Status of Petrale sole (*Eopsetta jordani*) along the US west coast in 2019

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Contents

Executive Summary

Stock

This assessment reports the status of the Petrale sole (*Eopsetta jordani*) off U.S. coast of California, Oregon, and Washington using data through 2018. While petrale sole are modeled as a single stock, the spatial aspects of the coast-wide population are addressed through geographic separation of data sources/fleets where possible. There is currently no genetic evidence suggesting distinct biological stocks of petrale sole off the U.S. coast. The limited tagging data available to describe adult movement suggests that petrale sole may have some homing ability for deep water spawning sites but also have the ability to move long distances between spawning sites, inter-spawning season, as well as seasonally.

Landings

While records do not exist, the earliest catches of Petrale sole are reported in 1876 in California and 1884 in Oregon. In this assessment, fishery removals have been divided among 4 fleets: 1) winter North trawl, 2) summer North trawl, 3) winter South trawl, and 4) summer South trawl. Landings for the North fleet are defined as fish landed in Washington and Oregon ports. Landings for the South fleet are defined as fish landed in California ports. Recent annual catches during 1981-2014 range between 749-2,903 mt (Table XX, Figure XX). Petrale sole are caught nearly exclusively by trawl fleets; non-trawl gears contribute less than 3% of the catches. Based on the 2005 assessment, annual catch limits (ACLs) were reduced to 2499 mt for 2007-2008. Following the 2009 assessment ACLs were further reduced to a low of 976 mt for 2011 and have subsequently increased to a high value of 3,136 for 2017. From the inception of the fishery through the war years, the vast majority of catches occurred between March and October (the summer fishery), when the stock is dispersed over the continental shelf. The post-World War II period witnessed a steady decline in the amount and proportion of annual catches occurring during the summer months (March-October). Conversely, Petrale sole catch during the winter season (November-February), when the fishery targets spawning aggregations, has exhibited a steadily increasing trend since the 1940s. From the mid-1980s through the early 2000s, catches during the winter months were roughly equivalent to or exceeded catches throughout the remainder of the year, whereas during the past 10 years the relative catches during the winter and summer have been more variable across years (Figure XX). Petrale sole are a desirable market species and discarding has historically been low.

Table a: Landings (mt) for the past 10 years for Petrale sole by source.

Year	Winter (N)	Summer (N)	Winter (S)	Summer (S)	Total Landings
2009	846.71	641.75	469.66	250.38	2208.49
2010	258.09	292.34	77.60	120.95	748.98
2011	221.60	423.11	39.59	77.70	762.00
2012	406.05	477.71	124.46	107.63	1115.85
2013	509.04	1007.26	130.10	278.35	1924.74
2014	852.90	860.31	273.40	354.19	2340.80

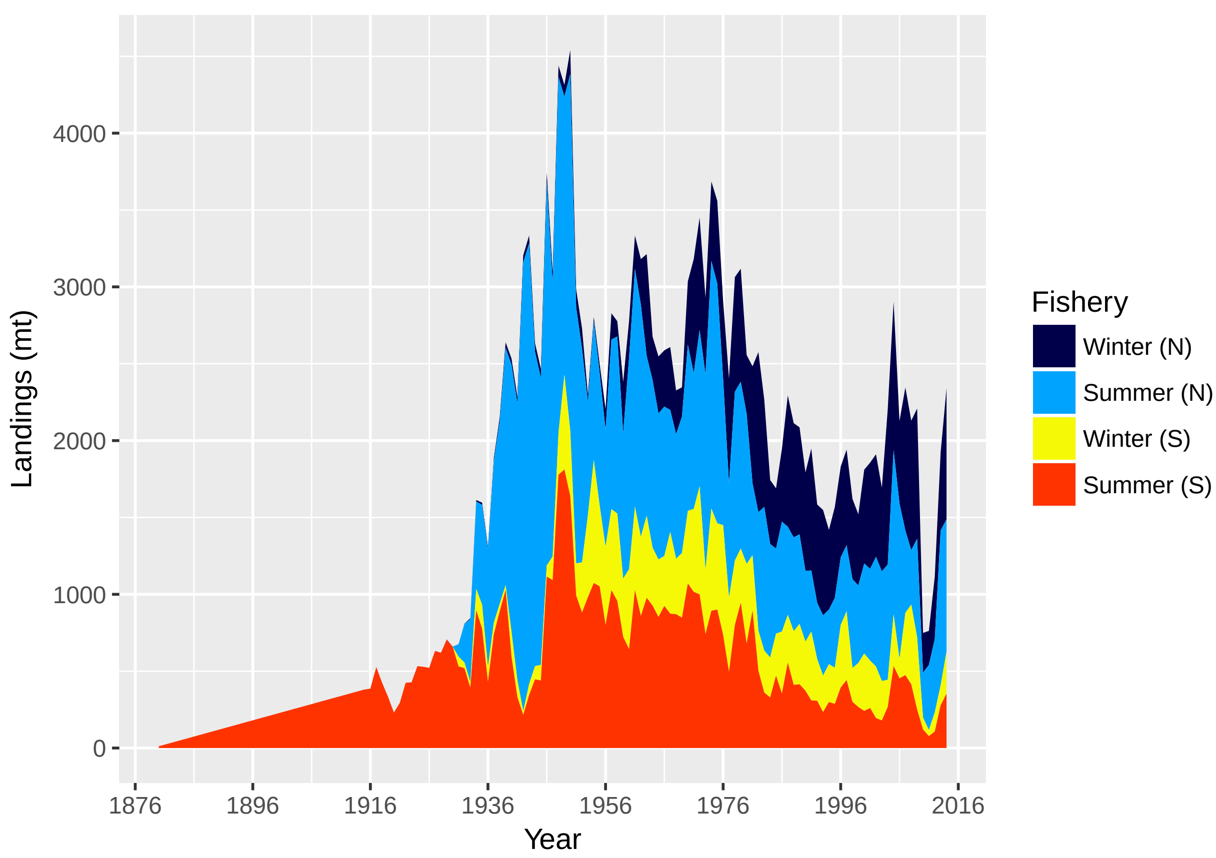

Figure a: Landings of Petrale sole by the Northern and Southern winter and summer fleets of the US west coast.

Data and Assessment

This an update assessment for Petrale sole, which was last assessed in 2013 and updated in 2015. The update assessment was conducted using the length- and age-structured modeling software Stock Synthesis (version 3.30.03.XX). The coastwide population was modeled allowing separate growth and mortality parameters for each sex (a two-sex model) with the fishing year beginning on November 1 and ending on October 31. The fisheries are structured seasonally based on winter (November to February) and summer (March to October) fishing seasons due to the development and growth of the wintertime fishery, which began in the 1950s. In recent decades wintertime catches have often exceed summertime catches. The fisheries modeled as the North Winter and North Summer, where the north includes both Washington and Oregon, and South Winter and South Summer encompasses California fisheries.

The model includes catch, length- and age-frequency data from the trawl fleets as well as standardized winter fishery catch-per-unit-effort (CPUE) indices. Biological data are derived from both port and on-board observer sampling programs. The National Marine Fisheries Service (NMFS) early (1980, 1983, 1986, 1989, 1992) and late (1995, 1998, 2001, and 2004) Triennial bottom trawl survey and the Northwest Fisheries Science Center (NWFSC) trawl survey (2003-2018) relative biomass indices and biological sampling provide fishery independent information on relative trend and demographics of the Petrale sole stock.

Updated Data

The base stock assessment model structure is consistent with the 2013 assessment and the 2015 update, except as noted here. Additions to the model include 1) landings data for 2015 - 2018, 2) commercial composition data (age and length) for 2015 - 2018, 3) NWFSC groundfish trawl survey index for 2015 - 2018, and 4) age and length composition data from the NWFSC groundfish trawl survey.

Modifications from the previous assessment model include:

1. Survey indices were calculated using VAST.
2. Length-weight relationship parameters estimated outside of the stock assessment model from the NWFSC groundfish trawl survey data up to 2018 and input as fixed values.
3. Early commercial age data for OR and WA were not combined, consistent with the 2011 assessment.
4. Fitting using SS v.3.30.XX.
5. Model tuning to re-weight data.

Stock Biomass

The predicted spawning output from the base model ...

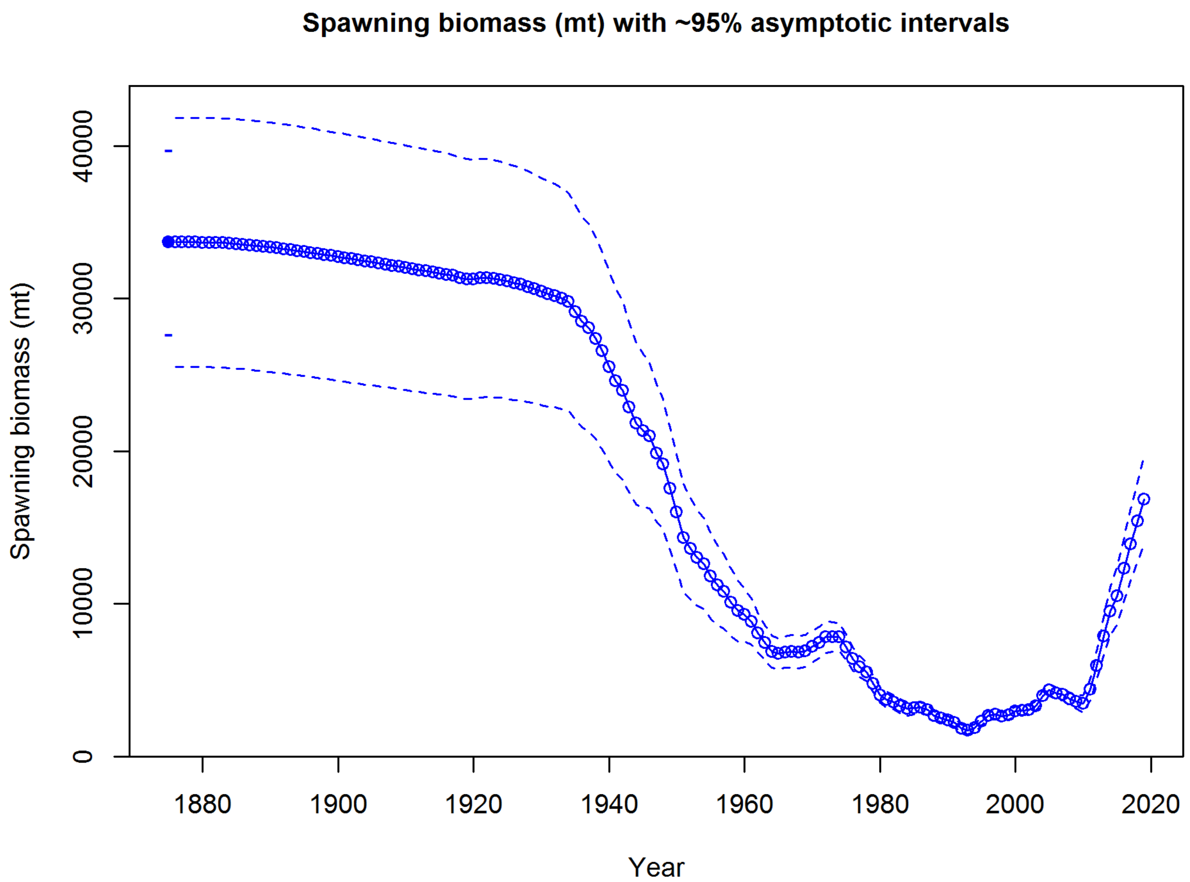

Figure b: Estimated time-series of spawning output trajectory (circles and line: median; light broken lines: 95% credibility intervals) for the base assessment model.

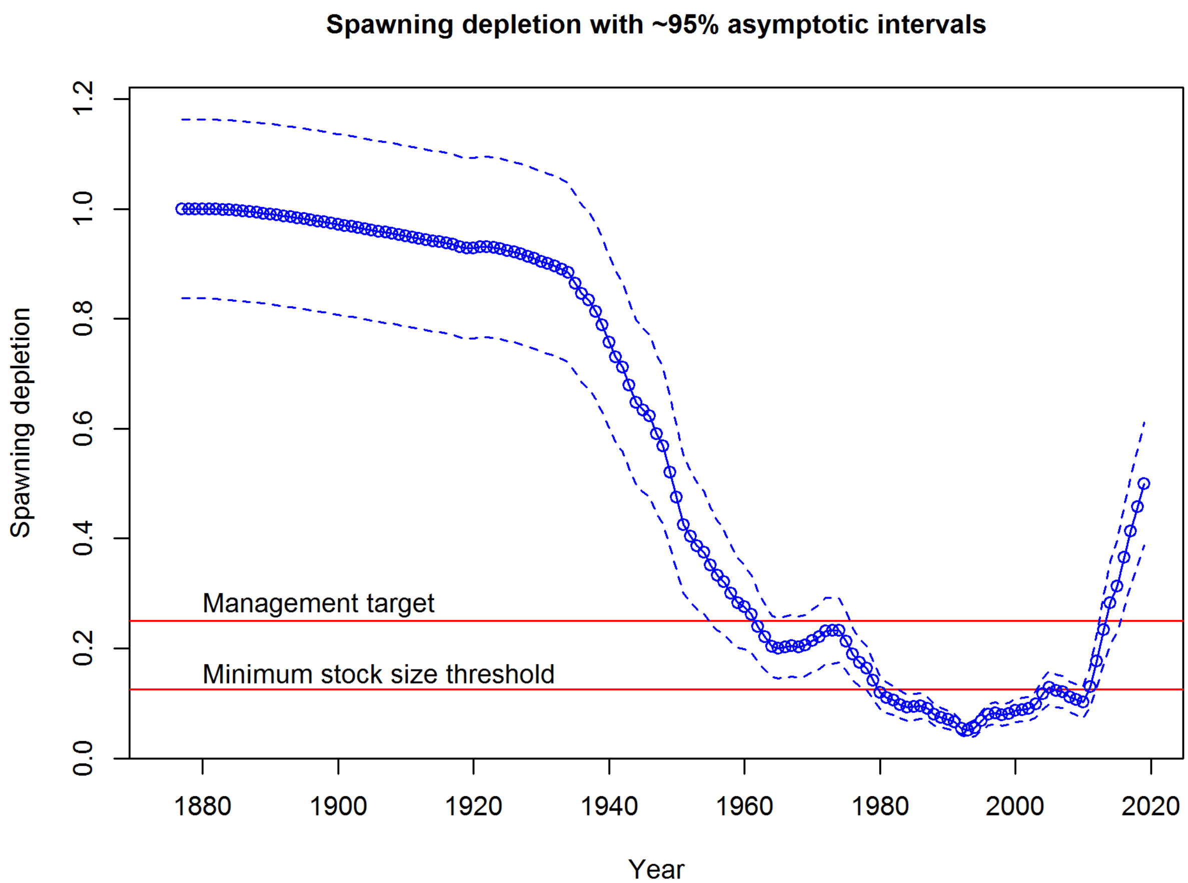

Figure c: Estimated time-series of relative spawning output (depletion) (circles and line: median; light broken lines: 95% credibility intervals) for the base assessment model.

Table b: Recent trend in estimated spawning output (mt) and estimated relative spawning output (depletion).

Year	Spawning Output (mt)	˜ 95% Confidence Interval	Estimated Depletion	˜ 95% Confidence Interval
2010	3448	2895 - 4001	0.102	0.073 - 0.131
2011	4396	3691 - 5101	0.130	0.094 - 0.167
2012	5957	5020 - 6895	0.177	0.128 - 0.225
2013	7887	6641 - 9133	0.234	0.171 - 0.297
2014	9514	7942 - 11086	0.282	0.207 - 0.358
2015	10531	8672 - 12390	0.313	0.229 - 0.396
2016	12329	10225 - 14433	0.366	0.273 - 0.458
2017	13910	11567 - 16254	0.413	0.314 - 0.512
2018	15401	12797 - 18005	0.457	0.352 - 0.562
2019	16841	13924 - 19758	0.500	0.388 - 0.612

Recruitment

Recruitment deviations were estimated for the entire assessment period…

Table c: Recent estimated trend in recruitment and estimated recruitment deviations determined from the base model. The recruitment deviations for 2016 and 2017 were fixed at zero within the model.

Year	Estimated Recruitment	˜ 95% Confidence Interval	Estimated Recruitment Devs.	˜ 95% Confidence Interval
2010	9787	6190 - 15473	-0.144	-0.509 - 0.220
2011	9683	5721 - 16387	-0.209	-0.654 - 0.236
2012	13760	7506 - 25228	0.067	-0.467 - 0.601
2013	12874	5985 - 27695	-0.060	-0.789 - 0.668
2014	14272	6300 - 32334	-0.000	-0.784 - 0.784
2015	14418	6351 - 32730	0.000	-0.784 - 0.784
2016	14621	6422 - 33289	0.000	-0.784 - 0.784
2017	14760	6470 - 33673	0.000	-0.784 - 0.784
2018	14867	6506 - 33972	0.000	-0.784 - 0.784
2019	14953	6534 - 34219	0.000	-0.784 - 0.784

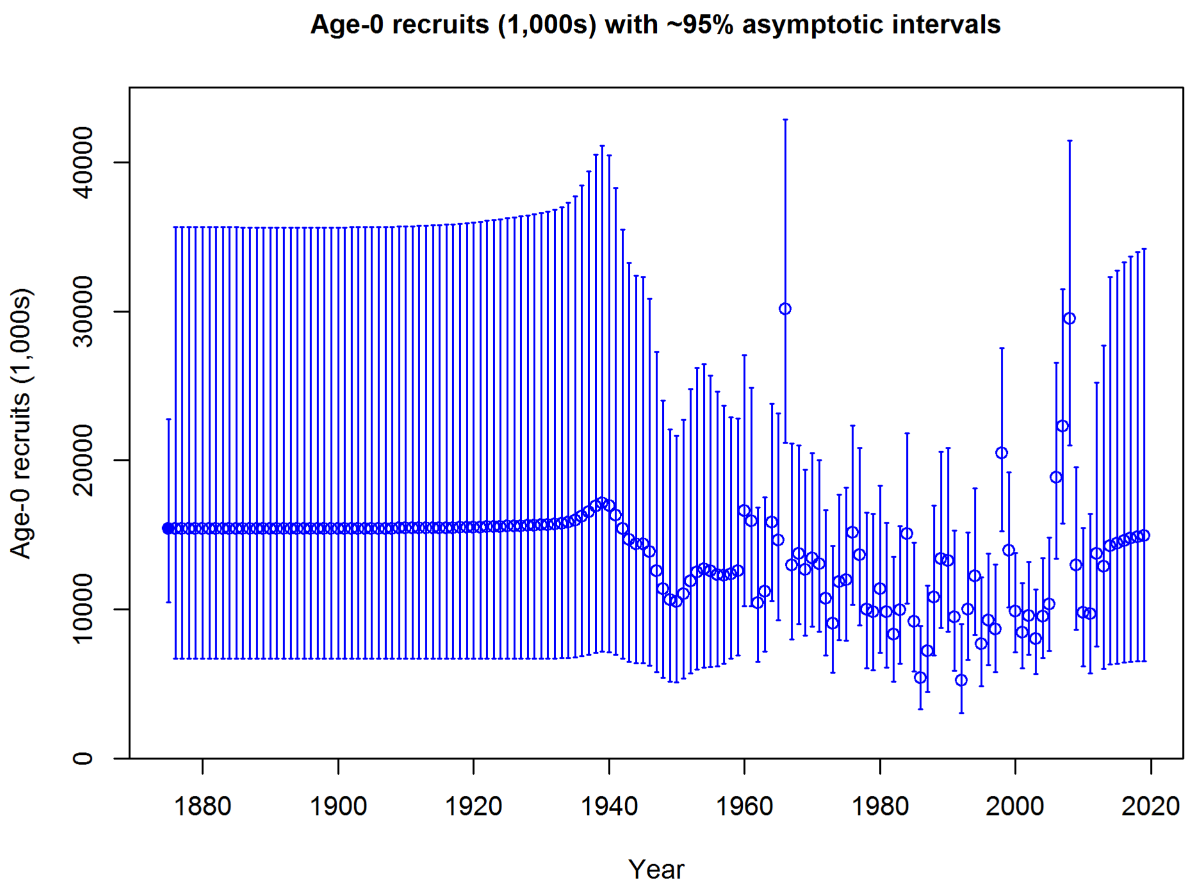

Figure d: Time-series of estimated Petrale sole recruitments for the base model with 95% confidence or credibility intervals.

Exploitation Status

The spawning output of Petrale sole...

Table d: Recent trend in spawning potential ratio (1-SPR)/(1-SPR50) and summary exploitation rate for age 3+ biomass for Petrale sole.

Year	(1-SPR)/ (1-SPR50%)	~ 95% Confidence Interval	Exploitation Rate	~ 95% Confidence Interval
2009	0.847	0.793 - 0.900	0.278	0.236 - 0.319
2010	0.672	0.583 - 0.762	0.099	0.080 - 0.117
2011	0.581	0.487 - 0.674	0.063	0.052 - 0.074
2012	0.592	0.503 - 0.682	0.074	0.061 - 0.086
2013	0.656	0.572 - 0.739	0.110	0.092 - 0.128
2014	0.654	0.571 - 0.736	0.124	0.103 - 0.145
2015	0.006	0.004 - 0.008	0.001	0.000 - 0.001
2016	0.005	0.004 - 0.007	0.000	0.000 - 0.001
2017	0.005	0.003 - 0.006	0.000	0.000 - 0.000
2018	0.004	0.003 - 0.005	0.000	0.000 - 0.000

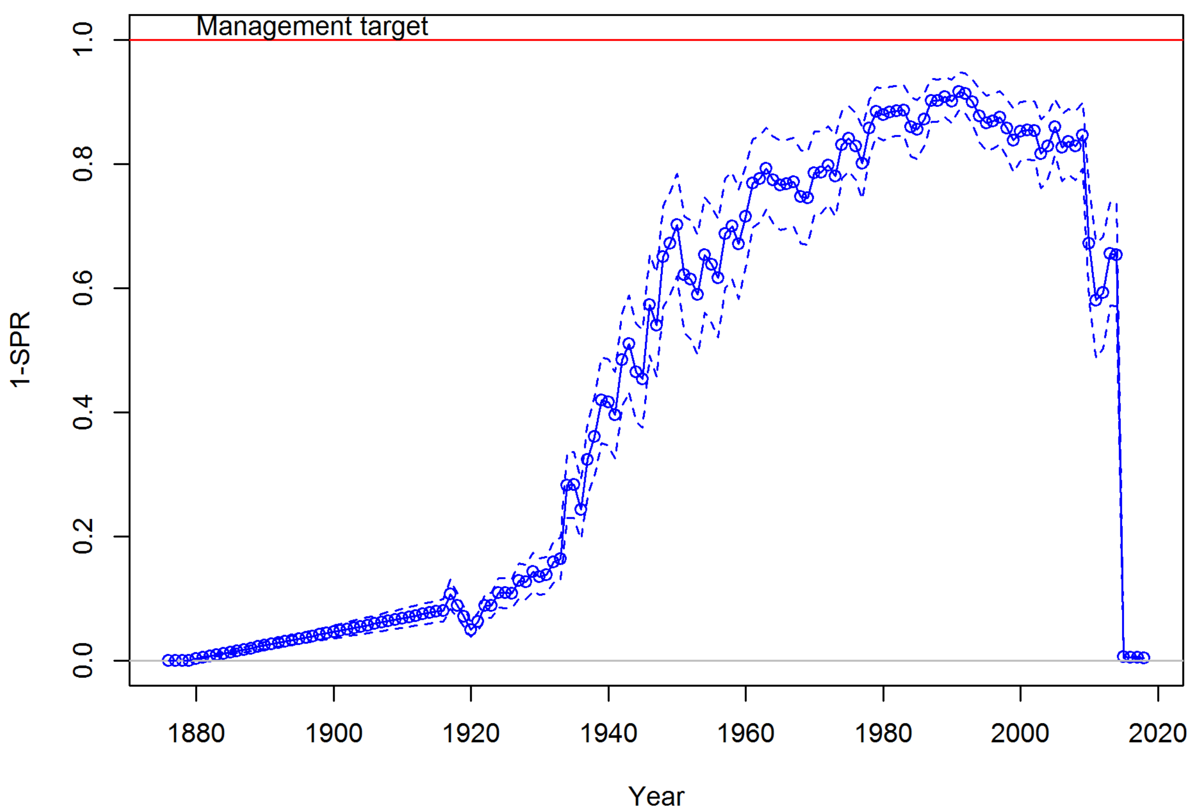

Figure e: Estimated relative spawning potential ratio (1-SPR)/(1-SPR30%) for the base model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the SPR30% harvest rate. The last year in the time-series is 2018.

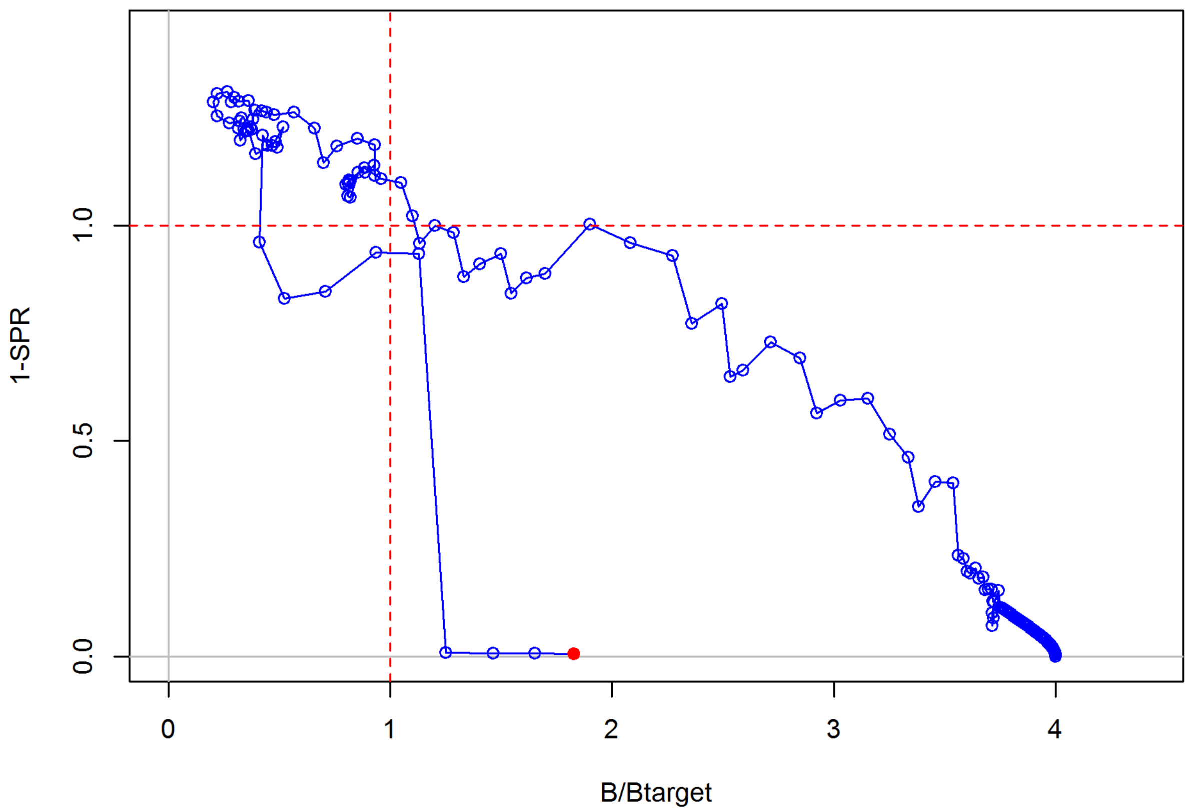

Figure f: Phase plot of estimated (1-SPR)/(1-SPR30%) vs. depletion (B/Btarget) for the base case model. The red circle indicates 2018 estimated status and exploitation for Petrale sole.

Ecosystem Considerations

Reference Points

This stock assessment estimates that the spawning output of Petrale sole is above the management target. Due to reduced landing and the large 2008 year-class, an increasing trend in spawning output was estimated in the base model. The estimated depletion in 2019 is 50.0% ($\sim$ 95% asymptotic interval: $\pm$ 38.8%-61.2%), corresponding to an unfished spawning output of 16,841 mt ($\sim$ 95% asymptotic interval: 13,924-19,758 mt). Unfished age 3+ biomass was estimated to be 53,873.7 mt in the base model. The target spawning output based on the biomass target ($SB_{25\%}$) is 8,423.3 mt, with an equilibrium catch of 2,729.5 mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{30\%}$ is 2,702.4 mt. Estimated MSY catch is at a 2,742.2 spawning output of 7,323.1 mt (21.7% depletion)

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

Quantity	**Estimate**	**~2.5% Confidence Interval**	**~97.5% Confidence Interval**
Unfished spawning output (mt)	33693.4	27542.4	39844.4
Unfished age 3+ biomass (mt)	53873.7	45675.1	62072.3
Unfished recruitment (R0, thousands)	15430.6	9369.1	21492.1
Spawning output(2019 mt)	16841.1	13924	19758.2
Relative spawning output (depletion) (2019)	0.5	0.388	0.612
Reference points based on $\mathbf{SB_{25\%}}$			
Proxy spawning output ($B_{25\%}$)	8423.3	6885.6	9961.1
SPR resulting in $B_{25\%}$ ($SPR_{B25\%}$)	0.274	0.251	0.297
Exploitation rate resulting in $B_{25\%}$	0.166	0.147	0.186
Yield with $SPR_{B25\%}$ at $B_{25\%}$ (mt)	2729.5	2472.1	2986.8
Reference points based on SPR proxy for MSY			
Spawning output	9329.8	7316.9	11342.7
$SPR_{30\%}$			
Exploitation rate corresponding to $SPR_{30\%}$	0.151	0.125	0.178
Yield with $SPR_{30\%}$ at SB_{SPR} (mt)	2702.4	2414.6	2990.2
Reference points based on estimated MSY values			
Spawning output at MSY (SB_{MSY})	7323.1	5504.8	9141.4
SPR_{MSY}	0.242	0.18	0.304
Exploitation rate at MSY	0.187	0.157	0.216
MSY (mt)	2742.2	2502.5	2982

Management Performance

Exploitation rates on Petrale sole...

Table f: Recent trend in total catch and landings (mt) relative to the management guidelines. Estimated total catch reflect the landings plus the model estimated discarded biomass based on discard rate data.

Year	OFL (mt; ABC prior to 2011)	ACL (mt; OY prior to 2011)	Total Landings (mt)	Estimated Total Catch (mt)
2009	2,811	2433	2208	2323
2010	2,751	1200	749	914
2011	1,021	976	762	781
2012	1,275	1160	1116	1135
2013	2,711	2592	1925	1954
2014	2,774	2652	2341	2361
2015	3,073	2816	10	10
2016	3,208	2910	10	10
2017	3,208	3,136	10	10
2018	3,152	3,013	10	10

Unresolved Problems and Major Uncertainties

1. The current data for Petrale sole weighted according to the Francis weighting...

Decision Table

Model uncertainty has been described by the estimated uncertainty within the base model and by the sensitivities to different model structure.

Table g: Projections of potential OFL (mt) and ABC (mt) and the estimated spawning output and relative depletion based on ABC removals. The 2019 and 2020 removals are set at the harvest limits currently set by management of XXX mt per year.

Year	OFL	ABC	Spawning Output (mt)	Relative Depletion
2019	4834	4640	16841	0.500
2020	4396	4219	15401	0.457
2021	4036	3873	14183	0.421
2022	3750	3599	13192	0.392
2023	3532	3389	12412	0.368
2024	3367	3231	11814	0.351
2025	3244	3113	11362	0.337
2026	3152	3025	11020	0.327
2027	3082	2958	10758	0.319
2028	3028	2906	10554	0.313
2029	2986	2865	10394	0.308
2030	2952	2832	10266	0.305

Table h: Decision table summary of 10-year projections beginning in 2021 for alternate states of nature based on an axis of uncertainty for the base model. The removals in 2019 and 2020 were set at the defined management specification of XXX mt for each year assuming full attainment. The range of natural mortality values corresponded to the 12.5 and 87.5th quantile from the uncertainty around final spawning biomass. Columns range over low, mid, and high states of nature, and rows range over different assumptions of catch levels. The SPR50 catch stream is based on the equilibrium yield applying the SPR50 harvest rate.

			States of nature					
			M = 0.04725		M = 0.054		M = 0.0595	
	Year	Catch	Spawning Output	Depletion (%)	Spawning Output	Depletion (%)	Spawning Output	Depletion (%)
ABC	2019	4340	3944	62.9	5741	83.3	7505	96.8
	2020	4229	3909	62.4	5745	83.4	7542	97.3
	2021	4108	3858	61.6	5723	83.1	7546	97.3
	2022	3984	3784	60.4	5666	82.2	7503	96.8
	2023	3862	3695	59.0	5586	81.1	7427	95.8
	2024	3748	3600	57.4	5494	79.7	7332	94.6
	2025	3644	3502	55.9	5395	78.3	7226	93.2
	2026	3551	3404	54.3	5292	76.8	7113	91.8
	2027	3467	3308	52.8	5188	75.3	6996	90.3
	2028	3389	3213	51.3	5084	73.8	6879	88.7
SPR50	2019	1822	3944	62.9	5741	83.3	7505	96.8
	2020	1822	4022	64.2	5857	85.0	7654	98.7
	2021	1822	4083	65.1	5946	86.3	7768	100.2
	2022	1822	4117	65.7	5996	87.0	7830	101.0
	2023	1822	4131	65.9	6016	87.3	7852	101.3
	2024	1822	4133	65.9	6017	87.3	7848	101.2
	2025	1822	4125	65.8	6004	87.1	7824	100.9
	2026	1822	4110	65.6	5979	86.8	7786	100.4
	2027	1822	4090	65.3	5947	86.3	7736	99.8
	2028	1822	4067	64.9	5908	85.8	7679	99.1

Research and Data Needs

There are many areas of research that could be undertaken to benefit the understanding and assessment of Petrale sole. Below, are issues that are considered of importance.

1. **Natural mortality**:
2. **Steepness**:
3. **Basin-wide understanding of stock structure, biology, connectivity, and distribution:**

Table i: Base model results summary.

Quantity	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
OFL (mt)	2,751	1,021	1,275	2,711	2,774	3,073	3,208	3,208	3,152	1
ACL (mt)	1200	976	1160	2592	2652	2816	2910	3,136	3,013	1
Landings (mt)	749	762	1116	1925	2341	10	10	10	10	
Total Est. Catch (mt)	914	781	1135	1954	2361	10	10	10	10	
(1-SPR)(1-$SPR_{50\%}$)	0.672	0.581	0.592	0.656	0.654	0.006	0.005	0.005	0.004	
Exploitation rate	0.099	0.063	0.074	0.110	0.124	0.001	0.000	0.000	0.000	
Age 3+ biomass (mt)	9271.69	12406.50	15359.80	17730.40	18994.80	19707.20	22306.10	24807.50	27178.10	29422.30
Spawning Output	3448	4396	5957	7887	9514	10531	12329	13910	15401	16841
95% CI	2895 - 4001	3691 - 5101	5020 - 6895	6641 - 9133	7942 - 11086	8672 - 12390	10225 - 14433	11567 - 16254	12797 - 18005	13924 - 19758
Relative Depletion	0.102	0.130	0.177	0.234	0.282	0.313	0.366	0.413	0.457	0.500
95% CI	0.073 - 0.131	0.094 - 0.167	0.128 - 0.225	0.171 - 0.297	0.207 - 0.358	0.229 - 0.396	0.273 - 0.458	0.314 - 0.512	0.352 - 0.562	0.388 - 0.612
Recruits	9787	9683	13760	12874	14272	14418	14621	14760	14867	14953
95% CI	6190 - 15473	5721 - 16387	7506 - 25228	5985 - 27695	6300 - 32334	6351 - 32730	6422 - 33289	6470 - 33673	6506 - 33972	6534 - 34219

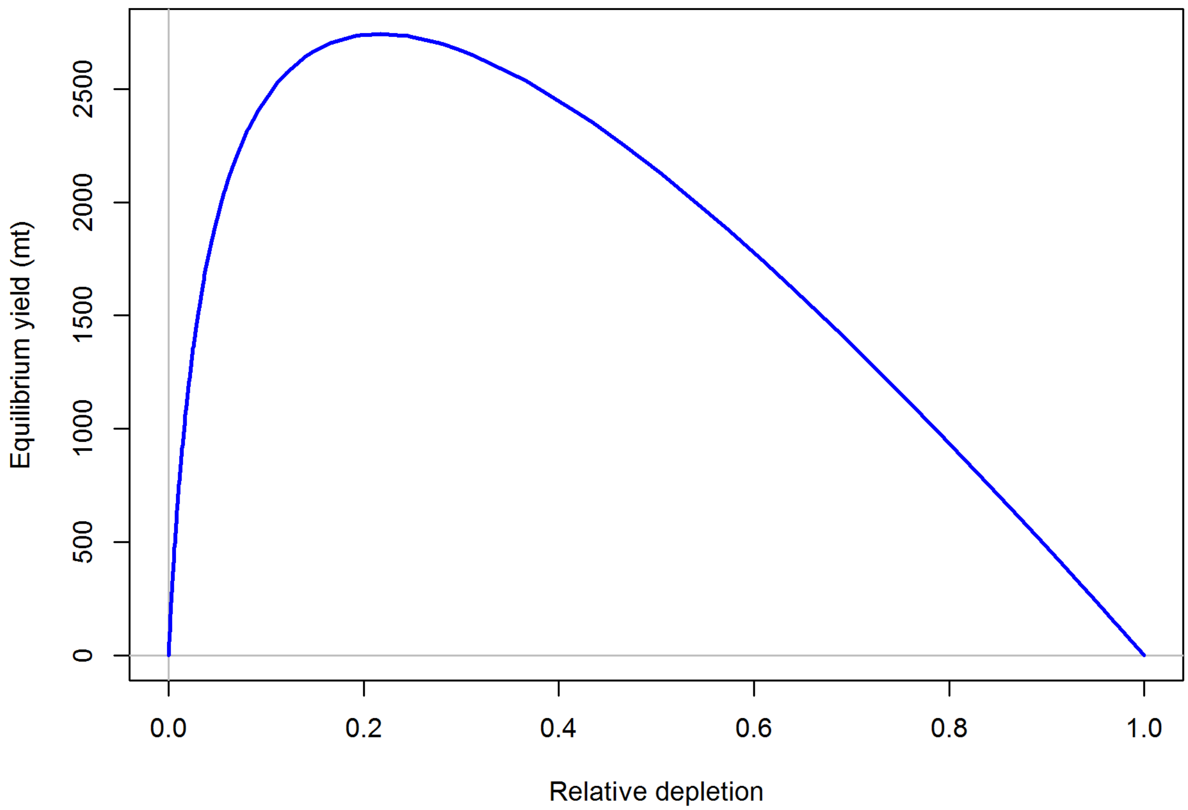

Figure g: Equilibrium yield curve for the base case model. Values are based on the 2018 fishery selectivity and with steepness fixed at 0.89.

1 Introduction

1.1 Distribution and Stock Structure

1.2 Historical and Current Fishery

1.3 Summary of Management History and Performance

1.4 Fisheries off Canada and Alaska

2 Data

Data used in the Petrale sole assessment are summarized in Figure 2. A description of each data source is provided below.

2.1 Fishery-Independent Data

2.1.1 Northwest Fisheries Science Center (NWFSC) Shelf-Slope Survey

2.1.2 Northwest Fisheries Science Center (NWFSC) Slope Survey

2.1.3 Triennial Shelf Survey

The Triennial shelf survey was first conducted by the AFSC in 1977 and spanned the time-frame 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. The survey design has changed slightly over the period of time. 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.

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 m. 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 m 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.

Although the Triennial shelf survey was used in the 2011 assessment, it was not used in the final base model for the current assessment for a number of reasons. First, there were concerns regarding the varying sampling and targeting of specific species by year across the time-series. Secondly, the Triennial shelf survey targeted the shelf of the West Coast and would not be expected to sample well slope species such as Petrale sole. There were limited observations of Petrale sole relative to other surveys (e.g. NWFSC shelf-slope survey) and the length and age distributions varied in such a manner that would indicate either poor sampling of Petrale sole or inconsistent sampling of the population.

2.2 Fishery-Dependent Data

2.2.1 Commercial Fishery Landings

Washington

Oregon

California

2.2.2 Discards

Data on discards of Petrale sole are available from two different data sources. The earliest source is referred to as the Pikitch data and comes from a study organized by Ellen Pikitch that collected trawl discards from 1985-1987 (Pikitch et al. 1988). The northern and southern boundaries of the study were 48°42′ N latitude and 42°60′ N latitude respectively, 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. Results of the Pikitch data were obtained from John Wallace (personal communication, NWFSC, NOAA) in the form of ratios of discard weight to retained weight of Petrale sole and sex-specific length frequencies. Discard estimates are shown in Table 9.

The second source is from the West Coast Groundfish Observer Program (WCGOP). This program is part of the NWFSC and has been recording discard observations since 2003.

Table 9 shows the discard ratios (discarded/(discarded + retained)) of Petrale sole from WCGOP. Since 2011, when the trawl rationalization program was implemented, observer coverage rates increased to nearly 100% for all the limited entry trawl vessels in the program and discard rates declined compared to pre-2011 rates. Discard rates were obtained for both the catch-share and the non-catch share sector for Petrale sole. A single discard rate was calculated by weighting discard rates based on the commercial landings by each sector. Coefficient of variations were calculated for the non-catch shares sector and pre-catch share years by bootstrapping vessels within ports because the observer program randomly chooses vessels within ports to be observed. Post-ITQ, all catch-share vessels have 100% observer coverage and discarding is assumed to be known.

2.2.3 Fishery Length and Age Data

2.2.3.1 Commercial Fishery

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

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

2.2.4 Historical Commercial Catch-Per-Unit Effort

2.3 Biological Data

2.3.1 Natural Mortality

2.3.2 Sex Ratio, Maturation, and Fecundity

2.3.3 Length-Weight Relationship

2.3.4 Growth (Length-at-Age)

2.3.5 Ageing Precision and Bias

2.4 History of Modeling Approaches Used for This Stock

2.4.1 Previous Assessments

3 Assessment

3.1 General Model Specifications and Assumptions

Stock Synthesis version 3.30.03.XX was used to estimate the parameters in the model. R4SS, version 1.XX.X, along with R version 3.3.2 were used to investigate and plot model fits. A summary of the data sources used in the model (details discussed above) is shown in Figure 2.

3.1.1 Changes Between the 2015 Update Assessment Model and Current Model

3.1.2 Summary of Fleets and Areas

3.1.3 Other Specifications

3.1.4 Modeling Software

The STAT team used Stock Synthesis version 3.30.03.XX developed by Dr. Richard Methot at the NWFSC (Methot and Wetzel 2013). This most recent version was used because it included improvements and corrections to older versions.

3.1.5 Priors

3.1.6 Data Weighting

3.1.7 Estimated and Fixed Parameters

3.1.8 Key Assumptions and Structural Choices

3.1.9 Bridging Analysis

3.1.10 Convergence

3.2 Base Model Results

3.2.1 Parameter Estimates

3.2.2 Fits to the Data

3.2.3 Population Trajectory

3.2.4 Uncertainty and Sensitivity Analyses

3.2.5 Retrospective Analysis

3.2.6 Historical Analysis

3.2.7 Likelihood Profiles

3.2.8 Reference Points

4 Harvest Projections and Decision Tables

5 Regional Management Considerations

6 Research Needs

There are many areas of research that could be improved to benefit the understanding and assessment of Petrale sole. Below, are issues that are considered of importance.

1. **Natural mortality**:

7 Acknowledgments

Many people were instrumental in the successful completion of this assessment and their contribution is greatly appreciated.

8 Tables

Table 1: Landings for each fleet for the modeled years.

Year	Winter North	Summer North	Winter South	Summer South
1875	0	0	0	0
1876	0	0	0	1
1877	0	0	0	1
1878	0	0	0	1
1879	0	0	0	1
1880	0	0	0	12
1881	0	0	0	22
1882	0	0	0	33
1883	0	0	0	43
1884	0	0	0	54
1885	0	0	0	64
1886	0	0	0	75
1887	0	0	0	85
1888	0	0	0	96
1889	0	0	0	106
1890	0	0	0	117
1891	0	0	0	128
1892	0	0	0	138
1893	0	0	0	149
1894	0	0	0	159
1895	0	0	0	170
1896	0	0	0	180
1897	0	0	0	191
1898	0	0	0	201
1899	0	0	0	212
1900	0	0	0	223
1901	0	0	0	233
1902	0	0	0	244
1903	0	0	0	254
1904	0	0	0	265
1905	0	0	0	275
1906	0	0	0	286
1907	0	0	0	296
1908	0	0	0	307
1909	0	0	0	318
1910	0	0	0	328
1911	0	0	0	339
1912	0	0	0	349
1913	0	0	0	360
1914	0	0	0	370

Year	Winter North	Summer North	Winter South	Summer South
1915	0	0	0	381
1916	0	0	0	386
1917	0	0	0	526
1918	0	0	0	424
1919	0	0	0	333
1920	0	0	0	230
1921	0	0	0	294
1922	0	0	0	425
1923	0	0	0	427
1924	0	0	0	533
1925	0	0	0	528
1926	0	0	0	522
1927	0	0	0	632
1928	0	0	0	620
1929	0	2	0	706
1930	0	1	0	659
1931	0	81	63	531
1932	2	251	36	520
1933	6	408	39	392
1934	10	568	139	896
1935	14	650	155	777
1936	16	770	95	432
1937	20	1051	75	741
1938	27	1187	48	890
1939	35	1545	31	1029
1940	39	1737	162	597
1941	41	1803	111	331
1942	46	2919	24	216
1943	51	2867	72	345
1944	55	2047	86	447
1945	60	1866	102	439
1946	64	2492	72	1116
1947	69	1778	154	1093
1948	74	2315	273	1778
1949	76	1809	617	1812
1950	156	2322	424	1638
1951	118	1666	208	993
1952	131	1390	326	882
1953	46	737	533	981
1954	27	903	801	1073

Year	Winter North	Summer North	Winter South	Summer South
1955	57	863	526	1052
1956	137	759	508	801
1957	171	1103	527	1027
1958	99	1152	568	957
1959	332	947	379	723
1960	241	1374	520	644
1961	217	1547	542	1029
1962	295	1512	515	859
1963	663	1038	534	978
1964	282	1090	378	927
1965	370	950	374	853
1966	366	972	325	925
1967	409	793	532	874
1968	284	811	361	871
1969	190	887	421	848
1970	412	1081	472	1071
1971	743	883	540	1016
1972	730	1017	703	1000
1973	497	1272	417	742
1974	517	1611	665	893
1975	539	1559	561	901
1976	506	951	713	737
1977	682	743	484	495
1978	746	1098	419	801
1979	734	1086	353	945
1980	382	976	518	680
1981	761	468	360	895
1982	1041	771	262	502
1983	696	935	273	361
1984	416	739	260	329
1985	392	553	273	471
1986	474	714	403	355
1987	854	573	311	556
1988	743	610	349	411
1989	696	583	393	415
1990	641	460	319	373
1991	793	397	448	310
1992	640	366	272	307
1993	685	392	237	234
1994	518	355	246	299

Year	Winter North	Summer North	Winter South	Summer South
1915	0	0	0	381
1916	0	0	0	386
1917	0	0	0	526
1918	0	0	0	424
1919	0	0	0	333
1920	0	0	0	230
1921	0	0	0	294
1922	0	0	0	425
1923	0	0	0	427
1924	0	0	0	533
1925	0	0	0	528
1926	0	0	0	522
1927	0	0	0	632
1928	0	0	0	620
1929	0	2	0	706
1930	0	1	0	659
1931	0	81	63	531
1932	2	251	36	520
1933	6	408	39	392
1934	10	568	139	896
1935	14	650	155	777
1936	16	770	95	432
1937	20	1051	75	741
1938	27	1187	48	890
1939	35	1545	31	1029
1940	39	1737	162	597
1941	41	1803	111	331
1942	46	2919	24	216
1943	51	2867	72	345
1944	55	2047	86	447
1945	60	1866	102	439
1946	64	2492	72	1116
1947	69	1778	154	1093
1948	74	2315	273	1778
1949	76	1809	617	1812
1950	156	2322	424	1638
1951	118	1666	208	993
1952	131	1390	326	882
1953	46	737	533	981
1954	27	903	801	1073

Year	Winter North	Summer North	Winter South	Summer South
1995	591	454	236	287
1996	591	440	406	394
1997	621	430	448	442
1998	522	577	221	300
1999	463	504	287	267
2000	610	586	374	241
2001	691	597	308	260
2002	667	714	335	195
2003	544	713	256	180
2004	1010	750	177	267
2005	964	1069	337	533
2006	537	1012	125	454
2007	930	536	404	475
2008	842	354	519	414
2009	847	642	470	250
2010	258	292	78	121
2011	222	423	40	78
2012	406	478	124	108
2013	509	1007	130	278
2014	853	860	273	354
2015	0	0	0	10
2016	0	0	0	10
2017	0	0	0	10
2018	0	0	0	10

Table 2: Recent trend in estimated total catch relative to management guidelines. The estimated total catch includes the total landings plus the model estimated discard mortality based upon discard rate data.

Year	OFL (mt; ABC prior to 2011)	ACL (mt; OY prior to 2011)	Total landings (mt)	Estimated total catch (mt)
2009	2,811	2433	2208	2323
2010	2,751	1200	749	914
2011	1,021	976	762	781
2012	1,275	1160	1116	1135
2013	2,711	2592	1925	1954
2014	2,774	2652	2341	2361
2015	3,073	2816	10	10
2016	3,208	2910	10	10
2017	3,208	3,136	10	10
2018	3,152	3,013	10	10

Table 3: Description of the data used to create the indices, the modeling platform used to generate the estimates, and the model configuration.

	Early Triennial	Late Triennial	NWFS Shelf-Slope
Depth	55-100, 100-400	55- 100, 100-500	55-100, 100-183, 183-549
Latitude	INPFC	INPFC	INPFC
Model	VAST	VAST	VAST
Error Structure			
Knots			
Spatial	Y		Y
Temporal	Y		Y
Vessel-Year	N		Y

Table 4: Description of the strata used to create the indices for the NWFSC Shelf-Slope survey.

Strata	Depth Lower Bound	Depth Upper Bound	Latitude South	Latitude North
Shallow Vancouver	55	100	47.00	49.00
Shallow Columbia	55	100	43.00	47.00
Shallow Eureka	55	100	40.50	43.00
Shallow Monterey	55	100	38.00	40.50
Shallow Conception	55	100	34.50	38.00
Mid Vancouver	100	183	47.00	49.00
Mid Columbia	100	183	43.00	47.00
Mid Eureka	100	183	40.50	43.00
Mid Monterey	100	183	38.00	40.50
Mid Conception	100	183	34.50	38.00
Deep Van/Col/Eur	183	549	40.50	49.00
Deep Montery	183	549	38.00	40.50
Deep Conception	183	549	34.50	38.00

Table 5: Summary of the fishery-independent biomass/abundance time-series used in the stock assessment. The standard error includes the input annual standard error and model estimated added variance.

	Winter N.		Winter S.		Triennial Early		Triennial Late		NWFSC Combo	
Year	Obs	SE	Obs	SE	Obs	SE	Obs	SE	Obs	SE
1980	-	-	-	-	1864	0.49	-	-	-	-
1983	-	-	-	-	2300	0.29	-	-	-	-
1986	-	-	-	-	2193	0.31	-	-	-	-
1987	1.09	0.28	1.08	0.56	-	-	-	-	-	-
1988	1.16	0.27	0.91	0.33	-	-	-	-	-	-
1989	0.92	0.27	0.53	0.43	3234	0.27	-	-	-	-
1990	0.76	0.28	0.96	0.46	-	-	-	-	-	-
1991	0.86	0.27	0.90	0.36	-	-	-	-	-	-
1992	0.56	0.28	0.59	0.68	2126	0.28	-	-	-	-
1993	0.56	0.27	0.86	0.35	-	-	-	-	-	-
1994	0.50	0.28	0.71	0.30	-	-	-	-	-	-
1995	0.66	0.28	0.90	0.30	-	-	2407	0.33	-	-
1996	0.77	0.29	1.25	0.30	-	-	-	-	-	-
1997	0.85	0.28	0.82	0.28	-	-	-	-	-	-
1998	1.01	0.29	0.93	0.31	-	-	3548	0.30	-	-
1999	0.71	0.29	0.83	0.29	-	-	-	-	-	-
2000	0.67	0.28	0.62	0.29	-	-	-	-	-	-
2001	0.83	0.27	0.66	0.29	-	-	3832	0.30	-	-
2002	0.93	0.28	0.80	0.29	-	-	-	-	-	-
2003	1.02	0.28	0.85	0.29	-	-	-	-	18698	0.13
2004	1.63	0.28	1.71	0.31	-	-	9713	0.32	22866	0.12
2005	1.85	0.28	1.93	0.29	-	-	-	-	22056	0.11
2006	2.01	0.28	1.58	0.29	-	-	-	-	19276	0.12
2007	2.04	0.28	2.07	0.28	-	-	-	-	19428	0.12
2008	1.96	0.27	1.62	0.28	-	-	-	-	15981	0.12
2009	2.12	0.27	1.76	0.28	-	-	-	-	15893	0.12
2010	-	-	-	-	-	-	-	-	22700	0.11
2011	-	-	-	-	-	-	-	-	30022	0.10
2012	-	-	-	-	-	-	-	-	36628	0.12
2013	-	-	-	-	-	-	-	-	51165	0.12
2014	-	-	-	-	-	-	-	-	58504	0.11

Table 6: Summary of NWFSC shelf-slope survey length samples used in the stock assessment. The sample sizes were calculated according to Stewart and Hamel (2014), which determined that the approximate realized sample size for flatfish species was 3.09 fish per tow.

Year	Tows	Fish	Sample Size
2003	46	1426	111
2004	34	565	82
2005	38	526	92
2006	33	659	80
2007	50	628	121
2008	39	539	94
2009	46	471	111
2010	53	907	128
2011	53	921	128
2012	50	1175	121
2013	45	732	109
2014	52	991	126
2015	69	1165	167
2016	50	1150	121

Table 7: Summary of NWFSC shelf-slope survey age samples used in the stock assessment. The sample sizes were calculated according to Stewart and Hamel (2014), which determined that the approximate realized sample size for flatfish species was 3.09 fish per tow.

Year	Tows	Fish	Sample Size
2003	45	432	109
2004	34	219	82
2005	38	257	92
2006	33	254	80
2007	50	439	121
2008	39	328	94
2009	45	331	109
2010	53	579	128
2011	53	674	128
2012	49	699	119
2013	44	553	106
2014	52	626	126
2015	68	840	165
2016	44	703	106

Table 8: Summary of Triennial survey length samples used in the stock assessment. The sample sizes were calculated according to Stewart and Hamel (2014), which determined that the approximate realized sample size for flatfish species was 3.09 fish per tow.

Year	Tows	Fish	Sample Size
1980	18	1315	43
1983	40	2820	97
1986	17	877	41
1989	42	1851	102
1992	33	1182	80
1995	71	1136	172
1998	81	1482	196
2001	74	669	179
2004	63	1240	153

Table 9: Summary of discard rates used in the model by each data source (continued on next page).

Year	Source	Discard Rate	Standard Error
2007	WinterN	0.004	0.002
2004	WinterN	0.001	0.001
2008	WinterN	0.028	0.014
2005	WinterN	0.001	0.000
2002	WinterN	0.007	0.003
2009	WinterN	0.027	0.016
2006	WinterN	0.012	0.021
2003	WinterN	0.007	0.019
2010	WinterN	0.209	0.054
2011	WinterN	0.001	0.021
2012	WinterN	0.001	0.021
2013	WinterN	0.001	0.021
2014	WinterN	0.002	0.021
1985	WinterN	0.022	0.110
1986	WinterN	0.021	0.116
1987	WinterN	0.027	0.119
2004	SummerN	0.091	0.032
2005	SummerN	0.040	0.009
2002	SummerN	0.212	0.027
2006	SummerN	0.078	0.017
2003	SummerN	0.145	0.090
2007	SummerN	0.107	0.020
2008	SummerN	0.054	0.011
2009	SummerN	0.202	0.062
2010	SummerN	0.089	0.026
2011	SummerN	0.032	0.021
2012	SummerN	0.015	0.021
2013	SummerN	0.023	0.021
1985	SummerN	0.035	0.042
1986	SummerN	0.034	0.043
1987	SummerN	0.032	0.045

Year	Source	Discard Rate	Standard Error
2002	WinterS	0.035	0.025
2003	WinterS	0.006	0.003
2004	WinterS	0.025	0.052
2005	WinterS	0.006	0.006
2009	WinterS	0.021	0.015
2006	WinterS	0.075	0.043
2010	WinterS	0.278	0.060
2007	WinterS	0.018	0.014
2008	WinterS	0.010	0.006
2011	WinterS	0.001	0.021
2012	WinterS	0.003	0.021
2013	WinterS	0.000	0.021
2014	WinterS	0.000	0.021
2002	SummerS	0.058	0.016
2009	SummerS	0.023	0.008
2006	SummerS	0.038	0.016
2003	SummerS	0.036	0.013
2010	SummerS	0.056	0.012
2007	SummerS	0.065	0.021
2004	SummerS	0.033	0.015
2008	SummerS	0.026	0.015
2005	SummerS	0.012	0.003
2011	SummerS	0.041	0.021
2012	SummerS	0.013	0.021
2013	SummerS	0.004	0.021

Table 10: Summary of Winter North fishery length samples used in the stock assessment (continued on next page). Sample sizes were calculated according to method described above in Section 2.2.3.

Year	Trips	Fish	Sample Size
1966	1	238	7
1967	5	1020	35
1968	3	912	21
1969	4	1213	28
1970	13	1830	92
1971	22	4698	155
1972	23	4561	162
1973	17	4134	120
1974	20	4806	141
1975	19	3637	134
1976	21	3677	148
1977	32	4846	226
1978	52	7715	367
1979	34	3414	240
1980	55	5425	388
1981	40	3921	282
1982	48	4824	339
1983	39	3944	275
1984	31	3102	219
1985	45	4508	318
1986	40	4002	282
1987	43	3053	304
1988	9	601	64
1989	16	798	113
1990	12	599	85
1991	8	216	38
1994	43	2608	304
1995	49	3161	346
1996	64	3085	452
1997	76	3570	537
1998	56	3450	395
1999	58	2812	409
2000	49	2004	326
2001	59	1696	293
2002	50	1666	280
2003	67	1661	296
2004	53	1202	219
2005	51	1277	227
2006	59	1486	264
2007	81	2248	391
2008	101	3058	523
2009	107	3207	550
2010	134	2872	530
2011	100	1943	368
2012	97	1873	355
2013	117	2167	416
2014	140	2850	533
2015	110	2504	456
2016	131	2158	429

Table 11: Summary of Summer North fishery length samples used in the stock assessment (continued on next page). Sample sizes were calculated according to method described above in Section 2.2.3.

Year	Trips	Fish	Sample Size
1966	1	238	7
1967	5	1020	35
1968	3	912	21
1969	4	1213	28
1970	13	1830	92
1971	22	4698	155
1972	23	4561	162
1973	17	4134	120
1974	20	4806	141
1975	19	3637	134
1976	21	3677	148
1977	32	4846	226
1978	52	7715	367
1979	34	3414	240
1980	55	5425	388
1981	40	3921	282
1982	48	4824	339
1983	39	3944	275
1984	31	3102	219
1985	45	4508	318
1986	40	4002	282
1987	43	3053	304
1988	9	601	64
1989	16	798	113
1990	12	599	85
1991	8	216	38
1994	43	2608	304
1995	49	3161	346
1996	64	3085	452
1997	76	3570	537
1998	56	3450	395
1999	58	2812	409
2000	49	2004	326
2001	59	1696	293
2002	50	1666	280
2003	67	1661	296
2004	53	1202	219
2005	51	1277	227
2006	59	1486	264
2007	81	2248	391
2008	101	3058	523
2009	107	3207	550
2010	134	2872	530
2011	100	1943	368
2012	97	1873	355
2013	117	2167	416
2014	140	2850	533
2015	110	2504	456
2016	131	2158	429

Table 12: Summary of Winter South fishery length samples used in the stock assessment (continued on next page). Sample sizes were calculated according to method described above in Section 2.2.3.

Year	Trips	Fish	Sample Size
1966	1	238	7
1967	5	1020	35
1968	3	912	21
1969	4	1213	28
1970	13	1830	92
1971	22	4698	155
1972	23	4561	162
1973	17	4134	120
1974	20	4806	141
1975	19	3637	134
1976	21	3677	148
1977	32	4846	226
1978	52	7715	367
1979	34	3414	240
1980	55	5425	388
1981	40	3921	282
1982	48	4824	339
1983	39	3944	275
1984	31	3102	219
1985	45	4508	318
1986	40	4002	282
1987	43	3053	304
1988	9	601	64
1989	16	798	113
1990	12	599	85
1991	8	216	38
1994	43	2608	304
1995	49	3161	346
1996	64	3085	452
1997	76	3570	537
1998	56	3450	395
1999	58	2812	409
2000	49	2004	326
2001	59	1696	293
2002	50	1666	280
2003	67	1661	296
2004	53	1202	219
2005	51	1277	227
2006	59	1486	264
2007	81	2248	391
2008	101	3058	523
2009	107	3207	550
2010	134	2872	530
2011	100	1943	368
2012	97	1873	355
2013	117	2167	416
2014	140	2850	533
2015	110	2504	456
2016	131	2158	429

Table 13: Summary of Summer South fishery length samples used in the stock assessment (continued on next page). Sample sizes were calculated according to method described above in Section 2.2.3.

Year	Trips	Fish	Sample Size
1966	1	238	7
1967	5	1020	35
1968	3	912	21
1969	4	1213	28
1970	13	1830	92
1971	22	4698	155
1972	23	4561	162
1973	17	4134	120
1974	20	4806	141
1975	19	3637	134
1976	21	3677	148
1977	32	4846	226
1978	52	7715	367
1979	34	3414	240
1980	55	5425	388
1981	40	3921	282
1982	48	4824	339
1983	39	3944	275
1984	31	3102	219
1985	45	4508	318
1986	40	4002	282
1987	43	3053	304
1988	9	601	64
1989	16	798	113
1990	12	599	85
1991	8	216	38
1994	43	2608	304
1995	49	3161	346
1996	64	3085	452
1997	76	3570	537
1998	56	3450	395
1999	58	2812	409
2000	49	2004	326
2001	59	1696	293
2002	50	1666	280
2003	67	1661	296
2004	53	1202	219
2005	51	1277	227
2006	59	1486	264
2007	81	2248	391
2008	101	3058	523
2009	107	3207	550
2010	134	2872	530
2011	100	1943	368
2012	97	1873	355
2013	117	2167	416
2014	140	2850	533
2015	110	2504	456
2016	131	2158	429

Table 14: Summary of Winter North fishery age samples used in the stock assessment. Sample sizes were calculated according to method described above in Section 2.2.3.

Year	Trips	Fish	Sample Size
1981	20	1901	141
1982	40	2776	282
1983	33	3317	233
1984	27	2625	191
1985	21	2096	148
1986	17	1693	120
1987	24	1193	169
1988	4	199	28
1994	8	238	41
1999	18	863	127
2000	14	677	99
2001	40	1349	226
2002	38	1414	233
2003	40	1309	221
2004	30	854	148
2005	37	1018	177
2006	49	1258	223
2007	63	1825	315
2008	44	1129	200
2009	75	1548	289
2010	54	1264	228
2011	85	1230	255
2012	7	331	49
2013	10	265	47
2014	91	587	172
2015	78	513	149
2016	21	254	56

Table 15: Summary of Summer North fishery age samples used in the stock assessment. Sample sizes were calculated according to method described above in Section 2.2.3.

Year	Trips	Fish	Sample Size
1981	20	1901	141
1982	40	2776	282
1983	33	3317	233
1984	27	2625	191
1985	21	2096	148
1986	17	1693	120
1987	24	1193	169
1988	4	199	28
1994	8	238	41
1999	18	863	127
2000	14	677	99
2001	40	1349	226
2002	38	1414	233
2003	40	1309	221
2004	30	854	148
2005	37	1018	177
2006	49	1258	223
2007	63	1825	315
2008	44	1129	200
2009	75	1548	289
2010	54	1264	228
2011	85	1230	255
2012	7	331	49
2013	10	265	47
2014	91	587	172
2015	78	513	149
2016	21	254	56

Table 16: Summary of Winter South fishery age samples used in the stock assessment. Sample sizes were calculated according to method described above in Section 2.2.3.

Year	Trips	Fish	Sample Size
1981	20	1901	141
1982	40	2776	282
1983	33	3317	233
1984	27	2625	191
1985	21	2096	148
1986	17	1693	120
1987	24	1193	169
1988	4	199	28
1994	8	238	41
1999	18	863	127
2000	14	677	99
2001	40	1349	226
2002	38	1414	233
2003	40	1309	221
2004	30	854	148
2005	37	1018	177
2006	49	1258	223
2007	63	1825	315
2008	44	1129	200
2009	75	1548	289
2010	54	1264	228
2011	85	1230	255
2012	7	331	49
2013	10	265	47
2014	91	587	172
2015	78	513	149
2016	21	254	56

Table 17: Summary of Summer South fishery age samples used in the stock assessment. Sample sizes were calculated according to method described above in Section 2.2.3.

Year	Trips	Fish	Sample Size
1981	20	1901	141
1982	40	2776	282
1983	33	3317	233
1984	27	2625	191
1985	21	2096	148
1986	17	1693	120
1987	24	1193	169
1988	4	199	28
1994	8	238	41
1999	18	863	127
2000	14	677	99
2001	40	1349	226
2002	38	1414	233
2003	40	1309	221
2004	30	854	148
2005	37	1018	177
2006	49	1258	223
2007	63	1825	315
2008	44	1129	200
2009	75	1548	289
2010	54	1264	228
2011	85	1230	255
2012	7	331	49
2013	10	265	47
2014	91	587	172
2015	78	513	149
2016	21	254	56

Table 18: Estimated ageing error vectors used in the assessment model

V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13
	Age Error 1		Age Error 2		Age Error 3		Age Error 4		Age Error 5		Age Error 6	
True Age	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0	0.3	0.17	0.2	0.12	0.5	0.13	0.5	0.13	0.5	0.15	0.0	0.00
1	1.3	0.17	1.3	0.12	1.4	0.13	1.5	0.13	1.5	0.15	0.7	0.00
2	2.4	0.23	2.4	0.18	2.4	0.25	2.4	0.27	2.5	0.30	2.0	0.08
3	3.4	0.29	3.4	0.25	3.3	0.38	3.4	0.40	3.5	0.45	3.2	0.17
4	4.5	0.36	4.4	0.32	4.3	0.51	4.4	0.53	4.5	0.60	4.4	0.26
5	5.4	0.44	5.4	0.40	5.2	0.64	5.4	0.67	5.5	0.75	5.4	0.35
6	6.4	0.52	6.4	0.49	6.2	0.76	6.3	0.80	6.5	0.90	6.4	0.46
7	7.4	0.61	7.3	0.59	7.1	0.89	7.3	0.93	7.5	1.05	7.4	0.56
8	8.3	0.71	8.3	0.70	8.1	1.02	8.3	1.07	8.6	1.20	8.2	0.67
9	9.2	0.81	9.1	0.82	9.0	1.14	9.3	1.20	9.6	1.35	9.0	0.79
10	10.1	0.92	10.0	0.96	10.0	1.27	10.3	1.33	10.6	1.51	9.8	0.92
11	10.9	1.04	10.9	1.11	10.9	1.40	11.2	1.47	11.6	1.66	10.5	1.05
12	11.8	1.18	11.7	1.27	11.9	1.53	12.2	1.60	12.6	1.81	11.1	1.19
13	12.6	1.32	12.5	1.45	12.8	1.65	13.2	1.74	13.6	1.96	11.7	1.34
14	13.4	1.48	13.2	1.66	13.8	1.78	14.2	1.87	14.6	2.11	12.3	1.49
15	14.2	1.64	14.0	1.88	14.7	1.91	15.1	2.00	15.6	2.26	12.8	1.66
16	14.9	1.82	14.7	2.12	15.7	2.03	16.1	2.14	16.6	2.41	13.3	1.83
17	15.7	2.02	15.4	2.39	16.6	2.16	17.1	2.27	17.6	2.56	13.8	2.01

Table 19: Specifications of the base model for Petrale sole.

Model Specification	Base Model
Starting year	1918
Population characteristics	
Maximum age	60
Gender	2
Population lengths	5-50 cm by 1 cm bins
Summary biomass (mt)	Age 3+
Data characteristics	
Data lengths	11-47 cm by 1 cm bins
Data ages	1-40 ages
Minimum age for growth calculations	3
Maximum age for growth calculations	20
First mature age	0
Starting year of estimated recruitment	1940
Fishery characteristics	
Fishing mortality method	Discrete
Maximum F	0.9
Catchability	Analytical estimate
Fishery selectivity	Double Normal
At-Sea Hake selectivity	Double Normal
POP survey selectivity	Logistic
Triennial survey	Double Normal
AFSC slope survey	Double Normal
NWFSC slope survey	Double Normal
NWFSC shelf-slope survey	Double Normal
Fishery time blocks	
Fishery selectivity	1918-1999, 2000-2016
Fishery retention	1918-1991, 1992-2001, 2002-2007, 2008, 2009-2010, 2011-2016

Table 20: Data weights applied when using Francis data weighting in the base model. The data weights were acquired after a single model weighting iteration.

Fleet	Lengths	Ages
Fishery	0.096	0.217
At-sea hake	0.104	0.032
Pacific ocean perch survey	1.000	1
AFSC slope survey	0.077	-
NWFSC slope survey	0.565	0.304
NWFSC shelf-slope survey	0.031	0.363

Table 21: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD
NatM_p_1_Fem_GP_1	0.145225	6	(0.005, 0.5)	OK	0.02	Log_Norm (-1.888,
L_at_Amin_Fem_GP_1	15.845	2	(10, 45)	OK	0.43	None
L_at_Amax_Fem_GP_1	54.4466	3	(35, 80)	OK	0.41	None
VonBert_K_Fem_GP_1	0.133126	2	(0.04, 0.5)	OK	0.01	None
SD_young_Fem_GP_1	0.188842	3	(0.01, 1)	OK	0.01	None
SD_old_Fem_GP_1	0.0261186	4	(0.01, 1)	OK	0.01	None
Wtlen_1_Fem_GP_1	0.00000208	-3	(-3, 3)			Normal (0.0000020
Wtlen_2_Fem_GP_1	3.4737	-3	(1, 5)			Normal (3.4737, 0.
Mat50%_Fem_GP_1	33.1	-3	(10, 50)			Normal (33.1, 0.8)
Mat_slope_Fem_GP_1	-0.743	-3	(-3, 3)			Normal (-0.743, 0.
Eggs/kg_inter_Fem_GP_1	1	-3	(-3, 3)			Normal (1, 1)
Eggs/kg_slope_wt_Fem_GP_1	0	-3	(-3, 3)			Normal (0, 1)
NatM_p_1_Mal_GP_1	0.154074	6	(0.005, 0.6)	OK	0.02	Log_Norm (-1.58,
L_at_Amin_Mal_GP_1	16.5356	2	(10, 45)	OK	0.32	None
L_at_Amax_Mal_GP_1	43.2138	3	(35, 80)	OK	0.41	None
VonBert_K_Mal_GP_1	0.202	2	(0.04, 0.5)	OK	0.01	None
SD_young_Mal_GP_1	0.136535	3	(0.01, 1)	OK	0.01	None
SD_old_Mal_GP_1	0.047	4	(0.01, 1)	OK	0.01	None
Wtlen_1_Mal_GP_1	0.00000305	-3	(-3, 3)			Normal (0.0000030
Wtlen_2_Mal_GP_1	3.36054	-3	(-3, 5)			Normal (3.36054,
CohortGrowDev	1	-4	(0, 1)			None
FracFemale_GP_1	0.5	-99	(0.01, 0.99)			None
SR_LN(R0)	9.64411	1	(5, 20)	OK	0.20	None
SR_BH_steep	0.886714	5	(0.2, 1)	OK	0.05	Normal (0.8, 0.09)
SR_sigmaR	0.4	-99	(0, 2)			Normal (0.9, 5)
SR_regime	0	-2	(-5, 5)			Normal (0, 0.2)

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Table 21: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
SR_autocorr	0	-99	(0, 0)			None
Early_InitAge_31	0.000000528495	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_30	0.000000611006	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_29	0.000000706397	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_28	0.000000816424	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_27	0.000000943504	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_26	0.00000109007	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_25	0.0000012592	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_24	0.00000145403	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_23	0.00000167871	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_22	0.00000193731	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_21	0.0000022349	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_20	0.00000257722	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_19	0.00000297037	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_18	0.00000342164	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_17	0.00000393927	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_16	0.00000453191	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_15	0.00000521008	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_14	0.00000598481	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_13	0.00000686874	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_12	0.00000787562	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_11	0.00000902076	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_10	0.000010321	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_9	0.0000117949	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_8	0.0000134619	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_7	0.000015342	3	(-4, 4)	act	0.40	dev (NA, NA)

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Table 21: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD
Early_InitAge_6	0.0000174561	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_5	0.0000198321	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_4	0.000022511	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_3	0.0000255426	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_2	0.0000289766	3	(-4, 4)	act	0.40	dev (NA, NA)
Early_InitAge_1	0.0000328658	3	(-4, 4)	act	0.40	dev (NA, NA)
LnQ_base_WinterN(1)	-6.45763	1	(-20, 5)	OK	2.46	None
Q_power_WinterN(1)	-0.188646	3	(-5, 5)	OK	0.32	None
LnQ_base_WinterS(3)	-1.15355	1	(-20, 5)	OK	2.12	None
Q_power_WinterS(3)	-0.875184	3	(-5, 5)	OK	0.27	None
LnQ_base_TriEarly(5)	-0.701485	-1	(-15, 15)			None
Q_extraSD_TriEarly(5)	0.162458	5	(0.001, 2)	OK	0.10	None
LnQ_base_TriLate(6)	-0.321808	-1	(-15, 15)			None
Q_extraSD_TriLate(6)	0.18423	4	(0.001, 2)	OK	0.11	None
LnQ_base_NWFSC(7)	1.18496	-1	(-15, 15)			None
LnQ_base_WinterN(1)_BLK5add_2004	0.50935	3	(-0.99, 0.99)	OK	0.18	Normal (0, 0.5)
LnQ_base_WinterN(1)_dev_se	99	-5	(0.0001, 2)			Normal (99, 0.5)
LnQ_base_WinterN(1)_dev_autocorr	0	-6	(-0.99, 0.99)			Normal (0, 0.5)
LnQ_base_WinterS(3)_BLK5add_2004	0.63472	3	(-0.99, 0.99)	OK	0.22	Normal (0, 0.5)
LnQ_base_WinterS(3)_dev_se	99	-5	(0.0001, 2)			Normal (99, 0.5)
LnQ_base_WinterS(3)_dev_autocorr	0	-6	(-0.99, 0.99)			Normal (0, 0.5)
Size_DblN_peak_WinterN(1)	47.4519	1	(15, 75)	OK	0.86	None
Size_DblN_top_logit_WinterN(1)	3	-3	(-5, 3)			None
Size_DblN_ascend_se_WinterN(1)	3.95961	2	(-4, 12)	OK	0.14	None
Size_DblN_descend_se_WinterN(1)	14	-3	(-2, 15)			None
Size_DblN_start_logit_WinterN(1)	-999	-4	(-15, 5)			None

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Table 21: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD
Size_DblN_end_logit_WinterN(1)	-999	-4	(-5, 5)			None
Retain_L_infl_WinterN(1)	26.2995	1	(10, 40)	OK	2.66	None
Retain_L_width_WinterN(1)	1.6456	2	(0.1, 10)	OK	0.47	None
Retain_L_asymptote_logit_WinterN(1)	9.10901	4	(-10, 10)	OK	15.53	None
Retain_L_maleoffset_WinterN(1)	0	-2	(-10, 10)			None
SzSel_Male_Peak_WinterN(1)	-9.20159	3	(-15, 15)	OK	0.71	None
SzSel_Male_Ascend_WinterN(1)	-1.14011	4	(-15, 15)	OK	0.20	None
SzSel_Male_Descend_WinterN(1)	0	-4	(-15, 15)			None
SzSel_Male_Final_WinterN(1)	0	-4	(-15, 15)			None
SzSel_Male_Scale_WinterN(1)	1	-4	(-15, 15)			None
Size_DblN_peak_SummerN(2)	53.4978	1	(15, 75)	OK	1.33	None
Size_DblN_top_logit_SummerN(2)	3	-3	(-5, 3)			None
Size_DblN_ascend_se_SummerN(2)	5.35125	2	(-4, 12)	OK	0.11	None
Size_DblN_descend_se_SummerN(2)	14	-3	(-2, 15)			None
Size_DblN_start_logit_SummerN(2)	-999	-4	(-15, 5)			None
Size_DblN_end_logit_SummerN(2)	-999	-4	(-5, 5)			None
Retain_L_infl_SummerN(2)	30.6935	1	(10, 40)	OK	0.35	None
Retain_L_width_SummerN(2)	1.24031	2	(0.1, 10)	OK	0.20	None
Retain_L_asymptote_logit_SummerN(2)	9.53634	4	(-10, 10)	OK	12.16	None
Retain_L_maleoffset_SummerN(2)	0	-2	(-10, 10)			None
SzSel_Male_Peak_SummerN(2)	-13.8296	3	(-20, 15)	OK	1.04	None
SzSel_Male_Ascend_SummerN(2)	-1.94386	4	(-15, 15)	OK	0.18	None
SzSel_Male_Descend_SummerN(2)	0	-4	(-15, 15)			None
SzSel_Male_Final_SummerN(2)	0	-4	(-15, 15)			None
SzSel_Male_Scale_SummerN(2)	1	-4	(-15, 15)			None
Size_DblN_peak_WinterS(3)	41.3517	1	(15, 75)	OK	1.48	None

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Table 21: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD
Size_DblN_top_logit_WinterS(3)	3	-3	(-5, 3)			None
Size_DblN_ascend_se_WinterS(3)	4.62019	2	(-4, 12)	OK	0.11	None
Size_DblN_descend_se_WinterS(3)	14	-3	(-2, 15)			None
Size_DblN_start_logit_WinterS(3)	-999	-4	(-15, 5)			None
Size_DblN_end_logit_WinterS(3)	-999	-4	(-5, 5)			None
Retain_L_infl_WinterS(3)	28.9028	1	(10, 40)	OK	0.53	None
Retain_L_width_WinterS(3)	1.54071	2	(0.1, 10)	OK	0.41	None
Retain_L_asymptote_logit_WinterS(3)	4.06707	4	(-10, 10)	OK	2.19	None
Retain_L_maleoffset_WinterS(3)	0	-2	(-10, 10)			None
SzSel_Male_Peak_WinterS(3)	-14.9943	3	(-15, 15)	LO	0.18	None
SzSel_Male_Ascend_WinterS(3)	-2.5614	4	(-15, 15)	OK	0.34	None
SzSel_Male_Descend_WinterS(3)	0	-4	(-15, 15)			None
SzSel_Male_Final_WinterS(3)	0	-4	(-15, 15)			None
SzSel_Male_Scale_WinterS(3)	1	-4	(-15, 15)			None
Size_DblN_peak_SummerS(4)	42.9054	1	(15, 75)	OK	1.41	None
Size_DblN_top_logit_SummerS(4)	3	-3	(-5, 3)			None
Size_DblN_ascend_se_SummerS(4)	4.76612	2	(-4, 12)	OK	0.17	None
Size_DblN_descend_se_SummerS(4)	14	-3	(-2, 15)			None
Size_DblN_start_logit_SummerS(4)	-999	-4	(-15, 5)			None
Size_DblN_end_logit_SummerS(4)	-999	-4	(-5, 5)			None
Retain_L_infl_SummerS(4)	28.9753	1	(10, 40)	OK	0.34	None
Retain_L_width_SummerS(4)	1.17814	2	(0.1, 10)	OK	0.17	None
Retain_L_asymptote_logit_SummerS(4)	9.48579	4	(-10, 10)	OK	13.27	None
Retain_L_maleoffset_SummerS(4)	0	-2	(-10, 10)			None
SzSel_Male_Peak_SummerS(4)	-10.7592	3	(-15, 15)	OK	1.42	None
SzSel_Male_Ascend_SummerS(4)	-1.5039	4	(-15, 15)	OK	0.32	None

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Table 21: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD
SzSel_Male_Descend_SummerS(4)	0	-4	(-15, 15)			None
SzSel_Male_Final_SummerS(4)	0	-4	(-15, 15)			None
SzSel_Male_Scale_SummerS(4)	1	-4	(-15, 15)			None
Size_DblN_peak_TriEarly(5)	35.2821	1	(15, 61)	OK	1.20	None
Size_DblN_top_logit_TriEarly(5)	3	-2	(-5, 3)			None
Size_DblN_ascend_se_TriEarly(5)	4.23223	1	(-4, 12)	OK	0.20	None
Size_DblN_descend_se_TriEarly(5)	14	-2	(-2, 15)			None
Size_DblN_start_logit_TriEarly(5)	-999	-4	(-15, 5)			None
Size_DblN_end_logit_TriEarly(5)	-999	-4	(-5, 5)			None
SzSel_Male_Peak_TriEarly(5)	-3.64025	2	(-15, 15)	OK	1.11	None
SzSel_Male_Ascend_TriEarly(5)	-0.52011	2	(-15, 15)	OK	0.23	None
SzSel_Male_Descend_TriEarly(5)	0	-3	(-15, 15)			None
SzSel_Male_Final_TriEarly(5)	0	-3	(-15, 15)			None
SzSel_Male_Scale_TriEarly(5)	1	-4	(-15, 15)			None
Size_DblN_peak_TriLate(6)	36.5398	1	(15, 61)	OK	0.87	None
Size_DblN_top_logit_TriLate(6)	3	-2	(-5, 3)			None
Size_DblN_ascend_se_TriLate(6)	4.63706	1	(-4, 12)	OK	0.11	None
Size_DblN_descend_se_TriLate(6)	14	-2	(-2, 15)			None
Size_DblN_start_logit_TriLate(6)	-999	-4	(-15, 5)			None
Size_DblN_end_logit_TriLate(6)	-999	-4	(-5, 5)			None
SzSel_Male_Peak_TriLate(6)	-2.74342	2	(-15, 15)	OK	0.91	None
SzSel_Male_Ascend_TriLate(6)	-0.112703	2	(-15, 15)	OK	0.14	None
SzSel_Male_Descend_TriLate(6)	0	-3	(-15, 15)			None
SzSel_Male_Final_TriLate(6)	0	-3	(-15, 15)			None
SzSel_Male_Scale_TriLate(6)	1	-4	(-15, 15)			None
Size_DblN_peak_NWFSC(7)	43.0692	1	(15, 61)	OK	0.89	None

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Table 21: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD
Size_DblN_top_logit_NWFSC(7)	3	-2	(-5, 3)			None
Size_DblN_ascend_se_NWFSC(7)	5.17712	1	(-4, 12)	OK	0.08	None
Size_DblN_descend_se_NWFSC(7)	14	-2	(-2, 15)			None
Size_DblN_start_logit_NWFSC(7)	-999	-4	(-15, 5)			None
Size_DblN_end_logit_NWFSC(7)	-999	-4	(-5, 5)			None
SzSel_Male_Peak_NWFSC(7)	-5.64121	2	(-15, 15)	OK	0.77	None
SzSel_Male_Ascend_NWFSC(7)	-0.457461	2	(-15, 15)	OK	0.09	None
SzSel_Male_Descend_NWFSC(7)	0	-3	(-15, 15)			None
SzSel_Male_Final_NWFSC(7)	0	-3	(-15, 15)			None
SzSel_Male_Scale_NWFSC(7)	1	-4	(-15, 15)			None
Size_DblN_peak_WinterN(1)_BLK1add_1973	-0.688296	4	(-31.6, 28.4)	OK	0.75	Normal (0, 14.2)
Size_DblN_peak_WinterN(1)_BLK1add_1983	-2.45449	4	(-31.6, 28.4)	OK	0.74	Normal (0, 14.2)
Size_DblN_peak_WinterN(1)_BLK1add_1993	-1.92897	4	(-31.6, 28.4)	OK	0.66	Normal (0, 14.2)
Size_DblN_peak_WinterN(1)_BLK1add_2003	-0.917011	4	(-31.6, 28.4)	OK	0.57	Normal (0, 14.2)
Size_DblN_peak_WinterN(1)_BLK1add_2011	-0.582325	4	(-31.6, 28.4)	OK	0.61	Normal (0, 14.2)
Retain_L_infl_WinterN(1)_BLK2add_2003	-3.00112	4	(-16.19, 13.81)	OK	4.38	Normal (0, 6.905)
Retain_L_infl_WinterN(1)_BLK2add_2010	5.09177	4	(-16.19, 13.81)	OK	3.03	Normal (0, 6.905)
Retain_L_infl_WinterN(1)_BLK2add_2011	-0.297993	4	(-16.19, 13.81)	OK	2.77	Normal (0, 6.905)
Retain_L_width_WinterN(1)_BLK2add_2003	0.345301	4	(-1.601, 8.299)	OK	0.50	Normal (0, 0.8005)
Retain_L_width_WinterN(1)_BLK2add_2010	0.486194	4	(-1.601, 8.299)	OK	0.72	Normal (0, 0.8005)
Retain_L_width_WinterN(1)_BLK2add_2011	-0.799192	4	(-1.601, 8.299)	OK	0.47	Normal (0, 0.8005)
Retain_L_asymptote_logit_WinterN(1)_BLK2repl_2003	7.42439	4	(-10, 10)	OK	2.21	None
Retain_L_asymptote_logit_WinterN(1)_BLK2repl_2010	1.48813	4	(-10, 10)	OK	0.47	None
Retain_L_asymptote_logit_WinterN(1)_BLK2repl_2011	9.6108	4	(-10, 10)	OK	1.05	None
Size_DblN_peak_SummerN(2)_BLK1add_1973	-1.977	4	(-38.8, 21.2)	OK	0.77	Normal (0, 10.6)
Size_DblN_peak_SummerN(2)_BLK1add_1983	-5.51487	4	(-38.8, 21.2)	OK	1.08	Normal (0, 10.6)

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Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD
Size_DblN_peak_SummerN(2)_BLK1add_1993	-5.56794	4	(-38.8, 21.2)	OK	1.08	Normal (0, 10.6)
Size_DblN_peak_SummerN(2)_BLK1add_2003	-3.5376	4	(-38.8, 21.2)	OK	0.68	Normal (0, 10.6)
Size_DblN_peak_SummerN(2)_BLK1add_2011	-1.2146	4	(-38.8, 21.2)	OK	0.67	Normal (0, 10.6)
Retain_L_infl_SummerN(2)_BLK3add_2003	-0.102783	4	(-20.679, 9.321)	OK	0.53	Normal (0, 4.6605)
Retain_L_infl_SummerN(2)_BLK3add_2009	1.37648	4	(-20.679, 9.321)	OK	0.58	Normal (0, 4.6605)
Retain_L_infl_SummerN(2)_BLK3add_2011	-2.10256	4	(-20.679, 9.321)	OK	0.59	Normal (0, 4.6605)
Retain_L_width_SummerN(2)_BLK3add_2003	0.0976239	4	(-1.0278, 8.8722)	OK	0.26	Normal (0, 0.5139)
Retain_L_width_SummerN(2)_BLK3add_2009	0.256144	4	(-1.0278, 8.8722)	OK	0.27	Normal (0, 0.5139)
Retain_L_width_SummerN(2)_BLK3add_2011	0.314495	4	(-1.0278, 8.8722)	OK	0.23	Normal (0, 0.5139)
Retain_L_asymptote_logit_SummerN(2)_BLK3repl_2003	5.03826	4	(-10, 10)	OK	0.74	None
Retain_L_asymptote_logit_SummerN(2)_BLK3repl_2009	5.03315	4	(-10, 10)	OK	1.47	None
Retain_L_asymptote_logit_SummerN(2)_BLK3repl_2011	7.80579	4	(-10, 10)	OK	2.33	None
Size_DblN_peak_WinterS(3)_BLK1add_1973	-2.45756	4	(-25.422, 34.578)	OK	2.39	Normal (0, 12.711)
Size_DblN_peak_WinterS(3)_BLK1add_1983	3.73714	4	(-25.422, 34.578)	OK	1.67	Normal (0, 12.711)
Size_DblN_peak_WinterS(3)_BLK1add_1993	7.53015	4	(-25.422, 34.578)	OK	1.88	Normal (0, 12.711)
Size_DblN_peak_WinterS(3)_BLK1add_2003	5.10183	4	(-25.422, 34.578)	OK	1.54	Normal (0, 12.711)
Size_DblN_peak_WinterS(3)_BLK1add_2011	5.84389	4	(-25.422, 34.578)	OK	1.62	Normal (0, 12.711)
Retain_L_infl_WinterS(3)_BLK2add_2003	-3.36625	4	(-18.816, 11.184)	OK	1.65	Normal (0, 5.592)
Retain_L_infl_WinterS(3)_BLK2add_2010	3.89582	4	(-18.816, 11.184)	OK	1.54	Normal (0, 5.592)
Retain_L_infl_WinterS(3)_BLK2add_2011	-4.58878	4	(-18.816, 11.184)	OK	2.99	Normal (0, 5.592)
Retain_L_width_WinterS(3)_BLK2add_2003	0.37731	4	(-1.0443, 8.8557)	OK	0.42	Normal (0, 0.52215
Retain_L_width_WinterS(3)_BLK2add_2010	0.10348	4	(-1.0443, 8.8557)	OK	0.46	Normal (0, 0.52215
Retain_L_width_WinterS(3)_BLK2add_2011	-0.0333518	4	(-1.0443, 8.8557)	OK	0.62	Normal (0, 0.52215
Retain_L_asymptote_logit_WinterS(3)_BLK2repl_2003	6.56919	4	(-10, 10)	OK	2.33	None
Retain_L_asymptote_logit_WinterS(3)_BLK2repl_2010	2.38578	4	(-10, 10)	OK	1.51	None
Retain_L_asymptote_logit_WinterS(3)_BLK2repl_2011	5.68242	4	(-10, 10)	OK	1.62	None

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Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD
Size_DblN_peak_SummerS(4)_BLK1add_1973	-5.21452	4	(-28.0793, 31.9207)	OK	1.67	Normal (0, 14.0397
Size_DblN_peak_SummerS(4)_BLK1add_1983	-7.57553	4	(-28.0793, 31.9207)	OK	2.82	Normal (0, 14.0397
Size_DblN_peak_SummerS(4)_BLK1add_1993	0.313191	4	(-28.0793, 31.9207)	OK	2.04	Normal (0, 14.0397
Size_DblN_peak_SummerS(4)_BLK1add_2003	3.03797	4	(-28.0793, 31.9207)	OK	1.49	Normal (0, 14.0397
Size_DblN_peak_SummerS(4)_BLK1add_2011	2.51447	4	(-28.0793, 31.9207)	OK	1.63	Normal (0, 14.0397
Retain_L_infl_SummerS(4)_BLK3add_2003	-1.62454	4	(-19.055, 10.945)	OK	0.99	Normal (0, 5.4725)
Retain_L_infl_SummerS(4)_BLK3add_2009	-1.19525	4	(-19.055, 10.945)	OK	1.32	Normal (0, 5.4725)
Retain_L_infl_SummerS(4)_BLK3add_2011	-0.404496	4	(-19.055, 10.945)	OK	0.91	Normal (0, 5.4725)
Retain_L_width_SummerS(4)_BLK3add_2003	0.620496	4	(-0.876, 9.024)	OK	0.24	Normal (0, 0.438)
Retain_L_width_SummerS(4)_BLK3add_2009	0.347709	4	(-0.876, 9.024)	OK	0.26	Normal (0, 0.438)
Retain_L_width_SummerS(4)_BLK3add_2011	0.260948	4	(-0.876, 9.024)	OK	0.24	Normal (0, 0.438)
Retain_L_asymptote_logit_SummerS(4)_BLK3repl_2003	9.15396	4	(-10, 10)	OK	11.68	None
Retain_L_asymptote_logit_SummerS(4)_BLK3repl_2009	8.32342	4	(-10, 10)	OK	11.14	None
Retain_L_asymptote_logit_SummerS(4)_BLK3repl_2011	9.76153	4	(-10, 10)	OK	6.66	None
LnQ_base_WinterN(1)_DEVmult_1987	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_1988	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_1989	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_1990	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_1991	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_1992	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_1993	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_1994	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_1995	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_1996	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_1997	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_1998	0		(NA, NA)			dev (NA, NA)

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Table 21: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD
LnQ_base_WinterN(1)_DEVmult_1999	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_2000	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_2001	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_2002	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_2003	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_2004	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_2005	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_2006	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_2007	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_2008	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterN(1)_DEVmult_2009	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_1987	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_1988	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_1989	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_1990	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_1991	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_1992	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_1993	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_1994	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_1995	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_1996	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_1997	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_1998	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_1999	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_2000	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_2001	0		(NA, NA)			dev (NA, NA)

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Table 21: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD
LnQ_base_WinterS(3)_DEVmult_2002	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_2003	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_2004	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_2005	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_2006	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_2007	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_2008	0		(NA, NA)			dev (NA, NA)
LnQ_base_WinterS(3)_DEVmult_2009	0		(NA, NA)			dev (NA, NA)

Table 22: Results from 50 jitters from the base model.

Status	Base.Model
Returned to base case	27
Found local minimum	23
Found better solution	0
Total	50

Table 23: Likelihood components from the base model

Likelihood Component	Value
Total	1734.38
Survey	-76.89
Discard	-167.68
Mean-body weight data	-80.85
Length-frequency data	830.54
Age-frequency data	1034.82
Recruitment	-24.47
Forecast Recruitment	0.01
Parameter Priors	7.48
Parameter Softbounds	0.04

Table 24: Summary of reference points and management quantities for the base case.

Quantity	**Estimate**	**~95% Confidence Interval**
Unfished spawning output (mt)	33693.4	27542.4 - 39844.4
Unfished age 3+ biomass (mt)	53873.7	45675.1 - 62072.3
Unfished recruitment (R0, thousands)	15430.6	10458.2 - 22767.1
Spawning output(2019 mt)	16841.1	13924 - 19758.2
Depletion (2019)	0.5	0.388 - 0.612
Reference points based on $\mathbf{SB_{40\%}}$		
Proxy spawning output ($B_{25\%}$)	8423.3	6885.6 - 9961.1
SPR resulting in $B_{25\%}$ ($SPR_{B25\%}$)	0.274	0.251 - 0.297
Exploitation rate resulting in $B_{25\%}$	0.166	0.147 - 0.186
Yield with $SPR_{B25\%}$ at $B_{25\%}$ (mt)	2729.5	2472.1 - 2986.8
Reference points based on SPR proxy for MSY		
Spawning output	9329.8	7316.9 - 11342.7
SPR_{proxy}	0.3	
Exploitation rate corresponding to SPR_{proxy}	0.151	0.125 - 0.178
Yield with SPR_{proxy} at SB_{SPR} (mt)	2702.4	2414.6 - 2990.2
Reference points based on estimated MSY values		
Spawning output at MSY (SB_{MSY})	7323.1	5504.8 - 9141.4
SPR_{MSY}	0.242	0.18 - 0.304
Exploitation rate at MSY	0.187	0.157 - 0.216
MSY (mt)	2742.2	2502.5 - 2982

Table 25: Time-series of population estimates from the base model.

Year	Total biomass (mt)	Spawning output (million eggs)	Summary biomass 3+	Relative biomass	Age-0 recruits	Estimated total catch (mt)	1-SPR	Exploit. rate
1876	53,874	33,694	53,326	1.00	15,431	1	0	0
1877	53,873	33,693	53,325	1.00	15,431	1	0	0
1878	53,872	33,692	53,324	1.00	15,431	1	0	0
1879	53,872	33,692	53,323	1.00	15,431	1	0	0
1880	53,871	33,691	53,322	1.00	15,432	12	0	0
1881	53,860	33,684	53,312	1.00	15,432	22	0	0
1882	53,840	33,670	53,291	1.00	15,431	33	0.003	0.001
1883	53,810	33,650	53,262	1.00	15,431	44	0.003	0.001
1884	53,772	33,625	53,224	1.00	15,431	55	0.003	0.001
1885	53,727	33,594	53,179	1.00	15,431	65	0.003	0.001
1886	53,675	33,558	53,126	1.00	15,431	76	0.006	0.001
1887	53,616	33,518	53,068	0.99	15,430	87	0.006	0.002
1888	53,552	33,474	53,004	0.99	15,430	97	0.006	0.002
1889	53,483	33,426	52,935	0.99	15,430	108	0.006	0.002
1890	53,410	33,375	52,861	0.99	15,429	119	0.006	0.002
1891	53,332	33,322	52,784	0.99	15,429	129	0.009	0.002
1892	53,251	33,265	52,703	0.99	15,428	140	0.009	0.003
1893	53,167	33,207	52,618	0.99	15,428	151	0.009	0.003
1894	53,080	33,146	52,531	0.98	15,428	162	0.009	0.003

Table 25: Time-series of population estimates from the base model.

Year	Total biomass (mt)	Spawning output (million eggs)	Summary biomass 3+	Relative biomass	Age-0 recruits	Estimated total catch (mt)	1-SPR	Exploit. rate
1895	52,990	33,083	52,442	0.98	15,428	172	0.012	0.003
1896	52,898	33,019	52,350	0.98	15,427	183	0.012	0.003
1897	52,804	32,953	52,256	0.98	15,427	194	0.012	0.004
1898	52,709	32,887	52,161	0.98	15,427	204	0.012	0.004
1899	52,612	32,819	52,064	0.97	15,427	215	0.012	0.004
1900	52,514	32,750	51,966	0.97	15,428	226	0.015	0.004
1901	52,415	32,680	51,866	0.97	15,428	237	0.015	0.005
1902	52,315	32,609	51,766	0.97	15,428	247	0.015	0.005
1903	52,214	32,538	51,666	0.97	15,429	258	0.015	0.005
1904	52,112	32,467	51,564	0.96	15,430	269	0.015	0.005
1905	52,010	32,394	51,462	0.96	15,431	279	0.018	0.005
1906	51,908	32,322	51,359	0.96	15,433	290	0.018	0.006
1907	51,805	32,249	51,256	0.96	15,435	301	0.018	0.006
1908	51,702	32,176	51,153	0.95	15,437	312	0.018	0.006
1909	51,599	32,103	51,050	0.95	15,439	322	0.021	0.006
1910	51,496	32,030	50,947	0.95	15,442	333	0.021	0.007
1911	51,392	31,956	50,844	0.95	15,446	344	0.021	0.007
1912	51,289	31,883	50,740	0.95	15,450	354	0.021	0.007
1913	51,187	31,810	50,638	0.94	15,455	365	0.021	0.007
1914	51,084	31,736	50,535	0.94	15,460	376	0.024	0.007
1915	50,982	31,663	50,433	0.94	15,466	387	0.024	0.008
1916	50,881	31,591	50,332	0.94	15,473	392	0.024	0.008
1917	50,785	31,521	50,236	0.94	15,480	534	0.033	0.011
1918	50,564	31,369	50,014	0.93	15,487	430	0.027	0.009
1919	50,460	31,293	49,910	0.93	15,497	338	0.021	0.007
1920	50,457	31,284	49,907	0.93	15,508	234	0.015	0.005
1921	50,562	31,347	50,011	0.93	15,521	298	0.018	0.006
1922	50,606	31,372	50,054	0.93	15,535	431	0.027	0.009
1923	50,524	31,313	49,972	0.93	15,548	434	0.027	0.009
1924	50,448	31,258	49,895	0.93	15,562	541	0.033	0.011
1925	50,277	31,139	49,725	0.92	15,576	536	0.033	0.011
1926	50,126	31,032	49,572	0.92	15,591	530	0.033	0.011
1927	49,995	30,938	49,442	0.92	15,608	642	0.039	0.013
1928	49,772	30,782	49,218	0.91	15,624	630	0.039	0.013
1929	49,582	30,646	49,027	0.91	15,642	718	0.042	0.015
1930	49,326	30,466	48,770	0.90	15,661	670	0.042	0.014
1931	49,141	30,332	48,585	0.90	15,686	687	0.042	0.014
1932	48,963	30,201	48,406	0.90	15,721	820	0.048	0.017
1933	48,685	30,000	48,127	0.89	15,768	855	0.048	0.018
1934	48,411	29,797	47,852	0.88	15,853	1638	0.084	0.034
1935	47,426	29,120	46,865	0.86	15,997	1620	0.084	0.035
1936	46,538	28,498	45,973	0.85	16,228	1329	0.072	0.029
1937	46,017	28,107	45,446	0.83	16,550	1909	0.096	0.042
1938	45,026	27,393	44,447	0.81	16,910	2177	0.108	0.049
1939	43,899	26,572	43,308	0.79	17,142	2669	0.126	0.062
1940	42,449	25,513	41,846	0.76	16,968	2565	0.126	0.061
1941	41,272	24,617	40,665	0.73	16,304	2311	0.12	0.057
1942	40,502	23,987	39,904	0.71	15,412	3231	0.144	0.081
1943	38,996	22,880	38,423	0.68	14,682	3368	0.153	0.088
1944	37,490	21,830	36,948	0.65	14,406	2666	0.138	0.072
1945	36,720	21,342	36,200	0.63	14,380	2498	0.135	0.069
1946	36,111	21,015	35,599	0.62	13,860	3793	0.171	0.107

Table 25: Time-series of population estimates from the base model.

Year	Total biomass (mt)	Spawning output (million eggs)	Summary biomass 3+	Relative biomass	Age-0 recruits	Estimated total catch (mt)	1-SPR	Exploit. rate
1947	34,245	19,889	33,739	0.59	12,572	3141	0.162	0.093
1948	32,990	19,157	32,507	0.57	11,367	4515	0.195	0.139
1949	30,379	17,545	29,942	0.52	10,642	4412	0.201	0.147
1950	27,826	16,002	27,428	0.47	10,528	4631	0.21	0.169
1951	25,040	14,316	24,662	0.42	11,016	3040	0.186	0.123
1952	23,756	13,607	23,377	0.40	11,893	2786	0.183	0.119
1953	22,684	13,013	22,285	0.39	12,482	2363	0.177	0.106
1954	21,996	12,617	21,569	0.37	12,693	2892	0.195	0.134
1955	20,823	11,827	20,378	0.35	12,559	2570	0.192	0.126
1956	20,035	11,209	19,585	0.33	12,341	2275	0.186	0.116
1957	19,623	10,816	19,178	0.32	12,274	2917	0.207	0.152
1958	18,690	10,111	18,252	0.30	12,382	2873	0.21	0.157
1959	17,888	9,532	17,450	0.28	12,558	2454	0.201	0.141
1960	17,570	9,277	17,126	0.28	16,631	2869	0.213	0.168
1961	16,954	8,831	16,478	0.26	15,926	3449	0.231	0.209
1962	15,926	8,083	15,343	0.24	10,430	3295	0.234	0.215
1963	15,195	7,450	14,668	0.22	11,210	3344	0.237	0.228
1964	14,496	6,866	14,117	0.20	15,860	2802	0.231	0.198
1965	14,321	6,740	13,890	0.20	14,645	2662	0.231	0.192
1966	14,322	6,830	13,757	0.20	30,151	2689	0.231	0.196
1967	14,430	6,882	13,808	0.20	12,986	2729	0.231	0.198
1968	14,781	6,817	13,833	0.20	13,745	2438	0.225	0.176
1969	15,629	6,917	15,162	0.21	12,649	2491	0.222	0.164
1970	16,502	7,202	16,021	0.21	13,453	3216	0.237	0.201
1971	16,633	7,460	16,177	0.22	13,035	3335	0.237	0.206
1972	16,498	7,812	16,024	0.23	10,720	3602	0.24	0.225
1973	15,914	7,832	15,469	0.23	9,056	3102	0.234	0.201
1974	15,520	7,836	15,150	0.23	11,843	3915	0.249	0.258
1975	14,098	7,163	13,756	0.21	11,974	3774	0.252	0.274
1976	12,617	6,396	12,194	0.19	15,157	3103	0.249	0.254
1977	11,685	5,874	11,238	0.17	13,639	2549	0.24	0.227
1978	11,343	5,540	10,818	0.16	9,990	3276	0.258	0.303
1979	10,409	4,770	9,951	0.14	9,846	3393	0.264	0.341
1980	9,385	4,018	9,031	0.12	11,374	2847	0.264	0.315
1981	8,816	3,715	8,456	0.11	9,829	2740	0.264	0.324
1982	8,276	3,542	7,884	0.11	8,326	2757	0.267	0.35
1983	7,695	3,287	7,356	0.10	9,946	2485	0.267	0.338
1984	7,255	3,110	6,945	0.09	15,053	1933	0.258	0.278
1985	7,274	3,151	6,888	0.09	9,192	1879	0.258	0.273
1986	7,376	3,199	6,886	0.09	5,397	2144	0.261	0.311
1987	7,251	3,048	6,951	0.09	7,193	2555	0.27	0.367
1988	6,659	2,680	6,452	0.08	10,830	2358	0.27	0.366
1989	6,127	2,506	5,844	0.07	13,416	2303	0.273	0.394
1990	5,591	2,372	5,188	0.07	13,288	1962	0.27	0.378
1991	5,423	2,223	4,951	0.07	9,484	2148	0.276	0.434
1992	5,228	1,836	4,787	0.05	5,212	1825	0.273	0.381
1993	5,402	1,708	5,094	0.05	10,017	1693	0.27	0.332
1994	5,746	1,851	5,524	0.05	12,254	1552	0.264	0.281
1995	6,205	2,296	5,836	0.07	7,664	1684	0.261	0.289
1996	6,538	2,686	6,135	0.08	9,278	1936	0.261	0.316
1997	6,609	2,768	6,325	0.08	8,685	2057	0.261	0.325
1998	6,539	2,643	6,207	0.08	20,481	1746	0.258	0.281

Table 25: Time-series of population estimates from the base model.

Year	Total biomass (mt)	Spawning output (million eggs)	Summary biomass 3+	Relative biomass	Age-0 recruits	Estimated total catch (mt)	1-SPR	Exploit. rate
1999	6,785	2,729	6,395	0.08	13,960	1626	0.252	0.254
2000	7,334	2,941	6,656	0.09	9,890	1923	0.255	0.289
2001	7,837	2,986	7,371	0.09	8,435	1986	0.255	0.269
2002	8,397	3,035	8,055	0.09	9,564	2079	0.255	0.258
2003	8,865	3,305	8,558	0.10	8,015	1789	0.246	0.209
2004	9,506	3,950	9,176	0.12	9,522	2285	0.249	0.249
2005	9,574	4,345	9,278	0.13	10,325	3002	0.258	0.324
2006	8,824	4,131	8,474	0.12	18,853	2210	0.249	0.261
2007	8,717	4,060	8,286	0.12	22,276	2400	0.252	0.29
2008	8,642	3,766	7,942	0.11	29,498	2175	0.249	0.274
2009	9,204	3,584	8,371	0.11	12,984	2323	0.255	0.278
2010	10,199	3,448	9,272	0.10	9,787	914	0.201	0.099
2011	12,845	4,396	12,406	0.13	9,683	781	0.174	0.063
2012	15,710	5,957	15,360	0.18	13,760	1135	0.177	0.074
2013	18,104	7,887	17,730	0.23	12,874	1954	0.198	0.11
2014	19,478	9,514	18,995	0.28	14,272	2361	0.195	0.124
2015	20,175	10,531	19,707	0.31	14,418	10	0.003	0.001
2016	22,815	12,329	22,306	0.37	14,621	10	0.003	0
2017	25,322	13,910	24,808	0.41	14,760	10	0	0
2018	27,699	15,401	27,178	0.46	14,867	10	0	0
2019	29,948	16,841	29,422	0.50	14,953	-	-	-

Table 26: Sensitivity of the base model

Label	Base	Harmonic weights	Steepness = 0.40	Steepness = 0.72	Old Maturity	Old Fecundity	2008 Recruitment
Total Likelihood	1639.130	2441.720	1639.950	1638.250	1639.140	1639.130	1877.740
Survey Likelihood	-13.514	-13.870	-13.676	-13.421	-13.515	-13.509	-12.863
Discard Likelihood	-34.574	-17.102	-34.425	-34.744	-34.578	-34.578	56.929
Length Likelihood	143.504	742.387	143.129	143.932	143.501	143.516	191.232
Age Likelihood	1531.080	1711.000	1531.410	1530.680	1531.100	1531.070	1636.830
Recruitment Likelihood	11.618	18.273	11.623	11.661	11.620	11.616	4.595
Forecast Recruitment Likelihood	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Parameter Priors Likelihood	1.000	1.000	1.870	0.125	1.000	1.000	1.000
Parameter Deviation Likelihood	0.000	0.000	0.000	0.000	0.000	0.000	0.000
log(R0)	9.402	9.270	9.341	9.450	9.401	9.403	9.392
SB Virgin	6889.170	6155.290	6475.990	7239.700	6758.200	8213.080	6908.240
SB 2017	5280.380	3723.450	3585.220	7002.320	5280.670	6473.350	4074.950
Depletion 2017	0.766	0.605	0.554	0.967	0.781	0.788	0.590
Total Yield - SPR 50	1822.490	1620.140	1028.650	2560.050	1818.760	1844.750	1823.380
Steepness	0.500	0.500	0.400	0.720	0.500	0.500	0.500
Natural Mortality - Female	0.054	0.054	0.054	0.054	0.054	0.054	0.054
Length at Amin - Female	20.754	20.649	20.753	20.756	20.753	20.754	20.373
Length at Amax - Female	41.601	41.726	41.596	41.611	41.601	41.601	41.727
Von Bert. k - Female	0.167	0.169	0.167	0.167	0.167	0.167	0.175
SD young - Female	1.349	1.336	1.349	1.348	1.349	1.349	1.397
SD old - Female	2.560	2.772	2.562	2.558	2.561	2.560	2.516
Natural Mortality - Male	0.054	0.054	0.054	0.054	0.054	0.054	0.054
Length at Amin - Male	20.754	20.649	20.753	20.756	20.753	20.754	20.373
Length at Amax - Male	38.925	38.933	38.917	38.938	38.926	38.925	39.087
Von Bert. k - Male	0.198	0.201	0.198	0.197	0.198	0.198	0.204
SD young - Male	1.349	1.336	1.349	1.348	1.349	1.349	1.397
SD old - Male	2.280	2.587	2.281	2.279	2.280	2.280	2.203

Table 27: Sensitivity of the base model

Label	Base	Include Triennial	Only Triennial	Include CPUE	Canadian Data	WA Research Lengths	OR Special Projects
Total Likelihood	1639.13	1665.44	164.52	1639.13	1732.43	1661.35	1704.70
Survey Likelihood	-13.51	-12.94	-4.72	-13.51	-13.75	-13.52	-13.56
Discard Likelihood	-34.57	-34.44	-41.41	-34.57	-34.34	-34.53	-33.98
Length Likelihood	143.50	149.40	103.50	143.50	183.12	164.57	171.18
Age Likelihood	1531.08	1550.29	98.85	1531.08	1583.84	1532.08	1566.68
Recruitment Likelihood	11.62	12.11	5.13	11.62	12.53	11.73	13.36
Forecast Recruitment Likelihood	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parameter Priors Likelihood	1.00	1.00	3.16	1.00	1.00	1.00	1.00
Parameter Deviation Likelihood	0.00	0.00	0.00	0.00	0.00	0.00	0.00
log(R0)	9.40	9.34	9.18	9.40	9.40	9.38	9.33
SB Virgin	6889.17	6509.19	5494.23	6889.17	6932.47	6705.96	6447.45
SB 2017	5280.38	4763.81	614.09	5280.38	5046.25	5015.16	4700.25
Depletion 2017	0.77	0.73	0.11	0.77	0.73	0.75	0.73
Total Yield - SPR 50	1822.49	1721.47	26.65	1822.49	1856.88	1788.49	1699.53
Steepness	0.50	0.50	0.33	0.50	0.50	0.50	0.50
Natural Mortality - Female	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Length at Amin - Female	20.75	20.76	20.75	20.75	20.74	20.74	20.78
Length at Amax - Female	41.60	41.60	41.60	41.60	41.66	41.53	41.64
Von Bert. k - Female	0.17	0.17	0.17	0.17	0.17	0.17	0.17
SD young - Female	1.35	1.35	1.35	1.35	1.35	1.35	1.34
SD old - Female	2.56	2.56	2.56	2.56	2.55	2.56	2.58
Natural Mortality - Male	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Length at Amin - Male	20.75	20.76	20.75	20.75	20.74	20.74	20.78
Length at Amax - Male	38.93	38.92	38.92	38.93	38.95	38.89	38.98
Von Bert. k - Male	0.20	0.20	0.20	0.20	0.20	0.20	0.20
SD young - Male	1.35	1.35	1.35	1.35	1.35	1.35	1.34
SD old - Male	2.28	2.28	2.28	2.28	2.28	2.29	2.34

Table 28: Data weights applied when using harmonic data weighting.

Fleet	Lengths	Ages
Fishery	0.361	0.77
At-sea hake	0.621	0.14
Pacific ocean perch survey	1.000	1
AFSC slope survey	0.696	1
NWFSC slope survey	0.463	-
NWFSC shelf-slope survey	0.549	0.348

Table 29: Projection of potential OFL, spawning biomass, and depletion for the base case model. The removals in 2017 and 2018 were set at the defined management specification of 281 mt for each year assuming full attainment.

Year	OFL (mt)	ACL (mt)	Spawning Output	Depletion (%)
2019	4753	4340	5741	83.3
2020	4632	4229	5745	83.4
2021	4499	4108	5723	83.1
2022	4364	3984	5666	82.2
2023	4230	3862	5586	81.1
2024	4105	3748	5494	79.8
2025	3991	3644	5395	78.3
2026	3889	3551	5292	76.8
2027	3797	3467	5188	75.3
2028	3712	3389	5084	73.8

Table 30: Decision table summary of 10-year projections beginning in 2021 for alternate states of nature based on an axis of uncertainty for the base model. The removals in 2017 and 2018 were set at the defined management specification of 281 mt for each year assuming full attainment. Columns range over low, mid, and high states of nature over natural mortality, and rows range over different assumptions of catch levels. An entry of "–" indicates that the stock is driven to very low abundance under the particular scenario.

			States of nature					
			M = 0.04725		M = 0.054		M = 0.0595	
	Year	Catch	Spawning Output	Depletion (%)	Spawning Output	Depletion (%)	Spawning Output	Depletion (%)
ABC	2019	4340	3944	62.9	5741	83.3	7505	96.8
	2020	4229	3909	62.4	5745	83.4	7542	97.3
	2021	4108	3858	61.6	5723	83.1	7546	97.3
	2022	3984	3784	60.4	5666	82.2	7503	96.8
	2023	3862	3695	59.0	5586	81.1	7427	95.8
	2024	3748	3600	57.4	5494	79.7	7332	94.6
	2025	3644	3502	55.9	5395	78.3	7226	93.2
	2026	3551	3404	54.3	5292	76.8	7113	91.8
	2027	3467	3308	52.8	5188	75.3	6996	90.3
	2028	3389	3213	51.3	5084	73.8	6879	88.7
SPR50	2019	1822	3944	62.9	5741	83.3	7505	96.8
	2020	1822	4022	64.2	5857	85.0	7654	98.7
	2021	1822	4083	65.1	5946	86.3	7768	100.2
	2022	1822	4117	65.7	5996	87.0	7830	101.0
	2023	1822	4131	65.9	6016	87.3	7852	101.3
	2024	1822	4133	65.9	6017	87.3	7848	101.2
	2025	1822	4125	65.8	6004	87.1	7824	100.9
	2026	1822	4110	65.6	5979	86.8	7786	100.4
	2027	1822	4090	65.3	5947	86.3	7736	99.8
	2028	1822	4067	64.9	5908	85.8	7679	99.1

9 Figures

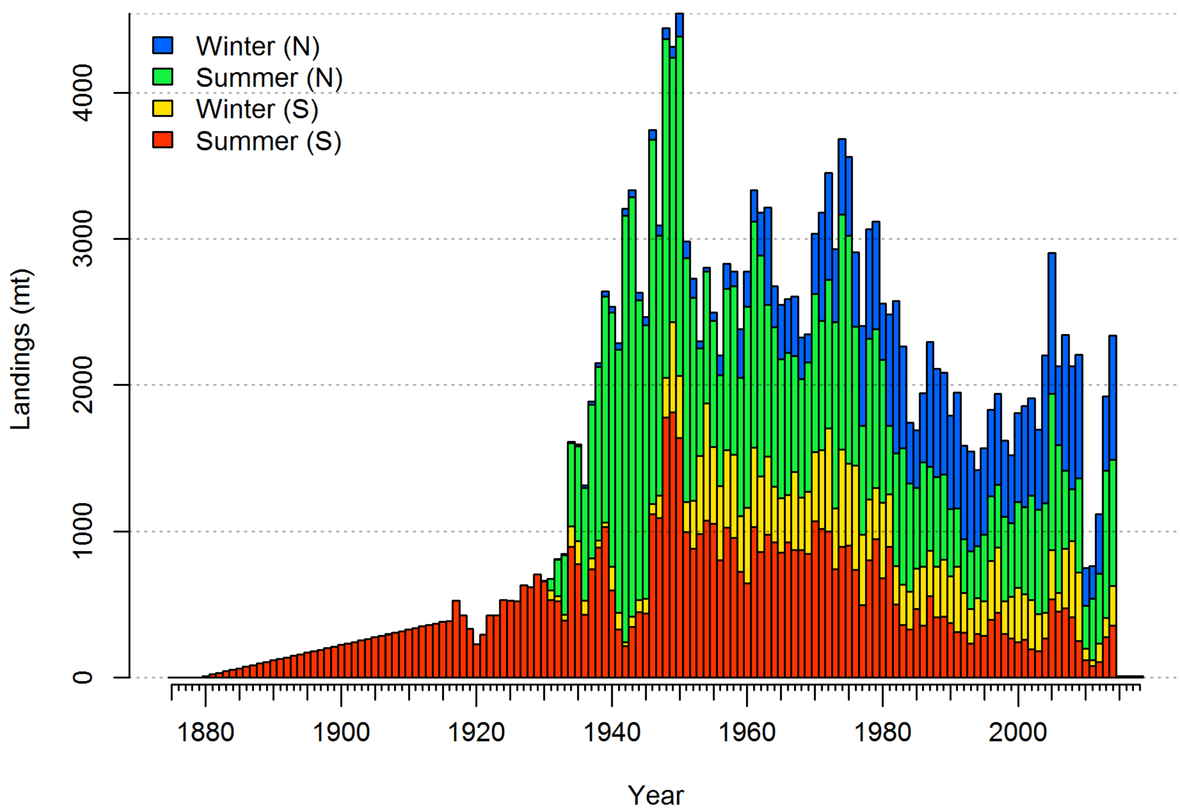

Figure 1: Total catches Petrale sole through 2016.

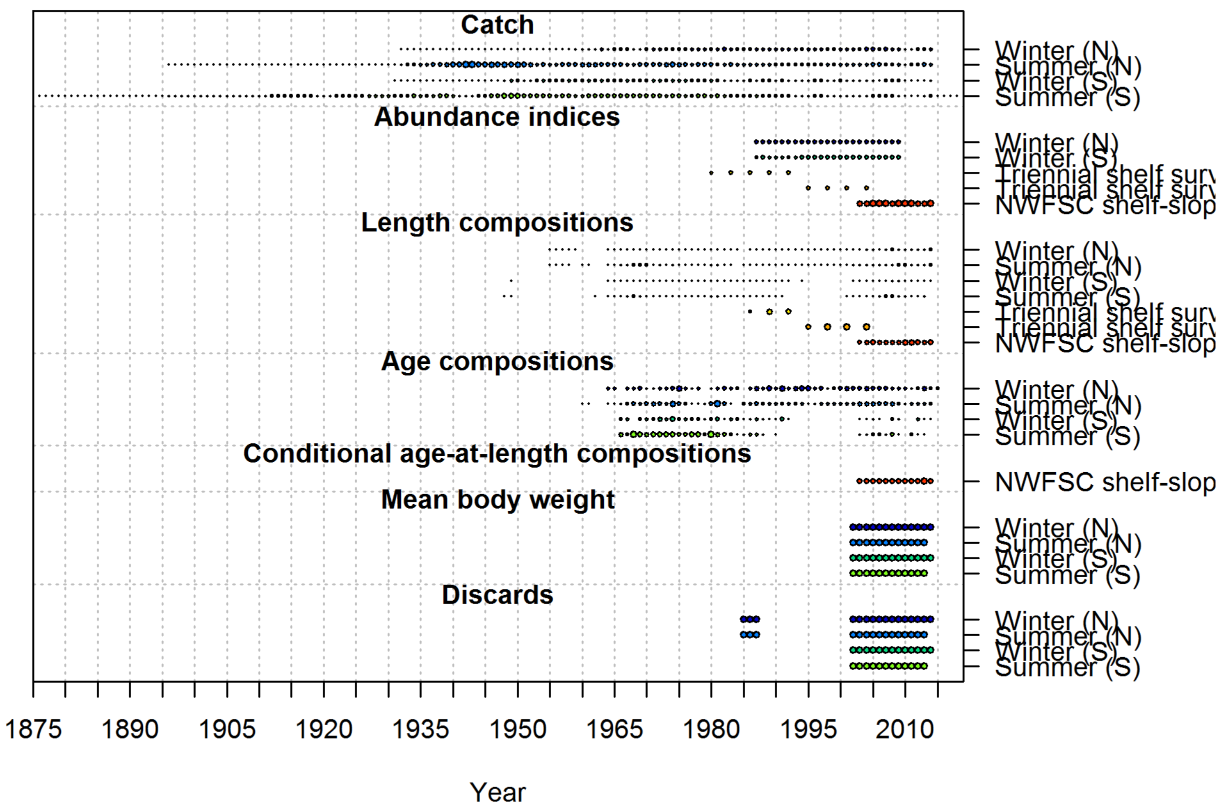

Figure 2: Summary of data sources used in the base model.

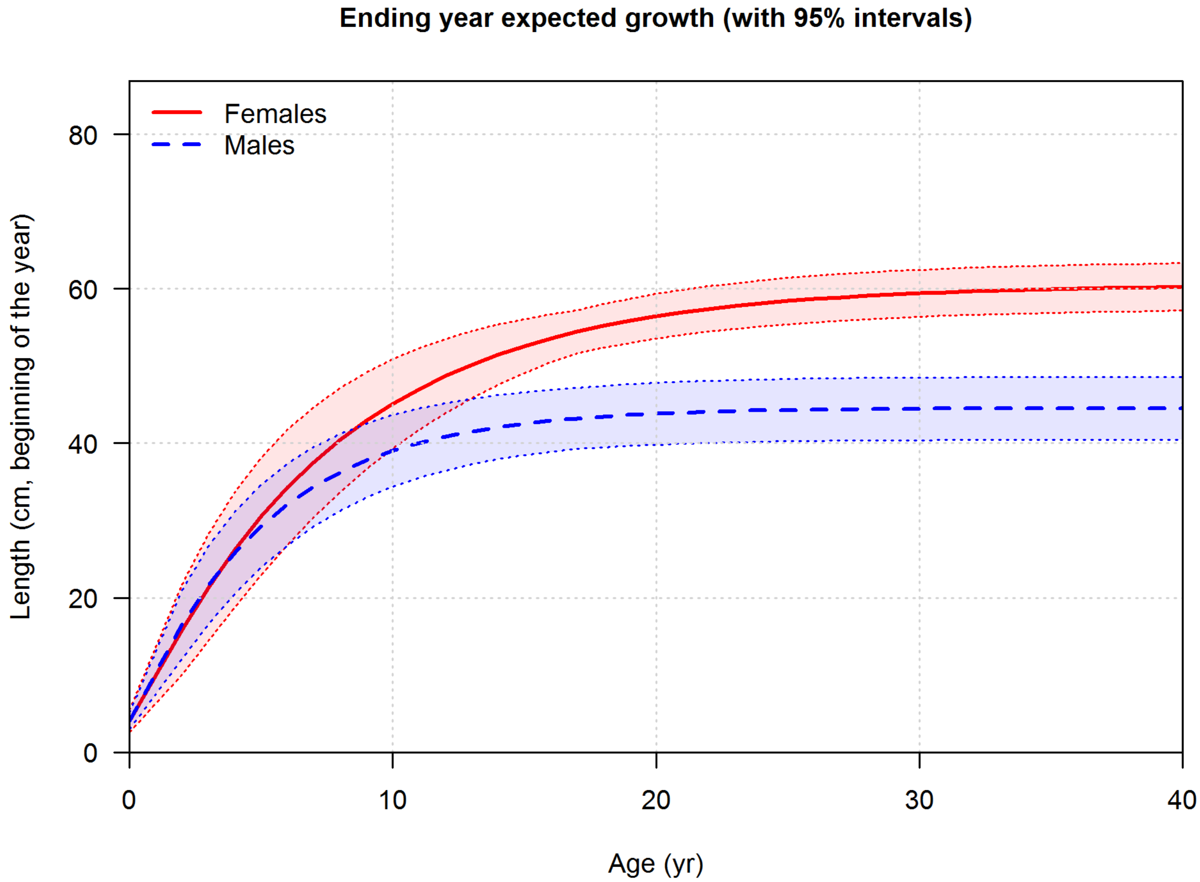

Figure 3: Estimated length-at-age for male and female for Petrale sole with estimated CV.

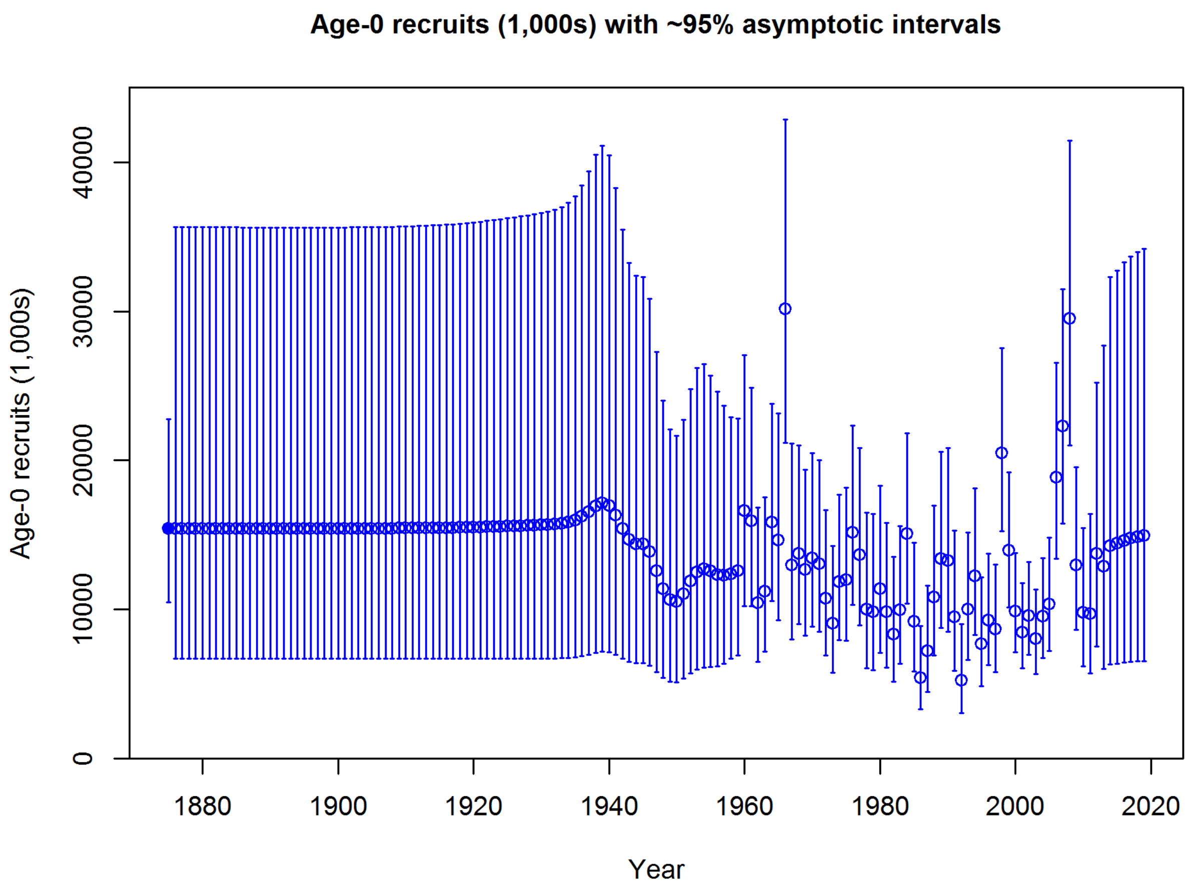

Figure 4: Estimated time-series of recruitment for Petrale sole.

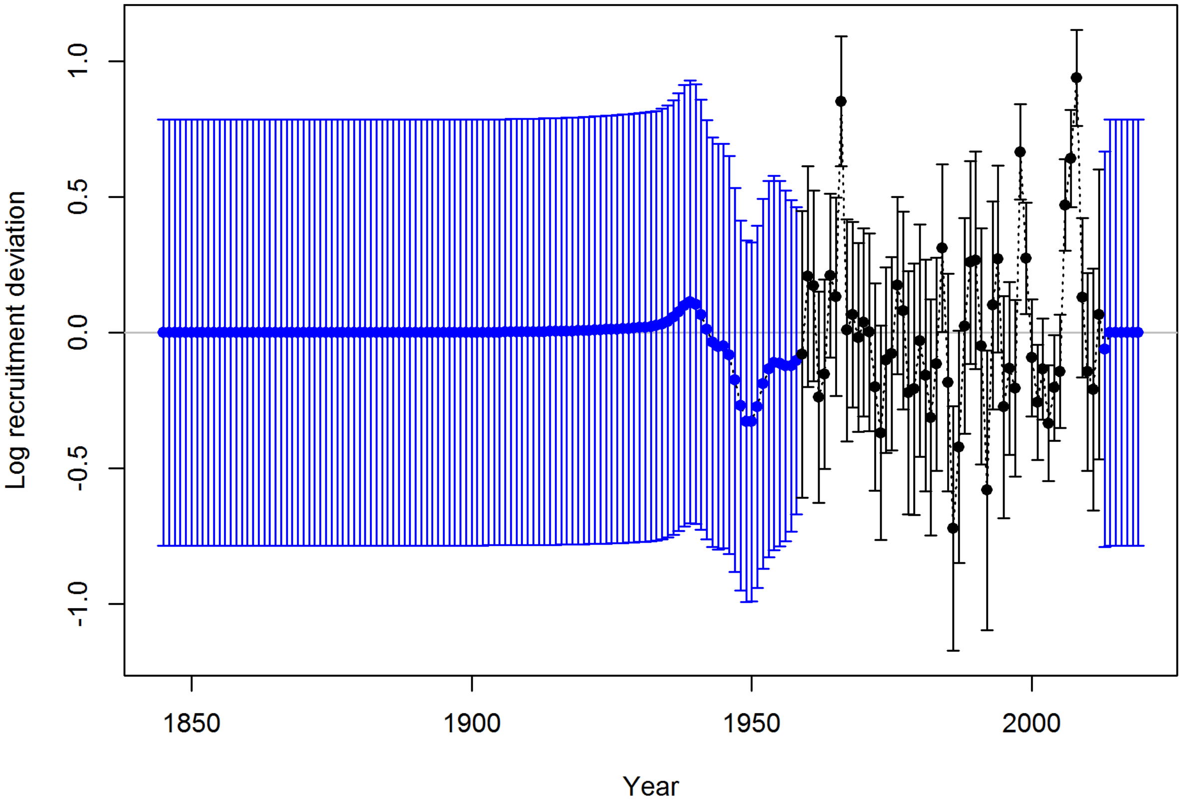

Figure 5: Estimated time-series of recruitment deviations for Petrale sole.

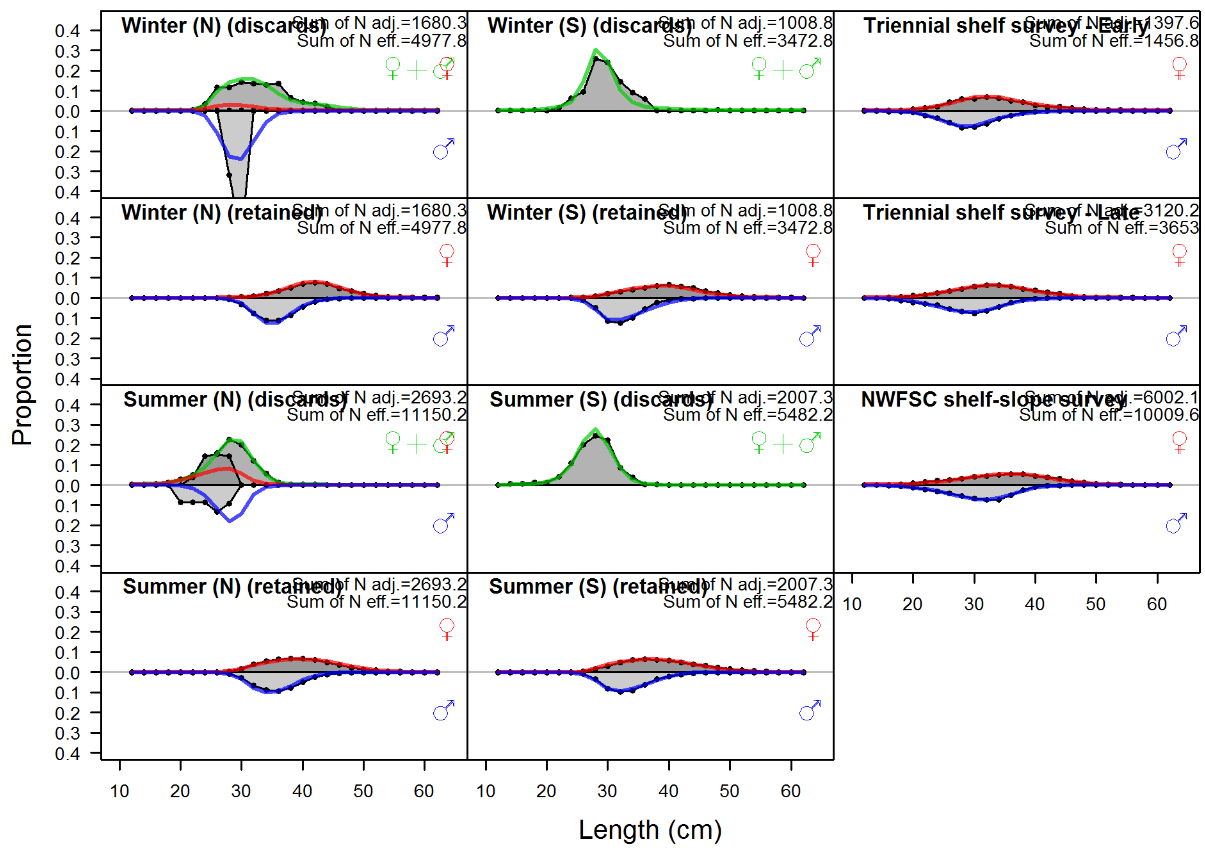

Figure 6: Length compositions aggregated across time by fleet. Labels 'retained' and 'discard' indicate retained or discarded samples for each fleet. Panels without this designation represent the whole catch. The Triennial shelf survey length data were not used in the final model, but the implied model fits are shown.

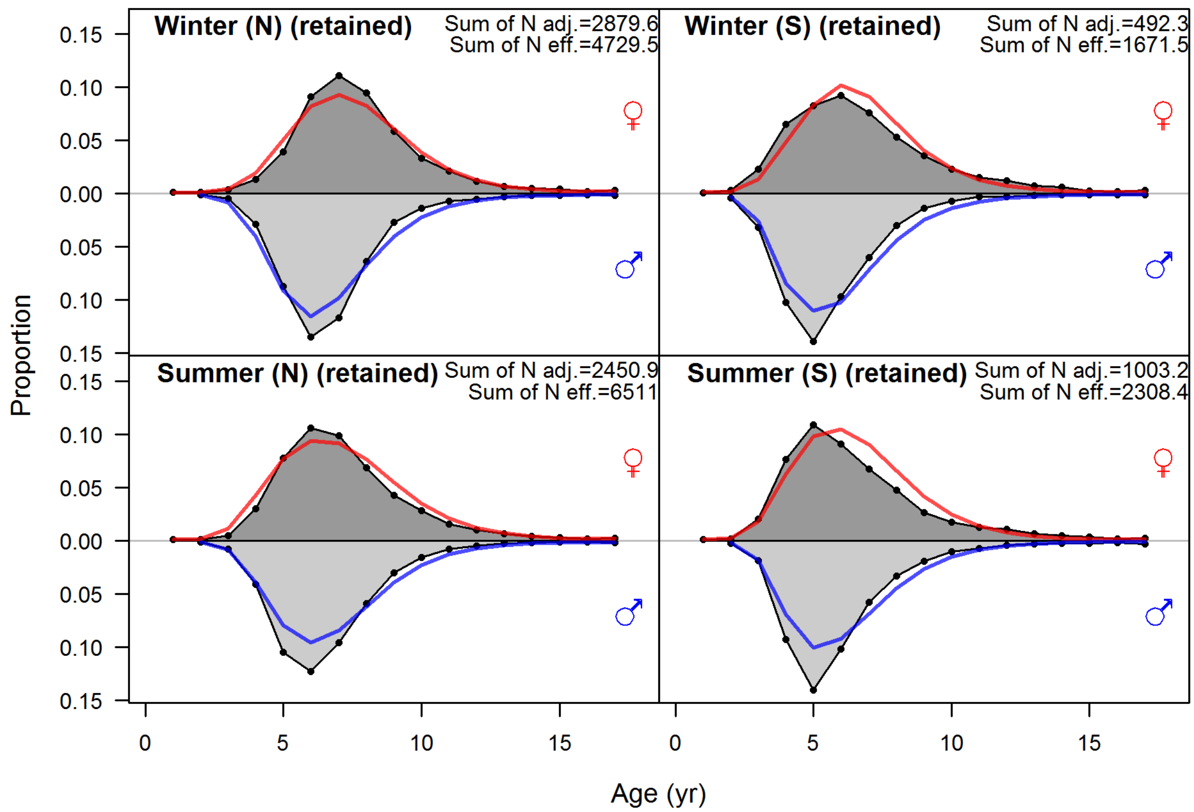

Figure 7: Age compositions aggregated across time by fleet. The Triennial shelf survey age data were not used in the final model, but the implied model fits are shown.

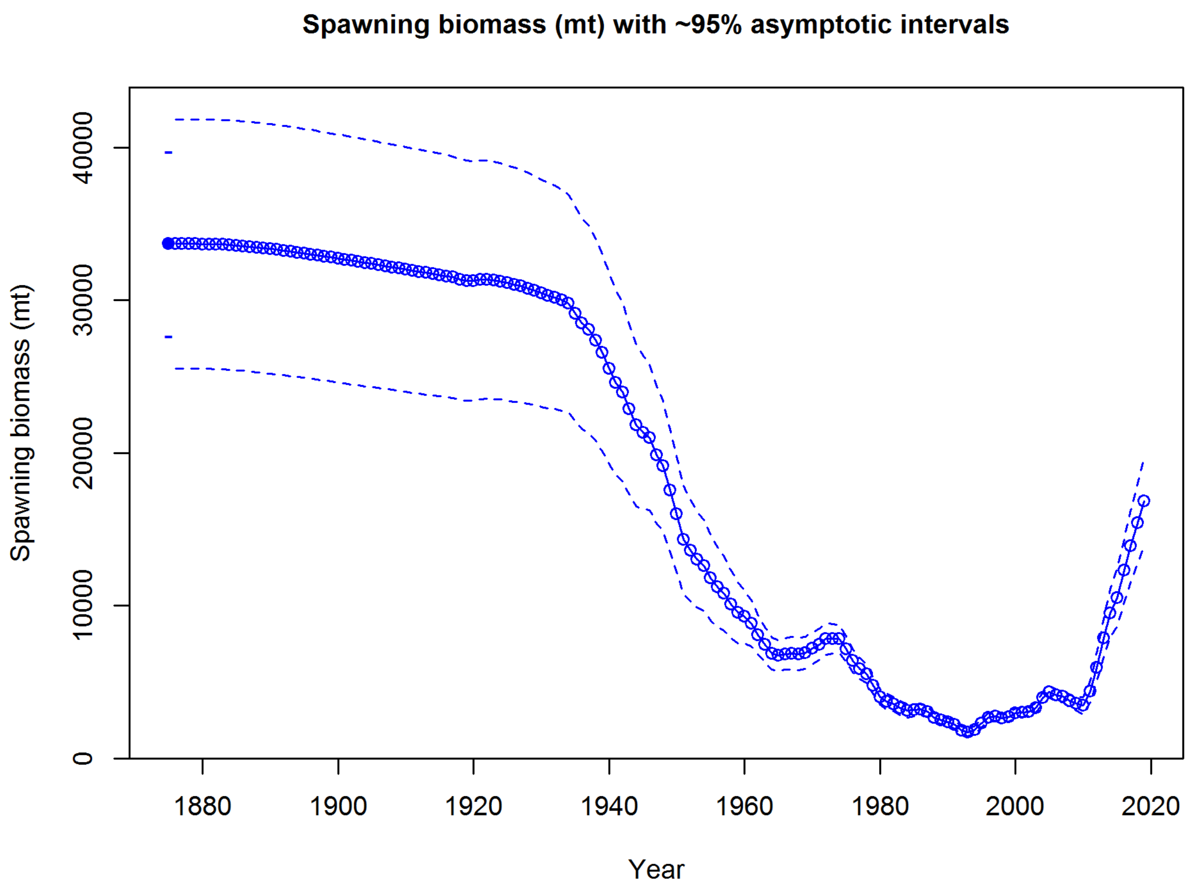

Figure 8: Estimated time-series of spawning output trajectory (circles and line: median; light broken lines: 95% credibility intervals) for Petrale sole.

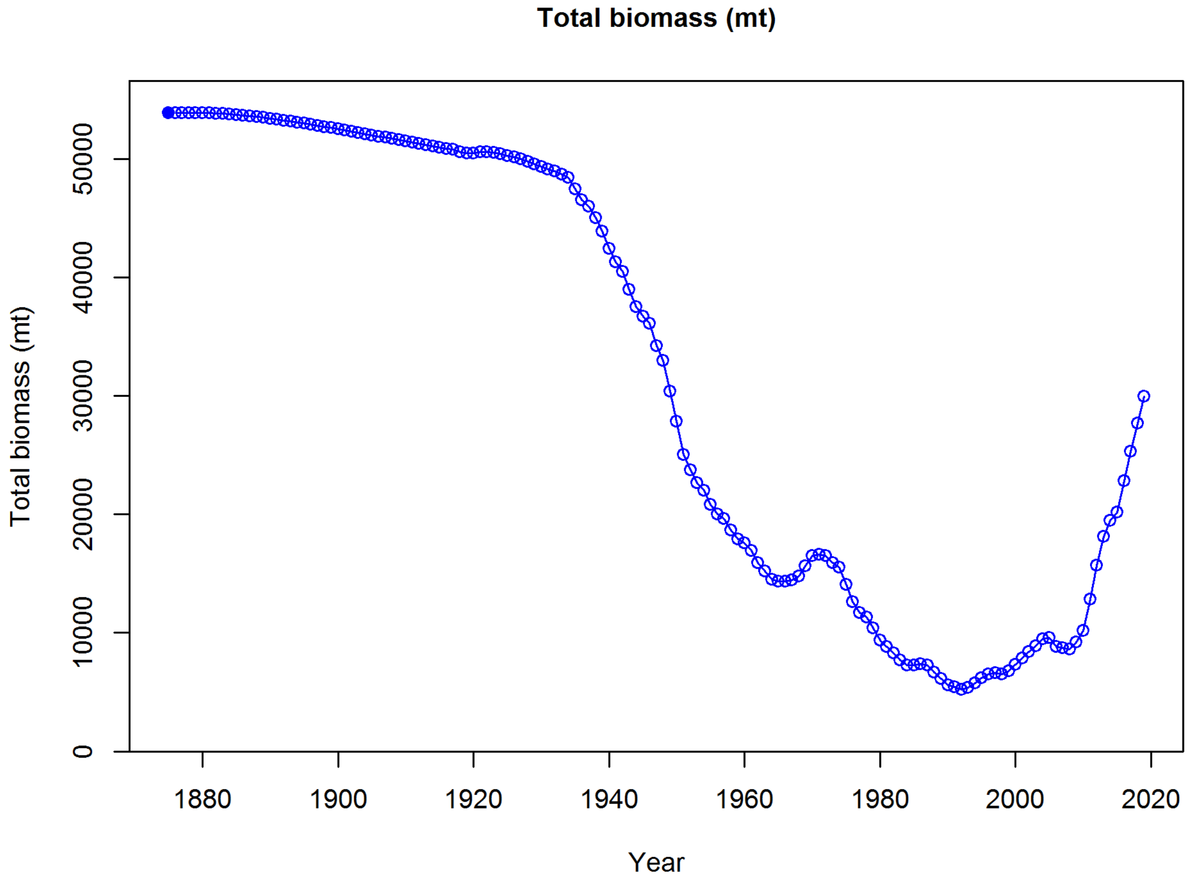

Figure 9: Estimated time-series of total biomass for Petrale sole.

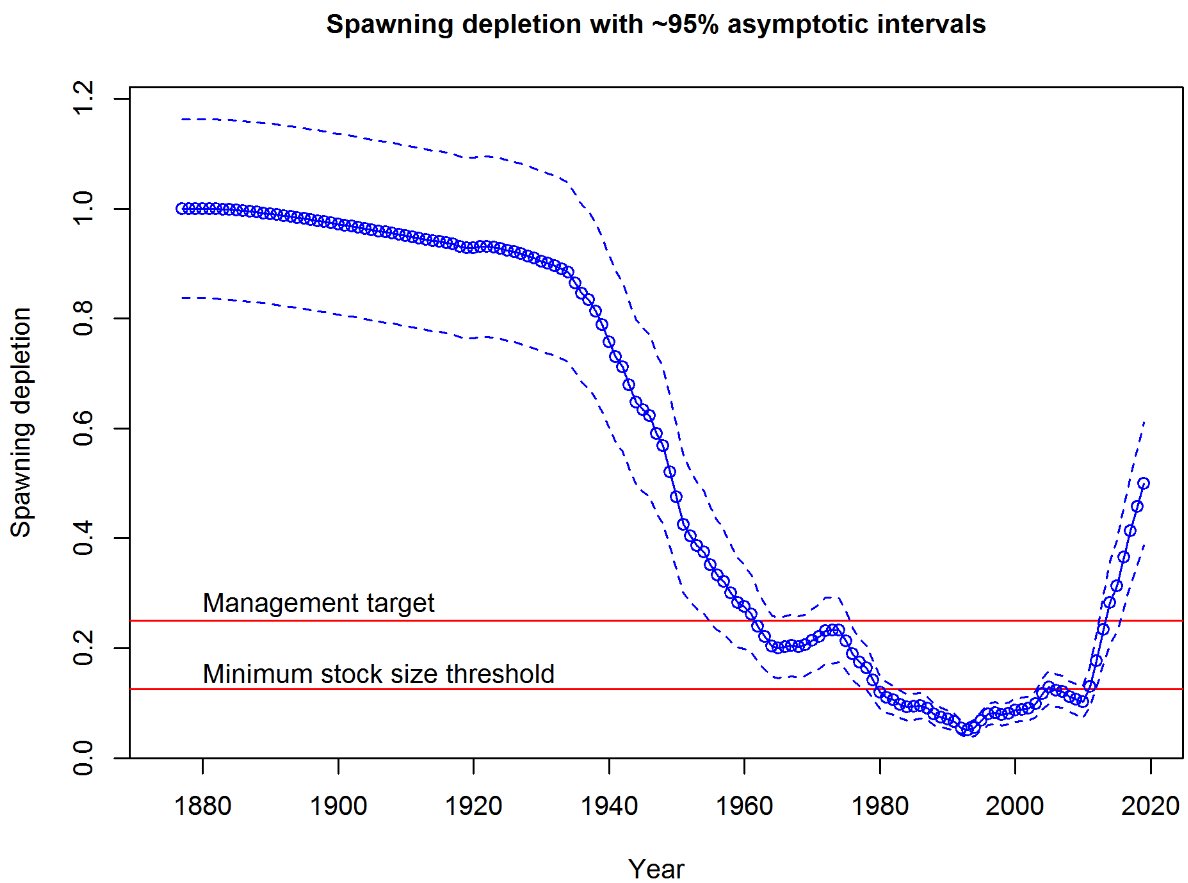

Figure 10: Estimated time-series of relative spawning output (depletion) (circles and line: median; light broken lines: 95% credibility intervals) for Petrale sole.

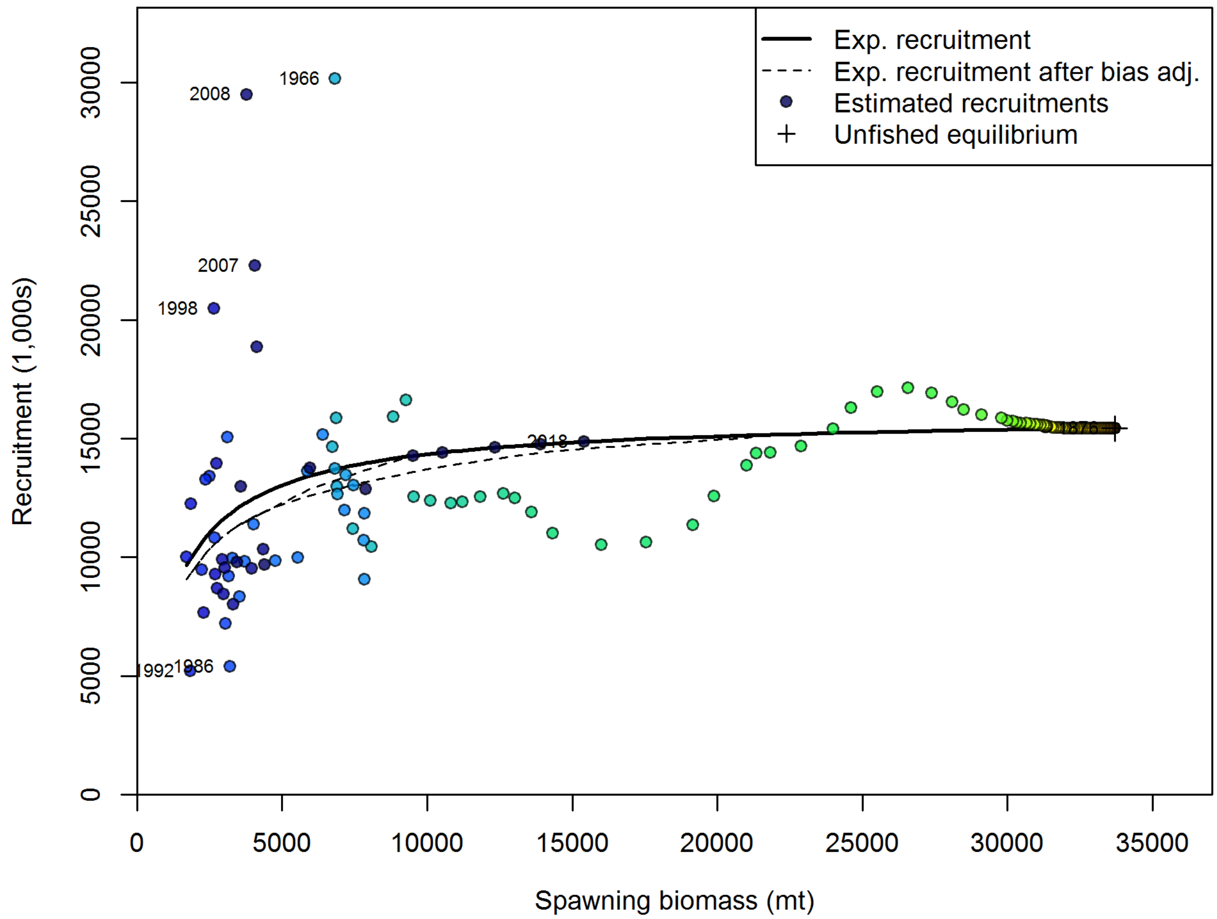

Figure 11: Estimated recruitment (red circles) and the assumed stock-recruit relationship (black line). The green line shows the effect of the bias correction for the lognormal distribution

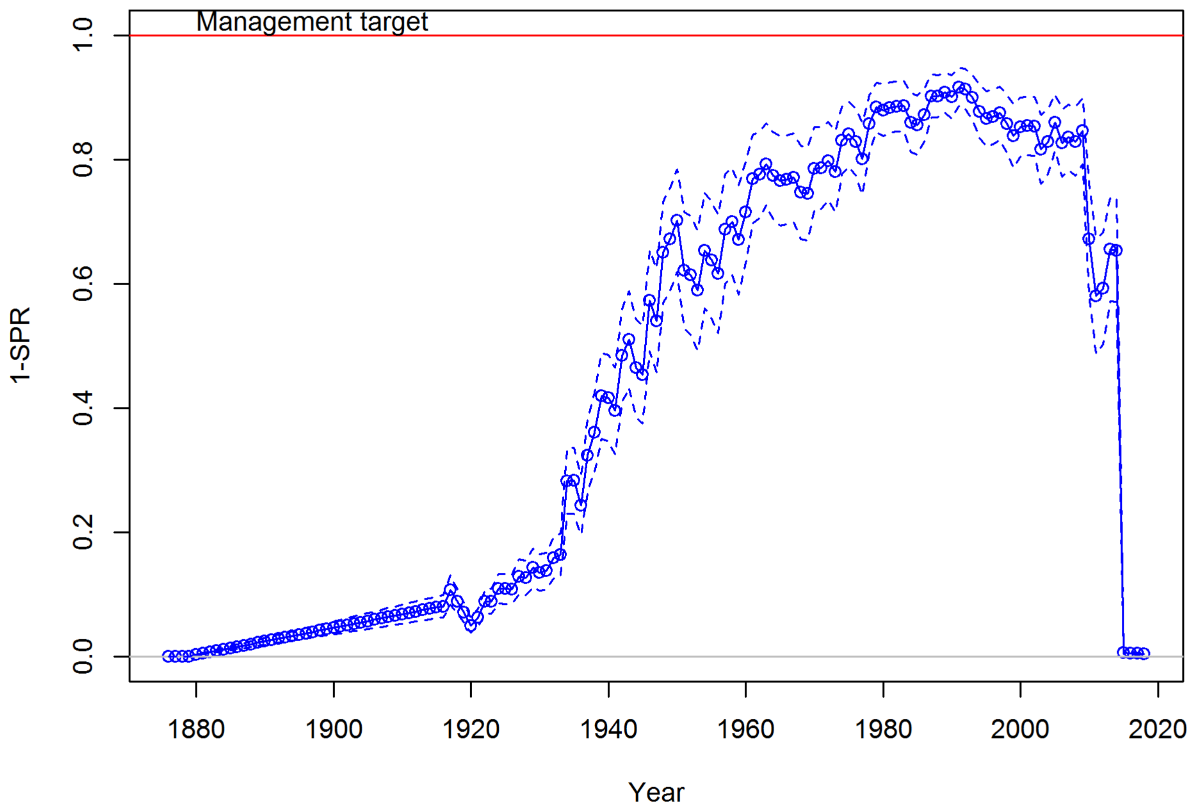

Figure 12: Estimated spawning potential ratio (1-SPR)/(1-SPR30%) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the SPR30% harvest rate. The last year in the time series is 2018.

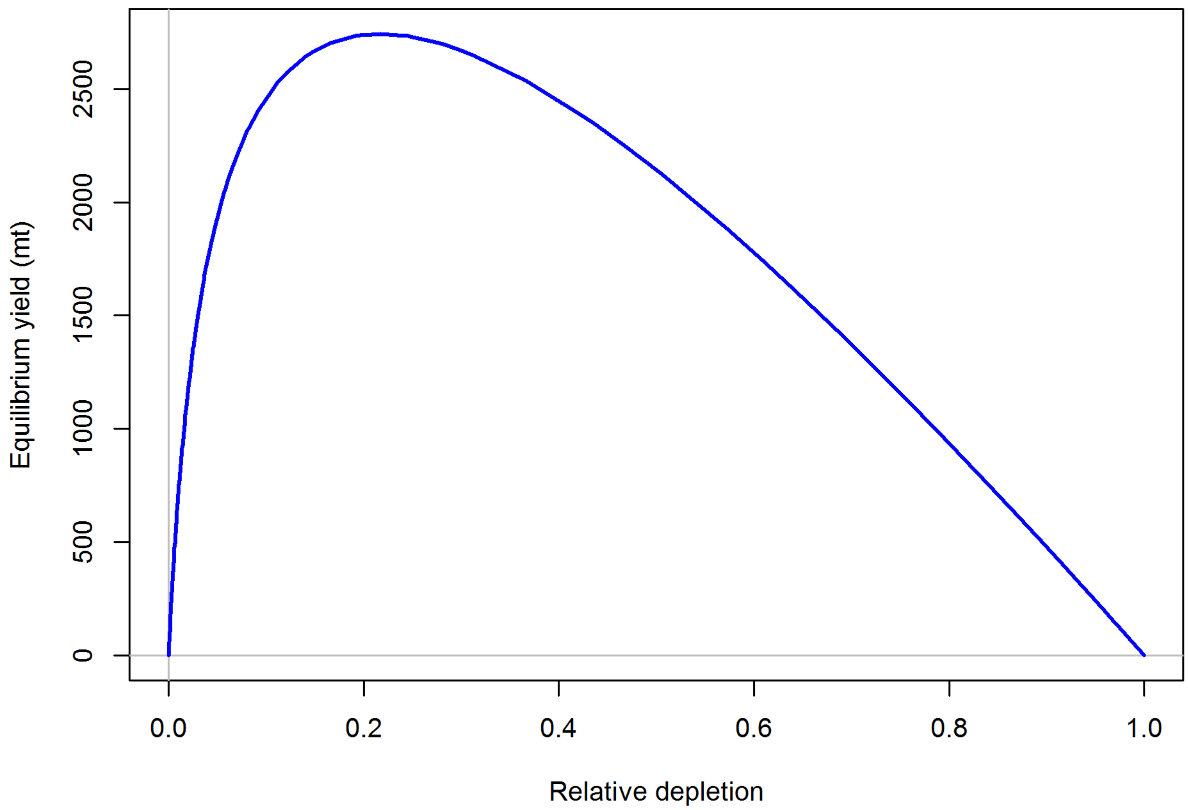

Figure 13: Equilibrium yield curve for the base case model. Values are based on the 2018 fishery selectivity and with steepness fixed at 0.89.

10 References

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