

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



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

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- ²² Fishery Management Council, Portland, OR. Available from
- ²³ <http://www.pcouncil.org/groundfish/stock-assessments/>

24 The Combined Status of Gopher (*Sebastodes*
25 *carnatus*) and Black-and-Yellow Rockfishes
26 (*Sebastodes chrysomelas*) in U.S. Waters Off
27 California in 2019

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⁹⁶ **Executive Summary**

executive-summary

⁹⁷ **Stock**

stock

- ⁹⁸ This assessment reports the status of the GBYR (*Sebastes carnatus/Sebastes chrysomelas*)
⁹⁹ resource in U.S. waters off the coast of ... using data through 2018.

¹⁰⁰ **Catches**

catches

¹⁰¹ Information on historical landings of GBYR are available back to xxxx... (Table [a](#)). Com-
¹⁰² mercial landings were small during the years of World War II, ranging between 4 to 28 metric
¹⁰³ tons (mt) per year.

¹⁰⁴ (Figures [a-b](#))
¹⁰⁵ (Figure [c](#))

¹⁰⁶ Since 2000, annual total landings of GBYR have ranged between 70-169 mt, with landings
¹⁰⁷ in 2018 totaling 92 mt.



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

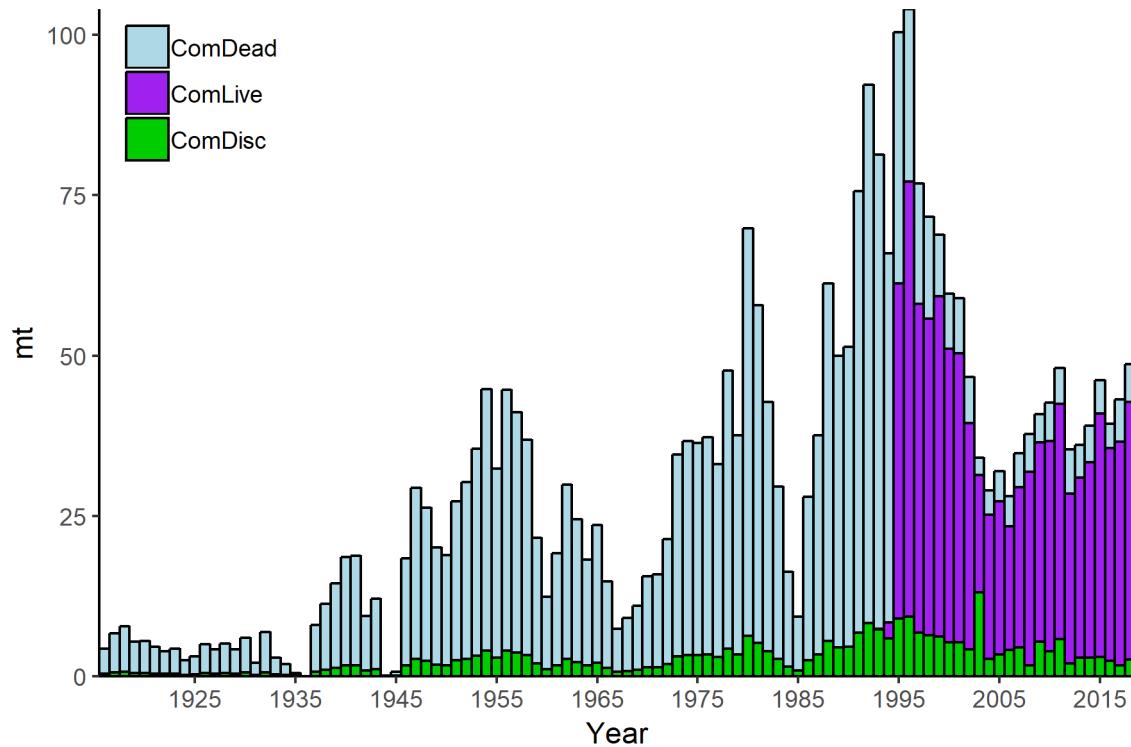


Figure b: Catch history of GBYR for the commercial fleet by dead and live landings, and discards. Catches in 1936 and 1946 were minimal. ^{fig:Exec_catch2}

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

Year	Commercial Retained	Commercial Discard	Recreational North	Recreational South	tab:Exec_catch
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

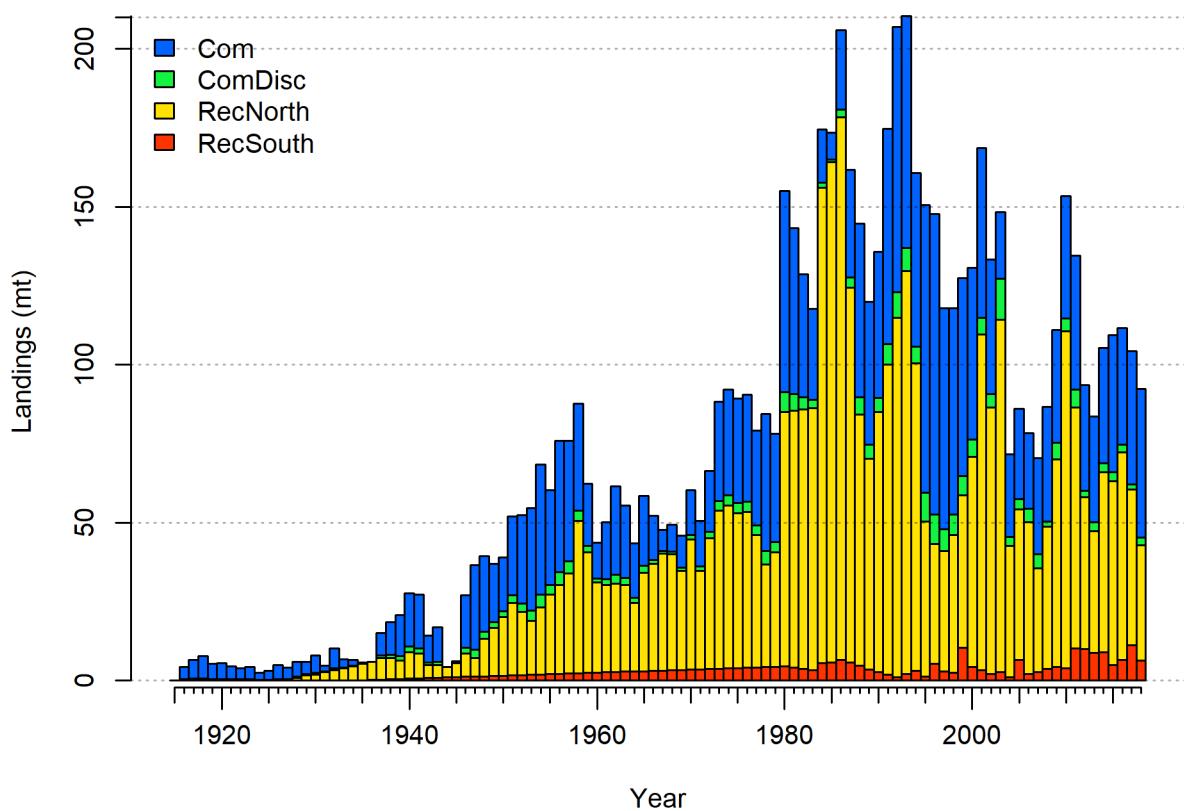


Figure c: Catch history of GBYR in the model. [fig:r4ss_catches](#)

¹⁰⁸ **Data and Assessment**

data-and-assessment

¹⁰⁹ This a new full assessment for GBYR, which was last assessed in . . . using Stock Synthesis
¹¹⁰ Version xx. This assessment uses the newest version of Stock Synthesis (3.30.xx). The model
¹¹¹ begins in 1916, and assumes the stock was at an unfished equilibrium that year.

¹¹² (Figure d).

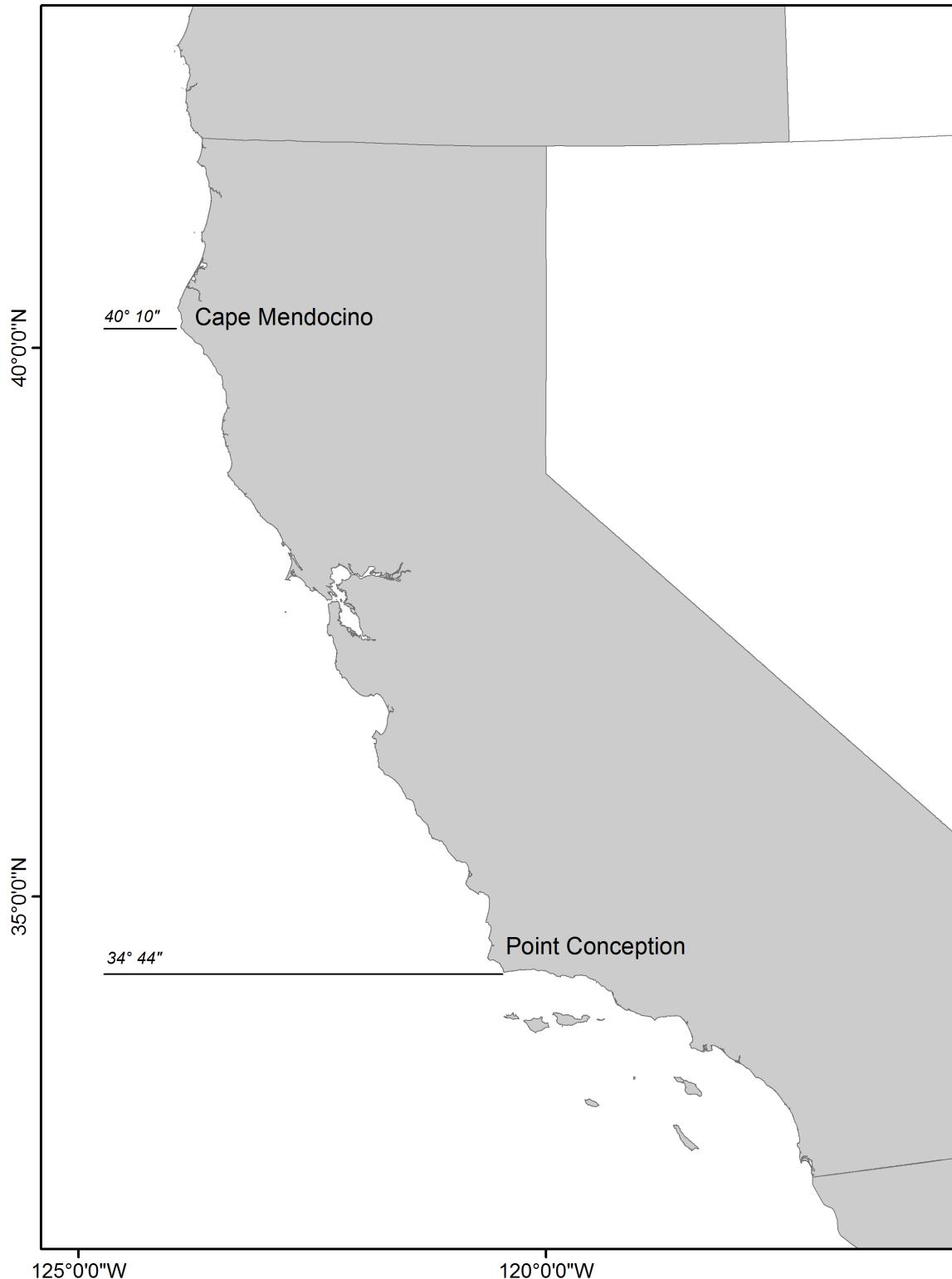


Figure d: Map depicting the core distribution of gopher and black-and-yellow rockfishes. The stock assessment is bounded at Cape Mendocino in the north to the U.S./Mexico border in the south. [fig:assess_region_map](#)

¹¹³ **Stock Biomass**

stock-biomass

¹¹⁴ (Figure e and Table b).

¹¹⁵ The 2018 estimated spawning biomass relative to unfished equilibrium spawning biomass is
¹¹⁶ above the target of 40% of unfished spawning biomass at 4 690% (95% asymptotic interval:
¹¹⁷ ± 3 150% - 6 230%) (Figure f). Approximate confidence intervals based on the asymptotic
¹¹⁸ variance estimates show that the uncertainty in the estimated spawning biomass is high.

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

Year	Spawning Output (million eggs)	~ 95% confidence interval	Estimated depletion	~ 95% confidence interval
2010	908	537 - 1279	65.87	47.32 - 84.43
2011	838	489 - 1187	60.78	43.48 - 78.07
2012	779	449 - 1108	56.50	40.35 - 72.65
2013	744	431 - 1058	53.98	38.85 - 69.11
2014	718	416 - 1019	52.07	37.76 - 66.39
2015	685	392 - 979	49.71	35.88 - 63.55
2016	658	367 - 949	47.73	34.06 - 61.41
2017	637	345 - 929	46.19	32.38 - 60
2018	629	330 - 929	45.66	31.35 - 59.97
2019	647	329 - 965	46.93	31.52 - 62.34

Spawning output with ~95% asymptotic intervals

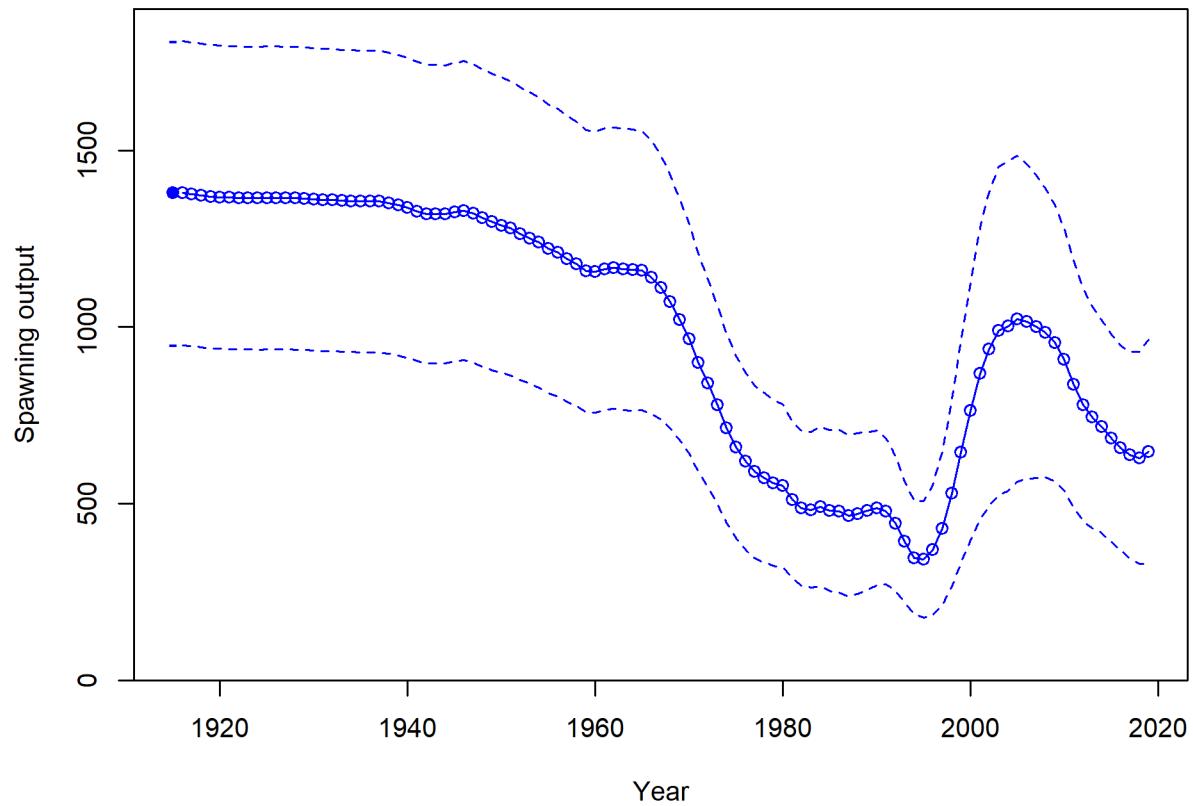


Figure e: Time series of spawning biomass trajectory (circles and line; median; light broken lines: 95% credibility intervals) for the base case assessment model. | [fig:Spawnbio_all](#)

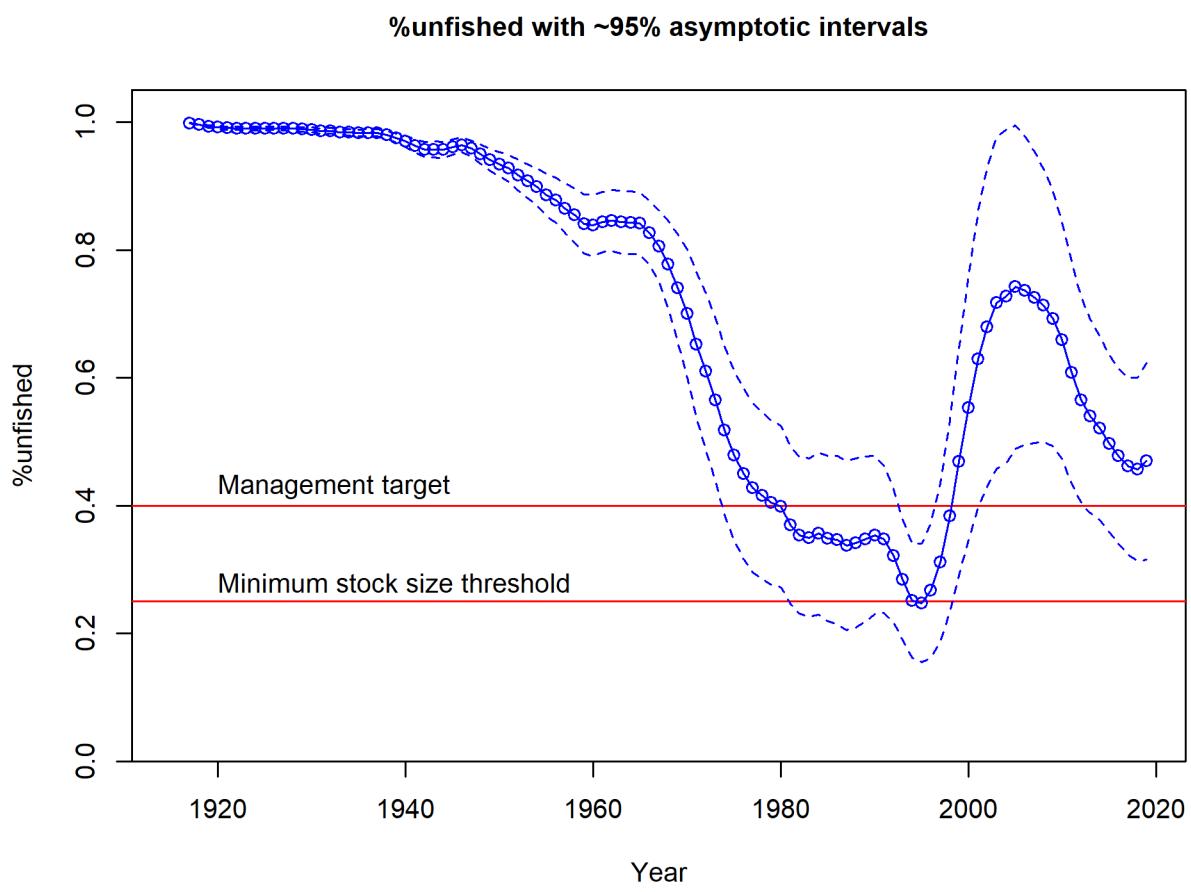


Figure f: Estimated percent depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model. fig:Re1Deplete_all

¹¹⁹ **Recruitment**

recruitment

¹²⁰ Recruitment deviations were estimated from xxxx-xxxx (Figure g and Table c).

Table c: Recent recruitment for the GBYR assessment.

Year	Estimated Recruitment (1,000s)	~ 95% confidence interval
2010	4419	1585 - 12319
2011	3732	1292 - 10782
2012	3733	1258 - 11079
2013	4836	1638 - 14278
2014	8499	2927 - 24675
2015	12739	4397 - 36906
2016	9468	3184 - 28158
2017	6205	1985 - 19398
2018	4678	1447 - 15122
2019	4980	1504 - 16490

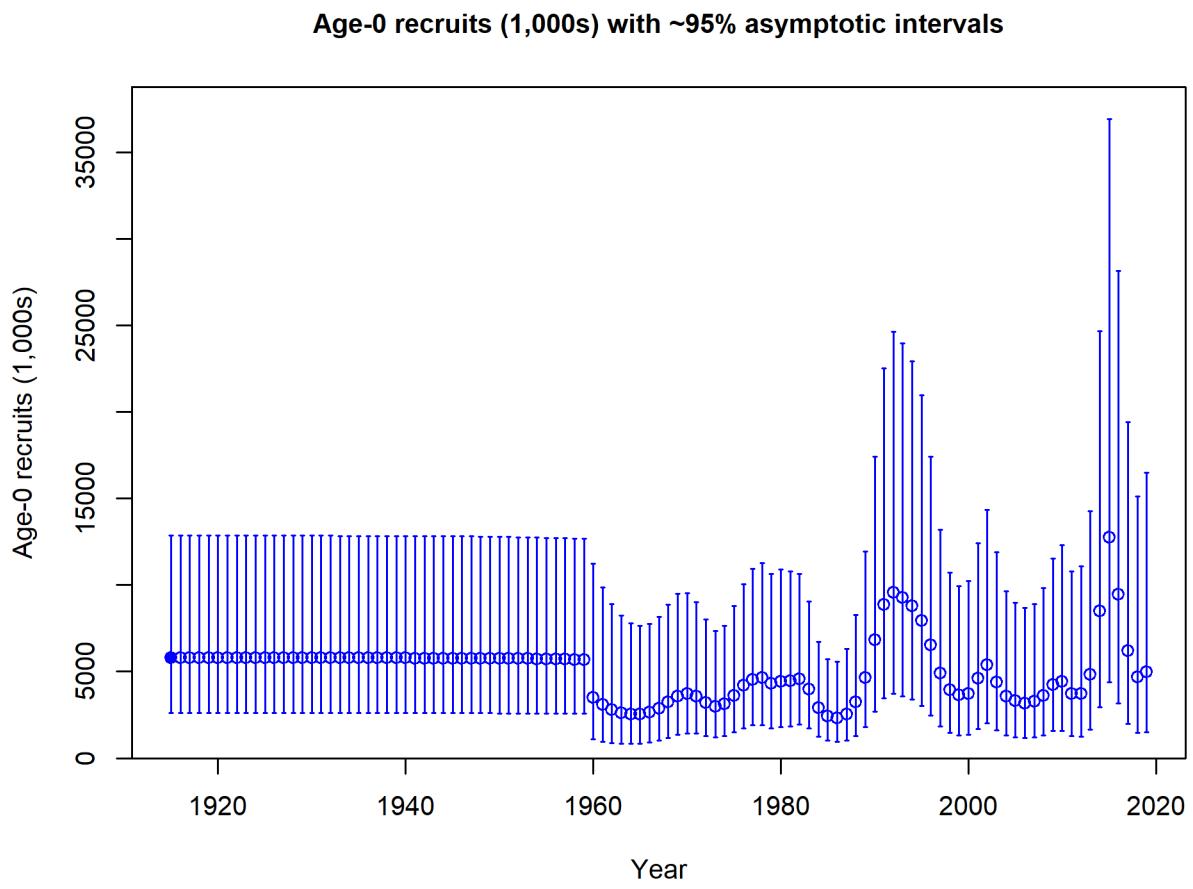


Figure g: Time series of estimated GBYR recruitments for the base-case model with 95% confidence or credibility intervals. [fig:Recruits_all](#)

₁₂₁ **Exploitation status**

exploitation-status

₁₂₂ Harvest rates estimated by the base model management target levels (Table d and
₁₂₃ Figure h).

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

Year	Fishing intensity	~ 95% confidence interval	Exploitation rate	~ 95% confidence interval	tab:SPR_Exploit_mod1
2009	0.55	0.32 - 0.77	0.07	0.04 - 0.1	
2010	0.68	0.42 - 0.93	0.10	0.06 - 0.14	
2011	0.67	0.41 - 0.92	0.09	0.05 - 0.13	
2012	0.56	0.33 - 0.8	0.07	0.04 - 0.1	
2013	0.54	0.31 - 0.77	0.06	0.04 - 0.09	
2014	0.64	0.39 - 0.88	0.08	0.04 - 0.11	
2015	0.67	0.41 - 0.92	0.08	0.04 - 0.12	
2016	0.70	0.44 - 0.96	0.08	0.04 - 0.12	
2017	0.70	0.43 - 0.96	0.07	0.03 - 0.11	
2018	0.66	0.39 - 0.93	0.06	0.03 - 0.09	

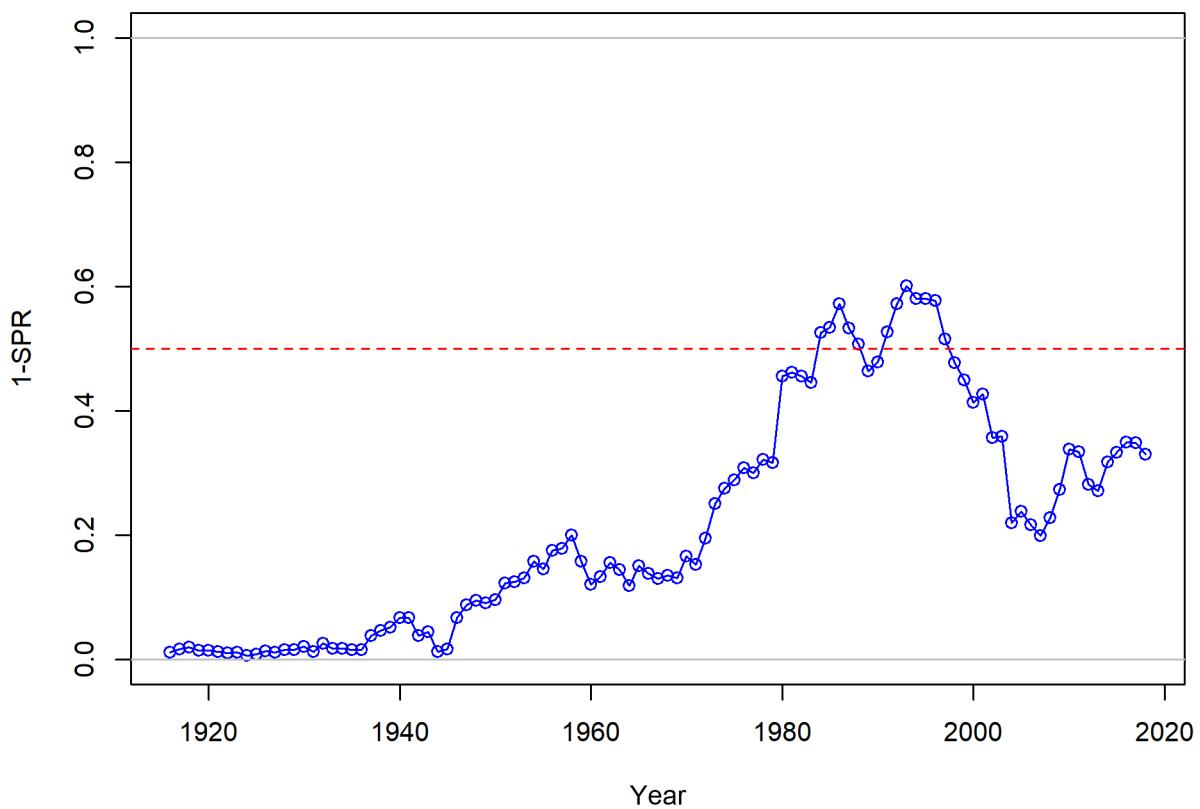


Figure h: Estimated spawning potential ratio (SPR) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing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

¹²⁴ **Ecosystem Considerations**

ecosystem-considerations

- ¹²⁵ In this assessment, ecosystem considerations were not explicitly included in the analysis.
¹²⁶ This is primarily due to a lack of relevant data and results of analyses (conducted elsewhere)
¹²⁷ that could contribute ecosystem-related quantitative information for the assessment.

¹²⁸ **Reference Points**

reference-points

- ¹²⁹ This stock assessment estimates that GBYR in the model is above the biomass target
¹³⁰ ($SB_{40\%}$), and well above the minimum stock size threshold ($SB_{25\%}$). The estimated rel-
¹³¹ ative depletion level for the base model in 2019 is 4 690% (95% asymptotic interval: ± 3
¹³² 150% - 6 230%, corresponding to an unfished spawning biomass of 647 million eggs (95%
¹³³ asymptotic interval: 329 - 965 million eggs) of spawning biomass in the base model (Table
¹³⁴ e). Unfished age 1+ biomass was estimated to be 2,356 mt in the base case model. The
¹³⁵ target spawning biomass ($SB_{40\%}$) is 551 million eggs, which corresponds with an equilibrium
¹³⁶ yield of 205 mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$
¹³⁷ is 190 mt (Figure i).

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

Quantity	Estimate	tab:Ref_pts_mod1	
		Low	High
		2.5% limit	2.5% limit
Unfished spawning output (million eggs)	1,379	948	1,809
Unfished age 1+ biomass (mt)	2,356	1,730	2,981
Unfished recruitment (R_0)	5,795	979	10,611
Spawning output(2018 million eggs)	629	330	929
Depletion (2018)	0.457	0.314	0.6
Reference points based on SB_{40%}			
Proxy spawning output ($B_{40\%}$)	551	433	670
SPR resulting in $B_{40\%}$ ($SPR_{B40\%}$)	0.458	0.458	0.458
Exploitation rate resulting in $B_{40\%}$	0.154	0.106	0.203
Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt)	205	110	299
Reference points based on SPR proxy for MSY			
Spawning output	615	483	748
SPR_{proxy}	0.5		
Exploitation rate corresponding to SPR_{proxy}	0.134	0.092	0.176
Yield with SPR_{proxy} at SB_{SPR} (mt)	190	103	277
Reference points based on estimated MSY values			
Spawning output at MSY (SB_{MSY})	292	223	362
SPR_{MSY}	0.289	0.271	0.306
Exploitation rate at MSY	0.274	0.197	0.351
Dead Catch MSY (mt)	243	124	363
Retained Catch MSY (mt)	243	124	363

¹³⁸ Management Performance

management-performance

¹³⁹ Table f

¹⁴⁰ 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 estimates 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

¹⁴¹ Decision Table

decision-table

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

Year	OFL
2019	217.28
2020	197.06
2021	194.47
2022	205.65
2023	224.80
2024	244.52
2025	258.19
2026	262.29
2027	257.14
2028	245.90
2029	232.57
2030	220.43

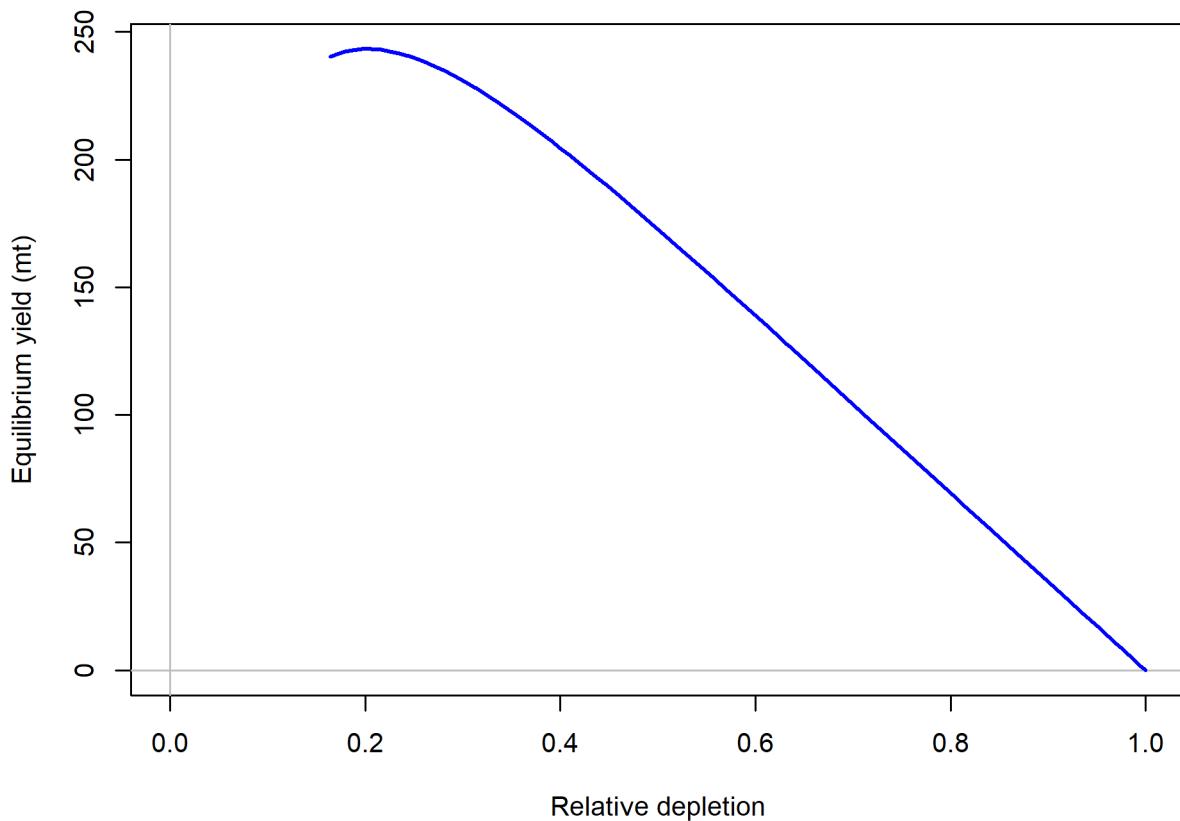


Figure i: Equilibrium yield curve for the base case model. Values are based on the 2018 fishery selectivity and with steepness fixed at 0.718. [fig:Yield_all]

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.

		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
40-10 Rule, Low M	2019	-	-	-	-	-	-
	2020	-	-	-	-	-	-
	2021	-	-	-	-	-	-
	2022	-	-	-	-	-	-
	2023	-	-	-	-	-	-
	2024	-	-	-	-	-	-
	2025	-	-	-	-	-	-
	2026	-	-	-	-	-	-
	2027	-	-	-	-	-	-
	2028	-	-	-	-	-	-
40-10 Rule	2019	-	-	-	-	-	-
	2020	-	-	-	-	-	-
	2021	-	-	-	-	-	-
	2022	-	-	-	-	-	-
	2023	-	-	-	-	-	-
	2024	-	-	-	-	-	-
	2025	-	-	-	-	-	-
	2026	-	-	-	-	-	-
	2027	-	-	-	-	-	-
	2028	-	-	-	-	-	-
40-10 Rule, High M	2019	-	-	-	-	-	-
	2020	-	-	-	-	-	-
	2021	-	-	-	-	-	-
	2022	-	-	-	-	-	-
	2023	-	-	-	-	-	-
	2024	-	-	-	-	-	-
	2025	-	-	-	-	-	-
	2026	-	-	-	-	-	-
	2027	-	-	-	-	-	-
	2028	-	-	-	-	-	-
Average Catch	2019	-	-	-	-	-	-
	2020	-	-	-	-	-	-
	2021	-	-	-	-	-	-
	2022	-	-	-	-	-	-
	2023	-	-	-	-	-	-
	2024	-	-	-	-	-	-
	2025	-	-	-	-	-	-
	2026	-	-	-	-	-	-
	2027	-	-	-	-	-	-
	2028	-	-	-	-	-	-

Table i: Base case results summary.

	Quantity	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Landings (mt)											
Total Est. Catch (mt)											
OFL (mt)											
ACL (mt)											
(1-SPR)(1-SPR _{50%})	0.68	0.67	0.56	0.54	0.64	0.67	0.70	0.70	0.70	0.66	
Exploitation rate	0.10	0.09	0.07	0.06	0.08	0.08	0.08	0.08	0.07	0.06	
Age 1+ biomass (mt)	1631.62	1554.22	1461.05	1392.82	1360.40	1341.77	1329.04	1357.66	1437.18	1558.84	
Spawning Output	908	838	779	744	718	685	658	637	629	647	
95% CI	537 - 1279	489 - 1187	449 - 1108	431 - 1058	416 - 1019	392 - 979	367 - 949	345 - 929	330 - 929	329 - 965	
Depletion	65.9	60.8	56.5	54.0	52.1	49.7	47.7	46.2	45.7	46.9	
95% CI	47.32 - 84.43	43.48 - 78.07	40.35 - 72.65	38.85 - 69.11	37.76 - 66.39	35.88 - 63.55	34.06 - 61.41	32.38 - 60	31.35 - 59.97	31.52 - 62.34	
Recruits	4419	3732	3733	4836	8499	12739	9468	6205	4678	4980	
95% CI	1585 - 12319	1292 - 10782	1258 - 11079	1638 - 14278	2927 - 24675	4397 - 36906	3184 - 28158	1985 - 19398	1447 - 15122	1504 - 16490	

¹⁴² **Research and Data Needs**

research-and-data-needs

¹⁴³ We recommend the following research be conducted before the next assessment:

¹⁴⁴ 1. xxxx:

¹⁴⁵ 2. xxxx:

¹⁴⁶ 3. xxxx:

¹⁴⁷ 4. xxxx:

¹⁴⁸ 5. xxxx:

149 **1 Introduction**

introduction

150 **1.1 Basic Information and Life History**

basic-information-and-life-history

151 *Population Structure and Complex Assessment Considerations*

152 There have been a number of analyses conducted on the genetic differentiation between go-
153 pher rockfish and black-and-yellow rockfish. The studies have yielded some range of results,
154 but have generally concluded that there is unusually low genetic differentiation between the
155 two species. The most frequently used measure of genetic analyses to evaluate evidence for
156 population differentiation is the fixation index (F_{ST}), defined as the proportion of the total
157 genetic variation in one sub-population (subscript S) relative to the total genetic variation
158 (subscript T) (Hauser and Carvalho 2008, Waples et al. 2008). Values of F_{ST} range from
159 0 to 1 where a zero value implies the populations are panmictic and a value closer to one
160 implies the two populations are genetically independent. Values of F_{ST} thought to be consis-
161 tent with biologically meaningful genetic differentiation and demographic isolation between
162 populations range from 0.05 to 0.1 (Waples and Gaggiotti 2006). It is also important to
163 note that F_{ST} values are dependent on the study's sample size and it may not necessarily be
164 appropriate to compare them across studies.

165 Morphologically, gopher and black-and-yellow rockfishes are almost indistinct, except for
166 their color variation (Hubbs and Schultz 1933). Early efforts to evaluate whether the two
167 species were genetically distinct began with an allozyme analysis by Seeb et al. (1986),
168 which did not detect genetic differentiation between gopher and black-and-yellow rockfish.
169 However, as allozymes are proteins that are often conserved, this early work was not neces-
170 sarily representative of genome-wide relationships between the two groups. In a subsequent
171 study of restriction site polymorphisms, Hunter et al. (1994) found slight but significant
172 differences between species based on restriction fragment length polymorphisms (RFLP's).
173 Following that study, an analysis of the mitochondrial control region by Alesandrini and
174 Bernardi (1999) did not detect differences between the two species, although mtDNA also
175 has limitations regarding how results can be extrapolated across the nuclear genome. Anal-
176 ysis of seven microsatellite loci by Narum et al. (2004) found an F_{ST} of 0.049 across the
177 overlapping range of the two species, which provided some evidence of divergence, although
178 such divergence is relatively low compared to other species within *Sebastes*. Those authors
179 characterized their results as suggesting that the two are “reproductively isolated incipient
180 species.” Buonaccorsi et al. (2011) found an even lower F_{ST} of 0.01 using 25 microsatellite
181 loci, and concluded that gopher and black-and-yellow rockfish “have not completed the spe-
182 ciation process.” All of these studies are indicative of low levels of genetic divergence and a
183 high probability of ongoing gene flow between the two nominal species.

184 Most recently, an analysis of rockfish species assignment using microhaplotypes by Baetscher
185 (2019) observed mistaken genetic assignment of a small number of individuals between go-
186 pher and black-and-yellow rockfishes, while no other species among the 54 rockfishes analyzed

187 resulted in mis-assignments. In addition, comparisons of F_{ST} values within the study indicated
188 that the level of genetic differentiation observed between gopher and black-and-yellow
189 rockfishes is lower than that observed among all other pairwise comparisons of the 54 species
190 in the *Sebastodes* genus that were included in their analysis. Baetscher (2019) characterized the
191 results as suggestive of the two species representing “sister species with evidence of ongoing
192 gene flow,” noting that a more rigorous evaluation of the level of genetic distinction between
193 these two species would benefit from whole-genome sequencing of representatives from each
194 species group.

195 In addition to the differences in coloration, the depth distribution and range differ between
196 the two species. The range of both species extends from Cape Blanco Oregon to Baja
197 California. Both species are uncommon north of Fort Bragg, California and black-and-yellow
198 rockfish is uncommon south of Point Conception, California. However, gopher rockfish can
199 be found as far south as Punta San Roque on the Baja peninsula. Gopher rockfish are found
200 in rocky reef habitat from the intertidal to depths of 264 ft (80 m) with a predominant depth
201 distribution of 30 to 120 ft (9-37 m), while the black-and-yellow rockfish occupies depths
202 from the intertidal to 120 ft (40 m) and is predominantly observed in depths shallower than
203 60 ft (18 m) (Eschmeyer et al. 1983, Love et al. 2002).

204 Both species are solitary, sedentary, and territorial species with home ranges of 10-12 square
205 meters (Love et al. 2002). A large percentage (67-71%) of black-and-yellow rockfish returned
206 to the site of capture within two weeks after translocated within 50 m (Hallacher 1984). Lea
207 et al. (1999) found that gopher rockfish exhibit minor patterns of movement (<12.8 km)
208 with all fish being recaptured on the same reef system where they were tagged. Matthews
209 (1985) found that 11.8% of tagged and recaptured gopher rockfish, and 25% of black-and-
210 yellow rockfish, moved from four low-relief natural reefs to a new high-relief artificial reef
211 in Monterey Bay. The maximum distance between the natural and artificial reefs traveled
212 by gopher or black-and-yellow rockfish was 1.6 km. After only a year, the fish assemblage
213 on the artificial reef closely resembled that of the nearby natural reefs. The paper did no
214 address the spatial segregation of gopher and black-and-yellow rockfish on the new artificial
215 reef.

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

222 Both species are be feed at night, with similar diets composed primarily of crabs and
223 shrimp, supplemented by fish and cephalopods (Larson 1972, 1985, Love et al. 2002). Loury
224 et al. (2015) found no significant differences in the diet of gopher rockfish inside and outside
225 the 35 year old Point Lobos Marine Protected Area (MPA). She did find the diet of gopher
226 rockfish at Año Nuevo (shallower and north of Point Lobos) was dominated by crabs and
227 dominated by brittle stars at southern, deeper study locations. Zuercher (2019) examined

228 the diets of a suite of nearshore rockfish species including black-and-yellow and found that
229 they relied on hard-bodied benthic invertebrates such as Brachyuran crabs, shrimps, other
230 arthropods, and octopus. The diet of black-and-yellow rockfish remained the same across
231 sampling years, but they occupied a lower trophic level during the upwelling season.

232 1.2 Early Life History

early-life-history

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

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

249 1.3 Map

map

250 A map showing the scope of the assessment and depicting boundaries at Cape Mendocino
251 to the north and the U.S./ Mexico border at the south (Figure 1). The recreational fishing
252 fleet was split into two fleets at Point Conception.

253 1.4 Ecosystem Considerations

ecosystem-considerations-1

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

257 1.5 Fishery Information

fishery-information

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

262 Gopher and black-and-yellow (referred to from hereon as GBYR when discussing the com-
263 plex) rockfish have been a minor component of the commercial and recreational rockfish
264 fishery since at least the late 1960s (CFIS and RecFIN). The commercial catch histories
265 of the two species cannot easily be separated (Figure 2). From 1916-1936 only black-and-
266 yellow rockfish were reported in the landings, and an average of 0.04 mt of black-and-yellow
267 rockfish are reported from 1937-1983. Black-and-yellow rockfish reappear in the landings in
268 1984 with 7.2 mt landed commercially. From 1985-1988 the trend switches and only black-
269 and-yellow rockfish appear in the commercial landings, with gopher rockfish averaging 0.1
270 mt landed, and 0 mt reported in 1987. From 1988 and on, the landings are dominated by
271 gopher rockfish, and both species are represented in the commercial landings.

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

275 The live fish fishery began in the early 1990s, with the first reported commercial landings of
276 live gopher rockfish in 1993, and black-and-yellow rockfish a year later. By 1995 over half
277 (57%; 39 mt) of the commercial landings were from the live fish fishery. This increased quickly
278 over the next few years and has been on average 84% of the landed gopher and black-and-
279 yellow rockfish (also referred to GBYR to reference the complex in this assessment) since
280 2000. The majority of the landings are from gopher rockfish north of Point Conception.
281 Landings of live GBYR south of Point Conception were higher in the late 1990s, (max. 3.2
282 mt in 1999), and have been averaging 0.4 mt since 2003.

283 The ex-vessel value of GBYR increased from less than \$40,000 in 1984 and peaked at \$680,452
284 in 1996 (Figure 3). The ex-vessel revenue has been fairly stable at around \$500,000 a year
285 since 2007. Prior to the live fish fishery in 1994, the average price per pound for either
286 species was around \$2 a pound. The live fish fishery increased the value of both species to
287 an average of \$6-\$8 a pound. The maximum reported value of either a gopher or black-and-
288 yellow rockfish was \$20 a pound in 2003.

289 The recreational GBYR fishery for California is most prominent north of Point Conception
290 throughout the entire catch history (Figure a). The recreational landings increased from
291 1928 to 1980. The sharp increase in the 1980s could be an artifact of the MRFSS sampling
292 program that began in 1980; however, the more recent recreational landings also exhibit a
293 cyclical trend of years with high catches followed by period of decreased recreational landings.
294 The CRFS era recreational total mortality represents the most accurate description of the
295 recreational fleet's catches in terms of area, mode and species (Figure 4).

296 Recreational GBYR catches are dominated by gopher rockfish north of Point Conception in
297 the private/rental (PR) and party/charter (PC or CPFV) modes. South of Point Conception
298 gopher rockfish are predominately caught by the CPFV fleet, with all other modes being
299 insignificant. The total recreational mortality of black-and-yellow rockfish south of Point
300 Conception since 2005 is 3 mt, compared to 106 mt north of Point Conception. The total
301 mortality since 2005 for gopher rockfish is 86 mt south of Point Conception and 669 mt north
302 of Point Conception.

303 1.6 Summary of Management History

summary-of-management-history

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

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

323 In 2000, changes in the PFMC’s rockfish management structure resulted in the discontinued
324 use of the *Sebastodes* complex, and was replaced with three species groups: nearshore, shelf,
325 and slope rockfishes (January 4, 2000; 65 FR 221), of which GBYR are included in the
326 nearshore group. Within the nearshore group, they are included in the “shallow nearshore
327 rockfish” component.

328 During the late 1990s and early 2000s, major changes also occurred in the way that California
329 managed its nearshore fishery. The Marine Life Management Act (MLMA), which was passed
330 in 1998 by the California Legislature and enacted in 1999, required that the FGC adopt an
331 FMP for nearshore finfish ([Wilson-Vandenberg et al. 2014](#)). It also gave authority to the
332 FGC to regulate commercial and recreational nearshore fisheries through FMPs and provided
333 broad authority to adopt regulations for the nearshore fishery during the time prior to

334 adoption of the nearshore finfish FMP. Within this legislation, the Legislature also included
335 commercial size limits for ten nearshore species including GBYR (10-inch minimum size)
336 and a requirement that commercial fishermen landing these ten nearshore species possess a
337 nearshore permit.

338 Following adoption of the Nearshore FMP and accompanying regulations by the FGC in fall
339 of 2002, the FGC adopted regulations in November 2002 which established a set of marine
340 reserves around the Channel Islands in southern California (which became effective April
341 2003). The FGC also adopted a nearshore restricted access program in December 2002
342 (which included the establishment of a Deeper Nearshore Permit) to be effective starting in
343 the 2003 fishing year.

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

352 The state of California has adopted regulatory measures to manage the fishery based on
353 the harvest guidelines set forth by the PFMC. The commercial open access and limited
354 entry fixed gear sectors have undergone three different spatial management changes in since
355 2000. Since 2005, both have managed the area south of 40°10' N. latitude as one area. The
356 open access commercial fishery is managed based on bimonthly allowable catches, that have
357 ranged from 200 pounds to 1800 pounds per two months since 2000. From 2005 to 2018, the
358 catch limits have doubled and are now set at 1200 pounds per two months (for all months)
359 with March and April remaining closed. The limited entry fixed year sector has followed the
360 same pattern as the open access sector with bi-monthly limits and a doubling of the catch
361 since 2005. The limited entry trawl fleet is managed on monthly limits on an annual basis.
362 Since 2011, the limit has been 300 pounds per month for non-IFQ species. A history of
363 California's commercial regulations from 2000-2018 can be found in [Appendix A](#). A 10-inch
364 total length minimum size limit was implemented in 1999 for both species in the commercial
365 fleet.

366 Significant regulatory changed in California's recreational sector began with a change from
367 unlimited number of hooks and lines allowed in 1999 and prior to no more than three hooks
368 and one line per angler in 2000. Since 2001, the limit has been no more than two hooks and
369 one line per angler. There is no size limit in the recreational fishery for gopher or black-and-
370 yellow rockfish. GBYR are part of the nearshore complex which has had a sub-bag limit
371 within the rockfish bag limit since 1999. The nearshore sub-bag limit has been 10 fish since
372 2005.

373 California also began spatial management, closures, and depth restrictions for the recre-
374 ational fleet in 2000. In general, the recreational season north of Point Conception extends

375 from April to December, and south of Point Conception from March to December. In the
376 area that GBYR are most commonly landed, from Monterey to Morro Bay, the depth restric-
377 tions have been between 30 and 40 fathoms until 2017. In 2017 the depth restrictions were
378 eased by 10 fathoms, opening up fishing depths along the central California coast that had
379 not been open consistently since 2002. In both 2017 and 2018, the deepest 10 fathoms was
380 closed prior to the season in December due to high by-catch rates of yelloweye rockfish, one
381 of two rockfish species that are still overfished. A full history of the recreational regulations
382 relating to the spatial management of the fleet can be found in [Appendix B](#).

383 1.7 Management Performance

[management-performance-1](#)

384 The contribution of GBYR to the minor nearshore rockfish OFLs is currently derived from
385 two sources: 1) forecasts from Key et al. ([2005](#)), from Cape Mendocino to Point Conception,
386 and 2) a Depletion Corrected Average Catch (DCAC (MacCall [2009](#))) for the area south of
387 Point Conception. The total mortality of the minor nearshore rockfish has been below the
388 ACL in all years (2011-2016). Total mortality estimates from the NWFSC are not yet
389 available are not yet available for 2017-2018. GBYR total mortality was on average 20%
390 of the total minor nearshore rockfish total mortality from 2011-2016. A summary of these
391 values as well as other base case summary results can be found in Table [f](#).

392 1.8 Fisheries Off Mexico or Canada

[fisheries-off-mexico-or-canada](#)

393 The range of GBYR does not extend north to the Canadian border, and they are rarely
394 encountered in Oregon and Washington. The southern end of the gopher rockfish's range
395 extends to Punta San Roque (southern Baja California) while the southern end of the black-
396 and-yellow rockfish's range extends to Isla Natividad (central Baja California) (Love et al.
397 [2002](#)). However, black-and-yellow rockfish are rare south of Point Conception, California.
398 This was no available information on the fishery for GBYR at the time of this assessment,
399 nor additional details on the abundance or distribution patterns in Mexican waters.

400 2 Assessment

[assessment](#)

401 2.1 Data

[data](#)

402 Data used in the GBYR assessment are summarized in Figure [5](#). Descriptions of the data
403 sources are in the following sections.

404 **2.1.1 Commercial Fishery Landings**

commercial-fishery-landings

405 *Overview of gopher and black-and-yellow catch history*

406 Commercial fishery landings for gopher and black-and-yellow rockfishes have not been re-
407 ported consistently by species throughout the available catch history (Figure 2). The period
408 from 1916-1935 indicates that only black-and-yellow rockfish were landed in the commercial
409 fishery, which then switched to predominately gopher rockfish from 1937-1984. From 1985-
410 1988 the landings data suggest that only black-and-yellow rockfish were landed and not until
411 1995 are both species well-represented in the catches. Pearson et al. (2008) noted:

412 The fact that the majority of estimated landings are not based on actual sam-
413 pling, combined with the likelihood for misidentification [between gopher and
414 black-and-yellow rockfishes], suggests that our landing estimates are generally
415 unreliable [see Figure 37 in Pearson et al. (2008)]. This is particularly true for
416 the time interval between 1983 and 1988. Between 1983 and 1988, market cat-
417 egory 962 (group gopher) landings increased sharply while market category 263
418 (gopher rockfish) landings declined (not visible in Figure 37 since the stratum
419 was unsampled and the landings were converted to unspecified rockfish). Port
420 samples indicated a shift from gopher rockfish to black-and-yellow rockfish during
421 the same time interval, suggesting problems with identification. We suggest that
422 if black-and-yellow landings are combined with gopher landings, the estimates
423 would be generally reliable for the group.

424 There is no way to tease apart the historical catches by species and even across north and
425 south of Point Conception prior to about 1995. This precludes the ability to model the catch
426 histories for either species accurately. Given these constraints, all commercial data were
427 combined to represent one commercial fleet in the assessment. Additional details regarding
428 this decision are described below.

429 The stock assessment of gopher rockfish in 2005 did not include black-and-yellow rockfish
430 landings. A comparison of the recreational and commercial landings from the 2005 assess-
431 ment to those used in this assessment suggest the 2005 assessment may have included some
432 black-and-yellow rockfish landings (Figure 6). The 2005 assessment estimated recreational
433 landings from 1969-1980 based on a ratio of commercial to recreational landings, whereas
434 this assessment makes use of the California Catch Reconstruction landings estimates (Ral-
435 ston et al. 2010).

436 *Commercial Landings Data Sources*

437 The California Catch Reconstruction (Ralston et al. 2010) contains landings estimates of
438 commercial landings from 1916-1968 and was queried on 4 April 2019 for GBYR. There were
439 no estimated gopher rockfish landings prior to 1937. Landings in this database are divided

440 into trawl and ‘non-trawl.’ Since the majority of GBYR are caught in the commercial fixed
441 gear fisheries, only estimated catch in the ‘non-trawl’ was used. A total of 0.154 mt (3.18%)
442 were removed from Eureka commercial landings (based on current proportions of commercial
443 catch from north of Cape Mendocino in Eureka) since the assessment represents the GBYR
444 stock south of Cape Mendocino. The majority of GBYR commercial landings (avg. 83%)
445 are landed in the Monterey and Morro Bay port complexes.

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

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

466 Commercial landings from 1981-2018 were queried for a final time from the CALCOM
467 database on 4 April 2019 and from PacFIN on 3 June 2019. There are very small dif-
468 ferences in commercial landings between CALCOM and PacFIN from 1981-2018 (Figure 7).
469 Landings estimates from PacFIN were used in the assessment (Table 1). Landings were
470 stratified by year, quarter, live/dead, market category, gear group, port complex, and source
471 of species composition data (actual port samples, borrowed samples, or assumed nominal
472 market category). Data from individual quarters were aggregated at the year level. Fish
473 landed live or dead were combined, due to changes over time in the reliability of condi-
474 tion information (Don Pearson, retired NMFS SWFSC, personal communication). From
475 1916-1968, on average, 74% of GBYR were landed north of Point Conception, which rose to
476 97% from 1978-2018. Given the smaller landings south of Point Conception and the similar
477 length composition of GBYR north and south of Point Conception, no spatial separation
478 was considered for the commercial fleet.

479 **2.1.2 Commercial Discards**

commercial-discards

480 The West Coast Groundfish Observer Program (WCGOP) provides observer data on dis-
481 carding across fishery sectors back to 2003. Gopher and black-and-yellow rockfishes have
482 species-specific depth-stratified commercial fishery discard mortality rates (Pacific Fishery
483 Management Council 2018). In consultation with WCGOP staff, the STAT used estimates of
484 total discard mortality from WCGOP's Groundfish Expanded Mortality Multiyear (GEMM)
485 report. WCGOP observes between 1-5% of nearshore fixed gear landings annually south of
486 40°10' N. latitude (coverage rates available [here](#)). The expanded estimates of total discard
487 weight by species is calculated as the ratio of the observed discard weight of the individ-
488 ual species divided by the observed landed weight from PacFIN landing receipts. WCGOP
489 discard estimates for the nearshore fixed gear fishery take into account the depth distribu-
490 tion of landings in order to appropriately apply the depth-stratified discard mortality rates
491 by species (Somers, K.A., J. Jannot, V. Tuttle, K. Richerson and McVeigh 2018). The
492 discard mortality for 2018 was estimated as an average of the discard mortality from 2013-
493 2017. Discard mortality was estimated from the period prior to WCGOP discard estimates
494 (1916-2002) based on the average discard mortality rate from 2003-2016 (2017 was excluded
495 because 2017 discard mortality was disproportionately higher than all other years) (Table
496 1).

497 **2.1.3 Commercial Fishery Length and Age Data**

commercial-fishery-length-and-age-data

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

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

510 A total of 46 ages were available for gopher rockfish from the commercial fisheries 2009-2011,
511 2016, and 2018. Though sparse, the data were included as conditional age-at-length for the
512 commercial fleet.

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

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

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

517 Commercial length composition data are made available from PacFIN and the expanded
518 catch-weight length compositions were provided by Andi Stephens (NWFSC) processed
519 through the [PacFIN Utilities](#) package. We compared differences between the catch-weighted
520 length composition expansions from CALCOM and PacFIN. We were unable to reconcile the
521 difference between the two data sets. Sample sizes became more similar if the PacFIN data
522 were restricted to the same market categories used by CALCOM in the expansion. However,
523 both data sets apply other filters that we did not have time to explore. For instance, in the
524 year 2000, 290 more fish were used in the CALCOM expansion than in PacFIN, but in 2002,
525 150 more fish were used in the PacFIN expansions that were not used in CALCOM. Given
526 these caveats, Figure 8 shows the percent difference in the expanded length comps within a
527 year. The biggest difference is in length bin 32 in 2006. However, the same number of fish
528 and samples were used to expand the 2006 lengths in both databases, indicating there are
529 also fundamental differences in how the data are treated. Full documentation is not available
530 for the PacFIN length composition expansion program. Consequently the STAT chose to use
531 a query that they could completely understand and selectively develop from the CALCOM
532 database for the base model, although a sensitivity was conducted using the PacFIN-derived
533 length composition data.

534 2.1.4 Recreational Fishery Landings and Discards

recreational-fishery-landings-and-discards

535 *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 Point Conception (Figure 9). The recreational catches estimated by Ralston et al. (2010) were discussed with the paper's co-authors and also Commercial Passenger Fishing Vessel (CPFV), i.e., party/charter mode, 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.

552 The California Catch Reconstruction applied a linear ramp from 1928-1936 that was
553 not altered in this assessment. From 1937-1979 a linear ramp was developed from the
554 1936 estimate to the average recreational landing from 1980 and 1983 (1981-1982 catches
555 interpolated as described in the next section) of 4.3 mt. The recreational catches north of
556 Point Conception were not altered from the original catch reconstruction. The resulting
557 alternate recreational catch streams are in (Table 3 and Figure 10).

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

559 From 1980-2003, the Marine Recreational Fisheries Statistics Survey (MRFSS) executed a
560 dockside (angler intercept) sampling program in Washington, Oregon, and California (see
561 Holliday et al. (1984) for a description of methods). Data from this survey are available from
562 the Recreational Fisheries Information Network [RecFIN](#). RecFIN serves as a repository for
563 recreational fishery data for California, Oregon, and Washington. Catch estimates for years
564 1980-2003 were downloaded on 23 March 2019, and are consistent from 1992-2004 with the
565 previous assessment (Key et al. 2005) (Figure 6).

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

581 Catches from north of Cape Mendocino were removed based on a CRFS-era average of frac-
582 tion of recreational landings north of Cape Mendocino by mode (3.3% of shore-based, 0.1% of
583 CPFV, and 0.2% of private/rental were removed). From 1980-1989, San Luis Obispo County
584 was sampled as part of Southern California (personal observation from MRFSS Type 3 sam-
585 pler examined catch where county is available for 1980-2004). This assessment separates the
586 recreational fleet at Point Conception. Recreational landings were re-allocated from southern
587 California from 1980-1992 by fleet based on the average proportion of recreational landings
588 in northern California from 1996-2004 (after sampling of the CPFV fleet in northern Cali-
589 fornia resumed). The average proportion re-allocated from southern to northern California
590 for the CPFV mode was 85%, 97% for the private/rental mode, and 81% for the shore-based
591 modes. Data were pooled over all years and modes to estimate the landings re-allocation
592 for the shore-based modes. Total recreational landings for 1981 and 1982 were 18.8 mt and

593 18.6 mt, respectively. These landings were >60 mt lower than any of the neighboring years.
594 Landings from 1981-1982 were interpolated from the 1980 and 1983 landings.

595 *California Recreational Fisheries Survey (CRFS), 2004-2016*

596 MRFSS was replaced with the California Recreational Fisheries Survey (CRFS) beginning
597 January 1, 2004. Among other improvements to MRFSS, CRFS provides higher sampling
598 intensity, finer spatial resolution (6 districts vs. 2 regions), and onboard CPFV sampling.
599 Estimates of catch from 2004-2018 were downloaded from the RecFIN database a final time
600 on 4 June 2019, We queried and aggregated CRFS data to match the structure of the MRFSS
601 data, by year, and region (Table 3). Catches in the shore-based modes are small compared
602 to the CPFV and private rental modes. All modes are combined, but separated at Point
603 Conception for two recreational fleets in this assessment, just as was done for the California
604 Catch Reconstruction and MRFSS time series.

605 *Recreational Discards*

606 Recreational discards were only added to the California Catch Reconstruction landings, as
607 Ralston et al. (2010) did not address discards for the recreational reconstruction. Recre-
608 ational removals from the California Department of Fish and Wildlife MRFSS era (1980-
609 2003) includes catch type A + B1. Catch type A refers to estimates of catch based on
610 sampler-examined catch. Catch type B1 includes mainly angler-reported discard, but also
611 angler-reported retained fish that were unavailable to the sampler during the interview (e.g.,
612 fillets). The CRFS era removals account for depth-stratified discard mortality rate and the
613 catch time series includes both retained and discarded catch (total mortality). We calculated
614 the ratio of dead discards to total mortality from the CRFS era by region and mode. The
615 region average across modes was applied to the California Catch Reconstruction as a con-
616 stant. The result added 4.68% annually to recreational removals north of Point Conception
617 and 4.05% annually to the removals South of Point Conception). The final time series of
618 landings and discard mortality are in Table 3.

619 **2.1.5 Recreational Fishery Length and Age Data**

recreational-fishery-length-and-age-data

620 Recreational length composition samples for California were obtained from several sources,
621 depending on the time period and boat mode (Table 2). This assessment makes use of a
622 much longer time series of length composition data, relative to the previous assessment, as
623 described below. Input sample sizes for recreational length composition data were based on
624 the number of observed trips, when available. Other proxies that were used to estimate the
625 number of trips are described below.

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

628 *CPFV length composition data, 1959-1978*

629 The earliest available length data for this assessment were described by Karpov et al. (1995),
630 who assembled a time series (1959-1972) of available California CPFV length data (made
631 available courtesy of W. Van Buskirk). For GBYR, data from 1959-1961 and 1966 were
632 available north of Point Conception and from 1959-1961 from south of Pt Conception. A
633 total of 716 (680 north of Point Conception) unsexed measurements of retained fish (no
634 discards) were included in the assessment (Table 2). Sampling of these length data did not
635 follow a consistent protocol over time and areas (data are unweighted), and therefore may
636 not be representative of total catch. Since the number of trips sampled was not reported
637 by Karpov et al. (1995), we assume the number of sampled trips is proportional to the
638 number of measured fish in each year, and estimated the number of trips using the ratio of
639 fish measured per trip in the MRFSS data (roughly 10 fish per trip).

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

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

647 Unsexed length data of retained fish were collected by MRFSS dockside samplers and down-
648 loaded from the RecFIN website. We identified a subset of lengths that were converted from
649 weight measurements, and these were excluded from the final data set (Table 2). The length
650 measurements from Collins and Crooke (n.d.) from 1975-1978 are assumed to all be from
651 retained fish. As of 2003, the CDFW Onboard Observer program has taken length mea-
652 surements for discarded fish. The retained catch is measured during the dockside (angler
653 intercept) surveys.

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

659 During the recent restructuring of the CRFS data on RecFIN, a “trip” identifier was not
660 carried over for all modes, and trip-level sample sizes could not be extracted from the bio-
661 logical detail table on RecFIN. A proxy for initial sample sizes for 2004-2018 were developed
662 using the 2015 data for which I had access to raw data files by mode from CDFW. In more
663 recent years, sampling of the shore-based modes has declined and were not sampled at all
664 in 2018. Samples sizes were calculated by mode as the number of port-days (or site-days for
665 shore-based modes) during bi-weekly intervals (e.g., Jan 1-15, Jan 16-31, etc). The number
666 of port-days sampled in the bi-weekly intervals was used as the initial sample size for number
667 of trips to calculate initial input sample sizes using Ian Stewart’s method (described above).
668 All length data were re-weighted in the assessment model.

669 **2.1.6 Fishery-Dependent Indices of Abundance**

[fishery-dependent-indices-of-abundance](#)

670 A summary of all indices in the assessment can be found in Table 27. Figure 11 shows each
671 index scaled to the mean value of that index to show them all on the same scale, i.e., the
672 mean of each index in the plot is 1.

673 **MRFSS Dockside CPFV Index**

674 From 1980 to 2003 the MRFSS program conducted dockside intercept surveys of recreational
675 fishing fleet. The program was temporarily suspended from 1990-1992 due to lack of fund-
676 ing. For purposes of this assessment, the MRFSS time series was truncated at 1998 due to
677 sampling overlap with the onboard observer program (i.e., the same observer samples the
678 catch while onboard the vessel and also conducts the dockside intercept survey for the same
679 vessel). Each entry in the RecFIN Type 3 database corresponds to a single fish examined
680 by a sampler at a particular survey site. Since only a subset of the catch may be sampled,
681 each record also identifies the total number of that species possessed by the group of anglers
682 being interviewed. The number of anglers and the hours fished are also recorded. The data,
683 as they exist in RecFIN, do not indicate which records belong to the same boat trip. A
684 description of the algorithms and process used to aggregate the RecFIN records to the trip
685 level is outlined Supplemental Materials (“Identifying Trips in RecFIN”).

686 Initial trip filters included eliminating trips targeting species caught near the surface waters
687 for all or part of the trip, including trips with catch of bluefin tuna, yellowfin tuna, skipjack,
688 and albacore.

689 The following filtering steps were applied to gopher rockfish, as well as the sum of the
690 two species to represent GBYR. No filtering or indices were developed for black-and-yellow
691 rockfish alone due to the sparseness in the data. In the raw data, unfiltered data, black-
692 and-yellow rockfish only occurred in 48 trips that did not also observe gopher rockfish.
693 There were an additional 65 trips that encountered both species. There was little difference
694 between indices developed for gopher-only and the GBYR complex for both north and south
695 of Point Conception (Figure 12). The descriptions of the filtering and data below represent
696 those for the GBYR complex.

697 The species composition of catch in California varies greatly with latitude.
698 Therefore, Stephens-MacCall filtering was applied independently for north and south of Point
699 Conception. Separate indices were also developed to represent two recreational fleets in the
700 model. Since recreational fishing trips target a wide variety of species, standardization of
701 the catch rates requires selecting trips that are likely to have fished in habitats containing
702 GBYR. The Stephens-MacCall (2004) filtering approach was used to identify trips with a
703 high probability of catching GBYR, based on the species composition of the catch in a given
704 trip. Prior to applying the Stephens-MacCall filter, we identified potentially informative
705 predictor species, i.e., species with sufficient sample sizes and temporal coverage (at least 30
706 positive trips total) to inform the binomial model. Coefficients from the Stephens-MacCall

707 analysis (a binomial GLM) are positive for species which co-occur with GBYR, and negative
708 for species that are not caught with GBYR. Each of these filtering steps and the resulting
709 number of trips remaining in the sampling frame are provided in Table 16.

710 *MRFSS Filtering and Index Standardization for North of Point Conception.* Prior to the
711 Stephens-MacCall filter, a total of 2,788 trips were retained for the analysis. As expected,
712 positive indicators of GBYR trips include several species of nearshore rockfish, treefish, kelp
713 rockfish, and blue rockfish, and the strongest counter-indicator was striped bass (Figure
714 13). While the filter is useful in identifying co-occurring or non-occurring species assuming
715 all effort was exerted in pursuit of a single target, the targeting of more than one target
716 species can result in co-occurrence of species in the catch that do not truly co-occur in
717 terms of habitat associations informative for an index of abundance. Stpehens and MacCall
718 (Stephens and MacCall 2004) recommended including all trips above a threshold where the
719 false negatives and false positives are equally balanced. However, this does not have any
720 biological relevance and for this data set, we assume that if a GBYR was landed, the anglers
721 had to have fished in appropriate habitat, especially given how territorial GBYR and both
722 species are strongly associated with rocky habitat.

723 Two levels of possible filtering were applied using the Stephens-MacCall filter (Table 16).
724 The Stephens-MacCall filtering method identified the probability of occurrence (in this case
725 0.4) at which the rate of “false positives” equals “false negatives.” The trips selected using
726 this criteria were compared to an alternative method including all the “false positive” trips,
727 regardless of the probability of encountering GBYR (Table 19). This assumes that if GBYR
728 were caught, the anglers must have fished in appropriate habitat during the trip. The catch
729 included in this index is “sampler-examined” and the samplers are well trained in species
730 identification. The last filter applied was to exclude years after 1999 due to a number of
731 regulation changes, and years in which there were less than 20 observed trips. The final
732 index is represented by 544 trips, 220 of which encountered GBYR.

733 Due to the large number of zeros in the data, we modeled catch per angler hour (CPUE;
734 number of fish per angler hour) using maximum likelihood and Bayesian negative binomial
735 regression. Models incorporating temporal (year, 2-month waves) and geographic (region
736 and area_x) factors were evaluated. Counties were grouped into three regions, north of
737 Sonoma county, Sonoma county through Santa Cruz county, and San Luis Obispo county.
738 Based on AIC values from maximum likelihood fits (Table 17), a main effects model including
739 all factors (year, region, area_x, and 2-month waves) was fit in the “rstanarm” R package
740 (version 2.18.2). Diagnostic checks of the Bayesian model fit (Neff, Rhat, and Monte Carlo
741 standard error values) were all reasonable. Predicted means by stratum (Year) were strongly
742 correlated with observed means, suggesting a reasonable fit to the data (Figure 15). The
743 NB model generated data sets with roughly 50-70% zeros, compared to the observed 60%
744 (Figure 16).

745 The index represents the years 1984-1989, 1995, 1996 and 1999. There is not a lot of contrast
746 in the index, except for a small increase in 1986. The final index values and associated log
747 standard error included in the assessment can be found in Table 6.

748 *MRFSS Filtering and Index Standardization for South of Point Conception.* Prior to the
749 Stephens-MacCall filter, a total of 7,334 trips were available for the analysis. As expected,
750 positive indicators of GBYR trips included several nearshore species, e.g., kelp rockfish,
751 treefish, and black croaker, while the strongest counter-indicator was opaleye (Figure 17).
752 While the filter is useful in identifying co-occurring or non-occurring species assuming all
753 effort was exerted in pursuit of a single target, the targeting of more than one target species
754 can result in co-occurrence of species in the catch that do not truly co-occur in terms of
755 habitat associations informative for an index of abundance. For consistency with the methods
756 used north of Point Conception (Table 16) the index includes the trips identified as “false
757 positives” from the Stephens-MacCall filtering that had a lower threshold level of 0.22 (Table
758 20). The last filter applied was to exclude years after 1999 due to a number of regulation
759 changes, and years in which there were less than 20 observed trips. The final index is
760 represented by 475 trips, 342 of which encountered GBYR.

761 Catch per angler hour (CPUE; number of fish per angler hour) was modelled using the delta-
762 GLM approach (Lo et al. 1992, Stefánsson 1996). A negative binomial model was explored,
763 but the proportion of zeroes was not well estimated in the negative binomial models. This
764 is likely due to the facts that MRFSS sampling effort was higher south of Point Conception,
765 and GBYR are also rare south of Point Conception, both leading to a higher proportion of
766 zeroes in the trip data than for north of Point Conception.

767 Model selection using Akaike Information Criterion (AIC) supported inclusion of year, region,
768 area_x, and 2-month waves. Counties were grouped into three regions, Santa Barbara to
769 Ventura counties, Los Angeles and Orange counties, and San Diego county for both the
770 positive observation model and the binomial model. Area_x is a measure of distance from
771 shore, a categorical variable indicating whether most of the fishing occurred inside or outside
772 three nautical miles from shore.

773 The resulting index for south of Point Conception represents different years than the index for
774 north of Point Conception (Table 6). The index starts in 1980 with continuous data through
775 1986, and three additional years in 1996, 1998 and 1999. The index increases through 1983
776 and a marked decrease to 1986. The index for the three years in the 1990s does not exhibit
777 any significant trend.

778 CPFV Onboard Observer Surveys

779 Onboard observer survey data were available from three sources for this assessment, 1)
780 a CDFW survey in central California from 1987-1998 (referred to as the Deb Wilson-
781 Vandenberg onboard observer survey, (Reilly et al. 1998)), 2) the CDFW CPFV onboard
782 observer survey from 1999-2018, and 3) a Cal Poly survey from 2003-2018. During an on-
783 board observer trip the sampler rides along on the CPFV and records location-specific catch
784 and discard information to the species level for a subset of anglers onboard the vessel. The
785 subset of observed anglers is usually a maximum of 15 people the observed anglers change
786 during each fishing stop. The catch cannot be linked to an individual, but rather to a specific
787 fishing location. The sampler also records the starting and ending time, number of anglers

788 observed, starting and ending depth, and measures discarded fish.

789 The fine-scale catch and effort data allow us to better filter the data for indices to fishing
790 stops within suitable habitat for the target species.

791 The state of California implemented a statewide sampling program in 1999 (Monk et al.
792 2014). California Polytechnic State University (Cal Poly) has conducted an independent
793 onboard sampling program as of 2003 for boats in Port San Luis and Morro Bay, and follows
794 the protocols established in Reilly et al. (1998). Cal Poly has modified protocols reflect
795 sampling changes that CDFW has also adopted, e.g., observing fish as they are encountered
796 instead of at the level of a fisher's bag. Therefore, the Cal Poly data area incorporated in
797 the same index as the CDFW data from 1999-2018. The only difference is that Cal Poly
798 measures the length of both retained and discarded fish.

799 We generated separate relative indices of abundance in for the 1987-1999 and 2000-2018
800 data sets due to the number of regulation changes occurring throughout the time period (see
801 Appendix B). Separate indices were also developed for north and south of Point Conception.

802 *Deb Wilson-Vandenberg Onboard Observer Index Filtering and Standardization.* A large
803 effort was made by the SWFSC to recover data from the the original data sheets for this
804 survey and developed into a relational database (Monk et al. 2016). The specific fishing
805 locations at each fishing stop were recorded at a finer scale than the catch data for this survey.
806 We aggregated the relevant location information (time and number of observed anglers) to
807 match the available catch information. Between April 1987 and July 1992 the number of
808 observed anglers was not recorded for each fishing stop, but the number of anglers aboard the
809 vessel is available. We imputed the number of observed anglers using the number of anglers
810 aboard the vessel and the number of observed anglers at each fishing stop from the August
811 1992-December 1998 data (see Supplemental materials for details). In 1987, trips were only
812 observed in Monterey, CA and were therefore excluded from the analysis. The years 1990
813 and 1991 were also removed for low sample sizes. Final data filters included removing reefs
814 that never encountered GBYR, drifts that had fishing times outside 95% of the data, and
815 fishing stops with depths <9 m and >69m. The final data set contained 2,411 fishing stops,
816 with 1,096 of those encountering GBYR (Figure 18).

817 The index was fit using a delta-GLM model, with a lognormal model (AIC: 1,088) selected
818 over a gamma model (AIC: 1,143) for the positive encounters. Covariates considered in
819 the full model included year, depth, and month (Table 8). The model selected by AIC for
820 both the lognormal and binomial components of the delta-GLM included year, depth and
821 reef. Depth was included in 10 m depth bins and eight reefs were select in the final model
822 (Figure coming). The final index did not indicate an increasing trend that was seen in the
823 2005 gopher rockfish assessment using the same data set (Figure 19). A number of reasons
824 include that finer-scale location data was keypunched in 2012 for this survey, the index in
825 this assessment includes black-and-yellow rockfish, and different filters were applied to the
826 data. However, the the same peaks and decreases in the two indices are present.

827 *CDFW and Cal Poly Onboard Observer Index Filtering and Standardization* As described
828 above the CDFW and Cal Poly onboard observer programs are identical in that the same

829 protocols are followed. The only difference is that Cal Poly measures both retained and
830 discarded fish from the observed anglers. CDFW measures discarded fish only from the
831 observed anglers, and measures retained fish as part of the angler interview at the bag level.
832 Cal Poly has also begun collecting otoliths during the onboard observer trips, which are used
833 as conditional age-at-length data the recreational fishery north of Point Conception in this
834 assessment.

835 A number of filters are applied to these data. All of the Cal Poly data have been through
836 a QA/QC process once key-punched, whereas a number of errors remain in the data from
837 CDFW. Data sheets from CDFW are not longer available prior to 2012 and staff constraints
838 have also prevented a quality control review of the data.

839 Each drift was assigned to a reef (hard bottom). Hard bottom was extracted from the
840 [California Seafloor Mapping Project](#), with bathymetric data from state waters available at
841 a 2 m resolution. Reefs were developed based on a number of factors described in the
842 supplemental material (“Reef Delineation”).

843 Initial filters were applied to the entire data set, north and south of Point Conception com-
844 bined. After an initial clean-up of the data, 67,850 drifts remained, with GBYR present
845 in 9,317 (Table 9). This was reduced to 25,427 drifts with GBYR present in 7,250 drifts
846 after filtering the data to remove potential outliers in the time fished and observed anglers,
847 limiting the data to reefs that observed GBYR and were sampled in at least 2/3 of all years,
848 and to drifts with starting locations within 1,000 m of a reef.

849 Recreational fishing trips north and south of Point Conception can be fundamentally different
850 due to differences in habitat structure, target species, and weather.

851 *Filtering and Index Standardization for north of Point Conception* The number of drifts
852 remaining before region specific filtering was 13,792, with 6,036 drifts encountering GBYR
853 (Table 9).

854 Because GBYR are strongly associated with hard bottom habitat, the distance from a reef at
855 the start of a drift was re-examined for drifts encountering GBYR. The maximum distance
856 was 872 m, but the 97% quantile dropped to 42 m and was chosen as a reasonable cutoff
857 value, and only resulted in a reduction of 182 drifts that encountered gopher rockfish. The
858 final data were filtered to ensure all selected reefs were sampled in at least 2/3 of all years,
859 leaving 12,965 drifts for the final index, 5,796 of which encountered GBYR (Figure 20).

860 The index of abundance was modeled with a delta-GLM modeling approach, with year,
861 month, 10 m depth bins from 10-59 m, and 12 reefs as possible covariates. A lognormal
862 model (AIC: 12,185) was selected over a gamma (AIC: 12,520) for the positive observations
863 using AIC. The full model was selected by AIC for the lognormal and binomial components
864 of the delta-GLM. The index indicates a relatively stable trend from 2001-2009 and a steady
865 decrease from 2010-2013. The relative index of abundance has increased since 2014.

866 *Filtering and Index Standardization for south of Point Conception* The bathymetric data is
867 not available at as fine-scale resolution for the Southern California Bight and more of the

868 trips and drifts target mid-water species, including mid-water rockfish (Table 9). Therefore,
869 instead of using distance to reef as a filter, we filtered the data to drifts that encountered
870 20% or more groundfish. This resulted in the total number of drifts decreasing from 11,635
871 to 5,495, but only decreased the number of drifts encountering GBYR from 1,277 to 1,171.
872 A final check was made to ensure all reefs were sampled in at least 2/3 of all years, leaving
873 5,440 drift for the final index, of which 1,132 encountered GBYR (Figure 21).

874 The index of abundance was modeled with the a delta-GLM modeling approach, with year,
875 month, 10 m depth bins from 10-59 m, and four reefs as possible covariates. A lognormal
876 model (AIC: 162) was selected over a gamma (AIC: 277) for the positive observations using
877 AIC. A model with year, depth and reef was selected by AIC for both the lognormal and
878 binomial components of the delta-GLM. The index indicates a relatively stable trend from
879 2001-2004 and a steady increase from 2005-2017.

880 **2.1.7 Fishery-Dependent Indices: Available Length and Age Data** *fishery-dependent-indices-available-length-and-age-data*

881 Length data associated with the MRFSS dockside CPFV survey and the current onboard ob-
882 server surveys conducted by CDFW are incorporated into the biological data pulled from the
883 respective data sources, MRFSS and CRFS. The additional length data are not incorporated
884 as separate length composition data as they represent the same portion of the population
885 sampled by the CDFW onboard observer program.

886 Cal Poly collected otoliths from the onboard observer program starting in 2017 as part of
887 a special study to correlate fish length before and and after the fish was filleted by the
888 deckhands onboard the CPFV vessels. All fish collected in 2017 only had associated post-
889 fillet lengths and were not used in the assessment since the study has not been finalized nor
890 has the method been endorsed by the SSC. A subset of fish form the 2018 collection included
891 both pre- and post-fillet length and were used in the assessment as conditional age-at-length
892 data associated with the recreational fleet north of Point Conception.

893 Length composition from Deb Wilson-Vandenberg's onboard observer survey are included
894 in the assessment. This program measured both retained and discarded fish, and represent
895 the portion of the population sampled with the spatial extent of the index. This onboard
896 observer program continued during the period from 1990-1992 when MRFSS was on hiatus.

897 **2.1.8 Fishery-Independent Data Sources** *fishery-independent-data-sources*

898 Neither of the two fishery-independent surveys described below have previously been used
899 in stock assessments as indices of abundance.

900 **California Collaborative Fisheries Research Project**

901 The California Collaborative Fisheries Research Project, CCFRP, is a fishery-independent
902 hook-and-line survey designed to monitor nearshore fish populations at a series of sampling
903 locations both inside and adjacent to MPAs along the central California coast (Wendt and
904 Starr 2009, Starr et al. 2015). The CCFRP survey began in 2007 and was originally designed
905 as a statewide program in collaboration with NMFS scientists and fishermen. From 2007-
906 2016 the CCFRP project was focused on the central California coast, and has monitored four
907 MPAs consistently since then (Figure 22). In 2017, the program was expanded coastwide
908 within California. The index of abundance was developed from the four MPAs sampled
909 consistently (Año Nuevo and Point Lobos by Moss Landing Marine Labs; Point Buchon and
910 Piedras Blancas by Cal Poly).

911 The survey design for CCFRP consists a number 500 x 500 m cells both within and outside
912 each MPA. On any given survey day for a chose site cells are randomly selected within a
913 stratum (MPA and/or reference cells). CPFVs are chartered for the survey and the fishing
914 captain is allowed to search within the cell for a fishing location. During a sampling event,
915 each cell is fished for a total of 30-45 minutes by volunteer anglers. Each fish encountered is
916 recorded, measured, and can be linked back to a particular angler, and released (or descended
917 to depth). Starting in 2017, a subset of fish have been retained to collect otoliths and fin clips,
918 needed biological information for nearshore species. For the index of abundance, CPUE was
919 modelled at the level of the drift, similar to the fishery-dependent onboard observer survey
920 described above.

921 The CCFRP data are quality controlled at the time they are key punched and little filtering
922 was needed for the index. Cells not consistently sampled over time were excluded as well as
923 cells that never encountered GBYR. CCFRP samples shallower depths to avoid barotrauma-
924 induced mortality. The index was constrained to 5-39m in 5 m depth bins. The final index
925 included 4,920 drifts, 3,848 of which encountered GBYR.

926 We modeled catch per angler hour (CPUE; number of fish per angler hour) using maximum
927 likelihood and Bayesian negative binomial regression. The proportion of zeroes in this data
928 was relatively small (22%), and if overdispersion were not present, the regression would
929 innately become Poisson. Models incorporating temporal (year, month) and geographic
930 (MPA site and MPA vs Reference cells) factors were evaluated. Based on AIC values from
931 maximum likelihood fits (Table 15), a main effects model including all factors (year, month,
932 site and MPA/REF) was fit in the “rstanarm” R package (version 2.18.2). Diagnostic checks
933 of the Bayesian model fit (Neff, Rhat, and Monte Carlo standard error values) were all
934 reasonable. Predicted means by stratum (Year) were strongly correlated with observed
935 means, suggesting a reasonable fit to the data (Figure 23). The NB model generated data
936 sets with roughly 18-22% zeros, compared to the observed 22% (Figure 16).

937 The CCFRP index of abundance closely matches the trend observers in the onboard observer
938 index from 2009-2018 (Figure 11). The index decreases from 2009 to 2013, and then exhibits
939 the same increase through 2018. When both indices are standardized to their means, the
940 values for 2013 and 2018 are the same.

941 *CCFRP Length Measurements and Available Ages*

942 The CCFRP program measures every fish encountered to the nearest half centimeter. A
943 total of 22,470 GBYR were measured by CCFRP from 2007-2018, of which only 212 were
944 black-and-yellow rockfish. The length distributions for each of the four MPAs used in the
945 index for this assessment show slight difference in their peaks (Figure 25). Año Nuevo is the
946 most northern site and Point Buchon the most southern.

947 Conditional age-at-length data were also incorporated into the assessment from the CCFRP
948 program, including two master's theses that are products of the CCFRP. Erin Loury (Loury
949 2011) collected gopher rockfish otoliths as part of her thesis work from 2007-2009 that in-
950 cluded specimens from both inside and outside the MPAs. Natasha Meyers-Cherry (Meyers-
951 Cherry 2014) conducted another thesis focused on the life history of gopher rockfish and
952 collected otoliths from 2011-2012, also both inside and outside the MPAs. Both MLML and
953 Cal Poly began routinely collecting otoliths from a select number of fish in 2017 as part of
954 the CCFRP program. Also included in the conditional age-at-length data for this fleet are
955 otoliths collected in 2018 by the University of California Davis Bodega Marine Lab CCFRP
956 program.

957 Partnership for Interdisciplinary Studies of Coastal Oceans

958 The Partnership for Interdisciplinary Studies of Coastal Oceans, [PISCO-UCSC](#), conducts
959 a number of surveys to monitor the kelp forests, one of which is a kelp forest fish survey.
960 PISCO has monitored fish population in the 0-20 m depth range as part of the Marine Life
961 Protection Act (MLPA) since 1998. Paired sites inside and outside MPAs are surveyed to
962 monitor the long-term dynamics of the kelp forest ecosystem and provide insight into the
963 effect of MPAs on kelp forest species. PISCO conducts the fish surveys from late July through
964 September. At each site, benthic, midwater, and canopy scuba transects are conducted at
965 5, 10, 15, and 20 m depth. All divers are trained in species identification. Along each 30
966 m transect, divers enumerate all identifiable non-cryptic fish, and measure total length to
967 the nearest centimeter. PISCO surveys are conducted by the University of California Santa
968 Cruz (UCSC) in central California and through the University of California Santa Barbara
969 in southern California. All PISCO data were provided by Dan Malone (UCSC).

970 The majority of filtering for the PISCO data set was to determine which sites to keep for
971 the final index. After initial filtering the data for GBYR in southern California were too
972 sparse to be considered for the index of abundance. Gopher and black-and-yellow rockfish
973 were also rarely observed in the midwater and canopy transects, and therefore the index is
974 based only on the benthic transects. Only sites sampled consistently throughout the time
975 period 2001-2018 were kept for the index. Multiple transects can be conducted along the
976 same line within a sampling event. All transects within a site were combined and effort was
977 modeled as the number of transects represented in the number of fish observed. The final
978 index included 3,231 transects, of which 1,729 observed GBYR (Figure 26).

979 We modeled number of fish observed per transect(s) using maximum likelihood and Bayesian
980 negative binomial regression. Models incorporating temporal (year, month) and geographic
981 (site and zone) factors were evaluated. The zone is a factor indicating the depth stratification

982 at a site, i.e., 5 m, 10 m, 15 m, or 20 m targeted bottom depth.. Based on AIC values from
983 maximum likelihood fits (Table 13), a main effects model including all factors (year, month,
984 site and zone) was fit in the “rstanarm” R package (version 2.18.2). Diagnostic checks of the
985 Bayesian model fit (Neff, Rhat, and Monte Carlo standard error values) were all reasonable.
986 Predicted means by stratum (Year) were strongly correlated with observed means, suggesting
987 a reasonable fit to the data (Figure 27). The NB model generated data sets with roughly
988 16-25% zeros, compared to the observed 23% (Figure 28).

989 The final index decreases from 2001 to the late 2000s, with lower estimates of relative abun-
990 dance from 2005-2010. From 2010 to 2015, the index increases and peaks in 2015, before
991 the decreasing trends from 2016-2018. The trend observed in this index is counter to that
992 observed in the onboard observer and CCFRP indices for north of Point Conception (Fig-
993 ure 11). The PISCO survey is sampling different habitat types than the other two surveys,
994 and covers much shallower depths. It’s possible that the PISCO index captures recruitment
995 pulses, but because this index includes both young-of-the-year and adult fish, the trend may
996 be captured in the model.

997 *PISCO Length Measurements*

998 Every GBYR observed by PISCO divers except one, had an associated length measurement
999 ($N = 11,965$). Divers measure fish to the nearest centimeter, and are trained to measure fish
1000 underwater and be aware of possible biases, e.g., ambient light, body color, visibility, and
1001 body shape. Both juvenile and adult GBYR were observed in the PISCO kelp forest fish
1002 survey data (Figure 29). Of note is the similarity in length distributions both between the
1003 species and for the two species combined across sites. Fish in the 10-17 cm size range (ap-
1004 proximately) are not observed in this survey. There is significant post-settlement mortality
1005 for both species, which is thought to be due to density-dependent predation (Johnson 2006,
1006 2007). Secondly, both species are cryptic and observed more often at night than during the
1007 day (Mark Carr, PISCO-UCSC, personal communication).

1008 **2.1.9 Biological Parameters and Data**

biological-parameters-and-data

1009 Neither gopher nor black-and-yellow rockfish have forked tails, therefore total length and
1010 fork length are equal. All of the data provided for this assessment were either in fork length
1011 or total length.

1012 (Table 4)

1013 **Length and Age Compositions**

1014 Length compositions were provided from the following sources:

- 1015 • CALCOM (*commercial retained dead fish*, 1987, 1992-2018)

- WCGOP (*commercial discarded fish*, 2004-2018)
- Deb Wilson-Vandenberg'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 30 and Table 4. Descriptions and details of the length composition data are in the above section for each fleet or survey.

Age Structures

A total of 2,421 otoliths were incorporated in this assessment and a summary by source can be found in Table 21. The final base model excludes the commercial age data that were sparse and not representative of the fishery. Gopher rockfish comprised 79% of the samples (922 females, 879 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), collected from 1983-1986 (Figure 31).

Of the available ages, 94% were collected during fishery-independent surveys. The remaining 6% were recreational dockside surveys and collected by Cal Poly during their CPFV onboard observer survey (36 otoliths) in 2018. Black-and-yellows represent 20% of the samples collected, and are mainly derived from Jody Zaitlin'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 explored by species and sex.

No significant differences were found in growth between gopher and black-and-yellow rockfishes (Figure 32) or between males and females (Figure 33), species combined.

Aging Precision and Bias

1051 Uncertainty in ageing error was estimated using a collection of 115 gopher and black-and-
1052 yellow rockfish otoliths with two age reads (Figure 35). Age-composition data used in the
1053 model were from a number of sources described above. All otoliths were read by Don Pearson
1054 (NMFS SWFSC, no retired) who also conducted all blink double reads.

1055 Ageing error was estimated using publicly available software (Thorson et al. 2012). The
1056 software setting for bias was set to unbiased since the same reader conducted the first and
1057 second readings. The best fit model chose by AIC for the standard deviation was a constant
1058 coefficient of variation for reader one ad mirrored for reader two (Figure 36).

1059 The resulting estimate indicated a standard deviation in age readings increasing from 0.74
1060 years at age 0 to a standard deviation of 2.07 years at age 28, the first year of the plus group
1061 in the assessment model.

1062 Weight-Length

1063 The weight-length relationship is based on the standard power function: $W = \alpha(L^\beta)$ where
1064 W is individual weight (kg), L is length (cm), and α and β are coefficients used as constants.

1065 The weight-length relationships was estimated from the three studies, Loury (2011), Meyers-
1066 Cherry (2014) (both gopher rockfish only from CCFRP) and Zaitlin (Zaitlin 1986) (black-
1067 and-yellow rockfish only). Only one weight-length relationship was estimated for the GBYR
1068 complex. The estimated parameters are $\alpha = 8.84e^{-006}$ and $\beta = 3.25584$. The estimated
1069 relationship is similar to that estimated by Lea et al. (1999) for gopher rockfish (Figure
1070 37). The weight-length relationship estimated here was used in the assessment model to
1071 best represent the GBYR complex.

1072 Sex Ratio, Maturity, and Fecundity

1073 The sex ratio for GBYR is assumed to be 50:50 as there is no evidence to suggest otherwise.

1074 Zaitlin (1986) found that females reached 50% maturity at 17.5 cm or 4 years of age in
1075 Central California and were 100% mature by age 6, with the same age of maturity found
1076 in southern California though individuals were smaller at age; all ages from this study were
1077 surface ages and have been re-read for this assessment. Echeverria (1987) estimated maturity
1078 for 17 rockfish species in central California. She found the size at first maturity and the size
1079 at 50% maturity for male and female gopher rockfish to be 17 cm total length, and 100%
1080 mature by 21 cm. Black-and-yellow rockfish males and females were first mature at 14 cm,
1081 50% of females were mature at 15 cm, 50% of males mature at 16 cm. Male black-and-yellow
1082 rockfish were 100% mature at 20 cm and females at 19 cm. In southern California waters,
1083 both males and females were found to reach first maturity at 13 cm total length (Larson
1084 1980). We did not have any samples from southern California to re-analyze the maturity
1085 ogive for that portion of the population.

1086 The maturity data from Zaitlin (1986) (422 black-and-yellow rockfish) were re-analyzed along
1087 with samples from Meyers-Cherry (2014) (115 gopher rockfish). Combining the two data sets
1088 provided an updated maturity ogive for the GBYR complex females (Figure 34). The first
1089 observed mature fish was 19 cm and the length at 50% was 21.66 cm, larger than suggested
1090 from the studies in the 1980s. Using only the gopher data, 50% was estimated at 23.33 cm
1091 and for black-and-yellow rockfish at 21.26 cm. An important note is that the smaller fish
1092 from these studies were black-and-yellow rockfish and the larger fish were gopher rockfish.
1093 Although not used in this assessment, the estimate of 50% maturity for 23 GBYR from
1094 these studies was 21.88 cm. The age at 50% mature increased in this assessment to 21.66
1095 cm, which is 3.96 cm larger than the value used in the 2005 assessment.

1096 Mature females in central California release larvae between January and July, peaking in
1097 February, March, and May (Larson 1980, Lea et al. 1999, Love et al. 2002). Both species of
1098 GBYR release one brood per season (Love et al. 2002). Black-and-yellow rockfish females
1099 can produce 25,000 - 450,000 eggs spawning from January to May. Gopher rockfish females
1100 ranging between 176 and 307 grams carry approximately 249 eggs per gram of body weight
1101 (MacGregor 1970). The fecundity estimates used in this assessment were provided by E.J.
1102 Dick (NMFS SWFSC) from a meta-analysis of fecundity in the genus *Sebastodes* (Dick et al.
1103 2017).

1104 Natural Mortality

1105 Hamel (2015) developed a method for combining meta-analytic approaches to relating the
1106 natural mortality rate M to other life-history parameters such as longevity, size, growth
1107 rate and reproductive effort, to provide a prior on M . In that same issue of ICESJMS,
1108 Then et al. (2015), provided an updated data set of estimates of M and related life history
1109 parameters across a large number of fish species, from which to develop an M estimator
1110 for fish species in general. They concluded by recommending M estimates be based on
1111 maximum age alone, based on an updated Hoenig non-linear least squares (nls) estimator
1112 $M = 4.899 * A_{max}^{-0.916}$. The approach of basing M priors on maximum age alone was one that
1113 was already being used for west coast rockfish assessments. However, in fitting the alternative
1114 model forms relating $-0.916M$ to A_{max} , Then et al. (2015) did not consistently apply their
1115 transformation. In particular, in real space, one would expect substantial heteroscedasticity
1116 in both the observation and process error associated with the observed relationship of M to
1117 A_{max} . Therefore, it would be reasonable to fit all models under a log transformation. This
1118 was not done. Reevaluating the data used in Then et al. (2015) by fitting the one-parameter
1119 A_{max} model under a log-log transformation (such that the slope is forced to be -1 in the
1120 transformed space (as in Hamel (2015)), the point estimate for M is:

$$M = \frac{5.4}{A_{max}} \quad (1)$$

1121 The above is also the median of the prior. The prior is defined as a lognormal with mean
1122 $\ln \frac{5.4}{A_{max}}$ and SE = 0.4384343 (Owen Hamel, personal communication, NMFS). Using a max-

1123 imum age of 28 the point estimate and median of the prior is 0.211138, which is used as a
1124 prior for in the assessment model.

1125 **2.1.10 Environmental or Ecosystem Data Included in the Assessment** environmental-or-ecosystem-data-included-in-the-assessment

1126 In this assessment, neither environmental nor ecosystem considerations were explicitly in-
1127 cluded in the analysis. This is primarily due to a lack of relevant data and results of analyses
1128 (conducted elsewhere) that could contribute ecosystem-related quantitative information for
1129 the assessment.

1130 **2.2 Previous Assessments**

previous-assessments

1131 **2.2.1 History of Modeling Approaches Used for this Stock** history-of-modeling-approaches-used-for-this-stock

1132 This is the first full assessment for black-and-yellow rockfish. Black-and-yellow rockfish was
1133 assessed coastwide as a data poor species using Depletion-Based Stock Reduction Analysis
1134 (DB-SRA) (Dick and MacCall [2010](#)). The DB-SRA model assigned a 40% probability that
1135 the then recent (2008-2009) catch exceeded the 2010 OFL.

1136 Gopher rockfish south of Point Conception was assessed as a data poor species in 2010 (Dick
1137 and MacCall [2010](#)). A Depletion-Corrected Average Catch (DCAC) model was used due to
1138 time constraints. The mean yield from the DCAC distribution was 25.5 mt.

1139 Gopher rockfish north of Point Conception ($34^{\circ}27'$ N. latitude) was first assessed a full stock
1140 assessment in 2005 (Key et al. [2005](#)) using SS2 (verion 1.19). The assessment was sensitive
1141 to the CPVF onboard observer index of abundance (referred to as Deb Wilson-Vandenbergs
1142 onboard observer index in this assessment). The final decision table was based around the
1143 emphasis given to the index, with a value of 5 given a 40% probability and used in the
1144 baseline model. The stock was found to be at 97% depletion.

1145 **2.2.2 2005 Assessment Recommendations**

assessment-recommendations

1146 The 2005 STAR panel only had one recommendation specific to gopher rockfish. However,
1147 they had a number of generic rockfish recommendations that can be found in the STAR
1148 panel report available [here](#).

1149 **Recommendation 1:** Additional length and age composition data should be
1150 collected for gopher rockfish. This would help to characterize spatial and

1151 **possibly temporal variation in growth**

1153 2019 STAT response: Additional age and length data have been collected from a num-
1154 ber of sources, the majority of which have been fishery-independent studies, including
1155 two master's theses focused on gopher rockfish. Only a handful of otoliths have been
1156 collected for gopher rockfish south of Point Conception. Additional length composition
1157 data are available since the last assessment.

1158

2.3 Model Description

model-description

1159 The mode descriptions in the following sections reflect decisions and modelling choices the
1160 STAT team made prior to the STAR panel. Changes from the pre-STAR base model to the
1161 final post-STAR base model are documented in the “Responses to the Current STAR Panel
1162 Requests” section. None of the data changed during the STAR panel, and the figures and
1163 tables reflect the post-STAR final base model.

1164

2.3.1 Transition to the Current Stock Assessment

transition-to-the-current-stock-assessment

1165 The first formal stock assessment for gopher rockfish was conducted in 2005 (Key et al.
1166 2005). There are two major differences between the 2005 assessment this assessment, 1) this
1167 assessment models gopher and black-and-yellow rockfish as a complex, and 2) this assessment
1168 includes the area south of Point Conception.

1169 The 2005 model conducted in SS2 version 1.19 was first transitioned to SS3.24z as a bridge
1170 model, before moving forward to SS3.30. Below, we describe the most important changes
1171 made since the last full assessment in 2005 and explain rationale for each change. Some of
1172 these items are changes due to structure changes with Stock Synthesis, and some denote
1173 parameters chosen for options that were not available in SS2 (version 1.19).

1174 Changes in the bridge model from SS2 version 1.9 to SS3.24z and SS3.30.13.08 include:

1175 The way growth is modeled for age-0 fish has changed. More recent versions of Stock Syn-
1176 thesis model length-at-age for fish below the first reference age (A_{min}) as linearly increasing
1177 from the initial length bin to the length given by the $L_{at}A_{min}$ parameter. The minimum
1178 population length bin was reduced from 10 cm in the 2005 assessment to 4 cm in this as-
1179 essment. The timing of settlement was set at July to reflect the month at which the
1180 young-of-the-year are expected to be at 4 cm (Figure 38). The length data leading to this
1181 decision were provided by Diana Baetscher (UCSC) and were collected via Standard Mon-
1182 itoring Unit for the Recruitment of Fishes (SMURFs) (???) from the UCSC-PISCO kelp
1183 forest fish survey as part of her dissertation work on rockfish genetics (Baetscher 2019).

1184 This stock assessment retains a single fleet for the commercial fishery, and also includes
1185 a commercial discard fleet. Data on commercial discards were not available for and not
1186 included in the 2005 assessment. The decision to retain one commercial fleet was made by
1187 examining the length distributions across species, fishing gears, and space, i.e., north and
1188 south of Point Conception (Figure 39). There is very little difference between the length
1189 composition of gopher and black-and-yellow rockfish landed in the commercial fleet north
1190 of Point Conception which contributed 97% of the commercial landings from 1978-2018.
1191 The length distributions suggest that gopher rockfish south of Point Conception landed
1192 dead south of Point Conception dead are slightly smaller on average than north of Point
1193 Conception. However, there is not enough data available to justify splitting the commercial
1194 fishery north and south of Point Conception. The length compositions of discarded fish are
1195 small in all for of the subplots, suggesting size-based discarding. Because Stock Synthesis
1196 is not set up to handle depth-dependent discard mortality rates and we're modelling two
1197 species as a complex with differing depth-dependent discard mortality rates, the time series
1198 of commercial discards was incorporated as a fleet.

1199 This assessment incorporates the area south of Point Conception, which was previously
1200 excluded from the 2005 assessment. The length composition data suggested that while the
1201 lengths of gopher and black-and-yellow rockfish were similar, fish encountered south of Point
1202 Conception were smaller (Figure 40). The recreational catches from the man made mode
1203 are negligible and did not influence the decision to split the fleet at Point Conception. The
1204 similarity of the length distributions between species and among modes within a region were
1205 similar and justified one recreational fleet.

1206 The 2005 model was a length-based model. This assessment uses conditional age-at-length
1207 from fish aged from a number of sources (Table 21).

1208 Differences in both the recreational and commercial catches used in this assessment are
1209 described in detail in the 1.5 section.

1210 The bias adjustment for recruitment deviations did not exist in SS2 (version 1.19). We set
1211 1973-2012 as the range of years with full bias adjustment to span the time series that was
1212 modeled.

1213 The previous assessment modeled selectivity of the commercial fleet as logistic curve, and
1214 both parameters for the logistic selectivity were estimated. Selectivity for the onboard CPFV
1215 survey and recreational fleet were modeled using the double logistic. The current assessment
1216 uses the six parameter double normal for all fleets for which selectivity is estimated and not
1217 mirrored. The MRFSS dockside CPFV surveys and the CPFV onboard observer surveys are
1218 mirrored to the recreational fishing fleets, north and south of Point Conception, respectively.

1219 The 2005 assessment did not include any time blocks. This assessment includes two time
1220 blocks for the commercial fleet (1916-1998 and 1999-2018). A 10-inch minimum size limit
1221 was placed on the commercial fleet in 1999, which was reflected in the CALCOM length
1222 composition data. No additional time blocks were added for the recreational fleet. GBYR

1223 are a minor component of the nearshore rockfish complex and no significant changes were
1224 detected in the landings or length composition during the time when regulations changed
1225 (1999-2002).

1226 The 2005 assessment considered two candidate fishery-dependent indices of abundance, the
1227 Deb Wilson-Vandenbergh onboard observer CPFV survey and a dockside intercept survey
1228 from MRFSS and RecFIN from 1983-2003. However, the dockside index was removed at the
1229 request of the STAR panel, citing “did not provide a reliable measure of relative abundance
1230 due to changes in regulations and fishery targeting during the 1990s-2000s.” The current
1231 assessment uses a version of the MRFSS database that has been more robustly aggregated to
1232 the trip level. Starting in 1999, the CDFW began the onboard observer program (described
1233 in the indices of abundance). Once the program ramped up by the mid-2000s, almost all of
1234 the CPFV groundfish trips sampled as onboard observer trips were also sampled as angler
1235 intercept surveys, i.e., dockside interviews. Using both the onboard observer data and the
1236 dockside interviews for this time period would result in developing indices from the same
1237 fish. The onboard observer program provides greater detail in terms of catch and location
1238 than the dockside sampler examined catch. The onboard observer indices do not include the
1239 years 1999 and 2000 due to the number of regulation changes occurring in those two years.

1240 The fishery-independent indices are all new for this assessment; the PISCO kelp forest fish
1241 survey and the CCFRP hook-and-line survey.

1242 Maturity was changed for this assessment based upon newly available data described in the
1243 biological specifications of this assessment.

1244 The 2005 assessment pre-STAR base model fixed steepness for gopher rockfish at 1.0, which
1245 was then changed to 0.65 (the Dorn prior at the time) during the STAR panel. In this
1246 assessment, steepness was set at 0.72, the mean of the prior developed from a meta-analysis of
1247 West Coast groundfish, with a standard deviation of 0.16 (see Accepted Practices Guidelines
1248 for Groundfish Stock Assessments in the supplemental material).

1249 The prior for female natural mortality was updated to the median of the prior from a meta-
1250 analysis conducted by Owen Hamel (see Accepted Practices Guidelines for Groundfish Stock
1251 Assessments in the supplemental material). Assuming a maximum age of 28 years, the
1252 median of the prior is 0.211138, close to the fixed value used in the 2005 assessment of 0.2.

1253 Due to the fact that the 2005 model only included gopher rockfish and excluded the area
1254 south of Point Conception, a complete bridge model was not developed. Comparison of
1255 the 2005 input data, catch streams, and indices are provided throughout the document in
1256 appropriate sections.

1257 **2.3.2 Summary of Data for Fleets and Areas**

summary-of-data-for-fleets-and-areas

1258 There are 12 fleets in the base model. They include:

1259 *Commercial*: The commercial fleets include two separate fleets, one for GBYR landed (all
1260 gears combined), and one for commercial dead discards.

1261 *Recreational*: The recreational fleets include two fleets, one for north of Point Conception
1262 and one for south of Point Conception (all mode combined).

1263 *Fishery-Dependent Surveys*: There are five fishery-dependent survey fleets, one each for
1264 north and south of Point Conception from the MFRSS CPFV dockside survey, one each
1265 for north and south of Point Conception from the CDFW/Cal Poly onboard observer survey,
1266 and one from the Deb Wilson-Vandenberg CPFV onboard observer survey that represents
1267 north of Point Conception only.

1268 *Research*: There are third main sources of fishery-independent data available the CCFRP
1269 survey the PISCO kelp forest fish survey. A third survey fleet is included as a “dummy”
1270 fleet to allow incorporation of additional conditional age-at-length composition data from the
1271 Zaitlin and Abrams theses, the Pearson groundfish cruise, and the special study conducted
1272 during the SWFSC’s juvenile rockfish and ecosystem cruise. This dummy fleet includes 1,067
1273 ages of gopher and black-and-yellow rockfish. This dummy fleet does not have any length or
1274 catches associated with it.

1275 2.3.3 Other Specifications

other-specifications

1276 Stock synthesis has a broad suite of structural options available. Where possible, the ‘default’
1277 or most commonly used approaches are applied to this stock assessment. The assessment
1278 is a one-sex model, as no significant differences in growth between males and females was
1279 detected in external analyses.

1280 The length composition data for some years and fleets was small, and may not be representative
1281 of the total catch. Length composition data were removed from the model if fewer
1282 than 20 fish were measured in a given year and fleet. From 1985-1989, two surveys measured
1283 fish from the recreational party/charter fleet, the Ally et al. (Ally et al. 1991) onboard
1284 observer survey and the dockside intercept survey. The number of trips and fish sampled by
1285 the onboard observer survey was far greater than the RecFIN survey and were used in the
1286 model. Initial input sample sizes were also capped at 400 for each set of length composition
1287 data.

1288 The time-series of landings begins in 1916 for the commercial fleet and in 1928 for the
1289 recreational fleet. This captures the inception of the fishery, so the stock is assumed to be
1290 in equilibrium at the beginning of the modeled period.

1291 The internal population dynamics model tracks ages 0-28, where age 28 is the ‘plus-group.’
1292 There are relatively few observations in the age compositions that are greater than age 28.
1293 The population length bins and the length composition length bins are set at 1-cm bins from
1294 fish 4-40 cm.

1295 The extra standard deviation parameter was added to all indices except the Deb Wilson-
1296 Vandenberg CPFV onboard observer index and the MRFSS dockside index for north of Point
1297 Conception that both had relatively large estimated variances associated with them. The
1298 extra parameter was explored, but estimated to be on the lower bound, and was removed for
1299 the final base model. All other indices, both recent recreational onboard observer indices,
1300 CCFRP, PISCO, and the MRFSS dockside index south of Point Conception, were estimated
1301 with relatively small variances (10-20%) from their respective indices. Extra variance was
1302 estimated for these indices in the base model.

1303 The following likelihood components are included in this model: catch, indices, discards,
1304 length compositions, age compositions, recruitments, parameter priors, and parameter soft
1305 bounds. See the SS technical documentation for details (???).

1306 Electronic SS model files including the data, control, starter, and forecast files can be found
1307 on the [PFMC ftp site](#).

1308 2.3.4 Modeling Software

`modeling-software`

1309 The STAT team used Stock Synthesis 3 version 3.30.13.08 by Dr. Richard Methot at the
1310 NWFSC. This most recent version was used, since it included improvements and corrections
1311 to older versions. The r4SS package (GitHub release number v1.35.1) was used to post-
1312 process output data from Stock Synthesis.

1313 2.3.5 Data Weighting

`data-weighting`

1314 Length composition and conditional-age-at-length (CAAL) compositions sample sizes for the
1315 base model were tuned by the “Francis method,” based on equation TA1.8 in Francis (???),
1316 and implemented in the r4ss package. This approach involves comparing the residuals in
1317 the model’s expected mean length with respect to the observed mean length and associated
1318 uncertainty derived from the composition vectors and their associated input sample sizes.
1319 The sample sizes are then tuned so that the observed and expected variability are consistent.
1320 After adjustment to the sample sizes, models were not re-tuned if the bootstrap uncertainty
1321 value around the tuning factor overlapped 1.0.

1322 As outlined in the Best Practices, a sensitivity run was conducted with length and
1323 conditional-age-at-length (CAAL) compositions were re-weighted using the Ianelli-McAllister
1324 harmonic mean method (???). Additionally, weighting using the Dirichelet-Multinomial
1325 likelihood, that includes and estimable parameter (theta) that scales the input sample
1326 size, was explored. However, the model did not converge when the Dirichelet-Multinomial
1327 likelihood was applied to a number of of the fleets with composition data. Given this, and
1328 the current challenges with this method described in the Stock Synthesis manual (???), the
1329 Francis weightings were applied in the base model.

1330 A series of sensitivities were conducted to determine the need to estimate extra variability
1331 parameters were estimated and added to the survey CPUE indices, and described below in
1332 the Estimated Parameters section.

1333 2.3.6 Priors

priors

1334 The log-normal prior for female natural mortality were based on a meta-analysis completed
1335 by Hamel (2015), as described under “Natural Mortality.” Natural mortality was estimated
1336 using with a prior of, 0.211 for an assumed maximum age of 28.

1337 The prior for steepness (h) assumes a beta distribution with parameters based on an update
1338 for the Thorson-Dorn rockfish prior (Dorn, M. and Thorson, J., pers. comm.), which was
1339 endorsed by the Science and Statistical Committee in 2019. The prior is a beta distribution
1340 with $mu=0.72$ and $sigma=0.16$. Steepness is fixed in the base model at the mean of the
1341 prior.

1342 2.3.7 Estimated and Fixed Parameters

estimated-and-fixed-parameters

1343 A full list of all estimated and fixed parameters is provided in Tables 23. Time-invariant,
1344 growth is estimated in this assessment, with all SS growth parameters being estimated. The
1345 log of the unexploited recruitment level for the Beverton-Holt stock-recruit function is treated
1346 as an estimated parameter. Annual recruitment deviations are estimated beginning in 1978.
1347 The survey catchability parameters are calculated analytically (set as scaling factors) such
1348 that the estimate is median unbiased, which is comparable to the way q is treated in most
1349 groundfish assessments.

1350 The base model has a total of 111 estimated parameters in the following categories:

- 1351 • Natural mortality
- 1352 • Equilibrium recruitment (R_0) and 71 recruitment deviations
- 1353 • Stock recruitment autocorrelation parameter
- 1354 • Five growth parameters
- 1355 • Five index extra standard deviation parameter, and
- 1356 • 27 selectivity parameters

1357 The estimated parameters are described in greater detail below and a full list of all estimated
1358 and parameters is provided in Table 23.

1359 *Growth.* Five growth parameters were estimated for the one-sex model: three von Bertalanffy parameters and two parameters for CV as a function of length-at-age related to variability in length-at-age for small and large fish.

1362 *Natural Mortality.* The estimated natural mortality of 0.217647 is close to the mean of the
1363 prior, 0.1928571.

1364 *Selectivity.* Selectivity for all fleets was estimated as double-normal.

1365 Selectivity was estimated as asymptotic for the commercial fleet, with one time block.
1366 Asymptotic selectivity was also estimated for both recreational fleets, Deb Wilson-Vandenberg's onboard observer survey, and the PISCO. Three parameters were estimated
1368 for each of these fleets, the peak, the ascending width, and the selectivity at the first bin.

1369 Dome-shaped selectivity was estimated for the commercial discard fleet and the CCFRP
1370 survey. Five of the size parameters were estimated for the commercial discard selectivity
1371 (selectivity at the last bin was fixed). Four parameters were estimated for the CCFRP
1372 length compositions (selectivity at the first and last bins was fixed)

1373 *Other Estimated Parameters.* Recruitment deviations for the base model are estimated from
1374 1978 to 2018. The base model also included estimated recruitment deviations for the forecast
1375 years, although these have no impact on the model estimates for the current year.

1376 Many variations of the base case model were explored during this analysis. Sensitivities to
1377 asymptotic vs. domed selectivity were explored for the appropriate fisheries, e.g. commercial
1378 fisheries and surveys, as well as estimating selectivity and mirroring fleet selectivities. Time
1379 blocked selectivity without the time block from 1999-2019 for the recreational fisheries was
1380 investigated.

1381 Much time was also spent tuning the advanced recruitment bias adjustment options.
1382 Sensitivities were performed to each of the thirteen advanced options for recruitment, e.g.,
1383 early recruitment deviation start year, early recruitment deviation phase, years with bias
1384 adjustments, and maximum bias adjustment. The final base model sets the first year of
1385 recruitment deviations just prior to when the majority of fishery/survey length composition
1386 are available.

1387 Initial runs showed that the estimated recruitments were highly auto-correlated.
1388 Therefore, an auto-correlation parameter was late estimated and its value was estimated to
1389 be positive and significantly different from zero.

1390 Several models were also investigated where steepness and natural mortality were either
1391 estimated, fixed at their respective priors.

1392 Xi, Anything else to add to this section??

1393 *Other Fixed Parameters.* The stock-recruitment steepness is fixed at the SSC approved
1394 steepness prior for rockfish of 0.72.

1395 2.4 Model Selection and Evaluation

model-selection-and-evaluation

1396 2.4.1 Key Assumptions and Structural Choices

key-assumptions-and-structural-choices

1397 Key assumptions in the model are that it is appropriate to model gopher and black-and-
1398 yellow rockfish as a complex. The catch histories are inseparable at this time, especially
1399 for the commercial landings. The biological information available also precluded complete
1400 analyses of difference in growth, i.e., the majority of black-and-yellow rockfish aged were
1401 small fish and small fish were lacking for gopher rockfish. Data from both species were used
1402 to provide a complete picture of the growth curve.

1403 The assessment is a one area model with fleets as areas for the recreational fishery. There
1404 were only a handful of aged gopher rockfish from south of Point Conception, and not enough
1405 other biological information available that would have justified a multi-area model.

1406 2.4.2 Alternate Models Considered

alternate-models-considered

1407 A number of models were run with different catch histories for the recreational fleet south of
1408 Point Conception, given that the catch histories were modified from the original data. None
1409 of the alternatives explored altered the model at any significant level due to the fact that
1410 the recreational catches south of Point Conception are relatively small. Results from select
1411 sensitivity runs compared to the base model are in Table 26.

1412 Two sensitivities were also performed altering the commercial discard catch history. The
1413 discard catch was set to zero for all years prior to 2004, the year when WCGOP estimates
1414 were first available, and to a constant rate of 17% of the commercial landings, the maximum
1415 discard rate observed in the WCGOP data. Neither of these sensitivities resulted in any
1416 significant change to the model outputs.

1417 Sensitivities of the model to the spawning and settlement months were also explored. The
1418 base model originally set settlement month to January. Both gopher and black-and-yellow
1419 rockfish settle at a small size (~2 cm) and over a course of several months. After exploring the
1420 young-of-the-year length data made available by Diana Baetscher, the timing of settlement
1421 was moved to July for the base model, when the majority of GBYR are 4 cm, the size of the
1422 smallest length bin. The change of the timing of settlement had little effect on the model
1423 results.

- 1424 Runs of the base case model estimating steepness were also considered.
- 1425 A sensitivity of the model to using the commercial length composition data from PacFIN
1426 was also considered. The fits to the changed only slightly, (increasing depletion from 0.46
1427 to 0.48) but given the concerns outlined in the discussion on commercial length composition
1428 the base model includes the commercial length compositions from CALCOM.
- 1429 Sensitivities were developed to look at alternate selectivity patterns for the the commercial
1430 discard fleet and the CCFRP survey. Neither of the length compositions for these fleets
1431 observed larger fish. A time block for the commercial discard fishery was not considered
1432 since no length composition of discarded fish were available prior to 2004.
- 1433 Xi, any others to add here?

1434 2.4.3 Convergence

convergence

- 1435 Model convergence was determined by starting the minimization process from dispersed val-
1436 ues of the maximum likelihood estimates to determine if the model found a better minimum.
1437 Jitter is a SS option that generates random starting values from a normal distribution logis-
1438 tically transformed into each parameter's range (???). This was repeated 240 times and the
1439 minimum was reached in xx% of the runs (Table 22). The model did not experience conver-
1440 gence issues, e.g., final gradient was below 0.0001, when reasonable starting values were used
1441 and there were no difficulties in inverting the Hessian to obtain estimates of variability. We
1442 did sensitivity runs for convergence by changing the phases for key estimated parameters;
1443 neither the total log-likelihood nor the parameter estimates changed.

1444 2.5 Response to the Current STAR Panel Requests

response-to-the-current-star-panel-requests

- 1445 To be populated after the STAR panel.

1446 2.6 Base Case Model Results

base-case-model-results

- 1447 The following description of the model results reflects a base model that was developed prior
1448 to the STAR panel (this section will be updated after the STAR panel). The base model
1449 parameter estimates and their approximate asymptotic standard errors are shown in Table
1450 23 and the likelihood components are in Table 24. Estimates of derived reference points
1451 and approximate 95% asymptotic confidence intervals are shown in Table e. Time-series of
1452 estimated stock size over time are shown in Table 25.
- 1453 Steepness of the assumed Beverton-Holt stock-recruitment relationship was fixed at 0.72,
1454 and natural mortality was estimated to be 0.22.

1455 **2.6.1 Parameter Estimates**

parameter-estimates

1456 The base model produces estimates of growth parameters different from the external esti-
1457 mates. The external estimate of the von Bertalanffy growth coefficient k was 0.247, whereas
1458 the internal estimate was much lower at 0.121. Using the Schnute parameterization with the
1459 age for L1 set at 2 and L2 at 23, the external estimates of lengths at Amin and Amax were
1460 13.80 and 28.22, respectively. The internal estimates of the lengths for Amin and Amax were
1461 9.72 and 28.36, respectively. Natural mortality was estimated in the base model and natural
1462 mortality and the growth parameter k are negatively correlated, and the model sensitivity
1463 to growth and natural mortality are explored in the sensitivities.

1464 The additional survey variability (process error added directly to each year's input variabil-
1465 ity) for all surveys was estimated within the model.

1466 Selectivity curves were estimated for the fishery and survey fleets. The estimated selectivities
1467 for all fleets within the model are shown in Figure 41. The commercial fishery selectivities
1468 are all asymptotic. Maximum selectivity for the commercial fleet is reached at 34 cm from
1469 1916-1998 and also selected fish smaller than recent years. The implementation of the 10-
1470 in size limit resulted in a steeper selectivity curve, with fish fully selected at 31 cm from
1471 1999-2018 (Figure 42).

1472 The commercial discard fleet did not observe any fish over 36 cm in the 14 years of available
1473 data. The majority of the nearshore fishery for GBYR is the live fish fishery, and fishermen
1474 are fishing shallower waters in order to ensure that the landed fish remain alive. The larger
1475 GBYR likely reside in waters deeper than typically fished by this fleet.

1476 The recreational fleet north of Point Conception selects the largest fish of the other fleets,
1477 with full selectivity at 34 cm. Fish south of Point Conception encountered in the recreational
1478 fleet were noticeably smaller, and fully selected at 29 cm.

1479 The two fishery-independent surveys sample different habitats and depth ranges. The PISCO
1480 study only samples in 0-20 m depth and observes small young-of-the-year fish and adults,
1481 but not the 10-17 cm size range. The asymptotic selectivity for the PISCO survey does not
1482 go to zero on the ascending side since the young-of-the-year fish are observed. The CCFRP
1483 survey does not see the largest size classes, possibly due to the shallower maximum depth
1484 fished to reduce barotrauma. Dome shaped selectivity was estimated for this survey.

1485 The additional survey variability (process error added directly to each year's input variabil-
1486 ity) for all surveys was estimated within the model. The model estimated a small added
1487 variance for MRFSS dockside recreational index north of Point Conception that was then
1488 turned off for the final base model. The added variance for Deb's onboard observer survey
1489 was estimated at Deb's onboard observer survey 0.075398 but the model presented stability
1490 issues during jittering when the variability was turned off. Therefore, it was turned on for
1491 the final base model, and can be explored further. The added variances were highest for the
1492 recreational onboard observer survey north of Point Conception (0.235) and south of Point

1493 conception (0.595), the MRFSS dockside south of Point Conception (0.282), PISCO (0.2),
1494 and CCFRP (0.186).

1495 Recruitment deviations were estimated from 1978-2018 (Figure 43). Estimates of recruitment
1496 suggest that GBYR are characterized by cyclical years of high and low recruitment (Figure
1497 44). The years of highest estimated recruitment were in the early 1990s, followed by a period
1498 of below average recruitment, and another high recruitment pulse in the late 2010s. The
1499 PISCO kelp forest fish survey is the only fishery-independent survey that observed young-
1500 of-the-year GBYR in this assessment.

1501 The stock-recruit curve resulting from a fixed value of steepness is shown in Figure 45
1502 with estimated recruitments also shown. The stock is predicted to have never fallen to low
1503 enough levels that the steepness is obvious. Steepness was not estimated in this model,
1504 but sensitivities to estimating steepness when growth was fixed to an external estimate is
1505 discussed below.

1506 2.6.2 Fits to the Data

fits-to-the-data

1507 Model fits to the indices of abundance, fishery length composition, survey length composition,
1508 and conditional age-at-length observations are all discussed below. The full r4ss plotting
1509 output is available in the supplementary material.

1510 The fits to the five fishery-dependent and two fishery-independent survey indices are shown
1511 in Figures 46 - 52. The majority of the indices represent the area north of Point Conception
1512 only and not all of these were fit well by the assessment model. The MRFSS recreational
1513 dockside survey index north of Point Conception spanning the 1980s-1990s was fit well by the
1514 model without added variance, but relatively flat, and is not a very informative index. The
1515 index for Deb's CPFV onboard observer survey spanning 1988-1998 was well fit and indicates
1516 an increase in relative abundance in the last year of the survey. The current recreational
1517 CPFV onboard observer survey north of Point Conception from 2001-2018 was relatively
1518 well fit, except for the decline suggested 2013 and 2014. The increase in relative abundance
1519 observed in 2018 was not fit by the model, even with the added variance.

1520 The fishery-dependent indices for south of Point Conception were both relatively
1521 flat. The MRFSS CPFV dockside survey index was relatively well fit and indicated an
1522 increase in the last two years of the survey, 1998-1999. The current onboard observer survey
1523 representing 2001-2018 showed very little trend in the estimated CPUE, and the variance
1524 added to this survey was the highest for all indices.

1525 The fishery-independent PISCO kelp forest fish survey index indicates a cyclical trend that
1526 was not captured by the model fit. The fit to the index is relatively flat This may be in part
1527 due to the observation of both young-of-the-year, small juveniles, and adults in the survey.
1528 An alternative index of abundance teasing apart the two life stages will be developed and
1529 presented at the STAR panel.

1530 The model was not able to capture the trends observer in the fishery-independent CCFRP
1531 hook-and-line survey. The index suggested the same depressed relative abundance in 2013
1532 as the fishery-dependent onboard observer survey, that was also not captured here by the
1533 fit. The increasing trends in abundance from 2016-2018 was also not captured by the model
1534 fit, and the fit suggests a declining trend over the entire time series from 2007-2018.

1535 Fits to the length data are shown based on the proportions of lengths observed by year and
1536 the Pearson residuals-at-length for all fleets. Detailed fits to the length data by year and
1537 fleet are provided in Appendix 8. Aggregate fits by fleet are shown in Figure 53. Overall,
1538 the length composition all fit well. The fit to the the commercial discard length composition
1539 was underestimated at the peak, but otherwise captures the observations well. The same
1540 is true for one of the peaks at 25 cm for the PISCO data, that were the nosiest of all the
1541 length composition data. There are a handful of years within some of the annual length
1542 composition data that were not particularly well fit, e.g., 1980 and 1996 for RecSouth, but
1543 these were usually due to high frequencies of fish in a small number of length bins.

1544 The age data were also weighted according to Francis weighting which adjust the weight given
1545 to a data set based on the fit to the mean age by year. The mean age of the recreational
1546 fleet declined from 1980 to 1986, and the mean for 2017 was the highest of all years (Figure
1547 54). The conditional age data from the CCFRP data was not well fit for the earliest years
1548 in the data, but was reasonably well fit for the last four years of data (Figure 55). The
1549 conditional length composition data from the ‘dummy’ fleet was well fit, although heavily
1550 down-weighted. Age data in this fleet are from a number of sources and sampling programs
1551 (Figure 56).

1552 2.6.3 Uncertainty and Sensitivity Analyses

uncertainty-and-sensitivity-analyses

1553 A number of sensitivity analyses were conducted, including:

- 1554 1. Sensitivity 1
- 1555 2. Sensitivity 2
- 1556 3. Sensitivity 3
- 1557 4. Sensitivity 4
- 1558 5. Sensitivity 5, etc/

1559 2.6.4 Retrospective Analysis

retrospective-analysis

1560 A 4-year retrospective analysis was conducted by running the model using data only through
1561 2018 (retro 1), 2017 (retro 2), 2016 (retro 3), and 2015 (retro 4) (Table 28). The initial

1562 population size and estimation of trends in spawning biomass in the retrospective runs were
1563 lower than the base model (Figure 57). All retrospective runs converged to the same low
1564 point in the 1990s and the diverged for the remainder of the time series.

1565 The recruitment deviations in the more recent years shrink towards zero the more years are
1566 removed from the model (Figure 58).

1567 2.6.5 Likelihood Profiles

likelihood-profiles

1568 Likelihood profiles were conducted for R_0 , steepness, and over natural mortality values sep-
1569 arately. These likelihood profiles were conducted by fixing the parameter at specific values
1570 and estimated the remaining parameters based on the fixed parameter value.

1571 2.6.6 Reference Points

reference-points-1

1572 Reference points were calculated using the estimated selectivities and catch distribution
1573 among fleets in the most recent year of the model, (2017). Sustainable total yield (landings
1574 plus discards) were 190 mt when using an $SPR_{50\%}$ reference harvest rate and with a 95%
1575 confidence interval of 103 mt based on estimates of uncertainty. The spawning biomass
1576 equivalent to 40% of the unfished level ($SB_{40\%}$) was 551 mt.

1577 The predicted spawning output from the base model shows an initial decline starting the
1578 1950s, is then stable, and declines steeply until 1995 (Figure 68). The spawning output then
1579 rapidly increases through the early 2000s, and has been in a decline since 2006.

1580 The 2018 spawning biomass relative to unfished equilibrium spawning biomass is above the
1581 target of 40% of unfished levels (Figure 69). The relative fishing intensity, $(1 - SPR)/(1 -$
1582 $SPR_{50\%})$, was below the management target from 1981-1998, and below the minimum stock
1583 size threshold in 1995. The stock has been above the management target since 1999.

1584 Table e shows the full suite of estimated reference points for the base model and Figure 70
1585 shows the equilibrium curve based on a steepness value fixed at 0.72.

1586 3 Harvest Projections and Decision Tables

harvest-projections-and-decision-tables

1587 This section will be completed at or after the STAR panel.

1588 **4 Regional Management Considerations**

regional-management-considerations

1589 While the proportion of the stock residing within U.S. waters is unknown, the assessment
1590 provides an adequate geographic representation of the portion assessed for management
1591 purposes. There is little evidence that black-and-yellow rockfish extend into Mexico, and
1592 the proportion of gopher rockfish residing south of Pt. Conception is small. while there
1593 has been work on the genetic structure of the two species, there has not been work done
1594 within species to inform whether or not there is genetic spatial structure to the population.
1595 Given the relatively small area in the waters of California where these species occur, there
1596 is relatively little concern regarding exploitation in proportion to the regional distribution
1597 of abundance in the area assessed in this study.

1598 The state of California implements regional management for the recreational fleet in the
1599 form of five regions. Neither gopher nor black-and-yellow rockfish are a large component
1600 of the total recreational landings and are managed as part of a shallow nearshore rockfish
1601 complex. Current regional management appears appropriate for these species.

1602 **5 Research Needs**

research-needs

1603 This section will be completed at or after the STAR panel.

1604 **6 Acknowledgments**

acknowledgments

1605 This section will be completed at or after the STAR panel.

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

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	Source
			Commercial Removals	
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	Source
			Commercial Removals	
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.

Year	CALCOM		WCGOP		Rec North		Rec South		Deb VW		tab:length_samples_fishery
	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

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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
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

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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.

Year	CCFRP		PISCO	
	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.

Fleet	Years	Name	Type	Area	Method	tab:Index_summary Endorsed
5	1988-1998	Deb Wilson-Vandenberg's Onboard Observer Survey	Fishery-dependent	Central California	Delta lognormal	SSC
6	2001-2018	CRFSS CPFV Onboard Observer Survey	Fishery-dependent	North of Pt. Conception	Delta lognormal	SSC
7	2001-2018	CRFSS 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 inputs.

Year	Deb WV		MRFSS N		MRFSS S		Onboard N		Onboard S		CCFRP		PISCO	
	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

Filter	tab:Fleet5_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.

Model	Lognormal	Binomial	tab:Fleet5_AIC
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.

Filter	Drifts	Positive Drifts	tab:Fleet6_7_Filter
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	
Limit to reefs sampled in at least 2/3 of all years	32672	7517	
Limit to drifts 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 $\geq=20\%$ 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.

Model	Lognormal	Binomial	tab:Fleet6_AIC
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.

Model	Lognormal	Binomial	tab:Fleet7_AIC
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.

Filter	Transects	Positive Transects	tab:Fleet8_Filter
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	
Collapse repeated transects	1,928	1,487	

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

Model	AIC	tab:Fleet8_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.

Filter	Drifts	Positive Drifts	tab:Fleet9_Filter
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-occur and not present in at least 1% of all	2,788	620
Stephens-MacCall filter (keep all positives - selected filter)	806	620
Alternate Stephens-MacCall filter (keep only above threshold)	623	437
Remove years after 1999 due to regulation changes and with fewer than 20 trips	544	220
Start southern filtering	7,334	441
Remove species that never co-occur and not present in at least 1% of all	7,334	441
Stephens-MacCall filter (keep all positives - selected filter)	687	441
Alternate Stephens-MacCall filter (keep only above threshold)	430	184
Remove years after 1999 due to regulation changes and with fewer than 20 trips	475	342

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

Model	AIC	tab:Fleet10_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.

Model	Lognormal	Binomial	tab:Fleet11_AIC
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: Contingency table for the Stephens-MacCall filtering for the MRFSS dockside CPFV index for GBYR north of Pt. Conception.

	GBYR absent	GBYR present	tab:Fleet10_contingency
Above 0.4	186	437	
Below 0.4	1982	183	

Table 20: Contingency table for the Stephens-MacCall filtering for the MRFSS dockside CPFV index for GBYR south of Pt. Conception.

	GBYR absent	GBYR present	tab:Fleet11_contingency
Above 0.22	246	184	
Below 0.22	6647	257	

Table 21: Summary of age data used in the assessment.

Project	Source	Years	Region	Gear	Black-and-yellow	tab:Age_data_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 CPFFV 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 22: Results from 240 jitters from the base case model.

Description	Value	tab:jitter
Returned to base case	-	
Found local minimum	-	
Found better solution	-	
Error in likelihood	-	
Total	240	

Table 23: 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	0.217	2	(0.05, 0.4)	OK	0.030	Log_Norm (-1.6458, 0.4384)
2	L_at_Amin_Fem_GP_1	9.721	3	(4, 50)	OK	0.749	None
3	L_at_Amax_Fem_GP_1	28.361	3	(20, 60)	OK	0.953	None
4	VonBert_K_Fem_GP_1	0.121	3	(0.01, 0.3)	OK	0.031	None
5	CV_young_Fem_GP_1	0.268	3	(0.05, 0.5)	OK	0.035	None
6	CV_old_Fem_GP_1	0.116	3	(0.03, 0.3)	OK	0.015	None
7	Wtlen_1_Fem_GP_1	0.000	-3	(-3, 3)	None	None	None
8	Wtlen_2_Fem_GP_1	3.256	-3	(2, 4)	None	None	None
9	Mat50%_Fem_GP_1	21.666	-3	(-3, 3)	None	None	None
10	Mat_slope_Fem_GP_1	-0.906	-3	(-6, 3)	None	None	None
11	Eggs/kg_inter_Fem_GP_1	1.000	-3	(-3, 3)	None	None	None
12	Eggs/kg_slope_wt_Fem_GP_1	0.000	-3	(-3, 3)	None	None	None
13	CohortGrowDev	1.000	-1	(0.1, 10)	None	None	None
14	FracFemale_GP_1	0.500	-4	(0.000001, 0.999999)	OK	0.424	None
15	SR_LN(R0)	8.665	1	(2, 15)	OK	0.424	None
16	SR_BH_stEEP	0.720	-1	(0.2, 1)	Full_Beta (0.72, 0.16)	None	None
17	SR_sigmaR	0.500	-2	(0, 2)	None	None	None
18	SR_regime	0.000	-4	(-5, 5)	None	None	None
19	SR_autocorr	0.652	4	(-1, 1)	OK	0.115	None
103	LnQ_base_DebCPFV(5)	-7.033	-1	(-15, 15)	None	None	None
104	Q_extraSD_DebCPFV(5)	0.075	4	(0, 2)	OK	0.050	None
105	LnQ_base_RecOnboardNorth(6)	-7.751	-1	(-15, 15)	None	None	None
106	Q_extraSD_RecOnboardNorth(6)	0.235	4	(0.0001, 2)	OK	0.058	None
107	LnQ_base_RecOnboardSouth(7)	-10.332	-1	(-15, 15)	None	None	None
108	Q_extraSD_RecOnboardSouth(7)	0.595	4	(0.0001, 2)	OK	0.148	None

Continued on next page

Table 23: 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)
109	LnQ_base_PISCO(8)	-7.629	-1	(-15, 15) (0.0001, 2)	OK	0.073	None
110	Q_extraSD_PISCO(8)	0.200	4	(-15, 15) (0.0001, 2)	OK	0.073	None
111	LnQ_base_CCFRP(9)	-6.503	-1	(-15, 15) (0.0001, 2)	OK	0.074	None
112	Q_extraSD_CCFRP(9)	0.186	4	(-15, 15) (0.0001, 2)	OK	0.074	None
113	LnQ_base_RecDocksideNorth(10)	-8.798	-1	(-15, 15) (0, 2)	OK	None	None
114	Q_extraSD_RecDocksideNorth(10)	0.000	-4	(-15, 15) (0, 2)	OK	None	None
115	LnQ_base_RecDocksideSouth(11)	-9.736	-1	(-15, 15) (0.0001, 2)	OK	None	None
116	Q_extraSD_RecDocksideSouth(11)	0.282	4	(-15, 15) (0.0001, 2)	OK	0.110	None
117	Size_DbIN_peak_Com(1)	32.308	1	(19, 38)	OK	0.698	None
118	Size_DbIN_top_logit_Com(1)	8.000	-5	(-5, 10)	OK	0.698	None
119	Size_DbIN_ascend_se_Com(1)	3.107	5	(-9, 10)	OK	0.125	None
120	Size_DbIN_descend_se_Com(1)	5.000	-5	(-9, 9)	OK	0.125	None
121	Size_DbIN_start_logit_Com(1)	-11.893	5	(-15, -5)	OK	1.750	None
122	Size_DbIN_end logit_Com(1)	10.000	-5	(-5, 15)	OK	0.456	None
123	Size_DbIN_peak_ComDisc(2)	25.060	2	(19, 38)	OK	3.560	None
124	Size_DbIN_top_logit_ComDisc(2)	1.246	5	(-15, 10)	OK	0.219	None
125	Size_DbIN_ascend_se_ComDisc(2)	2.035	5	(-9, 10)	OK	48.388	None
126	Size_DbIN_descend_se_ComDisc(2)	-3.358	5	(-9, 9)	OK	19.029	None
127	Size_DbIN_start_logit_ComDisc(2)	-14.181	5	(-15, -5)	OK	None	None
128	Size_DbIN_end_logit_ComDisc(2)	-999.000	-5	(-5, 10)	OK	0.406	None
129	Size_DbIN_peak_RecNorth(3)	32.489	3	(19, 39)	OK	0.076	None
130	Size_DbIN_top_logit_RecNorth(3)	8.000	-5	(-5, 10)	OK	0.076	None
131	Size_DbIN_ascend_se_RecNorth(3)	3.263	5	(-9, 10)	OK	0.076	None
132	Size_DbIN_descend_se_RecNorth(3)	5.000	-5	(-9, 9)	OK	0.076	None
133	Size_DbIN_start_logit_RecNorth(3)	-12.169	5	(-15, -5)	OK	1.546	None
134	Size_DbIN_end_logit_RecNorth(3)	10.000	-5	(-5, 15)	OK	None	None
135	Size_DbIN_peak_RecSouth(4)	27.710	4	(19, 38)	OK	1.020	None

Continued on next page

Table 23: 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)
136	Size_DbIN_top_logit_RecSouth(4)	8.000	-5	(-5, 10)	OK	0.234	None
137	Size_DbIN_ascend_se_RecSouth(4)	3.094	5	(-9, 10)	OK	0.234	None
138	Size_DbIN_descend_se_RecSouth(4)	5.000	-5	(-9, 9)	OK	2.229	None
139	Size_DbIN_start_logit_RecSouth(4)	-8.787	5	(-15, -5)	OK	2.229	None
140	Size_DbIN_end_logit_RecSouth(4)	10.000	-5	(-5, 15)	OK	None	None
141	Size_DbIN_peak_DebCPFV(5)	30.874	5	(19, 38)	OK	0.566	None
142	Size_DbIN_top_logit_DebCPFV(5)	8.000	-5	(-5, 10)	OK	0.566	None
143	Size_DbIN_ascend_se_DebCPFV(5)	2.984	5	(-9, 10)	OK	0.108	None
144	Size_DbIN_descend_se_DebCPFV(5)	5.000	-5	(-9, 9)	OK	0.108	None
145	Size_DbIN_start_logit_DebCPFV(5)	-18.070	5	(-20, -5)	OK	35.319	None
146	Size_DbIN_end_logit_DebCPFV(5)	10.000	-5	(-5, 15)	OK	35.319	None
147	SizeSel_P1_RecOnboardNorth(6)	-1.000	-5	(-1, 10)	OK	0.508	None
148	SizeSel_P2_RecOnboardNorth(6)	-1.000	-5	(-1, 10)	OK	0.508	None
149	SizeSel_P1_RecOnboardSouth(7)	-1.000	-5	(-1, 10)	OK	0.508	None
150	SizeSel_P2_RecOnboardSouth(7)	-1.000	-5	(-1, 10)	OK	0.508	None
151	Size_DbIN_peak_PISCO(8)	30.994	5	(19, 38)	OK	3.422	None
152	Size_DbIN_top_logit_PISCO(8)	8.000	-5	(-15, 10)	OK	3.422	None
153	Size_DbIN_ascend_se_PISCO(8)	3.968	5	(-9, 10)	OK	0.508	None
154	Size_DbIN_descend_se_PISCO(8)	5.000	-5	(-9, 9)	OK	0.508	None
155	Size_DbIN_start_logit_PISCO(8)	-2.995	5	(-15, 15)	OK	0.729	None
156	Size_DbIN_end_logit_PISCO(8)	10.000	-5	(-5, 15)	OK	0.729	None
157	Size_DbIN_peak_CCFRP(9)	31.133	5	(19, 38)	OK	0.635	None
158	Size_DbIN_top_logit_CCFRP(9)	-10.611	5	(-15, 10)	OK	65.429	None
159	Size_DbIN_ascend_se_CCFRP(9)	3.135	5	(-9, 10)	OK	0.151	None
160	Size_DbIN_descend_se_CCFRP(9)	1.646	5	(-15, 9)	OK	0.831	None
161	Size_DbIN_start_logit_CCFRP(9)	-999.000	-5	(-15, -5)	OK	None	None
162	Size_DbIN_end_logit_CCFRP(9)	-999.000	-5	(-5, 10)	OK	None	None

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Table 23: 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)
163	SizeSel_P1.RecDocksideNorth(10)	-1.000	-5	(-1, 10)			None
164	SizeSel_P2.RecDocksideNorth(10)	-1.000	-5	(-1, 10)			None
165	SizeSel_P1.RecDocksideSouth(11)	-1.000	-5	(-1, 10)			None
166	SizeSel_P2.RecDocksideSouth(11)	-1.000	-5	(-1, 10)			None
167	Size_DblIN_peak_Com(1)_BLK1rep1_1999	28.951	6	(19, 38)	OK	0.306	None
168	Size_DblIN_ascend_se_Com(1)_BLK1rep1_1999	1.602	6	(-9, 10)	OK	0.154	None
169	Size_DblIN_start_logit_Com(1)_BLK1rep1_1999	-12.321	6	(-15, -5)	OK	3.908	None

Table 24: Likelihood components from the base model.

Likelihood component	Value	tab:like_components
TOTAL	516.161	
Catch	2.510E-07	
Survey	-32.202	
Length composition	372.526	
Age composition	189.302	
Recruitment	-13.508	
Forecast recruitment	2.430E-11	
Parameter priors	3.735E-02	
Parameter soft bounds	4.910E-03	

Table 25: 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	2365	1379	0.000	5795	4	0.00	0.99
1917	2362	1376	0.998	5794	7	0.00	0.98
1918	2358	1373	0.996	5793	8	0.00	0.98
1919	2354	1369	0.993	5792	5	0.00	0.99
1920	2353	1367	0.992	5791	5	0.00	0.99
1921	2351	1366	0.991	5790	5	0.00	0.99
1922	2350	1365	0.990	5790	4	0.00	0.99
1923	2350	1365	0.990	5790	4	0.00	0.99
1924	2350	1365	0.990	5790	2	0.00	0.99
1925	2350	1365	0.990	5790	3	0.00	0.99
1926	2350	1366	0.991	5790	5	0.00	0.99
1927	2349	1365	0.990	5790	4	0.00	0.99
1928	2349	1364	0.990	5790	6	0.00	0.98
1929	2348	1363	0.989	5789	6	0.00	0.98
1930	2346	1362	0.988	5789	8	0.00	0.98
1931	2344	1360	0.986	5788	5	0.00	0.99
1932	2344	1360	0.986	5788	10	0.00	0.97
1933	2341	1357	0.984	5786	7	0.00	0.98
1934	2340	1356	0.984	5786	7	0.00	0.98
1935	2339	1356	0.983	5786	6	0.00	0.99
1936	2340	1356	0.983	5786	6	0.00	0.98
1937	2339	1356	0.983	5786	15	0.01	0.96
1938	2334	1351	0.980	5784	18	0.01	0.95
1939	2326	1344	0.975	5781	21	0.01	0.95
1940	2319	1337	0.970	5778	28	0.01	0.93
1941	2308	1328	0.963	5774	27	0.01	0.93
1942	2299	1320	0.957	5770	14	0.01	0.96
1943	2300	1320	0.957	5770	17	0.01	0.96
1944	2299	1319	0.957	5770	4	0.00	0.99
1945	2306	1325	0.961	5773	6	0.00	0.98
1946	2310	1329	0.964	5775	27	0.01	0.93
1947	2301	1322	0.959	5771	37	0.02	0.91
1948	2287	1309	0.950	5766	39	0.02	0.91
1949	2273	1297	0.941	5760	37	0.02	0.91
1950	2263	1288	0.934	5756	39	0.02	0.90
1951	2254	1279	0.928	5752	52	0.02	0.88
1952	2237	1264	0.917	5745	52	0.02	0.88

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Table 25: Time-series of population estimates from the base-case model. Relative exploitation rate is $(1 - SPR)/(1 - SPR_{50\%})$.

Year	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative exploitation rate	SPR
1953	2223	1251	0.908	5739	55	0.02	0.87
1954	2209	1239	0.899	5733	68	0.03	0.84
1955	2189	1221	0.886	5724	60	0.03	0.85
1956	2177	1210	0.878	5718	76	0.03	0.83
1957	2157	1193	0.865	5709	76	0.04	0.82
1958	2140	1178	0.854	5701	88	0.04	0.80
1959	2118	1158	0.840	5690	62	0.03	0.84
1960	2111	1156	0.838	3483	44	0.02	0.88
1961	2113	1163	0.844	3080	50	0.02	0.87
1962	2097	1166	0.846	2804	61	0.03	0.84
1963	2054	1163	0.844	2620	56	0.03	0.86
1964	1996	1161	0.842	2527	43	0.02	0.88
1965	1929	1160	0.842	2529	58	0.03	0.85
1966	1839	1140	0.827	2633	52	0.03	0.86
1967	1746	1111	0.806	2861	48	0.03	0.87
1968	1654	1071	0.777	3225	49	0.03	0.87
1969	1564	1021	0.740	3577	46	0.03	0.87
1970	1485	965	0.700	3707	60	0.04	0.83
1971	1409	899	0.652	3564	51	0.04	0.85
1972	1354	841	0.610	3216	66	0.05	0.80
1973	1302	779	0.565	2967	88	0.07	0.75
1974	1246	714	0.518	3118	92	0.07	0.73
1975	1199	660	0.479	3625	89	0.07	0.71
1976	1162	620	0.450	4184	91	0.08	0.69
1977	1134	590	0.428	4545	79	0.07	0.70
1978	1126	573	0.416	4631	84	0.08	0.68
1979	1127	558	0.405	4302	78	0.07	0.68
1980	1144	550	0.399	4407	155	0.14	0.54
1981	1124	510	0.370	4463	143	0.13	0.54
1982	1123	487	0.353	4564	129	0.12	0.54
1983	1138	482	0.350	3969	118	0.10	0.55
1984	1161	491	0.356	2907	174	0.15	0.47
1985	1150	481	0.349	2417	173	0.15	0.47
1986	1134	478	0.346	2300	206	0.18	0.43
1987	1089	465	0.337	2529	162	0.15	0.47
1988	1059	471	0.342	3239	145	0.14	0.49
1989	1029	479	0.348	4648	120	0.12	0.54

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Table 25: Time-series of population estimates from the base-case model. Relative exploitation rate is $(1 - SPR)/(1 - SPR_{50\%})$.

Year	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative exploitation rate	SPR
1990	1012	488	0.354	6825	136	0.14	0.52
1991	1000	479	0.347	8848	175	0.18	0.47
1992	994	444	0.322	9565	207	0.21	0.43
1993	1013	392	0.284	9259	210	0.21	0.40
1994	1079	347	0.251	8804	161	0.15	0.42
1995	1211	341	0.248	7957	150	0.13	0.42
1996	1371	368	0.267	6548	148	0.11	0.42
1997	1536	429	0.312	4898	118	0.08	0.48
1998	1701	529	0.384	3935	118	0.07	0.52
1999	1832	646	0.468	3633	127	0.07	0.55
2000	1913	762	0.553	3739	131	0.07	0.59
2001	1949	868	0.629	4593	169	0.09	0.57
2002	1928	937	0.679	5372	133	0.07	0.64
2003	1900	989	0.718	4392	148	0.08	0.64
2004	1848	1003	0.727	3555	72	0.04	0.78
2005	1832	1023	0.742	3304	86	0.05	0.76
2006	1794	1016	0.737	3184	78	0.04	0.78
2007	1750	1001	0.726	3271	70	0.04	0.80
2008	1701	984	0.714	3606	87	0.05	0.77
2009	1638	954	0.692	4245	111	0.07	0.73
2010	1561	908	0.659	4419	153	0.10	0.66
2011	1467	838	0.608	3732	135	0.09	0.67
2012	1399	779	0.565	3733	94	0.07	0.72
2013	1368	744	0.540	4836	84	0.06	0.73
2014	1355	718	0.521	8499	105	0.08	0.68
2015	1349	685	0.497	12739	109	0.08	0.67
2016	1373	658	0.477	9468	112	0.08	0.65
2017	1447	637	0.462	6205	104	0.07	0.65
2018	1566	629	0.457	4678	92	0.06	0.67
2019	1702	647	0.469	4980			

Table 26: Sensitivity of the base model to dropping or down-weighting data sources and alternative assumptions about growth.

Label	Base (Francis weights)	Default weights	Harmonic mean weights	Estimate equal M and h	Drop PR data	Drop PC data	tab:Sensitivity_model1
TOTAL_like	-	-	-	-	-	-	-
Catch_like	-	-	-	-	-	-	-
Equil_catch_like	-	-	-	-	-	-	-
Survey_like	-	-	-	-	-	-	-
Length_comp_like	-	-	-	-	-	-	-
Age_comp_like	-	-	-	-	-	-	-
Parm_priors_like	-	-	-	-	-	-	-
SSB_Unfished_thousand_mt	-	-	-	-	-	-	-
TotBio_U_nfished	-	-	-	-	-	-	-
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 27: Summary of the biomass/abundance time series used in the stock assessment.

Fleet	Years	Name	Fishery ind.	Filtering	Method	tab:Index_summary 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
8	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 28: 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	0.22	0.21	0.21	0.21	0.20
Steepness	0.72	0.72	0.72	0.72	0.72
InR0	8.69	8.55	8.47	8.35	8.00
Total Biomass (mt)	2303.87	2191.89	2053.59	1809.09	1507.21
Depletion	0.47	0.40	0.38	0.34	0.24
SPR ratio	1.00	1.00	0.99	0.98	0.91
Female Lmin	9.67	9.72	10.19	10.68	10.96
Female Lmax	28.35	28.04	27.87	27.64	27.35
Female K	0.12	0.13	0.13	0.12	0.13
Negative log-likelihood					
TOTAL	557.52	512.02	495.38	478.75	462.70
Equilibrium catch	0.00	0.00	0.00	0.00	0.00
Survey	-33.05	-31.54	-30.76	-30.45	-33.29
Length composition	372.66	359.78	346.36	334.97	324.08
Age composition	231.94	197.60	193.75	189.87	188.74
Recruitment	-14.09	-13.96	-14.16	-15.86	-16.83
Forecast Recruitment	0.06	0.03	0.03	0.03	0.00
Parameter priors	0.00	0.00	0.00	0.00	0.00

Table 29: Summaries of key assessment outputs and likelihood values from selected likelihood profile runs on virgin recruitment ($\ln R_0$) and steepness. Note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for the year of 2017.

Label	R07400	R07800	R08200	R08600	R09000	h0410	h0570	h0710	h0870	h0990
Female M										
Steepness										
$\ln R_0$										
Total biomass (m)										
Depletion (%)										
SPR_ratio										
Female Lmin										
Female Lmax										
Female K										
Male Lmin (offset)										
Male Lmax (offset)										
Male K (offset)										
Negative log-likelihood										
TOTAL										
Catch										
Equil_catch										
Survey										
Length_comp										
Age_comp										
Recruitment										
Forecast_Recruitment										
Parm_priors										
Parm_softbounds										
Parm_devs										
Crash_Pen										

Table 30: 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					
Steepness					
InR0					
Total biomass (m)					
Depletion (%)					
SPR ratio					
Female Lmin					
Female Lmax					
Female K					
Male Lmin (offset)					
Male Lmax (offset)					
Male K (offset)					
Negative log-likelihood					
TOTAL					
Catch					
Equil_catch					
Survey					
Length_comp					
Age_comp					
Recruitment					
Forecast_Recruitment					
Parm_priors					
Parm_softbounds					
Parm_devs					
Crash_Pen					

Table 31: Projection of potential OFL, spawning biomass, and depletion for the base case model.

Yr	OFL contribution (mt)	ACL landings (mt)	Age 5+ biomass (mt)	Spawning Biomass (mt)	tab:Forecast_mod1 Depletion
2019	217.281	217.281	1693.610	646.975	0.469
2020	197.064	197.064	1741.930	646.975	0.469
2021	194.474	194.474	1787.340	646.975	0.469
2022	205.651	205.651	1815.360	646.975	0.469
2023	224.800	224.801	1818.880	646.975	0.469
2024	244.523	244.522	1797.120	646.975	0.469
2025	258.190	258.191	1754.220	646.975	0.469
2026	262.286	262.286	1698.090	646.975	0.469
2027	257.142	257.143	1638.280	646.975	0.469
2028	245.895	245.895	1583.330	646.975	0.469
2029	232.574	232.574	1538.780	646.975	0.469
2030	220.434	220.435	1506.460	646.975	0.469

₁₆₀₇ 8 Figures

figures

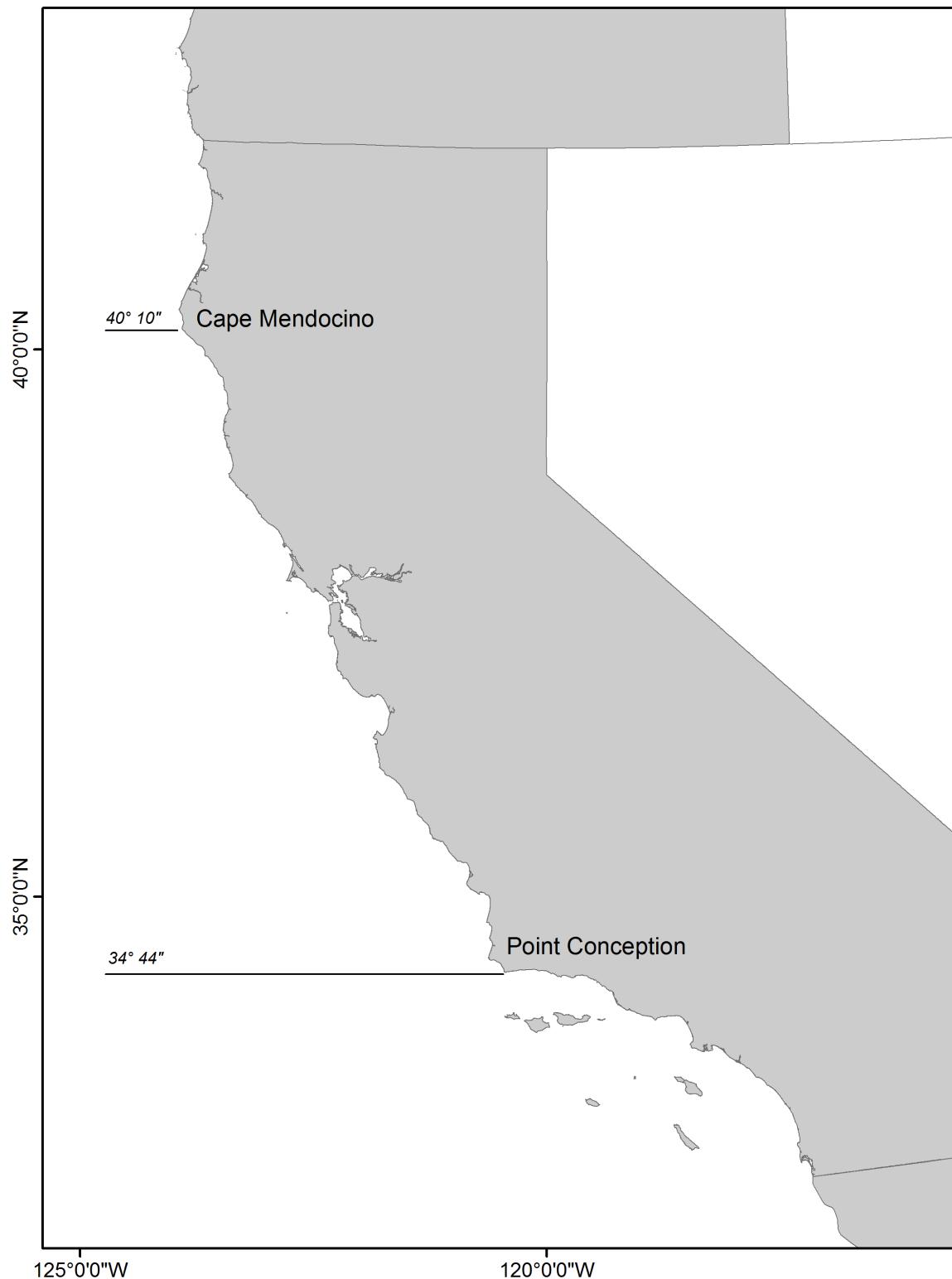


Figure 1: Map showing the management area for gopher and black-and-yellow rockfish from Cape Mendocino to the U.S.-Mexico border. fig:assess_region_map1

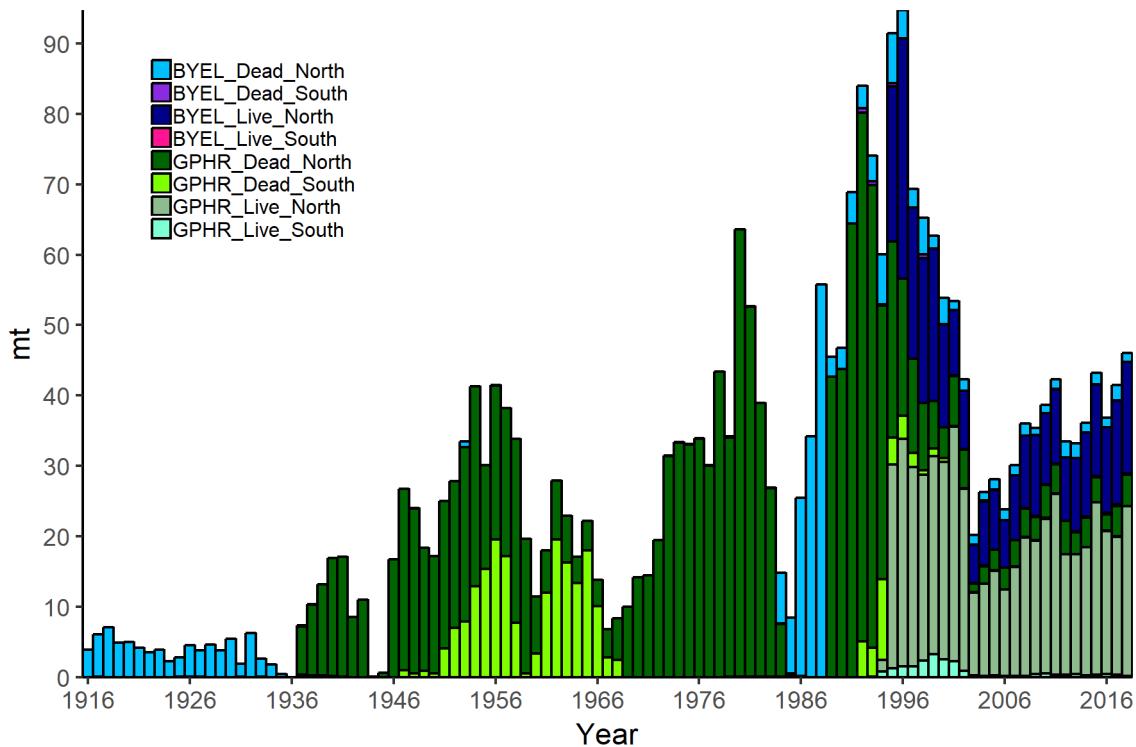


Figure 2: Commercial landings for gopher (GPHR) and black-and-yellow (BYEL) rockfishes landed live and dead north and south of Point Conception. All catch time series were combined for the assessment into one commercial fleet.

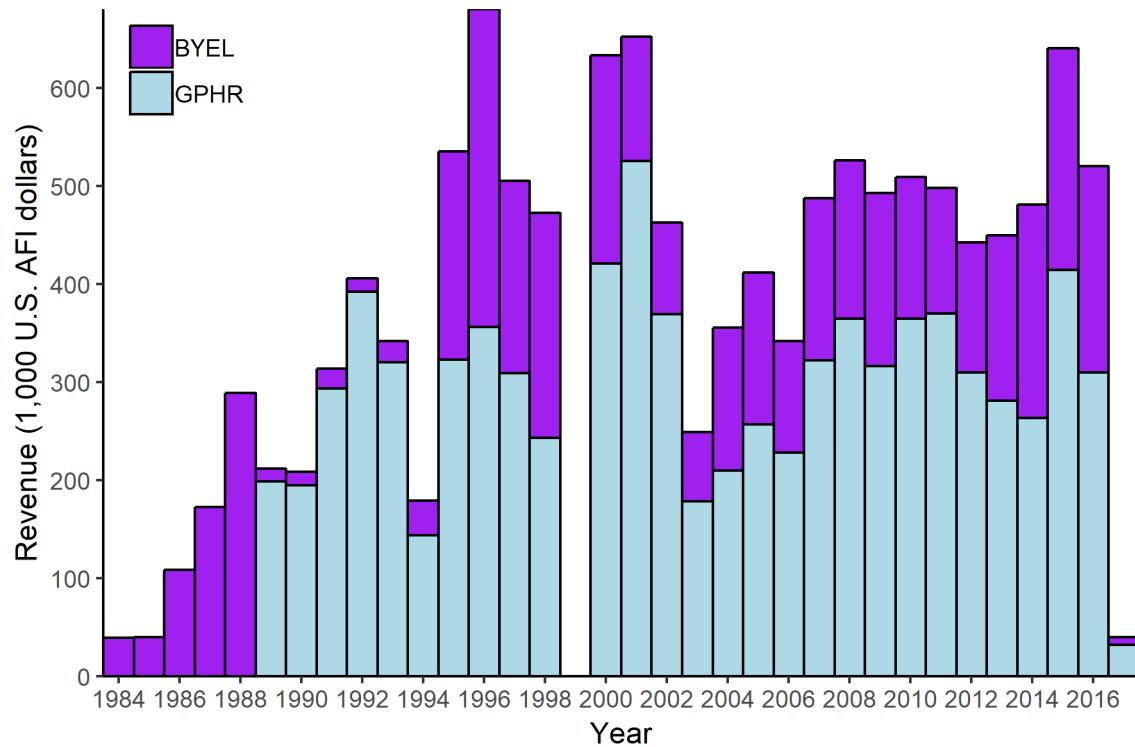


Figure 3: Annual ex-vessel revenue, adjusted for inflation (AFI) in thousands of dollars for gopher and black-and-yellow rockfish. [fig:GBY_revenue](#)

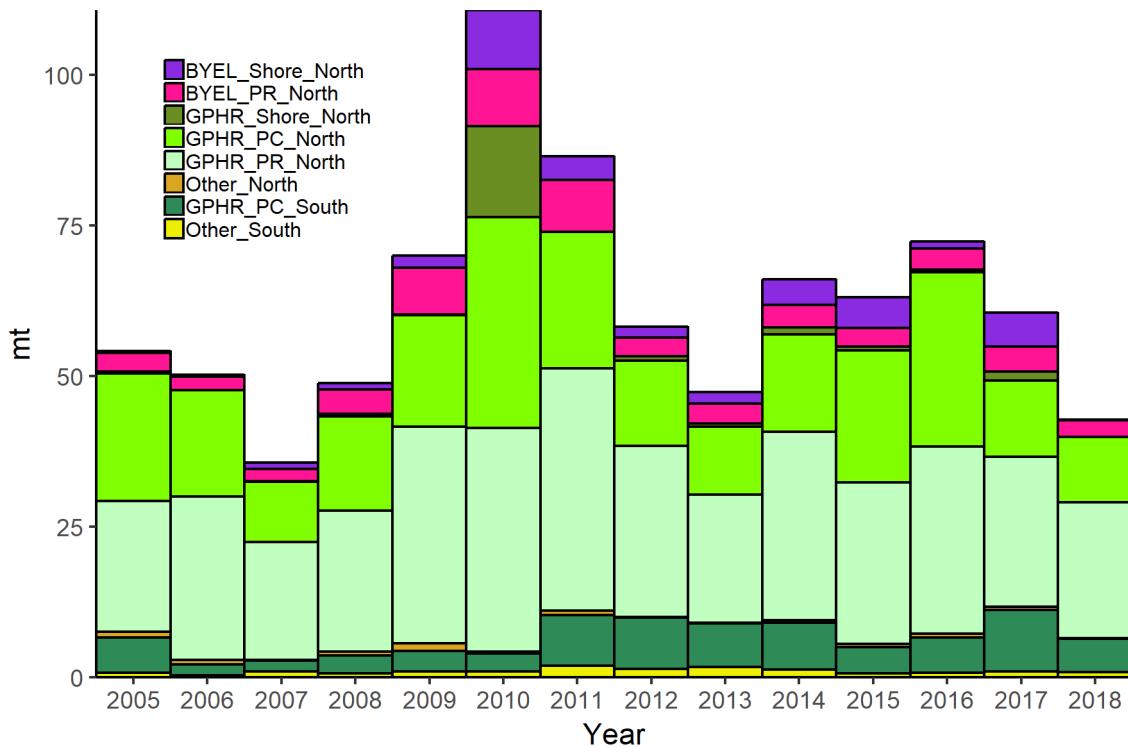


Figure 4: Recreational total mortality for gopher rockfish (GPHR) and black-and-yellow (BYEL) rockfish from the CDFW CRFS sampling era by mode and split north and south of Point Conception. fig:CFRS_catches

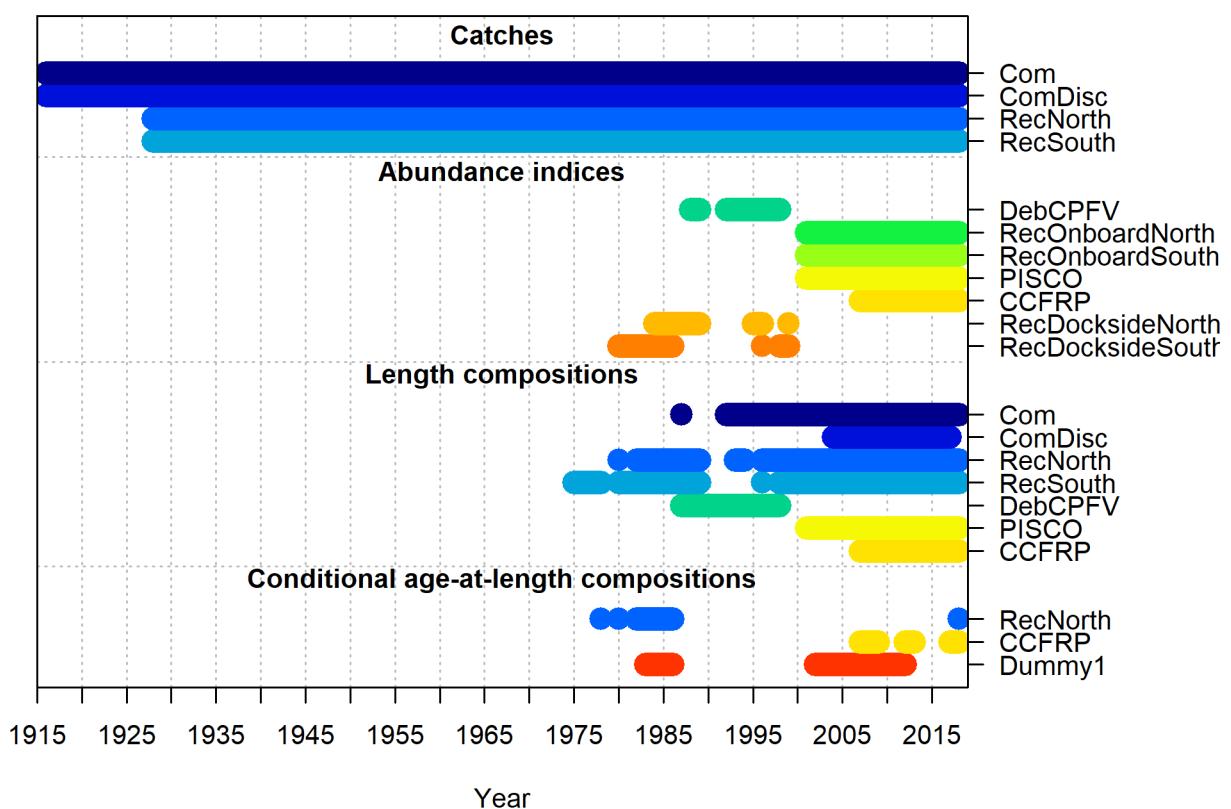


Figure 5: Summary of data sources used in the model. `fig: data_plot`

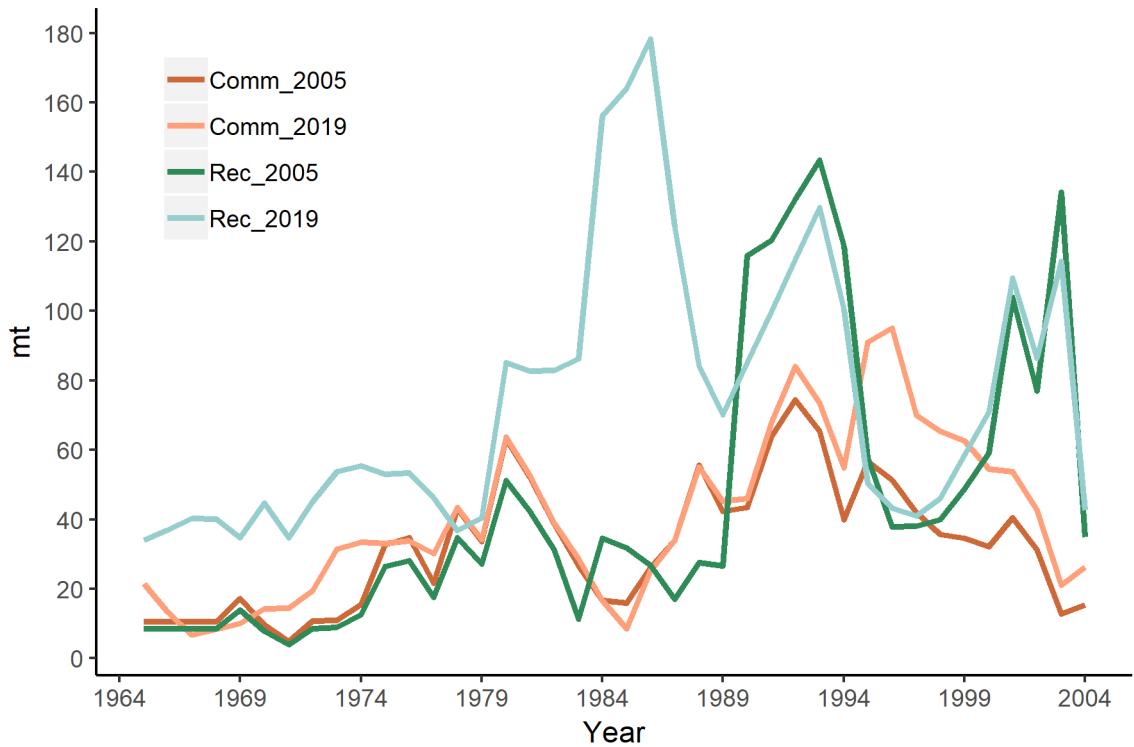


Figure 6: Comparison of the recreational and commercial fishery landings from the 2005 assessment to this 2019 assessment. Note that the 2019 assessment includes both gopher and black-and-yellow rockfish where the 2005 assessment represents gopher rockfish only. The 2005 assessment also did not include landings from south of Point Conception. | [fig:Assessment_comp](#)

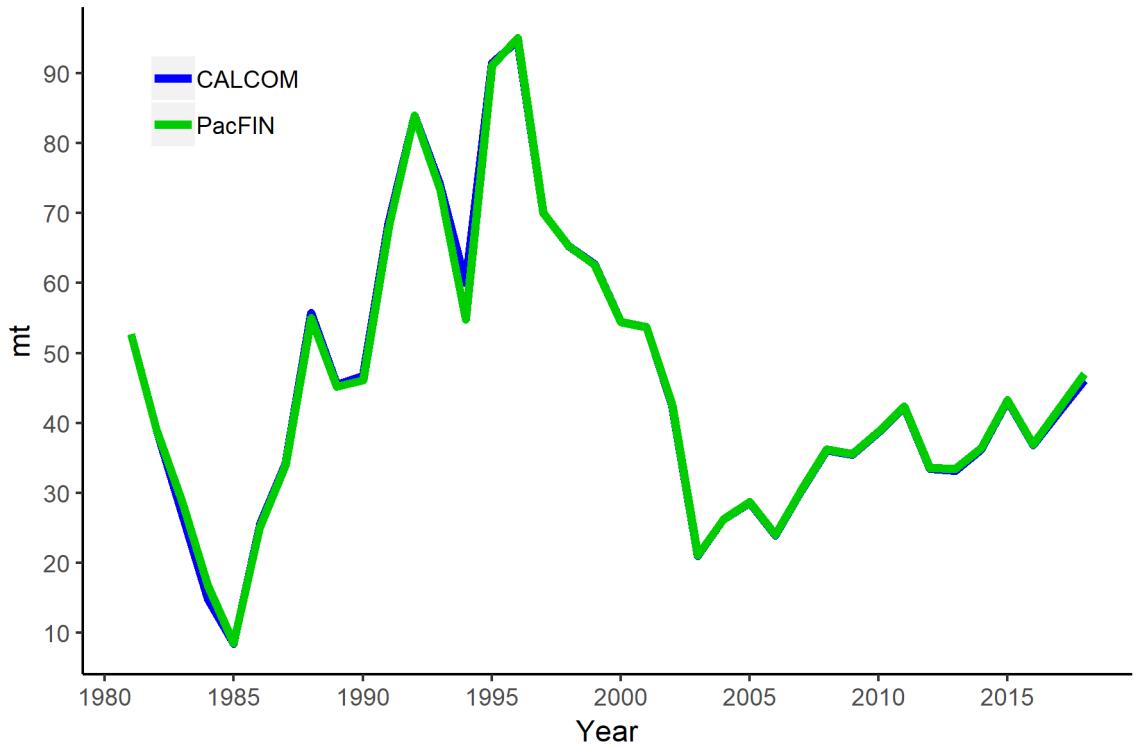


Figure 7: Commercial landings estimates from CALCOM add PacFIN. fig:Calcom_vs_Pacfin

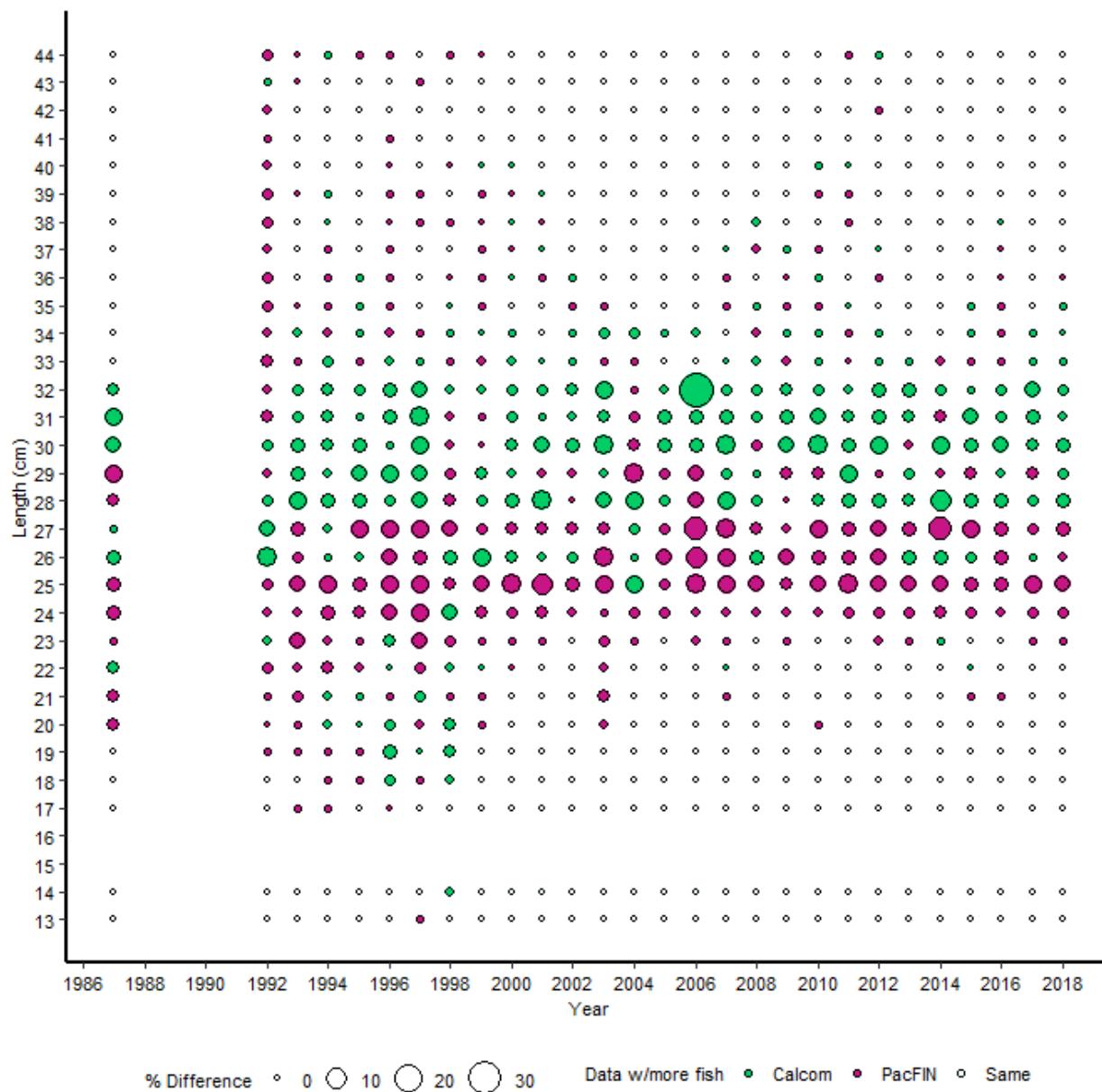


Figure 8: Percent differences in the expanded length compositions by year from CALCOM and PacFIN. The same market categories were used for each dataset, but each database was subject to further independent filtering criteria and expansion algorithms. fig:Calcom_vs_pacfin_length

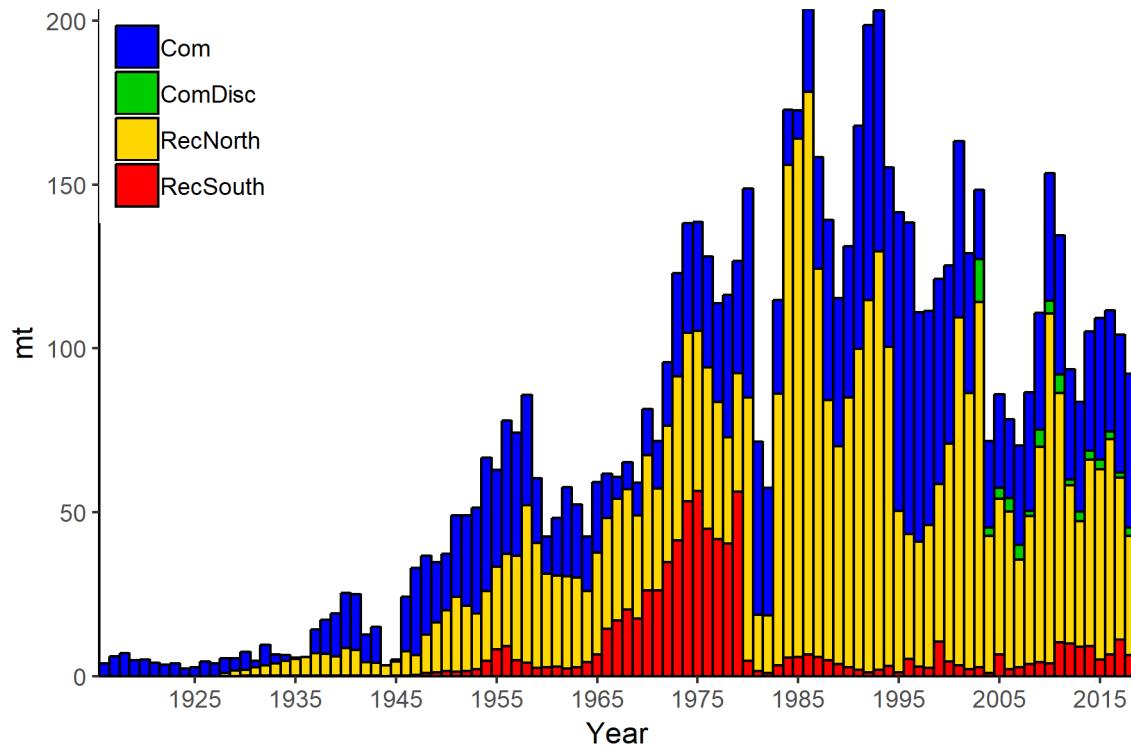


Figure 9: Commercial and recreational landings estimates prior to any data modification or interpolation to the recreational catches or hindcasting of commercial discards. [fig:Catches_original](#)

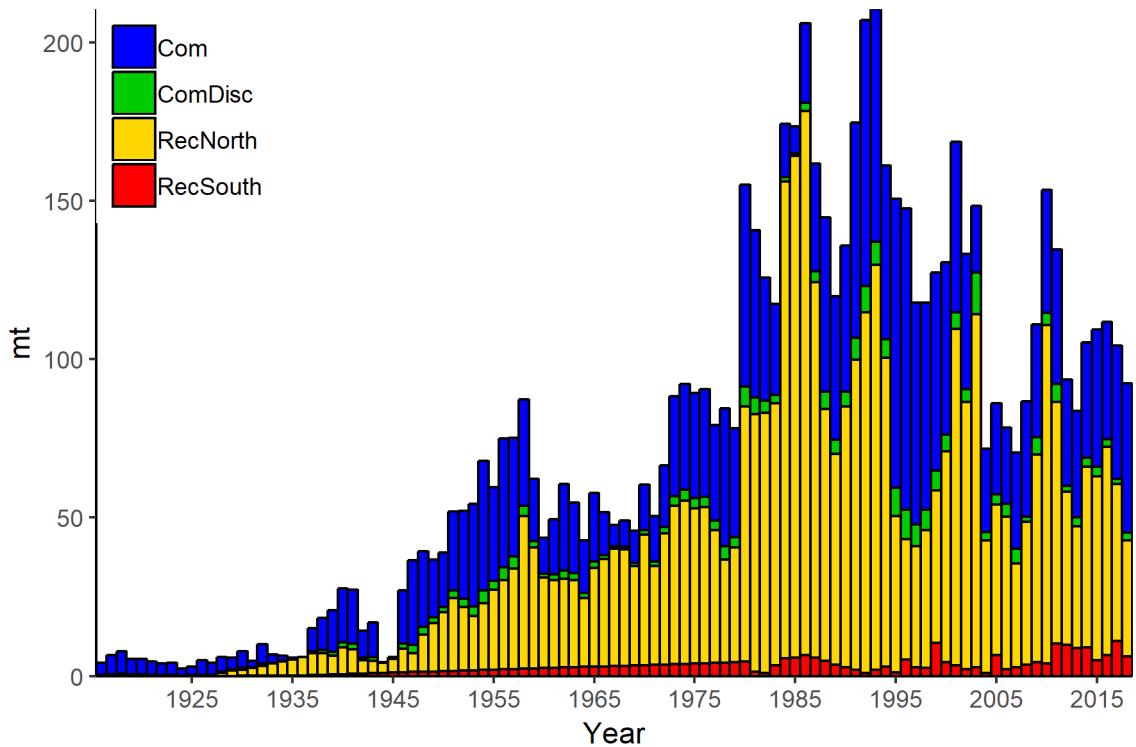


Figure 10: Commercial and recreational landings estimates after data modification and interpolations were made to the recreational catches and commercial discards. [fig:Catches_alternate](#)

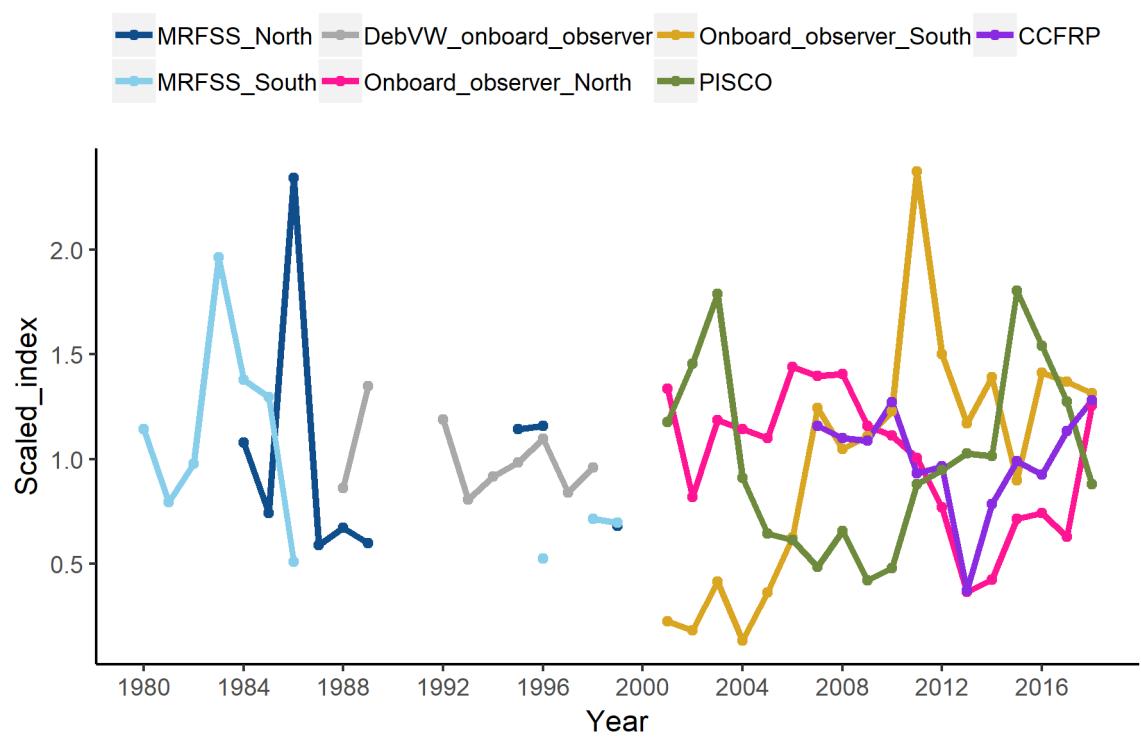


Figure 11: Comparison of all indices of abundance (scaled to their means). [fig:All_index_compar](#)

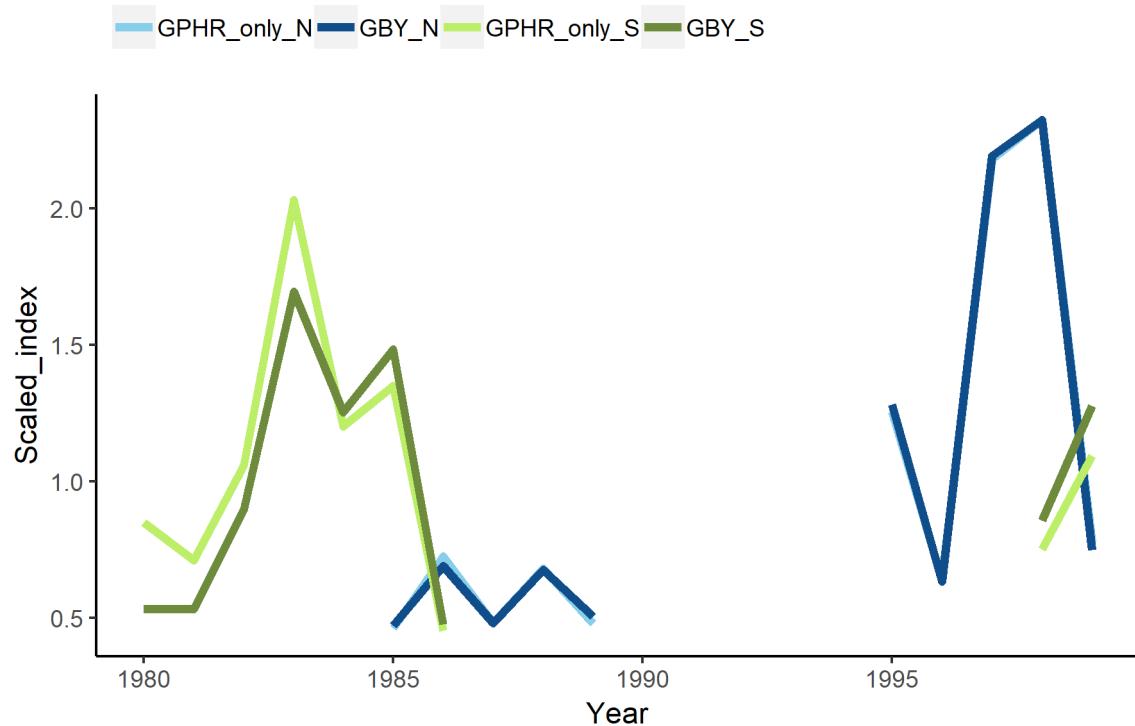


Figure 12: Comparison of indices of abundance (scaled to their means) for the MRFSS dockside CPFV survey between a gopher-only and GBYR complex index for north and south of Point Conception. [fig:MRFSS_index_compare](#)

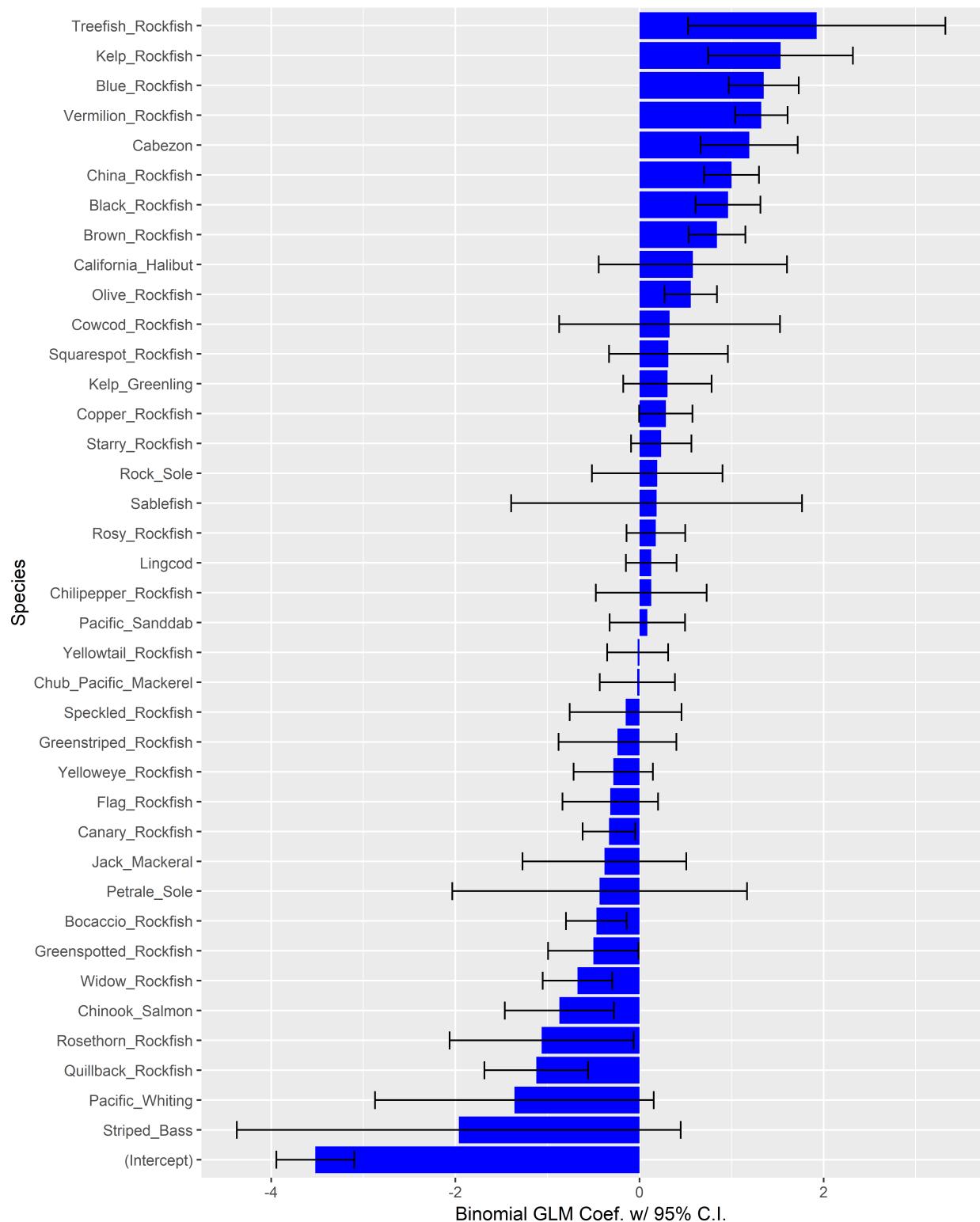


Figure 13: Species coefficients from the binomial GLM for presence/absence of GBYR in the Marine Recreational Fisheries Statistics Survey (MRFSS) CPFV mode dockside survey data set north of Point Conception. Horizontal bars are 95% confidence intervals. fig:Fleet10_SM_filter

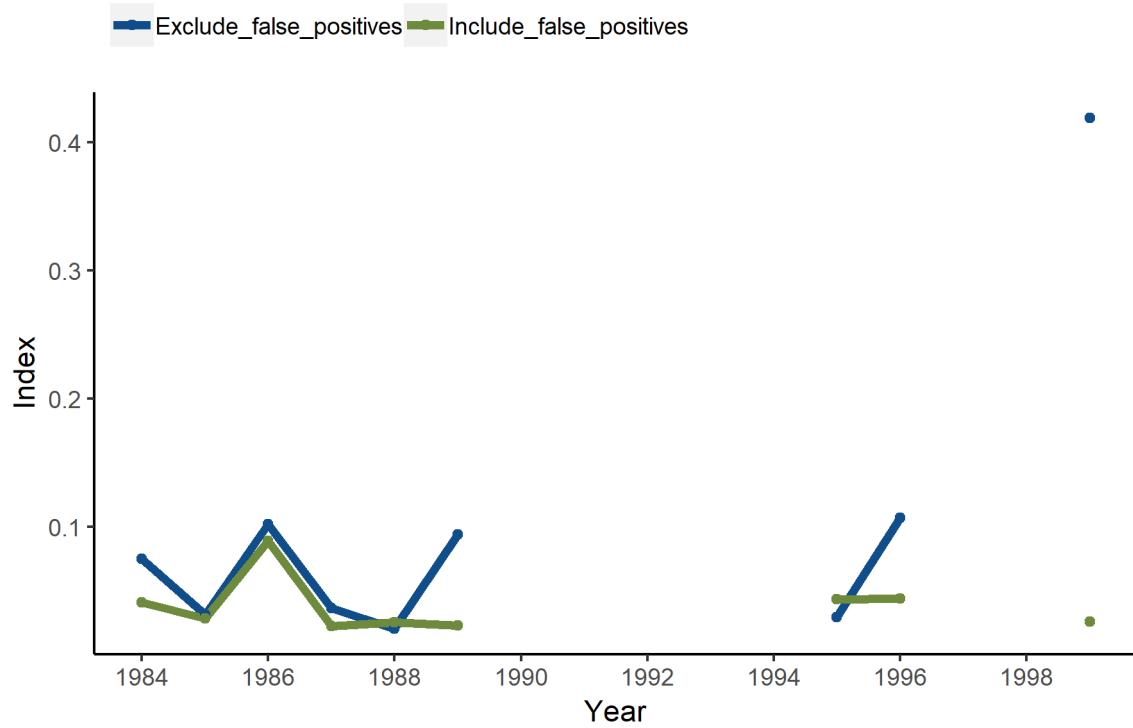


Figure 14: Comparisons of the indices of abundance for GBYR north of Point Conception from the MRFSS dockside CPVS survey that either include or exclude the trips identified as false positives from the Stephens-MacCall filter. [fig:MRFSS_index_N_SM_falsepos](#)

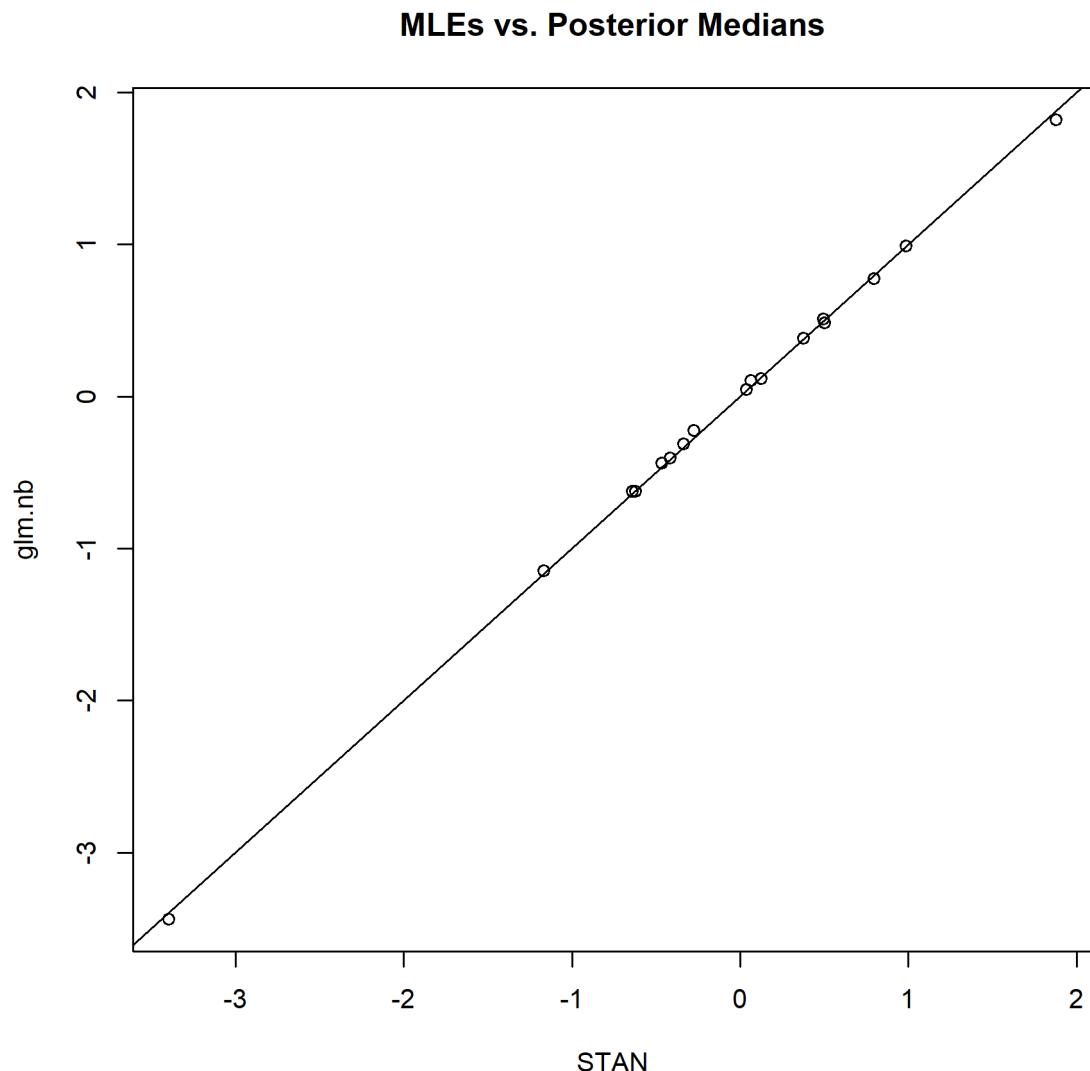


Figure 15: Comparison of negative binomial predictions (CPUE) to observed means in each stratum (year). MRFSS CPFV dockside index north of Point Conception. The 1:1 plot is for reference. [fig:Fleet10_MLE_stan](#)

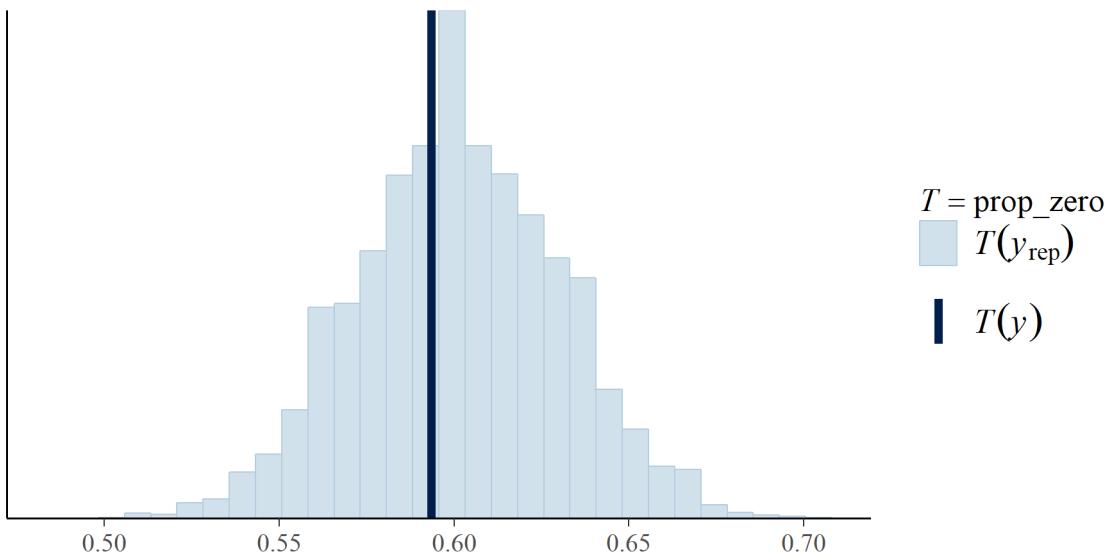


Figure 16: Posterior predictive distribution of the proportion of zero observations in replicate data sets generated by the negative binomial model for MRFSS dockside CPFV index north of Point Conception. [fig:Fleet10_prop_zero_STAN](#)

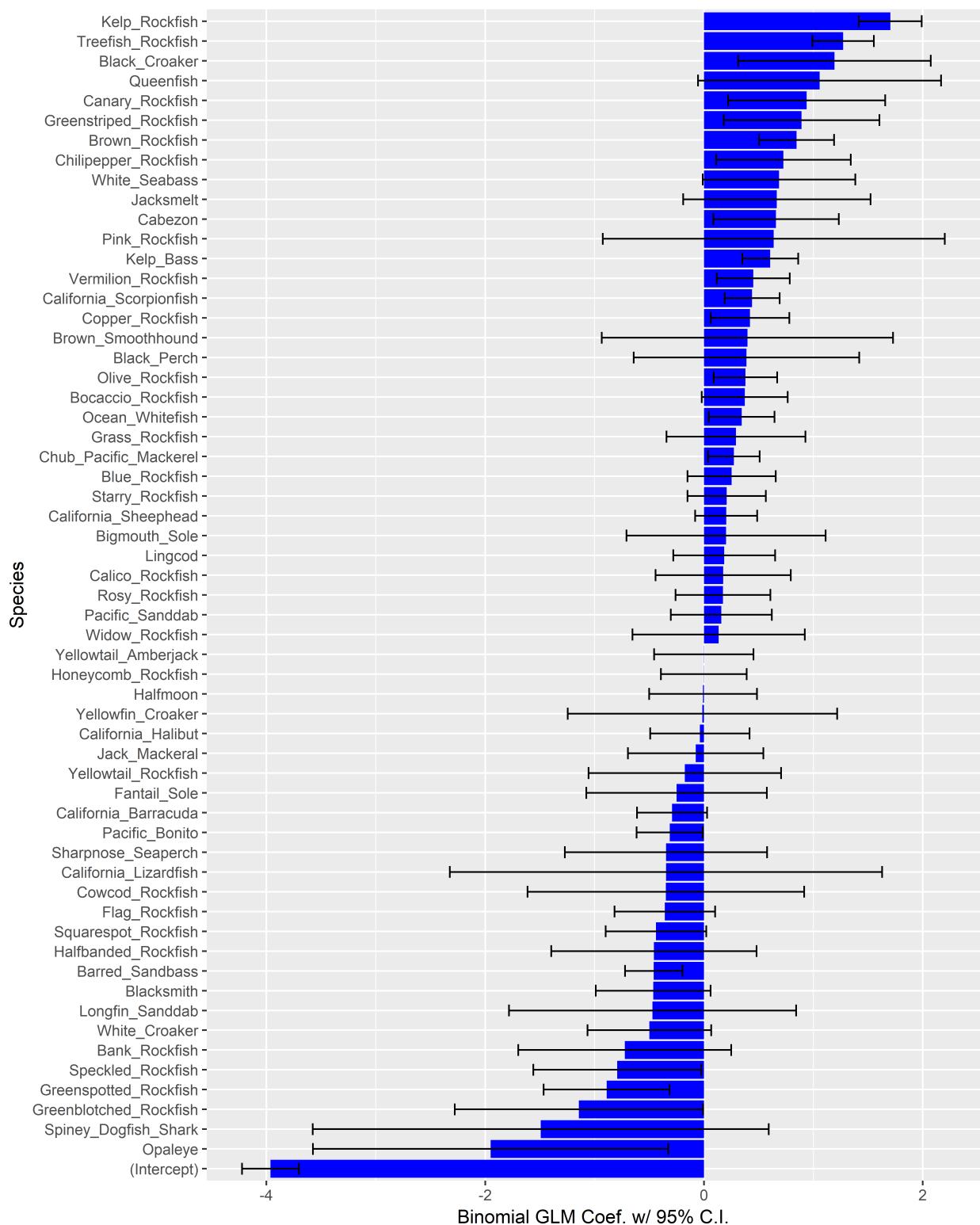


Figure 17: Species coefficients from the binomial GLM for presence/absence of GBYR in the Marine Recreational Fisheries Statistics Survey (MRFSS) CPFV mode dockside survey data set north of Point Conception. Horizontal bars are 95% confidence intervals. fig:Fleet11_SM_filter

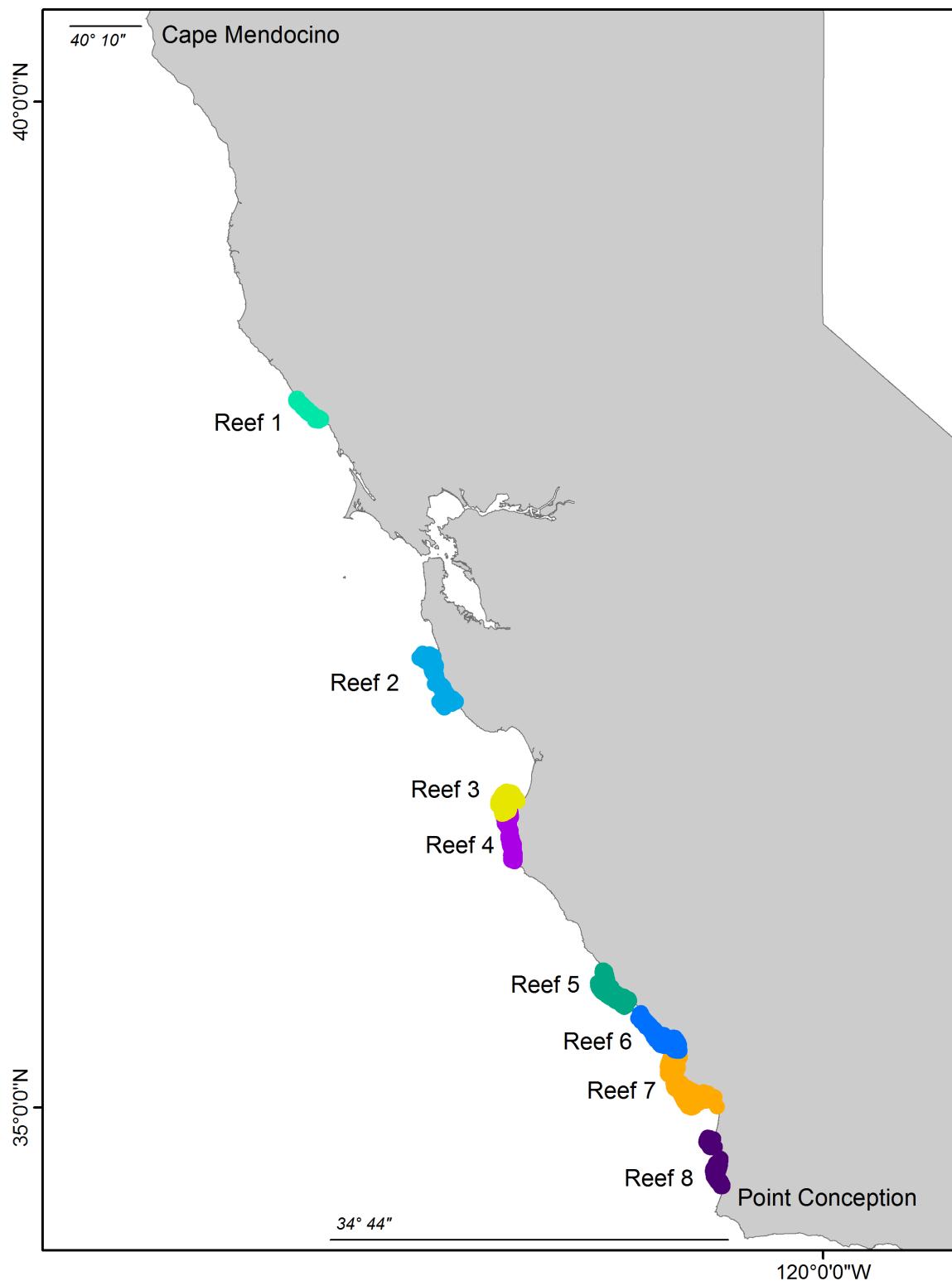


Figure 18: Map of the reefs used in the Deb Wilson-Vandenbervy CPFV onboard observer survey index of abundance. [fig:DebWV_sites](#)

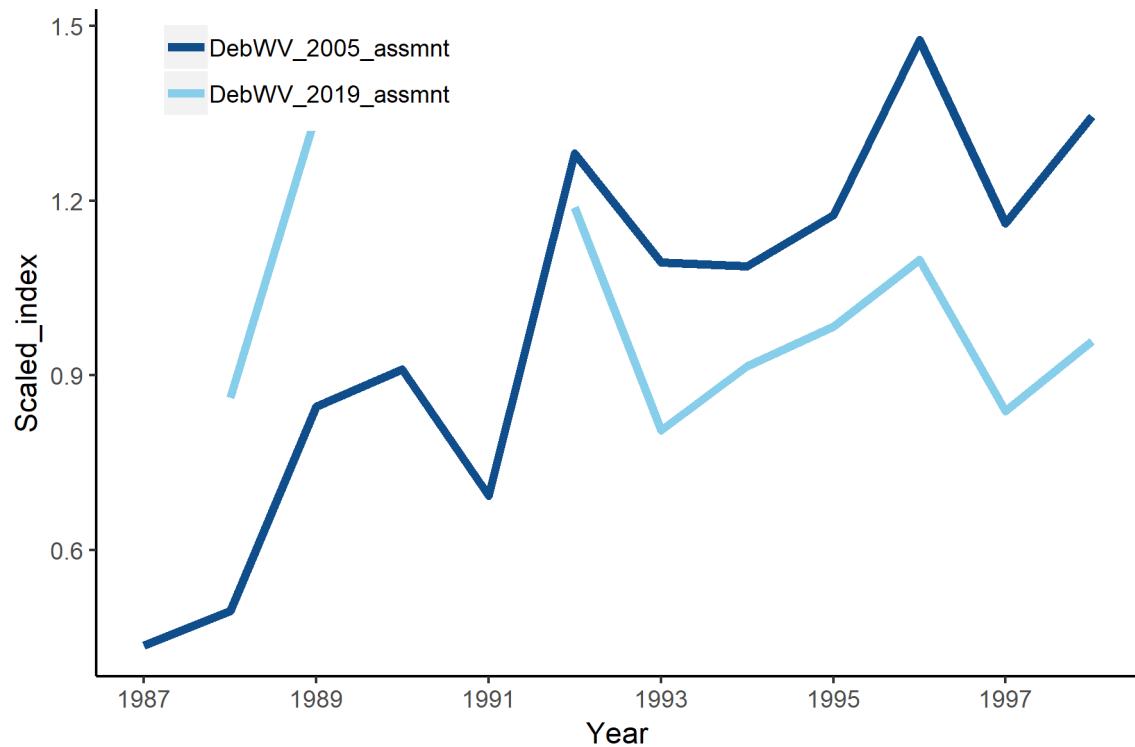


Figure 19: Comparison of the index developed for the Deb Wilson-Vandenberg CPFV onboard observer survey from the 2005 assessment and for the 2019 assessment. | Fig:DebWV_index_compare

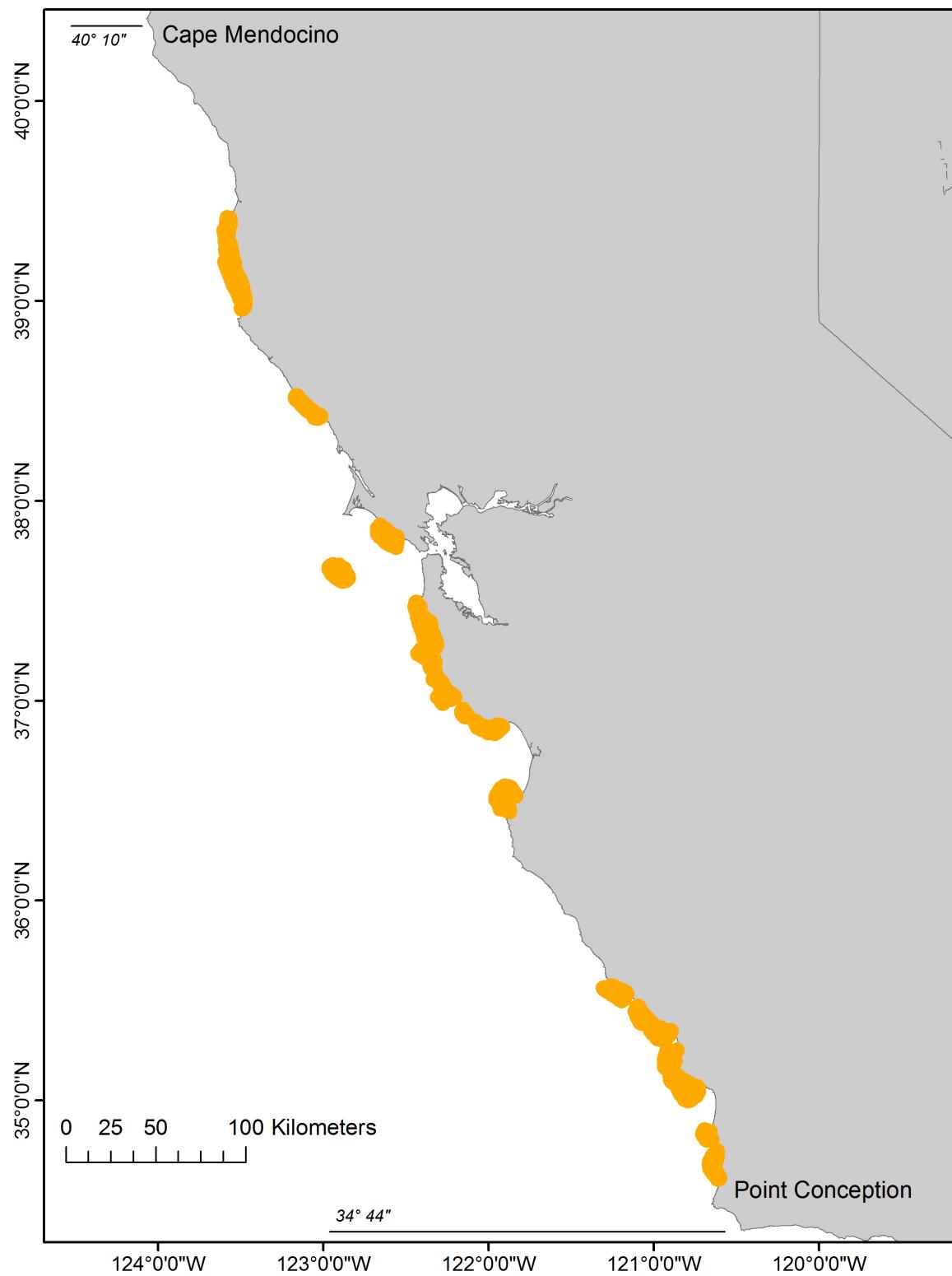


Figure 20: Map of the reefs selected for the final index for the onboard observer surveys (CDFW and Cal Poly) north of Point Conception

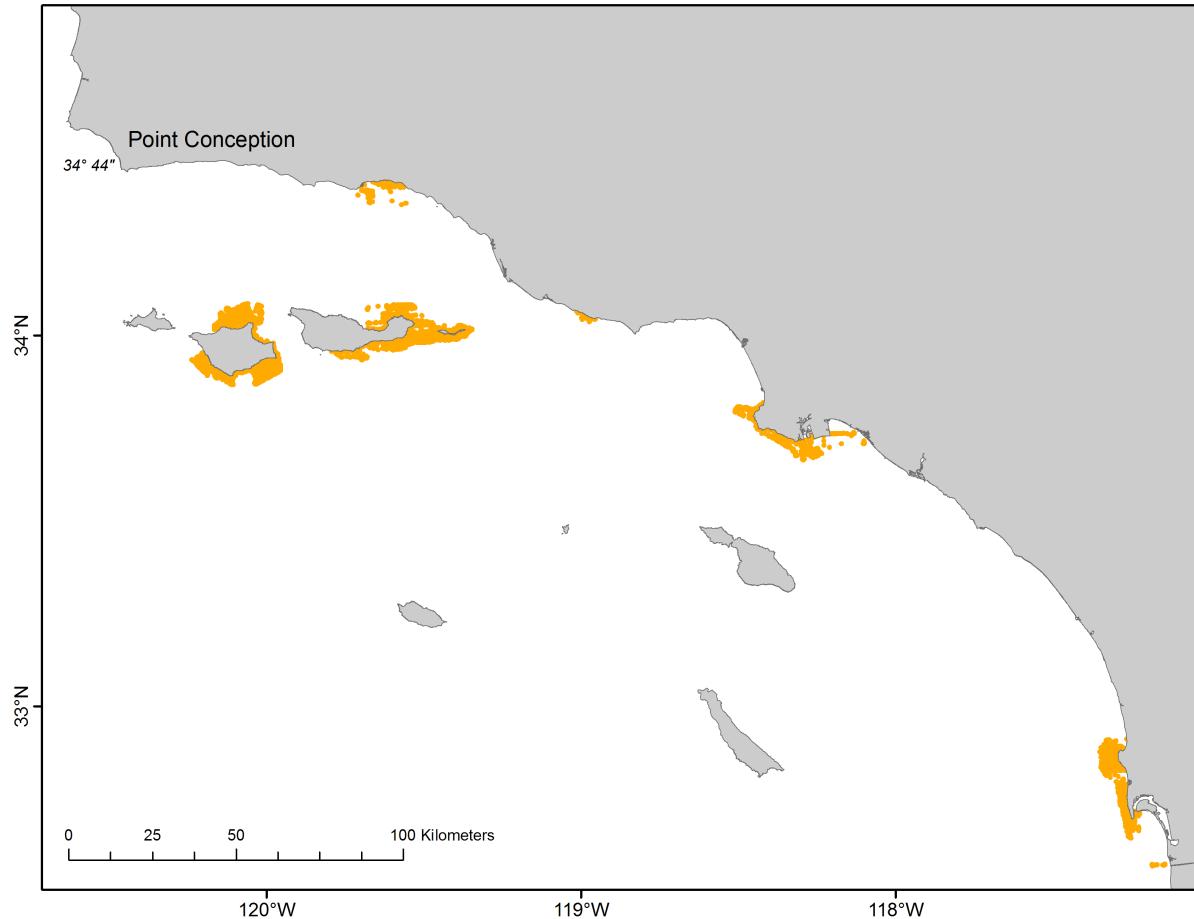


Figure 21: Map of the reefs selected for the final index for the CDFW onboard observer survey south of Point Conception | [fig:Unboard_observer_south_sites](#)

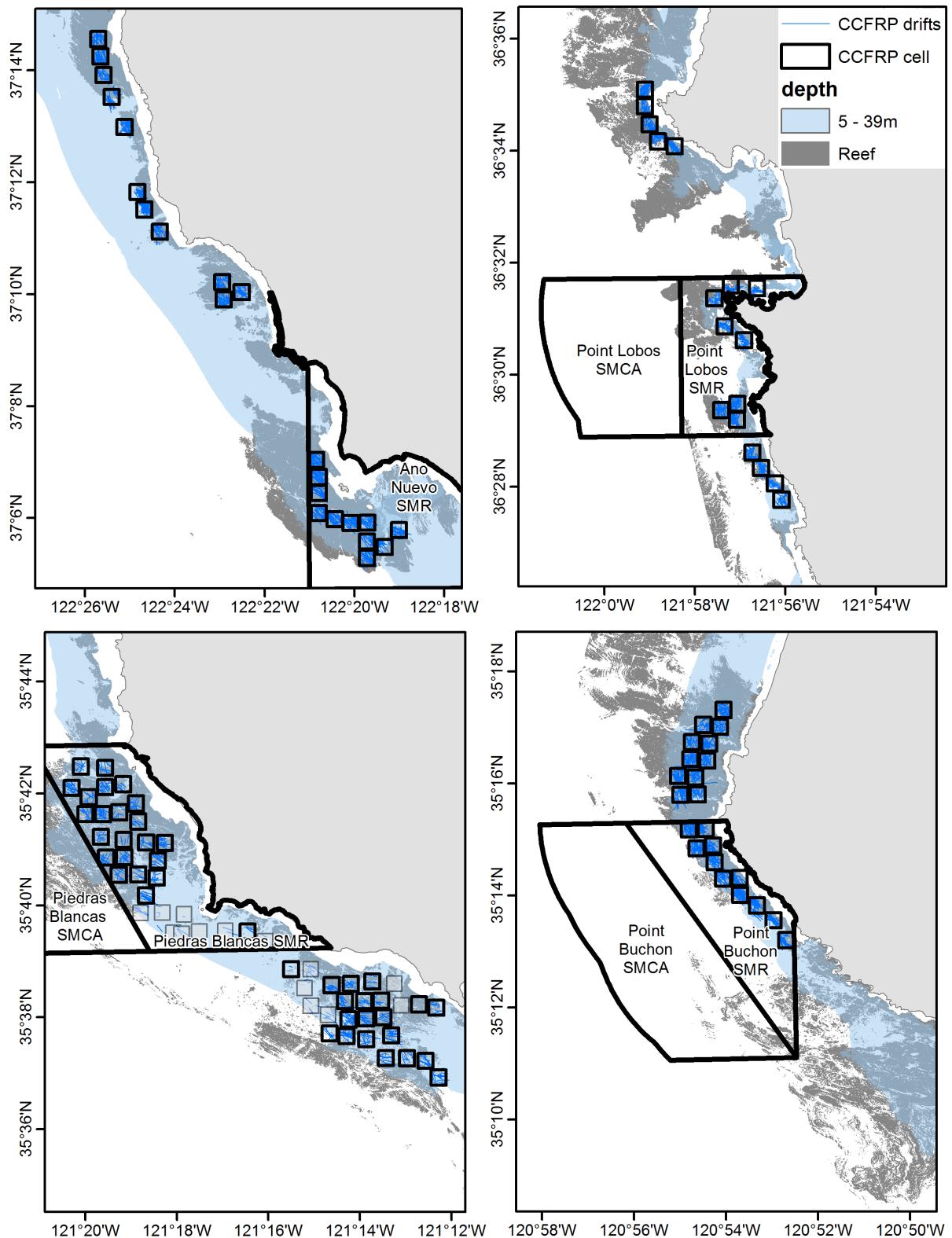


Figure 22: Map of the four MPAs sample consistently through time for the CCFRP fishery-independent survey. [fig:CCFRP_sites](#)

MLEs vs. Posterior Medians

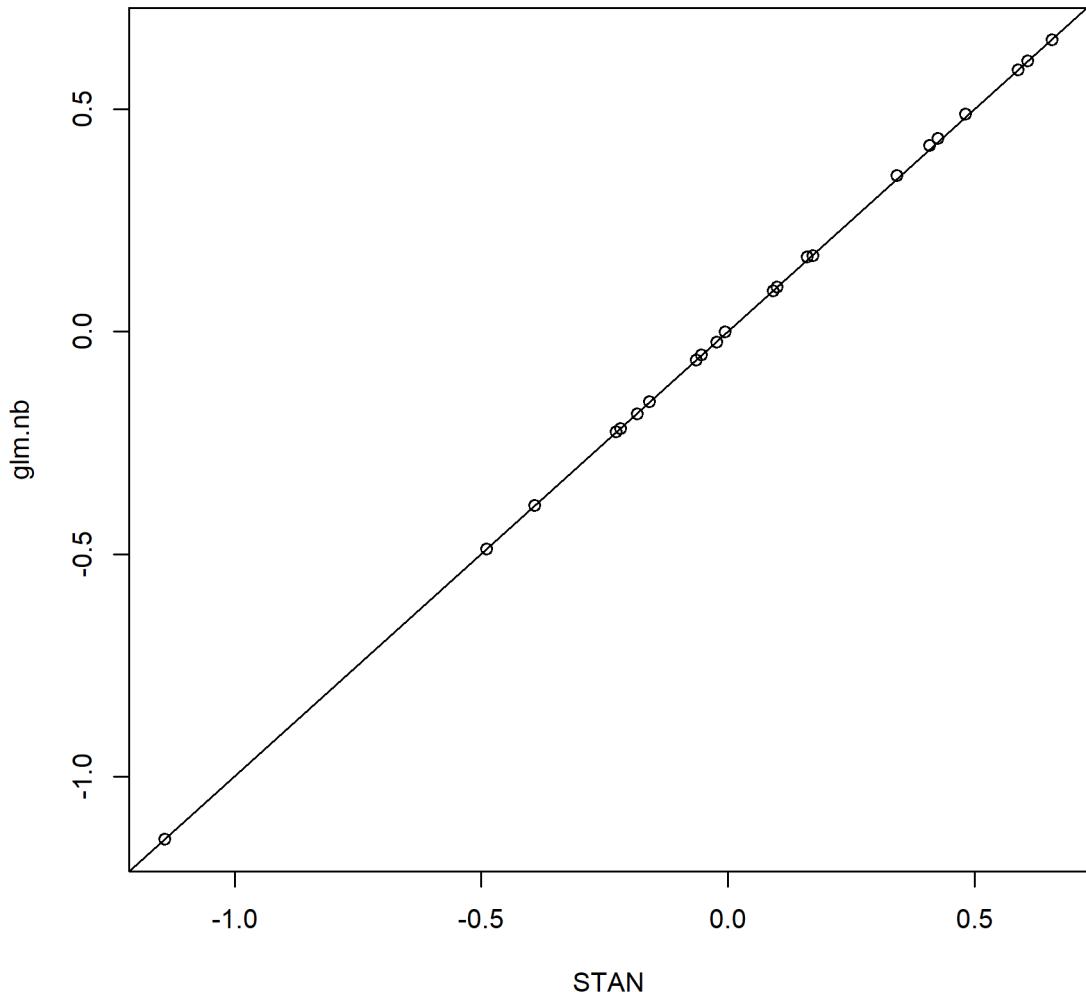


Figure 23: Comparison of negative binomial predictions (CPUE) to observed means in each stratum (year) for the CCFRP index. The 1:1 plot is for reference.

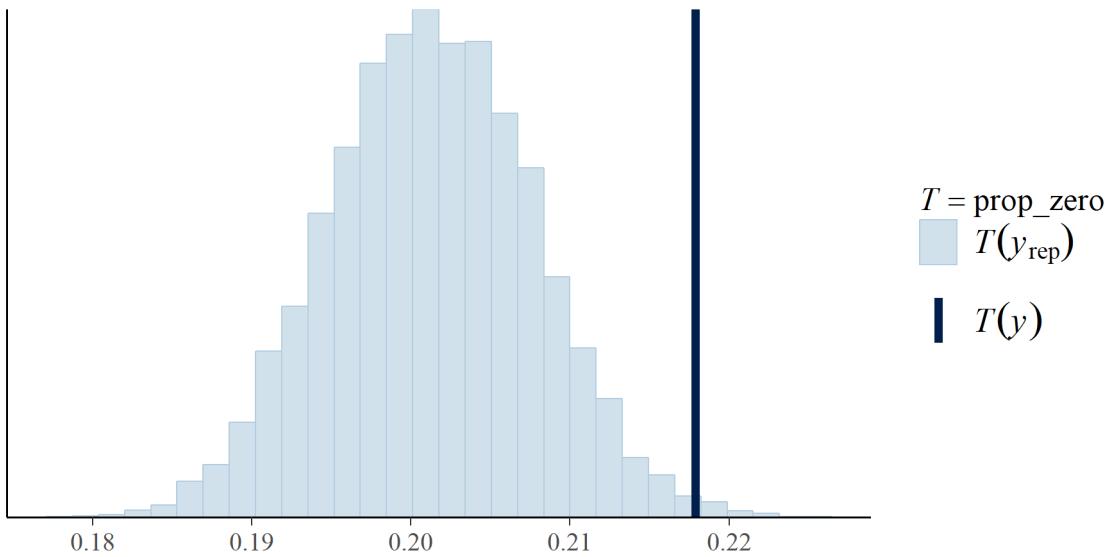


Figure 24: Posterior predictive distribution of the proportion of zero observations in replicate data sets generated by the negative binomial model for the CCFRP index. [fig:Fleet9_prop_zero_STAN](#)

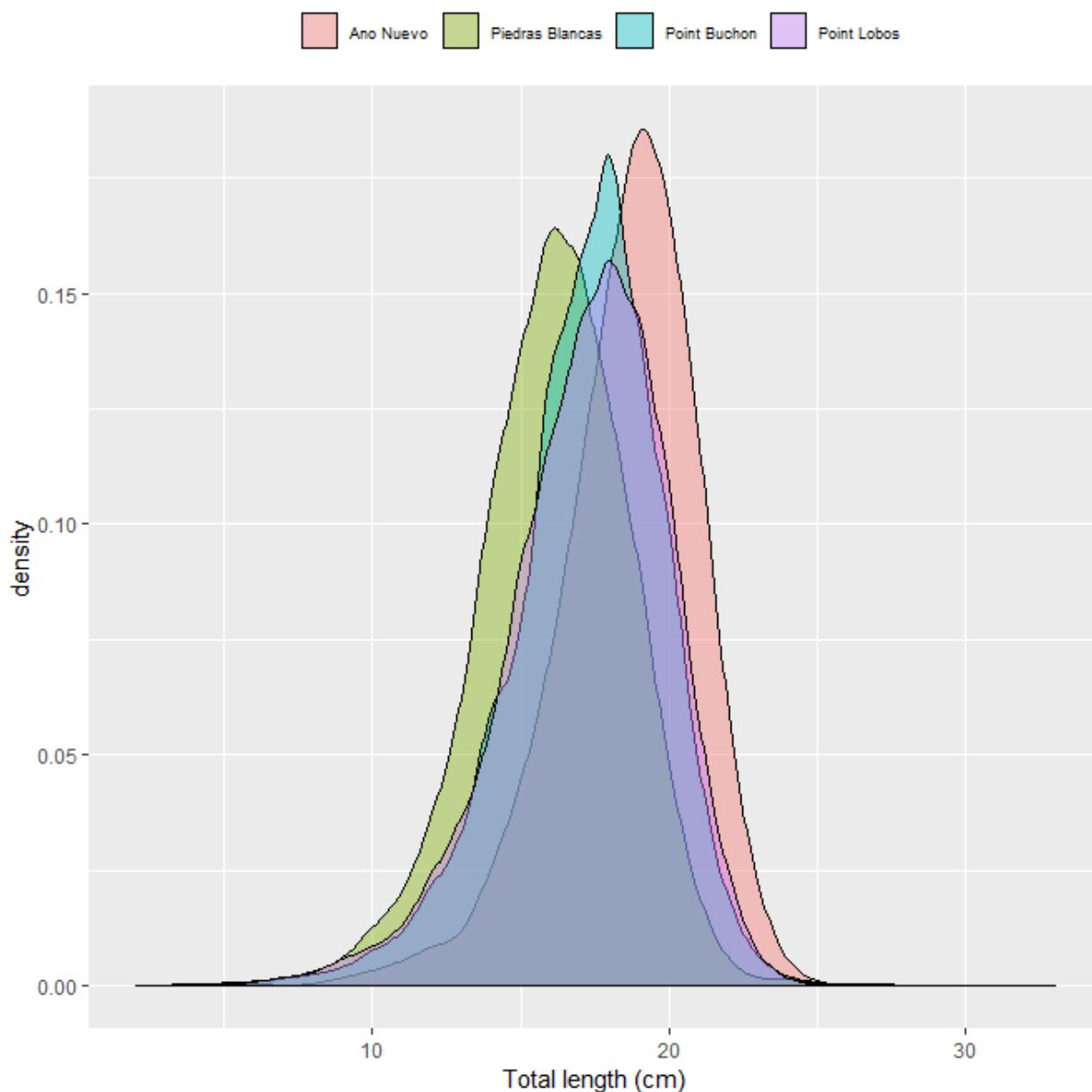


Figure 25: Length distributions of GBYR for the four MPAs sampled by the CCFRP survey used in this assessment. | [CCFRP_lengths_by_site](#)

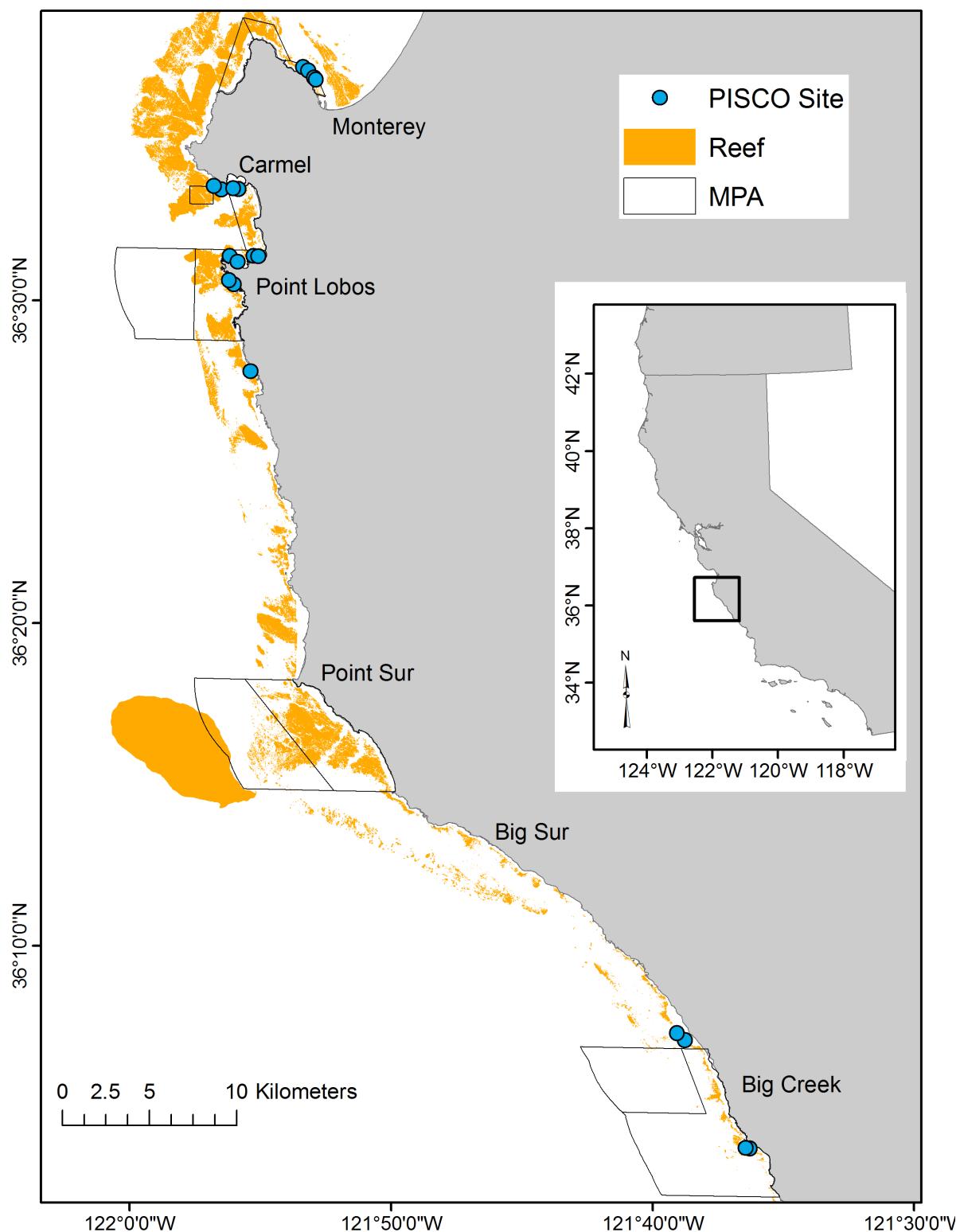


Figure 26: Map of the sites sampled consistently through time for the PISCO kelp forest fish survey. | [fig:PISCO_sites](#)

MLEs vs. Posterior Medians

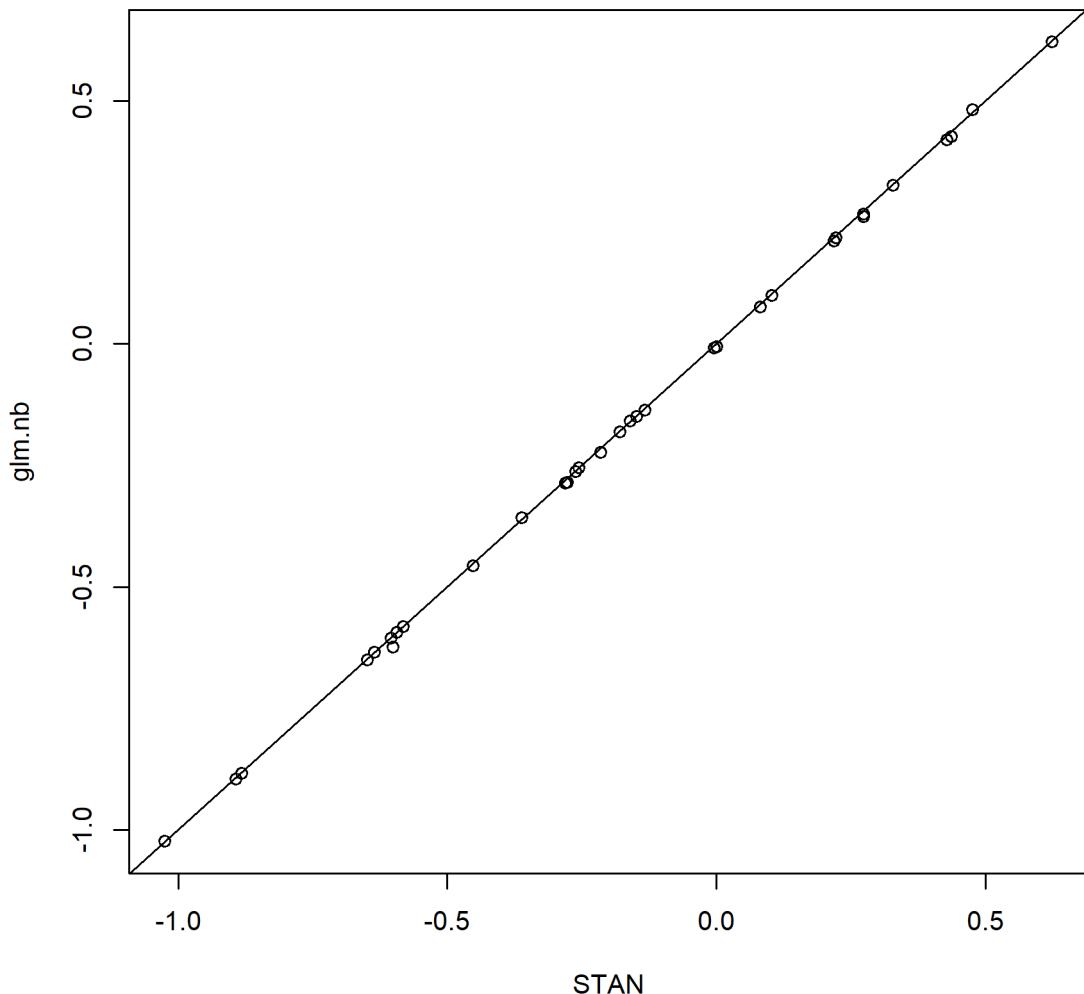


Figure 27: Comparison of negative binomial predictions (CPUE) to observed means in each stratum (year) for the PISCO kelp forest fish survey index. The 1:1 plot is for reference. [fig:Fleet8_MLE](#)

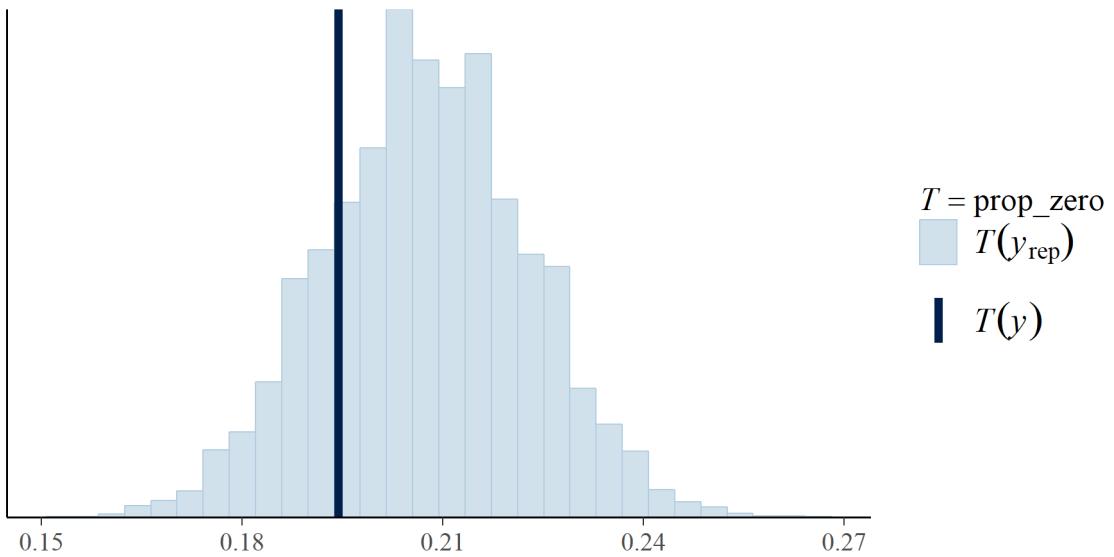


Figure 28: Posterior predictive distribution of the proportion of zero observations in replicate data sets generated by the negative binomial model for the PISCO kelp forest fish survey. [fig:Fleet8_pr](#)

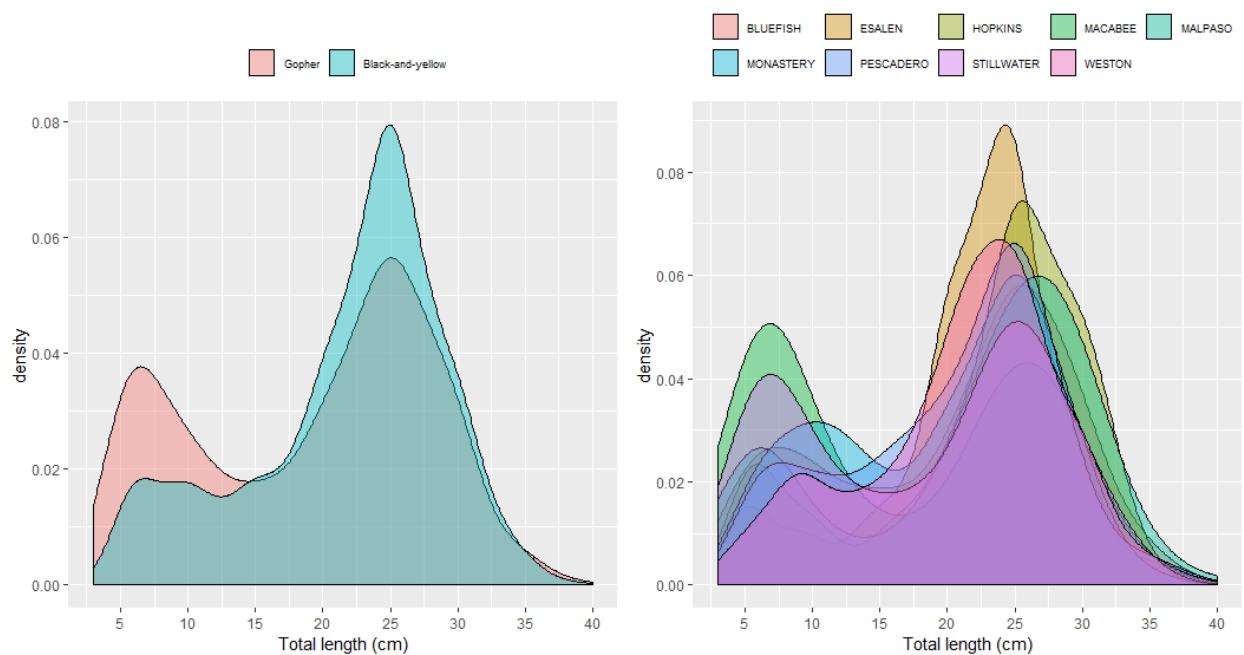


Figure 29: Plots of the length distributions from the PISCO kelp forest fish survey by species (left) and for combined species by site (right) for sites included in the final index of abundance. [fig:PISCO_Lengths](#)

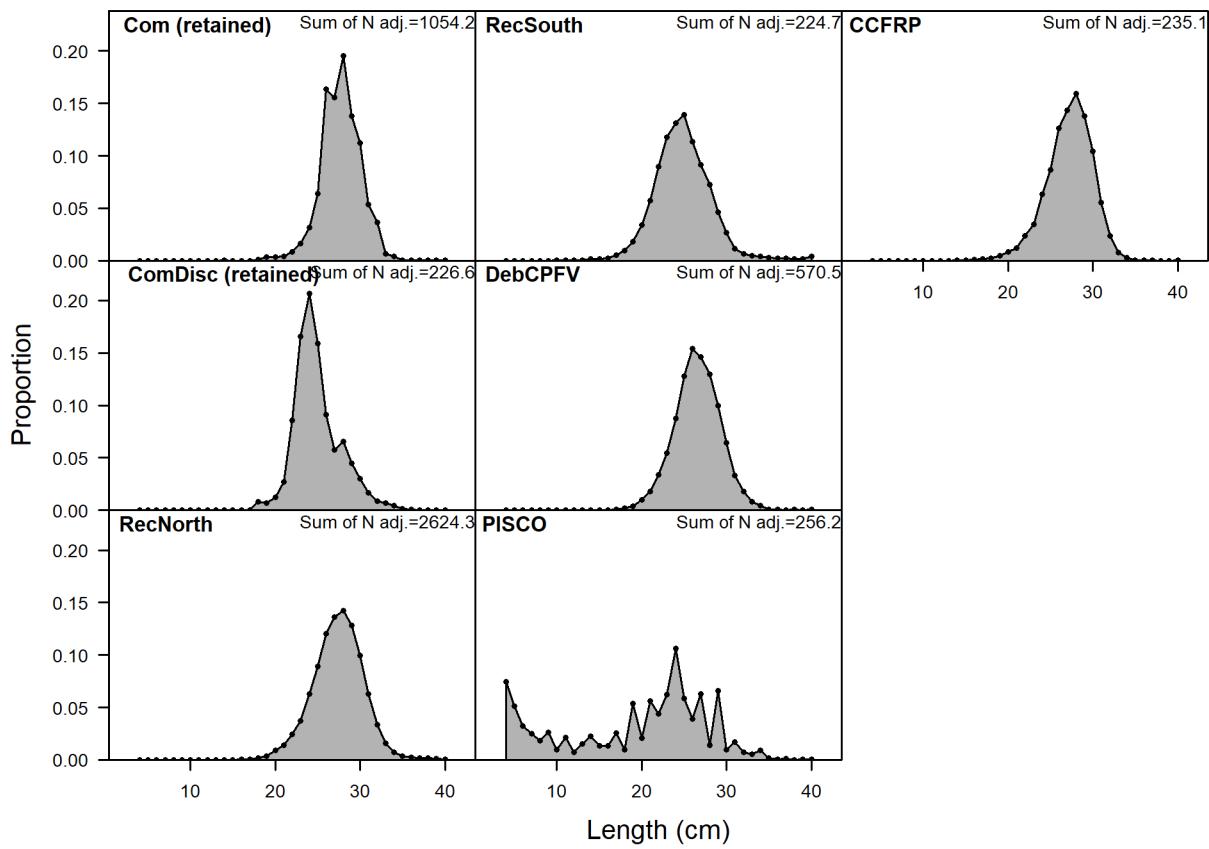


Figure 30: Length comp data, aggregated across time by fleet. Labels ‘retained’ and ‘discard’ indicate discarded or retained sampled for each fleet. Panels without this designation represent the whole catch. | [fig:comp_lendat_aggregated_across_time](#)

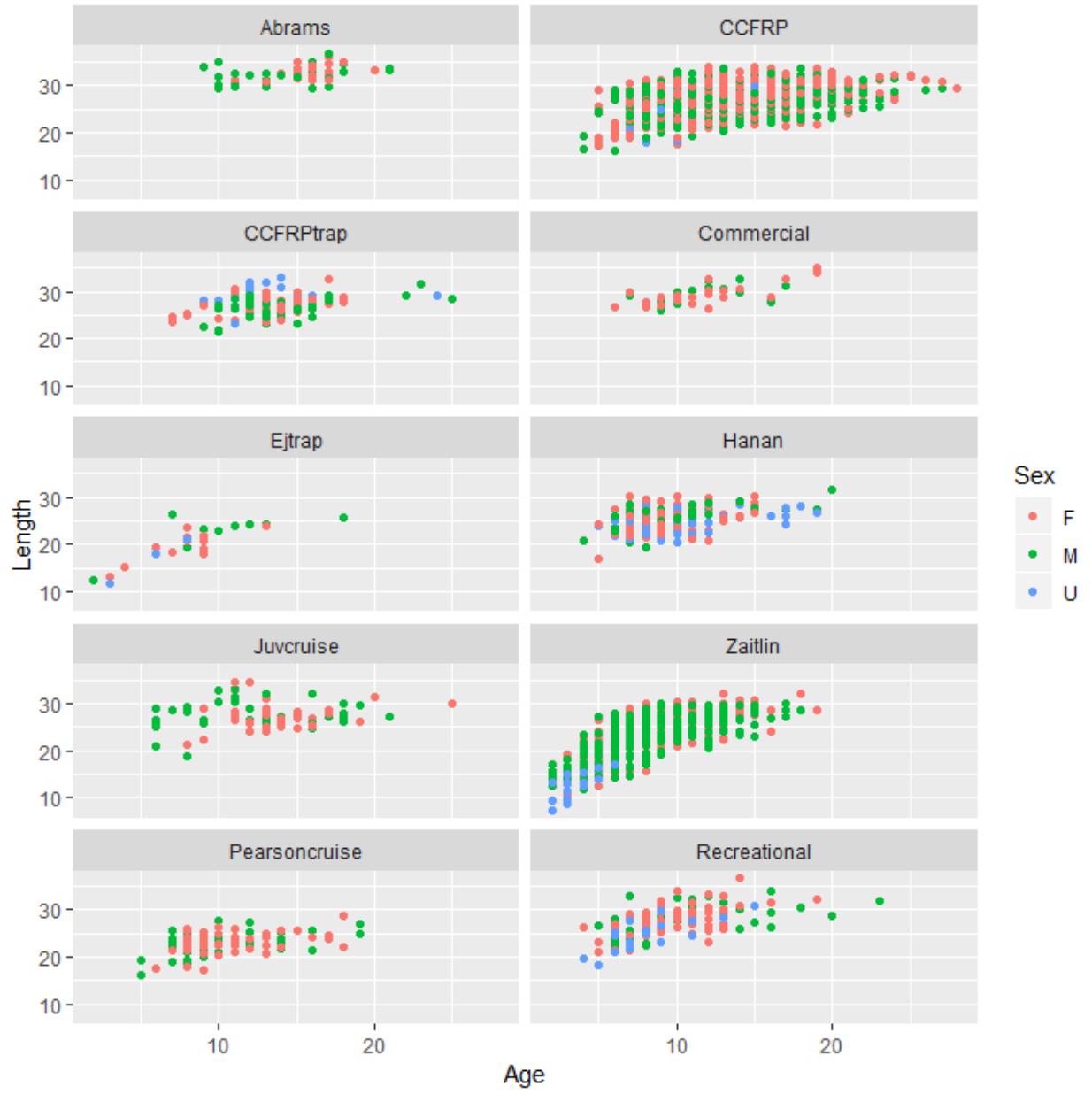


Figure 31: Available length-at-age data for gopher and black-and-yellow rockfish by sex and data source. The Zaitlin study is all black-and-yellow rockfish. The remaining plots represent gopher rockfish

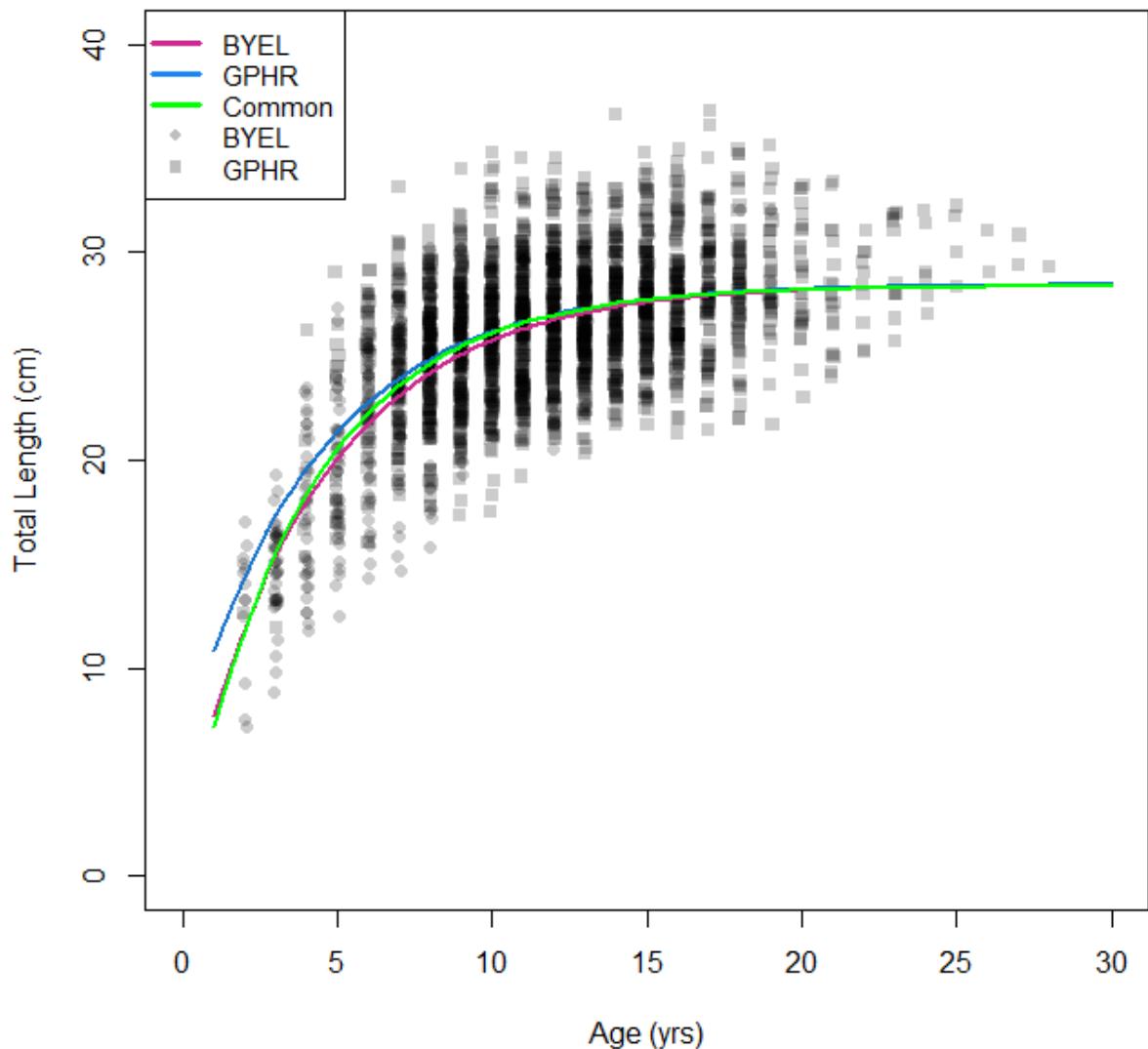


Figure 32: External estimates of growth for gopher and black-and-yellow rockfish from fits to von Bertalanffy growth models. | [Growth_by_species](#)

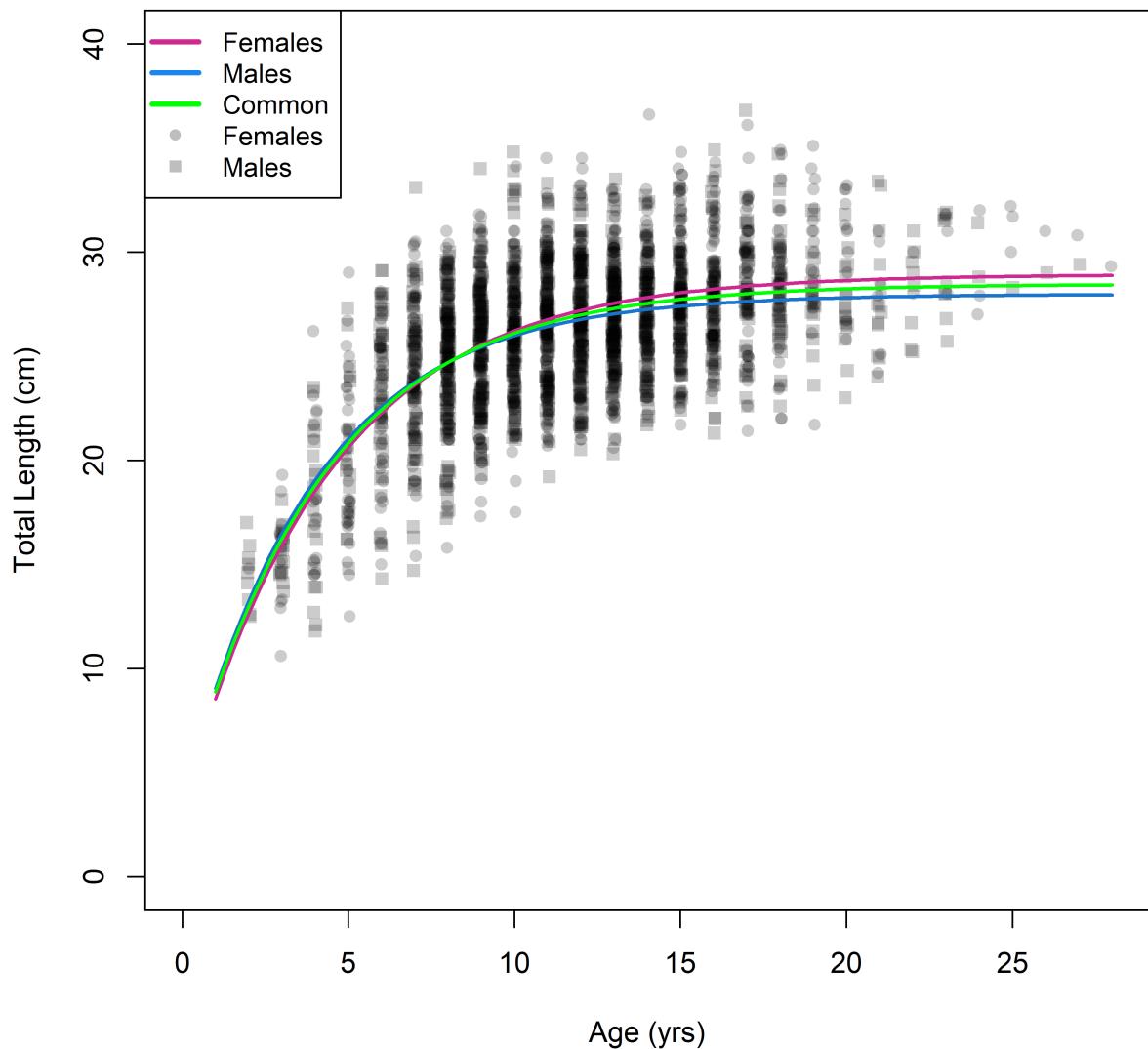


Figure 33: External estimates of growth for GBYR combined by sex from fits to von Bertalanffy growth models. | [Growth_by_sex](#)

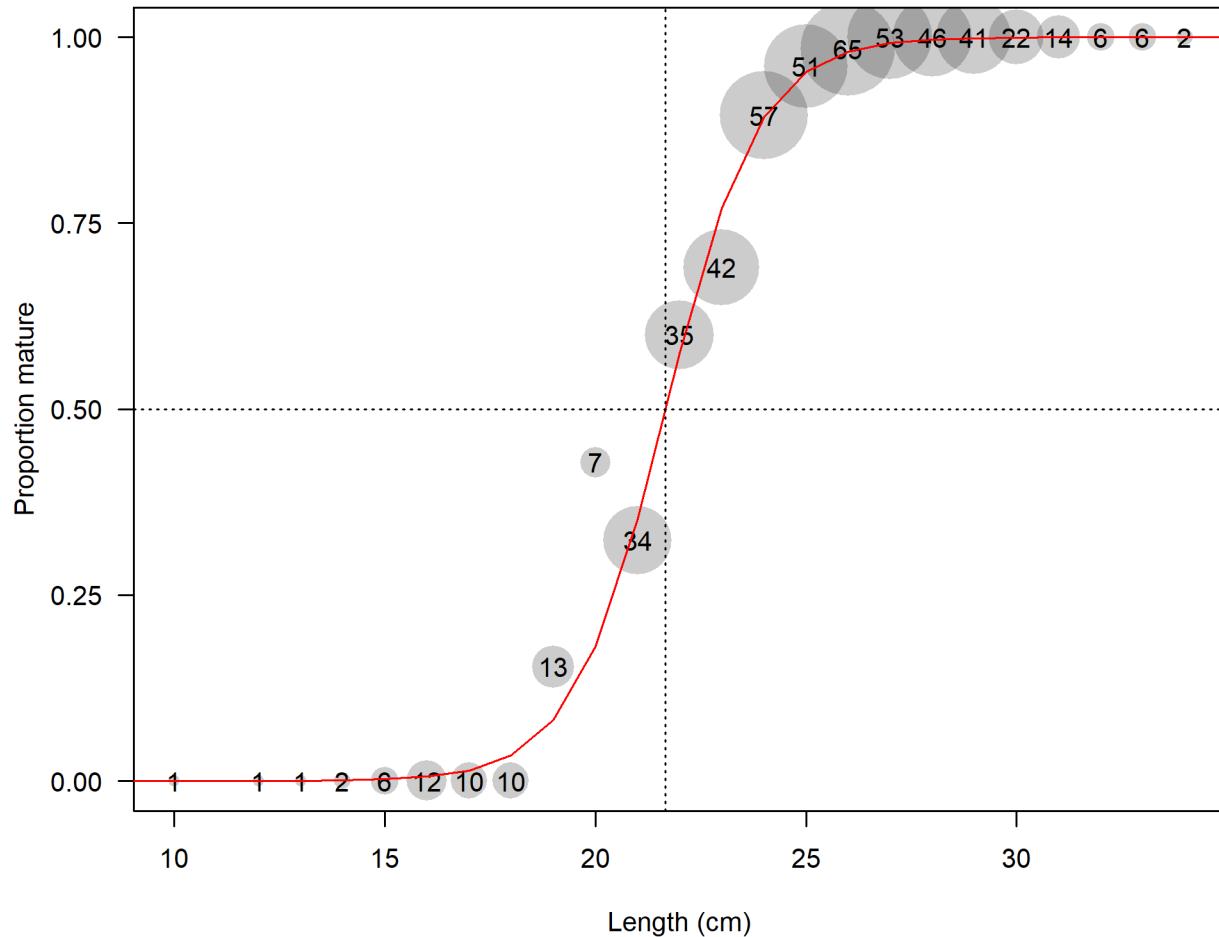
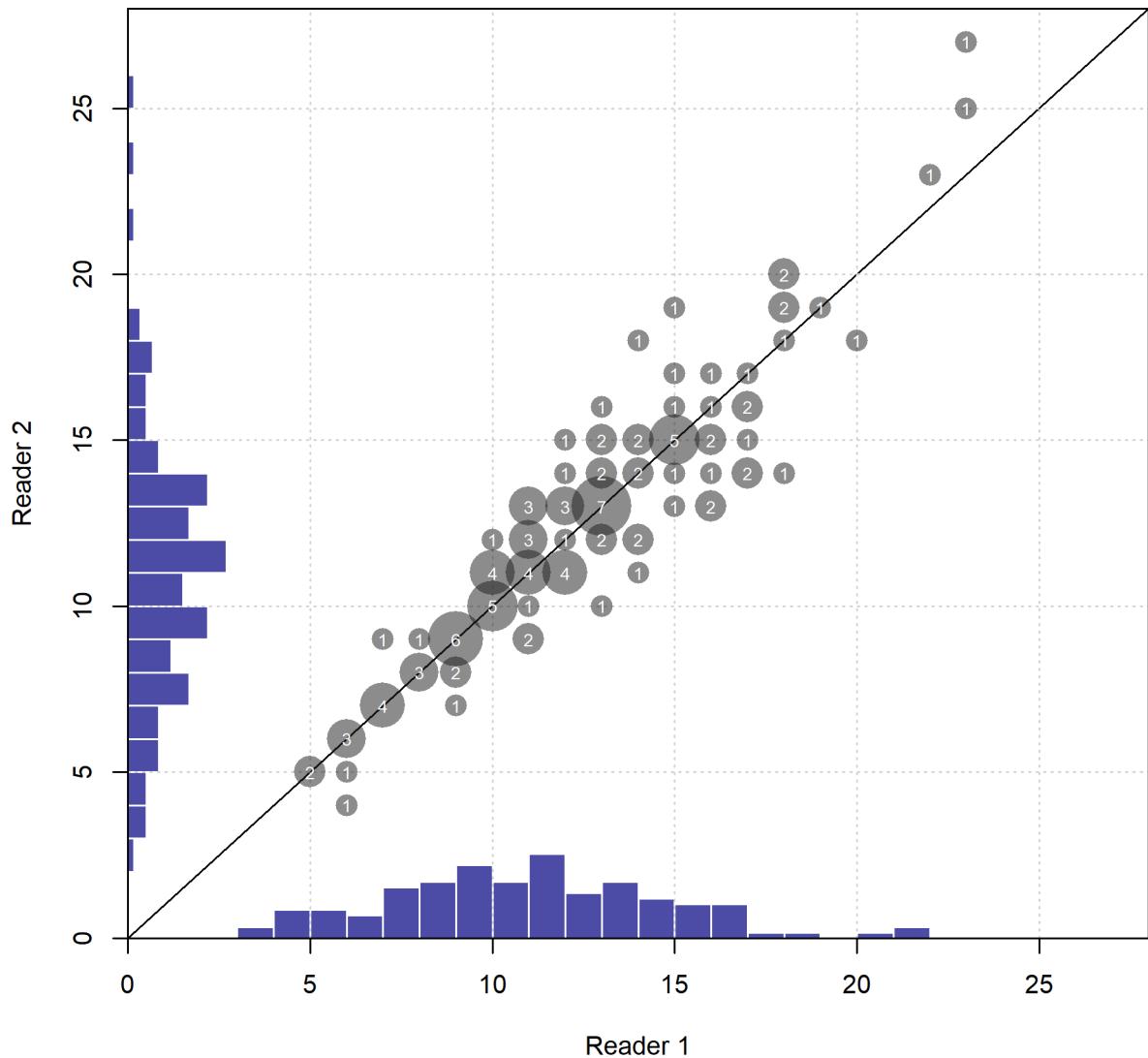


Figure 34: Maturity ogive for females estimated from black-and-yellow rockfish from Zaitlin (1986) and gopher rockfish from Meyers-Cherry (2014). Sample sizes at a given length are shown in the circles. [fig:GBY_maturity_ogive](#)



Reads(dot), Sd(blue), expected_read(red solid line),
and 95% CI for expected_read(red dotted line)

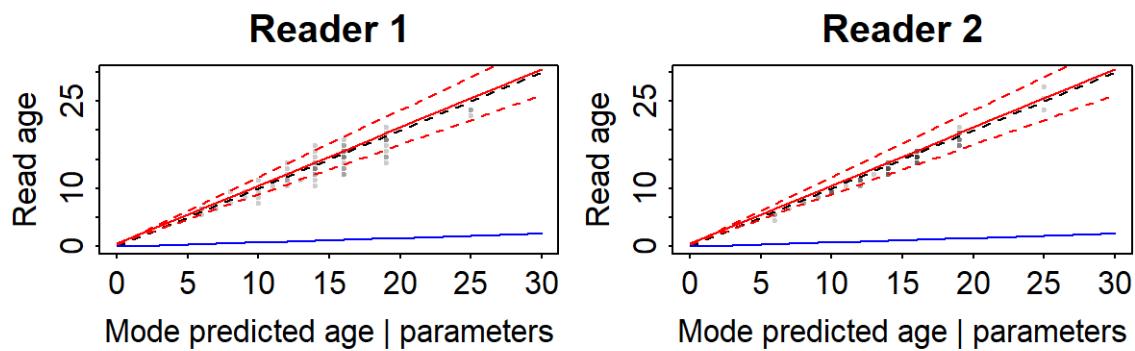


Figure 36: True versus predicted age for two current age readers at the NWFSC from the ageing error software with unbiased reads and curvilinear standard deviation for both readers.
fig:GBY_age_error2

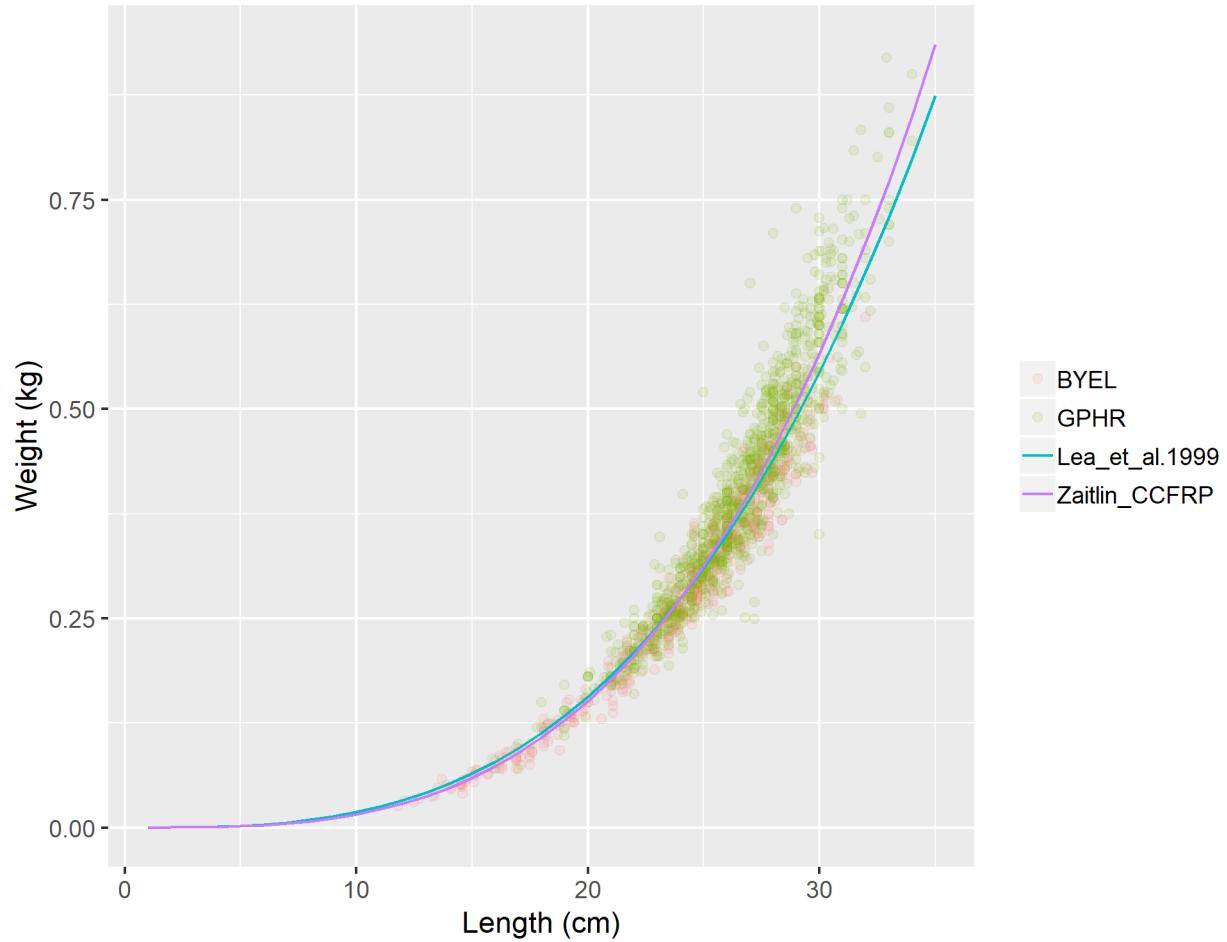


Figure 37: Comparison of the gopher rockfish weight-length curves from Lee et al. (1999) and the estimated from black-and-yellow rockfishes from Zaitlin (1986), and gopher rockfishes from Loury (2011) and Meyers-Cherry(2014). The estimated curve from the current data is used in this assessment. [fig:GBY_weight_length](#)

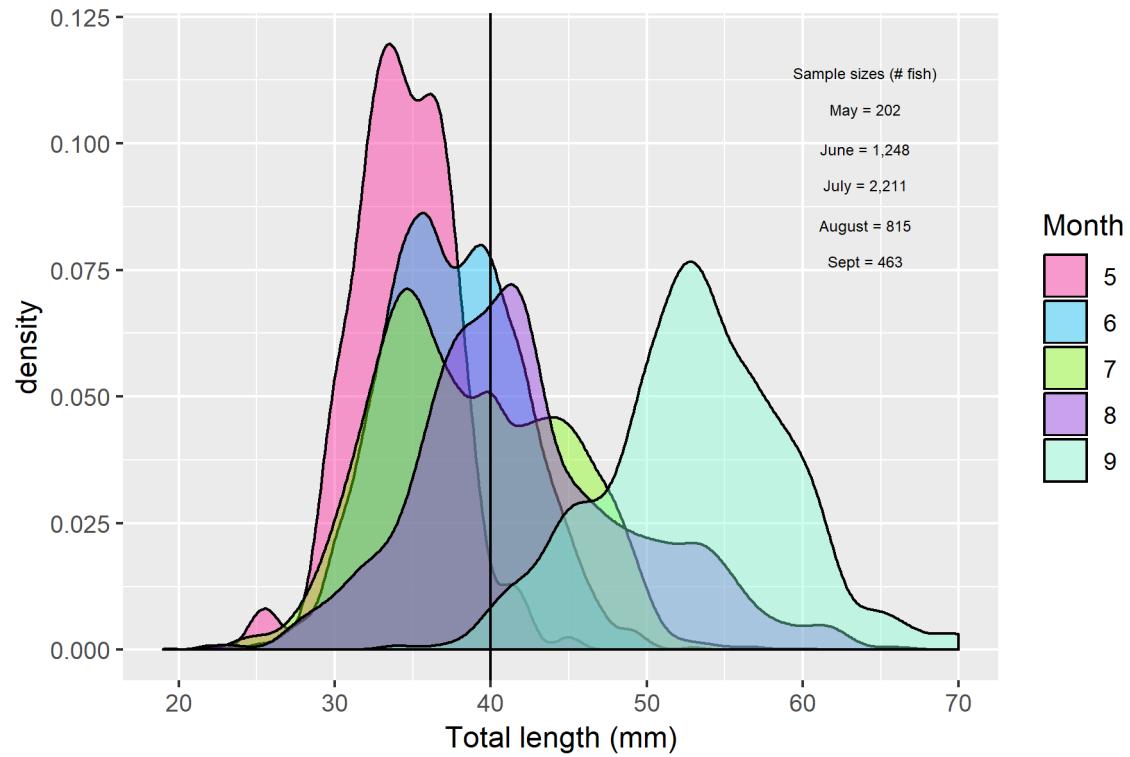


Figure 38: Length distribution by month for GBYR captured using a sampling tool called a Standard Monitoring Unit for the Recruitment of Fishes (SMURFs) from the UCSC-PISCO kelp forest fish survey, specifically as part of Diana Baetscher's dissertation work (Baetscher 2019). [fig:SMURF_lengths](#)

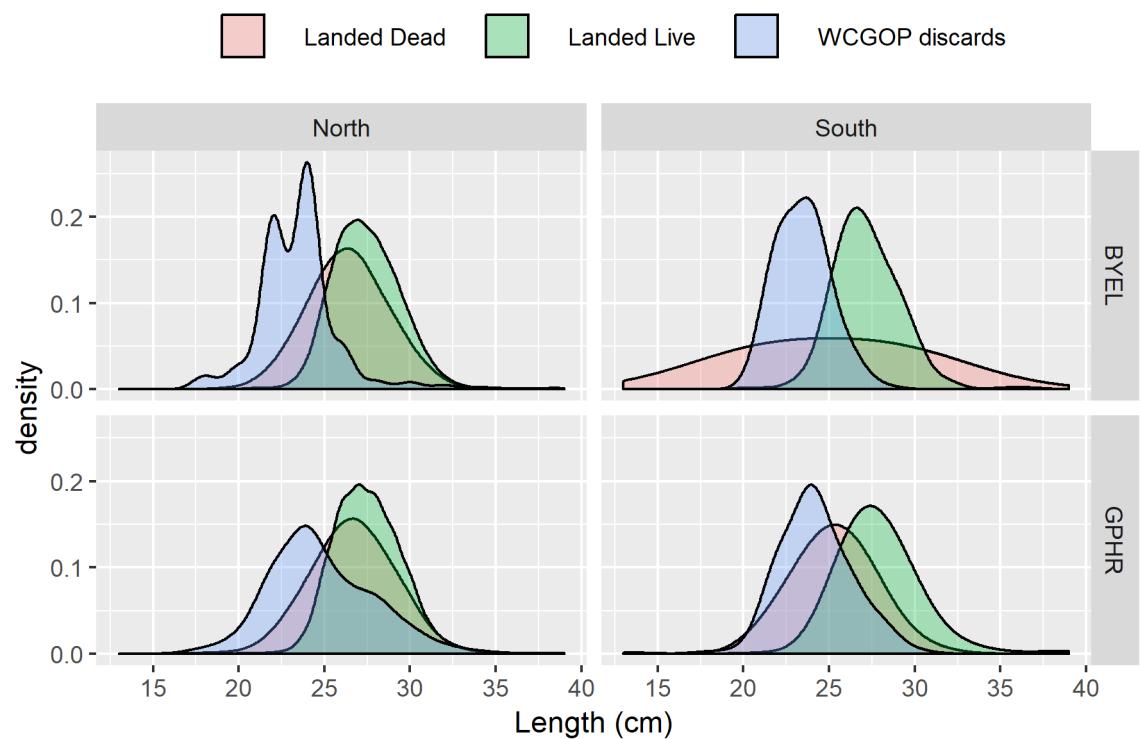


Figure 39: Length distributions of gopher and black-and-yellow rockfish for the commercial fleet and WCGOP discards north and south of Point Conception. The commercial landings were also separated between fish landed live and fish landed dead for this figure. [fig:Comm_lengths_justified](#)

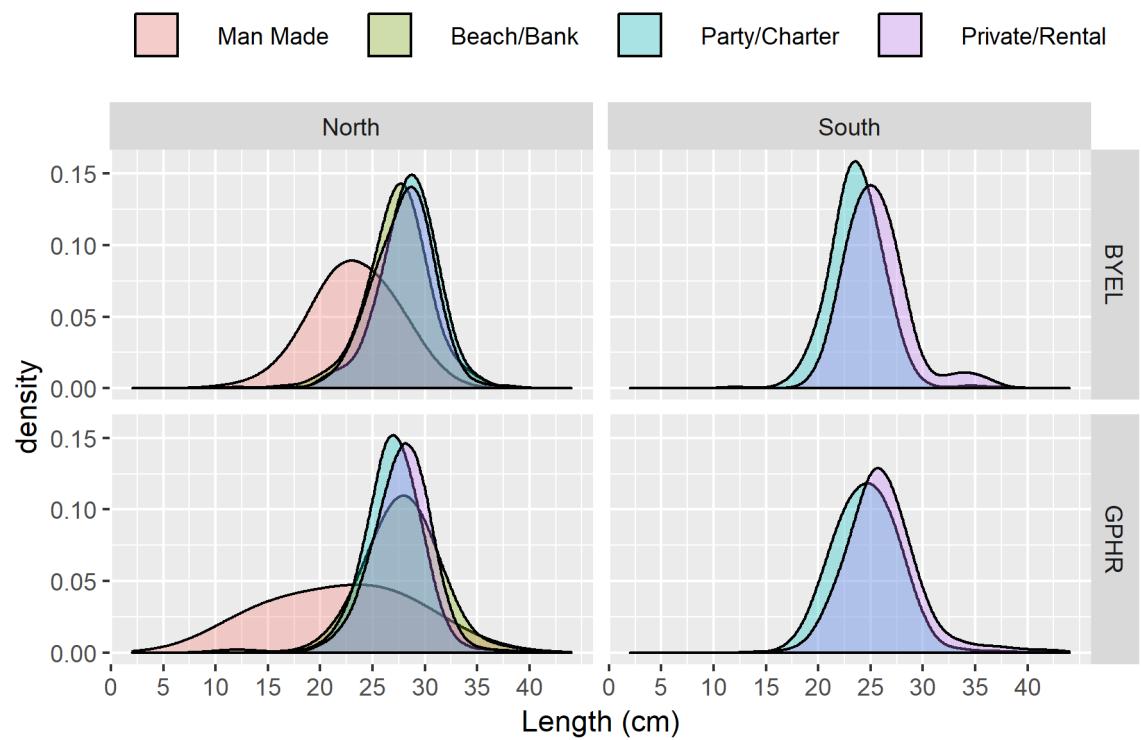


Figure 40: Length distributions of gopher and black-and-yellow rockfish for the recreational fleet north and south of Point Conception and by mode. fig:Rec_lengths_justification

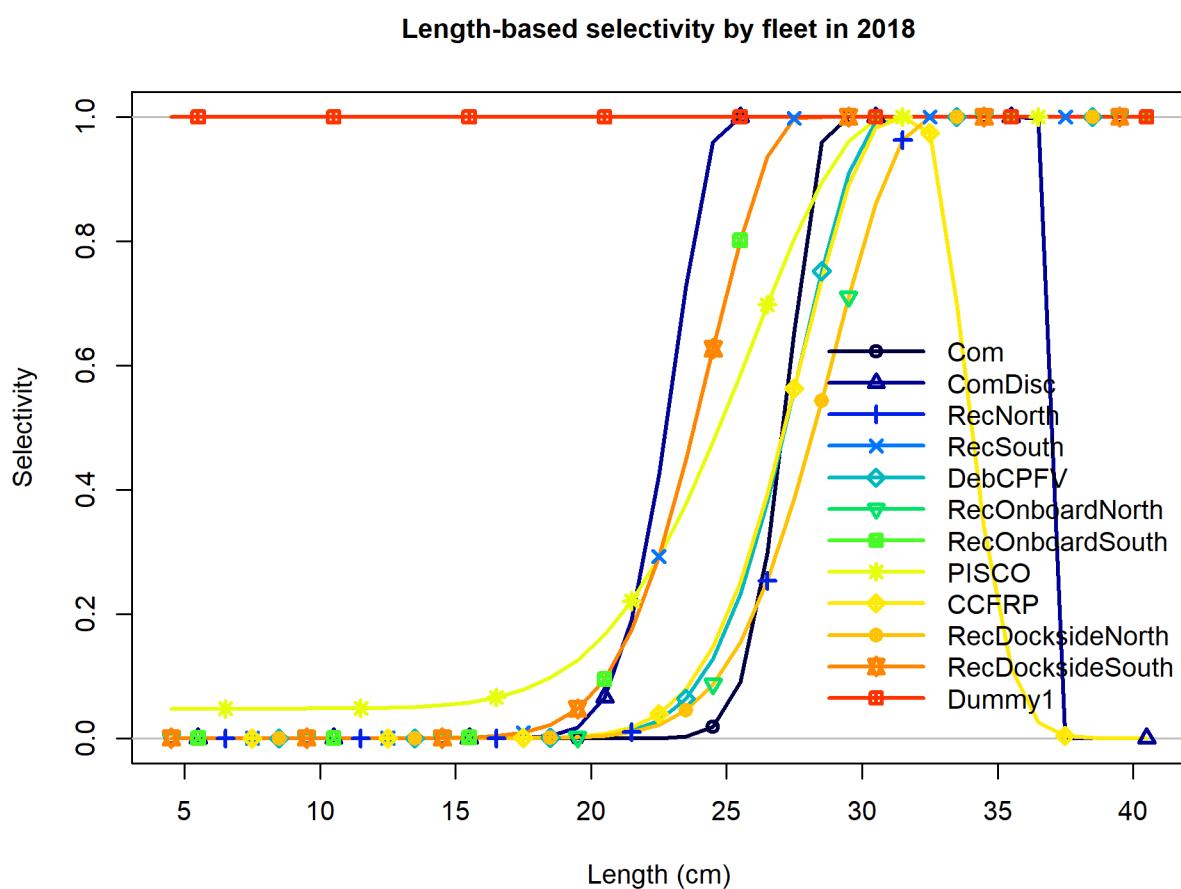


Figure 41: Selectivity at length for all of the fleets in the base model. fig:sel01_multiple_fle

Time-varying selectivity for Com

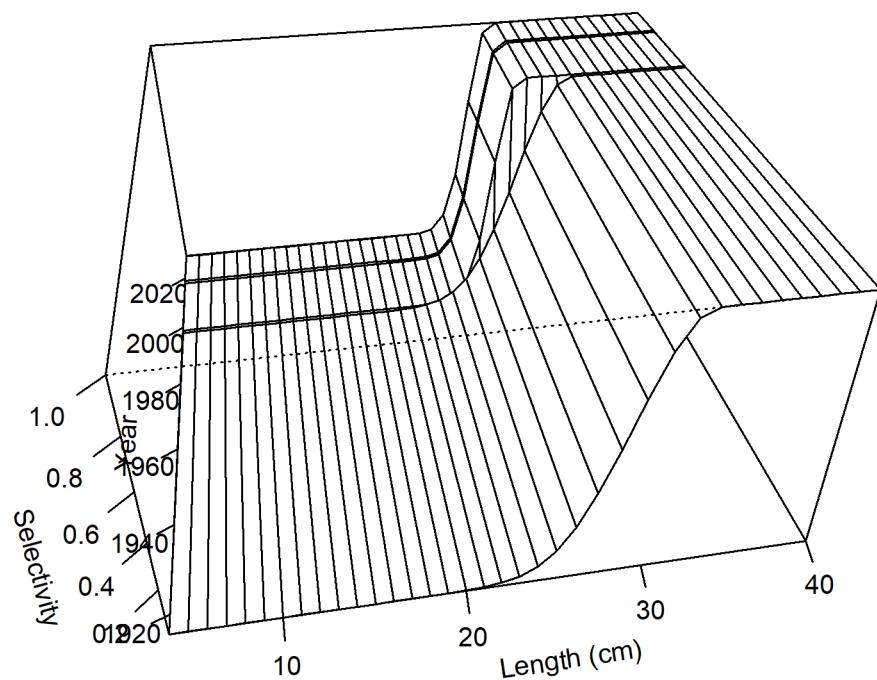


Figure 42: Surface plot of Female time-varying selectivity for the commercial fleet, with time blocks from 1916-1998 and 1999-2018. fig:sel03_len_timevary_surf_flt1sex1

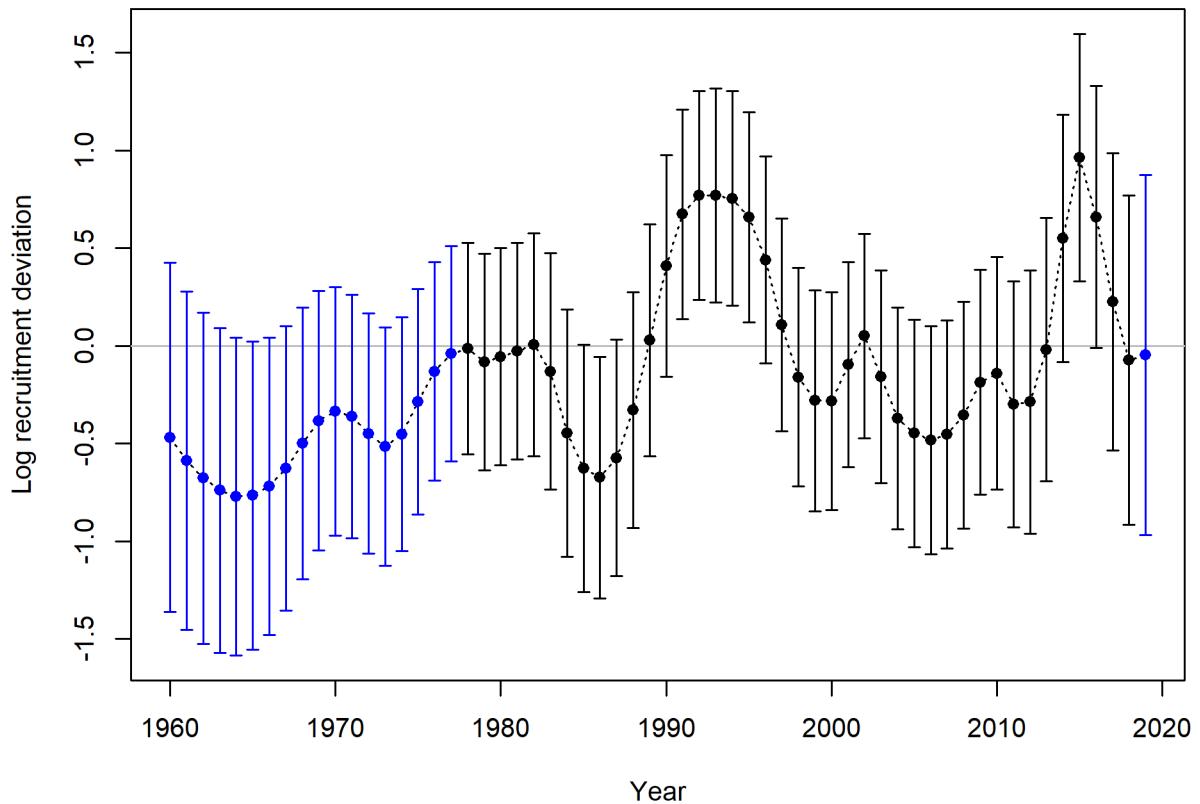


Figure 43: Estimated time-series of recruitment deviations for GBYR with 95% intervals. fig:recdevs2

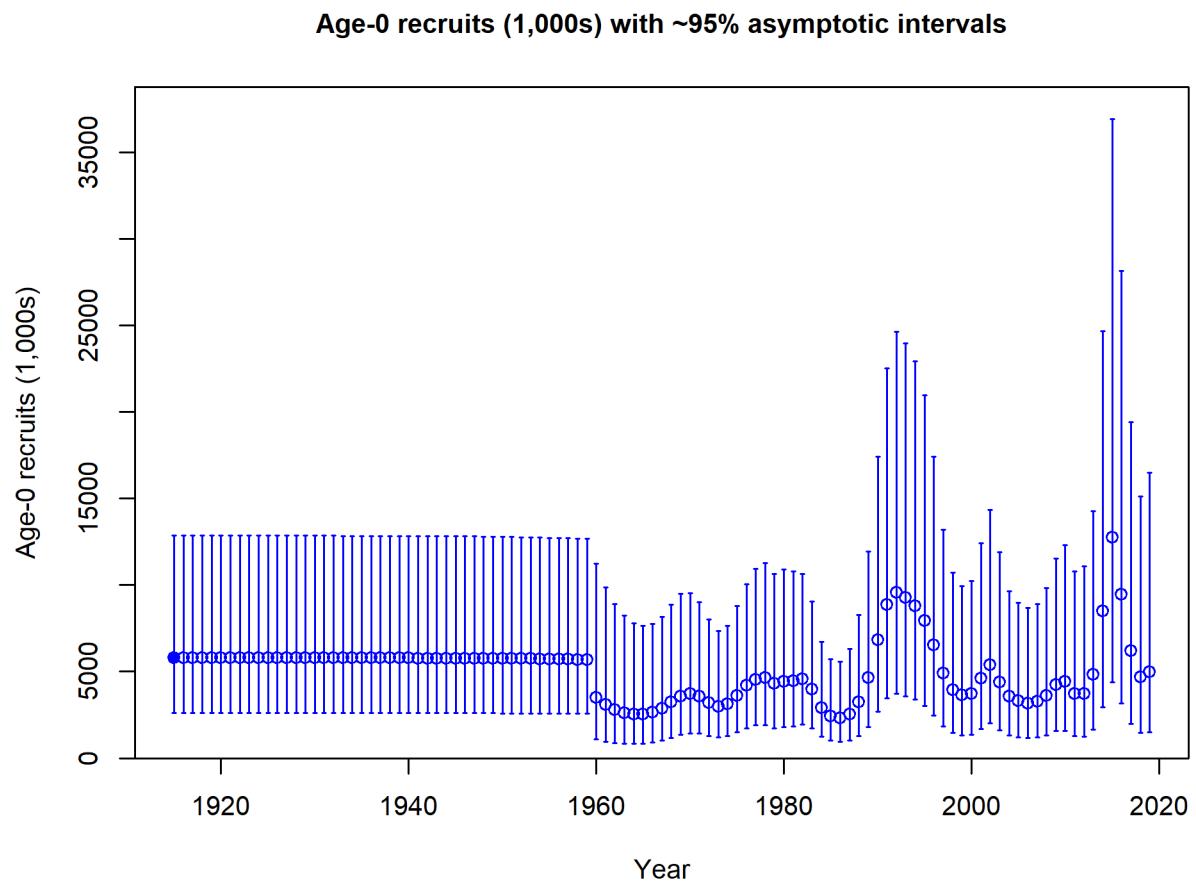


Figure 44: Time series of estimated GBYR recruitments for the base-case model with 95% confidence or credibility intervals. [fig:Recruit_mod1](#)

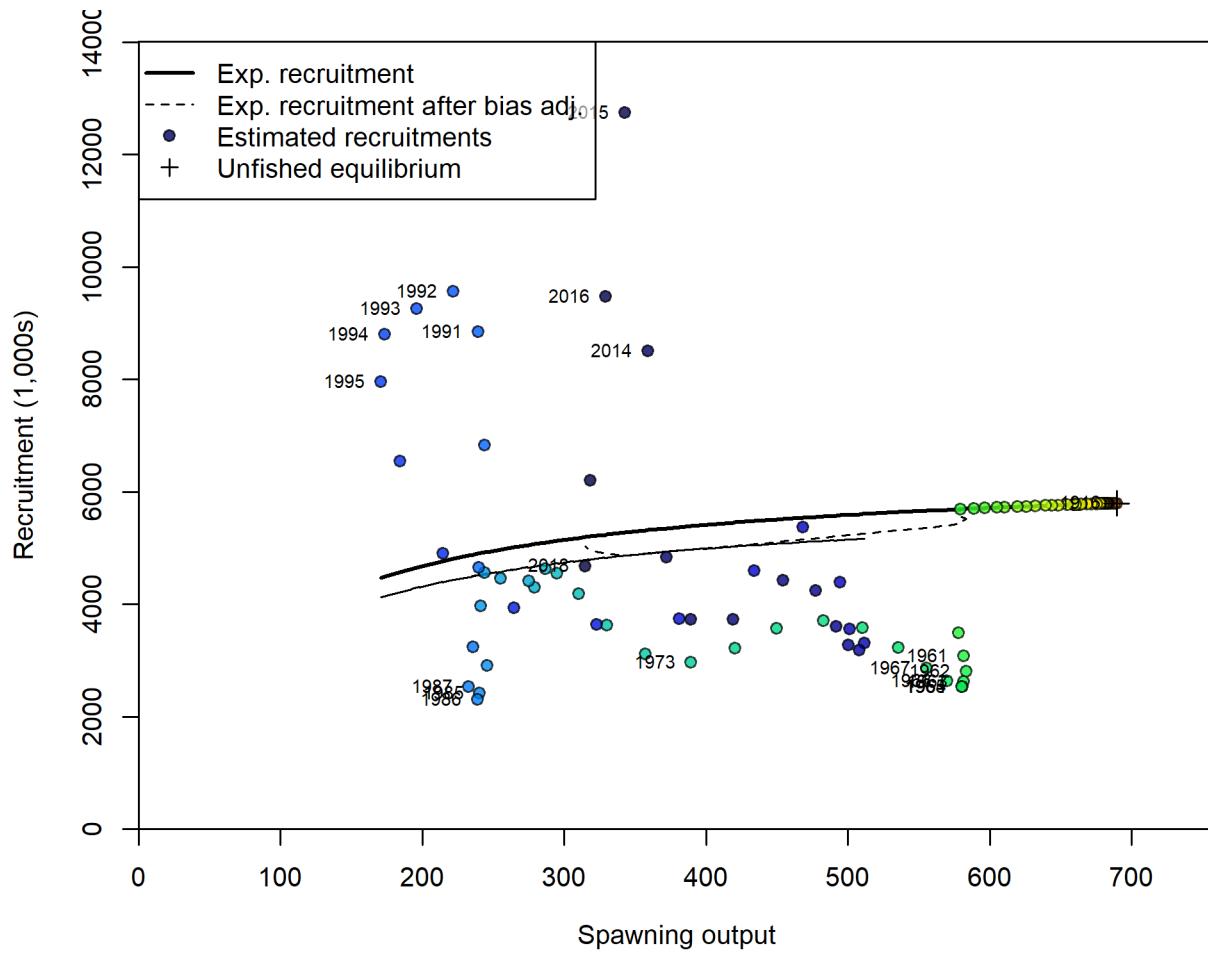


Figure 45: Estimated recruitment (red circles) and the assumed stock-recruit relationship (black line) for GBYR. The green line shows the effect of the bias correction for the lognormal distribution. ^{fig:SR_curve2}

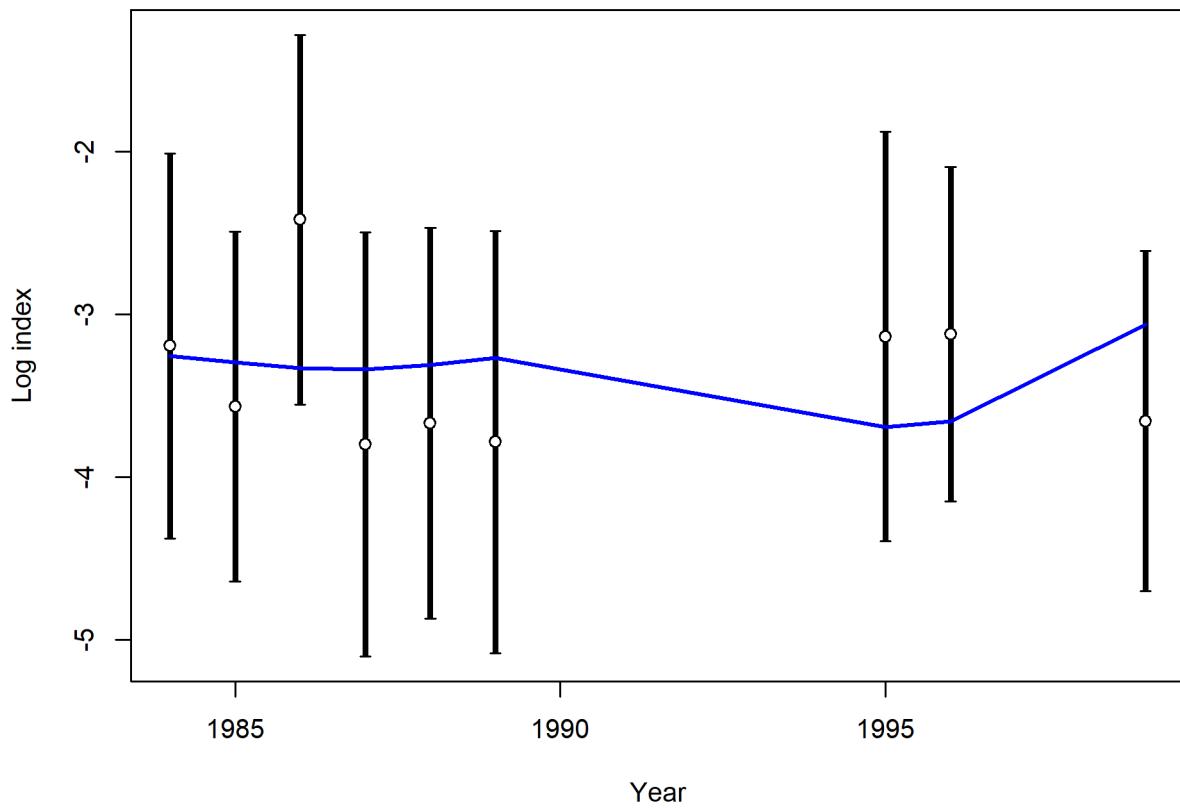


Figure 46: Fit to log index data on log scale for the recreational MRFSS dockside CPFV fishery north of Point Conception. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. [fig:index5_logcpuefit_RecDocksideNorth](#)

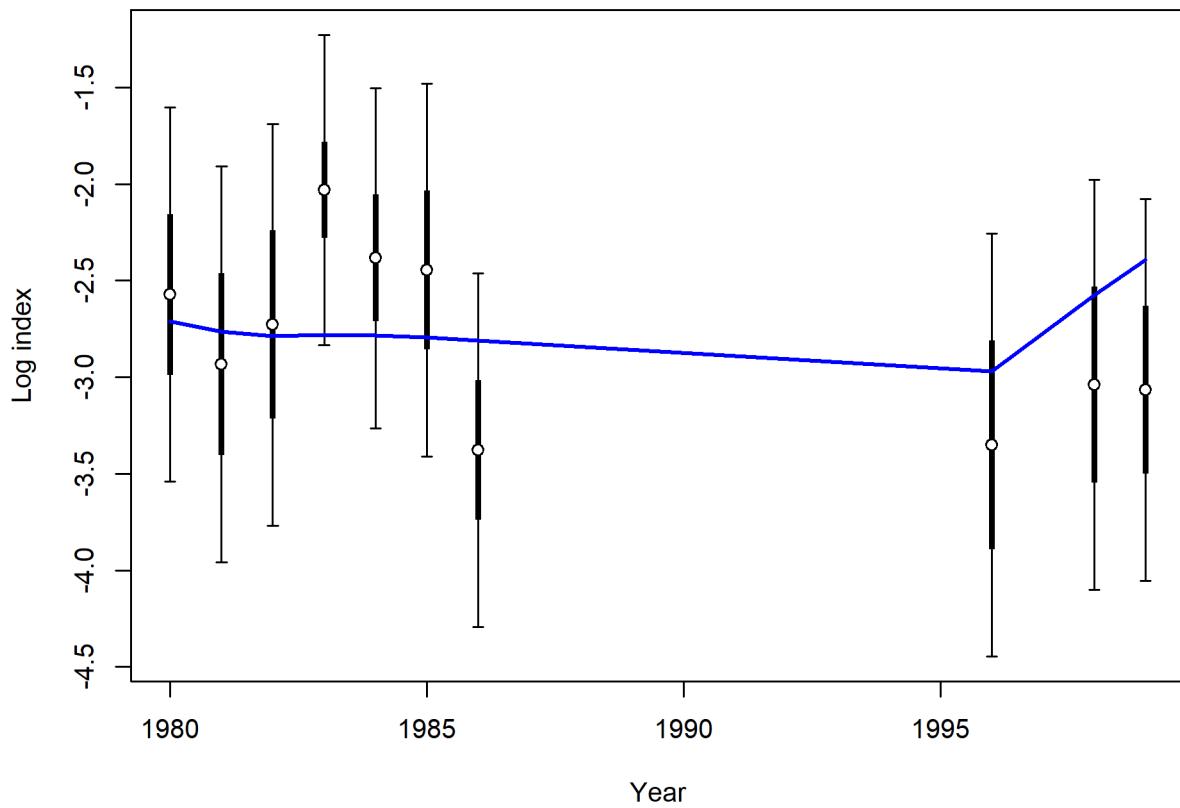


Figure 47: Fit to log index data on log scale for the recreational MRFSS dockside CPFV fishery south of Point Conception. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. [fig:index5_logcpuefit_RecDocksideSouth](#)

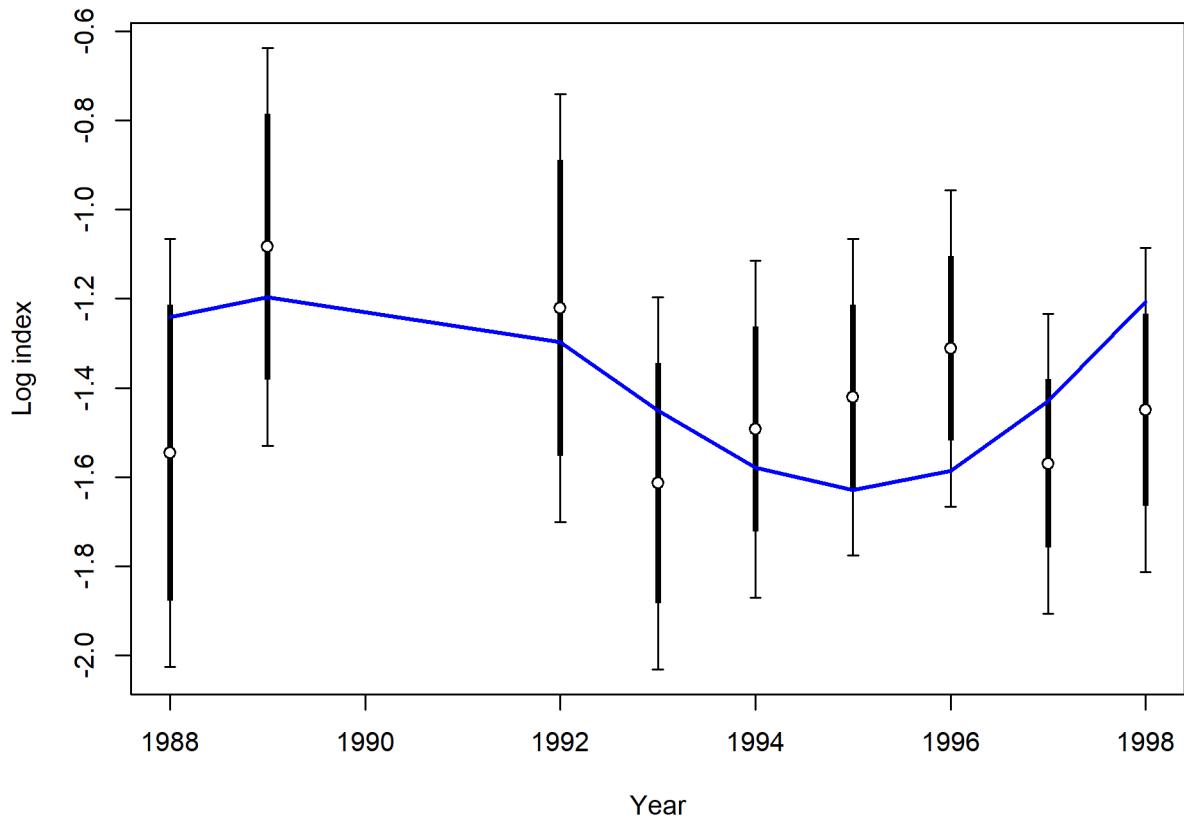


Figure 48: Fit to log index data on log scale for the recerational Deb's CPFV onboard observer program, representing north of Point Conception. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. [fig:index5_logcpuefit_DebCPFV](#)

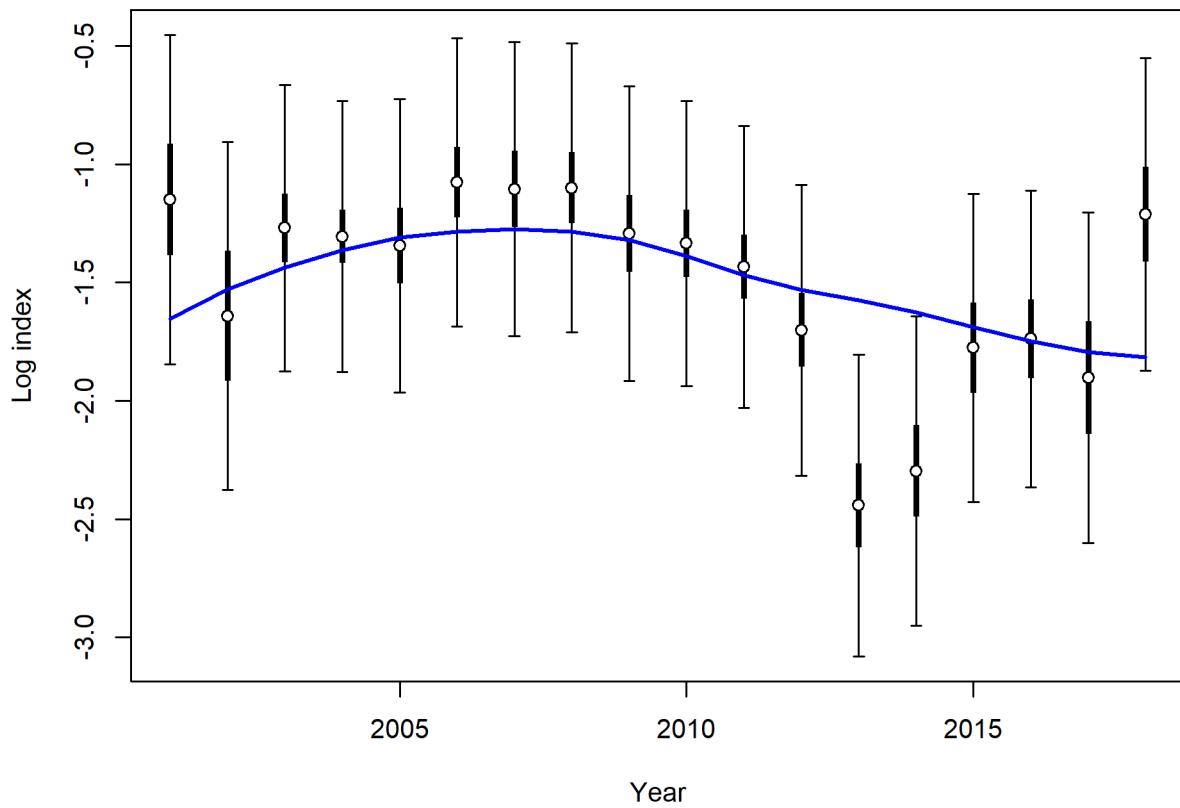


Figure 49: Fit to log index data on log scale for the recerational current CPFV onboard observer program north of Point Conception. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. [fig:index5_logcpuefit_RecOnboardNorth](#)

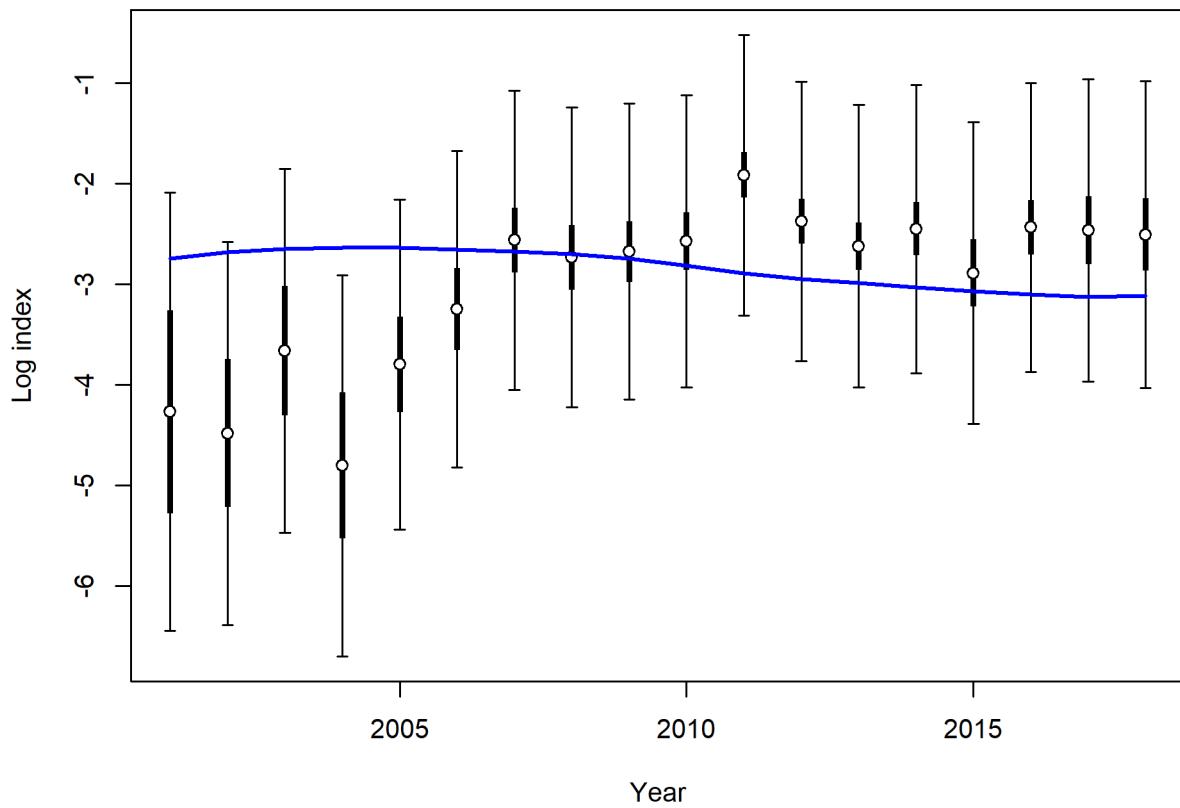


Figure 50: Fit to log index data on log scale for the recerational current CPFV onboard observer program south of Point Conception. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. [fig:index5_logcpuefit_RecOnboardSouth](#)

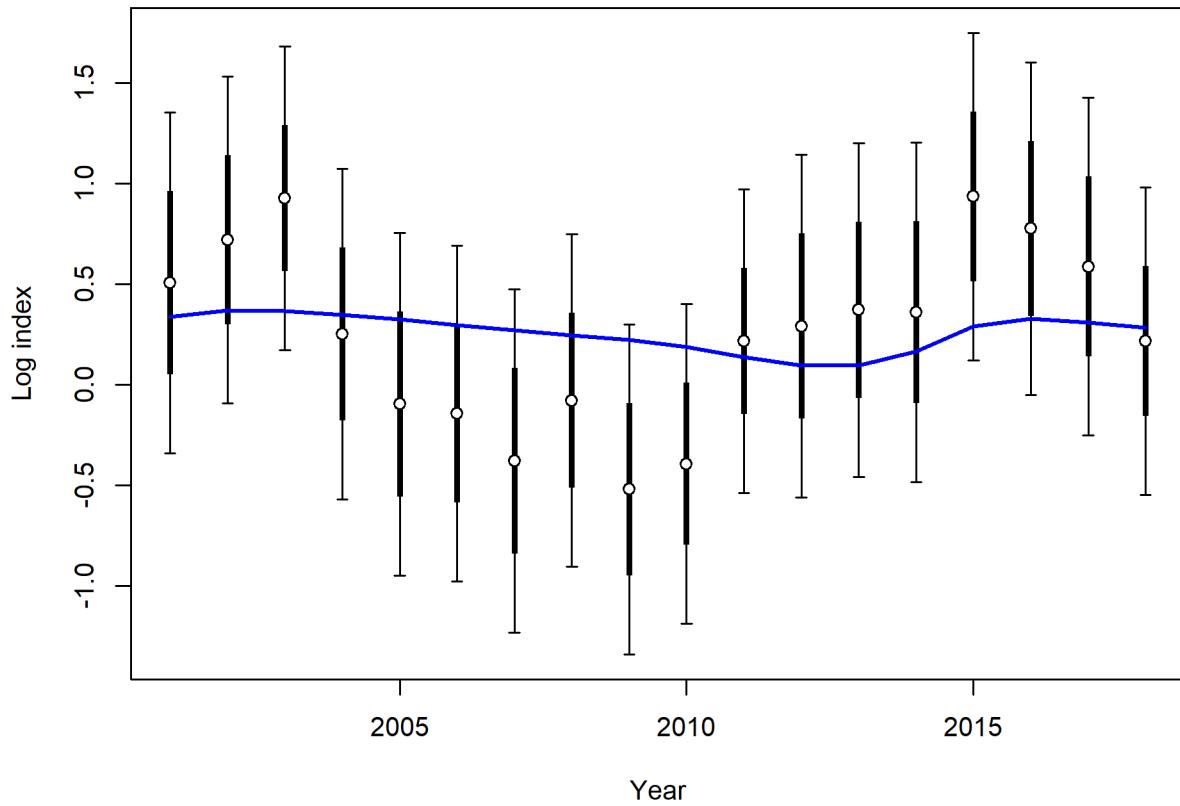


Figure 51: Fit to log index data on log scale for the fishery-independent PISCO kelp forest fish survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. fig:index5_log

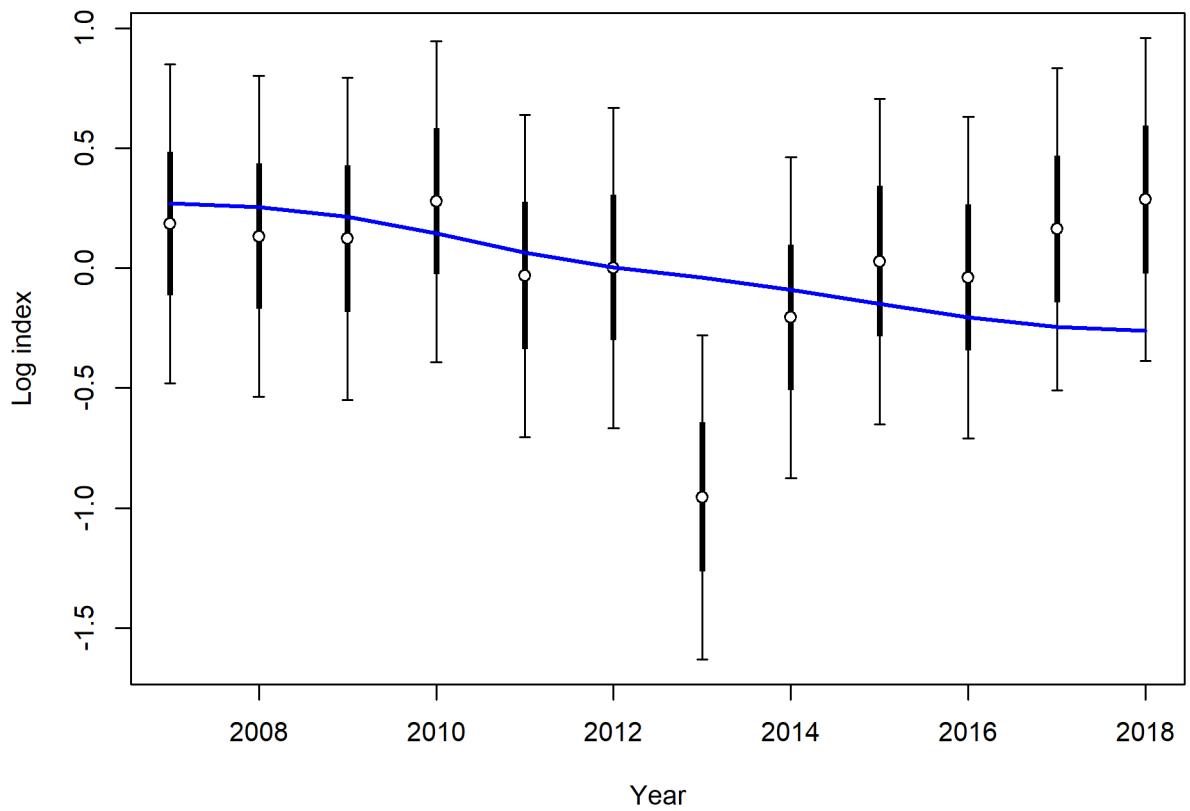


Figure 52: Fit to log index data on log scale for the fishery-independent CCFRP hook-and-line survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. fig:index5_log

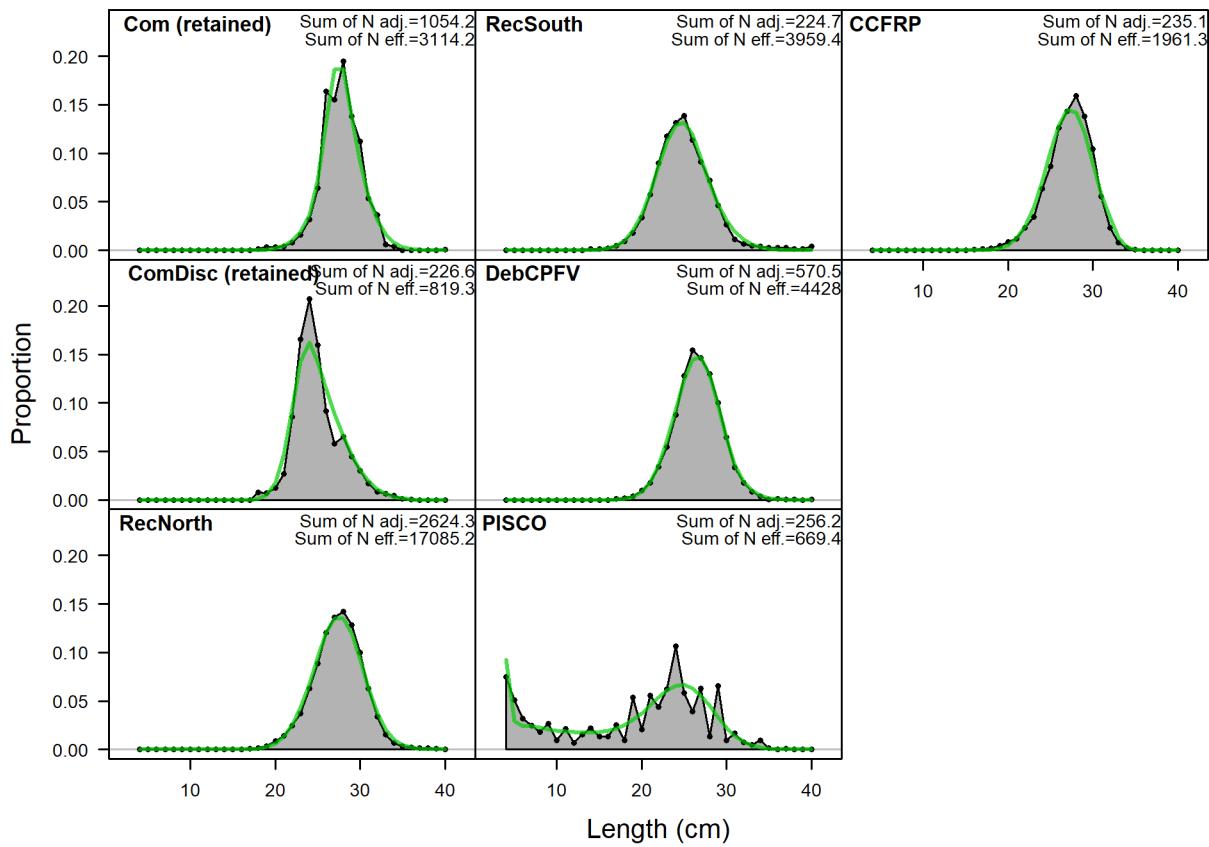


Figure 53: Length compositions aggregated across time by fleet. [fig:comp_lenfit__aggregat](#)

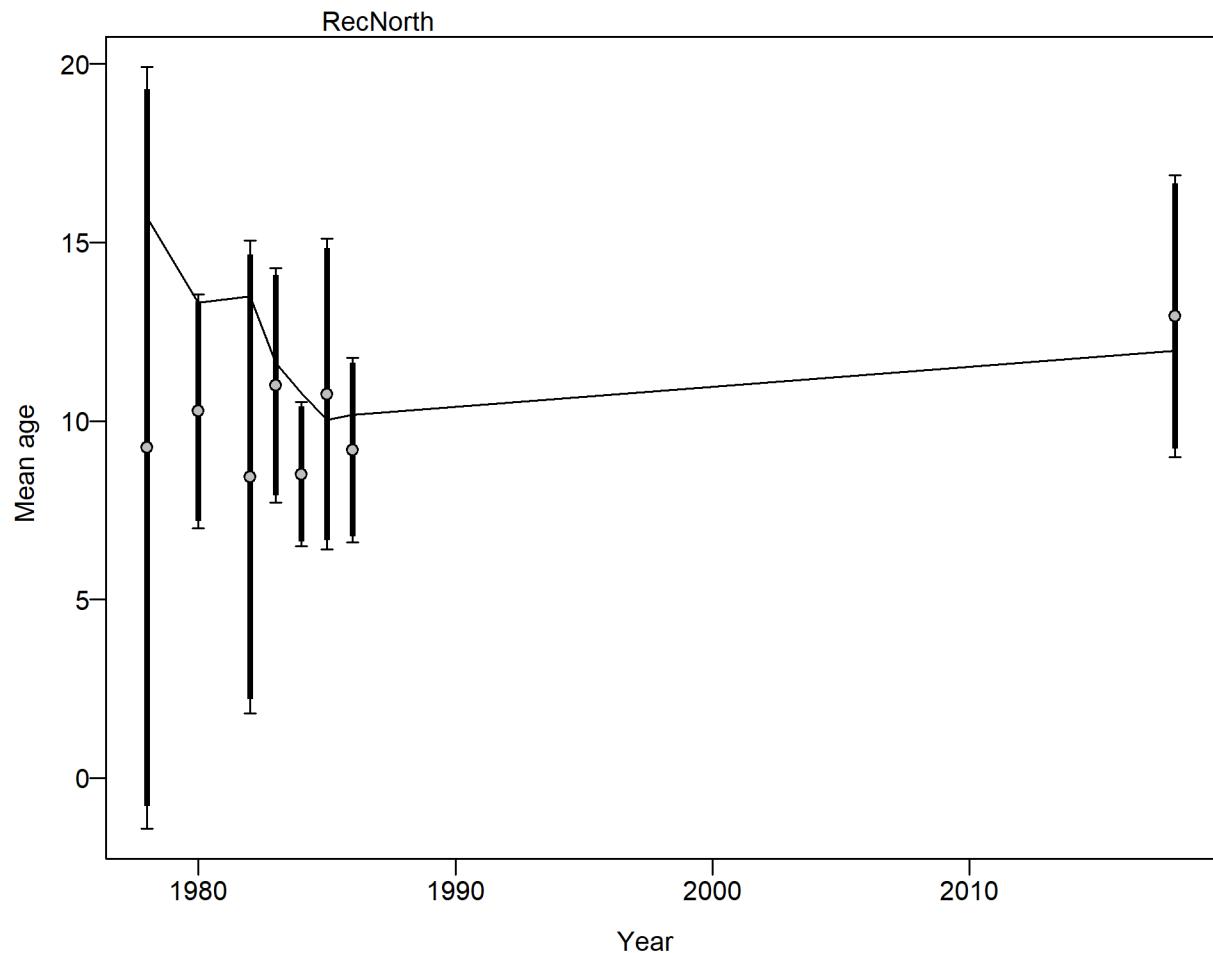


Figure 54: Mean age for the recreational fishery (ages from north of Point Conception only) with 95% confidence intervals based on current sample sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% interval) is 0.028296 (0.38876-2.719596). For more info, see Francis et al. (2011).
 fig:comp_condAALfit_data_weighting_TA1.8_condAgeRecNorth

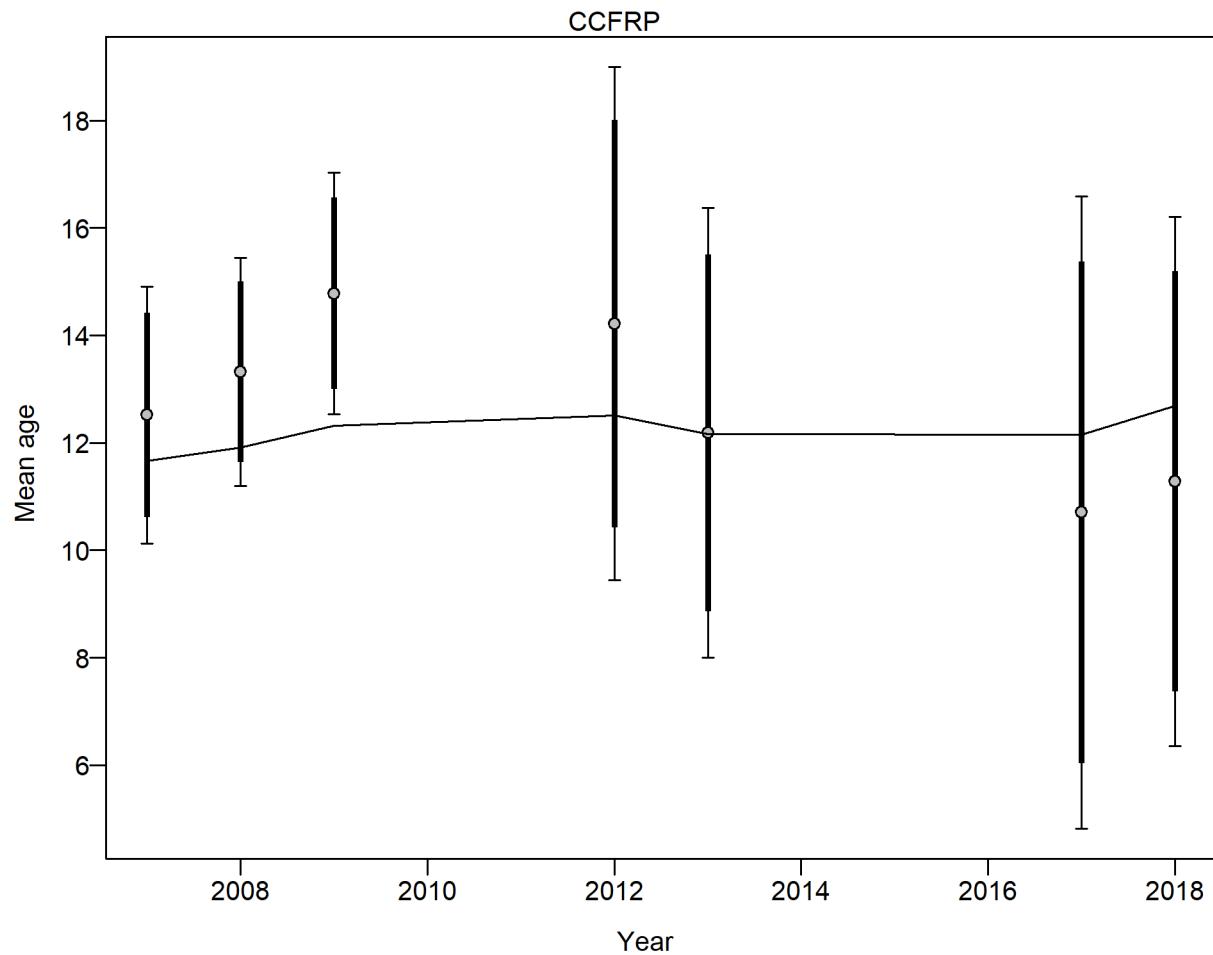


Figure 55: Mean age for the CCFRP survey with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% interval) is 0.072621 (0.358703-3.907361). For more info, see Francis et al. (2011). fig:comp_condAALfit_

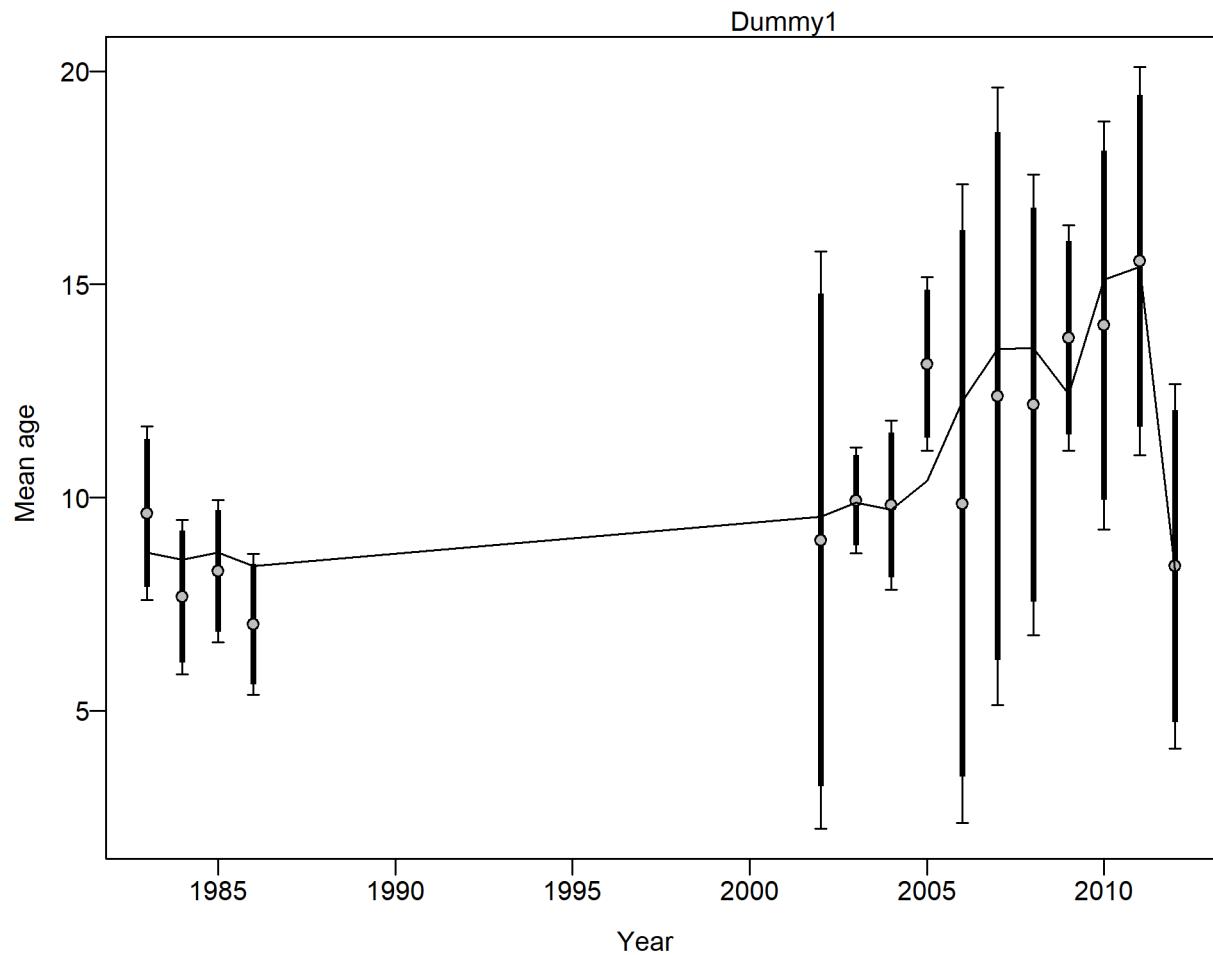


Figure 56: Mean age for the 'dummy' fleet with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% interval) is NA (NA-NA). For more info, see Francis et al. (2011). fig:comp_condAALfit_data_weighting

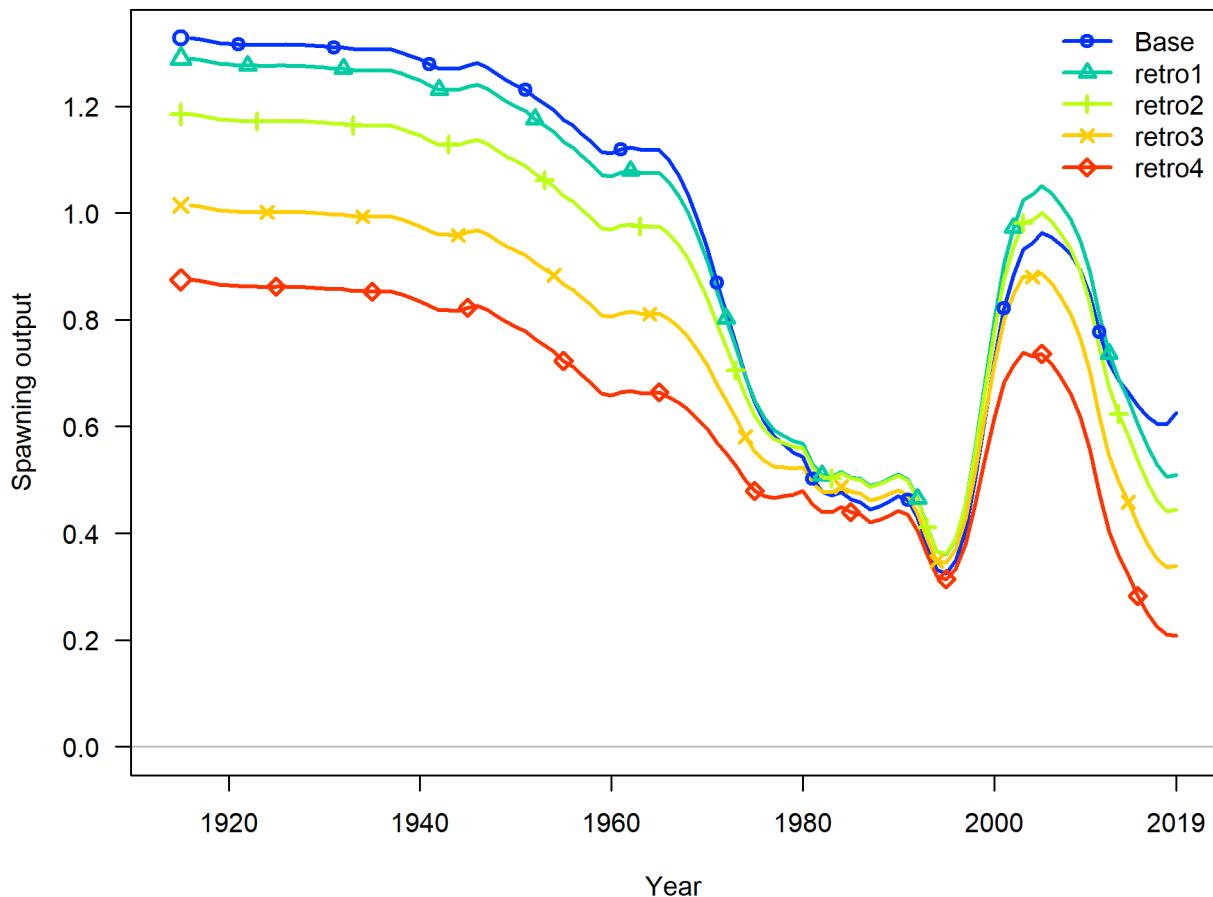


Figure 57: Retrospective pattern for spawning output. [fig:retro_spawnb](#)

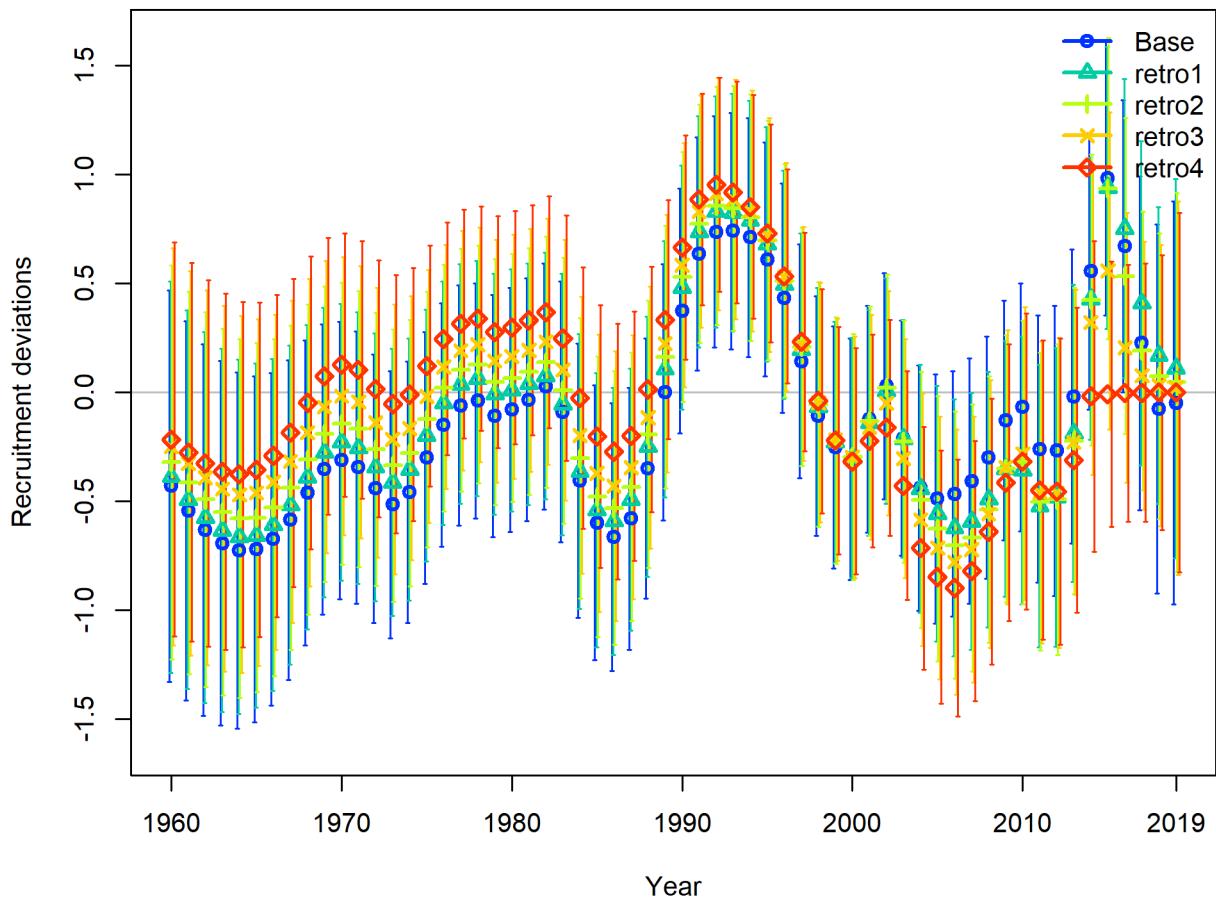


Figure 58: Retrospective pattern for estimated recruitment deviations. fig:retro_recdev

Changes in length-composition likelihoods by fleet

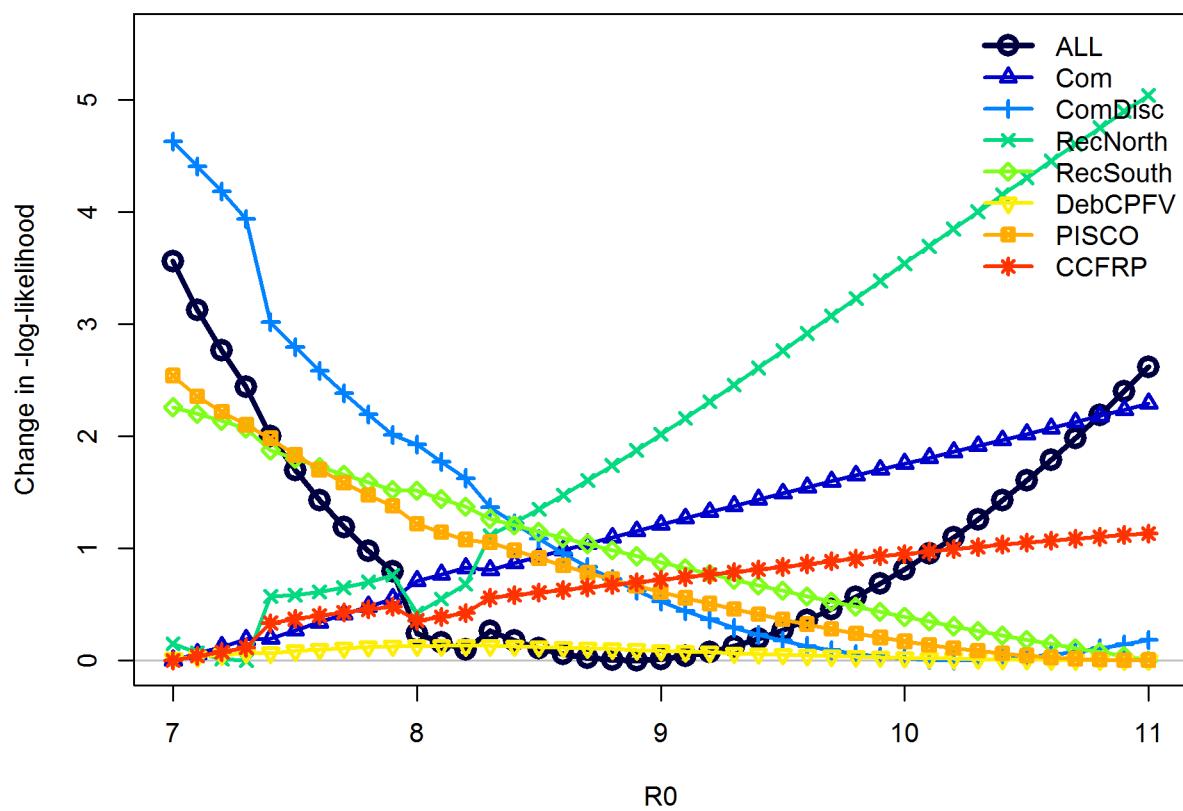


Figure 59: Likelihood profile across R_0 values by fleet. [fig:profile_R0_piner](#)

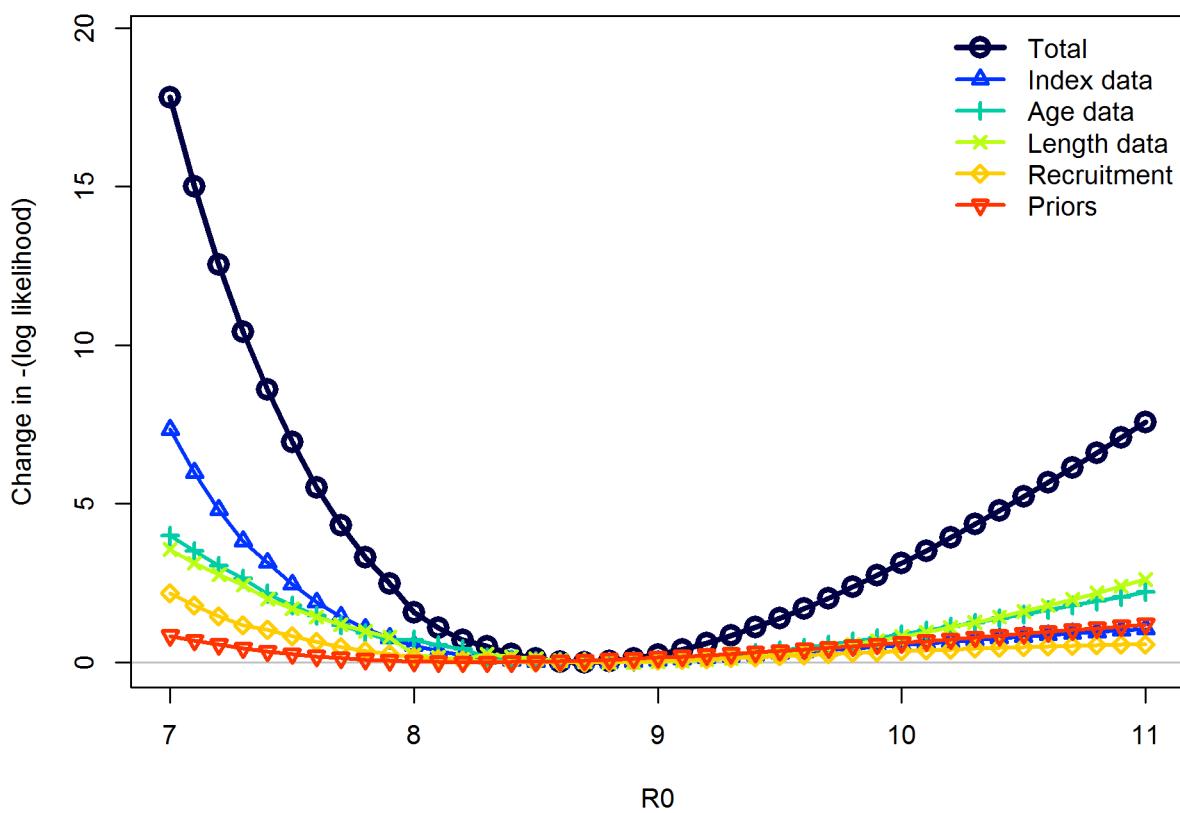


Figure 60: Likelihood profile across R_0 values for each data type. [fig:profile_R0_like](#)

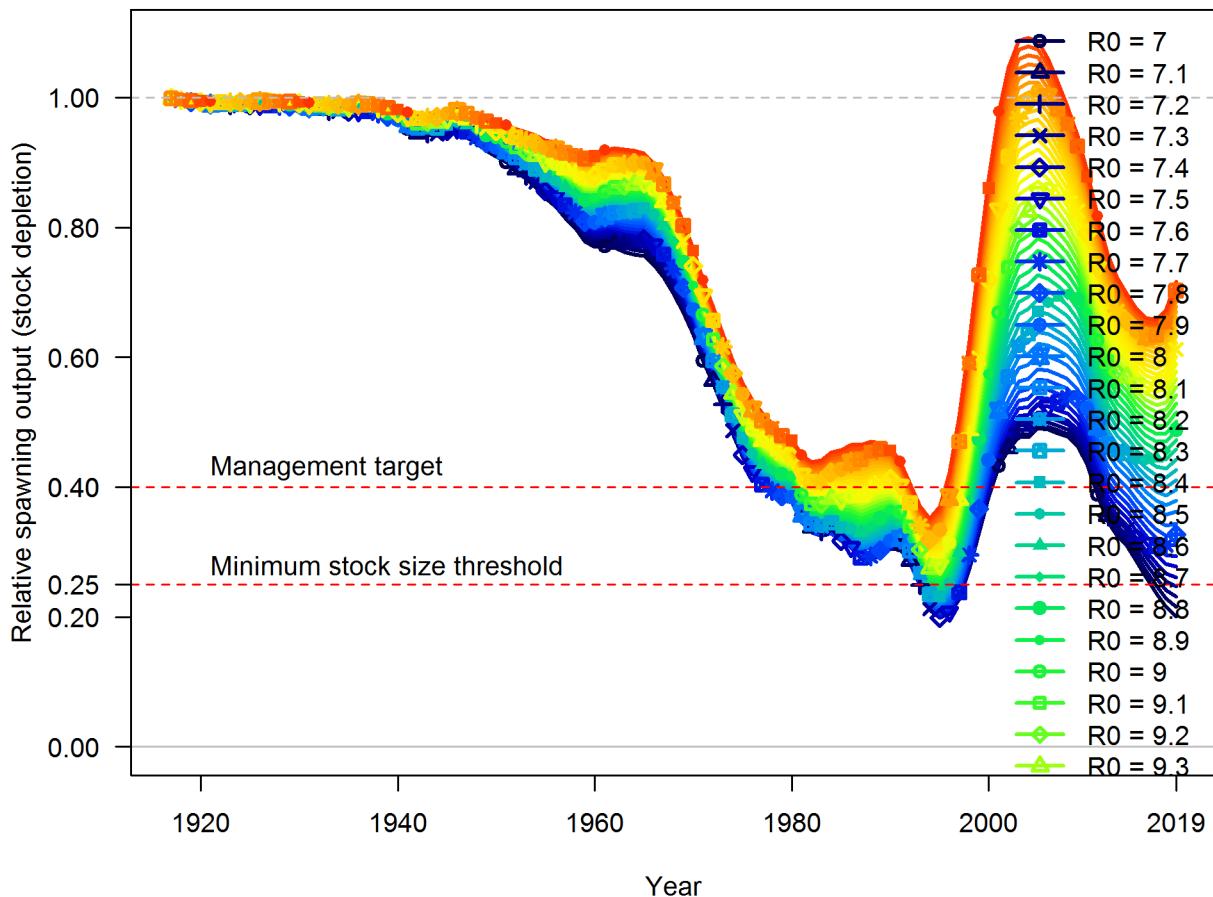


Figure 61: Trajectories of depletion across values of R_0 . [fig:profile_R0_depl](#)

Changes in length-composition likelihoods by fleet

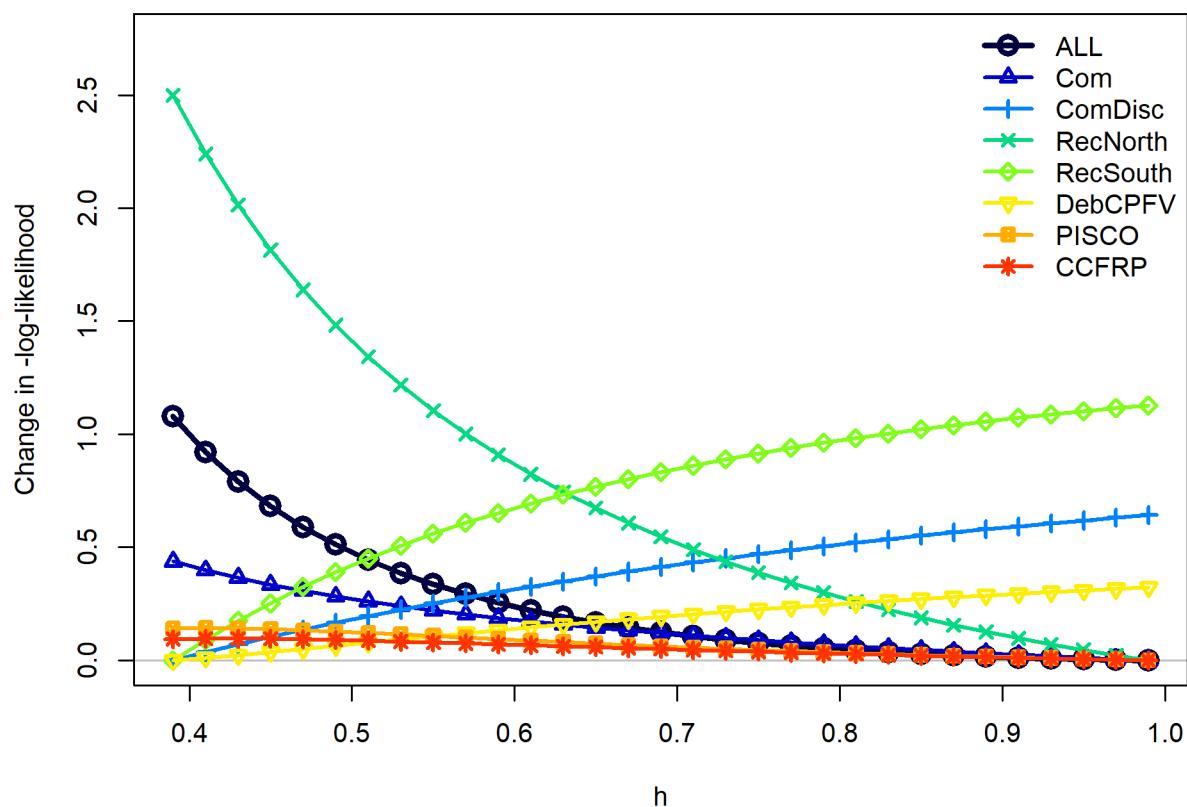


Figure 62: Likelihood profile across steepness values by fleet. [fig:profile_h_piner](#)

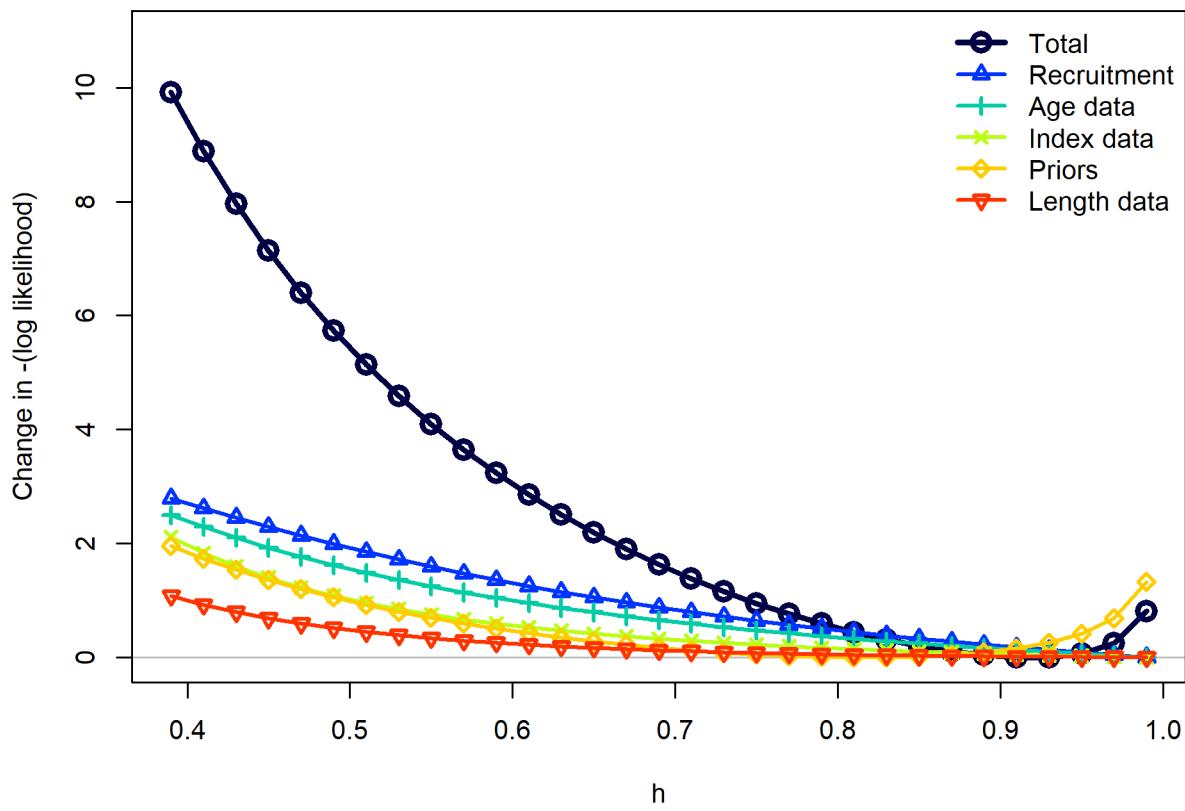


Figure 63: Likelihood profile across steepness values for each data type. [fig:profile_h_like](#)

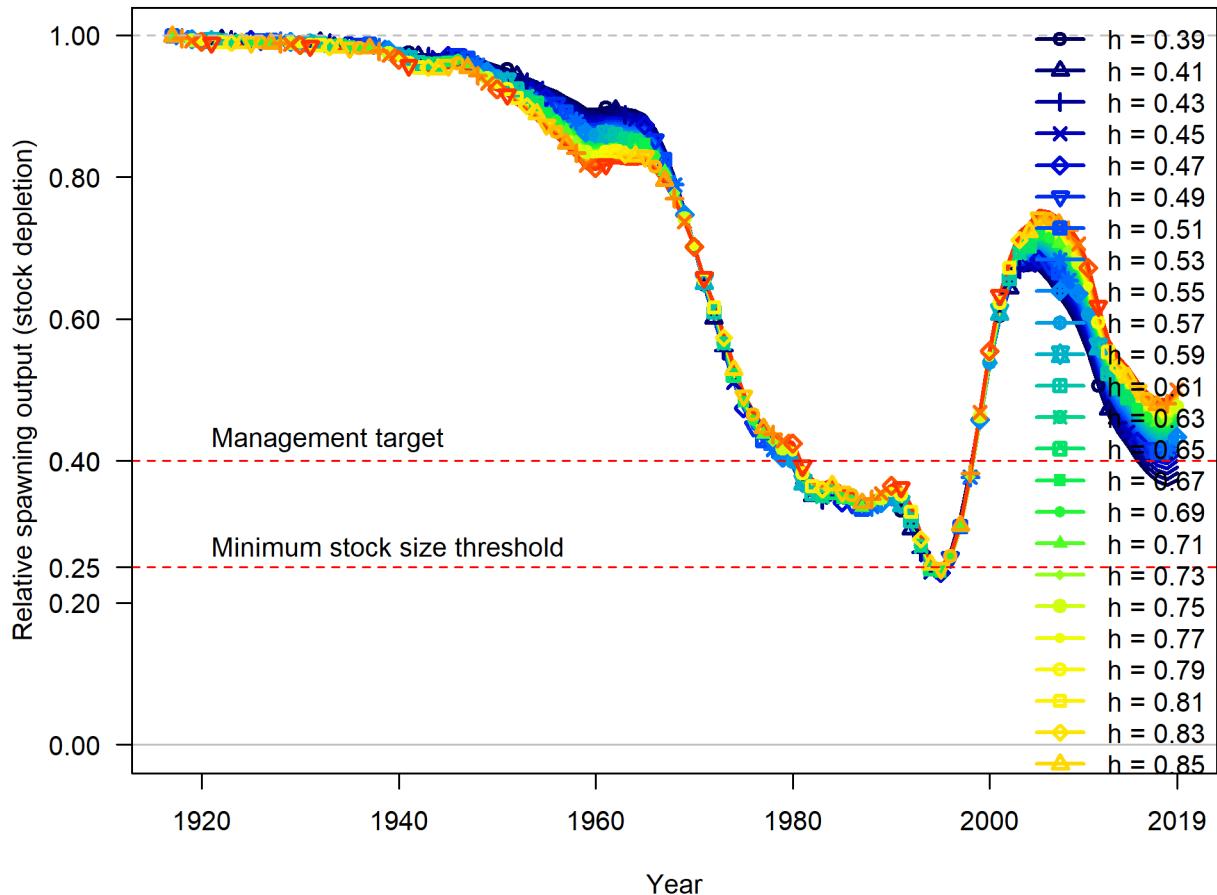


Figure 64: Trajectories of depletion across values of steepness. [fig:profile_h_depl](#)

Changes in length-composition likelihoods by fleet

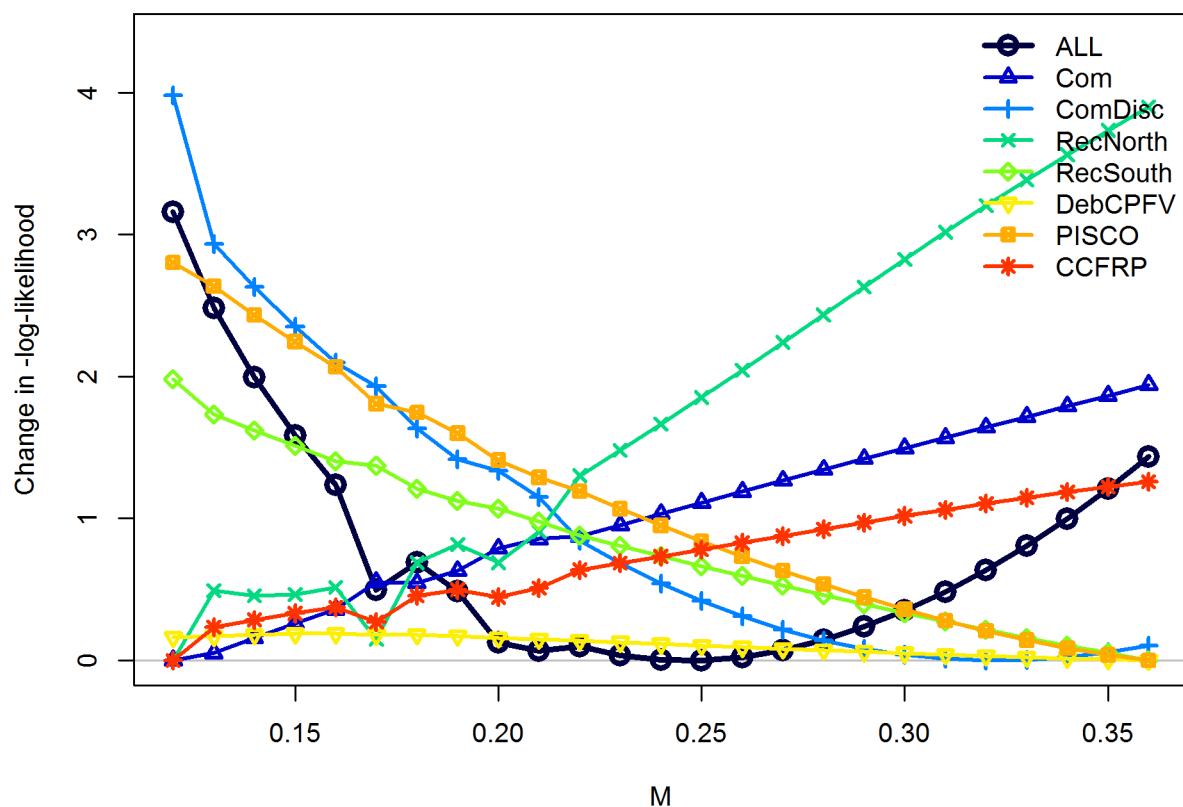


Figure 65: Likelihood profile across female natural mortality values by fleet. fig:profile_m_piner

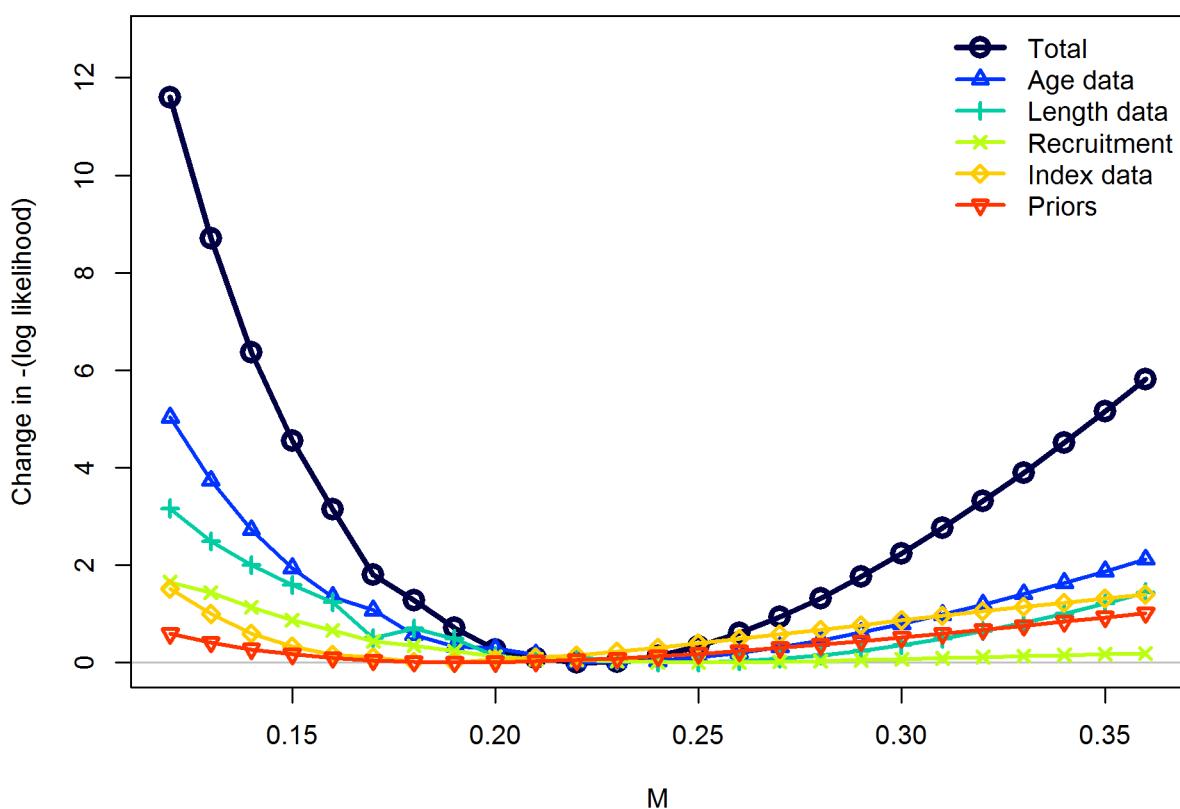


Figure 66: Likelihood profile across female natural mortality values for each data type. `fig:profile_m`

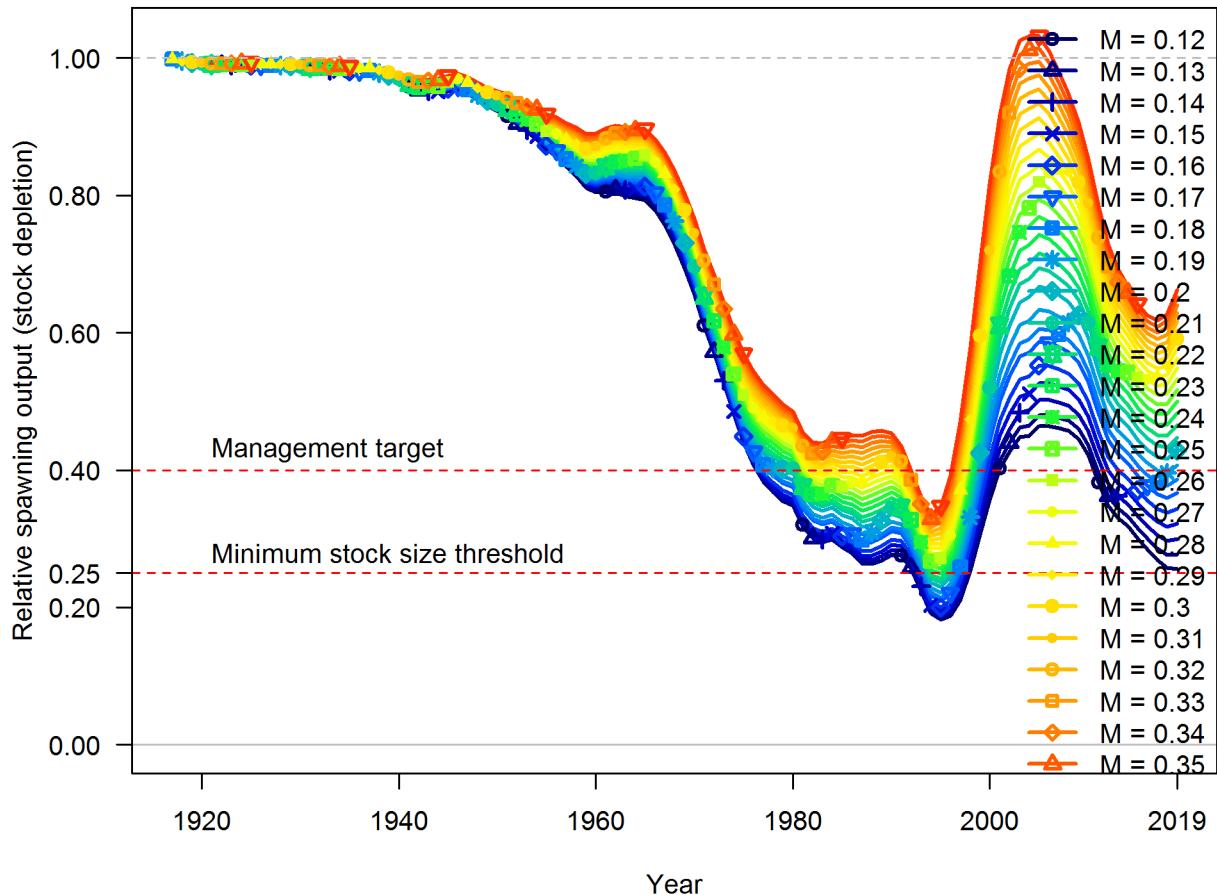


Figure 67: Trajectories of depletion across values of female natural mortality. `fig:profile_m_depl`

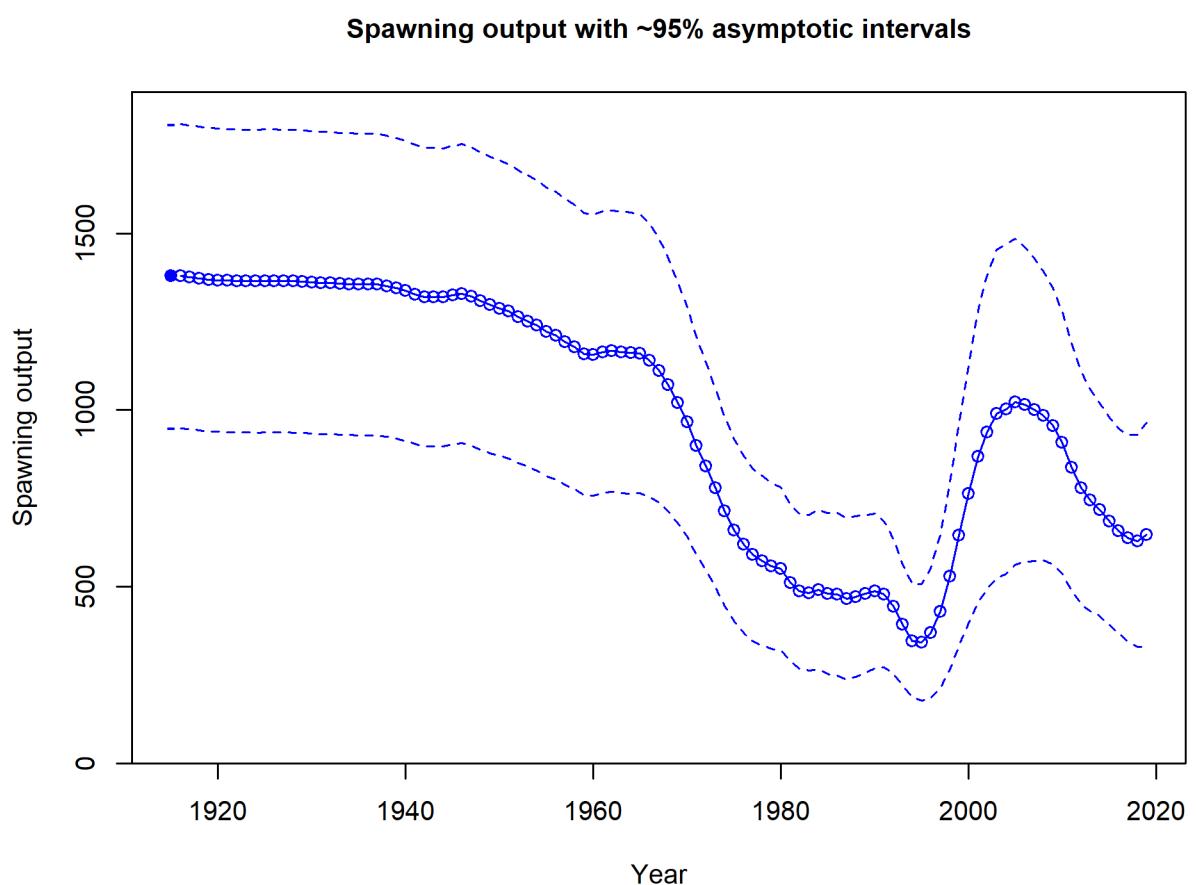


Figure 68: Estimated spawning biomass (mt) with approximate 95% asymptotic intervals. fig:ts7_Spawn

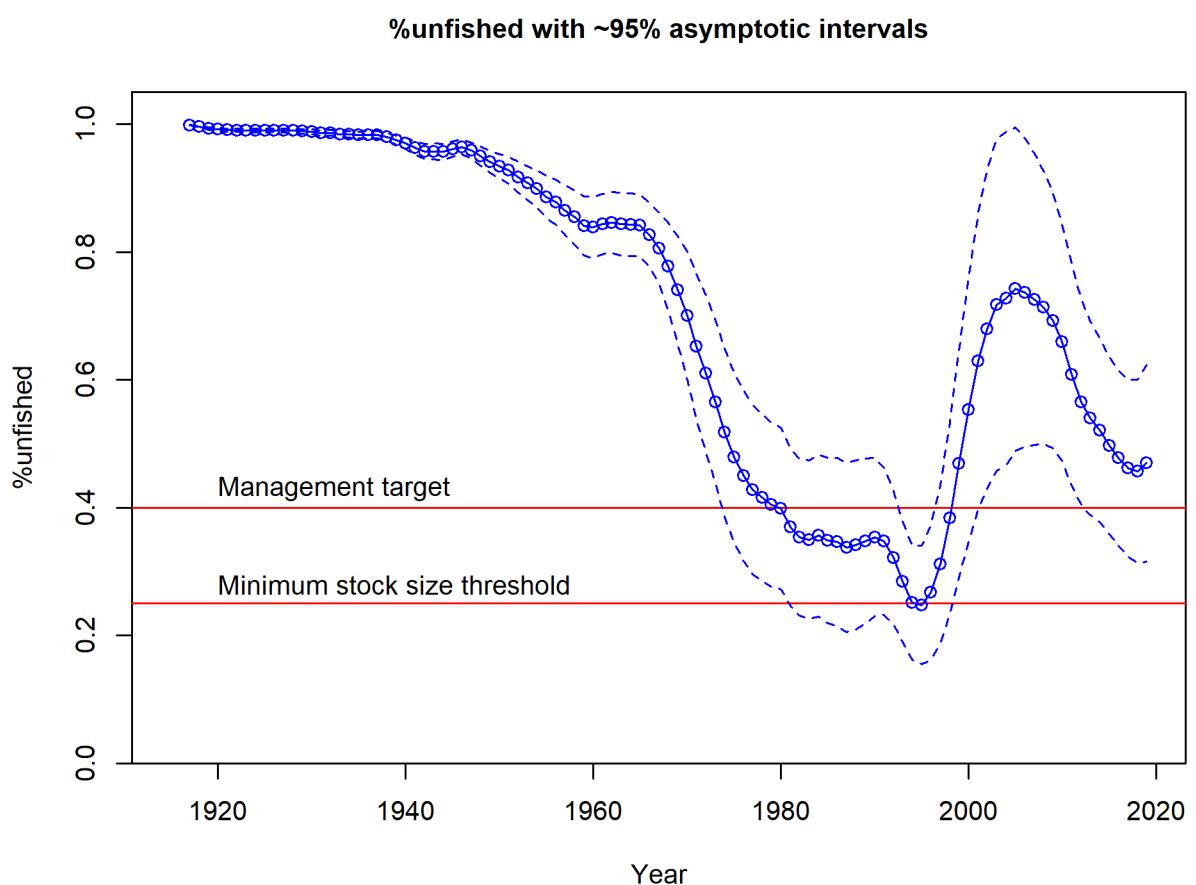


Figure 69: Estimated spawning depletion with approximate 95% asymptotic intervals. fig:ts9_unfish

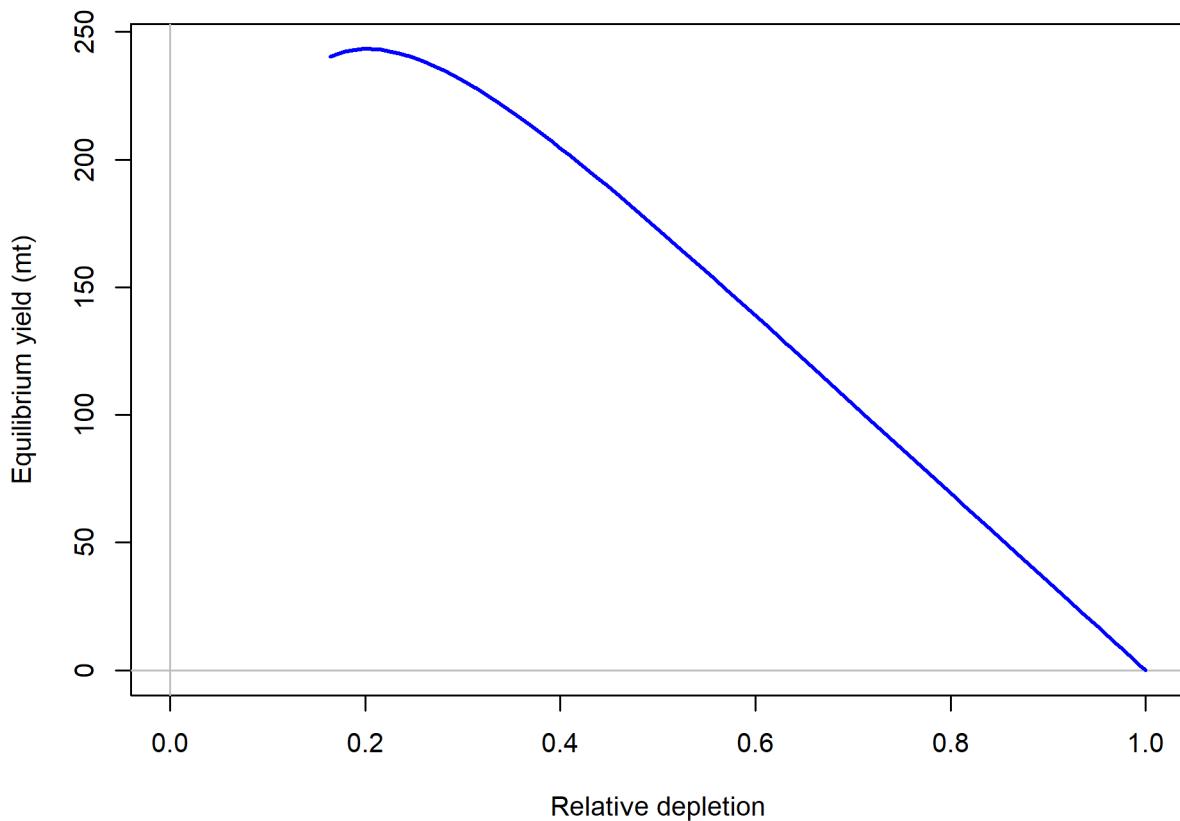


Figure 70: Equilibrium yield curve for the base case model. Values are based on the 2018 fishery selectivity and with steepness fixed at 0.718. | [fig:yield1_yield_curve](#)

¹⁶⁰⁹ **Appendix A. California's Commercial Fishery Regula-**
¹⁶¹⁰ **tions**

appendix-a.-californias-commercial-fishery-regulations

California Commercial Regulations for Open Access Fixed Gear			
Year Month	40°10'-34°27'	34°27' - Mex.	40°10' - Mex.
2000 Jan	550 lbs/2 mths*	Closed*	
2000 Mar	Closed*	550 lbs/2 mths*	
2000 May	550 lbs/2 mths		
		800 lbs/2 mths shoreward of 20 fm; otherwise closed	
2001 Jan	1800 lbs/2 mths		
2001 Mar	Closed	1800 lbs/2 mths	
		800 lbs/2 mths shoreward of 20 fm; otherwise closed	
2001 May			
2001 Jul	1800 lbs/2 mths	1800 lbs/2 mths	
2002 Jan	1200 lbs/2 mths	Closed	
2002 Mar	Closed	1200 lbs/2 mths	
		1200 lbs/2 mths shoreward of 20 fm; otherwise closed	
2002 May			
2002 Jul	1200 lbs/2 mths		
		1200 lbs/2 mths shoreward of 20 fm; otherwise closed	
2002 Sep			
2002 Nov	Closed	Closed	
2003 Jan			200 lbs/2 mths
2003 Mar			Closed
2003 May			400 lbs/2 mths
2003 Jul			400 lbs/2 mths
2003 Sep			300 lbs/2 mths
2003 Nov			200 lbs/2 mths
2004 Jan	300 lbs/2 mths	Closed	
2004 Mar	Closed	300 lbs/2 mths	
2004 May	500 lbs/2 mths	500 lbs/2 mths	
2004 Jul	600 lbs/2 mths	600 lbs/2 mths	
2004 Sep	500 lbs/2 mths	500 lbs/2 mths	
2004 Nov	300 lbs/2 mths	300 lbs/2 mths	
2005-2006 Jan			300 lbs/2 mths
2005-2006 Mar			Closed
2005-2006 May			500 lbs/2 mths
2005-2006 Jul			600 lbs/2 mths
2005-2006 Sep			500 lbs/2 mths
2005-2006 Nov			300 lbs/2 mths
2007-2008 Jan			600 lbs/2 mths
2007-2008 Mar			Closed
2007-2008 May			800 lbs/2 mths
2007-2008 Jul			900 lbs/2 mths
2007-2008 Sep			800 lbs/2 mths
2007-2008 Nov			600 lbs/2 mths
2009-2016 Jan			600 lbs/2 mths
2009-2016 Mar			Closed
2009-2016 May			800 lbs/2 mths
2009-2016 Jul			900 lbs/2 mths
2009-2016 Sep			800 lbs/2 mths
2009-2016 Nov			1000 lbs/2 mths
2017-2018 Jan			1200 lbs/2 mths
2017-2018 Mar			Closed
2017-2018 May			1200 lbs/2 mths
2017-2018 Jul			1200 lbs/2 mths
2017-2018 Sep			1200 lbs/2 mths
2017-2018 Nov			1200 lbs/2 mths

Figure A2^{fig:Comm_regs1}

California Commercial Regulations for Limited Entry Fixed Gear			
Year Month	40°10'-34°27'	34°27' - Mex.	40°10' - Mex.
2000 Jan	1000 lbs/2 mths*	closed*	
2000 Mar	closed*	1000 lbs/2 mths*	
2000 May	1000 lbs/2 mths*	1000 lbs/2 mths*	
2001 Jan	2000 lbs/2 mths	2000 lbs/2 mths shoreward of 20 fm; otherwise closed	
2001 Apr	closed	2000 lbs/2 mths	
2001 May	2000 lbs/2 mths shoreward of 20 fm; otherwise closed		
2001 Jul	2000 lbs/2 mths	2000 lbs/2 mths	
2002 Jan	1600 lbs/2 mths	closed	
2002 Mar	closed		
2002 May	1600 lbs/2 mths shoreward of 20 fm; otherwise closed	2000 lbs/2 mths	
2002 Jul	1600 lbs/2 mths		
2002 Sep	1600 lbs/2 mths shoreward of 20 fm; otherwise closed		
2002 Nov	closed	closed	
2003 Jan			200 lbs/2 mths
2003 Mar			closed
2003 May			400 lbs/2 mths
2003 Jul			400 lbs/2 mths
2003 Sep			300 lbs/2 mths
2003 Nov			200 lbs/2 mths
2004 Jan	300 lbs/2 mths	closed	
2004 Mar	closed	300 lbs/2 mths	
2004 May	500 lbs/2 mths	500 lbs/2 mths	
2004 Jul	600 lbs/2 mths	600 lbs/2 mths	
2004 Sep	500 lbs/2 mths	500 lbs/2 mths	
2004 Nov	300 lbs/2 mths	300 lbs/2 mths	
2005-2006 Jan			300 lbs/2 mths
2005-2006 Mar			closed
2005-2006 May			500 lbs/2 mths
2005-2006 Jul			600 lbs/2 mths
2005-2006 Sep			500 lbs/2 mths
2005-2006 Nov			300 lbs/2 mths
2007-2008 Jan			600 lbs/2 mths
2007-2008 Mar			closed
2007-2008 May			800 lbs/2 mths
2007-2008 Jul			900 lbs/2 mths
2007-2008 Sep			800 lbs/2 mths
2007-2008 Nov			600 lbs/2 mths
2009 Jan			600 lbs/2 mths
2009 Mar			closed
2009 May			800 lbs/2 mths
2009 Jul			900 lbs/2 mths
2009 Sep			800 lbs/2 mths
2009 Nov			800 lbs/2 mths
2010-2011 Jan			600 lbs/2 mths
2010-2011 Mar			closed
2010-2011 May			800 lbs/2 mths
2010-2011 Jul			900 lbs/2 mths
2010-2011 Sep			800 lbs/2 mths
2010-2011 Nov			600 lbs/2 mths
2012-2016 Jan			600 lbs/2 mths
2012-2016 Mar			closed
2012-2016 May			800 lbs/2 mths
2012-2016 Jul			900 lbs/2 mths
2012-2016 Sep			800 lbs/2 mths
2012-2016 Nov			1000 lbs/2 mths
2017-2018 Jan			1200 lbs/2 mths
2017-2018 Mar			closed
2017-2018 May			1200 lbs/2 mths
2017-2018 Jul			1200 lbs/2 mths
2017-2018 Sep			1200 lbs/2 mths
2017-2018 Nov			1200 lbs/2 mths

Figure A3^{fig:Comm_regs2}

California Commercial Regulations for Limited Entry Trawl for 40°10' - Mex.			
Year Month	All trawls	Large footrope or midwater trawl	Small footrope
2000-2001 Jan	200 lbs/mth		
2002-2003 Jan	300 lbs/mth		
2004 Jan		closed	300 lbs/mth
2004 Nov			closed
2005-2010 Jan		closed	300 lbs/mth
2011-2018 Jan	300 lbs/mth, nonIFQ species		

Figure A4^{fig:Comm_regs3}

¹⁶¹¹ **Appendix B. California's Recreational Fishery Regula-**
¹⁶¹² **tions**

appendix-b.-californias-recreational-fishery-regulations

California's Recreational Fishing Regulations										
Year	Month	Northern	Mendocino	North-Central	San Francisco	South-Central	Central	South-Central	Southern	
2000	Jan	Open					Open		Closed	
2000	Feb	Open					Open		Closed	
2000	Mar	Open					Closed		Open	
2000	Apr	Open					Closed		Open	
2000	May	Open					Open		Open	
2000	Jun	Open					Open		Open	
2000	Jul	Open					Open		Open	
2000	Aug	Open					Open		Open	
2000	Sep	Open					Open		Open	
2000	Oct	Open					Open		Open	
2000	Nov	Open					Open		Open	
2000	Dec	Open					Open		Open	
2001	Jan	Open					Open		Closed	
2001	Feb	Open					Open		Closed	
2001	Mar	Open					Closed		Open	
2001	Apr	Open					Closed		Open	
2001	May	Open					20		Open	
2001	Jun	Open					20		Open	
2001	Jul	Open					Open		Open	
2001	Aug	Open					Open		Open	
2001	Sep	Open					Open		Open	
2001	Oct	Open					Open		Open	
2001	Nov	Open					20		Open	
2001	Dec	Open					20		20	
2002	Jan	Open					Open		Closed	
2002	Feb	Open					Open		Closed	
2002	Mar	Open					Closed		Open	
2002	Apr	Open					Closed		Open	
2002	May	Open					20		Open	
2002	Jun	Open					20		Open	
2002	Jul	Open					20		20	
2002	Aug	Open					20		20	
2002	Sep	Open					20		20	
2002	Oct	Open					20		20	
2002	Nov	Open					Closed		Closed	
2002	Dec	Open					Closed		Closed	
2003	Jan	Open					Closed		Closed	
2003	Feb	Open					Closed		Closed	
2003	Mar	Open					Closed		Closed	
2003	Apr	Open					Closed		Closed	
2003	May	Open					Closed		Closed	
2003	Jun	Open					Closed		Closed	
2003	Jul	Open					20		20	
2003	Aug	Open					20		20	
2003	Sep	Open					20		30	
2003	Oct	Open					20		30	
2003	Nov	Open					20		30	
2003	Dec	Open->Closed					20->Closed		30->Closed	
2004	Jan	Open					30		Closed	
2004	Feb	Open					30		Closed	
2004	Mar	Open					Closed		60	
2004	Apr	Open					Closed		60	
2004	May	30					20		60	
2004	Jun	30					20		60	
2004	Jul	30					Closed		60	
2004	Aug	30					20		60	
2004	Sep	30					20		30	
2004	Oct	30					20		30	
2004	Nov	30					20		60	
2004	Dec	30					20		60	

Figure B2^{fig:Rec_regs1}

Latitude Range		42°-40°10'	40°10'-38°57'	40°10'-37°11'	38°57'-37°11'	37°11'-36°	37°11'-34°27'	36°-34°27'	34°27'-Mex.
Year	Month	Northern	Mendocino	North-Central	San Francisco	South-Central	Central	South-Central	Southern
2005	Jan	Closed		Closed		Closed		Closed	Closed
2005	Feb	Closed		Closed		Closed		Closed	Closed
2005	Mar	Closed		Closed		Closed		Closed	60
2005	Apr	Closed		Closed		Closed		Closed	60
2005	May	30		Closed		Closed		40	60
2005	Jun	30		Closed		Closed		40	60
2005	Jul	30		20		20		40	60
2005	Aug	30		20		20		40	60
2005	Sep	30		20		20		40	30
2005	Oct	30		20		20		Closed	30
2005	Nov	30		20		20		Closed	60
2005	Dec	30		20		20		Closed	60
2006	Jan	Closed		Closed		Closed		Closed	Closed
2006	Feb	Closed		Closed		Closed		Closed	Closed
2006	Mar	Closed		Closed		Closed		Closed	60
2006	Apr	Closed		Closed		Closed		Closed	60
2006	May	30		Closed		Closed		40	60
2006	Jun	30		Closed		Closed		40	60
2006	Jul	30		30		30		40	60
2006	Aug	30		30		30		40	60
2006	Sep	30		30		30		40	60
2006	Oct	30		30		30		40	60
2006	Nov	30		30		30		Closed	60
2006	Dec	30		30		30		Closed	60
2007	Jan	Closed		Closed		Closed		Closed	Closed
2007	Feb	Closed		Closed		Closed		Closed	Closed
2007	Mar	Closed		Closed		Closed		Closed	60
2007	Apr	Closed		Closed		Closed		Closed	60
2007	May	30		Closed		40		40	60
2007	Jun	30		30		40		40	60
2007	Jul	30		30		40		40	60
2007	Aug	30		30		40		40	60
2007	Sep	30		30		40		40	60
2007	Oct	Closed		Closed		40		40	60
2007	Nov	Closed		Closed		40		40	60
2007	Dec	Closed		Closed		Closed		Closed	60
2008	Jan	Closed	Closed		Closed	Closed		Closed	Closed
2008	Feb	Closed	Closed		Closed	Closed		Closed	Closed
2008	Mar	Closed	Closed		Closed	Closed		Closed	60
2008	Apr	Closed	Closed		Closed	Closed		Closed	60
2008	May	20	Closed		Closed	40		40	60
2008	Jun	20	20		20	40		40	60
2008	Jul	20	20		20	40		40	60
2008	Aug	20	20		20	40		40	60
2008	Sep	Closed	Closed		20	40		40	60
2008	Oct	Closed	Closed		20	40		40	60
2008	Nov	Closed	Closed		20	40		40	60
2008	Dec	Closed	Closed		Closed	Closed		Closed	60
2009	Jan	Closed	Closed		Closed	Closed		Closed	Closed
2009	Feb	Closed	Closed		Closed	Closed		Closed	Closed
2009	Mar	Closed	Closed		Closed	Closed		Closed	60
2009	Apr	Closed	Closed		Closed	Closed		Closed	60
2009	May	Closed->20	Closed->20		Closed	40		40	60
2009	Jun	20	20		Closed->20	40		40	60
2009	Jul	20	20		20	40		40	60
2009	Aug	20	20->Closed		20	40		40	60
2009	Sep	20->Closed	Closed		20	40		40	60
2009	Oct	Closed	Closed		20	40		40	60
2009	Nov	Closed	Closed		Closed	40->Closed		40->Closed	60
2009	Dec	Closed	Closed		Closed	Closed		Closed	60

Figure B3
fig:Rec_regs2

Latitude Range		42°-40°10'	40°10'-38°57'	40°10'-37°11'	38°57'-37°11'	37°11'-36°	37°11'-34°27'	36°-34°27'	34°27'-Mex.
Year	Month	Northern	Mendocino	North-Central	San Francisco	South-Central	Central	South-Central	Southern
2010	Jan	Closed	Closed		Closed	Closed		Closed	Closed
2010	Feb	Closed	Closed		Closed	Closed		Closed	Closed
2010	Mar	Closed	Closed		Closed	Closed		Closed	60
2010	Apr	Closed	Closed		Closed	Closed		Closed	60
2010	May	Closed->20	Closed->20		Closed	Closed		40	60
2010	Jun	20	20		Closed->30	Closed->20		40	60
2010	Jul	20	20		30	20		40	60
2010	Aug	20	20->Closed		30	20		40	60
2010	Sep	20->Closed	Closed		30	20		40	60
2010	Oct	Closed	Closed		30	20		40	60
2010	Nov	Closed	Closed		Closed	Closed		40->Closed	60
2010	Dec	Closed	Closed		Closed	Closed		Closed	60
2011	Jan	Closed	Closed		Closed		Closed	Closed	Closed
2011	Feb	Closed	Closed		Closed		Closed	Closed	Closed
2011	Mar	Closed	Closed		Closed		Closed	60	60
2011	Apr	Closed	Closed		Closed		Closed	60	60
2011	May	Closed->20	Closed->20		Closed		40	60	60
2011	Jun	20	20		Closed->30		40	60	60
2011	Jul	20	20		30		40	60	60
2011	Aug	20	20->Closed		30		40	60	60
2011	Sep	20	Closed		30		40	60	60
2011	Oct	20	Closed		30		40	60	60
2011	Nov	Closed	Closed		30		40	60	60
2011	Dec	Closed	Closed		30		40	60	60
2012	Jan	Closed	Closed		Closed		Closed	Closed	Closed
2012	Feb	Closed	Closed		Closed		Closed	Closed	Closed
2012	Mar	Closed	Closed		Closed		Closed	60	60
2012	Apr	Closed	Closed		Closed		Closed	60	60
2012	May	Closed->20	20->Closed		Closed		40	60	60
2012	Jun	20	20		30		40	60	60
2012	Jul	20	20		30		40	60	60
2012	Aug	20	20->Closed		30		40	60	60
2012	Sep	20	Closed		30		40	60	60
2012	Oct	20	Closed		30		40	60	60
2012	Nov	Closed	Closed		30		40	50	50
2012	Dec	Closed	Closed		30		40	50	50
2013	Jan	Closed	Closed		Closed		Closed	Closed	Closed
2013	Feb	Closed	Closed		Closed		Closed	Closed	Closed
2013	Mar	Closed	Closed		Closed		Closed	50	50
2013	Apr	Closed	Closed		Closed		Closed	50	50
2013	May	Closed->20	Closed->20		Closed		40	50	50
2013	Jun	20	20		30		40	50	50
2013	Jul	20	20		30		40	50	50
2013	Aug	20	20		30		40	50	50
2013	Sep	20	20->Closed		30		40	50	50
2013	Oct	20	Closed		30		40	50	50
2013	Nov	Closed	Closed		30		40	50	50
2013	Dec	Closed	Closed		30		40	50	50
2014	Jan	Closed	Closed		Closed		Closed	Closed	Closed
2014	Feb	Closed	Closed		Closed		Closed	Closed	Closed
2014	Mar	Closed	Closed		Closed		Closed	50	50
2014	Apr	Closed	Closed		Closed		Closed	50	50
2014	May	Closed->20	Closed->20		Closed		40	50	50
2014	Jun	20	20		30		40	50	50
2014	Jul	20	20		30		40	50	50
2014	Aug	20	20		30		40	50	50
2014	Sep	20	20->Closed		30		40	50	50
2014	Oct	20	Closed		30		40	50	50
2014	Nov	Closed	Closed		30		40	50	50
2014	Dec	Closed	Closed		30		40	50	50

Figure B4^{fig:Rec_regs3}

Latitude Range		42°-40°10'	40°10'-38°57'	40°10'-37°11'	38°57'-37°11'	37°11'-36°	37°11'-34°27'	36°-34°27'	34°27'-Mex.
Year	Month	Northern	Mendocino	North-Central	San Francisco	South-Central	Central	South-Central	Southern
2015	Jan	Closed	Closed		Closed		Closed		Closed
2015	Feb	Closed	Closed		Closed		Closed		Closed
2015	Mar	Closed	Closed		Closed		Closed		Closed
2015	Apr	Closed	Closed		Closed->30		40		Closed
2015	May	Closed->20	Closed->20		30		40		Closed
2015	Jun	20	20		30		40		Closed
2015	Jul	20	20		30		40		Closed
2015	Aug	20	20		30		40		Closed
2015	Sep	20	20		30		40		Closed
2015	Oct	20	20		30		40		Closed
2015	Nov	Closed	Closed		30		40		Closed
2015	Dec	Closed	Closed		30		40		Closed
2016	Jan	Closed	Closed		Closed		Closed		Closed
2016	Feb	Closed	Closed		Closed		Closed		Closed
2016	Mar	Closed	Closed		Closed		Closed		Closed
2016	Apr	Closed	Closed		Closed->30		40		Closed
2016	May	Closed->20	Closed->20		30		40		Closed
2016	Jun	20	20		30		40		Closed
2016	Jul	20	20		30		40		Closed
2016	Aug	20	20		30		40		Closed
2016	Sep	20	20		30		40		Closed
2016	Oct	20	20		30		40		Closed
2016	Nov	Closed	Closed		30		40		Closed
2016	Dec	Closed	Closed		30		40		Closed
2017	Jan	Closed	Closed		Closed		Closed		Closed
2017	Feb	Closed	Closed		Closed		Closed		Closed
2017	Mar	Closed	Closed		Closed		Closed		60
2017	Apr	Closed	Closed		Closed		50		60
2017	May	30	20		40		50		60
2017	Jun	30	20		40		50		60
2017	Jul	30	20		40		50		60
2017	Aug	30	20		40		50		60
2017	Sep	30	20		40		50		60
2017	Oct	30->20	20		40->30		50->40		60
2017	Nov	20	20		30		40		60
2017	Dec	20	20		30		40		60
2018	Jan	Closed	Closed		Closed		Closed		60
2018	Feb	Closed	Closed		Closed		Closed		60
2018	Mar	Closed	Closed		Closed		Closed		60
2018	Apr	Closed	Closed		Closed		50		60
2018	May	30	20		40		50		60
2018	Jun	30	20		40		50		60
2018	Jul	30	20		40		50		60
2018	Aug	30->20	20		40->30		50->40		60
2018	Sep	20	20		30		40		60
2018	Oct	20	20		30		40		60
2018	Nov	20	20		30		40		60
2018	Dec	20	20		30		40		60

Figure B5^{fig:Rec_reg4}

₁₆₁₃ **Appendix C. Detailed fits to length composition data**

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

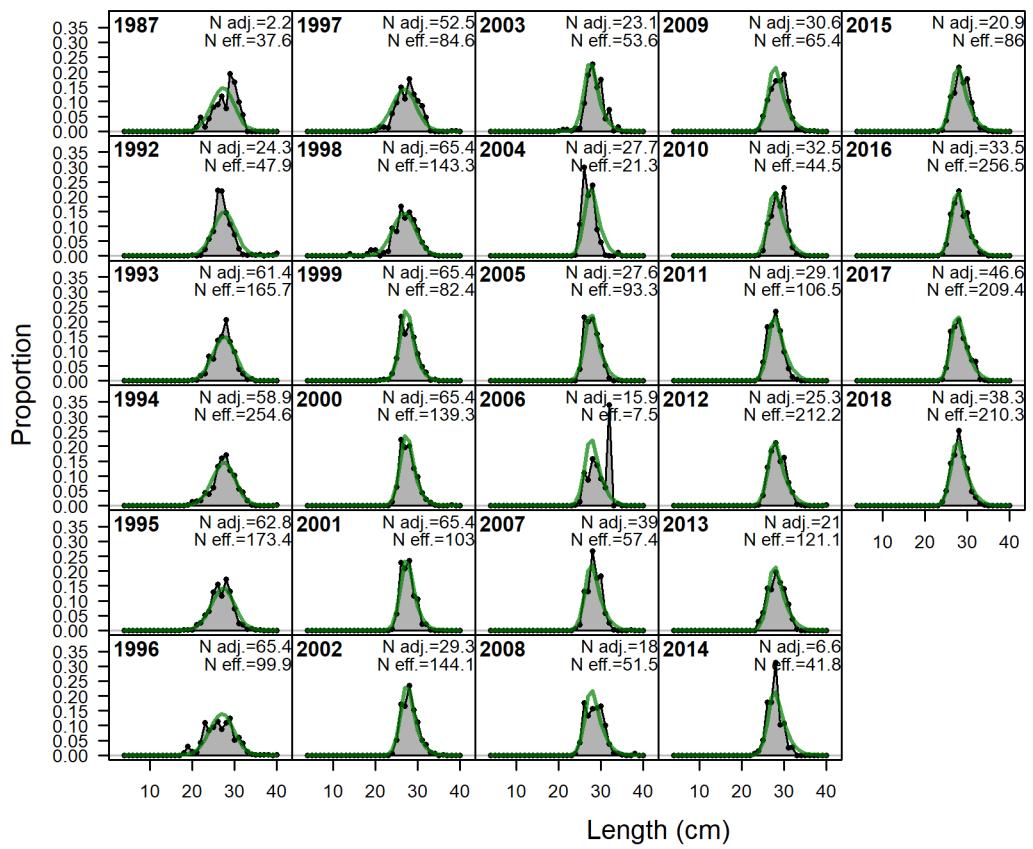


Figure C2: Length comps, retained, Com. ‘N adj.’ is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAlister_Iannelli tuning method. [fig:mod1_1_comp_1enfit_fltimkt2](#)

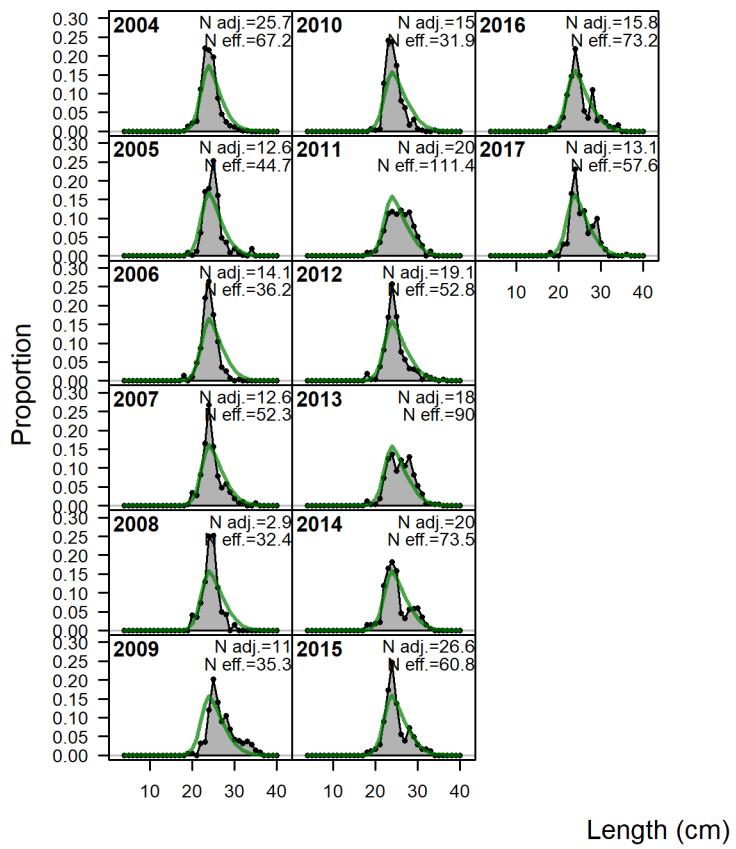


Figure C3: Length comps, retained, ComDisc. ‘N adj.’ is the input sample size after data_weighting adjustment. N_eff. is the calculated effective sample size used in the McAlister_Iannelli tuning method. ^{fig:mod1_2_comp_1enfit_flt2mkt2}

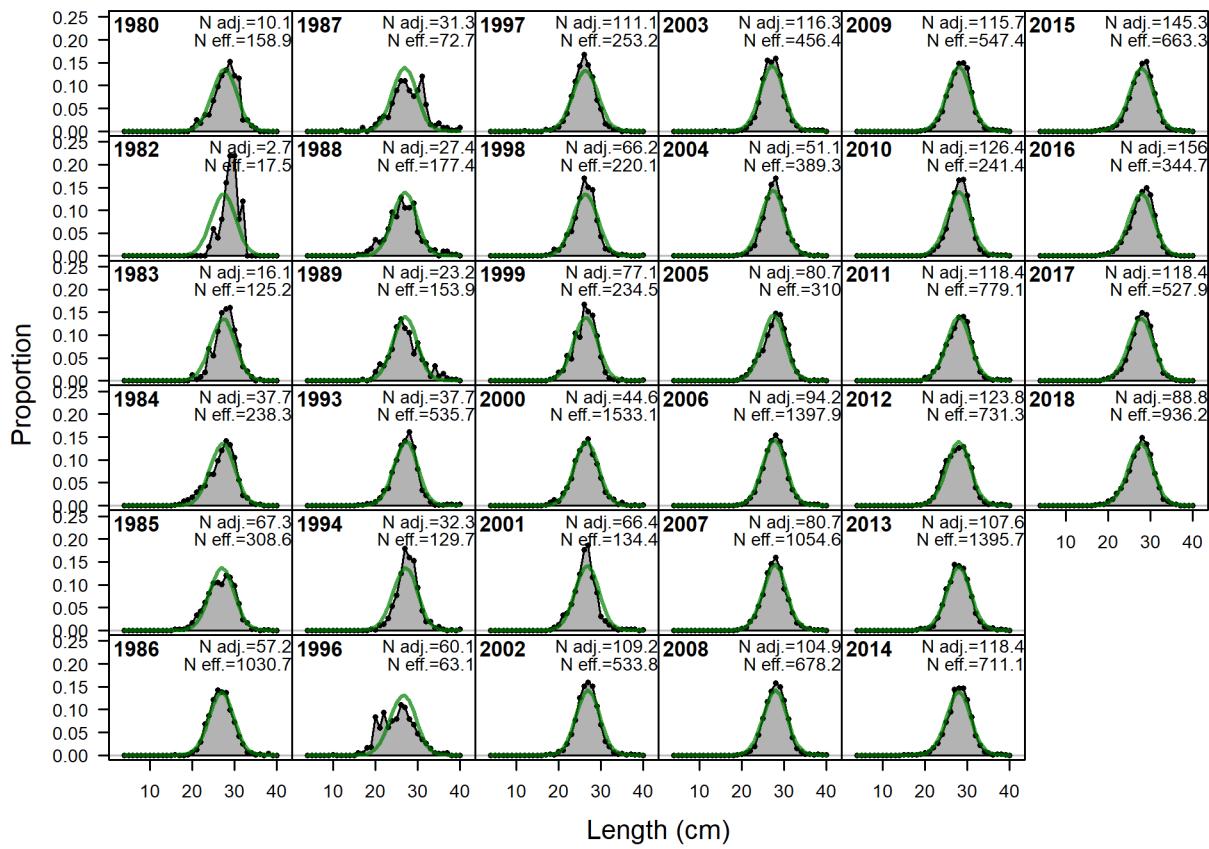


Figure C4: Length comps, whole catch, RecNorth. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Iannelli tuning method. | [fig:mod1_3_comp_lenfit_flt3mkto](#)

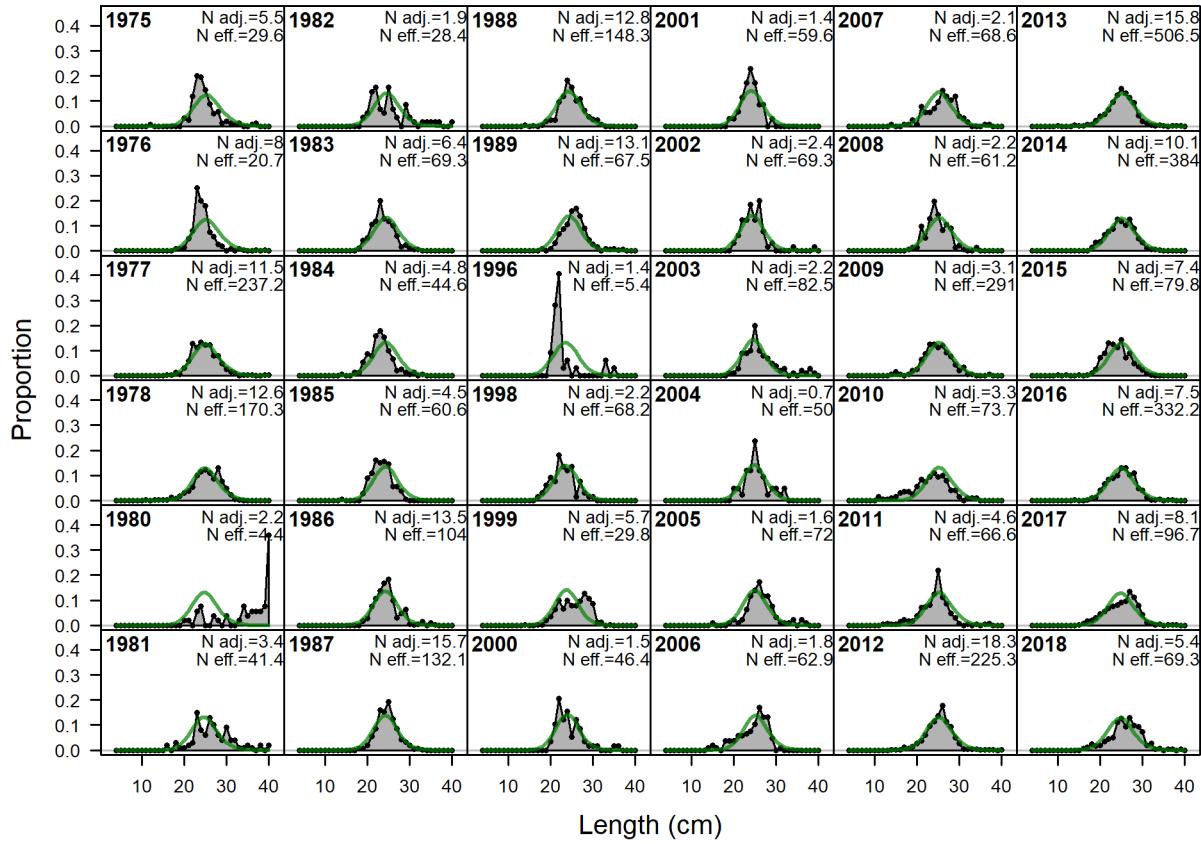


Figure C5: Length comps, whole catch, RecSouth. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method. | [fig:mod1_4_comp_lenfit_flt4mkt0](#)

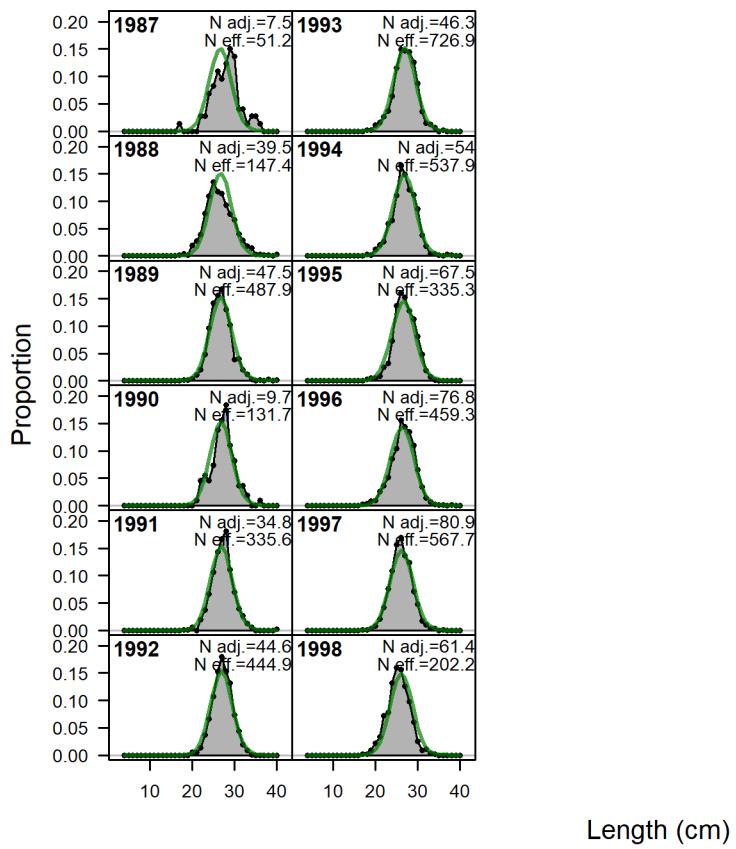


Figure C6: Length comps, whole catch, DebCPFV. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method. | [fig:mod1_5_comp_lenfit_flt5mkto](#)

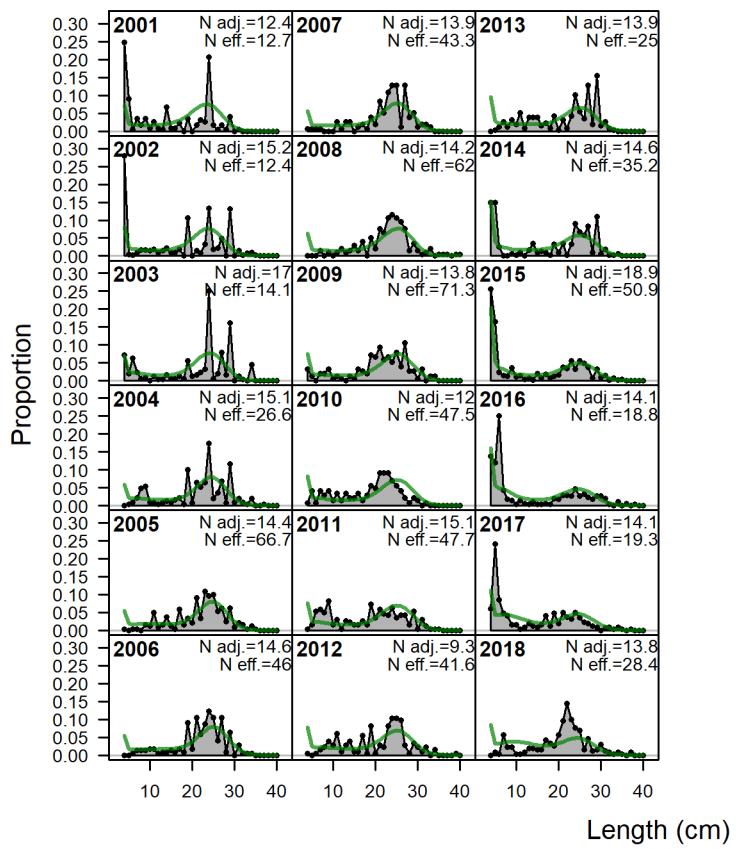


Figure C7: Length comps, whole catch, PISCO. ‘N adj.’ is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAlister_Iannelli tuning method. [fig:mod1_6_comp_1enfit_flt8mkt0](#)

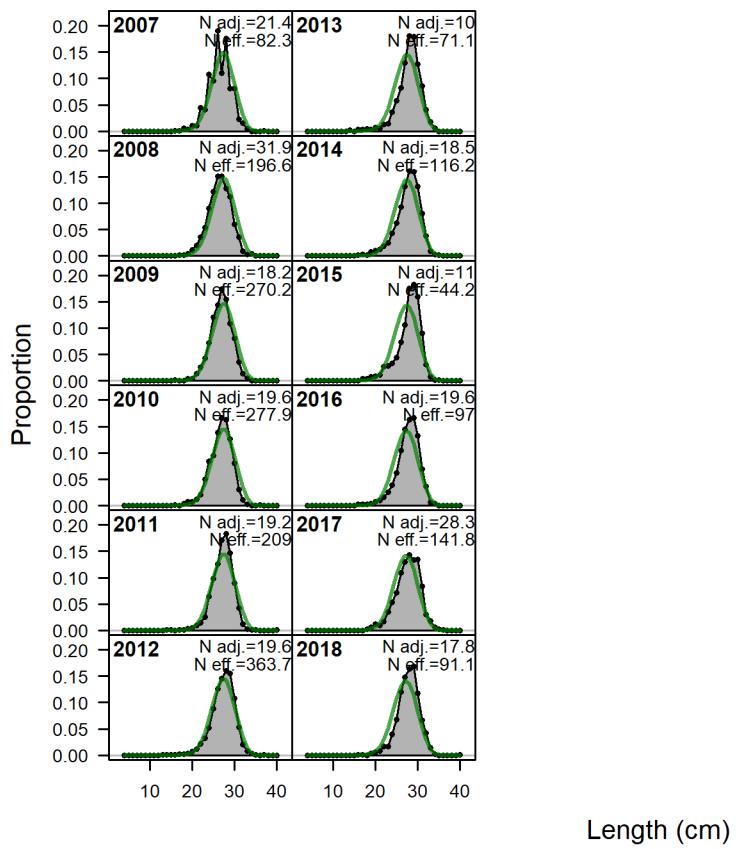


Figure C8: Length comps, whole catch, CCFRP. ‘N adj.’ is the input sample size after data_weighting adjustment. N_eff. is the calculated effective sample size used in the McAlister_Iannelli tuning method. [fig:mod1_7_comp_1enfit_flt9mkt0](#)

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