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

Jason M. Cope[1], Vladlena Gertseva[1], R. Claire Rosmond[2], Fabio P. Caltabellotta[3] and Alison D. Whitman[4]

1. NOAA Fisheries Northwest Fisheries Science Center, 2725 Montlake Boulevard East
2. NOAA Fisheries Northwest Fisheries Science Center, 2032 SE Osu Drive
3. Washington Department of Fish and Wildlife, 48 Devonshire Road
4. Oregon Department of Fish and Wildlife, 2040 Southeast Marine Science Drive

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Fisheries Science Center

Table of contents

Please cite this publication as:

Cope, J.M., V. Gertseva, R.C. Rosemond, F.P. Caltabellotta, A.D. Whitman. Status of the Rougheye and Blackspotted Rockfishes stock off the U.S. West Coast in 2025.2025. Prepared by [COMMITTEE]. [XX] p.

Disclaimer

These materials do not constitute a formal publication and are for information only. They are in a pre-review, pre-decisional state and should not be formally cited or reproduced. They are to be considered provisional and do not represent any determination or policy of NOAA or the Department of Commerce.

1 Executive Summary

1.1 Stock Description

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

1.2 Catches

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

Table 1: Recent catches (mt) by fleet and total catch (mt) summed across fleets.

Year	Trawl	Trawl discard	Non-trawl	Non-trawl discard	Midwater trawl	At-sea-hake	Total Catch
2015	31	10	47	14	19.26010	21.8019	142.1482
2016	31	8	60	13	15.53260	29.6339	157.2776
2017	22	12	59	34	2.48250	38.1484	168.4370
2018	16	45	47	15	2.57640	161.2370	286.1558
2019	22	14	39	31	9.24547	125.3660	240.7692
2020	10	11	24	1	28.91830	41.8824	116.7398
2021	10	24	21	2	21.39070	37.6155	116.9144
2022	12	24	19	3	18.62890	65.4553	141.1317
2023	13	22	19	0	26.21650	38.4973	119.3817
2024	10	22	10	0	69.14520	29.3232	141.0490

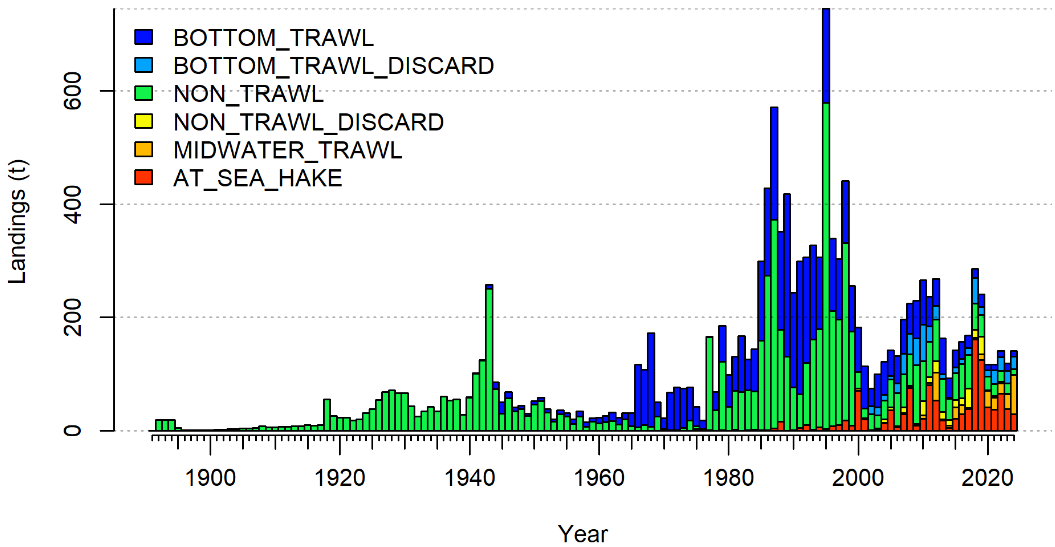

Figure 1: Landings in metric tons (mt) by year for each fleet.

1.2.1 Data and Assessments

The only previous stock assessment for Rougheye/Blackspotted Rockfishes for the west coast area was done in 2013. This assessment separates the discard catches from the retained fisheries, maintains the at-sea-hake fishery as its own fishery, and adds a midwater fishery that has emerged in the last 10 years. This stock assessment adds 10+ years of additional length data, and adds several more years of age data (included as conditioned on length data). The same four groundfish abundance surveys (Triennial, Alaska Slope, Northwest Fishery Science Center Slope, and the West Coast Groundfish Bottom Trawl Survey (WCGBTS)) as used in the last stock assessment are used here, with an extension to 2024 to the the WCGBTS. The index standardization of all survey data uses the newer approach of applying spatiotemporal generalized linear mixed models.

1.2.2 Stock Output and Dynamics

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

Table 2: Estimated recent trend in spawning biomass and the fraction unfished and the 95 percent intervals.

Year	Spawning Biomass (mt)	Lower Interval (mt)	Upper Interval (mt)	Fraction Unfished	Lower Interval	Upper Interval
2015	34,423,400.00	- 38,392,985.96	107,239,785.96	1.018	0.903	1.133
2016	34,279,500.00	- 38,234,463.51	106,793,463.51	1.013	0.898	1.129
2017	34,124,300.00	- 38,063,329.51	106,311,929.51	1.009	0.893	1.125
2018	33,961,500.00	- 37,883,919.80	105,806,919.80	1.004	0.888	1.120
2019	33,796,900.00	- 37,702,390.16	105,296,190.16	0.999	0.883	1.115
2020	33,638,100.00	- 37,527,408.29	104,803,608.29	0.995	0.878	1.111
2021	33,492,900.00	- 37,367,049.91	104,352,849.91	0.990	0.874	1.107
2022	33,368,200.00	- 37,229,702.72	103,966,102.72	0.987	0.870	1.103
2023	33,268,700.00	- 37,120,466.56	103,657,866.56	0.984	0.867	1.100
2024	33,196,200.00	- 37,041,069.35	103,433,469.35	0.981	0.864	1.098
2025	33,149,000.00	- 36,989,879.16	103,287,879.16	0.980	0.863	1.097

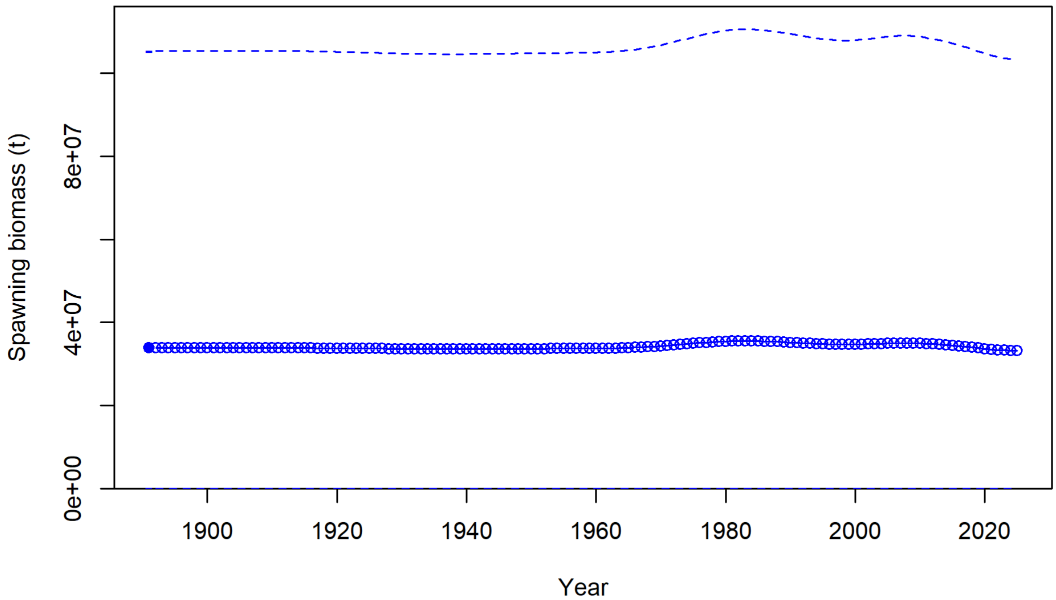

Figure 2: Estimated time series of spawning output (trillions of eggs) for the base model.

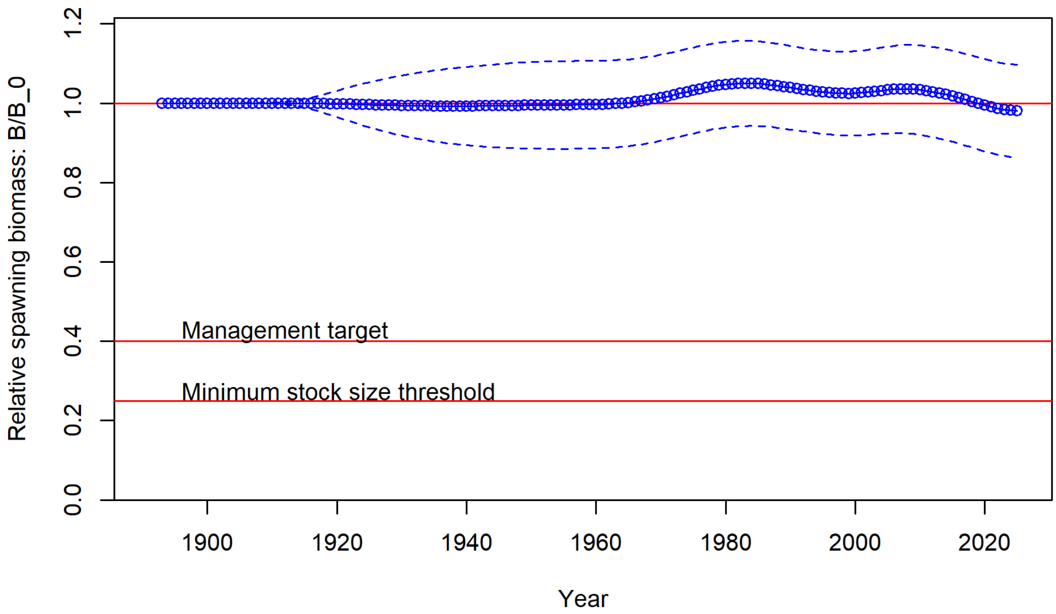

Figure 3: Estimated time series of fraction of unfished spawning output for the base model.

1.3 Recruitment

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

Table 3: Estimated recent trend in recruitment (1,000s) and recruitment deviations and the 95 percent intervals.

Year	Recruitment (1,000s)	Lower Interval (1,000s)	Upper Interval (1,000s)	Recruitment Deviations	Lower Interval	Upper Interval
2015	1,511,340	248,243	9,201,243	-0.471	-1.286	0.344
2016	1,979,970	324,265	12,089,734	-0.207	-1.038	0.624
2017	4,790,490	799,112	28,717,856	0.670	-0.067	1.406
2018	2,979,140	490,569	18,091,802	0.188	-0.613	0.990
2019	2,742,760	451,197	16,672,830	0.099	-0.707	0.906
2020	1,913,990	311,339	11,766,455	-0.267	-1.129	0.596
2021	2,163,970	348,159	13,450,095	-0.150	-1.066	0.765
2022	2,435,110	387,447	15,304,688	-0.032	-0.999	0.935

2023	2,513,300	398,819	15,838,445	0.000	-0.980	0.980
2024	2,512,760	398,733	15,835,059	0.000	-0.980	0.980
2025	2,512,410	398,678	15,832,831	0.000	-0.980	0.980

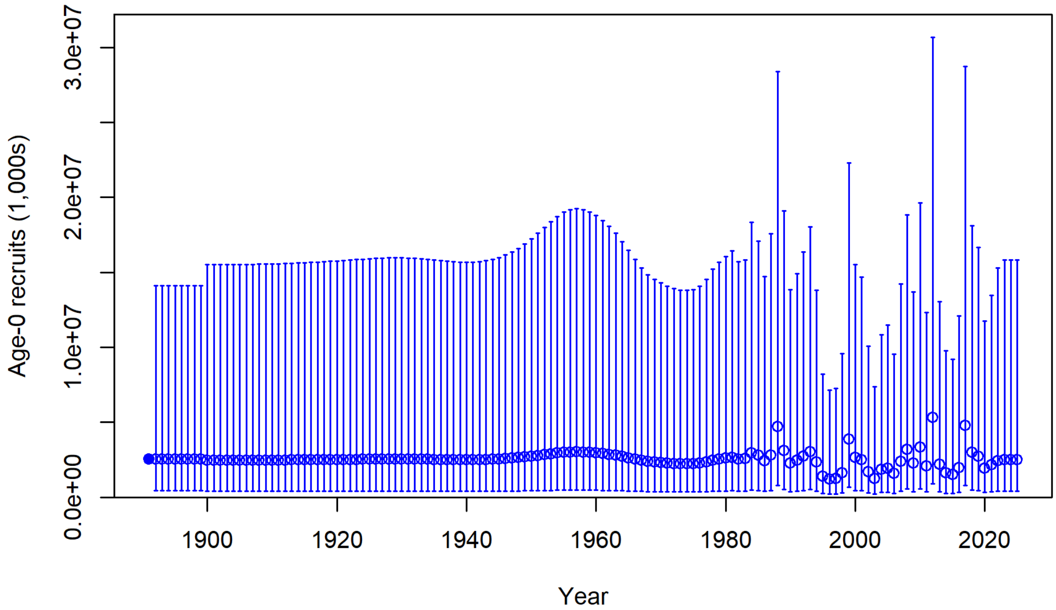

Figure 4: Estimated time series of age-0 recruits for the base model.

1.4 Ecosysystem Consideration

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

1.5 Reference Points

A list of estimates of the current state of the population, as well as reference points based on 1) a target unfished spawning output of 40%, 2) a spawning potential ratio of 0.5, and 3) the model estimate of maximum sustainable yield, are all listed in Table 4. SPR, or the spawning potential ratio, is the fraction of expected lifetime reproductive output under a given fishing intensity divided by unfished expected lifetime reproductive output.

Table 4: Summary of reference points and management quantities, including estimates of the 95 percent intervals.

Reference Point	Estimate	Lower Interval	Upper Interval
Unfished Spawning Biomass (mt)	33,823,300.0	-37,731,849.1	105,378,449.1
Unfished Age 3+ Biomass (mt)	91,888,400	-102,443,989	286,220,789
Unfished Recruitment (R0)	2,517,380	-2,812,409	7,847,169
2025 Spawning Biomass (mt)	33,149,000	-36,989,879	103,287,879
2025 Fraction Unfished	0.980	0.863	1.097
Reference Points Based SB40%	—	—	—
Proxy Spawning Biomass (mt) SB40%	13,529,300	-15,092,838	42,151,438
SPR Resulting in SB40%	0.458	0.458	0.458
Exploitation Rate Resulting in SB40%	0.025	0.023	0.027
Yield with SPR Based On SB40% (mt)	1,066,490	-1,190,075	3,323,055
Reference Points Based on SPR Proxy for MSY	—	—	—
Proxy Spawning Biomass (mt) (SPR50)	15,090,400	-16,834,277	47,015,077
SPR50	0.500	—	—
Exploitation Rate Corresponding to SPR50	0.022	0.020	0.024
Yield with SPR50 at SB SPR (mt)	1,020,570	-1,138,801	3,179,941
Reference Points Based on Estimated MSY Values	—	—	—
Spawning Biomass (mt) at MSY (SB MSY)	9,559,670	-10,664,022	29,783,362
SPR MSY	0.352	0.346	0.359
Exploitation Rate Corresponding to SPR MSY	0.035	0.032	0.038
MSY (mt)	1,123,230	-1,253,579	3,500,039

1.6 Management Performance

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

Table 5: Recent trend in the overfishing limits (OFL), the acceptable biological catches (ABCs), the annual catch limits (ACLs), and the total dead catch (landings + discards) all in metric tons (mt).

Year	OFL (mt)	ABC (mt)	ACL (mt)	Total dead catch (mt)
2015	NA	NA	NA	142.1482
2016	NA	NA	NA	157.2776
2017	NA	NA	NA	168.4370
2018	NA	NA	NA	286.1558
2019	NA	NA	NA	240.7692
2020	NA	NA	NA	116.7398
2021	NA	NA	NA	116.9144
2022	NA	NA	NA	141.1317
2023	NA	NA	NA	119.3817
2024	NA	NA	NA	141.0490

1.7 Evaluation of Scientific Uncertainty

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

1.8 Harvest Projections and Decision Tables

Projections of the overfishing limit, acceptable biological catch, and annual catch limit, all based on a P* of 0.45 and a log-space standard deviation of the overfishing limit of 0.5 are included in Table 6. Assumed catches for 2025 and 2026 for this projection were provided by the Groundfish Management Team, and catches from 2027 onward assume full attainment of the acceptable biological catch.

Table 6: Potential OFLs (mt), ABCs (mt), ACLs (mt), the buffer between the OFL and ABC, estimated spawning biomass, and fraction unfished with adopted OFLs and ACLs and assumed catch for the first two years of the projection period.

Year	Adopted OFL (mt)	Adopted ACL (mt)	Assumed Catch (mt)	OFL (mt)	Buffer	ABC (mt)	ACL (mt)	Spawning Biomass (mt)
2025	—	—	2,035,440	—	—	—	—	33,149,000.000
2026	—	—	1,991,420	—	—	—	—	32,335,500.000
2027	—	—	—	1,949,140	0.935	1,822,440	1,822,440	31,562,700.000
2028	—	—	—	1,911,430	0.930	1,777,630	1,777,630	30,875,500.000
2029	—	—	—	1,875,500	0.926	1,736,710	1,736,710	30,224,400.000
2030	—	—	—	1,841,290	0.922	1,697,670	1,697,670	29,607,400.000
2031	—	—	—	1,808,660	0.917	1,658,550	1,658,550	29,022,500.000
2032	—	—	—	1,777,390	0.913	1,622,760	1,622,760	28,467,200.000
2033	—	—	—	1,747,170	0.909	1,588,180	1,588,180	27,937,000.000
2034	—	—	—	1,717,890	0.904	1,552,970	1,552,970	27,428,300.000
2035	—	—	—	1,689,580	0.900	1,520,620	1,520,620	26,939,700.000
2036	—	—	—	1,662,280	0.896	1,489,410	1,489,410	26,469,300.000

```
##| label: tbl-es-decision
##| warning: false
##| echo: false
##| eval: !expr eval_tables
```

```
##| tbl-cap: !expr if(eval_tables) decision_table_cap
##| tbl-pos: H

#table_decision(
#  list(mod_low_A, mod_base_A, mod_high_A),
#  list(mod_low_B, mod_base_B, mod_high_B),
# list(mod_low_C, mod_base_C, mod_high_C)
#
#
```

1.9 Unresolved Problems and Major Uncertainties

Test G

1.10 Research and Data Needs

Test H

1 Introduction

This document presents the stock assessment for the Rougheye (*Sebastes aleutianus*) and Blackspotted (*Sebastes melanostictus*) rockfishes, two species that form one management complex. This report is for the year 2025 in state and federal waters from California to Washington State, excluding consideration of the Puget Sound and Salish Sea (Figure 5). It seeks to use available catch, biological compositions in the for of lengths and ages, and potential indices of abundance and is the first assessment since the 2013 stock assessment (Hicks, Wetzel, and Harms 2013).

1.1 Stock Structure

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

1. Rougheye and Blackspotted rockfishes are two different species– can we separate them as two stocks and conduct separate assessments? Rougheye rockfish were first described in 1811 as *Perca variabilis* by German zoologist Peter Simon Pallas (Jordan and Evermann 1898), and assigned to various taxa at least 15 times since (Love, Yoklavich, and Thorsteinson 2002). Some descriptions noted both light and dark color morphs, which, along with possible confusion with several morphologically similar co-occurring species (e.g., *S. borealis* and *S. melanostomus*) have contributed to the persistent ambiguity in formal descriptions of Rougheye Rockfish (Orr and Hawkins 2008). The first genetic studies conducted in the late 1960s and early 1970s (Tsuyuki et al. 1968; Tsuyuki and Westrheim 1970) observed diversity suggestive of two genetic types within specimens identified as Rougheye Rockfish. Allozyme studies conducted over the next two decades (Seeb 1986; S. Hawkins, Heifetz, and Pohl 1997; S. L. Hawkins et al. 2005) provided additional evidence suggesting two separate genetic types within field-identified Rougheye Rockfish. Genetic variation between the two types, supported by both nuclear and mitochondrial DNA, was determined to be sufficiently conclusive to separate two species: "Type I" and "Type II" Rougheye Rockfish (Anthony J. Gharrett et al. 2005). Meristic and morphometric comparisons of the two species suggested certain characters such as gill raker counts and length, snout length, anal base length, and pectoral fin base were significantly different, and in combination could reliably, though not definitively, distinguish between the species(A. J. Gharrett et al. 2006). The two separate species were formally re-described by Orr and Hawkins (2008) with the Type II group retaining *S. aleutianus* and the common name Rougheye Rockfish. Blackspotted rockfish was proposed as the common name for the Type I group along with the scientific name of *S. melanostictus*,

re-establishing nomenclature from one of the species complex's earlier descriptions (Matsubara 1934).

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

Despite some identification advances and Rougheye and Blackspotted rockfishes are clearly genetically distinct species, data historically and contemporaneously remain available only for the Rougheye/Blackspotted Rockfish complex, not at the species level. While we treat these species as one assessed stock complex, we recognize and are mindful of the above species distinctions as we conduct our analyses.

2. Both species range into Canada and Alaska– are they one stock? While genetics studies have focused mostly on identification of the two species, little is known about the population structure of either species. This assessment and the 2013 assessment (Hicks, Wetzel, and Harms 2013) represent the most southerly range of these species. Comparing the absolute abundance of the 2013 assessment to the most current estimates of the Alaskan stocks, the absolute number in this southerly

range is much smaller than in the Gulf of Alaska (GOA), but higher than in the Bering Sea/Aleutian Island (BSAI) stock (Figure 6). The two smaller stocks have similar trend of decline and stabilization, whereas the higher biomass GOA stock looks to have not dropped at all over the time period considered (Figure 7). We assume here that the west coast stocks of Rougheye/Blackspotted rockfishes are distinct management units from those in Alaska.

1.2 Life History

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

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

Like all *Sebastes* species, Rougheye and Blackspotted Rockfishes give birth to live young. Larvae released has been documented between February and June and extrusion lengths are between 4.5-5.3 mm (Love, Yoklavich, and Thorsteinson 2002). There are no studies on the fecundity of rougheye rockfish on the west coast of the U.S.

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

1.3 Ecosystem considerations

1.4 Historical and Current Fishery Information

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

After many attempts to start trawl fisheries off the west coast of the United States in the late 1800's, the availability of the otter trawl and the diesel engine in the mid-1920's helped the trawl fisheries expand (Douglas and Division 1998). The trawl fisheries really became established during World War II when demand increased for shark livers and bottomfish. A mink food fishery also developed during World War II (Jones and Harry 1961), and post-war catches for rockfishes, including Rougheye/Blackspotted Rockfishes, increased (Niska 1976). Foreign fleets began fishing for rockfish in the mid 1960's until the EEZ was implemented in 1977 (J. B. Rogers 2003). Since 1977, landings of rockfish were high until management restrictions were implemented in 2000. Longline catches of rougheye rockfish are present from the turn of the century and continue in recent years, targeting sablefish and halibut. The catches by state for the trawl and hook & line fleets as well as for the Pacific whiting at-sea fleet are shown in ******.

A long-term directed fishery has not occurred for rougheye rockfish and historical discarding practices are not well known. Rougheye rockfish inhabit deeper water as adults, which were fished less often historically. More detailed information of the fisheries by state is given in Section ******* where the reconstructed landings are discussed.

1.5 Management History and Performance

Rougheye/Blackspotted Rockfishes has been a small component of groundfish fisheries and catches of Rougheye/Blackspotted Rockfishes have been governed by restrictions on assemblages of species, of which these species are a member. However, the distribution of fishing effort in areas where Rougheye/Blackspotted Rockfishes might be encountered has also been affected by catch restrictions on co-occurring, rebuilding species, as well as associated area closures instituted to promote rebuilding. The first imposed landings limits on a coastwide Sebastes complex (Rougheye/Blackspotted Rockfishes being one of the 50 rockfishes in the complex) were instituted in 1983. Ongoing concern that shelf and slope rockfishes may be undergoing overfishing led the attempt by J. S. Rogers et al. (1996) to describe the status of most rockfishes contained in the Sebastes complex. Rougheye/Blackspotted Rockfishes information content was low, and using the Triennial survey to calculate an average biomass and assuming that fishing mortality equals natural mortality provided estimates of exploitation rates that indicated the stock was undergoing very high exploitation rates in both management areas. The dividing line between the northern and southern management areas was shifted to 40º 10’ N latitude in 1999 and the Sebastes complex was subsequently divided into nearshore, shelf, and slope complexes in 2000. Rougheye/Blackspotted Rockfishes has been managed under trip limits for the minor slope rockfish complex in both north and south management areas since this time.

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

Though managed as part of a complex, OFL contributions for Rougheye/Blackspotted Rockfishes were calculated using DB-SRA in 2010 for the 2011-2012 management cycle. This lead to the observation that recent catches had frequently exceeded the OFL contribution estimated using data-poor, catch-only methods provided a strong indication that a more thorough evaluation of Rougheye/Blackspotted Rockfishes stock status and sustainable harvest levels be undertaken, using all available data. A full assessment of Rougheye/Blackspotted Rockfishes was undertaken in 2013 and indicated the stock complex was above management target levels (Hicks, Wetzel, and Harms (2013)). Recent management performance for Rougheye/Blackspotted Rockfishes as a part of the nothern minor slope rockfish complex is provided in Table (**?**) (ALI IS STILL CREATING THIS TABLE - WILL ADD TEXT FOR IT LATER).

1.6 Fisheries off Canada and Alaska

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

Rougheye rockfish have been managed as a bycatch only species in Alaska since 1991 with catches ranging between 130 and 2,418 mt and peaking in the late 1980s and early 1990s (Sullivan et al. 2023). Generally, about 55-75% of the catch are trawl-caught and 30-45% from hook-and-line (mainly, longline) fisheries. Since 2017 the move to pot gear in the sablefish fishery has decreased the longline catches. Discards since 2013 have ranged from 11.6% (in 2023) and 45% (in 2018). The Rougheye/Blackspotted complex catch levels generally are between 20% and 60% of the Total Allowable Catch since the

2005 when the complex began to be managed separately. The most recent age-structured integrated stock assessments of this complex in the Bering Sea and Aluetian Islands (Spencer, Ianelli, and Laman 2003) and for the Gulf of Alaska (Sullivan et al. 2023) do not indicate either overfishing or the stocks being overfished.

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

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

2 Data

Data from a wide range of programs were available for possible inclusion in the current assessment model. Descriptions of each data source included in the model (Figure 8) and sources that were explored but not included in the base model are provided below. Data that were excluded from the base model were excluded only after being explicitly explored during the development of this stock assessment and found to be inappropriate for use or had not changed since their past exploration for previous Rougheye/Blackspotted stock assessments when they were not used.

2.1 Fishery-dependent data

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

Fishery depended data for Rougheye/Blackspotted complex in this assessment are divided among six fleets, which include: * Fleet 1: Commercial bottom trawl fishery * Fleet 2: Commercial non-trawl gear (mainly the long-line fishery) fishery * Fleet 3: Dead discard bottom trawl fleet * Fleet 4: Dead discard non-trawl fleet * Fleet 5: Contemporary mid-water fishery * Fleet 6: Bycatch within the at-sea hake fishery

Recreational catch is inconsequential and not accounted for in this assessment.

2.1.1 Commercial Fishery Landings

2.1.1.1 Recent landings

Recent commercial landings of Rougheye/Blackspotted Rockfishes (2000-2024 for Washington, 1987–2022 for Oregon and 1981–2022 for California,) were obtained from PacFIN, a regional fisheries database that manages fishery-dependent information in cooperation with West Coast state agencies and National Marine Fisheries Service (NMFS). Catch data were extracted from PacFIN on April 21, 2015, by state and then combined into the fishing fleets used in the assessment. Time series of recent landings by fleet and state are reported in Table X and shown in Figures X to X.

2.1.1.2 Historical Landings

Historical landings of Rougheye/Blackspotted Rockfishes were reconstructed by state, by year (Table X, Figure X).

The Washington historical landings (1889–2000) were provided by Washington Department of Fish and Wildlife (WDFW), who recently conducted historical catch reconstruction for rockfish special including rougheye rockfish (pers. comm. T. Tsou, WDFW). The three main sources used in this reconstruction (SpeciesSumOutput2_2017.csv- ADD TABLE) are from the US Fish Commission Report (UFSC), Washington Bound Volumes, and Washington Statistical Bulletin. The historical species composition is based on the various historical reports and interviews of old-time fishermen and dockside samplers. The 1981 to 2000 landings are different from PacFIN records due to a revised approach for apportioning out more unidentified rockfish ("URCK") in fish tickets to the species level. This revised approach relaxed the borrowing rules for missing data currently used in the WDFW species allocation algorithm (Tsou at al., 2015 - CAN'T FIND IN BIB). New Washington historical landings represent improvement to the assessment.

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

The California historical landings were informed by several sources. Landings from the most recent "historical" period (between 1969 and 1980) were available from the CalCOM database for the California Cooperative Survey (CalCOM) database. Earlier landing records (between 1931 and 1968) were reconstructed by the Southwest Fisheries Science Center (Ralston et al. (2010)).

Comparison of Rougheye/Blackspotted rockfish historical landings by state and fleet between this and 2013 assessment is provided in Figure 9. The largest differences in this assessment from 2013 model are in Washington landings (Figure 12), with newly estimated landings being generally lower than those used in previous assessment. The new WDFW catch reconstruction completed by WDFW is considered an improvement.

Historical California and Oregon landings did not change substantially (Figure 10 and Figure 11), with the exception of a few years. Discrepancies in California and Oregon non-trawl landings between the 2013 and 2025 assessments are caused by the fact that non-trawl fleet in 2013 assessment was limited to only fixed gear, when in 2025 assessment non-trawl includes all non-trawl gear groups. Slight discrepancies in Oregon trawl landings between 1987 and 1999, are from adding previously non-reported landings of Rougheye/Blackspotted in the unspecified rockfish market categories (see details above).

The update in historical changes shows only minor differences in model outputs (Figure 13; Figure 14).

2.1.1.3 Bycatch in the foreign POP fishery

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

2.1.1.4 At-Sea Hake Catches

Rougheye/Blackspotted Rockfishes has long been bycaught in the fishery for the coastal population of Pacific hake, which is almost exclusively conducted with mid-water trawls. Large-scale harvesting of Pacific hake in the United States began in 1966, when factory trawlers from the Soviet Union and other countries began targeting this stock. After the 200-mile U.S. Exclusive Economic Zone was declared in 1977, a Joint-Venture fishery was initiated between United States trawlers and Soviet factory trawlers acting as motherships (larger, slower ships for fish processing and storage while at sea). By 1989 the U.S. fleet capacity had grown to a level sufficient to harvest the entire quota, and no further foreign fishing was allowed. The Pacific hake fishery is currently 100% observed by the at-sea hake observer program (A-SHOP) and data on bycatch species, including Rougheye/Blackspotted Rockfishes, is being routinely collected.

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

2.1.2 Discards

2.1.2.1 Historical discard

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

The historical discard information comes from Pikitch et al. (1988), and often referred to as the Pikitch study. The Pikitch study was conducted between 1985 and 1987 between 48 42' and 42 60' N. latitude, which is primarily within the Columbia INPFC area (Pikitch et al. 1988, Rogers and Pikitch 1992). Participation in the study was voluntary and included vessels using bottom, midwater and shrimp trawl gears. Observers of normal fishing operations on commercial vessels collected the data, estimated the total weight of the catch by tow, and recorded the weight of species retained and discarded in the sample. There were limited observations of Rougheye/Blackspotted Rockfishes in the Pikitch study. There are no midwater trawl records of Rougheye/Blackspotted Rockfishes, and only few fish records of bottom trawl catches, based on which for bottom trawl discard rate (discard weight over total weight) is just 0.09%. Therefore, no historical discard was assumed in the model.

2.1.2.2 Recent Discard

With the introduction of trip limits for rockfish in early 2000, limited discard has been observed in bottom trawl and non-trawl fisheries. In 2002, the West Coast Groundfish Observer Program (WCGOP) was implemented on the West Coast of the United States, which began with gathering bycatch and discard information for the limited entry trawl and fixed gear fleets. Observer coverage has expanded to include the California halibut trawl, the nearshore fixed gear and pink shrimp trawl fisheries. Since 2011, trawl fisheries have been managed with catch shares under a system of annual individual fishing quotas (IFQs) for the shoreside sector (i.e., vessels delivering to shoreside processors) and harvest cooperatives for the at-sea hake sectors (catcher-processors who catch and process hake at sea; and Motherships, factory processors that take delivery of hake from catcher vessels at sea). Constant monitoring of catch using observers or electronic monitoring (EM) is required to participate in the trawl catch share fishery.

The discard amounts of Rougheye/Blackspotted Rockfishes for the period between 2002 and 2023 were obtained from WCGOP by year and fleet (bottom trawl, mid-water trawl and non-trawl).Discard amounts were provided for both the catch share and the non-catch share sector for Rougheye/Blackspotted Rockfishes.

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

The discarding amounts of Rougheye/Blackspotted Rockfishes within bottom trawl and non-trawl fleets were included in the model as separate fleets.

2.1.2.2.1 Bottom Trawl Discard

Bottom trawl discard amounts are provided in Table XX. Prior to 2011, before the start of the catch share program, the discard of Rougheye/Blackspotted Rockfishes ranged between 1 metric ton and 60 metric tons, averaging at 23 metric tons a year. After 2011, the discard has been very low, not exceeding 0.5 metric ton a year.

2.1.2.2.2 Non-Trawl Discard

Non-trawl discard amounts are provided in Table XX. Non-trawl discard of Rougheye/Blackspotted Rockfishes were made in both catch share and non-catch share sectors. Discard amounts in these sectors were combined by year to represent total discard within the fleet. The discards within the fleets ranged between 0.5 metrci ton and 35 metric tons, with 10 metric tons as average per year.

2.1.3 Fishery Length and Age Data

2.1.3.1 Commercial Landings Length and Ages

The fishery length and age data for bottom trawl, non-trawl and midwater trawl fleets were obtained from Pacific Fisheries Information Network (PacFIN) Biological Data System (BDS) database. The fishery length and age samples were collected by port samplers.

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

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

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

Were $N_{b,j,y}$ is the number of lengths in each length bin (b) by sex (j) and year (y) within each fleet. $L_{b,j,t}$ represents an individual length sample by bin (b) and sex (j) within an individual fishing trip (t). As the first stage expansion, $L_{b,j,t}$ was multiplied by the ratio of landed catch (LC_t) within that trip (t) to portion of catch sampled for lengths (SC_t) within the same trip (t). In the second stage expansion, the individual length sample ($L_{b,j,t}$) was multiplied by the ratio of landed catch ($LC_{s,y}$) within individual state (s) and year (y) to catch weights sampled for lengths ($SC_{s,y}$) within the same state (s) and year (y). As the final step, the expanded length samples from the same size bin and sex were summed across all trips and states (combined into a single fleet) within a single year, to obtain the total number of lengths in each length bin by sex, year and fleet ($N_{b,j,y}$). The same calculations were repeated for each length bin (26 bins total), to develop sex specific length frequencies for each fishing fleet by year. Since coastwide catches in the assessment model were divided between South (California) and North (Oregon-Washington) fleets, the second stage expansion of length samples was relevant to only North fleet.

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 conditional-age-at-length data were not expanded and were binned according to length, age, sex, and year.

The filtering and cleaning of the PacFIN data and the length and age composition expansion was conducted using the pacfintools package in R (**?**). The filtering steps included removing samples with missing vital information.

Length and age data collected from commercial landings for each fleet are summarized by the number of trips and fish sampled by year. Figures XX show plots of the commercial length and age composition data across time for each fishery fleet.

Initial input values for the multinomial samples sizes determine the relative weights applied in fitting the annual composition data within the set of observations for each fishing fleet in the model. The initial input values in this assessment were were calculated as a function of the number of trips and number of fish via the Stewart Method (pers.comm. I. Stewart, International Pacific Halibut Commission (IPHC)). The method is based on analysis of the input and model derived effective sample sizes from West Coast groundfish stock assessments. A piece-wise linear regression was used to estimate the increase in effective sample size per sample based on fish-per-sample and the maximum effective sample size for large numbers of individual fish. The resulting equations are:

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

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

2.1.3.1.1 Commercial Discard Lengths

Discard length composition data for both discard fleets were available from WCGOP. WCGOP length composition data were not sex-specific. WCGOP raw observations were expanded to the haul level, to account for differences in catch among hauls.

No age data were available for discarded fish.

2.1.3.1.2 At-sea hake Fishery Length and Age Compositions

The length and age data were provided for

2.2 Fishery-independent data

Data from four fishery-independent surveys were used in this assessment, which included three historical survey and one current survey:

- AFSC/NWFSC West Coast Triennial (every three years) Shelf survey (1980-2004)
- Alaska Fishery Science Center Slope survey (1997-2001)
- Northwest Fisheries Science Center Slope Center (1999-2001)
- West Coast Groundfish Bottom Trawl Survey (WCGBTS; 2003-2024)

Three sources of information are produced by these surveys: indices of relative abundance, length-frequency distributions, and age-frequency distributions.

Geostatistical models of biomass density were fit to survey data using spatial and spatiotemporal GLMMs with TMB or sdmTMB. Only the WCGBTS has new data for this assessment, but new methods to develop an index of abundance were applied to all surveys to update all indices. The model used a delta model with a lognormal distribution for the catch-rate component. Two distributions (gamma and lognormal) were considered for the catch-rate component, but the lognormal error structure was used because it is able to better account for extreme catch events observed for Rougheye/Blackspotted Rockfishes in all four surveys. Comparing the standardized versions (i.e., Z-scores, which puts all the indices on the same scale for better comparison of trends) of the indices shows very similar trends among each model output, suggesting little difference in choice of model type. The variance in the indices is generally high (0.3-0.5), suggesting the information content in these indices is low. This is not a surprise given the challenge of sampling these species with trawl gear. Overall, catches densities are highest in northern Oregon and Washington.

2.2.1 AFSC/NWFSC West Coast Triennial Shelf Survey

2.2.1.1 Survey Description

The triennial survey was first conducted by the AFSC in 1977 and spanned the timeframe from 1977– 2004. The survey's design and sampling methods are most recently described in **Weinberg et al. (2002)**. Its basic design was a series of equally-spaced transects from which searches for tows in a specific depth range were initiated **(Figure X)**. The survey design has changed slightly over the period of time **(Table X, Figure X)**. In general, all of the surveys were conducted in the mid-summer through early fall: the 1977 survey was conducted from early July through late September; the surveys from 1980 through 1989 ran from mid-July to late September; the 1992 survey spanned from mid-July through early October; the 1995 survey was conducted from early June to late August; the 1998 survey ran from early June through early August; and the 2001 and 2004 surveys were conducted in May-July **(Figure X)**.

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

Given the different depths surveyed during 1977, the data from that year were not included in this assessment. Water hauls **(Zimmermann et al. 2003)** and tows located in Canadian waters were also excluded from the analysis of this survey. The survey was analyzed as an early series (1980–1992) and a late series (1995–2004), as has been done in other West Coast rockfish assessments.

2.2.1.2 Abundance Index

Geostatistical models of biomass density were fit to survey data using spatial and spatiotemporal GLMMs with TMB or sdmTMB. The model used a delta model with a lognormal distribution for the catch-rate component.

A logit-link was used for encounter probability and a log-link for positive catch rates. The response variable was catch (mt) with an offset of area (km^2) to account for differences in effort. Fixed effects were estimated for each year. The following additional covariates were included: pass. Vessel-year effects, which 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, Punt, and Methot 2004; J. T. Thorson and Ward 2014).

Spatial and spatiotemporal variation was included in the encounter probability and the positive catch rate model. Spatial variation was approximated using 200 knots, where more knots led to non-estimable standard errors because the positive encounters are too sparse to support the dense spatiotemporal structure.

In this assessment, two indices with a split in 1995 (to account for change in spatial coverage and survey timing) were used, with separate catchability parameters estimated for pre-1995 period and from 1995 forward. Sensitivity analysis was conducted to evaluate impact of using a single abundance index (1980–2004).

2.2.1.3 Length Compositions

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

Length compositions were separated into males and females. These length compositions were expanded to account for subsampling tows, with further expansion based upon the stratification by depth and latitude. The stratifications for length data expansions are provided in Table XX.

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

Processing of length data was conducted using the {nwfscSurvey} package in R (**?**).

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

2.2.2 AFSC Slope Survey

2.2.2.1 Survey Description

The AFSC slope survey was initiated in 1984. The survey methods are described in Lauth (2000). Prior to 1997, the survey was conducted in different latitudinal ranges each year (Table 5). In this assessment, only data from 1997, 1999, 2000 and 2001 were used – these years were consistent in latitudinal range (from 34o30' N. latitude to the U.S.-Canada border) and depth coverage (183-1280 m; 100-700 fm). #### Abundance Index

2.2.2.2 Length Compositions

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

Length compositions were separated into males and females. These length compositions were expanded to account for subsampling tows, with further expansion based upon the stratification by depth and latitude. The stratifications for length data expansions are provided in Table XX.

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

Processing of length data was conducted using the {nwfscSurvey} package in R (**?**).

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

2.2.3 NWFSC Slope Survey

2.2.3.1 Survey Description

The NWFSC slope survey was conducted annually from 1999 to 2002 (Keller et al., 2007). The surveyed area ranged between 34o50' and 48o07' N. latitude, encompassing the U.S. Vancouver, Columbia, Eureka, Monterey INPFC areas, and a portion of the Conception area, and consistently covered depths from 100 to 700 fm (183-1280 m) (Table 5).

2.2.3.2 Abundance Index

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

2.2.4 NWFSC West Coast Groundfish Bottom Trawl Survey

2.2.4.1 Survey Description

The WCGBTS is based on a random-grid design; covering the coastal waters from a depth of 55–1,280 m (Bradburn, Keller, and Horness 2011). This design generally uses four industry-chartered vessels per year assigned to a roughly equal number of randomly selected grid cells and divided into two 'passes' of the coast. Two vessels fish from north to south during each pass between late May to early October. This design therefore incorporates both vessel-to-vessel differences in catchability, as well as variance associated with selecting a relatively small number (approximately 700) of possible cells from a very large set of possible cells spread from the Mexican to the Canadian borders.

2.2.4.2 Abundance Index

Geostatistical models of biomass density were fit to survey data using spatial and spatiotemporal GLMMs with TMB or sdmTMB. The model used a delta model with a lognormal distribution for the catch-rate component.

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

The response variable in the model was catch (mt) with an offset of area (km2) to account for differences in effort. Fixed effects were estimated for each year. The following additional covariate was included: pass. Spatial variation, but not spatiotemporal variation, was included in the encounter probability and the positive catch rate model. Spatial variation was approximated using 200 knots, where more knots led to non-estimable standard errors.

2.2.4.3 Length and Age compositions

Length bins from 1o to 80 cm in 2 cm increments were used to summarize the length frequency of the survey catches in each year. The first length bin includes all observations less than 12 cm and the last bin includes all fish larger than 80 cm. Table **??** shows the number of lengths taken by the survey.

Length compositions were separated into males and females. These length compositions were expanded to account for subsampling tows, with further expansion based upon the stratification by depth and latitude. The stratification for length data expansions are provided in Table **??**.

Age distributions included bins from age 1 to age 100, with the last bin including all fish of greater age. Table **??** shows the number of ages taken by the survey. Age distributions were included in the model as conditional-age-at-length (CAAL) observations. The marginal Northwest Fisheries Science Center West Coast Groundfish Bottom Trawl Survey (WCGBTS) age-compositions were also included, but only for easier viewing of strong cohorts. The conditional-age-at-length 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 for all fishery-independent surveys The input sample sizes for length composition data for all fishery-independent surveys were calculated based on Stewart and Hamel (2014) as Input N$_y$ = $2.43 * N_{tow}$ where the 2.43 value was estimated for a group of shelf and slope rockfish species.

The input sample size of CAAL data was set at the number of fish at each length by sex and by year. The marginal age compositions were only used for comparing the implied fits while the CAAL data were used in the likelihood.

2.3 Biological Parameters

The major biological inputs to the models are natural mortality, age and growth parameters, weight-length, maturity and stock-recruitment parameters. The following sections outline the treatment of each section. One change from the previous assessment is moving to a two sex from the one-sex specification from 2013. The 2013 stock assessment one-sex specification was based on the observation that the biology of females and males was very similar, thus justifying the simplifying assumption of one sex. The following sections below demonstrates that females and males do generally have similar growth, though there are differences, but may have different natural mortality values. The current assessment will use a two sex configuration that allows for flexibility to set female and male parameters either equal (i.e., functionally equivalent to a one sex model) and or sex-specific. Figure 15 and Figure 16 show that using a two sex configuration with the same life history parameters for females and males is equivalent to the one sex model. Note that the one sex model sums up both female and male biomass, thus why it is twice the size as the two sex female-only spawning output (Figure 16).

2.3.1 Natural Mortality

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

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

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

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

The 2013 U.S. west coast stock assessment used a prior built around a mean of 0.034 (corresponding to a maximum age of 163), but estimated natural mortality at 0.042 (maximum age between 128-129 years; Figure M). The 2023 Gulf of Alaska assessment built a prior conditional on a estimate of natural mortality from their 5 oldest aged individuals that ranged from 126-135 years. This resulted in a mean value of 0.042, similar to the 2013 U.S. west coast stock assessment. The 2023 Bering Sea/Aleutian Islands assessment used M = 0.05 (assumed longevity of 108), and the recent Canadian assessments considered a range of M values from 0.03 to 0.055 (assumed maximum ages of 180 to 98 years; Figure 17).

We attempt to estimate natural mortality, as was done in the 2013 U.S. West coast assessment. Examining the available age data, the oldest 10 individuals range from

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

Related to this issue of possible age truncation, applying a catch curve analysis (taking the log of the abundance of numbers of samples in available age classes) on the aggregated ages across all age sources by sex, the total mortality (Natural + Fishing mortality= Total mortality) is 0.046 for females and 0.035 for males, which may indicate the natural mortality could be lower than that used in the 2013 assessment, but within the range of values considered in other areas (Figure 18). This also indicates the possibility of estimating sex-specific natural mortality, as natural mortality may differ by sex. The two sex model allows for this type of model specification exploration. Further exploration was done my truncating the upper ages considered, with the assumption that the older ages may also not be sampled fully (i.e., dome-shaped selectivity). We considered both 100 (Figure 19) and 80 (Figure 20) as upper age cut-offs. The less older individuals included, the higher the estimate of total mortality, and this a higher natural mortality. But we can see a general overestimate of how many older individuals are expected using these higher Z values, thus dome-shapeness does not see to explain the sampling of these older individuals.

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

2.3.2 Age and Growth Relationship

Age and length data are used to estimate important growth parameters. Figure 21 has the currently available age and length data. Female and male sample sizes are very similar. Estimated growth curves are also presented in Figure 21 and the parameters are provided in Table AL_1. The West Coast Groundfish Bottom Trawl Survey clearly and importantly samples the smallest, youngest individuals compared to the other two data sources. This allows for a better estimate of the age at size 0 (t_0) and growth coefficient (k). The female asymptotic size (L_∞) is estimated notably higher from the PacFIN data, though male estimates of Linf are similar across the data sets. The overall externally derived estimates of female and male Rougheye/Blackspotted Rockfishes are

$$\text{Females } L_\infty = 58.81 \text{ cm; } k = 0.08\text{; } t_0 = \text{-1.19}$$

$$\text{Males } L_\infty = 57.13 \text{ cm; } k = 0.09\text{; } t_0 = \text{-1.26}$$

The coefficient of variation (CV) of length by age and sex are shown in Figure 22. This is a measure of the variation in length for a given age class. Sample sizes are highest from the youngest ages up to around 70 (females) to 80 (males) years. The smoothed line shows the average response, and indicates similar CVs values for females and males, with the highest at the youngest ages, but generally 0.1. The amount and range of age samples, along with repeated length samples within an age class, allows growth parameters (L_∞, k, t_0, and CVs at age) to be estimated in the model. Ages are conditioned on lengths in the model in order to estimate growth within the model. We also explore sensitivity in growth values by pre-specifying growth to different values.

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

2.3.3 Ageing Bias and Precision

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

There are eight primary readers that provided the available ages, two of which often split the ageing duties. Figure 23 shows which reader assignments are given to each year of ages by data source. Reader 7 is the mix of two readers that shared reading duties within years.

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

Model selection criteria included AIC corrected for small sample size (AICc), which converges to AIC when sample sizes are large, and Bayesian Information Criterion (BIC). Both ADMB and TMB were run using an (ageing error shiny app). Model selection was then compared between ADMB and TMB, which did not always agree, so model selection criteria was added across the two modeling approaches to get an overall model selection criteria. Ageing error matrices were also inspected for behavior in the best supported models to make sure outrageously large precision or bias was not chosen (effectively rendering the ages worthless, which is not an assumption of the quality of the ages). Figure 24 and Figure 25 show the bias and imprecision assumptions applied for each ageing error (AE) matrix.

2.3.4 Length-Weight Relationship

Female and male length-weight relationships were determined using data from the PacFIN database, West Coast Groundfish Bottom Trawl Survey, and ASHOP samples. Samples size by sex were: female (N=13839), males (13625), and unknown sex (53). Each of the data sources estimated very similar length-weight relationships (Figure 26).

The resultant sex-specific length-weight relationships are given in Figure 27, with the following individual values:

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

These values are very similar to the previous assessment that used a combine sex value of a=0.0000096 and b=3.12000 (Figure 27).

2.3.5 Maturity

An updated maturity analysis for the Rougheye/Blackspotted rockfish complex with additional samples to estimate the length at which 50% of females in the population are mature (L50) is completed. Biological maturity identifies females that are physiologically capable of spawning. Functional maturity identifies females that are physiologically capable of spawning and will likely spawn in a given year. The most recent L50 estimate (not yet updated) of biological maturity is 43.84 cm and the most recent L50 estimate (not yet updated) of functional maturity is 48.44 cm.

2.3.6 Fecundity

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

2.3.7 Stock-Recruitment Function and Compensation

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

2.3.8 Sex Ratio

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

2.4 Environmental and ecosystem data

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

2.5 Assessment

2.5.1 History of Modeling Approaches

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

A 2013 benchmark stock assessment (Hicks, Wetzel, and Harms 2013) updated the modeling framework to the integrated statistical catch-at-age model Stock Synthesis 3, which is different from the delay-difference model with an assumed stock status prior in 2010 used in the DB-SRA analysis. The 2013 assessment used a substantially updated catch history, indices of abundance, and biological compositions (lengths and ages). The natural mortality value was also updated to be higher than that used in the DB-SRA model. The stock assessment was accepted for management as a Category 2 stock assessment.

2.5.2 Most Recent STAR Panel Recommendations

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

2.5.2.1 General recommendations

1. Investigate data-weighting options. *This has been an ongoing research topic in stock assessments since this panel, and several options are no available for consideration.*
2. A workshop for constructing abundance indices from survey GLMMs. *This is another topic that has developed greatly since this time. Our use of spatio-temporal models are described in the data section on abundance indices.*
3. Continue collection of ages. *This had been done, and this assessment benefits from several more years of age data.*
4. Exploring historical catches. *This again has been an ongoing topic and addressed for many of our groundfishes. We use the latest estimates in this assessment.*
5. SSC guidance on decision tables. *Decision table discussion evolve after every stock assessment cycle, and we are using the latest approaches to decision tables in this assessment.*

6. Investigate fishery-independent slope surveys, such as submersibles. *These surveys are not currently available for slope species.*

2.5.2.2 Stock-specific recommendations

1. Collecting additional age data. *This has been done and included in this stock assessment.*
2. Collecting genetic material to explore distinguishing Rougheye and Blackspotted Rockfishes. *This work has been done as was presented earlier in the document when discussing stock structure decisions.*
3. The cause of the re-occurring decrease in sizes around 40cm. $$$$$$$$$$$$$$$$
4. Additional maturity and fecundity studies. *While no fecundity studies are available, updated maturity is presented in the maturity section of the document.*
5. Age validation. *While no age validation study has been completed, the agers are confident what annuli represent a year's worth of growth. Multiple ages are available and ageing error is characterized in this stock assessment.*
6. Understanding stock structure. *Discussed in the stock structure section of this document.*
7. Connectivity of stocks across the species ranges. *This is also discussed in the stock structure section of the document.*

2.5.3 Response to SSC Groundfish Subcommittee Recommendations

2.6 Current Modelling Platform

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

2.6.1 Bridging the Assessment Model from Stock Synthesis 3.24 (2013) to 3.30 (2025)

More than 10 years have passed from the last assessment and in that time, the model and the Stock Synthesis 3 (SS3) modelling framework has undergone many changes. While the specific changes in the model can be found in the model change log, here we simply update the model from the older 3.24O version to the newer 3.30.22.1 version. We want to ensure that any update to the newest SS3 model software is not a cause of any changes in model outputs when we hold all data and model specifications to be exactly the same as in 2013. We therefore transferred all the older data and model specifications to the newest version of SS3 and compared the outputs. The status (Figure 28) and scale (Figure 29) of both models are exactly the same, as are the estimates of within model uncertainty. This allows us to conclude that we can move forward using the latest version of SS3 without concern of inheriting any model difference due solely to the choice of the SS3 version.

2.7 Model Structure, Evaluation, and Specification

2.7.1 Fleet and Survey Designations

The model is structured to track several fleets and include data from several surveys. Defining fleets is largely based on differing fleet selectivity (i.e., how the fishery captures fish by length and/or age). In the stock assessment model, selectivity translates into how the removals are taken via length and/or age out of the population. Currently, the following fleet structure is being used to model commercial fishery removals as there is no record of a recreational fishery for this stock complex:

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

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

For this assessment, we plan to treat discards in trawl and non-trawl fisheries as separate fleets from landings fleets. This approach provides several advantages, including:

- With separate discard fleets, we can easily track relative amounts of landings and discards within a fishery (they are not being combined into the total catch).
- This approach provides more flexibility to explore different selectivity assumptions for both landed and discarded fish –dome-shaped vs asymptotic, mirroring one to the other, etc.

- We can easily compare how similar (or different) selection curves for retained and discarded fish (easier than in case of selectivity and retention curves estimated within a single fleet).
- The biological data for landings and discards are collected independently (port sampling vs on-board observers), using different sampling approaches. Treating landings and discards as separate fleets in the model allows us to weight these data separately as well, to balance the representation of samples.

The change in treating discards as separate fleets does not impact model results (Figure 30 and Figure 31), regardless of the selectivity form being assumed for the discard fleets. This provides evidence moving to using discard fleets will not induce *a prior* differences in the model outputs, but it will offer more modelling flexibility.

We use length-based selectivity curves for all fleets for the current stock assessment model (as was done in the 2013 assessment), as there is no reason to believe significant age-based selectivity is occurring. We will consider logistic and dome-shaped selectivity options.

As reported in the data section, the following surveys are included in the model:

- Survey 1: Triennial (every three years) survey (1980-2004)

- Survey 2: Alaska Fishery Science Center Slope survey (1997-2001)
- Survey 3: Northwest Fisheries Science Center Slope Center (1999-2001)
- Survey 4: West Coast Groundfish Bottom Trawl Survey (WCGBTS; 2003-2024)

The specifications of the assessment are listed in Table **??**.

2.8 Model Likelihood Components

There are five primary likelihood components for each assessment model:

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

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

2.9 Reference Model Exploration, Key Assumptions and Specification

The reference model for Rougheye/Blackspotted Rockfishes was developed to balance parsimony and realism, and the goal was to estimate a spawning output trajectory and relative stock status for the stocks of Rougheye/Blackspotted Rockfishes in state and federal waters off the U.S. west coast. The model contains many assumptions to achieve parsimony and uses different data types and sources to estimate reality. A series of investigative model runs were done to achieve the final base model. Constructing integrated models (i.e., those fitting many data types) takes considerable model exploration using different configurations of the following treatments:

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

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

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

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

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

- Estimate or fix M

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

After much consideration, it was determined that some parameters were inestimable (M, L_{min} for both sexes), some did not move much for initial values and could be fixed (e.g., CV at length values, some selectivity parameters), and others could be estimated (e.g., L_∞, k, lnR_0). Estimation of L_min returned very high estimates of L_∞ for both sexes, thus the L_{min} value for both females and males was fixed to the external estimates. No priors were used on any of the estimated parameters except female L_∞ which used a normal prior and a standard deviation set a bit higher from the external fit to the growth curve (0.2). Length-at-maturity, fecundity-weight, and length-weight relationship, steepness (h) and recruitment variance were all fixed.

The selectivity of all fisheries were estimated as logistic even if dome-shaped selectivity was an option (and starting values begin at a strong dome-shaped position). Constant selectivity was assumed for the whole time period as there was no reason to suggest otherwise, and is consistent with the previous stock assessment treatment.

The full list of estimate and fixed parameters are found in Table }.

The biggest uncertainty was in the treatment of sex-specific M, as estimation came in very low for both sexes versus observed ages in the population and the treatment in the last assessment. This parameter affects both scale and status, and thus is a valuable parameter to consider for characterizing model specification error and defining states of nature. Both likelihood profiles and sensitivities explore the influence of this parameter on derived model outputs.

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

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

2.9.1 Data Weighting

The reference model allowed for the estimation of additional variance on all surveys. The ability to add variance to indices allows the model to balance model fit to that data while acknowledging that variances may be underestimated in the index standardization. A sensitivity was run with no extra variance estimated, as well as removal of the index data were explored.

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

2.9.2 Model Changes from the Last Assessment

Besides the additional of eight years of data and some changes in the estimation of some parameters, the biggest changes to the 2015 assessment are:

- Change in the removal history, particularly updates to historical data and new catches since 2013.
- Adding discard fleets instead of using retention curves.
- Using spatio-temporal approaches (sdmTMB) to define indices of abundance versus the former GLMM approach.
- Adding more biological compositions, mainly in years since 2013, but also some historical ages.
- Specifying a two sex instead of one sex model.

2.9.3 Reference Model Diagnostics and Results

2.9.3.1 Model Convergence and Acceptability

2.9.4 Base Model Results

2.9.4.1 Fits to the Data

2.9.4.1.1 Lengths

2.9.4.2 Conditional Age at Length and Marginal Ages

2.9.4.3 Fits to Indices of Abundance

2.9.5 Reference Model Outputs

2.9.5.1 Parameter Estimates

2.9.5.2 Population Trajectory

2.10 Characterizing uncertainty

2.10.1 Sensitivity Analyses

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

2.10.1.1 Data treatment sensitivities

Data treatments explored were as follows:

- Treatment of abundance indiecs 1. 2015 dockside survey

   2. 2015 dockside survey, no extra variance estimated
   3. No extra variance on private boat index

   - Data weighting

   11. No data-weighting
   12. Dirichlet data-weighting
   13. McAllister-Ianelli data weighting

- Other

   14. 2015 removal history

Likelihood values and estimates of key parameters and derived quantities from each sensitivity are available in Table . Derived quantities relative to the reference model are provided in Figure . Time series of spawning output and relative spawning output are shown in Figures and .

2.10.1.2 Model Specification Sensitivities

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

- Life history estimation
   - Natural mortality (M)
      1. Estimate M

2. Lorenzen age varying M
3. Use Oregon 2023 assessment sex-specific M values (females = 0.19; males = 0.17)
4. Maintain sex ratio in age and length data (sex option 3) and estimate M

- Growth parameters
  6. Fix all growth parameters to external values
  7. Fix all growth parameters to external values, estimate M
  8. Estimate L_min
  9. Fix $t_0 = 0$
  10. Estimate CV_{young} and CV_{old}
- Reproductive Biology
  10. Use biological maturity ogive
  11. Use functional maturity ogive
  12. Fecundity proportional to weight
- Recruitment estimation
  13. No recruitment estimation
  14. Estimate recruitment for all years in the model

Other

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

2.10.2 Likelihood Profiles

2.10.3 Retrospective Analysis

A five-year retrospective analysis was conducted by running the model and sequentially removing one year of data up through minus 5 years. Retrospective spawning output (Figure) and relatives stock status (Figure) estimates show a generally consistent pattern in population scale and trend, within the error of the reference model. All models show the population increasing. This results in a stock status in the precautionary zone over the 5 year consideration. The Mohn's rho evaluation of the degree of retrospective pattern in given in Table and shown in Figure . The relative error in the data peels are below significant levels.

2.10.4 Unresolved Problems and Major Uncertainties

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

2.11 Acknowledgements

2.12 References

Bradburn, M. J., A. A. Keller, and B. H. Horness. 2011. "The 2003 to 2008 U.S. West Coast Bottom Trawl Surveys of Groundfish Resources Off Washington, Oregon, and California: Estimates of Distribution, Abundance, Length, and Age Composition." NMFS-NWFSC-114. Seattle, WA: U.S. Department of Commerce.

Canada, Fisheries and Oceans. 2012. "Management Plan for the Rougheye/Blackspotted Rockfish Complex (Sebastes Aleutianus and S. Melanostictus) and Longspine Thornyhead (Sebastolobus Altivelis) in Canada [Final]."

Cope, Jason M., and Owen S. Hamel. 2022. "Upgrading from M Version 0.2: An Application-Based Method for Practical Estimation, Evaluation and Uncertainty Characterization of Natural Mortality." *Fisheries Research* 256 (December): 106493. https://doi.org/10.1016/j.fishres.2022.106493.

Dick, E. J., and A. D MacCall. 2010. "Estimates of Sustainable Yield for 50 Data-Poor Stocks in the Pacifc Coast Ground Fishery Management Plan." *NOAA Technical Memorandum NMFS* NOAA-TM-NMFS-SWFSC-460.

Douglas, David A., and Oregon Fish Division. 1998. "Species Composition of Rockfish in Catches by Oregon Trawlers, 1963-93." Marine {Program}.

Francis, R. I. C. Chris. 2011. "Data Weighting in Statistical Fisheries Stock Assessment Models." *Canadian Journal of Fisheries and Aquatic Sciences* 68 (6): 1124–38. https://doi.org/10.1139/f2011-025.

Gharrett, A. J., C. W. Mecklenburg, L. W. Seeb, Z. Li, A. P. Matala, A. K. Gray, and J. Heifetz. 2006. "Do Genetically Distinct Rougheye Rockfish Sibling Species Differ Phenotypically?" *Transactions of the American Fisheries Society* 135 (3): 792–800. https://doi.org/10.1577/T05-136.1.

Gharrett, Anthony J., Andrew P. Matala, Eric L. Peterson, Andrew K. Gray, Zhouzhou Li, and Jonathan Heifetz. 2005. "Two Genetically Distinct Forms of Rougheye Rockfish Are Different Species." *Transactions of the American Fisheries Society* 134 (1): 242–60. https://doi.org/10.1577/T04-055.1.

Hamel, Owen S., and Jason M. Cope. 2022. "Development and Considerations for Application of a Longevity-Based Prior for the Natural Mortality Rate." *Fisheries Research* 256 (December): 106477. https://doi.org/10.1016/j.fishres.2022.106477.

Harris, Jeremy P., Charles Hutchinson, and Sharon Wildes. 2019. "Using Otolith Morphometric Analysis to Improve Species Discrimination of Blackspotted Rockfish (Sebastes Melanostictus) and Rougheye Rockfish (S. Aleutianus)." *Fishery Bulletin* 117 (3): 234–45. https://go.gale.com/ps/i.do?p=AONE&sw=w&issn=00900656&v=2.1&it=r&id=GALE%7CA603632222&sid=googleScholar&linkaccess=abs.

Hawkins, Sharon L., Jonathan Heifetz, Christine M. Kondzela, John Pohl, Richard L. Wilmot, Oleg N. Katugin, and Vladimir N. Tuponogov. 2005. "Genetic Variation of Rougheye Rockfish (Sebastes Aleutianus) and Shortraker Rockfish (S. Borealis) Inferred from Allozymes." *Fishery Bulletin* 103 (3): 524–35.

Hawkins, Sharon, Jonathan Heifetz, and John Pohl. 1997. "Genetic Population Structure of Rougheye Rockfish (Sebastes Aleutianus) Inferred from Allozyme Variation."

National {Marine} {Fisheries} {Service}, {Alaska} {Fishery} {Science} {Quarterly} {Report} July - August - September.

Helser, T. E., A. E. Punt, and R. D. Methot. 2004. "A Generalized Linear Mixed Model Analysis of a Multi-Vessel Fishery Resouce Survey." *Fisheries Research* 70: 251–64.

Hicks, Allan C, Chantell Wetzel, and John Harms. 2013. "The Status of Rougheye Rockfish (Sebastes Aleutianus) and Blackspotted Rockfish (S. Melanostictus) as a Complex Along the U.S. West Coast in 2013." Pacific Fishery Management Council, 7700 Ambassador Place NE, Suite 200, Portland, OR 97220.

Jones, W. A., and G. Y. Harry Jr. 1961. "The Oregon Trawl Fishery for Mink Food-1948-1957." 8 (1).

Jordan, David Starr, and Barton Warren Evermann. 1898. "The Fishes of North and Middle America: A Descriptive Catalogue of the Species of Fish-Like Vertebrates Found in the Waters of North America, North of the Isthmus of Panama, Pt. II." *Bulletin of the United States National Museum* 47: 1241–2183.

Karnowski, M., V. V. Gertseva, and Andi Stephens. 2014. "Historical Reconstruction of Oregon's Commercial Fisheries Landings." Salem, OR: Oregon Department of Fish; Wildlife.

Love, M. S. 2011. *Certainly More Than You Want to Know About the Fishes of the Pacific Coast*. Really Big Press.

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. *The Rockfishes of the Northeast Pacific*. 1st Edition. Berkeley: University of California Press.

Matsubara, K. 1934. "Studies on the Scorpaenoid Fishes of Japan. I. Descriptions of One New Genus and Five New Species." *Journal of the Imperial Fishery Institute* 30: 199. https://cir.nii.ac.jp/crid/1370283693151216527.

Maunder, Mark N., Owen S. Hamel, Hui-Hua Lee, Kevin R. Piner, Jason M. Cope, André E. Punt, James N. Ianelli, Claudio Castillo-Jordán, Maia S. Kapur, and Richard D. Methot. 2023. "A Review of Estimation Methods for Natural Mortality and Their Performance in the Context of Fishery Stock Assessment." *Fisheries Research* 257 (January): 106489. https://doi.org/10.1016/j.fishres.2022.106489.

McAllister, M. K., and J. N. Ianelli. 1997. "Bayesian Stock Assessment Using Catch-Age Data and the Sampling — Importance Resampling Algorithm." *Canadian Journal of Fisheries and Aquatic Sciences* 54 (2): 284–300. https://doi.org/10.1139/f96-285.

McClure, Michelle M., Melissa A. Haltuch, Ellen Willis-Norton, David D. Huff, Elliott L. Hazen, Lisa G. Crozier, Michael G. Jacox, et al. 2023. "Vulnerability to Climate Change of Managed Stocks in the California Current Large Marine Ecosystem." *Frontiers in Marine Science* 10. https://doi.org/10.3389/fmars.2023.1103767.

Niska, Edwin L. 1976. "Species Compositionof Rockfish in Catches by Oregon Trawlers, 1963-71." Informational {Report} 76-7.

Orr, James W., and Sharon Hawkins. 2008. "Species of the Rougheye Rockfish Complex: Resurrection of Sebastes Melanostictus (Matsubara, 1934) and a Redescription of Sebastes Aleutianus (Jordan and Evermann, 1898)(Teleostei: Scorpaeniformes)." *Fishery Bulletin* 106 (2): 111–34. http://aquaticcommons.org/8844/.

Punt, A. E., D. C. Smith, K. KrusicGolub, and S. Robertson. 2008. "Quantifying Age-

Reading Error for Use in Fisheries Stock Assessments, with Application to Species in Australia's Southern and Eastern Scalefish and Shark Fishery." *Canadian Journal of Fisheries and Aquatic Sciences* 65 (9): 1991–2005. https://doi.org/10.1139/F08-111.

Ralston, Stephen, Don E. Pearson, John C. Field, and Meisha Key. 2010. "Documentation of the California Catch Reconstruction Project." US Department of Commerce, National Oceanic; Atmospheric Adminstration, National Marine.

Report, COSEWIC Status. 2007. "COSEWIC Assessment and Status Report on the Rougheye Rockfish Sebastes Sp. Type i and Sebastes Sp. Type II in Canada." Ottawa.

Rogers, J. B. 2003. "Species Allocation of *Sebastes* and *Sebastolobus* Species Caught by Foreign Countries Off Washington, Oregon, and California, U.S.A. In 1965-1976." Unpublished document.

Rogers, J. S., M. Wilkins, D. Kamakawa, Farron R. Wallace, T. Builder, M. Zimmerman, M. Kander, and B. Culver. 1996. "Status of the Remaining Rockfish in the Sebastes Complex in 1996 and Recommendations for Management in 1997." Pacific Fishery Management Council 2130 SW fifth Ave. Suite 224, Portland, Ore. 97210.

Seeb, L. W. 1986. *Biochemical Systematics and Evolution of the Scorpaenid Genus Sebastes*. University of Washington. https://books.google.com/books?id=CfJ6nQEACAAJ.

Spencer, Paul D, James N Ianelli, and Ned Laman. 2003. "Assessment of the Blackspotted and Rougheye Rockfish Stock Complex in the Bering Sea and Aleutian Islands." {NPFMC} {Bering} {Sea} and {Aleutian} {Islands} {SAFE}.

Starr, P J, and R Haigh. 2020. "Rougheye/Blackspotted Rockfish (Sebastes Aleutianus/Melanostictus) Stock Assessment for British Columbia in 2020." *DFO Can. Sci. Advis. Sec. Res. Doc.* 2020/020: 384.

Stewart, Ian J., and Owen S. Hamel. 2014. "Bootstrapping of Sample Sizes for Length- or Age-Composition Data Used in Stock Assessments." *Canadian Journal of Fisheries and Aquatic Sciences* 71 (4): 581–88. https://doi.org/10.1139/cjfas-2013-0289.

Sullivan, J. Y., J. A. Zahner, M. C. Siple, and B. E. Ferriss. 2023. "Assessment of the Rougheye and Blackspotted Rockfish Stock Complex in the Gulf of Alaska." {NPFMC} {Gulf} of {Alaska} {SAFE}.

Thorson, J. T., Ian J. Stewart, and A. E. Punt. 2012. "nwfscAgeingError: A User Interface in R for the Punt *Et Al.* (2008) Method for Calculating Ageing Error and Imprecision." *Available from: Http://Github.com/Pfmc-Assessments/nwfscAgeingError/*.

Thorson, J. T., and E. J. Ward. 2014. "Accounting for Vessel Effects When Standardizing Catch Rates from Cooperative Surveys." *Fisheries Research* 155: 168–76. https://doi.org/10.1016/j.fishres.2014.02.036.

Thorson, James T., Kelli F. Johnson, R. D. Methot, and I. G. Taylor. 2017. "Model-Based Estimates of Effective Sample Size in Stock Assessment Models Using the Dirichlet-Multinomial Distribution." *Fisheries Research* 192: 84–93. https://doi.org/10.1016/j.fishres.2016.06.005.

Tsuyuki, H., E. Roberts, R. H. Lowes, W. Hadaway, and S. J. Westrheim. 1968. "Contribution of Protein Electrophoresis to Rockfish (Scorpaenidae) Systematics."

Journal of the Fisheries Research Board of Canada 25 (11): 2477–2501. https://doi.org/10.1139/f68-216.

Tsuyuki, H., and S. J. Westrheim. 1970. "Analyses of the Sebastes Aleutianus–S. Melanostomus Complex, and Description of a New Scorpaenid Species, Sebastes Caenaematicus, in the Northeast Pacific Ocean." *Journal of the Fisheries Research Board of Canada* 27 (12): 2233–54. https://doi.org/10.1139/f70-252.

2.13 Tables

Table 7: Landings in metric tons (mt) by year for each fleet.

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

Table 7: Landings in metric tons (mt) by year for each fleet. *(continued)*

Year	Total (mt)	Trawl (mt)	Trawl Discard (mt)	Non-trawl (mt)	Non-trawl discard (mt)	Midwater trawl (mt)	At-sea-
1942	126	2	0	124	0	0	
1943	258	7	0	251	0	0	
1944	85	11	0	74	0	0	
1945	50	20	0	30	0	0	
1946	69	11	0	58	0	0	
1947	42	7	0	35	0	0	
1948	44	5	0	39	0	0	
1949	31	5	0	26	0	0	
1950	52	6	0	46	0	0	
1951	59	6	0	53	0	0	
1952	38	6	0	32	0	0	
1953	21	5	0	16	0	0	
1954	36	6	0	30	0	0	
1955	32	6	0	26	0	0	
1956	21	8	0	13	0	0	
1957	35	9	0	26	0	0	
1958	15	7	0	8	0	0	
1959	23	7	0	16	0	0	
1960	23	10	0	13	0	0	
1961	26	11	0	15	0	0	
1962	32	14	0	18	0	0	
1963	24	13	0	11	0	0	
1964	31	11	0	20	0	0	
1965	31	23	0	8	0	0	
1966	117	111	0	6	0	0	
1967	108	98	0	10	0	0	
1968	172	165	0	7	0	0	
1969	50	25	0	25	0	0	
1970	23	19	0	4	0	0	
1971	68	67	0	1	0	0	
1972	76	75	0	1	0	0	
1973	75	69	0	6	0	0	
1974	76	58	0	18	0	0	
1975	43	35	0	5	0	0	
1976	19	16	0	2	0	0	
1977	166	1	0	164	0	0	
1978	69	33	0	36	0	0	
1979	185	63	0	121	0	0	
1980	99	56	0	43	0	0	
1981	131	61	0	68	0	0	
1982	167	99	0	68	0	0	
1983	126	55	0	70	0	0	
1984	144	75	0	67	0	0	
1985	298	139	0	158	0	0	
1986	428	154	0	273	0	0	
1987	570	198	0	368	0	0	
1988	351	173	0	162	0	0	
1989	418	287	0	131	0	0	
1990	244	167	0	76	0	0	
1991	299	235	0	59	0	0	
1992	306	186	0	110	0	0	
1993	327	166	0	159	0	0	
1994	306	127	0	173	0	0	
1995	744	165	0	576	0	0	
1996	339	127	0	204	0	0	

Table 7: Landings in metric tons (mt) by year for each fleet. *(continued)*

Year	Total (mt)	Trawl (mt)	Trawl Discard (mt)	Non-trawl (mt)	Non-trawl discard (mt)	Midwater trawl (mt)	At-sea-H
1997	303	107	0	186	0	0	
1998	441	110	0	313	0	0	
1999	256	81	0	166	0	0	
2000	183	79	0	29	0	4	
2001	114	74	0	18	0	1	
2002	75	31	15	27	1	0	
2003	100	58	15	23	2	0	
2004	122	58	10	34	5	1	
2005	142	45	6	50	5	0	
2006	132	48	17	59	1	0	
2007	197	60	37	59	10	2	
2008	226	54	36	56	3	1	
2009	229	67	46	104	1	2	
2010	267	79	64	71	25	6	
2011	237	53	27	63	9	4	
2012	268	47	24	74	20	49	
2013	163	64	7	59	12	3	
2014	93	34	2	37	10	4	
2015	143	31	10	47	14	19	
2016	158	31	8	60	13	16	
2017	167	22	12	59	34	2	
2018	287	16	45	47	15	3	
2019	240	22	14	39	31	9	
2020	117	10	11	24	1	29	
2021	116	10	24	21	2	21	
2022	142	12	24	19	3	19	
2023	118	13	22	19	0	26	
2024	140	10	22	10	0	69	

Table 8: Recent trend in the overfishing limits (OFL), the acceptable biological catches (ABCs), the annual catch limits (ACLs), and the total catch all in metric tons (mt).

Year	OFL (mt)	ABC (mt)	ACL (mt)	Catch (mt)
2015	NA	NA	NA	142
2016	NA	NA	NA	157
2017	NA	NA	NA	168
2018	NA	NA	NA	286
2019	NA	NA	NA	241
2020	NA	NA	NA	117
2021	NA	NA	NA	117
2022	NA	NA	NA	141
2023	NA	NA	NA	119
2024	NA	NA	NA	141

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

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

#“‘

Table 9: Specifications and structure of the model.

Section	Configuration
Maximum age	140
Sexes	Females, males
Population bins	4-84 cm by 2 cm bins
Summary biomass (mt) age	3+
Number of areas	1
Number of seasons	1
Number of growth patterns	1
Start year	1892
End year	2024
Data length bins	10-80 cm by 2 cm bins
Data age bins	1-100 by 1 year

Table 10: Estimated parameters in the model.

Type	Count
Natural Mortality (M)	2
M time-variation	0
Growth mean	6
Growth variability	4
Growth time-variation	0
Stock-recruit	1
Stock-recruit variation	0
Rec. dev. time series	125
Rec. dev. initial age	0
Rec. dev. forecast	12
Index	1
Index time-variation	1
Size selectivity	33
Size selectivity time-variation	17
Retention	0
Retention time-variation	0
Age selectivity	0
Age selectivity time-variation	0

Table 11: Likelihood components by source.

Label	Total
TOTAL	7,093.5
Catch	0.0
Equil catch	0.0
Survey	-27.4
Length comp	479.7
Age comp	6,645.1
Recruitment	-4.2
InitEQ Regime	0.0
Forecast Recruitment	0.0
Parm priors	0.2
Parm softbounds	0.0
Parm devs	0.0
Crash Pen	0.0

Table 12: Parameter estimates, estimation phase, parameter bounds, estimation status estimated standard deviation (SD), prior information [distribution(mean, SD) used in the base model.

Label	Value	Phase	Bounds	Status	SD	Prior
NatM_uniform_Fem_GP_1	0.0436	2	(0.001, 0.2)	ok	0.00168	lognormal(0.034, 0.542)
L_at_Amin_Fem_GP_1	-4.18	2	(-100, 25)	ok	0.823	none
L_at_Amax_Fem_GP_1	59.3	2	(40, 90)	ok	0.39	none
VonBert_K_Fem_GP_1	0.0829	2	(0.01, 0.15)	ok	0.00217	none
CV_young_Fem_GP_1	0.0604	2	(1e-06, 1)	ok	0.0145	none
CV_old_Fem_GP_1	0.0868	2	(1e-06, 1)	ok	0.00294	none
Wtlen_1_Fem_GP_1	8.78e-06	-3	(-3, 3)	fixed	0	none
Wtlen_2_Fem_GP_1	3.15	-3	(-3, 4)	fixed	0	none
Mat50%_Fem_GP_1	46.5	-3	(1, 60)	fixed	0	none
Mat_slope_Fem_GP_1	-0.254	-3	(-30, 3)	fixed	0	none
Eggs/kg_inter_Fem_GP_1	1	-3	(-3, 3)	fixed	0	none
Eggs/kg_slope_wt_Fem_GP_1	0	-3	(-3, 3)	fixed	0	none
NatM_uniform_Mal_GP_1	0.0397	2	(0.001, 0.2)	ok	0.00159	lognormal(0.034, 0.542)
L_at_Amin_Mal_GP_1	-4.29	2	(-100, 25)	ok	0.825	none
L_at_Amax_Mal_GP_1	57.2	2	(40, 90)	ok	0.324	none
VonBert_K_Mal_GP_1	0.089	2	(0.01, 0.15)	ok	0.00225	none
CV_young_Mal_GP_1	0.0903	2	(1e-06, 1)	ok	0.0184	none
CV_old_Mal_GP_1	0.0794	2	(1e-06, 1)	ok	0.00288	none
Wtlen_1_Mal_GP_1	1.18e-05	-3	(-3, 3)	fixed	0	none
Wtlen_2_Mal_GP_1	3.07	-3	(-3, 4)	fixed	0	none
CohortGrowDev	1	-4	(0, 1)	fixed	0	none
FracFemale_GP_1	0.5	-5	(1e-06, 1)	fixed	0	none
SR_LN(R0)	14.7	1	(1, 15)	ok	1.08	none
SR_BH_steep	0.72	-3	(0.25, 0.99)	fixed	0	beta(0.720, 0.152)
SR_sigmaR	0.5	-4	(0, 2)	fixed	0	none

Label	Value	Phase	Bounds	Status	SD	Prior
SR_regime	0	-4	(-5, 5)	fixed	0	none
SR_autocorr	0	-99	(0, 0)	fixed	0	none
Main_RecrDev_1900	-0.0205	3	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1901	-0.0206	3	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1902	-0.0206	3	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1903	-0.0206	3	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1904	-0.0205	3	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1905	-0.0203	3	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1906	-0.02	3	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1907	-0.0196	3	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1908	-0.0192	3	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1909	-0.0186	3	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1910	-0.018	3	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1911	-0.0172	3	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1912	-0.0163	3	(-5, 5)	dev	0.496	normal(0.00, 0.50)
Main_RecrDev_1913	-0.0154	3	(-5, 5)	dev	0.496	normal(0.00, 0.50)
Main_RecrDev_1914	-0.0143	3	(-5, 5)	dev	0.496	normal(0.00, 0.50)
Main_RecrDev_1915	-0.0131	3	(-5, 5)	dev	0.496	normal(0.00, 0.50)
Main_RecrDev_1916	-0.0118	3	(-5, 5)	dev	0.497	normal(0.00, 0.50)
Main_RecrDev_1917	-0.0104	3	(-5, 5)	dev	0.497	normal(0.00, 0.50)
Main_RecrDev_1918	-0.00894	3	(-5, 5)	dev	0.497	normal(0.00, 0.50)
Main_RecrDev_1919	-0.00732	3	(-5, 5)	dev	0.498	normal(0.00, 0.50)
Main_RecrDev_1920	-0.00562	3	(-5, 5)	dev	0.498	normal(0.00, 0.50)
Main_RecrDev_1921	-0.00384	3	(-5, 5)	dev	0.498	normal(0.00, 0.50)
Main_RecrDev_1922	-0.00201	3	(-5, 5)	dev	0.498	normal(0.00, 0.50)
Main_RecrDev_1923	-0.000185	3	(-5, 5)	dev	0.499	normal(0.00, 0.50)
Main_RecrDev_1924	0.00159	3	(-5, 5)	dev	0.499	normal(0.00, 0.50)
Main_RecrDev_1925	0.00325	3	(-5, 5)	dev	0.499	normal(0.00, 0.50)

Label	Value	Phase	Bounds	Status	SD	Prior
Main_RecrDev_1926	0.00471	3	(-5, 5)	dev	0.499	normal(0.00, 0.50)
Main_RecrDev_1927	0.00591	3	(-5, 5)	dev	0.5	normal(0.00, 0.50)
Main_RecrDev_1928	0.00675	3	(-5, 5)	dev	0.5	normal(0.00, 0.50)
Main_RecrDev_1929	0.00716	3	(-5, 5)	dev	0.499	normal(0.00, 0.50)
Main_RecrDev_1930	0.00709	3	(-5, 5)	dev	0.499	normal(0.00, 0.50)
Main_RecrDev_1931	0.00652	3	(-5, 5)	dev	0.499	normal(0.00, 0.50)
Main_RecrDev_1932	0.00545	3	(-5, 5)	dev	0.498	normal(0.00, 0.50)
Main_RecrDev_1933	0.00392	3	(-5, 5)	dev	0.498	normal(0.00, 0.50)
Main_RecrDev_1934	0.00202	3	(-5, 5)	dev	0.497	normal(0.00, 0.50)
Main_RecrDev_1935	-0.000115	3	(-5, 5)	dev	0.496	normal(0.00, 0.50)
Main_RecrDev_1936	-0.00233	3	(-5, 5)	dev	0.496	normal(0.00, 0.50)
Main_RecrDev_1937	-0.00443	3	(-5, 5)	dev	0.495	normal(0.00, 0.50)
Main_RecrDev_1938	-0.0062	3	(-5, 5)	dev	0.494	normal(0.00, 0.50)
Main_RecrDev_1939	-0.0074	3	(-5, 5)	dev	0.494	normal(0.00, 0.50)
Main_RecrDev_1940	-0.0078	3	(-5, 5)	dev	0.494	normal(0.00, 0.50)
Main_RecrDev_1941	-0.00715	3	(-5, 5)	dev	0.494	normal(0.00, 0.50)
Main_RecrDev_1942	-0.0052	3	(-5, 5)	dev	0.494	normal(0.00, 0.50)
Main_RecrDev_1943	-0.00171	3	(-5, 5)	dev	0.494	normal(0.00, 0.50)
Main_RecrDev_1944	0.00355	3	(-5, 5)	dev	0.496	normal(0.00, 0.50)
Main_RecrDev_1945	0.0108	3	(-5, 5)	dev	0.497	normal(0.00, 0.50)
Main_RecrDev_1946	0.0201	3	(-5, 5)	dev	0.499	normal(0.00, 0.50)
Main_RecrDev_1947	0.0317	3	(-5, 5)	dev	0.502	normal(0.00, 0.50)
Main_RecrDev_1948	0.0455	3	(-5, 5)	dev	0.505	normal(0.00, 0.50)
Main_RecrDev_1949	0.0615	3	(-5, 5)	dev	0.508	normal(0.00, 0.50)
Main_RecrDev_1950	0.0794	3	(-5, 5)	dev	0.513	normal(0.00, 0.50)
Main_RecrDev_1951	0.0986	3	(-5, 5)	dev	0.517	normal(0.00, 0.50)
Main_RecrDev_1952	0.118	3	(-5, 5)	dev	0.522	normal(0.00, 0.50)
Main_RecrDev_1953	0.138	3	(-5, 5)	dev	0.527	normal(0.00, 0.50)

Label	Value	Phase	Bounds	Status	SD	Prior
Main_RecrDev_1954	0.155	3	(-5, 5)	dev	0.531	normal(0.00, 0.50)
Main_RecrDev_1955	0.168	3	(-5, 5)	dev	0.535	normal(0.00, 0.50)
Main_RecrDev_1956	0.177	3	(-5, 5)	dev	0.537	normal(0.00, 0.50)
Main_RecrDev_1957	0.18	3	(-5, 5)	dev	0.538	normal(0.00, 0.50)
Main_RecrDev_1958	0.178	3	(-5, 5)	dev	0.536	normal(0.00, 0.50)
Main_RecrDev_1959	0.17	3	(-5, 5)	dev	0.534	normal(0.00, 0.50)
Main_RecrDev_1960	0.159	3	(-5, 5)	dev	0.53	normal(0.00, 0.50)
Main_RecrDev_1961	0.144	3	(-5, 5)	dev	0.525	normal(0.00, 0.50)
Main_RecrDev_1962	0.125	3	(-5, 5)	dev	0.52	normal(0.00, 0.50)
Main_RecrDev_1963	0.101	3	(-5, 5)	dev	0.513	normal(0.00, 0.50)
Main_RecrDev_1964	0.0731	3	(-5, 5)	dev	0.505	normal(0.00, 0.50)
Main_RecrDev_1965	0.041	3	(-5, 5)	dev	0.497	normal(0.00, 0.50)
Main_RecrDev_1966	0.00762	3	(-5, 5)	dev	0.489	normal(0.00, 0.50)
Main_RecrDev_1967	-0.0232	3	(-5, 5)	dev	0.482	normal(0.00, 0.50)
Main_RecrDev_1968	-0.0487	3	(-5, 5)	dev	0.476	normal(0.00, 0.50)
Main_RecrDev_1969	-0.0675	3	(-5, 5)	dev	0.472	normal(0.00, 0.50)
Main_RecrDev_1970	-0.0812	3	(-5, 5)	dev	0.468	normal(0.00, 0.50)
Main_RecrDev_1971	-0.0921	3	(-5, 5)	dev	0.465	normal(0.00, 0.50)
Main_RecrDev_1972	-0.102	3	(-5, 5)	dev	0.463	normal(0.00, 0.50)
Main_RecrDev_1973	-0.106	3	(-5, 5)	dev	0.461	normal(0.00, 0.50)
Main_RecrDev_1974	-0.103	3	(-5, 5)	dev	0.461	normal(0.00, 0.50)
Main_RecrDev_1975	-0.0949	3	(-5, 5)	dev	0.461	normal(0.00, 0.50)
Main_RecrDev_1976	-0.0733	3	(-5, 5)	dev	0.464	normal(0.00, 0.50)
Main_RecrDev_1977	-0.0381	3	(-5, 5)	dev	0.468	normal(0.00, 0.50)
Main_RecrDev_1978	0.0105	3	(-5, 5)	dev	0.474	normal(0.00, 0.50)
Main_RecrDev_1979	0.0407	3	(-5, 5)	dev	0.477	normal(0.00, 0.50)
Main_RecrDev_1980	0.0644	3	(-5, 5)	dev	0.478	normal(0.00, 0.50)
Main_RecrDev_1981	0.0854	3	(-5, 5)	dev	0.477	normal(0.00, 0.50)

Label	Value	Phase	Bounds	Status	SD	Prior
Main_RecrDev_1982	0.048	3	(-5, 5)	dev	0.472	normal(0.00, 0.50)
Main_RecrDev_1983	0.0587	3	(-5, 5)	dev	0.469	normal(0.00, 0.50)
Main_RecrDev_1984	0.201	3	(-5, 5)	dev	0.468	normal(0.00, 0.50)
Main_RecrDev_1985	0.147	3	(-5, 5)	dev	0.45	normal(0.00, 0.50)
Main_RecrDev_1986	0.00167	3	(-5, 5)	dev	0.447	normal(0.00, 0.50)
Main_RecrDev_1987	0.157	3	(-5, 5)	dev	0.479	normal(0.00, 0.50)
Main_RecrDev_1988	0.676	3	(-5, 5)	dev	0.409	normal(0.00, 0.50)
Main_RecrDev_1989	0.267	3	(-5, 5)	dev	0.457	normal(0.00, 0.50)
Main_RecrDev_1990	-0.0436	3	(-5, 5)	dev	0.425	normal(0.00, 0.50)
Main_RecrDev_1991	0.043	3	(-5, 5)	dev	0.401	normal(0.00, 0.50)
Main_RecrDev_1992	0.141	3	(-5, 5)	dev	0.395	normal(0.00, 0.50)
Main_RecrDev_1993	0.251	3	(-5, 5)	dev	0.369	normal(0.00, 0.50)
Main_RecrDev_1994	-0.00575	3	(-5, 5)	dev	0.348	normal(0.00, 0.50)
Main_RecrDev_1995	-0.526	3	(-5, 5)	dev	0.349	normal(0.00, 0.50)
Main_RecrDev_1996	-0.658	3	(-5, 5)	dev	0.339	normal(0.00, 0.50)
Main_RecrDev_1997	-0.646	3	(-5, 5)	dev	0.338	normal(0.00, 0.50)
Main_RecrDev_1998	-0.372	3	(-5, 5)	dev	0.35	normal(0.00, 0.50)
Main_RecrDev_1999	0.503	3	(-5, 5)	dev	0.256	normal(0.00, 0.50)
Main_RecrDev_2000	0.119	3	(-5, 5)	dev	0.334	normal(0.00, 0.50)
Main_RecrDev_2001	0.0713	3	(-5, 5)	dev	0.304	normal(0.00, 0.50)
Main_RecrDev_2002	-0.316	3	(-5, 5)	dev	0.33	normal(0.00, 0.50)
Main_RecrDev_2003	-0.636	3	(-5, 5)	dev	0.361	normal(0.00, 0.50)
Main_RecrDev_2004	-0.246	3	(-5, 5)	dev	0.348	normal(0.00, 0.50)
Main_RecrDev_2005	-0.19	3	(-5, 5)	dev	0.353	normal(0.00, 0.50)
Main_RecrDev_2006	-0.39	3	(-5, 5)	dev	0.385	normal(0.00, 0.50)
Main_RecrDev_2007	0.0216	3	(-5, 5)	dev	0.355	normal(0.00, 0.50)
Main_RecrDev_2008	0.312	3	(-5, 5)	dev	0.328	normal(0.00, 0.50)
Main_RecrDev_2009	-0.0249	3	(-5, 5)	dev	0.375	normal(0.00, 0.50)

Label	Value	Phase	Bounds	Status	SD	Prior
Main_RecrDev_2010	0.359	3	(-5, 5)	dev	0.311	normal(0.00, 0.50)
Main_RecrDev_2011	-0.13	3	(-5, 5)	dev	0.361	normal(0.00, 0.50)
Main_RecrDev_2012	0.803	3	(-5, 5)	dev	0.266	normal(0.00, 0.50)
Main_RecrDev_2013	-0.0882	3	(-5, 5)	dev	0.36	normal(0.00, 0.50)
Main_RecrDev_2014	-0.394	3	(-5, 5)	dev	0.39	normal(0.00, 0.50)
Main_RecrDev_2015	-0.471	3	(-5, 5)	dev	0.416	normal(0.00, 0.50)
Main_RecrDev_2016	-0.207	3	(-5, 5)	dev	0.424	normal(0.00, 0.50)
Main_RecrDev_2017	0.67	3	(-5, 5)	dev	0.376	normal(0.00, 0.50)
Main_RecrDev_2018	0.188	3	(-5, 5)	dev	0.409	normal(0.00, 0.50)
Main_RecrDev_2019	0.0995	3	(-5, 5)	dev	0.412	normal(0.00, 0.50)
Main_RecrDev_2020	-0.267	3	(-5, 5)	dev	0.44	normal(0.00, 0.50)
Main_RecrDev_2021	-0.15	3	(-5, 5)	dev	0.467	normal(0.00, 0.50)
Main_RecrDev_2022	-0.0319	3	(-5, 5)	dev	0.493	normal(0.00, 0.50)
Main_RecrDev_2023	-1.66e-07	3	(-5, 5)	dev	0.5	normal(0.00, 0.50)
Late_RecrDev_2024	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2025	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2026	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2027	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2028	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2029	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2030	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2031	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2032	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2033	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2034	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2035	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
ForeRecr_2036	0	5	(-5, 5)	dev	0.5	normal(0.00, 0.50)
LnQ_base_TRIENNIAL(7)	-9.11	1	(-10, 2)	ok	1.12	none

Label	Value	Phase	Bounds	Status	SD	Prior
LnQ_base_AK_SLOPE(8)	-10.8	-1	(-15, 15)	fixed	0	none
LnQ_base_NW_SLOPE(9)	-9.76	-1	(-15, 15)	fixed	0	none
LnQ_base_WCGBTS(10)	-10.2	-1	(-15, 15)	fixed	0	none
LnQ_base_TRIENNIAL(7)_BLK3repl_-1892	-10	1	(-10, 2)	LO	0.961	none
Size_DblN_peak_BOTTOM_TRAWL(1)	48.6	3	(15, 79)	ok	1.07	none
Size_DblN_top_logit_BOTTOM_-TRAWL(1)	-11.4	3	(-15, 20)	ok	55.2	none
Size_DblN_ascend_se_BOTTOM_-TRAWL(1)	4.44	3	(-4, 12)	ok	0.224	none
Size_DblN_descend_se_BOTTOM_-TRAWL(1)	2.48	4	(-2, 20)	ok	0.922	none
Size_DblN_start_logit_BOTTOM_-TRAWL(1)	-999	-3	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_BOTTOM_-TRAWL(1)	-0.405	4	(-1000, 20)	ok	0.3	none
Size_DblN_peak_BOTTOM_TRAWL_-DISCARD(2)	41.5	3	(15, 79)	ok	6.43	none
Size_DblN_top_logit_BOTTOM_-TRAWL_DISCARD(2)	-15	-3	(-15, 20)	fixed	0	none
Size_DblN_ascend_se_BOTTOM_-TRAWL_DISCARD(2)	6.47	3	(-4, 12)	ok	0.857	none
Size_DblN_descend_se_BOTTOM_-TRAWL_DISCARD(2)	4.99	4	(-2, 20)	ok	1.08	none
Size_DblN_start_logit_BOTTOM_-TRAWL_DISCARD(2)	-999	-3	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_BOTTOM_-TRAWL_DISCARD(2)	-999	-4	(-1000, 20)	fixed	0	none
Size_DblN_peak_NON_TRAWL(3)	49.7	3	(15, 70)	ok	0.842	none
Size_DblN_top_logit_NON_TRAWL(3)	-11.4	3	(-15, 20)	ok	56.1	none
Size_DblN_ascend_se_NON_-TRAWL(3)	3.91	3	(-4, 12)	ok	0.238	none

Label	Value	Phase	Bounds	Status	SD	Prior
Size_DblN_descend_se_NON_-TRAWL(3)	2.2	4	(-2, 20)	ok	0.622	none
Size_DblN_start_logit_NON_TRAWL(3)	-999	-3	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_NON_TRAWL(3)	0.204	4	(-1000, 20)	ok	0.347	none
Size_DblN_peak_NON_TRAWL_-DISCARD(4)	47.8	3	(15, 70)	ok	2.22	none
Size_DblN_top_logit_NON_TRAWL_-DISCARD(4)	-15	-3	(-15, 20)	fixed	0	none
Size_DblN_ascend_se_NON_TRAWL_-DISCARD(4)	3.49	3	(-4, 12)	ok	0.739	none
Size_DblN_descend_se_NON_-TRAWL_DISCARD(4)	6.94	4	(-2, 20)	ok	1.59	none
Size_DblN_start_logit_NON_TRAWL_-DISCARD(4)	-999	-3	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_NON_TRAWL_-DISCARD(4)	-999	-4	(-1000, 20)	fixed	0	none
Size_DblN_peak_MIDWATER_-TRAWL(5)	51.8	3	(15, 79)	ok	2.78	none
Size_DblN_top_logit_MIDWATER_-TRAWL(5)	-15	-3	(-15, 20)	fixed	0	none
Size_DblN_ascend_se_MIDWATER_-TRAWL(5)	4.61	3	(-4, 12)	ok	0.46	none
Size_DblN_descend_se_MIDWATER_-TRAWL(5)	20	-4	(-2, 20)	fixed	0	none
Size_DblN_start_logit_MIDWATER_-TRAWL(5)	-999	-3	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_MIDWATER_-TRAWL(5)	-999	-4	(-1000, 20)	fixed	0	none
Size_DblN_peak_AT_SEA_HAKE(6)	48.7	3	(15, 70)	ok	1.75	none
Size_DblN_top_logit_AT_SEA_HAKE(6)	-15	-3	(-15, 20)	fixed	0	none
Size_DblN_ascend_se_AT_SEA_-HAKE(6)	3.53	3	(-4, 12)	ok	0.565	none

Label	Value	Phase	Bounds	Status	SD	Prior
Size_DblN_descend_se_AT_SEA_-HAKE(6)	20	-4	(-2, 20)	fixed	0	none
Size_DblN_start_logit_AT_SEA_-HAKE(6)	-999	-2	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_AT_SEA_-HAKE(6)	-999	-4	(-1000, 20)	fixed	0	none
Size_DblN_peak_TRIENNIAL(7)	16.8	3	(13, 50)	ok	2.69	none
Size_DblN_top_logit_TRIENNIAL(7)	-10.1	3	(-15, 20)	ok	68.8	none
Size_DblN_ascend_se_TRIENNIAL(7)	1.41	3	(-4, 12)	ok	2.08	none
Size_DblN_descend_se_TRIENNIAL(7)	5.4	3	(-2, 20)	ok	0.557	none
Size_DblN_start_logit_TRIENNIAL(7)	-15	-2	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_TRIENNIAL(7)	-4.78	4	(-1000, 20)	ok	3.08	none
Size_DblN_peak_AK_SLOPE(8)	37	3	(13, 50)	ok	2.52	none
Size_DblN_top_logit_AK_SLOPE(8)	-15	-3	(-15, 20)	fixed	0	none
Size_DblN_ascend_se_AK_SLOPE(8)	5.04	3	(-4, 12)	ok	0.536	none
Size_DblN_descend_se_AK_SLOPE(8)	4.64	4	(-2, 20)	ok	0.389	none
Size_DblN_start_logit_AK_SLOPE(8)	-15	-2	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_AK_SLOPE(8)	-15	-4	(-1000, 20)	fixed	0	none
Size_DblN_peak_WCGBTS(10)	20.7	3	(13, 50)	ok	4.38	none
Size_DblN_top_logit_WCGBTS(10)	-2.93	3	(-15, 20)	ok	2.61	none
Size_DblN_ascend_se_WCGBTS(10)	3.53	3	(-4, 12)	ok	1.76	none
Size_DblN_descend_se_WCGBTS(10)	4.25	4	(-2, 20)	ok	1.37	none
Size_DblN_start_logit_WCGBTS(10)	-15	-2	(-1000, 20)	fixed	0	none
Size_DblN_end_logit_WCGBTS(10)	-0.948	4	(-1000, 20)	ok	0.351	none
Size_DblN_peak_BOTTOM_-TRAWL(1)_BLK1repl_1892	46.3	3	(15, 70)	ok	1.64	none
Size_DblN_top_logit_BOTTOM_-TRAWL(1)_BLK1repl_1892	-10.4	3	(-15, 20)	ok	65.7	none
Size_DblN_ascend_se_BOTTOM_-TRAWL(1)_BLK1repl_1892	4.99	3	(-4, 12)	ok	0.314	none

Label	Value	Phase	Bounds	Status	SD	Prior
Size_DblN_descend_se_BOTTOM_-TRAWL(1)_BLK1repl_1892	2.46	4	(-2, 20)	ok	1.08	none
Size_DblN_end_logit_BOTTOM_-TRAWL(1)_BLK1repl_1892	-1.44	4	(-15, 20)	ok	0.416	none
Size_DblN_peak_NON_TRAWL(3)_-BLK2repl_1892	45.3	3	(15, 70)	ok	0.974	none
Size_DblN_top_logit_NON_TRAWL(3)_-BLK2repl_1892	-2.24	3	(-15, 20)	ok	0.406	none
Size_DblN_ascend_se_NON_-TRAWL(3)_BLK2repl_1892	2.05	3	(-4, 12)	ok	0.669	none
Size_DblN_start_logit_NON_-TRAWL(3)_BLK2repl_1892	-2	4	(-2, 20)	LO	1.26e-05	none
Size_DblN_end_logit_NON_-TRAWL(3)_BLK2repl_1892	-1.27	4	(-15, 20)	ok	0.28	none
Size_DblN_peak_AT_SEA_HAKE(6)_-BLK4repl_2020	52.1	3	(15, 70)	ok	4.69	none
Size_DblN_ascend_se_AT_SEA_-HAKE(6)_BLK4repl_2020	4.15	3	(-4, 12)	ok	1.02	none
Size_DblN_peak_TRIENNIAL(7)_-BLK5repl_1995	21.5	3	(13, 50)	ok	2.52	none
Size_DblN_top_logit_TRIENNIAL(7)_-BLK5repl_1995	-8.71	3	(-15, 20)	ok	81	none
Size_DblN_ascend_se_TRIENNIAL(7)_-BLK5repl_1995	3.48	3	(-4, 12)	ok	1.05	none
Size_DblN_descend_se_-TRIENNIAL(7)_BLK5repl_1995	4	3	(-2, 20)	ok	0.649	none
Size_DblN_end_logit_TRIENNIAL(7)_-BLK5repl_1995	-2.66	4	(-1000, 20)	ok	0.365	none

Table 13: Summary of reference points and management quantities, including estimates of the 95 percent intervals.

Reference Point	Estimate	Lower Interval	Upper Interval
Unfished Spawning Biomass (mt)	33,823,300	-37,731,849	105,378,449
Unfished Age 3+ Biomass (mt)	91,888,400	-102,443,989	286,220,789
Unfished Recruitment (R0)	2,517,380	-2,812,409	7,847,169
2025 Spawning Biomass (mt)	33,149,000	-36,989,879	103,287,879
2025 Fraction Unfished	0.980	0.863	1.097
Reference Points Based SB40%	—	—	—
Proxy Spawning Biomass (mt) SB40%	13,529,300	-15,092,838	42,151,438
SPR Resulting in SB40%	0.458	0.458	0.458
Exploitation Rate Resulting in SB40%	0.025	0.023	0.027
Yield with SPR Based On SB40% (mt)	1,066,490	-1,190,075	3,323,055
Reference Points Based on SPR Proxy for MSY	—	—	—
Proxy Spawning Biomass (mt) (SPR50)	15,090,400	-16,834,277	47,015,077
SPR50	0.500	—	—
Exploitation Rate Corresponding to SPR50	0.022	0.020	0.024
Yield with SPR50 at SB SPR (mt)	1,020,570	-1,138,801	3,179,941
Reference Points Based on Estimated MSY Values	—	—	—
Spawning Biomass (mt) at MSY (SB MSY)	9,559,670	-10,664,022	29,783,362
SPR MSY	0.352	0.346	0.359
Exploitation Rate Corresponding to SPR MSY	0.035	0.032	0.038
MSY (mt)	1,123,230	-1,253,579	3,500,039

Table 14: Time series of population estimates from the base model.

Year	Total Biomass (mt)	Spawning Biomass (mt)	Total Biomass 3+ (mt)	Fraction Unfished	Age-0 Recruits (1,000s)	Total Mortality (mt)	1-SPR	Exploita-tion Rate
1892	91941400	33823300	91888400	1.000	2517380	19	0.000	0.000
1893	91941400	33823300	91888400	1.000	2517380	19	0.000	0.000
1894	91941400	33823300	91888400	1.000	2517380	19	0.000	0.000
1895	91941400	33823300	91888300	1.000	2517380	5	0.000	0.000
1896	91941400	33823300	91888300	1.000	2517380	1	0.000	0.000
1897	91941400	33823300	91888300	1.000	2517380	1	0.000	0.000
1898	91941400	33823300	91888300	1.000	2517380	1	0.000	0.000
1899	91941400	33823300	91888300	1.000	2517380	1	0.000	0.000
1900	91941300	33823300	91888300	1.000	2466270	2	0.000	0.000
1901	91941100	33823300	91888300	1.000	2466020	2	0.000	0.000
1902	91940300	33823300	91888300	1.000	2465940	3	0.000	0.000
1903	91938300	33823300	91886300	1.000	2466040	3	0.000	0.000
1904	91934400	33823300	91882500	1.000	2466320	4	0.000	0.000
1905	91928300	33823300	91876400	1.000	2466810	4	0.000	0.000
1906	91919500	33823300	91867500	1.000	2467500	4	0.000	0.000
1907	91907700	33823200	91855700	1.000	2468420	5	0.000	0.000
1908	91892800	33823100	91840800	1.000	2469570	8	0.000	0.000
1909	91874800	33822800	91822800	1.000	2470960	6	0.000	0.000
1910	91853700	33822200	91801700	1.000	2472580	6	0.000	0.000
1911	91829900	33821100	91777800	1.000	2474450	7	0.000	0.000
1912	91803400	33819200	91751300	1.000	2476560	7	0.000	0.000
1913	91774700	33816200	91722600	1.000	2478920	8	0.000	0.000
1914	91744100	33812000	91691900	1.000	2481540	8	0.000	0.000
1915	91712000	33806300	91659800	0.999	2484420	10	0.000	0.000
1916	91678700	33799200	91626400	0.999	2487570	9	0.000	0.000
1917	91644800	33790500	91592400	0.999	2490990	10	0.000	0.000
1918	91610600	33780400	91558100	0.999	2494670	55	0.000	0.000
1919	91576400	33769000	91523900	0.998	2498620	26	0.000	0.000
1920	91542800	33756600	91490300	0.998	2502800	23	0.000	0.000
1921	91510200	33743400	91457500	0.998	2507160	23	0.000	0.000
1922	91478900	33729600	91426200	0.997	2511640	18	0.000	0.000
1923	91449400	33715300	91396500	0.997	2516130	20	0.000	0.000
1924	91421900	33700900	91368900	0.996	2520490	32	0.000	0.000
1925	91396800	33686500	91343800	0.996	2524570	38	0.000	0.000
1926	91374400	33672300	91321300	0.996	2528170	54	0.000	0.000
1927	91355000	33658500	91301800	0.995	2531090	69	0.000	0.000
1928	91338900	33645200	91285600	0.995	2533110	72	0.000	0.000
1929	91326100	33632600	91272800	0.994	2534070	66	0.000	0.000
1930	91316900	33620900	91263600	0.994	2533820	67	0.000	0.000
1931	91311400	33610200	91258000	0.994	2532290	44	0.000	0.000
1932	91309500	33600600	91256100	0.993	2529500	25	0.000	0.000
1933	91311100	33592300	91257800	0.993	2525580	35	0.000	0.000
1934	91316100	33585300	91262800	0.993	2520740	42	0.000	0.000
1935	91324000	33579800	91270900	0.993	2515310	34	0.000	0.000
1936	91334700	33575800	91281600	0.993	2509720	61	0.000	0.000
1937	91347500	33573200	91294500	0.993	2504440	53	0.000	0.000
1938	91361900	33572300	91309100	0.993	2500010	56	0.000	0.000
1939	91377600	33572900	91324800	0.993	2497000	28	0.000	0.000
1940	91393800	33575100	91341100	0.993	2496010	59	0.000	0.000
1941	91410000	33578600	91357400	0.993	2497670	102	0.000	0.000
1942	91425700	33583400	91373100	0.993	2502580	125	0.000	0.000
1943	91440500	33589400	91387800	0.993	2511380	257	0.000	0.000

Table 14: Time series of population estimates from the base model. *(continued)*

Year	Total Biomass (mt)	Spawning Biomass (mt)	Total Biomass 3+ (mt)	Fraction Unfished	Age-0 Recruits (1,000s)	Total Mortality (mt)	1-SPR	Exploita-tion Rate
1944	91454100	33596200	91401400	0.993	2524670	85	0.000	0.000
1945	91466900	33603800	91413900	0.994	2543040	50	0.000	0.000
1946	91478800	33611800	91425500	0.994	2566990	69	0.000	0.000
1947	91490300	33619900	91436600	0.994	2596960	41	0.000	0.000
1948	91502200	33628000	91447900	0.994	2633210	44	0.000	0.000
1949	91515500	33635700	91460600	0.994	2675700	31	0.000	0.000
1950	91531900	33642900	91476100	0.995	2723980	53	0.000	0.000
1951	91553100	33649400	91496400	0.995	2776920	59	0.000	0.000
1952	91581300	33655100	91523500	0.995	2832430	38	0.000	0.000
1953	91619100	33660200	91560200	0.995	2887300	20	0.000	0.000
1954	91669300	33664700	91609300	0.995	2937250	36	0.000	0.000
1955	91735000	33668900	91673900	0.995	2977400	32	0.000	0.000
1956	91819100	33673300	91757000	0.996	3003410	20	0.000	0.000
1957	91924500	33678600	91861600	0.996	3012700	35	0.000	0.000
1958	92053600	33685400	91990200	0.996	3005310	15	0.000	0.000
1959	92208000	33694700	92144600	0.996	2983390	22	0.000	0.000
1960	92388700	33707600	92325500	0.997	2949720	23	0.000	0.000
1961	92595400	33725200	92532800	0.997	2905900	26	0.000	0.000
1962	92826900	33749000	92765000	0.998	2851630	32	0.000	0.000
1963	93080700	33780300	93019900	0.999	2785670	23	0.000	0.000
1964	93353500	33820300	93293900	1.000	2708210	32	0.000	0.000
1965	93640700	33870300	93582500	1.001	2622990	31	0.000	0.000
1966	93937000	33931200	93880500	1.003	2531090	117	0.000	0.000
1967	94236100	34003600	94181500	1.005	2448530	108	0.000	0.000
1968	94531400	34087800	94478700	1.008	2381690	172	0.000	0.000
1969	94815800	34183300	94764600	1.011	2331940	51	0.000	0.000
1970	95082300	34289300	95032400	1.014	2295330	22	0.000	0.000
1971	95324500	34404300	95275600	1.017	2265340	68	0.000	0.000
1972	95536500	34526400	95488300	1.021	2239210	76	0.000	0.000
1973	95713500	34652900	95666000	1.025	2224070	75	0.000	0.000
1974	95852100	34781200	95805000	1.028	2226410	77	0.000	0.000
1975	95949600	34908000	95902700	1.032	2239640	43	0.000	0.000
1976	96004900	35030000	95957800	1.036	2283720	19	0.000	0.000
1977	96018000	35144000	95970500	1.039	2360240	166	0.000	0.000
1978	95990500	35246700	95941800	1.042	2472200	69	0.000	0.000
1979	95925700	35335300	95875300	1.045	2542430	185	0.000	0.000
1980	95828500	35407300	95775900	1.047	2597300	99	0.000	0.000
1981	95705200	35460900	95651300	1.048	2646060	131	0.000	0.000
1982	95562500	35495000	95507600	1.049	2542870	167	0.000	0.000
1983	95407300	35508900	95352100	1.050	2563810	126	0.000	0.000
1984	95246000	35503000	95191700	1.050	2947810	144	0.000	0.000
1985	95083200	35478100	95027400	1.049	2786950	299	0.000	0.000
1986	94925600	35435800	94865000	1.048	2403250	428	0.000	0.000
1987	94779500	35378200	94722200	1.046	2799110	571	0.000	0.000
1988	94649000	35308400	94593400	1.044	4690650	351	0.000	0.000
1989	94536300	35229500	94469700	1.042	3109580	418	0.000	0.000
1990	94459900	35145200	94370700	1.039	2272250	244	0.000	0.000
1991	94428200	35059200	94366800	1.037	2471150	299	0.000	0.000
1992	94438100	34974800	94388800	1.034	2717650	306	0.000	0.000
1993	94484200	34895000	94430400	1.032	3025600	327	0.000	0.000
1994	94559900	34822400	94502100	1.030	2334420	306	0.000	0.000
1995	94660600	34759500	94601900	1.028	1384430	745	0.000	0.000
1996	94776100	34708300	94732200	1.026	1212210	339	0.000	0.000

Table 14: Time series of population estimates from the base model. *(continued)*

Year	Total Biomass (mt)	Spawning Biomass (mt)	Total Biomass 3+ (mt)	Fraction Unfished	Age-0 Recruits (1,000s)	Total Mortality (mt)	1-SPR	Exploitation Rate
1997	94888800	34671300	94860500	1.025	1227170	303	0.000	0.000
1998	94977200	34650700	94951000	1.024	1614170	441	0.000	0.000
1999	95024300	34648500	94992900	1.024	3871170	256	0.000	0.000
2000	95015800	34666200	94971700	1.025	2635650	183	0.000	0.000
2001	94963200	34702800	94888300	1.026	2514310	114	0.000	0.000
2002	94873600	34755100	94819900	1.028	1707110	74	0.000	0.000
2003	94754200	34817900	94706200	1.029	1239770	100	0.000	0.000
2004	94605200	34884100	94570800	1.031	1831120	122	0.000	0.000
2005	94420000	34946000	94390600	1.033	1938050	142	0.000	0.000
2006	94194600	34995300	94156000	1.035	1587000	132	0.000	0.000
2007	93929100	35024300	93888900	1.036	2394530	197	0.000	0.000
2008	93622400	35027100	93583400	1.036	3199780	225	0.000	0.000
2009	93279300	35001500	93226000	1.035	2285510	230	0.000	0.000
2010	92917100	34948900	92852800	1.033	3353390	266	0.000	0.000
2011	92543800	34873600	92492000	1.031	2070900	237	0.000	0.000
2012	92182000	34780700	92113200	1.028	5297620	268	0.000	0.000
2013	91834500	34674000	91778700	1.025	2187730	163	0.000	0.000
2014	91532100	34554900	91437800	1.022	1622510	93	0.000	0.000
2015	91279700	34423400	91236800	1.018	1511340	142	0.000	0.000
2016	91071100	34279500	91036800	1.013	1979970	157	0.000	0.000
2017	90897000	34124300	90858300	1.009	4790490	168	0.000	0.000
2018	90744200	33961500	90690500	1.004	2979140	286	0.000	0.000
2019	90627800	33796900	90536800	0.999	2742760	241	0.000	0.000
2020	90551700	33638100	90491400	0.995	1913990	117	0.000	0.000
2021	90517400	33492900	90463600	0.990	2163970	117	0.000	0.000
2022	90516500	33368200	90474500	0.987	2435110	141	0.000	0.000
2023	90539500	33268700	90492400	0.984	2513300	119	0.000	0.000
2024	90578800	33196200	90527100	0.981	2512760	141	0.000	0.000
2025	90628500	33149000	90575600	0.980	2512410	2035439	0.500	0.022
2026	88657700	32335500	88604900	0.956	2506170	1991424	0.500	0.022
2027	86764500	31562700	86711700	0.933	2499970	1822443	0.480	0.021
2028	85071700	30875500	85019000	0.913	2494230	1777632	0.479	0.021
2029	83453100	30224400	83400500	0.894	2488570	1736709	0.477	0.021
2030	81904200	29607400	81851700	0.875	2483000	1697673	0.476	0.021
2031	80422900	29022500	80370500	0.858	2477530	1658546	0.474	0.021
2032	79009100	28467200	78956800	0.842	2472160	1622756	0.473	0.021
2033	77659100	27937000	77607000	0.826	2466840	1588179	0.472	0.020
2034	76371700	27428300	76319700	0.811	2461580	1552970	0.470	0.020
2035	75147000	26939700	75095100	0.796	2456360	1520618	0.469	0.020
2036	73982000	26469300	73930200	0.783	2451170	1489408	0.468	0.020

#“‘{r, results = “asis”} ##| label: tbl-projections ##| warning: false ##| echo: false ##| eval: !expr eval_tables ##| tbl-cap: !expr if(eval_tables) projections_cap ##| tbl-pos: H

#projections_table |> # gt::gt() |> # gt::fmt_number(# columns = c(2:5, 7:9), # decimals = 0 #) |> # gt::fmt_number(# columns = c(6, 10), # decimals = 3 #) |> # gt::tab_options(# table.font.size = 12, # latex.use_longtable = TRUE #) |> # gt::sub_missing(# columns = tidyselect::everything(), # missing_text = “—” #) |> # gt::cols_align(# align = “center” #) |> # gt::cols_width(# tidyselect::everything() ~ px(75) #) |> # gt::as_latex()

#“‘

2.14 Figures

2.14.1 Introduction

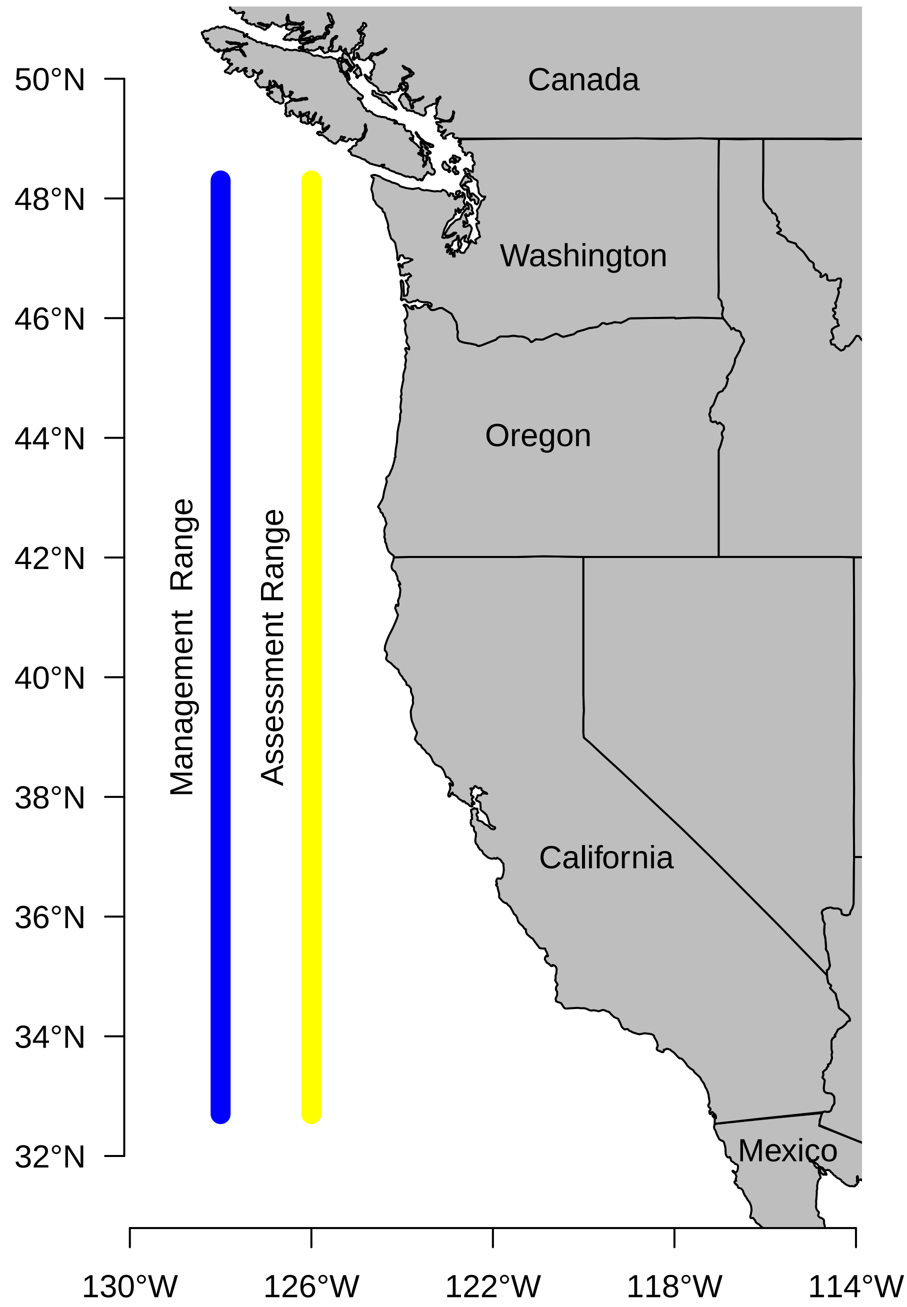

Figure 5: Map of the assessment area.

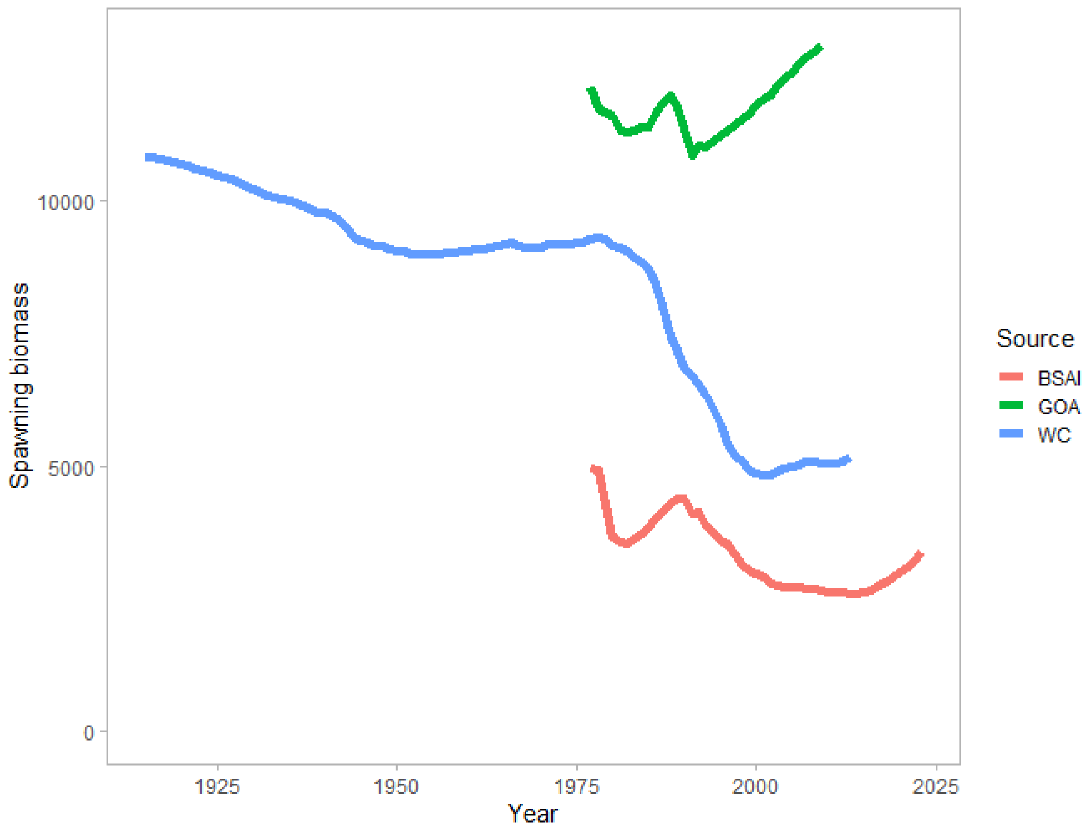

Figure 6: Estimates of spawning biomass (current spawning output/unfished spawning output) for the Rougheye/Blackspotted rockfish complex from the two most recent Alaska (Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA)) and the 2013 U.S. west coast stock assessment.

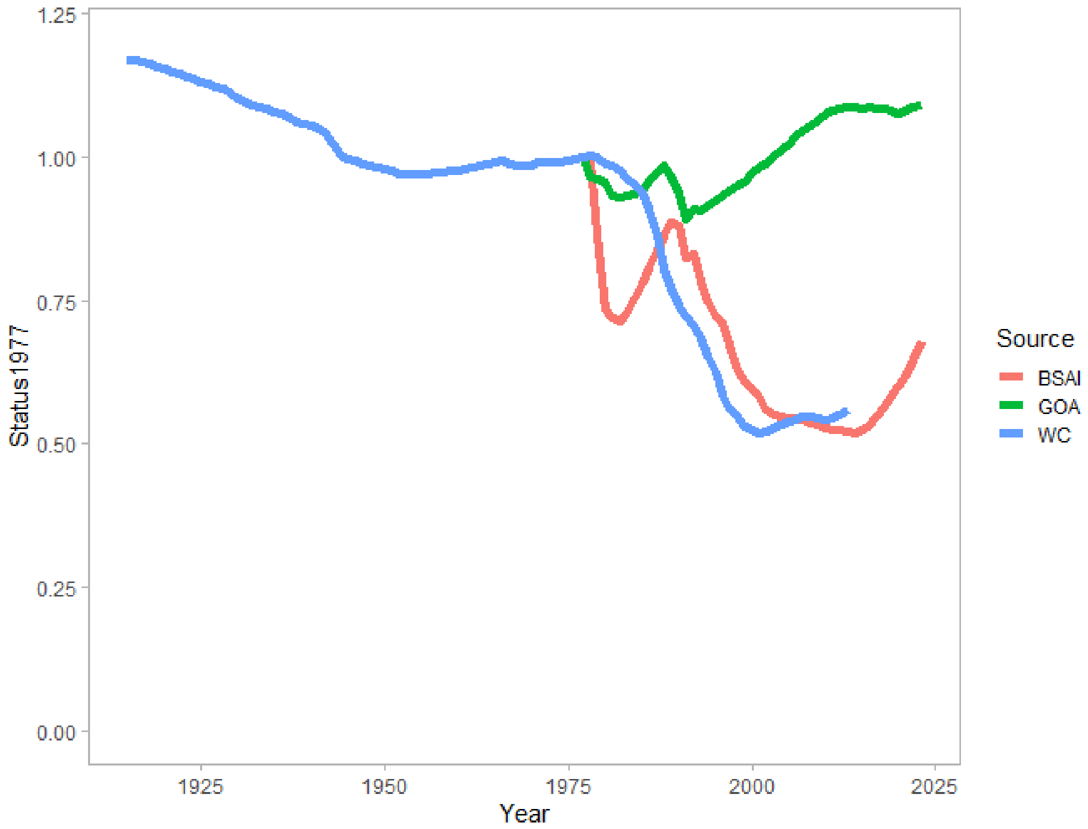

Figure 7: Estimates of relative stock size (current spawning output/unfished spawning output) relative to 1977 (the common year in all stock assessments compared) for the Rougheye/Blackspotted rockfish complex from the two most recent Alaska (Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA))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

2.14.2 Data

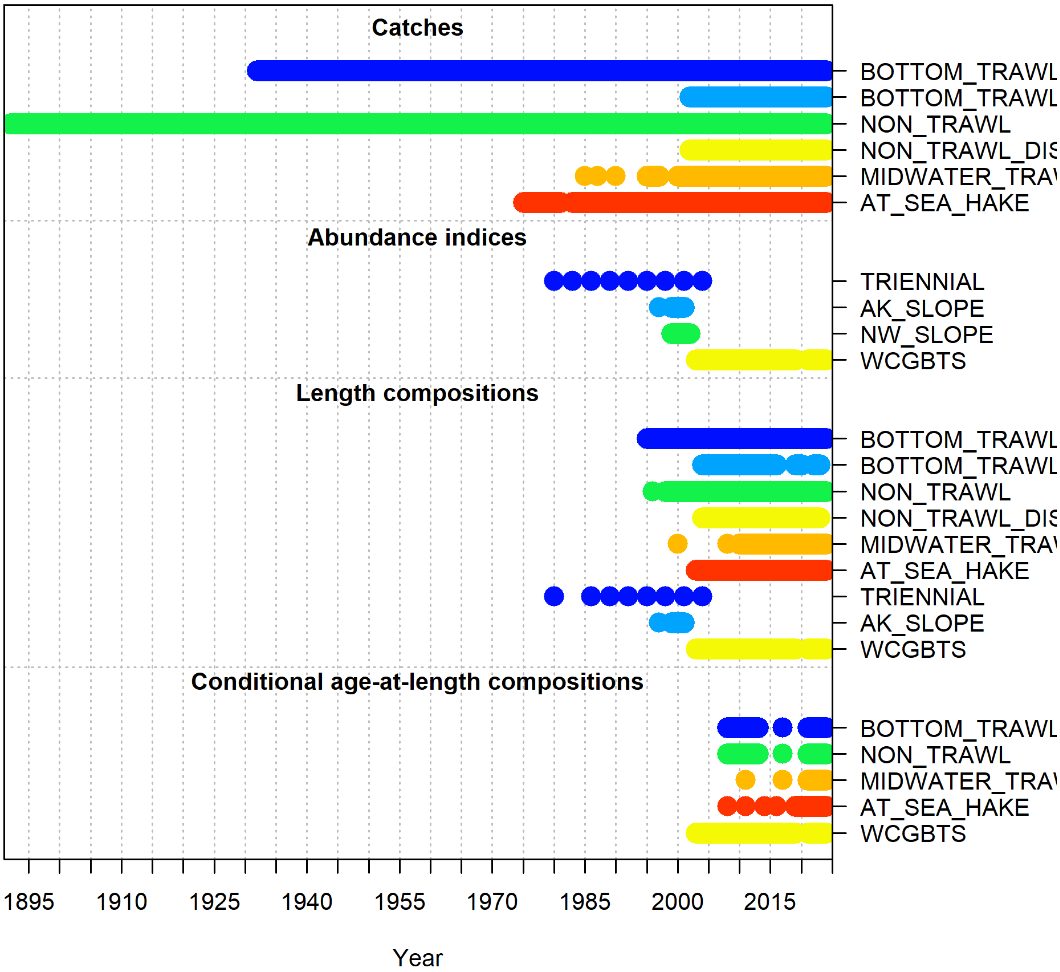

Figure 8: Data used in the base model.

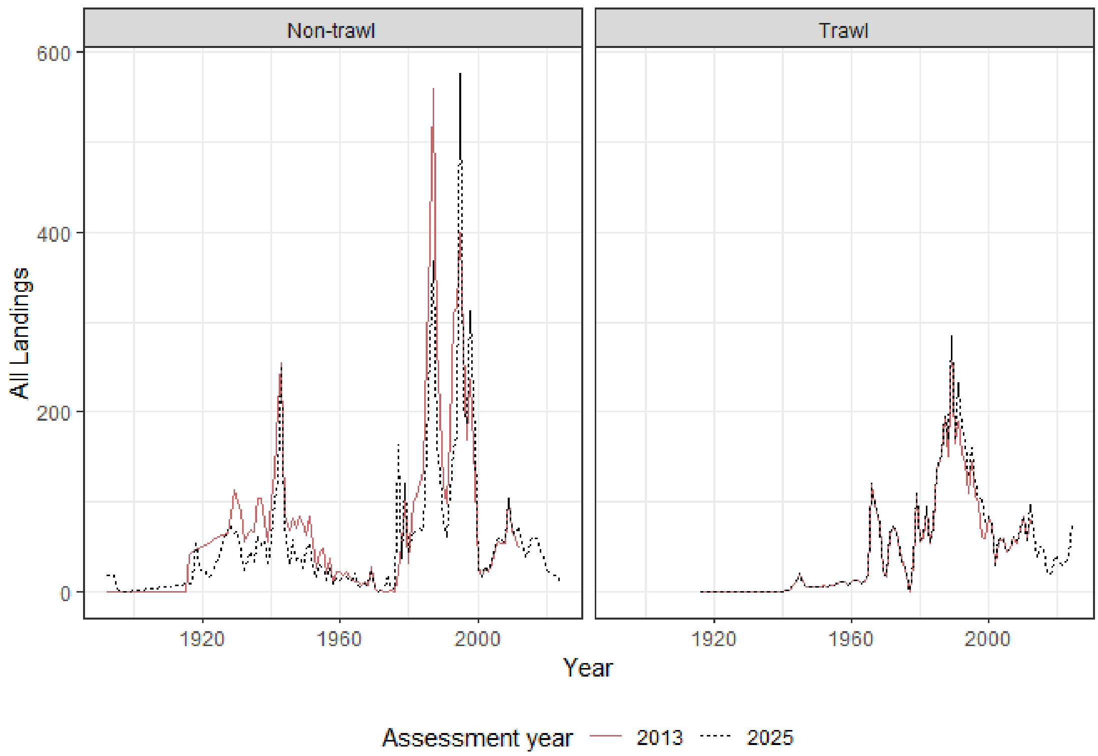

Figure 9: Landings across all states for non-trawl and trawl fisheries compared between the 2013 assessment and updated landings for the 2025 stock assessment model.

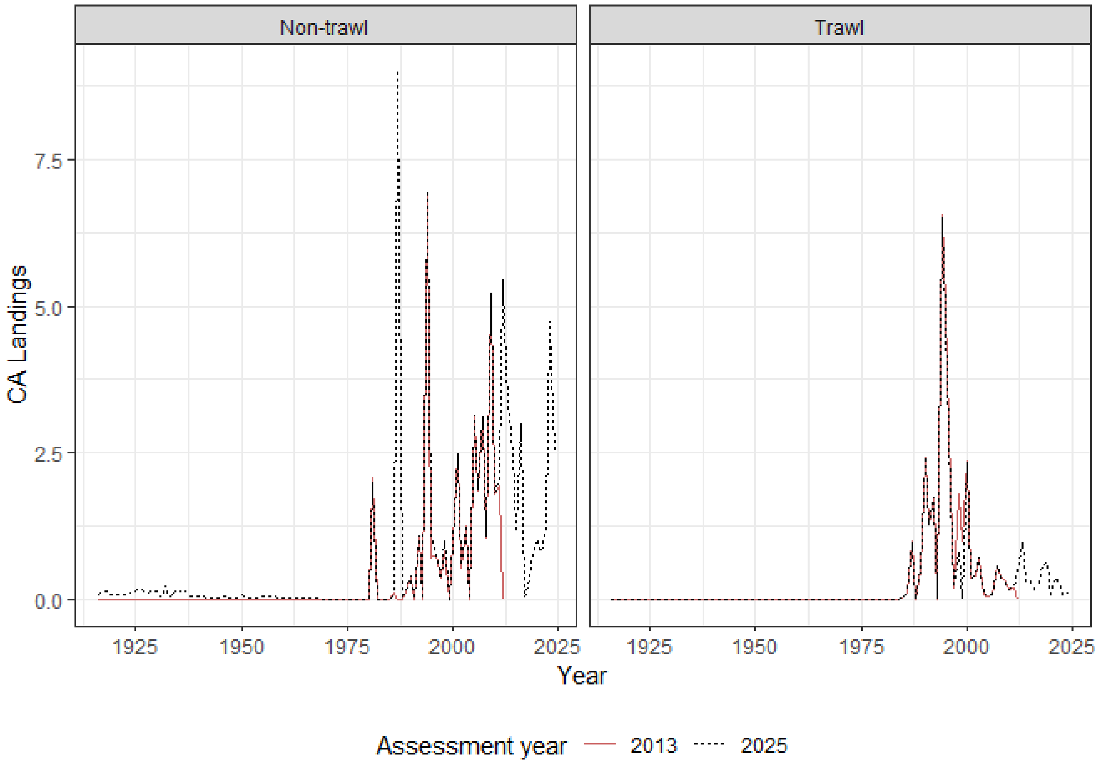

Figure 10: California state landings for non-trawl and trawl fisheries compared between the 2013 assessment and updated landings for the 2025 stock assessment model.

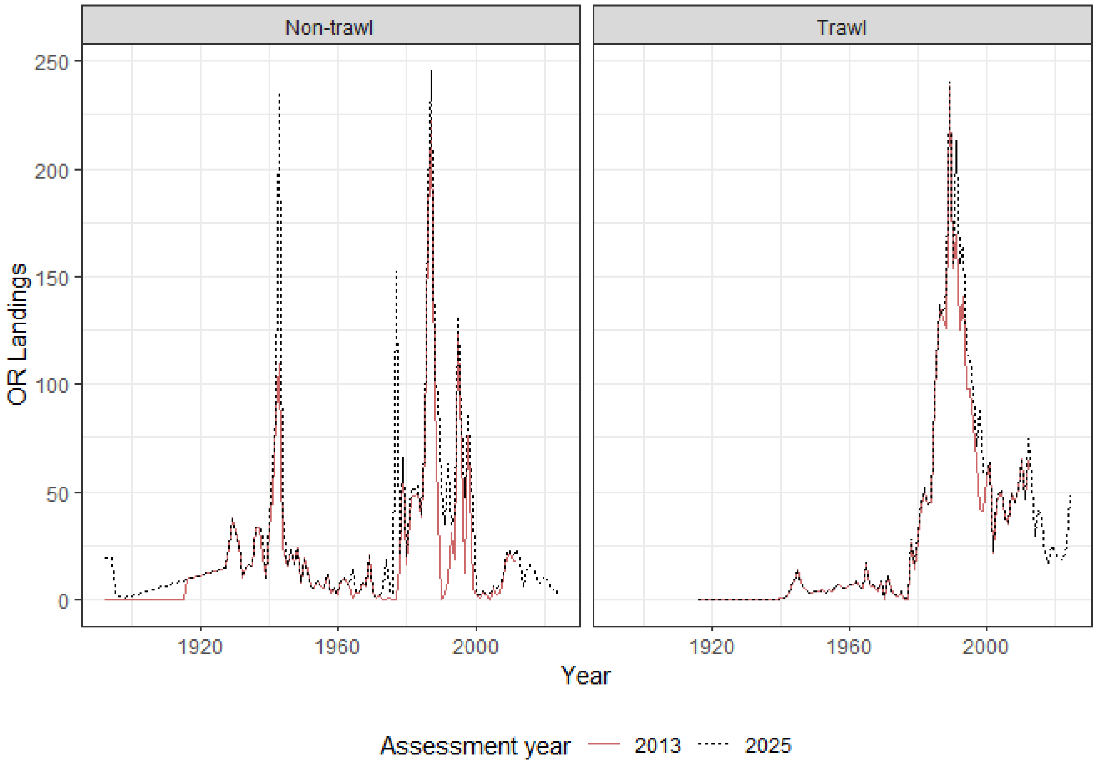

Figure 11: Oregon state landings for non-trawl and trawl fisheries compared between the 2013 assessment and updated landings for the 2025 stock assessment model.

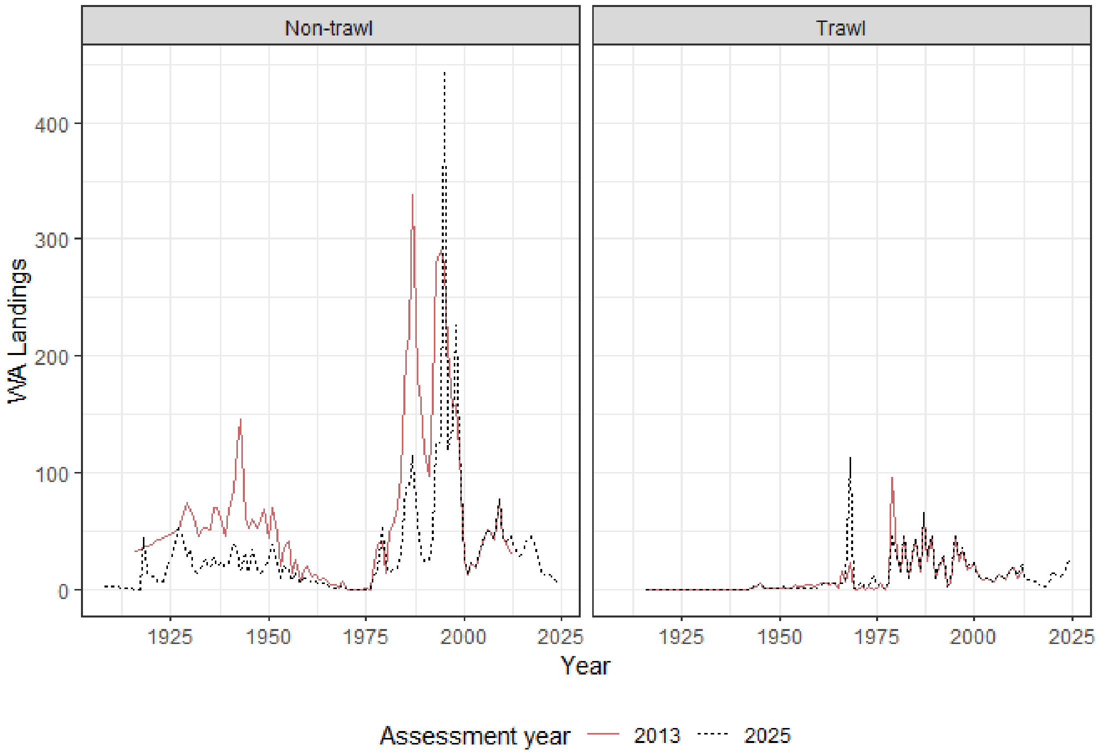

Figure 12: WA. Washington state landings for non-trawl and trawl fisheries compared between the 2013 assessment and updated landings for the 2025 stock assessment model.

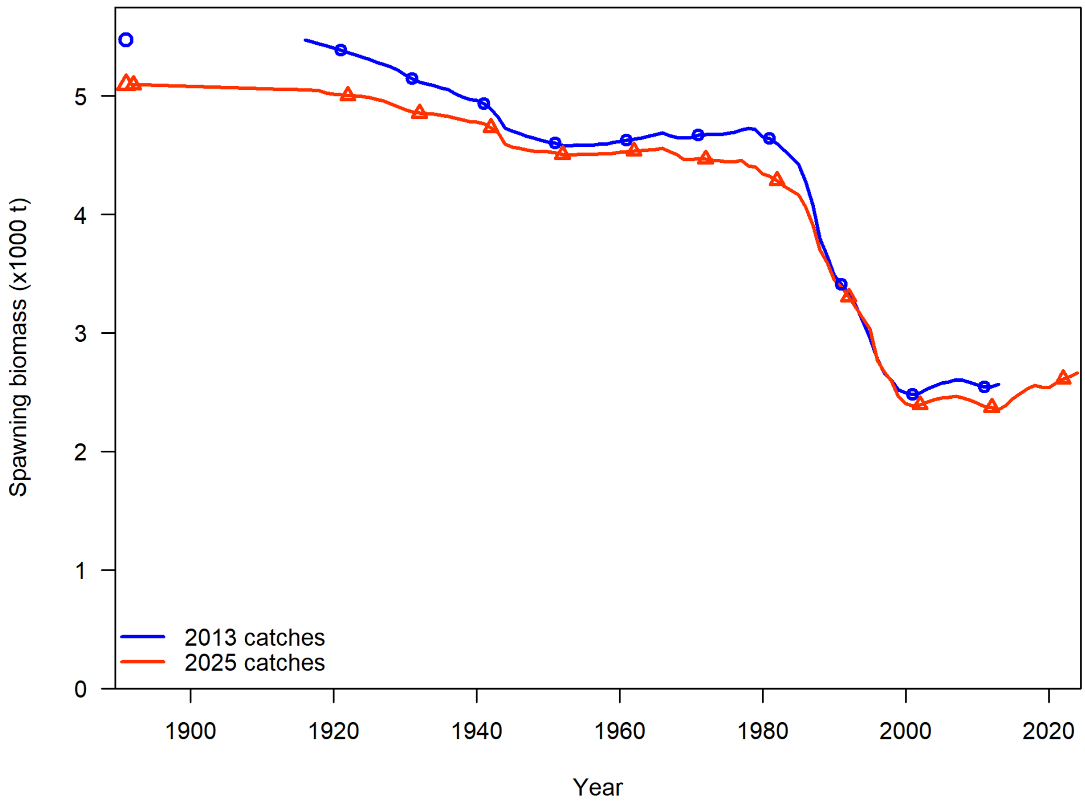

Figure 13: Comparison of spawning output using updated catches vs using catches from the 2013 Rougheye/Blackspotted Rockfishes assessment.

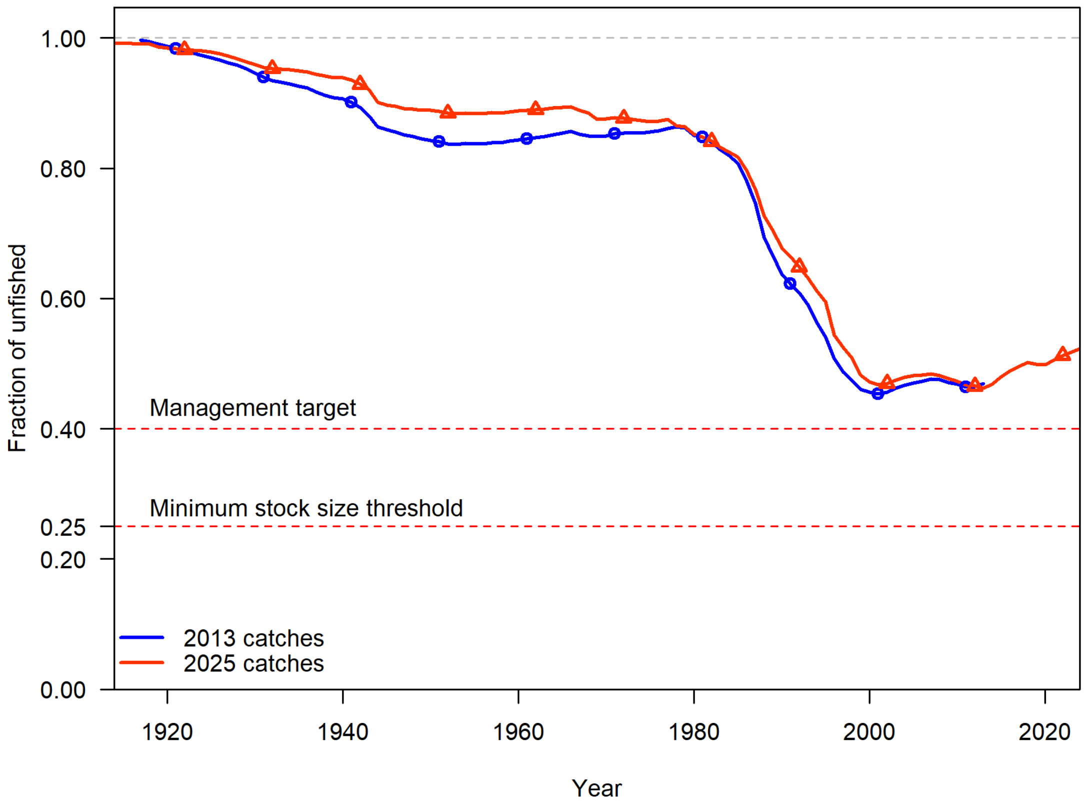

Figure 14: Comparison of relative spawning output using updated catches vs using catches from the 2013 Rougheye/Blackspotted Rockfishes assessment.

2.14.3 Biology

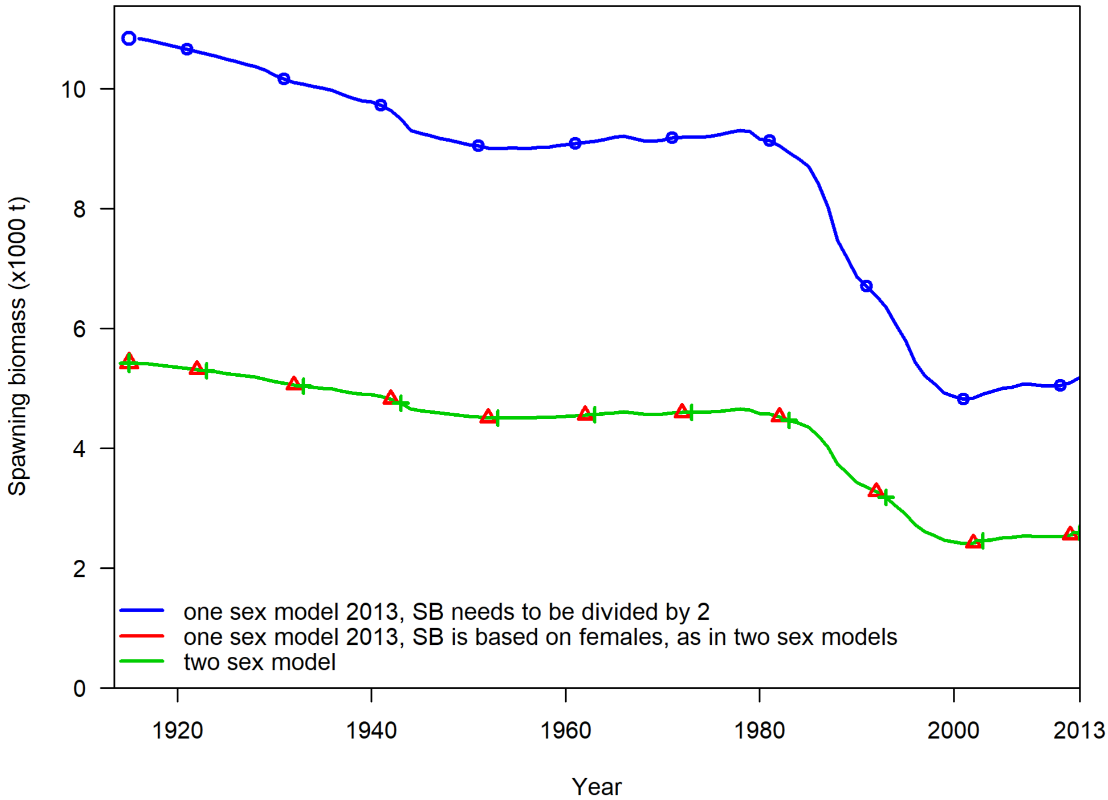

Figure 15: Comparison of spawning output using the 1 sex and 2 sexes set to equal values models based on the 2013 Rougheye/Blackspotted Rockfishes assessment data. The 1 sex model has double the biomass because it includes both females and males.

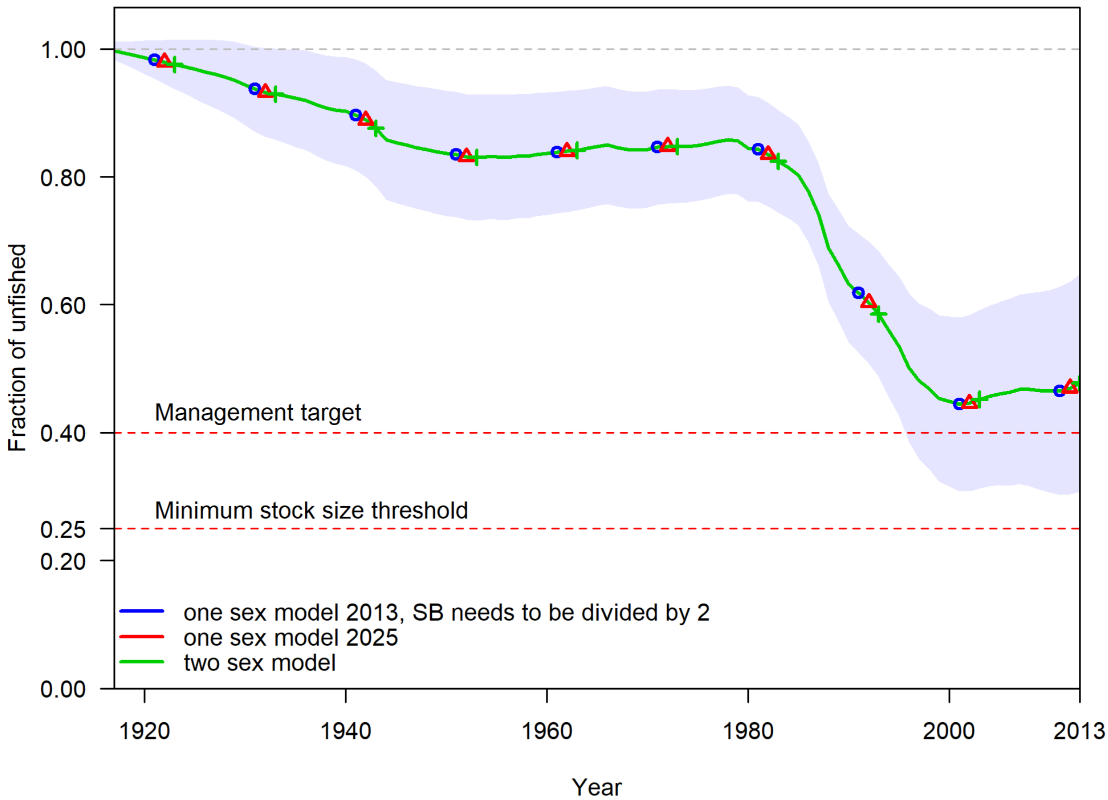

Figure 16: Comparison of spawning output using the 1 sex and 2 sexes set to equal values models based on the 2013 Rougheye/Blackspotted Rockfishes assessment data.

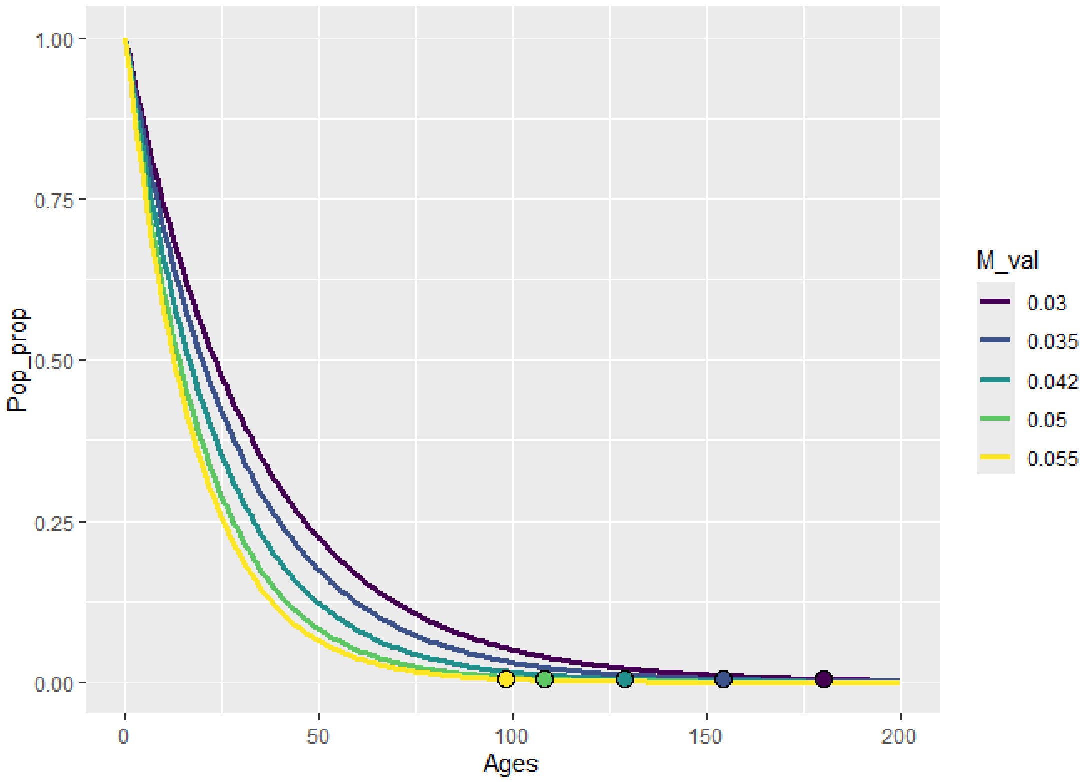

Figure 17: Natural mortality curves by age in years for values of natural mortality used in various Rougheye/Blackspotted Rockfish stock assessments. Dots indicate the range of assumed maximum ages using the equation from Hamel and Cope 2022.

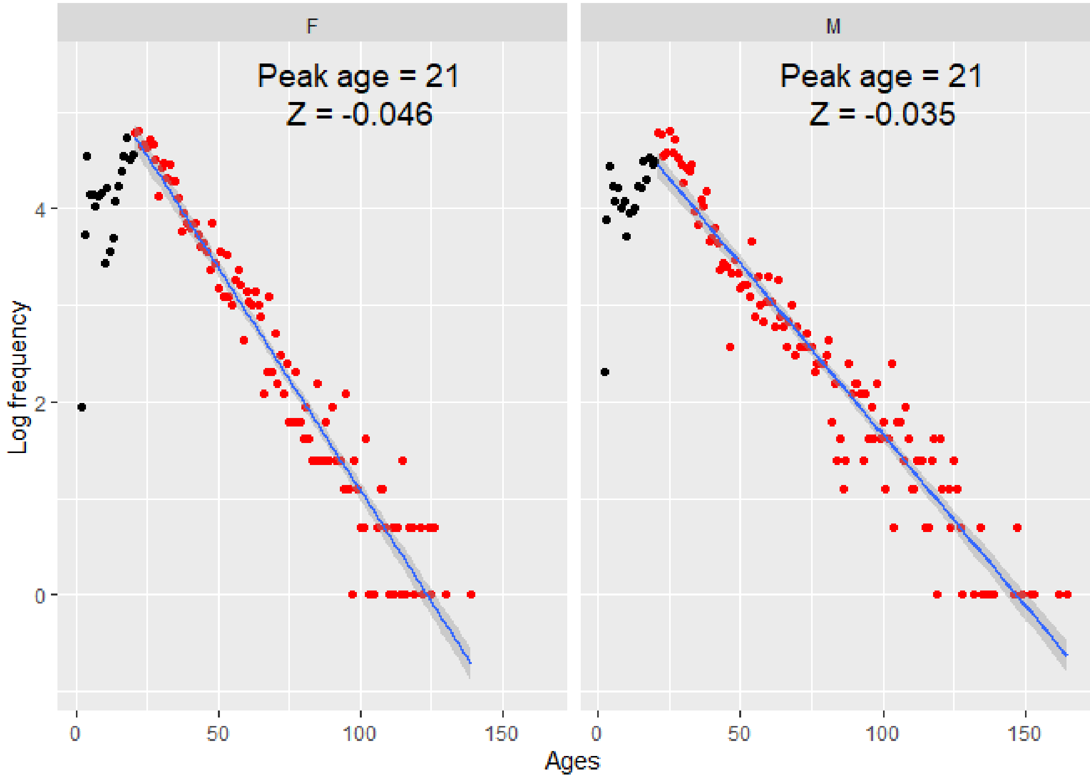

Figure 18: Catch curve (log abundance by age) analysis on aggregated ages over all age sources by sex (black points). The peak selected age was 21 for both sexes, so the linear model was run from age 21 until the oldest age (red points). The slope of the linear model is equal to the estimate of an aggregate total mortality (Z).

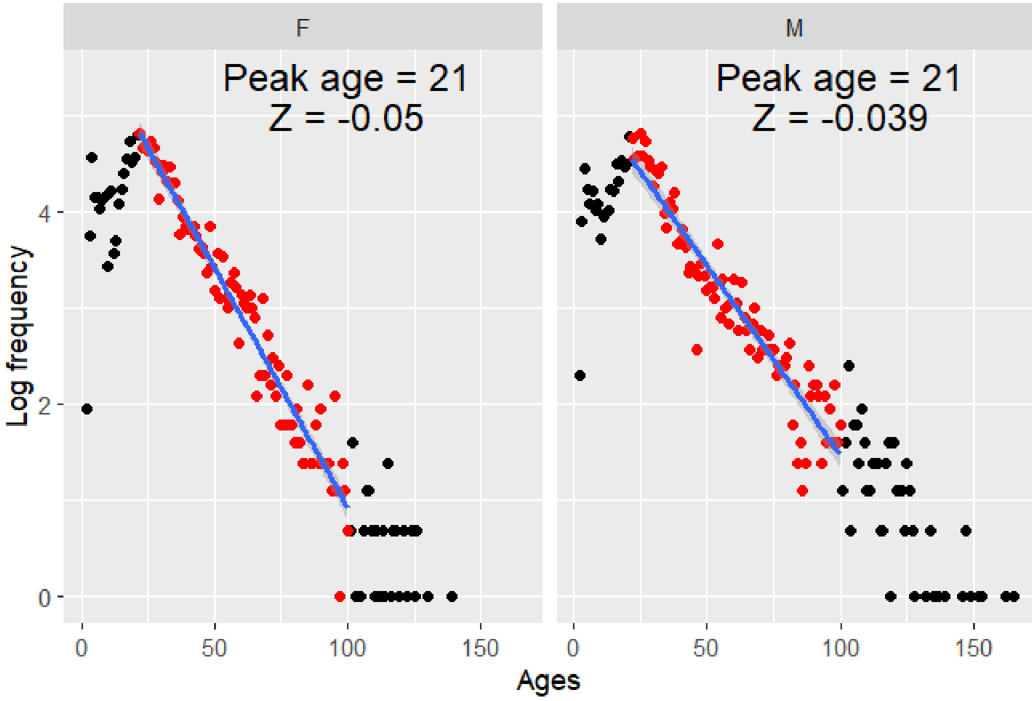

Figure 19: Catch curve (log abundance by age) analysis on aggregated ages over all age sources by sex (black points). The peak selected age was 21 for both sexes with a max age of 100, so the linear model was run from age 21 until age 100 (red points). The slope of the linear model is equal to the estimate of an aggregate total mortality (Z).

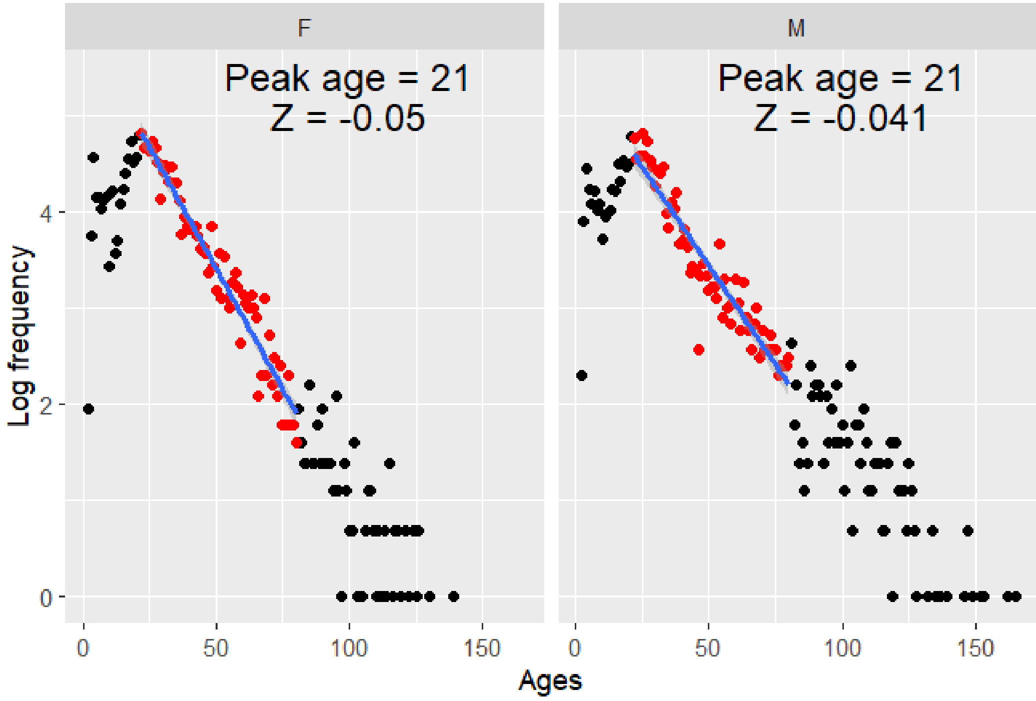

Figure 20: Catch curve (log abundance by age) analysis on aggregated ages over all age sources by sex (black points). The peak selected age was 21 for both sexes with a max age of 80, so the linear model was run from age 21 until age 80 (red points). The slope of the linear model is equal to the estimate of an aggregate total mortality (Z).

Figure 21: Age and length data, with fitted von Bertalanffy growth curves, by sex and data source for the Rougheye/Blackspotted rockfish complex. Sample sizes (N) are also provided.

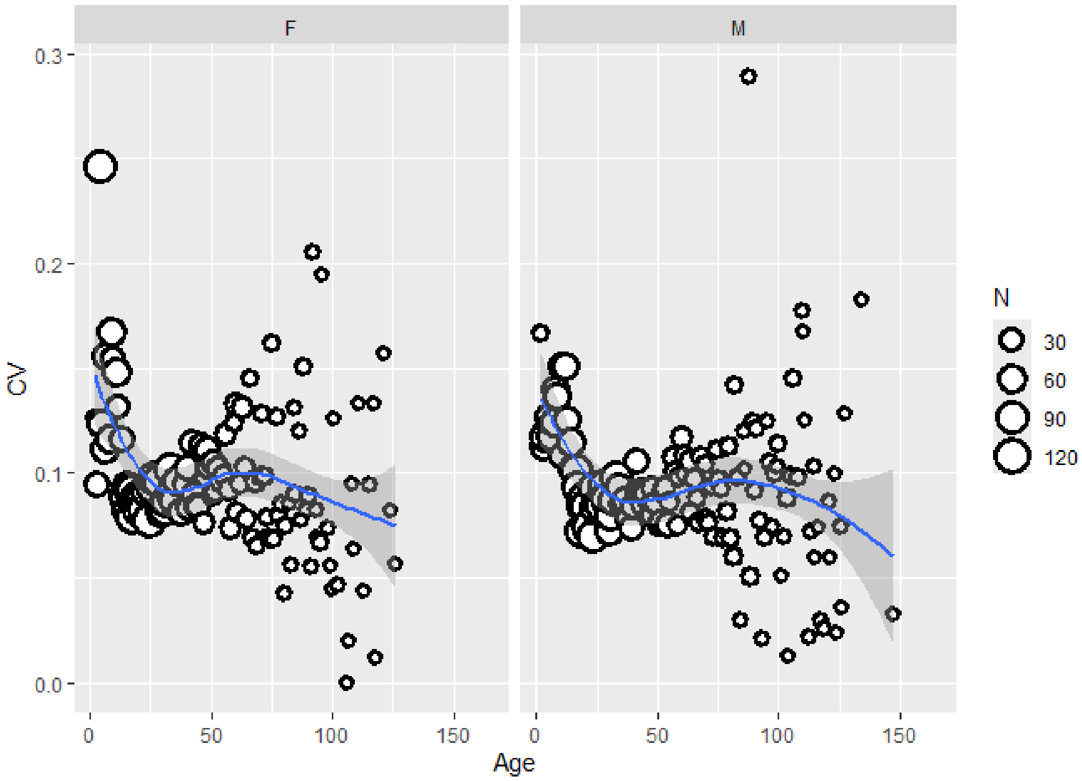

Figure 22: Coefficient of variation by age and sex for all sources of Rougheye/Blackspotted rockfishes ages. Sample sizes (N) are also indicated by size of the point. The line is a smoothed loess (polynomial) line that gives a moving average of CV by age and sex.

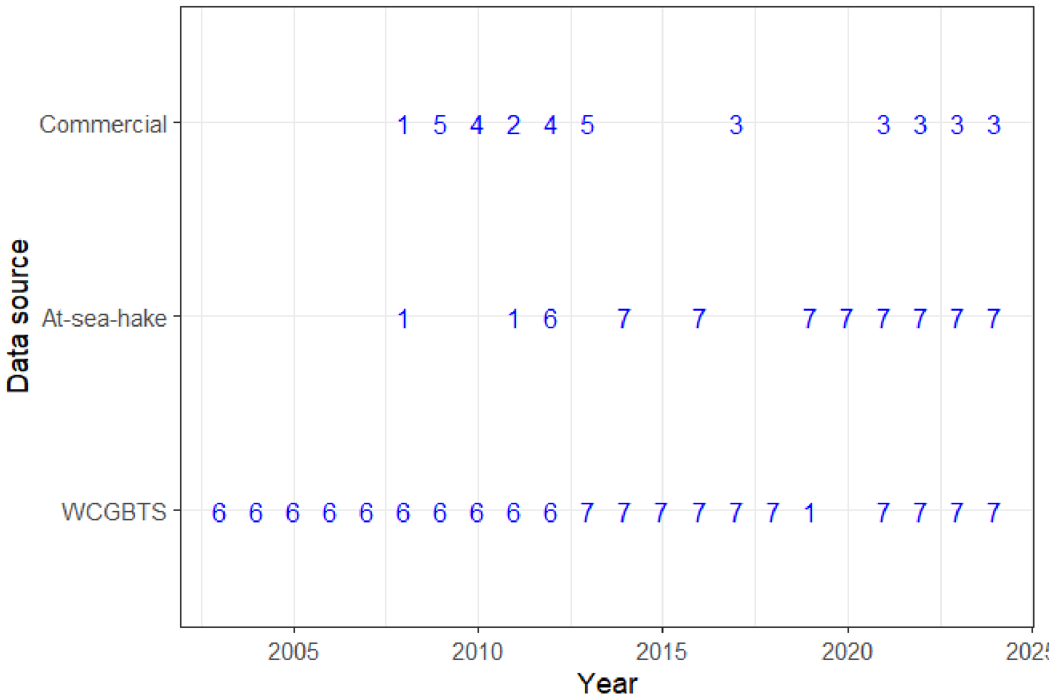

Figure 23: Ageing error matrix assignments by year and data source. The number indicates which ageing error matrix was used for conditional ages within those years and data sources. 'Commercial' is a combination of all commercial fleets.

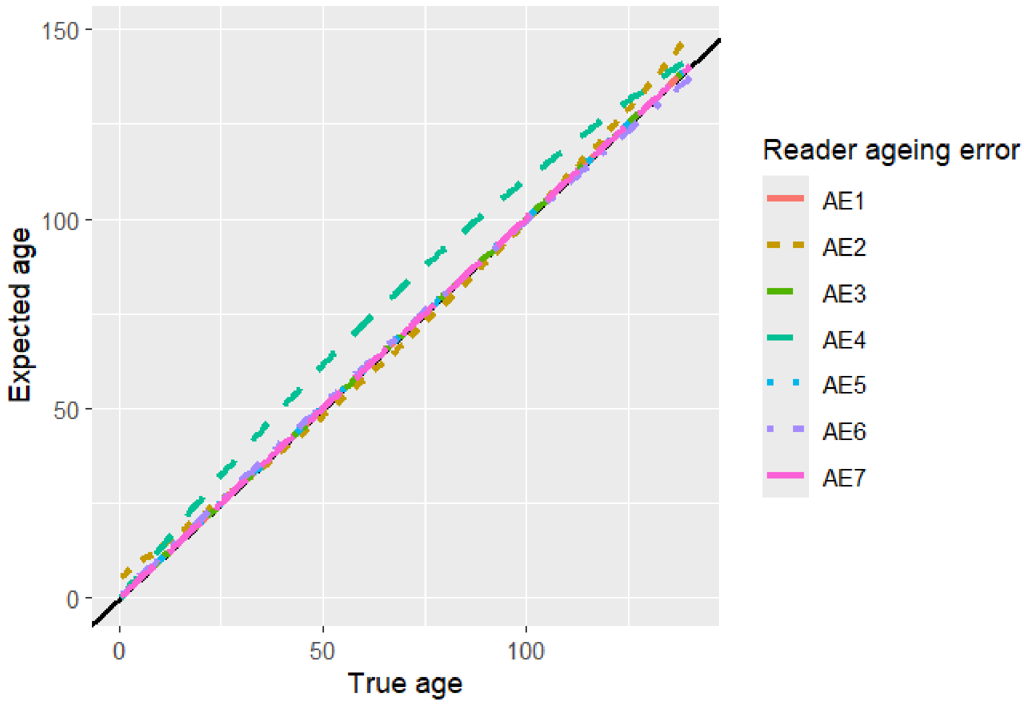

Figure 24: Estimated bias used for each of the seven ageing error matrices.

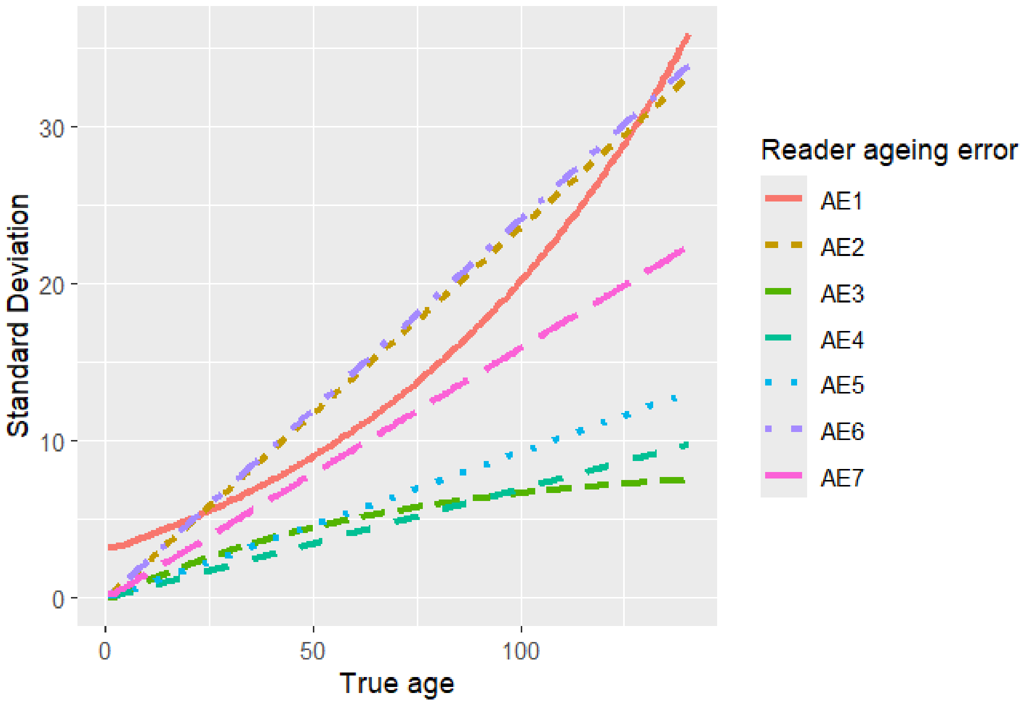

Figure 25: Estimated imprecision (as a standard deviation) used for each of the seven ageing error matrices.

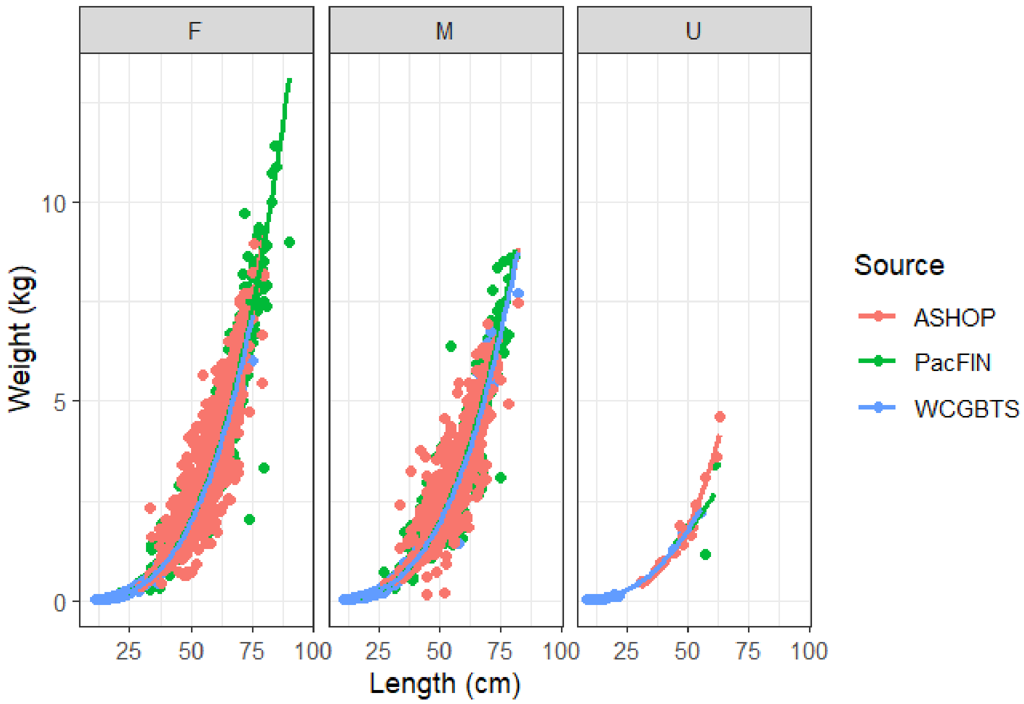

Figure 26: Length and weight samples by sex and data source. Lines are the power function fits by data source.

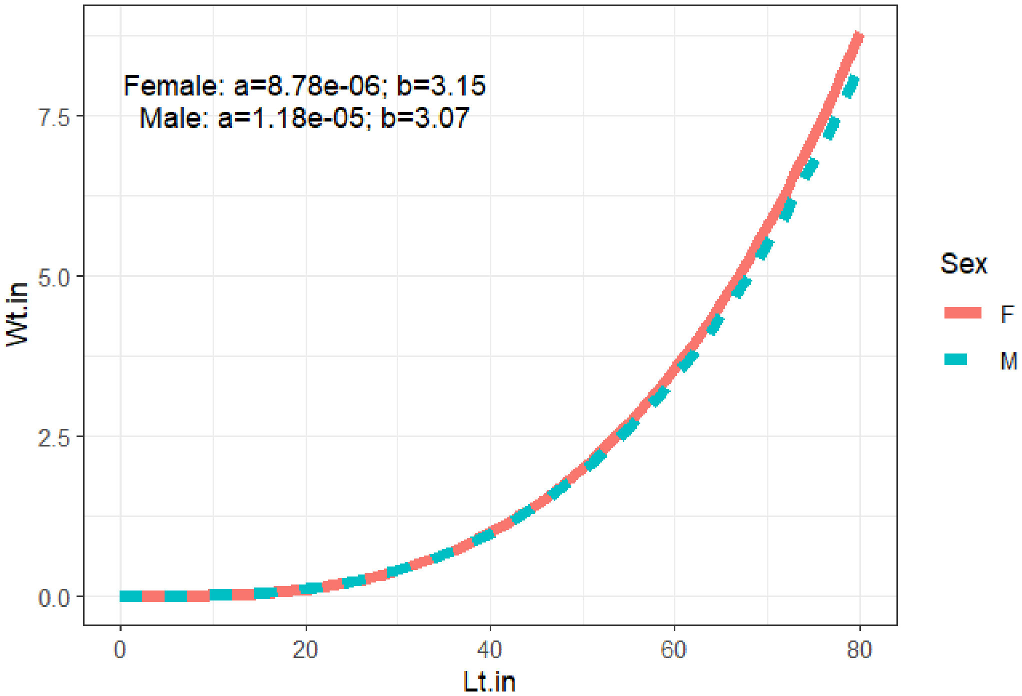

Figure 27: Realized length and weight relationships for female and male Rougheye/Blackspotted Rockfishes.

2.14.4 Model Bridging

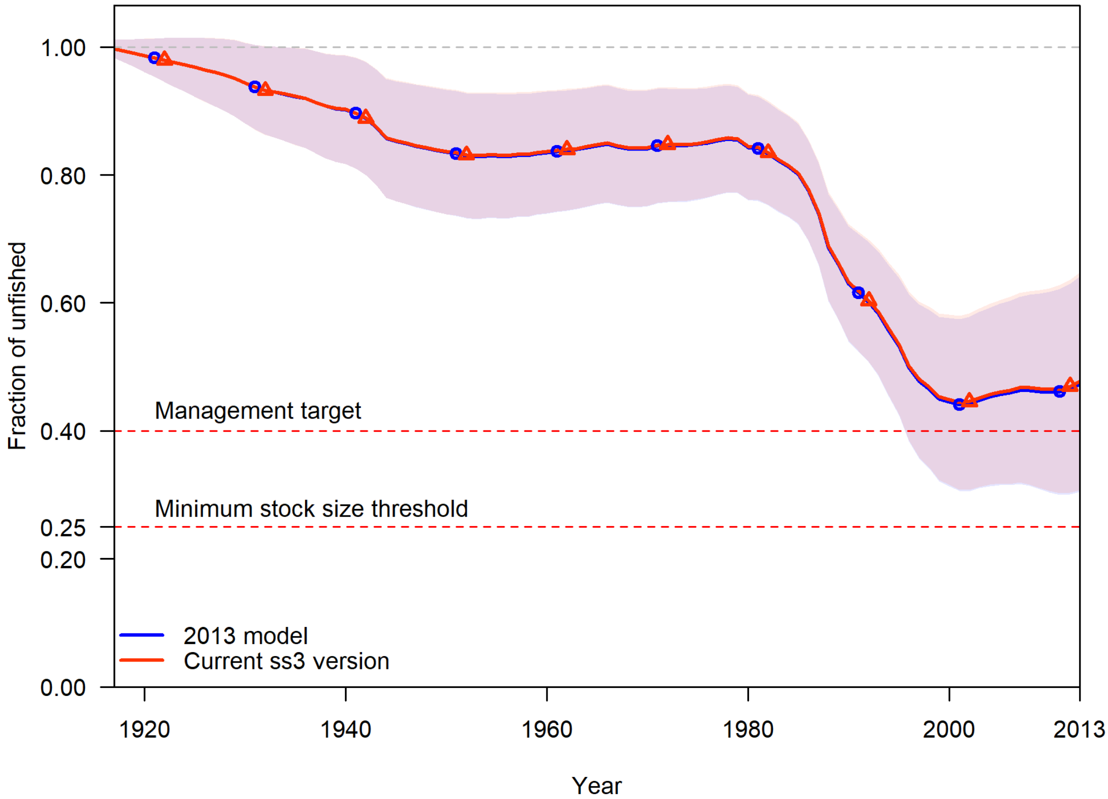

Figure 28: Estimates of relative stock size (current spawning output/unfished spawning output) for the Rougheye/Blackspotted rockfish complex in U.S. west coast waters from the 2013 assessment, and compared to the using the same data in the newest version of SS3 (3.30.22.1).

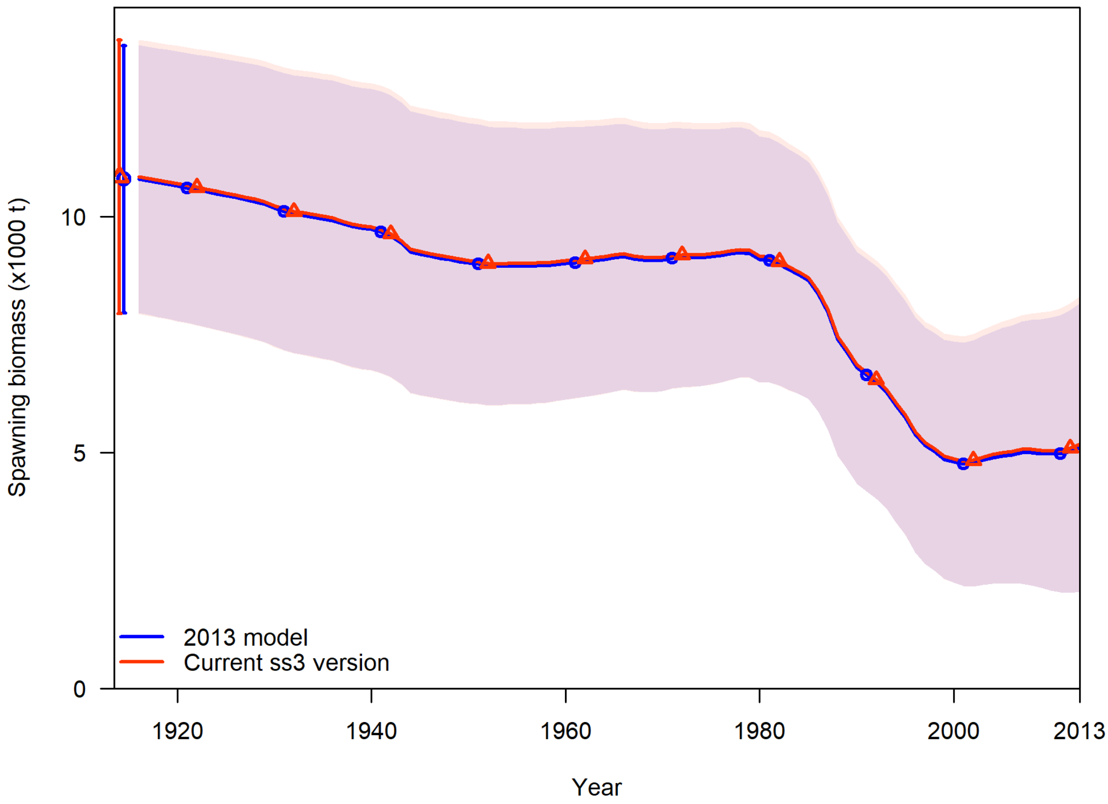

Figure 29: Estimates of spawning output for the Rougheye/Blackspotted rockfish complex in U.S. west coast waters from the 2013 assessment, and compared to the same data in the newest version of SS3 (3.30.22.1). Shading denotes 95% confidence intervals. Shading denotes 95% confidence intervals.

2.14.5 Model Specification

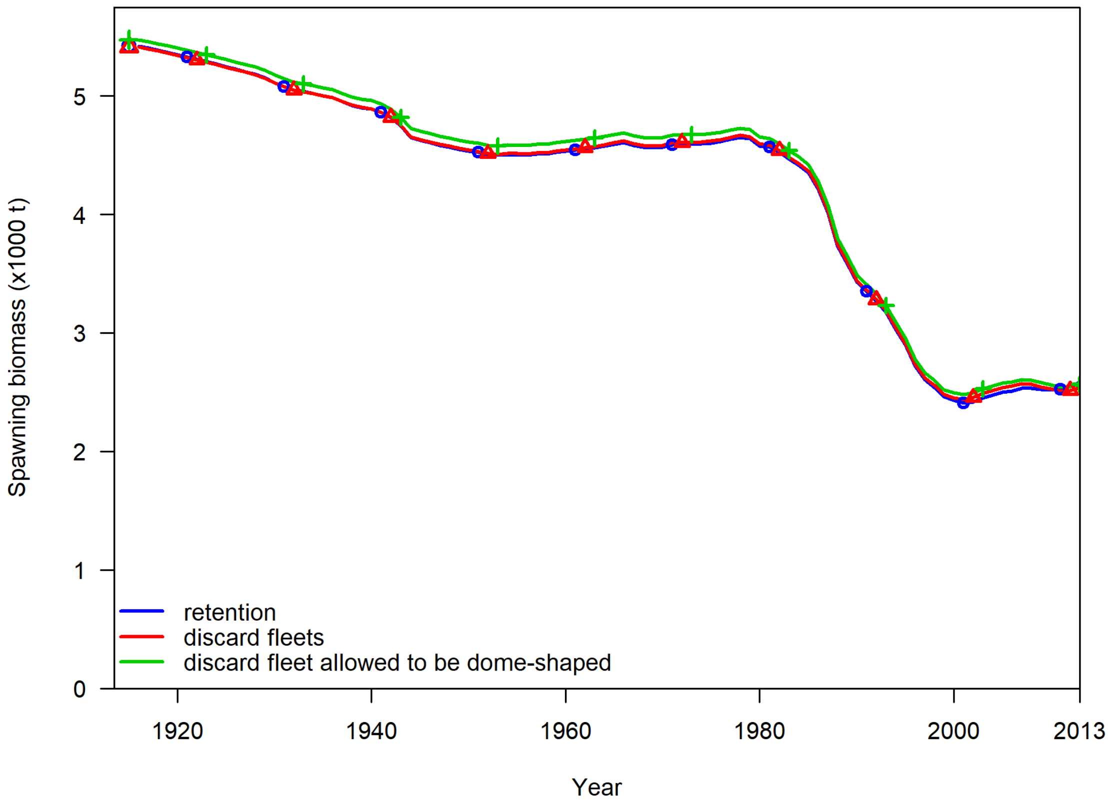

Figure 30: Comparison of spawning output using retention curves or discard fleets using the 2013 Rougheye/Blackspotted Rockfishes assessment.

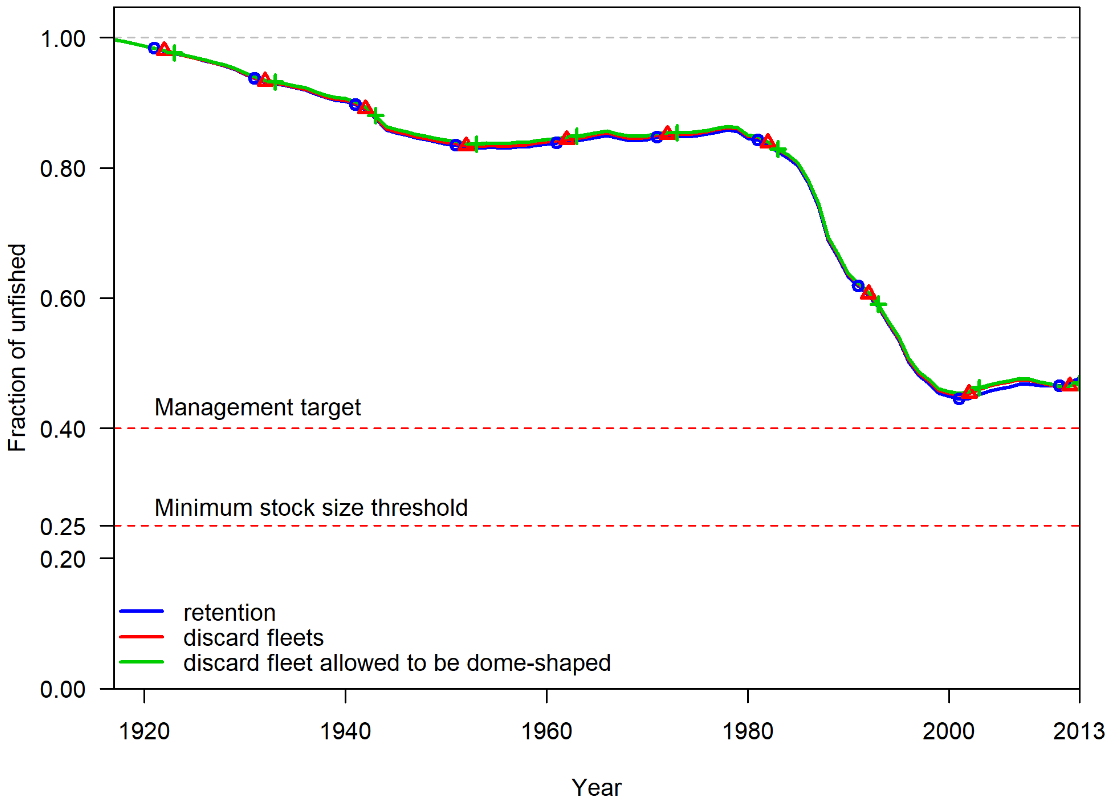

Figure 31: Comparison of relative spawning output using retention curves or discard fleets using the 2013 Rougheye/Blackspotted Rockfishes assessment.

2.14.6 Time-series

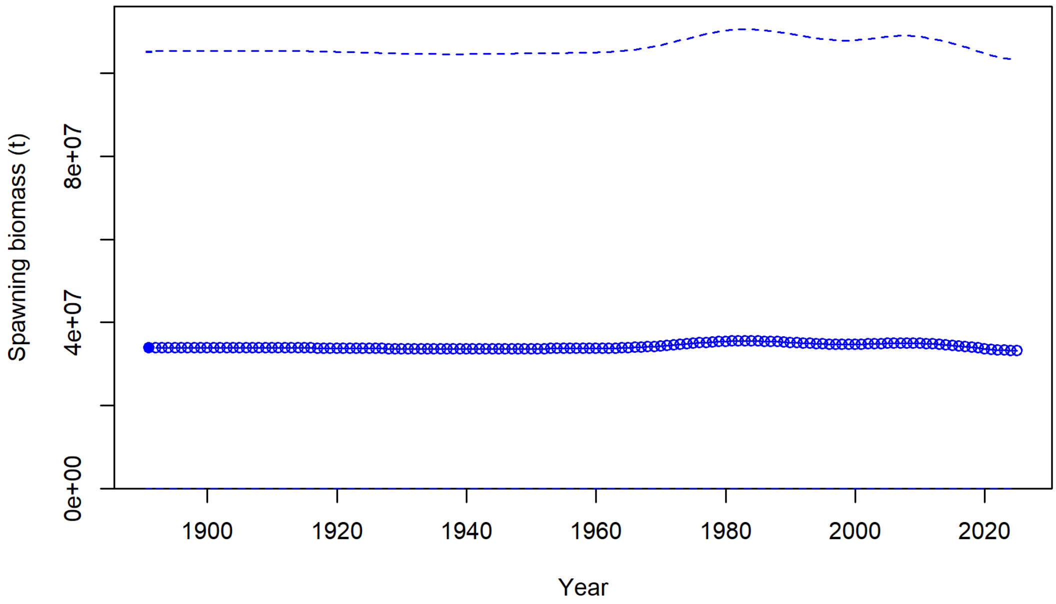

Figure 32: Estimated time series of spawning biomass for the base model.

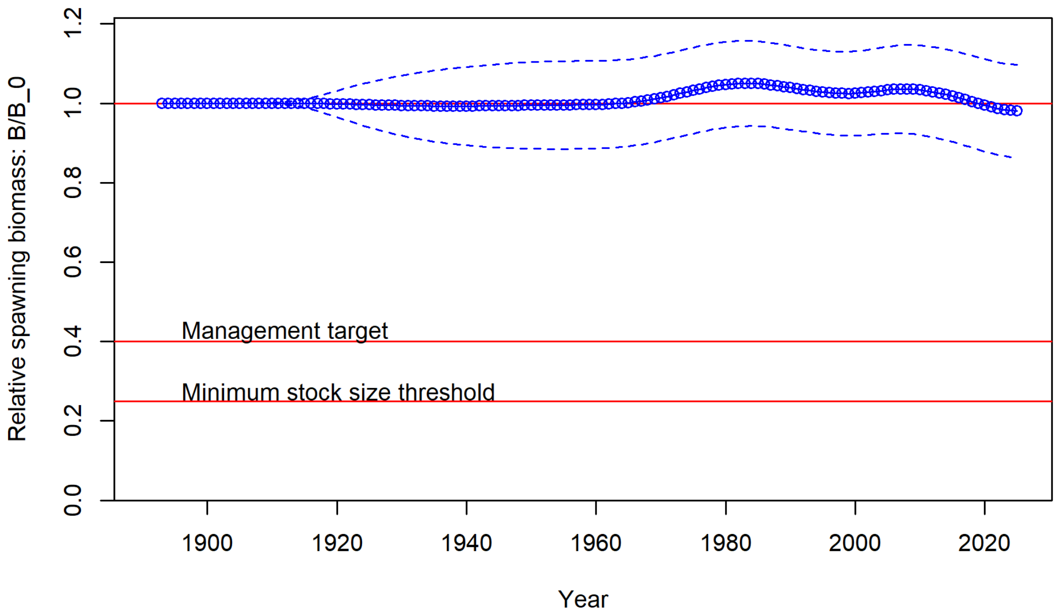

Figure 33: Estimated time series of fraction of unfished spawning biomass for the base model.

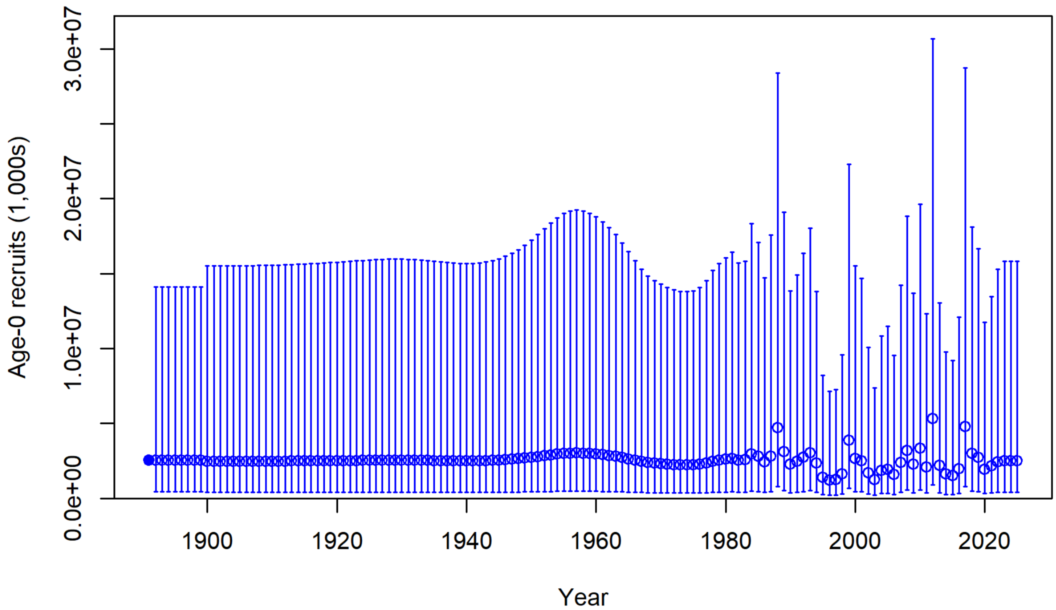

Figure 34: Estimated time series of age-0 recruits for the base model.

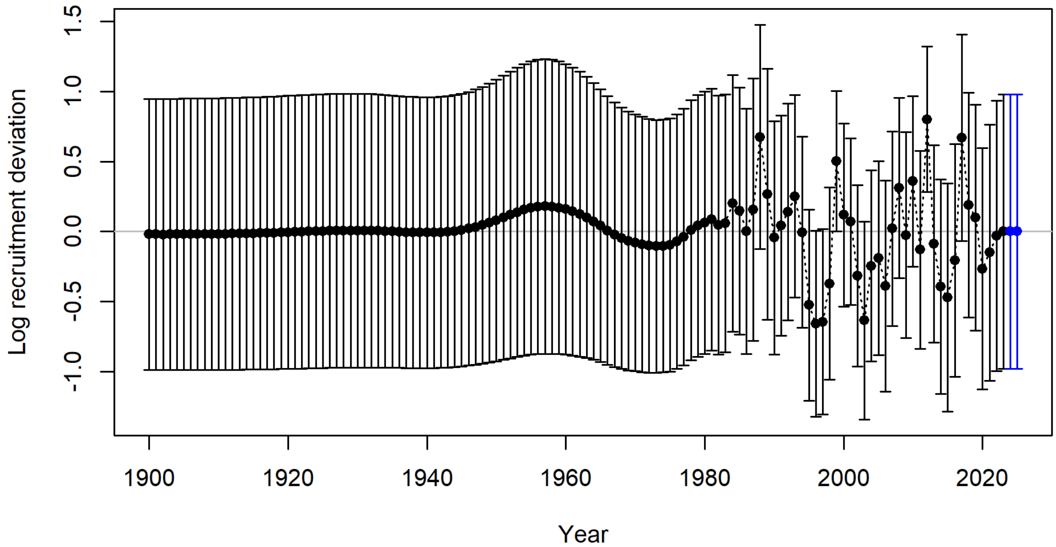

Figure 35: Estimated time series of recruitment deviations for the base model.

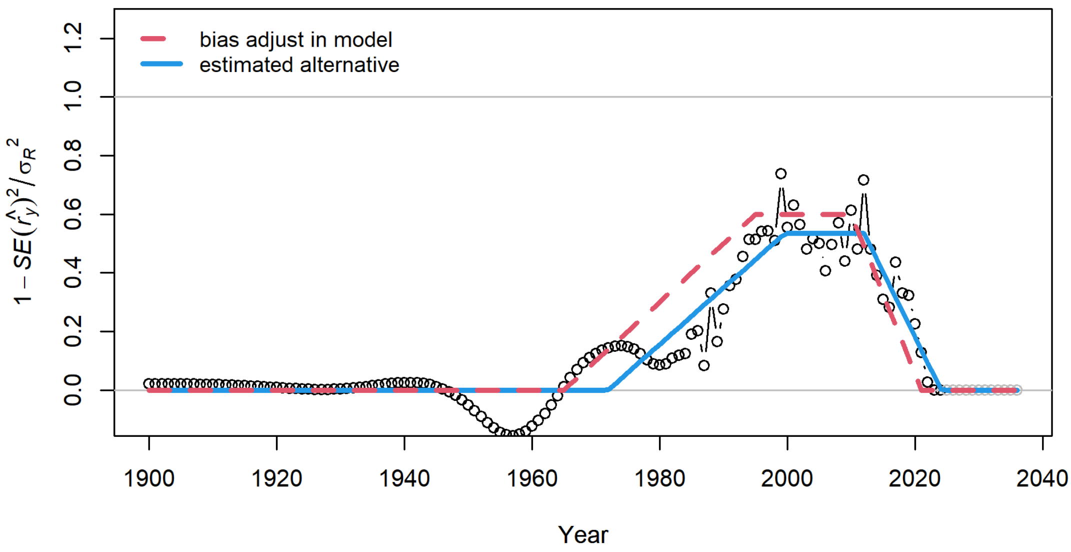

Figure 36: Bias adjustment applied to the recruitment deviations (red line). Points are transformed variances relative to the assumed variance of recruitment.

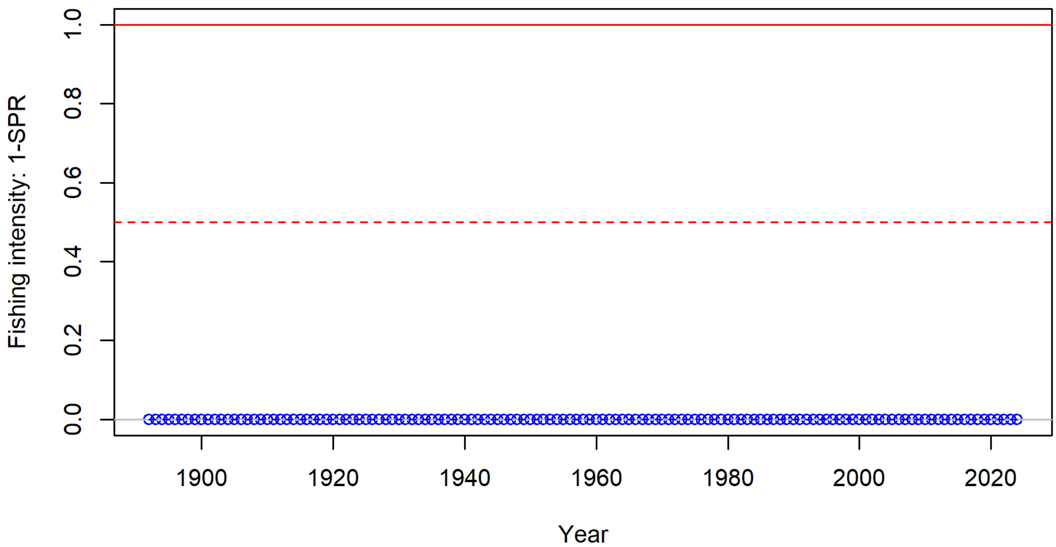

Figure 37: Estimated time series of fishing intensity for the base model.

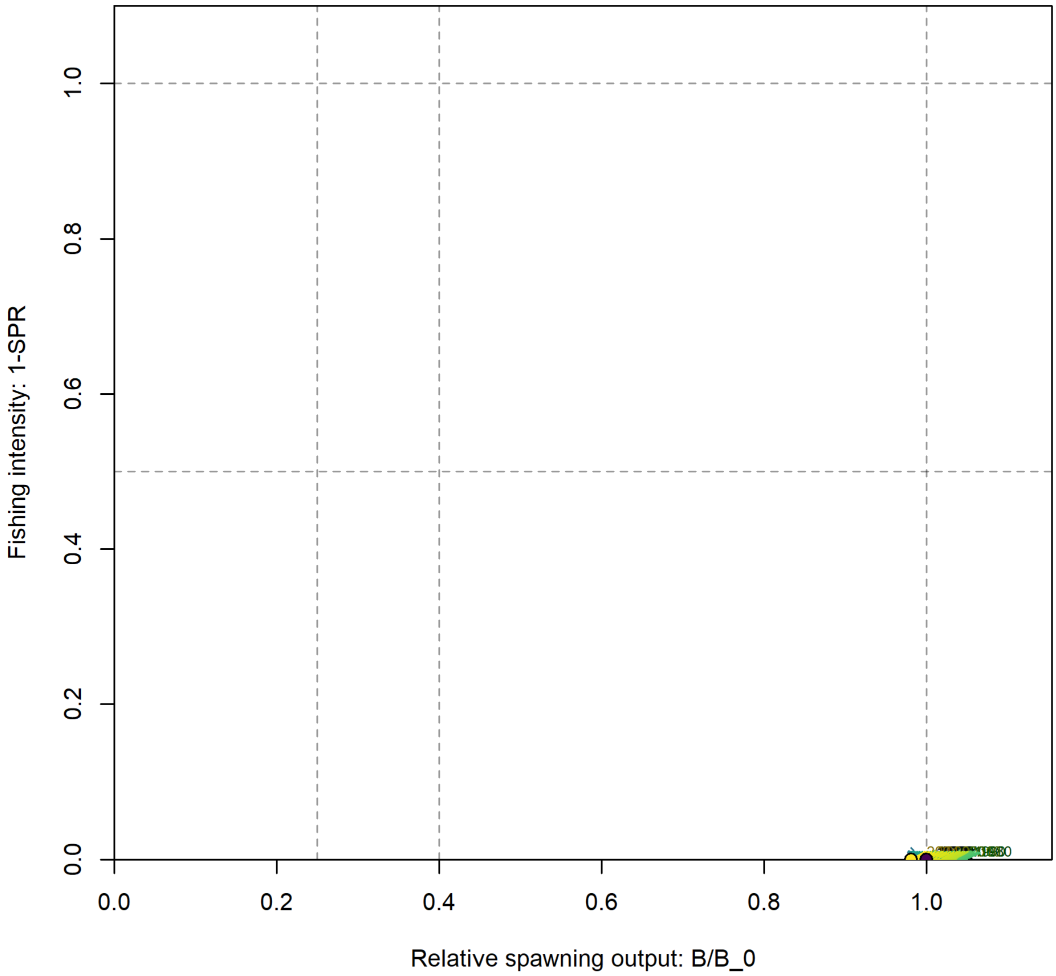

Figure 38: Phase plot of fishing intensity versus fraction unfished for the base model.

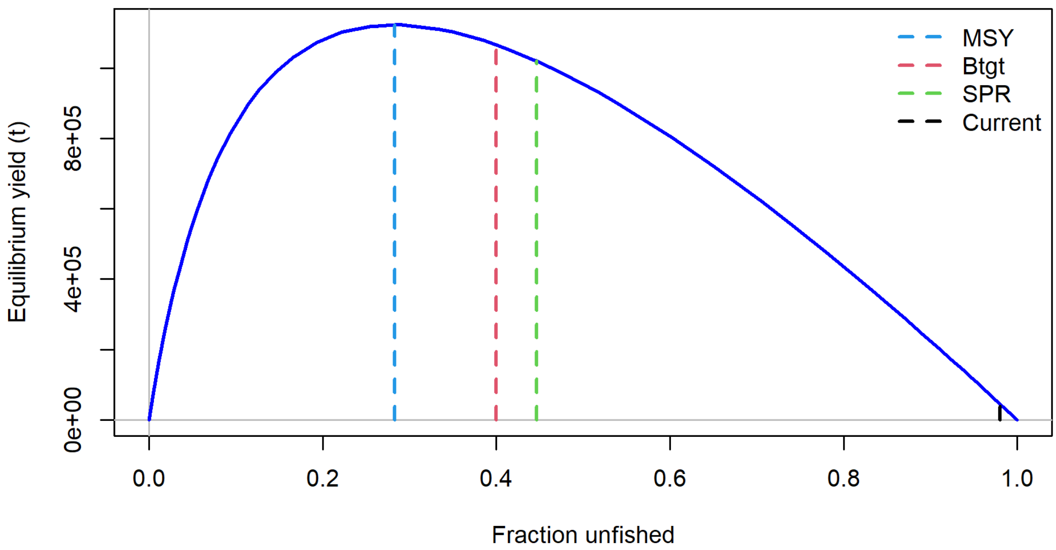

Figure 39: Estimated yield curve with reference points for the base model.

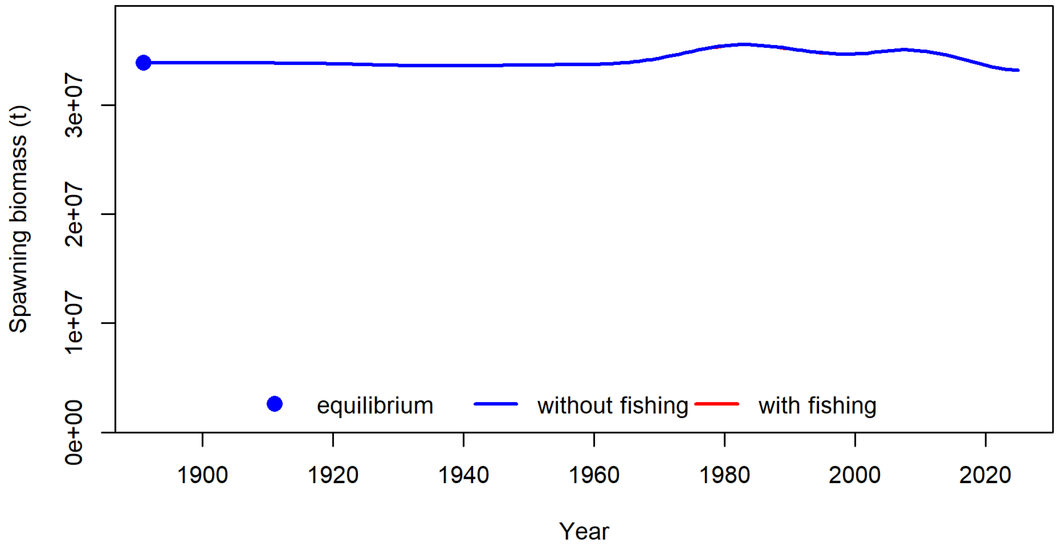

Figure 40: Dynamic B0 plot. The lower line shows the time series of estimated spawning output in the presence of fishing mortality. The upper line shows the time series that could occur under the same dynamics (including deviations in recruitment), but without fishing. The point at the left represents the unfished equilibrium.

2.15 Sensitivity Analyses and Retrospectives

2.16 Likelihood Profiles

2.17 Reference Points and Forecasts

2.18 Notes

2.19 Appendices