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.

Melissa H. Monk[1]
Xi He[1]

[1]Southwest Fisheries Science Center, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, 110 McAllister Way, Santa Cruz, California 95060

2019-06-20

This report may be cited as:

Monk, M. H. and X. He. 2019. The Combined Status of Gopher (*Sebastes carnatus*) and Black-and-Yellow Rockfishes (*Sebastes chrysomelas*) in U.S. Waters Off California in 2019. Pacific Fishery Management Council, Portland, OR. Available from http://www.pcouncil.org/groundfish/stock-assessments/

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

executive-summary

Stock

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

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.

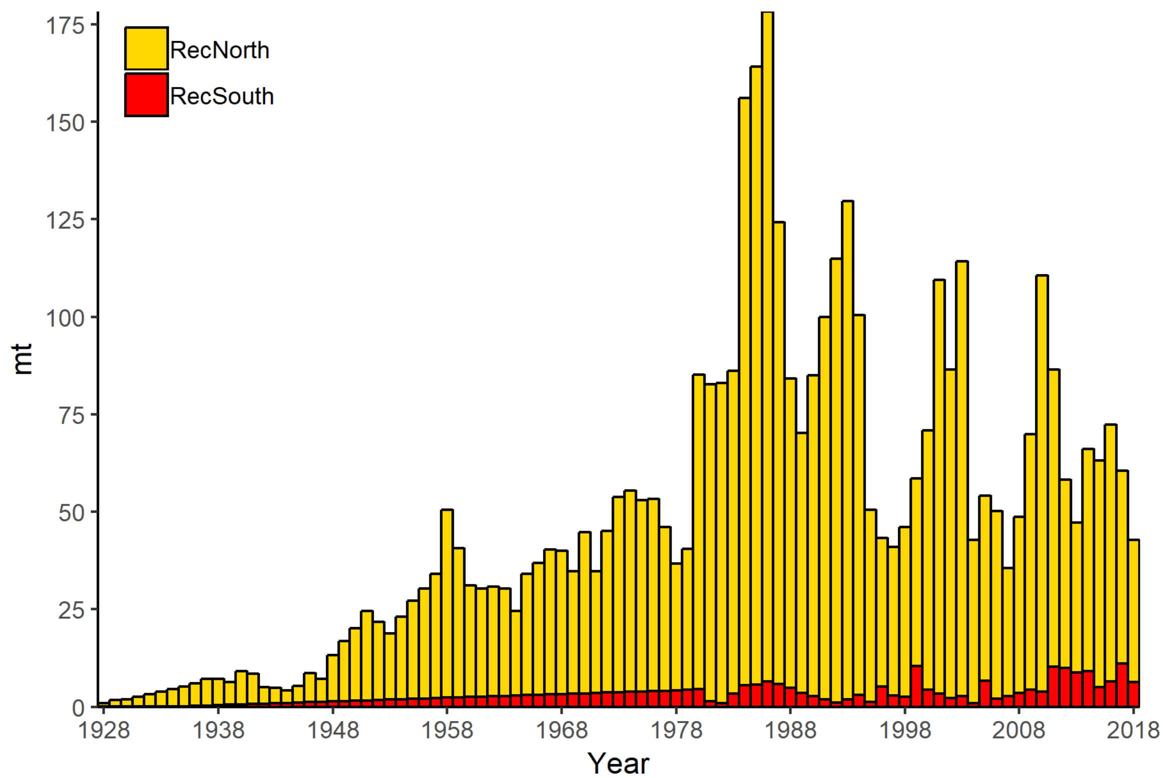


Figure a: Catch history of GBYR for the recreational fleet. fig:Exec_catch1

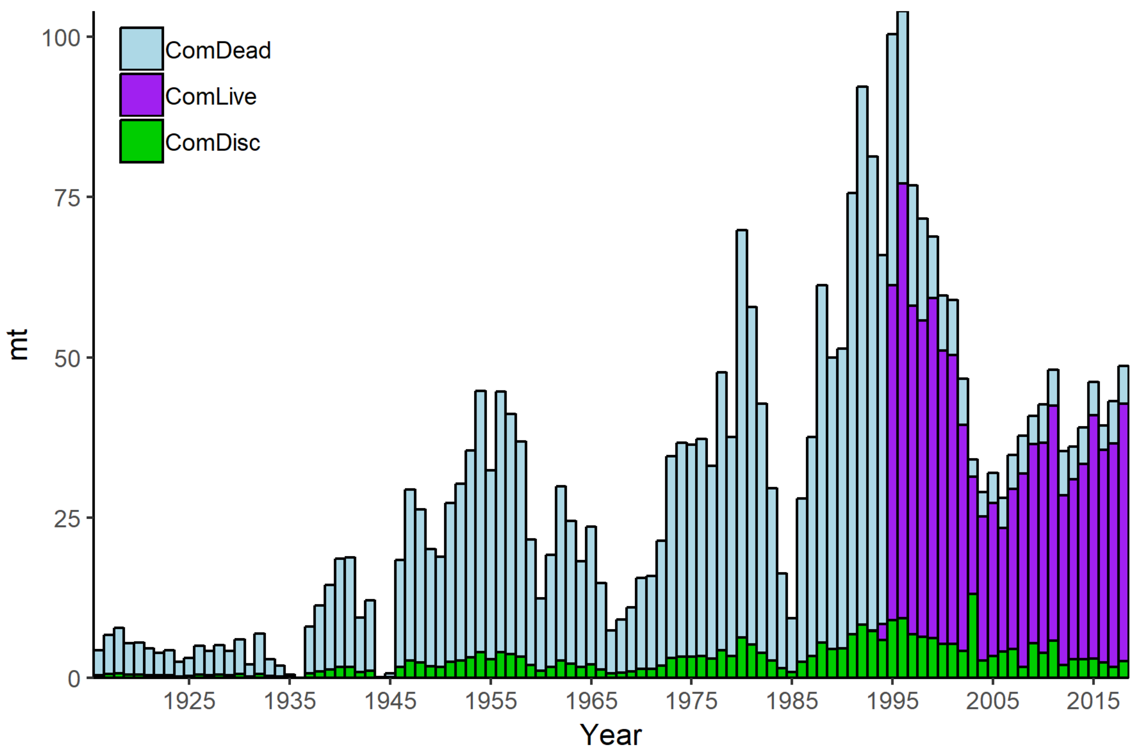


Figure b: Catch history of GBYR for the commercial fleet by dead and live landings, and discards. Catches in 1936 and 1946 were minimal. fig:Exec_catch2

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

tab:Exec_catch

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

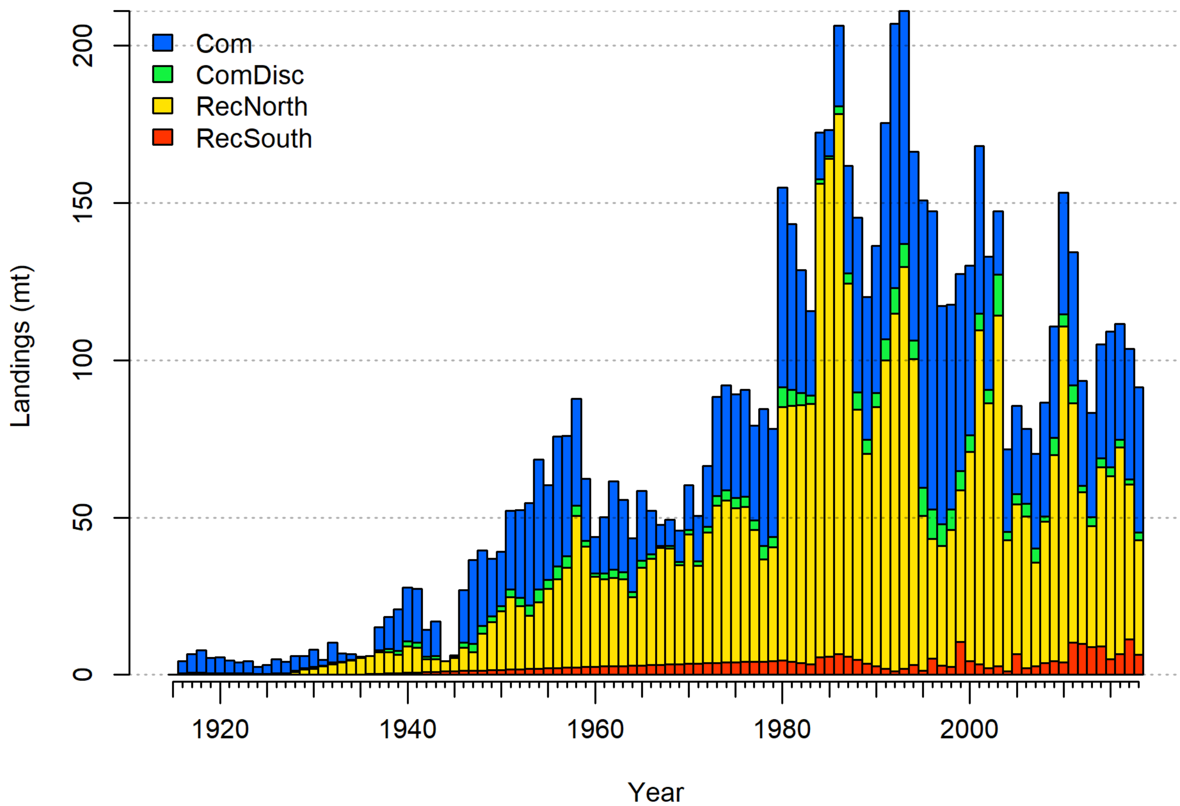


Figure c: Catch history of GBYR in the model. fig:r4ss_catches

Data and Assessment

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).

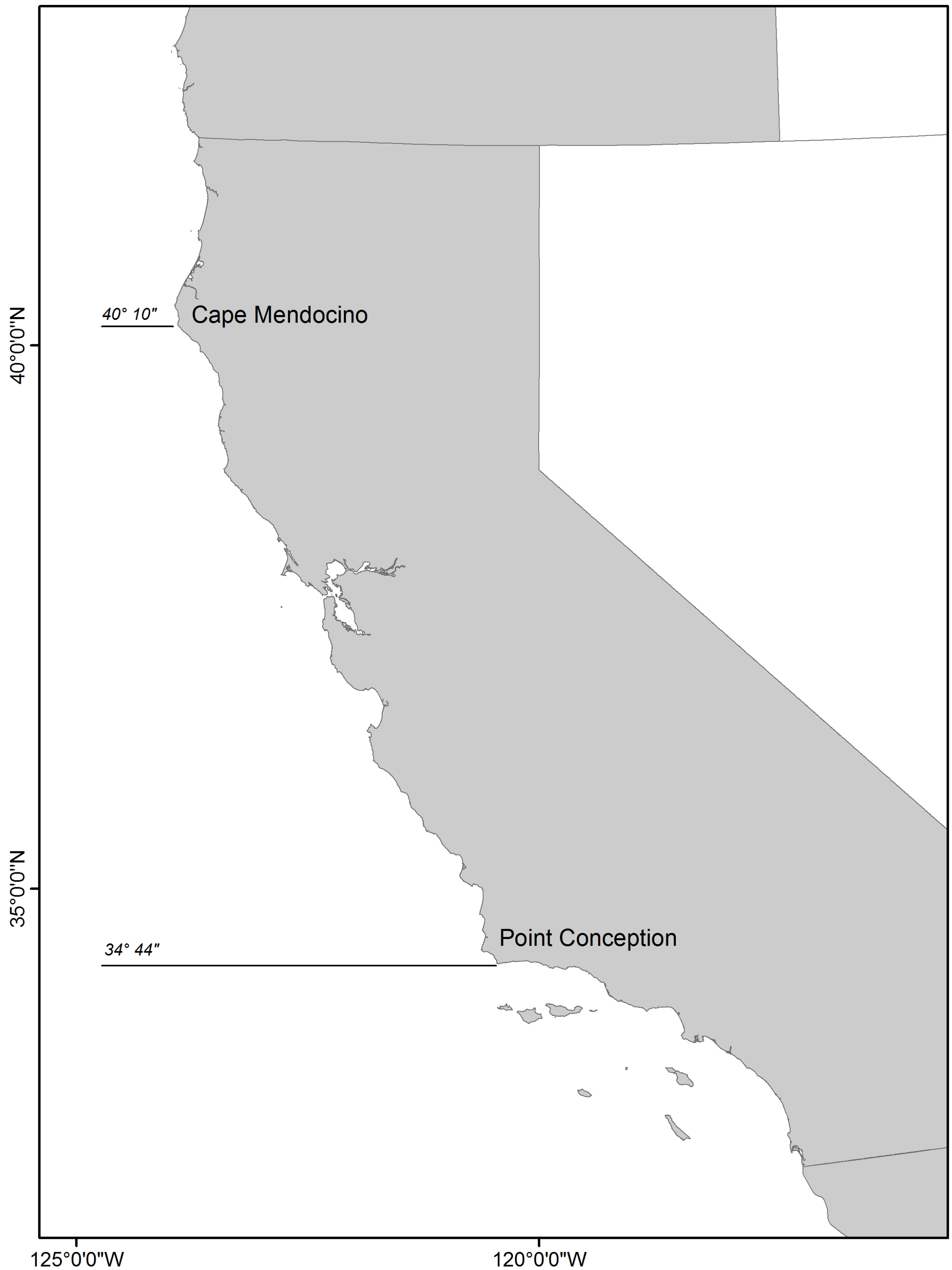


Figure d: Map depicting the core distribution of gopher and black-and-yellow rockfishes. The stock assessment is bounded at Cape Mendocino in the north to the U.S./Mexico border in the south. fig:assess_region_map

Stock Biomass

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.

tab:SpawningDeplete_mod1

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

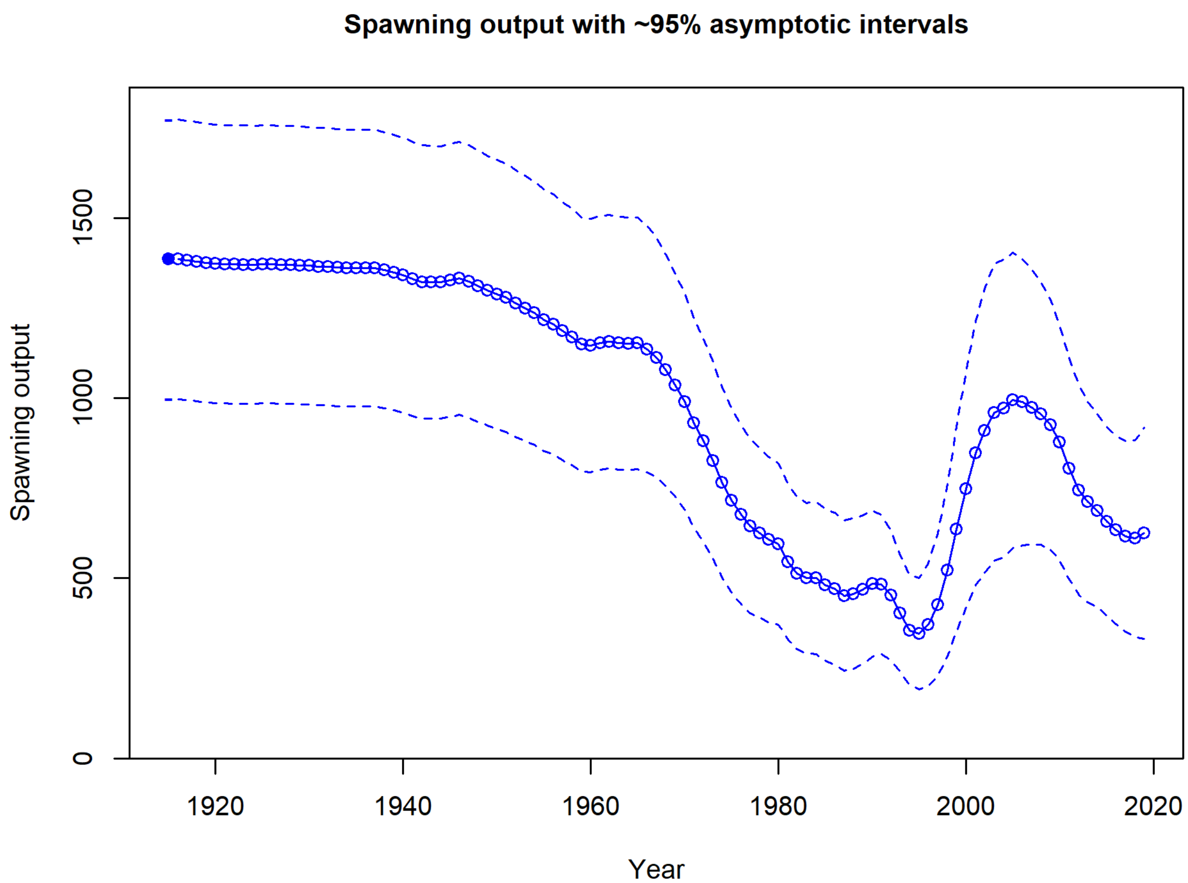


Figure e: Time series of spawning biomass trajectory (circles and line: median; light broken lines: 95% credibility intervals) for the base case assessment model. fig:Spawnbio_all

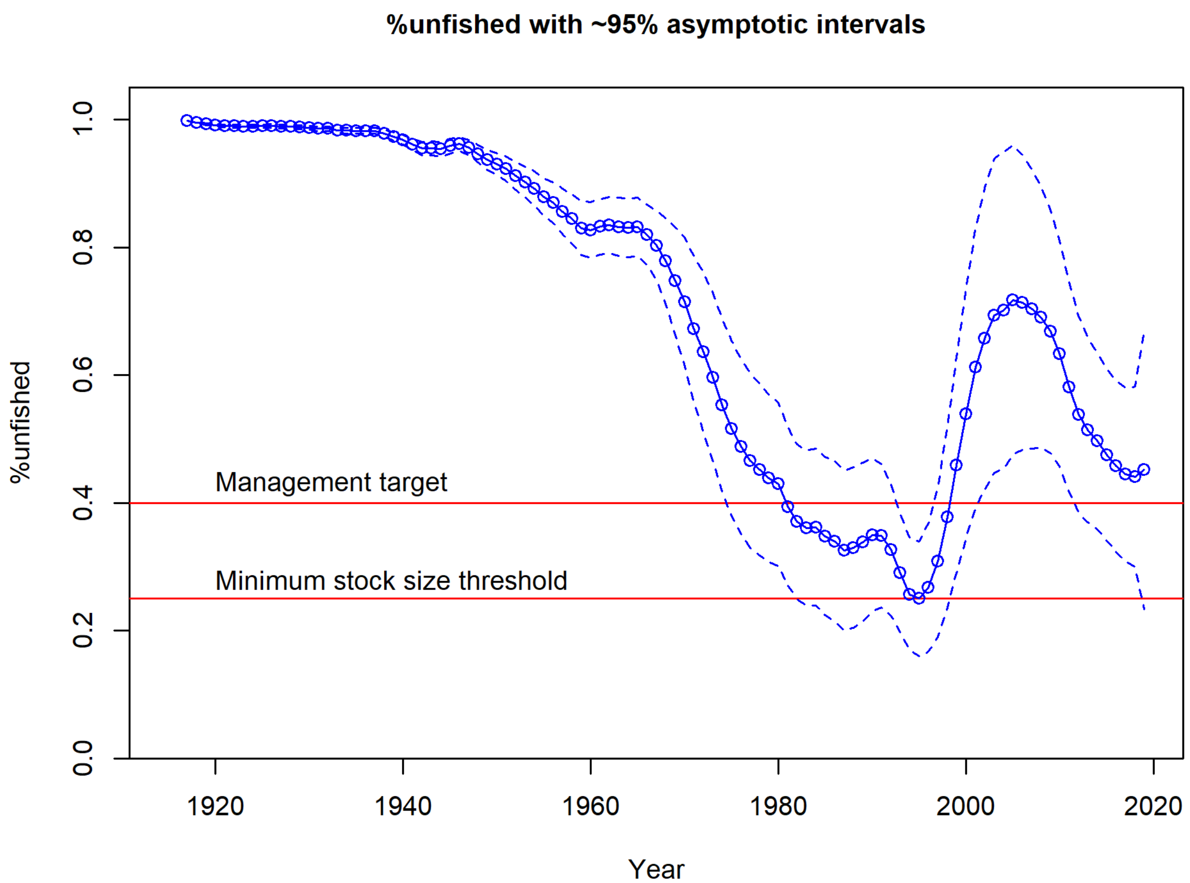


Figure f: Estimated percent depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model. fig:RelDeplete_all

Recruitment

recruitment

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

Table c: Recent recruitment for the GBYR assessment.

tab:Recruit_mod1

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

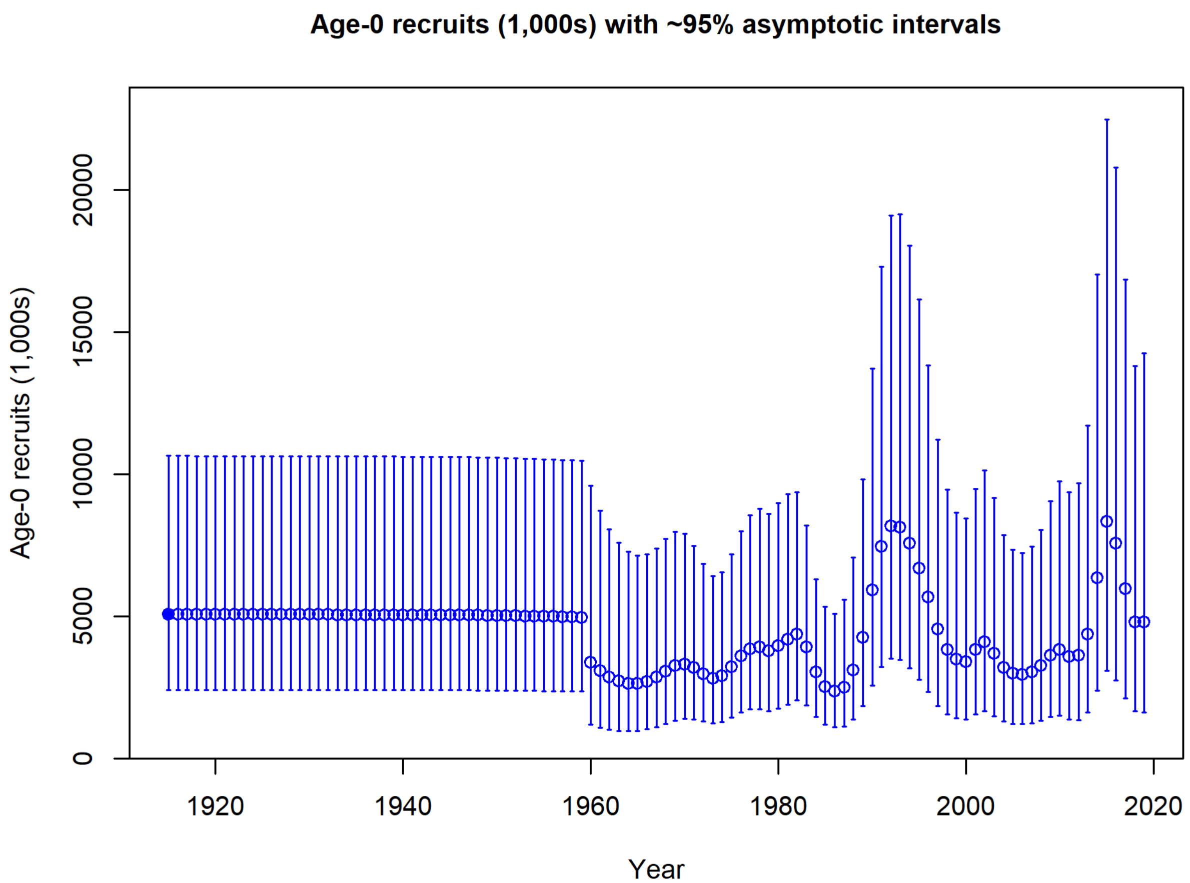


Figure g: Time series of estimated GBYR recruitments for the base-case model with 95% confidence or credibility intervals. fig:Recruits_all

Exploitation status

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}.

tab:SPR_Exploit_mod1

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

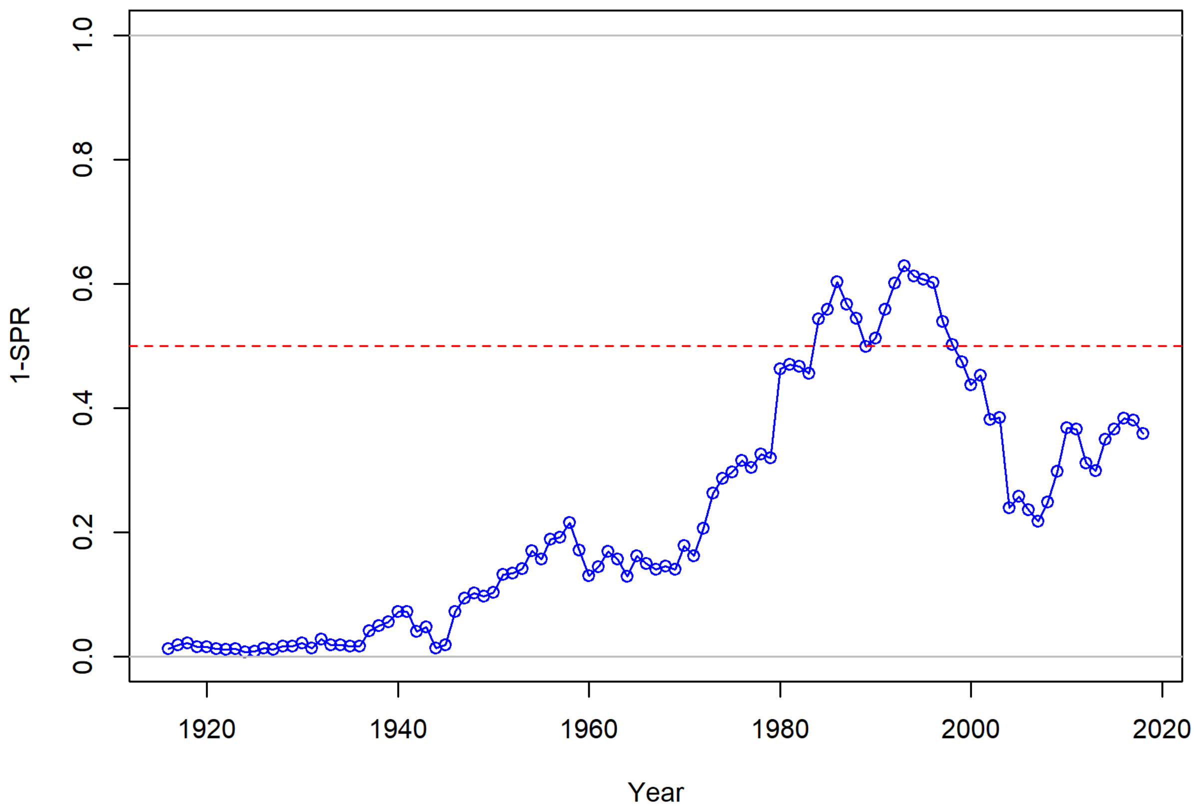


Figure h: Estimated spawning potential ratio (SPR) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing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

Ecosystem Considerations

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

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: ± 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 2,199 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.

tab:Ref_pts_mod1

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)	2,199	1,696	2,701
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

management-performance

Table f

Unresolved Problems and Major Uncertainties

unresolved-problems-and-major-uncertainties

Table f: Recent trend in total mortality for gopher and black-and-yellow rockfishes (GBYR), combined, relative to the management guidelines for the minor nearshore rockfish south of 40°10′ N. latitude. Total mortality estiamtes are based on annual reports from the NMFS NWFSC

tab:mnmgt_perform

	GBYR	Minor Nearshore Rockfish		
Year	Total mortality	Total mortality	ACL	OFL
2011	122.87	436	1,001	1,156
2012	91.96	445	1,001	1,145
2013	104.53	495	990	1,164
2014	103.63	596	990	1,160
2015	107.95	676	1,114	1,313
2016	111.55	641	1,006	1,288
2017	-	-	1,329	1,163
2018	-	-	1,344	1,179

138 # Decision Table

decision-table

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

tab:OFL_projection

Year	OFL
2019	182.79

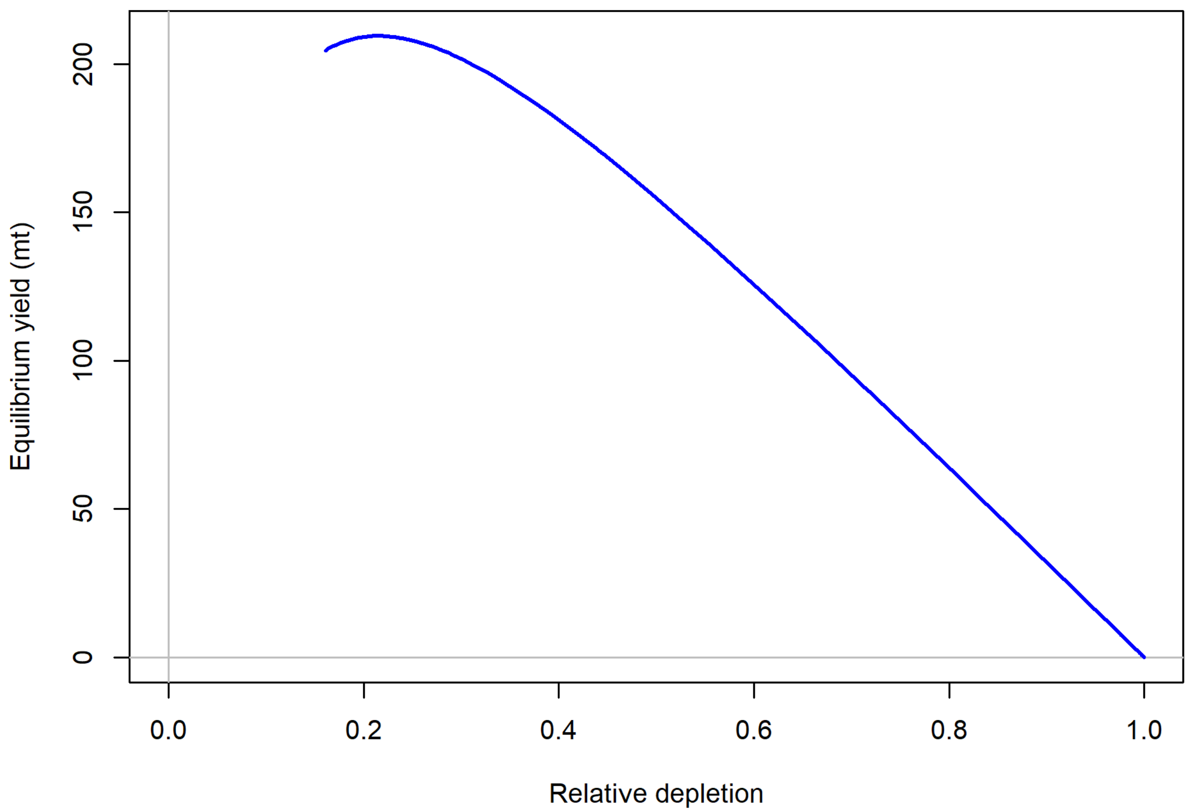


Figure i: Equilibrium yield curve for the base case model. Values are based on the 2018 fishery selectivity and with steepness fixed at 0.718. fig:Yield_all

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.

tab:Decision_table_mod1

			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.

tab:base_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

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

introduction

1.1 Basic Information and Life History

basic-information-and-life-history

Population Structure and Complex Assessment Considerations

There have been a number of analyses of the genetic differentiation between gopher rockfish and black-and-yellow rockfish that have yielded some range of results, but have generally concluded that there is unusually low genetic differentiation between the two species. The most frequently used measure of genetic analyses to evaluate evidence for population differentiation is the fixation index (F_{ST}), defined as the proportion of the total genetic variation in one subpopulation (subscript S) relative to the total genetic variation (subscript T) (Hauser and Carvalho 2008, Waples et al. 2008). Values of F_{ST} range from 0 to 1 where a zero value implies the populations are panmictic and a value closer to one implies the two populations are genetically independent. Values of F_{ST} thought to be consistent with biologically meaningful genetic differentiation and demographic isolation between populations range from 0.05 to 0.1 (Waples and Gaggiotti 2006). It is also important to note that F_{ST} values are dependent on the study's sample size and it may not necessarily be appropriate to compare them across studies.

Morphologically, gopher and black-and-yellow rockfishes are almost indistinct, except for their color variation (Hubbs and Schultz 1933). Early efforts to evaluate whether the two species were genetically distinct began with an allozyme analysis by Seeb et al. (1986), which did not detect genetic differentiation between gopher and black-and-yellow rockfish. However, as allozymes are proteins that are often conserved due against variation, this early work was not enormously conclusive. In a subsequent study of restriction site polymorphisms, Hunter et al. (1994) found slight but significant differences between species based on restriction fragment length polymorphisms (RFLP's). Following that study, an analysis of the mitochondrial control region by Alesandri and Bernardi (1999) did not detect differences between the two species, although there were limitations regarding how representative those results were across the genome. Analysis of seven microsatellite loci by Narum et al. (2004) found an F_{ST} of 0.049 across the overlapping range of the two species, which provided some evidence of divergence, although such divergence is relatively low compared to other species within *Sebastes. Those authors characterized their results as suggesting that the two are "reproductively isolated incipient species."
Buonaccorsi et al. (2011) found an even lower F_{ST} of 0.01 using 25 loci, and concluded that gopher and black-and-yellow rockfish "have not completed the speciation process." All of these studies are indicative of low levels of genetic divergence and a high probability of ongoing gene flow between the two nominal species.

Most recently, an analysis of microhaplotypes by Baetscher (2019) observed a higher frequency of mis-assignments of individuals to between gopher and black-and-yellow rockfishes compared to all other pairs of species in the genus *Sebastes*. In addition, comparisons of F_{ST}

values within the study indicated that the level of genetic differentiation observed between gopher and black-and-yellow rockfishes is less than that observed among all other pairwise comparisons of the 54 species in the *Sebastes* genus that were included in their analysis. Baetscher (2019) characterized the results as suggestive of the two species representing "sister species with evidence of ongoing gene flow," noting that a more rigorous evaluation of the level of genetic distinction between these two species would benefit from whole-genome sequencing of representatives from each species group.

In addition to the differences in coloration, the depth distribution and range differ between the two species. The range of both species extends from Cape Blanco Oregon to Baja California. Both specides are uncommon north of Fort Bragg, California and black-and-yellow rockfish is uncommon south of Pt. Conception, California. Howver, gopher rockfish can be found as far south as Punta San Roque on the Baja peninsula.Gopher rockfish are found in rocky reef habitat from the intertidal to depths of 264 ft (80 m) with a predominant depth distribution of 30 to 120 ft (9-37 m), while the black-and-yellow rockfish occupies depths from the intertidal to 120 ft (40 m) and is predominantly observed in depths shallower than 60 ft (18 m) (Eschmeyer et al. 1983, Love et al. 2002).

Both species are solitary, sedentary, territorial species with home ranges of 10-12 square meters, with occasional extended trips (Love et al. 2002). A large percentage (67-71%) of black-and-yellow rockfish retuend to the site of capture within two weeks after tranlocated within 50 m (Hallacher 1984). Lea et al. (1999) found that gopher rockfish exhibit minor patterns of movement (<1.5 nm, 2.8 km) with all fish being recaptured on the same reef system where they were tagged. Another study, conducted by (Matthews 1985), reported movements up to 1.2 km by gopher rockfish that traveled from a low-relief natural reef to a high-relief artificial reef. The change in substrate type may have been a factor in the movement in the Matthews(1985) study.

Larson (1980) conducted a study on the territoriality and segregation between gopher and black-and-yellow rockfishes. When one species was removed, the other extended its depth range to areas where the other previously occupied, indicating interspecifci competition plays a role in controlling their depth distributions where both species are present. Of the two species, black-and-yellow rockfish are socially dominant and agressive towards excluding gopher rockfish from shallower waters.

Both species are be feed at night, with similar diets composed primarily of crabs and shrimp,supplemented by fish and cephalopods (Larson 1972, Hallacher and Roberts 1985, Love et al. 2002). Loury et al. (Loury et al. 2015) found no significant differnces in the diet of gopher rockfish inside and outside the 35 year old Point Lobos Marine Protected Area (MPA). She did find the diet of gopher rockfish at Ano Nuevo (shallower and north of Point Lobos) dominated by crabs and dominated by brittle stars at southern, deeper study locations. Zuercher (2019) examined the diets of a suite of nearshore rockfish species including black-and-yellow and found that they relied on hard-bodied benthic invertebrates such as Brachyuran crabs, shrimps, other anthropods, and octopus. The diet of black-and-yellow rockfish remained the same across sampling years, but they occupied a lower trophic level during the upwelling season.

1.2 Early Life History

`early-life-history`

Both gopher and black-and-yellow rockfish are viviparous and release one brood per season between January and July (Echeverria 1987). Larvae are approximately 4 mm in length at birth and have a 1-2 month pelagic stage before recruiting to the kelp forest canopy, i.e., surface fronds of *Macrosystis pyrifera* and *Cysteoseira osmundacea* at around 15-21 mm (Anderson 1983, Wilson et al. 2008). The larvae are transparent until they reach juvenile stage at 22-23 mm. Differences in coloration begin to occur at 25-30 mm and can be used to identify one species from the other. Gopher rockfish become more orange and brown, while black-and-yellow rockfish become more black and yellow. Benthic juveniles associate with *Macrosystis* holdfasts and sporophylls (Anderson 1983). Gopher and black-and-yellow rockfish have similar development

The juveniles undergo ontogenetic migration down the stalks to deeper depths, finally settling on rocky reef habitat in their respective adult depth distribution. Juvenile bocaccio and other fish predate on young of year and other reef dwelling species including Cabezon predate on post-settlement juveniles. Individuals avoid rough surge conditions and predators by hiding in the rocky bottom during the daylight hours, then returning to more open water at dusk (Love et al. 2002).

1.3 Map

`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

`ecosystem-considerations-1`

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

`fishery-information`

The hook-and-line fishery off California developed in the late 19th century (Love et al. 2002). The rockfish trawl fishery was established in the early 1940s, when the United States became involved in World War II and wartime shortage of red meat created an increased demand for other sources of protein (Harry and Morgan 1961, Alverson et al. 1964).

Gopher and black-and-yellow (referred to from hereon as GBRY when discussing the complex) rockfish have been a minor component of the commercial and recreational rockfish fishery since at least the late 1960s (CFIS and RecFIN). The commercial catch histories of the two species cannot easily be separated (Figure **??**). From 1916-1936 only black-and-yellow rockfish were reported in the landings, and an average of 0.04 mt of black-and-yellow rockfish are reported from 1937-1983. Black-and-yellow rockfish reappear in the landings in 1984 with 7.2 mt landed commercially. From 1985-1988 the trend switches and only black-and-yellow rockfish appear in the commercial landings, with gopher rockfish averaging 0.1 mt landed, and 0 mt reported in 1987. From 1988 and on, the landings are dominated by gopher rockfish, and both species are represented in the commercial landings.

The landings from south of Pt. Conception are minor throughout the time period, with peaks in the 1950s and 60s for gopher rockfish. Black-and-yellow rockfish are rare south of Pt. Conception and expected that these catches are minimal.

The live fish fishery began in the early 1990s, with the first commercial landings of live gopher rockfish in 1993, and black-and-yellow rockfish a year later. By 1995 over half (57%; 39 mt) of the commercial landings were from the live fish fishery. This increased quickly over the next few years and has been on average 84% of the landed GBYR since 2000. The majority of the landings are from gopher rockfish north of Pt. Conception. Landings of live GBYR south of Pt. Conception wer higher in the late 1990s, (max. 3.2 mt in 1999), and have been averaging 0.4 mt since 2003.

The ex-vessel value of GBYR increased from less than $40,000 in 1984 and peaked at $680,452 in 1996 (Figure 1). The ex-vessel revenue has been fairly stable at around $500,000 a year since 2007. Prior to the live fish fishery in 1994, the average price per pound for either species was around $2 a pound. The live fish fishery increased the value of both species to an average of $6-$8 a pound. The maximum reported value of either a gopher or black-and-yellow rockfish was $20 a pound in 2003.

The recreational GBYR fishery for California is most prominent north of Pt. Conception throughout the entire catch history (Figure a). The recreational landings increased from 1928 to 1980. The sharp increase in the 1980s could be an artifact of the MRFSS sampling program that began in 1980; however, the more recent recreational landings also exhibit a cyclical trend of years with high catches followed by period of decreased recreational landings. The CRFS era recreational total mortality represents the most accurate description of the recreational fleet's catches in terms of area, mode and species (Figure 2).

Recreational catches are dominated by gopher rockfish north of Pt. Conception in the private/rental (PR) and party/chater (PC or CPFV) modes. South of Pt. Conception gopher rockfish are predominately caught by the CPFV fleet, with all other modes being insignifcant. The total recreational mortality of black-and-yellow rockfish south of Pt. Conception since

2005 is 3 mt, compared to 106 mt north of Pt. Conception. The total mortality since 2005 for gopher rockfish is 86 mt south of Pt. Conception and 669 mt north of Pt. Conception.

1.6 Summary of Management History

summary-of-management-history

Prior to the adoption of the Pacific Coast Groundfish Fishery Management Plan (FMP) in 1982, GBYR were managed through a regulatory process that included the California Department of Fish and Wildlife (CDFW) along with either the California State Legislature or the Fish and Game Commission (FGC) depending on the sector (recreation or commercial) and fishery. With implementation of the Pacific Coast Groundfish FMP, GBYR came under the management authority of the Pacific Fishery Management Council (PFMC), and were managed as part of the *Sebastes* complex. Because neither species had undergone rigorous stock assessment and did not compose a large fraction of the landings they were classified and managed as part of "Remaining Rockfish" under the larger heading of "Other Rockfish" (PFMC (2002, 2004)).

Since the early 1980s a number of federal regulatory measures have been used to manage the commercial rockfish fishery including cumulative trip limits (generally for two- month periods) and seasons. Starting in 1994 the commercial groundfish fishery sector was divided into two components: limited entry and open access with specific regulations designed for each component. Other regulatory actions for the general rockfish categories have included area closures, gear restrictions, and cumulative bimonthly trip limits set for the four different commercial sectors - limited entry fixed gear, limited entry trawl, open access trawl, and open access non-trawl. Harvest guidelines are also used to regulate the annual harvest for both the recreational and commercial sectors.

In 2000, changes in the PFMC's rockfish management structure resulted in the discontinued use of the *Sebastes* complex, and was replaced with three species groups: nearshore, shelf, and slope rockfishes (January 4, 2000; 65 FR 221), of which GBYR are included in the nearshore group. Within the nearshore group, they are included in the "shallow nearshore rockfish" component.

During the late 1990s and early 2000s, major changes also occurred in the way that California managed its nearshore fishery. The Marine Life Management Act (MLMA), which was passed in 1998 by the California Legislature and enacted in 1999, required that the FGC adopt an FMP for nearshore finfish (Wilson-Vandenberg et al. 2014). It also gave authority to the FGC to regulate commercial and recreational nearshore fisheries through FMPs and provided broad authority to adopt regulations for the nearshore fishery during the time prior to adoption of the nearshore finfish FMP. Within this legislation, the Legislature also included commercial size limits for ten nearshore species including GBYR (10-inch minimum size) and a requirement that commercial fishermen landing these ten nearshore species possess a nearshore permit.

Following adoption of the Nearshore FMP and accompanying regulations by the FGC in fall of 2002, the FGC adopted regulations in November 2002 which established a set of marine reserves around the Channel Islands in southern California (which became effective April 2003). The FGC also adopted a nearshore restricted access program in December 2002 (which included the establishment of a Deeper Nearshore Permit) to be effective starting in the 2003 fishing year.

Also, since the enactment of the MLMA, the Council and State in a coordinated effort developed and adopted various management specifications to keep harvest within the harvest targets, including seasonal and area closures (e.g. the CCAs; a closure of Cordell Banks to specific fishing), depth restrictions, minimum size limits, and bag limits to regulate the recreational fishery and license and permit regulations, finfish trap permits, gear restrictions, seasonal and area closures (e.g. the RCAs and CCAs; a closure of Cordell Banks to specific fishing), depth restrictions, trip limits, and minimum size limits to regulate the commercial fishery.

The state of California has adopts regulatory measures to manage the fishery based on the harvest guidelines set forth by the PFMC. The commercial open access and limited entry fixed gear sectors have undergone three different spatial management changes in since 2000. Since 2005, both have managed the area south of $40°10'$ N. latitude as one area. he open access commercial fishery is managed based on bimonthly allowable catches, that have ranged from 200 pounds to 1800 pounds per two months since 2000.
From 2005 to 2018, the catch limits have doubled and are now set at 1200 pounds per two months (for all months) with March and April remaining closed. The limited entry fixed year sector has followed the same pattern as the open access sector with bi-monthly limits and a doubling of the catch since 2005. The limited entry trawl fleet is managed on monthly limits on an annual basis. Since 2011, the limit has been 300 pounds per month for non-IFQ species. A history of California's commercial regulations from 2000-2018 can be found in Appendix X.

Significant regulatory changed in California's recreational sector began with a change from unlimited number of hooks and lines allowed in 1999 and prior to no more than three hooks and one line per angler in 2000. Since 2001, the limit has been no more than two hooks and one line per angler. There is no size limit in the recreational fishery for gopher or black-and-yellow rockfish. GBYR are part of the nearshore complex which has had a sub-bag limit within the rockfish bag limit since 1999. The nearshore sub-bag limit has been 10 fish since 2005.

California also began spatial management, closures, and depth restrictions for the recreational fleet in 2000. In general, the recreational season north of Pt. Conception extends from April to December, and south of Pt. Conception from March to December. In the area that GBYR are most commonly landed, from Monterey to Morro Bay, the depth restrictions have been between 30 and 40 fathoms until 2017. In 2017 the depth restrictions were eased by 10 fathoms, opening up fishing depths along the central California coast that had not been open consistently since 2002. In both 2017 and 2018, the deepest 10 fathoms was closed prior to the season in December due to high by-catch rates of yelloweye rockfish, one of two rockfish species that are still overfished. A full history of the recrational regulations relating to teh spatial management of the fleet can be found in Appendix XXX.

1.7 Management Performance

management-performance-1

NEED TO FINISH
The contribution of GBYR to the minor nearshore rockfish OFLs is currently derived from two sources: 1) forecasts from Key et al. (2005), from Cape Mendocino to Pt. Conception and 2) a Depletion Corrected Average Catch (DCAC (MacCall 2009)) for the area south of Point Conception. Estimated catch of GBYR has been...... A summary of these values as well as other base case summary results can be found in Table f.

1.8 Fisheries Off Mexico or Canada

fisheries-off-mexico-or-canada

The range of GBYR does not extend north to the Canadian border, and they are rarely encountered in Oregon and Washington. The southern end of the gopher rockfish's range extends to Punta San Roque (southern Baja California) while the southern end of the black-and-yellow rockfish's range extends to Isla Natividad (central Baja California) (Love et al. 2002). However, black-and-yellow rockfish are rare south fo Pt. Conception, California. This was no available information on the fishery for GBYR at the time of this assessment, nor additional details on the abundance or distribution patterns in Mexican waters.

2 Assessment

assessment

2.1 Data

data

Data used in the GBYR assessment are summarized in Figure 3. Descriptions of the data sources are in the following sections.

2.1.1 Commercial Fishery Landings

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 **??**). 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 1). 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

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 1).

2.1.3 Commercial Fishery Length and Age Data

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 2). The 2005 assessmentused commercial length composition information from CALCOM, but did not include black-and-yellow rockfish and is not directlycomparable. 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):

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

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

Commercial length composition data are made available from PacFIN and the expanded catch-weight legnth compositions were provided by Andi Stephens (NWFSC) processed through the PacFIN Utilities package. We compares differences between the catch-weighted length composition expansions from CALCOM and PacFIN. We were unable to reconcile the difference between the two datasets. Sample sizes became more similar if the PacFIN data were restricted to the same market categories used by CALCOM in the expansion. However, both datasets apply other filters that we did not have time to explore. For instance, in the year 2000, 290 more fish were used in the CALCOM expansion than in PacFIN, but in 2002, 150 more fish were used in the PacFIN expansions that were not used in CALCOM. Given these caveats, Figure 6 shows the percent difference in the expanded length comps within a year. The biggest difference is in length bin 32 in 2006. However, the same number of fish and samples were used to expand the 2006 lengths in both databases, indicating there are also fundamental differences in how the data are treated. Full documentation is not available for the PacFIN length composition expansion program. The base model for this assessment uses the CALCOM length compsition data as described above, but a sentistivy was conducted using the PacFIN length composition data.

2.1.4 Recreational Fishery Removals and Discards
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 7). 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 3 and Figure 8).

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 3). 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 3.

2.1.5 Recreational Fishery Length and Age Data

`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 2). 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 2). 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 2). 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

`fishery-dependent-indices-of-abundance`

Data Source 1

Data Source 1 Index Standardization

Table 6)

(Table 4) *Data Source 1 Length Composition*

Data Source 2

Data Source 3

2.1.7 Fishery-Independent Data Sources

`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

biological-parameters-and-data

Neither gophr nor black-and-yellow rockfish have forked tails, therefore total legnth and fork length are equal. All of the data provided for this assessment were either in fork length or total length.

Length and Age Compositions

Length compositions were provided from the following sources:

- CALCOM (*commercial retained dead fish*, 1987, 1992-2018)
- WCGOP (*commercial discarded fish*, 2004-2018)
- Deb Wilson-Vandenber's onboard observer survey (*recreational charter retained and discarded catch*, 1987-1998)
- California recreational sources combined (*recreational charter retained catch*)
  - Miller and Gotshall dockside survey (1959-1966)
  - Ally et al. onboard observer survey (1985-1987)
  - Collins and Crooke onboard observer survey (1975-1978)
  - MRFSS dockside survey (1980-2003)
  - CRFS onboard and dockside survey (2004-2018)
- PISCO dive survey (*research*, 2001-2018)
- CCFRP hook-and-line survey (*research*, 2007-2018)

The length composition of all fisheries aggregated across time by fleet is in Figure 9. Descriptions and details of the length composition data are in the above section for each fleet or survey.

Age Structures

A total of 2,467 otoliths were incorporated in this assessment and a summary by source can be found in Table 19. Gopher rockfish comprised 80% of the samples (946 females, 901 males, 121 unknown sex), and all but a few black-and-yellow rockfish (247 females, 232 males, 20 unknown sex) came from a directed study by Jody Zaitlin (1986) (Figure 10).

Of the available ages, 91% were collected during fishery-independent surveys.
An additional 36 otoliths were collected by Cal Poly during their CPFV onboard observer survey in 2018. The remaining 7.5% were from commercial port samples or recreational dockside surveys. Black-and-yellows represent 20% of the samples collected, and are mainly derived from Ralph Larson's work in Monterey Bay.

All otoliths were read by Don Pearson (NMFS SWFSC, now retired) and ages ranged from 1-28. The aged black-and-yellow rockfish ranged in length from 7-32 cm with a mean of 24 cm and gopher rockfish ranged in length from 11-36 cm, with a mean of 26. In terms of ages, the black-and-yellow rockfish ranged from 2-19 and gophers from 2-28. Fits to the 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, were explore by species and sex.

No significant differences were found in growth between males and females, or between gopher and black-and-yellow rockfishes.

Aging Precision and Bias

Weight-Length

Sex Ratio, Maturity, and Fecundity Gopher Females mature at 20.7 cm and live to 24 years old. Mature females in Central California release larvae between January and July (**???** et. al. 2002).

Black-and-yellow Females mature at 17 cm producing 25,000 - 450,000 eggs spawning from January to May. One brood is released per season for both black and yellow and gopher rockfish (**???** et. al. 2002).

Females reach 50% maturity at 17.5 cm or 4 years of age in Central California and were 100% mature by age 6, with the same age of maturity found in southern California though individuals were smaller at age (Zaitlin 1986).

Natural Mortality

2.1.9 Environmental or Ecosystem Data Included in the Assessment

`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

previous-assessments

2.2.1 History of Modeling Approaches Used for this Stock

history-of-modeling-approaches-used-for-this-stock

2.2.2 yyyy Assessment Recommendations

yyyy-assessment-recommendations

Recommendation 1:

STAT response: xxxxx

Recommendation 2:

STAT response: xxxxx

Recommendation 3:

STAT response: xxxx

2.3 Model Description

model-description

2.3.1 Transition to the Current Stock Assessment

transition-to-the-current-stock-assessment

2.3.2 Summary of Data for Fleets and Areas

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

other-specifications

2.3.4 Modeling Software

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

data-weighting

2.3.6 Priors

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

estimated-and-fixed-parameters

A full list of all estimated and fixed parameters is provided in Tables 21.

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 21.

Growth.

Natural Mortality.

Selectivity.

Other Estimated Parameters.

Other Fixed Parameters.

2.4 Model Selection and Evaluation

model-selection-and-evaluation

2.4.1 Key Assumptions and Structural Choices

key-assumptions-and-structural-choices

2.4.2 Alternate Models Considered

alternate-models-considered

2.4.3 Convergence

convergence

2.5 Response to the Current STAR Panel Requests

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

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 21 and the likelihood components are in Table 22. 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 23.

2.6.1 Parameter Estimates

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 13 with estimated recruitments also shown.

2.6.2 Fits to the Data

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

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

retrospective-analysis

2.6.5 Likelihood Profiles

likelihood-profiles

2.6.6 Reference Points

reference-points-1

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 23

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 25 shows the equilibrium curve based on a steepness value xxx.

3 Harvest Projections and Decision Tables

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

regional-management-considerations

5 Research Needs

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

acknowledgments

7 Tables

tables

Table 1: Commercial landings and discards (mt) from the commercial fisheries. Data sources are the California Catch Reconstruction, CALCOM, PacFIN, and WCGOP GEMM report.

Year	Landings	Discards	Total Commercial Removals	Source
1916	3.88	0.38	4.27	Catch Reconstruction
1917	6.03	0.59	6.63	Catch Reconstruction
1918	7.06	0.69	7.75	Catch Reconstruction
1919	4.91	0.48	5.39	Catch Reconstruction
1920	5.01	0.49	5.50	Catch Reconstruction
1921	4.13	0.41	4.54	Catch Reconstruction
1922	3.56	0.35	3.90	Catch Reconstruction
1923	3.84	0.38	4.22	Catch Reconstruction
1924	2.22	0.22	2.44	Catch Reconstruction
1925	2.78	0.27	3.05	Catch Reconstruction
1926	4.48	0.44	4.92	Catch Reconstruction
1927	3.81	0.37	4.18	Catch Reconstruction
1928	4.60	0.45	5.06	Catch Reconstruction
1929	3.81	0.37	4.18	Catch Reconstruction
1930	5.40	0.53	5.93	Catch Reconstruction
1931	1.93	0.19	2.11	Catch Reconstruction
1932	6.24	0.61	6.85	Catch Reconstruction
1933	2.58	0.25	2.84	Catch Reconstruction
1934	1.75	0.17	1.92	Catch Reconstruction
1935	0.43	0.04	0.47	Catch Reconstruction
1936	0.01	0.00	0.01	Catch Reconstruction
1937	7.27	0.71	7.98	Catch Reconstruction
1938	10.29	1.01	11.30	Catch Reconstruction
1939	13.13	1.29	14.42	Catch Reconstruction
1940	16.90	1.66	18.56	Catch Reconstruction
1941	17.06	1.67	18.73	Catch Reconstruction
1942	8.55	0.84	9.38	Catch Reconstruction
1943	11.00	1.08	12.08	Catch Reconstruction
1944	0.05	0.00	0.05	Catch Reconstruction
1945	0.59	0.06	0.65	Catch Reconstruction
1946	16.71	1.64	18.35	Catch Reconstruction
1947	26.71	2.62	29.33	Catch Reconstruction
1948	23.95	2.35	26.30	Catch Reconstruction
1949	18.29	1.79	20.09	Catch Reconstruction
1950	17.15	1.68	18.83	Catch Reconstruction
1951	24.83	2.44	27.26	Catch Reconstruction

Continues next page

tab:CommCatches

Table 1: Commercial landings and discards (mt) from the commercial fisheries. Data sources are the California Catch Reconstruction, CALCOM, PacFIN, and WCGOP GEMM report.

Year	Landings	Discards	Total Commercial Removals	Source
1952	27.59	2.71	30.29	Catch Reconstruction
1953	32.30	3.17	35.47	Catch Reconstruction
1954	40.75	4.00	44.74	Catch Reconstruction
1955	29.49	2.89	32.38	Catch Reconstruction
1956	40.66	3.99	44.65	Catch Reconstruction
1957	37.52	3.68	41.20	Catch Reconstruction
1958	33.56	3.29	36.86	Catch Reconstruction
1959	19.62	1.92	21.54	Catch Reconstruction
1960	11.30	1.11	12.41	Catch Reconstruction
1961	17.49	1.72	19.20	Catch Reconstruction
1962	27.18	2.67	29.85	Catch Reconstruction
1963	22.29	2.19	24.48	Catch Reconstruction
1964	16.55	1.62	18.17	Catch Reconstruction
1965	21.50	2.11	23.61	Catch Reconstruction
1966	13.44	1.32	14.76	Catch Reconstruction
1967	6.70	0.66	7.36	Catch Reconstruction
1968	8.29	0.81	9.10	Catch Reconstruction
1969	9.99	0.98	10.97	CALCOM
1970	14.21	1.39	15.60	CALCOM
1971	14.41	1.41	15.83	CALCOM
1972	19.42	1.91	21.33	CALCOM
1973	31.43	3.08	34.51	CALCOM
1974	33.41	3.28	36.69	CALCOM
1975	33.08	3.25	36.33	CALCOM
1976	33.90	3.33	37.23	CALCOM
1977	30.13	2.96	33.09	CALCOM
1978	43.41	4.26	47.67	CALCOM
1979	34.24	3.36	37.60	CALCOM
1980	63.65	6.24	69.89	CALCOM
1981	52.71	5.17	57.87	PacFIN
1982	38.97	3.82	42.79	PacFIN
1983	28.67	2.64	31.30	PacFIN
1984	16.74	1.45	18.20	PacFIN
1985	8.54	0.83	9.37	PacFIN
1986	25.16	2.50	27.66	PacFIN
1987	34.05	3.36	37.40	PacFIN
1988	54.98	5.47	60.44	PacFIN
1989	45.22	4.46	49.68	PacFIN

Continues next page

tab:CommCatches

Table 1: Commercial landings and discards (mt) from the commercial fisheries. Data sources are the California Catch Reconstruction, CALCOM, PacFIN, and WCGOP GEMM report.

Year	Landings	Discards	Total Commercial Removals	Source
1990	46.08	4.59	50.67	PacFIN
1991	67.98	6.75	74.73	PacFIN
1992	83.91	8.24	92.15	PacFIN
1993	73.43	7.27	80.70	PacFIN
1994	54.84	5.89	60.74	PacFIN
1995	91.10	8.97	100.07	PacFIN
1996	95.08	9.29	104.37	PacFIN
1997	69.99	6.81	76.80	PacFIN
1998	65.29	6.40	71.70	PacFIN
1999	62.65	6.15	68.80	PacFIN
2000	54.44	5.29	59.72	PacFIN
2001	53.76	5.24	59.00	PacFIN
2002	42.64	4.15	46.79	PacFIN
2003	21.08	13.04	34.12	PacFIN & WCGOP
2004	26.25	2.66	28.91	PacFIN & WCGOP
2005	28.67	3.33	31.99	PacFIN & WCGOP
2006	24.05	4.10	28.15	PacFIN & WCGOP
2007	30.36	4.50	34.87	PacFIN & WCGOP
2008	36.22	1.63	37.85	PacFIN & WCGOP
2009	35.62	5.38	40.99	PacFIN & WCGOP
2010	38.83	3.92	42.75	PacFIN & WCGOP
2011	42.39	5.72	48.12	PacFIN & WCGOP
2012	33.55	1.93	35.48	PacFIN & WCGOP
2013	33.45	2.85	36.31	PacFIN & WCGOP
2014	36.40	2.85	39.24	PacFIN & WCGOP
2015	43.25	2.93	46.18	PacFIN & WCGOP
2016	36.96	2.42	39.38	PacFIN & WCGOP
2017	42.04	1.65	43.68	PacFIN & WCGOP
2018	47.00	2.54	49.54	PacFIN & WCGOP

Table 2: Length composition sample sizes for fishery dependent data. Continuous years begin in 1975. Recreational north samples include Karpov et al., MRFSS, and CRFS data. Recreational south samples include Karpov et al., Collins and Crooke unpub., Ally et al. 1991, MRFSS, and CRFS data.

tab:length_samples_fishery

	CALCOM		WCGOP		Rec North		Rec South		Deb VW	
Year	Trips	Lengths	Trips	Lengths	Trips	Lengths	Trips	Lengths	Trips	Lengths
1959					27	271	2.10	21		
1960					39	394	1.40	14		
1961					1	8	0.10	1		
1966					1	7				
1975							50.00	159		
1976							73.00	224		
1977							96.00	392		
1978							91.00	533		
1979										
1980					4	164	21.00	53		
1981					1	19	30.00	100		
1982					1	50	17.00	58		
1983					6	323	60.00	170		
1984					14	849	42.00	150		
1985					35	1027	34.00	180		
1986					36	826	28.00	86		
1987	2	82			28	392	5.00	7	14	73
1988					30	303	10.00	30	54	664
1989					19	303	7.00	11	70	727
1990									17	109
1991									38	722
1992	56	671							55	838
1993	148	1648			14	1094	8.00	24	75	614
1994	170	1379			12	608	1.00	15	86	735
1995	174	1523							90	1171
1996	256	3270			74	607	14.00	32	100	1364
1997	140	1319			95	1424	7.00	23	107	1415
1998	206	2549			89	614	19.00	66	83	1048
1999	251	3283			49	1112	33.00	301		
2000	384	4918			21	695	12.00	58		
2001	142	2179			46	929	14.00	35		
2002	59	870			58	1656	22.00	65		
2003	55	625			72	1690	15.00	100		
2004	63	770	72	572	19	2023	3.00	42		
2005	72	700	42	260	30	3217	8.00	93		
2006	31	478	42	266	35	3737	9.00	106		
2007	80	1165	37	268	30	3200	10.00	126		
2008	46	503	12	46	39	4165	11.00	132		
2009	73	854	22	263	43	4612	15.00	184		
2010	75	925	37	344	47	4992	16.00	192		
2011	61	858	68	366	44	4692	22.00	270		
2012	57	709	69	302	46	4904	89.00	1081		
2013	48	581	56	348	40	4339	77.00	930		
2014	15	184	62	388	44	4746	49.00	595		
2015	48	578	93	521	54	5789	36.00	436		
2016	77	928	56	317	58	6265	37.00	444		
2017	67	1581	49	226	44	4691	39.00	478		
2018	67	1210			33	3563	26.00	317		

Table 3: Recreational removals (mt) of GBYR. Data sources are the California Catch Reconstruction (modified for south of Pt. Conception), MRFSS (modified for 1981-1982), and CRFS.

Year	North of Pt. Conception	South of Pt. Conception	Total Recreational Removals	Source
1928	0.84	0.02	0.85	Catch Reconstruction
1929	1.67	0.03	1.70	Catch Reconstruction
1930	1.92	0.05	1.97	Catch Reconstruction
1931	2.56	0.06	2.62	Catch Reconstruction
1932	3.20	0.08	3.28	Catch Reconstruction
1933	3.84	0.09	3.93	Catch Reconstruction
1934	4.48	0.11	4.59	Catch Reconstruction
1935	5.12	0.12	5.24	Catch Reconstruction
1936	5.76	0.22	5.98	Catch Reconstruction
1937	6.82	0.31	7.14	Catch Reconstruction
1938	6.71	0.41	7.12	Catch Reconstruction
1939	5.87	0.50	6.37	Catch Reconstruction
1940	8.45	0.60	9.05	Catch Reconstruction
1941	7.81	0.69	8.51	Catch Reconstruction
1942	4.15	0.79	4.94	Catch Reconstruction
1943	3.97	0.88	4.85	Catch Reconstruction
1944	3.26	0.98	4.24	Catch Reconstruction
1945	4.35	1.07	5.42	Catch Reconstruction
1946	7.48	1.17	8.65	Catch Reconstruction
1947	5.92	1.26	7.18	Catch Reconstruction
1948	11.81	1.36	13.17	Catch Reconstruction
1949	15.30	1.45	16.76	Catch Reconstruction
1950	18.65	1.55	20.20	Catch Reconstruction
1951	22.97	1.64	24.61	Catch Reconstruction
1952	19.99	1.74	21.73	Catch Reconstruction
1953	17.02	1.83	18.85	Catch Reconstruction
1954	21.16	1.93	23.09	Catch Reconstruction
1955	25.23	2.02	27.25	Catch Reconstruction
1956	28.17	2.12	30.28	Catch Reconstruction
1957	31.80	2.21	34.01	Catch Reconstruction
1958	48.15	2.31	50.46	Catch Reconstruction
1959	38.25	2.40	40.65	Catch Reconstruction
1960	28.66	2.50	31.15	Catch Reconstruction
1961	27.74	2.59	30.33	Catch Reconstruction
1962	28.04	2.69	30.73	Catch Reconstruction
1963	27.53	2.78	30.32	Catch Reconstruction
1964	21.73	2.88	24.61	Catch Reconstruction

Continues next page

Table 3: Recreational removals (mt) of GBYR. Data sources are the California Catch Reconstruction (modified for south of Pt. Conception), MRFSS (modified for 1981-1982), and CRFS. tab:Rec_removal

Year	North of Pt. Conception	South of Pt. Conception	Total Recreational Removals	Source
1965	31.10	2.97	34.07	Catch Reconstruction
1966	33.85	3.07	36.91	Catch Reconstruction
1967	37.08	3.16	40.25	Catch Reconstruction
1968	36.78	3.26	40.03	Catch Reconstruction
1969	31.46	3.35	34.81	Catch Reconstruction
1970	41.25	3.45	44.70	Catch Reconstruction
1971	31.18	3.54	34.72	Catch Reconstruction
1972	41.50	3.64	45.13	Catch Reconstruction
1973	50.02	3.73	53.75	Catch Reconstruction
1974	51.60	3.83	55.43	Catch Reconstruction
1975	49.01	3.92	52.93	Catch Reconstruction
1976	49.30	4.02	53.32	Catch Reconstruction
1977	41.99	4.11	46.10	Catch Reconstruction
1978	32.57	4.21	36.77	Catch Reconstruction
1979	36.23	4.30	40.53	Catch Reconstruction
1980	80.56	4.54	85.10	MRFSS
1981	81.32	1.42	82.74	Estimated
1982	82.08	0.90	82.99	Estimated
1983	82.85	3.29	86.14	MRFSS
1984	150.47	5.58	156.05	MRFSS
1985	158.34	5.74	164.08	MRFSS
1986	171.81	6.52	178.33	MRFSS
1987	118.51	5.78	124.29	MRFSS
1988	79.43	4.80	84.23	MRFSS
1989	66.61	3.57	70.19	MRFSS
1990	82.33	2.73	85.06	MRFSS
1991	98.04	1.89	99.93	MRFSS
1992	113.76	1.04	114.80	MRFSS
1993	127.71	1.97	129.68	MRFSS
1994	97.39	3.03	100.42	MRFSS
1995	49.25	1.19	50.44	MRFSS
1996	38.06	5.23	43.28	MRFSS
1997	38.15	2.84	40.99	MRFSS
1998	43.55	2.52	46.07	MRFSS
1999	48.17	10.45	58.61	MRFSS
2000	66.53	4.39	70.92	MRFSS
2001	106.23	3.29	109.53	MRFSS

Continues next page

tab:Rec_removal

Table 3: Recreational removals (mt) of GBYR. Data sources are the California Catch Reconstruction (modified for south of Pt. Conception), MRFSS (modified for 1981-1982), and CRFS.

Year	North of Pt. Conception	South of Pt. Conception	Total Recreational Removals	Source
2002	84.28	2.15	86.43	MRFSS
2003	111.50	2.70	114.20	MRFSS
2004	41.75	0.98	42.73	CRFS
2005	47.51	6.59	54.10	CRFS
2006	48.10	2.13	50.22	CRFS
2007	32.88	2.70	35.58	CRFS
2008	45.14	3.61	48.74	CRFS
2009	65.64	4.30	69.94	CRFS
2010	106.76	3.90	110.67	CRFS
2011	76.16	10.24	86.40	CRFS
2012	48.25	9.89	58.14	CRFS
2013	38.43	8.86	47.28	CRFS
2014	56.96	9.06	66.02	CRFS
2015	58.09	5.00	63.09	CRFS
2016	65.72	6.57	72.29	CRFS
2017	49.36	11.15	60.51	CRFS
2018	36.48	6.30	42.78	CRFS

Table 4: Length composition sample sizes for survey data.

tab:length_samples_survey

	CCFRP		PISCO	
Year	Trips	Lengths	Trips	Lengths
2001			55	222
2002			56	438
2003			64	473
2004			64	312
2005			65	241
2006			68	220
2007	35	2147	68	156
2008	52	3143	67	198
2009	35	1579	68	154
2010	32	2201	58	144
2011	32	1727	68	260
2012	32	1820	40	183
2013	32	685	61	258
2014	32	1655	61	313
2015	18	1121	64	622
2016	32	2015	56	346
2017	58	2402	58	317
2018	29	1975	60	264

¡!– ** –¿

Table 5: Summary of indices used in this assessment.

tab:Index_summary

Fleet	Years	Name	Type	Area	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 6: Index inpus.

tab:Indices

	Deb WV		MRFSS N		MRFSS S		Onboard N		Onboard S		CCFRP		PISCO	
Year	Obs	se_log	Obs	se_log	Obs	se_log	Obs	se_log	Obs	se_log	Obs	se_log	Obs	se_log
1980					0.08	0.21								
1981					0.05	0.24								
1982					0.07	0.25								
1983					0.13	0.13								
1984			0.04	0.60	0.09	0.17								
1985			0.03	0.55	0.09	0.21								
1986			0.09	0.58	0.03	0.19								
1987			0.02	0.66										
1988	0.22	0.17	0.03	0.61										
1989	0.34	0.15	0.02	0.66										
1990														
1991														
1992	0.30	0.17												
1993	0.20	0.14												
1994	0.23	0.12												
1995	0.25	0.10	0.04	0.64										
1996	0.28	0.10	0.04	0.52	0.04	0.28								
1997	0.21	0.09												
1998	0.24	0.11			0.05	0.26								
1999			0.03	0.53	0.05	0.22								
2000														
2001							0.32	0.12	0.01	0.52			1.66	0.23
2002							0.19	0.14	0.01	0.37			2.05	0.21
2003							0.28	0.07	0.03	0.33			2.53	0.19
2004							0.27	0.06	0.01	0.37			1.29	0.22
2005							0.26	0.08	0.02	0.24			0.91	0.24
2006							0.34	0.08	0.04	0.21			0.87	0.23
2007							0.33	0.08	0.08	0.16	1.20	0.15	0.69	0.24
2008							0.33	0.08	0.06	0.16	1.14	0.16	0.92	0.22
2009							0.27	0.08	0.07	0.16	1.13	0.16	0.59	0.22
2010							0.26	0.07	0.08	0.15	1.32	0.16	0.67	0.21
2011							0.24	0.07	0.15	0.11	0.97	0.16	1.24	0.19
2012							0.18	0.08	0.09	0.11	1.00	0.15	1.34	0.23
2013							0.09	0.09	0.07	0.12	0.38	0.16	1.45	0.22
2014							0.10	0.10	0.09	0.13	0.81	0.15	1.43	0.23
2015							0.17	0.10	0.06	0.17	1.03	0.16	2.55	0.22
2016							0.18	0.08	0.09	0.14	0.96	0.16	2.17	0.22
2017							0.15	0.12	0.08	0.17	1.18	0.16	1.80	0.23
2018							0.30	0.10	0.08	0.18	1.33	0.16	1.24	0.19

¡!– ** –¿

Table 7: Data filtering steps for Deb Wilson-Vandenberg's CPFV onboard observer index of abundance

tab:Fleet5_Filter

Filter	Drifts	Positive Drifts
Remove errors, missing data	6691	1470
Remove 1987 (sampled only MNT), 1990-1991 low sample sizes	4283	1372
Remove reefs that never encountered GBY	4022	1372
Remove lower and upper 2.5% of time fished	3762	1300
Remove depth less than 9 m and greater than 69 m	3515	1279
Remove reefs with low sample rates	2411	1096

Table 8: Model selection for Deb Wilson-Vandenberg's CPFV onboard observer index of abundance. Bold values indicate the model selected.

tab:Fleet5_AIC

Model	Lognormal	Binomial
Year	2834	3330
Year + Depth	2781	2906
Year + Reef	2716	2880
Year + Month	2839	3286
Year + Depth + Reef	**2625**	**2488**
Year + Month+ Reef	2725	2844
Year + Depth + Month	2780	2902
Year+ Depth+Month+Reef	2632	2479

Table 9: Data filtering steps for the CRFS CPFV onboard observer index of abundance for north and south of Pt. Conception.

tab:Fleet6_7_Filter

Filter	Drifts	Positive Drifts
Data from SQL filtered for missing data	67850	9317
Remove years prior to 2001 and north of Cape Mendocino	64448	9129
Depth, remove 1% data on each tail of positive catches	50846	8955
Time fished, remove 1% data on each tail	50100	8903
Observed anglers, remove 1% data on each tail	48089	8774
Limit to reefs observering gopher/byel in at least 20 drifts	29639	8025
Limite to reefs sampled in at least 2/3 of all years	32672	7517
Limite to drifs within 1000 m of a reef	27355	7358
Put depth in 10m depth bins, remove 0-9 and 60-69 m bins	25427	7250
Start of north filtering	13792	6036
Filter to drifts within 43 m of a reef, 97% quantile	13145	5854
Make sure reefs still sampled at least 2/3 of years	12965	5796
Start of south filtering	11635	1277
Filter to drifts with >=20% groundfish and recheck reefs	5495	1171
Make sure reefs still sampled at least 2/3 of years	5440	1132

Table 10: Model selection for the CRFS CPFV onboard observer index of abundance for north of Pt. Conception. Bold values indicate the model selected.

tab:Fleet6_AIC

Model	Lognormal	Binomial
Year	14135	17531
Year + Month	14120	17529
Year + Depth	13953	17025
Year + Reef	14126	17293
Year + Month + Depth	13951	17027
Year + Month + Depth + Reef	**13921**	**16674**

Table 11: Model selection for the CRFS CPFV onboard observer index of abundance for south of Pt. Conception. Bold values indicate the model selected.

tab:Fleet7_AIC

Model	Lognormal	Binomial
Year	2798	5490
Year + Month	2799	5487
Year + Depth	2744	5159
Year + Reef	2653	5390
Year + Depth + Reef	**2652**	**5071**
Year + Depth + Reef + Month	2663	5072

Table 12: Data filtering steps for the PISCO dive survey.

tab:Fleet8_Filter

Filter	Transects	Positive Transects
Remove missing data and retain only bottom transects	22,055	6,330
Remove month of June - few samples	21,941	6,318
Remove dives earlier than 2004 for UCSB and 2001 for UCSC	20,659	6,165
Keep sites sampled in at least half of all years (UCSC and UCSB separate)	14,721	4,097
Keep sites observing GBYR in at least half of all years	12,139	4,002
Remove transects denoted as old, no longer sampled	10,712	3,268
Subset to just UCSC sites	5,686	2,939
Use only consistently sampled sites	3,231	1,729

Table 13: Model selection for the PISCO dive survey data.

tab:Fleet8_AIC

Model	AIC
Year	5,687
Year + Month	5,672
Year + Month + Site	5,623
Year + Month + Site + Zone	**5,512**

Table 14: Data filtering steps for the fishery-independent CCFRP hook-and-line survey.

tab:Fleet9_Filter

Filter	Drifts	Positive Drifts
All data	5,886	Drift and catch data not merged
Remove missing data and cells not sampled consistently at Piedras Blancas	4,942	3,857
Remove cells that never encountered GBYR	4,934	3,857
Remove depth bins with little or no sampling (keep 5-39 m)	4,920	3,848

Table 15: Model selection for the fishery-independent CCFRP hook-and-line survey.

tab:Fleet9_AIC

Model	AIC
Year	23,212
Year + Month	23,214
Year + Depth	22,901
Year + Depth + Site	22,642
Year + Depth + Site + MPA/REF	**22,341**

Table 16: Data filtering steps for the MRFSS dockside intercept survey index of abundance for north and south of Pt. Conception.

tab:Fleet10_11_Filter

Filter	Trips	Positive Trips
All data	10,392	1,061
Remove north of Cape Mendocino	10,327	1,061
Remove trips targetting offshore species	10,122	1,061
Start northern filtering	2,788	620
Remove species that never co-occurand not present in at least 1% of all	2,788	620
Stephens-MacCall filter (keep all positives)	806	620
Stephens-MacCall filter (keep only above threshold)	623	437
Start southern filtering	7,334	441
Remove species that never co-occurand not present in at least 1% of all	7,334	441
Stephens-MacCall filter (keep all positives)	687	441
Stephens-MacCall filter (keep only above threshold)	430	184

Table 17: Model selection for the MRFSS dockside intercept survey north of Pt. Conception. Bold values indicate the model selected.

tab:Fleet10_AIC

Model	AIC
Year	1,481
Year + Region	1,429
Year + Region + Area_X	1,403
Year + Region + Area_X + Wave	1,397

Table 18: Model selection for the MRFSS dockside intercept survey south of Pt. Conception. Bold values indicate the model selected.

tab:Fleet11_AIC

Model	Lognormal	Binomial
Year	911	552
Year+ Wave	908	538
Year + Wave + Area_X	905	540
Year + Wave + Area_X + SubRegion	**903**	**537**
Year + Wave + SubRegion	908	536

Table 19: Summary of age data used in the assessment.

tab:Age_data

Project	Source	Years	Region	Gear	Black.and.yellow	Gopher
Port sampling	Commercial	2009-2010; 2018	Bodega; Morro Bay	hook-and-line	0	46
CDFW sampling	Recreational	1978; 1980; 1982-1986	Morro Bay; San Francisco	hook-and-line	0	138
Cal Poly onboard observer	Recreational	2018	Morro Bay	hook-and-line	0	36
E.J.'s trap survey	Research	2012	Monterey	trap	1	25
Zaitlin thesis	Research	1983-1986	Monterey	spear	491	0
Pearson groundfish cruise	Research	2002-2005	Monterey	hook-and-line	0	118
Hanan CPFV survey	Research	2003-2004	Morro Bay; Santa Barbara	hook-and-line	0	189
Juv. rockfish cruise special study	Research	2004-2005	Monterey	hook-and-line	0	79
CCFRP	Research	2007-2013	Central CA	hook-and-line	7	1,191
CCFRP trap	Research	2008-2009	Central CA	trap	0	87
Abrams thesis	Research	2010-2011	Fort Bragg	hook-and-line	0	59
Total					**499**	**1,968**

Table 20: Results from 100 jitters from the base case model.

tab:jitter

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

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

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

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

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

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

tab:model_params

Table 22: Likelihood components from the base model.

tab:like_components

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 23: 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

Continues next page

Table 23: Time-series of population estimates from the base-case model. Relative exploitation rate is $(1 - SPR)/(1 - SPR_{50\%})$. tab:Timeseries_mo

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

Continues next page

Table 23: Time-series of population estimates from the base-case model. Relative exploitation rate is $(1 - SPR)/(1 - SPR_{50\%})$. tab:Timeseries_mo

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

`tab:Sensitivity_model1`

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

tab:Index_summary

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 26: 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.

tab:retro

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 27: 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.

tab:like_profiles

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 28: 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.

tab:like_profiles

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

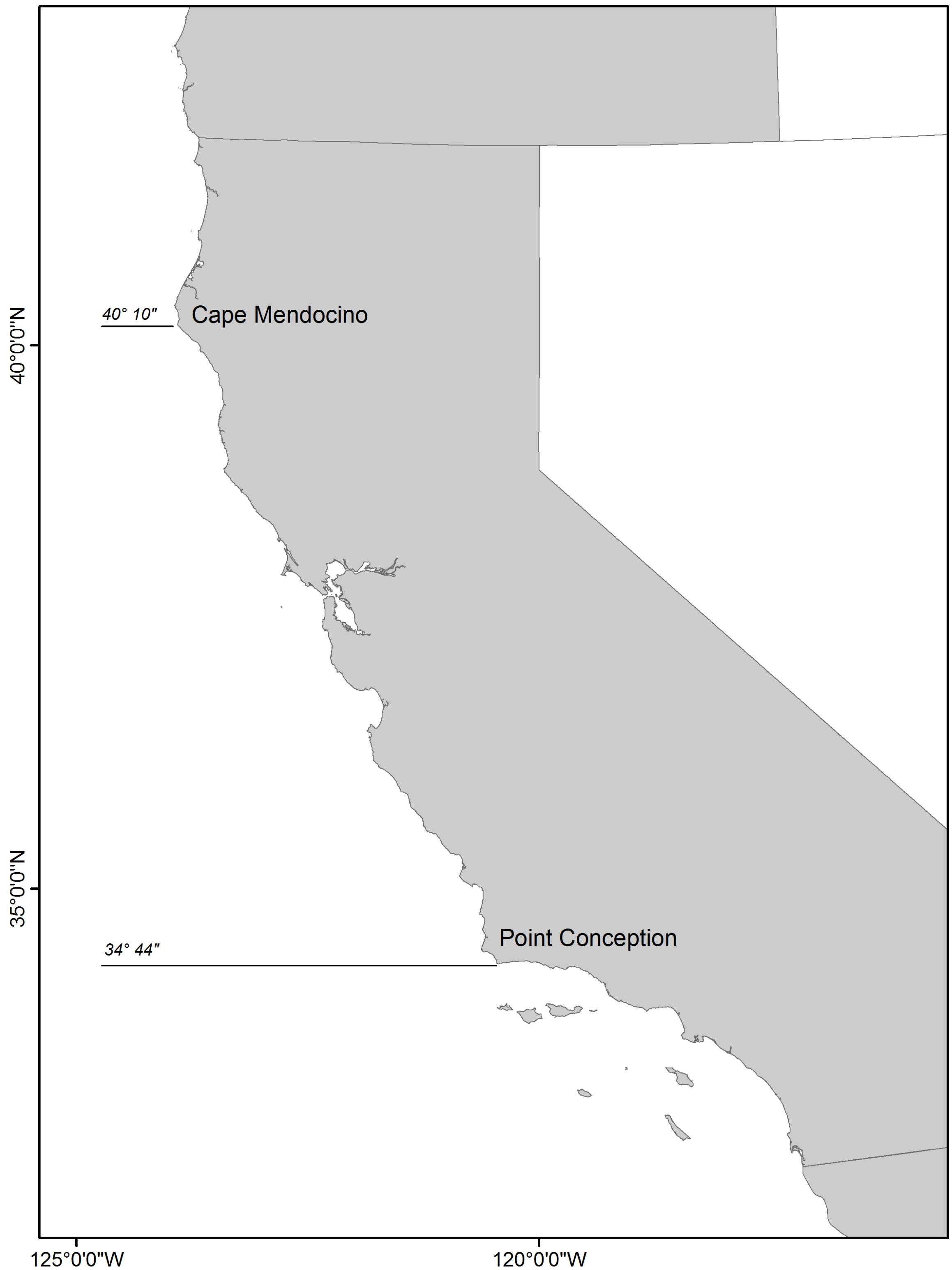
Table 29: Projection of potential OFL, spawning biomass, and depletion for the base case model.

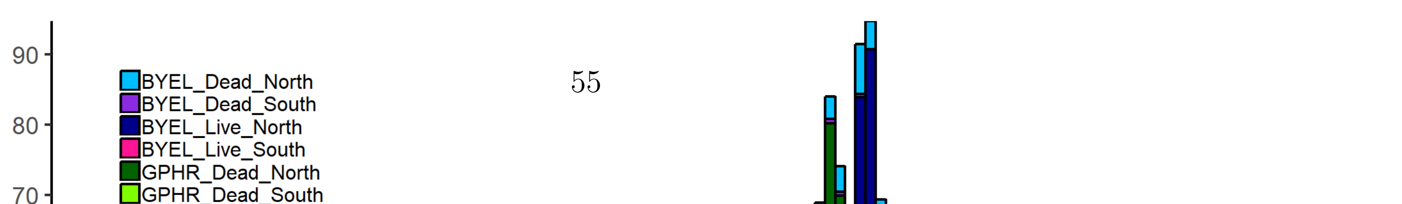
tab:Forecast_mod1

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

figures





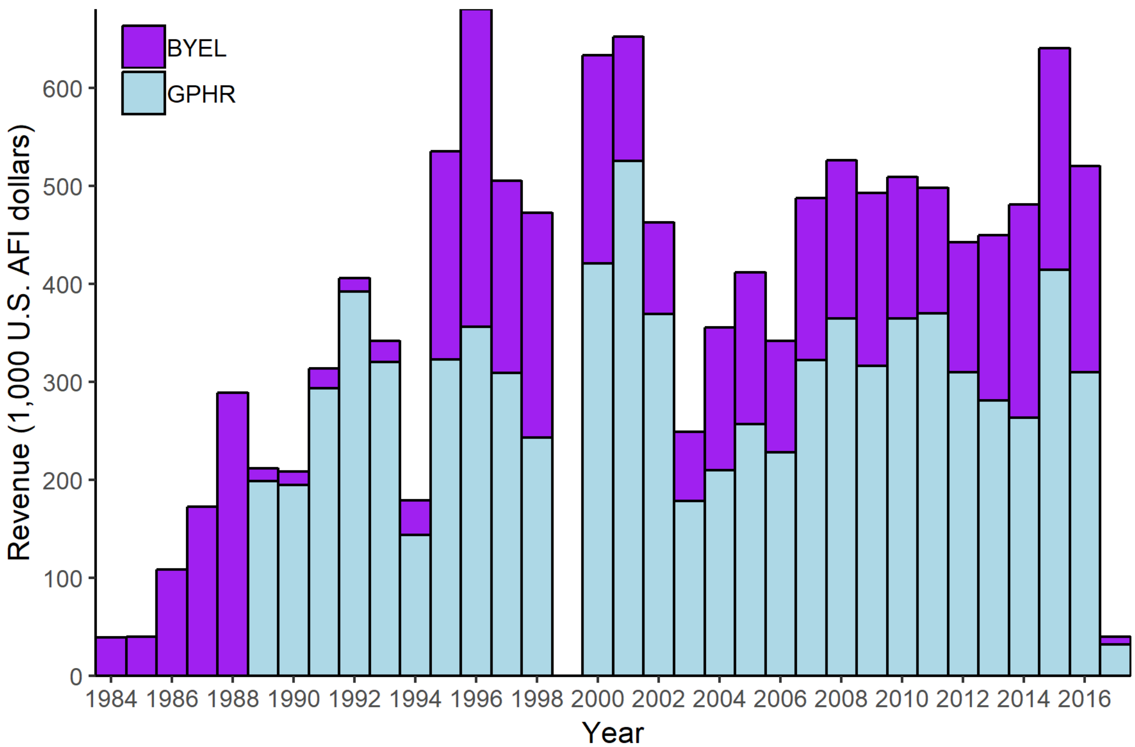


Figure 1: Annual ex-vessel revenue, adjusted for inflation (AFI) in thousands of dollars for gopher and black-and-yellow rockfish. fig:GBY_revenue

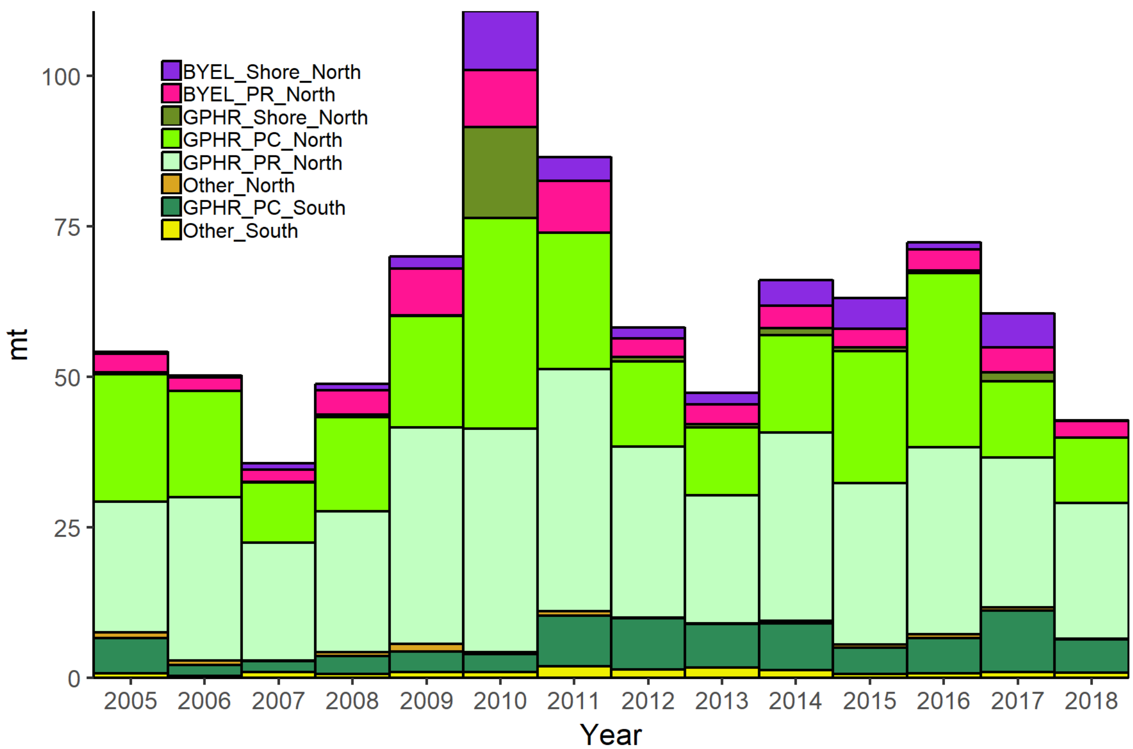


Figure 2: Recreational total mortality for gopher rockfish (GPHR) and black-and-yellow (BYEL) rockfish from the CDFW CRFS sampling era by mode and split north and south of Pt. Conception. fig:CFRS_catches

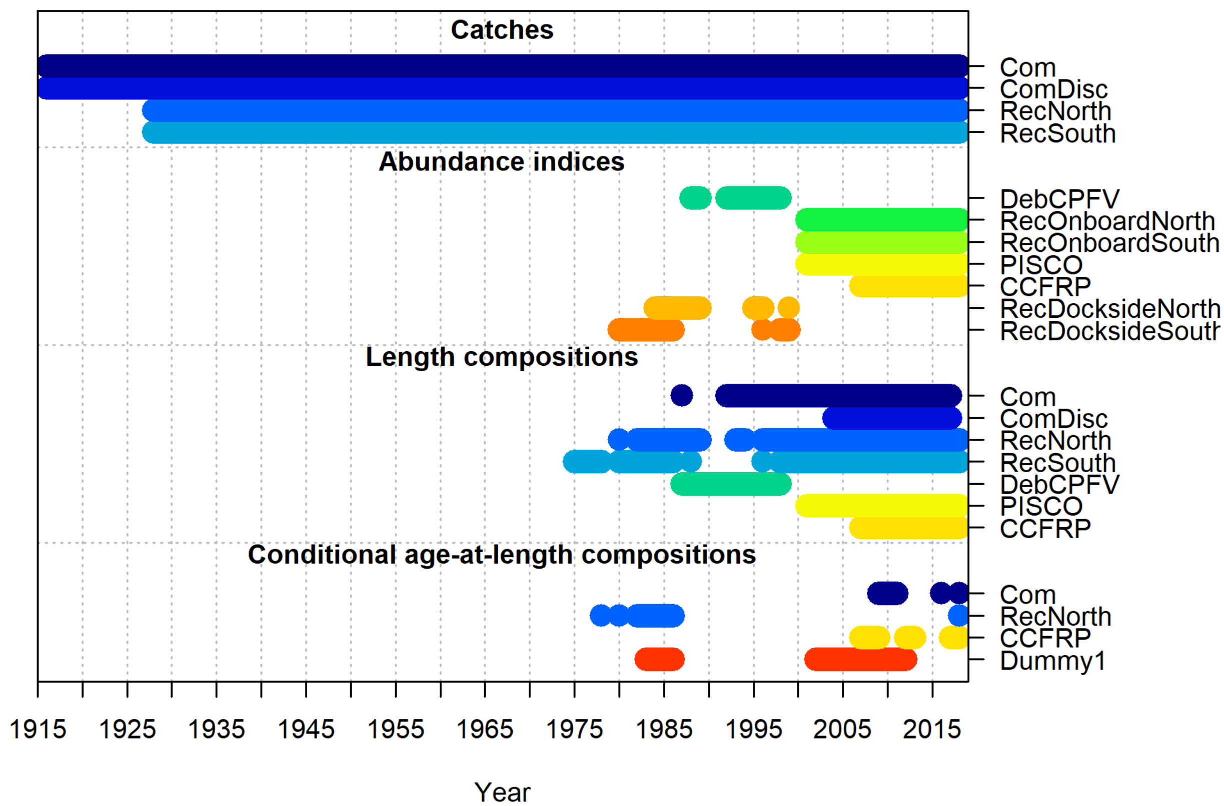


Figure 3: Summary of data sources used in the model. fig:data_plot

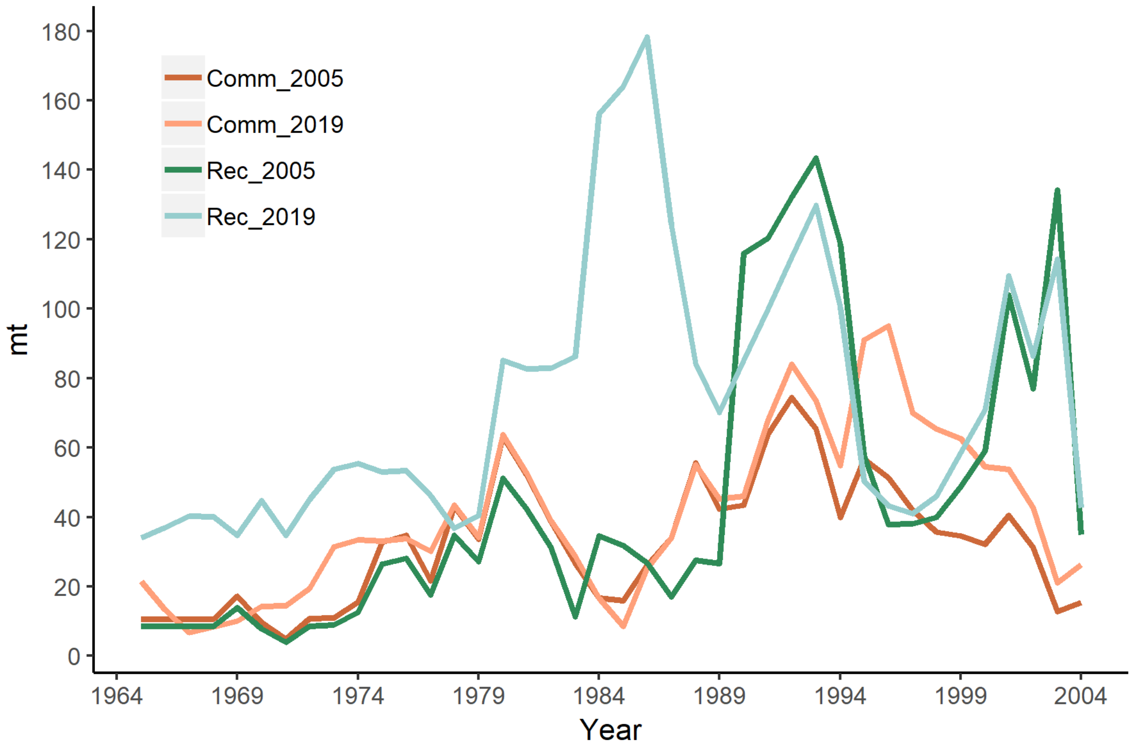


Figure 4: Comparison of the recreational and commercial fishery landings from the 2005 assessment to this 2019 assessment. Note that the 2019 assessment includes both gopher and black-and-yellow rockfish where the 2005 assessment represents gopher rockfish only. The 2005 assessment also did not include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

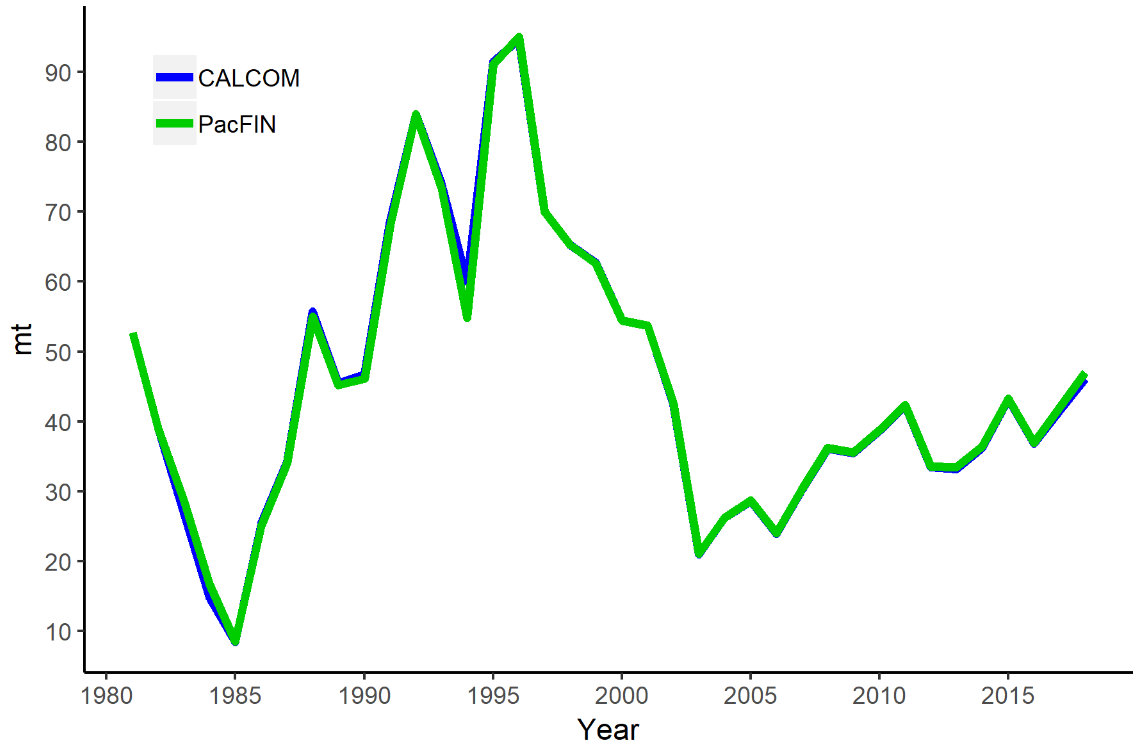


Figure 5: Commercial landings estimates from CALCOM add PacFIN. fig:Calcom_vs_Pacfin

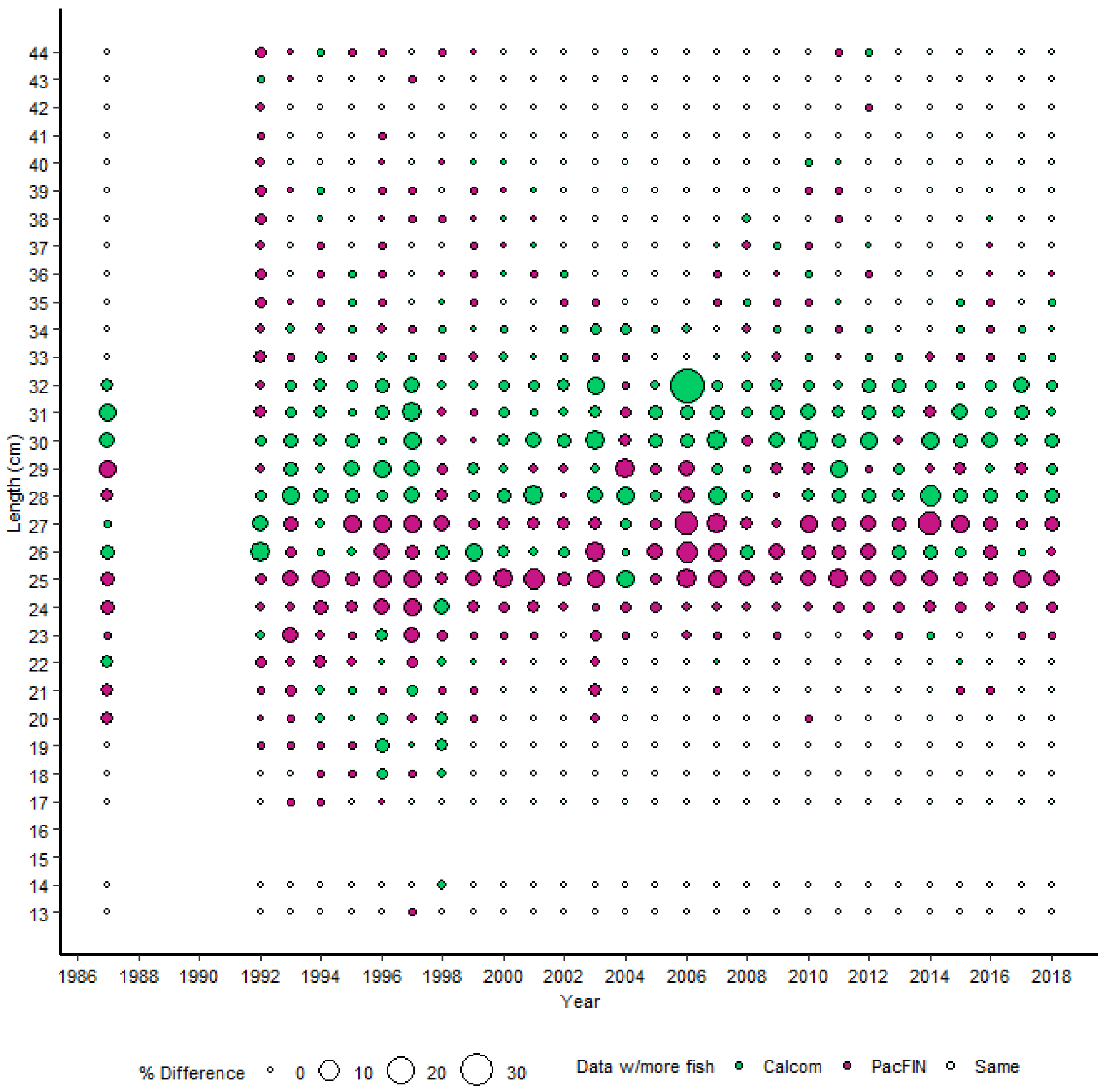


Figure 6: Percent differences in the expanded length compositions by year from CALCOM and PacFIN. The same market categories were used for each dataset, but each database was subject to further independent filtering criteria and expansion algorithms. fig:Calcom_vs_pacfin_length

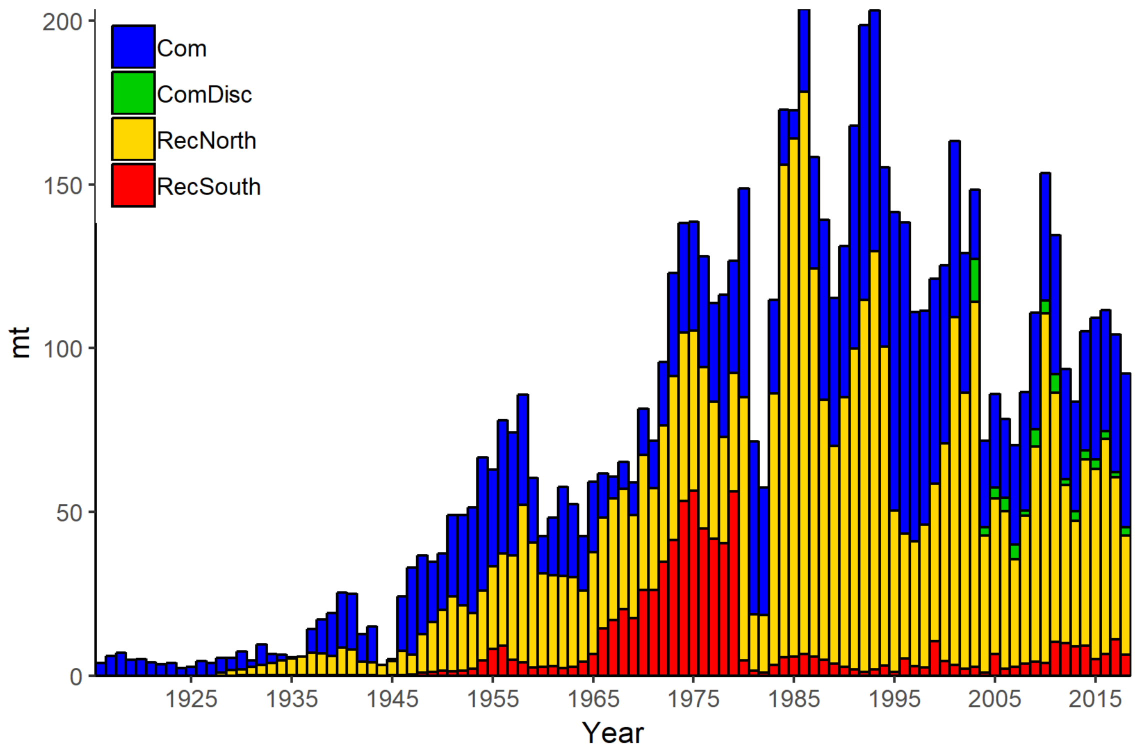


Figure 7: Commercial and recreational landings estimates prior to any data modification or interpolation to the recreational catches or hindcasting of commercial discards. fig:Catches_original

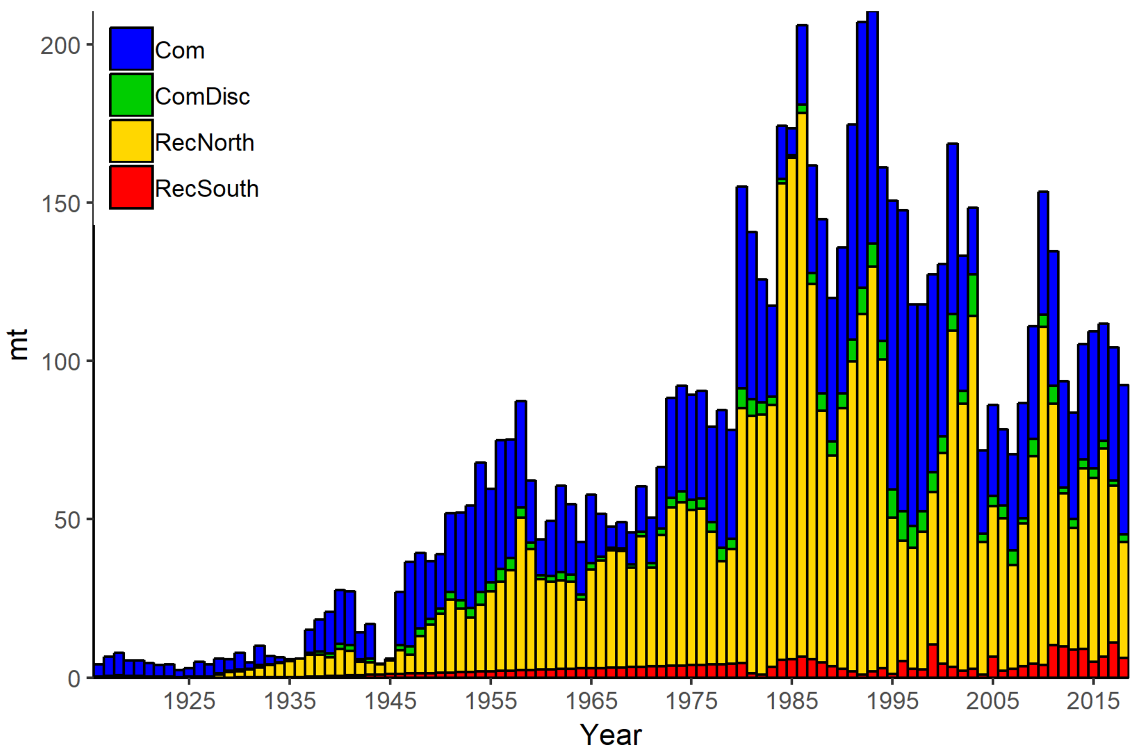


Figure 8: Commercial and recreational landings estimates after data modification and interpolations were made to the recreational catches and commercial discards. fig:Catches_alternate

¡!– ** –¿

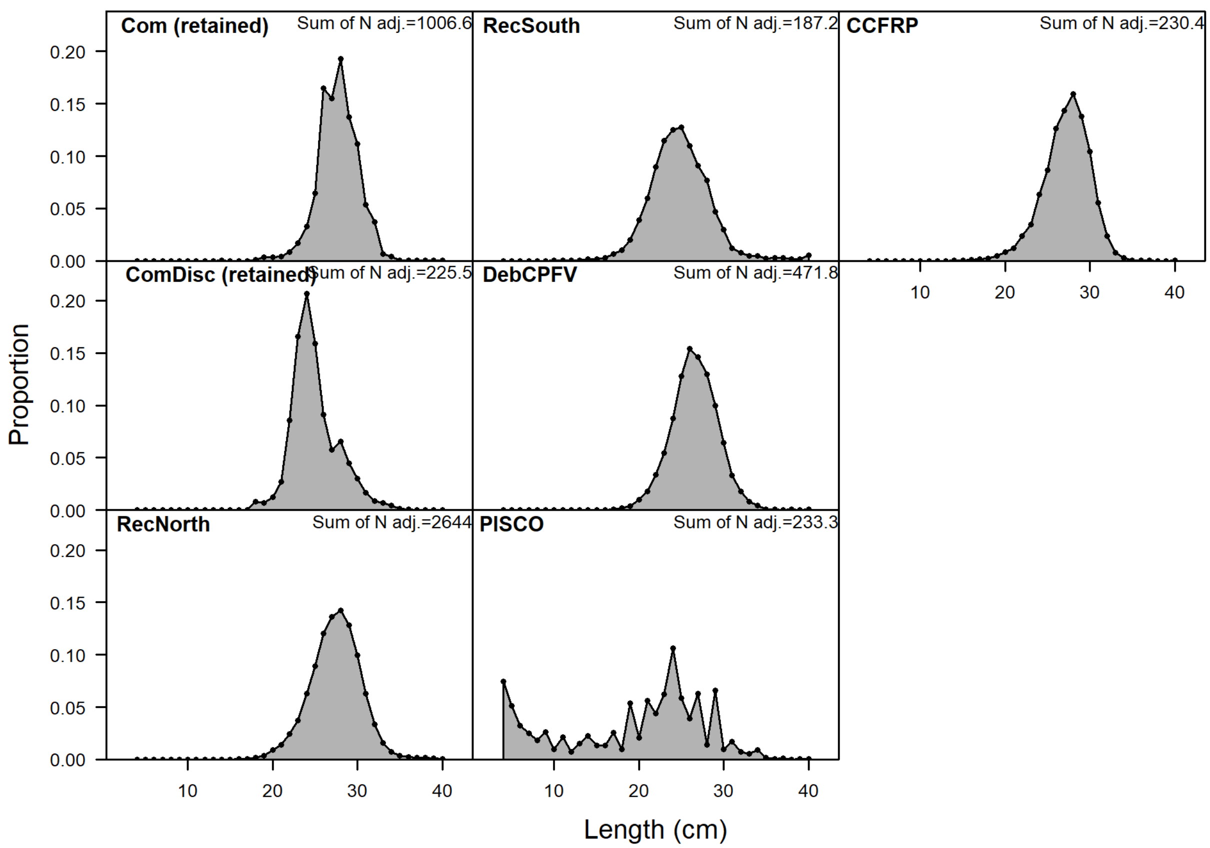


Figure 9: Length comp data, aggregated across time by fleet. Labels 'retained' and 'discard' indicate discarded or retained sampled for each fleet. Panels without this designation represent the whole catch. fig:comp_lendat_aggregated_across_time

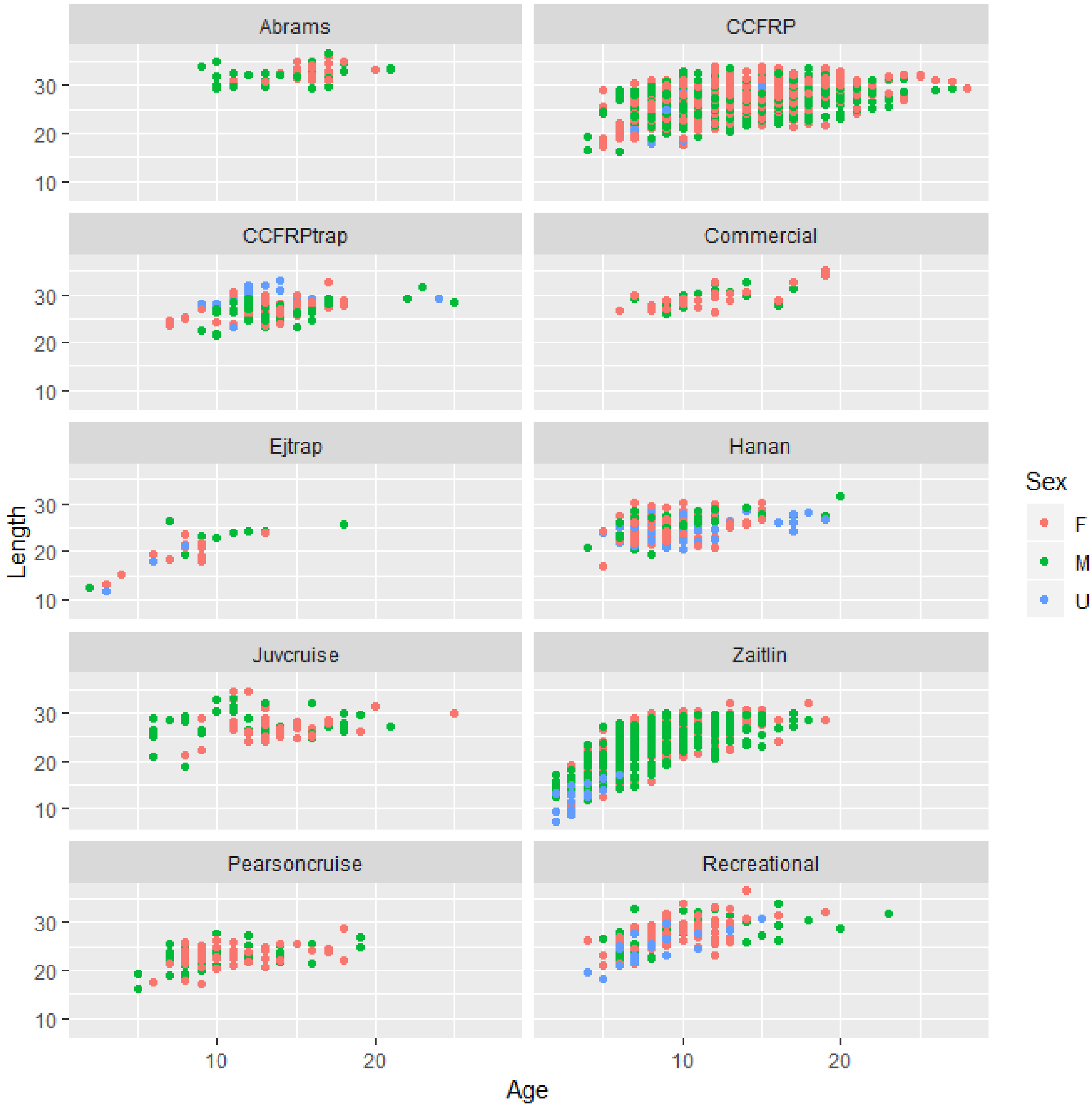


Figure 10: Available length-at-age data for gopher and black-and-yellow rockfish by sex and data source. The Zaitlin study is all black-and-yellow rockfish. The remaining plots represent gopher rockfish [fig:growth_samples]

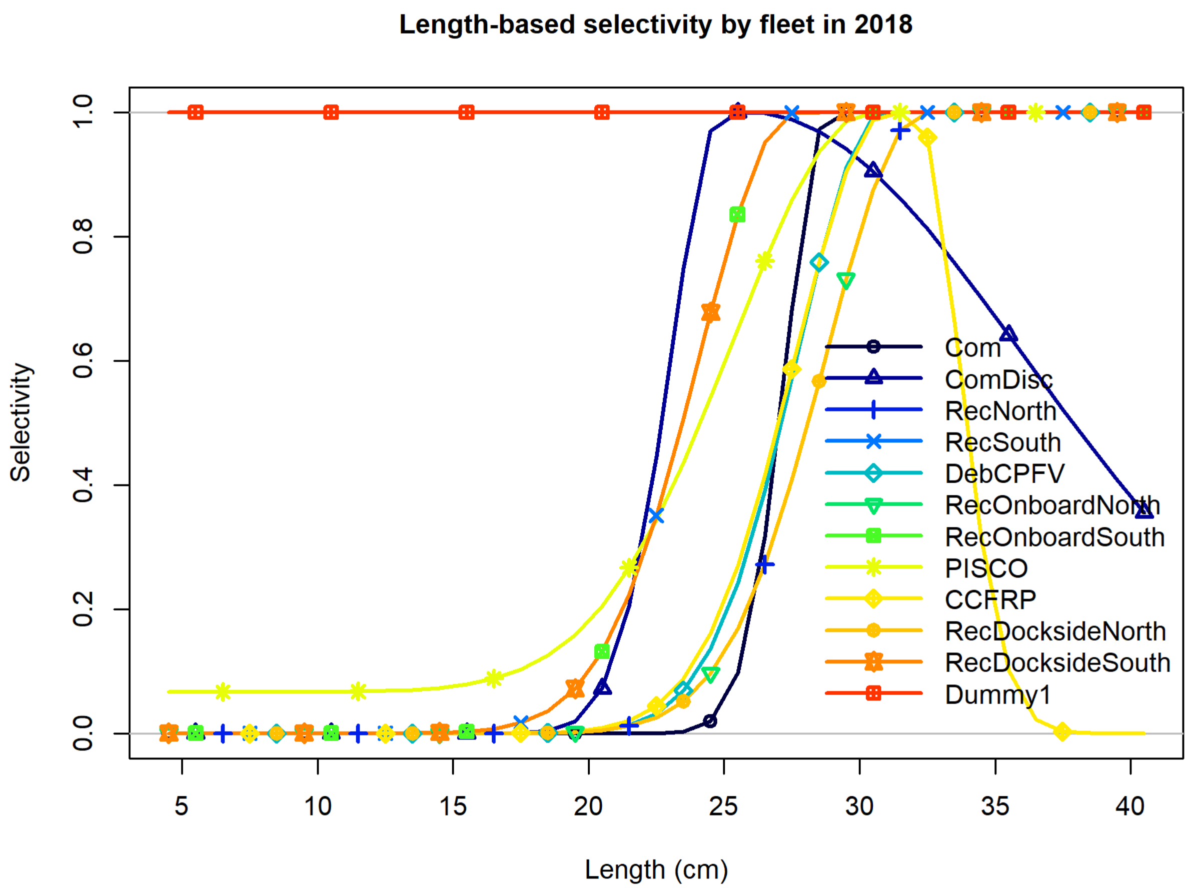


Figure 11: Selectivity at length for all of the fleets in the base model. fig:sel01_multiple_fle

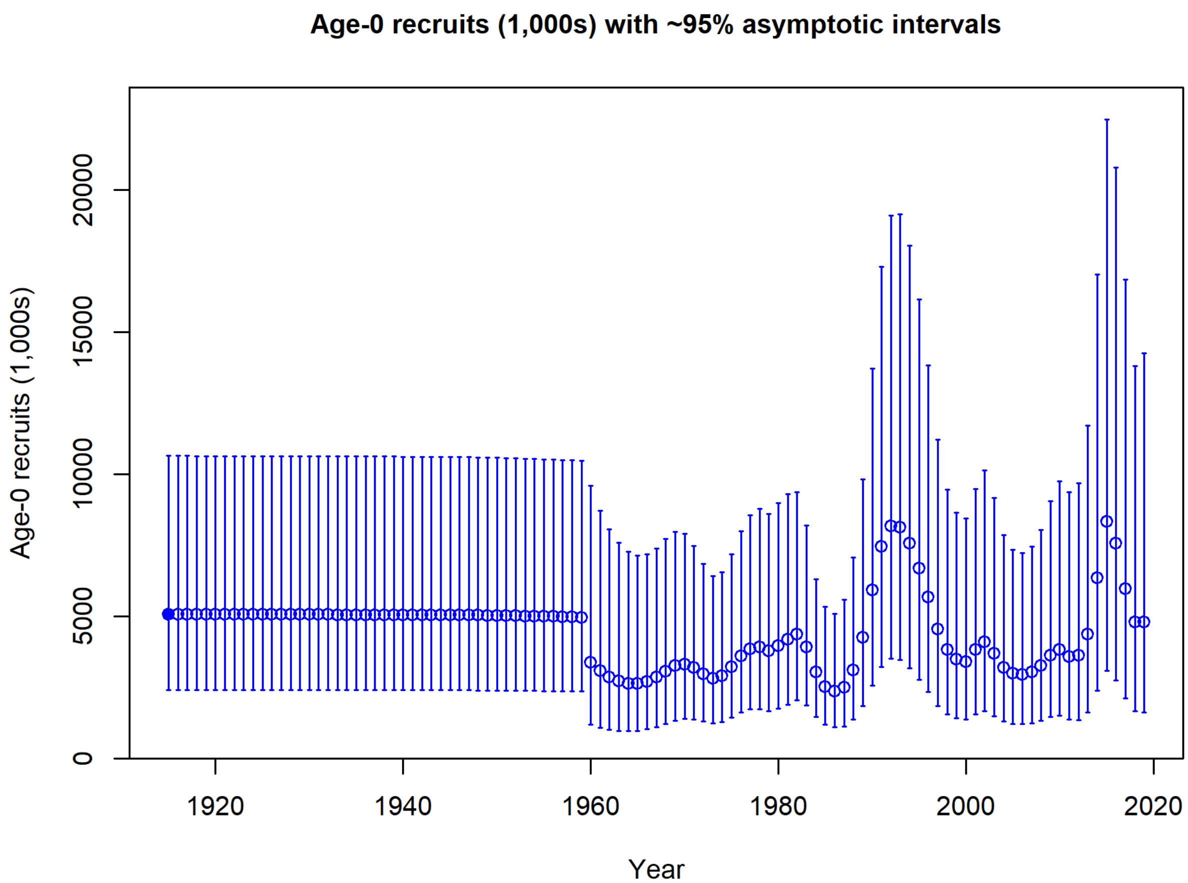


Figure 12: Time series of estimated GBYR recruitments for the base-case model with 95% confidence or credibility intervals. fig:Recruit_mod1

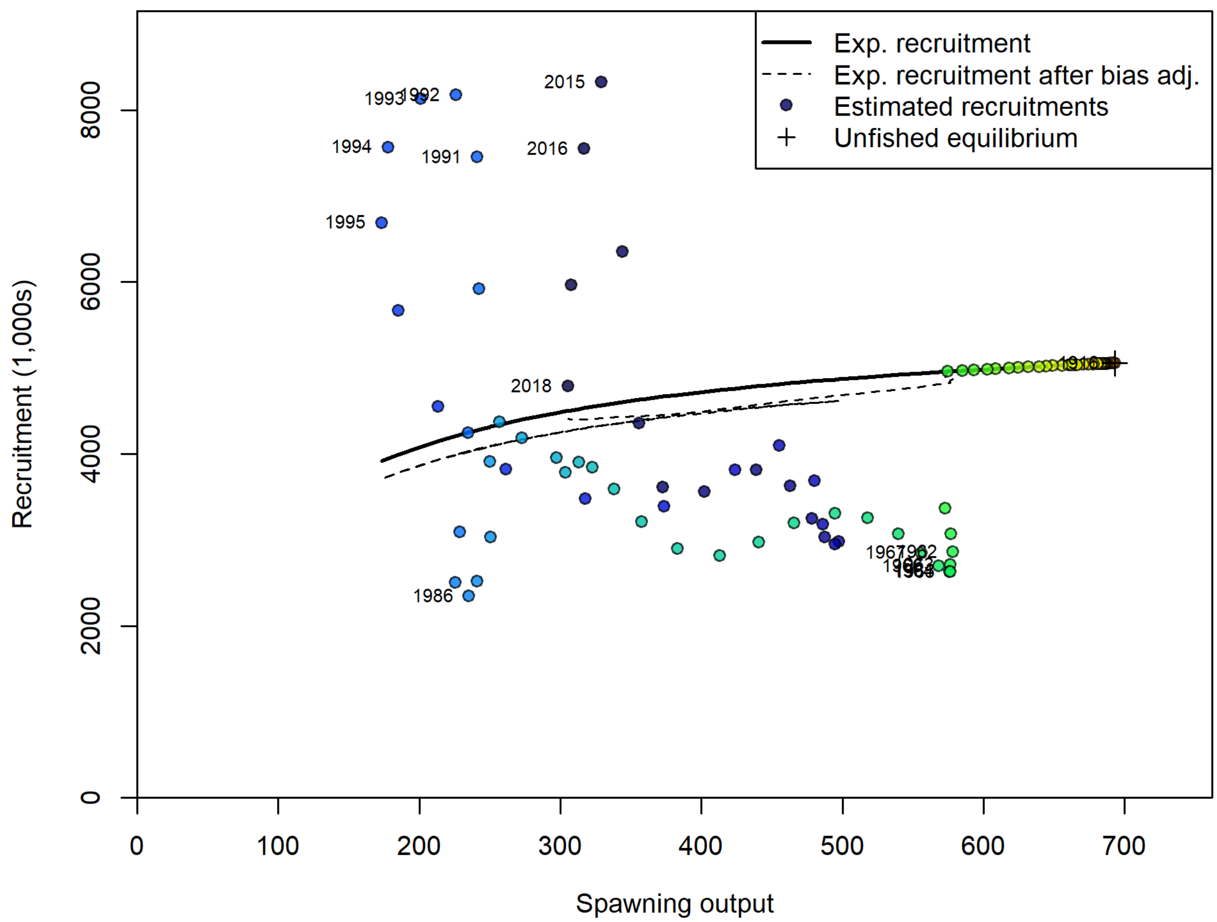


Figure 13: Estimated recruitment (red circles) and the assumed stock-recruit relationship (black line) for GBYR. The green line shows the effect of the bias correction for the lognormal distribution. fig:SR_curve2

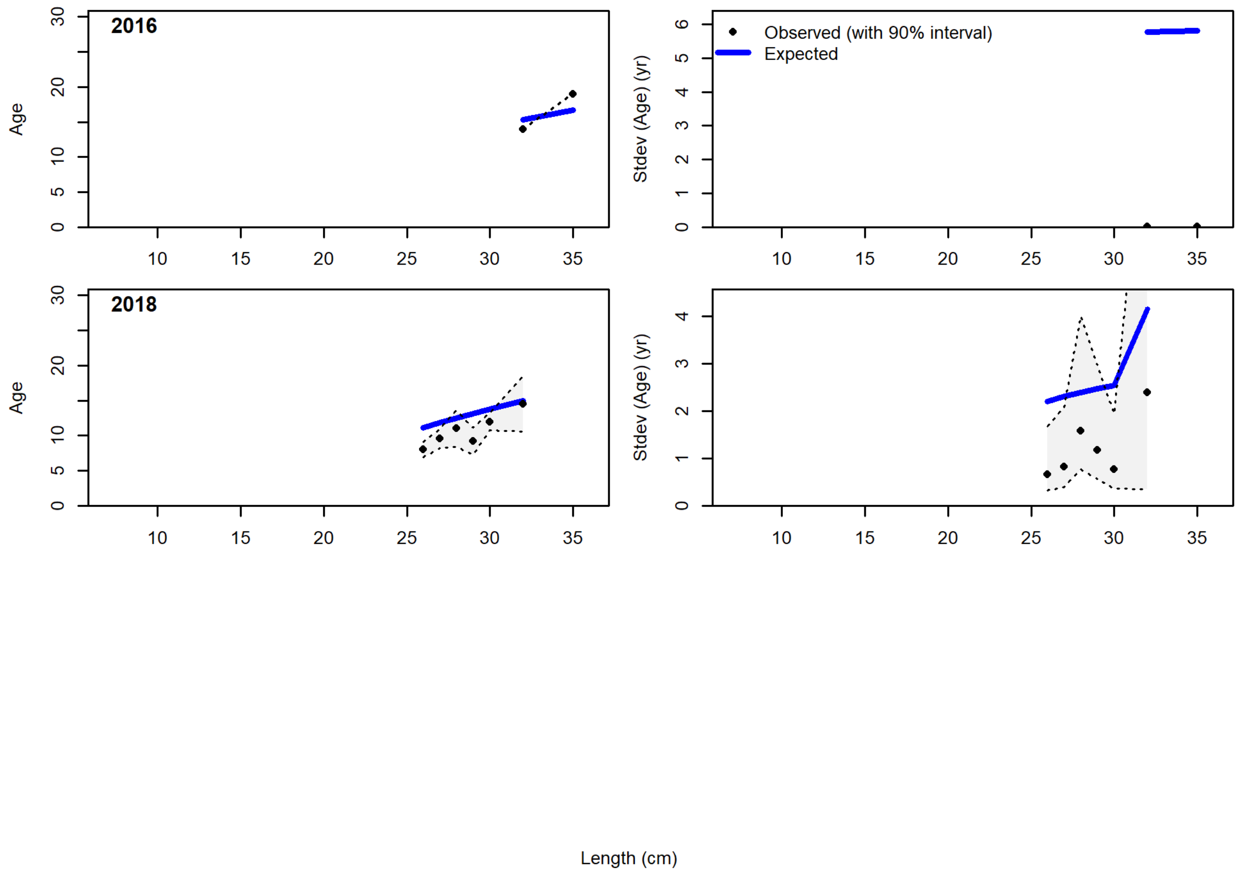


Figure continued from previous page

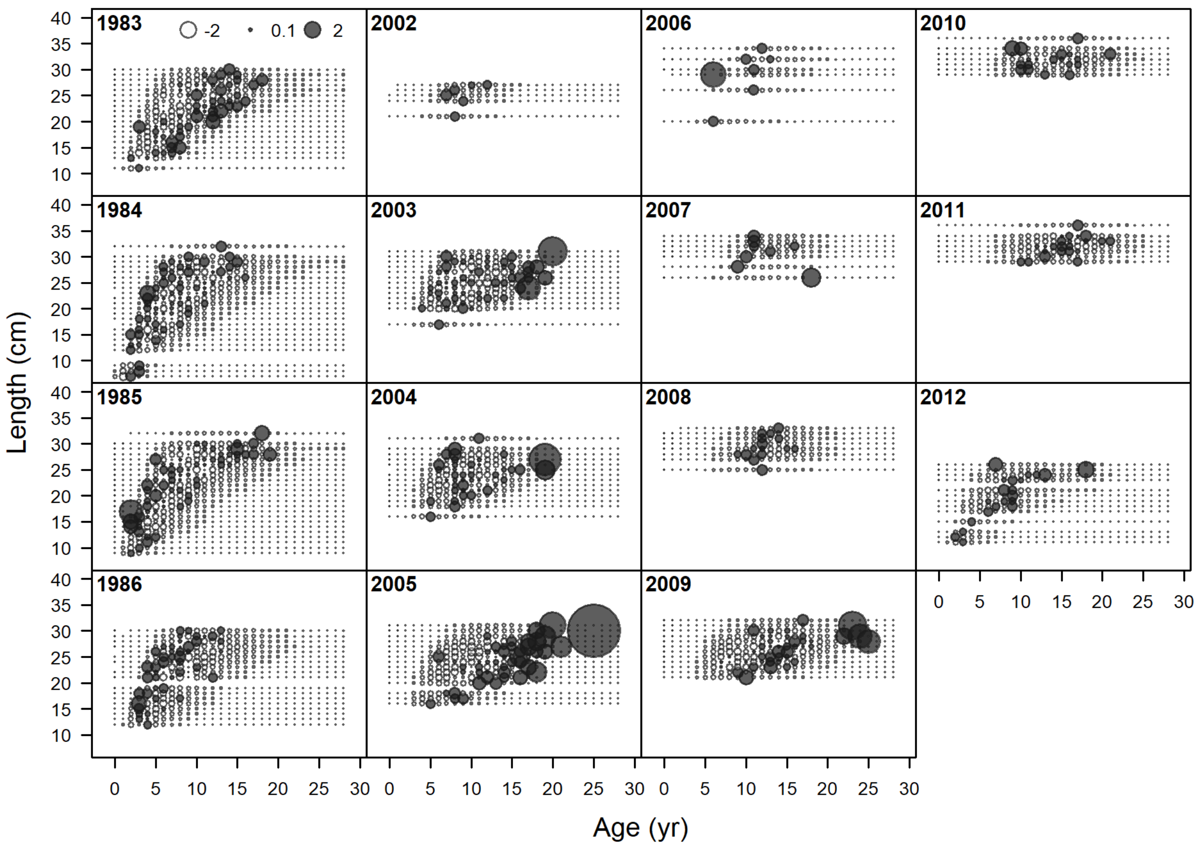


Figure 14: Pearson residuals, whole catch, Dummy1 (max=20.61) fig:mod1_4_comp_condAALf

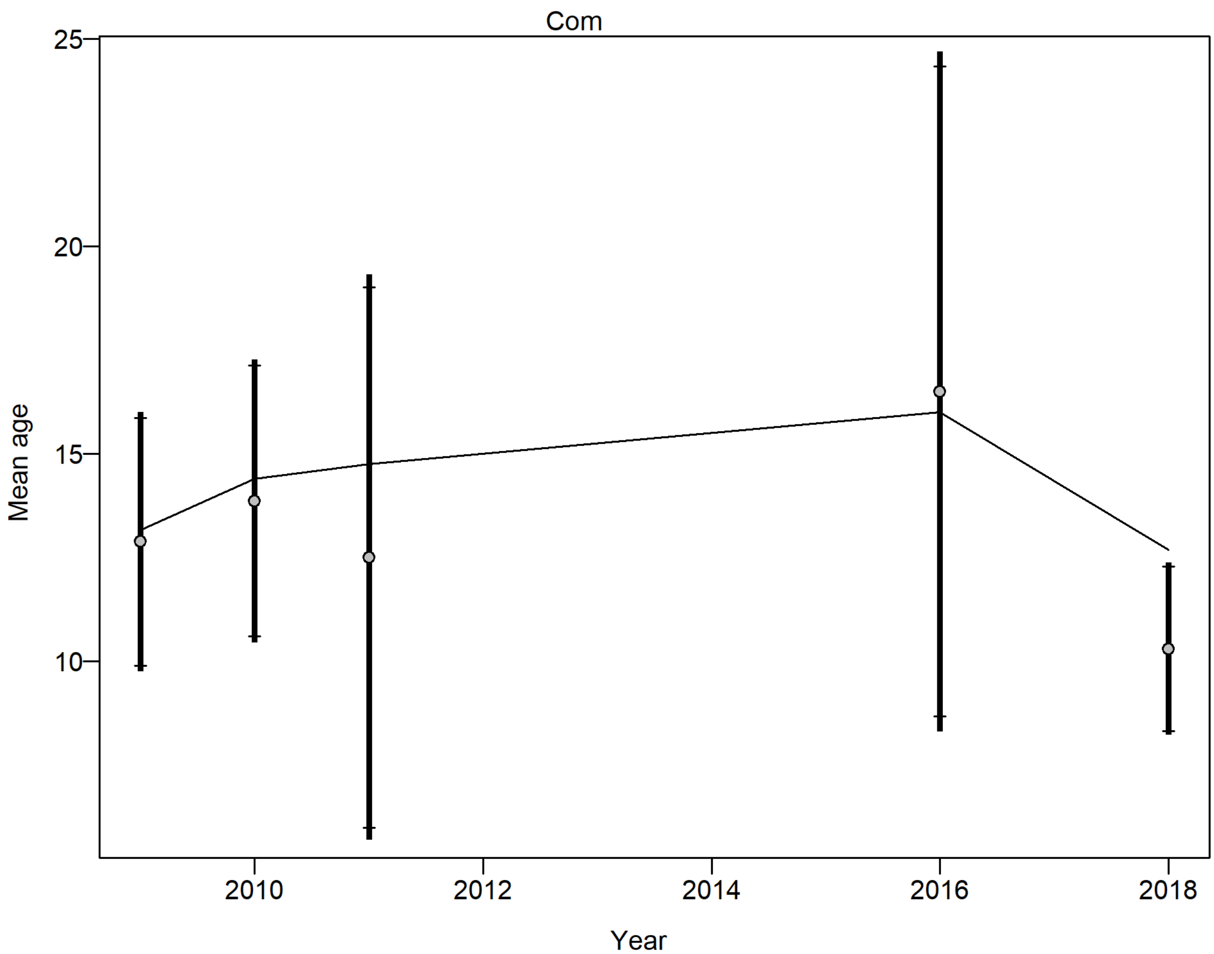


Figure 15: Mean age from conditional data (aggregated across length bins) for Com with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% 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. fig:mod1_5_com

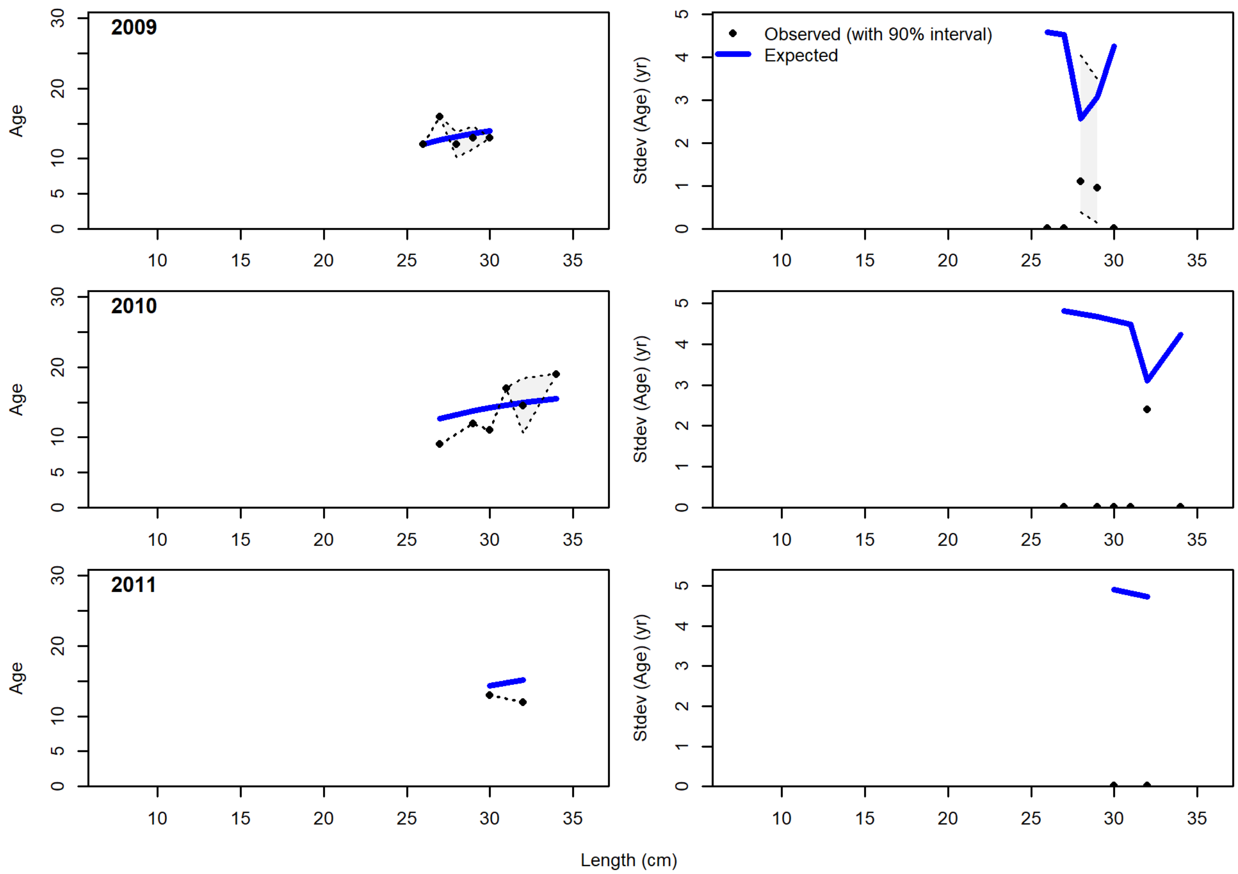


Figure 16: Conditional AAL plot, whole catch, Com (plot 1 of 2) These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.) with 90% CIs based on the chi_square distribution. fig:mod1_6_comp_conc

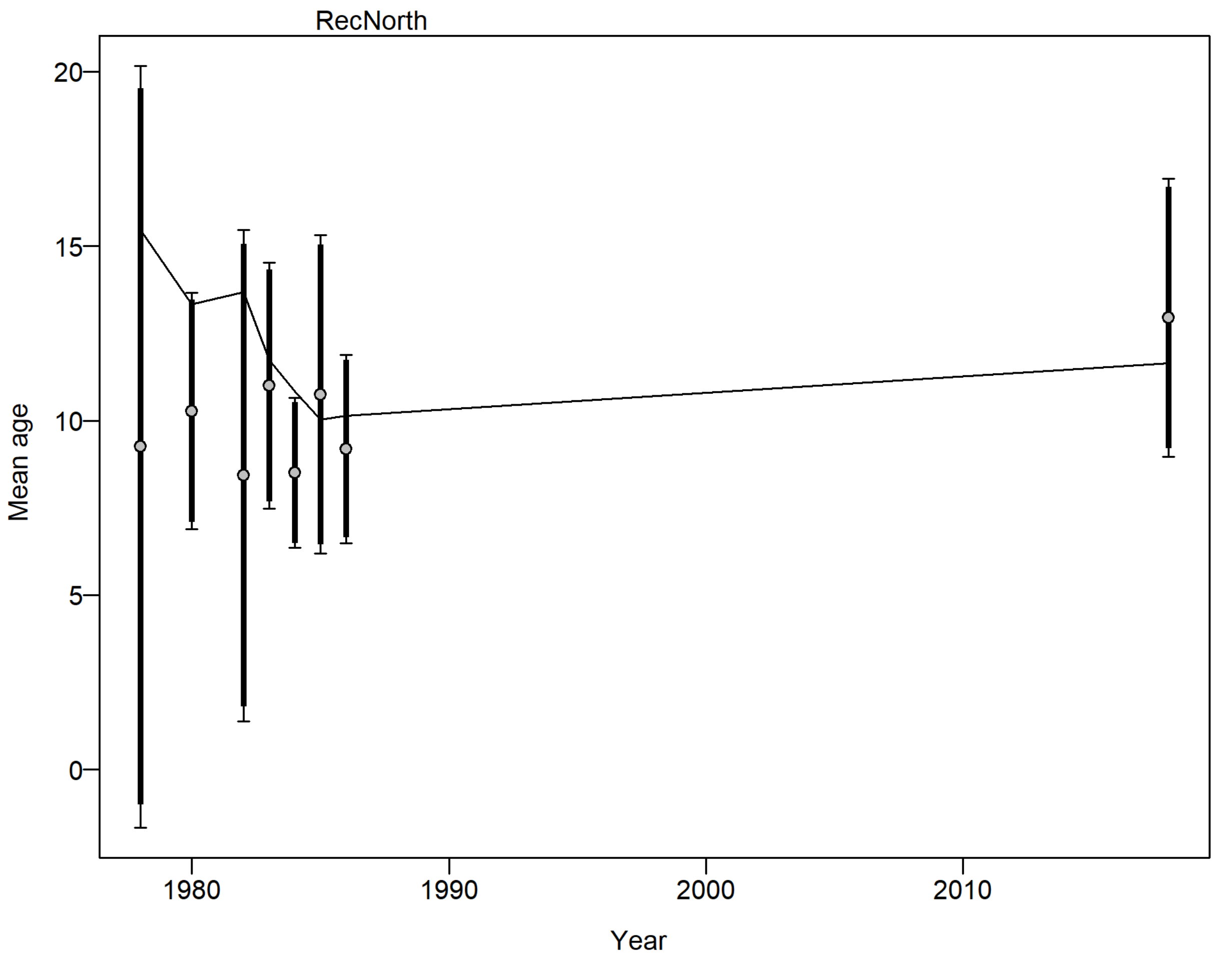


Figure 17: Mean age from conditional data (aggregated across length bins) for RecNorth with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 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. fig:mod1_8_comp_condAALfit_data_weighting_TA1.8_condAgeRecNorth

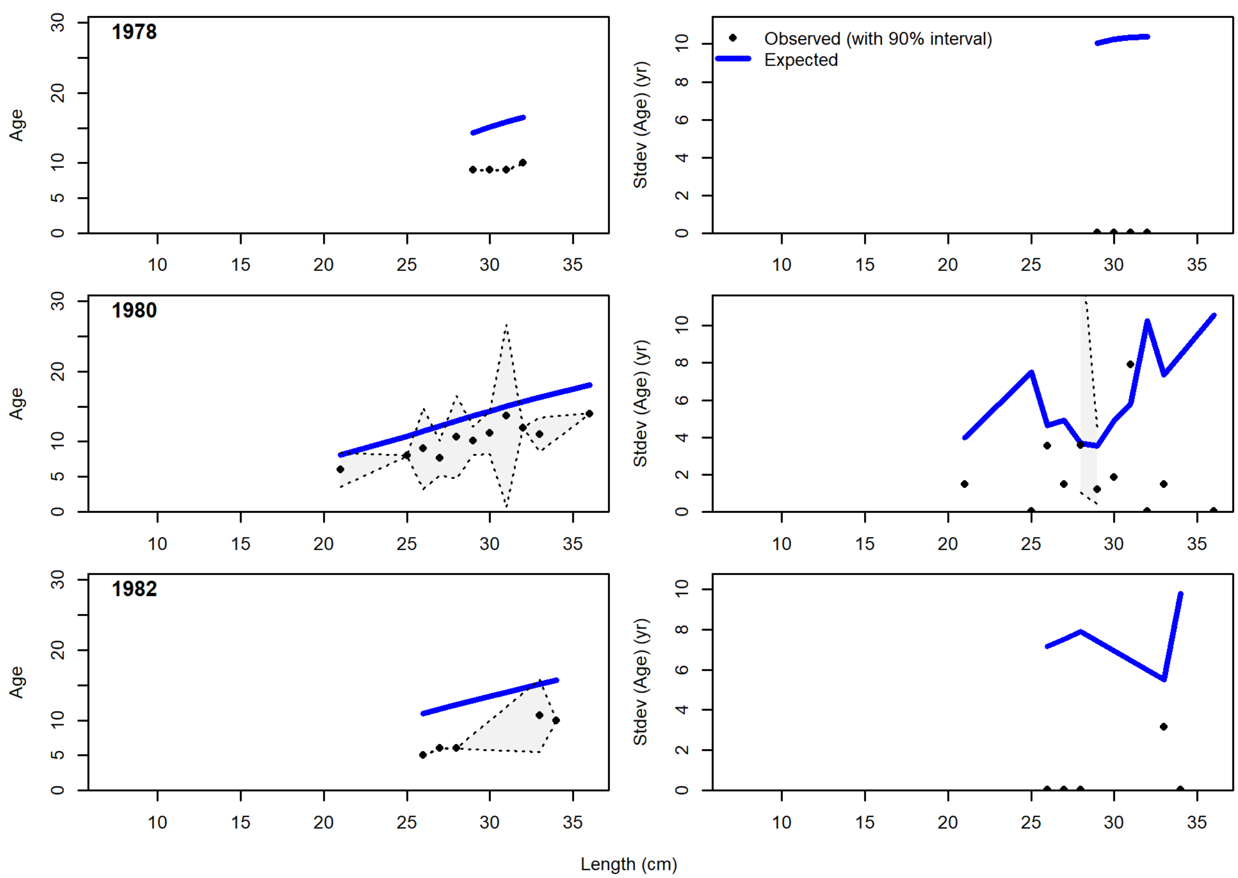


Figure 18: Conditional AAL plot, whole catch, RecNorth (plot 1 of 3) These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.) with 90% CIs based on the chi_square distribution. fig:mod1_9_comp_condAALfit_Andre_plotsflt3mkt0_page1

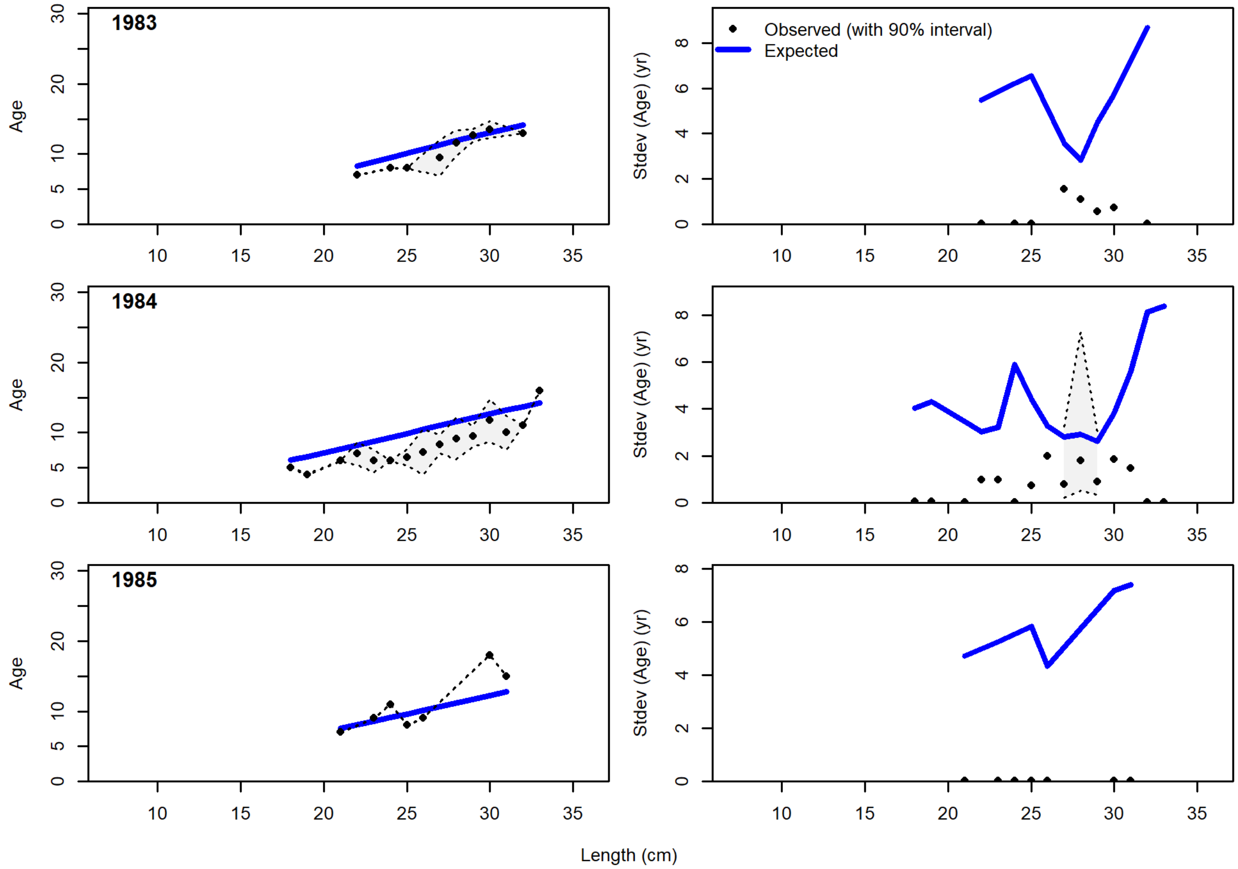
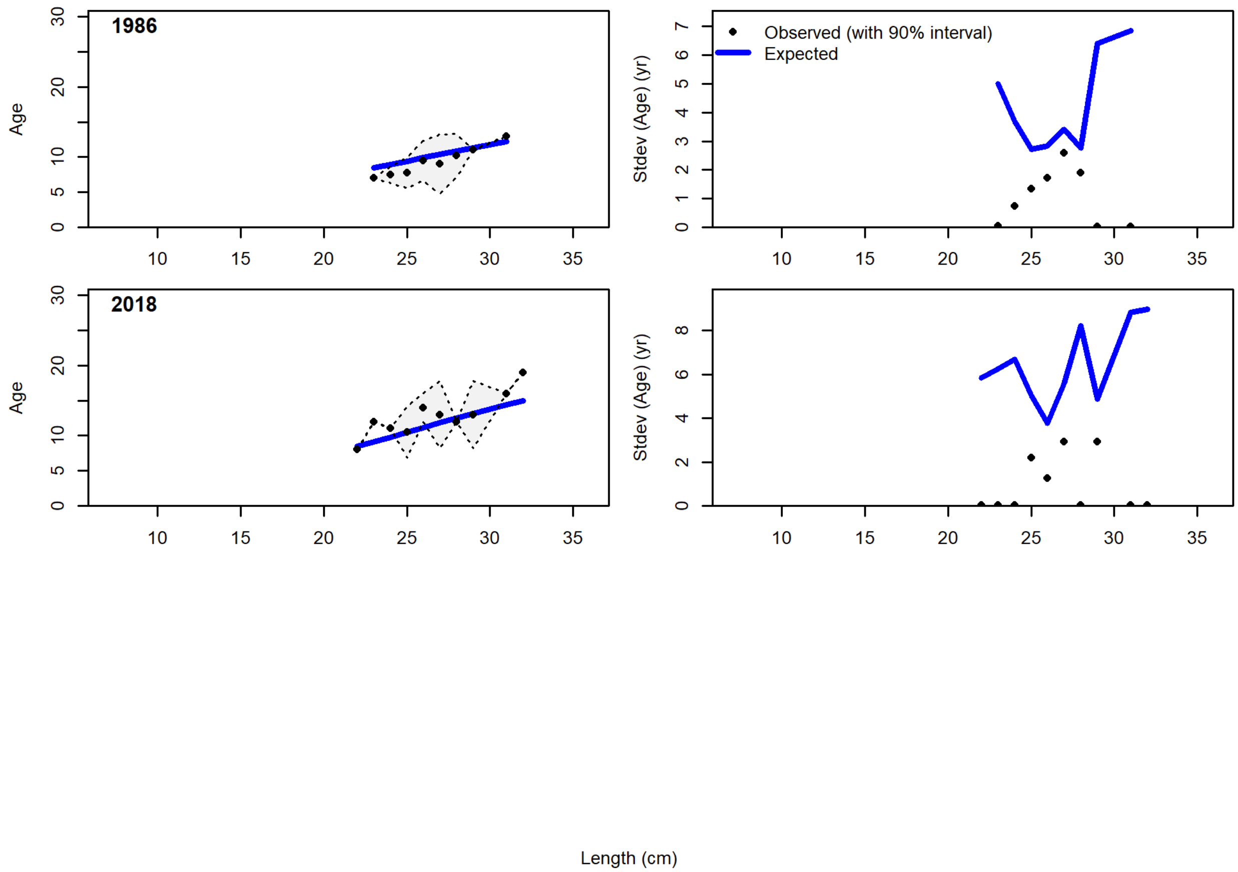


Figure continued from previous page



846

847 Figure continued from previous page

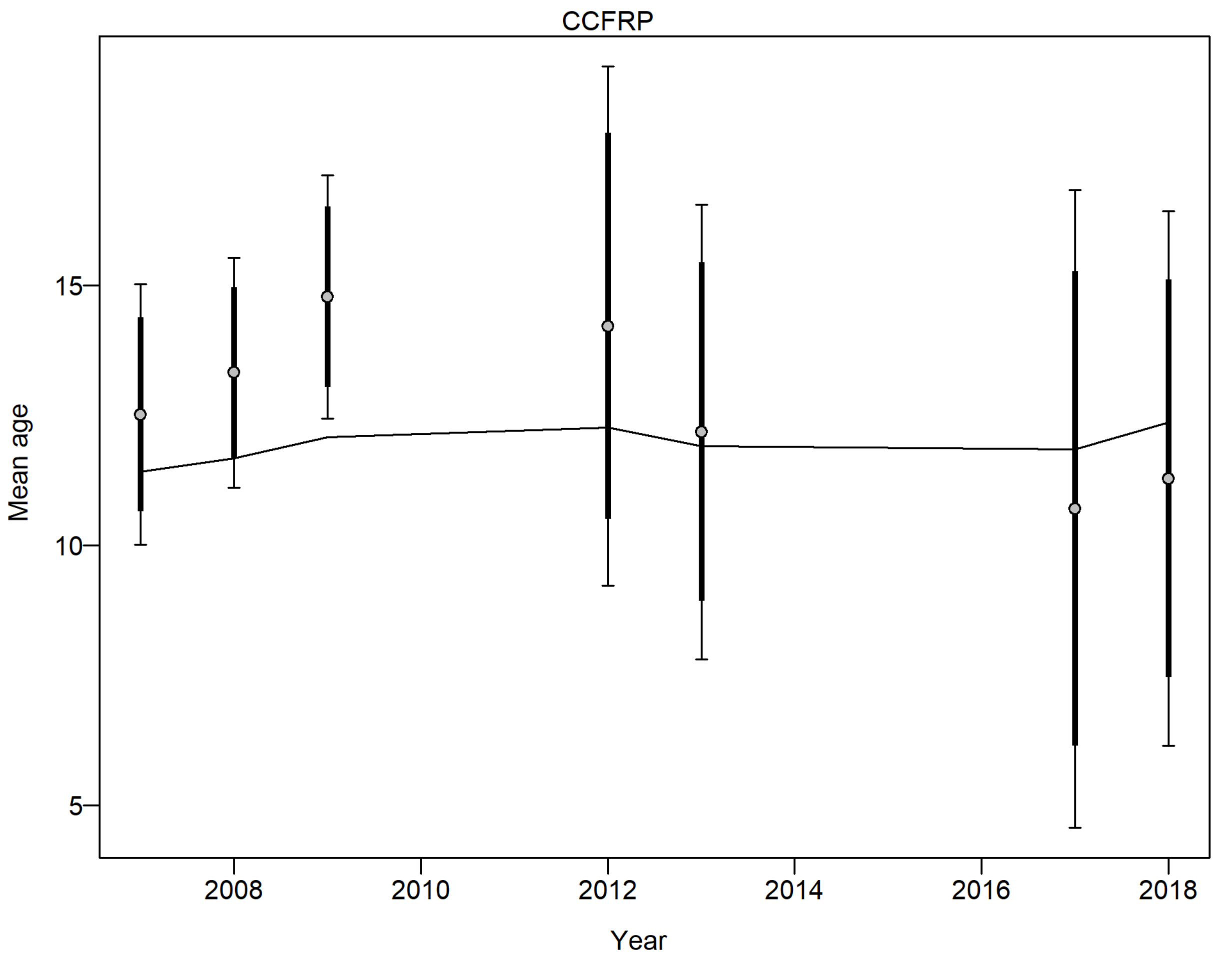


Figure 19: Mean age from conditional data (aggregated across length bins) for CCFRP with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 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. fig:mod1_12_co

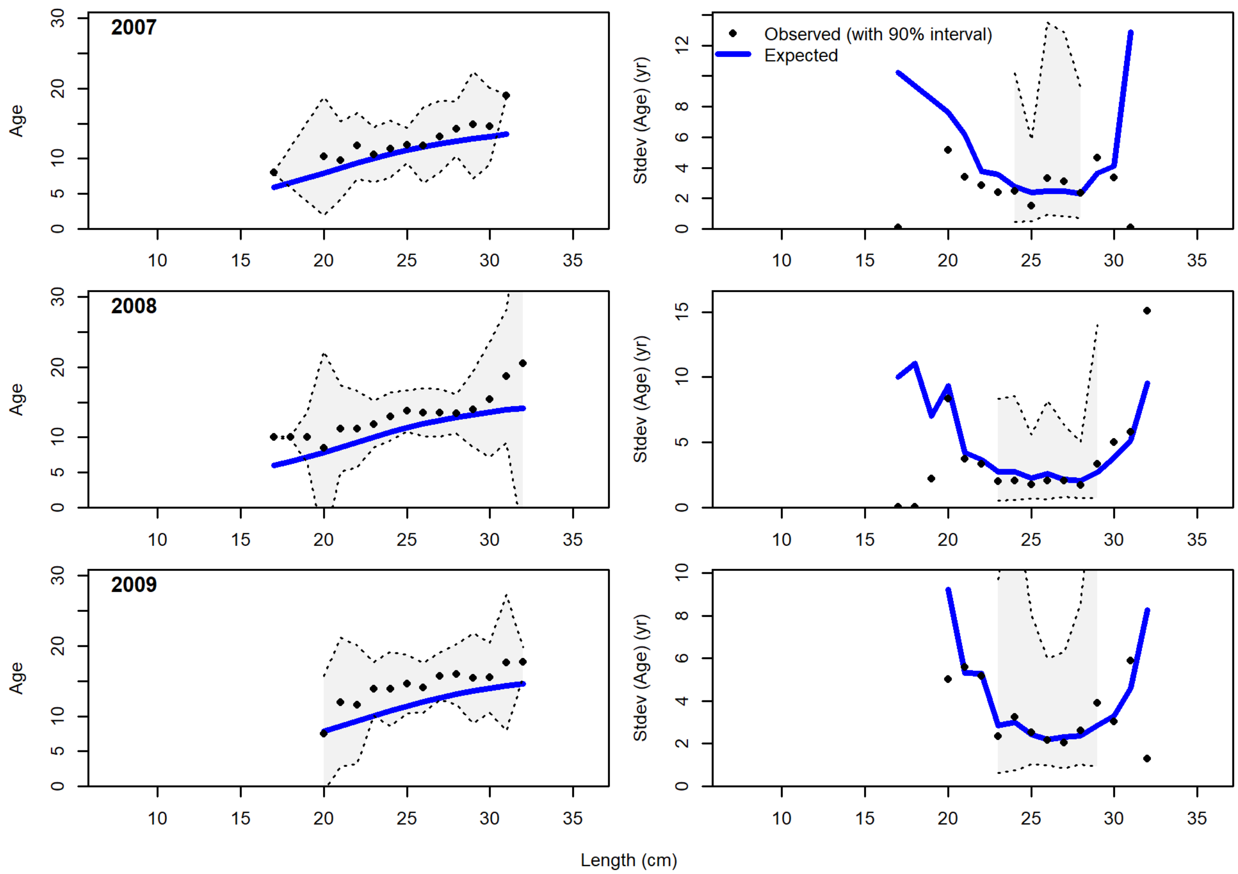
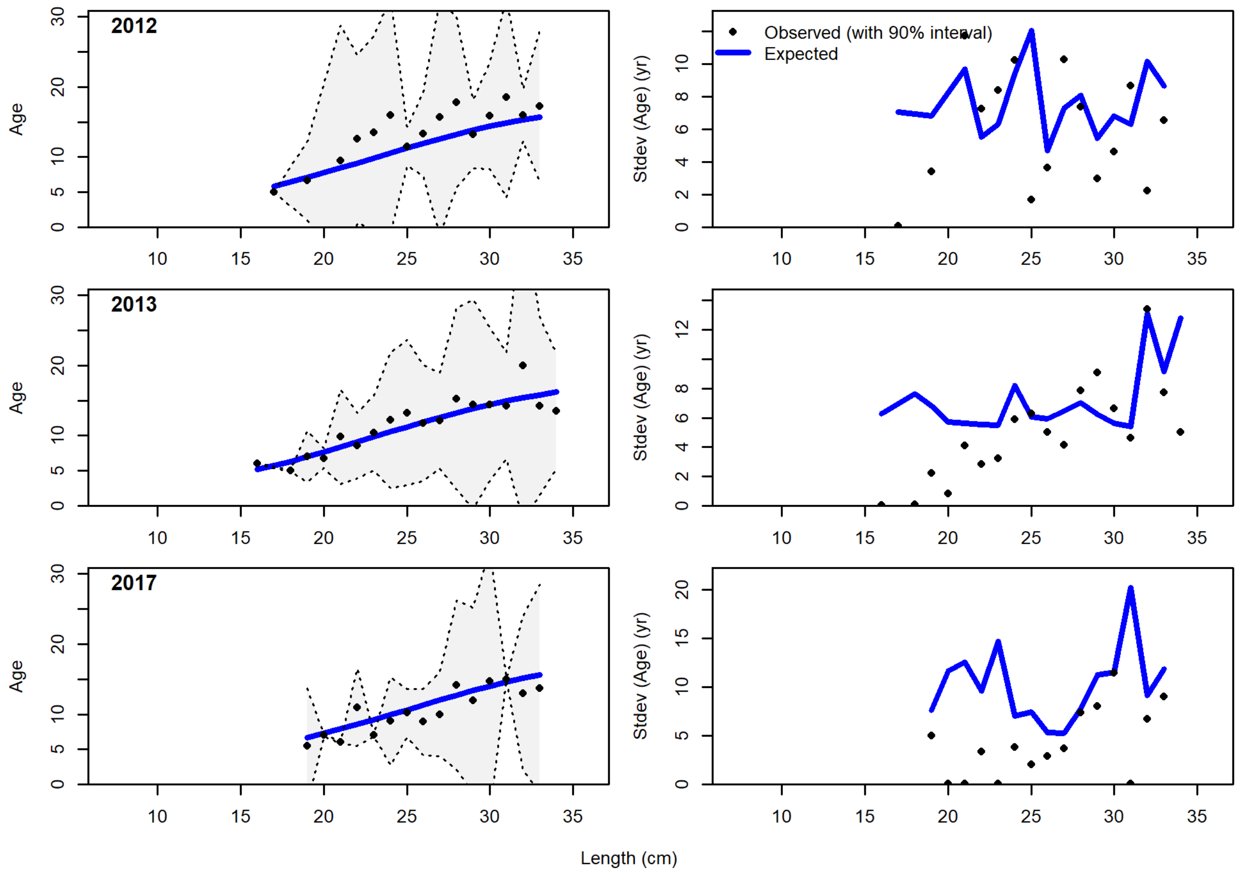


Figure 20: Conditional AAL plot, whole catch, CCFRP (plot 1 of 3) These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.) with 90% CIs based on the chi_square distribution. fig:mod1_13_c



848

849 Figure continued from previous page

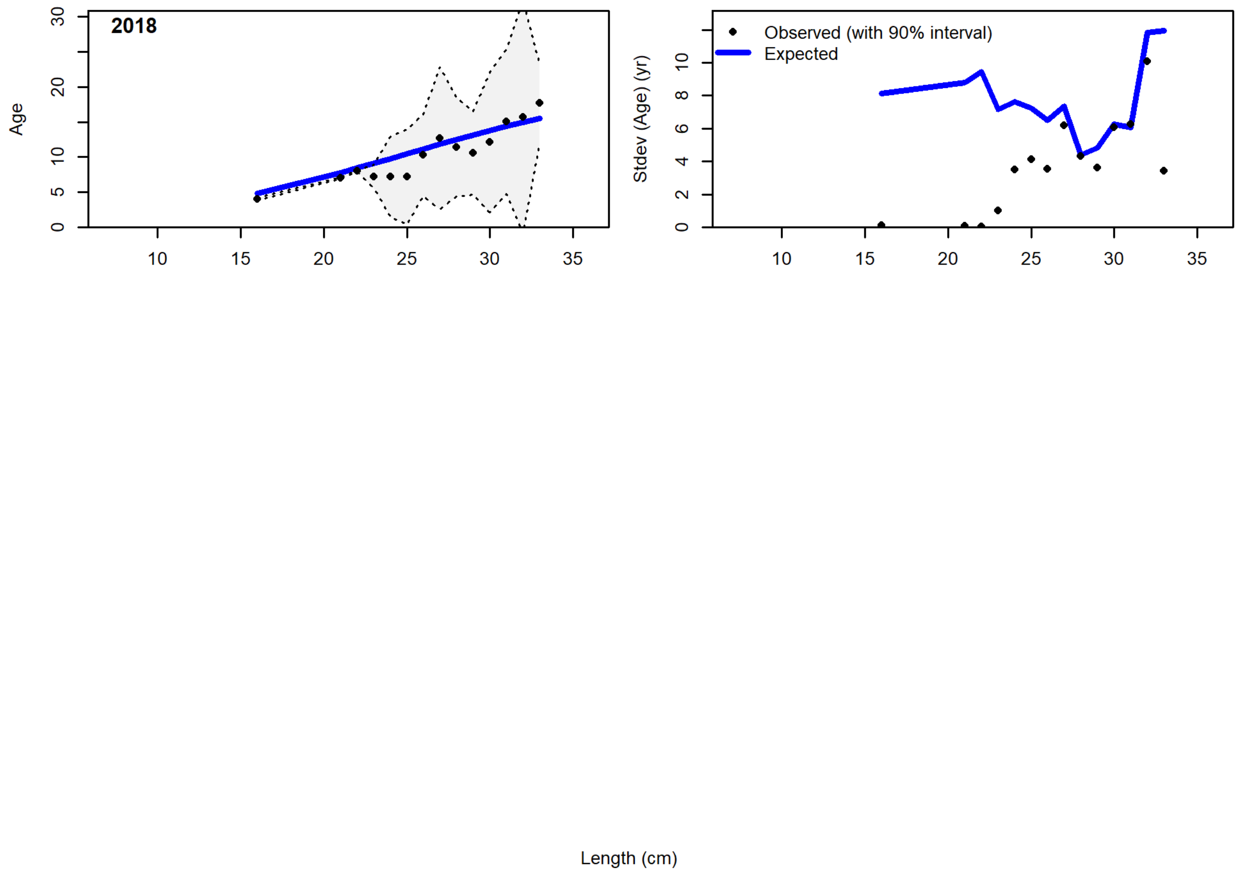


Figure continued from previous page

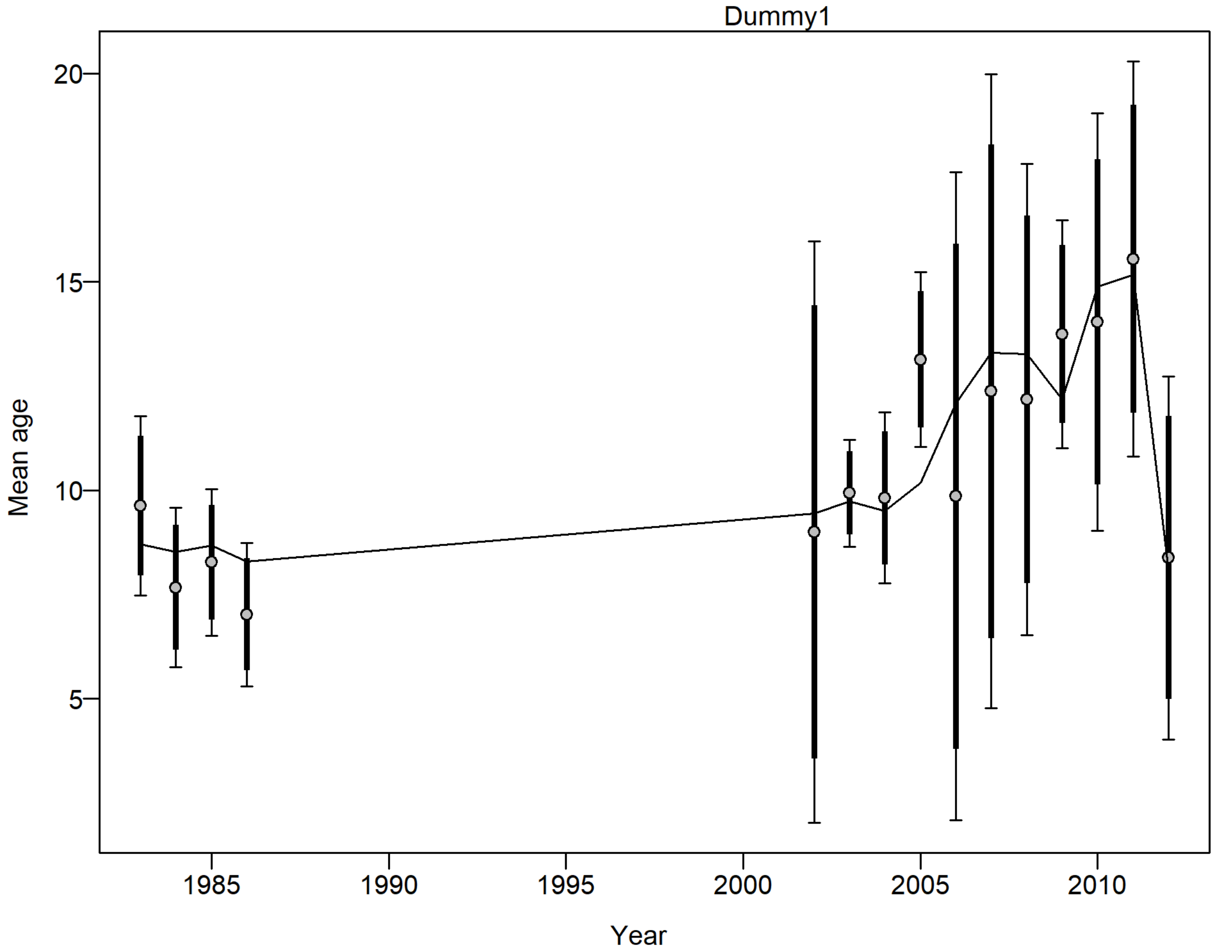


Figure 21: Mean age from conditional data (aggregated across length bins) for Dummy1 with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 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. fig:mod1_16_co

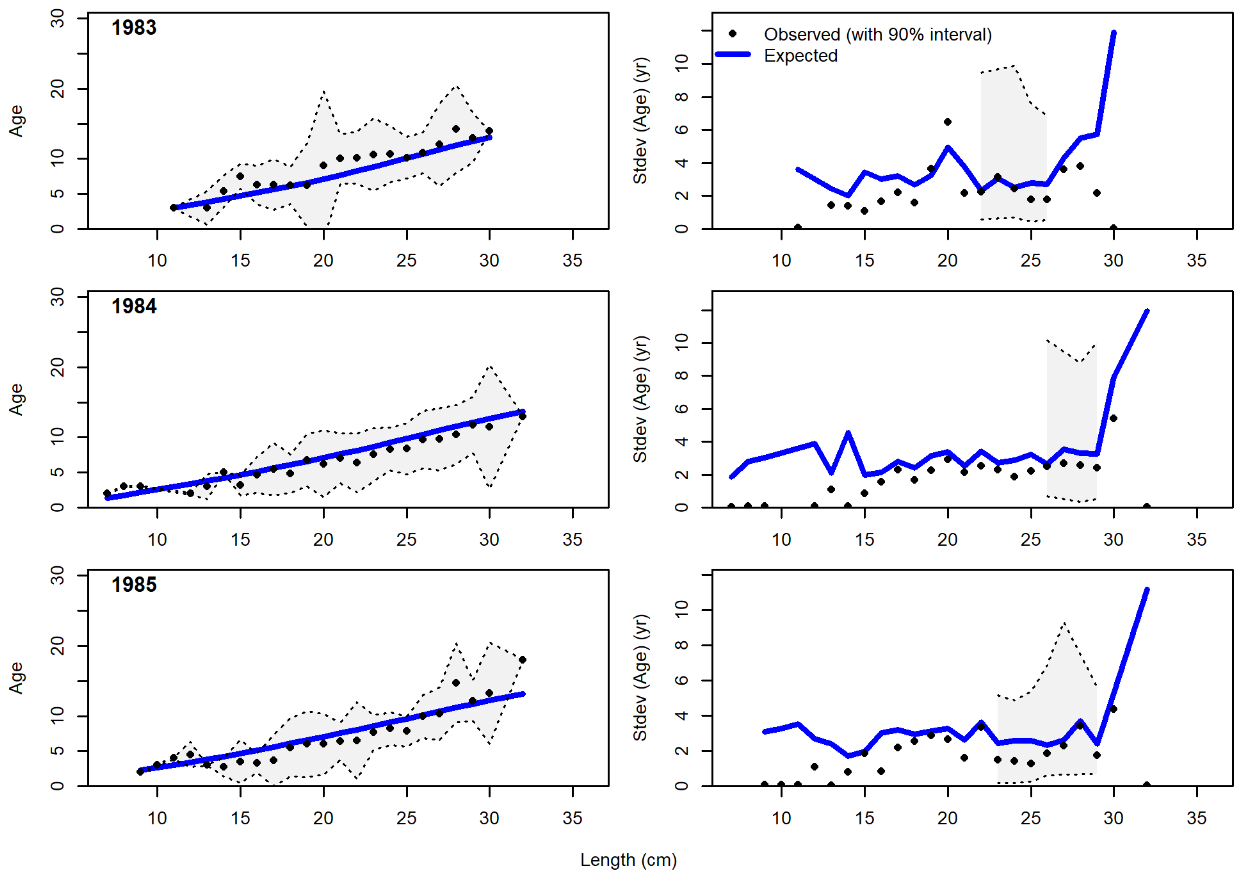


Figure 22: Conditional AAL plot, whole catch, Dummy1 (plot 1 of 5) These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.) with 90% CIs based on the chi_square distribution. fig:mod1_17_c

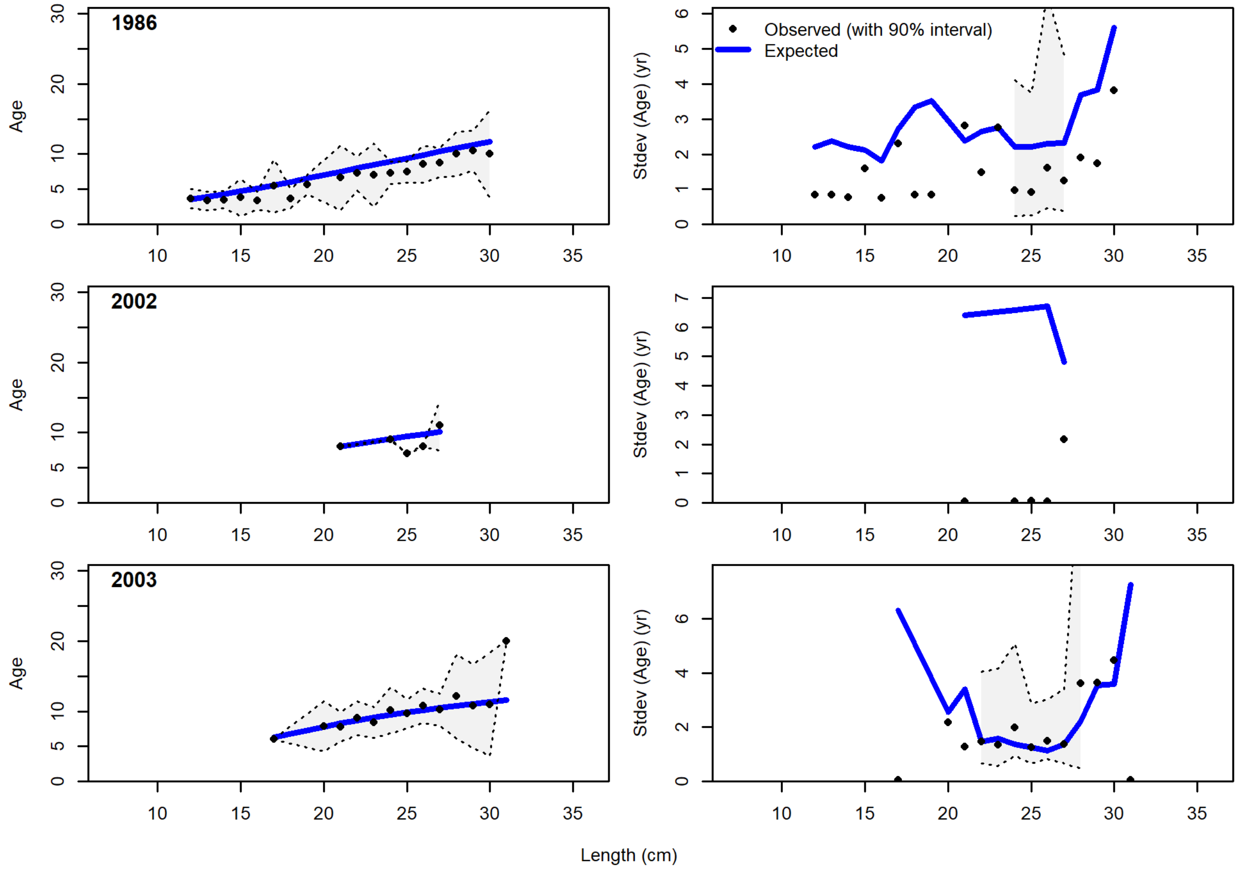


Figure continued from previous page

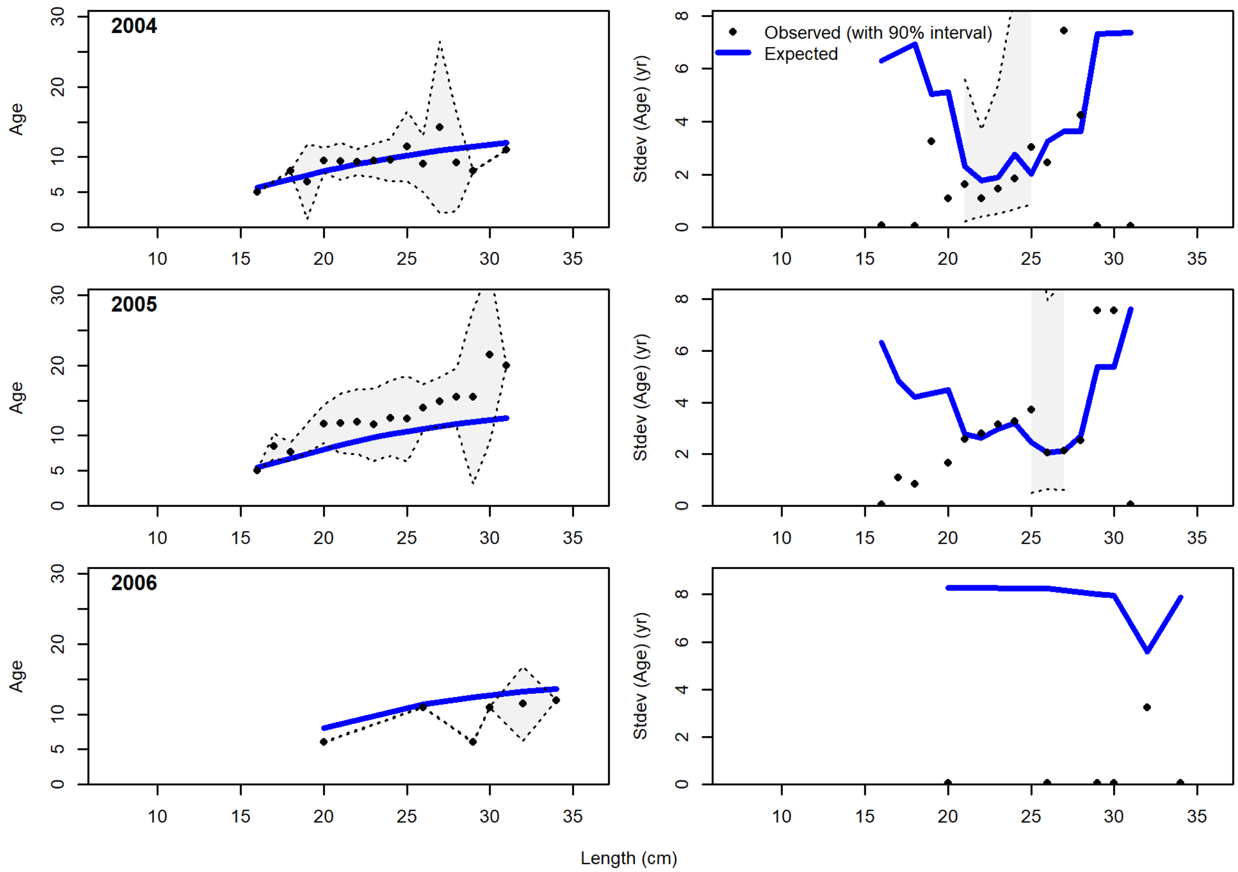


Figure continued from previous page

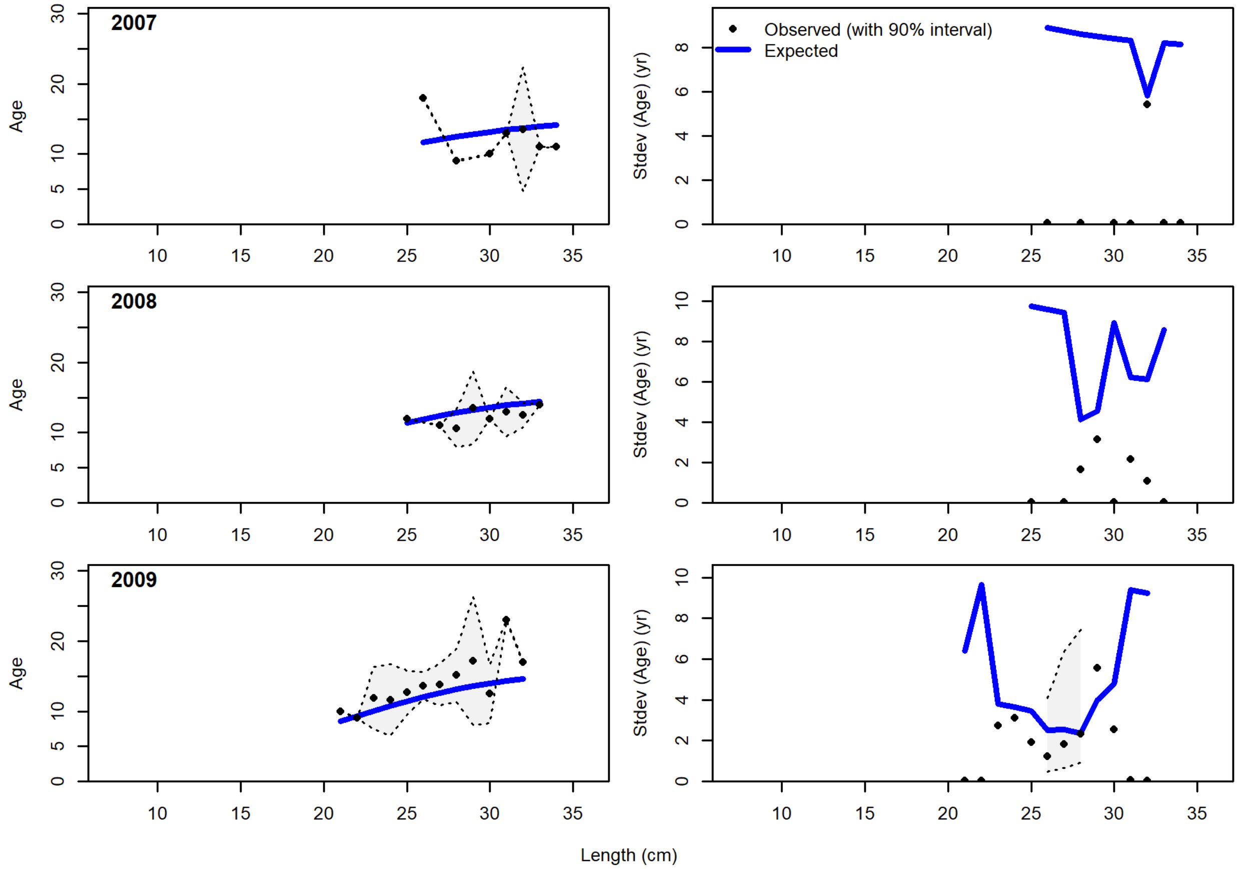


Figure continued from previous page

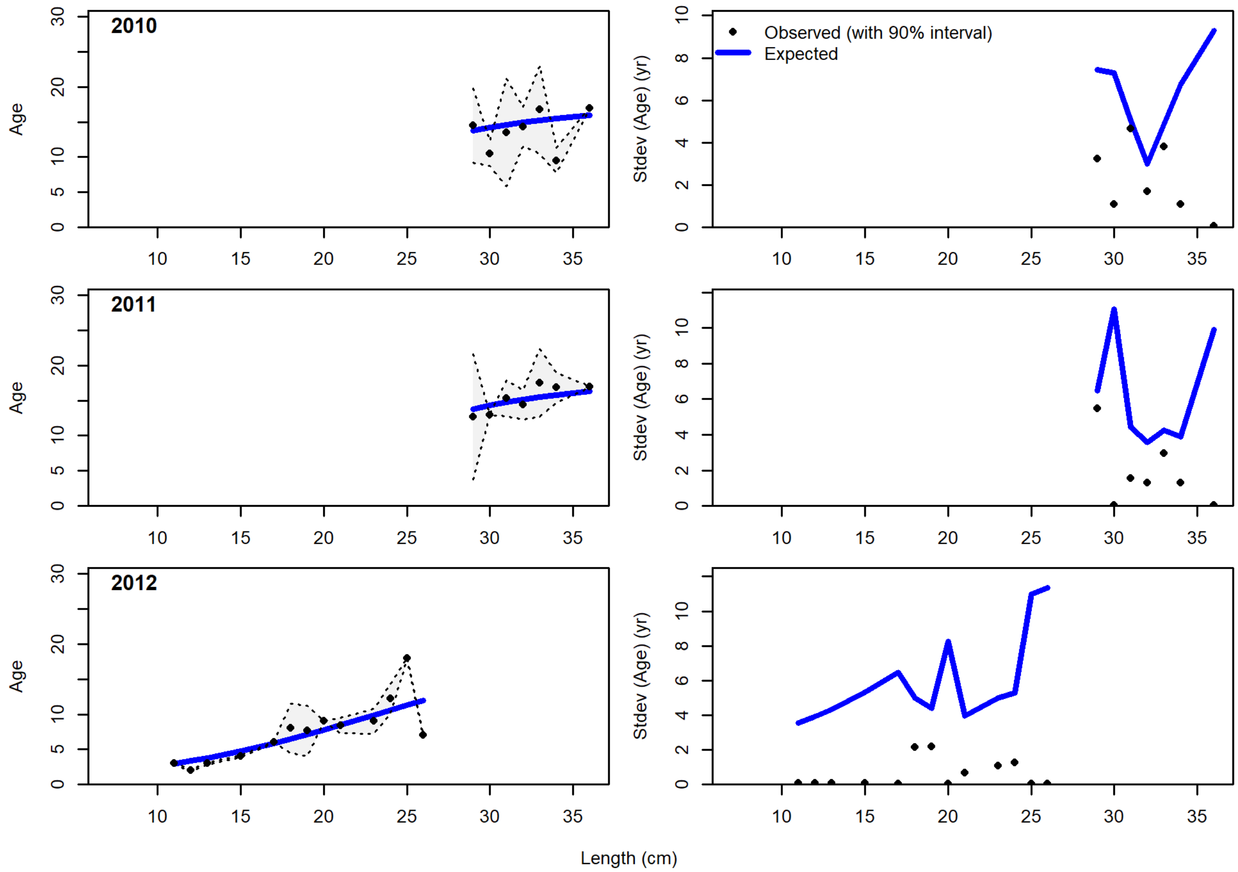


Figure continued from previous page

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

¡!– ** –¿

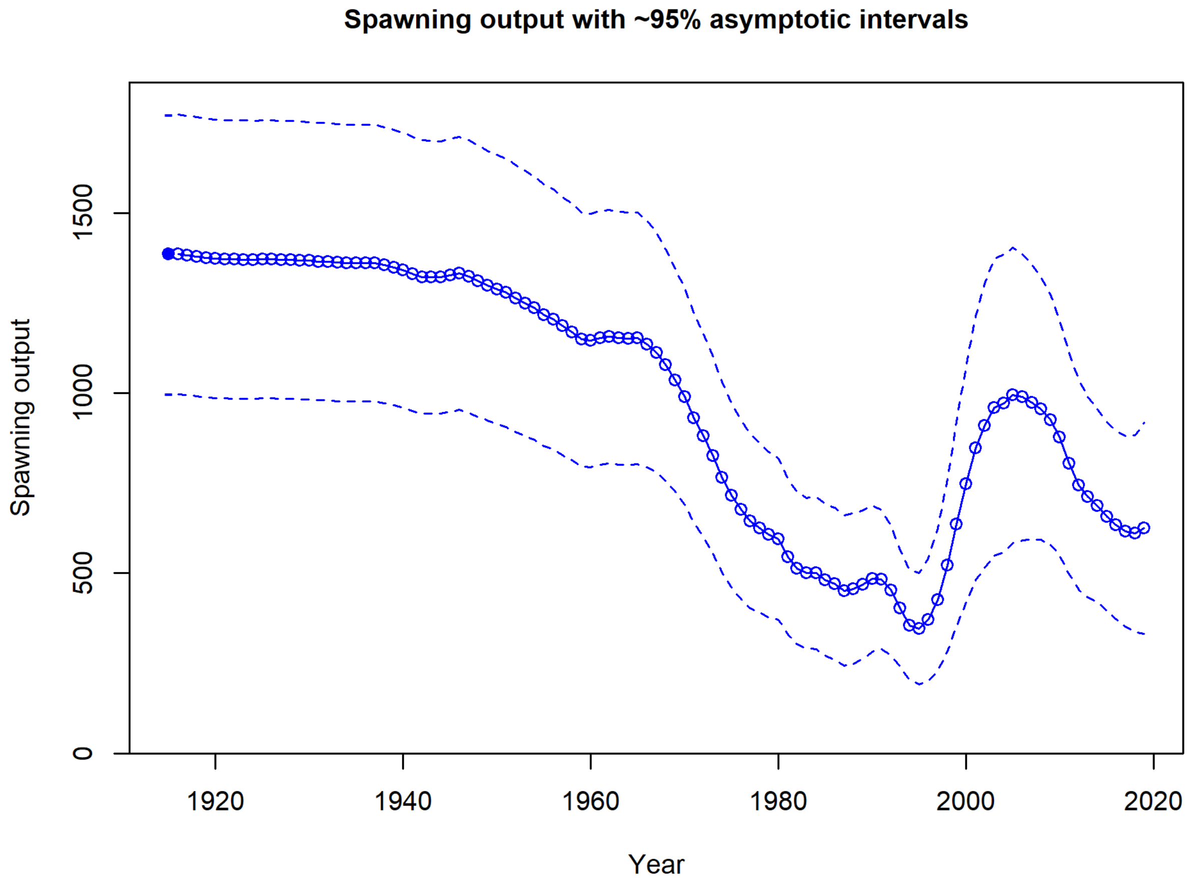


Figure 23: Estimated spawning biomass (mt) with approximate 95% asymptotic intervals. fig:ts7_Spawn

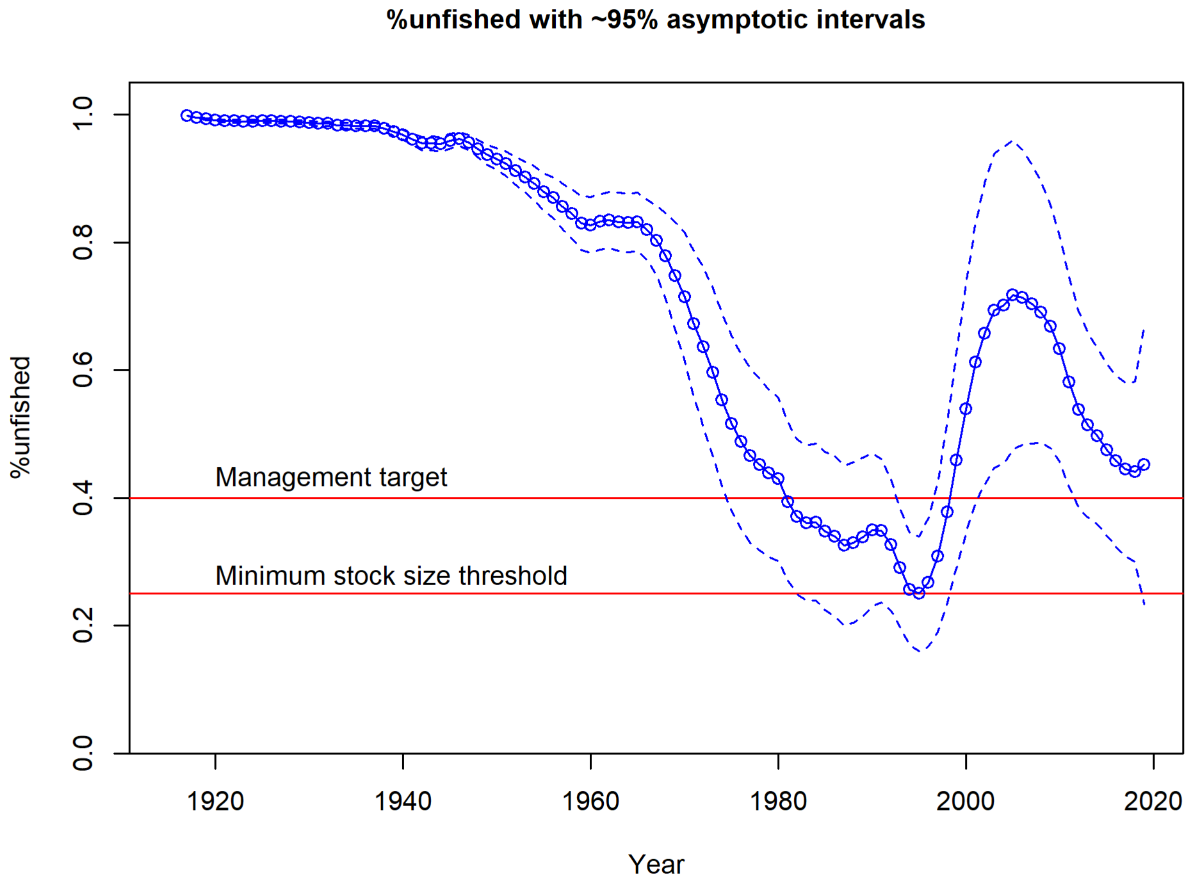


Figure 24: Estimated spawning depletion with approximate 95% asymptotic intervals. fig:ts9_unfishe

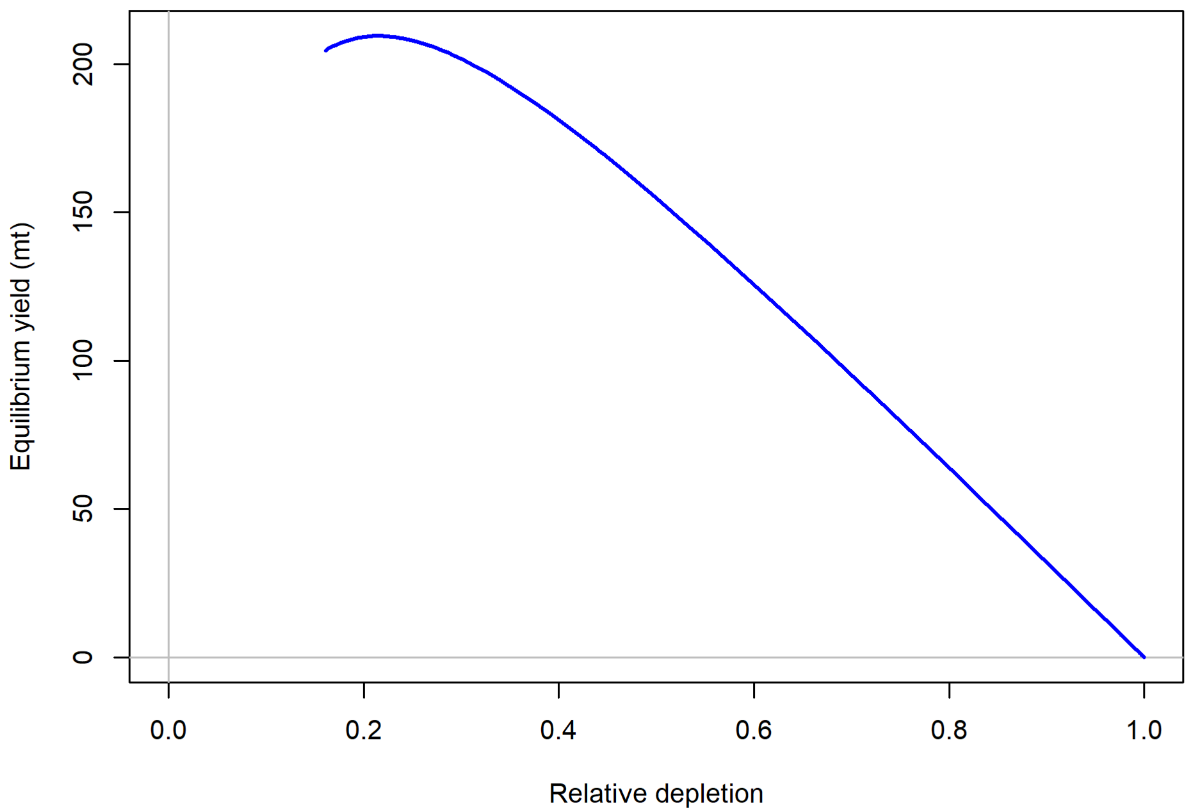


Figure 25: Equilibrium yield curve for the base case model. Values are based on the 2018 fishery selectivity and with steepness fixed at 0.718. fig:yield1_yield_curve

¡!– ** –¿

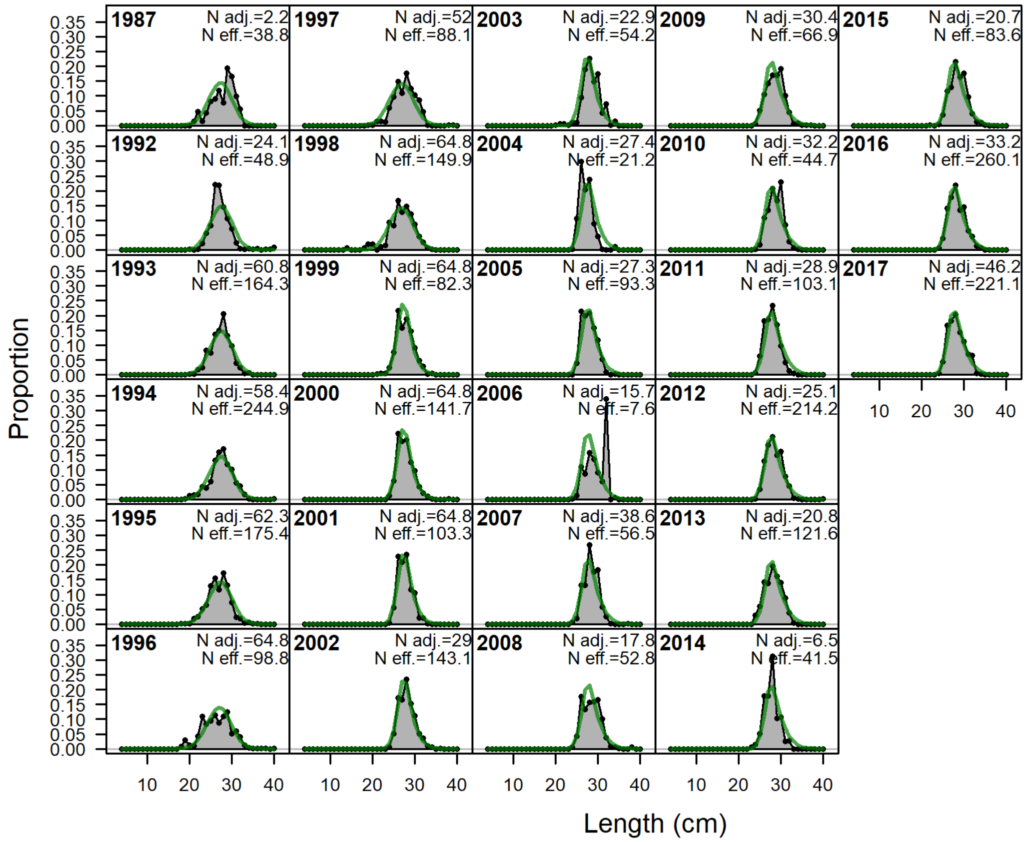


Figure A26: Length comps, retained, Com. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method. fig:mod1_1_comp_lenfit_flt1mkt2

Appendix A. Detailed fits to length composition data

appendix-a.-detailed-fits-to-length-composition-data

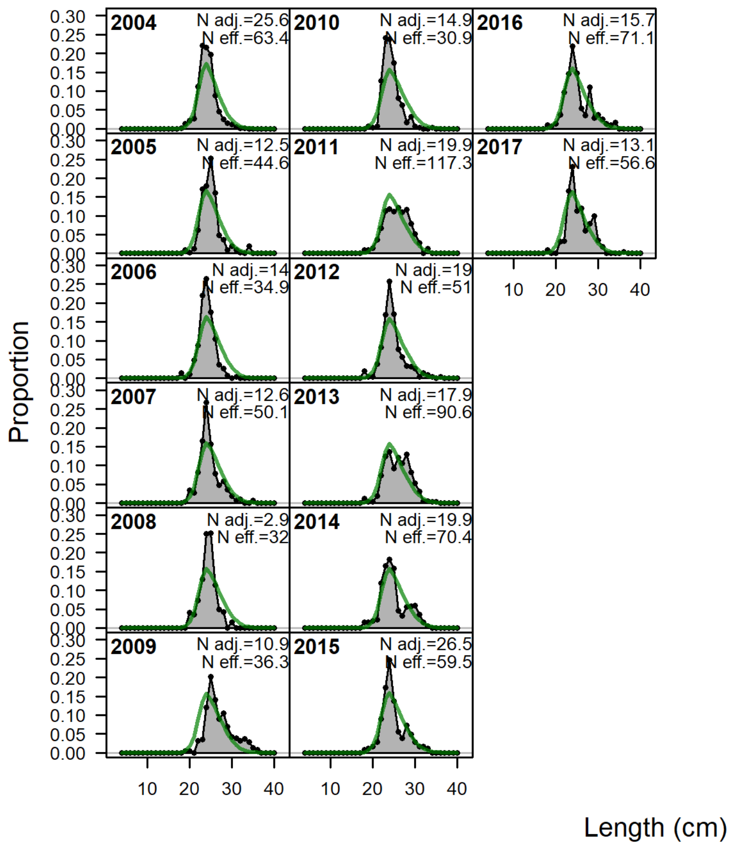


Figure A27: Length comps, retained, ComDisc. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method. fig:mod1_2_comp_lenfit_flt2mkt2

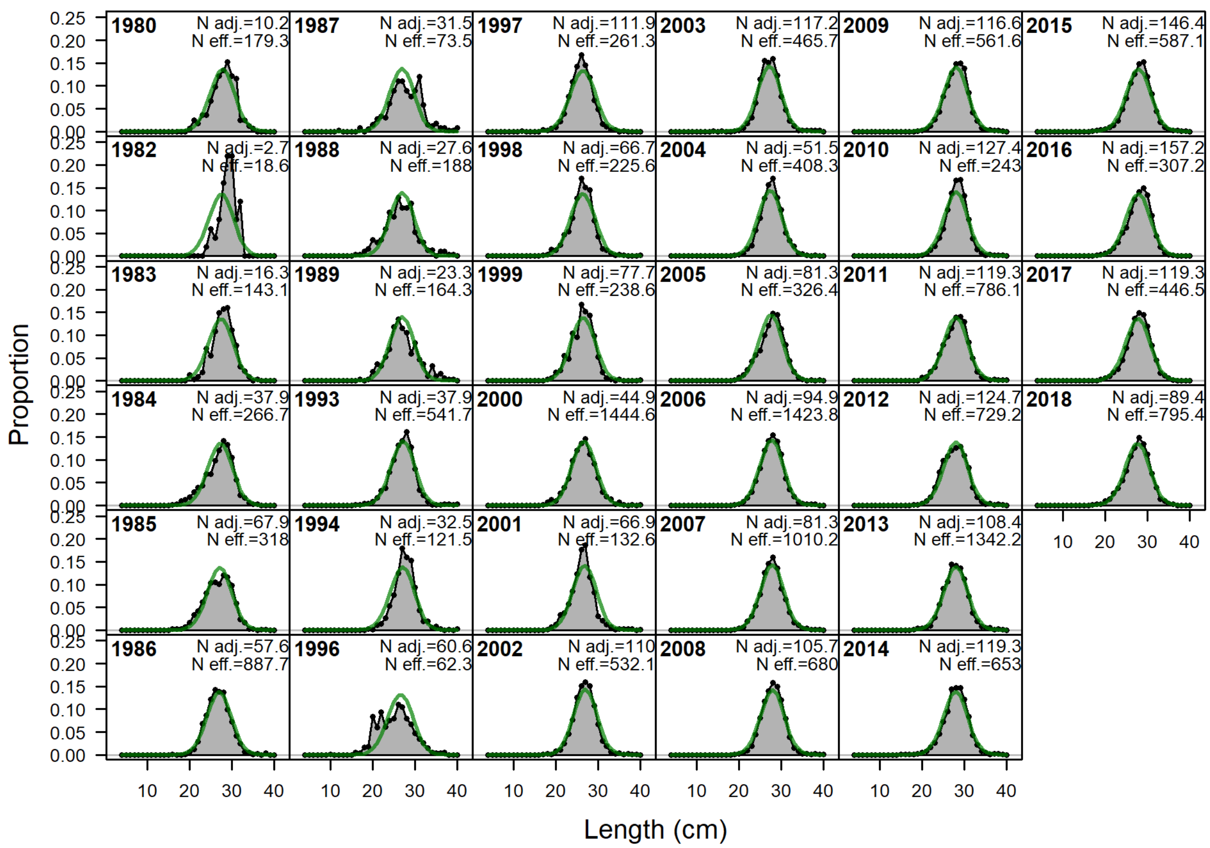


Figure A28: Length comps, whole catch, RecNorth. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method. fig:mod1_3_comp_lenfit_flt3mkt0

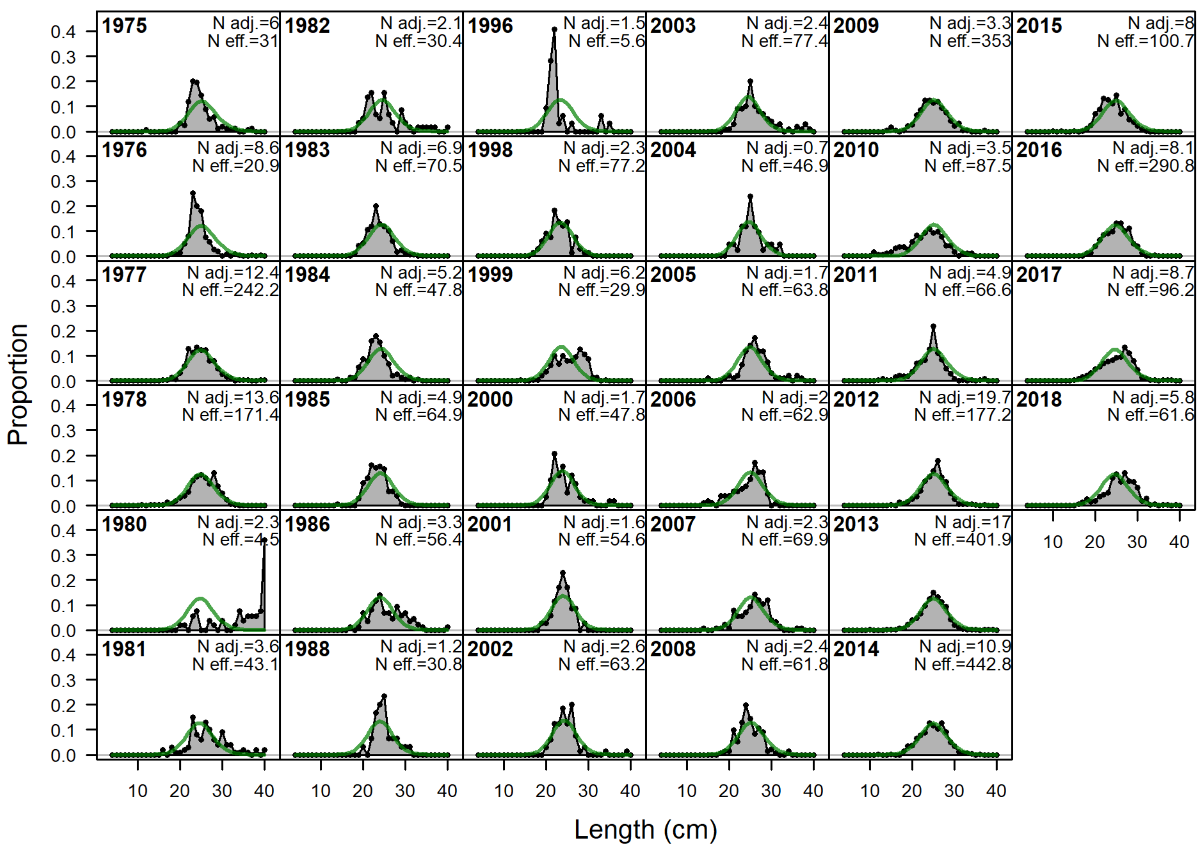


Figure A29: Length comps, whole catch, RecSouth. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method. fig:mod1_4_comp_lenfit_flt4mkt0

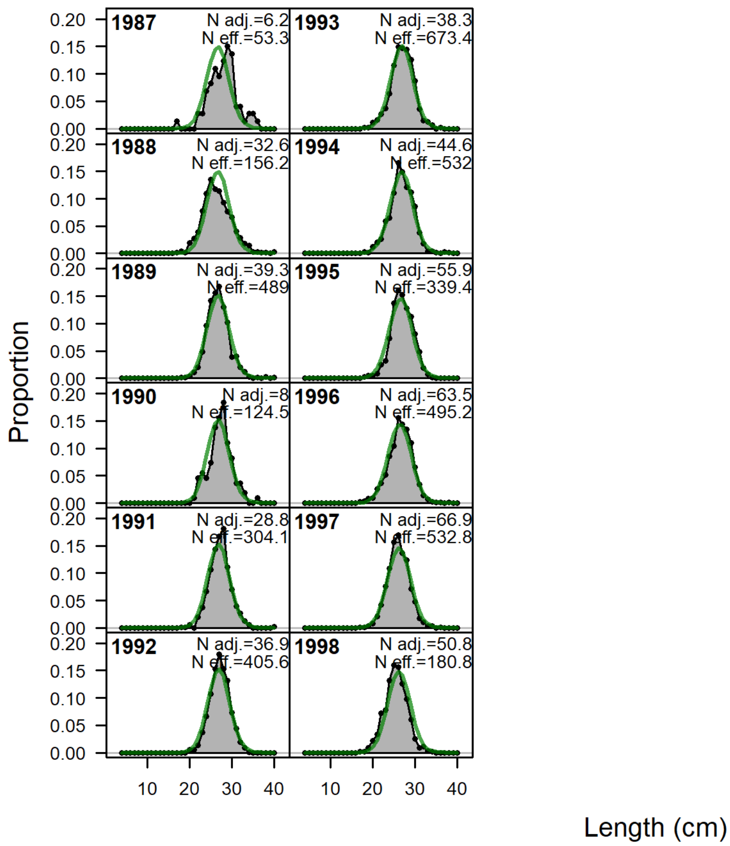


Figure A30: Length comps, whole catch, DebCPFV. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method. fig:mod1_5_comp_lenfit_flt5mkt0

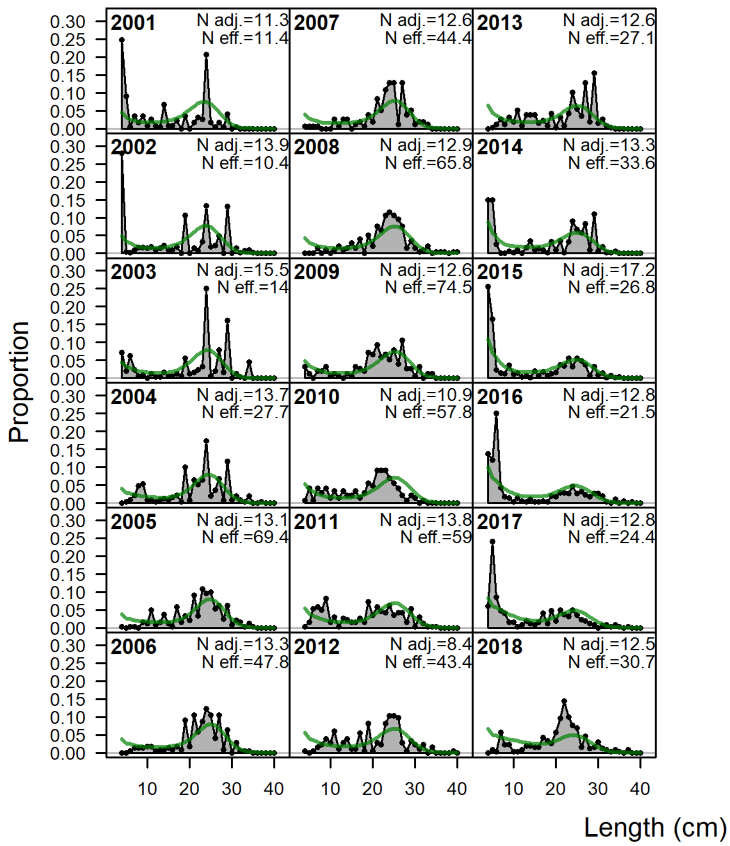


Figure A31: Length comps, whole catch, PISCO. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method. fig:mod1_6_comp_lenfit_flt8mkt0

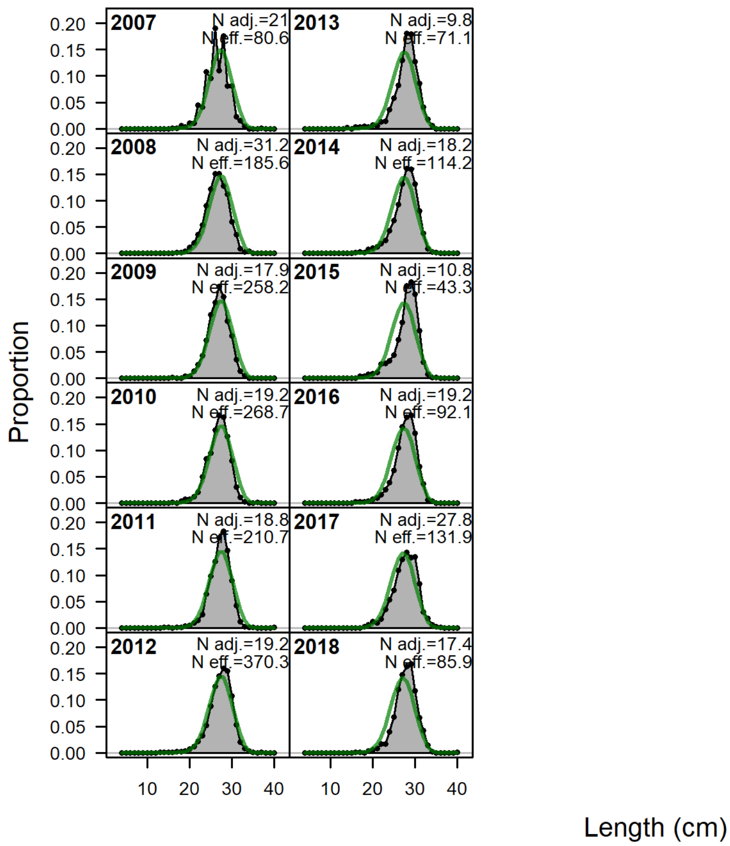


Figure A32: Length comps, whole catch, CCFRP. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method. fig:mod1_7_comp_lenfit_flt9mkt0

References

references

Alesandrini, S., and Bernardi, G. 1999. Ancient species flocks and recent speciation events: What can rockfishes teach us about cichlids (and vice-versa)? Journal of Molecular Evolution **49**: 814–818.

Ally, J., Ono, D., Read, R.B., and Wallace, M. 1991. Status of major southern California marine sport fish species with management recommendations, based on analyses of catch and size composition data collected on board commercial passenger fishing vessels from 1985 through 1987. Marine Resources Division Administrative Report No. 90-2.

Alverson, D.L., Pruter, a T., and Ronholt, L.L. 1964. A Study of Demersal Fishes and Fisheries of the Northeastern Pacific Ocean. Institute of Fisheries, University of British Columbia.

Anderson, T.W. 1983. Identification and development of nearshore juvenile rockfishes (genus \emph{Sebastes}) in central California kelp forests. Thesis, California State Univeristy, Fresno.

Baetscher, D. 2019. Larval dispersal of nearshore rockfishes. Dissertation, University of Santa Cruz. Available from https://escholarship.org/uc/item/85b3j8w0.

Bertalanffy, L. von. 1938. A quantitative theory of organic growth. Human Biology **10**: 181–213.

Buonaccorsi, V.P., Narum, S.R., Karkoska, K.A., Gregory, S., Deptola, T., and Weimer, A.B. 2011. Characterization of a genomic divergence island between black-and-yellow and gopher \emph{Sebastes} rockfishes. Molecular Ecology **20**(12): 2603–2618. doi: 10.1111/j.1365-294X.2011.05119.x.

Collins, R., and Crooke, S. (n.d.). An evaluation of the commercial passenger fishing vessel record system and the results of sampling the Southern California catch for species and size composition, 1975-1978. Unpublished report.

Echeverria, T. 1987. Thirty-four species of California rockfishes: maturity and seasonality of reproduction. Fishery Bulletin **85**: 229–250.

Eschmeyer, W., Herald, E., and Hammann, H. 1983. A field guide to Pacific coast fishes North America.

Hallacher, L.E. 1984. Relocation of original territories by displaced black-and-yellow rockfish, Sebastes chrysomelas, from Carmel Bay, California. California Department of FIsh and Game **70**: 158–162.

Hallacher, L.E., and Roberts, D.A. 1985. Differential utilization of space and food by the inshore rockfishes (Scorpaenidae: Sebastes) of Carmel Bay, California. Environmental Biology of Fishes **12**(2): 91–110. doi: 10.1007/BF00002762.

Hamel, O. 2015. A method for calculating a meta-analytical prior for the natural mortality rate using multiple life history correlates. ICES Journal of Marine Science **72**: 62–69.

Harry, G., and Morgan, A. 1961. History of the trawl fishery, 1884-1961. Oregon Fish Commission Research Briefs **19**: 5–26.

Hauser, L., and Carvalho, G.R. 2008. Paradigm shifts in marine fisheries genetics: ugly hypotheses slain by beautiful facts. Fish and Fisheries **9**(4): 333–362. doi: 10.1111/j.1467-2979.2008.00299.x.

Holliday, M.C., Deuel, D.G., and Scogin, W.M. 1984. Marine Recreational Fishery Statistics Survey, Pacific Coast, 1979-1980. National Marine Fisheries Server National Fishery Staistics Program, Current Fishery Statistics Number **8321**.

Hubbs, C., and Schultz, L. 1933. Description of two new American species refereable to the genus \emph{Sebastodes}, with notes on related species. University of Washintgon Publications in Biology **2**: 15–44.

Hunter, K. 1994. Incipient speciation in rockfish \emph{Sebastes carnatus} and \emph{Sebastes chrysomelas}. Dissertation, California State University, Northridge.

Karpov, K.A., Albin, D.P., and Van Buskirk, W. 1995. The marine recreational fishery in northern California and central California: a historical comparison (1958–86), status of stocks (1980–1986), and effects of changes in the California Current. California Department of Fish Game Fish Bulletin **176**.

Key, M., MacCall, A., Bishop, T., and Leos, B. 2005. Stock assessment of the gopher rockfish (Sebastes carnatus). Available from http://137.110.142.7/publications/FED/00780.pdf.

Larson, R. 1972. The food habits of four kelp-bed rockfishes (Scorpaenidae, Sebastes) off Santa Barbara, California. PhD thesis, University of California, Santa Barbara. Available from http://aquaticcommons.org/11241/.

Larson, R.J. 1980. Territorial behavior of the black and yellow rockfish and gopher rockfish (Scorpaenidae, Sebastes). Marine Biology **58**(2): 111–122. doi: 10.1007/BF00396122.

Lea, R., McAllister, R., and VenTresca, D. 1999. Biological aspects of nearshore rockfishes of the genus \emph{Sebastes} from Central California, with notes on ecologically related sport fishes. California Department of Fish and Game, Fish Bulletin **177**.

Loury, E., Bros, S., Starr, R., Ebert, D., and Calliet, G. 2015. Trophic ecology of the gopher rockfish Sebastes carnatus inside and outside of central California marine protected areas.

Marine Ecology Progress Series **536**: 229–241. Available from https://www.int-res.com/abstracts/meps/v536/p229-241/.

Love, M., Yoklavich, M., and Thorsteinson, L. 2002. The rockfishes of the northeast Pacific. University of California Press, Berkeley, CA, USA.

MacCall, A.D. 2009. Depletion-corrected average catch: A simple formula for estimating sustainable yields in data-poor situations. ICES Journal of Marine Science **66**: 2267–2271.

Matthews, K. 1985. Species similarity and movement of fishes on natural and artificial reefs in Monterey Bay, California. Bulletin of Marine Science **37**: 252–270. Available from https://www.ingentaconnect.com/content/umrsmas/bullmar/1985/00000037/00000001/art00019.

Narum, S.R., Buonaccorsi, V.P., Kimbrell, C.A., and Vetter, R.D. 2004. Genetic Divergence between Gopher Rockfish \emph{Sebastes carnatus} and Black and Yellow Rockfish \emph{Sebastes chrysomelas}. Copeia **2004**(4): 926–931. doi: 10.1643/cg-02-061r2.

Pacific Fishery Management Council. 2002. Status of the Pacific Coast Groundfish Fishery Through 2001 and Acceptable Biological Catches for 2002: Stock Assessment and Fishery Evaluation. Pacific Fishery Management Council, Portland, OR.

Pacific Fishery Management Council. 2004. Pacific coast groundfish fishery management plan: fishery management plan for the California, Oregon, and Washington groundfish fishery as amended through Amendment 17. Pacific Fishery Management Council, Portland, OR.

Pacific Fishery Managment Council. 2018. Status of the Pacific Coast Groundfish Fishery: Stock Assessment and Fishery Evaluation.

Pearson, D.E., Erwin, B., and Key, M. 2008. Reliability of California's groundfish landings estimates from 1969-2006. NOAA Technical Memorandum **NMFS-SWFSC**.

Ralston, S., Pearson, D., Field, J., and Key, M. 2010. Documentation of California catch reconstruction project. NOAA-TM-NMFS-SWFSC-461.

Sampson, D.B., and Crone, P.R. 1997. Commercial Fisheries Data Collection Procedures for U.S. Pacific Coast Groundfish. NOAA Technical Memorandum **NMFS-NWFSC**.

Seeb, L. 1986. Biochemical systematics and evolution of the scorpaenid genus \emph{Sebastes}. Dissertation, University of Washington.

Somers, K.A., J. Jannot, V. Tuttle, K. Richerson, N.R., and McVeigh, J. 2018. Estimated discard and catch of groundfish species in the 2017 US west coast fisheries.. NOAA Fisheries, NWFSC Observer Program, 2725 Montlake Blvd E., Seattle, WA 98112.

Waples, R.S., and Gaggiotti, O. 2006. What is a population? An empirical evaluation of some genetic methods for identifying the number of gene pools and their degree of connectivity. Molecular Ecology **15**: 1419–1439. doi: 10.1111/j.1365-294X.2006.02890.x.

Waples, R.S., Punt, A.E., and Cope, J.M. 2008. Integrating genetic data into management of marine resources: How can we do it better? Fish and Fisheries **9**(4): 423–449. doi: 10.1111/j.1467-2979.2008.00303.x.

Wilson, J., Broitman, B., Caselle, J., and Wendt, D. 2008. Recruitment of coastal fishes and oceanographic variability in central California. Estuarine Coastal and Shelf Science **79**: 483–490. Available from https://www.sciencedirect.com/science/article/pii/S0272771408001972.

Wilson-Vandenberg, D., Larinto, T., and Key, M. 2014. Implementing California's Nearshore Fishery Management Plan - twelve year later. California Fish and Game **100**(2): 186–214.

Zaitlin, J. 1986. Geographical variation in the life history of Sebastes chrysomelas. PhD thesis, San Francisco State University. Available from https://scholar.google.com/scholar?hl=en{\&}as{_}sd

Zuercher, R. 2019. Social and ecological connectivitiy in kelp forest ecosystems. Dissertation, Univeristy of California Santa Cruz.