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 Description

This document presents the stock assessment for the Rougheye (*Sebastes aleutianus*) and Blackspotted (*Sebastes melanostictus*) Rockfishes, two species that form one management complex. Despite some identification advances and Rougheye and Blackspotted rockfishes are clearly genetically distinct species, data historically and contemporaneously remain available mostly for the Rougheye/Blackspotted Rockfish complex, not consistently at the species level. 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. This report is for the year 2025 in state and federal waters from California to Washington State, excluding consideration of the Puget Sound and Salish Sea (Figure 5). It seeks to use available catch, biological compositions in the for of lengths and ages, and potential indices of abundance and is the first assessment since the 2013 stock assessment (Hicks, Wetzel, and Harms 2013).

1.2 Catches

Rougheye/Blackspotted Rockfishes are mainly incidentally caught and retained, and caught mainly by trawl (both bottom and midwater) and non-trawl (largely hook and line gear) in commercial fisheries (Figure 1). The non-trawl removals were dominate until the 1960s were trawl-caught Rougheye/Blackspotted Rockfishes increased. The biggest removals were reported in the 1980s and came from the trawl fishery, but the most recent largest catches come from the at-sea-hake fishery (Table 1). Discards are generally thought to be negligible to low for most fo the time series.

Table 1: 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

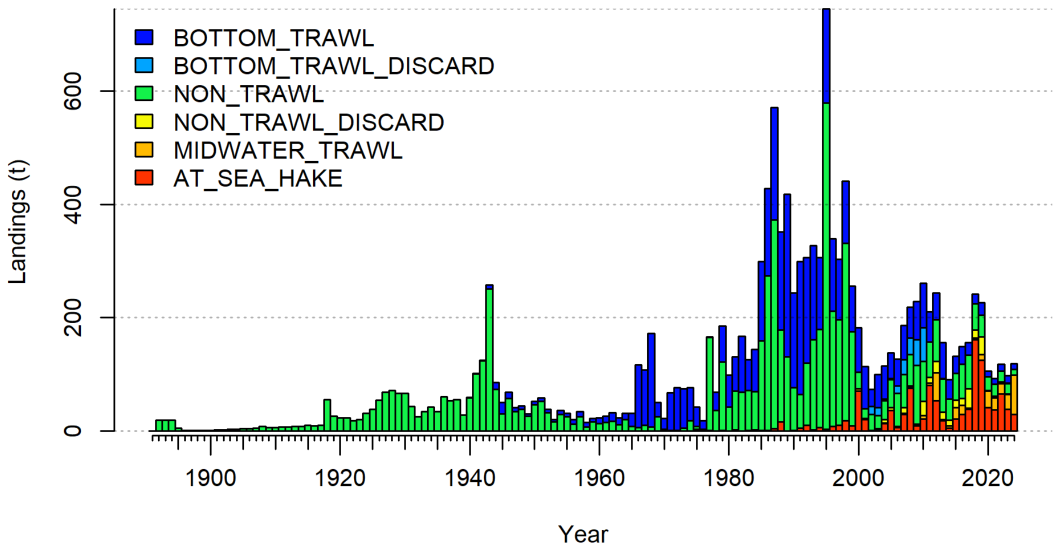

Figure 1: Landings in metric tons (mt) by year for each fleet.

1.2.1 Data and Assessments

The only previous stock assessment for Rougheye/Blackspotted Rockfishes for the west coast area was done in 2013. This assessment separates the discard catches from the retained fisheries, maintains the at-sea-hake fishery as its own fishery, and adds a midwater fishery that has emerged in the last 10 years. This stock assessment adds 10+ years of additional length data, and adds several more years of age data (included as conditioned on length data). The same four groundfish abundance surveys (Triennial, Alaska Slope, Northwest Fishery Science Center Slope, and the West Coast Groundfish Bottom Trawl Survey (WCGBTS)) 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.

1.2.2 Stock Output and Dynamics

The model estimates that the population , but increased through the 2000s to mid 2010s (Figure 2, Figure 3). Since 2017 (coincident with the increase in catches), spawning output has been gradually declining, but is still well above the management target of 40% of unfished spawning depletion (Table 2).

Table 2: 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

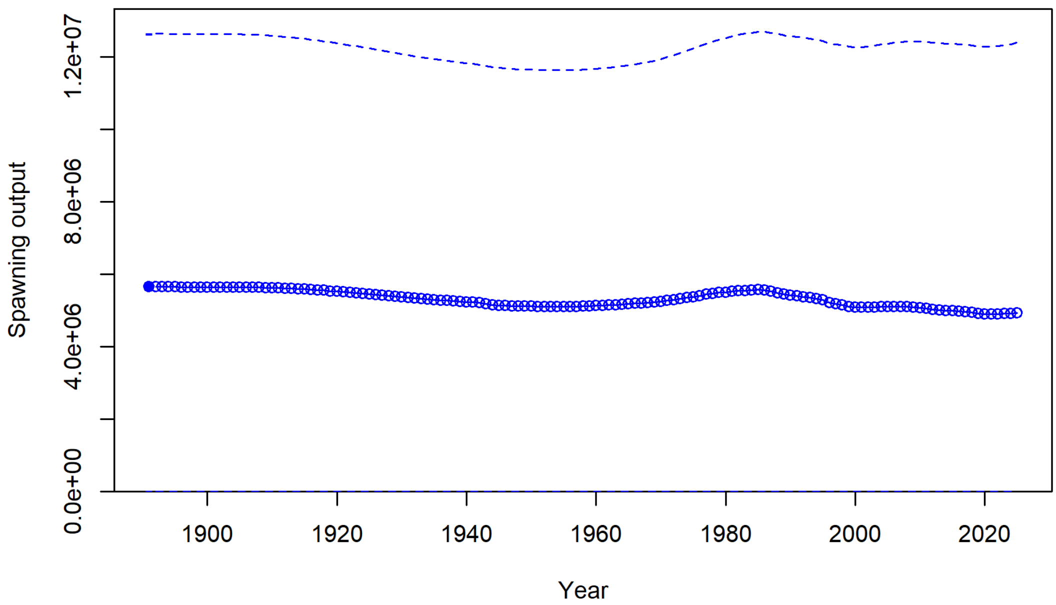

Figure 2: Estimated time series of spawning output (trillions of eggs) for the base model.

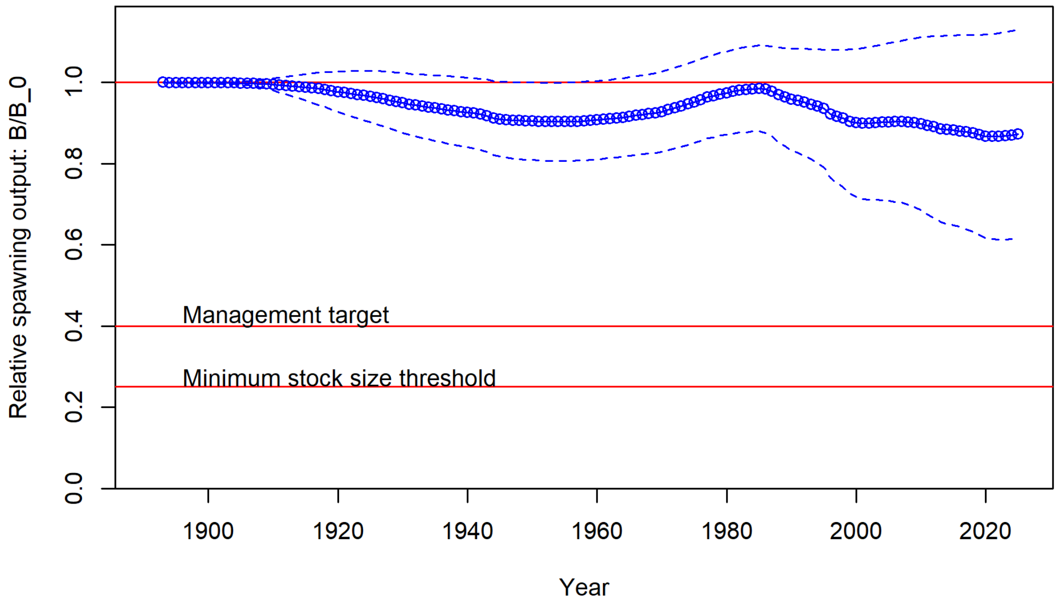

Figure 3: Estimated time series of fraction of unfished spawning output for the base model.

1.3 Recruitment

The estimated largest recruitment event throughout the time series was in 2008, which supported an increase in the population leading up to 2017 (Table 3, Figure 4). Recruitment is estimated to be relatively low in the later 2010s, but the model estimates that 2021 and 2023 may support large year classes in the future, with the estimates driven by the new recruitment index for both years.

Table 3: 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

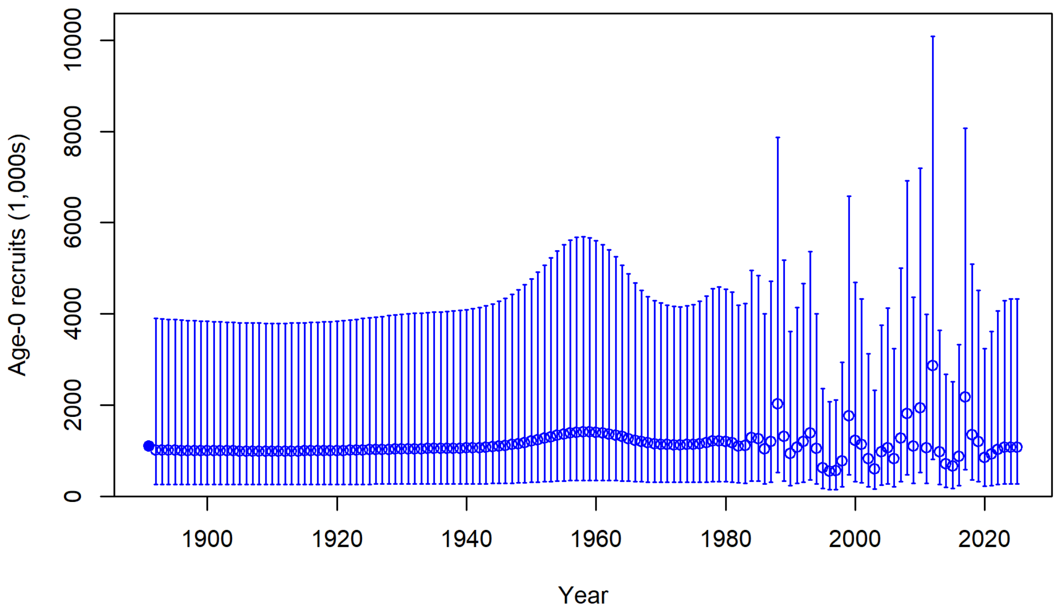

Figure 4: Estimated time series of age-0 recruits for the base model.

1.4 Ecosysystem Consideration

The assessment includes a sensitivity model with an oceanographic recruitment index. A number of ecosystem and environmental conditions were compiled by a team of ecosystem scientists at the NWFSC specific to the life history and distribution of northern yellowtail. These conditions included an evaluation of oceanographic conditions impacting recruitment, habitat change, prey availability, predator and competitor abundance, and climate vulnerability.

1.5 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 4. SPR, or the spawning potential ratio, is the fraction of expected lifetime reproductive output under a given fishing intensity divided by unfished expected lifetime reproductive output.

Table 4: 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

1.6 Management Performance

Although catch increased substantially in 2017, it has still been well below the overfishing limit, allowable biological catch, and annual catch limit (Table 5). Attainment of the OFL has averaged around 50% since the increase in landings, and was even lower in prior years.

Table 5: 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).

Year	OFL (mt)	ABC (mt)	ACL (mt)	Total dead catch (mt)
2015	NA	NA	NA	132.09211
2016	NA	NA	NA	148.95011
2017	NA	NA	NA	156.01664
2018	NA	NA	NA	241.51647
2019	NA	NA	NA	226.59244
2020	NA	NA	NA	106.07466
2021	NA	NA	NA	92.76237
2022	NA	NA	NA	117.42518
2023	NA	NA	NA	97.62859
2024	NA	NA	NA	118.93545

1.7 Evaluation of Scientific Uncertainty

The largest uncertainty in this model is the inability to fit a marked increase in the bottom trawl survey from 2014-2019. This coincides with an increase in catch-per-unit-effort from the midwater trawl fishery (which accounts for the majority of landings). The increase is likely due to the record 2008 year class, but the estimated size of the year class does not lead to a large enough increase to fit the survey index, and it is especially hard to fit the sudden decrease and then flattening of the index, given the estimated natural mortality rate and that catches were relatively stable from 2017-2024. The current assessment estimates that the stock is more depleted than it was in 2017, the time of the last assessment, which is likely the case. The magnitude of that difference is more uncertain.

1.8 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 of 0.5 are included in Table 6. Assumed catches for 2025 and 2026 for this projection were provided by the Groundfish Management Team, and catches from 2027 onward assume full attainment of the acceptable biological catch.

Table 6: 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
2025	—	—	968	—	—	—	—	4,929,120.000
2026	—	—	955	—	—	—	—	4,841,850.000
2027	—	—	—	942	0.935	880	880	4,760,140.000
2028	—	—	—	930	0.930	865	865	4,690,410.000
2029	—	—	—	919	0.926	851	851	4,624,410.000
2030	—	—	—	908	0.922	837	837	4,561,470.000
2031	—	—	—	897	0.917	823	823	4,501,170.000
2032	—	—	—	886	0.913	809	809	4,443,180.000
2033	—	—	—	876	0.909	796	796	4,386,880.000
2034	—	—	—	865	0.904	782	782	4,331,770.000
2035	—	—	—	854	0.900	769	769	4,277,630.000
2036	—	—	—	843	0.896	756	756	4,224,160.000

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# list(mod_low_C, mod_base_C, mod_high_C)
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#
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1.9 Unresolved Problems and Major Uncertainties

Test G

1.10 Research and Data Needs

Test H

1 Introduction

Rougheye (*Sebastes aleutianus*) and Blackspotted (*Sebastes melanostictus*) rockfishes, 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 et al. 2002, 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 (Gharrett et al. 2005, Hawkins et al. 2005) and have had phenotypic characteristics useful for identifying the species in the field identified (Gharrett et al. 2005, 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 and provides management advice for the two species combined. In this assessment, the term "rougheye rockfish" refers to rougheye/blackspotted rockfish unless specified.

These species are also closely related to shortraker rockfish (S. borealis) and are sometimes difficult to distinguish from shortraker rockfish without looking at the gill rakers.

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1.1 Choice of Stock Structure

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

1. 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 seems to be little ability to separate current or historical fishery data reliably in order to separate these two species into two stocks. Therefoire, 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.

2. 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 6). 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 7). 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 5). 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 Important features of 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 `r` Spp‘ 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. `r` Spp‘ 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 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.

Since 1977, landings of rockfish were higher until management restrictions were implemented in 2000. `r` Spp‘ 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 9.

1.7 Summary of Management History

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.

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 contained in the Sebastes complex. `r` Spp‘ information content was low, and using the Triennial survey to calculate an average biomass and assuming that fishing mortality equals natural mortality provided estimates of exploitation rates that indicated 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 40º 10’ N latitude in 1999 and the Sebastes complex was subsequently divided into nearshore, shelf, and slope complexes in 2000.

Rougheye/Blackspotted Rockfishes has been managed under trip limits for the minor slope rockfish complex in both north and south management areas since this time.

1.8 Management Performance

Table Table 7 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 as a part of the nothern minor slope rockfish complex is provided in Table (?) (ALI IS STILL CREATING THIS TABLE - WILL ADD TEXT FOR IT LATER).

1.9 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 8. 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 and state are reported in **Table X**. Figure 9 shows catches by 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 **(SpeciesSumOutput2_2017.csv-ADD TABLE)**. 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 10. The largest differences in this assessment from 2013 model are in Washington landings (Figure 13), 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 11 and Figure 12), 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 41; Figure 42).

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.

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 XX**. 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 **Table XX**. 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 midwater 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 fleet and year are summarized in **Tables XX-XX**.

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 14 through Figure 20 show length frequencies for bottom trawl, non-trawl and mid-water fleets by year, and Figure 25 through Figure 29 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. 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 16 and Figure 19).

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 16 and Figure 19).

Age distributions were included in the model as CAAL observations, binned according to length, age, sex, and year (Figure 30 through Figure 31).

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 XX**.

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 used to fit to survey data using spatial and spatiotemporal GLMMs with TMB or sdmTMB. The method is based on a delta model. Two distributions (gamma and lognormal) were considered for the catch-rate component. Comparing the standardized versions (i.e., Z-scores, which puts all the indices on the same scale for better comparison of trends) shows very similar trends among each model output in the indices, suggesting little difference in choice of model type. The lognormal error structure was selected for all surveys because it was shown to be able to better account for extreme catch events. The variance in the indices is generally high (0.3-0.5), suggesting the information content in these indices is low. Overall, catch densities are highest in northern Oregon and Washington.

Standardized indices for all four surveys overlaid are shown in Figure 35, where each index is rescaled to have mean observation = 1.0.

Description of each survey is provided below; information available from each survey and 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 XX)**. 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

Geostatistical models of biomass density were fit to survey data from the WCGBTS using Template Model Builder (TMB) (Kristensen et al. 2016) via the Species Distribution Models with Template Model Builder (`sdmTMB`) R package (Anderson et al. 2024) as configured within the indexwc R package (Johnson et al. 2025). These models can account for latent spatial factors with a constant spatial Gaussian random field and spatiotemporal deviations to evolve as a random walk Gaussian random field (J. T. Thorson et al. 2015). Delta-gamma and delta-lognormal distributions were investigated. Results are only shown for the model that led to the best model diagnostics, defined as similar distributions of theoretical normal quantiles and model quantiles (**fig-wcgbts_-qq**), high precision, lack of extreme predictions, and low Akaike information criterion (AIC). Estimates of biomass from this best model were predicted using a grid based on available survey locations.

The final 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 swept (km^2) to account for differences in effort. Fixed effects were estimated for each year and pass. The index was estimated for the area north of 42 degrees North. The data were truncated to depths shallower 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. Spatial variation was included in the encounter probability and 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 spatial structure.

The biomass estimates produced for this assessment using `sdmTMB` are comparable to the biomass estimates produced in the previous benchmark assessment (Figure 36). The index is relatively flat with high variation (Figure 37).

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 **(Figure XX)**. **Table XX** 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**.

Age distributions included bins from age 1 to age 100, with the last bin including all fish of greater age. **Table XX** 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 22 shows WCGBTS length frequencies by year, and Figure 32 through Figure 34 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 X)**.

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 **(Figure X)**.

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 index standardization followed a similar procedure to one used to generate the WCGBTS index, when geostatistical models of biomass density were fit to survey data using spatial and spatiotemporal GLMMs with TMB or sdmTMB. The model used a delta model with a lognormal distribution for the catch-rate component. No pass covariate was included in the analysis since Triennial Survey design did not include multiple passes.

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 estimated index is shown in Figure 38. 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 XX)**.

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 XX** 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 23 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 index standardization followed a similar procedure to one used to generate the WCGBTS and Triennial Survey indices, when geostatistical models of biomass density were fit to survey data using spatial and spatiotemporal GLMMs with TMB or sdmTMB. The model used a delta model with a lognormal distribution for the catch-rate component. As in case of Triennial survey, no pass covariate was included in the analysis.

The AFSC Slope Survey index is shown in Figure 39. 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 XX** 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 24 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 $\text{N}_y = 2.43 * N_{tow}$ 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 index standardization followed a similar procedure to one used to generate the other survey indices, when geostatistical models of biomass density were fit to survey data using spatial and spatiotemporal GLMMs with TMB or sdmTMB. The model used a delta model with a lognormal distribution for the catch-rate component. No pass covariate was included in the analysis.

The NWFSC Slope Survey index is shown in Figure 40. 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 43 and Figure 44 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 44).

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 $ln(5.4/A_{\max})$ 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 45).

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 46). 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 47) and 80 (Figure 48) 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 49 has the currently available age and length data. Female and male sample sizes are very similar. Estimated growth curves are also presented in Figure 49 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

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

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

The coefficient of variation (CV) of length by age and sex are shown in Figure 50. 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 $L_\infty = 51.43$, $k = 0.06$ and $t_0 = -3.30$ and $L_\infty = 54.2$ 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 51 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 -Punt et al. (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 52 and Figure 53 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 54).

The resultant sex-specific length-weight relationships are given in Figure 55, 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 55).

2.3.5 Maturity

Maturity for the Rougheye/Blackspotted Rockfish complex was estimated using 473 maturity samples collected from 2015 to 2024 on gls{odfw} and gls{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 XXX table Melissa provided**) and maturity ogives (**Fig. XXX figure Melissa provided, the one comparing biological and functional maturity**). 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 XXX table Melissa provided and Figure XXX figure Melissa provided, the one comparing overall functional maturity at length and for the two species**). 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 XXX table Melissa provided and Figure XXX figure Melissa provided, the one comparing overall functional maturity at age and for the two species**).

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.

Then,Rougheye/Blackspotted Rockfishes was assessment 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.

This benchmark assessment represents the first assessment of Rougheye/Blackspotted Rockfishes since 2013 (Hicks, Wetzel, and Harms 2013). Within this assessment, we re-evaluated all the data sources available for Rougheye/Blackspotted Rockfishes, reanalysed previously used data with current statistical methods and best practices, and re-evaluated modelling assumptions. Detailed description of changes made since 2013 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 since this panel, and several options are no available for consideration.*
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.*
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 not currently 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.
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 agers 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 stock structure section of this document.*
7. Connectivity of stocks across the species ranges. *This is also discussed in the stock structure section 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.

Bridging analysis was conducted to illustrate the impact of incremental changes. 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.
- Specifying 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 61 and Figure 60).
- Change in fleet structure, to include bottom trawl and non-trawl discards as separate fleets (see Section 3.4.3 for details). Results did not impact the model output (Figure 58 and Figure 59).
- Change in fleet structure, to split mid-water trawl catches from bottom trawl removals, 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.
- Adding 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 62).
- 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. Updating weight-length parameters did not produce a noticeable change. Model with new maturity parameters had slightly lower scale as length at 50% maturity now is slightly higher.
- 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.
- Allowing the bottom trawl fishery to have some amount of dome-shaped selectivity, consistent with the bottom trawl surveys. This change resulted in the increase of

stock scale.

- Fixing natural mortality for male at the value informed by Hamel and Cope (2022) based on maximum ages observed for Rougheye/Blackspotted Rockfishes, while estimating female natural mortality using Hamel and Cope (2022) prior, to allow natural mortality values in light with maximum ages observed.

The list above documents only the most important changes made to this assessment relative to the previous one.

With new fecundity parameters, the model produces spawning output rather that spawning biomass, and 2013 model 2025 spawning outputs are no longer comparable. However, we ran 2013 model with new fecundity parameters to allow for comparison between assessments, and the results of bridging analysis with most impactful changes are shown in Figure 62 and Figure 63. This assessment (compared to 2013 assessment) estimates higher stock scale, primarily due to change in treatment of fishery selectivity parameters. Change in selectivity assumptions allow to substantially improve fits to length and age composition data in fisheries and surveys, while changes in life history parameters (specifically, natural mortality) allowed for model to anchor the model on natural mortality values consistent with maximum ages observed.

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 5). 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 9). 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 12.

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 64). 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 Reference Model Diagnostics and Results

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 65).

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 66 and Figure 67). 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 Fits to the Data

3.7.2.1 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 68). 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 69 and Figure 70)
- Bottom trawl discard (Figure 71)
- Non-trawl (Figure 72 and Figure 73)
- Non-trawl discard (Figure 74)
- Midwater trawl (Figure 75)
- At-sea-hake (Figure 76)

Surveys

- Triennial (Figure 77)
- Alaska slope (Figure 78)
- West Coast Groundfish Bottom Trawl (Figure 79)

Pearson residuals of fits to the fishery (Figure 80) and survey (Figure 81) 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 82 to Figure 90). 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.

3.7.3 Ages

3.7.3.1 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 91 to Figure 100), 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 101 to Figure 105). 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 106 to Figure 122).

3.7.3.2 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 123 to Figure 127). 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.

3.7.4 Fits to Indices of Abundance

The fits to the 4 available indices of abundance demonstrate little information content in the survey indices (Figure 128 to Figure 131). 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 Reference Model Outputs

3.8.1 Parameter Estimates

Estimated parameters by category are given in Table 11. The reference model parameter estimates along with asymptotic standard errors are shown in Table 12 and the likelihood components are shown in Table 13. Estimates of derived outputs and reference points and approximate 95 percent asymptotic confidence intervals are provided in Table 14.

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 12 and Figure 132), 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 133) 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 134). 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 135). Values for the estimated selectivity parameters are in Table 12.

The estimate of initial recruitment (lnR_0) is much higher than the previous assessment (6.995 vs. 6.20). While this is a large increase in the scale of the stock, a value of 6.995 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 (). 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 = 0.621/6.995), 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 15 and plotted in Figure 136. 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 137; 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 138. The bias adjustment plot (Figure 139) 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 140). Noticeable recruitment years are seen in 1988, 1993, 1999, 2008, 2010, 2012, and 2017 (Figure 141). 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 were as follows:

- Removal of single data sources
  - 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
- Data weighting - JASON - DID YOU DO THIS? ADD THIS.
  11. No data-weighting
  12. Dirichlet data-weighting
  13. McAllister-Ianelli data weighting
- Other - DO WE HAVE OTHERS?

Likelihood values and estimates of key parameters and derived quantities from each data source removal sensitivity are available in Table 16 to Table 19. Additionally, time series of spawning output and relative spawning output are shown in Figure 146 to Figure 153. Derived quantities relative of all data removal sensitivities to the reference model are summarized in Figure 154. Generally, the removal of indices of abundance decreased both the spawning output and the relative spawning output as compared to the base model (Figure 146 and Figure 147). 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 148 and Figure 149). 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 150 and Figure 151). 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 152 and Figure 153). Again, the WCGBTS appears to be the most influential of the data sources with age composition information.

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 .

3.9.1.2 Model Specification Sensitivities

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

- Life history estimation
  - Natural mortality (M)
    1. Estimate M
    2. Lorenzen age varying M
    3. Use Oregon 2023 assessment sex-specific M values (females = 0.19; males = 0.17)
    4. Maintain sex ratio in age and length data (sex option 3) and estimate M
  - Growth parameters
    6. Fix all growth parameters to external values
    7. Fix all growth parameters to external values, estimate M
    8. Estimate L_min
    9. Fix $t_0 = 0$
    10. Estimate CV_{young} and CV_{old}
  - Reproductive Biology

Sensitivity analyses were conducted to examine the impacts of including different reproductive biology data and parameterization in the assessment. We examined using proportional fecundity to weight (instead of an exponential relationship), functional maturity at age (instead of length), functional maturity at length for Blackspotted Rockfish (instead of all data available for the complex), functional maturity at length for Rougheye Rockfish (instead of all data available for the complex), and biological maturity at length for the complex (instead of functional maturity at length for the complex). 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 recruitment for all years in the model
```

Other

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 Likelihood Profiles

3.9.3 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) and relatives stock status (Figure) estimates show a generally consistent pattern in population scale and trend, within the error of the reference model. All models show the population increasing. This results in a stock status in the precautionary zone over the 5 year consideration. 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.

3.9.4 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 Acknowledgements

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6 Tables

Table 7: 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 8: 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-H
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 8: 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 8: 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-
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 9: 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

#“‘{r, results = “asis”} ##| label: tbl-area-spex ##| warning: false ##| echo: false ##| tbl-cap: “Adopted coastwide OFL (mt) and ABC (mt) values and the area-based ACL (mt) north and south of 36 N. latitude by year.” ##| tbl-pos: H

#area_management_table |> # gt::gt() |> # gt::fmt_number(# columns = c(2:5), # decimals = 0 #) |> # gt::tab_options(# table.font.size = 12, # latex.use_longtable = TRUE #) |> # gt::as_latex()

#“‘

Table 10: 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 11: 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

Table 12: 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
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

Label	Value	Phase	Bounds	Status	SD	Prior
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)
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)

Label	Value	Phase	Bounds	Status	SD	Prior
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)
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)

Label	Value	Phase	Bounds	Status	SD	Prior
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)
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)

Label	Value	Phase	Bounds	Status	SD	Prior
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)
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)

Label	Value	Phase	Bounds	Status	SD	Prior
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)
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)

Label	Value	Phase	Bounds	Status	SD	Prior
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
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

Label	Value	Phase	Bounds	Status	SD	Prior
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
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

Label	Value	Phase	Bounds	Status	SD	Prior
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
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

Label	Value	Phase	Bounds	Status	SD	Prior
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
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

Label	Value	Phase	Bounds	Status	SD	Prior
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 13: 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 14: 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 15: 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 15: 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 15: 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	Exploita- tion 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

<—- sensitivities —>

Table 16: 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 17: 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 18: 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 19: 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

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7 Figures

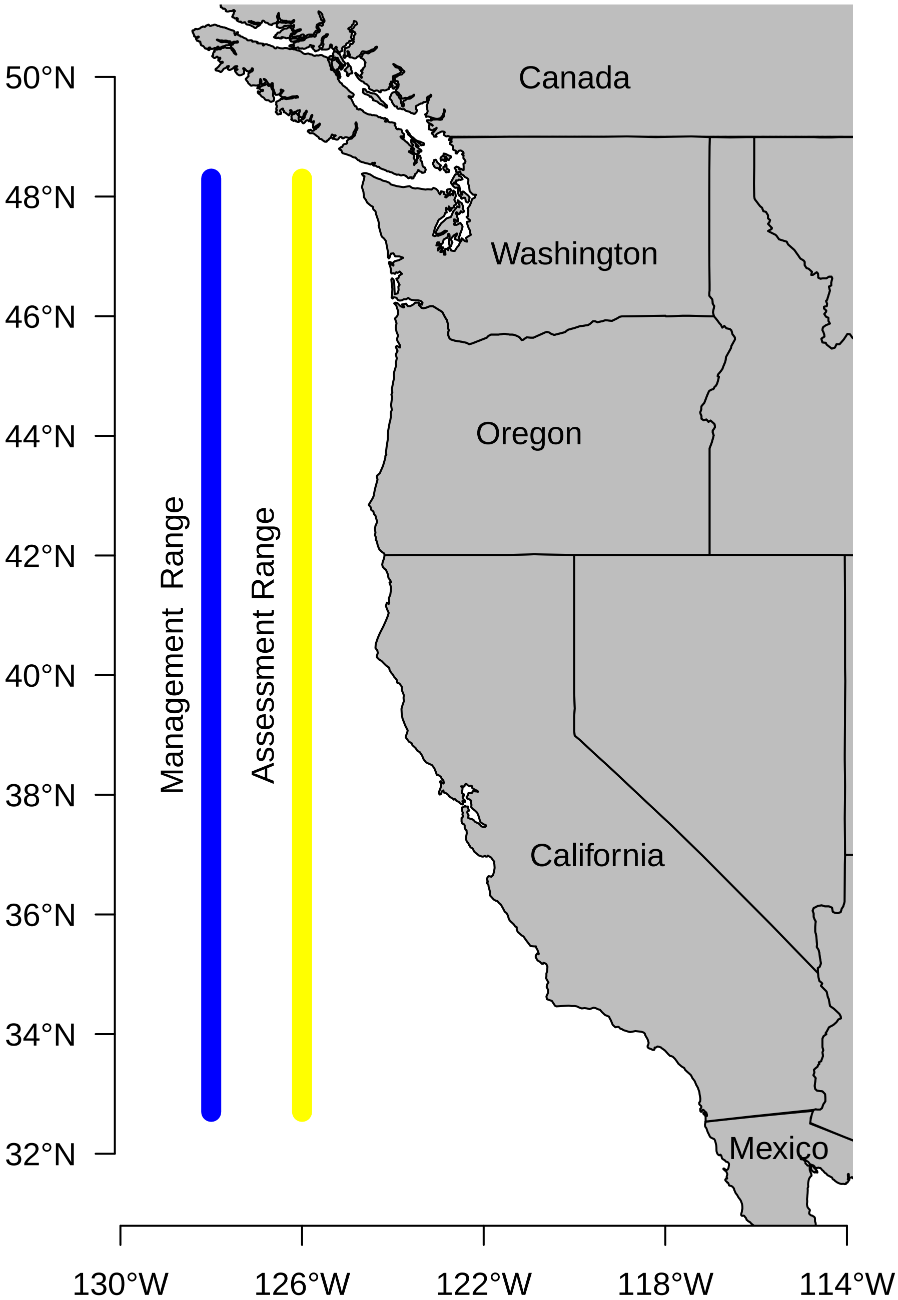

Figure 5: Map of the assessment area.

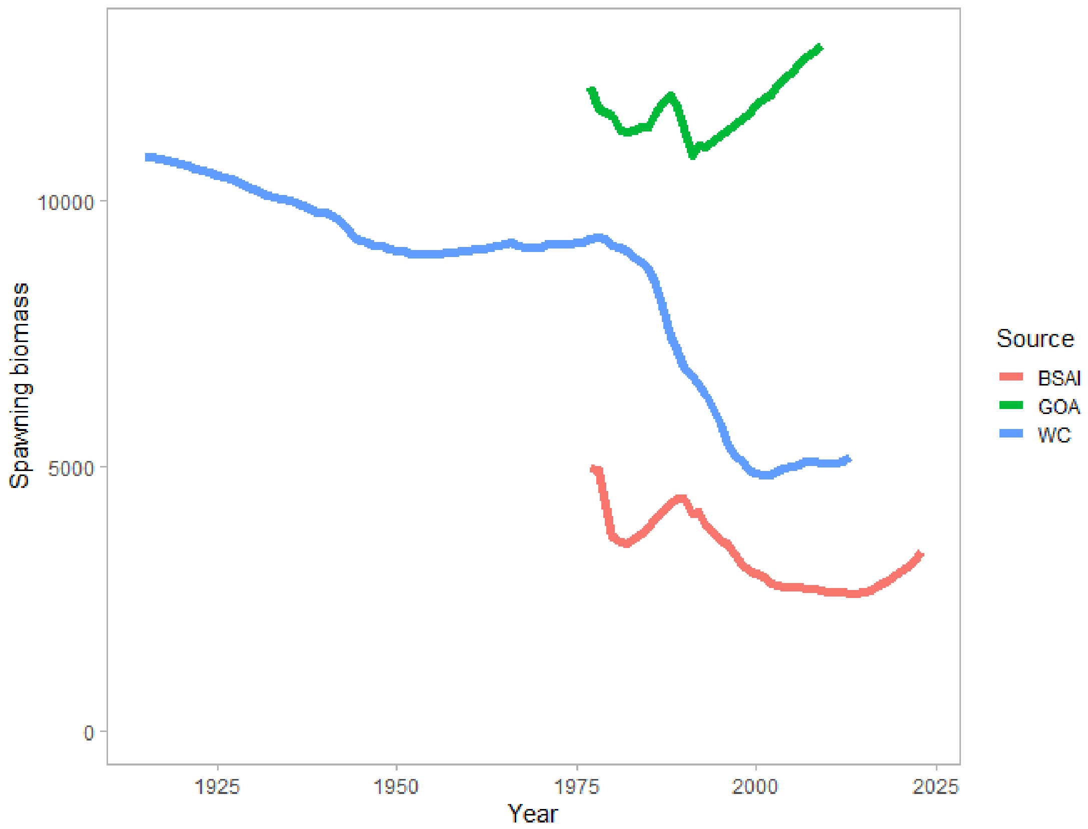

Figure 6: Estimates of spawning biomass (current spawning output/unfished spawning output) for the Rougheye/Blackspotted rockfish complex from the two most recent Alaska (Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA)) and the 2013 U.S. west coast stock assessment.

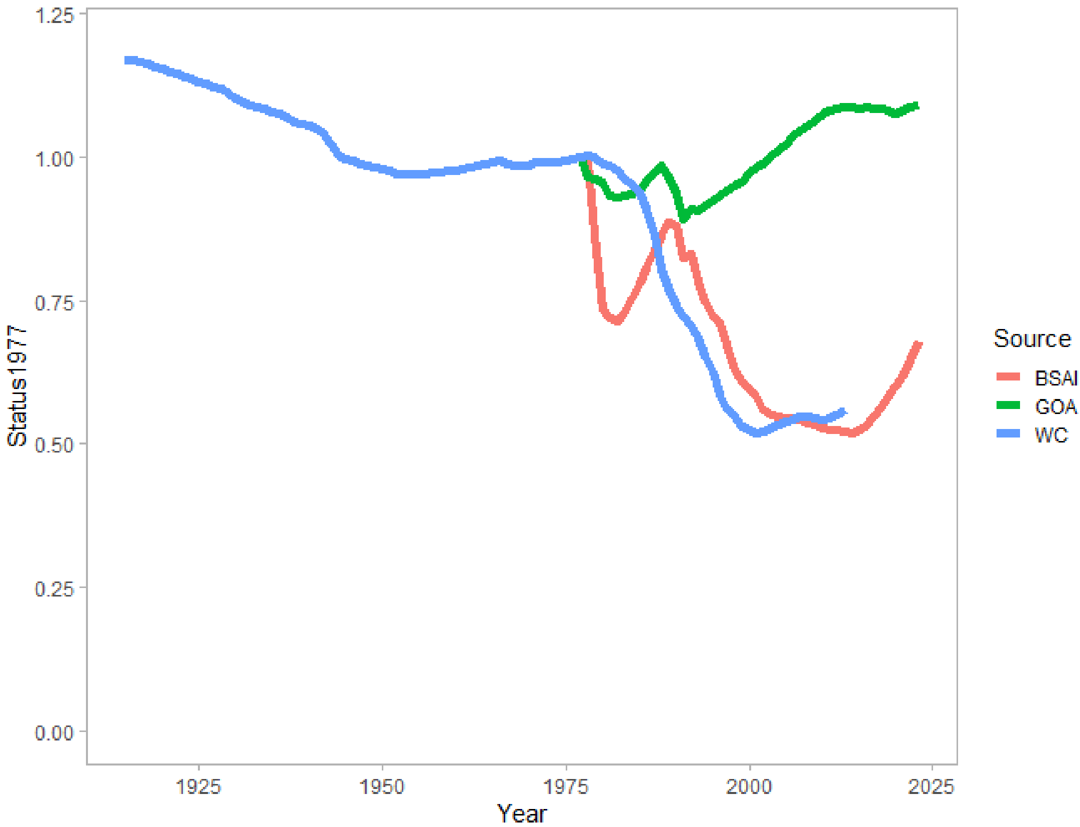

Figure 7: Estimates of relative stock size (current spawning output/unfished spawning output) relative to 1977 (the common year in all stock assessments compared) for the Rougheye/Blackspotted rockfish complex from the two most recent Alaska (Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA)) and the 2013 U.S. west coast stock assessment.

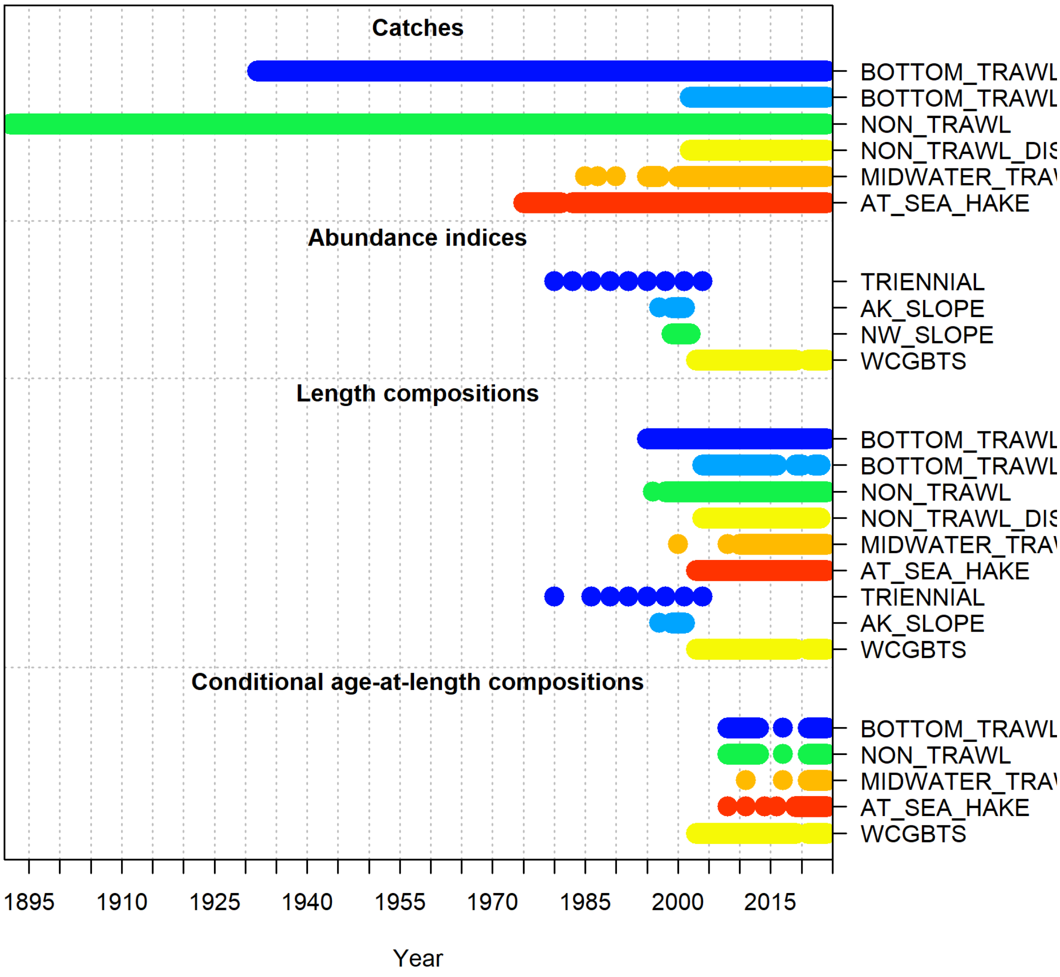

Figure 8: Data used in the base model.

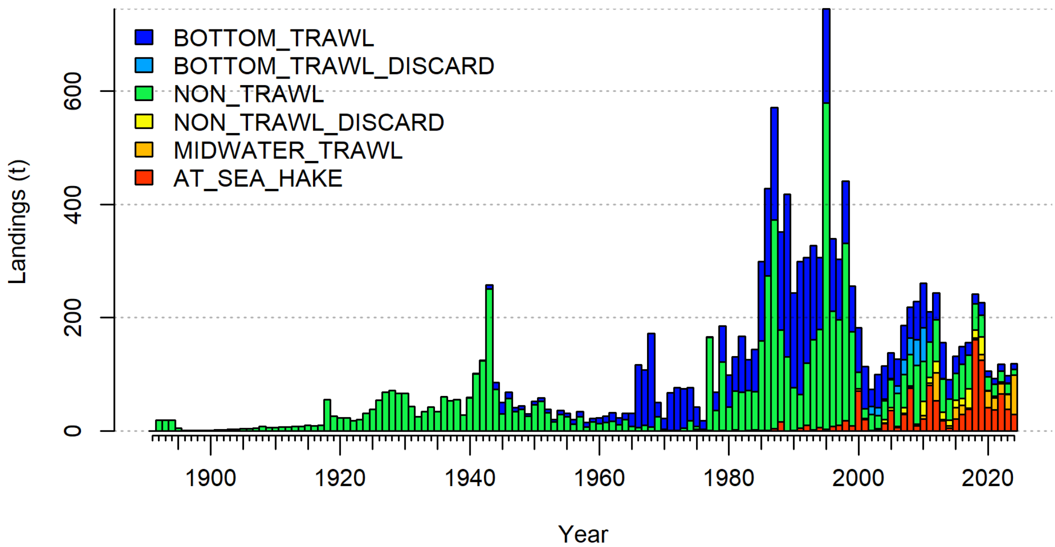

Figure 9: Landings by fleet.

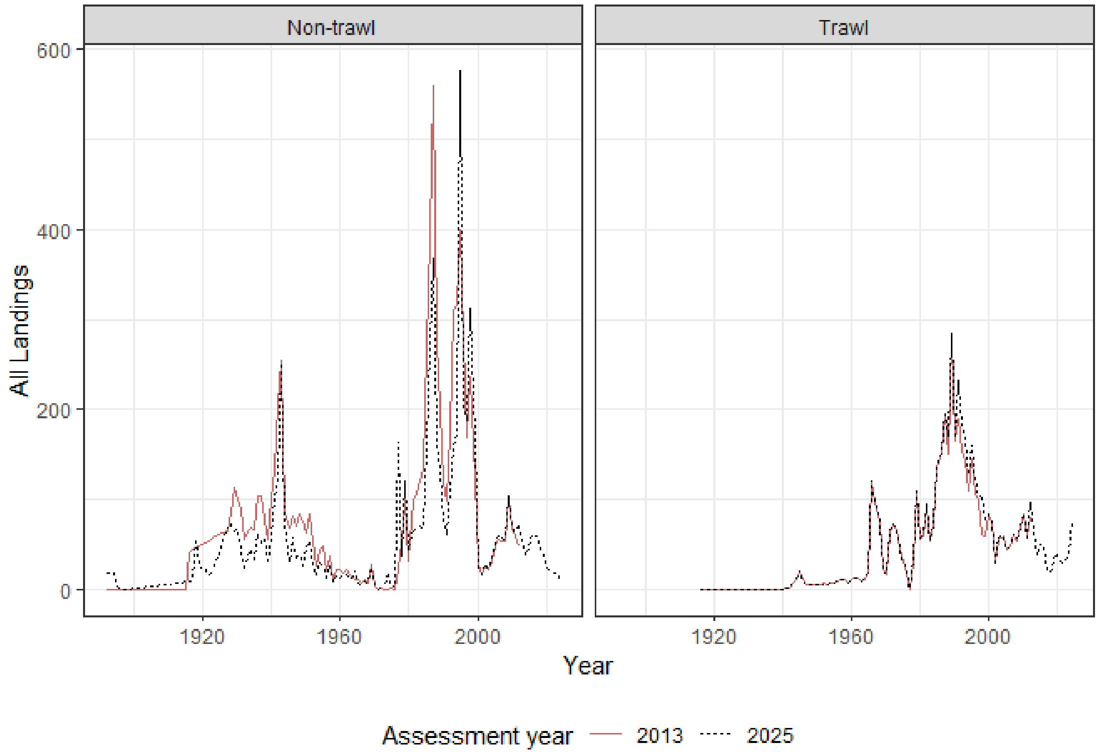

Figure 10: Landings across all states for non-trawl and trawl fisheries compared between the 2013 assessment and updated landings for the 2025 stock assessment model.

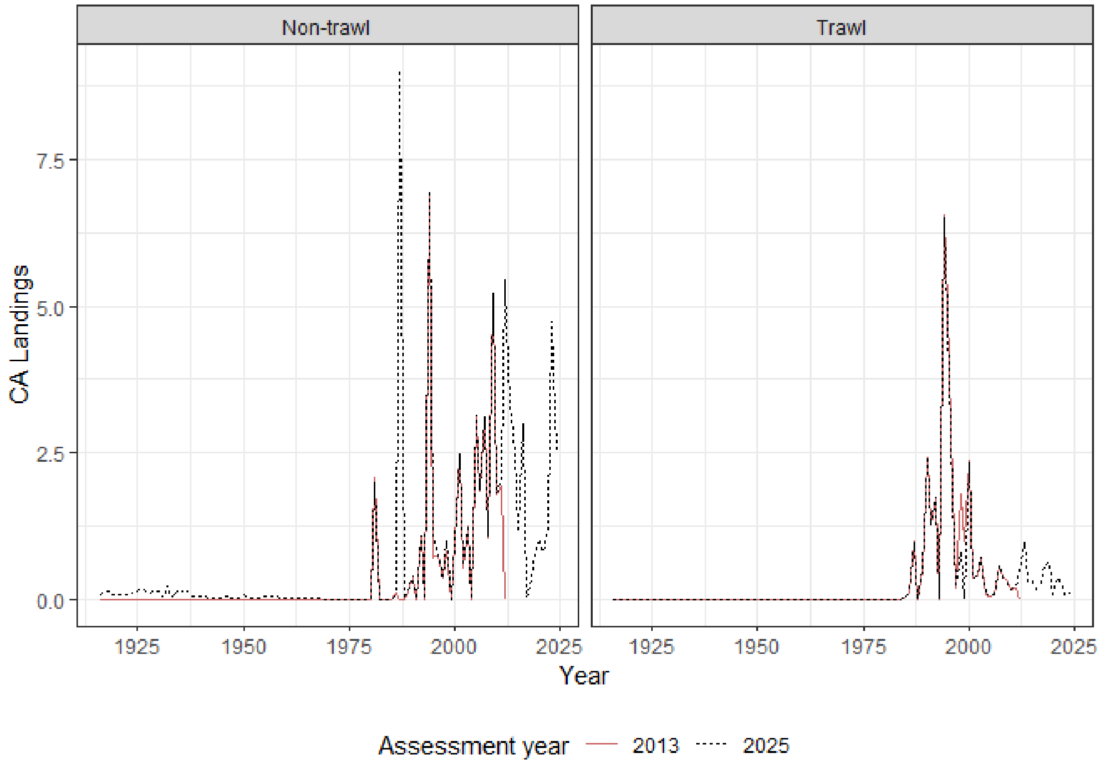

Figure 11: California state landings for non-trawl and trawl fisheries compared between the 2013 assessment and updated landings for the 2025 stock assessment model.

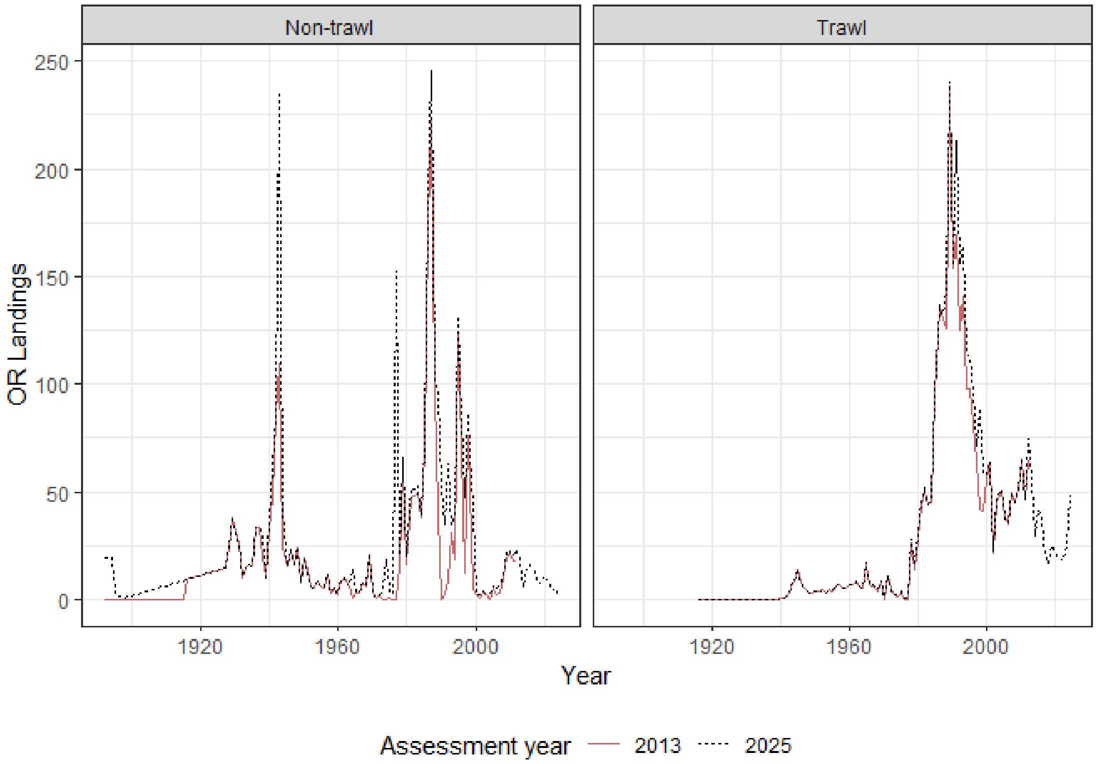

Figure 12: Oregon state landings for non-trawl and trawl fisheries compared between the 2013 assessment and updated landings for the 2025 stock assessment model.

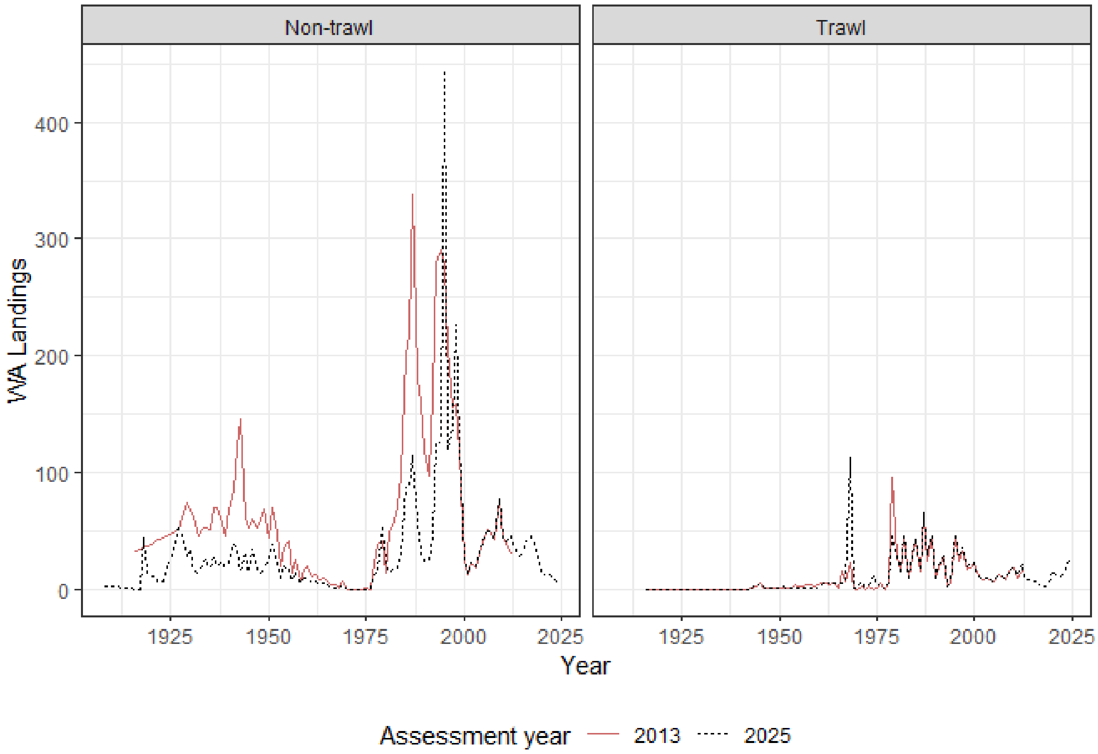

Figure 13: WA. Washington state landings for non-trawl and trawl fisheries compared between the 2013 assessment and updated landings for the 2025 stock assessment model.

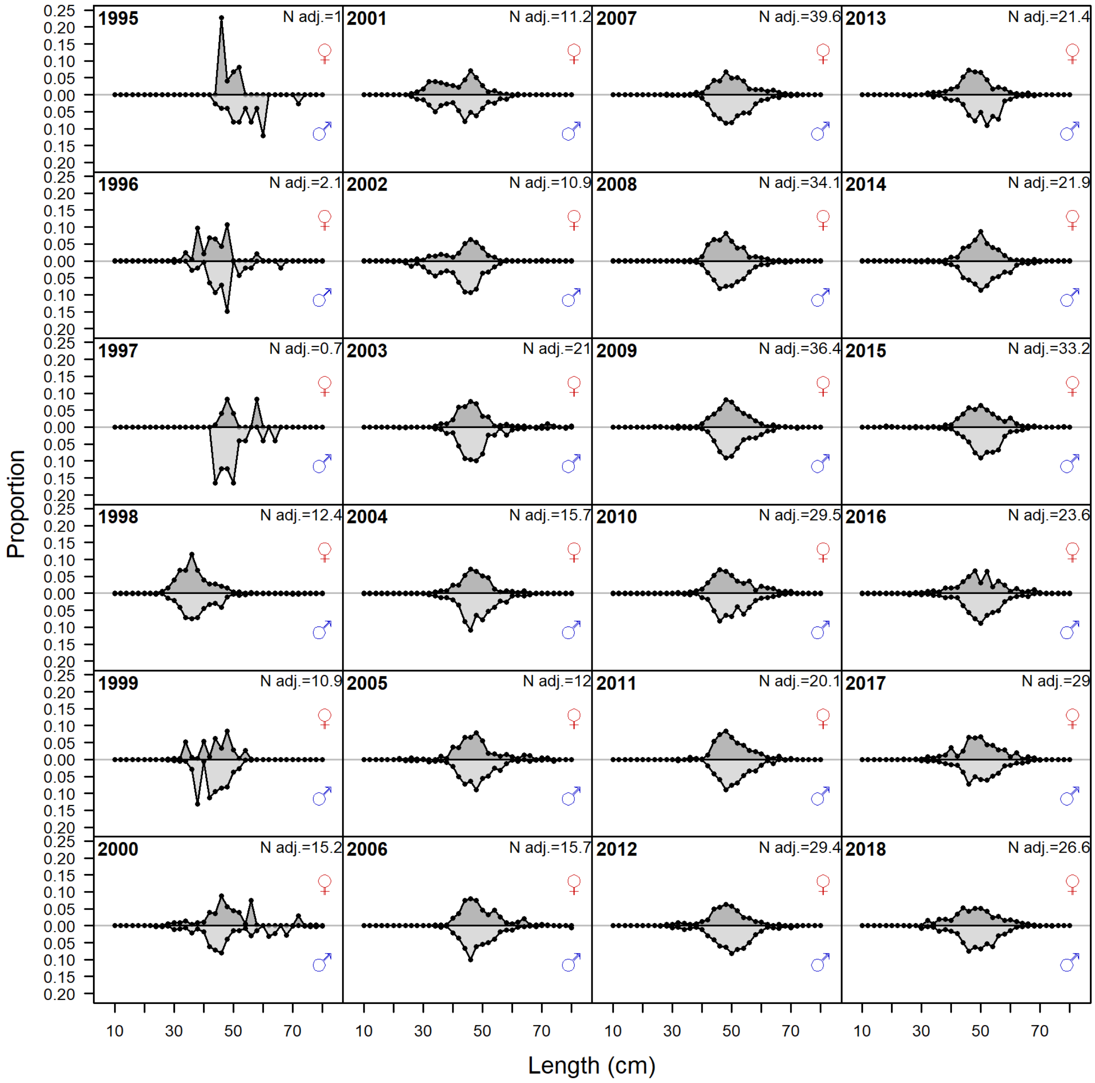

Figure 14: Length composition data for bottom trawl fleet.

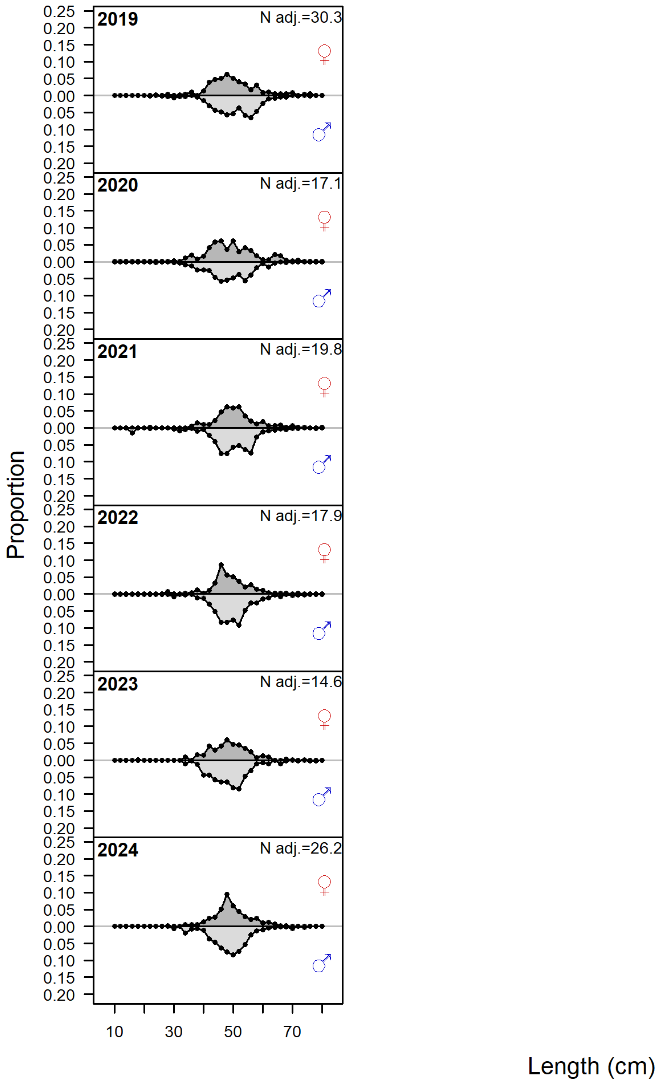

Figure 15: Length composition data for bottom trawl fleet, continued.

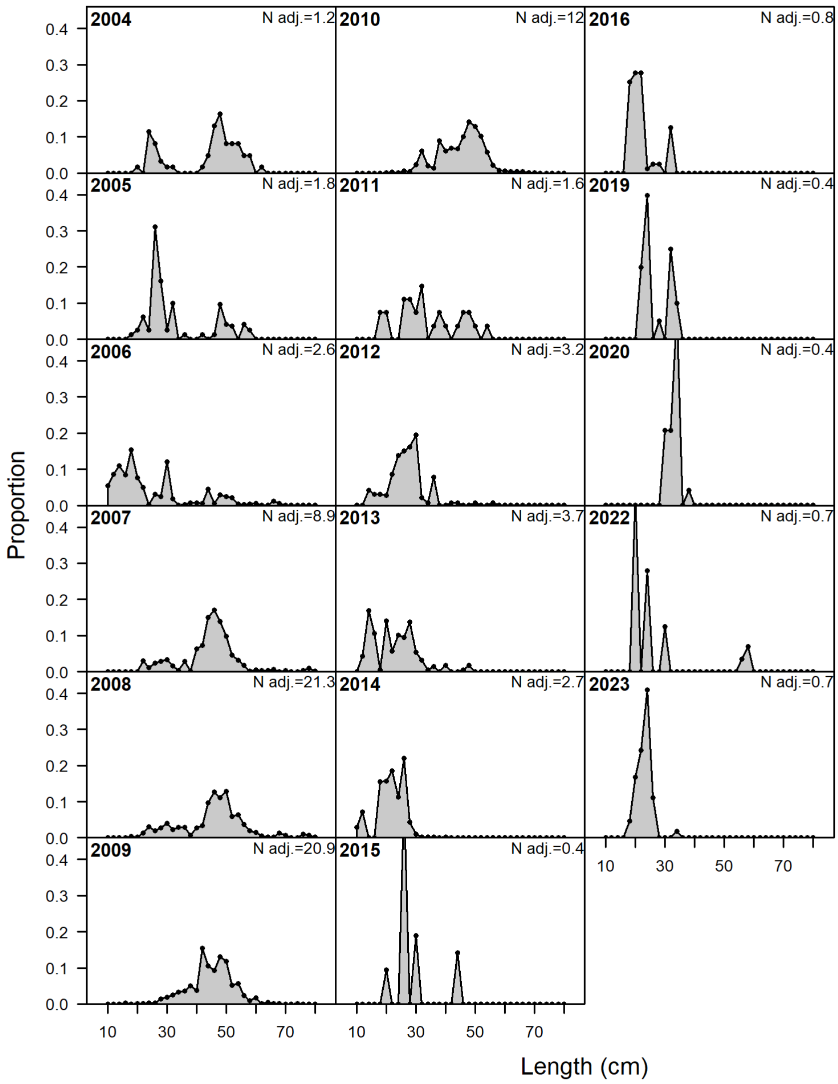

Figure 16: Length composition data for bottom trawl discard fleet.

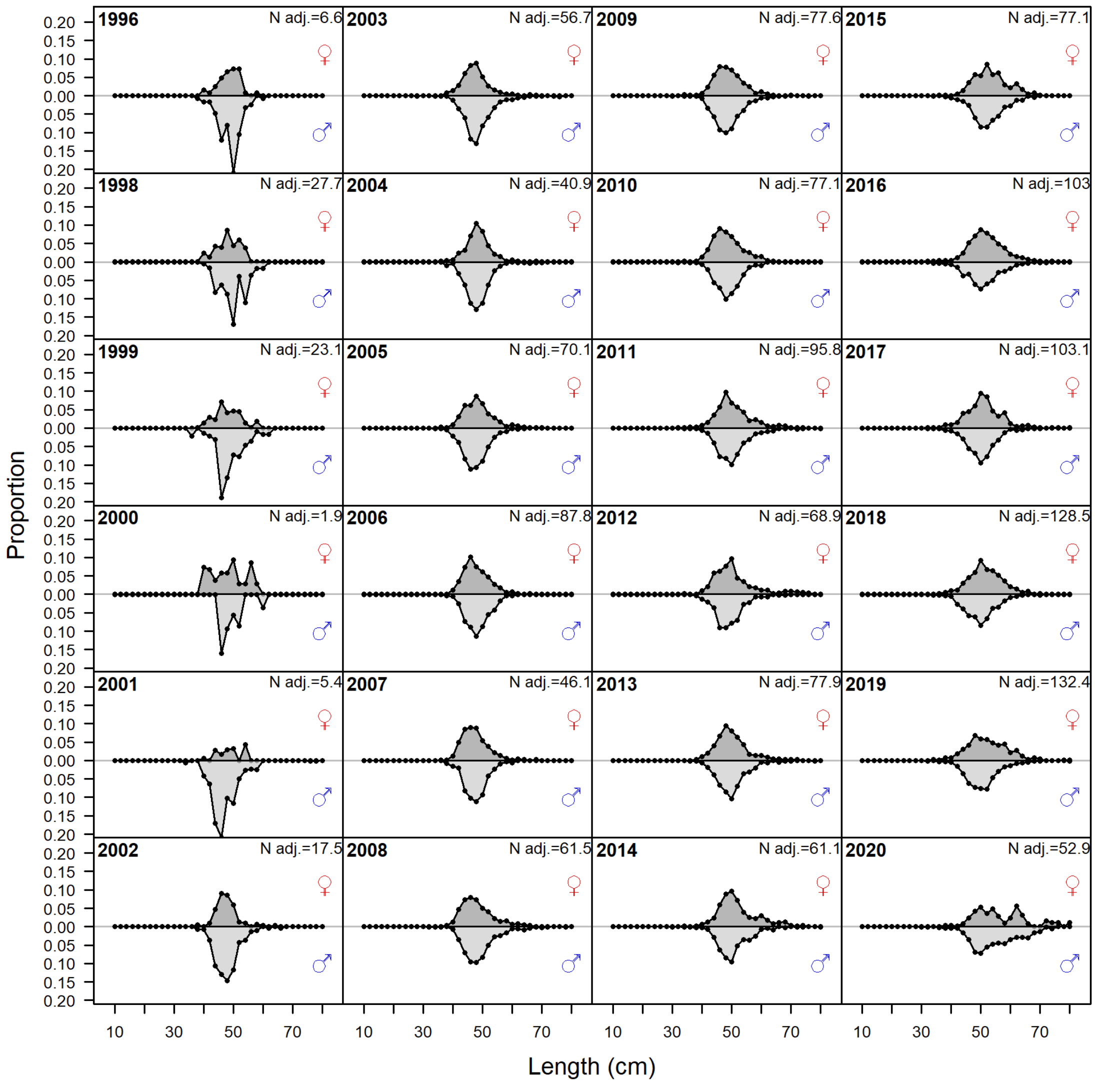

Figure 17: Length composition data for non-trawl fleet.

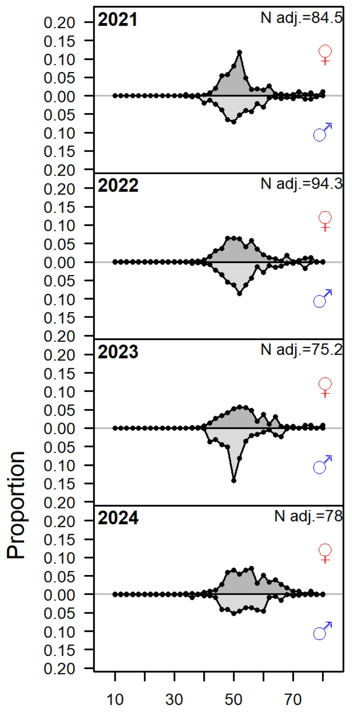

Figure 18: Length composition data for non-trawl fleet, continued.

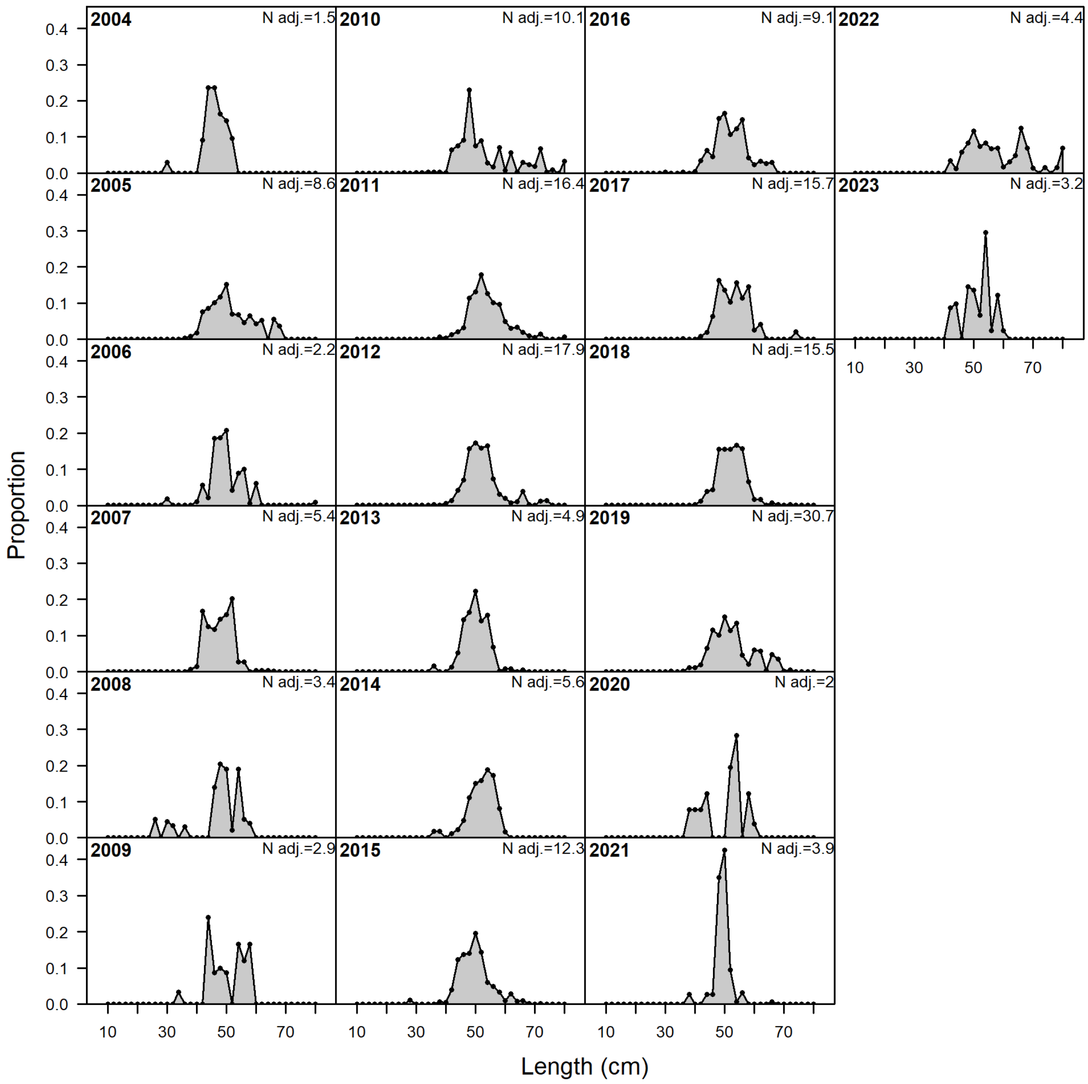

Figure 19: Length composition data for non-trawl discard fleet.

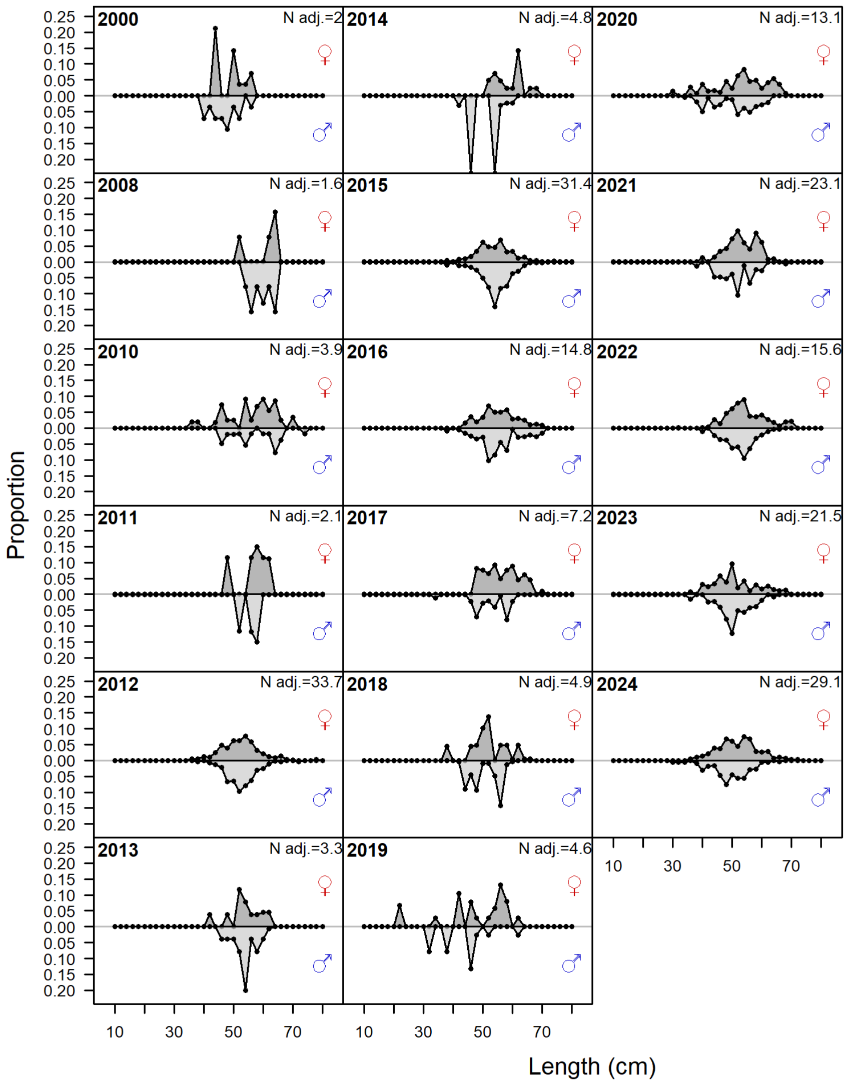

Figure 20: Length composition data for mid-water trawl fleet.

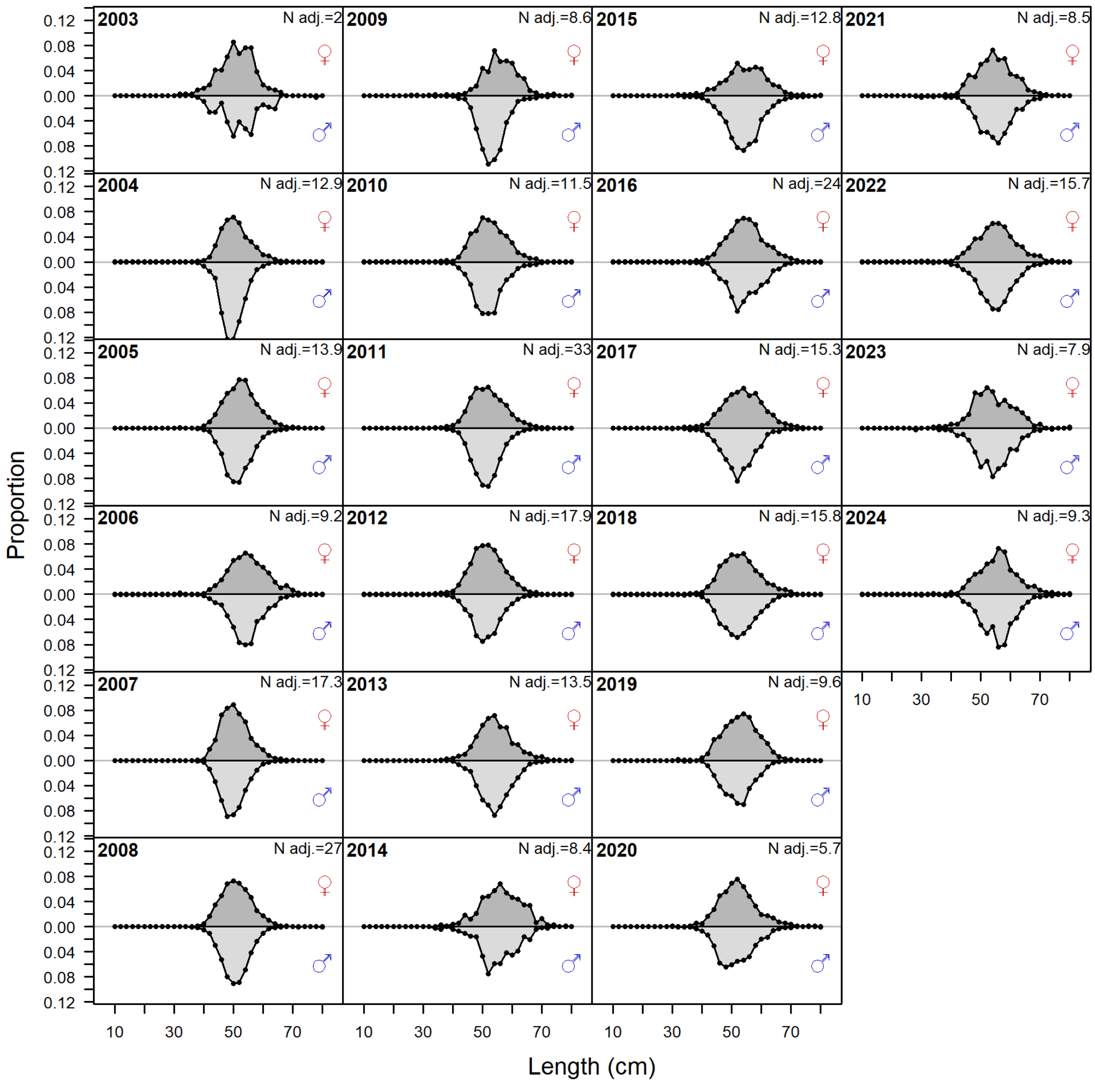

Figure 21: Length composition data for At-sea Hake fleet.

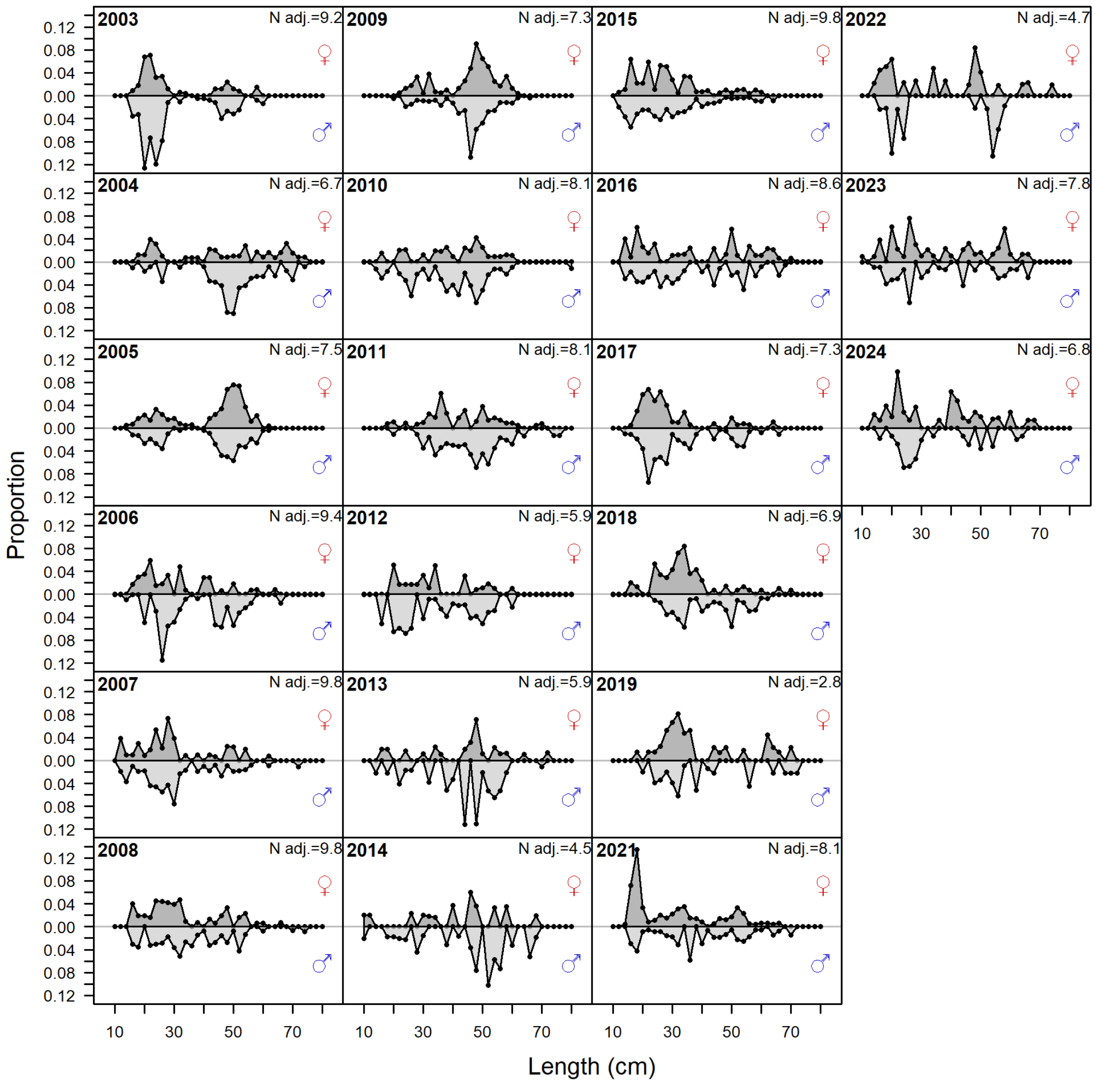

Figure 22: Length composition data for WCGBTS.

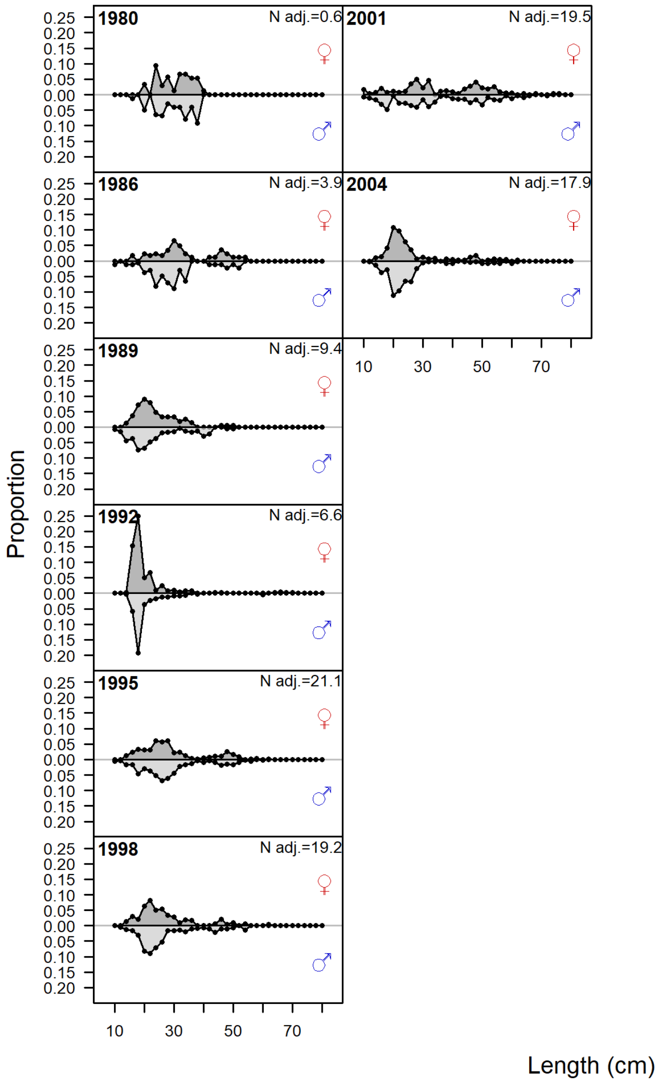

Figure 23: Length composition data for Triennial Survey.

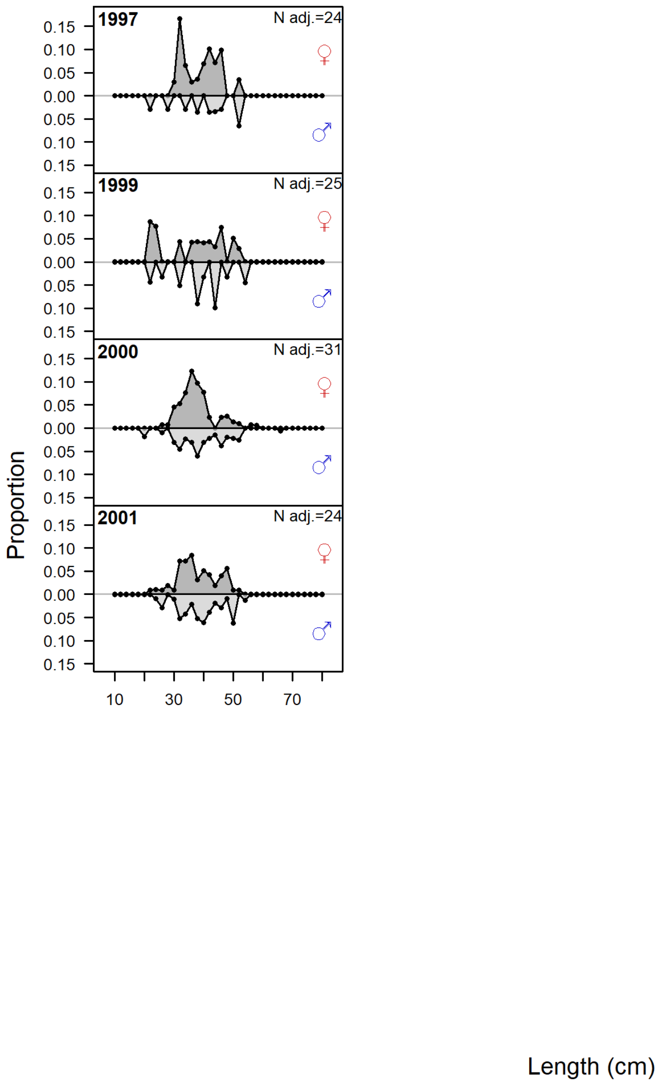

Figure 24: Length composition data for AFSC Slope Survey.

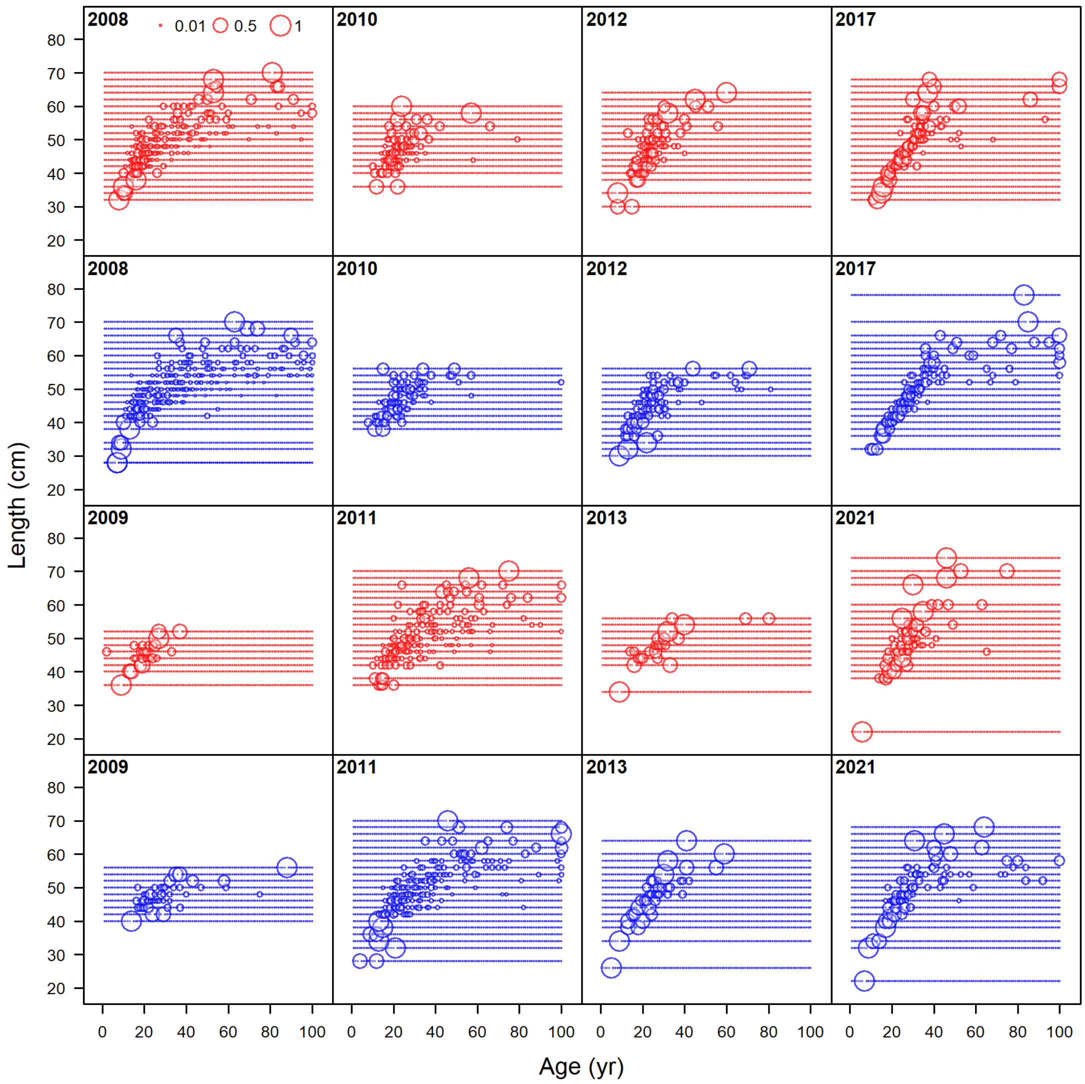

Figure 25: Length composition data for bottom trawl fleet.

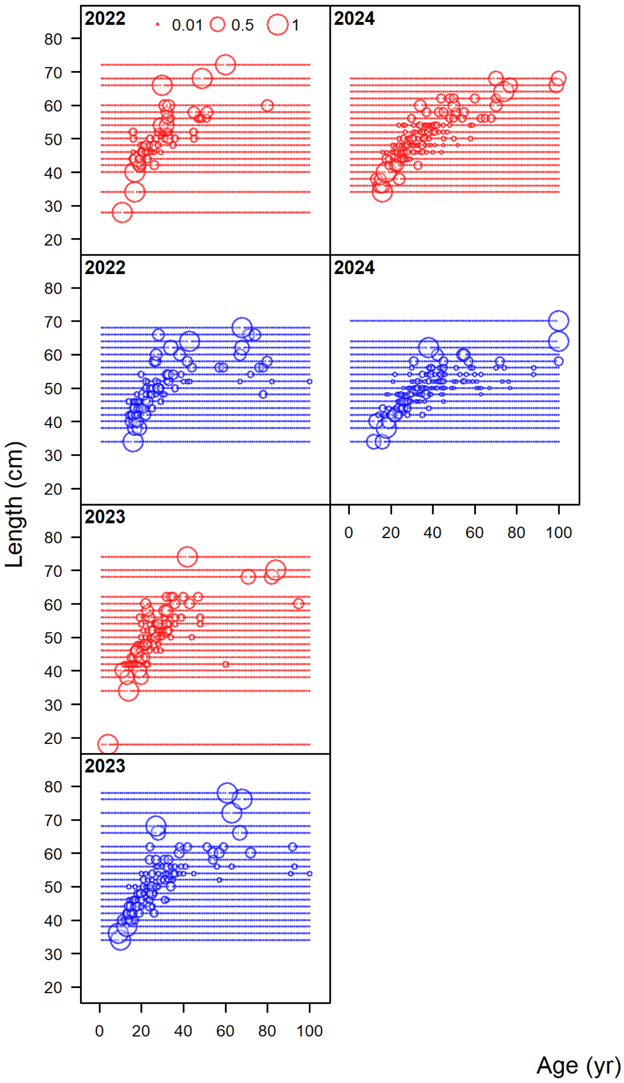

Figure 26: Length composition data for bottom trawl fleet, continued.

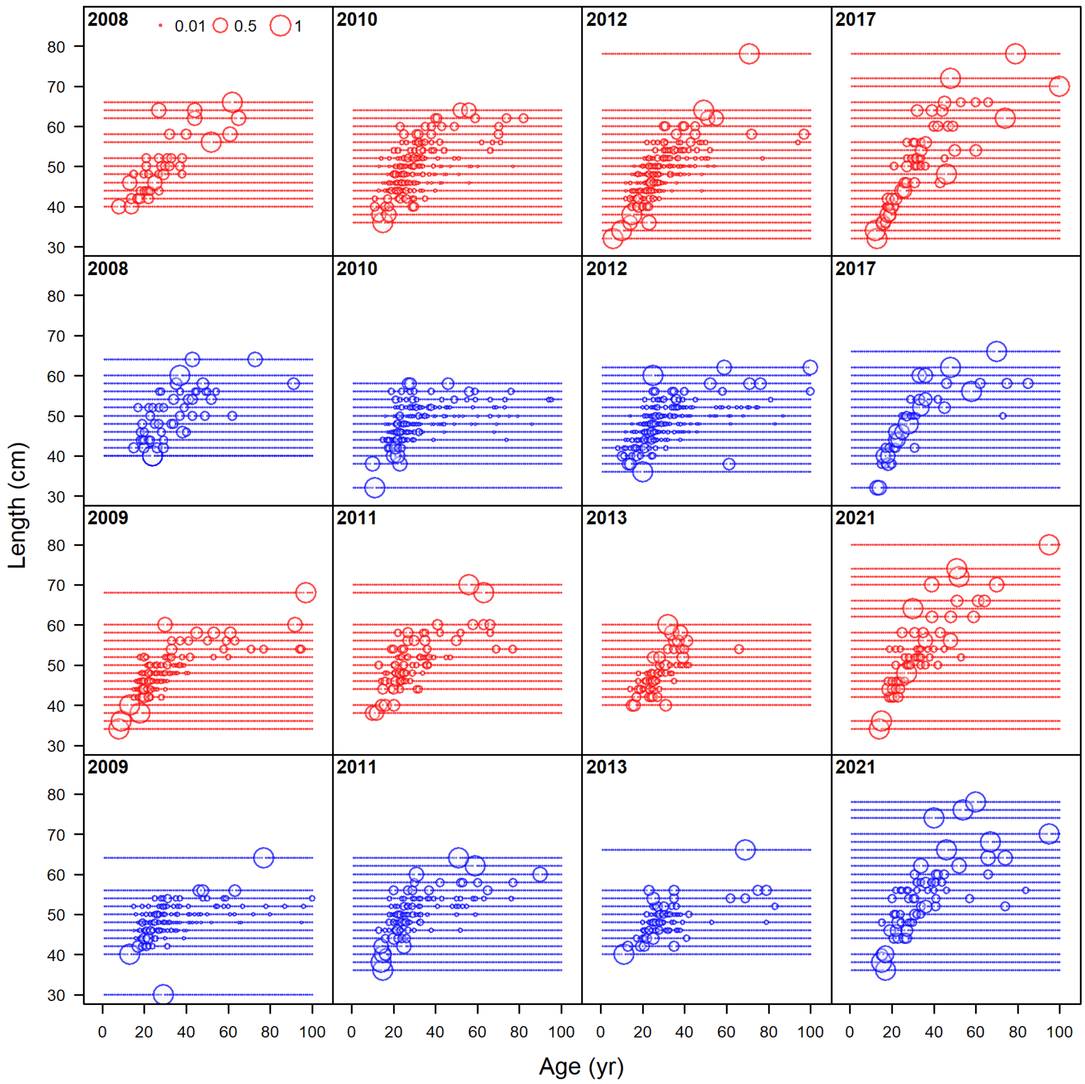

Figure 27: Conditional ages-at-length composition data for non-trawl fleet.

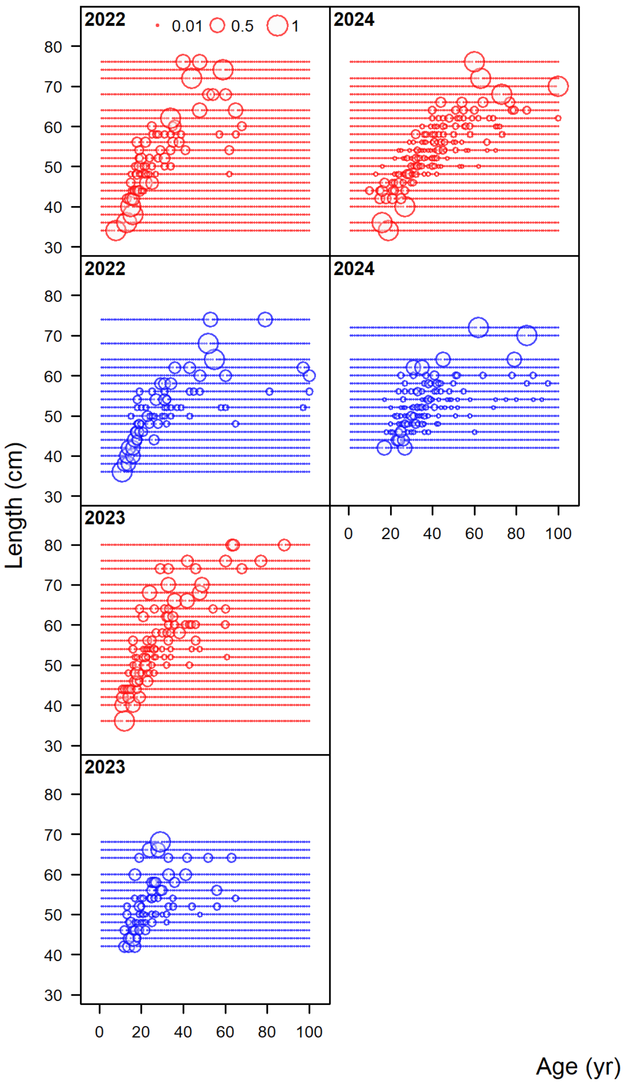

Figure 28: Conditional ages-at-length composition data for non-trawl fleet, continued.

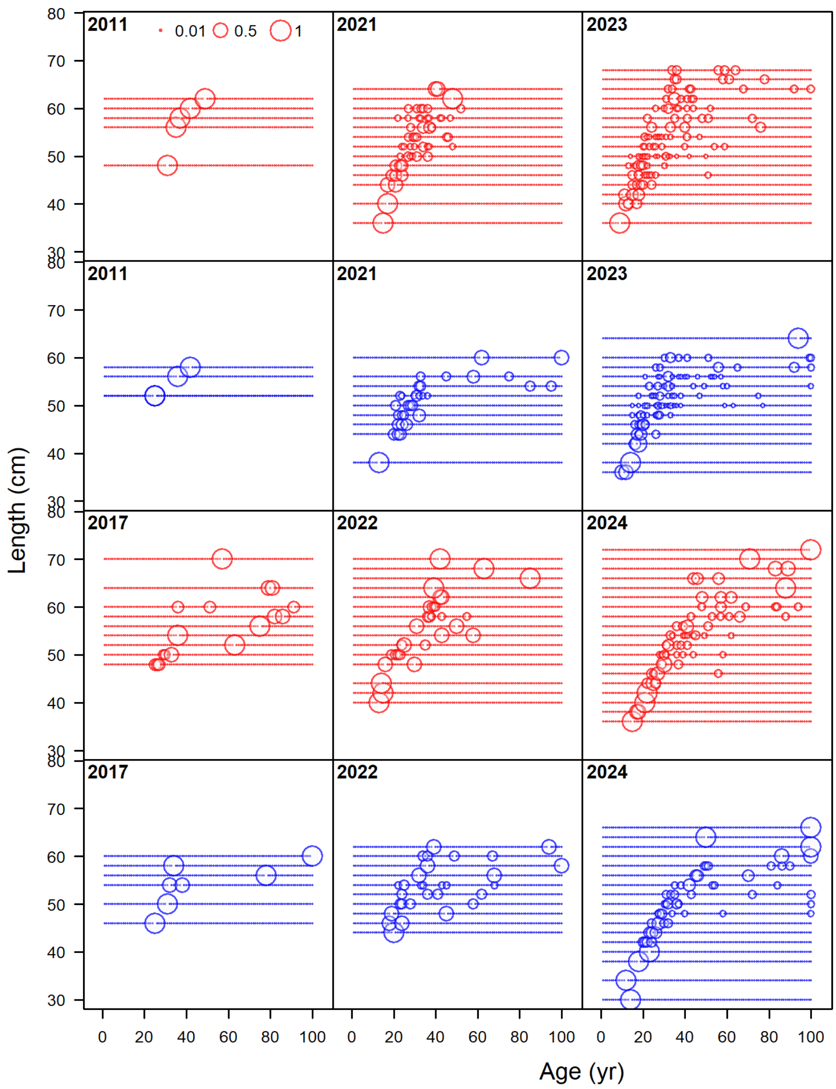

Figure 29: Conditional ages-at-length composition data for Midwater trawl fleet.

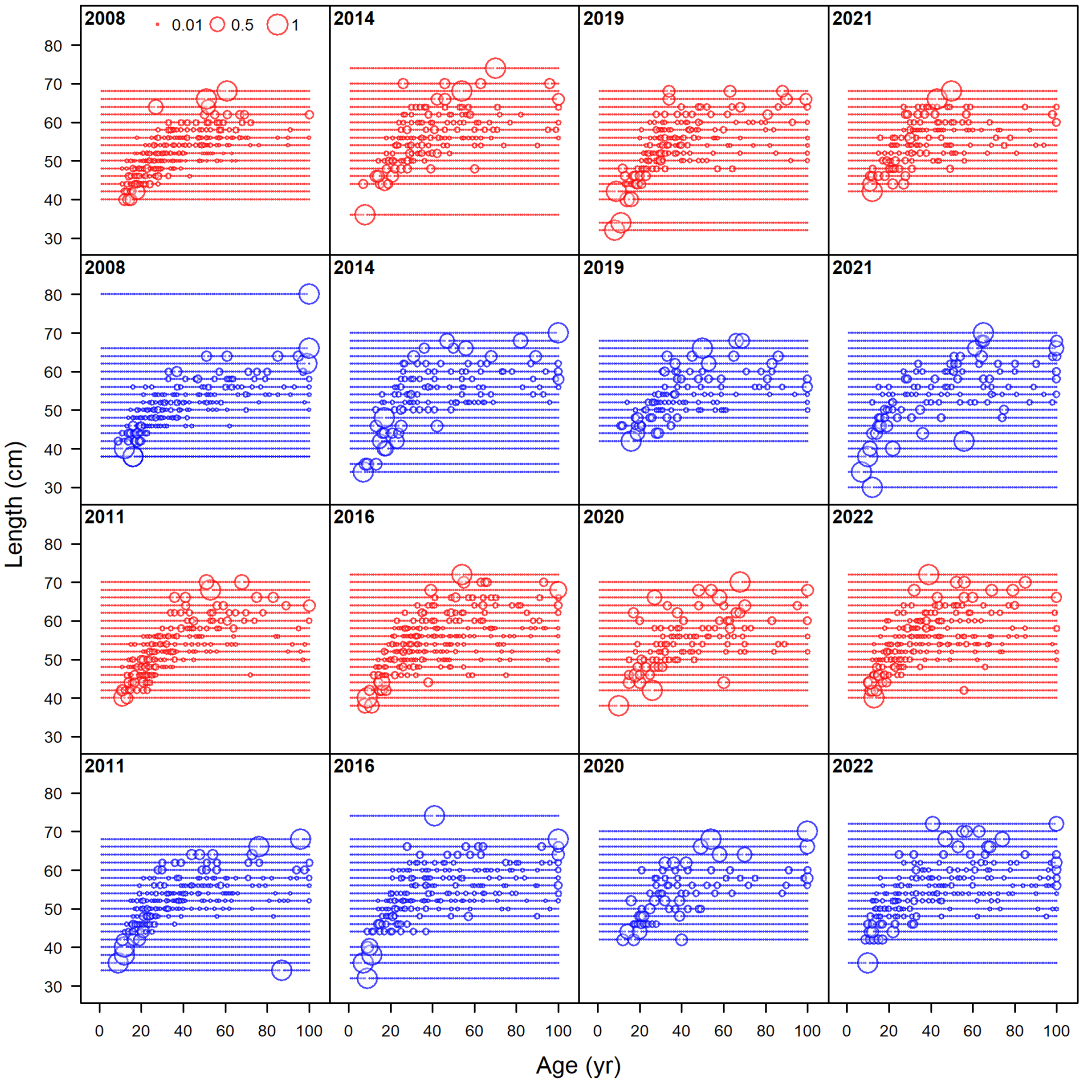

Figure 30: Conditional ages-at-length composition data for At-Sea Hake fleet.

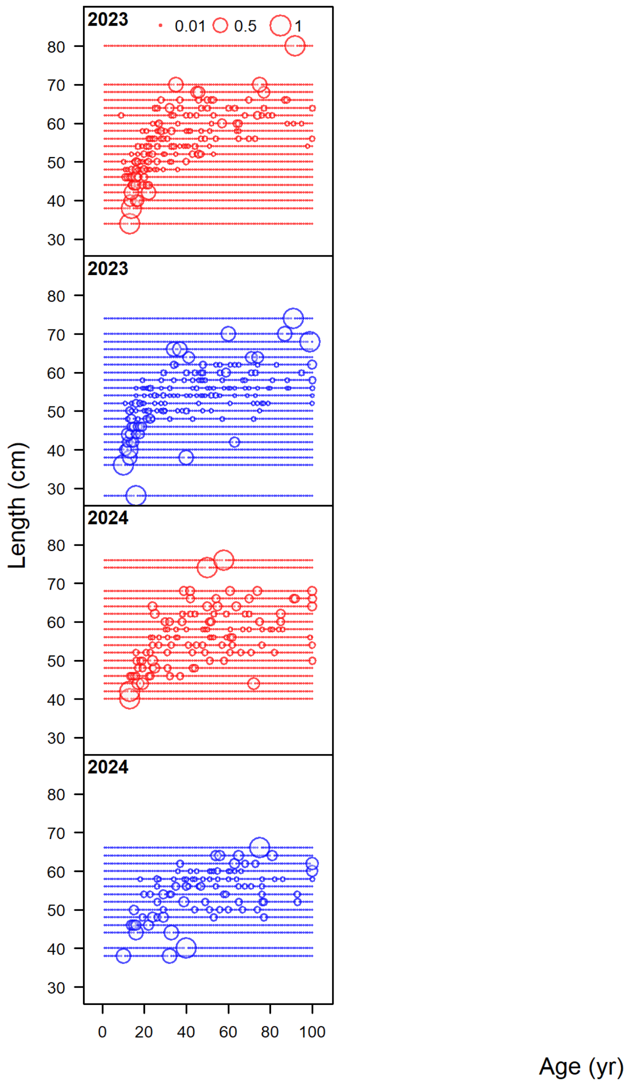

Figure 31: Conditional ages-at-length composition data for At-Sea Hake fleet, continued.

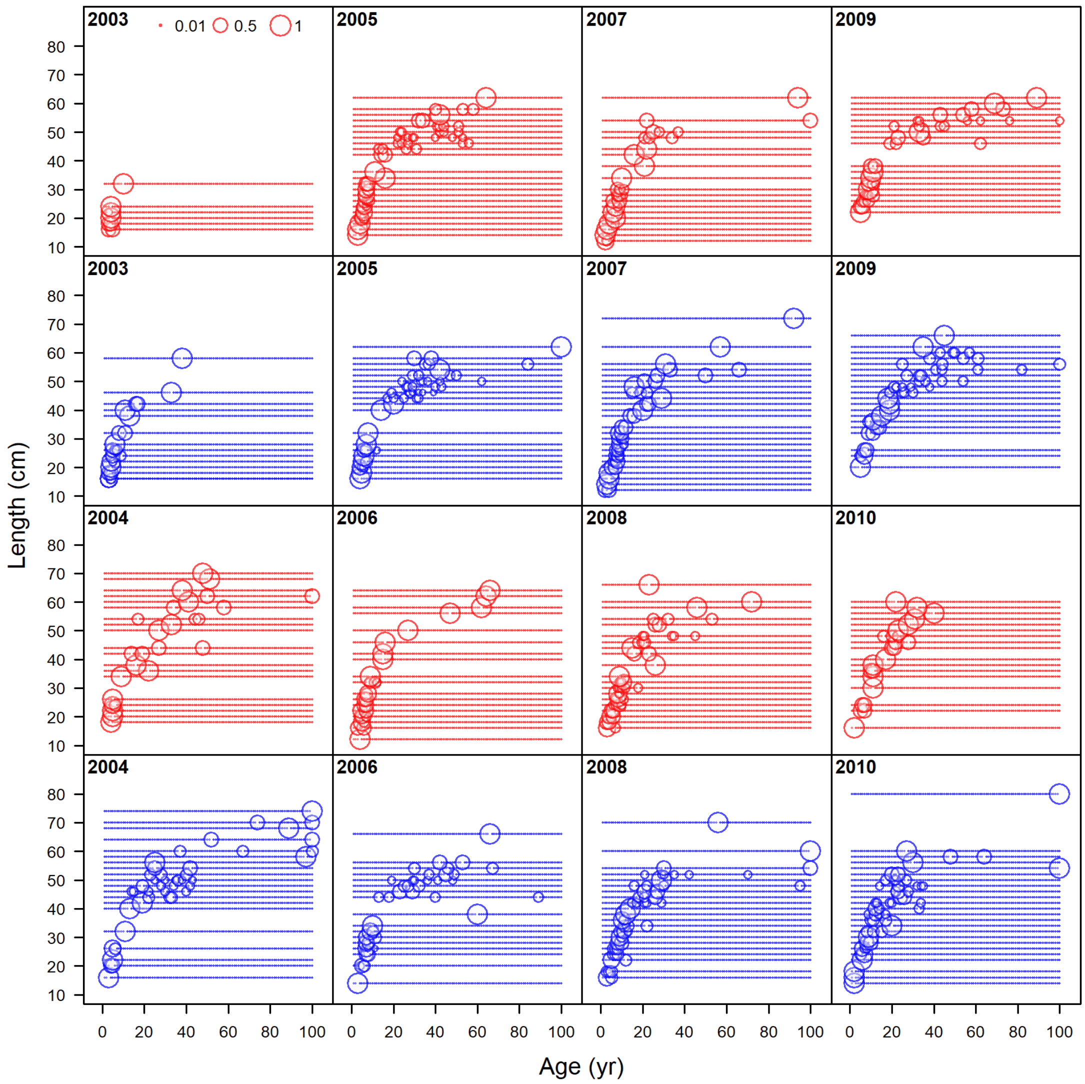

Figure 32: Conditional ages-at-length composition data for WCGBTS.

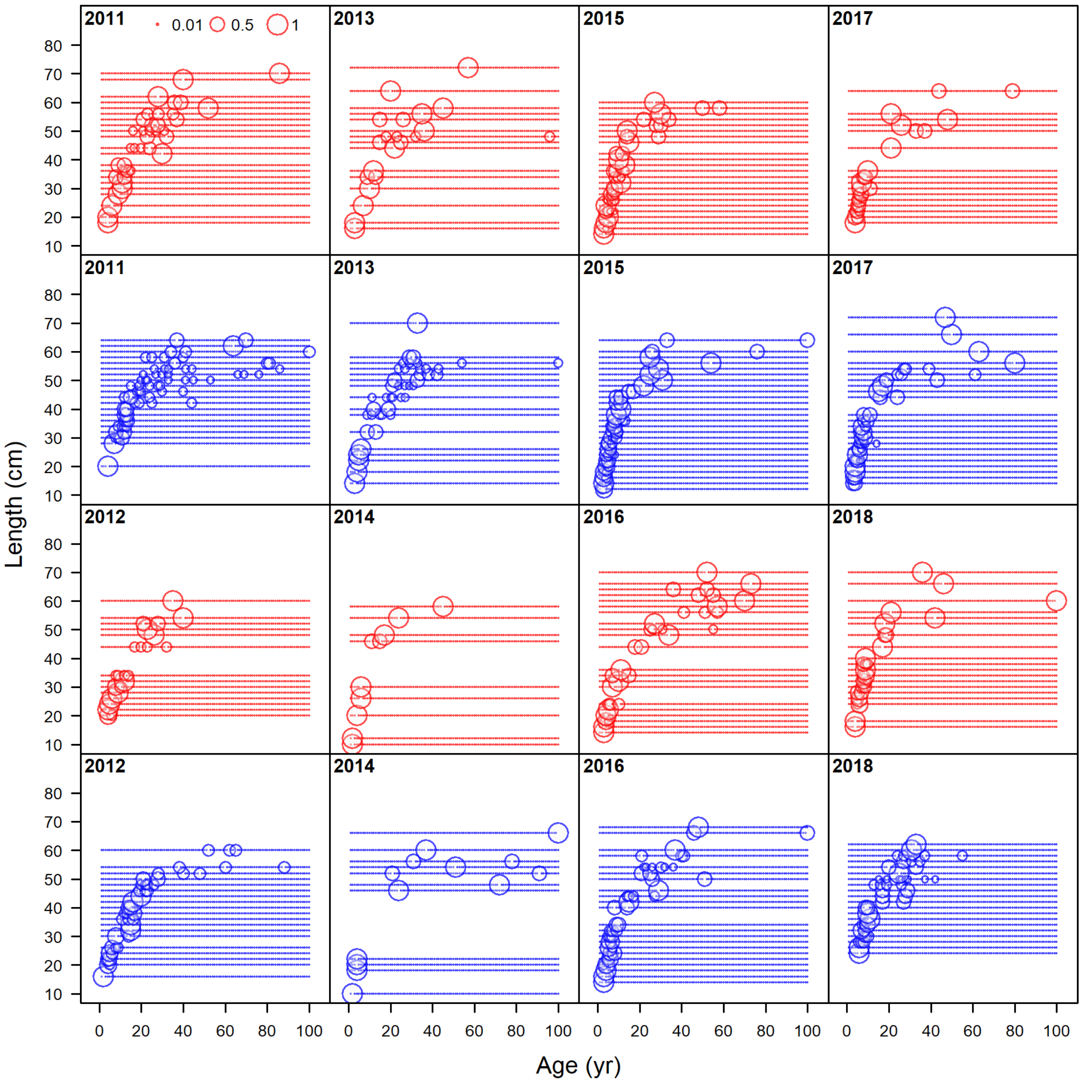

Figure 33: Conditional ages-at-length composition data for WCGBTS, continued.

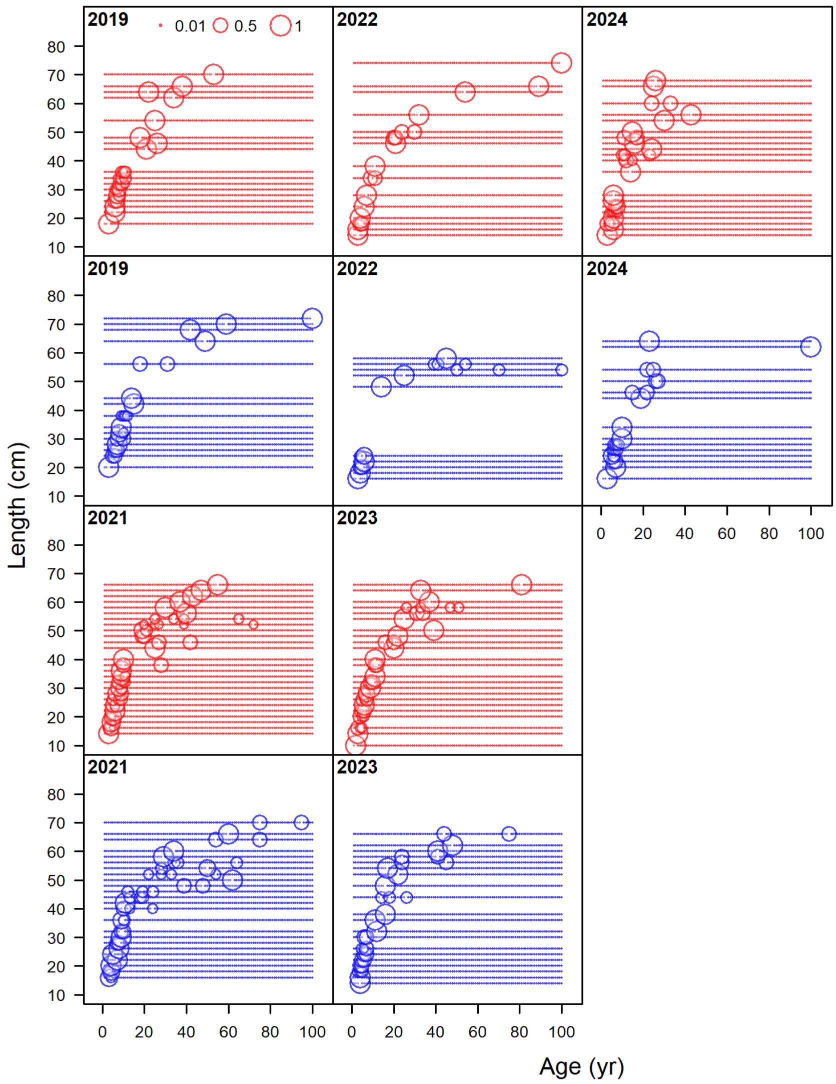

Figure 34: Conditional ages-at-length composition data for WCGBTS, continued.

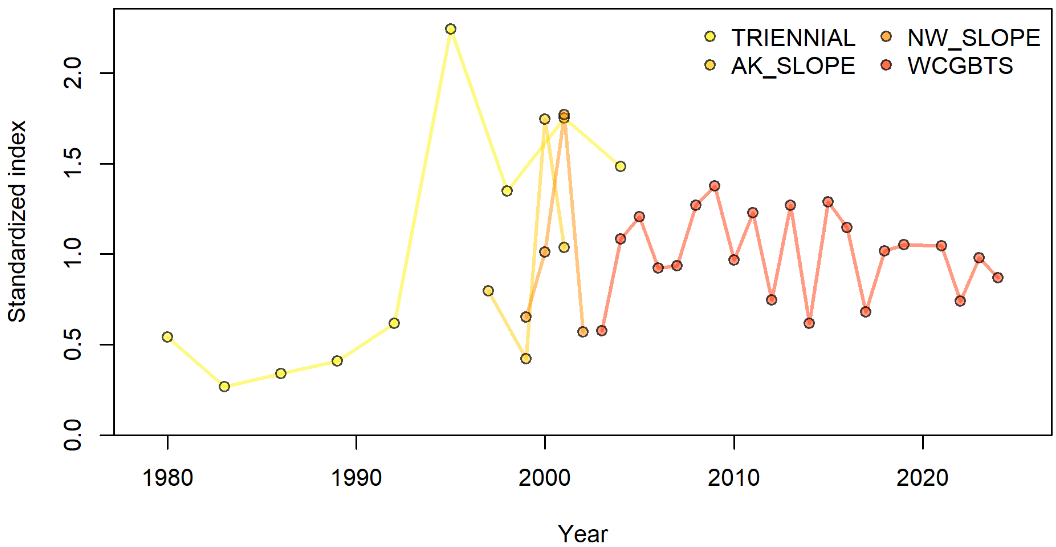

Figure 35: Standardized indices.

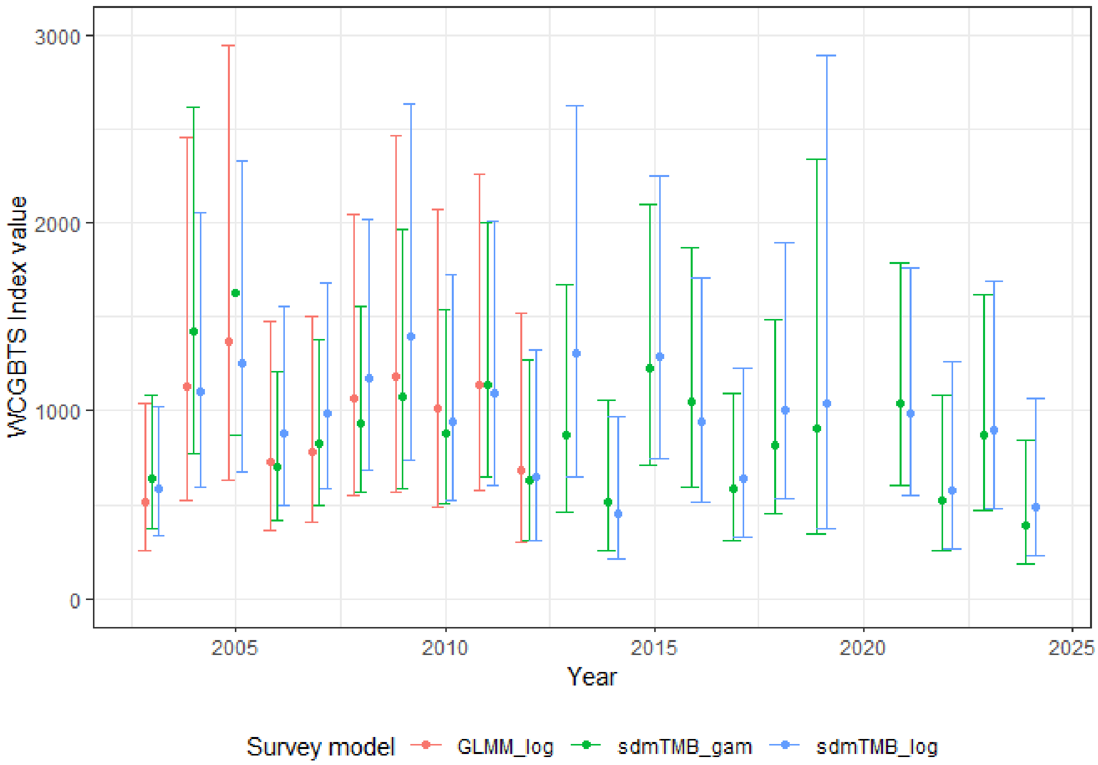

Figure 36: Comparison of the West Coast Groundfish Bottom Trawl Survey (WCGBTS) index from the previous assessment (GLMM) and the WCGBTS index of abundance used in this assessment (sdmTMB, lognormal distribution).

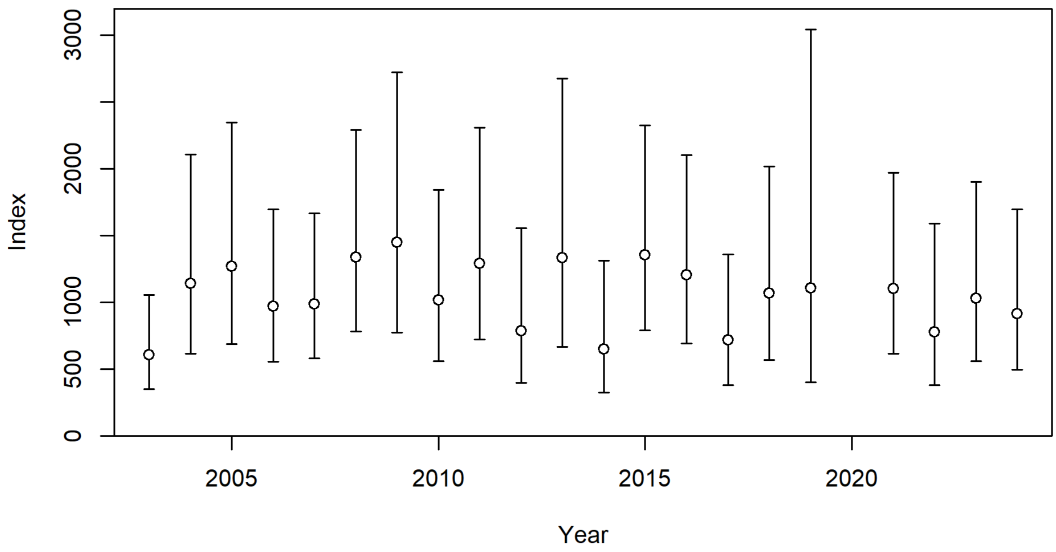

Figure 37: WCGBTS index.

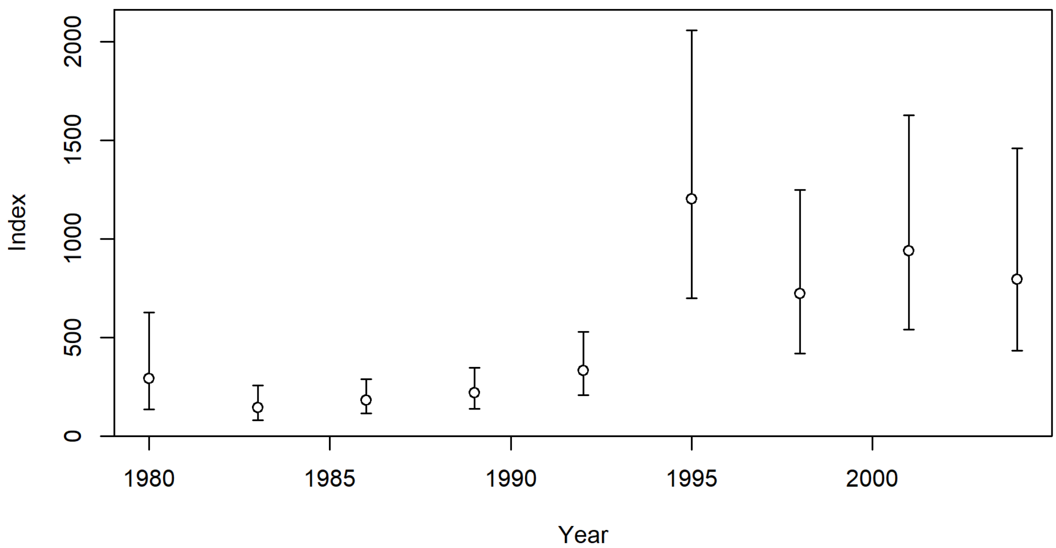

Figure 38: Triennial Survey index.

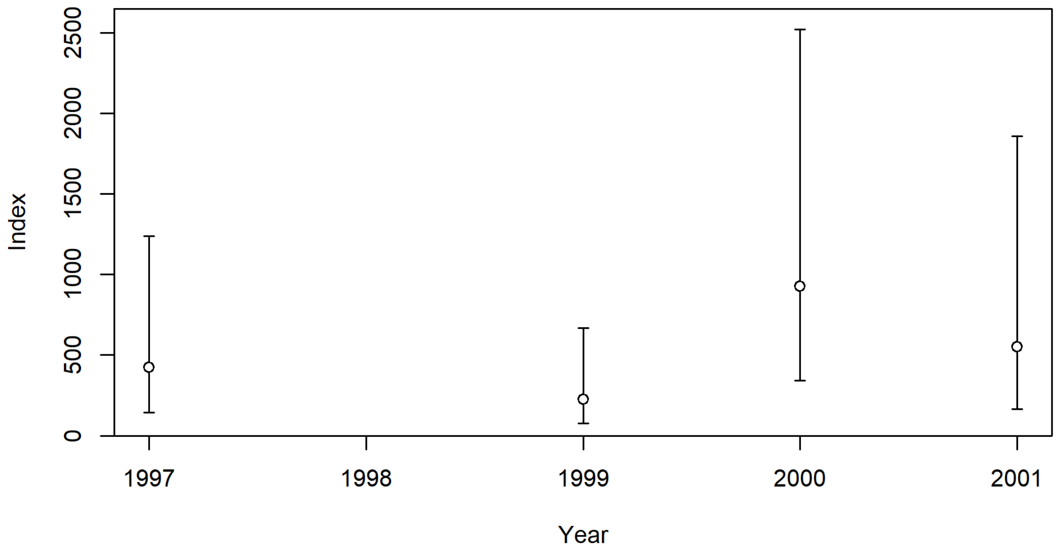

Figure 39: AFSC Slope Survey index.

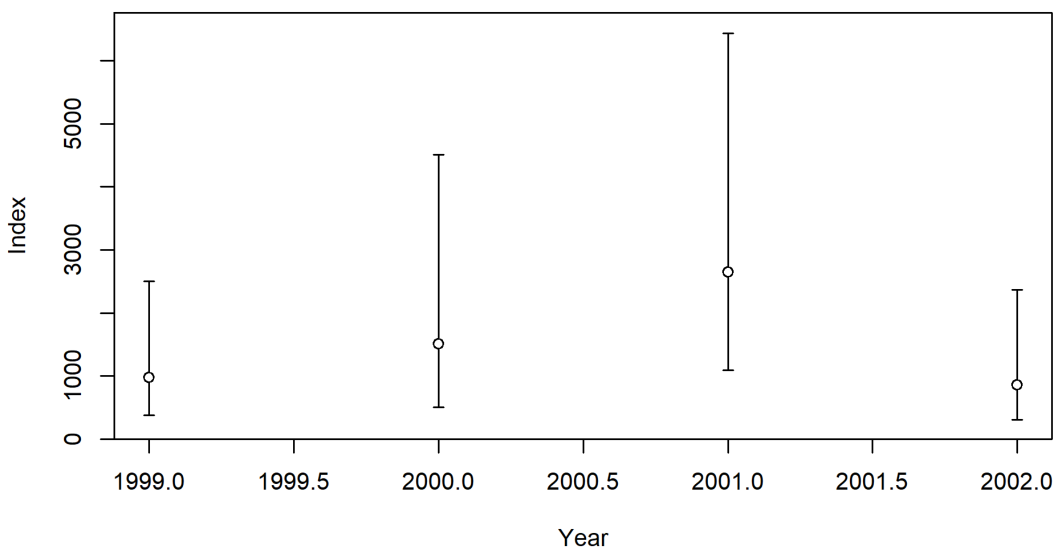

Figure 40: NWFSC Slope Survey index.

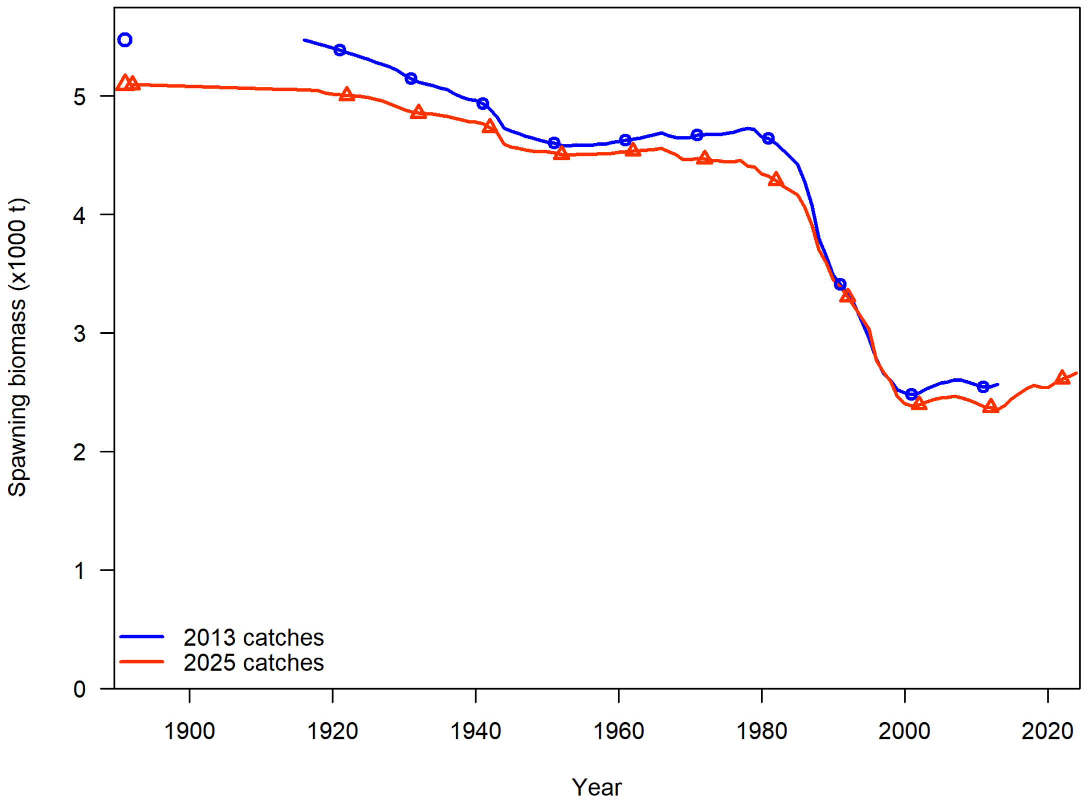

Figure 41: Comparison of spawning output using updated catches vs using catches from the 2013 Rougheye/Blackspotted Rockfishes assessment.

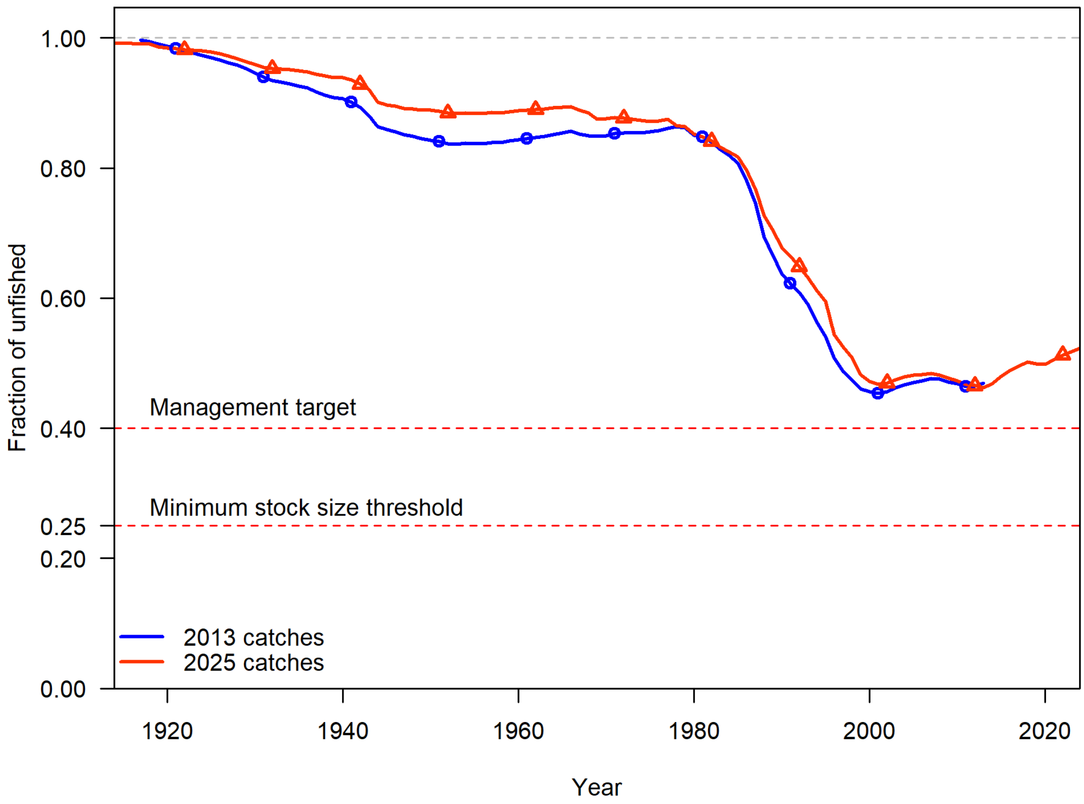

Figure 42: Comparison of relative spawning output using updated catches vs using catches from the 2013 Rougheye/Blackspotted Rockfishes assessment.

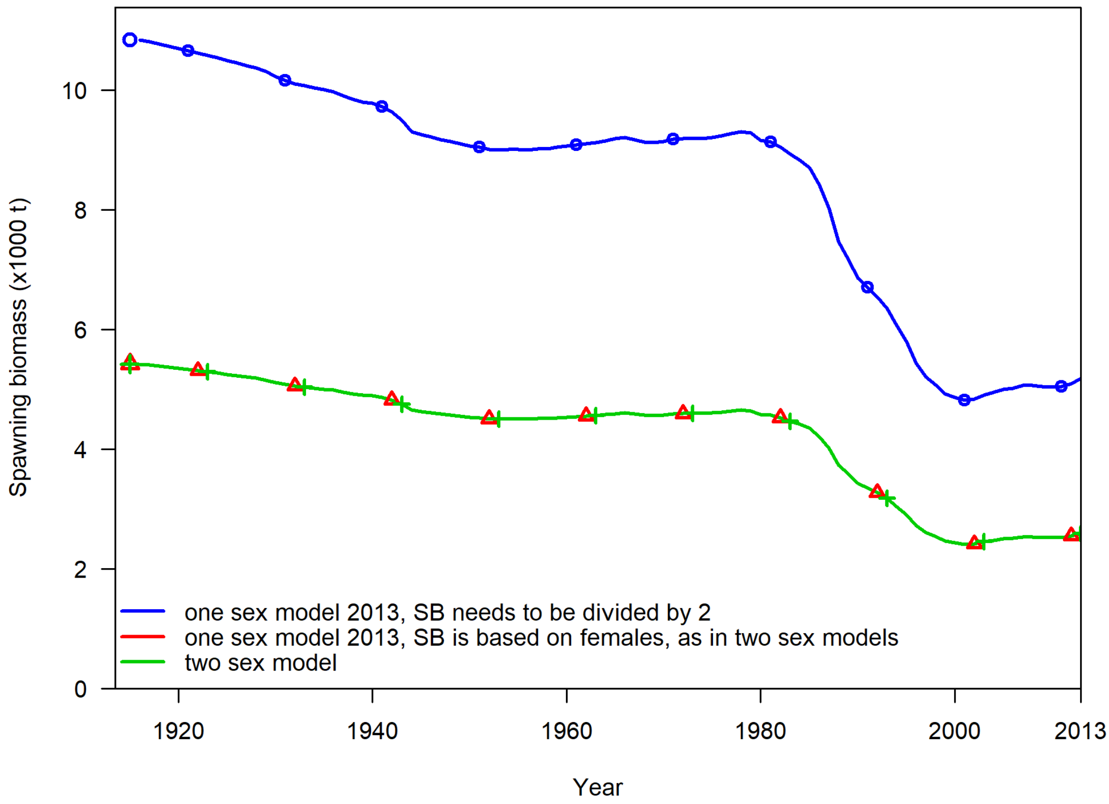

Figure 43: Comparison of spawning output using the 1 sex and 2 sexes set to equal values models based on the 2013 Rougheye/Blackspotted Rockfishes assessment data. The 1 sex model has double the biomass because it includes both females and males.

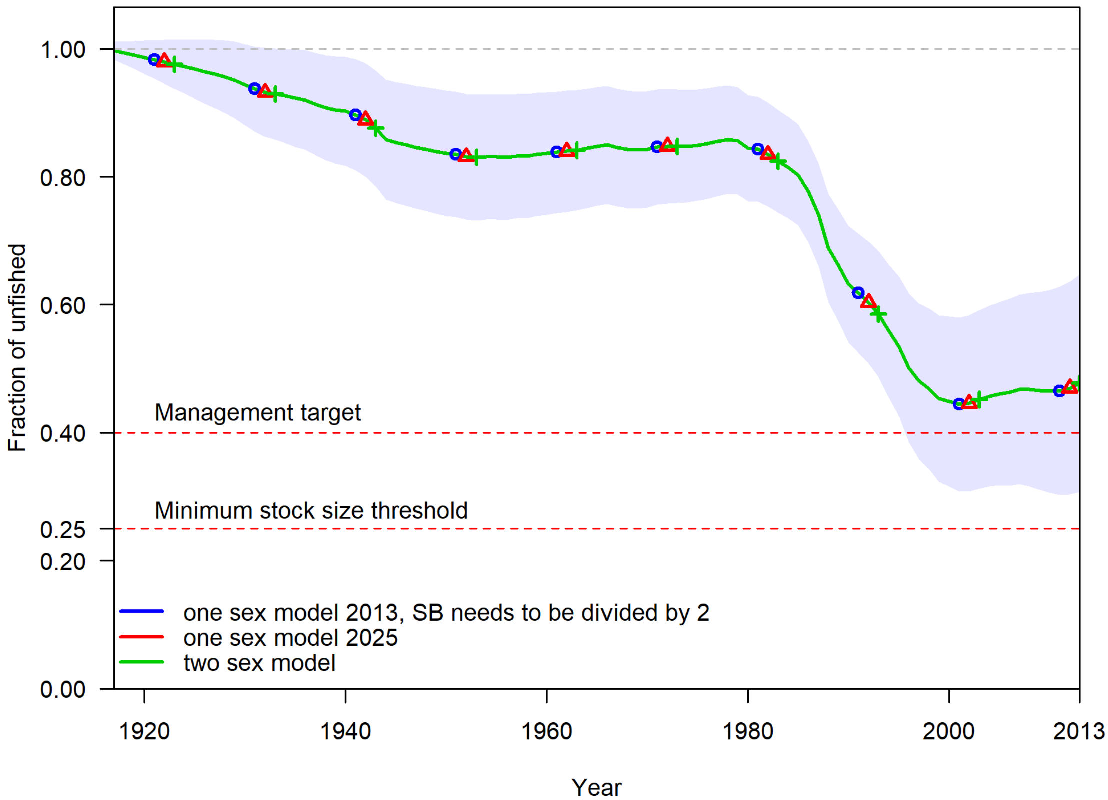

Figure 44: Comparison of spawning output using the 1 sex and 2 sexes set to equal values models based on the 2013 Rougheye/Blackspotted Rockfishes assessment data.

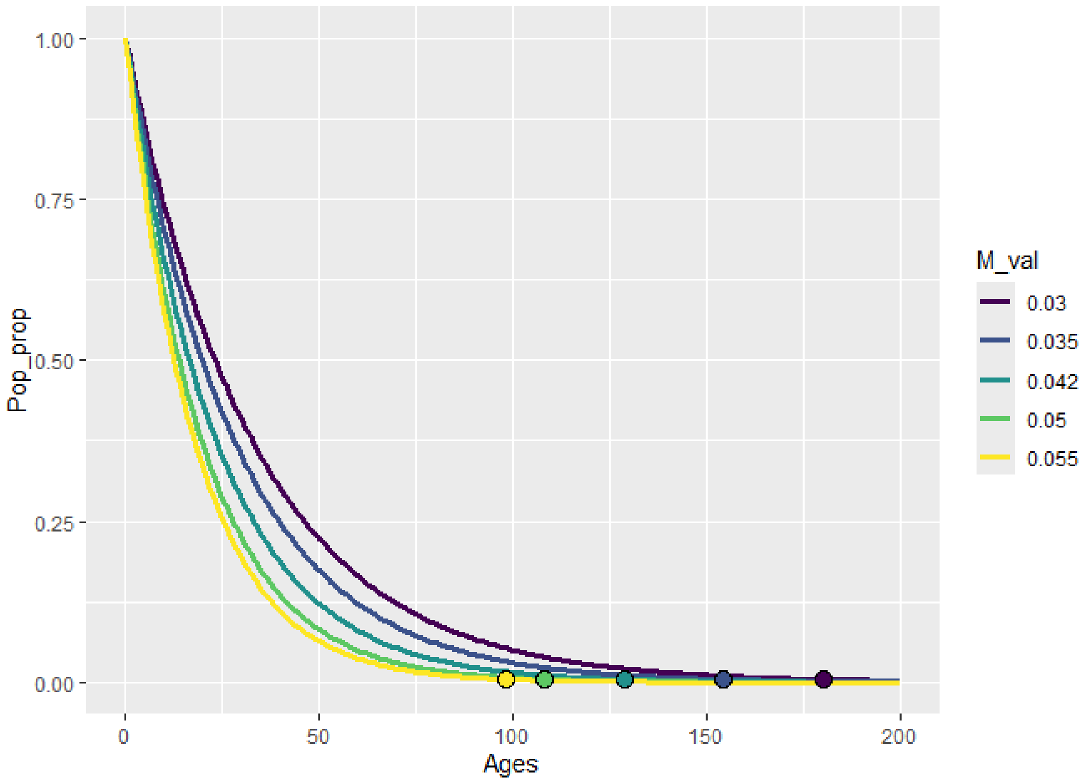

Figure 45: Natural mortality curves by age in years for values of natural mortality used in various Rougheye/Blackspotted Rockfish stock assessments. Dots indicate the range of assumed maximum ages using the equation from Hamel and Cope 2022.

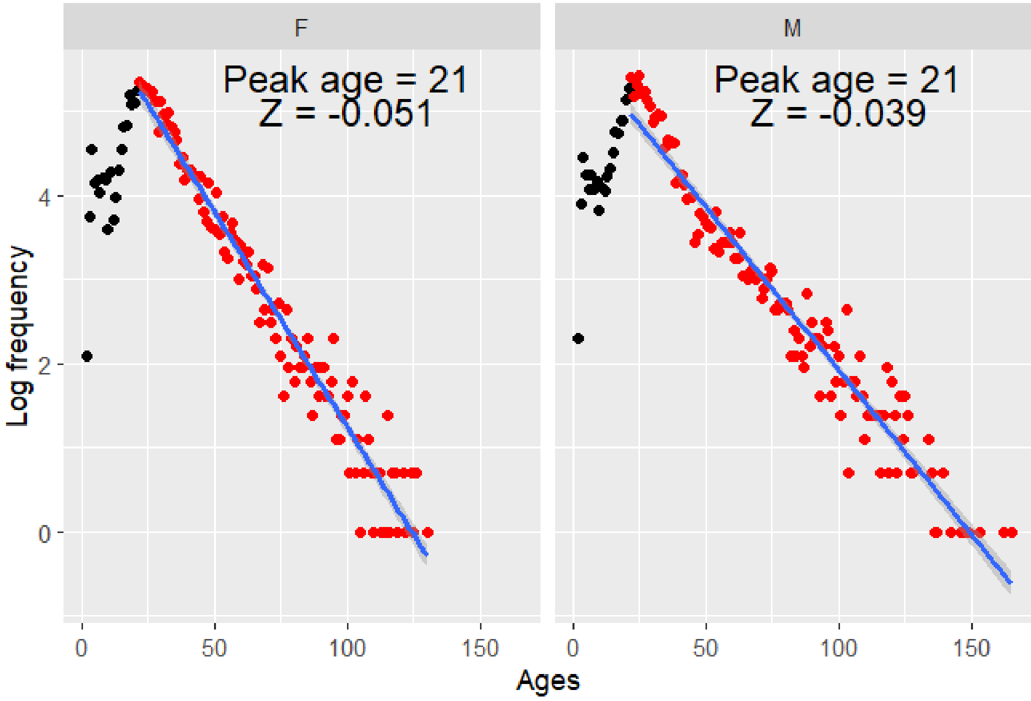

Figure 46: Catch curve (log abundance by age) analysis on aggregated ages over all age sources by sex (black points). The peak selected age was 21 for both sexes, so the linear model was run from age 21 until the oldest age (red points). The slope of the linear model is equal to the estimate of an aggregate total mortality (Z).

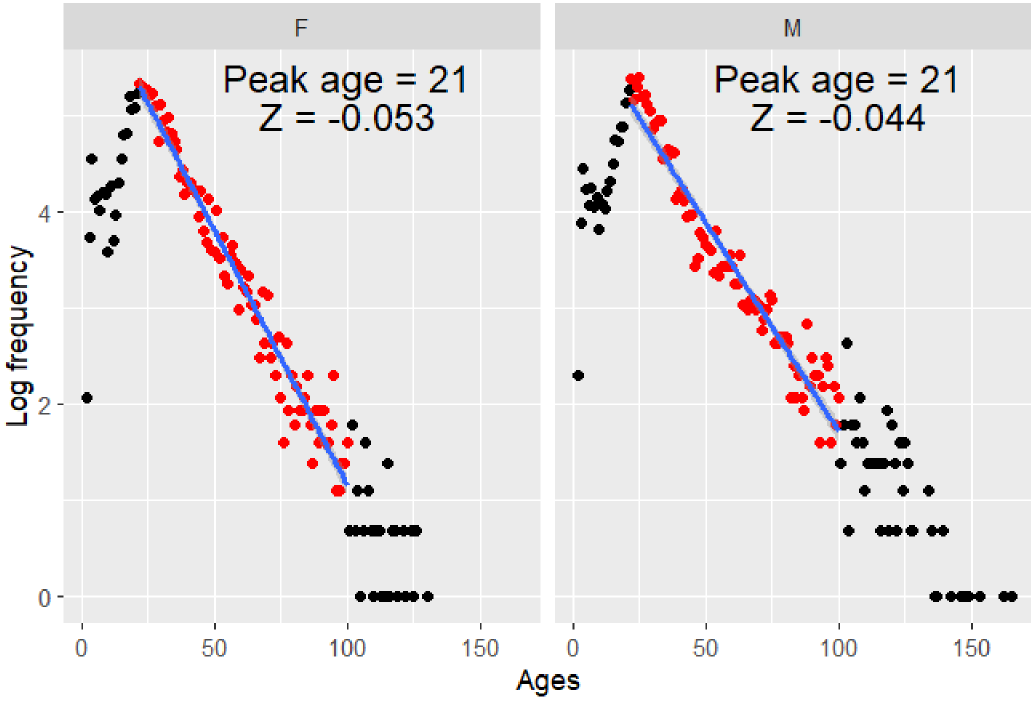

Figure 47: Catch curve (log abundance by age) analysis on aggregated ages over all age sources by sex (black points). The peak selected age was 21 for both sexes with a max age of 100, so the linear model was run from age 21 until age 100 (red points). The slope of the linear model is equal to the estimate of an aggregate total mortality (Z).

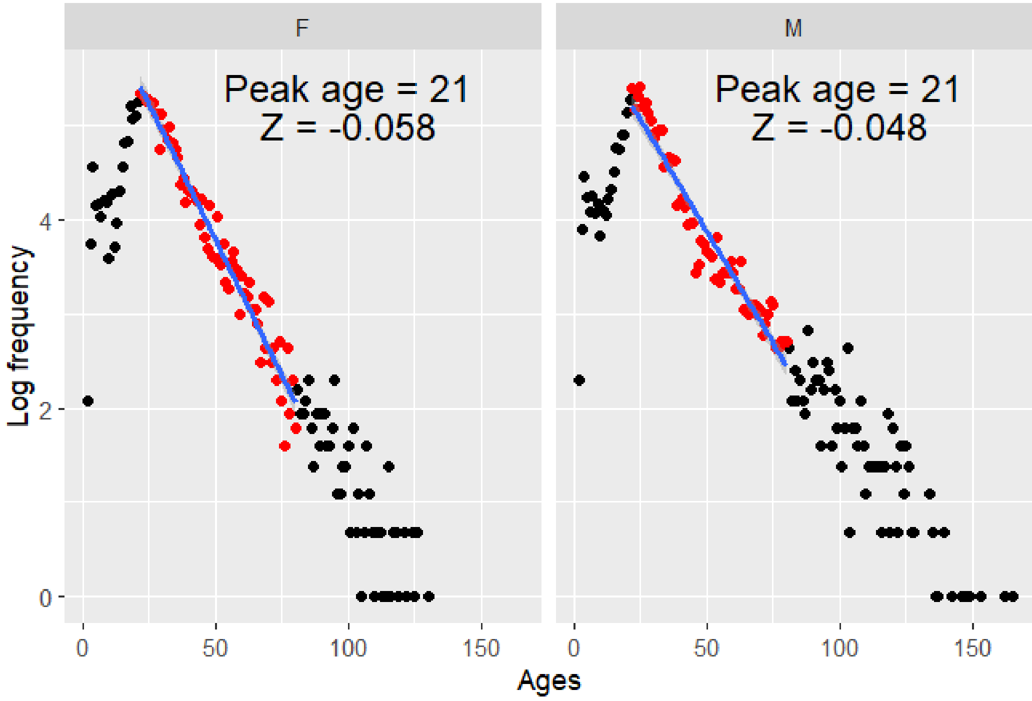

Figure 48: Catch curve (log abundance by age) analysis on aggregated ages over all age sources by sex (black points). The peak selected age was 21 for both sexes with a max age of 80, so the linear model was run from age 21 until age 80 (red points). The slope of the linear model is equal to the estimate of an aggregate total mortality (Z).

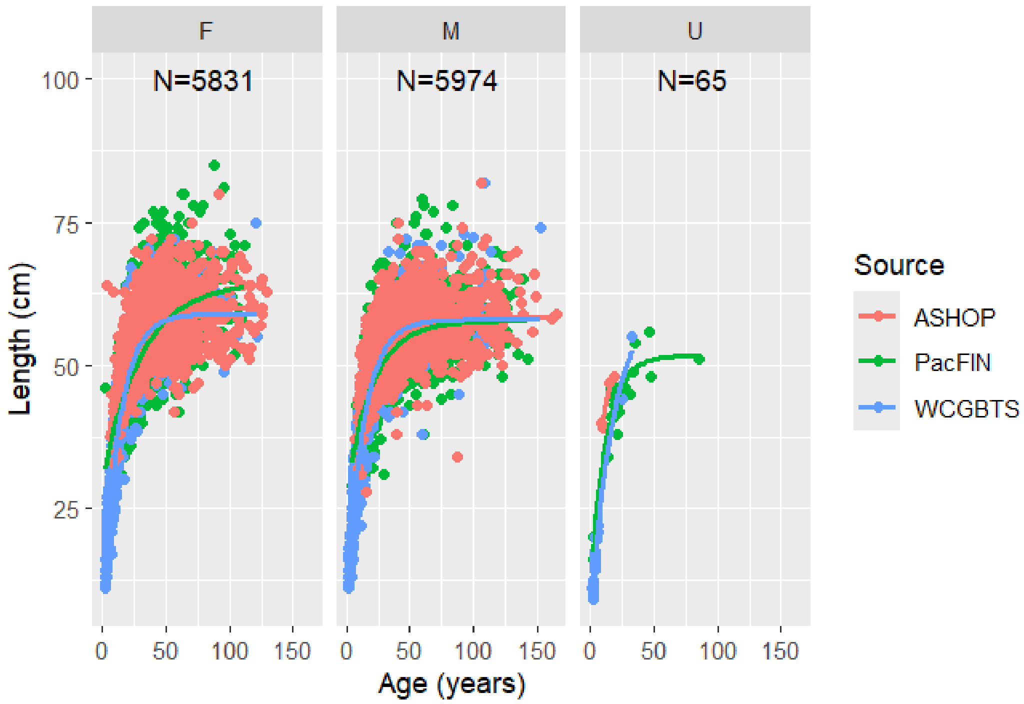

Figure 49: Age and length data, with fitted von Bertalanffy growth curves, by sex and data source for the Rougheye/Blackspotted rockfish complex. Sample sizes (N) are also provided.

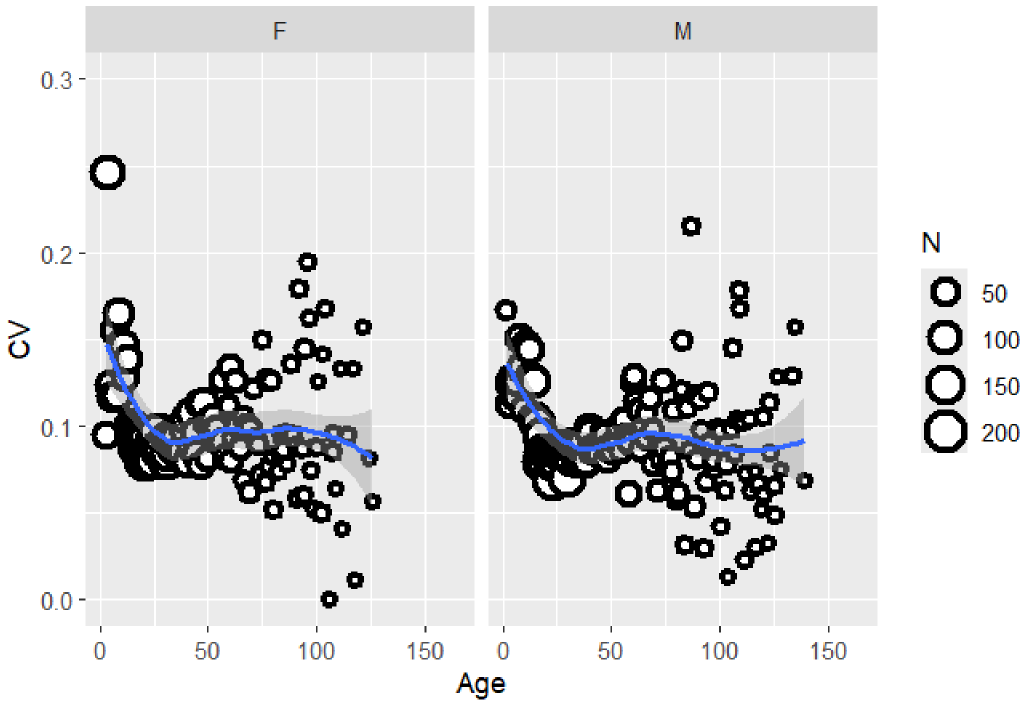

Figure 50: Coefficient of variation by age and sex for all sources of Rougheye/Blackspotted rockfishes ages. Sample sizes (N) are also indicated by size of the point. The line is a smoothed loess (polynomial) line that gives a moving average of CV by age and sex.

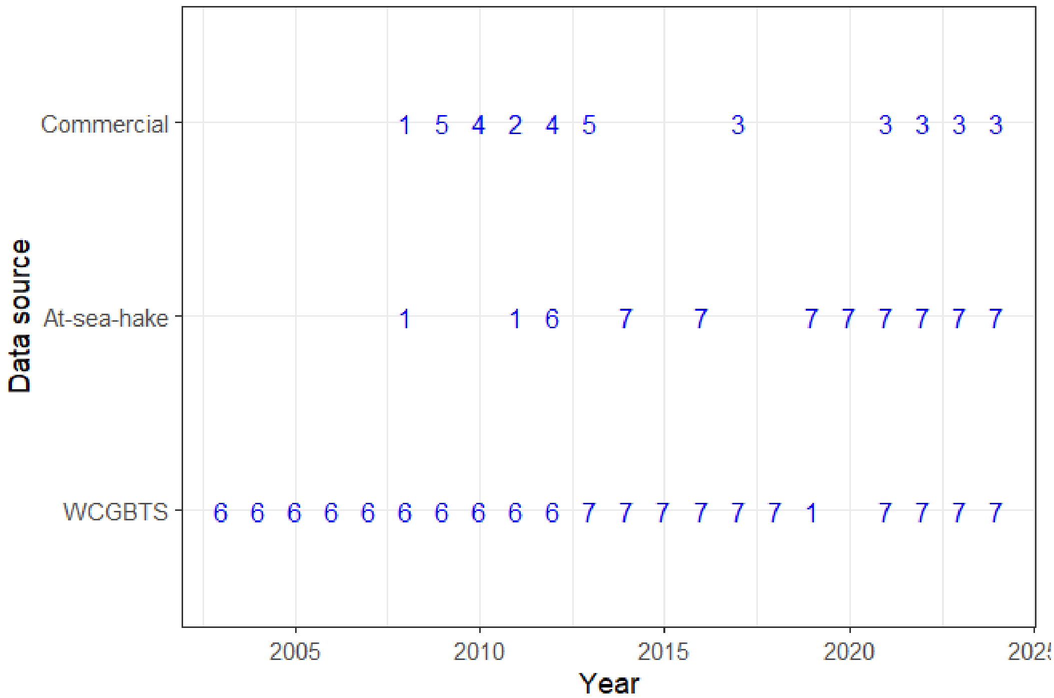

Figure 51: Ageing error matrix assignments by year and data source. The number indicates which ageing error matrix was used for conditional ages within those years and data sources. ‘Commercial’ is a combination of all commercial fleets.

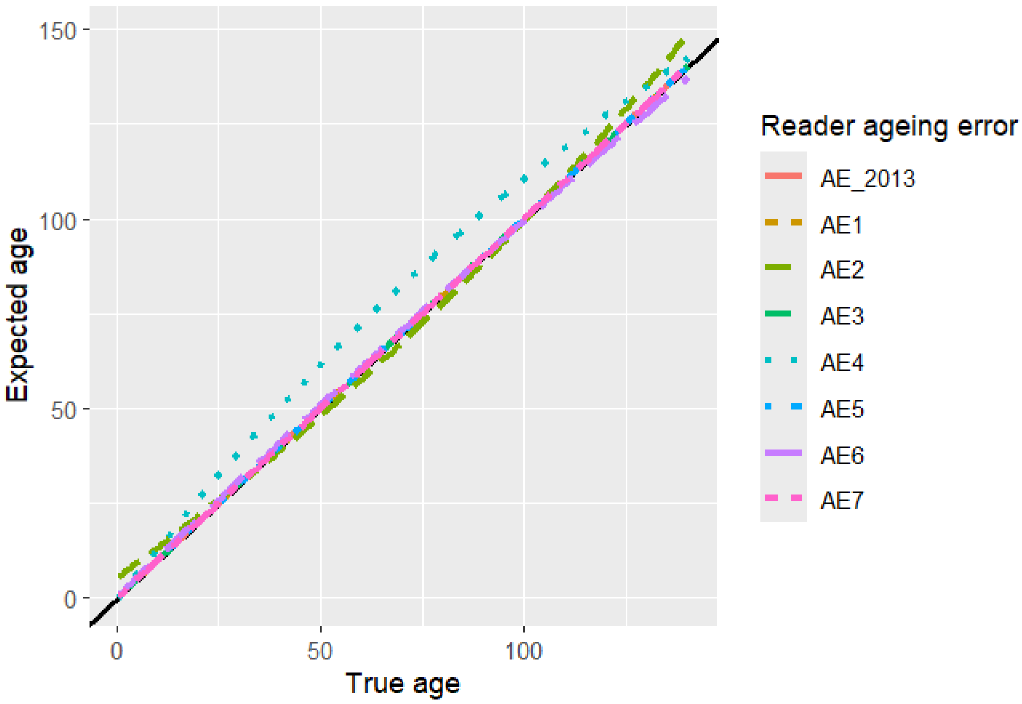

Figure 52: Estimated bias used for each of the seven ageing error matrices.

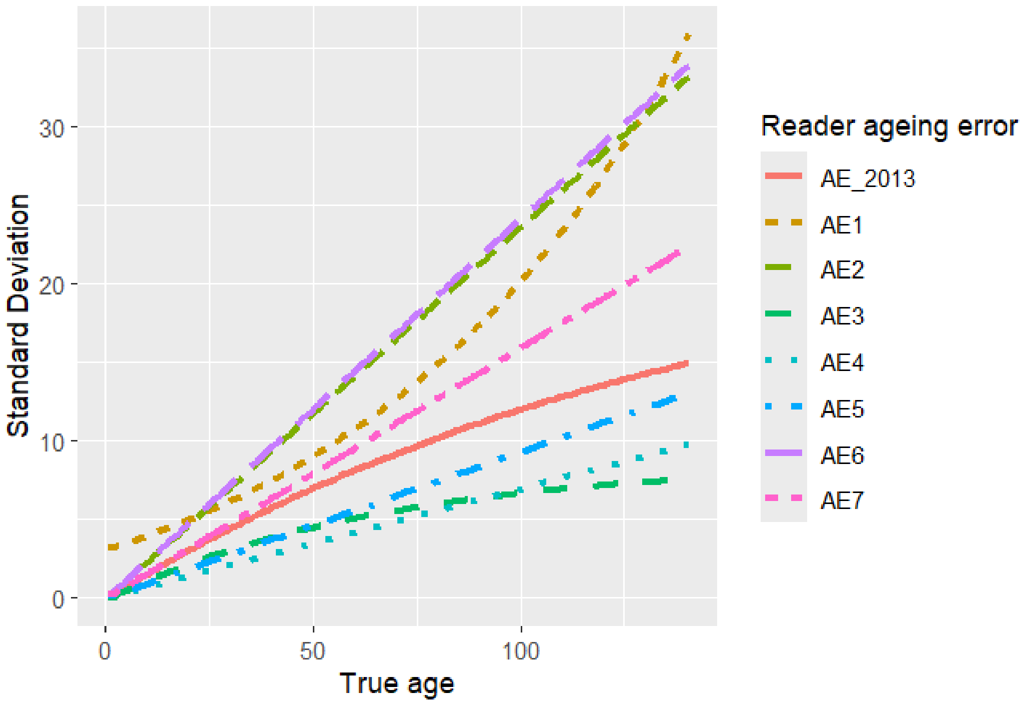

Figure 53: Estimated imprecision (as a standard deviation) used for each of the seven ageing error matrices.

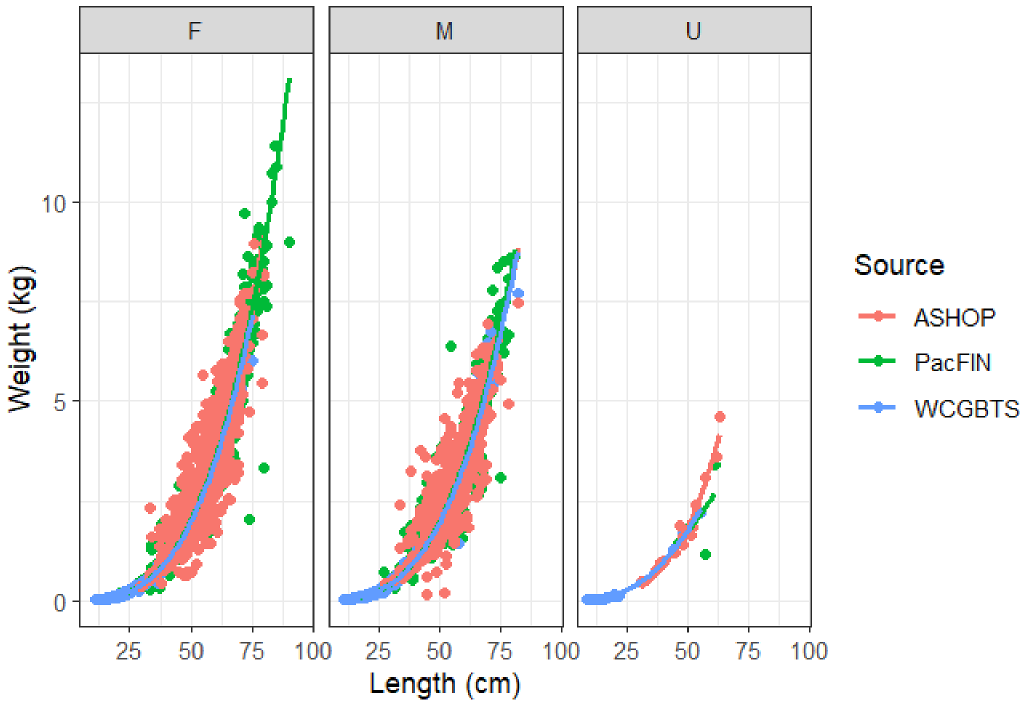

Figure 54: Length and weight samples by sex and data source. Lines are the power function fits by data source.

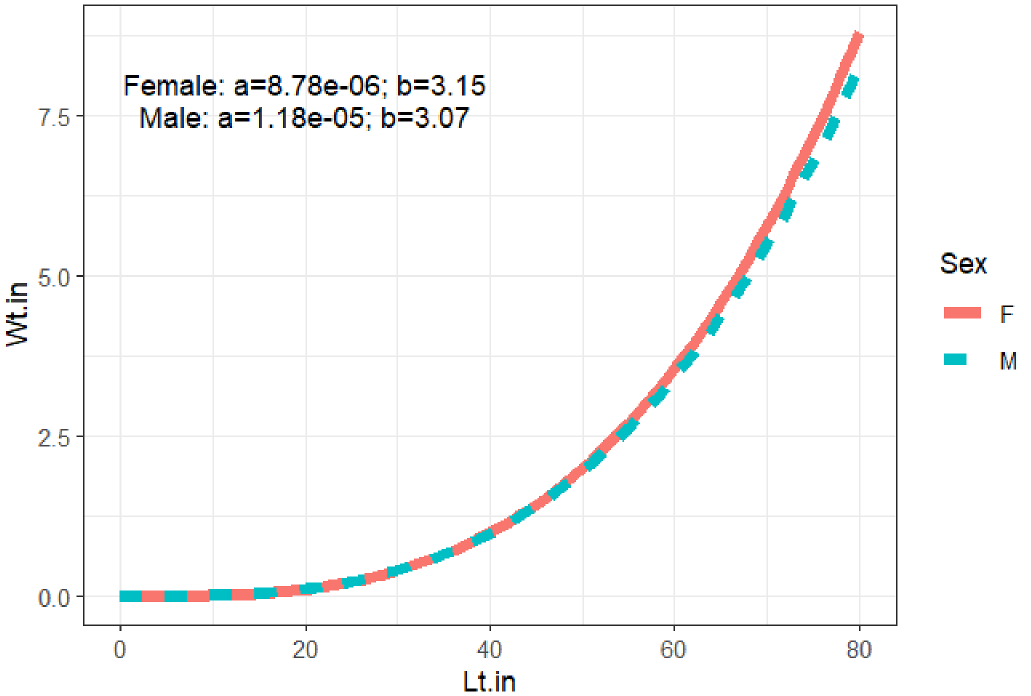

Figure 55: Realized length and weight relationships for female and male Rougheye/Blackspotted Rockfishes.

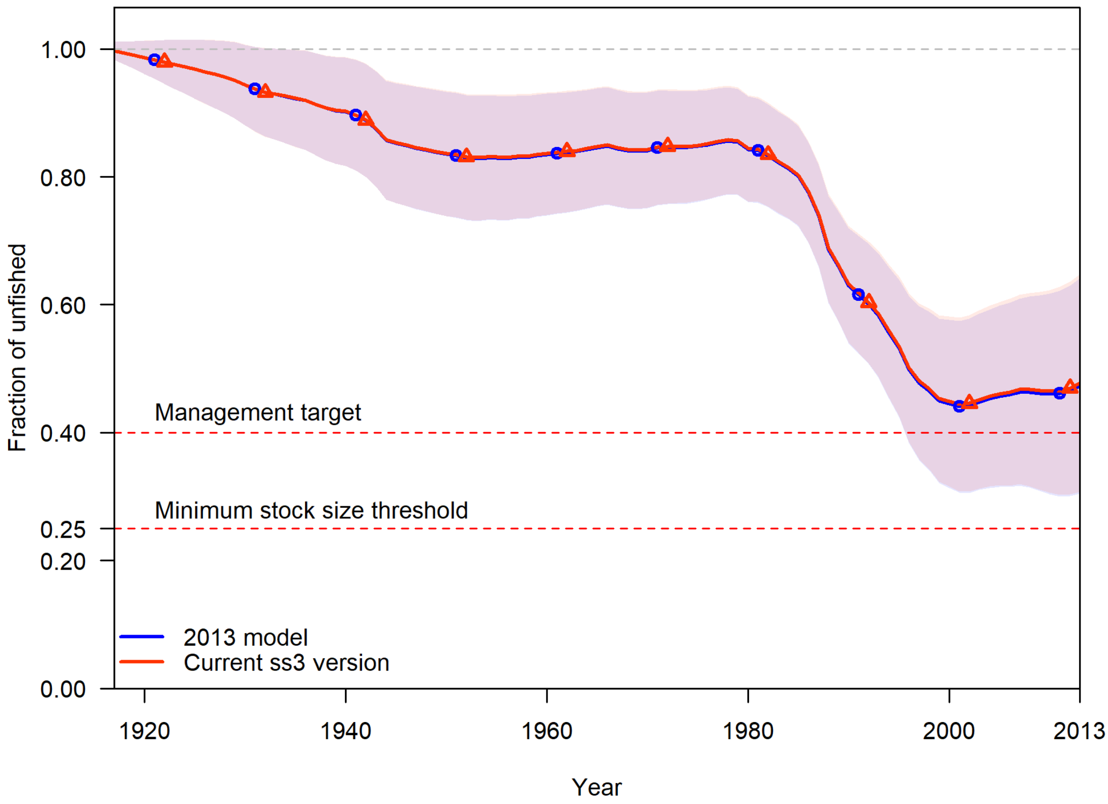

Figure 56: Estimates of relative stock size (current spawning output/unfished spawning output) for the Rougheye/Blackspotted rockfish complex in U.S. west coast waters from the 2013 assessment, and compared to the using the same data in the newest version of SS3 (3.30.22.1).

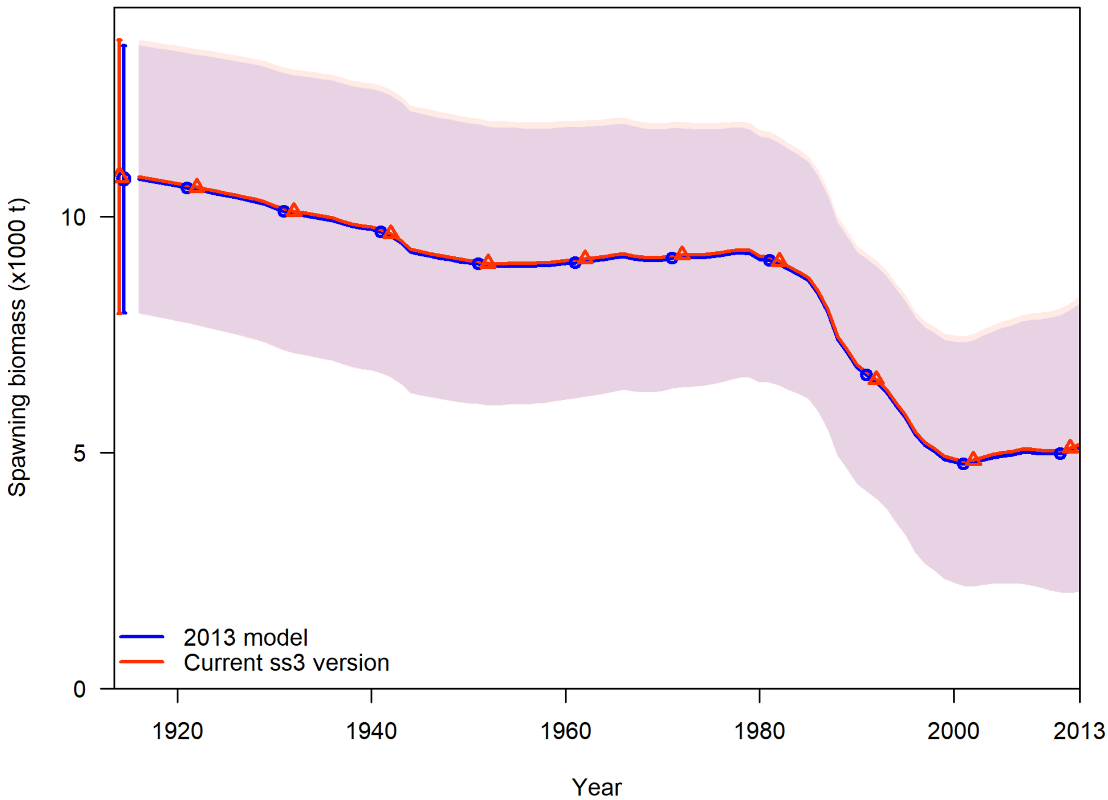

Figure 57: Estimates of spawning output for the Rougheye/Blackspotted rockfish complex in U.S. west coast waters from the 2013 assessment, and compared to the same data in the newest version of SS3 (3.30.22.1). Shading denotes 95% confidence intervals. Shading denotes 95% confidence intervals.

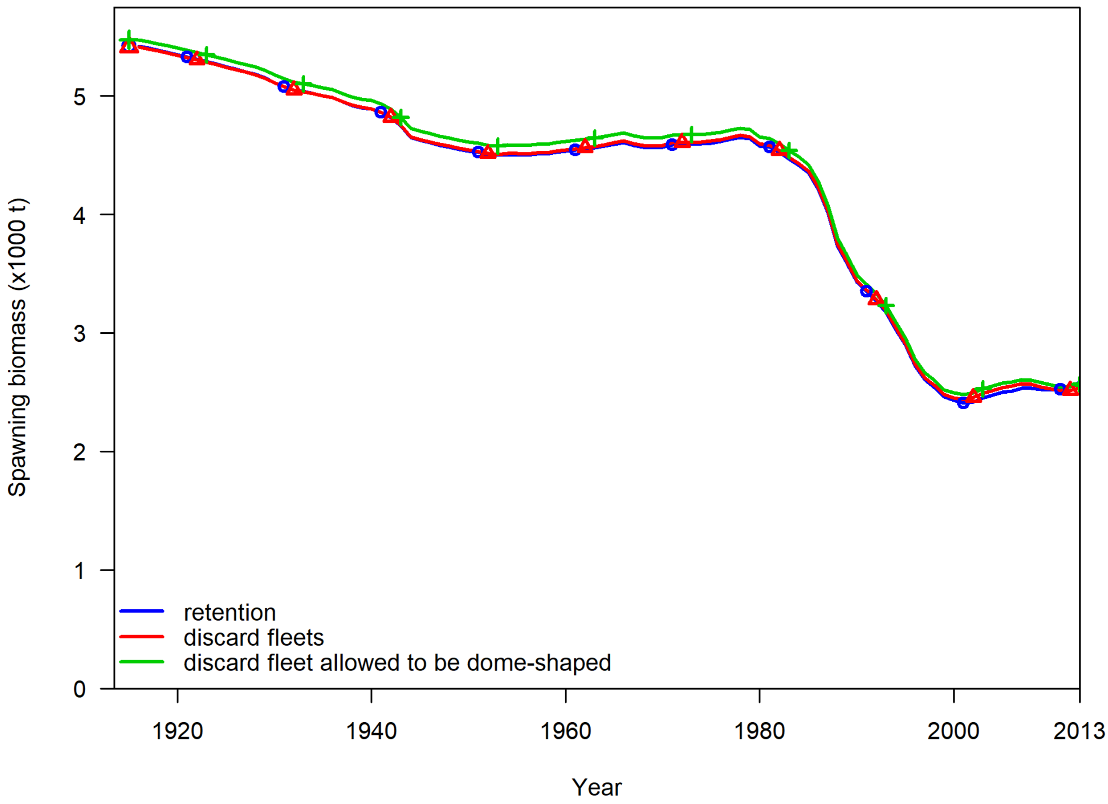

Figure 58: Comparison of spawning output using retention curves or discard fleets using the 2013 Rougheye/Blackspotted Rockfishes assessment.

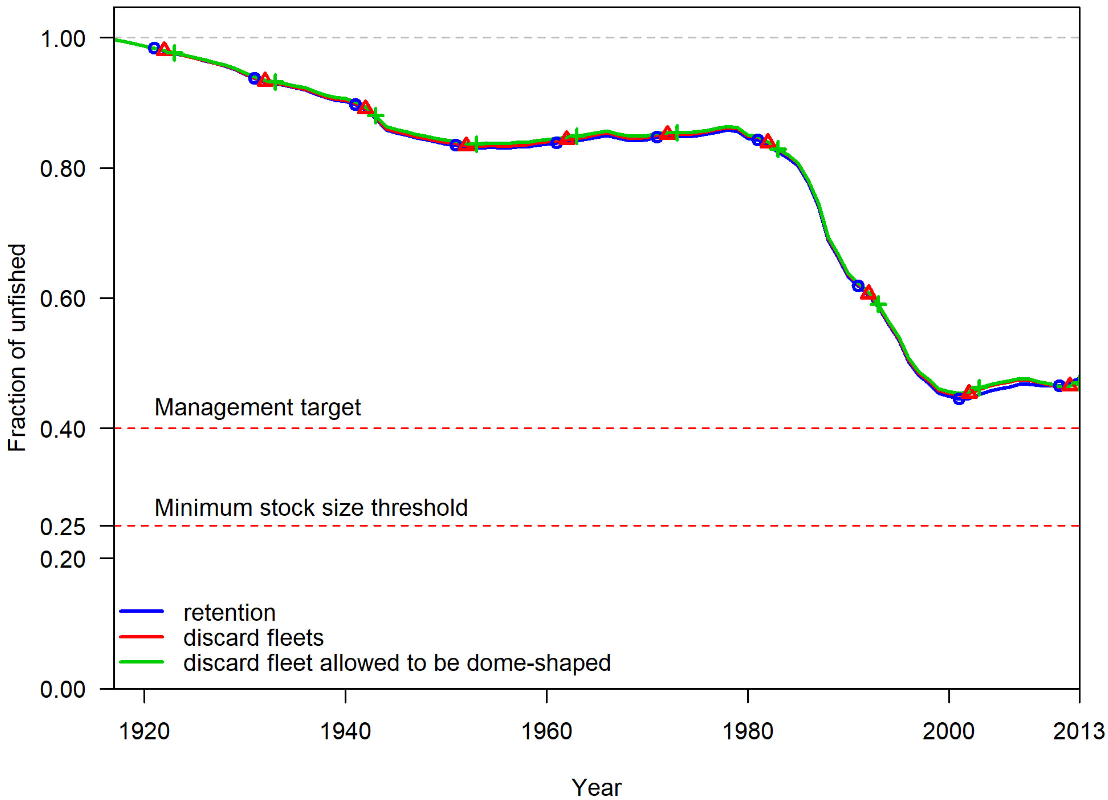

Figure 59: Comparison of relative spawning output using retention curves or discard fleets using the 2013 Rougheye/Blackspotted Rockfishes assessment.

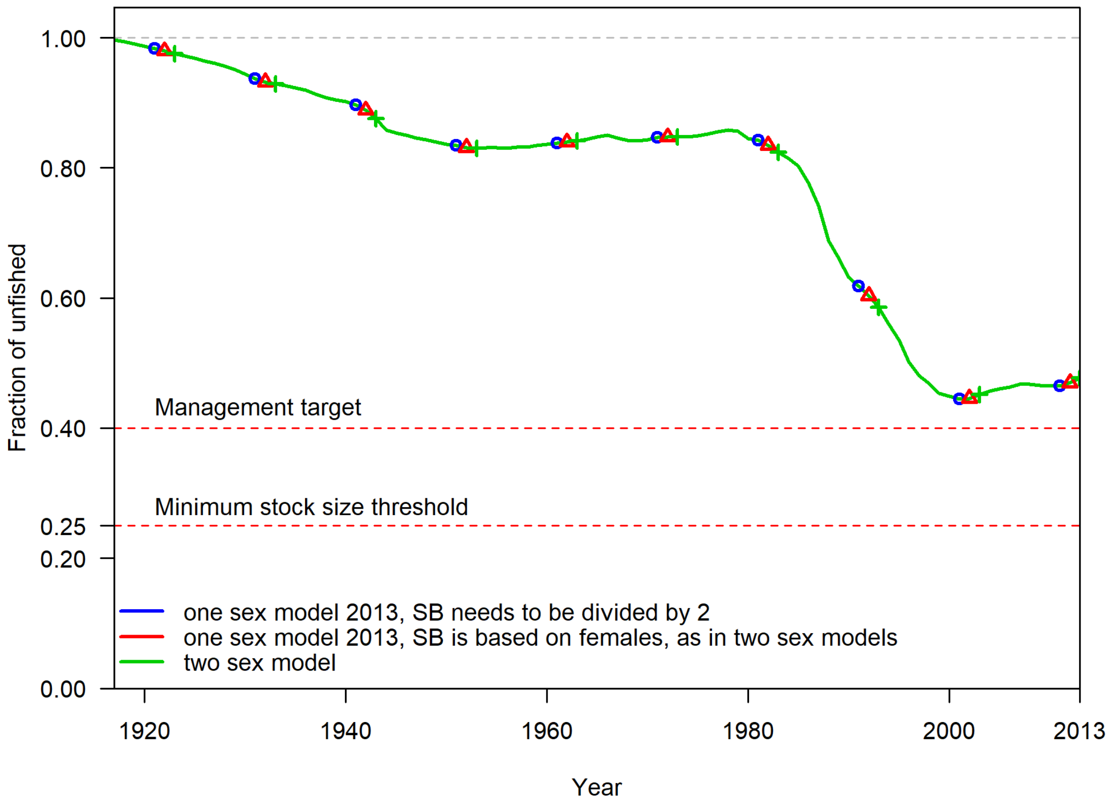

Figure 60: Comparison of relative spawning output between one sex and two sex models.

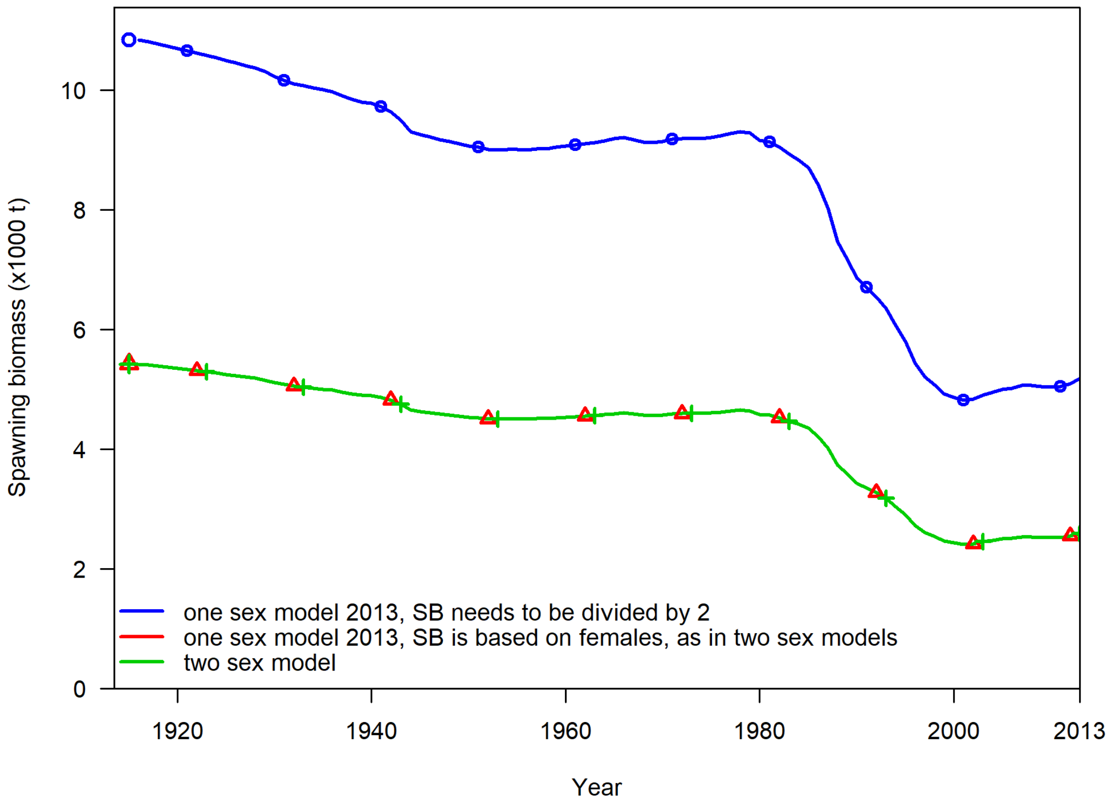

Figure 61: Comparison of spawning output between one sex and two sex models.

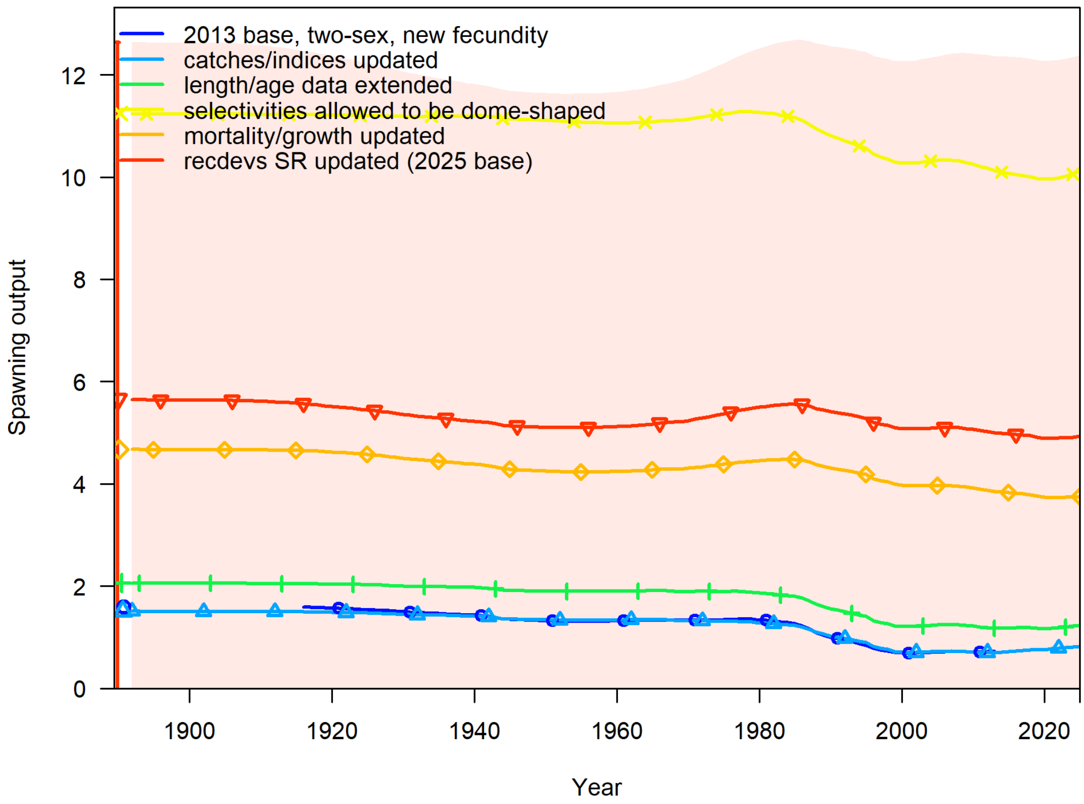

Figure 62: Time series of estimated spawning output for briding analysis.

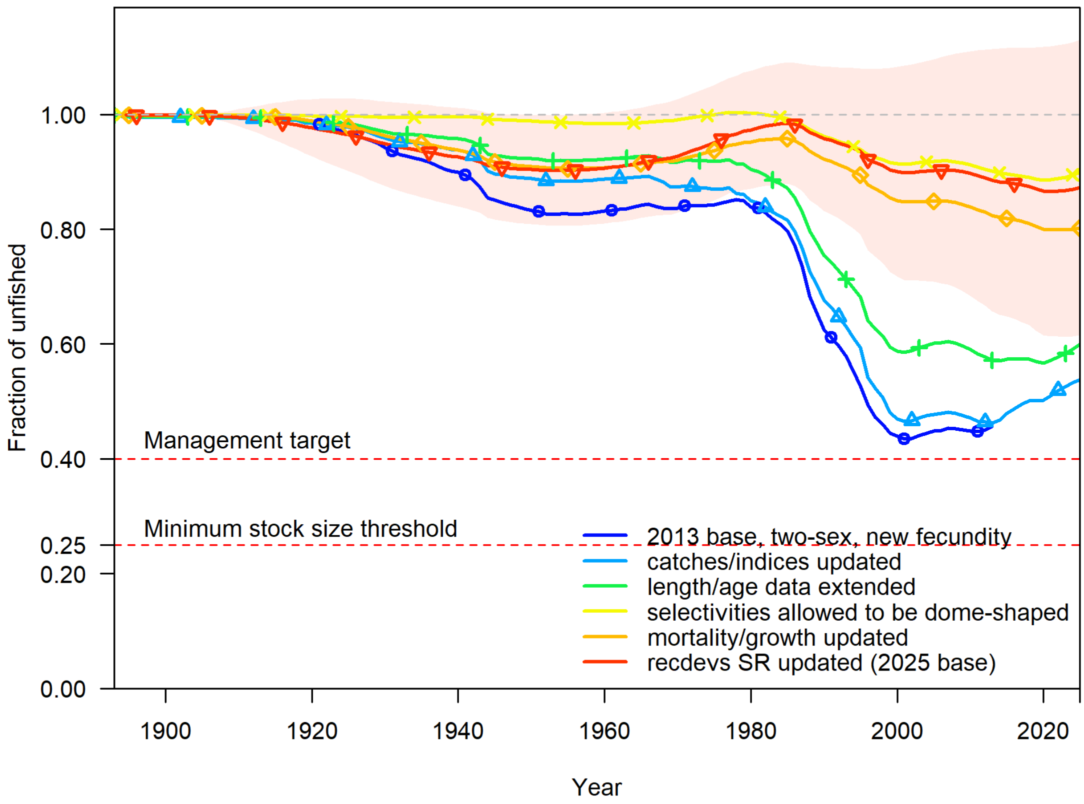

Figure 63: Time series of fraction of unfished spawning output for briding analysis.

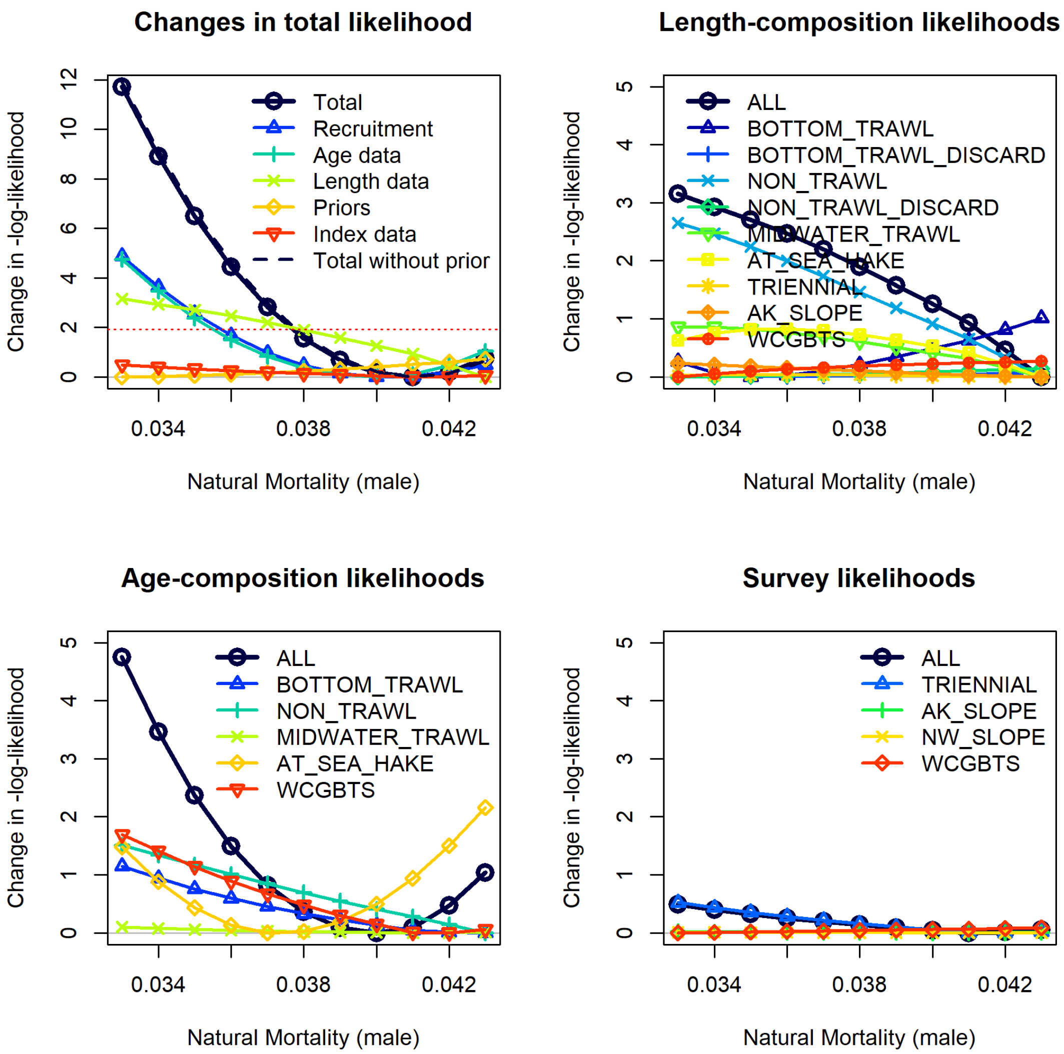

Figure 64: Likelihood profile and component likelihoods used to establish a fixed value for male natural mortality.

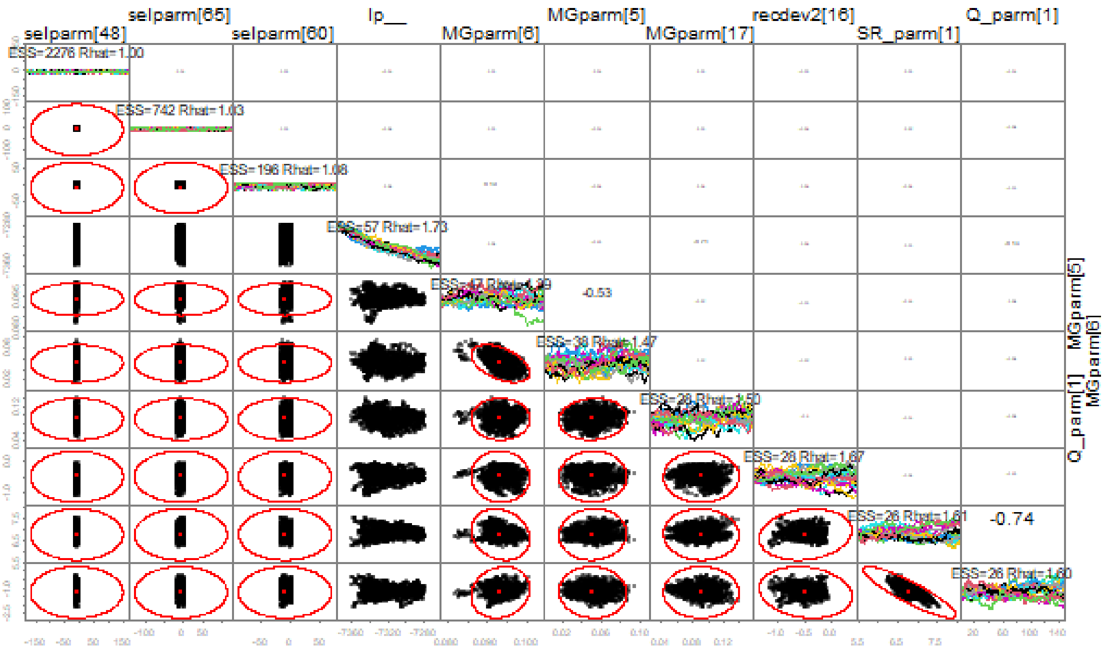

Figure 65: Pairs plots of the fastest mixing parameters from running 2000 posterior draws (keeping every draw) using the random walk Metropolis algorithm. Parameters that show little to no movement are recommended to be fixed to improve model speed and efficiency.

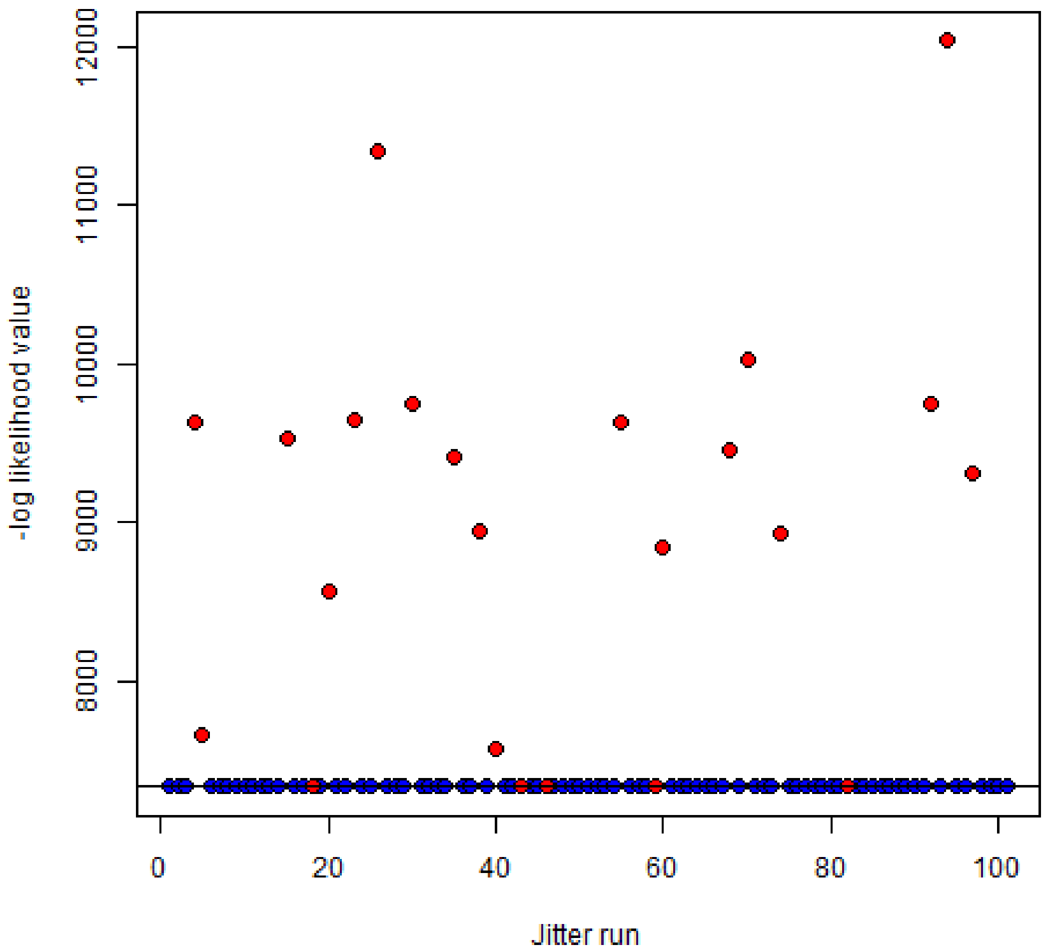

Figure 66: Jitter runs (using a value of 0.01) for the reference model, with jitter run number on the x-axis and -log likelihood value on the y-axis. Blue dot are models that match the likelihood value of the reference model, while red dots deviate from the reference model. All red dots are above the blue dots, indicating no better fit to the reference model was found.

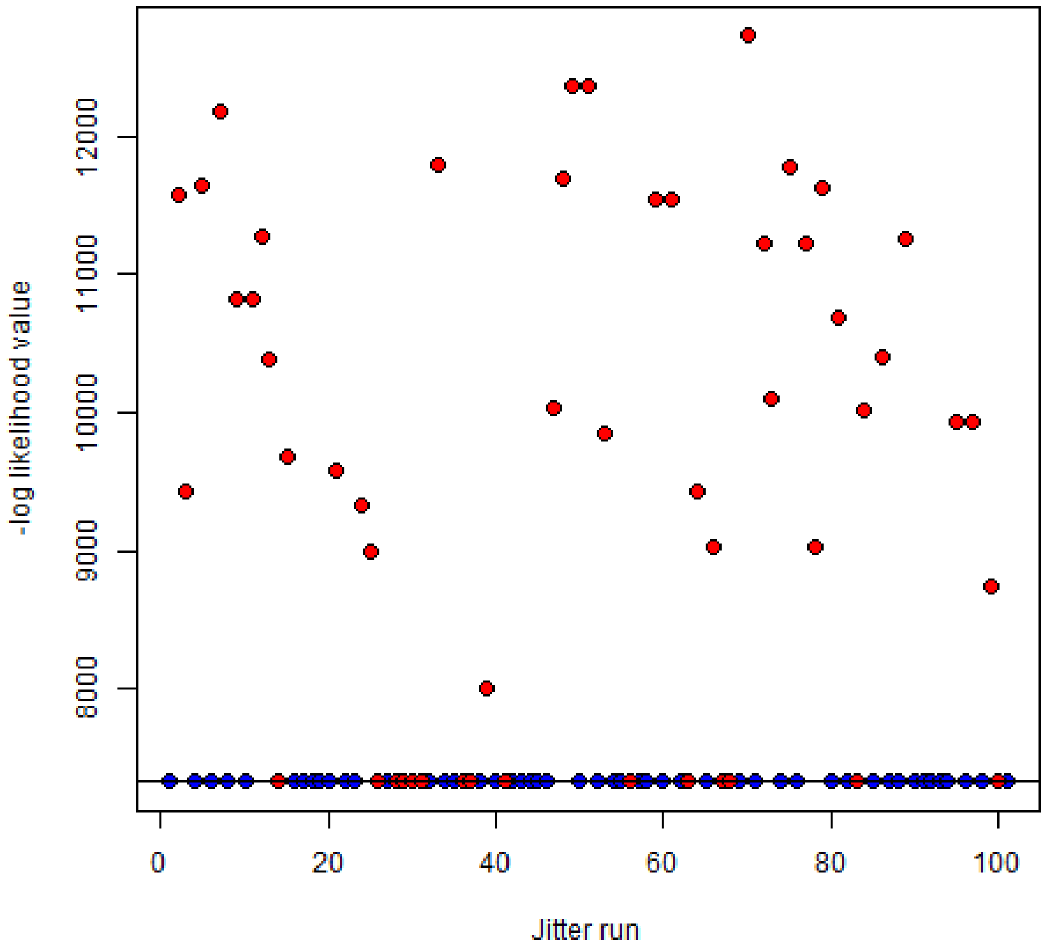

Figure 67: Jitter runs (using a value of 0.05) for the reference model, with jitter run number on the x-axis and -log likelihood value on the y-axis. Blue dot are models that match the likelihood value of the reference model, while red dots deviate from the reference model. All red dots are above the blue dots, indicating no better fit to the reference model was found.

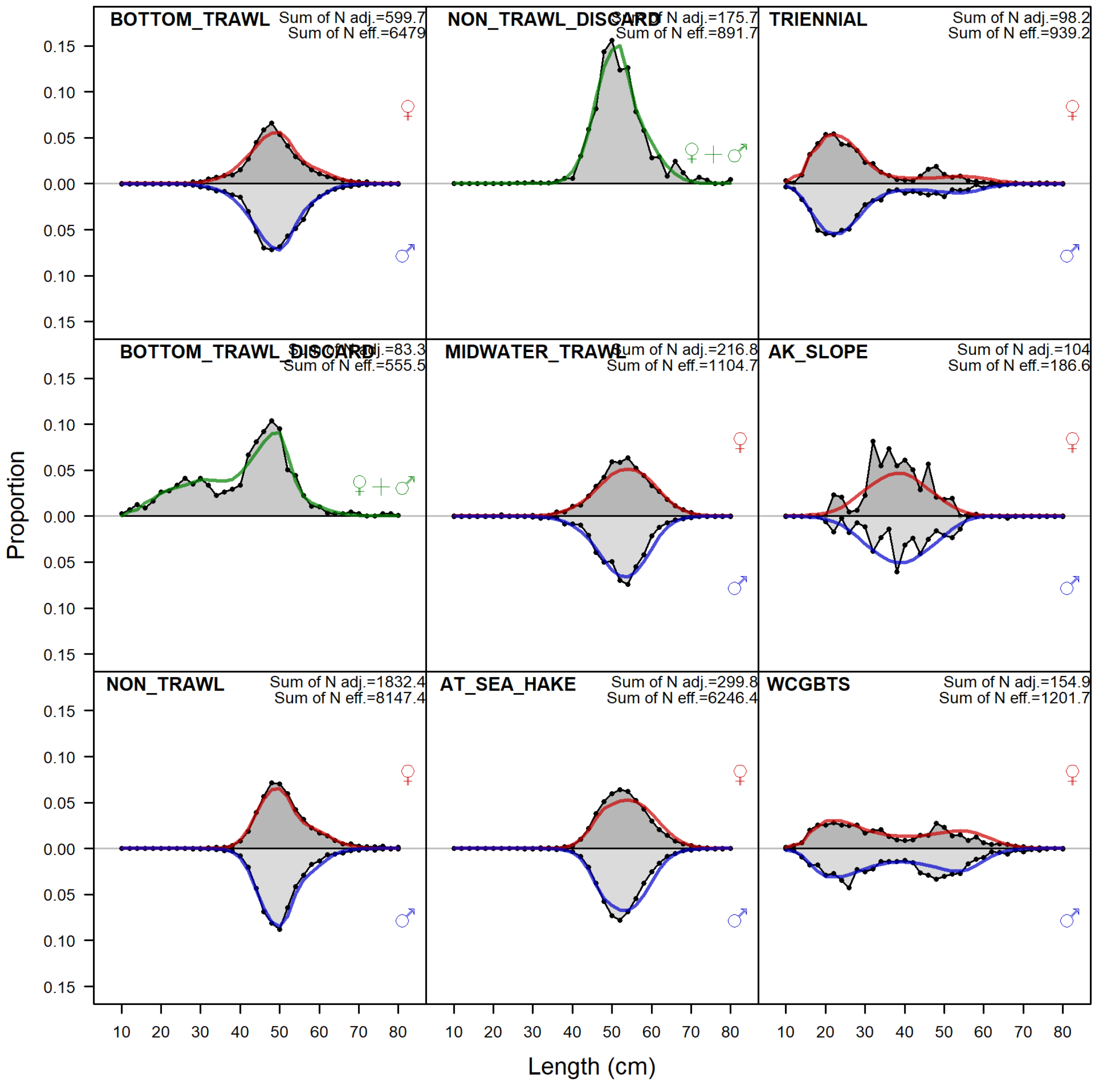

Figure 68: Aggregated length (cm) compositions over all years.

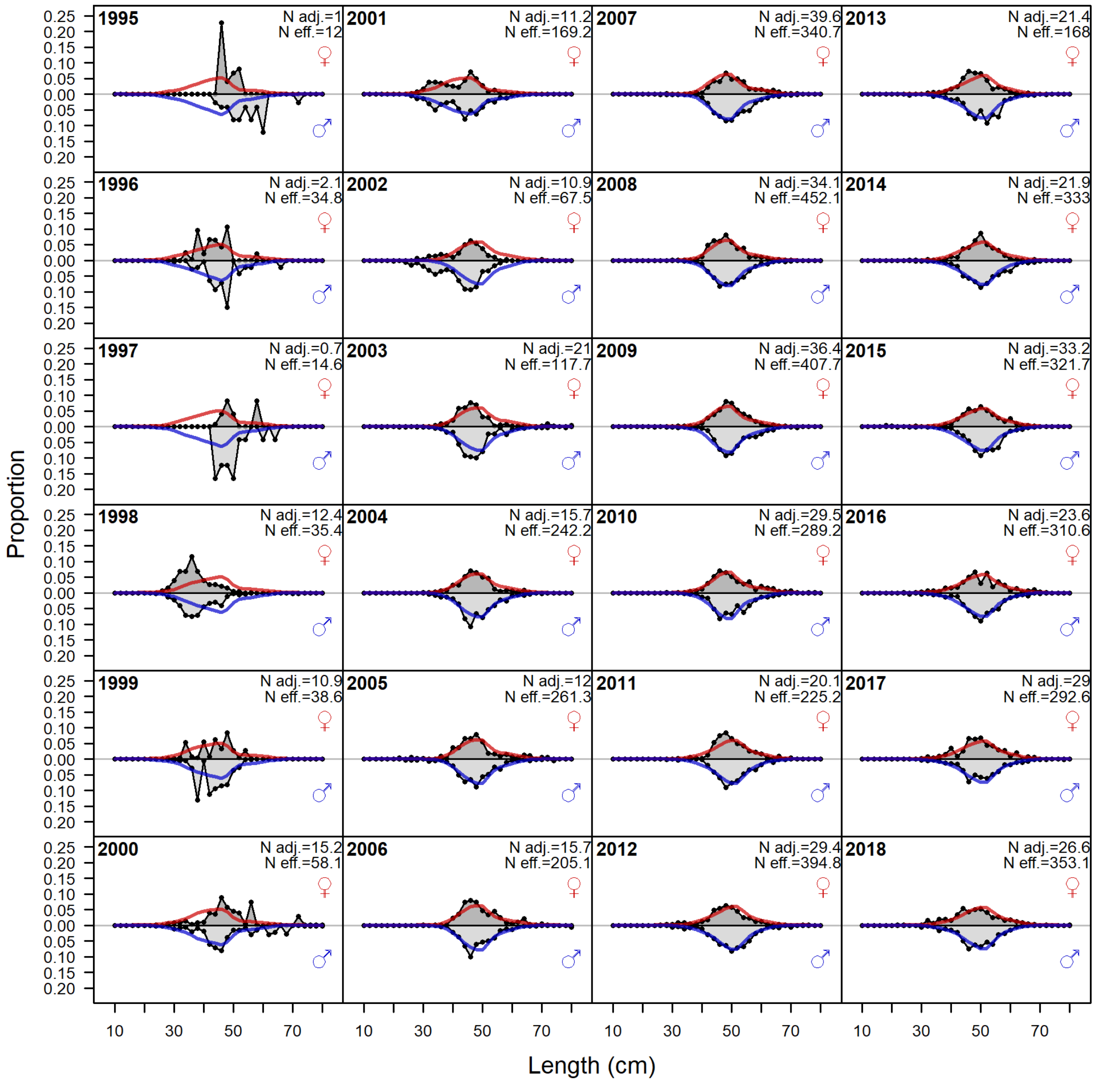

Figure 69: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the bottom trawl fishery in years available between 1995-2018.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

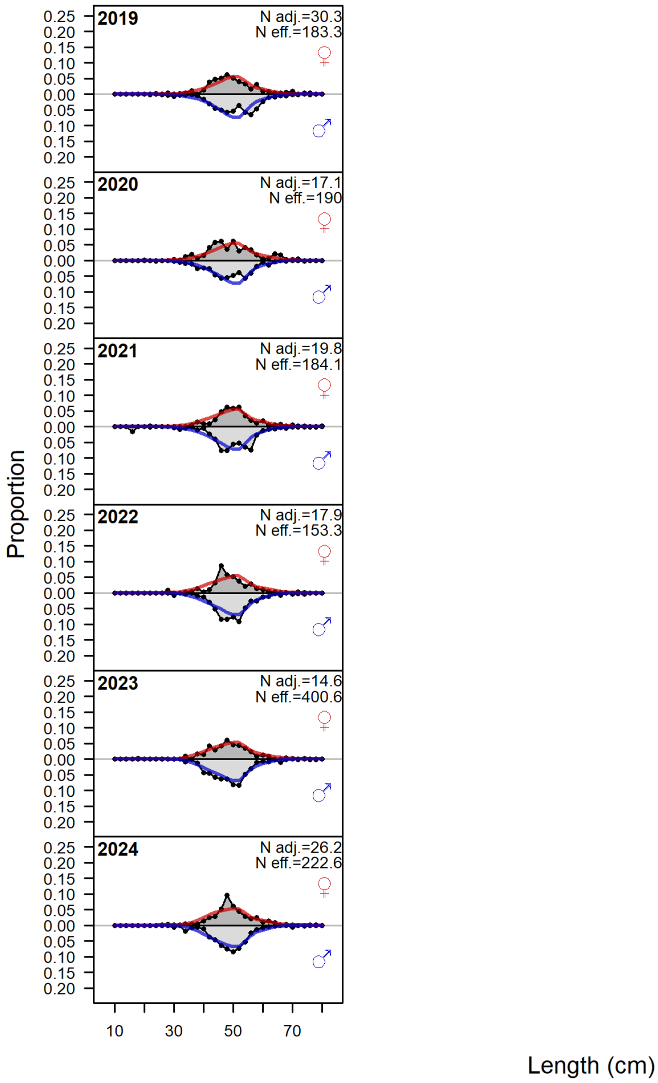

Figure 70: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the bottom trawl fishery in years available between 2019-2024.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

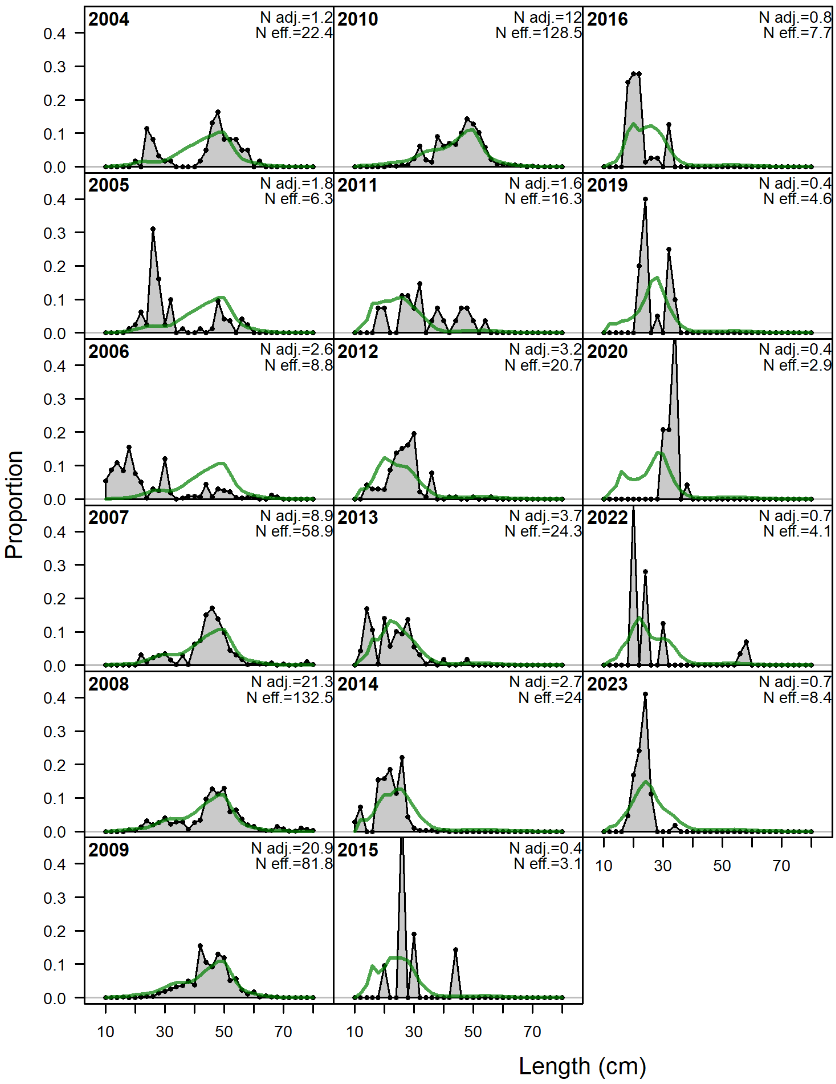

Figure 71: Observed (gray density plot) and expected (density lines) length compositions by year for the bottom trawl discard fishery in years available between 2004-2023.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

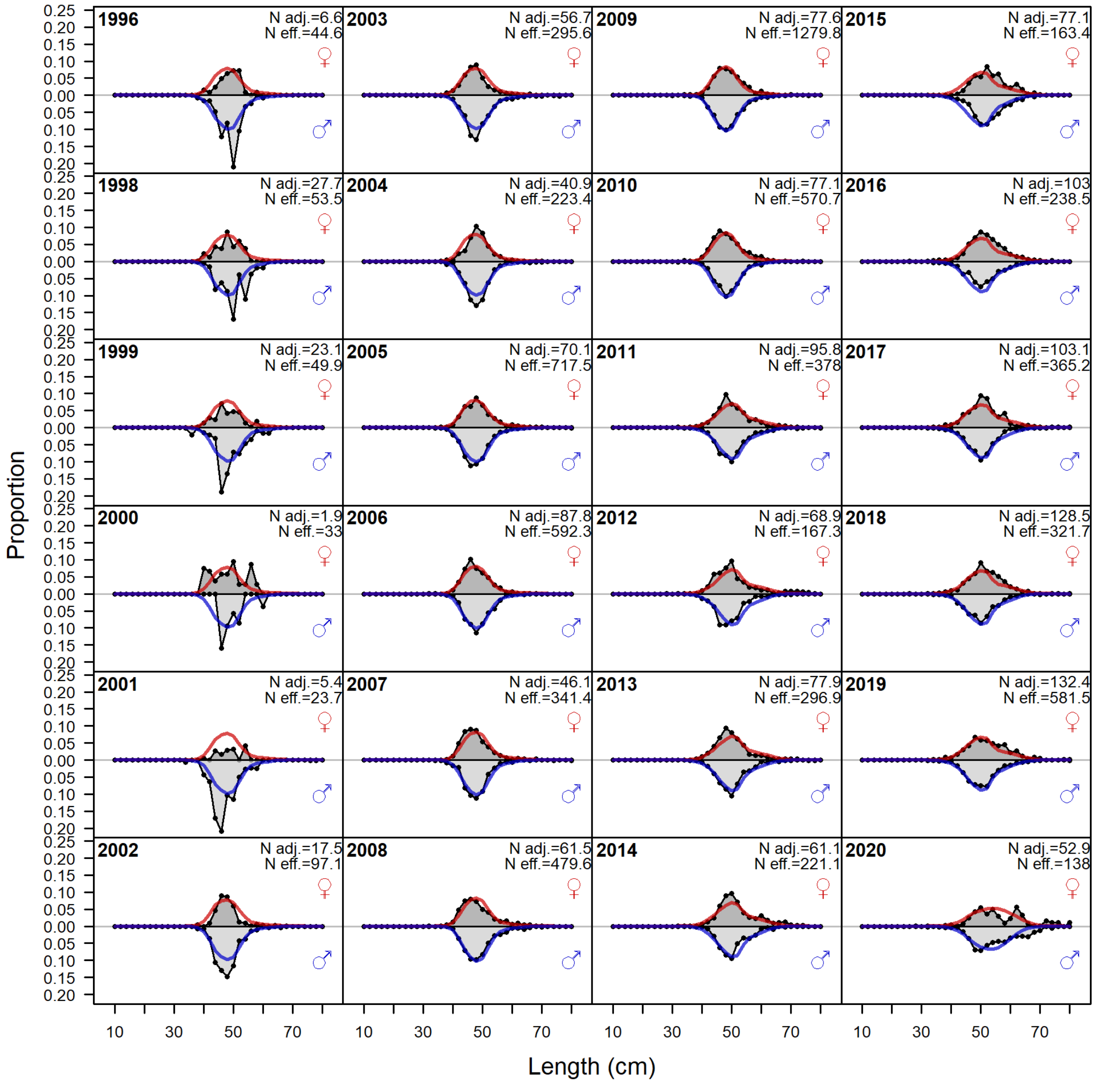

Figure 72: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the non-trawl fishery in years available between 1996-2020.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

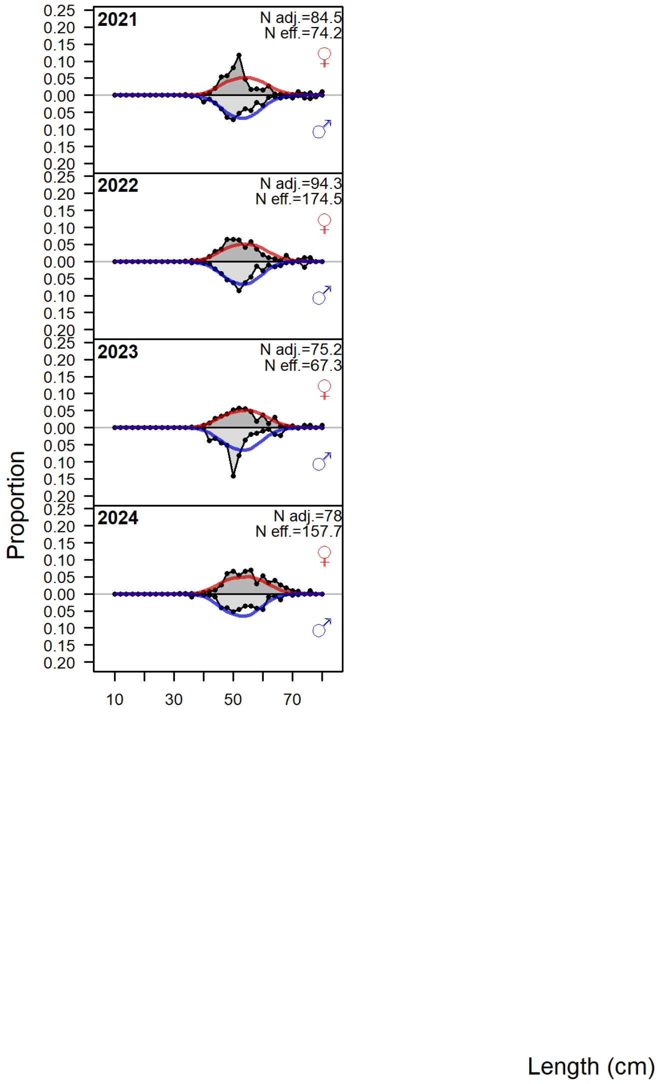

Figure 73: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the non-trawl fishery in years available between 2021-2024.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

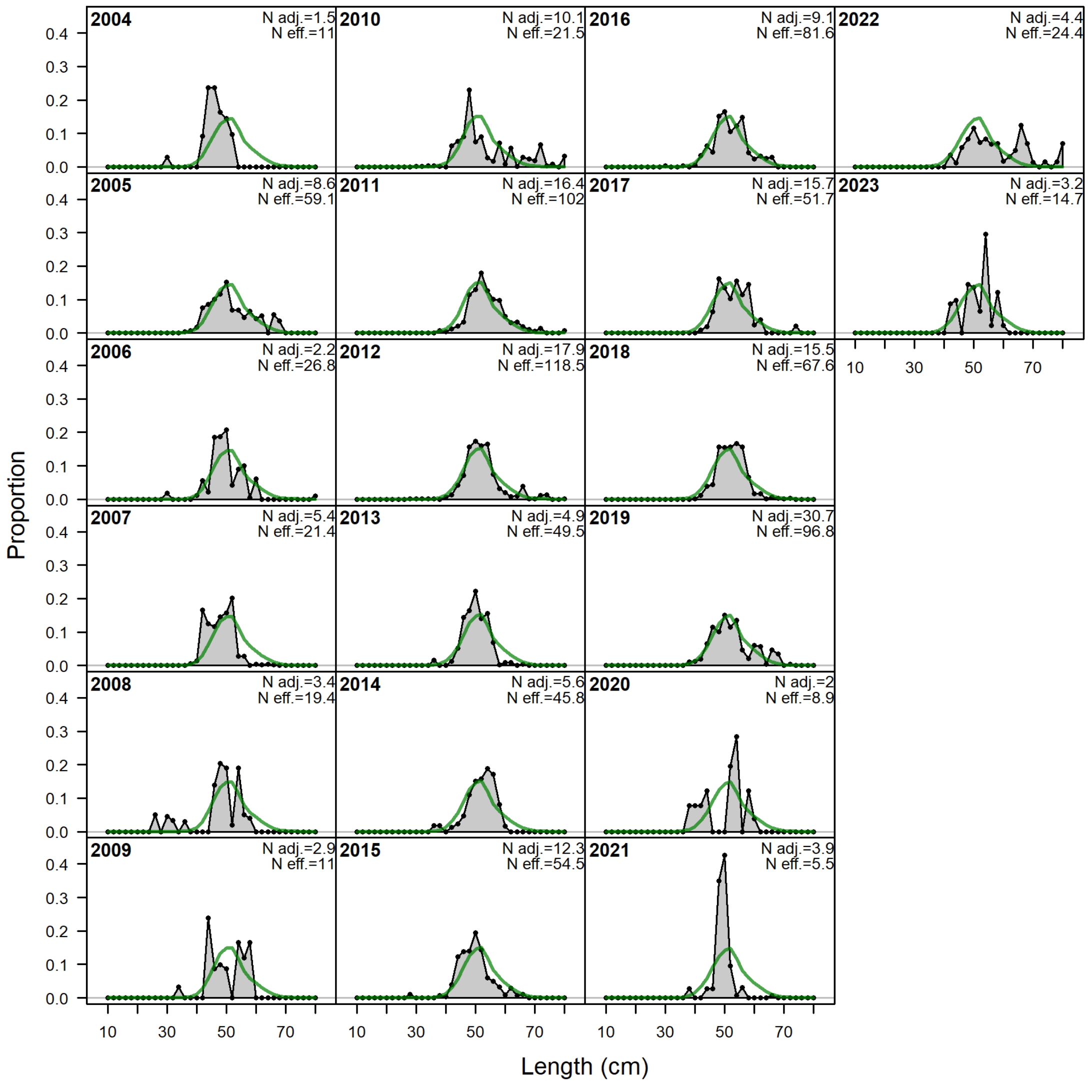

Figure 74: Observed (gray density plot) and expected (density lines) length compositions by year for the midwater trawl fishery in years available between 2004-2024.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

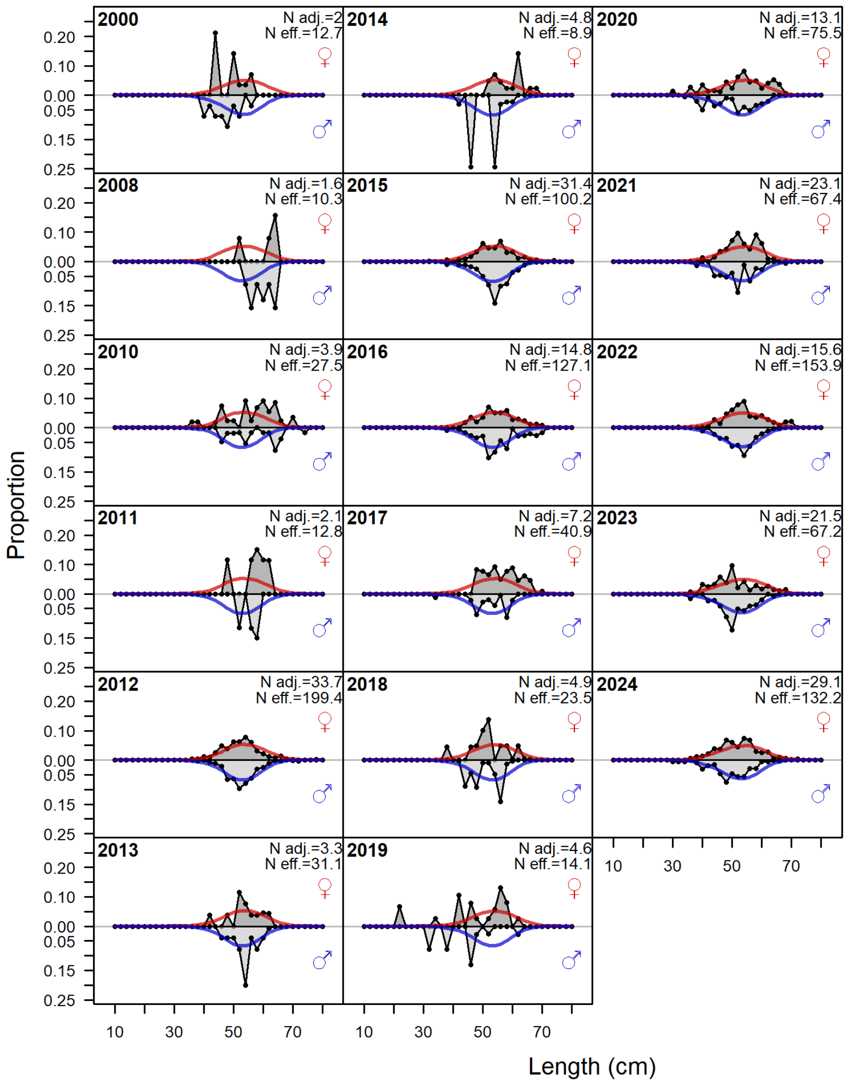

Figure 75: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the non-trawl discard fishery in years available between 2000-2023.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

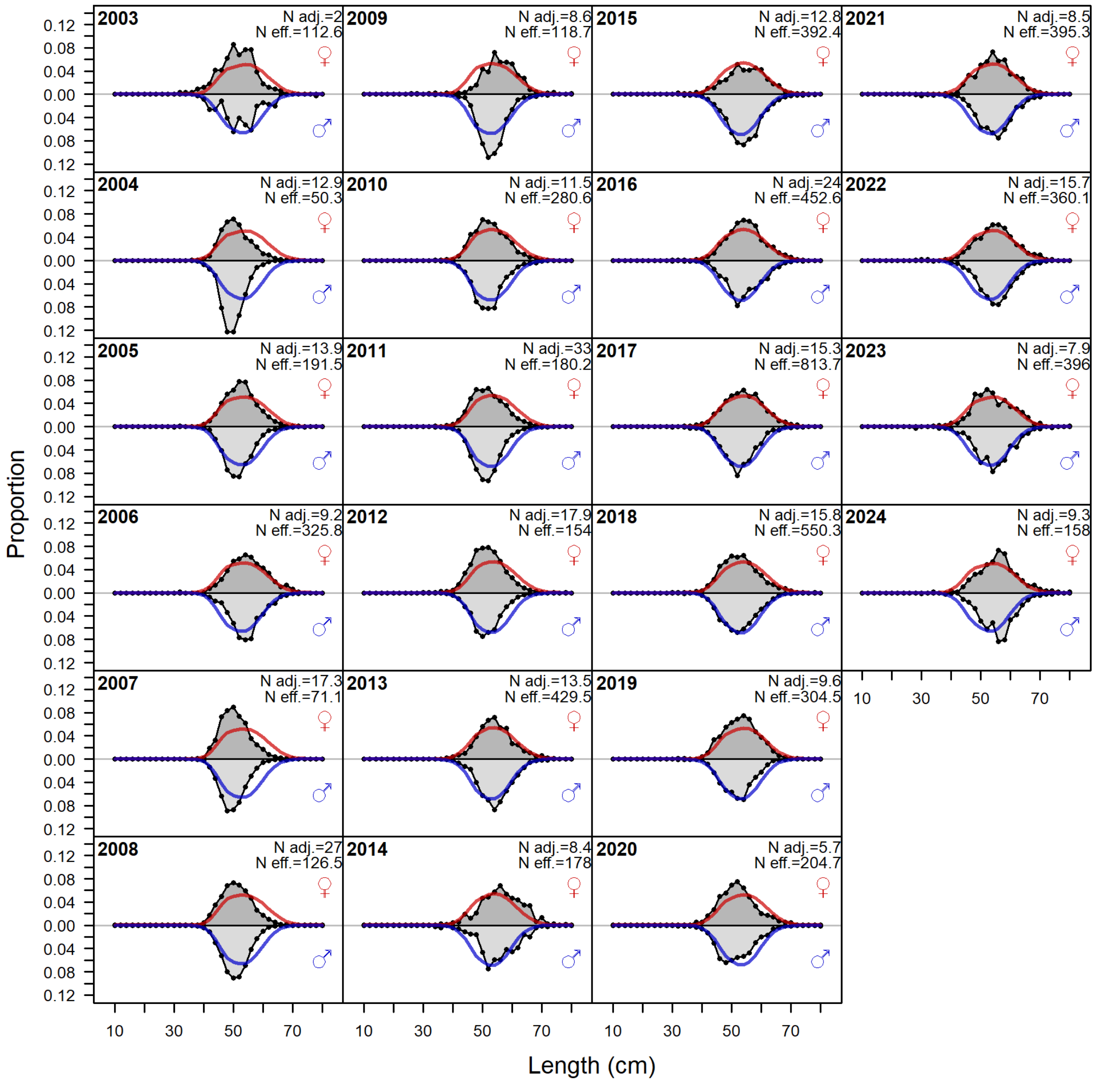

Figure 76: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the at-sea-hake fishery in years available between 2003-2024.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

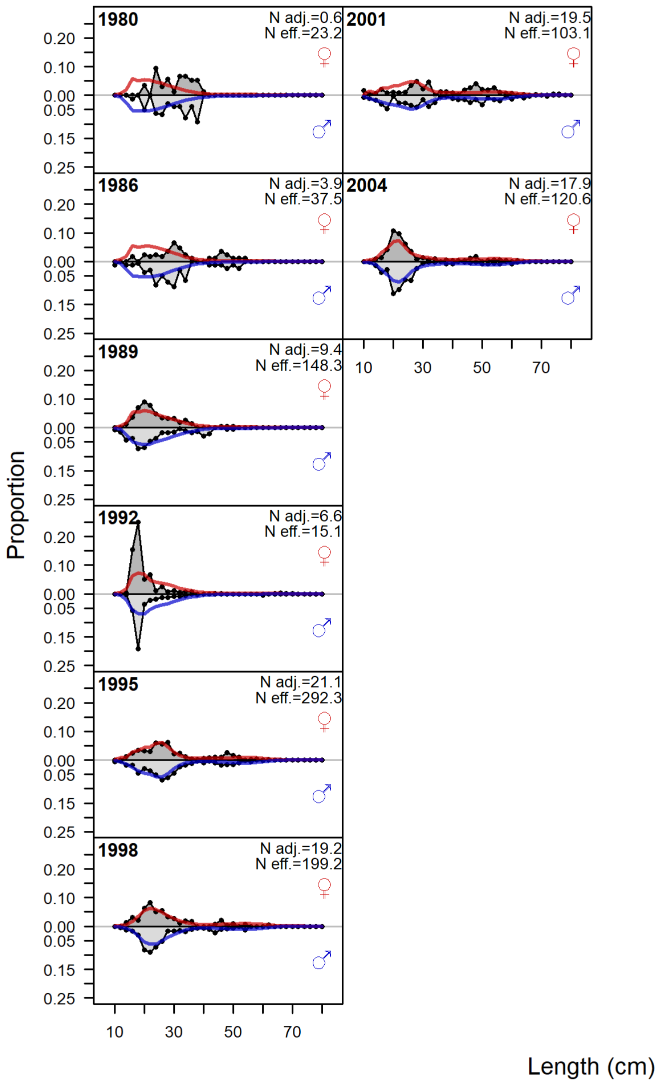

Figure 77: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the Triennial Bottom Trawl Survey in years available between 1980-2004.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in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

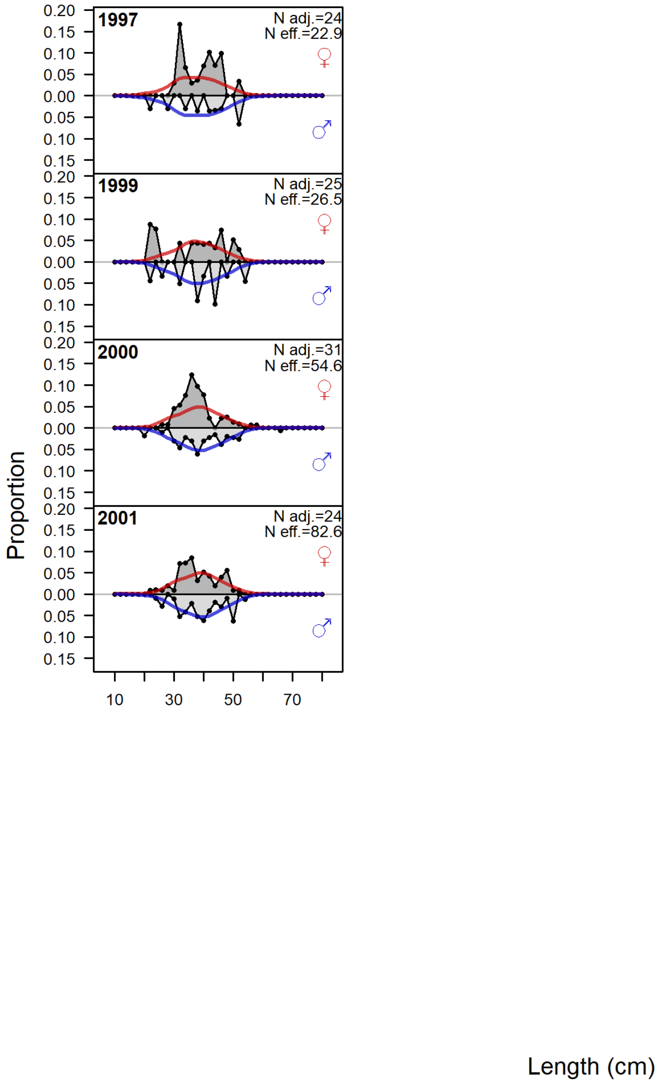

Figure 78: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the Alaskan Slope Bottom Trawl Survey in years available between 1997-2001.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

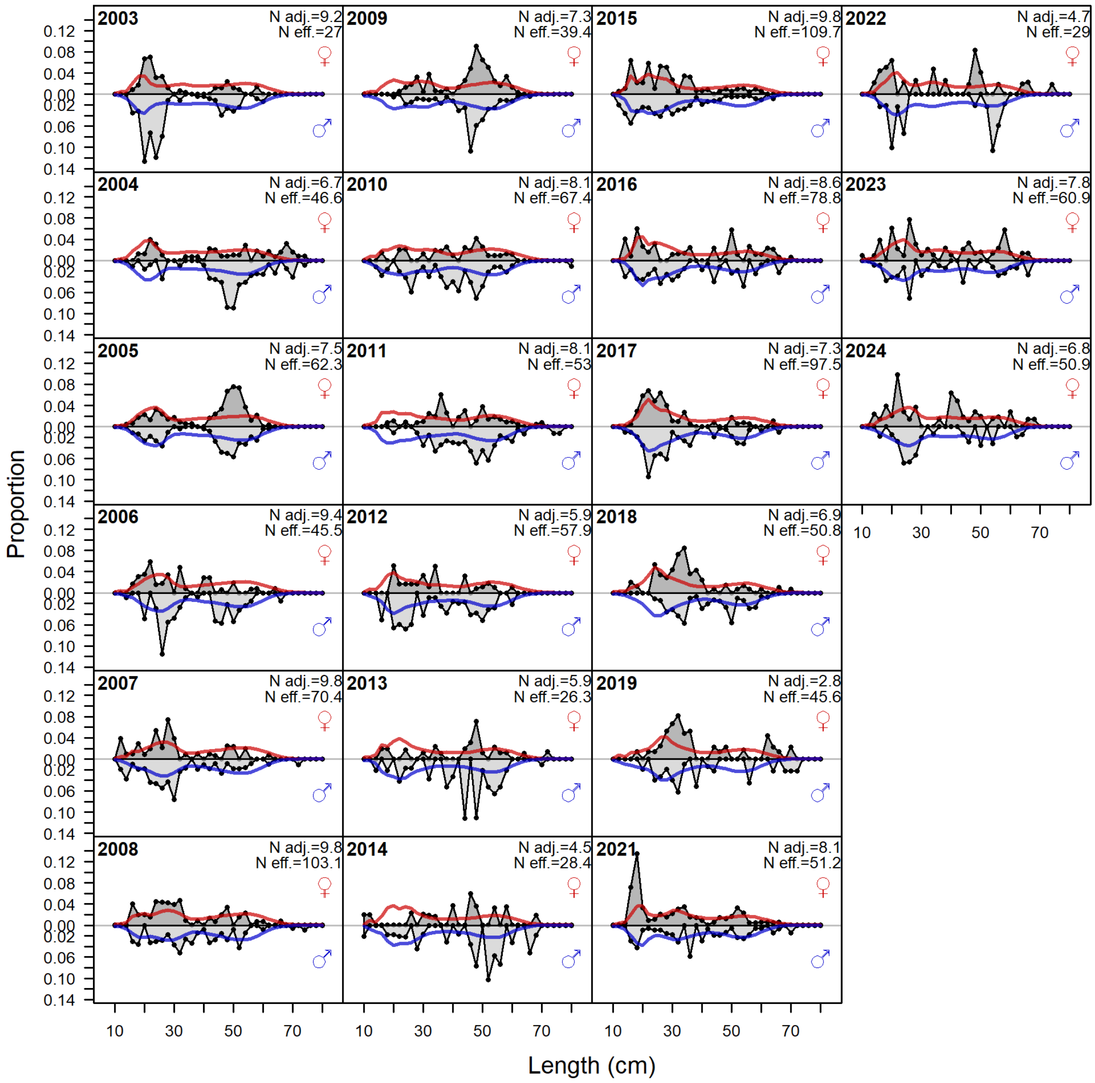

Figure 79: Observed (gray density plot) and expected (density lines by sex) length compositions by year for the West Coast Groundfish Bottom Trawl Survey in years available between 1980-2004.'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

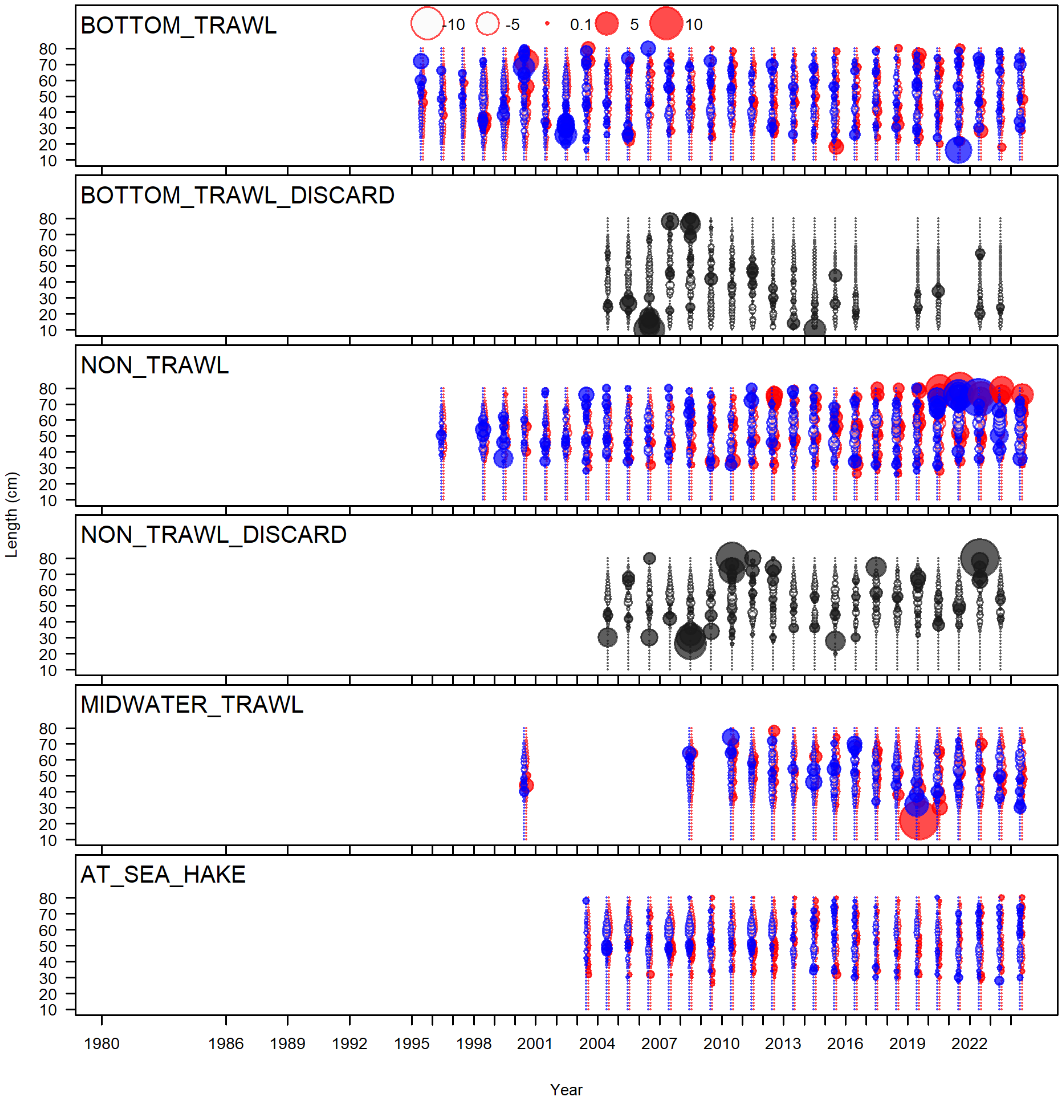

Figure 80: Pearson residuals of length fits for each fishing fleet. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

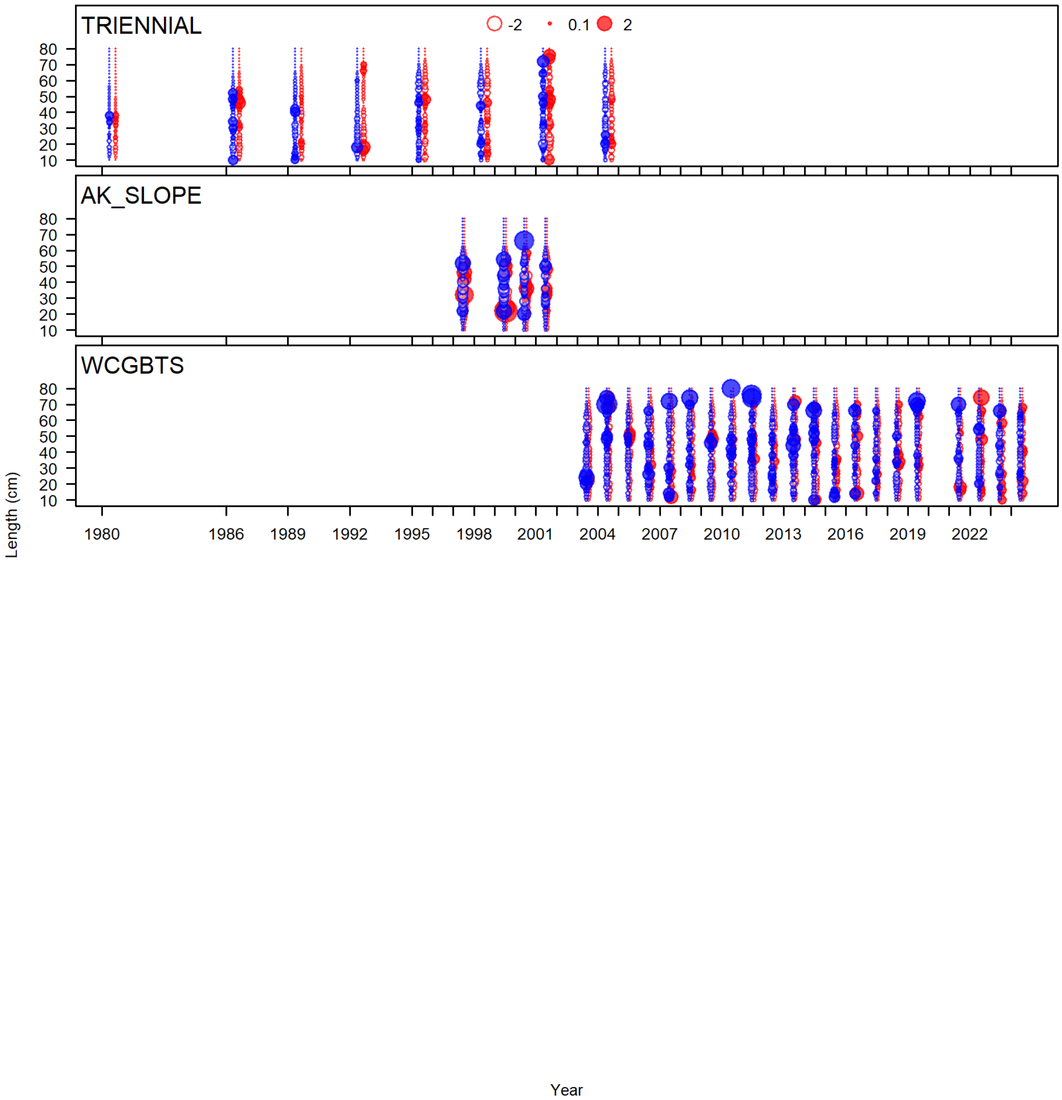

Figure 81: Pearson residuals of length fits for each survey. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

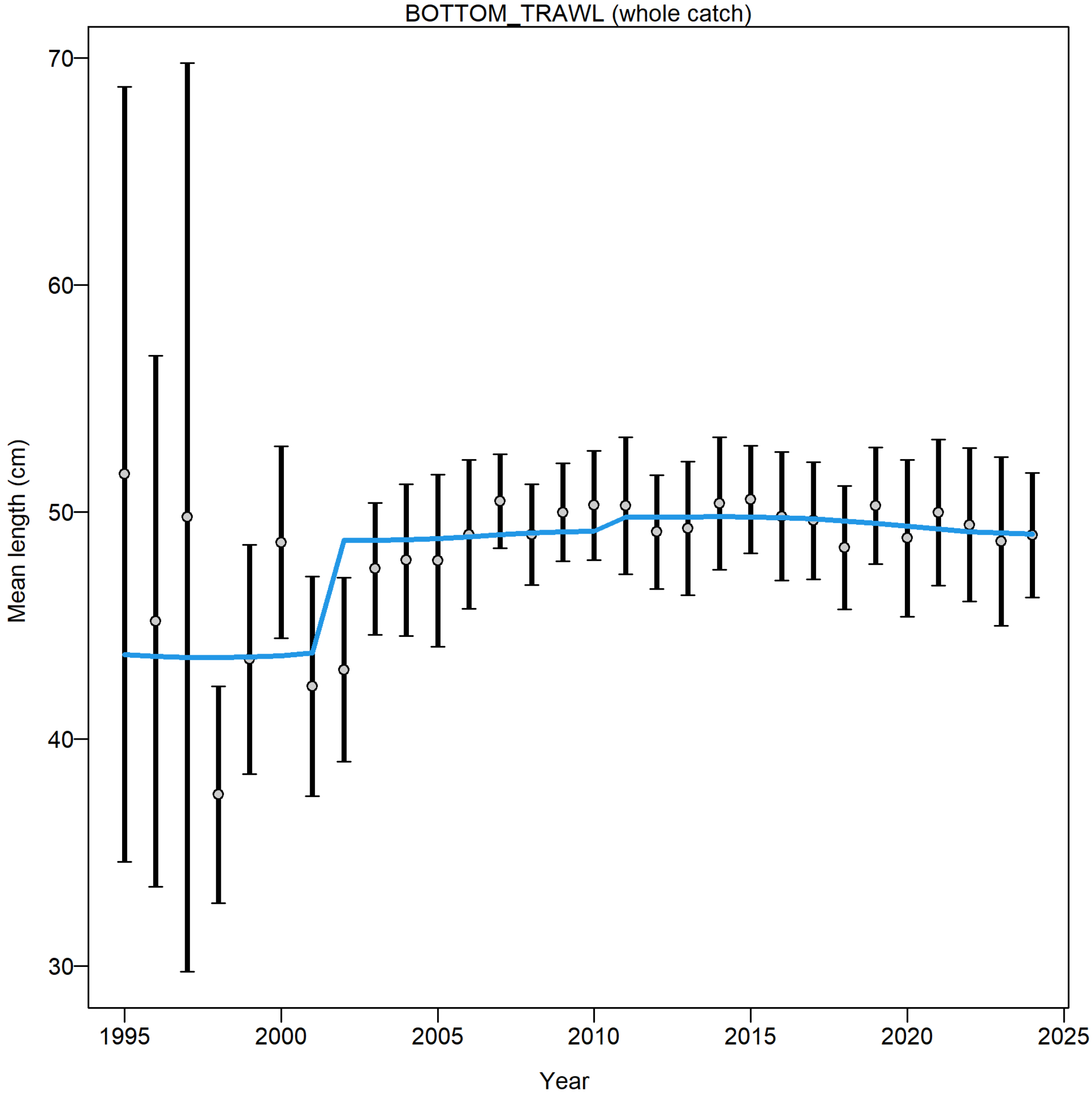

Figure 82: Mean length (cm) index from the bottom trawl fishery with 95 percent confidence intervals based on sample sizes and data weighting.

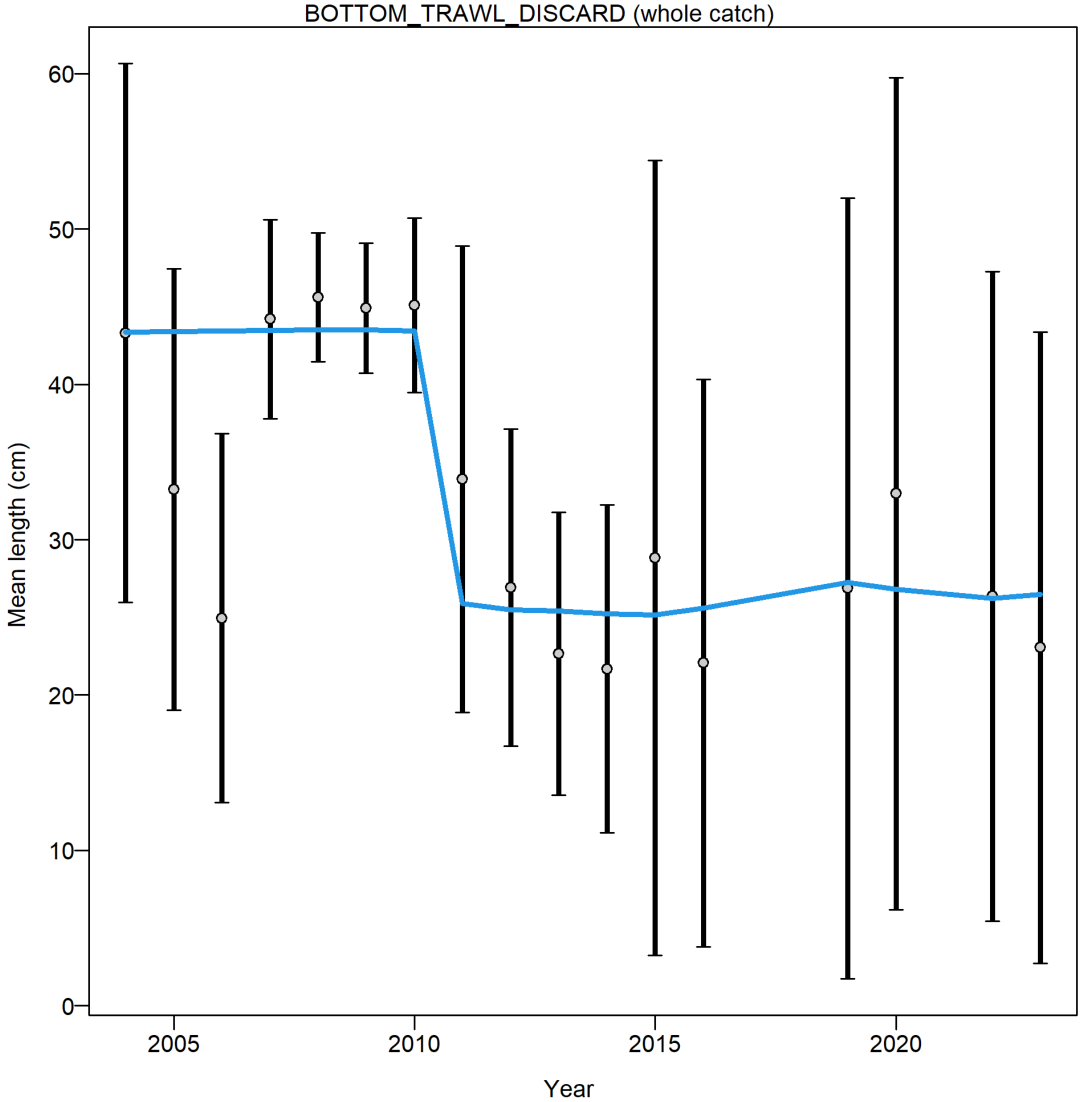

Figure 83: Mean length (cm) index from the bottom trawl discard fishery with 95 percent confidence intervals based on sample sizes and data weighting.

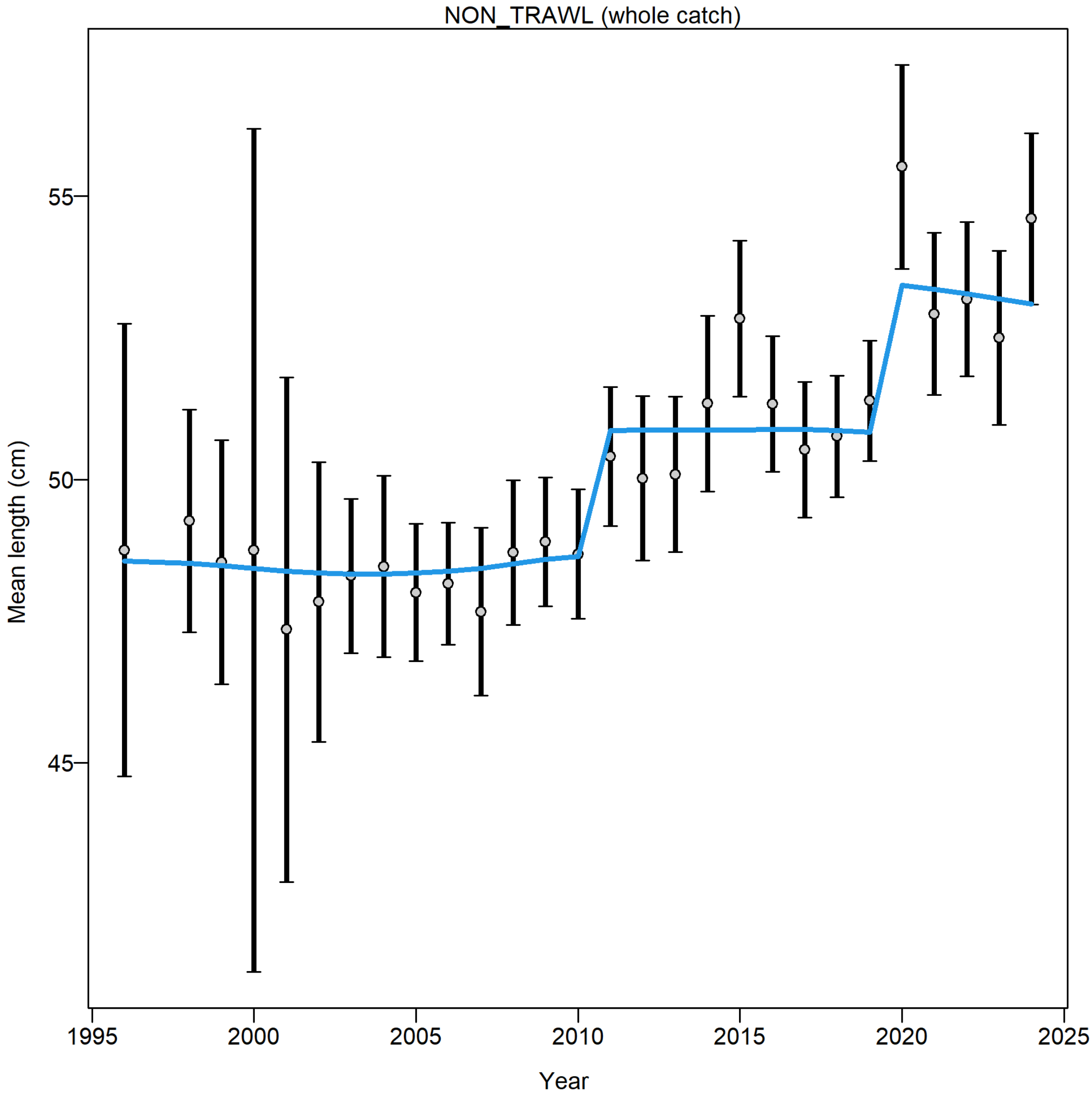

Figure 84: Mean length (cm) index from the non-trawl fishery with 95 percent confidence intervals based on sample sizes and data weighting.

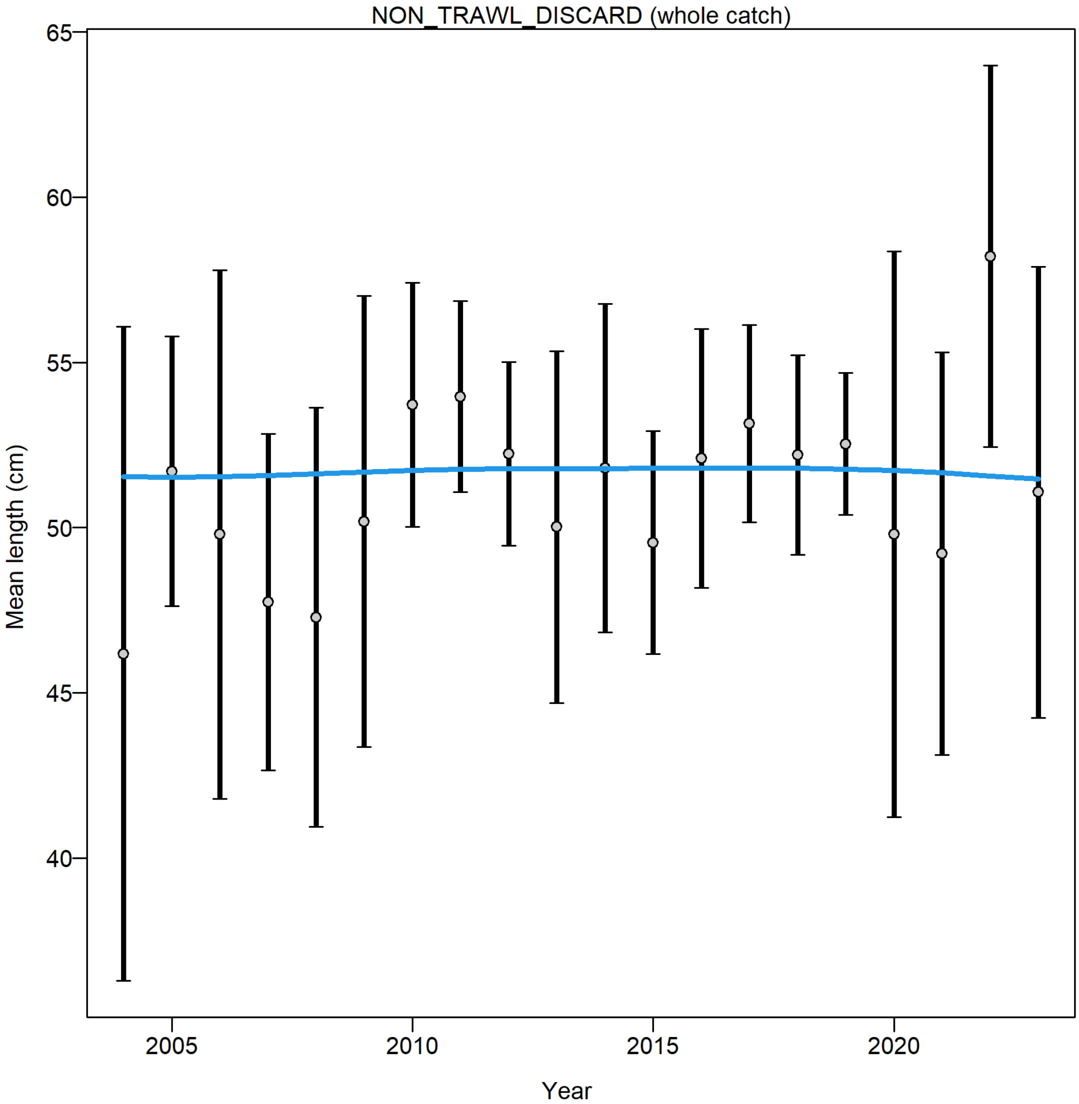

Figure 85: Mean length (cm) index from the non-trawl discard fishery with 95 percent confidence intervals based on sample sizes and data weighting.

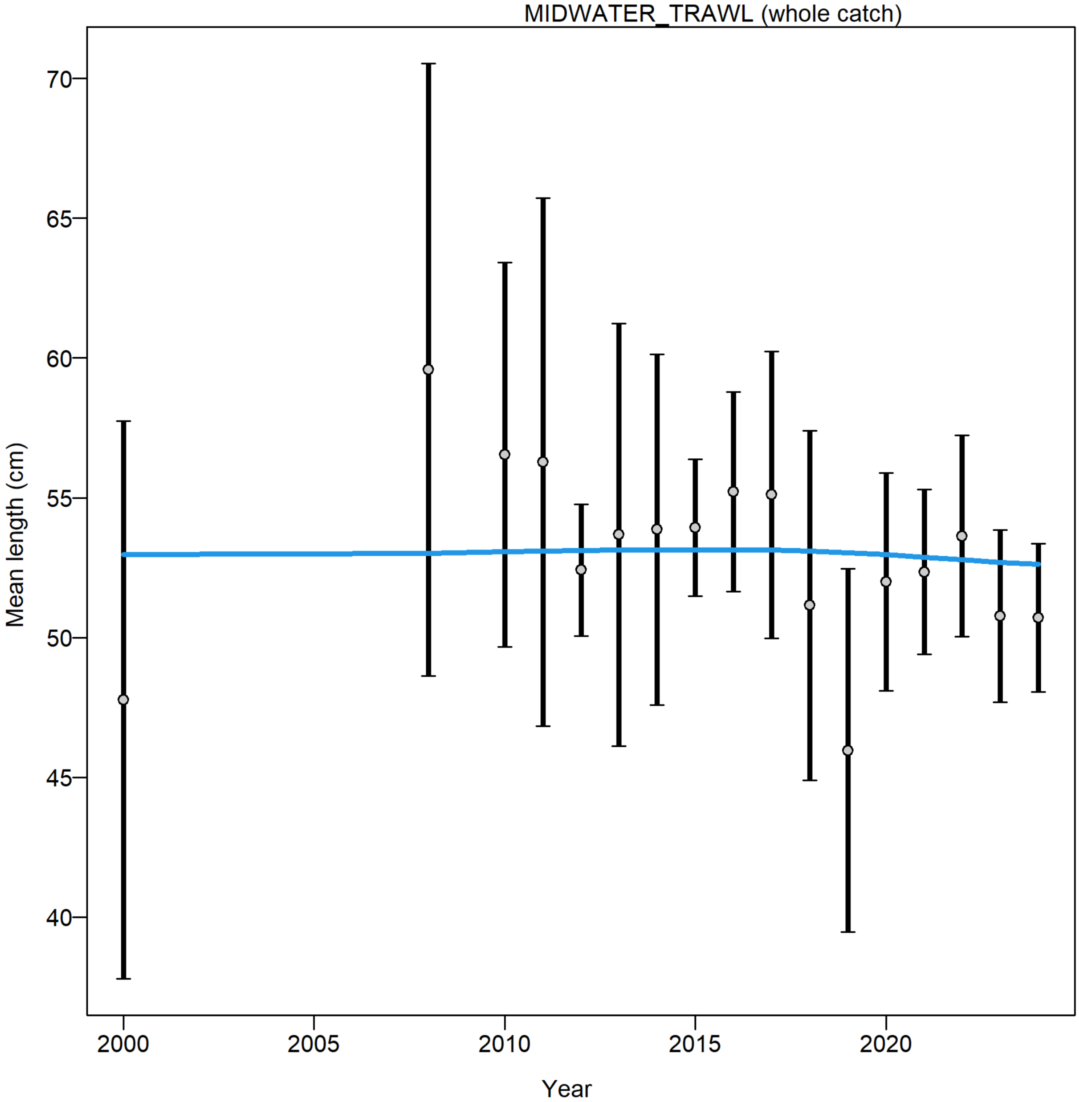

Figure 86: Mean length (cm) index from the midwater trawl fishery with 95 percent confidence intervals based on sample sizes and data weighting.

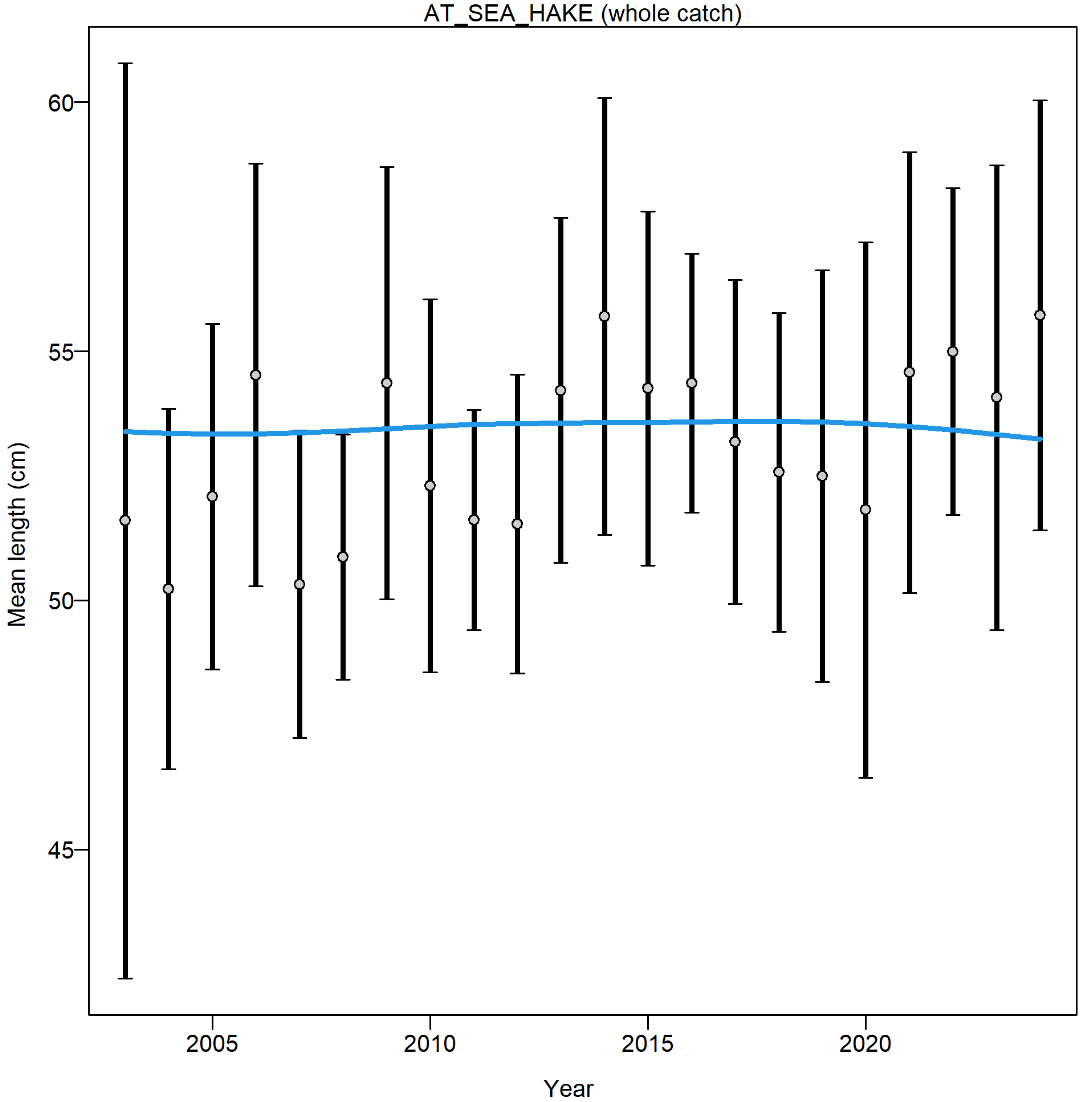

Figure 87: Mean length (cm) index from the at-sea-hake fishery with 95 percent confidence intervals based on sample sizes and data weighting.

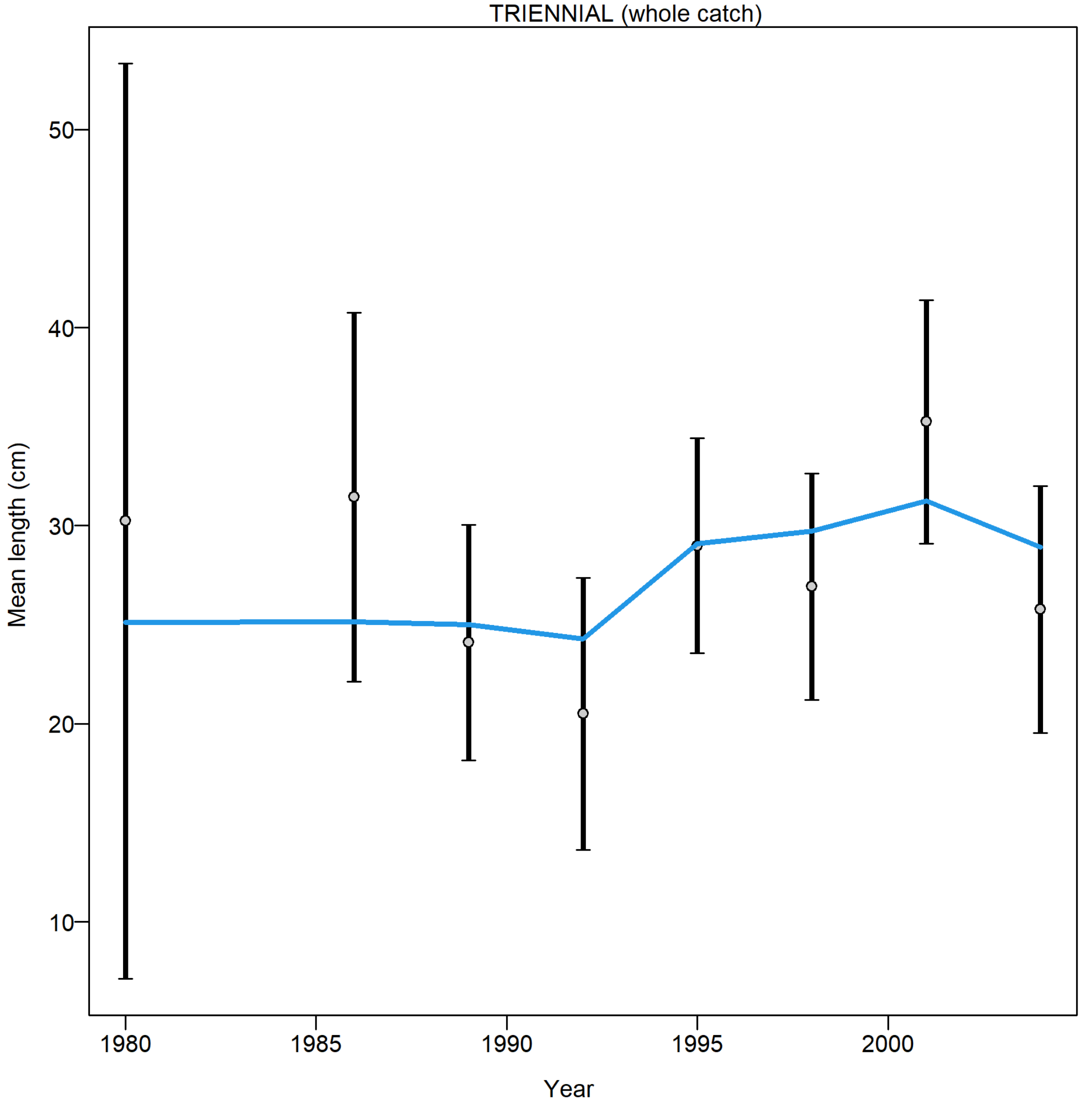

Figure 88: Mean length (cm) index from the Triennial survey with 95 percent confidence intervals based on sample sizes and data weighting.

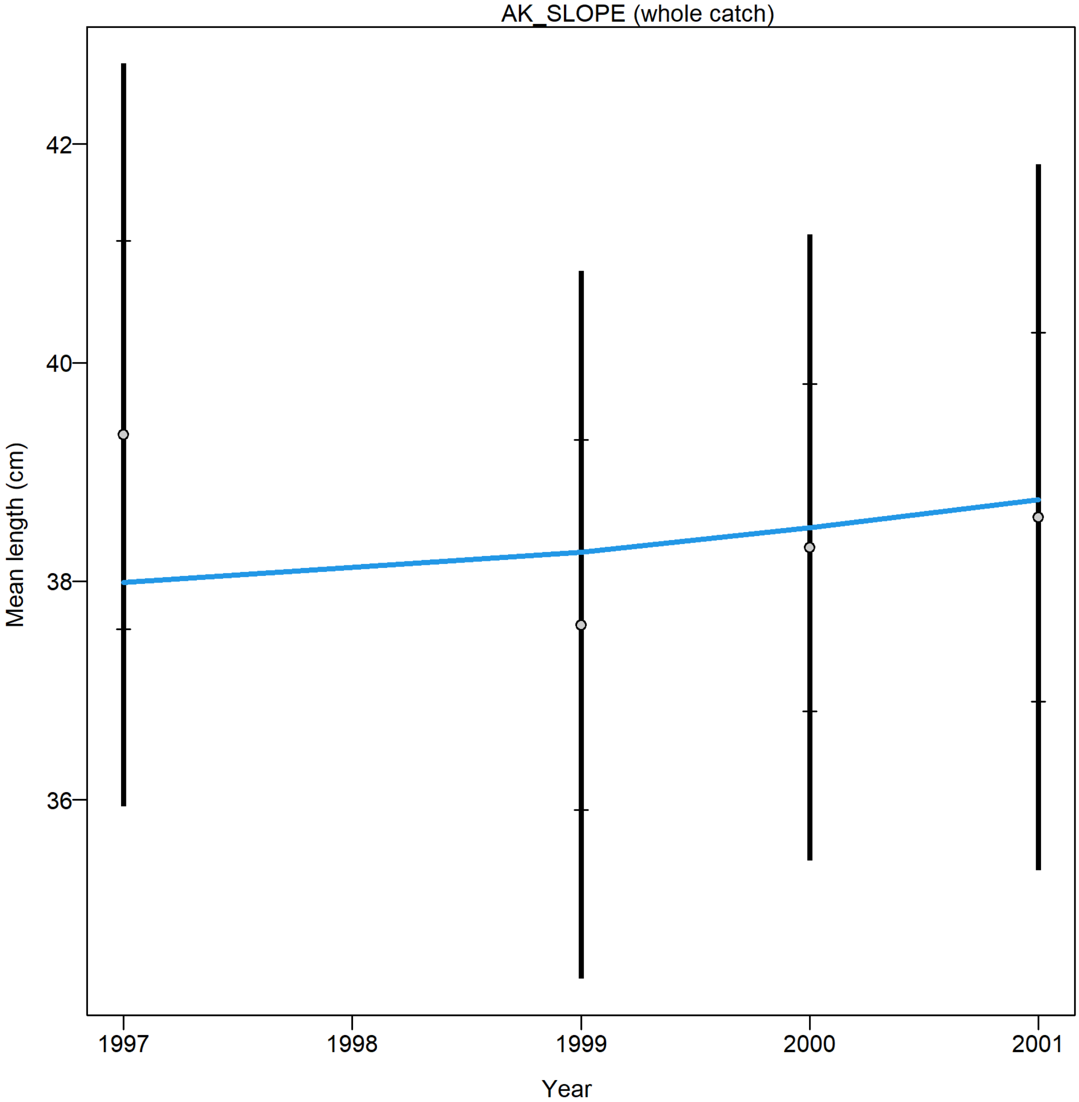

Figure 89: Mean length (cm) index from the Alaskan slope survey with 95 percent confidence intervals based on sample sizes and data weighting.

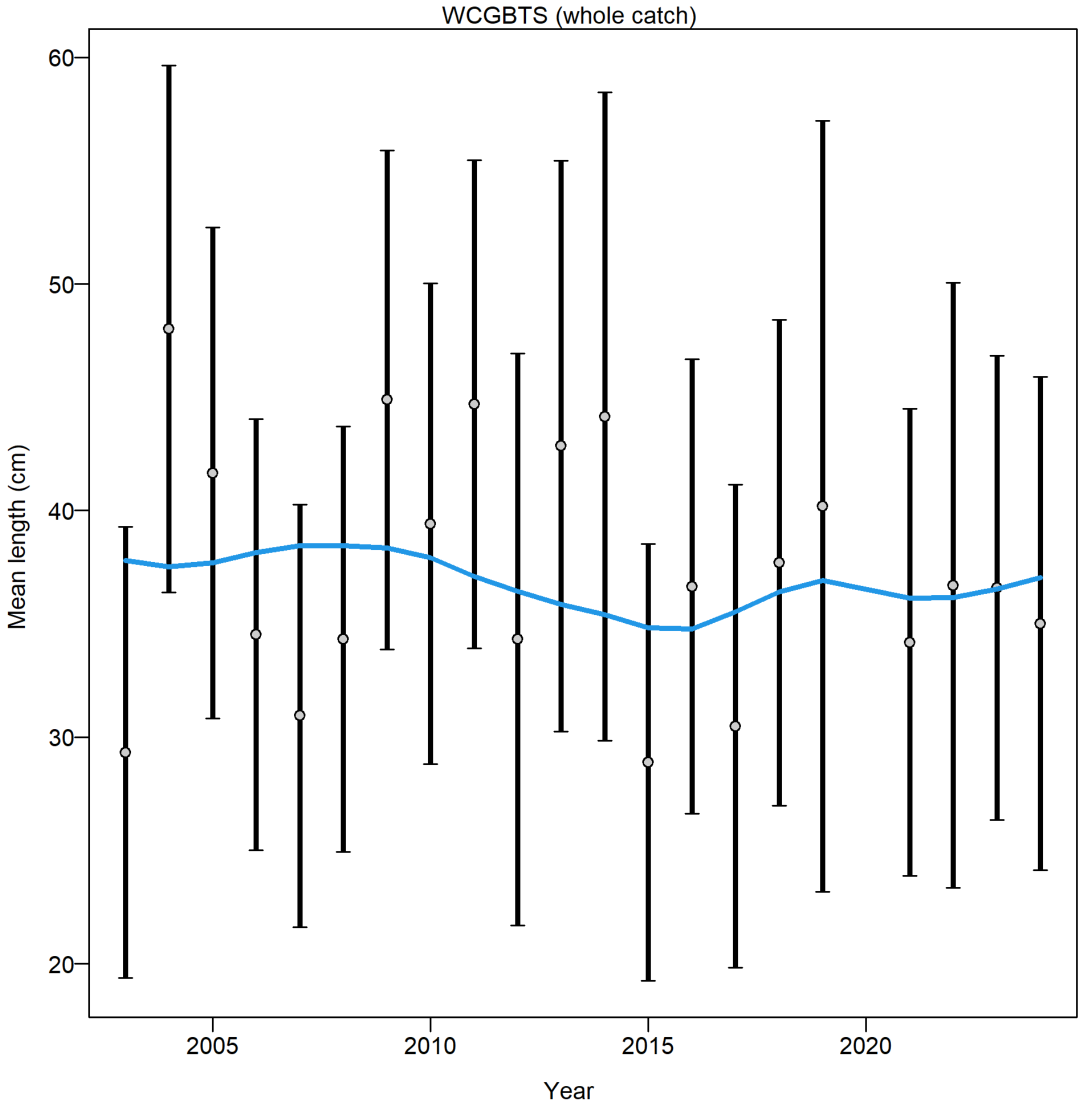

Figure 90: Mean length (cm) index from the West Coast Groundfish Bottom Trawl survey with 95 percent confidence intervals based on sample sizes and data weighting.

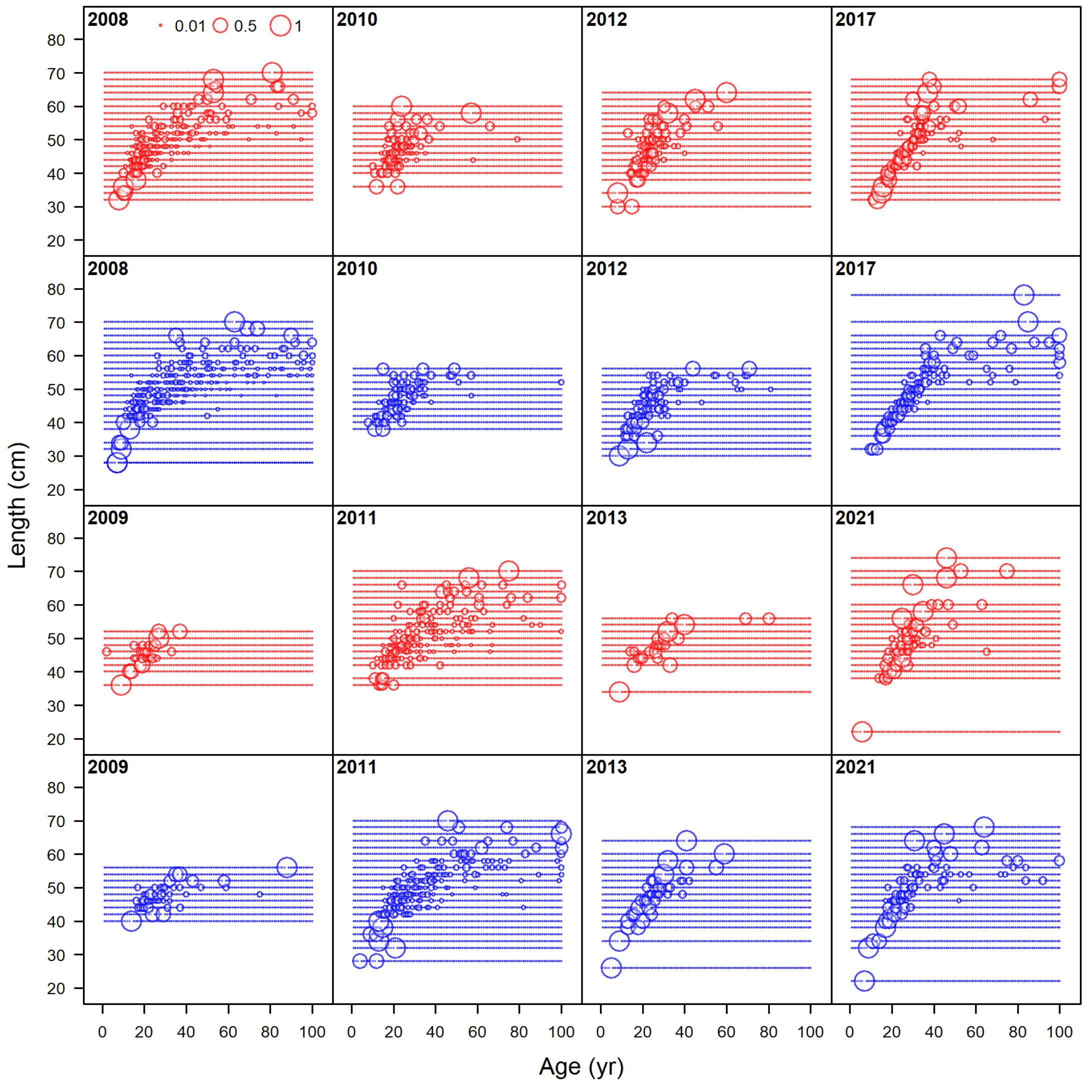

Figure 91: Pearson residuals of conditional age at length fits for the bottom trawl fishery in the years 2008-2021. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

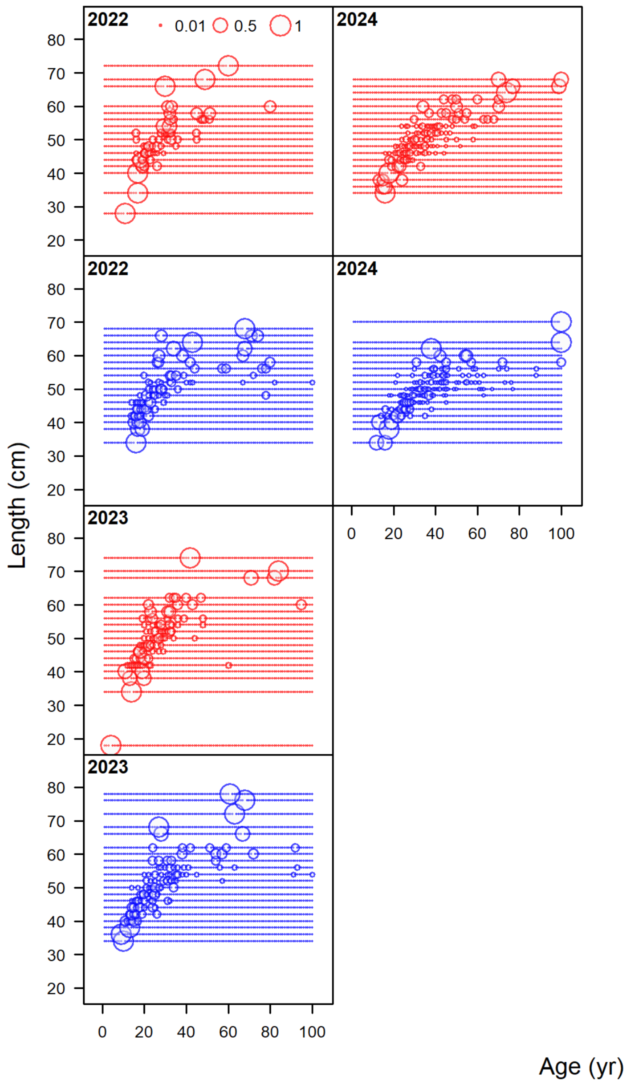

Figure 92: Pearson residuals of conditional age at length fits for the bottom trawl fishery in the years 2022-2024. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

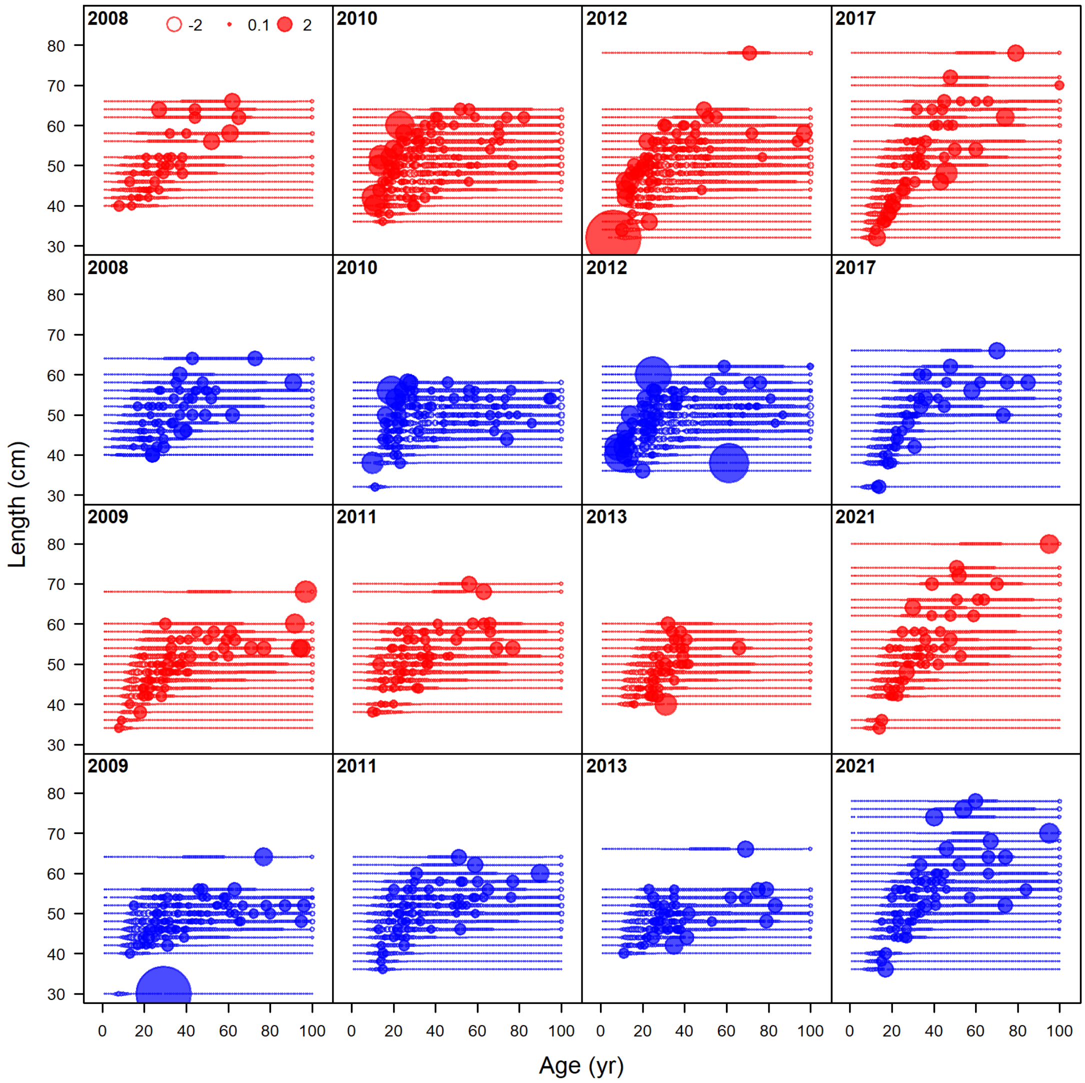

Figure 93: Pearson residuals of conditional age at length fits for the non-trawl fishery in the years 2008-2021. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

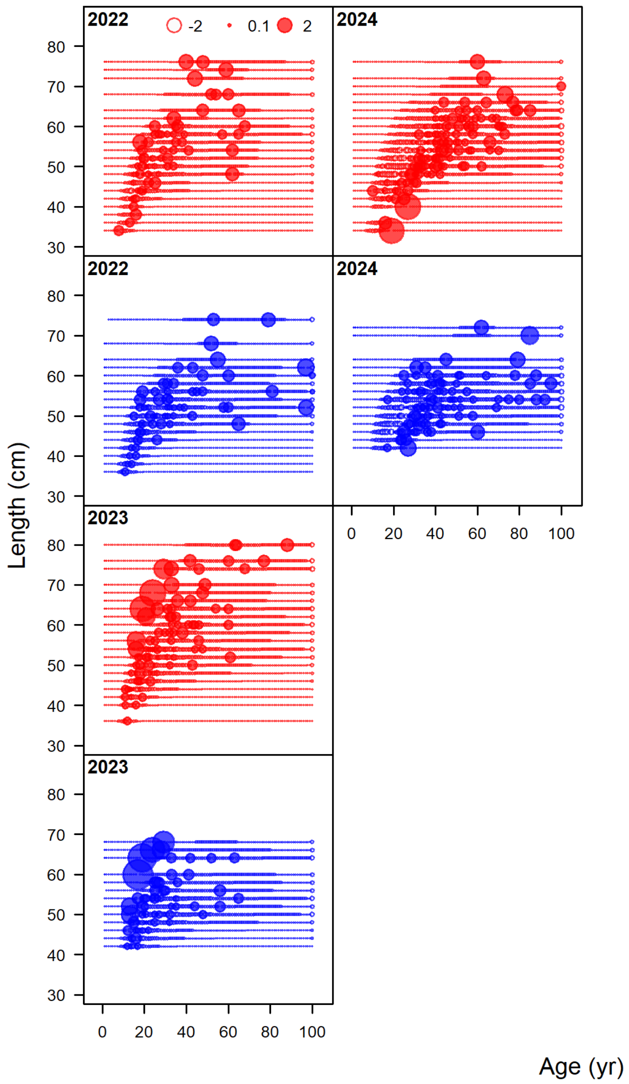

Figure 94: Pearson residuals of conditional age at length fits for the non-trawl fishery in the years 2022-2024. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

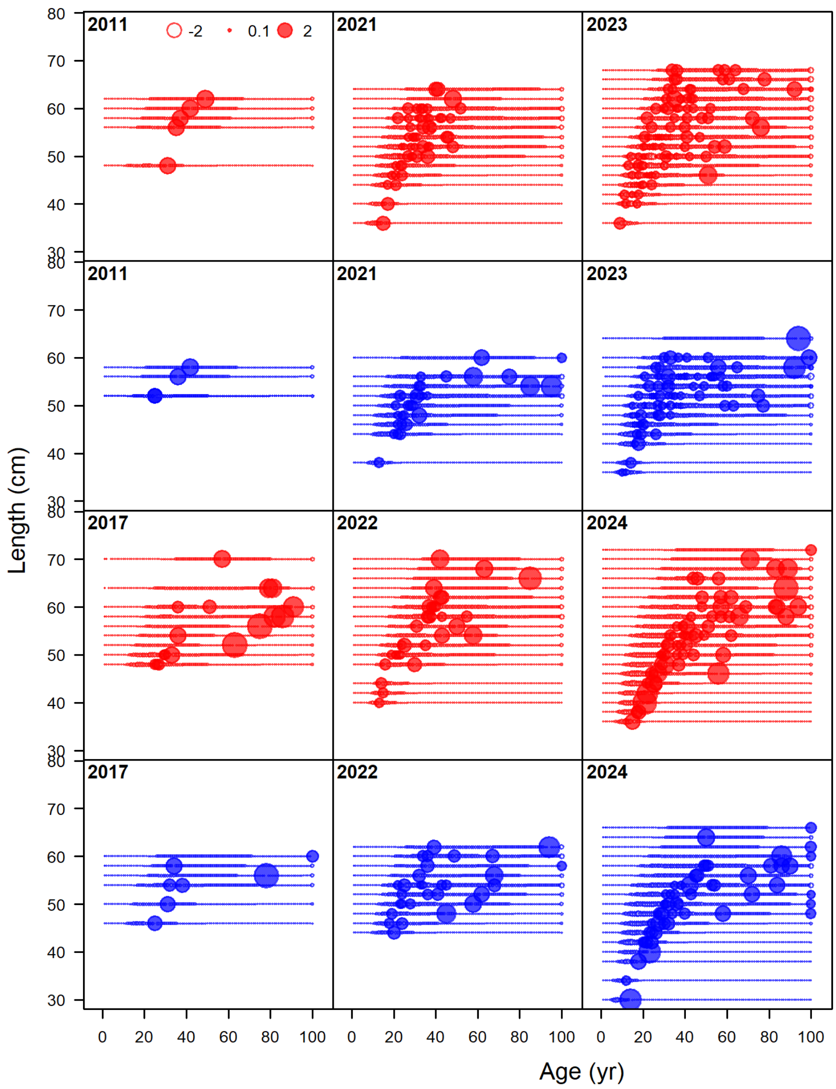

Figure 95: Pearson residuals of conditional age at length fits for the midwater trawl fishery. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

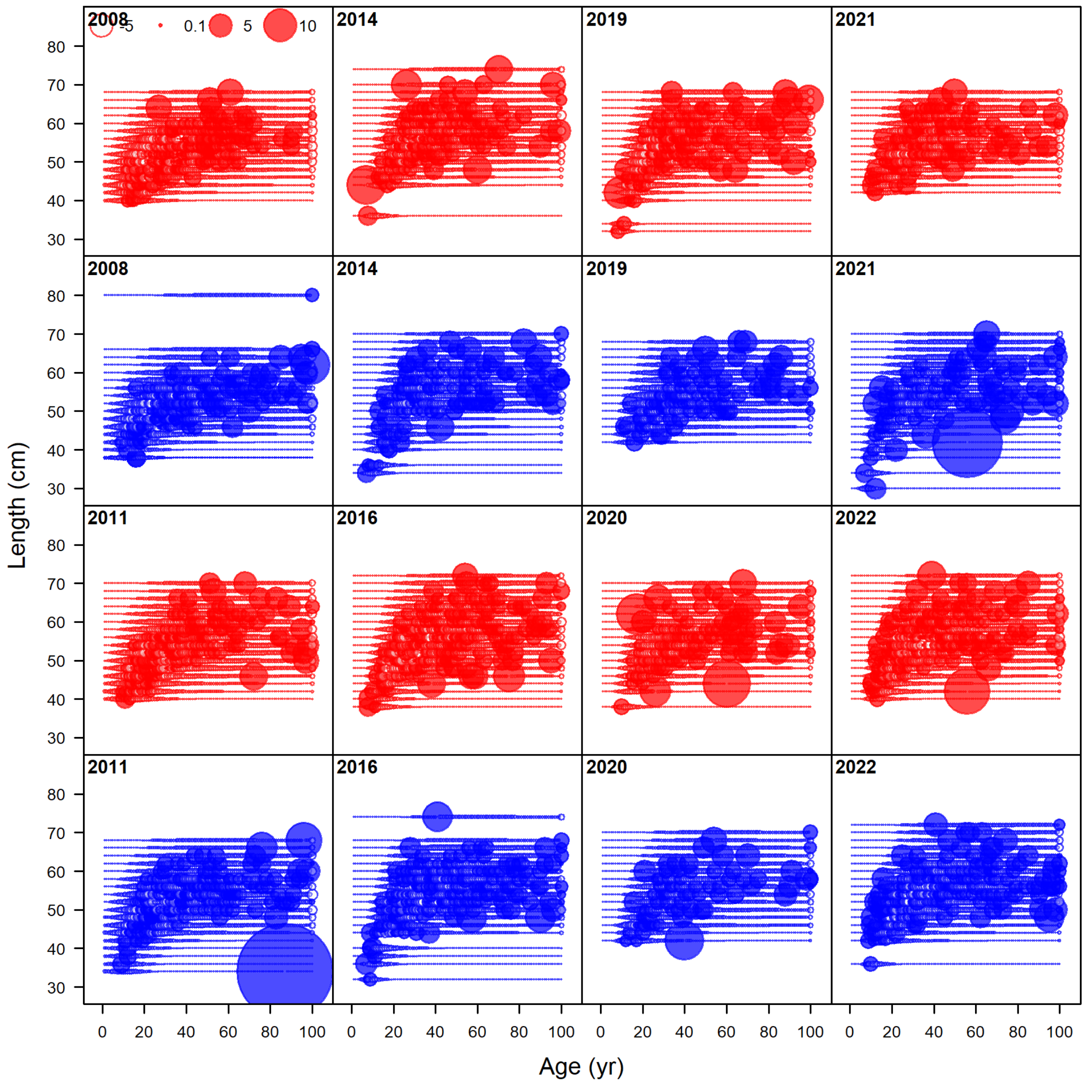

Figure 96: Pearson residuals of conditional age at length fits for the at-sea-hake fishery in the years 2008-2022. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

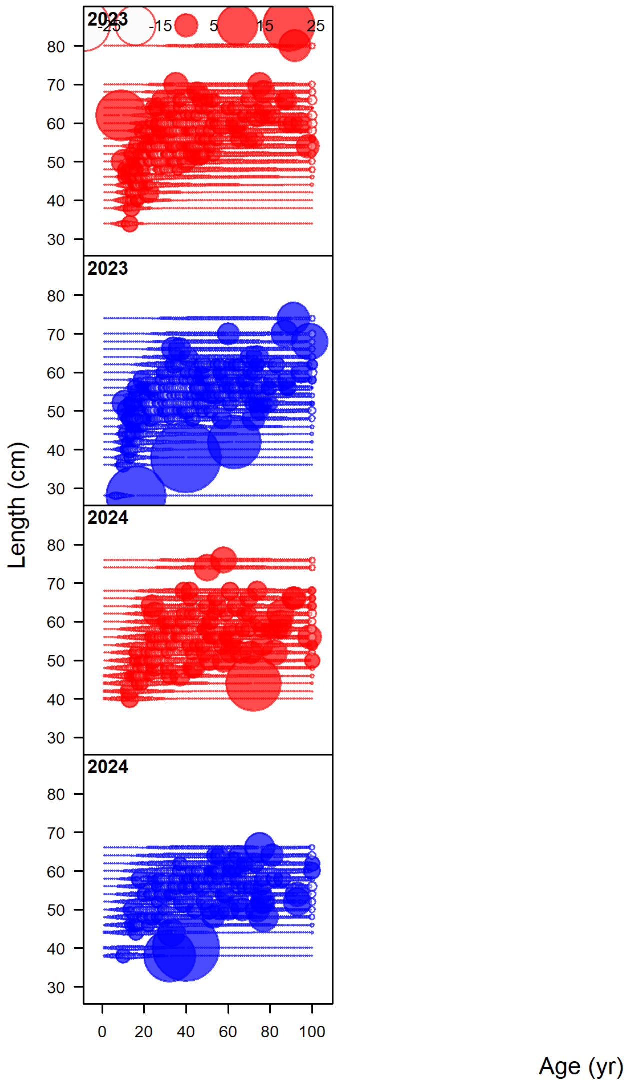

Figure 97: Pearson residuals of conditional age at length fits for the at-sea-hake fishery in the years 2023-2024. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

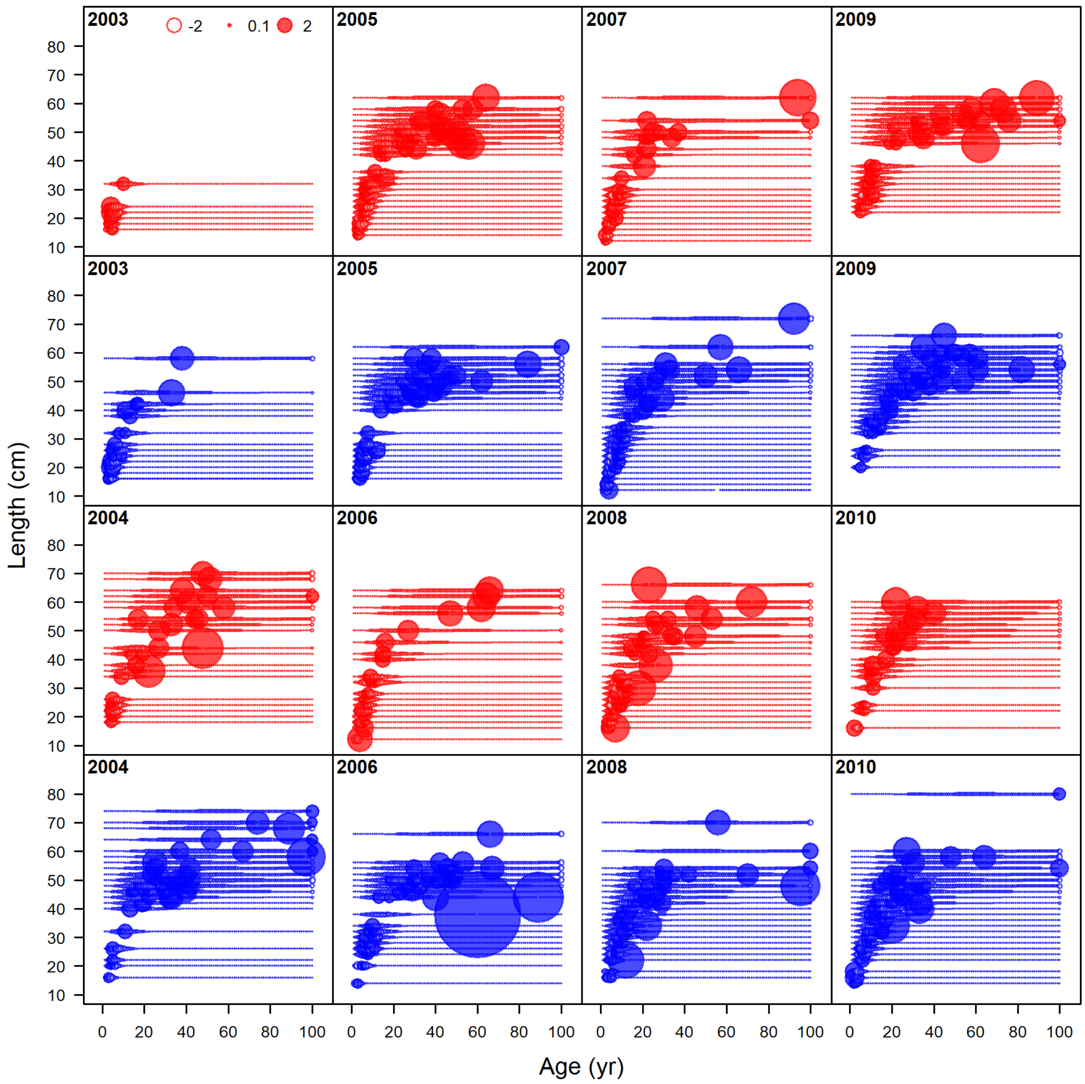

Figure 98: Pearson residuals of conditional age at length fits for the West Coast Groundfish Bottom Trawl survey in the years 2003-2010. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

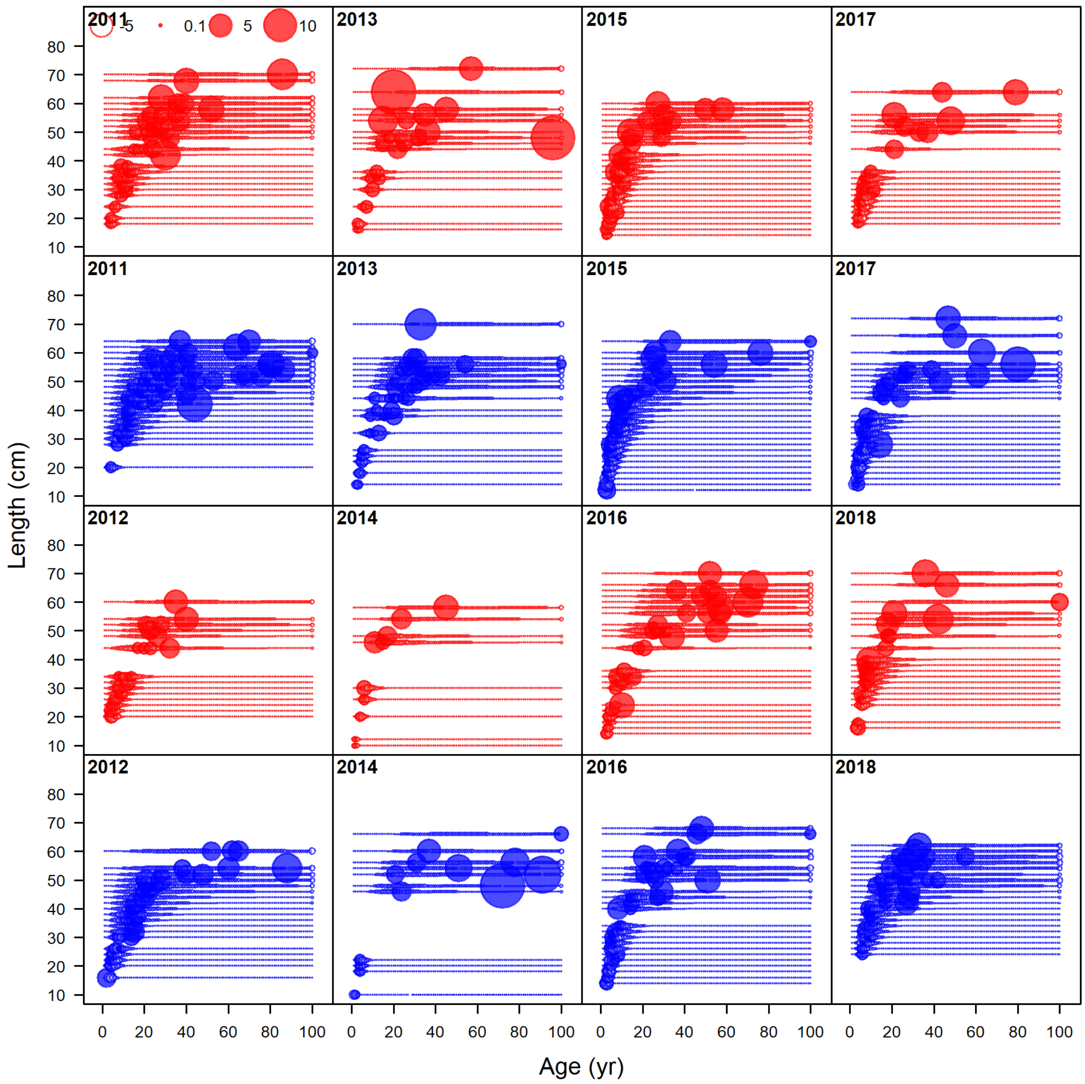

Figure 99: Pearson residuals of conditional age at length fits for the West Coast Groundfish Bottom Trawl survey in the years 2011-2018. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

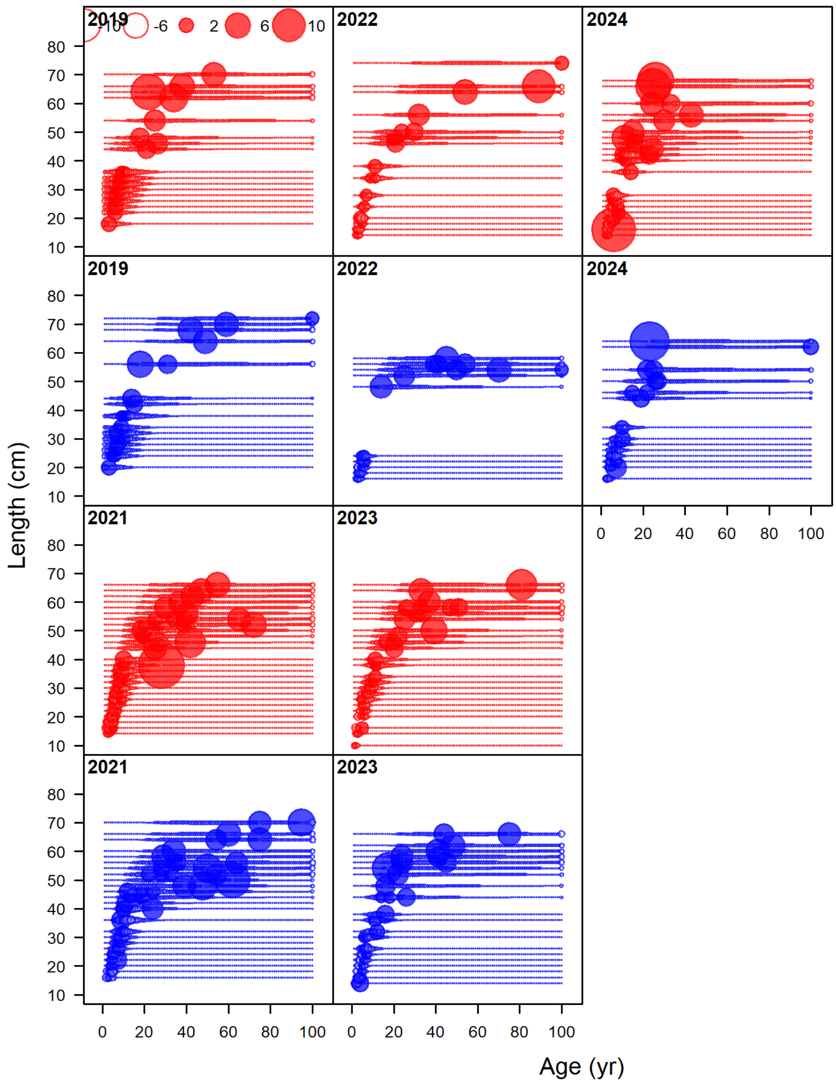

Figure 100: Pearson residuals of conditional age at length fits for the West Coast Groundfish Bottom Trawl survey in the years 2019-2024. Closed bubble are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

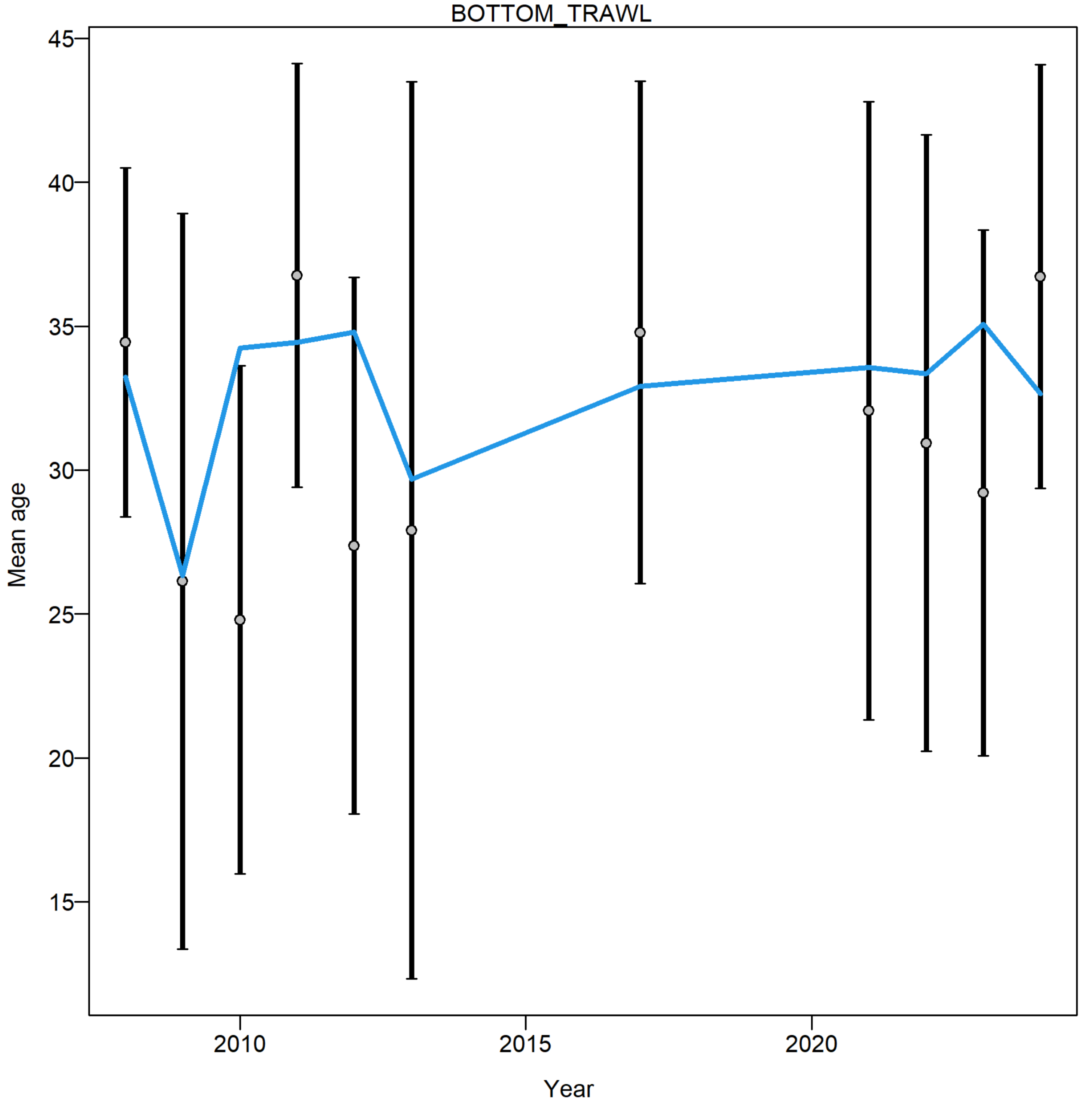

Figure 101: Mean age from conditional age-at-length data for the trawl fishery with 95% confidence intervals based on current samples sizes and data weighting.

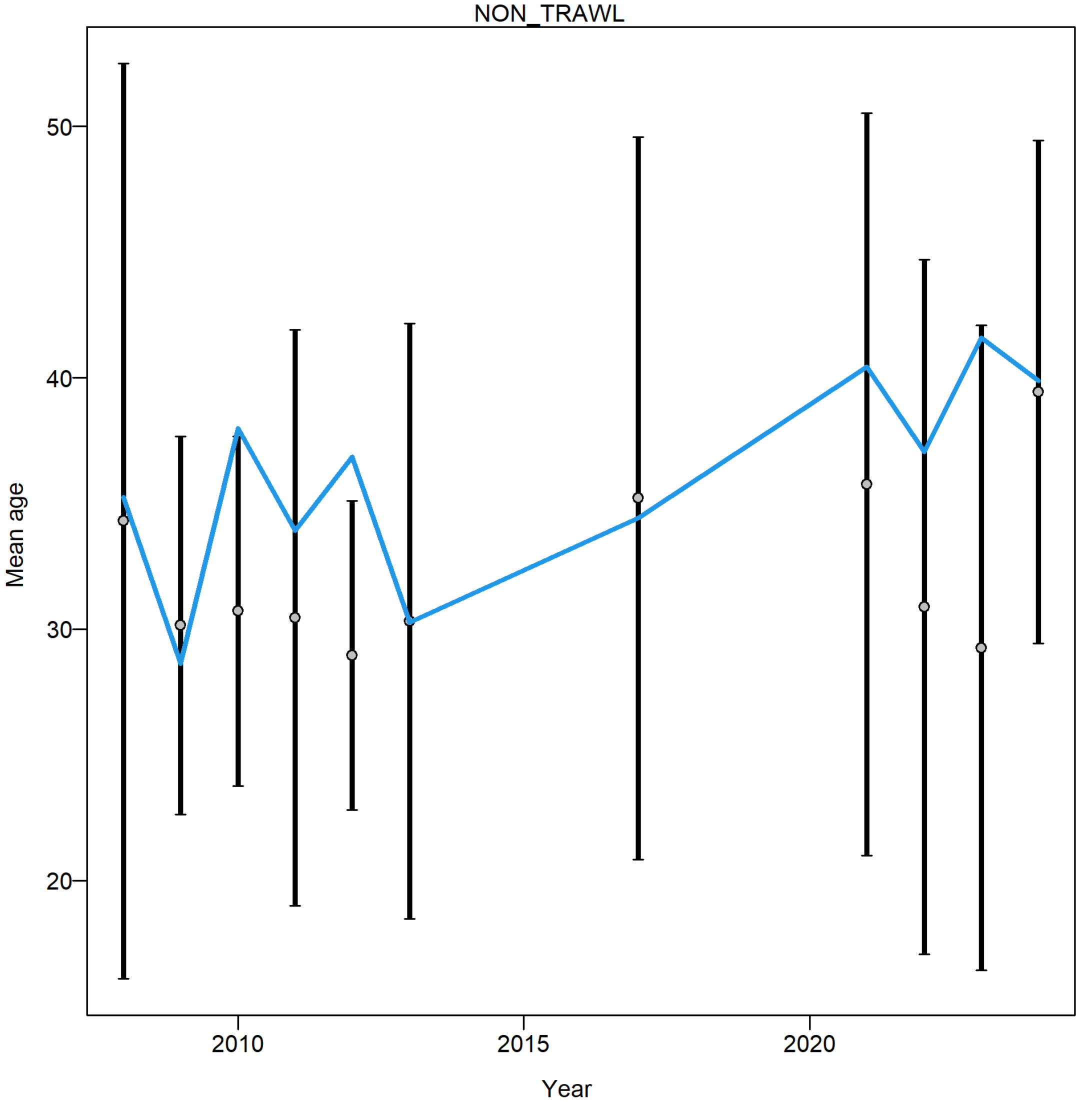

Figure 102: Mean age from conditional age-at-length data for the non-trawl fishery with 95% confidence intervals based on current samples sizes and data weighting.

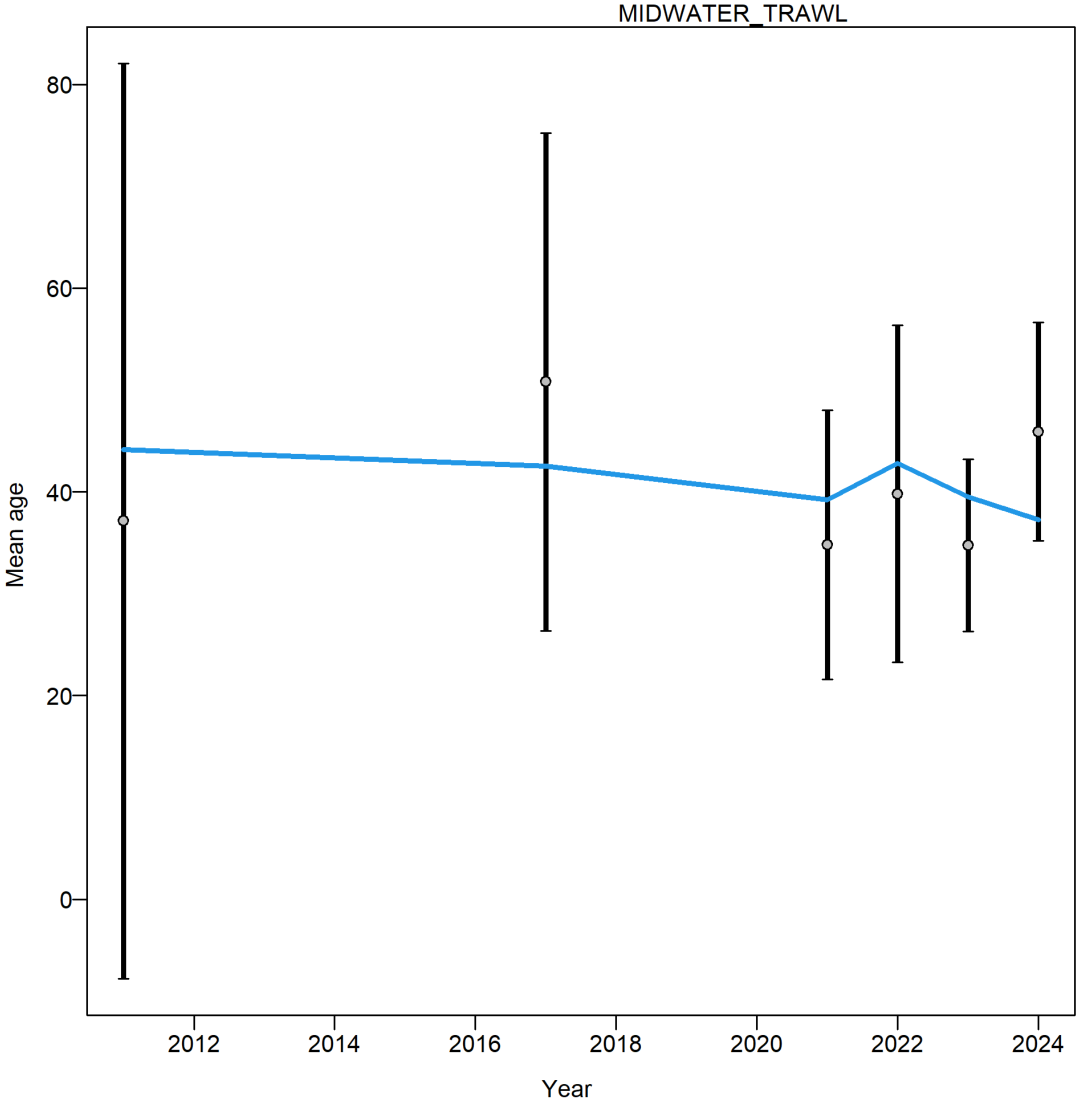

Figure 103: Mean age from conditional age-at-length data for the midwater trawl fishery with 95% confidence intervals based on current samples sizes and data weighting.

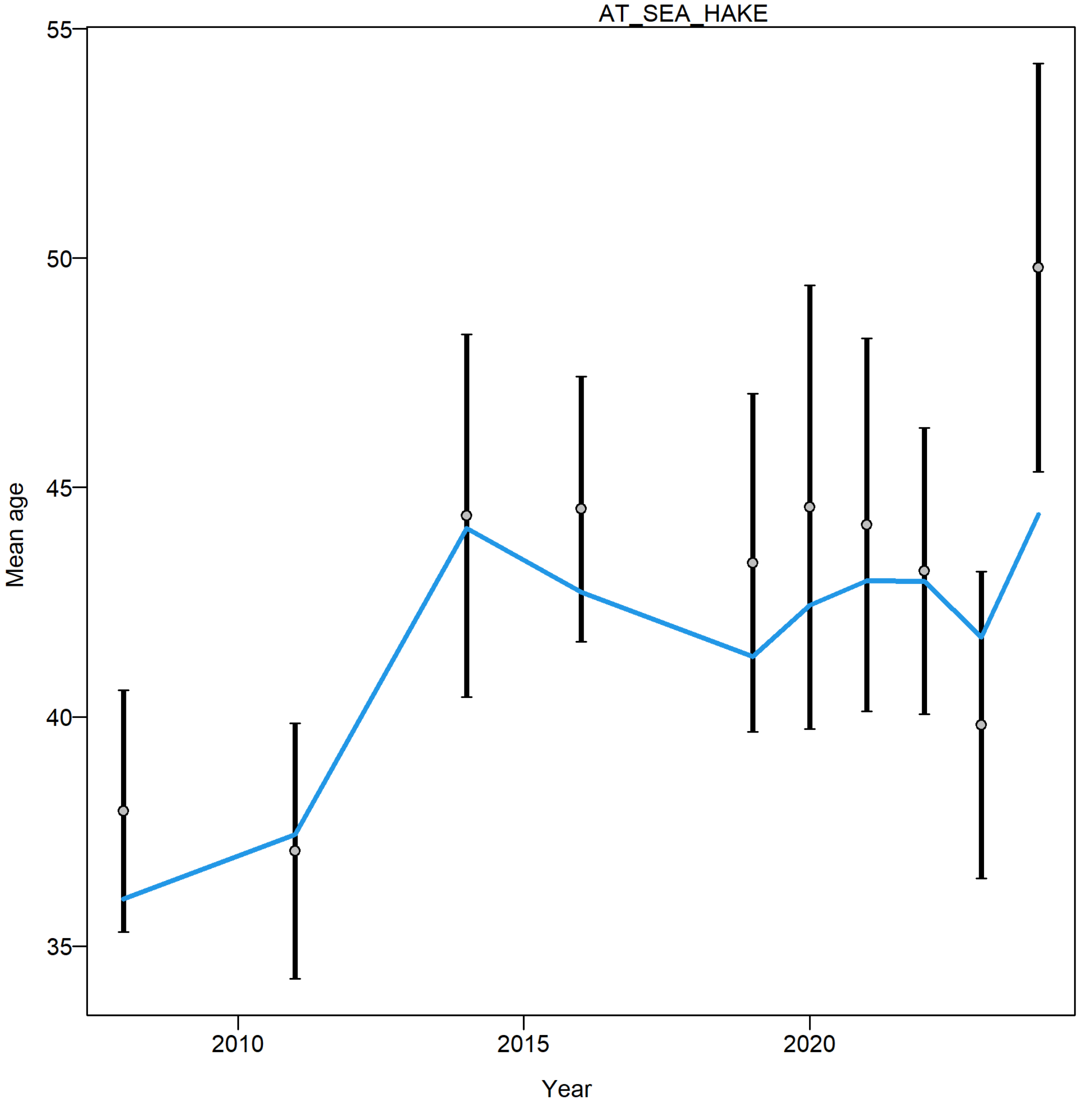

Figure 104: Mean age from conditional age-at-length data for the at-sea-hake fishery with 95% confidence intervals based on current samples sizes and data weighting.

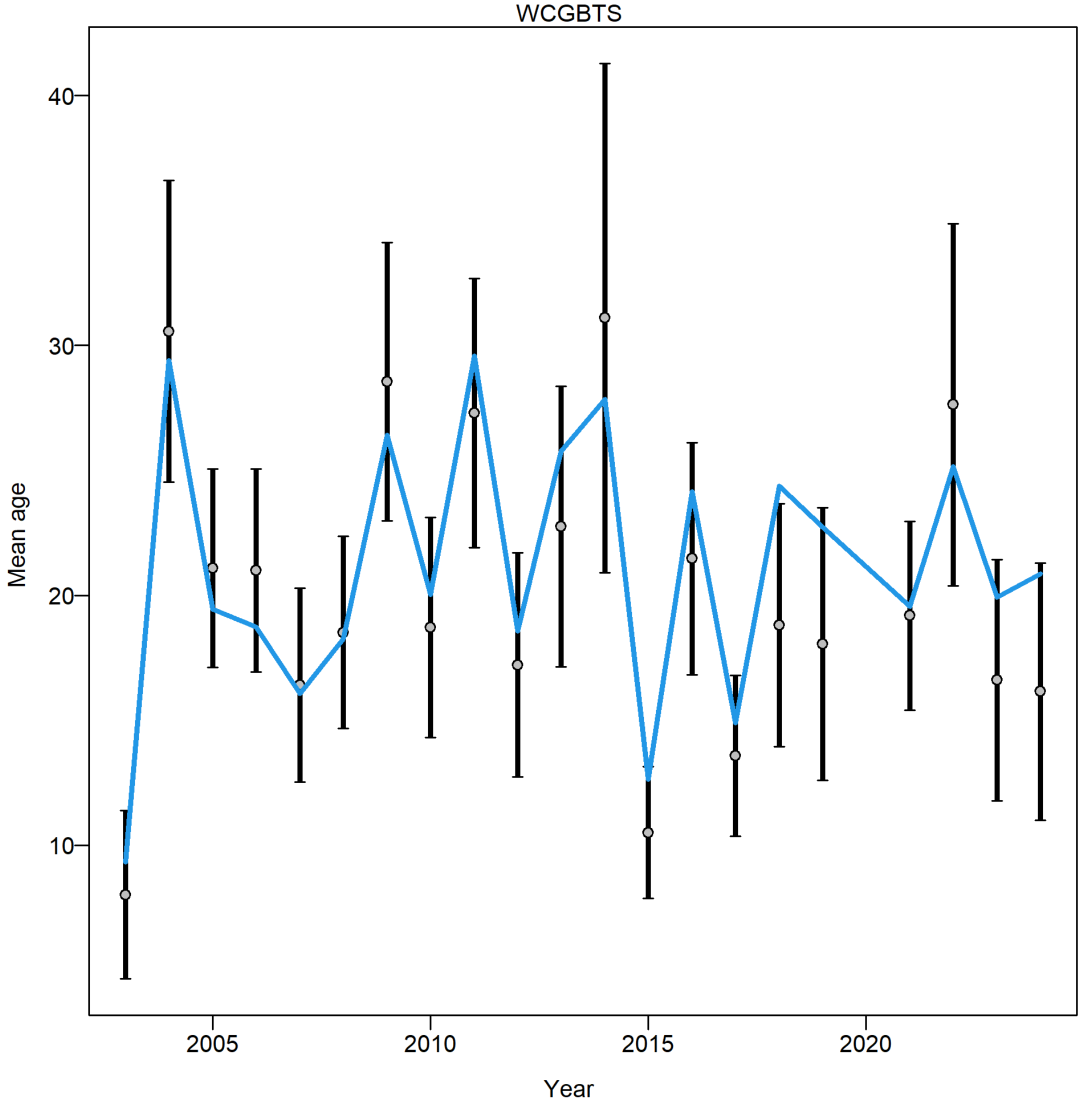

Figure 105: Mean age from conditional age-at-length data for the West Coast Groundfish Bottom Trawl survey with 95% confidence intervals based on current samples sizes and data weighting.

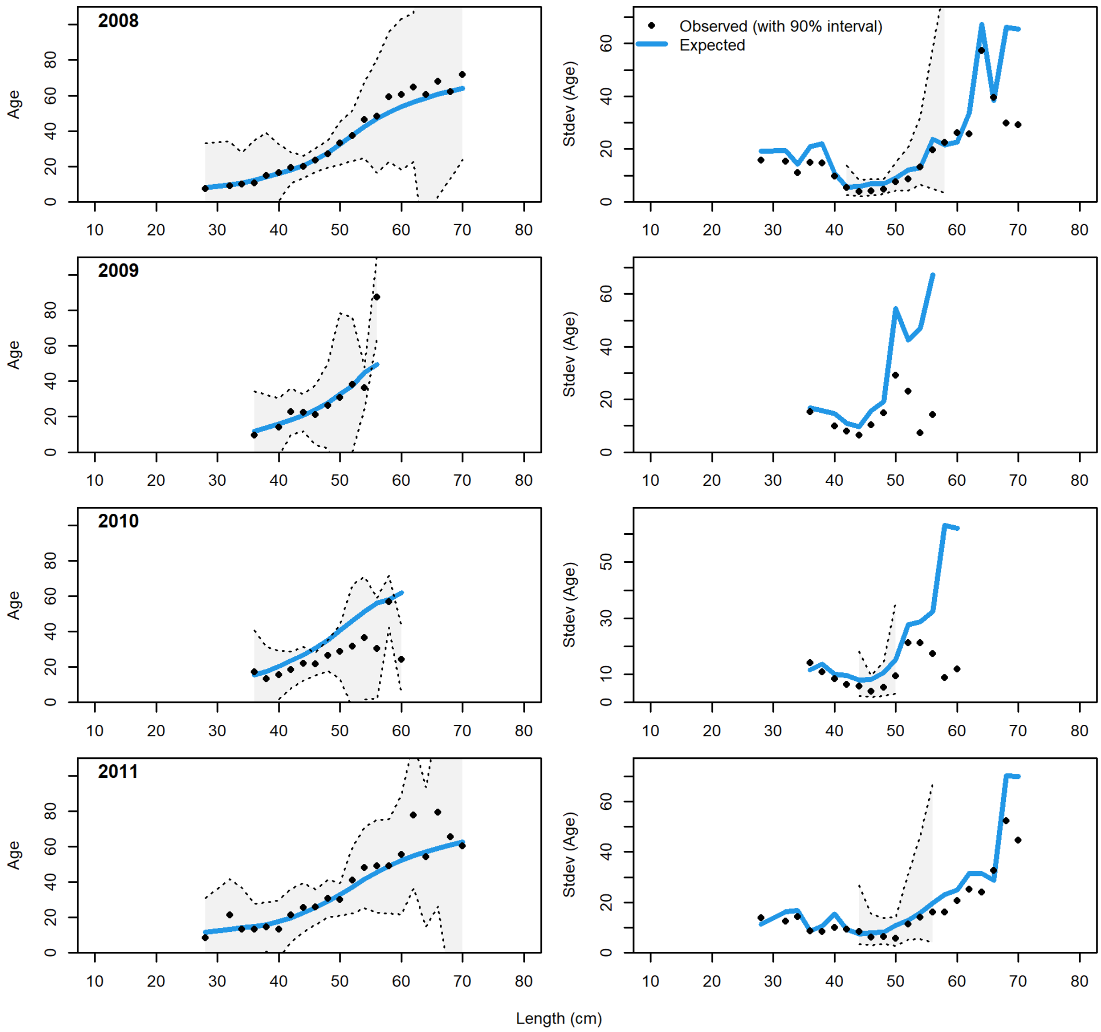

Figure 106: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the bottom trawl fishery in years 2008-2011. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

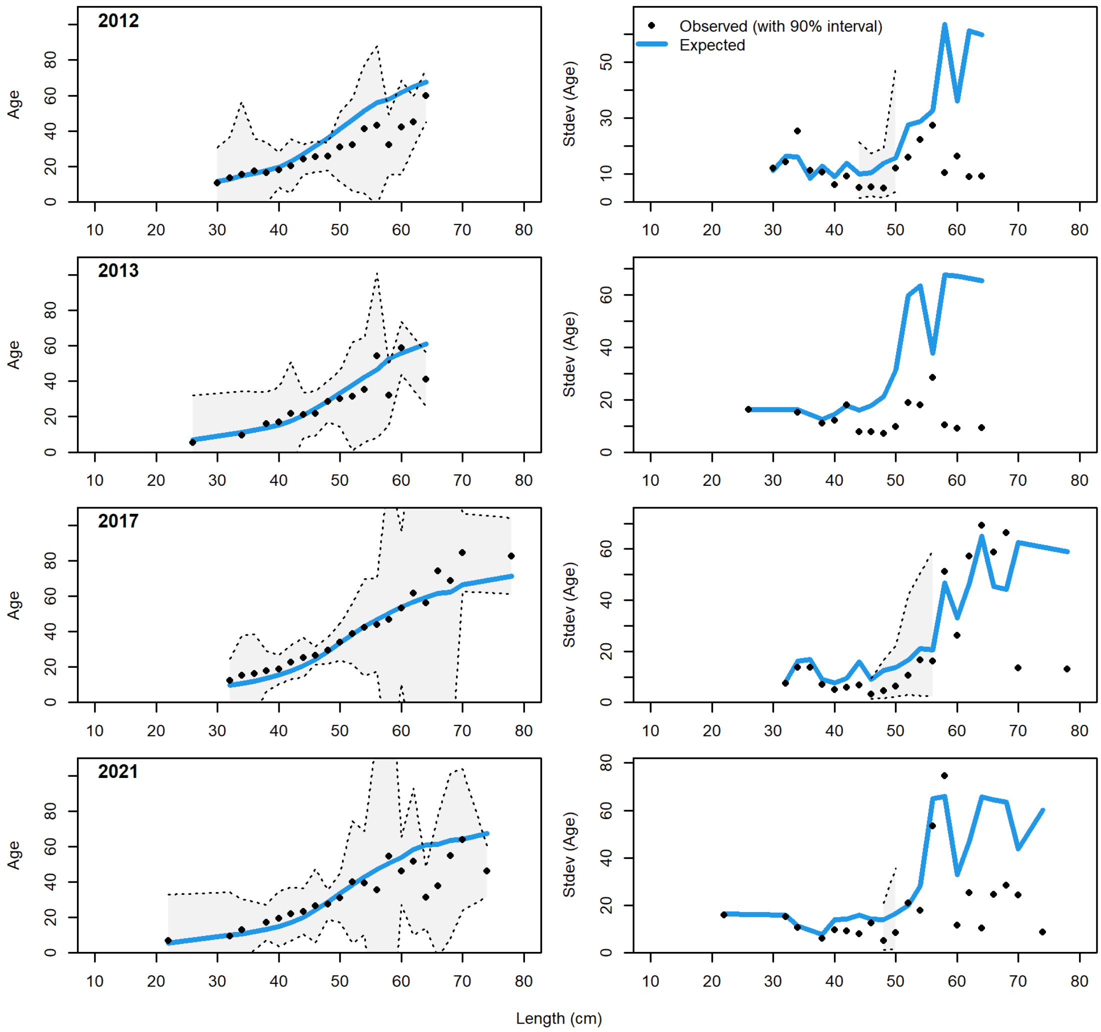

Figure 107: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the bottom trawl fishery in years 2012-2021. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

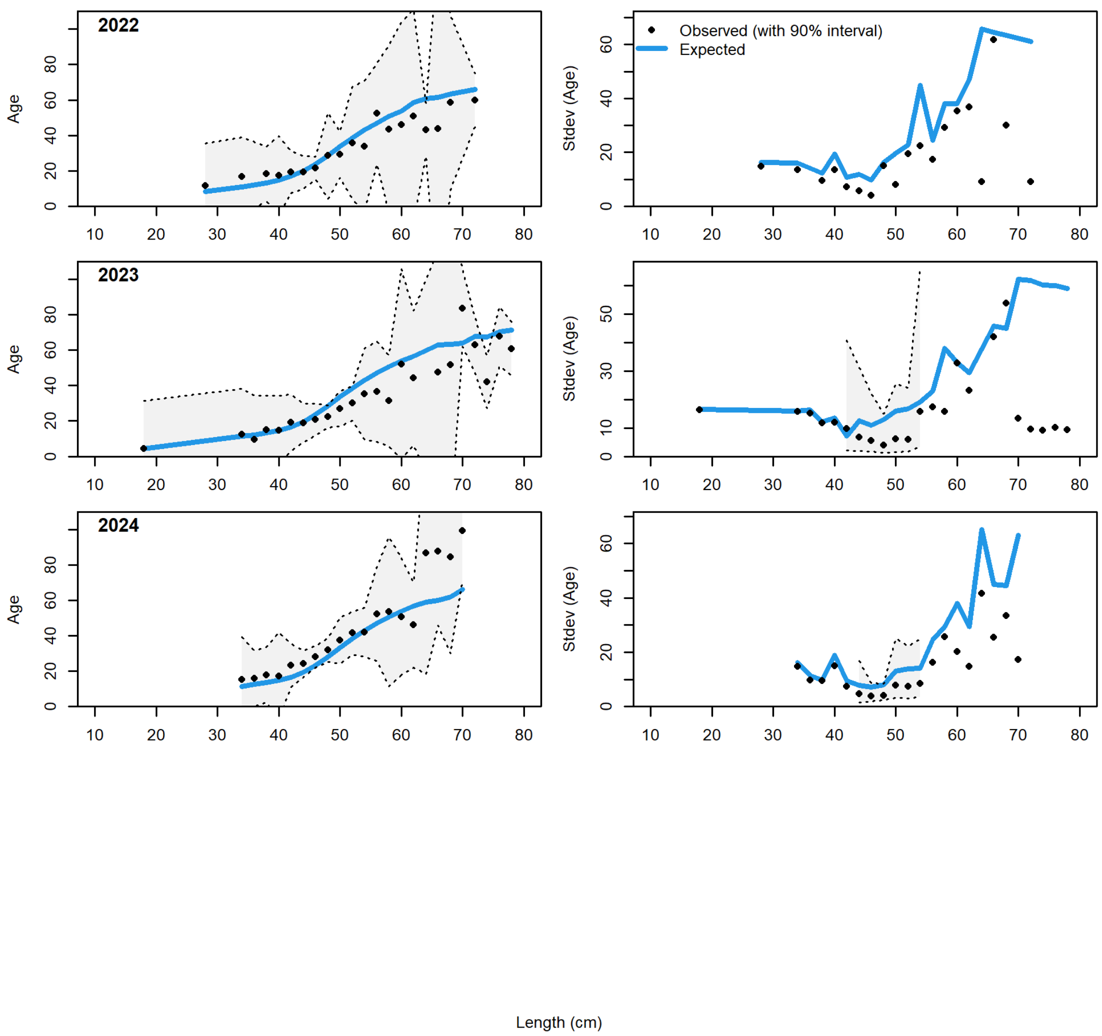

Figure 108: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the bottom trawl fishery in years 2022-2024. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

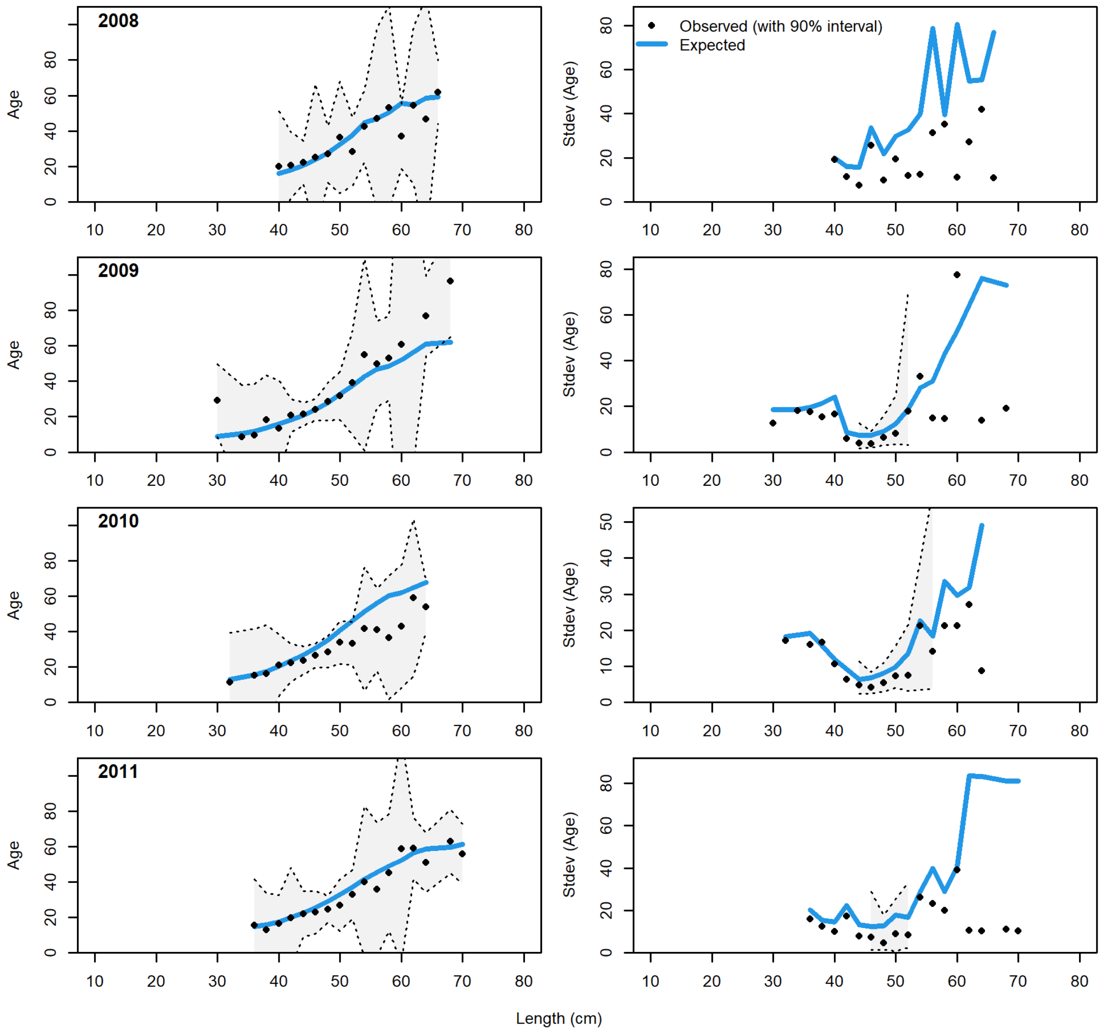

Figure 109: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the non-trawl fishery in years 2008-2011. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

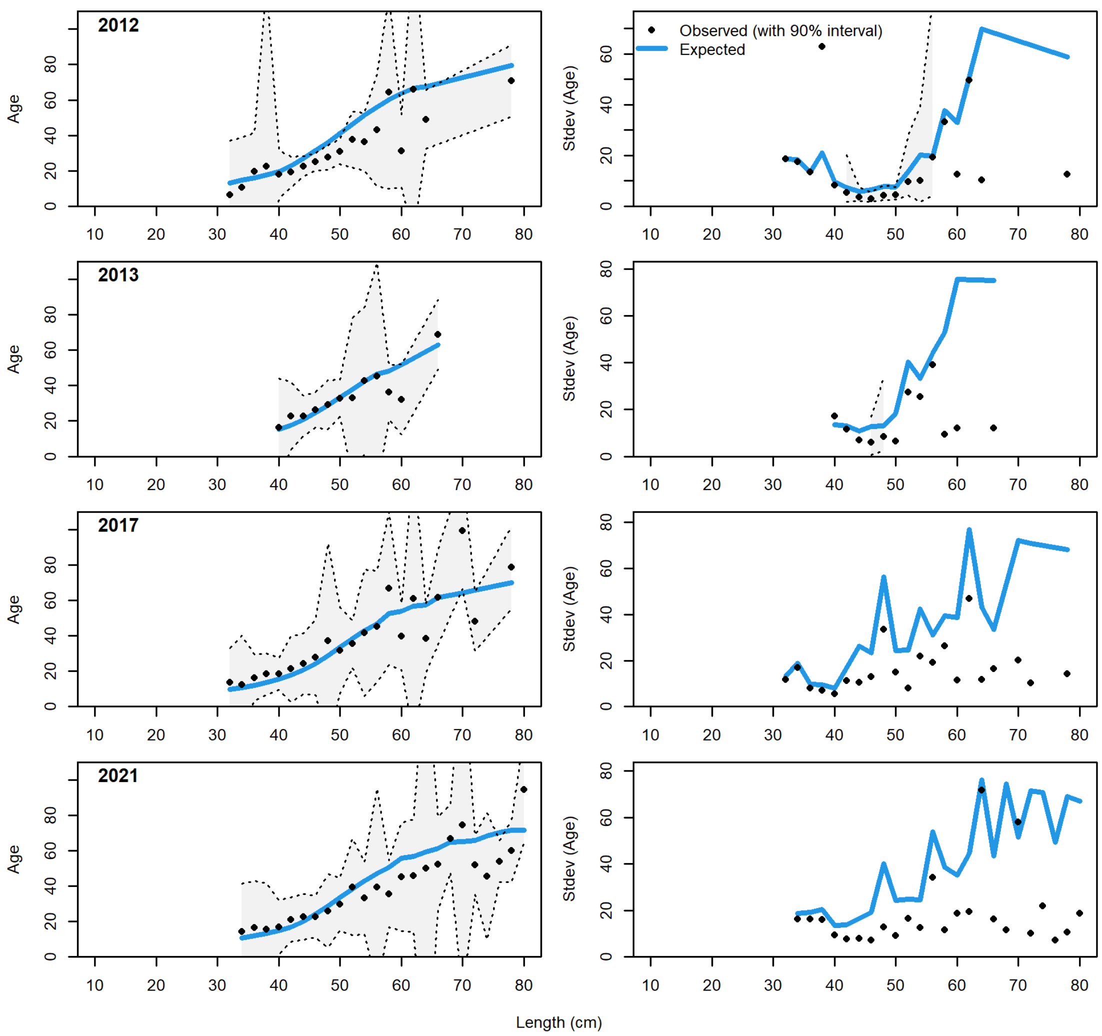

Figure 110: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the non-trawl fishery in years 2012-2021. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

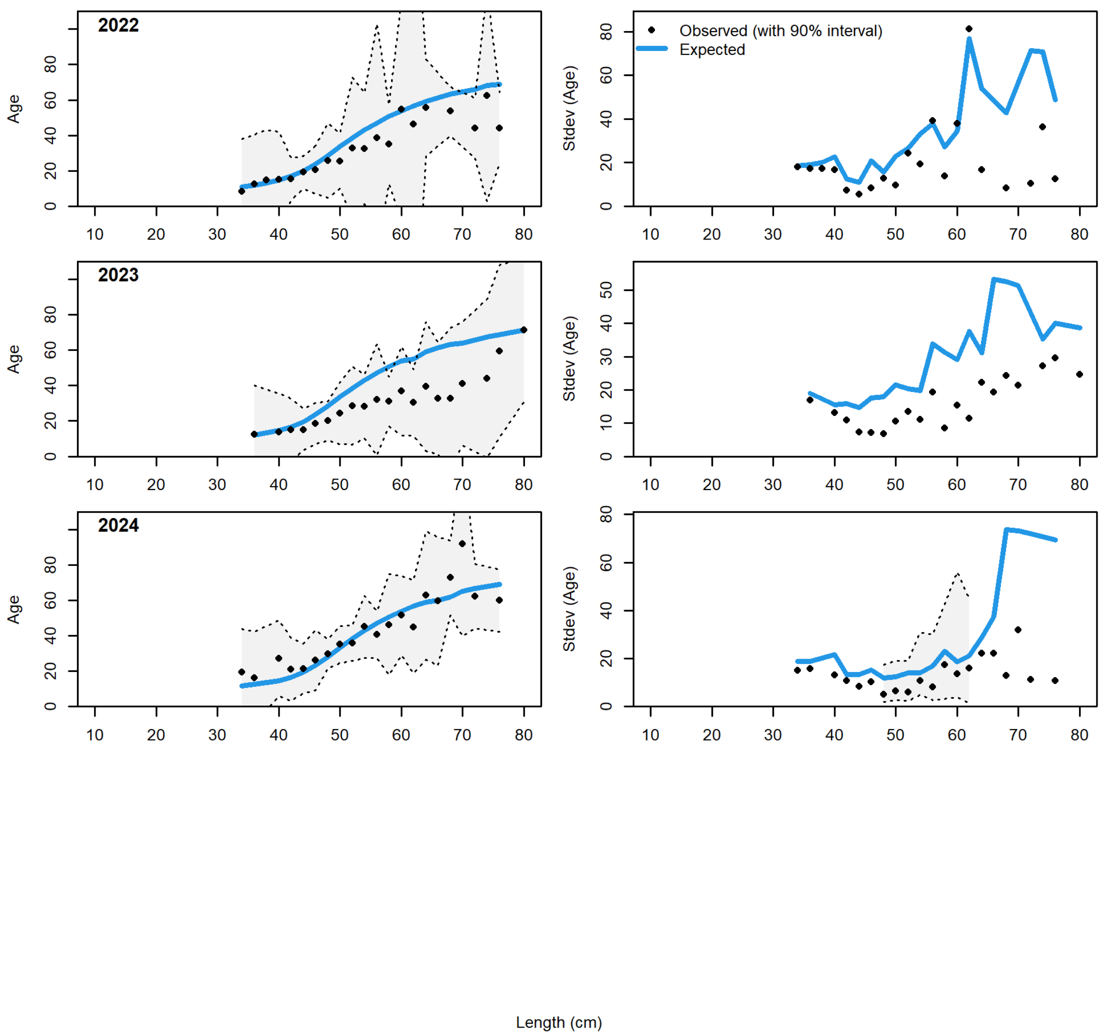

Figure 111: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the non-trawl fishery in years 2022-2024. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

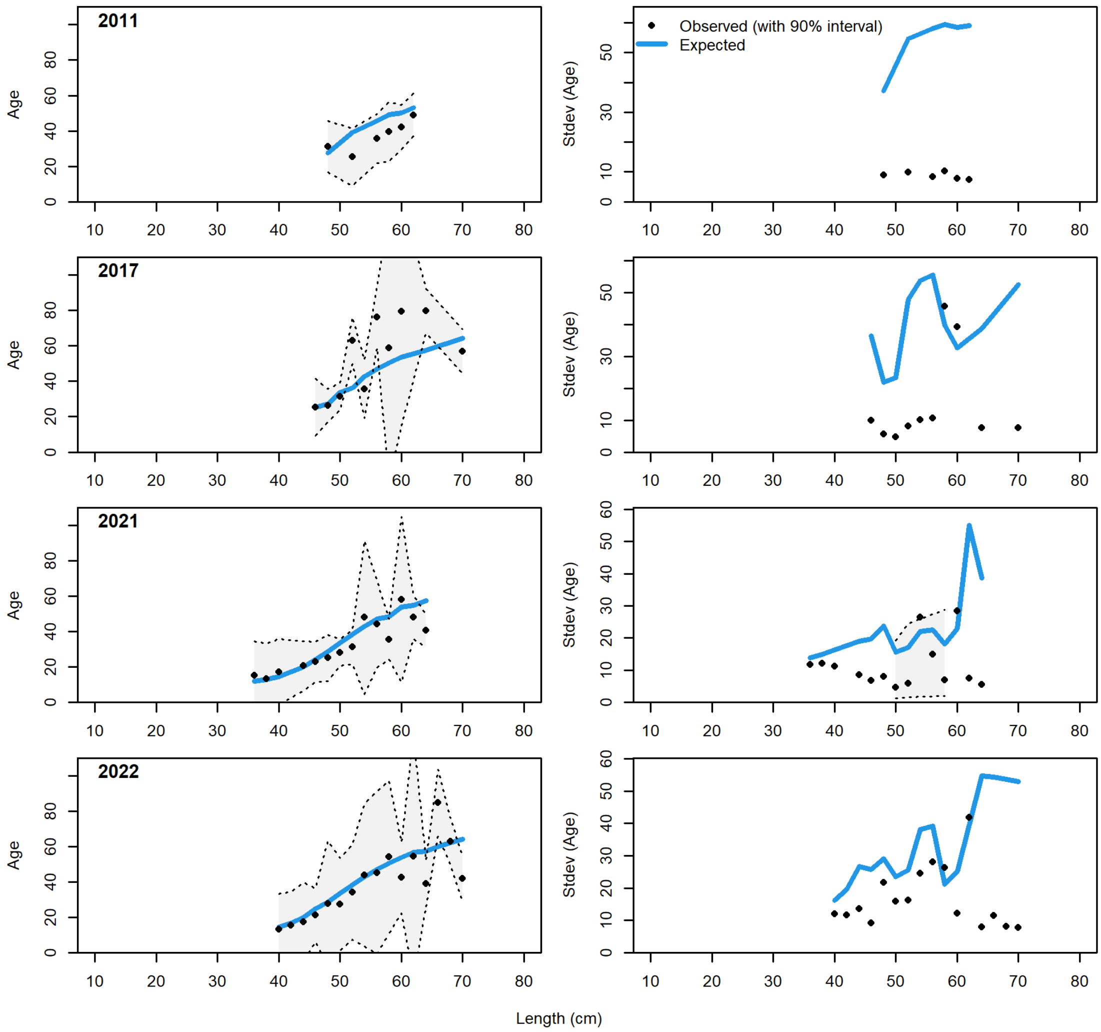

Figure 112: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the midwater trawl fishery in years 2011-2022. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

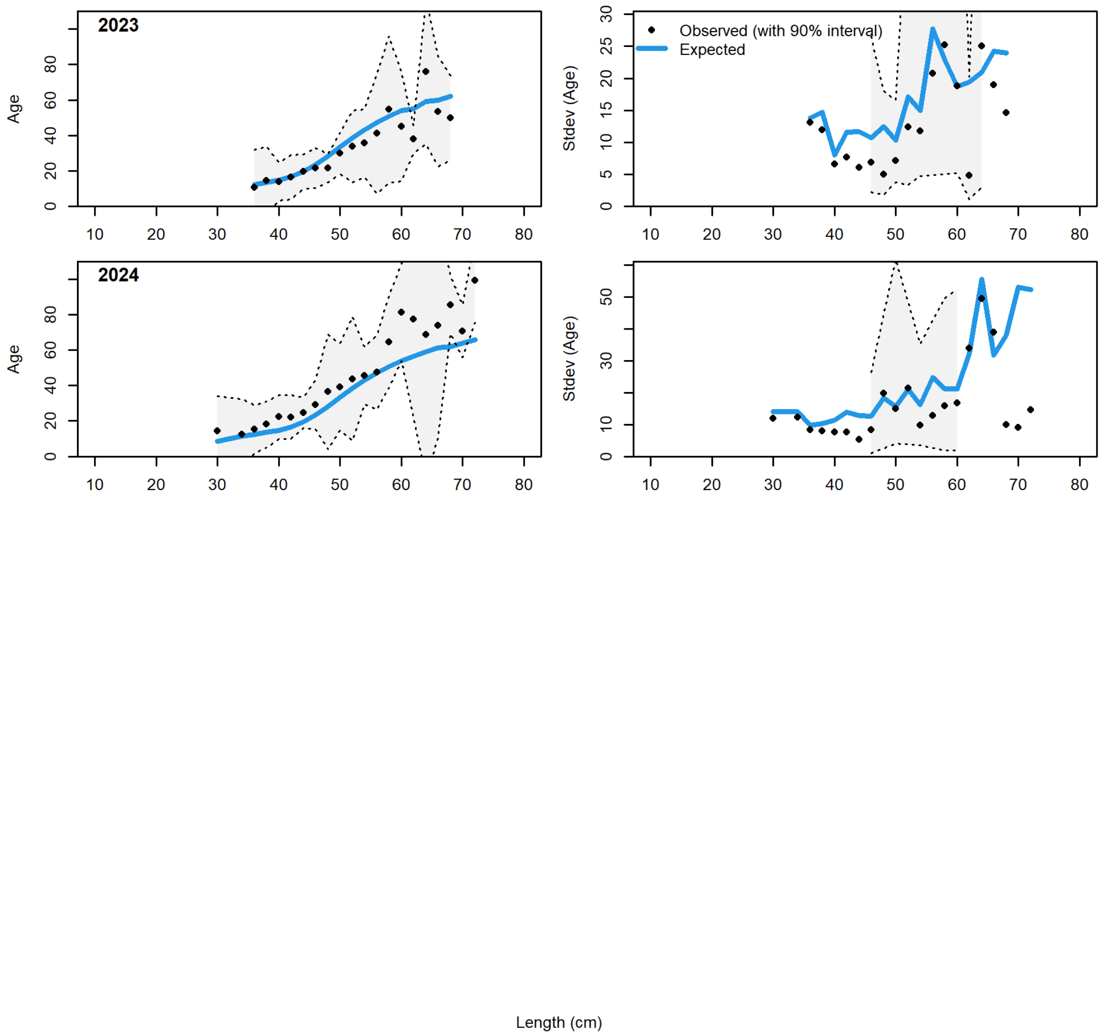

Figure 113: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the non-trawl fishery in years 2023-2024. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

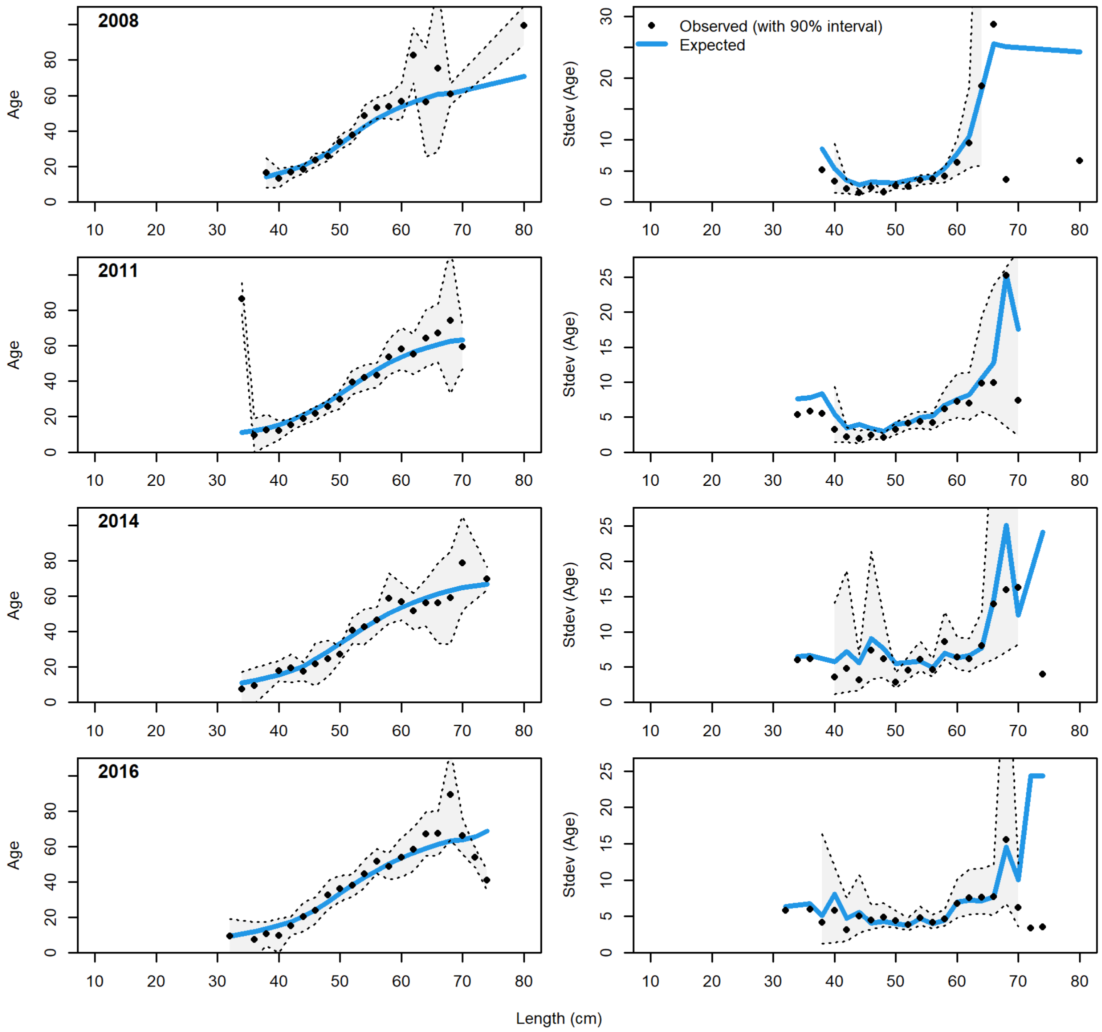

Figure 114: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the at-sea-hake fishery in years 2008-2016. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

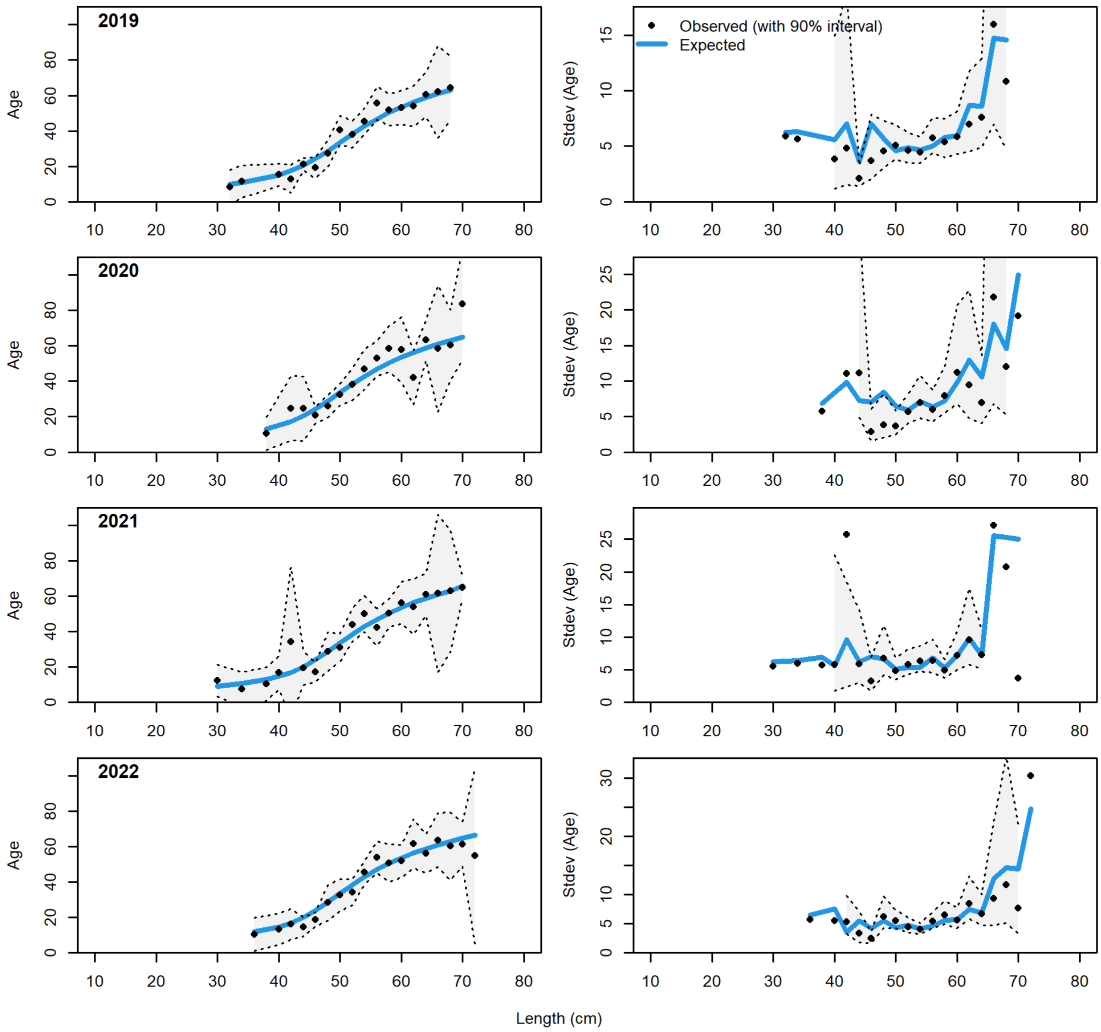

Figure 115: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the at-sea-hake fishery in years 2019-2022. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

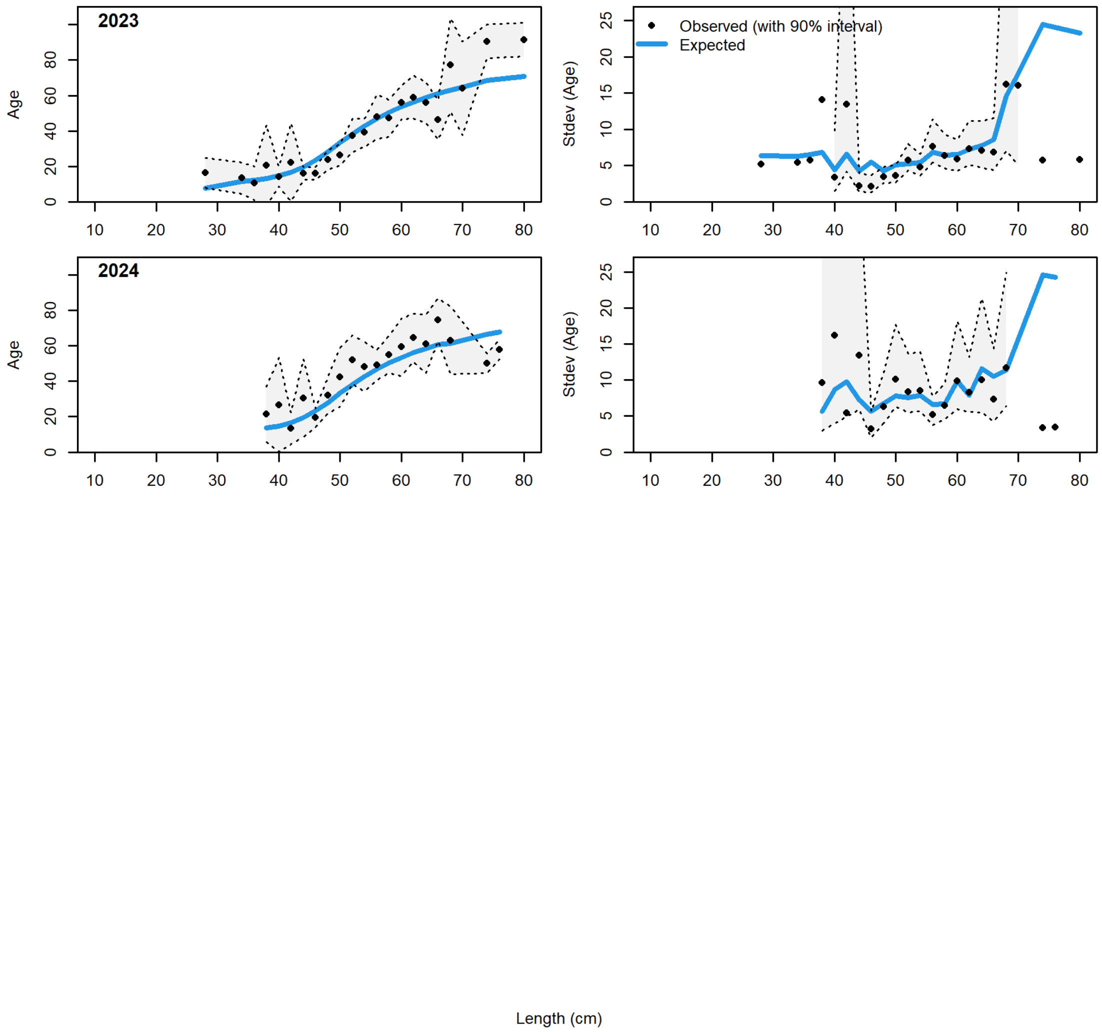

Figure 116: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the at-sea-hake fishery in years 2023-2024. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

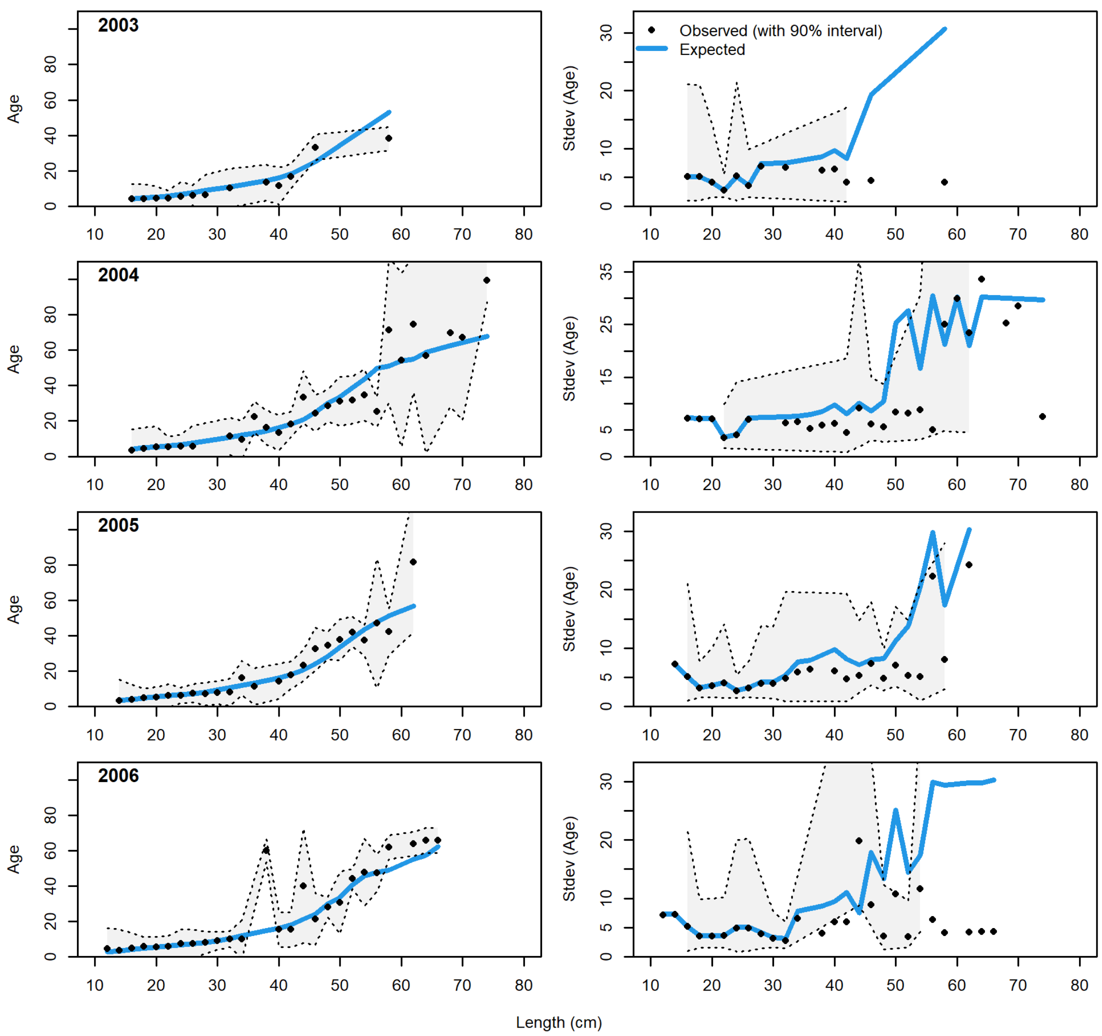

Figure 117: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the West Coast Groundfish Bottom Trawl survey in years 2003-2006. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

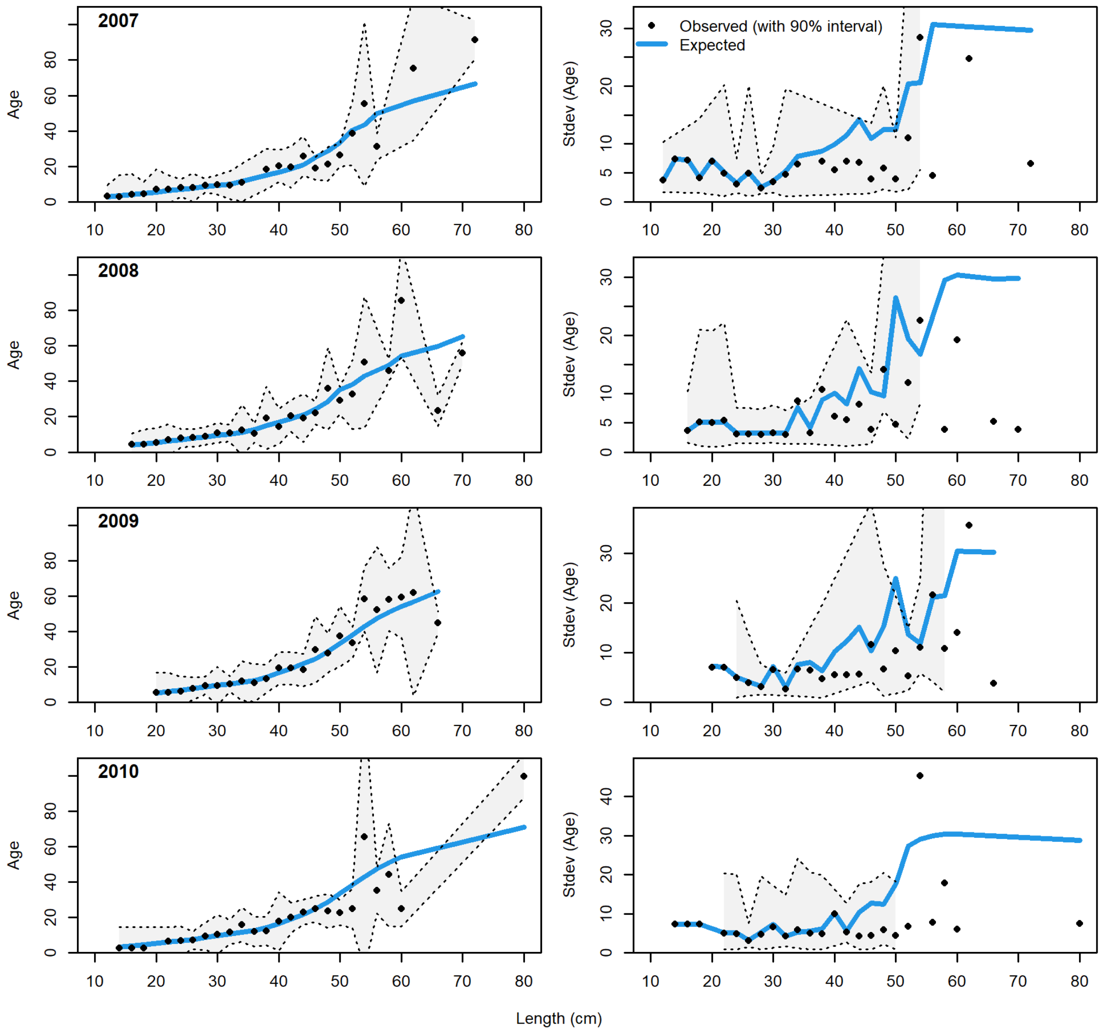

Figure 118: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the West Coast Groundfish Bottom Trawl survey in years 2007-2010. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

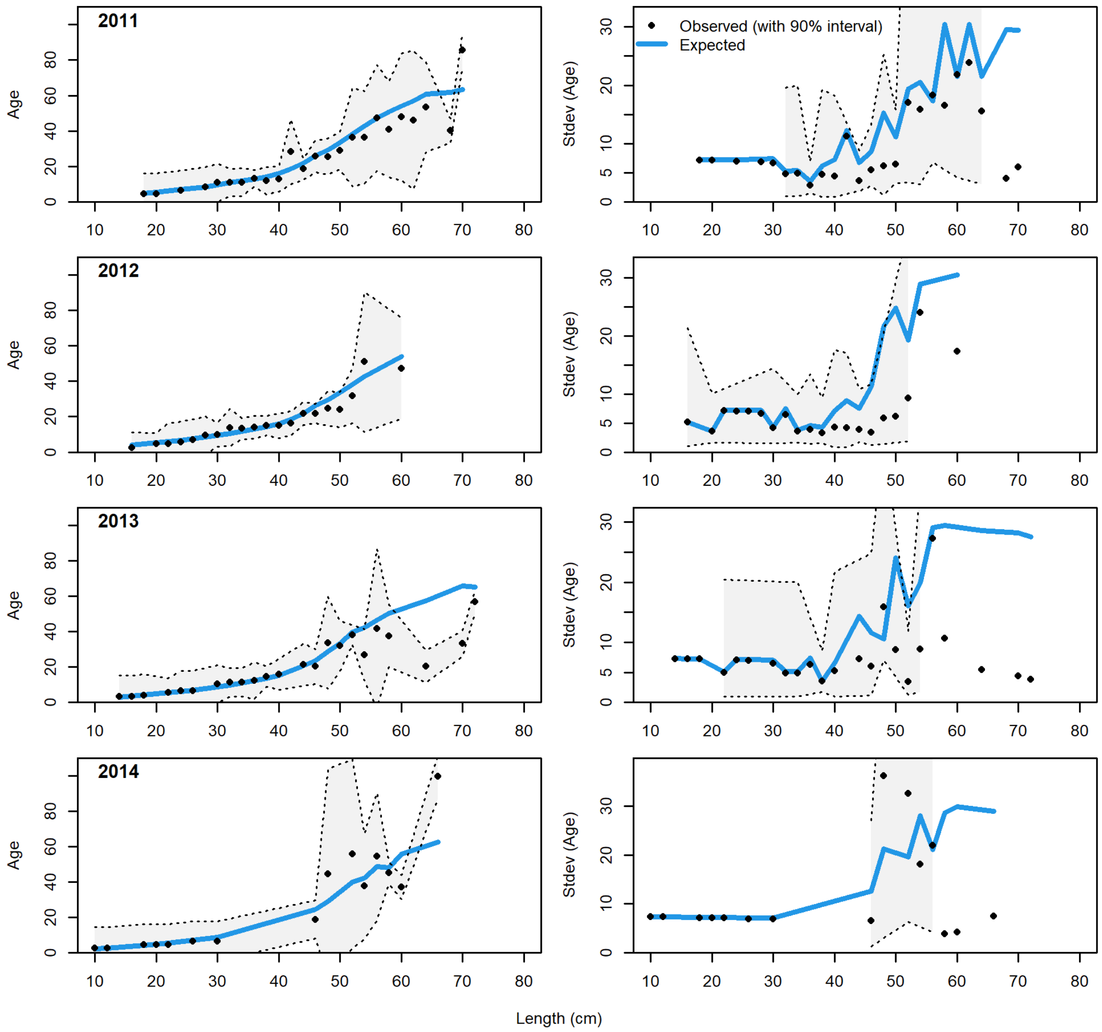

Figure 119: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the West Coast Groundfish Bottom Trawl survey in years 2011-2014. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

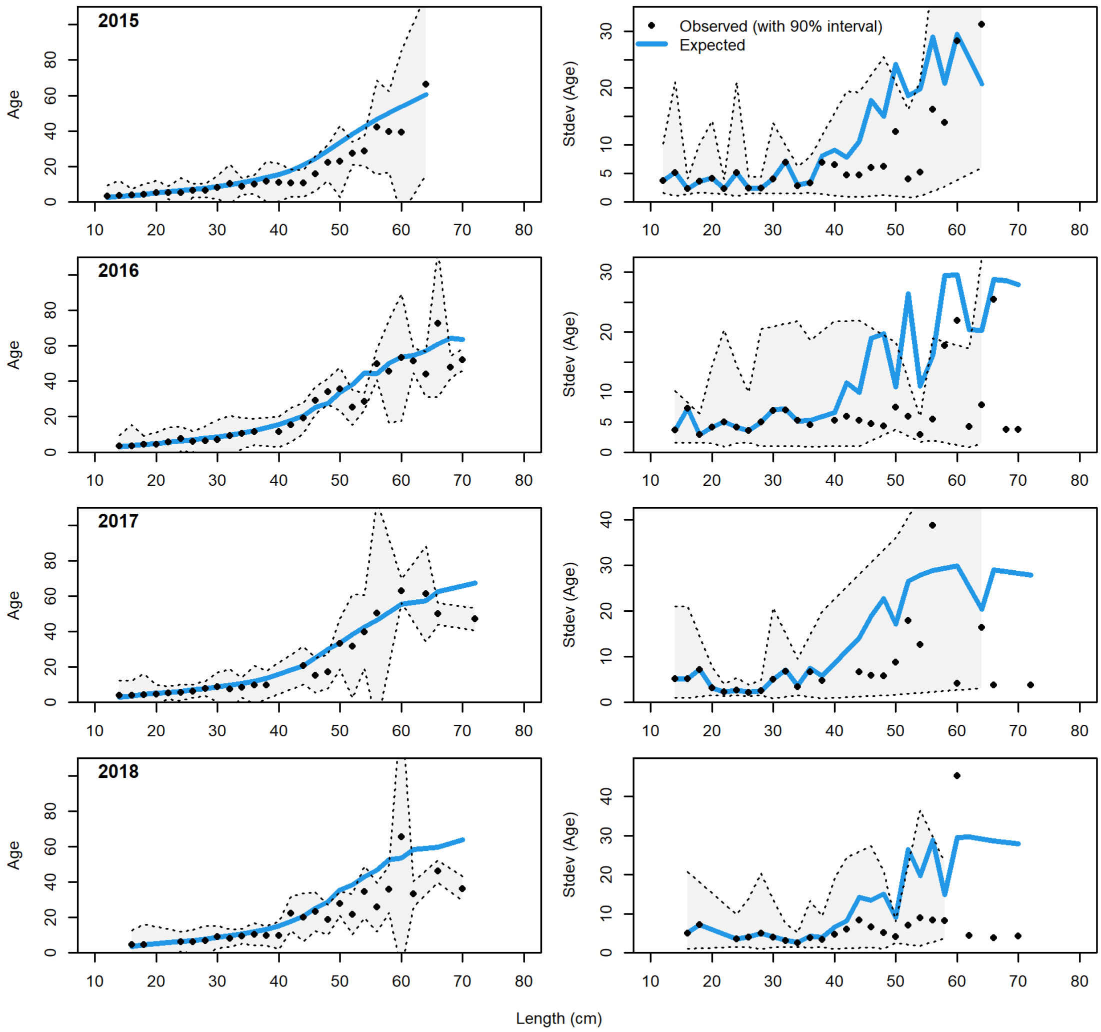

Figure 120: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the West Coast Groundfish Bottom Trawl survey in years 2015-2018. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

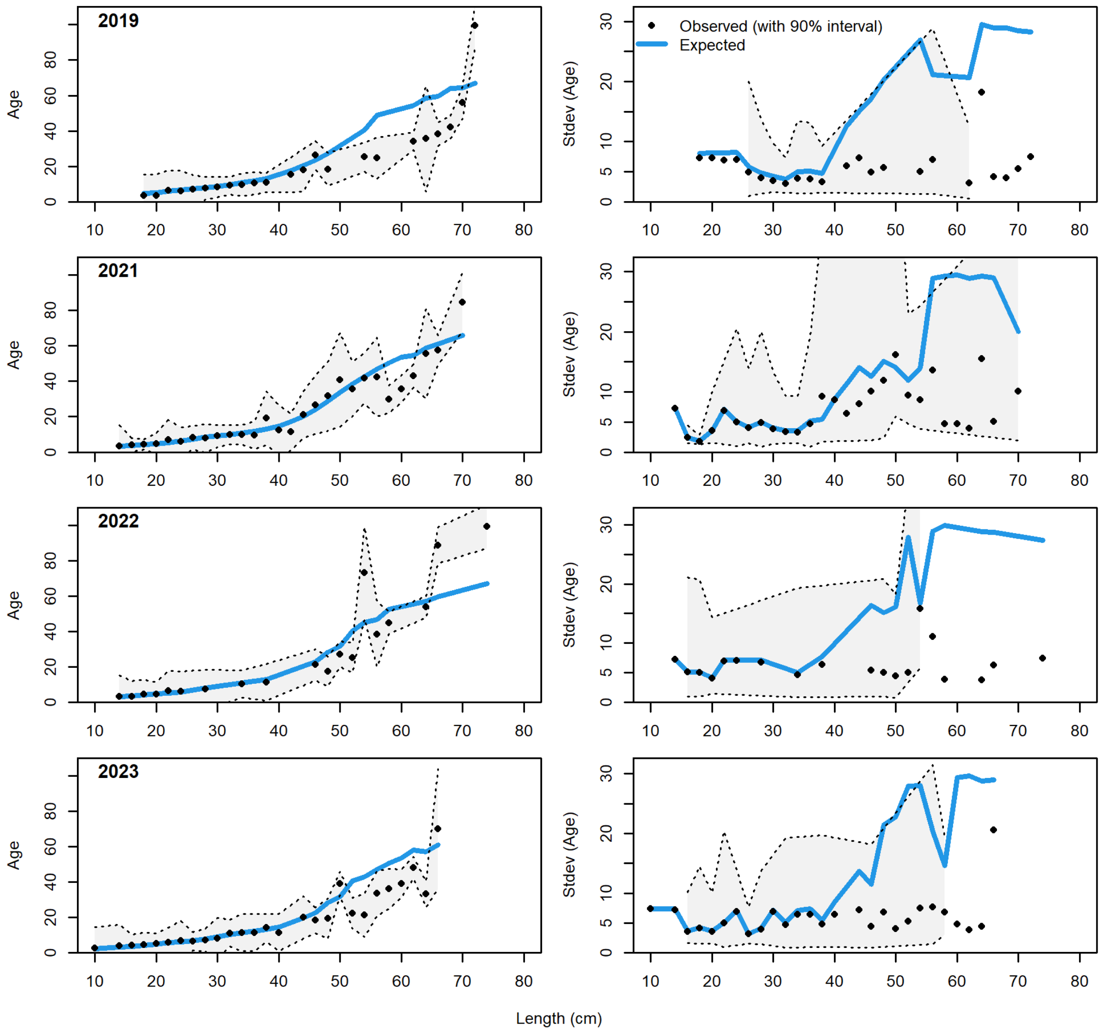

Figure 121: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the West Coast Groundfish Bottom Trawl survey in years 2019-2023. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

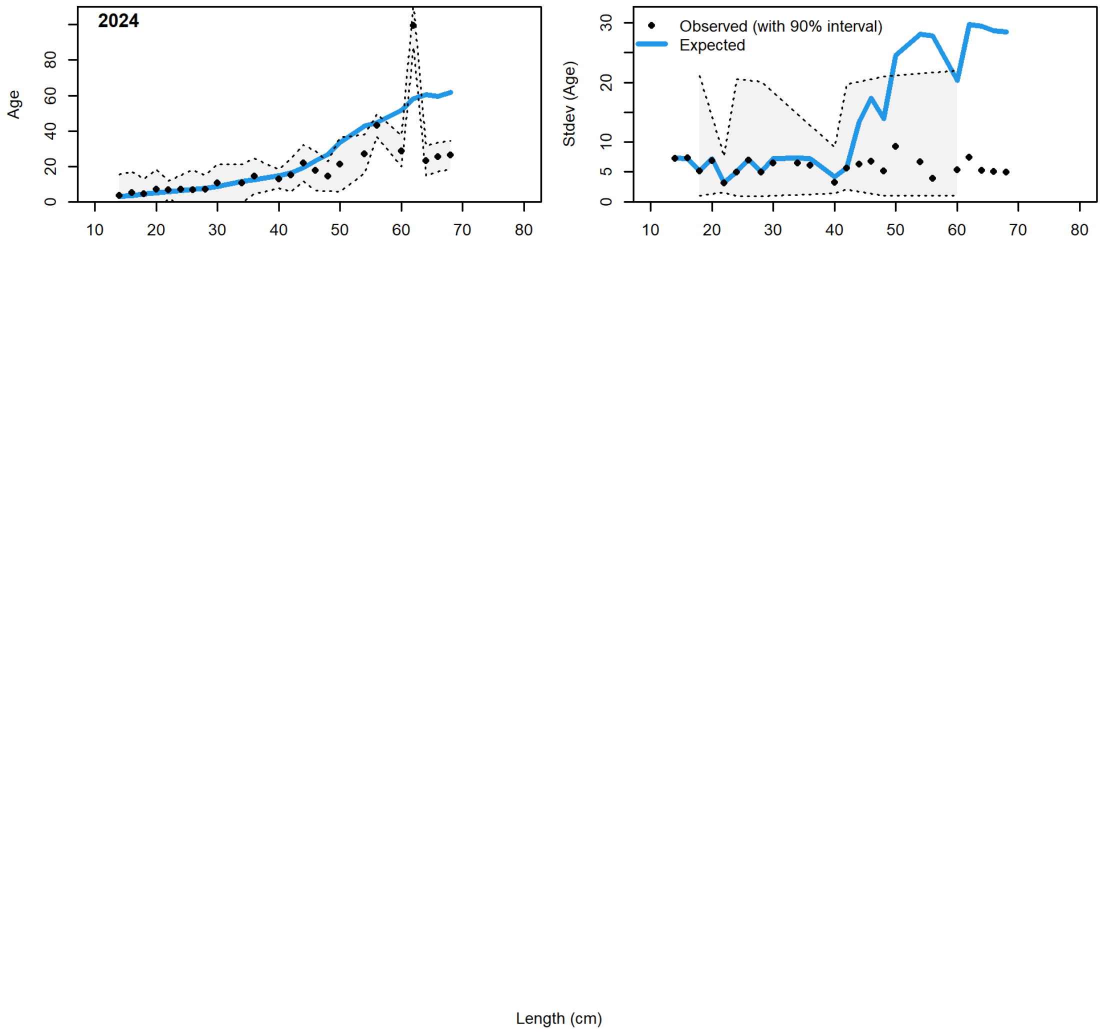

Figure 122: Conditional age at length plot showing mean age (left panels) and standard deviation (right panels) for the West Coast Groundfish Bottom Trawl survey in 2024. The CIs are 90% based on adding 1.64 SE of mean to the data for the left panels and the standard error of mean age at length (obs. and exp.) with 90% CIs based on the chi-square distribution.

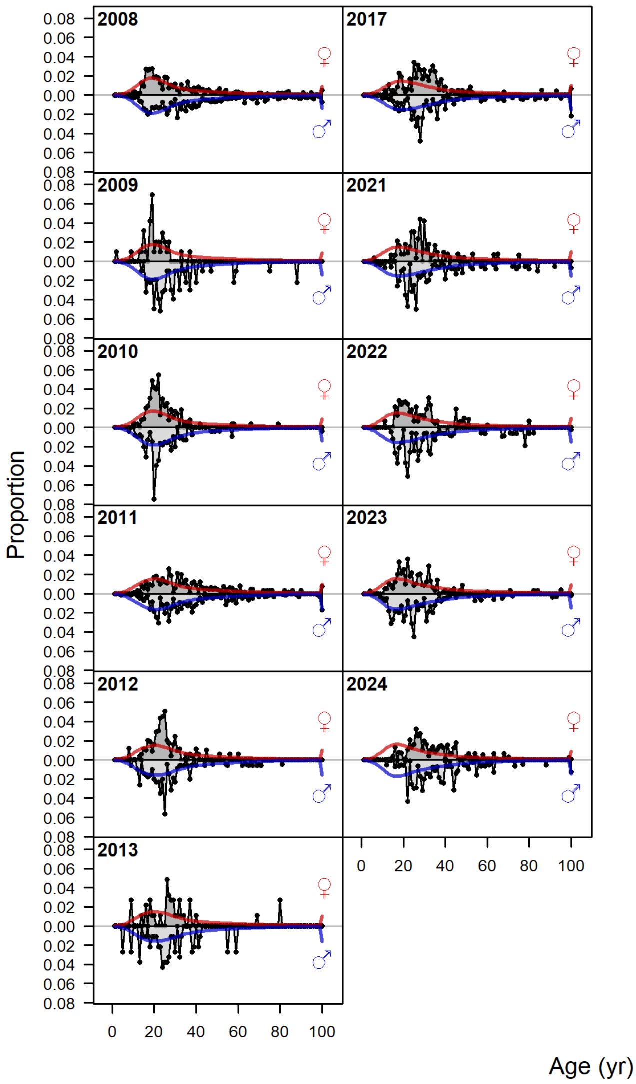

Figure 123: Realized fits (lines) to the marginal age composition data (density) for the bottom trawl fishery.

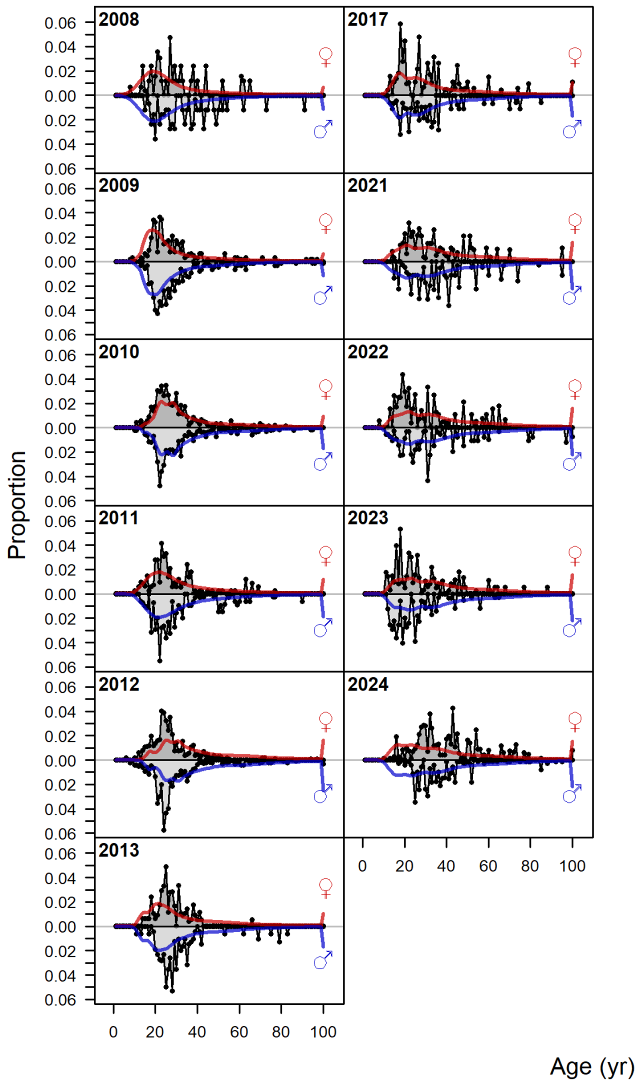

Figure 124: Realized fits (lines) to the marginal age composition data (density) for the non-trawl fishery.

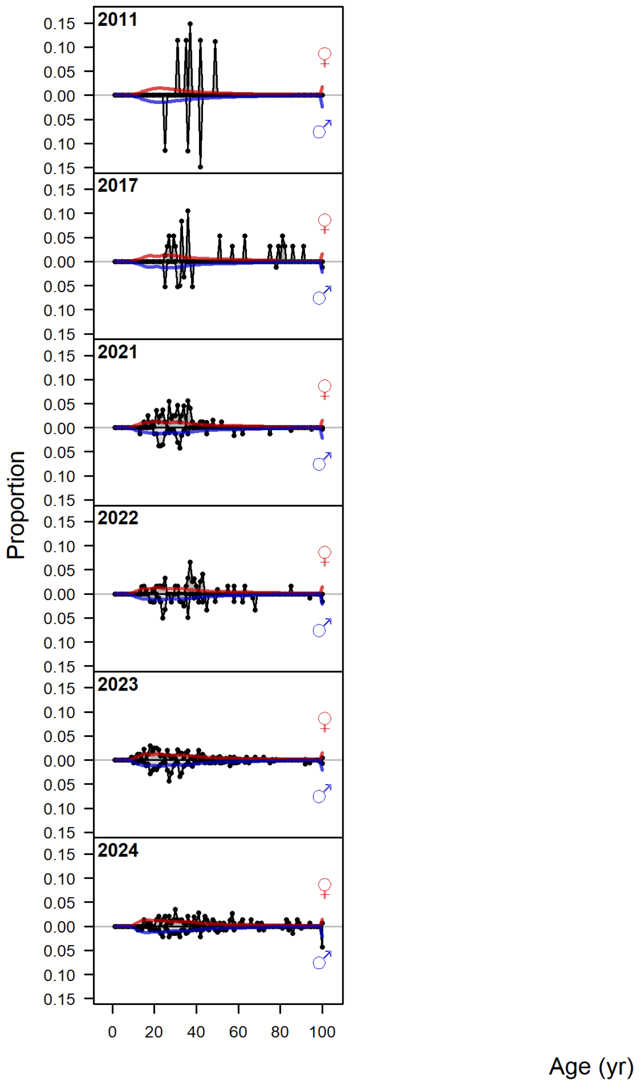

Figure 125: Realized fits (lines) to the marginal age composition data (density) for the midwater trawl fishery.

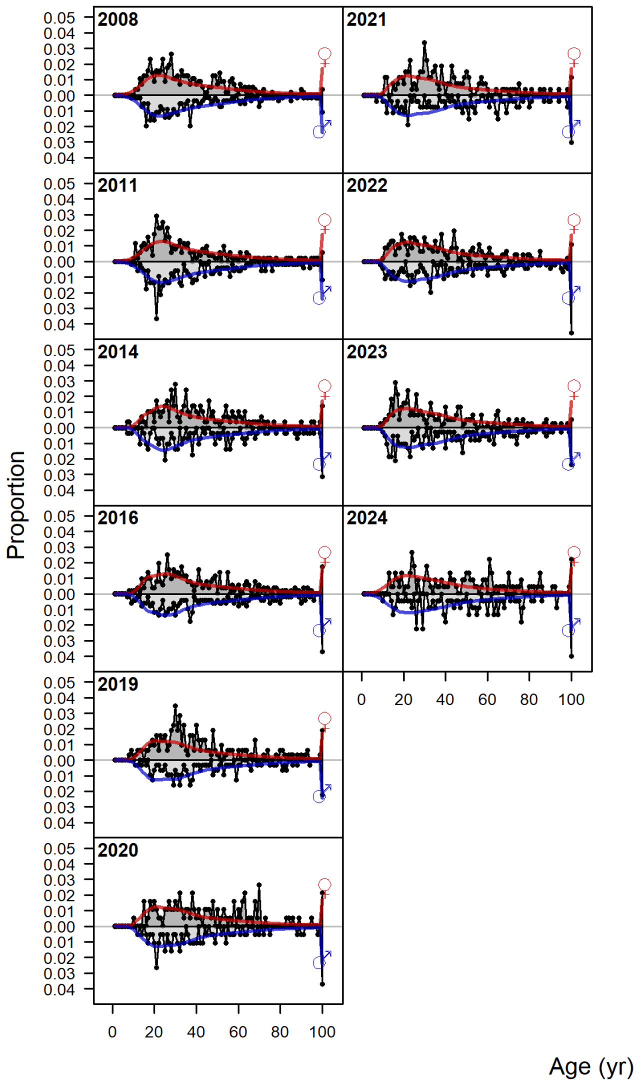

Figure 126: Realized fits (lines) to the marginal age composition data (density) for the at-sea-hake fishery.

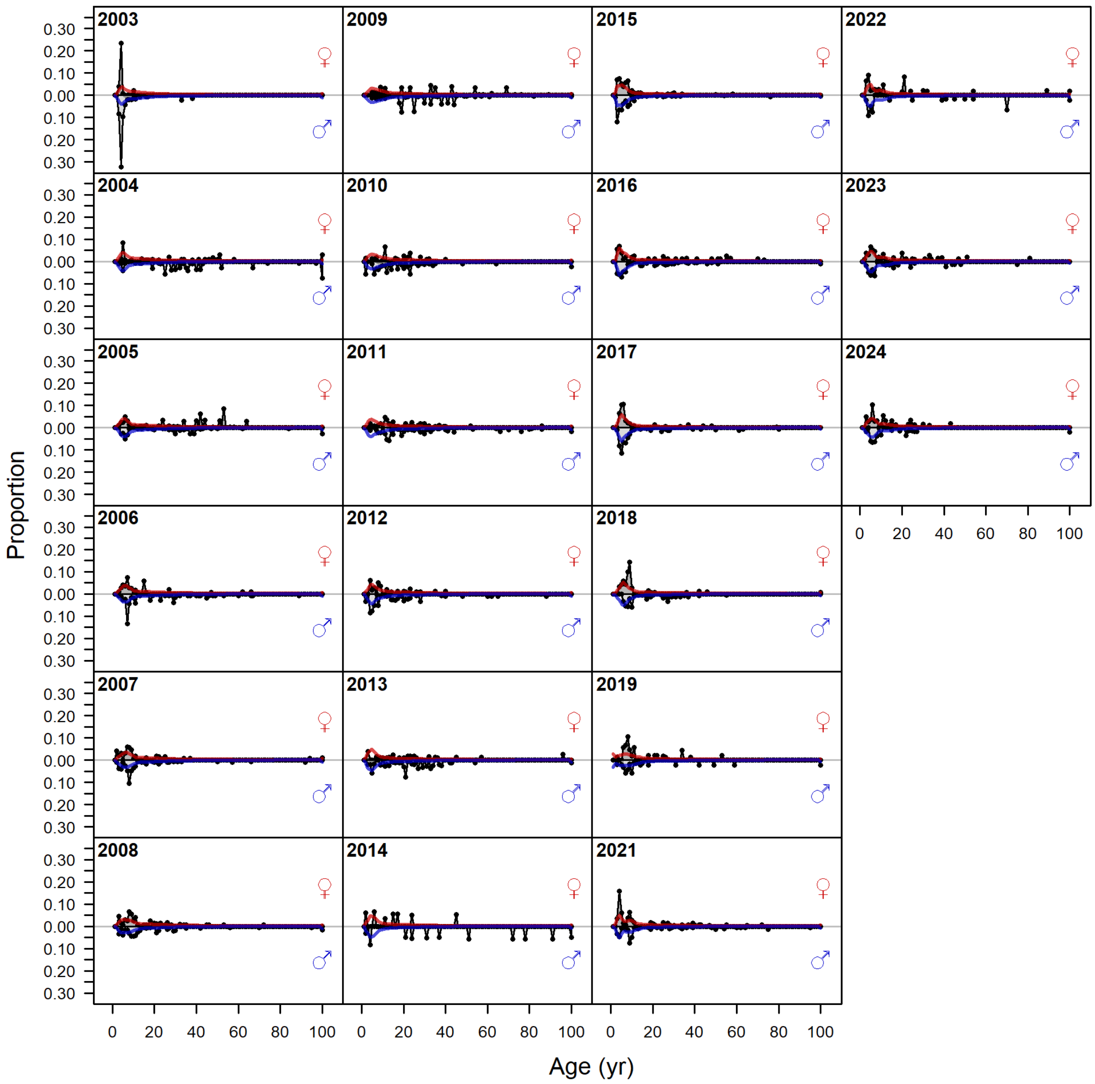

Figure 127: Realized fits (lines) to the marginal age composition data (density) for the West Coast Groundfish Bottom Trawl survey.

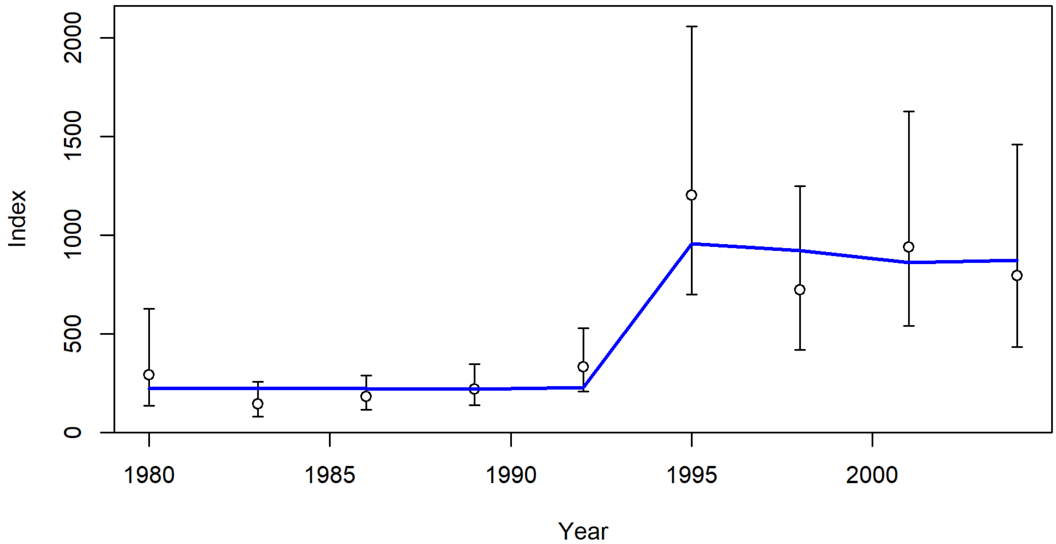

Figure 128: Fit to index data for Triennial survey. Lines indicate 95% uncertainty interval around index values based on the assumption of lognormal error.

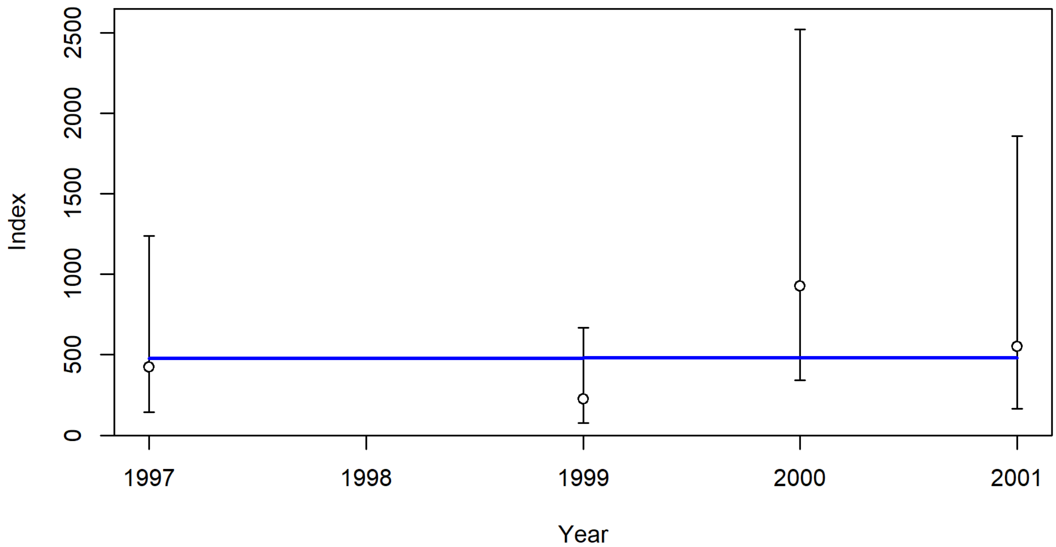

Figure 129: Fit to index data for the Alaska Slope survey. Lines indicate 95% uncertainty interval around index values based on the assumption of lognormal error.

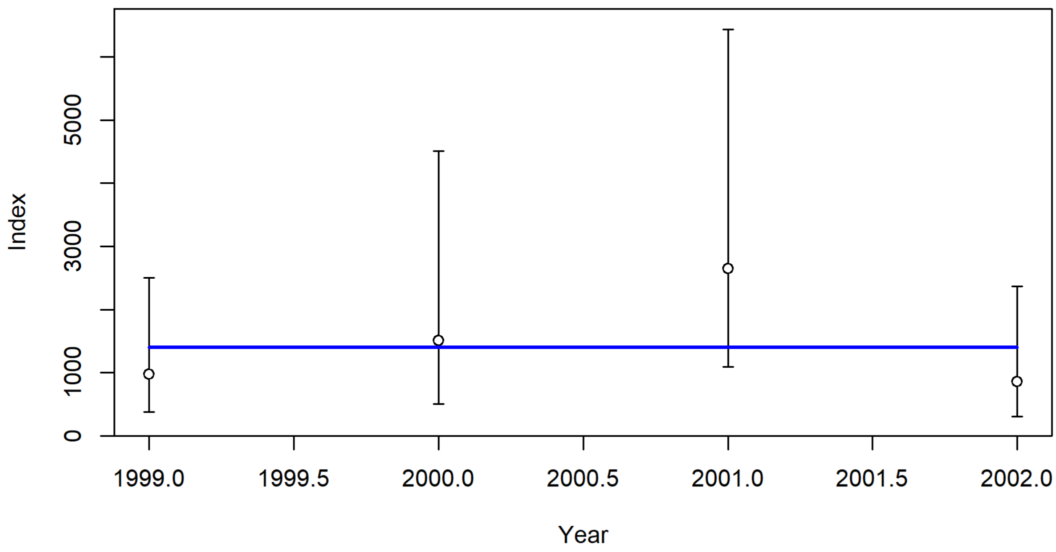

Figure 130: Fit to index data for Northwest Fisheries Science Center Slope survey. Lines indicate 95% uncertainty interval around index values based on the assumption of lognormal error.

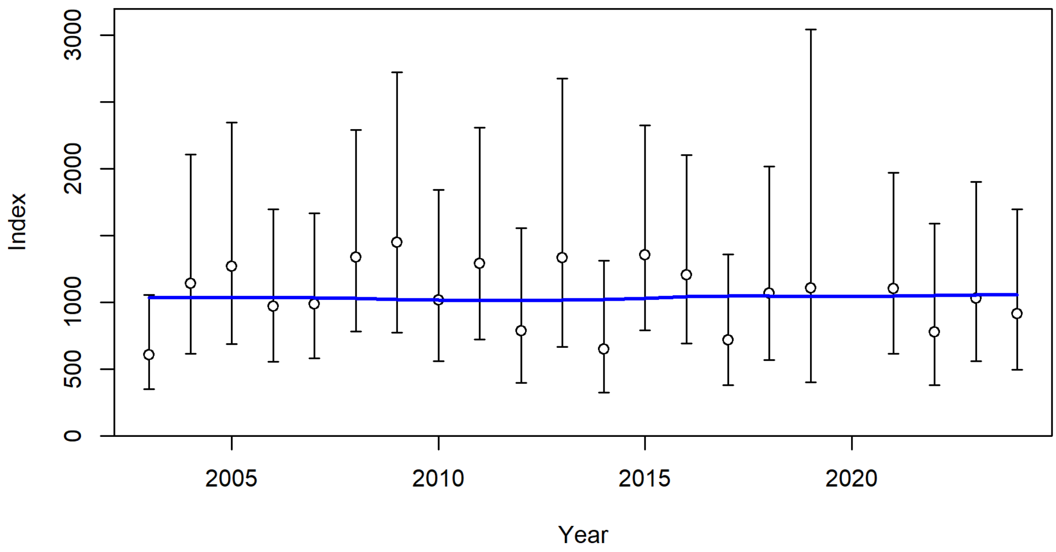

Figure 131: Fit to index data for West Coast Groundfish Bottom Trawl survey. Lines indicate 95% uncertainty interval around index values based on the assumption of lognormal error.

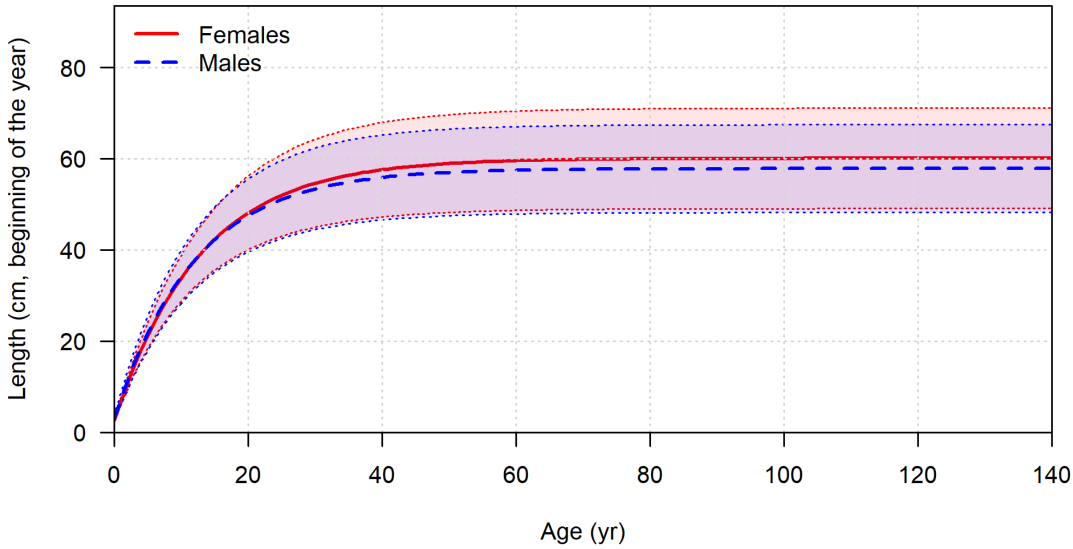

Figure 132: Estimated age and growth relatioship in the reference model .Shaded area indicates 95% distribution of length at age around estimated growth curve.

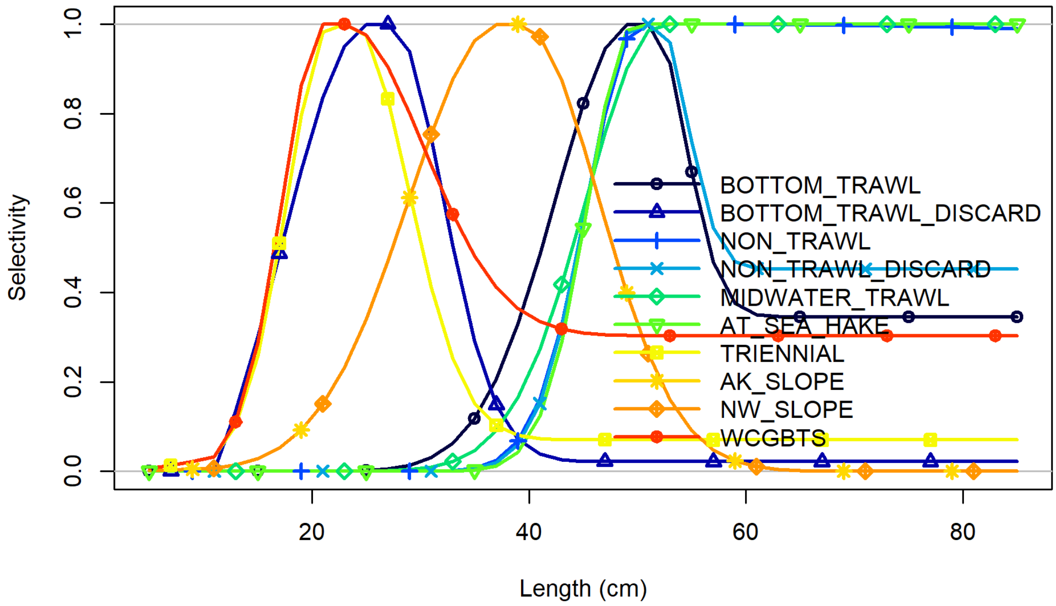

Figure 133: Ending selectivity at length for each fishery and survey.

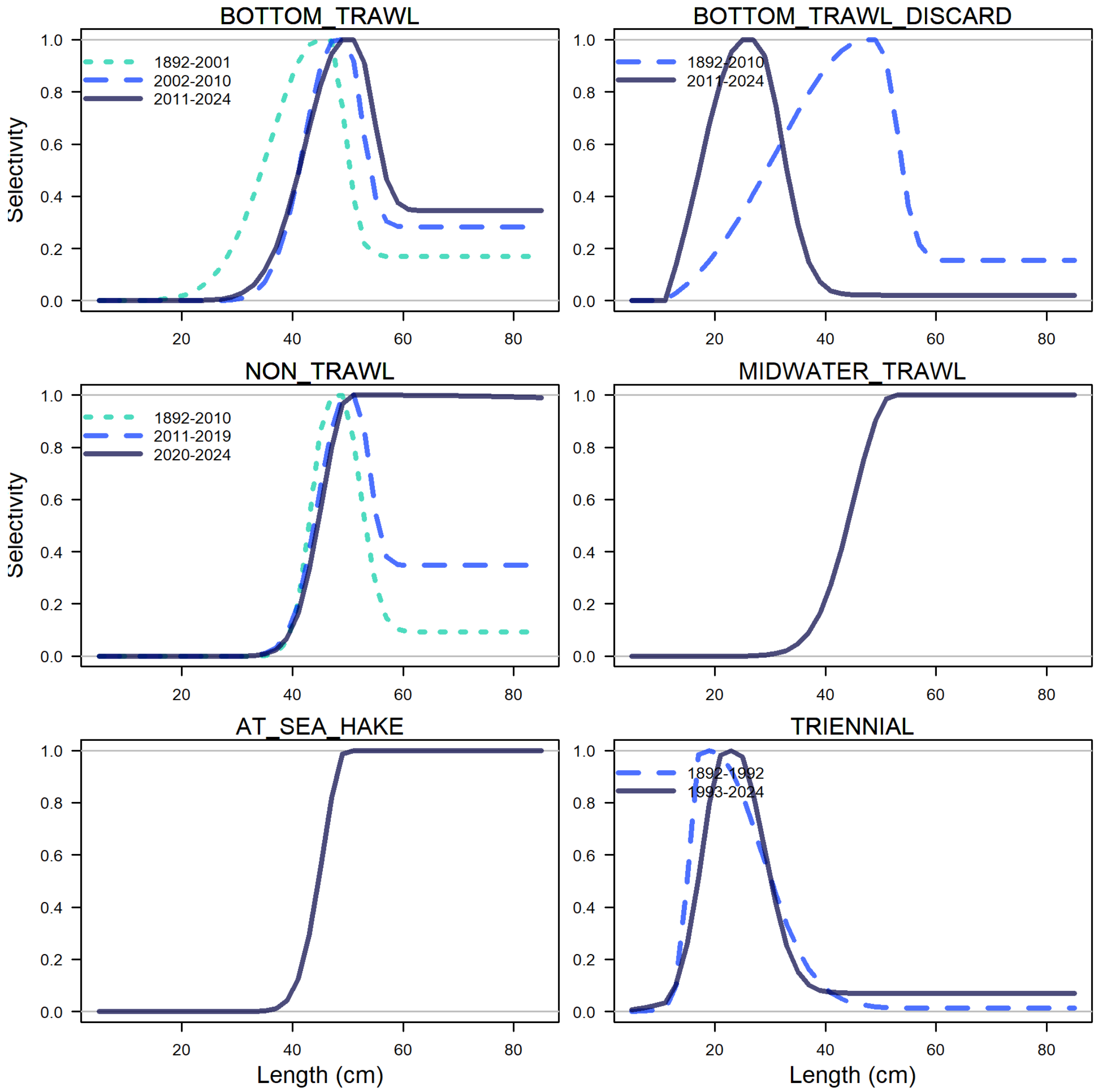

Figure 134: Time-varying selectivity for each fleet and survey with time blocks.

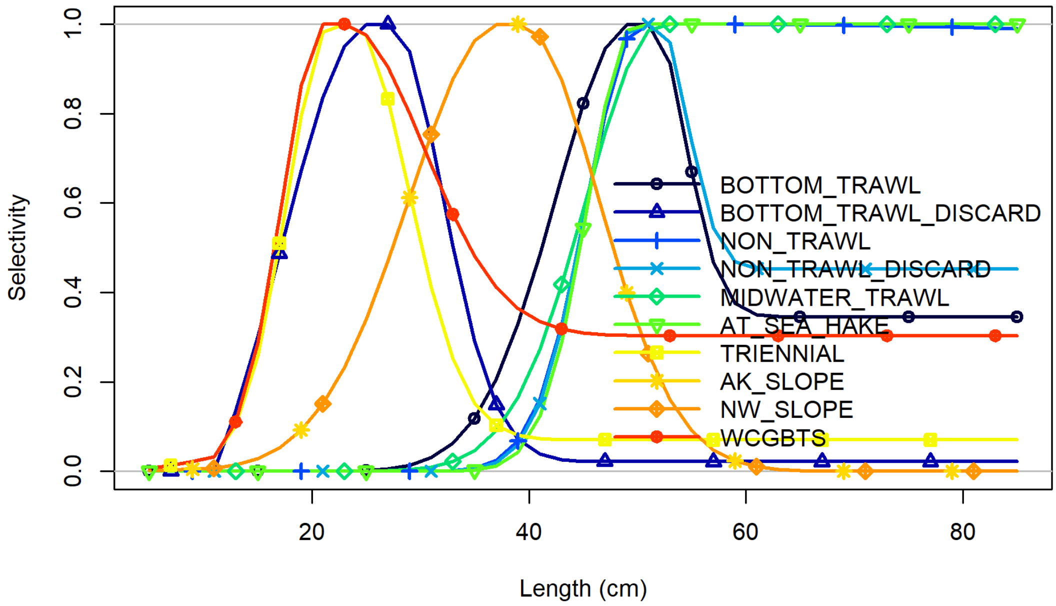

Figure 135: Ending selectivity at age derived from lengths for each fishery and survey.

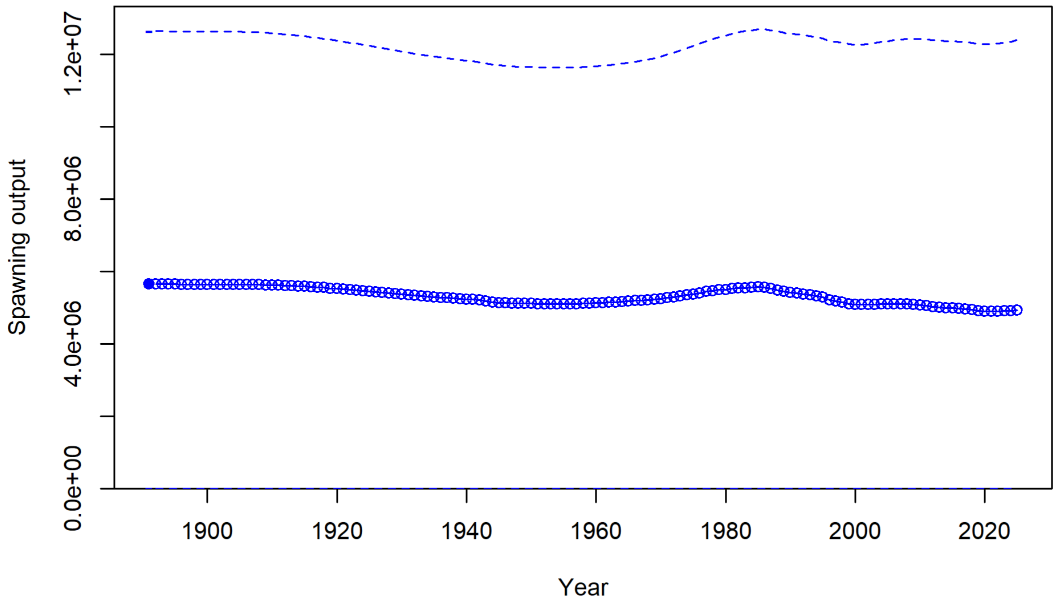

Figure 136: Estimated time series of spawning output (in millions of eggs) for the reference model.

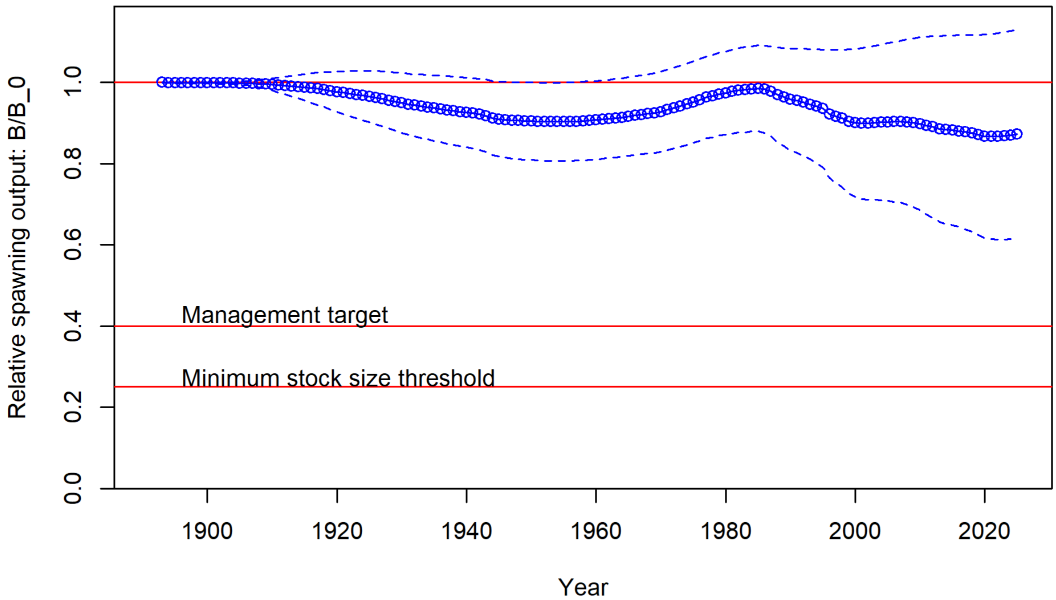

Figure 137: Estimated time series of fraction of unfished spawning output for the reference model.

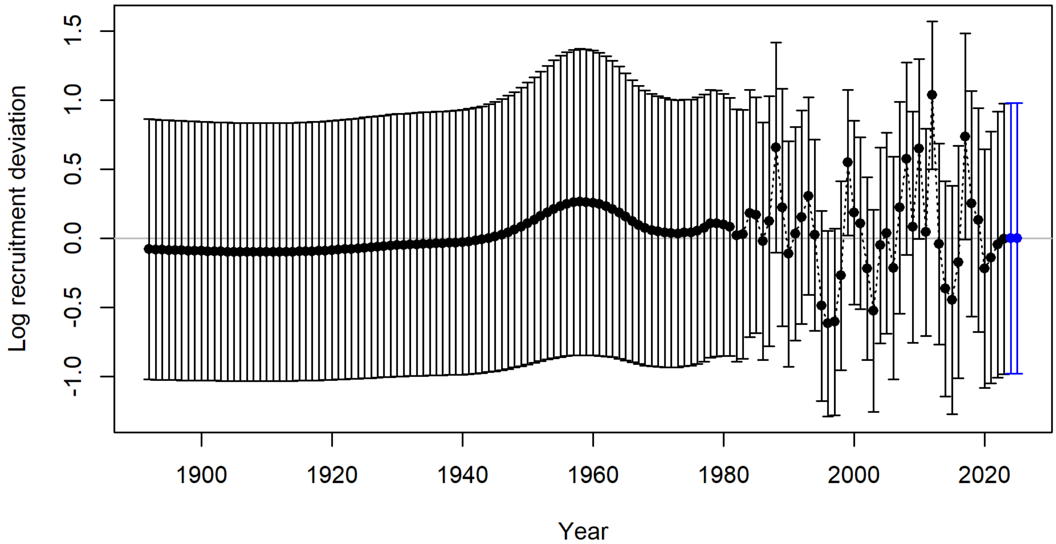

Figure 138: Estimated time series of recruitment deviations for the base model.

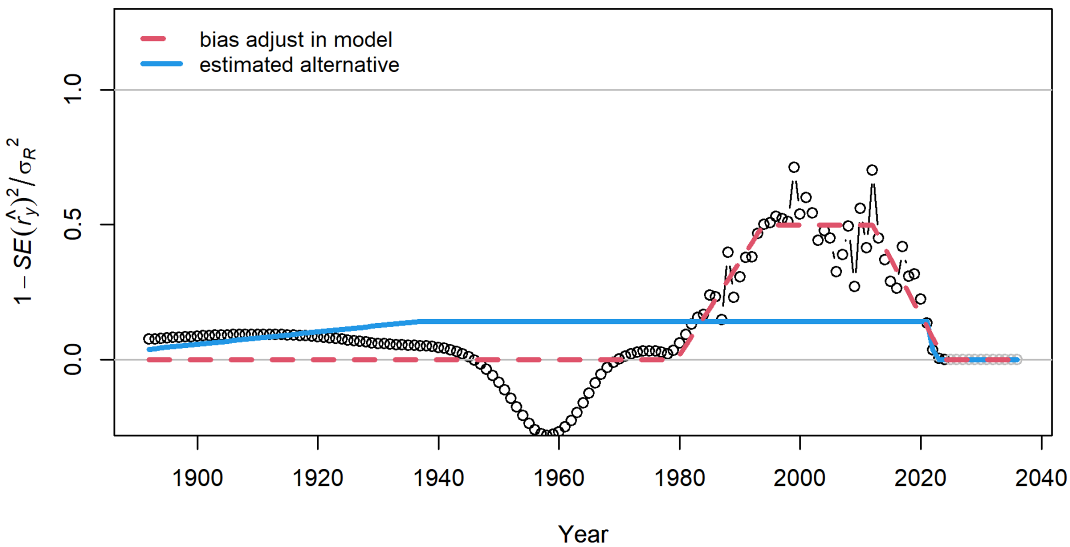

Figure 139: Bias adjustment applied to the recruitment deviations (red line). Points are transformed variances relative to the assumed variance of recruitment.

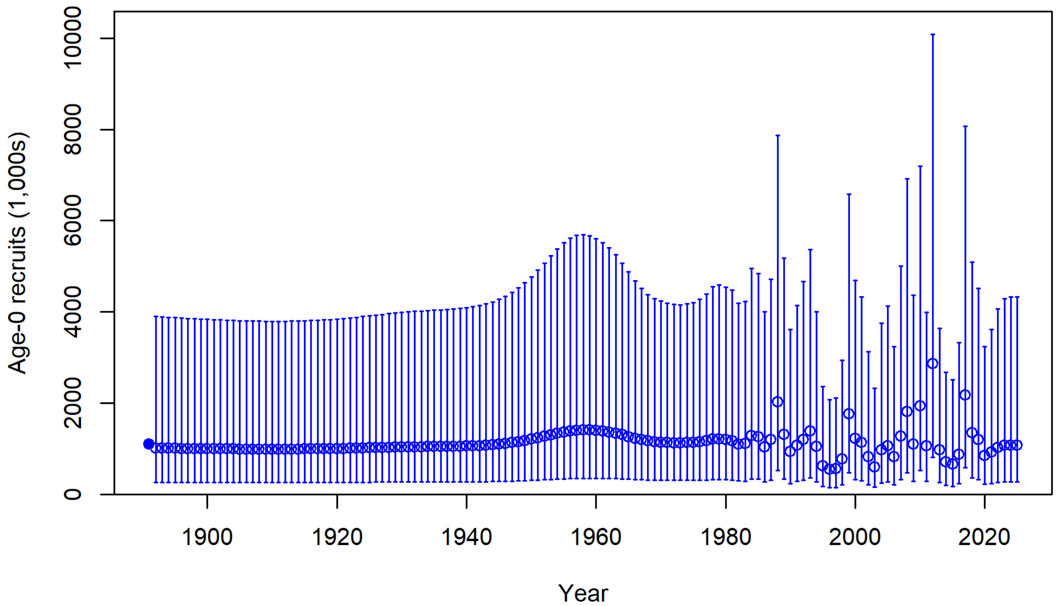

Figure 140: Estimated time series of age-0 recruits for the base model.

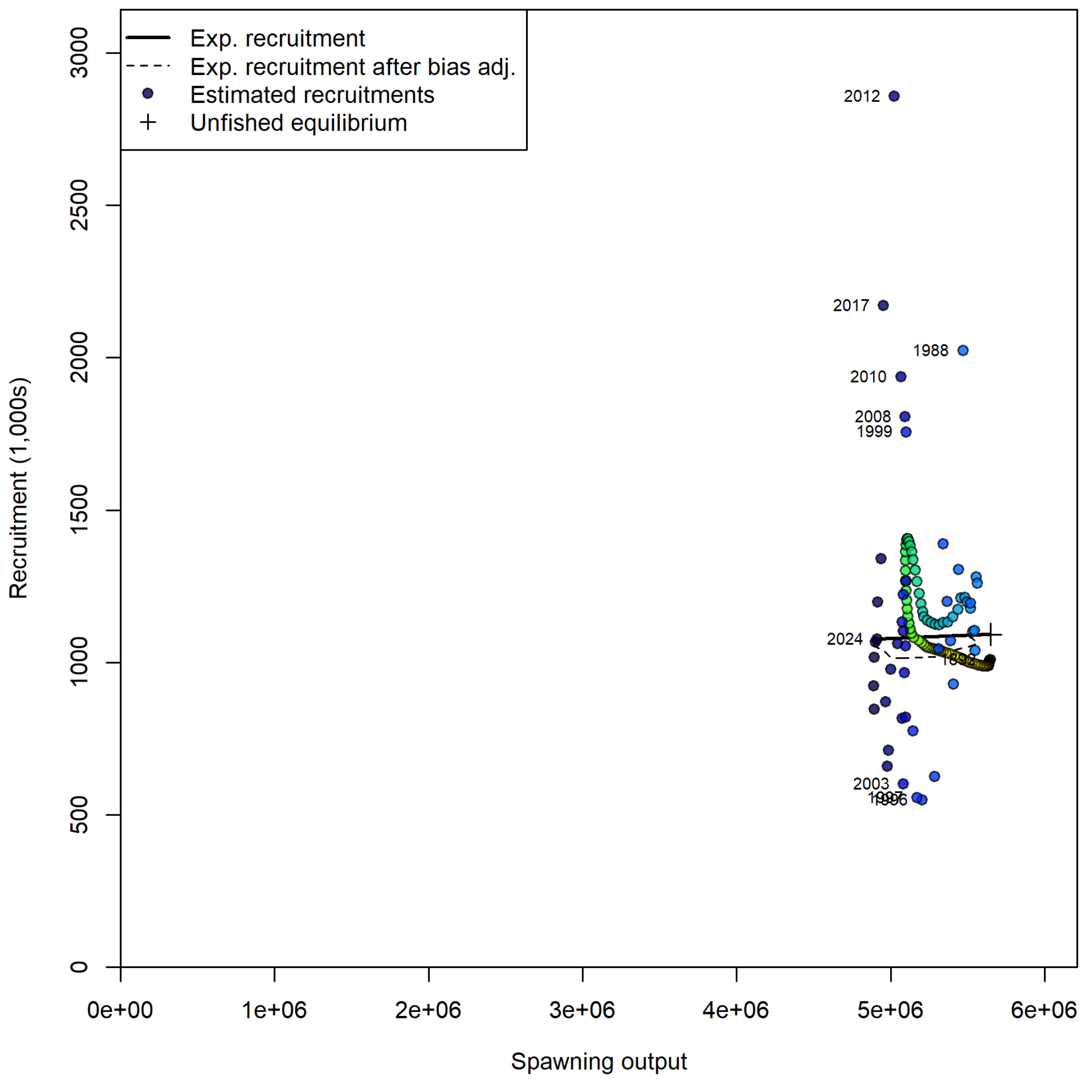

Figure 141: Stock-recruit curve with labels on first, last, and years with (log) deviations > 0.5. Point colors indicate year, with warmer colors indicating earlier years and cooler colors in showing later years.

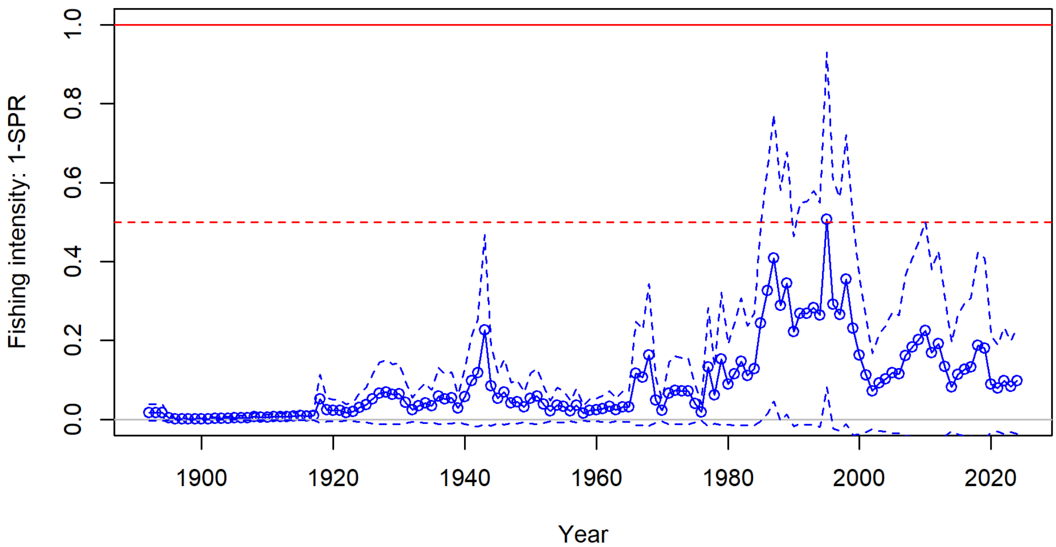

Figure 142: Estimated time series of fishing intensity for the base model.

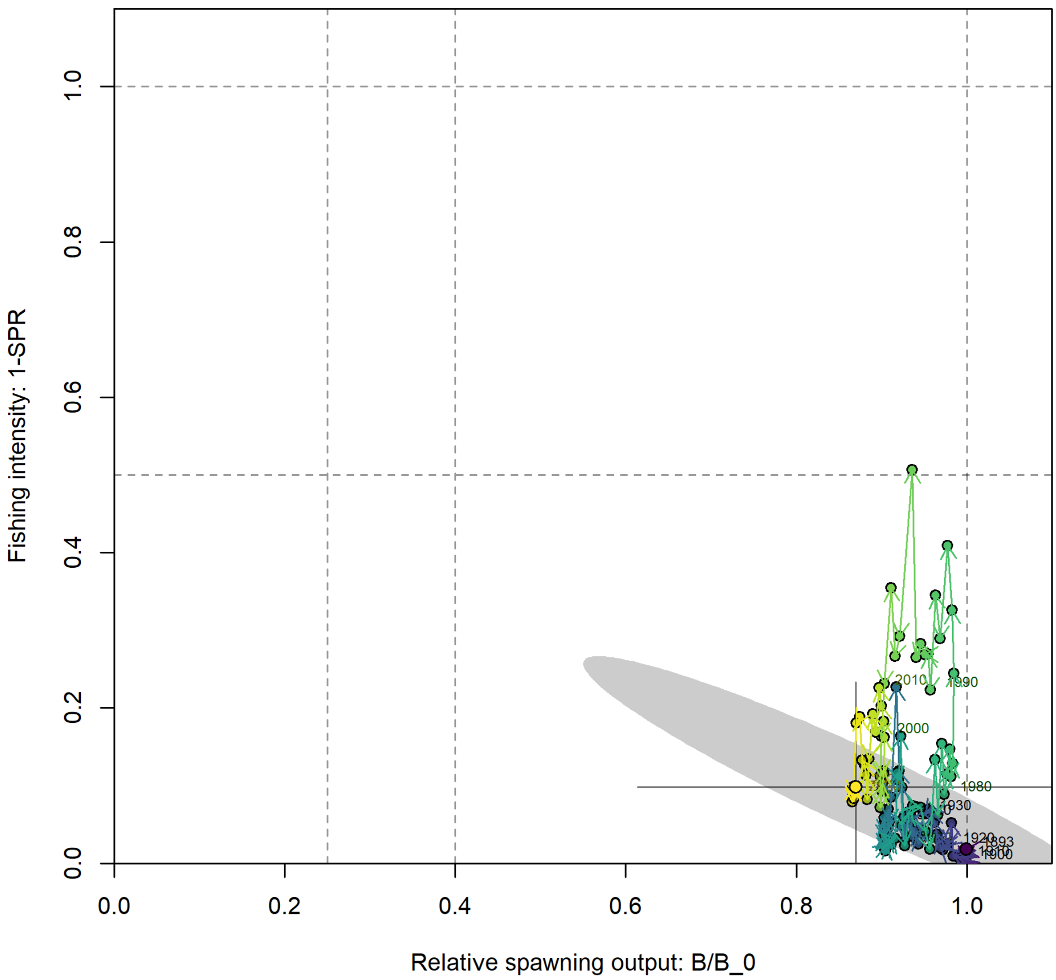

Figure 143: Phase plot of fishing intensity versus fraction unfished for the base model.

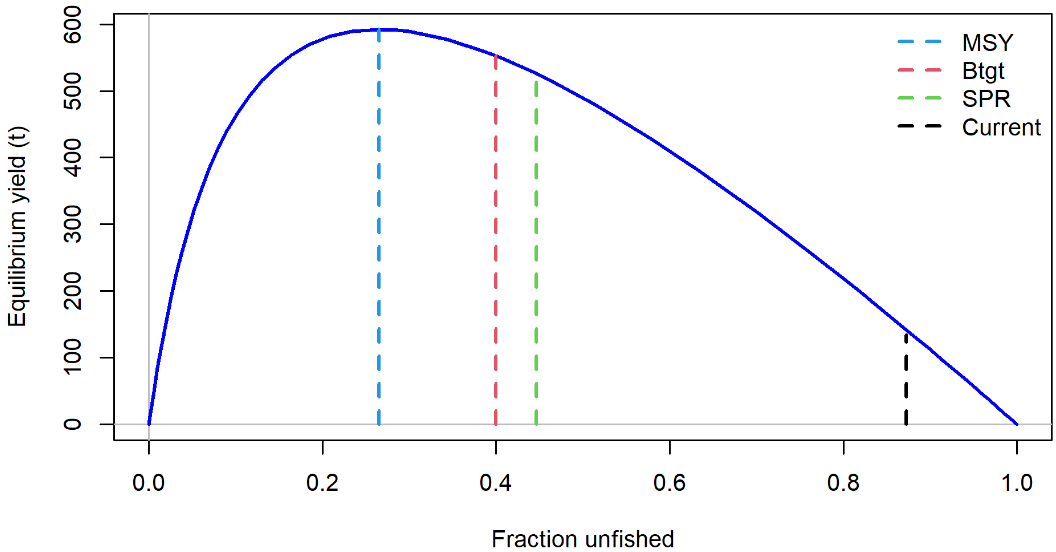

Figure 144: Estimated yield curve with reference points for the base model.

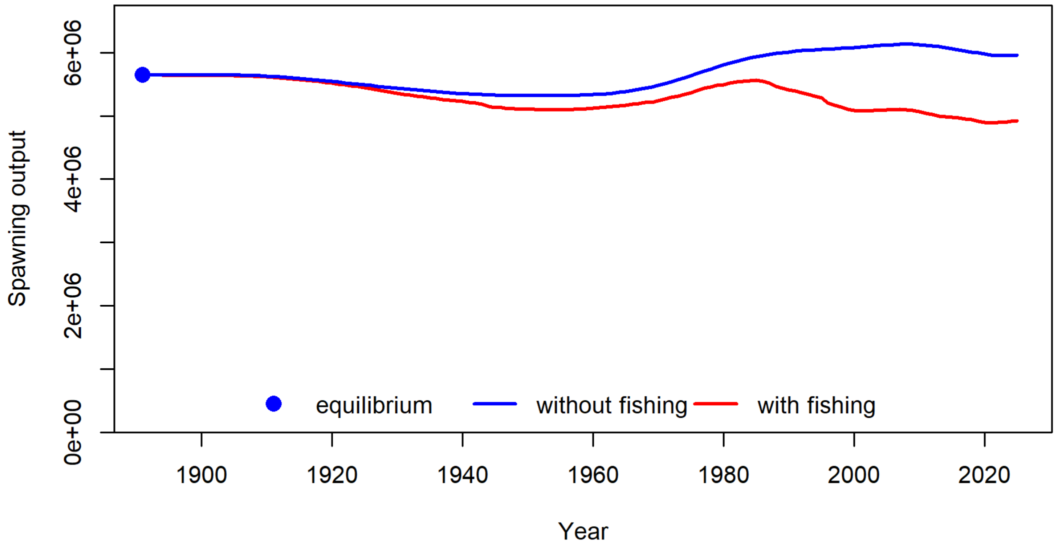

Figure 145: Dynamic B0 plot. The lower line shows the time series of estimated spawning output in the presence of fishing mortality. The upper line shows the time series that could occur under the same dynamics (including deviations in recruitment), but without fishing. The point at the left represents the unfished equilibrium.

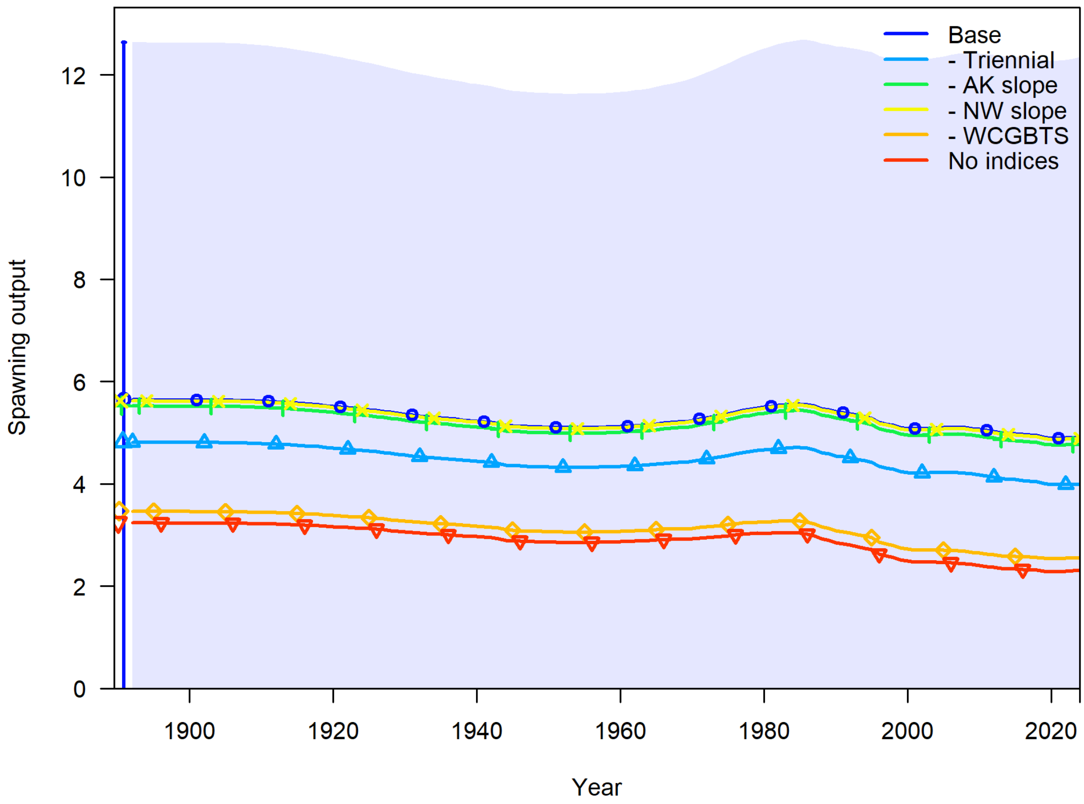

Figure 146: Spawning output (millions of eggs) across data removal sensitivities (indices).

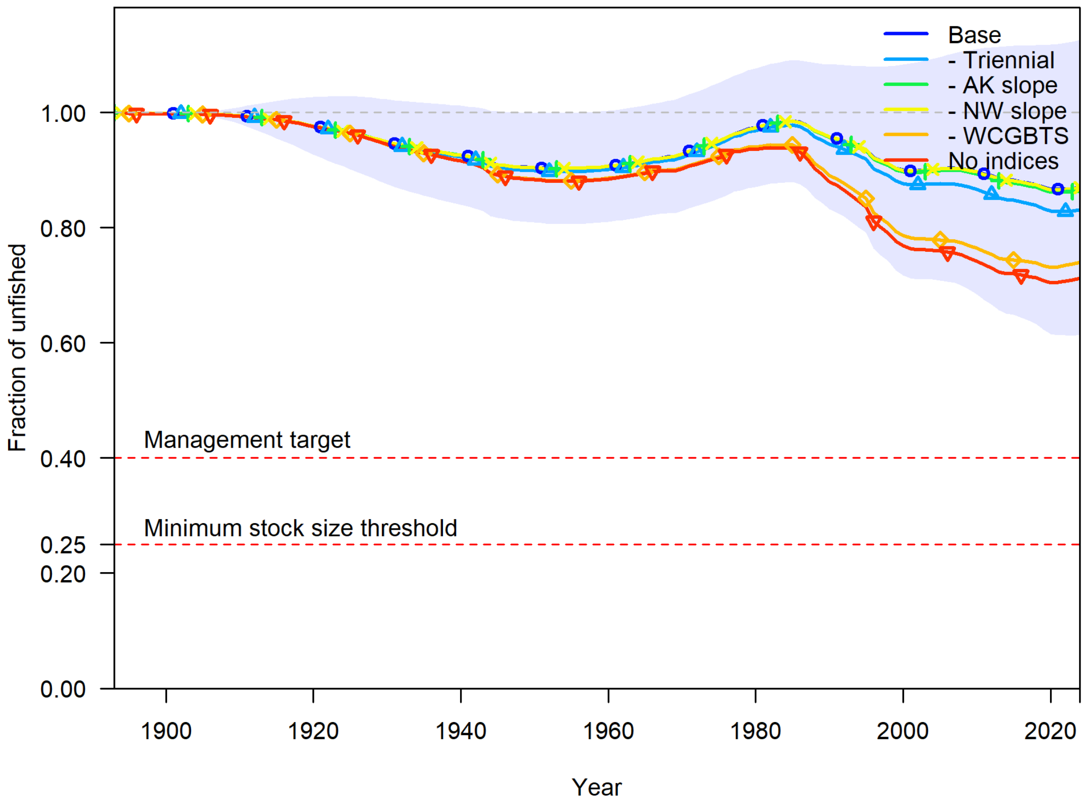

Figure 147: Relative spawning output (fraction unfished) across data removal sensitivities (indices).

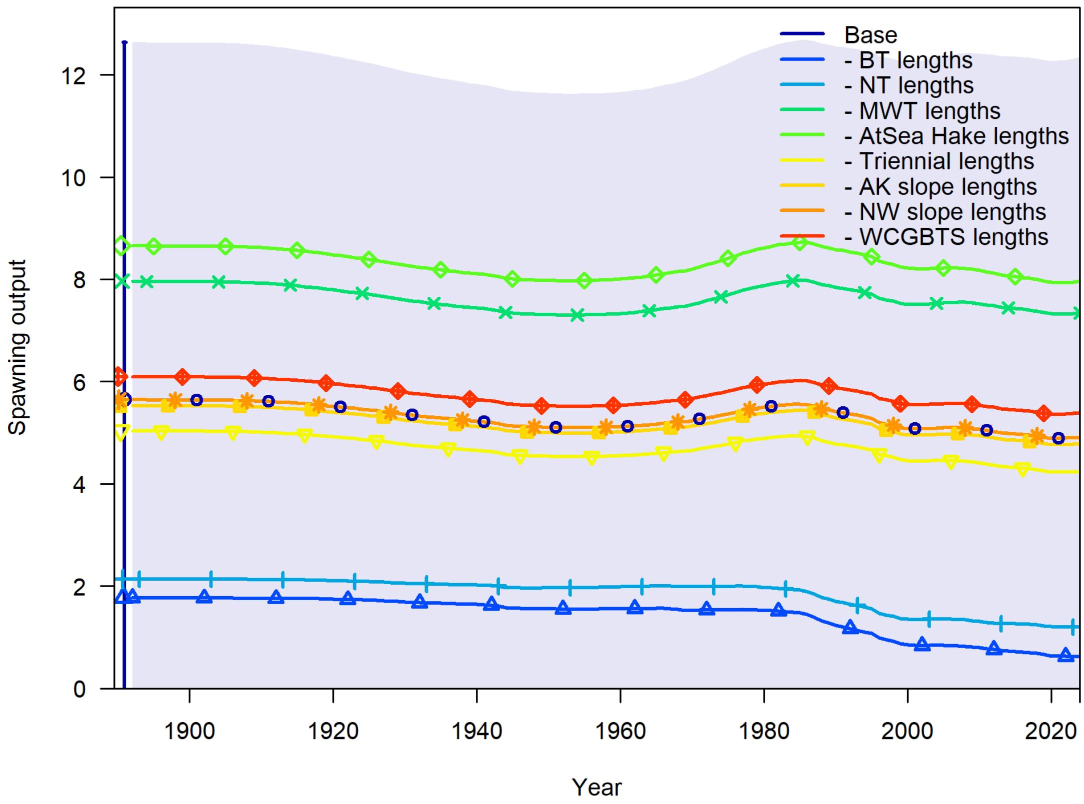

Figure 148: Spawning output (millions of eggs) across data removal sensitivities (length compositions by fleet).

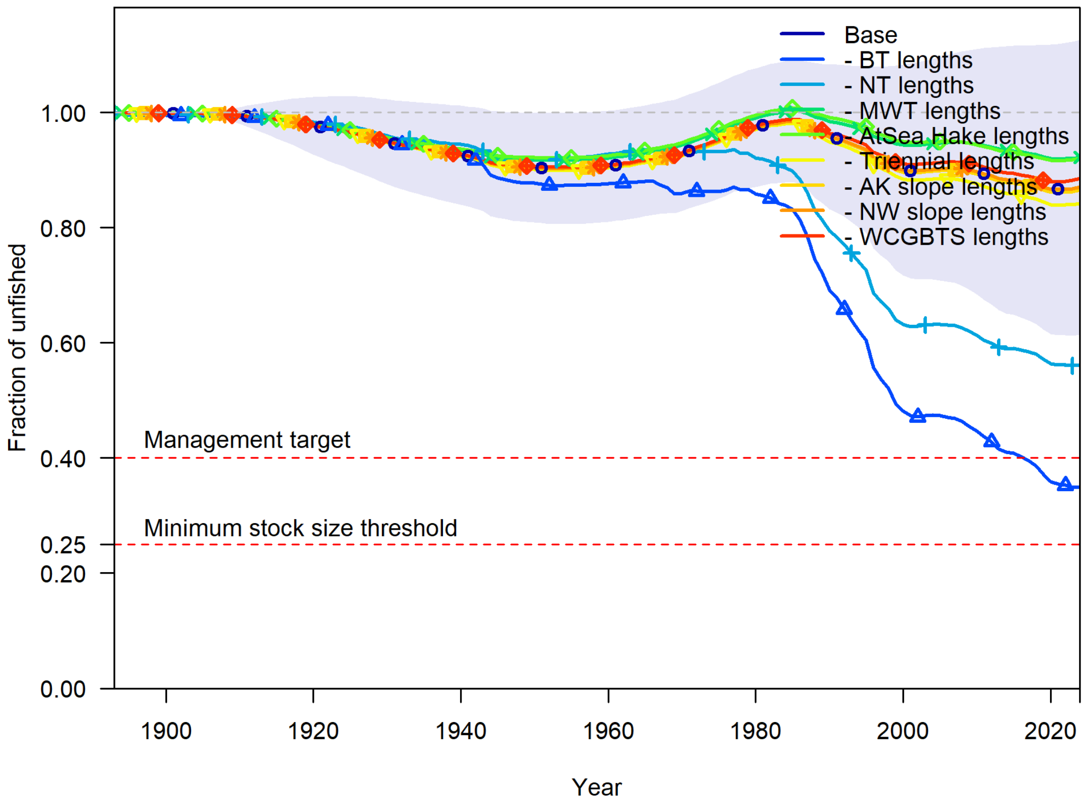

Figure 149: Relative spawning output (fraction unfished) across data removal sensitivities (length compositions by fleet).

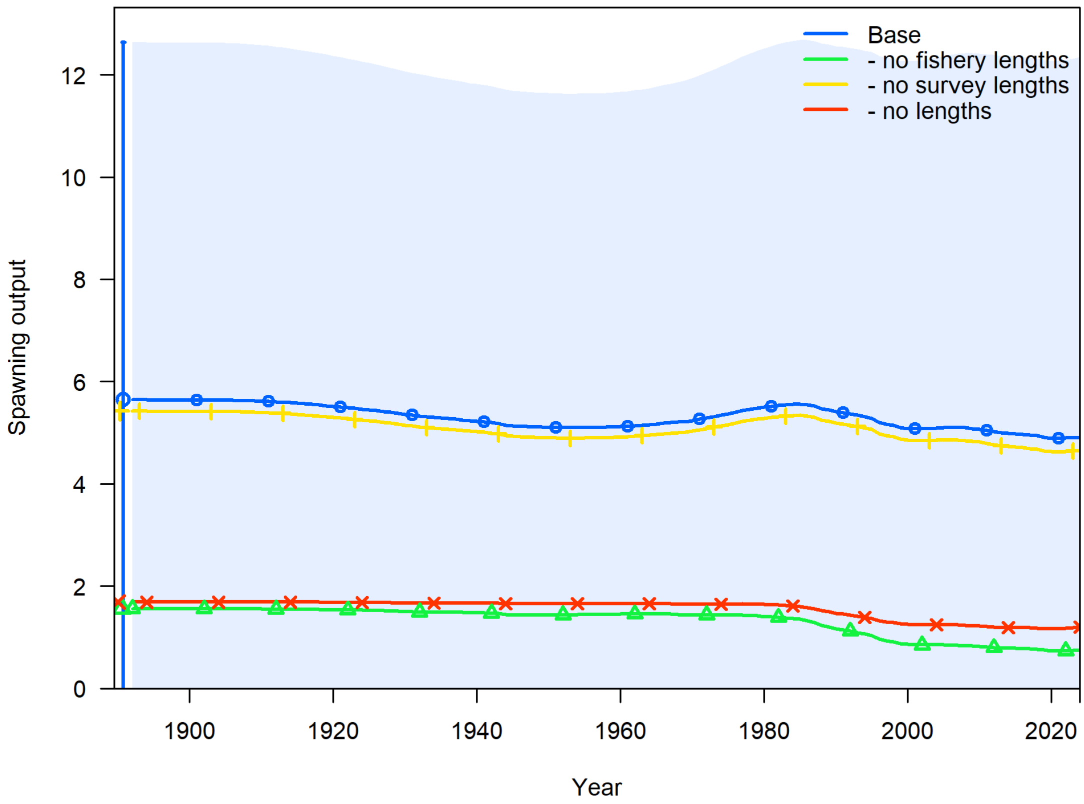

Figure 150: Spawning output (millions of eggs) across data removal sensitivities (length compositions by source).

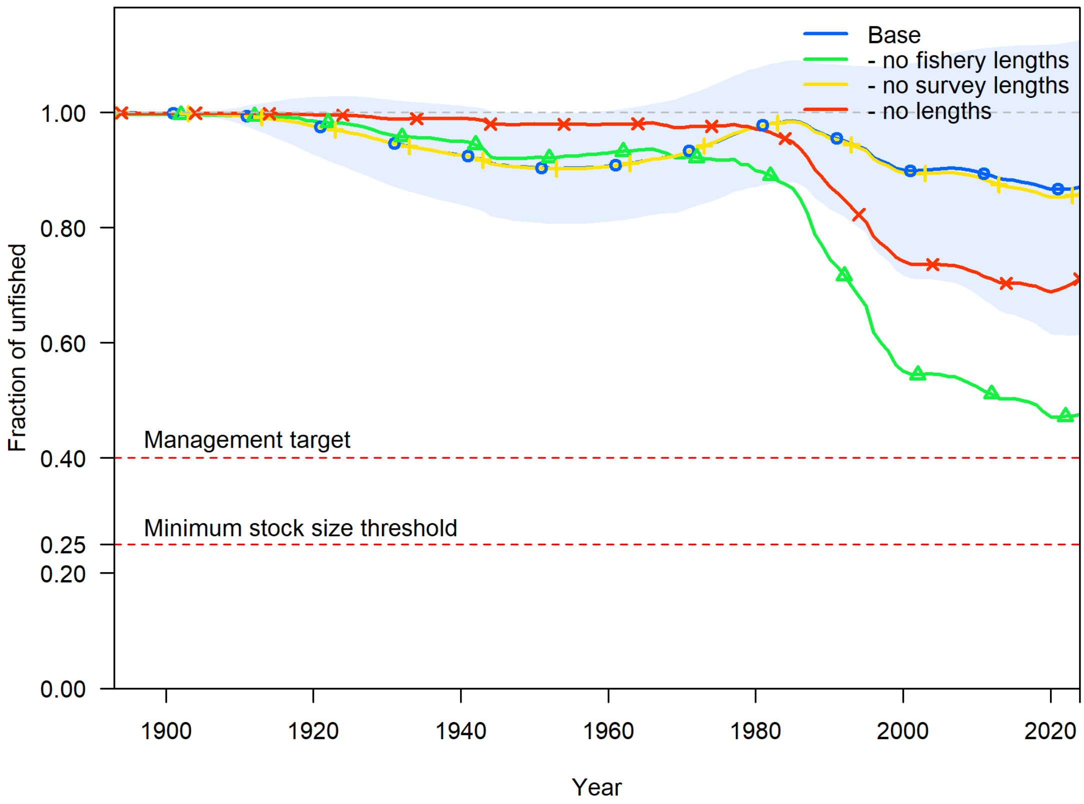

Figure 151: Relative spawning output (fraction unfished) across data removal sensitivities (length compositions by source).

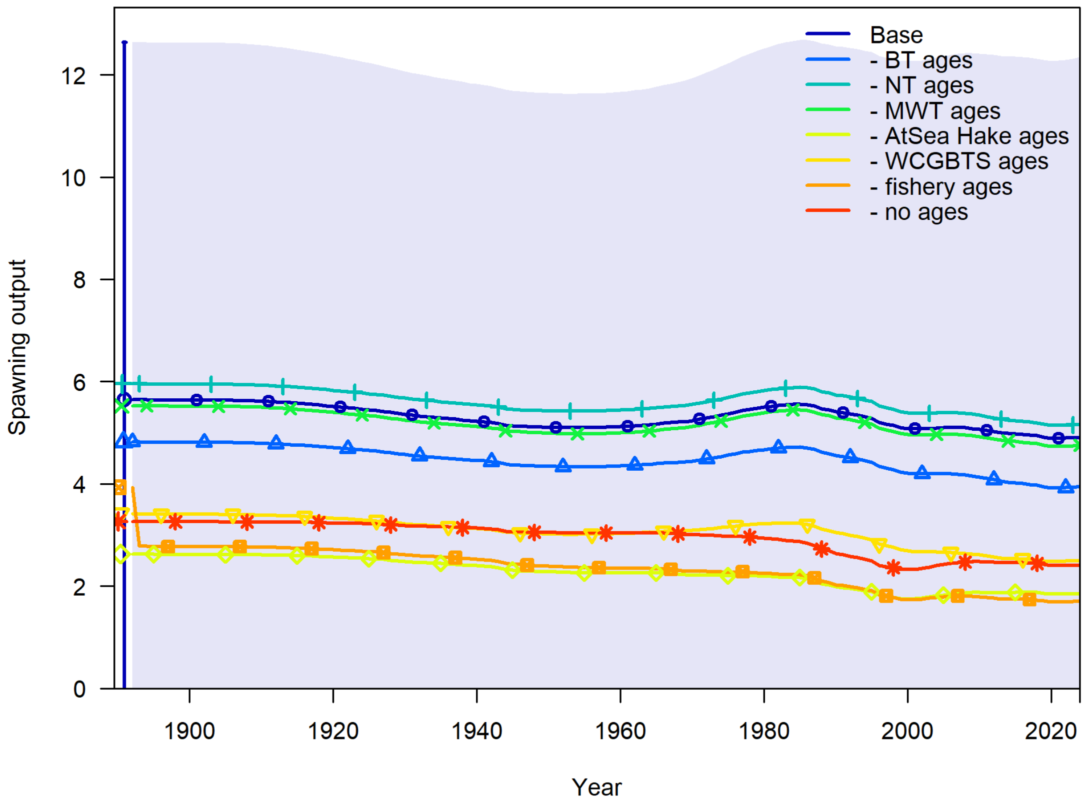

Figure 152: Spawning output (millions of eggs) across data removal sensitivities (age compositions by fleet).

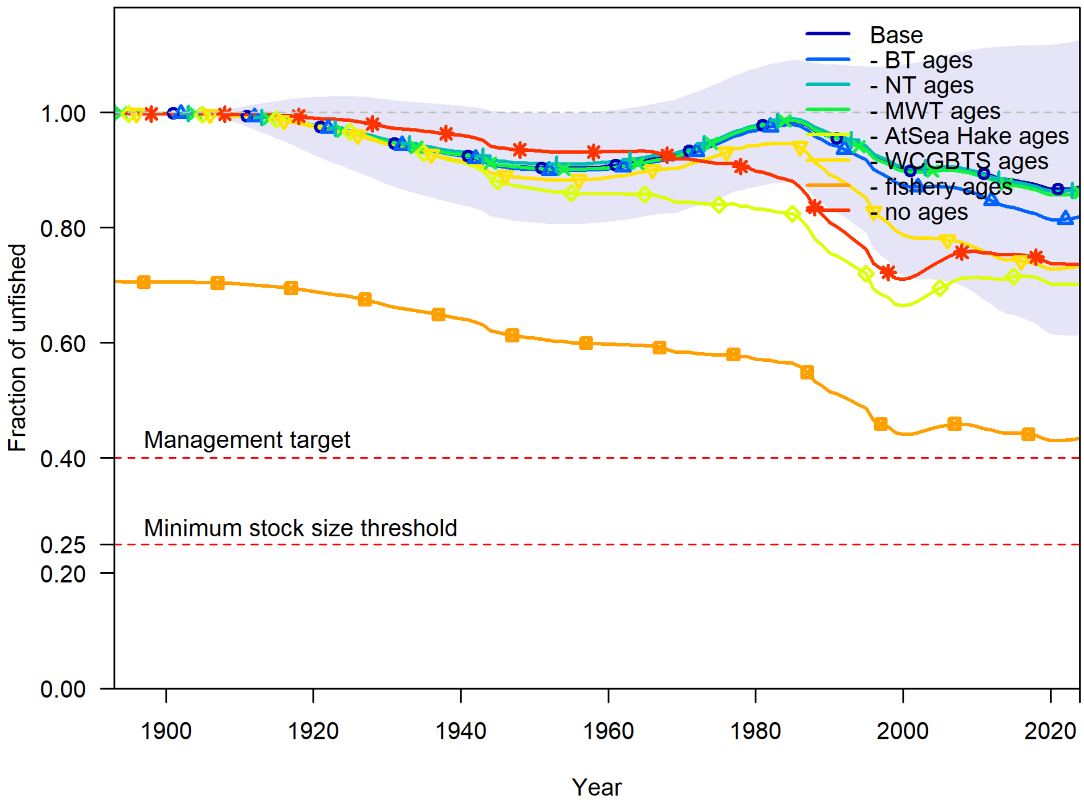

Figure 153: Relative spawning output (fraction unfished) across data removal sensitivities (age compositions by fleet).

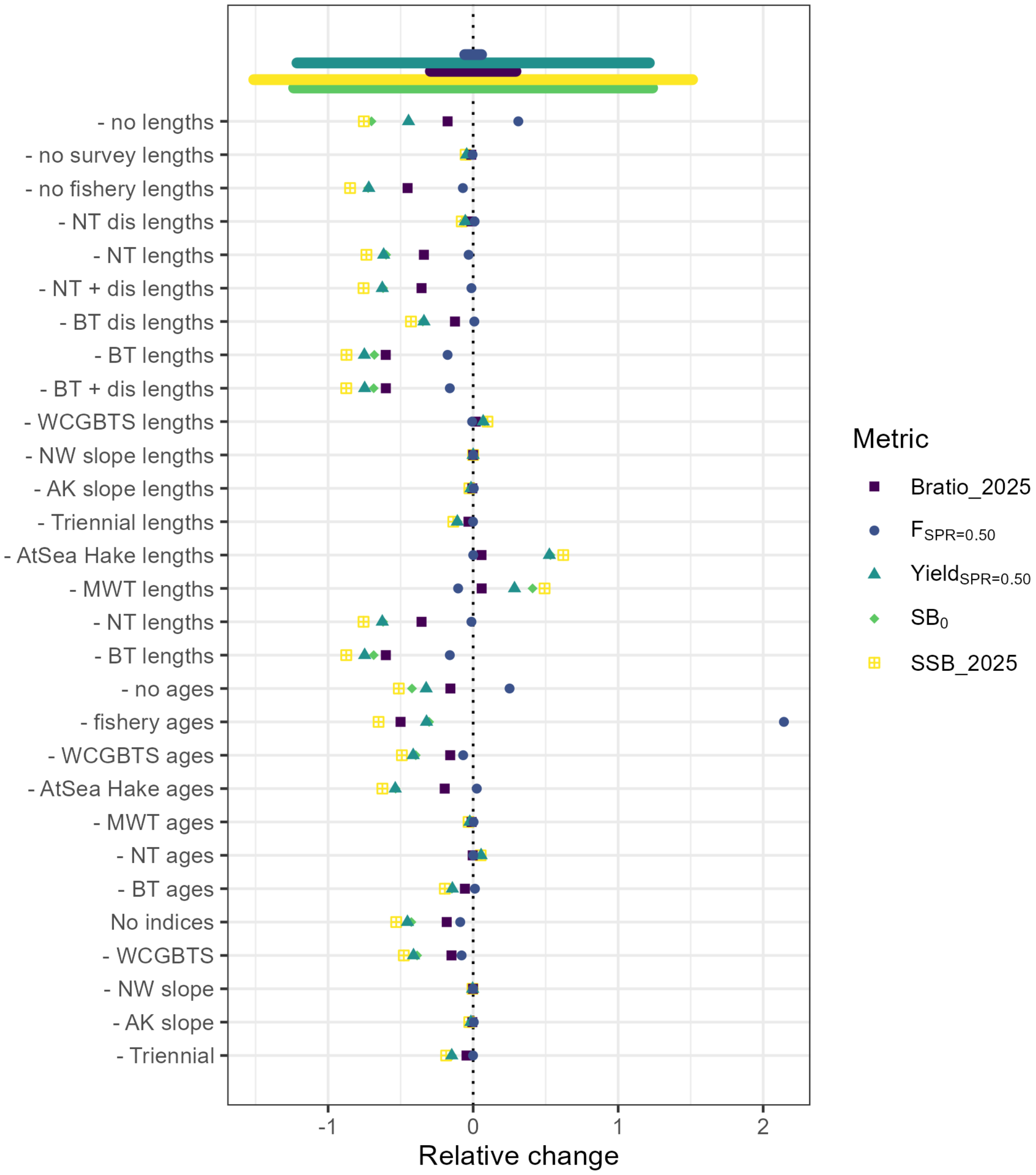

Figure 154: Relative change in management quantities across models conducted as sensitivities (removal of data sources).

8 Notes

9 Appendices