# Status of widow rockfish stock off the U.S. West Coast in 2025


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## Disclaimer

## Executive summary

### Stock

This is an update assessment of widow rockfish (*Sebastes entomelas*) that reside in the waters off California, Oregon, and Washington from the U.S.-Canada border in the north to the U.S.-Mexico border in the south. The most recent benchmark was conducted in 2015 (Hicks and Wetzel 2015) which was then updated in 2019 (Adams et al. 2019). This assessment represents the second update of the 2015 benchmark stock assessment. Widow rockfish inhabit water depths of 25–370 m from northern Baja California, Mexico to Southeastern Alaska. Although catches north of the U.S.-Canada border and south of the U.S.-Mexico border were not included in this assessment, it is not certain if those populations contribute to the biomass of widow rockfish off of the U.S. West Coast, possibly through adult migration and/or larval dispersion. Following the 2015 benchmark assessment (Hicks and Wetzel 2015), this update assessment is based on a single coastwide area model.

### Catches

Historically, fisheries have caught widow rockfish since the turn of the 20th century. Landings in the trawl fishery are estimated to have increased into the 1940s and remained relatively constant and small (below 1,000 mt per year) throughout the 1950s and into the 1960s before catches increased from a foreign trawl fleet in the 1970s, with a peak at almost 5,000 mt in 1967. Catches by a midwater trawl fleet increased rapidly in the late 1970s following the discovery that widow rockfish form large aggregations at night.

Total landings of widow rockfish peaked in the early 1980s, increasing from approximately 1,000 metric tons (mt) in 1978 to over 25,000 mt in 1981. The large landings in the early 1980s were curtailed with trip limits beginning in 1982, which resulted in a decline in landings throughout the 1980s and 1990s following sequential reductions in the trip limits. From 2000 to 2003, landings of widow rockfish dropped from over 4,000 mt to about 40 mt and remained low through 2016. Catches increased rapidly following the quota share reallocation in 2017, and have been near or above 10,000 mt in all years between 2018 and 2024. Midwater trawl gears in groundfish and Pacific hake/whiting (*Merluccius productus*, hereafter "hake") fisheries account for the majority of the recent catch.

Widow rockfish are a desirable market species and it is believed that discarding was low historically. However, management restrictions (e.g., trip limits) resulted in a substantial amount of discarding beginning in the early 1980s. Trawl rationalization was introduced in 2011. Between 2011 and 2024 very little discarding of widow rockfish is estimated to have occurred. Recent discards in the model informed by data from the West Coast Groundfish Observer Program (WCGOP), and total catches (discards plus landings) are reported in addition to landings. Landings for the past ten years are in Table i and for the entire time series in Figure i.

Table i: Recent landings for the bottom trawl, midwater trawl, at-sea hake, net, and hook-and-line fisheries and the total landings across fisheries and the total mortality (discards + landings) (mt). 100% mortality is assumed for discards and catch sources are described below.

| Year | Bottom Trawl | Midwater Trawl | At-Sea Hake | Net | Hook-and-line | Total Landings | Total Mortality |
|---|---|---|---|---|---|---|---|
| 2015 | 12.2 | 479.2 | 386.2 | 0.0 | 2.1 | 879.7 | 879.9 |
| 2016 | 9.6 | 588.0 | 440.8 | 0.0 | 1.0 | 1,039.4 | 1,039.6 |
| 2017 | 35.9 | 4,852.1 | 1,455.2 | 0.0 | 2.7 | 6,345.9 | 6,361.5 |
| 2018 | 35.9 | 9,374.3 | 1,081.3 | 0.0 | 1.6 | 10,493.2 | 10,522.9 |
| 2019 | 27.9 | 8,157.9 | 1,101.6 | 0.0 | 2.1 | 9,289.4 | 9,315.3 |
| 2020 | 73.6 | 7,532.2 | 746.7 | 0.0 | 2.7 | 8,355.2 | 8,379.6 |
| 2021 | 103.7 | 10,141.3 | 617.3 | 0.0 | 4.5 | 10,866.9 | 10,899.7 |
| 2022 | 126.8 | 10,839.8 | 1,119.0 | 0.1 | 8.8 | 12,094.4 | 12,129.7 |
| 2023 | 82.3 | 10,228.0 | 673.2 | 0.0 | 7.1 | 10,990.6 | 11,023.5 |
| 2024 | 27.6 | 9,160.8 | 533.8 | 0.0 | 12.9 | 9,735.1 | 9,764.1 |

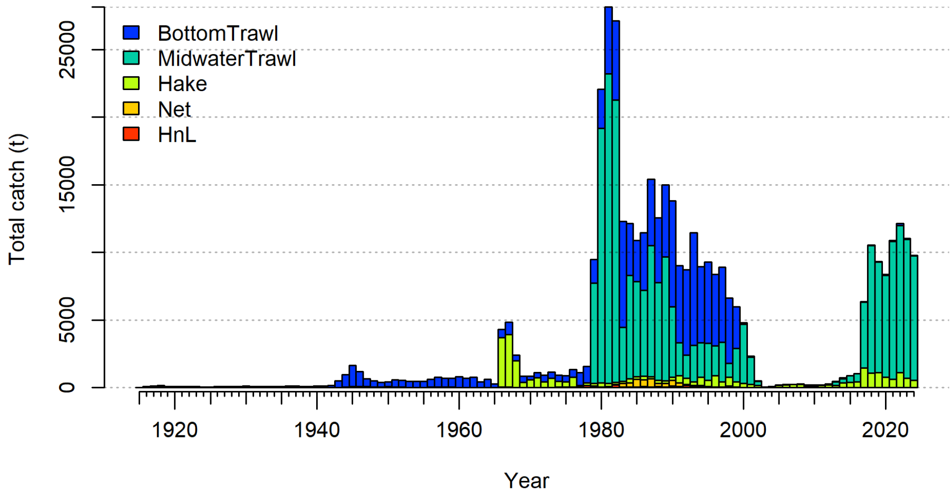



Figure i: Landings of widow rockfish from 1916 to 2024 for bottom trawl, midwater trawl, net, and hook-and-line fisheries, and catches of widow rockfish for the foreign (1966–1976) and Pacific Whiting (hake) fisheries (green).

#### Data and Assessment

This assessment uses the length- and age-structured modeling software Stock Synthesis (version 3.30.23.1). The coastwide population was modeled assuming separate growth and mortality parameters for males and females from 1916 to 2024.

The model includes catch, age, and length data for five fishing fleets: 1) a coastwide shore-based bottom trawl fleet (1916–2024), 2) a coastwide shore-based midwater trawl fleet (1979–2024), 3) a mostly midwater trawl fleet that targets hake and includes a foreign and at-sea fleet (1975–2024), a domestic shore-based fleet (1991–2024), and foreign vessels that targeted hake and rockfish between 1966–1976, 4) a net fishery consisting of catches mostly from California (1981–2024), and 5) a coastwide hook-and-line fishery (1916–2024). There are three older fishery-dependent CPUE indices retained from the 2015 benchmark: 1) Oregon bottom trawl (1984-1999), 2) at-sea foreign hake (1977-1988), and 3) at-sea domestic hake fleets (1983-1998).

The 2015 benchmark and 2019 update assessments estimated discards using retention curves for the bottom trawl, midwater trawl, and hook-and-line fleets based on discard biomass and length composition data from the WCGOP. Changes to the underlying discard length composition data for the hook-and-line fleet from WCGOP illustrated that very large recruitment events previously estimated for 2013 and 2014 were mainly driven by very small amounts of composition data for a minor fleet responsible for less than one-tenth of a percent of the catch in the last decade. With the updated data, this led to implausible population dynamics, so the decision was made to add discard biomass from the Groundfish Expanded Mortality Multi-Year (GEMM) to the landed catch for the hook-and-line fleet, rather than estimating retention. Retention is still estimated for the midwater and bottom trawl fleets, which have more data available.

Data from three fishery-independent surveys were also included in the model: 1) length composition and an index for the Alaska Fisheries Science Center/Northwest Fisheries Science Center West Coast Triennial Shelf Survey (Triennial Survey) were retained from the 2015 benchmark (1977–2004), 2) conditional age-at-length composition and an index for the Northwest Fisheries Science Center West Coast Groundfish Bottom Trawl Survey (WCGBTS) (2003-2024), and 3) a recruitment index from the National Marine Fisheries Service (NMFS) SWFSC and NWFSC/PWCC Midwater Trawl Survey (Juvenile Survey) (2004-2024).

The base model estimated parameters for length-based selectivity for all fleets and surveys, retention curves for the bottom trawl and midwater trawl fleets, a sex-specific length-at-age relationship, sex-specific natural mortality, and recruitment deviations. A Beverton-Holt stock-recruitment function was used to model productivity, and the steepness parameter was fixed at 0.72 based on a steepness meta-analysis (Thorson et al. 2019) for west coast rockfishes.

Natural mortality and steepness are major sources of uncertainty. We used high and low combinations of these parameters to define a range of states of nature, with results presented in a decision table.

#### Stock biomass and dynamics

The time series of estimated spawning biomass (SB) and relative SB is in Figure ii and Figure iii, respectively, and for the most recent year in Table ii. The SB declined rapidly with the developing domestic midwater fishery in the late 1970s and early 1980s, and remained low until 2000. A combination of strong recruitment and low catches resulted in a steady increase in SB through 2016. A target fishery for widow rockfish was reestablished in 2017. The stock exhibits a decline in most recent years with the increased catches since 2017.

The 2025 SB relative to unfished equilibrium SB is 55%, above the target of 40% (95% confidence interval of 36 - 74%).

SB is estimated to be at 46,934 mt in 2025 (95% confidence interval of 23,842 - 70,026 mt). The uncertainty in the estimated SB is high, especially in the early years.

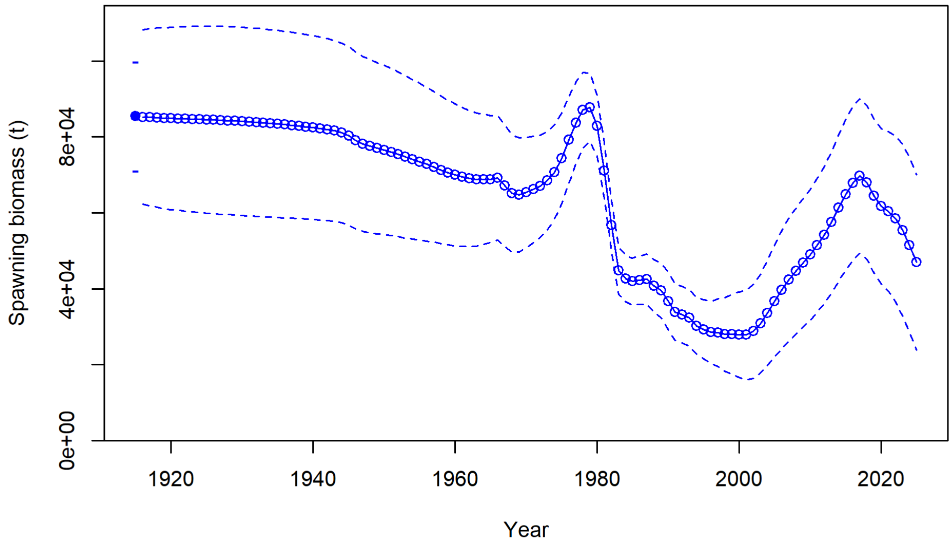



Figure ii: Estimated female SB time-series from the base model (solid line) with asymptotic 95% confidence interval (dashed lines).

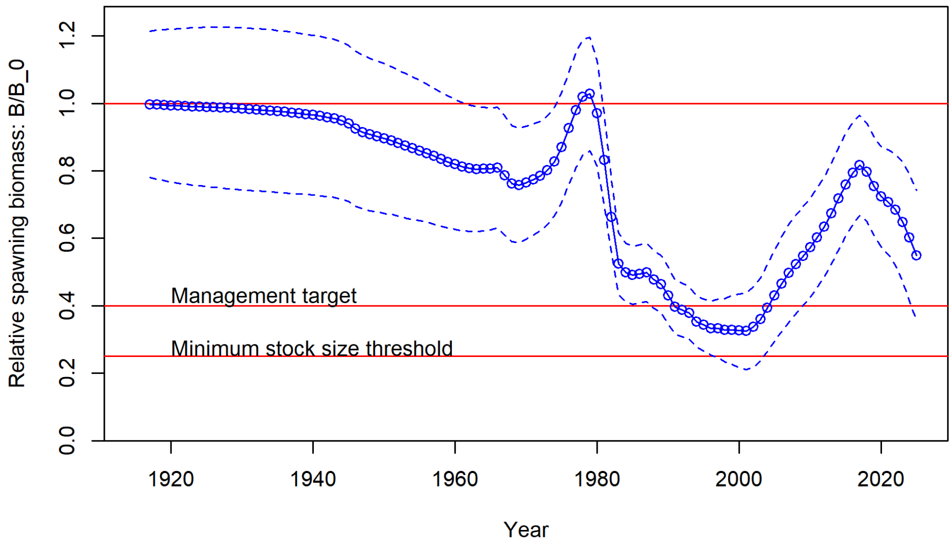



Figure iii: Estimated relative SB (depletion) with asymptotic 95% confidence interval (dashed lines) for the base case assessment model.

Table ii: Recent trend in estimated female SB (mt) and relative SB (depletion).

| Year | SB (mt) | Lower Interval (mt) | Upper Interval (mt) | Fraction Unfished | Lower Interval | Upper Interval |
|---|---|---|---|---|---|---|
| 2015 | 64,875 | 44,970 | 84,779 | 0.759 | 0.607 | 0.912 |
| 2016 | 67,860 | 47,551 | 88,170 | 0.794 | 0.642 | 0.946 |
| 2017 | 69,742 | 49,338 | 90,147 | 0.816 | 0.668 | 0.964 |
| 2018 | 68,048 | 47,780 | 88,316 | 0.796 | 0.651 | 0.942 |
| 2019 | 64,425 | 44,166 | 84,685 | 0.754 | 0.608 | 0.900 |
| 2020 | 61,799 | 41,325 | 82,272 | 0.723 | 0.574 | 0.872 |
| 2021 | 60,418 | 39,384 | 81,453 | 0.707 | 0.552 | 0.862 |
| 2022 | 58,448 | 36,576 | 80,319 | 0.684 | 0.519 | 0.849 |
| 2023 | 55,414 | 32,753 | 78,074 | 0.648 | 0.471 | 0.826 |
| 2024 | 51,498 | 28,406 | 74,590 | 0.603 | 0.416 | 0.790 |
| 2025 | 46,934 | 23,842 | 70,026 | 0.549 | 0.356 | 0.742 |

### Recruitment

Recruitment deviations were estimated for the entire time series modeled. There is little information regarding recruitment prior to 1965, and the uncertainty in these estimates is expressed in the model.

There are several very large, but uncertain, estimates of recruitment (in descending order of magnitude) in 1970, 2008, 2016, and 1971. The five lowest recruitment events (in ascending order) occurred in 2012, 2019, 2020, 2011, and 1976. Estimates of recruitment appear to be episodic and characterized by periods of low recruitment (Figure iv, Figure v).

The 2019 update assessment (Adams et al. 2019) estimated the largest recruitment on record in 2013, and above-average recruitment in 2014. With the more stable treatment of hook-and-line discards in this assessment, and the additional years of data, 2013 is now estimated as only the tenth-largest recruitment on record, and 2014 is estimated as below average.

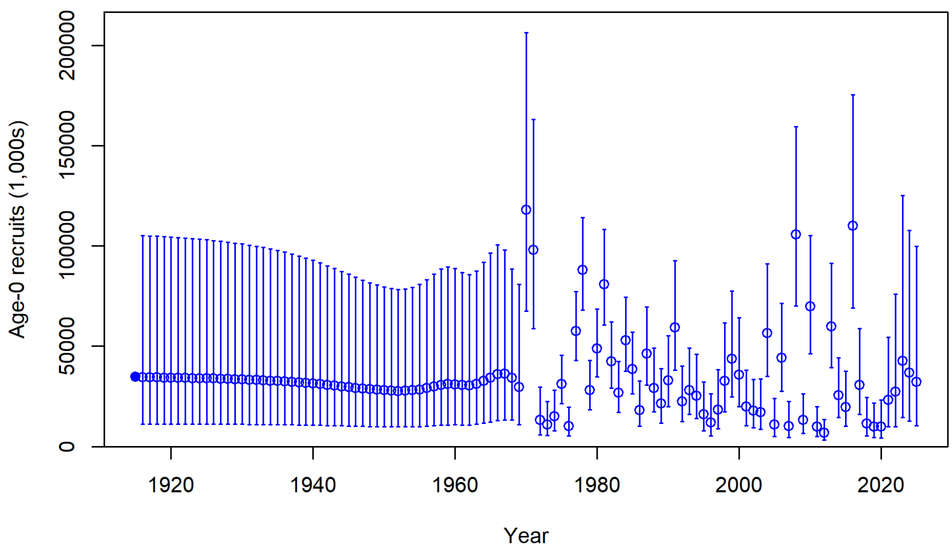



Figure iv: Time-series of estimated recruitments (medians as open circles) for the base case model with asymptotic 95% confidence interval (vertical bars). Estimated unfished equilibrium recruitment ($R_0$) is indicated with a filled circle.

Table iii: Recent estimated trend in widow rockfish recruitment with asymptotic 95% confidence intervals determined from the base model.

| Year | Recruitment (1,000s) | Lower Interval (1,000s) | Upper Interval (1,000s) | Recruitment Deviations | Lower Interval | Upper Interval |
|---|---|---|---|---|---|---|
| 2015 | 19,521 | 10,156 | 37,519 | -0.393 | -0.957 | 0.170 |
| 2016 | 109,956 | 68,979 | 175,276 | 1.330 | 1.044 | 1.616 |
| 2017 | 30,617 | 15,953 | 58,762 | 0.036 | -0.500 | 0.572 |
| 2018 | 11,426 | 5,316 | 24,558 | -0.965 | -1.641 | -0.289 |
| 2019 | 9,785 | 4,428 | 21,621 | -1.131 | -1.838 | -0.425 |
| 2020 | 9,810 | 4,170 | 23,078 | -1.141 | -1.931 | -0.352 |
| 2021 | 23,221 | 9,901 | 54,461 | -0.295 | -1.100 | 0.510 |
| 2022 | 27,255 | 9,772 | 76,019 | -0.148 | -1.191 | 0.894 |
| 2023 | 42,726 | 14,600 | 125,030 | 0.291 | -0.816 | 1.397 |
| 2024 | 36,829 | 12,590 | 107,733 | 0.135 | -0.969 | 1.238 |

### Exploitation status

The population declined throughout the 1980s and 1990s when fishing intensity was above the management target. The population then increased between 2000 and 2016 when fishing intensity was well below the management management target. Fishing intensity has increased substantially since 2017, and is estimated to have been above the management target since 2018, though the relative spawning output remains above the management target of 40%. Recent fishing intensities are in Table iv, and a full time series of relative spawning output and fishing intensity is in Figure v.

Table iv: Estimated recent trend in relative fishing intensity ((1-SPR)/(1-$SPR_{50\%}$)) and exploitation rate (as the proportion of age 4+ biomass) with asymptotic 95% confidence intervals for both quantities.

| Year | (1-SPR)/(1-SPR50%) | Lower Interval (SPR) | Upper Interval (SPR) | Exploitation Rate | Lower Interval (Rate) | Upper Interval (Rate) |
|---|---|---|---|---|---|---|
| 2015 | 0.140 | 0.091 | 0.189 | 0.007 | 0.005 | 0.009 |
| 2016 | 0.156 | 0.103 | 0.208 | 0.008 | 0.006 | 0.010 |
| 2017 | 0.713 | 0.533 | 0.893 | 0.047 | 0.033 | 0.061 |
| 2018 | 1.038 | 0.821 | 1.255 | 0.080 | 0.056 | 0.104 |
| 2019 | 1.016 | 0.789 | 1.242 | 0.077 | 0.053 | 0.101 |
| 2020 | 0.996 | 0.758 | 1.234 | 0.067 | 0.044 | 0.089 |
| 2021 | 1.158 | 0.903 | 1.412 | 0.088 | 0.057 | 0.119 |
| 2022 | 1.211 | 0.941 | 1.481 | 0.105 | 0.064 | 0.145 |
| 2023 | 1.179 | 0.883 | 1.475 | 0.106 | 0.061 | 0.150 |
| 2024 | 1.175 | 0.849 | 1.502 | 0.105 | 0.056 | 0.154 |

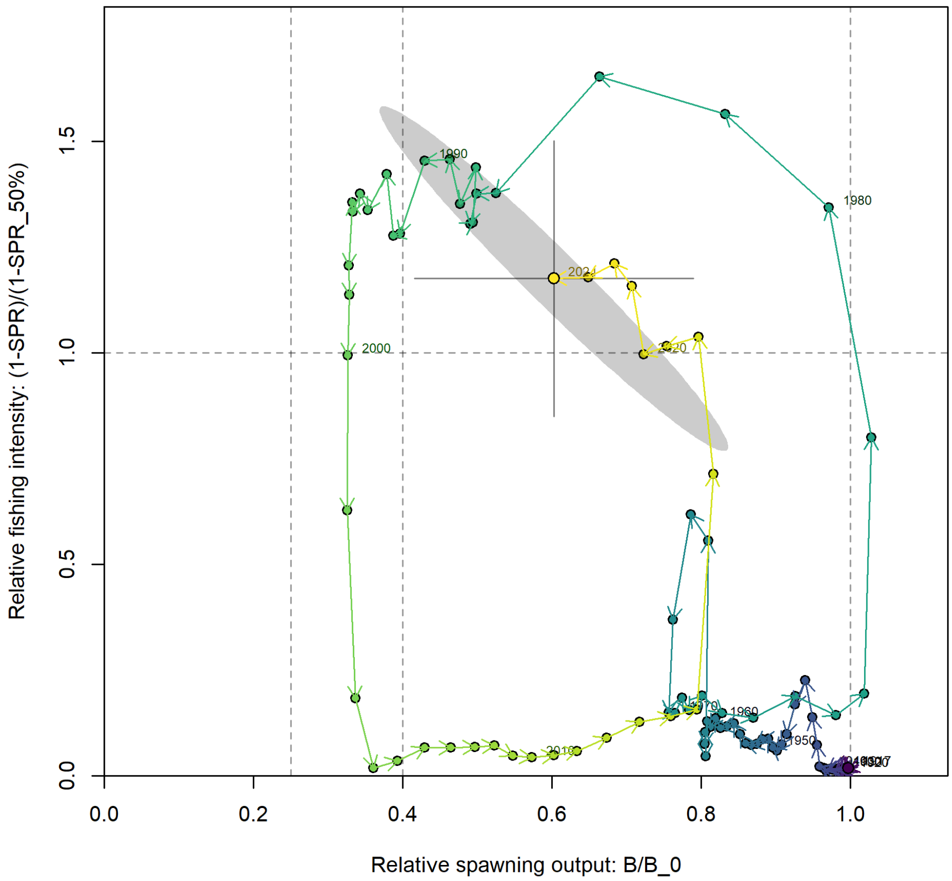



Figure v: Phase plot of fishing intensity ((1-SPR)/(1-$SPR_{50\%}$)) versus fraction unfished (spawning output, ($B/B_0$). Lines through the final point show marginal asymptotic 95% intervals for each dimension. The shaded ellipse is an approximate 95% confidence region which accounts for the estimated covariance between the two quantities.

### Ecosystem considerations

Recruitment is a key mechanism by which the ecosystem may directly impact the population dynamics of widow rockfish; however, the specific pathways through which environmental conditions exert influence on widow rockfish dynamics are unclear. Changes in the environment may result in changes in other population processes, as well. Unfortunately, there are few data available for widow rockfish that provide insights into these effects.

Fishing has effects on habitats, in addition to the population itself. Rockfish are often associated with habitats containing living structures such as sponges and corals which fishing may threaten. Recent studies on essential fish habitat are beginning to characterize important locations for rockfish throughout their life history; however there is little current information available to evaluate the specific effects of fishing on the ecosystem characteristics pertinent to the management of widow rockfish.

### Reference points

Reference points were calculated using the estimated selectivity parameters and average catch distribution among fleets in the most recent five years of the model (2019-2024). 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 (SPR) of 0.5, and 3) the model estimate of maximum sustainable yield (MSY), are all listed in Table v. The SPR is expected lifetime reproductive output under a given fishing intensity as a proportion of the unfished expected lifetime reproductive output.

While the estimate of population scale (total SB) has remained relatively steady across the 2015, 2019, and 2025 assessments, unfished recruitment ($R_0$) and natural mortality (M), which are positively correlated, have declined from 2015 (female M of 0.157 yr$^{-1}$) to 2019 (0.144 yr$^{-1}$) to 2025 (0.122 yr$^{-1}$). Thus, although the population scale is estimated consistently, additional years of data (in particular, age composition data) following the re-opening of the fishery have led the model to estimate that the population is less productive, which results in lower yields at all three reference points (proxy based on spawning output, proxy based on fishing intensity, and model estimate of MSY).

Table v: Summary of reference points and management quantities for the base case model.

| Reference Point | Estimate | Lower Interval | Upper Interval |
|---|---|---|---|
| Unfished Spawning Biomass (mt) | 85,460.9 | 71,025.0 | 99,896.8 |
| Unfished Age 4+ Biomass (mt) | 158,958.0 | 132,188.0 | 185,728.0 |
| Unfished Recruitment (R0) | 34,799.0 | 23,869.3 | 45,728.7 |
| 2025 Spawning Biomass (mt) | 46,934.0 | 23,842.5 | 70,025.5 |
| 2025 Fraction Unfished | 0.549 | 0.356 | 0.742 |
| **Reference Points Based SB40%** | | | |
| Proxy Spawning Biomass (mt) SB40% | 34,184.4 | 28,410.0 | 39,958.8 |
| SPR Resulting in SB40% | 0.458 | 0.458 | 0.458 |
| Exploitation Rate Resulting in SB40% | 0.086 | 0.078 | 0.094 |
| Yield with SPR Based On SB40% (mt) | 6,105.3 | 4,749.2 | 7,461.4 |
| **Reference Points Based on SPR Proxy for MSY** | | | |
| Proxy Spawning Biomass (mt) (SPR50) | 38,128.7 | 31,688.1 | 44,569.3 |
| SPR50 | 0.5 | | |
| Exploitation Rate Corresponding to SPR50 | 0.075 | 0.068 | 0.082 |
| Yield with SPR50 at SB SPR (mt) | 5,822.1 | 4,532.8 | 7,111.5 |
| **Reference Points Based on Estimated MSY Values** | | | |
| Spawning Biomass (mt) at MSY (SB MSY) | 22,681.2 | 18,897.0 | 26,465.4 |
| SPR MSY | 0.337 | 0.334 | 0.34 |
| Exploitation Rate Corresponding to SPR MSY | 0.13 | 0.117 | 0.142 |
| MSY (mt) | 6,526.0 | 5,062.2 | 7,989.8 |

#### Management performance

Since annual catch limits for widow rockfish increased in 2017 and new fishing opportunities for use of midwater trawl gear became available, attainment of the annual catch limit has been high (Table vi). Specifically, attainment of the annual catch limit (ACL) has exceeded 70% every year since 2018, averaged 77% from 2017-2024, and was as high as 88% in 2022.

Table vi: Recent trend in total catch and commercial landings (mt) relative to the management guidelines. Estimated total catch reflects the commercial landings plus the model estimated dead discarded biomass.

| Year | OFL (mt) | ABC (mt) | ACL (mt) | Landings (mt) | Total Mortality (mt) |
|---|---|---|---|---|---|
| 2015 | 4,137 | 3,929 | 2,000 | 880 | 880 |
| 2016 | 3,990 | 3,790 | 2,000 | 1,039 | 1,040 |
| 2017 | 14,130 | 13,508 | 13,508 | 6,346 | 6,362 |
| 2018 | 13,237 | 12,655 | 12,655 | 10,493 | 10,523 |
| 2019 | 12,375 | 11,830 | 11,831 | 9,289 | 9,315 |
| 2020 | 11,714 | 11,199 | 11,199 | 8,355 | 8,380 |
| 2021 | 15,749 | 14,725 | 14,725 | 10,867 | 10,900 |
| 2022 | 14,826 | 13,788 | 13,788 | 12,094 | 12,130 |
| 2023 | 13,633 | 12,624 | 12,624 | 10,991 | 11,024 |
| 2024 | 12,453 | 11,482 | 11,482 | 9,735 | 9,764 |

#### Harvest projections and decision table

Uncertainty in both natural mortality (estimated for both sexes) and steepness (not estimated in the model) contributed greatly to uncertainty in the results. A combination of these two factors was used as the axis of uncertainty to define low and high states of nature. This differed from the 2019 assessment which included a third factor, 2013 recruitment strength. The 2013 year class is no longer a major source of uncertainty, and there is no recent similarly large estimate of recruitment. The 12.5% and 87.5% quantiles for female and male natural mortality (independently) were chosen as low and high values (0.113 $yr^{-1}$ and 0.131 $yr^{-1}$ for females; 0.126 $yr^{-1}$ and 0.144 $yr^{-1}$ for males). Steepness was fixed in the base model and is not incorporated in the estimation uncertainty. The 12.5% and 87.5% quantiles from the steepness prior (without widow rockfish data) were used to define the low and high values of steepness (0.536 and 0.904). The low combination of these two factors defined the low state of nature and the high combination of these two factors defined the high state of nature. The predictions of SB in 2025 from the low and high states of nature are close to the 12.5% and 87.5% quantiles from the base model.

A twelve year projection of the base model with two catch streams based on ACL = Acceptable Biological Catch (ABC) based on adjustments of P* = 0.45 and P* = 0.40 were conducted (Table viii).

Projections with catches based on the predicted ACL using the SPR rate of 50%, the 40:10 control rule, and a 0.45 P* adjustment using a sigma of 0.50 in 2027 suggest the SB (Table viii) is likely to initially decrease under all states of nature before partially rebounding under the base case and high state of nature. Predicted ACL catches range from 4,238 mt in `ctch_rng$yr[ctch_rng$stat == "min" & ctch_rng$scenario == "P*0.45"]` to 5,360 mt in `ctch_rng$yr[ctch_rng$stat == "max" & ctch_rng$scenario == "P*0.45"]`.

Projections with catches based on the predicted ACL using the SPR rate of 50%, the 40:10 control rule, and a 0.40 P* adjustment using a sigma of 0.50 from 2027 onward suggest that the SB is likely to initially decrease under all states of nature before partially rebounding under the base case and high state of nature. Predicted ACL catches range from 3,957 mt in `ctch_rng$yr[ctch_rng$stat == "min" & ctch_rng$scenario == "P*0.40"]` to 4,973 mt in `ctch_rng$yr[ctch_rng$stat == "max" & ctch_rng$scenario == "P*0.40"]`.

Table vii: Potential overfishing limit (OFL) (mt), ABC (mt), ACL (mt), the buffer between the OFL and ABC, estimated SB (mt), and fraction of unfished SB with adopted OFL and ACL and assumed catch for the first two years of the projection period. The predicted OFL is the calculated total catch determined by FSPR=50%.

| Year | Adopted OFL (mt) | Adopted ACL (mt) | Assumed Catch (mt) | OFL (mt) | Buffer | ABC (mt) | ACL (mt) | SB (mt) | Fraction Unfished |
|---|---|---|---|---|---|---|---|---|---|
| 2025 | 12,254 | 11,237 | 10,669 | - | - | - | - | 46,934 | 0.549 |
| 2026 | 11,382 | 10,392 | 9,824 | - | - | - | - | 41,475 | 0.485 |
| 2027 | - | - | - | 4,533 | 0.935 | 4,238 | 4,238 | 36,918 | 0.432 |
| 2028 | - | - | - | 4,676 | 0.93 | 4,349 | 4,349 | 36,217 | 0.424 |
| 2029 | - | - | - | 5,051 | 0.926 | 4,677 | 4,677 | 36,388 | 0.426 |
| 2030 | - | - | - | 5,428 | 0.922 | 5,004 | 5,004 | 36,993 | 0.433 |
| 2031 | - | - | - | 5,685 | 0.917 | 5,213 | 5,213 | 37,635 | 0.440 |
| 2032 | - | - | - | 5,826 | 0.913 | 5,320 | 5,320 | 38,143 | 0.446 |
| 2033 | - | - | - | 5,895 | 0.909 | 5,359 | 5,359 | 38,507 | 0.451 |
| 2034 | - | - | - | 5,929 | 0.904 | 5,360 | 5,360 | 38,773 | 0.454 |
| 2035 | - | - | - | 5,950 | 0.9 | 5,355 | 5,355 | 38,990 | 0.456 |
| 2036 | - | - | - | 5,968 | 0.896 | 5,347 | 5,347 | 39,183 | 0.458 |

Table viii: Summary table of 12-year projections beginning in 2025 for alternate states of nature based on the axis of uncertainty (a combination of M, h). Columns range over low, mid, and high state of nature, and rows range over different assumptions of total catch levels (discards + retained). Catches in 2025 and 2026 are allocated using the percentage of landings for each fleet in 2019-2024.

| | | | State of nature | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Low | | Base | | High | |
| **Management decision** | Year | catch (mt) | SB (mt) | Depletion (%) | SB (mt) | Depletion (%) | SB (mt) | Depletion (%) |
| | 2025 | 10,669 | 34,412 | 37.5 | 46,934 | 54.9 | 55,743 | 65.7 |
| ACLp*=0.40, | 2026 | 9,824 | 29,166 | 31.8 | 41,475 | 48.5 | 49,924 | 58.8 |
| sigma=0.50 | 2027 | 3,957 | 24,814 | 27.0 | 36,918 | 43.2 | 45,052 | 53.1 |
| | 2028 | 4,059 | 24,414 | 26.6 | 36,362 | 42.5 | 44,260 | 52.2 |
| | 2029 | 4,360 | 24,786 | 27.0 | 36,674 | 42.9 | 44,428 | 52.3 |
| | 2030 | 4,659 | 25,472 | 27.7 | 37,429 | 43.8 | 45,123 | 53.2 |
| | 2031 | 4,852 | 26,079 | 28.4 | 38,235 | 44.7 | 45,935 | 54.1 |
| | 2032 | 4,943 | 26,440 | 28.8 | 38,912 | 45.5 | 46,675 | 55.0 |
| | 2033 | 4,971 | 26,563 | 28.9 | 39,448 | 46.2 | 47,318 | 55.8 |
| | 2034 | 4,973 | 26,524 | 28.9 | 39,883 | 46.7 | 47,891 | 56.4 |
| | 2035 | 4,956 | 26,405 | 28.8 | 40,260 | 47.1 | 48,417 | 57.0 |
| | 2036 | 4,937 | 26,271 | 28.6 | 40,611 | 47.5 | 48,913 | 57.6 |
| | 2025 | 10,669 | 34,412 | 37.5 | 46,934 | 54.9 | 55,743 | 65.7 |
| ACLp*=0.45, | 2026 | 9,824 | 29,166 | 31.8 | 41,475 | 48.5 | 49,924 | 58.8 |
| sigma=0.50 | 2027 | 4,238 | 24,814 | 27.0 | 36,918 | 43.2 | 45,052 | 53.1 |
| | 2028 | 4,349 | 24,269 | 26.4 | 36,218 | 42.4 | 44,117 | 52.0 |
| | 2029 | 4,677 | 24,497 | 26.7 | 36,389 | 42.6 | 44,146 | 52.0 |
| | 2030 | 5,004 | 25,028 | 27.3 | 36,994 | 43.3 | 44,694 | 52.7 |
| | 2031 | 5,213 | 25,462 | 27.7 | 37,636 | 44.0 | 45,350 | 53.4 |
| | 2032 | 5,320 | 25,642 | 27.9 | 38,144 | 44.6 | 45,928 | 54.1 |
| | 2033 | 5,359 | 25,577 | 27.9 | 38,508 | 45.1 | 46,410 | 54.7 |

| | | | State of nature | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Low | | Base | | High | |
| **Management decision** | Year | catch (mt) | SB (mt) | Depletion (%) | SB (mt) | Depletion (%) | SB (mt) | Depletion (%) |
| | 2034 | 5,360 | 25,350 | 27.6 | 38,774 | 45.4 | 46,826 | 55.2 |
| | 2035 | 5,355 | 25,046 | 27.3 | 38,990 | 45.6 | 47,207 | 55.6 |
| | 2036 | 5,348 | 24,723 | 26.9 | 39,183 | 45.8 | 47,564 | 56.0 |

### Scientific uncertainty

The model estimate of the log-scale standard deviation of the OFL in 2025 is 0.287. This is less than the default SSC value of 0.5 for a category 1 assessment, so harvest projections assume an initial sigma of 0.5.

### Unresolved problems and major uncertainties

Major sources of uncertainty include landings, discards, natural mortality, and recruitment, which are discussed below.

Because widow rockfish is a marketable species, historical discard rates were likely lower than less desirable or smaller species. This assessment assumed that discarding was nearly negligible before management restrictions began in 1982. Once trip limits were introduced, discarding tended to be an all or none event; rare, but large, discard events are unlikely to have been detected given low observer coverage. From 2002 onward, the WCGOP has provided data on discards from vessels that were randomly selected for observer coverage, thus some uncertainty is present in the total amount discarded. The implementation of trawl rationalization in 2011 resulted in almost 100% observer coverage for the trawl fleet and very little incentive to discard widow rockfish. The open access fixed-gear fleet is not monitored by the full observer coverage required under trawl rationalization. Discard mortality is assumed to be 100%, which may overestimate actual mortality (Jarvis & Lowe, 2007), but given the low number of discards, is likely to have a minimal effect on assessment results.

There may also be uncertainty in the ability of bottom trawl surveys to reliably estimate abundances of widow rockfish, which spend a significant portion of their time in mid-water (Wilkins 1986). Multiple surveys are used in the assessment, but further consideration of additional surveys is reasonable.

This assessment attempts to capture uncertainty in M by estimating it inside the model (thereby propagating uncertainty in M into uncertainty in SB and other derived quantities), and by incorporating variation in M in a decision table. Model sensitivities and profiles over M showed that current stock status was highly sensitive to the assumption about natural mortality.

Widow rockfish is a relatively long-lived fish, and their natural mortality (M) is likely to be lower than many managed fish stocks (e.g., gadoids). Ages above 50 years have been observed and it is expected that natural mortality could be less than 0.10 $yr^{-1}$ (the median of the prior for natural mortality used in this assessment). However, even with length and age data available back to the late 1970s, M was estimated at 0.122 for females and 0.135 $yr^{-1}$ for males, with a small amount of uncertainty (e.g., a 6.4% coefficient of variation for females).

Notably, the estimated M for both sexes from this assessment are lower than those from the 2015 and 2019 assessments, for which natural mortality was estimated above 0.15 $yr^{-1}$ and

0.14 $yr^{-1}$, respectively. The estimates of M varied slightly depending on the weight given to age and length data, or removing recent years of data, but M was always estimated above 0.12 $yr^{-1}$. The likelihood profile over natural mortality provides support for values up to or above 0.14 $yr^{-1}$, but with greater curvature than in the 2019 assessment, suggesting additional data has reduced the support for higher natural mortality values. A contributing factor to this change may be the increased mean age and frequency of older fish in catch observed by the WCGBTS survey in recent years. The successful rebounding of the stock as a result of reduced fishing pressure from 2003-2016 may have allowed year classes to age and become fully observed by WCGBTS. However, consideration should be given in future assessments to structural changes which may improve the fits to WCGBTS CAAL data, which are poor in some years.

Steepness was fixed at 0.720 in the base model, but a likelihood profile showed that it would be estimated at a value less than that. Estimates of M increased with lower steepness, while unfished SB increased and current SB decreased. Sustainable yields at the $SPR_{50\%}$ reference harvest rate ranged from approximately 2641 to 5992 mt depending on the value of steepness.

### Research and Data Needs

- **Natural mortality:** Uncertainty in natural mortality translates into uncertain estimates of status and sustainable fishing levels for widow rockfish. The collection of additional age data, re-reading of older age samples, reading old age samples that are unread, and improved understanding of the life-history of widow rockfish may reduce that uncertainty. Investigating the ageing error and bias would help to understand the influences that the age data have on this assessment, particularly the influence of age data on natural mortality.
- **Historical landings and discards:** Although progress has been made in reconstructing historical catches of rockfish on the U.S. West Coast, historical landings and discards continue to be uncertain for widow rockfish and improvements would increase the certainty that fishing removals are applied appropriately. Because landings are assumed to be known exactly in the assessment model, uncertainty in the predictions does not include uncertainty in the landings. A thorough look at historical landings, species compositions, and discarding practices would reduce the potential uncertainty that is not entirely accounted for. In addition, discard composition data have become available for the midwater trawl fleet in recent years and should be included in future assessments.
- **Sex-specific selectivity:** The midwater and bottom trawl length-composition data fits showed divergent residual patterns between male and female fish. The underlying mechanism driving this pattern is unclear, and could be related to growth, sexing error, or to sex-specific selectivity (e.g., when widow rockfish aggregate, sexes possibly may be aggregating separately). Sex-specific selectivity for these two fleets could be explored or included to address this.

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

# 1 Introduction

This is an assessment of widow rockfish that inhabit the waters off California, Oregon, and Washington from the U.S.-Canadian border in the north to the U.S.-Mexico border in the south, and does not include Puget Sound.

*Sebastes entomelas* (widow rockfish) is named after its black-lined gut cavity (*ento* meaning within and *melas* meaning black). It has been referred to as buda, beccafico (Italian bird), and viuva (widow) prior to the 1930s. More recently, the widow rockfish is also called brownie, belinda bass, brown bomber, and soft brown.

## 1.1 Distribution and Stock Structure

Widow rockfish inhabit water depths of 25–370 m from northern Baja California, Mexico to Southeastern Alaska, and are most abundant from British Columbia to Northern California. Although catches north of the U.S.-Canada border or south of the U.S.-Mexico border were not included in this assessment, it is possible that these populations contribute to the biomass of widow rockfish off of the U.S. West Coast through adult migration and/or larval dispersion.

This assessment is based on a single coastwide area model. There is little evidence of genetically separate stocks along the U.S. coast and past assessments have used a single area versus a two-area assessment model and results were found to be similar (He et al. 2011). There is some evidence of biological differences between areas. For example, widow rockfish collected off California tend to mature at a smaller length than widow rockfish collected off of Oregon (Barss and Echeverria 1987). This could be due to environmental or anthropogenic effects rather than genetic differences.

## 1.2 Life History

This section is not required for an update assessment; please refer to the most recent benchmark assessment (Hicks and Wetzel 2015) for information.

## 1.3 Ecosystem Considerations

This section is not required for an update assessment; please refer to the most recent benchmark assessment (Hicks and Wetzel 2015) for information.

### 1.4 Fishery description

This section is not required for an update assessment; please refer to the most recent benchmark assessment (Hicks and Wetzel 2015) for information.

### 1.5 Management History

Management history prior to 2015 is detailed in the most recent benchmark assessment (Hicks and Wetzel 2015). In 2017, the NMFS implemented a quota share (QS) reallocation rule, which re-established a target fishery for widow rockfish by allocating quotas among permit holders based on historical allocations, removing daily vessel limits, and allowing the trading of QS (NMFS 2017).

### 1.6 Management performance

Total mortality estimates from the WCGOP and from the stock assessment might differ due to the use of different methods. Investigation into how these methods differ is beyond the scope of an update assessment. Table 3 shows that recent landings have been below recommended catch levels. Landings are a considerable amount below the ACL, and it is unlikely that total mortality has exceeded the ACL in the last 10 years.

### 1.7 Fisheries off Canada and Alaska

This section is not required for an update assessment; please refer to the most recent benchmark assessment (Hicks and Wetzel 2015) for information.

# 2 Data

Many sources of data were available for this assessment (Figure 27), including indices of abundance, landings, discards, and length and age observations from fishery-dependent and fishery-independent sources. Data used in this assessment are described below. No new data sources were considered in this update assessment.

## 2.1 Fishery-independent data

Data from three fishery-independent surveys were used in this assessment: 1) the SWFSC and NWFSC/PWCC Midwater Trawl Survey (hereafter, "juvenile survey"); 2) the Alaska Fisheries Science Center (AFSC)/NWFSC Triennial Shelf Trawl Survey (hereafter, "triennial survey"); and 3) the NWFSC West Coast Groundfish Bottom Trawl Survey (hereafter, "WCGBTS"). Depth and latitude strata used to analyze the catch-rates, length compositions, and age compositions are the same as in the 2019 update assessment (Adams et al. 2019) and shown in Table 10.

### 2.1.1 Alaska Fisheries Science Center/Northwest Fisheries Science Center West Coast Triennial Shelf Survey

The Alaska Fisheries Science Center/Northwest Fisheries Science Center West Coast Triennial Shelf Survey (Triennial Survey) was first conducted by the Alaska Fisheries Science Center (AFSC) in 1977 and was conducted every three years, ending 2004. The survey's design and sampling methods are most recently described in (Weinberg et al. 2002).

The time series suggests a possible slightly increasing trend in biomass from 1980–1983, although is relatively flat until the end of the period in 2001 and 2004 when the index declines significantly. The index and length compositions for this historical Triennial survey were unchanged from the previous assessment. Please refer to the most recent benchmark assessment (Hicks and Wetzel 2015) and most recent update assessment (Adams et al. 2019) for details on those data inputs.

### 2.1.2 Northwest Fisheries Science Center West Coast Groundfish Bottom Trawl Survey

The Northwest Fisheries Science Center West Coast Groundfish Bottom Trawl Survey (WCG-BTS) has been conducted annually, since 2003. It is based on a random-grid design; covering the coastal waters between depths of 55–1,280 m (Bradburn et al. 2011). No survey occurred in 2020 due to Coronavirus pandemic (COVID-19). Widow rockfish are not commonly caught in the WCGBTS. Higher catch rates occur north of 40° N latitude and catches are rare south of 36° N latitude. Few large fish are found shallower than 100 m and few small fish are found in the deeper water of the slope. There is no clear trend in length with latitude other than smaller fish tend to occur south of approximately 36° N latitude, and there appears to be some very small fish found near 39° N latitude.

For this assessment, geostatistical models of biomass density were fit to survey data using the R package Species Distribution Models with Template Model Builder (`sdmTMB`) (Anderson et al. 2022). This is an updated approach compared to the 2015 benchmark assessment (non-spatial delta-GLMM) and the 2019 update assessment (VAST delta-lognormal model). The `sdmTMB` model used a 200 knot mesh of the survey area (Thorson et al. 2015). The prediction grid was truncated to only include available survey locations in depths between 55–500 m to limit extrapolating beyond the data and edge effects. Tweedie, delta-binomial, delta-gamma, and mixture distributions, which allow for extreme catch events, were investigated. The positive catch weight model includes survey pass ('first' for early season or 'second' for late season) and year. Vessel-year effects, which have traditionally been included in index standardization for this survey, were not included as the estimated variance for the random effect was close to zero. Vessel-year effects were more prominent when models did not include spatial effects and were included for each unique combination of vessel and year in the data to account for the random selection of commercial vessels used during sampling (Helser et al. 2004; Thorson and Ward 2014).

Results are shown for the delta-gamma and delta-lognormal distributions, which reported the best diagnostics among the explored models (Figure 2). Both models converged (positive definite Hessian matrix) but predicted data from both models showed slightly right-heavy tails compared to the assumed likelihoods, with the gamma model having stronger divergence. Spatiotemporal estimates of biomass from the delta-lognormal model were then converted into annual indices using sdmtmb::get_index() function by integrating across the spatial domain of the survey (Anderson et al. 2022).

Overall, the delta-lognormal index estimates is more comparable to the 2019 spatiotemporal VAST-based index than the delta-gamma index, and less influenced by extreme catch events, particularly in 2013 and 2016; for these reasons, in addition to better model performance observed above, the delta-lognormal sdmTMB-based index was used for the base model in this assessment. The delta-lognormal mean value (2262.824) was slightly lower than the means of the index values used in the 2015 benchmark assessment (2701.12) and the 2019 update assessment (3301.765). However, since these are used as relative indices, these differences in mean values have no impact in themselves on the outcome of the assessment. Comparisons of the different error structures, design-based estimate and the VAST index used in 2019 are in Figure 3.

Length, age, and conditional age-at-length compositions were processed using the nwfscSurvey package in R publicly available on GitHub (Wetzel et al. 2025). Length compositions were created by expanding to the tow and summing to give a strata specific composition Table 7.

Strata definition was retained from the benchmark assessment. The strata compositions were combined to a coastwide composition using a design-based index of abundance from each stratum. The design based index is constructed by taking the average catch per unit effort (CPUE) defined as catch per area swept across tows in each stratum and year. The sum of strata specific composition data was then calculated, weighting by the average CPUE per stratum multiplied by the area of each stratum. Age distributions were included in the model as conditional-age-at-length (CAAL) observations. The marginal age-compositions were also included, but only for easier viewing of strong cohorts. The CAAL data were not expanded and were binned according to length, age, sex, and year.

The input sample sizes for length and marginal age-composition data were calculated based on (Stewart and Hamel 2014). The input sample size of CAAL data was set at the number of fish at each length by sex and by year. Expanded length frequencies from this survey show intermittent years of small fish; the 2018–2024 period generally suggests most fish are around 40–45cm in length (Figure 4). Strong cohorts are not immediately apparent and it seems that ageing error may result in some variability between years. Conditional age-at-length proportions (Figure 5) show relatively consistent length-at-age with few outliers.

#### 2.1.3 SWFSC and NWFSC/PWCC Midwater Trawl Survey

An updated coastwide pre-recruit index of abundance for 2001-2024 for widow rockfish was created using data from three midwater trawl surveys targeting young-of-the-year (YOY) rockfish (Juvenile Survey), provided by Tanya Rogers (SWFSC, pers. comm.). All surveys used identical gear, enabling the construction of a consistent coastwide index spanning from 36°N to the U.S./Canada border since 2004. Sampling in 2020 was limited due to the COVID-19 pandemic and excluded from all models. In 2010 and 2012, coverage was incomplete, so these years excluded from the final model to align with the 2019 assessment. Following the 2015 and 2019 assessments, data from 2001–2003 were also excluded due to limited spatial coverage (36°30  to 38°20  N latitude).

The index was built using a spatial GLM with the sdmTMB package (Anderson et al. 2022), modeling 100-day standardized catch-per-tow as a function of year (fixed effect), Julian date (GAM smoother, k = 4), spatial random field, and spatiotemporal random effects. Models with Tweedie, delta-lognormal, and delta-gamma error structures were compared; DHARMa residuals and simulation-based diagnostics indicated the Tweedie model performed best. The index shows a moderately strong increasing trend in juvenile abundance from 2017 to 2023, with a slight decline in 2024 (Figure 36). Recent values remain high relative to the previous decade, and uncertainty estimates support the robustness of this trend.

## 2.2 Fishery-dependent data

### 2.2.1 Landings

Widow rockfish is primarily caught by bottom trawl and midwater trawl gears (Table 1). This species also commonly bycaught by fishery targeting Pacific hake/whiting (*Merluccius productus*, hereafter "hake"). Minimal amounts are also taken by non-trawl gears such as hook-and-line and net (Table 9).

The definitions of fishing fleets have not been changed from those in the 2015 and 2019 assessments. Five fishing fleets were specified within the model: 1) a shorebased bottom trawl fleet with coastwide catches from 1916–2024, 2) a shorebased midwater trawl fleet with coastwide catches from 1979–2024, 3) a mostly midwater trawl fleet that targets hake and includes a foreign and at-sea fleet with catches from 1975–2024, a domestic shorebased fleet that targeted Pacific Hake with catches from 1991–2024, and foreign vessels that targeted Pacific Hake and rockfish between 1966–1976, 4) a net fishery consisting of catches mostly from California from 1981–2024, and 5) a hook-and-line fishery (predominantly longline) with coastwide catches from 1916–2024. As in previous assessments, catches from Puget Sound and those from commercial shrimp trawls, commercial pots, and recreational fisheries were excluded (as these are generally minimal).

Landings from the 1916-2018 period were carried forward into this assessment with slight modifications to the midwater and bottom trawl catches from California. Because PacFIN appears to underestimate midwater trawl catches in California in 1979-1980 when midwater trawl fishery for widow rockfish developed (Edward Dick, Pers. Comms.) we adjusted midwater and bottom trawl catches from California in these years to reflect the ratio of California midwater to bottom trawl catches in 1981-1982.

Recent catches (2019-onward) were extracted from PacFIN for commercial shorebased data and NORPAC for at-sea hake fishery bycatch, and were otherwise appended onto the 1916-2018 landings and apportioned among fleets using the same criteria as those documented in the 2015 benchmark assessment Hicks and Wetzel (2015).

### 2.2.2 Fishery catch-per-unit-effort

Three fishery-dependent CPUE indices were included as in the most recent update assessment (Adams et al. 2019). Indices were derived from 1) Oregon bottom trawl (1984-1999), 2) hake at-sea foreign (1977-1988), and 3) hake at-sea domestic fleets (1983-1998). These were not updated; please refer to the most recent benchmark assessment (Hicks and Wetzel 2015) and most recent update assessment (Adams et al. 2019) for information.

#### 2.2.3 Fishery length and age data

Biological data from commercial fisheries that caught widow rockfish were extracted from PacFIN on March 25, 2025 and from the NORPAC database on February 3, 2025. Lengths and age samples taken during port sampling in California, Oregon, and Washington were used to generate length and age compositions. The data were classified into bottom trawl, midwater trawl, hake trawl, net, and hook-and-line fleets. For each fleet, the raw observations were expanded to the trip level, to account for differences in samples sizes relative to 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 widow rockfish landings among states combined into a single fleet (second stage expansion).

Table 4 shows the number of trips sampled and Table 5 shows the number of lengths taken for each year, gear, and fleet for non-hake fleets from the three states. Table 6 shows these numbers for the shoreside and at-sea hake fisheries. Expanded length compositions for bottom trawl, midwater trawl, hake, net, and hook-and-line fleets are shown in Figure 6 to Figure 10. Age compositions for the five fleets are shown in Figure 11 and Figure 15. Occasional cohorts appear to move through the population, indicating that widow rockfish population dynamics may be characterized by episodic recruitment events.

#### 2.2.4 Discards

Data on discards of widow rockfish are available from three different sources. Historical sources included Pikitch et al. (1988) and Enhanced Data Collection Project (EDCP, Sampson and Lee (2002)). These historical sources were not reanalyzed for this update assessment, and discard amounts were not changed from the last assessment. Sex-specific length frequencies were also available from Pikitch et al. (1988). Length compositions for discards show a wide range of sizes being discarded, with a peak around 40 cm (Figure 16).

The West Coast Groundfish Observer Program (WCGOP) provided information on recent discard of widow rockfish between 2002–2023. Since 2011, under trawl rationalization, 100% observer coverage is required for the limited entry trawl sectors, which resulted in a large increase in data and ability to determine discard behavior. Discard estimates are shown in Table 9 and range from 0 to 3,353.3 mt.

Discard length data for 2004-2023 was provided by WCGOP. In line with the 2015 and 2019 assessments, these data were used to estimate retention curves for bottom trawl and hook-and-like fleets. WCGOP discard lengths for the bottom trawl fleet from 2004-2017 are unchanged from the 2019 assessment, and new data were added for 2018-2023.

Major changes occurred only in the treatment of the hook-and-line discard data. Previous assessments in 2015 and 2019 erroneously combined WCGOP length composition data for the hook-and-line fleet with data from nearshore fixed gear fleets (pot, net).The current assessment omitted these nearshore fixed gear data from the hook-and-line data in the model. This change resulted in changes to the discard length distribution and years for which data was available (Figure 17). The hook-and-line removals comprised only approximately 0.2% of the total removals over the last twenty years (Table 1), with discard being a small fraction of that. The biological samples of the discard amount are also scarce, with input sample sizes not exceeding 6 and averaging around 3 per year. With this limited data, the model was unable to reliably estimate retention parameters and exhibited substantial sensitivity to even slight changes in discard amounts within the hook-and-line fleet. Therefore, in this assessment, we added the hook-and-line discard amounts to hook-and-line landings.

The commencement of trawl rationalization in 2011 led to 100% observer coverage for the bottom and midwater trawl fleets. As a result, coefficients of variation (CV) were fixed at 5% for observed discards. For years preceding this, CV were fixed at values used in the 2015 benchmark assessment Table 9. Length compositions of the discards for the bottom trawl fleet can be seen in Figure 18.

Discard length composition data became available this year for the midwater trawl fleet, but was not available for previous assessments. These newly available data for midwater trawl fleets (hake, rockfish) beginning in 2016, were not included in this updated assessment as this would require major changes to the model structure which are beyond the scope of this update assessment but will need to be considered in the next full assessment.

#### 2.2.5 Biological data

The approach to the estimation of all biological parameters was the same as in the 2019 update assessment, Adams et al. (2019).

##### 2.2.5.1 Weight-length relationship

Weight-at-length data were updated for this assessment. Following the approach used in the 2015 benchmark, data used to estimate the length-weight relationship for widow rockfish were gathered from commercial catch sampling schemes (PACFIN, ASHOP) and fishery-independent surveys (Triennial and WCGBT Survey).

The following relationships between weight and length for females and males were used in the current assessment:

$$\text{Females:} \qquad weight = 1.5885 \times 10^{-5} \cdot length^{2.9873}$$

$$\text{Males:} \qquad weight = 1.4507 \times 10^{-5} \cdot length^{3.0123}$$

where weight is measured in kilograms and length in cm. These parameters were used in the assessment as fixed.

#### 2.2.5.2 Maturity schedule

Maturity parameters in this update assessment were carried over from 2015 benchmark and 2019 update assessments; please refer to the most recent benchmark assessment (Hicks and Wetzel 2015) and most recent update assessment (Adams et al. 2019) for information.

#### 2.2.5.3 Fecundity

Fecundity is assumed proportional to the biomass of mature females, as was the case in the most recent benchmark assessment (Hicks and Wetzel 2015) and most recent update assessment (Adams et al. 2019).

#### 2.2.5.4 Natural Mortality

In this assessment, natural mortality (M) is estimated for females and males, while using the Hamel and Cope (2022) prior. The prior on M has been updated to reflect the most recent guidance from Hamel and Cope (2022); the log-mean therefore remains unchanged while the log-SD has been set to 0.31. Using a maximum age of 54 the point estimate and median of the prior on M is 0.10.

#### 2.2.5.5 Length-at-age

Growth parameters were fully estimated within the assessment model, for females and males separately following the same formulation in 2015 and 2019 assessment models.

#### 2.2.5.6 Ageing bias and imprecision

Ageing error matrices were unchanged from the previous assessment; please refer to the most recent benchmark assessment (Hicks and Wetzel 2015) and most recent update assessment (Adams et al. 2019) for information.

### 2.3 Environmental and Ecosystem Data

This assessment did not use any environmental or ecosystem data related to the stock.

# 3 Assessment model

## 3.1 History of modeling approaches

This section is not required for an update assessment; please refer to the most recent benchmark assessment (Hicks and Wetzel 2015) and most recent update assessment (Adams et al. 2019) for information.

## 3.2 Responses to most recent past STAR Panel recommendations

There are no recommendations from the most recent STAR Panel to address.

## 3.3 Responses to SSC Groundfish Subcommittee requests

There are no requests from the SSC Groundfish Subcommittee.

## 3.4 Model Structure and Assumptions

### 3.4.1 Model Changes from the Last Assessment

The assessment followed the same model structure as the 2015 benchmark assessment (Hicks and Wetzel 2015) and 2019 update assessment (Adams et al. 2019). The changes made to the previous assessment model include:

- **Adding most recent data from commercial fleets** (as described in "Data" section of this report).
- **Updating WCGBTS index using current methodology** (as described in "Data" section of this report).
- **Updating the prior for natural mortality** based on Hamel and Cope (2022).
- **Updating length-weight parameters estimated** by including most recent data.
- **Extending the main period for estimating recruitment deviations and updating recruitment bias adjustment parameters** based on Methot and Taylor (2011).
- **Adding a block to the retention curve for the midwater trawl fleet and a block to hake fleet selectivity to account for recent changes in fleet behavior.** Adding a block to the retention curve for midwater trawl allowed for recent increases in midwater trawl discards (from 2017 forward), and improved fit to discard amounts modeled in

the assessment. Adding a block to hake fleet selectivity accounted for a change in fish mean length (2020–2024) due to shifts in the spatial distribution of the hake fleet and to improve fit to length compositions (Holland and Martin 2019). Neither change had a discernible influence on the estimated SSB. See the "Model Bridging" section for additional detail.

- **Adding hook-and-line discards to landings in the hook-and-line fleet.** WCGOP corrected discard lengths for the hook-and-line fleet to omit nearshore fixed gear samples, which were erroneously included with the hook-and-line fleet in the previous benchmark (Hicks and Wetzel 2015) and update assessments (Adams et al. 2019). This resulted in changes to the discard length distribution and years for which data was available Figure 17. Because of decreased sample sizes of hook-and-line discard length data available, this update assessment model was unable to reliably estimate retention parameters and exhibited substantial sensitivity to even slight changes in discard amounts within the hook-and-line fleet. Therefore, in this assessment, we added the hook-and-line discard to hook-and-line landings. Removal of the hook-and-line discard lengths translated into lower estimated recruitment in the 2010s than that of in 2019 update assessment (higher recruitment estimates in the 2019 assessment were previously informed by erroneous estimates of smaller fish, which were corrected in this assessment by combining the hock-and-line discards and landings). Lower recruitment in turn contributed to a decrease in stock size in recent years.

Comparison of SB and fraction unfished between 2019 update assessment model and this 2025 model are shown in Figure 21 to Figure 24. See "Model Bridging" section for further details.

#### 3.4.1.1 Model Bridging

The exploration of models began by bridging from the 2019 update assessment to SS3 version 3.30.2, which produced no discernible difference. We then focused on data bridging (Figure 25). Updating the catch series did not have a substantial effect on the historical biomass; the stock biomass increasing from 2000–2020 before decreasing up to the current period.

Updates to discards, particularly the removal of hook and line discard amounts and length composition data, had the most significant impact on the absolute stock biomass (SSB): absolute SSB before 1980 was slightly lower than the 2019 update assessment estimates, and noticeably lower from the mid 2010s through the current year. Updates to model indices and composition data, following updates to discards, lead to minor changes in SSB estimates. Removal of hook-and-line discard data had the largest effect on recent relative SSB (fraction of unfished biomass) in recent years; updates to all other data sets, following updates to discards, lead to minor changes in recent relative SSB estimates (Figure 26).

Additional model bridging changes included (1) updating the prior for natural mortality (M) to follow that recommended by Hamel and Cope (2022), (2) updating fixed parameters of the male and female length-weight curve by fitting to data from the WCGBTS, ASHOP, and the Triennial Survey outside the model, (3) re-fitting the bias adjustment ramp for recruitment deviates, (4) adding a block on retention in the midwater trawl fishery from 2011–2016 and allowing estimation of retention in the final years of the model, which was previously fixed at 0.99, (5) adding a block to hake fleet selectivity from 2020–2024, and (6) re-fitting the model using the MLE as initial values following a jittering analysis, which revealed the previous MLE was a local minimum. These changes collectively resulted in a very small decrease in relative SSB post-1990, and pairwise correlations among all shared parameters in these models were high ($>$0.999). Bridging from the previous prior on M to the Hamel and Cope (2022) prior is detailed in the "Priors" section. None of these model bridging steps had a substantial effect on the estimates of stock biomass (Figure 25).

To estimate discards in the model, time blocks for changes in selectivity and retention in discard data were used. Except for the aforementioned addition of blocks to the midwater trawl and hake fleets, the same structure for time blocks was used as in the most recent update assessment (Adams et al. 2019). The addition of midwater trawl and hake fleets block was necessitated by poor fits to midwater trawl discards and the length composition data from the hake fleet in from 2020–2024, respectively. The poor fit to hake fleet length composition data may be due to the high variability in the distribution of the hake fleet between years, as the fleet moves to avoid bycatch (Holland and Martin 2019). Poor fit to midwater trawl discards is thought to be due to (1) the previous decision to fix late-year retention to 0.99 which represented an overestimate of the (very low) discards in 2011–2016, and (2) the reallocation of quota shares and subsequent increase in midwater trawl discards in 2017. These choices are described in more detail in the "Fits to Data" section.

#### 3.4.2 Modeling Platform and Structure

For this update assessment, new versions of the previously used software were used. The 2019 update assessment used Stock Synthesis v3.30.13 to estimate the model; and R4SS version 1.35.3 and R version 3.5.3 to investigate and plot the 2019 model fits. This update used Stock Synthesis v3.30.2 to estimate the model; and R4SS version 1.52.0 and R version 4.5.0 to investigate and plot the model fits. A summary of the data sources used in the model (details discussed above) is shown in Figure 27.

#### 3.4.3 Model Overview

The model is a two-sex, age-structured model starting in 1916 with an accumulated age group at 40 years. Sex-specific growth and natural mortality were estimated. The lengths in the population were tracked by 1 cm intervals and the length data were binned into 2 cm intervals. Ageing error was retained from the 2015 benchmark assessment (Hicks and Wetzel 2015). Fecundity was assumed to be proportional to body weight, thus SB was used as the measure of spawning output.

#### 3.4.3.1 Model Fleets and Areas

The assessment uses a single-area model, consistent with the previous benchmark and update assessments Adams et al. (2019). Multiple fisheries encounter widow rockfish. The definitions of fishing fleets have not been changed from previous benchmark and update assessments Adams et al. (2019).

### 3.4.4 Model Parameters

#### 3.4.4.1 Estimated and Fixed Parameters

There were 214 estimated parameters in the base model. These included one parameter for recruitment (R0), 10 sex-specific parameters for sex-specific growth, two sex-specific natural mortality parameters, four parameters for the catchability (q) of the hake and the Triennial Survey of abundance (catchability for other indices were calculated analytically using the "float" option in SS3), four parameters each for extra variability for the hake, bottom trawl, juvenile and foreign-at-sea indices of abundance, 49 parameters for selectivity, retention, and time blocking of the fleets, eight parameters for survey selectivity, 125 recruitment deviations, and 12 forecast recruitment deviations.

Fixed parameters in the model included steepness, standard deviation of recruitment deviates, maturity at age, and length-weight parameters Consistent with the previous full assessment (Adams et al. 2019), steepness was fixed at 0.72, matching the mean of the current west coast rockfish steepness prior (Thorson et al. 2019), described below in the "Priors" section. A likelihood profile were done for steepness. The standard deviation of recruitment deviates was fixed at 0.60. Maturity at age was fixed as described in the previous update assessment, Adams et al. (2019). Length-weight parameters were fixed at estimates using length-weight observations from the WCGBTS (Figure 19 and Table 13).

All selectivity curves in the final base model were length based and the same shape as the 2019 update, with the exception of the WCGBTS survey fleet. The final base model assumed asymptotic selectivity (using the double-normal formulation in SS3) for each fishery, except for the midwater trawl fishery, following the 2015 benchmark assessment (Hicks and Wetzel 2015). The WCGBTS and Triennial Survey both used spline curves. The WCGBTS survey fleet selectivity was estimated to be slightly lower at lengths greater than 45 cm, compared to the selectivity estimated in 2019.

Time blocks were used for selectivity and retention parameters in the bottom trawl, midwater trawl, hake and hook-and-line fisheries as indicated in Table 12.

#### 3.4.4.2 Priors

The prior on natural mortality (M) in the previous assessment was defined as a lognormal with mean on the log-scale of ln(5.4/Amax) and SD(ln(M)) = 0.44 following analysis of the data in Then et al. (2015) by Owen Hamel. In the current assessment the prior on M has been updated to reflect guidance from Hamel and Cope (2022); the log-mean therefore remains unchanged while the log-SD has been set to 0.31. Using a maximum age of 54 the point estimate and median of the prior on M is 0.10.

The prior for steepness (h) assumes a beta distribution with parameters based on an update of the Dorn rockfish prior (commonly used in past West Coast rockfish assessments) conducted by Jim Thorson (pers. comm, NWFSC, NOAA), which was reviewed and endorsed by the SSC in 2015. During the stock assessment review in 2015, it was decided that the steepness prior should be developed without the past widow rockfish data to avoid using the same data to inform both the model prior and likelihood. Without widow rockfish, the prior used for the 2015 assessment was a beta distribution with mean = 0.798 and SD = 0.132 (corresponding beta parameters $\alpha = 6.59$ and $\beta = 1.667$). The 2019 update assessments used the current West Coast rockfish steepness prior with mean = 0.72 and SD = 0.16 ($\alpha = 4.95$, $\beta = 1.93$) which was approved for use in all rockfish stock assessments for 2019. This update assessment uses the same prior as the 2019 update assessment (Adams et al. 2019).

#### 3.4.4.3 Recruitment deviations

Recruitment deviations from 1900–2024 were estimated to appropriately quantify uncertainty; inappropriate specifications can have a large effect on model uncertainty. The standard deviation of recruitment variability (sigma-R) was assumed to be 0.6 in the 2015 assessment, based on iteratively tuning to a value slightly less than the observed variability of recruitment deviations in the period 1975–2010 in 2015 (Figure 35). The earliest length-composition data occur in 1976 and the earliest age data were in 1978. The most informed years for estimating recruitment deviations based on available composition data were from about the mid-1970s to about 2019. The period from 1900–1970 was fit using an early series with little or no bias adjustment, the main period of recruitment deviates was 1971–2020 using a bias adjustment ramp, and 2021 onward was fit using forecast recruitment deviates with little bias adjustment. Methot and Taylor (2011) summarize the reasoning behind varying levels of bias adjustment based on the information available to estimate the deviates.

#### 3.4.4.4 Sample weights

As the most recent benchmark assessment (Hicks and Wetzel 2015) used the McAllister and Ianelli (1997) method and changing the weighting method is outside the TOR for an update, the Francis (2011) weighting method is presented as a sensitivity.

In the current assessment, the weighting method the composition datasets in SS3 was to use variance adjustment factors as the weighting factors. The fleet and data-type (length or age) factor was entered as variance adjustments factors until the harmonic mean of the effective sample sizes matched the mean of the adjusted input sample sizes (McAllister and Ianelli 1997). Once the weighting was determined, lambda factors for all fleets with both marginal length and marginal age compositions were down-weighted by 0.5 to account for the potential double use of data since length and age are observed from the same fish. This differs from McAllister & Ianelli weighting method the 2019 update assessment, which weighted composition data via the lambdas (Adams et al. 2019).

#### 3.4.5 Key Assumptions and Structural Choices

This section is not required for an update assessment; please refer to the most recent full assessment (Hicks and Wetzel 2015) for additional information.

### 3.5 Base Model Results

As a supplement to the model results figures included in this report and described below, a full set of diagnostic plots created by the r4ss package (Taylor et al. 2021) is available on the assessment GitHub repository (github.com/mcgoodman/widow_rockfish_2025) along with the Stock Synthesis input files.

#### 3.5.1 Parameter Estimates

The base model parameter estimates along with asymptotic standard errors are shown in Table 13 and the likelihood components are shown in Table 14. Estimates of key derived parameters and asymptotic 95% confidence intervals are shown in Table 15.

The estimates of natural mortality (0.122 $yr^{-1}$ and 0.135 $yr^{-1}$ for females and males, respectively) were higher than suggested by the medians of the prior distributions used in this assessment and the 2015 assessment. Fixing M at lower values than those estimates resulted in a pattern of reduced recruitment immediately before the fishery started (Figure 60). This suggests that the model is attempting to reduce the number of observations of older fish in the data. The estimates of M fall within the 95% quantile range of the prior distribution

(0.055– 0.184), and are shown in Figure 28. These estimates are lower than those of the 2015 benchmark assessment (Female: 0.1572, Male: 0.1705; Hicks and Wetzel (2015)) and the 2019 update assessment (Female 0.1444, Male: 0.1549; Adams et al. (2019), Figure 28).

Updating age composition data resulted in the largest decrease in M among the various intermediate models bridging from the 2019 assessment. This is broadly consistent with observations of older individuals in updated age composition data. For instance, the maximum age for widow rockfish in the WCGBTS data prior to 2019 was 37 yrs with a 99$^{th}$ percentile of 29, while data collected since include individuals up to 51 with a 99$^{th}$ percentile of 34. Updating that natural mortality prior resulted in a comparatively small decrease in M (Figure 28).

Estimating M is difficult in stock assessments, and the estimated values may represent model misspecification instead of the actual life-history trait. However, in alternative models to the base, the estimates of M were not higher than 0.13 yr$^{-1}$ (Table 17), except when forcing asymptotic selectivity on the midwater trawl fleet (Table 17). Uncertainty in the estimated M was also much less than the range of the prior (Figure 28).

Selectivity curves were estimated for commercial and survey fleets and parameter estimates are provided in Table 13. The estimated selectivity, retention, and keep (the product of selectivity and retention) curves for the trawl and hook-and-line fleets are shown in Figure 29. The selectivity curves showed a shift to larger fish in 2002 for the bottom trawl fishery, a shift to smaller fish in 2003 for the hook-and-line fishery, and a strong dome-shaped selectivity for the midwater fleet. The bottom trawl shift is consistent with the introduction of the Rockfish Conservation Area (RCA) and gear restrictions (shoreward of the 18 RCA) that virtually eliminated fishing in shelf habitats where smaller widow rockfish would more likely be encountered. Around this same time, the fixed-gear RCA specifications began preventing fishing between 30 and 100 m. The strong dome-shape of the midwater fleet suggests a lack of observations of older females, and, to some extent, older males as well. Due to it consistently approaching the lower bound when estimated, the decision was made to fix the log-ascending width of the hook-and-line fleet selectivity curve at -5.

The retention curves (Figure 32) showed a shift to retaining a lower percentage of fish since trip limits were introduced. The asymptote of the retention curve for the bottom trawl fishery sequentially decreased as more management restrictions were introduced to about 50% retention of larger fish in the 1998-2010 period. In recent years, bottom trawl retention is estimated at approximately 99%.

Midwater trawl and hook-and-line fisheries estimated an asymptote to retention just above 80% for the period 1983-2010. Both the selectivity for the hake fleet and the selectivity of the net fleet did not support dome-shaped selectivity (Figure 29). The estimated selectivity curves for the Triennial and WCGBTS were similar to each other except that the triennial survey selected larger fish (Figure 30). The WCGBTS exhibited a more pronounced dome-shaped selectivity compared to the 2015 assessment.

In the 2015 assessment, additional survey variability (observation error added directly to each year's input variability) for the Triennial Survey and WCGBTS was not estimated in the model because initial runs estimated the it at zero (Hicks and Wetzel 2015). To avoid bound issues in estimation of the Hessian, the authors fixed these at zero because the model results included reasonable estimates of variance. We retained the same modelling approach for the update assessment. The additional standard deviation added to the fishery-dependent indices was quite large: 0.16 for the bottom trawl index and 0.58 for the foreign at-sea hake fleet. The additional variability on the juvenile survey was the highest, at 1.25, giving the index very little weight in the model.

The estimates of maximum size for both females and males (Table 13) did not differ substantially from Adams et al. (2019). Estimates of k were slightly different in the model, but that is expected when accounting for selectivity. Estimated growth curves are shown in (Figure 33).

Estimates of recruitment suggest that the widow rockfish population is characterized by variable recruitment with occasional strong recruitment events and periods of low recruitment (Figure 34, Table 15). There is little information regarding recruitment prior to 1965.

#### 3.5.2 Fits to the Data

Fits to data are discussed for survey abundance indices, discard data (biomass and length compositions), length composition data for the fisheries and surveys, marginal age compositions for the fisheries, and conditional age-at-length observations for the WCGBTS.

Survey indices and total discards were fitted assuming a lognormal likelihood. The five indices of abundance (three survey series, and two fishery indices of abundance) are shown in Figure 36. The Triennial Survey treatment was consistent with Adams et al. (2019). Extra standard error was estimated for all of the series except for the two survey series (Table 13). None of the series showed patterns in residuals, and with the large amount of error, none of the series showed serious lack of fit. The recent WCGBTS showed a general increase from 2003 - 2015 followed by a general decrease from 2016 - 2024, which was also estimated in the base model (Figure 36). The model did not fit the indices variability well, particularly years with relatively low (2015, 2021, 2022) or high (2016) estimates of abundance, as might be expected for a long-lived rockfish species.

The 2019 model applied four time blocks to midwater trawl retention, with constant fixed discard rates of 1% in both early years (1916-1981) and late years (2011 onward). With the addition of new discard data since the 2017 reallocation, the use of a fixed discard rate from 2011 onward resulted in poor fits to the discard data. Therefore the current assessment utilizes an additional block on retention from 2011-2016, with the final block beginning in 2017; retention is estimated in both the 2011-2016 and 2017-2024 time blocks, though it remains fixed for the earliest time block (1916-1981) at the value used in the previous assessment. The first time block with discard data was 1983 to 2001. Predicted discards for all three years of the Pikitch data (1985–1987) were underfit, but within the confidence limits (Figure 37). EDCP data in 1997 and 1998 were underfit. The second time block was from 2002-2010, which contained only one observation in 2002 (and was fit exactly, as expected). Discard rates were overestimated in 2012-2013 and underestimated in 2015-2016, though they were generally well fit in in the 2017-2024 time blocks.

Annual fits to the length-composition data are depicted using Pearson residuals-at-length for all fleets in Figures 38 and 39. More detailed plots of fitted and observed proportions at length are shown in Appendix A. Pearson residuals for the fisheries (Figures 38, 39) do not show consistent patterns, but they do show that some fleets are not fitting some cohorts well. Each fleet also shows that there are periods where older fish are underestimated or overestimated. The net fishery observed some very large fish in the first two years of data, but did not observe those fish in later years. This pattern was not seen in any other fishery. There were also years where females showed positive residuals (filled circle, observed $>$ expected) and males showed negative residuals (e.g., Figure 38, early years of bottom trawl and midwater trawl). It is uncertain if this pattern is related to growth, sexing error, or to sex-specific selectivity (e.g., widow rockfish sexes may aggregate separately). Similar residuals patterns were present in the last benchmark assessment; the authors attributed them to sampling error and the use of some time-invariant parameters (Hicks and Wetzel 2015) and suggested they would require complicated modelling assumptions to alleviate. However, the residuals were mostly less than 2 in absolute value, especially for fleets that were well informed by data. The model fits the marginal length composition integrated among years for each fleet well (Figure 40).

The fits to bottom trawl discard length frequencies were generally good except in the years since trawl rationalization began (2011). These recent years observed small fish, which the estimated selectivity of the trawl fleet did not allow for. There were no other years that showed small fish being caught by the trawl fleet. Attempting to explain these small fish with additional time blocks on selectivity and retention did not help because explaining the small fish in the discards worsened the fits to the landed and larger fish. Discards are extremely small in this time period, so it is unlikely that a misfit here will have a large effect on the model. Combining the discard length frequencies over years may not be appropriate for the bottom trawl fishery due to the likely changes in discarding practices, but Figure 38 shows the prediction of discarding smaller females than observed and a more peaked observed distribution of discarded males than predicted.

The WCGBTS and WCGBTS length frequencies showed underestimation of older fish in some years and underestimation of younger fish in others (Figure 41). The combined WCGBTS length frequencies across years displayed a weakly bimodal distribution with a valley around 37 cm, which the model approximated well (Figure 40). Fits to the Triennial Survey length frequencies (which have not been updated in this assessment) show underestimation of 35-45 cm males and overestimation of similar length females, as in Hicks and Wetzel (2015).

Age data were fitted as marginal age compositions for the fishing fleets and as conditional age-at-length for the WCGBTS, which were expanded by tow and then by strata. Expanded age-at-length data were used, following the 2015 benchmark assessment (Hicks and Wetzel (2015)). Pearson residuals for the commercial fleets are shown in Figures 38 and 39. For the trawl fisheries in Figure 38, there are diagonal patterns corresponding to cohorts ageing through the years, though with instances where diagonals seems to shift, such as for the midwater trawl fishery in 1981–1991. The patterns match the length compositions residuals in some cases. The bottom trawl fishery shows the largest residuals in the most recent years, which could indicate a change in selectivity. The net and hook-and-line fits to age compositions (Figure 39) showed larger residuals than the trawl fisheries. As with the fits to the length compositions, the net fishery underestimated observed counts of older fish in early years, and what appears to be a poorly fit cohort beginning in 1988. The residuals were typically less than 2 for fits to the age data. However, the female age compositions occasionally produced some large residuals that were not consistently seen in the male age compositions. Aggregating across years shows that the fit to age comps was good for the trawl fleets and less so for the net and hook-and-line fleets, which had smaller sample sizes (Figure 42). The modes of the aggregated data were somewhat more pronounced that those estimated.

The observed and expected age-at-length are shown in Figure 43 for the twelve years of the WCGBTS observations. The fits generally match the observations with some misfit at larger lengths. The standard deviation of age-at-length was variable and often the expectation was higher than the observations at larger lengths. Plots with the residuals for individual observations showed reasonably good fits to the conditional age-at-length data from the NWFSC shelf/combo survey (Figure 44). Some outliers are apparent, with large residuals mostly at smaller lengths for a given age.

#### 3.5.3 Population Trajectory

The predicted SB (mt) is given in Table 16 and plotted in Figure 45. The predicted SB from the base model generally showed a slight decline over the time series until 1966 when the foreign fleet began. A short, but sharp decline occurred, followed by a steep increase due to strong recruitment. The SB declined rapidly with the developing domestic midwater fishery in the late 1970s and early 1980s. The stock continued to decline until 2000 when a combination of strong recruitment and low catches resulted in a quick increase from 2000 - 2018. The stock declined rapidly from 2019 until the end of the time series, due to a combination of increased catches and low recruitment.

The 2025 SB relative to unfished SB is above the target of 40% of unfinished SB (54.9%), with a low of 32.6% in 2000 (Figure 47). This suggests that widow rockfish was not overfished, as was inferred from previous assessments (Williams et al. 2000). Approximate confidence intervals based on the asymptotic variance estimates show that the uncertainty in the estimated SB is high, especially in the early years. It should be noted that while the stock is currently above the 40% target, the target does fall within the approximate 95% confidence interval (Figure 47).

Recruitment deviations (Figure 34 and discussed in Section 3.3.1) provide a more realistic portrayal of uncertainty. There are very large, but uncertain, estimates of recruitment in 1970, 2008, 2016, and 1971 (in descending order of magnitude). Other large recruitment events (in descending order of magnitude) occurred in 1978, 1981, 2010, and 1991. The five lowest recruitments (in ascending order) occurred in 2012, 2019, 2020, 2011, and 1976. The 2008 and 2016 year classes were estimated as 2 of the 4 strongest year classes. The 2019 update assessment estimated the 2013 recruitment as the strongest year class over the duration of the fishery, however the current assessment does not support this. It may be worthwhile to investigate the periods of strong and weak year classes further to see if it is an artifact of the data, a consistent autocorrelation, or a result of the environment. The input bias adjustment ramp matched the estimated ramp (Figure 35).

The stock-recruit curve resulting from a fixed value of steepness is shown in Figure 35 with estimated annual recruitment also shown. The stock is predicted to have never fallen to low enough levels that the steepness is obvious. However, the lowest levels of predicted SB showed some of the smallest recruitment events and very few above average recruitment events. Steepness was not estimated in this model, but sensitivities to alternative values of steepness are discussed below.

## 3.6 Model Diagnostics

### 3.6.1 Convergence

Model convergence was determined by examining the final gradient, checking that the Hessian was positive (semi-)definite, and initializing the minimizer from perturbed values around the maximum likelihood estimates (MLE) to determine if the model found a better minimum ("jittering"). Initial jittering analyses indicated that the model had converged to a false (local) minimum, though the difference in log-likelihoods at the previous estimates and the new MLE was small (<0.5). After accepting the new MLE as the base model, jittering was repeated 100 times with a jitter coefficient of 0.10 and (using a convergence threshold of 0.01) a better minimum was not found. 13% of the jittered models achieved the minimum negative log-likelihood and 20% were within two likelihood units. Through the jittering done as explained above and likelihood profiles, we are confident that the base case as presented represents the best fit to the data given the assumptions made. There were no difficulties in inverting the Hessian to obtain the parameter variance-covariance matrix. Likelihood profile runs which fixed M, R0 and h at more extreme values did not initially converge. This was addressed by using the parameter estimates from models with less extreme values as starting values in subsequent models. Convergence was defined as the lowest negative log-likelihood achieved with jittering where the Hessian matrix was invertible.

#### 3.6.2 Parameter Uncertainty

Parameter estimates are shown in Table 13 and Table 16 along with approximate asymptotic standard errors. The only parameters with an absolute value of correlation greater than 0.95 were the female and male natural mortality parameters, which is expected. Estimates of key derived quantities are given in Table 15 along with approximate 95% asymptotic confidence intervals. There is a reasonable amount of uncertainty in the estimates of biomass. The confidence interval of the 2025 estimate of depletion is 35.59%–74.24% and mostly above the management target of 40% of the unfished SB.

#### 3.6.3 Sensitivity Analyses

Sensitivity analysis was performed to determine the model behavior under different assumptions than those of the base case model. 8 sensitivity analyses were conducted to explore the potential differences in model structure and assumptions, including:

1. Fixed natural mortality at 0.1 for both sexes (2015 assessment prior)
2. Fixed natural mortality at 0.124 $yr^{-1}$ for females and 0.129 $yr^{-1}$ for males (2011 assessment prior)
3. Forcing asymptotic selectivity on the midwater trawl fleet
4. Fitting logistic curves for WCGBTS selectivities
5. Weighting the composition data using the Francis (2011) method
6. Updated Washington catch reconstruction
7. Inclusion of previously excluded shrimp trawl data
8. Exclusion of triennial survey data

Likelihood values and estimates of key parameters are shown in Table 17. Predicted SB trajectories, estimated recruitment deviations and comparisons of model estimates for 2025 are shown in Figure 52, Figure 53 and Figure 54. The estimates of SSB in 2025 ranged from 25.35 to 55.58 thousand metric tons across the sensitivity runs, with fixing natural mortality to 0.1 (2015 assessment prior) resulting in the lowest estimate and forcing asymptotic selectivity on the midwater trawl fleet resulting in the highest estimate. Generally, the trajectory of the SB was qualitatively similar across all tested models, e.g., peak around late 1970s and late 2010s, projected decrease in biomass in 2025 followed by some recovery into the 2030s; the quantitative magnitude of these trends did vary across cases.

Fixing M at values lower than the base case estimate resulted in decreases in estimated SB. The alternative weighting using the Francis method generally increased the estimate of SB across the time series. Other changes, including forcing asymptotic selectivity on the midwater fleet, forcing logistic selectivity on the WCGBTS, and excluding the triennial survey had relatively small effects on SB Figure 53 and recruitment Figure 52. Changes to the historical landings (updating WA catch reconstruction and including shrimp trawl data) had no discernible on the estimated SB.

#### 3.6.4 Retrospective Analysis

First, a 5-year retrospective analysis was conducted by running the model using data only through 2020, 2021, 2022, 2023, and 2024 progressively (Figure 55). The initial scale of the SB was effectively unchanged for all retrospective runs. Removing 4–5 years of data led to slightly higher estimated SB over the last 15 years.In contrast, removing only 1–2 years resulted lower estimated SB over the period. Removing 1-5 years of data resulted in increased estimated recruitment over the past 5 years, but decreased estimates in 10 years prior to this. Despite these minor differences, population trends from all retrospective runs were very close, and there were no consistent patterns as years were removed. No concerning patterns were observed in the retrospective analysis.

Estimated SB from the base model was comapred with previous assessments. For assessments prior to 2009 (2000, 2003, 2005, 2009), SB was compared with spawning output, and SB for models thereafter (2011, 2015, 2019) Figure 48.The current update follows a similar trend to prvious assessments over the model period, and estimated SB falls within the mid-range of previous assessments.

#### 3.6.5 Likelihood Profiles and key parameters

Likelihood profiles were conducted for unfished virgin recruitment (*R0*), steepness ($h$) and sex-specific natural mortality ($M$) values simultaneously. These likelihood profiles were conducted by fixing the parameter at specific values and removing the prior on the parameter being profiled. Without the original prior distribution the MLE estimates from the base case will likely be different than the MLE in the likelihood profile, but this displays what information the data have.

For profiles of natural mortality, the negative log-likelihood was minimized at a value of 0.135 for males, and a value of 0.121 for females. Profiles for natural mortality for each sex are illustrated in (Figure 58, Figure 59). For steepness, the negative log-likelihood was minimized at a steepness of 0.275, however the 95% confidence interval extends over the entire range of possible steepness values. Profiles for steepness are illustrated in (Figure 57).

Natural mortality for both sexes increased as R0 was fixed at increasingly large values, as did SB in the final year. For R0, the negative log-liklihood was minimized at a value of 10.46, which supports the base model estimates of R0 at 10.457.Profiles for R0 are illustrated in Figure 56.

# 4 Management

## 4.1 Reference Points

Reference points were calculated using the estimated selectivity parameters and catch distribution among fleets in the five most recent years of the model (2019-2024). Sustainable total yields (landings plus discards) were 5,822 mt when using an $SPR_{50\%}$ reference harvest rate with a 95% confidence interval of 4,533 to 7,111 mt. The SB equivalent to 40% of the unfished spawning output ($SB_{40\%}$) was 34,184 mt. Catches between the late 1990s and 2016 were well below the point estimate of potential long-term yields calculated using an $SPR_{50\%}$ reference point, and the population is estimated to have increased continuously throughout that time period. However, catches from 2017 through 2024 were above the point estimate of potential long-term yields using an $SPR_{50\%}$ reference point (by an average 68%), exceeding the upper bound of the confidence interval in all years since 2018.

The predicted SB from the base model generally showed a slight decline until the late 1970s, followed by steep increase above unfished equilibrium biomass and reaching a peak in 1979. This was followed by a steep decrease up to the mid-1980s, and then a more gradual decease through 2000 (Figure 47). Between 2001 and 2016, the SB increased continuously due to small catches and several years of high recruitment (though with lower than average recruitment in other recent years). The SB relative to unfished equilibrium SB climbed above the target of 40% of unfished SB in the early 2000s. It is estimated to still be above the target, though the lower bound of the 95% confidence interval lies between the target and minimum stock size threshold (Figure 47). The fishing intensity (relative 1-SPR) exceeded the current estimates of the harvest rate limit ($SPR_{50\%}$) throughout the 1980s and early 1990s, and has again since 2018 (Figure 50). Exploitation rates on widow rockfish between 2001 and 2016 were predicted to be far below target levels. In recent years, the stock has experienced exploitation rates that have been above the target level while the biomass level has remained above the target level (Figure 51).

The equilibrium yield plot is shown in Figure 61, based on a steepness value fixed at 0.720. The predicted maximum sustainable yield under the assumptions of this assessment occurs near 27% of equilibrium unfished SB, however this represents only 12% higher yield with considerably more risk than under the 50% SPR policy, which occurs near 45% of unfished SB.

## 4.2 Unresolved problems and major uncertainties

Major sources of uncertainty include landings, discards, natural mortality, and recruitment, which are discussed below.

Because widow rockfish is a marketable species, historical discard rates were likely lower than less desirable or smaller species. This assessment assumed that discarding was nearly negligible before management restrictions began in 1982. Once trip limits were introduced, discarding tended to be an all or none event; rare, but large, discard events are unlikely to have been detected given low observer coverage. From 2002 onward, the WCGOP has provided data on discards from vessels that were randomly selected for observer coverage, thus some uncertainty is present in the total amount discarded. The implementation of trawl rationalization in 2011 resulted in almost 100% observer coverage for the trawl fleet and very little incentive to discard widow rockfish. The open access fixed-gear fleet is not monitored by the full observer coverage required under trawl rationalization. Discard mortality is assumed to be 100%, which may overestimate actual mortality (Jarvis & Lowe, 2007), but given the low number of discards, is likely to have a minimal effect on assessment results.

There may also be uncertainty in the ability of bottom trawl surveys to reliably estimate abundances of widow rockfish, which spend a significant portion of their time in mid-water (Wilkins 1986). Multiple surveys are used in the assessment, but further consideration of additional surveys is reasonable.

This assessment attempts to capture uncertainty in M by estimating it inside the model (thereby propagating uncertainty in M into uncertainty in SB and other derived quantities), and by incorporating variation in M in a decision table. Model sensitivities and profiles over M showed that current stock status was highly sensitive to the assumption about natural mortality.

Widow rockfish is a relatively long-lived fish, and their natural mortality (M) is likely to be lower than many managed fish stocks (e.g., gadoids). Ages above 50 years have been observed and it is expected that natural mortality could be less than 0.10 $yr^{-1}$ (the median of the prior for natural mortality used in this assessment). However, even with length and age data available back to the late 1970s, M was estimated at 0.122 for females and 0.135 $yr^{-1}$ for males, with a small amount of uncertainty (e.g., a 6.4% coefficient of variation for females).

Notably, the estimated M for both sexes from this assessment are lower than those from the 2015 and 2019 assessments, for which natural mortality was estimated above 0.15 $yr^{-1}$ and 0.14 $yr^{-1}$, respectively. The estimates of M varied slightly depending on the weight given to age and length data, or removing recent years of data, but M was always estimated above 0.12 $yr^{-1}$. The likelihood profile over natural mortality provides support for values up to or above 0.14 $yr^{-1}$, but with greater curvature than in the 2019 assessment, suggesting additional data has reduced the support for higher natural mortality values. A contributing factor to this change may be the increased mean age and frequency of older fish in catch observed by the WCGBTS survey in recent years. The successful rebounding of the stock as a result of reduced fishing pressure from 2003-2016 may have allowed year classes to age and become fully observed by WCGBTS. However, consideration should be given in future assessments to structural changes which may improve the fits to WCGBTS CAAL data, which are poor in some years.

Steepness was fixed at 0.720 in the base model, but a likelihood profile showed that it would be estimated at a value less than that. Estimates of M increased with lower steepness, while unfished SB increased and current SB decreased. Sustainable yields at the $SPR_{50\%}$ reference harvest rate ranged from approximately 2641 to 5992 mt depending on the value of steepness.

### 4.3 Harvest Projections and Decision Tables

Uncertainty in both natural mortality (estimated for both sexes) and steepness (not estimated in the model) contributed greatly to uncertainty in the results. A combination of these two factors was used as the axis of uncertainty to define low and high states of nature. The 12.5% and 87.5% quantiles for female and male natural mortality (independently) were chosen as low and high values (0.113 $yr^{-1}$ and 0.131 $yr^{-1}$ for females; 0.126 $yr^{-1}$ and 0.144 $yr^{-1}$ for males). Steepness is probably the most important factor since it was fixed in the base model and is not incorporated in the estimation uncertainty. The 12.5% and 87.5% quantiles from the steepness prior were used to define the low and high values of steepness (0.536 and 0.904). The low combination of these two factors defined the low state of nature and the high combination of these two factors defined the high state of nature. The predictions of SB in 2025 from the low and high states of nature are close to the 12.5% and 87.5% quantiles from the base model.

Previous assessments included recent large recruitment events as a third axis of uncertainty. As no similarly large and uncertain recruitment events occurred in the recent period, this axis was not included in the harvest projection.

This assessment synthesizes many sources of data and estimates recruitment variability, thus it is classified as a Category 1 stock assessment. Therefore, the sigma to determine the catch reduction to account for scientific uncertainty is 0.50.

A twelve year projection of the base model with two catch streams based on ACL = ABC based on adjustments of P* = 0.45 and P* = 0.40 were conducted (Table viii).

Projections with catches based on the predicted ACL using the SPR rate of 50%, the 40:10 control rule, and a 0.45 P* adjustment using a sigma of 0.50 from 2027 onward suggest that the SB is likely to initially decrease under all states of nature before partially rebounding under the base case and high state of nature (Table 20). Predicted ACL catches range from 4,238 mt in `ctch_rng$yr[ctch_rng$stat == "min" & ctch_rng$scenario == "P*0.45"]` to 5,360 mt in `ctch_rng$yr[ctch_rng$stat == "max" & ctch_rng$scenario == "P*0.45"]`.

Projections with catches based on the predicted ACL using the SPR rate of 50%, the 40:10 control rule, and a 0.40 P* adjustment using a sigma of 0.50 from 2027 onward suggest that the SB is likely to initially decrease under all states of nature before partially rebounding under the base case and high state of nature. Predicted ACL catches range from 3,957 mt in `ctch_rng$yr[ctch_rng$stat == "min" & ctch_rng$scenario == "P*0.40"]` to 4,973 mt in `ctch_rng$yr[ctch_rng$stat == "max" & ctch_rng$scenario == "P*0.40"]`.

### 4.4 Evaluation of Scientific Uncertainty

SB is estimated to be at 46,934 mt in 2025, with a sigma of 0.251. OFL is estimated to be 6,271 mt in 2025 with a coefficient of variation of 0.2874.

### 4.5 Regional management considerations

Widow rockfish are managed on a coastwide basis and observed more often in the WCGBTS north of latitude 40° 10  N. Bottom trawl catches in California have historically been as large as in Oregon and larger than in Washington, but recently catches in California have been small. Future assessments and management of widow rockfish may want to monitor where catches are being taken to make sure that specific areas are not being overexploited. In addition, research on the connectivity along the coast as well as regional differences would help to inform the potential for overfishing specific areas.

### 4.6 Research and Data Needs

There are many areas of research that could be improved to benefit the understanding and assessment of widow rockfish:

- **Natural mortality:** Uncertainty in natural mortality translates into uncertain estimates of status and sustainable fishing levels for widow rockfish. The collection of additional age data, re-reading of older age samples, reading old age samples that are unread, and improved understanding of the life-history of widow rockfish may reduce that uncertainty. Investigating the ageing error and bias would help to understand the influences that the age data have on this assessment, particularly the influence of age data on natural mortality.

- **Historical landings and discards:** Although progress has been made in reconstructing historical catches of rockfish on the U.S. West Coast, historical landings and discards continue to be uncertain for widow rockfish and improvements would increase the certainty that fishing removals are applied appropriately. Because landings are assumed to be known exactly in the assessment model, uncertainty in the predictions does not include uncertainty in the landings. A thorough look at historical landings, species compositions, and discarding practices would reduce the potential uncertainty that is not entirely accounted for. In addition, discard composition data have become available for the midwater trawl fleet in recent years and should be included in future assessments.

- **Sex-specific selectivity:** The midwater and bottom trawl length-composition data fits showed divergent residual patterns between male and female fish. The underlying mechanism driving this pattern is unclear, and could be related to growth, sexing error, or to sex-specific selectivity (e.g., when widow rockfish aggregate, sexes possibly may be aggregating separately). Sex-specific selectivity for these two fleets could be explored or included to address this.

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

# 5 Tables

## 5.1 Data

### 5.1.1 Fishery-dependent data

Table 1: Landings for bottom trawl, midwater trawl, net, and hook-and-line (mt) fisheries from Washington, Oregon, and California.

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | CA | WA | CA | OR | WA |
| 1916 | 6.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 71.8 | 0.3 | 0.0 |
| 1917 | 9.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 111.9 | 0.3 | 0.0 |
| 1918 | 11.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 128.5 | 0.3 | 0.0 |
| 1919 | 7.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 88.6 | 0.3 | 0.0 |
| 1920 | 8.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 90.7 | 0.4 | 0.0 |
| 1921 | 6.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 75.1 | 0.4 | 0.0 |
| 1922 | 5.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 65.2 | 0.4 | 0.0 |
| 1923 | 6.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 71.7 | 0.4 | 0.0 |
| 1924 | 3.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 46.2 | 0.4 | 0.0 |
| 1925 | 3.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 58.7 | 0.4 | 0.0 |
| 1926 | 8.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 85.5 | 0.4 | 0.0 |
| 1927 | 11.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 66.4 | 0.5 | 0.0 |
| 1928 | 16.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 72.0 | 0.8 | 0.0 |
| 1929 | 23.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 62.1 | 1.3 | 0.0 |
| 1930 | 20.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 90.4 | 1.2 | 0.0 |
| 1931 | 20.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 78.6 | 0.9 | 0.0 |
| 1932 | 21.7 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 77.7 | 0.3 | 0.0 |
| 1933 | 34.3 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 50.9 | 0.5 | 0.0 |
| 1934 | 30.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 59.7 | 0.5 | 0.0 |

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | CA | WA | CA | OR | WA |
| 1935 | 28.9 | 0.2 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 67.9 | 0.5 | 0.0 |
| 1936 | 23.4 | 0.7 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 84.3 | 1.2 | 0.0 |
| 1937 | 33.6 | 1.3 | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 66.3 | 1.3 | 0.0 |
| 1938 | 32.2 | 0.0 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 49.6 | 1.0 | 0.0 |
| 1939 | 38.8 | 1.9 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 34.2 | 0.7 | 0.0 |
| 1940 | 30.6 | 43.7 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 43.9 | 1.5 | 0.0 |
| 1941 | 24.8 | 67.3 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 34.1 | 1.9 | 0.0 |
| 1942 | 5.4 | 126.1 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.2 | 3.1 | 0.0 |
| 1943 | 28.3 | 439.2 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 18.0 | 3.9 | 0.0 |
| 1944 | 148.6 | 770.7 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 38.0 | 1.4 | 0.0 |
| 1945 | 353.4 | 1,196.6 | 3.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 66.8 | 1.1 | 0.0 |
| 1946 | 353.2 | 735.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 69.7 | 1.3 | 0.0 |
| 1947 | 98.1 | 452.8 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 91.3 | 0.7 | 0.0 |
| 1948 | 139.4 | 297.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 39.6 | 1.2 | 0.0 |
| 1949 | 75.1 | 254.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 43.9 | 0.6 | 0.0 |
| 1950 | 70.9 | 286.8 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 63.4 | 0.8 | 0.0 |
| 1951 | 249.4 | 252.9 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 49.1 | 0.6 | 0.0 |
| 1952 | 236.6 | 264.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 39.9 | 0.6 | 0.0 |
| 1953 | 242.6 | 211.5 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 13.7 | 0.3 | 0.0 |
| 1954 | 155.8 | 267.3 | 3.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 21.3 | 0.4 | 0.0 |
| 1955 | 166.3 | 277.5 | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 18.2 | 0.4 | 0.0 |
| 1956 | 196.8 | 361.3 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 41.8 | 0.3 | 0.0 |
| 1957 | 233.1 | 489.5 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 37.4 | 0.6 | 0.0 |
| 1958 | 284.3 | 380.4 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 36.6 | 0.1 | 0.0 |
| 1959 | 229.9 | 412.8 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 28.6 | 0.2 | 0.0 |
| 1960 | 180.0 | 608.6 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 21.9 | 0.2 | 0.0 |
| 1961 | 118.4 | 543.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.0 | 0.5 | 0.0 |

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | CA | WA | CA | OR | WA |
| 1962 | 115.9 | 623.8 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.4 | 0.4 | 0.0 |
| 1963 | 221.2 | 190.2 | 2.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 19.6 | 0.4 | 0.0 |
| 1964 | 104.1 | 480.9 | 3.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 13.0 | 0.1 | 0.0 |
| 1965 | 155.9 | 80.6 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 20.2 | 0.6 | 0.0 |
| 1966 | 123.0 | 455.8 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 37.4 | 0.4 | 0.0 |
| 1967 | 141.9 | 743.9 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 31.9 | 1.1 | 0.0 |
| 1968 | 155.0 | 240.6 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 19.0 | 1.0 | 0.0 |
| 1969 | 223.5 | 229.3 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 17.6 | 2.3 | 0.0 |
| 1970 | 257.3 | 27.7 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 9.0 | 0.9 | 0.0 |
| 1971 | 316.2 | 50.6 | 11.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.2 | 1.8 | 0.0 |
| 1972 | 411.9 | 51.8 | 14.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 17.8 | 2.3 | 0.0 |
| 1973 | 428.1 | 20.9 | 32.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.8 | 2.5 | 0.0 |
| 1974 | 426.4 | 7.3 | 6.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 41.3 | 3.1 | 0.0 |
| 1975 | 429.9 | 9.0 | 12.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 28.4 | 1.6 | 0.0 |
| 1976 | 467.3 | 56.0 | 36.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 39.5 | 2.2 | 0.0 |
| 1977 | 459.0 | 340.0 | 125.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 38.1 | 2.6 | 0.0 |
| 1978 | 538.9 | 340.1 | 336.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 157.4 | 3.8 | 0.0 |
| 1979 | 916.9 | 519.4 | 305.0 | 1,398.5 | 3,746.0 | 2,199.8 | 0.0 | 0.0 | 97.1 | 6.4 | 0.0 |
| 1980 | 2,109.2 | 410.8 | 338.4 | 3,217.2 | 8,460.7 | 6,969.4 | 0.0 | 3.4 | 55.9 | 3.7 | 0.0 |
| 1981 | 2,660.2 | 1,527.1 | 681.2 | 2,627.4 | 13,861.9 | 6,183.5 | 15.5 | 3.2 | 67.5 | 4.0 | 0.0 |
| 1982 | 3,656.7 | 782.8 | 522.0 | 7,008.1 | 8,184.4 | 5,458.0 | 38.1 | 37.1 | 180.6 | 5.9 | 0.0 |
| 1983 | 3,667.1 | 1,403.6 | 1,554.6 | 205.1 | 1,495.6 | 1,656.5 | 280.0 | 14.5 | 23.5 | 10.2 | 0.0 |
| 1984 | 1,434.6 | 1,428.5 | 381.8 | 1,378.6 | 3,982.8 | 1,064.6 | 324.8 | 26.6 | 22.8 | 3.8 | 0.0 |
| 1985 | 1,363.0 | 895.1 | 317.6 | 1,281.6 | 3,423.4 | 1,214.6 | 585.8 | 40.2 | 26.1 | 1.1 | 0.0 |
| 1986 | 1,640.4 | 1,230.1 | 716.1 | 362.2 | 3,150.5 | 1,834.1 | 500.8 | 0.0 | 81.5 | 1.9 | 0.0 |
| 1987 | 2,261.1 | 1,185.5 | 698.4 | 0.0 | 5,114.5 | 3,013.1 | 584.6 | 0.0 | 52.4 | 2.7 | 0.0 |
| 1988 | 1,585.3 | 1,152.8 | 1,290.3 | 0.0 | 4,305.6 | 1,785.0 | 220.7 | 0.0 | 72.3 | 1.0 | 0.2 |

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | CA | WA | CA | OR | WA |
| 1989 | 1,838.3 | 2,027.5 | 647.7 | 0.0 | 4,957.7 | 2,726.9 | 253.6 | 0.1 | 44.7 | 0.4 | 0.0 |
| 1990 | 1,812.7 | 2,289.3 | 1,210.4 | 0.0 | 3,352.8 | 1,021.1 | 411.2 | 0.0 | 126.9 | 7.3 | 0.2 |
| 1991 | 996.4 | 1,989.2 | 878.9 | 0.0 | 1,779.9 | 260.2 | 234.8 | 0.0 | 89.7 | 5.2 | 0.3 |
| 1992 | 917.4 | 2,709.5 | 646.5 | 0.0 | 1,183.8 | 282.5 | 45.4 | 0.0 | 165.8 | 9.2 | 0.5 |
| 1993 | 1,088.3 | 3,457.0 | 1,109.8 | 1.2 | 1,706.8 | 547.9 | 51.6 | 0.0 | 63.7 | 44.7 | 0.5 |
| 1994 | 557.9 | 2,600.7 | 644.1 | 210.0 | 1,564.4 | 387.5 | 58.4 | 0.0 | 71.7 | 9.6 | 0.4 |
| 1995 | 1,361.1 | 2,386.7 | 339.0 | 292.7 | 1,283.4 | 700.7 | 57.6 | 0.0 | 19.0 | 7.2 | 0.1 |
| 1996 | 1,056.8 | 2,292.1 | 237.9 | 238.8 | 998.2 | 609.4 | 16.1 | 0.0 | 21.6 | 11.0 | 0.1 |
| 1997 | 1,032.5 | 2,502.8 | 241.7 | 253.6 | 1,453.1 | 735.8 | 16.4 | 0.0 | 22.4 | 15.6 | 0.0 |
| 1998 | 686.2 | 1,641.1 | 188.4 | 81.6 | 493.4 | 307.8 | 48.7 | 0.0 | 62.4 | 24.1 | 0.0 |
| 1999 | 485.0 | 945.0 | 182.7 | 100.1 | 1,634.2 | 315.9 | 10.0 | 0.0 | 29.0 | 14.7 | 0.1 |
| 2000 | 34.2 | 19.6 | 2.9 | 680.8 | 2,604.8 | 379.4 | 6.8 | 0.0 | 11.9 | 2.5 | 0.0 |
| 2001 | 9.3 | 28.8 | 1.0 | 310.3 | 1,092.4 | 287.1 | 7.0 | 0.0 | 6.4 | 0.7 | 0.0 |
| 2002 | 8.7 | 6.0 | 2.4 | 40.0 | 151.7 | 59.8 | 0.0 | 0.0 | 0.4 | 0.1 | 0.0 |
| 2003 | 3.1 | 0.3 | 0.2 | 0.4 | 0.0 | 9.3 | 0.4 | 0.0 | 0.3 | 0.6 | 0.0 |
| 2004 | 5.9 | 2.4 | 0.1 | 7.5 | 0.0 | 21.3 | 0.0 | 0.0 | 0.2 | 0.1 | 0.0 |
| 2005 | 2.7 | 0.2 | 0.2 | 5.2 | 0.0 | 27.6 | 0.1 | 0.0 | 0.4 | 0.8 | 0.1 |
| 2006 | 3.8 | 2.0 | 0.3 | 3.6 | 0.0 | 9.3 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 |
| 2007 | 2.7 | 1.8 | 0.3 | 1.0 | 0.0 | 0.5 | 2.9 | 0.0 | 1.6 | 0.3 | 0.0 |
| 2008 | 0.2 | 1.7 | 0.2 | 29.2 | 0.0 | 12.9 | 0.0 | 0.0 | 1.2 | 0.0 | 0.0 |
| 2009 | 1.9 | 2.1 | 0.2 | 2.3 | 0.0 | 34.1 | 0.2 | 0.0 | 0.4 | 0.0 | 0.0 |
| 2010 | 1.2 | 2.9 | 0.7 | 9.0 | 0.0 | 45.7 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| 2011 | 1.1 | 10.0 | 7.2 | 0.0 | 12.4 | 31.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2012 | 2.3 | 27.0 | 12.0 | 0.0 | 5.9 | 41.5 | 0.0 | 0.0 | 0.2 | 0.1 | 0.0 |
| 2013 | 4.8 | 44.0 | 2.4 | 0.0 | 204.5 | 36.6 | 0.0 | 0.0 | 0.9 | 0.1 | 0.0 |
| 2014 | 2.7 | 46.1 | 22.5 | 0.0 | 259.7 | 46.9 | 0.0 | 0.0 | 1.7 | 0.1 | 0.0 |
| 2015 | 1.8 | 10.4 | 0.0 | 0.0 | 386.7 | 92.5 | 0.0 | 0.0 | 1.6 | 0.4 | 0.0 |

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **CA** | **OR** | **WA** | **CA** | **OR** | **WA** | **CA** | **WA** | **CA** | **OR** | **WA** |
| 2016 | 0.4 | 8.4 | 0.8 | 0.0 | 574.5 | 13.5 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 |
| 2017 | 1.0 | 34.3 | 0.6 | 51.9 | 4,770.3 | 29.9 | 0.0 | 0.0 | 2.3 | 0.3 | 0.1 |
| 2018 | 21.4 | 14.5 | 0.1 | 215.9 | 7,605.9 | 1,552.4 | 0.0 | 0.0 | 1.5 | 0.0 | 0.0 |
| 2019 | 10.3 | 17.6 | 0.0 | 142.6 | 6,752.5 | 1,262.8 | 0.0 | 0.0 | 2.1 | 0.0 | 0.0 |
| 2020 | 8.7 | 64.9 | 0.0 | 84.8 | 5,834.1 | 1,613.3 | 0.0 | 0.0 | 2.3 | 0.2 | 0.3 |
| 2021 | 20.1 | 83.4 | 0.2 | 169.3 | 8,395.5 | 1,576.5 | 0.0 | 0.0 | 4.2 | 0.0 | 0.4 |
| 2022 | 60.0 | 66.8 | 0.0 | 499.1 | 8,794.5 | 1,546.2 | 0.0 | 0.0 | 8.4 | 0.0 | 0.3 |
| 2023 | 35.5 | 46.8 | 0.0 | 493.4 | 8,108.4 | 1,626.3 | 0.0 | 0.0 | 6.1 | 1.0 | 0.0 |
| 2024 | 16.0 | 11.6 | 0.0 | 0.0 | 7,449.8 | 1,711.0 | 0.0 | 0.0 | 11.9 | 0.9 | 0.1 |

Table 2: Catch (mt) from the foreign & domestic at-sea fleet and the domestic shoreside hake fleet. Catches (mt) from the hake at-sea fishery as determined by onboard observers.

| Year | Foreign & Domestic | Shoreside hake | | |
|---|---|---|---|---|
| | At-sea | CA | OR | WA |
| 1966 | 3,670.0 | 0.0 | 0.0 | 0.0 |
| 1967 | 3,902.0 | 0.0 | 0.0 | 0.0 |
| 1968 | 1,956.0 | 0.0 | 0.0 | 0.0 |
| 1969 | 358.0 | 0.0 | 0.0 | 0.0 |
| 1970 | 554.0 | 0.0 | 0.0 | 0.0 |
| 1971 | 701.0 | 0.0 | 0.0 | 0.0 |
| 1972 | 421.0 | 0.0 | 0.0 | 0.0 |
| 1973 | 656.0 | 0.0 | 0.0 | 0.0 |
| 1974 | 418.0 | 0.0 | 0.0 | 0.0 |
| 1975 | 391.2 | 0.0 | 0.0 | 0.0 |
| 1976 | 718.5 | 0.0 | 0.0 | 0.0 |
| 1977 | 119.3 | 0.0 | 0.0 | 0.0 |
| 1978 | 191.9 | 0.0 | 0.0 | 0.0 |
| 1979 | 197.9 | 0.0 | 0.0 | 0.0 |
| 1980 | 272.0 | 0.0 | 0.0 | 0.0 |
| 1981 | 227.9 | 0.0 | 0.0 | 0.0 |
| 1982 | 157.5 | 0.0 | 0.0 | 0.0 |
| 1983 | 131.5 | 0.0 | 0.0 | 0.0 |
| 1984 | 294.7 | 0.0 | 0.0 | 0.0 |
| 1985 | 182.6 | 0.0 | 0.0 | 0.0 |
| 1986 | 256.8 | 0.0 | 0.0 | 0.0 |
| 1987 | 181.3 | 0.0 | 0.0 | 0.0 |
| 1988 | 231.6 | 0.0 | 0.0 | 0.0 |

| Year | Foreign & Domestic | Shoreside hake | | |
|---|---|---|---|---|
| | At-sea | CA | OR | WA |
| 1989 | 212.0 | 0.0 | 0.0 | 0.0 |
| 1990 | 230.2 | 0.0 | 0.0 | 0.0 |
| 1991 | 471.3 | 42.7 | 39.0 | 9.3 |
| 1992 | 389.6 | 13.5 | 42.1 | 6.2 |
| 1993 | 173.2 | 0.4 | 91.2 | 11.0 |
| 1994 | 370.7 | 2.1 | 210.8 | 28.6 |
| 1995 | 228.6 | 7.2 | 192.1 | 36.8 |
| 1996 | 252.2 | 5.7 | 475.1 | 104.7 |
| 1997 | 215.5 | 7.2 | 133.9 | 22.1 |
| 1998 | 268.5 | 40.4 | 278.0 | 28.1 |
| 1999 | 191.8 | 12.7 | 166.4 | 15.2 |
| 2000 | 205.4 | 7.7 | 70.9 | 4.7 |
| 2001 | 174.0 | 9.2 | 26.4 | 9.0 |
| 2002 | 154.9 | 1.2 | 2.6 | 1.4 |
| 2003 | 14.5 | 0.4 | 7.6 | 4.6 |
| 2004 | 21.2 | 7.4 | 12.4 | 8.5 |
| 2005 | 80.1 | 5.2 | 59.1 | 13.6 |
| 2006 | 143.0 | 3.6 | 11.3 | 35.3 |
| 2007 | 146.0 | 1.0 | 46.1 | 35.3 |
| 2008 | 115.2 | 29.2 | 36.1 | 37.5 |
| 2009 | 26.6 | 2.3 | 46.6 | 59.8 |
| 2010 | 44.6 | 9.0 | 35.3 | 17.5 |
| 2011 | 38.4 | 0.0 | 79.9 | 19.5 |
| 2012 | 79.2 | 0.0 | 85.1 | 17.1 |
| 2013 | 31.2 | 0.0 | 115.1 | 29.2 |
| 2014 | 56.2 | 0.0 | 250.1 | 35.9 |

| Year | Foreign & Domestic | Shoreside hake | | |
|---|---|---|---|---|
| | At-sea | CA | OR | WA |
| 2015 | 37.4 | 0.0 | 267.9 | 80.8 |
| 2016 | 193.8 | 0.0 | 187.6 | 59.3 |
| 2017 | 481.3 | 0.0 | 791.1 | 182.8 |
| 2018 | 207.6 | 0.0 | 720.3 | 153.4 |
| 2019 | 198.9 | 0.0 | 605.6 | 297.0 |
| 2020 | 86.1 | 0.0 | 474.4 | 186.2 |
| 2021 | 115.5 | 0.0 | 419.7 | 82.1 |
| 2022 | 187.1 | 0.0 | 728.8 | 203.1 |
| 2023 | 206.5 | 0.0 | 368.8 | 98.0 |
| 2024 | 66.6 | 0.0 | 408.3 | 59.0 |

Table 3: Recent trend in the OFL, ABC, ACL, total landings, total mortality all in metric tons (mt).

| Year | OFL (mt) | ABC (mt) | ACL (mt) | Landings (mt) | Total Mortality (mt) |
|---|---|---|---|---|---|
| 2015 | 4,137 | 3,929.00 | 2,000 | 879.68 | 879.87 |
| 2016 | 3,990 | 3,790.00 | 2,000 | 1,039.43 | 1,039.61 |
| 2017 | 14,130 | 13,508.28 | 13,508 | 6,345.94 | 6,361.51 |
| 2018 | 13,237 | 12,654.57 | 12,655 | 10,493.17 | 10,522.90 |
| 2019 | 12,375 | 11,830.50 | 11,831 | 9,289.44 | 9,315.29 |
| 2020 | 11,714 | 11,198.58 | 11,199 | 8,355.24 | 8,379.59 |
| 2021 | 15,749 | 14,725.32 | 14,725 | 10,866.89 | 10,899.74 |
| 2022 | 14,826 | 13,788.18 | 13,788 | 12,094.43 | 12,129.73 |
| 2023 | 13,633 | 12,624.16 | 12,624 | 10,990.57 | 11,023.51 |
| 2024 | 12,453 | 11,481.67 | 11,482 | 9,735.12 | 9,764.13 |

Table 4: Number of trips sampled for length data by gear and state for non-hake fisheries.

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | CA | WA | CA | OR | WA |
| 1971 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 1977 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1978 | 50 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 |
| 1979 | 32 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 3 | 0 | 0 |
| 1980 | 101 | 0 | 0 | 6 | 0 | 19 | 0 | 0 | 1 | 0 | 1 |
| 1981 | 72 | 3 | 0 | 59 | 20 | 31 | 0 | 0 | 6 | 0 | 0 |
| 1982 | 88 | 7 | 0 | 89 | 34 | 41 | 1 | 0 | 11 | 0 | 0 |
| 1983 | 158 | 16 | 0 | 46 | 10 | 25 | 18 | 0 | 9 | 0 | 0 |
| 1984 | 146 | 20 | 0 | 29 | 12 | 22 | 25 | 0 | 4 | 0 | 0 |
| 1985 | 149 | 20 | 0 | 25 | 35 | 16 | 81 | 0 | 5 | 0 | 0 |
| 1986 | 108 | 17 | 0 | 25 | 28 | 27 | 59 | 0 | 16 | 0 | 0 |
| 1987 | 88 | 29 | 0 | 49 | 74 | 36 | 37 | 0 | 3 | 0 | 0 |
| 1988 | 79 | 30 | 7 | 37 | 42 | 14 | 43 | 0 | 2 | 0 | 0 |
| 1989 | 81 | 49 | 14 | 30 | 67 | 16 | 81 | 0 | 7 | 0 | 0 |
| 1990 | 80 | 58 | 11 | 39 | 62 | 30 | 74 | 0 | 8 | 0 | 0 |
| 1991 | 74 | 76 | 20 | 17 | 63 | 15 | 23 | 0 | 12 | 0 | 0 |
| 1992 | 55 | 98 | 22 | 5 | 41 | 9 | 31 | 0 | 53 | 1 | 0 |

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | CA | WA | CA | OR | WA |
| 1993 | 60 | 69 | 28 | 5 | 49 | 8 | 19 | 0 | 39 | 0 | 0 |
| 1994 | 54 | 67 | 13 | 2 | 21 | 16 | 34 | 0 | 38 | 0 | 0 |
| 1995 | 53 | 47 | 17 | 11 | 14 | 16 | 14 | 0 | 7 | 0 | 0 |
| 1996 | 49 | 33 | 17 | 11 | 12 | 13 | 4 | 0 | 10 | 0 | 0 |
| 1997 | 54 | 49 | 16 | 10 | 21 | 19 | 2 | 0 | 20 | 0 | 0 |
| 1998 | 41 | 43 | 26 | 3 | 11 | 8 | 5 | 0 | 15 | 0 | 0 |
| 1999 | 38 | 28 | 21 | 5 | 19 | 11 | 1 | 0 | 3 | 1 | 0 |
| 2000 | 14 | 0 | 3 | 16 | 44 | 19 | 0 | 0 | 8 | 1 | 0 |
| 2001 | 12 | 6 | 2 | 10 | 38 | 11 | 0 | 0 | 2 | 3 | 0 |
| 2002 | 22 | 8 | 7 | 1 | 15 | 10 | 1 | 0 | 2 | 0 | 0 |
| 2003 | 7 | 0 | 1 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 |
| 2004 | 5 | 1 | 1 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 4 | 2 | 0 | 0 | 0 | 10 | 0 | 0 | 1 | 0 | 0 |
| 2006 | 7 | 3 | 2 | 0 | 0 | 8 | 0 | 0 | 4 | 1 | 0 |
| 2007 | 7 | 16 | 4 | 0 | 0 | 3 | 0 | 0 | 4 | 1 | 0 |
| 2008 | 5 | 18 | 5 | 0 | 0 | 12 | 0 | 0 | 2 | 0 | 0 |
| 2009 | 19 | 30 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 |
| 2010 | 18 | 22 | 1 | 0 | 0 | 11 | 0 | 0 | 0 | 2 | 0 |

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | CA | WA | CA | OR | WA |
| 2011 | 6 | 14 | 9 | 0 | 1 | 6 | 0 | 0 | 1 | 0 | 0 |
| 2012 | 14 | 19 | 5 | 0 | 4 | 7 | 0 | 0 | 3 | 1 | 0 |
| 2013 | 20 | 21 | 1 | 0 | 6 | 6 | 0 | 0 | 9 | 1 | 0 |
| 2014 | 18 | 20 | 3 | 0 | 5 | 7 | 0 | 0 | 12 | 2 | 0 |
| 2015 | 37 | 23 | 0 | 0 | 18 | 4 | 0 | 0 | 9 | 7 | 2 |
| 2016 | 27 | 14 | 0 | 0 | 7 | 1 | 0 | 0 | 2 | 4 | 2 |
| 2017 | 22 | 41 | 0 | 3 | 33 | 3 | 0 | 0 | 5 | 2 | 3 |
| 2018 | 31 | 25 | 7 | 10 | 60 | 4 | 0 | 0 | 3 | 4 | 7 |
| 2019 | 34 | 33 | 1 | 2 | 48 | 12 | 0 | 0 | 7 | 3 | 2 |
| 2020 | 29 | 18 | 0 | 2 | 31 | 5 | 0 | 0 | 13 | 8 | 1 |
| 2021 | 42 | 18 | 2 | 4 | 39 | 7 | 0 | 0 | 10 | 2 | 0 |
| 2022 | 13 | 10 | 0 | 12 | 46 | 4 | 0 | 0 | 2 | 5 | 2 |
| 2023 | 20 | 7 | 0 | 7 | 51 | 7 | 0 | 0 | 3 | 7 | 5 |
| 2024 | 27 | 13 | 0 | 0 | 52 | 9 | 0 | 0 | 16 | 9 | 4 |

Table 5: Number of lengths of widow rockfish by gear and state for non-hake fisheries.

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **CA** | **OR** | **WA** | **CA** | **OR** | **WA** | **CA** | **WA** | **CA** | **OR** | **WA** |
| 1971 | 0 | 0 | 0 | 0 | 0 | 408 | 0 | 0 | 0 | 0 | 0 |
| 1977 | 0 | 0 | 0 | 96 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1978 | 303 | 0 | 0 | 0 | 0 | 0 | 66 | 0 | 0 | 0 | 0 |
| 1979 | 436 | 0 | 0 | 0 | 0 | 0 | 34 | 0 | 7 | 0 | 0 |
| 1980 | 727 | 0 | 0 | 13 | 0 | 1,900 | 0 | 0 | 1 | 0 | 2 |
| 1981 | 444 | 250 | 0 | 1,340 | 1,746 | 3,100 | 0 | 0 | 19 | 0 | 0 |
| 1982 | 932 | 792 | 0 | 3,144 | 3,960 | 4,100 | 1 | 0 | 84 | 0 | 0 |
| 1983 | 1,352 | 478 | 0 | 1,411 | 321 | 2,500 | 103 | 0 | 31 | 0 | 0 |
| 1984 | 1,722 | 2,394 | 0 | 1,278 | 1,525 | 2,199 | 126 | 0 | 11 | 0 | 0 |
| 1985 | 1,853 | 2,233 | 0 | 1,176 | 3,971 | 1,600 | 557 | 0 | 8 | 0 | 0 |
| 1986 | 1,740 | 1,425 | 0 | 1,032 | 2,788 | 2,650 | 321 | 0 | 120 | 0 | 0 |
| 1987 | 998 | 865 | 0 | 1,744 | 2,198 | 1,942 | 262 | 0 | 11 | 0 | 0 |
| 1988 | 763 | 916 | 350 | 1,230 | 1,239 | 700 | 334 | 0 | 3 | 0 | 0 |
| 1989 | 1,007 | 1,099 | 700 | 1,325 | 1,843 | 800 | 450 | 0 | 23 | 0 | 0 |
| 1990 | 1,202 | 1,320 | 550 | 1,510 | 1,454 | 1,500 | 612 | 0 | 37 | 0 | 0 |
| 1991 | 1,596 | 1,569 | 997 | 761 | 1,442 | 750 | 268 | 0 | 75 | 0 | 0 |
| 1992 | 1,470 | 1,982 | 1,100 | 222 | 1,760 | 450 | 231 | 0 | 689 | 2 | 0 |

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | CA | WA | CA | OR | WA |
| 1993 | 1,682 | 1,410 | 1,400 | 231 | 1,156 | 400 | 275 | 0 | 238 | 0 | 0 |
| 1994 | 1,359 | 1,464 | 650 | 112 | 557 | 842 | 410 | 0 | 554 | 0 | 0 |
| 1995 | 1,539 | 1,066 | 850 | 519 | 296 | 800 | 175 | 0 | 22 | 0 | 0 |
| 1996 | 1,364 | 845 | 704 | 437 | 316 | 650 | 132 | 0 | 80 | 0 | 0 |
| 1997 | 2,063 | 1,231 | 557 | 382 | 620 | 950 | 80 | 0 | 212 | 0 | 0 |
| 1998 | 1,368 | 1,013 | 865 | 125 | 291 | 400 | 179 | 0 | 318 | 0 | 0 |
| 1999 | 1,420 | 727 | 952 | 240 | 514 | 550 | 1 | 0 | 104 | 20 | 0 |
| 2000 | 263 | 0 | 101 | 641 | 1,147 | 950 | 0 | 0 | 65 | 1 | 0 |
| 2001 | 139 | 98 | 2 | 349 | 960 | 550 | 0 | 0 | 4 | 20 | 0 |
| 2002 | 318 | 185 | 136 | 39 | 319 | 500 | 2 | 0 | 74 | 0 | 0 |
| 2003 | 234 | 0 | 46 | 0 | 0 | 208 | 0 | 0 | 0 | 0 | 0 |
| 2004 | 26 | 18 | 3 | 0 | 0 | 508 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 27 | 48 | 0 | 0 | 0 | 399 | 0 | 0 | 4 | 0 | 0 |
| 2006 | 79 | 58 | 7 | 0 | 0 | 461 | 0 | 0 | 36 | 1 | 0 |
| 2007 | 12 | 302 | 104 | 0 | 0 | 250 | 0 | 0 | 64 | 1 | 0 |
| 2008 | 8 | 274 | 76 | 0 | 0 | 1,086 | 0 | 0 | 27 | 0 | 0 |
| 2009 | 170 | 316 | 0 | 0 | 0 | 1,079 | 0 | 0 | 0 | 0 | 0 |
| 2010 | 205 | 233 | 100 | 0 | 0 | 903 | 0 | 0 | 0 | 5 | 0 |

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | CA | WA | CA | OR | WA |
| 2011 | 32 | 246 | 93 | 0 | 30 | 550 | 0 | 0 | 17 | 0 | 0 |
| 2012 | 136 | 353 | 241 | 0 | 95 | 688 | 0 | 0 | 9 | 7 | 0 |
| 2013 | 153 | 365 | 39 | 0 | 215 | 486 | 0 | 0 | 102 | 1 | 0 |
| 2014 | 134 | 324 | 106 | 0 | 150 | 700 | 0 | 0 | 242 | 4 | 0 |
| 2015 | 263 | 295 | 0 | 0 | 530 | 400 | 0 | 0 | 45 | 11 | 2 |
| 2016 | 143 | 254 | 0 | 0 | 210 | 100 | 0 | 0 | 38 | 4 | 24 |
| 2017 | 316 | 864 | 0 | 158 | 949 | 125 | 0 | 0 | 73 | 3 | 23 |
| 2018 | 645 | 161 | 12 | 507 | 1,492 | 350 | 0 | 0 | 32 | 7 | 10 |
| 2019 | 566 | 346 | 50 | 90 | 1,149 | 600 | 0 | 0 | 47 | 6 | 7 |
| 2020 | 593 | 228 | 0 | 83 | 759 | 233 | 0 | 0 | 134 | 15 | 1 |
| 2021 | 850 | 226 | 8 | 183 | 890 | 307 | 0 | 0 | 67 | 3 | 0 |
| 2022 | 272 | 185 | 0 | 502 | 1,025 | 180 | 0 | 0 | 11 | 7 | 3 |
| 2023 | 376 | 135 | 0 | 316 | 1,125 | 571 | 0 | 0 | 18 | 97 | 13 |
| 2024 | 540 | 164 | 0 | 0 | 1,255 | 830 | 0 | 0 | 268 | 86 | 10 |

Table 6: Number of hauls or trips and number of lengths sampled from the at-sea hake and shoreside hake fisheries.

| Year | Number of hauls (at-sea) or trips (shoreside) | | Number of lengths | |
|---|---|---|---|---|
| | Domestic at-sea | Shoreside | Domestic at-sea | Shoreside |
| 1992 | 214 | 0 | 1,474 | 0 |
| 1993 | 239 | 0 | 1,468 | 0 |
| 1994 | 361 | 3 | 3,458 | 78 |
| 1995 | 304 | 19 | 1,789 | 570 |
| 1996 | 332 | 18 | 2,620 | 540 |
| 1997 | 397 | 30 | 2,841 | 869 |
| 1998 | 481 | 32 | 2,431 | 975 |
| 1999 | 598 | 52 | 3,070 | 1,551 |
| 2000 | 571 | 33 | 2,845 | 1,004 |
| 2001 | 522 | 19 | 1,758 | 576 |
| 2002 | 369 | 3 | 1,204 | 70 |
| 2003 | 291 | 2 | 665 | 26 |
| 2004 | 512 | 19 | 1,670 | 380 |
| 2005 | 1,228 | 1 | 5,538 | 50 |
| 2006 | 1,295 | 14 | 6,104 | 594 |
| 2007 | 1,491 | 21 | 10,658 | 860 |
| 2008 | 1,138 | 36 | 7,324 | 966 |
| 2009 | 400 | 24 | 1,976 | 845 |
| 2010 | 980 | 43 | 4,734 | 1,214 |
| 2011 | 982 | 43 | 3,605 | 1,286 |
| 2012 | 914 | 46 | 4,779 | 1,291 |
| 2013 | 901 | 40 | 3,808 | 1,160 |
| 2014 | 773 | 50 | 3,970 | 1,452 |

| Year | Number of hauls (at-sea) or trips (shoreside) | | Number of lengths | |
|---|---|---|---|---|
| | Domestic at-sea | Shoreside | Domestic at-sea | Shoreside |
| 2015 | 522 | 36 | 2,312 | 1,313 |
| 2016 | 801 | 49 | 3,934 | 1,465 |
| 2017 | 997 | 57 | 5,406 | 1,353 |
| 2018 | 461 | 65 | 2,245 | 1,283 |
| 2019 | 469 | 73 | 2,642 | 1,536 |
| 2020 | 214 | 37 | 902 | 839 |
| 2021 | 310 | 61 | 1,776 | 1,279 |
| 2022 | 333 | 88 | 1,489 | 1,745 |
| 2023 | 469 | 68 | 1,738 | 1,525 |
| 2024 | 83 | 60 | 251 | 1,231 |

Table 7: Number of trips sampled for ages by gear and state for non-hake fisheries.

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | CA | WA | CA | OR | WA |
| 1978 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1979 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1980 | 27 | 0 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 0 |
| 1981 | 14 | 3 | 0 | 30 | 20 | 31 | 0 | 0 | 0 | 0 | 0 |
| 1982 | 87 | 6 | 0 | 71 | 34 | 40 | 1 | 0 | 4 | 0 | 0 |
| 1983 | 151 | 16 | 0 | 45 | 10 | 25 | 5 | 0 | 2 | 0 | 0 |
| 1984 | 144 | 20 | 0 | 29 | 12 | 22 | 10 | 0 | 2 | 0 | 0 |
| 1985 | 137 | 20 | 0 | 25 | 33 | 16 | 65 | 0 | 3 | 0 | 0 |
| 1986 | 106 | 17 | 0 | 22 | 28 | 27 | 53 | 0 | 3 | 0 | 0 |
| 1987 | 84 | 27 | 0 | 49 | 62 | 36 | 27 | 0 | 0 | 0 | 0 |
| 1988 | 67 | 29 | 6 | 34 | 41 | 14 | 39 | 0 | 2 | 0 | 0 |
| 1989 | 75 | 49 | 14 | 30 | 66 | 16 | 75 | 0 | 3 | 0 | 0 |
| 1990 | 70 | 58 | 11 | 32 | 62 | 30 | 65 | 0 | 2 | 0 | 0 |
| 1991 | 65 | 76 | 20 | 17 | 63 | 15 | 19 | 0 | 9 | 0 | 0 |
| 1992 | 45 | 93 | 22 | 4 | 26 | 9 | 21 | 0 | 15 | 0 | 0 |
| 1993 | 28 | 67 | 28 | 0 | 49 | 8 | 6 | 0 | 3 | 0 | 0 |
| 1994 | 28 | 67 | 13 | 2 | 21 | 15 | 7 | 0 | 1 | 0 | 0 |

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | CA | WA | CA | OR | WA |
| 1995 | 8 | 45 | 17 | 3 | 13 | 16 | 0 | 0 | 0 | 0 | 0 |
| 1996 | 36 | 32 | 14 | 6 | 11 | 13 | 2 | 0 | 1 | 0 | 0 |
| 1997 | 42 | 46 | 11 | 10 | 20 | 19 | 0 | 0 | 9 | 0 | 0 |
| 1998 | 27 | 42 | 14 | 2 | 11 | 8 | 2 | 0 | 3 | 0 | 0 |
| 1999 | 29 | 27 | 19 | 3 | 18 | 10 | 0 | 0 | 0 | 0 | 0 |
| 2000 | 8 | 0 | 2 | 9 | 42 | 19 | 0 | 0 | 3 | 0 | 0 |
| 2001 | 2 | 6 | 0 | 4 | 35 | 10 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 17 | 8 | 2 | 1 | 15 | 10 | 1 | 0 | 0 | 0 | 0 |
| 2003 | 3 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 |
| 2004 | 3 | 0 | 1 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 0 | 2 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 |
| 2006 | 6 | 3 | 1 | 0 | 0 | 8 | 0 | 0 | 2 | 1 | 0 |
| 2007 | 6 | 16 | 4 | 0 | 0 | 3 | 0 | 0 | 3 | 1 | 0 |
| 2008 | 5 | 18 | 5 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 |
| 2009 | 8 | 29 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 |
| 2010 | 7 | 21 | 1 | 0 | 0 | 11 | 0 | 0 | 0 | 2 | 0 |
| 2011 | 0 | 5 | 7 | 0 | 1 | 5 | 0 | 0 | 0 | 0 | 0 |
| 2012 | 0 | 8 | 5 | 0 | 0 | 7 | 0 | 0 | 0 | 1 | 0 |

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | CA | WA | CA | OR | WA |
| 2013 | 0 | 7 | 1 | 0 | 3 | 5 | 0 | 0 | 0 | 0 | 0 |
| 2014 | 0 | 4 | 2 | 0 | 1 | 7 | 0 | 0 | 0 | 0 | 0 |
| 2015 | 0 | 22 | 0 | 0 | 14 | 4 | 0 | 0 | 0 | 0 | 1 |
| 2016 | 0 | 13 | 0 | 0 | 6 | 1 | 0 | 0 | 0 | 0 | 2 |
| 2017 | 0 | 36 | 0 | 0 | 31 | 3 | 0 | 0 | 0 | 0 | 3 |
| 2018 | 0 | 25 | 7 | 0 | 46 | 4 | 0 | 0 | 0 | 0 | 7 |
| 2019 | 0 | 16 | 1 | 0 | 34 | 12 | 0 | 0 | 0 | 0 | 1 |
| 2020 | 0 | 15 | 0 | 0 | 25 | 5 | 0 | 0 | 0 | 2 | 0 |
| 2021 | 0 | 12 | 2 | 0 | 31 | 6 | 0 | 0 | 0 | 0 | 0 |
| 2022 | 0 | 8 | 0 | 0 | 45 | 4 | 0 | 0 | 0 | 0 | 2 |
| 2023 | 0 | 5 | 0 | 0 | 48 | 7 | 0 | 0 | 0 | 1 | 5 |
| 2024 | 0 | 7 | 0 | 0 | 42 | 7 | 0 | 0 | 0 | 0 | 0 |

Table 8: Number of trips sampled for ages by gear and state for non-hake fisheries.

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | CA | WA | CA | OR | WA |
| 1978 | 107 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1979 | 269 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | CA | WA | CA | OR | WA |
| 1980 | 404 | 0 | 0 | 0 | 0 | 1,775 | 0 | 0 | 0 | 0 | 0 |
| 1981 | 205 | 109 | 0 | 598 | 600 | 3,050 | 0 | 0 | 0 | 0 | 0 |
| 1982 | 834 | 174 | 0 | 2,382 | 1,019 | 3,944 | 1 | 0 | 18 | 0 | 0 |
| 1983 | 1,283 | 475 | 0 | 1,365 | 321 | 2,480 | 55 | 0 | 3 | 0 | 0 |
| 1984 | 1,678 | 600 | 0 | 1,278 | 360 | 2,194 | 89 | 0 | 5 | 0 | 0 |
| 1985 | 1,762 | 589 | 0 | 1,176 | 963 | 1,591 | 477 | 0 | 4 | 0 | 0 |
| 1986 | 1,704 | 680 | 0 | 913 | 939 | 2,594 | 188 | 0 | 5 | 0 | 0 |
| 1987 | 968 | 805 | 0 | 1,742 | 1,837 | 1,940 | 186 | 0 | 0 | 0 | 0 |
| 1988 | 692 | 886 | 298 | 1,132 | 1,209 | 695 | 290 | 0 | 3 | 0 | 0 |
| 1989 | 919 | 1,099 | 695 | 1,323 | 1,794 | 799 | 403 | 0 | 6 | 0 | 0 |
| 1990 | 1,051 | 1,310 | 550 | 1,309 | 1,447 | 1,497 | 533 | 0 | 8 | 0 | 0 |
| 1991 | 1,308 | 1,566 | 991 | 761 | 1,413 | 748 | 164 | 0 | 23 | 0 | 0 |
| 1992 | 676 | 1,889 | 1,097 | 82 | 574 | 450 | 87 | 0 | 91 | 0 | 0 |
| 1993 | 472 | 1,361 | 1,398 | 0 | 1,155 | 400 | 57 | 0 | 3 | 0 | 0 |
| 1994 | 516 | 1,463 | 650 | 54 | 556 | 749 | 58 | 0 | 1 | 0 | 0 |
| 1995 | 167 | 1,027 | 850 | 68 | 276 | 800 | 0 | 0 | 0 | 0 | 0 |
| 1996 | 873 | 827 | 699 | 158 | 292 | 649 | 88 | 0 | 7 | 0 | 0 |
| 1997 | 892 | 1,164 | 549 | 187 | 593 | 949 | 0 | 0 | 55 | 0 | 0 |

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **CA** | **OR** | **WA** | **CA** | **OR** | **WA** | **CA** | **WA** | **CA** | **OR** | **WA** |
| 1998 | 1,019 | 987 | 699 | 82 | 291 | 400 | 84 | 0 | 46 | 0 | 0 |
| 1999 | 1,026 | 706 | 950 | 133 | 479 | 500 | 0 | 0 | 0 | 0 | 0 |
| 2000 | 157 | 0 | 100 | 353 | 1,067 | 948 | 0 | 0 | 12 | 0 | 0 |
| 2001 | 43 | 98 | 0 | 132 | 858 | 485 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 294 | 179 | 99 | 21 | 319 | 488 | 2 | 0 | 0 | 0 | 0 |
| 2003 | 87 | 0 | 0 | 0 | 0 | 208 | 0 | 0 | 0 | 0 | 0 |
| 2004 | 7 | 0 | 3 | 0 | 0 | 506 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 0 | 48 | 0 | 0 | 0 | 399 | 0 | 0 | 0 | 0 | 0 |
| 2006 | 74 | 58 | 6 | 0 | 0 | 361 | 0 | 0 | 5 | 1 | 0 |
| 2007 | 11 | 302 | 54 | 0 | 0 | 150 | 0 | 0 | 23 | 1 | 0 |
| 2008 | 8 | 274 | 75 | 0 | 0 | 600 | 0 | 0 | 0 | 0 | 0 |
| 2009 | 81 | 315 | 0 | 0 | 0 | 759 | 0 | 0 | 0 | 0 | 0 |
| 2010 | 54 | 231 | 50 | 0 | 0 | 539 | 0 | 0 | 0 | 5 | 0 |
| 2011 | 0 | 63 | 84 | 0 | 30 | 250 | 0 | 0 | 0 | 0 | 0 |
| 2012 | 0 | 80 | 73 | 0 | 0 | 163 | 0 | 0 | 0 | 7 | 0 |
| 2013 | 0 | 190 | 26 | 0 | 90 | 153 | 0 | 0 | 0 | 0 | 0 |
| 2014 | 0 | 91 | 52 | 0 | 30 | 229 | 0 | 0 | 0 | 0 | 0 |
| 2015 | 0 | 152 | 0 | 0 | 69 | 195 | 0 | 0 | 0 | 0 | 1 |

| Year | Bottom Trawl | | | Midwater Trawl | | | Net | | Hook-and-Line | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | CA | WA | CA | OR | WA |
| 2016 | 0 | 156 | 0 | 0 | 36 | 28 | 0 | 0 | 0 | 0 | 24 |
| 2017 | 0 | 209 | 0 | 0 | 223 | 100 | 0 | 0 | 0 | 0 | 23 |
| 2018 | 0 | 161 | 12 | 0 | 495 | 200 | 0 | 0 | 0 | 0 | 10 |
| 2019 | 0 | 55 | 49 | 0 | 176 | 597 | 0 | 0 | 0 | 0 | 1 |
| 2020 | 0 | 61 | 0 | 0 | 134 | 233 | 0 | 0 | 0 | 3 | 0 |
| 2021 | 0 | 53 | 8 | 0 | 135 | 300 | 0 | 0 | 0 | 0 | 0 |
| 2022 | 0 | 44 | 0 | 0 | 281 | 129 | 0 | 0 | 0 | 0 | 3 |
| 2023 | 0 | 28 | 0 | 0 | 312 | 320 | 0 | 0 | 0 | 2 | 13 |
| 2024 | 0 | 33 | 0 | 0 | 248 | 340 | 0 | 0 | 0 | 0 | 0 |

Table 9: Discard totals (mt) for two fleets derived from Pikitch data, EDCP data, and WCGOP data.

| Fleet | Year | Source | Discards | CV |
|---|---|---|---|---|
| Bottom Trawl | 1985 | Pikitch | 463 | 49.53% |
| Bottom Trawl | 1986 | Pikitch | 535 | 53.11% |
| Bottom Trawl | 1987 | Pikitch | 1,036 | 42.57% |
| Bottom Trawl | 1995 | EDCP | 925 | 83.18% |
| Bottom Trawl | 1996 | EDCP | 3,084 | 67.07% |
| Bottom Trawl | 1997 | EDCP | 3,353 | 75.06% |
| Bottom Trawl | 1998 | EDCP | 43 | 48.80% |
| Bottom Trawl | 1999 | EDCP | 5 | 68.78% |
| Bottom Trawl | 2002 | WCGOP | 13 | 43.07% |
| Bottom Trawl | 2003 | WCGOP | 1 | 81.96% |
| Bottom Trawl | 2004 | WCGOP | 5 | 75.89% |
| Bottom Trawl | 2005 | WCGOP | 10 | 44.61% |
| Bottom Trawl | 2006 | WCGOP | 0 | 135.56% |
| Bottom Trawl | 2007 | WCGOP | 14 | 61.57% |
| Bottom Trawl | 2008 | WCGOP | 4 | 44.54% |
| Bottom Trawl | 2009 | WCGOP | 27 | 33.77% |
| Bottom Trawl | 2010 | WCGOP | 23 | 54.32% |
| Bottom Trawl | 2011 | WCGOP | 0 | 5.00% |
| Bottom Trawl | 2012 | WCGOP | 0 | 5.00% |
| Bottom Trawl | 2013 | WCGOP | 2 | 5.00% |
| Bottom Trawl | 2014 | WCGOP | 0 | 5.00% |
| Bottom Trawl | 2015 | WCGOP | 0 | 5.00% |
| Bottom Trawl | 2016 | WCGOP | 0 | 5.00% |
| Bottom Trawl | 2017 | WCGOP | 0 | 5.00% |
| Bottom Trawl | 2018 | WCGOP | 0 | 5.00% |
| Bottom Trawl | 2019 | WCGOP | 1 | 5.00% |

| Fleet | Year | Source | Discards | CV |
|---|---|---|---|---|
| Bottom Trawl | 2020 | WCGOP | 0 | 5.00% |
| Bottom Trawl | 2021 | WCGOP | 0 | 5.00% |
| Bottom Trawl | 2022 | WCGOP | 0 | 5.00% |
| Bottom Trawl | 2023 | WCGOP | 0 | 5.00% |
| Midwater | 1985 | Pikitch | 1,502 | 24.09% |
| Midwater | 1986 | Pikitch | 1,321 | 23.64% |
| Midwater | 1987 | Pikitch | 1,798 | 26.20% |
| Midwater | 1997 | EDCP | 1 | 83.26% |
| Midwater | 1998 | EDCP | 19 | 80.00% |
| Midwater | 2002 | WCGOP | 39 | 40.71% |
| Midwater | 2012 | WCGOP | 0 | 5.00% |
| Midwater | 2013 | WCGOP | 0 | 5.00% |
| Midwater | 2014 | WCGOP | 0 | 5.00% |
| Midwater | 2015 | WCGOP | 1 | 5.00% |
| Midwater | 2016 | WCGOP | 2 | 5.00% |
| Midwater | 2017 | WCGOP | 10 | 5.00% |
| Midwater | 2018 | WCGOP | 37 | 5.00% |
| Midwater | 2019 | WCGOP | 19 | 5.00% |
| Midwater | 2020 | WCGOP | 45 | 5.00% |
| Midwater | 2021 | WCGOP | 36 | 5.00% |
| Midwater | 2022 | WCGOP | 48 | 5.00% |
| Midwater | 2023 | WCGOP | 17 | 5.00% |

#### 5.1.2 Fishery-independent data

Table 10: Stratifications used for the WCGBTS.

| Strata | Area (km2) | Depth1 | Depth2 | Latitude1 | Latitude2 |
|---|---|---|---|---|---|
| A | 10,687.86 | 55 | 183 | 34.5 | 40.5 |
| B | 3,394.82 | 183 | 400 | 34.5 | 40.5 |
| C | 23,042.39 | 55 | 183 | 40.5 | 49.0 |
| D | 7,667.81 | 183 | 400 | 40.5 | 49.0 |

Table 11: Number of positive tows, lengths, and ages in each year from the Triennial survey (Tri) and the WCGBTS (NW).

| Year | Number of positive tows | | Number of tows with lengths | | Number of lengths | | Number of tows with ages | | Number of ages | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tri | NW | Tri | NW | Tri | NW | Tri | NW | Tri | NW |
| 1977 | 80 | | 1 | | 9 | | | | | |
| 1980 | 38 | | 3 | | 166 | | 1 | | 22 | |
| 1983 | 70 | | 5 | | 385 | | | | | |
| 1986 | 46 | | 8 | | 317 | | | | | |
| 1989 | 38 | | 20 | | 713 | | | | | |
| 1992 | 50 | | 10 | | 708 | | | | | |
| 1995 | 43 | | 43 | | 500 | | | | | |
| 1998 | 59 | | 58 | | 738 | | | | | |
| 2001 | 28 | | 28 | | 130 | | | | | |
| 2003 | | 20 | | 18 | | 216 | | | | |
| 2004 | 36 | 12 | 33 | 12 | 219 | 84 | | 12 | | 43 |
| 2005 | | 20 | | 20 | | 78 | | 18 | | 65 |
| 2006 | | 26 | | 26 | | 172 | | 26 | | 89 |
| 2007 | | 27 | | 27 | | 92 | | 27 | | 83 |
| 2008 | | 17 | | 17 | | 26 | | 15 | | 20 |
| 2009 | | 31 | | 31 | | 141 | | 31 | | 123 |
| 2010 | | 28 | | 28 | | 240 | | 28 | | 116 |
| 2011 | | 31 | | 31 | | 313 | | 31 | | 152 |
| 2012 | | 32 | | 32 | | 181 | | 32 | | 91 |
| 2013 | | 18 | | 18 | | 364 | | 18 | | 246 |
| 2014 | | 29 | | 28 | | 349 | | 28 | | 264 |
| 2015 | | 21 | | 21 | | 149 | | 21 | | 93 |
| 2016 | | 40 | | 40 | | 888 | | 40 | | 556 |
| 2017 | | 30 | | 30 | | 310 | | 30 | | 213 |

| Year | Number of positive tows | | Number of tows with lengths | | Number of lengths | | Number of tows with ages | | Number of ages | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tri | NW | Tri | NW | Tri | NW | Tri | NW | Tri | NW |
| 2018 | | 34 | | 34 | | 410 | | 34 | | 353 |
| 2019 | | 23 | | 23 | | 219 | | 23 | | 161 |
| 2021 | | 18 | | 17 | | 66 | | 17 | | 66 |
| 2022 | | 18 | | 18 | | 125 | | 18 | | 109 |
| 2023 | | 30 | | 29 | | 159 | | 29 | | 110 |
| 2024 | | 35 | | 35 | | 485 | | 35 | | 347 |

### 5.2 Model results

Table 12: Specifications of the base assessment model for widow rockfish.

| | | |
|---|---|---|
| *Starting year* | | 1916 |
| *Population characteristics* | | |
| | Maximum age | 40 |
| | Genders | 2 |
| | Population length bins | 6-60 cm by 1 cm bins |
| | Summary biomass (mt) | Age 4+ |
| *Data characteristics* | | |
| | Data lengths | 8-56 cm by 2 cm bins |
| | Data ages | 14611 |
| | First reference age for growth calcs | 3 |
| | Second reference age for growth calcs | 40 |
| | First mature age | 3 |
| | Starting year of estimated recruitment | 1900 |
| *Fishery characteristics* | | |
| | Catchability | Analytical estimate |
| | Fishery selectivity (not midwater trawl) | Asymptotic Double Normal |

| | | |
|---|---|---|
| | Midwater trawl fishery selectivity | Dome-shaped Double Normal |
| | Juvenile survey selectivity | Double Normal |
| | Triennial survey selectivity | Cubic spline with 3 nodes |
| | WCGBTS selectivity | Cubic spline with 3 nodes |
| *Fishery time blocks* | | |
| | Bottom trawl selectiviy | 1916 - 2001, 2002 - |
| | Bottom trawl retention | 1916 - 1981, 2011 - |
| | Midwater trawl selectivtiy | 1916–1982, 1983–2001, 2002–2010, 2011– |
| | Midwater trawl retention | 1916–1982, 1983–2001, 2002–2010, 2011–2016, 2017 - |
| | Hake trawl selectivity | 1916 - 2019, 2020 - |
| | Hook-and-line selectivity | 1916–2002, 2003– |

Table 13: Parameter estimates, parameter bounds (low, high), estimation status, estimated standard deviation (SD), prior information [distribution(mean, SD)] used in the base model.

| Label | Value | Bounds | Status | SD | Prior |
|---|---|---|---|---|---|
| NatM_uniform_Fem_GP_1 | 0.122 | (0.01, 0.3) | ok | 0.00785 | lognormal(0.100, 0.310) |
| L_at_Amin_Fem_GP_1 | 20.7 | (10, 40) | ok | 0.457 | none |
| L_at_Amax_Fem_GP_1 | 49.5 | (35, 60) | ok | 0.259 | none |
| VonBert_K_Fem_GP_1 | 0.181 | (0.01, 0.4) | ok | 0.00623 | none |
| CV_young_Fem_GP_1 | 0.116 | (0.01, 0.4) | ok | 0.00929 | none |
| CV_old_Fem_GP_1 | 0.048 | (0.01, 0.4) | ok | 0.00268 | none |
| Wtlen_1_Fem_GP_1 | 1.59e-05 | (-3, 3) | fixed | 0 | none |
| Wtlen_2_Fem_GP_1 | 2.99 | (-3, 10) | fixed | 0 | none |
| Mat50%_Fem_GP_1 | 5.47 | (-3, 50) | fixed | 0 | none |
| Mat_slope_Fem_GP_1 | -0.775 | (-3, 3) | fixed | 0 | none |
| Eggs/kg_inter_Fem_GP_1 | 1 | (-1, 1) | fixed | 0 | none |
| Eggs/kg_slope_wt_Fem_GP_1 | 0 | (0, 1) | fixed | 0 | none |
| NatM_uniform_Mal_GP_1 | 0.135 | (0.01, 0.3) | ok | 0.00802 | lognormal(0.100, 0.310) |
| L_at_Amin_Mal_GP_1 | 21 | (10, 40) | ok | 0.393 | none |
| L_at_Amax_Mal_GP_1 | 43.6 | (35, 60) | ok | 0.235 | none |
| VonBert_K_Mal_GP_1 | 0.245 | (0.01, 0.4) | ok | 0.00936 | none |
| CV_young_Mal_GP_1 | 0.0947 | (0.01, 0.4) | ok | 0.00708 | none |

| Label | Value | Bounds | Status | SD | Prior |
|---|---|---|---|---|---|
| CV_old_Mal_GP_1 | 0.0563 | (0.01, 0.4) | ok | 0.00276 | none |
| Wtlen_1_Mal_GP_1 | 1.45e-05 | (-3, 3) | fixed | 0 | none |
| Wtlen_2_Mal_GP_1 | 3.01 | (-3, 10) | fixed | 0 | none |
| CohortGrowDev | 1 | (0, 2) | fixed | 0 | none |
| FracFemale_GP_1 | 0.5 | (1e-06, 1) | fixed | 0 | none |
| SR_LN(R0) | 10.5 | (1, 20) | ok | 0.16 | none |
| SR_BH_steep | 0.72 | (0.2, 1) | fixed | 0 | beta(0.720, 0.160) |
| SR_sigmaR | 0.6 | (0, 2) | fixed | 0 | none |
| SR_regime | 0 | (-5, 5) | fixed | 0 | none |
| SR_autocorr | 0 | (0, 0.5) | fixed | 0 | none |
| Early_InitAge_16 | -0.00192 | (-5, 5) | dev | 0.599 | normal(0.00, 0.60) |
| Early_InitAge_15 | -0.00216 | (-5, 5) | dev | 0.599 | normal(0.00, 0.60) |
| Early_InitAge_14 | -0.00243 | (-5, 5) | dev | 0.599 | normal(0.00, 0.60) |
| Early_InitAge_13 | -0.00273 | (-5, 5) | dev | 0.599 | normal(0.00, 0.60) |
| Early_InitAge_12 | -0.00307 | (-5, 5) | dev | 0.599 | normal(0.00, 0.60) |
| Early_InitAge_11 | -0.00344 | (-5, 5) | dev | 0.599 | normal(0.00, 0.60) |
| Early_InitAge_10 | -0.00385 | (-5, 5) | dev | 0.599 | normal(0.00, 0.60) |
| Early_InitAge_9 | -0.0043 | (-5, 5) | dev | 0.599 | normal(0.00, 0.60) |
| Early_InitAge_8 | -0.00479 | (-5, 5) | dev | 0.599 | normal(0.00, 0.60) |

| Label | Value | Bounds | Status | SD | Prior |
|---|---|---|---|---|---|
| Early_InitAge_7 | -0.00531 | (-5, 5) | dev | 0.598 | normal(0.00, 0.60) |
| Early_InitAge_6 | -0.00588 | (-5, 5) | dev | 0.598 | normal(0.00, 0.60) |
| Early_InitAge_5 | -0.00648 | (-5, 5) | dev | 0.598 | normal(0.00, 0.60) |
| Early_InitAge_4 | -0.00714 | (-5, 5) | dev | 0.598 | normal(0.00, 0.60) |
| Early_InitAge_3 | -0.00786 | (-5, 5) | dev | 0.598 | normal(0.00, 0.60) |
| Early_InitAge_2 | -0.00865 | (-5, 5) | dev | 0.598 | normal(0.00, 0.60) |
| Early_InitAge_1 | -0.00951 | (-5, 5) | dev | 0.597 | normal(0.00, 0.60) |
| Early_RecrDev_1916 | -0.0105 | (-5, 5) | dev | 0.597 | normal(0.00, 0.60) |
| Early_RecrDev_1917 | -0.0115 | (-5, 5) | dev | 0.597 | normal(0.00, 0.60) |
| Early_RecrDev_1918 | -0.0127 | (-5, 5) | dev | 0.596 | normal(0.00, 0.60) |
| Early_RecrDev_1919 | -0.0139 | (-5, 5) | dev | 0.596 | normal(0.00, 0.60) |
| Early_RecrDev_1920 | -0.0153 | (-5, 5) | dev | 0.596 | normal(0.00, 0.60) |
| Early_RecrDev_1921 | -0.0168 | (-5, 5) | dev | 0.595 | normal(0.00, 0.60) |
| Early_RecrDev_1922 | -0.0185 | (-5, 5) | dev | 0.595 | normal(0.00, 0.60) |
| Early_RecrDev_1923 | -0.0204 | (-5, 5) | dev | 0.594 | normal(0.00, 0.60) |
| Early_RecrDev_1924 | -0.0224 | (-5, 5) | dev | 0.594 | normal(0.00, 0.60) |
| Early_RecrDev_1925 | -0.0246 | (-5, 5) | dev | 0.593 | normal(0.00, 0.60) |
| Early_RecrDev_1926 | -0.0271 | (-5, 5) | dev | 0.592 | normal(0.00, 0.60) |
| Early_RecrDev_1927 | -0.0298 | (-5, 5) | dev | 0.592 | normal(0.00, 0.60) |

| Label | Value | Bounds | Status | SD | Prior |
|---|---|---|---|---|---|
| Early_RecrDev_1928 | -0.0327 | (-5, 5) | dev | 0.591 | normal(0.00, 0.60) |
| Early_RecrDev_1929 | -0.036 | (-5, 5) | dev | 0.59 | normal(0.00, 0.60) |
| Early_RecrDev_1930 | -0.0395 | (-5, 5) | dev | 0.589 | normal(0.00, 0.60) |
| Early_RecrDev_1931 | -0.0434 | (-5, 5) | dev | 0.588 | normal(0.00, 0.60) |
| Early_RecrDev_1932 | -0.0476 | (-5, 5) | dev | 0.587 | normal(0.00, 0.60) |
| Early_RecrDev_1933 | -0.0523 | (-5, 5) | dev | 0.585 | normal(0.00, 0.60) |
| Early_RecrDev_1934 | -0.0574 | (-5, 5) | dev | 0.584 | normal(0.00, 0.60) |
| Early_RecrDev_1935 | -0.0629 | (-5, 5) | dev | 0.583 | normal(0.00, 0.60) |
| Early_RecrDev_1936 | -0.069 | (-5, 5) | dev | 0.581 | normal(0.00, 0.60) |
| Early_RecrDev_1937 | -0.0757 | (-5, 5) | dev | 0.579 | normal(0.00, 0.60) |
| Early_RecrDev_1938 | -0.0831 | (-5, 5) | dev | 0.577 | normal(0.00, 0.60) |
| Early_RecrDev_1939 | -0.0913 | (-5, 5) | dev | 0.575 | normal(0.00, 0.60) |
| Early_RecrDev_1940 | -0.1 | (-5, 5) | dev | 0.573 | normal(0.00, 0.60) |
| Early_RecrDev_1941 | -0.11 | (-5, 5) | dev | 0.57 | normal(0.00, 0.60) |
| Early_RecrDev_1942 | -0.121 | (-5, 5) | dev | 0.567 | normal(0.00, 0.60) |
| Early_RecrDev_1943 | -0.132 | (-5, 5) | dev | 0.565 | normal(0.00, 0.60) |
| Early_RecrDev_1944 | -0.144 | (-5, 5) | dev | 0.562 | normal(0.00, 0.60) |
| Early_RecrDev_1945 | -0.156 | (-5, 5) | dev | 0.559 | normal(0.00, 0.60) |
| Early_RecrDev_1946 | -0.167 | (-5, 5) | dev | 0.556 | normal(0.00, 0.60) |

| Label | Value | Bounds | Status | SD | Prior |
|---|---|---|---|---|---|
| Early_RecrDev_1947 | -0.179 | (-5, 5) | dev | 0.553 | normal(0.00, 0.60) |
| Early_RecrDev_1948 | -0.19 | (-5, 5) | dev | 0.551 | normal(0.00, 0.60) |
| Early_RecrDev_1949 | -0.2 | (-5, 5) | dev | 0.548 | normal(0.00, 0.60) |
| Early_RecrDev_1950 | -0.208 | (-5, 5) | dev | 0.546 | normal(0.00, 0.60) |
| Early_RecrDev_1951 | -0.214 | (-5, 5) | dev | 0.544 | normal(0.00, 0.60) |
| Early_RecrDev_1952 | -0.217 | (-5, 5) | dev | 0.543 | normal(0.00, 0.60) |
| Early_RecrDev_1953 | -0.214 | (-5, 5) | dev | 0.543 | normal(0.00, 0.60) |
| Early_RecrDev_1954 | -0.205 | (-5, 5) | dev | 0.544 | normal(0.00, 0.60) |
| Early_RecrDev_1955 | -0.188 | (-5, 5) | dev | 0.546 | normal(0.00, 0.60) |
| Early_RecrDev_1956 | -0.164 | (-5, 5) | dev | 0.55 | normal(0.00, 0.60) |
| Early_RecrDev_1957 | -0.135 | (-5, 5) | dev | 0.553 | normal(0.00, 0.60) |
| Early_RecrDev_1958 | -0.108 | (-5, 5) | dev | 0.556 | normal(0.00, 0.60) |
| Early_RecrDev_1959 | -0.0933 | (-5, 5) | dev | 0.557 | normal(0.00, 0.60) |
| Early_RecrDev_1960 | -0.0949 | (-5, 5) | dev | 0.554 | normal(0.00, 0.60) |
| Early_RecrDev_1961 | -0.104 | (-5, 5) | dev | 0.549 | normal(0.00, 0.60) |
| Early_RecrDev_1962 | -0.0997 | (-5, 5) | dev | 0.546 | normal(0.00, 0.60) |
| Early_RecrDev_1963 | -0.0661 | (-5, 5) | dev | 0.546 | normal(0.00, 0.60) |
| Early_RecrDev_1964 | -0.0107 | (-5, 5) | dev | 0.549 | normal(0.00, 0.60) |
| Early_RecrDev_1965 | 0.049 | (-5, 5) | dev | 0.55 | normal(0.00, 0.60) |

| Label | Value | Bounds | Status | SD | Prior |
|---|---|---|---|---|---|
| Early_RecrDev_1966 | 0.11 | (-5, 5) | dev | 0.545 | normal(0.00, 0.60) |
| Early_RecrDev_1967 | 0.125 | (-5, 5) | dev | 0.531 | normal(0.00, 0.60) |
| Early_RecrDev_1968 | 0.081 | (-5, 5) | dev | 0.504 | normal(0.00, 0.60) |
| Early_RecrDev_1969 | -0.048 | (-5, 5) | dev | 0.533 | normal(0.00, 0.60) |
| Main_RecrDev_1970 | 1.34 | (-5, 5) | dev | 0.281 | normal(0.00, 0.60) |
| Main_RecrDev_1971 | 1.16 | (-5, 5) | dev | 0.263 | normal(0.00, 0.60) |
| Main_RecrDev_1972 | -0.843 | (-5, 5) | dev | 0.415 | normal(0.00, 0.60) |
| Main_RecrDev_1973 | -1.01 | (-5, 5) | dev | 0.365 | normal(0.00, 0.60) |
| Main_RecrDev_1974 | -0.7 | (-5, 5) | dev | 0.324 | normal(0.00, 0.60) |
| Main_RecrDev_1975 | 0.043 | (-5, 5) | dev | 0.198 | normal(0.00, 0.60) |
| Main_RecrDev_1976 | -1.09 | (-5, 5) | dev | 0.333 | normal(0.00, 0.60) |
| Main_RecrDev_1977 | 0.66 | (-5, 5) | dev | 0.141 | normal(0.00, 0.60) |
| Main_RecrDev_1978 | 1.08 | (-5, 5) | dev | 0.118 | normal(0.00, 0.60) |
| Main_RecrDev_1979 | -0.0648 | (-5, 5) | dev | 0.203 | normal(0.00, 0.60) |
| Main_RecrDev_1980 | 0.493 | (-5, 5) | dev | 0.157 | normal(0.00, 0.60) |
| Main_RecrDev_1981 | 1.02 | (-5, 5) | dev | 0.126 | normal(0.00, 0.60) |
| Main_RecrDev_1982 | 0.4 | (-5, 5) | dev | 0.173 | normal(0.00, 0.60) |
| Main_RecrDev_1983 | -0.0195 | (-5, 5) | dev | 0.209 | normal(0.00, 0.60) |
| Main_RecrDev_1984 | 0.666 | (-5, 5) | dev | 0.135 | normal(0.00, 0.60) |

| Label | Value | Bounds | Status | SD | Prior |
|---|---|---|---|---|---|
| Main_RecrDev_1985 | 0.354 | (-5, 5) | dev | 0.156 | normal(0.00, 0.60) |
| Main_RecrDev_1986 | -0.402 | (-5, 5) | dev | 0.272 | normal(0.00, 0.60) |
| Main_RecrDev_1987 | 0.533 | (-5, 5) | dev | 0.161 | normal(0.00, 0.60) |
| Main_RecrDev_1988 | 0.0775 | (-5, 5) | dev | 0.222 | normal(0.00, 0.60) |
| Main_RecrDev_1989 | -0.225 | (-5, 5) | dev | 0.265 | normal(0.00, 0.60) |
| Main_RecrDev_1990 | 0.224 | (-5, 5) | dev | 0.204 | normal(0.00, 0.60) |
| Main_RecrDev_1991 | 0.828 | (-5, 5) | dev | 0.13 | normal(0.00, 0.60) |
| Main_RecrDev_1992 | -0.146 | (-5, 5) | dev | 0.229 | normal(0.00, 0.60) |
| Main_RecrDev_1993 | 0.0869 | (-5, 5) | dev | 0.198 | normal(0.00, 0.60) |
| Main_RecrDev_1994 | -0.00149 | (-5, 5) | dev | 0.215 | normal(0.00, 0.60) |
| Main_RecrDev_1995 | -0.453 | (-5, 5) | dev | 0.286 | normal(0.00, 0.60) |
| Main_RecrDev_1996 | -0.743 | (-5, 5) | dev | 0.35 | normal(0.00, 0.60) |
| Main_RecrDev_1997 | -0.31 | (-5, 5) | dev | 0.309 | normal(0.00, 0.60) |
| Main_RecrDev_1998 | 0.276 | (-5, 5) | dev | 0.229 | normal(0.00, 0.60) |
| Main_RecrDev_1999 | 0.564 | (-5, 5) | dev | 0.186 | normal(0.00, 0.60) |
| Main_RecrDev_2000 | 0.365 | (-5, 5) | dev | 0.198 | normal(0.00, 0.60) |
| Main_RecrDev_2001 | -0.228 | (-5, 5) | dev | 0.256 | normal(0.00, 0.60) |
| Main_RecrDev_2002 | -0.343 | (-5, 5) | dev | 0.247 | normal(0.00, 0.60) |
| Main_RecrDev_2003 | -0.398 | (-5, 5) | dev | 0.28 | normal(0.00, 0.60) |

| Label | Value | Bounds | Status | SD | Prior |
|---|---|---|---|---|---|
| Main_RecrDev_2004 | 0.778 | (-5, 5) | dev | 0.127 | normal(0.00, 0.60) |
| Main_RecrDev_2005 | -0.889 | (-5, 5) | dev | 0.36 | normal(0.00, 0.60) |
| Main_RecrDev_2006 | 0.502 | (-5, 5) | dev | 0.142 | normal(0.00, 0.60) |
| Main_RecrDev_2007 | -0.996 | (-5, 5) | dev | 0.373 | normal(0.00, 0.60) |
| Main_RecrDev_2008 | 1.35 | (-5, 5) | dev | 0.0954 | normal(0.00, 0.60) |
| Main_RecrDev_2009 | -0.736 | (-5, 5) | dev | 0.304 | normal(0.00, 0.60) |
| Main_RecrDev_2010 | 0.92 | (-5, 5) | dev | 0.117 | normal(0.00, 0.60) |
| Main_RecrDev_2011 | -1.04 | (-5, 5) | dev | 0.321 | normal(0.00, 0.60) |
| Main_RecrDev_2012 | -1.43 | (-5, 5) | dev | 0.319 | normal(0.00, 0.60) |
| Main_RecrDev_2013 | 0.744 | (-5, 5) | dev | 0.132 | normal(0.00, 0.60) |
| Main_RecrDev_2014 | -0.123 | (-5, 5) | dev | 0.227 | normal(0.00, 0.60) |
| Main_RecrDev_2015 | -0.393 | (-5, 5) | dev | 0.287 | normal(0.00, 0.60) |
| Main_RecrDev_2016 | 1.33 | (-5, 5) | dev | 0.146 | normal(0.00, 0.60) |
| Main_RecrDev_2017 | 0.0359 | (-5, 5) | dev | 0.273 | normal(0.00, 0.60) |
| Main_RecrDev_2018 | -0.965 | (-5, 5) | dev | 0.345 | normal(0.00, 0.60) |
| Main_RecrDev_2019 | -1.13 | (-5, 5) | dev | 0.361 | normal(0.00, 0.60) |
| Main_RecrDev_2020 | -1.14 | (-5, 5) | dev | 0.403 | normal(0.00, 0.60) |
| Late_RecrDev_2021 | -0.295 | (-5, 5) | dev | 0.411 | normal(0.00, 0.60) |
| Late_RecrDev_2022 | -0.148 | (-5, 5) | dev | 0.532 | normal(0.00, 0.60) |

| Label | Value | Bounds | Status | SD | Prior |
|---|---|---|---|---|---|
| Late_RecrDev_2023 | 0.291 | (-5, 5) | dev | 0.564 | normal(0.00, 0.60) |
| Late_RecrDev_2024 | 0.135 | (-5, 5) | dev | 0.563 | normal(0.00, 0.60) |
| ForeRecr_2025 | 0 | (-5, 5) | dev | 0.6 | normal(0.00, 0.60) |
| ForeRecr_2026 | 0 | (-5, 5) | dev | 0.6 | normal(0.00, 0.60) |
| ForeRecr_2027 | 0 | (-5, 5) | dev | 0.6 | normal(0.00, 0.60) |
| ForeRecr_2028 | 0 | (-5, 5) | dev | 0.6 | normal(0.00, 0.60) |
| ForeRecr_2029 | 0 | (-5, 5) | dev | 0.6 | normal(0.00, 0.60) |
| ForeRecr_2030 | 0 | (-5, 5) | dev | 0.6 | normal(0.00, 0.60) |
| ForeRecr_2031 | 0 | (-5, 5) | dev | 0.6 | normal(0.00, 0.60) |
| ForeRecr_2032 | 0 | (-5, 5) | dev | 0.6 | normal(0.00, 0.60) |
| ForeRecr_2033 | 0 | (-5, 5) | dev | 0.6 | normal(0.00, 0.60) |
| ForeRecr_2034 | 0 | (-5, 5) | dev | 0.6 | normal(0.00, 0.60) |
| ForeRecr_2035 | 0 | (-5, 5) | dev | 0.6 | normal(0.00, 0.60) |
| ForeRecr_2036 | 0 | (-5, 5) | dev | 0.6 | normal(0.00, 0.60) |
| LnQ_base_BottomTrawl(1) | -5.98 | (-25, 25) | fixed | 0 | none |
| Q_extraSD_BottomTrawl(1) | 0.163 | (0, 2) | ok | 0.0605 | none |
| LnQ_base_Hake(3) | -11.1 | (-20, 2) | ok | 0.189 | none |
| Q_extraSD_Hake(3) | 0.371 | (0, 2) | ok | 0.0863 | none |
| LnQ_base_JuvSurvey(6) | -4.86 | (-25, 25) | fixed | 0 | none |

| Label | Value | Bounds | Status | SD | Prior |
|---|---|---|---|---|---|
| Q_extraSD_JuvSurvey(6) | 1.25 | (0, 2) | ok | 0.307 | none |
| LnQ_base_Triennial(7) | -2.04 | (-4, 4) | ok | 0.372 | none |
| Q_extraSD_Triennial(7) | 0 | (0, 2) | fixed | 0 | none |
| LnQ_base_WCGBTS(8) | -3.47 | (-25, 25) | fixed | 0 | none |
| Q_extraSD_WCGBTS(8) | 0 | (0, 2) | fixed | 0 | none |
| LnQ_base_ForeignAtSea(9) | -11.4 | (-25, 25) | fixed | 0 | none |
| Q_extraSD_ForeignAtSea(9) | 0.578 | (0, 2) | ok | 0.152 | none |
| LnQ_base_Hake(3)_BLK10add_1991 | 0.464 | (1e-04, 2) | ok | 0.224 | normal(0.500, 0.500) |
| LnQ_base_Triennial(7)_BLK9add_1995 | 0.154 | (1e-04, 2) | ok | 0.357 | normal(0.500, 0.500) |
| Size_DblN_peak_BottomTrawl(1) | 43.5 | (10, 59) | ok | 2.72 | none |
| Size_DblN_top_logit_BottomTrawl(1) | -1.78 | (-5, 10) | ok | 70.7 | none |
| Size_DblN_ascend_se_BottomTrawl(1) | 4.6 | (-4, 12) | ok | 0.423 | none |
| Size_DblN_descend_se_BottomTrawl(1) | 9 | (-2, 10) | fixed | 0 | none |
| Size_DblN_start_logit_BottomTrawl(1) | -9 | (-9, 10) | fixed | 0 | none |
| Size_DblN_end_logit_BottomTrawl(1) | 8 | (-9, 9) | fixed | 0 | none |
| Retain_L_infl_BottomTrawl(1) | 3.66 | (-5, 60) | ok | 176 | none |
| Retain_L_width_BottomTrawl(1) | 0.944 | (0.01, 8) | ok | 20 | none |
| Retain_L_asymptote_logit_BottomTrawl(1) | 4.6 | (-10, 10) | fixed | 0 | none |
| Retain_L_maleoffset_BottomTrawl(1) | 0 | (-10, 10) | fixed | 0 | none |

| Label | Value | Bounds | Status | SD | Prior |
|---|---|---|---|---|---|
| Size_DblN_peak_MidwaterTrawl(2) | 36.9 | (10, 59) | ok | 0.739 | none |
| Size_DblN_top_logit_MidwaterTrawl(2) | -9.43 | (-10, 10) | ok | 14.5 | none |
| Size_DblN_ascend_se_MidwaterTrawl(2) | 2.86 | (-4, 12) | ok | 0.31 | none |
| Size_DblN_descend_se_MidwaterTrawl(2) | 3.93 | (-2, 10) | ok | 0.746 | none |
| Size_DblN_start_logit_MidwaterTrawl(2) | -9 | (-9, 10) | fixed | 0 | none |
| Size_DblN_end_logit_MidwaterTrawl(2) | -1.31 | (-9, 9) | ok | 1.06 | none |
| Retain_L_infl_MidwaterTrawl(2) | -5 | (-5, 60) | fixed | 0 | none |
| Retain_L_width_MidwaterTrawl(2) | 1.2 | (0.01, 8) | fixed | 0 | none |
| Retain_L_asymptote_logit_MidwaterTrawl(2) | 5.77 | (-10, 10) | ok | 0.0189 | none |
| Retain_L_maleoffset_MidwaterTrawl(2) | 0 | (-10, 10) | fixed | 0 | none |
| Size_DblN_peak_Hake(3) | 33.5 | (10, 59) | ok | 1.7 | none |
| Size_DblN_top_logit_Hake(3) | -1.95 | (-5, 10) | ok | 56.1 | none |
| Size_DblN_ascend_se_Hake(3) | 2.08 | (-4, 12) | ok | 1.03 | none |
| Size_DblN_descend_se_Hake(3) | 9 | (-2, 10) | fixed | 0 | none |
| Size_DblN_start_logit_Hake(3) | -9 | (-9, 10) | fixed | 0 | none |
| Size_DblN_end_logit_Hake(3) | 8 | (-9, 9) | fixed | 0 | none |
| Size_DblN_peak_Net(4) | 42.6 | (10, 59) | ok | 0.902 | none |
| Size_DblN_top_logit_Net(4) | 2.51 | (-5, 10) | ok | 168 | none |
| Size_DblN_ascend_se_Net(4) | 3.56 | (-4, 12) | ok | 0.214 | none |

| Label | Value | Bounds | Status | SD | Prior |
|---|---|---|---|---|---|
| Size_DblN_descend_se_Net(4) | 9 | (-2, 10) | fixed | 0 | none |
| Size_DblN_start_logit_Net(4) | -9 | (-9, 10) | fixed | 0 | none |
| Size_DblN_end_logit_Net(4) | 8 | (-9, 9) | fixed | 0 | none |
| Size_DblN_peak_HnL(5) | 23.4 | (10, 59) | ok | 0.261 | none |
| Size_DblN_top_logit_HnL(5) | 2.5 | (-5, 10) | ok | 167 | none |
| Size_DblN_ascend_se_HnL(5) | -5 | (-5, 12) | fixed | 0 | none |
| Size_DblN_descend_se_HnL(5) | 9 | (-2, 10) | fixed | 0 | none |
| Size_DblN_start_logit_HnL(5) | -9 | (-9, 10) | fixed | 0 | none |
| Size_DblN_end_logit_HnL(5) | 8 | (-9, 9) | fixed | 0 | none |
| Retain_L_infl_HnL(5) | 15.2 | (-5, 60) | ok | 377 | none |
| Retain_L_width_HnL(5) | 2.82 | (0.01, 8) | ok | 65.1 | none |
| Retain_L_asymptote_logit_HnL(5) | 7.43 | (-10, 15) | ok | 102 | none |
| Retain_L_maleoffset_HnL(5) | 0 | (-10, 10) | fixed | 0 | none |
| SizeSpline_Code_Triennial(7) | 0 | (0, 2) | fixed | 0 | none |
| SizeSpline_GradLo_Triennial(7) | 0.119 | (-0.001, 1) | ok | 0.0359 | none |
| SizeSpline_GradHi_Triennial(7) | 0.0396 | (-1, 1) | ok | 0.0988 | none |
| SizeSpline_Knot_1_Triennial(7) | 24 | (8, 56) | fixed | 0 | none |
| SizeSpline_Knot_2_Triennial(7) | 34 | (8, 56) | fixed | 0 | none |
| SizeSpline_Knot_3_Triennial(7) | 48 | (8, 56) | fixed | 0 | none |

| Label | Value | Bounds | Status | SD | Prior |
|---|---|---|---|---|---|
| SizeSpline_Val_1_Triennial(7) | -1.82 | (-10, 10) | ok | 0.317 | none |
| SizeSpline_Val_2_Triennial(7) | -1 | (-10, 10) | fixed | 0 | none |
| SizeSpline_Val_3_Triennial(7) | 0.448 | (-10, 10) | ok | 0.265 | none |
| SizeSpline_Code_WCGBTS(8) | 0 | (0, 2) | fixed | 0 | none |
| SizeSpline_GradLo_WCGBTS(8) | 0.468 | (-0.001, 1) | ok | 0.114 | none |
| SizeSpline_GradHi_WCGBTS(8) | -0.1 | (-1, 1) | ok | 0.0573 | none |
| SizeSpline_Knot_1_WCGBTS(8) | 24 | (8, 56) | fixed | 0 | none |
| SizeSpline_Knot_2_WCGBTS(8) | 34 | (8, 56) | fixed | 0 | none |
| SizeSpline_Knot_3_WCGBTS(8) | 48 | (8, 56) | fixed | 0 | none |
| SizeSpline_Val_1_WCGBTS(8) | -2.23 | (-10, 10) | ok | 0.249 | none |
| SizeSpline_Val_2_WCGBTS(8) | -1 | (-10, 10) | fixed | 0 | none |
| SizeSpline_Val_3_WCGBTS(8) | -0.0896 | (-10, 10) | ok | 0.152 | none |
| SizeSel_P1_ForeignAtSea(9) | 1 | (-2, 60) | fixed | 0 | none |
| SizeSel_P2_ForeignAtSea(9) | -1 | (-2, 60) | fixed | 0 | none |
| minage@sel=1_JuvSurvey(6) | 0 | (0, 1) | fixed | 0 | none |
| maxage@sel=1_JuvSurvey(6) | 0 | (0, 1) | fixed | 0 | none |
| minage@sel=1_WCGBTS(8) | 0 | (0, 1) | fixed | 0 | none |
| maxage@sel=1_WCGBTS(8) | 40 | (0, 50) | fixed | 0 | none |
| Size_DblN_peak_BottomTrawl(1)_BLK4repl_1916 | 39 | (10, 59) | ok | 0.819 | none |

| Label | Value | Bounds | Status | SD | Prior |
|---|---|---|---|---|---|
| Size_DblN_ascend_se_BottomTrawl(1)_BLK4repl_1916 | 3.43 | (-4, 12) | ok | 0.256 | none |
| Retain_L_infl_BottomTrawl(1)_BLK2repl_1982 | 27.2 | (-5, 50) | ok | 4.01 | none |
| Retain_L_infl_BottomTrawl(1)_BLK2repl_1990 | 27.5 | (-5, 50) | ok | 4 | none |
| Retain_L_width_BottomTrawl(1)_BLK2repl_1982 | 0.967 | (0.01, 5) | ok | 2.18 | none |
| Retain_L_width_BottomTrawl(1)_BLK2repl_1990 | 1.83 | (0.01, 5) | ok | 1.81 | none |
| Retain_L_asymptote_logit_BottomTrawl(1)_BLK1repl_-1982 | 1.71 | (-10, 10) | ok | 0.268 | none |
| Retain_L_asymptote_logit_BottomTrawl(1)_BLK1repl_-1990 | 0.764 | (-10, 10) | ok | 0.336 | none |
| Retain_L_asymptote_logit_BottomTrawl(1)_BLK1repl_-1998 | 0.105 | (-10, 10) | ok | 0.156 | none |
| Size_DblN_peak_MidwaterTrawl(2)_BLK7repl_1916 | 38.7 | (10, 59) | ok | 0.989 | none |
| Size_DblN_peak_MidwaterTrawl(2)_BLK7repl_1983 | 38 | (10, 59) | ok | 0.439 | none |
| Size_DblN_peak_MidwaterTrawl(2)_BLK7repl_2002 | 37.4 | (10, 59) | ok | 1.88 | none |
| Size_DblN_ascend_se_MidwaterTrawl(2)_BLK7repl_1916 | 3.37 | (-4, 12) | ok | 0.284 | none |
| Size_DblN_ascend_se_MidwaterTrawl(2)_BLK7repl_1983 | 3.08 | (-4, 12) | ok | 0.139 | none |
| Size_DblN_ascend_se_MidwaterTrawl(2)_BLK7repl_2002 | 2.79 | (-4, 12) | ok | 0.684 | none |
| Size_DblN_descend_se_MidwaterTrawl(2)_BLK7repl_-1916 | 4.25 | (-2, 10) | ok | 0.951 | none |
| Size_DblN_descend_se_MidwaterTrawl(2)_BLK7repl_-1983 | 3.07 | (-2, 10) | ok | 0.6 | none |

| Label | Value | Bounds | Status | SD | Prior |
|---|---|---|---|---|---|
| Size_DblN_descend_se_MidwaterTrawl(2)_BLK7repl_-2002 | -1.39 | (-2, 10) | ok | 10.6 | none |
| Size_DblN_end_logit_MidwaterTrawl(2)_BLK7repl_1916 | -1.97 | (-9, 9) | ok | 3.06 | none |
| Size_DblN_end_logit_MidwaterTrawl(2)_BLK7repl_1983 | -0.424 | (-9, 9) | ok | 0.337 | none |
| Size_DblN_end_logit_MidwaterTrawl(2)_BLK7repl_2002 | 1.63 | (-9, 9) | ok | 1.93 | none |
| Retain_L_asymptote_logit_MidwaterTrawl(2)_-BLK12repl_1916 | 4.59 | (-10, 10) | fixed | 0 | none |
| Retain_L_asymptote_logit_MidwaterTrawl(2)_-BLK12repl_1983 | 1.66 | (-10, 10) | ok | 0.138 | none |
| Retain_L_asymptote_logit_MidwaterTrawl(2)_-BLK12repl_2002 | 1.85 | (-10, 10) | ok | 0.407 | none |
| Retain_L_asymptote_logit_MidwaterTrawl(2)_-BLK12repl_2011 | 8.95 | (-10, 10) | ok | 0.0224 | none |
| Size_DblN_peak_Hake(3)_BLK11repl_1916 | 42.7 | (10, 59) | ok | 0.653 | none |
| Size_DblN_top_logit_Hake(3)_BLK11repl_1916 | 2.5 | (-5, 10) | ok | 168 | none |
| Size_DblN_ascend_se_Hake(3)_BLK11repl_1916 | 3.71 | (-4, 12) | ok | 0.138 | none |
| Size_DblN_peak_HnL(5)_BLK5repl_1916 | 37.2 | (15, 59) | ok | 2.02 | none |
| Size_DblN_ascend_se_HnL(5)_BLK5repl_1916 | 3.75 | (-4, 12) | ok | 0.469 | none |
| Retain_L_infl_HnL(5)_BLK3repl_1916 | -5 | (-5, 50) | fixed | 0 | none |
| Retain_L_width_HnL(5)_BLK3repl_1916 | 1.2 | (0.1, 8) | fixed | 0 | none |
| Retain_L_asymptote_logit_HnL(5)_BLK3repl_1916 | 4.59 | (-10, 10) | fixed | 0 | none |

Table 14: Likelihood components and other quantities related to the minimization of the base case model.

| component | log.likelihood | lambdas |
|---|---|---|
| Total | 19,016.5 | |
| Survey | 8.045 | |
| Discard | 16,793.200 | |
| Length composition | 829.491 | |
| Age composition | 1,367.190 | |
| Recruitment | 17.314 | 1 |
| Forecast Recruitment | 0.294 | 1 |
| Priors | 0.903 | 1 |
| Softbounds | 0.011 | |

Table 15: Estimates of key derived parameters and reference points with approximate 95% asymptotic confidence intervals.

| Reference Point | Estimate | 95% Confidence Interval |
|---|---|---|
| **Unfished Spawning Biomass (mt)** | **85460.9** | **71024.981 - 99896.819** |
| Unfished Age 4+ Biomass (mt) | 158958 | 132188.028 - 185727.972 |
| Unfished Recruitment (R0) | 34799 | 23869.261 - 45728.739 |
| 2025 Spawning Biomass (mt) | 46934 | 23842.488 - 70025.512 |
| 2025 Fraction Unfished | 0.549 | 0.356 - 0.742 |
| Reference Points Based SB40% | | |
| **Proxy Spawning Biomass (mt) SB40%** | **34184.4** | **28410.033 - 39958.767** |
| SPR Resulting in SB40% | 0.458 | 0.458 - 0.458 |
| Exploitation Rate Resulting in SB40% | 0.086 | 0.078 - 0.094 |
| Yield with SPR Based On SB40% (mt) | 6105.29 | 4749.169 - 7461.411 |

| Reference Point | Estimate | 95% Confidence Interval |
|---|---|---|
| **Reference Points Based on SPR Proxy for MSY** | | |
| Proxy Spawning Biomass (mt) (SPR50) | 38128.7 | 31688.062 - 44569.338 |
| SPR50 | 0.5 | |
| Exploitation Rate Corresponding to SPR50 | 0.075 | 0.068 - 0.082 |
| Yield with SPR50 at SB SPR (mt) | 5822.12 | 4532.758 - 7111.482 |
| Reference Points Based on Estimated MSY Values | | |
| **Spawning Biomass (mt) at MSY (SB MSY)** | **22681.2** | **18896.96 - 26465.44** |
| SPR MSY | 0.337 | 0.334 - 0.34 |
| Exploitation Rate Corresponding to SPR MSY | 0.13 | 0.117 - 0.142 |
| MSY (mt) | 6525.99 | 5062.203 - 7989.777 |

Table 16: Time series of population estimates from the base case model.

| Year | Total Biomass (mt) | Spawning Biomass (mt) | Total Biomass 4+ (mt) | Fraction Unfished | Age-0 Recruits (1,000s) | Total Mortality (mt) | (1-SPR)/(1-SPR_50%) | Exploitation Rate |
|---|---|---|---|---|---|---|---|---|
| 1916 | 164,298.0 | 85,266.3 | 158,512.0 | 0.998 | 34,429.1 | 79.1 | 0.012 | 0.0 |
| 1917 | 164,157.0 | 85,193.5 | 158,375.0 | 0.997 | 34,390.2 | 123.1 | 0.018 | 0.0 |
| 1918 | 163,973.0 | 85,096.1 | 158,198.0 | 0.996 | 34,346.9 | 141.5 | 0.021 | 0.0 |
| 1919 | 163,773.0 | 84,989.4 | 158,005.0 | 0.994 | 34,299.2 | 97.7 | 0.014 | 0.0 |
| 1920 | 163,618.0 | 84,908.8 | 157,857.0 | 0.994 | 34,248.4 | 100.0 | 0.015 | 0.0 |
| 1921 | 163,460.0 | 84,827.5 | 157,706.0 | 0.993 | 34,192.8 | 82.9 | 0.012 | 0.0 |
| 1922 | 163,316.0 | 84,755.9 | 157,570.0 | 0.992 | 34,132.6 | 72.0 | 0.011 | 0.0 |
| 1923 | 163,177.0 | 84,689.5 | 157,441.0 | 0.991 | 34,066.9 | 79.0 | 0.012 | 0.0 |
| 1924 | 163,025.0 | 84,617.1 | 157,298.0 | 0.990 | 33,994.9 | 50.8 | 0.007 | 0.0 |
| 1925 | 162,893.0 | 84,557.8 | 157,177.0 | 0.989 | 33,916.8 | 62.9 | 0.009 | 0.0 |
| 1926 | 162,738.0 | 84,487.8 | 157,033.0 | 0.989 | 33,831.0 | 95.6 | 0.014 | 0.0 |
| 1927 | 162,539.0 | 84,394.9 | 156,847.0 | 0.988 | 33,736.5 | 79.3 | 0.012 | 0.0 |
| 1928 | 162,345.0 | 84,306.5 | 156,667.0 | 0.986 | 33,633.6 | 90.3 | 0.013 | 0.0 |
| 1929 | 162,127.0 | 84,206.4 | 156,464.0 | 0.985 | 33,521.1 | 87.6 | 0.013 | 0.0 |
| 1930 | 161,897.0 | 84,101.7 | 156,251.0 | 0.984 | 33,398.3 | 113.5 | 0.017 | 0.0 |
| 1931 | 161,625.0 | 83,976.1 | 155,997.0 | 0.983 | 33,264.0 | 100.9 | 0.015 | 0.0 |
| 1932 | 161,348.0 | 83,850.4 | 155,740.0 | 0.981 | 33,118.0 | 101.1 | 0.015 | 0.0 |

| Year | Total Biomass (mt) | Spawning Biomass (mt) | Total Biomass 4+ (mt) | Fraction Unfished | Age-0 Recruits (1,000s) | Total Mortality (mt) | (1-SPR)/(1-SPR_50%) | Exploitation Rate |
|---|---|---|---|---|---|---|---|---|
| 1933 | 161,051.0 | 83,716.5 | 155,465.0 | 0.980 | 32,959.2 | 86.7 | 0.013 | 0.0 |
| 1934 | 160,746.0 | 83,581.3 | 155,183.0 | 0.978 | 32,787.0 | 91.8 | 0.014 | 0.0 |
| 1935 | 160,410.0 | 83,432.8 | 154,873.0 | 0.976 | 32,599.7 | 99.1 | 0.015 | 0.0 |
| 1936 | 160,039.0 | 83,268.6 | 154,531.0 | 0.974 | 32,395.7 | 111.8 | 0.017 | 0.0 |
| 1937 | 159,626.0 | 83,084.5 | 154,148.0 | 0.972 | 32,172.8 | 104.6 | 0.016 | 0.0 |
| 1938 | 159,187.0 | 82,890.3 | 153,742.0 | 0.970 | 31,928.7 | 84.7 | 0.013 | 0.0 |
| 1939 | 158,732.0 | 82,691.9 | 153,323.0 | 0.968 | 31,660.4 | 77.4 | 0.011 | 0.0 |
| 1940 | 158,242.0 | 82,480.1 | 152,873.0 | 0.965 | 31,367.9 | 121.9 | 0.018 | 0.0 |
| 1941 | 157,665.0 | 82,224.0 | 152,339.0 | 0.962 | 31,050.0 | 130.8 | 0.019 | 0.0 |
| 1942 | 157,033.0 | 81,942.8 | 151,754.0 | 0.959 | 30,708.0 | 148.1 | 0.022 | 0.0 |
| 1943 | 156,334.0 | 81,630.3 | 151,107.0 | 0.955 | 30,350.6 | 495.6 | 0.072 | 0.0 |
| 1944 | 155,251.0 | 81,098.6 | 150,079.0 | 0.949 | 29,981.0 | 970.4 | 0.138 | 0.0 |
| 1945 | 153,684.0 | 80,284.5 | 148,571.0 | 0.939 | 29,597.8 | 1,637.7 | 0.225 | 0.0 |
| 1946 | 151,479.0 | 79,093.1 | 146,427.0 | 0.925 | 29,206.0 | 1,171.8 | 0.168 | 0.0 |
| 1947 | 149,757.0 | 78,185.6 | 144,767.0 | 0.915 | 28,843.2 | 649.7 | 0.098 | 0.0 |
| 1948 | 148,536.0 | 77,581.1 | 143,611.0 | 0.908 | 28,506.4 | 482.5 | 0.074 | 0.0 |
| 1949 | 147,442.0 | 77,060.1 | 142,580.0 | 0.902 | 28,198.5 | 378.1 | 0.059 | 0.0 |
| 1950 | 146,401.0 | 76,577.8 | 141,597.0 | 0.896 | 27,937.7 | 427.9 | 0.067 | 0.0 |
| 1951 | 145,260.0 | 76,040.2 | 140,509.0 | 0.890 | 27,747.7 | 559.5 | 0.087 | 0.0 |

| Year | Total Biomass (mt) | Spawning Biomass (mt) | Total Biomass 4+ (mt) | Fraction Unfished | Age-0 Recruits (1,000s) | Total Mortality (mt) | (1-SPR)/(1-SPR_50%) | Exploitation Rate |
|---|---|---|---|---|---|---|---|---|
| 1952 | 143,954.0 | 75,400.1 | 139,249.0 | 0.882 | 27,657.0 | 547.0 | 0.086 | 0.0 |
| 1953 | 142,638.0 | 74,744.2 | 137,969.0 | 0.875 | 27,707.1 | 474.0 | 0.075 | 0.0 |
| 1954 | 141,389.0 | 74,110.6 | 136,741.0 | 0.867 | 27,937.7 | 452.5 | 0.072 | 0.0 |
| 1955 | 140,176.0 | 73,474.8 | 135,528.0 | 0.860 | 28,382.4 | 469.7 | 0.076 | 0.0 |
| 1956 | 138,994.0 | 72,822.8 | 134,319.0 | 0.852 | 29,047.8 | 607.0 | 0.098 | 0.0 |
| 1957 | 137,769.0 | 72,099.8 | 133,035.0 | 0.844 | 29,864.9 | 768.4 | 0.124 | 0.0 |
| 1958 | 136,536.0 | 71,312.4 | 131,708.0 | 0.834 | 30,634.1 | 708.7 | 0.116 | 0.0 |
| 1959 | 135,564.0 | 70,612.7 | 130,616.0 | 0.826 | 31,063.2 | 678.4 | 0.112 | 0.0 |
| 1960 | 134,858.0 | 70,008.3 | 129,787.0 | 0.819 | 30,983.9 | 819.1 | 0.135 | 0.0 |
| 1961 | 134,270.0 | 69,428.9 | 129,107.0 | 0.812 | 30,534.9 | 683.9 | 0.115 | 0.0 |
| 1962 | 134,054.0 | 69,057.7 | 128,863.0 | 0.808 | 30,358.3 | 765.2 | 0.128 | 0.0 |
| 1963 | 133,956.0 | 68,780.7 | 128,794.0 | 0.805 | 31,090.1 | 437.8 | 0.075 | 0.0 |
| 1964 | 134,323.0 | 68,823.7 | 129,193.0 | 0.805 | 32,555.4 | 607.4 | 0.103 | 0.0 |
| 1965 | 134,638.0 | 68,872.0 | 129,456.0 | 0.806 | 34,239.5 | 262.1 | 0.046 | 0.0 |
| 1966 | 135,424.0 | 69,186.3 | 130,061.0 | 0.810 | 36,090.6 | 4,293.5 | 0.555 | 0.0 |
| 1967 | 132,613.0 | 67,204.3 | 126,993.0 | 0.786 | 36,136.6 | 4,830.6 | 0.618 | 0.0 |
| 1968 | 129,823.0 | 65,113.4 | 123,958.0 | 0.762 | 34,141.9 | 2,392.8 | 0.369 | 0.0 |
| 1969 | 129,869.0 | 64,681.8 | 123,879.0 | 0.757 | 29,705.4 | 852.4 | 0.149 | 0.0 |
| 1970 | 132,003.0 | 65,358.1 | 125,806.0 | 0.765 | 117,956.0 | 854.9 | 0.148 | 0.0 |

| Year | Total Biomass (mt) | Spawning Biomass (mt) | Total Biomass 4+ (mt) | Fraction Unfished | Age-0 Recruits (1,000s) | Total Mortality (mt) | (1-SPR)/(1-SPR_50%) | Exploitation Rate |
|---|---|---|---|---|---|---|---|---|
| 1971 | 135,234.0 | 66,197.7 | 127,932.0 | 0.775 | 97,968.9 | 1,095.6 | 0.184 | 0.0 |
| 1972 | 140,068.0 | 67,012.7 | 129,623.0 | 0.784 | 13,102.0 | 924.0 | 0.155 | 0.0 |
| 1973 | 147,148.0 | 68,496.6 | 130,705.0 | 0.801 | 11,028.7 | 1,160.7 | 0.189 | 0.0 |
| 1974 | 155,516.0 | 70,747.0 | 145,157.0 | 0.828 | 14,922.5 | 907.5 | 0.148 | 0.0 |
| 1975 | 163,348.0 | 74,355.5 | 161,141.0 | 0.870 | 31,265.3 | 876.9 | 0.137 | 0.0 |
| 1976 | 168,367.0 | 79,186.4 | 165,965.0 | 0.927 | 10,066.1 | 1,325.8 | 0.188 | 0.0 |
| 1977 | 170,114.0 | 83,774.7 | 166,721.0 | 0.980 | 57,610.0 | 1,094.7 | 0.143 | 0.0 |
| 1978 | 170,141.0 | 87,041.7 | 165,210.0 | 1.018 | 88,095.1 | 1,582.8 | 0.193 | 0.0 |
| 1979 | 169,050.0 | 87,834.9 | 163,555.0 | 1.028 | 28,022.9 | 9,480.1 | 0.799 | 0.1 |
| 1980 | 160,679.0 | 82,964.6 | 150,110.0 | 0.971 | 48,686.1 | 22,055.9 | 1.344 | 0.1 |
| 1981 | 141,925.0 | 71,098.8 | 130,826.0 | 0.832 | 80,892.0 | 28,136.0 | 1.565 | 0.2 |
| 1982 | 120,210.0 | 56,724.2 | 113,485.0 | 0.664 | 42,390.4 | 27,109.5 | 1.653 | 0.2 |
| 1983 | 102,375.0 | 44,854.7 | 92,851.5 | 0.525 | 26,878.4 | 12,275.8 | 1.378 | 0.1 |
| 1984 | 101,481.0 | 42,614.4 | 90,894.4 | 0.499 | 52,852.0 | 12,134.2 | 1.376 | 0.1 |
| 1985 | 101,428.0 | 41,907.4 | 94,902.9 | 0.490 | 38,597.5 | 10,890.0 | 1.304 | 0.1 |
| 1986 | 102,040.0 | 42,236.9 | 96,093.9 | 0.494 | 18,137.1 | 11,448.1 | 1.309 | 0.1 |
| 1987 | 101,258.0 | 42,561.0 | 93,749.0 | 0.498 | 46,273.0 | 15,398.2 | 1.439 | 0.2 |
| 1988 | 95,829.1 | 40,747.5 | 90,256.3 | 0.477 | 29,117.1 | 12,539.8 | 1.352 | 0.1 |
| 1989 | 92,172.3 | 39,582.5 | 87,547.9 | 0.463 | 21,401.1 | 14,995.7 | 1.458 | 0.2 |

| Year | Total Biomass (mt) | Spawning Biomass (mt) | Total Biomass 4+ (mt) | Fraction Unfished | Age-0 Recruits (1,000s) | Total Mortality (mt) | (1-SPR)/(1-SPR_50%) | Exploitation Rate |
|---|---|---|---|---|---|---|---|---|
| 1990 | 85,241.6 | 36,717.2 | 78,827.0 | 0.430 | 33,028.4 | 13,820.9 | 1.454 | 0.2 |
| 1991 | 79,240.2 | 33,879.2 | 74,533.1 | 0.396 | 59,437.7 | 9,022.4 | 1.282 | 0.1 |
| 1992 | 77,717.0 | 33,108.7 | 72,869.3 | 0.387 | 22,328.1 | 8,723.2 | 1.277 | 0.1 |
| 1993 | 76,555.5 | 32,323.5 | 69,946.8 | 0.378 | 28,046.8 | 11,463.4 | 1.423 | 0.2 |
| 1994 | 73,021.2 | 30,163.7 | 65,579.5 | 0.353 | 25,272.1 | 8,935.7 | 1.337 | 0.1 |
| 1995 | 72,112.9 | 29,283.6 | 68,064.9 | 0.343 | 15,970.3 | 9,294.6 | 1.376 | 0.1 |
| 1996 | 70,303.7 | 28,496.1 | 66,025.0 | 0.333 | 11,877.3 | 8,385.1 | 1.334 | 0.1 |
| 1997 | 68,628.4 | 28,428.9 | 65,117.2 | 0.333 | 18,299.9 | 8,919.0 | 1.355 | 0.1 |
| 1998 | 65,488.7 | 27,978.2 | 62,896.2 | 0.327 | 32,754.4 | 6,613.0 | 1.206 | 0.1 |
| 1999 | 63,803.4 | 28,037.4 | 60,983.9 | 0.328 | 43,721.4 | 5,963.2 | 1.137 | 0.1 |
| 2000 | 62,475.0 | 27,859.6 | 58,167.0 | 0.326 | 35,763.9 | 4,782.1 | 0.994 | 0.1 |
| 2001 | 62,621.7 | 27,819.7 | 56,597.2 | 0.326 | 19,765.5 | 2,319.5 | 0.627 | 0.0 |
| 2002 | 65,861.2 | 28,768.1 | 59,464.2 | 0.337 | 17,751.6 | 484.4 | 0.183 | 0.0 |
| 2003 | 71,276.7 | 30,836.2 | 66,466.5 | 0.361 | 17,094.1 | 46.4 | 0.018 | 0.0 |
| 2004 | 76,929.7 | 33,598.2 | 73,604.6 | 0.393 | 56,433.5 | 99.2 | 0.035 | 0.0 |
| 2005 | 81,959.0 | 36,703.3 | 78,343.4 | 0.429 | 10,857.9 | 203.5 | 0.066 | 0.0 |
| 2006 | 86,534.8 | 39,697.8 | 81,748.4 | 0.465 | 44,310.3 | 221.2 | 0.066 | 0.0 |
| 2007 | 90,875.3 | 42,425.2 | 84,052.9 | 0.496 | 10,023.4 | 244.9 | 0.068 | 0.0 |
| 2008 | 95,523.1 | 44,658.3 | 91,680.9 | 0.523 | 105,585.0 | 272.7 | 0.071 | 0.0 |

| Year | Total Biomass (mt) | Spawning Biomass (mt) | Total Biomass 4+ (mt) | Fraction Unfished | Age-0 Recruits (1,000s) | Total Mortality (mt) | (1-SPR)/(1-SPR_50%) | Exploitation Rate |
|---|---|---|---|---|---|---|---|---|
| 2009 | 100,241.0 | 46,813.3 | 93,505.4 | 0.548 | 13,217.9 | 186.2 | 0.047 | 0.0 |
| 2010 | 105,960.0 | 48,948.8 | 99,309.2 | 0.573 | 69,744.6 | 179.1 | 0.043 | 0.0 |
| 2011 | 112,437.0 | 51,487.7 | 100,295.0 | 0.602 | 9,868.3 | 212.2 | 0.048 | 0.0 |
| 2012 | 119,791.0 | 54,158.1 | 114,910.0 | 0.634 | 6,723.6 | 270.8 | 0.058 | 0.0 |
| 2013 | 126,419.0 | 57,537.2 | 118,826.0 | 0.673 | 59,944.3 | 470.4 | 0.089 | 0.0 |
| 2014 | 131,943.0 | 61,295.5 | 129,467.0 | 0.717 | 25,407.5 | 722.7 | 0.127 | 0.0 |
| 2015 | 135,696.0 | 64,874.7 | 131,583.0 | 0.759 | 19,520.8 | 879.9 | 0.140 | 0.0 |
| 2016 | 138,433.0 | 67,860.2 | 130,583.0 | 0.794 | 109,956.0 | 1,039.6 | 0.156 | 0.0 |
| 2017 | 141,114.0 | 69,742.5 | 135,586.0 | 0.816 | 30,617.3 | 6,361.5 | 0.713 | 0.0 |
| 2018 | 138,921.0 | 68,048.0 | 131,076.0 | 0.796 | 11,425.9 | 10,522.9 | 1.038 | 0.1 |
| 2019 | 133,283.0 | 64,425.4 | 120,929.0 | 0.754 | 9,785.1 | 9,315.3 | 1.016 | 0.1 |
| 2020 | 129,585.0 | 61,798.8 | 125,854.0 | 0.723 | 9,810.3 | 8,379.6 | 0.996 | 0.1 |
| 2021 | 125,676.0 | 60,418.4 | 123,819.0 | 0.707 | 23,221.1 | 10,899.7 | 1.158 | 0.1 |
| 2022 | 117,662.0 | 58,447.5 | 115,702.0 | 0.684 | 27,254.9 | 12,129.7 | 1.211 | 0.1 |
| 2023 | 107,183.0 | 55,413.6 | 104,427.0 | 0.648 | 42,725.5 | 11,023.5 | 1.179 | 0.1 |
| 2024 | 97,265.0 | 51,498.1 | 92,763.3 | 0.603 | 36,828.9 | 9,764.1 | 1.175 | 0.1 |
| 2025 | 89,108.4 | 46,934.0 | 83,590.4 | 0.549 | 32,227.1 | 10,668.6 | 1.328 | 0.1 |
| 2026 | 81,249.7 | 41,475.0 | 74,612.0 | 0.485 | 31,546.3 | 9,823.6 | 1.389 | 0.1 |
| 2027 | 75,784.8 | 36,917.5 | 69,955.8 | 0.432 | 30,854.6 | 4,238.0 | 0.959 | 0.1 |

| Year | Total Biomass (mt) | Spawning Biomass (mt) | Total Biomass 4+ (mt) | Fraction Unfished | Age-0 Recruits (1,000s) | Total Mortality (mt) | (1-SPR)/(1-SPR_50%) | Exploitation Rate |
|---|---|---|---|---|---|---|---|---|
| 2028 | 77,057.2 | 36,217.2 | 71,718.5 | 0.424 | 30,736.0 | 4,348.9 | 0.956 | 0.1 |
| 2029 | 78,736.8 | 36,388.5 | 73,499.4 | 0.426 | 30,765.4 | 4,677.0 | 0.953 | 0.1 |
| 2030 | 80,272.4 | 36,993.3 | 75,106.6 | 0.433 | 30,867.2 | 5,004.4 | 0.950 | 0.1 |
| 2031 | 81,452.8 | 37,635.2 | 76,294.7 | 0.440 | 30,972.5 | 5,213.0 | 0.947 | 0.1 |
| 2032 | 82,316.7 | 38,143.4 | 77,148.6 | 0.446 | 31,053.8 | 5,319.6 | 0.944 | 0.1 |
| 2033 | 82,963.5 | 38,507.2 | 77,778.7 | 0.451 | 31,110.9 | 5,359.0 | 0.942 | 0.1 |
| 2034 | 83,484.7 | 38,773.2 | 78,284.6 | 0.454 | 31,152.1 | 5,359.7 | 0.938 | 0.1 |
| 2035 | 83,944.5 | 38,989.7 | 78,732.9 | 0.456 | 31,185.3 | 5,354.7 | 0.936 | 0.1 |
| 2036 | 84,367.7 | 39,183.2 | 79,147.8 | 0.458 | 31,214.8 | 5,347.5 | 0.933 | 0.1 |

Table 17: Quantities of interest from the sensitivity analyses.

| | **Base model** | **M = 0.1** | **M = 0.124 female, M = 0.129 male** | **MWT asymptotic selex** | **WCGBTS logistic selex** | **Including shrimp trawl** | **New WA catch recon.** | **Excluding triennial** | **Francis weighting** |
|---|---|---|---|---|---|---|---|---|---|
| **Difference from Base Model Likelihood** | | | | | | | | | |
| Total | 19,016.500 | 21.900 | 5.600 | 237.400 | -0.100 | 1.100 | 685.200 | -95.300 | -1,303.800 |
| Survey | 8.045 | 2.092 | 0.145 | 0.985 | 0.348 | 0.005 | -0.053 | -1.400 | 0.076 |
| Length | 829.491 | 2.232 | -0.991 | 99.324 | 11.320 | 0.002 | 0.053 | -92.505 | -597.089 |
| Age | 1,367.190 | 10.400 | 6.300 | 53.590 | -11.710 | 0.010 | -0.150 | -0.540 | -694.088 |
| Discards | 16,793.200 | 0.700 | 0.200 | 0.800 | 0.000 | 1.100 | 685.400 | 0.000 | 0.100 |
| Recruitment | 17.314 | 7.352 | 0.207 | 0.989 | 0.075 | 0.007 | 0.000 | -0.657 | -13.089 |
| Forecast recruitment | 0.294 | 0.053 | 0.002 | 0.003 | -0.069 | 0.000 | -0.001 | -0.017 | -0.149 |
| Parameter priors | 0.903 | -0.839 | -0.131 | 0.445 | -0.049 | 0.000 | -0.022 | -0.149 | 0.512 |
| **Parameter values** | | | | | | | | | |
| Natural mortality (female) | 0.122 | 0.100 | 0.124 | 0.134 | 0.120 | 0.122 | 0.122 | 0.124 | 0.133 |
| Length at Amin (female) | 20.658 | 20.676 | 20.717 | 21.534 | 20.419 | 20.658 | 20.660 | 20.512 | 20.536 |

| | Base model | M = 0.1 | M = 0.124 female, M = 0.129 male | MWT asymptotic selex | WCGBTS logistic selex | Including shrimp trawl | New WA catch recon. | Excluding triennial | Francis weighting |
|---|---|---|---|---|---|---|---|---|---|
| Length at Amax (female) | 49.492 | 49.369 | 49.481 | 49.394 | 49.347 | 49.492 | 49.492 | 49.428 | 49.450 |
| CV young (female) | 0.116 | 0.115 | 0.114 | 0.104 | 0.119 | 0.116 | 0.116 | 0.118 | 0.121 |
| CV old (female) | 0.048 | 0.049 | 0.048 | 0.047 | 0.048 | 0.048 | 0.048 | 0.048 | 0.047 |
| vBL k (female) | 0.181 | 0.185 | 0.182 | 0.174 | 0.187 | 0.181 | 0.181 | 0.183 | 0.179 |
| Natural mortality (male) | 0.135 | 0.100 | 0.129 | 0.142 | 0.134 | 0.135 | 0.134 | 0.137 | 0.147 |
| Length at Amin (male) | 21.018 | 21.090 | 21.068 | 21.123 | 21.002 | 21.018 | 21.019 | 21.036 | 20.609 |
| Length at Amax (male) | 43.608 | 43.429 | 43.495 | 42.991 | 43.817 | 43.608 | 43.609 | 43.620 | 43.507 |
| CV young (male) | 0.095 | 0.093 | 0.094 | 0.091 | 0.097 | 0.095 | 0.095 | 0.094 | 0.101 |
| CV old (male) | 0.056 | 0.058 | 0.057 | 0.057 | 0.055 | 0.056 | 0.056 | 0.056 | 0.053 |
| vBL k (male) | 0.245 | 0.246 | 0.245 | 0.257 | 0.244 | 0.245 | 0.245 | 0.244 | 0.258 |

**Quantity**

| | Base model | M = 0.1 | M = 0.124 female, M = 0.129 male | MWT asymptotic selex | WCGBTS logistic selex | Including shrimp trawl | New WA catch recon. | Excluding triennial | Francis weighting |
|---|---|---|---|---|---|---|---|---|---|
| Virgin recruitment (thousands) | 34.799 | 21.003 | 33.238 | 43.231 | 33.617 | 34.804 | 34.735 | 36.926 | 46.056 |
| ln(R0) | 10.457 | 9.952 | 10.412 | 10.674 | 10.423 | 10.457 | 10.456 | 10.517 | 10.738 |
| SSB unfished (mt) | 158,958 | 146,924 | 154,430 | 169,851 | 158,176 | 158,994 | 159,453 | 163,646 | 178,711 |
| SB0 (thousand mt) | 85.461 | 75.897 | 79.590 | 87.720 | 85.613 | 85.482 | 85.756 | 88.152 | 94.196 |
| SSB 2025 (thousand mt) | 46.934 | 25.349 | 42.767 | 55.576 | 44.510 | 46.932 | 46.976 | 51.300 | 55.190 |
| B ratio 2025 | 0.549 | 0.334 | 0.537 | 0.634 | 0.520 | 0.549 | 0.548 | 0.582 | 0.586 |
| SPR ratio 2025 | 1.175 | 1.555 | 1.193 | 0.981 | 1.230 | 1.175 | 1.176 | 1.118 | 1.018 |

Table 18: Estimated data weights derived using the McAllister-Ianelli and Francis methods.

| Fleet | Composition data type | McAllister Ianelli weighting (base model) | Francis weighting (alternative) |
|---|---|---|---|
| BottomTrawl | Length | 0.050650 | 0.047336 |
| Hake | Length | 0.027593 | 0.022136 |
| HnL | Length | 0.163975 | 0.151737 |
| MidwaterTrawl | Length | 0.043474 | 0.037357 |
| Net | Length | 0.117189 | 0.123590 |
| Triennial | Length | 0.092958 | 0.092528 |
| WCGBTS | Length | 0.101256 | 0.091040 |
| BottomTrawl | Age | 0.208474 | 0.237723 |
| Hake | Age | 0.182336 | 0.219824 |
| HnL | Age | 0.527511 | 0.526337 |
| MidwaterTrawl | Age | 0.130392 | 0.128981 |
| Net | Age | 0.185949 | 0.210475 |
| WCGBTS | Age | 0.122436 | 0.119538 |

### 5.3 Management

Table 19: Potential OFL, ABC, ACL, the buffer between the OFL and ABC, estimated SB (mt), and fraction of unfished SB with adopted OFL and ABC and assumed catch for the first two years of the projection period. The predicted OFL is the calculated total catch determined by FSPR=50%.

| Year | Adopted OFL (mt) | Adopted ACL (mt) | Assumed Catch (mt) | OFL (mt) | Buffer | ABC (mt) | ACL (mt) | SB (mt) | Fraction Unfished |
|---|---|---|---|---|---|---|---|---|---|
| 2025 | 12,254 | 11,237 | 10,669 | - | - | - | - | 46,934 | 0.549 |
| 2026 | 11,382 | 10,392 | 9,824 | - | - | - | - | 41,475 | 0.485 |
| 2027 | - | - | - | 4,533 | 0.935 | 4,238 | 4,238 | 36,918 | 0.432 |
| 2028 | - | - | - | 4,676 | 0.93 | 4,349 | 4,349 | 36,217 | 0.424 |
| 2029 | - | - | - | 5,051 | 0.926 | 4,677 | 4,677 | 36,388 | 0.426 |
| 2030 | - | - | - | 5,428 | 0.922 | 5,004 | 5,004 | 36,993 | 0.433 |
| 2031 | - | - | - | 5,685 | 0.917 | 5,213 | 5,213 | 37,635 | 0.440 |
| 2032 | - | - | - | 5,826 | 0.913 | 5,320 | 5,320 | 38,143 | 0.446 |
| 2033 | - | - | - | 5,895 | 0.909 | 5,359 | 5,359 | 38,507 | 0.451 |
| 2034 | - | - | - | 5,929 | 0.904 | 5,360 | 5,360 | 38,773 | 0.454 |
| 2035 | - | - | - | 5,950 | 0.9 | 5,355 | 5,355 | 38,990 | 0.456 |
| 2036 | - | - | - | 5,968 | 0.896 | 5,347 | 5,347 | 39,183 | 0.458 |

Table 20: Summary table of 12-year projections beginning in 2027 for alternate states of nature based on the axis of uncertainty (a combination of M, h). Columns range over low, mid, and high state of nature, and rows range over different assumptions of total catch levels (discards + retained). Catches in 2025 and 2026 are allocated using the percentage of landings for each fleet in 2019-2024.

| | | | State of nature | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Low | | Base | | High | |
| **Management decision** | Year | catch (mt) | SB (mt) | Depletion (%) | SB (mt) | Depletion (%) | SB (mt) | Depletion (%) |
| | 2025 | 10,669 | 34,412 | 37.5 | 46,934 | 54.9 | 55,743 | 65.7 |
| ACLp*=0.40, | 2026 | 9,824 | 29,166 | 31.8 | 41,475 | 48.5 | 49,924 | 58.8 |
| sigma=0.50 | 2027 | 3,957 | 24,814 | 27.0 | 36,918 | 43.2 | 45,052 | 53.1 |
| | 2028 | 4,059 | 24,414 | 26.6 | 36,362 | 42.5 | 44,260 | 52.2 |
| | 2029 | 4,360 | 24,786 | 27.0 | 36,674 | 42.9 | 44,428 | 52.3 |
| | 2030 | 4,659 | 25,472 | 27.7 | 37,429 | 43.8 | 45,123 | 53.2 |
| | 2031 | 4,852 | 26,079 | 28.4 | 38,235 | 44.7 | 45,935 | 54.1 |
| | 2032 | 4,943 | 26,440 | 28.8 | 38,912 | 45.5 | 46,675 | 55.0 |
| | 2033 | 4,971 | 26,563 | 28.9 | 39,448 | 46.2 | 47,318 | 55.8 |
| | 2034 | 4,973 | 26,524 | 28.9 | 39,883 | 46.7 | 47,891 | 56.4 |
| | 2035 | 4,956 | 26,405 | 28.8 | 40,260 | 47.1 | 48,417 | 57.0 |
| | 2036 | 4,937 | 26,271 | 28.6 | 40,611 | 47.5 | 48,913 | 57.6 |
| | 2025 | 10,669 | 34,412 | 37.5 | 46,934 | 54.9 | 55,743 | 65.7 |
| ACLp*=0.45, | 2026 | 9,824 | 29,166 | 31.8 | 41,475 | 48.5 | 49,924 | 58.8 |
| sigma=0.50 | 2027 | 4,238 | 24,814 | 27.0 | 36,918 | 43.2 | 45,052 | 53.1 |
| | 2028 | 4,349 | 24,269 | 26.4 | 36,218 | 42.4 | 44,117 | 52.0 |
| | 2029 | 4,677 | 24,497 | 26.7 | 36,389 | 42.6 | 44,146 | 52.0 |
| | 2030 | 5,004 | 25,028 | 27.3 | 36,994 | 43.3 | 44,694 | 52.7 |
| | 2031 | 5,213 | 25,462 | 27.7 | 37,636 | 44.0 | 45,350 | 53.4 |
| | 2032 | 5,320 | 25,642 | 27.9 | 38,144 | 44.6 | 45,928 | 54.1 |
| | 2033 | 5,359 | 25,577 | 27.9 | 38,508 | 45.1 | 46,410 | 54.7 |

| | | | State of nature | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Low | | Base | | High | |
| **Management decision** | Year | catch (mt) | SB (mt) | Depletion (%) | SB (mt) | Depletion (%) | SB (mt) | Depletion (%) |
| | 2034 | 5,360 | 25,350 | 27.6 | 38,774 | 45.4 | 46,826 | 55.2 |
| | 2035 | 5,355 | 25,046 | 27.3 | 38,990 | 45.6 | 47,207 | 55.6 |
| | 2036 | 5,348 | 24,723 | 26.9 | 39,183 | 45.8 | 47,564 | 56.0 |

# 6 Figures

## 6.1 Data

### 6.1.1 Indices

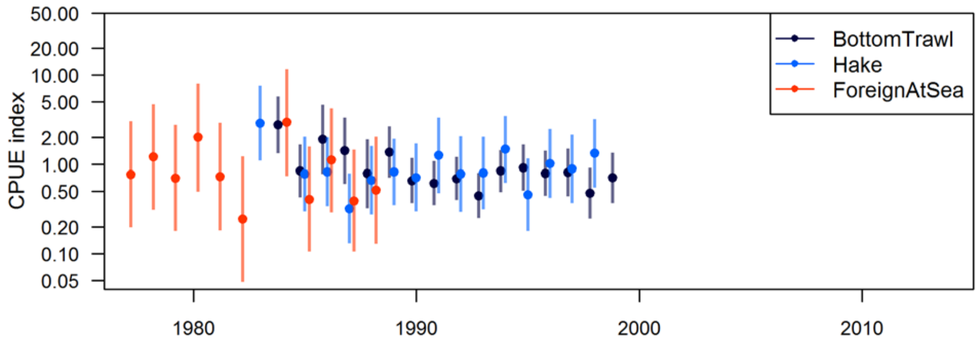



Figure 1: Fishery-dependent indices of abundance from the 2011 assessment scaled to the mean of their own series.

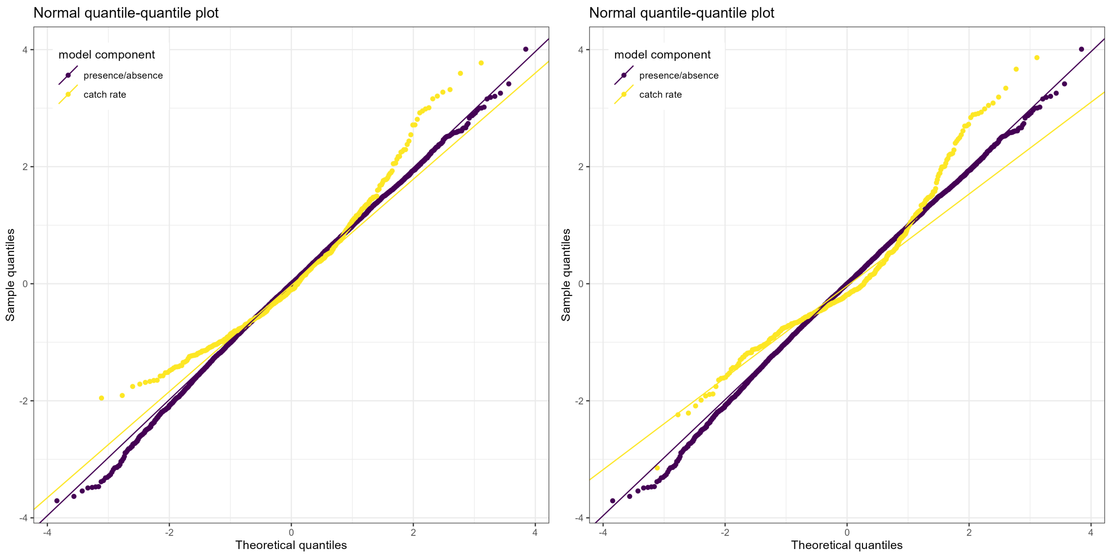



Figure 2: QQ plots for delta-gamma (panel 1) and delta-lognormal (panel 2, used in base model) sdmTMB index.

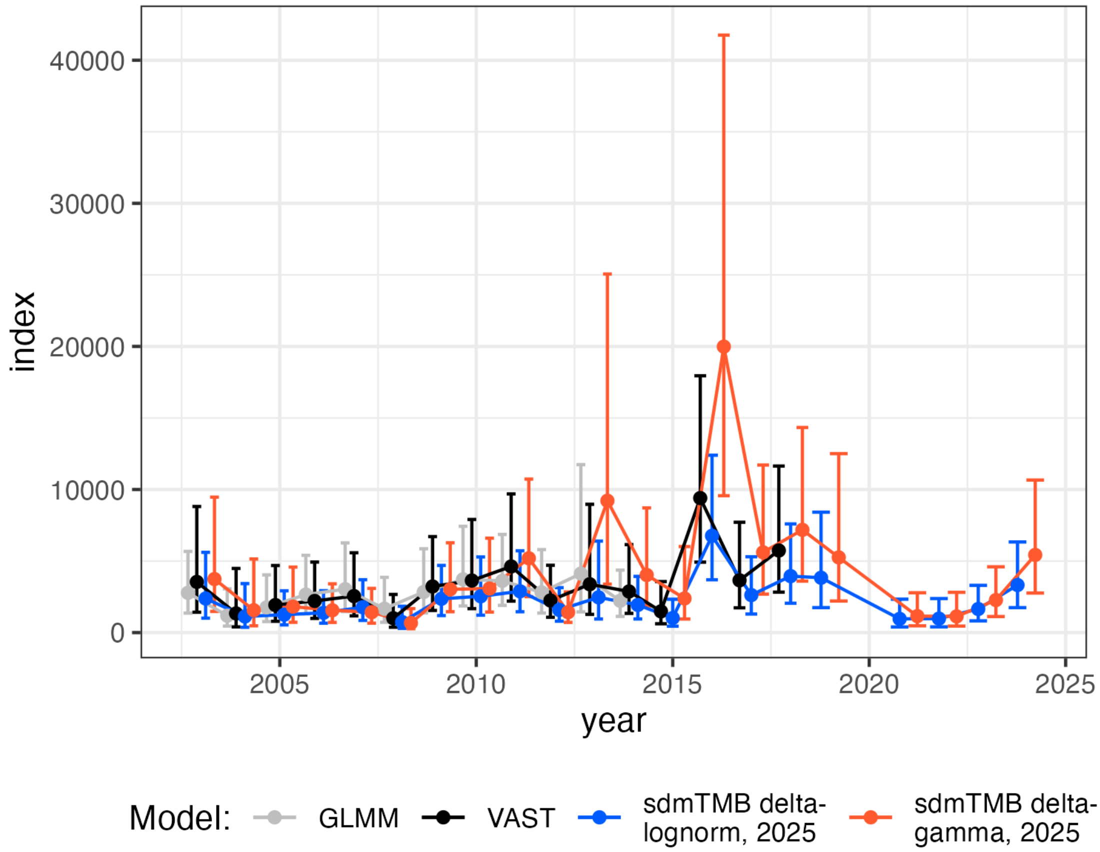



Figure 3: Comparison of the estimated index of relative abundance for the West Coast Groundfish Bottom Trawl Survey using a GLMM (gray line, 2015 stock assessment), VAST (black line, 2019 stock assessment), a delta-gamma sdmTMB index (blue line) and a delta-lognormal sdmTMB index (red line, used in base model). The error bars give 5 and 95% intervals for each survey.

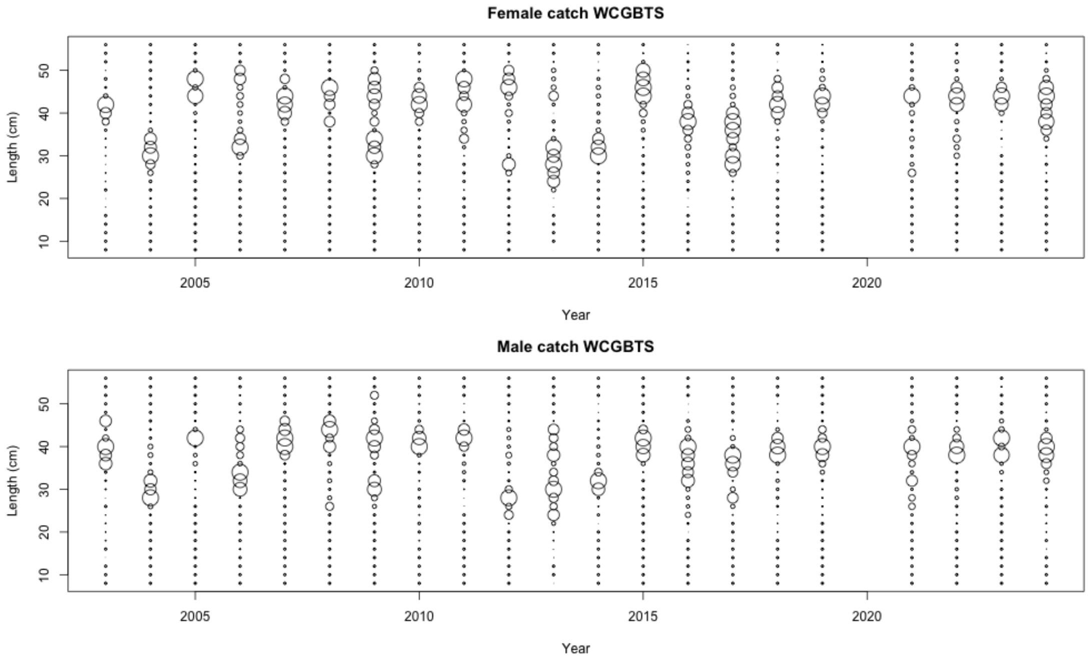
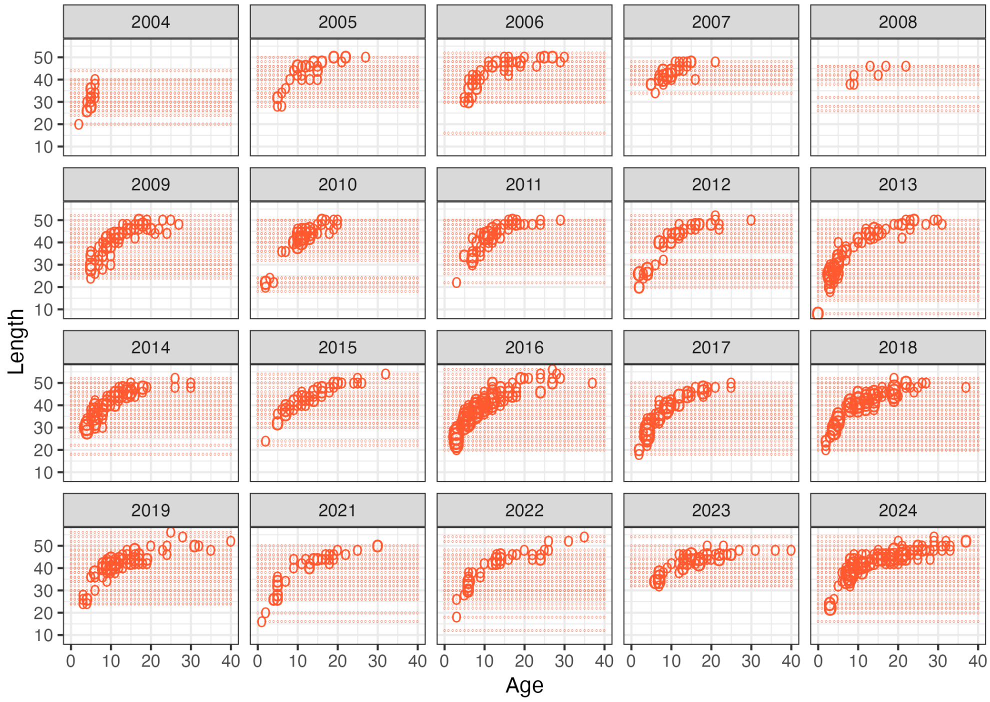



Figure 4: Expanded length compositions for the WCGBTS



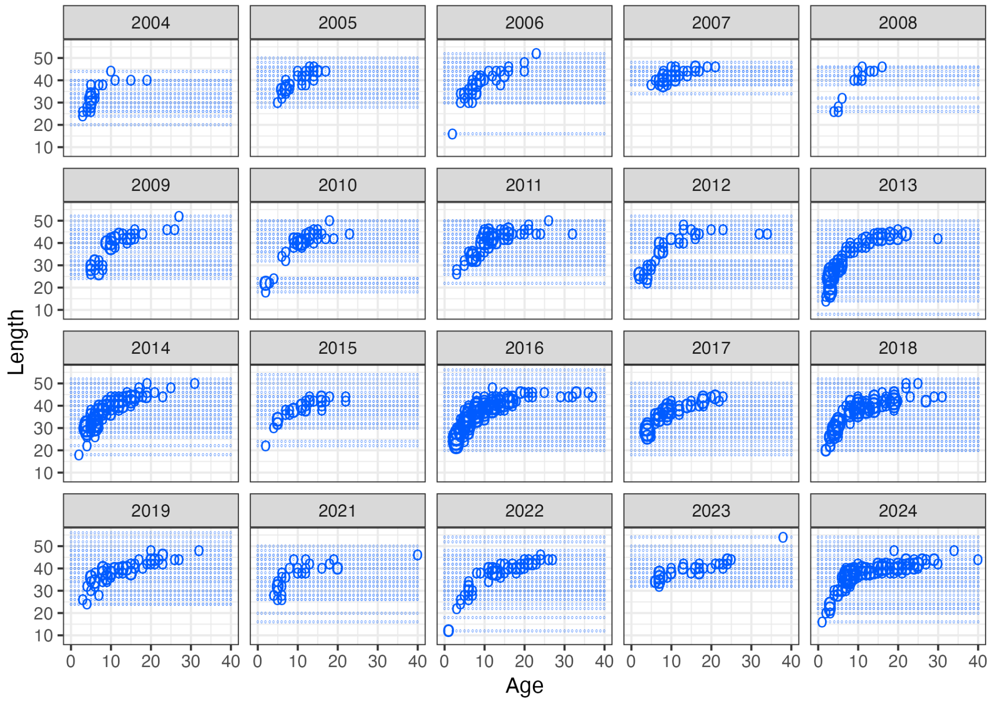




Figure 5: Conditional age-at-length from WCGBTS observations for females (red) and males (blue).

### 6.1.2 Composition data

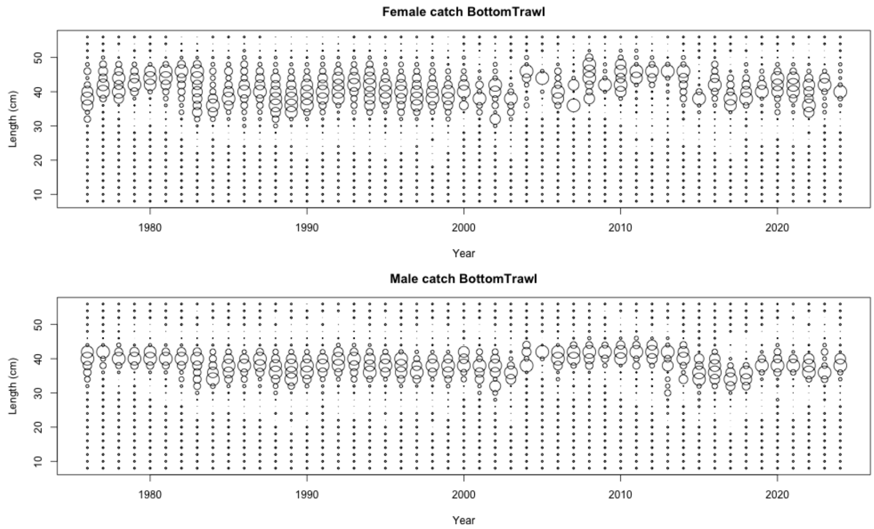



Figure 6: Expanded length compositions for the bottom trawl fishery. The area of the circle is proportional to the proportion-at-length.

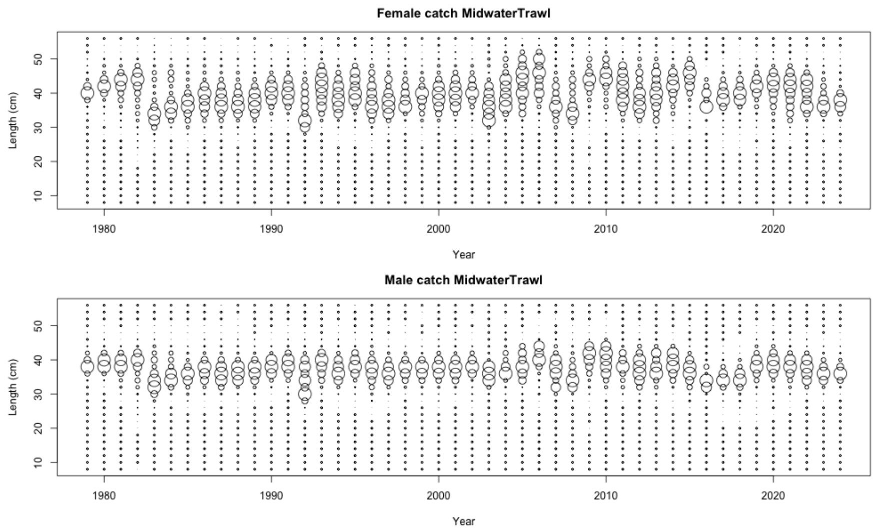



Figure 7: Expanded length compositions for the midwater trawl fishery. The area of the circle is proportional to the proportion-at-length.

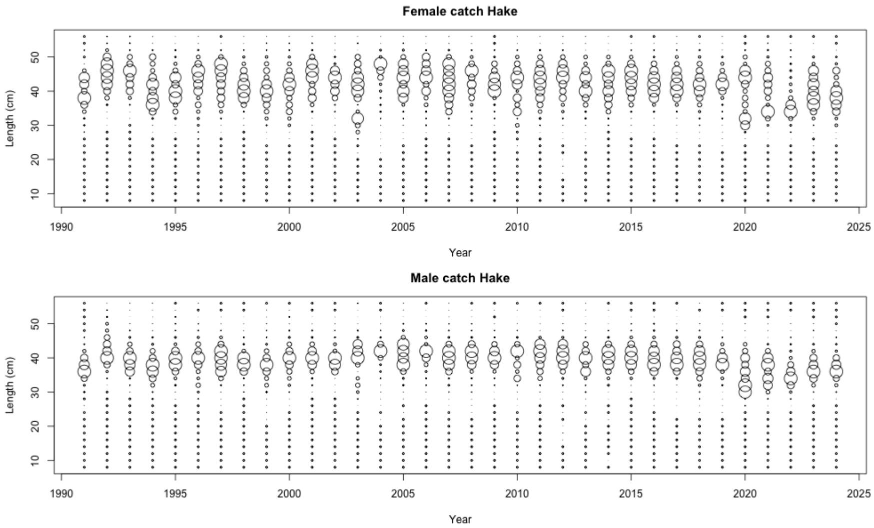



Figure 8: Expanded length compositions for the hake fishery. The area of the circle is proportional to the proportion-at-length.

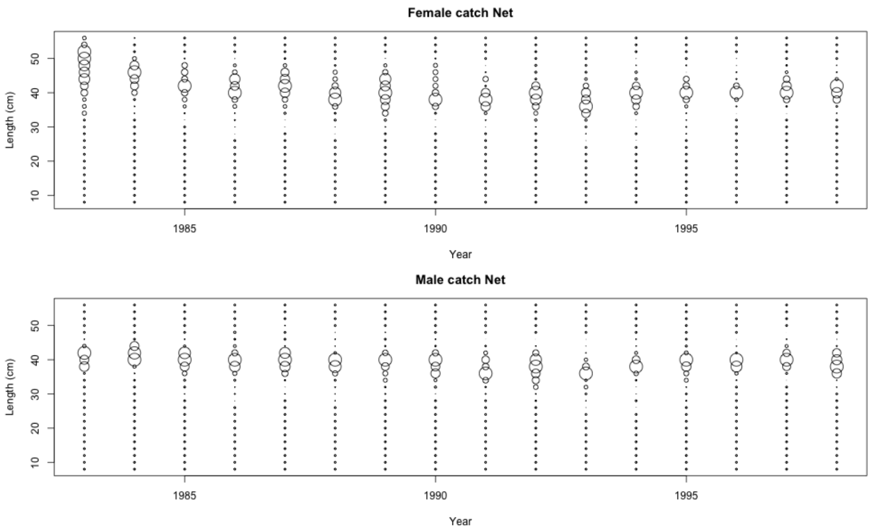



Figure 9: Expanded length compositions for the net fishery. The area of the circle is proportional to the proportion-at-length.

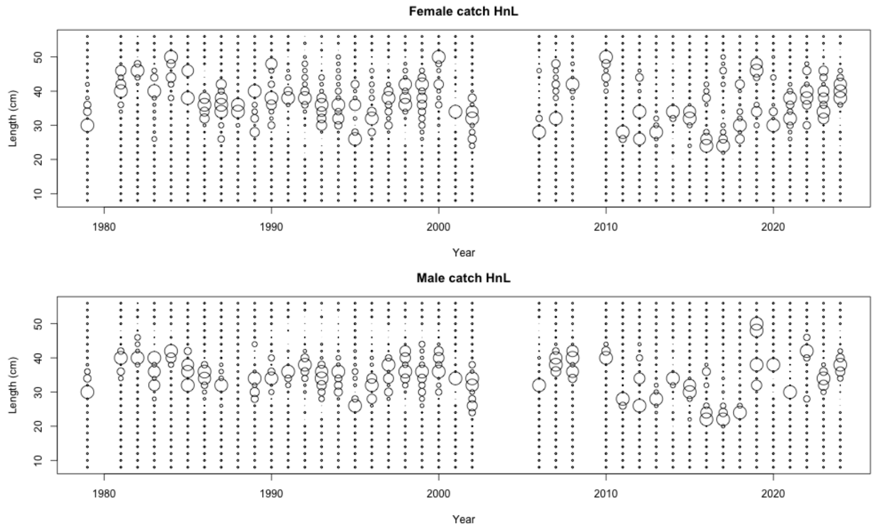



Figure 10: Expanded length compositions for the hook-and-line fishery. The area of the circle is proportional to the proportion-at-length.

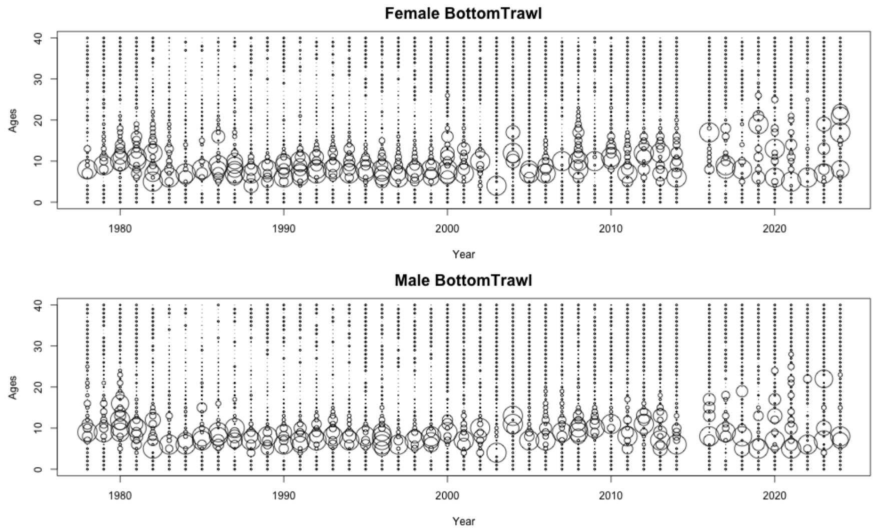



Figure 11: Expanded age compositions for the bottom trawl fishery. The area of the circle is proportional to the proportion-at-age.

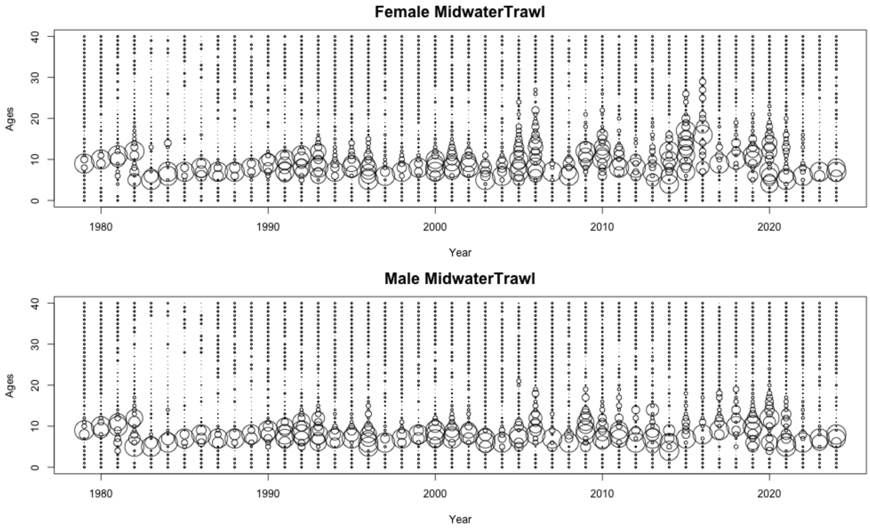



Figure 12: Expanded age compositions for the midwater trawl fishery. The area of the circles is proportional to the proportion-at-age.

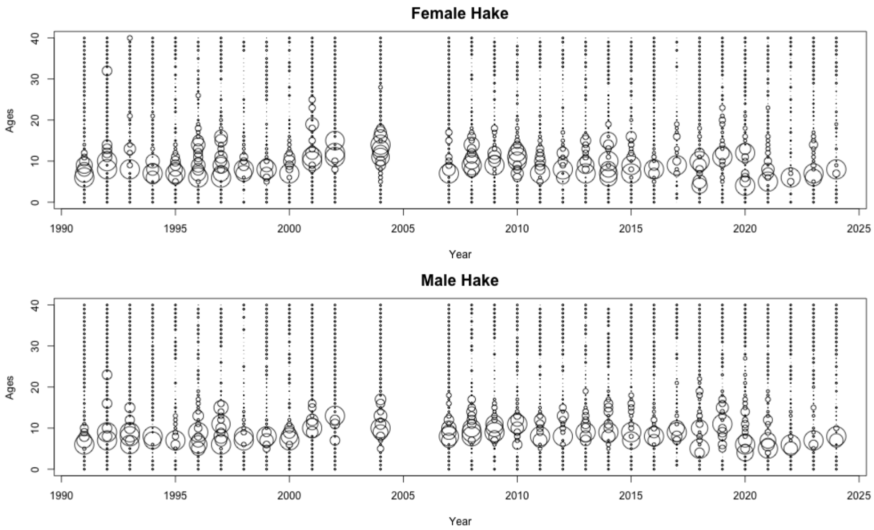



Figure 13: Expanded age compositions for the hake fishery. The area of the circles is proportional to the proportion-at-age.

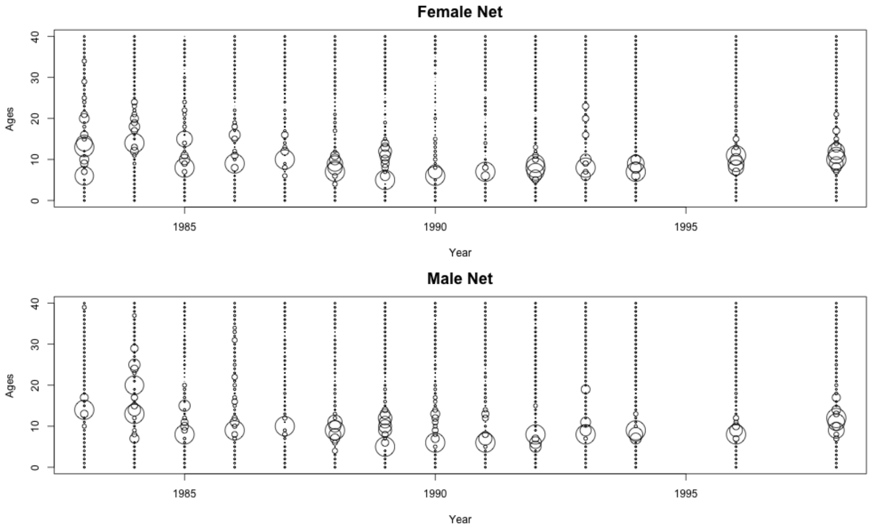



Figure 14: Expanded age compositions for the net fishery. The area of the circles is proportional to the proportion-at-age.

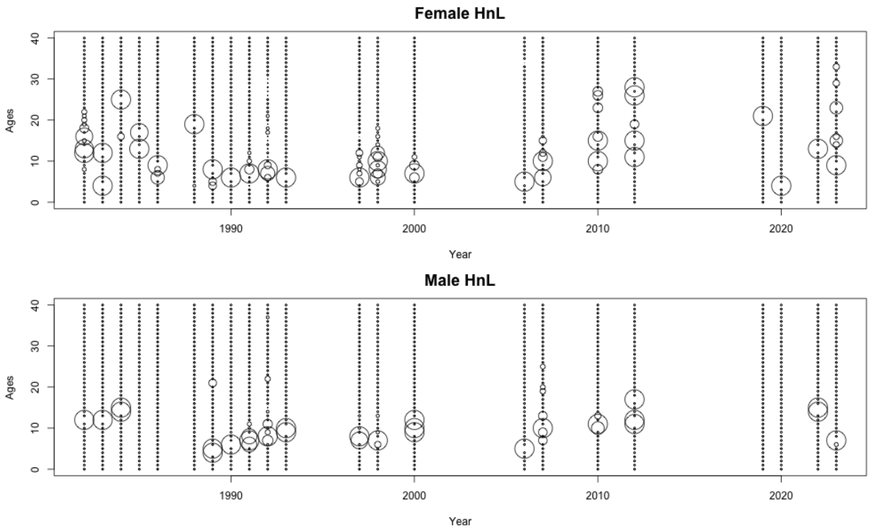
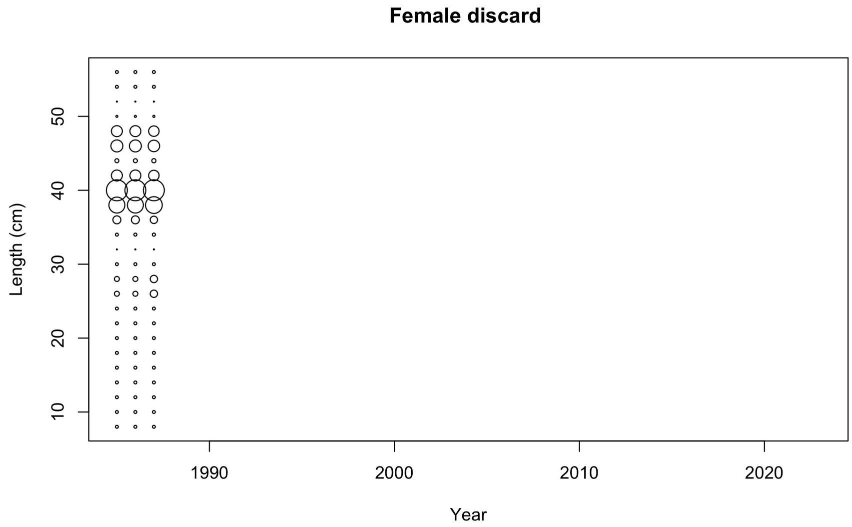



Figure 15: Expanded age compositions for the hook-and-line fishery. The area of the circles is proportional to the proportion-at-age.



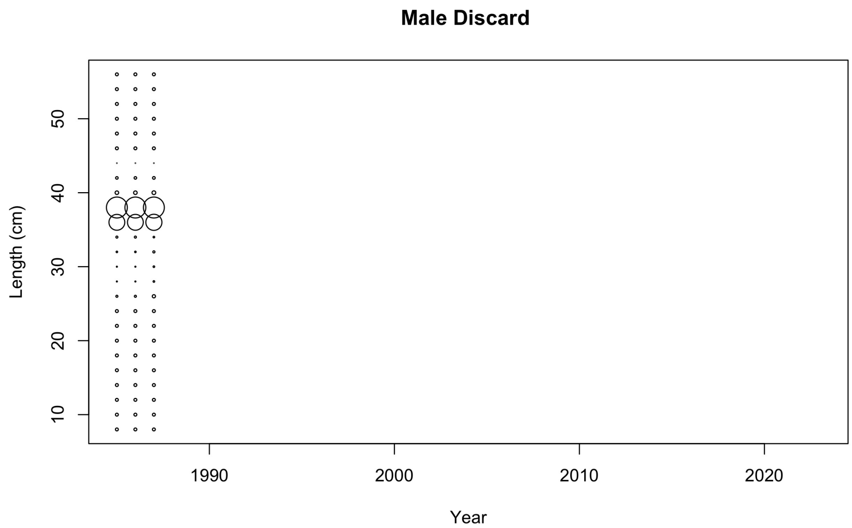




Figure 16: Length compositions for discards from the Pikitch study. The discard length comps were fitted into the model.

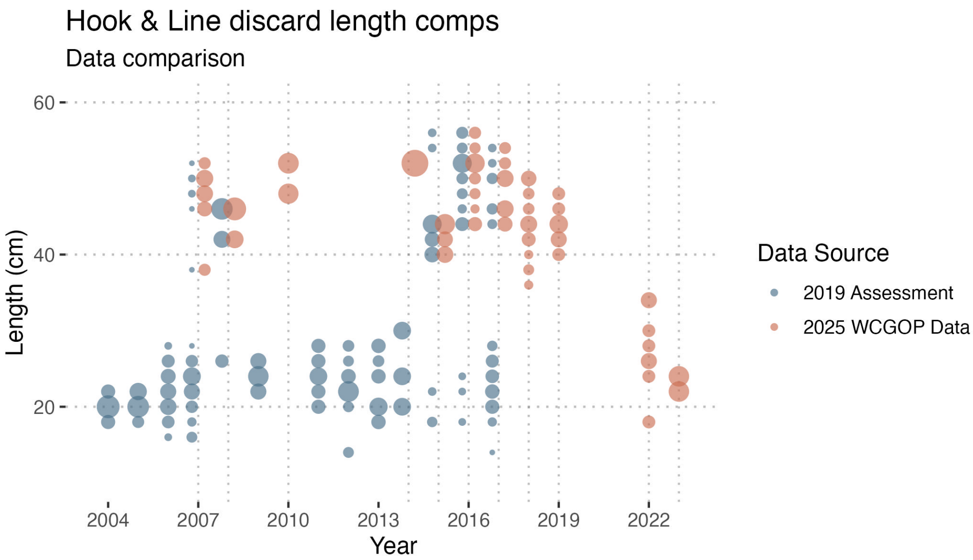



Figure 17: Comparison between discard data for the hook-and-line fleet from the 2019 assessment, which included nearshore fixed gear fleets, and discards queried from WCGOP for this assessment.

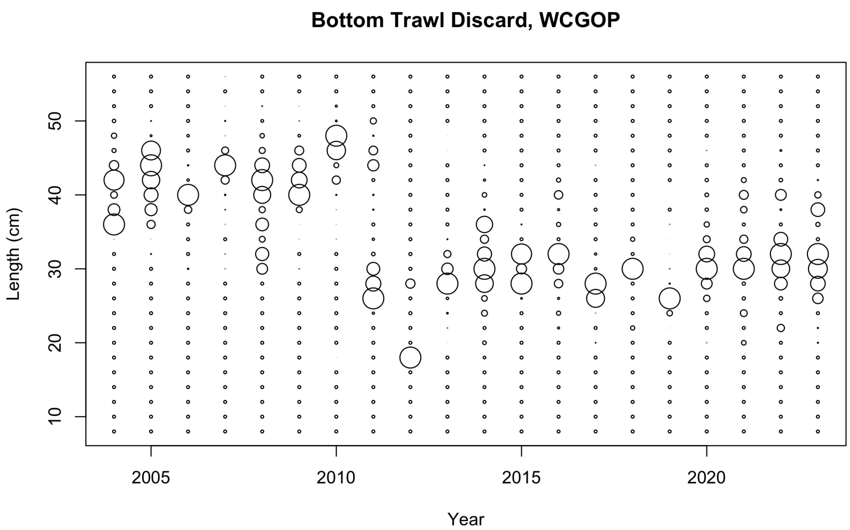



Figure 18: Length compositions of the discards for the bottom trawl.

### 6.1.3 Biological data

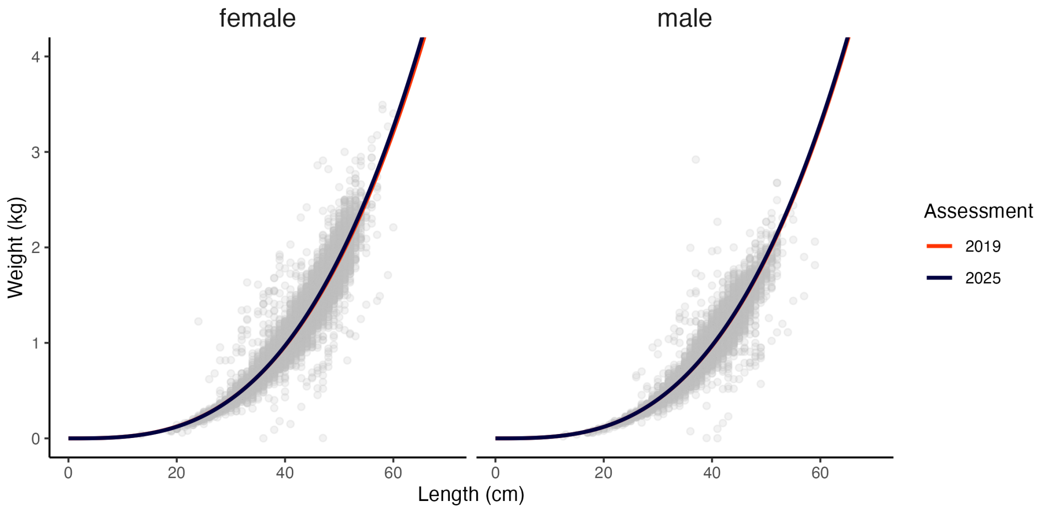



Figure 19: Fits to weight-at-length observations (dashed line) for females (left) and males (right) from the previous and current assessments. Fits to the current assessment use observations from all data sources (points)

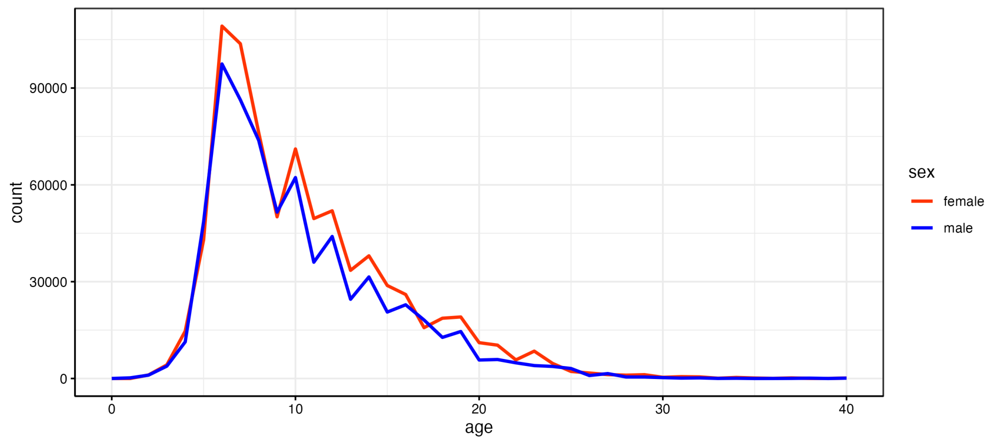



Figure 20: Number at age observed from all data for female and male widow rockfish.

## 6.2 Model

### 6.2.1 Bridging

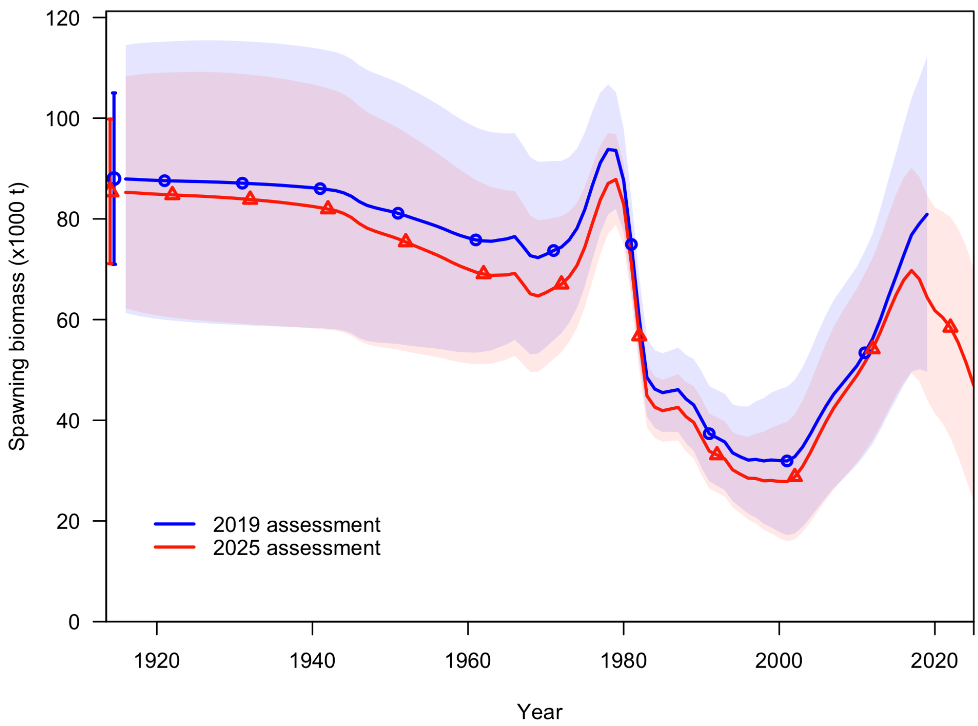



Figure 21: Time series of spawning stock biomass (SSB) estimates and asymptotic 95% confidence intervals estimates from 2019 and 2025 base models.

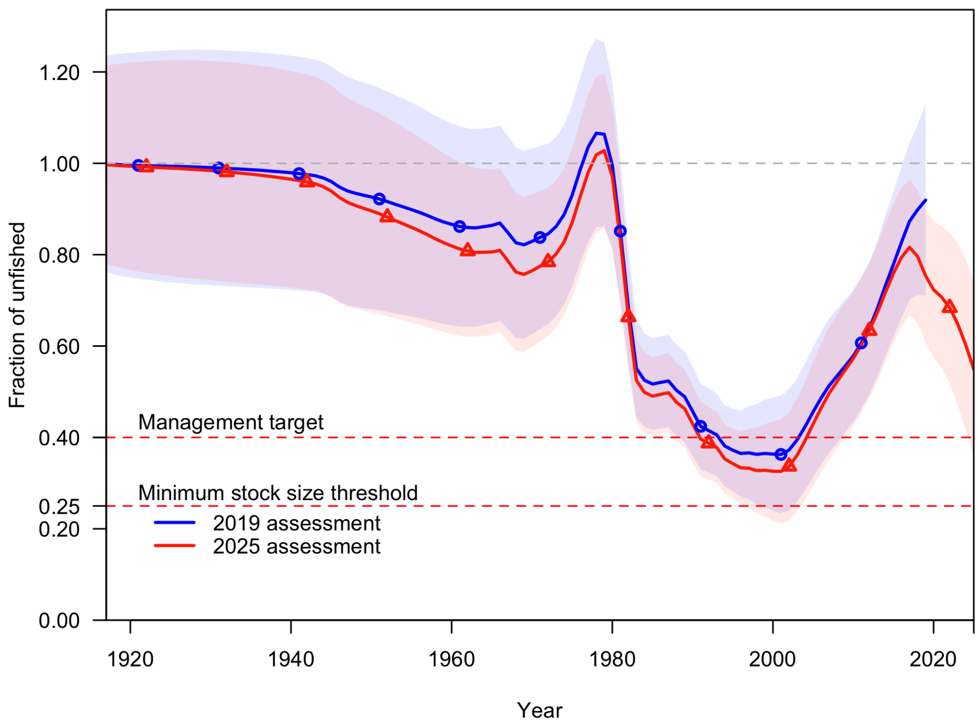



Figure 22: Time series of fraction of unfished spawning stock biomass estimates and asymptotic 95% confidence intervals estimates from 2019 and 2025 base models.

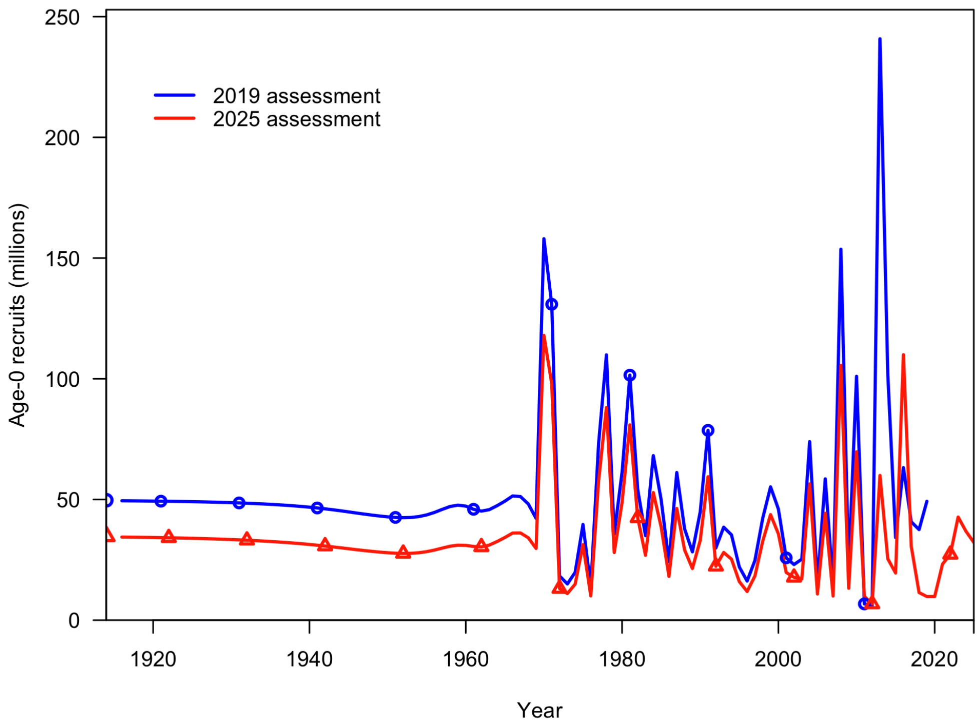



Figure 23: Estimates of age-0 recruits (in millions of individuals) from 2019 and 2025 base models.

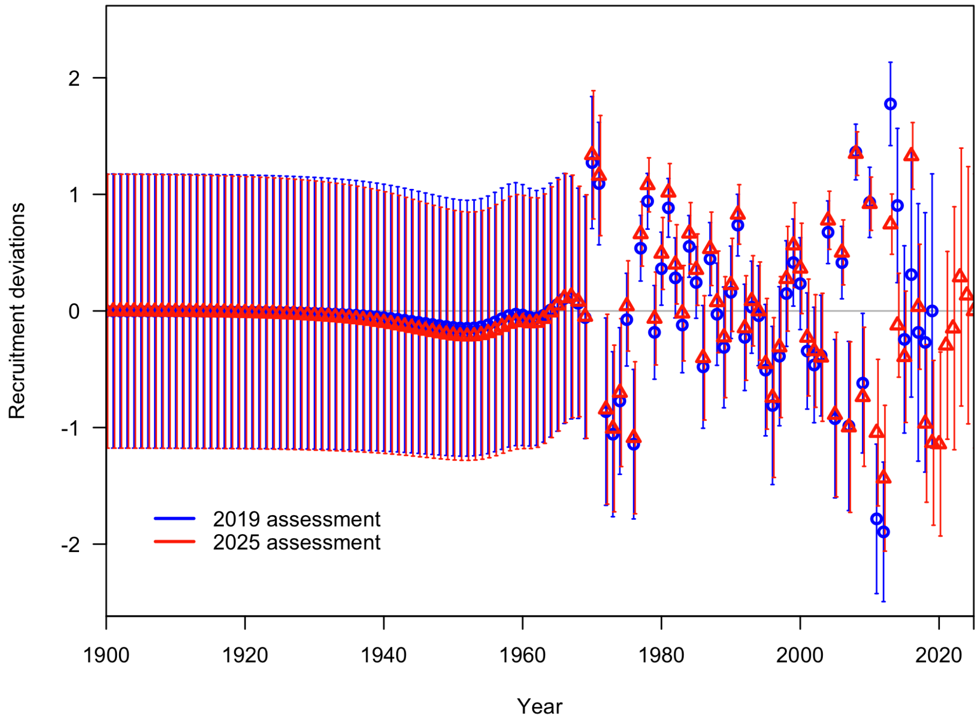



Figure 24: Estimates of age-0 (log-)recruitment deviations from 2019 and 2025 base models, with asymptotic 95% confidence intervals.

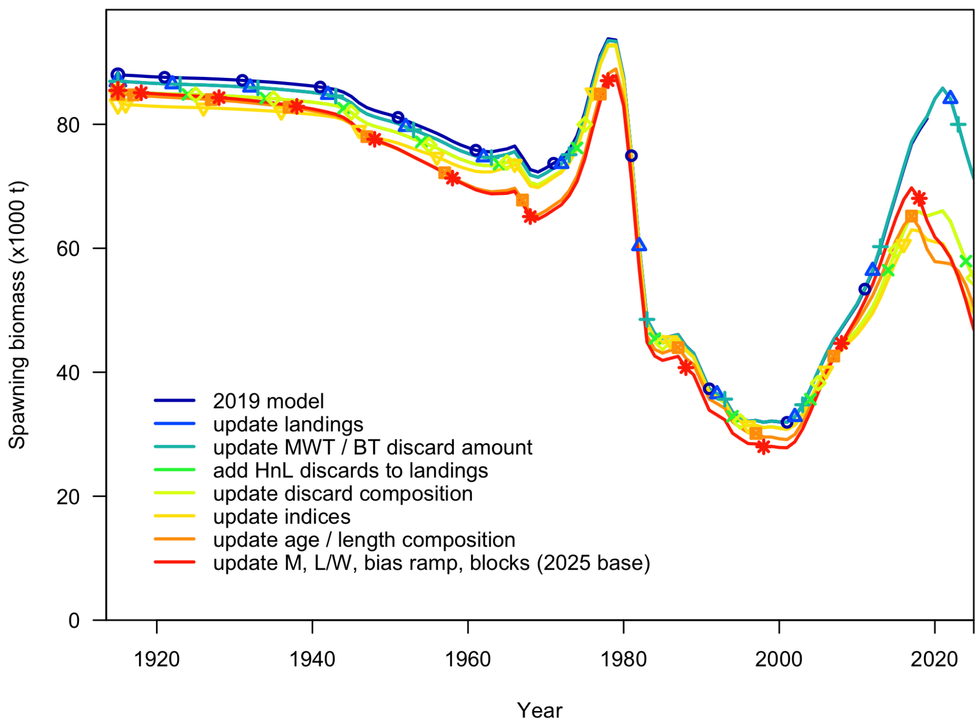



Figure 25: Time series of spawning stock biomass (SSB) estimates from model runs bridging from the 2019 assessment (dark blue) to the current base model (red). For illustration purposes, the addition of midwater and bottom trawl discards (without updating hook-and-line discards) precedes the addition of hook-and-line discards to hook-and-line landings. Some bridging steps with minimal impact on SSB are grouped (including updating mortality priors, length/weight regression estimates, stock-recruitment bias ramp estimation, and the addition of blocks on midwater and hake retention).

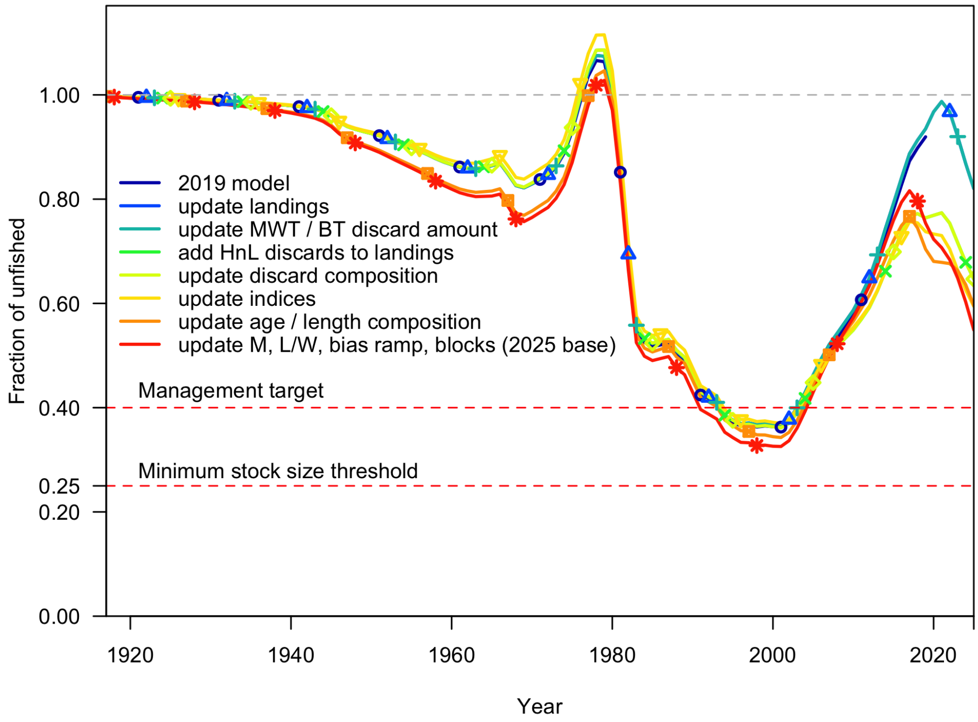



Figure 26: Time series of relative spawning stock biomass (fraction unfished / depletion) estimates from model runs bridging from the 2019 assessment (dark blue) to the current base model (red).

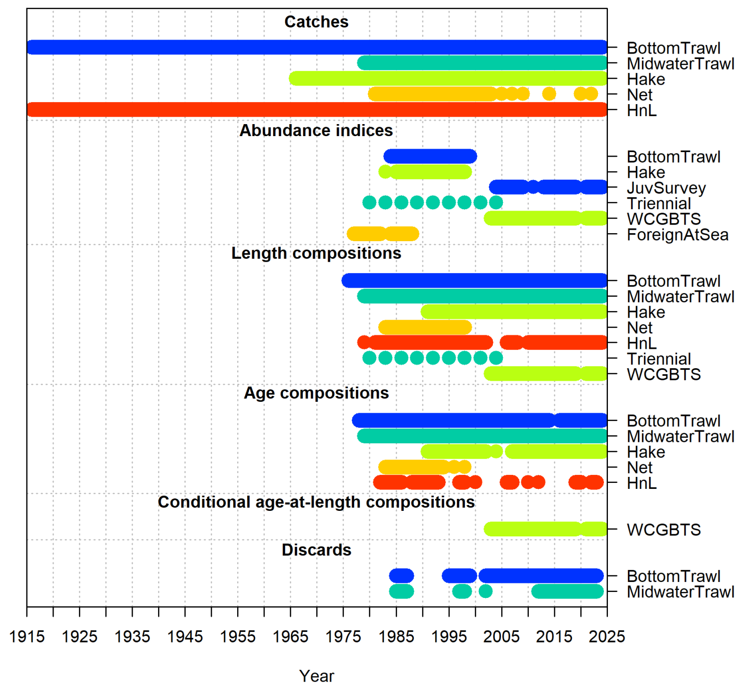



Figure 27: Data sources by type and year that were used in the base model.

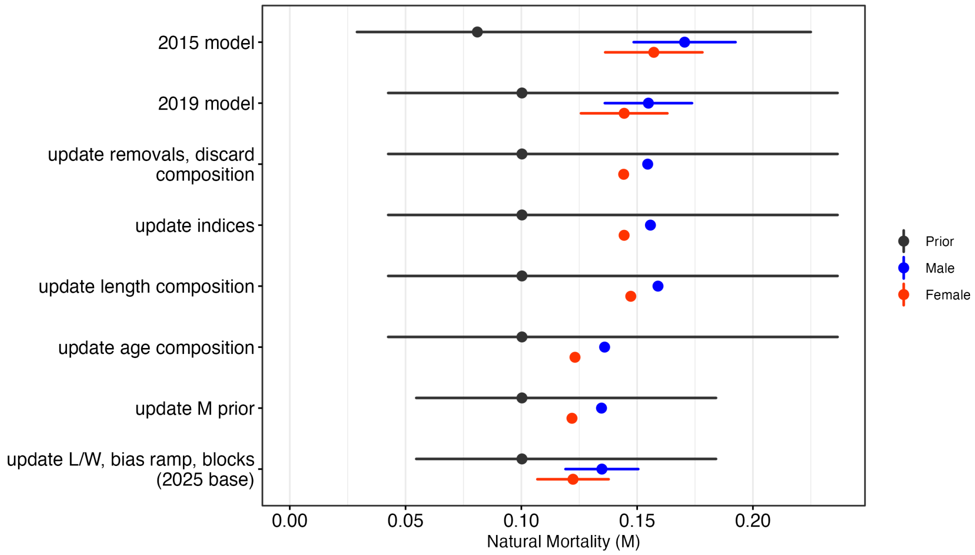



Figure 28: The prior for natural mortality (grey, M, yr-1 ) and the estimated M for females (red) and males (blue) from the 2015 base model, 2019 base model, and selected intermediate models bridging to the 2025 base model. Prior 95% quantiles are based on the assumed lognormal distribution. Confidence intervals for estimated male and female M are shown only for the 2015, 2019, and 2025 base models and are based on a normal asymptotic approximation to the sampling distribution. Depicted bridging models are selected to highlight changes with a notable impact on M.

### 6.2.2 Selectivity

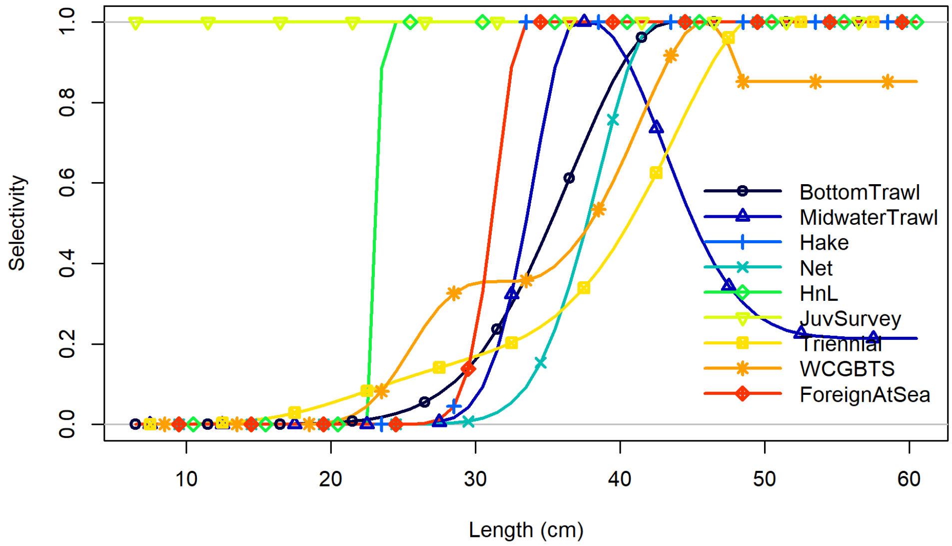



Figure 29: Estimated selectivity for different fleets and surveys.

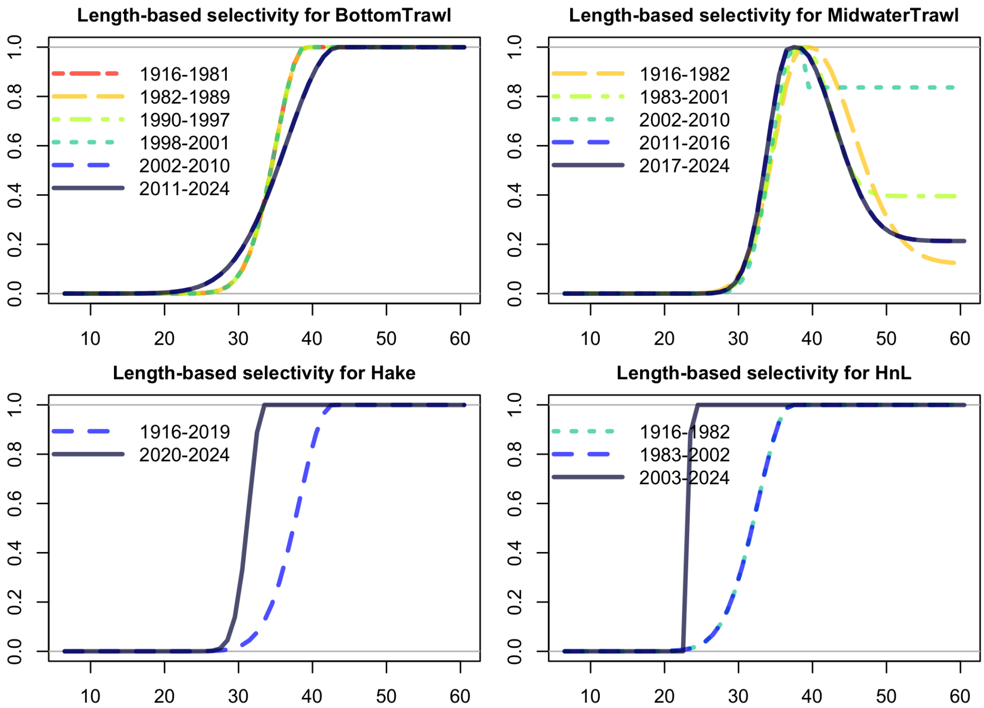



Figure 30: Estimated selectivity curves by time block for bottom trawl, midwater trawl, hake, and hook-and-line fleets.

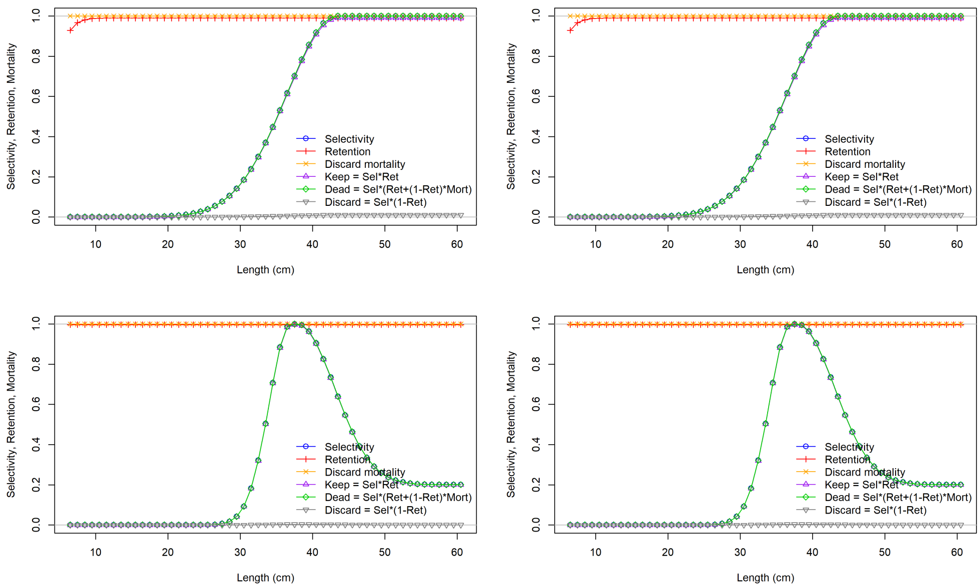



Figure 31: Estimated selectivity for Bottom Trawl (top row) and Midwater Trawl (bottom row) for males (left column) and females (right column)

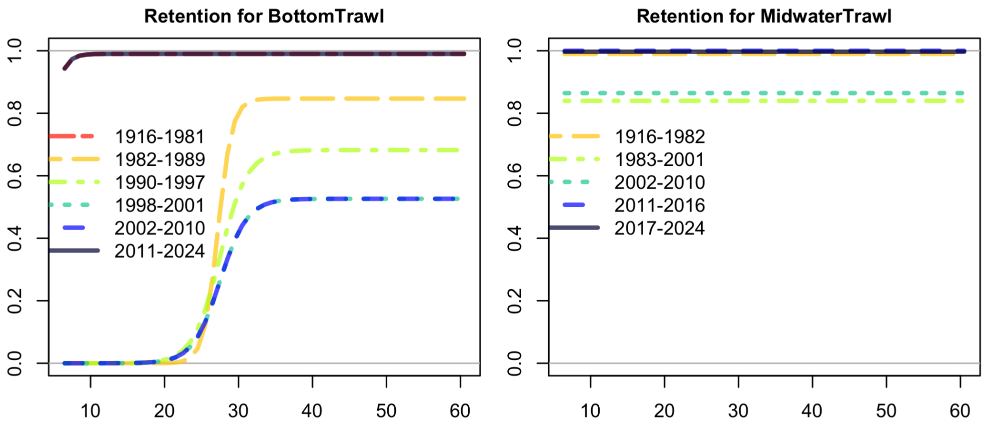



Figure 32: Estimated retention curves by time block for bottom and midwater trawl fleets.

### 6.2.3 Biology

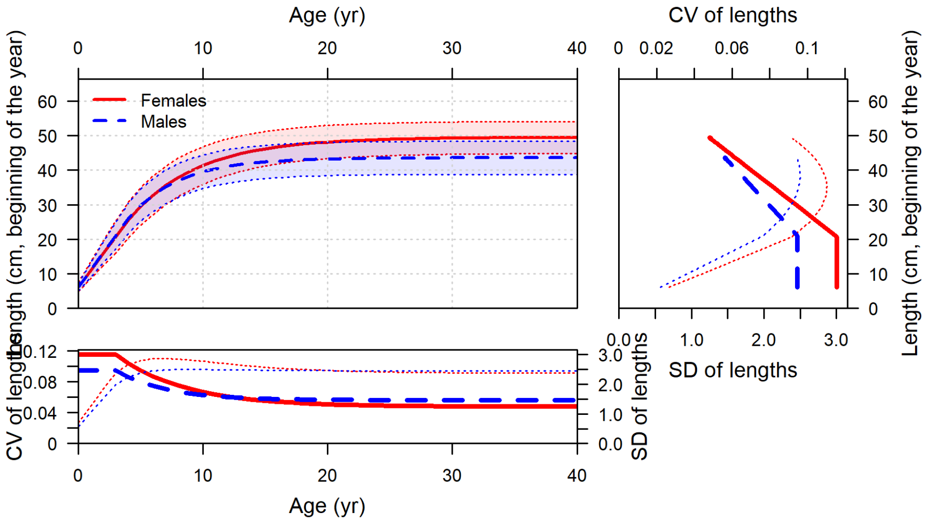



Figure 33: Length at age (top-left panel) with estimated coefficient of variation (CV, thick line) and calculated standard deviation (SD, thin line) versus length at age in the top-right panel and versus age in the lower-left panel.

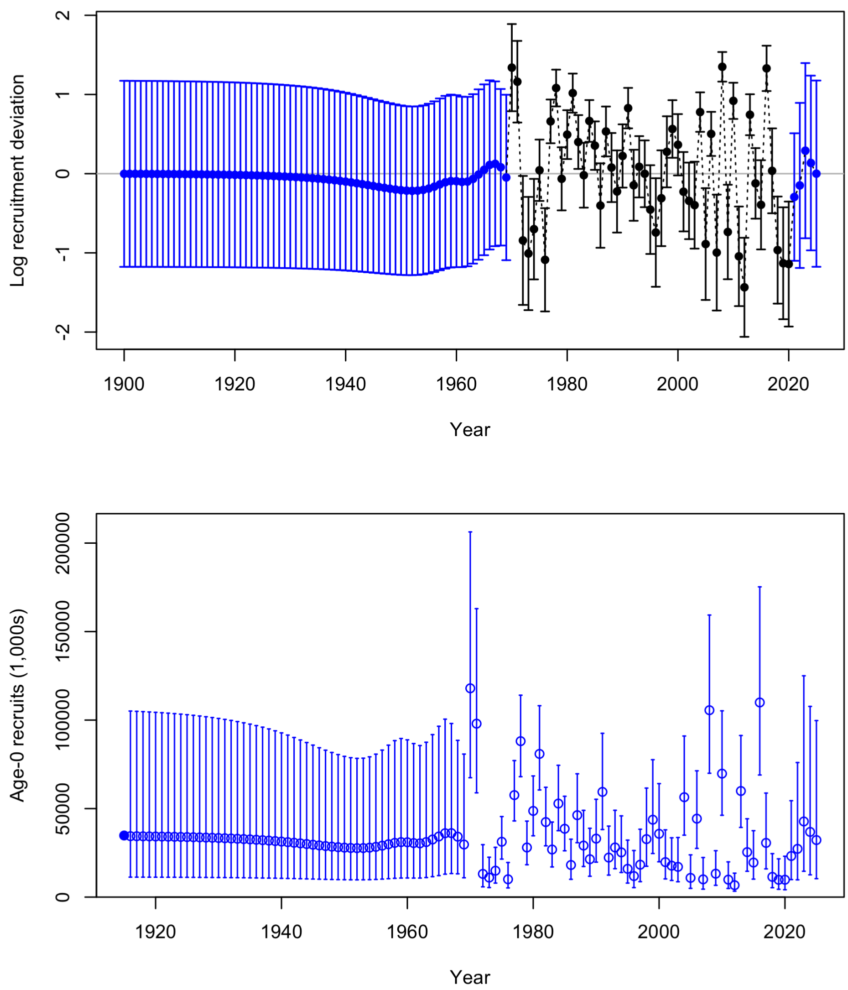



Figure 34: Estimates of recruitment (upper) and recruitment deviates (lower) with approximate asymptotic 95% confidence intervals (vertical lines) from the MLE estimates.

#### 6.2.4 Fits to data

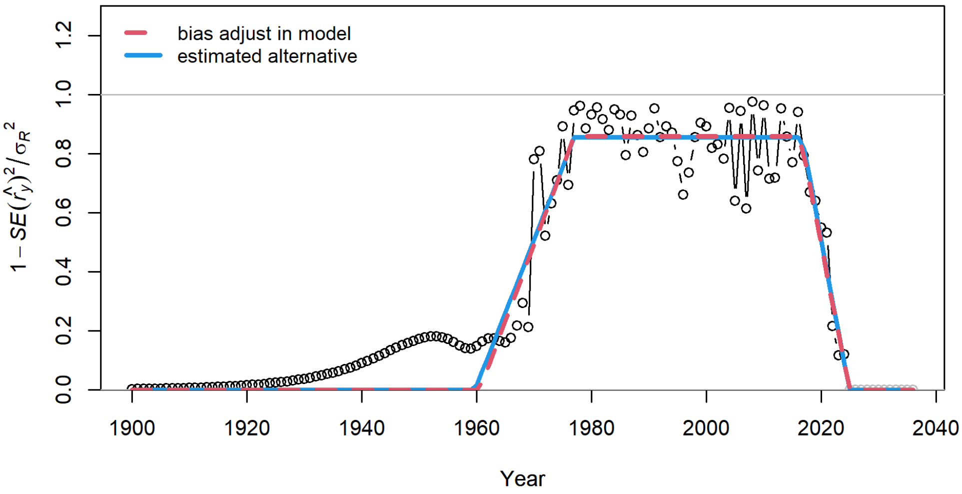



Figure 35: Estimated and input recruitment bias adjustment ramp. Red line shows current settings for bias adjustment ramp. Red line shows current settings for bias adjustment specified in the model. Blue line shows least squares estimate of alternative bias adjustment relationship for recruitment deviations.

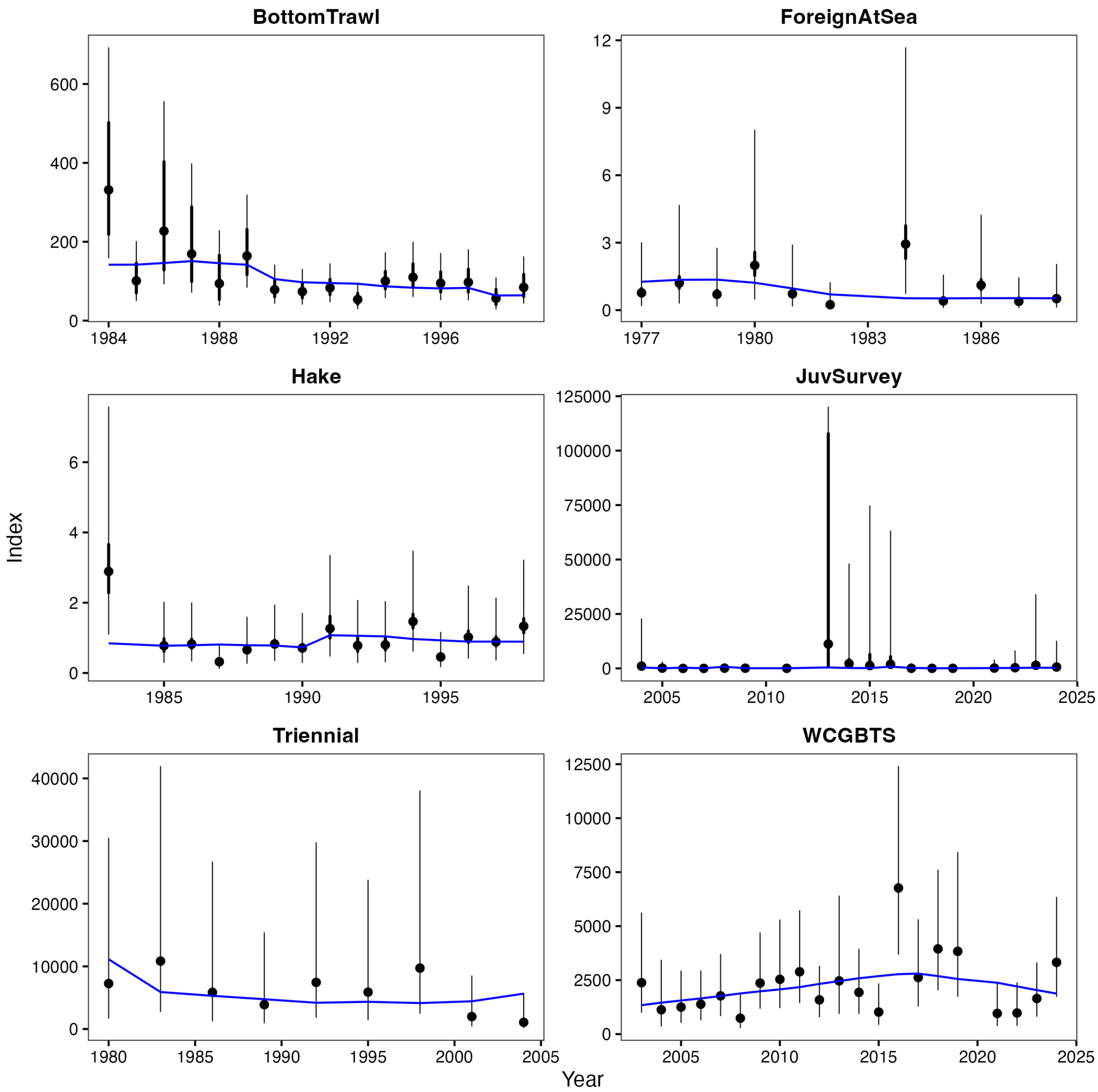



Figure 36: Fits (blue lines) to the abundance estimates (black points) for the base model. A separate q is estimated for the Hake series starting in 1991. Except the juvenile survey (counts) all indices are biomass-based. 95% confidence intervals are shown assuming a normal distribution of the log-estimates. Thicker lines (if present) indicate input uncertainty before addition of the estimated additional uncertainty parameter. The y-axis of the juvenile survey is truncated to highlight interannual variability in counts.

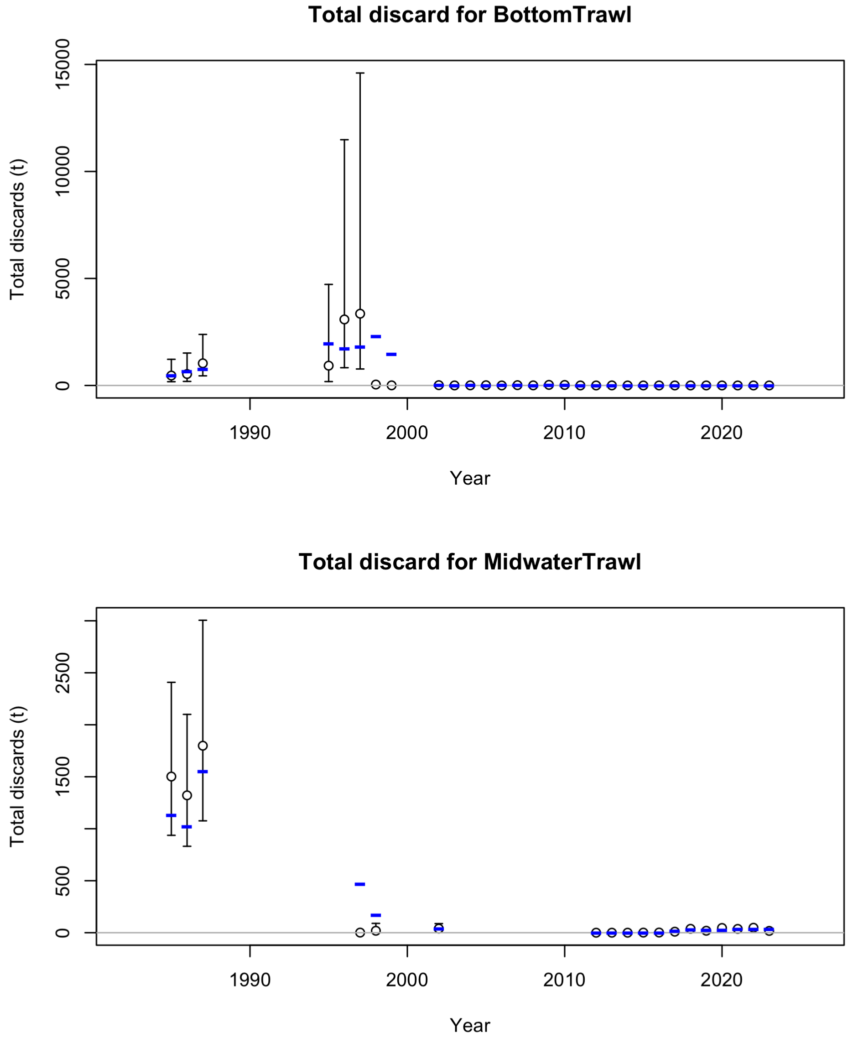



Figure 37: Predicted (blue line) and observed (open circles) discards for the bottom trawl (top) and midwater trawl (bottom) fleets from the base model. 95% confidence intervals are shown for the observations.

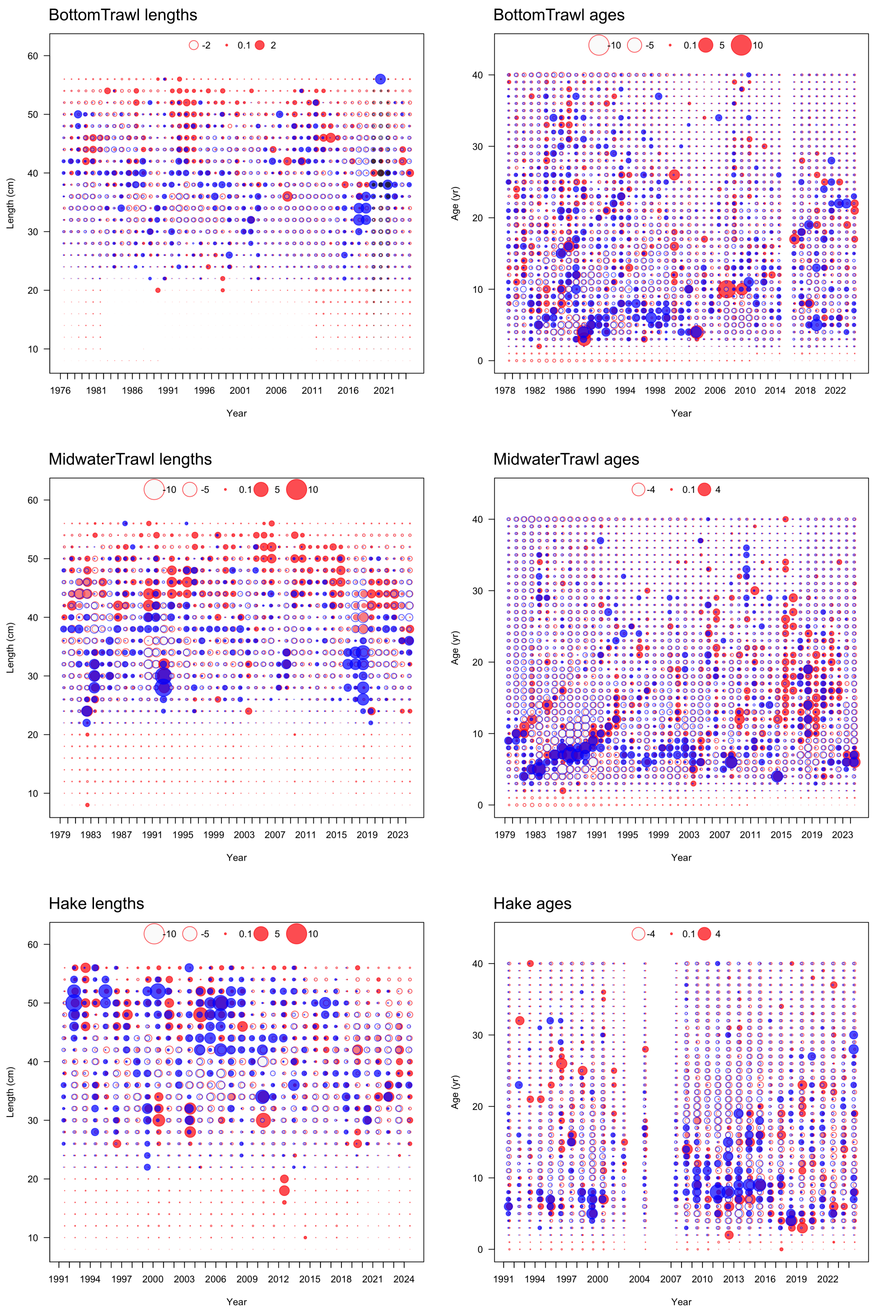



Figure 38: Pearson residuals for fits to length frequency data (left) and age frequency data (right) for landings from the trawl commercial fleets (rows). Filled circles indicate that the fitted proportion was less than the observed proportion. Red indicates females, blue males, and gray unsexed.

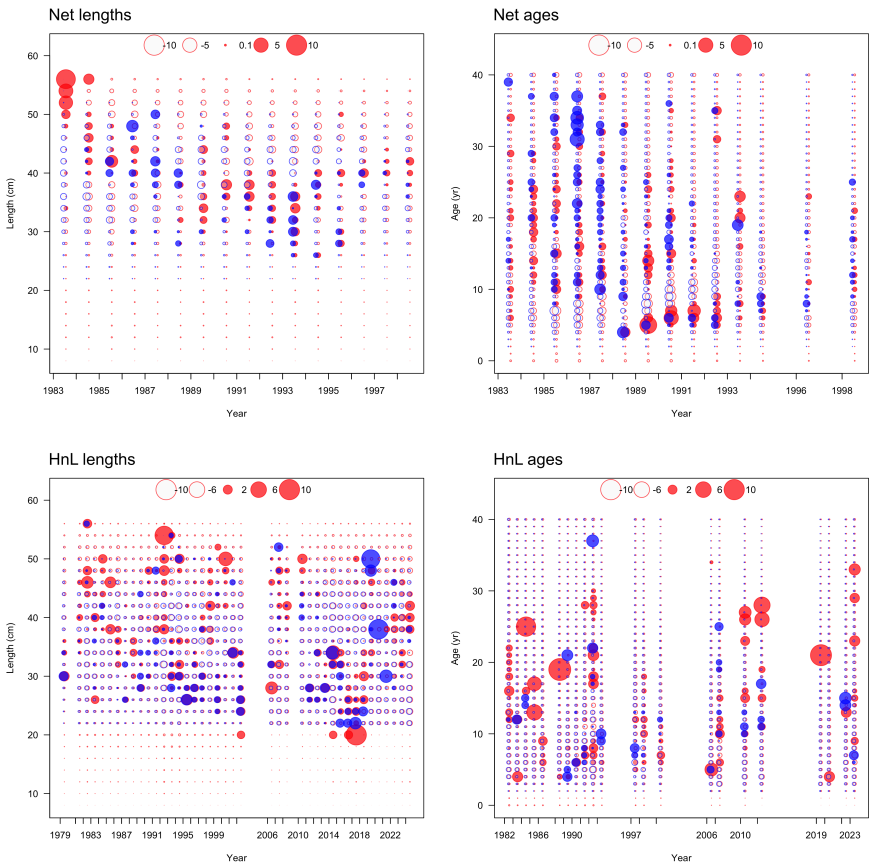



Figure 39: Pearson residuals for fits to length frequency data (left) and age frequency data (right) for landings from the net and hook-and-line commercial fleets (rows). Filled circles indicate that the fitted proportion was less than the observed proportion. Red indicates females, blue males, and gray unsexed.

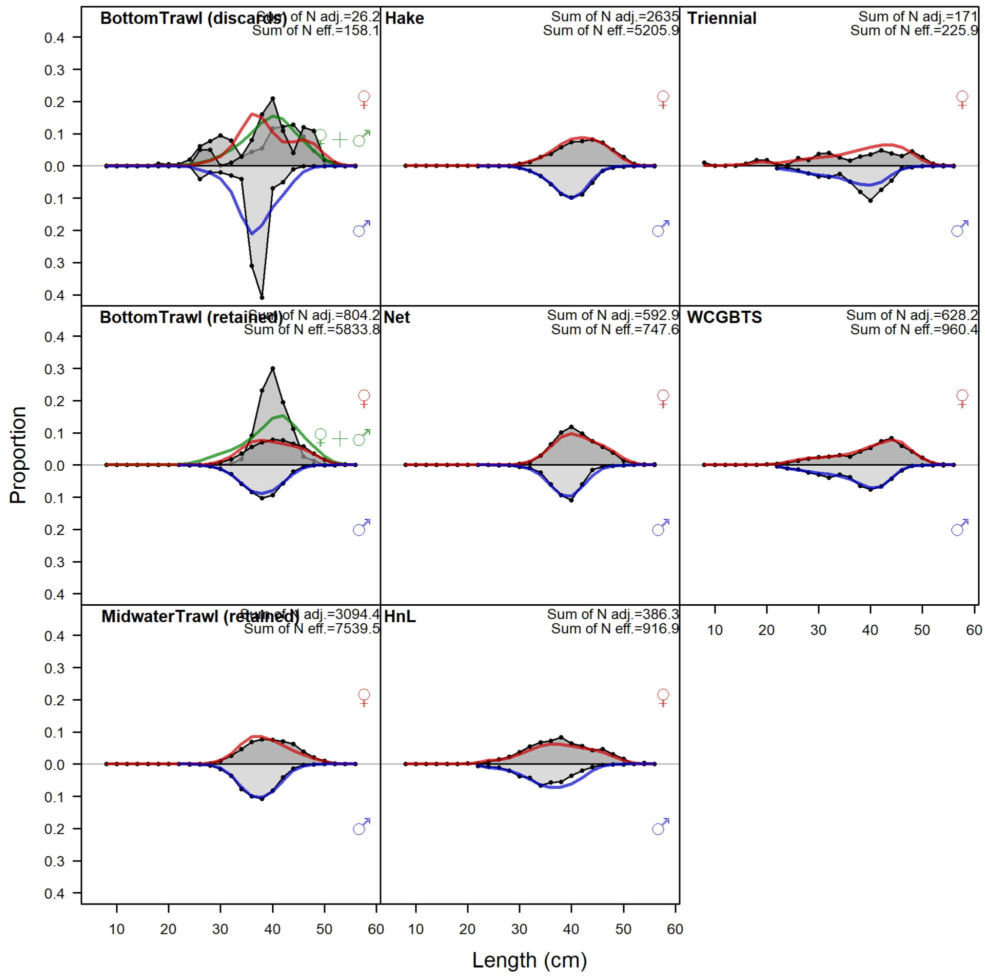



Figure 40: Combined length frequencies for all years from fishery (retained catch) and survey length frequency data (points). Fits are shown by the red line (females) and blue line (males).

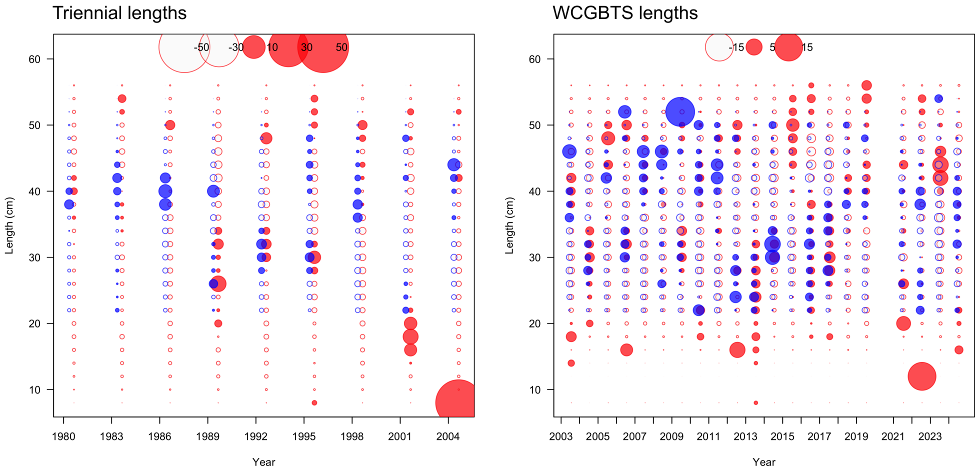



Figure 41: Pearson residuals for fits to the triennial survey length frequency data (left) and WCGBTS length frequency data (right). Filled circles indicate that the fitted proportion was less than the observed proportion. Red indicates females, blue males, and gray unsexed.

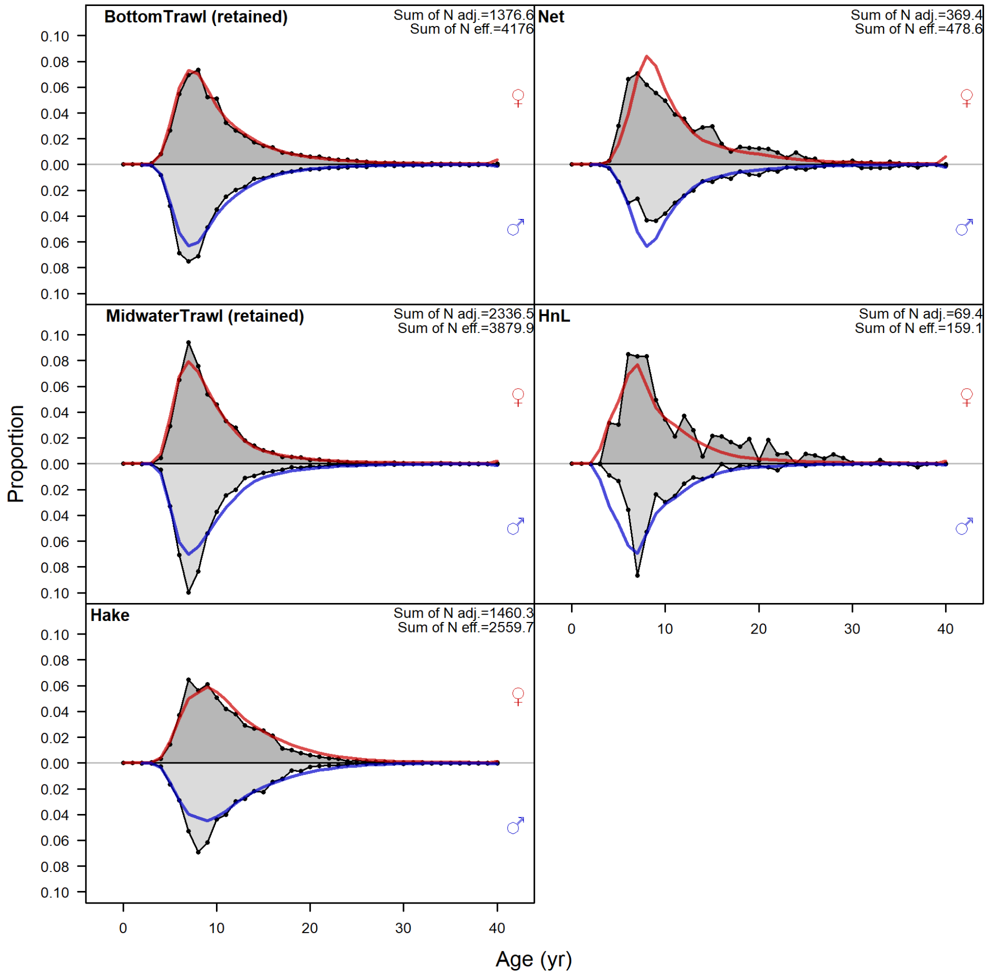



Figure 42: Combined age frequencies for all years from fishery (retained catch) and survey length frequency data (points). Fits are shown by the red line (females) and blue line (males).

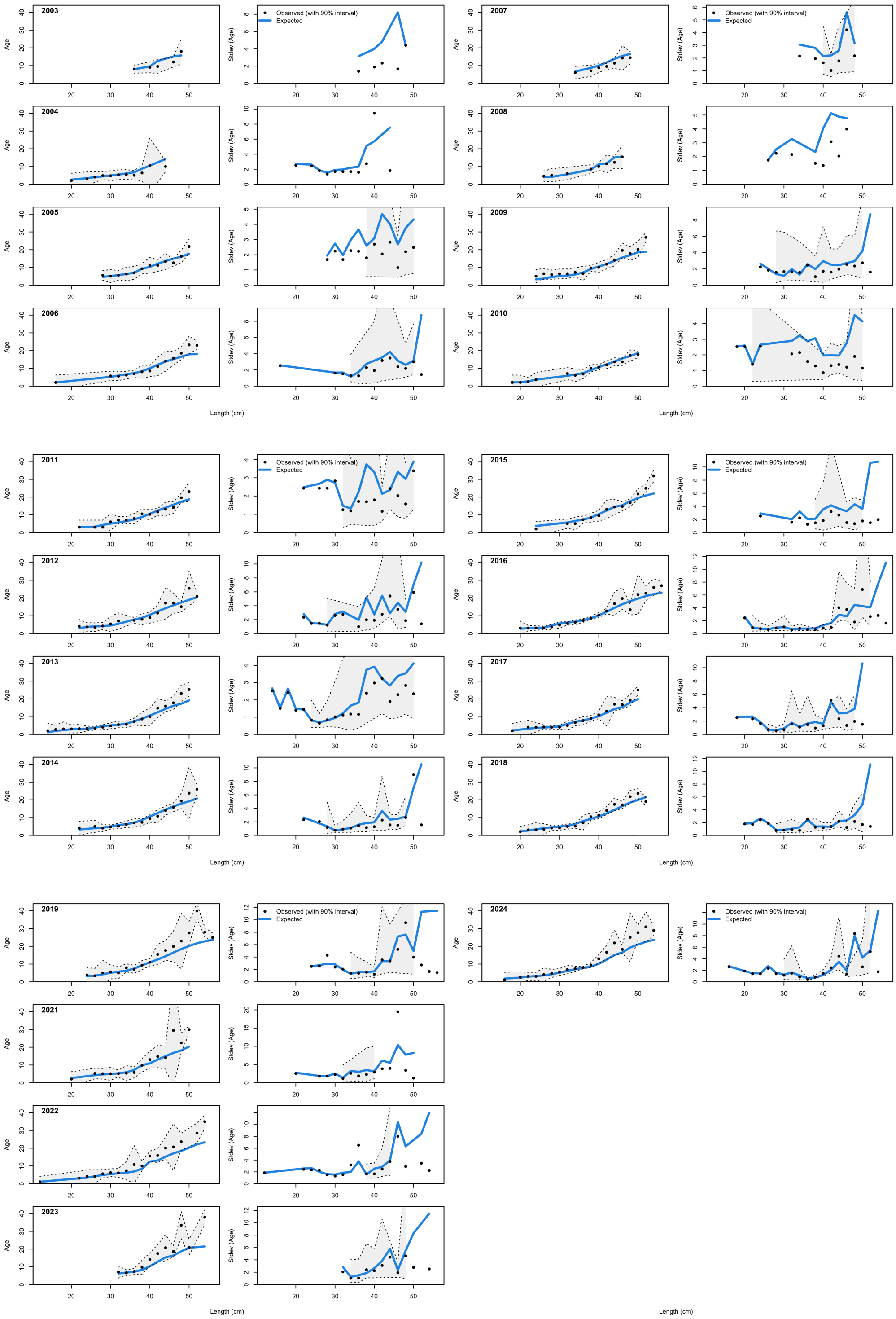



Figure 43: Observed and expected age-at-length with 95% confidence intervals (left) and observed and expected standard deviation of age-at-length with 95% confidence intervals (right) for the WCGBTS.

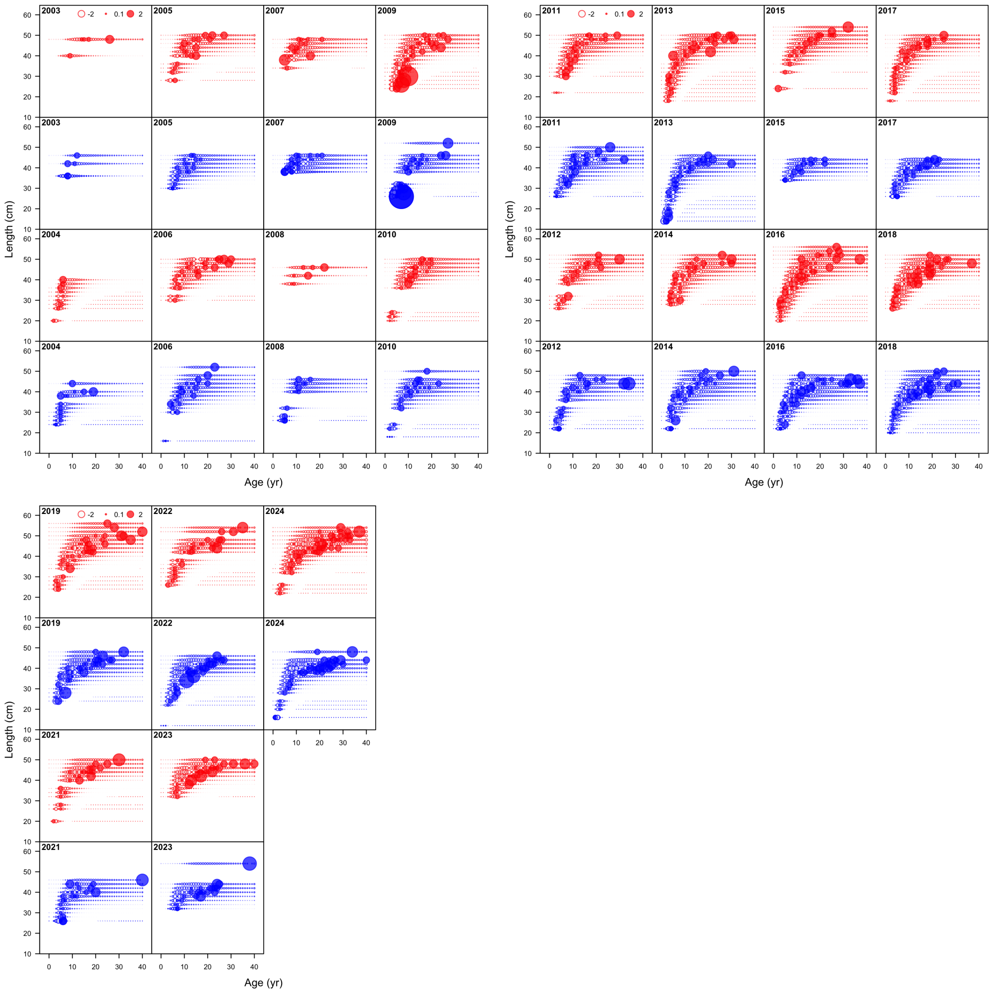


Figure 44: Combined age and length frequency data for all years from fishery (retained catch) and survey length frequency data (points) for females (red) and males (blue).

#### 6.2.5 Timeseries

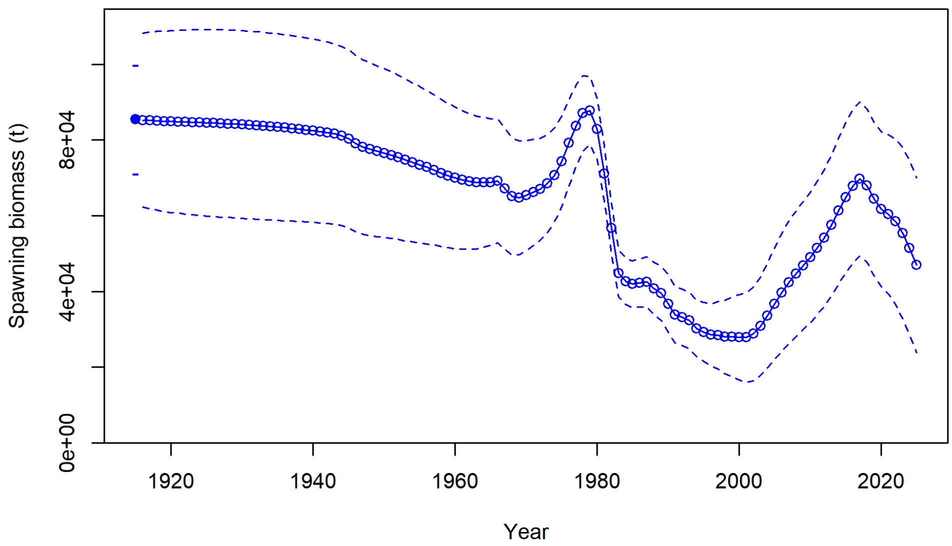



Figure 45: Predicted SB (thousand mt) for widow rockfish using the base assessment. The solid line is the MLE estimate, and the dashed lines depict the approximate asymptotic 95% confidence intervals.

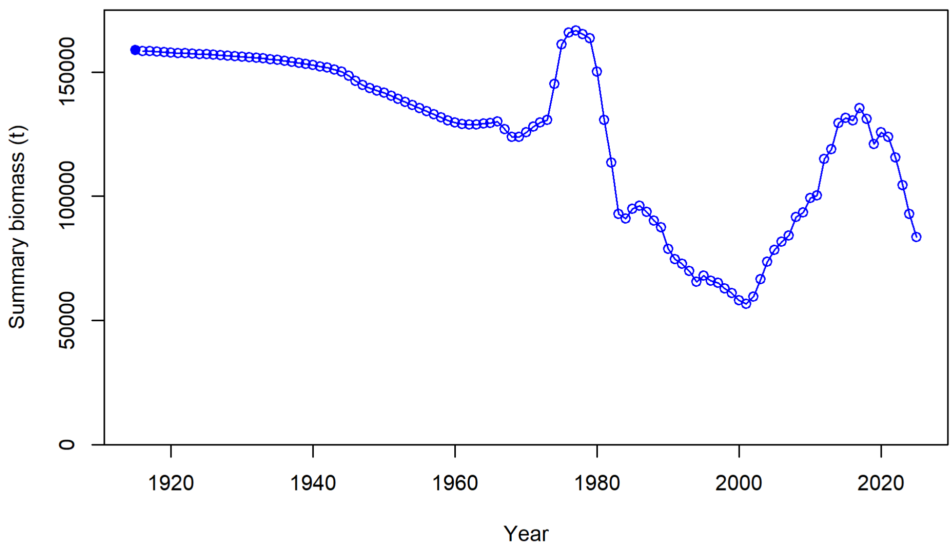



Figure 46: Predicted summary biomass (age 4+) from the base model.

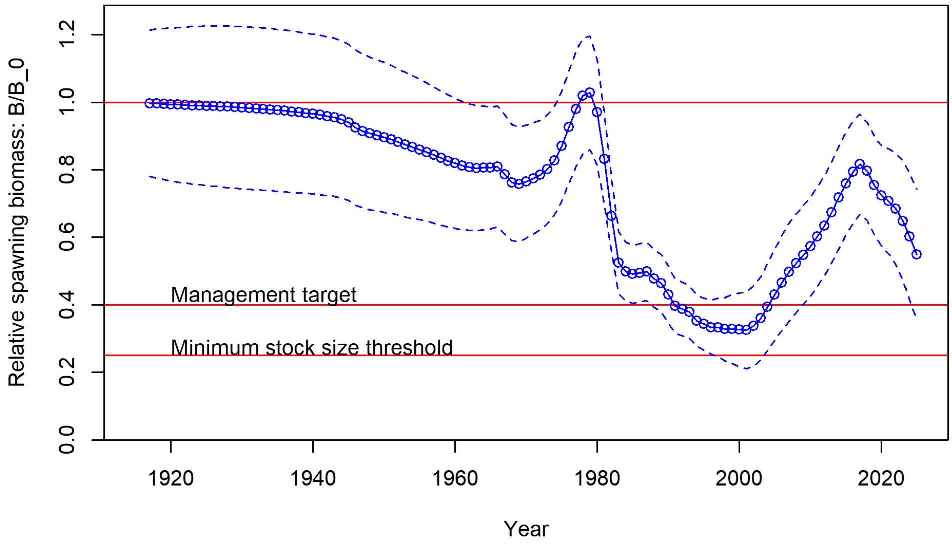



Figure 47: Predicted relative SB from the widow rockfish base assessment model. The solid blue line is the MLE estimate, and the dashed lines depict the approximate asymptotic 95% confidence intervals. The red lines show the equilibrium level (100%), the management target of 40% of unfished biomass, and the minimum stock size threshold of 25% of unfished biomass.

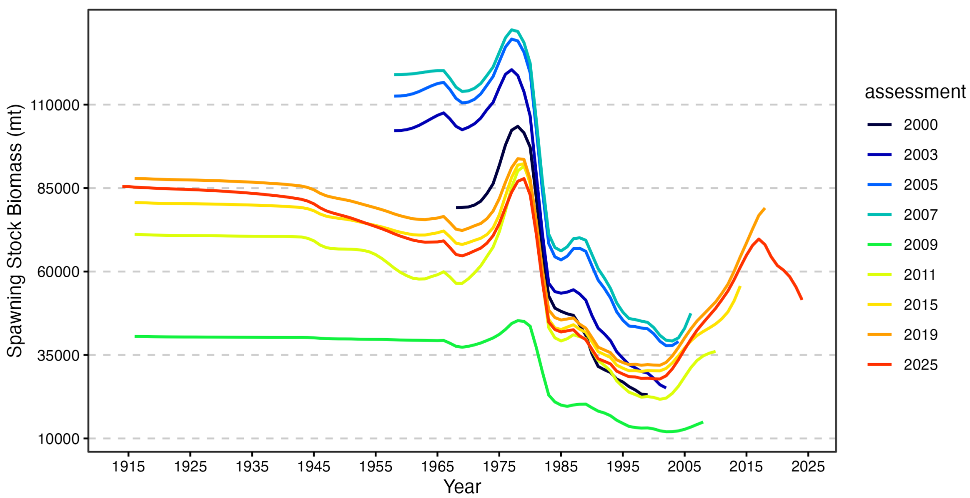



Figure 48: Predicted SB (2011 onward) or spawning output (2000-2009) from past assessments in comparison with the current assessment.

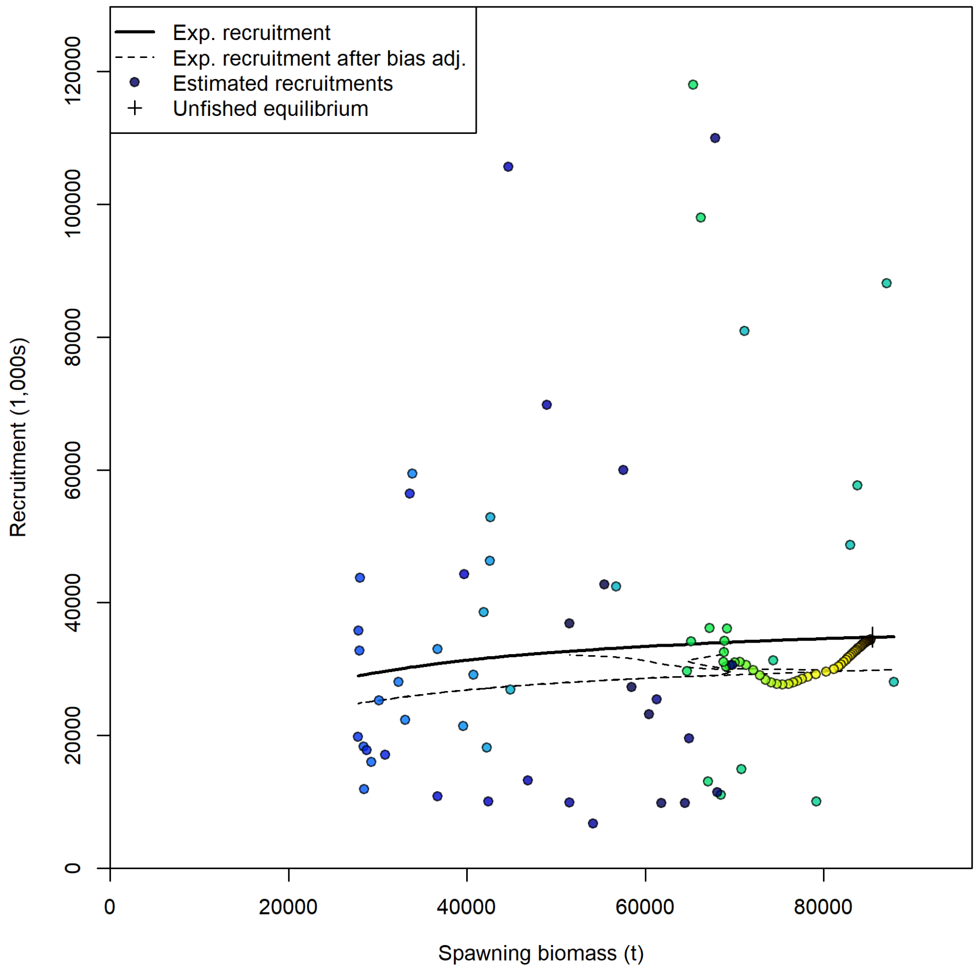



Figure 49: Estimated recruitment and the assumed stock-recruit relationship (black line). The dashed line shows the effect of the bias correction for the lognormal distribution.

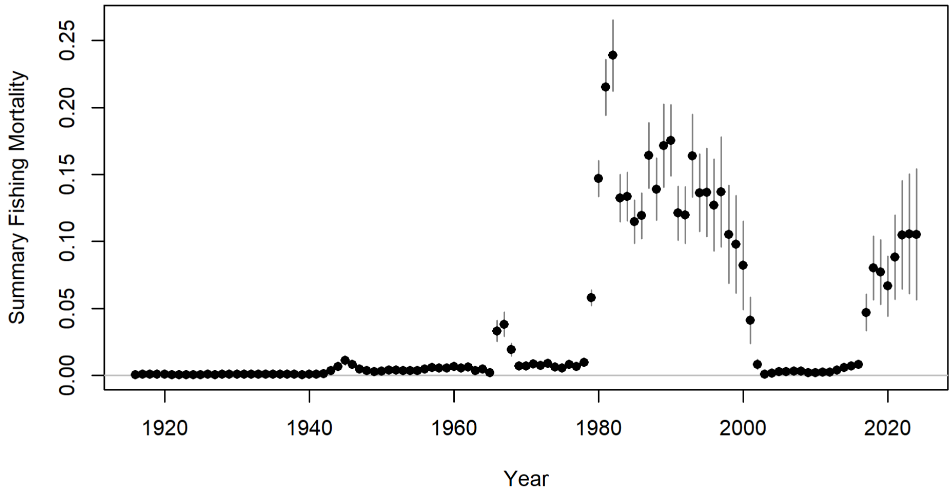



Figure 50: Plot of the summary fishing mortality for each year of the model with 95% confidence intervals.

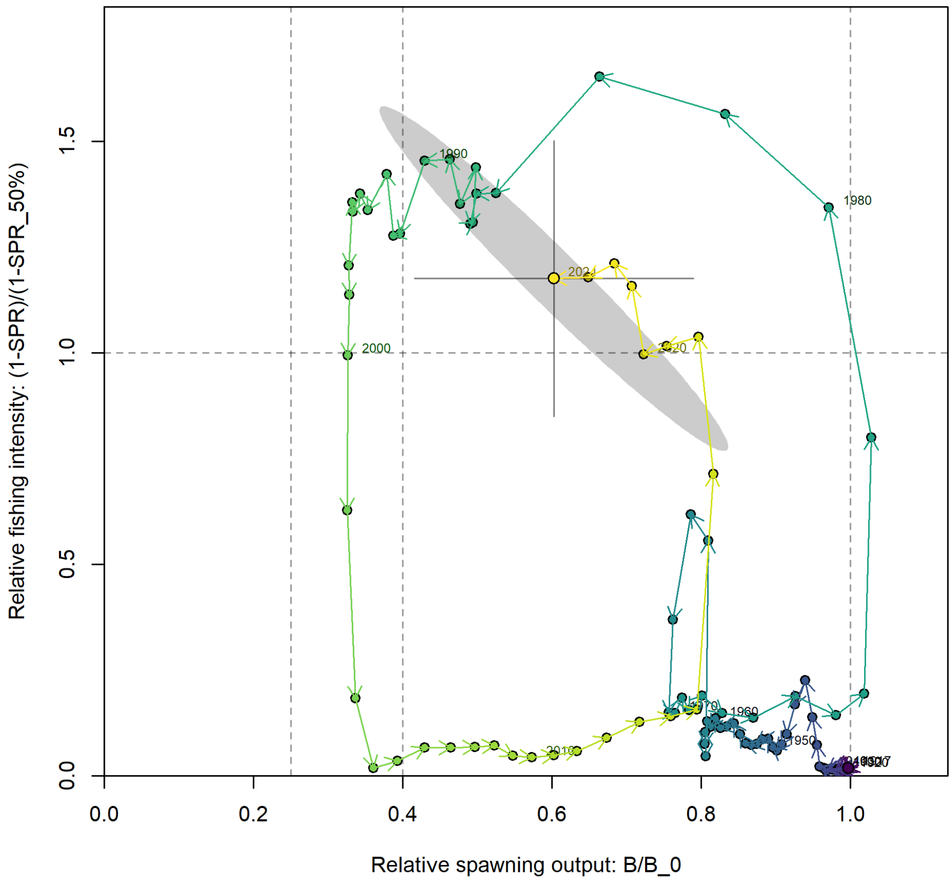



Figure 51: Phase plot of relative (1-SPR)/(1-SPR_50%) (y-axis) and depletion (x-axis) for widow rockfish.

### 6.3 Model Diganostics

#### 6.3.1 Sensitivity analyses

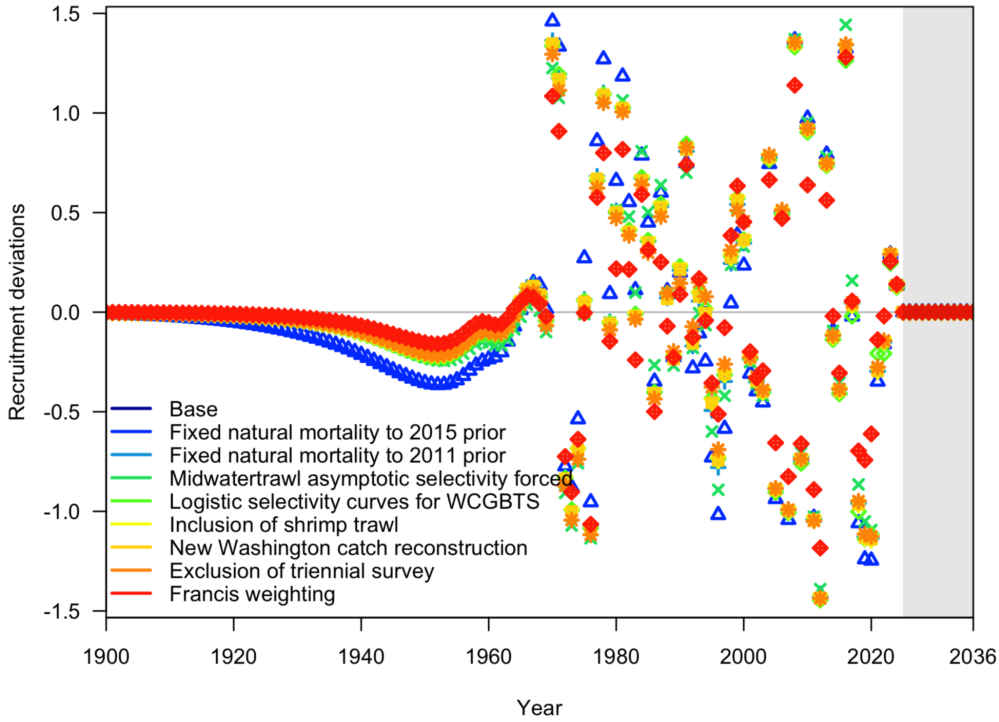



Figure 52: Estimates of recruitment deviations for sensitivity models.

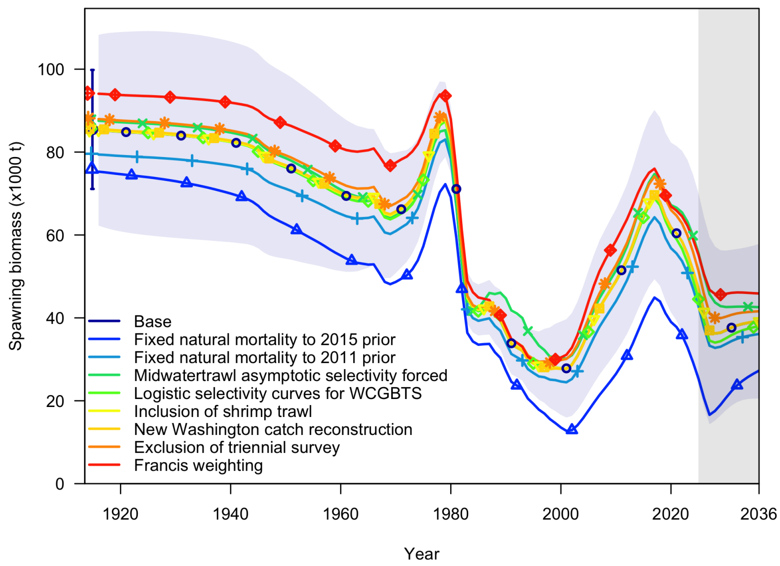



Figure 53: SB (with 95% confidence interval around the base model) for the base model and sensitivity runs.


Figure 54: Comparision of model estimated quantities for 2025, given as percent of the base model estimated value, by sensitivity run.

#### 6.3.2 Retrospective analysis

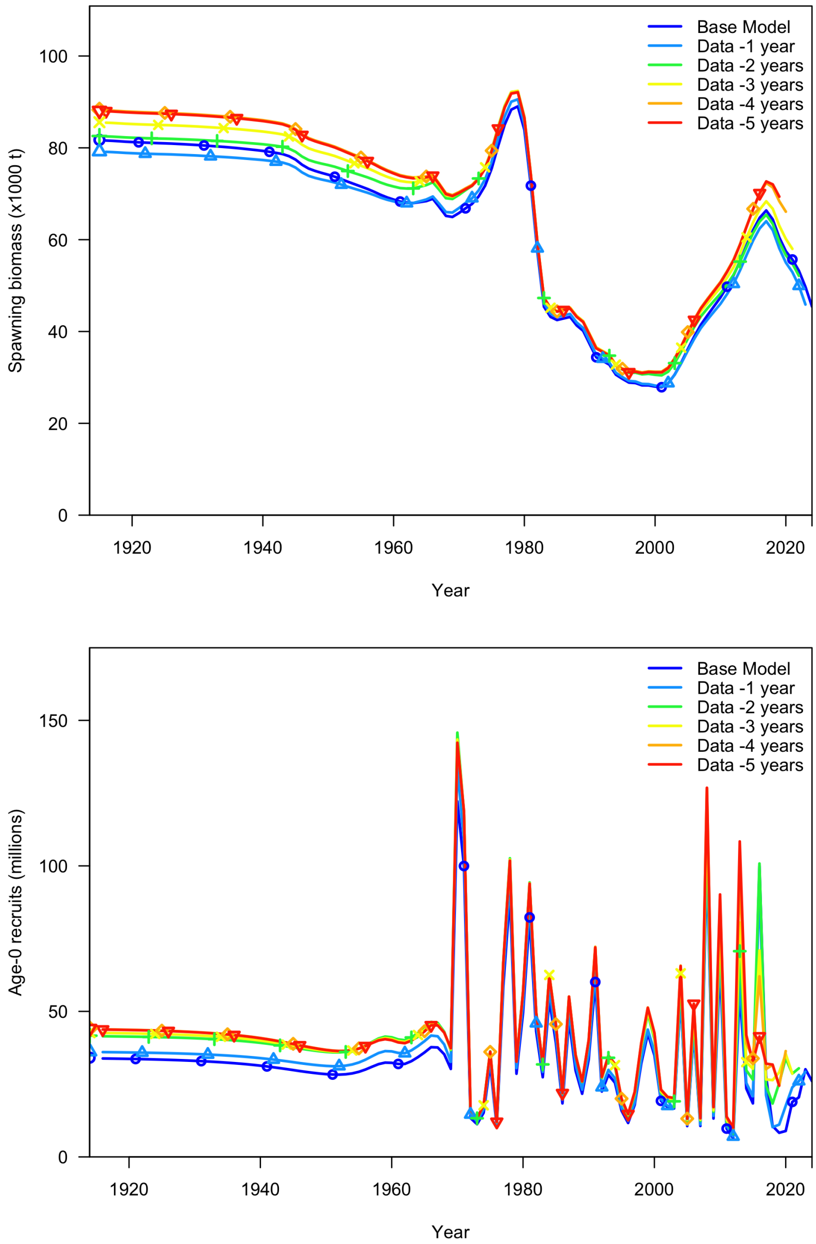



Figure 55: Five-year retrospective estimates of SB (top) and recruitment deviations (bottom).

### 6.3.3 Likelihood profiles

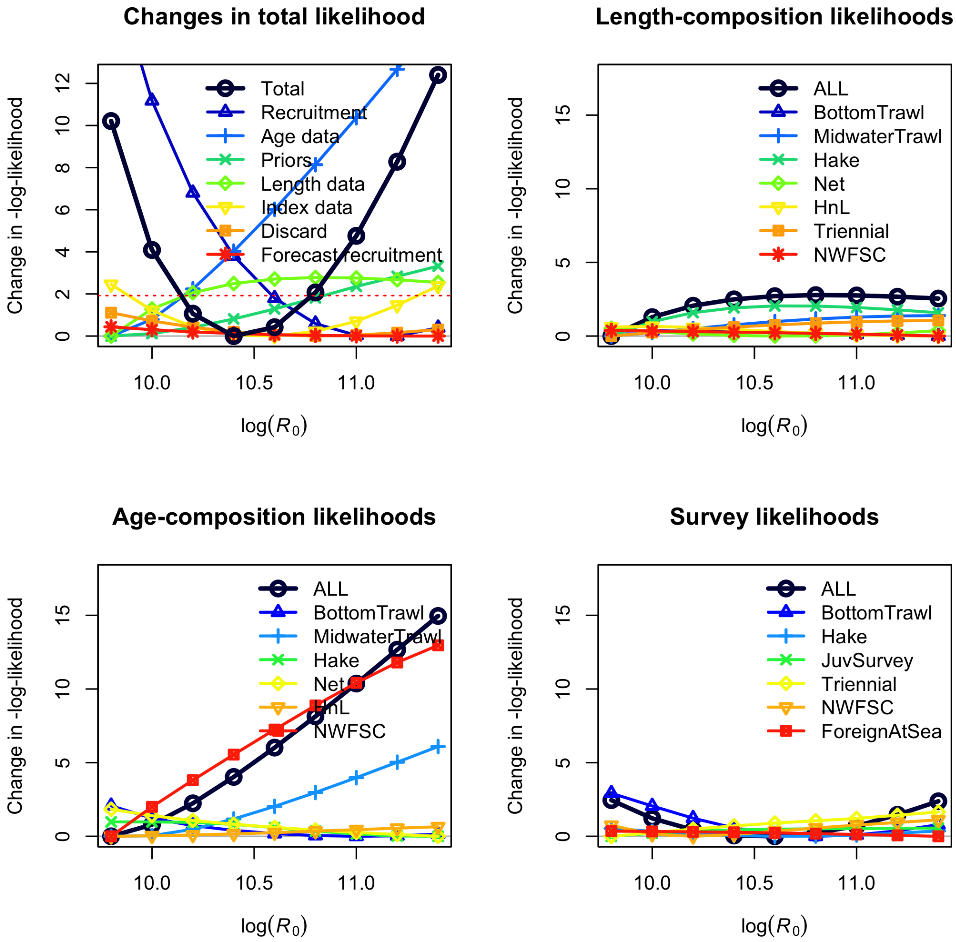



Figure 56: Likelihood components in the likelihood profile for unfished equilibrium recruitment (R0)

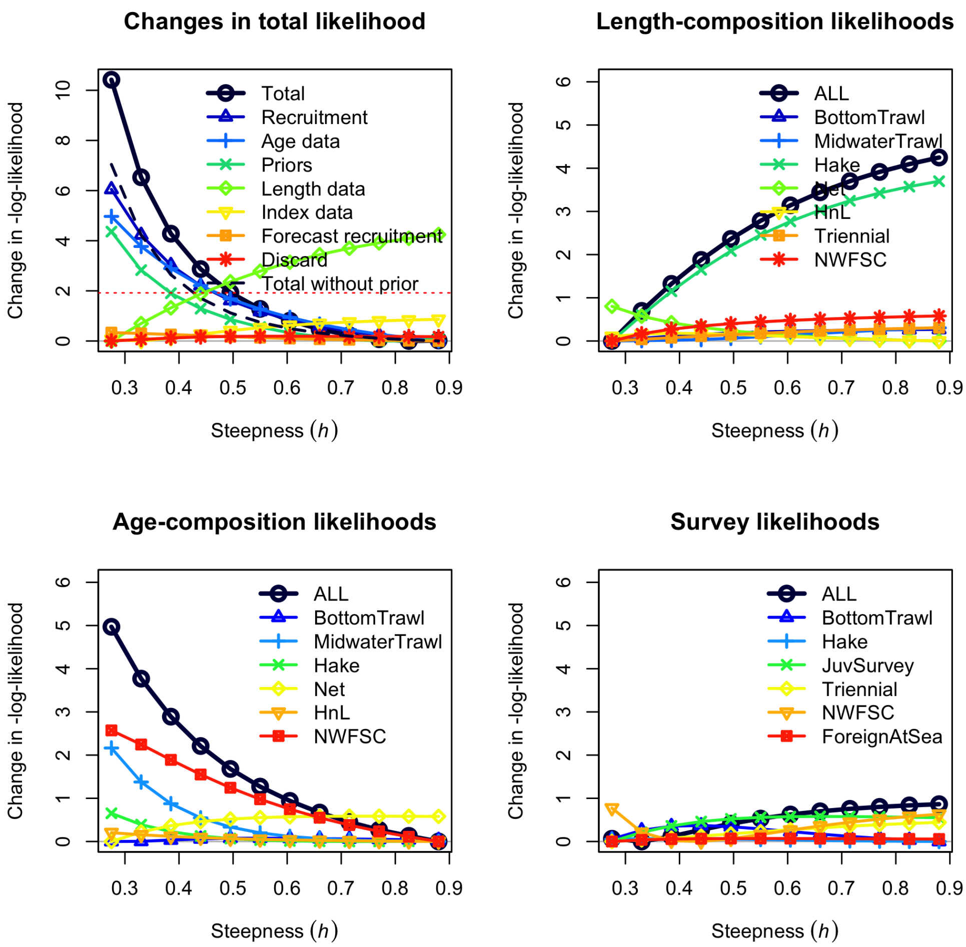



Figure 57: Likelihood components in the likelihood profile for steepness (h).

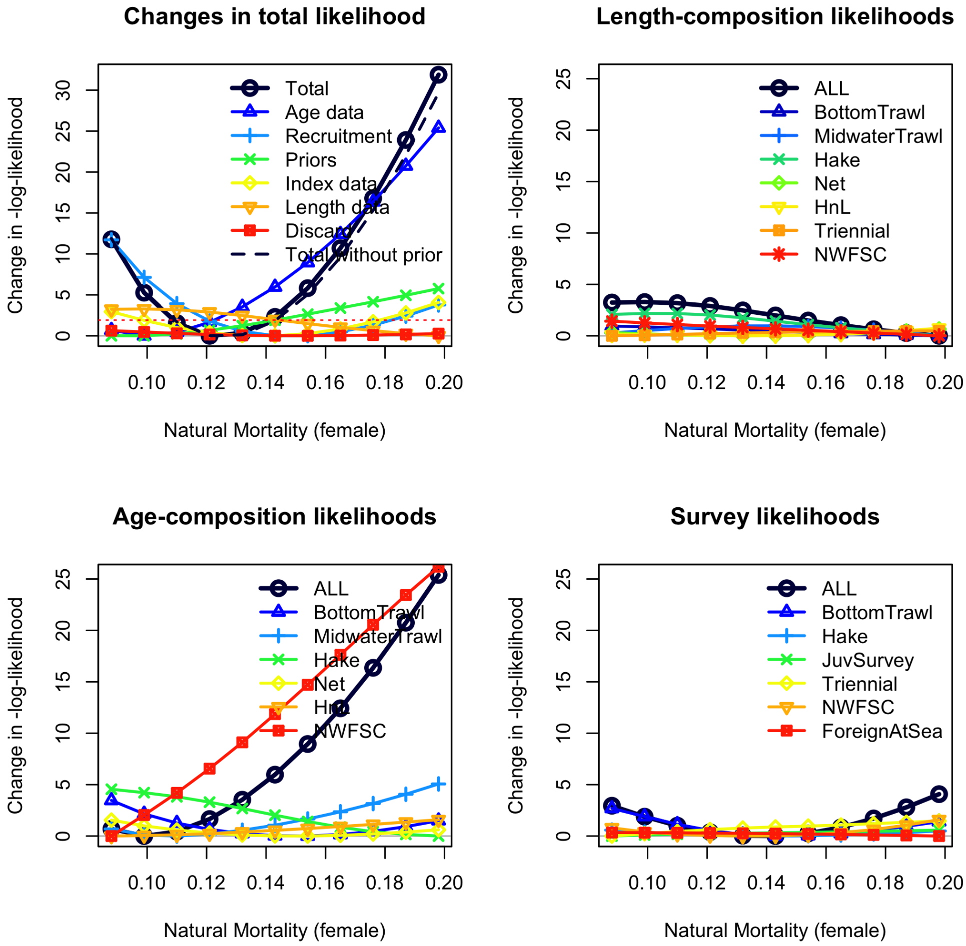



Figure 58: Likelihood components in the likelihood profile for female natural mortality (M). Male natural mortality are set to the same value.

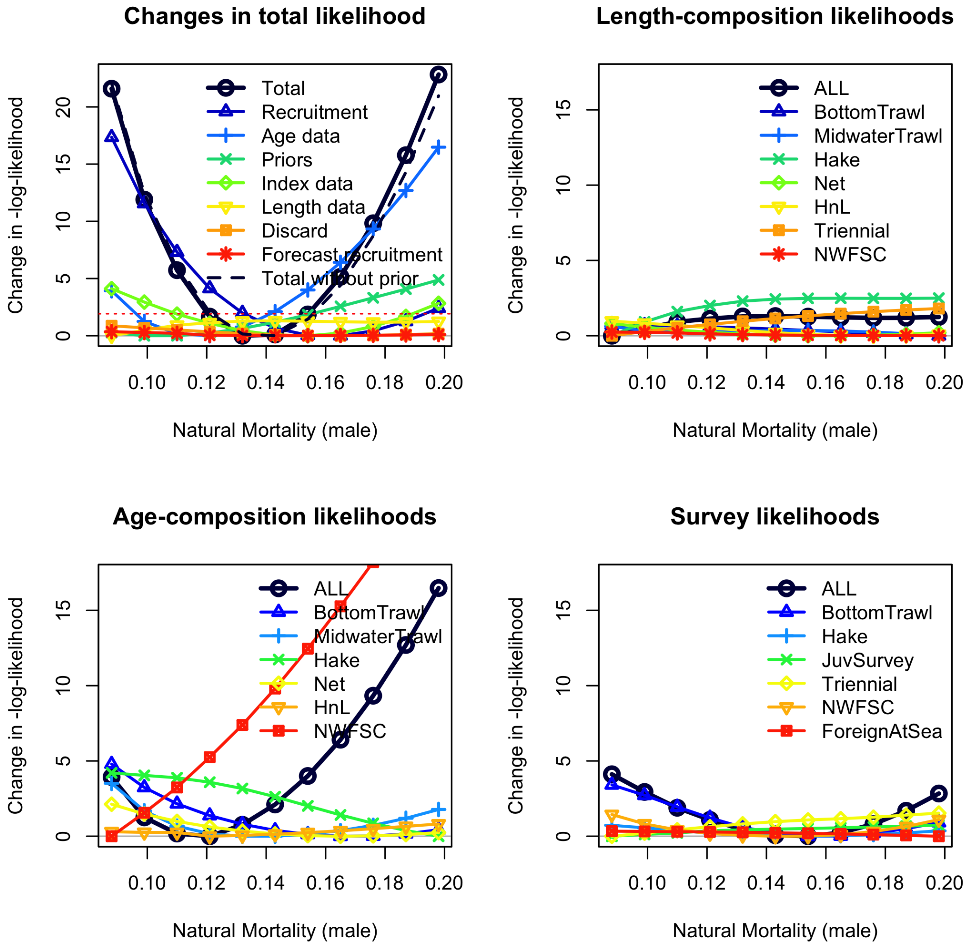



Figure 59: Likelihood components in the likelihood profile for male natural mortality (M). Female natural mortality is set to the same value.

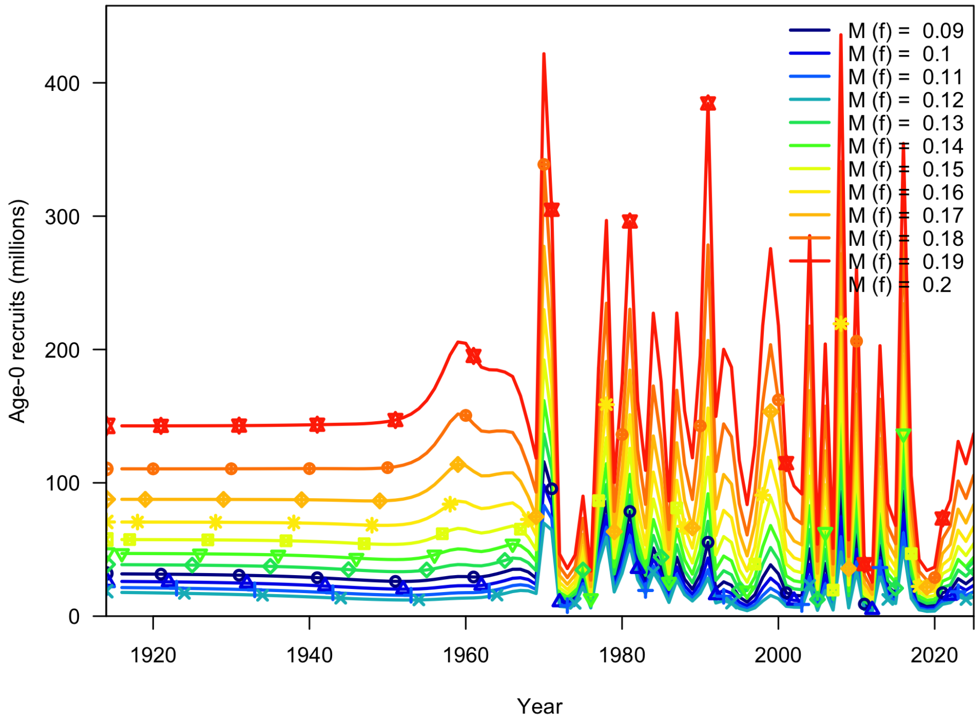



Figure 60: Time series of recruitment estimates for models with different fixed values of natural mortality (M)

### 6.4 Management

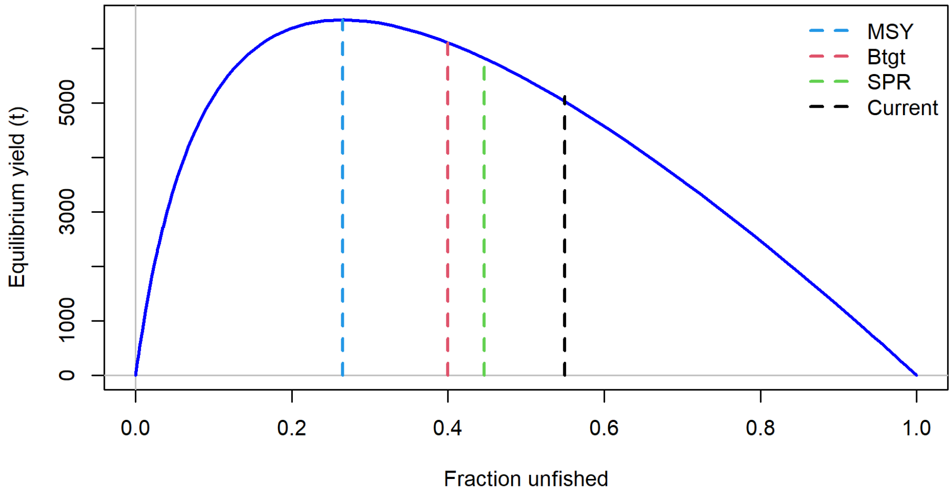



Figure 61: Estimated plot of equilibrium yield vs the fraction of unfished biomass.

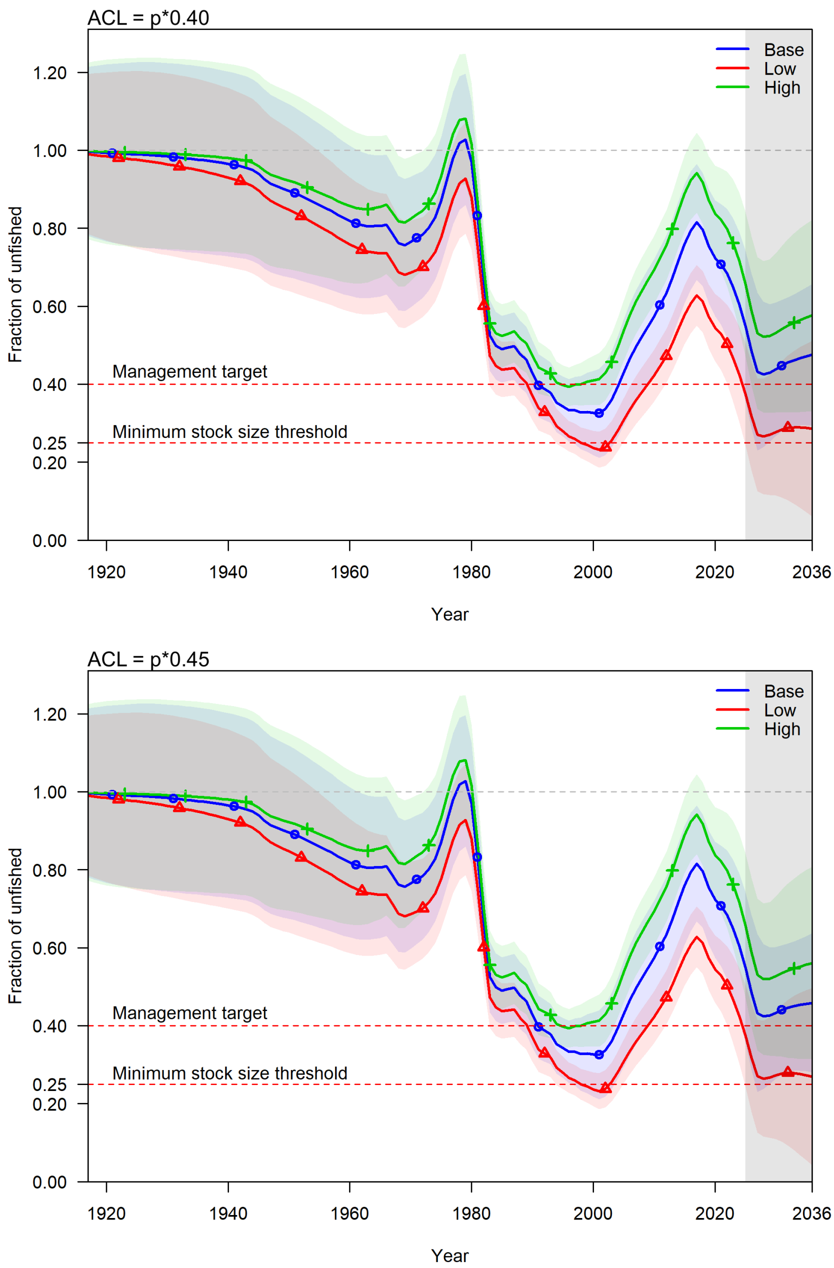



Figure 62: Base model, low state of nature, and high state of nature SB trajectories under two catch scenarios: ACL = p*0.4, ACL = p*0.45 for 2027 to 2036. The shaded areas indicate the 12.5% and 87.5% lognormal quantiles of spawning biomass.

## 7 References

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# 8 Appendix A: Annual fits to length and age composition and supplemental figures

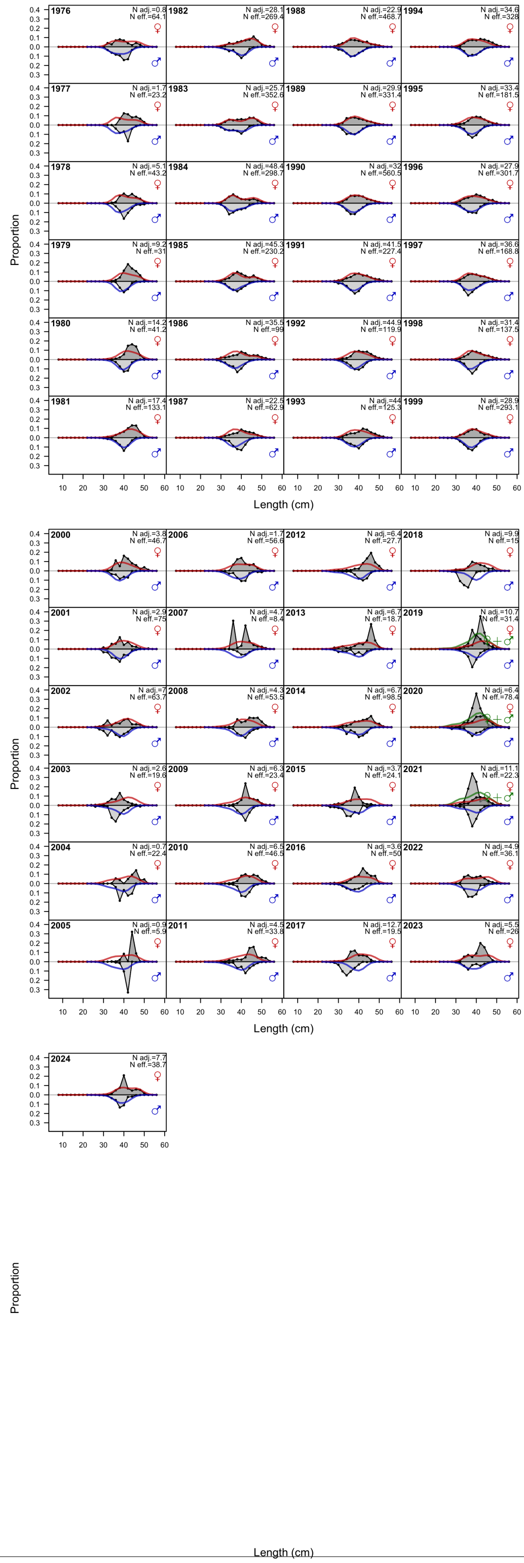


Figure A1: Fits to the retained length compositions for the bottom trawl fleet.

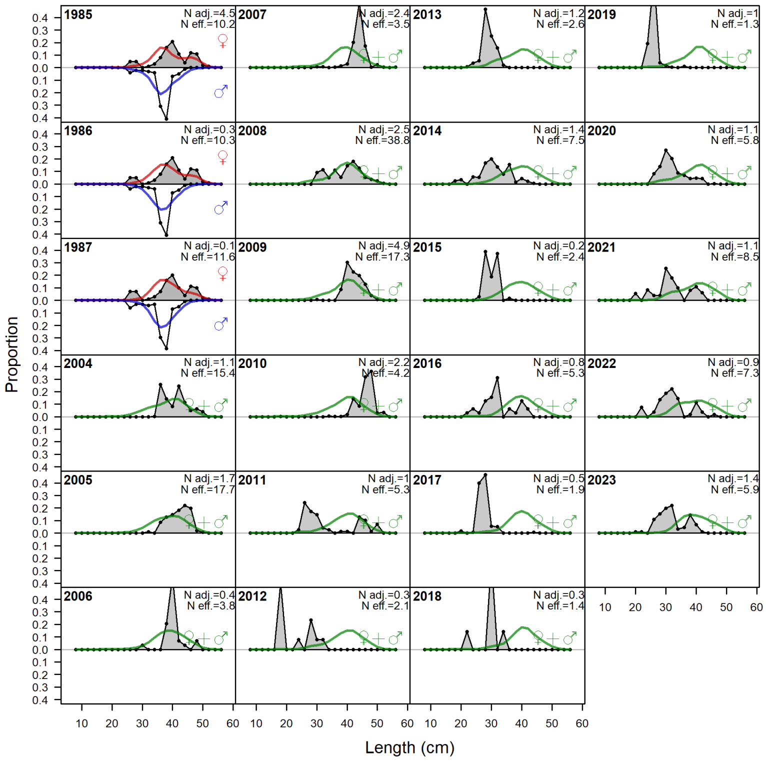


Figure A2: Fits to the discarded length compositions for the bottom trawl fleet.

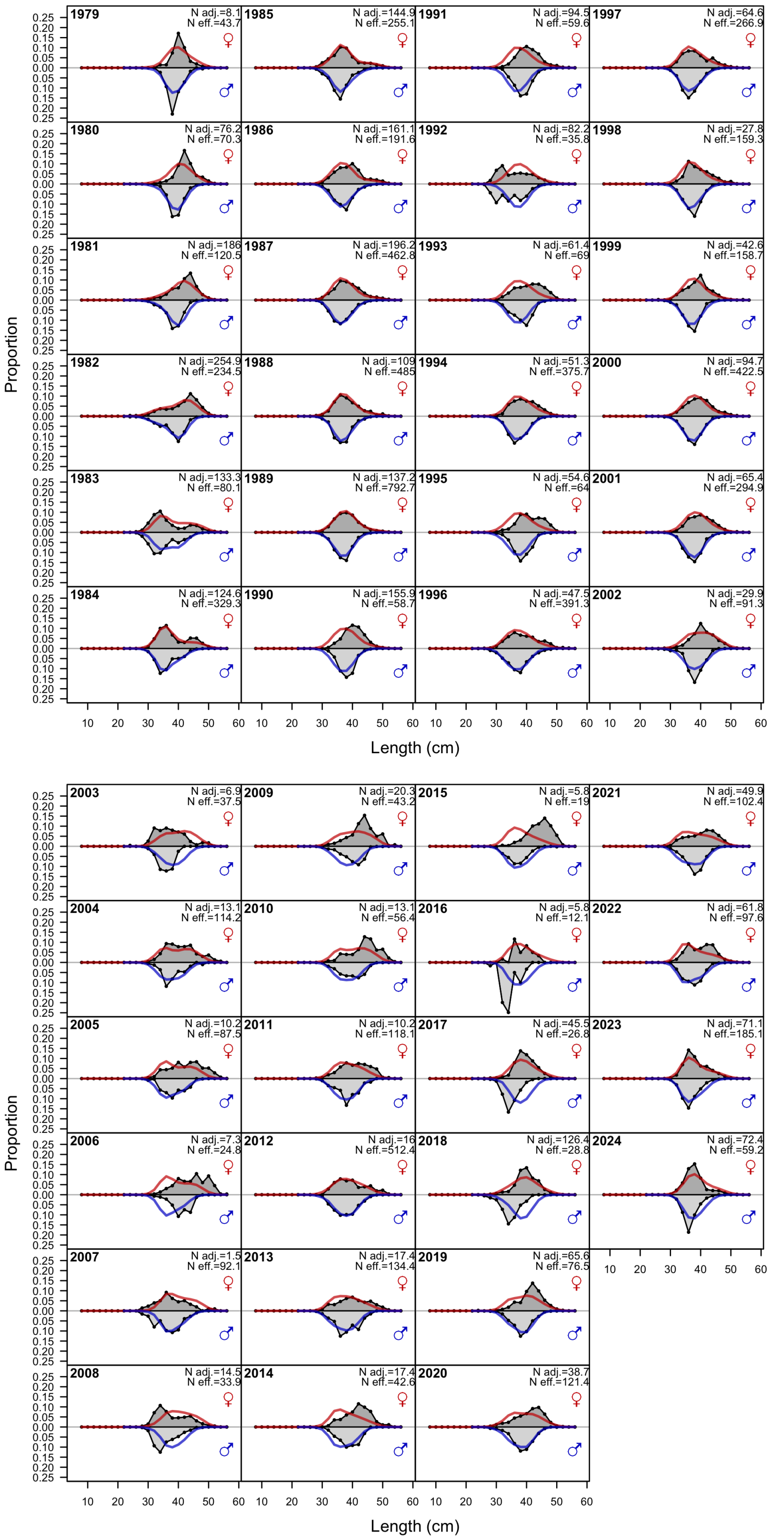


Figure A3: Fits to the retained length compositions for the midwater trawl fleet.

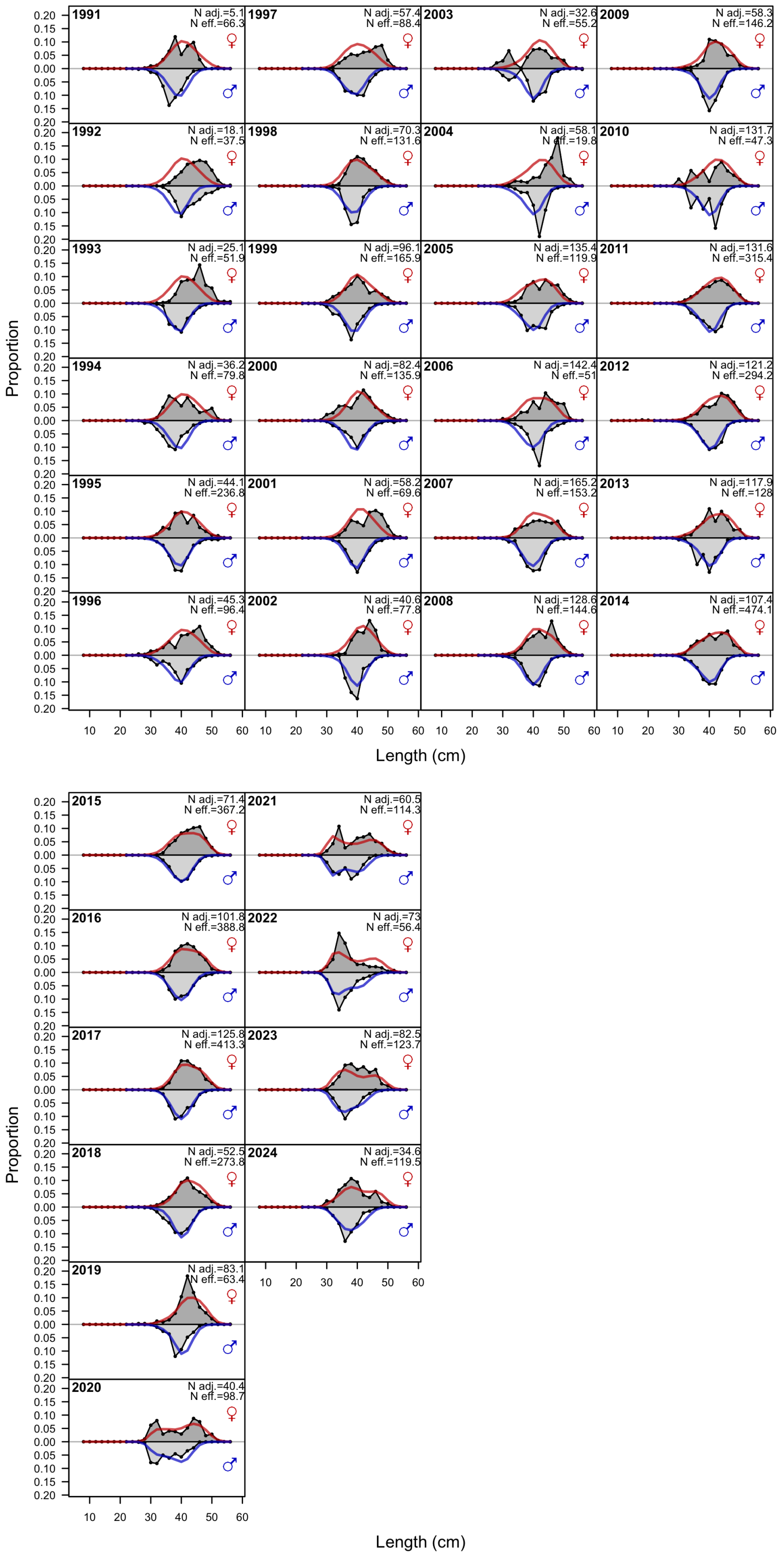


Figure A4: Fits to the retained length compositions for the hake fleet.

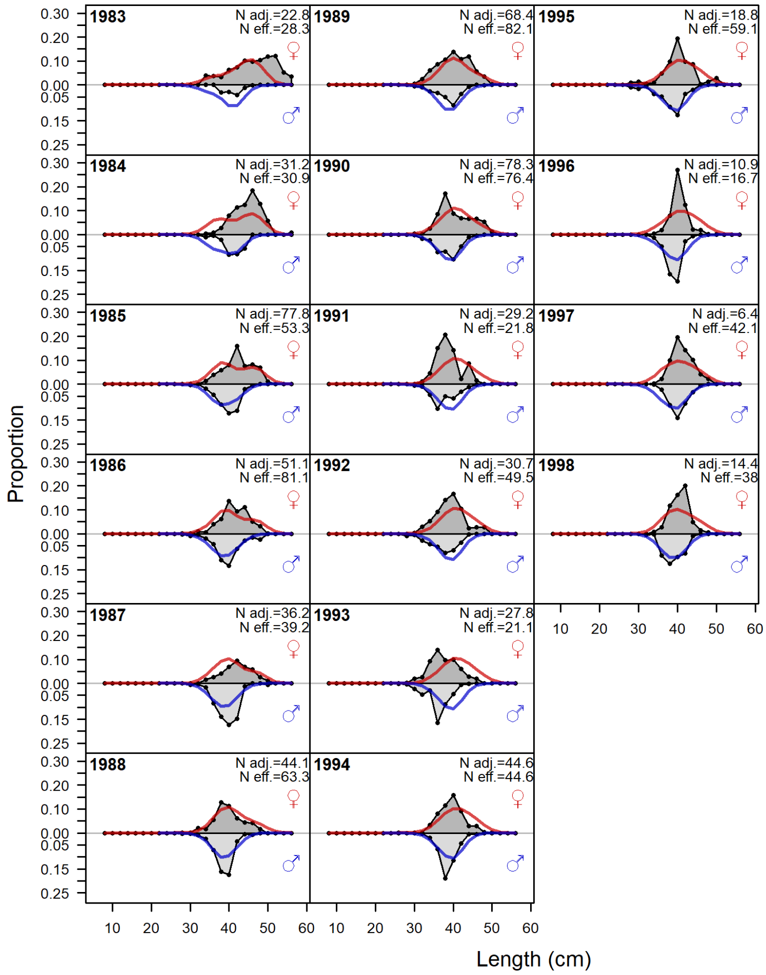


Figure A5: Fits to the retained length compositions for the net fleet.

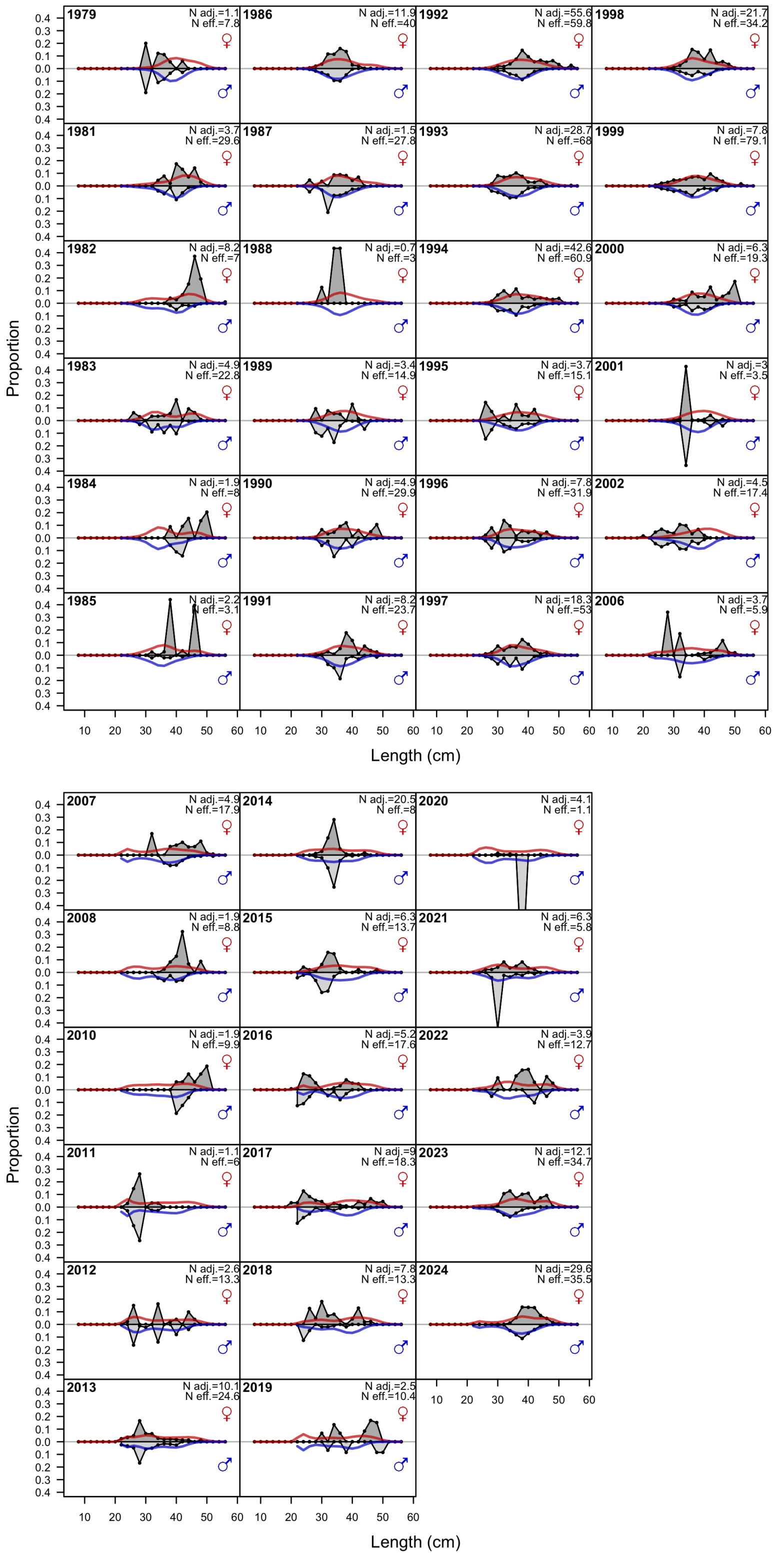


Figure A6: Fits to the retained length compositions for the hook-and-line fleet.

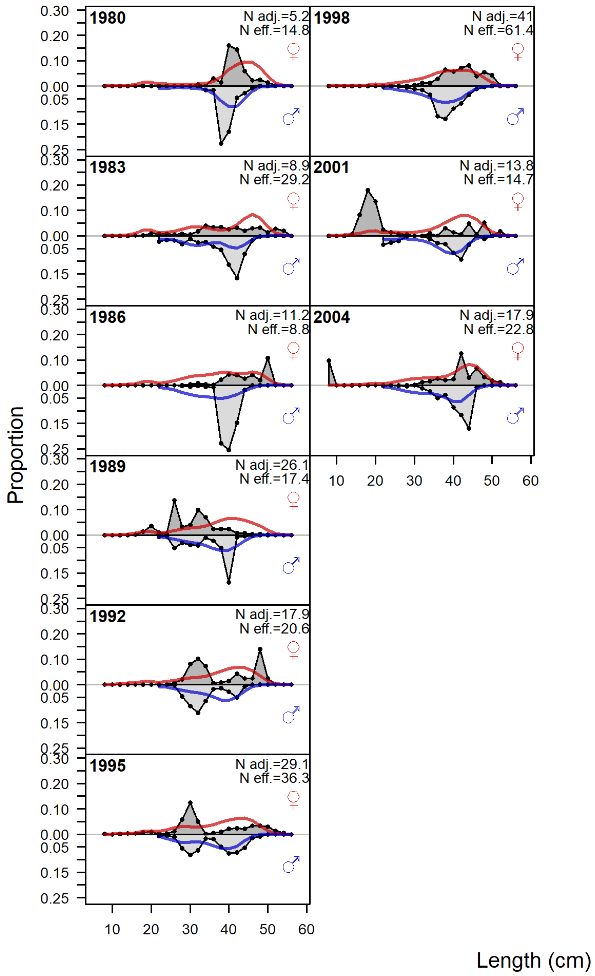


Figure A7: Fits to the length compositions for the triennial survey.

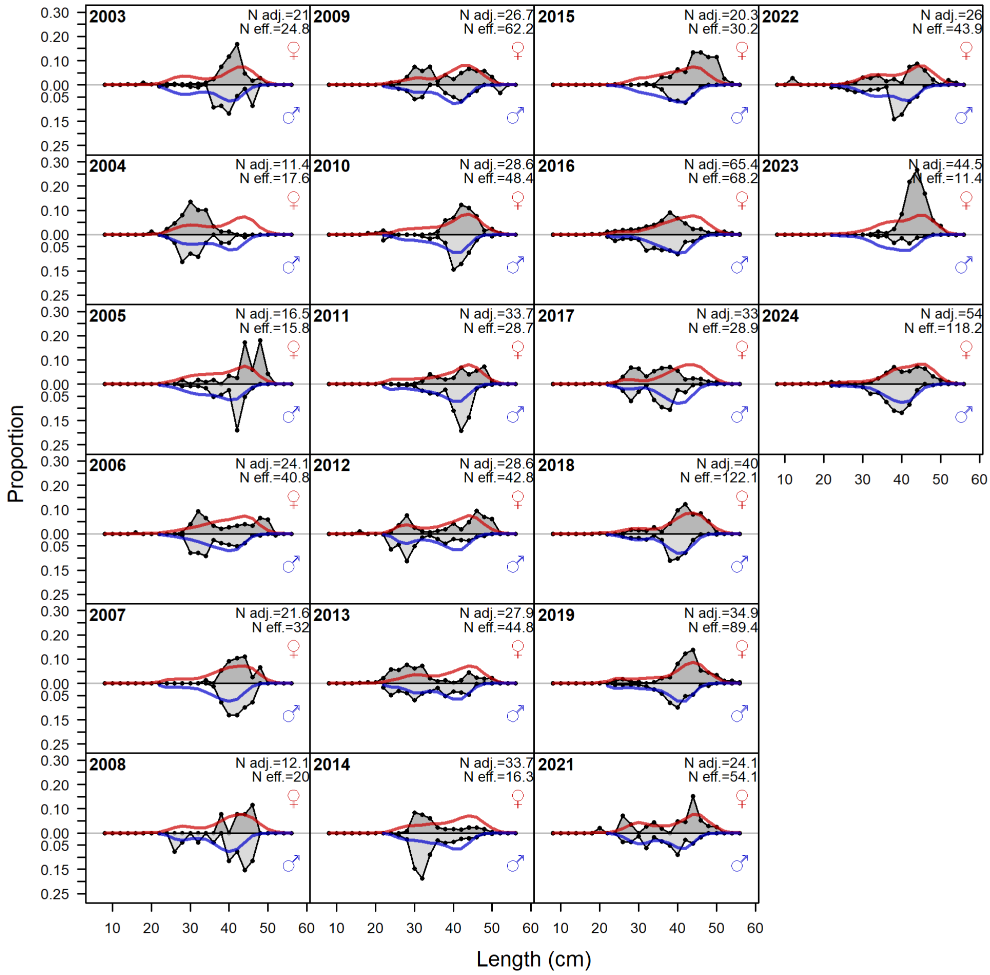


Figure A8: Fits to the length compositions for the WCGBTS.

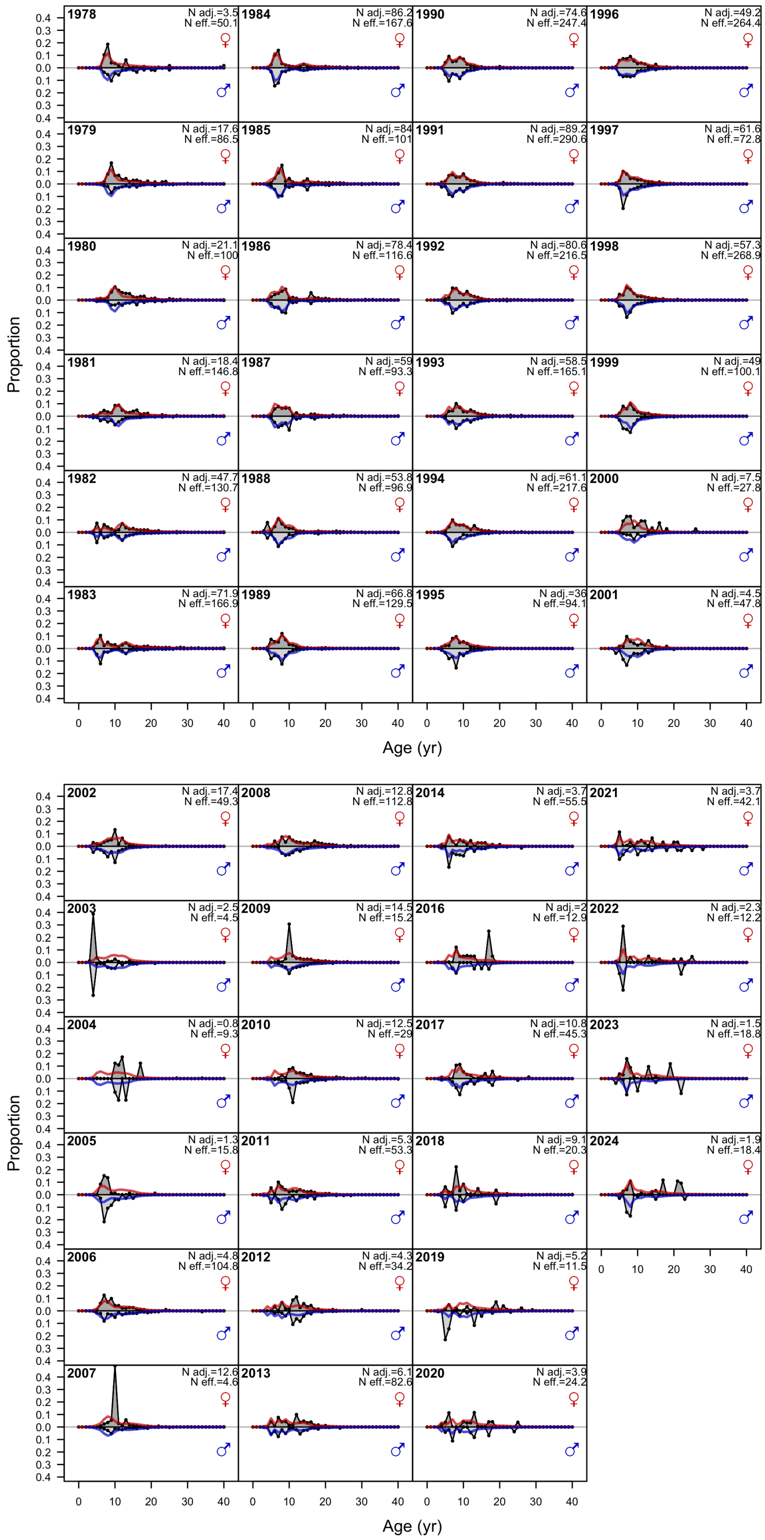


Figure A9: Fits to the retained age compositions for the bottom trawl fleet.

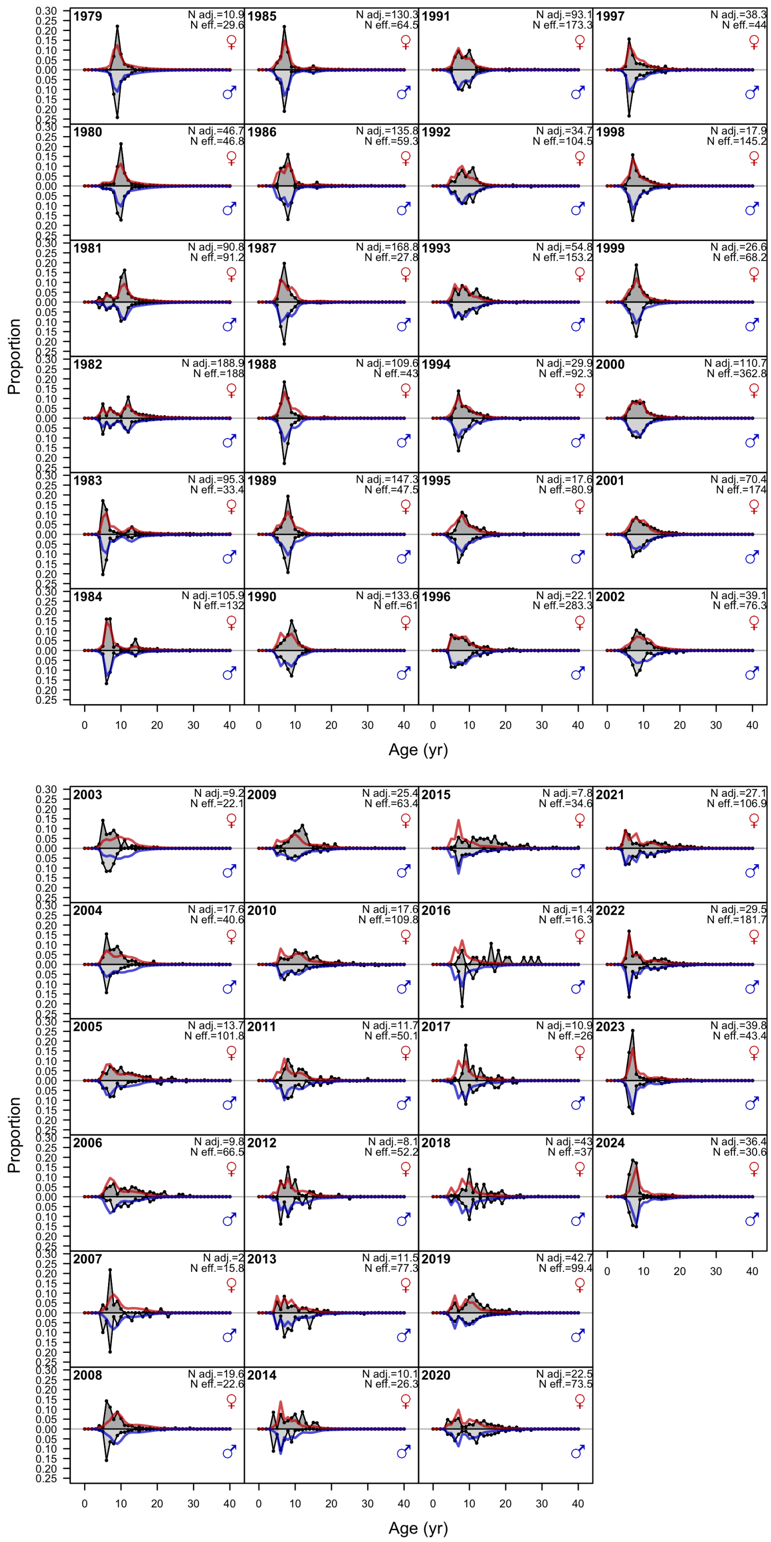

Figure A10: Fits to the retained age compositions for the midwater trawl fleet.

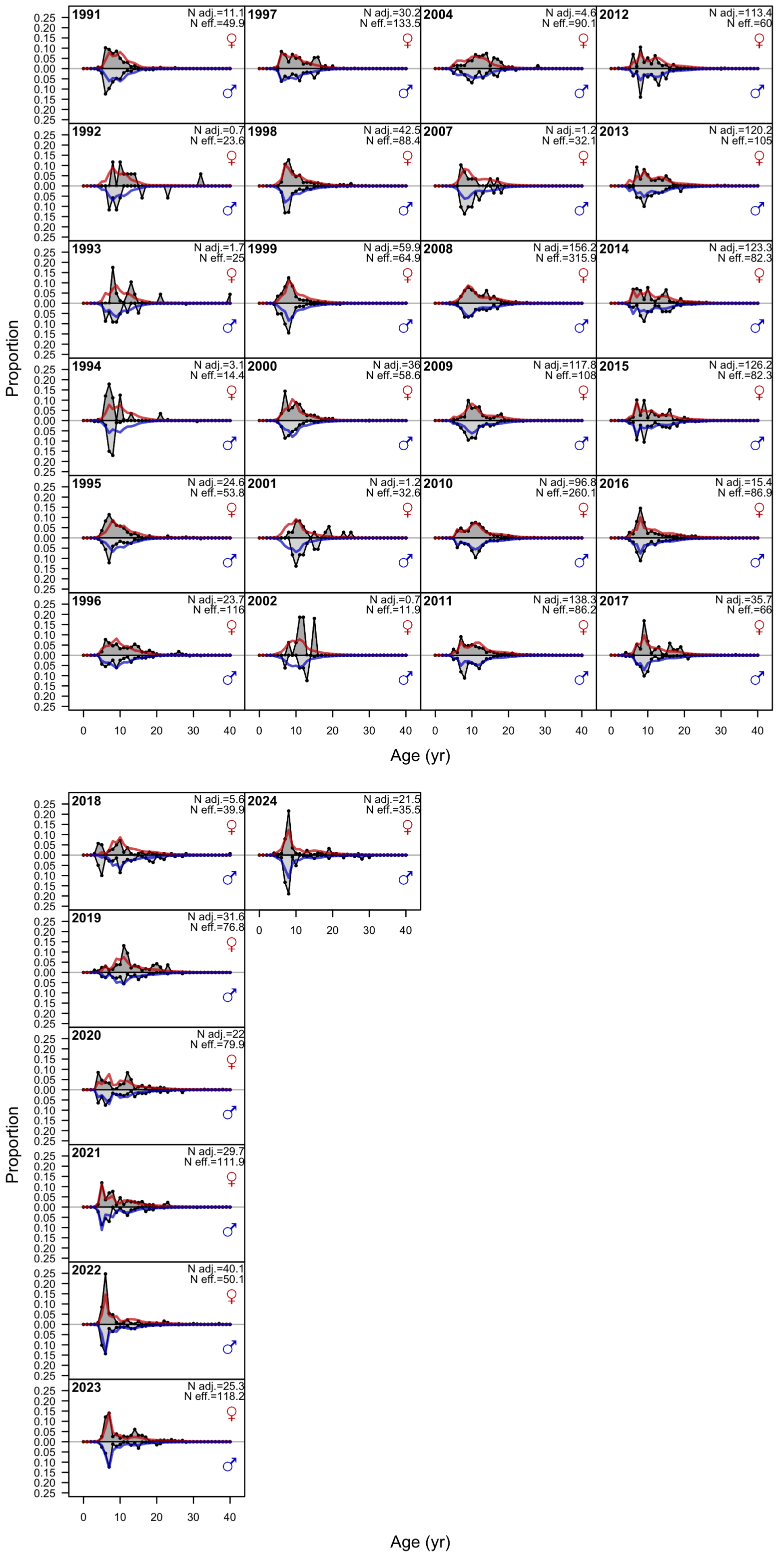

Figure A11: Fits to the retained age compositions for the hake fleet.

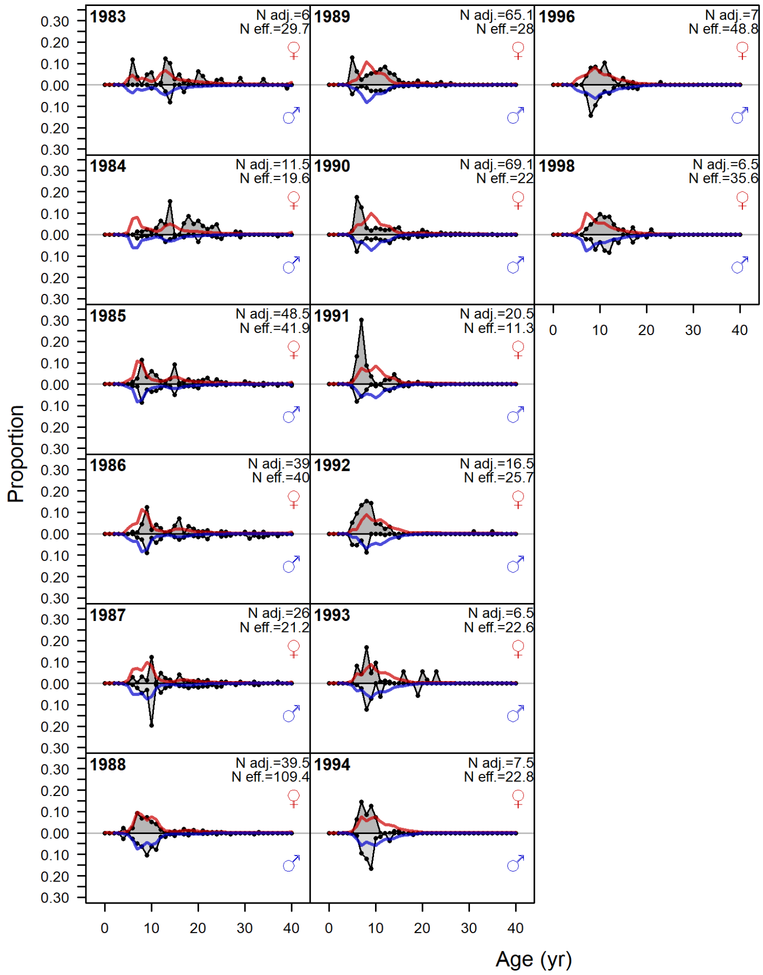


Figure A12: Fits to the retained age compositions for the net fleet.

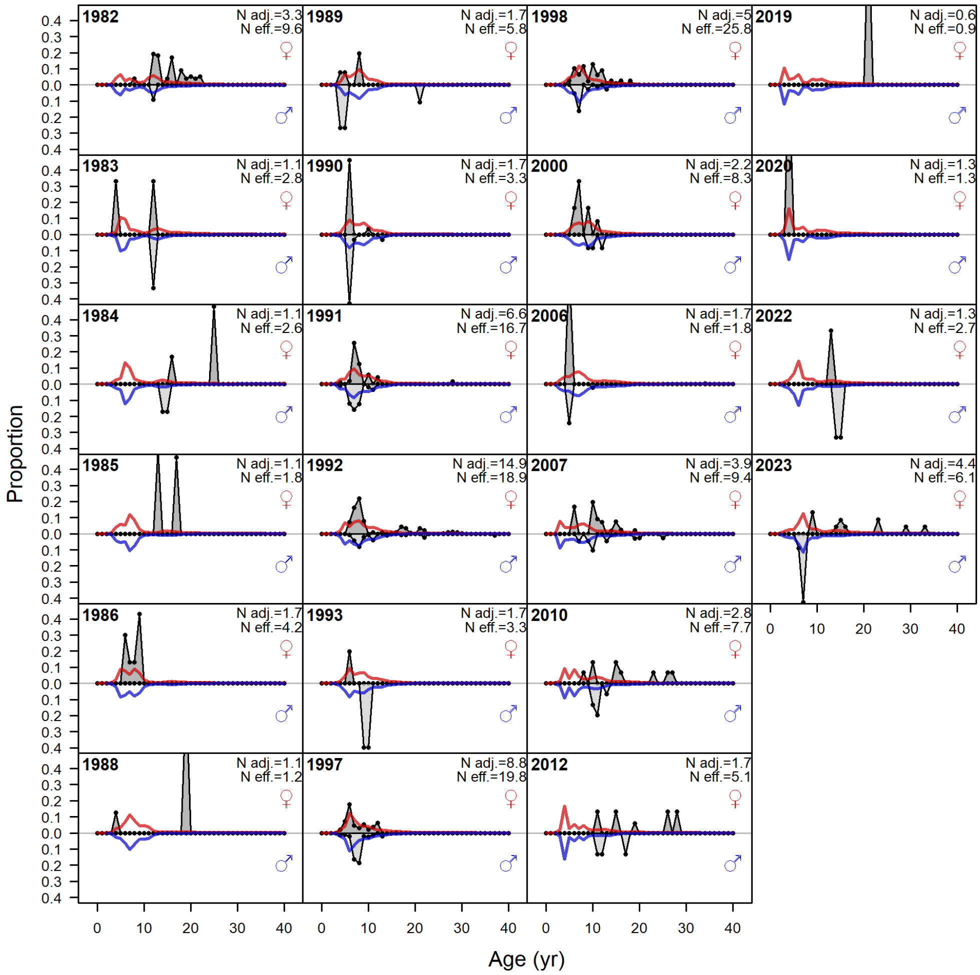


Figure A13: Fits to the retained age compositions for the hook-and-line fleet.

## Acronyms

**ABC** Acceptable Biological Catch. xvi, xvii, 27, 38, 87

**ACL** annual catch limit. xv, xvi, xvii, 2, 27, 28, 38, 87, 141

**GEMM** Groundfish Expanded Mortality Multi-Year. vi

**Juvenile Survey** SWFSC and NWFSC/PWCC Midwater Trawl Survey. vi, 5

**NMFS** National Marine Fisheries Service. vi, 2

**OFL** overfishing limit. xvii, xx, 28, 38, 87

**SB** spawning biomass. vi, vii, viii, xiii, xvi, xvii, xx, xxi, 12, 14, 20, 21, 22, 23, 24, 25, 26, 27, 28, 87, 126, 127, 132, 134, 141

`sdmTMB` Species Distribution Models with Template Model Builder. 4

**SPR** spawning potential ratio. xiii, xvi, 27, 28

**Triennial Survey** Alaska Fisheries Science Center/Northwest Fisheries Science Center West Coast Triennial Shelf Survey. vi, 3, 13, 14, 18, 19

**WCGBTS** Northwest Fisheries Science Center West Coast Groundfish Bottom Trawl Survey. vi, xxi, 3, 11, 13, 14, 17, 18, 19, 20, 23, 26, 27, 28

**WCGOP** West Coast Groundfish Observer Program. iii, v, xx, 2, 26