Figures

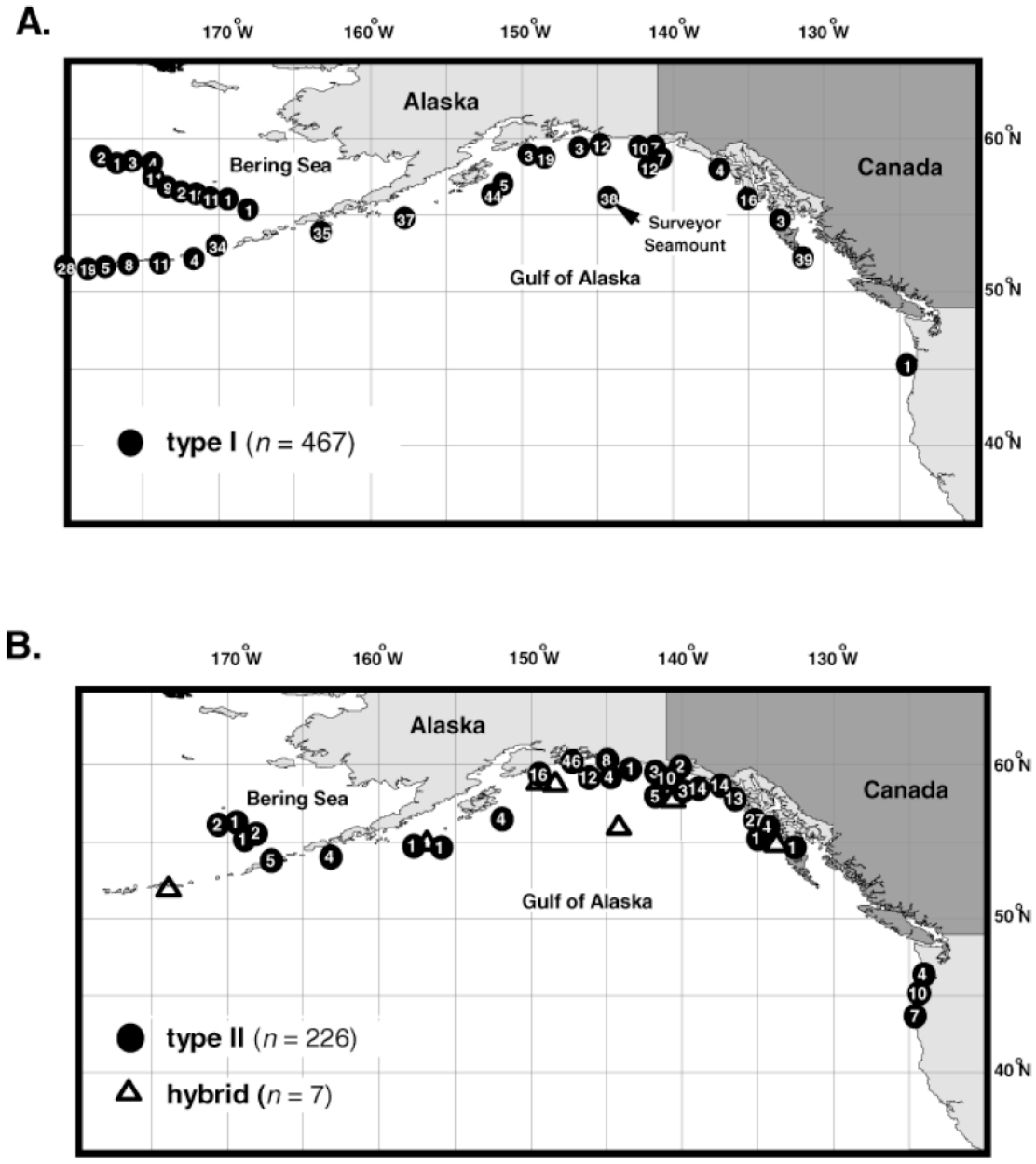

Figure 14.1. Distribution type I (i.e., blackspotted rockfish, *S. melanostictus*) and type II (i.e., rougheye rockfish, *S. aleutianus*) fish previously thought to be a single species of rougheye rockfish, based mtDNA and microsatellite genetic analyses. From Gharrett et al. (2005).

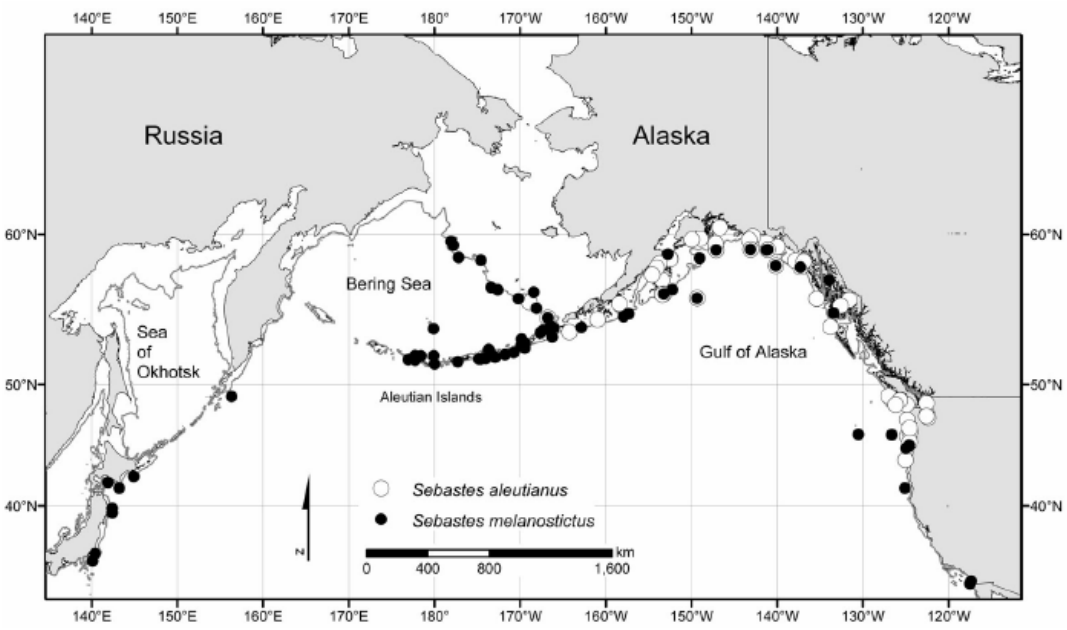

Figure 14.2. Distribution blackspotted rockfish (*S. melanostictus*) and rougheye rockfish (*S. aleutianus*) based upon genetic, morphometric, and meristic analyses. From Orr and Hawkins (2008).

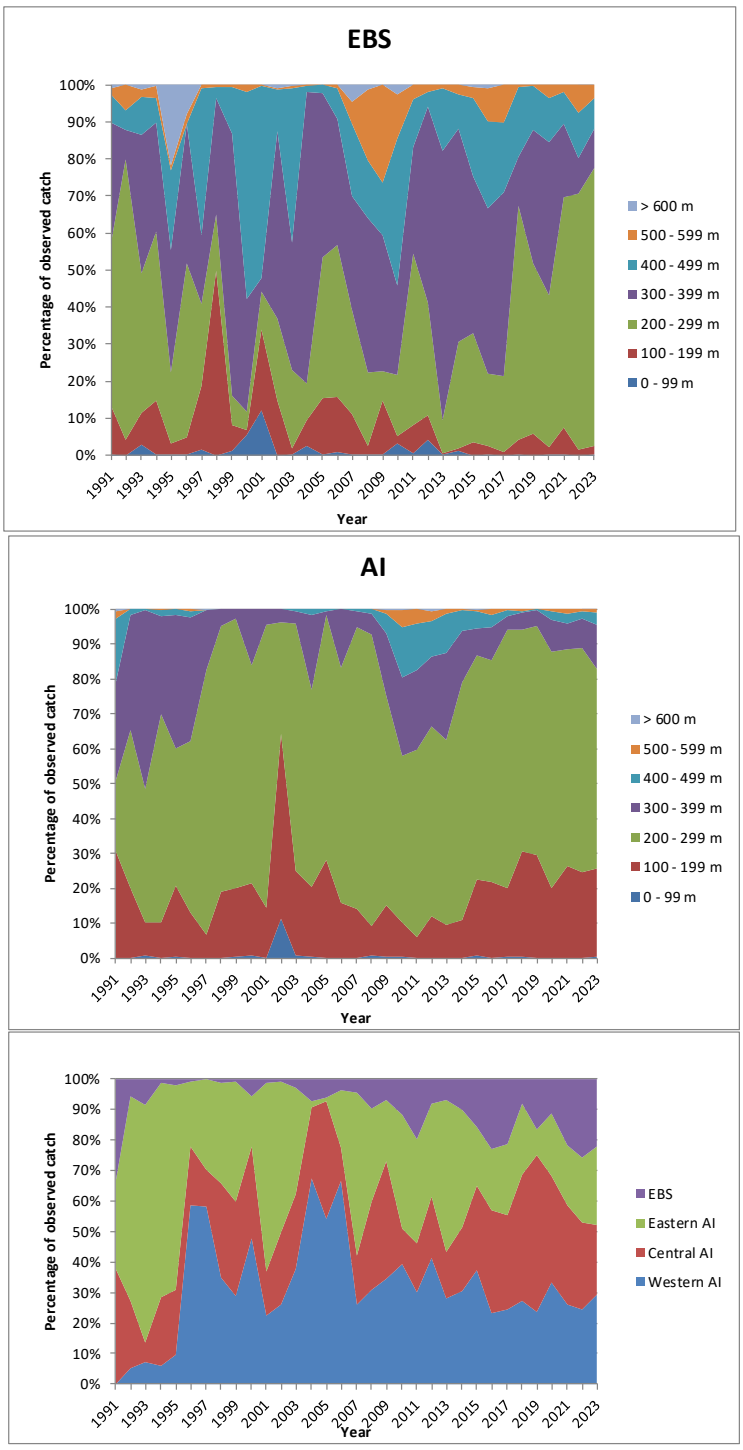

Figure 14.3. Distribution of observed BSAI blackspotted/rougheye rockfish catch (from North Pacific Groundfish Observer Program) by depth zone for the AI (top panel) and EBS (middle panel), and by BSAI subarea (bottom panel) from 1991 to 2023.

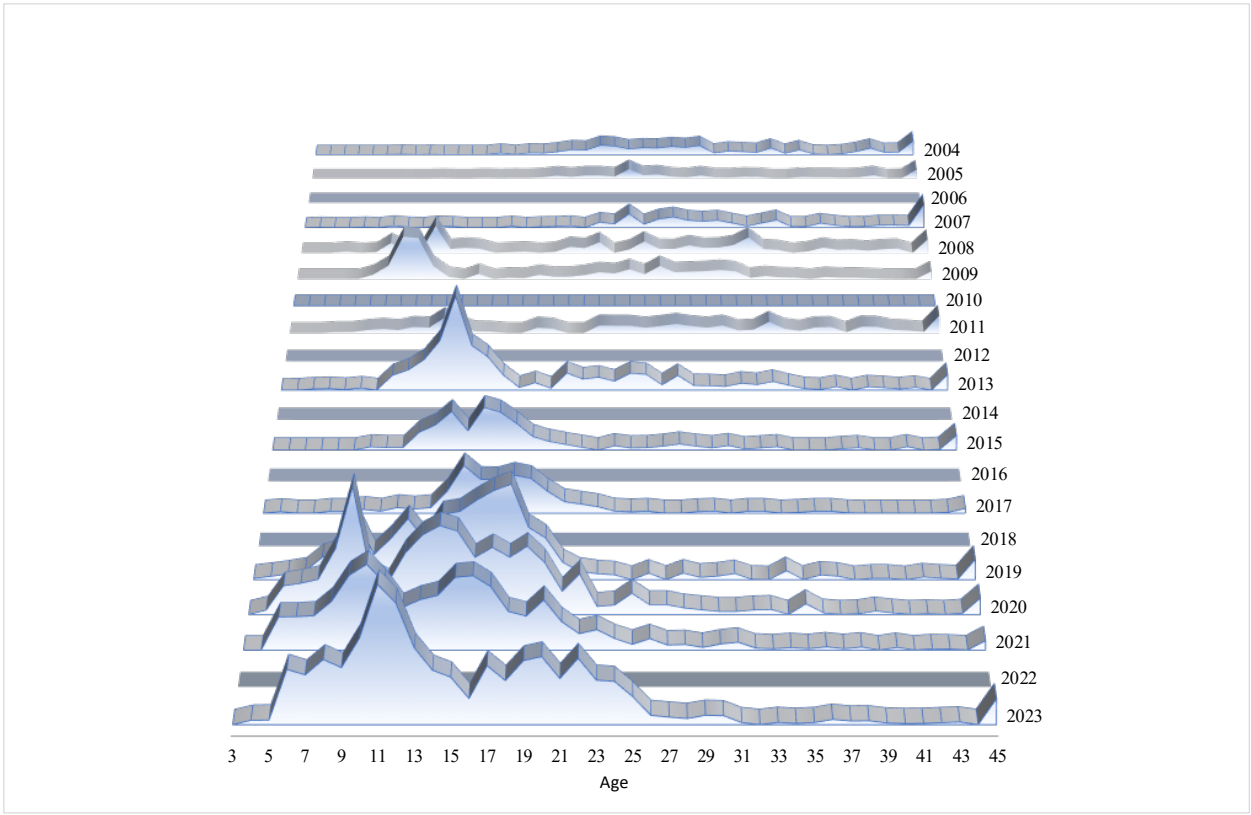

Figure 14.4. Fishery age composition data for the BSAI, scaled to the extrapolated number of fish caught from Observer sampling.

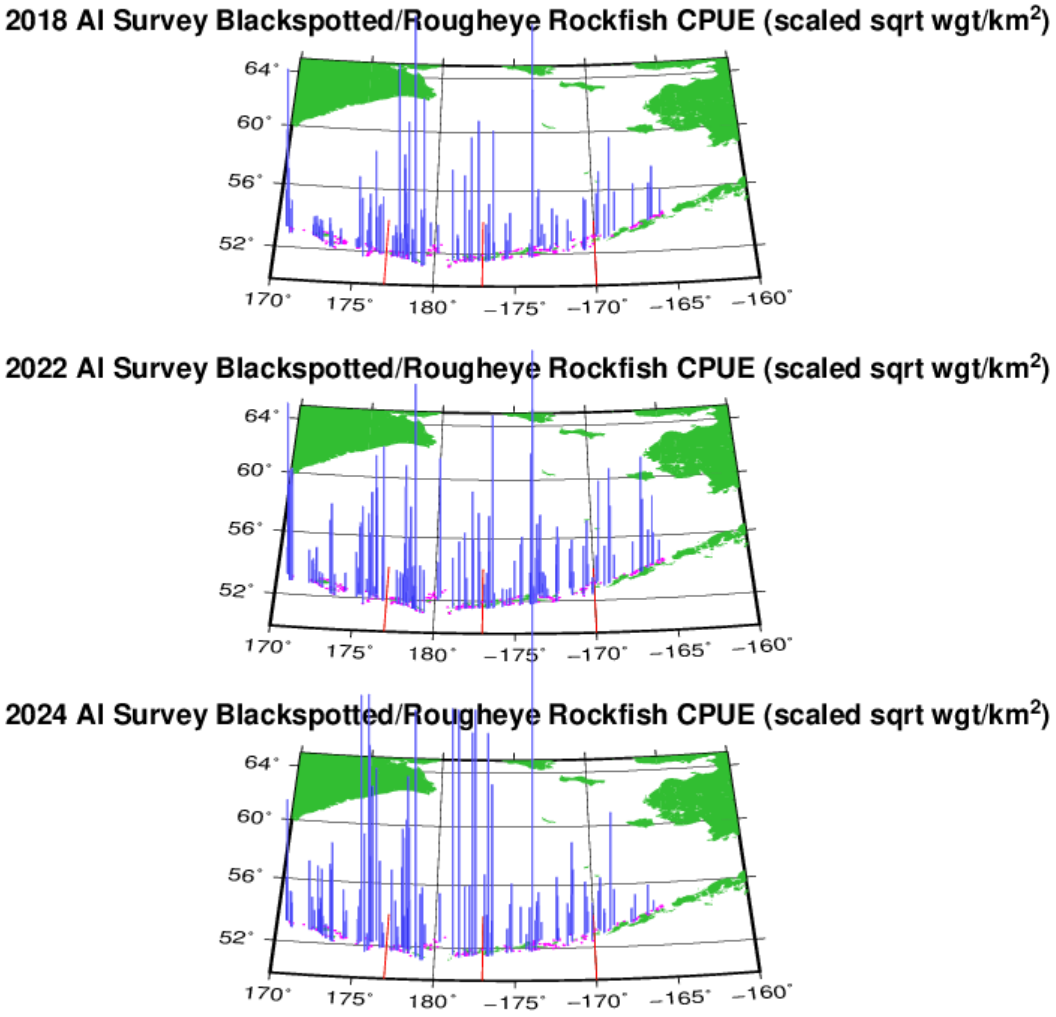

Figure 14.5. Scaled Aleutian Islands (AI) survey combined blackspotted and rougheye rockfish CPUE (kg/km^2) from 2016-2024; the symbol × denotes tows with no catch. The red lines indicate boundaries between the western Aleutian Islands (WAI), central Aleutian Islands (CAI), eastern Aleutian Islands (EAI), and eastern Bering Sea (EBS) areas.

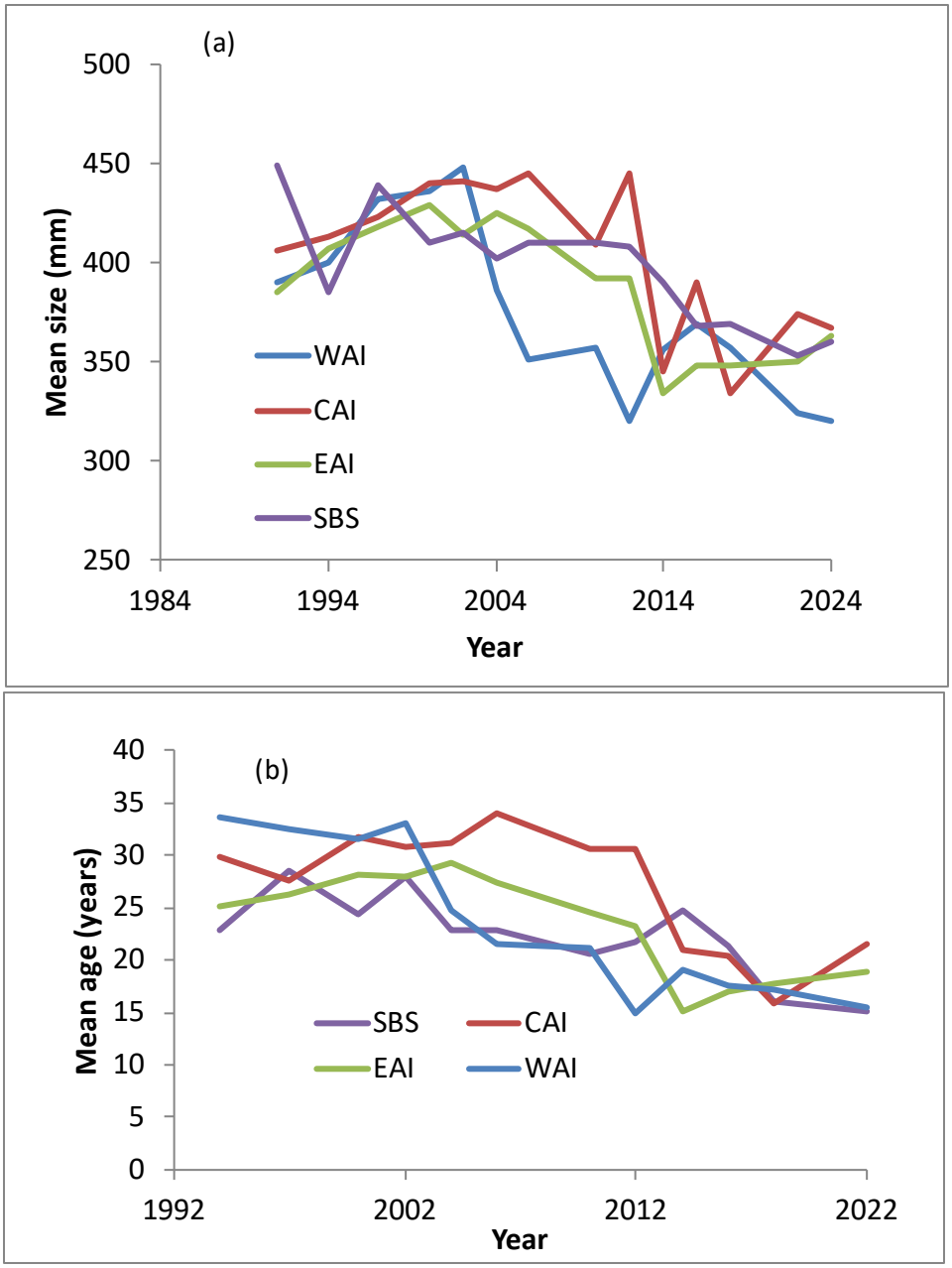

Figure 14.10. Mean size (a) and age (b) of blackspotted/rougheye rockfish from the 1991-2024 AI trawl surveys by subarea.

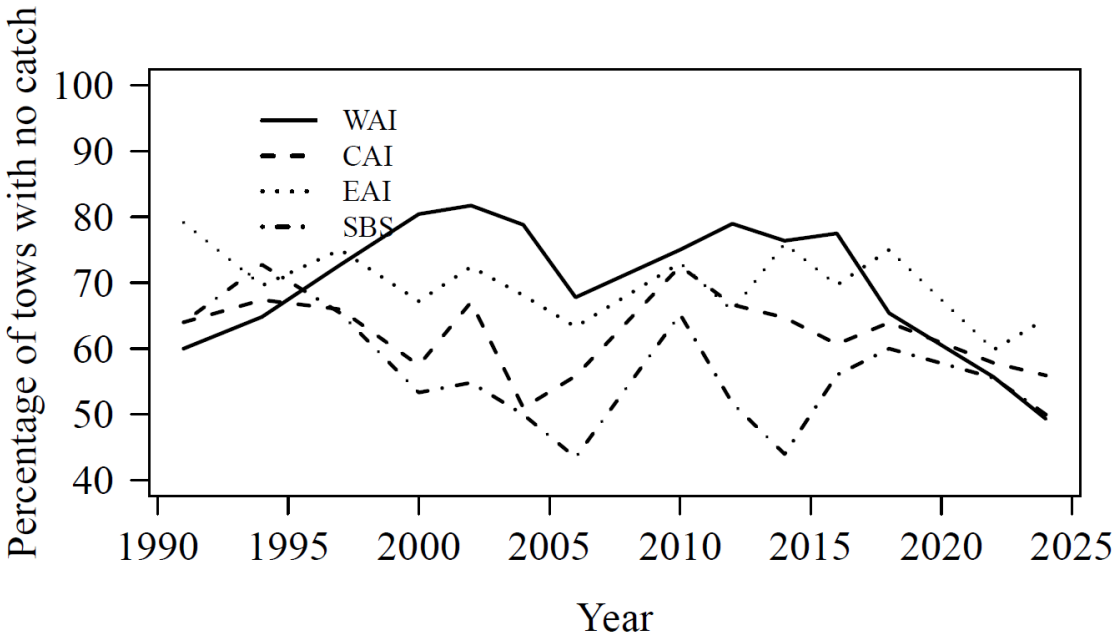

Figure 14.11. Percentage of survey tows with no catch of blackspotted/rougheye rockfish from the 1991-2024 AI trawl surveys by subarea.

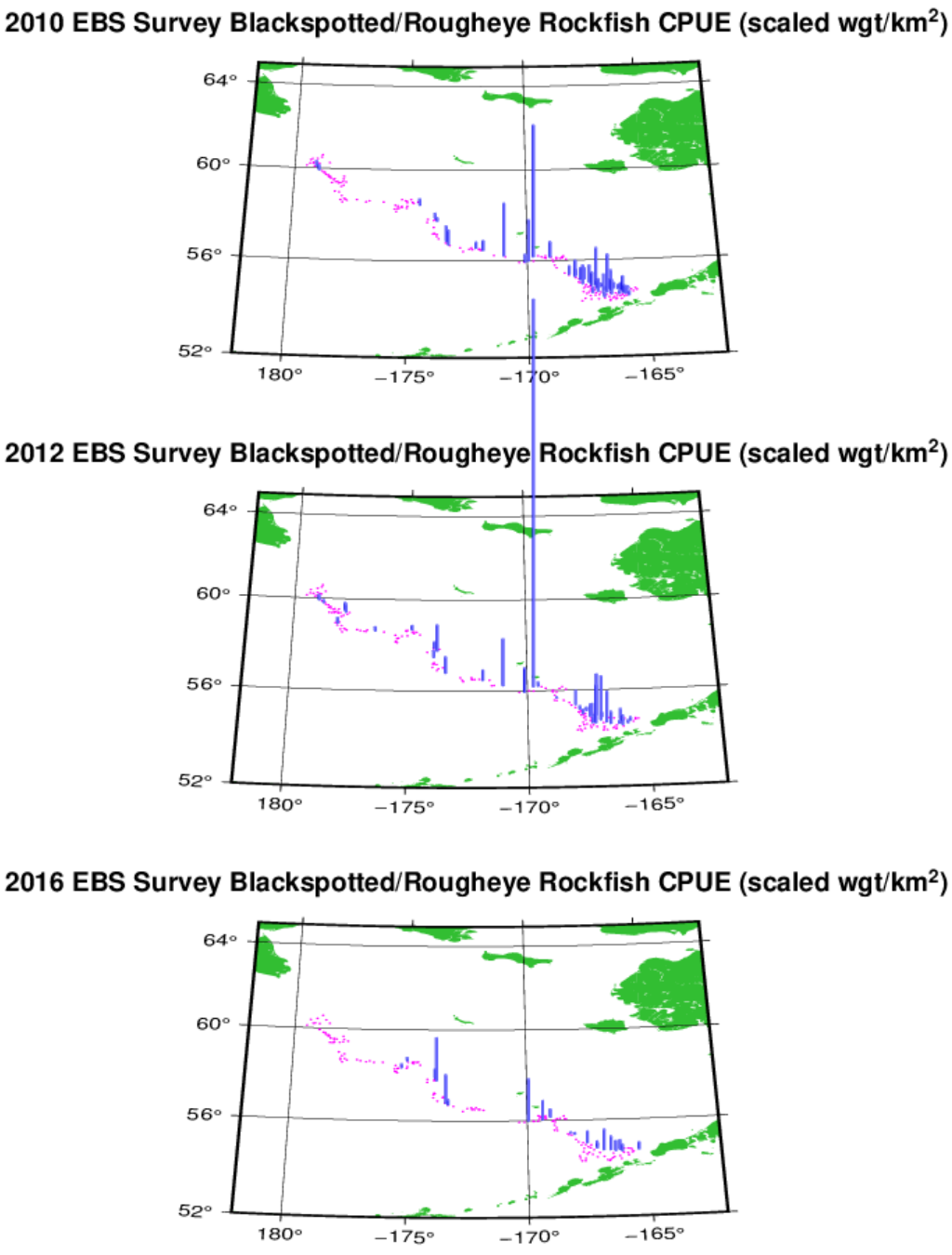

Figure 14.12. Scaled EBS survey combined blackspotted and rougheye rockfish CPUE (kg/km^2) from 2010-2016; the symbol × denotes tows with no catch.

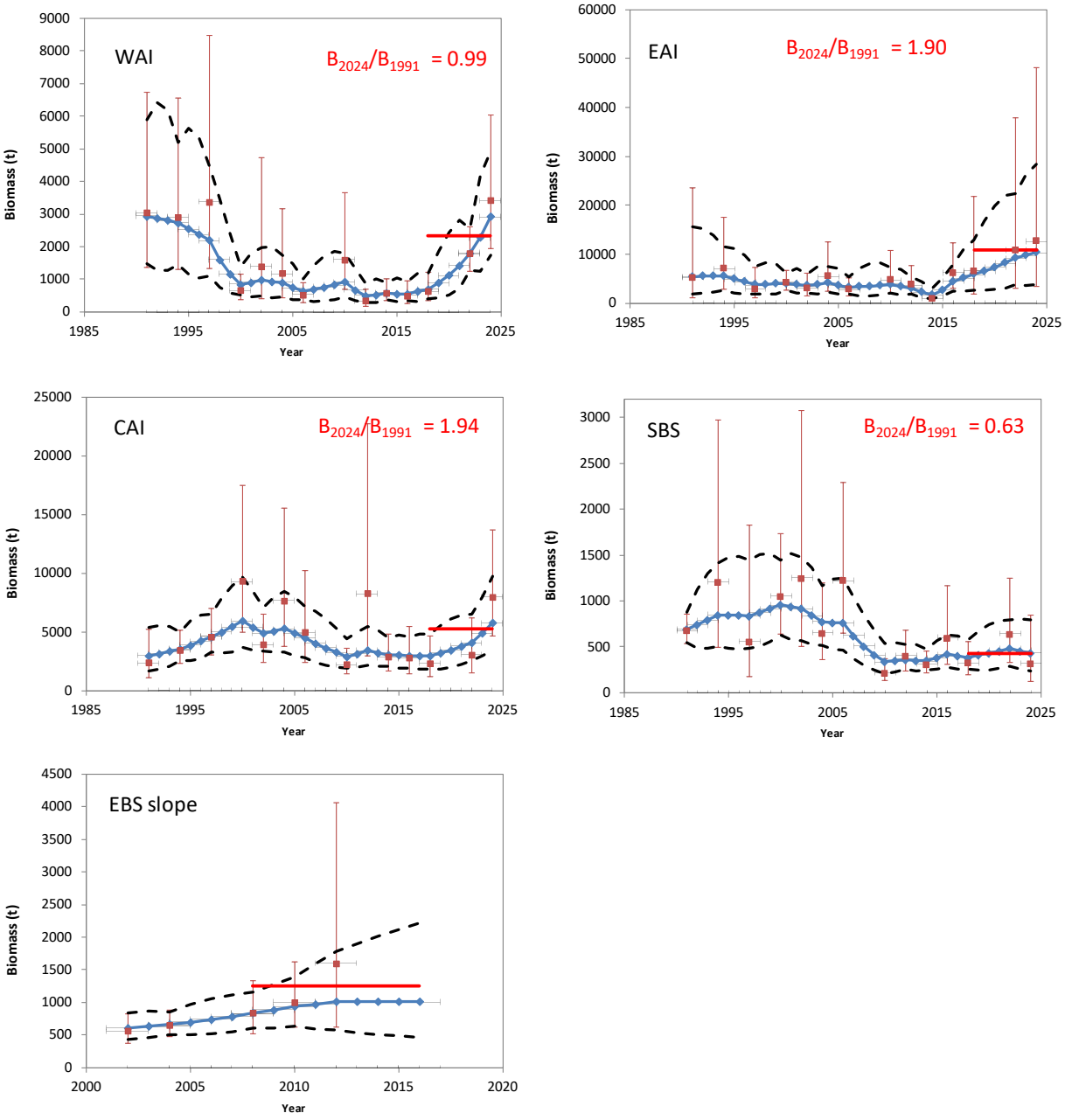

Figure 14.13. Time series of AI and EBS slope trawl survey biomass by subarea, with the fits from a random effects model to smooth the time series. The ratio of the biomass estimate in 2024 to that in 1991 indicates relative change over this time period. The horizontal red lines show the estimate from a weighted average of the three most recent surveys.

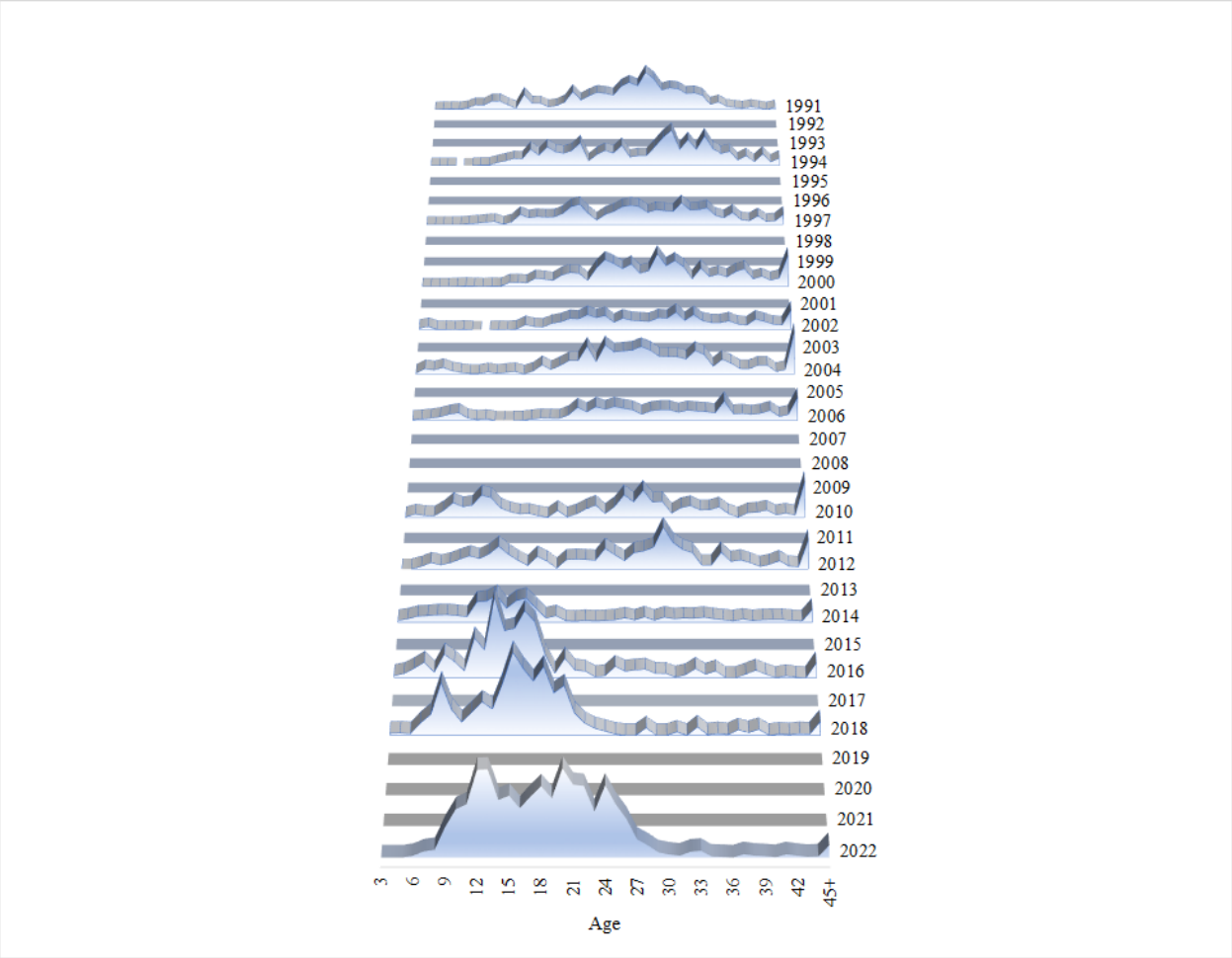

Figure 14.14. Estimated abundance by age from the Aleutian Islands trawl survey, 1991-2022.

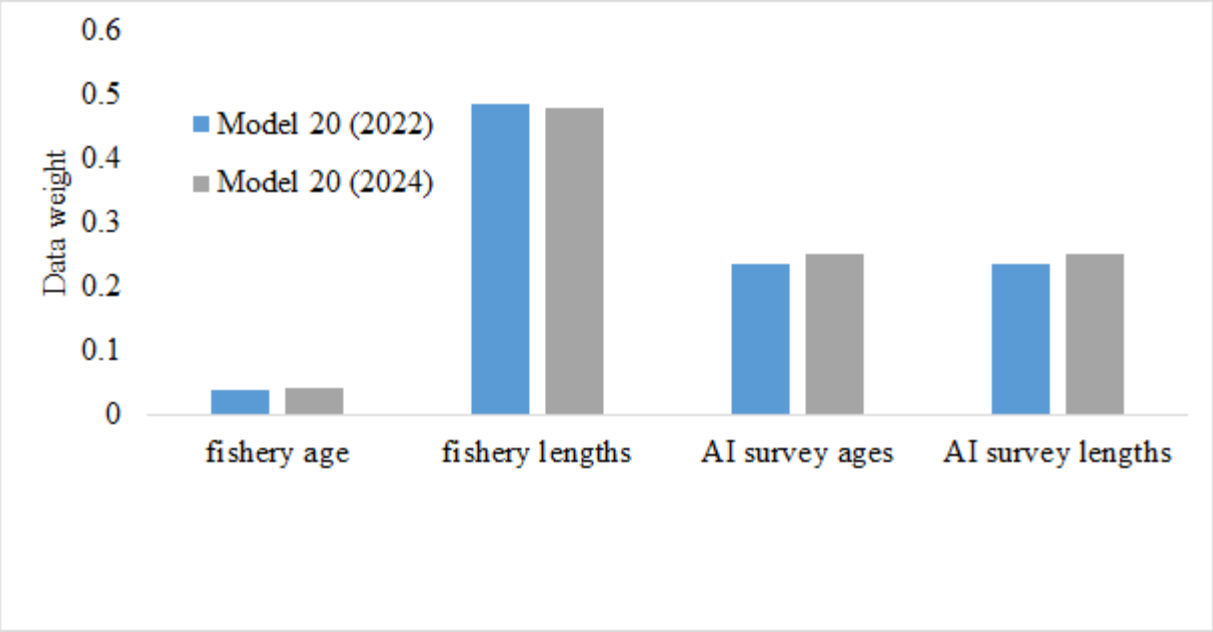

Figure 14.15. Estimated stage 2 composition data weights for 2022 and 2024 assessment models.

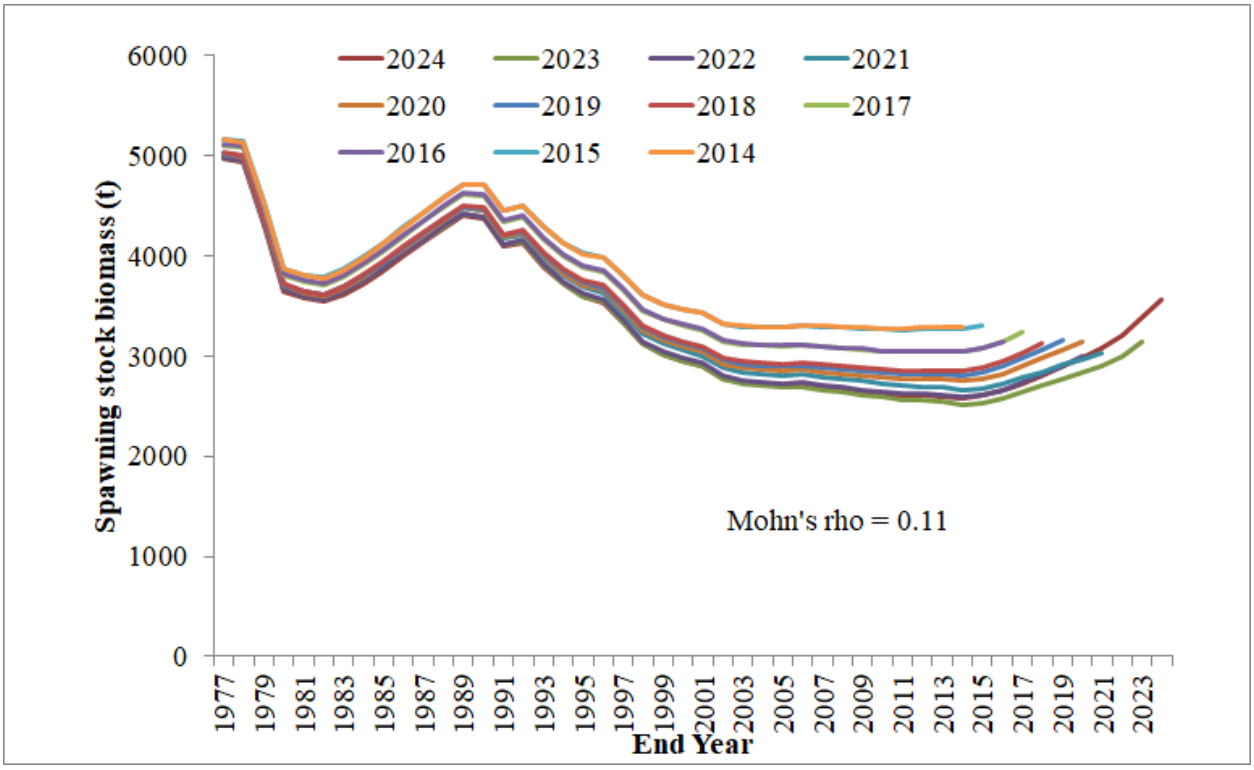

Figure 14.16. Retrospective estimate of SSB from model 20 (2024).

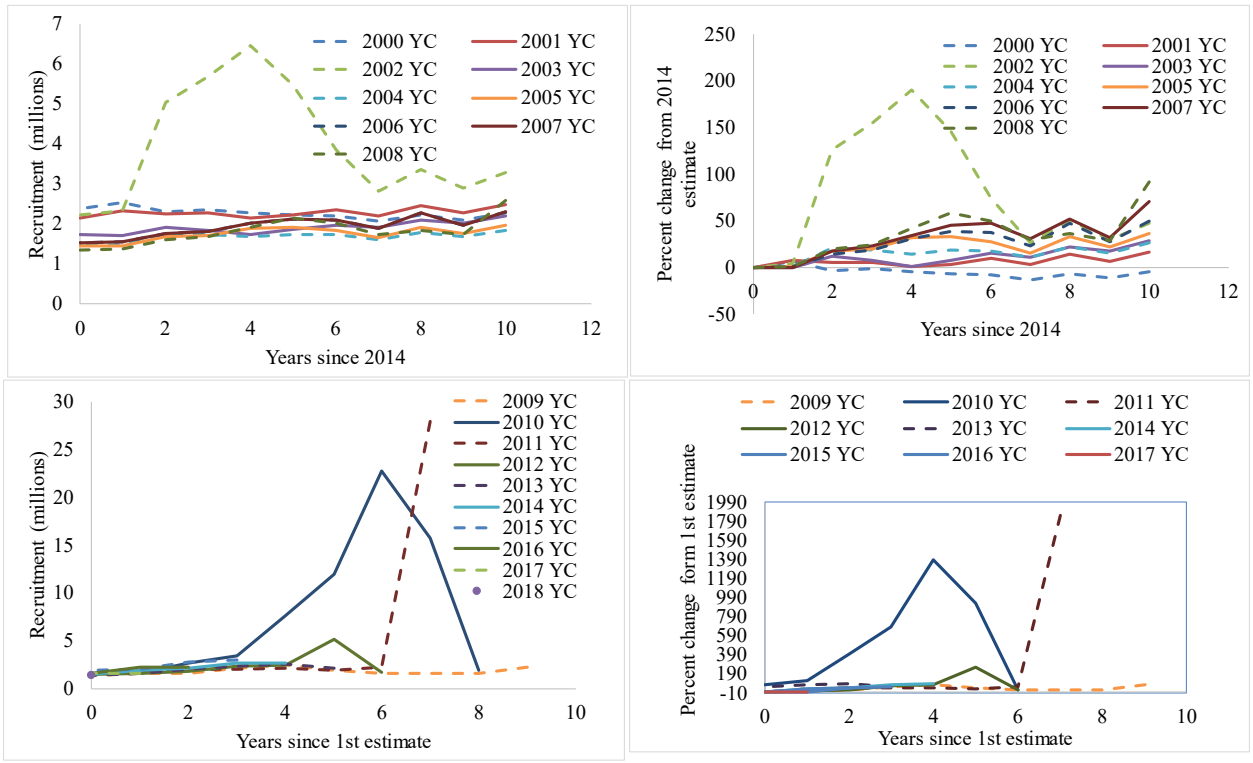

Figure 14.17. Retrospective estimates of recruitment for the 2000 – 2018 year classes, as a function of the years since either the first estimate or 2014 (whichever is later), for model 20 (2024).

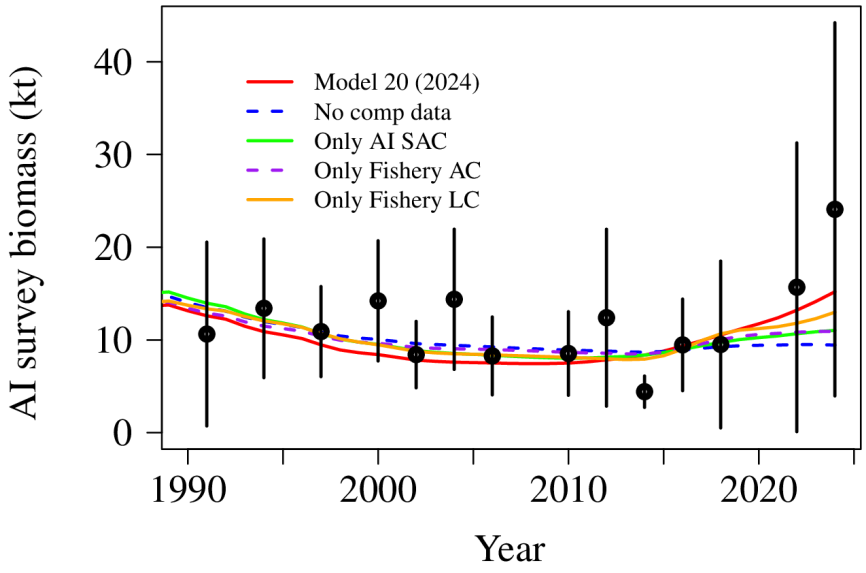

Figure 14.18. Fit to the AI survey biomass time series from model 20 (2024), and from sensitivity runs in which either all or all but one composition data is removed.

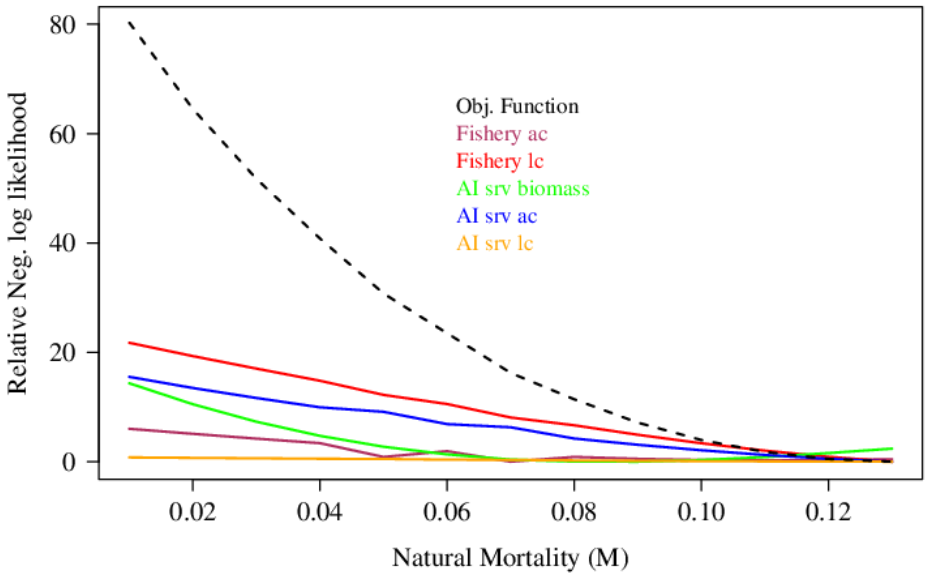

Figure 14.19. Likelihood profile for the estimated natural mortality parameter (*M*).

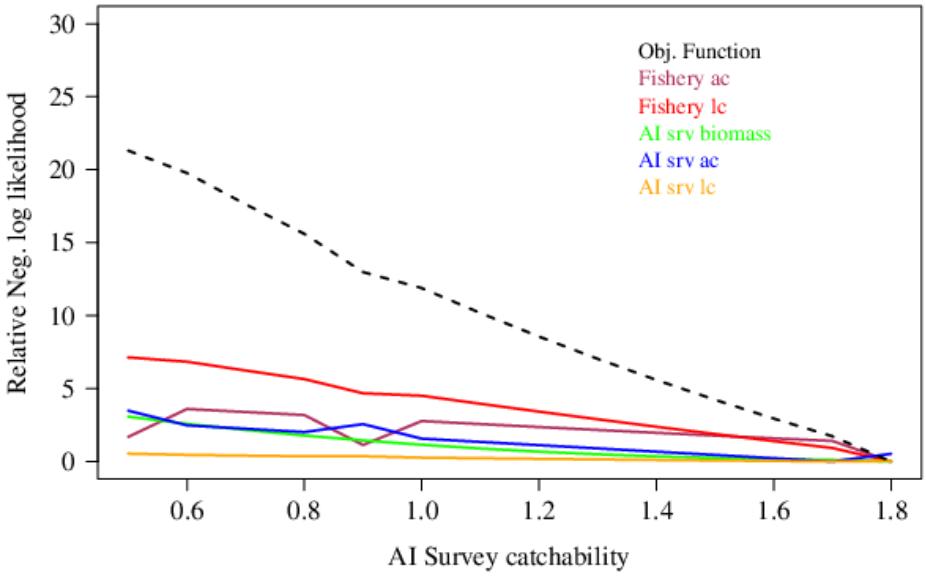

Figure 14.20. Likelihood profile for the estimated catchability of the AI trawl survey.

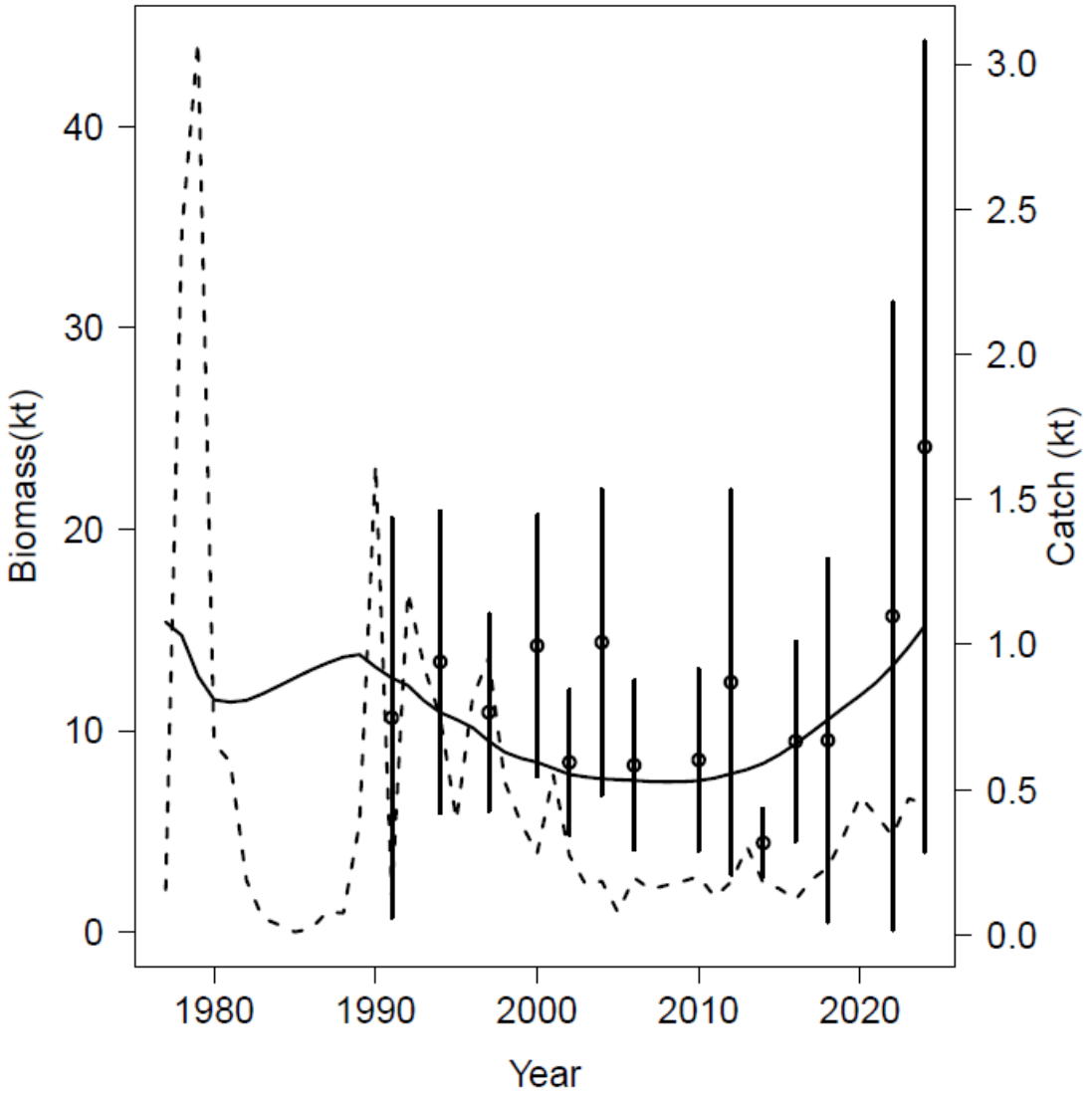

Figure 14.21. Observed Aleutian Islands (AI) survey biomass for blackspotted/rougheye rockfish (data points, +/- 2 standard deviations), predicted survey biomass (solid line), and harvest (dashed line).

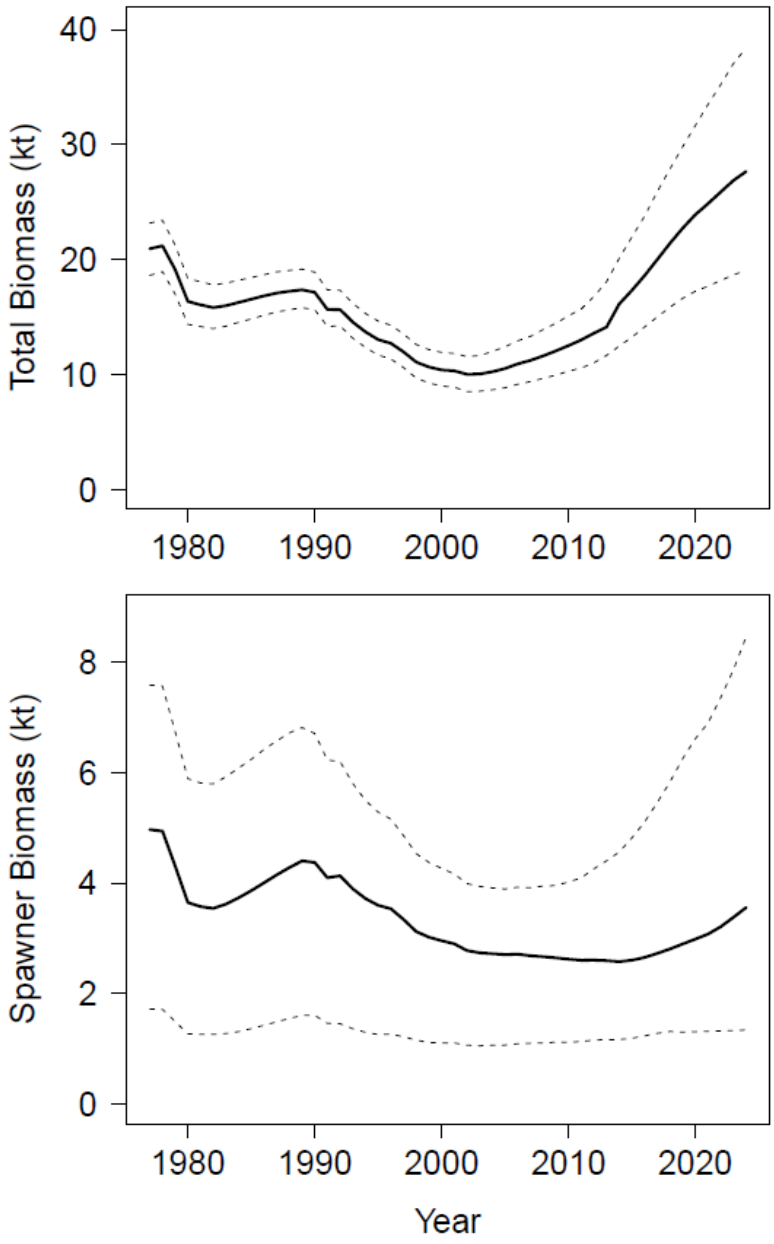

Figure 14.22. Total (top panel) and spawner (bottom panel) biomass for BSAI blackspotted/rougheye rockfish, with 95% confidence intervals from MCMC integration.

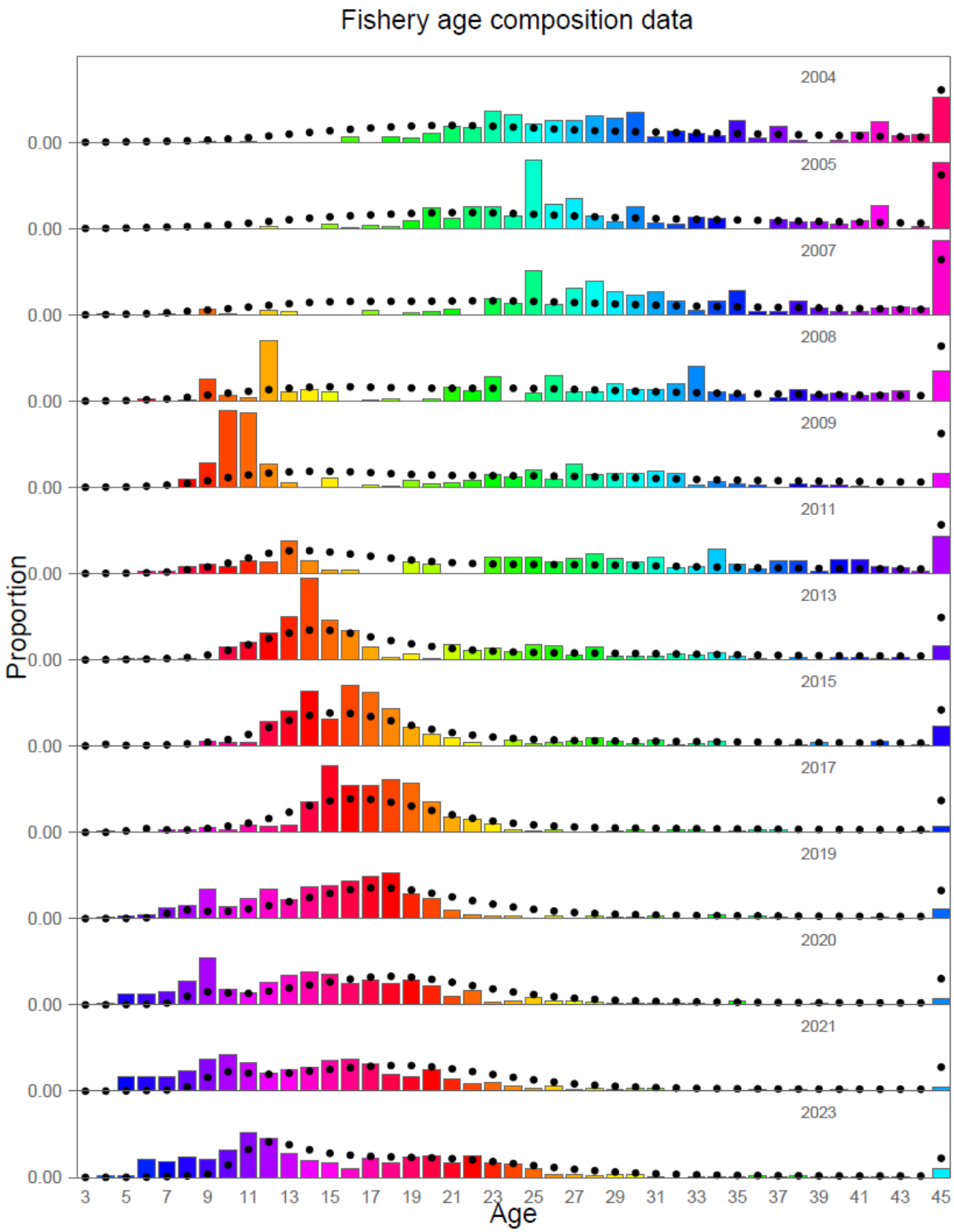

Figure 14.23. Model fits (dots) to fishery age composition data (columns) for BSAI blackspotted/rougheye, 2004-2023. Colors correspond to cohorts (except for the 45+ group).

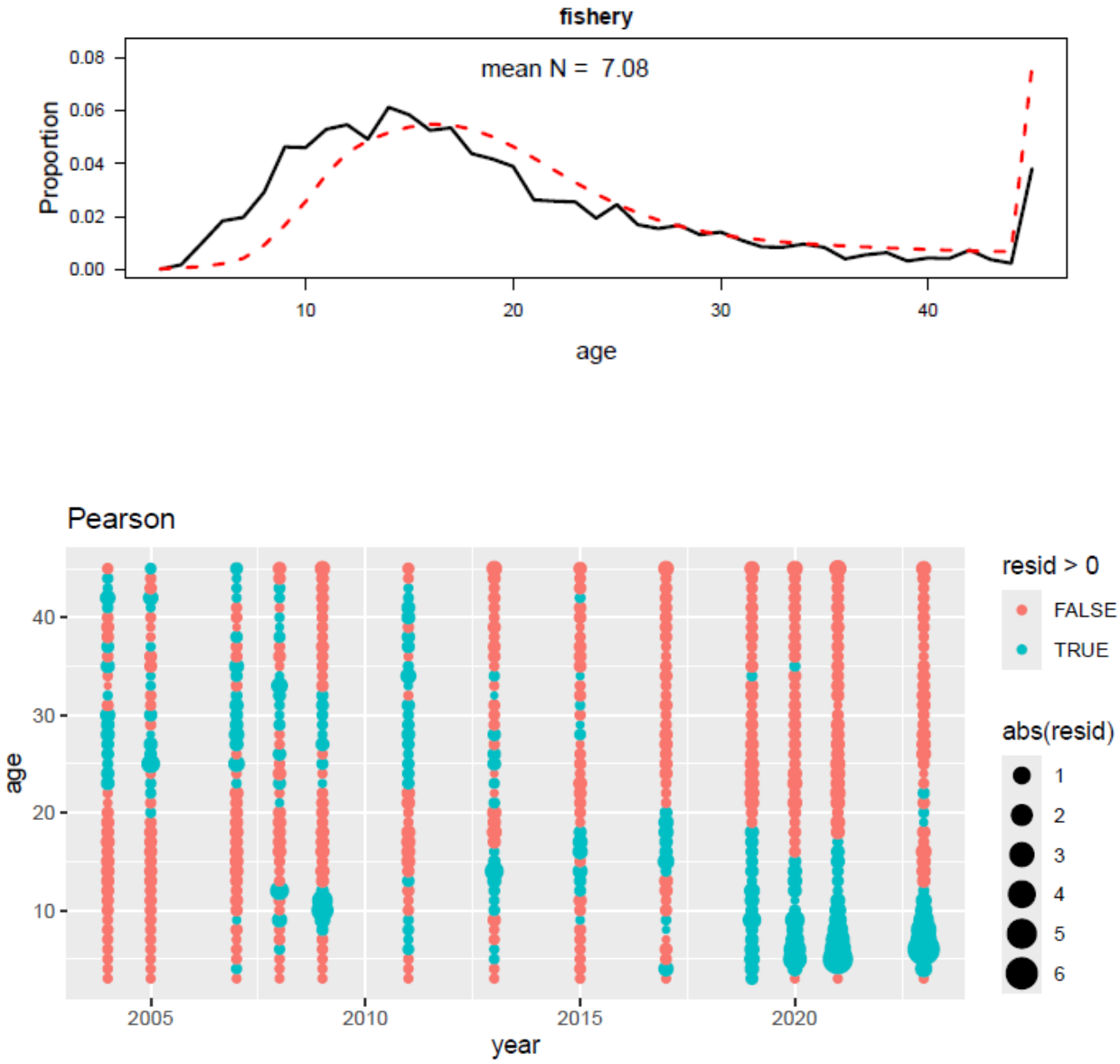

Figure 14.24. Aggregated observed (black) and estimated (red) fishery age compositions (top panel) and Pearson residuals (bottom panel).

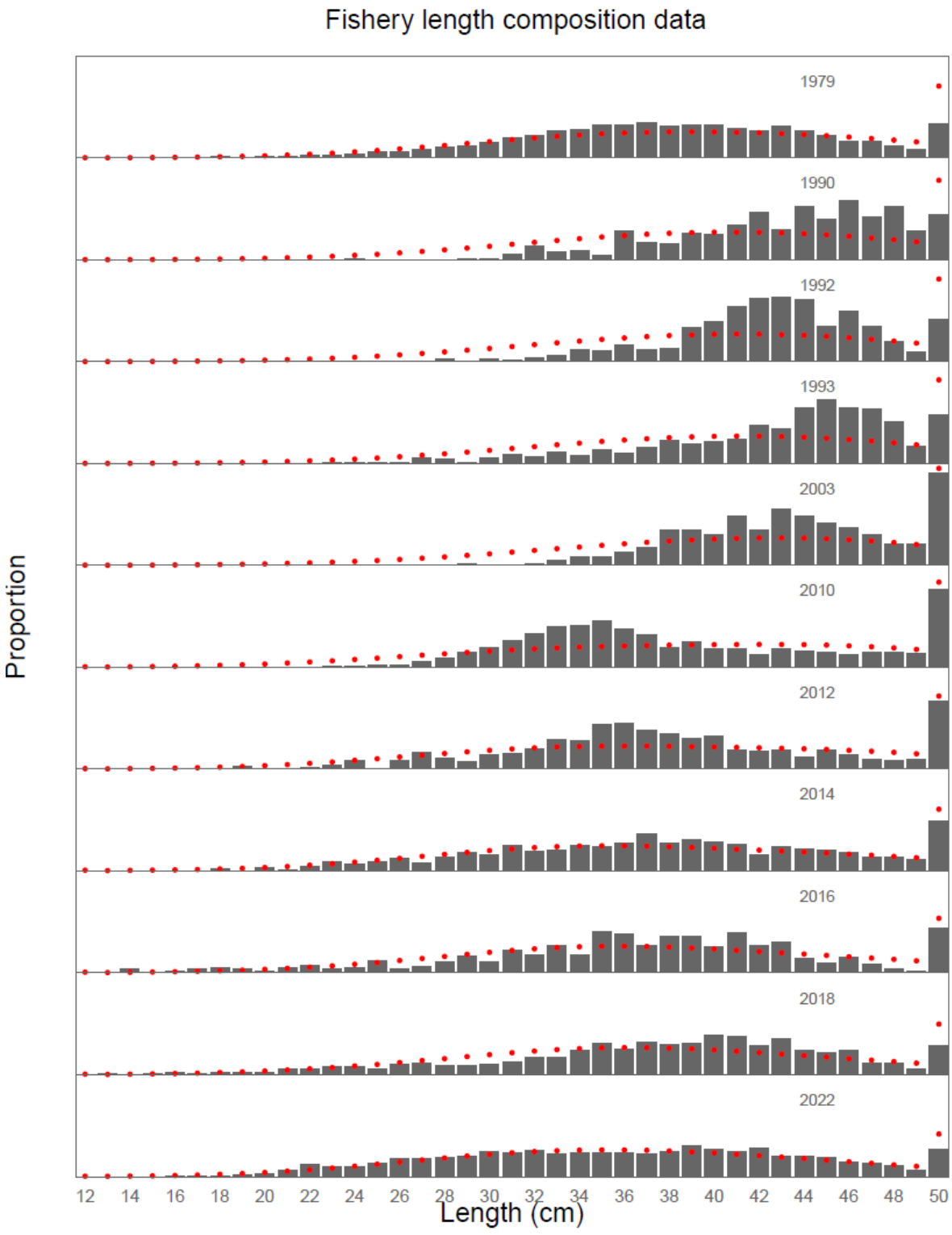

Figure 14.25. Model fits (dots) to the fishery length composition data (columns) for AI blackspotted/rougheye rockfish, 1979-2022.

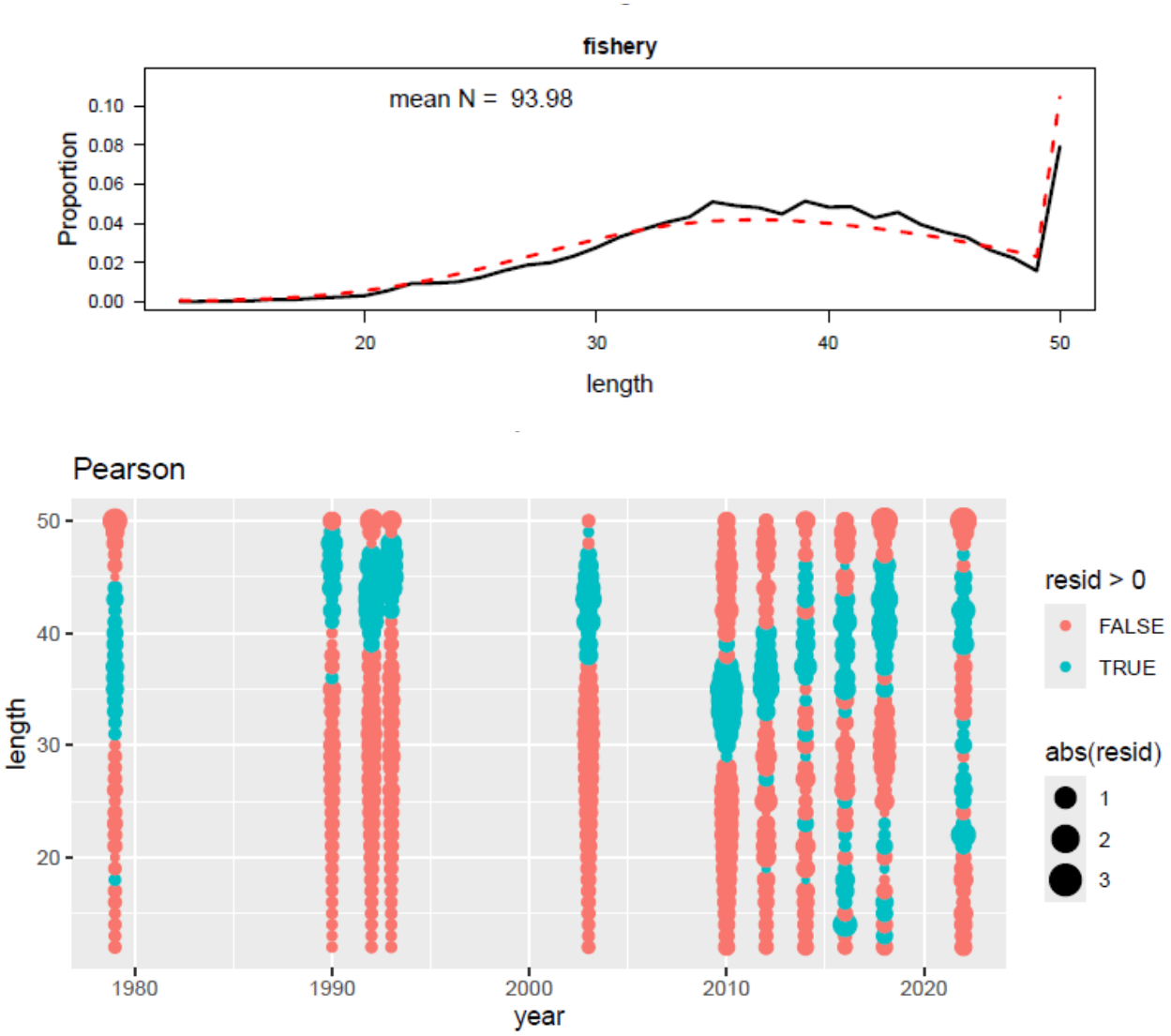

Figure 14.26. Aggregated observed (black) and estimated (red) fishery length compositions (top panel) and Pearson residuals (bottom panel).

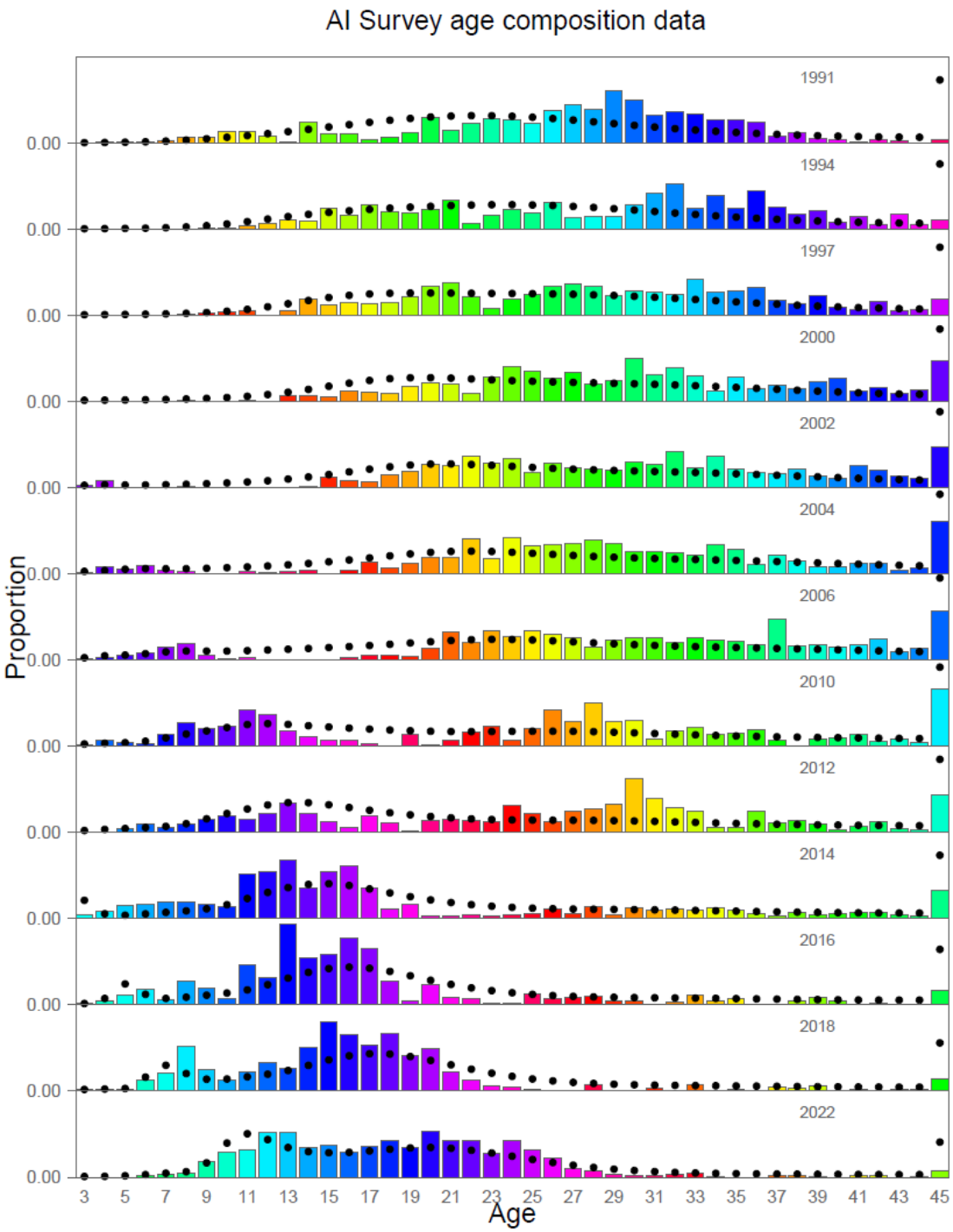

Figure 14.27. Model fits (dots) to AI survey age composition data (columns) for blackspotted/rougheye, 1991-2022. Colors correspond to cohorts (except for the 45+ group).

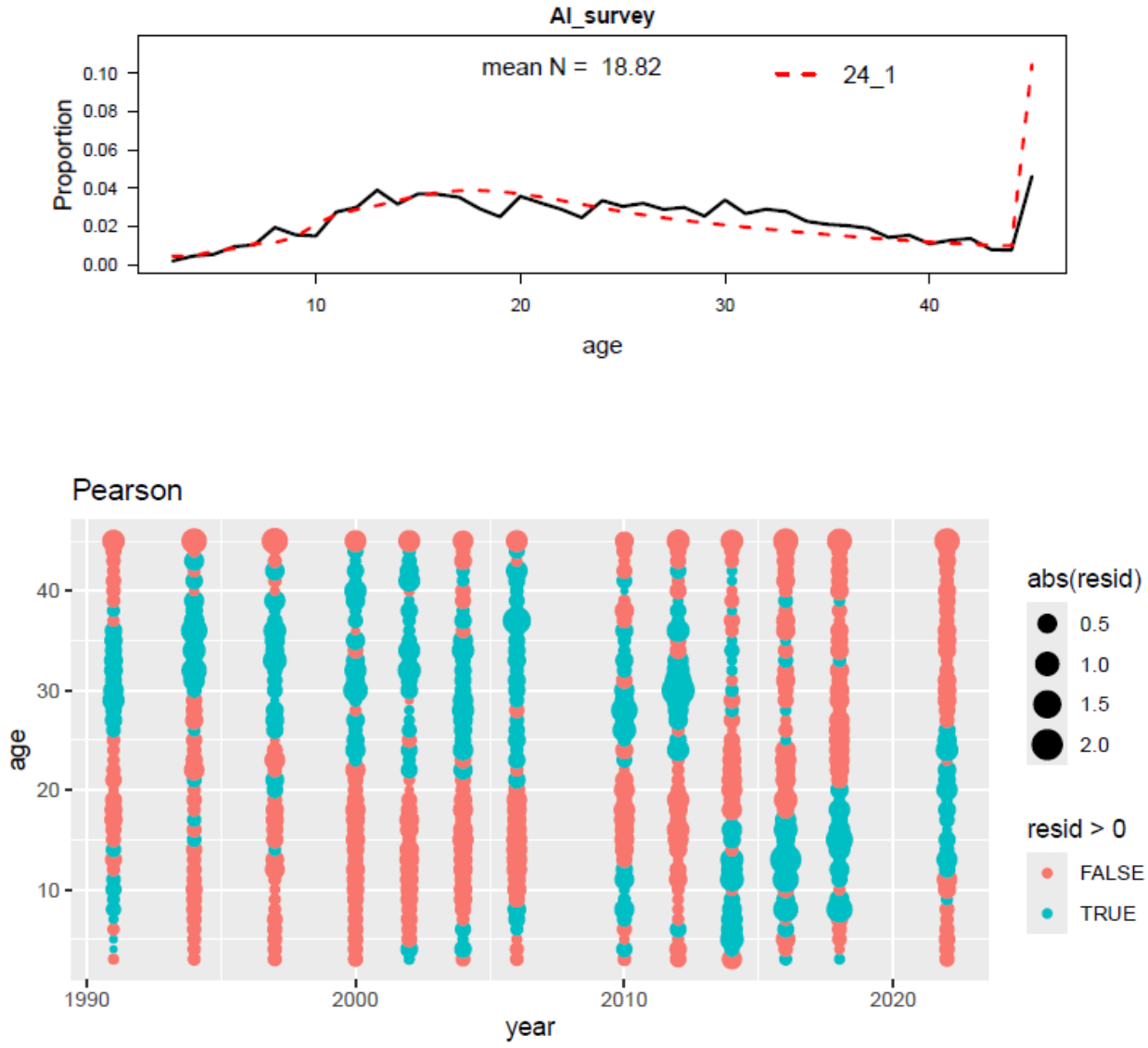

Figure 14.28. Aggregated observed (black) and estimated (red) AI survey age compositions (top panel) and Pearson residuals (bottom panel).

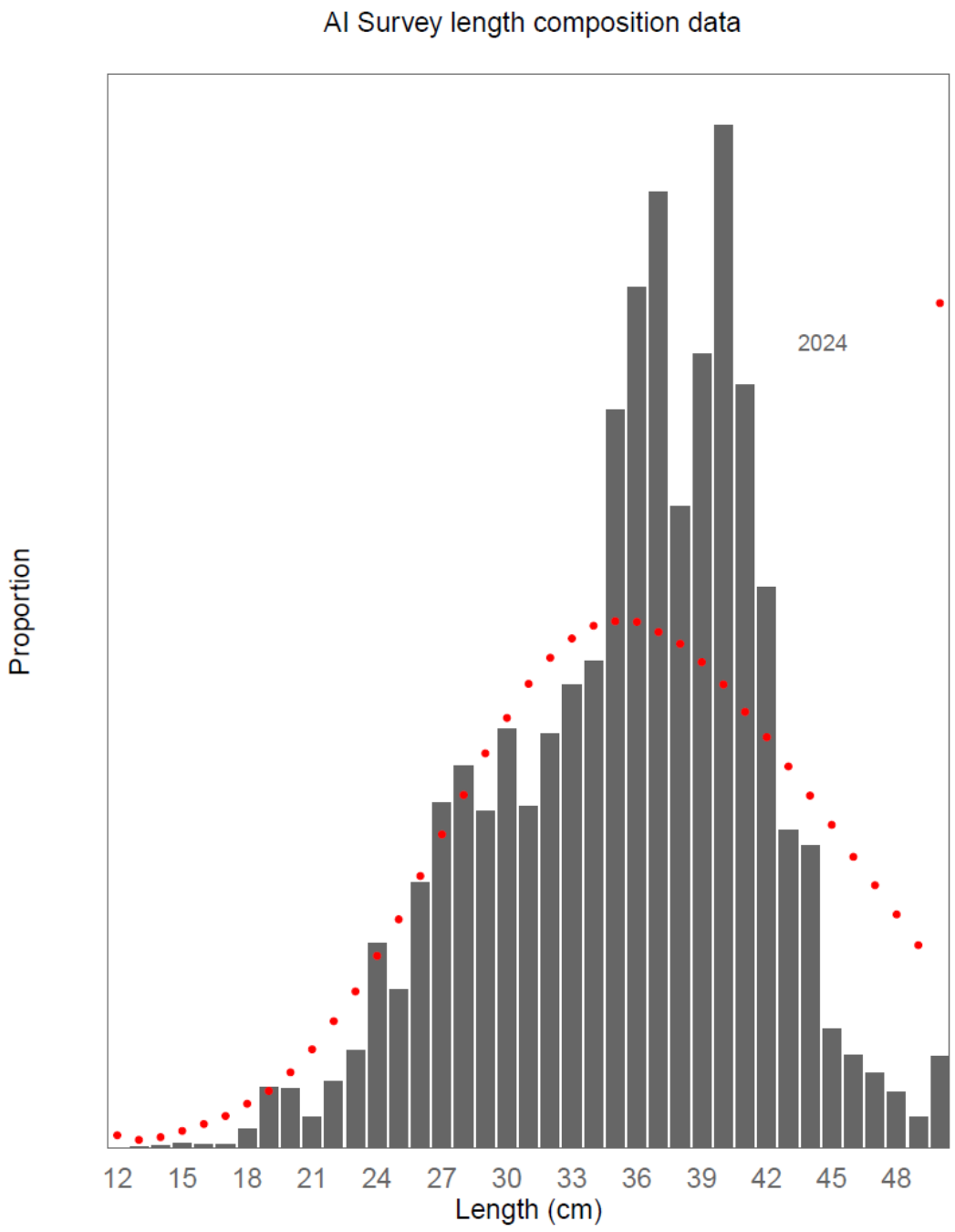

Figure 14.29. Model fits (dots) to 2024 AI survey length composition data (columns) for blackspotted/rougheye rockfish.

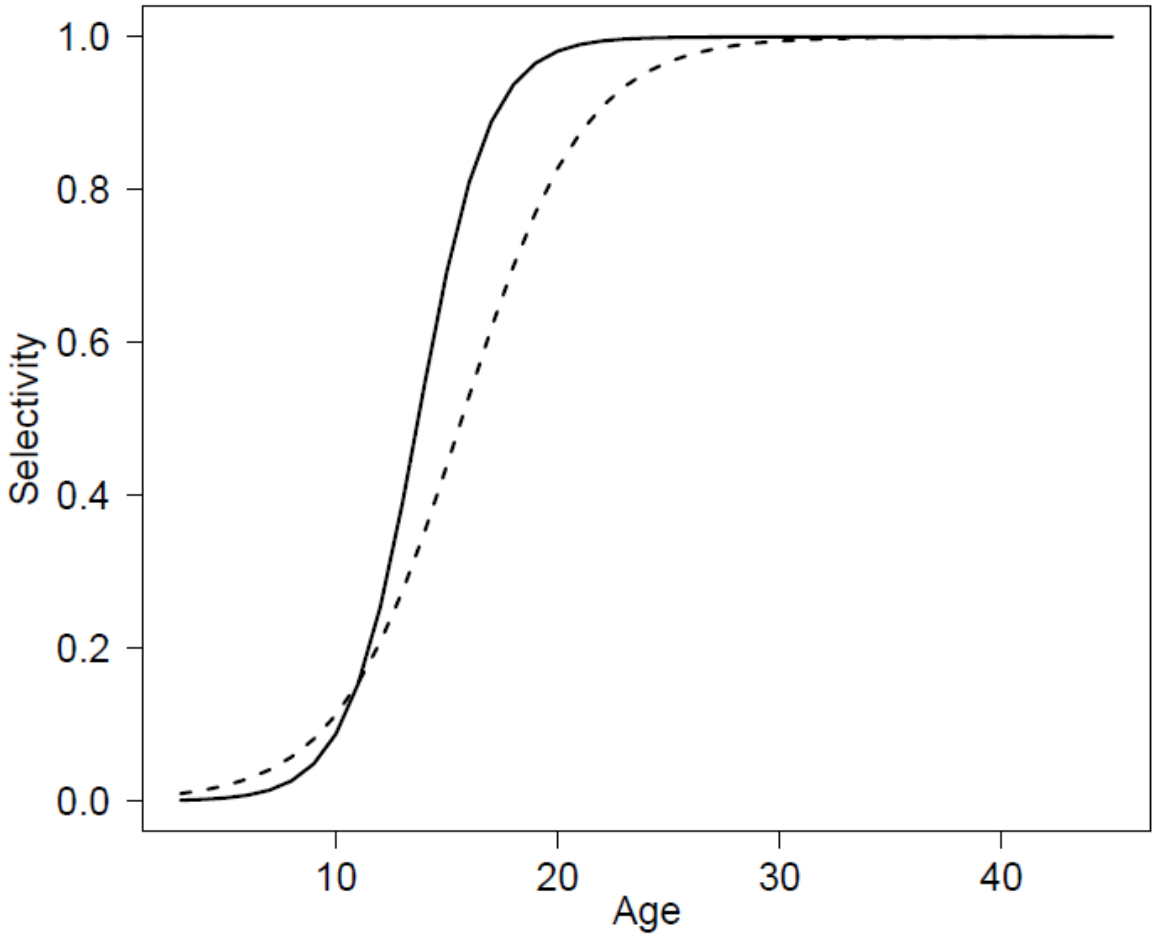

Figure 14.30. Estimated fishery (solid line) and AI survey (black dashed line) selectivity curves by age for blackspotted/rougheye rockfish.

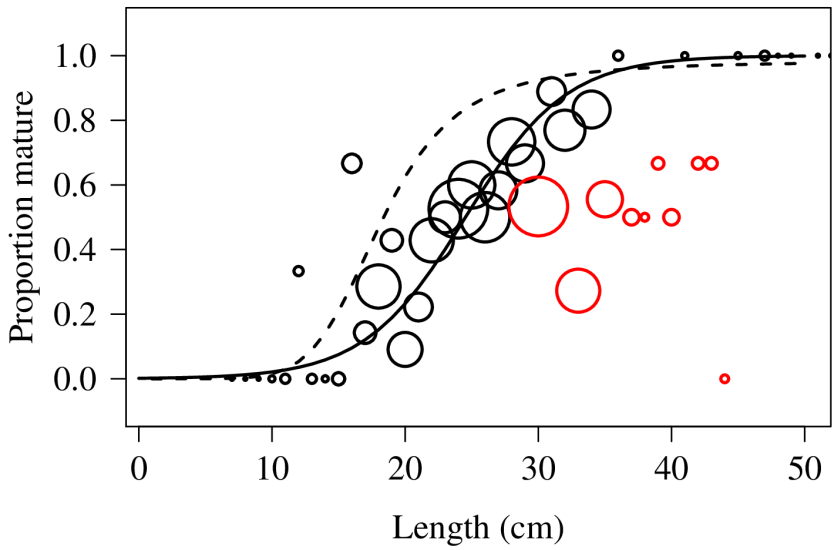

Figure 14.31. Observed and estimated proportion mature at age from data collected in the GAO from Dr. Christina Conrath (black circles and solid line, respectively). Symbol size is scaled by the number of observations. Red data point represent outliers which had unusually low proportion mature for old fish, and were not used for model estimation. For reference, the maturity ogive used in the 2018 assessment is shown as the dashed line.

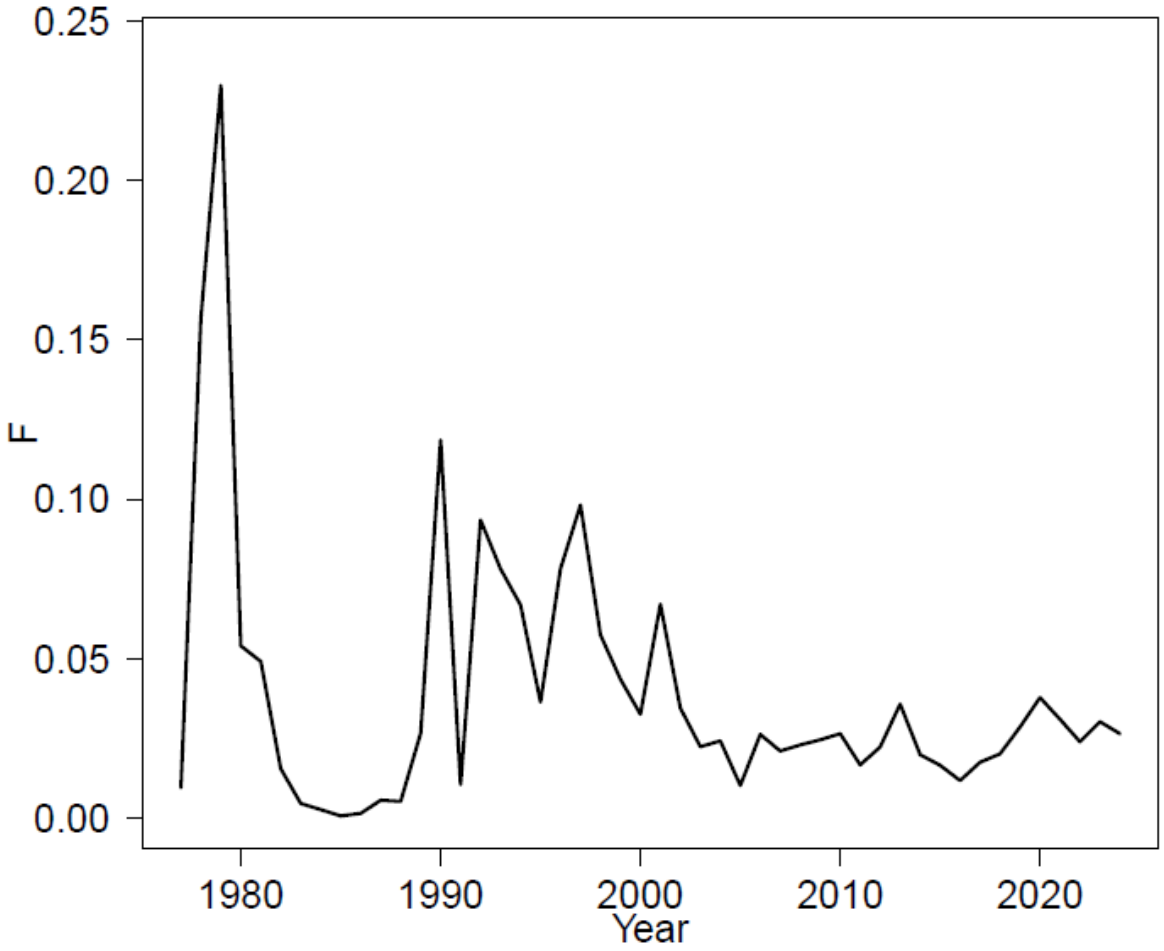

Figure 14.32. Estimated fully selected fishing mortality for blackspotted/rougheye rockfish.

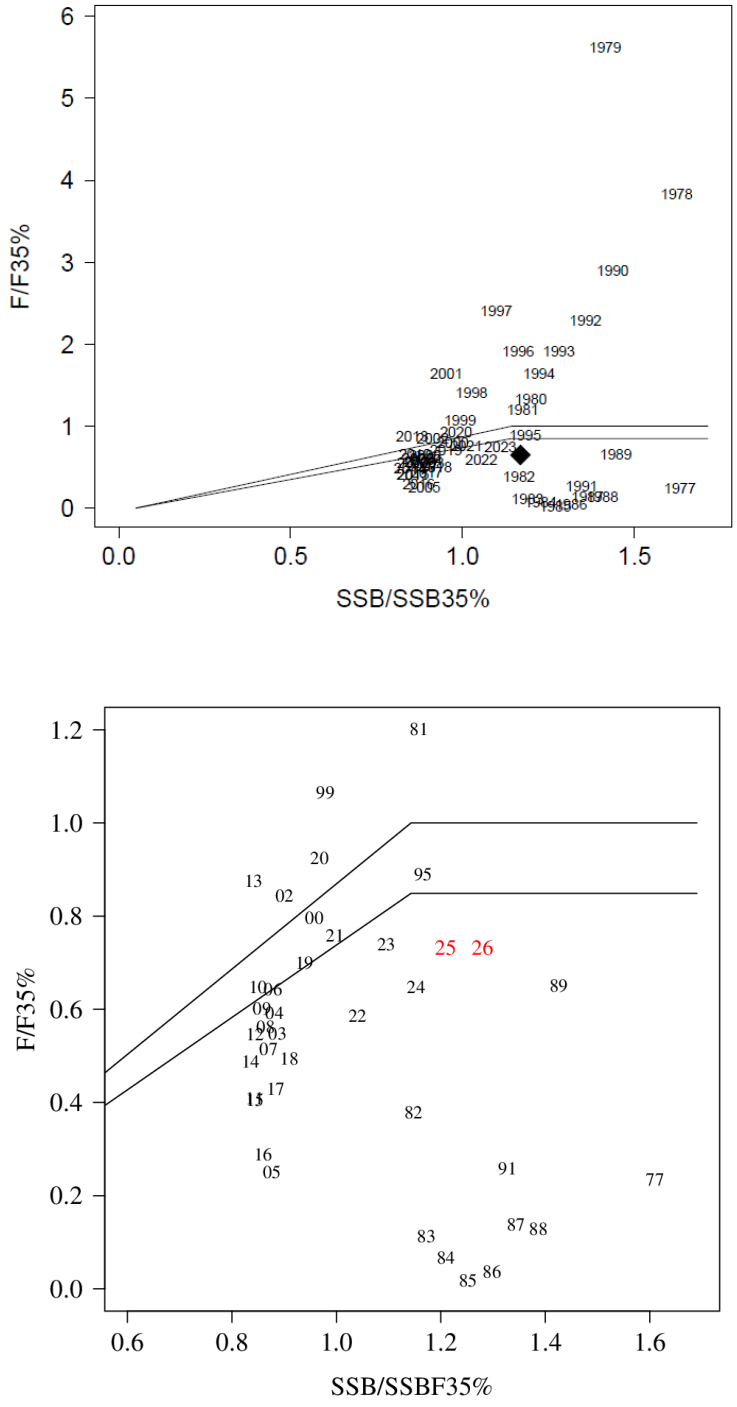

Figure 14.33. (Top panel) Estimated fishing mortality and SSB in reference to OFL (upper line) and ABC (lower line) harvest control rules, with 2024 shown as the diamond symbol. The bottom panel shows the projected stock status and *F* for 2025 and 2026.

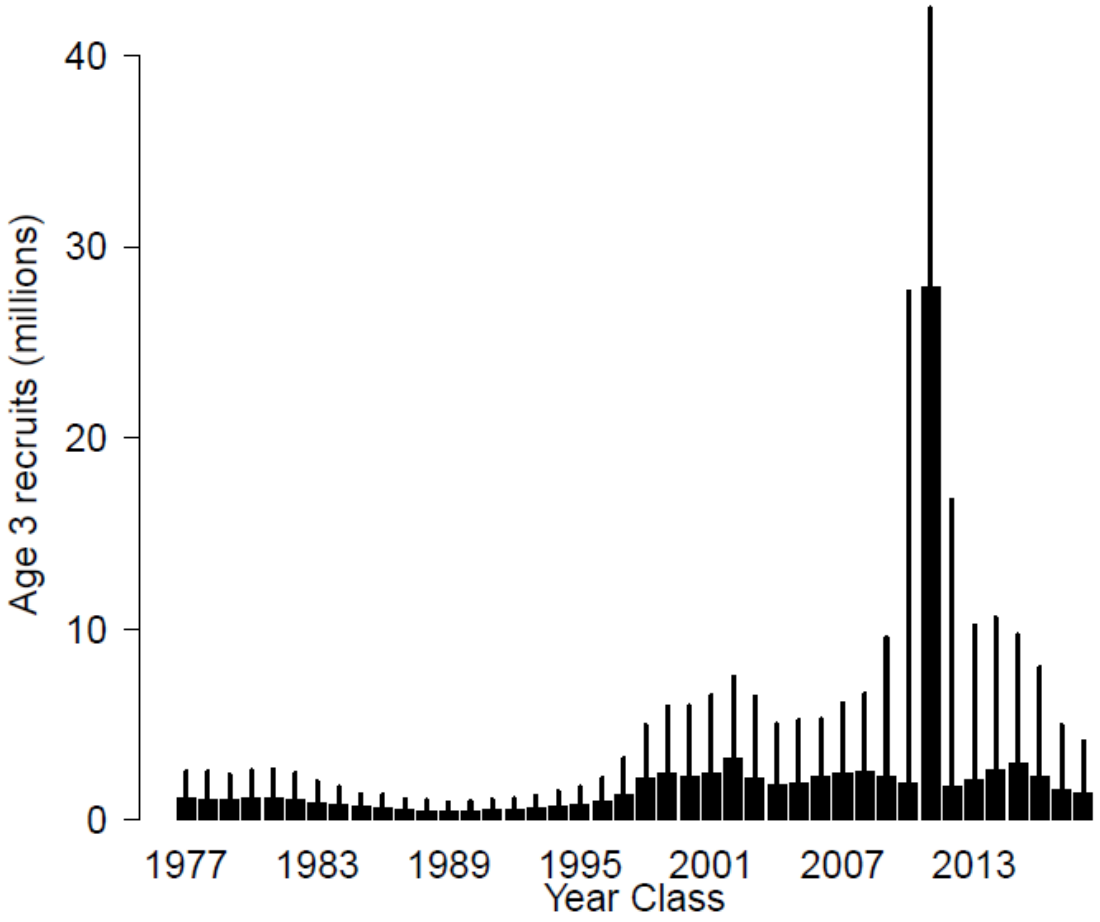

Figure 14.34. Estimated recruitment (age 3) of blackspotted/rougheye rockfish, with 95% CI. limits obtained from MCMC integration.

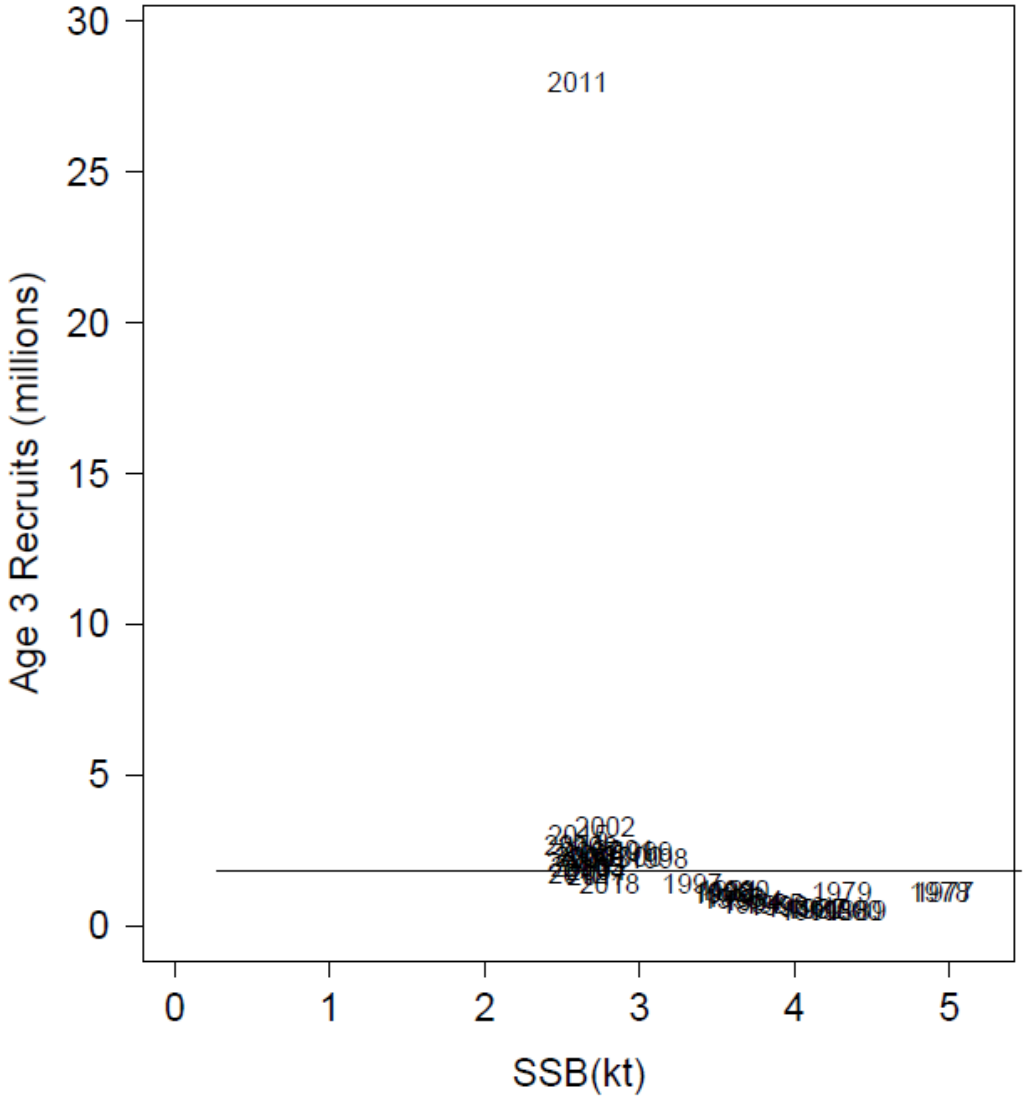

Figure 14.35. Scatterplot of blackspotted/rougheye rockfish spawner-recruit data; label is year class. Horizontal line is median recruitment.

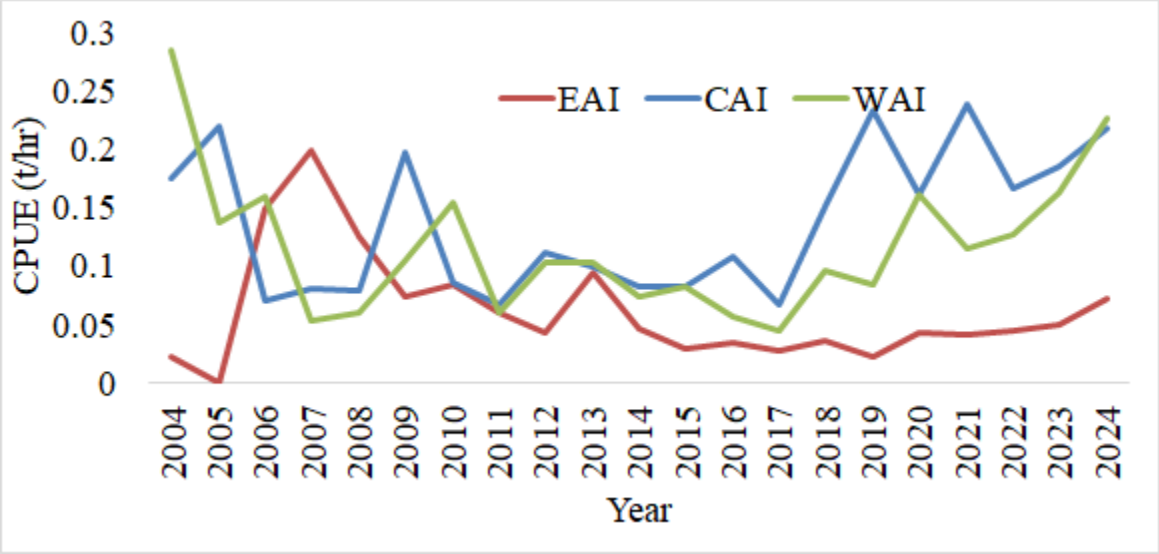

Figure 14.36. Bycatch of blackspotted/rougheye rockfish (t/hr) in tows targeting POP by AI subarea, from tows sampled for species composition in the North Pacific Groundfish Observer Program.

Appendix 14A. Update on Plan Team and SSC requests for the BSAI Blackspotted/rougheye stock assessment, with preliminary model runs

Introduction

In 2022, the Bering Sea/Aleutian Islands Plan Team and the Statistical and Scientific Committee of the North Pacific Fisheries Management Council made several recommendations regarding the BSAI blackspotted/rougheye rockfish (BSRE) assessment model:

(SSC, October 2022). *The SSC acknowledged the changes in the IPHC longline survey sampling design in 2020 but noted that the survey was highly correlated with the bottom trawl survey prior to 2020. Given the retrospective bias in the current model and its difficulty in assessing the scale of the stock, the SSC recommends the author explore use of the pre-2020 data in the assessment with emphasis on sampling in untrawlable habitats.*

(BSAI Plan Team, November 2022). *The Team discussed the lack of larger fish in fishery composition data and recommended examining the NMFS and IPHC longline survey data to determine if larger fish may be in the population and not showing up in the fishery. The Team also recommended looking at the rate of blackspotted/rougheye to Pacific ocean perch in the survey tows over the time series.*

(SSC, December 2022). *Recognizing that the proportion of rougheye rockfish is much smaller in the BSAI than in the GOA and that species identification remains an issue, the SSC requests the author, to the extent possible, separate survey trends by species to refine understanding of species-specific impacts.*

The purpose of this report is to address the items above that concern the BSAI blackspotted/rougheye stock assessment and its input data, and present potential options for the 2024 assessment.

1) Inclusion of the IPHC longline survey in the model

Estimates of the Relative Population Number (RPN) are available from the IPHC longline survey beginning in 1998. The sampling design for this survey was substantially changed beginning in 2021, with no sampling in the WAI.

In a 2022 document presented to the BSAI Plan Team, it was noted that the IPHC RPN values are generally consistent with the AFSC trawl survey ($r^2 = 0.71$). However, this correlation only used the years in common for both time series and does not reflect the period in the late 1990s when the AI longline survey was relatively stable but the IPHC survey declined sharply (Figure 14A.1).

A model that includes the IPHC was run (model 24.1), and was compared to the 2022 assessment model (model 20) with respect to several quantities. The fit to the IPHC longline survey generally shows a poor residual pattern with the early 1990s years with high IPHC RPNs being underfit and most years between 2005 and 2015 being overfit (Figure 14A.2).

The fit to the AI trawl survey was similar between the two models, with the exception of the years since 2015 in which the model 24.1 shows a relative stable biomass trend, in contrast with model 20 which

showed a more pronounced biomass increase (Figure 14A.3). This pattern also holds for the AI total biomass (Figure 14A.4).

Inclusion of the IPHC longline survey had very little effect on the fits to the age and length composition data. In Figures 14A.5 and 14A.6, the observed and predicted age and length compositions, respectively, are shown for the two models, aggregated across years and weighted by the year-specific data weightings within each data type used in the 2022 assessment. The predicted age compositions for the AI trawl survey are nearly identical to each other (Figure 14A.5, upper panel), and the predicted fishery age compositions are differ only slightly from each other (Figure 14A.5, lower panel). The fit to the fishery length composition data are also very similar between the models (Figure 14A.6).

The IPHC longline survey does not have any size or age composition data available for blackspotted-rougheye rockfish, as length and otoliths are only routinely sampled for halibut. Thus, there is no information by which to estimate a survey selectivity curve for the IPHC survey, and the estimated IPHC selectivity in model 24.1 is 1 for all ages (Figure 14A.7). The assumption that young fish are fully selected in this survey is in contrast with the AI trawl survey, and accounts for the differences in the biomass trends between the two models. In the 2022 assessment, the cause of the rapid increase in biomass in recent years was the observation of young fish for which AI trawl survey selectivity is typically small, which leads to an inference of large recent recruitment. If all ages are equally selected in the IPHC longline survey, then large recent year classes are not necessary to fit the scale of the IPHC index, and the lower level of recruitments results in a flatter trend of total biomass in recent years.

2) Comparison of size compositions between survey and fishery data

Comparisons between fishery and survey size compositions can help assess whether a portion of the size groups exist in the survey data but not the fishery data. As mentioned above, size composition data for blackspotted/rougheye rockfish are not available in the IPHC longline survey. The available data sets with size composition data are the AI trawl survey, the AFSC longline survey, and the fishery data separated by the trawl and longline gear types. The length compositions for the AFSC longline survey were restricted to the AI area covered by this survey, which is the EAI and a portion of the CAI. The length compositions for the fishery and the AFSC trawl survey were restricted to the EAI and CAI and shown separately for each of these areas. Comparisons between the fishery and survey size compositions are shown in Figure 14A.8 by area for different time periods. Each of the time periods shows the combined size composition for 3 years of fishery catch that bracket a year in which both the AI trawl survey and the AI portion of the AFSC longline survey were conducted.

For most of the early comparisons in the EAI, the cumulative size distributions for the AI trawl survey and the AFSC longline survey are very similar to each other, particularly for sizes above 40 cm, although in the 2009-2011 and 2001 – 2013 time periods the trawl survey has a larger proportion of smaller fish (i.e., ~ 30 cm). In the CAI, the size distributions between the two surveys are also similar to each other, but the longline survey shows slightly larger fish in the 1999-2001, 2001-2003, and 2003-2005 periods. In the most recent periods (i.e., 2013-2023), the trawl survey typically shows larger proportions of smaller fish than the longline survey.

The size compositions from the fishery trawl and longline gear show a variety of patterns relative to the survey data, either larger sizes (EAI, 1999-2001, 2001-2003), smaller sizes (CAI, 2011-2013), bracketing the survey compositions (EAI, 2011-2013), or sizes similar to the survey data (CAI, 1999-2001, 2001-2003, 2003-2005 and EAI 2015-2017).

In most of the time periods, the cumulative proportions are very similar at the upper end of the distributions (i.e., about the 90% percentile), indicating that the largest fish seen is similar between the fishery and surveys. In the EAI since 2015, the longline survey has observed larger fish than the trawl survey. However, the sizes observed at the 90% percentiles in both the trawl and longline fishery data are either similar to or larger than those in the longline survey.

In summary, there are a variety of patterns observed in comparing the fishery size compositions to the two surveys, but there is not an indication of larger sizes in the population than in the fishery.

3) Rate of blackspotted/rougheye catch to Pacific ocean perch catch in the AI survey tows.

Catches from the survey are expressed as catch per unit effort (CPUE; kg/km^2), and the rate catches are defined as (rougheye-blackspotted CPUE)/(POP CPUE). This rate is defined only for those hauls with a positive catch of POP. The proportion of AI survey tows with positive POP catches has increased from approximately 50% in the early 1990s to greater than 70% since 2014 (Figure 14A.9a). For the tows with positive POP catch, the proportion that also had positive rougheye catch has been relatively consistent prior to the 2022 survey and averaged 34%; however, the value for the 2022 survey increased to 44%. The mean bycatch rate ranged between 0.84 and 2.37 between the 1991 and 2006 survey with an average of 1.45. However, in the 2010 – 2022 surveys the bycatch rates ranged between 0.16 and 0.59 with an average of 0.31. These data suggest that the decline in the bycatch rate is not due to increasing number of POP tows with no blackspotted/rougheye catch, but rather smaller sizes of blackspotted/rougheye being caught in the survey. This conclusion is also supported by the smaller sizes observed in the survey length composition data.

Summary, and recommendations for November 2024 assessment

Inclusion of the IPHC RPN values for blacksptted/rougheye in the assessment is not recommended. The lack of blackspotted/rougheye size and age composition data for this survey precludes the estimation of a survey selectivity curve, without which the scaling of the survey index to population abundance cannot be reliably estimated.

A variety of patterns were observed in comparing the fishery size compositions to the two surveys, but there is not an indication of larger sizes in the population than in the fishery. Additionally, examination of bycatch rates, and the percent occurrence of blackspotted rougheye in tows with positive POP catch, indicate that the decline in the bycatch rate is not due to increasing number of POP tows with no blackspotted/rougheye catch, but rather smaller sizes of blackspotted/rougheye being caught in the survey. Finally, the length compositions and the bycatch rates are consistent with previous data presented to the Plan Team, which noted that the declines in size were observed in both the fishery and AI trawl survey.

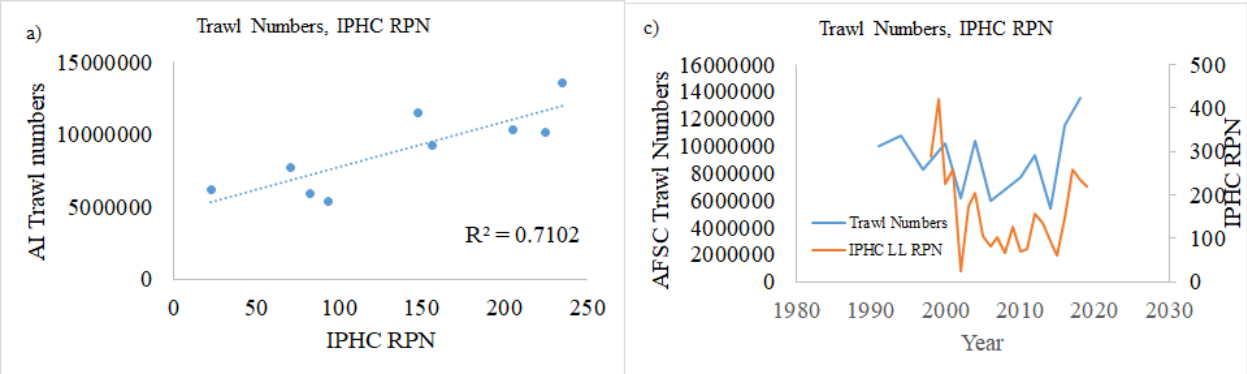

Figure 14A.1. Correlation between IPHC longline survey RPN estimates and AFSC trawl survey abundance estimates from the Aleutian Islands (areas WAI, CAI, and EAI).

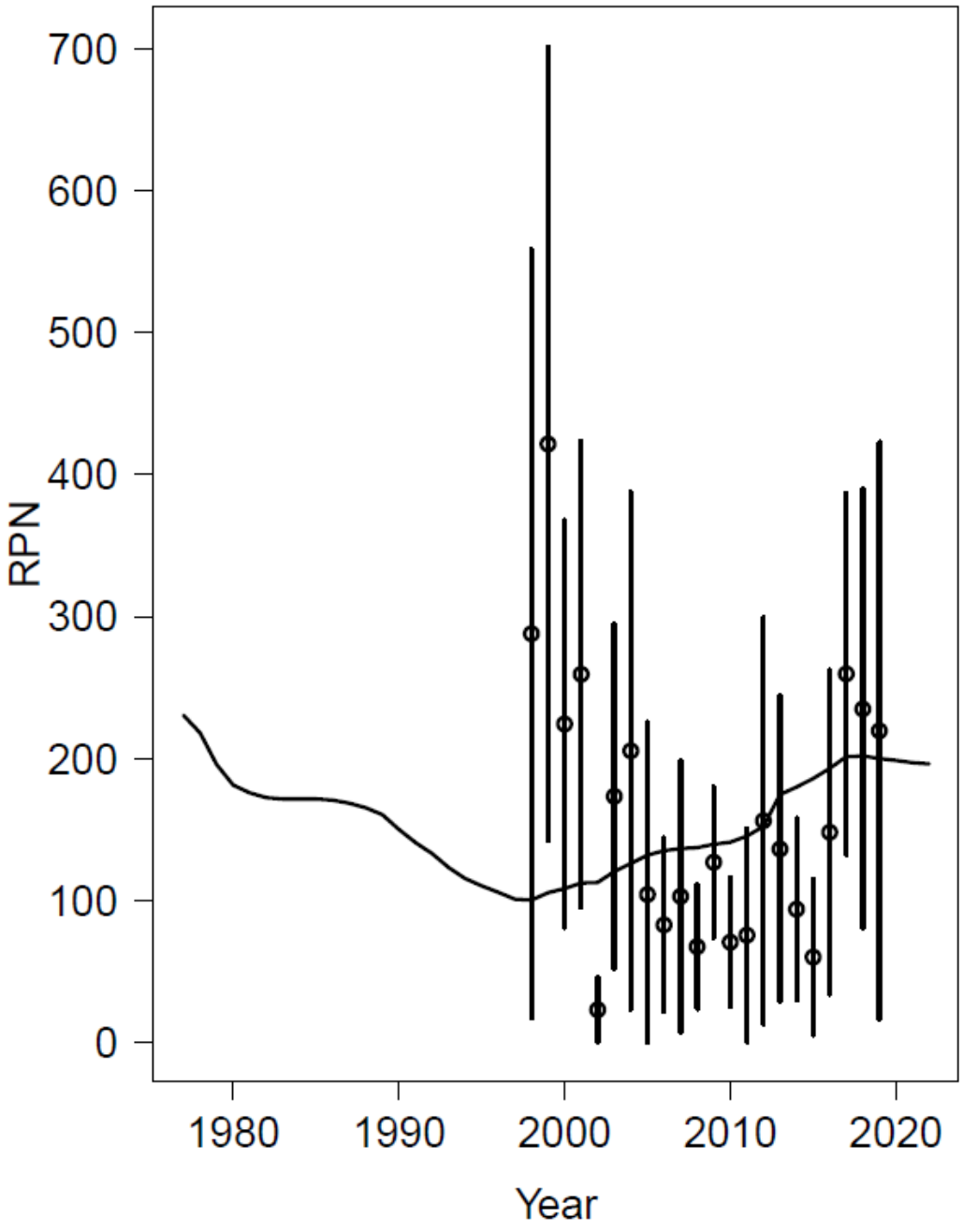

Figure 14A.2. Fit to the IPHC RPN time series for model 24.1.

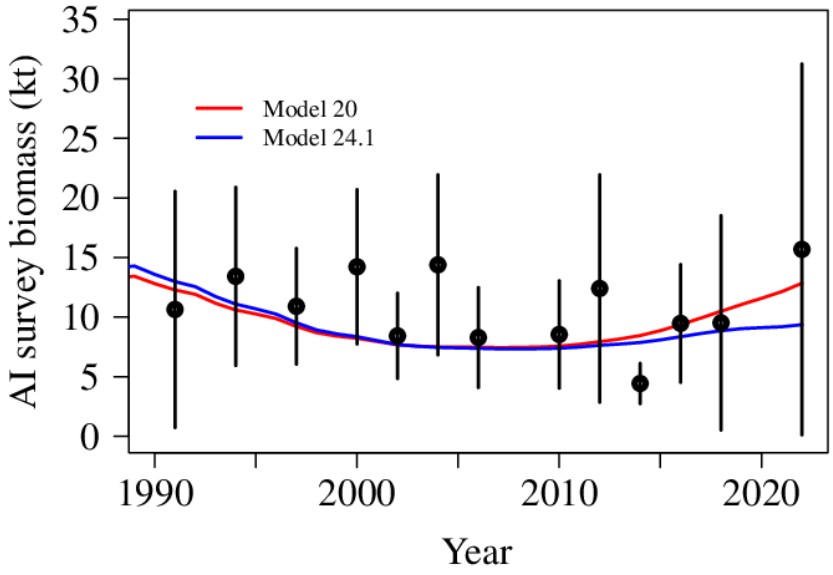

Figure 14A.3 Fit to the AI survey biomass time series for models either with (model 24.1) and without (model 20) inclusion of the IPHC RPN values for blackspotted/rougheye.

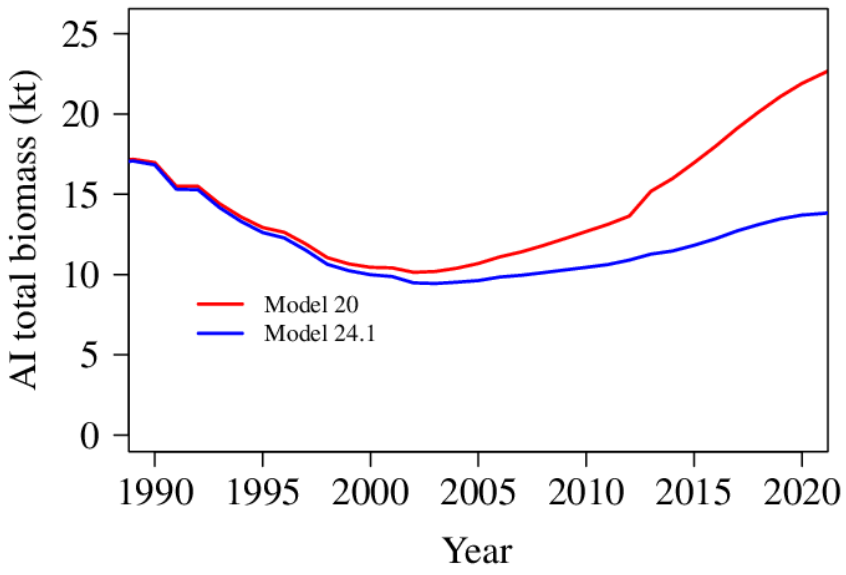

Figure 14A.4. Estimated total biomass for models either with (Model 24.1) and without (Model 20) inclusion of the IPHC RPN values for blackspotted/rougheye rockfish.

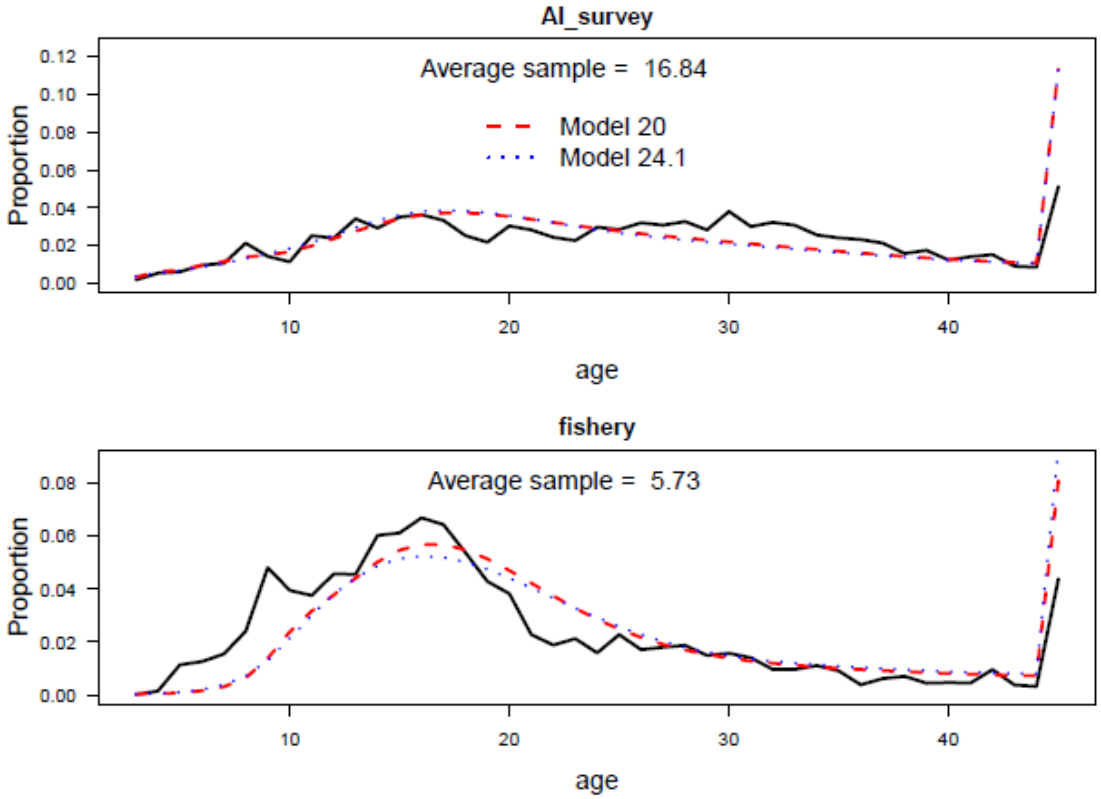

Figure 14A.5. Aggregated age composition data and fits from models either with (model 24.1) and without (model 20) for the AI survey and fishery. Years within a data type were weighted by the year-specific sample size.

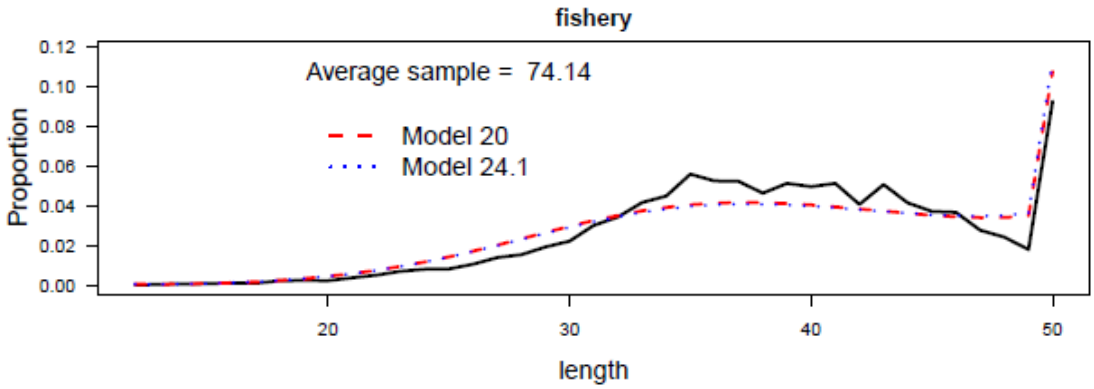

Figure 14A.6. Aggregated length composition data and fits from models either with (model 24.1) and without (model 20) for the AI fishery. Years within a data type were weighted by the year-specific sample size.

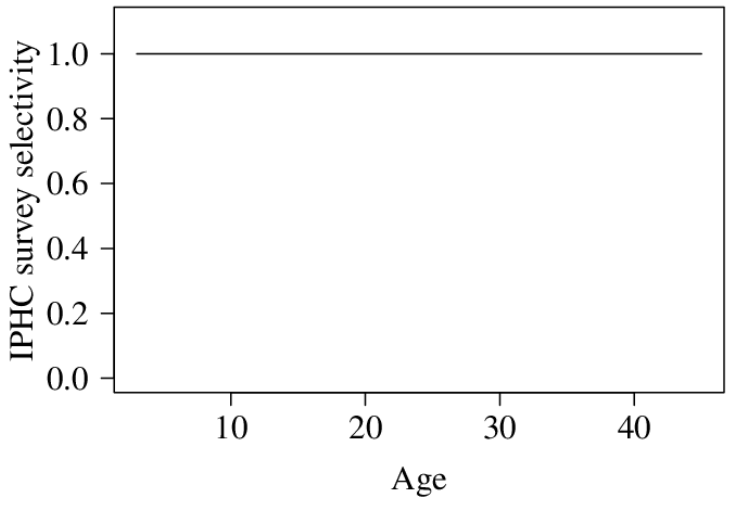

Figure 14A.7. Estimated survey selectivity for the IPHC RPN survey index in model 24.1.

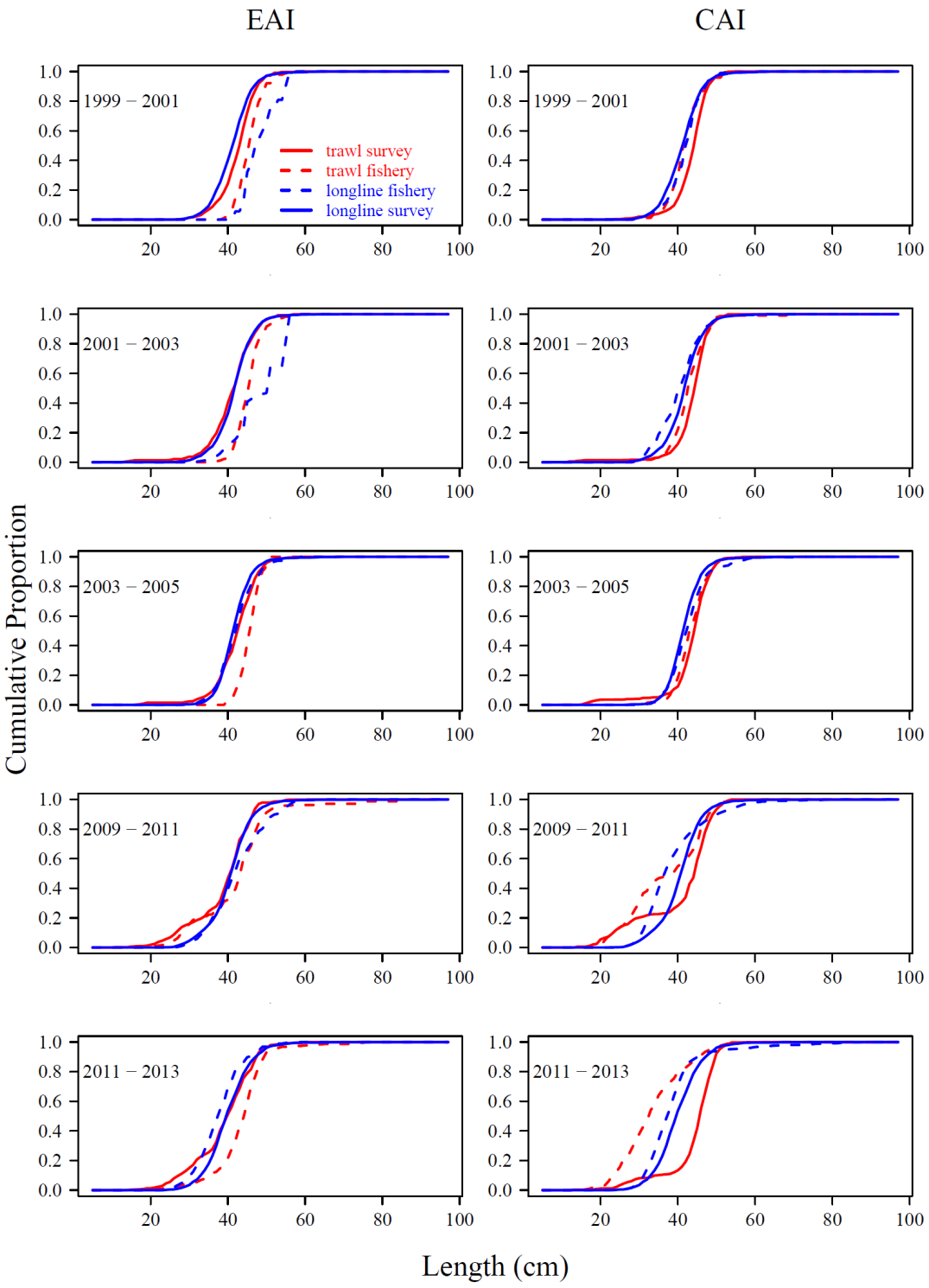

Figure 14A.8. Cumulative distributions of fish size in the AI trawl survey, AFSC longline survey (AI area), and the AI fishery (separated by trawl and longline gear), by area and time periods.

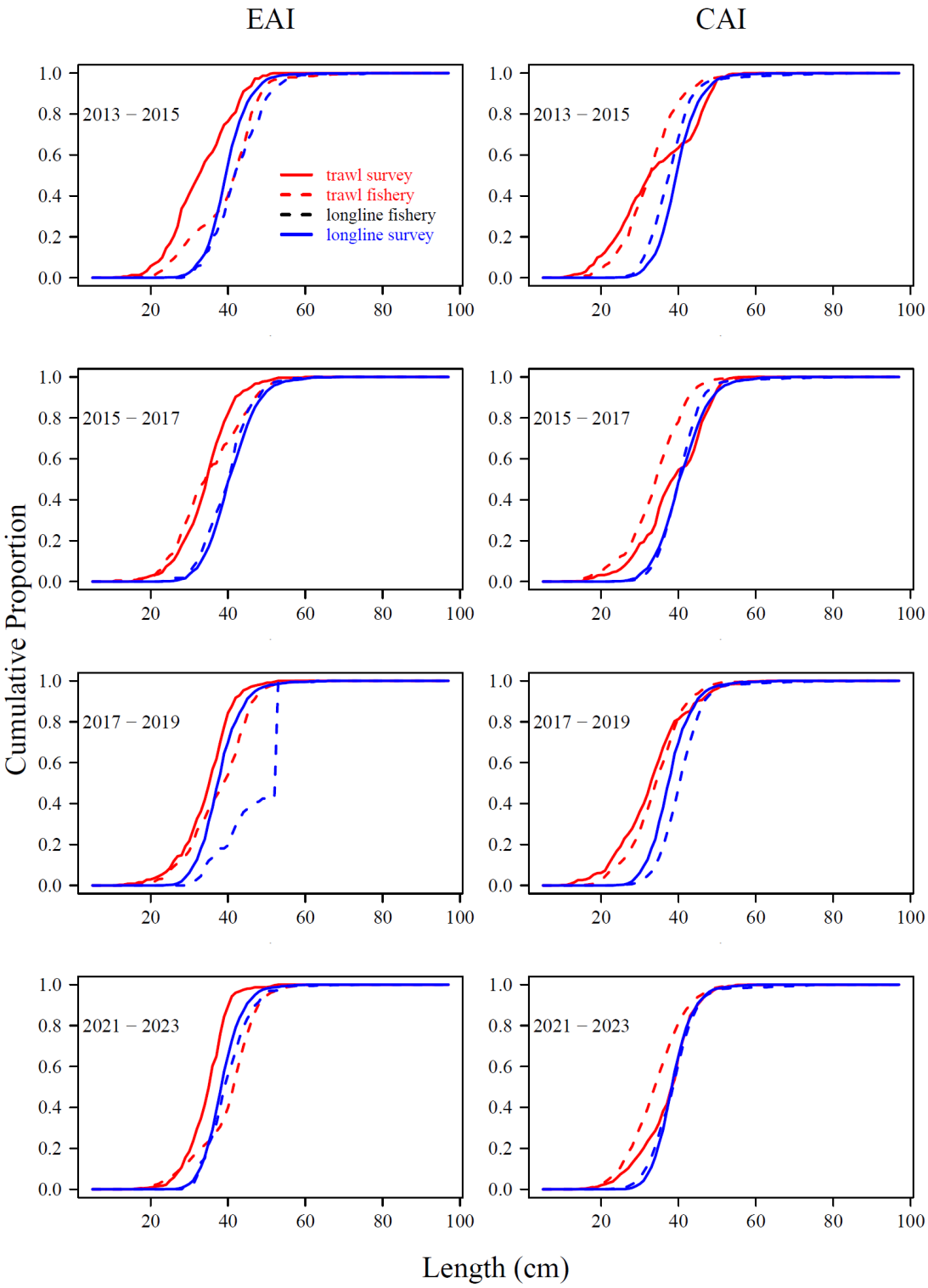

Figure 14A.8, continued).

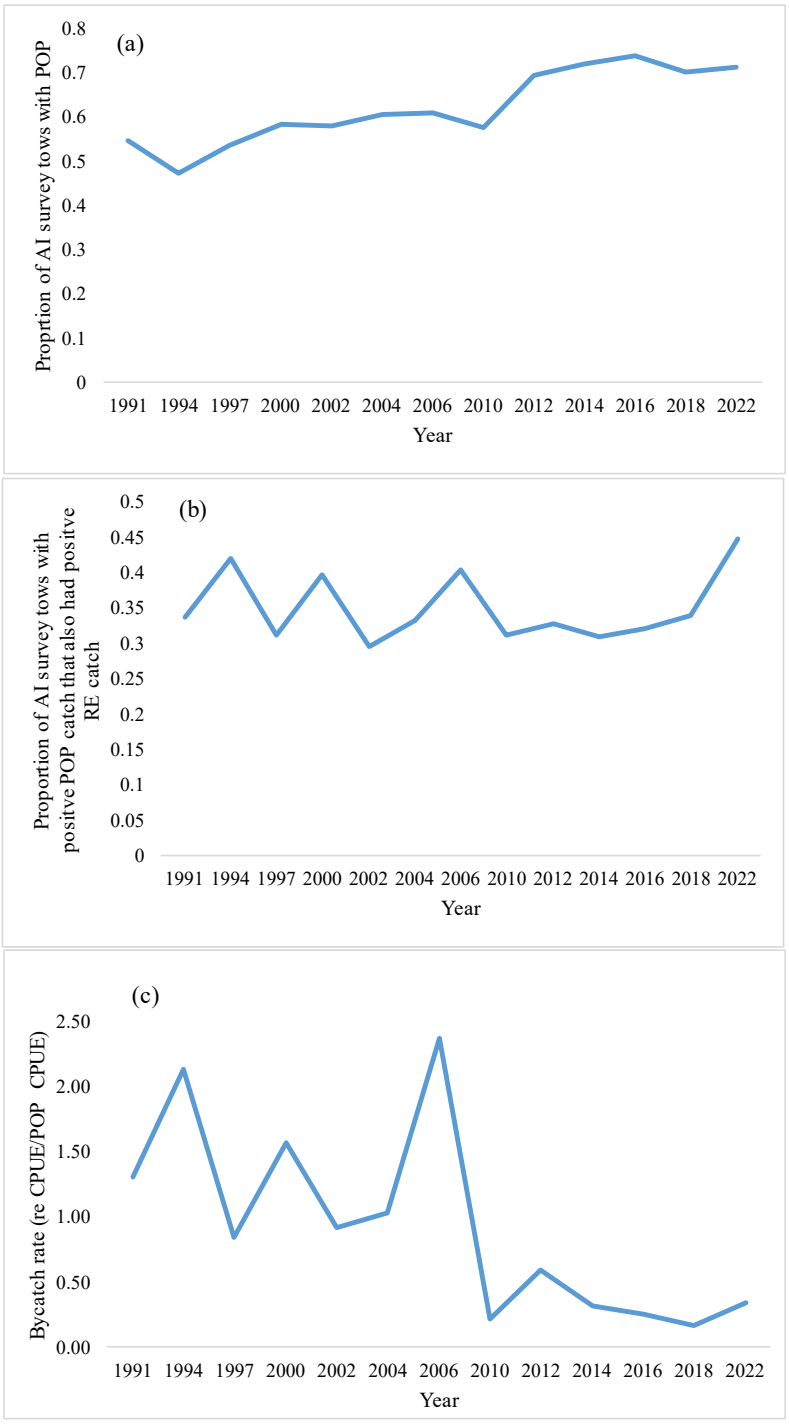

Figure A.9. Proportion of AI survey tows with POP (a), occurrence of blackspotted/rougheye rockfish in AI survey tows with POP (b), and bycatch rates of rougheye to POP in the AI survey (c).

Appendix 14B. Area-specific exploitation rates

Area-specific exploitation rates are defined here as the yearly catch within a subarea divided by an estimate of the subarea biomass at the beginning of the year. Area-specific exploitation rates are generated to assess whether subarea harvest is disproportionate to biomass, which could result in reductions of subarea biomass for stocks with spatial structure.

For each year from 2004 through 2024, the biomass for the subareas was obtained by partitioning the estimated total AI biomass (ages 3+) at the beginning of the year (obtained from 2024 AI blackspotted/rougheye age-structured model). The biomass estimates from the 2024 AI age-structured model are assumed to be the best available information on the time series of total biomass for the AI area, and this method can be considered a "retrospective" look at past exploitation rates. The distribution of biomass across the AI subareas was obtained by fitting a random walk smoother (with changes in biomass modeled as random effects) to the time series of biomass within each subarea, and computing the relative spatial distribution of the smoothed results. The smoothed biomass estimates for the SBS area and the EBS slope survey were used as the best available biomass estimates for the EBS area. Catches through October 5, 2024, were obtained from the Catch Accounting System database.

To evaluate the potential impact upon the population, exploitation rates were compared to two reference levels: 1) 0.75 times the estimated rate of natural mortality (M), which is the fishing mortality F_{abc} that produces the allowable biological catch for Tier 5 stocks; and 2) the exploitation rate for each year that would result from applying a fishing rate of $F_{40\%}$ to the estimated beginning-year numbers, and this rate is defined as $U_{F40\%}$. The $U_{F40\%}$ rate takes into account maturity, fishing selectivity, size-at-age, and time-varying number at age, and thus may be seen as more appropriate for Tier 3 stocks because harvest recommendations are based upon this age-structured information. Blackspotted/rougheye rockfish were assessed as a Tier 5 stock prior to 2009, and as a Tier 3 stock since 2009.

The exploitation rate in the WAI has been above $U_{F40\%}$ for each year since 2004. Exploitation rates in the WAI from 2014 to 2017 have declined from generally higher levels from 2004-2013 (Figure 14B.1). However, the WAI exploitation rate in 2020 increased to 0.09, the largest observed since 2006 and approximately 4.4 times $U_{F40\%}$ reference value of 0.019, before declining from 2021 to 2023. The exploitation rates for the CAI have also been increasing and were above $U_{F40\%}$ from 2019 - 2021. The exploitation rates in the EBS have increased rapidly from 2018 – 2023, and averaged 4.2 times $U_{F40\%}$ from 2021 – 2023 before decreasing to 1.2 times $U_{F40\%}$ in 2024 (based on the partial year 2024 catches). It is important to note that in recent years, blackspotted/rougheye rockfish have been managed as Tier 3b stock and the F values used for management were lower than $F_{40\%}$.

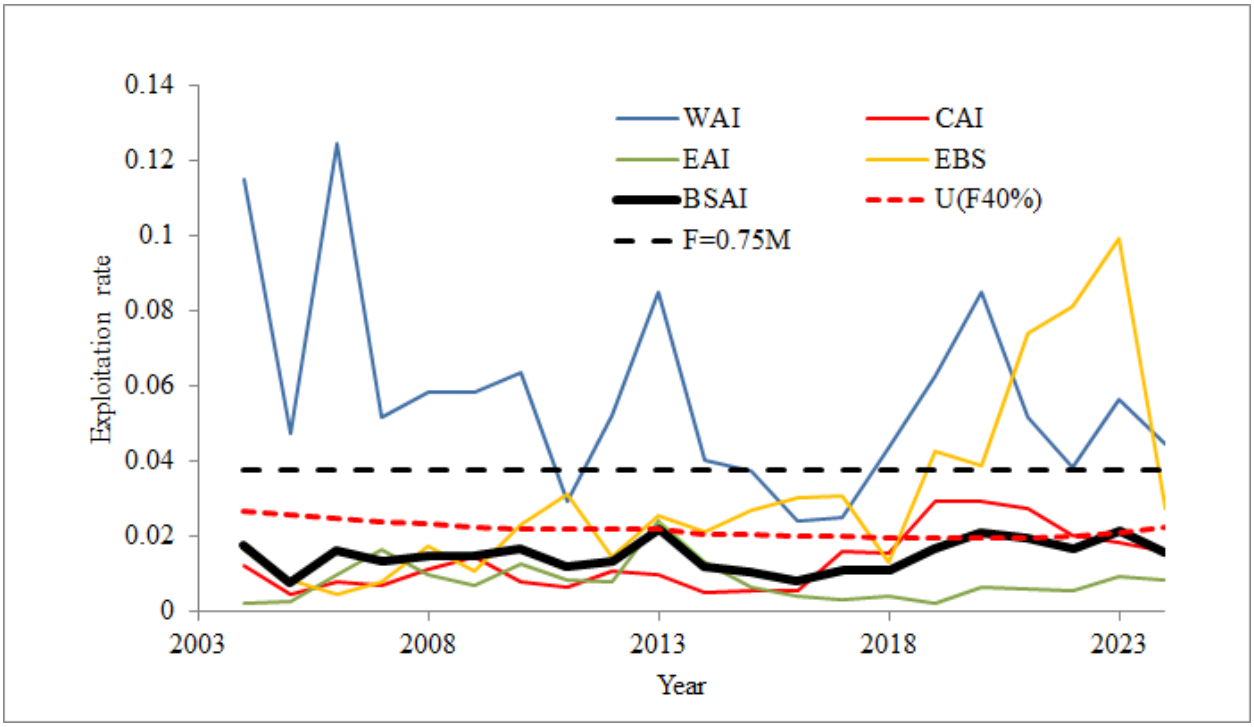

Figure 14B.1. Exploitation rates within BSAI subareas for blackspotted/rougheye rockfish, with reference exploitation rates of 0.75*M and $U_{F40\%}$.

Appendix 14C. Supplemental Catch Data.

In order to comply with the Annual Catch Limit (ACL) requirements, non-commercial removals that do not occur during directed groundfish fishing activities are reported (Table 14C.1). In these datasets, blackspotted /rougheye rockfish are often reported as rougheye rockfish. This includes removals incurred during research, subsistence, personal use, recreational, and exempted fishing permit activities, but does not include removals taken in fisheries other than those managed under the groundfish FMP. These estimates represent additional sources of removals to the existing Catch Accounting System estimates. For BSAI blackspotted/rougheye rockfish, these estimates can be compared to the trawl research removals reported in previous assessments. BSAI blackspotted/rougheye rockfish research removals are small relative to the fishery catch. The majority of removals are taken by the Alaska Fisheries Science Center's (AFSC) biennial bottom trawl survey which is the primary research survey used for assessing the population status of BSAI blackspotted/rougheye rockfish. The annual amount of blackspotted/rougheye rockfish captured in research longline gear did not exceed 1.1 t. Total removals ranged between 2010 and 2023 ranged between 0.005 t and 1.08 t.

Appendix Table 14C.1. Removals of BSAI blackspotted/rougheye rockfish (t) from activities other than groundfish fishing. Trawl and longline include research survey and occasional short-term projects. "Other" is recreational, personal use, and subsistence harvest.

Year	Source	Trawl	Longline	Other
1977	NMFS-AFSC survey databases	0.000		
1978		0.002		
1979		0.468		
1980		6.844		
1981		1.086		
1982		0.963		
1983		9.780		
1984		0.000		
1985		3.719		
1986		24.241		
1987		0.006		
1988		0.200		
1989		0.001		
1990		0.018		
1991		1.994		
1992		0.014		
1993		0.000		
1994		2.769		
1995		0.003		
1996		0.001		
1997		2.596		
1998		0.000		
1999		0.010		
2000		3.343		
2001		0.001		
2002		2.276		
2003		0.011		
2004		3.499		
2005		0.001		
2006		1.976		
2007		0.001		
2008		0.205		
2009		0.006		
2010	AKFIN database	0.133	0.424	
2011		0.005	0.154	
2012		0.132	0.300	
2013		0.000	0.299	
2014		0.032	0.508	
2015		0.000	0.216	
2016		0.048	0.334	
2017		0.000	1.080	
2018		0.018	0.623	
2019		0.000	1.009	
2020		0.000	0.149	
2021		0.000	0.175	
2022		0.067	0.340	
2023		0.005	0.000	