Status of the Rougheye and Blackspotted Rockfishes stock off the U.S. West Coast in 2025

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1 Executive Summary

1.1 Stock

This assessment reports the status of the Rougheye (*Sebastes aleutianus*) and Blackspotted (*Sebastes melanostictus*) Rockfishes that reside in the waters off California, Oregon, and Washington from the U.S.- Canadian border in the north to the U.S.-Mexico border in the south.

These two species are difficult to differentiate visually in the catch, thus they are commonly reported and treated as one management complex. Despite recent advances in species identification of Rougheye/Blackspotted Rockfishes as genetically distinct species, there is still little ability to reliably separate historical fishery data in order to differentiate these two species into two stocks. Therefore, this assessment maintains a species complex approach, though given absolute presence off the U.S. West Coast, this may be considered more of a Rougheye than Blackspotted Rockfish stock assessment. While we treat these species as one assessed stock complex, we recognize and are mindful of the above species distinctions as we conduct our analyses.

1.2 Catches

Rougheye/Blackspotted Rockfishes are not targeted by a specific fishery, but are desirable and marketable, thus are typically retained when caught.

The historical reconstruction of landings for Rougheye/Blackspotted Rockfishes suggests that non-trawl (largely hook-and-line gear) fisheries have caught Rougheye/Blackspotted Rockfishes since the turn of the 20th century and landings in the trawl fishery are estimated to have gradually increased since the 1940's, and first peaked in the late 1960's through 1970s, when the foreign trawl fleet was targeting Pacific Ocean perch. The declaration of the Exclusive Economic Zone resulted in the buildup of a domestic fleet and landings increased rapidly into the late 1980's and early 1990's. Subsequently, landings declined in the late 1990's, with catches under 250 metric tons in the last two decades. The contribution of mid-water trawl catches gradually grew over the past 15 years, and now they represent majority of the trawl removals.

Since Rougheye/Blackspotted Rockfishes are a desirable market species, discarding has been low historically. However, management restrictions (e.g., trip limits) have resulted in increased discarding since early 2000s. Trawl rationalization was introduced in 2011, and since then very little discarding of Rougheye/Blackspotted Rockfishes has occurred.

Rougheye/Blackspotted Rockfishes also has long been bycaught in the fishery for the coastal population of Pacific hake, which is almost exclusively conducted with mid-water trawls. In recent years, contribution of the mid-water trawl catches within shoreside trawl landings gradually grew and in most recent year and now they represent majority of the trawl removals. Time series of landings are shown Figure i, with recent landings detailed in Table i.

Table i: Recent landings by fleet, total landings summed across fleets, and the total dead catch including discards.

Year	Trawl	Trawl discard	Non-trawl	Non-trawl discard	Midwater trawl	At-sea-hake	Total Landings	Total Dead (mt)
2015	30.67	0.01	46.56	13.79	19.26	21.80	132.09	132.09
2016	30.79	0.11	60.27	12.61	15.53	29.63	148.95	148.95
2017	21.93	0.00	59.03	34.42	2.48	38.15	156.02	156.02
2018	16.49	0.00	46.67	14.55	2.58	161.24	241.52	241.52
2019	22.06	0.04	38.75	31.13	9.25	125.37	226.59	226.59
2020	9.86	0.03	24.35	1.03	28.92	41.88	106.07	106.07
2021	10.33	0.01	21.06	2.36	21.39	37.62	92.76	92.76
2022	11.54	0.02	19.06	2.72	18.63	65.46	117.43	117.43
2023	13.29	0.48	18.67	0.48	26.22	38.50	97.63	97.63
2024	9.97	0.12	9.90	0.48	69.15	29.32	118.94	118.94

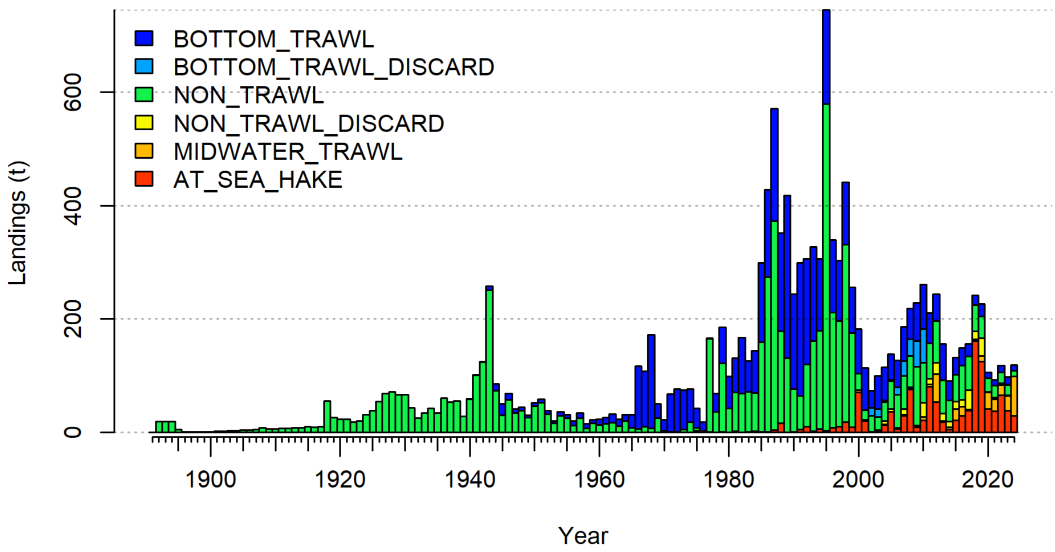

Figure i: Landings in metric tons (mt) by year for each fleet.

1.3 Data and Assessments

The only previous stock assessment for Rougheye/Blackspotted Rockfishes for the U.S. West Coast area was done in 2013 (Hicks, Wetzel, and Harms 2013). It was conducted with Stock Synthesis statistical catch-at-age modelling framework (Methot and Wetzel 2013).

This 2025 assessment also uses Stock Synthesis, version 3.30.23.1. The modeling period begins in 1892, and the stock prior to that is assumed to be in an unfished equilibrium condition.

Rougheye/Blackspotted Rockfishes fishery-dependent data in this assessment are divided among six fleets, treating discard catches separately from the retained fisheries. Following 2013 assessment, it maintains the at-sea-hake fishery as its own fleet, and adds a mid-water fishery that has emerged in the last decade. This stock assessment adds 10+ years of additional length data, and several more years of age data (included as conditioned on length data). The same four surveys (the West Coast Groundfish Bottom Trawl Survey (WCGBTS), AFSC/NWFSC Triennial Shelf Survey, AFSC Slope Survey and NWFSC Slope Survey) as used in the last stock assessment are used here, with an extension to 2024 to the the WCGBTS. The index standardization of all survey data uses the newer approach of applying spatiotemporal generalized linear mixed models.

This is a sex-specific model. Females and males have separate growth curves and sex-specific weight-at-length parameters. Growth is assumed to follow the von Bertalanffy growth model, and the assessment explicitly estimates all parameters describing somatic growth. The natural mortality for females is estimated in the assessment and natural mortality for males is fixed an the value generated from meta-analytical study. Externally estimated life history parameters, including those defining the length-weight relationship, female fecundity and maturity schedule were revised for this assessment to incorporate new information. Recruitment dynamics are assumed to follow the Beverton-Holt stock-recruit function, and recruitment deviations are estimated. Stock-recruitment steepness is fixed at the value generated from meta-analytical study. The base model estimates parameters for selectivity based on length data, and estimated selectivity curves are a mix of dome-shaped (for bottom trawl gears) and logistic (for mid-water gears).

1.4 Stock Output and Dynamics

The model estimates that the stock complex currently is in a healthy state, well above management target (Figure ii, Figure iii). Approximate confidence intervals based on the asymptotic variance estimates show that the uncertainty in the estimated spawning output is high. Estimates of spawning biomass in most recent decade are shown in Table ii.

Fraction unfished shows slight decline between 1940s and the 1960s, also also gradual decline since early-1980s, which correspond to catch history.

Table ii: Estimated recent trend in spawning output and the fraction unfished and the 95 percent confidence intervals.

Year	Spawning output	Lower Interval (mt)	Upper Interval (mt)	Fraction Unfished	Lower Interval	Upper Interval
2015	4,980,880	-2,394,229	12,355,989	0.882	0.648	1.115
2016	4,969,040	-2,407,010	12,345,090	0.880	0.644	1.116
2017	4,954,860	-2,421,249	12,330,969	0.877	0.638	1.116
2018	4,939,980	-2,435,854	12,315,814	0.875	0.633	1.116

2019	4,914,880	-2,461,229	12,290,989	0.870	0.623	1.117
2020	4,893,940	-2,484,344	12,272,224	0.867	0.615	1.118
2021	4,891,640	-2,492,250	12,275,530	0.866	0.613	1.119
2022	4,895,270	-2,498,753	12,289,293	0.867	0.613	1.121
2023	4,900,640	-2,508,886	12,310,166	0.868	0.612	1.123
2024	4,913,820	-2,516,893	12,344,533	0.870	0.614	1.126
2025	4,929,120	-2,527,916	12,386,156	0.873	0.615	1.130

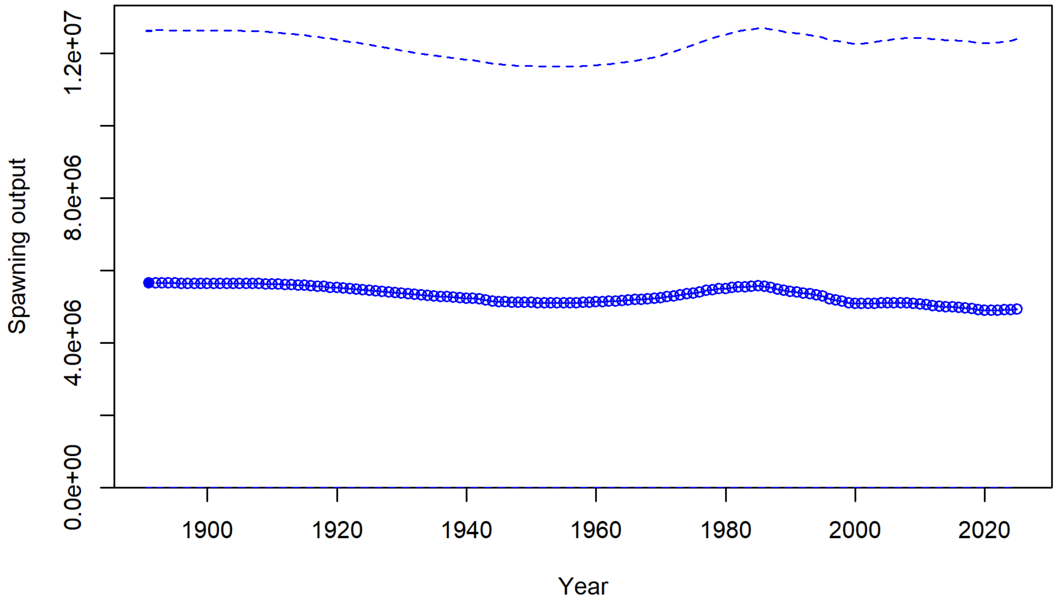

Figure ii: Estimated time series of spawning output (trillions of eggs) for the base model.

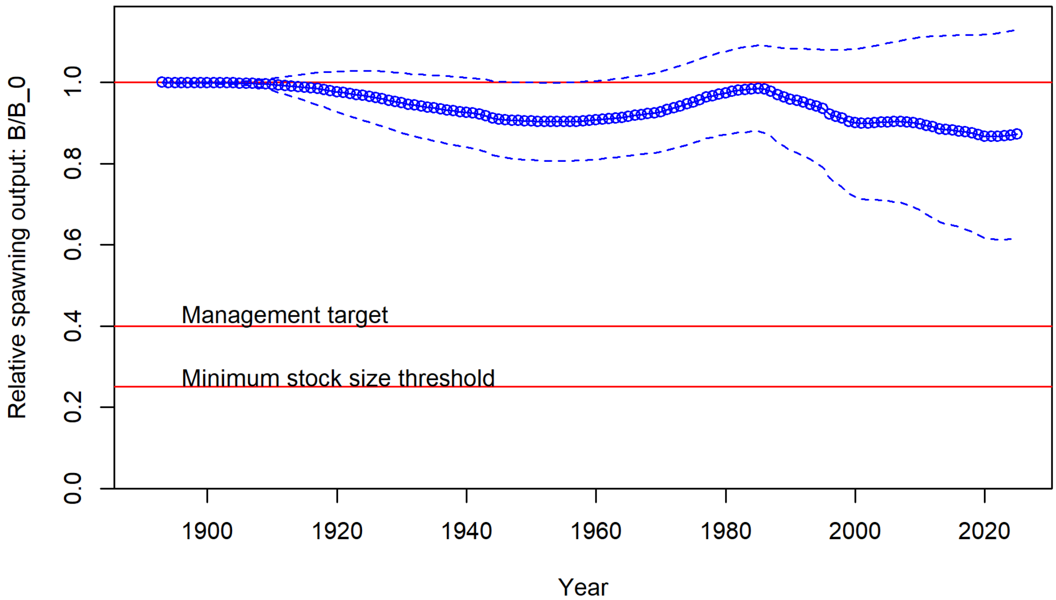

Figure iii: Estimated time series of fraction of unfished spawning output for the base model.

1.5 Recruitment

Recruitment dynamics (Table iii, Figure iv) are assumed to follow Beverton-Holt stock-recruit function and the steepness parameter was fixed at the value of 0.72, which is the mean of steepness prior probability distribution, derived from meta-analysis of rockfish stocks. The level of virgin recruitment (R0) is estimated to inform the magnitude of the initial stock size. Annual recruitment is treated as stochastic. "Main" recruitment deviations were estimated for modeled years between 1892 and 2023, with forecast recruitment period starting in 2024 (Figure v).

Table iii: Estimated recent trend in recruitment (1,000s) and recruitment deviations and the 95 percent confidence intervals.

Year	Recruit-ment (1,000s)	Lower Interval (1,000s)	Upper Interval (1,000s)	Recruit-ment Deviations	Lower Interval	Upper Interval
2015	659	173	2,515	-0.445	-1.271	0.382
2016	870	228	3,328	-0.172	-1.012	0.668
2017	2,172	584	8,071	0.738	-0.009	1.484
2018	1,341	354	5,087	0.251	-0.565	1.066
2019	1,197	317	4,517	0.132	-0.678	0.943
2020	846	221	3,242	-0.220	-1.083	0.643
2021	923	236	3,608	-0.138	-1.050	0.774
2022	1,017	254	4,067	-0.046	-1.008	0.916
2023	1,067	266	4,286	-0.003	-0.982	0.975
2024	1,076	268	4,323	0.000	-0.980	0.980
2025	1,076	268	4,324	0.000	-0.980	0.980

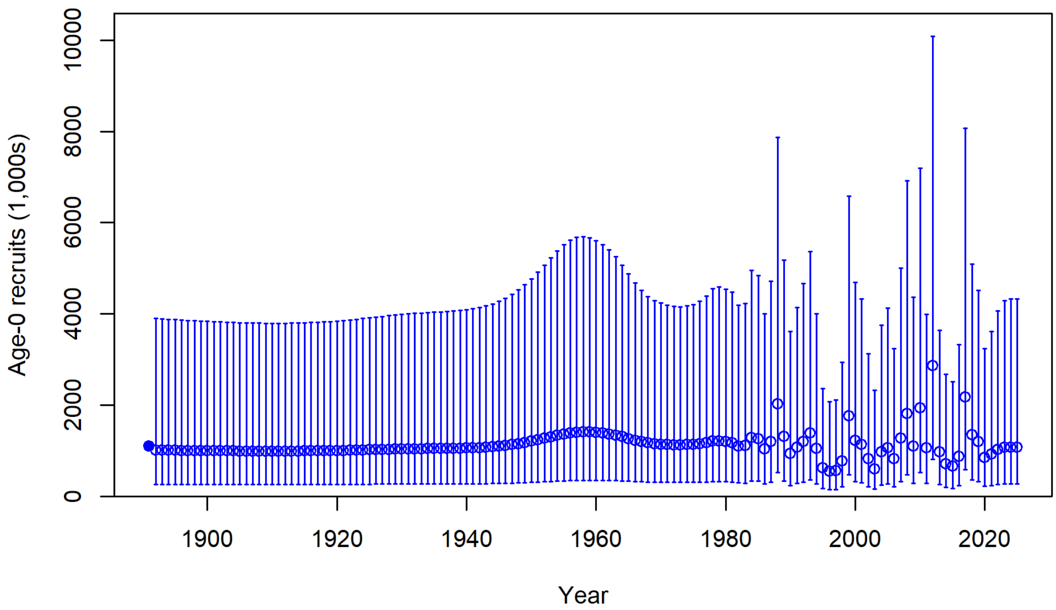

Figure iv: Estimated time series of age-0 recruits for the base model.

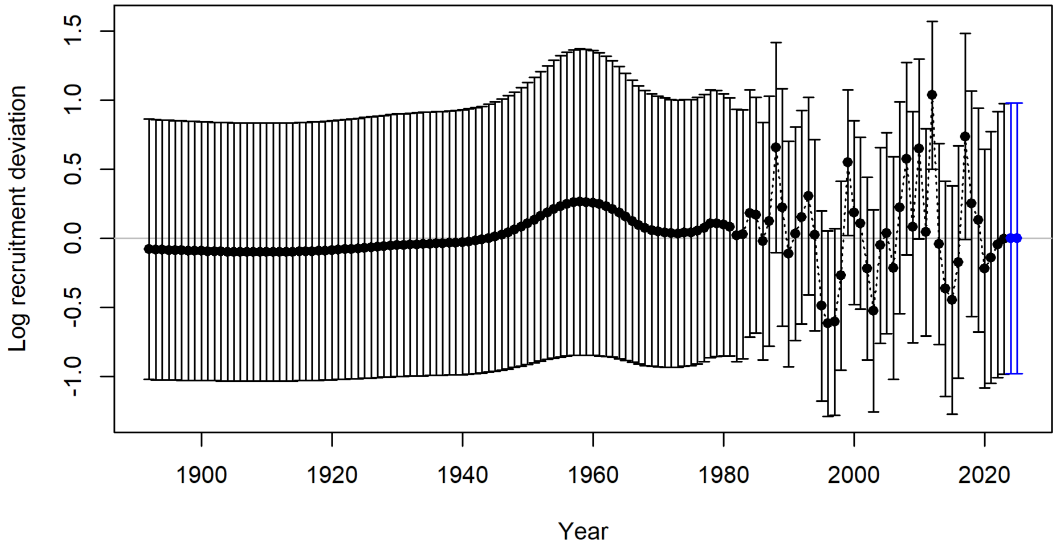

Figure v: Estimated time series of recruitment deviations for the base model.

1.6 Exploitation Status

Two measures of exploitation are fishing intensity and exploitation rate. Fishing intensity is defined here as 1 - SPR, where SPR (Spawning Potential Ratio) is the equilibrium spawning output at a given combination of F and selectivity relative to spawning output at unfished equilibrium. Using the units of 1-SPR means that more intense fishing is associated with a higher value. The value of 1-SPR in the absence of fishing is 0 and the maximum is 1.0 if all spawning fish are being killed before spawning. The Pacific Fishery Management Council (PFMC) has chosen an SPR target of 0.5 for Rougheye/Blackspotted Rockfishes so harvest which leads to SPR below 0.5, or fishing intensity (1-SPR) greater than 0.5 would be overfishing. Exploitation rate is defined as the catch relative to age 26+ biomass. This metric is included because interpretation is simple, but it is not used as a basis for management.

Exploitation rates were below the management target of a fishing intensity that leads to a SPR of 0.5 throughout most of the time series except for 1995, when the catch peaked at 744 metric tons (Table iv, Figure vi).

Table iv: Estimated recent trend in fishing intensity 1-SPR, where SPR is the spawning potential ratio, and the exploitation rate, along with the 95 percent confidence intervals for both quantities.

Year	1-SPR	Lower Interval (SPR)	Upper Interval (SPR)	Exploitation Rate	Lower Interval (Rate)	Upper Interval (Rate)
2015	0.114	-0.038	0.266	0.004	-0.002	0.011
2016	0.127	-0.041	0.296	0.005	-0.002	0.013
2017	0.133	-0.042	0.307	0.005	-0.003	0.013
2018	0.188	-0.047	0.423	0.008	-0.004	0.021
2019	0.180	-0.048	0.408	0.008	-0.004	0.019
2020	0.090	-0.034	0.213	0.004	-0.002	0.009
2021	0.079	-0.031	0.190	0.003	-0.002	0.008
2022	0.098	-0.036	0.233	0.004	-0.002	0.010
2023	0.083	-0.032	0.199	0.003	-0.002	0.009
2024	0.098	-0.036	0.233	0.004	-0.002	0.011

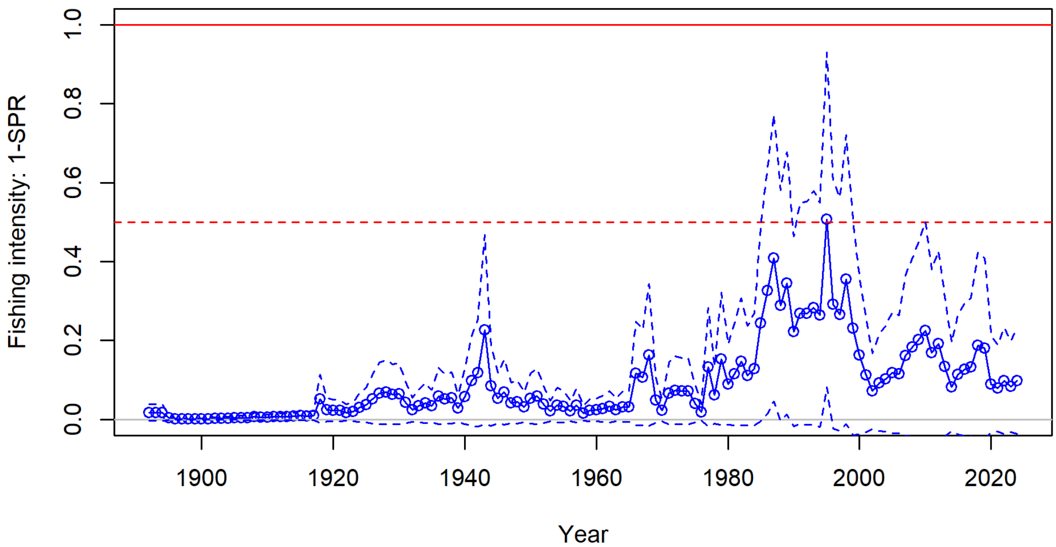

Figure vi: Estimated time series of the fishing intensity (1 - SPR), where SPR is the spawning potential ratio, with approximate 95% asymptotic intervals. The horizontal line at 0.5 corresponds to SPR = 0.5, the management reference point. The horizontal line at 1.0 corresponds to SPR = 0 (all spawning fish removed from the population).

1.7 Ecosysystem Consideration

Rockfishes are an important component of the California Current ecosystem along the U.S. West Coast, with its many dozens of species filling various niches in both soft and hard bottom habitats from the nearshore to the continental slope. Rougheye/Blackspotted Rockfishes are one of the larger species of rockfishes and occupy shelf areas when they are young and move into deeper slope waters with age. As they age, they tend to become more solitary, but may form aggregations during the spawning season. Due to a paucity of life-history data for Rougheye/Blackspotted Rockfishes, most ecosystem considerations are implied from the understanding of rockfishes in general.

Recruitment is one mechanism by which the ecosystem may directly impact the population dynamics of Rougheye/Blackspotted Rockfishes. The specific pathways through which environmental conditions exert influence on Rougheye/Blackspotted Rockfishes dynamics are unclear, however, changes in water temperature and currents, distribution of prey and predators, and the amount and timing of upwelling are all possible linkages. Changes in the environment may also result in changes in age-at-maturity, fecundity, growth, and survival which can affect how the status of the stock and its susceptibility to fishing are determined. Unfortunately, there are no data for Rougheye/Blackspotted Rockfishes that provide insights into these effects.

1.8 Reference Points

A list of estimates of the current state of the population, as well as reference points based on 1) a target unfished spawning output of 40%, 2) a spawning potential ratio of 0.5, and 3) the model estimate of maximum sustainable yield, are all listed in Table v. Equilibrium yield curve for the base case model is shown in Figure viii.

Unfished spawning stock output for Rougheye/Blackspotted Rockfishes is estimated to be 5,647,660 million eggs (95% confidence interval: ,<1–12,581,189 million eggs). The management biomass target for Rougheye/Blackspotted Rockfishes is defined as 40% of the unfished spawning output (40%), which is estimated by the model to be 2,259,070 million eggs (95% confidence interval: <1–5,032,478 million eggs), which corresponds, in a theoretical equilibrium state, to an exploitation rate (catch / age 26+ biomass) of 0.048 (Table v, Figure viii). This harvest rate provides an equilibrium yield of 553 mt at 40% (95% confidence interval: 0–1,224 mt). Catch limits are determined by an SPR = 50% reference point which is associated with equilibrium exploitation rate of 0.040. The model estimate of maximum sustainable yield (MSY) is 592 mt (95% confidence interval: 0–1,311 mt). The estimated spawning stock output at MSY is 1,497,160 million eggs (95% confidence interval: 0–3,337,633 million eggs). The exploitation rate corresponding to the estimated FMSY proxy of SPR = 34% is 0.085.

Table v: Summary of reference points and management quantities, including estimates of the 95 percent confidence intervals. SO is spawning output, SPR is the spawning potential ratio, and MSY is maximum sustainable yield.

Reference Point	Estimate	Lower Interval	Upper Interval
Unfished Spawning output	5,647,660.0	-1,285,869.4	12,581,189.4
Unfished Age 26+ Biomass (mt)	33,631	-7,663	74,925
Unfished Recruitment (R0)	1,092	-237	2,420
2025 Spawning output	4,929,120	-2,527,916	12,386,156
2025 Fraction Unfished	0.873	0.615	1.130
Reference Points Based SO40%	—	—	—
Proxy Spawning output SO40%	2,259,070	-514,338	5,032,478
SPR Resulting in SO40%	0.458	0.458	0.458
Exploitation Rate Resulting in SO40%	0.048	0.045	0.051
Yield with SPR Based On SO40% (mt)	553	-119	1,224
Reference Points Based on SPR Proxy for MSY	—	—	—
Proxy Spawning output (SPR50)	2,519,730	-573,681	5,613,141
SPR50	0.500	—	—
Exploitation Rate Corresponding to SPR50	0.040	0.038	0.042
Yield with SPR50 at SO SPR (mt)	526	-113	1,165
Reference Points Based on Estimated MSY Values	—	—	—
Spawning output at MSY (SO MSY)	1,497,160	-343,313	3,337,633
SPR MSY	0.337	0.334	0.339
Exploitation Rate Corresponding to SPR MSY	0.085	0.079	0.090
MSY (mt)	592	-127	1,311

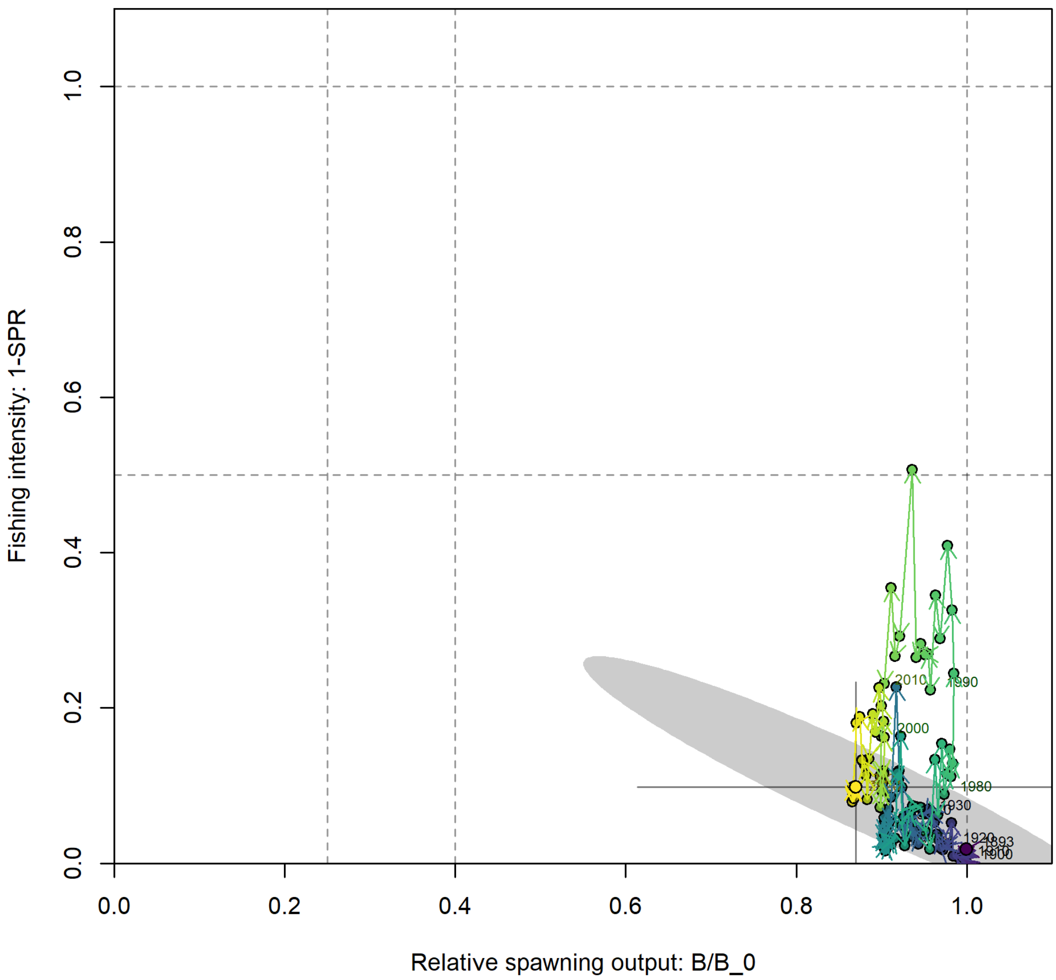

Figure vii: Phase plot of fishing intensity versus fraction unfished.

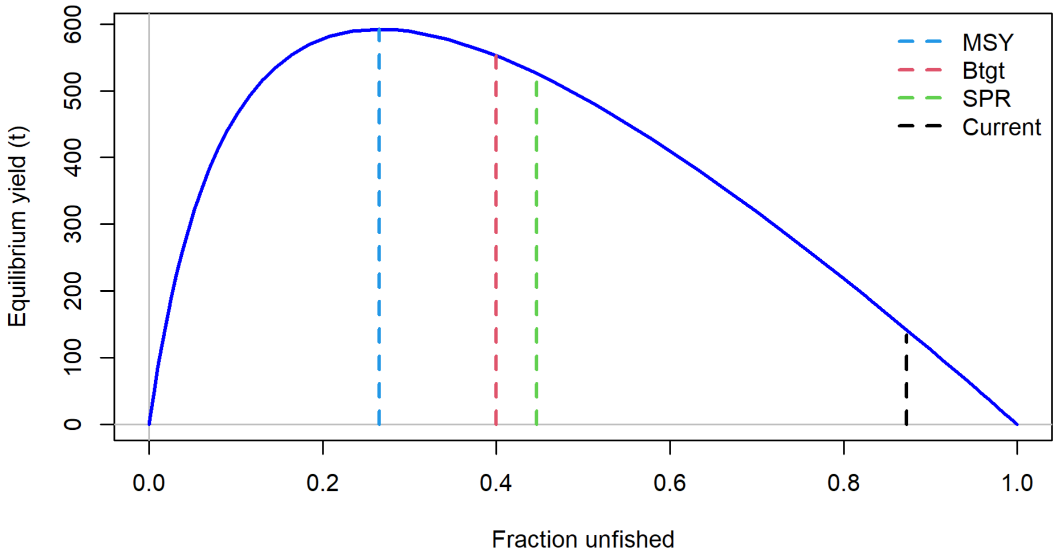

Figure viii: Equilibrium yield curve for the base case model. Values are based on the most recent fishery selectivities and retention curves and with steepness fixed at 0.72.

1.9 Management Performance

In the last ten years total dead catches of Rougheye/Blackspotted Rockfishes have been below the annual catch limit. The last ten years total dead catches for Rougheye/Blackspotted Rockfishes against he overfishing limits (OFLs), the acceptable biological catches (ABCs), the annual catch limits (ACLs) are shown in Table vi.

Table vi: Recent trend in the overfishing limits (OFL), the acceptable biological catches (ABCs), the annual catch limits (ACLs), and the total dead catch (landings + discards) all in metric tons (mt). Specifications are combined across north and south of 40'10.

Year	OFL (mt)	ABC (mt)	ACL (mt)	Catch (mt)
2015	206	188.1	188.1	132.1
2016	211	192.7	192.7	149.0
2017	215	196.3	196.3	156.0
2018	219	199.9	199.9	241.5
2019	222	202.7	202.7	226.6
2020	224	204.5	204.5	106.1
2021	237	195.8	195.8	92.8
2022	238	194.7	194.7	117.4

2023	238	192.8	192.8	97.6
2024	238	194.7	194.7	118.9

1.10 Unresolved problems and major uncertainties

Rougheye/Blackspotted Rockfishes are one of the longest lived species of rockfish on the West Coast and therefore natural mortality is likely to be lower than for other rockfish species. This assessment attempts to capture uncertainty by estimating natural mortality for females and integrating that uncertainty into the derived biomass estimates, but also balance it with using meta-analytical prior of maximum age-based natural mortality by fixing the male natural mortality .

Shape of the selectivity curves in bottom trawl and non-trawl gears.

1.11 Harvest Projections and Decision Tables

Projections of the overfishing limit, acceptable biological catch, and annual catch limit, all based on a P^* of 0.45 and a log-space standard deviation of the overfishing limit (σ) of 0.5 are included in Table vii. Assumed catches for 2025 and 2026 for this projection were provided by the PFMC Groundfish Management Team, and catches from 2027 onward assume full attainment of the acceptable biological catch.

No decision table needed in draft assessments undergoing review.

Table vii: Potential OFLs (mt), ABCs (mt), ACLs (mt), the buffer between the OFL and ABC, estimated spawning output, and fraction unfished with adopted OFLs and ACLs and assumed catch for the first two years of the projection period.

Year	Adopted OFL (mt)	Adopted ACL (mt)	Assumed Catch (mt)	OFL (mt)	Buffer	ABC (mt)	ACL (mt)	Spawning output	Fraction Unfished
2025	—	—	968	—	—	—	—	4,929,120.000	0.873
2026	—	—	955	—	—	—	—	4,841,850.000	0.857
2027	—	—	—	942	0.935	880	880	4,760,140.000	0.843
2028	—	—	—	930	0.930	865	865	4,690,410.000	0.831
2029	—	—	—	919	0.926	851	851	4,624,410.000	0.819
2030	—	—	—	908	0.922	837	837	4,561,470.000	0.808
2031	—	—	—	897	0.917	823	823	4,501,170.000	0.797
2032	—	—	—	886	0.913	809	809	4,443,180.000	0.787
2033	—	—	—	876	0.909	796	796	4,386,880.000	0.777
2034	—	—	—	865	0.904	782	782	4,331,770.000	0.767
2035	—	—	—	854	0.900	769	769	4,277,630.000	0.757
2036	—	—	—	843	0.896	756	756	4,224,160.000	0.748

1.12 Scientific Uncertainty

The model estimated uncertainty around the 2025 spawning output for is = 0.6836465. The uncertainty around the OFL is = 0.6713586. These values underestimate the overall uncertainty as they do not incorporate the model structural uncertainty and do not account for any time-varying dynamics other than recruitment. The estimated uncertainty values are higher than the Category 1 default =0.5, so all projections will use the estimated .

1.13 Research and Data Needs

There are many areas of research that could be improved to benefit the understanding and assessment of Rougheye/Blackspotted Rockfishes. Below, we identify several of them that we consider particularly important.

- Understanding the stock structure and biology of Rougheye and Blackspotted Rockfishes: This assessment reports the status of Rougheye/Blackspotted Rockfishes as a pooled complex because it is extremely difficult to separate the catches of each species even in recent data, and attempting to do so would greatly increase the uncertainty in the predictions. Because little is known about the respective biology and catch histories of the two species, it is unclear whether managing them as a complex may place one species at disproportionate risk of overfishing relative to the other. Additional research that will provide insight into the distribution, life history, biological characteristics, and catch and discard profiles of the two species is recommended. Such an endeavor would like require the efforts of at sea observers in all fleets, biologists aboard fishery-independent surveys, and port samplers along the entire West Coast requiring broad, inter-agency collaboration.
- Understanding of coatwide stock structure, connectivity, and distribution: This is a stock assessment for Rougheye/Blackspotted Rockfishes off of the west coast of the U.S. and does not consider data from British Columbia or Alaska. Further investigating and comparing the data and predictions from British Columbia and Alaska to determine if there are similarities with the U.S. West Coast observations would help to define the connectivity between rougheye rockfish north of the U.S.-Canada border.
- Natural mortality: Uncertainty in natural mortality translates into uncertain estimates of status and sustainable fishing levels for Rougheye/Blackspotted Rockfishes. Rougheye/Blackspotted Rockfishes are one of the longest lived species of rockfish (with maximum age as old as 205 years reported in the literature). Assessment model was able to estimate female natural mortality, consistent with maximum age based meta-analytical prior, but with male natural mortality fixed at the median of the prior. The collection of additional age data and further research of the life-history of Rougheye/Blackspotted Rockfishes may improve our understanding of Rougheye/Blackspotted Rockfishes natural mortality.

- Historical landings and discards, including investigation of fisheries selectivity: The substantial progress has been made in reconstructing historical landings of rockfishes on the U.S. West Coast, including those for Rougheye/Blackspotted Rockfishes. This assessment highlighted the importance of understanding of fishery selectivity assumptions associated with removals and how fishery selectivity changes throughout the years. Further understanding of this area would help reduce uncertainty in estimated scale of the stock.

1 Introduction

Rougheye (*Sebastes aleutianus*) and Blackspotted (*Sebastes melanostictus*) rockfishes are two species that form one management complex.

Rougheye rockfish are a long-lived rockfish named after a series of 2-10 spines along the lower rim of their eyes. They have also been called blackthroat or blacktip rockfish Love (2011). Blackspotted rockfish are distributed in similar locations as rougheye rockfish and it is very difficult to visually distinguish the two species. These two species may hybridize on occasion (Love 2011).

It has only been from recent genetic studies that these two separate species have been identified S. L. Hawkins et al. (2005) and have had phenotypic characteristics useful for identifying the species in the field identified Orr and Hawkins (2008). Before then, data are available for one species called Rougheye Rockfish which included Rougheye Rockfish and Blackspotted Rockfish. Due to the difficulty in distinguishing these two species and the lack of historical separation of the species in all of the data, this assessment combines any data for Blackspotted Rockfish with Rougheye Rockfish into Rougheye/Blackspotted Rockfishes and provides management advice for the two species combined. These species are also closely related to Shortraker Rockfish (*Sebastes borealis*) and are sometimes difficult to distinguish from Shortraker Rockfish without looking at the gill rakers.

1.1 Stock Structure

There are at least two questions to think about when considering stock structure for Rougheye/Blackspotted Rockfishes when doing a stock assessment.

- Since Rougheye and Blackspotted Rockfishes are two different species, can they be separated as two stocks and conduct separate assessments?

Rougheye rockfish were first described in 1811 as *Perca variabilis* by German zoologist Peter Simon Pallas (Jordan and Evermann 1898), and assigned to various taxa at least 15 times since (Love, Yoklavich, and Thorsteinson 2002). Some descriptions noted both light and dark color morphs, which, along with possible confusion with several morphologically similar co-occurring species (e.g., *Sebastes borealis* and *Sebastes melanostomus*) have contributed to the persistent ambiguity in formal descriptions of Rougheye Rockfish (Orr and Hawkins 2008). The first genetic studies conducted in the late 1960s and early 1970s (Tsuyuki et al. 1968; Tsuyuki and Westrheim 1970) observed diversity suggestive of two genetic types within specimens identified as Rougheye Rockfish. Allozyme studies conducted over the next two decades (Seeb 1986; S. Hawkins, Heifetz, and Pohl 1997; S.

L. Hawkins et al. 2005) provided additional evidence suggesting two separate genetic types within field-identified Rougheye Rockfish. Genetic variation between the two types, supported by both nuclear and mitochondrial DNA, was determined to be sufficiently conclusive to separate two species: "Type I" and "Type II" Rougheye Rockfish (Anthony J. Gharrett et al. 2005). Meristic and morphometric comparisons of the two species suggested certain characters, such as gill raker counts and length, snout length, anal base length, and pectoral fin base, were significantly different, and in combination could reliably, though not definitively, distinguish between the species (A. J. Gharrett et al. 2006). The two separate species were formally re-described by Orr and Hawkins (2008) with the Type II group retaining *Sebastes aleutianus* and the common name Rougheye Rockfish. Blackspotted Rockfish was proposed as the common name for the Type I group along with the scientific name of *Sebastes melanostictus*, re-establishing nomenclature from one of the species complex's earlier descriptions (Matsubara 1934).

These two species remain difficult to consistently differentiate visually in the catch, thus are still commonly reported and treated as a species complex. Otolith morphometrics (e.g., shape, size, weight) have shown some promise in possibly identifying these species in Alaskan waters (97.3% Blackspotted and 86.2% of Rougheye rockfishes were accurately identified) and possibly using older otoliths to break out historical information by species (Harris, Hutchinson, and Wildes 2019). Frey et al. (in prep.) provided insight into the ability of the Northwest Fisheries Science Center West Coast Groundfish Bottom Trawl Survey biologists to identify the two species, with 90% of genetically identified Rougheye rockfish being correctly identified in the field. When mis-identifications occurred, it was usually a Blackspotted rockfish being mis-identified as a Rougheye rockfish. There were few mis-identifications when a fish was identified as a Blackspotted rockfish. While this is promising for potential future species-specific data coming from the survey, it does not alleviate the historical problem of separating fishery data into the two species. Frey et al. (in prep.) therefore also considered whether ecological factors like depth or latitude could help separate samples by species. They found that both species occur within the range of this assessment's considered areas (California to Washington), and heavily spatially overlap. Interestingly, there seem to be relative hot spots for these species where one species is more common than the other, and in general, Rougheye Rockfish seems to be more common than Blackspotted Rockfish (however, Blackspotted Rockfish may be the more common of the two in parts of Alaska; Anthony J. Gharrett et al. (2005); S. L. Hawkins et al. (2005); Orr and Hawkins (2008)).

Despite recent advances in species identification ofRougheye/Blackspotted Rockfishes as genetically distinct species, there is little ability to separate current or historical fishery data reliably in order to separate these two species into two stocks. Therefore, this assessment maintains a species complex approach, though given absolute presence off the U.S. West Coast, this may be considered more of a Rougheye than Blackspotted Rockfish stock assessment. We also note that throughout the range of these stocks, all current assessments to this point have maintained a species complex approach. While we treat these species as one assessed stock complex, we recognize and are mindful of the above species distinctions as we conduct our analyses.

- Both species range into Canada and Alaska – are they one stock?

While genetics studies have focused mostly on identification of the two species, little is known about the population structure of either species. This assessment and the 2013 assessment (Hicks, Wetzel, and Harms 2013) represent the most southerly range of these species. Comparing the absolute abundance of the 2013 assessment to the most current estimates of the Alaskan stocks, the absolute number in this southerly range is much smaller than in the Gulf of Alaska (GOA), but higher than in the Bering Sea/Aleutian Island (BSAI) stock (Figure 2). The two smaller stocks have similar trend of decline and stabilization, whereas the higher biomass GOA stock looks to have not dropped at all over the time period considered (Figure 3). We assume here that the west coast stocks of Rougheye/Blackspotted Rockfishes are distinct management units from those in Alaska.

1.2 Distribution

Rougheye/Blackspotted Rockfishes range from northern California up to and throughout Alaska and into Japan (Anthony J. Gharrett et al. 2005; S. L. Hawkins et al. 2005; Orr and Hawkins 2008). Both are long-lived (>100 years), with Rougheye Rockfish having the distinction of the oldest ever aged *Sebastes* species at 205 years old. They both greatly overlap in latitude and depth (shallower than 100 m to at least 439 m), and are generally considered slope rockfish, with an ontogenetic shift from shallower to deeper, and adults commonly found at 360 m (around 200 fathoms). Rougheye seems to be proportionally more abundant when survey samples are genetically identified, and Blackspotted Rockfish tend to be found, on average, deeper than Rougheye Rockfish (S. L. Hawkins et al. 2005; Orr and Hawkins 2008).

Rougheye/Blackspotted Rockfishes are often associated with structure, such as hard, rocky bottoms and steep habitats. They are rarely found on the deep flats. They can be found alone or in aggregations (Love, Yoklavich, and Thorsteinson 2002), with aggregations often differentiated by age. Younger fish may school and are often found in shallower waters on the shelf, junveiles and subadults can be found together, and larger fish may form larger aggregations in the Pacific Northwest during the autumn and winter. These two species may also hybridize on occasion (Love 2011). These species are closely related to Shortraker Rockfish (*S. borealis*) and are sometimes difficult to distinguish from Shortraker Rockfish without looking at the gill rakers. One major distinguishing feature of Rougheye Rockfish are the 2–10 spines along the lower rim of their eyes, hence the common name "rougheye".

1.3 A Map Showing the Scope of the Assessment

This assessment treats the U.S. Rougheye/Blackspotted Rockfishes resource from the Mexican border to the Canadian border as a single coastwide stock (Figure 1). The U.S.-Canadian border is the northern boundary for the assessed stock, although the basis for this choice is due to political and current management needs rather than the population dynamics The assessment excludes consideration of the Puget Sound and Salish Sea.

1.4 Life History

Like all *Sebastes* species, Rougheye/Blackspotted Rockfishes give birth to live young. Larvae released has been documented between February and June and extrusion lengths are between 4.5-5.3 mm (Love, Yoklavich, and Thorsteinson 2002). Dick et al. (2017) showed that rockfishes exhibit a non-proportional relationship of fecundity to weight, with larger individuals producing more eggs than expected only by weight. Although Neither Rougheye or Blackspotted Rockfishes have a species- or subfamily-specific estimate for this relationship, this stock assessment uses the unobserved Genus Sebastes values to inform fecundity to weight relationship for Rougheye/Blackspotted Rockfishes.

A wide range of prey items make up the diet of Rougheye/Blackspotted Rockfishes. Crangid and pandalid shrimps make up the majority of their diets, and larger individuals, greater than 30 cm, feeding upon other fishes (Love 2011). They are also known to feed upon gammarid amphipods; mysids, crabs, polychaetes, and octopuses (Love, Yoklavich, and Thorsteinson 2002; Love 2011).

1.5 Ecosystem Considerations

1.6 Historical and Current Fishery Information

Rougheye/Blackspotted Rockfishes are not targeted by a specific fishery, but are desirable and marketable, thus are typically retained when captured. They are often caught in bottom trawl, mid-water trawl, and longline fisheries. Small numbers have been observed in pot, shrimp, and recreational fisheries.

Longline catches of Rougheye/Blackspotted Rockfishes are present from the turn of the century and continue in recent years, targeting sablefish and halibut.

After many attempts to start trawl fisheries off the west coast of the United States in the late 1800's, the availability of the otter trawl and the diesel engine in the mid-1920's helped the trawl fisheries expand (Douglas and Division 1998). The trawl fisheries became established during World War II when demand increased for bottomfish. A mink food fishery also developed during World War II (Jones and Harry 1961), and post-war catches for rockfishes, including Rougheye/Blackspotted Rockfishes, increased (Niska 1976). Between mid-1960s and mid-1970s, foreign trawl fleets from the former Soviet Union, Japan, Poland, Bulgaria and East Germany targeted aggregations of Pacific ocean perch in the Northeast Pacific Ocean, in the waters off the U.S. West Coast (Love, Yoklavich, and Thorsteinson 2002), until the EEZ was implemented in 1977 (J. B. Rogers 2003).

Also, large-scale harvesting of Pacific hake in the United States began in late-1960s, when factory trawlers from the Soviet Union and other countries began targeting this stock. After the 200-mile U.S. Rougheye/Blackspotted Rockfishes is commonly caught in this fishery. Exclusive Economic Zone was declared in 1977, a Joint-Venture fishery was initiated between United States trawlers and Soviet factory trawlers acting as motherships (larger, slower ships for fish processing and storage while at sea). By 1989 the U.S. fleet capacity had grown to a level sufficient to harvest the entire quota, and no further foreign fishing was allowed.

Since 1977, landings of rockfish were higher until management restrictions were implemented in 2000. Rougheye/Blackspotted Rockfishes inhabit deeper water as adults, which were fished less often historically. More detailed information of the fisheries by state is given in Section 2.1, where the reconstructed catches are discussed. The catches by state in fleets as well as for the Pacific whiting at-sea fleet are shown in Figure 5.

1.7 Summary of Management History and Management Performance

Rougheye/Blackspotted Rockfishes has been a small component of groundfish fisheries and catches of Rougheye/Blackspotted Rockfishes have been governed by restrictions on assemblages of species, of which these species are a member. However, the distribution of fishing effort in areas where Rougheye/Blackspotted Rockfishes might be encountered has also been affected by catch restrictions on co-occurring, rebuilding species, as well as associated area closures instituted to promote rebuilding. The first imposed landings limits on a coastwide Sebastes complex (Rougheye/Blackspotted Rockfishes being one of the 50 rockfishes in the complex) were instituted in 1983.

This complex was divided in to two management areas north and south of 43º00’ N in 1994. Ongoing concern that shelf and slope rockfishes may be undergoing overfishing led the attempt by J. S. Rogers et al. (1996) to describe the status of most rockfishes in the Sebastes complex. Rougheye/Blackspotted Rockfishes information content was low. To estinated exploitation rates of Rougheye Rockfish J. S. Rogers et al. (1996) assumed fishing mortality being to equal to natural mortality and used AFSC/NWFSC Triennial

Shelf Survey to calculate an average biomass. The analysis found that the stock was undergoing very high exploitation rates in both management areas.

The dividing line between the northern and southern management areas was shifted to 40º10’ N latitude in 1999 and the Sebastes complex was subsequently divided into nearshore, shelf, and slope complexes in 2000. Rougheye Rockfish has been managed under trip limits for the minor slope rockfish complex in both north and south management areas since this time.

Table Table 1 summarizes major management changes since 2000. Some important changes include the implementation of Rockfish Conservation Areas (RCA’s) in 2002, the beginning of trawl rationalization in 2011, and the lifting of the RCAs beginning in 2020 with the removal of the trawl RCA in Oregon and California and loosening restrictions in the non-trawl RCAs in 2023 and 2024.

Though managed as part of a complex, OFL contributions for Rougheye/Blackspotted Rockfishes were calculated using DB-SRA in 2010 for the 2011-2012 management cycle. This lead to the observation that recent catches had frequently exceeded the OFL contribution estimated using data-poor, catch-only methods provided a strong indication that a more thorough evaluation of Rougheye/Blackspotted Rockfishes stock status and sustainable harvest levels be undertaken, using all available data. A full assessment of Rougheye/Blackspotted Rockfishes was undertaken in 2013 and indicated the stock complex was above management target levels (Hicks, Wetzel, and Harms (2013)). Recent management performance for Rougheye/Blackspotted Rockfishes is provided in Table 2 for north and south of 40’10. Rougheye/Blackspotted Rockfishes is managed as a part of the slope rockfish complex.

1.8 Fisheries off Canada and Alaska

Rougheye/Blackspotted Rockfishes are distributed throughout Canada and Alaska and are commonly caught in trawl and longline fisheries. Alaska conducts assessments biennially for the Rougheye/Blackspotted complex, and two have been recently done: one for the Bering Sea and Aluetian Islands (Spencer, Ianelli, and Laman 2003) and the other for the Gulf of Alaska (Sullivan et al. 2023). Canada completed an assessment in 2020 (Starr and Haigh 2020). The fisheries and assessments for each country are described below.

Rougheye rockfish have been managed as a bycatch only species in Alaska since 1991 with catches ranging between 130 and 2,418 mt and peaking in the late 1980s and early 1990s (Sullivan et al. 2023). Generally, about 55-75% of the catch are trawl-caught and 30-45% from hook-and-line (mainly, longline) fisheries. Since 2017 the move to pot gear in the sablefish fishery has decreased the longline catches. Discards since 2013 have ranged from 11.6% (in 2023) and 45% (in 2018). The Rougheye/Blackspotted complex catch levels generally are between 20% and 60% of the Total Allowable Catch since the 2005 when the complex began to be managed separately. The most recent age-structured integrated stock assessments of this complex in the Bering Sea and Aluetian Islands (Spencer, Ianelli, and Laman 2003) and for the Gulf of Alaska (Sullivan et al. 2023) do not indicate either overfishing or the stocks being overfished.

Canada identified two species of Rougheye Rockfish (Type I and Type II) in 2007 and designated both species of special concern, which means that they may become threatened or endangered because of a combination of biological characteristics and identified threats (Report 2007). This designation was given because biomass estimates are uncertain and no strong trends are observed, there is evidence of truncation of the age distribution and overall mortality has doubled, it is a long-lived, low-fecundity Sebastes species, which is susceptible to population collapse and slow recovery, and because the difficulty in separating the two species may result in potential impacts on one of the species going unnoticed. Subsequently, the species were identified as rougheye rockfish and blackspotted rockfish and a management plan was created in 2012 with a goal of sustaining the populations of rougheye and blackspotted rockfishes (Canada 2012). Five high priority and seven low priority actions have been identified to address the threats to the populations and support the management goal.

The first Canadian stock assessment for these species, using a integrated catch-at-age model, was conducted in 2022 to estimated stock status of two Rougheye/Blackspotted (REBS) rockfishes management units (REBS north and REBS south) a the beginning of 2021. The REBS north stock was in the healthy zone in the reference model. The REBS south stock was likely in the healthy zone, but with an elevated possibility of being in the cautious zone.

2 Data

Data from a wide range of sources were evaluated within this assessment. Data sources included in the assessment model are summarized in Figure 4. Description of each data source used in the model is provided below.

2.1 Fishery-dependent data

Rougheye/Blackspotted Rockfishes are not targeted by a specific fishery, but are desirable and marketable, thus are typically retained when caught. They are often captured in bottom trawl, mid-water trawl, and longline fisheries. They are also commonly bycaught within the at-sea hake fishery. Small numbers have been observed in pot and shrimp trawl. Recreational catch is inconsequential and not accounted for in this assessment.

Rougheye/Blackspotted Rockfishes fishery-dependent data in this assessment are divided among six fleets, which include:

- Fleet 1: Commercial bottom trawl fishery.
- Fleet 2: Dead discard from bottom trawl fishery.
- Fleet 3: Commercial non-trawl (mainly the long-line) fishery.
- Fleet 4: Dead discard from non-trawl fishery.
- Fleet 5: Contemporary mid-water trawl fishery.
- Fleet 6: At-sea hake fishery bycatch.

For description and details on fleet structure, please refer to Section Section 3.4.3.

2.1.1 Commercial Fishery Landings

Recent and historical fisheries catches were compiled by state and then combined into the fishing fleets used in the assessment. Time series of catches by fleet are reported in Table 3 and shown in Figure 5. The landings for each fleet by state are given in Table 5 for bottom trawl, Table 6 for non-trawl, and Table 7 for mid-water trawl fleet.

2.1.1.1 Recent landings

Recent commercial landings of Rougheye/Blackspotted Rockfishes (2000-2024 for Washington, 1987–2024 for Oregon and 1981–2024 for California,) were obtained from Pacific

Fisheries Information Network (PacFIN), a regional fisheries database that manages fishery-dependent information in cooperation with West Coast state agencies and National Marine Fisheries Service (NMFS). Catch data were extracted from PacFIN on April 24, 2025.

2.1.1.2 Historical Landings

Historical landings of Rougheye/Blackspotted Rockfishes were reconstructed by state.

The Washington historical landings (1889–2000) of Rougheye/Blackspotted Rockfishes were provided by Washington Department of Fish and Wildlife (WDFW), who recently conducted historical catch reconstruction for rockfish species, including Rougheye/Blackspotted Rockfishes (pers. comm. T. Tsou, WDFW). The three main sources used in this reconstruction included the US Fish Commission Report (UFSC), Washington Bound Volumes, and Washington Statistical Bulletin. The historical species composition was based on the various historical reports and interviews of fishermen and dockside samplers. The landings between 1981 and 2000 were also provided by WDFW (rather than obtained from PacFIN), since WDFW developed and used a improved method for apportioning unidentified rockfish (URCK) category in fish tickets to the individual species landings. This improved approach relaxed the borrowing rules for missing data used in the WDFW species allocation algorithm that feeds into PacFIN (pers. comm. T. Tsou, WDFW). New Washington historical landings represent improvement to the assessment.

The Oregon historical landings (1896–1986) were obtained from Oregon historical catch reconstruction, conducted by Oregon Department of Fish and Wildlife (ODFW) in collaboration with NWFSC (Karnowski, Gertseva, and Stephens (2014)). The Oregon landings for the period between 1987 and 1999 were also provided by the ODFW. For that period, Oregon PacFIN landings were supplemented with the additional estimates of Rougheye/Blackspotted Rockfisheslandings reported within unspecified rockfish market categories (i.e., URCK and POP1; Fish and Wildlife (2017)).

The California historical landings were informed by several sources. Landings from the most recent "historical" period (between 1969 and 1980) were obtained from the California Cooperative Survey (CalCOM) database. Earlier landing records (between 1931 and 1968) were informed by the rockfish historical catch reconstruction conducted by the NOAA's Southwest Fisheries Science Center (Ralston et al. (2010)).

Comparison of Rougheye/Blackspotted Rockfishes historical landings by state and fleet between this and 2013 assessment is provided in Figure 6. The largest differences in this assessment from 2013 model are in Washington landings (Figure 9), with newly estimated landings being generally lower than those used in previous assessment. The new WDFW catch reconstruction completed by WDFW is considered an improvement.

Historical California and Oregon landings did not change substantially (Figure 7 and Figure 8), with the exception of a few years. Discrepancies in California and Oregon non-trawl landings between the 2013 and 2025 assessments are caused by the fact that non-trawl fleet in 2013 assessment was limited to only fixed gear, when in 2025 assessment non-trawl fleet includes all non-trawl gear groups. Slight discrepancies in Oregon trawl landings between 1987 and 1999, are from adding previously non-reported landings of Rougheye/Blackspotted Rockfishes in the unspecified rockfish market categories (see details above).

The update in historical changes shows only minor differences in model outputs (Figure 37; Figure 38).

2.1.1.3 Bycatch in the foreign POP fishery

Between mid-1960s and mid-1970s, foreign trawl fleets from the former Soviet Union, Japan, Poland, Bulgaria and East Germany targeted aggregations of Pacific ocean perch in the Northeast Pacific Ocean, in the waters off the U.S. West Coast (Love, Yoklavich, and Thorsteinson 2002). J. B. Rogers (2003) estimated removals of rockfish species caught within this foreign POP fishery, including removals of Rougheye/Blackspotted Rockfishes. In the assessment, Rougheye/Blackspotted Rockfishes bycatch in the foreign POP fishery between 1966 and 1976 as estimated by J. B. Rogers (2003) were added to commercial bottom trawl fleet.

2.1.1.4 At-Sea Hake Catches

Rougheye/Blackspotted Rockfishes has long been bycaught in the fishery for the coastal population of Pacific hake, which is almost exclusively conducted with mid-water trawls.

Large-scale harvesting of Pacific hake in the United States began in late-1960s, when factory trawlers from the Soviet Union and other countries began targeting this stock. After the 200-mile U.S. Exclusive Economic Zone was declared in 1977, a Joint-Venture fishery was initiated between United States trawlers and Soviet factory trawlers acting as mother-ships (larger, slower ships for fish processing and storage while at sea). By 1989 the U.S. fleet capacity had grown to a level sufficient to harvest the entire quota, and no further foreign fishing was allowed. The Pacific hake fishery is currently 100% observed by the at-sea hake observer program (A-SHOP) and data on bycatch species, including Rougheye/Blackspotted Rockfishes, is being routinely collected.

Annual amounts of Rougheye/Blackspotted Rockfishes bycatch (retained and discarded) in the Pacific hake fishery were obtained from the North Pacific Database Program (NORPAC). That time series covers the period between 1977 and 2024 and include catches by foreign and domestic fisheries as well as removals during the time of Joint Ventures (JV). Rougheye/Blackspotted Rockfishes catches within the at-sea hake fishery were treated in the model as a separate fleet (Table 5).

2.1.2 Discards

2.1.2.1 Historical discard

Historically, little to no discarding was observed for Rougheye/Blackspotted Rockfishes.

The historical discard information comes from Pikitch, Erickson, and Wallace (1988), and often referred to as the Pikitch study. The Pikitch study was conducted between 1985 and 1987 between 48°42' and 42°60' N. latitude, which is primarily within the Columbia INPFC area (Pikitch, Erickson, and Wallace 1988). Participation in the study was voluntary and included vessels using bottom, midwater and shrimp trawl gears. Observers of normal fishing operations on commercial vessels collected the data, estimated the total weight of the catch by tow, and recorded the weight of species retained and discarded in the sample.

There are no midwater trawl records of Rougheye/Blackspotted Rockfishesin the Pikitch, Erickson, and Wallace (1988), and only few fish records of bottom trawl catches, based on which discard rate (discard weight over total weight) for bottom trawl was just 0.09%. Therefore, no historical discard was assumed in the model.

2.1.2.2 Recent Discard

With the introduction of trip limits for rockfish in early 2000, limited discard has been observed for Rougheye/Blackspotted Rockfishesin bottom trawl and non-trawl fisheries.

In 2002, the West Coast Groundfish Observer Program (WCGOP) was implemented on the West Coast of the United States, which began with gathering bycatch and discard information for the limited entry trawl and fixed gear fleets. Observer coverage has expanded to include the California halibut trawl, the nearshore fixed gear and pink shrimp trawl fisheries. Since 2011, trawl fisheries have been managed with catch shares under a system of annual individual fishing quotas (IFQs) for the shoreside sector (i.e., vessels delivering to shoreside processors) and harvest cooperatives for the at-sea hake sectors (catcher-processors who catch and process hake at sea; and Motherships, factory processors that take delivery of hake from catcher vessels at sea). Constant monitoring of catch using observers or electronic monitoring (EM) is required to participate in the trawl catch share fishery.

The discard amounts of Rougheye/Blackspotted Rockfishes for the period between 2002 and 2023 were obtained from WCGOP by year and fleet (bottom trawl, mid-water trawl and non-trawl), for both the catch share and the non-catch share sector. The discarding amounts of Rougheye/Blackspotted Rockfishes within bottom trawl and non-trawl fleets were included in the model as separate fleets.

Mid-water trawl discard was not present in non-catch share sector and was extremely minimal (virtually non-existing) in catch-share sector, with discard amounts averaging to 10kg per year. Therefore, in the model, no discard was assumed for mid-water trawl fleet.

2.1.2.2.1 Bottom Trawl Discard

Bottom trawl discard amounts by year are provided in Table 3 and shown in Figure 5. Prior to 2011, before the start of the catch share program, the discard of Rougheye/Blackspotted Rockfishes ranged between 1 metric ton and 60 metric tons, averaging at 23 metric tons a year. After 2011, the discard has been very low, not exceeding 0.5 metric ton a year. No discard data were available for 2024, and we used the average discard amount for 2019 - 2023 period to approximate 2024 discards for bottom trawl discard fleet.

2.1.2.2.2 Non-Trawl Discard

Non-trawl discard amounts by year are provided in are provided in Table 3 and shown in Figure 5. Non-trawl discard of Rougheye/Blackspotted Rockfishes were made in both catch share and non-catch share sectors. Discard amounts in these sectors were combined by year to represent total discard within the fleet. The discards within this fleet ranged between 0.5 metric ton and 35 metric tons, with 10 metric tons as average per year. No discard data were available for 2024, and the 2023 discard amount was assumed for 2024 for non-trawl discard fleet.

2.1.3 Fishery Length and Age Data

Length bins from 10 to 80 cm in 2 cm increments were used to summarize the length frequency of the catches in each year. The first length bin includes all observations less than 10 cm and the last bin includes all fish 80 cm and longer. Age distributions included bins from age 1 to age 100, with the first bin including all fish ages 0 and 1 and the last bin including all fish age 100 and above.

2.1.3.1 Commercial Landings Length and Ages

The fishery length and age data for bottom trawl, non-trawl and mid-water trawl fleets, based on samples collected by port samplers, were obtained from the PacFIN Biological Data System (BDS) database and extracted on April 24, 2025. The number of trips and fish sampled for lengths and ages by state and year are summarized in Table 8 through Table 11, by fishing fleet.

Commercial length-frequency distributions were developed for each fleet and year, for which observations were available

Females and males distributions were treated separately, to track sex-specific differences. For each fleet, the raw observations were expanded to the trip level, to account for differences in samples sizes relative catch weights among trips (first stage expansion). The expanded length observations were then further expanded to state level, to account for differences in sampling intensity of Rougheye/Blackspotted Rockfishes landings among states combined into a single fleet (second stage expansion). The expansion algorithm can be illustrated with the following equation:

$$N_{b,j,y} = \sum_{s=1}^{s=k} \sum_{t=1}^{t=n} L_{b,j,t} \cdot \left(\frac{LC_t}{SC_t}\right) \cdot \left(\frac{LC_{s,y}}{SC_{s,y}}\right)$$

Where $N_{b,j,y}$ is the number of lengths in each length bin (b) by sex (j) and year (y) within each fleet. $L_{b,j,t}$ represents an individual length sample by bin (b) and sex (j) within an individual fishing trip (t). In the first stage expansion, $L_{b,j,t}$ was multiplied by the ratio of landed catch (LC_t) within that trip (t) to a portion of catch sampled for lengths (SC_t) within the same trip (t). In the second stage expansion, the individual length sample ($L_{b,j,t}$) was multiplied by the ratio of landed catch ($LC_{s,y}$) within individual state (s) and year (y) to catch weights sampled for lengths ($SC_{s,y}$) within the same state (s) and year (y). As the final step, the expanded length samples from the same size bin and sex were summed across all trips and states (combined into a single fleet) within a single year, to obtain the total number of lengths in each length bin by sex, year and fleet ($N_{b,j,y}$). The same calculations were repeated for each length bin, to develop sex specific length frequencies for each fishing fleet by year.

Age distributions were included in the model as conditional-age-at-length (CAAL) observations. The marginal age-compositions were also included, but only for evaluating the implied fits, while the CAAL data were used in the likelihood. The CAAL data were not expanded and were binned according to length, age, sex, and year.

The filtering and processing of the PacFIN length and age composition data were conducted using the Pacific Fisheries Information Network tools (PacFINtools) package in R (Wetzel, Johnson, and Hicks 2025). The filtering steps included removing samples with missing vital information.

Figure 10 through Figure 16 show length frequencies for bottom trawl, non-trawl and mid-water fleets by year, and Figure 21 through Figure 25 show the commercial length and CAAL distributions by year for the same fleets.

The initial input values for length compositions in this assessment were calculated as a function of the number of trips and number of fish via the Stewart Method (pers.comm. I. Stewart, International Pacific Halibut Commission (IPHC)). The method is based on analysis of the input and model derived effective sample sizes from West Coast groundfish stock assessments. A piece-wise linear regression was used to estimate the increase in effective sample size per sample based on fish-per-sample and the maximum effective sample size for large numbers of individual fish. The resulting equations are:

$$\text{Input effN} = N_{\text{trips}} + 0.138 * N_{\text{fish}} \text{ if } N_{\text{fish}}/N_{\text{trips}} \text{ is } < 44$$

$$\text{Input effN} = 7.06 * N_{\text{trips}} \text{ if } N_{\text{fish}}/N_{\text{trips}} \text{ is } \geq 44$$

The input sample size of CAAL data was set at the number of fish at each length by sex and by year.

2.1.3.1.1 Commercial Discard Lengths

Discard length composition data for both bottom trawl and non-trawl discard fleets were available from WCGOP. The number of trips, hauls and fish sampled for lengths by year are summarized in Table 12, by discard fleet.

Discard length composition data were not sex-specific. Discard raw length observations were expanded to the haul level, to account for differences in catch among hauls (Figure 12 and Figure 15).

The initial input values for length compositions were calculated via the Stewart Method (see above).

No age data were available for discarded fish.

2.1.3.1.2 At-sea hake Fishery Length and Age Compositions

The sex-specific length and age data for at-sea hake fleet were collected by the at-sea hake observer program (a-shop) and available through NORPAC database (Figure 12 and Figure 15). Age distributions were included in the model as CAAL observations, binned according to length, age, sex, and year (Figure 26 through Figure 27).

The number of hauls and fish sampled by year and used to create length frequency and CAAL distributions are summarized in Table 13.

Input sample sizes for length compositions were based on the number of hauls sampled by year. The input sample size of CAAL data was set at the number of fish at each length by sex and by year.

The marginal age compositions were constructed, but only used in the model for evaluating the implied fits, while the CAAL data were used in the likelihood.

2.2 Fishery-independent data

Data from four fishery-independent surveys were used in this assessment:

- Survey 1: West Coast Groundfish Bottom Trawl Survey (WCGBTS; 2003-2024)
- Survey 2: Triennial (every three years) Survey (1980-2004)

- Survey 3: Alaska Fishery Science Center (AFSC) Slope Survey (1997-2001)
- Survey 4: Northwest Fisheries Science Center (NWFSC) Slope Survey (1999-2001)

The surveys temporal and spatial coverage is summarized in Table 15.

Information produced by these surveys included indices of relative abundance (all four surveys), length-frequency distributions (WCGBTS and Triennial survey), and age-frequency distributions (WCGBTS).

Only the WCGBTS has new data for this assessment, but new methods were applied to all surveys to develop new indices of abundance.

In this assessment, geostatistical models of biomass density were fit to survey data using the R package Species Distribution Models with Template Model Builder (`sdmTMB`) (Anderson et al. 2022). These models can account for latent spatial factors with a constant spatial Gaussian random field and spatiotemporal deviations to evolve as a random walk Guassian random field (J. T. Thorson et al. 2015). Tweedie, delta-binomial, delta-gamma, and mixture distributions, which allow for extreme catch events, were investigated. Results are only shown for the distribution that led to the best model diagnostics, e.g., similar distributions of theoretical normal quantiles and model quantiles, high precision, lack of extreme predictions that are incompatible with the life history, and low Akaike information criterion (AIC). Estimates of biomass from this best model were predicted using a grid based on available survey locations. The {indexwc} R package (Johnson et al. 2025) was used to conduct the analysis and code to reproduce the analysis is available at https://pfmc-assessments.github.io/indexwc/.

Standardized indices for all four surveys overlaid are shown in Figure 31, where each index is rescaled to have mean observation = 1.0.

Description of each survey is provided below; details on methods used to process the data are also discussed.

2.2.1 NWFSC West Coast Groundfish Bottom Trawl Survey

2.2.1.1 Survey Description

The Northwest Fisheries Science Center West Coast Groundfish Bottom Trawl Survey (WCGBTS) is conducted annually since 2003 Table 15. The survey's design and sampling methods are most recently described in detail in Keller, Wallace, and Methot (2017). The survey is based on a random-grid design, covering the coastal waters from a depth of 100 to 700 fm (183-1280 m). This design generally uses four industry-chartered vessels per year assigned to a roughly equal number of randomly selected grid cells and divided into two 'passes' of the coast. Two vessels fish from north to south during each pass between late May to early October. This design therefore incorporates both vessel-to-vessel differences in catchability, as well as variance associated with selecting a relatively small number (approximately 700) of possible cells from a very large set of possible cells spread from the Mexican to the Canadian borders.

2.2.1.2 Abundance Index

The data were truncated to depths less than 875 m prior to modeling given that there were zero positive encounters in depths deeper than 875 m. The prediction grid was also truncated to only include available survey locations in depths between 55–875 m to limit extrapolating beyond the data and edge effects.

The chosen model used a delta model with a lognormal distribution for the catch-rate component. A logit-link was used for encounter probability and a log-link for positive catch rates. The response variable was catch (mt) with an offset of area (km^2) to account for differences in effort. Fixed effects were estimated for each year. The following additional covariates were included: pass. Vessel-year effects, which were historically used for index standardization of this survey, were not included because the estimated variance for the random effect was close to zero. Vessel-year effects were more prominent when models did not include spatial effects and instead vessel-year terms accounted for the random selection of commercial vessels used during sampling (Helser, Punt, and Methot 2004; J. T. Thorson and Ward 2014).

Spatial and spatiotemporal variation were not included in either the encounter probability nor the positive catch rate model. Spatial variation was approximated using 200 knots, where more knots led to non-estimable standard errors because the positive encounters are too sparse to support the dense spatiotemporal structure.

The biomass estimates produced for this assessment using `sdmTMB` are comparable to the biomass estimates produced in the previous benchmark assessment (Figure 32). The index is relatively flat with high variation (Figure 33).

2.2.1.3 Length and Age compositions

Length bins from 1o to 80 cm in 2 cm increments were used to summarize the length frequency of the survey catches in each year. Table 16 shows the number of lengths taken by the survey.

Length compositions were separated into males and females. These length compositions were expanded to account for difference in catch among tows, with further expansion based upon the stratification by depth and latitude using the {nwfscSurvey} package in R (Wetzel, Johnson, and Hicks 2025). The stratification for length data expansions are provided in Table 14.

Age distributions included bins from age 1 to age 100, with the last bin including all fish of greater age. Table 17 shows the number of ages taken by the survey. Age distributions were included in the model as CAAL observations. The marginal age compositions were only used for comparing the implied fits, while the CAAL data were used in the likelihood. The CAAL data were not expanded and were binned according to length, age, sex, and year.

Figure 18 shows WCGBTS length frequencies by year, and Figure 28 through Figure 30 show the WCGBTS length and CAAL distributions by year.

The input sample sizes for length composition data were calculated based on Stewart and Hamel (2014) as Input $\mathrm{N}_y = 2.43 * N_{tow}$ where the 2.43 value was estimated for a group of shelf and slope rockfish species.

The input sample size of CAAL data was set at the number of fish at each length by sex and by year.

2.2.2 AFSC/NWFSC West Coast Triennial Shelf Survey

2.2.2.1 Survey Description

The Triennial Survey was first conducted by the AFSC in 1977 and continued until 2004. The survey's design and sampling methods are most recently described in **Weinberg et al. (2002)**. Its basic design was a series of equally-spaced transects from which searches for tows in a specific depth range were initiated.

The survey spatial coverage and timing has changed over the period of survey duration Table 15.

Haul depths ranged from 91–457 m during the 1977 survey with no hauls shallower than 91 m. The surveys in 1980, 1983, and 1986 covered the West Coast south to 36.8°N latitude and a depth range of 55–366 meters. The surveys in 1989 and 1992 covered the same depth range but extended the southern range to 34.5°N (near Point Conception). From 1995 through 2004, the surveys covered the consistent depth range 55–500 meters and surveyed south to 34.5°N. In the final year of the triennial series (2004), the NWFSC conducted the survey and followed very similar protocols as the AFSC, which conducted surveys in all previous years.

All of the surveys were conducted in the mid-summer through early fall: the 1977 survey was conducted from early July through late September; the surveys from 1980 through 1989 ran from mid-July to late September; the 1992 survey spanned from mid-July through early October; the 1995 survey was conducted from early June to late August; the 1998 survey ran from early June through early August; and the 2001 and 2004 surveys were conducted in May-July.

Water hauls (Zimmermann et al. 2001) and tows located in Canadian waters were also excluded from the analysis of this survey. Given the different depths surveyed during 1977, the data from that year were not included in this assessment.

2.2.2.2 Abundance Index

The Triennial Survey was analyzed as an early series (1980–1992) and a late series (1995–2004) to account for change in spatial coverage and survey timing, as Rougheye/Blackspotted Rockfishesexhibit ontogenetic movements when individuals gradually shift their distribution toward deeper waters as the grow and mature. Separate catchability parameters were estimated for pre-1995 period and from 1995 forward. Separate selectivity curves were estimated for early and late survey periods as well.

The data for the early series were truncated to depths less than 350 m, and for late series to depths less than 500 m prior to modeling given that there were zero positive encounters in depths deeper than 500 m. The prediction grid was also truncated to only include available survey locations in depths between 55–500 m to limit extrapolating beyond the data and edge effects.

The chosen model used a delta model with a lognormal distribution for the catch-rate component. A logit-link was used for encounter probability and a log-link for positive catch rates. The response variable was catch (mt) with an offset of area (km^2) to account for differences in effort. Fixed effects were estimated for each year. No other covariates were modeled. Vessel-year effects, which were historically used for index standardization of this survey, were not included because the estimated variance for the random effect was close to zero. Vessel-year effects were more prominent when models did not include spatial effects and instead vessel-year terms accounted for the random selection of commercial vessels used during sampling (Helser, Punt, and Methot 2004; J. T. Thorson and Ward 2014).

Spatial and spatiotemporal variation were included in the encounter probability but not the positive catch rate model. Spatial variation was approximated using 100 knots, where more knots led to non-estimable standard errors because the positive encounters are too sparse to support the dense spatiotemporal structure.

The estimated index is shown in Figure 34. The index exhibits an increase in biomass from 1995 forward, that corresponds to a change in Triennial Survey depth coverage, when the survey extended to the deeper area Table 15.

2.2.2.3 Length Compositions

Length bins from 10 to 80 cm in 2 cm increments were used to summarize the length frequency of the survey catches in each year. Table 16 shows the number of lengths taken by the survey.

Length compositions were separated into males and females. These length compositions were expanded to account for difference in catch among tows, with further expansion based upon the stratification by depth and latitude using the {nwfscSurvey} package in R (Wetzel, Johnson, and Hicks 2025). The stratification for length data expansions are provided in Table XX. Figure 19 shows Triennial Survey length frequencies by year,

The input sample sizes for length composition data for all fishery-independent surveys were calculated based on Stewart and Hamel (2014) as Input $N_y = 2.43 * N_{tow}$ where the 2.43 value was estimated for a group of shelf and slope rockfish species.

There are no Rougheye/Blackspotted Rockfishes age data from the Triennial Survey.

2.2.3 AFSC Slope Survey

2.2.3.1 Survey Description

The AFSC slope survey was initiated in 1984. The survey methods are described in Lauth (2000). Prior to 1997, the survey was conducted in different latitudinal ranges each year. In this assessment, only data from 1997, 1999, 2000 and 2001 were used – these years were consistent in latitudinal range (from 34°30’ N. latitude to the U.S.-Canada border) and depth coverage (183-1280 m; 100-700 fm).

2.2.3.2 Abundance Index

The prediction grid was truncated to only include available survey locations in depths deeper than 183 to limit extrapolating beyond the data and edge effects.

The chosen model used a delta model with a lognormal distribution for the catch-rate component. A logit-link was used for encounter probability and a log-link for positive catch rates. The response variable was catch (mt) with an offset of area (km^2) to account for differences in effort. Fixed effects were estimated for each year. No other covariates were modeled. Vessel-year effects, which were historically used for index standardization of this survey, were not included becausethe estimated variance for the random effect was close to zero. Vessel-year effects were more prominent when models did not include spatial effects and instead vessel-year terms accounted for the random selection of commercial vessels used during sampling (Helser, Punt, and Methot 2004; J. T. Thorson and Ward 2014).

Spatial and spatiotemporal variation were not included in either the encounter probability nor the positive catch rate model. Spatial variation was approximated using 100 knots, where more knots led to non-estimable standard errors because the positive encounters are too sparse to support the dense spatiotemporal structure.

The AFSC Slope Survey index is shown in Figure 35. The index is short, and does not exhibits significant change over the four year period.

2.2.3.3 Length Compositions

Length bins from 10 to 80 cm in 2 cm increments were used to summarize the length frequency of the survey catches in each year. Table 16 shows the number of lengths taken by the survey.

Length compositions were separated into males and females. These length compositions were expanded to account for difference in catch among tows, with further expansion based upon the stratification by depth and latitude using the {nwfscSurvey} package in R (Wetzel, Johnson, and Hicks 2025). The stratification for length data expansions are provided in Table XX. Figure 20 shows AFSC Slope Survey length frequencies by year.

The input sample sizes for length composition data for all fishery-independent surveys were calculated based on Stewart and Hamel (2014) as Input $N_y = 2.43 * N_{tow}$ where the 2.43 value was estimated for a group of shelf and slope rockfish species.

There are no Rougheye/Blackspotted Rockfishes age data from the AFSC Slope Survey.

2.2.4 NWFSC Slope Survey

2.2.4.1 Survey Description

The NWFSC slope survey was conducted annually from 1999 to 2002. The survey's design and sampling methods are described in Keller et al.(2007). The surveyed area ranged between 34°50' and 48°07' N. latitude, encompassing the U.S. Vancouver, Columbia, Eureka, Monterey INPFC areas, and a portion of the Conception area, and consistently covered depths from 100 to 700 fm (183-1280 m) (Table XX).

2.2.4.2 Abundance Index

The prediction grid was truncated to only include available survey locations in depths deeper than 183 to limit extrapolating beyond the data and edge effects.

The chosen model used a delta model with a lognormal distribution for the catch-rate component. A logit-link was used for encounter probability and a log-link for positive catch rates. The response variable was catch (mt) with an offset of area (km^2) to account for differences in effort. Fixed effects were estimated for each year. No other covariates were modeled. Vessel-year effects, which were historically used for index standardization of this survey, were not included because the estimated variance for the random effect was close to zero. Vessel-year effects were more prominent when models did not include spatial effects and instead vessel-year terms accounted for the random selection of commercial vessels used during sampling (Helser, Punt, and Methot 2004; J. T. Thorson and Ward 2014).

Spatial and spatiotemporal variation were not included in either the encounter probability nor the positive catch rate model. Spatial variation was approximated using 100 knots, where more knots led to non-estimable standard errors because the positive encounters are too sparse to support the dense spatiotemporal structure.

The NWFSC Slope Survey index is shown in Figure 36. The index is short, and, as in case of AFSC SLope Survey, does not exhibits significant change over the four year period.

There are no Rougheye/Blackspotted Rockfishes length and age data from the NWFSC Slope Survey. Given that spatial coverage of NWFSC Slope Survey is the same of AFSC Slope Survey, selectivity of the NWFSC SLope Survey was assumed the same as selectivity of AFSC Slope Survey (mirrored in the model).

2.3 Biological Parameters

The major biological inputs to the models are natural mortality, age and growth parameters, weight-length, maturity and stock-recruitment parameters. The following sections outline the treatment of each section. One change from the previous assessment is moving to a two sex from the one-sex specification from 2013. The 2013 stock assessment one-sex specification was based on the observation that the biology of females and males was very similar, thus justifying the simplifying assumption of one sex. The following sections below demonstrates that females and males do generally have similar growth, though there are differences, but may have different natural mortality values. The current assessment will use a two sex configuration that allows for flexibility to set female and male parameters either equal (i.e., functionally equivalent to a one sex model) and or sex-specific. Figure 39 and Figure 40 show that using a two sex configuration with the same life history parameters for females and males is equivalent to the one sex model. Note that the one sex model sums up both female and male biomass, thus why it is twice the size as the two sex female-only spawning output (Figure 40).

2.3.1 Natural Mortality

Natural mortality is a highly influential parameter in age-structured stock assessments. It defines the rate of natural death by age, and thus establishes a stable age-structure and expectation of longevity, and interacts with growth and reproduction to determine stock productivity. It is a very difficult parameter to directly measure, thus empirical relationships based on life history parameters are often used to indirectly determine its value or build prior distributions in belief of what it is in the event we do attempt to estimate it in the model (Cope and Hamel (2022); Hamel and Cope (2022); Maunder et al. (2023)). If length and age data are available, it may be possible to estimate it in the model.

An estimate of maximum age tends to be the most reliable life history parameter related to natural mortality to inform its estimation. Cope and Hamel (2022) (The Natural Mortality Tool) provide the most up-to-date examination of the relationship between maximum age and natural mortality

$$M = \frac{5.4}{A_{\max}}$$

where M is natural mortality and A_{max} is the assumed maximum age. The prior is defined as a lognormal distribution with mean $ln(5.4/A_{\text{max}})$ and standard error = 0.31. This is the equation typically used to estimate a natural mortality point estimate, but is underpinned by the choice of the value of A_{max}. This equation assumes that the proportion of the stable population at this maximum age is 0.4517%. If we take humans as an example, the longest lived human is 122 years. This is not the maximum age, but the oldest ever recorded age. The maximum age that corresponds to 0.4517% of the population is around 100 years. For Rougheye/Blackspotted, the oldest ever aged individual is 205 years with unknown ageing error. We did not consider this as a realistic maximum age.

The 2013 U.S. west coast stock assessment used a prior built around a mean of 0.034 (corresponding to a maximum age of 163), but estimated natural mortality at 0.042 (maximum age between 128-129 years; **Figure M**). The 2023 Gulf of Alaska assessment built a prior conditional on a estimate of natural mortality from their 5 oldest aged individuals that ranged from 126-135 years. This resulted in a mean value of 0.042, similar to the 2013 U.S. west coast stock assessment. The 2023 Bering Sea/Aleutian Islands assessment used M = 0.05 (assumed longevity of 108), and the recent Canadian assessments considered a range of M values from 0.03 to 0.055 (assumed maximum ages of 180 to 98 years; Figure 41).

We attempt to estimate natural mortality, as was done in the 2013 U.S. West coast assessment. Examining the available age data, the oldest 10 individuals range from 139 to 165 and were all males. For females, the 10 oldest individuals range from 130 to 121 years. If those oldest ages were used in the Hamel and Cope (2022) longevity estimator, these ages would correspond to a range of natural mortality values of 0.033 to 0.039 for males, which include the mean of the prior used in the 2013 assessment. For females, it corresponds to natural mortality values of 0.039 to 0.045. All these assume that the sampled population has enough of an age structure still available for sampling, as opposed to having some level of age truncation from the theoretical unfished stable age distribution.

Related to this issue of possible age truncation, applying a catch curve analysis (taking the log of the abundance of numbers of samples in available age classes) on the aggregated ages across all age sources by sex, the total mortality (Natural + Fishing mortality= Total mortality) is 0.046 for females and 0.035 for males, which may indicate the natural mortality could be lower than that used in the 2013 assessment, but within the range of values considered in other areas (Figure 42). This also indicates the possibility of estimating sex-specific natural mortality, as natural mortality may differ by sex. The two sex model allows for this type of model specification exploration. Further exploration was done my truncating the upper ages considered, with the assumption that the older ages may also not be sampled fully (i.e., dome-shaped selectivity). We considered both 100 (Figure 43) and 80 (Figure 44) as upper age cut-offs. The less older individuals included, the higher the estimate of total mortality, and this a higher natural mortality. But we can see a general overestimate of how many older individuals are expected using these higher Z values, thus dome-shapeness does not see to explain the sampling of these older individuals.

One challenge to estimating natural mortality within the model is the interaction of estimating dome-shaped selectivity with estimating natural mortality. If all fleets assume some level of dome-shaped selectivity, it is difficult to determine if the unseen larger, older individuals are due to natural death or fishing mortality. Typically, at least one major fleet needs to achieve full selectivity for the larger, older individuals. The 2013 assessment suggested some dome-shaped selectivity in the two major fleets, thus any natural mortality estimates are evaluated depending on the forms of fleet selectivity.

2.3.2 Growth (Length-at-Age)

Age and length data are used to estimate important growth parameters. Figure 45 has the currently available age and length data. Female and male sample sizes are very similar. Estimated growth curves are also presented in Figure 45 and the parameters are provided in Table AL_1. The West Coast Groundfish Bottom Trawl Survey clearly and importantly samples the smallest, youngest individuals compared to the other two data sources. This allows for a better estimate of the age at size 0 (t_0) and growth coefficient (k). The female asymptotic size (L_∞) is estimated notably higher from the PacFIN data, though male estimates of Linf are similar across the data sets. The overall externally derived estimates of female and male Rougheye/Blackspotted Rockfishes are

$$\text{Females } L_\infty = 59.03 \text{ cm; } k = 0.07\text{; } t_0 = \text{-}2.45$$

$$\text{Males } L_\infty = 56.69 \text{ cm; } k = 0.08\text{; } t_0 = \text{-}2.03$$

The coefficient of variation (CV) of length by age and sex are shown in Figure 46. This is a measure of the variation in length for a given age class. Sample sizes are highest from the youngest ages up to around 70 (females) to 80 (males) years. The smoothed line shows the average response, and indicates similar CVs values for females and males, with the highest at the youngest ages, but generally 0.1. The amount and range of age samples, along with repeated length samples within an age class, allows growth parameters (L_∞, k, t_0, and CVs at age) to be estimated in the model. Ages are conditioned on lengths in the model in order to estimate growth within the model. We also explore sensitivity in growth values by pre-specifying growth to different values.

We note that the growth values being estimated in our data are notably different than those used in Alaska. For instance, the growth parameters for the BSAI stock is L_∞ = 51.43, k = 0.06 and t_0 = -3.30 and L_∞ = 54.2 cm, k = 0.07, t_0= -1.5 for the GOA population (both sexes combined). These growth parameters shows a larger size and faster growth of the West Coast stock complex versus those in Alaska, though the West Coast stock complex is more similar to the GOA complex.

2.3.3 Ageing Bias and Precision

Counting ages from ageing structures in long-lived, temperate fishes is challenging. Ages derived from these structures can be hard to reproduce within and between readers (i.e., imprecision), and may not contain the true age (i.e., bias). Stock assessment outputs can be affected by bias and imprecision in ageing, thus it is important to quantify and integrate this source of variability when fitting age data in assessments. In Stock Synthesis 3, this is done by including ageing error matrices that include the mean age (row 1) and standard deviation in age (row 2). Ageing bias is implemented when the inputted mean age deviates from the expected middle age for any given age bin (e.g., 1.75 inputted versus 1.5 being the true age for the age 1 bin); ageing imprecision is given as the standard deviation for each age bin.

There are eight primary readers that provided the available ages, two of which often split the ageing duties. Figure 47 shows which reader assignments are given to each year of ages by data source. Reader 7 is the mix of two readers that shared reading duties within years.

Estimation of ageing error matrices used the approach of (2008) in two different forms: one developed in AD Model Builder (nwfscAgeingError (J. T. Thorson, Stewart, and Punt 2012)) and one adapted to Template Model Builder framework (TMB). The ageing error matrix offers a way to calculate both bias and imprecision in age reads. Reader 1 is always considered unbiased, but may be imprecise. Bias relative to the primary reader is given for the second reader. There were three age readers that were assumed to be unbiased. In those cases, 12 model configurations based on different assumptions of imprecision (constant CV, curvilinear standard deviation, or curvilinear CV, along with an option to either share or independently estimate imprecision between readers) were considered. For the other four age readers that could be biased and/or imprecise, thirty-six total model configurations were explored that included the above imprecision models as well as an exploration of the functional form of bias (e.g., no bias, constant coefficient of variation, or non-linear bias) in the second reader.

Model selection criteria included AIC corrected for small sample size (AICc), which converges to AIC when sample sizes are large, and Bayesian Information Criterion (BIC). Both ADMB and TMB were run using an (ageing error shiny app). Model selection was then compared between ADMB and TMB, which did not always agree, so model selection criteria was added across the two modeling approaches to get an overall model selection criteria. Ageing error matrices were also inspected for behavior in the best supported models to make sure outrageously large precision or bias was not chosen (effectively rendering the ages worthless, which is not an assumption of the quality of the ages). Figure 48 and Figure 49 show the bias and imprecision assumptions applied for each ageing error (AE) matrix.

2.3.4 Length-Weight Relationship

Female and male length-weight relationships were determined using data from the PacFIN database, West Coast Groundfish Bottom Trawl Survey, and ASHOP samples. Samples size by sex were: female (N=13839), males (13625), and unknown sex (53). Each of the data sources estimated very similar length-weight relationships (Figure 50).

The resultant sex-specific length-weight relationships are given in Figure 51, with the following individual values:

- Females: $W = 0.000008L^{3.15}$
- Males: $W = 0.000012L^{3.07}$

These values are very similar to the previous assessment that used a combine sex value of a=0.0000096 and b=3.12000 (Figure 51).

2.3.5 Maturity

Maturity for the Rougheye/Blackspotted Rockfish complex was estimated using 473 maturity samples collected from 2015 to 2024 on Oregon Department of Fish and Wildlife (ODFW) and Washington Department of Fish and Wildlife (WDFW) surveys and the gls{indexwc} in California, Oregon, and Washington waters (M. Head, pers. comm.). The samples included 194 samples genetically assigned as Rougheye Rockfish, 71 samples genetically assigned as Blackspotted Rockfish, and 208 samples with no genetic assignment. The maturity schedule was assumed to be length-based, as in the 2013 benchmark assessment. This assessment used the functional classification of maturity to describe the maturity schedule, which not only identifies the individuals that are physiologically capable of producing yolk (those that are biologically mature), but also accounts for the occurrence of abortive maturation and skipped spawning, so the functional maturity classification is a more accurate representation of the individuals that may actually spawn in a given year. This is a difference from the 2013 benchmark assessment, which did not explicitly estimate functional maturity, and instead assumed the biological classification of maturity.

Biological maturity and functional maturity observations were fitted in separate models. Biological maturity and functional maturity status observations (0 = immature and 1 =

mature) were fitted in a logistic regression model (glm R function, family = binomial, link = “logit”). The estimated model parameters were used to calculate length at 50% maturity (L50%; Table 18) and maturity ogives (Figure 52). The delta method was used to calculate 95% confidence intervals of L50% estimates. The estimated L50% (functional maturity; L50%fxn) was 46.53 cm and the estimated slope of the maturity oogive was 0.25. Sensitivities were run using the estimate of biological maturity and the maturity estimate used in the 2013 benchmark assessment. There was little evidence of skipped spawning, so we did not explore fitting the data with a spline model.

Because there are known life history differences between Rougheye Rockfish and Blackspotted Rockfish, maturity was also estimated for each species, using the samples that were genetically assigned to each species, respectively, using the same methods as above (Table 18 and Figure 53). Two sensitivities were run using the functional maturity L50% (and slope) estimated for 1) Rougheye Rockfish and 2) Blackspotted Rockfish (which mature at larger sizes on average than Rougheye Rockfish).

Sensitivities were run using functional age at 50% maturity estimate for the species complex (n = 372) and for each species separately. Age at 50% maturity was estimated using the same methods as for length at 50% maturity (Table 18 and Figure 54).

2.3.6 Fecundity

The 2013 U.S. west coast stock assessment assumed that fecundity was proportional to weight. Dick et al. (2017) provided a study on rockfishes showing that rockfishes routinely have a non-proportional relationship of fecundity to weight, with larger individuals producing more eggs than expected only by weight. Neither Rougheye or Blackspotted rockfishes have a species- of subfamily-specific estimate for this relationship, so this stock assessment uses the unobserved Genus Sebastes values of a = 6.538e-06 and b = 4.043 using the F=aL^b relationship. In order to adapt the a parameter for SS3, the equation (a*10^b)/1000 was used to scale the a parameter to millions of eggs. This results in a = 7.218466e-05.

2.3.7 Stock-Recruitment Function and Compensation

The Beverton-Holt stock recruit relationship is assumed, as it was in the 2013 assessment, to describe the relationship between spawning biomass and recruitment. The steepness parameter may be considered for estimation, but it is notoriously difficult to estimate in assessment models. The 2013 stock assessment used the previous rockfish steepness mean value of 0.77, but this has subsequently been updated to 0.72, to a value that represents a stock with somewhat lower recruitment compensation. Natural variation in recruitment (i.e., not deterministically taken from the stock-recruit curve) is apparent in the length and age data (as notable length or age classes growing/ageing over time), so deviations in recruitment are estimated.

2.3.8 Sex Ratio

No information on the sex ratio at birth was available so it was assumed to be 50:50.

2.4 Environmental and ecosystem data

This stock assessment does not explicitly incorporate trophic interactions, habitat factors or environmental factors into the assessment model. More predation, diet and habitat work, and mechanistic linkages to environmental conditions would be needed to incorporate these elements into the stock assessment and should remain a priority. McClure et al. (2023) report the climate vulnerability for several west coast groundfishes, including Rougheye/Blackspotted Rockfishes. Rougheye/Blackspotted Rockfishes demonstrated both high biological sensitivity and high climate exposure risk, to give it an overall high vulnerability score to climate change. This result should also be considered with the fact that, like many rockfishes, periods of low productivity is not unusual to Rougheye/Blackspotted Rockfishes and their extended longevity (though admittedly this seems shorter than previously believed and should be reconsidered) has historically allowed them to wait for advantageous productivity periods. Stressors such as habitat degradation and climate change could bring significant challenges to population sustainability. Regardless, no environmental or ecosystem data are directly incorporated into the stock assessment model.

3 Assessment Model

3.1 History of Modeling Approaches

Rougheye Rockfish (not including Blackspotted) on the U.S. Pacific Coast was first evaluated in 2010 by Dick and MacCall (2010) using depletion-based stock reduction analysis (DB-SRA), as Category 3 stock. That model estimated the population had greater than a 50% probability of exceeding the estimated proxy overfishing level in 2010 if the harvest remained at the observed levels. DB-SRA estimated a proxy OFL for Rougheye Rockfish of 78.7 mt with a 95% confidence interval between 4.7-587 metric tons.

The first benchmark assessment forRougheye/Blackspotted Rockfishes was conducted in 2013 (Hicks, Wetzel, and Harms 2013). A 2013 benchmark stock assessment used Stock Synthesis (version 3.24O) integrated statistical catch-at-age model, which is different from the delay-difference model with an assumed stock status prior DB-SRA analysis used in 2010. The stock assessment has been used for management as a Category 2 stock assessment. The 2013 assessment used a substantially updated catch history, indices of abundance, and biological compositions (lengths and ages). The natural mortality value was also updated to be higher value than the one used in the DB-SRA model. The 2013 assessment also assumed logistic selectivity for all fleets and surveys, except for Triennial Shelf Survey, which was allowed to be dome-shaped. With higher natural mortality and asymptotic selectivity assumptions, the 2013 assessment estimated 2013 spawning biomass to be at 47% relative to unfished equilibrium spawning biomass, with a 95% confidence interval between 30.5% - 64.2%. The 2013 spawning biomass was estimated to be 2,552 metric tons, with a 95% confidence interval between 1,024 - 4,081 metric tons.

With this new benchmark assessment, we re-evaluate all the data sources available for Rougheye/Blackspotted Rockfishes, analyse new and re-analyse previously used data with current statistical methods and best practices, and re-evaluate modelling assumptions. Detailed description of changes made since 2013 benchamrk assessment is provided in Section 3.3.

3.2 Response to Most Recent STAR Panel Recommendations

There were several recommendations from the 2013 STAR panel, broken into two categories

3.2.1 General recommendations

1. *Investigate data-weighting options.* This has been an ongoing research topic in stock assessments over the last several decades, and several options are now available for consideration James T. Thorson et al. (2017). In this assessment, we use Francis (2011) method, and explores other methods of data weighting within sensitivity analysis described in Section 3.9.1.
2. *A workshop for constructing abundance indices from survey GLMMs.* This is another topic that has developed greatly since this time. Our use of spatio-temporal models are described in the data section on abundance indices Anderson et al. (2022).
3. *Continue collection of ages.* This had been done, and this assessment benefits from several more years of age data.
4. *Exploring historical catches.* This again has been an ongoing topic and addressed for many of our groundfishes. We use the latest estimates in this assessment.
5. *SSC guidance on decision tables.* Decision table discussion evolve after every stock assessment cycle, and we are using the latest approaches to decision tables in this assessment.
6. *Investigate fishery-independent slope surveys, such as submersibles.* These surveys are still not available for slope species.

3.2.2 Stock-specific recommendations

1. *Collecting additional age data.* This has been done and included in this stock assessment.
2. *Collecting genetic material to explore distinguishing Rougheye and Blackspotted Rockfishes.* This work has been done as was presented earlier in the document when discussing stock structure decisions.
3. *The cause of the re-occurring decrease in sizes around 40cm.* The data continue to exhibit a lack of 35-40cm fish in fleets that catch smaller fish (WCGBTS and Triennial Survey, and bottom trawl discard fleet), creating bimodal distributions of length data (Figure 66). We found that this pattern is not caused by the relative depth distribution of two stocks within the complex, with Rougheye Rockfish being shallower and Blackspotted Rockfish deeper. Figure 55 (pers. comm. P. Frey, NWFSC) shows the length distribution of Rougheye Rockfish and Blackspotted Rockfish identified to species using genetics, and the Rougheye Rockfish still shows a bimodal length distribution. Further analysis reveals that this bimodal length distribution is not limited to Rougheye/Blackspotted Rockfishes, but is also evident in multiple other rockfish species. We continue to explore data to understand mechanisms behind this pattern, which are potentially related to accessibility of trawl gear to habitats specific to that size group. In this assessment we were able

to fit the bimodal length distribution by allowing surveys' selectivity curves more flexibility, and not fixing it asymptotic as in the previous assessment.

4. *Additional maturity and fecundity studies.* While no fecundity studies are available, updated maturity is presented in the maturity section of the document.
5. *Age validation.* While no age validation study has been completed, the age readers are confident what annuli represent a year's worth of growth. Multiple ages are available and ageing error is characterized in this stock assessment.
6. *Understanding stock structure.* Discussed in the Section 1.1 of this document.
7. *Connectivity of stocks across the species ranges.* This is also discussed in the Section 1.1 of the document.

3.3 Model Changes from the Last Assessment and Bridging Analysis

The last full assessment of Rougheye/Blackspotted Rockfishes was conducted in 2013. The 2013 assessment model was the starting point for this assessment. We included a number of improvements related to use of data, model structure and modeling techniques. Below, we describe the most important changes made since the last assessment:

- Upgraded the model to Stock Synthesis 3.30.22.1 version. This is standard practice to capitalize on newly developed features and corrections to older versions as well as improvements in computational efficiency. The list of changes made to Stock Synthesis since 2013 can be found in the model change log. No discernible differences were produce by this change. The status (Figure 56) and scale (Figure 57) of both models are exactly the same, as are the estimates of within model uncertainty.
- Specified a two-sex model, instead of one-sex model, to allow sex-specific estimation of natural mortality and growth. No discernible differences were produce by this change either (Figure 39 and Figure 40).
- Included bottom trawl and non-trawl discards as separate fleets (see Section 3.4.3 for details), instead of treating them as part of the same fleets as landings. Results did not impact the model output (Figure 58 and Figure 59).
- Split mid-water trawl catches from bottom trawl landings and treat them as a separate fleet (see Section 3.4.3 for details), to account for gradually increasing contribution of mid-water trawl catches. Results did not impact the model output.
- Updated historical and current fishery removals, to include most up to date information. Since 2013 assessment, WDFW completed historical catch reconstruction of rockfish, and newly estimated landings represent improvement. For the period between 1987 and 1999, Oregon PacFIN landings were supplemented with the additional estimates of Rougheye/Blackspotted Rockfisheslandings reported within unspecified rockfish market categories. Results did not impact the model output.
- Recalculated survey abundance indices using sdmTMB geostatistical model. Results did not impact the model output.

- Added more biological compositions, mainly in years since 2013, but also some historical ages. Adding more composition data resulted in sight increase in stock scale (Figure 60).
- Updated input sample sizes associated with fisheries and survey length composition data to using a function of number of trips and number and fish (rather than number of trips and number of hauls, as in previous assessment), to follow current best practices and ensure a consistent treatment of fishery and survey input data.
- Updated ageing error matrices.
- Updated weight-length, maturity and fecundity parameters, to include most up to date and improved information.
- Updated spawn-recruit parameters with Beverton-Holt steepness fixed at 0.72, and recruitment variability at 0.5 for consistency with the calculated recruitment variability in the model.
- Assumed natural mortality for males consistent with maximum ages of observed for Rougheye/Blackspotted Rockfishes, while estimating female natural mortality using the Hamel and Cope (2022) prior. Previously, natural mortality for both sexes was estimated within the model, but estimated values were higher than expected for maximum ages observed for this stock. This change reduced the natural mortality values for both sexes, which resulted in decreased scale of the stock.
- Provided flexibility for the bottom trawl fleet and bottom trawl surveys to estimate dome-shaped selectivity (Figure 132), previously assumed asymptotic. This change was prompted by the lack of fit to length compositions data. Also, the examination of mean fish lengths by fleet indicated that the bottom trawl fleet capture smaller fish than midwater-trawl and non-trawl gear. This change resulted in a substantial increase of stock scale, and is considered an improvement to the model structure. We also allowed estimated selectivity to vary with time in both the bottom trawl and non-trawl fleets, to account for management changes that can impact selectivity of these fleets.

Bridging analysis was conducted to illustrate the impacts of incremental changes. With the new fecundity parameters, the 2025 model produces spawning output (in millions of eggs) rather than spawning biomass (in mt as in 2013 model); so with different metrics, these outputs were no longer comparable between the two models. However, we ran the 2013 model with new fecundity parameters to allow for direct comparison of the results from the bridging runs. The bridging analysis, with the most influential steps done sequentially, is shown in Figure 60 and Figure 61.

This assessment (compared to 2013 assessment) estimates much higher stock scale, primarily, as discussed above, due to changes in treatment of selectivity parameters and relaxing asymptotic selectivity assumptions for the bottom trawl fleet and bottom trawl surveys. Changes in selectivity assumptions allow to substantially improve fits to length and age composition data in fisheries and surveys. The stock scale was also affected by the changes in treatment of natural mortality, bringing the scale down to a lower level compared to the previously used natural mortality assumption.

3.4 General Model Specifications

3.4.1 Modelling Platform

Stock Synthesis statistical catch-at-age modelling framework (Methot and Wetzel 2013), version 3.30.23.1, is used for this assessment. This framework allows the integration of a variety of data types and model specifications. The Stock Assessment Continuum tool (https://github.com/shcaba/SS-DL-tool) was also used to explore model efficiency, likelihood profiling, retrospective analyses, and plotting sensitivities. The companion R package r4ss (version 1.51.0) along with R version 4.4.3 were used to investigate and plot model fits.

3.4.2 Model Structure

This stock assessment is for the Rougheye/Blackspotted Rockfishes, two species that form one management complex. Assessment area is from the U.S.-Mexican border om the south to the U.S. Canadian border on the north (Figure 1). The assessment excludes consideration of the Puget Sound and Salish Sea. Within this area, the assessment treats the U.S. Rougheye/Blackspotted Rockfishes resource as a single coastwide stock.

This is a sex-specific model. The sex-ratio at birth is assumed to be 1:1. Females and males have separate growth curves (fully estimated within the model) and sex-specific weight-at-length parameters. The model assumes a constant natural mortality of 0.036 yr-1 for males, while natural mortality for females is estimated based on Hamel and Cope (2022). The length frequency distributions are represented as thirty six 2-cm bins ranging between 10 and 80 cm. Population length bins are defined at a finer 2-cm scale, ranging between 4 and 84 cm. Age data is included as conditional age-at length compositions with bins ranging between 1 and 100 years.

The modeling period begins in 1892, and the stock prior to that is assumed to be in an unfished equilibrium condition.

3.4.3 Fleet Definitions

The model is structured to track six fleets and include data from four surveys.

Defining fleets is largely based on differing fleet selectivity (i.e., how the fishery captures fish by length and/or age). In the stock assessment model, selectivity translates into how the removals are taken via length and/or age out of the population. In this assessment, the following fleet structure is being used to model commercial fishery removals:

- Fleet 1: Commercial bottom trawl fishery.
- Fleet 2: Dead discard from bottom trawl fishery.
- Fleet 3: Commercial non-trawl (mainly the long-line) fishery.
- Fleet 4: Dead discard from non-trawl fishery.
- Fleet 5: Contemporary mid-water trawl fishery.
- Fleet 6: At-sea hake fishery bycatch.

In 2013 assessment (Hicks, Wetzel, and Harms 2013), fisheries removals were split among three fleets - trawl, hook-and-line and at-sea hake fishery bycatch. For the first two fleets (trawl and hook-and-line), removals were divided between landings and discards, with selectivity and retention curves estimated within the model.

In this assessment, we treat discards in trawl and non-trawl fisheries as separate fleets from landings fleets.

Treating discards as separates fleets from landings provides several advantages, including:

- With separate discard fleets, we can easily track relative amounts of landings and discards within a fishery (they are not being combined into the total catch).
- This approach provides more flexibility to explore different selectivity assumptions for both landed and discarded fish dome-shaped vs asymptotic, mirroring one to the other, etc.
- This approach allows to avoid hard to diagnose issues that come from estimating retention curves (especially with limited amount of data).
- The biological data for landings and discards are collected independently (port sampling vs on-board observers), and using different sampling approaches. Treating landings and discards as separate fleets in the model allows us to weight those data sources separately as well, to balance the representation of samples.

The change in treating discards as separate fleets does not impact model results (Figure 58 and Figure 59), regardless of the selectivity form being assumed for the discard fleets. Historically, no discarding was observed for Rougheye/Blackspotted Rockfishes (Pikitch, Erickson, and Wallace 1988), see Section 2.1.2.1 for details. The 2013 assessment estimated zero historical discard for both trawl and fixed gear fleets, based on the available data. In this assessment, therefore, we assume no discard until early 2000, when the first Rougheye/Blackspotted Rockfishes was observed after the introduction of trip limits for rockfish.

We also split trawl fishery data into bottom trawl and mid-water trawl fleets. Catch data indicates that contribution of mid-water trawl catches gradually grew over the past 20 years, and now they represent majority of the trawl removals (Figure 5). Historical information on mid-water catches of Rougheye/Blackspotted Rockfishes comes from Pikitch, Erickson, and Wallace (1988), which has no records of Rougheye/Blackspotted Rockfishes mid-water trawl catches, neither retained nor discarded. Also, Oregon historical catch reconstruction (Karnowski, Gertseva, and Stephens 2014) has only one record of 0.0002 metric tons of Rougheye/Blackspotted Rockfishes taken in 1985, even though the mid-water trawl catches had their own market category in Oregon since the early-1980s (Karnowski, Gertseva, and Stephens 2014), and multiple rockfish species are reported as caught by this gear. This information suggest that historically Rougheye/Blackspotted Rockfishes mid-water catches were negligible.

As reported in Section 2.2, the following surveys are included in the model:

- Survey 1: West Coast Groundfish Bottom Trawl Survey (WCGBTS; 2003-2024)
- Survey 2: Triennial (every three years) Survey (1980-2004)

- Survey 3: Alaska Fishery Science Center (AFSC) Slope Survey (1997-2001)
- Survey 4: Northwest Fisheries Science Center (NWFSC) Slope Survey (1999-2001)

We use length-based selectivity curves for all fleets for this stock assessment model (as was done in the 2013 assessment), as there is no evidence that significant age-based selectivity is occurring. We considered logistic and dome-shaped selectivity options for various combinations of fleets and time periods during model development.

3.4.4 Model Likelihood Components

There are five primary likelihood components for each assessment model:

1. Fit to length composition samples.
2. Fit to age composition samples (all fit as conditional age-at-length).
3. Fit to survey indices of abundance.
4. Penalties on recruitment deviations (specified differently for each model).
5. Prior distribution penalties

In addition, there is a catch component to the likelihood, but catches are essentially fit without error. Additionally, there is a crash penalty that is invoked if true catches would cause the stock to go extinct. The penalty would alter catches to avoid extinction, but any presence of a crash penalty is used as in indication that the model has been mispecified, so this likelihood contribution should always be 0.

3.4.5 Data Weighting

Initial sample sizes for the length and conditional age-at-length compositions were also considered for additional data-weighting. The method of Francis (2011), specifically equation TA1.8, was used to re-weight the length and conditional age-at-length composition data against other inputs and likelihood components. The Francis method treats mean length and age as indices, with effective sample size defining the variance around the mean. If the variability around the mean does not encompass model predictions, the data should be down-weighted until predictions fit within the intervals. This method accounts for correlation in the data (i.e., the multinomial distribution), but can be sensitive to years that are outliers, as the amount of down-weighting is applied to all years within a data source, and are not year-specific. Sensitivities were performed examining different data-weighting treatments: 1) the Dirichlet-Multinomial approach (James T. Thorson et al. 2017), 2) the McAllister-Ianelli Harmonic Mean approach (McAllister and Ianelli 1997), or 3) no additional data-weighting.

The ability to estimate additional variance for indices allows the model to balance model fit to that data while acknowledging that variances may be underestimated in the index standardization. Given the large inputted variances and the limited contrast in the index trends did not require the consideration of further variance estimation. Removal of the index data was explored to demonstrate the limited influence of this data in the model.

3.5 Model Parameters

3.5.1 Estimated and Fixed Parameters

The full list of estimated and fixed parameters are found in Table 21.

All growth parameters were estimable and did not change across the large majority of explored model scenarios, so they were estimated in the reference model. Natural mortality (M) was not estimable for both sexes. When attempted, both values were estimated at values that caused the scale to approach the higher end of reasonable values, and thus not a risk neutral option. In order to balance model fit and reality, a likelihood profile was conducted on natural mortality for males (females M being estimated) in order to find the lowest supported (i.e., within 2 negative log likelhood units) by the data male M value. The profile shows conflicting information in the data, where lengths support higher natural mortality values and ages support lower natural mortality (Figure 62). It is expected that ages would be more informative to natural mortality, which encourages considering just the age component likelihood. Most of the age components are not well informed for natural mortality, though the at-sea-hake fishery sampled age data does seem to be informative. This fishery has a logisitic selectivity, thus obtaining large and old individuals. Using this component likelihood, the value of 0.036 for male M is the lowest value supported. The reference model this fixes male M to this value and estimates female M. Length-at-maturity, fecundity-weight, and length-weight relationship were all fixed, as is the only treatment option in SS3.

For recruitment, steepness (h) was not estimable and was fixed to the rockfish prior of 0.72. Recruitment variability was set at 0.5 and checked for consistency with the calculated recruitment variability in the model. Recruitment deviations were estimated as a deviation not constrained to sum to 0, and initially estimated for the full time series. If the full time series was not estimated, the scale and status of the stock increased to unrealistically high levels, so the full time series estimation was retained. Given the longevity of these species, information on recruitment going deeper into the time series is not unreasonable.

3.5.2 Selectivity Assumptions

The selectivity of all fisheries and surveys were estimated either as logistic or dome-shaped selectivity. Blocks were also added as described in the data section. In the attempt to fit the biological data, it was found that bottom trawl fisheries, just as the trawl surveys were treated, only fit the data if the selectivity was domed. All fisheries that had final dome-shaped selectivity were given the flexibility to be logistic if it led to a better fit. The midwater, at-sea-hake and the final block of the non-trawl fisheries all required logistic selectivity to fit the data. The use of dome-shaped selectivity for the bottom trawl was a major difference from the previous stock assessment. The choice of selectivity for the bottom trawl survey changed the scale and status of the stock and therefore a major source of sensitivity.

3.6 Model Selection and Key Assumptions

The reference model for Rougheye/Blackspotted Rockfishes was developed to balance parsimony and realism, and the goal was to estimate a risk neutral spawning output trajectory and relative stock status for the stocks of Rougheye/Blackspotted Rockfishes in state and federal waters off the U.S. West Coast. To achieve the above goals, the model uses different data types and sources to estimate reality, but relies on simplifying assumptions when the data are not informative to parameters. A series of investigative model runs were done to achieve the final reference model. Constructing integrated models (i.e., those fitting many data types) takes considerable model exploration using different configurations of the following treatments:

- Data types and weighting

- Parameter treatments: which parameter can, cannot and do not need to be estimated
- Phasing of parameter estimation
- Exploration of local minima vs global minimum (see Model Convergence and Acceptability section below)

Regarding data types, different biological data (i.e., length and/or age composition) with and without the catch time series (and no additional data weighting) were first included to obtain an understanding of the signal of stock status coming from the data (Figure XXXXXX). The length and age only models assume fixed life history values (growth fixed to external estimates, natural mortality assume the reference model values) and constant catch over the entire time series, while estimating the selectivity of each fleet. Under this constraint, the lengths suggest a stock status lower than the reference model, while the ages consider the stock is less depleted than supported by the ages (with no ageing error), and more similar to the reference model. Adding ageing error, Putting the two data sources together produce an intermediate stock status in the lower precautionary zone. Adding the catch time series substantially changes the stock status trajectory, with length or age only model above the reference stocks status. Combining the two came out just under the reference model. Only one model includes recruitment deviations, and demonstrates more dynamics behavior similar to that seen when biological compositions are unweighted (see Model Specification Sensitivities section).

Stock scale was comparable once removal history was included, and demonstrates a large sensitivity to the scale of the stock given the data with no additional weighting included (Figure).

Numerous exploratory models that included all data types and a variety of model specifications were subsequently explored and too numerous to fully report. In summary, the estimation of which life history parameters to estimate and fix was liberally explored.

The following is a list of things that were explored, typically in combination with one another

- Estimate or fix M
- Estimate or fix any of the three growth parameter for each sex
- Estimate or fix the stock-recruit relationship
- Estimate or assume constant recruitment. If estimating recruitment, for what years?
- Estimate additional survey variance, and for which survey?
- Logistic or dome-shaped selectivity?
- Estimate or fix selectivity parameters

The biggest uncertainty was in the treatment of sex-specific M and the selectivity of the bottom trawl fishery. The combination of these two sources covered the extent of all other sources of uncertainty observed and presented in the “Characterizing uncertainty” section of the document. The parameters uncertainty is different than the uncertainty derived from data treatment, such as ageing error and data-weighting. While these issues cause large uncertainty in stock scale and status estimates, the choice of treatments are based on the common challenge of balancing information content (i.e., what should the data be informing in the stock assessment) in the data within an integrated statistical frameworks. Those explorations are also provided in the “Characterizing uncertainty” section.

General attributes of the reference model are that indices of abundance are assumed to have lognormal measurement errors. Length compositions and conditional age at length samples are all assumed to follow a multinomial sampling distribution, where the sample size is fixed at the input sample size calculated during compositional example, and where this input sample size is subsequently reweighted to account for additional sources of overdispersion (see below). Recruitment deviations were also estimated are assumed to follow a lognormal distribution, where the standard deviation of this distribution is tuned as noted above.

Sensitivity scenarios and likelihood profiles (on lnR_0, steepness, and natural mortality) were used to explore uncertainty in the above model specifications and are reported in the “Characterizing uncertainty” section.

3.7 Model Diagnostics

3.7.1 Model Convergence and Acceptability

While there is no definitive measure of model convergence, several measures are routinely applied. These criteria include a low maximum gradient (0.0015865), inversion of the Hessian (passed), acceptable fits to data (passed), and reasonable parameter values (passed).

Model efficiency was explored by doing a short run Bayesian analysis using the Random Walk Metropolis with 2,000 draws, keeping all the draws and examining the fast mixing parameters. Those estimated parameters that do not move much from the initial values slow the model down and are recommended to be fixed at the starting value (Monnahan et al. 2019). No additional parameters were fixed based on this analysis (Figure 63).

An extra effort was given to ensure the model did not rest on a local likelihood minimum. This was done by starting the minimization process from dispersed parameter values away from the maximum likelihood estimates to determine if the approach found a better model fit (i.e., minimum negative log-likelihood value). Starting parameters used a jitter shift value of 0.01 and 0.05. Both jitter scenarios were repeated 100 times with 78 out of 100 (jitter 0.01) and 49 out of 100 (jitter 0.05) runs returned to the reference model likelihood (Figure 64 and Figure 65). Out of the combined 200 jitter runs, a better fit, lower negative log-likelihood model was not found in any of the remaining runs. The reference model did not experience convergence issues when provided reasonable starting values. Through the jittering and likelihood profiles, the present reference model represents the best fit to the data given the assumptions.

3.7.2 Likelihood Profiles

3.7.3 Retrospective Analysis

A five-year retrospective analysis was conducted by running the model and sequentially removing one year of data up through minus 5 years. Retrospective spawning output (Figure 145) and relatives stock status (Figure 146) show a distinct sensitivity to the removal of the lastest data. Both the scale and status drop when missing the latest model. Once two years are removed, the model returns to something more similar to the reference model. After several additional model runs to explore why this sensitivity is occuring, it was clear that removal of the most recent age data in all fleets causes this pattern. Looking at each of the fisheries mean age data time series, all 4 sources of age data, which have different selectivities, but all of which to some degree include bigger and older individuals, show the consistent pattern of decreasing mean age from 2022 to 2023, and an increase in 2024. These changes, except for the large increase in scale for the -4 and -5, are within the uncertainty of the reference model. The Mohn's rho evaluation of the degree of retrospective pattern in given in Table and shown in Figure . The relative error in the data peels are below significant levels.

3.7.4 Fits to the Data

3.7.4.1 Lengths

Fits to the length data are examined based on the Pearson residuals-at-length, the annual mean lengths, and aggregated length composition data for the commercial and recreational fleets. The aggregate fit to each length composition demonstrates acceptable fits to each fleet and survey source (Figure 66). One noticeable behavior is the trade-off in fit between the fit in the bottom trawl fishery versus the fit in the at-sea-hake (ASHOP) fishery. This current model specification was the best trade off of fits between the two.

Fits to the annual length composition are provided for the following fisheries and surveys:

Fishery

- Bottom trawl (Figure 67 and Figure 68)
- Bottom trawl discard (Figure 69)
- Non-trawl (Figure 70 and Figure 71)
- Non-trawl discard (Figure 72)
- Midwater trawl (Figure 73)
- At-sea-hake (Figure 74)

Surveys

- Triennial (Figure 75)
- Alaska slope (Figure 76)
- West Coast Groundfish Bottom Trawl (Figure 77)

Pearson residuals of fits to the fishery (Figure 78) and survey (Figure 79) length data are reasonably small with no distinct patterns.

Model fits to the mean lengths, assuming Francis data-weighting of 1 and blocking patterns, demonstrate fits within the error bars of most years and no strong residual patterns (Figure 80 to Figure 88). A notable observation in the means lengths within blocks generally show a lack of trend, not surprising given how many years an individual may be at its maximum size. This is in contrast with the age data that do show more nuances in age structure trend (see next section on age fits for more detail). This demonstrates the general lack of contrast in the length data.

3.7.5 Ages

3.7.5.1 Conditional Age at Length

Fits to the sex-specific conditional age at length data are examined based on the age-at-length Pearson residuals, the annual mean ages, and mean age at length by year for the four fishery and one survey source. Pearson residuals were of reasonable size with no distinct patterns (Figure 89 to Figure 98), as most of the residuals were small and not noteworthy and demonstrate the expected shape of the growth curve. There is more contrast in the age data compared to the length data (Figure 99 to Figure 103). While the mean age for fisheries varied by gear selectivity (25-35 years for bottom trawl; 30-40 years for non-trawl; ~40 for midwater trawl; 40-50 years for the at-sea-hake fishery), one commonality was the increase in mean age in the last year of the model. This consistent increase in mean age across fisheries with different selectivities is important to remember when interpreting the retrospective pattern of the model. Mean age for the West Coast Groundfish Bottom Trawl survey, which catch much smaller and less larger individuals, fluctuated around 20 and did not show an mean age increase in the final year. Fits to the mean ages by length bins show acceptable fits consistent with model expectations (Figure 104 to Figure 120).

3.7.5.2 Marginal Age

Marginal age compositions are not fit in the model, but they are included in order to see how well they fit the reference model without influencing the likelihood (Figure 121 to Figure 125). Marginal length and age composition cannot be used in the same model because of the overlap of fish in both samples. This is why ages conditioned on lengths are often used with the length compositions. But it still stands that age compositions, instead of lengths, could be used. So adding the marginal age compositions passively (i.e., not contributing to the overall likelihood of the model) can offer insight into how consistent they are with the current model fit. Overall the realized fits are good.

3.7.6 Fits to Indices of Abundance

The fits to the 4 available indices of abundance demonstrate little information content in the survey indices (Figure 126 to Figure 129). The are all mostly flat with large uncertainty. Such lack of contrast and high uncertainty in the abundance measure indicate the indices contribute little influence to the model (see data sensitvities section below for more details).

3.8 Model Results

As a supplement to the model results figures included in this report and described below, a full set of diagnostic plots created by the {r4ss} package is available at https://github.com/shcaba/REBS-2025 along with the Stock Synthesis input files.

3.8.1 Parameter Estimates

Estimated parameters by category are given in Table 20. The reference model parameter estimates along with asymptotic standard errors are shown in Table 21 and the likelihood components are shown in Table 22. Estimates of derived outputs and reference points and approximate 95 percent asymptotic confidence intervals are provided in Table 23.

The estimate of female natural mortality is higher than the assumed value for males, which fits the expectation given the oldest individuals in the population are all males, and within reason (0.039) given the oldest individual aged female sampled.

Estimated growth parameters values are similar to the externally estimated values (Table 21 and Figure 130), though with some important difference. The estimated L_∞ and k for both sexes were slightly greater and lower than the values estimated externally, respectively. This is not surprising, given external fits assume all variability is in the length at age, while the model incorporates ageing error. Both females and males reach their maximum size at relatively young ages (< half their presumed longevity), thus possibly limiting the information content of lengths on the underlying age structure.

Estimated ending selectivity curves for each fleet and survey (Figure 131) are a mix of dome-shaped (for bottom trawl gears) and logistic (for midwater gears) and look plausible given the biology (i.e., as a model convergence check for realism, the selectivity curves must look plausible). The surveys show the greatest degree of dome-shapeness, while the fisheries selectivities included sampling of at least some of the larger individuals. Time-varying selectivity showed mostly the same functional form for each fleet, despite changes in the selectivity, except for the non-trawl fishery, which changed from dome-shaped in the earlier blocks to logistic in the most recent time period (Figure 132). The realized age selectivity based on the length-based selectivity show even more truncated sampling of older individuals in some of the dome-shaped fleets (Figure 133). Values for the estimated selectivity parameters are in Table 21.

The estimate of initial recruitment (lnR_0) is much higher than the previous assessment (7 vs. 6.20). While this is a large increase in the scale of the stock, a value of 7 is not unusual for shelf and/or slope rockfish species. The estimate of (lnR_0) for Rougheye/Blackspotted Rockfishes is well within the range of other groundfishes in similar habitat (Figure 134). And given this assessment is for two species, the estimate for (lnR_0) is reasonable. There is also a very large variability estimated for this parameter (Coefficient of variation = 0.62), thus scale is generally very poorly informed in this model.

3.8.2 Population Trajectory

The predicted spawning output (in millions of eggs) is provided in Table 24 and plotted in Figure 135. Estimated spawning output shows a decline in the early part of the time series due to poor recruitment, but rise before 1980 from offsetting recruitments (all not well informed), followed by a slight decline during the heaviest period of fishing, though moderated by recruitments in several years over the past 4 decades. The uncertainty around the estimate of spawning output is enormous, highlighting a major feature of the model output.

Relative spawning output never declined below the management target ($SO_{40\%}$) and currently is estimated well above the target (Figure 136; 0.87 in 2025). The uncertainty in stocks status also does not support the stock being below the management target of $SO_{40\%}$. This uncertainty is based only on the asymptotic estimation of variance from one risk neutral model. Further uncertainty exploration is needed to capture a fuller range of uncertainty (see Sensitivity section).

The time series of estimated annual recruitment deviations are shown in Figure 137. The bias adjustment plot (Figure 138) indicates that the most informed recruitment deviations occur after 1980. While post-1980 is the most informed, the recruitment deviations before that time period, while less assure, are important for the model to prepare the population structure for the upcoming increase in fishing while reconciling weak, but still present, signals in recruitment from the biological compositions that can contain information on recruitment for decades given the long-liveness of these species. Sensitvities to when recruitment estimation begins in the model is shown in the Sensitivity section. Numbers of age-0 individuals indicate those years of particularly strong recruitment (Figure 139). Noticeable recruitment years are seen in 1988, 1993, 1999, 2008, 2010, 2012, and 2017 (Figure 140). This amounts to roughly two notable recruitments per decade. Given this assessment is tracking two species, it is hard to tell whether the species are synchronized or showing their own recruiment pulse in this signal.

3.9 Characterizing uncertainty

3.9.1 Sensitivity Analyses

Sensitivity analyses were conducted to evaluate model sensitivity to alternative data treatment and model specifications.

3.9.1.1 Data treatment sensitivities

Data treatments explored the removal of data types (indices and biological compositions), data weighting options and ageing error treatment.

3.9.1.1.1 Removal of data sources

The following data source sensitivities were explored:

- Remove a single index of abundance (Triennial, Alaska slope, NW slope, WCGBTS, all indices)
- For each fleet and index, including discard fleets, removal of length composition data
- For each fleet and the WCGBTS, removal of age composition data

Likelihood values and estimates of key parameters and derived quantities from each data source removal sensitivity are available in Table 25 to Table 28. Additionally, time series of spawning output and relative spawning output are shown in Figure 147 to Figure 154. Derived quantities relative of all data removal sensitivities to the reference model are summarized in Figure 155. Generally, the removal of indices of abundance decreased both the spawning output and the relative spawning output as compared to the base model (Figure 147 and Figure 148). Of these, the WCGBTS appears to have the most significant impact. Removal of the bottom trawl (bottom trawl + discards) and non-trawl (non-trawl + discards) fishery length compositions decreased the spawning output and the relative spawning output, whereas removal of the mid-water trawl and the at-sea hake length compositions increased the spawning output and relative spawning output (Figure 149 and Figure 150). Of the length composition removals, the most influential data sources appear to be the fishery fleets and removal of the survey length compositions had a limited impact on both spawning output and relative spawning output compared to the base model (Figure 151 and Figure 152). Finally, the removal of any age composition data source decreased the spawning output, with the exception of the mid-water trawl ages, and decreased the relative spawning output (Figure 153 and Figure 154). Again, the WCGBTS appears to be the most influential of the data sources with age composition information.

3.9.1.1.2 Data weighting

The following data weighting sensitivities were explored:

- No data-weighting
- Dirichlet data-weighting
- McAllister-Ianelli data weighting

Likelihood values and estimates of key parameters and derived quantities from each data weighting sensitivity are available in . Comparison plots for the results relative to the reference model are in Figure 156 and Figure 157. Each data weighting scenario up-weighted the influence of the length data relative to the age data. This resulted in a large drop in the stock scale, but little change in the high stock status. These changes were within the uncertainty of the base model, though at the low end for the stock scale.

3.9.1.1.3 Ageing error

The following ageing error sensitivities were explored:

- No Ageing error for all sources (unbiased and precise ages)
- No ageing error for each source at a time

Likelihood values and estimates of key parameters and derived quantities from each ageing error sensitivity are available in . Comparison plots for the results relative to the reference model are in Figure 158 and Figure 159. A drop in both stock scale and stock status is generally observed when the ageing error is removed. One notable observation is that the recruitment events become less resolved and variance increases in lengths at age when ages are assumed biased and precise. When the ages are taken as true, all variation between lengths and ages are interpreted in the lengths, while the recruitment must interpret the age composition precisely, thus assigning positive recruitment deviations to years adjacent to strong recruitment years seen in the reference model. Having more positive recruitment can compensate for a lower initial stock size, causing the initial stock size to decrease. All in stock scale and status changes were within the uncertainty of the base model.

3.9.1.2 Sensitivities to Model Specification

Model specifications looked at the treatment of life history parameters selectivity and the estimation of recruitment. All scenarios match the reference model specifications in all other aspects unless otherwise stated.

- Life history parameters
  - Natural mortality (M)
    1. Estimate female M
    2. Fix M to 2013 value
    3. Lorenzen age varying M
  - Growth parameters
    4. Fix all growth parameters to external values
  - Reproductive Biology
    5. Proportional fecundity to weight
    6. Functional maturity at age
    7. Functional maturity at length for Blackspotted Rockfish
    8. Functional maturity at length for Rougheye Rockfish
    9. Biological maturity at length

Summaries of the model results for these sensitivities are presented in **Table X** and **Figure X**. Model output showed that the base model was most sensitive to using maturity at age instead of maturity at length, with a decrease in relative depletion from the 1970's to 1990's using maturity at age. For this long-lived species, age may be a more precise determination of maturity (because there is a wide range of lengths per age); however, age data is more limited. The base model was less sensitive to the other changes, with similar output between the base and alternative models.

- Recruitment estimation

13. No recruitment estimation
14. Estimate from 1940 onward
15. Estimate from 1980 onward

- Selectivity

16. Logistic selectivity for all fisheries and time blocks
17. Logistic selectivity for bottom trawl fishery
18. Logistic selectivity for non-trawl fishery

Likelihood values and estimates of key parameters and derived quantities from each sensitivity are available in Table . Derived quantities relative to the reference model are provided in Figure . Time series of spawning output and relative spawning output are shown in Figures and . None of the sensitivities indicated an overfished stock.

3.9.2 Unresolved Problems and Major Uncertainties

There are no major unresolved problems in the stock assessment, but there are many sources of uncertainty. Natural mortality remains a large source of uncertainty. The estimation of growth also required fixing certain parameters, leading to an underestimation of uncertainty in the model. The stock-recruit relationship is assumed to be a Beverton-Holt relationship with a fixed steepness of 0.72. Large uncertainty was shown if the nature of this relationship varies either deterministically or over time. The full time series of recruitment deviations were not informed, which creates some historical and contemporary uncertainty. Likewise, all life history values are assumed constant, so any time-varying issues that are directional could create more uncertainty.

4 Management

4.1 Reference Points

Reference points were calculated using the estimated fishery selectivity and removals in the most recent year of the model (2024, Table 29). Sustainable total yields were 526.16 mt when using an $SPR_{50\%}$ reference harvest rate. The spawning output equivalent to 40 percent of the unfished spawning output ($SB_{40\%}$) was 2.51973×10^6 millions of eggs.

The 2025 spawning output relative to unfished equilibrium spawning output is above the Rougheye/Blackspotted Rockfishes relative biomass target of 40 percent (Figure 164). The fishing intensity, $1 - SPR$, was below or just slightly above harvest rate limit ($SPR_{50\%}$) from the mid-1980s through the 1990s. Removals since 2000 have been below the point estimate of potential long-term yields calculated using an $\mathrm{SPR}_{50\%}$ reference point (Table 30 and Figure 165). The equilibrium estimates of yield relative to biomass based on a steepness value fixed at 0.72 are provided in Figure 166, where vertical dashed lines indicate the estimate of fraction unfished at the start of 2025 (current) and the estimated management targets calculated based on the relative target biomass (B target), the SPR target, and the maximum sustainable yield (MSY).

Reference points were based on the rockfish $\mathrm{F}_{MSY\%}$ proxy ($\mathrm{SPR}_{50\%}$), target relative biomass (40%), and estimated selectivity and catch for each fleet (Table 29). The proxy MSY values of management quantities are by definition more conservative compared to the estimated MSY and MSY relative to 40% of unfished spawning output because of the assumed steepness value. Sustainable total yield, removals, using the proxy $\mathrm{SPR}_{50\%}$ is 526.16 mt. The spawning output equivalent to 40% of the unfished spawning output ($\mathrm{SO}_{40\%}$) calculated using the SPR target ($\mathrm{SPR}_{50\%}$) was 2.51973×10^6 millions of eggs.

The 2025 spawning biomass relative to unfished equilibrium spawning biomass, based on the 2024 fishing year, is 0.87%, above the management target of 40% of unfished spawning output. The relative biomass and the ratio of the estimated SPR to the management target ($\mathrm{SPR}_{50\%}$) across all model years are shown in Figure 167 where cooler colors (purple) represent early years and warmer colors (yellow) represent recent years. The stock staus has not decreased below the target relative biomass, and fishing intensity (except for in 1995) has been below the target fishing intensity based on $\mathrm{SPR}_{50\%}$.

4.2 Management performance

In the last ten years total dead catches of Rougheye/Blackspotted Rockfishes have been below the annual catch limit. The last ten years total dead catches for Rougheye/Blackspotted Rockfishes against he overfishing limits (OFLs), the acceptable biological catches (ABCs), the annual catch limits (ACLs) are shown in Table 31.

4.3 Harvest Projections and Decision Tables

The Rougheye/Blackspotted Rockfishes assessment is being considered as a category 1 assessment with a $P^* = 0.45$, $\sigma = 0.50$, and a time-varying buffer applied to set the ABC below the OFL. These multipliers are also combined with the rockfish MSY proxy of SPR_{50} and the 40-10 harvest control rule to calculate OFLs and ACLs. Projections of the overfishing limit, acceptable biological catch, and annual catch limit, all based on a P^* of 0.45 and a log-space standard deviation of the overfishing limit (σ) of 0.50 are included in Table 32. Assumed catches for 2025 and 2026 for this projection were provided by the PFMC Groundfish Management Team, and catches from 2027 onward assume full attainment of the acceptable biological catch.

No decision table needed in draft assessments undergoing review.

4.4 Evaluation of Scientific Uncertainty

The model estimated uncertainty around the 2025 spawning output for is $\sigma = 0.6836465$. The uncertainty around the OFL is$\sigma = 0.6713586$. These σ values underestimate the overall uncertainty as they do not incorporate the model structural uncertainty and do not account for any time-varying dynamics other than recruitment. The estimated uncertainty values are higher than the Category 1 default $\sigma = 0.5$, so all projections will use the estimated σ. The alternative states of nature used to bracket uncertainty in the decision table assist with encapsulating model structure uncertainty.

4.5 Research and Data Needs

There are many areas of research that could be improved to benefit the understanding and assessment of Rougheye/Blackspotted Rockfishes. Below, we identify several of them that we consider particularly important.

- Understanding the stock structure and biology of Rougheye and Blackspotted Rockfishes: This assessment reports the status of Rougheye/Blackspotted Rockfishes as a pooled complex because it is extremely difficult to separate the catches of each species even in recent data, and attempting to do so would greatly increase the uncertainty in the predictions. Because little is known about the respective biology and catch histories of the two species, it is unclear whether managing them as a complex may place one species at disproportionate risk of overfishing relative to the other. Additional research that will provide insight into the distribution, life history, biological characteristics, and catch and discard profiles of the two species is recommended. Such an endeavor would like require the efforts of at sea observers in all fleets, biologists aboard fishery-independent surveys, and port samplers along the entire West Coast requiring broad, inter-agency collaboration.

- Understanding of coatwide stock structure, connectivity, and distribution: This is a stock assessment for Rougheye/Blackspotted Rockfishes off of the west coast of the U.S. and does not consider data from British Columbia or Alaska. Further investigating and comparing the data and predictions from British Columbia and Alaska to determine if there are similarities with the U.S. West Coast observations would help to define the connectivity between rougheye rockfish north of the U.S.-Canada border.

- Natural mortality: Uncertainty in natural mortality translates into uncertain estimates of status and sustainable fishing levels for Rougheye/Blackspotted Rockfishes. Rougheye/Blackspotted Rockfishes are one of the longest lived species of rockfish (with maximum age as old as 205 years reported in the literature). Assessment model was able to estimate female natural mortality, consistent with maximum age based meta-analytical prior, but with male natural mortality fixed at the median of the prior. The collection of additional age data and further research of the life-history of Rougheye/Blackspotted Rockfishes may improve our understanding of Rougheye/Blackspotted Rockfishes natural mortality.

- Historical landings and discards, including investigation of fisheries selectivity: The substantial progress has been made in reconstructing historical landings of rockfishes on the U.S. West Coast, including those for Rougheye/Blackspotted Rockfishes. This assessment highlighted the importance of understanding of fishery selectivity assumptions associated with removals and how fishery selectivity changes throughout the years. Further understanding of this area would help reduce uncertainty in estimated scale of the stock.

5 Acknowledgements

6 References

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7 Tables

Table 1: Major management actions since 2000 that have impacted the management of the Rougheye/Blackspotted complex.

Year	Management Action
2000	Minor slope rockfish complex formed north and south of 40\\textdegree{} 10 N and is subject to bi-monthly vessel limits. New limited entry trawl gear restrictions implemented for large footrope trawl gear, small footrope trawl gear, and midwater trawl gear.
2002	Rockfish Conservation Areas (RCA) established. Large footrope gear prohibited inside 275 m. Open access trip limits revised for the minor slope rockfish complex.
2005	Selective flatfish trawl required shoreward of the RCA north of 40\\textdegree{} 10 N
2006	Ammendment 19 established essential fish habitat (EFH) boundaries and conservation areas.
2007	Seasonal changes of trawl RCA boundaries and periodic closures within certain latitude boundaries (e.g., north of Cape Alava at 48\\textdegree{}10 N. latitude to the U.S.- Canada border) started in 2007.
2011	Trawl rationalization began, establishing the IFQ fishery.
2015	Canary rockfish rebuilt; increased attainment of mid-water rockfishes when implemented in 2017.
2020	Trawl RCA off OR and CA removed (WA RCA remained in place)
2023	Non-bottom contact hook and line gear allowed in non-trawl RCA south of WA-OR border.
2024	Multiple non-trawl RCA south of WA-OR border rule updates, ultimately pushing fixed gear effort onto the shelf/slope.

Table 2: Recent trend in the overfishing limits (OFL), the acceptable biological catches (ABCs), the annual catch limits (ACLs), and the total dead catch (landings + discards) all in metric tons (mt) for the Rougheye/Blackspotted complex north and south of 40'10.

	North of 40'10'			South of 40'10'			Combined			
	OFL (mt)	ABC (mt)	ACL (mt)	OFL (mt)	ABC (mt)	ACL (mt)	OFL (mt)	ABC (mt)	ACL (mt)	Catch (mt)
2015	201.9	184.3	184.3	4.1	3.8	3.8	206	188.1	188.1	132.1
2016	206.8	188.8	188.8	4.2	3.9	3.9	211	192.7	192.7	149.0
2017	210.7	192.4	192.4	4.3	3.9	3.9	215	196.3	196.3	156.0
2018	214.6	195.9	195.9	4.4	4.0	4.0	219	199.9	199.9	241.5
2019	217.6	198.7	198.7	4.4	4.0	4.0	222	202.7	202.7	226.6
2020	219.5	200.4	200.4	4.5	4.1	4.1	224	204.5	204.5	106.1
2021	232.3	191.8	191.8	4.7	3.9	3.9	237	195.8	195.8	92.8
2022	233.2	190.8	190.8	4.8	3.9	3.9	238	194.7	194.7	117.4
2023	233.2	188.9	188.9	4.8	3.9	3.9	238	192.8	192.8	97.6
2024	233.2	190.8	190.8	4.8	3.9	3.9	238	194.7	194.7	118.9

Table 3: Landings in metric tons (mt) by year for each fleet.

Year	Total (mt)	Trawl (mt)	Trawl Discard (mt)	Non-trawl (mt)	Non-trawl discard (mt)	Midwater trawl (mt)	At-sea-
1891	0	0	0	0	0	0	
1892	19	0	0	19	0	0	
1893	19	0	0	19	0	0	
1894	19	0	0	19	0	0	
1895	5	0	0	5	0	0	
1896	1	0	0	1	0	0	
1897	1	0	0	1	0	0	
1898	1	0	0	1	0	0	
1899	1	0	0	1	0	0	
1900	2	0	0	2	0	0	
1901	2	0	0	2	0	0	
1902	3	0	0	3	0	0	
1903	3	0	0	3	0	0	
1904	4	0	0	4	0	0	
1905	4	0	0	4	0	0	
1906	4	0	0	4	0	0	
1907	5	0	0	5	0	0	
1908	8	0	0	8	0	0	
1909	6	0	0	6	0	0	
1910	6	0	0	6	0	0	
1911	7	0	0	7	0	0	
1912	7	0	0	7	0	0	
1913	8	0	0	8	0	0	
1914	8	0	0	8	0	0	
1915	10	0	0	10	0	0	
1916	9	0	0	9	0	0	
1917	10	0	0	10	0	0	
1918	55	0	0	55	0	0	
1919	26	0	0	26	0	0	
1920	23	0	0	23	0	0	
1921	23	0	0	23	0	0	
1922	18	0	0	18	0	0	
1923	20	0	0	20	0	0	
1924	32	0	0	32	0	0	
1925	38	0	0	38	0	0	
1926	54	0	0	54	0	0	
1927	69	0	0	69	0	0	
1928	72	0	0	72	0	0	
1929	66	0	0	66	0	0	
1930	67	0	0	67	0	0	
1931	44	0	0	44	0	0	
1932	25	0	0	25	0	0	
1933	35	0	0	35	0	0	
1934	42	0	0	42	0	0	
1935	34	0	0	34	0	0	
1936	61	0	0	61	0	0	
1937	53	0	0	53	0	0	
1938	55	0	0	55	0	0	
1939	28	0	0	28	0	0	
1940	60	1	0	59	0	0	
1941	102	1	0	101	0	0	
1942	126	2	0	124	0	0	
1943	258	7	0	251	0	0	
1944	85	11	0	74	0	0	

Table 3: Landings in metric tons (mt) by year for each fleet. *(continued)*

Year	Total (mt)	Trawl (mt)	Trawl Discard (mt)	Non-trawl (mt)	Non-trawl discard (mt)	Midwater trawl (mt)	At-sea-H
1945	50	20	0	30	0	0	
1946	69	11	0	58	0	0	
1947	42	7	0	35	0	0	
1948	44	5	0	39	0	0	
1949	31	5	0	26	0	0	
1950	52	6	0	46	0	0	
1951	59	6	0	53	0	0	
1952	38	6	0	32	0	0	
1953	21	5	0	16	0	0	
1954	36	6	0	30	0	0	
1955	32	6	0	26	0	0	
1956	21	8	0	13	0	0	
1957	35	9	0	26	0	0	
1958	15	7	0	8	0	0	
1959	23	7	0	16	0	0	
1960	23	10	0	13	0	0	
1961	26	11	0	15	0	0	
1962	32	14	0	18	0	0	
1963	24	13	0	11	0	0	
1964	31	11	0	20	0	0	
1965	31	23	0	8	0	0	
1966	117	111	0	6	0	0	
1967	108	98	0	10	0	0	
1968	172	165	0	7	0	0	
1969	50	25	0	25	0	0	
1970	23	19	0	4	0	0	
1971	68	67	0	1	0	0	
1972	76	75	0	1	0	0	
1973	75	69	0	6	0	0	
1974	76	58	0	18	0	0	
1975	43	35	0	5	0	0	
1976	19	16	0	2	0	0	
1977	166	1	0	164	0	0	
1978	69	33	0	36	0	0	
1979	185	63	0	121	0	0	
1980	99	56	0	43	0	0	
1981	131	61	0	68	0	0	
1982	167	99	0	68	0	0	
1983	126	55	0	70	0	0	
1984	144	75	0	67	0	0	
1985	298	139	0	158	0	0	
1986	428	154	0	273	0	0	
1987	570	198	0	368	0	0	
1988	351	173	0	162	0	0	
1989	418	287	0	131	0	0	
1990	244	167	0	76	0	0	
1991	299	235	0	59	0	0	
1992	306	186	0	110	0	0	
1993	327	166	0	159	0	0	
1994	306	127	0	173	0	0	
1995	744	165	0	576	0	0	
1996	339	127	0	204	0	0	
1997	303	107	0	186	0	0	
1998	441	110	0	313	0	0	
1999	256	81	0	166	0	0	

Table 3: Landings in metric tons (mt) by year for each fleet. *(continued)*

Year	Total (mt)	Trawl (mt)	Trawl Discard (mt)	Non-trawl (mt)	Non-trawl discard (mt)	Midwater trawl (mt)	At-sea-H
2000	183	79	0	29	0	4	
2001	114	74	0	18	0	1	
2002	74	31	14	27	1	0	
2003	100	58	15	23	2	0	
2004	115	58	3	34	5	1	
2005	137	45	1	50	5	0	
2006	127	48	12	59	1	0	
2007	187	60	27	59	10	2	
2008	219	54	29	56	3	1	
2009	228	67	45	104	1	2	
2010	263	79	60	71	25	6	
2011	210	53	0	63	9	4	
2012	244	47	0	74	20	49	
2013	156	64	0	59	12	3	
2014	91	34	0	37	10	4	
2015	133	31	0	47	14	19	
2016	150	31	0	60	13	16	
2017	155	22	0	59	34	2	
2018	242	16	0	47	15	3	
2019	226	22	0	39	31	9	
2020	106	10	0	24	1	29	
2021	92	10	0	21	2	21	
2022	118	12	0	19	3	19	
2023	96	13	0	19	0	26	
2024	118	10	0	10	0	69	

Table 4: Recent trend in the overfishing limits (OFL), the acceptable biological catches (ABCs), the annual catch limits (ACLs), and the total catch all in metric tons (mt).

Year	OFL (mt)	ABC (mt)	ACL (mt)	Catch (mt)
2015	NA	NA	NA	132
2016	NA	NA	NA	149
2017	NA	NA	NA	156
2018	NA	NA	NA	242
2019	NA	NA	NA	227
2020	NA	NA	NA	106
2021	NA	NA	NA	93
2022	NA	NA	NA	117
2023	NA	NA	NA	98
2024	NA	NA	NA	119

Table 5: Landings (metric tons) for botton trawl fleet by state and bycatch within POP historcial fishery.

Year	California	Oregon	Washington	POP_Fishery_Bycatch	Total
1932	0	0	0	0	0
1933	0	0	0	0	0
1934	0	0	0	0	0
1935	0	0	0	0	0
1936	0	0	0	0	0
1937	0	0	0	0	0
1938	0	0	0	0	0
1939	0	0	0	0	0
1940	0	0	0	0	1
1941	0	1	0	0	1
1942	0	1	0	0	2
1943	0	5	2	0	7
1944	0	9	3	0	11
1945	0	14	6	0	20
1946	0	8	3	0	11
1947	0	5	1	0	7
1948	0	3	2	0	5
1949	0	3	1	0	5
1950	0	4	2	0	6
1951	0	4	2	0	6
1952	0	5	1	0	6
1953	0	3	1	0	5
1954	0	4	2	0	6
1955	0	4	2	0	6
1956	0	6	2	0	8
1957	0	7	2	0	9
1958	0	6	2	0	7
1959	0	5	1	0	7
1960	0	7	3	0	10
1961	0	7	4	0	11
1962	0	8	6	0	14
1963	0	6	7	0	13
1964	0	6	6	0	11
1965	0	17	7	0	23
1966	0	7	6	98	111
1967	0	7	6	85	98
1968	0	4	114	47	165
1969	0	9	2	15	25
1970	0	0	1	17	19
1971	0	11	7	49	67
1972	0	6	1	68	75
1973	0	3	4	63	69
1974	0	2	11	45	58
1975	0	4	4	27	35
1976	0	0	3	12	16
1977	0	0	0	0	1
1978	0	28	6	0	33
1979	0	16	47	0	63
1980	0	30	26	0	56

1981	0	45	16		0	61
1982	0	52	47		0	99
1983	0	44	11		0	55
1984	0	45	30		0	75
1985	0	96	44		0	139
1986	0	137	17		0	154
1987	1	132	66		0	198
1988	0	144	29		0	173
1989	0	240	46		0	287
1990	2	154	11		0	167
1991	1	213	21		0	235
1992	2	155	29		0	186
1993	0	164	3		0	166
1994	7	115	5		0	127
1995	5	113	48		0	165
1996	2	97	29		0	127
1997	0	71	36		0	107
1998	1	89	21		0	110
1999	0	60	21		0	81
2000	2	56	21		0	79
2001	0	64	10		0	74
2002	0	22	8		0	31
2003	1	47	10		0	58
2004	0	51	8		0	58
2005	0	38	7		0	45
2006	0	35	13		0	48
2007	1	50	10		0	60
2008	0	45	8		0	54
2009	0	51	15		0	67
2010	0	63	16		0	79
2011	0	43	10		0	53
2012	0	32	15		0	47
2013	1	54	8		0	64
2014	0	27	7		0	34
2015	0	30	1		0	31
2016	0	28	3		0	31
2017	0	20	2		0	22
2018	1	15	1		0	16
2019	1	21	1		0	22
2020	0	10	0		0	10
2021	0	9	1		0	10
2022	0	10	1		0	12
2023	0	13	0		0	13
2024	0	10	0		0	10

Table 6: Landings (metric tons) for non-trawl fleet by state.

Year	California	Oregon	California.1	Total
1892	0	19	0	19
1893	0	19	0	19
1894	0	19	0	19
1895	0	5	0	5
1896	0	1	0	1
1897	0	1	0	1
1898	0	1	0	1
1899	0	1	0	1
1900	0	2	0	2
1901	0	2	0	2
1902	0	3	0	3
1903	0	3	0	3
1904	0	4	0	4
1905	0	4	0	4
1906	0	4	0	4
1907	0	5	0	5
1908	0	5	3	8
1909	0	6	0	6
1910	0	6	0	6
1911	0	7	0	7
1912	0	7	0	7
1913	0	8	0	8
1914	0	8	0	8
1915	0	9	2	10
1916	0	9	0	9
1917	0	10	0	10
1918	0	10	45	55
1919	0	11	15	26
1920	0	11	12	23
1921	0	12	11	23
1922	0	12	6	18
1923	0	13	8	20
1924	0	13	19	32
1925	0	14	24	38
1926	0	14	40	54
1927	0	15	54	69
1928	0	24	48	72
1929	0	38	28	66
1930	0	32	35	67
1931	0	26	17	44
1932	0	10	15	25
1933	0	14	20	35
1934	0	16	26	42
1935	0	15	18	34
1936	0	34	27	61
1937	0	33	20	53
1938	0	31	24	55
1939	0	10	19	28
1940	0	37	22	59
1941	0	61	39	101

1942	0	87	36	124
1943	0	235	15	251
1944	0	42	32	74
1945	0	16	14	30
1946	0	23	35	58
1947	0	17	18	35
1948	0	24	15	39
1949	0	8	18	26
1950	0	19	27	46
1951	0	14	39	53
1952	0	6	26	32
1953	0	6	10	16
1954	0	9	21	30
1955	0	6	19	26
1956	0	5	7	13
1957	0	11	14	26
1958	0	3	4	8
1959	0	6	10	16
1960	0	2	11	13
1961	0	9	7	15
1962	0	10	7	18
1963	0	6	5	11
1964	0	14	6	20
1965	0	3	5	8
1966	0	3	3	6
1967	0	8	2	10
1968	0	6	1	7
1969	0	21	4	25
1970	0	4	0	4
1971	0	1	0	1
1972	0	1	0	1
1973	0	6	0	6
1974	0	18	0	18
1975	0	5	0	5
1976	0	2	0	2
1977	0	152	12	164
1978	0	20	16	36
1979	0	66	55	121
1980	0	19	23	43
1981	2	51	15	68
1982	0	51	17	68
1983	0	53	17	70
1984	0	39	28	67
1985	0	71	87	158
1986	0	185	88	273
1987	9	245	114	368
1988	0	103	60	162
1989	0	98	33	131
1990	0	51	24	76
1991	0	34	25	59
1992	1	63	46	110
1993	0	34	125	159
1994	7	39	127	173
1995	1	131	444	576

1996	1	85	119	204
1997	0	47	139	186
1998	1	86	226	313
1999	0	41	125	166
2000	1	2	26	29
2001	2	2	13	18
2002	1	4	23	27
2003	1	3	18	23
2004	0	2	31	34
2005	3	6	40	50
2006	2	5	52	59
2007	3	6	49	59
2008	1	11	44	56
2009	5	21	77	104
2010	2	22	46	71
2011	2	20	40	63
2012	5	23	45	74
2013	3	19	37	59
2014	3	6	29	37
2015	1	14	32	47
2016	3	16	41	60
2017	0	13	46	59
2018	0	7	39	47
2019	1	8	30	39
2020	1	11	13	24
2021	1	9	12	21
2022	1	4	14	19
2023	5	5	9	19
2024	2	2	5	10

Table 7: Landings (metric tons) for mid-water trawl fleet by state.

Year	California	Oregon	Washington	Total
1985	0	0	0	0
1986	0	0	0	0
1987	0	0	0	0
1988	0	0	0	0
1989	0	0	0	0
1990	0	0	0	0
1991	0	0	0	0
1992	0	0	0	0
1993	0	0	0	0
1994	0	0	0	0
1995	0	0	0	0
1996	0	0	0	0
1997	0	0	0	0
1998	0	0	0	0
1999	0	0	0	0
2000	0	2	3	4
2001	0	0	1	1
2002	0	0	0	0
2003	0	0	0	0
2004	0	0	1	1
2005	0	0	0	0
2006	0	0	0	0
2007	0	0	2	2
2008	0	0	1	1
2009	0	0	2	2
2010	0	3	3	6
2011	0	3	1	4
2012	0	42	7	49
2013	0	3	0	3
2014	0	2	2	4
2015	0	12	7	19
2016	0	11	4	16
2017	0	1	1	2
2018	0	1	1	3
2019	0	4	5	9
2020	0	13	16	29
2021	0	11	10	21
2022	0	7	11	19
2023	0	13	13	26
2024	0	43	27	69

Table 8: Summary of fishery sampling effort (number of trips and fish sampled) by state used to create length frequency distributions of the bottom trawl fleet.

Year	N_Trips_CA	N_Fish_CA	N_Trips_OR	N_Fish_OR	N_Trips_WA	N_Fish_WA	Input_N
1995	3	4	1	22	0	0	8
1996	6	15	2	44	0	0	16
1997	1	1	1	24	0	0	5
1998	0	0	0	0	24	509	94
1999	2	3	1	33	19	404	83
2000	4	11	1	12	28	573	115
2001	1	1	5	111	18	334	86
2002	3	3	1	5	26	378	83
2003	4	6	8	46	31	794	160
2004	1	1	20	318	13	300	119
2005	1	1	20	258	9	184	91
2006	5	5	29	254	9	297	120
2007	13	17	53	815	21	722	301
2008	15	32	42	659	14	673	259
2009	11	16	65	891	14	448	277
2010	8	12	60	711	8	354	225
2011	9	12	37	386	16	263	153
2012	15	25	46	409	18	612	223
2013	11	15	45	515	7	195	163
2014	11	15	61	507	7	113	167
2015	12	20	63	778	15	382	253
2016	19	28	42	631	8	144	180
2017	19	38	76	728	8	87	221
2018	14	19	61	650	12	169	203
2019	21	59	81	730	7	92	231
2020	3	3	51	381	9	101	130
2021	15	33	53	353	11	135	151
2022	6	19	33	373	11	230	136
2023	6	6	20	254	8	296	111
2024	21	38	23	357	22	569	199

Table 9: Summary of fishery sampling effort (number of trips and fish sampled) by state used to create length frequency distributions of the non-trawl fleet.

Year	N_Trips_CA	N_Fish_CA	N_Trips_OR	N_Fish_OR	N_Trips_WA	N_Fish_WA	Input_N
1996	0	0	5	123	0	0	22
1998	0	0	2	44	11	678	92
1999	0	0	3	69	10	392	77
2000	1	9	1	23	0	0	6
2001	0	0	1	24	5	62	18
2002	2	13	0	0	17	268	58
2003	2	7	1	2	50	967	188
2004	0	0	0	0	33	741	135
2005	13	57	5	22	42	1167	232
2006	9	113	10	177	49	1323	291
2007	4	9	5	88	27	747	152
2008	8	47	7	121	34	953	204
2009	11	92	17	257	27	1115	257
2010	12	93	38	499	21	742	255
2011	15	60	44	544	32	1034	317
2012	4	17	34	318	27	847	228
2013	4	26	27	488	29	919	258
2014	1	2	24	176	31	882	202
2015	0	0	47	342	33	927	255
2016	3	15	49	459	53	1236	341
2017	0	0	61	441	73	1061	341
2018	0	0	88	477	93	1293	425
2019	0	0	68	379	117	1456	438
2020	1	1	40	242	33	489	175
2021	1	10	34	232	83	931	280
2022	0	0	53	344	90	881	312
2023	3	10	25	190	73	871	249
2024	27	102	29	162	65	731	258

Table 10: Summary of fishery sampling effort (number of trips and fish sampled) by state used to create length frequency distributions of the mid-water trawl fleet.

Year	N_Trips_OR	N_Fish_OR	Input_N
2000	1	28	5
2008	2	13	4
2010	3	48	10
2011	4	8	5
2012	19	460	82
2013	4	29	8
2014	9	19	12
2015	32	324	77
2016	16	147	36
2017	9	63	18
2018	6	44	12
2019	8	24	11
2020	15	124	32
2021	32	178	57
2022	17	154	38
2023	20	237	53
2024	26	327	71

Table 11: Summary of fishery sampling effort (number of trips and fish sampled) by state used to create conditional ages-at-length compositions.

Year	Fleet	N_Trips_OR	N_Fish_OR	N_Trips_WA	N_Fish_WA
2008	Bottom Trawl	38	630	0	0
2009	Bottom Trawl	0	0	3	87
2010	Bottom Trawl	0	0	7	217
2011	Bottom Trawl	36	384	2	39
2012	Bottom Trawl	0	0	9	191
2013	Bottom Trawl	0	0	2	66
2017	Bottom Trawl	49	257	0	0
2021	Bottom Trawl	39	172	0	0
2022	Bottom Trawl	26	174	0	0
2023	Bottom Trawl	20	253	0	0
2024	Bottom Trawl	22	182	6	202
2008	Non-trawl	4	51	3	41
2009	Non-trawl	0	0	10	406
2010	Non-trawl	0	0	17	562
2011	Non-trawl	1	3	9	234
2012	Non-trawl	0	0	22	710
2013	Non-trawl	0	0	6	179
2017	Non-trawl	39	118	0	0
2021	Non-trawl	31	132	0	0
2022	Non-trawl	37	160	0	0
2023	Non-trawl	25	190	0	0
2024	Non-trawl	25	77	21	278
2011	Midwater Trawl	4	8	0	0
2017	Midwater Trawl	8	25	0	0
2021	Midwater Trawl	25	95	0	0
2022	Midwater Trawl	15	66	0	0
2023	Midwater Trawl	20	235	0	0
2024	Midwater Trawl	25	141	0	0

Table 12: Summary of fishery sampling effort (number of trips, number of hauls and fish sampled) used to create length frequency distributions of discard fleets.

year	Fleet	N_Fish	N_Hauls	N_Trips	Input_N
2004	Bottom Trawl Discard	51	10	7	14
2005	Bottom Trawl Discard	36	20	16	21
2006	Bottom Trawl Discard	88	26	18	30
2007	Bottom Trawl Discard	456	123	40	103
2008	Bottom Trawl Discard	1104	324	95	247
2009	Bottom Trawl Discard	1026	295	101	243
2010	Bottom Trawl Discard	655	166	49	139
2011	Bottom Trawl Discard	27	14	14	18
2012	Bottom Trawl Discard	92	39	24	37
2013	Bottom Trawl Discard	115	46	27	43
2014	Bottom Trawl Discard	60	30	23	31
2015	Bottom Trawl Discard	5	4	4	5
2016	Bottom Trawl Discard	18	8	7	9
2019	Bottom Trawl Discard	14	4	3	5
2020	Bottom Trawl Discard	10	4	4	5
2022	Bottom Trawl Discard	13	6	6	8
2023	Bottom Trawl Discard	24	5	5	8
2004	Non-trawl Discard	22	5	3	6
2005	Non-trawl Discard	202	21	7	35
2006	Non-trawl Discard	34	10	4	9
2007	Non-trawl Discard	92	26	9	22
2008	Non-trawl Discard	33	18	9	14
2009	Non-trawl Discard	19	11	9	12
2010	Non-trawl Discard	180	49	16	41
2011	Non-trawl Discard	400	100	12	67
2012	Non-trawl Discard	395	114	18	73
2013	Non-trawl Discard	112	26	5	20
2014	Non-trawl Discard	108	26	8	23
2015	Non-trawl Discard	254	52	15	50
2016	Non-trawl Discard	154	39	16	37
2017	Non-trawl Discard	340	55	17	64
2018	Non-trawl Discard	320	60	19	63
2019	Non-trawl Discard	753	123	21	125
2020	Non-trawl Discard	21	6	5	8
2021	Non-trawl Discard	49	11	9	16
2022	Non-trawl Discard	76	22	8	18
2023	Non-trawl Discard	39	11	8	13

Table 13: Summary of fishery sampling effort (number of hauls and fish sampled) used to create length frequency distributions and CAAL of At-sea Hake fleet.

Year	N_Hauls	N_Lengths	N_Ages
2003	66	338	0
2004	425	2132	0
2005	461	3102	0
2006	305	1029	0
2007	572	5135	0
2008	893	7547	555
2009	284	1093	0
2010	380	1956	0
2011	1092	8672	508
2012	591	5176	0
2013	446	2233	0
2014	278	744	283
2015	424	2044	0
2016	794	3092	507
2017	507	2746	0
2018	524	2900	0
2019	317	2488	311
2020	189	1213	185
2021	282	1356	262
2022	519	2363	450
2023	260	776	373
2024	306	898	221

Table 14: Stratifications used for generate survey length compositions.

Survey	Strata	Depth1	Depth2	Latitude1	Latitude2
WCGBTS	Shallow OR	55	183	42	46
	Middle OR	183	350	42	46
	Deep OR	350	549	42	46
	Shallow WA	55	183	46	49
	Middle WA	183	350	46	49
	Deep WA	350	549	46	49
Triennial early	Shallow	55	183	42	49
	Deep	183	350	42	49
Triennial late	Shallow	55	183	42	49
	Deep	183	500	42	49
AFSC Slope	Shallow	183	549	42	46
	Deep	183	549	46	49

Table 15: Stratifications used for generate survey length compositions.

Survey	Year	Latitudes	Depths..fm.	Depths..m.
WCGBTS	2003 - 2019	32o 34'- 48o 27'	30-700	55-1,280
	2020 - 2024	32o 34'- 48o 27'	30-700	55-1,280
AFSC/NWFSC Triennial	1977	34o 00'- Canadian border	50-250	91-457
	1980	36o 48'- 49o 15'	30-200	55-366
	1983	36o 48'- 49o 15'	30-200	55-366
	1986	36o 48'- Border	30-200	55-366
	1989	34o 30'- 49o 40'	30-200	55-366
	1992	34o 30'- 49o 40'	30-200	55-366
	1995	34o 30'- 49o 40'	30-275	55-500
	1998	34o 30'- 49o 40'	30-275	55-500
	2001	34o 30'- 49o 40'	30-275	55-500
	2004	34o 30'- Canadian border	30-275	55-500
AFSC Slope	1988	44o 05'- 45o 30'	100-700	182-1,280
	1990	44o 30'- 40o 30'	100-700	182-1,280
	1991	38o 20'- 40o 30'	100-700	182-1,280
	1992	45o 30'- Border	100-700	182-1,280
	1993	43o 00'- 45o 30'	100-700	182-1,280
	1995	40o 30'- 43o 00'	100-700	182-1,280
	1996	43o 00'- Canadian border	100-700	182-1,280
	1997	34o 00'- Canadian border	100-700	182-1,280
	1999	34o 00'- Canadian border	100-700	182-1,280
	2000	34o 00'- Canadian border	100-700	182-1,280
	2001	34o 00'- Canadian border	100-700	182-1,280
NWFSC Slope	1999	34o 50'- 48o 10'	100-700	182-1,280
	2000	34o 50'- 48o 10'	100-700	182-1,280
	2001	34o 50'- 48o 10'	100-700	182-1,280
	2002	34o 50'- 48o 10'	100-700	182-1,280

Table 16: Summary of surveys' sampling effort (number of hauls and fish sampled) used to create length frequency distributions.

Year	Survey	N_Hauls	N_Fish	Input_N
2003	WCGBTS	33	111	80
2004	WCGBTS	24	111	58
2005	WCGBTS	27	259	65
2006	WCGBTS	34	99	82
2007	WCGBTS	35	106	85
2008	WCGBTS	35	120	85
2009	WCGBTS	26	125	63
2010	WCGBTS	29	89	70
2011	WCGBTS	29	113	70
2012	WCGBTS	21	82	51
2013	WCGBTS	21	67	51
2014	WCGBTS	20	39	39
2015	WCGBTS	35	181	85
2016	WCGBTS	31	103	75
2017	WCGBTS	26	173	63
2018	WCGBTS	25	97	60
2019	WCGBTS	10	57	24
2021	WCGBTS	29	139	70
2022	WCGBTS	19	41	41
2023	WCGBTS	28	78	68
2024	WCGBTS	28	59	59
1980	Triennial	2	70	4
1986	Triennial	10	94	24
1989	Triennial	24	276	58
1992	Triennial	17	290	41
1995	Triennial	54	432	131
1998	Triennial	49	240	119
2001	Triennial	50	287	121
2004	Triennial	46	315	111
1997	AFSC Slope	10	32	24
1999	AFSC Slope	11	25	25
2000	AFSC Slope	13	128	31
2001	AFSC Slope	10	99	24

Table 17: Summary of WCGBTS sampling effort (number of hauls and fish sampled) used to create conditional ages-at-length distributions.

Year	Survey	N_Hauls	N_Fish	Input_N
2003	WCGBTS	17	56	56
2004	WCGBTS	24	74	74
2005	WCGBTS	27	139	139
2006	WCGBTS	31	94	94
2007	WCGBTS	35	105	105
2008	WCGBTS	35	119	119
2009	WCGBTS	24	93	93
2010	WCGBTS	29	89	89
2011	WCGBTS	27	110	110
2012	WCGBTS	19	78	78
2013	WCGBTS	21	67	67
2014	WCGBTS	11	22	22
2015	WCGBTS	34	169	169
2016	WCGBTS	31	103	103
2017	WCGBTS	25	128	128
2018	WCGBTS	25	97	97
2019	WCGBTS	10	57	57
2021	WCGBTS	28	138	138
2022	WCGBTS	19	41	41
2023	WCGBTS	27	76	76
2024	WCGBTS	28	59	59

Table 18: Length and age at biological (L50_bio, A50_bio) and functional maturity (L50_fxn, A50_fxn) for the Rougheye and Blackspotted rockfish complex (RE/BS), and genetically confirmed Rougheye and Blackspotted separately. Only certain maturity determinations were used in this analysis.

data_used	n_length	L50_bio	L50_fxn	n_age	A50_bio	A50_fxn
RE/BS all data	473	42.92 (1.28)	46.53 (1.11)	372	21.23 (2.05)	26.02 (2.12)
RE/BS genetically confirmed	265	43.98 (1.86)	46.83 (1.64)	258	19.45 (2.16)	21.85 (2.14)
Rougheye Rockfish	194	39.86 (2.18)	43.57 (2.02)	188	13.89 (1.77)	15.80 (1.84)
Blackspotted Rockfish	71	49.46 (2.09)	51.45 (2.35)	70	26.18 (4.40)	29.27 (3.75)

Table 19: Specifications and structure of the model.

Section	Configuration
Maximum age	140
Sexes	Females, males
Population bins	4-84 cm by 2 cm bins
Summary biomass (mt) age	26+
Number of areas	1
Number of seasons	1
Number of growth patterns	1
Start year	1892
End year	2024
Data length bins	10-80 cm by 2 cm bins
Data age bins	1-100 by 1 year

Table 20: Estimated parameters in the model.

Type	Count
Natural Mortality (M)	1
M time-variation	0
Growth mean	6
Growth variability	4
Growth time-variation	0
Stock-recruit	1
Stock-recruit variation	0
Rec. dev. time series	133
Rec. dev. initial age	0
Rec. dev. forecast	12
Index	1
Index time-variation	1
Size selectivity	30
Size selectivity time-variation	24
Retention	0
Retention time-variation	0
Age selectivity	0
Age selectivity time-variation	0

\begin{landscape}

\end{landscape}

Table 21: Parameter estimates, estimation phase, parameter bounds, estimation status, estimated standard deviation (SD), prior information [distribution(mean, SD)] used in the base model.

Label	Value	Phase	Bounds	Status	SD	Prior
NatM_uniform_Fem_GP_1	0.0391	1	(0.001, 0.2)	ok	0.000835	lognormal(0.034, 0.310)
L_at_Amin_Fem_GP_1	-3.1	2	(-100, 25)	ok	0.621	none
L_at_Amax_Fem_GP_1	60.1	2	(40, 90)	ok	0.351	none
VonBert_K_Fem_GP_1	0.0786	2	(0.01, 0.15)	ok	0.00179	none
CV_young_Fem_GP_1	0.0513	2	(1e-06, 1)	ok	0.0143	none
CV_old_Fem_GP_1	0.0936	2	(1e-06, 1)	ok	0.00305	none
Wtlen_1_Fem_GP_1	8.78e-06	-3	(-3, 3)	fixed	0	none
Wtlen_2_Fem_GP_1	3.15	-3	(-3, 4)	fixed	0	none
Mat50%_Fem_GP_1	46.5	-3	(1, 60)	fixed	0	none
Mat_slope_Fem_GP_1	-0.254	-3	(-30, 3)	fixed	0	none
Eggs_scalar_Fem_GP_1	7.22e-05	-3	(-3, 3)	fixed	0	none
Eggs_exp_len_Fem_GP_1	4.04	-3	(-3, 5)	fixed	0	none
NatM_uniform_Mal_GP_1	0.036	-2	(0.001, 0.2)	fixed	0	lognormal(0.034, 0.310)
L_at_Amin_Mal_GP_1	-2.68	2	(-100, 25)	ok	1.05	none
L_at_Amax_Mal_GP_1	57.8	2	(40, 90)	ok	0.315	none
VonBert_K_Mal_GP_1	0.0837	2	(0.01, 0.15)	ok	0.00253	none
CV_young_Mal_GP_1	0.0911	2	(1e-06, 1)	ok	0.0197	none
CV_old_Mal_GP_1	0.085	2	(1e-06, 1)	ok	0.00296	none
Wtlen_1_Mal_GP_1	1.18e-05	-3	(-3, 3)	fixed	0	none
Wtlen_2_Mal_GP_1	3.07	-3	(-3, 4)	fixed	0	none
CohortGrowDev	1	-4	(0, 1)	fixed	0	none

Label	Value	Phase	Bounds	Status	SD	Prior
FracFemale_GP_1	0.5	-5	(1e-06, 1)	fixed	0	none
SR_LN(R0)	7	1	(1, 15)	ok	0.621	none
SR_BH_steep	0.72	-3	(0.25, 0.99)	fixed	0	beta(0.718, 0.152)
SR_sigmaR	0.5	-4	(0, 2)	fixed	0	none
SR_regime	0	-4	(-5, 5)	fixed	0	none
SR_autocorr	0	-99	(0, 0)	fixed	0	none
Main_RecrDev_1892	-0.0795	1	(-5, 5)	dev	0.481	normal(0.00, 0.50)
Main_RecrDev_1893	-0.0812	1	(-5, 5)	dev	0.48	normal(0.00, 0.50)
Main_RecrDev_1894	-0.0829	1	(-5, 5)	dev	0.48	normal(0.00, 0.50)
Main_RecrDev_1895	-0.0846	1	(-5, 5)	dev	0.48	normal(0.00, 0.50)
Main_RecrDev_1896	-0.0862	1	(-5, 5)	dev	0.479	normal(0.00, 0.50)
Main_RecrDev_1897	-0.0878	1	(-5, 5)	dev	0.479	normal(0.00, 0.50)
Main_RecrDev_1898	-0.0893	1	(-5, 5)	dev	0.479	normal(0.00, 0.50)
Main_RecrDev_1899	-0.0908	1	(-5, 5)	dev	0.478	normal(0.00, 0.50)
Main_RecrDev_1900	-0.0922	1	(-5, 5)	dev	0.478	normal(0.00, 0.50)
Main_RecrDev_1901	-0.0934	1	(-5, 5)	dev	0.478	normal(0.00, 0.50)
Main_RecrDev_1902	-0.0946	1	(-5, 5)	dev	0.477	normal(0.00, 0.50)
Main_RecrDev_1903	-0.0957	1	(-5, 5)	dev	0.477	normal(0.00, 0.50)
Main_RecrDev_1904	-0.0967	1	(-5, 5)	dev	0.477	normal(0.00, 0.50)
Main_RecrDev_1905	-0.0975	1	(-5, 5)	dev	0.477	normal(0.00, 0.50)
Main_RecrDev_1906	-0.0982	1	(-5, 5)	dev	0.476	normal(0.00, 0.50)
Main_RecrDev_1907	-0.0988	1	(-5, 5)	dev	0.476	normal(0.00, 0.50)
Main_RecrDev_1908	-0.0991	1	(-5, 5)	dev	0.476	normal(0.00, 0.50)
Main_RecrDev_1909	-0.0993	1	(-5, 5)	dev	0.476	normal(0.00, 0.50)
Main_RecrDev_1910	-0.0993	1	(-5, 5)	dev	0.476	normal(0.00, 0.50)
Main_RecrDev_1911	-0.0991	1	(-5, 5)	dev	0.476	normal(0.00, 0.50)
Main_RecrDev_1912	-0.0986	1	(-5, 5)	dev	0.476	normal(0.00, 0.50)
Main_RecrDev_1913	-0.098	1	(-5, 5)	dev	0.476	normal(0.00, 0.50)

Label	Value	Phase	Bounds	Status	SD	Prior
Main_RecrDev_1914	-0.0971	1	(-5, 5)	dev	0.476	normal(0.00, 0.50)
Main_RecrDev_1915	-0.0959	1	(-5, 5)	dev	0.477	normal(0.00, 0.50)
Main_RecrDev_1916	-0.0945	1	(-5, 5)	dev	0.477	normal(0.00, 0.50)
Main_RecrDev_1917	-0.0927	1	(-5, 5)	dev	0.477	normal(0.00, 0.50)
Main_RecrDev_1918	-0.0907	1	(-5, 5)	dev	0.478	normal(0.00, 0.50)
Main_RecrDev_1919	-0.0884	1	(-5, 5)	dev	0.478	normal(0.00, 0.50)
Main_RecrDev_1920	-0.0857	1	(-5, 5)	dev	0.479	normal(0.00, 0.50)
Main_RecrDev_1921	-0.0828	1	(-5, 5)	dev	0.479	normal(0.00, 0.50)
Main_RecrDev_1922	-0.0796	1	(-5, 5)	dev	0.48	normal(0.00, 0.50)
Main_RecrDev_1923	-0.0761	1	(-5, 5)	dev	0.48	normal(0.00, 0.50)
Main_RecrDev_1924	-0.0725	1	(-5, 5)	dev	0.481	normal(0.00, 0.50)
Main_RecrDev_1925	-0.0687	1	(-5, 5)	dev	0.482	normal(0.00, 0.50)
Main_RecrDev_1926	-0.0649	1	(-5, 5)	dev	0.482	normal(0.00, 0.50)
Main_RecrDev_1927	-0.0611	1	(-5, 5)	dev	0.483	normal(0.00, 0.50)
Main_RecrDev_1928	-0.0574	1	(-5, 5)	dev	0.484	normal(0.00, 0.50)
Main_RecrDev_1929	-0.0539	1	(-5, 5)	dev	0.484	normal(0.00, 0.50)
Main_RecrDev_1930	-0.0506	1	(-5, 5)	dev	0.485	normal(0.00, 0.50)
Main_RecrDev_1931	-0.0477	1	(-5, 5)	dev	0.485	normal(0.00, 0.50)
Main_RecrDev_1932	-0.0452	1	(-5, 5)	dev	0.486	normal(0.00, 0.50)
Main_RecrDev_1933	-0.0431	1	(-5, 5)	dev	0.486	normal(0.00, 0.50)
Main_RecrDev_1934	-0.0412	1	(-5, 5)	dev	0.486	normal(0.00, 0.50)
Main_RecrDev_1935	-0.0395	1	(-5, 5)	dev	0.487	normal(0.00, 0.50)
Main_RecrDev_1936	-0.0378	1	(-5, 5)	dev	0.487	normal(0.00, 0.50)
Main_RecrDev_1937	-0.036	1	(-5, 5)	dev	0.487	normal(0.00, 0.50)
Main_RecrDev_1938	-0.0338	1	(-5, 5)	dev	0.487	normal(0.00, 0.50)
Main_RecrDev_1939	-0.031	1	(-5, 5)	dev	0.488	normal(0.00, 0.50)
Main_RecrDev_1940	-0.0273	1	(-5, 5)	dev	0.489	normal(0.00, 0.50)
Main_RecrDev_1941	-0.0225	1	(-5, 5)	dev	0.49	normal(0.00, 0.50)

Label	Value	Phase	Bounds	Status	SD	Prior
Main_RecrDev_1942	-0.0164	1	(-5, 5)	dev	0.491	normal(0.00, 0.50)
Main_RecrDev_1943	-0.00858	1	(-5, 5)	dev	0.493	normal(0.00, 0.50)
Main_RecrDev_1944	0.00111	1	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1945	0.0129	1	(-5, 5)	dev	0.497	normal(0.00, 0.50)
Main_RecrDev_1946	0.0271	1	(-5, 5)	dev	0.501	normal(0.00, 0.50)
Main_RecrDev_1947	0.0436	1	(-5, 5)	dev	0.504	normal(0.00, 0.50)
Main_RecrDev_1948	0.0627	1	(-5, 5)	dev	0.509	normal(0.00, 0.50)
Main_RecrDev_1949	0.0843	1	(-5, 5)	dev	0.514	normal(0.00, 0.50)
Main_RecrDev_1950	0.108	1	(-5, 5)	dev	0.521	normal(0.00, 0.50)
Main_RecrDev_1951	0.134	1	(-5, 5)	dev	0.527	normal(0.00, 0.50)
Main_RecrDev_1952	0.16	1	(-5, 5)	dev	0.535	normal(0.00, 0.50)
Main_RecrDev_1953	0.186	1	(-5, 5)	dev	0.542	normal(0.00, 0.50)
Main_RecrDev_1954	0.211	1	(-5, 5)	dev	0.549	normal(0.00, 0.50)
Main_RecrDev_1955	0.232	1	(-5, 5)	dev	0.556	normal(0.00, 0.50)
Main_RecrDev_1956	0.249	1	(-5, 5)	dev	0.561	normal(0.00, 0.50)
Main_RecrDev_1957	0.259	1	(-5, 5)	dev	0.564	normal(0.00, 0.50)
Main_RecrDev_1958	0.263	1	(-5, 5)	dev	0.566	normal(0.00, 0.50)
Main_RecrDev_1959	0.262	1	(-5, 5)	dev	0.565	normal(0.00, 0.50)
Main_RecrDev_1960	0.257	1	(-5, 5)	dev	0.563	normal(0.00, 0.50)
Main_RecrDev_1961	0.247	1	(-5, 5)	dev	0.559	normal(0.00, 0.50)
Main_RecrDev_1962	0.232	1	(-5, 5)	dev	0.554	normal(0.00, 0.50)
Main_RecrDev_1963	0.212	1	(-5, 5)	dev	0.547	normal(0.00, 0.50)
Main_RecrDev_1964	0.186	1	(-5, 5)	dev	0.539	normal(0.00, 0.50)
Main_RecrDev_1965	0.156	1	(-5, 5)	dev	0.53	normal(0.00, 0.50)
Main_RecrDev_1966	0.125	1	(-5, 5)	dev	0.521	normal(0.00, 0.50)
Main_RecrDev_1967	0.0968	1	(-5, 5)	dev	0.514	normal(0.00, 0.50)
Main_RecrDev_1968	0.0744	1	(-5, 5)	dev	0.507	normal(0.00, 0.50)
Main_RecrDev_1969	0.0591	1	(-5, 5)	dev	0.503	normal(0.00, 0.50)

Label	Value	Phase	Bounds	Status	SD	Prior
Main_RecrDev_1970	0.0494	1	(-5, 5)	dev	0.5	normal(0.00, 0.50)
Main_RecrDev_1971	0.042	1	(-5, 5)	dev	0.497	normal(0.00, 0.50)
Main_RecrDev_1972	0.0361	1	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1973	0.0352	1	(-5, 5)	dev	0.493	normal(0.00, 0.50)
Main_RecrDev_1974	0.0403	1	(-5, 5)	dev	0.492	normal(0.00, 0.50)
Main_RecrDev_1975	0.0422	1	(-5, 5)	dev	0.492	normal(0.00, 0.50)
Main_RecrDev_1976	0.0554	1	(-5, 5)	dev	0.492	normal(0.00, 0.50)
Main_RecrDev_1977	0.0757	1	(-5, 5)	dev	0.493	normal(0.00, 0.50)
Main_RecrDev_1978	0.107	1	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1979	0.108	1	(-5, 5)	dev	0.492	normal(0.00, 0.50)
Main_RecrDev_1980	0.098	1	(-5, 5)	dev	0.484	normal(0.00, 0.50)
Main_RecrDev_1981	0.0848	1	(-5, 5)	dev	0.476	normal(0.00, 0.50)
Main_RecrDev_1982	0.0217	1	(-5, 5)	dev	0.466	normal(0.00, 0.50)
Main_RecrDev_1983	0.0285	1	(-5, 5)	dev	0.46	normal(0.00, 0.50)
Main_RecrDev_1984	0.181	1	(-5, 5)	dev	0.457	normal(0.00, 0.50)
Main_RecrDev_1985	0.169	1	(-5, 5)	dev	0.436	normal(0.00, 0.50)
Main_RecrDev_1986	-0.0205	1	(-5, 5)	dev	0.438	normal(0.00, 0.50)
Main_RecrDev_1987	0.125	1	(-5, 5)	dev	0.462	normal(0.00, 0.50)
Main_RecrDev_1988	0.657	1	(-5, 5)	dev	0.388	normal(0.00, 0.50)
Main_RecrDev_1989	0.223	1	(-5, 5)	dev	0.439	normal(0.00, 0.50)
Main_RecrDev_1990	-0.113	1	(-5, 5)	dev	0.416	normal(0.00, 0.50)
Main_RecrDev_1991	0.035	1	(-5, 5)	dev	0.394	normal(0.00, 0.50)
Main_RecrDev_1992	0.154	1	(-5, 5)	dev	0.394	normal(0.00, 0.50)
Main_RecrDev_1993	0.305	1	(-5, 5)	dev	0.365	normal(0.00, 0.50)
Main_RecrDev_1994	0.0239	1	(-5, 5)	dev	0.353	normal(0.00, 0.50)
Main_RecrDev_1995	-0.489	1	(-5, 5)	dev	0.351	normal(0.00, 0.50)
Main_RecrDev_1996	-0.617	1	(-5, 5)	dev	0.343	normal(0.00, 0.50)
Main_RecrDev_1997	-0.604	1	(-5, 5)	dev	0.345	normal(0.00, 0.50)

Label	Value	Phase	Bounds	Status	SD	Prior
Main_RecrDev_1998	-0.27	1	(-5, 5)	dev	0.35	normal(0.00, 0.50)
Main_RecrDev_1999	0.548	1	(-5, 5)	dev	0.268	normal(0.00, 0.50)
Main_RecrDev_2000	0.187	1	(-5, 5)	dev	0.34	normal(0.00, 0.50)
Main_RecrDev_2001	0.11	1	(-5, 5)	dev	0.316	normal(0.00, 0.50)
Main_RecrDev_2002	-0.218	1	(-5, 5)	dev	0.338	normal(0.00, 0.50)
Main_RecrDev_2003	-0.525	1	(-5, 5)	dev	0.373	normal(0.00, 0.50)
Main_RecrDev_2004	-0.0497	1	(-5, 5)	dev	0.362	normal(0.00, 0.50)
Main_RecrDev_2005	0.0375	1	(-5, 5)	dev	0.37	normal(0.00, 0.50)
Main_RecrDev_2006	-0.213	1	(-5, 5)	dev	0.411	normal(0.00, 0.50)
Main_RecrDev_2007	0.223	1	(-5, 5)	dev	0.391	normal(0.00, 0.50)
Main_RecrDev_2008	0.577	1	(-5, 5)	dev	0.356	normal(0.00, 0.50)
Main_RecrDev_2009	0.0826	1	(-5, 5)	dev	0.427	normal(0.00, 0.50)
Main_RecrDev_2010	0.647	1	(-5, 5)	dev	0.332	normal(0.00, 0.50)
Main_RecrDev_2011	0.0457	1	(-5, 5)	dev	0.383	normal(0.00, 0.50)
Main_RecrDev_2012	1.04	1	(-5, 5)	dev	0.273	normal(0.00, 0.50)
Main_RecrDev_2013	-0.0412	1	(-5, 5)	dev	0.371	normal(0.00, 0.50)
Main_RecrDev_2014	-0.364	1	(-5, 5)	dev	0.397	normal(0.00, 0.50)
Main_RecrDev_2015	-0.445	1	(-5, 5)	dev	0.422	normal(0.00, 0.50)
Main_RecrDev_2016	-0.172	1	(-5, 5)	dev	0.429	normal(0.00, 0.50)
Main_RecrDev_2017	0.738	1	(-5, 5)	dev	0.381	normal(0.00, 0.50)
Main_RecrDev_2018	0.251	1	(-5, 5)	dev	0.416	normal(0.00, 0.50)
Main_RecrDev_2019	0.132	1	(-5, 5)	dev	0.413	normal(0.00, 0.50)
Main_RecrDev_2020	-0.22	1	(-5, 5)	dev	0.44	normal(0.00, 0.50)
Main_RecrDev_2021	-0.138	1	(-5, 5)	dev	0.465	normal(0.00, 0.50)
Main_RecrDev_2022	-0.0461	1	(-5, 5)	dev	0.491	normal(0.00, 0.50)
Main_RecrDev_2023	-0.00314	1	(-5, 5)	dev	0.499	normal(0.00, 0.50)
Late_RecrDev_2024	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2025	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)

Label	Value	Phase	Bounds	Status	SD	Prior
ForeRecr_2026	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2027	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2028	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2029	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2030	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2031	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2032	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2033	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2034	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2035	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2036	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
LnQ_base_TRIENNIAL(7)	-1.49	1	(-10, 2)	ok	0.743	none
LnQ_base_AK_SLOPE(8)	-3.11	-1	(-15, 15)	fixed	0	none
LnQ_base_NW_SLOPE(9)	-2.04	-1	(-15, 15)	fixed	0	none
LnQ_base_WCGBTS(10)	-2.61	-1	(-15, 15)	fixed	0	none
LnQ_base_TRIENNIAL(7)_BLK3repl_-1892	-2.27	1	(-10, 2)	ok	0.77	none
Size_DblN_peak_BOTTOM_TRAWL(1)	49.3	3	(15, 79)	ok	1.02	none
Size_DblN_top_logit_BOTTOM_-TRAWL(1)	-11.5	-4	(-15, 20)	fixed	0	none
Size_DblN_ascend_se_BOTTOM_-TRAWL(1)	4.57	3	(-15, 12)	ok	0.207	none
Size_DblN_descend_se_BOTTOM_-TRAWL(1)	2.95	4	(-15, 20)	ok	0.694	none
Size_DblN_start_logit_BOTTOM_-TRAWL(1)	-999	-3	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_BOTTOM_-TRAWL(1)	-0.639	4	(-15, 20)	ok	0.344	none
Size_DblN_peak_BOTTOM_TRAWL_-DISCARD(2)	25.3	3	(15, 79)	ok	5.37	none

Label	Value	Phase	Bounds	Status	SD	Prior
Size_DblN_top_logit_BOTTOM_-TRAWL_DISCARD(2)	-15	-4	(-15, 20)	fixed	0	none
Size_DblN_ascend_se_BOTTOM_-TRAWL_DISCARD(2)	4.89	3	(-15, 12)	ok	2.42	none
Size_DblN_descend_se_BOTTOM_-TRAWL_DISCARD(2)	3.84	4	(-15, 20)	ok	1.49	none
Size_DblN_start_logit_BOTTOM_-TRAWL_DISCARD(2)	-15	-3	(-15, 20)	fixed	0	none
Size_DblN_end_logit_BOTTOM_-TRAWL_DISCARD(2)	-3.82	4	(-15, 20)	ok	1.31	none
Size_DblN_peak_NON_TRAWL(3)	50.3	3	(15, 70)	ok	1.25	none
Size_DblN_top_logit_NON_TRAWL(3)	-15	-4	(-15, 20)	fixed	0	none
Size_DblN_ascend_se_NON_-TRAWL(3)	3.86	3	(-15, 12)	ok	0.296	none
Size_DblN_descend_se_NON_-TRAWL(3)	20	-4	(-15, 20)	fixed	0	none
Size_DblN_start_logit_NON_TRAWL(3)	-999	-3	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_NON_TRAWL(3)	4.6	-4	(-15, 20)	fixed	0	none
Size_DblN_peak_NON_TRAWL_-DISCARD(4)	49.9	3	(15, 70)	ok	1.5	none
Size_DblN_top_logit_NON_TRAWL_-DISCARD(4)	-15	-4	(-15, 20)	fixed	0	none
Size_DblN_ascend_se_NON_TRAWL_-DISCARD(4)	3.75	3	(-15, 12)	ok	0.439	none
Size_DblN_descend_se_NON_-TRAWL_DISCARD(4)	2.66	4	(-15, 20)	ok	0.95	none
Size_DblN_start_logit_NON_TRAWL_-DISCARD(4)	-999	-3	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_NON_TRAWL_-DISCARD(4)	-0.192	4	(-15, 20)	ok	0.419	none
Size_DblN_peak_MIDWATER_-TRAWL(5)	52.2	3	(15, 79)	ok	2.31	none

Label	Value	Phase	Bounds	Status	SD	Prior
Size_DblN_top_logit_MIDWATER_-TRAWL(5)	-15	-4	(-15, 20)	fixed	0	none
Size_DblN_ascend_se_MIDWATER_-TRAWL(5)	4.57	3	(-15, 12)	ok	0.384	none
Size_DblN_descend_se_MIDWATER_-TRAWL(5)	20	-4	(-15, 20)	fixed	0	none
Size_DblN_start_logit_MIDWATER_-TRAWL(5)	-999	-3	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_MIDWATER_-TRAWL(5)	-999	-4	(-1000, 20)	fixed	0	none
Size_DblN_peak_AT_SEA_HAKE(6)	49.7	3	(15, 70)	ok	1.41	none
Size_DblN_top_logit_AT_SEA_HAKE(6)	-15	-4	(-15, 20)	fixed	0	none
Size_DblN_ascend_se_AT_SEA_-HAKE(6)	3.59	3	(-15, 12)	ok	0.419	none
Size_DblN_descend_se_AT_SEA_-HAKE(6)	20	-4	(-15, 20)	fixed	0	none
Size_DblN_start_logit_AT_SEA_-HAKE(6)	-999	-2	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_AT_SEA_-HAKE(6)	-999	-4	(-1000, 20)	fixed	0	none
Size_DblN_peak_TRIENNIAL(7)	21.8	3	(13, 50)	ok	1.94	none
Size_DblN_top_logit_TRIENNIAL(7)	-8.6	-4	(-15, 20)	fixed	0	none
Size_DblN_ascend_se_TRIENNIAL(7)	3.52	3	(-15, 12)	ok	0.587	none
Size_DblN_descend_se_TRIENNIAL(7)	3.95	4	(-15, 20)	ok	0.553	none
Size_DblN_start_logit_TRIENNIAL(7)	-999	-2	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_TRIENNIAL(7)	-2.58	4	(-15, 20)	ok	0.321	none
Size_DblN_peak_AK_SLOPE(8)	37.3	3	(13, 50)	ok	2.38	none
Size_DblN_top_logit_AK_SLOPE(8)	-15	-4	(-15, 20)	fixed	0	none
Size_DblN_ascend_se_AK_SLOPE(8)	4.94	3	(-15, 12)	ok	0.425	none
Size_DblN_descend_se_AK_SLOPE(8)	4.63	4	(-15, 20)	ok	0.381	none
Size_DblN_start_logit_AK_SLOPE(8)	-999	-2	(-1000, 20)	fixed	0	none

Label	Value	Phase	Bounds	Status	SD	Prior
Size_DblN_end_logit_AK_SLOPE(8)	-10.5	4	(-15, 20)	ok	64.7	none
Size_DblN_peak_WCGBTS(10)	21.1	3	(13, 50)	ok	3.76	none
Size_DblN_top_logit_WCGBTS(10)	-15	-4	(-15, 20)	fixed	0	none
Size_DblN_ascend_se_WCGBTS(10)	3.39	3	(-15, 12)	ok	1.08	none
Size_DblN_descend_se_WCGBTS(10)	4.65	4	(-15, 20)	ok	1.05	none
Size_DblN_start_logit_WCGBTS(10)	-999	-2	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_WCGBTS(10)	-0.834	4	(-15, 20)	ok	0.31	none
Size_DblN_peak_BOTTOM_-TRAWL(1)_BLK4repl_1892	44.7	3	(15, 70)	ok	2.95	none
Size_DblN_peak_BOTTOM_-TRAWL(1)_BLK4repl_2002	47.6	3	(15, 70)	ok	1.07	none
Size_DblN_ascend_se_BOTTOM_-TRAWL(1)_BLK4repl_1892	5.03	3	(-15, 12)	ok	0.51	none
Size_DblN_ascend_se_BOTTOM_-TRAWL(1)_BLK4repl_2002	4.1	3	(-15, 12)	ok	0.306	none
Size_DblN_descend_se_BOTTOM_-TRAWL(1)_BLK4repl_1892	2.65	4	(-15, 20)	ok	1.7	none
Size_DblN_descend_se_BOTTOM_-TRAWL(1)_BLK4repl_2002	2.75	4	(-15, 20)	ok	0.751	none
Size_DblN_end_logit_BOTTOM_-TRAWL(1)_BLK4repl_1892	-1.59	4	(-15, 20)	ok	0.585	none
Size_DblN_end_logit_BOTTOM_-TRAWL(1)_BLK4repl_2002	-0.934	4	(-15, 20)	ok	0.324	none
Size_DblN_peak_BOTTOM_TRAWL_-DISCARD(2)_BLK1repl_1892	47.7	3	(15, 79)	ok	2.49	none
Size_DblN_ascend_se_BOTTOM_-TRAWL_DISCARD(2)_BLK1repl_1892	6.32	3	(-15, 12)	ok	0.627	none
Size_DblN_descend_se_BOTTOM_-TRAWL_DISCARD(2)_BLK1repl_1892	3.01	4	(-15, 20)	ok	1.19	none
Size_DblN_end_logit_BOTTOM_-TRAWL_DISCARD(2)_BLK1repl_1892	-1.7	4	(-15, 20)	ok	0.77	none

Label	Value	Phase	Bounds	Status	SD	Prior
Size_DblN_peak_NON_TRAWL(3)_-BLK2repl_1892	46.8	3	(15, 70)	ok	0.484	none
Size_DblN_peak_NON_TRAWL(3)_-BLK2repl_2011	49.5	3	(15, 70)	ok	0.556	none
Size_DblN_ascend_se_NON_-TRAWL(3)_BLK2repl_1892	3.05	3	(-15, 12)	ok	0.207	none
Size_DblN_ascend_se_NON_-TRAWL(3)_BLK2repl_2011	3.81	3	(-15, 12)	ok	0.154	none
Size_DblN_descend_se_NON_-TRAWL(3)_BLK2repl_1892	3.17	4	(-15, 20)	ok	0.242	none
Size_DblN_descend_se_NON_-TRAWL(3)_BLK2repl_2011	2.32	4	(-15, 20)	ok	0.52	none
Size_DblN_end_logit_NON_-TRAWL(3)_BLK2repl_1892	-2.29	4	(-15, 20)	ok	0.258	none
Size_DblN_end_logit_NON_-TRAWL(3)_BLK2repl_2011	-0.626	4	(-15, 20)	ok	0.193	none
Size_DblN_peak_TRIENNIAL(7)_-BLK3repl_1892	17.4	3	(13, 50)	ok	2.64	none
Size_DblN_ascend_se_TRIENNIAL(7)_-BLK3repl_1892	2.09	3	(-15, 12)	ok	1.39	none
Size_DblN_descend_se_-TRIENNIAL(7)_BLK3repl_1892	5.11	4	(-15, 20)	ok	0.636	none
Size_DblN_end_logit_TRIENNIAL(7)_-BLK3repl_1892	-4.29	4	(-15, 20)	ok	1.69	none

Table 22: Likelihood components by source.

Label	Total
TOTAL	7,334.0
Catch	0.0
Equil catch	0.0
Survey	-26.8
Length comp	574.8
Age comp	6,783.5
Recruitment	2.3
InitEQ Regime	0.0
Forecast Recruitment	0.0
Parm priors	0.1
Parm softbounds	0.0
Parm devs	0.0
Crash Pen	0.0

Table 23: Summary of reference points and management quantities, including estimates of the 95 percent confidence intervals. SO is spawning output, SPR is the spawning potential ratio, and MSY is maximum sustainable yield.

Reference Point	Estimate	Lower Interval	Upper Interval
Unfished Spawning output	5,647,660	-1,285,869	12,581,189
Unfished Age 26+ Biomass (mt)	33,631	-7,663	74,925
Unfished Recruitment (R0)	1,092	-237	2,420
2025 Spawning output	4,929,120	-2,527,916	12,386,156
2025 Fraction Unfished	0.873	0.615	1.130
Reference Points Based SO40%	—	—	—
Proxy Spawning output SO40%	2,259,070	-514,338	5,032,478
SPR Resulting in SO40%	0.458	0.458	0.458
Exploitation Rate Resulting in SO40%	0.048	0.045	0.051
Yield with SPR Based On SO40% (mt)	553	-119	1,224
Reference Points Based on SPR Proxy for MSY	—	—	—
Proxy Spawning output (SPR50)	2,519,730	-573,681	5,613,141
SPR50	0.500	—	—
Exploitation Rate Corresponding to SPR50	0.040	0.038	0.042
Yield with SPR50 at SO SPR (mt)	526	-113	1,165
Reference Points Based on Estimated MSY Values	—	—	—
Spawning output at MSY (SO MSY)	1,497,160	-343,313	3,337,633
SPR MSY	0.337	0.334	0.339
Exploitation Rate Corresponding to SPR MSY	0.085	0.079	0.090
MSY (mt)	592	-127	1,311

Table 24: Time series of population estimates from the base model.

Year	Total Biomass (mt)	Spawning output	Total Biomass 26+ (mt)	Fraction Unfished	Age-0 Recruits (1,000s)	Total Mortality (mt)	1-SPR	Exploita-tion Rate
1892	47710.2	5647660	33630.8	1.000	1008	19	0.018	0.001
1893	47688.3	5645320	33617.4	1.000	1006	19	0.018	0.001
1894	47665.5	5642940	33603.6	0.999	1005	19	0.018	0.001
1895	47640.8	5640520	33589.4	0.999	1003	5	0.005	0.000
1896	47629.3	5639830	33584.7	0.999	1001	1	0.001	0.000
1897	47618.4	5639600	33582.5	0.999	1000	1	0.001	0.000
1898	47603.0	5639400	33580.1	0.999	998	1	0.001	0.000
1899	47583.2	5639270	33578.0	0.999	997	1	0.001	0.000
1900	47557.4	5639090	33575.6	0.998	995	2	0.002	0.000
1901	47525.6	5638830	33573.0	0.998	994	2	0.002	0.000
1902	47487.5	5638430	33570.1	0.998	993	3	0.002	0.000
1903	47443.2	5637810	33567.2	0.998	992	3	0.003	0.000
1904	47392.9	5636860	33564.3	0.998	991	4	0.003	0.000
1905	47336.8	5635430	33561.4	0.998	990	4	0.004	0.000
1906	47275.2	5633390	33558.6	0.997	989	4	0.004	0.000
1907	47208.5	5630620	33555.8	0.997	989	5	0.005	0.000
1908	47137.1	5627030	33552.9	0.996	988	8	0.007	0.000
1909	47058.4	5622250	33548.0	0.996	988	6	0.006	0.000
1910	46978.8	5616880	33544.5	0.995	988	6	0.006	0.000
1911	46895.7	5610630	33540.6	0.993	988	7	0.006	0.000
1912	46809.6	5603550	33536.3	0.992	988	7	0.007	0.000
1913	46721.0	5595680	33531.5	0.991	989	8	0.007	0.000
1914	46630.1	5587080	33526.3	0.989	990	8	0.008	0.000
1915	46537.5	5577840	33520.6	0.988	991	10	0.010	0.000
1916	46441.7	5567800	33513.4	0.986	992	9	0.009	0.000
1917	46346.8	5557440	33506.8	0.984	993	10	0.010	0.000
1918	46251.2	5546620	33427.6	0.982	995	55	0.052	0.002
1919	46105.0	5529880	33314.6	0.979	997	26	0.025	0.001
1920	45992.7	5516410	33221.0	0.977	1000	23	0.023	0.001
1921	45884.7	5503050	33128.3	0.974	1002	23	0.022	0.001
1922	45778.7	5489600	33035.1	0.972	1005	18	0.018	0.001
1923	45680.4	5476690	32945.1	0.970	1008	20	0.020	0.001
1924	45581.8	5463490	32853.2	0.967	1012	32	0.031	0.001
1925	45472.7	5448900	32753.1	0.965	1015	38	0.037	0.001
1926	45359.8	5433600	32648.5	0.962	1019	54	0.052	0.002
1927	45231.7	5416370	32532.4	0.959	1023	69	0.066	0.002
1928	45091.2	5397470	32406.1	0.956	1026	72	0.069	0.002
1929	44951.6	5378350	32277.8	0.952	1029	66	0.064	0.002
1930	44823.2	5360150	32154.1	0.949	1032	67	0.065	0.002
1931	44698.8	5342120	32030.4	0.946	1035	44	0.043	0.001
1932	44605.6	5327280	31924.0	0.943	1037	25	0.025	0.001
1933	44538.6	5315160	31832.4	0.941	1039	35	0.035	0.001
1934	44465.7	5302340	31735.7	0.939	1041	42	0.042	0.001
1935	44389.6	5289100	31635.9	0.937	1042	34	0.034	0.001
1936	44328.0	5277410	31544.1	0.934	1044	61	0.060	0.002
1937	44241.5	5263000	31436.4	0.932	1046	53	0.052	0.002
1938	44169.0	5250090	31337.0	0.930	1048	56	0.055	0.002
1939	44099.2	5237500	31239.5	0.927	1050	28	0.029	0.001
1940	44064.8	5228830	31164.5	0.926	1054	59	0.058	0.002
1941	44000.9	5217110	31072.6	0.924	1059	102	0.097	0.003
1942	43894.8	5200880	30955.3	0.921	1065	125	0.119	0.004
1943	43767.7	5182350	30824.8	0.918	1073	257	0.227	0.008

Table 24: Time series of population estimates from the base model. *(continued)*

Year	Total Biomass (mt)	Spawning output	Total Biomass 26+ (mt)	Fraction Unfished	Age-0 Recruits (1,000s)	Total Mortality (mt)	1-SPR	Exploitation Rate
1944	43499.0	5148360	30606.1	0.912	1083	85	0.085	0.003
1945	43429.1	5135700	30507.4	0.909	1095	50	0.053	0.002
1946	43404.5	5128140	30437.4	0.908	1111	69	0.070	0.002
1947	43364.4	5118950	30357.0	0.906	1129	41	0.042	0.001
1948	43361.5	5113770	30299.0	0.905	1151	44	0.045	0.001
1949	43362.1	5109000	30243.6	0.905	1176	31	0.031	0.001
1950	43384.9	5106600	30202.5	0.904	1204	53	0.053	0.002
1951	43391.2	5102310	30152.6	0.903	1235	59	0.059	0.002
1952	43400.0	5097980	30104.7	0.903	1268	38	0.039	0.001
1953	43441.9	5096790	30077.0	0.902	1302	20	0.021	0.001
1954	43514.7	5098400	30068.1	0.903	1334	36	0.037	0.001
1955	43583.0	5098920	30056.3	0.903	1363	32	0.032	0.001
1956	43670.2	5100670	30054.0	0.903	1385	20	0.022	0.001
1957	43785.6	5104600	30065.6	0.904	1400	35	0.035	0.001
1958	43902.1	5107720	30072.9	0.904	1406	15	0.016	0.000
1959	44058.5	5114130	30097.2	0.906	1405	22	0.023	0.001
1960	44224.8	5120710	30119.6	0.907	1397	23	0.024	0.001
1961	44409.1	5128470	30144.8	0.908	1383	26	0.027	0.001
1962	44608.3	5137250	30170.7	0.910	1363	32	0.033	0.001
1963	44818.6	5146940	30195.7	0.911	1337	23	0.024	0.001
1964	45054.3	5159350	30228.7	0.914	1303	32	0.032	0.001
1965	45294.7	5172670	30259.0	0.916	1265	31	0.032	0.001
1966	45547.4	5188380	30294.9	0.919	1227	117	0.116	0.004
1967	45714.7	5197650	30292.7	0.920	1192	108	0.107	0.004
1968	45895.1	5209750	30298.3	0.922	1166	172	0.164	0.006
1969	46006.1	5217520	30278.2	0.924	1149	51	0.049	0.002
1970	46246.5	5239120	30319.7	0.928	1138	22	0.023	0.001
1971	46513.5	5266170	30386.6	0.932	1130	68	0.067	0.002
1972	46724.0	5290930	30443.6	0.937	1124	76	0.074	0.003
1973	46914.3	5316580	30509.0	0.941	1124	75	0.072	0.002
1974	47093.3	5343690	30589.4	0.946	1130	77	0.072	0.003
1975	47256.2	5371460	30684.4	0.951	1133	43	0.041	0.001
1976	47441.9	5403410	30816.0	0.957	1149	19	0.018	0.001
1977	47638.7	5438200	30982.2	0.963	1173	166	0.133	0.005
1978	47658.4	5455390	31079.2	0.966	1211	69	0.062	0.002
1979	47771.8	5483400	31261.7	0.971	1212	185	0.154	0.006
1980	47744.7	5496990	31398.0	0.973	1198	99	0.089	0.003
1981	47801.2	5518720	31603.4	0.977	1178	131	0.115	0.004
1982	47811.6	5534650	31801.3	0.980	1101	167	0.147	0.005
1983	47773.3	5544570	31986.9	0.982	1104	126	0.111	0.004
1984	47771.2	5556220	32190.5	0.984	1280	144	0.128	0.004
1985	47741.9	5563640	32377.3	0.985	1260	299	0.245	0.009
1986	47534.8	5550950	32456.5	0.983	1038	428	0.326	0.013
1987	47179.8	5520160	32427.3	0.977	1194	571	0.409	0.018
1988	46663.4	5469750	32273.5	0.968	2024	351	0.289	0.011
1989	46393.1	5442960	32226.8	0.964	1304	418	0.345	0.013
1990	46055.2	5408190	32114.1	0.958	928	244	0.223	0.008
1991	45918.0	5391230	32063.4	0.955	1071	299	0.269	0.009
1992	45729.2	5367750	31946.5	0.950	1199	306	0.269	0.010
1993	45538.7	5341860	31782.7	0.946	1389	327	0.283	0.010
1994	45329.8	5312700	31575.5	0.941	1044	306	0.265	0.010
1995	45151.1	5285130	31357.4	0.936	625	745	0.507	0.024
1996	44488.3	5204800	30828.8	0.922	549	339	0.292	0.011

Table 24: Time series of population estimates from the base model. *(continued)*

Year	Total Biomass (mt)	Spawning output	Total Biomass 26+ (mt)	Fraction Unfished	Age-0 Recruits (1,000s)	Total Mortality (mt)	1-SPR	Exploitation Rate
1997	44276.9	5172560	30560.3	0.916	555	303	0.266	0.010
1998	44097.2	5145180	30307.8	0.911	775	441	0.355	0.015
1999	43751.8	5102470	29962.0	0.903	1756	256	0.231	0.009
2000	43593.4	5083200	29743.4	0.900	1223	183	0.164	0.006
2001	43514.5	5074260	29571.9	0.898	1132	114	0.112	0.004
2002	43495.5	5076370	29469.7	0.899	816	74	0.072	0.003
2003	43510.9	5084420	29410.7	0.900	600	99	0.093	0.003
2004	43492.5	5091010	29371.1	0.901	965	115	0.103	0.004
2005	43449.0	5096290	29332.2	0.902	1054	138	0.119	0.005
2006	43373.1	5098680	29280.7	0.903	820	127	0.115	0.004
2007	43295.7	5101820	29242.7	0.903	1268	187	0.162	0.006
2008	43148.5	5095830	29123.2	0.902	1807	218	0.183	0.007
2009	42967.1	5083190	28996.3	0.900	1102	228	0.202	0.008
2010	42771.1	5067410	29021.5	0.897	1938	261	0.226	0.009
2011	42551.8	5044980	29015.5	0.893	1061	210	0.168	0.007
2012	42420.7	5025490	28861.4	0.890	2857	244	0.192	0.008
2013	42280.3	5000810	28812.1	0.885	977	156	0.134	0.005
2014	42263.9	4986990	29488.9	0.883	711	91	0.082	0.003
2015	42349.8	4980880	29647.0	0.882	659	132	0.114	0.004
2016	42423.6	4969040	29475.5	0.880	870	149	0.127	0.005
2017	42501.9	4954860	29408.5	0.877	2172	156	0.133	0.005
2018	42587.3	4939980	29441.6	0.875	1341	242	0.188	0.008
2019	42610.7	4914880	29559.3	0.870	1197	227	0.180	0.008
2020	42665.4	4893940	29413.2	0.867	846	106	0.090	0.004
2021	42856.7	4891640	29028.0	0.866	923	93	0.079	0.003
2022	43067.4	4895270	28596.7	0.867	1017	117	0.098	0.004
2023	43254.9	4900640	28157.9	0.868	1067	98	0.083	0.003
2024	43457.8	4913820	27923.0	0.870	1076	119	0.098	0.004
2025	43632.4	4929120	28487.4	0.873	1076	968	0.500	0.034
2026	42972.7	4841850	27968.3	0.857	1074	955	0.500	0.034
2027	42327.6	4760140	27390.1	0.843	1072	880	0.481	0.032
2028	41755.2	4690410	26627.0	0.831	1070	865	0.480	0.032
2029	41196.8	4624410	25726.5	0.819	1069	851	0.478	0.033
2030	40651.3	4561470	25136.9	0.808	1067	837	0.477	0.033
2031	40118.7	4501170	24635.1	0.797	1065	823	0.476	0.033
2032	39600.1	4443180	23981.3	0.787	1064	809	0.474	0.034
2033	39095.0	4386880	23677.4	0.777	1062	796	0.473	0.034
2034	38603.9	4331770	23771.1	0.767	1060	782	0.472	0.033
2035	38128.4	4277630	23363.6	0.757	1059	769	0.470	0.033
2036	37668.2	4224160	23558.5	0.748	1057	756	0.469	0.032

Table 25: Base model sensitivity to the removal of data sources (indices).

Label	Base	- Triennial	- AK Slope	-NW slope	- WCGBTS	No indices
Diff. in likelihood from base model						
Total	0	-15.45	-52.23	1.03	-2058.14	-2129.36
Index	0	7.784	0.176	1.032	17.58	NA
Length comp	0	-21.986	-52.07	0	-92.246	-173.251
Age comp	0	-0.12	-0.22	0	-1976.5	-1975.13
Recruitment	0	-1.132	-0.128	-0.001	-6.988	-7.802
Parm priors	0	0.001	0.005	0	0.002	0.006
Estimates of key parameters						
Recruitment unfished millions	1.092	0.93	1.075	1.088	0.674	0.631
log(R0)	6.995	6.836	6.98	6.992	6.513	6.447
NatM uniform Female	0.039	0.039	0.039	0.039	0.039	0.039
NatM uniform Male	0.036	0.036	0.036	0.036	0.036	0.036
L at Amax Female	60.1	60.1	60.1	60.1	61.9	62.4
L at Amax Male	57.8	57.9	57.8	57.8	58.7	58.7
Estimates of derived quantities						
Unfished age 8+ bio 1000 mt	33.631	28.678	33.004	33.509	20.708	19.333
B0 millions of eggs	5647660	4816400	5526870	5627100	3465540	3241330
B2025 millions of eggs	4929120	4011930	4796650	4907010	2573150	2313870
Fraction unfished 2025	0.873	0.833	0.868	0.872	0.742	0.714
Fishing intensity 2024	0.098	0.119	0.1	0.099	0.182	0.2
Catchability for WCGBTS	0.074	0.089	0.075	0.074	NA	NA

Table 26: Base model sensitivity to the removal of data sources (length compositions by fleet).

Label	Base	- bottom trawl	- non-trawl	- mid-water trawl	- ASHOP	- Triennial	- AK slope	- NW slope	- WCG-BTS
Diff. in likelihood from base model									
Total	0	-128.29	-251.07	-59.31	-26.57	-25.13	-52.49	0	-83.81
Index	0	1.361	0.211	-0.117	0.006	-2.543	-0.048	0	0.019
Length comp	0	-115.595	-222.555	-58.149	-25.251	-22.257	-51.94	0	-82.399
Age comp	0	-11.77	-26.82	-0.63	-1.39	0.37	-0.29	0	-1.49
Recruitment	0	-2.186	-1.854	-0.423	0.073	-0.716	-0.227	0	0.065
Parm priors	0	-0.108	-0.062	0.005	-0.004	0	0.005	0	-0.006
Estimates of key parameters									
Recruitment unfished millions	1.092	0.277	0.401	1.536	1.628	0.972	1.076	1.092	1.166
log(R0)	6.995	5.623	5.995	7.337	7.395	6.88	6.981	6.995	7.061
NatM uniform Female	0.039	0.035	0.037	0.039	0.039	0.039	0.039	0.039	0.039
NatM uniform Male	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
L at Amax Female	60.1	60.2	59.1	60.2	60.5	60.1	60.1	60.1	60.1
L at Amax Male	57.8	57.5	57.4	58	58.2	57.8	57.8	57.8	57.9
Estimates of derived quantities									
Unfished age 8+ bio 1000 mt	33.631	9.566	12.602	47.494	51.097	29.983	33.04	33.631	36.135
B0 millions of eggs	5647660	1774240	2140660	7962190	8658500	5038190	5532480	5647660	6097240
B2025 millions of eggs	4929120	616218	1203260	7357030	7991000	4255270	4801130	4929120	5416980
Fraction unfished 2025	0.873	0.347	0.562	0.924	0.923	0.845	0.868	0.873	0.888
Fishing intensity 2024	0.098	0.536	0.313	0.072	0.063	0.113	0.1	0.098	0.091
Catchability for WCGBTS	0.074	0.349	0.236	0.051	0.047	0.085	0.075	0.074	0.068

Table 27: Base model sensitivity to the removal of data sources (length compositions by source).

Label	Base	- fishery	- survey	no lengths
Diff. in likelihood from base model				
Total	0	-454.05	-162.74	-617.35
Index	0	1.049	-3.924	-2.848
Length comp	0	-415.616	-157.698	-574.836
Age comp	0	-37.58	-0.45	-38.19
Recruitment	0	-1.929	-0.678	-2.429
Parm priors	0	0.011	-0.001	0.938
Estimates of key parameters				
Recruitment unfished thousands	1091.58	359.453	1042.2	769.18
log(R0)	6.995	5.885	6.949	6.645
NatM uniform Female	0.039	0.039	0.039	0.053
NatM uniform Male	0.036	0.036	0.036	0.036
L at Amax Female	60.1	57.4	60.2	56
L at Amax Male	57.8	56.5	57.9	56.7
Estimates of derived quantities				
Unfished age 8+ bio 1000 mt	33.631	10.074	32.222	16.412
B0 millions of eggs	5647660	1559520	5425890	1688620
B2025 millions of eggs	4929120	745994	4674580	1214190
Fraction unfished 2025	0.873	0.478	0.862	0.719
Fishing intensity 2024	0.098	0.403	0.104	0.175
Catchability for WCGBTS	0.074	0.286	6.426	7.108

Table 28: Base model sensitivity to the removal of data sources (age compositions by fleet).

Label	Base	- bottom trawl	- non-trawl	- mid-water trawl	- ASHOP	- WGCBTS	- fishery	no ages
Diff. in likelihood from base model								
Total	0	-467.49	-332.87	-182.78	-3886.07	-1988.26	-4868.13	-6840.569
Index	0	0.219	0.016	0.09	-0.455	0.006	-0.204	-1.149
Length comp	0	-0.58	-2.269	0.085	-30.757	-5.665	-37.129	-49.98
Age comp	0	-467.56	-330.26	-183.28	-3854.02	-1975.69	-4829.43	-6783.49
Recruitment	0	0.428	-0.36	0.329	-0.817	-6.922	-1.329	-5.862
Parm priors	0	-0.001	-0.003	-0.003	-0.03	0.008	-0.045	-0.092
Estimates of key parameters								
Recruitment unfished thousands	1091.58	925.774	1152.03	1062.2	486.651	669.58	504.669	647.515
log(R0)	6.995	6.831	7.049	6.968	6.188	6.507	6.224	6.473
NatM uniform Female	0.039	0.039	0.039	0.039	0.038	0.039	0.038	0.036
NatM uniform Male	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
L at Amax Female	60.1	60	60	60.1	59.6	61.7	58.4	55.3
L at Amax Male	57.8	57.7	57.7	57.8	57.4	58.7	56.9	54.2
Estimates of derived quantities								
Unfished age 8+ bio 1000 mt	33.631	28.572	35.428	32.801	15.219	20.495	15.741	19.027
B0 millions of eggs	5647660	4819970	5957400	5527370	2628770	3412570	3933420	3265070
B2025 millions of eggs	4929120	3968100	5184400	4772870	1844350	2507090	1714540	2402180
Fraction unfished 2025	0.873	0.823	0.87	0.863	0.702	0.735	0.436	0.736
Fishing intensity 2024	0.098	0.119	0.094	0.101	0.232	0.184	0.169	0.165
Catchability for WCGBTS	0.074	0.089	0.07	0.076	0.205	0.094	0.214	0.18

Table 29: Summary of reference points and management quantities, including estimates of the 95 percent confidence intervals. SO is spawning output, SPR is the spawning potential ratio, and MSY is maximum sustainable yield.

Reference Point	Estimate	Lower Interval	Upper Interval
Unfished Spawning output	5,647,660.0	-1,285,869.4	12,581,189.4
Unfished Age 26+ Biomass (mt)	33,631	-7,663	74,925
Unfished Recruitment (R0)	1,092	-237	2,420
2025 Spawning output	4,929,120	-2,527,916	12,386,156
2025 Fraction Unfished	0.873	0.615	1.130
Reference Points Based SO40%	—	—	—
Proxy Spawning output SO40%	2,259,070	-514,338	5,032,478
SPR Resulting in SO40%	0.458	0.458	0.458
Exploitation Rate Resulting in SO40%	0.048	0.045	0.051
Yield with SPR Based On SO40% (mt)	553	-119	1,224
Reference Points Based on SPR Proxy for MSY	—	—	—
Proxy Spawning output (SPR50)	2,519,730	-573,681	5,613,141
SPR50	0.500	—	—
Exploitation Rate Corresponding to SPR50	0.040	0.038	0.042
Yield with SPR50 at SO SPR (mt)	526	-113	1,165
Reference Points Based on Estimated MSY Values	—	—	—
Spawning output at MSY (SO MSY)	1,497,160	-343,313	3,337,633
SPR MSY	0.337	0.334	0.339
Exploitation Rate Corresponding to SPR MSY	0.085	0.079	0.090
MSY (mt)	592	-127	1,311

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Table 30: Time series of population estimates from the base model.

Year	Total Biomass (mt)	Spawning output	Total Biomass 26+ (mt)	Fraction Unfished	Age-0 Recruits (1,000s)	T
1892	47710.2	5647660	33630.8	1.000	1008	
1893	47688.3	5645320	33617.4	1.000	1006	
1894	47665.5	5642940	33603.6	0.999	1005	
1895	47640.8	5640520	33589.4	0.999	1003	
1896	47629.3	5639830	33584.7	0.999	1001	
1897	47618.4	5639600	33582.5	0.999	1000	
1898	47603.0	5639400	33580.1	0.999	998	
1899	47583.2	5639270	33578.0	0.999	997	
1900	47557.4	5639090	33575.6	0.998	995	
1901	47525.6	5638830	33573.0	0.998	994	
1902	47487.5	5638430	33570.1	0.998	993	
1903	47443.2	5637810	33567.2	0.998	992	
1904	47392.9	5636860	33564.3	0.998	991	
1905	47336.8	5635430	33561.4	0.998	990	
1906	47275.2	5633390	33558.6	0.997	989	
1907	47208.5	5630620	33555.8	0.997	989	
1908	47137.1	5627030	33552.9	0.996	988	
1909	47058.4	5622250	33548.0	0.996	988	
1910	46978.8	5616880	33544.5	0.995	988	
1911	46895.7	5610630	33540.6	0.993	988	
1912	46809.6	5603550	33536.3	0.992	988	
1913	46721.0	5595680	33531.5	0.991	989	
1914	46630.1	5587080	33526.3	0.989	990	
1915	46537.5	5577840	33520.6	0.988	991	
1916	46441.7	5567800	33513.4	0.986	992	
1917	46346.8	5557440	33506.8	0.984	993	
1918	46251.2	5546620	33427.6	0.982	995	
1919	46105.0	5529880	33314.6	0.979	997	
1920	45992.7	5516410	33221.0	0.977	1000	
1921	45884.7	5503050	33128.3	0.974	1002	
1922	45778.7	5489600	33035.1	0.972	1005	
1923	45680.4	5476690	32945.1	0.970	1008	
1924	45581.8	5463490	32853.2	0.967	1012	
1925	45472.7	5448900	32753.1	0.965	1015	
1926	45359.8	5433600	32648.5	0.962	1019	
1927	45231.7	5416370	32532.4	0.959	1023	
1928	45091.2	5397470	32406.1	0.956	1026	
1929	44951.6	5378350	32277.8	0.952	1029	
1930	44823.2	5360150	32154.1	0.949	1032	
1931	44698.8	5342120	32030.4	0.946	1035	
1932	44605.6	5327280	31924.0	0.943	1037	
1933	44538.6	5315160	31832.4	0.941	1039	
1934	44465.7	5302340	31735.7	0.939	1041	
1935	44389.6	5289100	31635.9	0.937	1042	
1936	44328.0	5277410	31544.1	0.934	1044	
1937	44241.5	5263000	31436.4	0.932	1046	
1938	44169.0	5250090	31337.0	0.930	1048	
1939	44099.2	5237500	31239.5	0.927	1050	
1940	44064.8	5228830	31164.5	0.926	1054	
1941	44000.9	5217110	31072.6	0.924	1059	
1942	43894.8	5200880	30955.3	0.921	1065	
1943	43767.7	5182350	30824.8	0.918	1073	
1944	43499.0	5148360	30606.1	0.912	1083	
1945	43429.1	5135700	30507.4	0.909	1095	
1946	43404.5	5128140	30437.4	0.908	1111	
1947	43364.4	5118950	30357.0	0.906	1129	
1948	43361.5	5113770	30299.0	0.905	1151	
1949	43362.1	5109000	30243.6	0.905	1176	
1950	43384.9	5106600	30202.5	0.904	1204	
1951	43391.2	5102310	30152.6	0.903	1235	
1952	43400.0	5097980	30104.7	0.903	1268	
1953	43441.9	5096790	30077.0	0.902	1302	
1954	43514.7	5098400	30068.1	0.903	1334	
1955	43583.0	5098920	30056.3	0.903	1363	
1956	43670.2	5100670	30054.0	0.903	1385	

Table 31: Recent trend in the overfishing limits (OFL), the acceptable biological catches (ABCs), the annual catch limits (ACLs), and the total dead catch (landings + discards) all in metric tons (mt). Specifications are combined across north and south of 40'10.

Year	OFL (mt)	ABC (mt)	ACL (mt)	Catch (mt)
2015	206	188.1	188.1	132.1
2016	211	192.7	192.7	149.0
2017	215	196.3	196.3	156.0
2018	219	199.9	199.9	241.5
2019	222	202.7	202.7	226.6
2020	224	204.5	204.5	106.1
2021	237	195.8	195.8	92.8
2022	238	194.7	194.7	117.4
2023	238	192.8	192.8	97.6
2024	238	194.7	194.7	118.9

Table 32: Potential OFLs (mt), ABCs (mt), ACLs (mt), the buffer between the OFL and ABC, estimated spawning output, and fraction unfished with adopted OFLs and ACLs and assumed catch for the first two years of the projection period.

Year	Adopted OFL (mt)	Adopted ACL (mt)	Assumed Catch (mt)	OFL (mt)	Buffer	ABC (mt)	ACL (mt)	Spawning output	Fraction Unfished
2025	—	—	968	—	—	—	—	4,929,120.000	0.873
2026	—	—	955	—	—	—	—	4,841,850.000	0.857
2027	—	—	—	942	0.935	880	880	4,760,140.000	0.843
2028	—	—	—	930	0.930	865	865	4,690,410.000	0.831
2029	—	—	—	919	0.926	851	851	4,624,410.000	0.819
2030	—	—	—	908	0.922	837	837	4,561,470.000	0.808
2031	—	—	—	897	0.917	823	823	4,501,170.000	0.797
2032	—	—	—	886	0.913	809	809	4,443,180.000	0.787
2033	—	—	—	876	0.909	796	796	4,386,880.000	0.777
2034	—	—	—	865	0.904	782	782	4,331,770.000	0.767
2035	—	—	—	854	0.900	769	769	4,277,630.000	0.757
2036	—	—	—	843	0.896	756	756	4,224,160.000	0.748

8 Figures

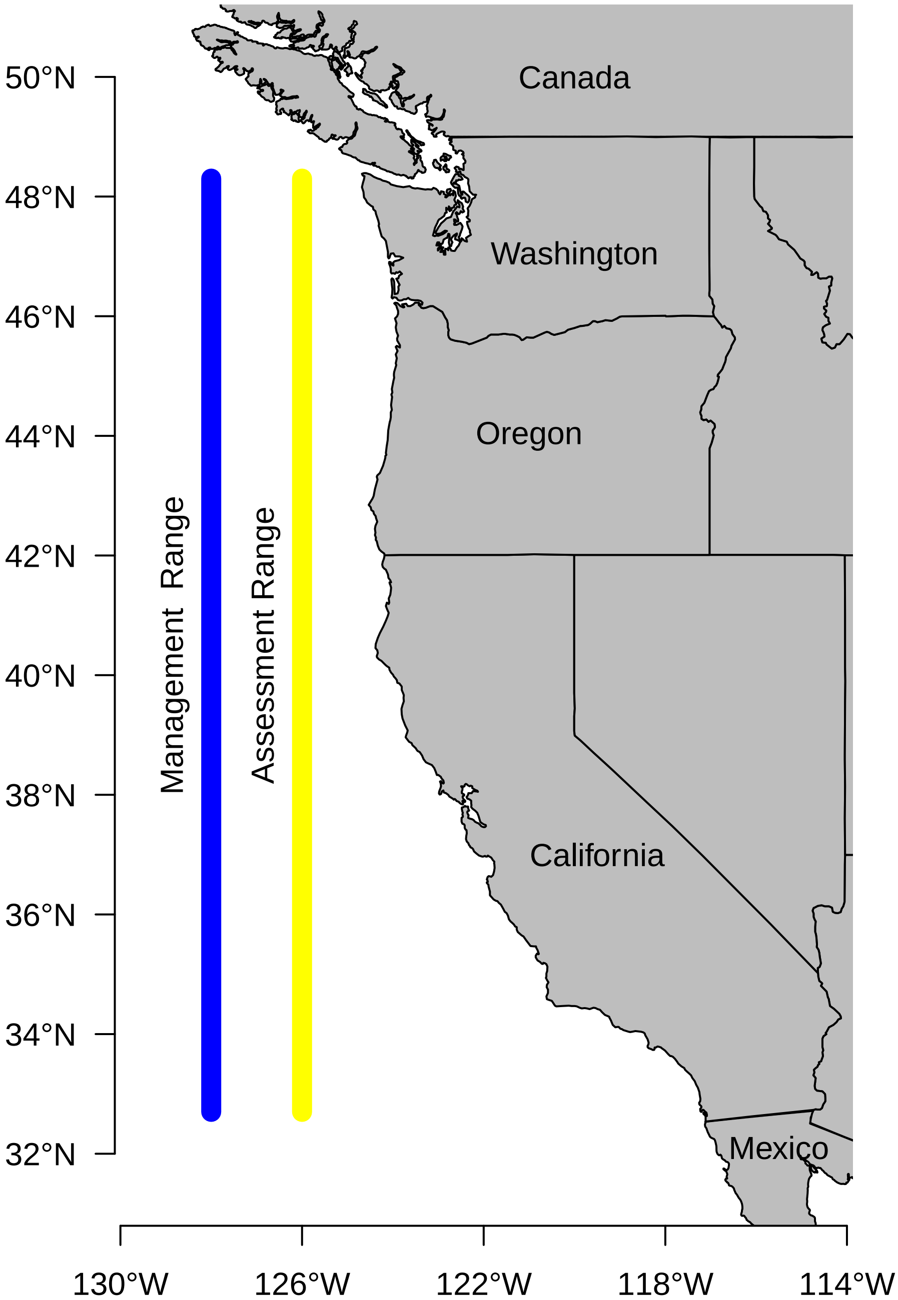

Figure 1: Map of the assessment area.

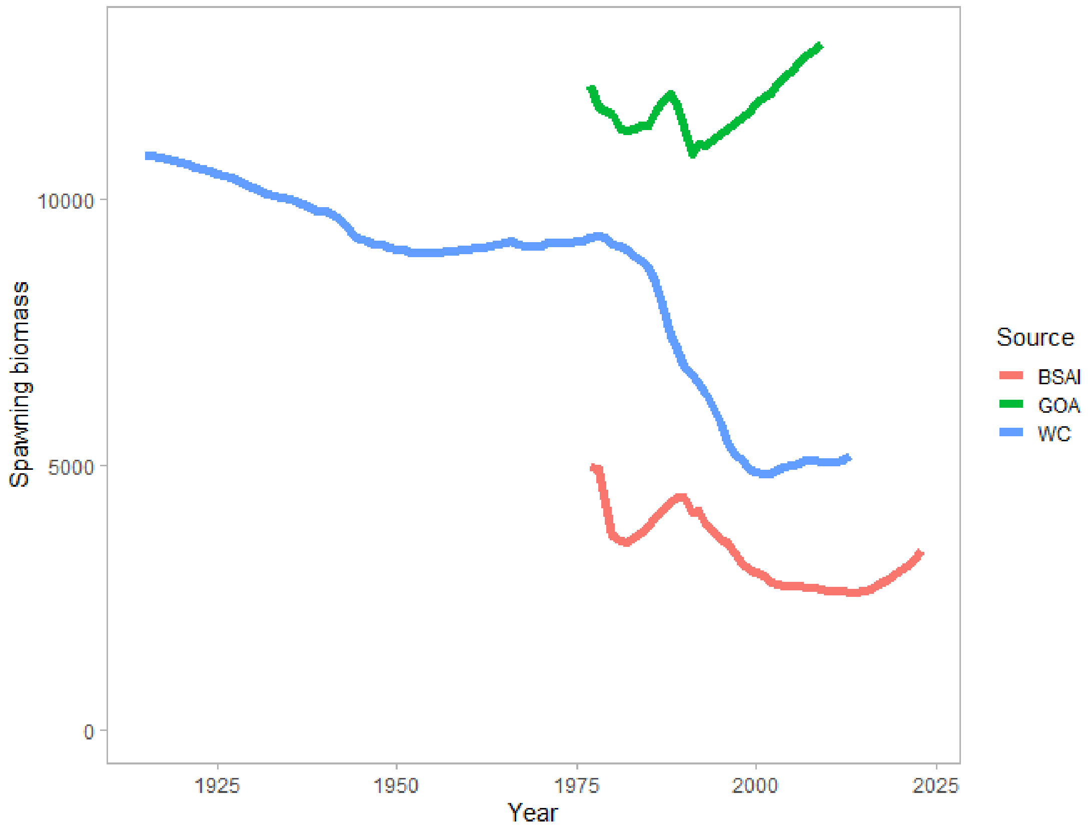

Figure 2: Estimates of spawning biomass (current spawning output/unfished spawning output) for the Rougheye/Blackspotted rockfish complex from the two most recent Alaska (Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA)) and the 2013 U.S. west coast stock assessment.

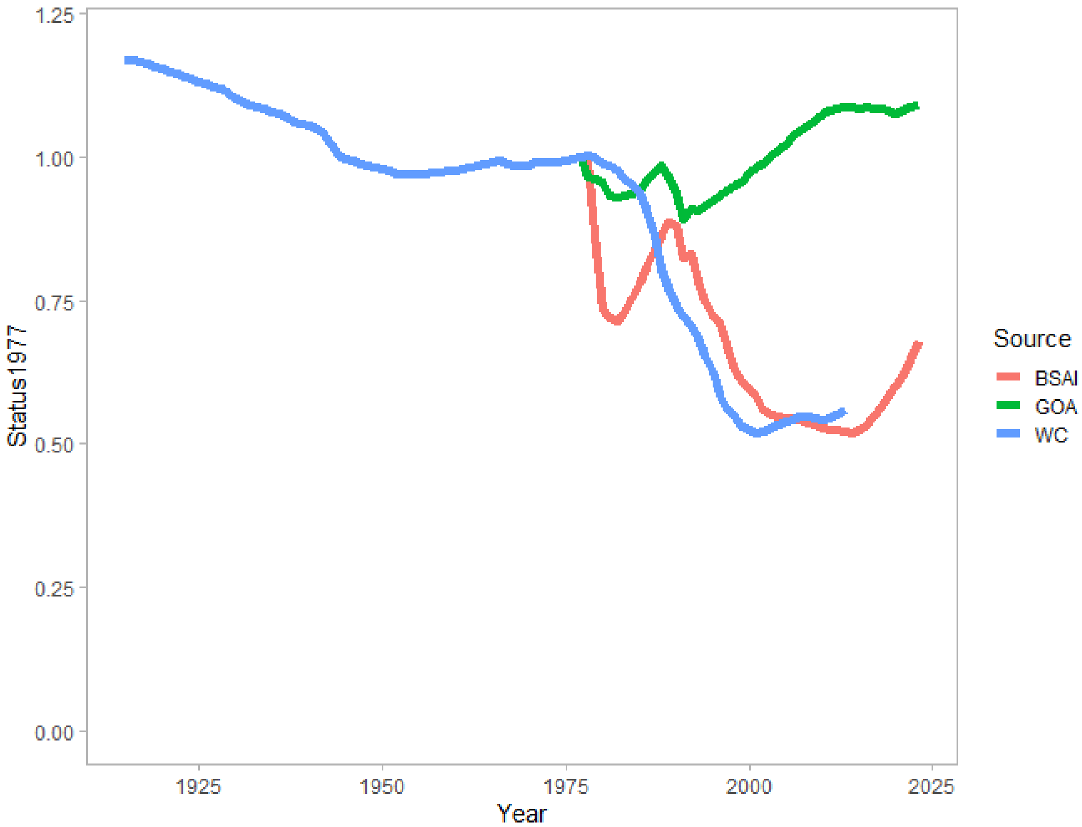

Figure 3: Estimates of relative stock size (current spawning output/unfished spawning output) relative to 1977 (the common year in all stock assessments compared) for the Rougheye/Blackspotted rockfish complex from the two most recent Alaska (Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA)) and the 2013 U.S. west coast stock assessment.

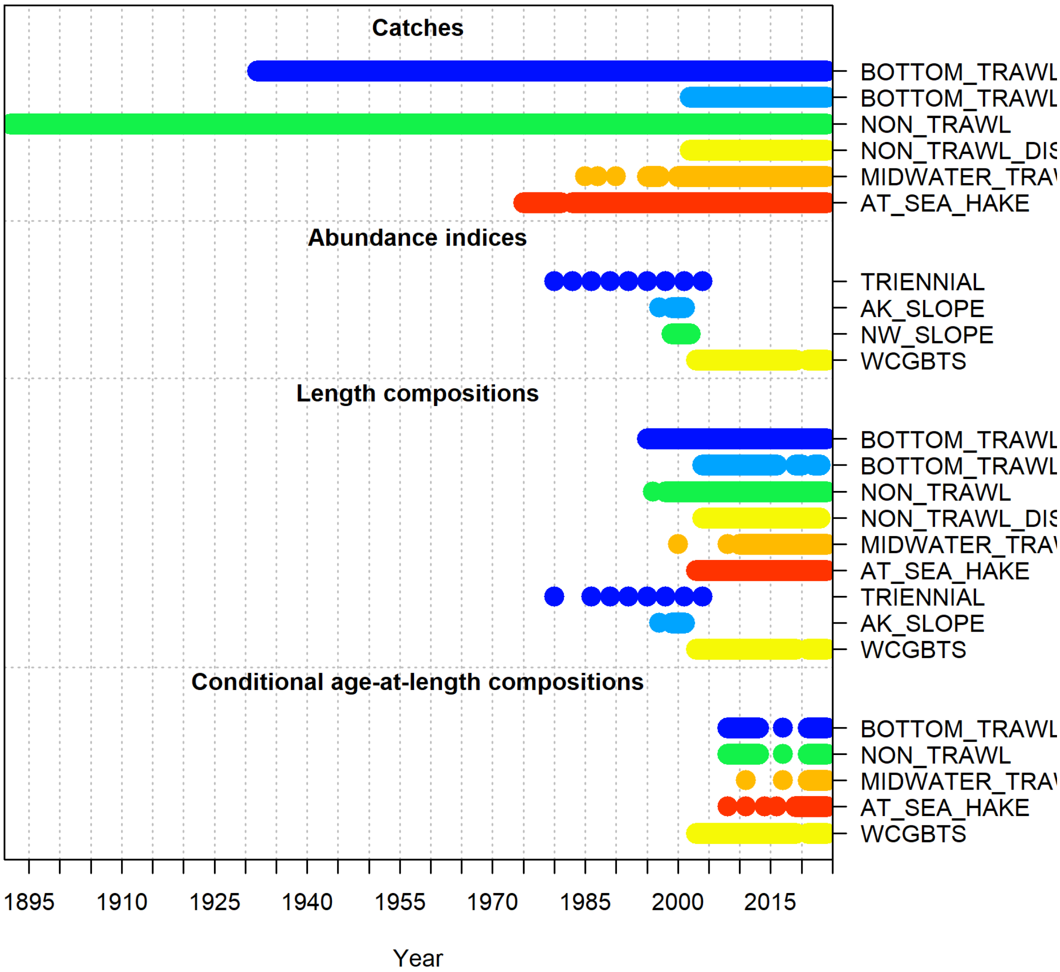

Figure 4: Data used in the base model.

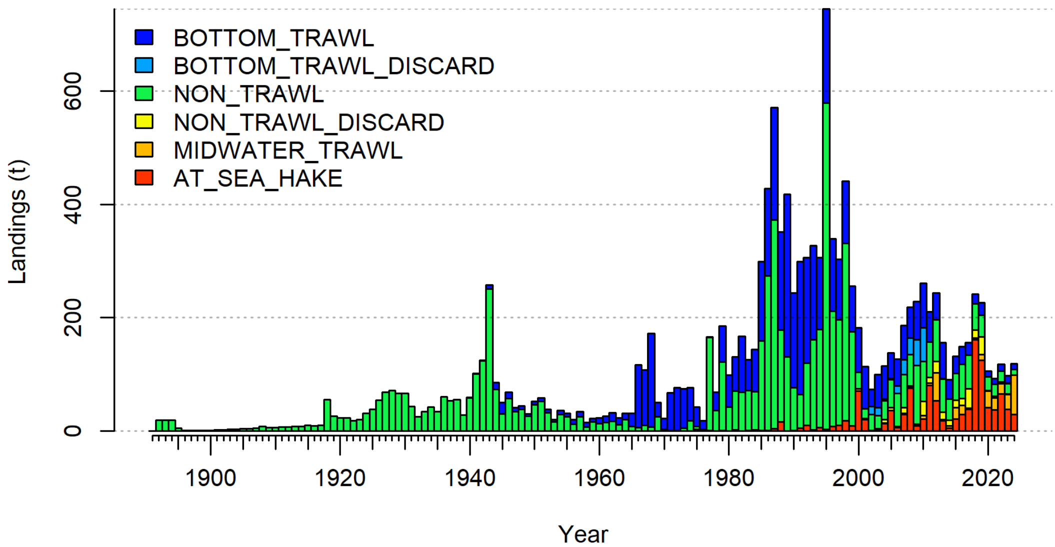

Figure 5: Landings by fleet.

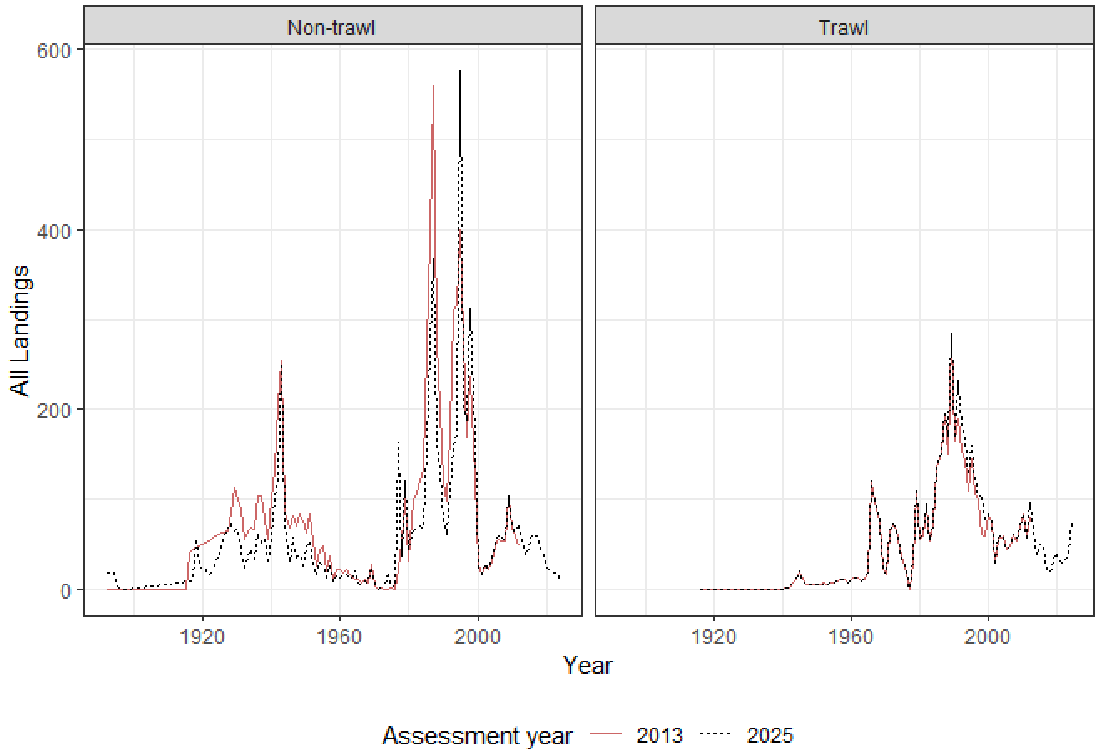

Figure 6: Landings across all states for non-trawl and trawl fisheries compared between the 2013 assessment and updated landings for the 2025 stock assessment model.

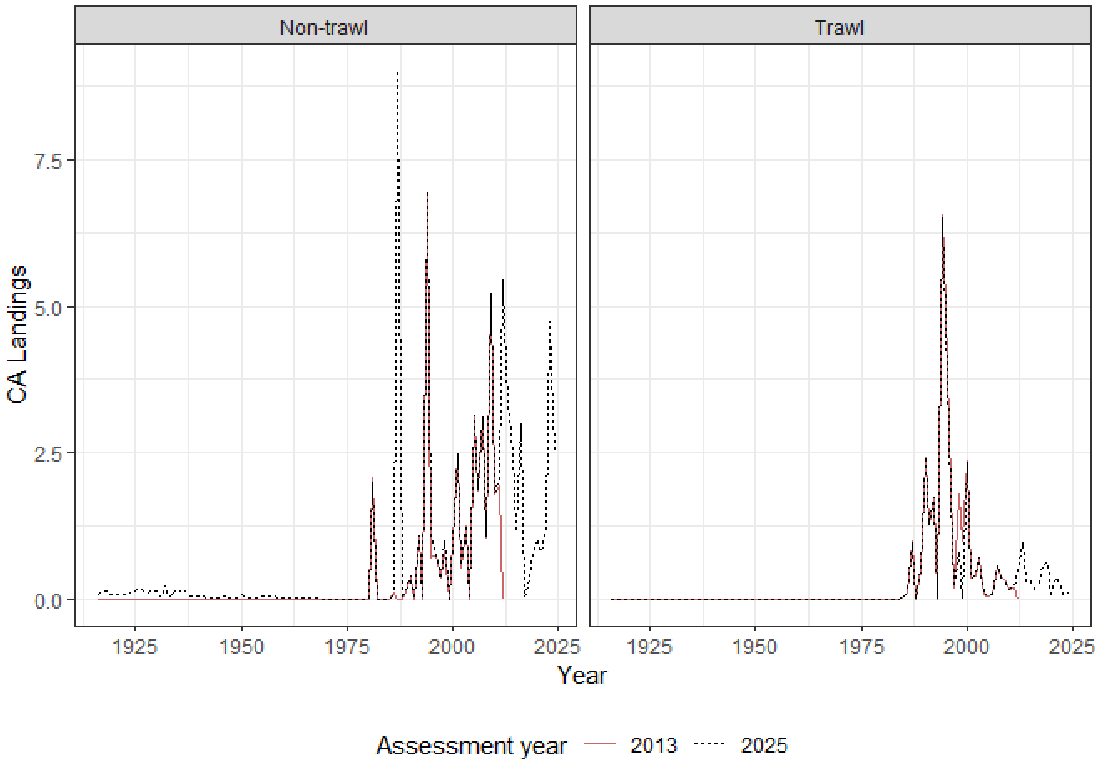

Figure 7: California state landings for non-trawl and trawl fisheries compared between the 2013 assessment and updated landings for the 2025 stock assessment model.

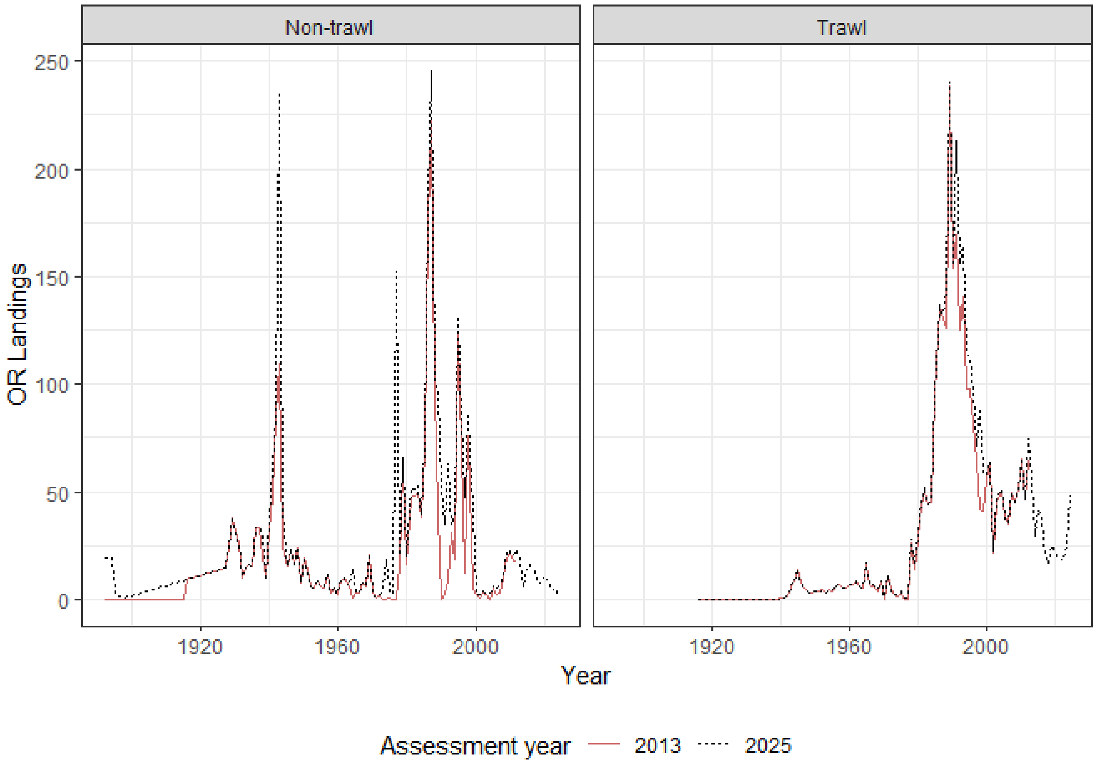

Figure 8: Oregon state landings for non-trawl and trawl fisheries compared between the 2013 assessment and updated landings for the 2025 stock assessment model.

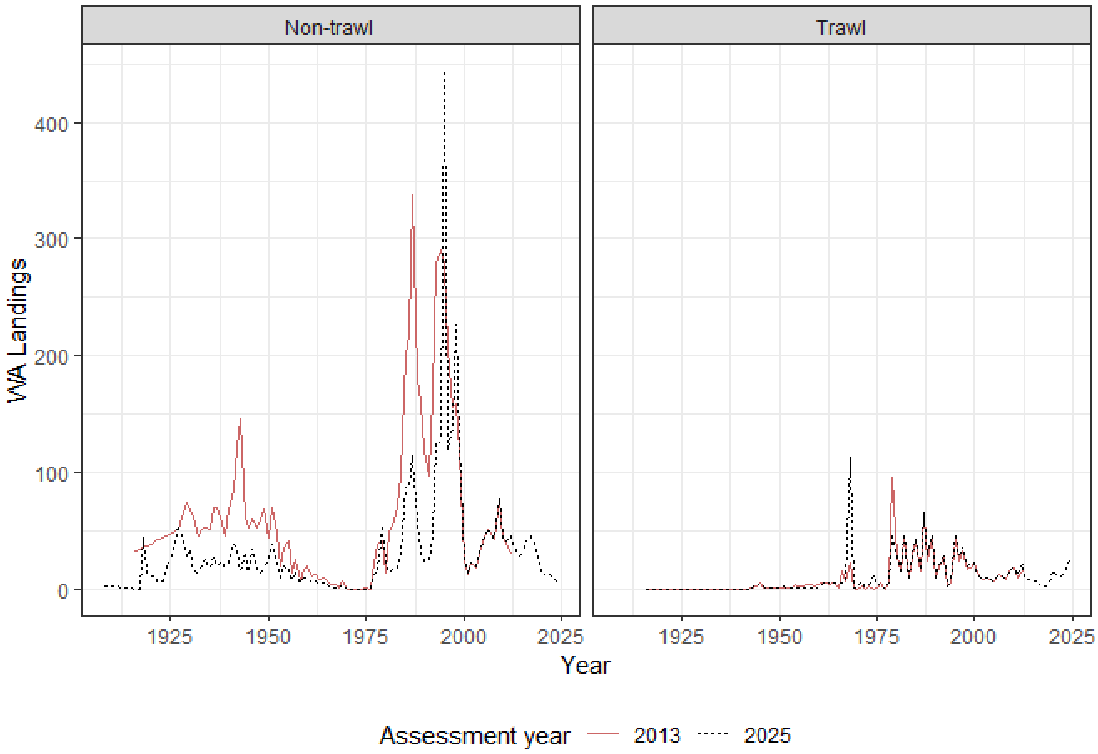

Figure 9: WA. Washington state landings for non-trawl and trawl fisheries compared between the 2013 assessment and updated landings for the 2025 stock assessment model.

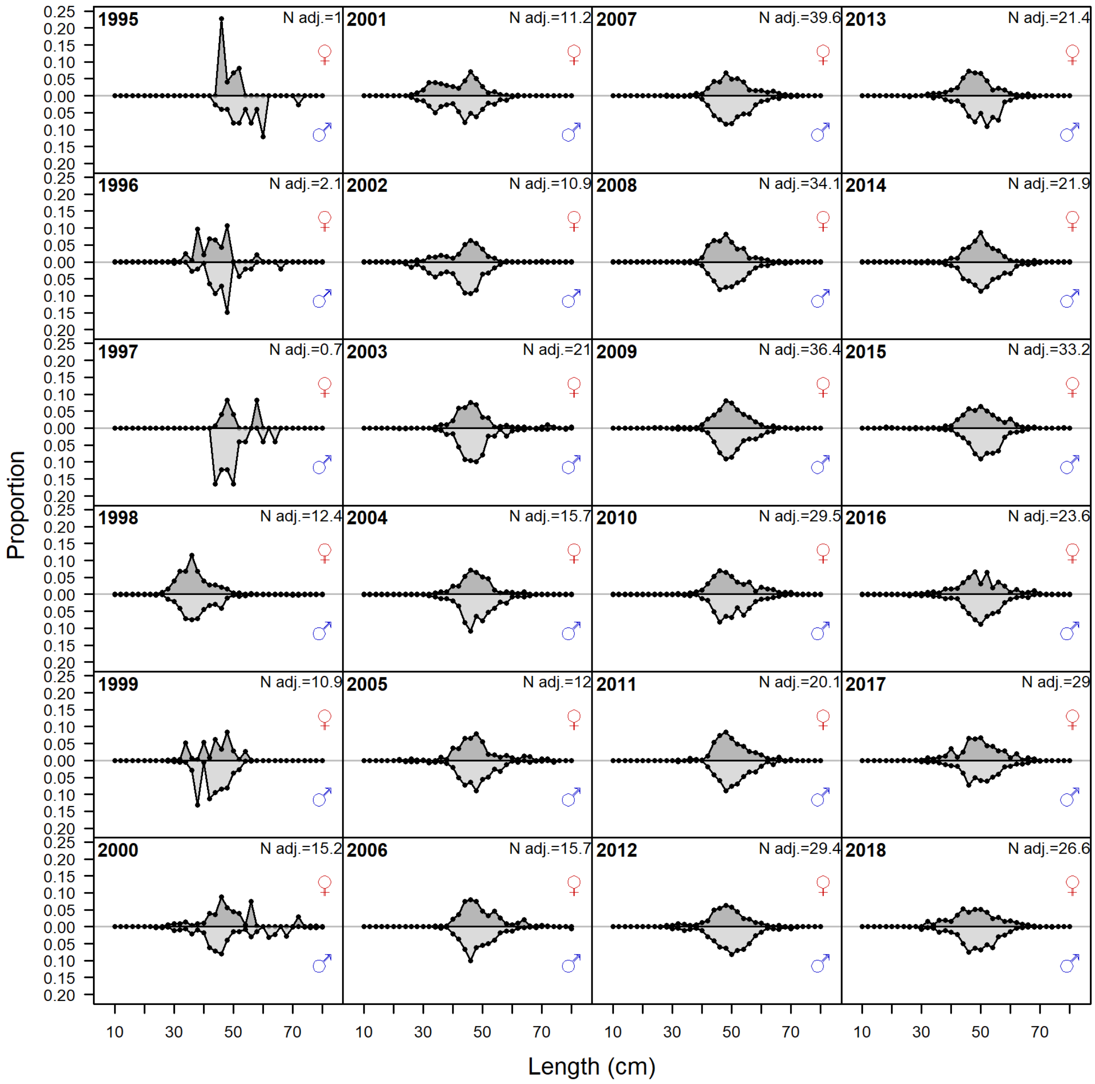

Figure 10: Length composition data for bottom trawl fleet.

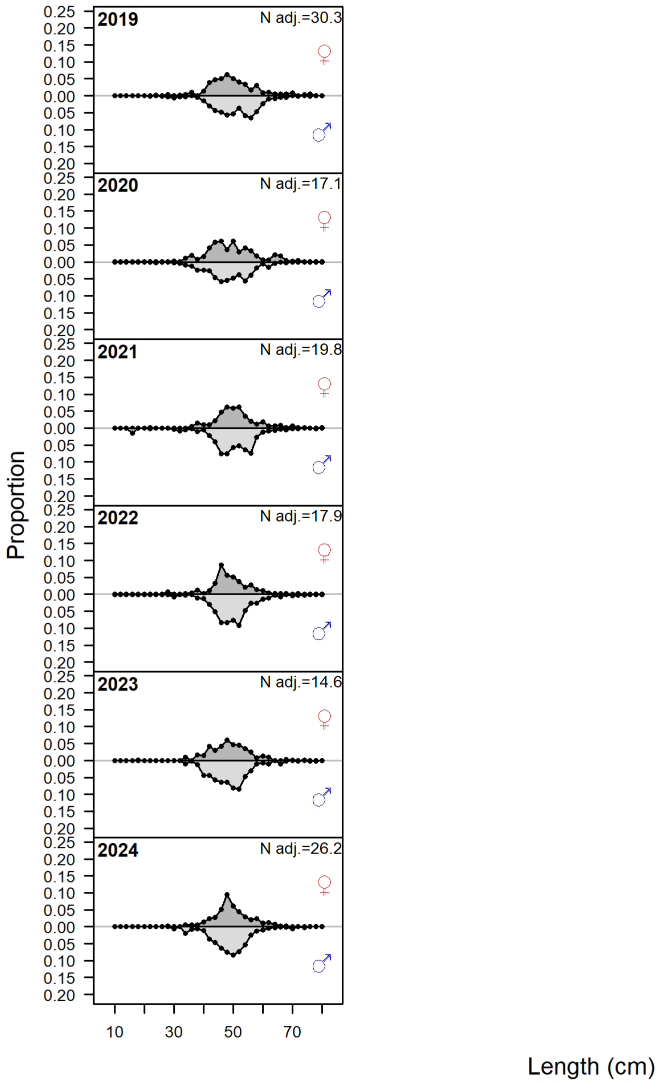

Figure 11: Length composition data for bottom trawl fleet, continued.

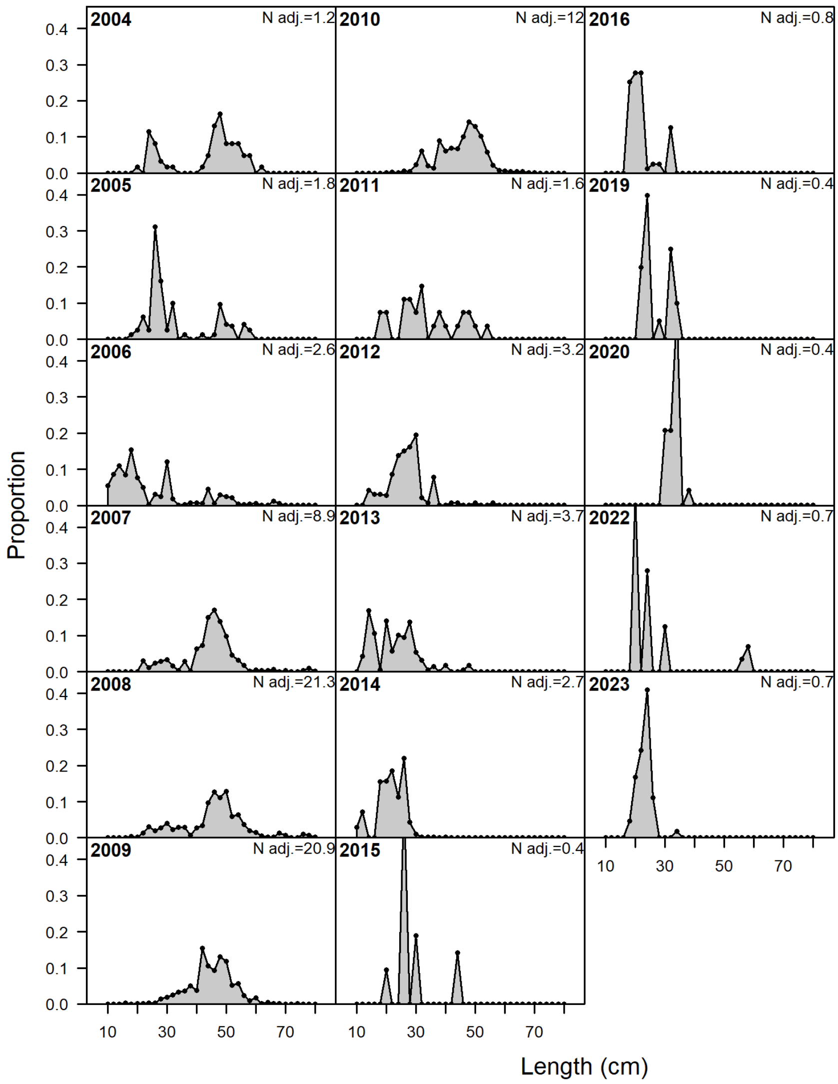

Figure 12: Length composition data for bottom trawl discard fleet.

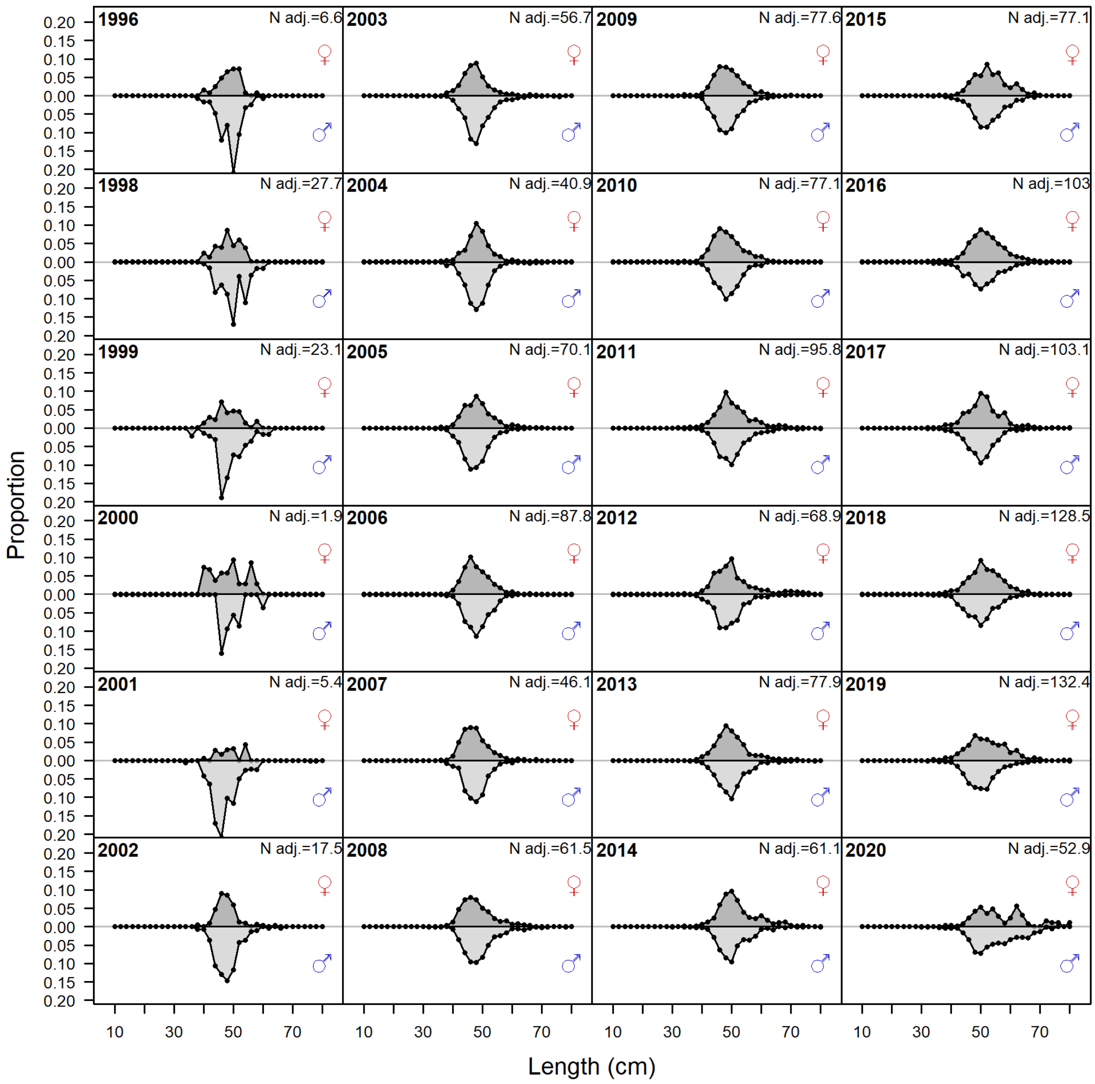

Figure 13: Length composition data for non-trawl fleet.

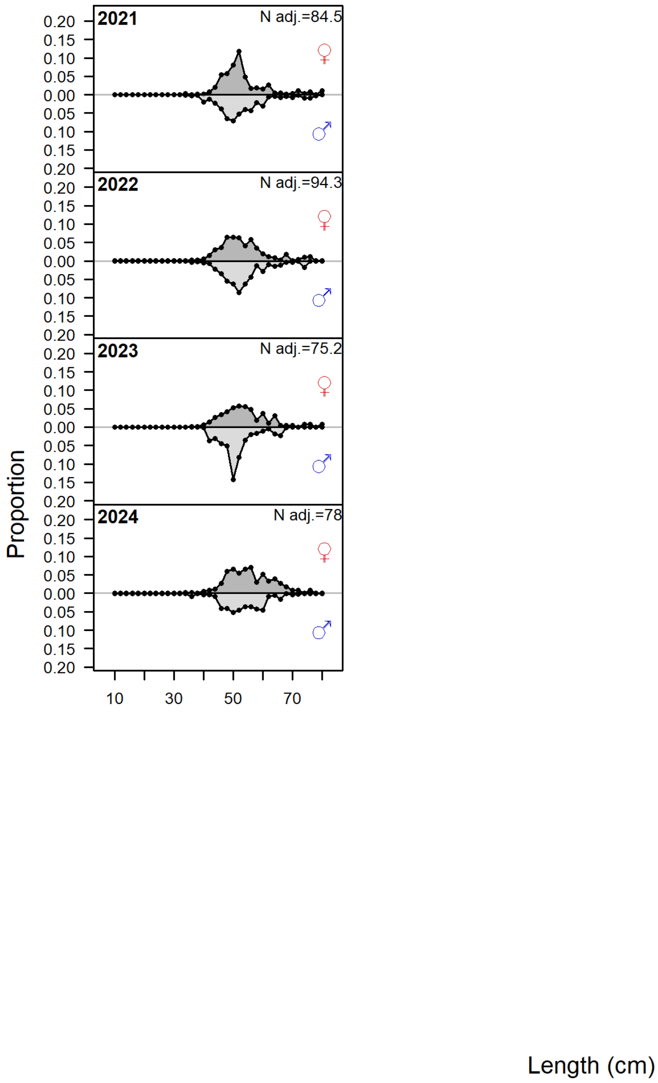

Figure 14: Length composition data for non-trawl fleet, continued.

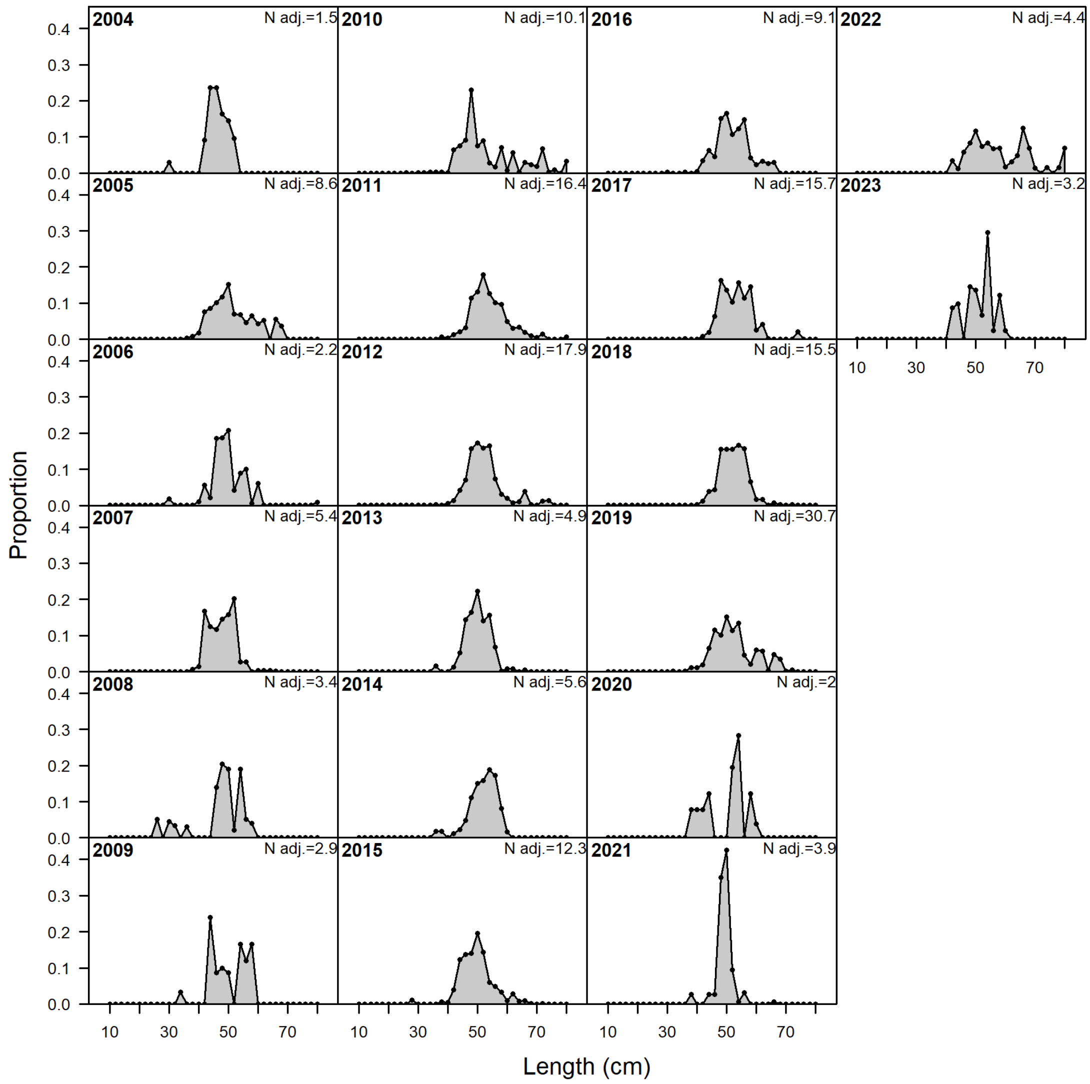

Figure 15: Length composition data for non-trawl discard fleet.

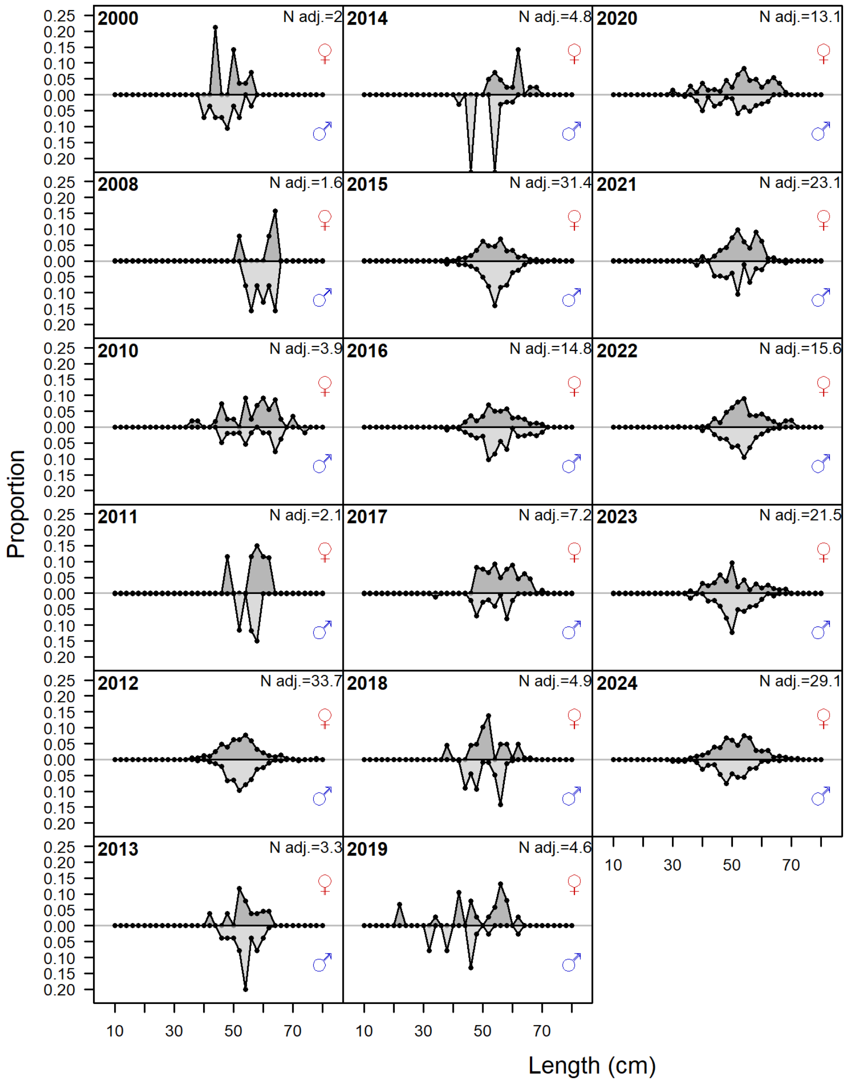

Figure 16: Length composition data for mid-water trawl fleet.

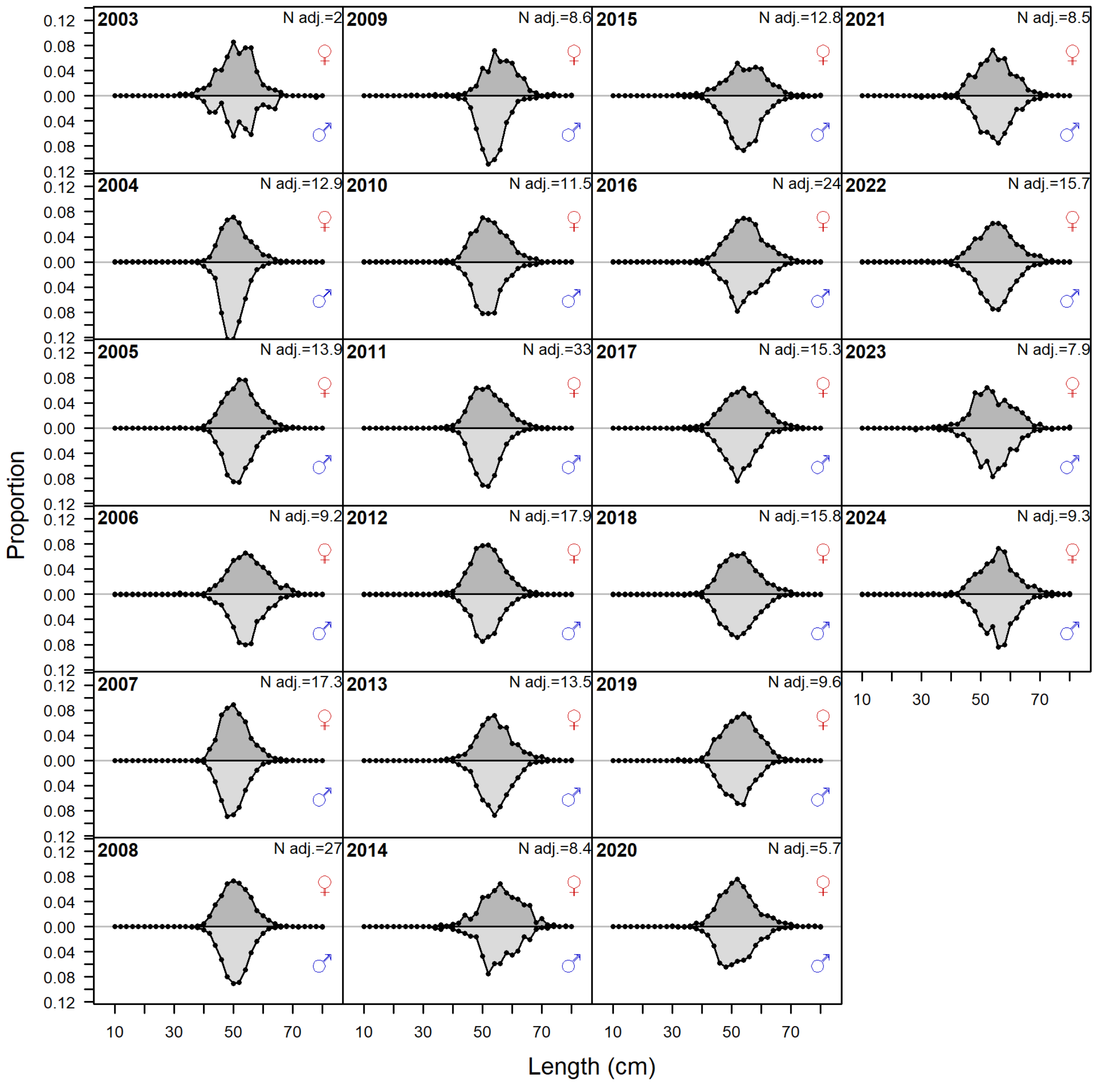

Figure 17: Length composition data for At-sea Hake fleet.

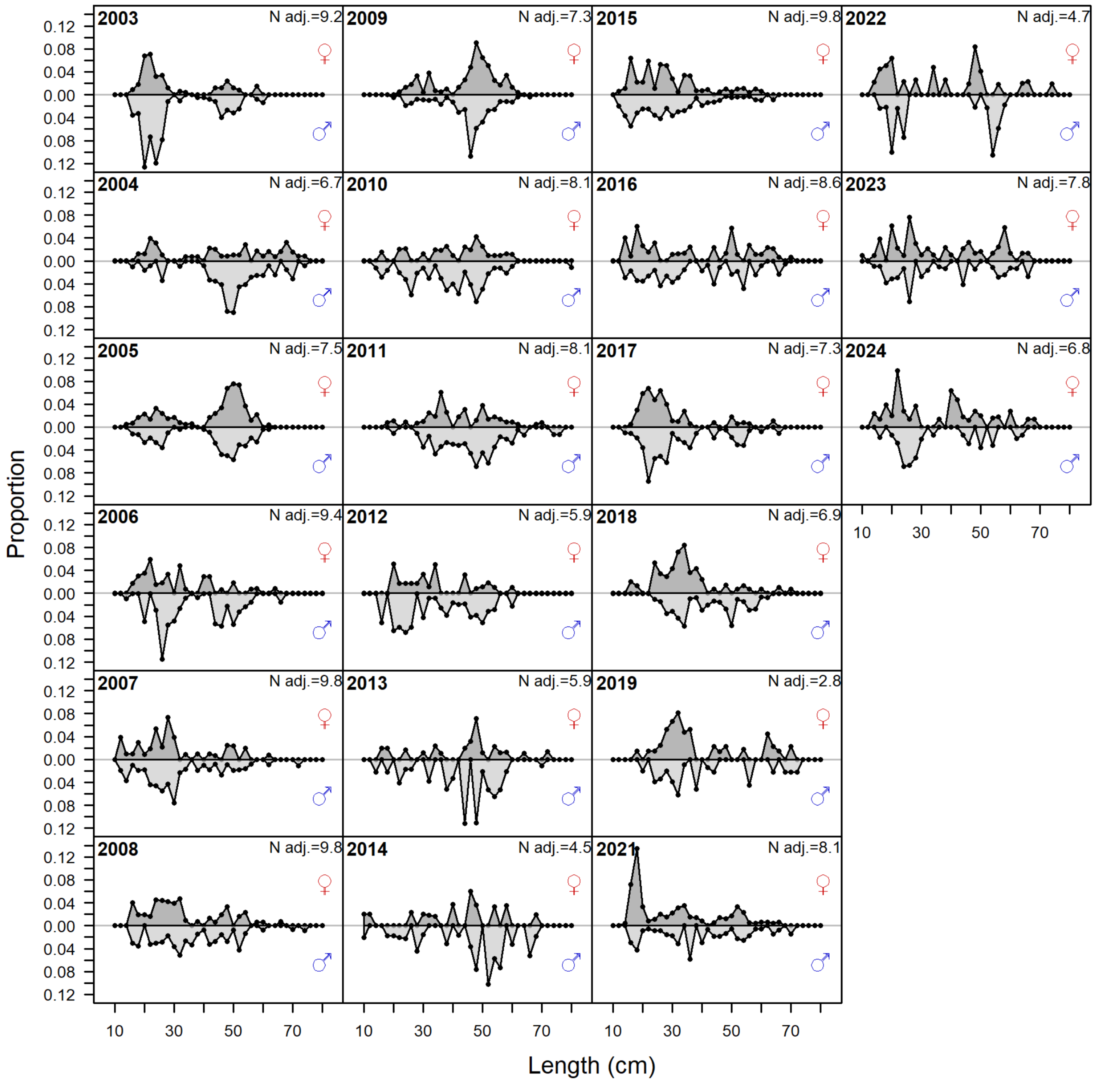

Figure 18: Length composition data for WCGBTS.

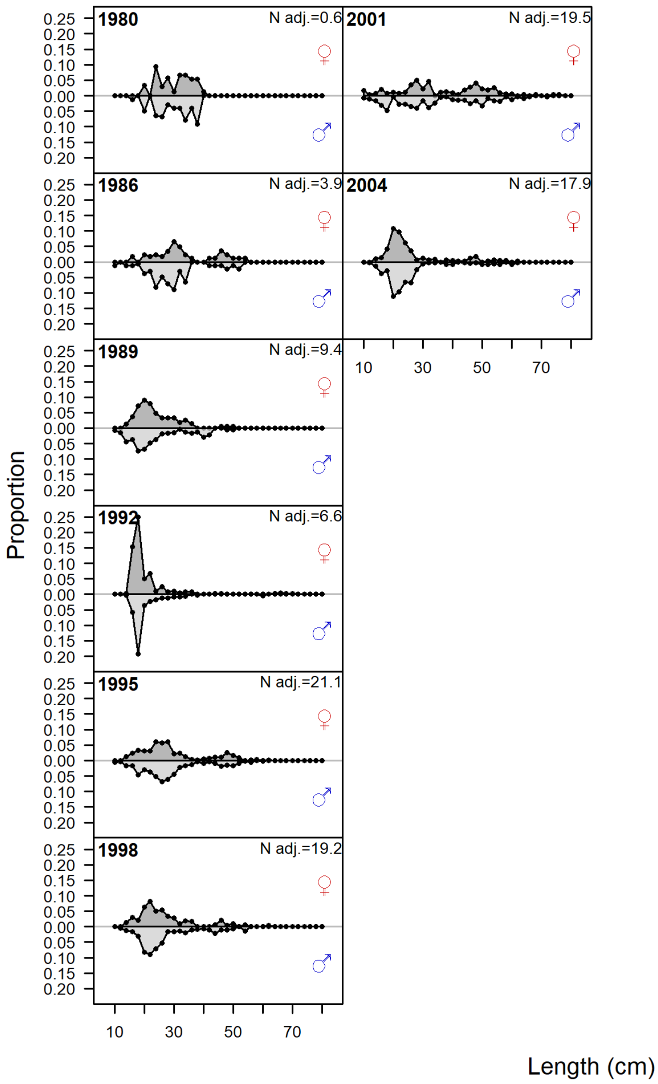

Figure 19: Length composition data for Triennial Survey.

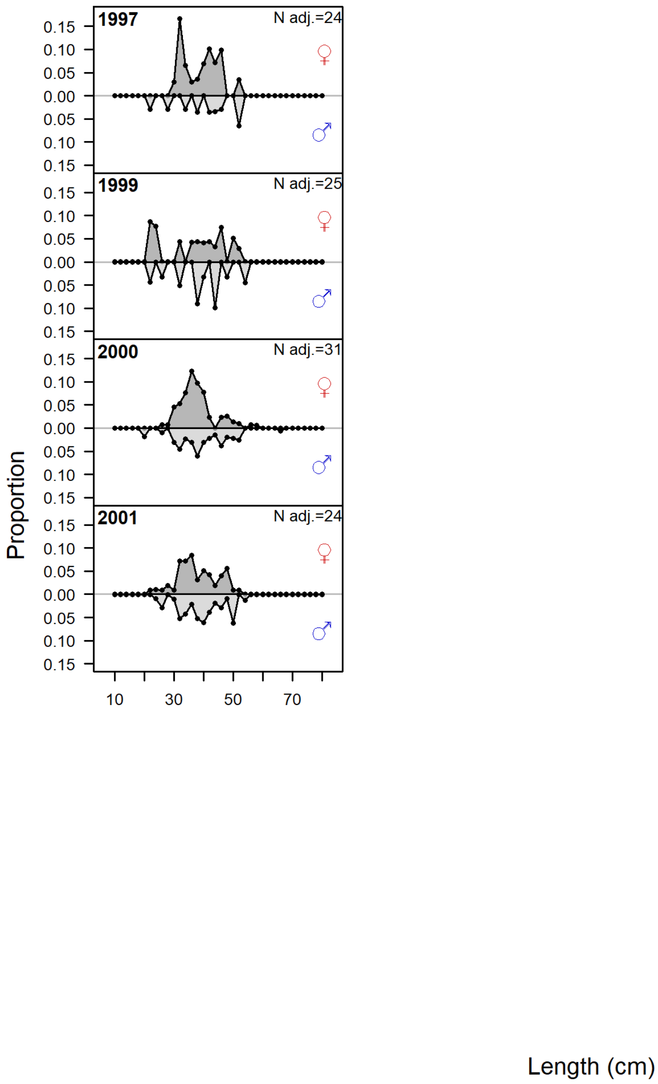

Figure 20: Length composition data for AFSC Slope Survey.

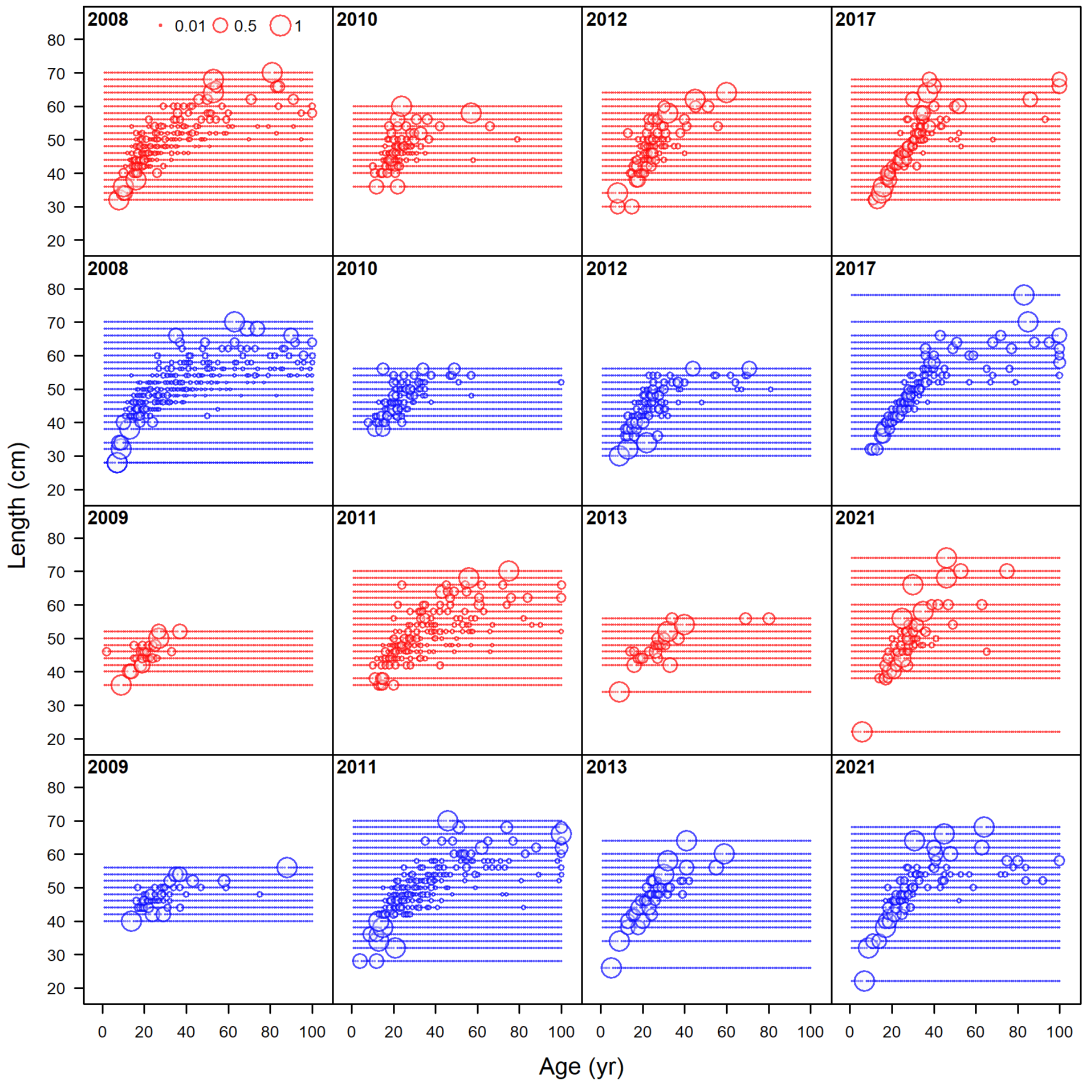

Figure 21: Length composition data for bottom trawl fleet.

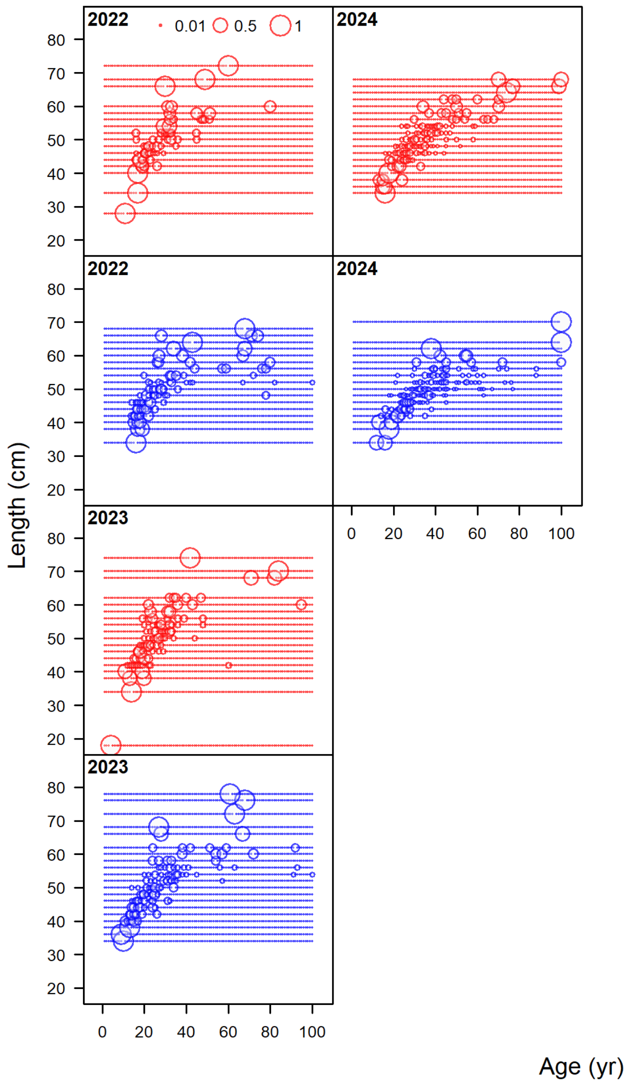

Figure 22: Length composition data for bottom trawl fleet, continued.

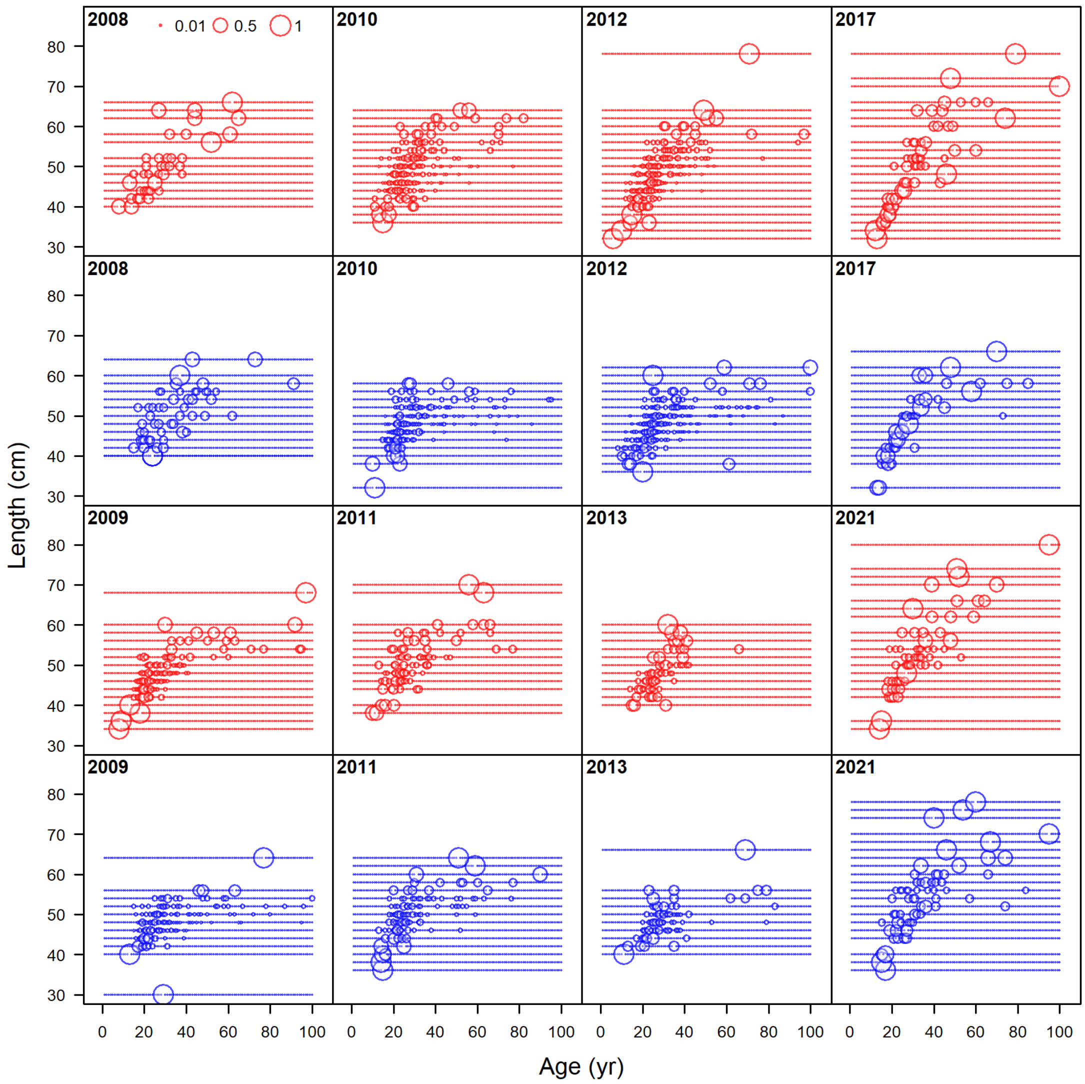

Figure 23: Conditional ages-at-length composition data for non-trawl fleet.

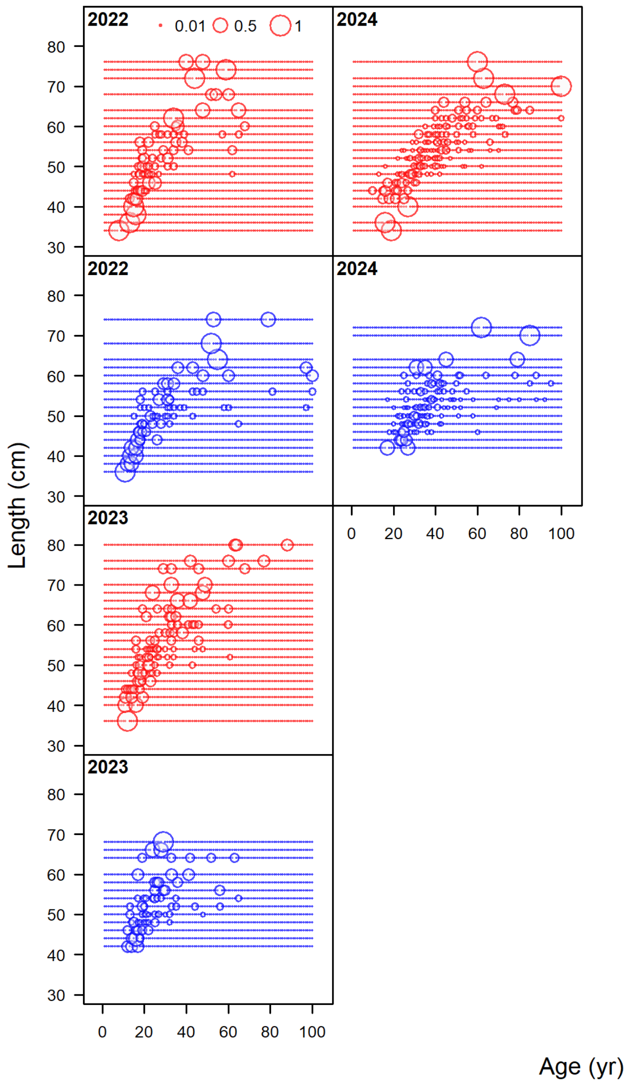

Figure 24: Conditional ages-at-length composition data for non-trawl fleet, continued.

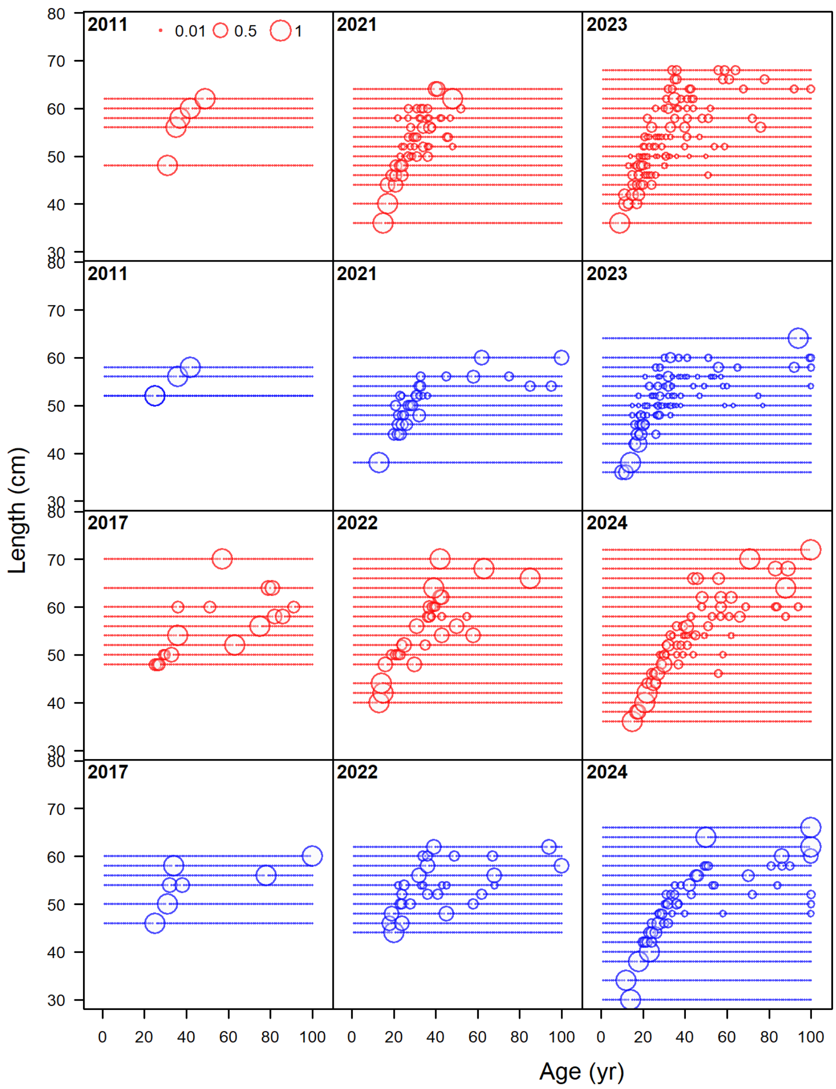

Figure 25: Conditional ages-at-length composition data for Midwater trawl fleet.

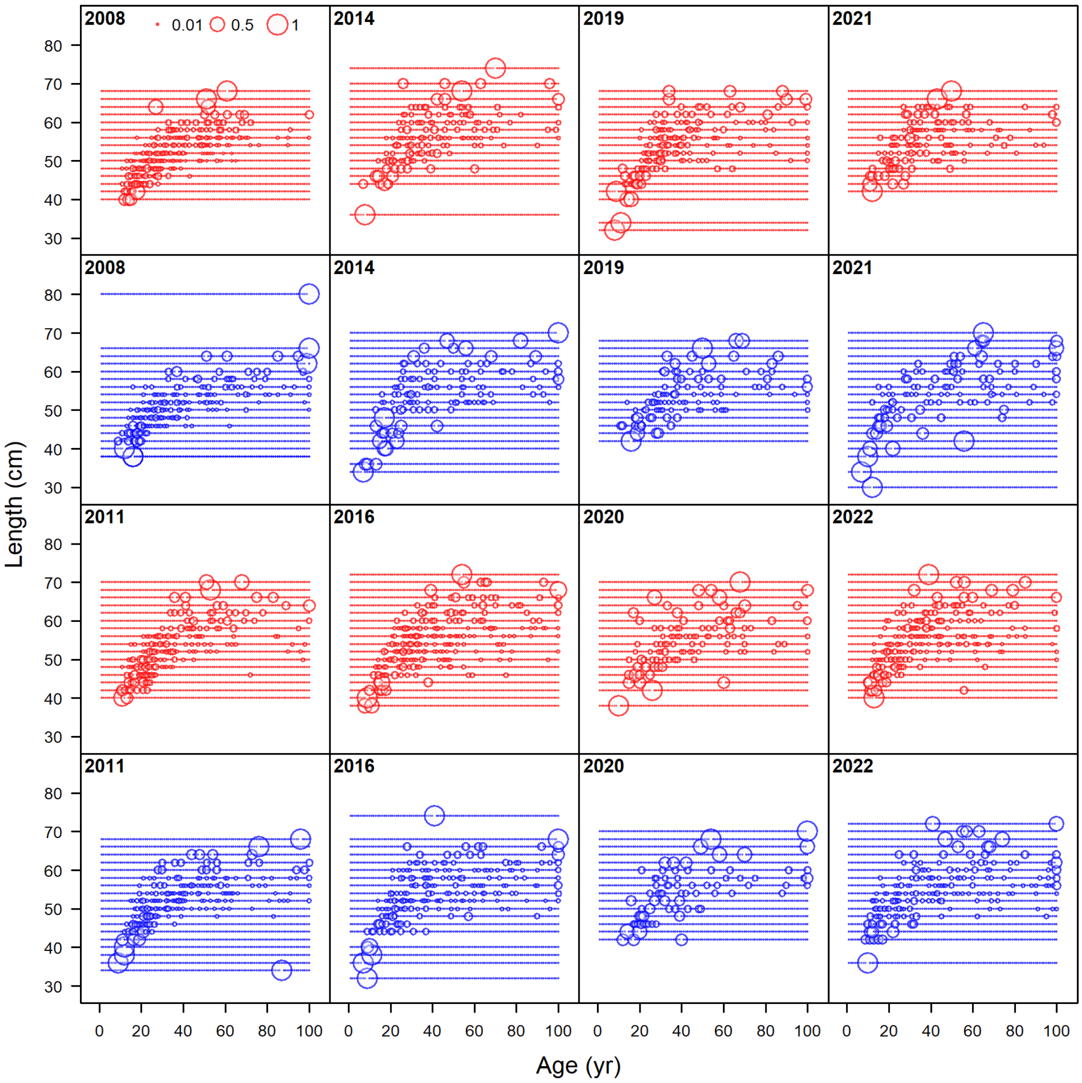

Figure 26: Conditional ages-at-length composition data for At-Sea Hake fleet.

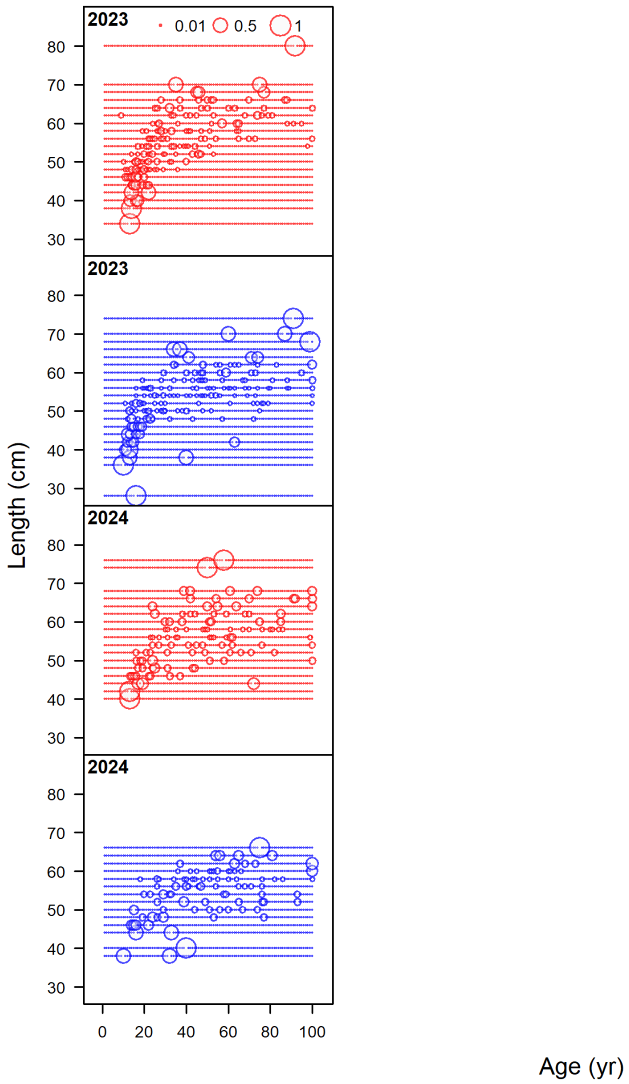

Figure 27: Conditional ages-at-length composition data for At-Sea Hake fleet, continued.

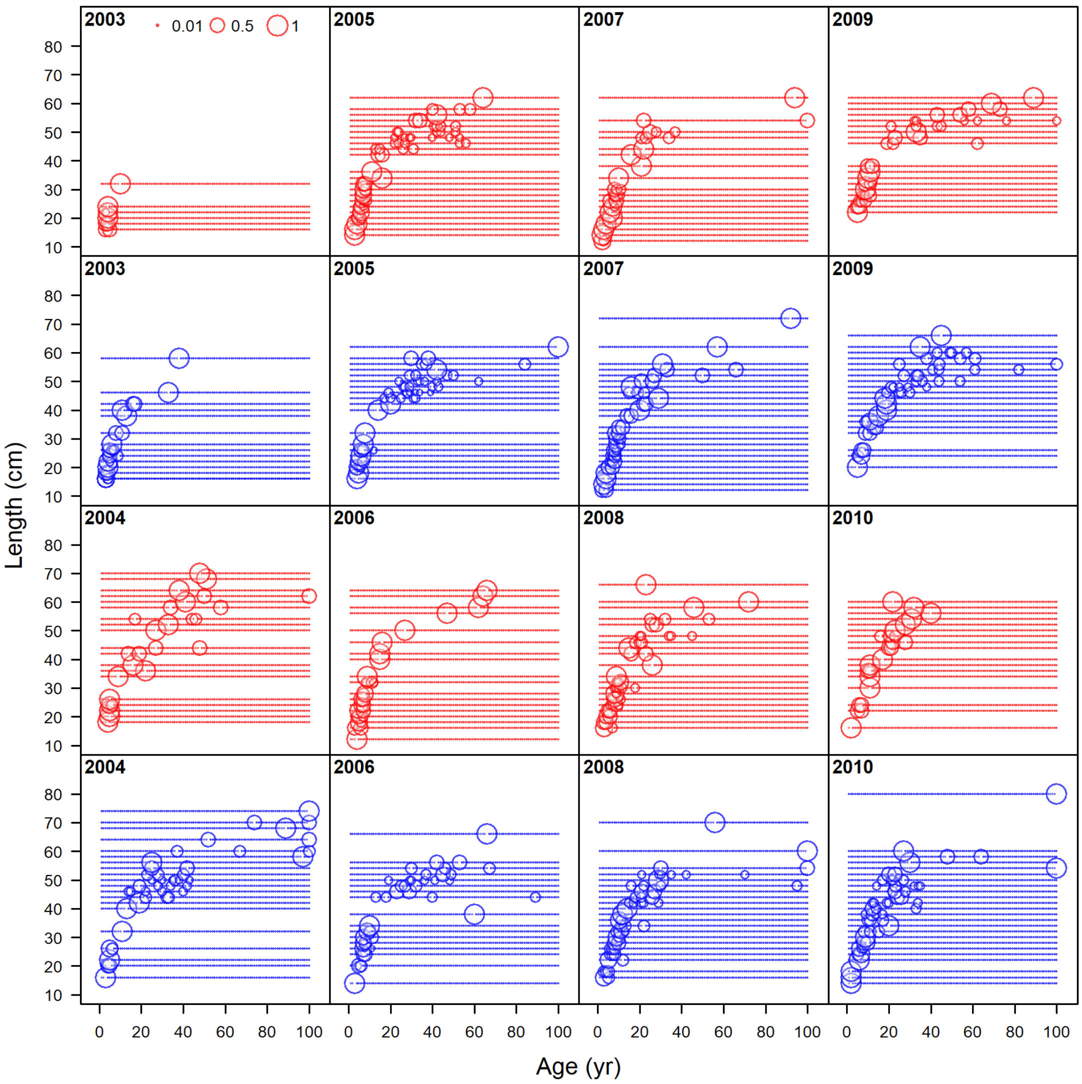

Figure 28: Conditional ages-at-length composition data for WCGBTS.

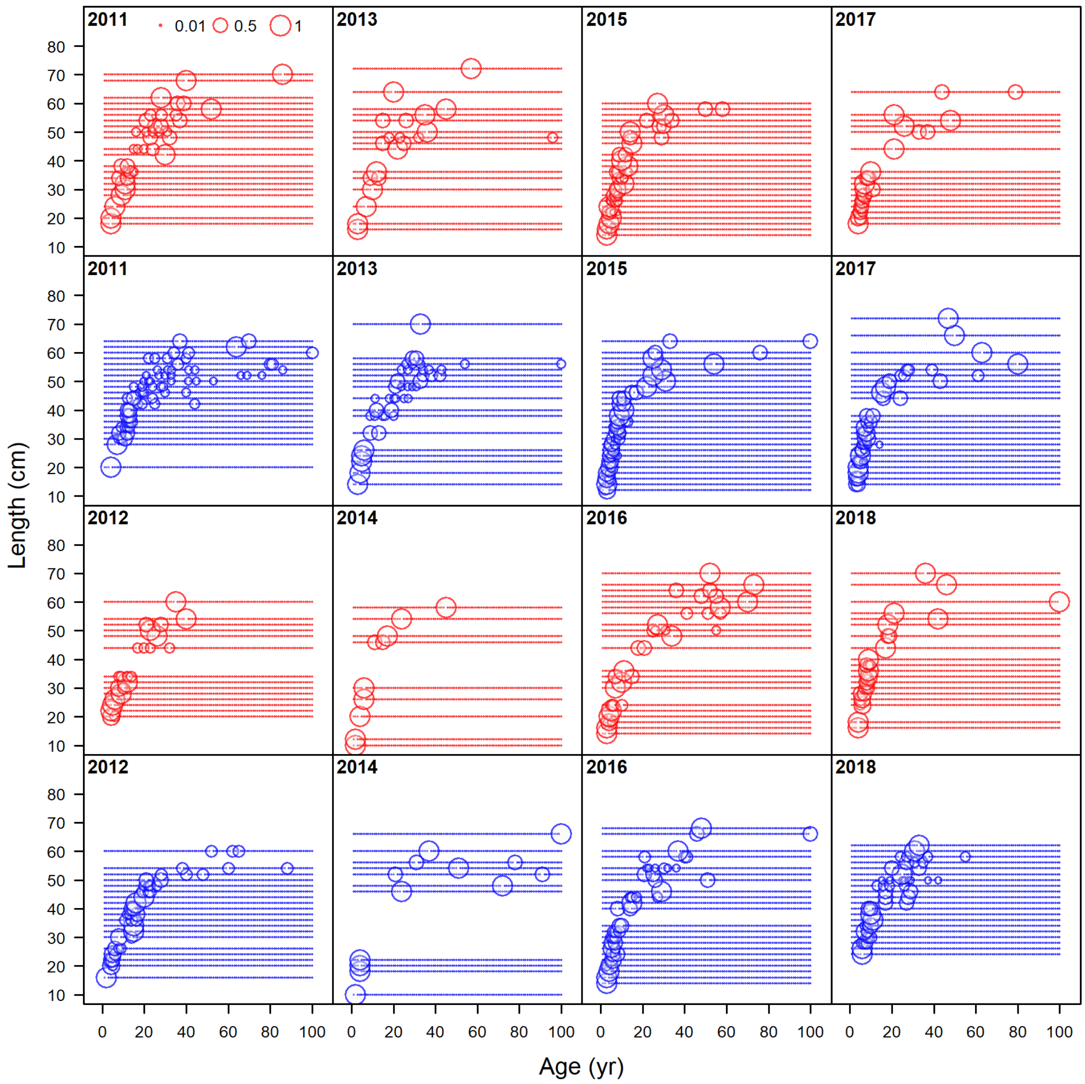

Figure 29: Conditional ages-at-length composition data for WCGBTS, continued.

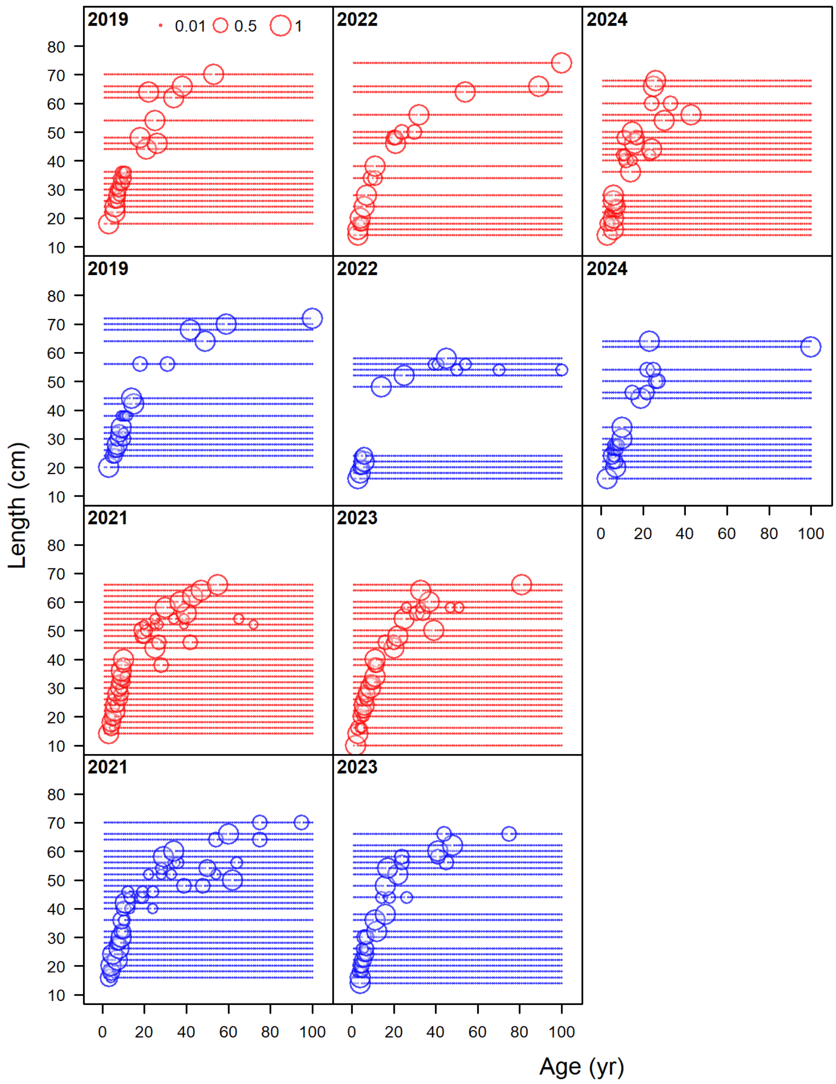

Figure 30: Conditional ages-at-length composition data for WCGBTS, continued.

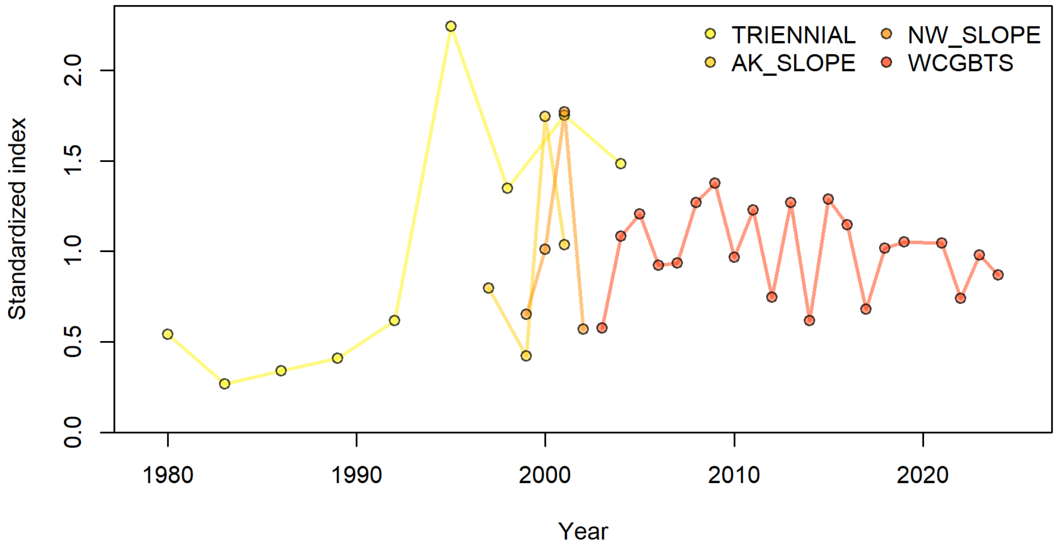

Figure 31: Standardized indices.

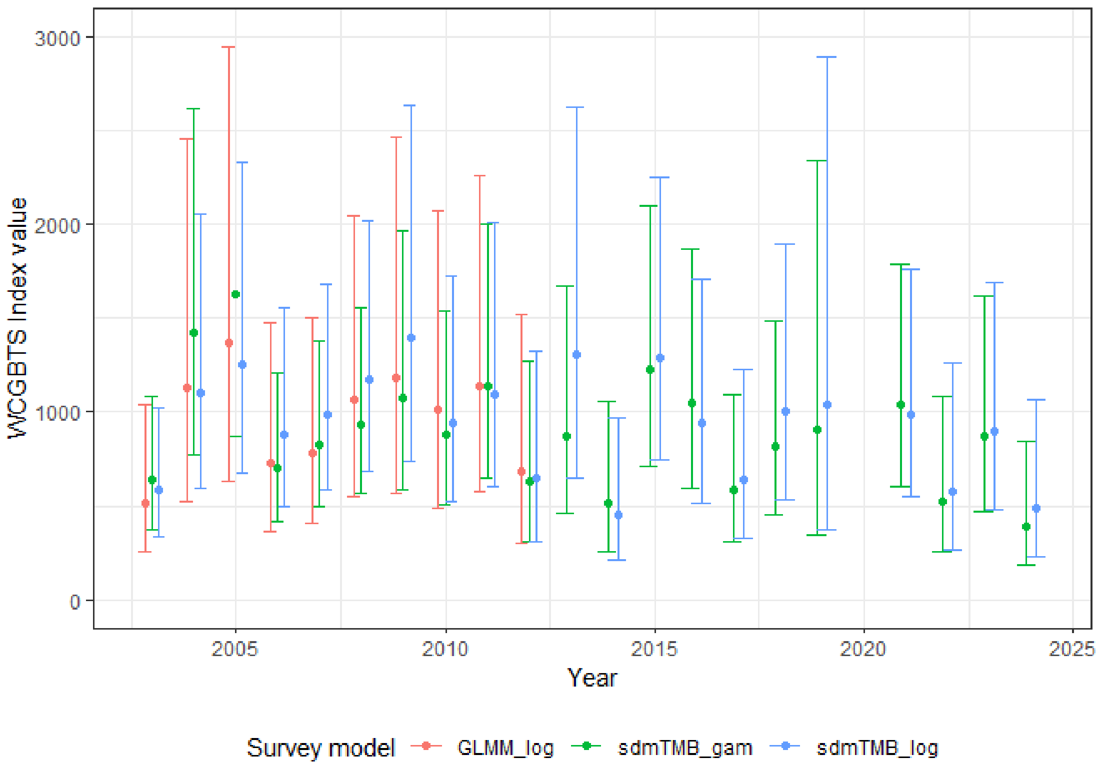

Figure 32: Comparison of the West Coast Groundfish Bottom Trawl Survey (WCGBTS) index from the previous assessment (GLMM) and the WCGBTS index of abundance used in this assessment (sdmTMB, lognormal distribution).

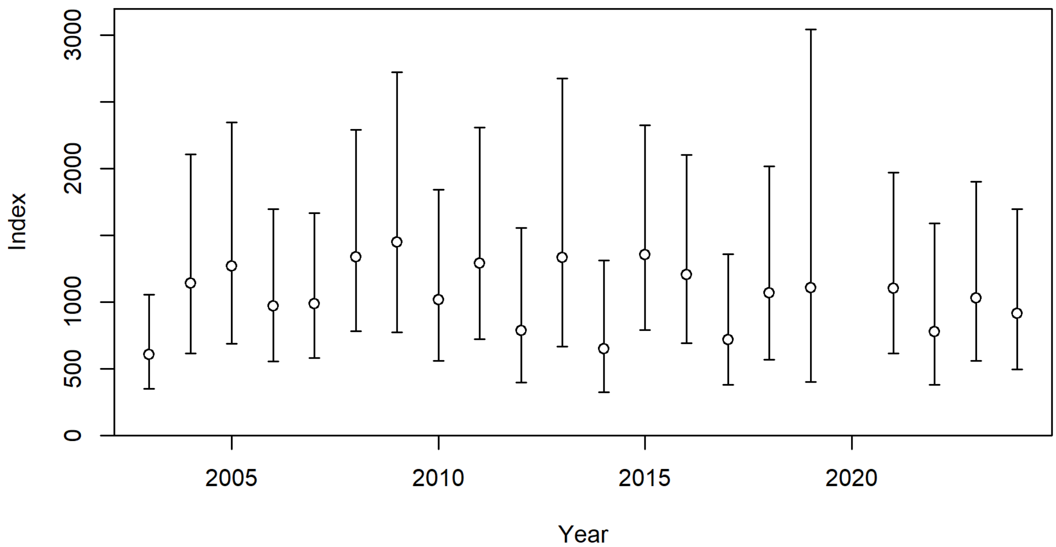

Figure 33: WCGBTS index.

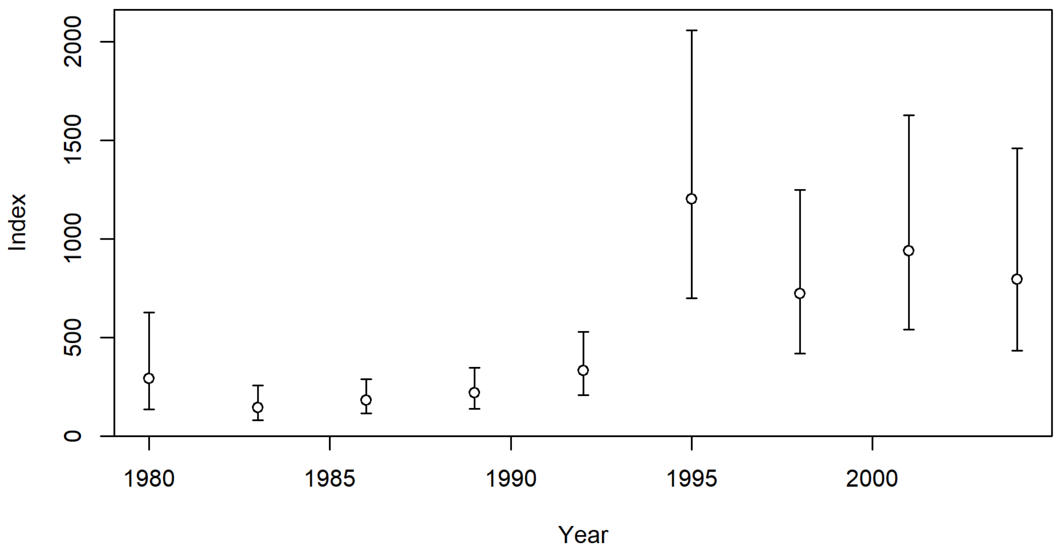

Figure 34: Triennial Survey index.

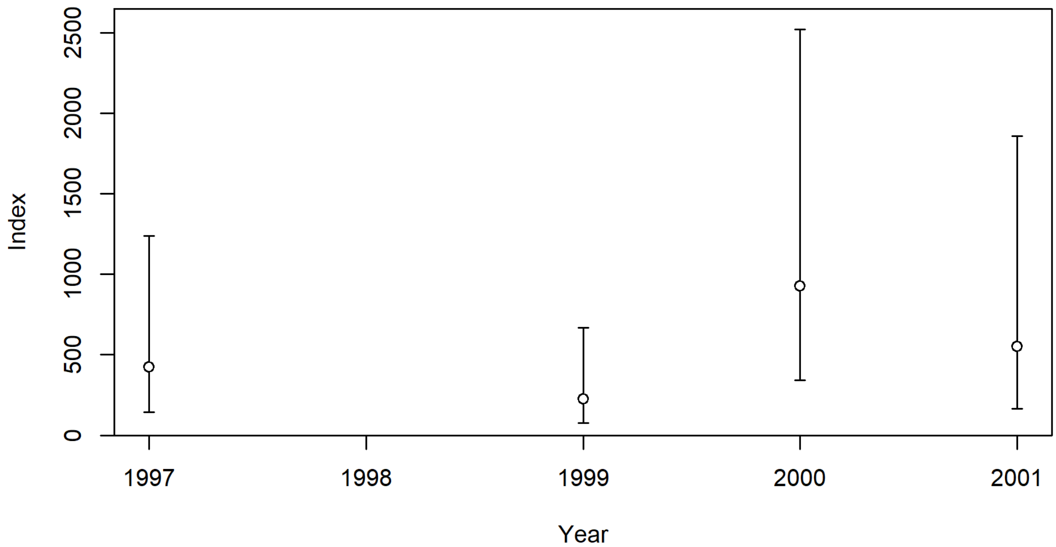

Figure 35: AFSC Slope Survey index.

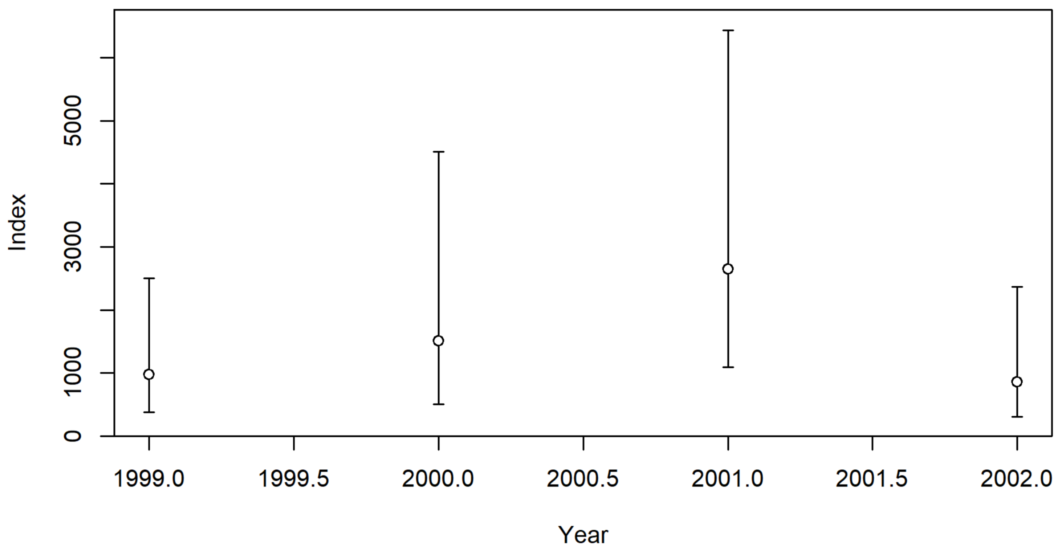

Figure 36: NWFSC Slope Survey index.

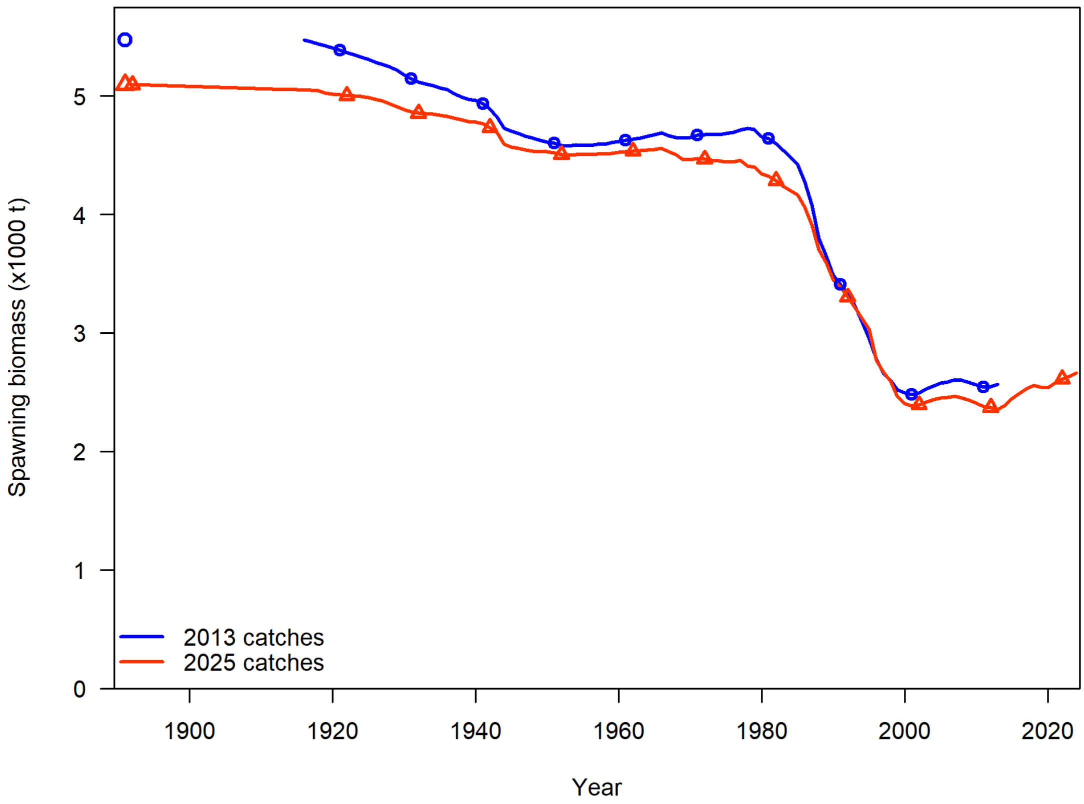

Figure 37: Comparison of spawning output using updated catches vs using catches from the 2013 Rougheye/Blackspotted Rockfishes assessment.

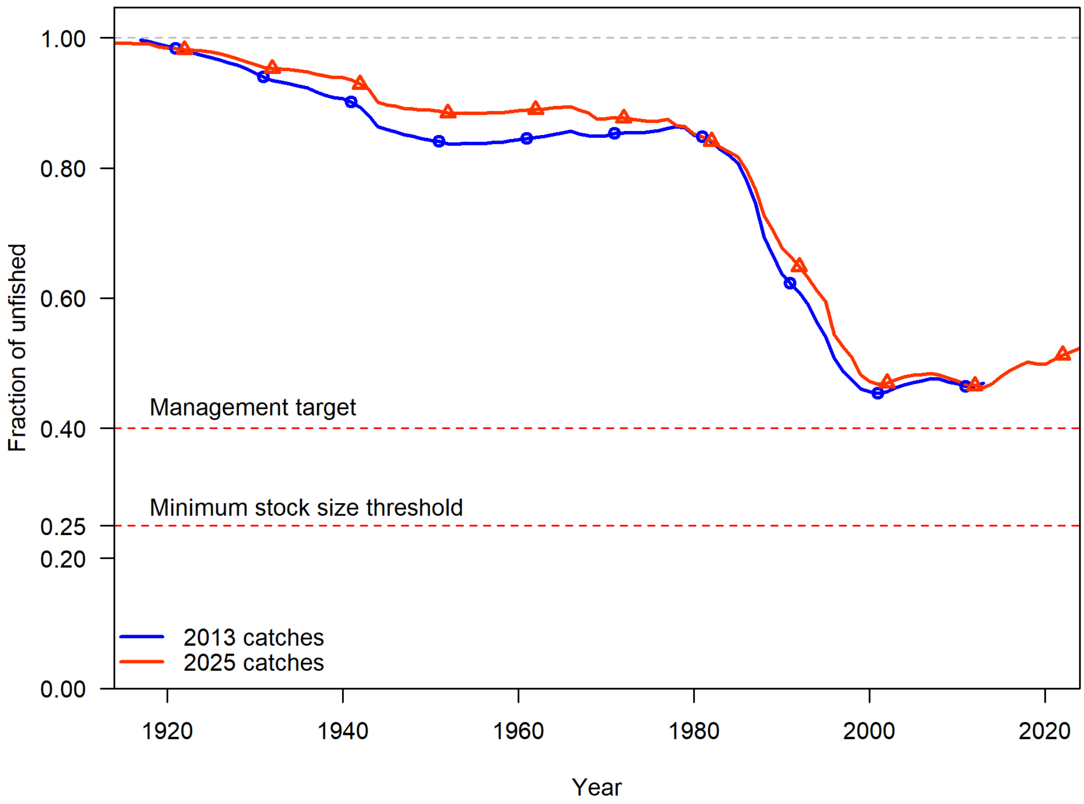

Figure 38: Comparison of relative spawning output using updated catches vs using catches from the 2013 Rougheye/Blackspotted Rockfishes assessment.

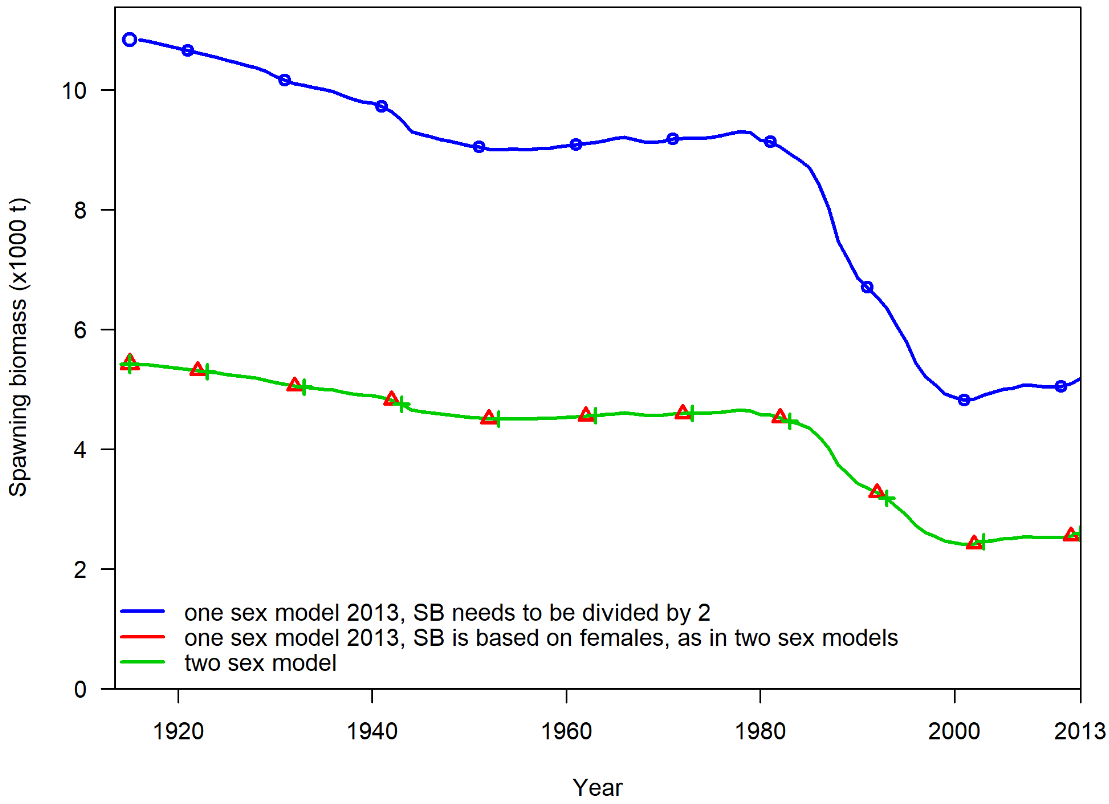

Figure 39: Comparison of spawning output using the 1 sex and 2 sexes set to equal values models based on the 2013 Rougheye/Blackspotted Rockfishes assessment data. The 1 sex model has double the biomass because it includes both females and males.

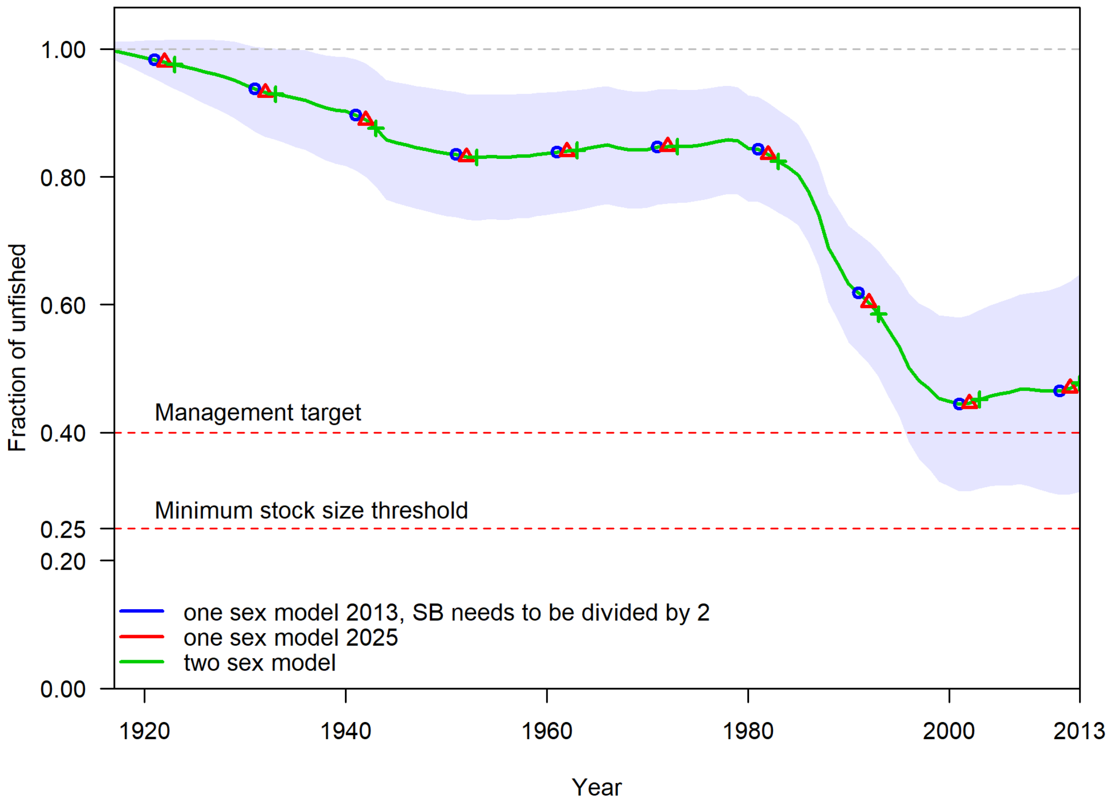

Figure 40: Comparison of spawning output using the 1 sex and 2 sexes set to equal values models based on the 2013 Rougheye/Blackspotted Rockfishes assessment data.

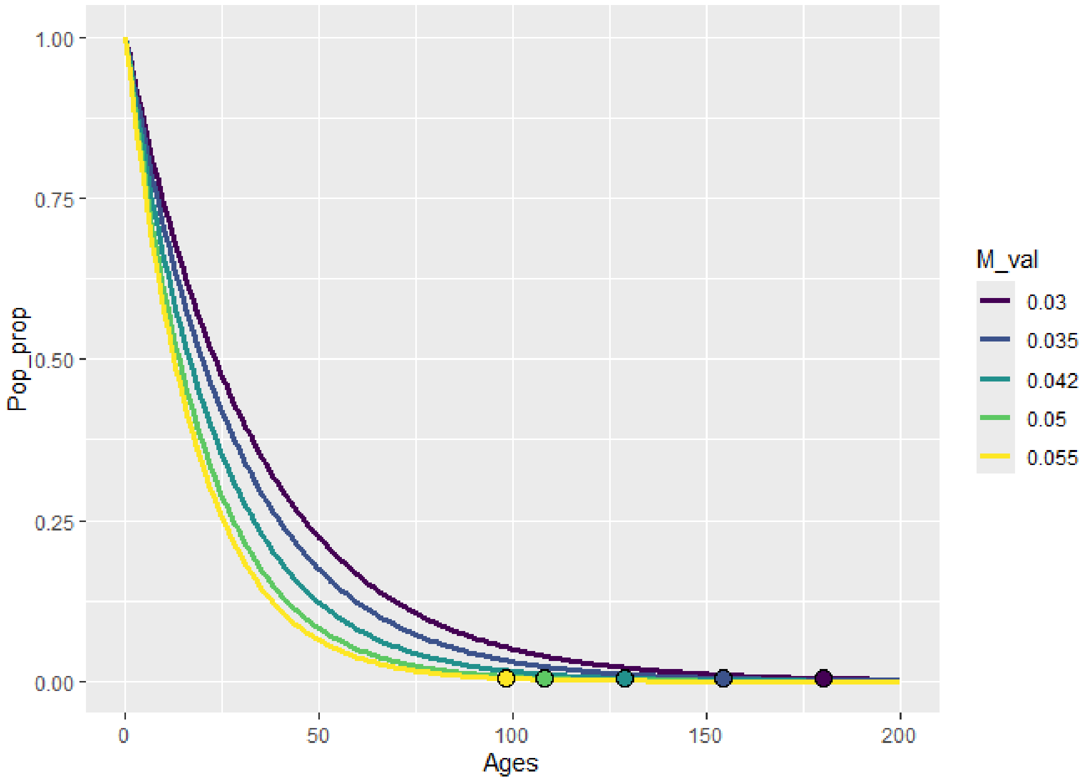

Figure 41: Natural mortality curves by age in years for values of natural mortality used in various Rougheye/Blackspotted Rockfish stock assessments. Dots indicate the range of assumed maximum ages using the equation from Hamel and Cope 2022.

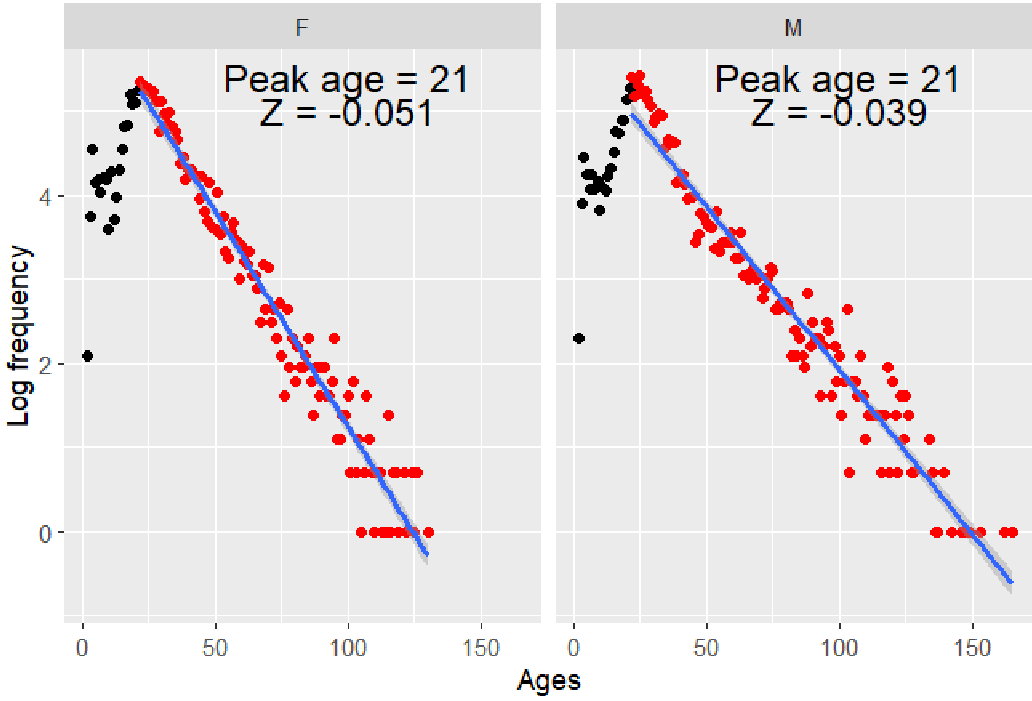

Figure 42: Catch curve (log abundance by age) analysis on aggregated ages over all age sources by sex (black points). The peak selected age was 21 for both sexes, so the linear model was run from age 21 until the oldest age (red points). The slope of the linear model is equal to the estimate of an aggregate total mortality (Z).

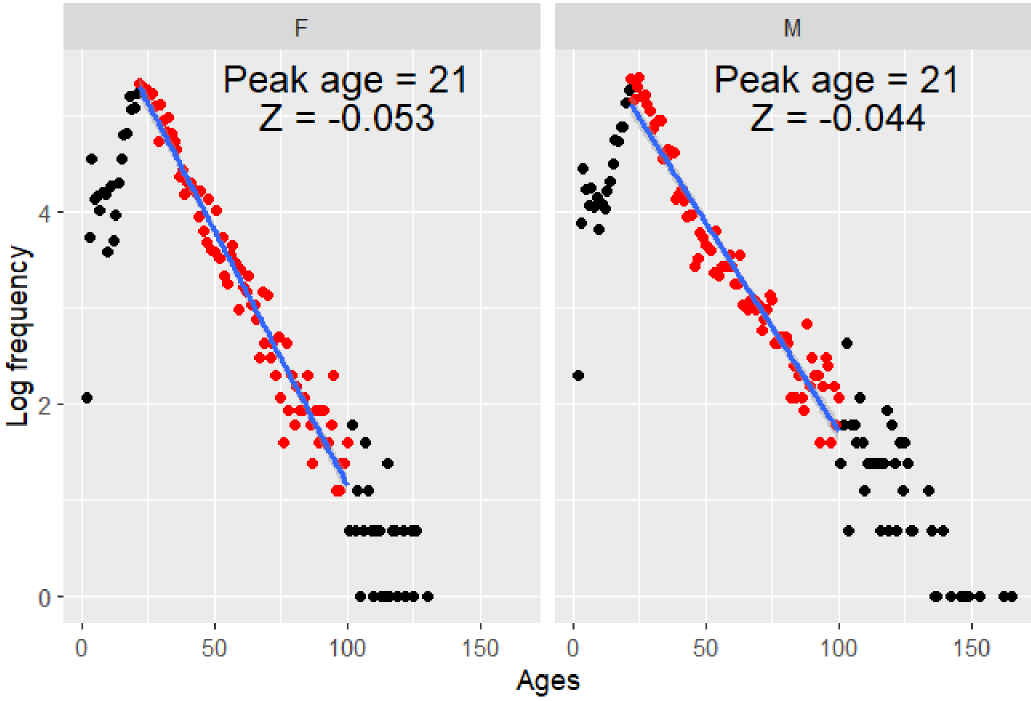

Figure 43: Catch curve (log abundance by age) analysis on aggregated ages over all age sources by sex (black points). The peak selected age was 21 for both sexes with a max age of 100, so the linear model was run from age 21 until age 100 (red points). The slope of the linear model is equal to the estimate of an aggregate total mortality (Z).

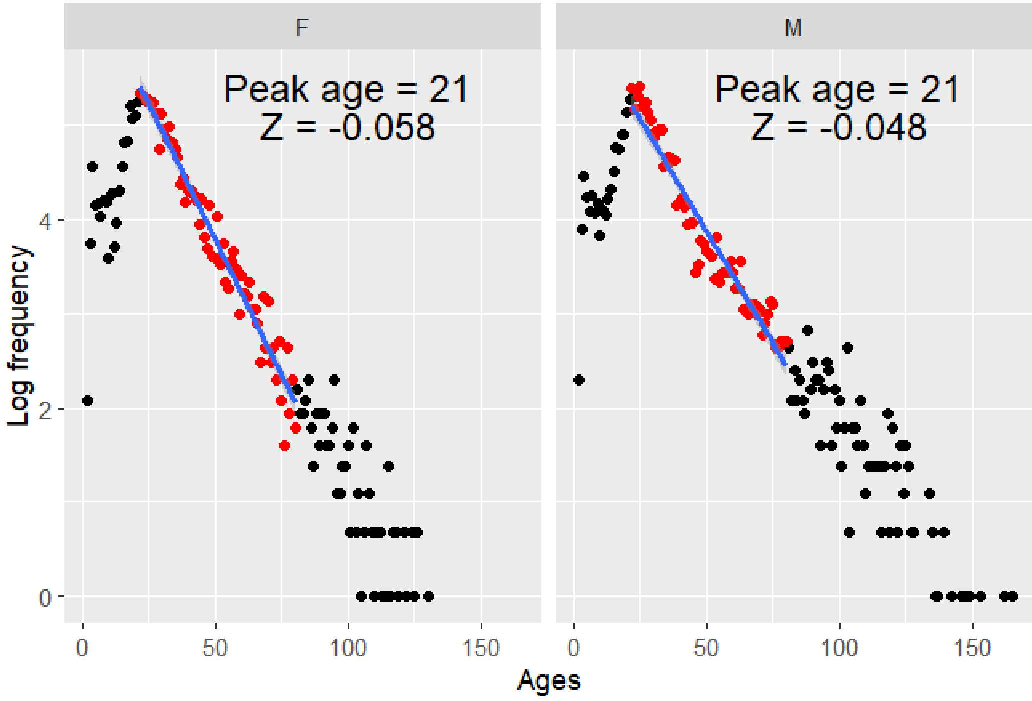

Figure 44: Catch curve (log abundance by age) analysis on aggregated ages over all age sources by sex (black points). The peak selected age was 21 for both sexes with a max age of 80, so the linear model was run from age 21 until age 80 (red points). The slope of the linear model is equal to the estimate of an aggregate total mortality (Z).

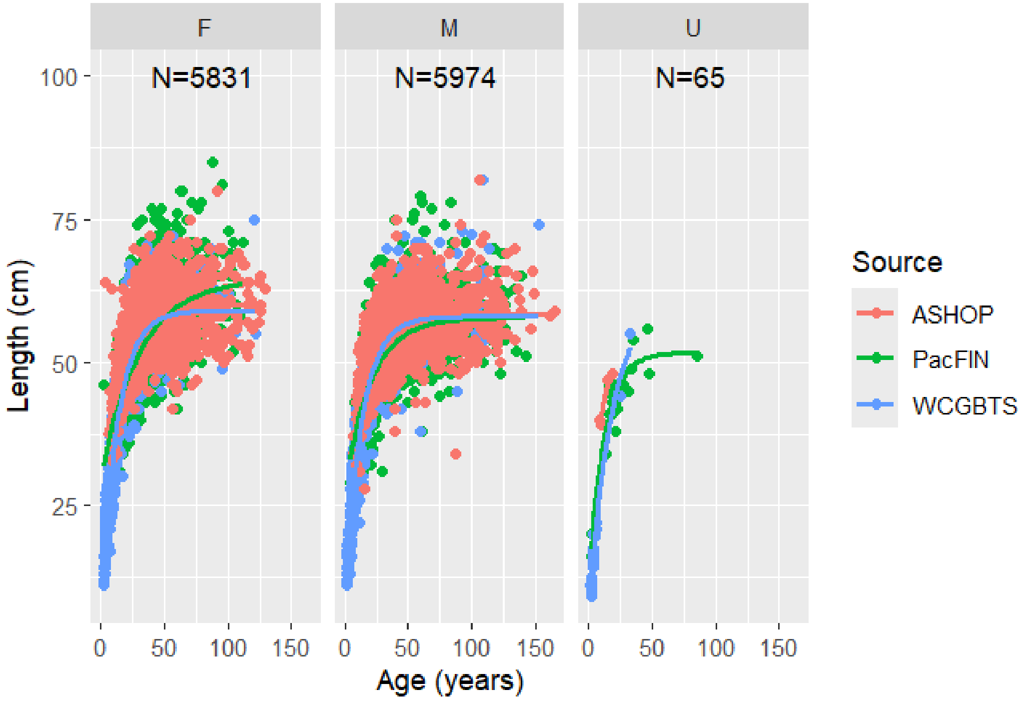

Figure 45: Age and length data, with fitted von Bertalanffy growth curves, by sex and data source for the Rougheye/Blackspotted rockfish complex. Sample sizes (N) are also provided.

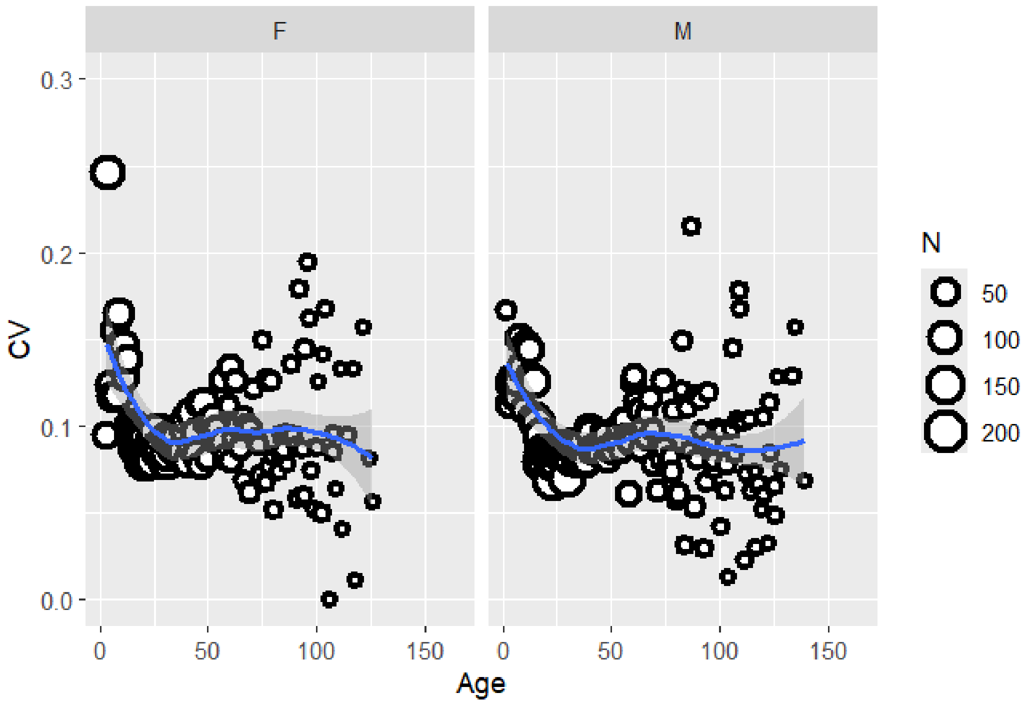

Figure 46: Coefficient of variation by age and sex for all sources of Rougheye/Blackspotted rockfishes ages. Sample sizes (N) are also indicated by size of the point. The line is a smoothed loess (polynomial) line that gives a moving average of CV by age and sex.

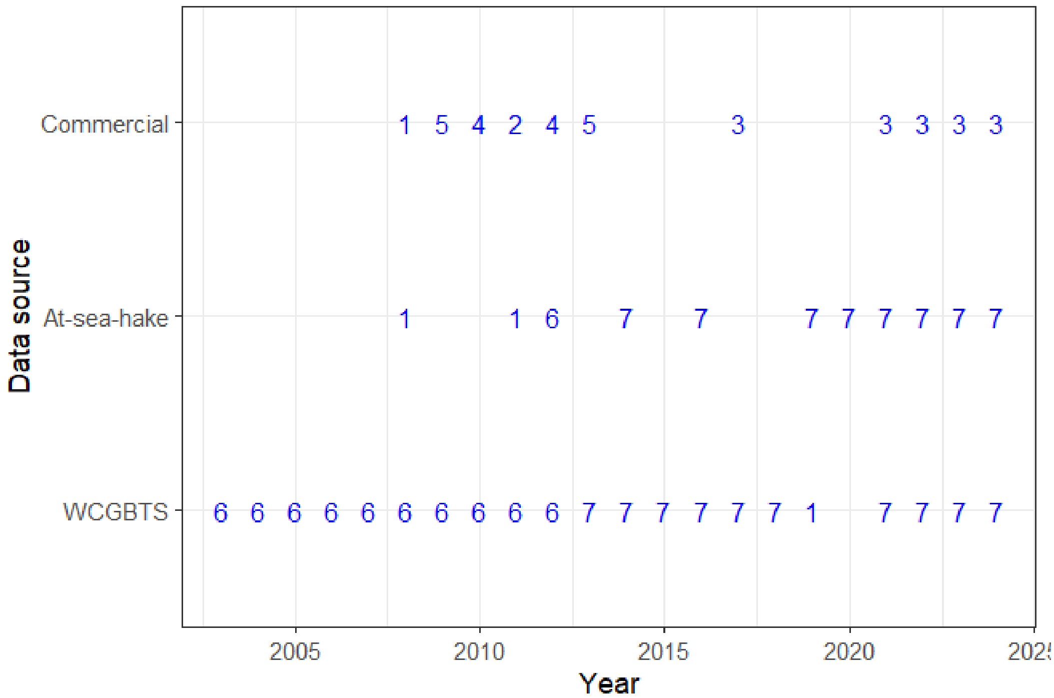

Figure 47: Ageing error matrix assignments by year and data source. The number indicates which ageing error matrix was used for conditional ages within those years and data sources. 'Commercial' is a combination of all commercial fleets.

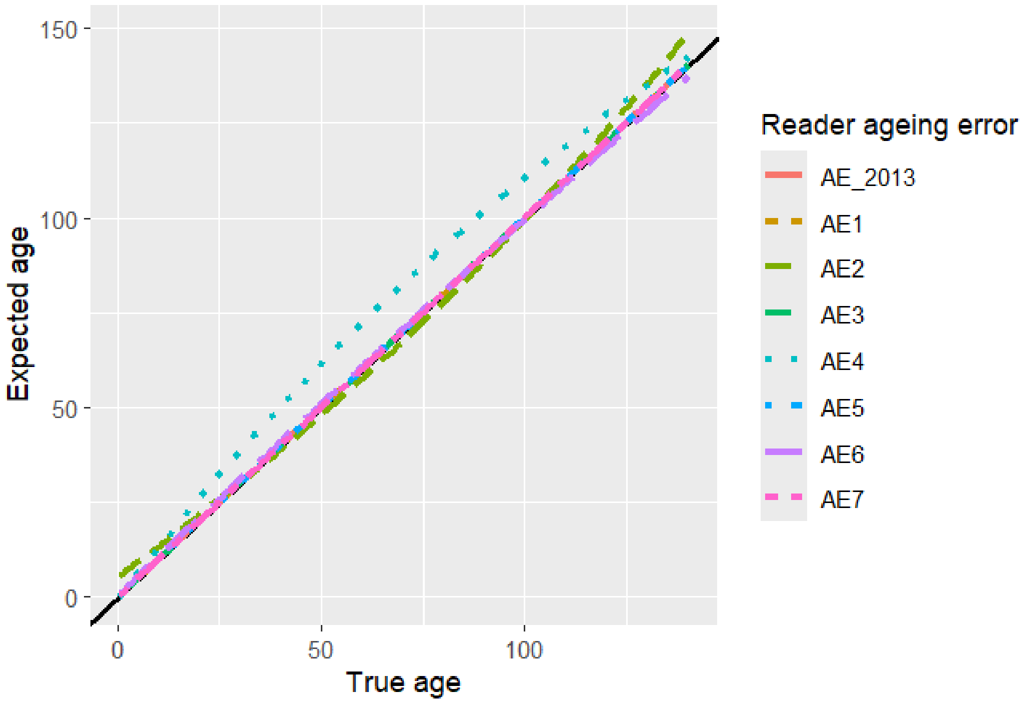

Figure 48: Estimated bias used for each of the seven ageing error matrices.

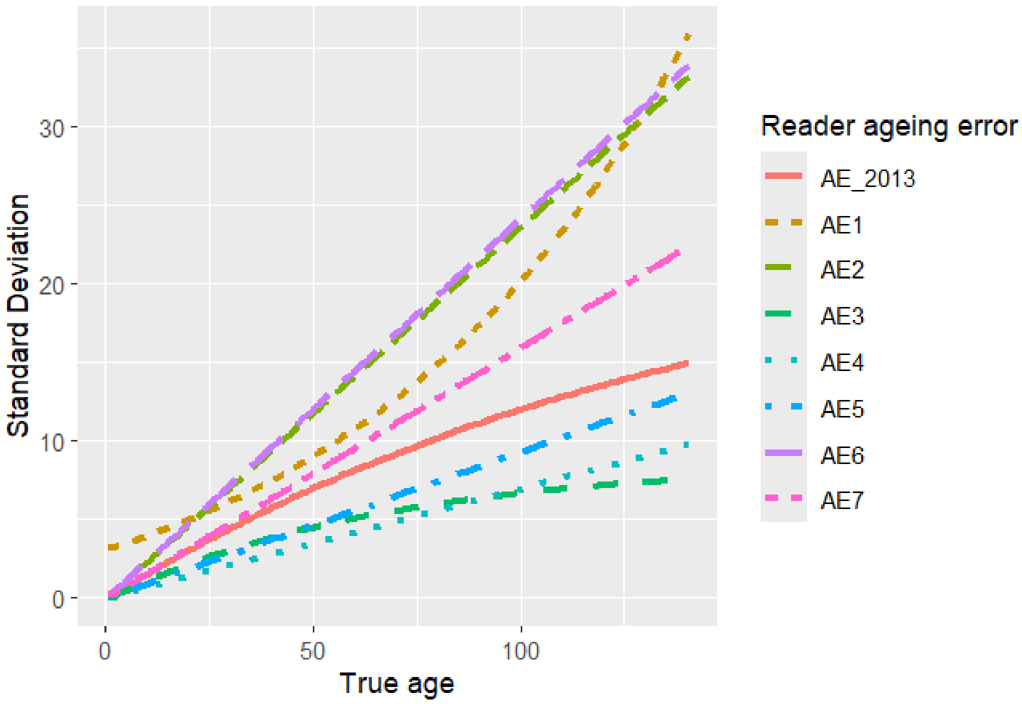

Figure 49: Estimated imprecision (as a standard deviation) used for each of the seven ageing error matrices.

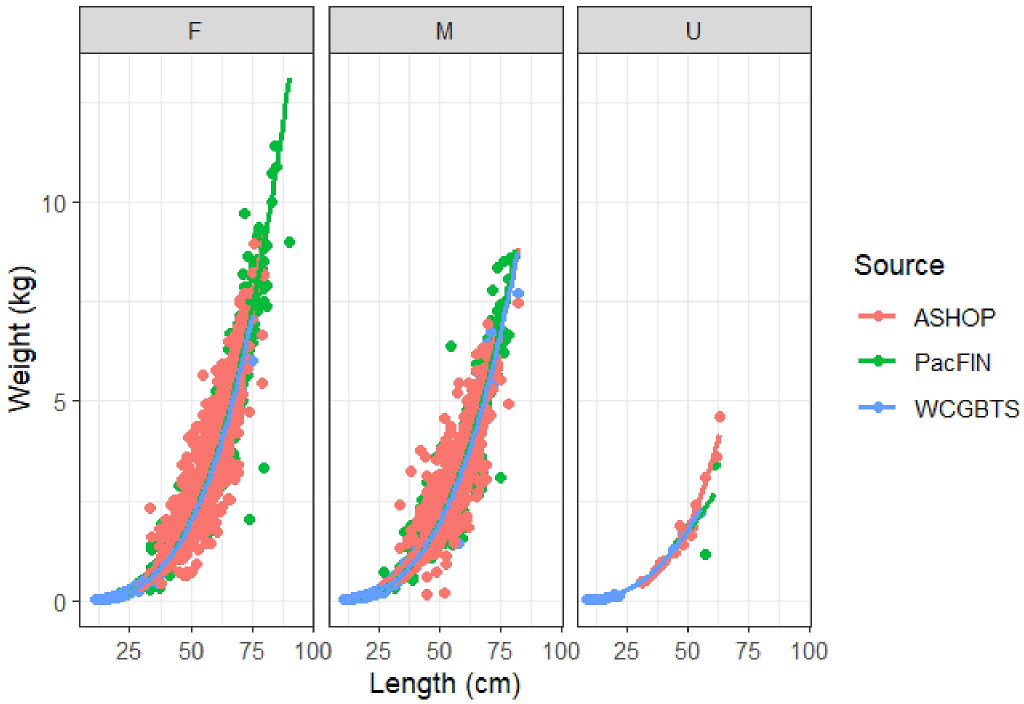

Figure 50: Length and weight samples by sex and data source. Lines are the power function fits by data source.

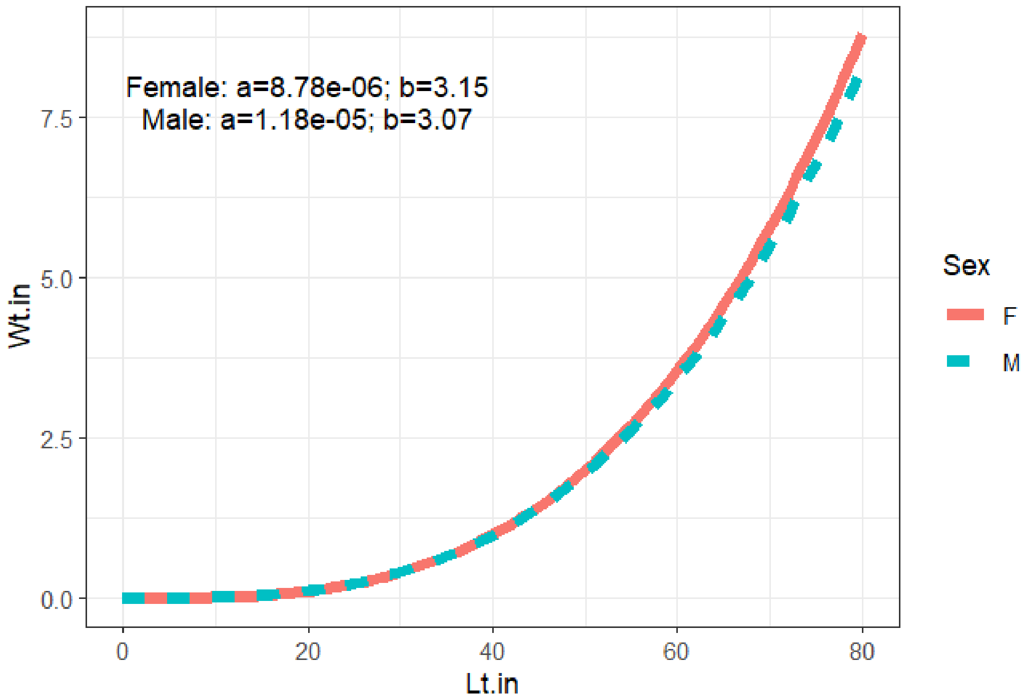

Figure 51: Realized length and weight relationships for female and male Rougheye/Blackspotted Rockfishes.

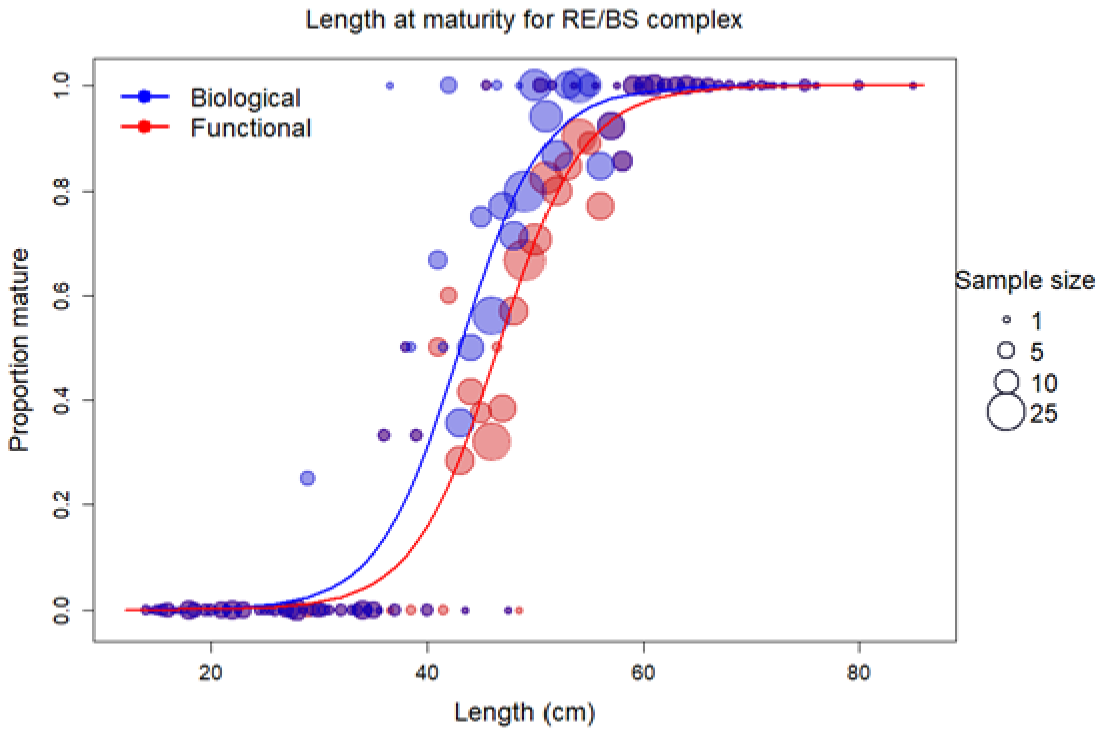

Figure 52: Placeholder.

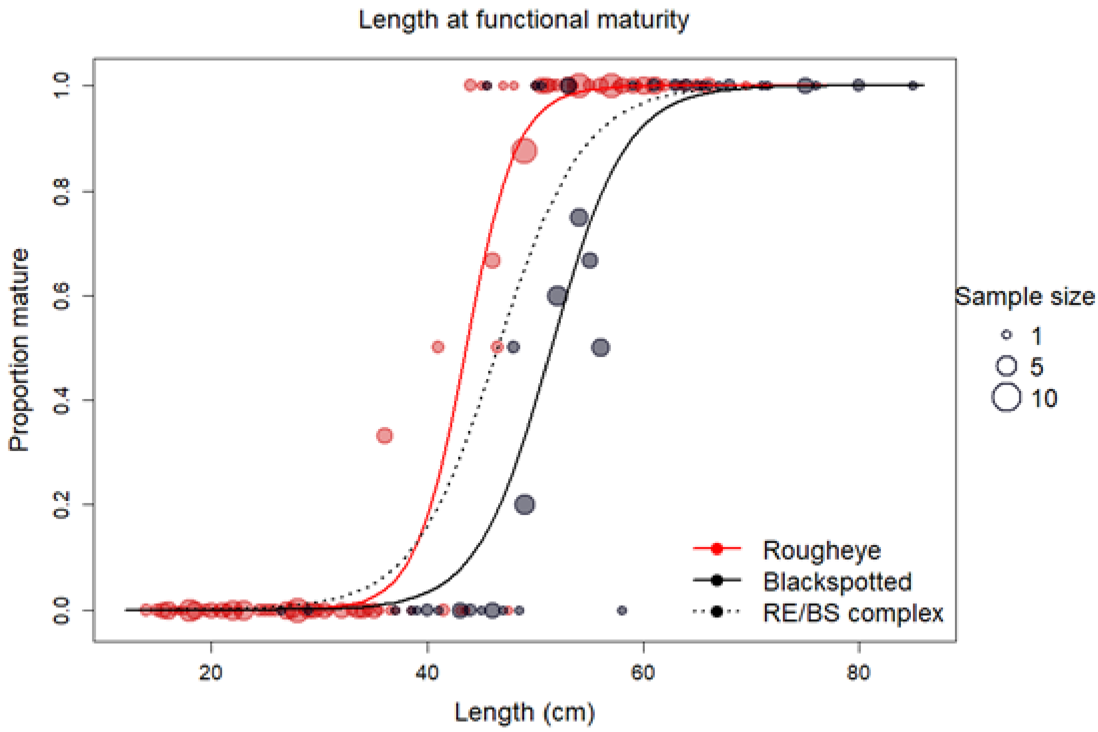

Figure 53: Placeholder.

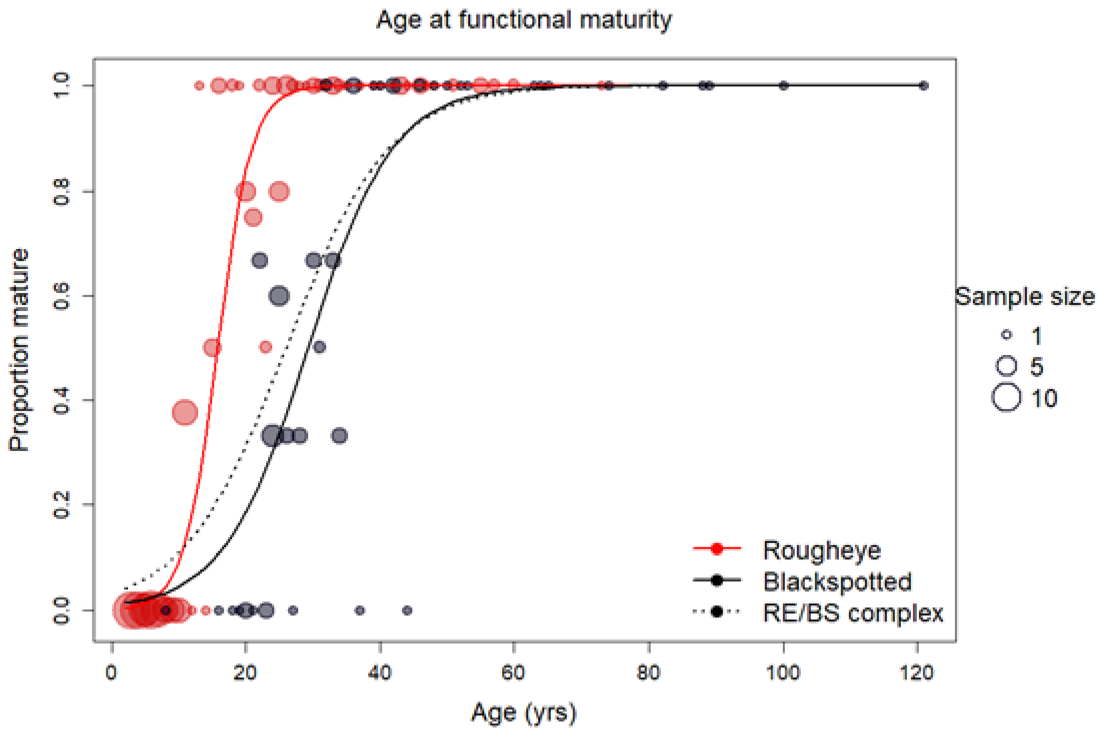

Figure 54: Placeholder.

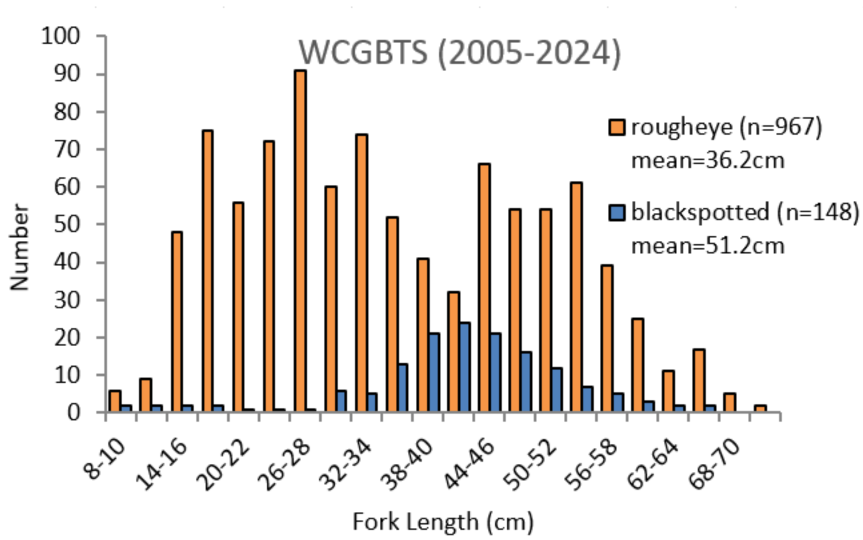

Figure 55: Length distribution of Rougheye Rockfish and Blackspotted Rockfish identified to species using genetics (pers. comm. P. Prey, NWFSC).

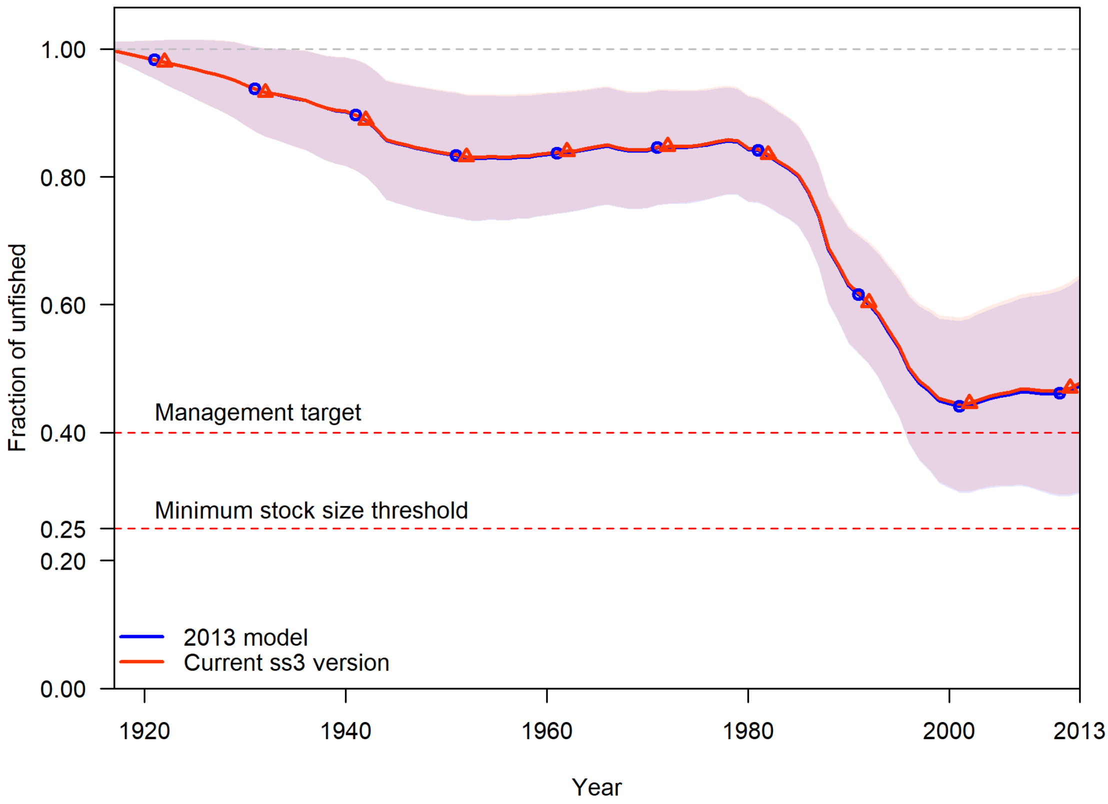

Figure 56: Estimates of relative stock size (current spawning output/unfished spawning output) for the Rougheye/Blackspotted rockfish complex in U.S. west coast waters from the 2013 assessment, and compared to the using the same data in the newest version of SS3 (3.30.22.1).

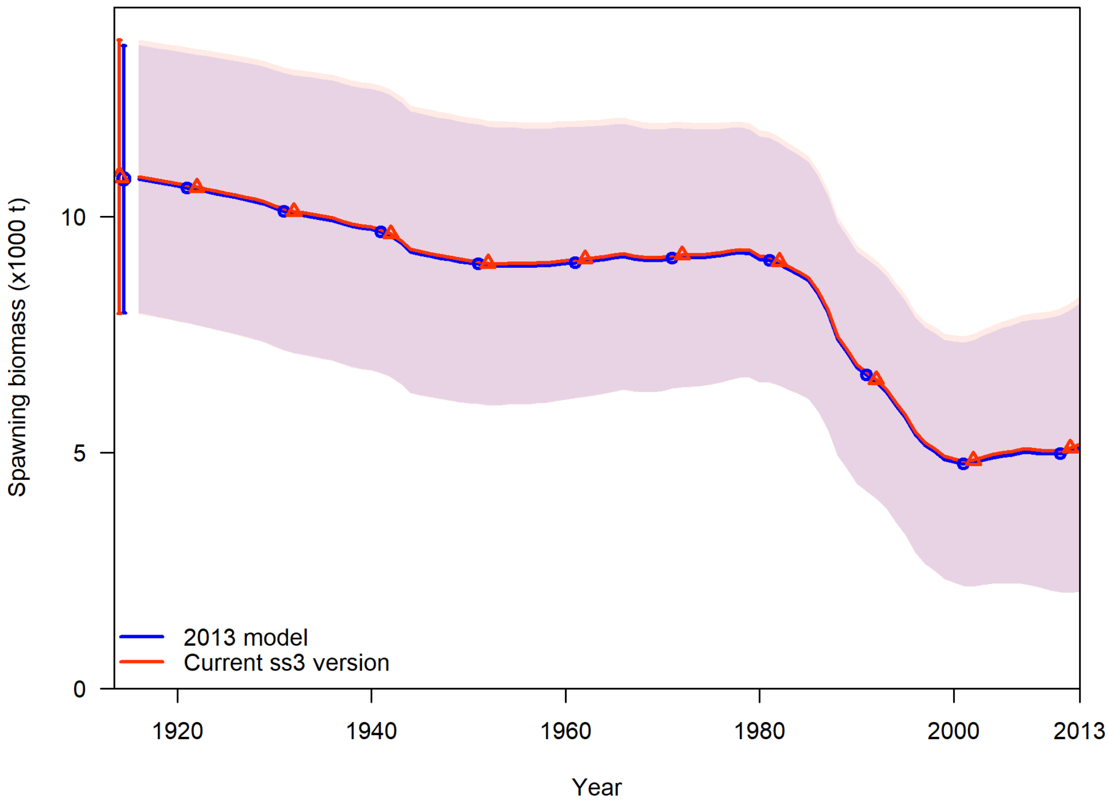

Figure 57: Estimates of spawning output for the Rougheye/Blackspotted rockfish complex in U.S. west coast waters from the 2013 assessment, and compared to the same data in the newest version of SS3 (3.30.22.1). Shading denotes 95% confidence intervals. Shading denotes 95% confidence intervals.

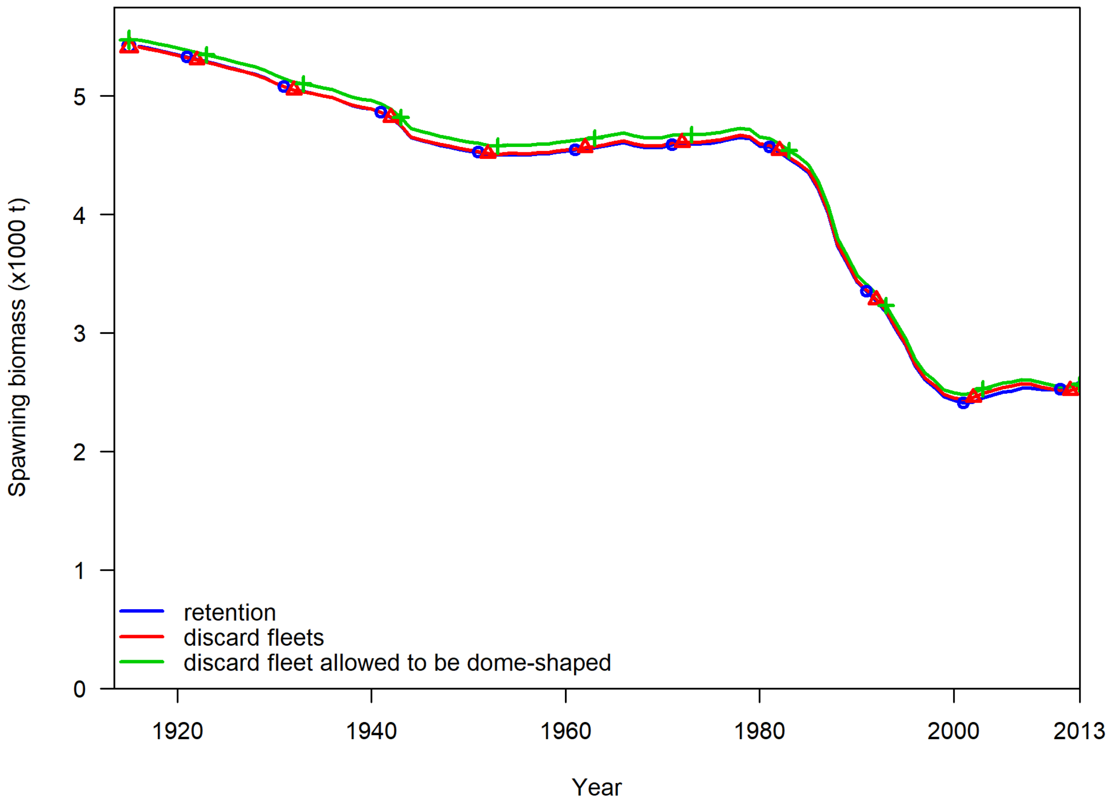

Figure 58: Comparison of spawning output using retention curves or discard fleets using the 2013 Rougheye/Blackspotted Rockfishes assessment.

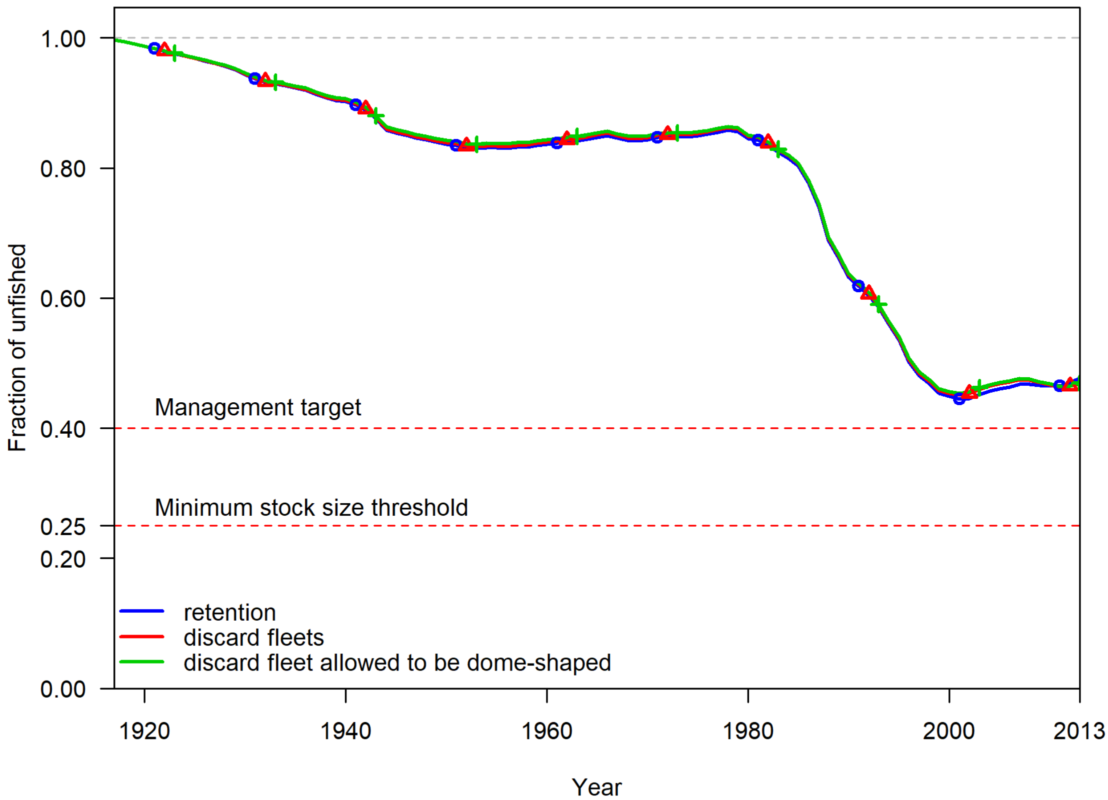

Figure 59: Comparison of relative spawning output using retention curves or discard fleets using the 2013 Rougheye/Blackspotted Rockfishes assessment.

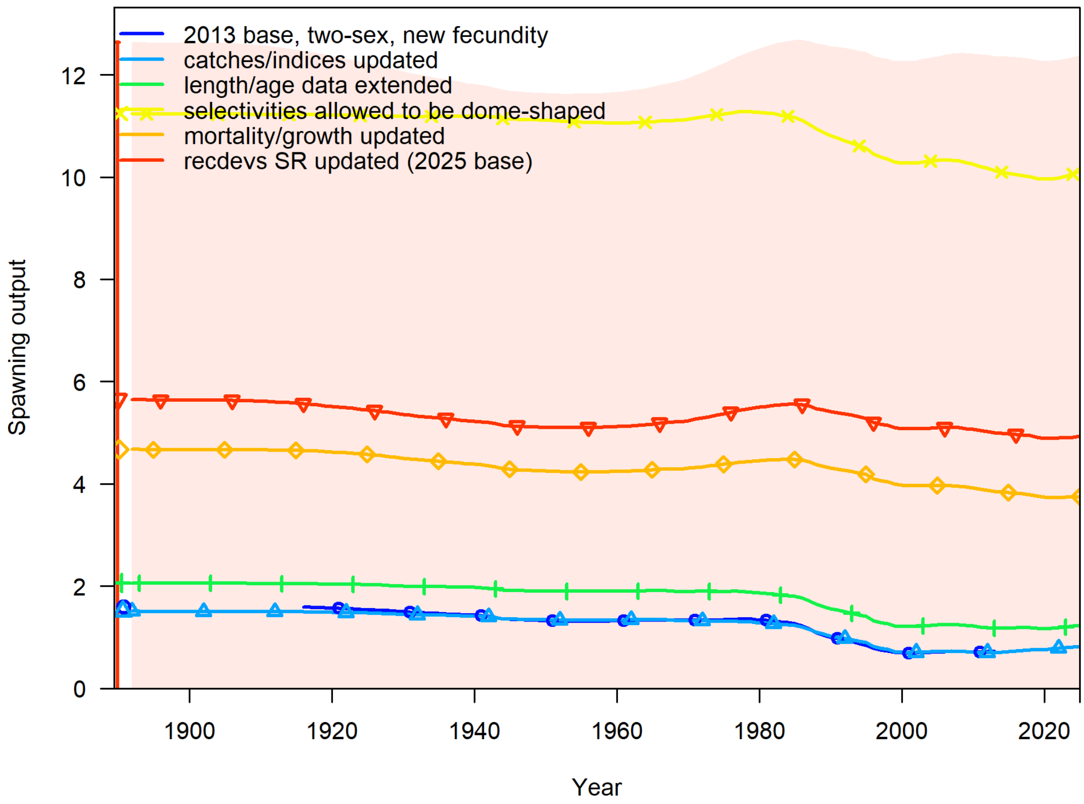

Figure 60: Time series of estimated spawning output for briding analysis.

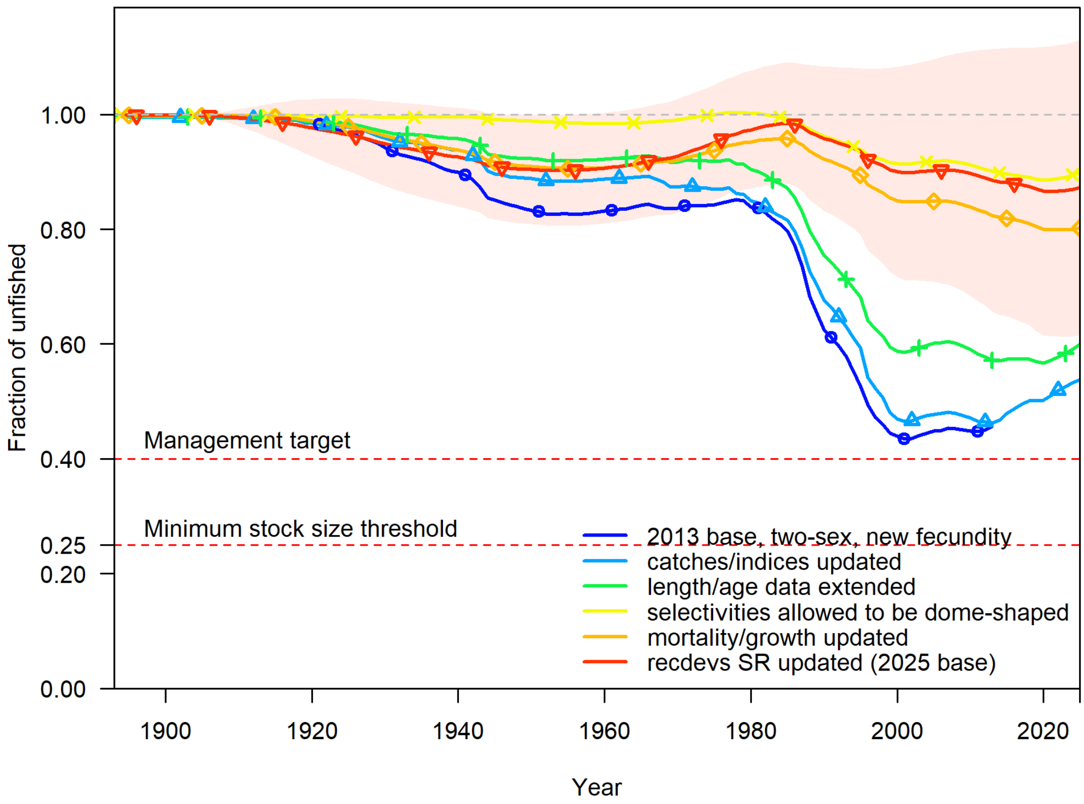

Figure 61: Time series of fraction of unfished spawning output for briding analysis.

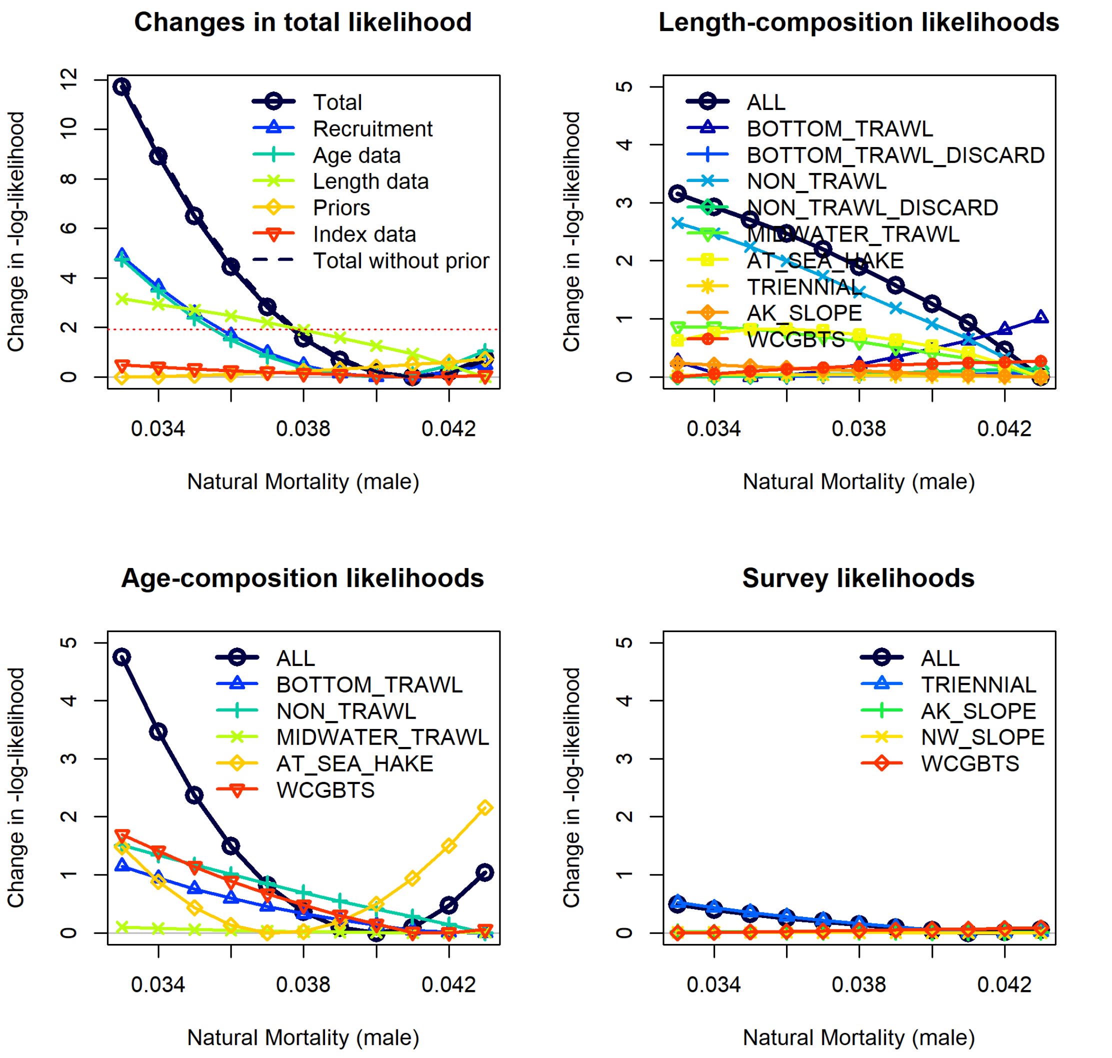

Figure 62: Likelihood profile and component likelihoods used to establish a fixed value for male natural mortality.

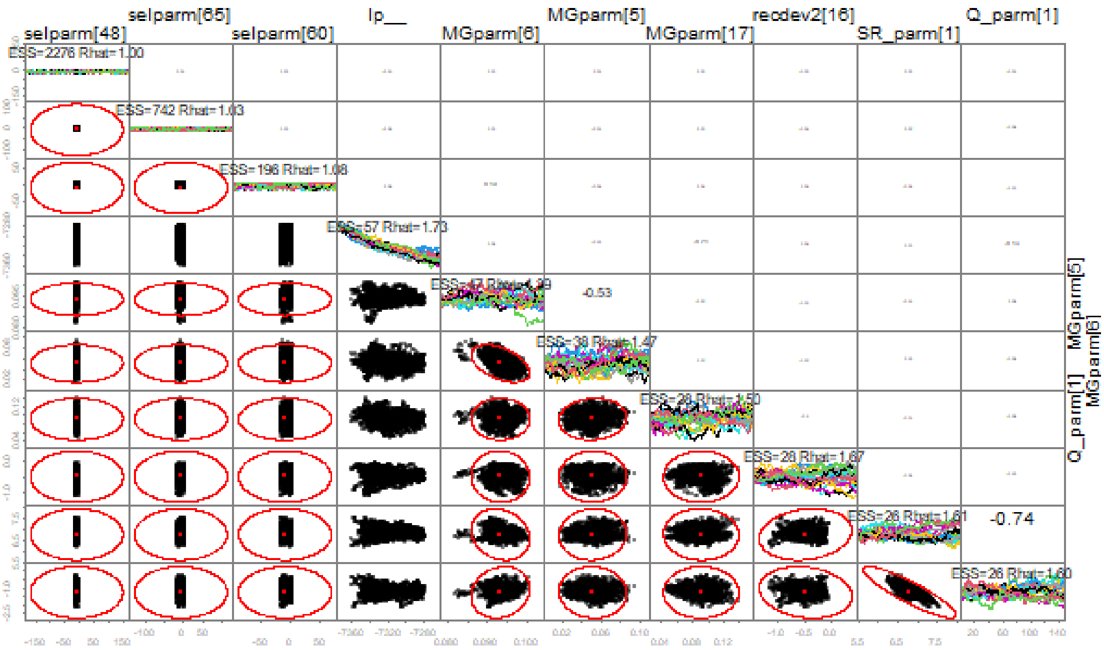

Figure 63: Pairs plots of the fastest mixing parameters from running 2000 posterior draws (keeping every draw) using the random walk Metropolis algorithm. Parameters that show little to no movement are recommended to be fixed to improve model speed and efficiency.

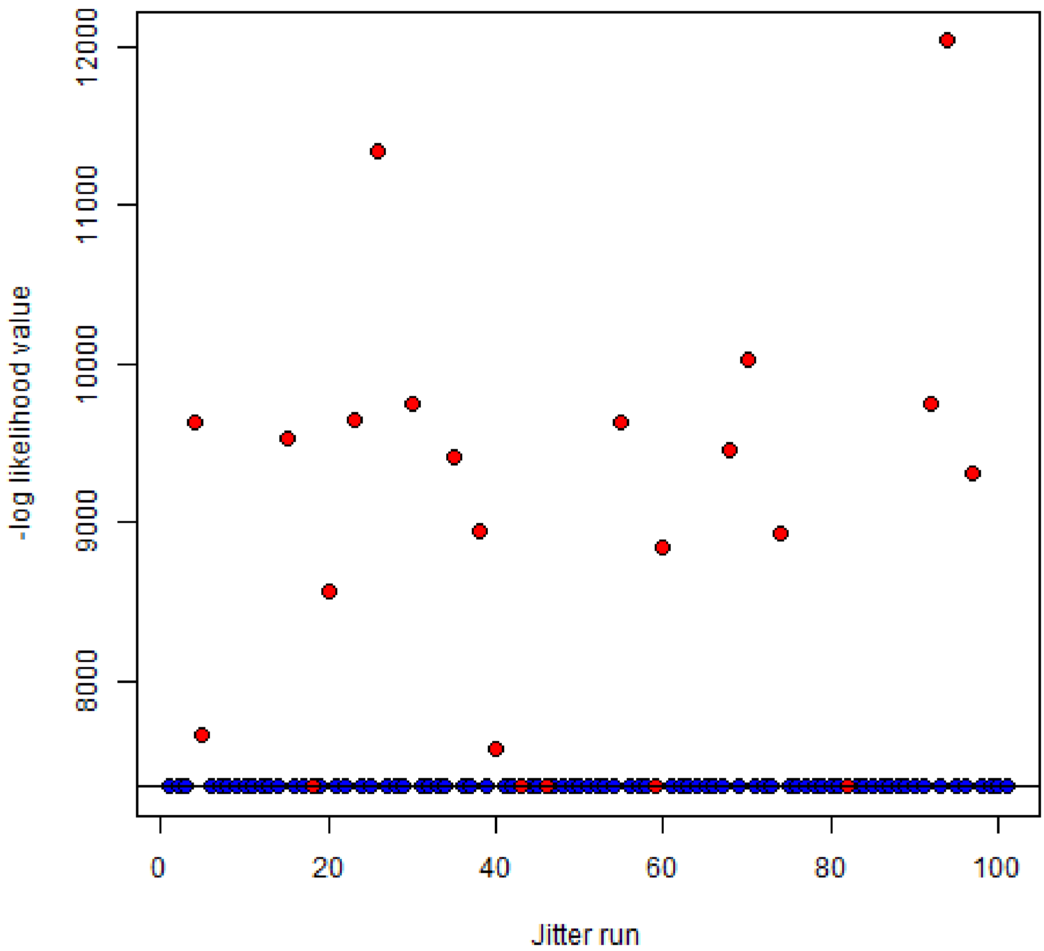

Figure 64: Jitter runs (using a value of 0.01) for the reference model, with jitter run number on the x-axis and -log likelihood value on the y-axis. Blue dot are models that match the likelihood value of the reference model, while red dots deviate from the reference model. All red dots are above the blue dots, indicating no better fit to the reference model was found.

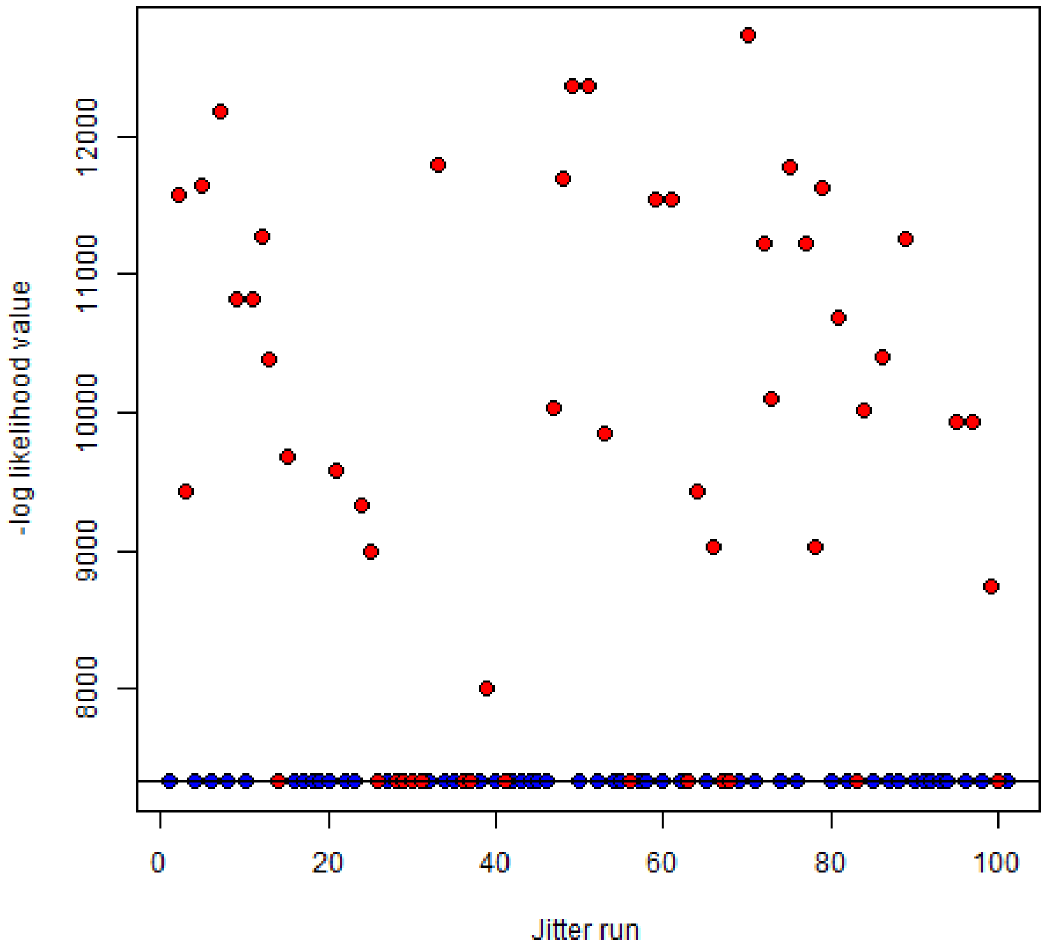

Figure 65: Jitter runs (using a value of 0.05) for the reference model, with jitter run number on the x-axis and -log likelihood value on the y-axis. Blue dot are models that match the likelihood value of the reference model, while red dots deviate from the reference model. All red dots are above the blue dots, indicating no better fit to the reference model was found.

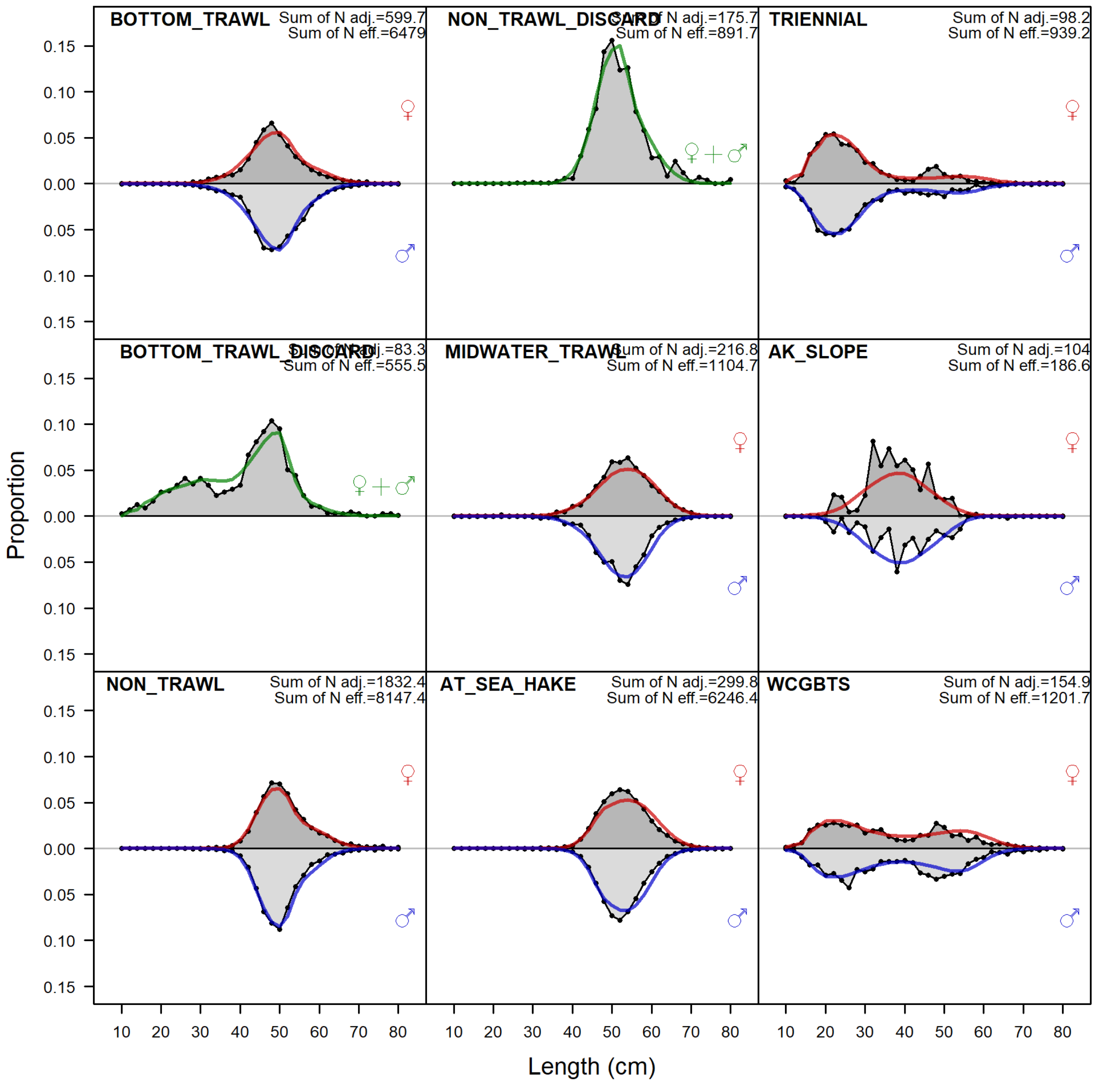

Figure 66: Aggregated length (cm) compositions over all years.

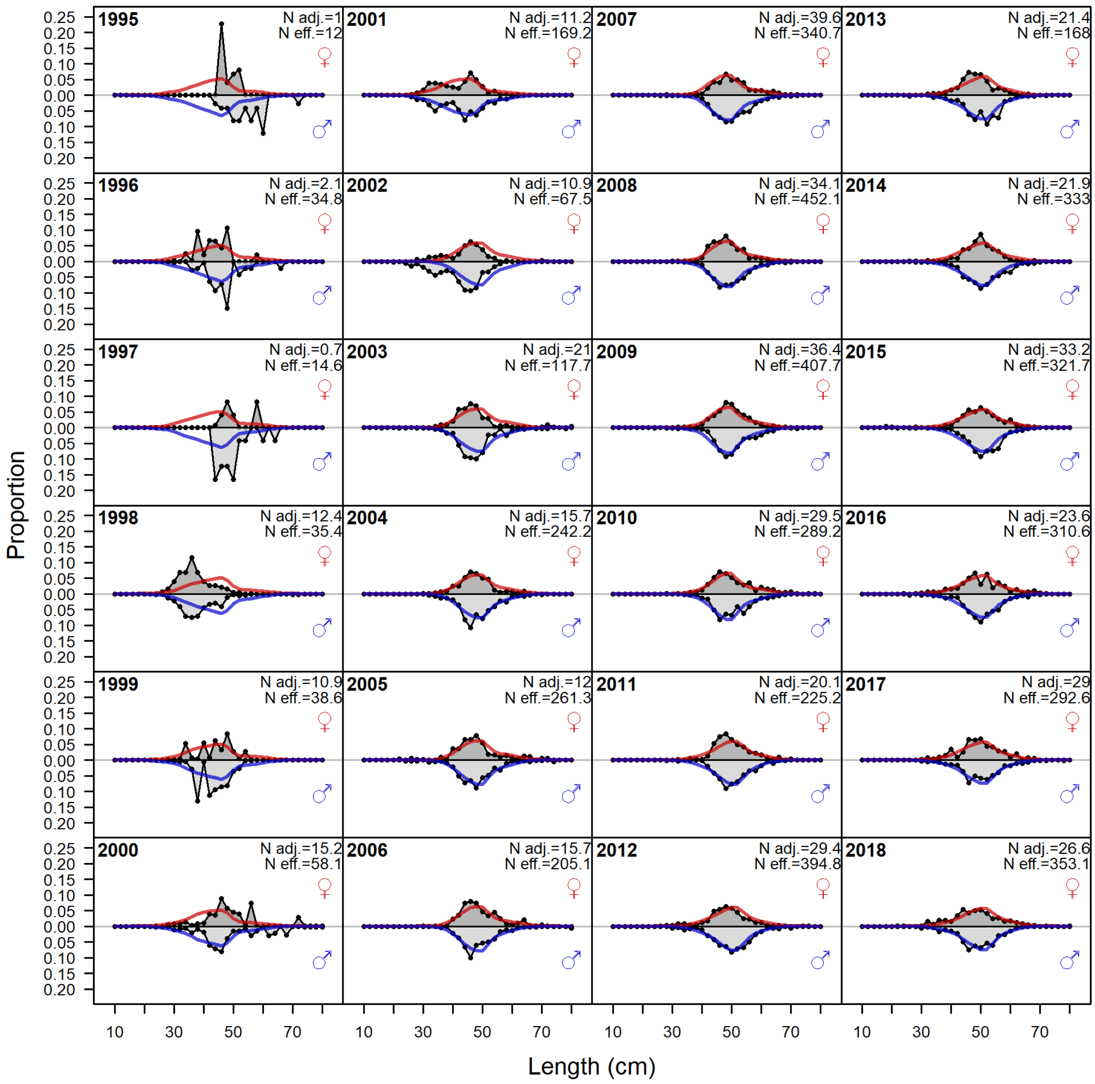

Figure 67: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the bottom trawl fishery in years available between 1995-2018.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

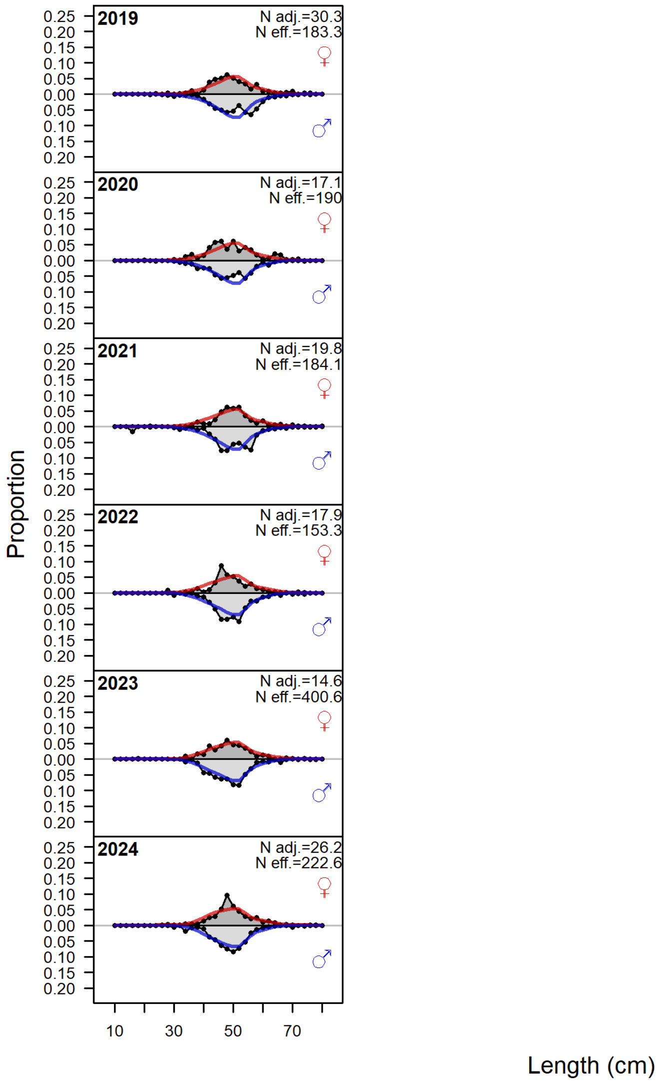

Figure 68: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the bottom trawl fishery in years available between 2019-2024.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

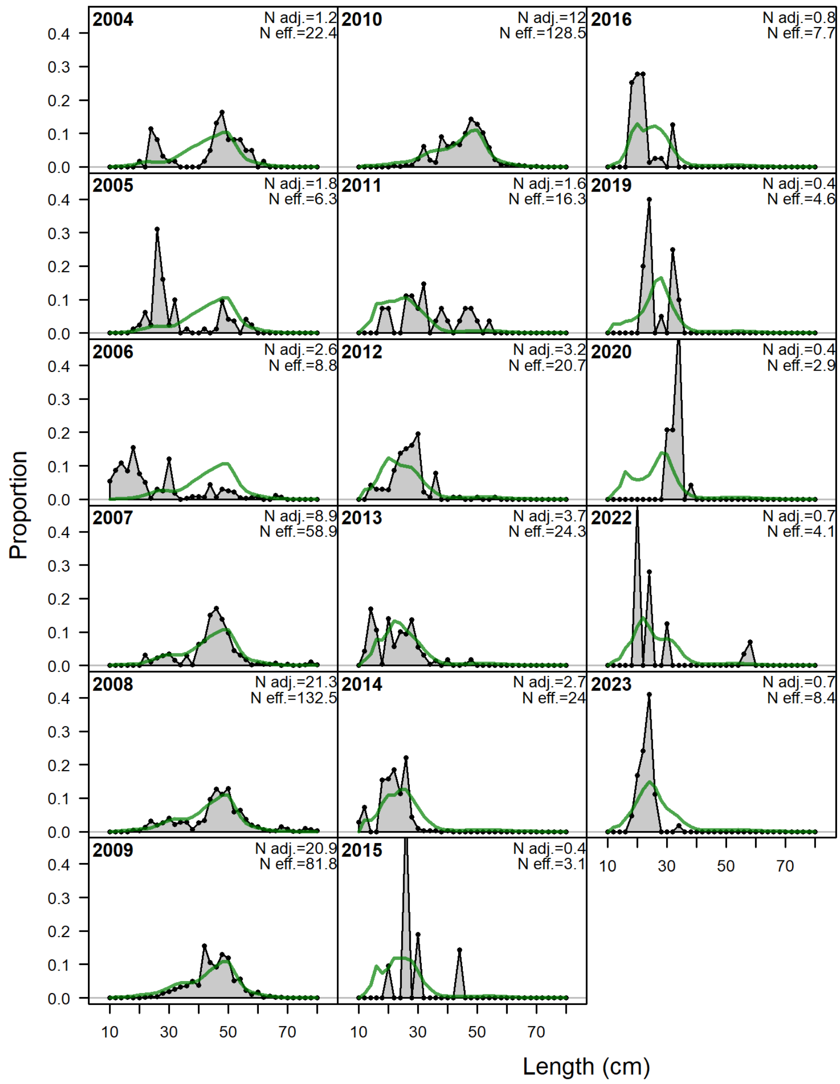

Figure 69: Observed (gray density plot) and expected (density lines) length compositions by year for the bottom trawl discard fishery in years available between 2004-2023.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

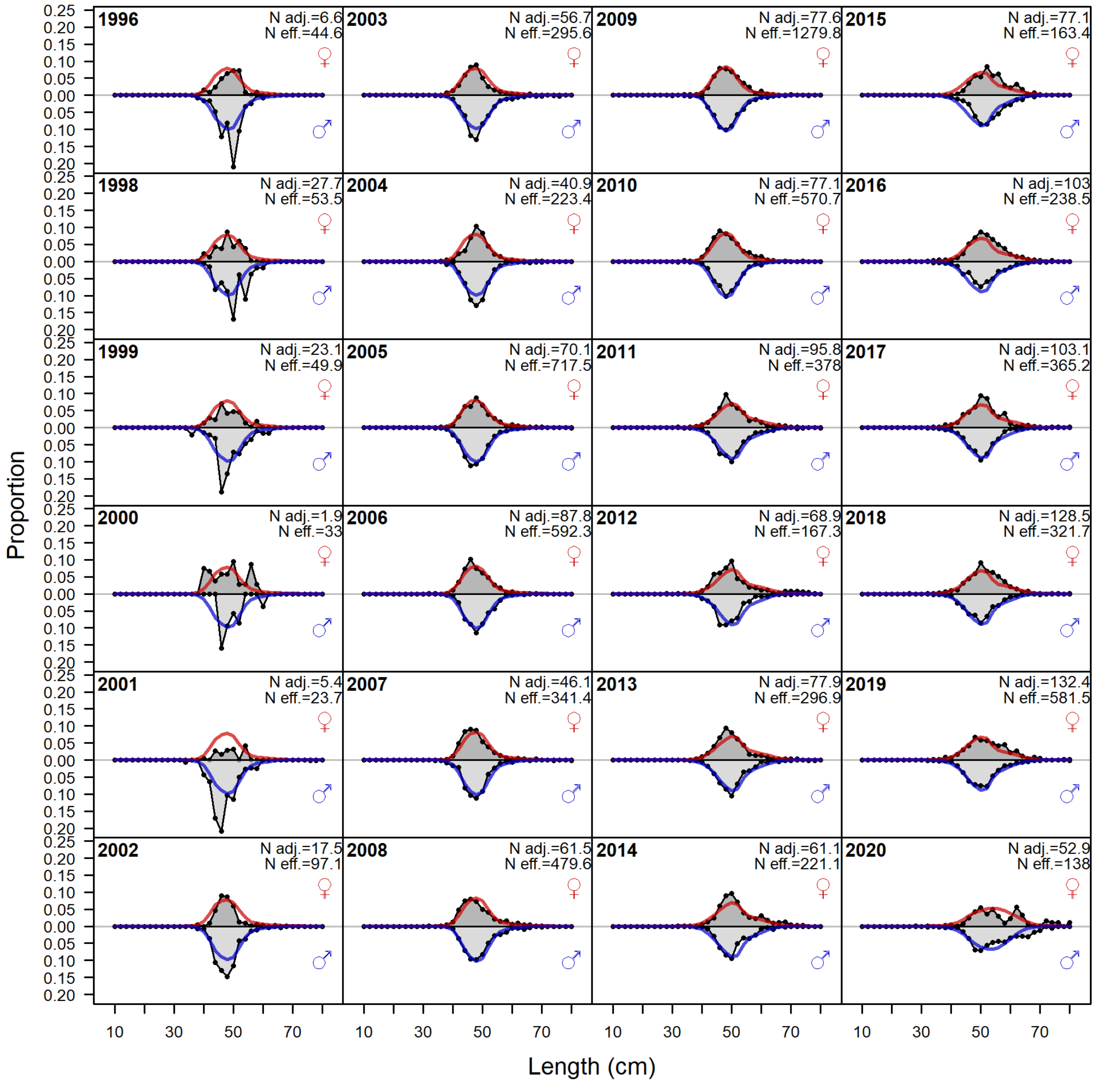

Figure 70: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the non-trawl fishery in years available between 1996-2020.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

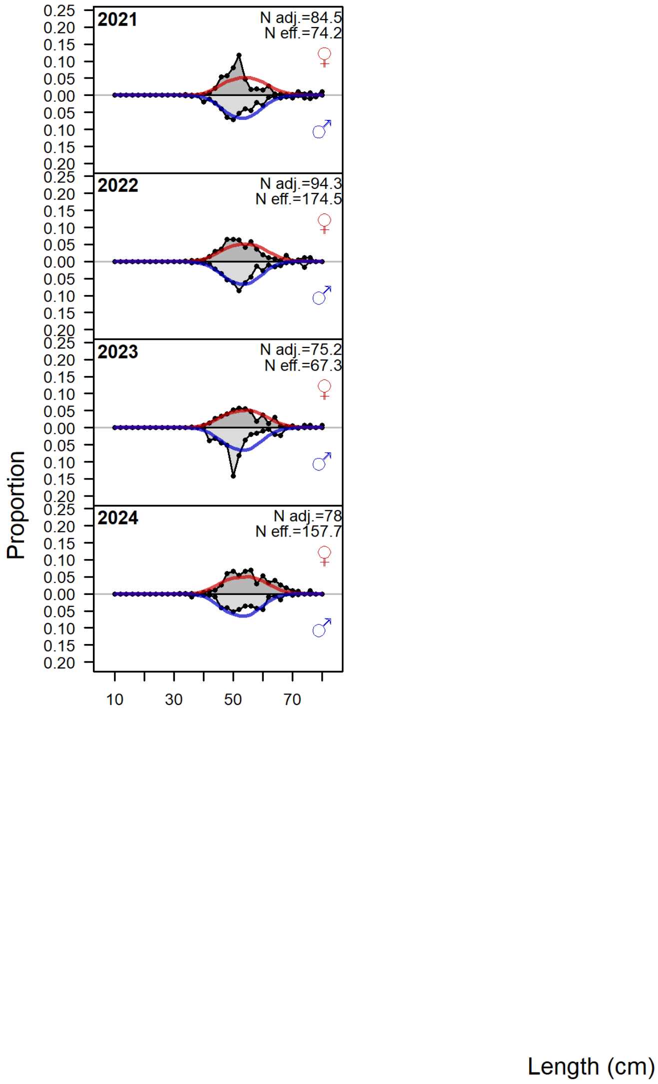

Figure 71: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the non-trawl fishery in years available between 2021-2024.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

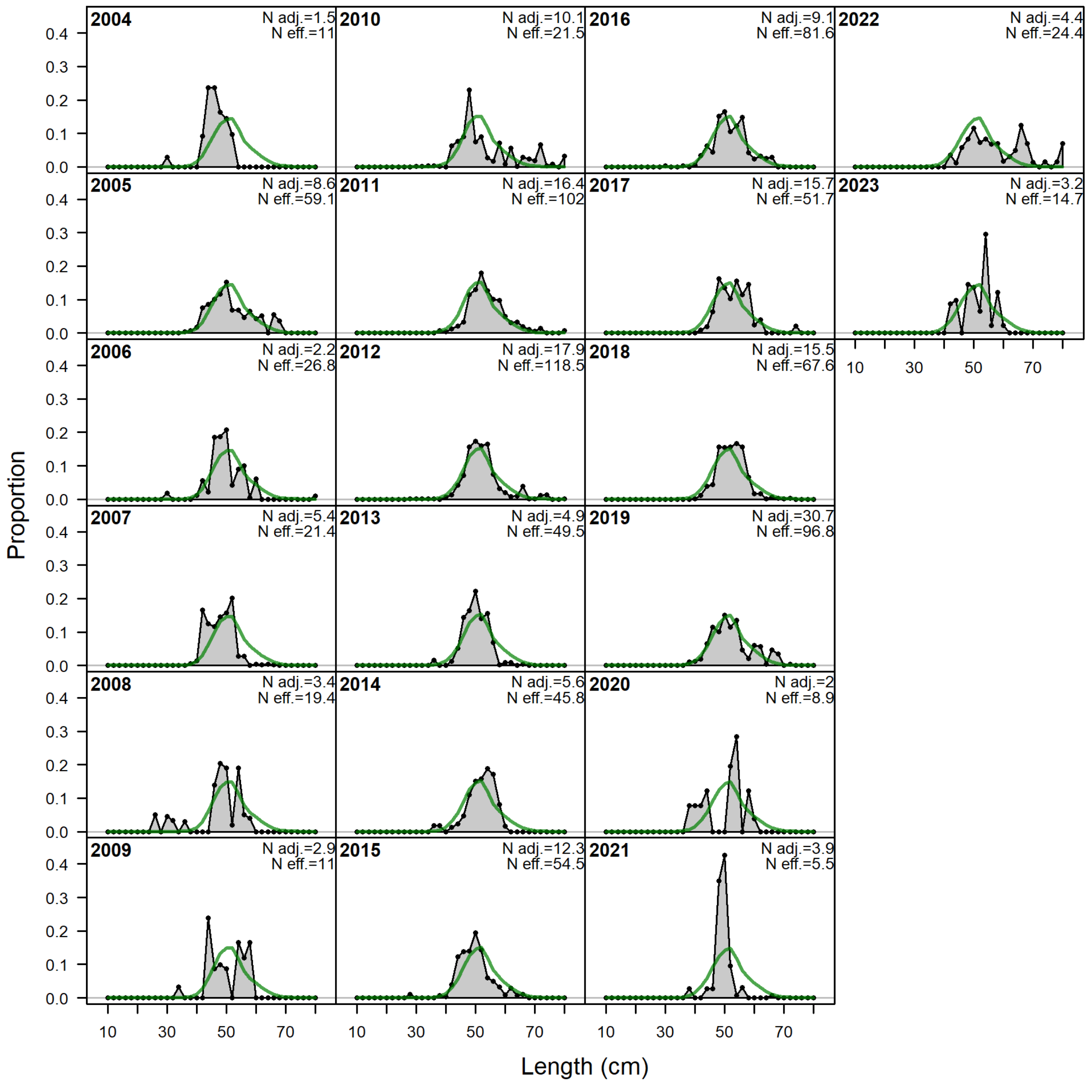

Figure 72: Observed (gray density plot) and expected (density lines) length compositions by year for the midwater trawl fishery in years available between 2004-2024.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

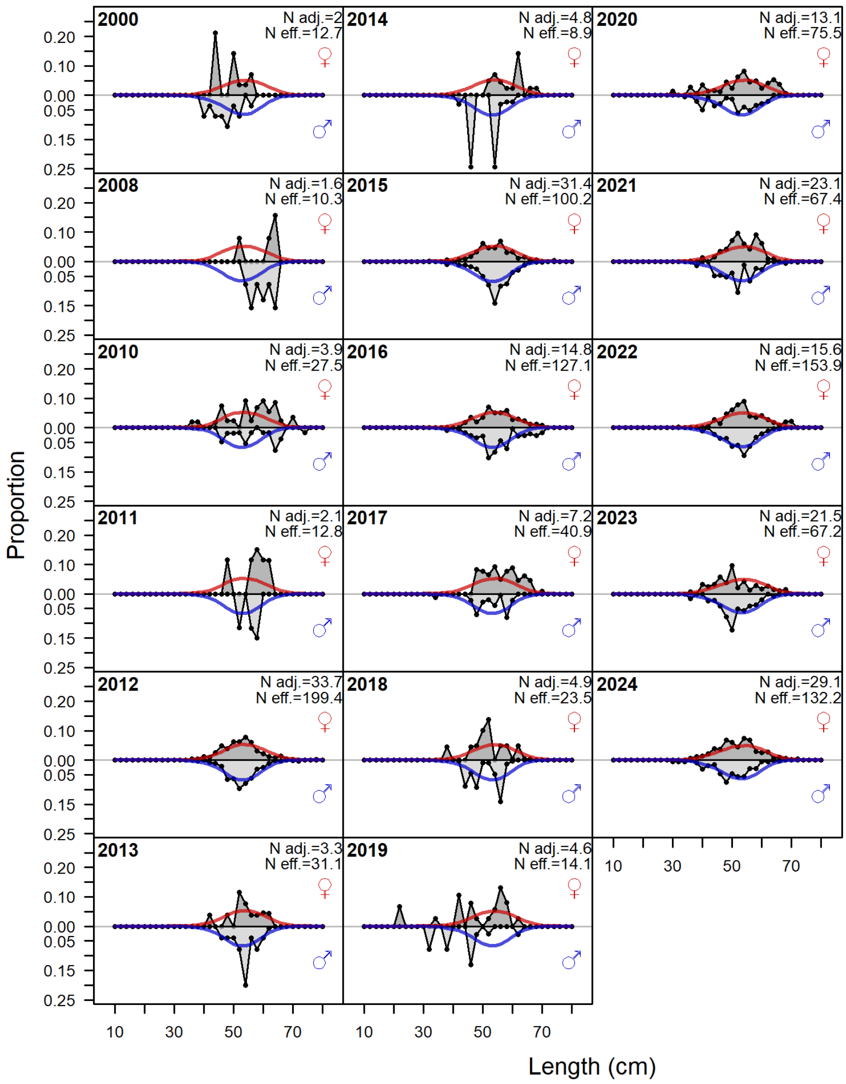

Figure 73: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the non-trawl discard fishery in years available between 2000-2023.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

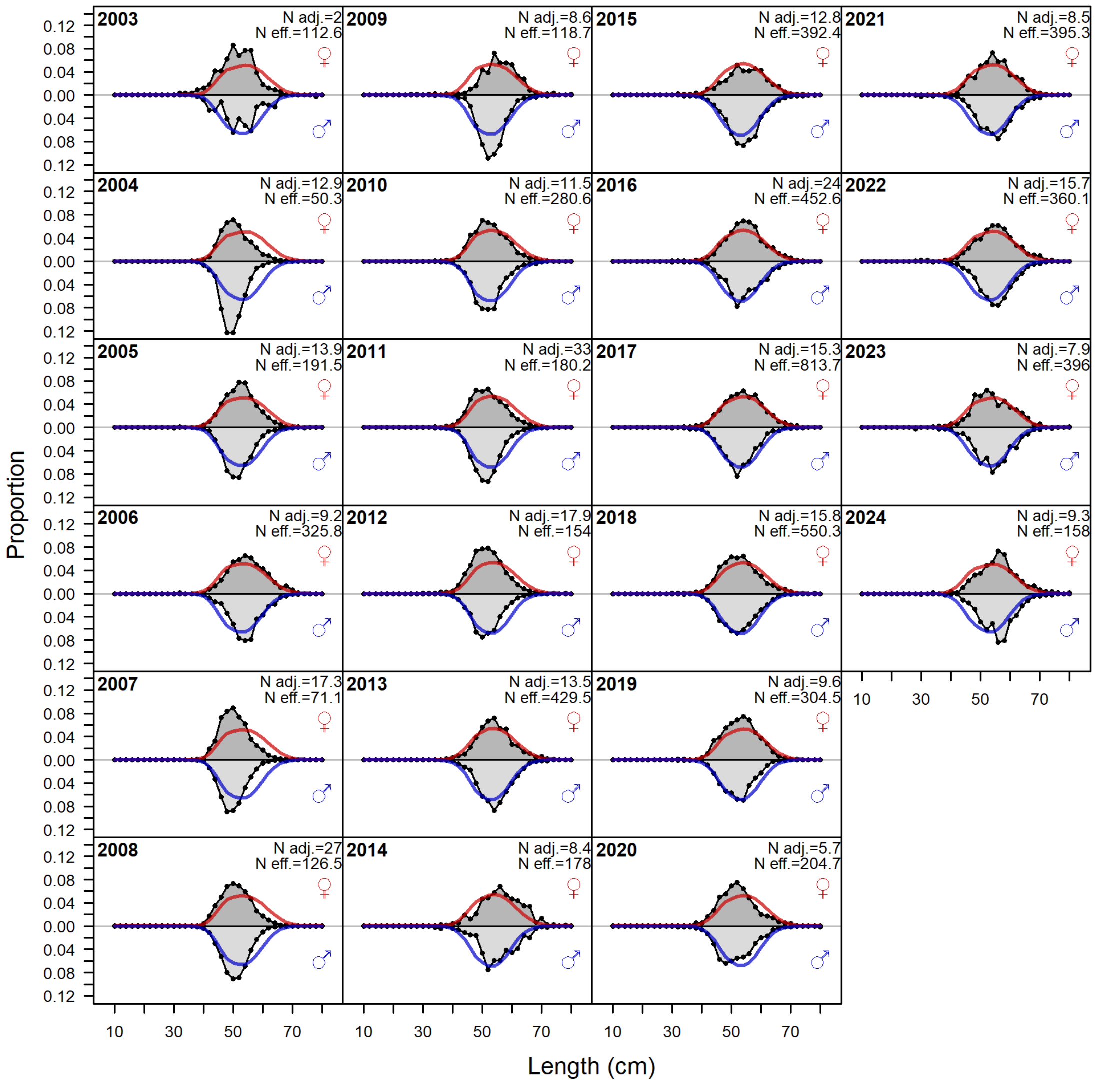

Figure 74: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the at-sea-hake fishery in years available between 2003-2024.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

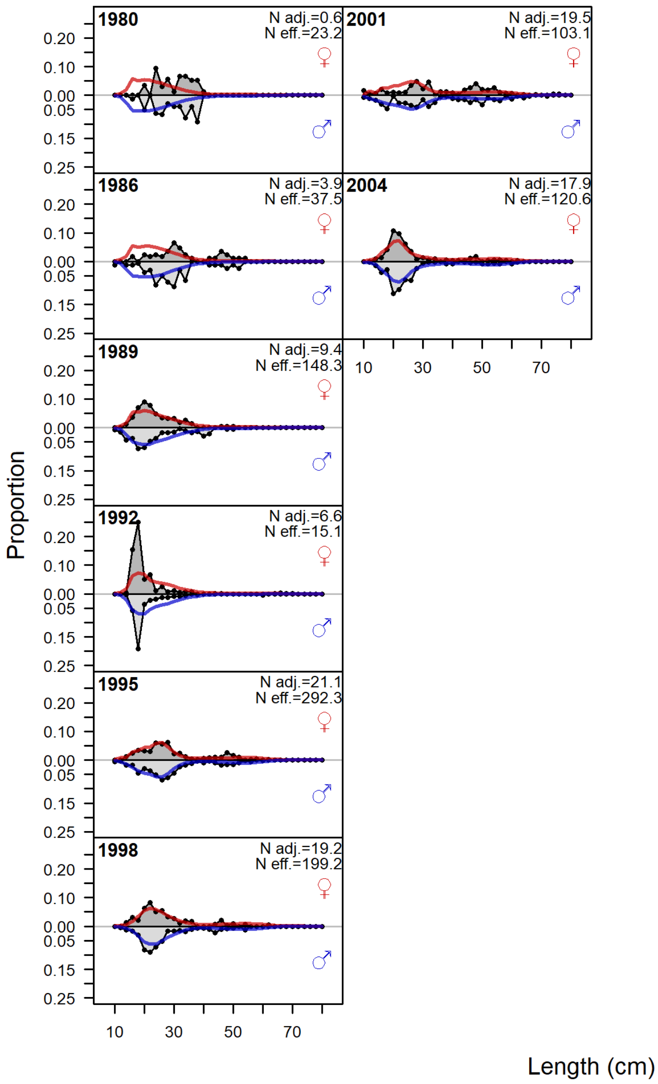

Figure 75: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the Triennial Bottom Trawl Survey in years available between 1980-2004.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

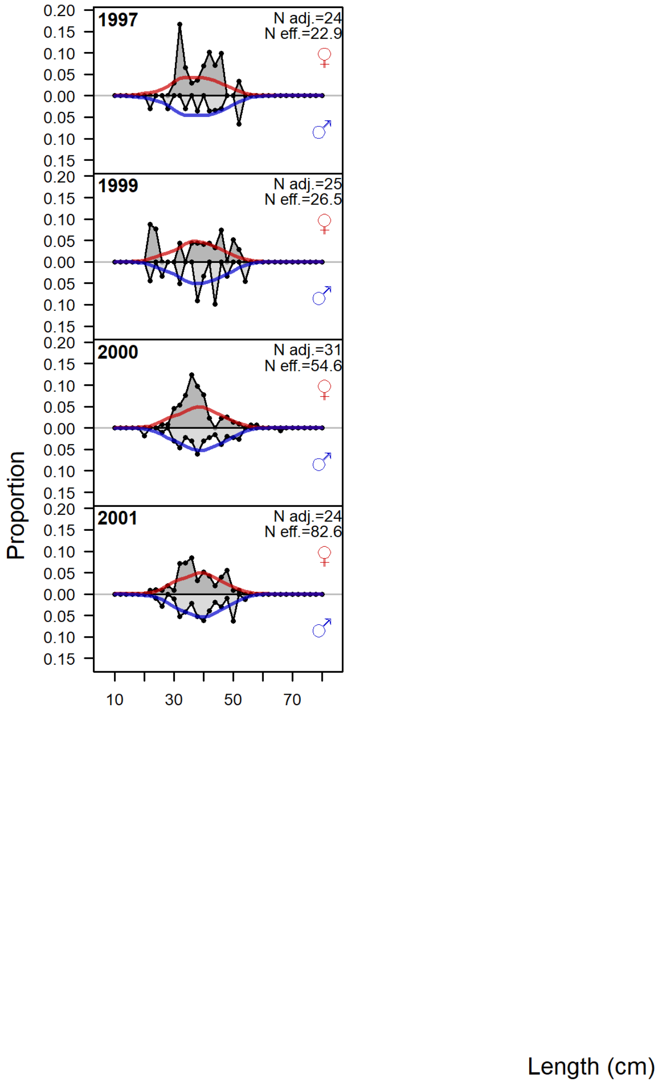

Figure 76: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the Alaskan Slope Bottom Trawl Survey in years available between 1997-2001.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

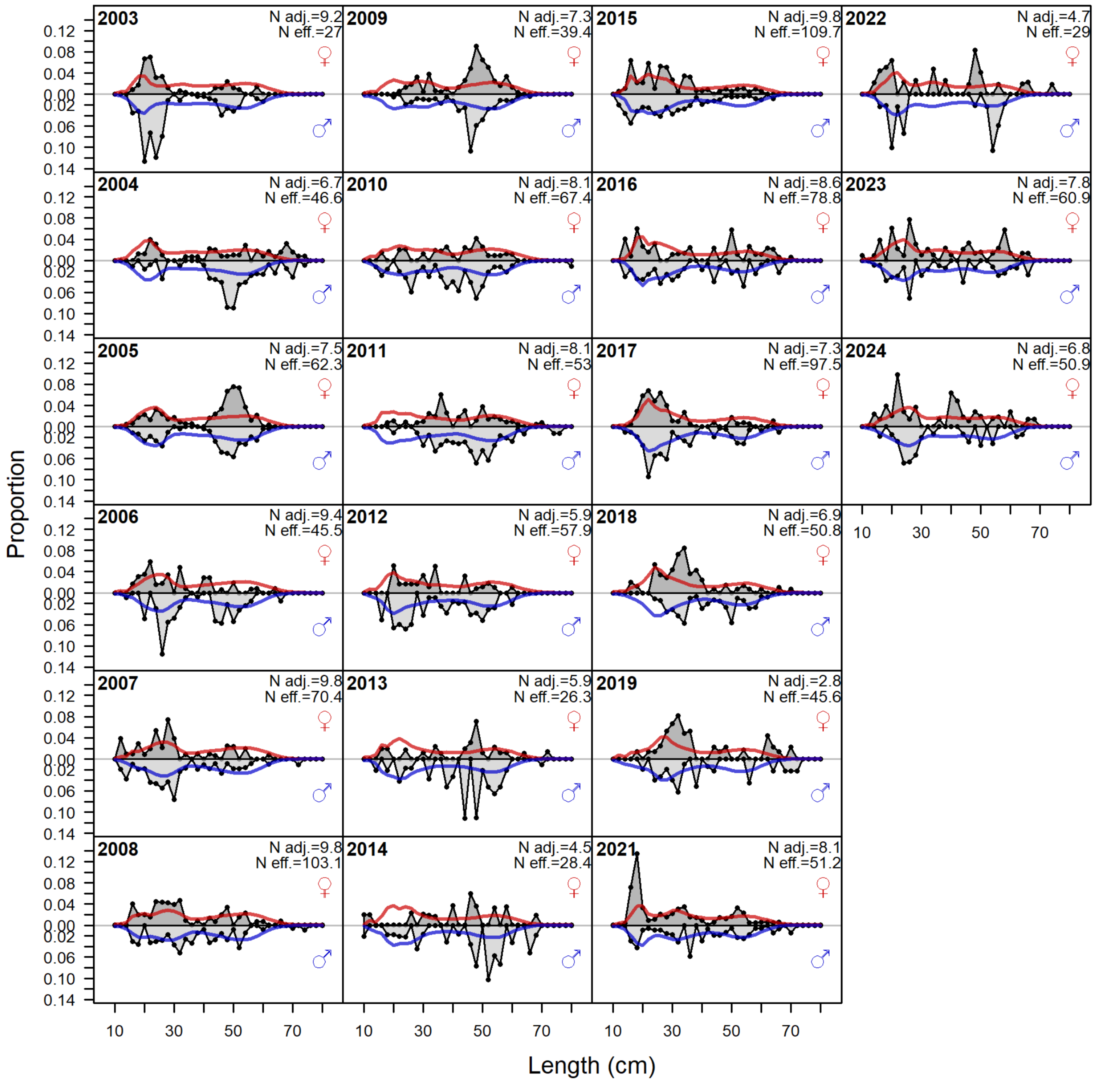

Figure 77: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the West Coast Groundfish Bottom Trawl Survey in years available between 1980-2004.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

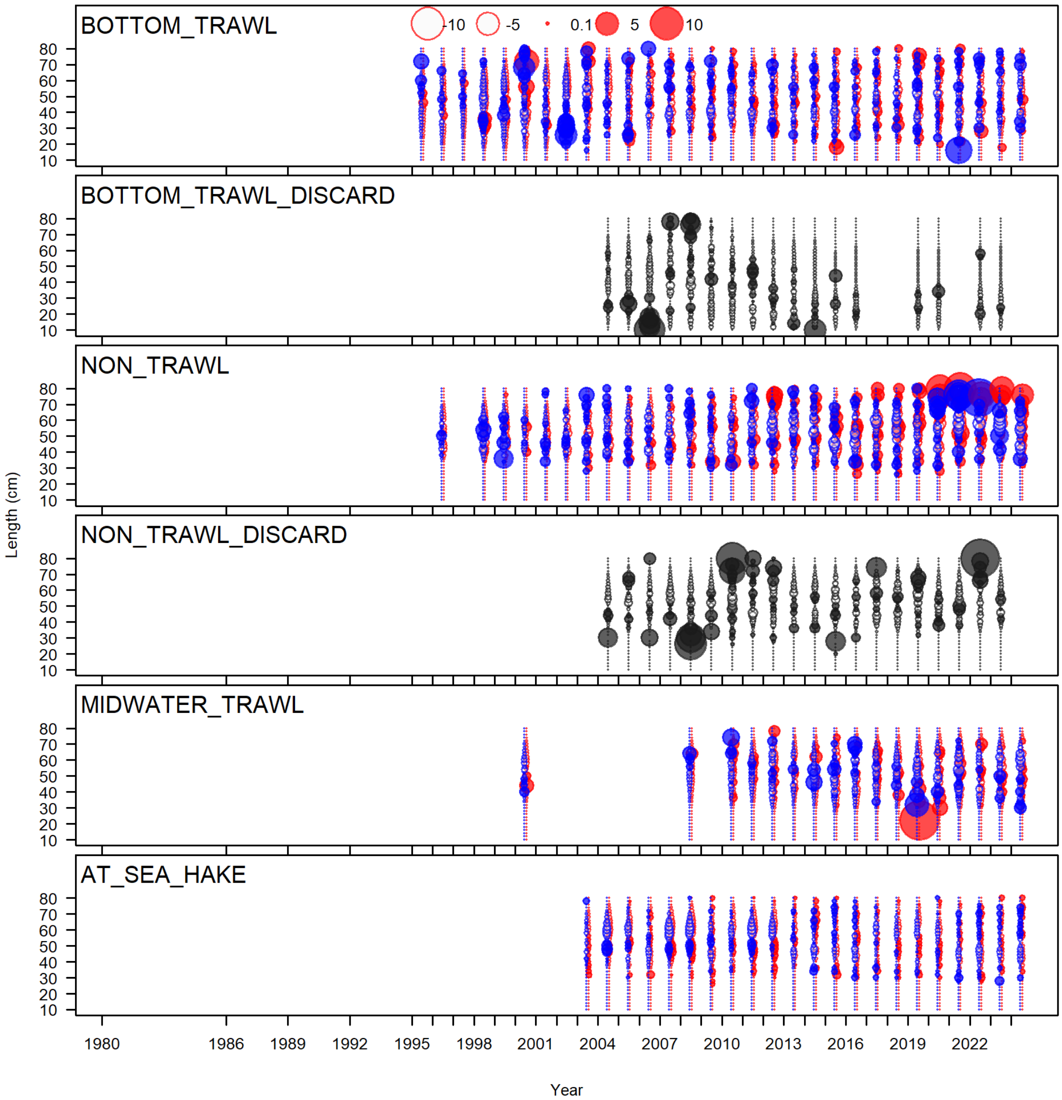

Figure 78: Pearson residuals of length fits for each fishing fleet. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

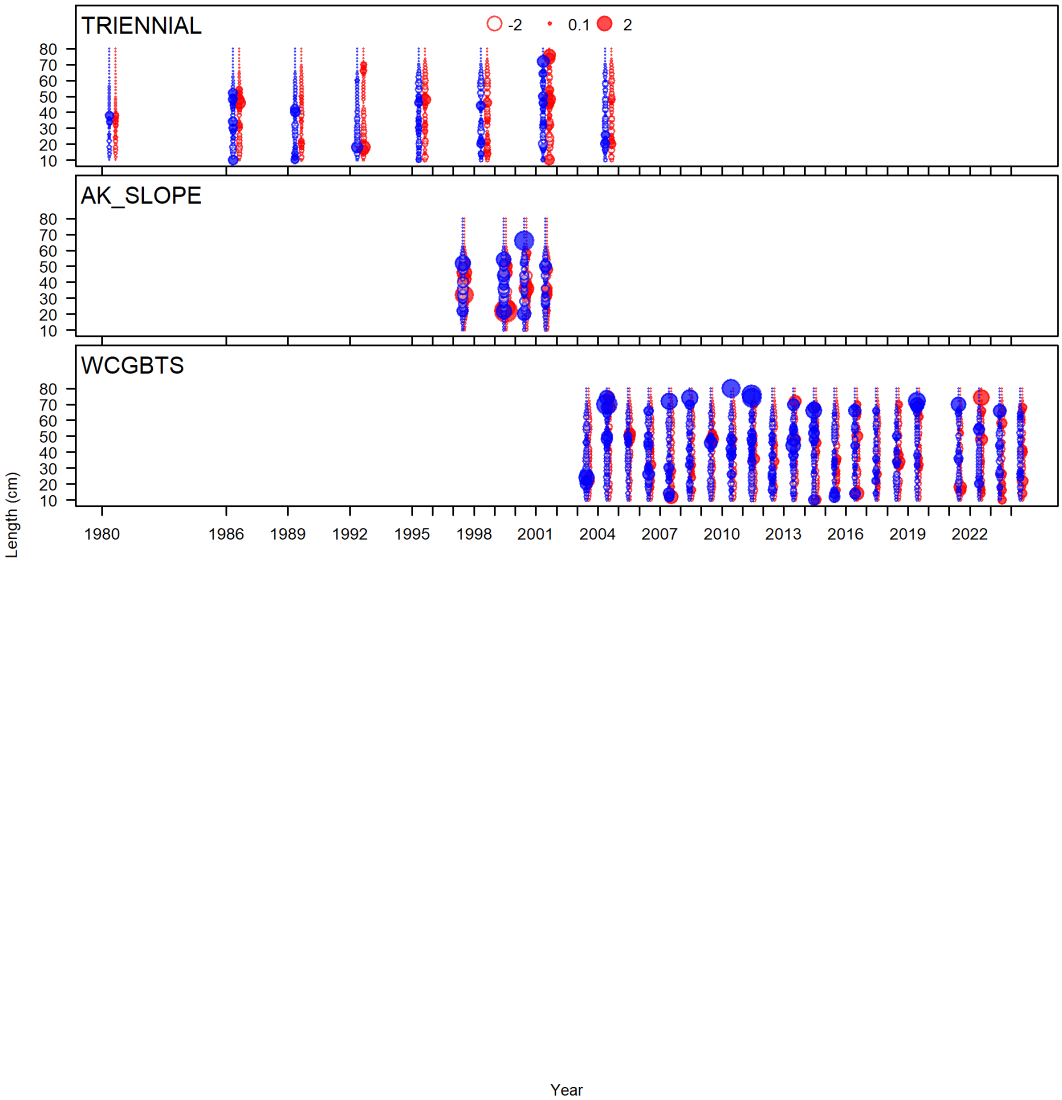

Figure 79: Pearson residuals of length fits for each survey. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

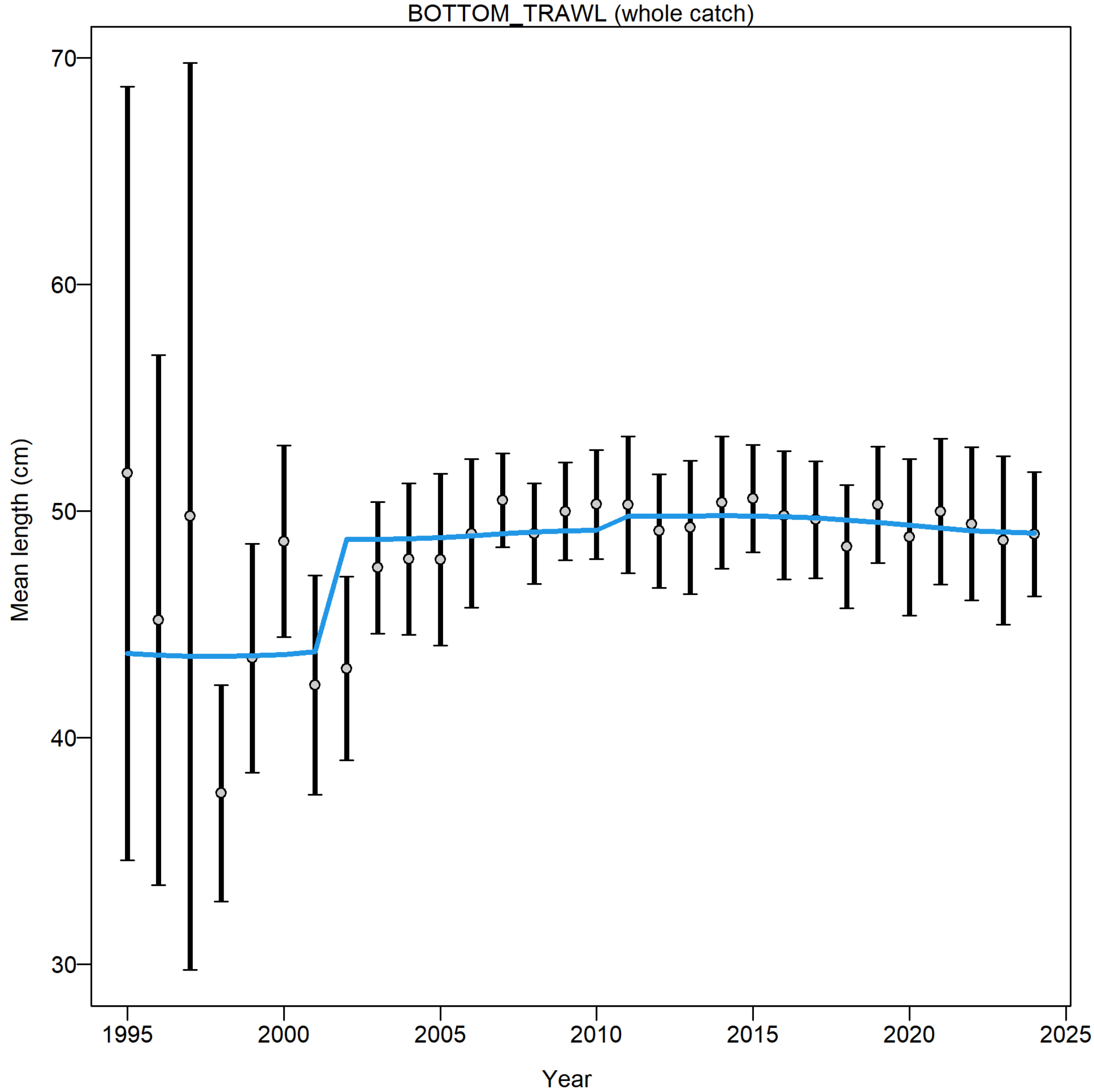

Figure 80: Mean length (cm) index from the bottom trawl fishery with 95 percent confidence intervals based on sample sizes and data weighting.

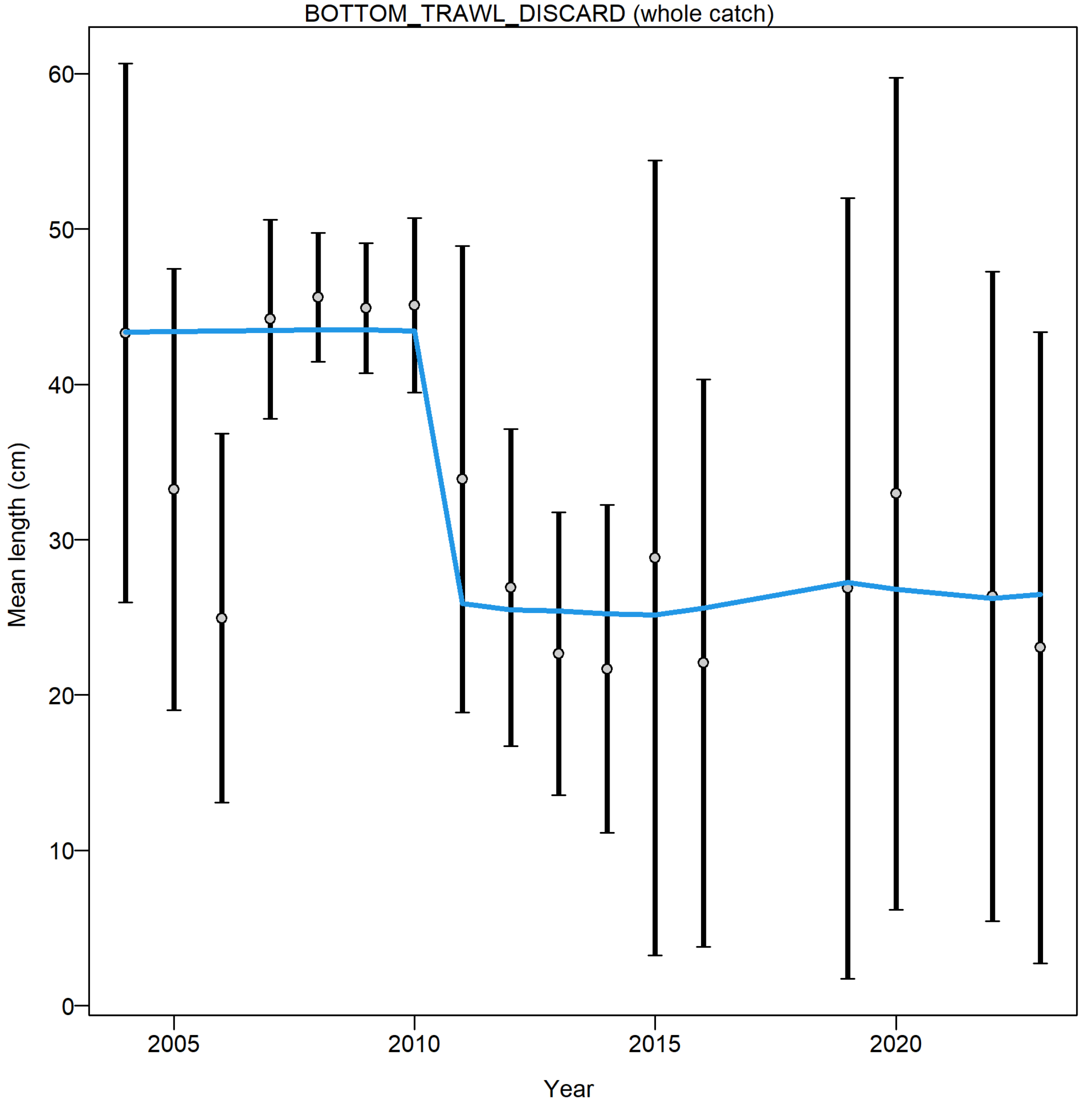

Figure 81: Mean length (cm) index from the bottom trawl discard fishery with 95 percent confidence intervals based on sample sizes and data weighting.

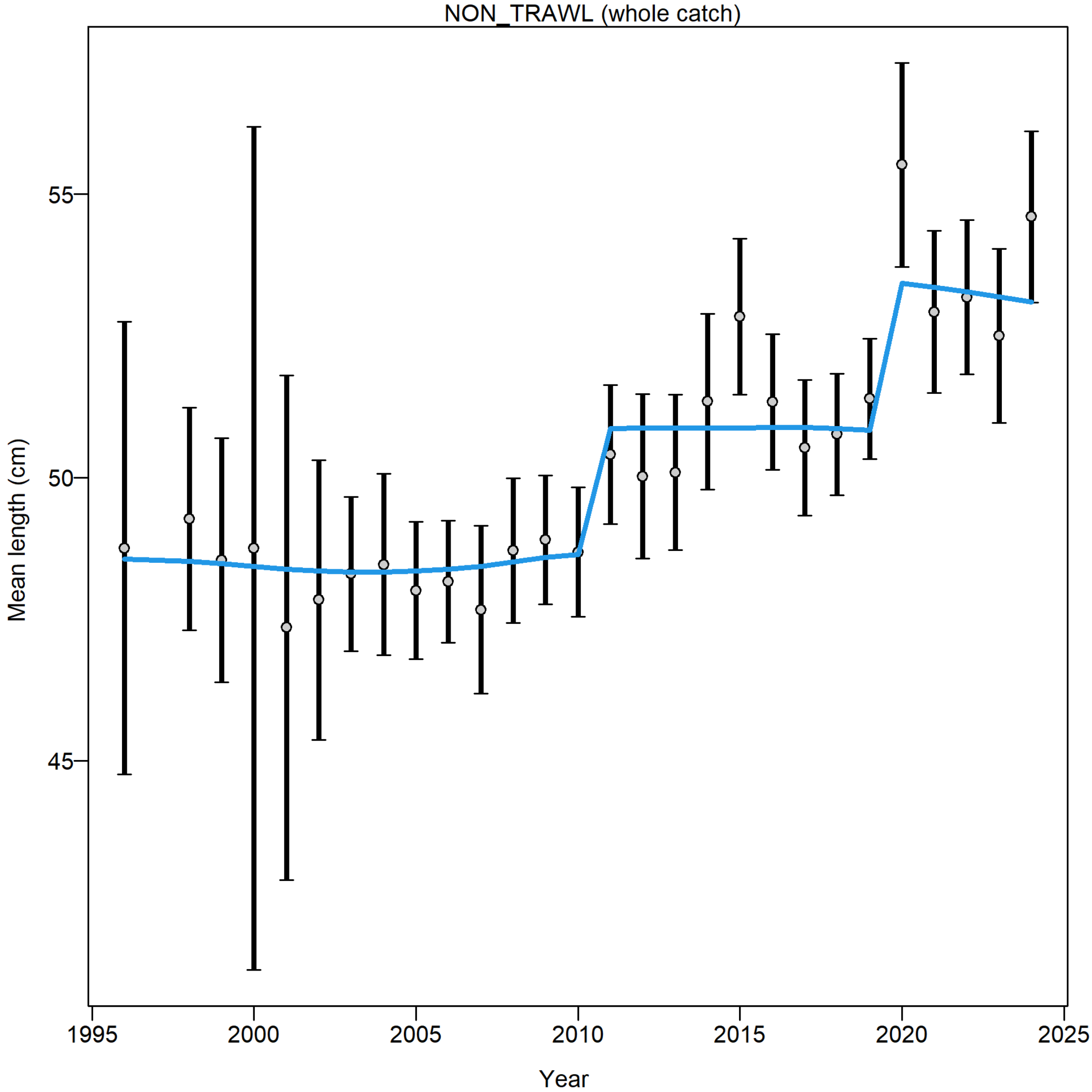

Figure 82: Mean length (cm) index from the non-trawl fishery with 95 percent confidence intervals based on sample sizes and data weighting.

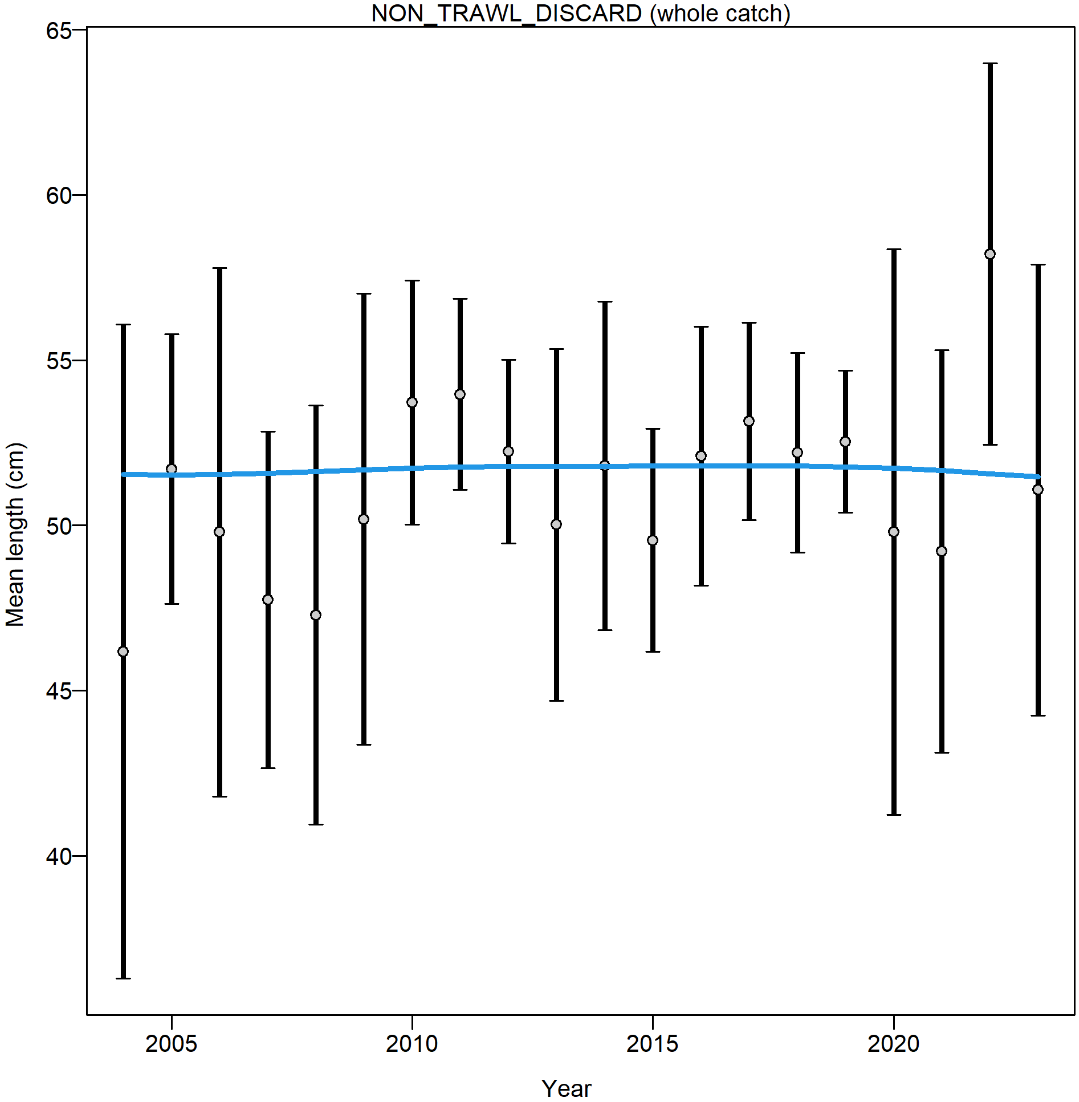

Figure 83: Mean length (cm) index from the non-trawl discard fishery with 95 percent confidence intervals based on sample sizes and data weighting.

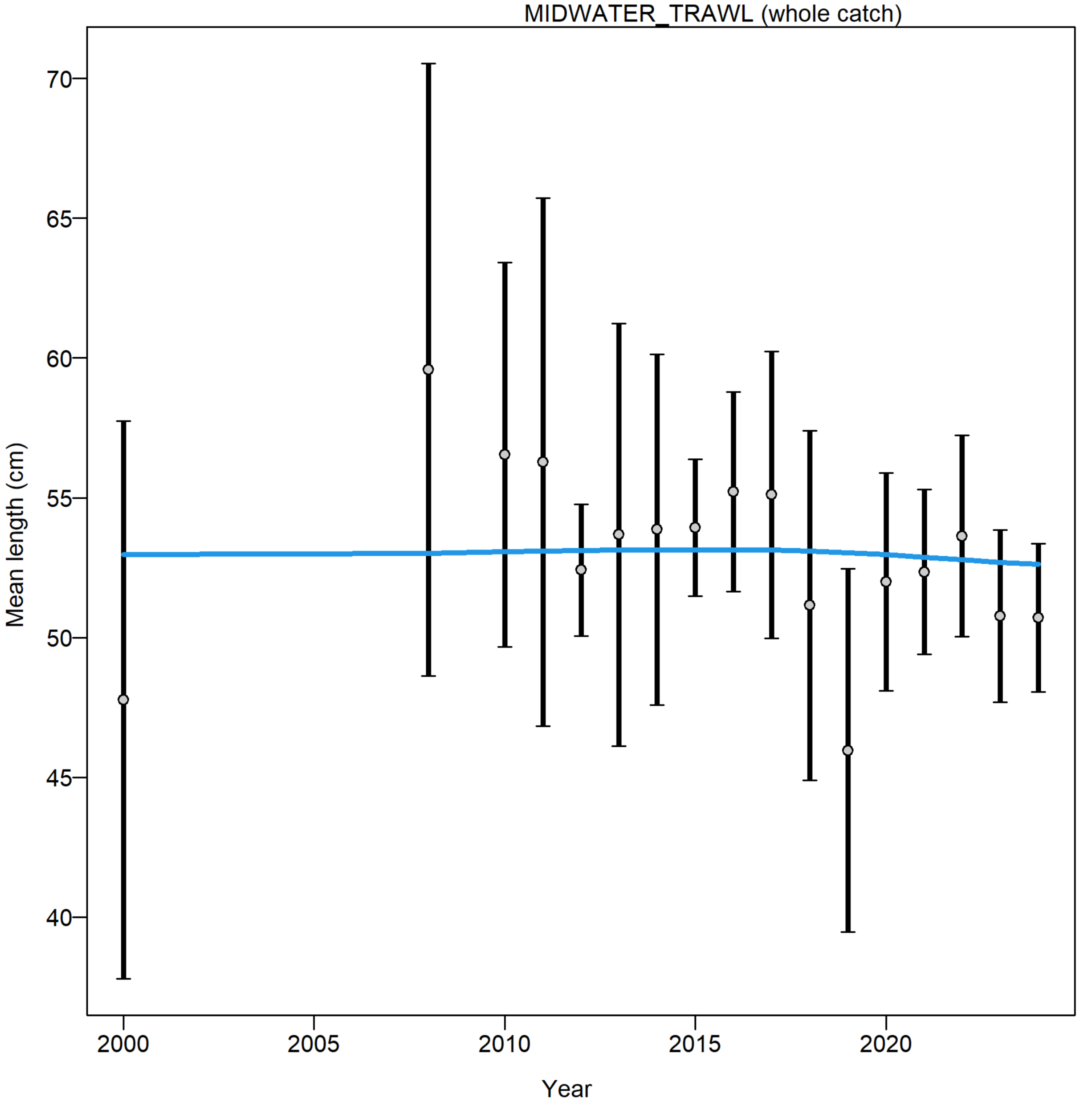

Figure 84: Mean length (cm) index from the midwater trawl fishery with 95 percent confidence intervals based on sample sizes and data weighting.

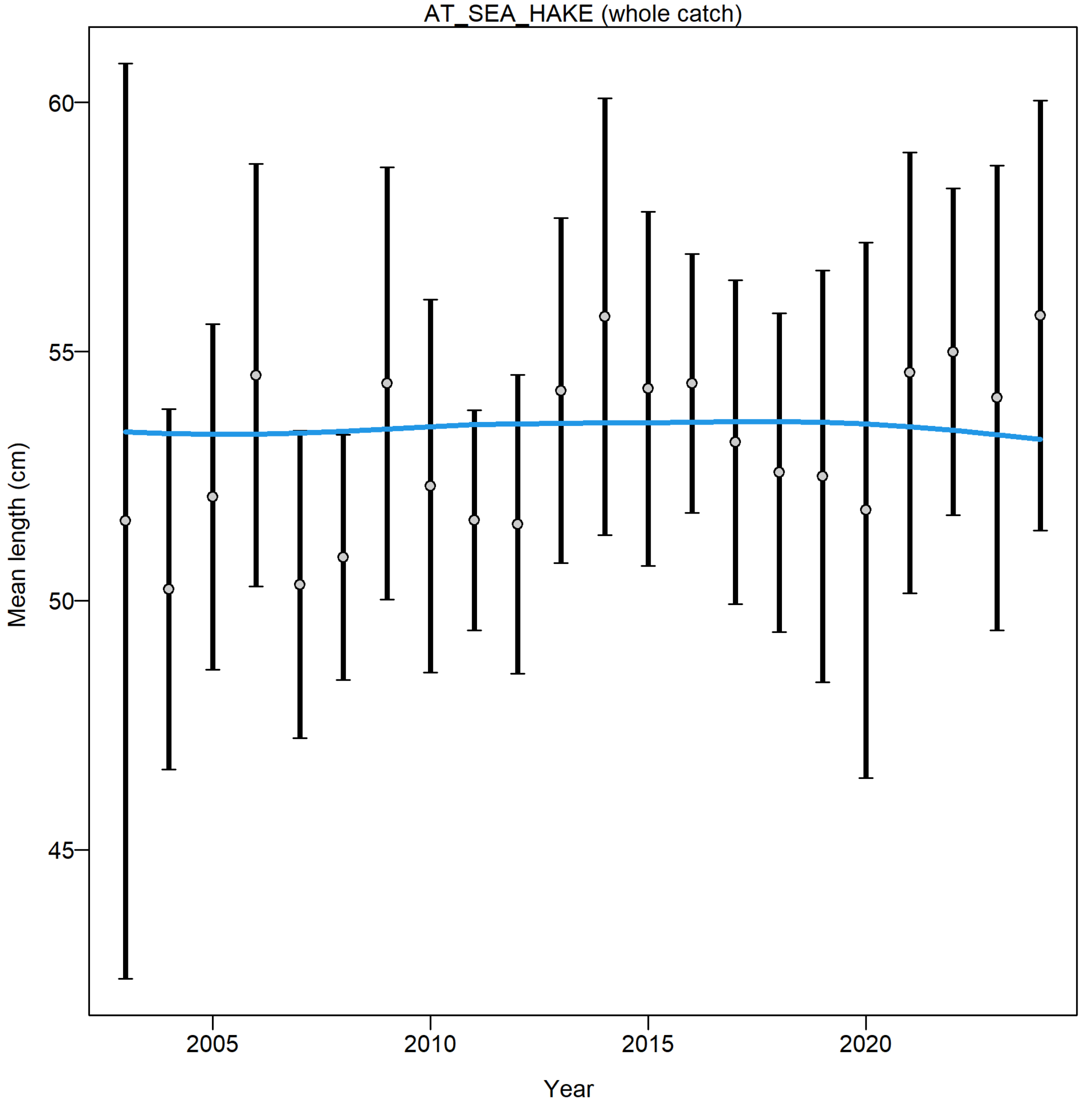

Figure 85: Mean length (cm) index from the at-sea-hake fishery with 95 percent confidence intervals based on sample sizes and data weighting.

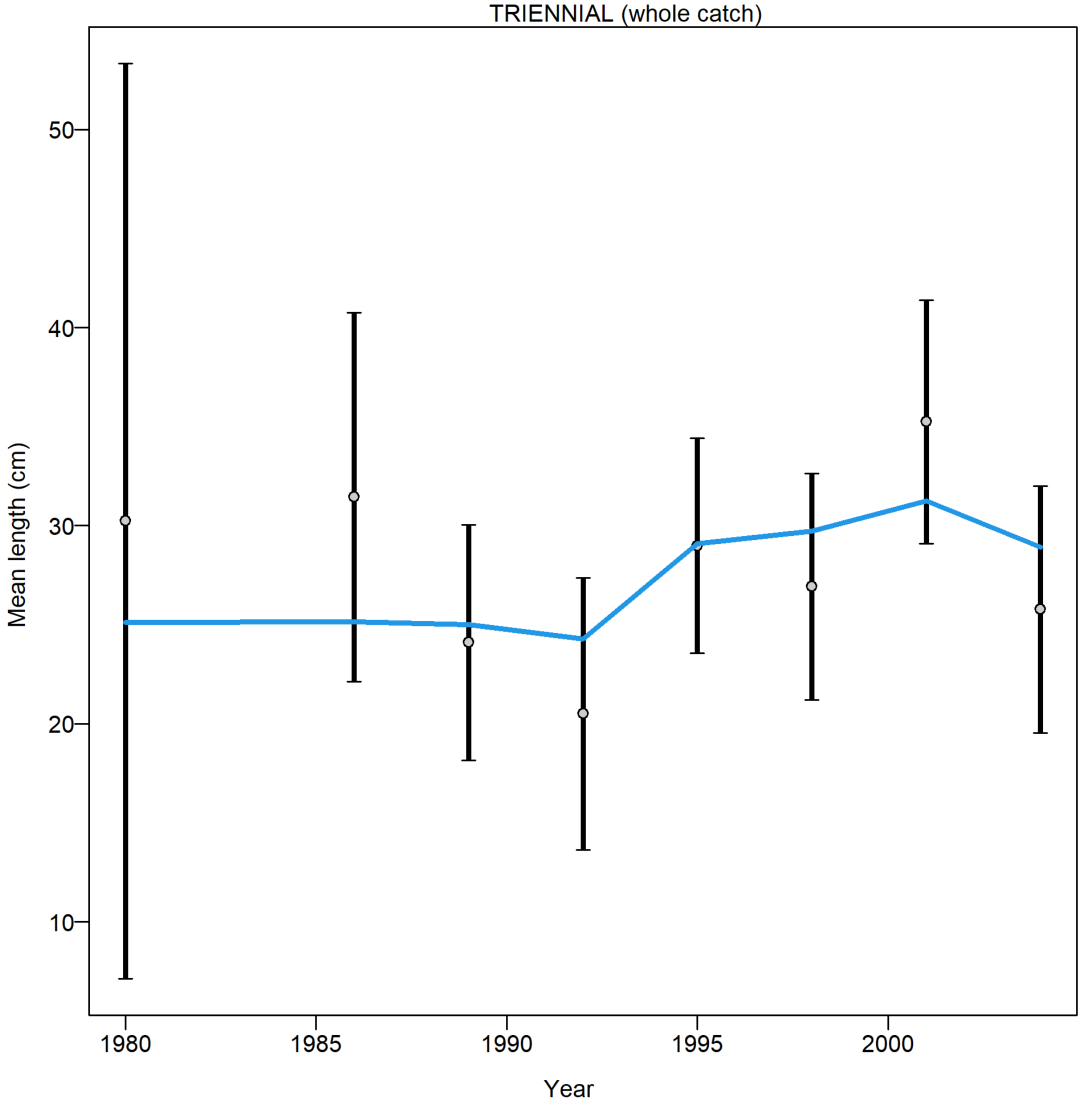

Figure 86: Mean length (cm) index from the Triennial survey with 95 percent confidence intervals based on sample sizes and data weighting.

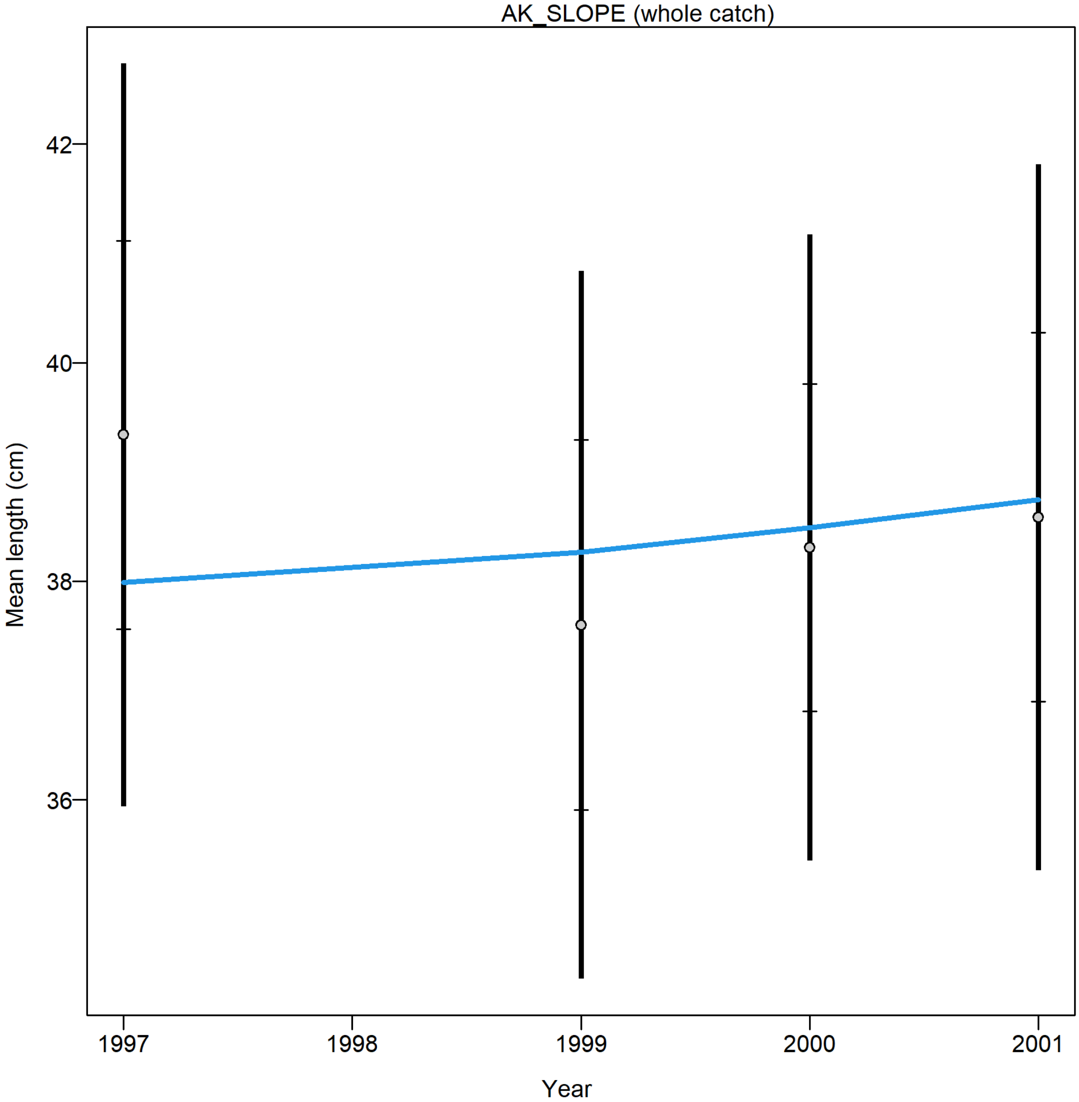

Figure 87: Mean length (cm) index from the Alaskan slope survey with 95 percent confidence intervals based on sample sizes and data weighting.

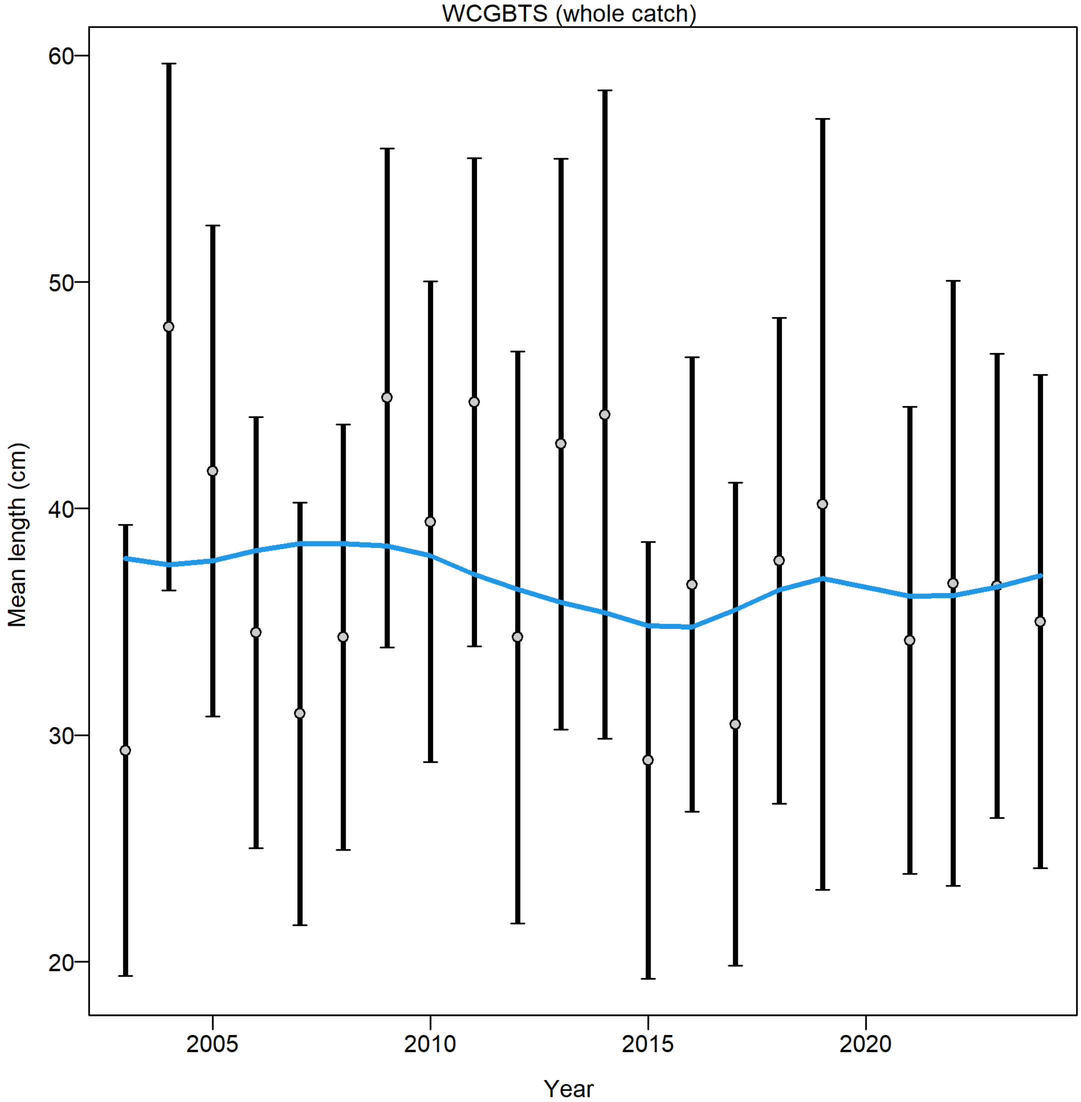

Figure 88: Mean length (cm) index from the West Coast Groundfish Bottom Trawl survey with 95 percent confidence intervals based on sample sizes and data weighting.

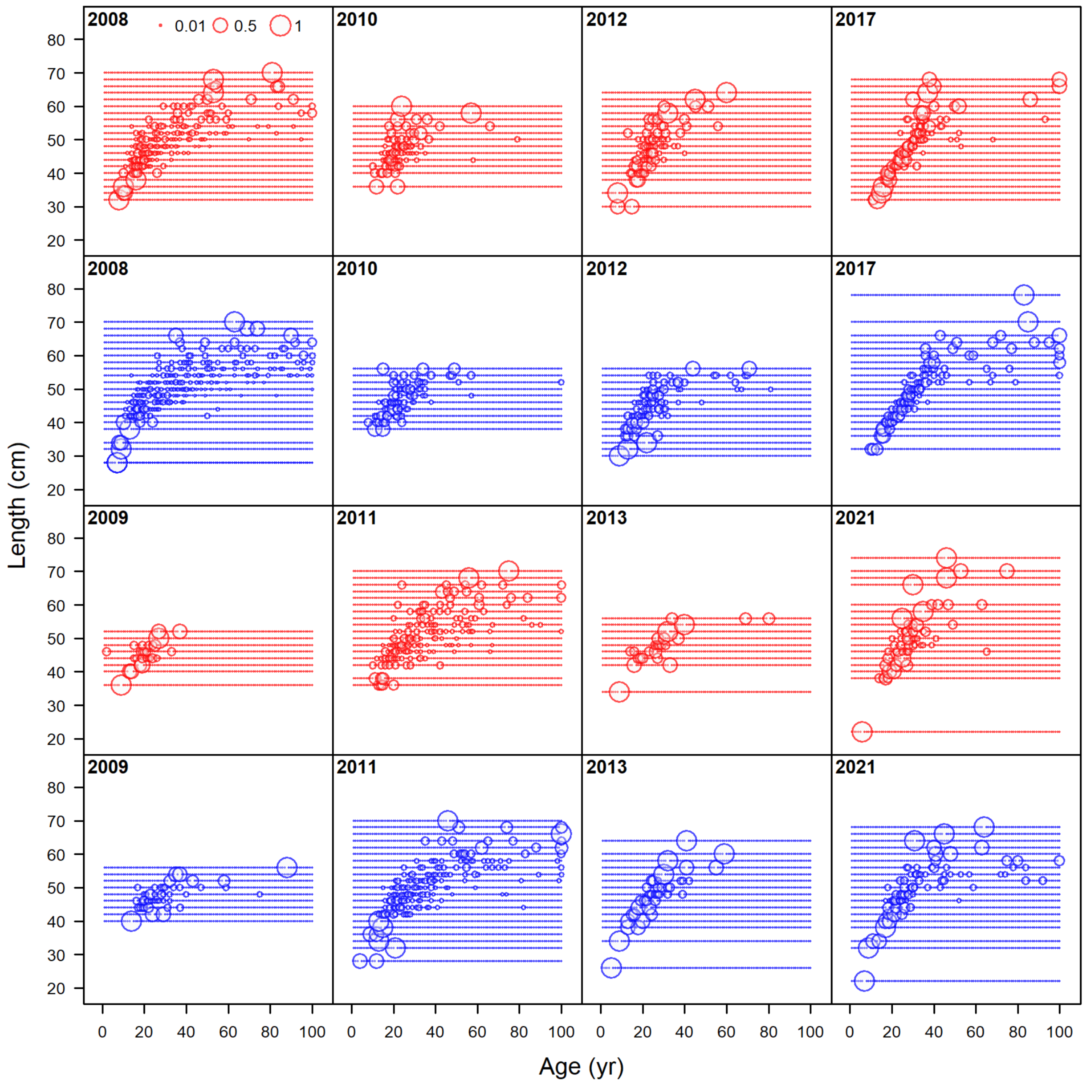

Figure 89: Pearson residuals of conditional age at length fits for the bottom trawl fishery in the years 2008-2021. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

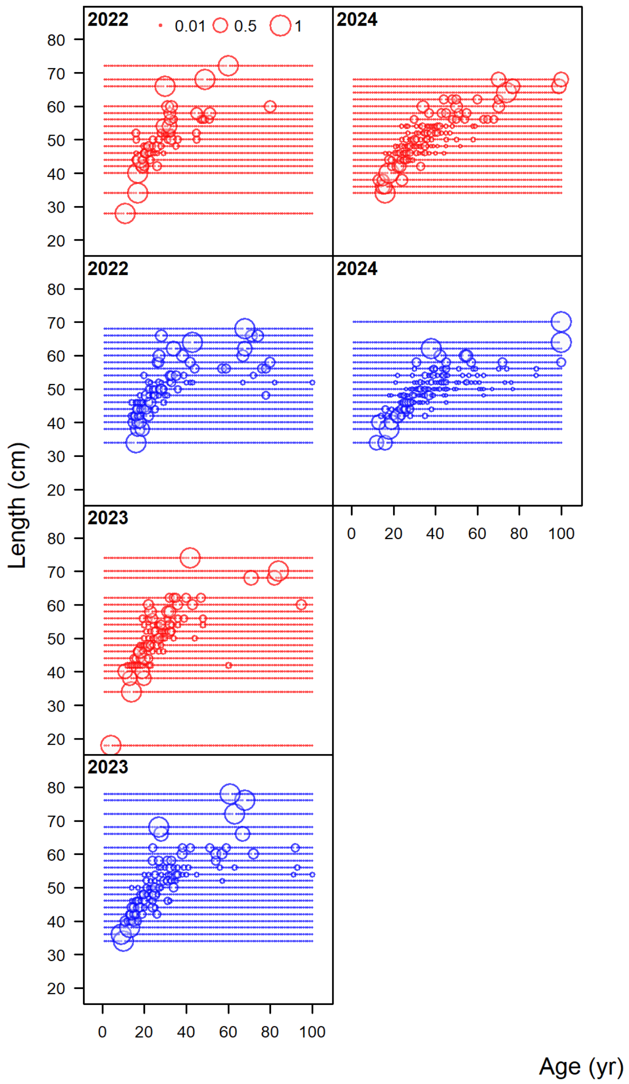

Figure 90: Pearson residuals of conditional age at length fits for the bottom trawl fishery in the years 2022-2024. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

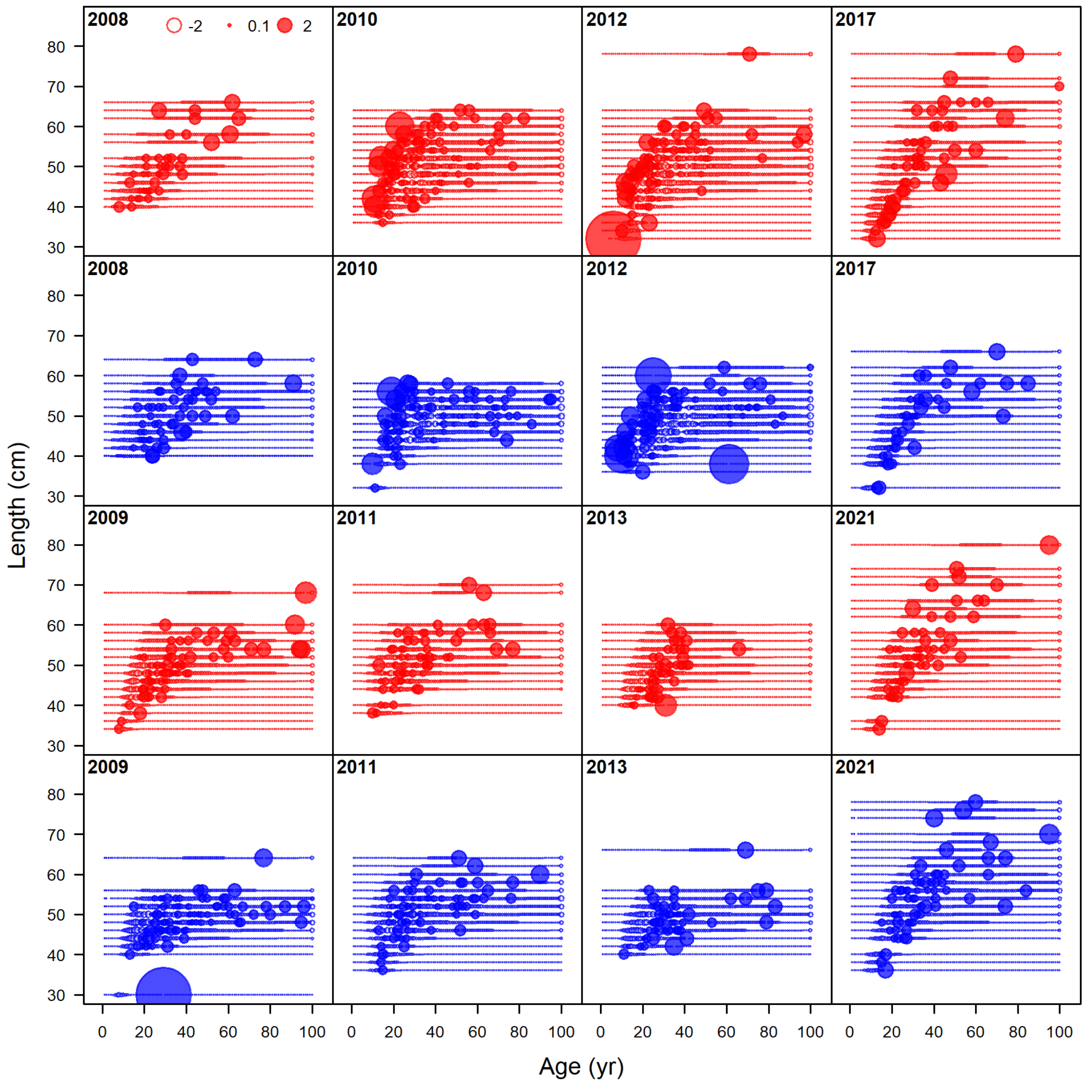

Figure 91: Pearson residuals of conditional age at length fits for the non-trawl fishery in the years 2008-2021. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

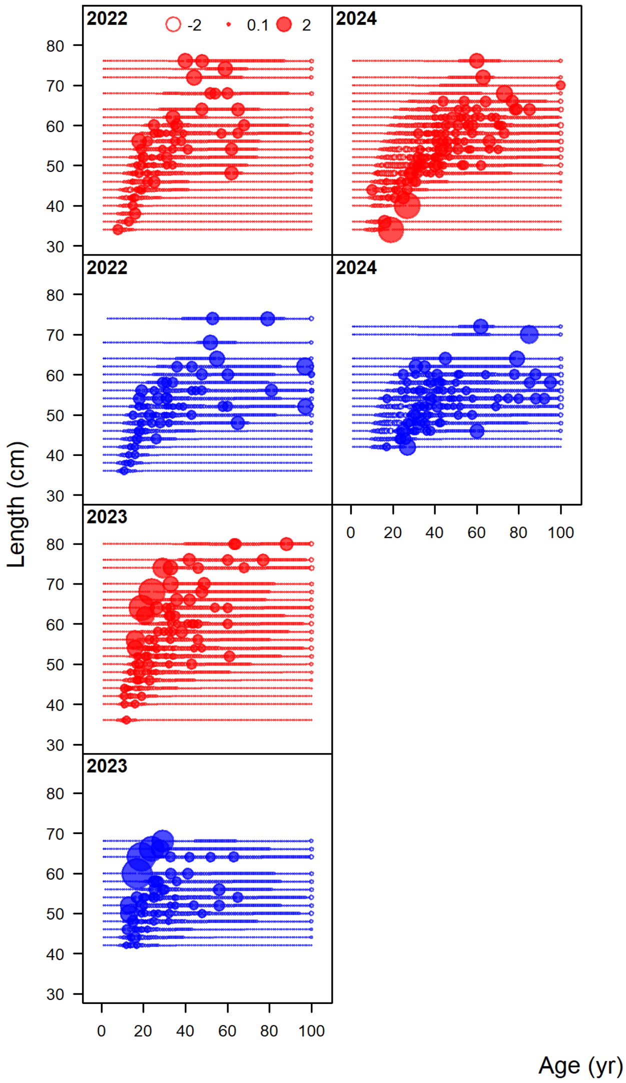

Figure 92: Pearson residuals of conditional age at length fits for the non-trawl fishery in the years 2022-2024. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

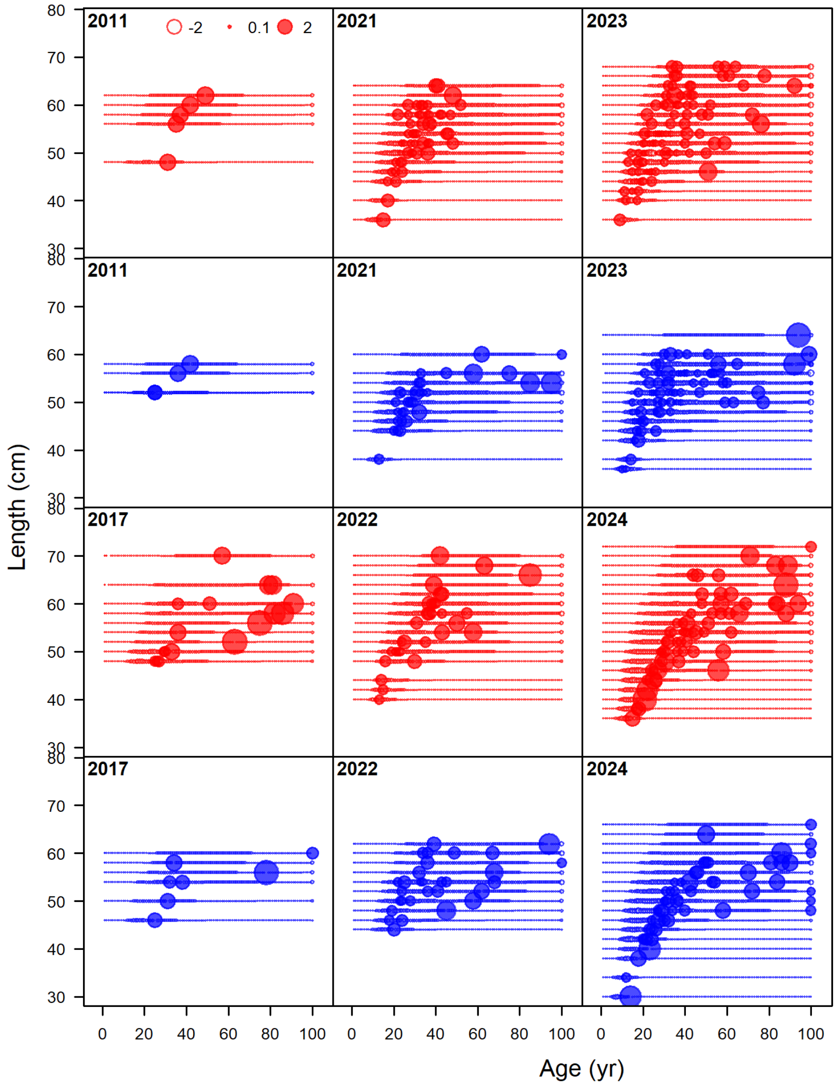

Figure 93: Pearson residuals of conditional age at length fits for the midwater trawl fishery. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

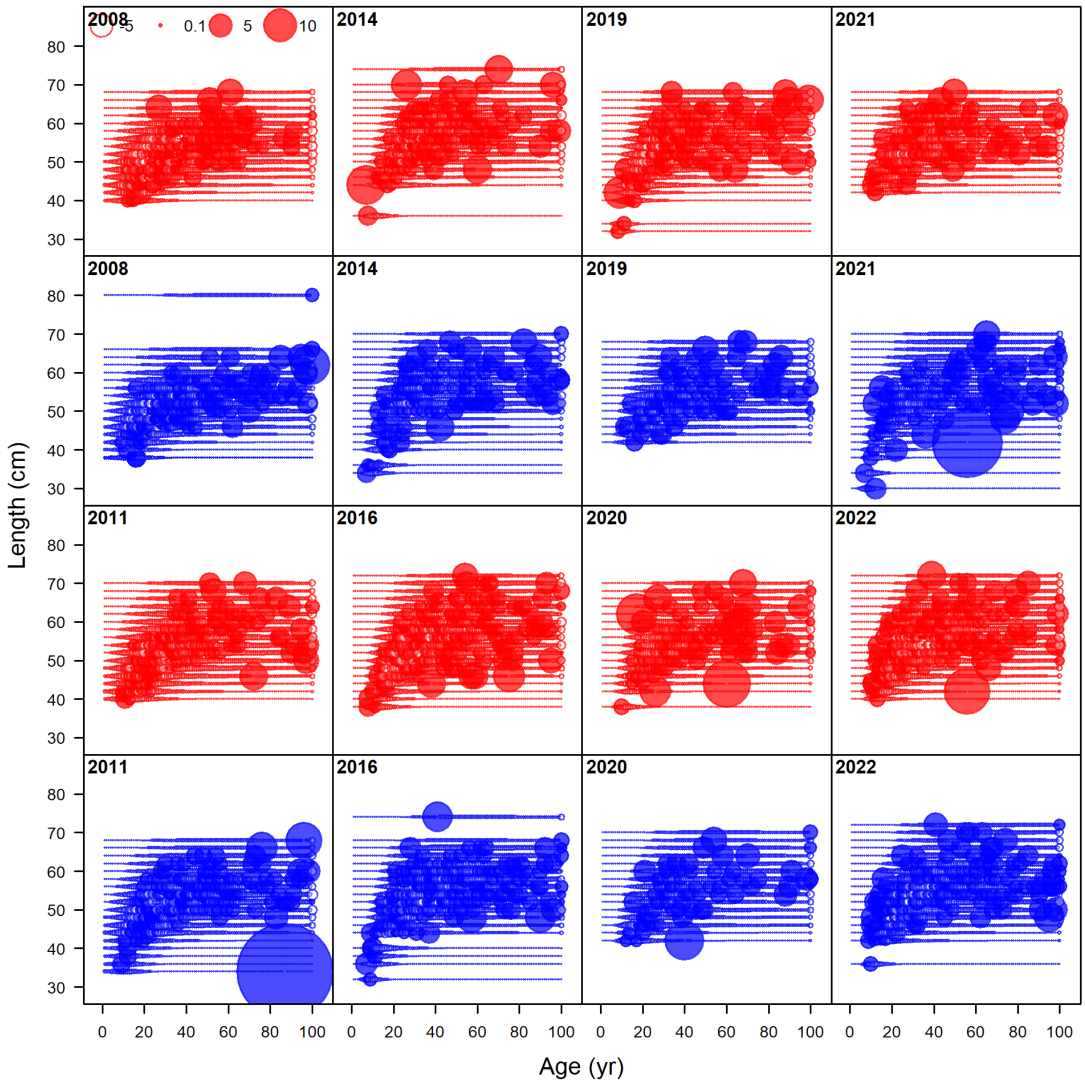

Figure 94: Pearson residuals of conditional age at length fits for the at-sea-hake fishery in the years 2008-2022. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

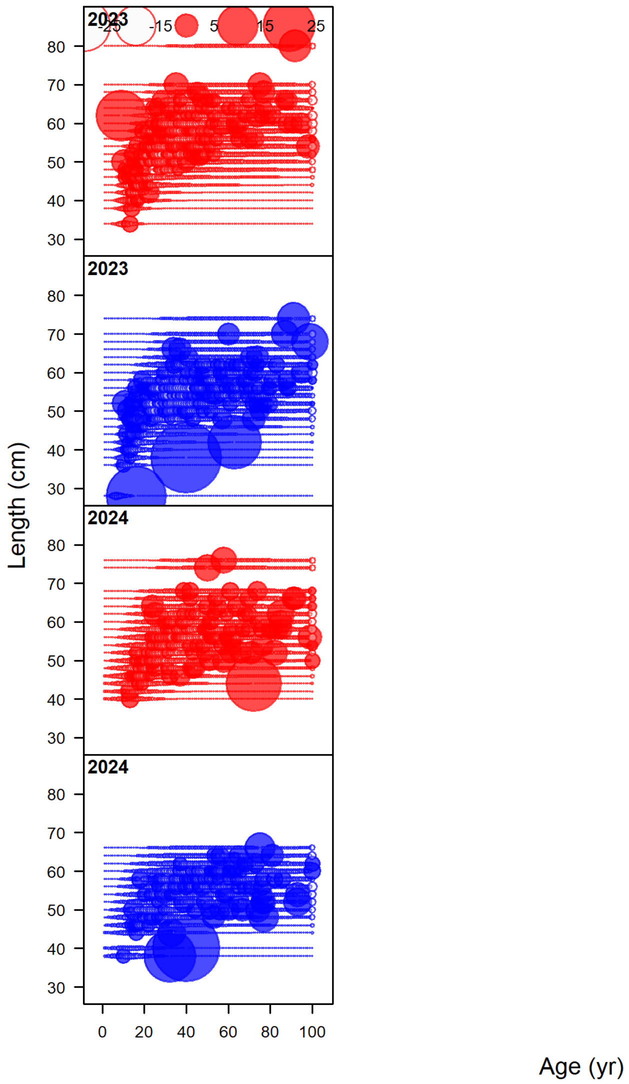

Figure 95: Pearson residuals of conditional age at length fits for the at-sea-hake fishery in the years 2023-2024. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

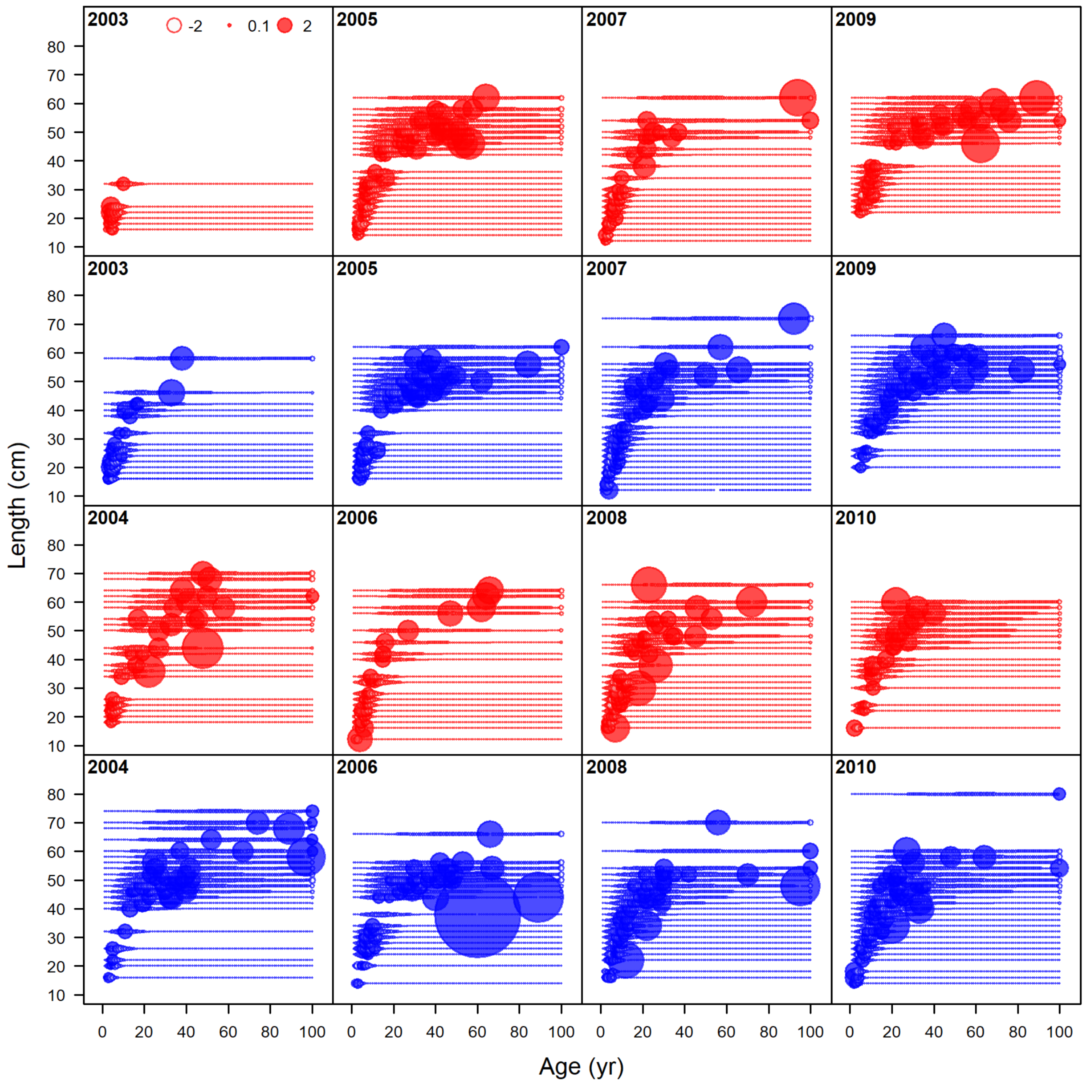

Figure 96: Pearson residuals of conditional age at length fits for the West Coast Groundfish Bottom Trawl survey in the years 2003-2010. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

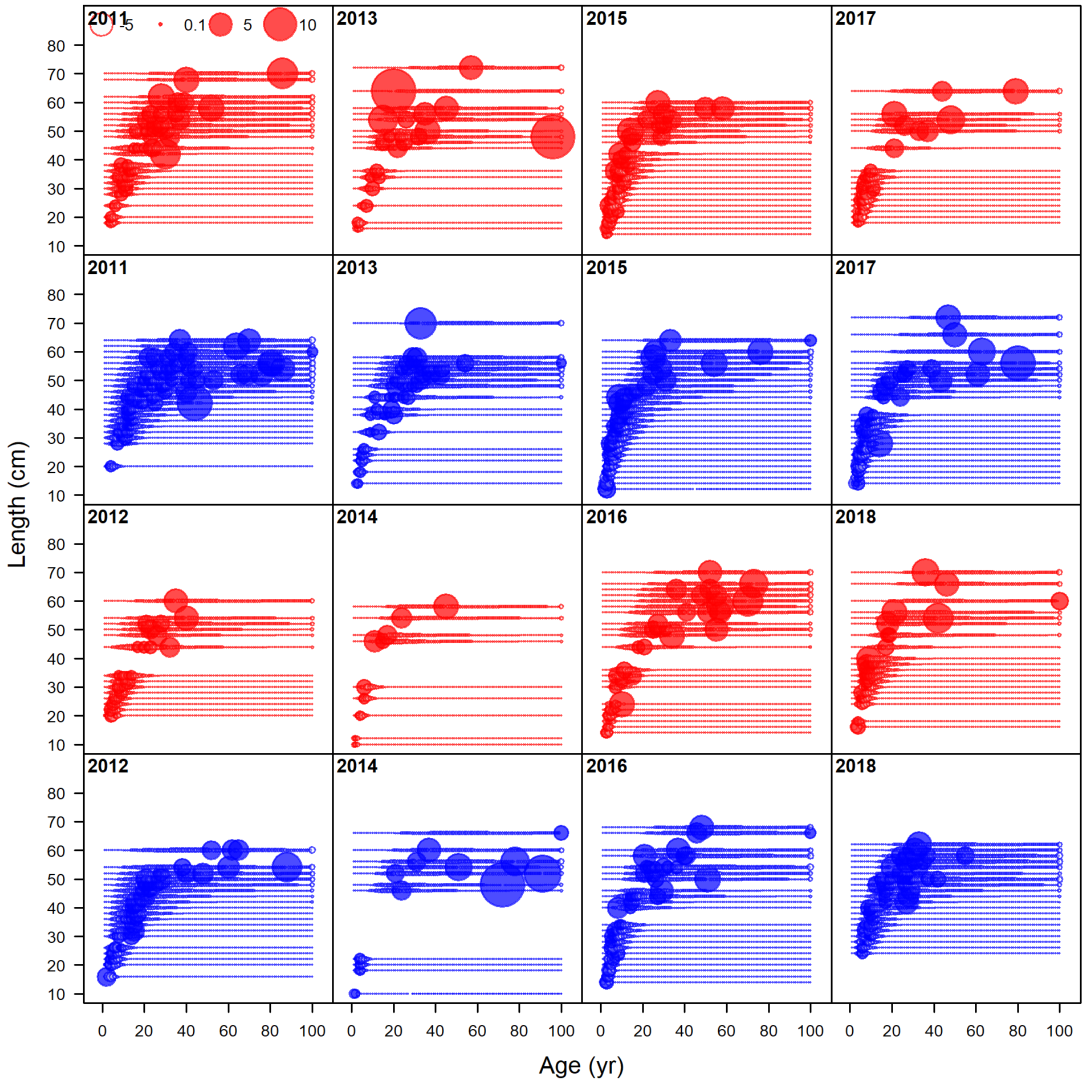

Figure 97: Pearson residuals of conditional age at length fits for the West Coast Groundfish Bottom Trawl survey in the years 2011-2018. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

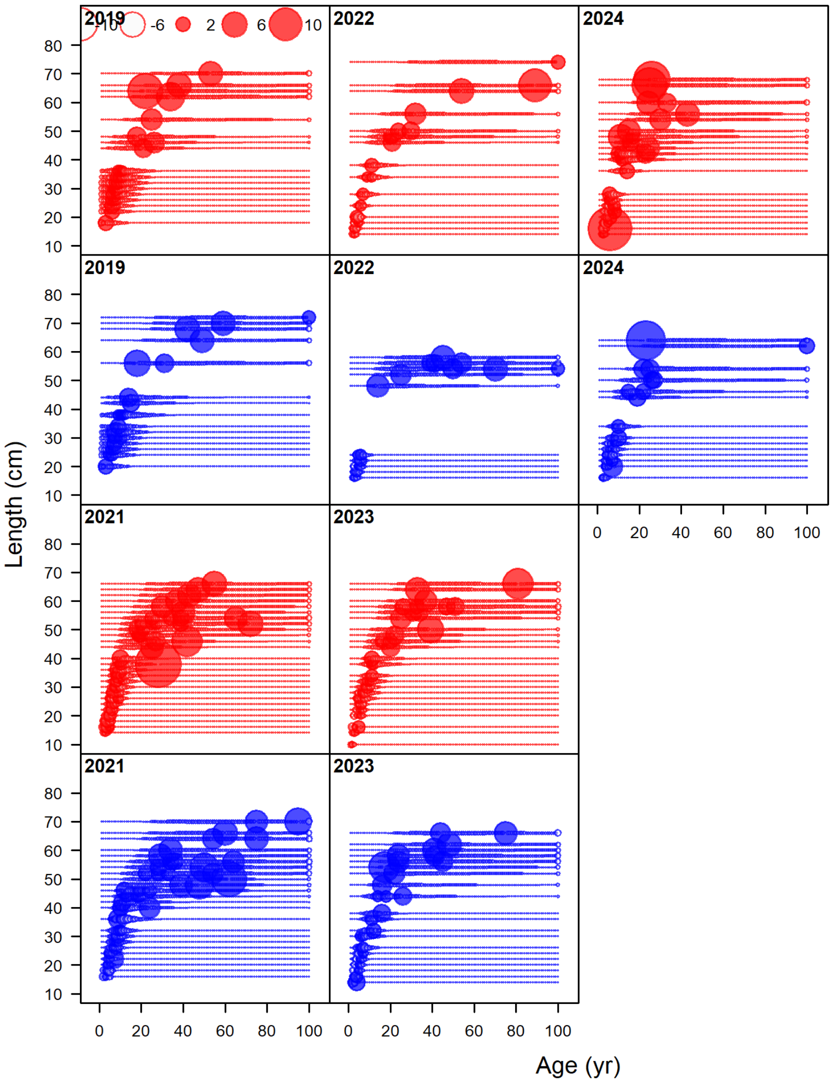

Figure 98: Pearson residuals of conditional age at length fits for the West Coast Groundfish Bottom Trawl survey in the years 2019-2024. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

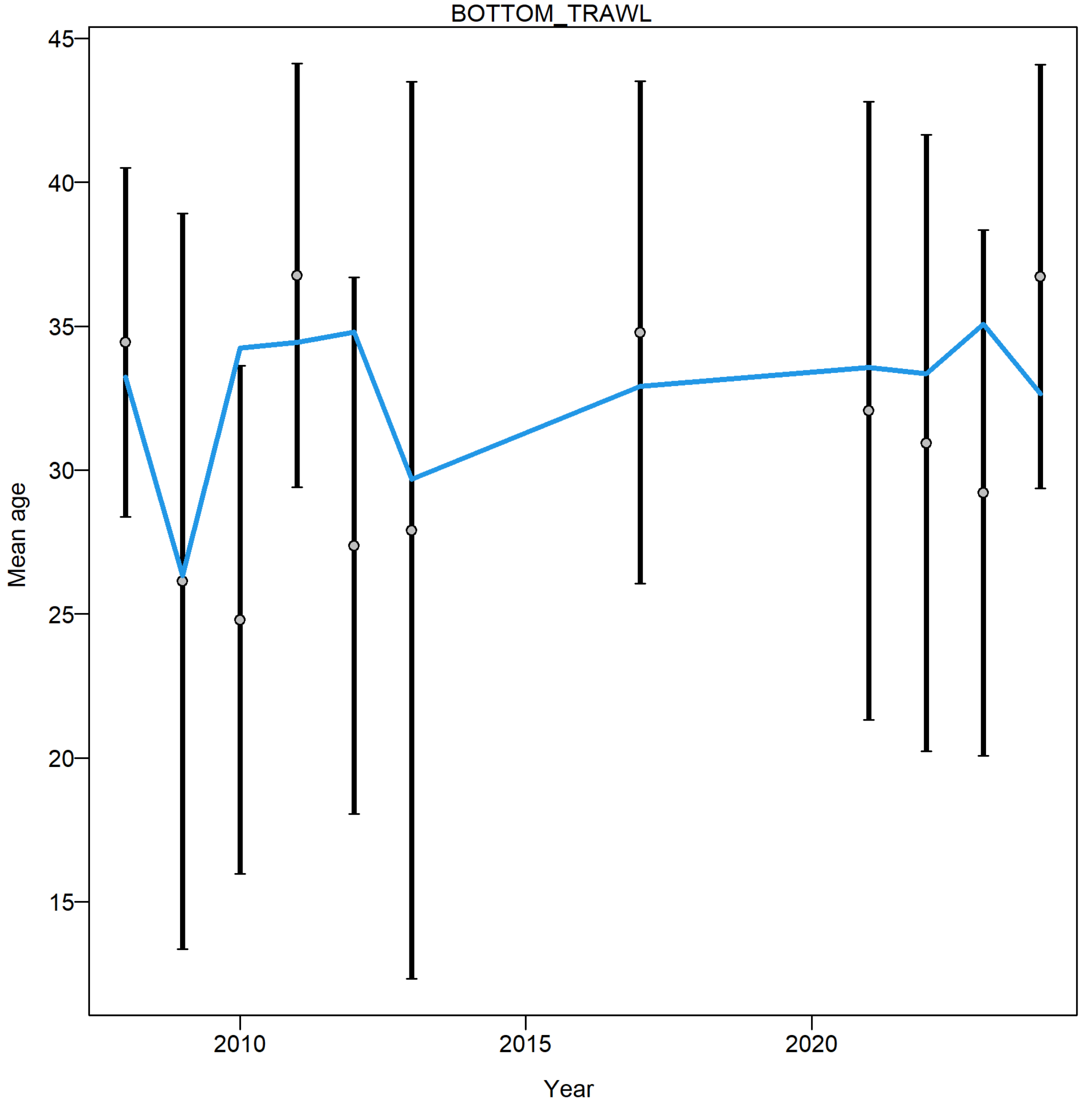

Figure 99: Mean age from conditional age-at-length data for the trawl fishery with 95% confidence intervals based on current samples sizes and data weighting.

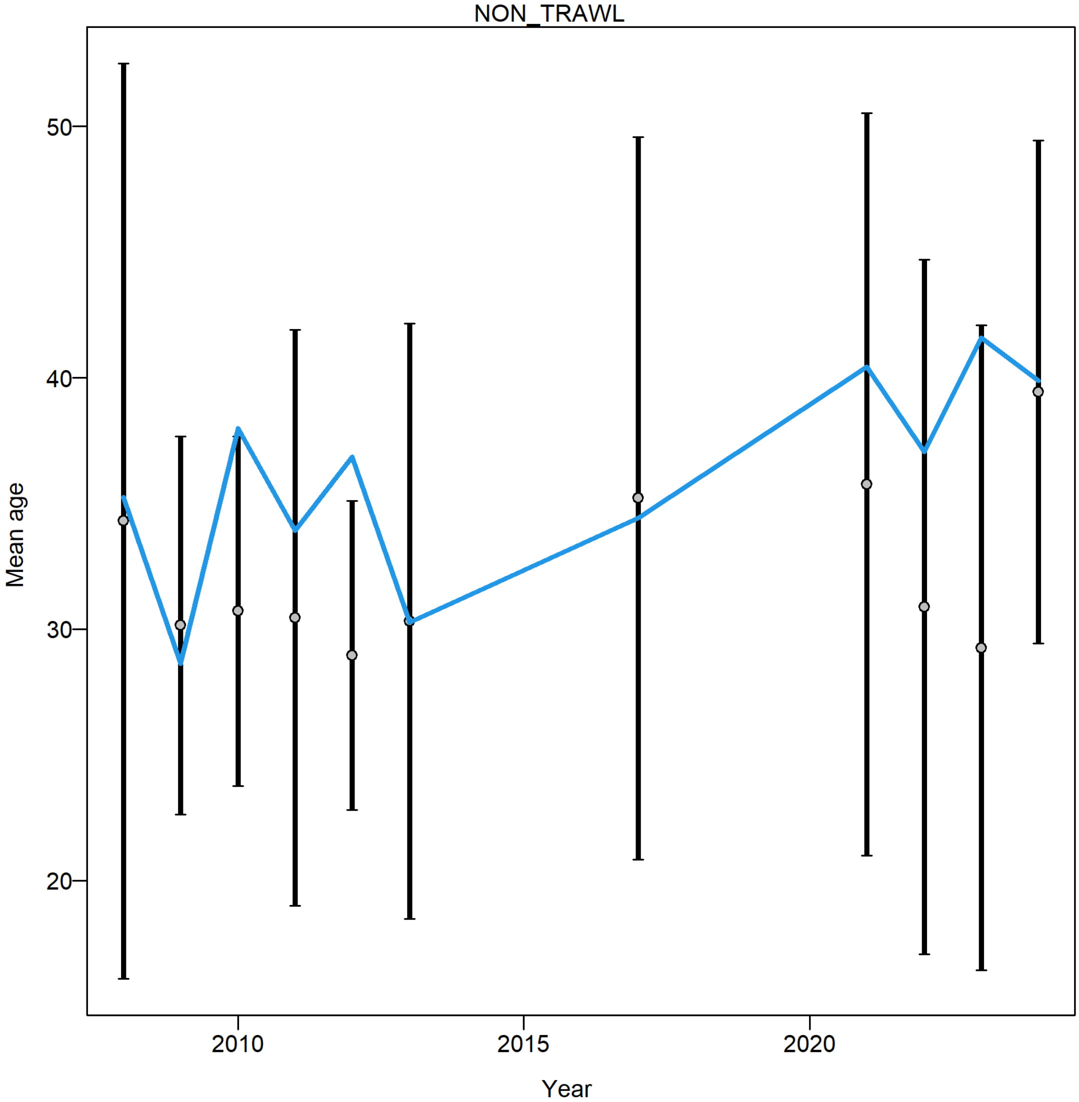

Figure 100: Mean age from conditional age-at-length data for the non-trawl fishery with 95% confidence intervals based on current samples sizes and data weighting.

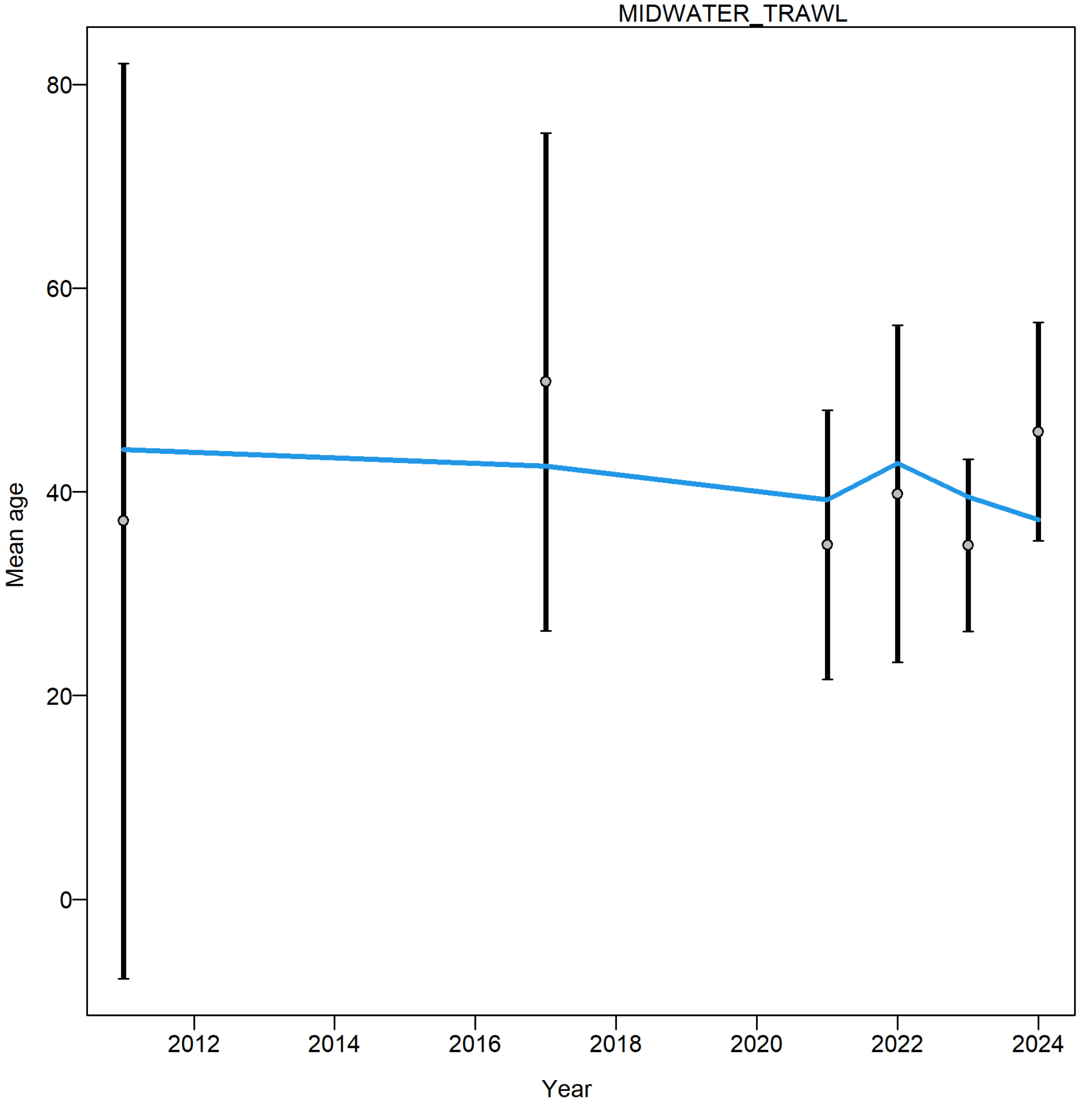

Figure 101: Mean age from conditional age-at-length data for the midwater trawl fishery with 95% confidence intervals based on current samples sizes and data weighting.

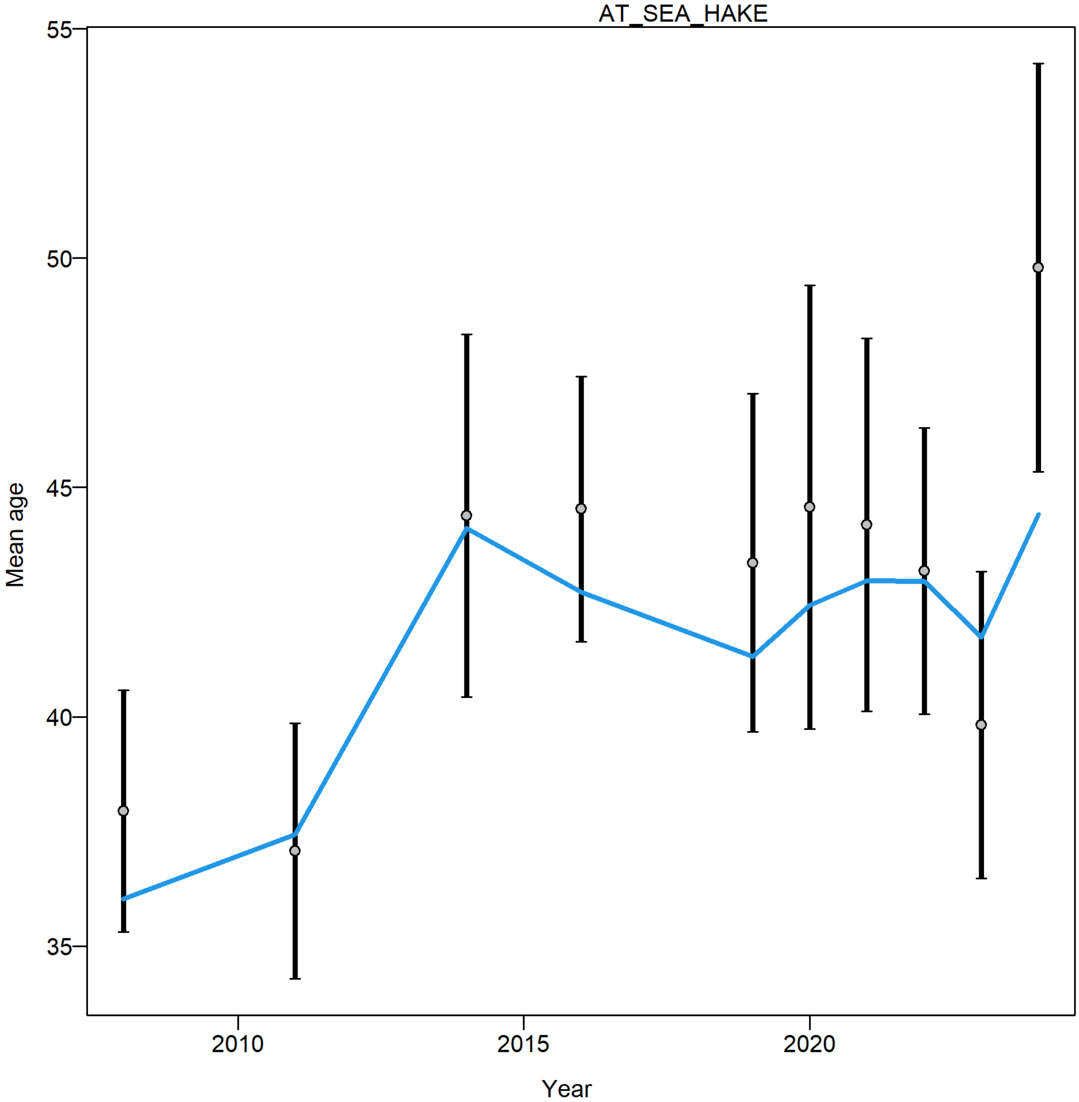

Figure 102: Mean age from conditional age-at-length data for the at-sea-hake fishery with 95% confidence intervals based on current samples sizes and data weighting.

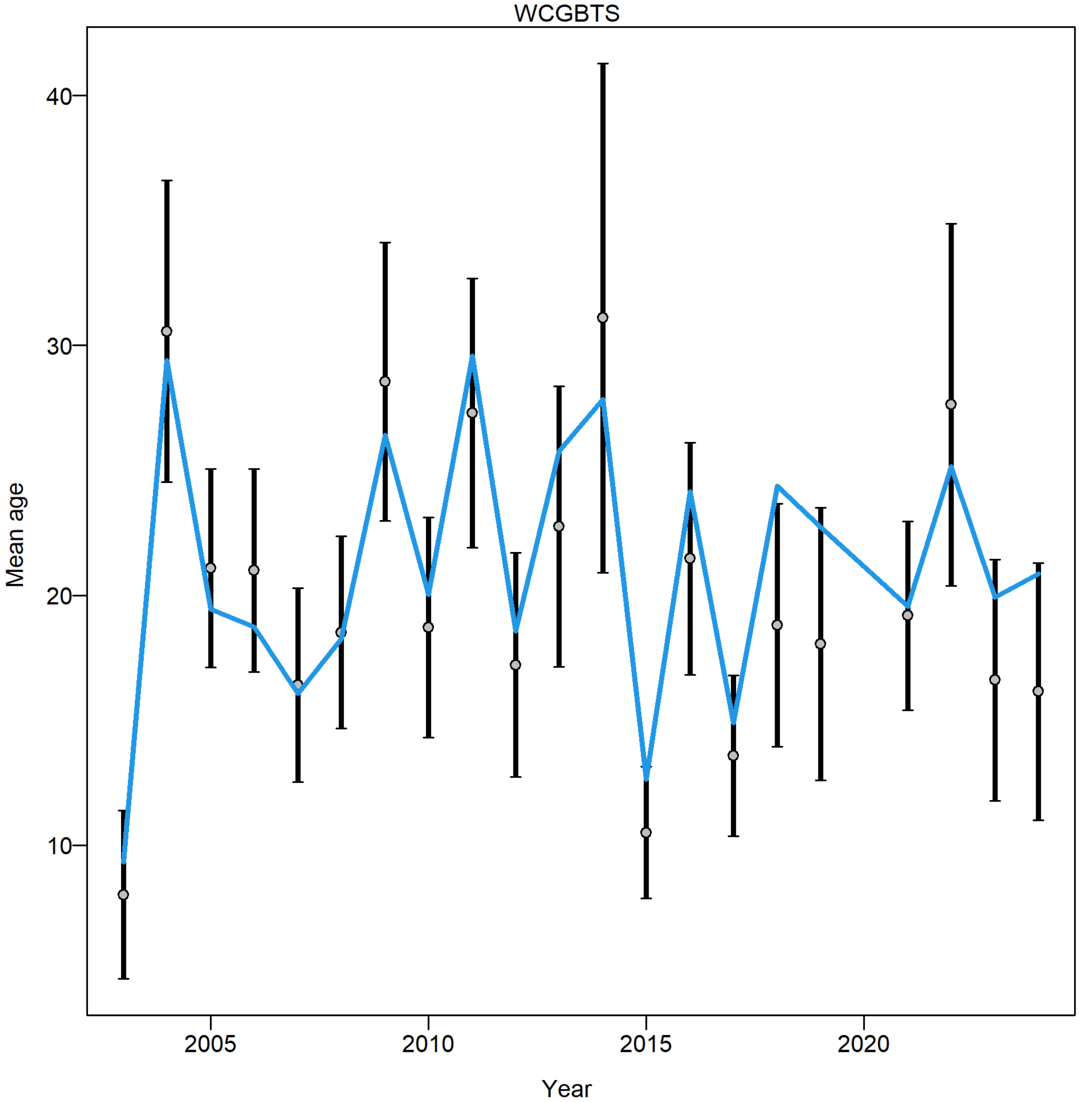

Figure 103: Mean age from conditional age-at-length data for the West Coast Groundfish Bottom Trawl survey with 95% confidence intervals based on current samples sizes and data weighting.

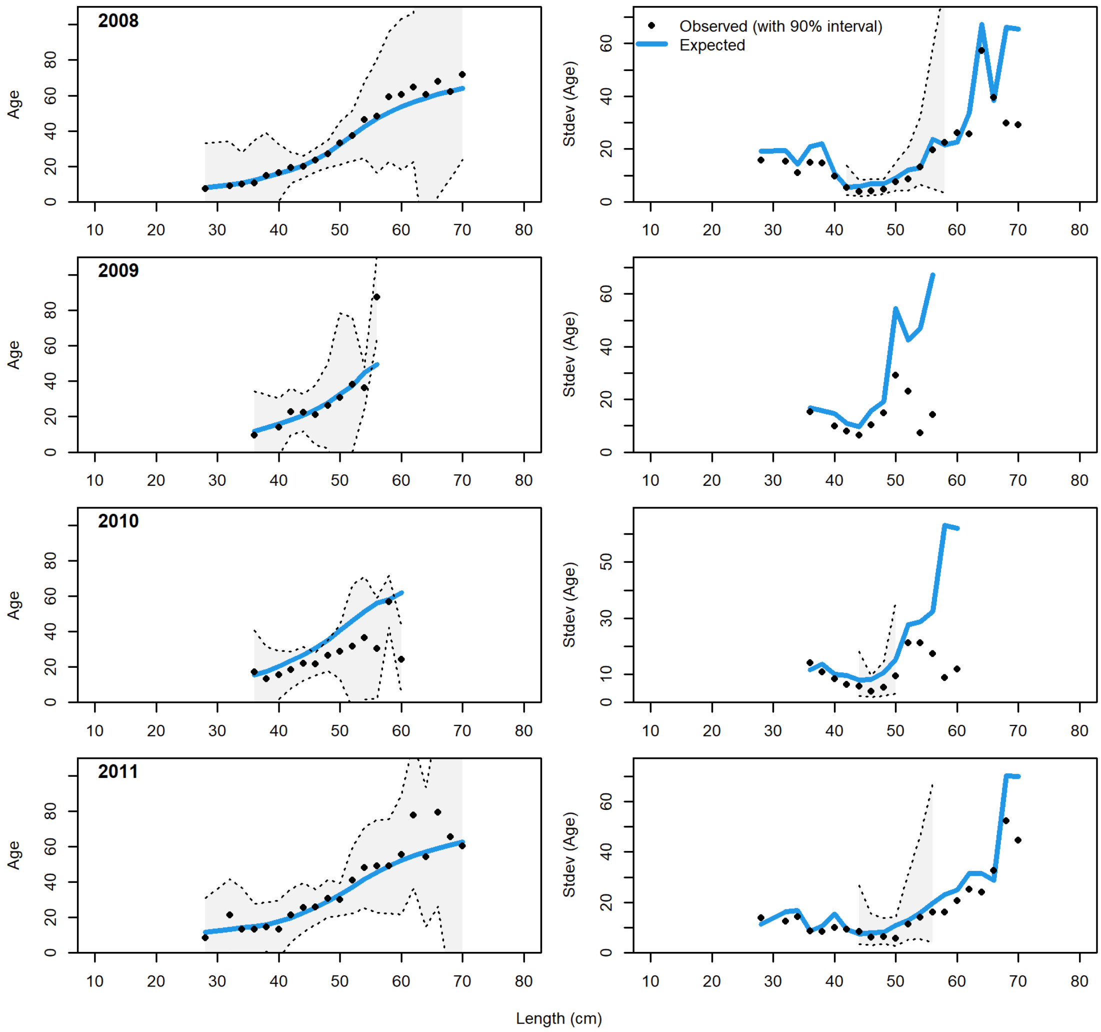

Figure 104: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the bottom trawl fishery in years 2008-2011. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

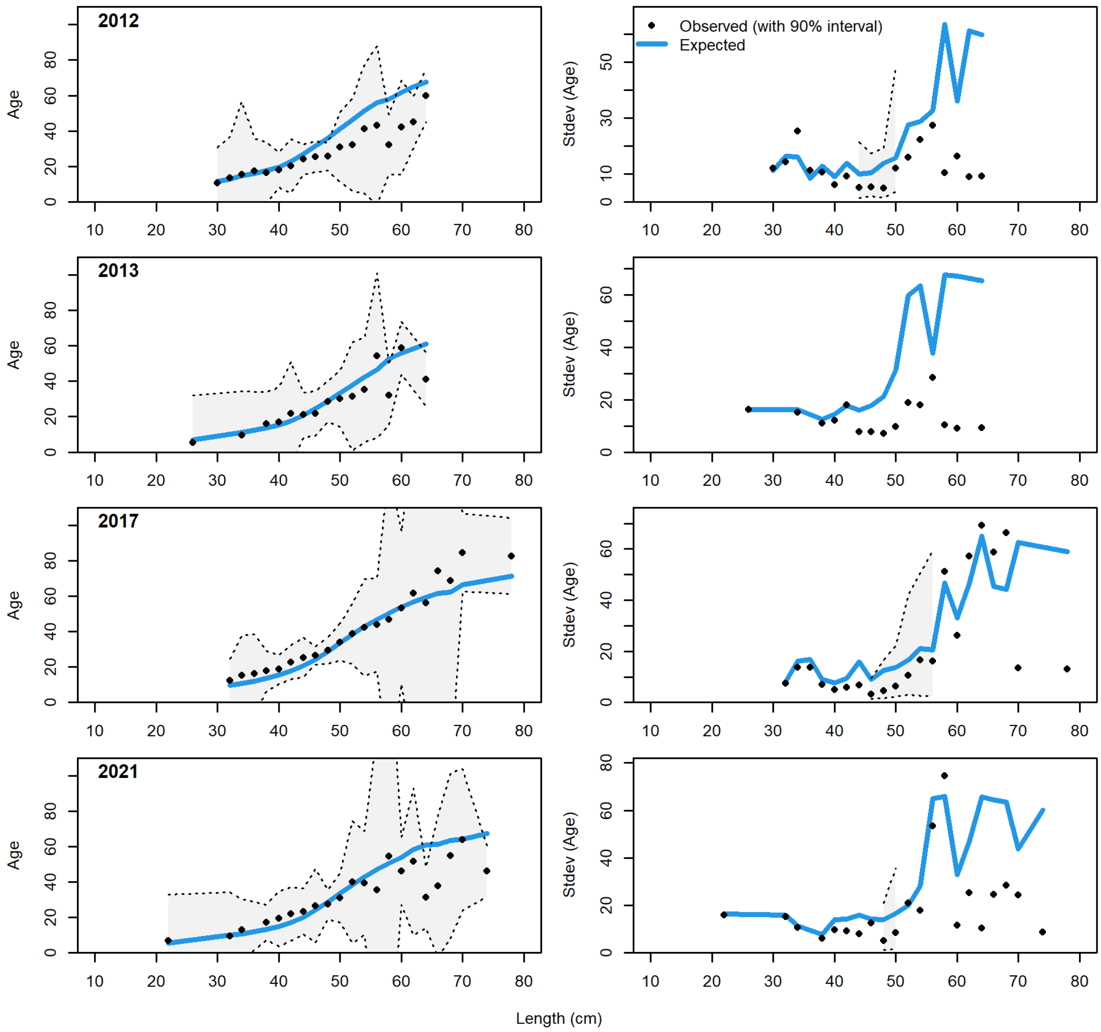

Figure 105: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the bottom trawl fishery in years 2012-2021. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

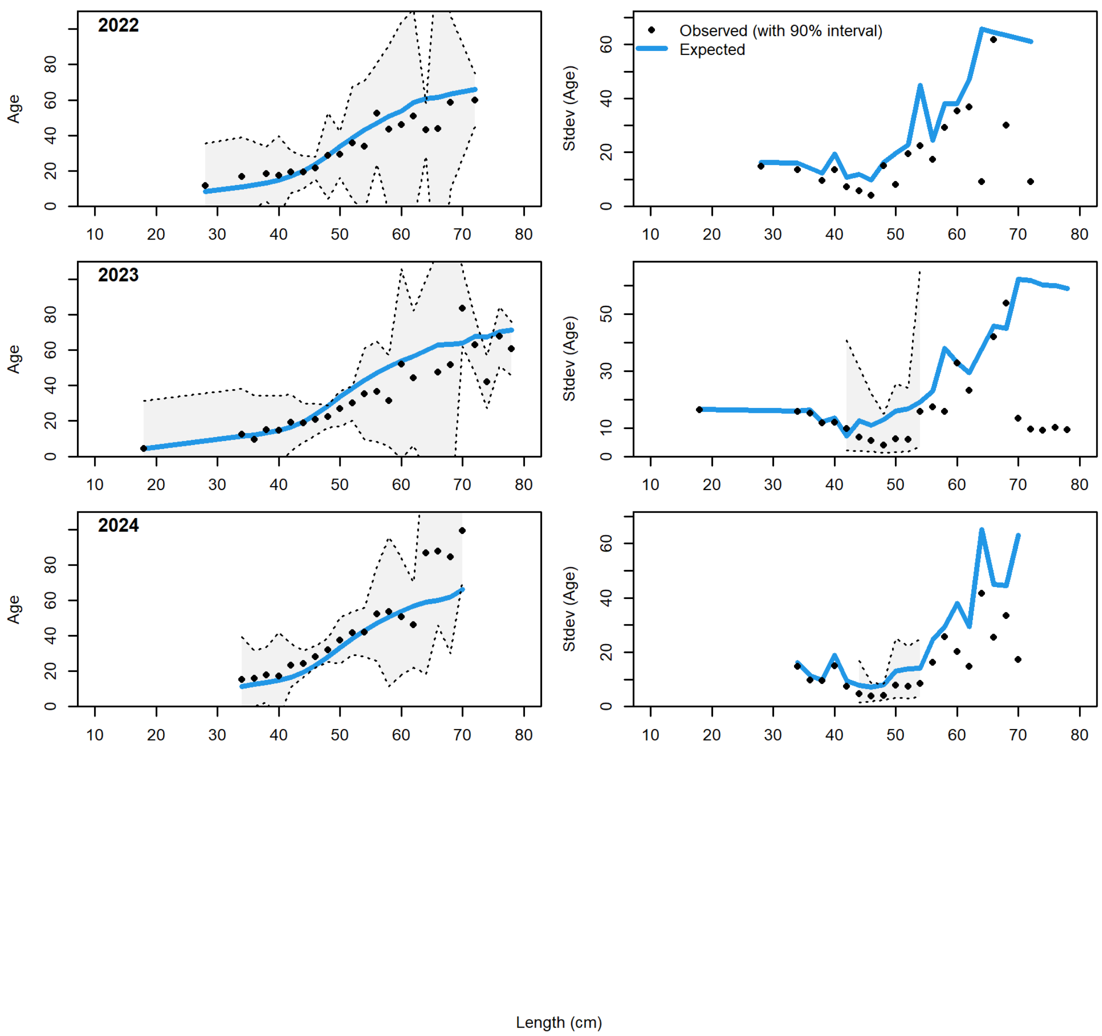

Figure 106: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the bottom trawl fishery in years 2022-2024. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

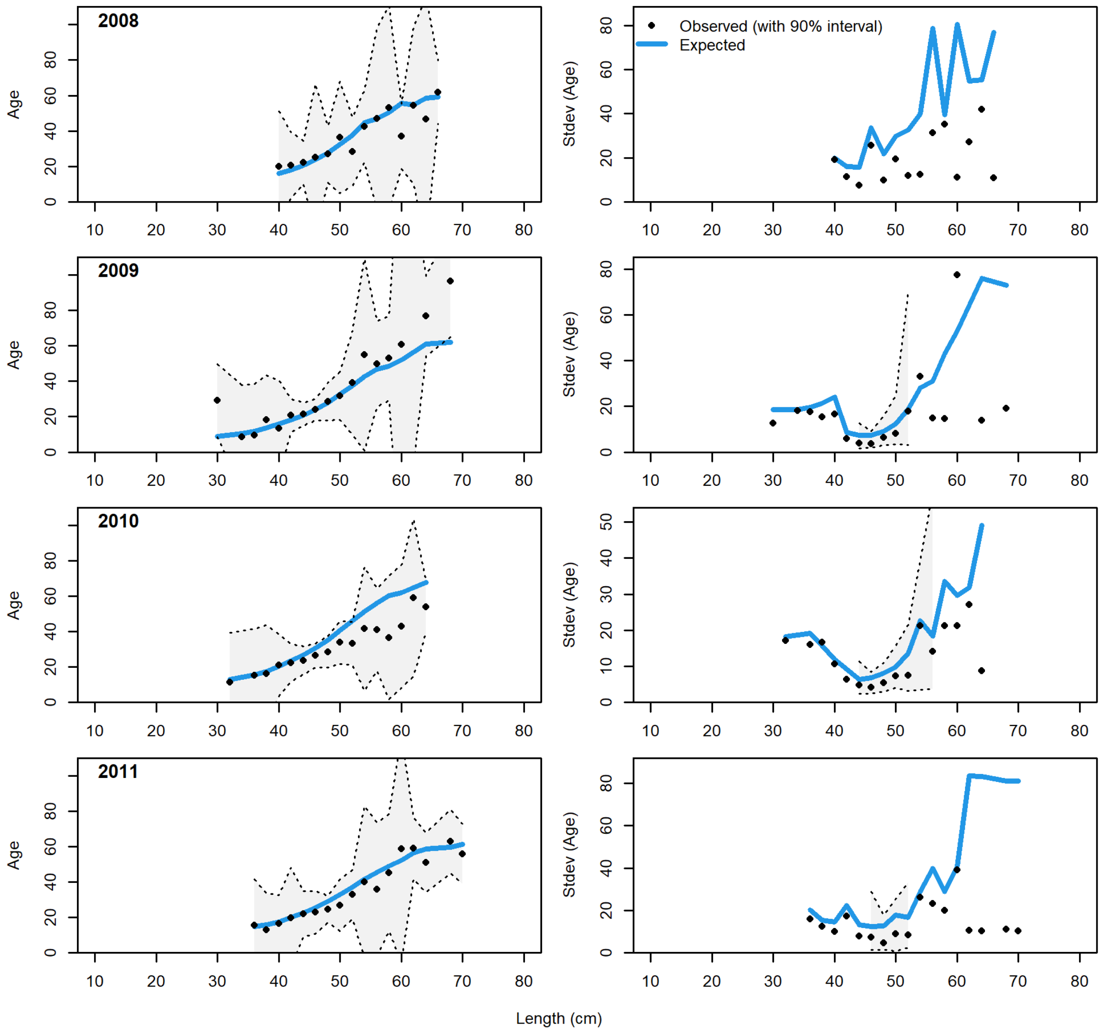

Figure 107: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the non-trawl fishery in years 2008-2011. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

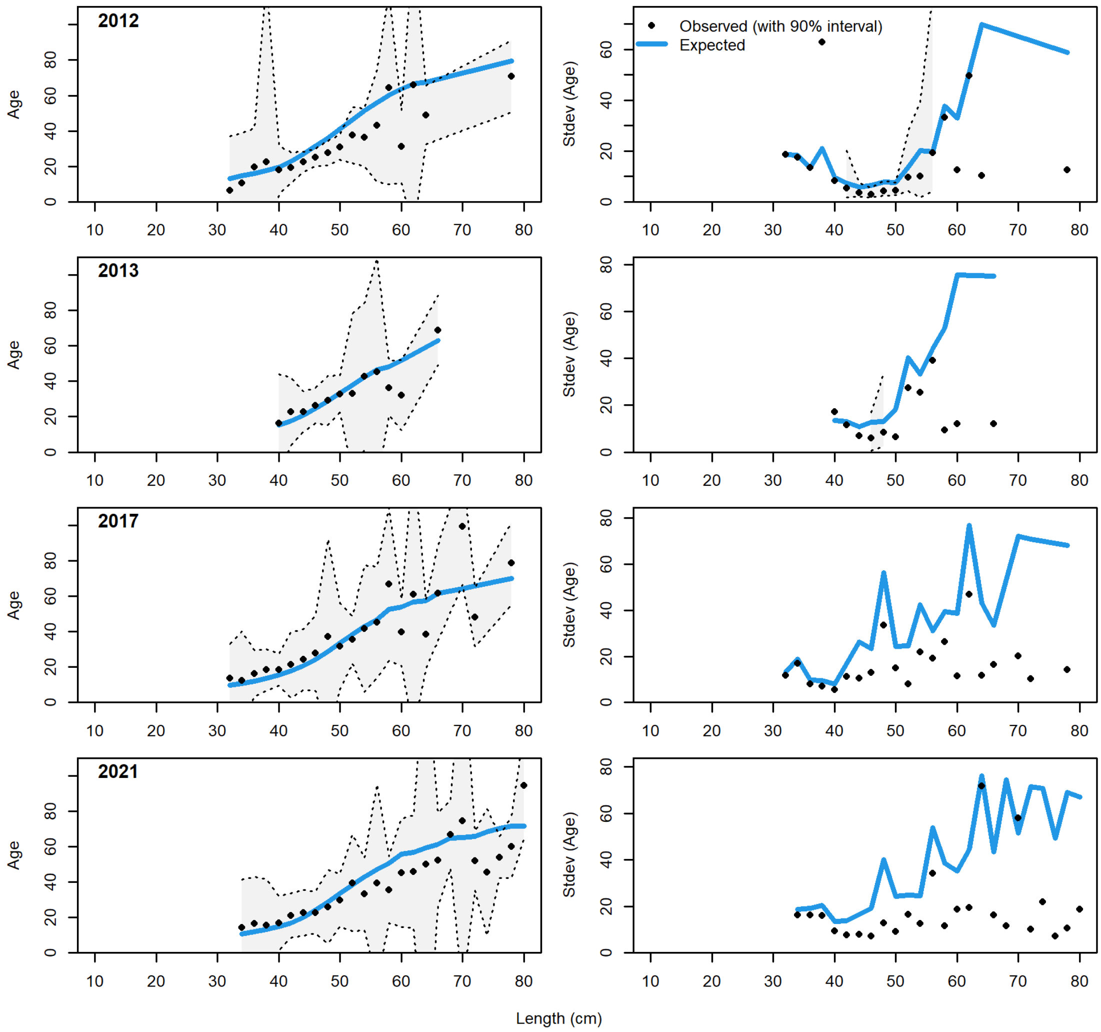

Figure 108: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the non-trawl fishery in years 2012-2021. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

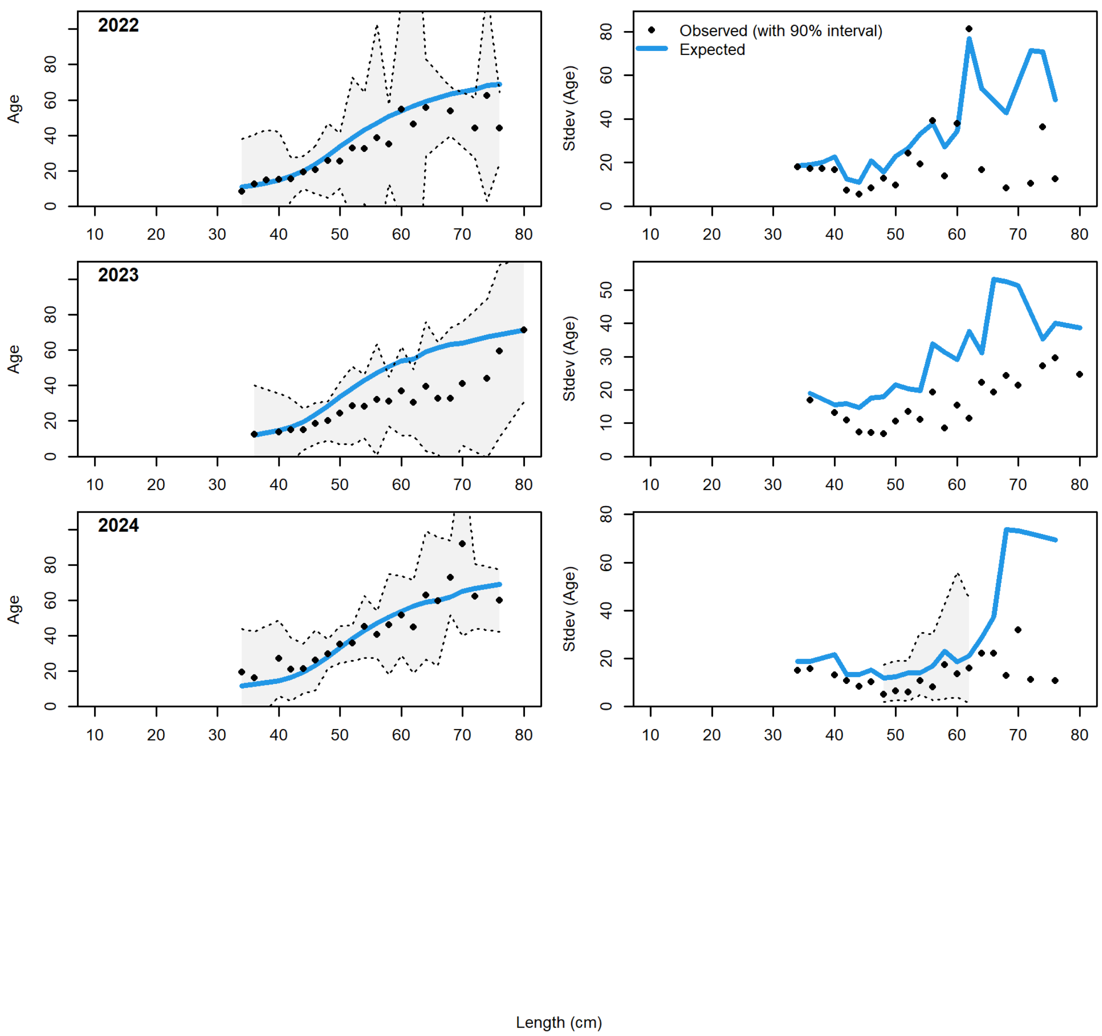

Figure 109: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the non-trawl fishery in years 2022-2024. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

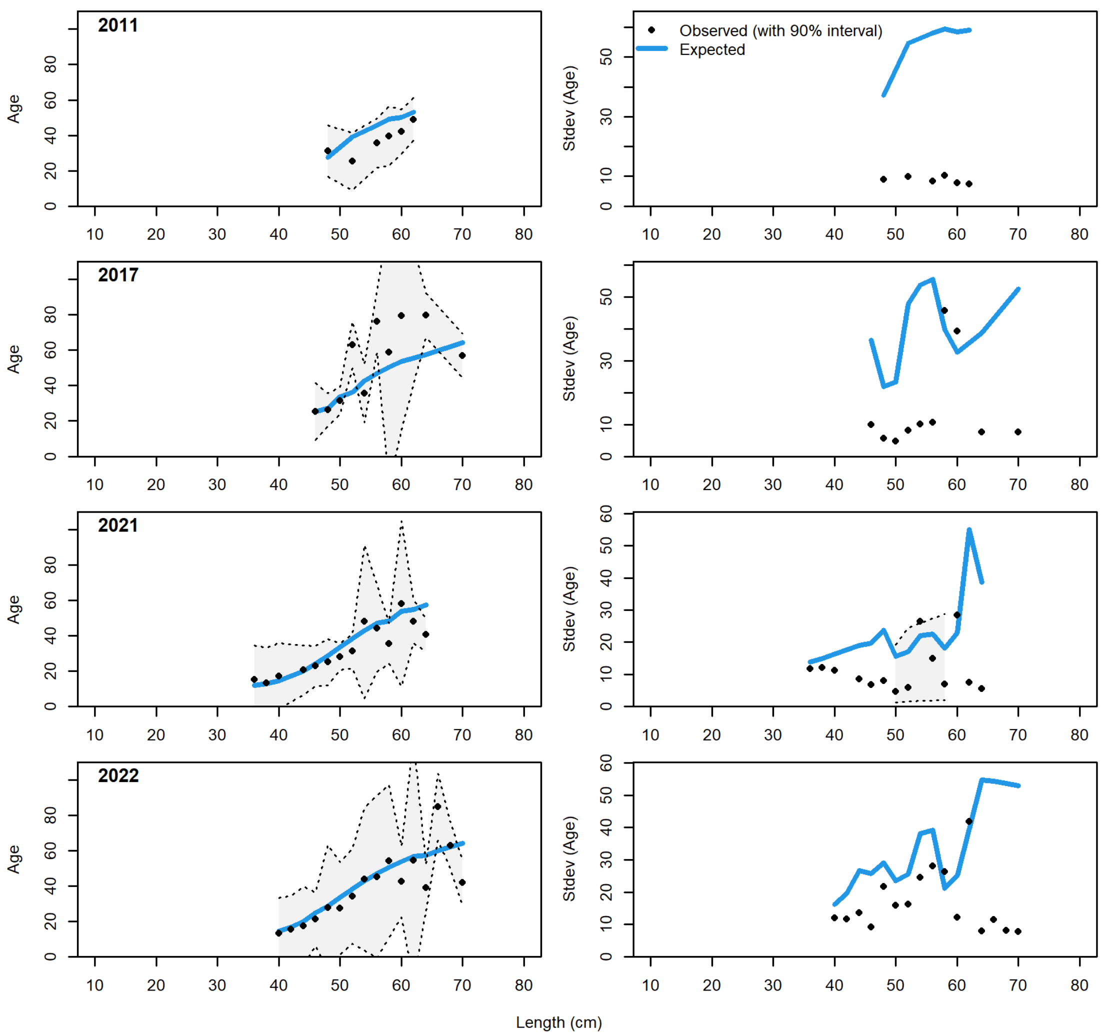

Figure 110: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the midwater trawl fishery in years 2011-2022. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

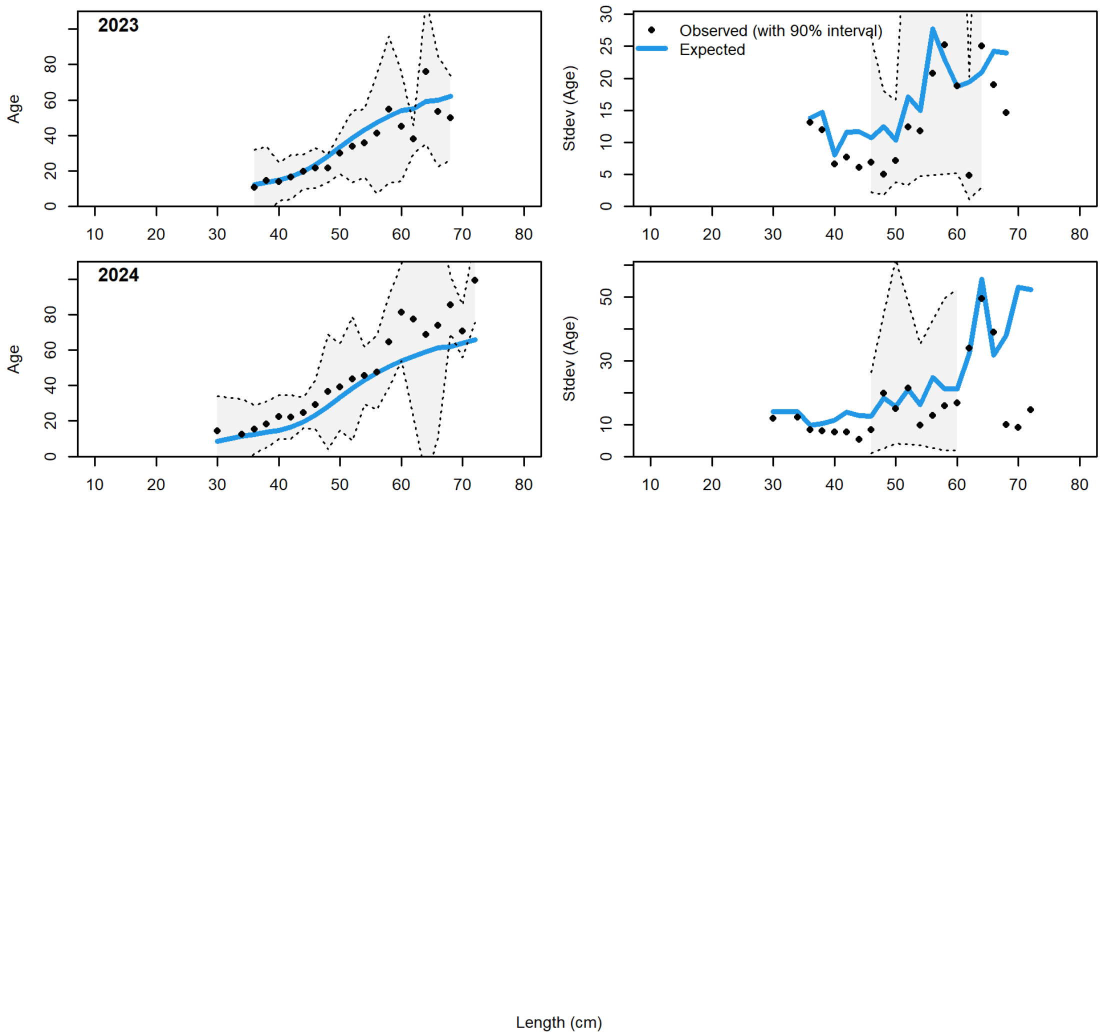

Figure 111: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the non-trawl fishery in years 2023-2024. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

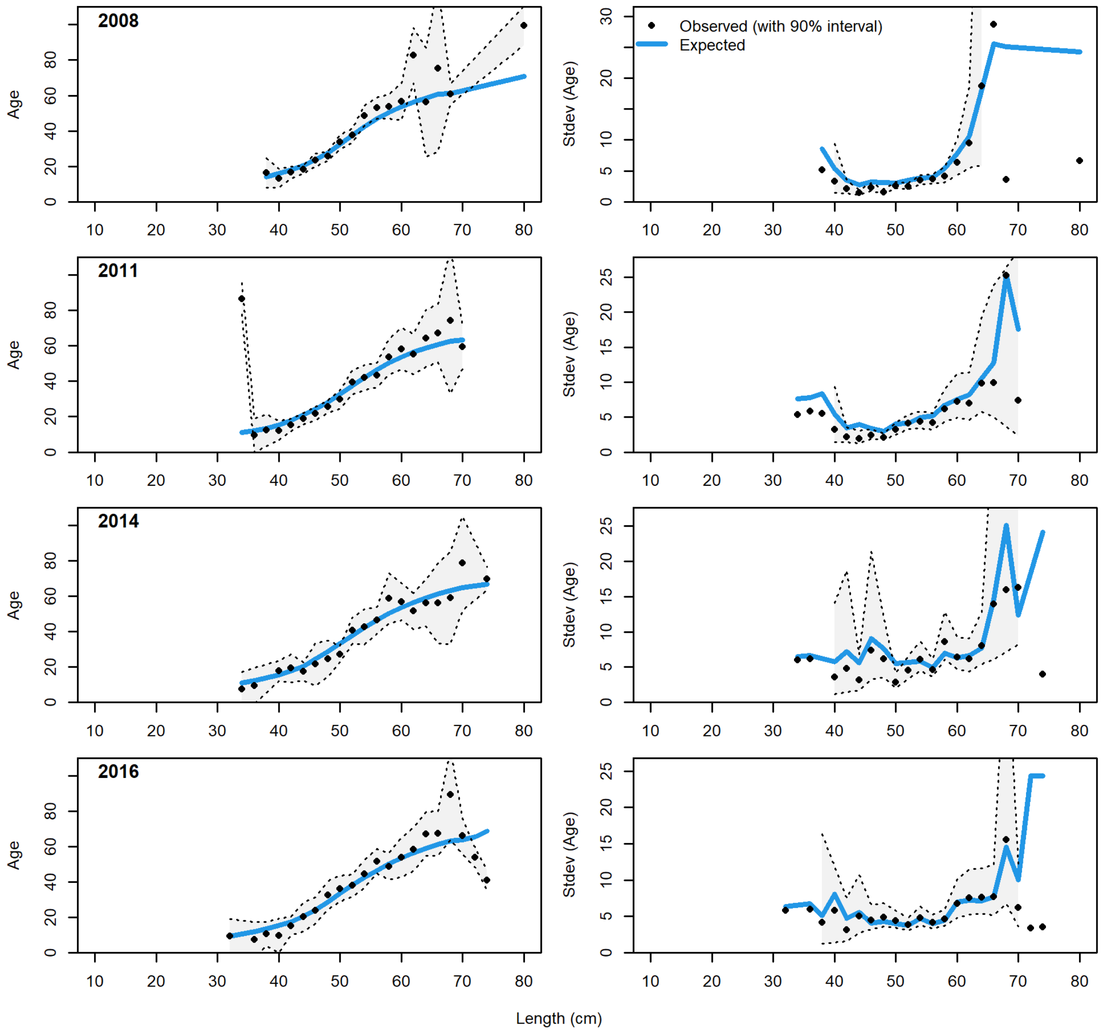

Figure 112: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the at-sea-hake fishery in years 2008-2016. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

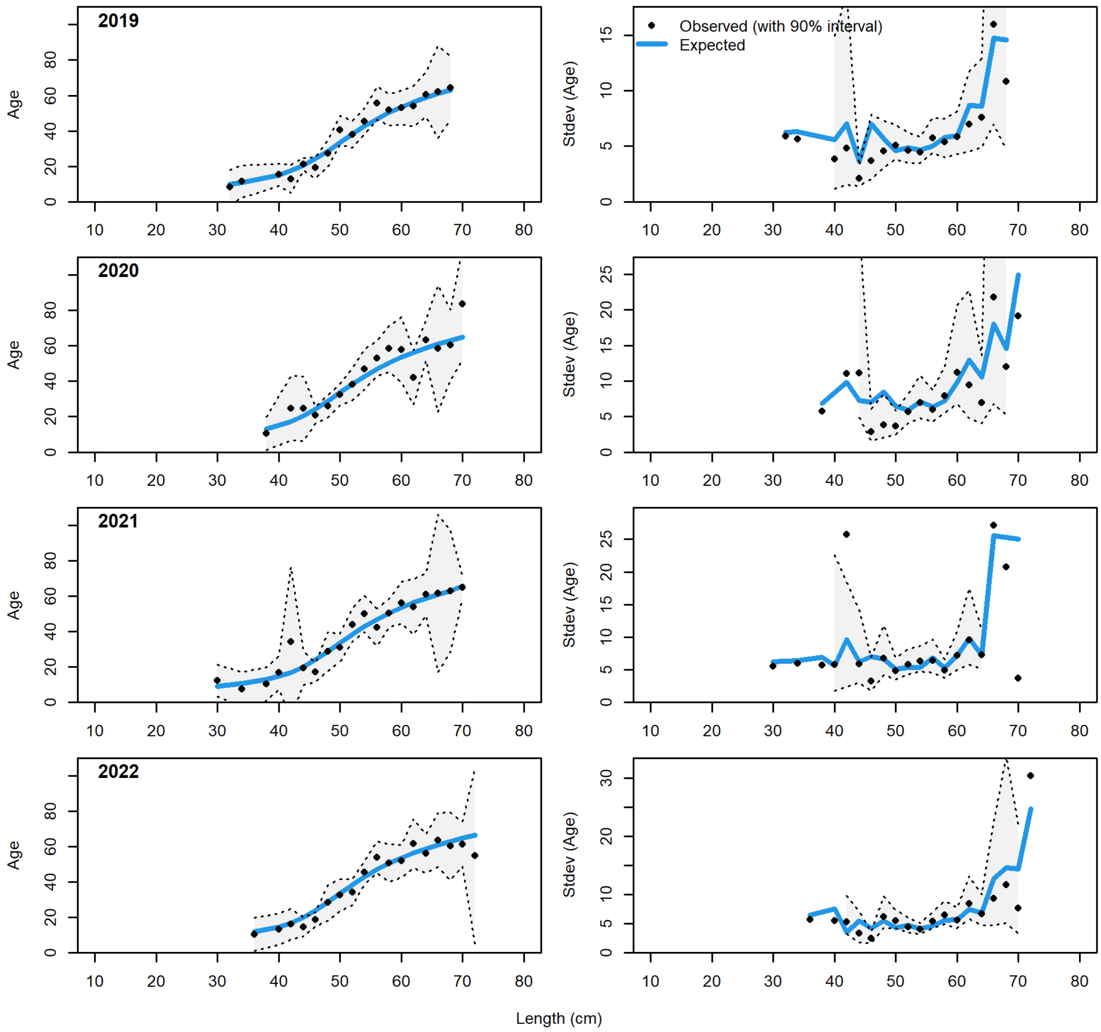

Figure 113: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the at-sea-hake fishery in years 2019-2022. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

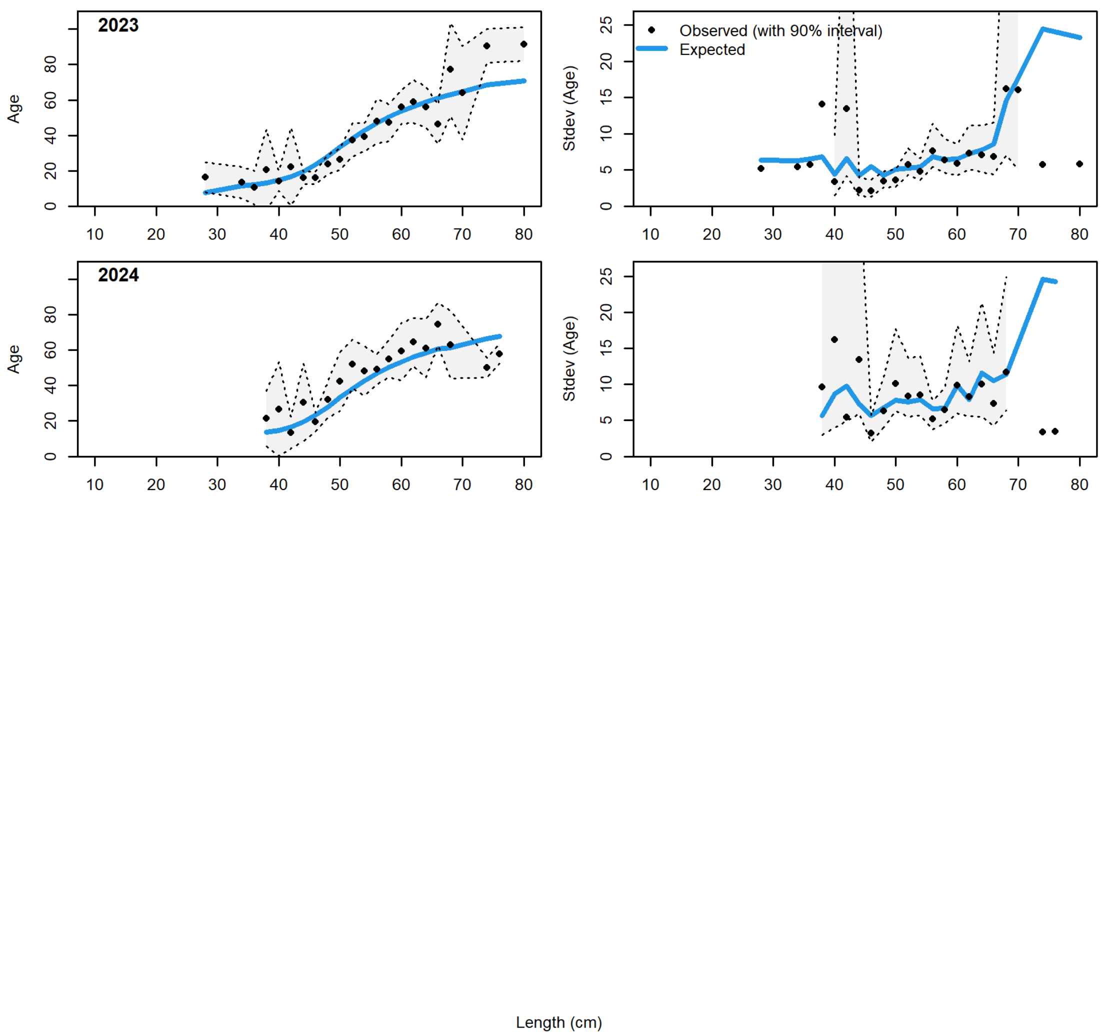

Figure 114: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the at-sea-hake fishery in years 2023-2024. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

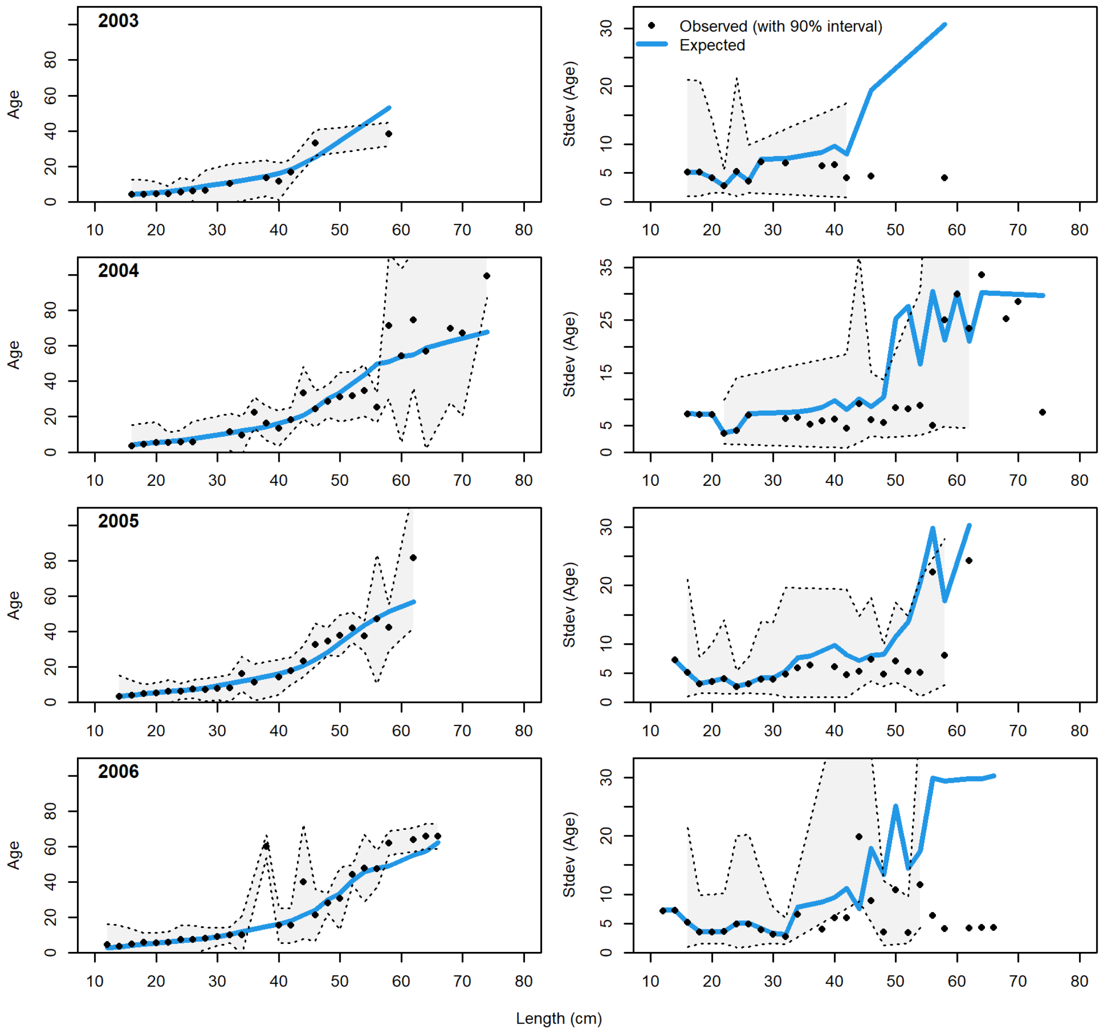

Figure 115: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the West Coast Groundfish Bottom Trawl survey in years 2003-2006. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

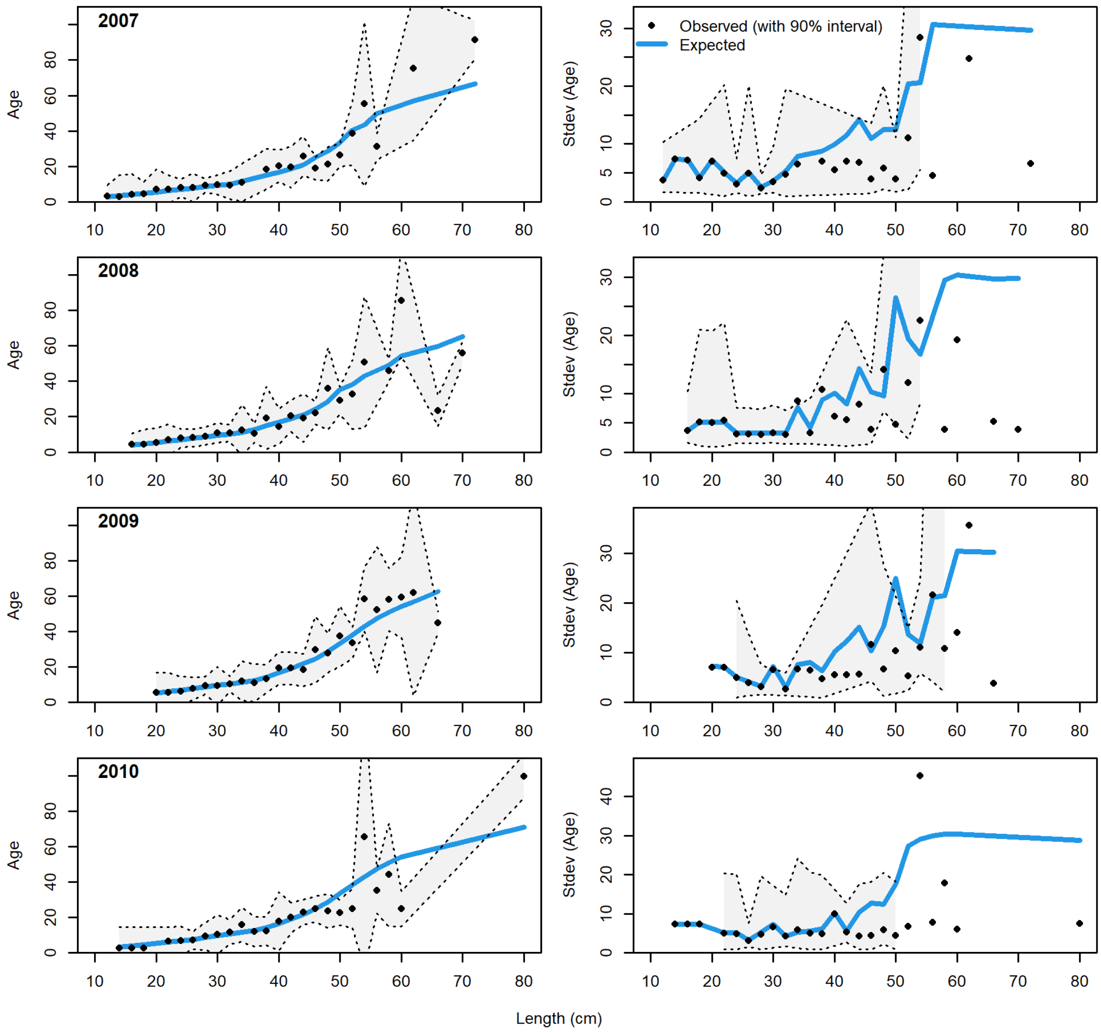

Figure 116: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the West Coast Groundfish Bottom Trawl survey in years 2007-2010. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

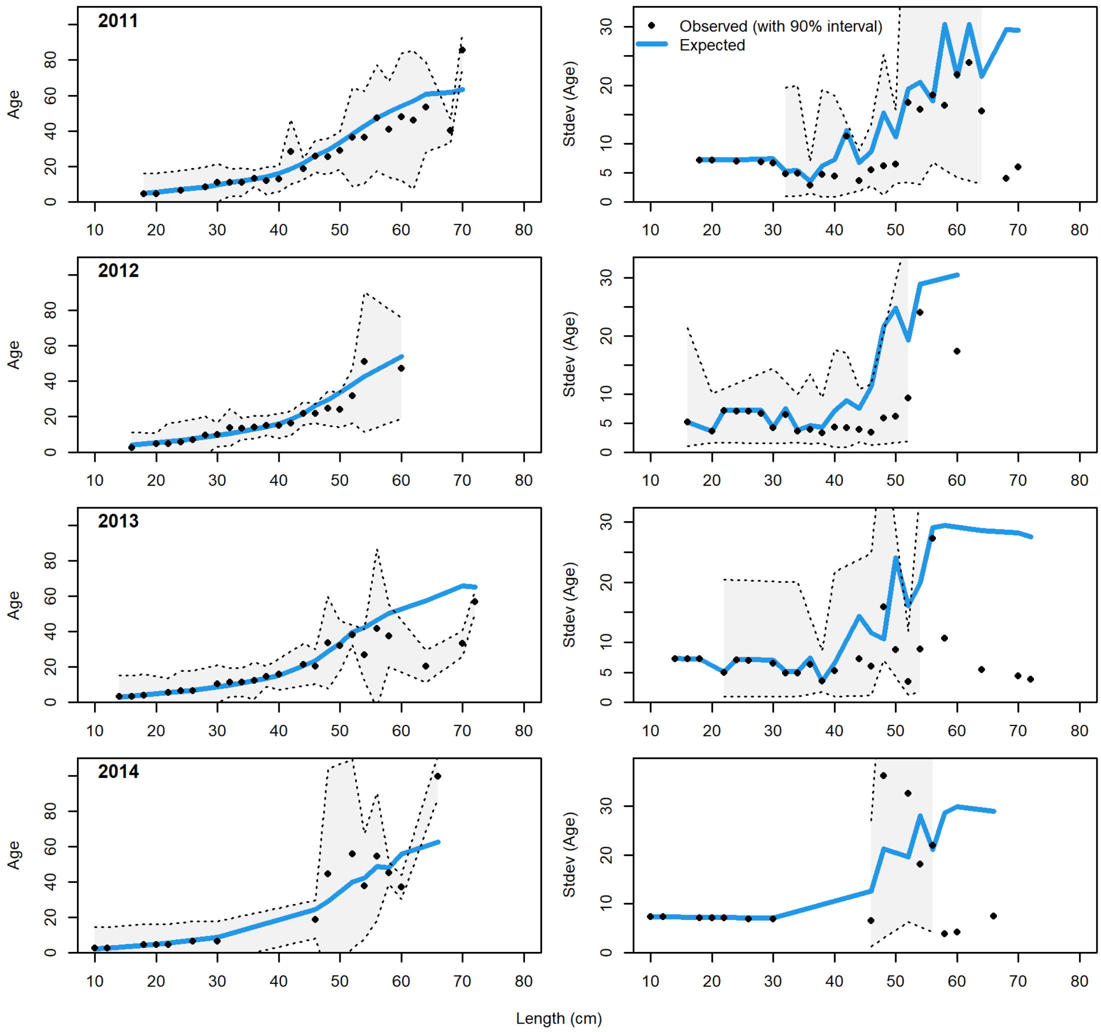

Figure 117: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the West Coast Groundfish Bottom Trawl survey in years 2011-2014. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

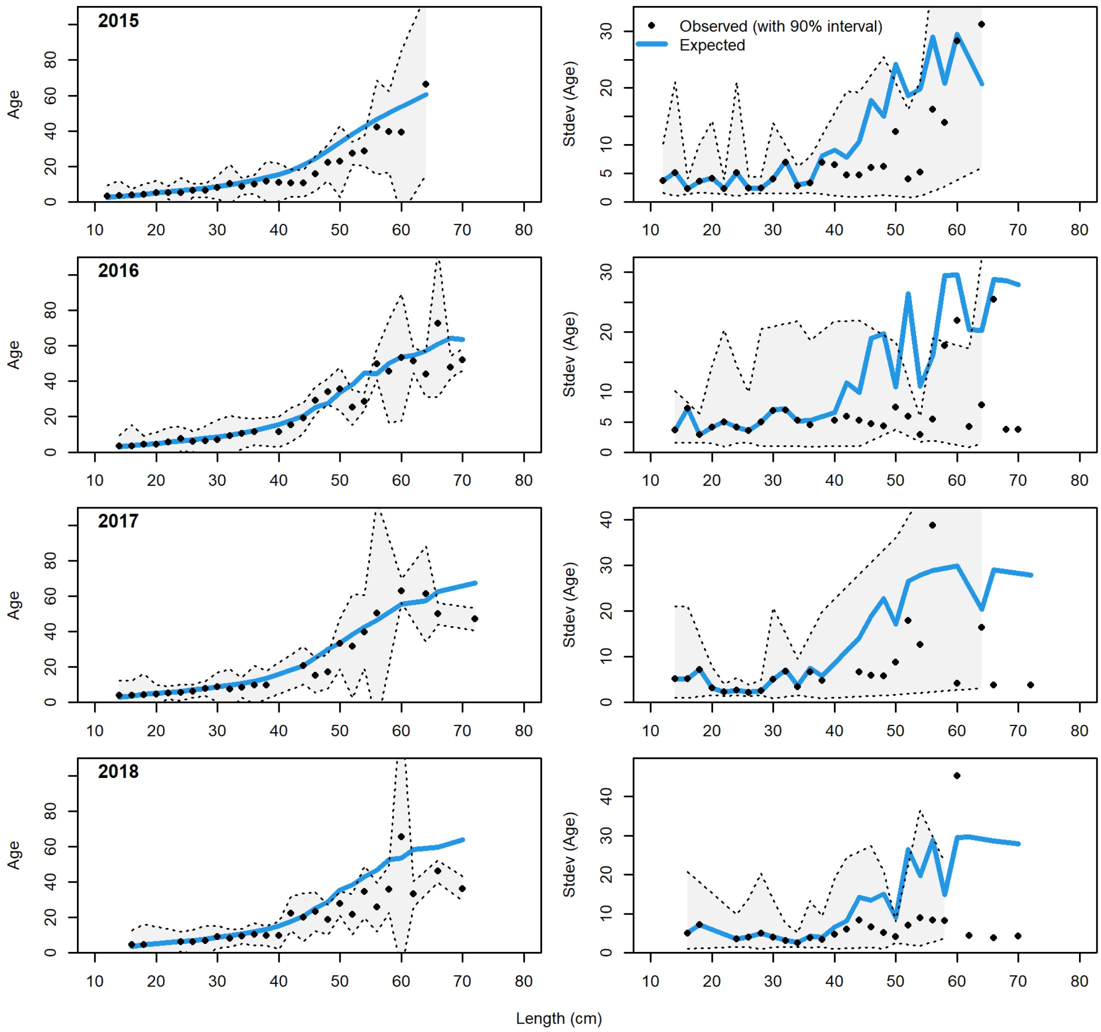

Figure 118: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the West Coast Groundfish Bottom Trawl survey in years 2015-2018. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

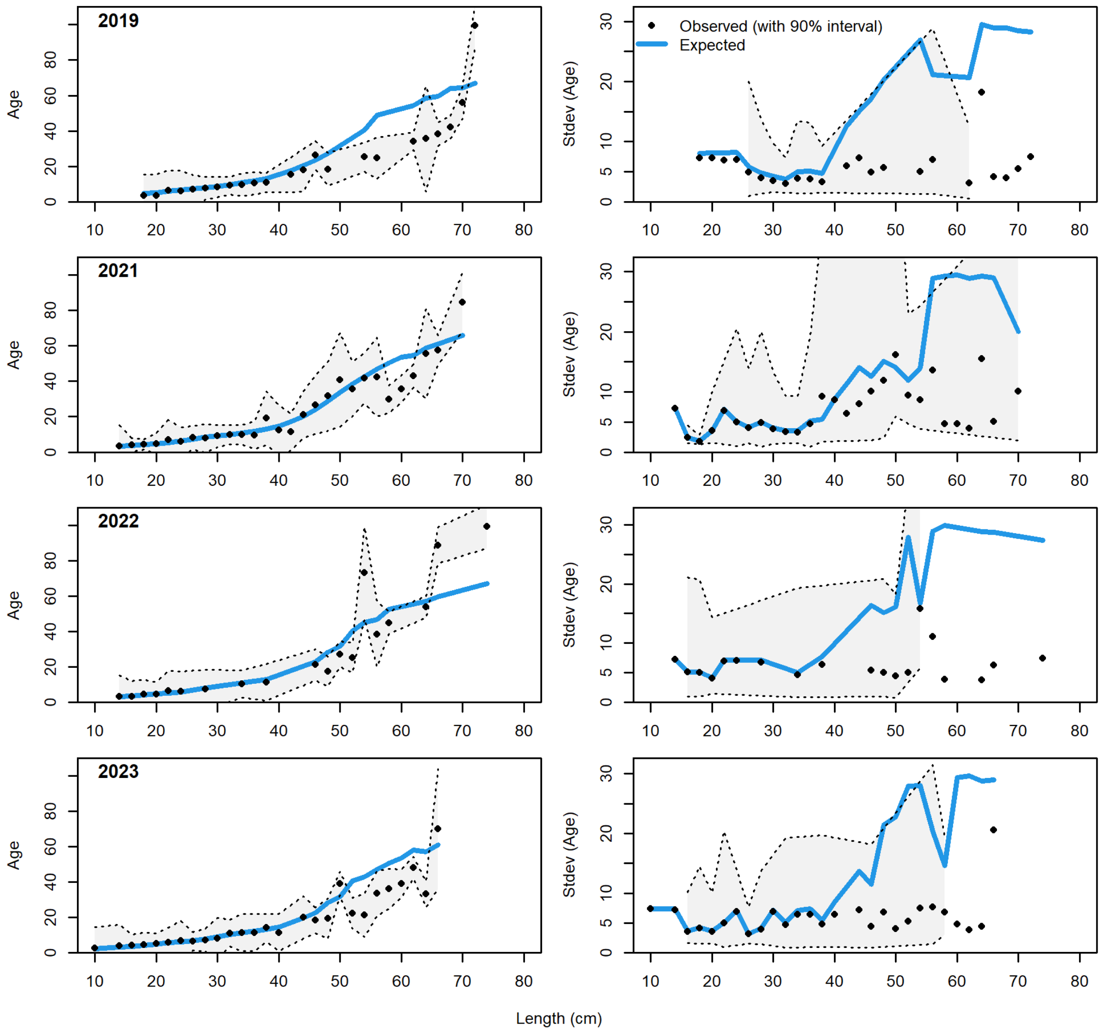

Figure 119: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the West Coast Groundfish Bottom Trawl survey in years 2019-2023. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

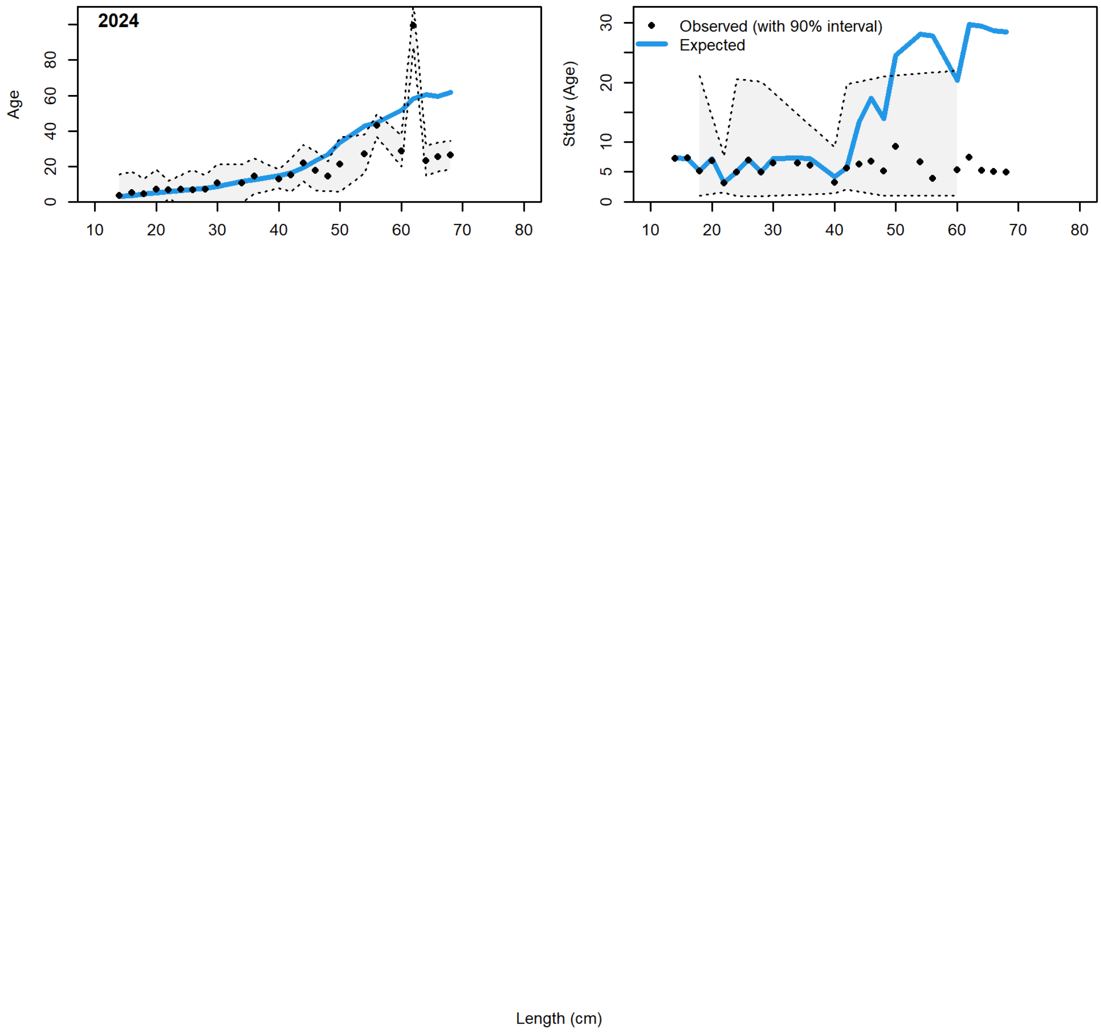

Figure 120: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the West Coast Groundfish Bottom Trawl survey in 2024. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

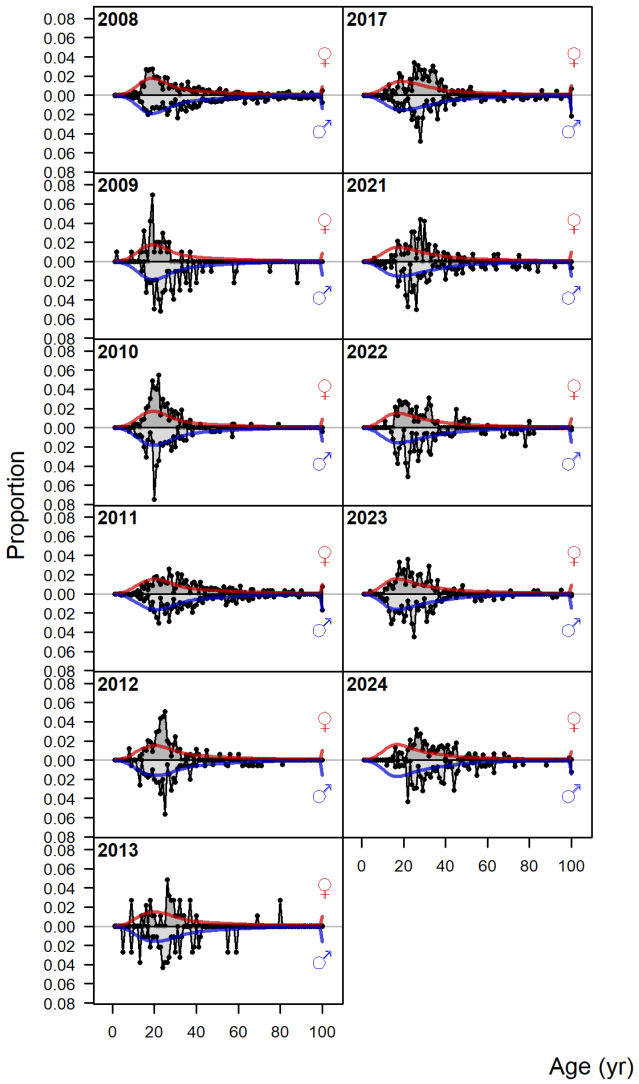

Figure 121: Realized fits (lines) to the marginal age composition data (density) for the bottom trawl fishery.

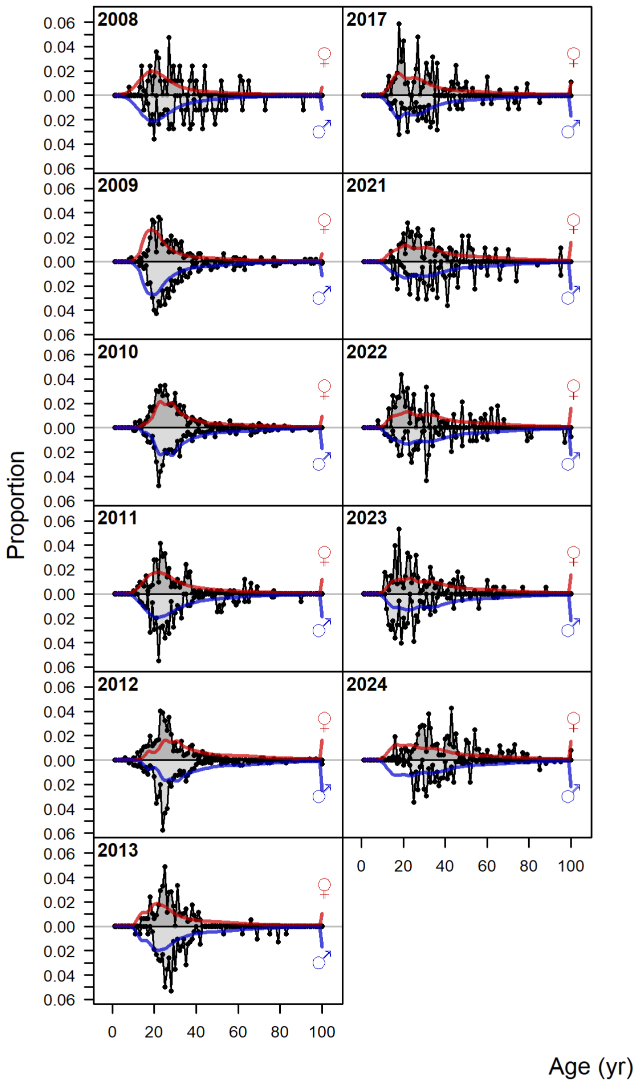

Figure 122: Realized fits (lines) to the marginal age composition data (density) for the non-trawl fishery.

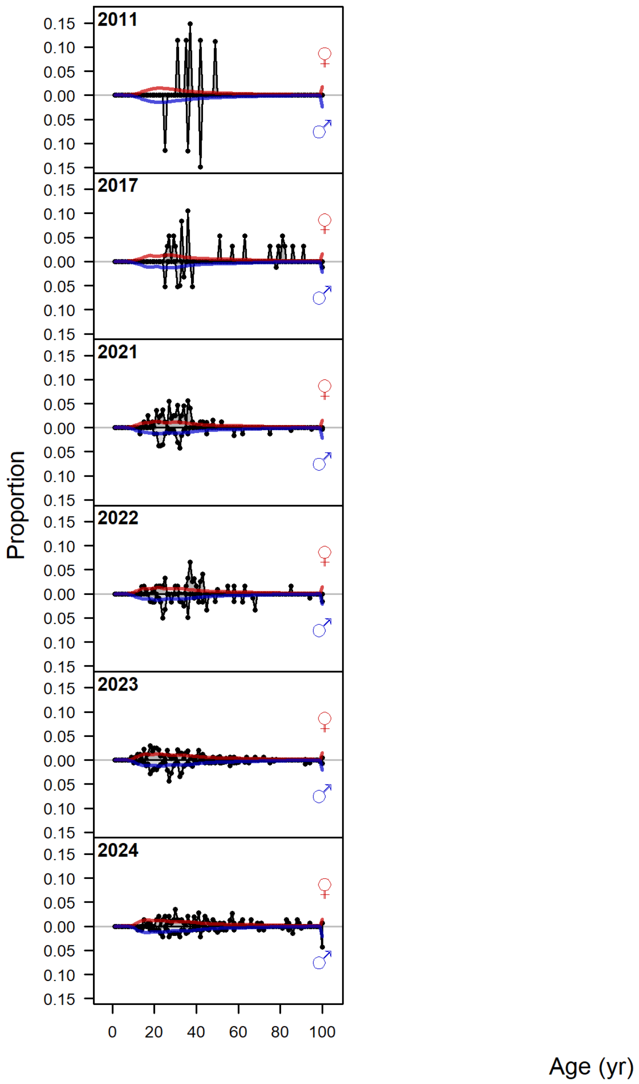

Figure 123: Realized fits (lines) to the marginal age composition data (density) for the midwater trawl fishery.

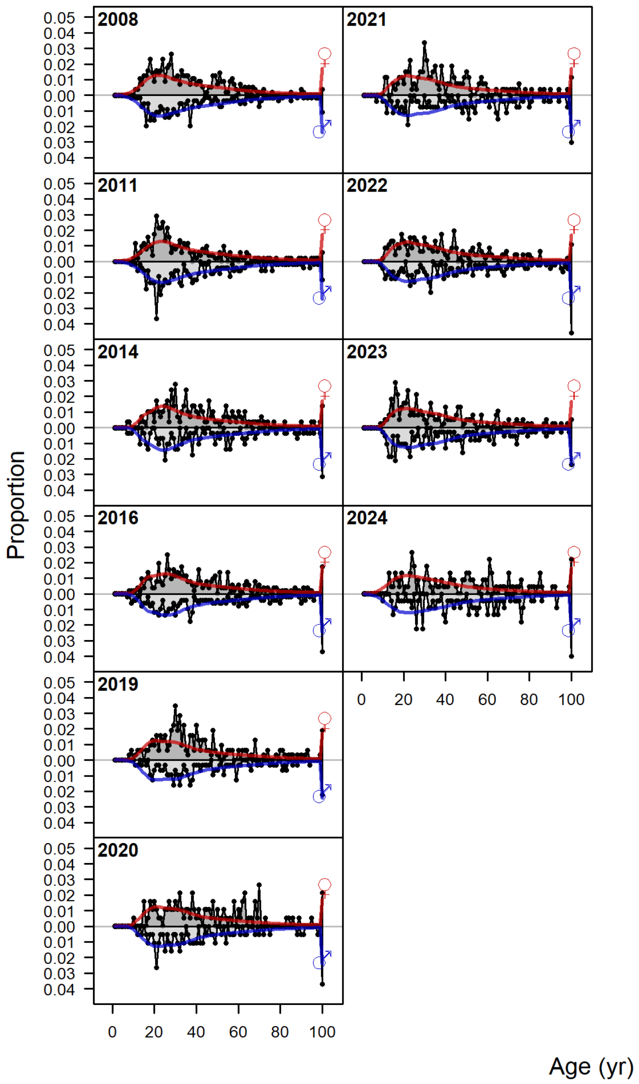

Figure 124: Realized fits (lines) to the marginal age composition data (density) for the at-sea-hake fishery.

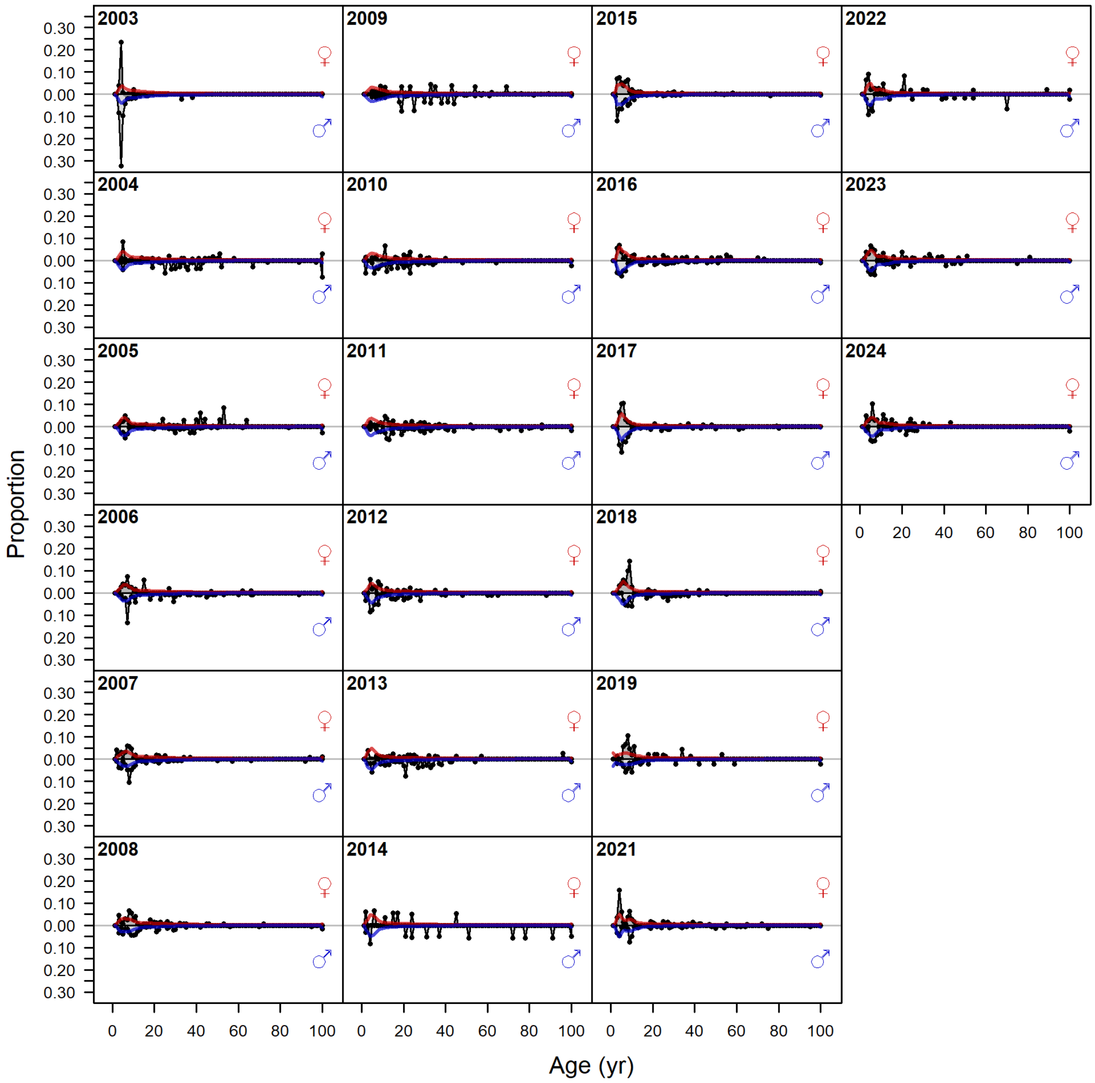

Figure 125: Realized fits (lines) to the marginal age composition data (density) for the West Coast Groundfish Bottom Trawl survey.

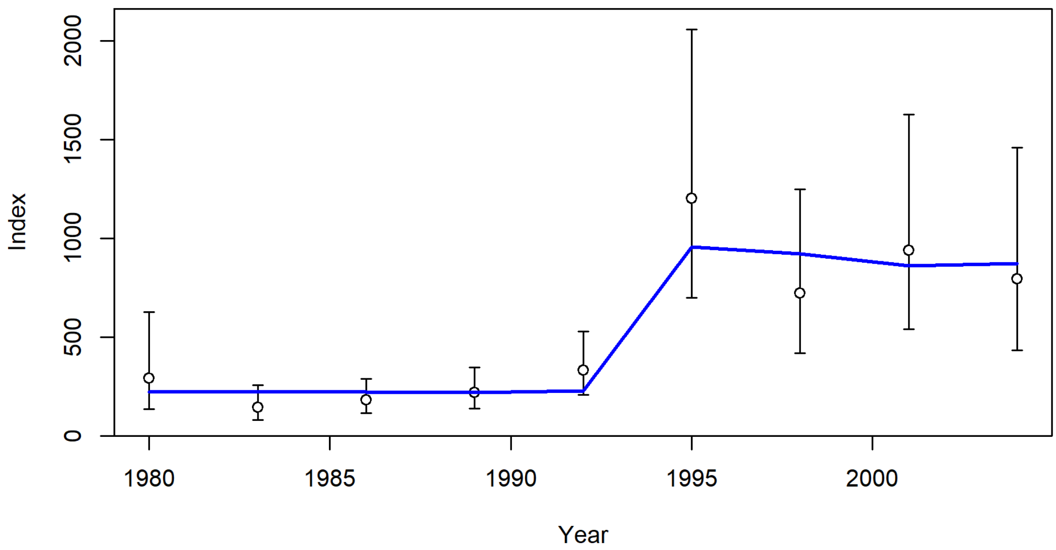

Figure 126: Fit to index data for Triennial survey. Lines indicate 95% uncertainty interval around index values based on the assumption of lognormal error.

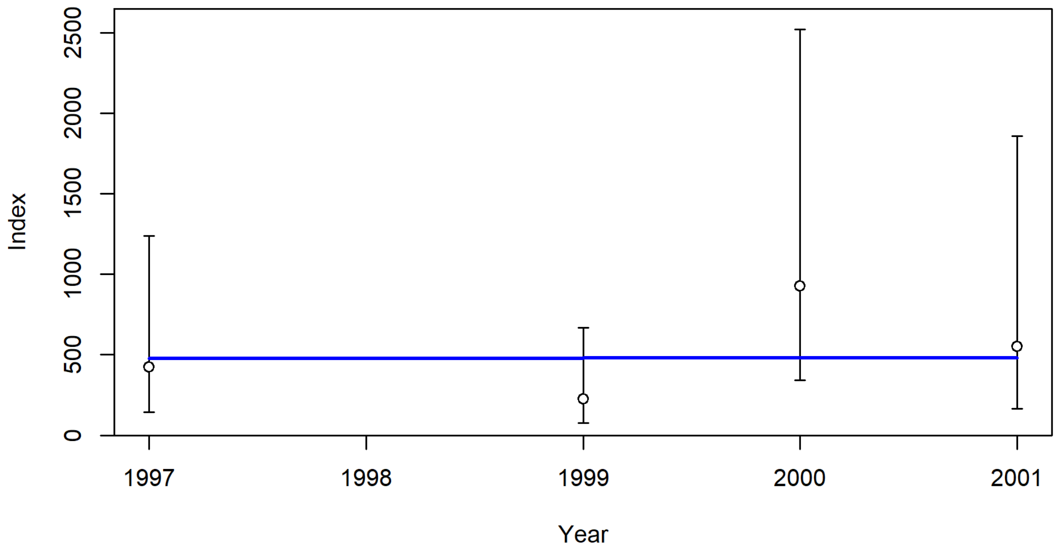

Figure 127: Fit to index data for the Alaska Slope survey. Lines indicate 95% uncertainty interval around index values based on the assumption of lognormal error.

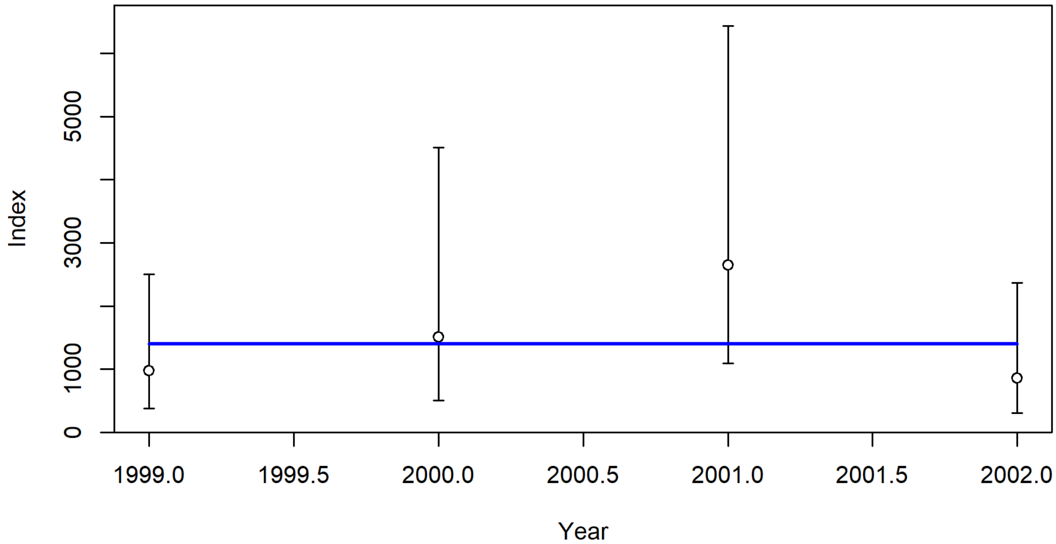

Figure 128: Fit to index data for Northwest Fisheries Science Center Slope survey. Lines indicate 95% uncertainty interval around index values based on the assumption of lognormal error.

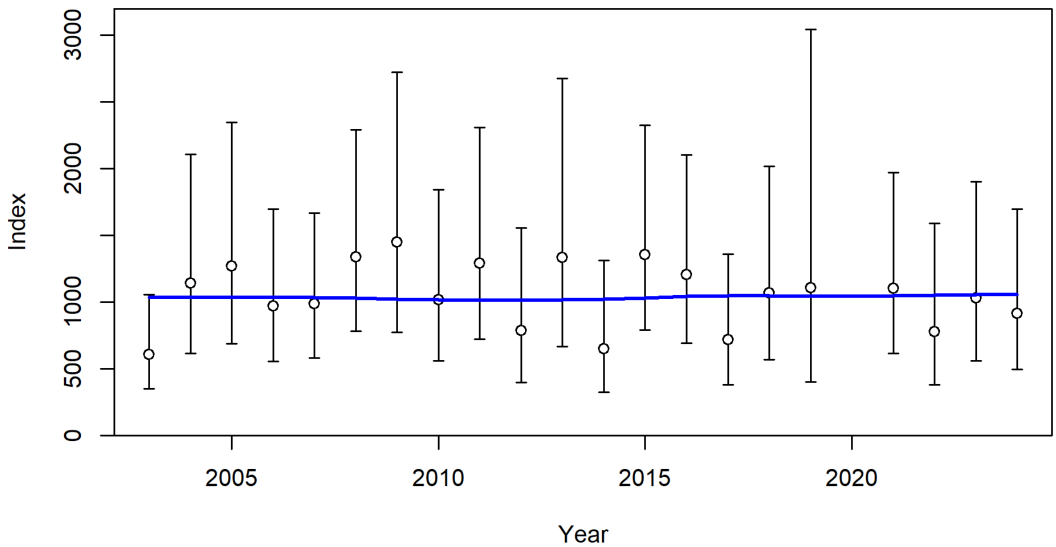

Figure 129: Fit to index data for West Coast Groundfish Bottom Trawl survey. Lines indicate 95% uncertainty interval around index values based on the assumption of lognormal error.

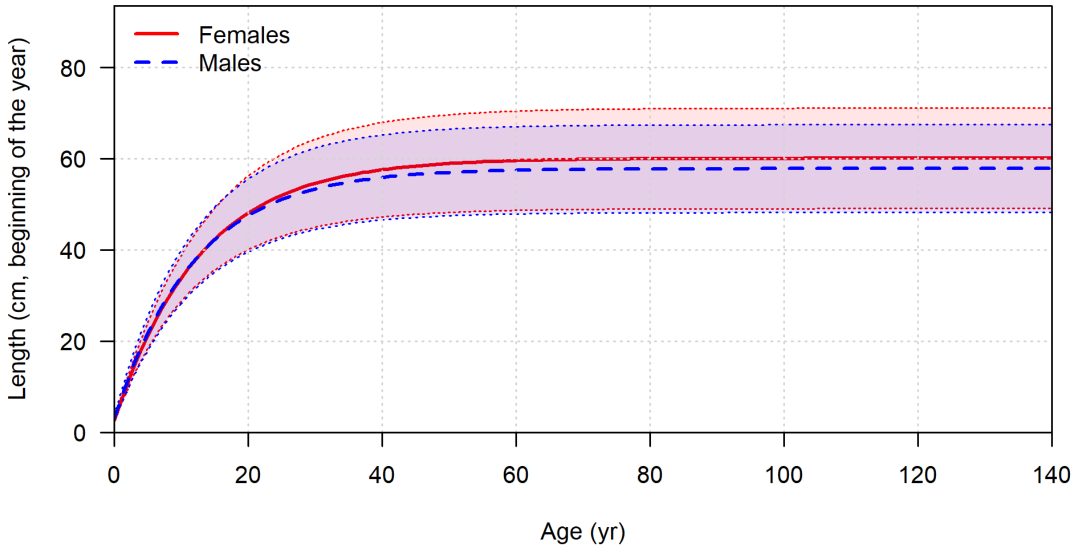

Figure 130: Estimated age and growth relatioship in the reference model .Shaded area indicates 95% distribution of length at age around estimated growth curve.

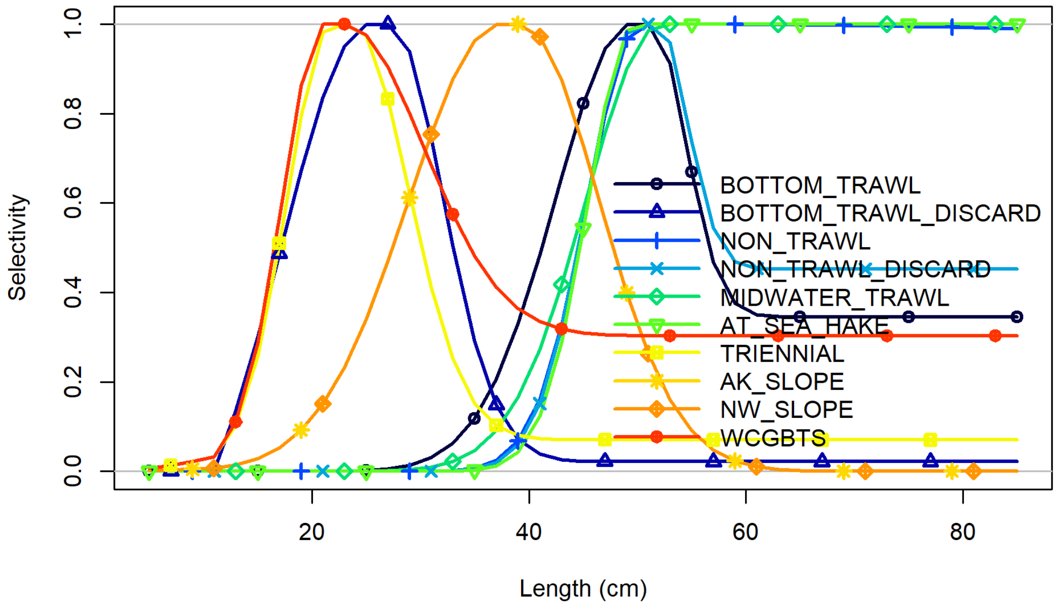

Figure 131: Ending selectivity at length for each fishery and survey.

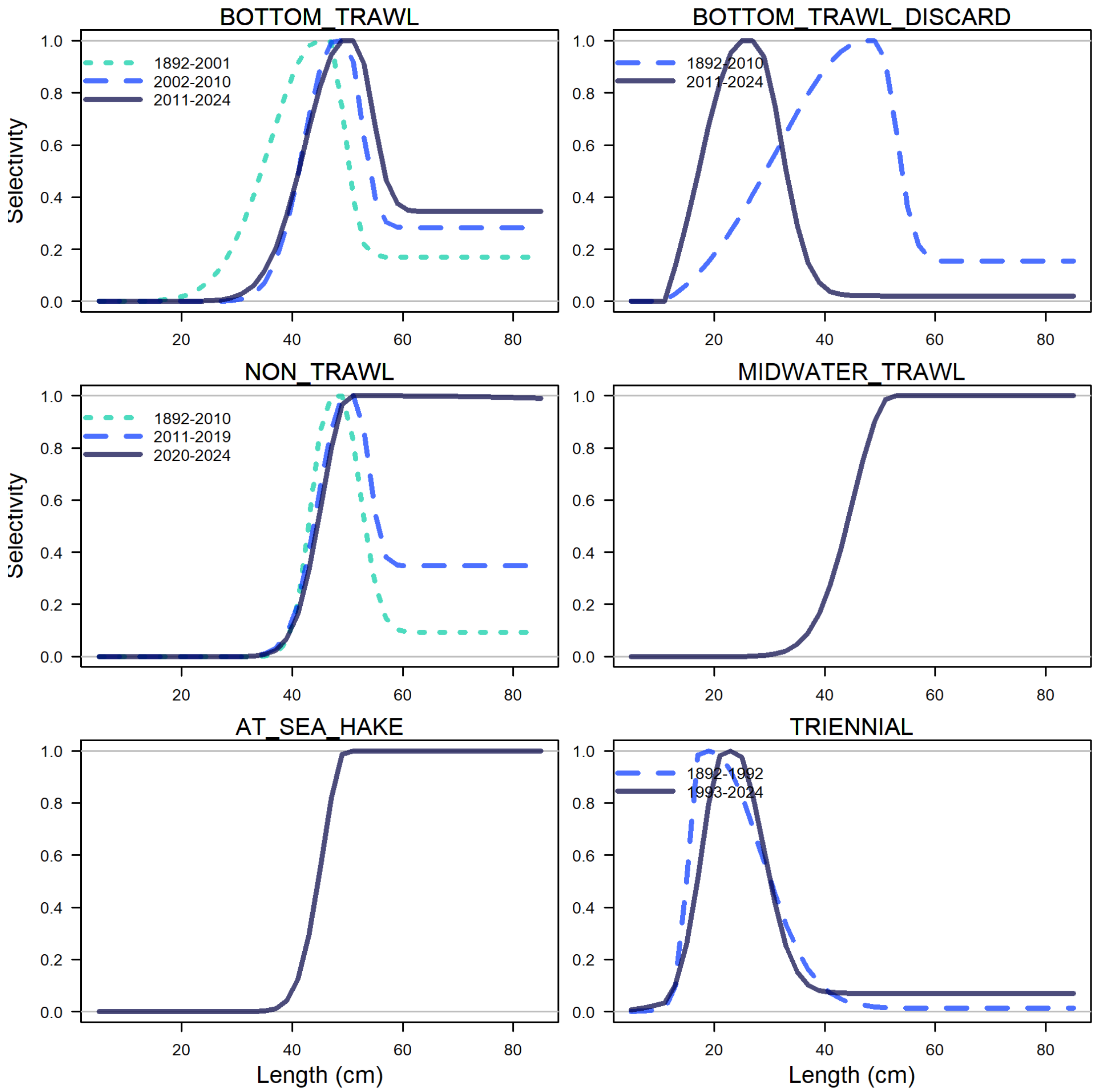

Figure 132: Time-varying selectivity for each fleet and survey with time blocks.

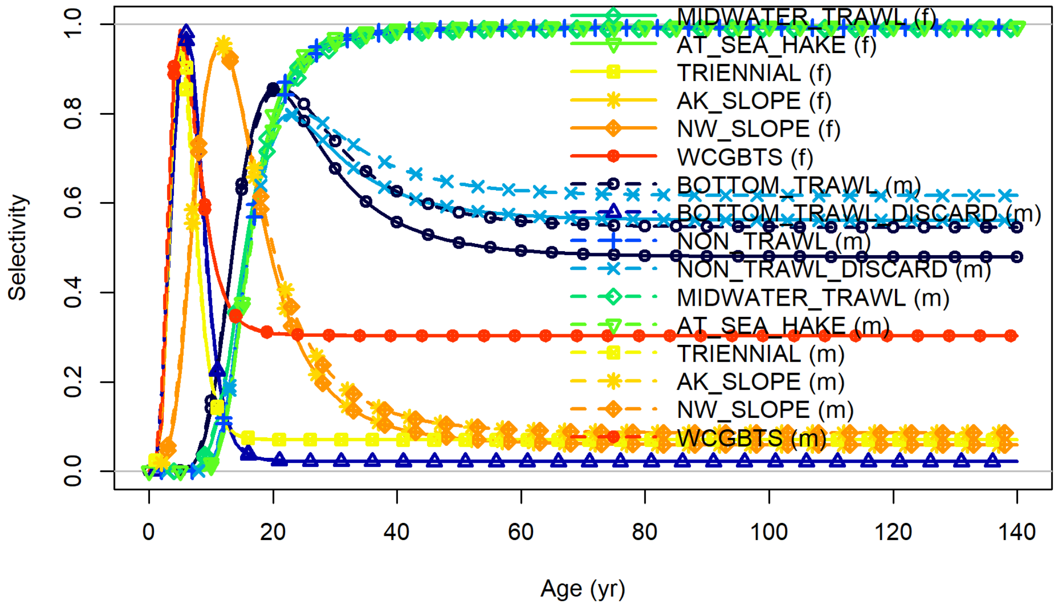

Figure 133: Ending selectivity at age derived from lengths for each fishery and survey.

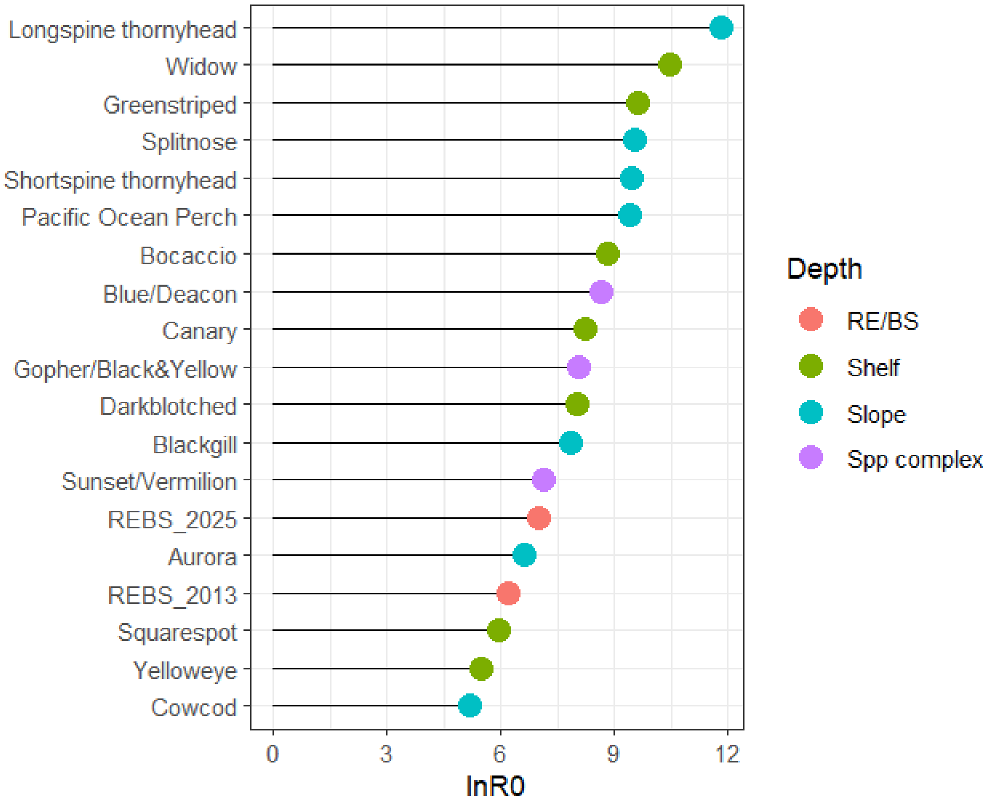

Figure 134: Estimated unfished recruitment (lnR0) for several assessed shelf and slope rockfishes.

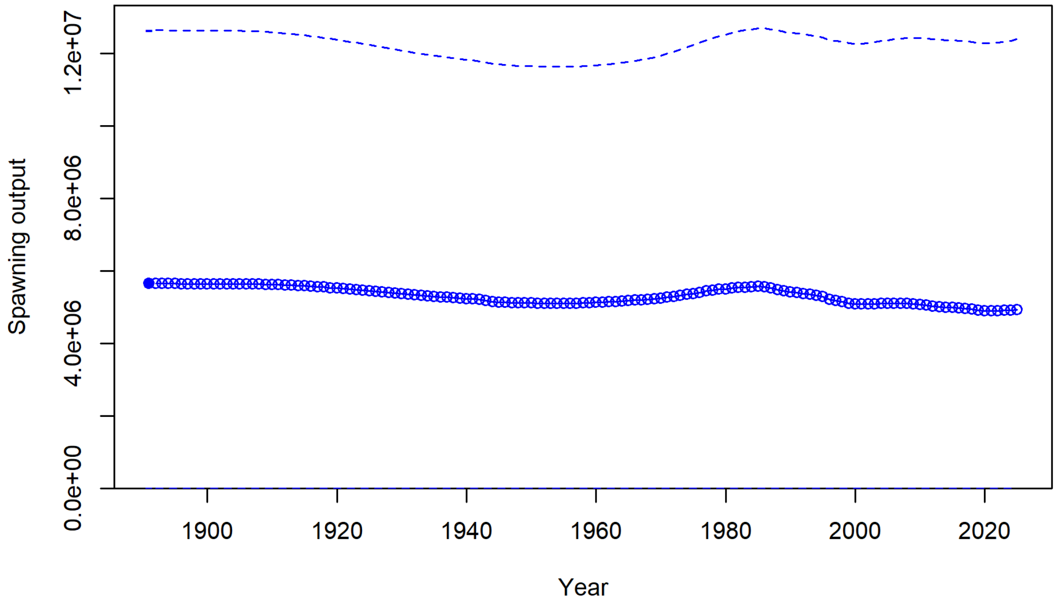

Figure 135: Estimated time series of spawning output (in millions of eggs) for the reference model.

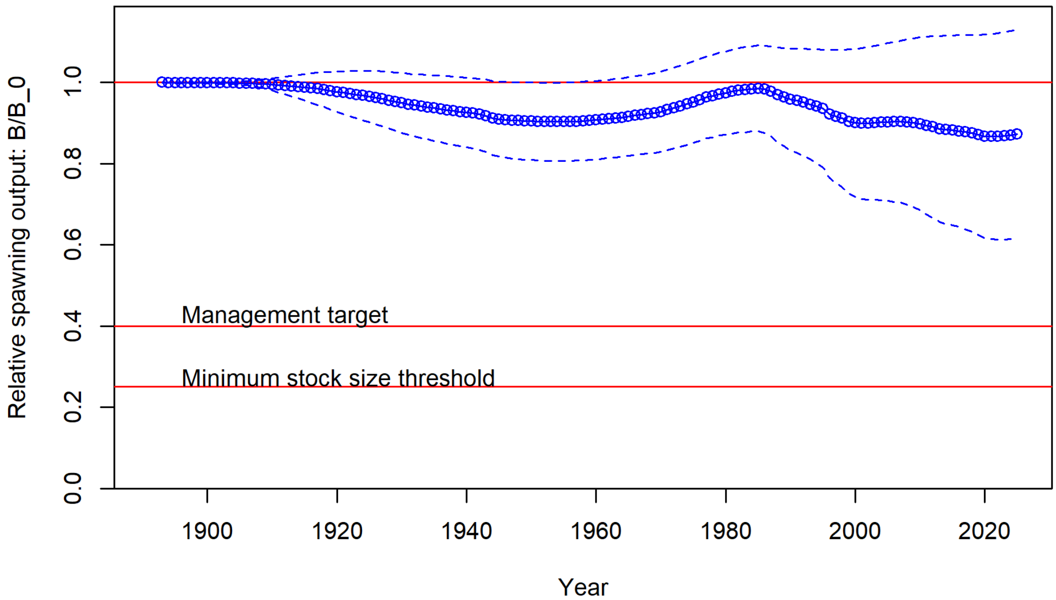

Figure 136: Estimated time series of fraction of unfished spawning output for the reference model.

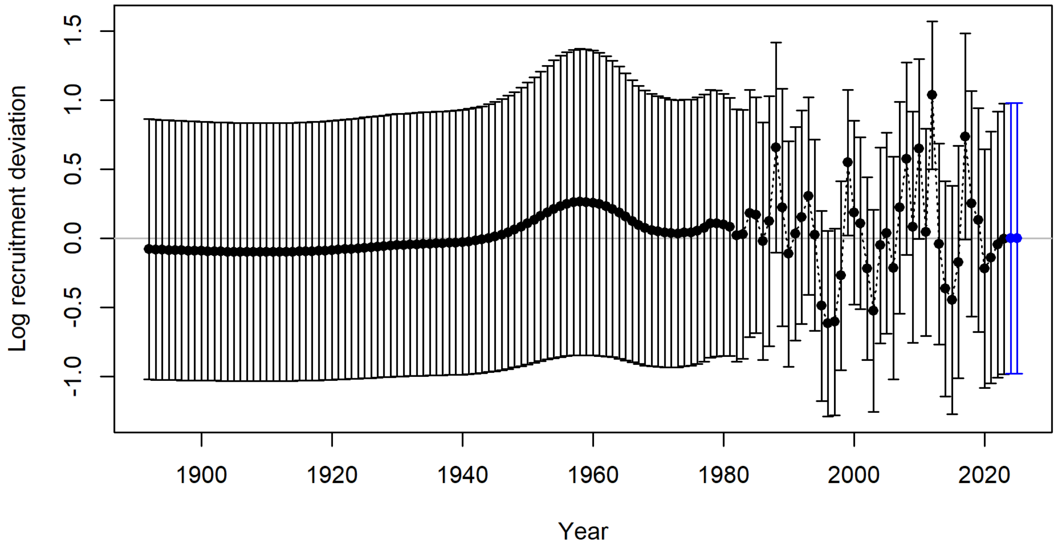

Figure 137: Estimated time series of recruitment deviations for the base model.

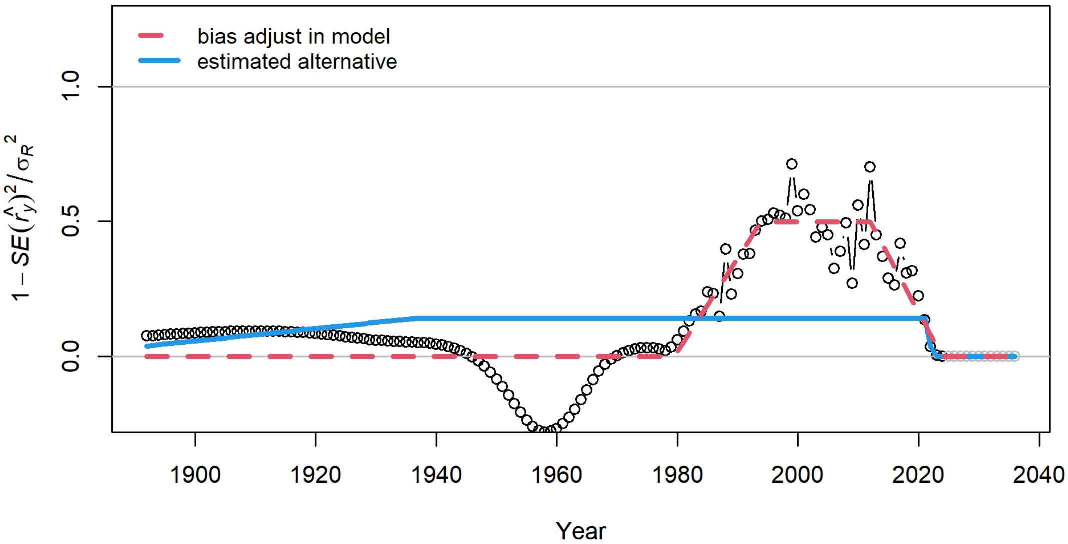

Figure 138: Bias adjustment applied to the recruitment deviations (red line). Points are transformed variances relative to the assumed variance of recruitment.

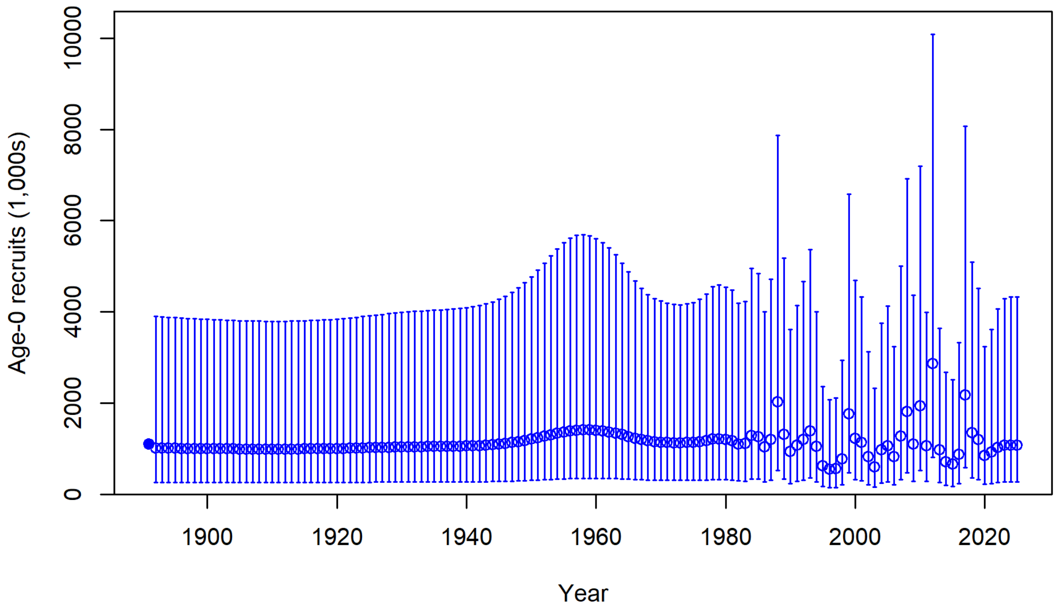

Figure 139: Estimated time series of age-0 recruits for the base model.

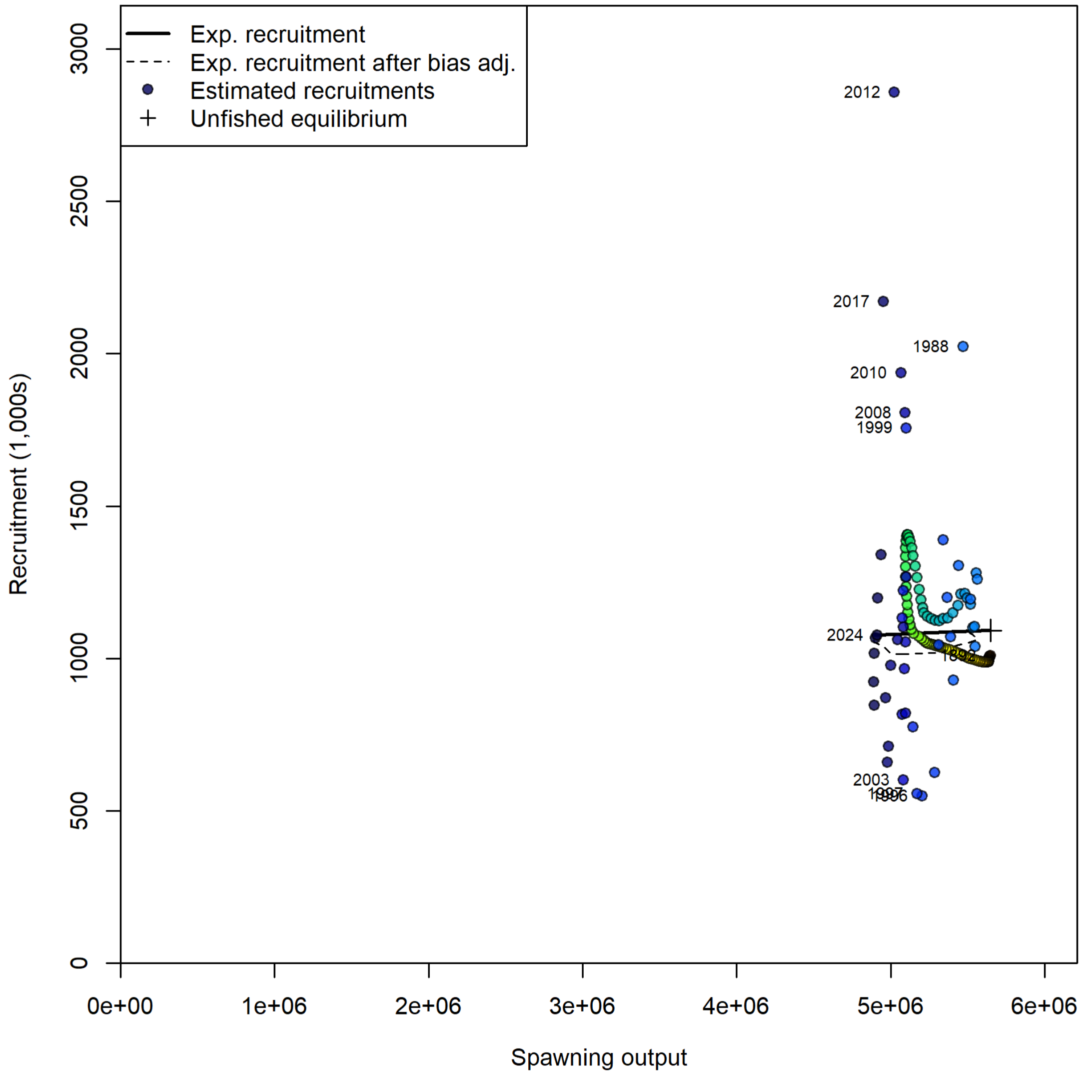

Figure 140: Stock-recruit curve with labels on first, last, and years with (log) deviations > 0.5. Point colors indicate year, with warmer colors indicating earlier years and cooler colors in showing later years.

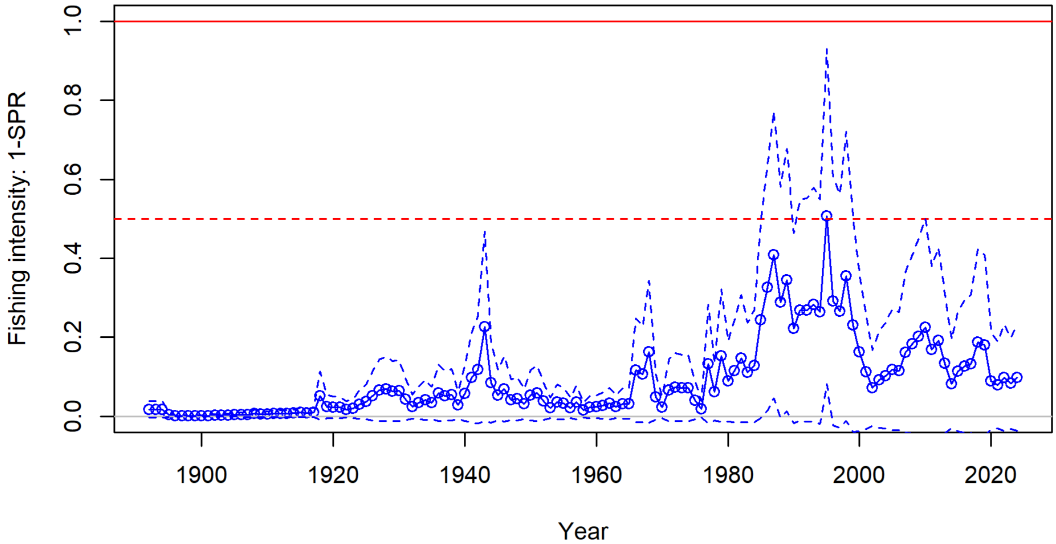

Figure 141: Estimated time series of fishing intensity for the base model.

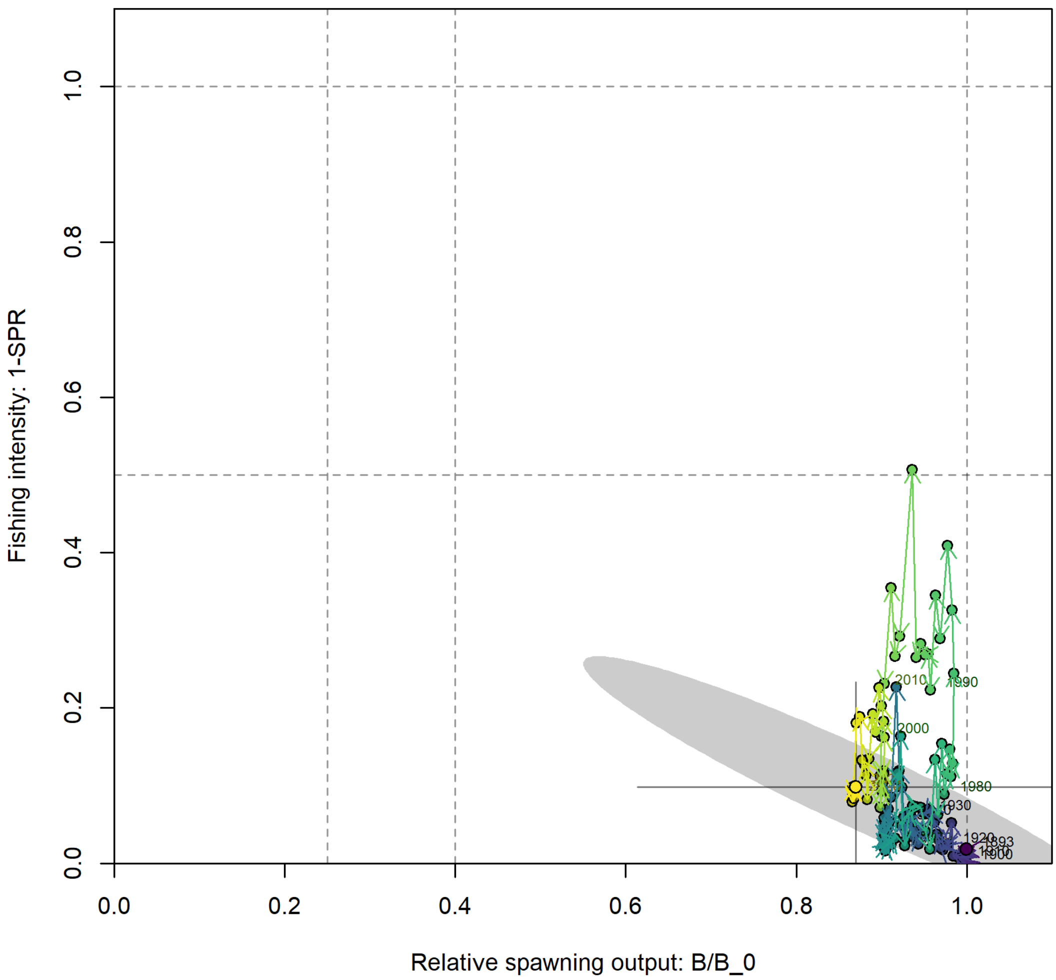

Figure 142: Phase plot of fishing intensity versus fraction unfished for the base model.

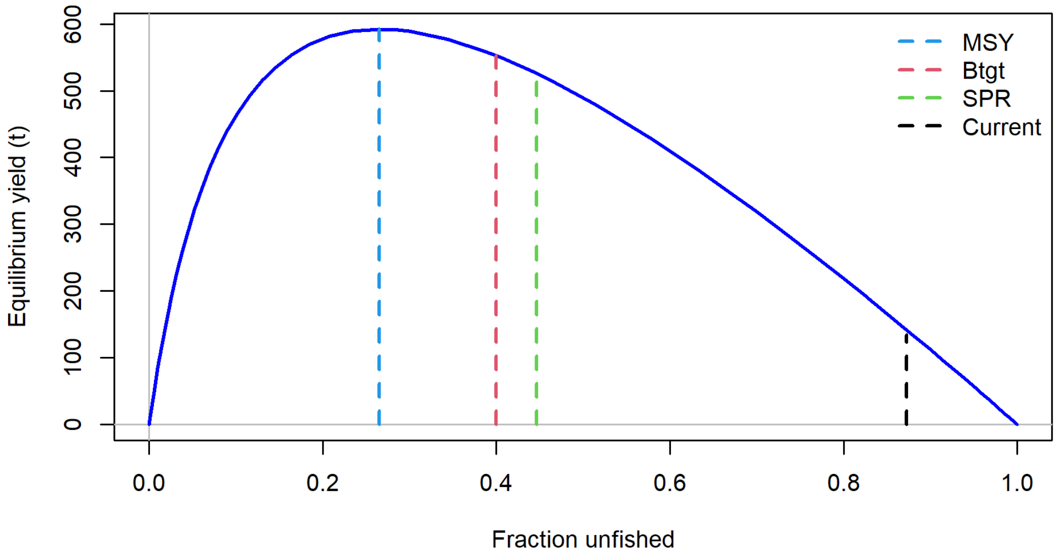

Figure 143: Estimated yield curve with reference points for the base model.

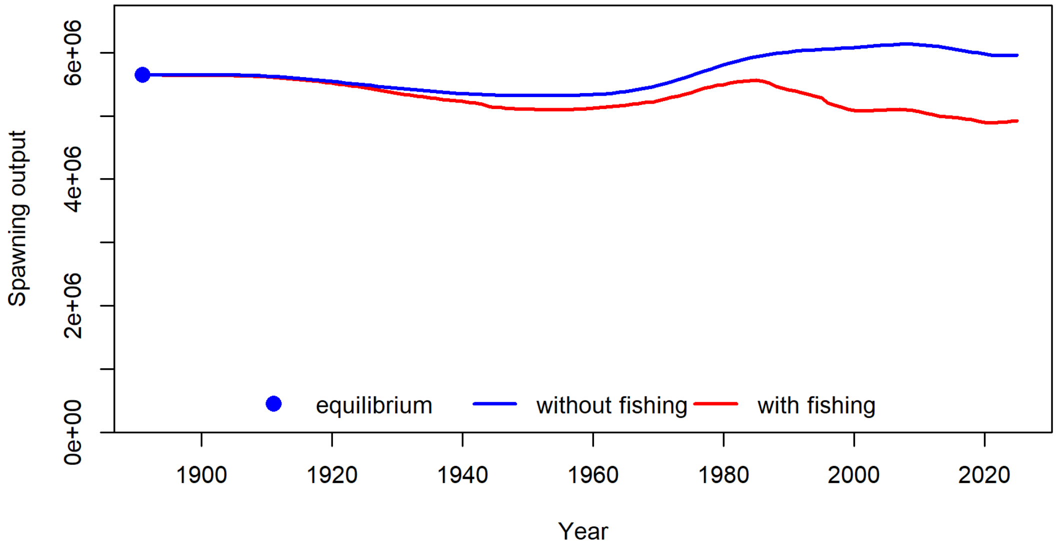

Figure 144: Dynamic B0 plot. The lower line shows the time series of estimated spawning output in the presence of fishing mortality. The upper line shows the time series that could occur under the same dynamics (including deviations in recruitment), but without fishing. The point at the left represents the unfished equilibrium.

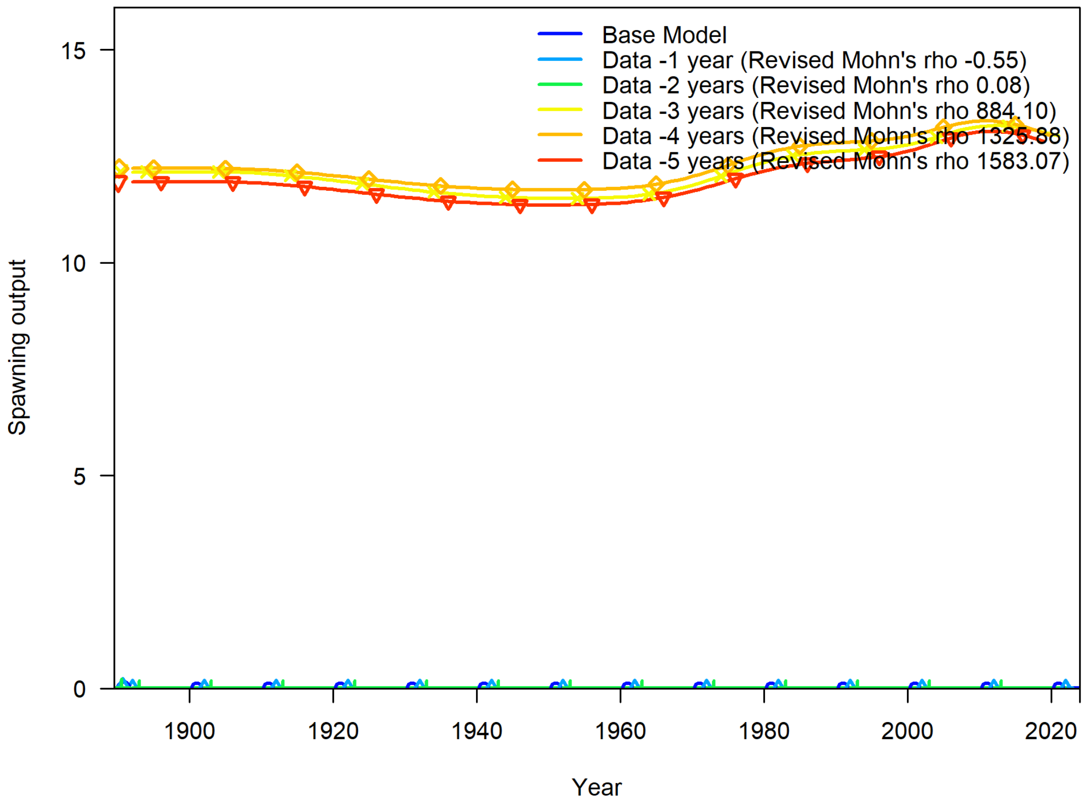

Figure 145: Change in the estimate of spawning output (millions of eggs) when the five most recent years of data area removed sequentially.

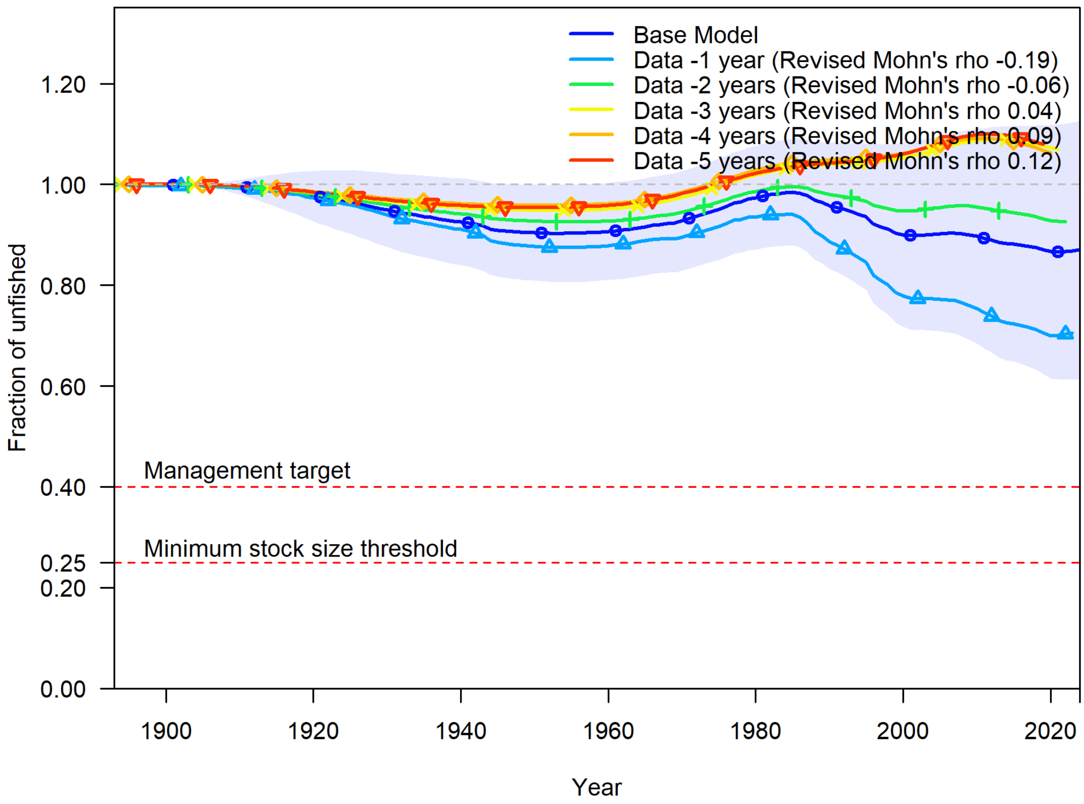

Figure 146: Change in the estimate of relative stock status when the five most recent years of data area removed sequentially.

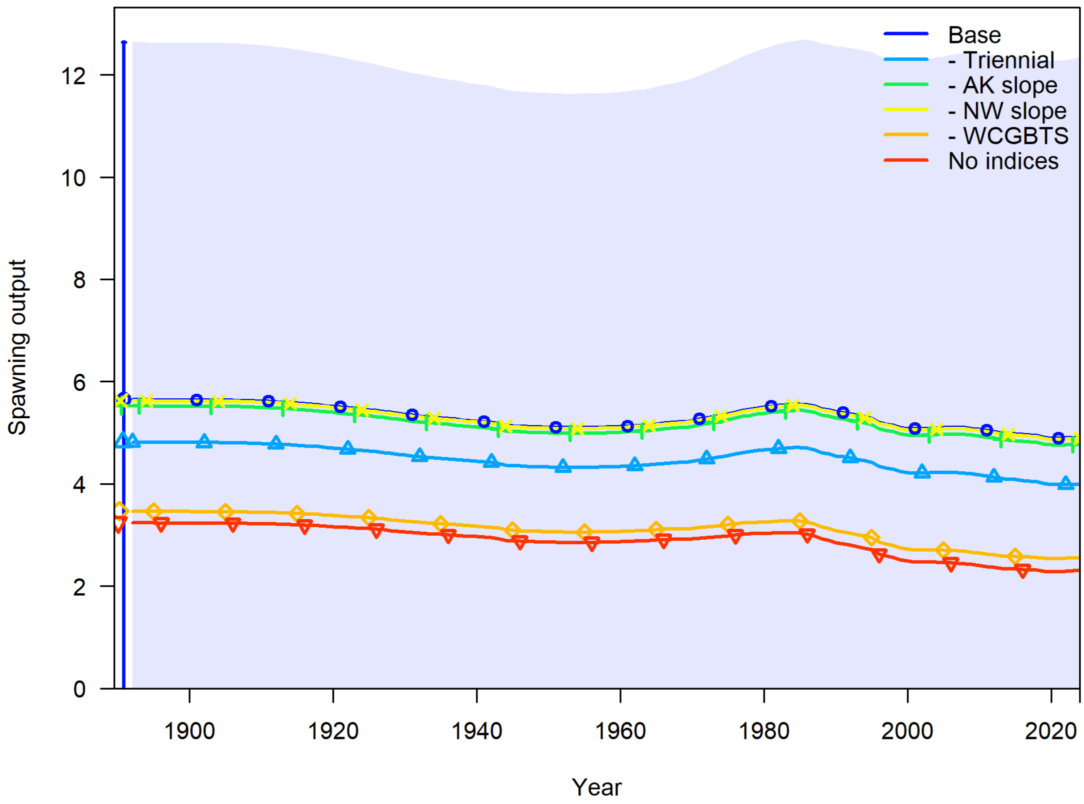

Figure 147: Spawning output (millions of eggs) across data removal sensitivities (indices).

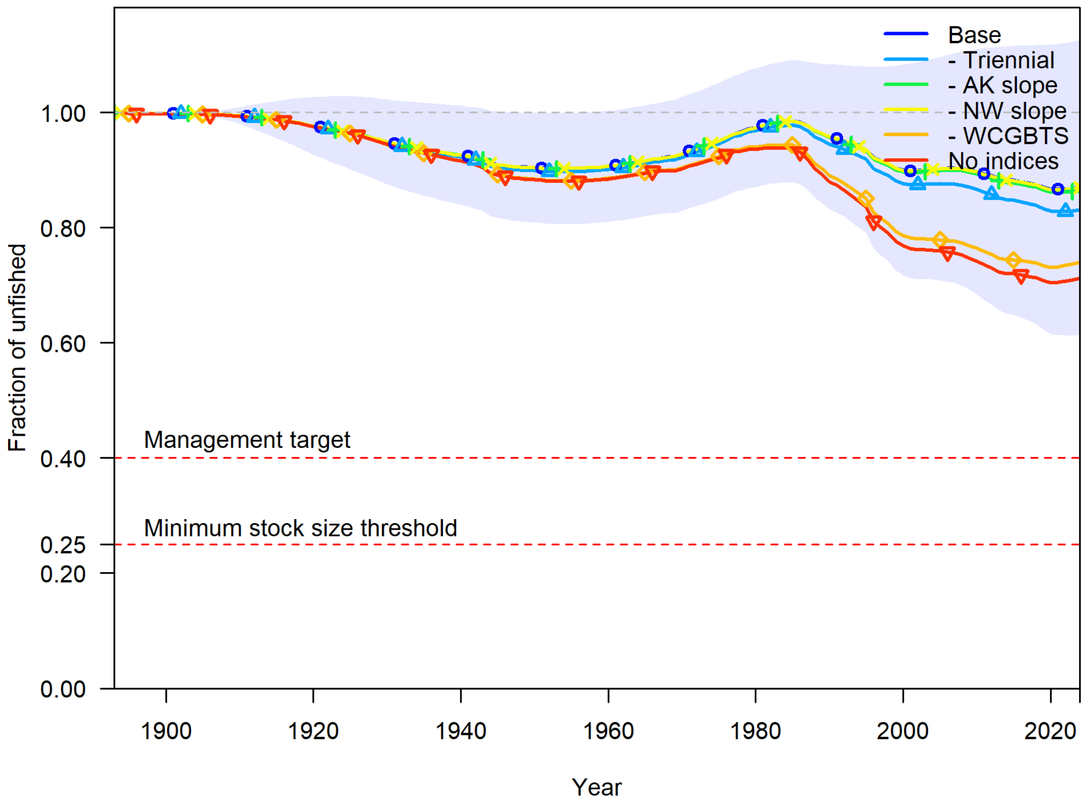

Figure 148: Relative spawning output (fraction unfished) across data removal sensitivities (indices).

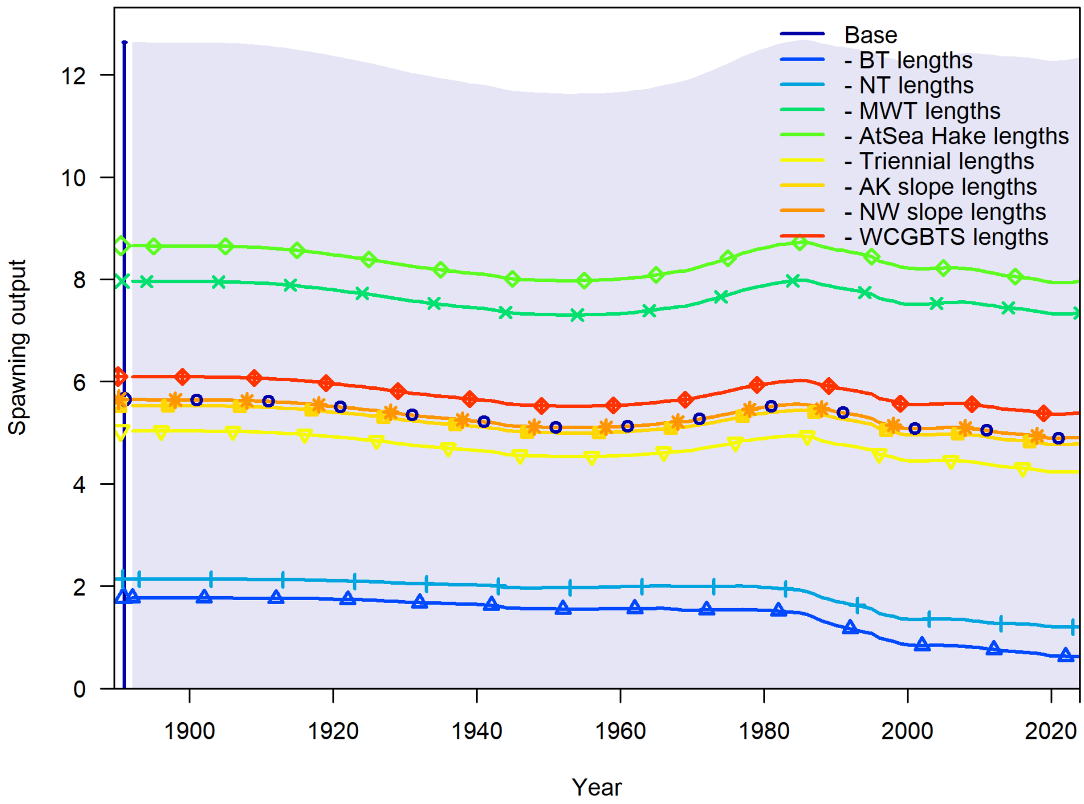

Figure 149: Spawning output (millions of eggs) across data removal sensitivities (length compositions by fleet).

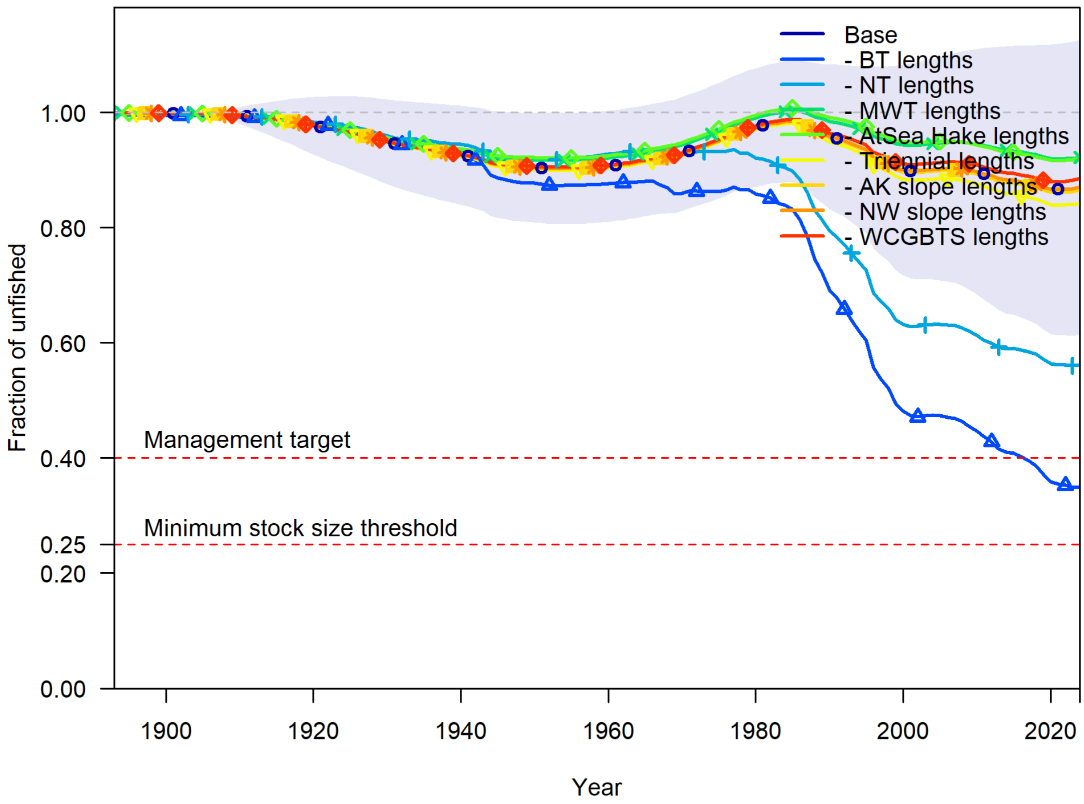

Figure 150: Relative spawning output (fraction unfished) across data removal sensitivities (length compositions by fleet).

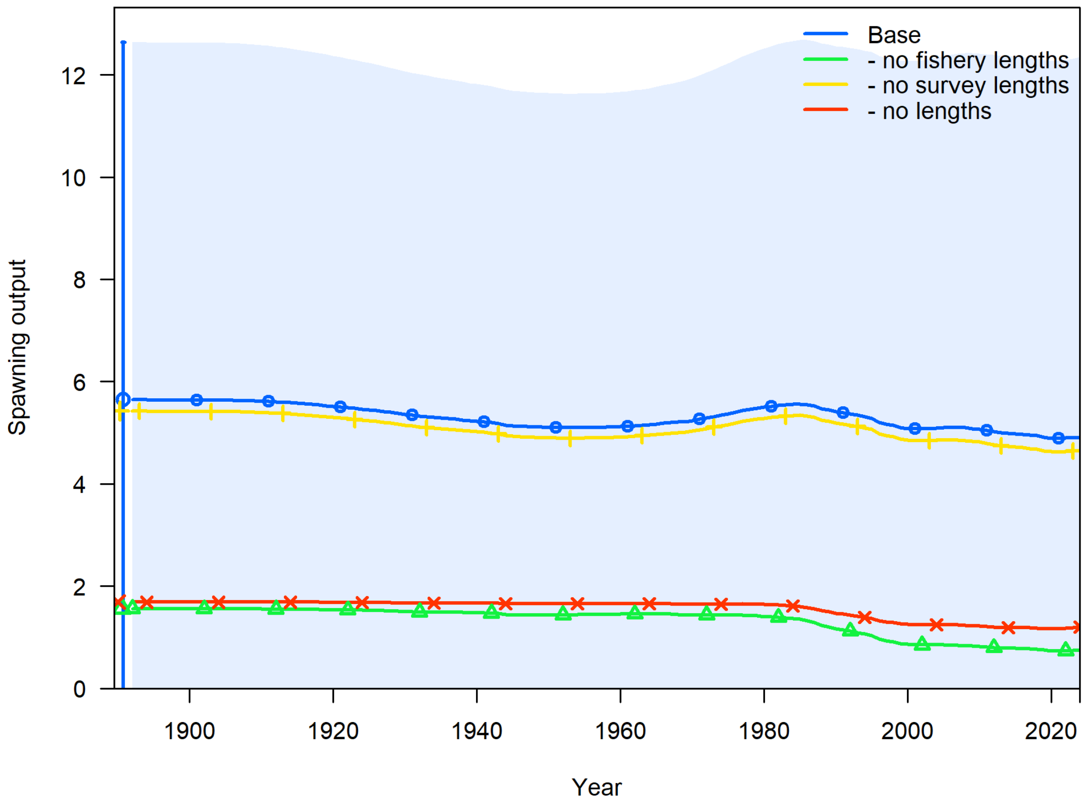

Figure 151: Spawning output (millions of eggs) across data removal sensitivities (length compositions by source).

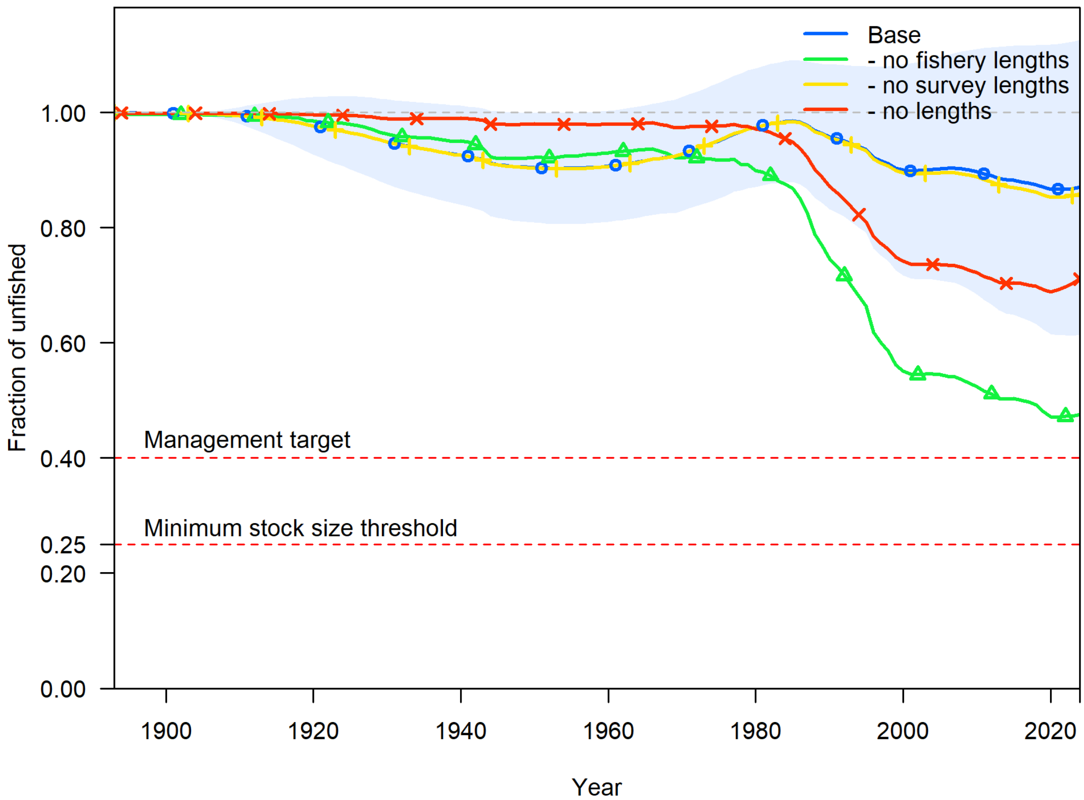

Figure 152: Relative spawning output (fraction unfished) across data removal sensitivities (length compositions by source).

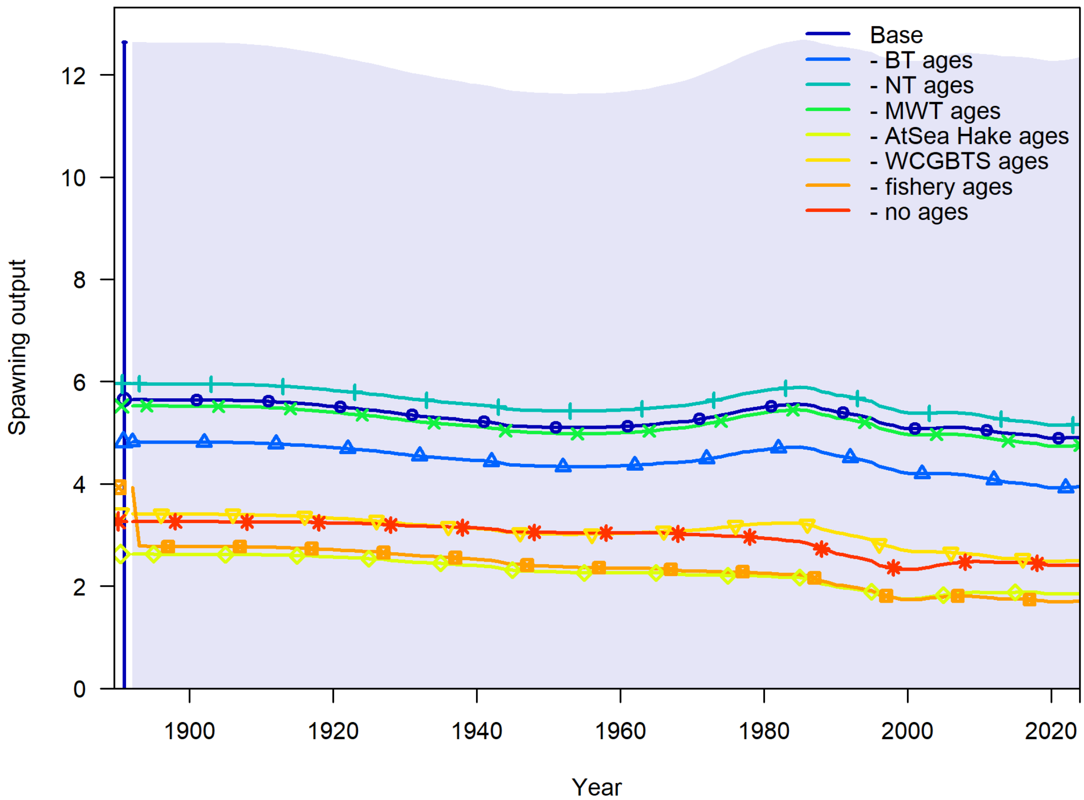

Figure 153: Spawning output (millions of eggs) across data removal sensitivities (age compositions by fleet).

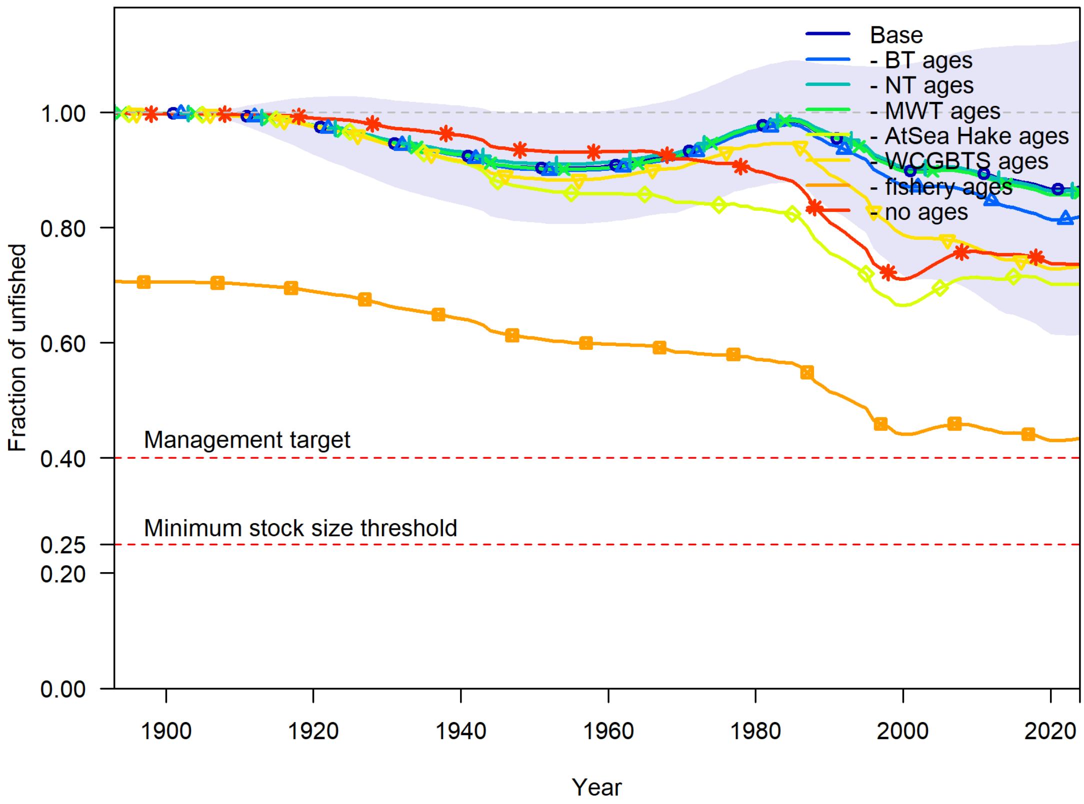

Figure 154: Relative spawning output (fraction unfished) across data removal sensitivities (age compositions by fleet).

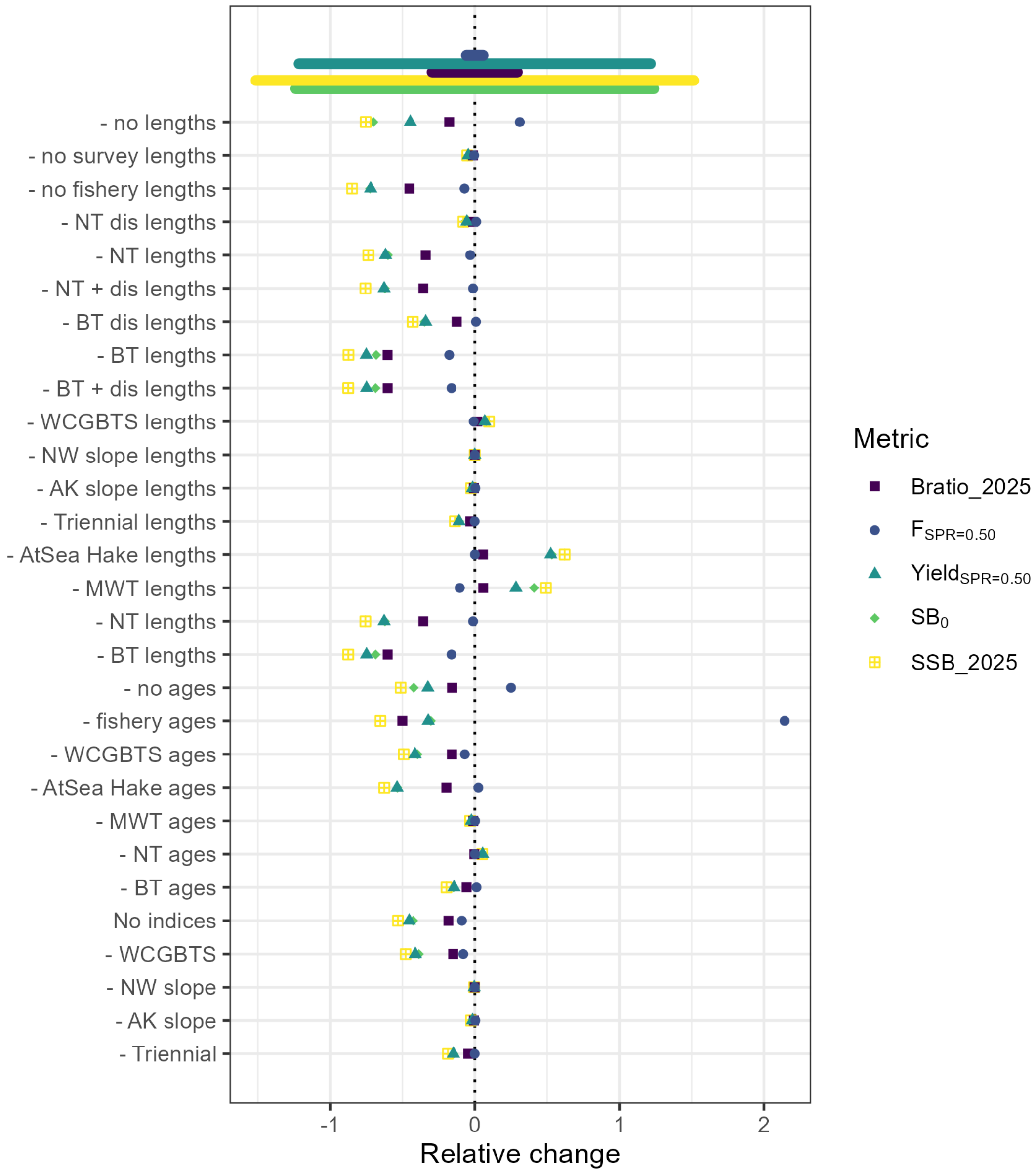

Figure 155: Relative change in management quantities across models conducted as sensitivities (removal of data sources).

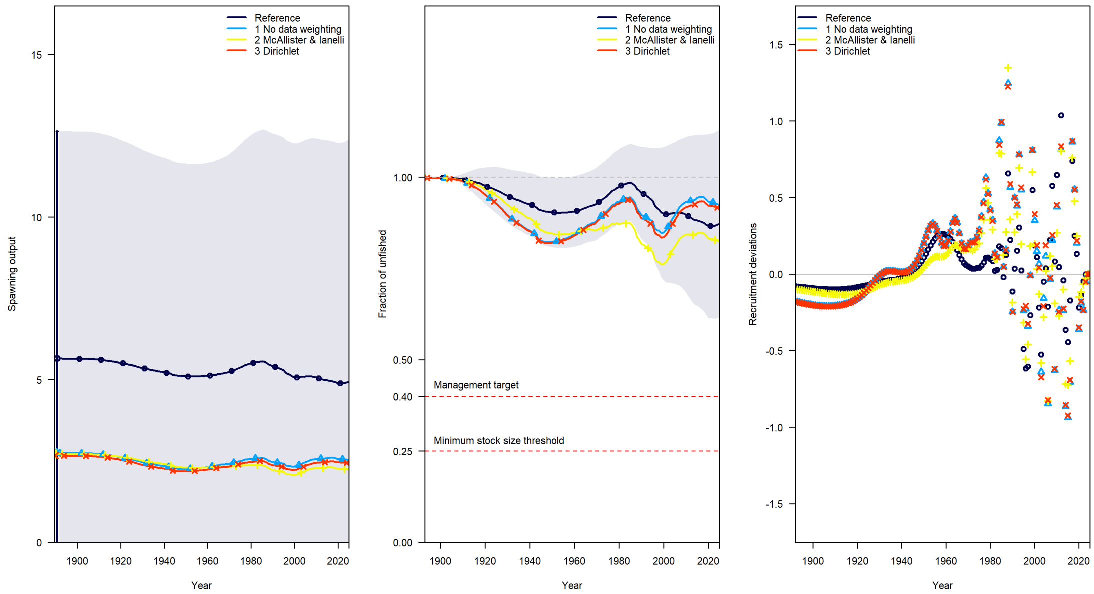

Figure 156: Comparison of spawning output (left panel), relative stock status (middle panel) and recruitment estimation (right panel) for models under different data weighting scenarios. The reference model uses the Francis method.

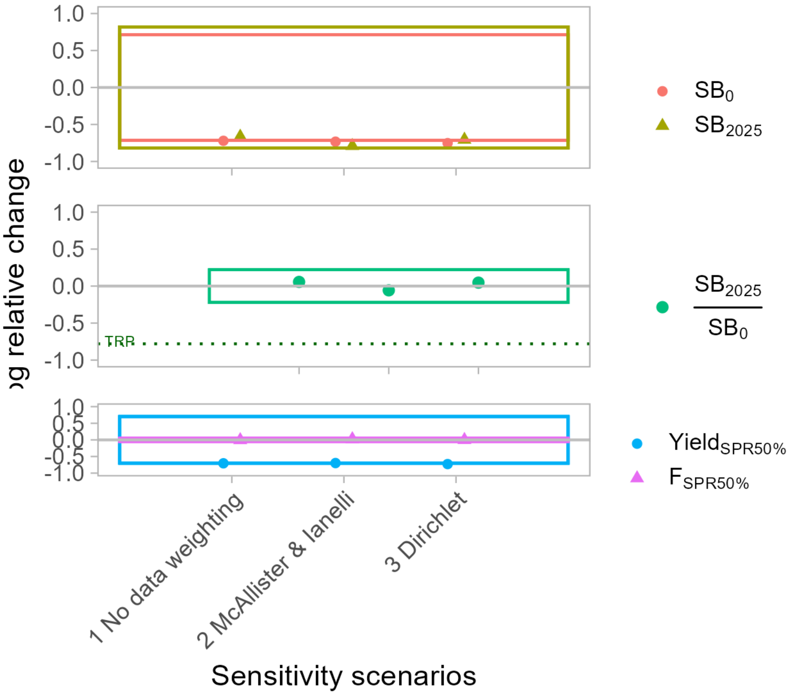

Figure 157: Log relative change (log((Model_sensi-Model_ref)/Model_ref)) in data weighting treatment for 5 derived quantities. Colored boxes indicate 95 percent confidence interval of the reference model. See 'Sensitivity Analysis' section for more details on each scenario.

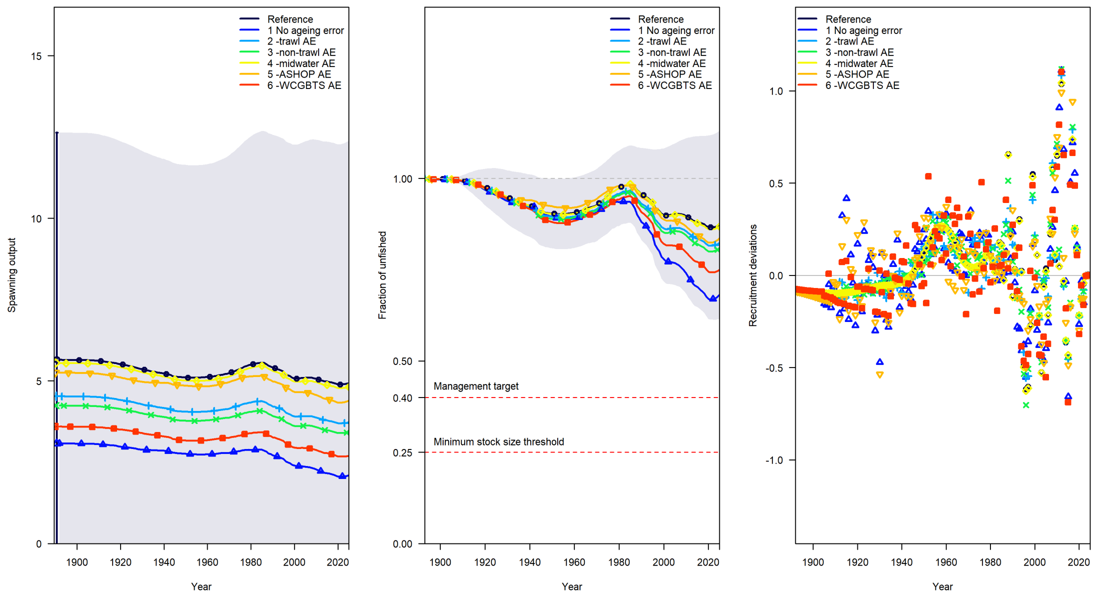

Figure 158: Comparison of spawning output (left panel), relative stock status (middle panel) and recruitment estimation (right panel) for models under different ageing error scenarios. The reference model uses ageing error matrices for all age sources.

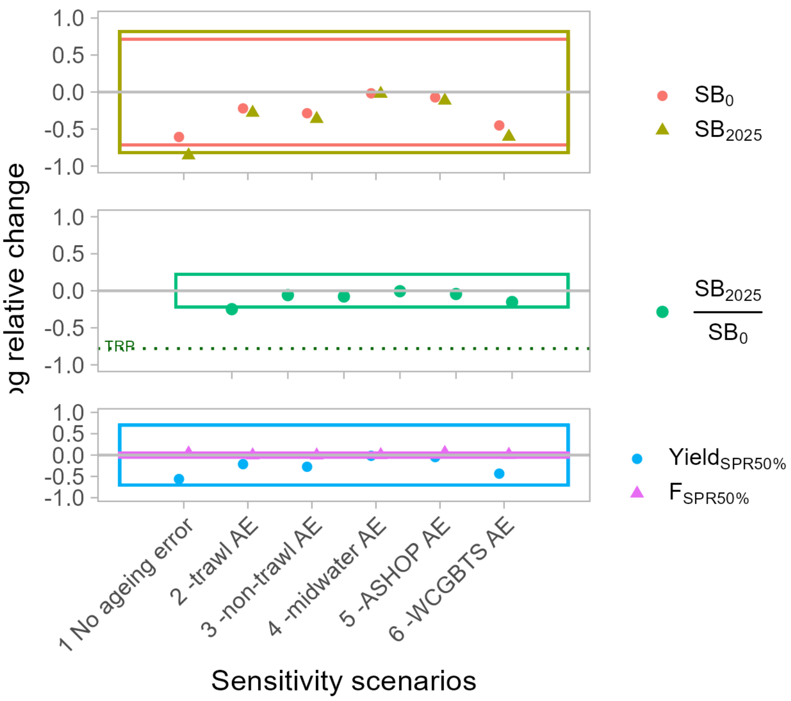

Figure 159: Log relative change (log((Model_sensi-Model_ref)/Model_ref)) in ageing error scenarios for 5 derived quantities. Colored boxes indicate 95 percent confidence interval of the reference model. See 'Sensitivity Analysis' section for more details on each scenario.

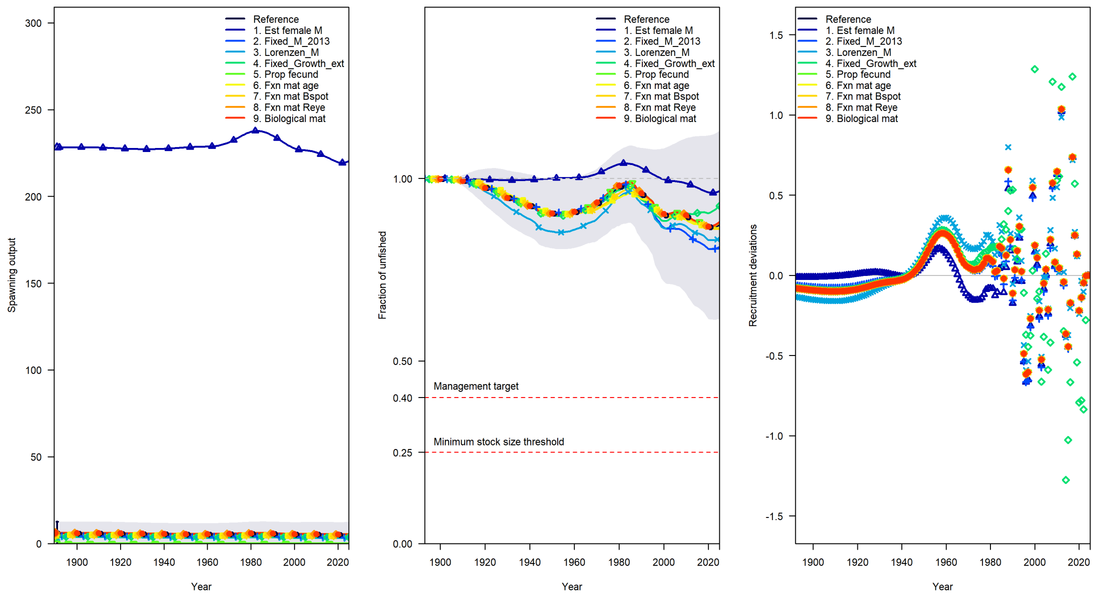

Figure 160: Comparison of spawning output (left panel), relative stock status (middle panel) and recruitment estimation (right panel) for models under different natural mortality, growth and reproductive biology scenarios. The reference model uses ageing error matrices for all age sources.

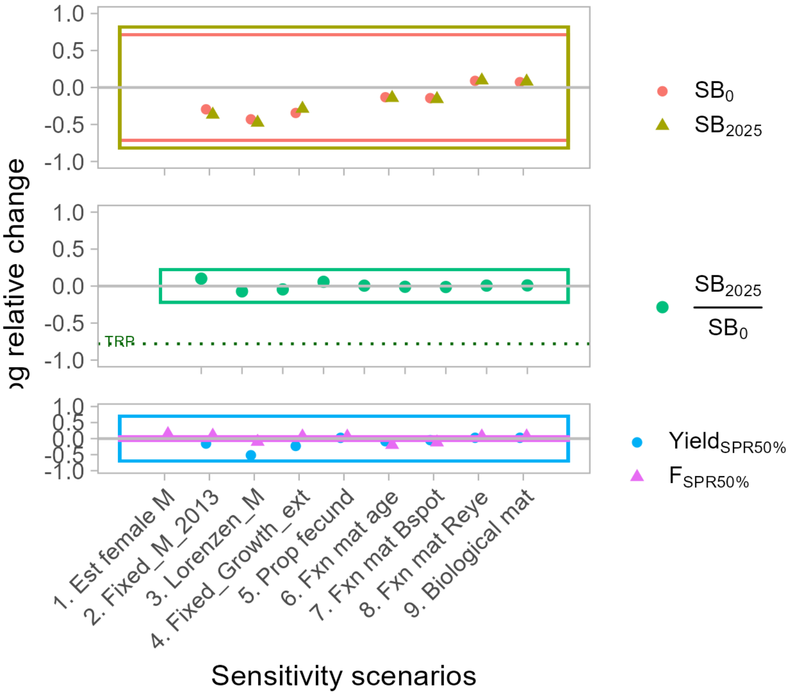

Figure 161: Log relative change (log((Model_sensi-Model_ref)/Model_ref)) in natural mortality, growth and reproductive biology scenarios for 5 derived quantities. Colored boxes indicate 95 percent confidence interval of the reference model. See 'Sensitivity Analysis' section for more details on each scenario.

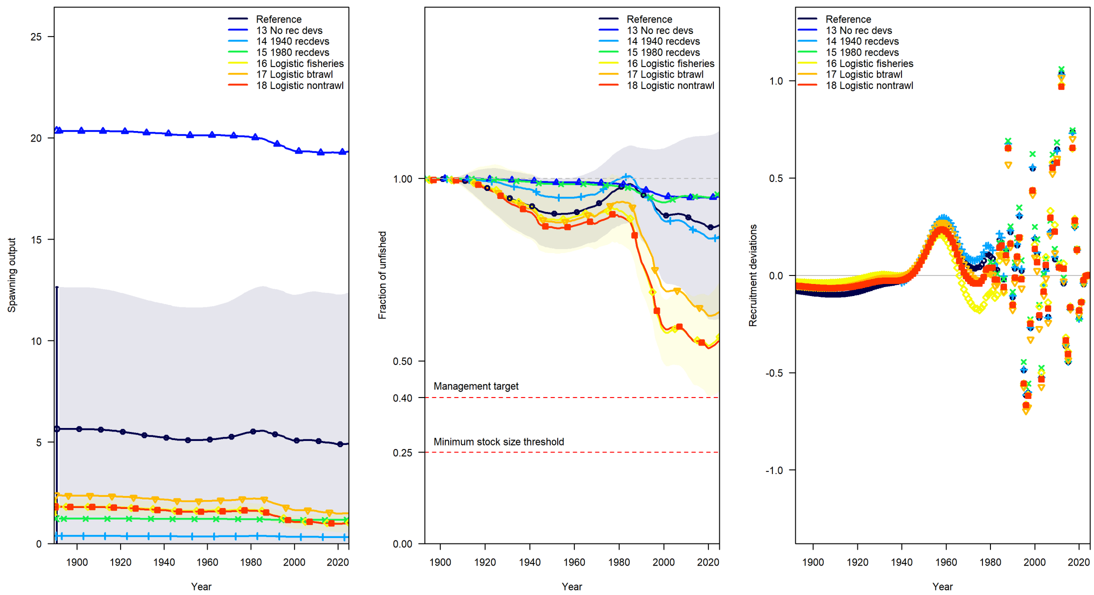

Figure 162: Comparison of spawning output (left panel), relative stock status (middle panel) and recruitment estimation (right panel) for models under different recruitment and selectivity scenarios. The reference model uses ageing error matrices for all age sources.

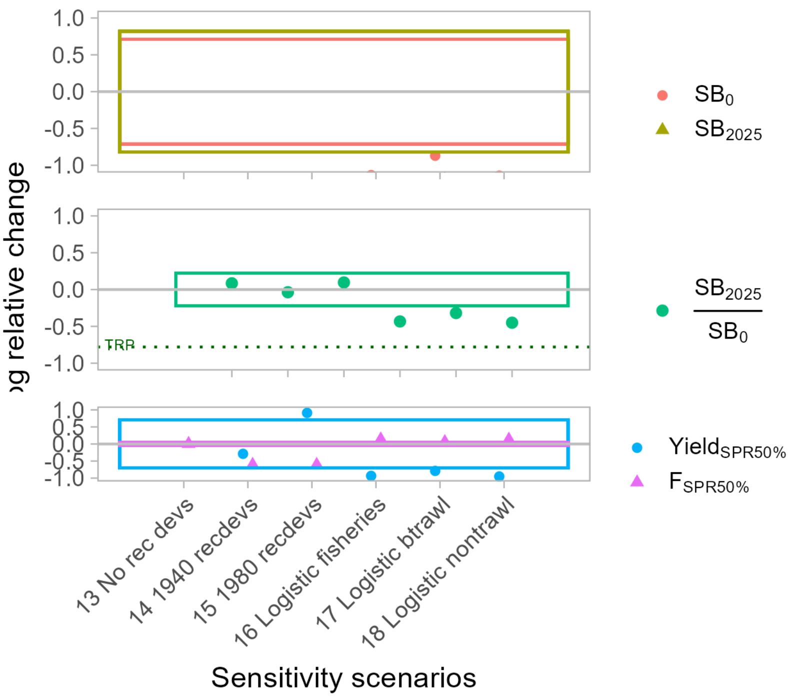

Figure 163: Log relative change (log((Model_sensi-Model_ref)/Model_ref)) in recruitment and selectivity scenarios for 5 derived quantities. Colored boxes indicate 95 percent confidence interval of the reference model. See 'Sensitivity Analysis' section for more details on each scenario.

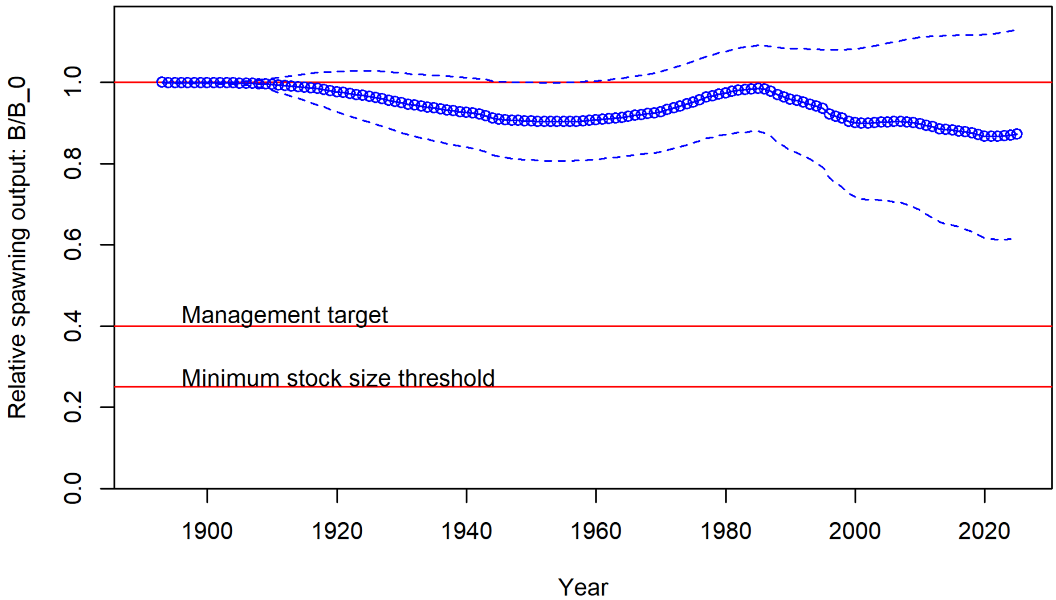

Figure 164: Placeholder.

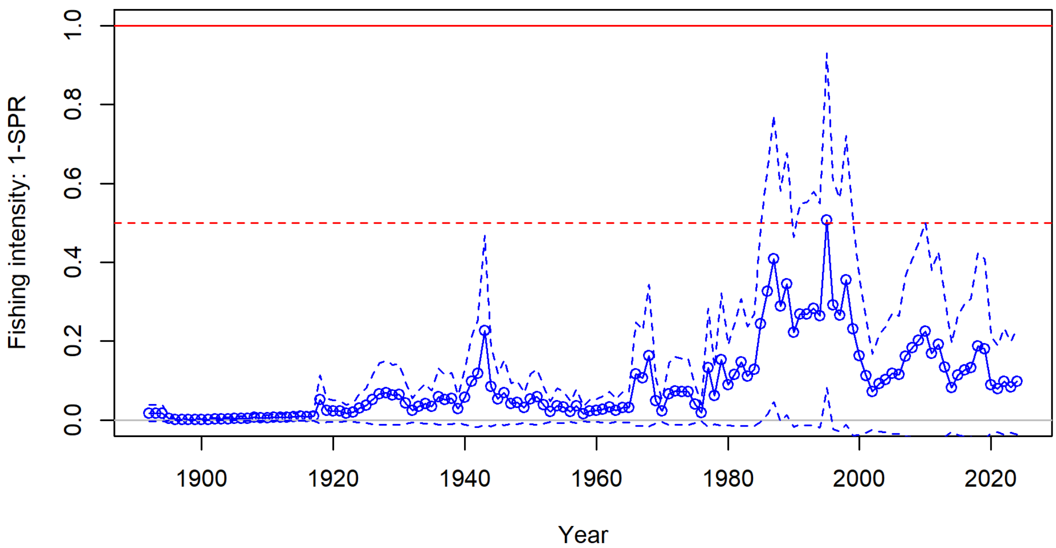

Figure 165: Placeholder.

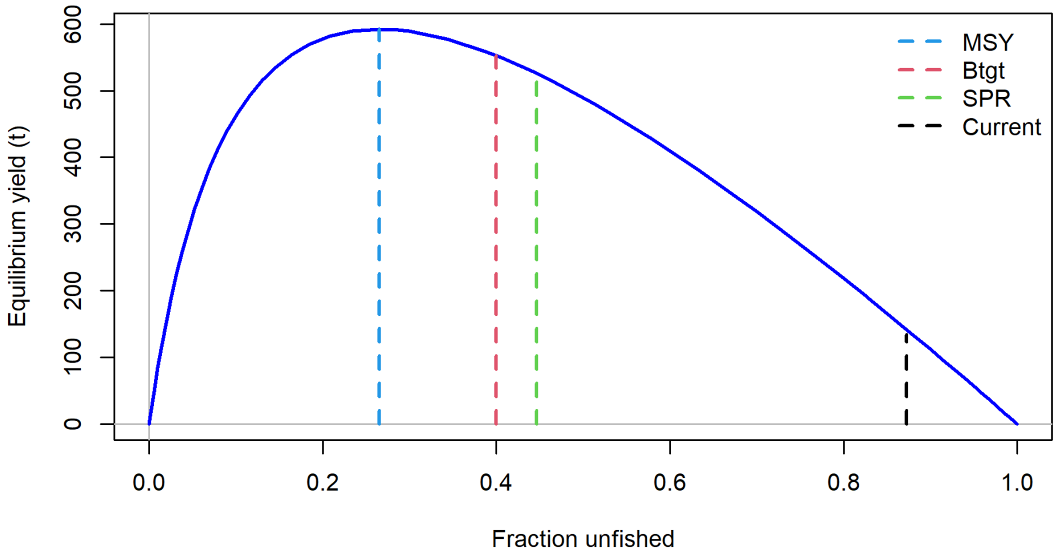

Figure 166: Placeholder.

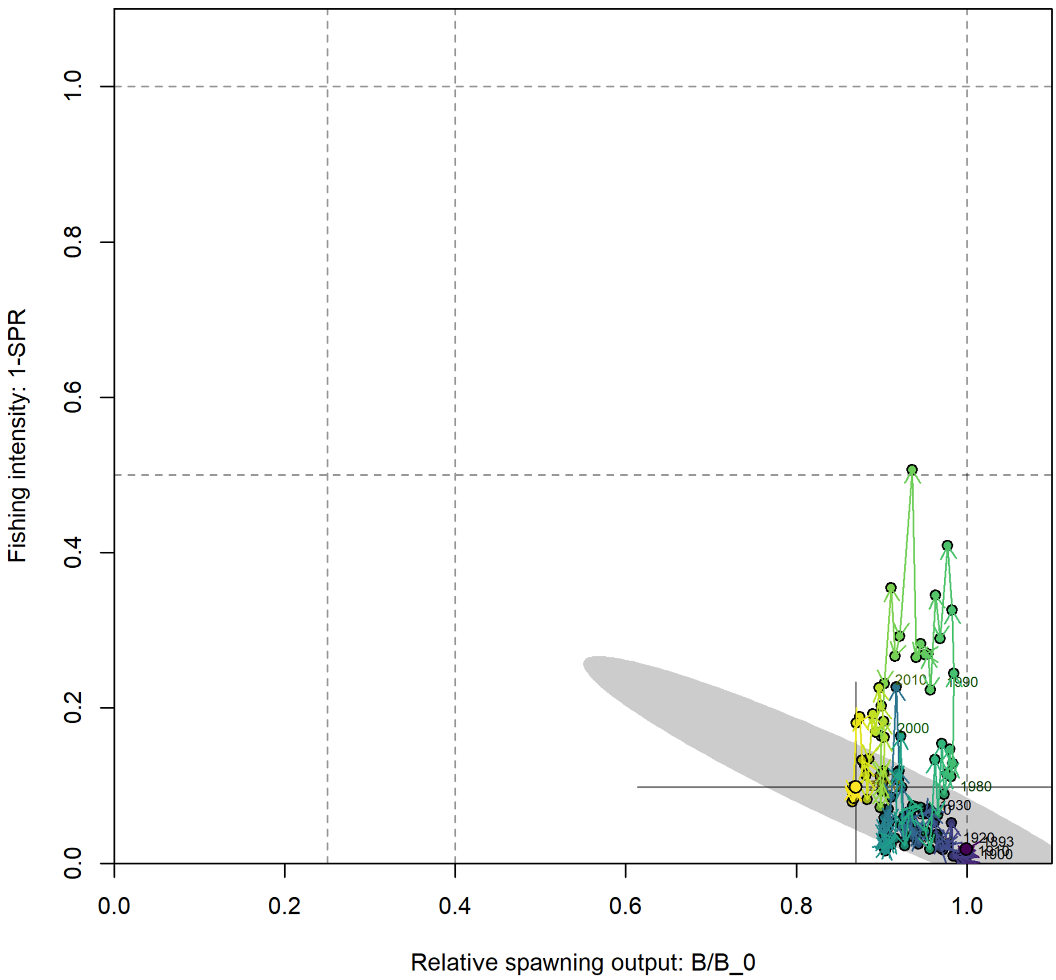

Figure 167: Placeholder.

9 Notes

10 Appendices