The Combined Status of Gopher (*Sebastes carnatus*) and Black-and-Yellow Rockfishes (*Sebastes chrysomelas*) in U.S. Waters Off California in 2019

Gopher rockfish (left) and black-and-yellow rockfish (right). Photos by Steve Lonhart.

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The Combined Status of Gopher (*Sebastes carnatus*) and Black-and-Yellow Rockfishes (*Sebastes chrysomelas*) in U.S. Waters Off California in 2019

Contents

Executive Summary

Stock

This assessment reports the status of the GBYR (*Sebastes carnatus/Sebastes chrysomelas*) resource in U.S. waters off the coast of ... using data through 2018.

Catches

Information on historical landings of GBYR are available back to xxxx... (Table a). Commercial landings were small during the years of World War II, ranging between 4 to 28 metric tons (mt) per year.

(Figures a-b)
(Figure c)

Since 2000, annual total landings of GBYR have ranged between 70-168 mt, with landings in 2018 totaling 91 mt.

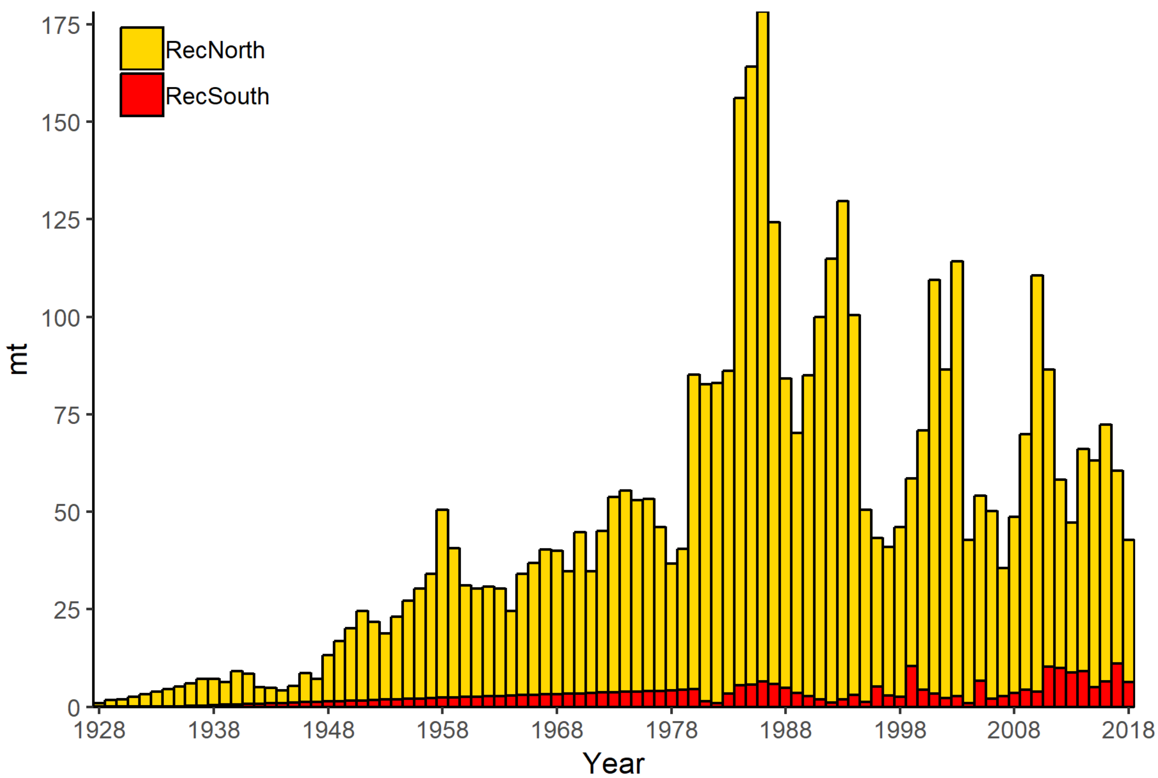

Figure a: Catch history of GBYR for the recreational fleet.

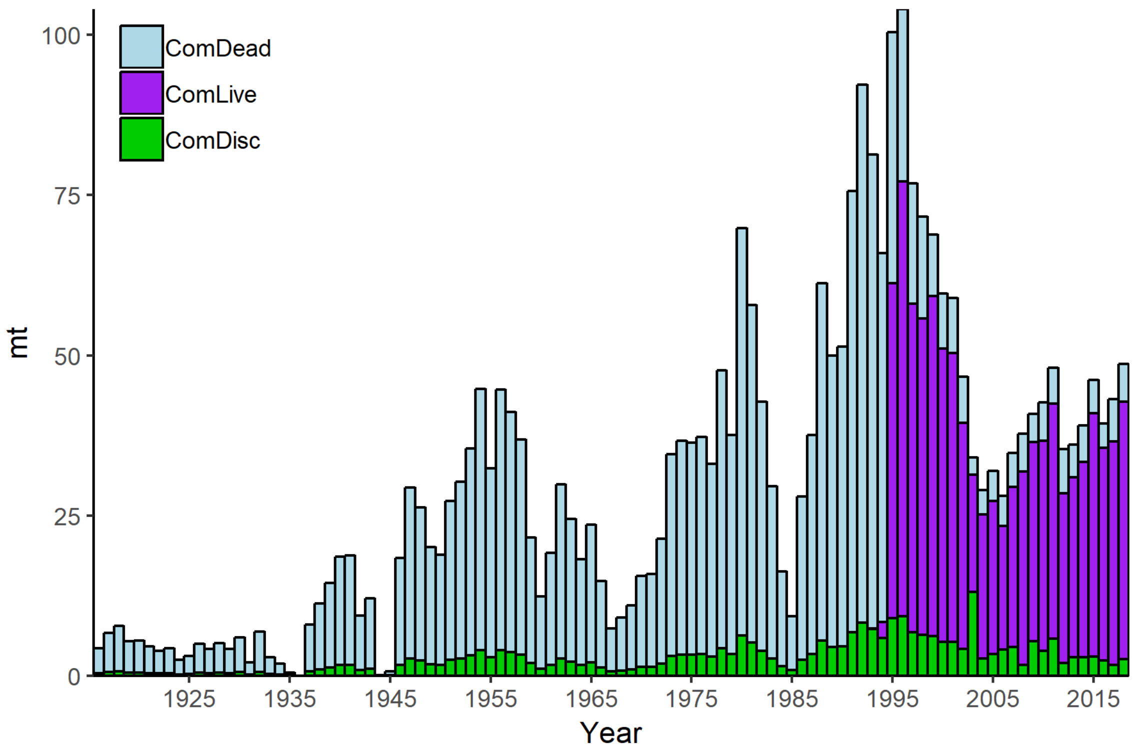

Figure b: Catch history of GBYR for the commercial fleet by dead and live landings, and discards. Catches in 1936 and 1946 were minimal.

Table a: Recent GBYR landings (mt) by fleet.

Year	Commercial Retained	Commercial Discard	Recreational North	Recreational South	Total
2009	35.62	5.38	65.64	4.30	110.93
2010	38.83	3.92	106.76	3.90	153.41
2011	42.39	5.72	76.16	10.24	134.52
2012	33.55	1.93	48.25	9.89	93.62
2013	33.45	2.85	38.43	8.86	83.59
2014	36.40	2.85	56.96	9.06	105.27
2015	43.25	2.93	58.09	5.00	109.27
2016	36.96	2.42	65.72	6.57	111.67
2017	42.04	1.65	49.36	11.15	104.19
2018	47.00	2.54	36.48	6.30	92.32

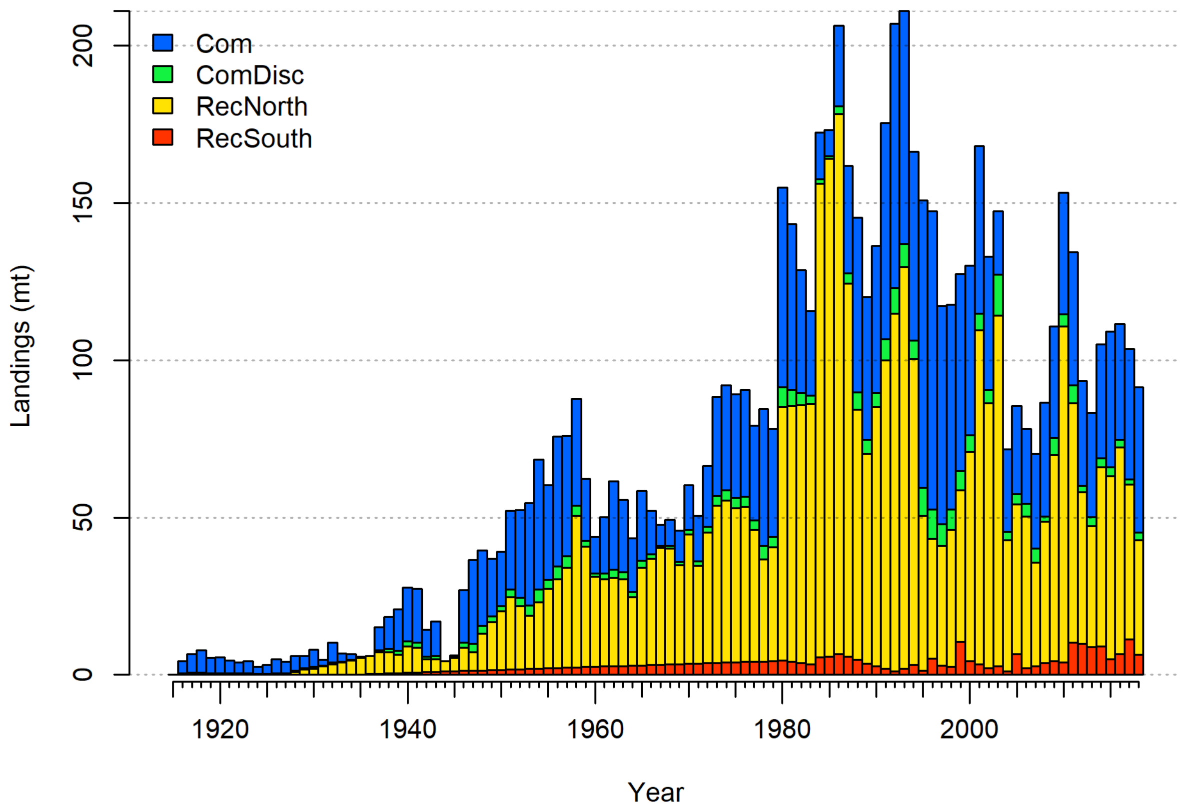

Figure c: Catch history of GBYR in the model.

Data and Assessment

This a new full assessment for GBYR, which was last assessed in ... using Stock Synthesis Version xx. This assessment uses the newest version of Stock Synthesis (3.30.xx). The model begins in 1916, and assumes the stock was at an unfished equilibrium that year.

(Figure d).

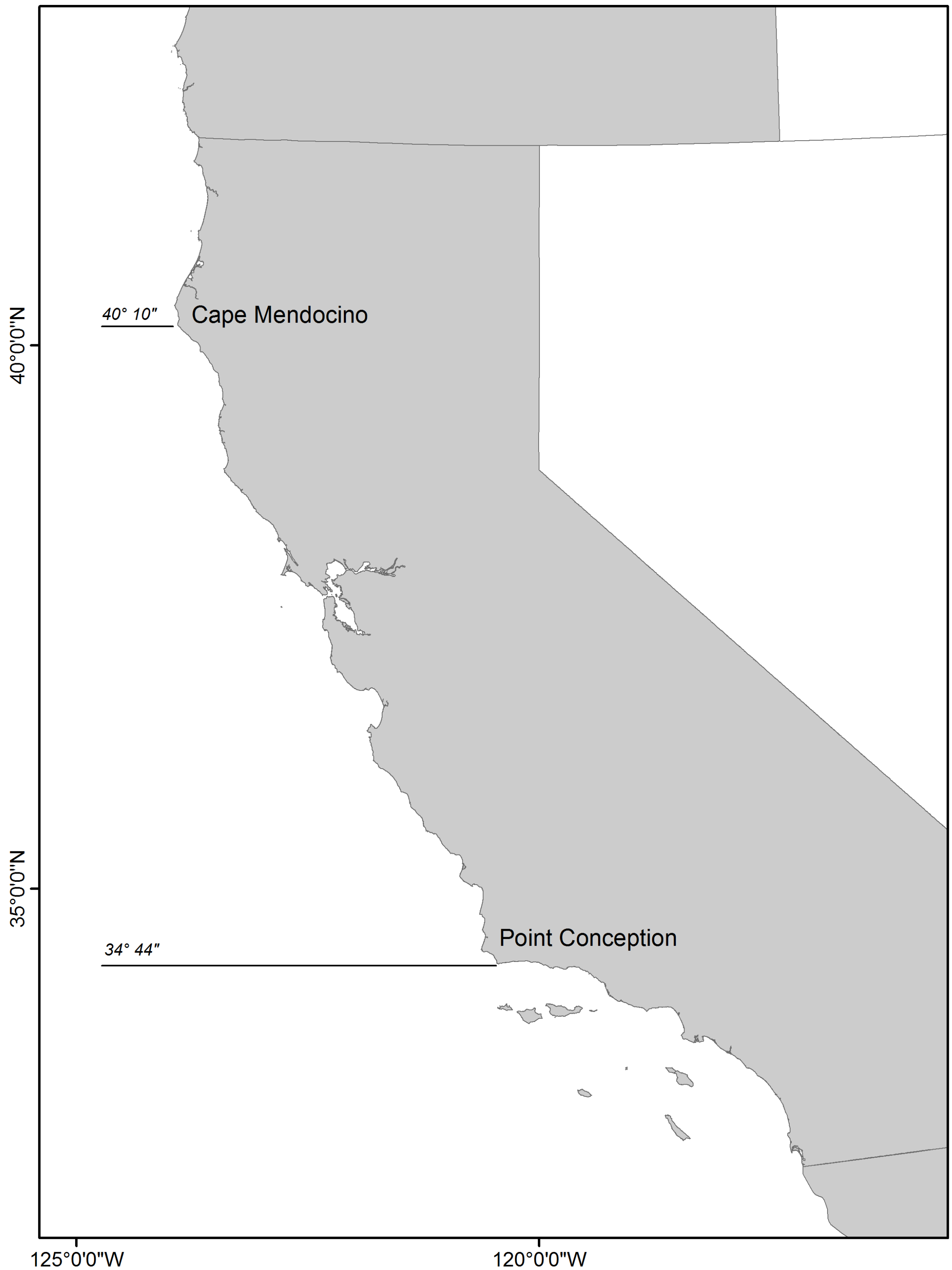

Figure d: Map depicting the core distribution of gopher and black-and-yellow rockfishes. The stock assessment is bounded at Cape Mendocino in the north to the U.S./Mexico border in the south.

Stock Biomass

(Figure e and Table b).

The 2018 estimated spawning biomass relative to unfished equilibrium spawning biomass is above the target of 40% of unfished spawning biomass at 4 520% (95% asymptotic interval: ± 2 340% - 6 700%) (Figure f). Approximate confidence intervals based on the asymptotic variance estimates show that the uncertainty in the estimated spawning biomass is high.

Table b: Recent trend in beginning of the year spawning output and depletion for the model for GBYR.

Year	Spawning Output (million eggs)	~ 95% confidence interval	Estimated depletion	~ 95% confidence interval
2010	877	550 - 1205	63.33	45.67 - 80.98
2011	805	497 - 1113	58.07	41.64 - 74.5
2012	745	454 - 1036	53.76	38.39 - 69.13
2013	712	434 - 990	51.37	36.9 - 65.84
2014	688	420 - 957	49.67	35.88 - 63.45
2015	658	395 - 921	47.49	34.08 - 60.9
2016	634	372 - 895	45.73	32.37 - 59.08
2017	616	351 - 880	44.43	30.83 - 58.03
2018	611	338 - 884	44.08	29.93 - 58.22
2019	626	332 - 919	45.17	23.35 - 66.98

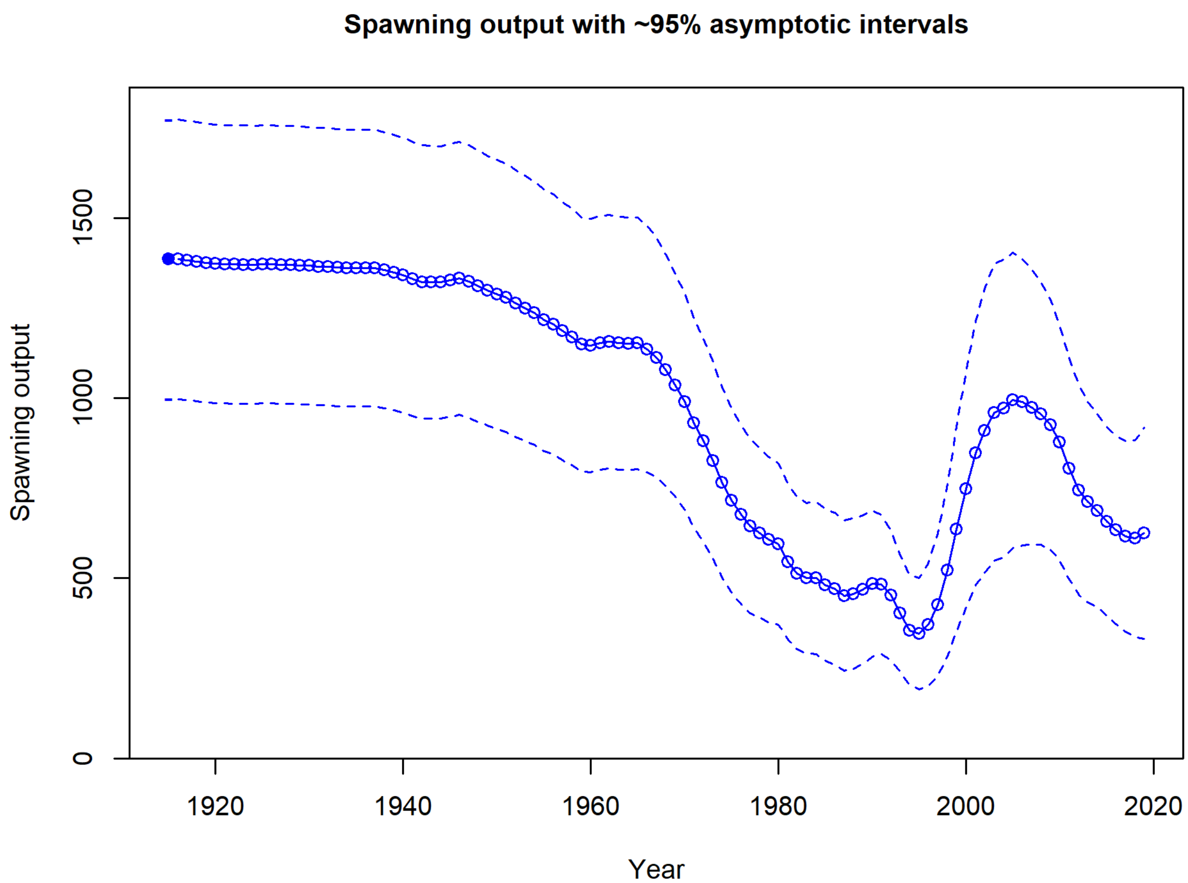

Figure e: Time series of spawning biomass trajectory (circles and line: median; light broken lines: 95% credibility intervals) for the base case assessment model.

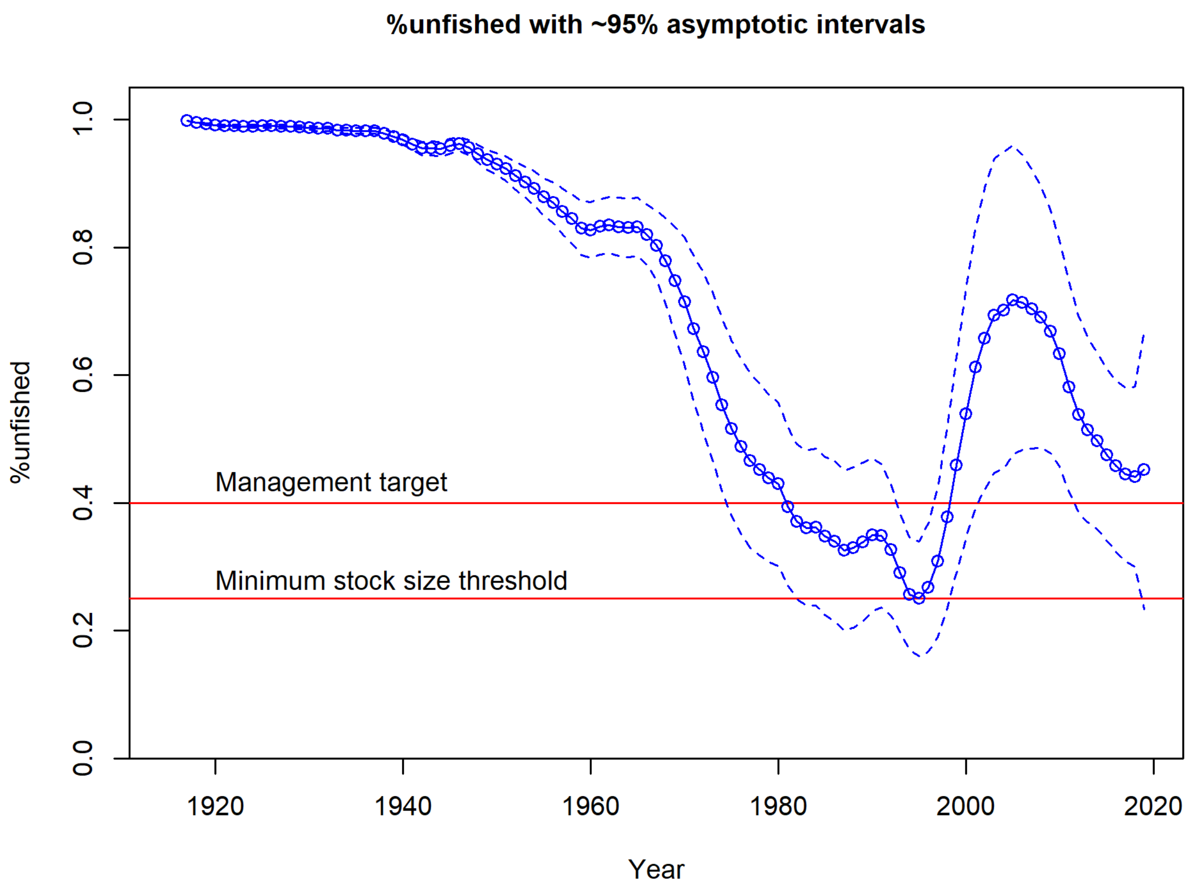

Figure f: Estimated percent depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model.

Recruitment

Recruitment deviations were estimated from xxxx-xxxx (Figure g and Table c).

Table c: Recent recruitment for the GBYR assessment.

Year	Estimated Recruitment (1,000s)	~ 95% confidence interval
2010	3817	1496 - 9738
2011	3564	1358 - 9354
2012	3610	1346 - 9679
2013	4355	1619 - 11711
2014	6351	2368 - 17032
2015	8323	3082 - 22476
2016	7554	2745 - 20791
2017	5963	2111 - 16842
2018	4790	1661 - 13814
2019	4789	1610 - 14244

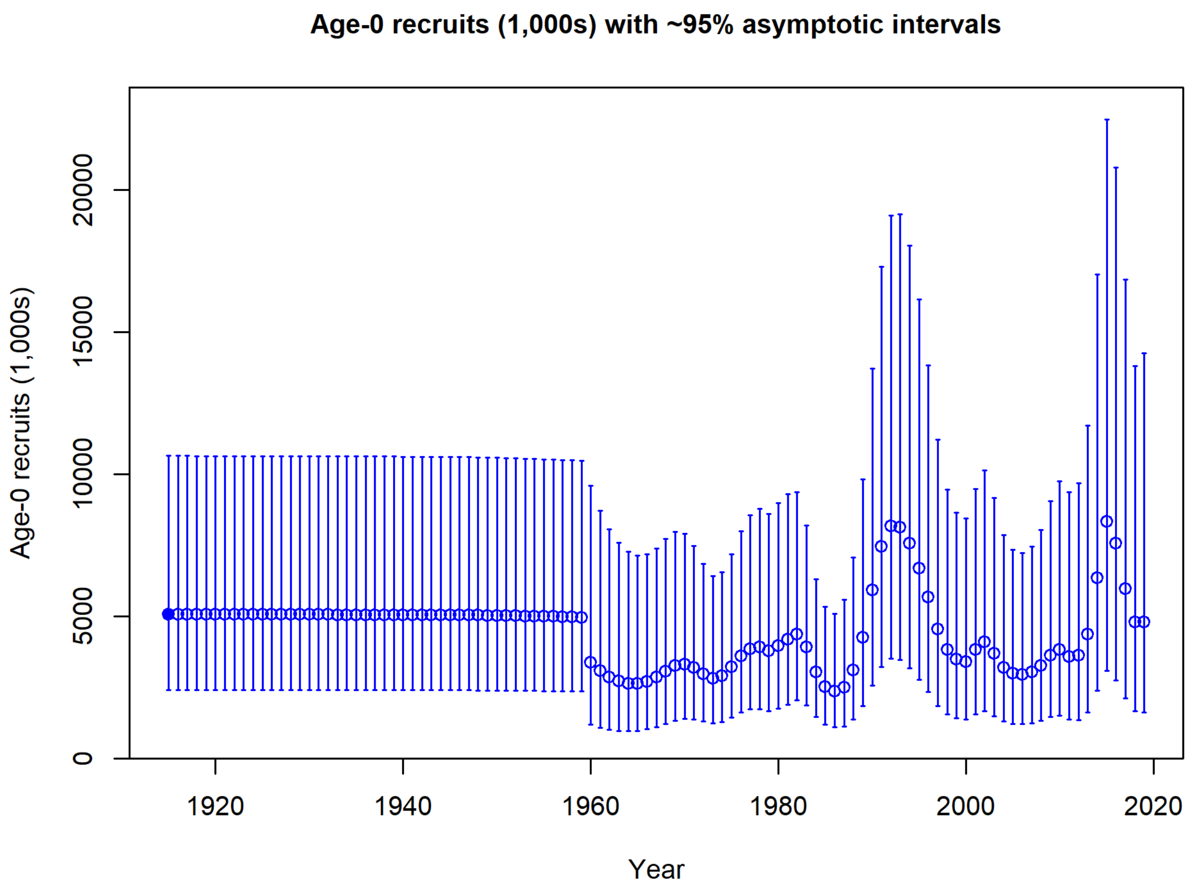

Figure g: Time series of estimated GBYR recruitments for the base-case model with 95% confidence or credibility intervals.

Exploitation status

Harvest rates estimated by the base model ….. management target levels (Table d and Figure h).

Table d: Recent trend in spawning potential ratio and exploitation for GBYR in the model. Fishing intensity is (1-SPR) divided by 50% (the SPR target) and exploitation is F divided by F_{SPR}.

Year	Fishing intensity	~ 95% confidence interval	Exploitation rate	~ 95% confidence interval
2009	0.60	0.37 - 0.82	0.07	0.05 - 0.1
2010	0.74	0.49 - 0.98	0.11	0.07 - 0.15
2011	0.73	0.48 - 0.98	0.10	0.06 - 0.14
2012	0.62	0.39 - 0.86	0.07	0.05 - 0.1
2013	0.60	0.37 - 0.83	0.07	0.04 - 0.09
2014	0.70	0.45 - 0.95	0.09	0.05 - 0.12
2015	0.73	0.48 - 0.99	0.09	0.05 - 0.13
2016	0.77	0.5 - 1.03	0.09	0.05 - 0.13
2017	0.76	0.49 - 1.03	0.08	0.04 - 0.12
2018	0.72	0.45 - 0.98	0.07	0.03 - 0.1

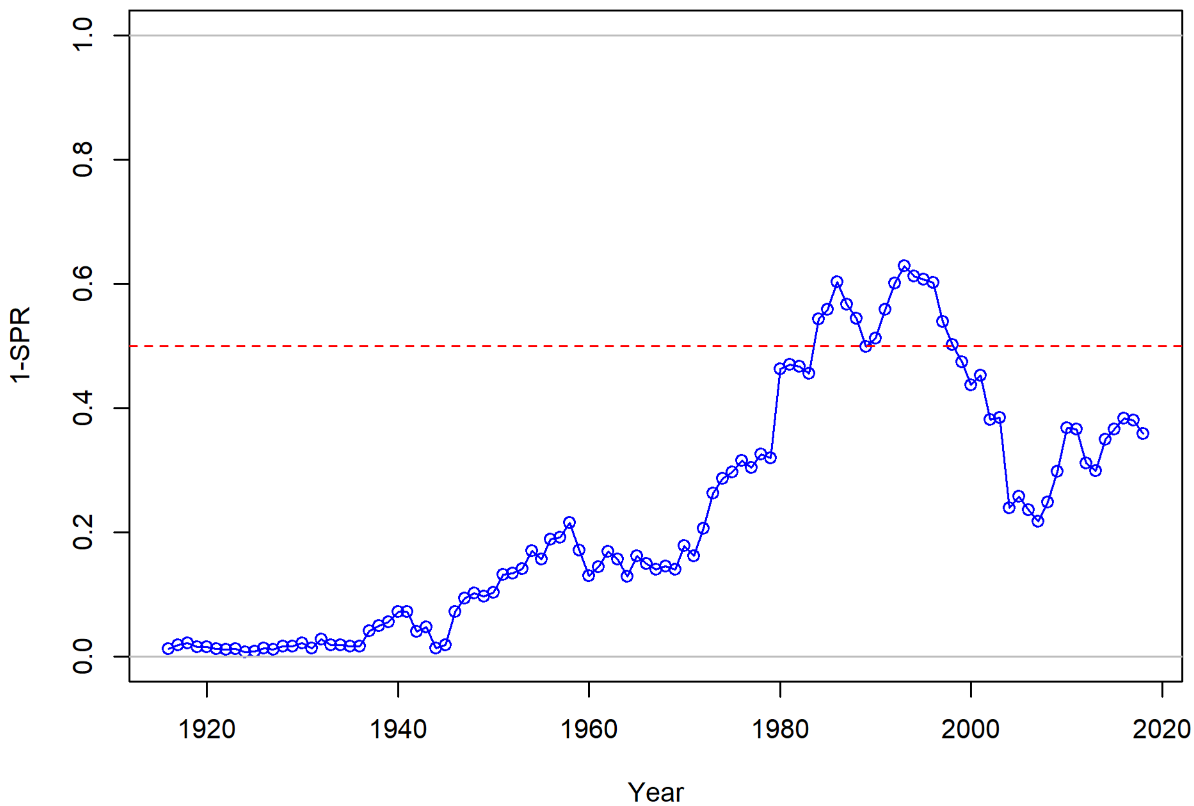

Figure h: Estimated spawning potential ratio (SPR) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$ harvest rate. The last year in the time series is 2018.

Ecosystem Considerations

In this assessment, ecosystem considerations were not explicitly included in the analysis. This is primarily due to a lack of relevant data and results of analyses (conducted elsewhere) that could contribute ecosystem-related quantitative information for the assessment.

Reference Points

This stock assessment estimates that GBYR in the model is above the biomass target ($SB_{40\%}$), and well above the minimum stock size threshold ($SB_{25\%}$). The estimated relative depletion level for the base model in 2019 is 4 520% (95% asymptotic interval: $\pm$ 2 340% - 6 700%, corresponding to an unfished spawning biomass of 626 million eggs (95% asymptotic interval: 332 - 919 million eggs) of spawning biomass in the base model (Table e). Unfished age 1+ biomass was estimated to be 2,206 mt in the base case model. The target spawning biomass ($SB_{40\%}$) is 554 million eggs, which corresponds with an equilibrium yield of 181 mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is 169 mt (Figure i).

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

Quantity	**Estimate**	**Low 2.5% limit**	**High 2.5% limit**
Unfished spawning output (million eggs)	1,386	997	1,774
Unfished age 1+ biomass (mt)	2,206	1,701	2,710
Unfished recruitment (R_0)	5,057	1,156	8,958
Spawning output(2018 million eggs)	611	338	884
Depletion (2018)	0.441	0.299	0.582
Reference points based on $\mathbf{SB_{40\%}}$			
Proxy spawning output ($B_{40\%}$)	554	449	659
SPR resulting in $B_{40\%}$ ($SPR_{B40\%}$)	0.458	0.458	0.458
Exploitation rate resulting in $B_{40\%}$	0.151	0.109	0.194
Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt)	181	110	252
Reference points based on SPR proxy for MSY			
Spawning output	618	501	735
SPR_{proxy}	0.5		
Exploitation rate corresponding to SPR_{proxy}	0.132	0.095	0.169
Yield with SPR_{proxy} at SB_{SPR} (mt)	169	104	235
Reference points based on estimated MSY values			
Spawning output at MSY (SB_{MSY})	298	239	357
SPR_{MSY}	0.291	0.282	0.3
Exploitation rate at MSY	0.262	0.18	0.344
Dead Catch MSY (mt)	209	123	296
Retained Catch MSY (mt)	209	123	296

Management Performance

Table f

Unresolved Problems and Major Uncertainties

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

Year	OFL (mt; ABC prior to 2011)	ABC (mt)	ACL (mt; OY prior to 2011)	Estimated total catch (mt)
2007	-	-	-	-
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	-	-	-	-
2014	-	-	-	-
2015	-	-	-	-
2016	-	-	-	-
2017	-	-	-	-
2018	-	-	-	-

Decision Table

Table g: Projections of potential OFL (mt) for each model, using the base model forecast.

Year	OFL
2019	182.79

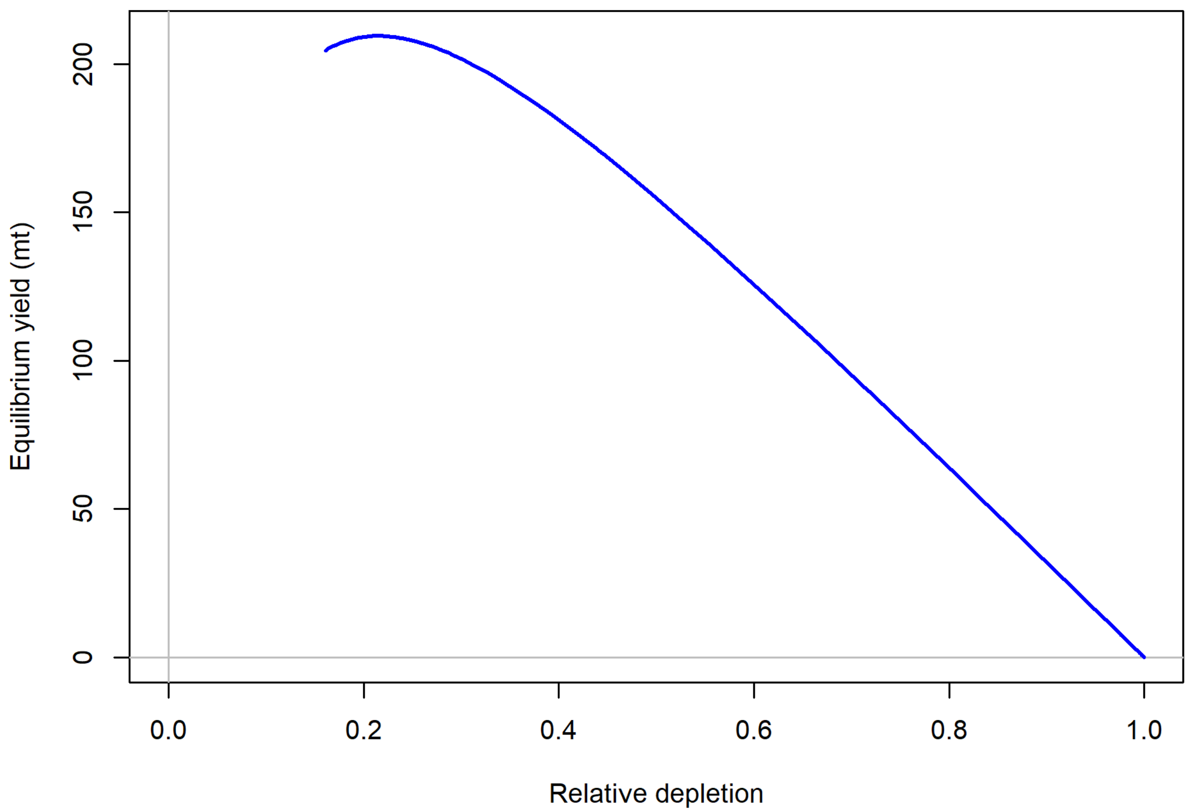

Figure i: Equilibrium yield curve for the base case model. Values are based on the 2018 fishery selectivity and with steepness fixed at 0.718.

Table h: Summary of 10-year projections beginning in 2020 for alternate states of nature based on an axis of uncertainty for the model. Columns range over low, mid, and high states of nature, 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					
			Low M 0.05		Base M 0.07		High M 0.09	
	Year	Catch	Spawning Output	Depletion	Spawning Output	Depletion	Spawning Output	Depletion
40-10 Rule, Low M	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-
40-10 Rule	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-
40-10 Rule, High M	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-
Average Catch	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-

Table i: Base case results summary.

Quantity	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Landings (mt)										
Total Est. Catch (mt)										
OFL (mt)										
ACL (mt)										
(1-SPR)(1-$SPR_{50\%}$)	0.74	0.73	0.62	0.60	0.70	0.73	0.77	0.76	0.72	
Exploitation rate	0.11	0.10	0.07	0.07	0.09	0.09	0.09	0.08	0.07	
Age 1+ biomass (mt)	1483.34	1412.40	1322.19	1255.68	1227.62	1215.60	1203.97	1213.90	1250.81	1322.40
Spawning Output	877	805	745	712	688	658	634	616	611	626
95% CI	550 - 1205	497 - 1113	454 - 1036	434 - 990	420 - 957	395 - 921	372 - 895	351 - 880	338 - 884	332 - 919
Depletion	63.3	58.1	53.8	51.4	49.7	47.5	45.7	44.4	44.1	45.2
95% CI	45.67 - 80.98	41.64 - 74.5	38.39 - 69.13	36.9 - 65.84	35.88 - 63.45	34.08 - 60.9	32.37 - 59.08	30.83 - 58.03	29.93 - 58.22	23.35 - 66.98
Recruits	3817	3564	3610	4355	6351	8323	7554	5963	4790	4789
95% CI	1496 - 9738	1358 - 9354	1346 - 9679	1619 - 11711	2368 - 17032	3082 - 22476	2745 - 20791	2111 - 16842	1661 - 13814	1610 - 14244

Research and Data Needs

We recommend the following research be conducted before the next assessment:

1. **xxxx**:
2. **xxxx**:
3. **xxxx**:
4. **xxxx**:
5. **xxxx**:

1 Introduction

1.1 Basic Information and Life History

1.2 Early Life History

1.3 Map

A map showing the scope of the assessment and depicting boundary at Pt. Conception for the recreational fishing fleet (Figure d).

1.4 Ecosystem Considerations

In this assessment, ecosystem considerations were not explicitly included in the analysis. This is primarily due to a lack of relevant data and results of analyses (conducted elsewhere) that could contribute ecosystem-related quantitative information for the assessment.

1.5 Fishery Information

1.6 Summary of Management History

1.7 Management Performance

Table f

1.8 Fisheries Off Mexico or Canada

2 Assessment

2.1 Data

Data used in the GBYR assessment are summarized in Figure 2. Descriptions of the data sources are in the following sections.

2.1.1 Commercial Fishery Landings

Overview of gopher and black-and-yellow catch history

Commercial fishery landings for gopher and black-and-yellow rockfishes have not been reported consistently by species throughout the available catch history (Figure 3). The period from 1916-1935 indicates that only black-and-yellow rockfish were landed in the commercial fishery, which then switched to predominately gopher rockfish from 1937-1984. From 1985-1988 the landings data suggest that only black-and-yellow rockfish were landed and not until 1995 are both species well-represented in the catches. There is no way to tease apart the historical catches by species and even across north and south of Pt. Conception prior to about 1995. This precludes the ability to model the catch histories for either species accurately. Given these constraints, all commercial data were combined to represent one commercial fleet in the assessment.

The stock assessment of gopher rockfish in 2005 did not include black-and-yellow rockfish landings. A comparison of recreational and commercial landings from the 2005 assessment to those used in this assessment suggest the 2005 assessment may have included some black-and-yellow rockfish landings (Figure 4). The 2005 assessment estimated recreational landings from 1969-1980 based on a ratio of commercial to recreational landings, where as this assessment makes use of the California Catch Reconstruction landings estimates (Ralston et al. 2010).

Commercial Landings Data Sources

The California Catch Reconstruction (Ralston et al. 2010) contains landings estimates of commercial landings from 1916-1968 and was queried on 4 April 2019 for GBYR. There were no estimated gopher rockfish landings prior to 1937. Landings in this database are divided into trawl and 'non-trawl.' Since the majority of GBYR are caught in the commercial fixed gear fisheries, only estimated catch in the 'non-trawl' was used. A total of 0.154 mt (3.18%) were removed from Eureka commercial landings (based on current proportions of commercial catch from north of Cape Mendocino in Eureka) since the assessment represents the GBYR stock south of Cape Mendocino. The majority of GBYR commercial landings (avg. 83%) are landed in the Monterey and Morro Bay port complexes.

Contemporary landings were extracted from two data sources, the California Cooperative Groundfish Survey, CALCOM) and the Pacific Fisheries Information Network PacFIN landings database.Both databases are based on the same data sources (CALCOM data), but apply a catch expansion based on different algorithms. CALCOM collects information including species composition data (i.e. the proportion of species landed in a sampling stratum), and landing receipts (sometimes called "fish tickets") that are a record of pounds landed in a given stratum. Strata in California are defined by market category, year, quarter, gear group, port complex, and disposition (live or dead). Although many market categories are named after actual species, catch in a given market category can consist of several species. These data form the basis for the "expanded"" landings, i.e., species composition data collected by port samplers were used to allocate pounds recorded on landing receipts to species starting in 1978. Use of the "Gopher Rockfish" or the "Black-and-Yellow Rockfish" categories alone to represent actual landings of GBY would not be accurate.

See Pearson et al. Appendix C (2008) for a simple example of the expansion calculations for the CALCOM database. A description of the landings in PacFIN can be found in Sampson and Crone (1997). Both databases, including species compositions, and expanded landings estimates are stored at the Pacific States Marine Fisheries Commission, a central repository of commercial landings data for the U.S. West Coast. As a note, CALCOM is the only source for landings from 1969-1980.

Commercial landings from 1981-2018 were queried for a final time from the CALCOM database on 4 April 2019 and from PacFIN on 3 June 2019. There are very small ifferences in commercial landings between CALCOM and PacFIN from 1981-2018 (Figure 5). Landings estimates from PacFIN were used in the assessment (Table **??**). Landings were stratified by year, quarter, live/dead, market category, gear group, port complex, and source of species composition data (actual port samples, borrowed samples, or assumed nominal market category). Data from individual quarters were aggregated at the year level. Fish landed live or dead were combined, due to changes over time in the reliability of condition information (D. Pearson, pers. comm.). From 1916-1968, on average, 74% of GBYR were landed north of Point Conception, which rose to 97% from 1978-2018. Given the smaller landings south of Pt. Conception and the similar length composition of GBYR north and south of Pt. Conception, no spatial separation was considered for the commercial fleet.

2.1.2 Commercial Discards

The West Coast Groundfish Observer Program (WCGOP) provides observer data on discarding across fishery sectors back to 2003. Gopher and black-and-yellow rockfishes have different depth-stratified commercial fishery discard mortality rates (Pacific Fishery Managment Council 2018). In consultation with WCGOP staff, the STAT used estimates of total discard mortality from WCGOP's Groundfish Expanded Mortality Multiyear (GEMM) report. WCGOP observes between 1-5% of nearshore fixed gear landings annually south of 40°10′ N. latitude (coverage rates available here). The expanded estimates of total discard weight by species is calculated as the ratio of the observed discard weight of the individual species divided by the observed landed weight
from PacFIN landing receipts. WCGOP discard estimates for the nearshore fixed gear fishery take into account the depth distribution of landings in order to appropriately apply the depth-stratified discard mortality rates by species (Somers, K.A., J. Jannot, V. Tuttle, K. Richerson and McVeigh 2018). The discard mortality for 2018 was estimated as an average of the discard mortality from 2013-2017. Discard mortality was estimated from the period prior to WCGOP discard estimates (1916-2002) based on the average discard mortality rate from 2003-2016 (2017 was excluded because 2017 discard mortality was disproportionately higher than all other years) (Table **??**).

2.1.3 Commercial Fishery Length and Age Data

Biological data from the commercial fisheries that caught GBYR were extracted from CALCOM on 9 May 2019. The CALCOM length composition data were catch-weighted to "expanded" length the raw length composition data (Table ??). The 2005 assessment used commercial length composition information from CALCOM, but did not include black-and-yellow rockfish and is not directly comparable. The 2005 assessment used 2 cm length bins from 16-40 cm, where this assessment uses 1 cm length bins from 4-40 cm. Sex was not available for the majority (99.5%) of the commercial length, and the assessment did not find sexual dimorphism in growth for either species. We aggregated the commercial length composition among all gears and regions south of Cape Mendocino.

Discard length compositions from WCGOP (2003-2017) were expanded based on the the discard estimates and were aggregated for all regions south of Cape Mendocino and across all fixed gear fisheries.

A total of 46 ages were available for gopher rockfish from the commercial fisheries 2009-2011, 2016, and 2018. Though sparse, the data were included as conditional age-at-length for the commercial fleet.

The input sample sizes for commercial length composition data were calculated via the Stewart Method for fisheries (Ian Stewart, personal communication, IPHC):

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

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

2.1.4 Recreational Fishery Removals and Discards

Historical recreational landings and discard, 1928-1980

Ralston et al. (2010) reconstructed estimates of recreational rockfish catch and discard in California, 1928-1980. Reported landings of total rockfish were allocated to species based on several sources of species composition data. Estimates of GBYR landings and discard (combined) from 1928-1979 are available from the SWFSC. For this assessment, historical recreational catch was stratified by year and area (north and south of Point Conception). The catches of GBYR reported in Ralston et al. (2010) are higher by an order of magnitude than expected given the more recent catches of GBYR in the MRFSS and CRFS eras south of Pt. Conception (Figure 6). The recreational catches estimated by Ralston et al. (2010) were discussed with the paper's co-authors and also CPFV captains in California. A consensus was reached that the estimated landings did not accurately represent the historical GBYR landings and an alternative catch stream should be developed. One possibility for the inflated catches of GBYR in southern California is that all nearshore shallow species were combined and all of the nearshore deep species were combined and a constant relative fraction between the two was used to assign catches to each combination of CDFW fishing block and year. The fraction of GBYR within the nearshore shallow species group was likely overestimated.

The California Catch Reconstruction applied a linear ramp from from 1928-1936 that was not altered in this assessment. From 1937-1979 a linear ramp was developed from the 1936 estimate to the average recreational landing from 1980 and 1983 (1981-1982 catches interpolated as described in the next section) of 4.3 mt. The recreational catches north of Pt. Conception were not altered from the original catch reconstruction. The resulting alternate recreational catch streams are in (Table **??** and Figure 7).

Marine Recreational Fisheries Statistics Survey (MRFSS), 1980-2003

From 1980-2003, the Marine Recreational Fisheries Statistics Survey (MRFSS) executed a dockside (angler intercept) sampling program in Washington, Oregon, and California (see Holliday et al. (1984) for a description of methods). Data from this survey are available from the Recreational Fisheries Information Network RecFIN. RecFIN serves as a repository for recreational fishery data for California, Oregon, and Washington. Catch estimates for years 1980-2003 were downloaded on 23 March 2019, and are consistent from 1992-2004 with the previous assessment (Key et al. 2005) (Figure 4).

MRFSS-era recreational removals for California were estimated for two regions: north and south of Point Conception. No finer-scale estimates of landings are available for this period. Catches were downloaded in numbers and weight. Catch in weight is sometimes missing from the database due to missing average weight estimates. We estimated average weights based on adjacent strata as needed, although the effect was relatively minor (7.4 mt over all years for gopher rockfish and 0.6 mt for black-and-yellow rockfish). Data were not available for the CPFVs in Northern California from 1980-1982, and we used the average value from this mode and region from 1983-1987 for these three years. MRFSS sampling was temporarily suspended from 1990-1992, and we used linear interpolation to fill the missing years. Sampling of CPFVs in Northern California was further delayed, and the linear interpolation spans the period 1990-1995 for this boat mode and region. Landings data for the shore-based modes (beach/bank, man-made/jetty and shore) were sparse throughout the MRFSS sampling. All three shore-based modes were combined by region and linear interpolations were applied missing data in 1981 for the Northern California and 1995, 1996-2001, and 2004 in Southern California.

Catches from north of Cape Mendocino were removed based on a CRFS-era average of fraction of recreational landings north of Cape Mendocino by mode (3.3% of shore-based, 0.1% of CPFV, and 0.2% of private/rental were removed). From 1980-1989, San Luis Obispo County was sampled as part of Southern California (personal observation from MRFSS Type 3 sampler examined catch where county is available for 1980-2004). This assessment separates the recreational fleet at Pt. Conception. Recreational landings were re-allocated from southern California from 1980-1992 by fleet based on the average proportion of recreational landings in northern California from 1996-2004 (after sampling of the CPFV fleet in northern California resumed). The average proportion re-allocated from southern to northern California for the CPFV mode was 85%, 97% for the private/rental mode, and 81% for the shore-based modes. Data were pooled over all years and modes to estimate the landings re-allocation for the shore-based modes. Total recreational landings for 1981 and 1982 were 18.8 mt and 18.6 mt, respectively. These landings were >60 mt lower than any of the neighboring years. Landings from 1981-1982 were interpolated from the 1980 and 1983 landings.

California Recreational Fisheries Survey (CRFS), 2004-2016

MRFSS was replaced with the California Recreational Fisheries Survey (CRFS) beginning January 1, 2004. Among other improvements to MRFSS, CRFS provides higher sampling intensity, finer spatial resolution (6 districts vs. 2 regions), and onboard CPFV sampling. Estimates of catch from 2004-2018 were downloaded from the RecFIN database a final time on 4 June 2019, We queried and aggregated CRFS data to match the structure of the MRFSS data, by year, and region (Table **??**). Catches in the shore-based modes are small compared to the CPFV and private rental modes. All modes are combined, but separated at Point Conception for two recreational fleets in this assessment, just as was done for the California Catch Reconstruction and MRFSS time series.

Recreational Discard

Recreational discards were only added to the California Catch Reconstruction landings, as Ralston et al. (2010) did not address discards for the recreational reconstruction. Recreational removals from the California Department of Fish and Wildlife MRFSS era (1980-2003) includes catch type A + B1. Catch type A refers to estimates of catch based on sampler-examined catch. Catch type B1 includes mainly angler-reported discard, but also angler-reported retained fish that were unavailable to the sampler during the interview (e.g., fillets). The CRFS era removals account for depth-stratified discard mortality rate and the catch time series includes both retained and discarded catch (total mortality). We calculated the ratio of dead discards to total mortality from the CRFS era by region and mode. The region average across modes was applied to the California Catch Reconstruction as a constant. The result added 4.68% annually to recreational removals north of Pt. Conception and 4.05% annually to the removals South of Pt. Conception). The final time series of landings and discard mortality are in Table **??**.

2.1.5 Recreational Fishery Length and Age Data

Recreational length composition samples for California were obtained from several sources, depending on the time period and boat mode (Table **??**). This assessment makes use of a much longer time series of length composition data, relative to the previous assessment, as described below. Input sample sizes for recreational length composition data were based on the number of observed trips, when available. Other proxies that were used to estimate the number of trips are described below.

There were no standardized coastwide surveys measure retained or discarded fish from the recreational fleet prior to 1980.

CPFV length composition data, 1959-1978

The earliest available length data for this assessment were described by Karpov et al. (1995), who assembled a time series (1959-1972) of available California CPFV length data (made available courtesy of W. Van Buskirk). For GBYR, data from 1959-1961 and 1966 were available north of Pt. Conception and from 1959-1961 from south of Pt Conception. A total of 716 (680 north of Pt. Conception) unsexed measuremenst of retained fish (no discards) were included in the assessment (Table **??**). Sampling of these length data did not follow a consistent protocol over time and areas (data are unweighted), and therefore may not be representative of total catch. Since the number of trips sampled was not reported by Karpov et al. (1995), we assume the number of sampled trips is proportional to the number of measured fish in each year, and estimated the number of trips using the ratio of fish measured per trip in the MRFSS data (roughly 10 fish per trip).

Collins and Crooke (n.d.) conducted an onboard observer survey of the CPFV fleet in southern California from 1975-1978. A total of 1,308 GBYR lengths were available from the study and were assumed to all be from retained fish. Ally et al. (1991) conducted an onboard observer program of the CPFV fleet from 1985-1987 in southern California. Because MRFSS data were available for this time period as well and represents multiple recreational modes, the Ally et al. (1991) length data were not used in the assessment.

MRFSS Recreational Length Data, 1980-1989 and 1993-2003

Unsexed length data of retained fish were collected by MRFSS dockside samplers and downloaded from the RecFIN website. We identified a subset of lengths that were converted from weight measurements, and these were excluded from the final data set (Table **??**). The length measurements from Collins and Crooke (n.d.) from 1975-1978 are assumed to all be from retained fish. As of 2003, the CDFW Onboard Observer program has taken length measurements for discarded fish. The retained catch is measured during the dockside (angler intercept) surveys.

The number of CPFV trips used as initial sample sizes for the MRFSS was based on the number of CPFV trips was determined from the trip-level MRFS CPFV database and the number of private boat trips was determined based on unique combinations of the variables ASSNID ,ID_CODE, MODE_FX, AREA_X, DIST, INTSITE, HRSF, CNTRBTRS, SUB_REG, WAVE, YEAR, and CNTY in the Type 3 (sampler-examined catch) data.

During the recent restructuring of the CRFS data on RecFIN, a "trip" identifier was not carried over for all modes, and trip-level sample sizes could not be extracted from the biological detail table on RecFIN. A proxy for initial sample sizes for 2004-2018 were developed using the 2015 data for which I had access to raw data files by mode from CDFW.
In more recent years, sampling of the shore-based modes has declined and were not sampled at all in 2018. Samples sizes were calculated by mode as the number of port-days (or

site-days for shore-based modes) during bi-weekly intervals (e.g., Jan 1-15, Jan 16-31, etc). The number of port-days sampled in the bi-weekly intervals was used as the initial sample size for number of trips to calculate initial input sample sizes using Ian Stewart's method (described above). All length data were re-weighted in the assessment model.

2.1.6 Fishery-Dependent Indices of Abundance

Data Source 1

Data Source 1 Index Standardization

Table **??**)

(Table **??**) *Data Source 1 Length Composition*

Data Source 2

Data Source 3

2.1.7 Fishery-Independent Data Sources

Data Source 1

Data Source 1 Index Standardization

Data Source 1 Length Composition

Data Source 2

2.1.8 Biological Parameters and Data

Length and Age Compositions

Length compositions were provided from the following sources:

- Source 1 (*type, e.g., commercial dead fish, research, recreational*, yyyy-yyyy)
- Source 2 (*type*, yyyy-yyyy)
- Source 3 (*research*, yyyy, yyyy, yyyy, yyyy)

The length composition of all fisheries aggregated across time by fleet is in Figure 8. Descriptions and details of the length composition data are in the above section for each fleet or survey.

Age Structures

von Bertalanffy growth curve (Bertalanffy 1938), $L_i = L_\infty e^{(-k[t-t_0])}$, where L_i is the length (cm) at age i, t is age in years, k is rate of increase in growth, t_0 is the intercept, and L_∞ is the asymptotic length.

Aging Precision and Bias

Weight-Length

Sex Ratio, Maturity, and Fecundity

Natural Mortality

2.1.9 Environmental or Ecosystem Data Included in the Assessment

In this assessment, neither environmental nor ecosystem considerations were explicitly included in the analysis. This is primarily due to a lack of relevant data and results of analyses (conducted elsewhere) that could contribute ecosystem-related quantitative information for the assessment.

2.2 Previous Assessments

2.2.1 History of Modeling Approaches Used for this Stock

2.2.2 yyyy Assessment Recommendations

Recommendation 1:

STAT response: xxxxx

Recommendation 2:

STAT response: xxxxx

Recommendation 3:

STAT response: xxxx

2.3 Model Description

2.3.1 Transition to the Current Stock Assessment

2.3.2 Summary of Data for Fleets and Areas

There are xxx fleets in the base model. They include:

Commercial: The commercial fleets include ...

Recreational: The recreational fleets include ...

Research: There are xx sources of fishery-independent data available ...

2.3.3 Other Specifications

2.3.4 Modeling Software

The STAT team used Stock Synthesis 3 version 3.30.05.03 by Dr. Richard Methot at the NWFSC. This most recent version was used, since it included improvements and corrections to older versions. The r4SS package (GitHub release number v1.27.0) was used to post-processing output data from Stock Synthesis.

2.3.5 Data Weighting

2.3.6 Priors

The log-normal prior for female natural mortality were based on a meta-analysis completed by Hamel (2015), as described under "Natural Mortality." Female natural mortality was fixed at the median of the prior, 0.xxx for an assumed maximum age of xx. An uninformative prior was used for the male offset natural mortality, which was estimated.

The prior for steepness (h) assumes a beta distribution with parameters based on an update for the Thorson-Dorn rockfish prior (Dorn, M. and Thorson, J., pers. comm.), which was endorsed by the Science and Statistical Committee in 2018. The prior is a beta distribution with mu=0.xxx and $sigma$=0.xxx. Steepness is fixed in the base model at the mean of the prior. The priors were applied in sensitivity analyses where these parameters were estimated.

2.3.7 Estimated and Fixed Parameters

A full list of all estimated and fixed parameters is provided in Tables 12.

The base model has a total of xxx estimated parameters in the following categories:

- xxx,
- xxx
- xxx, and
- xxx selectivity parameters

The estimated parameters are described in greater detail below and a full list of all estimated and parameters is provided in Table 12.

Growth.

Natural Mortality.

Selectivity.

Other Estimated Parameters.

Other Fixed Parameters.

2.4 Model Selection and Evaluation

2.4.1 Key Assumptions and Structural Choices

2.4.2 Alternate Models Considered

2.4.3 Convergence

2.5 Response to the Current STAR Panel Requests

Request No. 1:

Rationale: xxx

STAT Response: xxx

Request No. 2:

Rationale: xxx

STAT Response: xxx

Request No. 3:

Rationale: x.

STAT Response: xxx

Request No. 4:

Rationale: xxx

STAT Response: xxx

Request No. 5:

Rationale: xxx

STAT Response: xxx

2.6 Base Case Model Results

The following description of the model results reflects a base model that incorporates all of the changes made during the STAR panel (see previous section). The base model parameter estimates and their approximate asymptotic standard errors are shown in Table 12 and the likelihood components are in Table 13. Estimates of derived reference points and approximate 95% asymptotic confidence intervals are shown in Table e. Time-series of estimated stock size over time are shown in Table 14.

2.6.1 Parameter Estimates

The additional survey variability (process error added directly to each year's input variability) for all surveys was estimated within the model.

(Figure **??**).

The stock-recruit curve … Figure 11 with estimated recruitments also shown.

2.6.2 Fits to the Data

Model fits to the indices of abundance, fishery length composition, survey length composition, and conditional age-at-length observations are all discussed below.

2.6.3 Uncertainty and Sensitivity Analyses

A number of sensitivity analyses were conducted, including:

1. Sensitivity 1
2. Sensitivity 2
3. Sensitivity 3
4. Sensitivity 4
5. Sensitivity 5, etc/

2.6.4 Retrospective Analysis

2.6.5 Likelihood Profiles

2.6.6 Reference Points

Reference points were calculated using the estimated selectivities and catch distribution among fleets in the most recent year of the model, (2017). Sustainable total yield (landings plus discards) were 169 mt when using an $SPR_{50\%}$ reference harvest rate and with a 95% confidence interval of 104 mt based on estimates of uncertainty. The spawning biomass equivalent to 40% of the unfished level ($SB_{40\%}$) was 554 mt.

(Figure 21

The 2018 spawning biomass relative to unfished equilibrium spawning biomass is above/below the target of 40% of unfished levels (Figure **??**). The relative fishing intensity, $(1 - SPR)/(1 - SPR_{50\%})$, has been xxx the management target for the entire time series of the model.

Table e shows the full suite of estimated reference points for the base model and Figure 23 shows the equilibrium curve based on a steepness value xxx.

3 Harvest Projections and Decision Tables

The forecasts of stock abundance and yield were developed using the final base model, with the forecasted projections of the OFL presented in Table g.

The forecasted projections of the OFL for each model are presented in Table h.

4 Regional Management Considerations

5 Research Needs

There are a number of areas of research that could improve the stock assessment for GBYR. Below are issues identified by the STAT team and the STAR panel:

1. **xxxx**:

2. xxxx:
3. xxxx:
4. xxxx:
5. xxxx:

6 Acknowledgments

7 Tables

Table 1: Results from 100 jitters from the base case model.

Description	Value	NA	NA
Returned to base case	-	-	-
Found local minimum	-	-	-
Found better solution	-	-	-
Error in likelihood	-	-	-
Total	100	100	100

Table 2: 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).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
1	NatM_p_1_Fem_GP_1	0.207	2	(0.05, 0.4)	OK	0.028	Log_Norm (-1.6458, 0.4384)
2	L_at_Amin_Fem_GP_1	7.906	3	(4, 50)	OK	0.764	None
3	L_at_Amax_Fem_GP_1	28.290	3	(20, 60)	OK	0.817	None
4	VonBert_K_Fem_GP_1	0.143	3	(0.01, 0.3)	OK	0.026	None
5	CV_young_Fem_GP_1	0.258	3	(0.05, 0.5)	OK	0.038	None
6	CV_old_Fem_GP_1	0.119	3	(0.03, 0.3)	OK	0.012	None
7	Wtlen_1_Fem_GP_1	0.000	-3	(-3, 3)			None
8	Wtlen_2_Fem_GP_1	3.256	-3	(2, 4)			None
9	Mat50%_Fem_GP_1	21.666	-3	(-3, 3)			None
10	Mat_slope_Fem_GP_1	-0.906	-3	(-6, 3)			None
11	Eggs/kg_inter_Fem_GP_1	1.000	-3	(-3, 3)			None
12	Eggs/kg_slope_wt_Fem_GP_1	0.000	-3	(-3, 3)			None
13	CohortGrowDev	1.000	-1	(0.1, 10)			None
14	FracFemale_GP_1	0.500	-4	(0.000001, 0.999999)			None
15	SR_LN(R0)	8.528	1	(2, 15)	OK	0.394	None
16	SR_BH_steep	0.720	-1	(0.2, 1)			None
17	SR_sigmaR	0.400	-2	(0, 2)			None
18	SR_regime	0.000	-4	(-5, 5)			None
19	SR_autocorr	0.696	4	(-1, 1)	OK	0.101	None
81	LnQ_base_DebCPFV(5)	-7.079	-1	(-15, 15)			None
82	Q_extraSD_DebCPFV(5)	0.073	4	(0.0001, 2)	OK	0.048	None
83	LnQ_base_RecOnboardNorth(6)	-7.807	-1	(-15, 15)			None
84	Q_extraSD_RecOnboardNorth(6)	0.227	4	(0.0001, 2)	OK	0.056	None
85	LnQ_base_RecOnboardSouth(7)	-10.380	-1	(-15, 15)			None
86	Q_extraSD_RecOnboardSouth(7)	0.603	4	(0.0001, 2)	OK	0.149	None
87	LnQ_base_PISCO(8)	-7.695	-1	(-15, 15)			None

Continued on next page

Table 2: 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).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
88	Q_extraSD_PISCO(8)	0.209	4	(0.0001, 2)	OK	0.074	None
89	LnQ_base_CCFRP(9)	-6.534	-1	(-15, 15)			None
90	Q_extraSD_CCFRP(9)	0.184	4	(0.0001, 2)	OK	0.074	None
91	LnQ_base_RecDocksideNorth(10)	-8.896	-1	(-15, 15)			None
92	Q_extraSD_RecDocksideNorth(10)	0.000	-4	(0.0001, 2)			None
93	LnQ_base_RecDocksideSouth(11)	-9.856	-1	(-15, 15)			None
94	Q_extraSD_RecDocksideSouth(11)	0.279	4	(0.0001, 2)	OK	0.109	None
95	Size_DblN_peak_Com(1)	32.341	1	(19, 38)	OK	0.727	None
96	Size_DblN_top_logit_Com(1)	8.000	-5	(-5, 10)			None
97	Size_DblN_ascend_se_Com(1)	3.139	5	(-9, 10)	OK	0.127	None
98	Size_DblN_descend_se_Com(1)	5.000	-5	(-9, 9)			None
99	Size_DblN_start_logit_Com(1)	-11.574	5	(-15, -5)	OK	1.753	None
100	Size_DblN_end_logit_Com(1)	10.000	-5	(-5, 15)			None
101	Size_DblN_peak_ComDisc(2)	24.987	2	(19, 38)	OK	0.443	None
102	Size_DblN_top_logit_ComDisc(2)	-9.601	5	(-15, 10)	OK	76.674	None
103	Size_DblN_ascend_se_ComDisc(2)	2.038	5	(-9, 10)	OK	0.223	None
104	Size_DblN_descend_se_ComDisc(2)	5.317	5	(-9, 9)	OK	1.611	None
105	Size_DblN_start_logit_ComDisc(2)	-14.051	5	(-15, -5)	OK	21.227	None
106	Size_DblN_end_logit_ComDisc(2)	-999.000	-5	(-5, 10)			None
107	Size_DblN_peak_RecNorth(3)	32.386	3	(19, 39)	OK	0.410	None
108	Size_DblN_top_logit_RecNorth(3)	8.000	-5	(-5, 10)			None
109	Size_DblN_ascend_se_RecNorth(3)	3.282	5	(-9, 10)	OK	0.071	None
110	Size_DblN_descend_se_RecNorth(3)	5.000	-5	(-9, 9)			None
111	Size_DblN_start_logit_RecNorth(3)	-11.844	5	(-15, -5)	OK	1.528	None
112	Size_DblN_end_logit_RecNorth(3)	10.000	-5	(-5, 15)			None
113	Size_DblN_peak_RecSouth(4)	27.621	4	(19, 38)	OK	1.212	None
114	Size_DblN_top_logit_RecSouth(4)	8.000	-5	(-5, 10)			None

Continued on next page

Table 2: 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).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
115	Size_DblN_ascend_se_RecSouth(4)	3.220	5	(-9, 10)	OK	0.272	None
116	Size_DblN_descend_se_RecSouth(4)	5.000	-5	(-9, 9)			None
117	Size_DblN_start_logit_RecSouth(4)	-8.730	5	(-15, -5)	OK	2.853	None
118	Size_DblN_end_logit_RecSouth(4)	10.000	-5	(-5, 15)			None
119	Size_DblN_peak_DebCPFV(5)	30.869	5	(19, 38)	OK	0.625	None
120	Size_DblN_top_logit_DebCPFV(5)	8.000	-5	(-5, 10)			None
121	Size_DblN_ascend_se_DebCPFV(5)	3.011	5	(-9, 10)	OK	0.119	None
122	Size_DblN_descend_se_DebCPFV(5)	5.000	-5	(-9, 9)			None
123	Size_DblN_start_logit_DebCPFV(5)	-14.890	5	(-15, -5)	OK	3.305	None
124	Size_DblN_end_logit_DebCPFV(5)	10.000	-5	(-5, 15)			None
125	SizeSel_P1_RecOnboardNorth(6)	-1.000	-5	(-1, 10)			None
126	SizeSel_P2_RecOnboardNorth(6)	-1.000	-5	(-1, 10)			None
127	SizeSel_P1_RecOnboardSouth(7)	-1.000	-5	(-1, 10)			None
128	SizeSel_P2_RecOnboardSouth(7)	-1.000	-5	(-1, 10)			None
129	Size_DblN_peak_PISCO(8)	30.398	5	(19, 38)	OK	2.236	None
130	Size_DblN_top_logit_PISCO(8)	8.000	-5	(-15, 10)			None
131	Size_DblN_ascend_se_PISCO(8)	3.939	5	(-9, 10)	OK	0.381	None
132	Size_DblN_descend_se_PISCO(8)	5.000	-5	(-9, 9)			None
133	Size_DblN_start_logit_PISCO(8)	-2.641	5	(-15, 15)	OK	0.584	None
134	Size_DblN_end_logit_PISCO(8)	10.000	-5	(-5, 15)			None
135	Size_DblN_peak_CCFRP(9)	31.034	5	(19, 38)	OK	0.628	None
136	Size_DblN_top_logit_CCFRP(9)	-10.640	5	(-15, 10)	OK	65.115	None
137	Size_DblN_ascend_se_CCFRP(9)	3.152	5	(-9, 10)	OK	0.151	None
138	Size_DblN_descend_se_CCFRP(9)	1.654	5	(-15, 9)	OK	0.803	None
139	Size_DblN_start_logit_CCFRP(9)	-999.000	-5	(-15, -5)			None
140	Size_DblN_end_logit_CCFRP(9)	-999.000	-5	(-5, 10)			None
141	SizeSel_P1_RecDocksideNorth(10)	-1.000	-5	(-1, 10)			None

Continued on next page

Table 2: 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).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
142	SizeSel_P2_RecDocksideNorth(10)	-1.000	-5	(-1, 10)			None
143	SizeSel_P1_RecDocksideSouth(11)	-1.000	-5	(-1, 10)			None
144	SizeSel_P2_RecDocksideSouth(11)	-1.000	-5	(-1, 10)			None
145	Size_DblN_peak_Com(1)_BLK1repl_1999	28.866	6	(19, 38)	OK	0.327	None
146	Size_DblN_ascend_se_Com(1)_BLK1repl_1999	1.582	6	(-9, 10)	OK	0.170	None
147	Size_DblN_start_logit_Com(1)_BLK1repl_1999	-11.635	6	(-15, -5)	OK	3.280	None

Table 3: Likelihood components from the base model.

Likelihood component	Value
TOTAL	1097.30
Catch	0.00
Survey	-98.12
Length composition	763.02
Age composition	421.52
Recruitment	10.88
Forecast recruitment	0.00
Parameter priors	0.00
Parmeter soft bounds	0.01

Table 4: Time-series of population estimates from the base-case model. Relative exploitation rate is $(1 - SPR)/(1 - SPR_{50\%})$.

Year	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative exploitation rate	SPR
1916	2206	1386	0.000	5057	4	0.00	0.99
1917	2203	1383	0.998	5056	7	0.00	0.98
1918	2199	1379	0.996	5055	8	0.00	0.98
1919	2195	1376	0.993	5053	5	0.00	0.99
1920	2193	1374	0.991	5053	5	0.00	0.98
1921	2191	1372	0.990	5052	5	0.00	0.99
1922	2190	1371	0.990	5052	4	0.00	0.99
1923	2190	1371	0.990	5052	4	0.00	0.99
1924	2190	1371	0.989	5051	2	0.00	0.99
1925	2190	1371	0.990	5052	3	0.00	0.99
1926	2191	1372	0.990	5052	5	0.00	0.99
1927	2190	1371	0.989	5052	4	0.00	0.99
1928	2189	1370	0.989	5051	6	0.00	0.98
1929	2188	1369	0.988	5051	6	0.00	0.98
1930	2186	1368	0.987	5050	8	0.00	0.98
1931	2184	1366	0.986	5050	5	0.00	0.99
1932	2184	1366	0.986	5050	10	0.00	0.97
1933	2180	1362	0.983	5048	7	0.00	0.98
1934	2179	1362	0.983	5048	7	0.00	0.98
1935	2179	1361	0.982	5048	6	0.00	0.98
1936	2179	1361	0.982	5048	6	0.00	0.98
1937	2179	1361	0.982	5048	15	0.01	0.96
1938	2173	1356	0.978	5046	18	0.01	0.95
1939	2165	1349	0.973	5043	21	0.01	0.94
1940	2157	1342	0.968	5041	28	0.01	0.93
1941	2146	1331	0.961	5037	27	0.01	0.93
1942	2137	1323	0.955	5034	14	0.01	0.96
1943	2137	1323	0.955	5034	17	0.01	0.95
1944	2136	1322	0.954	5033	4	0.00	0.99
1945	2143	1328	0.958	5036	6	0.00	0.98
1946	2148	1333	0.962	5037	27	0.01	0.93
1947	2138	1324	0.956	5034	37	0.02	0.91
1948	2124	1311	0.946	5029	39	0.02	0.90
1949	2109	1298	0.937	5024	37	0.02	0.90
1950	2099	1288	0.930	5020	39	0.02	0.90
1951	2088	1279	0.923	5016	52	0.03	0.87
1952	2071	1263	0.912	5010	52	0.03	0.87

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Table 4: Time-series of population estimates from the base-case model. Relative exploitation rate is $(1 - SPR)/(1 - SPR_{50\%})$.

Year	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative exploitation rate	SPR
1953	2056	1249	0.902	5004	55	0.03	0.86
1954	2042	1236	0.892	4998	68	0.03	0.83
1955	2020	1217	0.878	4990	60	0.03	0.84
1956	2007	1205	0.870	4984	76	0.04	0.81
1957	1986	1186	0.856	4976	76	0.04	0.81
1958	1968	1170	0.844	4968	88	0.04	0.78
1959	1945	1149	0.829	4958	62	0.03	0.83
1960	1938	1146	0.827	3365	44	0.02	0.87
1961	1941	1153	0.832	3072	50	0.03	0.86
1962	1933	1156	0.835	2858	61	0.03	0.83
1963	1904	1153	0.832	2710	56	0.03	0.84
1964	1865	1152	0.831	2633	43	0.02	0.87
1965	1819	1153	0.832	2629	58	0.03	0.84
1966	1751	1136	0.820	2699	52	0.03	0.85
1967	1680	1112	0.803	2848	48	0.03	0.86
1968	1609	1079	0.779	3066	49	0.03	0.85
1969	1537	1036	0.748	3255	46	0.03	0.86
1970	1472	989	0.714	3306	60	0.04	0.82
1971	1405	931	0.672	3192	51	0.04	0.84
1972	1355	881	0.636	2969	66	0.05	0.79
1973	1303	826	0.596	2813	88	0.07	0.74
1974	1247	766	0.553	2896	92	0.07	0.71
1975	1198	715	0.516	3211	89	0.07	0.70
1976	1158	676	0.488	3589	91	0.08	0.69
1977	1125	645	0.465	3842	79	0.07	0.70
1978	1108	626	0.452	3906	84	0.08	0.67
1979	1096	607	0.438	3785	78	0.07	0.68
1980	1098	595	0.429	3954	155	0.14	0.54
1981	1062	546	0.394	4189	143	0.14	0.53
1982	1046	514	0.371	4369	129	0.12	0.53
1983	1050	500	0.361	3914	116	0.11	0.54
1984	1067	501	0.362	3032	172	0.16	0.46
1985	1054	482	0.348	2516	173	0.17	0.44
1986	1042	470	0.339	2347	206	0.20	0.40
1987	1007	451	0.326	2502	162	0.16	0.43
1988	989	457	0.330	3094	145	0.15	0.46
1989	973	469	0.338	4244	120	0.12	0.50

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Table 4: Time-series of population estimates from the base-case model. Relative exploitation rate is $(1 - SPR)/(1 - SPR_{50\%})$.

Year	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative exploitation rate	SPR
1990	967	485	0.350	5920	136	0.14	0.49
1991	956	482	0.348	7454	176	0.19	0.44
1992	941	452	0.326	8175	207	0.22	0.40
1993	939	402	0.290	8132	211	0.23	0.37
1994	974	356	0.257	7570	166	0.17	0.39
1995	1071	346	0.250	6691	151	0.14	0.39
1996	1203	370	0.267	5669	147	0.12	0.40
1997	1346	427	0.308	4550	117	0.09	0.46
1998	1497	523	0.377	3823	118	0.08	0.50
1999	1623	635	0.459	3480	127	0.08	0.53
2000	1708	747	0.539	3390	130	0.08	0.56
2001	1754	848	0.612	3816	168	0.10	0.55
2002	1744	910	0.657	4093	133	0.08	0.62
2003	1725	960	0.693	3685	147	0.09	0.62
2004	1675	972	0.701	3182	72	0.04	0.76
2005	1661	995	0.718	2983	86	0.05	0.74
2006	1625	989	0.714	2947	78	0.05	0.76
2007	1586	974	0.703	3028	70	0.04	0.78
2008	1544	957	0.691	3250	86	0.06	0.75
2009	1488	926	0.668	3626	111	0.07	0.70
2010	1418	877	0.633	3817	153	0.11	0.63
2011	1327	805	0.581	3564	134	0.10	0.63
2012	1261	745	0.538	3610	94	0.07	0.69
2013	1234	712	0.514	4355	83	0.07	0.70
2014	1225	688	0.497	6351	105	0.09	0.65
2015	1216	658	0.475	8323	109	0.09	0.63
2016	1225	634	0.457	7554	112	0.09	0.62
2017	1259	616	0.444	5963	104	0.08	0.62
2018	1329	611	0.441	4790	91	0.07	0.64
2019	1427	626	0.452	4789			

Table 5: Sensitivity of the base model to dropping or down-weighting data sources and alternative assumptions about growth.

Label	Base (Francis weights)	Default weights	Harmonic mean weights	Estimate equal M	Estimate equal M and h	Drop PR data	Drop PC data	Drop RecDD data
TOTAL_like	-	-	-	-	-	-	-	-
Catch_like	-	-	-	-	-	-	-	-
Equil_catch_like	-	-	-	-	-	-	-	-
Survey_like	-	-	-	-	-	-	-	-
Length_comp_like	-	-	-	-	-	-	-	-
Age_comp_like	-	-	-	-	-	-	-	-
Parm_priors_like	-	-	-	-	-	-	-	-
SSB_Unfished_thousand_mt	-	-	-	-	-	-	-	-
TotBio_Unfished	-	-	-	-	-	-	-	-
SmryBio_Unfished	-	-	-	-	-	-	-	-
Recr_Unfished_billions	-	-	-	-	-	-	-	-
SSB_Btgt_thousand_mt	-	-	-	-	-	-	-	-
SPR_Btgt	-	-	-	-	-	-	-	-
Fstd_Btgt	-	-	-	-	-	-	-	-
TotYield_Btgt_thousand_mt	-	-	-	-	-	-	-	-
SSB_SPRtgt_thousand_mt	-	-	-	-	-	-	-	-
Fstd_SPRtgt	-	-	-	-	-	-	-	-
TotYield_SPRtgt_thousand_mt	-	-	-	-	-	-	-	-
SSB_MSY_thousand_mt	-	-	-	-	-	-	-	-
SPR_MSY	-	-	-	-	-	-	-	-
Fstd_MSY	-	-	-	-	-	-	-	-
TotYield_MSY_thousand_mt	-	-	-	-	-	-	-	-
RetYield_MSY	-	-	-	-	-	-	-	-
Bratio_2015	-	-	-	-	-	-	-	-
F_2015	-	-	-	-	-	-	-	-
SPRratio_2015	-	-	-	-	-	-	-	-
Recr_2015	-	-	-	-	-	-	-	-
Recr_Virgin_billions	-	-	-	-	-	-	-	-
L_at_Amin_Fem_GP_1	-	-	-	-	-	-	-	-
L_at_Amax_Fem_GP_1	-	-	-	-	-	-	-	-
VonBert_K_Fem_GP_1	-	-	-	-	-	-	-	-
CV_young_Fem_GP_1	-	-	-	-	-	-	-	-
CV_old_Fem_GP_1	-	-	-	-	-	-	-	-

Table 6: Summary of the biomass/abundance time series used in the stock assessment.

Fleet	Years	Name	Fishery ind.	Filtering	Method	Endorsed
5	1988-1998	Deb Wilson-Vandenberg's Onboard Observer Survey	Fishery-dependent	Central California	Delta lognormal	SSC
6	2001-2018	CRFS CPFV Onboard Observer Survey	Fishery-dependent	North of Pt. Conception	Delta lognormal	SSC
7	2001-2018	CRFS CPFV Onboard Observer Survey	Fishery-dependent	South of Pt. Conception	Delta lognormal	SSC
8	2001-2018	PISCO Dive Survey	Fishery-independent	North of Pt. Conception	Negative Binomial	First use in stock assessment
9	2007-2018	CCFRP Hook-and-Line Survey	Fishery-independent	Central California	Negative Binomial	First use in stock assessment
10	1984-1999	MRFSS Dockside Survey	Fishery-dependent	North of Pt. Conception	Negative Binomial	SSC
11	1980-1999	MRFSS Dockside Survey	Fishery-dependent	South of Pt. Conception	Negative Binomial	SSC

Table 7: Summaries of key assessment outputs and likelihood values from the retrospective analysis. Note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for the year of 2017. The base model includes all of the data. Retro1 removes the last year of data (2016), Retro2 removes the last two years of data, Retro3 removes three years and Retro4 removes four years.

Label	Base	Retro1	Retro2	Retro3	Retro4
Female natural mortality	0.26	0.26	0.26	0.26	0.26
Steepness	0.72	0.72	0.72	0.72	0.72
lnR0	8.16	8.09	8.07	8.04	8.08
Total Biomass (mt)	2796.86	2593.78	2568.77	2498.07	2650.36
Depletion	57.41	53.57	50.74	50.72	54.78
SPR ratio	0.72	0.76	0.79	0.80	0.74
Female Lmin	12.43	12.45	12.90	12.63	13.03
Female Lmax	33.31	33.50	33.39	33.37	33.46
Female K	0.25	0.24	0.24	0.25	0.23
Male Lmin (offset)	0.00	0.00	0.00	0.00	0.00
Male Lmax (offset)	-0.16	-0.16	-0.15	-0.16	-0.15
Male K (offset)	-0.29	-0.30	-0.43	-0.41	-0.56
Negative log-likelihood	1097.30	1047.56	1009.37	961.81	897.04
No. parameters	0.00	0.00	0.00	0.00	0.00
TOTAL	0.00	0.00	0.00	0.00	0.00
Equililibrium catch	-98.12	-92.00	-89.12	-81.75	-80.59
Survey	763.02	739.90	720.39	700.10	670.66
Length composition	421.52	390.56	369.97	336.26	299.84
Age composition	10.88	9.09	8.12	7.20	7.12
Recruitment	0.00	0.00	0.00	0.00	0.00
Forecast Recruitment	0.00	0.00	0.00	0.00	0.00
Parameter priors	0.01	0.01	0.01	0.01	0.01

Table 8: Summaries of key assessment outputs and likelihood values from selected likelihood profile runs on virgin recruitment (lnR0) and steepness. Note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for the year of 2017.

Label	R07400	R07800	R08200	R08600	R09000	h0410	h0570	h0710	h0870	h0990
Female M	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Steepness	0.72	0.72	0.72	0.72	0.72	0.41	0.57	0.71	0.87	0.99
lnR0	7.40	7.80	8.20	8.60	9.00	8.34	8.21	8.16	8.13	8.11
Total biomass (m)	1623.19	2113.03	2894.72	4173.95	6142.97	3313.42	2943.85	2802.69	2712.12	2667.97
Depletion (%)	46.83	49.83	58.31	66.23	71.80	51.20	55.27	57.32	58.81	59.60
SPR ratio	1.05	0.91	0.70	0.49	0.34	0.68	0.71	0.72	0.72	0.73
Female Lmin	12.16	12.41	12.43	12.39	12.36	12.43	12.44	12.43	12.43	12.43
Female Lmax	34.29	33.83	33.26	32.76	32.42	33.19	33.28	33.31	33.33	33.34
Female K	0.24	0.25	0.25	0.26	0.26	0.25	0.25	0.25	0.25	0.25
Male Lmin (offset)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Male Lmax (offset)	-0.18	-0.17	-0.16	-0.15	-0.15	-0.16	-0.16	-0.16	-0.16	-0.16
Male K (offset)	-0.22	-0.31	-0.29	-0.24	-0.21	-0.27	-0.29	-0.29	-0.30	-0.30
Negative log-likelihood										
TOTAL	1117.15	1101.02	1097.33	1099.69	1102.95	1101.35	1098.58	1097.35	1096.72	1100.21
Catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Equil_catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Survey	-100.10	-99.20	-97.99	-97.00	-96.37	-98.27	-98.18	-98.12	-98.06	-98.03
Length_comp	761.18	760.12	763.44	767.61	770.76	765.11	763.69	763.05	762.58	762.33
Age_comp	437.32	427.37	421.09	418.57	417.98	420.58	421.24	421.51	421.68	421.77
Recruitment	18.74	12.72	10.80	10.50	10.58	12.55	11.40	10.90	10.56	10.38
Forecast_Recruitment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parm_priors	0.00	0.00	0.00	0.00	0.00	1.38	0.42	0.01	-0.04	3.76
Parm_softbounds	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Parm_devs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crash_Pen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 9: Summaries of key assessment outputs and likelihood values from selected likelihood profile runs on female natural mortality. Note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for the year of 2017.

Label	M0220	M0260	M0300	M0350	M0400
Female M	0.22	0.26	0.30	0.35	0.40
Steepness	0.72	0.72	0.72	0.72	0.72
lnR0	7.67	8.20	8.95	12.21	31.00
Total biomass (m)	2259.39	2861.79	4632.81	89473.50	9753570000000.00
Depletion (%)	47.72	58.15	68.08	79.27	79.74
SPR ratio	0.97	0.70	0.41	0.02	0.00
Female Lmin	12.39	12.44	12.43	12.39	12.24
Female Lmax	33.23	33.31	33.31	33.25	33.73
Female K	0.25	0.25	0.25	0.25	0.24
Male Lmin (offset)	0.00	0.00	0.00	0.00	0.00
Male Lmax (offset)	-0.16	-0.16	-0.15	-0.15	-0.15
Male K (offset)	-0.27	-0.30	-0.31	-0.32	-0.36
Negative log-likelihood					
TOTAL	1102.66	1096.96	1092.96	1089.92	1091.52
Catch	0.00	0.00	0.00	0.00	0.00
Equil_catch	0.00	0.00	0.00	0.00	0.00
Survey	-97.79	-98.14	-98.33	-98.33	-98.95
Length_comp	765.50	762.85	760.88	759.19	755.26
Age_comp	422.97	421.41	420.05	418.75	425.16
Recruitment	11.91	10.82	10.30	10.05	9.54
Forecast_Recruitment	0.00	0.00	0.00	0.00	0.00
Parm_priors	0.06	0.00	0.06	0.25	0.51
Parm_softbounds	0.01	0.01	0.01	0.00	0.00
Parm_devs	0.00	0.00	0.00	0.00	0.00
Crash_Pen	0.00	0.00	0.00	0.00	0.00

Table 10: Projection of potential OFL, spawning biomass, and depletion for the base case model.

Yr	OFL contribution (mt)	ACL landings (mt)	Age 5+ biomass (mt)	Spawning Biomass (mt)	Depletion
2019	182.795	182.795	1420.440	625.830	0.452

Table 11: Results from 100 jitters from the base case model.

Description	Value	NA	NA
Returned to base case	-	-	-
Found local minimum	-	-	-
Found better solution	-	-	-
Error in likelihood	-	-	-
Total	100	100	100

Table 12: 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).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
1	NatM_p_1_Fem_GP_1	0.207	2	(0.05, 0.4)	OK	0.028	Log_Norm (-1.6458, 0.4384)
2	L_at_Amin_Fem_GP_1	7.906	3	(4, 50)	OK	0.764	None
3	L_at_Amax_Fem_GP_1	28.290	3	(20, 60)	OK	0.817	None
4	VonBert_K_Fem_GP_1	0.143	3	(0.01, 0.3)	OK	0.026	None
5	CV_young_Fem_GP_1	0.258	3	(0.05, 0.5)	OK	0.038	None
6	CV_old_Fem_GP_1	0.119	3	(0.03, 0.3)	OK	0.012	None
7	Wtlen_1_Fem_GP_1	0.000	-3	(-3, 3)			None
8	Wtlen_2_Fem_GP_1	3.256	-3	(2, 4)			None
9	Mat50%_Fem_GP_1	21.666	-3	(-3, 3)			None
10	Mat_slope_Fem_GP_1	-0.906	-3	(-6, 3)			None
11	Eggs/kg_inter_Fem_GP_1	1.000	-3	(-3, 3)			None
12	Eggs/kg_slope_wt_Fem_GP_1	0.000	-3	(-3, 3)			None
13	CohortGrowDev	1.000	-1	(0.1, 10)			None
14	FracFemale_GP_1	0.500	-4	(0.000001, 0.999999)			None
15	SR_LN(R0)	8.528	1	(2, 15)	OK	0.394	None
16	SR_BH_steep	0.720	-1	(0.2, 1)			None
17	SR_sigmaR	0.400	-2	(0, 2)			None
18	SR_regime	0.000	-4	(-5, 5)			None
19	SR_autocorr	0.696	4	(-1, 1)	OK	0.101	None
81	LnQ_base_DebCPFV(5)	-7.079	-1	(-15, 15)			None
82	Q_extraSD_DebCPFV(5)	0.073	4	(0.0001, 2)	OK	0.048	None
83	LnQ_base_RecOnboardNorth(6)	-7.807	-1	(-15, 15)			None
84	Q_extraSD_RecOnboardNorth(6)	0.227	4	(0.0001, 2)	OK	0.056	None
85	LnQ_base_RecOnboardSouth(7)	-10.380	-1	(-15, 15)			None
86	Q_extraSD_RecOnboardSouth(7)	0.603	4	(0.0001, 2)	OK	0.149	None
87	LnQ_base_PISCO(8)	-7.695	-1	(-15, 15)			None

Continued on next page

Table 12: 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).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
88	Q_extraSD_PISCO(8)	0.209	4	(0.0001, 2)	OK	0.074	None
89	LnQ_base_CCFRP(9)	-6.534	-1	(-15, 15)			None
90	Q_extraSD_CCFRP(9)	0.184	4	(0.0001, 2)	OK	0.074	None
91	LnQ_base_RecDocksideNorth(10)	-8.896	-1	(-15, 15)			None
92	Q_extraSD_RecDocksideNorth(10)	0.000	-4	(0.0001, 2)			None
93	LnQ_base_RecDocksideSouth(11)	-9.856	-1	(-15, 15)			None
94	Q_extraSD_RecDocksideSouth(11)	0.279	4	(0.0001, 2)	OK	0.109	None
95	Size_DblN_peak_Com(1)	32.341	1	(19, 38)	OK	0.727	None
96	Size_DblN_top_logit_Com(1)	8.000	-5	(-5, 10)			None
97	Size_DblN_ascend_se_Com(1)	3.139	5	(-9, 10)	OK	0.127	None
98	Size_DblN_descend_se_Com(1)	5.000	-5	(-9, 9)			None
99	Size_DblN_start_logit_Com(1)	-11.574	5	(-15, -5)	OK	1.753	None
100	Size_DblN_end_logit_Com(1)	10.000	-5	(-5, 15)			None
101	Size_DblN_peak_ComDisc(2)	24.987	2	(19, 38)	OK	0.443	None
102	Size_DblN_top_logit_ComDisc(2)	-9.601	5	(-15, 10)	OK	76.674	None
103	Size_DblN_ascend_se_ComDisc(2)	2.038	5	(-9, 10)	OK	0.223	None
104	Size_DblN_descend_se_ComDisc(2)	5.317	5	(-9, 9)	OK	1.611	None
105	Size_DblN_start_logit_ComDisc(2)	-14.051	5	(-15, -5)	OK	21.227	None
106	Size_DblN_end_logit_ComDisc(2)	-999.000	-5	(-5, 10)			None
107	Size_DblN_peak_RecNorth(3)	32.386	3	(19, 39)	OK	0.410	None
108	Size_DblN_top_logit_RecNorth(3)	8.000	-5	(-5, 10)			None
109	Size_DblN_ascend_se_RecNorth(3)	3.282	5	(-9, 10)	OK	0.071	None
110	Size_DblN_descend_se_RecNorth(3)	5.000	-5	(-9, 9)			None
111	Size_DblN_start_logit_RecNorth(3)	-11.844	5	(-15, -5)	OK	1.528	None
112	Size_DblN_end_logit_RecNorth(3)	10.000	-5	(-5, 15)			None
113	Size_DblN_peak_RecSouth(4)	27.621	4	(19, 38)	OK	1.212	None
114	Size_DblN_top_logit_RecSouth(4)	8.000	-5	(-5, 10)			None

Continued on next page

Table 12: 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).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
115	Size_DblN_ascend_se_RecSouth(4)	3.220	5	(-9, 10)	OK	0.272	None
116	Size_DblN_descend_se_RecSouth(4)	5.000	-5	(-9, 9)			None
117	Size_DblN_start_logit_RecSouth(4)	-8.730	5	(-15, -5)	OK	2.853	None
118	Size_DblN_end_logit_RecSouth(4)	10.000	-5	(-5, 15)			None
119	Size_DblN_peak_DebCPFV(5)	30.869	5	(19, 38)	OK	0.625	None
120	Size_DblN_top_logit_DebCPFV(5)	8.000	-5	(-5, 10)			None
121	Size_DblN_ascend_se_DebCPFV(5)	3.011	5	(-9, 10)	OK	0.119	None
122	Size_DblN_descend_se_DebCPFV(5)	5.000	-5	(-9, 9)			None
123	Size_DblN_start_logit_DebCPFV(5)	-14.890	5	(-15, -5)	OK	3.305	None
124	Size_DblN_end_logit_DebCPFV(5)	10.000	-5	(-5, 15)			None
125	SizeSel_P1_RecOnboardNorth(6)	-1.000	-5	(-1, 10)			None
126	SizeSel_P2_RecOnboardNorth(6)	-1.000	-5	(-1, 10)			None
127	SizeSel_P1_RecOnboardSouth(7)	-1.000	-5	(-1, 10)			None
128	SizeSel_P2_RecOnboardSouth(7)	-1.000	-5	(-1, 10)			None
129	Size_DblN_peak_PISCO(8)	30.398	5	(19, 38)	OK	2.236	None
130	Size_DblN_top_logit_PISCO(8)	8.000	-5	(-15, 10)			None
131	Size_DblN_ascend_se_PISCO(8)	3.939	5	(-9, 10)	OK	0.381	None
132	Size_DblN_descend_se_PISCO(8)	5.000	-5	(-9, 9)			None
133	Size_DblN_start_logit_PISCO(8)	-2.641	5	(-15, 15)	OK	0.584	None
134	Size_DblN_end_logit_PISCO(8)	10.000	-5	(-5, 15)			None
135	Size_DblN_peak_CCFRP(9)	31.034	5	(19, 38)	OK	0.628	None
136	Size_DblN_top_logit_CCFRP(9)	-10.640	5	(-15, 10)	OK	65.115	None
137	Size_DblN_ascend_se_CCFRP(9)	3.152	5	(-9, 10)	OK	0.151	None
138	Size_DblN_descend_se_CCFRP(9)	1.654	5	(-15, 9)	OK	0.803	None
139	Size_DblN_start_logit_CCFRP(9)	-999.000	-5	(-15, -5)			None
140	Size_DblN_end_logit_CCFRP(9)	-999.000	-5	(-5, 10)			None
141	SizeSel_P1_RecDocksideNorth(10)	-1.000	-5	(-1, 10)			None

Continued on next page

Table 12: 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).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
142	SizeSel_P2_RecDocksideNorth(10)	-1.000	-5	(-1, 10)			None
143	SizeSel_P1_RecDocksideSouth(11)	-1.000	-5	(-1, 10)			None
144	SizeSel_P2_RecDocksideSouth(11)	-1.000	-5	(-1, 10)			None
145	Size_DblN_peak_Com(1)_BLK1repl_1999	28.866	6	(19, 38)	OK	0.327	None
146	Size_DblN_ascend_se_Com(1)_BLK1repl_1999	1.582	6	(-9, 10)	OK	0.170	None
147	Size_DblN_start_logit_Com(1)_BLK1repl_1999	-11.635	6	(-15, -5)	OK	3.280	None

Table 13: Likelihood components from the base model.

Likelihood component	Value
TOTAL	1097.30
Catch	0.00
Survey	-98.12
Length composition	763.02
Age composition	421.52
Recruitment	10.88
Forecast recruitment	0.00
Parameter priors	0.00
Parmeter soft bounds	0.01

Table 14: Time-series of population estimates from the base-case model. Relative exploitation rate is $(1 - SPR)/(1 - SPR_{50\%})$.

Year	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative exploitation rate	SPR
1916	2206	1386	0.000	5057	4	0.00	0.99
1917	2203	1383	0.998	5056	7	0.00	0.98
1918	2199	1379	0.996	5055	8	0.00	0.98
1919	2195	1376	0.993	5053	5	0.00	0.99
1920	2193	1374	0.991	5053	5	0.00	0.98
1921	2191	1372	0.990	5052	5	0.00	0.99
1922	2190	1371	0.990	5052	4	0.00	0.99
1923	2190	1371	0.990	5052	4	0.00	0.99
1924	2190	1371	0.989	5051	2	0.00	0.99
1925	2190	1371	0.990	5052	3	0.00	0.99
1926	2191	1372	0.990	5052	5	0.00	0.99
1927	2190	1371	0.989	5052	4	0.00	0.99
1928	2189	1370	0.989	5051	6	0.00	0.98
1929	2188	1369	0.988	5051	6	0.00	0.98
1930	2186	1368	0.987	5050	8	0.00	0.98
1931	2184	1366	0.986	5050	5	0.00	0.99
1932	2184	1366	0.986	5050	10	0.00	0.97
1933	2180	1362	0.983	5048	7	0.00	0.98
1934	2179	1362	0.983	5048	7	0.00	0.98
1935	2179	1361	0.982	5048	6	0.00	0.98
1936	2179	1361	0.982	5048	6	0.00	0.98
1937	2179	1361	0.982	5048	15	0.01	0.96
1938	2173	1356	0.978	5046	18	0.01	0.95
1939	2165	1349	0.973	5043	21	0.01	0.94
1940	2157	1342	0.968	5041	28	0.01	0.93
1941	2146	1331	0.961	5037	27	0.01	0.93
1942	2137	1323	0.955	5034	14	0.01	0.96
1943	2137	1323	0.955	5034	17	0.01	0.95
1944	2136	1322	0.954	5033	4	0.00	0.99
1945	2143	1328	0.958	5036	6	0.00	0.98
1946	2148	1333	0.962	5037	27	0.01	0.93
1947	2138	1324	0.956	5034	37	0.02	0.91
1948	2124	1311	0.946	5029	39	0.02	0.90
1949	2109	1298	0.937	5024	37	0.02	0.90
1950	2099	1288	0.930	5020	39	0.02	0.90
1951	2088	1279	0.923	5016	52	0.03	0.87
1952	2071	1263	0.912	5010	52	0.03	0.87

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Table 14: Time-series of population estimates from the base-case model. Relative exploitation rate is $(1 - SPR)/(1 - SPR_{50\%})$.

Year	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative exploitation rate	SPR
1953	2056	1249	0.902	5004	55	0.03	0.86
1954	2042	1236	0.892	4998	68	0.03	0.83
1955	2020	1217	0.878	4990	60	0.03	0.84
1956	2007	1205	0.870	4984	76	0.04	0.81
1957	1986	1186	0.856	4976	76	0.04	0.81
1958	1968	1170	0.844	4968	88	0.04	0.78
1959	1945	1149	0.829	4958	62	0.03	0.83
1960	1938	1146	0.827	3365	44	0.02	0.87
1961	1941	1153	0.832	3072	50	0.03	0.86
1962	1933	1156	0.835	2858	61	0.03	0.83
1963	1904	1153	0.832	2710	56	0.03	0.84
1964	1865	1152	0.831	2633	43	0.02	0.87
1965	1819	1153	0.832	2629	58	0.03	0.84
1966	1751	1136	0.820	2699	52	0.03	0.85
1967	1680	1112	0.803	2848	48	0.03	0.86
1968	1609	1079	0.779	3066	49	0.03	0.85
1969	1537	1036	0.748	3255	46	0.03	0.86
1970	1472	989	0.714	3306	60	0.04	0.82
1971	1405	931	0.672	3192	51	0.04	0.84
1972	1355	881	0.636	2969	66	0.05	0.79
1973	1303	826	0.596	2813	88	0.07	0.74
1974	1247	766	0.553	2896	92	0.07	0.71
1975	1198	715	0.516	3211	89	0.07	0.70
1976	1158	676	0.488	3589	91	0.08	0.69
1977	1125	645	0.465	3842	79	0.07	0.70
1978	1108	626	0.452	3906	84	0.08	0.67
1979	1096	607	0.438	3785	78	0.07	0.68
1980	1098	595	0.429	3954	155	0.14	0.54
1981	1062	546	0.394	4189	143	0.14	0.53
1982	1046	514	0.371	4369	129	0.12	0.53
1983	1050	500	0.361	3914	116	0.11	0.54
1984	1067	501	0.362	3032	172	0.16	0.46
1985	1054	482	0.348	2516	173	0.17	0.44
1986	1042	470	0.339	2347	206	0.20	0.40
1987	1007	451	0.326	2502	162	0.16	0.43
1988	989	457	0.330	3094	145	0.15	0.46
1989	973	469	0.338	4244	120	0.12	0.50

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Table 14: Time-series of population estimates from the base-case model. Relative exploitation rate is $(1 - SPR)/(1 - SPR_{50\%})$.

Year	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative exploitation rate	SPR
1990	967	485	0.350	5920	136	0.14	0.49
1991	956	482	0.348	7454	176	0.19	0.44
1992	941	452	0.326	8175	207	0.22	0.40
1993	939	402	0.290	8132	211	0.23	0.37
1994	974	356	0.257	7570	166	0.17	0.39
1995	1071	346	0.250	6691	151	0.14	0.39
1996	1203	370	0.267	5669	147	0.12	0.40
1997	1346	427	0.308	4550	117	0.09	0.46
1998	1497	523	0.377	3823	118	0.08	0.50
1999	1623	635	0.459	3480	127	0.08	0.53
2000	1708	747	0.539	3390	130	0.08	0.56
2001	1754	848	0.612	3816	168	0.10	0.55
2002	1744	910	0.657	4093	133	0.08	0.62
2003	1725	960	0.693	3685	147	0.09	0.62
2004	1675	972	0.701	3182	72	0.04	0.76
2005	1661	995	0.718	2983	86	0.05	0.74
2006	1625	989	0.714	2947	78	0.05	0.76
2007	1586	974	0.703	3028	70	0.04	0.78
2008	1544	957	0.691	3250	86	0.06	0.75
2009	1488	926	0.668	3626	111	0.07	0.70
2010	1418	877	0.633	3817	153	0.11	0.63
2011	1327	805	0.581	3564	134	0.10	0.63
2012	1261	745	0.538	3610	94	0.07	0.69
2013	1234	712	0.514	4355	83	0.07	0.70
2014	1225	688	0.497	6351	105	0.09	0.65
2015	1216	658	0.475	8323	109	0.09	0.63
2016	1225	634	0.457	7554	112	0.09	0.62
2017	1259	616	0.444	5963	104	0.08	0.62
2018	1329	611	0.441	4790	91	0.07	0.64
2019	1427	626	0.452	4789			

Table 15: Sensitivity of the base model to dropping or down-weighting data sources and alternative assumptions about growth.

Label	Base (Francis weights)	Default weights	Harmonic mean weights	Estimate equal M	Estimate equal M and h	Drop PR data	Drop PC data	Drop RecDD data
TOTAL_like	-	-	-	-	-	-	-	-
Catch_like	-	-	-	-	-	-	-	-
Equil_catch_like	-	-	-	-	-	-	-	-
Survey_like	-	-	-	-	-	-	-	-
Length_comp_like	-	-	-	-	-	-	-	-
Age_comp_like	-	-	-	-	-	-	-	-
Parm_priors_like	-	-	-	-	-	-	-	-
SSB_Unfished_thousand_mt	-	-	-	-	-	-	-	-
TotBio_Unfished	-	-	-	-	-	-	-	-
SmryBio_Unfished	-	-	-	-	-	-	-	-
Recr_Unfished_billions	-	-	-	-	-	-	-	-
SSB_Btgt_thousand_mt	-	-	-	-	-	-	-	-
SPR_Btgt	-	-	-	-	-	-	-	-
Fstd_Btgt	-	-	-	-	-	-	-	-
TotYield_Btgt_thousand_mt	-	-	-	-	-	-	-	-
SSB_SPRtgt_thousand_mt	-	-	-	-	-	-	-	-
Fstd_SPRtgt	-	-	-	-	-	-	-	-
TotYield_SPRtgt_thousand_mt	-	-	-	-	-	-	-	-
SSB_MSY_thousand_mt	-	-	-	-	-	-	-	-
SPR_MSY	-	-	-	-	-	-	-	-
Fstd_MSY	-	-	-	-	-	-	-	-
TotYield_MSY_thousand_mt	-	-	-	-	-	-	-	-
RetYield_MSY	-	-	-	-	-	-	-	-
Bratio_2015	-	-	-	-	-	-	-	-
F_2015	-	-	-	-	-	-	-	-
SPRratio_2015	-	-	-	-	-	-	-	-
Recr_2015	-	-	-	-	-	-	-	-
Recr_Virgin_billions	-	-	-	-	-	-	-	-
L_at_Amin_Fem_GP_1	-	-	-	-	-	-	-	-
L_at_Amax_Fem_GP_1	-	-	-	-	-	-	-	-
VonBert_K_Fem_GP_1	-	-	-	-	-	-	-	-
CV_young_Fem_GP_1	-	-	-	-	-	-	-	-
CV_old_Fem_GP_1	-	-	-	-	-	-	-	-

Table 16: Summary of the biomass/abundance time series used in the stock assessment.

Fleet	Years	Name	Fishery ind.	Filtering	Method	Endorsed
5	1988-1998	Deb Wilson-Vandenberg's Onboard Observer Survey	Fishery-dependent	Central California	Delta lognormal	SSC
6	2001-2018	CRFS CPFV Onboard Observer Survey	Fishery-dependent	North of Pt. Conception	Delta lognormal	SSC
7	2001-2018	CRFS CPFV Onboard Observer Survey	Fishery-dependent	South of Pt. Conception	Delta lognormal	SSC
8	2001-2018	PISCO Dive Survey	Fishery-independent	North of Pt. Conception	Negative Binomial	First use in stock assessment
9	2007-2018	CCFRP Hook-and-Line Survey	Fishery-independent	Central California	Negative Binomial	First use in stock assessment
10	1984-1999	MRFSS Dockside Survey	Fishery-dependent	North of Pt. Conception	Negative Binomial	SSC
11	1980-1999	MRFSS Dockside Survey	Fishery-dependent	South of Pt. Conception	Negative Binomial	SSC

Table 17: Summaries of key assessment outputs and likelihood values from the retrospective analysis. Note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for the year of 2017. The base model includes all of the data. Retro1 removes the last year of data (2016), Retro2 removes the last two years of data, Retro3 removes three years and Retro4 removes four years.

Label	Base	Retro1	Retro2	Retro3	Retro4
Female natural mortality	0.26	0.26	0.26	0.26	0.26
Steepness	0.72	0.72	0.72	0.72	0.72
lnR0	8.16	8.09	8.07	8.04	8.08
Total Biomass (mt)	2796.86	2593.78	2568.77	2498.07	2650.36
Depletion	57.41	53.57	50.74	50.72	54.78
SPR ratio	0.72	0.76	0.79	0.80	0.74
Female Lmin	12.43	12.45	12.90	12.63	13.03
Female Lmax	33.31	33.50	33.39	33.37	33.46
Female K	0.25	0.24	0.24	0.25	0.23
Male Lmin (offset)	0.00	0.00	0.00	0.00	0.00
Male Lmax (offset)	-0.16	-0.16	-0.15	-0.16	-0.15
Male K (offset)	-0.29	-0.30	-0.43	-0.41	-0.56
Negative log-likelihood	1097.30	1047.56	1009.37	961.81	897.04
No. parameters	0.00	0.00	0.00	0.00	0.00
TOTAL	0.00	0.00	0.00	0.00	0.00
Equililibrium catch	-98.12	-92.00	-89.12	-81.75	-80.59
Survey	763.02	739.90	720.39	700.10	670.66
Length composition	421.52	390.56	369.97	336.26	299.84
Age composition	10.88	9.09	8.12	7.20	7.12
Recruitment	0.00	0.00	0.00	0.00	0.00
Forecast Recruitment	0.00	0.00	0.00	0.00	0.00
Parameter priors	0.01	0.01	0.01	0.01	0.01

Table 18: Summaries of key assessment outputs and likelihood values from selected likelihood profile runs on virgin recruitment (lnR0) and steepness. Note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for the year of 2017.

Label	R07400	R07800	R08200	R08600	R09000	h0410	h0570	h0710	h0870	h0990
Female M	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Steepness	0.72	0.72	0.72	0.72	0.72	0.41	0.57	0.71	0.87	0.99
lnR0	7.40	7.80	8.20	8.60	9.00	8.34	8.21	8.16	8.13	8.11
Total biomass (m)	1623.19	2113.03	2894.72	4173.95	6142.97	3313.42	2943.85	2802.69	2712.12	2667.97
Depletion (%)	46.83	49.83	58.31	66.23	71.80	51.20	55.27	57.32	58.81	59.60
SPR ratio	1.05	0.91	0.70	0.49	0.34	0.68	0.71	0.72	0.72	0.73
Female Lmin	12.16	12.41	12.43	12.39	12.36	12.43	12.44	12.43	12.43	12.43
Female Lmax	34.29	33.83	33.26	32.76	32.42	33.19	33.28	33.31	33.33	33.34
Female K	0.24	0.25	0.25	0.26	0.26	0.25	0.25	0.25	0.25	0.25
Male Lmin (offset)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Male Lmax (offset)	-0.18	-0.17	-0.16	-0.15	-0.15	-0.16	-0.16	-0.16	-0.16	-0.16
Male K (offset)	-0.22	-0.31	-0.29	-0.24	-0.21	-0.27	-0.29	-0.29	-0.30	-0.30
Negative log-likelihood										
TOTAL	1117.15	1101.02	1097.33	1099.69	1102.95	1101.35	1098.58	1097.35	1096.72	1100.21
Catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Equil_catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Survey	-100.10	-99.20	-97.99	-97.00	-96.37	-98.27	-98.18	-98.12	-98.06	-98.03
Length_comp	761.18	760.12	763.44	767.61	770.76	765.11	763.69	763.05	762.58	762.33
Age_comp	437.32	427.37	421.09	418.57	417.98	420.58	421.24	421.51	421.68	421.77
Recruitment	18.74	12.72	10.80	10.50	10.58	12.55	11.40	10.90	10.56	10.38
Forecast_Recruitment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parm_priors	0.00	0.00	0.00	0.00	0.00	1.38	0.42	0.01	-0.04	3.76
Parm_softbounds	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Parm_devs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crash_Pen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 19: Summaries of key assessment outputs and likelihood values from selected likelihood profile runs on female natural mortality. Note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for the year of 2017.

Label	M0220	M0260	M0300	M0350	M0400
Female M	0.22	0.26	0.30	0.35	0.40
Steepness	0.72	0.72	0.72	0.72	0.72
lnR0	7.67	8.20	8.95	12.21	31.00
Total biomass (m)	2259.39	2861.79	4632.81	89473.50	9753570000000.00
Depletion (%)	47.72	58.15	68.08	79.27	79.74
SPR ratio	0.97	0.70	0.41	0.02	0.00
Female Lmin	12.39	12.44	12.43	12.39	12.24
Female Lmax	33.23	33.31	33.31	33.25	33.73
Female K	0.25	0.25	0.25	0.25	0.24
Male Lmin (offset)	0.00	0.00	0.00	0.00	0.00
Male Lmax (offset)	-0.16	-0.16	-0.15	-0.15	-0.15
Male K (offset)	-0.27	-0.30	-0.31	-0.32	-0.36
Negative log-likelihood					
TOTAL	1102.66	1096.96	1092.96	1089.92	1091.52
Catch	0.00	0.00	0.00	0.00	0.00
Equil_catch	0.00	0.00	0.00	0.00	0.00
Survey	-97.79	-98.14	-98.33	-98.33	-98.95
Length_comp	765.50	762.85	760.88	759.19	755.26
Age_comp	422.97	421.41	420.05	418.75	425.16
Recruitment	11.91	10.82	10.30	10.05	9.54
Forecast_Recruitment	0.00	0.00	0.00	0.00	0.00
Parm_priors	0.06	0.00	0.06	0.25	0.51
Parm_softbounds	0.01	0.01	0.01	0.00	0.00
Parm_devs	0.00	0.00	0.00	0.00	0.00
Crash_Pen	0.00	0.00	0.00	0.00	0.00

Table 20: Projection of potential OFL, spawning biomass, and depletion for the base case model.

Yr	OFL contribution (mt)	ACL landings (mt)	Age 5+ biomass (mt)	Spawning Biomass (mt)	Depletion
2019	182.795	182.795	1420.440	625.830	0.452

8 Figures

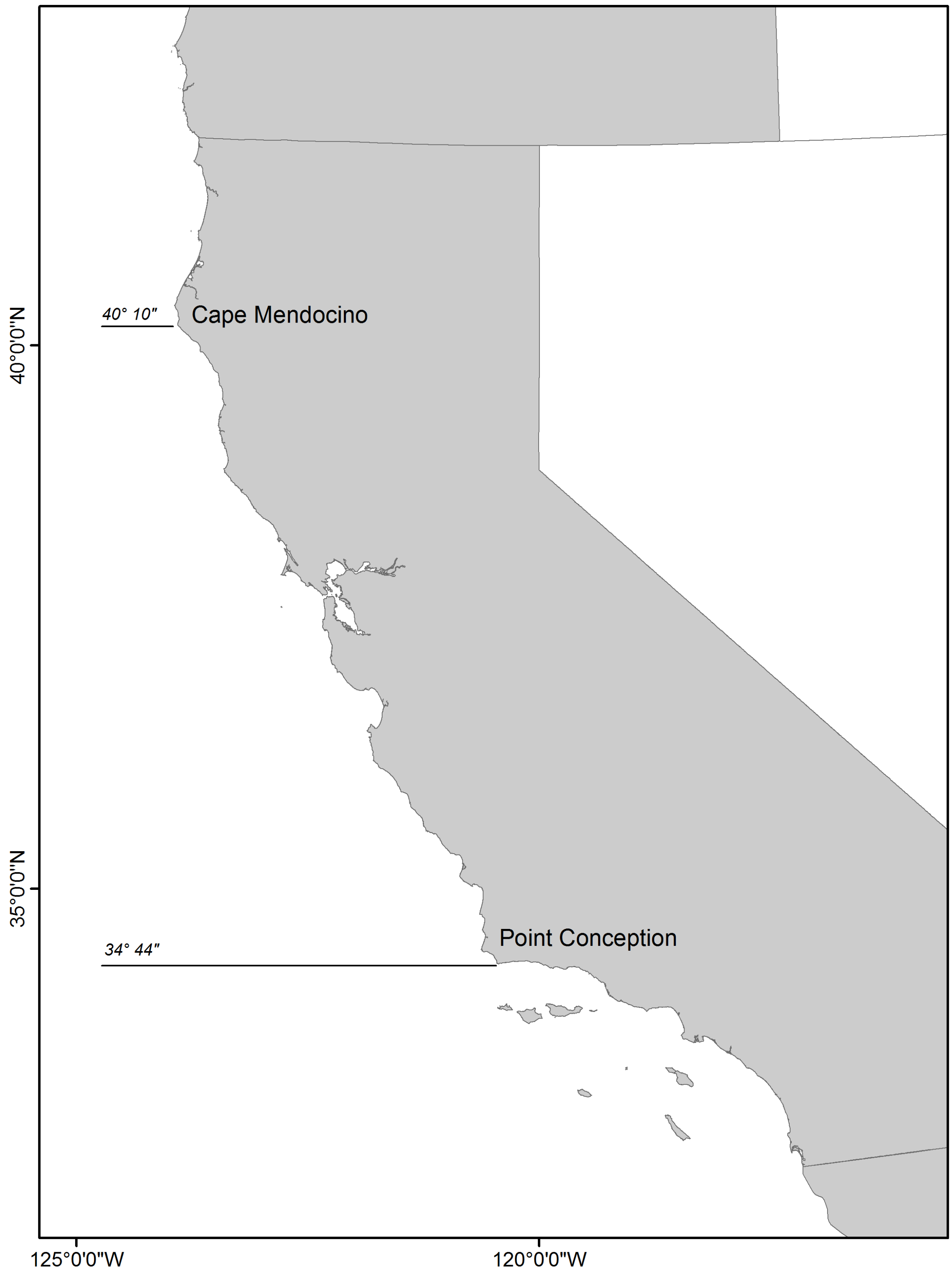

Figure 1: Map showing the management area for gopher and black-and-yellow rockfish from Cape Mendocino to the U.S. Mexico border.{fig:assess_reagion_map}

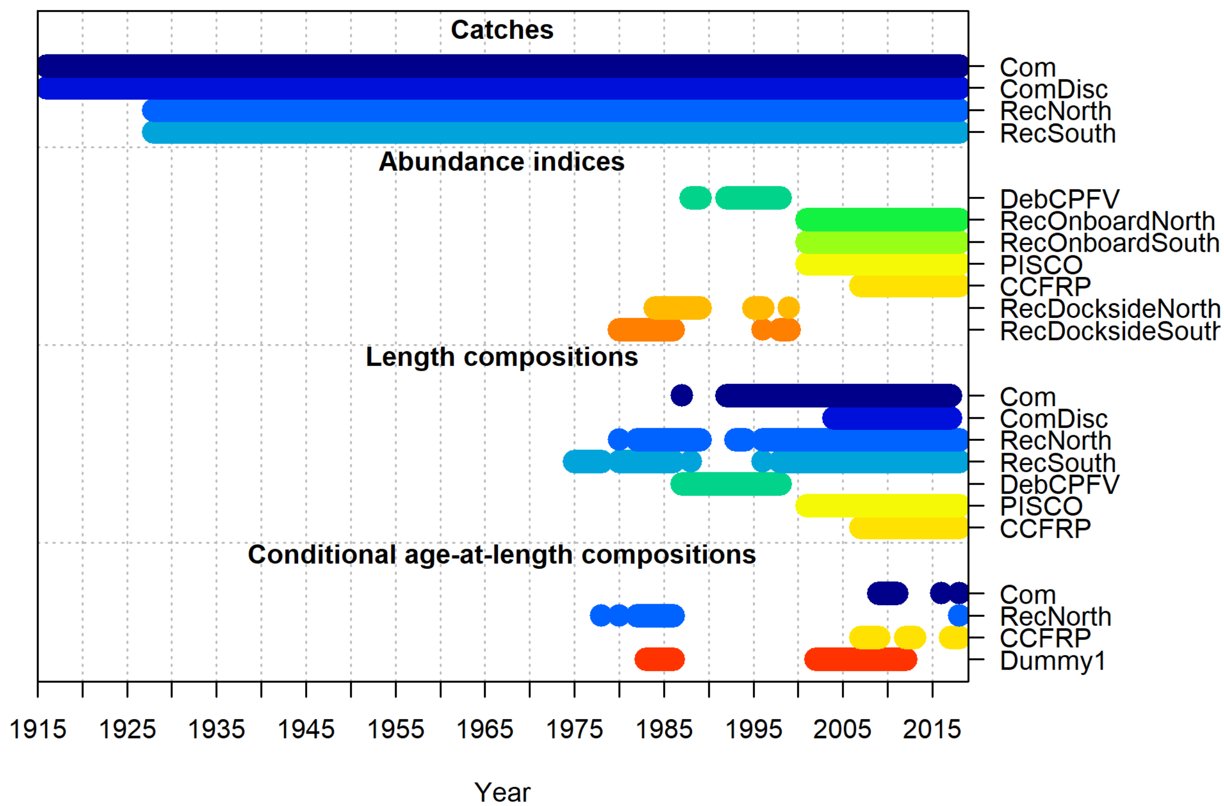

Figure 2: Summary of data sources used in the model.

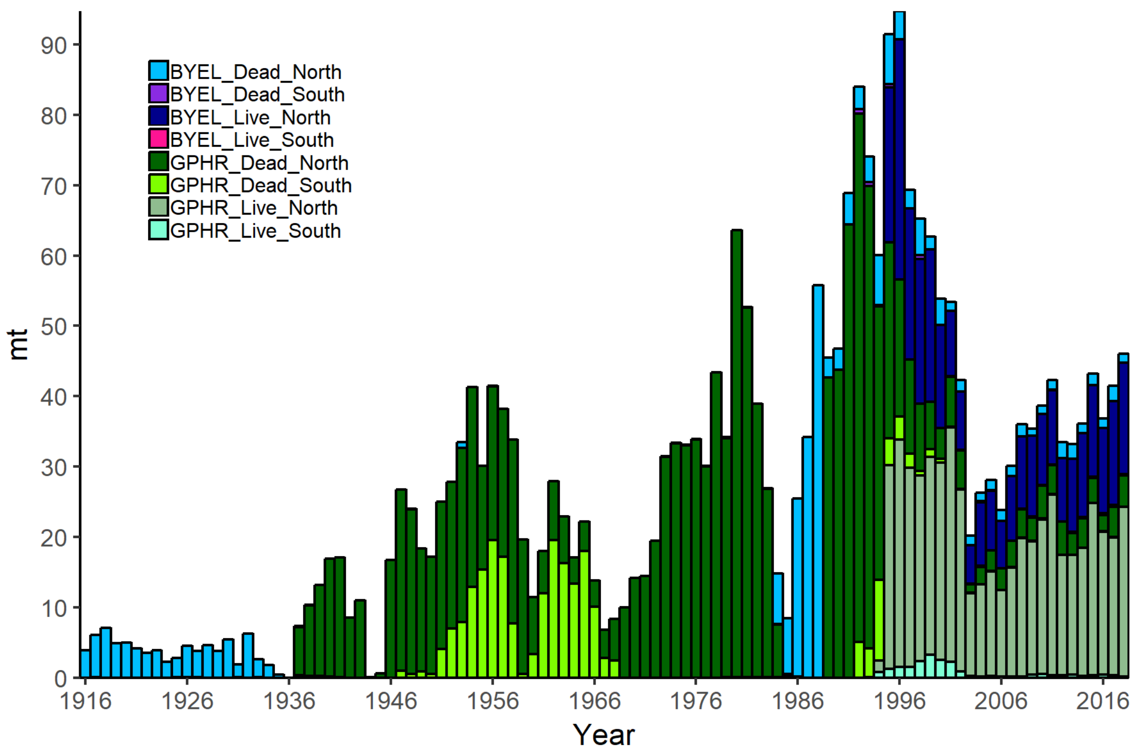

Figure 3: Commercial landings for gopher (GPHR) and black-and-yellow (BYEL) rockfishes landed live and dead north and south of Pt. Conception. All catch time series were combined for the assessment into one commercial fleet.

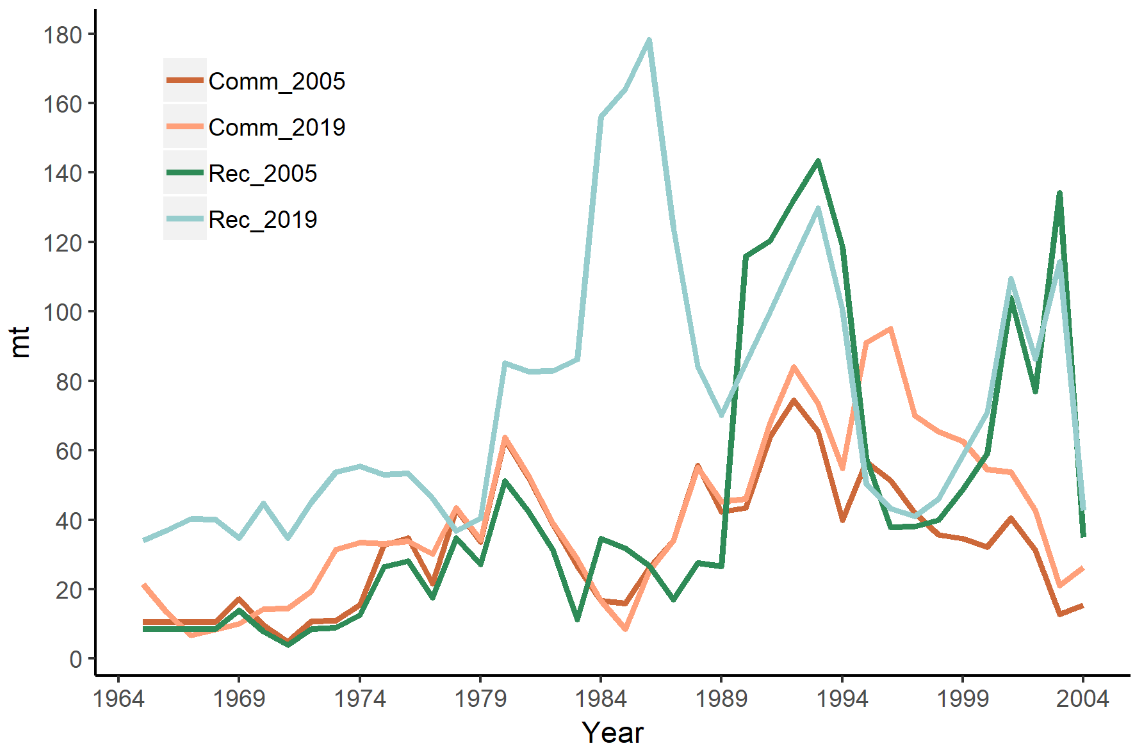

Figure 4: Comparison of the recreational and commercial fishery landings from the 2005 assessment to this 2019 assessment. Note that the 2019 assessment includes both gopher and black-and-yellow rockfish where the 2005 assessment represents gopher rockfish only. The 2005 assessment also did not include landings from south of Pt. Conception.

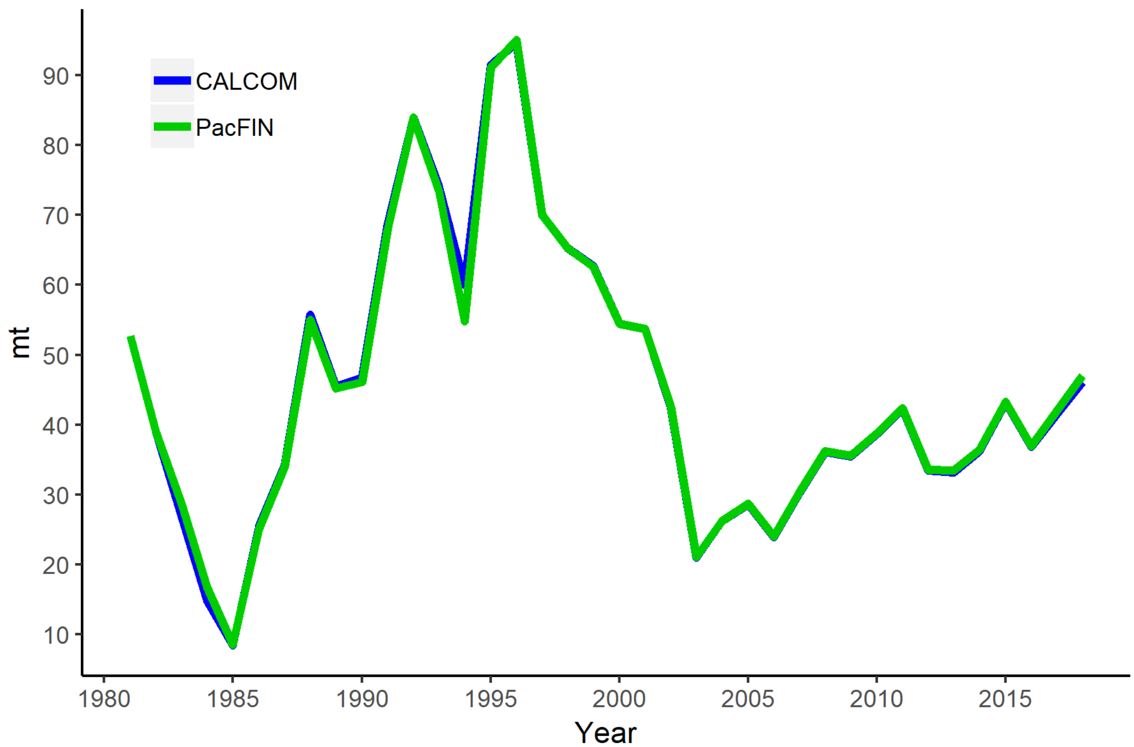

Figure 5: Commercial landings estimates from CALCOM add PacFIN.

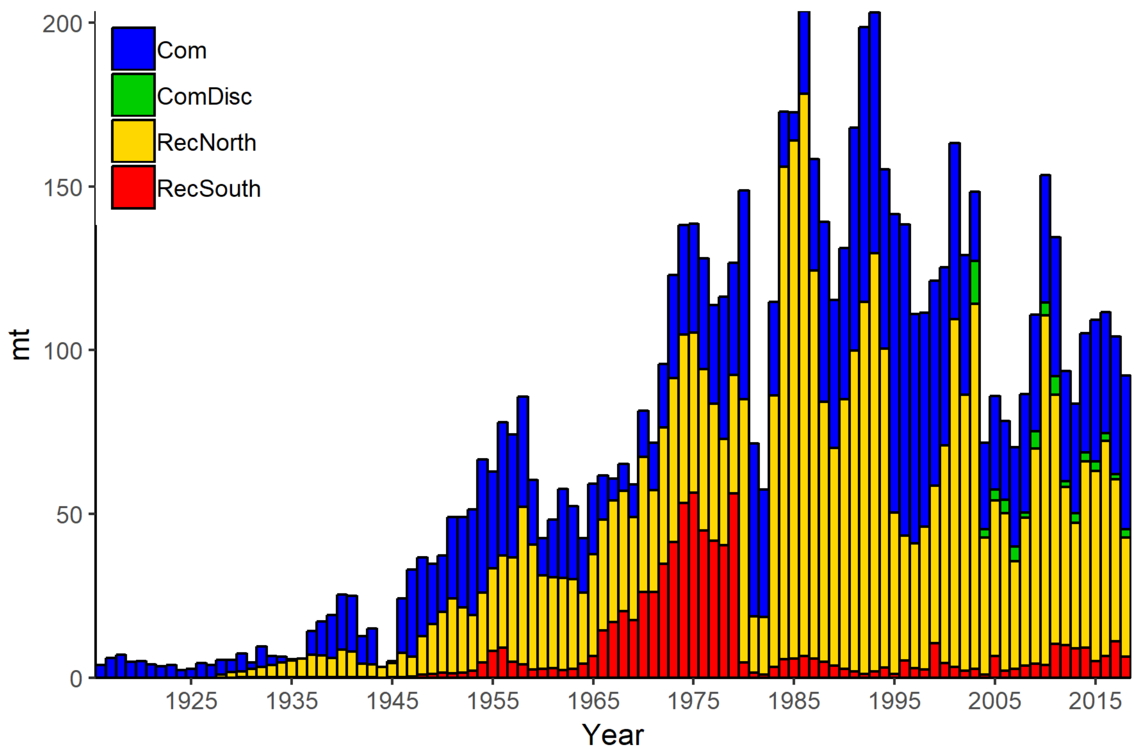

Figure 6: Commercial and recreational landings estimates prior to any data modification or interpolation to the recreational catches or hindcasting of commercial discards.

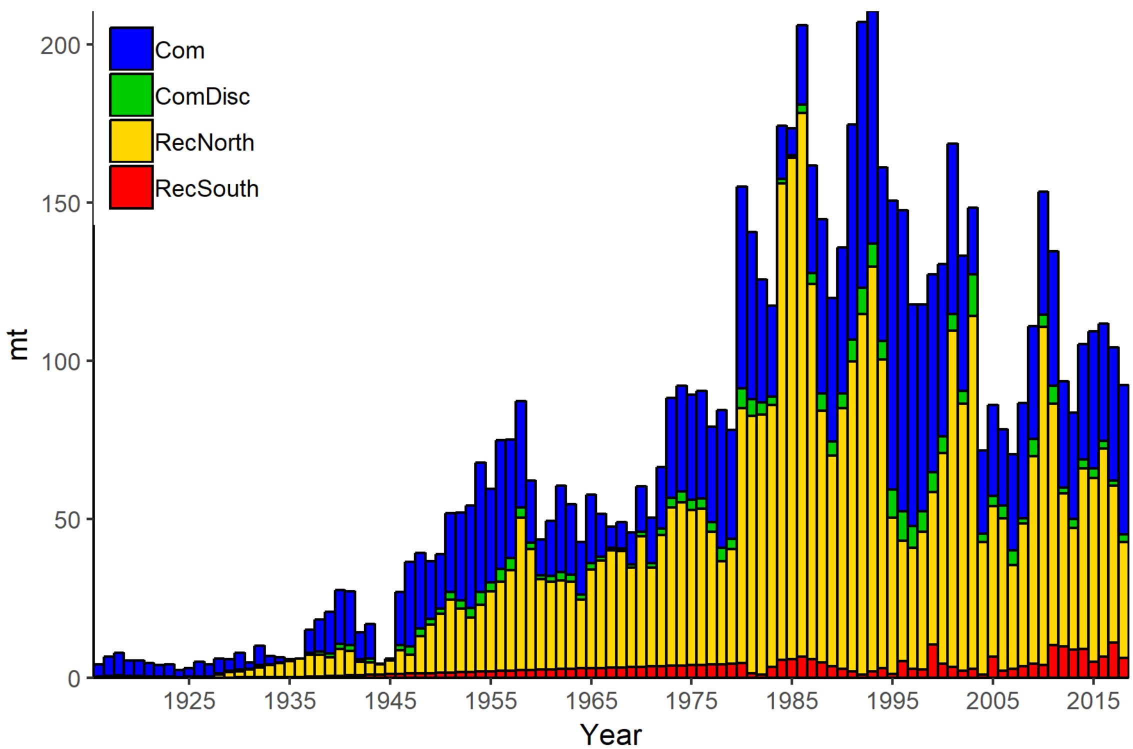

Figure 7: Commercial and recreational landings estimates after data modification and interpolations were made to the recreational catches and commercial discards.

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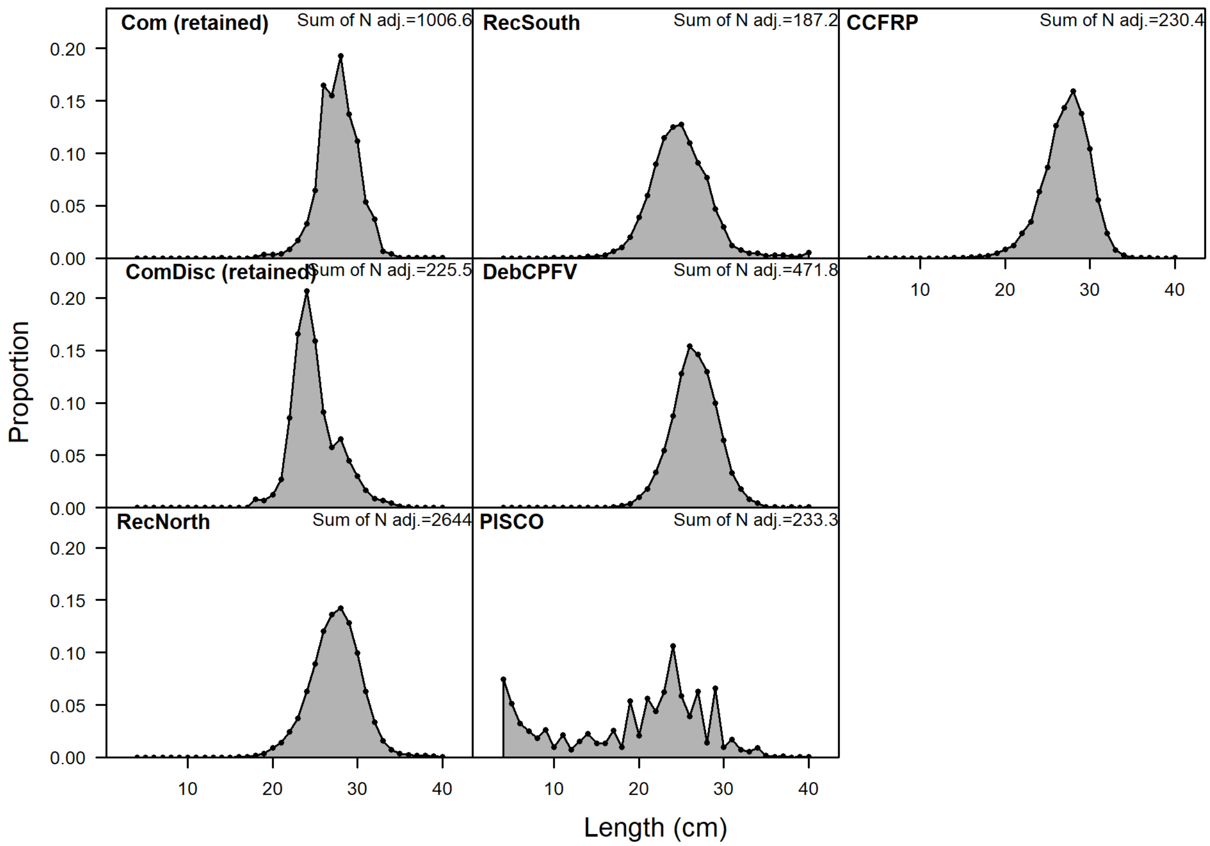


Figure 8: Length comp data, aggregated across time by fleet. Labels 'retained' and 'discard' indicate discarded or retained sampled for each fleet. Panels without this designation represent the whole catch.

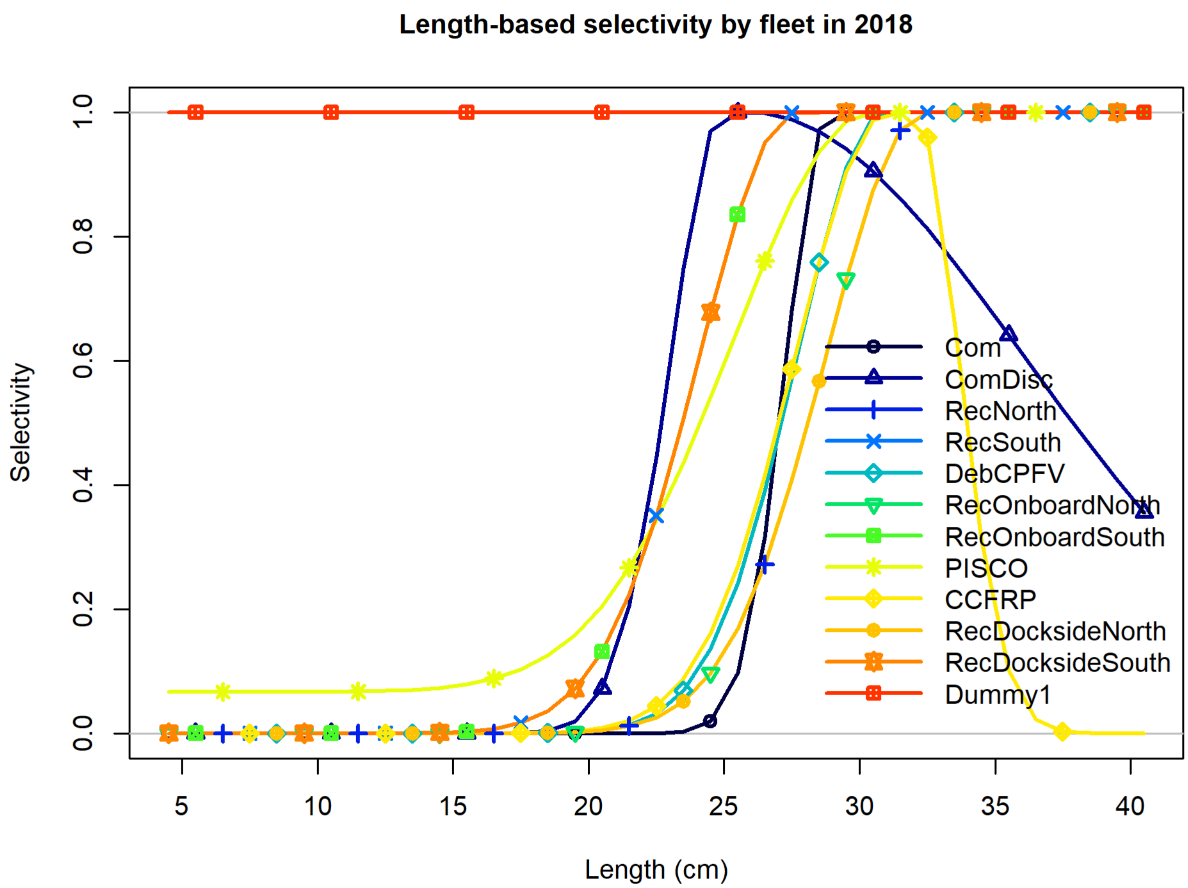


Figure 9: Selectivity at length for all of the fleets in the base model.

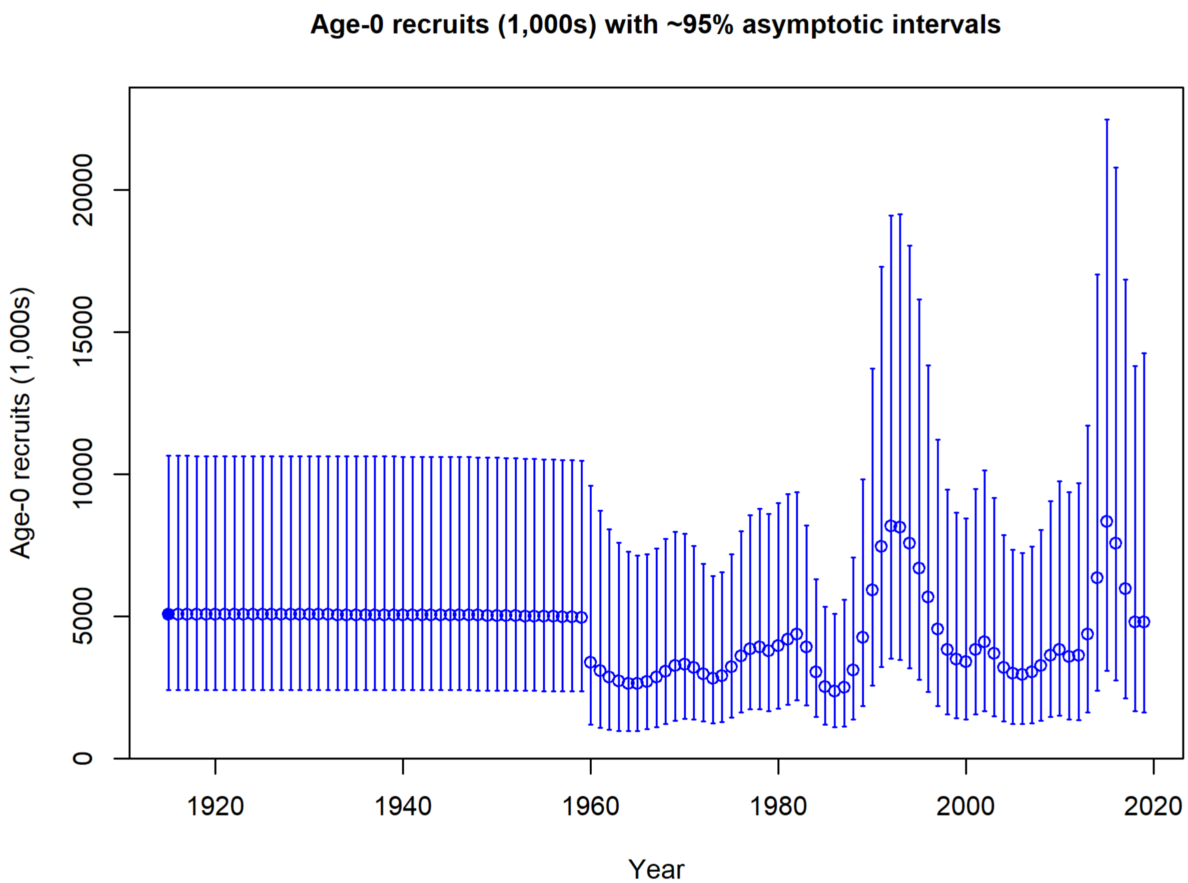


Figure 10: Time series of estimated GBYR recruitments for the base-case model with 95% confidence or credibility intervals.

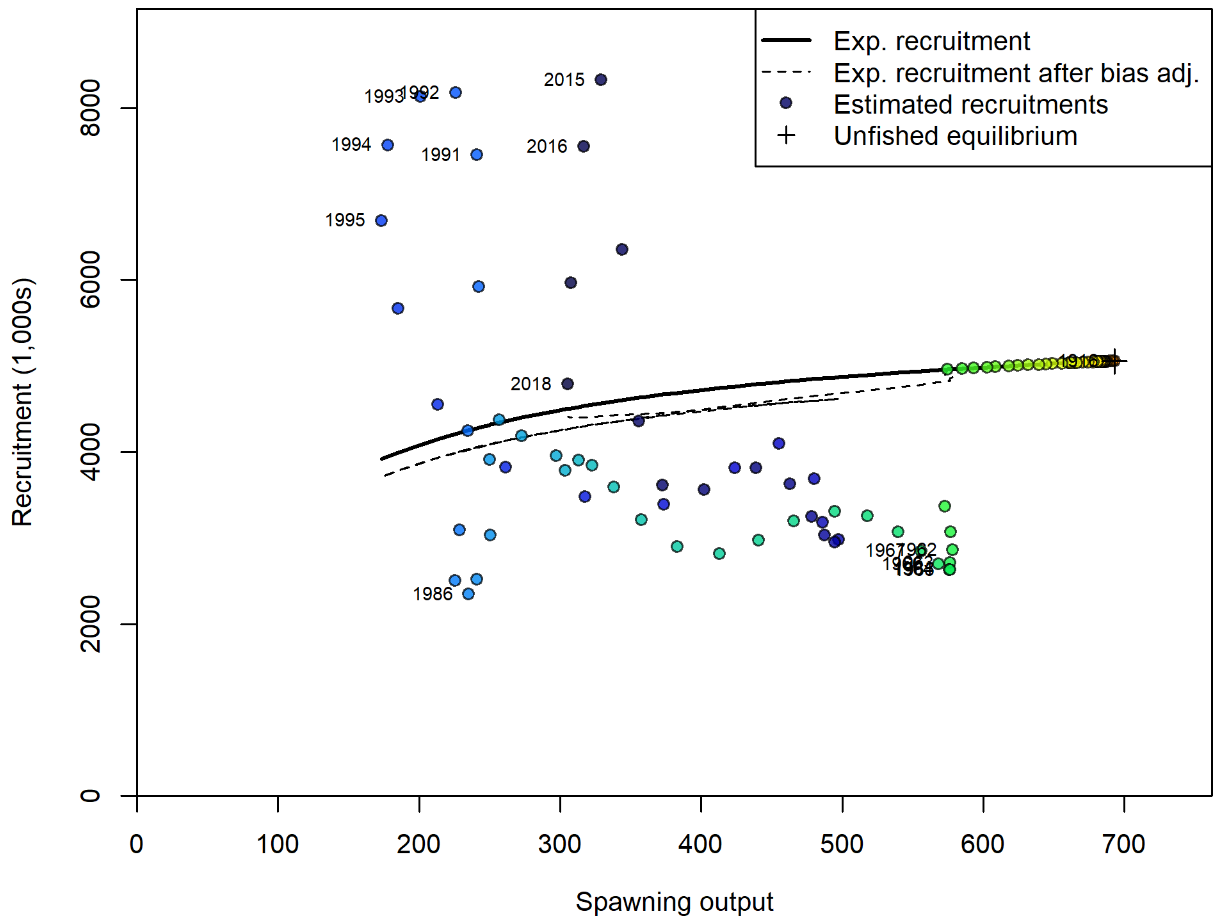
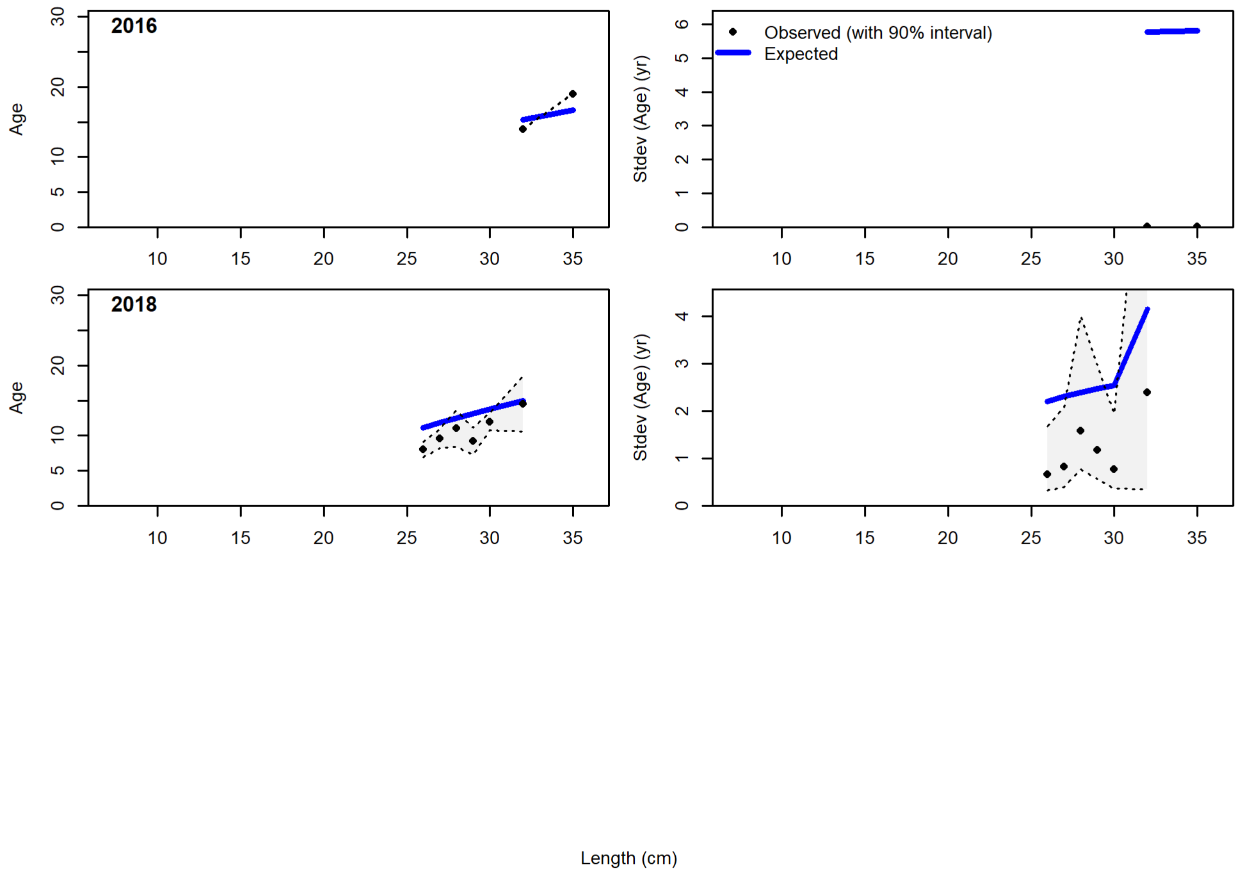


Figure 11: Estimated recruitment (red circles) and the assumed stock-recruit relationship (black line) for GBYR. The green line shows the effect of the bias correction for the lognormal distribution.



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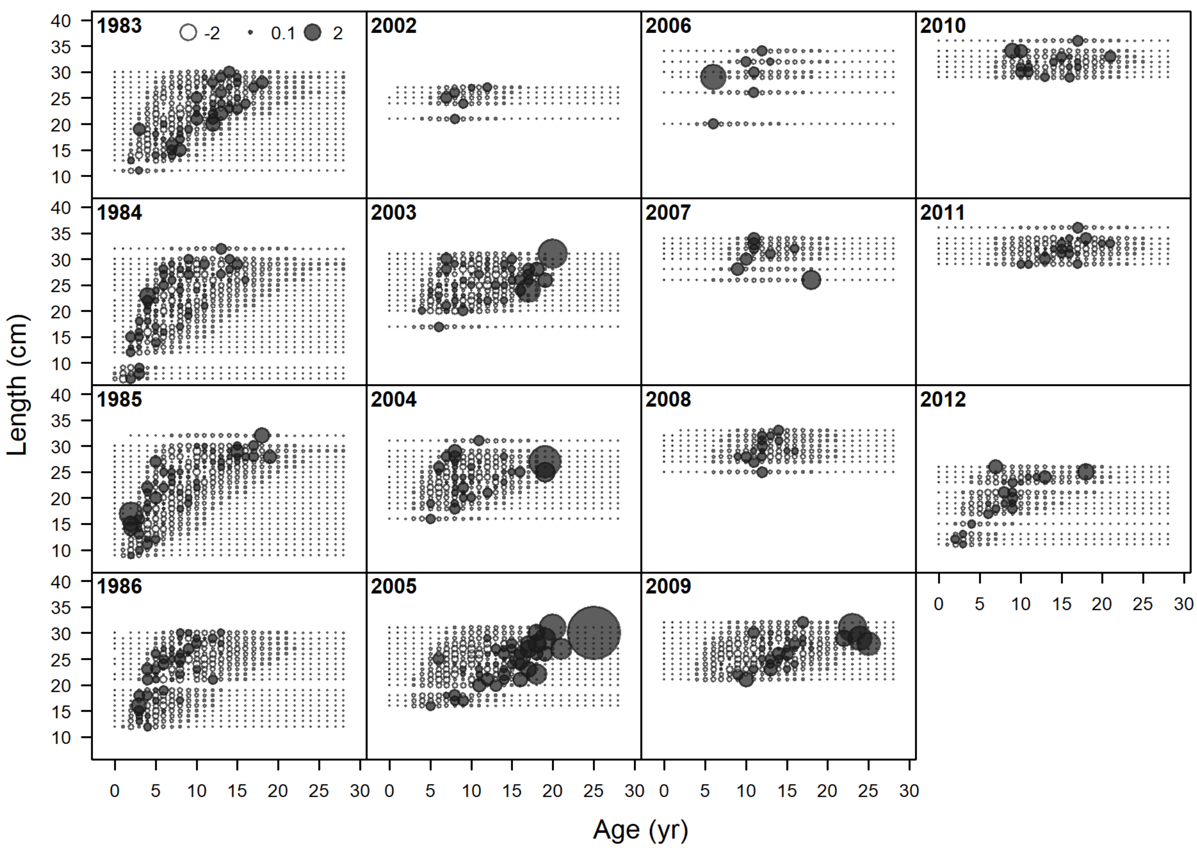


Figure 12: Pearson residuals, whole catch, Dummy1 (max=20.61)

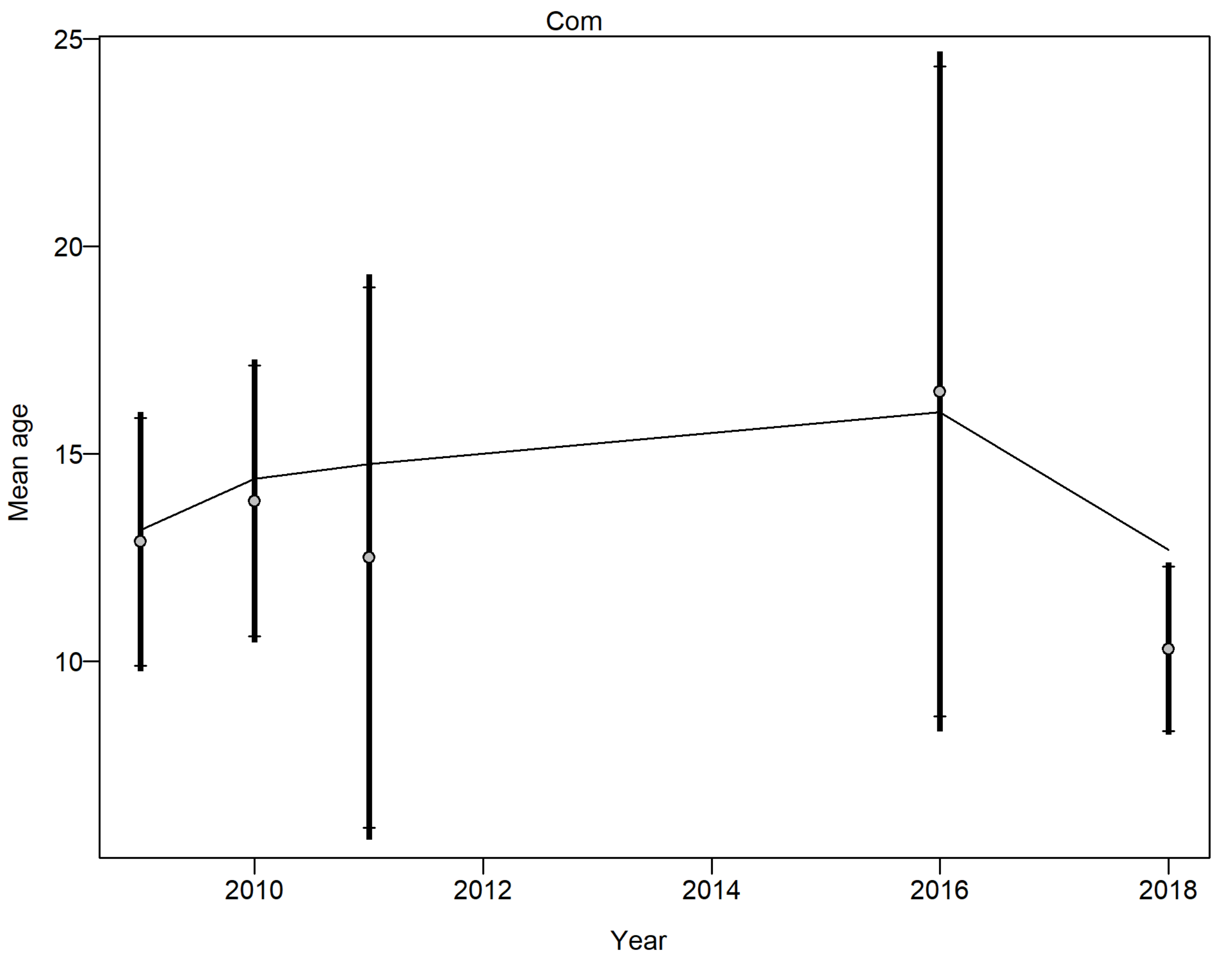


Figure 13: Mean age from conditional data (aggregated across length bins) for Com with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% interval) for conditional age_at_length data from Com: 1.0954 (0.6289_34.8175) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138.

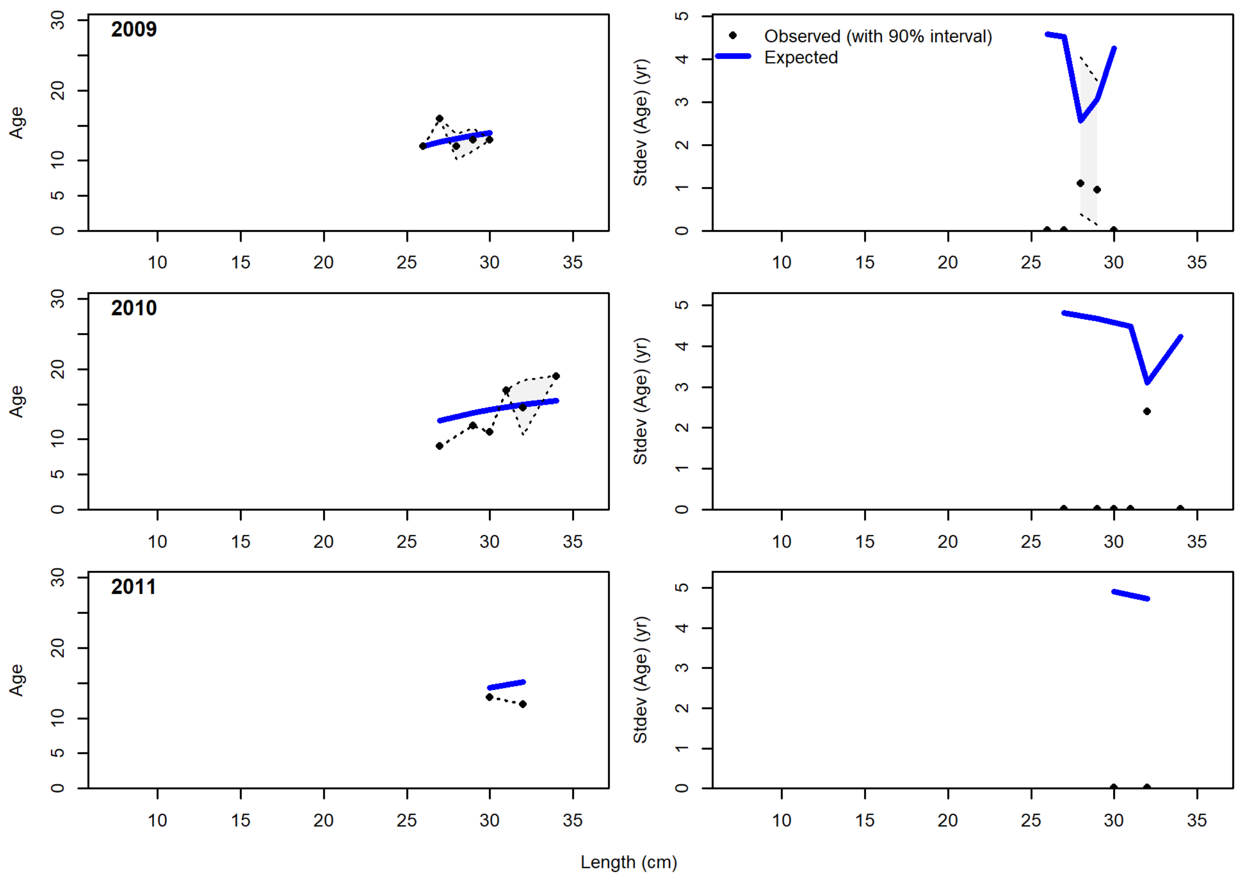


Figure 14: Conditional AAL plot, whole catch, Com (plot 1 of 2) These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.) with 90% CIs based on the chi_square distribution.

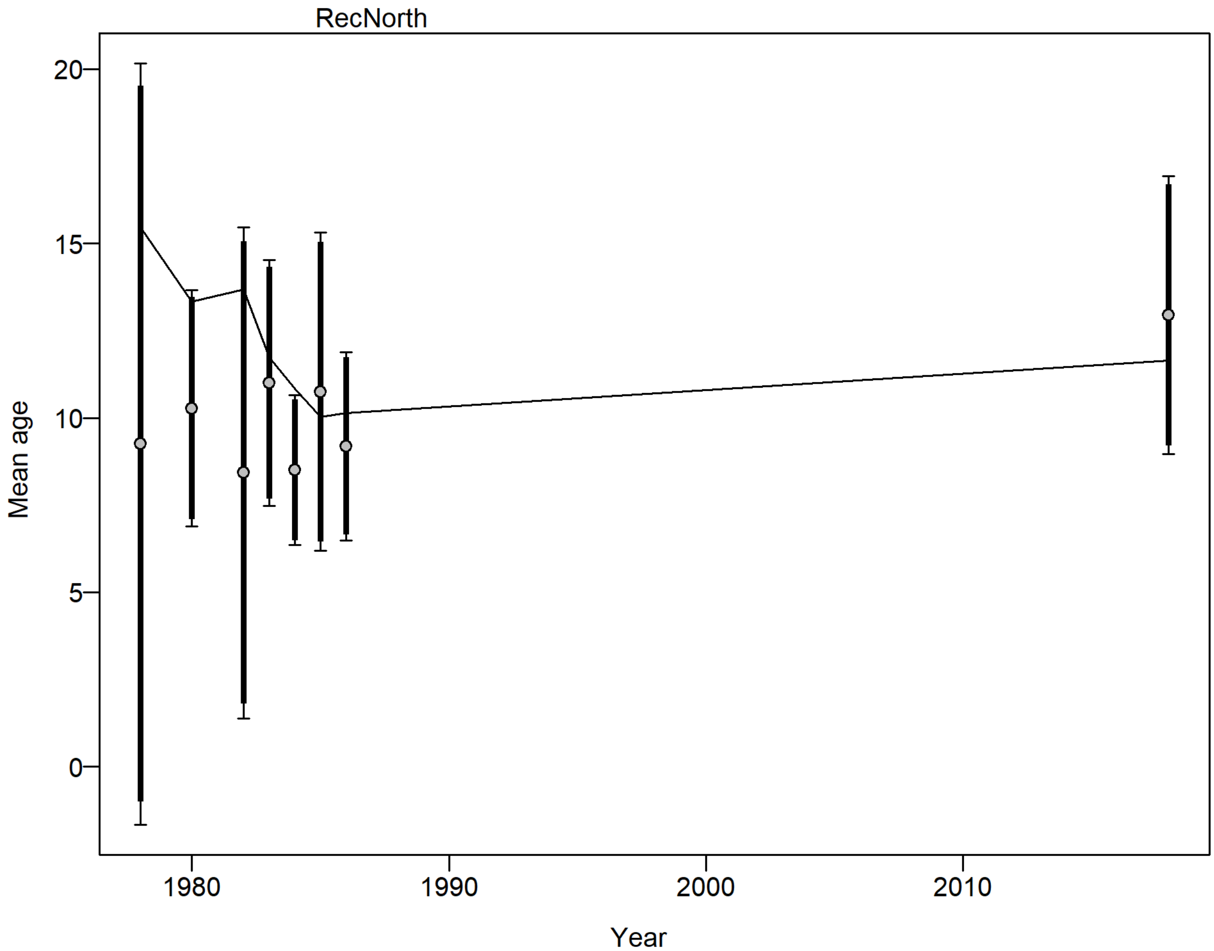


Figure 15: Mean age from conditional data (aggregated across length bins) for RecNorth with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% interval) for conditional age_at_length data from RecNorth: 0.8847 (0.5893_3.0634) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138.

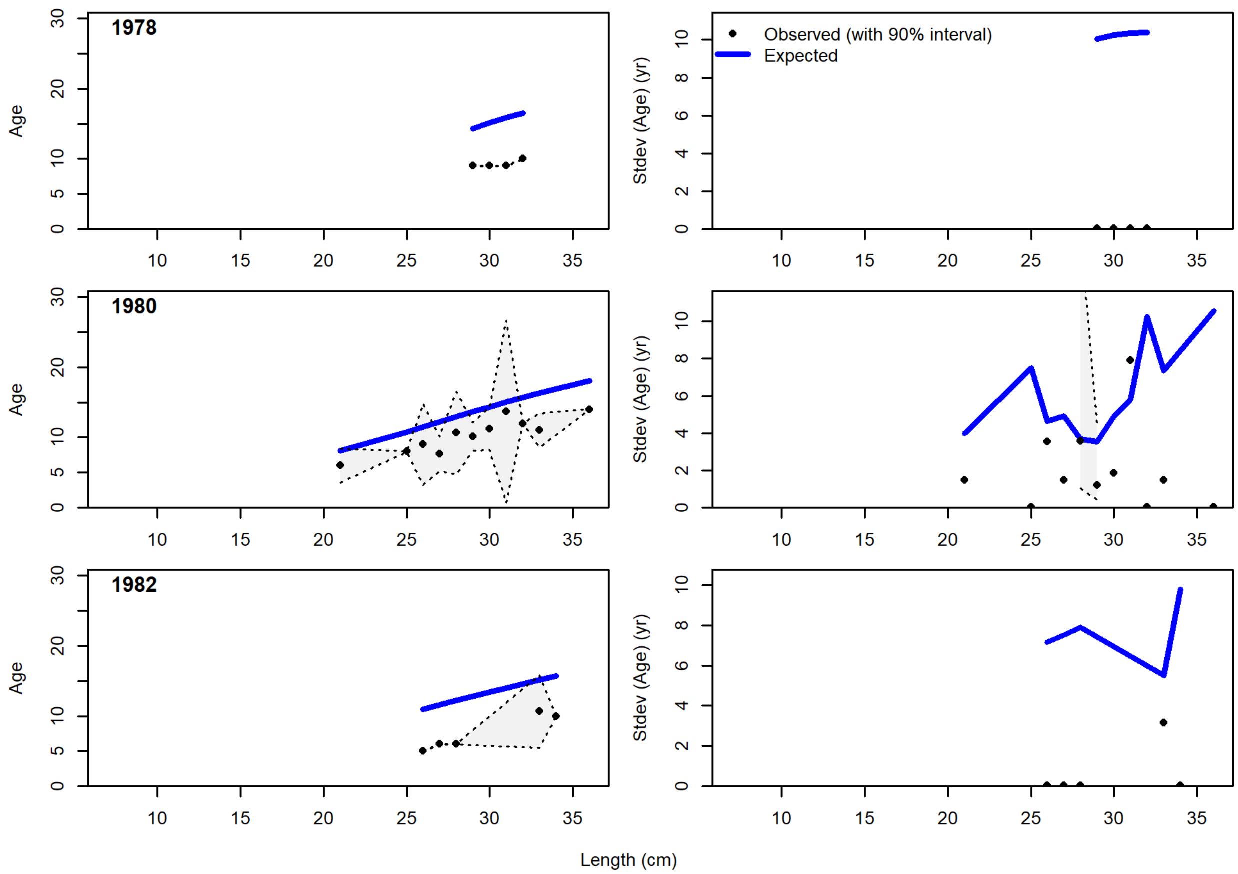
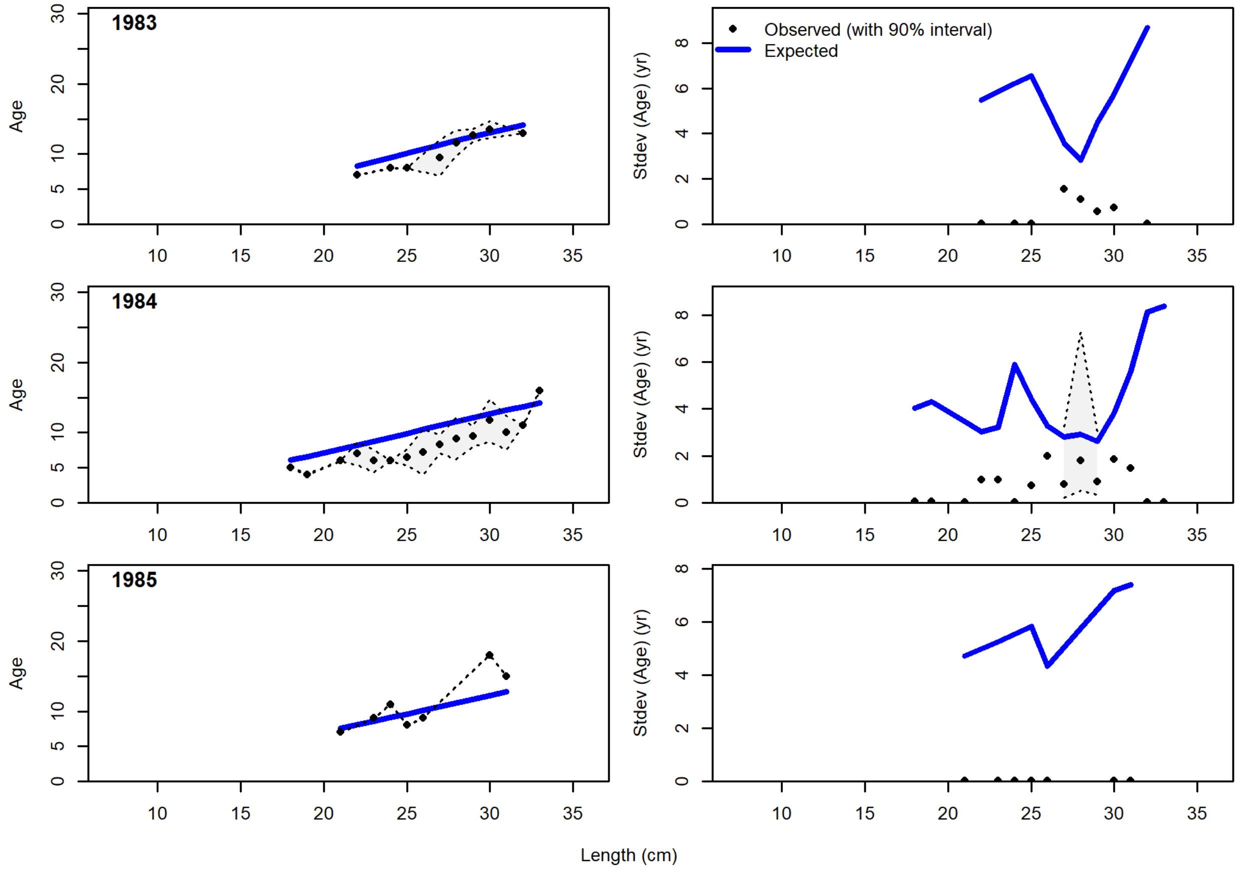


Figure 16: Conditional AAL plot, whole catch, RecNorth (plot 1 of 3) These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.) with 90% CIs based on the chi_square distribution.



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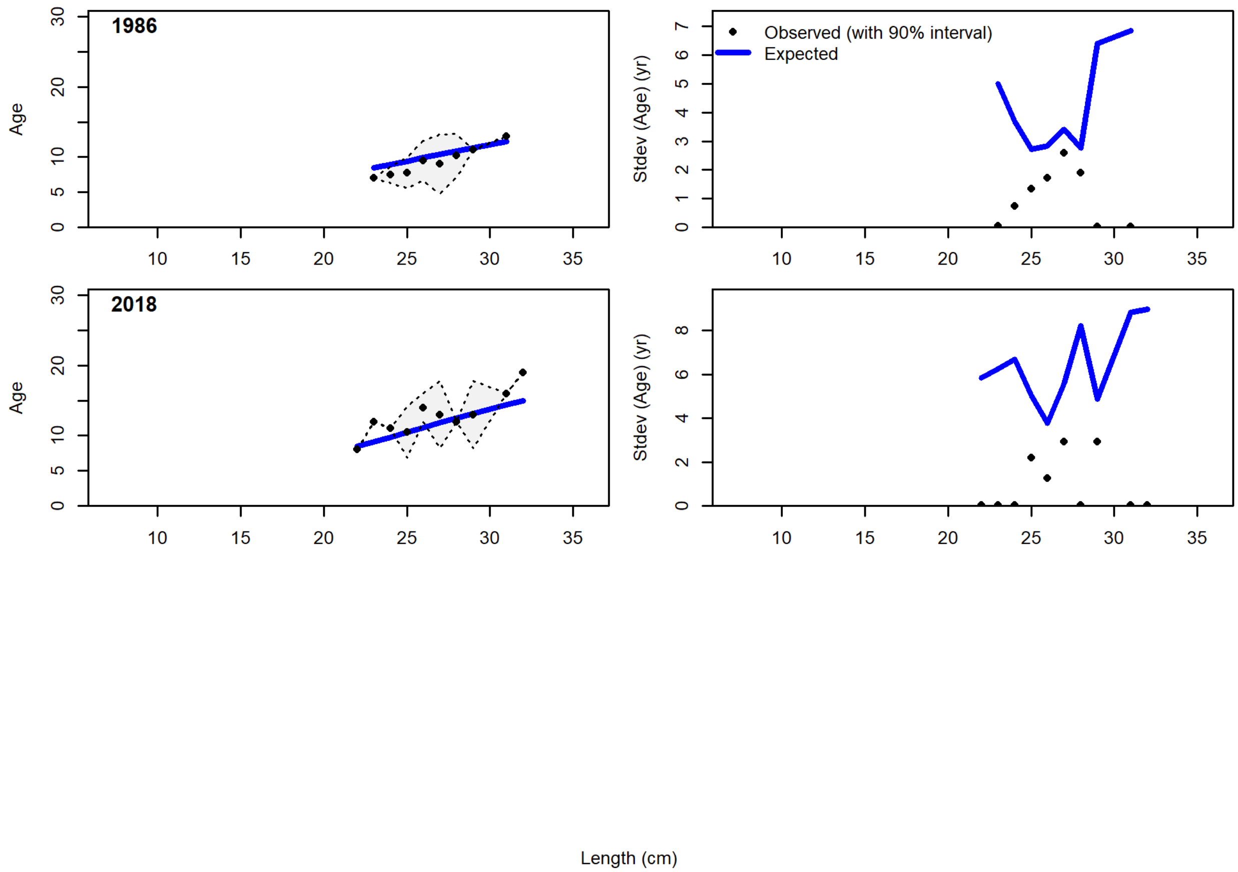

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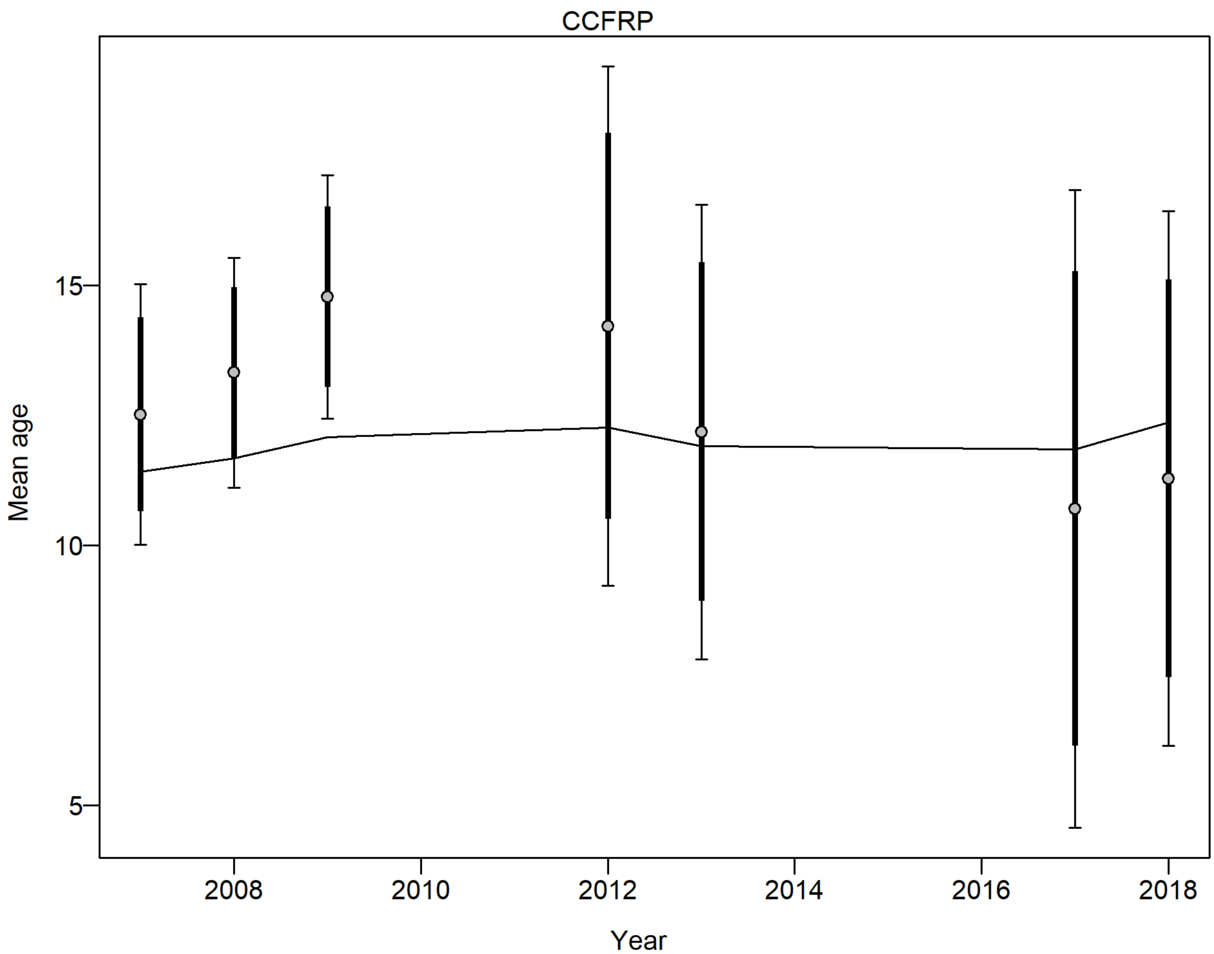


Figure 17: Mean age from conditional data (aggregated across length bins) for CCFRP with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% interval) for conditional age_at_length data from CCFRP: 0.554 (0.3378_2.4143) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138.

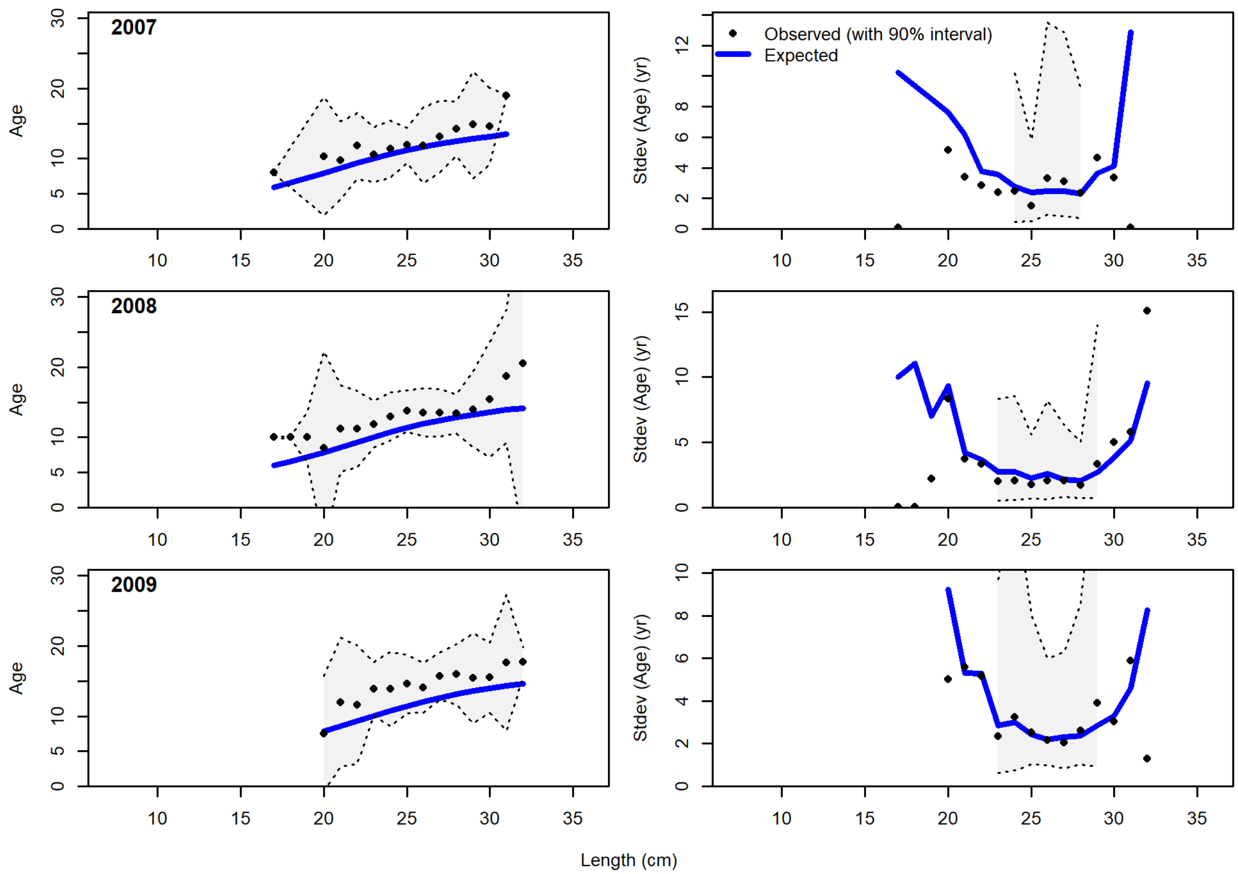
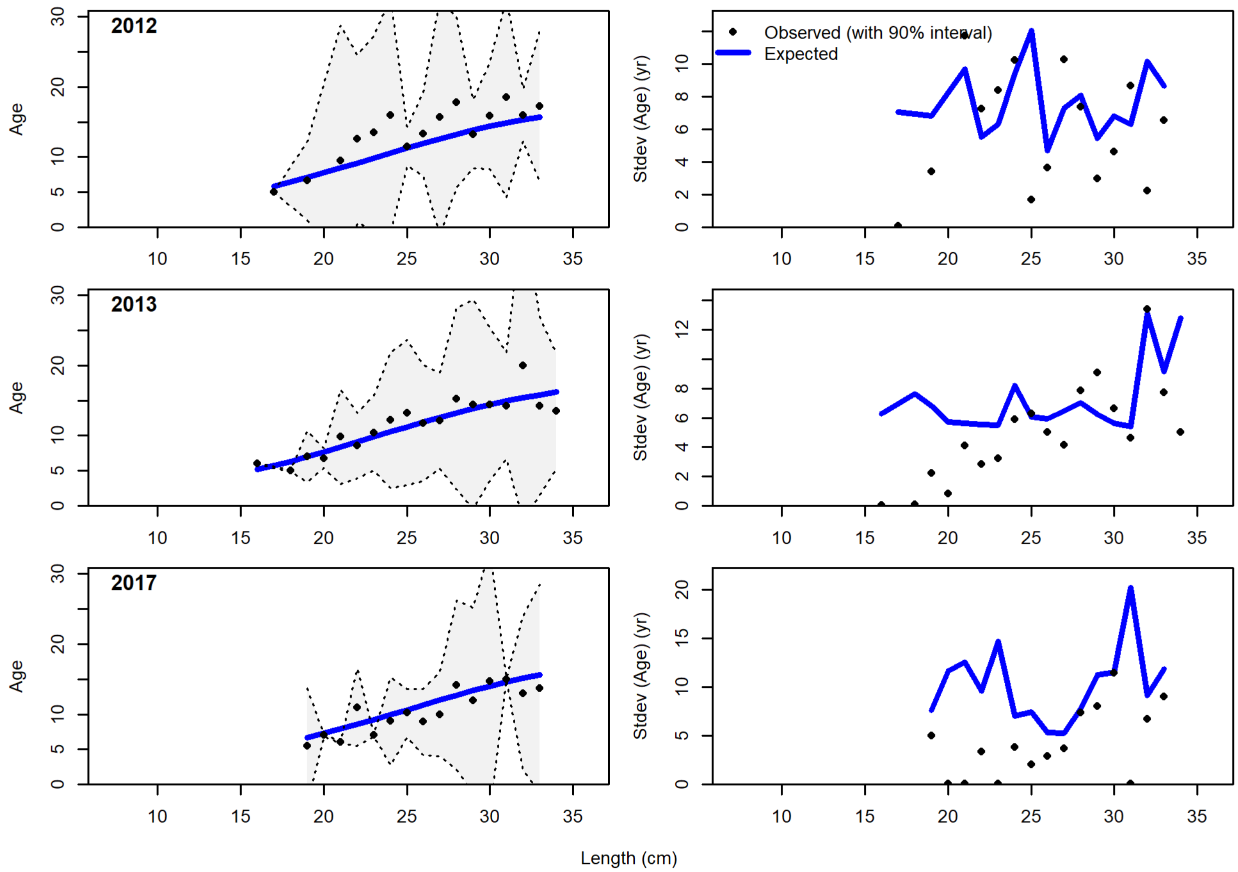


Figure 18: Conditional AAL plot, whole catch, CCFRP (plot 1 of 3) These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.) with 90% CIs based on the chi_square distribution.



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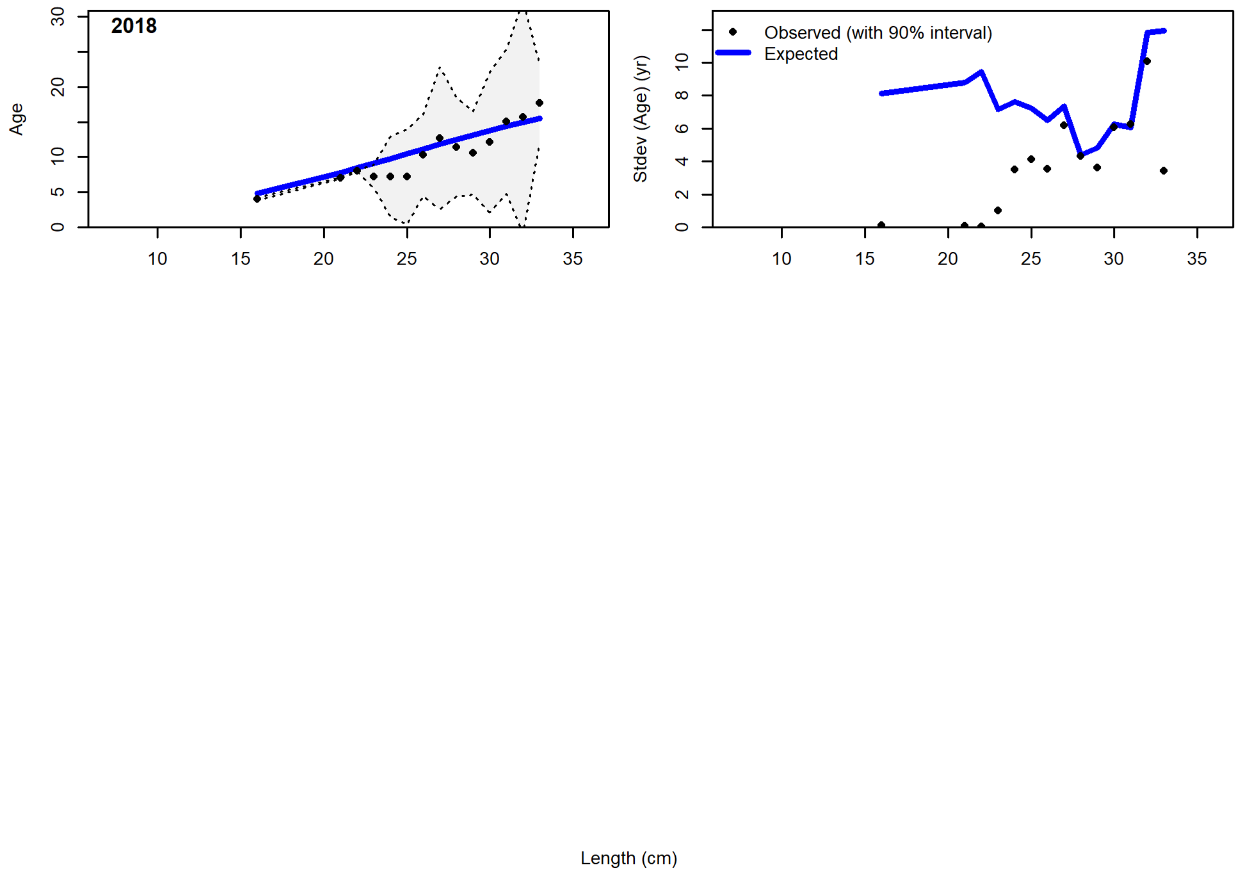

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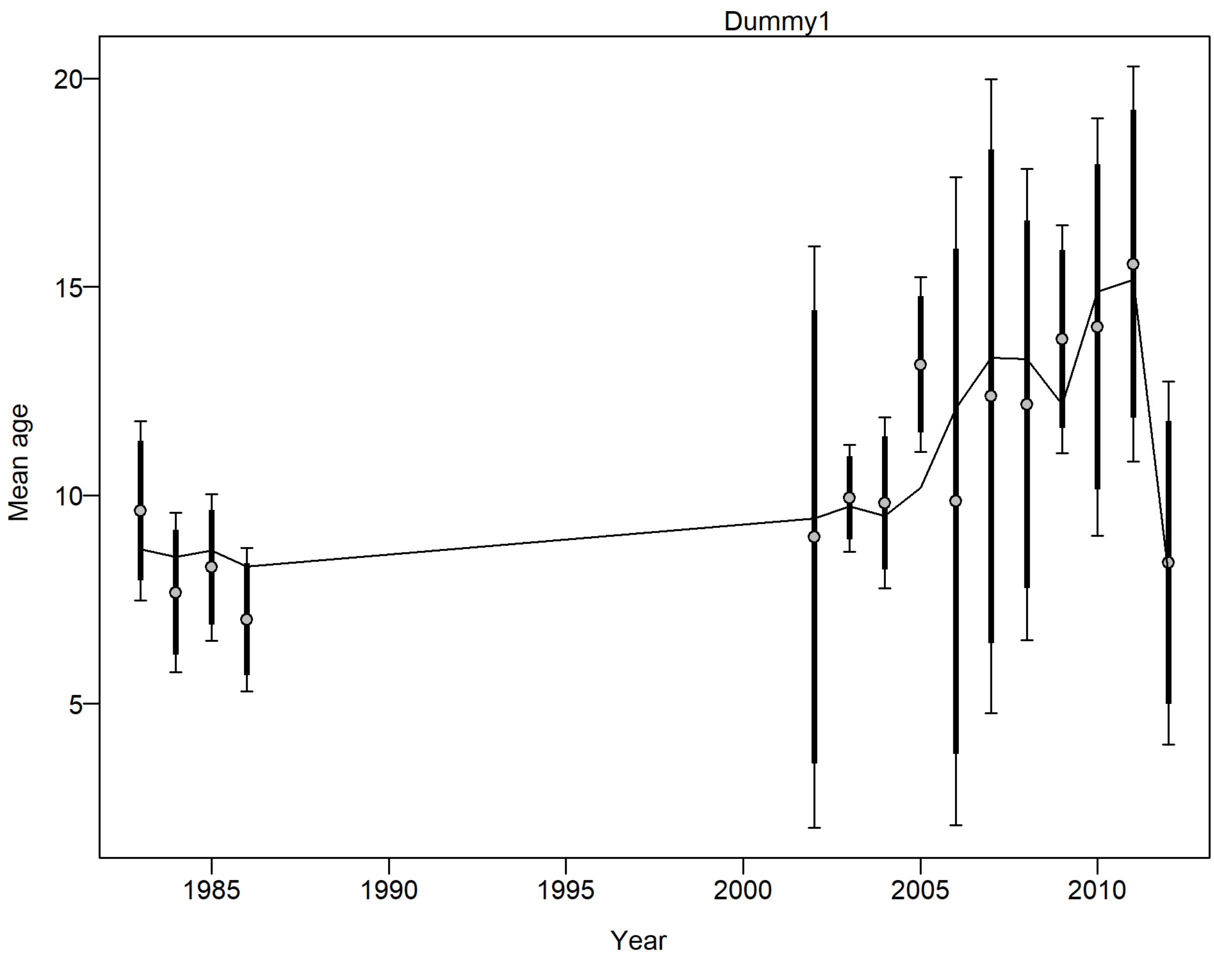


Figure 19: Mean age from conditional data (aggregated across length bins) for Dummy1 with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% interval) for conditional age_at_length data from Dummy1: 0.6075 (0.3142_2.9037) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138.

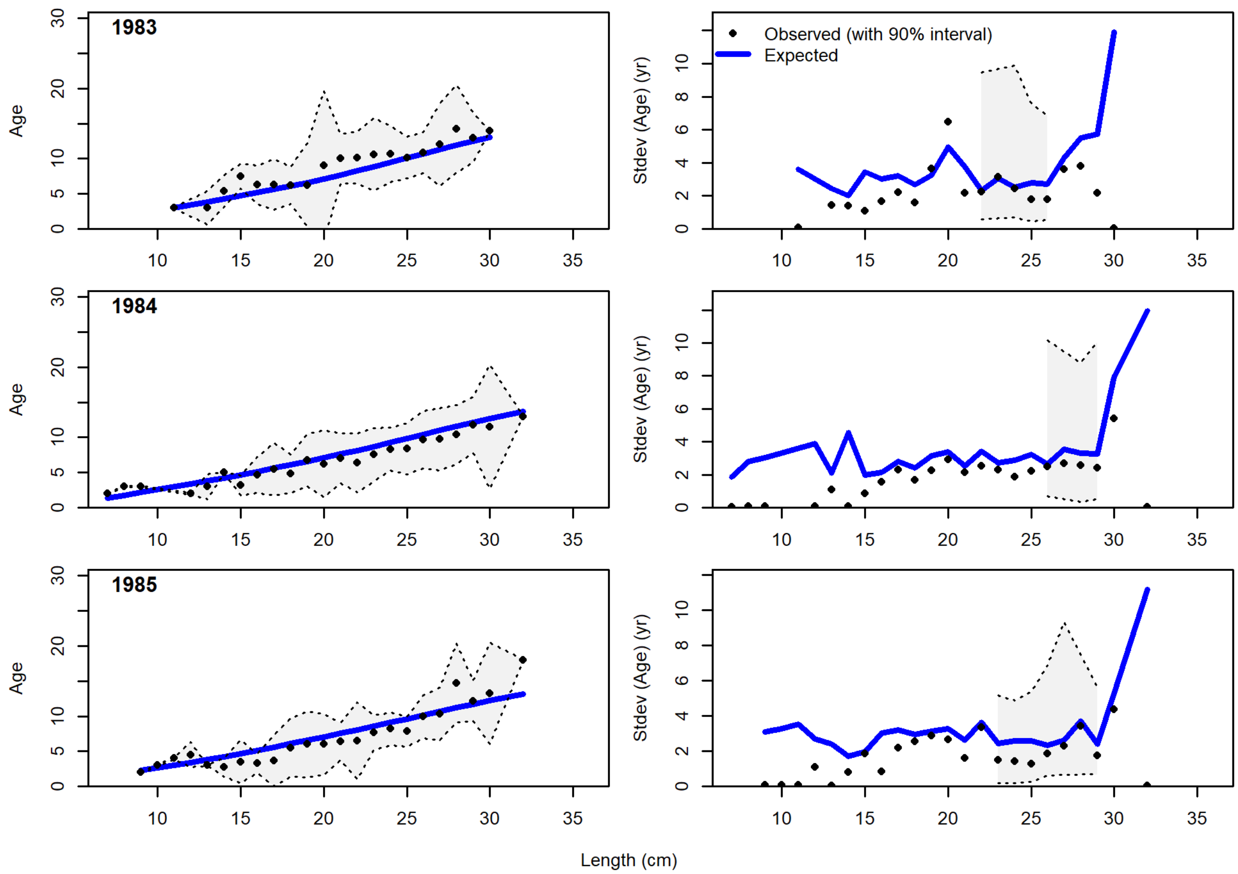
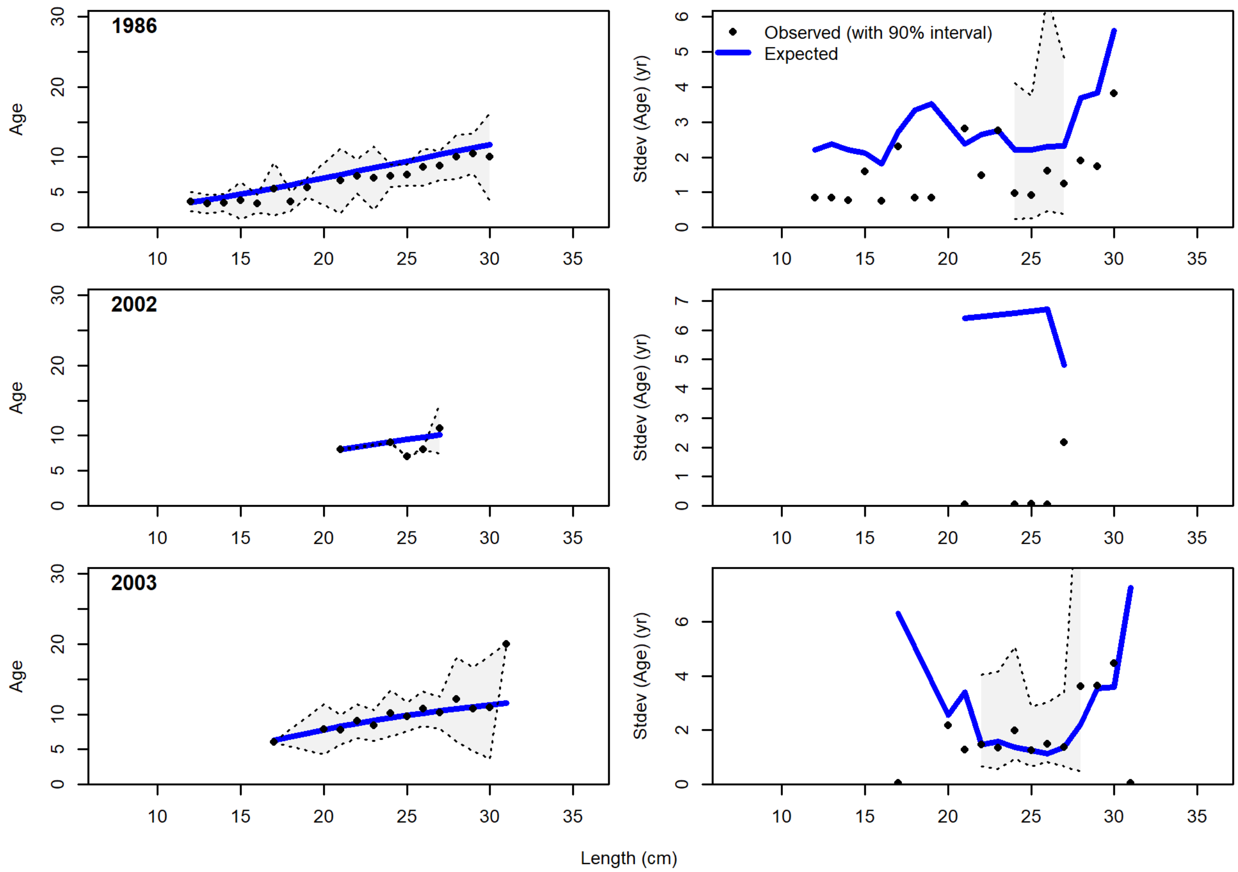


Figure 20: Conditional AAL plot, whole catch, Dummy1 (plot 1 of 5) These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.) with 90% CIs based on the chi_square distribution.



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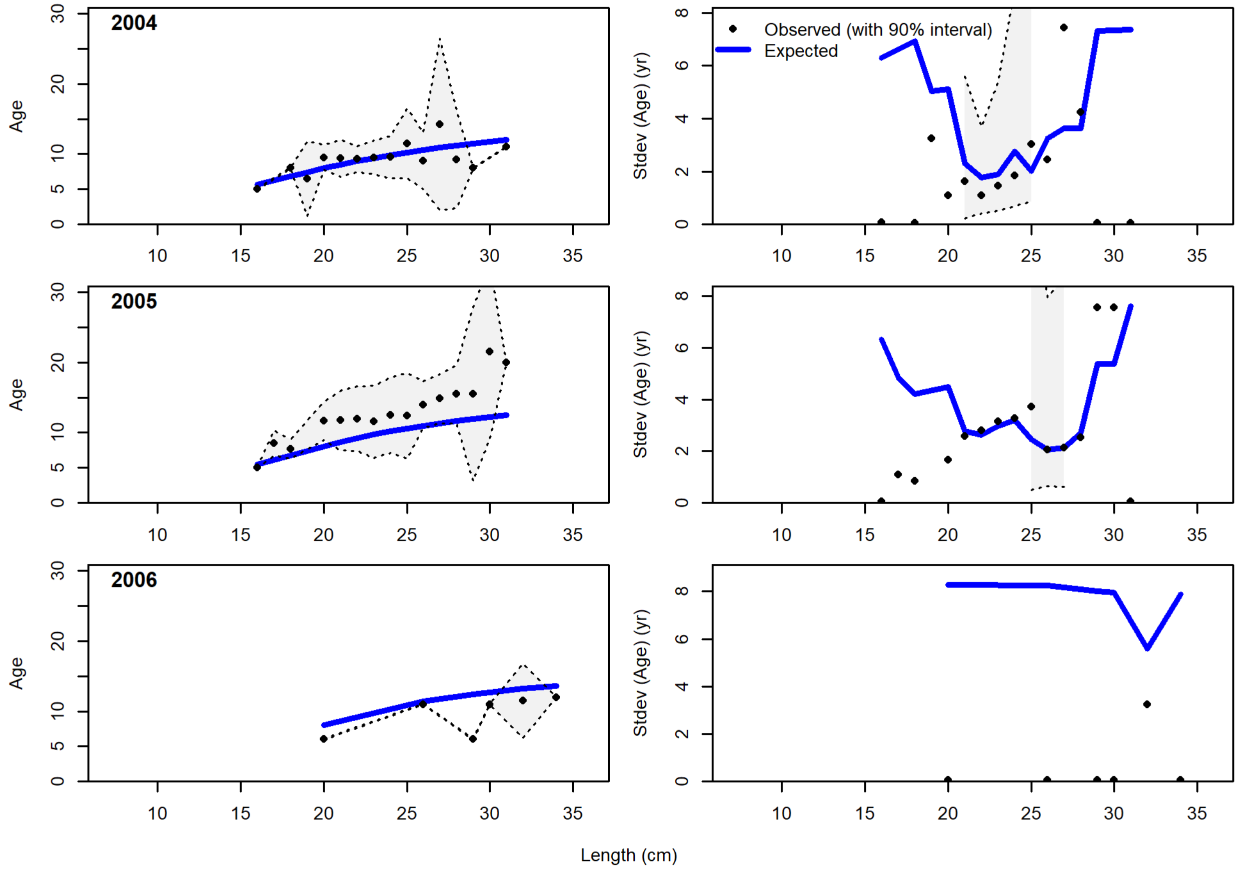

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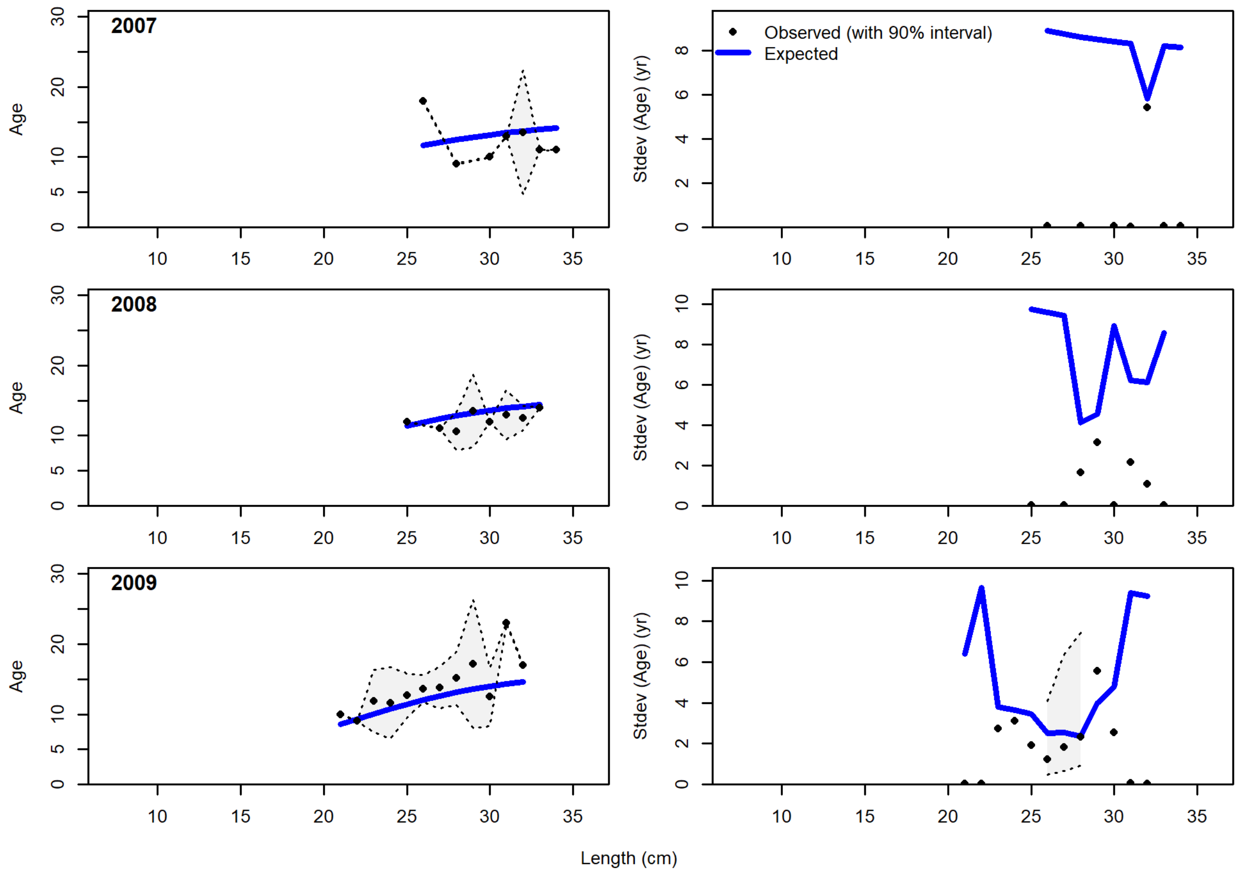

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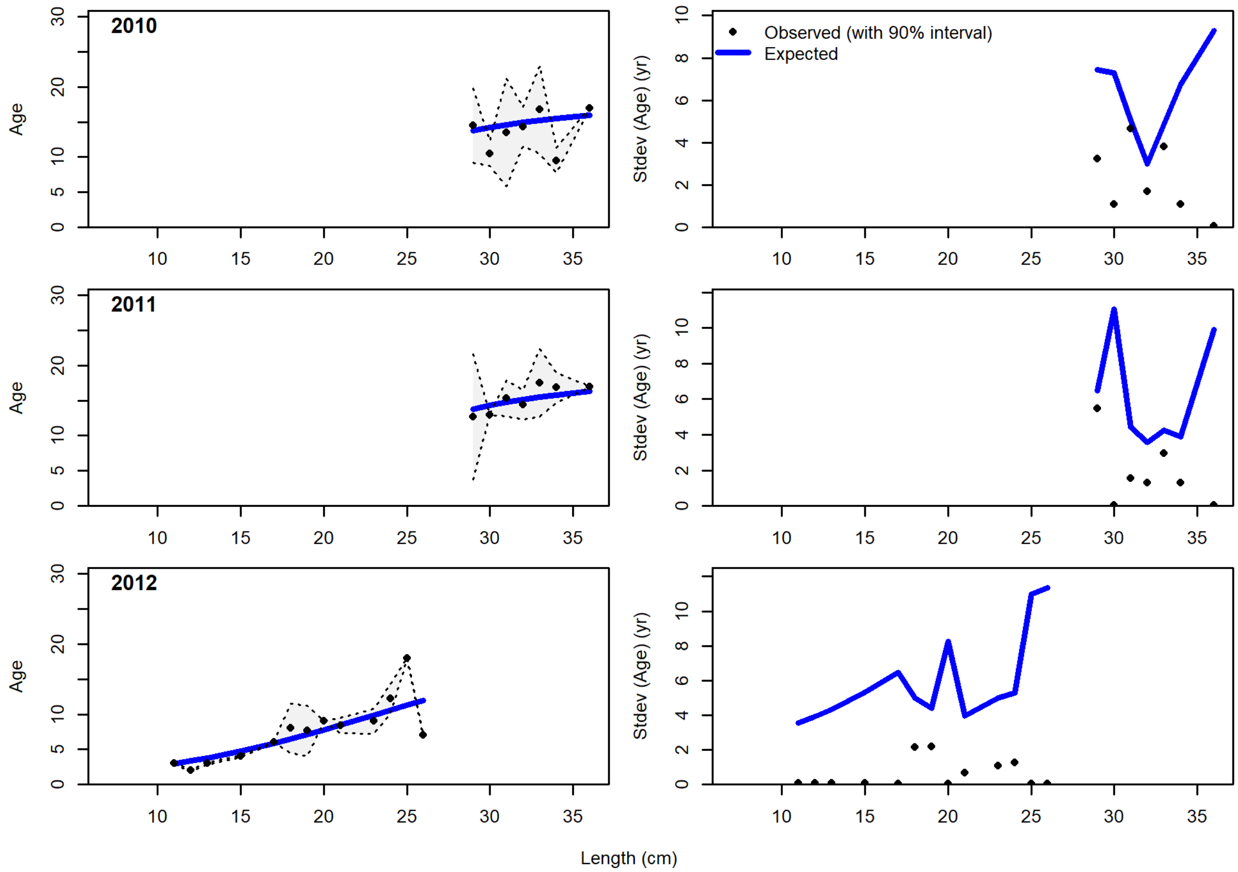

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¡!– ***********h Likelihood profile FIGURES******************************* –¿

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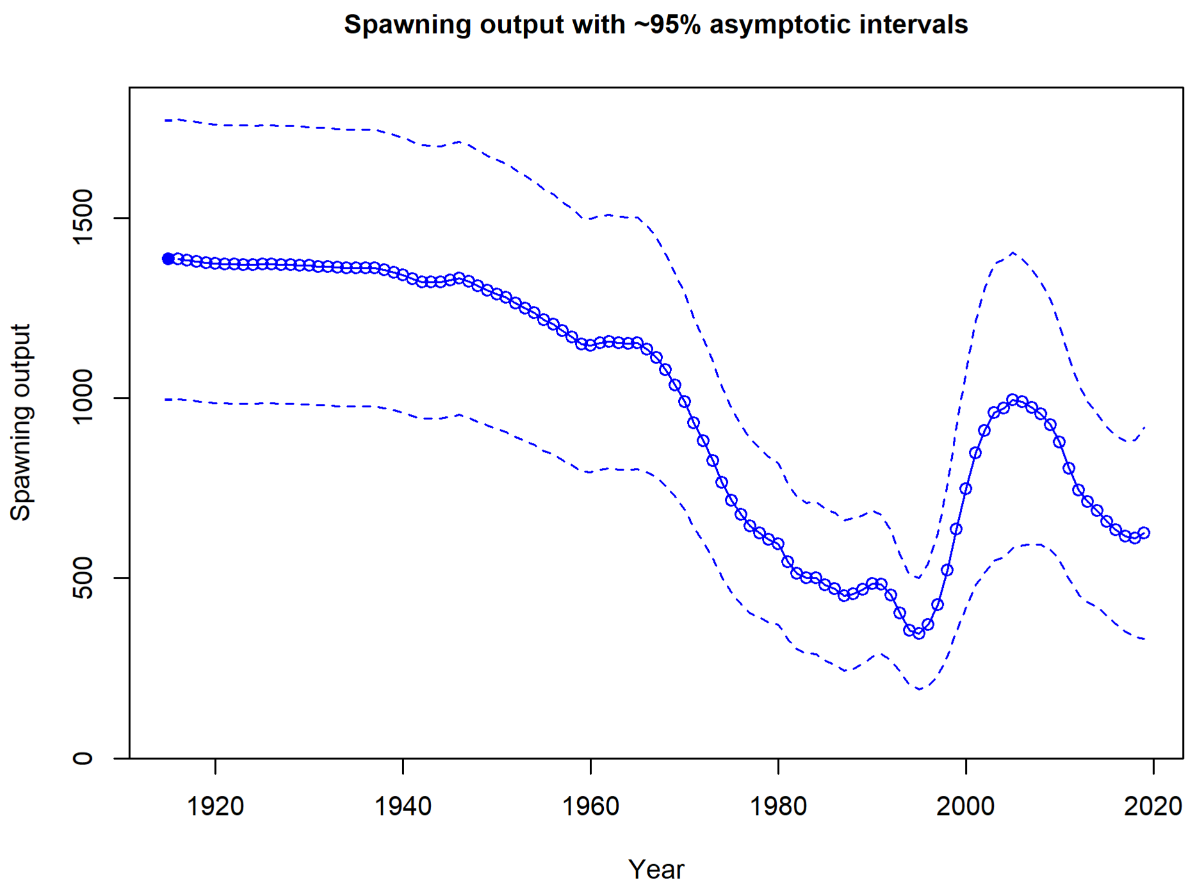

Figure 21: Estimated spawning biomass (mt) with approximate 95% asymptotic intervals.

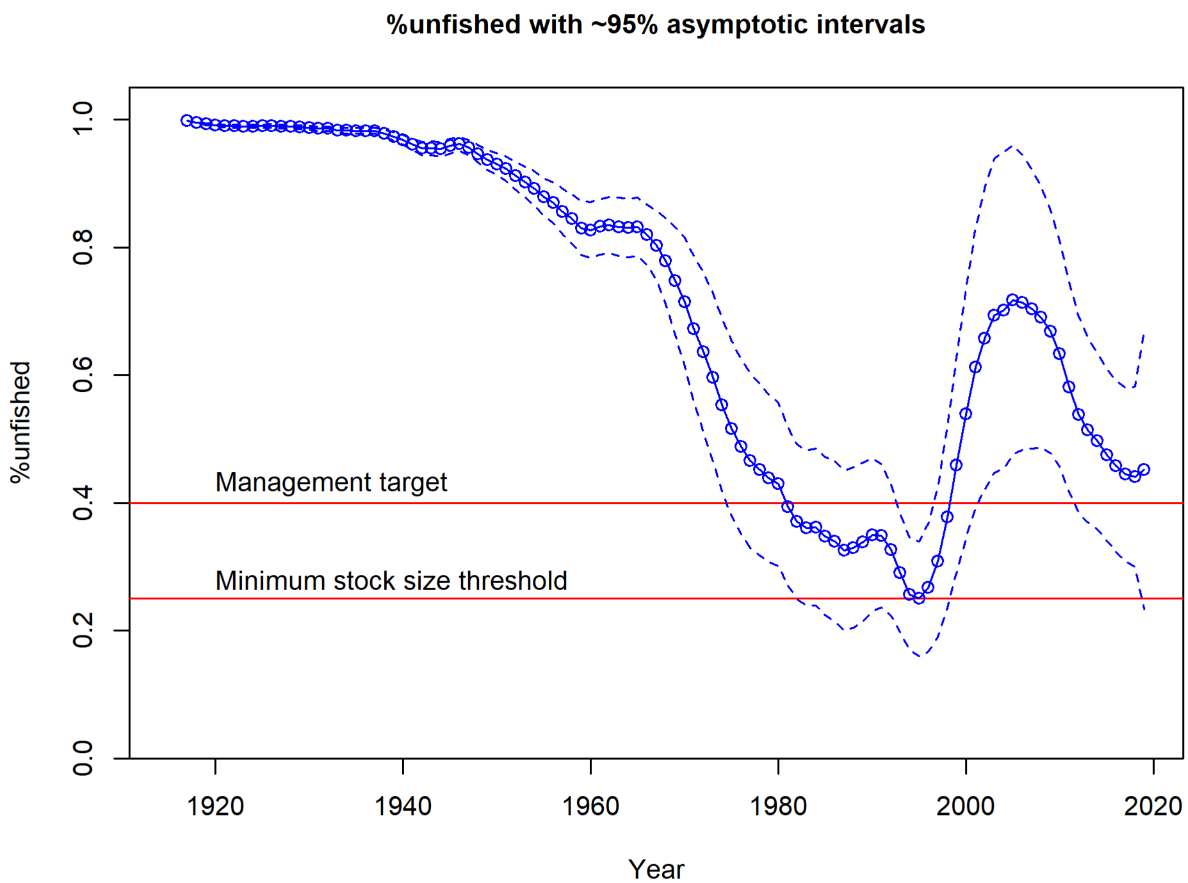

Figure 22: Estimated spawning depletion with approximate 95% asymptotic intervals.

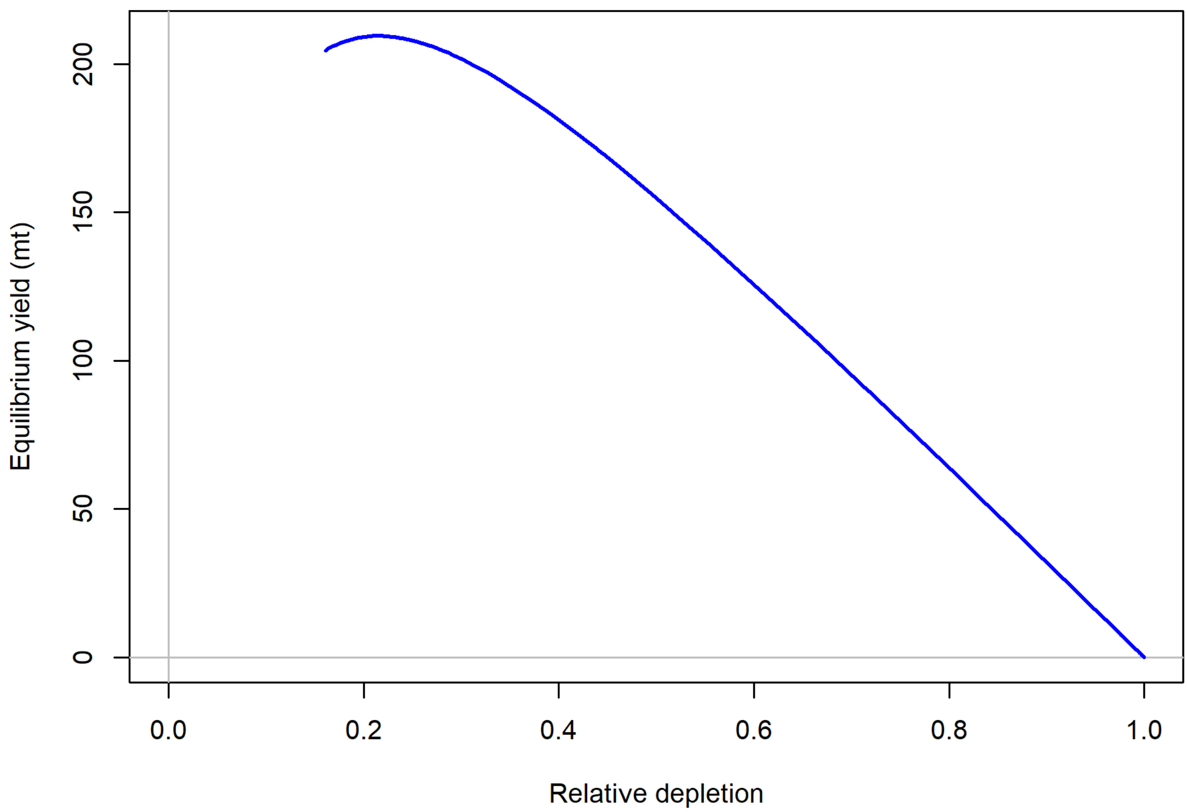

Figure 23: Equilibrium yield curve for the base case model. Values are based on the 2018 fishery selectivity and with steepness fixed at 0.718.

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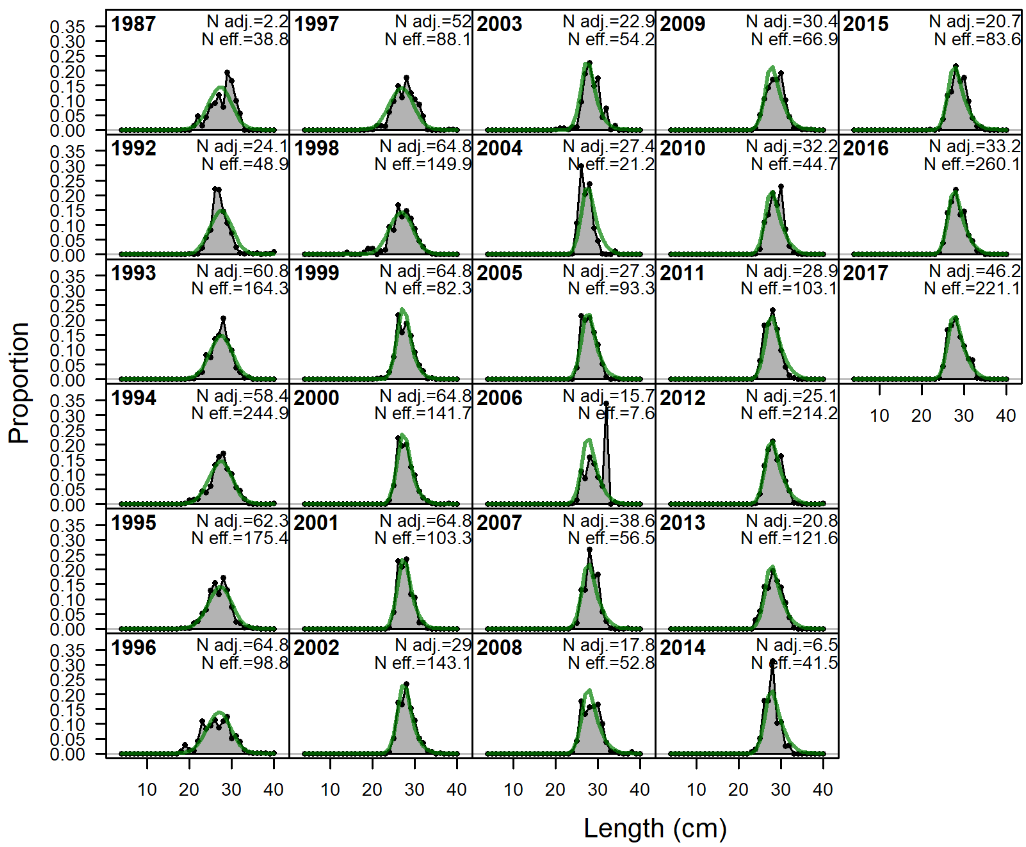

Figure A24: Length comps, retained, Com. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method.

Appendix A. Detailed fits to length composition data

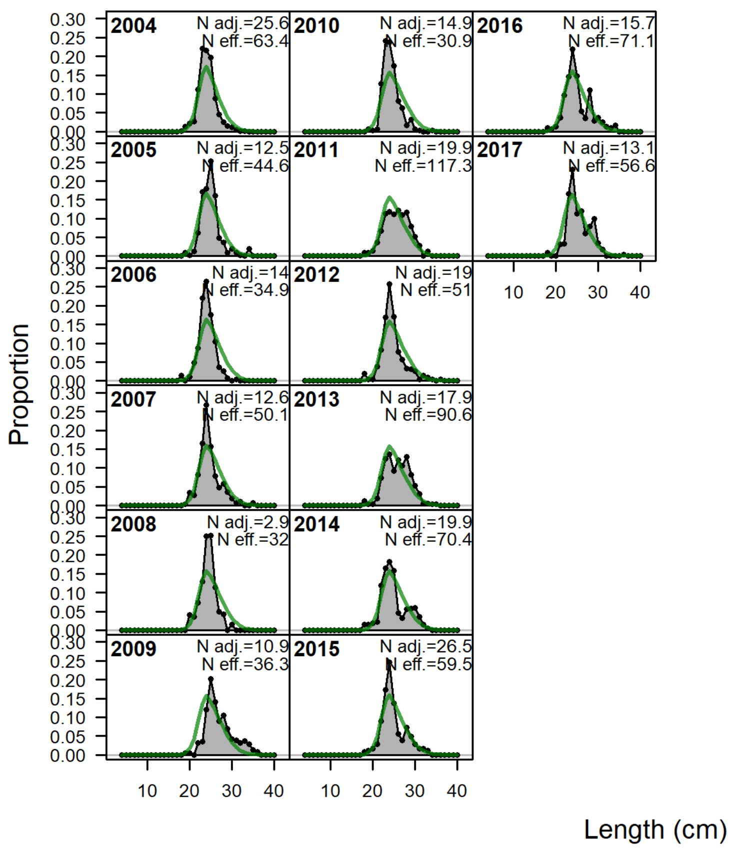

Figure A25: Length comps, retained, ComDisc. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method.

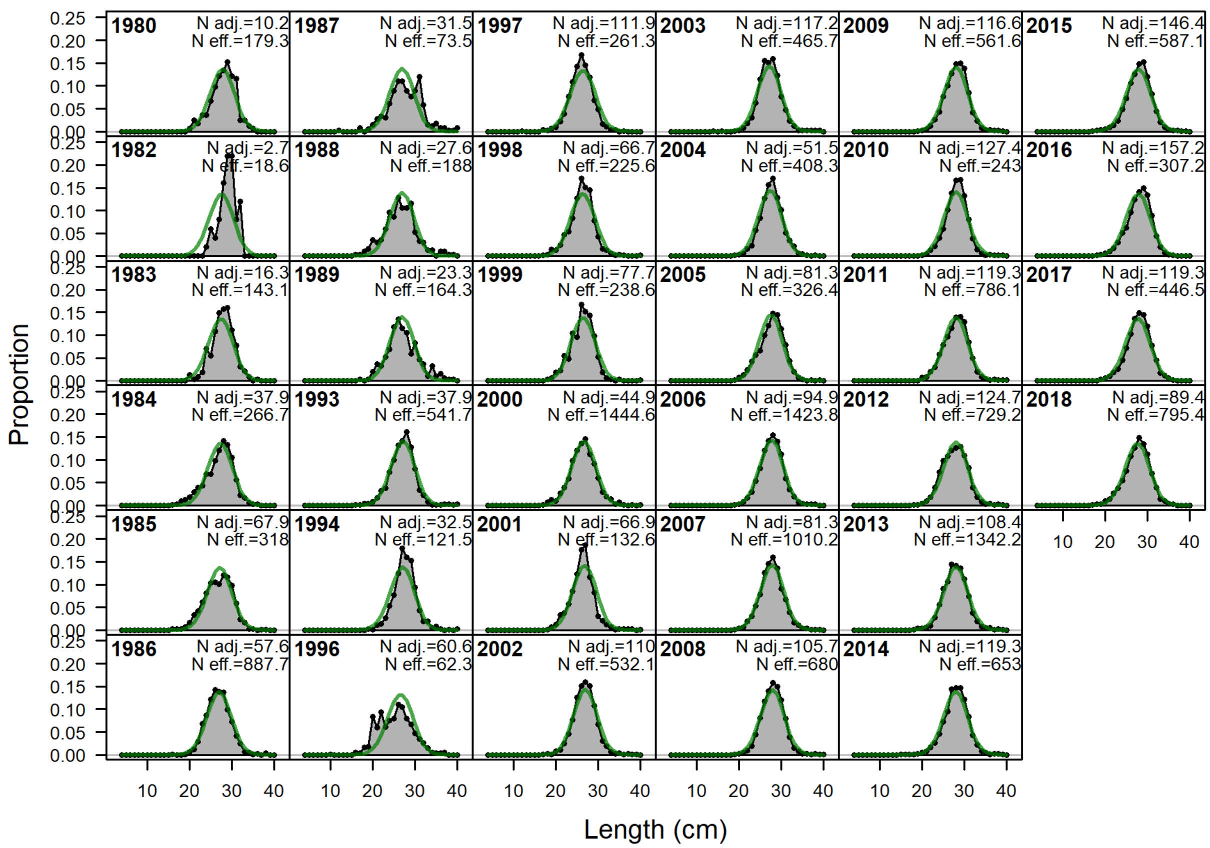

Figure A26: Length comps, whole catch, RecNorth. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method.

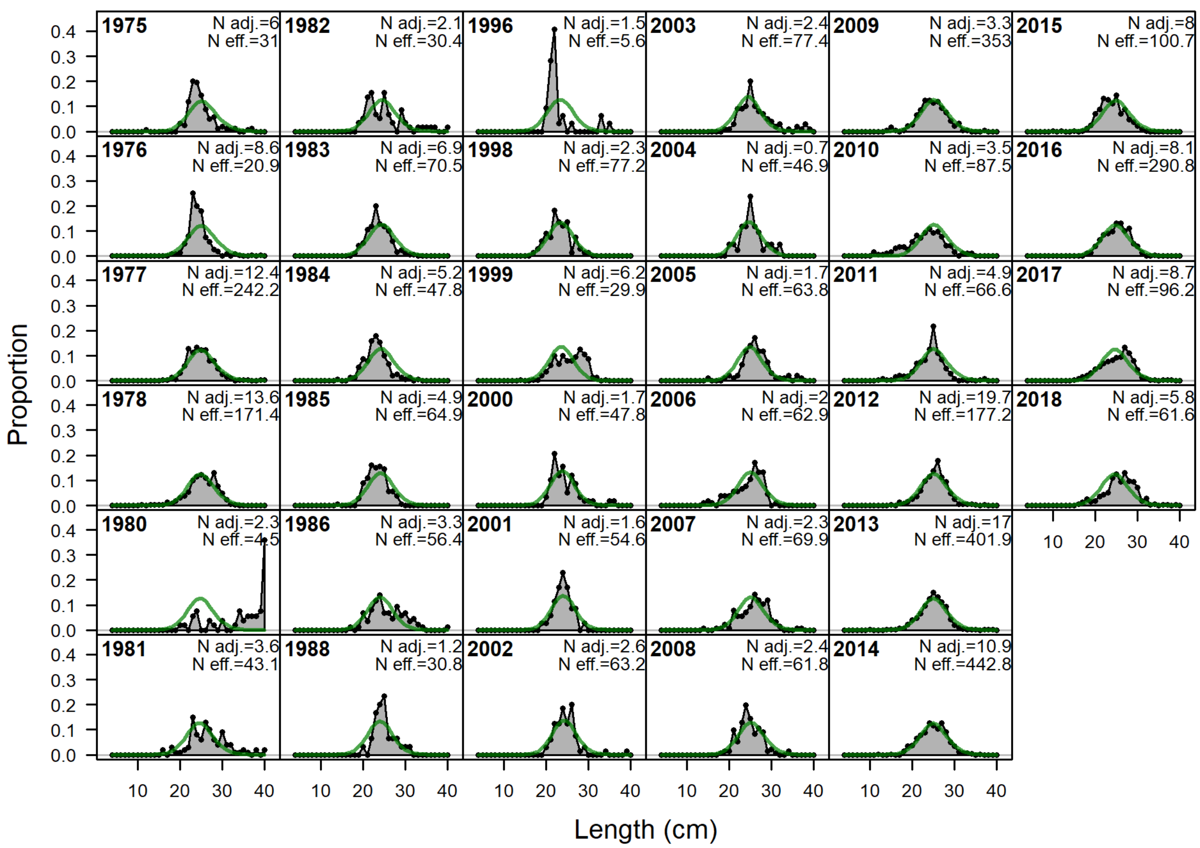

Figure A27: Length comps, whole catch, RecSouth. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method.

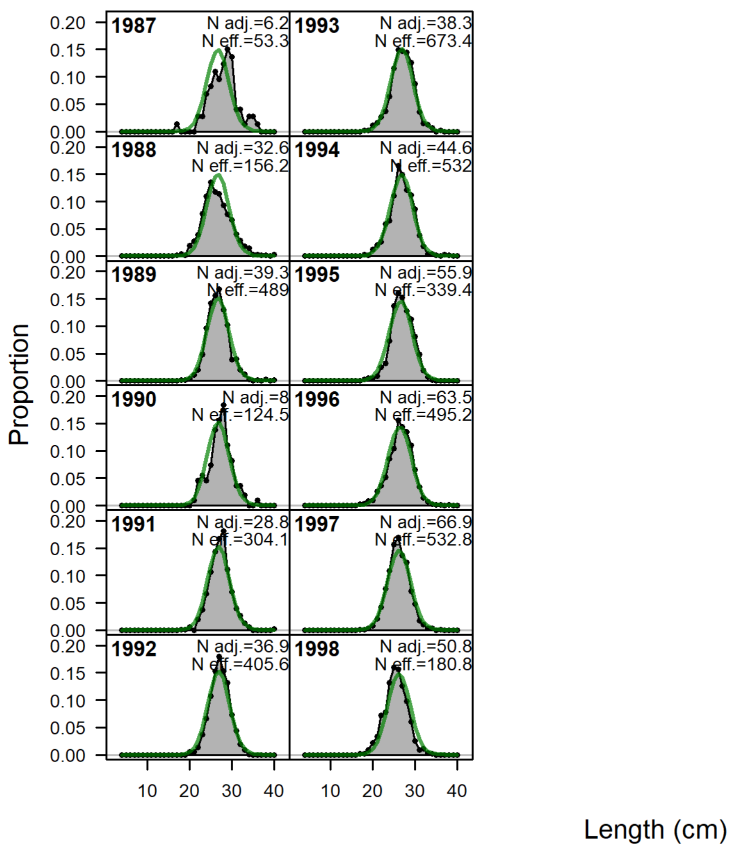

Figure A28: Length comps, whole catch, DebCPFV. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method.

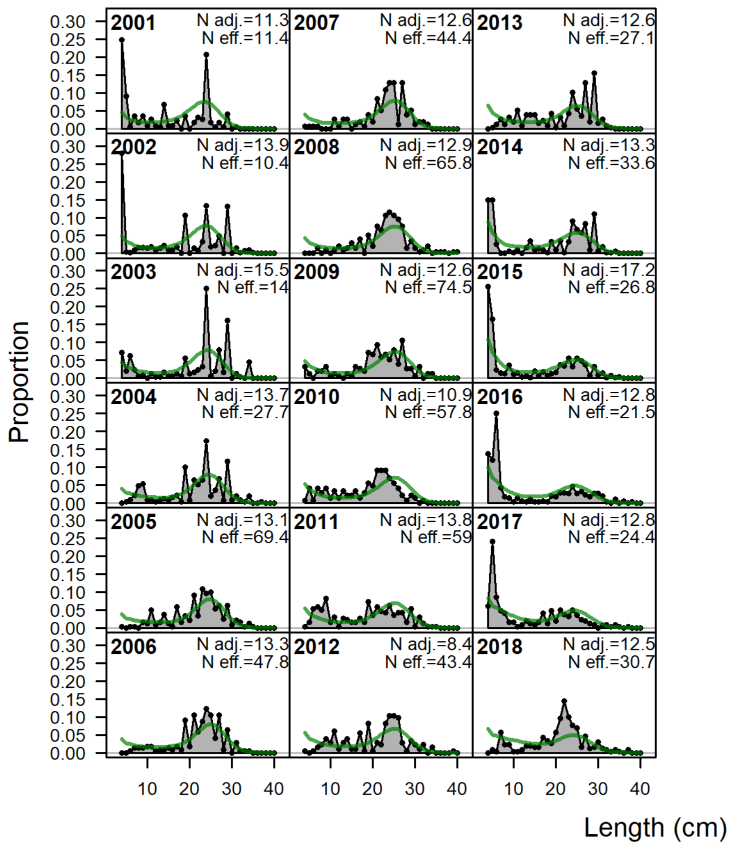

Figure A29: Length comps, whole catch, PISCO. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method.

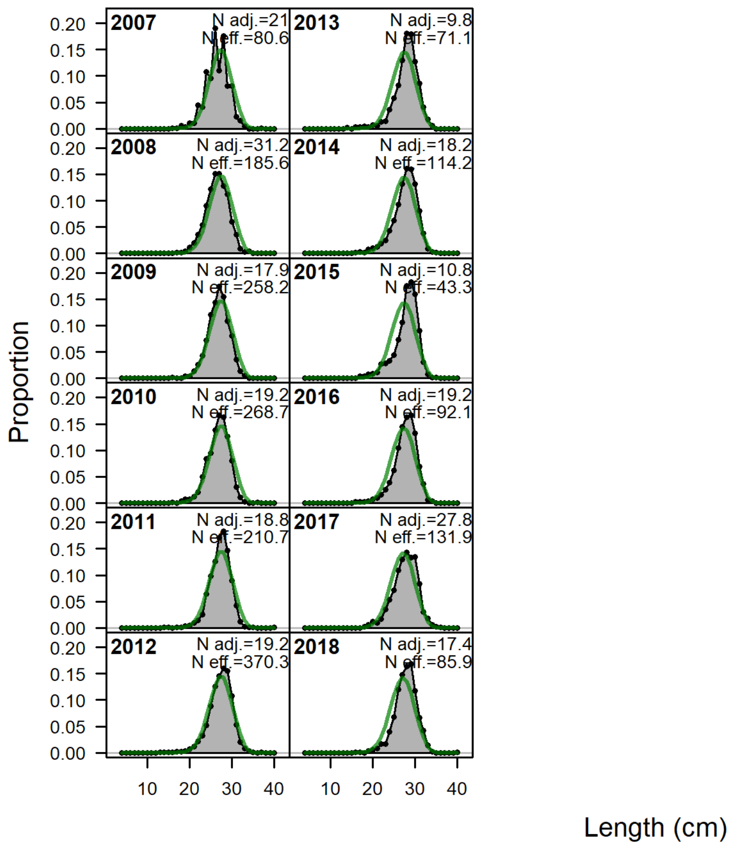

Figure A30: Length comps, whole catch, CCFRP. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method.

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