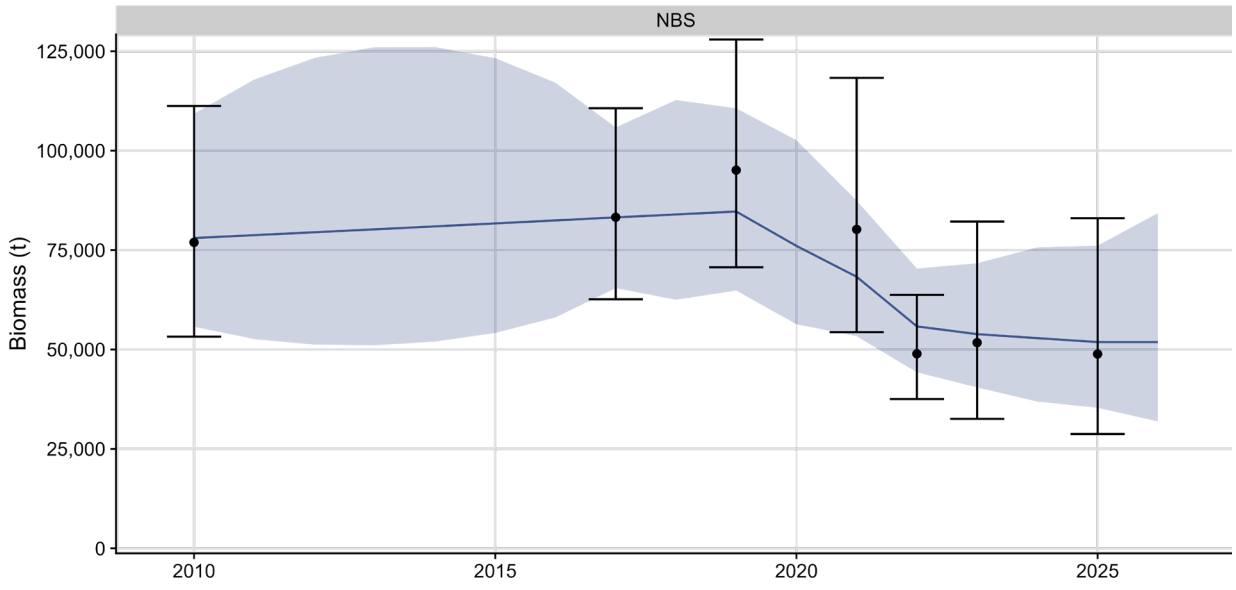


Figure 18B.4: Northern Bering Sea (NBS) Shelf survey Alaska skate biomass estimates and rema model outputs.

Appendix 18C. Non-commercial Catch Table

November 2026

Table 18C.1: Table of reported removals from non-commercial fisheries and surveys through 2025. ADFG is Alaska Department of Fish and Game (state waters), IPHC is the International Pacific Halibut Commission, and NMFS is National Marine Fisheries Service. Weight is in kilograms. Not all data sources provide both numbers and weight. The large weight of skates by trawl surveys in 2012 was due to an exempted fishing permit occurring that year, which only reported weight and not numbers. These catch totals are not used in the BSAI Skate Stock Complex assessment models and are presented here for information purposes only.

	ADFG		IPHC	NMFS Longline Survey		Trawl Surveys Combined	
Year	Number	Weight	Weight	Number	Weight	Number	Weight
2010	277	800	41,976	2,796	6,093	15,182	53,289
2011	28	217	25,617	3,167	5,393	12,776	55,802
2012	26	162	27,786	2,386	7,459	14,341	1,132,760
2013	18	138	42,782	3,585	7,980	8,387	29,136
2014	19	119	55,220	3,395	11,698	8,920	35,562
2015	20	117	42,530	3,250	5,836	8,319	33,217
2016	57	209	51,004	2,623	7,760	8,562	33,631
2017	99	278	42,615	3,682	8,573	5,256	24,407
2018	24	124	30,238	2,709	9,897	6,090	28,205
2019	24	146	33,479	2,564	3,253	4,660	21,615
2020	—	—	787	2,784	8,859	—	—
2021	33	278	9,564	2,624	12,044	4,774	20,955
2022	46	256	15,628	2,039	9,987	5,114	24,170
2023	14	154	—	2,178	9,932	4,143	18,654
2024	21	183	8,147	—	—	4,022	17,468
2025	27	265	1,501	—	—	4,455	16,130

Appendix 18D. Ecosystem Considerations of BSAI Skate Stock Complex

Elizabeth Siddon[1] and Ivonne Ortiz[2]

November 2026

[1] Alaska Fisheries Science Center
[2] University of Washington

Risk Table Summary for BSAI Skates

The following is a synthesis and interpretation of the most recent ecosystem information available for the Bering Sea and Aleutian Islands (BSAI) Skate Stock Complex, integrating information from the 2026 Eastern Bering Sea Ecosystem Status Report (Siddon, 2026) and Aleutian Islands Ecosystem Status Report (Ortiz, 2026). This information supports the risk table scores and is organized below by the proposed risk table categories. We include information related to recruitment (egg incubation, embryonic development, and neonate/early juvenile survival) in the Population Dynamics Considerations section. Information on current conditions impacting late-stage juveniles and adults is evaluated under Ecosystem Considerations.

Category Summary:

Assessment-related Considerations	Population Dynamics Considerations	Ecosystem Considerations	Fishery-informed Stock Considerations
Level #:	**Level 1 – Normal (no concern)**	**Level 1 – Normal (no concern)**	**Level #:**
	Although colder bottom temperatures may slightly extend egg incubation times, thermal conditions remain within historical operational ranges. Young skates may benefit from sufficient benthic prey, though anomalously low levels of benthic amphipods, and reduced top-down predation from Pacific cod and Pacific halibut populations.	While an expansive cold pool may cause adult Alaska skates to temporarily shift outside the standard survey area, late-stage juveniles and adults may benefit from strong benthic productivity. Furthermore, they experienced low-to-moderate prey competition and minimal top-down predation pressure due to declines in apex predators across the EBS.	

Overall Summary

Proper evaluation of risk is difficult for a data-limited stock. However, based on available ecosystem information, the overall environmental and ecosystem-related risk for BSAI skates is evaluated as 'Level 1 – Normal (no concern)'. In 2026, the eastern Bering Sea shelf experienced a sharp return to cool thermal conditions driven by late-winter north-to-south winds and sea ice expansion in March and April, producing a 2°C cold pool ~150% larger than in 2025.

Younger Skate Stages

All BSAI skate species are oviparous with temperature-sensitive embryonic development and prolonged egg case incubation (~3.5 years for Alaska skate). The colder 2026 bottom temperatures may slightly extend egg case incubation times over the EBS shelf, though temperatures remain within historical operational ranges with low vulnerability for Alaska skates (whereas long-term gradual warming in the Aleutian Islands may slightly shorten incubation times). Young skates feed on benthic infauna and small epifaunal invertebrates; indirect indicators of prey resources are sufficient as benthic forager biomass increased in 2026 and motile epifauna biomass remains >1 SD above the long-term mean. While increased benthic forager biomass suggests a slight increase in potential competition for space and benthic prey, non-limiting food supplies mitigate competition concerns. Predation on early life stages – including neonate predation by Pacific cod and Pacific halibut – remains low because Pacific cod biomass is below its long-term mean and Pacific halibut biomass remains near historical lows.

Adult Skates

Late-stage juvenile and adult skates are demersal generalists distributed across the EBS shelf, slope, and Aleutian Islands. However, Alaska skates display an inverse relationship with cold pool extent, which may indicate a spatial shift in adult distribution to outside the standard survey area when the cold pool occupies a large portion of the shelf habitat. Adult Alaska skates consume a varied diet of fish (such as pollock and herring) and benthic invertebrates and benefit from strong benthic productivity. Competition for prey remains low to moderate, and adult skates experience minimal top-down predation pressure due to general declines in apex predators across the EBS.

Population Dynamics Considerations

Risk Level 1 – Normal (no concern)

Environmental Processes

- All BSAI skate species are oviparous (egg-laying), with egg cases deposited in benthic nursery habitats where they undergo prolonged incubation periods (~3.5 years for Alaska skate; Hoff 2008). Embryo development rates are highly temperature-sensitive, with hatching times shortening between 4°C and 10°C, however skate species tend to select nursery sites that thermally stable..
- A six-week period of strong southward winds in March and April 2026 drove late-season sea ice expansion over the SEBS, into Bristol Bay, and to the Aleutian Islands (Thoman, 2026; EBS ESR). Depth-averaged water temperatures at M2 dropped nearly 3°C below historical averages in winter (McCabe et al., 2026; EBS ESR), and the summer 2°C cold pool was ~150% larger than in 2025 (Rohan and Barnett, 2026; EBS ESR).
- Colder bottom temperatures in 2026 may slightly extend egg incubation times over the EBS shelf relative to recent average thermal years (2022-2025) (Lemagie and Callahan, 2026; EBS ESR), but temperatures remain within historical ranges and represent low vulnerability for Alaska skates.
- In contrast, long-term gradual warming across the Aleutian Islands (Thoman, 2026; AI ESR) along with the step increase in SST (Lemagie and Callahan, 2026; AI ESR) and bottom temperatures in 2013-2014 (Rohan and Howard, 2026; AI ESR) may slightly shorten embryo incubation times in that region.

Prey

- Young skates feed on benthic infauna and small epifaunal invertebrates. Benthic foragers (as an indirect measure of infaunal prey) increased in 2026, and motile epifauna biomass remains >1 SD

above the long-term mean (Whitehouse, 2026; EBS ESR), indicating available food resources for young skates.

- In 2025, benthic amphipods were near anomalously low levels but similar to values for 2023-2024. Hermit crabs were just below their long-term mean in 2025 (Reum, 2026; EBS ESR); shrimp increased in the Aleutian Islands (Friedman 2026; AI ESR)

Competitors

- Biomass of the benthic foragers guild increased in 2026 (Whitehouse, 2026; EBS ESR), indicating a slight increase in potential competition for benthic prey and space, though non-limiting prey supplies (see above) mitigate competition concerns.

Predators

- Gastropod snails consume newly deposited egg cases (Hoff 2009), while Pacific cod and Pacific halibut prey on neonate skates near nursery grounds at low levels (Hoff 2010). Pacific cod biomass remains below its long-term mean (Whitehouse, 2026; EBS ESR), and Pacific halibut biomass remains near historical lows, indicating low predation pressure on early life stages of skates. Both Pacific cod and halibut increased in the Aleutians to near survey average biomass (cod) or stayed below the survey average near historical lows (halibut); most other apex predators have decreased (Ortiz, 2026; AI ESR).

Ecosystem Considerations:

Risk Level 1 – Normal (no concern)

Distribution

- Skates are demersal generalists distributed widely across the EBS shelf, slope, and Aleutian Islands. Alaska skate dominates the shelf, while Bering, whiteblotched, Aleutian, big and mud skates populate slope and Aleutian habitats.
- Survey trends indicate minor long-term northward range expansion and minor depth shifts (e.g., *Bathyraja* spp. moving deeper in the AI), but overall stock distribution remains stable.
- Leopard skate, which has consistently decreased from 2010-2022, increased from 443 in 2024 to 1,392 in 2026 based on survey biomass estimates

Environmental Processes

- Following near-average thermal conditions (2022-2025), 2026 marked a transition to cool conditions in the EBS (Lemagie and Callahan, 2026; EBS ESR). An extremely weak winter Aleutian Low (Lemagie and Wang, 2026; EBS ESR) and strong north-to-south winds in March/April (Hennon, 2026; EBS ESR) drove late ice advance over the SEBS (Thoman, 2026; EBS ESR).
- The 2°C cold pool extent was ~150% larger in 2026 than in 2025 (largest 2°C cold pool since 2012) (Rohan and Barnett, 2026; EBS ESR).
- The Alaska skate has an inverse relationship with cold pool extent. More research is needed, but may indicate a shift in adult skate distribution outside the standard survey area when the cold pool is occupying much of the shelf habitat
- Deeper bottom temperatures along the shelf break (longline survey) averaged 3.96°C in 2026, warmer than 2009-2013 levels (Siwicke, 2026; EBS ESR).
- In the Aleutians, 2026 bottom temperatures were > 1 SD warmer than the 1994-2012 mean across most of the WAI and CAI, but within 1 SD in the EAI. Temperatures have remained > 1 SD in the WAI except for 2024, in contrast to a decreasing trend since the maximum in 2016 in the CAI and EAI (Rohan and Howard 2026; AI ESR).

Prey

- Adult Alaska skates consume a varied diet of fish (including pollock and herring) and benthic invertebrates (e.g., *Chionoecetes* crabs, shrimp).
- Benthic forager biomass increased in 2026, and motile epifauna biomass remains high (>1 SD above long-term mean) (Whitehouse, 2026; EBS ESR), indicating good benthic productivity and sufficient prey resources.
- Prey availability is mixed in the Aleutians where Atka mackerel and pollock decreased slightly (Ortiz, 2026; AI ESR) while shrimp increased (Friedman, 2026; AI ESR). Reproductive success of seabirds suggests mixed conditions for fish prey in the western Aleutians and good conditions in the east (Rojek, 2026; AI ESR)

Competitors

- Biomass of other benthic foragers increased in 2026, while apex predator biomass (e.g., Pacific cod) remained below the long-term average (Whitehouse, 2026; EBS ESR), indicating that competition for prey remains low to moderate.

Predators

- Apex predators have generally declined across the EBS (Whitehouse, 2026; EBS ESR) and Aleutian Islands (Ortiz, 2026), resulting in minimal top-down predation pressure on adult skates.

Literature Cited

Hoff, G. R. 2008. A nursery site of the Alaska skate (*Bathyraja parmifera*) in the eastern Bering Sea. Fish. Bull. 106(3):233-244.

Hoff, G.R. 2009. Skate *Bathyraja* spp. egg predation in the eastern Bering Sea. J Fish Biol 74(1):250-69.

Hoff, G.R. 2010. Identification of skate nursery habitat in the eastern Bering Sea. Mar. Ecol. Prog. Ser. 403:243-254.

Ortiz, I. 2026. Ecosystem Status Report 2026: Aleutian Islands, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West 3rd Ave., Suite 400, Anchorage, Alaska 99501.

Siddon, E. 2026. Ecosystem Status Report 2026: Eastern Bering Sea, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West 3rd Ave., Suite 400, Anchorage, Alaska 99501.