

# 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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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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<sup>96</sup> **Executive Summary**

executive-summary

<sup>97</sup> **Stock**

stock

<sup>98</sup> This assessment reports the status of the gopher and black-and-yellow rockfish  
<sup>99</sup> complex (GBYR, *Sebastodes carnatus*/*Sebastodes chrysomelas*) resource in U.S. waters off the  
<sup>100</sup> coast of California south of Cape Mendocino (40°10' N. latitude) using data through 2018.  
<sup>101</sup> Both gopher and black-and-yellow rockfishes are most abundant north of Point Conception  
<sup>102</sup> (34°27' N. latitude) and are uncommon north of Point Arena (38°57' N. latitude). The range  
<sup>103</sup> of gopher rockfish extends into Baja California, but the black-and-yellow rockfish are rare  
<sup>104</sup> south of Point Conception.

<sup>105</sup> **Catches**

catches

<sup>106</sup> Information on historical landings of GBYR are available back to 1916 (Table [a](#)). The  
<sup>107</sup> recreational fleet began ramping up in the 1950s and has fluctuated over the the last 50  
<sup>108</sup> years (Figure [a](#)). The majority of GBYR recreational landings have been from north of Point  
<sup>109</sup> Conception throughout the time period modelled.

<sup>110</sup> Commercial landings were small during the years of World War II, ranging between 4 to 28  
<sup>111</sup> metric tons (mt) per year (Figure [b](#)). Commercial landings increased after World War II and  
<sup>112</sup> show periods of cyclical catch for gopher and black-and-yellow rockfishes. The commercial  
<sup>113</sup> live fish fishery began in the early 1990s, with the first reported live landings in 1993. Since  
<sup>114</sup> then the commercial catch has been dominated by the live fish fishery, with minimal landings  
<sup>115</sup> of dead gopher or black-and-yellow rockfishes. Estimates of total mortality of commercial  
<sup>116</sup> discards were available starting in 2004, and were estimated prior to then. The catches  
<sup>117</sup> aggregated by fleets modeled in this assessment can be found in Figure [c](#).

<sup>118</sup> Since 2000, annual total landings of catch and discards of GBYR have ranged between 70-169  
<sup>119</sup> mt, with landings (catch + discards) in 2018 totaling 92 mt.

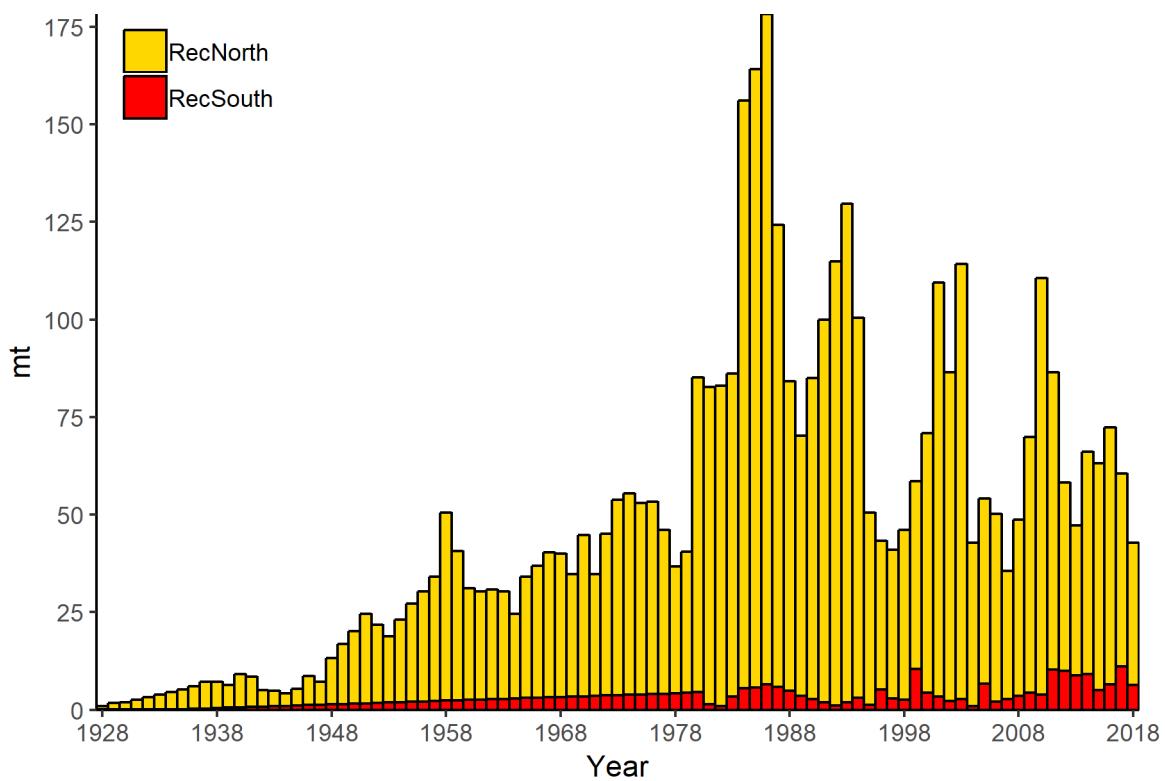


Figure a: Catch history of GBYR landings for the recreational fleet north (RecNorth) and south (RecSouth) of Point Conception..

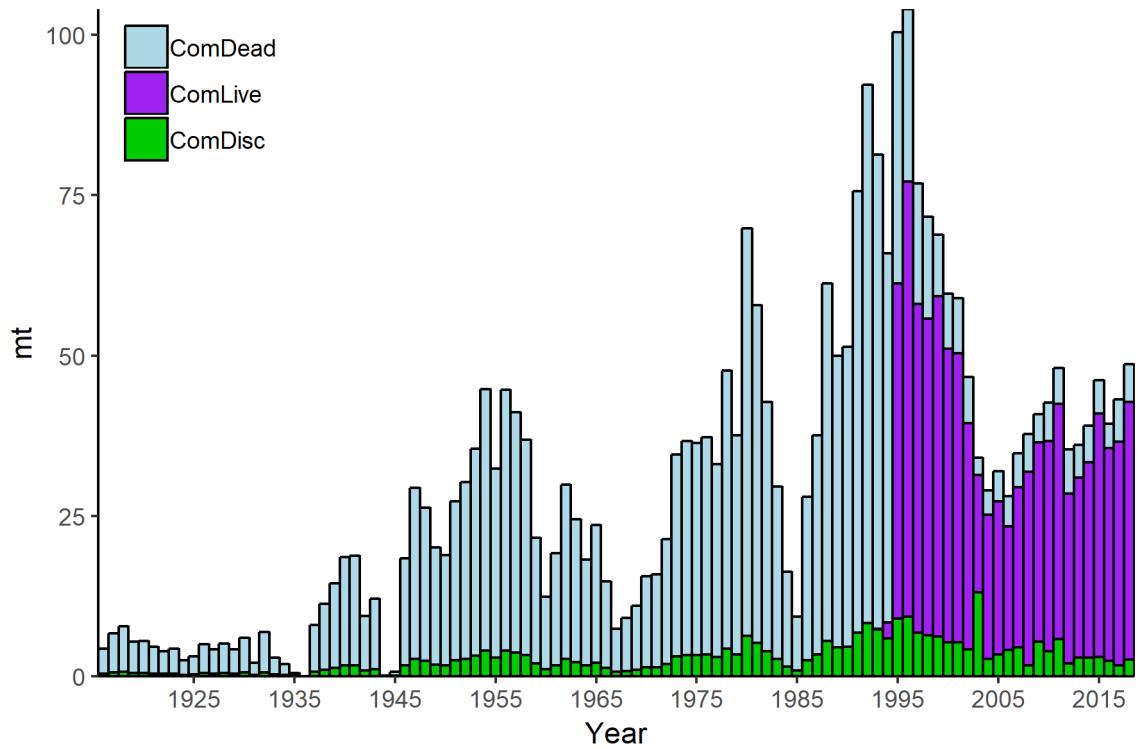


Figure b: Catch history of GBYR for the commercial fleet by dead (ComDead) and live (ComLive) landings, and discards (ComDisc). Catches in 1936 and 1946 were minimal. fig:Exec\_catch2

Table a: Recent GBYR landings (mt) by fleet, where the recreational fleet is split at Point Conception.

Year	Commercial	Commercial	Recreational	Recreational	<b>tab:Exec_catch</b>
	Retained	Discard	North	South	
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

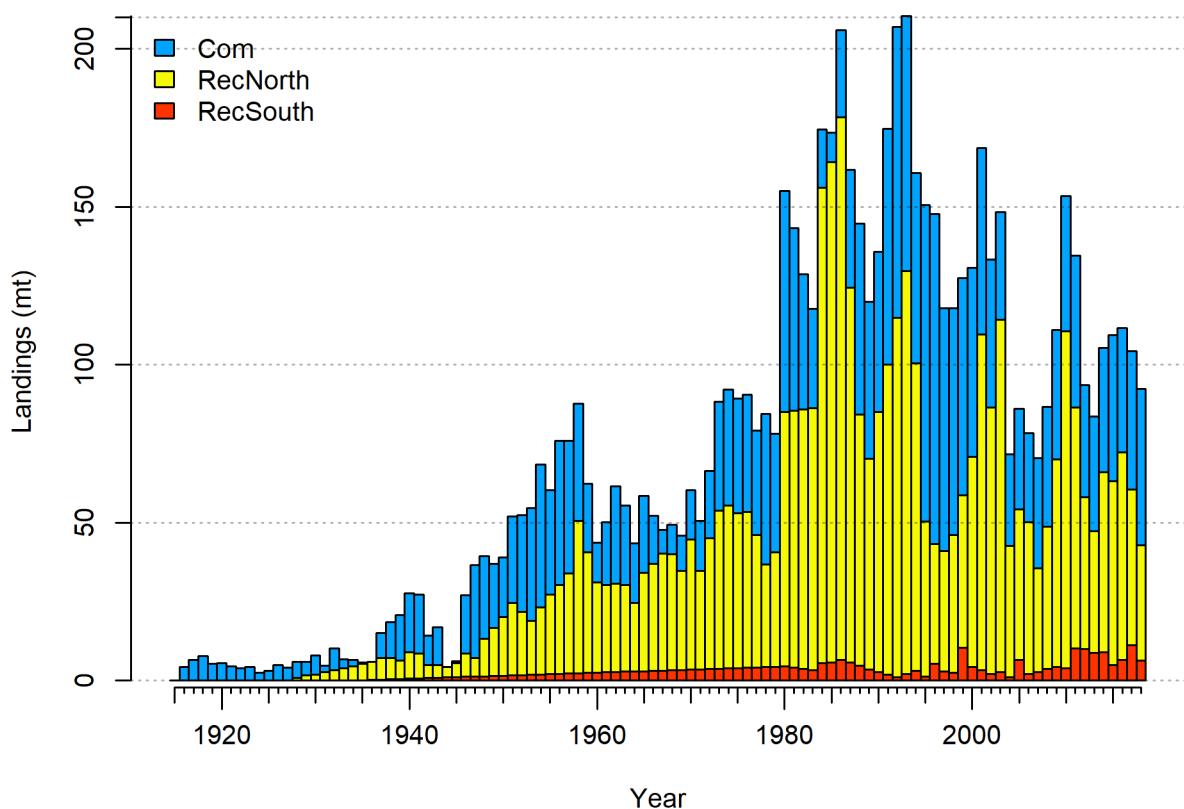


Figure c: Catch history of GBYR in the model. [fig:r4ss\\_catches](#)

120 **Data and Assessment**

data-and-assessment

121 Gopher rockfish north of Point Conception ( $34^{\circ}27'$  N. latitude) was first assessed as a full  
122 stock assessment in 2005 (Key et al. 2005) using SS2 (version 1.19). The assessment was  
123 sensitive to the recreational party boat onboard observer index of relative abundance (referred  
124 to as Deb Wilson-Vandenberg's onboard observer index in this assessment). The final decision  
125 table was based around the emphasis given to this index of relative abundance. The stock  
126 was found to be at 97% depletion in 2005.

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

130 This is the first full assessment to include data for black-and-yellow rockfish. Black-and-yellow  
131 rockfish was assessed coastwide as a data poor species using Depletion-Based Stock Reduction  
132 Analysis (DB-SRA) (Dick and MacCall 2010). The DB-SRA model assigned a 40% probability  
133 that the then recent (2008-2009) catch exceeded the 2010 OFL.

134 This assessment of the GBYR complex covers the area from Cape Mendocino to the  
135 U.S./Mexico border (Figure d). The length composition data suggested that while the  
136 lengths of gopher and black-and-yellow rockfish were similar, fish encountered south of Point  
137 Conception were smaller. The similarity of the length distributions between species and  
138 among modes within a region were similar and justified one combined recreational fleet within  
139 each of the two regions (north and south of Point Conception).

140 This stock assessment retains a single fleet for the commercial fishery, including discards.  
141 Data on commercial discards were not available for and not included in the 2005 assessment.  
142 The decision to retain one commercial fleet was made by examining the length distributions  
143 across species, fishing gears, and space, i.e., north and south of Point Conception. There is  
144 very little difference between the length composition of gopher and black-and-yellow rockfish  
145 landed in the commercial fleet north and south of Point Conception.

146 A number of sources of uncertainty are addressed in this assessment. This assessment includes  
147 length data, estimated growth, an updated length-weight curve, an updated maturity curve,  
148 a number of new indices, and new conditional age-at-length data.

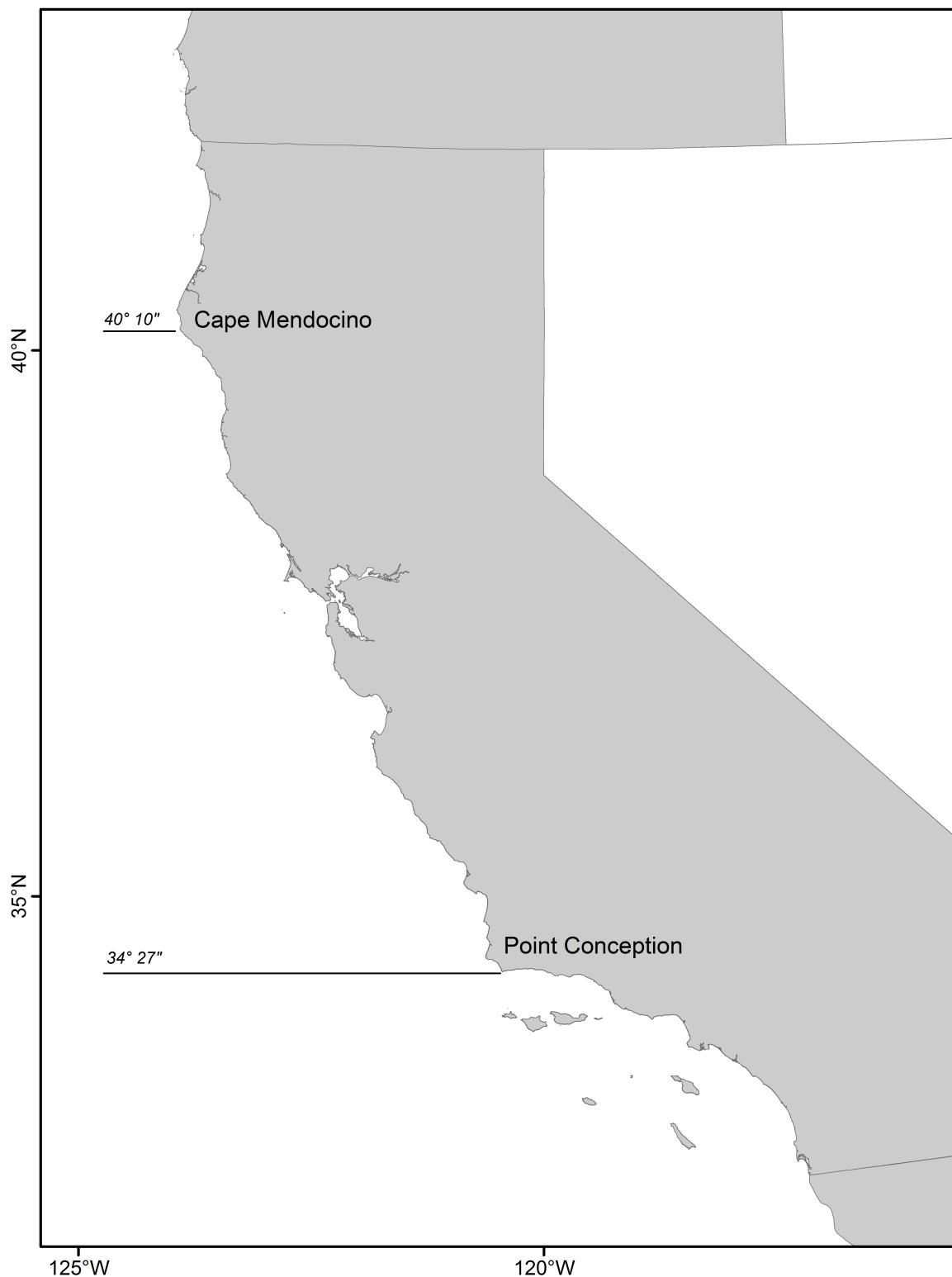


Figure d: Map depicting the core distribution of gopher and black-and-yellow rockfishes. The stock assessment is bounded at Cape Mendocino in the north to the U.S./Mexico border in the south. [fig:assess\\_region\\_map](#)

<sup>149</sup> **Stock Biomass**

stock-biomass

<sup>150</sup> The predicted spawning output from the base model generally showed a slight decline prior  
<sup>151</sup> to 1978, when the recruitment deviations were first estimated (Figure e and Table b). The  
<sup>152</sup> stock declined from 1978 to 1994, followed by a period of increase from 1995 to 2003. From  
<sup>153</sup> 2004-2018 the stock has been in decline, though increased in total biomass since 2016 and  
<sup>154</sup> exhibits stable spawning output since from 2018 to 2019. The 2019 estimated spawning  
<sup>155</sup> output relative to unfished equilibrium spawning output is above the target of 40% of unfished  
<sup>156</sup> spawning output at 43.82 (95% asymptotic interval: 33.57-54.06) (Figure f). Approximate  
<sup>157</sup> confidence intervals based on the asymptotic variance estimates show that the uncertainty in  
<sup>158</sup> the estimated spawning output is high, (95% asymptotic interval: 337-767 million eggs).

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	<sup>tab:SpawningDeplete_mod1</sup> ~ 95% confidence interval
2010	882	597 - 1168	69.99	58.05 - 81.92
2011	817	548 - 1086	64.77	53.48 - 76.06
2012	761	507 - 1014	60.33	49.63 - 71.03
2013	727	486 - 968	57.66	47.5 - 67.81
2014	697	466 - 928	55.31	45.56 - 65.05
2015	655	434 - 877	51.98	42.4 - 61.55
2016	614	399 - 828	48.69	39.16 - 58.22
2017	576	367 - 786	45.70	36.12 - 55.28
2018	553	344 - 762	43.85	34.08 - 53.63
2019	552	337 - 767	43.82	33.57 - 54.06

### Spawning output with ~95% asymptotic intervals

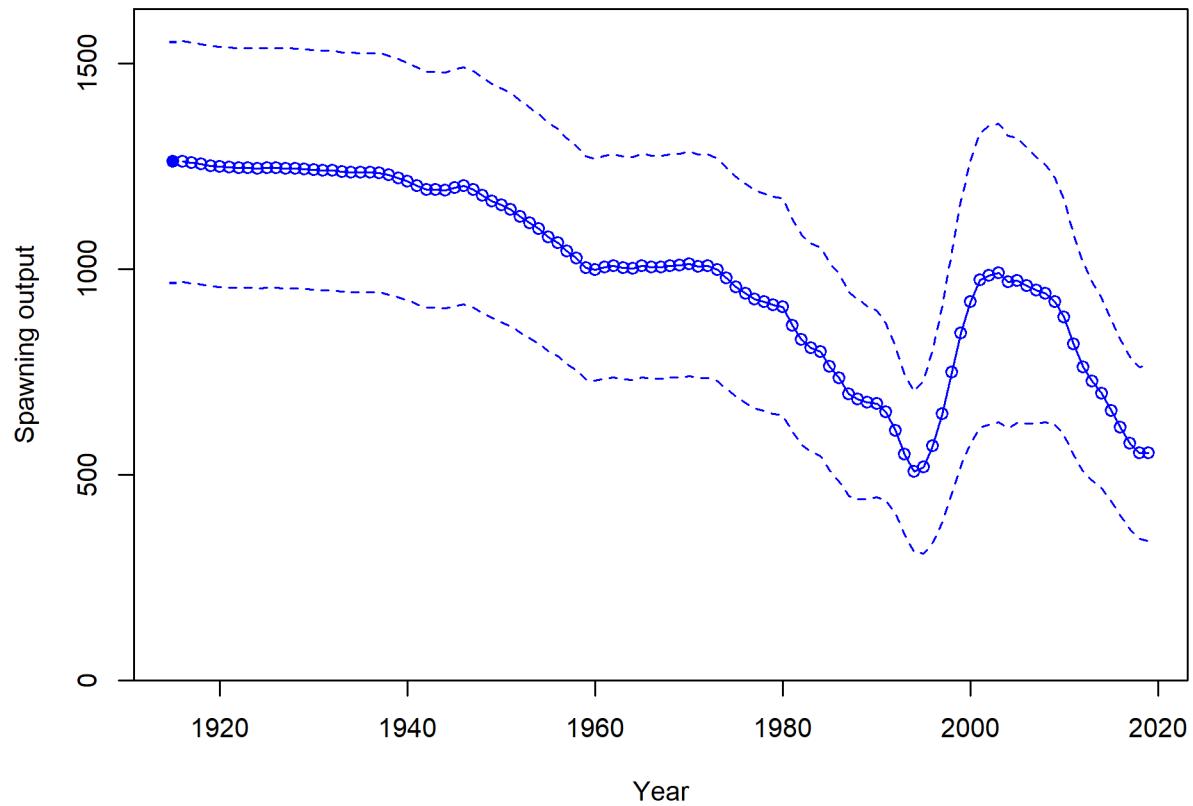


Figure e: Time series of spawning output trajectory (circles and line; median; light broken lines: 95% credibility intervals) for the base case assessment model. | [fig:Spawnbio\\_all](#)

### Fraction of unfished with ~95% asymptotic intervals

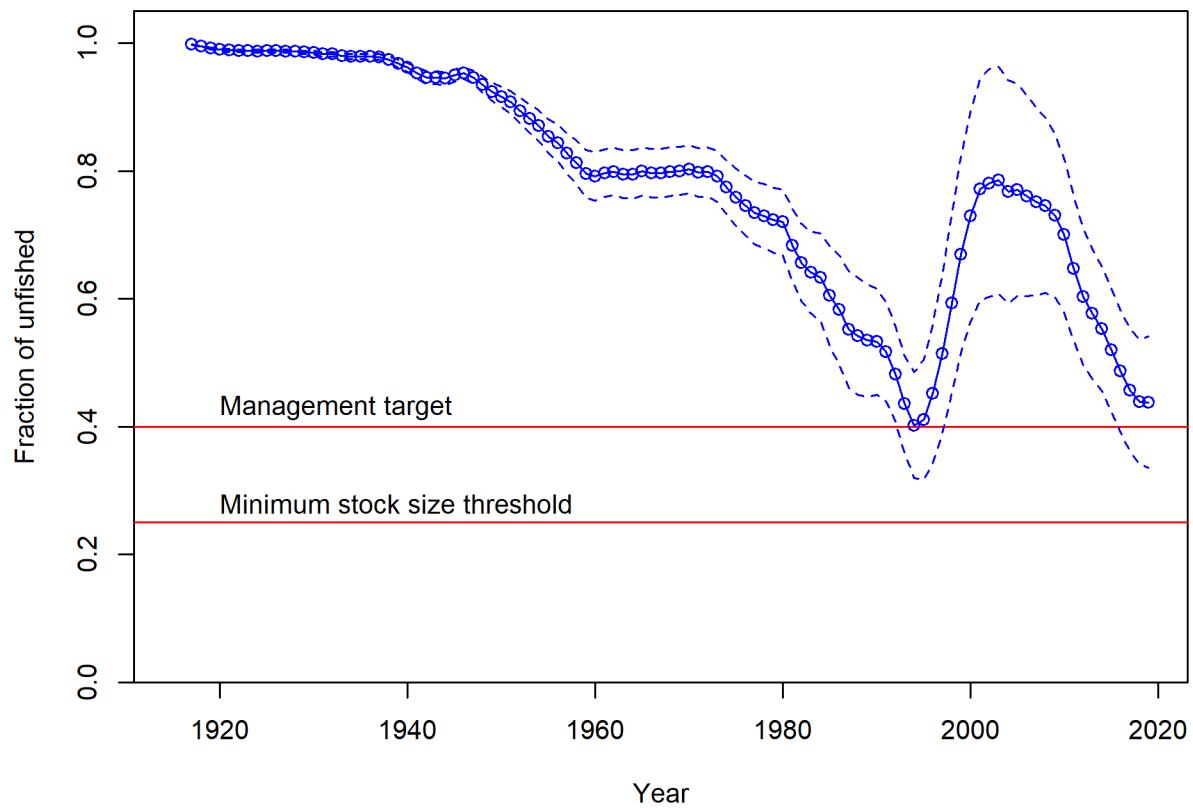


Figure f: Estimated fraction of unfished (percent depletion) with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model. fig:Re1Deplete\_all

<sup>159</sup> **Recruitment**

recruitment

<sup>160</sup> Recruitment deviations were estimated from 1979-2018 (Figure g and Table c). There are  
<sup>161</sup> estimates of very strong recruitment in 1991, with high recruitment pulses for a number of  
<sup>162</sup> other years including 1994-1995 and 2014-2015.

Table c: Recent recruitment for the GBYR assessment.

Year	Estimated Recruitment (1,000s)	~ 95% confidence interval
2010	2451	1257 - 4779
2011	2014	983 - 4127
2012	1800	761 - 4258
2013	1589	676 - 3734
2014	4568	2519 - 8284
2015	5264	2985 - 9282
2016	2487	1274 - 4857
2017	3701	1976 - 6935
2018	1432	664 - 3089
2019	2778	1086 - 7111

**Age-0 recruits (1,000s) with ~95% asymptotic intervals**

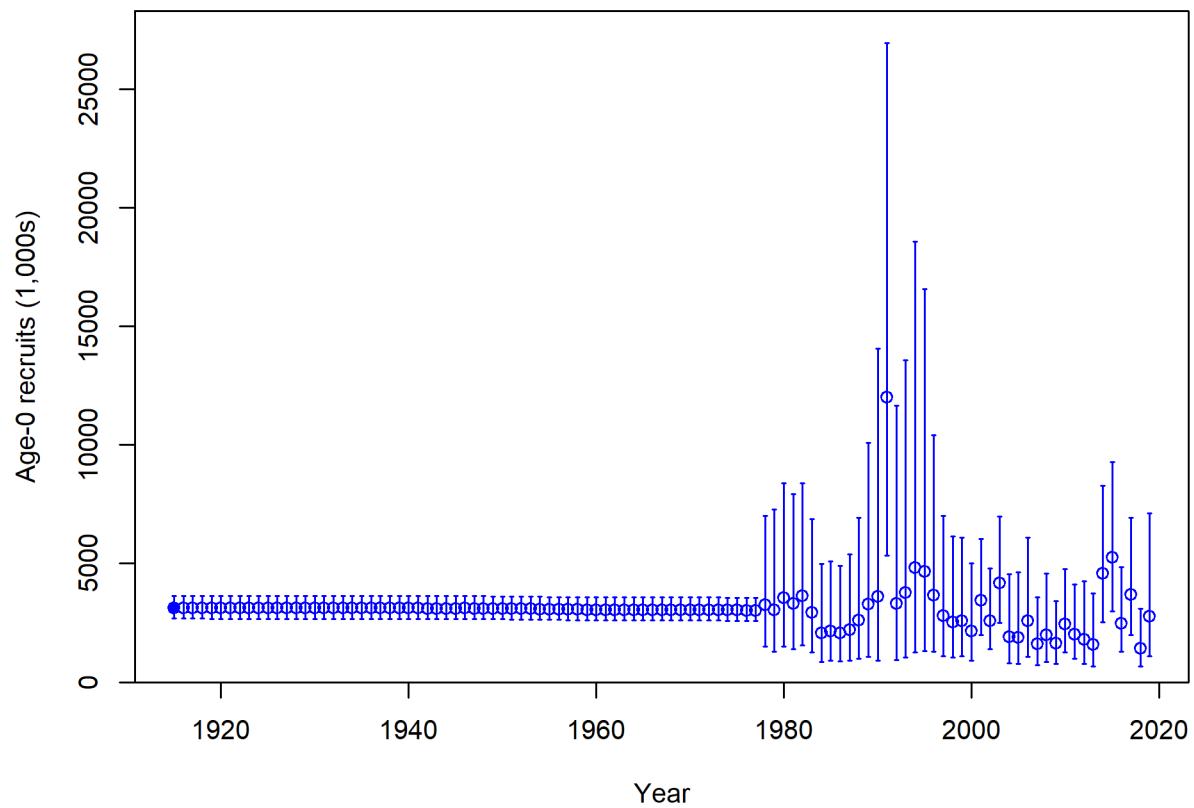


Figure g: Time series of estimated GBYR recruitments for the post-STAR base model with 95% confidence or credibility intervals. [fig:Recruits\\_all](#)

163 **Exploitation status**

exploitation-status

164 Harvest rates estimated by the base model indicate catch levels have been below the limits that  
165 would be associated with the Spawning Potential Ratio (SPR) = 50% limit (corresponding  
166 to a relative fishing intensity of 100%) (Table d and Figure h). SPR is calculated as the  
167 lifetime spawning potential per recruit at a given fishing level relative to the lifetime spawning  
168 potential per recruit with no fishing. The relative inverse SPR over the last decade increased  
169 ranged from 0.64 to 0.77 from 2009-2015, and ranged from 0.80 to 0.82 from 2016-2018 (Table  
170 d).

Table d: Recent trend in spawning potential ratio (entered as  $(1 - SPR)/(1 - SPR_{50\%})$ ) and exploitation for GBYR in the model.

Year	Estimated $(1-SPR)/(1-$ $SPR_{50\%})$	~ 95% confidence interval	Exploitation rate	95% confidence interval
2009	0.64	0.5 - 0.78	0.07	0.05 - 0.09
2010	0.78	0.64 - 0.93	0.10	0.08 - 0.13
2011	0.77	0.62 - 0.92	0.10	0.07 - 0.12
2012	0.67	0.52 - 0.81	0.07	0.05 - 0.09
2013	0.64	0.49 - 0.78	0.07	0.05 - 0.09
2014	0.74	0.59 - 0.88	0.09	0.06 - 0.11
2015	0.77	0.62 - 0.92	0.10	0.07 - 0.12
2016	0.81	0.66 - 0.96	0.10	0.07 - 0.13
2017	0.82	0.66 - 0.98	0.09	0.06 - 0.11
2018	0.80	0.63 - 0.96	0.07	0.05 - 0.1

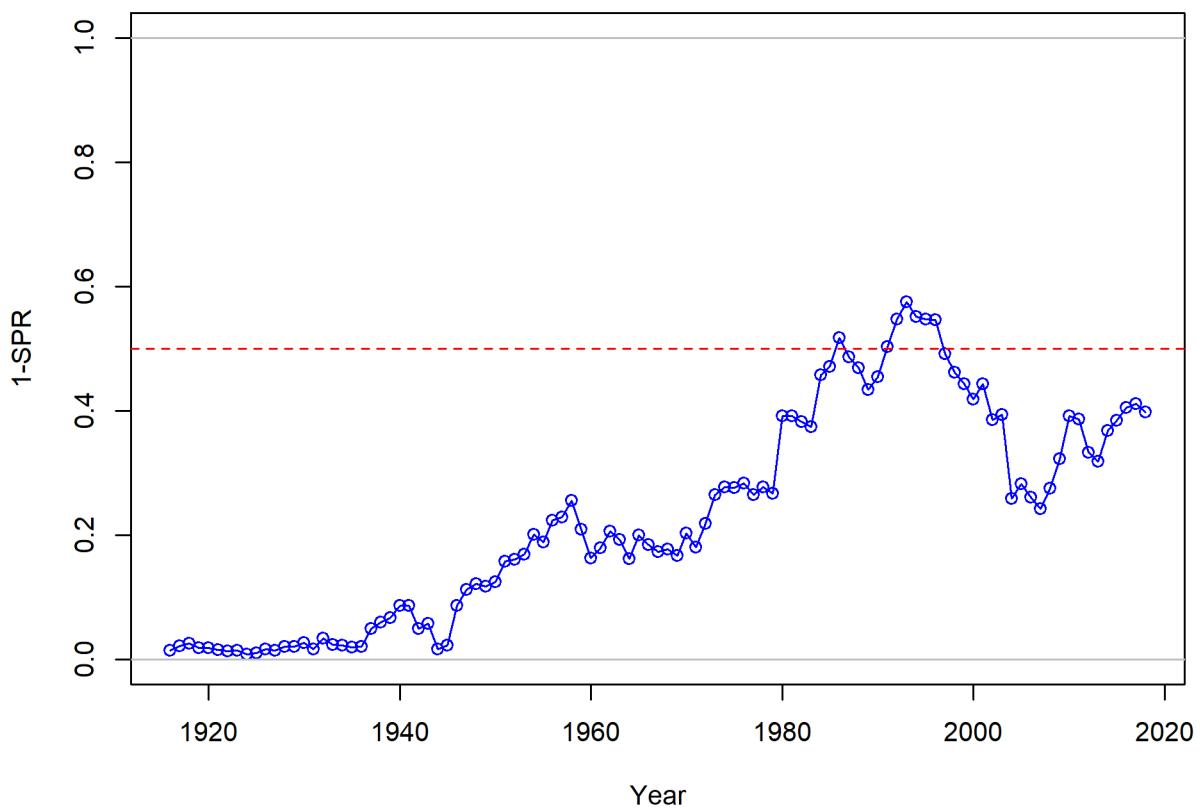


Figure h: Estimated inverse spawning potential ratio (SPR) for the post-STAR base model, plotted as one minus SPR so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the SPR<sub>50%</sub> harvest rate. The last year in the time series is 2018. fig:SPR\_all

<sup>171</sup> **Ecosystem Considerations**

ecosystem-considerations

- <sup>172</sup> In this assessment, ecosystem considerations were not explicitly included in the analysis.  
<sup>173</sup> This is primarily due to a lack of relevant data and results of analyses (conducted elsewhere)  
<sup>174</sup> that could contribute ecosystem-related quantitative information for the assessment.

<sup>175</sup> **Reference Points**

reference-points

- <sup>176</sup> This stock assessment estimates that GBYR in the model is above the biomass target ( $SB_{40\%}$ ),  
<sup>177</sup> and well above the minimum stock size threshold ( $SB_{25\%}$ ). The estimated relative depletion  
<sup>178</sup> level for the base model in 2018 is 0.439 (95% asymptotic interval: 0.341-0.536, corresponding  
<sup>179</sup> to an unfished spawning of 552 million eggs (95% asymptotic interval: 337 - 767 million eggs)  
<sup>180</sup> of spawning output in the base model (Table e). Unfished age 1+ biomass was estimated to  
<sup>181</sup> be 2,042 mt in the base case model. The target spawning output ( $SB_{40\%}$ ) is 504 million eggs,  
<sup>182</sup> which corresponds with an equilibrium yield of 143 mt. Equilibrium yield at the proxy  $F_{MSY}$   
<sup>183</sup> harvest rate corresponding to  $SPR_{50\%}$  is 134 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)	1,261	968	1,554
Unfished age 1+ biomass (mt)	2,042	1,637	2,448
Unfished recruitment ( $R_0$ )	3,125	2,643	3,606
Spawning output (2018 million eggs)	553	344	762
Depletion (2018)	0.439	0.341	0.536
<b>Reference points based on SB<sub>40%</sub></b>			
Proxy spawning output ( $B_{40\%}$ )	504	427	582
SPR resulting in $B_{40\%}$ ( $SPR_{B40\%}$ )	0.458	0.458	0.458
Exploitation rate resulting in $B_{40\%}$	0.126	0.109	0.144
Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt)	143	124	162
<b>Reference points based on SPR proxy for MSY</b>			
Spawning output	563	476	649
$SPR_{proxy}$	0.5		
Exploitation rate corresponding to $SPR_{proxy}$	0.111	0.096	0.126
Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt)	134	116	152
<b>Reference points based on estimated MSY values</b>			
Spawning output at MSY ( $SB_{MSY}$ )	281	235	328
$SPR_{MSY}$	0.299	0.29	0.308
Exploitation rate at MSY	0.209	0.174	0.244
Dead Catch MSY (mt)	163	141	185
Retained Catch MSY (mt)	163	141	185

## 184 Management Performance

management-performance

185 Gopher and black-and-yellow rockfishes are managed as part of the minor nearshore complex  
 186 in the Pacific Coast Groundfish Fishery Management Plan. The total mortality of the minor  
 187 nearshore rockfish has been below the ACL in all years (2011-2016). Total mortality estimates  
 188 from the NWFSC are not yet available for 2017-2018. GBYR total mortality was on average  
 189 20% of the total minor nearshore rockfish total mortality from 2011-2016. A summary of  
 190 these values as well as other base case summary results can be found in Table f.

Table f: Recent trend in total mortality for gopher and black-and-yellow rockfishes (GBYR), combined, relative to the management guidelines for Nearshore Rockfish South of  $40^{\circ}10' N$ . latitude. Total mortality estimates are based on annual reports from the NMFS NWFSC.

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

## 191 Unresolved Problems and Major Uncertainties

unresolved-problems-and-major-uncertainties

192 The major source of uncertainty identified during the STAR panel are the structure of two  
 193 species complex, the contribution of each of the two species to the complex, and differences  
 194 in biological parameters between the species. There is currently no information for either  
 195 species on regional differences in biological parameters and contributions to the complex.

## 196 Decision Table

decision-table

197 The forecasts of stock abundance and yield were developed using the post-STAR base model,  
 198 with the forecasted projections of the OFL presented in Table g. The total catches in 2019  
 199 and 2020 are set to the projected catch from the California Department of Fish and Wildlife  
 200 (CDFW) of 114 mt.

201 Uncertainty in the forecasts is based upon the three states of nature agreed upon at the  
 202 STAR panel and are based three states of nature of growth. The external estimate of growth  
 203 was different than the internal Stock Synthesis estimate. Given that natural mortality is  
 204 fixed in the post-STAR base model, and the growth parameter  $k$  is negatively correlated with  
 205 natural mortality,  $k$  was chosen as the axis of uncertainty. The high state of nature fixes  $k$  at  
 206 the external estimate, and the low state of nature is the same distance in log space from the  
 207 base as the high state of nature. The low state of nature fixed  $k$  at 0.046 and the L1 and L1  
 208 parameters were estimated at 14.1 and 30.6, respectively. The high state of nature fixed all  
 209 growth parameters,  $k = 0.248$ ,  $L1 = 13.8$ , and  $L2 = 28.5$  to the external estimate of growth  
 210 (due to improbable estimates of L1 and L2 if only  $k$  was fixed to the external estimate). The  
 211 growth parameters in the base model were estimated as  $k = 0.107$ ,  $L1 = 13.4$ , and  $L2 = 28.8$ .

212 The forecasted buffer ramp was calculated assuming a category 2 stock, with sigma = 1.0 and

213 a  $p^* = 0.45$ . The buffer ranges from 0.874 in 2021 ramping to 0.803 in 2030. For reference,  
 214 the model predicted sigma is 0.189 and the decision table-based sigma is 0.197. Current  
 215 medium-term forecasts based on the alternative states of nature project that the stock will  
 216 remain above the target threshold of 40% for all but two scenarios (Table h). The low state of  
 217 nature with the high catches results in a stock at 26.4% of unfished in 2030 and the base state  
 218 model with the high catches results in a stock at 33.2% of unfished in 2030. The base case  
 219 model with the base catches results in an increasing stock over the period from 2021-2030. If  
 220 the growth of GBYR is slower than the base model suggests, but the base case catches are  
 221 removed, the stock will be at the target threshold in 2030.

Table g: Projected OFL, default harvest control rule catch (ABC = ACL) above 40% SSB), biomass, and depletion using the post-STAR base case model with 2019-2020 catches set equal to the projected catch (114 mt) rather than the ABC.

Year	OFL (mt)	ABC Catch (mt)	Age 0+ Biomass (mt)	Spawning Output (million eggs)	Fraction unfished
2019	154	114	1281	552.5	43.8
2020	154	114	1292	558.3	44.3
2021	136	119	1291	578.2	45.9
2022	137	119	1296	601.1	47.7
2023	143	122	1300	621.5	49.3
2024	150	127	1302	633.3	50.2
2025	155	130	1300	636.2	50.5
2026	158	131	1295	632.6	50.2
2027	158	130	1290	626.0	49.7
2028	156	128	1286	619.4	49.1
2029	155	125	1284	614.8	48.8
2030	153	123	1283	612.7	48.6

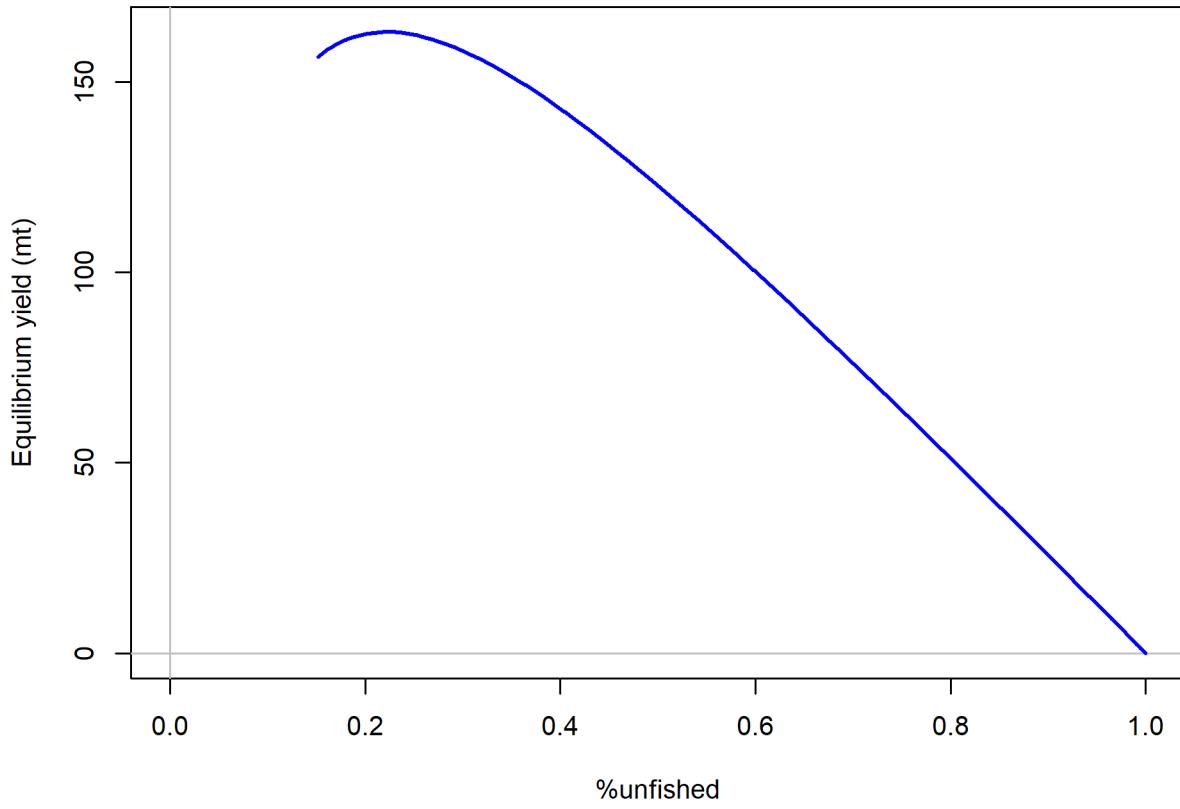


Figure i: Equilibrium yield curve for the base case model. Values are based on the 2018 fishery selectivity and with steepness fixed at 0.72. [fig:Yield\\_all](#)

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. The low state of nature fixed the growth parameter  $k$  at 0.046 and the high state fixes all growth parameters to the external estimate ( $k = 0.248$ ,  $L1 = 13.8$ ,  $L2 = 28.5$ ). For reference the base case estimated  $k = 0.106$ ,  $L1 = 13.4$  and  $L2 = 28.9$ . The 2019 and 2020 catches were set to the projected catch of 114 mt, provided by CDFW.

tab:Decision\_table\_mod1  
States of nature

	Year	Catch	Low State	Base State	High State			
			Spawning Output	Depletion	Spawning Output	Depletion	Spawning Output	
Default harvest for Low State	2019	114	444.4	37.3	552.5	43.8	1105.4	58.5
	2020	114	443.3	37.2	558.3	44.3	1168.8	61.9
	2021	75	449.6	37.7	578.2	45.9	1231.2	65.2
	2022	80	481.2	40.4	623.4	49.4	1296.5	68.6
	2023	85	510.4	42.8	660.8	52.4	1322.9	70.0
	2024	91	534.5	44.9	687.1	54.5	1329.1	70.4
	2025	96	552.0	46.3	702.5	55.7	1328.9	70.4
	2026	101	562.5	47.2	709.3	56.3	1326.8	70.2
	2027	104	567.1	47.6	710.4	56.3	1324.2	70.1
	2028	105	567.5	47.6	708.5	56.2	1321.7	70.0
	2029	105	565.8	47.5	706.1	56.0	1320.3	69.9
	2030	104	563.8	47.3	704.8	55.9	1320.2	69.9
Default harvest for Base State	2019	114	444.4	37.3	552.5	43.8	1105.4	58.5
	2020	114	443.3	37.2	558.3	44.3	1168.8	61.9
	2021	119	449.6	37.7	578.2	45.9	1231.2	65.2
	2022	119	460.9	38.7	601.1	47.7	1267.4	67.1
	2023	122	475.0	39.9	621.5	49.3	1270.6	67.3
	2024	127	486.5	40.8	633.3	50.2	1257.1	66.6
	2025	130	492.9	41.4	636.2	50.5	1240.8	65.7
	2026	131	493.9	41.5	632.6	50.2	1226.6	64.9
	2027	130	490.8	41.2	626.0	49.7	1216.1	64.4
	2028	128	485.6	40.8	619.4	49.1	1209.7	64.0
	2029	125	480.5	40.3	614.8	48.8	1207.0	63.9
	2030	123	476.8	40.0	612.7	48.6	1207.2	63.9
Default harvest for High State	2019	114	444.4	37.3	552.5	43.8	1105.4	58.5
	2020	114	443.3	37.2	558.3	44.3	1168.8	61.9
	2021	235	449.6	37.7	578.2	45.9	1231.2	65.2
	2022	225	410.9	34.5	544.4	43.2	1191.3	63.1
	2023	215	390.6	32.8	522.5	41.4	1132.0	59.9
	2024	204	377.9	31.7	503.3	39.9	1071.8	56.7
	2025	192	366.0	30.7	484.2	38.4	1025.9	54.3
	2026	183	353.2	29.7	466.5	37.0	996.7	52.8
	2027	177	340.4	28.6	451.7	35.8	980.5	51.9
	2028	173	328.9	27.6	440.7	34.9	972.2	51.5
	2029	170	320.2	26.9	433.5	34.4	968.2	51.3
	2030	168	314.3	26.4	429.2	34.0	966.0	51.1

Table i: Base case results summary.

Quantity	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total mortality (mt)	153	135	94	84	105	109	112	104	92	
Complex OFL (mt)	1,156	1,145	1,164	1,160	1,313	1,288	1,329	1,344		
Complex ACL (mt)	1,001	1,001	990	990	1,114	1,006	1,163	1,179		
(1-SPR)(1-SPR <sub>50%</sub> )	0.78	0.77	0.67	0.64	0.74	0.77	0.81	0.82		0.80
Exploitation rate	0.10	0.10	0.07	0.07	0.09	0.10	0.10	0.09	0.07	
Age 1+ biomass (mt)	1550.00	1469.27	1364.64	1283.44	1238.94	1196.76	1148.01	1143.82	1190.26	1237.83
Spawning Output	882	817	761	727	697	655	614	576	553	552
95% CI	597 - 1168	548 - 1086	507 - 1014	486 - 968	466 - 928	434 - 877	399 - 828	367 - 786	344 - 762	337 - 767
Depletion	70.0	64.8	60.3	57.7	55.3	52.0	48.7	45.7	43.9	43.8
95% CI	58.05 - 81.92	53.48 - 76.06	49.63 - 71.03	47.5 - 67.81	45.56 - 65.05	42.4 - 61.55	39.16 - 58.22	36.12 - 55.28	34.08 - 53.63	33.57 - 54.06
Recruits	2451	2014	1800	1589	4568	5264	2487	3701	1432	2778
95% CI	1257 - 4779	983 - 4127	761 - 4258	676 - 3734	2519 - 8284	2985 - 9282	1274 - 4857	1976 - 6935	664 - 3089	1086 - 7111

## 222 Research and Data Needs

research-and-data-needs

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

- 224 1. Investigate the structure of complex and contribution of each species to the GBYR  
225 complex. Investigate possible spatial differences in biological parameters within a single  
226 species and also between the two species. Little biological data for south of Point  
227 Conception or north of Point Arena were available for this assessment and is needed to  
228 better understand biological parameters.  
  
229 (a) Conduct life history studies  
230 (b) conduct research to identify the proportion of each species in population and in  
231 catches
- 232 2. Take a closer look at the Ralston (Ralston et al. 2010) historical catch reconstruction  
233 for gopher and black-and-yellow rockfishes. The recreational catch reconstruction for  
234 gopher rockfish south of Point Conception was an order of magnitude higher than  
235 expected when extracted for this assessment.
- 236 3. Refine the PISCO survey data and analysis to better identify age-0 fish in each month  
237 of survey. Occasional sampling during all months of the year would better help identify  
238 the length distribution of fish classified as age-0. This is the only recruitment index  
239 available for gopher and black-and-yellow rockfish. If possible, age data should be  
240 collected from the PISCO survey to aid in determining the growth of young gopher  
241 and black-and-yellow rockfish, and larger black-and-yellow rockfish.
- 242 4. Refine CCFRP survey index to look at alternative possible model structures, including  
243 a hierarchical structure and random effects. Limited time did not allow for these  
244 explorations during this assessment cycle. It is also strongly recommended to continue  
245 the coastwide sampling of the CCFRP program that began in 2017, as well as the  
246 collection of biological samples for nearshore rockfish species. The CCFRP survey  
247 is the only fishery-independent survey available for nearshore rockfish sampling the  
248 nearshore rocky reef habitats. As of this assessment, only two years of coastwide data  
249 are available, and the index was limited to the site in central California that have been  
250 monitored since 2007.
- 251 5. Collection of length and age data are recommended for both the commercial and  
252 recreational fisheries. Very little age data are available from either fishery for gopher  
253 rockfish and none for black-and-yellow rockfish.
- 254 6. Data collection and coordination across Research Recommendations 1-5 is needed to  
255 improve the efficacy of data collection and ensure that samples are representative of  
256 the data sources and the fisheries. For example, the conditional age-at-length data  
257 in the dummy fleet represent a number of sampling techniques, areas sampled, and  
258 selectivities. Better coordination of research efforts will allow the age data to be better

259 utilized by the assessment. Sampling of the commercial and recreational fleets by area in  
260 proportion to the length distribution of fish observed will also allow the model to better  
261 fit selectivity patterns and avoid possible patterns in the length and age composition  
262 residuals.

- 263 7. Investigate possible environmental drivers/co-variates for biological parameters, partic-  
264 ularly for recruitment.
- 265 8. Examine the CFRS angler interview data for the recreational private/rental mode to  
266 create a "trip" based identifier or catch and effort. This will enable the creation of an  
267 index of abundance for the private/rental mode as well as investigate if selectivity for  
268 this mode differs from the party/charter mode.
- 269 9. Resolve differences between CalCOM and PacFIN expanded length composition data  
270 sets.

271 **1 Introduction**

introduction

272 **1.1 Basic Information and Life History**

basic-information-and-life-history

273 *Population Structure and Complex Assessment Considerations*

274 There have been a number of analyses conducted on the genetic differentiation between  
275 gopher rockfish and black-and-yellow rockfish. The studies have yielded a range of results,  
276 but have generally concluded that there is unusually low genetic differentiation between the  
277 two species. The most frequently used measure of genetic analyses to evaluate evidence for  
278 population differentiation is the fixation index ( $F_{ST}$ ), defined as the proportion of the total  
279 genetic variation in one sub-population (subscript S) relative to the total genetic variation  
280 (subscript T) (Hauser and Carvalho 2008, Waples et al. 2008). Values of  $F_{ST}$  range from 0 to  
281 1 where a zero value implies the populations are panmictic and a value closer to one implies  
282 the two populations are genetically independent. Values of  $F_{ST}$  thought to be consistent with  
283 biologically meaningful genetic differentiation and demographic isolation between populations  
284 range from 0.01 to 0.05 (Waples and Gaggiotti 2006). It is also important to note that  $F_{ST}$   
285 values are dependent on the study's sample size and it may not necessarily be appropriate to  
286 compare them across studies.

287 Morphologically, gopher and black-and-yellow rockfishes are almost indistinct, except for  
288 their color variation (Hubbs and Schultz 1933). Early efforts to evaluate whether the two  
289 species were genetically distinct began with an allozyme analysis by Seeb et al. (1986), which  
290 did not detect genetic differentiation between gopher and black-and-yellow rockfish. However,  
291 as allozymes are proteins that are often conserved, this early work was not necessarily  
292 representative of genome-wide relationships between the two groups. In a subsequent study  
293 of restriction site polymorphisms, Hunter et al. (1994) found slight but significant differences  
294 between species based on restriction fragment length polymorphisms (RFLP's). Following  
295 that study, an analysis of the mitochondrial control region by Alesandrini and Bernardi (1999)  
296 did not detect differences between the two species, although mtDNA also has limitations  
297 regarding how results can be extrapolated across the nuclear genome. Analysis of seven  
298 microsatellite loci by Narum et al. (2004) found an  $F_{ST}$  of 0.049 across the overlapping range  
299 of the two species, which provided some evidence of divergence, although such divergence is  
300 relatively low compared to other species within *Sebastodes*. Those authors characterized their  
301 results as suggesting that the two are “reproductively isolated incipient species.” Buonaccorsi  
302 et al. (2011) found an even lower  $F_{ST}$  of 0.01 using 25 microsatellite loci, and concluded  
303 that gopher and black-and-yellow rockfish “have not completed the speciation process.” All  
304 of these studies are indicative of low levels of genetic divergence and a high probability of  
305 ongoing gene flow between the two nominal species.

306 Most recently, an analysis of rockfish species assignment using microhaplotypes by Baetscher  
307 (2019) observed mistaken genetic assignment of a small number of individuals between  
308 gopher and black-and-yellow rockfishes, while no other species among the 54 rockfishes

309 analyzed resulted in mis-assignments. In addition, comparisons of  $F_{ST}$  values within the  
310 study indicated that the level of genetic differentiation observed between gopher and black-  
311 and-yellow rockfishes is lower ( $F_{ST} = 0.015$ ) than that observed among all other pairwise  
312 comparisons of the 54 species in the *Sebastodes* genus that were included in their analysis.  
313 Baetscher (2019) characterized the results as suggestive of the two species representing “sister  
314 species with evidence of ongoing gene flow,” noting that a more rigorous evaluation of the level  
315 of genetic distinction between these two species would benefit from whole-genome sequencing  
316 of representatives from each species group.

317 In addition to the differences in coloration, the depth distribution and range differ between  
318 the two species. The range of both species extends from Cape Blanco Oregon to Baja  
319 California. Both species are uncommon north of Fort Bragg, California and black-and-yellow  
320 rockfish is uncommon south of Point Conception, California. However, gopher rockfish can  
321 be found as far south as Punta San Roque on the Baja peninsula. Gopher rockfish are found  
322 in rocky reef habitat from the intertidal to depths of 264 ft (80 m) with a predominant depth  
323 distribution of 30 to 120 ft (9-37 m), while the black-and-yellow rockfish occupies depths  
324 from the intertidal to 120 ft (40 m) and is predominantly observed in depths shallower than  
325 60 ft (18 m) (Eschmeyer et al. 1983, Love et al. 2002).

326 Both species are solitary, sedentary, and territorial with home ranges of 10-12 square meters  
327 (Love et al. 2002). A large percentage (67-71%) of black-and-yellow rockfish returned to the  
328 site of capture within two weeks after translocated within 50 m (Hallacher 1984). Lea et al.  
329 (1999) found that gopher rockfish exhibit minor patterns of movement (<12.8 km) with all  
330 fish being recaptured on the same reef system where they were tagged. Matthews (1985)  
331 found that 11.8% of tagged and recaptured gopher rockfish, and 25% of black-and-yellow  
332 rockfish, moved from four low-relief natural reefs to a new high-relief artificial reef in Monterey  
333 Bay. The maximum distance between the natural and artificial reefs traveled by gopher or  
334 black-and-yellow rockfish was 1.6 km. After only a year, the fish assemblage on the artificial  
335 reef closely resembled that of the nearby natural reefs. The paper did not address the spatial  
336 segregation of gopher and black-and-yellow rockfish on the new artificial reef.

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

343 Both species feed at night, with similar diets composed primarily of crabs and shrimp,  
344 supplemented by fish and cephalopods (Larson 1972, 1985, Love et al. 2002). Loury et al.  
345 (2015) found no significant differences in the diet of gopher rockfish inside and outside the  
346 year old Point Lobos Marine Protected Area (MPA). She did find the diet of gopher rockfish  
347 at Año Nuevo (shallower and north of Point Lobos) was dominated by crabs and dominated  
348 by brittle stars at southern, deeper study locations. Zuercher (2019) examined the diets of a  
349 suite of nearshore rockfish species including black-and-yellow and found that they relied on

350 hard-bodied benthic invertebrates such as Brachyuran crabs, shrimps, other arthropods, and  
351 octopus. The diet of black-and-yellow rockfish remained the same across sampling years, but  
352 they occupied a lower trophic level during the upwelling season.

## 353 1.2 Early Life History

early-life-history

354 Gopher and black-and-yellow rockfish have similar juvenile development. Both rockfish  
355 species are viviparous and release one brood per season between January and July (Echeverria  
356 1987). Larvae are approximately 4 mm in length at birth and have a 1-2 month pelagic stage  
357 before recruiting to the kelp forest canopy, i.e., surface fronds of *Macrosystis pyrifera* and  
358 *Cystoseira osmundacea* at around 15-21 mm (Anderson 1983, Wilson et al. 2008). The  
359 larvae are transparent until they reach juvenile stage at 22-23 mm. Differences in coloration  
360 between the two species begin to occur at 25-30 mm and can be used to identify one species  
361 from the other. Gopher rockfish become more orange and brown, while black-and-yellow  
362 rockfish become more black and yellow.

363 The juveniles undergo ontogenetic migration down the stalks to deeper depths, finally settling  
364 on rocky reef habitat in their respective adult depth distribution. Benthic juveniles associate  
365 with *Macrosystis* holdfasts and sporophylls (Anderson 1983). Juvenile bocaccio and other  
366 fish predate on young of year and other reef dwelling species; individuals avoid rough surge  
367 conditions and predators by hiding in the rocky bottom during the daylight hours, then  
368 returning to more open water at dusk (Love et al. 2002).

## 369 1.3 Map

map

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

## 373 1.4 Ecosystem Considerations

ecosystem-considerations-1

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

<sup>377</sup> **1.5 Fishery Information**

*fishery-information*

<sup>378</sup> The hook-and-line fishery off California developed in the late 19th century (Love et al. 2002).  
<sup>379</sup> The rockfish trawl fishery was established in the early 1940s, when the United States became  
<sup>380</sup> involved in World War II and wartime shortage of red meat created an increased demand for  
<sup>381</sup> other sources of protein (Harry and Morgan 1961, Alverson et al. 1964).

<sup>382</sup> Gopher and black-and-yellow (referred to from hereon as GBYR when discussing the complex)  
<sup>383</sup> rockfish have been a minor component of the commercial and recreational rockfish fishery  
<sup>384</sup> since at least the late 1960s (CFIS and RecFIN). The commercial catch histories of the two  
<sup>385</sup> species cannot easily be separated (Figure 2); from 1916-1936 only black-and-yellow rockfish  
<sup>386</sup> were reported in the landings, and an average of 0.04 mt of black-and-yellow rockfish are  
<sup>387</sup> reported from 1937-1983. Black-and-yellow rockfish reappear in the landings in 1984 with  
<sup>388</sup> 7.2 mt landed commercially. From 1985-1988 the trend switches and only black-and-yellow  
<sup>389</sup> rockfish appear in the commercial landings, with gopher rockfish averaging 0.1 mt landed,  
<sup>390</sup> and 0 mt reported in 1987. From 1988 and on, the landings are dominated by gopher rockfish,  
<sup>391</sup> and both species are represented in the commercial landings.

<sup>392</sup> The landings from south of Point Conception are minor throughout the time period, with  
<sup>393</sup> peaks in the 1950s and 1960s for gopher rockfish. Black-and-yellow rockfish are rare south of  
<sup>394</sup> Point Conception and it is therefore expected that these catches are minimal.

<sup>395</sup> The live fish fishery began in the early 1990s, with the first reported commercial landings  
<sup>396</sup> of live gopher rockfish in 1993, and black-and-yellow rockfish a year later. By 1995 over  
<sup>397</sup> half (57%; 39 mt) of the commercial landings were from the live fish fishery. This increased  
<sup>398</sup> quickly over the next few years and has been on average 84% of the landed gopher and  
<sup>399</sup> black-and-yellow rockfish since 2000. The majority of the landings are from gopher rockfish  
<sup>400</sup> north of Point Conception. Landings of live GBYR south of Point Conception were higher in  
<sup>401</sup> the late 1990s, (max. 3.2 mt in 1999), and have been averaging 0.4 mt since 2003.

<sup>402</sup> The ex-vessel value of GBYR increased from less than \$40,000 in 1984 and peaked at \$680,452  
<sup>403</sup> in 1996 (source: PacFIN, Figure 3). The ex-vessel revenue has been fairly stable at around  
<sup>404</sup> \$500,000 a year since 2007. Prior to the live fish fishery in 1994, the average price per pound  
<sup>405</sup> for either species was around \$2 a pound. The live fish fishery increased the value of both  
<sup>406</sup> species to an average of \$6-\$8 a pound, with maximum reported value of either a gopher or  
<sup>407</sup> black-and-yellow rockfish was \$20 a pound in 2003.

<sup>408</sup> The recreational GBYR fishery for California is most prominent north of Point Conception  
<sup>409</sup> throughout the entire catch history from 1928 to 1980 (Figure a).  
<sup>410</sup> The sharp increase in the 1980s could be an artifact of the MRFSS sampling program that  
<sup>411</sup> began in 1980; however, the more recent recreational landings also exhibit a cyclical trend of  
<sup>412</sup> years with high catches followed by period of decreased recreational landings. The California  
<sup>413</sup> Recreational Fisheries Survey (CRFS) era recreational total mortality represents the most  
<sup>414</sup> accurate description of the recreational fleet's catches in terms of area, mode and species  
<sup>415</sup> (Figure 4).

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

## 423 1.6 Summary of Management History

summary-of-management-history

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

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

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

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

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

458 Following adoption of the Nearshore FMP and accompanying regulations by the FGC in fall  
459 of 2002, the FGC adopted regulations in November 2002 which established a set of marine  
460 reserves around the Channel Islands in southern California (which became effective April  
461 2003). The FGC also adopted a nearshore restricted access program in December 2002 (which  
462 included the establishment of a Deeper Nearshore Permit) to be effective starting in the 2003  
463 fishing year.

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

472 The state of California has adopted regulatory measures to manage the fishery based on the  
473 harvest guidelines set forth by the PFMC. The commercial open access and limited entry  
474 fixed gear sectors have undergone three different spatial management changes since 2000.  
475 Since 2005, both have managed the area south of 40°10' N. latitude as one area. The open  
476 access commercial fishery is managed based on bimonthly allowable catches, that have ranged  
477 from 200 pounds to 1800 pounds per two months since 2000. From 2005 to 2018, the catch  
478 limits have doubled and are now set at 1200 pounds per two months (for all months) with  
479 March and April remaining closed. The limited entry fixed gear sector has followed the same  
480 pattern as the open access sector with bi-monthly limits and a doubling of the catch since  
481 2005. The limited entry trawl fleet is managed on monthly limits on an annual basis. Since  
482 2011, the limit has been 300 pounds per month for non-IFQ species. A history of California's  
483 commercial regulations from 2000-2018 can be found in [Appendix A](#). A 10-inch total length  
484 minimum size limit was implemented in 1999 for both species in the commercial fleet.

485 Significant regulatory changes in California's recreational sector began with a change from  
486 unlimited number of hooks and lines allowed prior to 2000 to no more than three hooks and  
487 one line per angler in 2000. Since 2001, the limit has been no more than two hooks and one  
488 line per angler. There is no size limit in the recreational fishery for gopher or black-and-yellow  
489 rockfish. A nearshore complex sub-bag limit that included GBYR was in place from 1999 to  
490 2005, but was eliminated thereafter.

491 California also began spatial management, including area closures, and depth restrictions for  
492 the recreational fleet in 2000. In general, the recreational season north of Point Conception  
493 extends from April to December, and south of Point Conception from March to December.

494 In the area that GBYR are most commonly landed, from Monterey to Morro Bay, the depth  
495 restrictions have been between 30 and 40 fathoms until 2017. In 2017 the depth restrictions  
496 were eased by 10 fathoms, opening up fishing depths along the central California coast that  
497 had not been open consistently since 2002. In both 2017 and 2018, the deepest 10 fathoms was  
498 closed prior to the season in December due to high by-catch rates of yelloweye rockfish, one  
499 of two rockfish species that are still overfished. A full history of the recreational regulations  
500 relating to the spatial management of the fleet can be found in [Appendix B](#).

## 501 1.7 Management Performance

[management-performance-1](#)

502 The contribution of GBYR to the nearshore rockfish OFLs is currently derived from two  
503 sources: 1) forecasts from Key et al. (2005), from Cape Mendocino to Point Conception,  
504 and 2) a Depletion Corrected Average Catch (DCAC (MacCall 2009)) for the area south  
505 of Point Conception. The total mortality of the nearshore rockfish south complex has been  
506 below the ACL in all years (2011-2016). Total mortality estimates from the NMFS NWFSC  
507 are not yet available for 2017-2018. GBYR total mortality was on average 20% of the total  
508 nearshore rockfish south total mortality from 2011-2016. The recent GBYR total mortality  
509 contributed approximately 9% to the nearshore rockfish south OFL, and GBYR catches have  
510 not exceeded the GBYR OFLs in recent years. GBYR is a small component of the nearshore  
511 rockfish south complex that includes twelve other species. A summary of these values as well  
512 as other post-STAR base model summary results can be found in Table [f](#).

## 513 1.8 Fisheries Off Mexico or Canada

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

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

# 521 2 Assessment

[assessment](#)

## 522 2.1 Data

[data](#)

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

525 **2.1.1 Commercial Fishery Landings**

commercial-fishery-landings

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

527 Commercial fishery landings for gopher and black-and-yellow rockfishes have not been reported  
528 consistently by species throughout the available catch history (Figure 2). The period from  
529 1916-1935 suggests that only black-and-yellow rockfish were landed in the commercial fishery,  
530 which then switched to predominately gopher rockfish from 1937-1984. From 1985-1988 the  
531 landings data suggest that only black-and-yellow rockfish were landed and not until 1995 are  
532 both species well-represented in the catches. Pearson et al. (2008) noted:

533 The fact that the majority of estimated landings are not based on actual sampling,  
534 combined with the likelihood for misidentification [between gopher and black-and-  
535 yellow rockfishes], suggests that our landing estimates are generally unreliable [see  
536 Figure 37 in Pearson et al. (2008)]. This is particularly true for the time interval  
537 between 1983 and 1988. Between 1983 and 1988, market category 962 (group  
538 gopher) landings increased sharply while market category 263 (gopher rockfish)  
539 landings declined (not visible in Figure 37 since the stratum was unsampled and  
540 the landings were converted to unspecified rockfish). Port samples indicated a shift  
541 from gopher rockfish to black-and-yellow rockfish during the same time interval,  
542 suggesting problems with identification. We suggest that if black-and-yellow  
543 landings are combined with gopher landings, the estimates would be generally  
544 reliable for the group.

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

550 The stock assessment of gopher rockfish in 2005 did not explicitly include black-and-yellow  
551 rockfish landings. A comparison of the recreational and commercial landings from the  
552 2005 assessment to those used in this assessment suggest the 2005 assessment may have  
553 included some black-and-yellow rockfish landings (Figure 6). The 2005 assessment estimated  
554 recreational landings from 1969-1980 based on a ratio of commercial to recreational landings,  
555 whereas this assessment makes use of the California Catch Reconstruction landings estimates  
556 (Ralston et al. 2010).

557 *Commercial Landings Data Sources*

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

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

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

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

586 Commercial landings from 1981-2018 were queried for a final time from the CALCOM  
587 database on 4 April 2019 and from PacFIN on 3 June 2019. There are very small differences  
588 in commercial landings between CALCOM and PacFIN from 1981-2018 ([Figure 7](#)). Landings  
589 estimates from PacFIN were used in the assessment ([Table 1](#)). Landings were stratified by  
590 year, quarter, live/dead, market category, gear group, port complex, and source of species  
591 composition data (actual port samples, borrowed samples, or assumed nominal market  
592 category). Data from individual quarters were aggregated at the year level. Fish landed live  
593 or dead were combined, due to changes over time in the reliability of condition information  
594 (Don Pearson, retired NMFS SWFSC, personal communication). From 1916-1968, on average,  
595 74% of GBYR were landed north of Point Conception, which rose to 97% from 1978-2018.  
596 Given the smaller landings south of Point Conception and the similar length composition of  
597 GBYR north and south of Point Conception, no spatial separation was considered for the  
598 commercial fleet.

599 **2.1.2 Commercial Discards**

commercial-discards

600 The West Coast Groundfish Observer Program (WCGOP) provides observer data on dis-  
601 carding across fishery sectors back to 2003. Gopher and black-and-yellow rockfishes have  
602 species-specific depth-stratified commercial fishery discard mortality rates (Pacific Fishery  
603 Management Council 2018). In consultation with WCGOP staff, the STAT used estimates of  
604 total discard mortality from WCGOP's Groundfish Expanded Mortality Multiyear (GEMM)  
605 report as the best available estimate of discards for GBYR. WCGOP observes between 1-5%  
606 of nearshore fixed gear landings annually south of 40°10' N. latitude (coverage rates available  
607 [here](#)). The expanded estimates of total discard weight by species is calculated as the ratio of  
608 the observed discard weight of the individual species divided by the observed landed weight  
609 from PacFIN landing receipts. WCGOP discard estimates for the nearshore fixed gear fishery  
610 take into account the depth distribution of landings in order to appropriately apply the  
611 depth-stratified discard mortality rates by species (Somers et al. 2018). The discard mortality  
612 for 2018 was estimated as an average of the discard mortality from 2013-2017. Discard  
613 mortality was estimated from the period prior to WCGOP discard estimates (1916-2002)  
614 based on the average discard mortality rate from 2004-2017 (2003 was excluded because 2003  
615 discard mortality was disproportionately higher than all other years) (Table 1).

616 **2.1.3 Commercial Fishery Length and Age Data**

commercial-fishery-length-and-age-data

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

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

629 A total of 46 ages were available for gopher rockfish from the commercial fisheries 2009-2011,  
630 2016, and 2018. Though sparse, the data were considered as conditional age-at-length for the  
631 commercial fleet, but not used in the final post-STAR base model.

632 The input sample sizes for commercial length composition data were calculated via the  
633 Stewart Method for fisheries (Ian Stewart, personal communication, IPHC, and developed at  
634 NWFSC):

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

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

637        The PacFIN commercial length composition and the expanded catch-weight length compo-  
638        sitions were provided by Andi Stephens (NWFSC) processed through the [PacFIN Utilities](#)  
639        package. We compared differences between the catch-weighted length composition expansions  
640        from CALCOM and PacFIN. We were unable to reconcile the difference between the two  
641        data sets. Sample sizes became more similar if the PacFIN data were restricted to the same  
642        market categories used by CALCOM in the expansion. However, both data sets apply other  
643        filters that we did not have time to explore. For instance, in the year 2000, 290 more fish were  
644        used in the CALCOM expansion than in PacFIN, but in 2002, 150 more fish were used in the  
645        PacFIN expansions that were not used in CALCOM. Given these caveats, Figure 8 shows  
646        the percent difference in the expanded length comps within a year. The biggest difference is  
647        in length bin 32 in 2006. However, the same number of fish and samples were used to expand  
648        the 2006 lengths in both databases, indicating there are also fundamental differences in how  
649        the data are treated. Full documentation is not available for the PacFIN length composition  
650        expansion program. Consequently the STAT chose to use a query that they could completely  
651        understand and selectively develop from the CALCOM database for the base model, although  
652        a sensitivity was conducted using the PacFIN-derived length composition data.

653        **2.1.4 Recreational Fishery Landings and Discards**

[recreational-fishery-landings-and-discards](#)

654        *Historical recreational landings and discards, 1928-1980*

655        Ralston et al. ([2010](#)) reconstructed estimates of recreational rockfish landings and discards  
656        in California, 1928-1980. Reported landings of total rockfish were allocated to species based  
657        on several sources of species composition data. Estimates of GBYR landings and discards  
658        (combined) from 1928-1979 are available from the SWFSC. For this assessment, historical  
659        recreational catch was stratified by year and area (north and south of Point Conception).  
660        The catches of GBYR reported in Ralston et al. ([2010](#)) are higher by an order of magnitude  
661        than expected given the more recent catches of GBYR in the MRFSS and CRFS eras south  
662        of Point Conception (Figure 9). The recreational catches estimated by Ralston et al. ([2010](#))  
663        were discussed with the paper's co-authors and also Commercial Passenger Fishing Vessel  
664        (CPFV), i.e., party/charter mode, captains in California. A consensus was reached that  
665        the estimated landings did not accurately represent the historical GBYR landings and an  
666        alternative catch stream should be developed. One possibility for the inflated catches of  
667        GBYR in southern California is that all nearshore shallow species were combined and a  
668        constant relative fraction between the two was used to assign catches to each combination of  
669        CDFW fishing block and year. The fraction of GBYR within the nearshore shallow species  
670        group was likely overestimated.

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

677 The total difference in the catch streams from Figure 9 and Figure 10 is plotted in Figure 11.  
678 The differences in the catches are due to the addition of commercial discards prior to 2004  
679 and the reduction of the recreational catches south of Point Conception.

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

681 From 1980-2003, the Marine Recreational Fisheries Statistics Survey (MRFSS) executed a  
682 dockside (angler intercept) sampling program in Washington, Oregon, and California (see  
683 Holliday et al. (1984) for a description of methods). Data from this survey are available from  
684 the Recreational Fisheries Information Network [RecFIN](#). RecFIN serves as a repository for  
685 recreational fishery data for California, Oregon, and Washington. Catch estimates for years  
686 1980-2003 were downloaded on 23 March 2019, and are consistent from 1992-2004 with the  
687 previous assessment (Key et al. 2005) (Figure 6).

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

703 Catches from north of Cape Mendocino were removed based on a CRFS-era average of  
704 fraction of recreational landings north of Cape Mendocino by mode (3.3% of shore-based,  
705 0.1% of CPFV, and 0.2% of private/rental were removed). From 1980-1989, San Luis Obispo  
706 County was sampled as part of Southern California (personal observation from MRFSS Type  
707 3 sampler examined catch where county is available for 1980-2004). This assessment separates  
708 the recreational fleet at Point Conception. Recreational landings were re-allocated from  
709 southern California from 1980-1992 by fleet based on the average proportion of recreational  
710 landings in northern California from 1996-2004 (after sampling of the CPFV fleet in northern

711 California resumed). The average proportion re-allocated from southern to northern California  
712 for the CPFV mode was 85%, 97% for the private/rental mode, and 81% for the shore-based  
713 modes. Data were pooled over all years and modes to estimate the landings re-allocation  
714 for the shore-based modes. Total recreational landings for 1981 and 1982 were 18.8 mt and  
715 18.6 mt, respectively. These landings were >60 mt lower than any of the neighboring years.  
716 Landings from 1981-1982 were interpolated from the 1980 and 1983 landings.

717 Onboard sampling of the CPFV fleet began in 1999. A sampler rides along during a CPFV  
718 trip and records the catch from a subset of anglers onboard the vessel at each fishing location.  
719 Effort data are also recorded, allowing for CPUE calculations at a fine spatial resolution.

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

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

730 *Recreational Discards*

731 Recreational discards were only added to the California Catch Reconstruction landings, as  
732 Ralston et al. (2010) did not address discards for the recreational reconstruction. Recreational  
733 removals from the California Department of Fish and Wildlife MRFSS era (1980-2003) includes  
734 catch type A + B1. Catch type A refers to estimates of catch based on sampler-examined  
735 catch. Catch type B1 includes mainly angler-reported discard, but also angler-reported  
736 retained fish that were unavailable to the sampler during the interview (e.g., fillets). The  
737 CRFS era removals account for depth-stratified discard mortality rate and the catch time  
738 series includes both retained and discarded catch (total mortality). We calculated the ratio of  
739 dead discards to total mortality from the CRFS era by region and mode. The region average  
740 across modes was applied to the California Catch Reconstruction as a constant. The result  
741 added 4.68% annually to recreational removals north of Point Conception and 4.05% annually  
742 to the removals South of Point Conception). The final time series of landings and discard  
743 mortality are in Table 3.

744 **2.1.5 Recreational Fishery Length and Age Data**

recreational-fishery-length-and-age-data

745 Recreational length composition samples for California were obtained from several sources,  
746 depending on the time period and boat mode (Table 2). This assessment makes use of a

747 much longer time series of length composition data, relative to the previous assessment, as  
748 described below. Input sample sizes for recreational length composition data were based on  
749 the number of observed trips, when available. Other proxies that were used to estimate the  
750 number of trips are described below.

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

753 *CPFV length composition data, 1959-1978*

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

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

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

772 Unsexed length data of retained fish were collected by MRFSS dockside samplers and  
773 downloaded from the RecFIN website. We identified a subset of lengths that were converted  
774 from weight measurements, and these were excluded from the final data set (Table 2). The  
775 length measurements from Collins and Crooke (n.d.) from 1975-1978 are assumed to all be  
776 from retained fish. As of 2003, the CDFW Onboard Observer program has taken length  
777 measurements for discarded fish. The retained catch is measured during the dockside (angler  
778 intercept) surveys.

779 The number of CPFV trips used as initial sample sizes for the MRFSS was based on the  
780 number of CPFV trips was determined from the trip-level MRFS CPFV database and  
781 the number of private boat trips was determined based on unique combinations of the  
782 variables ASSNID ,ID\_CODE, MODE\_FX, AREA\_X, DIST, INTSITE, HRSF, CNTRBTRS,  
783 SUB\_REG, WAVE, YEAR, and CNTY in the Type 3 (sampler-examined catch) data.

784 During the recent restructuring of the CRFS data on RecFIN, a “trip” identifier was not  
785 carried over for all modes, and trip-level sample sizes could not be extracted from the biological  
786 detail table on RecFIN. A proxy for initial sample sizes for 2004-2018 were developed using the  
787 2015 data for which I had access to raw data files by mode from CDFW. In more recent years,  
788 sampling of the shore-based modes has declined and were not sampled at all in 2018. Samples  
789 sizes were calculated by mode as the number of port-days (or site-days for shore-based modes)  
790 during bi-weekly intervals (e.g., Jan 1-15, Jan 16-31, etc). The number of port-days sampled  
791 in the bi-weekly intervals was used as the initial sample size for number of trips to calculate  
792 initial input sample sizes using Ian Stewart’s method (described above). All length data were  
793 re-weighted in the assessment model.

794 **2.1.6 Fishery-Dependent Indices of Abundance**  
*fishery-dependent-indices-of-abundance*

795 A summary of all indices in the post-STAR base model can be found in Table 5. Figure  
796 12 shows each index from the pre-STAR base model (before any were modified or removed  
797 from the model) scaled to the mean value of that index to show them all on the same scale,  
798 i.e., the mean of each index in the plot is 1. Figure 13 shows the final set of indices in the  
799 post-STAR base model, each scaled to their mean.

800 **MRFSS Dockside CPFV Index**

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

813 Initial trip filters included eliminating trips targeting species caught near the surface waters  
814 for all or part of the trip, including trips with catch of bluefin tuna, yellowfin tuna, skipjack,  
815 and albacore. Trips occurring in bays, e.g., San Francisco Bay, were also excluded.

816 The following filtering steps were applied to gopher rockfish, as well as the sum of the two  
817 species to represent GBYR. No filtering or indices were developed for black-and-yellow rockfish  
818 alone due to the sparseness in the data. In the raw data, unfiltered data, black-and-yellow  
819 rockfish only occurred in 48 trips that did not also observe gopher rockfish. There were  
820 an additional 65 trips that encountered both species. There was little difference between

821 indices developed for gopher-only and the GBYR complex for both north and south of Point  
822 Conception (Figure 14). The descriptions of the filtering and data below represent those for  
823 the GBYR complex.

824 The species composition of catch in California varies greatly with latitude. Therefore,  
825 Stephens-MacCall filtering was applied independently for north and south of Point Conception.  
826 Separate indices were also developed to represent two recreational fleets in the model. Since  
827 recreational fishing trips target a wide variety of species, standardization of the catch rates  
828 requires selecting trips that are likely to have fished in habitats containing GBYR. The  
829 Stephens-MacCall (2004) filtering approach was used to identify trips with a high probability  
830 of catching GBYR, based on the species composition of the catch in a given trip. Prior to  
831 applying the Stephens-MacCall filter, we identified potentially informative predictor species,  
832 i.e., species with sufficient sample sizes and temporal coverage (at least 30 positive trips  
833 total) to inform the binomial model. Coefficients from the Stephens-MacCall analysis (a  
834 binomial GLM) are positive for species which co-occur with GBYR, and negative for species  
835 that are not caught with GBYR. Each of these filtering steps and the resulting number of  
836 trips remaining in the sampling frame are provided in Table 18.

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

850 Two levels of possible filtering were applied using the Stephens-MacCall filter (Table 18).  
851 The Stephens-MacCall filtering method identified the probability of occurrence (in this case  
852 0.4) at which the rate of “false positives” equals “false negatives.” The trips selected using  
853 this criteria were compared to an alternative method including all the “false positive” trips,  
854 regardless of the probability of encountering GBYR (Table 21 and Figure 16). This assumes  
855 that if GBYR were caught, the anglers must have fished in appropriate habitat during the  
856 trip. The catch included in this index is “sampler-examined” and the samplers are well  
857 trained in species identification. The last filter applied was to exclude years after 1999 due to  
858 a number of regulation changes, and years in which there were less than 20 observed trips.  
859 The final index is represented by 544 trips, 220 of which encountered GBYR.

860 Due to the large number of zeros in the data, we modeled catch per angler hour (CPUE;  
861 number of fish per angler hour) using maximum likelihood and Bayesian negative binomial

regression. Models incorporating temporal (year, 2-month waves) and geographic (region and area\_x) factors were evaluated. Counties were grouped into three regions, north of Sonoma county, Sonoma county through Santa Cruz county, and San Luis Obispo county. Based on AIC values from maximum likelihood fits (Table 19), a main effects model including all factors (year, region, area\_x, and 2-month waves) was fit in the “rstanarm” R package (version 2.18.2). Diagnostic checks of the Bayesian model fit (Neff, Rhat, and Monte Carlo standard error values) were all reasonable. Predicted means by stratum (Year) were strongly correlated with observed means, suggesting a reasonable fit to the data (Figure 17). The NB model generated data sets with roughly 50-70% zeros, compared to the observed 60% (Figure 18).

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

*MRFSS Filtering and Index Standardization for South of Point Conception.*

Note, the MRFSS index for south of Point Conception was not used in the post-STAR base model.

Prior to the Stephens-MacCall filter, a total of 7,334 trips were available for the analysis. As expected, positive indicators of GBYR trips included several nearshore species, e.g., kelp rockfish, treefish, and black croaker, while the strongest counter-indicator was opaleye (Figure 19). While the filter is useful in identifying co-occurring or non-occurring species assuming all effort was exerted in pursuit of a single target, the targeting of more than one target species can result in co-occurrence of species in the catch that do not truly co-occur in terms of habitat associations informative for an index of abundance. For consistency with the methods used north of Point Conception (Table 18) the index includes the trips identified as “false positives” from the Stephens-MacCall filtering that had a lower threshold level of 0.22 (Table 22). The last filter applied was to exclude years after 1999 due to a number of regulation changes, and years in which there were less than 20 observed trips. The final index is represented by 475 trips, 342 of which encountered GBYR.

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

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

902 The resulting index for south of Point Conception represents different years than the index for  
903 north of Point Conception (Table 6). The index starts in 1980 with continuous data through  
904 1986, and three additional years in 1996, 1998 and 1999. The index increases through 1983  
905 and a marked decrease to 1986. The index for the three years in the 1990s does not exhibit  
906 any significant trend.

## 907 CPFV Onboard Observer Surveys

908 Onboard observer survey data were available from three sources for this assessment, 1) a  
909 CDFW survey in central California from 1987-1998 (referred to as the Deb Wilson-Vandenberg  
910 onboard observer survey, (Reilly et al. 1998))) the CDFW CPFV onboard observer survey  
911 from 1999-2018, and 3) a Cal Poly survey from 2003-2018. During an onboard observer  
912 trip the sampler rides along on the CPFV and records location-specific catch and discard  
913 information to the species level for a subset of anglers onboard the vessel. The subset of  
914 observed anglers is usually a maximum of 15 people the observed anglers change during each  
915 fishing stop. The catch cannot be linked to an individual, but rather to a specific fishing  
916 location. The sampler also records the starting and ending time, number of anglers observed,  
917 starting and ending depth, and measures discarded fish. The fine-scale catch and effort data  
918 allow us to better filter the data for indices to fishing stops within suitable habitat for the  
919 target species.

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

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

931 *Deb Wilson-Vandenberg Onboard Observer Index Filtering and Standardization.* A large  
932 effort was made by the SWFSC to recover data from the the original data sheets for this  
933 survey and developed into a relational database (Monk et al. 2016). The specific fishing  
934 locations at each fishing stop were recorded at a finer scale than the catch data for this survey.  
935 We aggregated the relevant location information (time and number of observed anglers) to  
936 match the available catch information. Between April 1987 and July 1992 the number of  
937 observed anglers was not recorded for each fishing stop, but the number of anglers aboard the  
938 vessel is available. We imputed the number of observed anglers using the number of anglers  
939 aboard the vessel and the number of observed anglers at each fishing stop from the August  
940 1992-December 1998 data (see Supplemental materials for details). In 1987, trips were only  
941 observed in Monterey, CA and were therefore excluded from the analysis. The years 1990

942 and 1991 were also removed for low sample sizes. Final data filters included removing reefs  
943 that never encountered GBYR, drifts that had fishing times outside 95% of the data, and  
944 fishing stops with depths <9 m and >69m. The final data set contained 2,411 fishing stops,  
945 with 1,096 of those encountering GBYR (Figure 20).

946 The index was fit using a delta-GLM model, with a lognormal model (AIC: 1,088) selected  
947 over a gamma model (AIC: 1,143) for the positive encounters. Covariates considered in the  
948 full model included year, depth, and month (Table 8). The model selected by AIC for both  
949 the lognormal and binomial components of the delta-GLM included year, depth and reef.  
950 Depth was included in 10 m depth bins and eight reefs were select in the final model. The  
951 final index did not indicate an increasing trend that was seen in the 2005 gopher rockfish  
952 assessment using the same data set (Figure 21). A number of reasons include that finer-scale  
953 location data was keypunched in 2012 for this survey, the index in this assessment includes  
954 black-and-yellow rockfish, and different filters were applied to the data. However, the the  
955 same peaks and decreases in the two indices are present.

956 *CDFW and Cal Poly Onboard Observer Index Filtering and Standardization* As described  
957 above the CDFW and Cal Poly onboard observer programs are identical in that the same  
958 protocols are followed. The only difference is that Cal Poly measures both retained and  
959 discarded fish from the observed anglers and CDFW measures only discarded fish from the  
960 observed anglers. CDFW measures retained fish as part of the angler interview at the bag and  
961 trip level. Cal Poly has also begun collecting otoliths during the onboard observer trips, which  
962 are used as conditional age-at-length data the recreational fishery north of Point Conception  
963 in this assessment.

964 A number of filters are applied to these data. All of the Cal Poly data have been through  
965 a QA/QC process once key-punched, whereas a number of errors remain in the data from  
966 CDFW. Data sheets from CDFW are no longer available prior to 2012 and staff constraints  
967 have also prevented a quality control review of the data.

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

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

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

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

983 Because GBYR are strongly associated with hard bottom habitat, the distance from a reef at  
984 the start of a drift was re-examined for drifts encountering GBYR. The maximum distance  
985 was 872 m, but the 97% quantile dropped to 42 m and was chosen as a reasonable cutoff  
986 value, and only resulted in a reduction of 182 drifts that encountered gopher rockfish. The  
987 final data were filtered to ensure all selected reefs were sampled in at least 2/3 of all years,  
988 leaving 12,965 drifts for the final index, 5,796 of which encountered GBYR (Figure 22).

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

995 *Filtering and Index Standardization for south of Point Conception*

996 Note, the CPFV onboard index for south of Point Conception was not used in the final  
997 post-STAR base model.

998 The bathymetric data is not available at as fine-scale resolution for the Southern California  
999 Bight and more of the trips and drifts target mid-water species, including mid-water rockfish  
1000 (Table 9). Therefore, instead of using distance to reef as a filter, we filtered the data to  
1001 drifts that encountered 20% or more groundfish. This resulted in the total number of drifts  
1002 decreasing from 11,635 to 5,495, but only decreased the number of drifts encountering GBYR  
1003 from 1,277 to 1,171. A final check was made to ensure all reefs were sampled in at least 2/3  
1004 of all years, leaving 5,440 drift for the final index, of which 1,132 encountered GBYR (Figure  
1005 23).

1006 The index of abundance was modeled with a delta-GLM modeling approach, with year,  
1007 month, 10 m depth bins from 10-59 m, and four reefs as possible covariates. A lognormal  
1008 model (AIC: 162) was selected over a gamma (AIC: 277) for the positive observations using  
1009 AIC. A model with year, depth and reef was selected by AIC for both the lognormal and  
1010 binomial components of the delta-GLM. The index indicates a relatively stable trend from  
1011 2001-2004 and a steady increase from 2005-2017.

1012 **2.1.7 Fishery-Dependent Indices: Available Length and Age Data**  
fishery-dependent-indices-available-length-and-age-data

1013 Length data associated with the MRFSS dockside CPFV survey and the current onboard  
1014 observer surveys conducted by CDFW are incorporated into the biological data pulled  
1015 from the respective data sources, MRFSS and CRFS. The additional length data are not

1016 incorporated as separate length composition data as they represent the same portion of the  
1017 population sampled by the CDFW onboard observer program.

1018 Cal Poly collected otoliths from the onboard observer program starting in 2017 as part of a  
1019 special study to correlate fish length before and after the fish was filleted by the deckhands  
1020 onboard the CPFV vessels. All fish collected in 2017 only had associated post-fillet lengths  
1021 and were not used in the assessment since the study has not been finalized nor has the  
1022 method been endorsed by the SSC. A subset of fish from the 2018 collection included both  
1023 pre- and post-fillet length and were used in the assessment as conditional age-at-length data  
1024 associated with the recreational fleet north of Point Conception.

1025 Length composition from Deb Wilson-Vandenberg's onboard observer survey are included  
1026 in the assessment. This program measured both retained and discarded fish, and represent  
1027 the portion of the population sampled with the spatial extent of the index. This onboard  
1028 observer program continued during the period from 1990-1992 when MRFSS was on hiatus.

1029 **2.1.8 Fishery-Independent Data Sources**

`fishery-independent-data-sources`

1030 The PISCO survey data have previously been used in one stock assessment (cabezon) and the  
1031 CCFRP data have not previously been used in stock assessments as an index of abundance.

1032 **California Collaborative Fisheries Research Project**

1033 The California Collaborative Fisheries Research Project, [CCFRP](#), is a fishery-independent  
1034 hook-and-line survey designed to monitor nearshore fish populations at a series of sampling  
1035 locations both inside and adjacent to MPAs along the central California coast (Wendt and  
1036 Starr [2009](#), Starr et al. [2015](#)). The CCFRP survey began in 2007 and was originally designed  
1037 as a statewide program in collaboration with NMFS scientists and fishermen. From 2007-2016  
1038 the CCFRP project was focused on the central California coast, and has monitored four  
1039 MPAs consistently since then (Figure [24](#)). In 2017, the program was expanded coastwide  
1040 within California. The index of abundance was developed from the four MPAs sampled  
1041 consistently (Año Nuevo and Point Lobos by Moss Landing Marine Labs; Point Buchon and  
1042 Piedras Blancas by Cal Poly).

1043 The survey design for CCFRP consists a number 500 x 500 m cells both within and outside  
1044 each MPA. On any given survey day site cells are randomly selected within a stratum (MPA  
1045 and/or reference cells). CPFVs are chartered for the survey and the fishing captain is allowed  
1046 to search within the cell for a fishing location. During a sampling event, each cell is fished for  
1047 a total of 30-45 minutes by volunteer anglers. Each fish encountered is recorded, measured,  
1048 and can be linked back to a particular angler, and released (or descended to depth). Starting  
1049 in 2017, a subset of fish have been retained to collect otoliths and fin clips that provide  
1050 needed biological information for nearshore species. For the index of abundance, CPUE was  
1051 modeled at the level of the drift, similar to the fishery-dependent onboard observer survey  
1052 described above.

1053 The CCFRP data are quality controlled at the time they are key punched and little filtering  
1054 was needed for the index. Cells not consistently sampled over time were excluded as well as  
1055 cells that never encountered GBYR. CCFRP samples shallower depths to avoid barotrauma-  
1056 induced mortality. The index was constrained to 5-39m in 5 m depth bins. The final index  
1057 included 4,920 drifts, 3,848 of which encountered GBYR.

1058 We modeled catch per angler hour (CPUE; number of fish per angler hour) using maximum  
1059 likelihood and Bayesian negative binomial regression. The proportion of zeroes in this data  
1060 was relatively small (22%), and if overdispersion were not present, the regression would  
1061 innately become Poisson. Models incorporating temporal (year, month) and geographic  
1062 (MPA site and MPA vs Reference cells) factors were evaluated. Based on AIC values from  
1063 maximum likelihood fits (Table 17), a main effects model including all factors (year, month,  
1064 site and MPA/REF) was fit in the “rstanarm” R package (version 2.18.2). Diagnostic checks  
1065 of the Bayesian model fit (Neff, Rhat, and Monte Carlo standard error values) were all  
1066 reasonable. Predicted means by stratum (Year) were strongly correlated with observed means,  
1067 suggesting a reasonable fit to the data (Figure 25). The NB model generated data sets with  
1068 roughly 18-22% zeros, compared to the observed 22% (Figure 26).

1069 The CCFRP index of abundance closely matches the trend observed in the CDFW/Cal Poly  
1070 onboard observer index from 2009-2018 (Figure 12). The index decreases from 2009 to 2013,  
1071 and then exhibits the same increase through 2018. When both indices are standardized to  
1072 their means, the values for 2013 and 2018 are the same.

### 1073 *CCFRP Length Measurements and Available Ages*

1074 The CCFRP program measures every fish encountered to the nearest half centimeter. A  
1075 total of 22,470 GBYR were measured by CCFRP from 2007-2018, of which only 212 were  
1076 black-and-yellow rockfish. The length distributions for each of the four MPAs used in the  
1077 index for this assessment show slight differences in the peak length (Figure 27). Año Nuevo  
1078 is the most northern site and Point Buchon the most southern.

1079 Conditional age-at-length data were also incorporated into the assessment from the CCFRP  
1080 program, including two master’s theses that are products of the CCFRP. Erin Loury (Loury  
1081 2011) collected gopher rockfish otoliths as part of her thesis work from 2007-2009 that included  
1082 specimens from both inside and outside the MPAs. Natasha Meyers-Cherry (Meyers-Cherry  
1083 2014) conducted another thesis focused on the life history of gopher rockfish and collected  
1084 otoliths from 2011-2012, also both inside and outside the MPAs. Both MLML and Cal  
1085 Poly began routinely collecting otoliths from a select number of fish in 2017 as part of the  
1086 CCFRP program. Also included in the conditional age-at-length data for this fleet are otoliths  
1087 collected in 2018 by the University of California Davis Bodega Marine Lab CCFRP program.

### 1088 **Partnership for Interdisciplinary Studies of Coastal Oceans**

1089 The Partnership for Interdisciplinary Studies of Coastal Oceans, [PISCO-UCSC](#), conducts  
1090 a number of surveys to monitor the kelp forests, one of which is a kelp forest fish survey.

1091 PISCO has monitored fish population in the 0-20 m depth range as part of the Marine Life  
1092 Protection Act (MLPA) since 1998. Paired sites inside and outside MPAs are surveyed to  
1093 monitor the long-term dynamics of the kelp forest ecosystem and provide insight into the  
1094 effect of MPAs on kelp forest species. PISCO conducts the fish surveys from late July through  
1095 September. At each site, benthic, midwater, and canopy scuba transects are conducted at  
1096 5, 10, 15, and 20 m depth. All divers are trained in species identification. Along each 30  
1097 m transect, divers enumerate all identifiable non-cryptic fish, and measure total length to  
1098 the nearest centimeter. PISCO surveys are conducted by the University of California Santa  
1099 Cruz (UCSC) in central California and through the University of California Santa Barbara  
1100 in southern California. All PISCO data were provided by Dan Malone (UCSC).

1101 The majority of filtering for the PISCO data set was to determine which sites to retain for  
1102 the final index. After initial filtering the data for GBYR in southern California were too  
1103 sparse to be considered for the index of abundance. Gopher and black-and-yellow rockfish  
1104 were also rarely observed in the midwater and canopy transects, and therefore the index is  
1105 based only on the benthic transects. Only sites sampled consistently throughout the time  
1106 period 2001-2018 were kept for the index. Multiple transects can be conducted along the  
1107 same line within a sampling event. All transects within a site were combined and effort was  
1108 modeled as the number of transects represented in the number of fish observed. The final  
1109 index included 3,231 transects, of which 1,729 observed GBYR (Figure 28).

1110 Three indices are described below. The pre-STAR base model includes a single index of  
1111 abundance for the PISCO survey. During the STAR panel the decision was made to include  
1112 two separate indices of abundance and selectivities for the PISCO data. The PISCO data  
1113 include information on age-0 recruitment and also older fish. The PISCO age-0 recruitment  
1114 index includes fish that are 6 cm or smaller, and the PISCO index for larger fish includes fish  
1115 15 cm and larger. There is uncertainty in the age of fish in the 7-14 cm range due to the  
1116 timing of sampling, growth, and the timing of ages, i.e., all fish turn one on Jan 1 in the SS  
1117 assessment model. Additionally, fish in the 7-14 cm are also not well sampled by the survey.

1118 For all three iterations of the index we modeled number of fish observed per transect(s) using  
1119 maximum likelihood and Bayesian regression. The index containing all data and the index  
1120 for larger fish (15+ cm) only were modeled as negative binomial, whereas the data for the  
1121 age-0 (for which the 4-6 cm fish serve as a proxy) index were sparse and modeled as binomial.  
1122 Models incorporating temporal (year, month) and geographic (site and zone) factors were  
1123 evaluated. The zone is a factor indicating the depth stratification at a site, i.e., 5 m, 10 m,  
1124 15 m, or 20 m targeted bottom depth.

1125 *Index based on all of the PISCO data (used in the pre-STAR base model).*

1126 Based on AIC values from maximum likelihood fits (Table 13), a main effects model including  
1127 all factors (year, month, site and zone) was fit in the “rstanarm” R package (version 2.18.2).  
1128 Diagnostic checks of the Bayesian model fit (Neff, Rhat, and Monte Carlo standard error  
1129 values) were all reasonable. Predicted means by stratum (Year) were strongly correlated  
1130 with observed means, suggesting a reasonable fit to the data (Figure 29). The NB model  
1131 generated data sets with roughly 16-25% zeros, compared to the observed 23% (Figure 30).

1132 The final index decreases from 2001 to the late 2000s, with lower estimates of relative  
1133 abundance from 2005-2010. From 2010 to 2015, the index increases and peaks in 2015, before  
1134 the decreasing trends from 2016-2018. The trend observed in this index is counter to that  
1135 observed in the onboard observer and CCFRP indices for north of Point Conception (Figure  
1136 12). The PISCO survey is sampling different habitat types than the other two surveys, and  
1137 covers much shallower depths. It's possible that the PISCO index captures recruitment pulses,  
1138 but because this index includes both young-of-the-year and adult fish, the trend may be  
1139 captured in the model.

1140 *PISCO index based on fish 15 cm and larger (used in the post-STAR base model).*  
1141 The same filtered dataset was used for the index for fish 15 cm and larger as for the PISCO  
1142 index that included all fish. Based on AIC values from maximum likelihood fits (Table 14), a  
1143 main effects model including all factors (year, month, site and zone) was fit in the “rstanarm”  
1144 R package (version 2.18.2). Diagnostic checks of the Bayesian model fit (Neff, Rhat, and  
1145 Monte Carlo standard error values) were all reasonable. Predicted means by stratum (Year)  
1146 were strongly correlated with observed means, suggesting a reasonable fit to the data (Figure  
1147 31). The NB model generated data sets with roughly 20-30% zeros, compared to the observed  
1148 25% (Figure 32).

1149 *PISCO recruitment index based on fish 6 cm and smaller (used in the post-STAR base model).*  
1150 The same filtered dataset was used for the index for fish 15 cm and larger as for the PISCO  
1151 index that included all fish. There was no consistent pattern in the presence of age-0 fish to  
1152 exclude any sites or zones. All years were included in the final index, even if sample sizes were  
1153 small. Age-0 fish were present in 14% of all transects. A negative binomial model was not  
1154 well fit to the data so a binomial (presence/absence) model was selected for the recruitment  
1155 index. Based on AIC values for maximum likelihood fits (Table 15), a main effects model  
1156 including year, month, and zone was fit in the “rstanarm” R package (version 2.18.2). The  
1157 resulting index has large standard errors for years with sparse data, including 2004-2008  
1158 and 2012-2013. A recruitment signal is present in the index in a number of years, including  
1159 2001-2003, 2010, and 2014-2017.

#### 1160 *PISCO Length Measurements*

1161 All but one GBYR observed by PISCO divers was measured ( $N = 11,965$ ). Divers measure  
1162 fish to the nearest centimeter, and are trained to measure fish underwater and be aware of  
1163 possible biases, e.g., ambient light, body color, visibility, and body shape. Both juvenile and  
1164 adult GBYR were observed in the PISCO kelp forest fish survey data (Figure 33). Of note  
1165 is the similarity in length distributions both between the species and for the two species  
1166 combined across sites. Fish in the 10-17 cm size range (approximately) are rarely observed in  
1167 this survey. There is significant post-settlement mortality for both species, which is thought  
1168 to be due to density-dependent predation (Johnson 2006, 2007). Secondly, both species can  
1169 be cryptic and observed at higher frequency by divers at night than during the day (Mark  
1170 Carr, PISCO-UCSC, personal communication).

1171 **2.1.9 Biological Parameters and Data**

biological-parameters-and-data

1172 Neither gopher nor black-and-yellow rockfish have forked tails, therefore total length and  
1173 fork length are equal. All of the data provided for this assessment were either in fork length  
1174 or total length.

1175 **Length and Age Compositions**

1176 Length compositions were provided from the following sources:

- 1177 • CALCOM (*commercial retained dead fish*, 1987, 1992-2018)
- 1178 • WCGOP (*commercial discarded fish*, 2004-2018)
- 1179 • Deb Wilson-Vandenberg's onboard observer survey (*recreational charter retained and*  
1180 *discarded catch*, 1987-1998)
- 1181 • California recreational sources combined (*recreational charter retained catch*)
  - 1182 – Miller and Gotshall dockside survey (1959-1966)
  - 1183 – Ally et al. onboard observer survey (1985-1987)
  - 1184 – Collins and Crooke onboard observer survey (1975-1978)
  - 1185 – MRFSS dockside survey (1980-2003)
  - 1186 – CRFS onboard and dockside survey (2004-2018)
- 1187 • PISCO dive survey (*research*, 2001-2018)
- 1188 • CCFRP hook-and-line survey (*research*, 2007-2018)

1189 The length composition of all fisheries aggregated across time by fleet is in Figure 34 and  
1190 Table 4. Descriptions and details of the length composition data are in the above section for  
1191 each fleet or survey.

1192 **Age Structures**

1193 A total of 2,421 otoliths were incorporated in this assessment and a summary by source can  
1194 be found in Table 23. The final base model excludes the commercial age data that were  
1195 sparse and not representative of the fishery. Gopher rockfish comprised 79% of the samples  
1196 (922 females, 879 males, 121 unknown sex), and all but a few black-and-yellow rockfish (247  
1197 females, 232 males, 20 unknown sex) came from a directed study by Jody Zaitlin (1986),  
1198 collected from 1983-1986 (Figure 35).

1199 Of the available ages, 94% were collected during fishery-independent surveys. The remaining  
1200 6% were recreational dockside surveys and collected by Cal Poly during their CPFV onboard  
1201 observer survey (36 otoliths) in 2018.

1202 All otoliths were read by Don Pearson (NMFS SWFSC, now retired) and estimated ages  
1203 ranged from 1-28. The aged black-and-yellow rockfish ranged in length from 7-32 cm with a  
1204 mean of 24 cm and gopher rockfish ranged in length from 11-36 cm, with a mean of 26. In  
1205 terms of ages, the black-and-yellow rockfish ranged from 2-19 and gophers from 2-28. Fits

1206 to the von Bertalanffy growth curve (Bertalanffy 1938),  $L_i = L_\infty e^{(-k[t-t_0])}$ , where  $L_i$  is the  
1207 length (cm) at age  $i$ ,  $t$  is age in years,  $k$  is rate of increase in growth,  $t_0$  is the intercept, and  
1208  $L_\infty$  is the asymptotic length, were explore by species and sex.

1209 No significant differences were found in growth between gopher and black-and-yellow rockfishes  
1210 (Figure 36) or between males and females (Figure 37), species combined.

## 1211 Aging Precision and Bias

1212 Uncertainty in ageing error was estimated using a collection of 376 gopher and black-and-  
1213 yellow rockfish otoliths with two age reads (Figure 38). Age-composition data used in the  
1214 model were from a number of sources described above. All otoliths were read by Don Pearson  
1215 (NMFS SWFSC, now retired) who also conducted all blind double reads.

1216 Ageing error was estimated using publicly available software (Thorson et al. 2012). The  
1217 software setting for bias was set to unbiased since the same reader conducted the first and  
1218 second readings. The best fit model chose by AIC for the standard deviation was a constant  
1219 coefficient of variation for reader one ad mirrored for reader two (Figure 39).

1220 The resulting estimate indicated a standard deviation in age readings increasing from 0.74  
1221 years at age 0 to a standard deviation of 2.07 years at age 28, the first year of the plus group  
1222 in the assessment model.

## 1223 Weight-Length

1224 The weight-length relationship is based on the standard power function:  $W = \alpha(L^\beta)$  where  
1225  $W$  is individual weight (kg),  $L$  is length (cm), and  $\alpha$  and  $\beta$  are coefficients used as constants.

1226 The weight-length relationships was estimated from the three studies, Loury (2011), Meyers-  
1227 Cherry (2014) (both gopher rockfish only from CCFRP) and Zaitlin (Zaitlin 1986) (black-  
1228 and-yellow rockfish only). Only one weight-length relationship was estimated for the GBYR  
1229 complex. The estimated parameters are  $\alpha = 8.84e^{-006}$  and  $\beta = 3.25584$ . The estimated  
1230 relationship is similar to that estimated by Lea et al. (1999) for gopher rockfish (Figure  
1231 40). The weight-length relationship estimated here was used in the assessment model to best  
1232 represent the GBYR complex.

## 1233 Sex Ratio, Maturity, and Fecundity

1234 The sex ratio for GBYR is assumed to be 50:50 as there is no evidence to suggest otherwise.

1235 Zaitlin (1986) found that females reached 50% maturity at 17.5 cm or 4 years of age in Central  
1236 California and were 100% mature by age 6, with the same age of maturity found in southern

1237 California though individuals were smaller at age. Echeverria (1987) estimated maturity for  
1238 17 rockfish species in central California. She found the size at first maturity and the size  
1239 at 50% maturity for male and female gopher rockfish to be 17 cm total length, and 100%  
1240 mature by 21 cm. Black-and-yellow rockfish males and females were first mature at 14 cm,  
1241 50% of females were mature at 15 cm, 50% of males mature at 16 cm. Male black-and-yellow  
1242 rockfish were 100% mature at 20 cm and females at 19 cm. In southern California waters,  
1243 both males and females were found to reach first maturity at 13 cm total length (Larson  
1244 1980). We did not have any samples from southern California to re-analyze the maturity  
1245 ogive for that portion of the population. Both Zaitlin and Echeverria estimated the maturity  
1246 ogives using ages from whole otoliths. A sample of 151 black-and-yellow rockfish otoliths  
1247 surface read by Zaitlin were also read by Don Pearson, and Zaitlin's ages were consistently  
1248 younger than Pearson's, by up to nine years. All of the available otoliths for this assessment  
1249 were re-aged using a combination of surface reading and break-and-burn methodology.

1250 The maturity data from Zaitlin (1986) (422 black-and-yellow rockfish) were re-analyzed along  
1251 with samples from Meyers-Cherry (2014) (115 gopher rockfish). Combining the two data sets  
1252 provided an updated maturity ogive for the GBYR complex females (Figure 41). The first  
1253 observed mature fish was 19 cm and the length at 50% was 21.66 cm, larger than suggested  
1254 from the estimate used by Key et al. (2005) in the 2005 assessment. After re-analyzing the  
1255 available data, the length at which 50% of female gopher rockfish were mature was estimated  
1256 at 23.33 cm, and was 21.26 cm for female black-and-yellow rockfish. An important note is  
1257 that the smaller fish from these studies were black-and-yellow rockfish and the larger fish  
1258 were gopher rockfish. Although not used in this assessment, the estimate of 50% maturity  
1259 for 23 GBYR from these studies was 21.88 cm. The age at 50% mature increased in this  
1260 assessment to 21.66 cm, which is 3.96 cm larger than the value used in the 2005 assessment.

1261 Mature females in central California release larvae between January and July, peaking in  
1262 February, March, and May (Larson 1980, Lea et al. 1999, Love et al. 2002). Both species of  
1263 GBYR release one brood per season (Love et al. 2002). Black-and-yellow rockfish females  
1264 can produce 25,000 - 450,000 eggs spawning from January to May. Gopher rockfish females  
1265 ranging between 176 and 307 grams carry approximately 249 eggs per gram of body weight  
1266 (MacGregor 1970). The fecundity estimates used in this assessment were provided by E.J.  
1267 Dick (NMFS SWFSC) from a meta-analysis of fecundity in the genus *Sebastes* (Dick et al.  
1268 2017).

## 1269 Natural Mortality

1270 Hamel (2015) developed a method for combining meta-analytic approaches to relating the  
1271 natural mortality rate  $M$  to other life-history parameters such as longevity, size, growth  
1272 rate and reproductive effort, to provide a prior on  $M$ . In that same issue of ICESJMS,  
1273 Then et al. (2015), provided an updated data set of estimates of  $M$  and related life history  
1274 parameters across a large number of fish species, from which to develop an  $M$  estimator  
1275 for fish species in general. They concluded by recommending  $M$  estimates be based on  
1276 maximum age alone, based on an updated Hoenig non-linear least squares (nls) estimator

1277  $M = 4.899 * A_{max}^{-0.916}$ . The approach of basing  $M$  priors on maximum age alone was one that  
1278 was already being used for west coast rockfish assessments. However, in fitting the alternative  
1279 model forms relating  $-0.916M$  to  $A_{max}$ , Then et al. (2015) did not consistently apply their  
1280 transformation. In particular, in real space, one would expect substantial heteroscedasticity  
1281 in both the observation and process error associated with the observed relationship of  $M$  to  
1282  $A_{max}$ . Therefore, it would be reasonable to fit all models under a log transformation. This  
1283 was not done. Reevaluating the data used in Then et al. (2015) by fitting the one-parameter  
1284  $A_{max}$  model under a log-log transformation (such that the slope is forced to be -1 in the  
1285 transformed space (as in Hamel (2015)), the point estimate for  $M$  is:

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

1286 The above is also the median of the prior. The prior is defined as a lognormal with mean  $\ln \frac{5.4}{A_{max}}$   
1287 and SE = 0.4384343 (Owen Hamel, personal communication, NMFS). Using a maximum age  
1288 of 28 the point estimate and median of the prior is 0.193, which is used as a prior for in the  
1289 assessment model and as a fixed quantity in the post-STAR base model.

### 1290 2.1.10 Environmental or Ecosystem Data Included in the Assessment [environmental-or-ecosystem-data-included-in-the-assessment](#)

1291 In this assessment, neither environmental nor ecosystem considerations were explicitly included  
1292 in the analysis. This is primarily due to a lack of relevant data and results of analyses  
1293 (conducted elsewhere) that could contribute ecosystem-related quantitative information for  
1294 the assessment.

## 1295 2.2 Previous Assessments

[previous-assessments](#)

### 1296 2.2.1 History of Modeling Approaches Used for this Stock [history-of-modeling-approaches-used-for-this-stock](#)

1297 This is the first full assessment to include data for black-and-yellow rockfish. Black-and-yellow  
1298 rockfish was assessed coastwide as a data poor species using Depletion-Based Stock Reduction  
1299 Analysis (DB-SRA) (Dick and MacCall 2010). The DB-SRA model assigned a 40% probability  
1300 that the then recent (2008-2009) catch exceeded the 2010 OFL.

1301 Gopher rockfish south of Point Conception was assessed as a data poor species in 2010 (Dick  
1302 and MacCall 2010). A Depletion-Corrected Average Catch (DCAC) model was used due to  
1303 time constraints. The mean yield from the DCAC distribution was 25.5 mt.

1304 Gopher rockfish north of Point Conception ( $34^{\circ}27'$  N. latitude) was first assessed as a full stock  
1305 assessment in 2005 (Key et al. 2005) using SS2 (version 1.19). The assessment was sensitive  
1306 to the CPFV onboard observer index of abundance (referred to as Deb Wilson-Vandenbergs  
1307 onboard observer index in this assessment). The final decision table was based around the  
1308 emphasis given to this index. The stock was found to be at 97% depletion in 2005.

## 1309 2.2.2 2005 Assessment Recommendations

assessment-recommendations

1310 The 2005 gopher rockfish STAR panel only had one recommendation specific to gopher  
1311 rockfish. However, they had a number of generic rockfish recommendations that can be found  
1312 in the STAR panel report available [here](#).

1313 **Recommendation 1: Additional length and age composition data should be**  
1314 **collected for gopher rockfish. This would help to characterize spatial and**  
1315 **possibly temporal variation in growth**

1316

1317 2019 STAT response: Additional age and length data have been collected from a number  
1318 of sources, the majority of which have been fishery-independent studies, including two  
1319 master's theses focused on gopher rockfish. Only a handful of otoliths have been  
1320 collected for gopher rockfish south of Point Conception. Additional length composition  
1321 data are available since the last assessment.

## 1322 2.3 Model Description

model-description

1323 The model descriptions in the following sections reflect decisions and modelling choices the  
1324 STAT team made prior to the STAR panel. Changes from the pre-STAR base model to the  
1325 final post-STAR base model are documented in the "Responses to the Current STAR Panel  
1326 Requests" section. During the STAR panel, the following structure change were made; 1) the  
1327 commercial retained and commercial discard fleets were combined into one commercial fleet,  
1328 2) the MRFSS recreational dockside and the CRFS recreational onboard indices south Point  
1329 Conception were removed, 3) the PISCO index was split into two indices, one representing  
1330 fish 15 cm and larger and an age-0 index representing fish 6 cm or less. All of the figures and  
1331 tables reflect the post-STAR final base model. The section on the PISCO index of abundance  
1332 has been updated to reflect the change in the indices.

1333 While investigating convergence issues in the cowcod assessment, Richard Methot (NMFS)  
1334 identified an issue with the performance of the 'sfabs' function in ADMB. This led to poor  
1335 convergence during the iterative search for  $F_{SPR}$  under certain conditions. Dr. Methot  
1336 resolved the issue, and provided a new 'safe' version of SS (V3.30.13.09) to the cowcod and  
1337 GBYR STATs on June 28, followed by an optimized executable on June 30. Apart from the  
1338 iterative  $F_{SPR}$  search mentioned above, other model outputs and analyses were unaffected by  
1339 the change. All of the base model results were run in this newest version of SS.

1340 **2.3.1 Transition to the Current Stock Assessment**  
transition-to-the-current-stock-assessment

1341 The first formal stock assessment for gopher rockfish was conducted in 2005 (Key et al.  
1342 2005). There are two major differences between the 2005 assessment this assessment, 1) this  
1343 assessment models gopher and black-and-yellow rockfish as a complex, and 2) this assessment  
1344 includes the area south of Point Conception.

1345 The 2005 model conducted in SS2 version 1.19 was first transitioned to SS3.24z as a bridge  
1346 model, before moving forward to SS3.30. Below, we describe the most important changes  
1347 made since the last full assessment in 2005 and explain rationale for each change. Some of  
1348 these items are changes due to structure changes with Stock Synthesis, and some denote  
1349 parameters chosen for options that were not available in SS2 (version 1.19).

1350 Changes in the bridge model from SS2 version 1.9 to SS3.24z and SS3.30.13.09 include:

1351 The way growth is modeled for age-0 fish has changed. More recent versions of Stock Synthesis  
1352 model length-at-age for fish below the first reference age ( $A_{min}$ ) as linearly increasing from the  
1353 initial length bin to the length given by the  $L_{at}A_{min}$  parameter. The minimum population  
1354 length bin was reduced from 10 cm in the 2005 assessment to 4 cm in this assessment. The  
1355 timing of settlement was set at July to reflect the month at which the young-of-the-year  
1356 are expected to be at 4 cm (Figure 42). The length data leading to this decision were  
1357 provided by Diana Baetscher (UCSC) and were collected via Standard Monitoring Unit for  
1358 the Recruitment of Fishes (SMURFs) (Ammann 2004) from the UCSC-PISCO kelp forest  
1359 fish survey as part of her dissertation work on rockfish genetics (Baetscher 2019).

1360 This stock assessment retains a single fleet for the commercial fishery, and also includes  
1361 a commercial discard fleet. Data on commercial discards were not available for and not  
1362 included in the 2005 assessment. The decision to retain one commercial fleet was made by  
1363 examining the length distributions across species, fishing gears, and space, i.e., north and  
1364 south of Point Conception (Figure 43). There is very little difference between the length  
1365 composition of gopher and black-and-yellow rockfish landed in the commercial fleet north of  
1366 Point Conception, which contributed 97% of the commercial landings from 1978-2018. The  
1367 length distributions suggest that gopher rockfish south of Point Conception landed dead  
1368 south of Point Conception are slightly smaller on average than north of Point Conception.  
1369 However, there is not enough data available to justify splitting the commercial fishery north  
1370 and south of Point Conception. The length compositions of discarded fish are small in all  
1371 of the subplots, suggesting size-based discarding. Because Stock Synthesis is not set up to  
1372 handle depth-dependent discard mortality rates and this assessment represents a species  
1373 complex with differing depth-dependent discard mortality rates for each species, the time  
1374 series of commercial discards was incorporated as a fleet.

1375 This assessment incorporates the area south of Point Conception, which was previously  
1376 excluded from the 2005 assessment. The length composition data suggested that while the  
1377 lengths of gopher and black-and-yellow rockfish were similar, fish encountered south of Point  
1378 Conception were smaller (Figure 44). The recreational catches from the man-made/jetty

mode are negligible and did not influence the decision to split the fleet at Point Conception. From 2005-2018, the man-made/jetty mode averaged 0.5% of the total recreational catch and discards north of Point Conception and 0.03% south of Point Conception. The similarity of the length distributions between species and among modes within a region were similar and justified one recreational fleet.

The 2005 model was a length-based model. This assessment uses conditional age-at-length from fish aged from a number of sources (Table 23).

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

The bias adjustment for recruitment deviations did not exist in SS2 (version 1.19). We set 1973-2015 as the range of years with full bias adjustment to span the time series that was modeled.

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

The 2005 assessment did not include any time blocks. This assessment includes two time blocks for the commercial fleet (1916-1998 and 1999-2018). A 10-inch minimum size limit was placed on the commercial fleet in 1999, which was reflected in the CALCOM length composition data. No additional time blocks were added for the recreational fleet. GBYR are a minor component of the nearshore rockfish complex and no significant changes were detected in the landings or length composition during the time when regulations changed (1999-2002).

The 2005 assessment considered two candidate fishery-dependent indices of abundance, the Deb Wilson-Vandenbergh onboard observer CPFV survey and a dockside intercept survey from MRFSS and RecFIN from 1983-2003. However, the dockside index was removed at the request of the STAR panel, citing “did not provide a reliable measure of relative abundance due to changes in regulations and fishery targeting during the 1990s-2000s.” The current assessment uses a version of the MRFSS database that has been more robustly aggregated to the trip level. Starting in 1999, the CDFW began angler interviews. Interviews are conducted for all the anglers on the boat, whereas the onboard data is only collected for a subset of anglers that changes with each fishing stop. Once the onboard observer program ramped up by the mid-2000s, almost all of the CPFV groundfish trips sampled as onboard observer trips were also sampled as angler interviews. Using both the onboard observer data and the dockside interviews for this time period would result in developing indices from the same fish. The fine-scale onboard observer data provides greater detail in terms of catch and location

<sup>1418</sup> than the angler interviews. The onboard observer indices do not include the years 1999 and  
<sup>1419</sup> 2000 due to the number of regulation changes occurring in those two years.

<sup>1420</sup> The fishery-independent indices are all new for this assessment; the PISCO kelp forest fish  
<sup>1421</sup> survey and the CCFRP hook-and-line survey.

<sup>1422</sup> Maturity was changed for this assessment based upon newly available data described in the  
<sup>1423</sup> biological specifications of this assessment.

<sup>1424</sup> The 2005 assessment pre-STAR base model fixed steepness for gopher rockfish at 1.0, which  
<sup>1425</sup> was then changed to 0.65 (the Dorn prior at the time) during the STAR panel. In this  
<sup>1426</sup> assessment, steepness was set at 0.72, the mean of the prior developed from a meta-analysis of  
<sup>1427</sup> West Coast groundfish, with a standard deviation of 0.16 (see Accepted Practices Guidelines  
<sup>1428</sup> for Groundfish Stock Assessments in the supplemental material).

<sup>1429</sup> The prior for female natural mortality was updated to the median of the prior from a  
<sup>1430</sup> meta-analysis conducted by Owen Hamel (see Accepted Practices Guidelines for Groundfish  
<sup>1431</sup> Stock Assessments in the supplemental material). Assuming a maximum age of 28 years, the  
<sup>1432</sup> median of the prior is 0.193, close to the fixed value used in the 2005 assessment of 0.2.

<sup>1433</sup> Due to the fact that the 2005 model only included gopher rockfish and excluded the area  
<sup>1434</sup> south of Point Conception, a complete bridge model was not developed. Comparison of  
<sup>1435</sup> the 2005 input data, catch streams, and indices are provided throughout the document in  
<sup>1436</sup> appropriate sections.

### <sup>1437</sup> 2.3.2 Summary of Data for Fleets and Areas

[summary-of-data-for-fleets-and-areas](#)

<sup>1438</sup> There are 10 fleets in the post-STAR base model. They include:

<sup>1439</sup> *Commercial*: There is one commercial fleet the includes GBYR landed (all gears combined)  
<sup>1440</sup> and dead discards.

<sup>1441</sup> *Recreational*: The recreational fishery include two fleets, one for north of Point Conception  
<sup>1442</sup> and one for south of Point Conception (all modes combined) and includes dead discards.

<sup>1443</sup> *Fishery-Dependent Surveys*: There are five fishery-dependent survey fleets, all north of Point  
<sup>1444</sup> Conception. There is one for MRFRSS CPFV dockside survey, one for the CDFW/Cal Poly  
<sup>1445</sup> onboard observer survey, and one from the Deb Wilson-Vandenberg CPFV onboard observer  
<sup>1446</sup> survey.

<sup>1447</sup> *Research*: There are two main sources of fishery-independent data available the CCFRP  
<sup>1448</sup> survey and the PISCO kelp forest fish survey. The PISCO survey was split into two indices  
<sup>1449</sup> in the post-STAR base, one representing age-0 recruitment and one for fish 15+ cm. A third

1450 survey fleet is included as a “dummy” fleet to allow incorporation of additional conditional  
1451 age-at-length composition data from the Zaitlin and Abrams theses, the Pearson groundfish  
1452 cruise, and the special study conducted during the SWFSC’s juvenile rockfish and ecosystem  
1453 cruise. This dummy fleet includes 1,067 ages of gopher and black-and-yellow rockfish. This  
1454 dummy fleet does not have any length composition data or catches associated with it.

### 1455 2.3.3 Other Specifications

other-specifications

1456 Stock Synthesis has a broad suite of structural options available. Where possible, the ‘default’  
1457 or most commonly used approaches are applied to this stock assessment. The assessment  
1458 is a one-sex model, as no significant differences in growth between males and females was  
1459 detected in external analyses.

1460 The length composition data for some years and fleets was small, and may not be representative  
1461 of the total catch. Length composition data were removed from the model if fewer than 20  
1462 fish were measured in a given year and fleet. From 1985-1989, two surveys measured fish from  
1463 the recreational party/charter fleet, the Ally et al. (Ally et al. 1991) onboard observer survey  
1464 and the dockside intercept survey. The number of trips and fish sampled by the onboard  
1465 observer survey was far greater than the MRFSS survey and were used in the model. Initial  
1466 input sample sizes were also capped at 400 for each set of length composition data.

1467 The time-series of landings begins in 1916 for the commercial fleet and in 1928 for the  
1468 recreational fleet. This captures the inception of the fishery, so the stock is assumed to be in  
1469 equilibrium at the beginning of the modeled period.

1470 The internal population dynamics model tracks ages 0-28, where age 28 is the ‘plus-group.’  
1471 There are relatively few observations in the age compositions that are greater than age 28.  
1472 The population length bins and the length composition length bins are set at 1-cm bins from  
1473 fish 4-40 cm.

1474 The extra standard deviation parameter was added to all indices except the MRFSS dockside  
1475 index for north of Point Conception and the PISCO age-0 index since both had relatively  
1476 large estimated variances associated with them. The extra parameter was explored, but  
1477 estimated to be on the lower bound, and was removed for the post-STAR base model. All  
1478 other indices, including the recreational onboard observer index, CCFRP, and PISCO (15+  
1479 cm fish), were estimated with relatively small variances (10-20%) from their respective indices.  
1480 Extra variance was estimated for these indices in the post-STAR base model.

1481 The following likelihood components are included in this model: catch, indices, discards,  
1482 length compositions, age compositions, recruitment, parameter priors, and parameter soft  
1483 bounds. See the SS technical documentation for details (Methot et al. 2019).

1484 Electronic SS model files including the data, control, starter, and forecast files can be found  
1485 on the [PFMC’s website](#).

1486 **2.3.4 Modeling Software**

modeling-software

1487 The STAT team used Stock Synthesis 3 version 3.30.13.09 (published on 6/28/2019) by  
1488 Dr. Richard Methot at the NWFSC. This most recent version was used, since it included  
1489 improvements and corrections to older versions. The r4SS package (GitHub release number  
1490 v1.35.1) was used to post-process output data from Stock Synthesis.

1491 **2.3.5 Data Weighting**

data-weighting

1492 Length composition and conditional-age-at-length (CAAL) compositions sample sizes for the  
1493 base model were tuned by the “Francis method,” based on equation TA1.8 in Francis (2011),  
1494 and implemented in the r4ss package. This approach involves comparing the residuals in  
1495 the model’s expected mean length with respect to the observed mean length and associated  
1496 uncertainty derived from the composition vectors and their associated input sample sizes.  
1497 The sample sizes are then tuned so that the observed and expected variability are consistent.  
1498 After adjustment to the sample sizes, models were not re-tuned if the bootstrap uncertainty  
1499 value around the tuning factor overlapped 1.0.

1500 As outlined in the Best Practices, a sensitivity run was conducted with length and conditional-  
1501 age-at-length (CAAL) compositions were re-weighted using the Ianelli-McAllister harmonic  
1502 mean method (McAllister and Ianelli 1997). Additionally, weighting using the Dirichlet-  
1503 Multinomial likelihood, that includes an estimable parameter (theta) that scales the in-  
1504 put sample size, was explored. However, the model did not converge when the Dirichlet-  
1505 Multinomial likelihood was applied to a number of the fleets with composition data. Given  
1506 this, and the current challenges with this method described in the Stock Synthesis manual  
1507 (Methot et al. 2019), the Francis weightings were applied in the pre-STAR and post-STAR  
1508 base models. The final post-STAR base model was re-weighted twice at which point the  
1509 Francis weights stabilized.

1510 A series of sensitivities were conducted to determine the need to estimate extra variability  
1511 parameters were estimated and added to the survey CPUE indices, and described below in  
1512 the Estimated Parameters section.

1513 **2.3.6 Priors**

priors

1514 The log-normal prior for female natural mortality were based on a meta-analysis completed  
1515 by Hamel (2015), as described under “Natural Mortality.” Natural mortality was estimated  
1516 using with a prior of, 0.193 (with log-space sigma of 0.438) for an assumed maximum age of  
1517 28. Natural mortality was fixed at the value of the prior in the post-STAR base model.

1518 The prior for steepness ( $h$ ) assumes a beta distribution with parameters based on an update  
1519 for the Thorson-Dorn rockfish prior (Dorn, M. and Thorson, J., pers. comm.), which was

1520 endorsed by the Science and Statistical Committee in 2019. The prior is a beta distribution  
1521 with  $mu=0.72$  and  $sigma=0.16$ . Steepness is fixed in the post-STAR base model at the mean  
1522 of the prior.

### 1523 2.3.7 Estimated and Fixed Parameters

estimated-and-fixed-parameters

1524 A full list of all estimated and fixed parameters is provided in Table 26. Time-invariant,  
1525 growth is estimated in this assessment, with all SS growth parameters being estimated. The  
1526 log of the unexploited recruitment level for the Beverton-Holt stock-recruit function is treated  
1527 as an estimated parameter. The main recruitment deviations estimated from 1978-2018,  
1528 with no early recruitment deviations. The survey catchability parameters are calculated  
1529 analytically (set as scaling factors) such that the estimate is median unbiased, which is  
1530 comparable to the way q is treated in most groundfish assessments.

1531 The post-STAR base model has a total of 61 estimated parameters in the following categories:

- 1532 • Equilibrium recruitment ( $R_0$ ) and 41 recruitment deviations
- 1533 • Five growth parameters
- 1534 • Four index extra standard deviation parameter, and
- 1535 • Ten selectivity parameters

1536 The estimated parameters are described in greater detail below and a full list of all estimated  
1537 and parameters is provided in Table 26.

1538 *Growth.* Five growth parameters were estimated for the one-sex model: three von Bertalanffy  
1539 parameters and two parameters for CV as a function of length-at-age related to variability in  
1540 length-at-age for small and large fish.

1541 *Selectivity.* Double-normal, asymptotic selectivity was estimated for all fleets with estimated  
1542 selectivity parameters.

1543 Three parameters were estimated for the recreational and commercial fleets, the peak, the  
1544 ascending width, and the selectivity at the first bin. Only the ascending width parameter  
1545 was estimated for the PISCO fleet for fish 15+ cm.

1546 The Deb Wilson-Vandenberg onboard observer fleet and the CCFRP fleet were mirrored to  
1547 the recreational fleet north of Point Conception.

1548 *Other Estimated Parameters.* Main recruitment deviations estimated from 1978 to 2018. The  
1549 post-STAR base model also included estimated recruitment deviations for the forecast years,  
1550 although these have no impact on the model estimates for the current year.

1551 Many variations of the base case model were explored during this analysis. Sensitivities to  
1552 asymptotic vs. domed selectivity were explored for the appropriate fisheries, e.g. commercial  
1553 fisheries and surveys, as well as estimating selectivity and mirroring fleet selectivities. Time  
1554 blocked selectivity without the time block from 1999-2019 for the recreational fisheries was  
1555 investigated.

1556 Much time was also spent tuning the advanced recruitment bias adjustment options.  
1557 Sensitivities were performed to each of the thirteen advanced options for recruitment, e.g.,  
1558 early recruitment deviation start year, early recruitment deviation phase, years with bias  
1559 adjustments, and maximum bias adjustment. The final post-STAR base model sets the  
1560 first year of recruitment deviations just prior to when the majority of fishery/survey length  
1561 composition are available.

1562 Several models were also investigated where steepness and natural mortality were either  
1563 estimated or fixed at their respective priors.

1564 *Other Fixed Parameters.* The stock-recruitment steepness was fixed at the SSC approved  
1565 steepness prior for rockfish of 0.72 and natural mortality was fixed at 0.193, the mean of the  
1566 prior given a maximum age of 28 years.

## 1567 2.4 Model Selection and Evaluation

model-selection-and-evaluation

### 1568 2.4.1 Key Assumptions and Structural Choices

key-assumptions-and-structural-choices

1569 Key assumptions in the model are that it is appropriate to model gopher and black-and-yellow  
1570 rockfish as a complex. The catch histories are inseparable at this time, especially for the early  
1571 commercial landings. The biological information available also precluded complete analyses  
1572 of difference in growth, i.e., the majority of black-and-yellow rockfish aged were small fish  
1573 and small fish were lacking for gopher rockfish. Data from both species were used to provide  
1574 a complete picture of the growth curve.

1575 The assessment is a one area model with fleets as areas for the recreational fishery. There  
1576 were only a handful of aged gopher rockfish from south of Point Conception, and not enough  
1577 other biological information available that would have justified a multi-area model.

### 1578 2.4.2 Alternate pre-STAR Models Considered

alternate-pre-star-models-considered

1579 A number of models were run with differing catch histories for the recreational fleet south of  
1580 Point Conception, given that the catch histories were modified from the original data. None  
1581 of the alternatives explored altered the model at any significant level due to the fact that the  
1582 recreational catches south of Point Conception are relatively small compare to catches north

1583 of Point Conception. Results from select sensitivity runs compared to the base model are in  
1584 Table 27.

1585 Two sensitivities were also performed altering the commercial discard catch history. The  
1586 discard catch was set to zero for all years prior to 2004, the year when WCGOP estimates  
1587 were first available, and to a constant rate of 17% of the commercial landings, the maximum  
1588 discard rate observed in the WCGOP data. Neither of these sensitivities resulted in any  
1589 significant change to the model outputs.

1590 Sensitivity of the model to the spawning and settlement months were also explored. The  
1591 base model originally set settlement month to January. Both gopher and black-and-yellow  
1592 rockfish settle at a small size (~2 cm) and over a course of several months. After exploring  
1593 the young-of-the-year length data made available by Diana Baetscher (UCSC), the timing of  
1594 settlement was moved to July for the base model, when the majority of GBYR are 4 cm, the  
1595 size of the smallest length bin. The change of the timing of settlement had little effect on the  
1596 model results.

1597 Runs of the base case model estimating steepness were also considered.

1598 A sensitivity of the model to using the commercial length composition data from PacFIN  
1599 was also considered. The fits changed only slightly, (increasing depletion from 0.46 to 0.48)  
1600 but given the concerns outlined in the discussion on commercial length composition the pre-  
1601 and post-STAR base models include the commercial length compositions from CALCOM.

1602 Sensitivities were developed to look at alternate selectivity patterns for the the commercial  
1603 discard fleet and the CCFRP survey. A time block for the commercial discard fishery was  
1604 not considered since no length composition of discarded fish were available prior to 2004.

#### 1605 2.4.3 Uncertainty and Sensitivity Analyses to the pre-STAR base 1606 uncertainty-and-sensitivity-analyses-to-the-pre-star-base

1607 A number of sensitivity analyses were conducted prior to the STAR panel, including:

- 1608 1. Fixing natural mortality at the prior of 0.193
- 1609 2. Fixing the von Bertalanffy  $k$  at the external estimate of 0.247
- 1610 3. Using the PacFIN expanded length composition data
- 1611 4. Data weighting scenarios including unweighted, harmonic means (McAllister-Ianelli  
method), and Francis weights

1612 The following sensitivities are based on the pre-STAR base model and indicate areas that the  
1613 STAT identified as either areas of uncertainty or model sensitivities outlined in the Accepted

1614 Practices and Guidelines document. A summary of parameters for all sensitivity runs is in  
1615 Table 27.

1616 Fixing either natural mortality or the von Bertalanffy  $k$  parameter results in a stock with  
1617 higher spawning output in 2018 as compared to the base model (Figure 45).

1618 Fixing either  $M$  or  $k$  demonstrates the negative correlation between the two parameters. The  
1619 von Bertalanffy  $k$  parameter is estimated at 0.12 when natural mortality (estimated at 0.21)  
1620 and growth are both estimated. When natural mortality is fixed at the prior of 0.193,  $k$  is  
1621 estimated at 0.14, but the two other growth parameters, L1 and L2 do not change much at  
1622 all. When  $k$  is fixed to the external estimate of 0.247, natural mortality is estimated at 0.16,  
1623 and the other growth parameters both decrease. A number of additional sensitivities to the  
1624 growth parameters will be presented at the STAR panel.

1625 Replacing the CALCOM commercial length composition data with the PacFIN length  
1626 composition results in the stock at an overall lower level of biomass than the base model.  
1627 Depletion in the final year with the PacFIN length composition is 0.50, compared to 0.46 in  
1628 the base model. A detailed discussion on the decision to use the CALCOM length composition  
1629 in the base model can be found in the discussion commercial length and age data, Section  
1630 (2.1.3).

1631 Data weighting is an area of uncertainty for stock assessment, and research is ongoing to  
1632 determine the effects of data weighting and the most appropriate initial sample sizes for  
1633 length and age composition data. The base model used the Stewart sample sizes for initial  
1634 sample sizes for the fishery data and either the Stewart sample sizes or number of “trips” for  
1635 the survey sample sizes. Weighting the data by the harmonic mean resulted in a model with  
1636 a total likelihood between the base model, which uses the Francis method for weighting, and  
1637 the model with default weights (Figure 46). The end year spawning output is almost identical  
1638 for the models using harmonic means and Francis weights, both of which down-weighted the  
1639 composition data.

1640 The Francis weights in the base model were stable, and did not tend to serially decrease  
1641 (down-weight) any of the data sets, which has been seen in other assessments. The final  
1642 base model re-weights the composition data only once. As discussed above in the data  
1643 weighting section, the Dirichlet-Multinomial weighting was explored, but a model with a  
1644 positive definite Hessian was not identified with the pre-STAR base model.

## 1645 2.5 Response to the Current STAR Panel Requests

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

1646 Request No. 1: Develop catch curves from age data as appropriate during  
1647 different periods of fishing intensity according to the model.

1648

1649           **Rationale:** To obtain an independent estimate of total mortality to better gauge  
1650           natural mortality given the model uncertainty.

1651           **STAT Response:** The STAT created two catch curves using the available age data for  
1652           gopher and black-and-yellow rockfish, one for the time period pre-2000 (629 available  
1653           ages) and the second from 2000-2018 (1,791 available ages) (Figure 47). The pre-2000  
1654           plot used fish aged eight and older, while the 2000-2018 plot used fish aged 13 and  
1655           older. The estimate of total mortality ( $Z$ ) was not very different between the two time  
1656           periods, 0.37 for the earlier period and 0.36 for the later years. If restricted to the same  
1657           ages (13 and older), the earlier period would have a steeper decline supporting higher  
1658           mortality rates in the earlier period and suggesting estimates of  $M$  are reasonable.

1659           **Request No. 2: Remove the indices from the Southern fleets 7 and 11 from the  
1660           model**

1662           **Rationale:** These cover a small portion of the population and would not be expected  
1663           to have the same trends as the majority of the population are in conflict with the  
1664           northern trends, and there is no straightforward way to combine indices from the two  
1665           separate regions.

1666           **STAT Response:** The STAT removed the two fishery-dependent indices representing  
1667           the portion of the stock south of Pt. Conception, the CDFW MRFSS-era dockside  
1668           survey and the CDFW CRFS-era onboard observer survey index (Figure 48). There  
1669           were minor changes to the model, with the total likelihood going from 515 to 511 and  
1670           the estimate of natural mortality going from 0.212 to 0.219.

1671           **Request No. 3: Add discard to commercial catch data in terms of both catch  
1672           and compositions (by weighting comps by the number of fish discarded or  
1673           retained), and remove selectivity time block. Apply discard rate back in  
1674           time.**

1676           **Rationale:** Simpler to have a single fleet for all commercial catch and the model is  
1677           likely to better reflect the actual dynamics.

1678           **STAT Response:** Response under Request #3a.

1679           **Request No. 3a: Remove commercial length comp data from 2000-2003 in  
1680           addition to request.**

1682           **Rationale:** Length limit imposed in 2000 but length discards not available until 2004.  
1683           Therefore, comp data from these years are not representative of total removals.

1684           **STAT Response:** The STAT combined the catches from the commercial retained  
1685           and commercial discard fleets, to create one commercial fleet representing both catch  
1686           streams (Figure 49). The length composition data from the two fleets from 2004-2017  
1687           were combined by weighting the length compositions by the catches from each fleet.  
1688           Compared to the pre-STAR base, the model run for request 3a, reduced the number of

1689 estimated parameters by 10, and resulted in a decrease in natural mortality to 0.195.  
1690 The overall model output did not change from the base model or the changes made  
1691 from Request #2. Nevertheless, the more appropriate treatment of the data in terms  
1692 of the processes reflected in the model was deemed to be an improvement and was used  
1693 in subsequent requests as the base model.

1694 **Request No. 4:** Split PISCO survey such that the 0-age fish (4 and 5 cm) are  
1695 in one survey and the 15 cm+ fish are in the other. Fix age selectivity to  
1696 age-0 only for the first fleet and use a logistic selectivity for the second fleet.  
1697

1698 **Rationale:** To separate out the recruitment index in the survey and to simplify the  
1699 selectivity assumptions for this fleet.

1700 **STAT Response:** Response under Request #4a.

1701 **Request No. 4a:** Include all years of the recruitment index developed above.  
1702

1703 **Rationale:** Years with low numbers of 4 and 5 cm fish indicate low recruitment and  
1704 provide contrast to years with large numbers of those fish.

1705 **STAT Response:** The STAT developed an index of abundance using only fish that  
1706 were 5 cm or less and re-developed the length composition data for the PISCO survey  
1707 representing fish 15 cm and larger. The effect of splitting the PISCO index into two  
1708 indices, one for young of the year and one representing older fish resulted in dampening  
1709 of the age-0 recruits seen in the previous models (Figure 50). This was seen as a weakness  
1710 in the model due to high uncertainty in the estimates due to limited compositional  
1711 evidence of such an extended period of improved recruitment. The appropriateness of  
1712 the size cutoff was investigated further in Request 8.

1713 **Request No. 5:** Remove the autocorrelation recruitment.  
1714

1715 **Rationale:** Given the sensitivity run presented, auto correlation didn't make much  
1716 of a difference in model results, and there was not adequate evidence in the data for  
1717 autocorrelation.

1718 **STAT Response:** Removing the autocorrelation in recruitment resulted in no signif-  
1719 icant change to the model output. There was little evidence for autocorrelation in  
1720 recruitment in the stock or that it provided much in the way of stability to the model,  
1721 it was therefore decided that the assessment should not implement this option.

1722 **Request No. 6: 1) Start recruit deviation in 1978 as main recruit devs. and 2)**  
1723 **Start these in 2001. Turn off all early recruit devs in both cases.**  
1724

1725 **Rationale:** The composition data does not seem to be informing the estimates of the  
1726 recruitment deviations but maybe driven by the artifacts in the catch data. The early  
1727 recruit deviations are uninformed and all in one direction. Recruitment indices start in  
1728 2001.

1729           **STAT Response:** : Starting the recruitment deviations in 2001 did not produce a  
1730           reasonable recruitment signal. Starting the recruitment deviations in 1978 provided  
1731           reasonable recruitment deviations and is a more appropriate starting year given the  
1732           lack of sufficient length data prior to this period.

1733           **Request No. 7: Start from model shown at request 6(1). Fix M at 0.193 and let**

1734           the model estimate k. Change the ramp to estimated level with up ramp

1735           from 1978 to 1979. Provide all appropriate diagnostics.

1737           **Rationale:** : STAT and STAR agree 6(1) was an improvement over the original base  
1738           model and the request refers to adjusting the ramp value and M treatment consistent  
1739           with the way these were dealt with in the original the pre-STAR-base model given the  
1740           new settings.

1741           **STAT Response:** Requests 7 and 8 were conducted for comparison and the plots  
1742           comparing the two requests are below Request 8. Fixing natural mortality at the mean  
1743           of the prior results in an increase in the growth parameter  $k$  from 0.145 to 0.147 from  
1744           Request 6 due to the decrease in the modeled natural mortality rate and the observed  
1745           correlation between estimated  $M$  and  $k$  values.

1746           **Request No. 8: Determine if 6 cm or larger fish should be included in PISCO**  
1747           **recruitment index. If so, update the PISCO index and include the updated**  
1748           **index in the model from Request 7 (above).**

1750           **Rationale:** Better to use all appropriate data for the recruitment index. The panel  
1751           felt the splitting of the PISCO index had advantages based on the results from Request  
1752           4, but given the temporal variability in the survey over time wanted to ensure that  
1753           the size cutoff included the majority of 0-group fish while minimizing the potential to  
1754           include 1-group individuals.

1755           **STAT Response:** After an email discussion with Mark Carr, Dan Malone (UCSC  
1756           PISCO) and Darren Johnson (CSU Long Beach) it was decided that fish of length 6  
1757           cm at the end of the year of birth would still all be young of the year fish during the  
1758           months in which the PISCO survey is conducted. Additional research could serve to  
1759           verify the appropriate lengths to include, perhaps by month. The PISCO age-0 index  
1760           developed for this request (including all fish size 4, 5, and 6 cm) resulted in a decrease  
1761           in the recruitment index in the early 2000s, and an increase in the recruitment index  
1762           in 2010 and from 2014-2018 relative to include only 4 and 5 cm individuals (Figure  
1763           51). The effects on spawning output of the revised PISCO age-0 index of abundance  
1764           (8b), and a fix to an issue in the selectivity mirroring, and an additional correction that  
1765           fixes the last year of bias adjustment to 2019 and not 2020 (8c) are shown in Figure 52.  
1766           With natural mortality fixed at 0.193, the growth parameter  $k$  is estimated at 0.114.  
1767           The estimate of length at age-2 (L1) is 13.37, similar to the external estimates.

1768           **Request No. 9: Mirror the DebWV\_CPFV selectivity to the RecN selec-**  
1769           **tivity. Fix the start logit parameter for the adult PISCO selectivity to**

1770 zero. Investigate appropriate methods for modeling selectivity for CCFRP.

1771

1772 **Rationale:** These will result in more appropriate and parsimonious treatment of  
1773 selectivity.

1774 **STAT Response:** The selectivity for the CCFRP index was also mirrored to the  
1775 Recreational North fleet since the length compositions were not drastically different  
1776 than the other fleets mirrored to the Recreational North fleet. The STAT could not  
1777 find a domed selectivity pattern that had reasonable parameter estimates. The STAT  
1778 also explored fitting asymptotic selectivity to the CCFRP index, but even when fixing  
1779 the peak parameter to the upper bound, other parameters were not well estimated.  
1780 Mirroring fleet selectivities was an advantage to the stability of the model.

1781 **Request No. 10: Perform a drop one out analysis for the index fleets.**

1782

1783 **Rationale:** To investigate the influence each of these data sets on the model.

1784 **STAT Response:** No single index had a substantial effect on the model output (Figure  
1785 53). Each index contributed to the status of the stock, with some indicating a an  
1786 increase over the base model developed for Request 9, and some estimating a decreased  
1787 stock status. Depending on which index was dropped, the year(s) of high recruitment  
1788 predicted in the early 1990s did shift, and was either attributed to a single year, or  
1789 spread over a few years. The PISCO age-0 index does inform recruitment and age-0  
1790 recruitment is dampened n recent years when this index is excluded.

1791 **2.6 Post-STAR Base Case Model Results**

post-star-base-case-model-results

1792 The following description of the model results reflects a base model that incorporates all  
1793 of the changes made during the STAR panel. A comparison of the pre-STAR base model  
1794 and the post-STAR base model can be found in Figures 54, 55, and 56 and Table 24. A  
1795 number of changes to the fleet structures, removal of surveys south of Point Conception, and  
1796 the splitting of the PISCO index into two indices to better reflect life stages contributed to  
1797 the changes. The final model also fixes natural mortality, whereas it was estimated in the  
1798 pre-STAR base model. The pre-STAR base model includes and ageing error matrix that was  
1799 developed using only half of the available double reads. The post-STAR base includes the  
1800 updated ageing error matrix (Figure 57), and the update did not significantly change the  
1801 model outputs. The remainder of the document referencing the base model (or base case)  
1802 refers to the post-STAR base model.

1803 The base model parameter estimates and their approximate asymptotic standard errors are  
1804 shown in Table 26 and the likelihood components are in Table 28. Estimates of derived  
1805 reference points and approximate 95% asymptotic confidence intervals are shown in Table e.  
1806 Time-series of estimated stock size over time are shown in Table 29.

1807 Steepness of the assumed Beverton-Holt stock-recruitment relationship was fixed at 0.72, and  
1808 natural mortality was fixed at 0.193.

1809 **2.6.1 Convergence**

convergence

1810 Model convergence was determined by starting the minimization process from dispersed values  
1811 of the maximum likelihood estimates to determine if the model found a better minimum.  
1812 Jitter is a SS option that generates random starting values from a normal distribution  
1813 logistically transformed into each parameter's range (Methot et al. 2019). This was repeated  
1814 300 times and the minimum was reached in 67% of the runs (Table 25). The model did not  
1815 experience convergence issues, e.g., final gradient was below 0.0001, when reasonable starting  
1816 values were used and there were no difficulties in inverting the Hessian to obtain estimates of  
1817 variability. We did sensitivity runs for convergence by changing the phases for key estimated  
1818 parameters; neither the total log-likelihood nor the parameter estimates changed.

1819 **2.6.2 Parameter Estimates**

parameter-estimates

1820 The base model produces estimates of growth parameters different from the external estimates  
1821 (Figure 58). The external estimate of the von Bertalanffy growth coefficient  $k$  was 0.247,  
1822 whereas the internal estimate was much lower at 0.107. Using the Schnute parameterization  
1823 with the age for L1 set at 2 and L2 at 23, the external estimates of lengths at Amin and  
1824 Amax were similar at 13.80 and 28.22, respectively. The internal estimates of the lengths for  
1825 Amin and Amax were 13.4 and 28.80, respectively. Given that natural mortality was fixed in  
1826 the base model and natural mortality and the growth parameter  $k$  are negatively correlated,  
1827 the model estimated a slower rate of growth. A number of other factors including the length  
1828 composition and selectivity affect the internal estimate of growth. Hence, growth was chosen  
1829 as the axis of uncertainty for the decision table.

1830 The estimated selectivities for all fleets within the model are shown in Figure 59. The  
1831 selectivity curves for the commercial fleet, recreational fleets north and south of Point  
1832 Conception, and the larger PISCO (15+ cm) were estimated. All of the selectivities are  
1833 asymptotic except for the PISCO age-0 index, which has an age selectivity set to 1.0. All of  
1834 the recreational indices and the CCFRP index selectivities were mirrored to the recreational  
1835 fleet north of Point Conception. Attempts to fit asymptotic and dome-shaped selectivity to  
1836 the CCFRP data resulted in poor estimation, large standard deviations, or a lack of fit to  
1837 the data. The aggregated CCFRP length composition over time was similar to the length  
1838 composition data of the recreational fleets north of Point Conception and mirroring the  
1839 CCFRP selectivity provided a more parsimonious model. The recreational fleet south of  
1840 Point Conception encounters smaller GBYR, which is reflected in the asymptotic selectivity  
1841 shifted to the left of all other fleets. Selectivities for the recreational fleet north of Point  
1842 Conception and the commercial fleet are very similar. Both fleets include length composition

1843 of retained and discarded fish, although no information on the size of discards is available  
1844 from the commercial fleet prior to 2004. The selectivity for the commercial fleet was kept  
1845 separate because the fleet has different fishing behavior than the recreational fleet and going  
1846 forward in time, may diverge further from the fleets depending on management decisions or  
1847 changes in fishing behavior. Selectivity for the PISCO (15+ cm fish) index was estimated as  
1848 the survey observes a wider range of length classes than the other fleets. The estimated peak  
1849 of the PISCO selectivity hit the upper bound of 38 and was fixed at 38 in the base model.  
1850 The age selectivity for the PISCO age-0 index was fixed at 1.0 and assumes that all age-0  
1851 fish are selected.

1852 The additional survey variability (process error added directly to each year's input variability)  
1853 for all surveys except the recreational dockside index north of Point Conception (RecDockside-  
1854 North) and the PISCO age-0 index, was estimated within the model. The added variance for  
1855 Deb's onboard observer survey was estimated at 0.06. The added variances were highest for  
1856 the recreational onboard observer survey north of Point Conception (0.237) PISCO (0.152),  
1857 and CCFRP (0.212).

1858 Recruitment deviations were estimated from 1978-2018 (Figure 60). Estimates of recruitment  
1859 suggest that GBYR are characterized by cyclical years of high and low recruitment (Figure  
1860 61). The final base model does not include early recruitment deviation and a steep bias  
1861 adjustment ramp from 1978 to 1979 of 0.32 that extends to 2019 Figure 62. The years of  
1862 highest estimated recruitment is 1991, with recruitment estimated more than double that  
1863 of any other year. Fish from this cohort can be observed in the length composition data  
1864 from Deb Wilson Vandenberg's onboard observer survey and recreational fleet north of Point  
1865 Conception in the later half of the 1990s. Additional periodic recruitment events are estimated  
1866 from 1994 and onward, with the peaks from 2001 and on driven by the PISCO age-0 index.  
1867 A period of below average recruitment was estimated from 2004-2013, with another high  
1868 recruitment pulse from 2014-2015.

1869 The stock-recruit curve resulting from a fixed value of steepness is shown in Figure 63. The  
1870 stock has not been depleted to a low enough level that would inform the estimation of  
1871 steepness. Steepness was not estimated in this model, and profiles over steepness values are  
1872 discussed below.

### 1873 2.6.3 Fits to the Data

fits-to-the-data

1874 Model fits to the indices of abundance, fishery length composition, survey length composition,  
1875 and conditional age-at-length observations are all discussed below. The full r4ss plotting  
1876 output is available in the supplementary material.

1877 The fits to the three fishery-dependent and three fishery-independent survey indices are  
1878 shown in Figures 64, 65, 66, 67, 68, and 69. All indices represent the area north of Point  
1879 Conception only, and not all of these were fit well by the assessment model. The MRFSS

1880 CPFV recreational dockside survey index north of Point Conception spanning the 1980s-1990s  
1881 was fit well by the model without added variance, but relatively flat, and is not a very  
1882 informative index. The index for Deb Wilson-Vandenbergs CPFV onboard observer survey  
1883 spanning 1988-1998 was well fit and indicates an increase in relative abundance in the last  
1884 year of the survey. The current recreational CDFW/Cal Poly onboard observer survey north  
1885 of Point Conception from 2001-2018 was relatively well fit, except for the decline suggested  
1886 2013 and 2014. The increase in relative abundance observed in 2018 was not fit by the model,  
1887 even with the added variance. The variance added to this survey was the highest for all  
1888 indices.

1889 The model did not capture the contrast in the PISCO index for 15+ cm fish, fitting a decline  
1890 to the time series from 2010 to 2018, when the index suggests an increase from 2010 to 2013  
1891 and another increase after a decline in 2016. The model does capture the PISCO age-0 index  
1892 without added variance. A number of years, e.g., 2004-2008, were marked by low relative  
1893 abundance of age-0 GBYR and have larger standard errors. The years with lower relative  
1894 abundance were not captured by the model, but fit to the upper bound of the input standard  
1895 error. The increases in age-0 GBYR in 2001, 2001, 2014-2015 and 2017 were captured in the  
1896 model fit.

1897 The model was not able to capture the trends observed in the fishery-independent CCFRP  
1898 hook-and-line survey. The index suggested the same depressed relative abundance in 2013 as  
1899 the fishery-dependent CRFS/Cal Poly onboard observer survey, that was also not captured  
1900 here by the fit. The increasing trends in abundance from 2016-2018 was also not captured by  
1901 the model fit, and the fit suggests a declining trend over the entire time series from 2007-2018.

1902 The base model was re-weighted twice using Francis weights for the length and age composition  
1903 data. Fits to the length data are shown based on the proportions of lengths observed by  
1904 year and the Pearson residuals-at-length for all fleets. Detailed fits to the length data by  
1905 year and fleet are provided in Appendix C. Aggregate fits by fleet are shown in Figure 70.  
1906 Overall, the length composition all fit well. The PISCO fleet has the noisiest of all the length  
1907 composition data, but on an annual basis, the length data were relatively well fit. The fit to  
1908 the aggregated CCFRP data suggests the model expects to see additional larger fish, which is  
1909 likely due to the mirroring of the selectivity. However, on an annual basis, there is a trade-off  
1910 with the CCFRP with under-fitting of the larger fish in the earlier years and an under-fitting  
1911 of the smaller fish expected in the later years (2013-2018).

1912 The mean age of the recreational fleet varied from 1980-1986 ranging from approximately  
1913 8-11, and increased in 2017 to approximately 13 (Figure 71). The conditional age data from  
1914 the CCFRP data was not well fit for the earliest years in the data, but was reasonably well  
1915 fit for the last four years of data (Figure 72). The conditional age composition data from the  
1916 ‘dummy’ fleet was well fit, although heavily down-weighted. Age data in this fleet are from a  
1917 number of sources and sampling programs (Figure 73).

1918 **2.6.4 Retrospective Analysis**

retrospective-analysis

1919 A 4-year retrospective analysis was conducted by running the model using data only through  
1920 2017 (Retro1), 2016 (Retro2), 2015 (Retro3), and 2014 (Retro4) (Table 30). The initial  
1921 population size and estimation of trends in spawning biomass in the retrospective runs were  
1922 lower than the base model, except for Retro1 (Figure 74). All retrospective runs followed the  
1923 same general trend, with the differences in the trends stemming from the change in recruitment  
1924 deviations (Figure 75). The PISCO age-0 index has a signal of increased recruitment in the  
1925 most recent years. For Retro2, Retro3, and Retro4, the trends in recruitment are not observed  
1926 by the model. There is no conditional age-at-length composition data for 2015-2016, leading  
1927 to the minor change in the age composition likelihood from Retro2 to Retro3 and Retro4  
1928 (Table 30). The age composition data in 2017 accounts for 2.5% of all available ages, and  
1929 4.5% of all fish aged were from 2018. The available length data in each year from 2015-2018  
1930 range from 4-6% of the total available length data. The length compositions of all the other  
1931 fleets have similar length distributions for 2015-2018 (Appendix C). Additional investigations  
1932 into the retrospective patterns will be made by the STAT.

1933 **2.6.5 Likelihood Profiles**

likelihood-profiles

1934 Likelihood profiles were conducted for  $R_0$ , steepness, and over natural mortality values  
1935 separately with the post-STAR base. These likelihood profiles were conducted by fixing the  
1936 parameter at specific values and estimated the remaining parameters based on the fixed  
1937 parameter value (Tables 31-32).

1938 In regards to values of  $R_0$ , the negative log-likelihood was minimized at approximately  $\log(R_0)$   
1939 of 8.0 (Table 31 and Figure 77). In terms of likelihood components, only the index data  
1940 minimize at the upper bound, while the other components minimize between 8.0 and 8.1.  
1941 The individual surveys tend to minimize at the upper bound or just below, while the length  
1942 composition data has conflicting trends, e.g., CCFRP and commercial fleets minimize at the  
1943 upper bound while the recreational north fleet minimizes at the lower bound (Figures 78-76).  
1944 The majority of data all consistently minimize around 8. Over the range of values of  $R_0$ ,  
1945 depletion ranged from 0.38-0.59 (Figure 79).

1946 For steepness, the negative log-likelihood reaches a minimum around a steepness near the upper  
1947 bound of 1.0 (Figures 80-81 and Table 31). The length composition likelihood components  
1948 declined towards the upper bound for Deb's onboard CPFV survey and the recreational  
1949 north fleet, while the other fleets either reached a minimum around 0.55 or at the lower  
1950 bound (Figure 82). Overall changes in the survey likelihood across the range of steepens was  
1951 less than 2.0, with surveys either minimized at the lower or upper bound (Figure 83). The  
1952 relative depletion for GBYR ranges from 0.375 to 0.493 across different assumed values of  
1953 steepness (Table 31).

1954 The negative log-likelihood was minimized at a natural mortality value around 0.21, slightly  
1955 higher than the prior of 0.193 (Table 32 and Figure 84). The age, length, index, and

1956 prior likelihood contributions were minimized at natural mortality values around 0.22, and  
1957 the recruitment contribution was minimized at the upper bound. (Table 32). The length  
1958 composition minimizes around a natural mortality value of 0.14, with the commercial,  
1959 recreational fleet north of Point Conception, and CCFRP data minimizing towards the lower  
1960 bound (Figure 85). The length data from Deb's CPFV survey minimizes around 0.22, while  
1961 the PISCO and recreational length compositions south of Point Conception minimize at the  
1962 upper bound. The PISCO and CCFRP surveys minimized around a natural mortality value  
1963 of 0.22, while the PISCO age-0 and overall survey likelihood minimized at the upper bound  
1964 of 0.3 (Figure 86). The relative depletion for GBYR ranged from 0.32-0.59 across alternative  
1965 values of natural mortality (Figure 87).

1966 A profile over the growth parameter  $k$  from 0.07 to 0.25 (with natural mortality fixed at 0.193)  
1967 log-likelihood minimized at 0.11 (Table 32 and Figure 88). The total change in the negative  
1968 log-likelihood is small until  $k$  increases higher than 0.15. The combined age data minimize at  
1969 a higher value of 0.18, while the remaining components minimize at the lower bound. The  
1970 age composition by fleet also has conflicting trends with the dummy fleet minimizing just  
1971 lower than the overall around 0.17, the CCFRP ages minimizing at the lower bound and the  
1972 RecNorth ages minimizing at the upper bound (Figure 89). The RecOnboardNorth survey  
1973 likelihood component was the only survey component minimized at the upper bound, with the  
1974 remaining survey component minimized at the lower bound of the  $k$  values explored (Figure  
1975 90). The resulting 2019 depletion over the range of  $k$  values spans 0.4 to 0.49 (Figure 91).

## 1976 2.6.6 Reference Points

reference-points-1

1977 Reference points were calculated using the estimated selectivities and catch distribution  
1978 among fleets in the most recent year of the model, 2018. Sustainable total yield (landings  
1979 plus discards) were 134 mt when using an  $SPR_{50\%}$  reference harvest rate and with a 95%  
1980 confidence interval of 116 mt based on estimates of uncertainty. The spawning biomass  
1981 equivalent to 40% of the unfished level ( $SB_{40\%}$ ) was 504 mt.

1982 The predicted spawning output from the base model shows an initial decline starting the  
1983 1950s, is then stable, and declines steeply until 1995 (Figure 92).

1984 The spawning output then rapidly increases through the early 2000s, and has been in a  
1985 decline since 2006.

1986 The 2018 spawning biomass relative to unfished equilibrium spawning biomass is above the  
1987 target of 40% of unfished levels (Figure 93). The relative fishing intensity,  $(1 - SPR)/(1 -$   
1988  $SPR_{50\%})$ , was above the management target in 1987 and from 1992-1996. The stock has  
1989 been below the management target since 1997.

1990 Table e shows the full suite of estimated reference points for the base model and Figure 94  
1991 shows the equilibrium curve based on a steepness value fixed at 0.72.

## **1992 3 Harvest Projections and Decision Tables**

harvest-projections-and-decision-tables

1993 The forecasts of stock abundance and yield were developed using the post-STAR base model,  
1994 with the forecasted projections of the OFL presented in Table g. The total catches in 2019  
1995 and 2020 are set to the projected catch from the California Department of Fish and Wildlife  
1996 (CDFW) of 114 mt.

1997 Uncertainty in the forecasts is based upon the three states of nature agreed upon at the  
1998 STAR panel and are based three states of nature of growth. The external estimate of growth  
1999 was different than the internal Stock Synthesis estimate. Given that natural mortality is  
2000 fixed in the post-STAR base model, and the growth parameter  $k$  is negatively correlated with  
2001 natural mortality,  $k$  was chosen as the axis of uncertainty. The high state of nature fixes  $k$  at  
2002 the external estimate, and the low state of nature is the same distance in log space from the  
2003 base as the high state of nature. The low state of nature fixed  $k$  at 0.046 and the L1 and L1  
2004 parameters were estimated at 14.1 and 30.6, respectively. The high state of nature fixed all  
2005 growth parameters,  $k = 0.248$ , L1 = 13.8, and L2 = 28.5 to the external estimate of growth  
2006 (due to improbable estimates of L1 and L2 if only  $k$  was fixed to the external estimate). The  
2007 growth parameters in the base model were estimated as  $k = 0.107$ , L1 = 13.4, and L2 = 28.8.

2008 The forecasted buffer ramp was calculated assuming a category 2 stock, with sigma = 1.0 and  
2009 a  $p^* = 0.45$ . The buffer ranges from 0.874 in 2021 ramping to 0.803 in 2030. For reference,  
2010 the model predicted sigma is 0.189 and the decision table-based sigma is 0.197. Current  
2011 medium-term forecasts based on the alternative states of nature project that the stock will  
2012 remain above the target threshold of 40% for all but two scenarios (Table h). The low state of  
2013 nature with the high catches results in a stock at 26.4% of unfished in 2030 and the base state  
2014 model with the high catches results in a stock at 33.2% of unfished in 2030. The base case  
2015 model with the base catches results in an increasing stock over the period from 2021-2030. If  
2016 the growth of GBYR is slower than the base model suggests, but the base case catches are  
2017 removed, the stock will be at the target threshold in 2030.

## **2018 4 Regional Management Considerations**

regional-management-considerations

2019 While the proportion of the stock residing within U.S. waters is unknown, the assessment  
2020 provides an adequate geographic representation of the portion assessed for management  
2021 purposes. There is little evidence that black-and-yellow rockfish extend into Mexico, and  
2022 the proportion of gopher rockfish residing south of Pt. Conception is small. While there has  
2023 been work on the genetic structure between the two species, there has not been work done  
2024 within each species to inform spatial structure of the populations. Given the relatively small  
2025 area in the waters of California where these species occur, there is relatively little concern  
2026 regarding exploitation in proportion to the regional distribution of abundance in the area  
2027 assessed in this study.

2028 The state of California implements regional management for the recreational fleet in the form  
2029 of five regions, referred to as management areas with differing depth and season restrictions.  
2030 Neither gopher nor black-and-yellow rockfish are a large component of the total recreational  
2031 landings and are managed as part of the nearshore rockfish complex. Current regional  
2032 management appears appropriate for these species.

## 2033 5 Research Needs

research-needs

2034 We recommend the following research be conducted before the next assessment:

- 2035 1. Investigate the structure of complex and contribution of each species to the GBYR  
2036 complex. Investigate possible spatial differences in biological parameters within a single  
2037 species and also between the two species. Little biological data for south of Point  
2038 Conception or north of Point Arena were available for this assessment and is needed to  
2039 better understand biological parameters.
  - 2040 (a) Conduct life history studies
  - 2041 (b) conduct research to identify the proportion of each species in population and in  
2042 catches
- 2043 2. Take a closer look at the Ralston (Ralston et al. 2010) historical catch reconstruction  
2044 for gopher and black-and-yellow rockfishes. The recreational catch reconstruction for  
2045 gopher rockfish south of Point Conception was an order of magnitude higher than  
2046 expected when extracted for this assessment.
- 2047 3. Refine the PISCO survey data and analysis to better identify age-0 fish in each month  
2048 of survey. Occasional sampling during all months of the year would better help identify  
2049 the length distribution of fish classified as age-0. This is the only recruitment index  
2050 available for gopher and black-and-yellow rockfish. If possible, age data should be  
2051 collected from the PISCO survey to aid in determining the growth of young gopher  
2052 and black-and-yellow rockfish, and larger black-and-yellow rockfish.
- 2053 4. Refine CCFRP survey index to look at alternative possible model structures, including  
2054 a hierarchical structure and random effects. Limited time did not allow for these  
2055 explorations during this assessment cycle. It is also strongly recommended to continue  
2056 the coastwide sampling of the CCFRP program that began in 2017, as well as the  
2057 collection of biological samples for nearshore rockfish species. The CCFRP survey  
2058 is the only fishery-independent survey available for nearshore rockfish sampling the  
2059 nearshore rocky reef habitats. As of this assessment, only two years of coastwide data  
2060 are available, and the index was limited to the site in central California that have been  
2061 monitored since 2007.

- 2062 5. Collection of length and age data are recommended for both the commercial and  
2063 recreational fisheries. Very little age data are available from either fishery for gopher  
2064 rockfish and none for black-and-yellow rockfish.
- 2065 6. Data collection and coordination across Research Recommendations 1-5 is needed to  
2066 improve the efficacy of data collection and ensure that samples are representative of  
2067 the data sources and the fisheries. For example, the conditional age-at-length data  
2068 in the dummy fleet represent a number of sampling techniques, areas sampled, and  
2069 selectivities. Better coordination of research efforts will allow the age data to be better  
2070 utilized by the assessment. Sampling of the commercial and recreational fleets by area in  
2071 proportion to the length distribution of fish observed will also allow the model to better  
2072 fit selectivity patterns and avoid possible patterns in the length and age composition  
2073 residuals.
- 2074 7. Investigate possible environmental drivers/co-variates for biological parameters, partic-  
2075 ularly for recruitment.
- 2076 8. Examine the CFRS angler interview data for the recreational private/rental mode to  
2077 create a "trip" based identifier or catch and effort. This will enable the creation of an  
2078 index of abundance for the private/rental mode as well as investigate if selectivity for  
2079 this mode differs from the party/charter mode.
- 2080 9. Resolve differences between CalCOM and PacFIN expanded length composition data  
2081 sets.

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## 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

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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

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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	126.00	362			
1987	2	82			28	392	131.00	529	14	73	
1988					30	303	110.00	410	54	664	
1989					19	303	111.00	436	70	727	
1990									17	109	
1991										38	722
1992	56	671								55	838
1993	148	1648			14	1094	8.00	24	75	614	
1994	170	1379			12	608	1.00	15	86	735	
1995	174	1523							90	1171	
1996	256	3270			74	607	14.00	32	100	1364	
1997	140	1319			95	1424	7.00	23	107	1415	
1998	206	2549			89	614	19.00	66	83	1048	
1999	251	3283			49	1112	33.00	301			
2000	384	4918			21	695	12.00	58			
2001	142	2179			46	929	14.00	35			
2002	59	870			58	1656	22.00	65			
2003	55	625			72	1690	15.00	100			
2004	63	770	72	572	19	2023	3.00	42			
2005	72	700	42	260	30	3217	8.00	93			
2006	31	478	42	266	35	3737	9.00	106			
2007	80	1165	37	268	30	3200	10.00	126			
2008	46	503	12	46	39	4165	11.00	132			
2009	73	854	22	263	43	4612	15.00	184			
2010	75	925	37	344	47	4992	16.00	192			
2011	61	858	68	366	44	4692	22.00	270			
2012	57	709	69	302	46	4904	89.00	1081			
2013	48	581	56	348	40	4339	77.00	930			
2014	15	184	62	388	44	4746	49.00	595			
2015	48	578	93	521	54	5789	36.00	436			
2016	77	928	56	317	58	6265	37.00	444			
2017	67	1581	49	226	44	4691	39.00	478			
2018	67	1210			33	3563	26.00	317			

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

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

*Continues next page*

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

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

*Continues next page*

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 the biomass/abundance time series used in the stock assessment. Blank fleet number indicates the index was not used in the post-STAR base model.

Fleet	Years	Name	Fishery ind.	Filtering	Method	tab:Index_summary
				Central	Delta	Endorsed
4	1988-1998	Deb Wilson-Vandenberg's Onboard Observer Survey	Fishery-dependent	California	Delta lognormal	SSC
5	2001-2018	CRFS CPFV Onboard Observer Survey	Fishery-dependent	North of Pt. Conception	Delta lognormal	SSC
59	2001-2018	CRFS CPFV Onboard Observer Survey	Fishery-dependent	South of Pt. Conception	Delta lognormal	SSC
6	2001-2018	PISCO Dive Survey 15+ cm fish	Fishery-independent	North of Pt. Conception	Negative Binomial	First use in stock assmnt
10	2001-2018	PISCO Dive Survey age=0 fish	Fishery-independent	North of Pt. Conception	Binomial	First use in stock assmnt
7	2007-2018	CCFRP Hook-and-Line Survey	Fishery-independent	Central California	Negative Binomial	First use in stock assmnt
8	1984-1999	MRFSS Dockside Survey	Fishery-dependent	North of Pt. Conception	Negative Binomial	SSC
	1980-1999	MRFSS Dockside Survey	Fishery-dependent	South of Pt. Conception	Delta lognormal	SSC

Table 6: Index inputs.

**tab:Indices**

Year	Deb WV		MRFSS N		MRFSS S		Onboard N		Onboard S		CCFRP		PISCO 15+cm		PISCO age-0	
	Obs	se_log	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			1.39	0.22	0.19	0.41		
2002					0.19	0.14	0.01	0.37			1.60	0.19	0.11	0.45		
2003					0.28	0.07	0.03	0.33			1.35	0.17	0.18	0.33		
2004					0.27	0.06	0.01	0.37			1.56	0.20	0.01	1.00		
2005					0.26	0.08	0.02	0.24			1.32	0.21	0.01	1.01		
2006					0.34	0.08	0.04	0.21			1.16	0.20	0.00	2.00		
2007					0.33	0.08	0.08	0.16	1.20	0.15	0.94	0.22	0.02	0.82		
2008					0.33	0.08	0.06	0.16	1.14	0.16	1.17	0.20	0.01	1.96		
2009					0.27	0.08	0.07	0.16	1.13	0.16	0.70	0.21	0.03	0.62		
2010					0.26	0.07	0.08	0.15	1.32	0.16	0.61	0.19	0.08	0.48		
2011					0.24	0.07	0.15	0.11	0.97	0.16	1.01	0.17	0.05	0.52		
2012					0.18	0.08	0.09	0.11	1.00	0.15	1.59	0.22	0.02	0.99		
2013					0.09	0.09	0.07	0.12	0.38	0.16	1.74	0.20	0.01	1.02		
2014					0.10	0.10	0.09	0.13	0.81	0.15	1.44	0.21	0.26	0.37		
2015					0.17	0.10	0.06	0.17	1.03	0.16	1.55	0.20	0.31	0.33		
2016					0.18	0.08	0.09	0.14	0.96	0.16	1.02	0.21	0.12	0.47		
2017					0.15	0.12	0.08	0.17	1.18	0.16	1.11	0.21	0.21	0.39		
2018					0.30	0.10	0.08	0.18	1.33	0.16	1.41	0.18	0.03	0.66		

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

Filter	Drifts	Positive Drifts	tab:Fleet5_Filter
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	<b>2625</b>	<b>2488</b>	
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	<b>13921</b>	<b>16674</b>	

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	<b>2652</b>	<b>5071</b>	
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	<b>5,512</b>	

Table 14: Model selection for the PISCO dive survey data for fish 15 cm and larger.

`tab:Fleet8large_AIC`

Model	AIC
Year	4,940
Year + Month	4,937
Year + Month + Site	4,770
Year + Month + Zone	<b>4,651</b>

Table 15: Model selection for the PISCO dive survey data recruitment index.

`tab:Fleet8age0_AIC`

Model	AIC
Year	708
Year + Month	703
Year + Month + Site	713
Year + Month + Site + Zone	<b>699</b>

Table 16: Data filtering steps for the fishery-independent CCFRP hook-and-line survey.

`tab:Fleet9_Filter`

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

Table 17: 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	<b>22,341</b>

Table 18: 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 targeting 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 19: Model selection for the MRFSS dockside intercept survey north of Pt. Conception. Bold values indicate the model selected.

tab:Fleet10\_AIC

Model	AIC
Year	1,481
Year + Region	1,429
Year + Region + Area_X	1,403
Year + Region + Area_X + Wave	<b>1,397</b>

Table 20: 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	<b>903</b>	<b>537</b>	
Year + Wave + SubRegion	908	536	

Table 21: 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 22: 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 23: Summary of available age data. All ages except the commercial ages were used in the assessment.

Project	Source	Years	Region	Gear	Black-and-yellow	Gopher	tab:Age_data
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	
<b>Total</b>					<b>499</b>	<b>1,968</b>	

Table 24: Comparison of ket parameters and likelihood components from the pre-STAR base model and the post-STAR base model.

Parameter	Value	tab:preSTAR_postSTAR_compare NA
Female M	0.21	0.19
Steepness	0.72	0.72
lnR0	8.60	8.05
Total biomass (mt)	2369.39	2046.78
Depletion	0.46	0.44
SPR ratio	1.00	0.90
Female Lmin	9.67	13.42
Female Lmax	28.44	28.80
Female K	0.12	0.11
Negative log-likelihood		
TOTAL	516.36	530.10
Catch	0.00	0.00
Survey	-32.17	-34.06
Length_comp	372.46	411.53
Age_comp	189.56	147.06
Recruitment	-13.51	5.58
Parm_priors	0.02	0.00
Parm_softbounds	0.00	0.00

Table 25: Results from 100 jitters from the base case model.

Description	Value	tab:jitter
MinLike	530.10	
MaxLike	538.08	
DiffLike	7.98	
MinMGC	0.00	
MaxMGC	0.00	
DepletionAtMinLikePercent	43.82	
DepletionAtMaxLikePercent	41.40	
DiffDepletionPercent	-2.41	
NJitter	300.00	
PropRunAtMinLike	0.67	
PropRunAtMaxLike	0.00	

Table 26: 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	0.193	-2	(0.05, 0.4)			0.4384 (-1.6458,
2	L_at_Amin_Fem_GP_1	13.422	3	(4, 50)	OK	0.853	None
3	L_at_Amax_Fem_GP_1	28.799	3	(20, 60)	OK	0.827	None
4	VonBert_K_Fem_GP_1	0.107	3	(0.01, 0.3)	OK	0.020	None
5	CV_young_Fem_GP_1	0.171	3	(0.05, 0.5)	OK	0.026	None
6	CV_old_Fem_GP_1	0.121	3	(0.03, 0.3)	OK	0.012	None
7	Wtlen_1_Fem_GP_1	0.000	-3	(-3, 3)	None		
8	Wtlen_2_Fem_GP_1	3.256	-3	(2, 4)	None		
9	Mat50%_Fem_GP_1	21.666	-3	(-3, 3)	None		
10	Mat_slope_Fem_GP_1	-0.906	-3	(-6, 3)	None		
11	Eggs/kg_inter_Fem_GP_1	1.000	-3	(-3, 3)	None		
12	Eggs/kg_slope_wt_Fem_GP_1	0.000	-3	(-3, 3)	None		
13	CohortGrowDev	1.000	-1	(0.1, 10)	None		
14	FracFemale_GP_1	0.500	-4	(0.000001, 0.999999)	None		
15	SR_LN(R0)	8.047	1	(2, 15)	OK	0.079	None
16	SR_BH_stEEP	0.720	-1	(0.2, 1)	Full_Beta (0.72, 0.16)		
17	SR_sigmaR	0.500	-2	(0, 2)	None		
18	SR_regime	0.000	-4	(-5, 5)	None		
19	SR_autocorr	0.000	-4	(-1, 1)	None		
85	LnQ_base_DebCPFV(4)	-7.157	-1	(-15, 15)	None		
86	Q_extraSD_DebCPFV(4)	0.060	4	(0, 2)	OK	0.045	None
87	LnQ_base_RecOnboardNorth(5)	-7.766	-1	(-15, 15)	None		
88	Q_extraSD_RecOnboardNorth(5)	0.237	4	(0.0001, 2)	OK	0.056	None
89	LnQ_base_PISCO(6)	-6.425	-1	(-15, 15)	None		
90	Q_extraSD_PISCO(6)	0.152	4	(0.0001, 2)	OK	0.061	None

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Table 26: 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)
91	LnQ_base_CCFRP(7)	-6.199	-1	(-15, 15)	OK	0.078	None
92	Q_extraSD_CCFRP(7)	0.212	4	(0.0001, 2)	OK	0.078	None
93	LnQ_base_RecDocksideNorth(8)	-9.288	-1	(-15, 15)	OK	0.078	None
94	LnQ_base_PISCOage(10)	-10.187	-1	(-15, 15)	OK	0.078	None
95	Size_DbLN_peak_Com(1)	31.058	1	(19, 38)	OK	0.383	None
96	Size_DbLN_top_logit_Com(1)	8.000	-5	(-5, 10)	OK	0.108	None
97	Size_DbLN_ascend_se_Com(1)	2.733	5	(-9, 10)	OK	0.108	None
98	Size_DbLN_descend_se_Com(1)	5.000	-5	(-9, 9)	OK	0.108	None
99	Size_DbLN_start_logit_Com(1)	-9.363	5	(-15, -5)	OK	0.971	None
100	Size_DbLN_end_logit_Com(1)	10.000	-5	(-5, 15)	OK	0.971	None
101	Size_DbLN_peak_RecNorth(2)	32.116	3	(19, 39)	OK	0.331	None
102	Size_DbLN_top_logit_RecNorth(2)	8.000	-5	(-5, 10)	OK	0.055	None
103	Size_DbLN_ascend_se_RecNorth(2)	3.202	5	(-9, 10)	OK	0.055	None
104	Size_DbLN_descend_se_RecNorth(2)	5.000	-5	(-9, 9)	OK	1.137	None
105	Size_DbLN_start_logit_RecNorth(2)	-11.110	5	(-15, -5)	OK	0.951	None
106	Size_DbLN_end_logit_RecNorth(2)	10.000	-5	(-5, 15)	OK	0.238	None
107	Size_DbLN_peak_RecSouth(3)	27.565	4	(19, 38)	OK	0.951	None
108	Size_DbLN_top_logit_RecSouth(3)	8.000	-5	(-5, 10)	OK	0.951	None
109	Size_DbLN_ascend_se_RecSouth(3)	3.078	5	(-9, 10)	OK	0.238	None
110	Size_DbLN_descend_se_RecSouth(3)	5.000	-5	(-9, 9)	OK	1.592	None
111	Size_DbLN_start_logit_RecSouth(3)	-7.504	5	(-15, -5)	OK	1.592	None
112	Size_DbLN_end_logit_RecSouth(3)	10.000	-5	(-5, 15)	OK	1.592	None
113	SizeSel_P1_DebCPFV(4)	-1.000	-5	(-1, 10)	OK	1.592	None
114	SizeSel_P2_DebCPFV(4)	-1.000	-5	(-1, 10)	OK	1.592	None
115	SizeSel_P1_RecOnboardNorth(5)	-1.000	-5	(-1, 10)	OK	1.592	None
116	SizeSel_P2_RecOnboardNorth(5)	-1.000	-5	(-1, 10)	OK	1.592	None
117	Size_DbLN_peak_PISCO(6)	38.000	-5	(19, 38)	OK	1.592	None

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Table 26: 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)
118	Size_DbLN_top_logit_PISCO(6)	8.000	-5	(-15, 10)	OK	0.085	None
119	Size_DbLN_ascend_se_PISCO(6)	4.699	5	(-9, 10)			None
120	Size_DbLN_descend_se_PISCO(6)	5.000	-5	(-9, 9)			None
121	Size_DbLN_start_logit_PISCO(6)	-17.029	-5	(-25, 15)			None
122	Size_DbLN_end_logit_PISCO(6)	10.000	-5	(-5, 15)			None
123	SizeSel_P1_CCFRP(7)	-1.000	-5	(-1, 10)			None
124	SizeSel_P2_CCFRP(7)	-1.000	-5	(-1, 10)			None
125	SizeSel_P1_RecDocksideNorth(8)	-1.000	-5	(-1, 10)			None
126	SizeSel_P2_RecDocksideNorth(8)	-1.000	-5	(-1, 10)			None
127	minage@sel=1_PISCOAge0(10)	0.000	-5	(0, 1)			None
128	maxage@sel=1_PISCOAge0(10)	0.000	-5	(0, 1)			None

Table 27: Sensitivity of the base model to alternative assumptions about natural mortality, growth, and using PacFIN-derived length composition data.

Label	Base model (Francis weights)	Fix M at prior	Fix k at external est.	PacFIN length comps	Default weighting	tab:Sensitivity_model1
TOTAL_like	516.36	516.61	524.71	508.20	4041.05	1734.79
Catch_like	0.00	0.00	0.00	0.00	0.00	0.00
Equil_catch_like	0.00	0.00	0.00	0.00	0.00	0.00
Survey_like	-32.17	-32.25	-31.21	-31.91	-25.08	-27.59
Length_comp_like	372.46	372.55	373.98	365.19	2192.10	1015.78
Age_comp_like	189.56	189.70	194.77	188.81	1872.77	753.42
Recruitment_like	-13.51	-13.40	-12.94	-13.99	1.13	-6.87
Param_prior_like	0.02	0.00	0.11	0.09	0.13	0.05
Param_softbounds_like	0.00	0.00	0.01	0.01	0.01	0.01
Female_M	0.21	0.19	0.16	0.23	0.24	0.22
Steepness	0.72	0.72	0.72	0.72	0.72	0.72
lnR0	8.60	8.33	7.86	8.87	9.03	8.80
Total Biomass	2369.39	2313.35	2322.80	2307.70	2321.26	2439.02
Depletion	0.46	0.43	0.42	0.00	0.50	0.49
SPR ratio	1.00	1.00	1.00	0.00	1.00	1.00
L_at_Amin_Fem_GP_1	9.67	9.61	8.53	9.91	9.62	9.88
L_at_Amax_Fem_GP_1	28.44	28.23	26.39	27.79	27.24	27.64
VonBert_K_Fem_GP_1	0.12	0.14	0.25	0.11	0.10	0.12
No. para	112.00	111.00	112.00	112.00	112.00	112.00

Table 28: Likelihood components from the base model.

Likelihood component	Value	tab:like_components
TOTAL	530.102	
Catch	1.450E-07	
Survey	-34.063	
Length composition	411.530	
Age composition	147.059	
Recruitment	5.575	
Forecast recruitment	0.000E+00	
Parameter priors	1.410E-06	
Parameter soft bounds	9.750E-04	

Table 29: 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	2047	1261	0.000	3125	4	0.00	0.99
1917	2044	1258	0.998	3124	7	0.00	0.98
1918	2040	1254	0.995	3123	8	0.00	0.97
1919	2036	1250	0.992	3122	5	0.00	0.98
1920	2033	1248	0.990	3122	5	0.00	0.98
1921	2032	1247	0.989	3121	5	0.00	0.98
1922	2031	1246	0.988	3121	4	0.00	0.99
1923	2030	1245	0.988	3121	4	0.00	0.99
1924	2029	1245	0.987	3121	2	0.00	0.99
1925	2030	1245	0.988	3121	3	0.00	0.99
1926	2030	1246	0.988	3121	5	0.00	0.98
1927	2029	1245	0.987	3121	4	0.00	0.99
1928	2029	1244	0.987	3121	6	0.00	0.98
1929	2027	1243	0.986	3120	6	0.00	0.98
1930	2026	1241	0.985	3120	8	0.00	0.97
1931	2023	1239	0.983	3119	5	0.00	0.98
1932	2023	1239	0.983	3119	10	0.01	0.97
1933	2019	1236	0.980	3118	7	0.00	0.98
1934	2018	1235	0.979	3118	7	0.00	0.98
1935	2018	1234	0.979	3118	6	0.00	0.98
1936	2017	1234	0.979	3118	6	0.00	0.98
1937	2017	1234	0.978	3118	15	0.01	0.95
1938	2011	1228	0.974	3117	18	0.01	0.94
1939	2003	1221	0.968	3115	21	0.01	0.93
1940	1995	1213	0.962	3113	28	0.01	0.91
1941	1983	1202	0.953	3110	27	0.01	0.91
1942	1973	1193	0.946	3107	14	0.01	0.95
1943	1973	1192	0.946	3107	17	0.01	0.94
1944	1971	1191	0.944	3107	4	0.00	0.98
1945	1978	1197	0.950	3109	6	0.00	0.98
1946	1982	1202	0.953	3110	27	0.01	0.91
1947	1972	1193	0.946	3108	37	0.02	0.89
1948	1957	1179	0.935	3104	39	0.02	0.88
1949	1942	1165	0.924	3100	37	0.02	0.88
1950	1931	1155	0.916	3097	39	0.02	0.88
1951	1919	1144	0.907	3094	52	0.03	0.84
1952	1901	1127	0.894	3089	52	0.03	0.84
1953	1885	1112	0.882	3085	55	0.03	0.83

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Table 29: 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
1954	1869	1098	0.871	3080	68	0.04	0.80
1955	1846	1077	0.854	3074	60	0.03	0.81
1956	1831	1064	0.844	3069	76	0.04	0.78
1957	1808	1043	0.827	3063	76	0.04	0.77
1958	1788	1025	0.813	3056	88	0.05	0.74
1959	1763	1003	0.795	3048	62	0.04	0.79
1960	1757	998	0.791	3047	44	0.02	0.84
1961	1764	1005	0.797	3049	50	0.03	0.82
1962	1766	1007	0.799	3050	61	0.03	0.79
1963	1759	1002	0.795	3048	56	0.03	0.81
1964	1758	1002	0.794	3048	43	0.02	0.84
1965	1764	1008	0.799	3050	58	0.03	0.80
1966	1760	1004	0.796	3049	52	0.03	0.82
1967	1760	1004	0.797	3049	48	0.03	0.83
1968	1763	1007	0.799	3050	49	0.03	0.82
1969	1764	1009	0.800	3051	46	0.03	0.83
1970	1767	1012	0.802	3052	60	0.03	0.80
1971	1761	1006	0.798	3050	51	0.03	0.82
1972	1762	1007	0.798	3050	66	0.04	0.78
1973	1752	998	0.791	3047	88	0.05	0.74
1974	1729	977	0.775	3039	92	0.05	0.72
1975	1707	957	0.759	3031	89	0.05	0.72
1976	1689	940	0.746	3024	91	0.05	0.72
1977	1673	926	0.734	3018	79	0.05	0.73
1978	1666	920	0.729	3257	84	0.05	0.72
1979	1657	912	0.723	3049	78	0.05	0.73
1980	1657	908	0.720	3557	155	0.09	0.61
1981	1610	862	0.683	3325	143	0.09	0.61
1982	1583	828	0.657	3627	129	0.08	0.62
1983	1575	808	0.641	2938	118	0.07	0.63
1984	1577	799	0.633	2076	174	0.11	0.54
1985	1539	763	0.605	2143	173	0.11	0.53
1986	1485	735	0.583	2061	206	0.14	0.48
1987	1400	696	0.552	2195	162	0.12	0.51
1988	1343	683	0.542	2609	145	0.11	0.53
1989	1297	675	0.535	3277	120	0.09	0.57
1990	1274	672	0.533	3596	136	0.11	0.55
1991	1269	652	0.517	11997	175	0.14	0.50

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Table 29: 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
1992	1267	608	0.482	3312	207	0.16	0.45
1993	1366	549	0.436	3764	210	0.15	0.43
1994	1490	507	0.402	4812	161	0.11	0.45
1995	1569	518	0.411	4650	150	0.10	0.45
1996	1663	569	0.451	3656	148	0.09	0.45
1997	1758	648	0.514	2786	118	0.07	0.51
1998	1843	748	0.594	2528	118	0.06	0.54
1999	1887	844	0.669	2579	127	0.07	0.56
2000	1888	919	0.729	2147	131	0.07	0.58
2001	1864	973	0.772	3459	169	0.09	0.56
2002	1797	985	0.781	2585	133	0.07	0.61
2003	1754	990	0.785	4185	148	0.08	0.61
2004	1702	968	0.767	1896	72	0.04	0.74
2005	1705	972	0.771	1891	86	0.05	0.72
2006	1687	959	0.761	2569	78	0.05	0.74
2007	1645	948	0.752	1600	70	0.04	0.76
2008	1608	940	0.746	1981	87	0.05	0.72
2009	1552	921	0.730	1634	111	0.07	0.68
2010	1473	882	0.700	2451	153	0.10	0.61
2011	1367	817	0.648	2014	135	0.10	0.61
2012	1286	761	0.603	1800	94	0.07	0.67
2013	1241	727	0.577	1589	84	0.07	0.68
2014	1203	697	0.553	4568	105	0.09	0.63
2015	1155	655	0.520	5264	109	0.10	0.62
2016	1147	614	0.487	2487	112	0.10	0.59
2017	1195	576	0.457	3701	104	0.09	0.59
2018	1240	553	0.439	1432	92	0.07	0.60
2019	1281	552	0.438	2778			

Table 30: Summaries of key assessment outputs and likelihood values from the retrospective analysis. The base model includes all of the data. Retro1 removes the last year of data (2018), Retro2 removes the last two years of data, Retro3 removes three years and Retro4 removes four years.

Label	Base	Retro1	Retro2	Retro3	Retro4
Female natural mortality	0.19	0.19	0.19	0.19	0.19
Steepness	0.72	0.72	0.72	0.72	0.72
lnR0	8.05	8.04	8.02	7.98	7.93
Total Unfished Biomass (mt)	2046.78	2021.95	1950.40	1864.26	1730.31
Depletion	0.44	0.39	0.37	0.35	0.32
SPR ratio	1.00	1.00	0.99	0.98	0.97
Female Lmin	13.42	13.19	12.78	12.70	12.52
Female Lmax	28.80	28.73	28.67	28.46	28.25
Female K	0.11	0.11	0.12	0.12	0.12
Negative log-likelihood					
TOTAL	530.10	507.41	494.56	484.87	472.75
Equilibrium catch	0.00	0.00	0.00	0.00	0.00
Survey	-34.06	-35.72	-34.67	-32.52	-32.50
Length composition	411.53	400.45	389.17	377.93	367.72
Age composition	147.06	136.61	133.40	132.14	130.62
Recruitment	5.58	6.07	6.67	7.32	6.90
Forecast Recruitment	0.00	0.00	0.00	0.00	0.00
Parameter priors	0.00	0.00	0.00	0.00	0.00

Table 31: Summaries of key assessment outputs and likelihood values from selected likelihood profile runs on virgin recruitment ( $\ln R_0$ ) and steepness. Depletion and SPR ratio are for the year 2019.

Label	R07500	R07750	R08000	R08250	R08500	h0390	h0550	h0710	h0850	tab:like_profiles h0990
Female M	0.19	0.19	0.19	0.19	0.19	0.27	0.23	0.21	0.20	0.20
Steepness	0.72	0.72	0.72	0.72	0.72	0.39	0.55	0.71	0.85	0.99
$\ln R_0$	7.50	7.75	8.00	8.25	8.50	9.71	9.02	8.62	8.39	8.23
Total unfished biomass (mt)	1136.52	1494.09	1948.53	2528.35	3313.95	4035.93	2872.00	2389.96	2158.79	2009.99
Depletion	0.38	0.37	0.42	0.51	0.59	0.38	0.43	0.46	0.48	0.49
SPR ratio	0.99	0.99	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00
Female Lmin	12.29	12.79	13.35	13.68	13.93	10.08	9.82	9.67	9.60	9.54
Female Lmax	27.47	28.25	28.78	28.67	28.23	28.74	28.55	28.45	28.38	28.34
Female K	0.14	0.12	0.11	0.11	0.12	0.10	0.12	0.12	0.13	0.13
Negative log-likelihood										
TOTAL	559.53	538.72	530.29	532.87	540.31	525.26	519.36	516.49	515.18	515.70
Catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Survey	-29.36	-30.94	-33.60	-35.55	-35.83	-30.36	-31.68	-32.16	-32.35	-32.46
Length_comp	414.22	412.12	411.34	413.52	417.35	373.67	372.78	372.47	372.35	372.29
Age_comp	154.09	146.67	146.61	149.75	152.41	191.65	190.34	189.60	189.18	188.88
Recruitment	20.58	10.87	5.94	5.14	6.38	-11.56	-12.69	-13.47	-13.94	-14.28
Parm_priors	0.00	0.00	0.00	0.00	0.00	1.85	0.60	0.04	-0.05	1.27
Parm_softbounds	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00

Table 32: Summaries of key assessment outputs and likelihood values from selected likelihood profile runs on female natural mortality and the growth parameter k. Depletion and SPR ratio are for the year 2019.

Label		M0140	M0180	M0220	M0260	M0300	K0070	K0110	K0150	K0200	K0250	tab:like_profiles2
Female M		0.14	0.18	0.22	0.26	0.30	0.19	0.19	0.19	0.19	0.19	
Steepness		0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	
InR0		7.61	8.16	8.70	9.25	9.80	8.06	8.05	8.03	7.99	7.96	
Total unfished biomass (mt)		2325.92	2290.85	2396.04	2613.52	2993.24	2049.72	2045.80	1992.79	1901.63	1856.94	
Depletion		0.32	0.40	0.47	0.54	0.59	0.40	0.44	0.46	0.47	0.49	
SPR ratio		0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Female Lmin		9.43	9.57	9.69	9.76	9.76	13.94	13.37	12.39	10.73	9.71	
Female Lmax		27.91	28.09	28.51	28.92	29.46	29.87	28.73	27.92	27.29	26.62	
Female K		0.18	0.15	0.12	0.09	0.07	0.07	0.11	0.15	0.20	0.25	
Negative log-likelihood												
TOTAL		520.87	517.09	516.39	517.29	518.96	531.89	530.11	532.03	536.74	542.96	
Catch		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Survey		-31.78	-32.25	-32.13	-31.84	-31.48	-34.86	-33.97	-32.58	-30.84	-29.45	
Length_comp		373.35	372.68	372.45	372.59	372.88	411.36	411.62	413.73	416.31	418.00	
Age_comp		191.76	189.93	189.56	189.86	190.58	149.97	146.86	144.62	144.22	146.40	
Recruitment		-12.73	-13.28	-13.54	-13.57	-13.53	5.43	5.61	6.26	7.04	8.01	
Parm_priors		0.27	0.01	0.04	0.23	0.51	0.00	0.00	0.00	0.00	0.00	
Parm_softbounds		0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	

<sub>2096</sub> **8 Figures**

**figures**

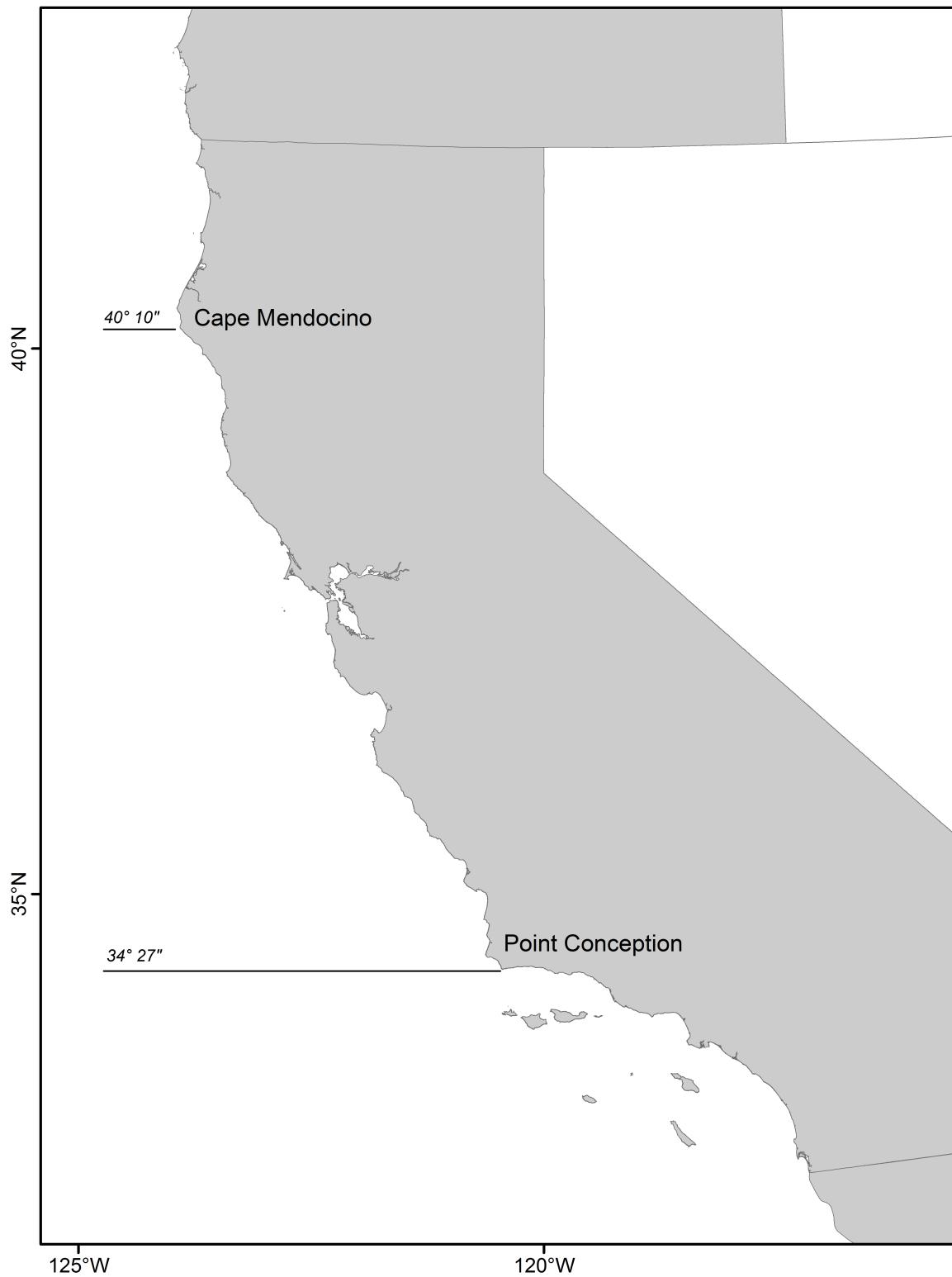


Figure 1: Map showing the management area for gopher and black-and-yellow rockfish from Cape Mendocino to the U.S.-Mexico border. fig:assess\_region\_map1

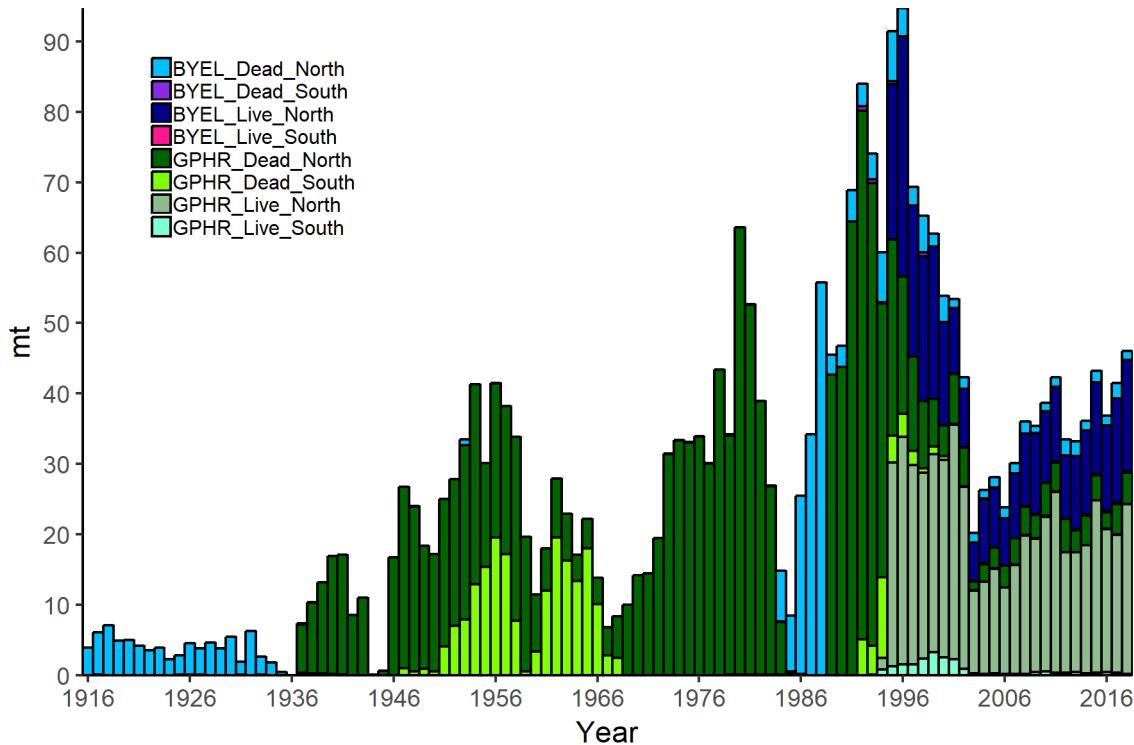


Figure 2: Commercial landings for gopher (GPHR) and black-and-yellow (BYEL) rockfishes landed live and dead north and south of Point Conception. All catch time series were combined for the assessment into one commercial fleet. fig:Catches\_livedeadNS\_gby

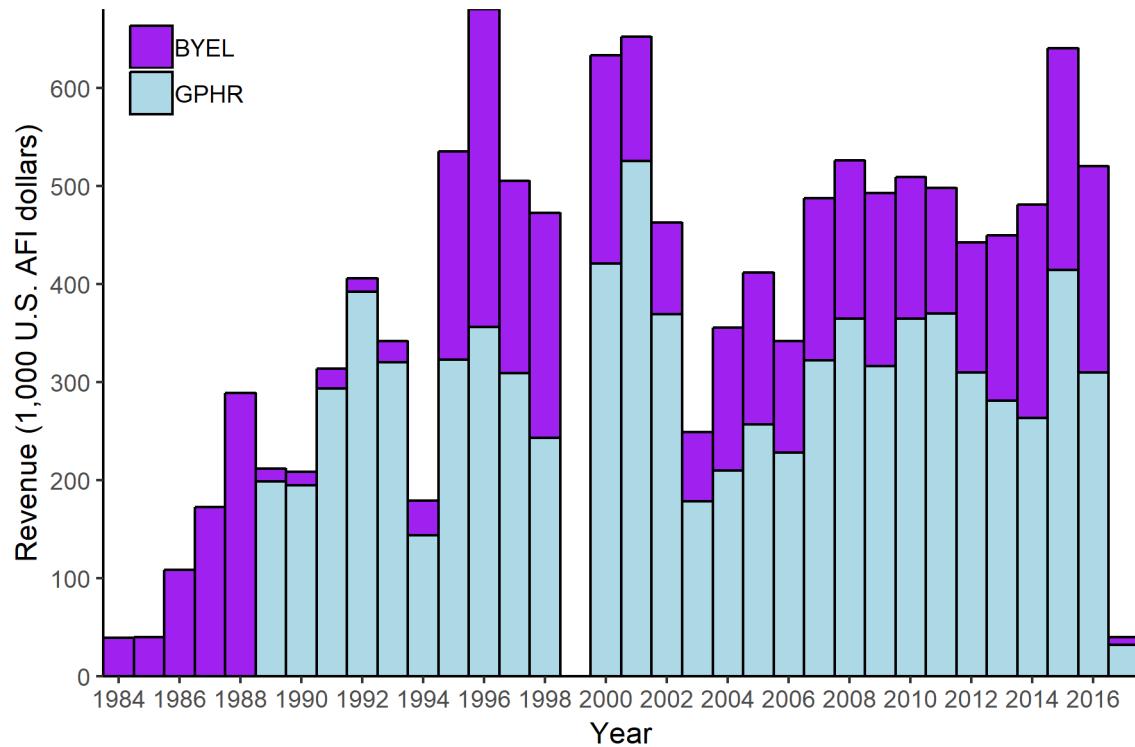


Figure 3: Annual ex-vessel revenue, adjusted for inflation (AFI) in thousands of dollars for gopher and black-and-yellow rockfish. [fig:GBY\\_revenue](#)

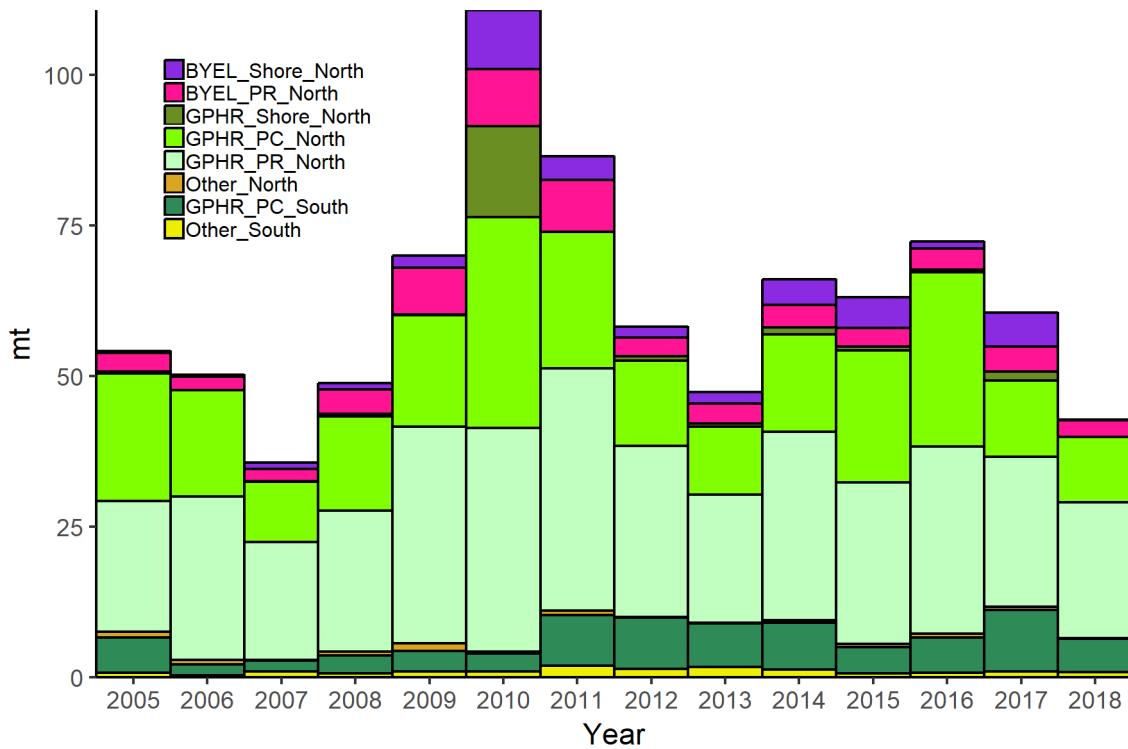


Figure 4: Recreational total mortality for gopher rockfish (GPHR) and black-and-yellow (BYEL) rockfish from the CDFW CRFS sampling era by mode and split north and south of Point Conception. fig:CRFS\_catches

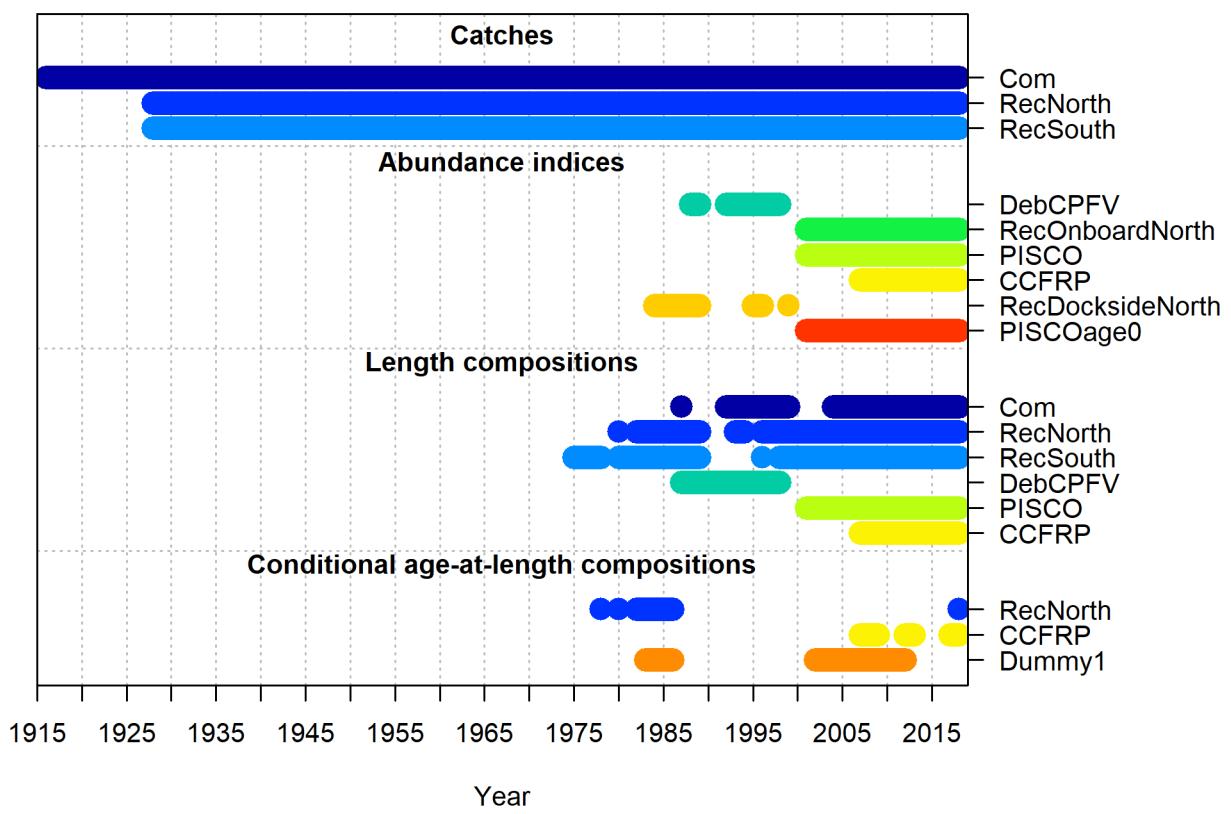


Figure 5: Summary of data sources used in the model. `fig: data_plot`

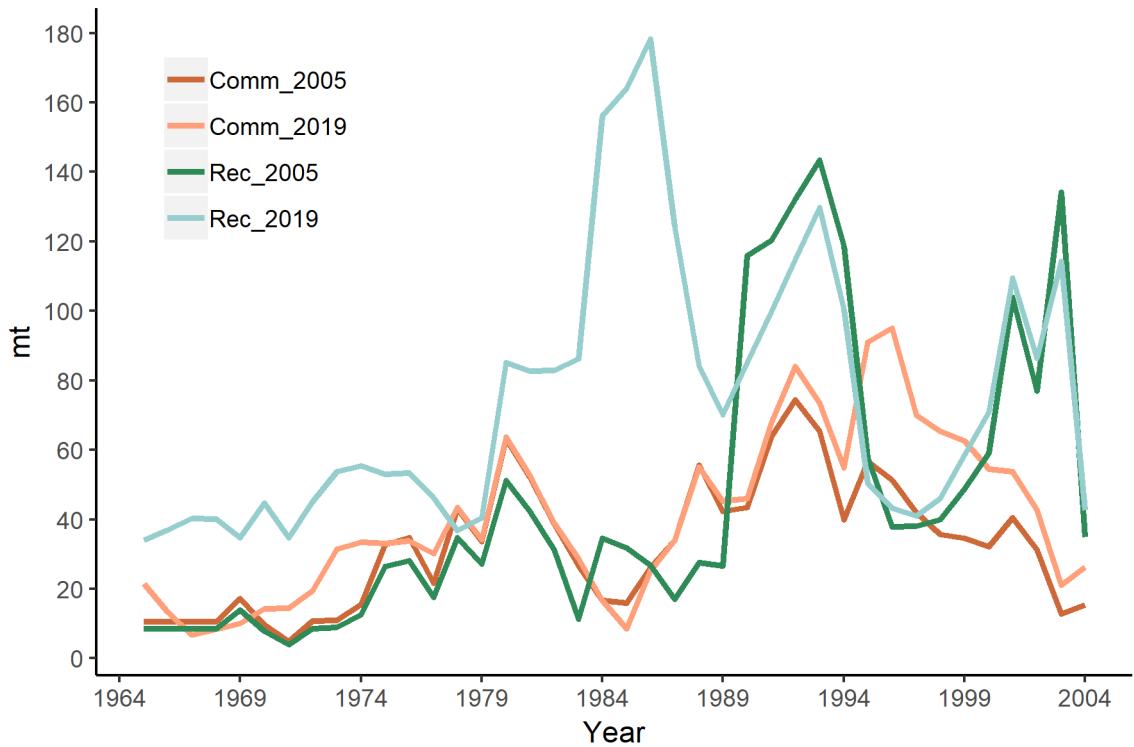


Figure 6: Comparison of the recreational and commercial fishery landings from the 2005 assessment to this 2019 assessment. Note that the 2019 assessment includes both gopher and black-and-yellow rockfish where the 2005 assessment represents gopher rockfish only. The 2005 assessment also did not include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

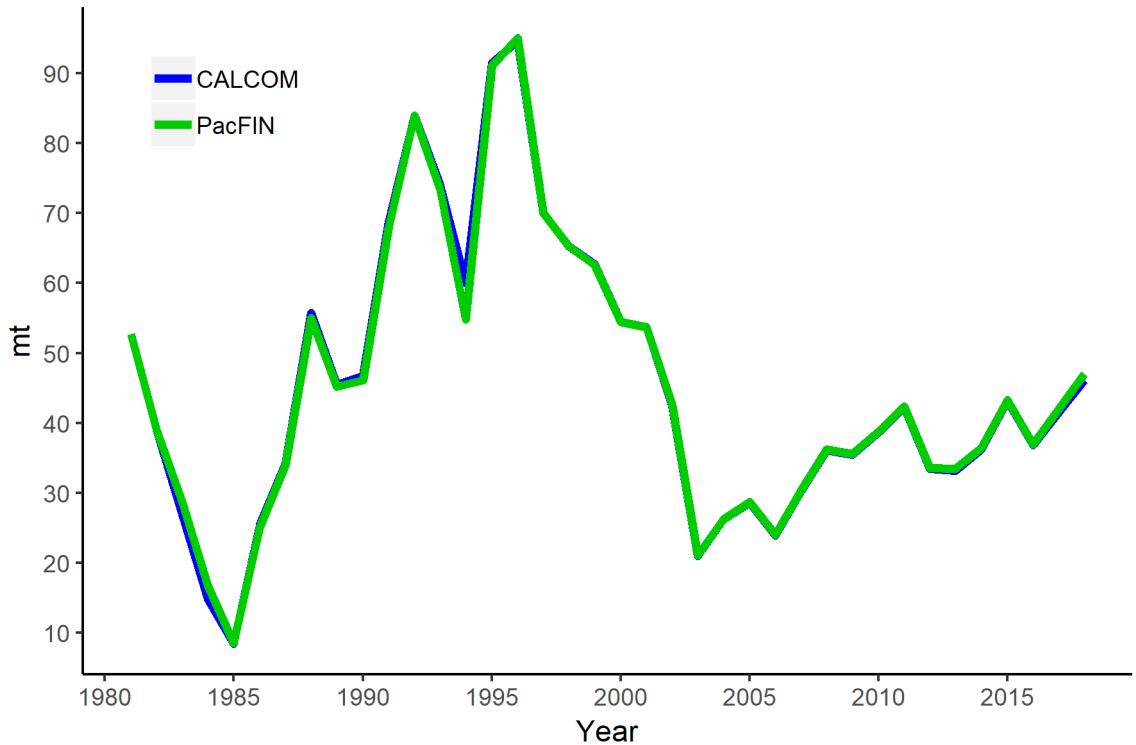


Figure 7: Commercial landings estimates from CALCOM and PacFIN. fig:Calcom\_vs\_Pacfinc

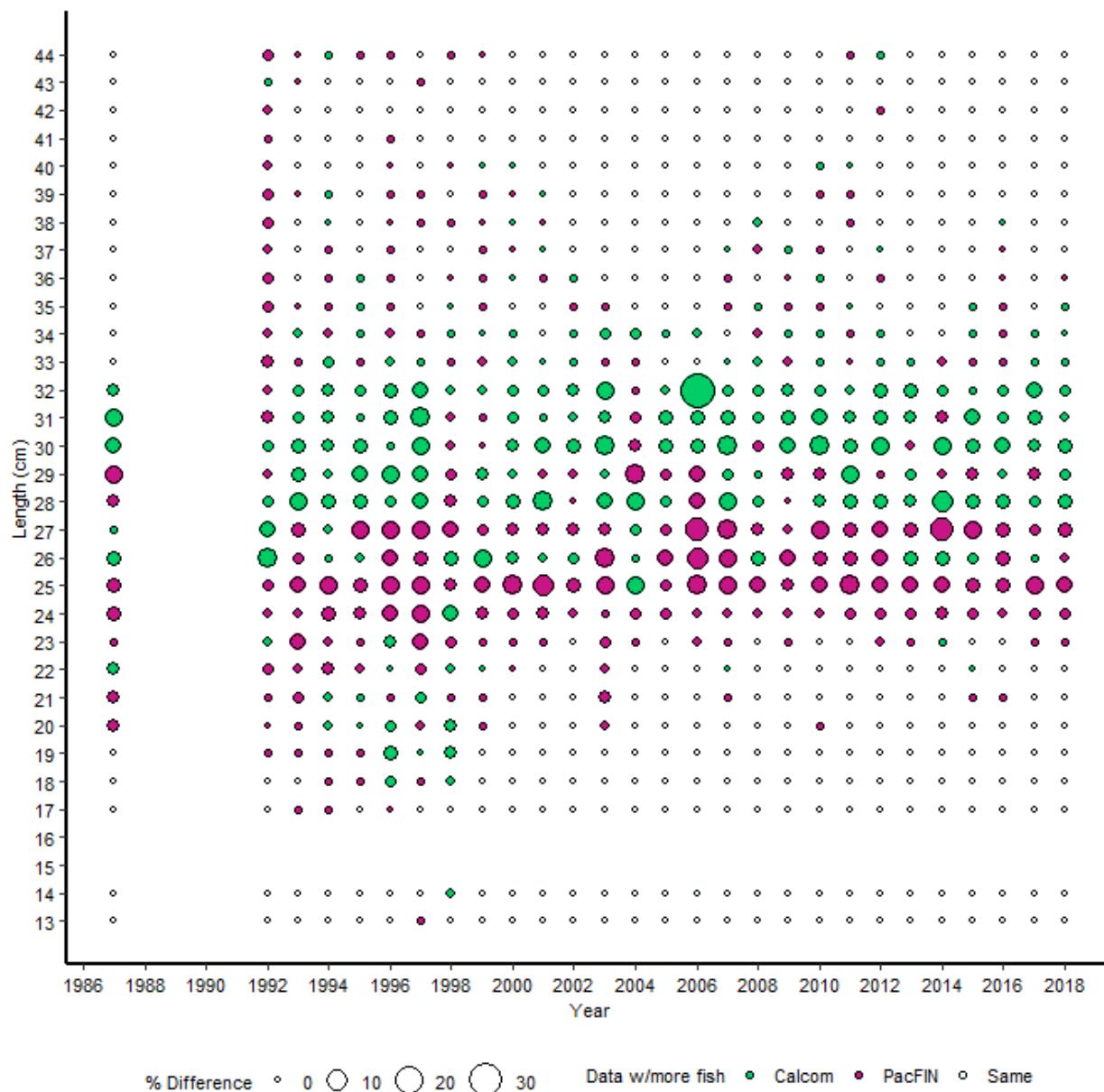


Figure 8: Percent differences in the expanded length compositions by year from CALCOM and PacFIN. The same market categories were used for each dataset, but each database was subject to further independent filtering criteria and expansion algorithms. [fig:Calcom\\_vs\\_pacfin\\_length](#)

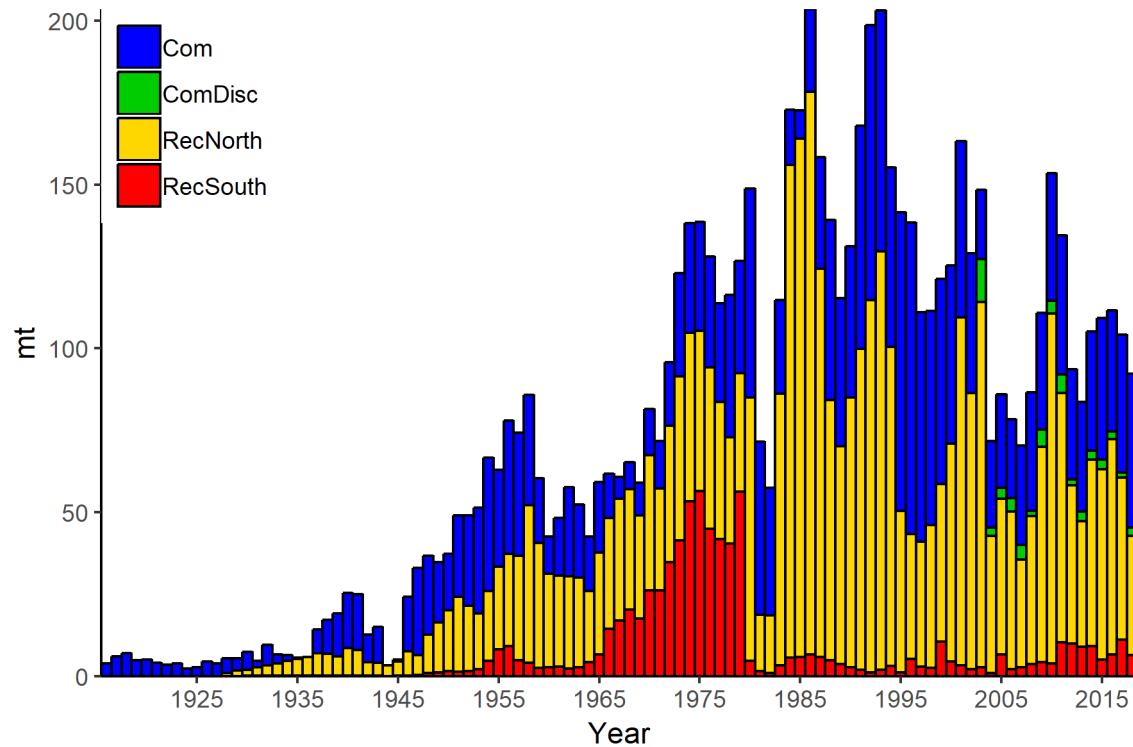


Figure 9: Commercial and recreational landings estimates prior to any data modification or interpolation to the recreational catches or hindcasting of commercial discards. [fig:Catches\\_original](#)

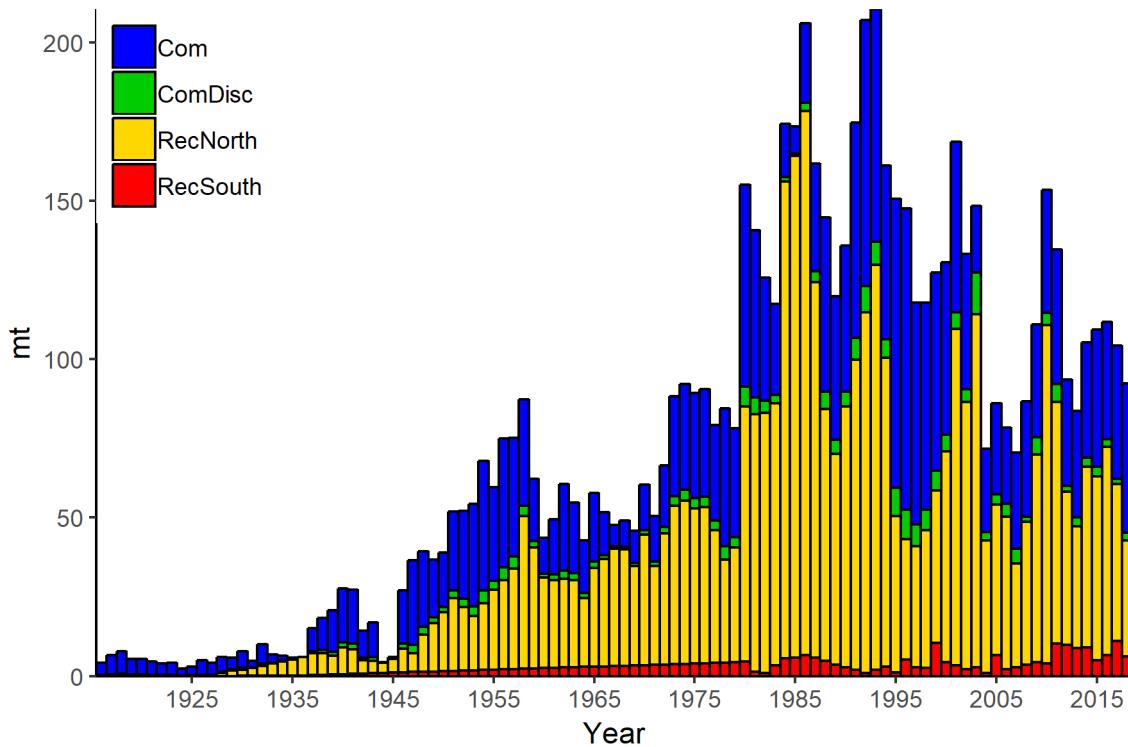


Figure 10: Commercial and recreational landings estimates after data modification and interpolations were made to the recreational catches and commercial discards. [fig:Catches\\_alternate](#)

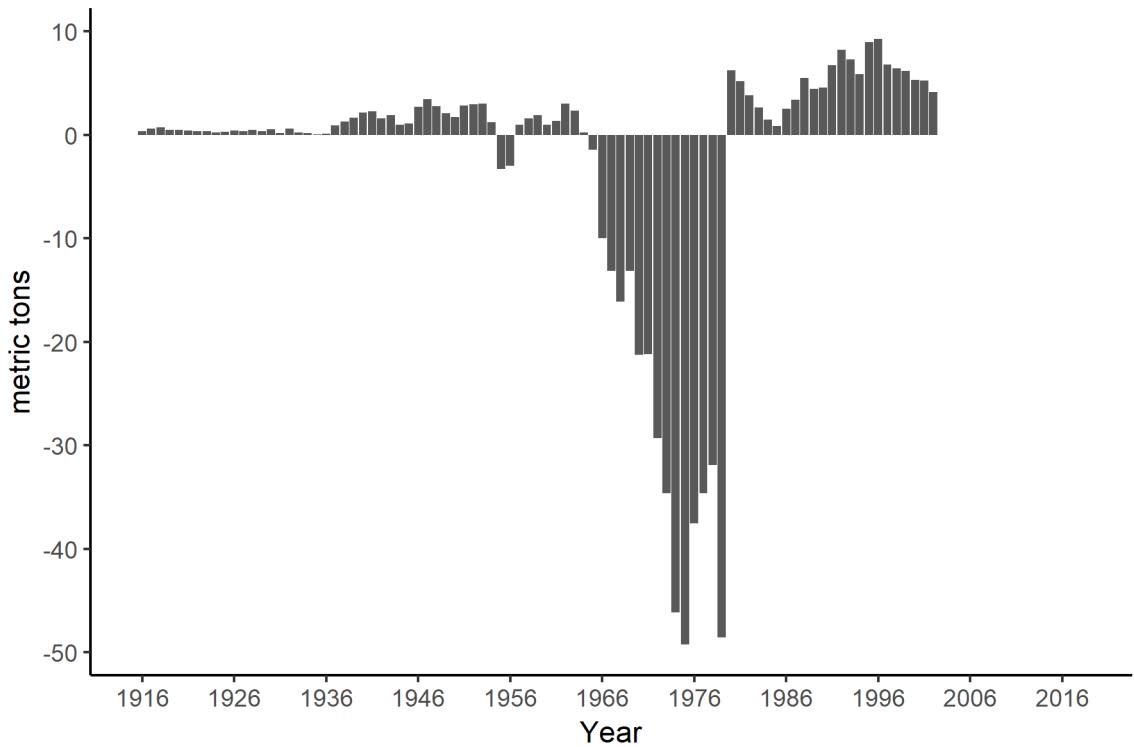


Figure 11: Difference in landings between the original and modified landings presented in the previous two figures. The only two fleets with modifications are recreational south and commercial discards. Negative values indicate catches removed from the original estimates and positive values represent the addition of landings from the commercial dicard fleet. [fig:catches\\_diff](#)

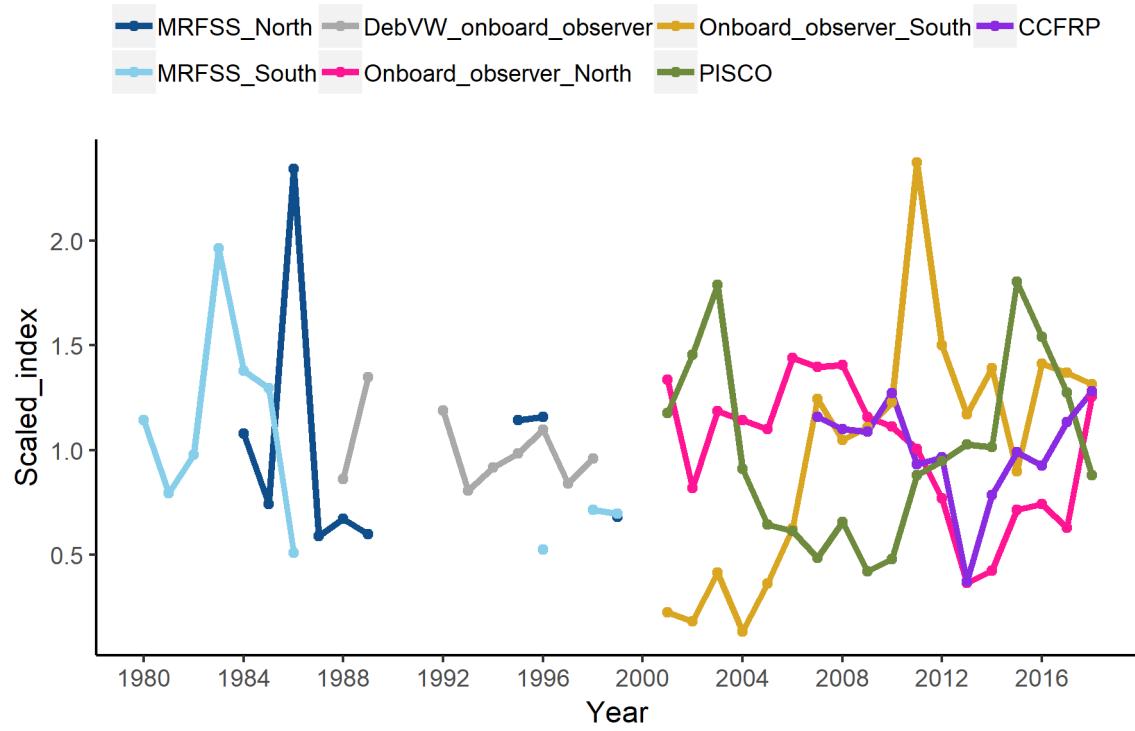


Figure 12: Comparison of all indices of abundance in the pre-STAR base model (with each index scaled to its mean). [fig:All\\_index\\_compare](#)

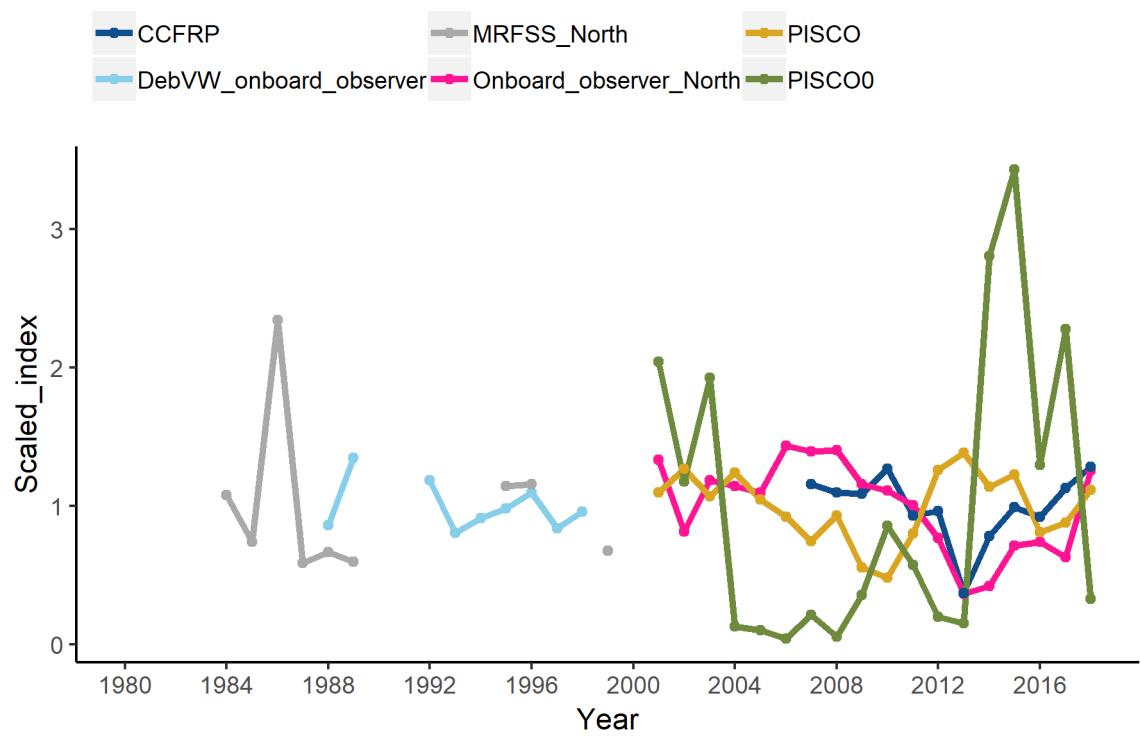


Figure 13: Comparison of all indices of abundance in the post-STAR base model (with each index scaled to its mean). [fig:All\\_index\\_compare\\_postSTAR](#)

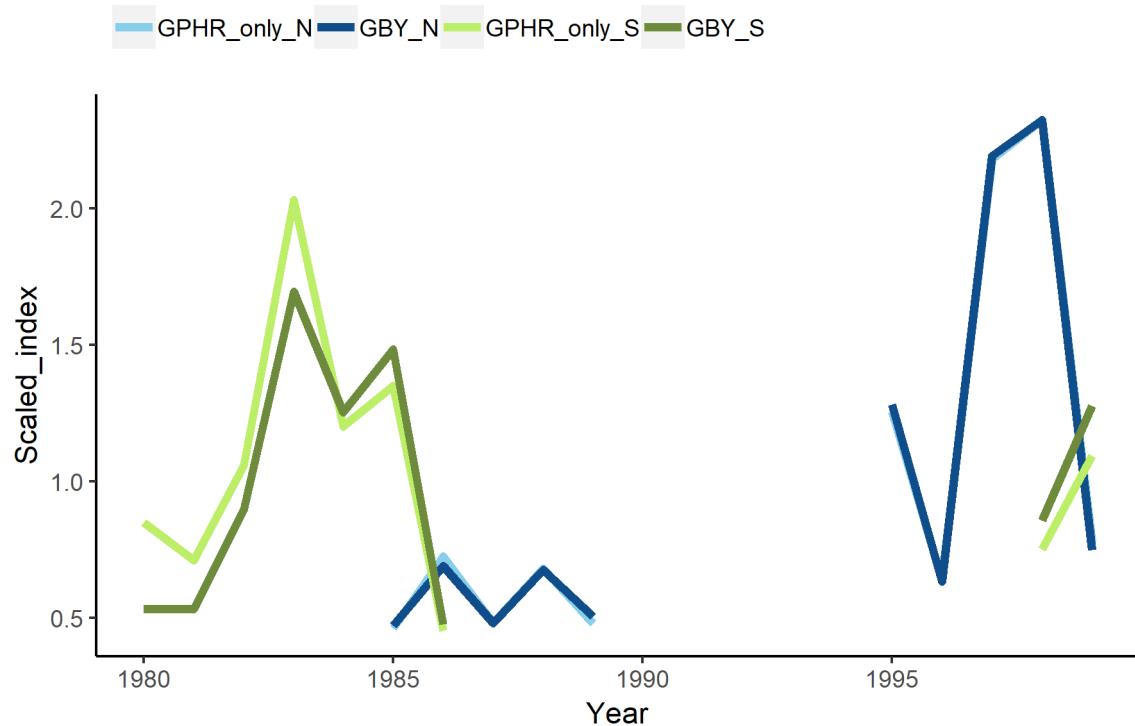


Figure 14: Comparison of indices of abundance (scaled to their means) for the MRFSS dockside CPFV survey between a gopher-only and GBYR complex index for north and south of Point Conception. [fig:MRFSS\\_index\\_compare](#)

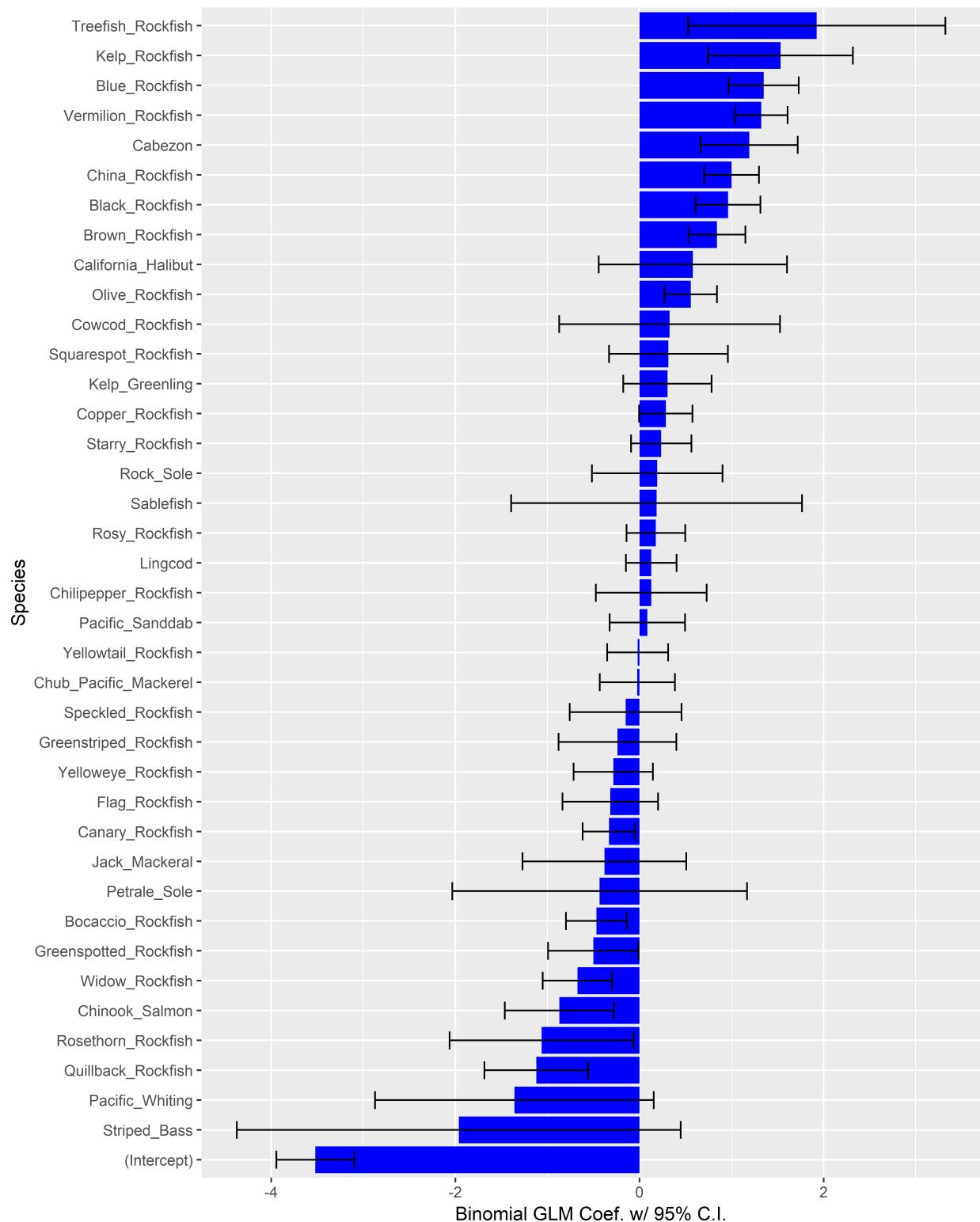


Figure 15: Species coefficients from the binomial GLM for presence/absence of GBYR in the Marine Recreational Fisheries Statistics Survey (MRFSS) CPFV mode dockside survey data set north of Point Conception. Horizontal bars are 95% confidence intervals. | [fig:Fleet10\\_SM\\_filter](#)

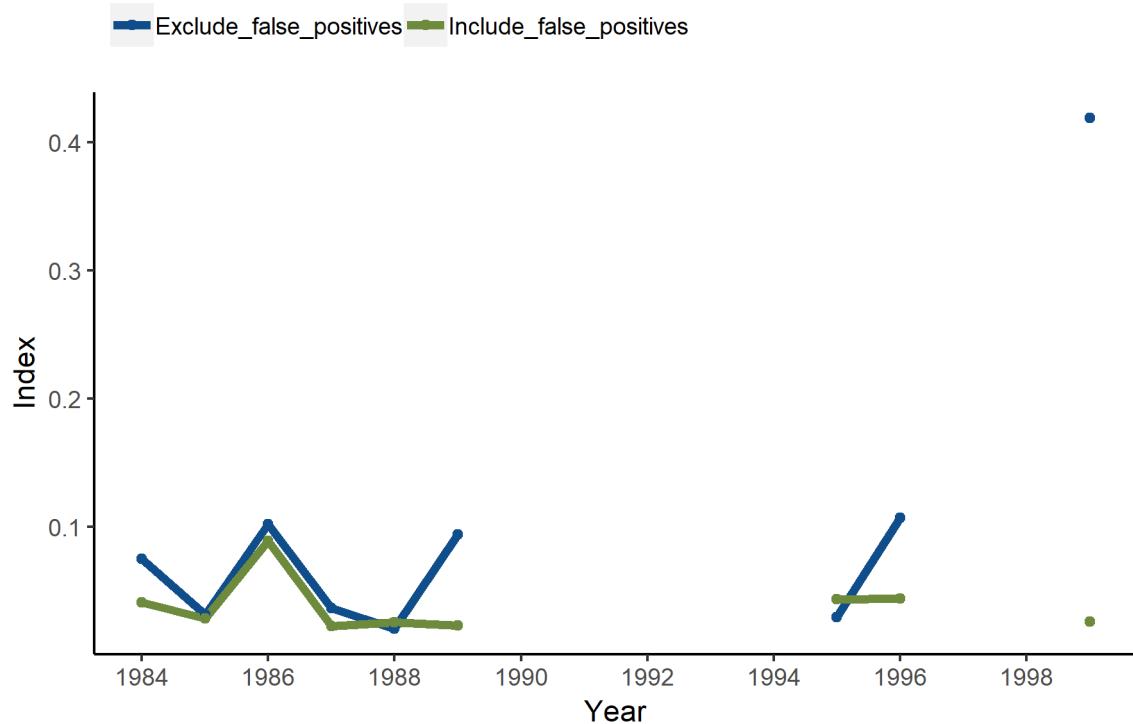


Figure 16: Comparisons of the indices of abundance for GBYR north of Point Conception from the MRFSS dockside CPFV survey that either include or exclude the trips identified as false positives from the Stephens-MacCall filter. fig:MRFSS\_index\_N\_SM\_falsepos

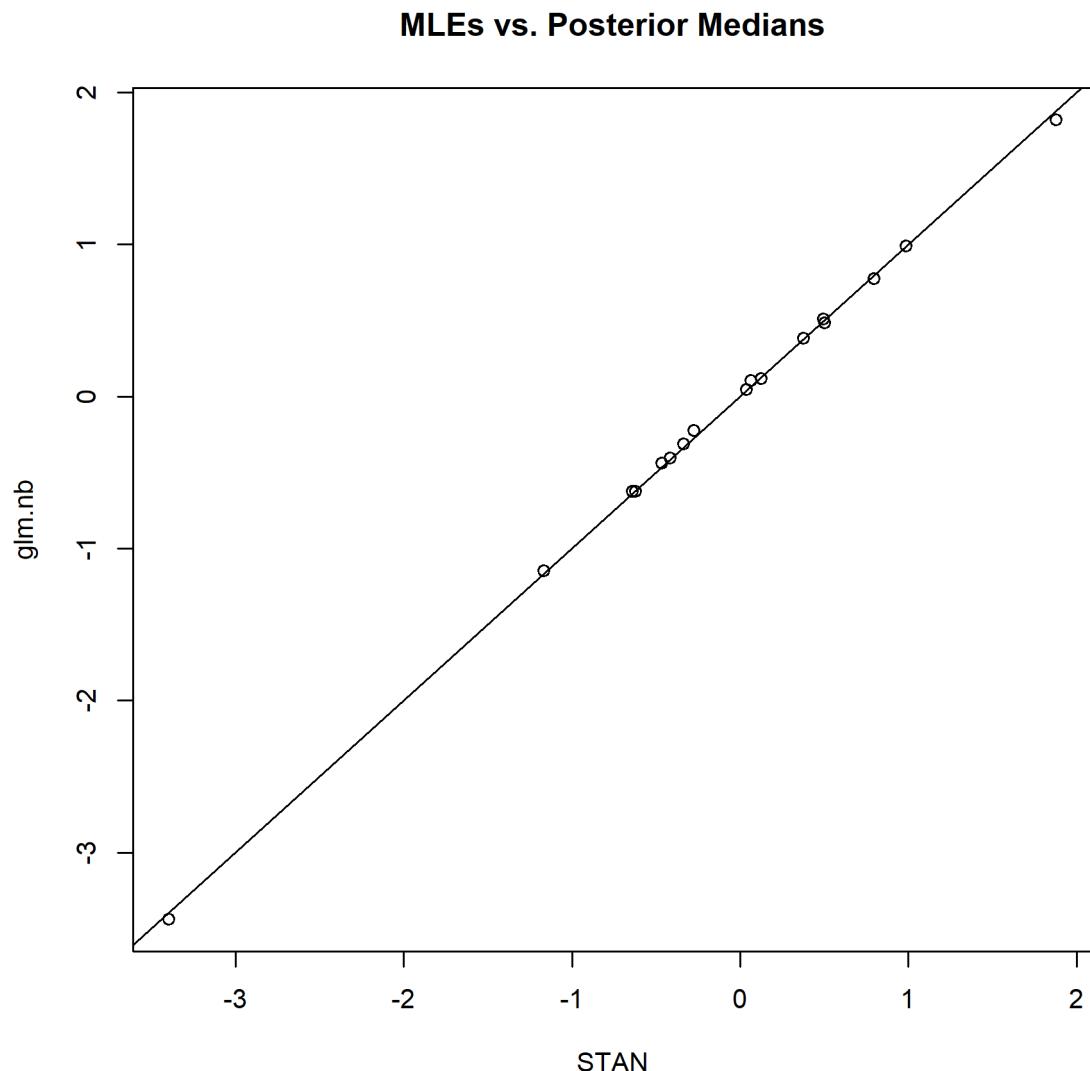


Figure 17: Comparison of negative binomial predictions (CPUE) to observed means in each stratum (year). MRFSS CPFV dockside index north of Point Conception. The 1:1 plot is for reference. fig:Fleet10\_MLE\_stan

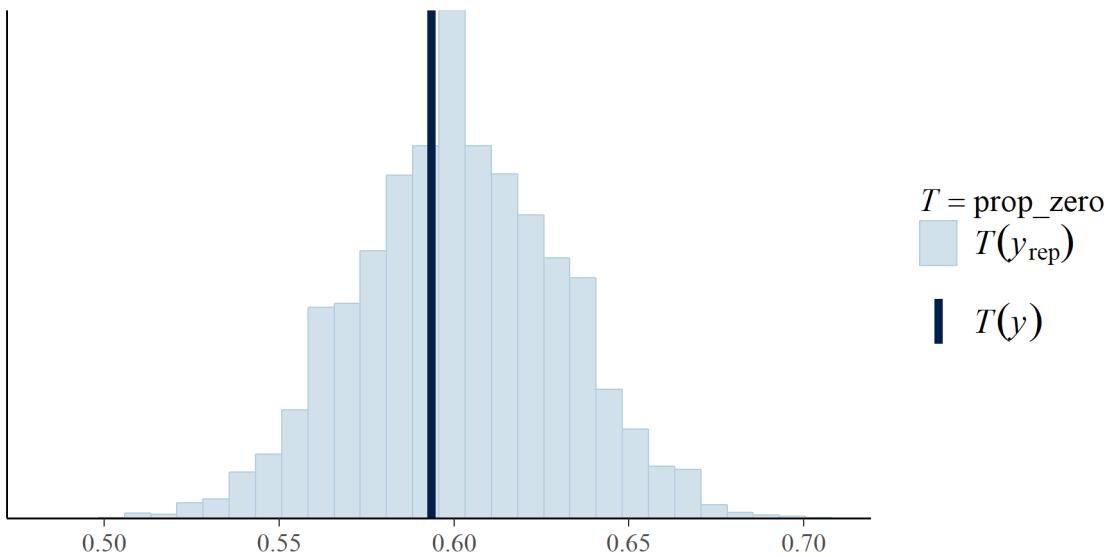


Figure 18: Posterior predictive distribution of the proportion of zero observations in replicate data sets generated by the negative binomial model for MRFSS dockside CPFV index north of Point Conception. [fig:Fleet10\\_prop\\_zero\\_STAN](#)

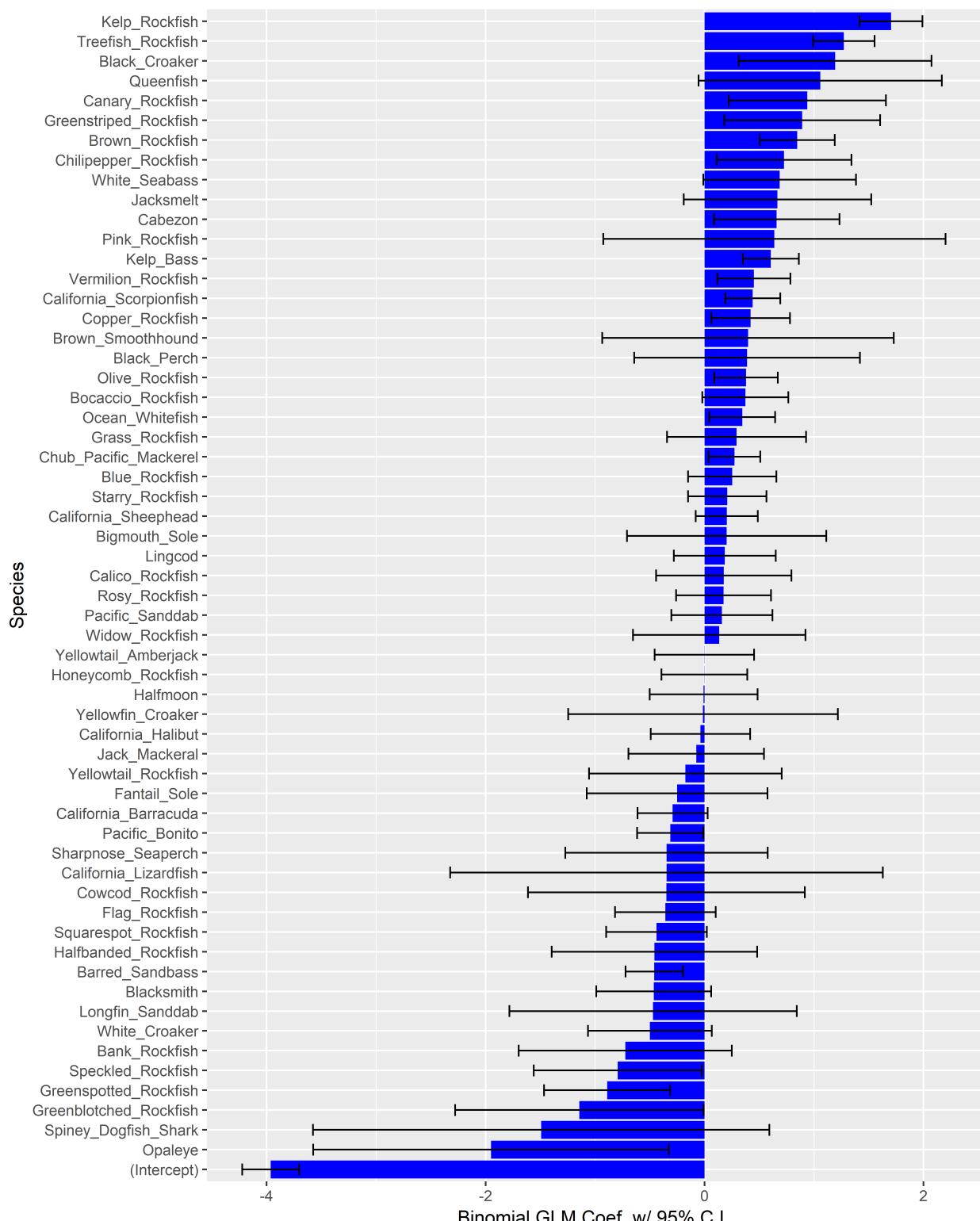


Figure 19: Species coefficients from the binomial GLM for presence/absence of GBYR in the Marine Recreational Fisheries Statistics Survey (MRFSS) CPFV mode dockside survey data set north of Point Conception. Horizontal bars are 95% confidence intervals. | [fig:Fleet11\\_SM\\_filter](#)

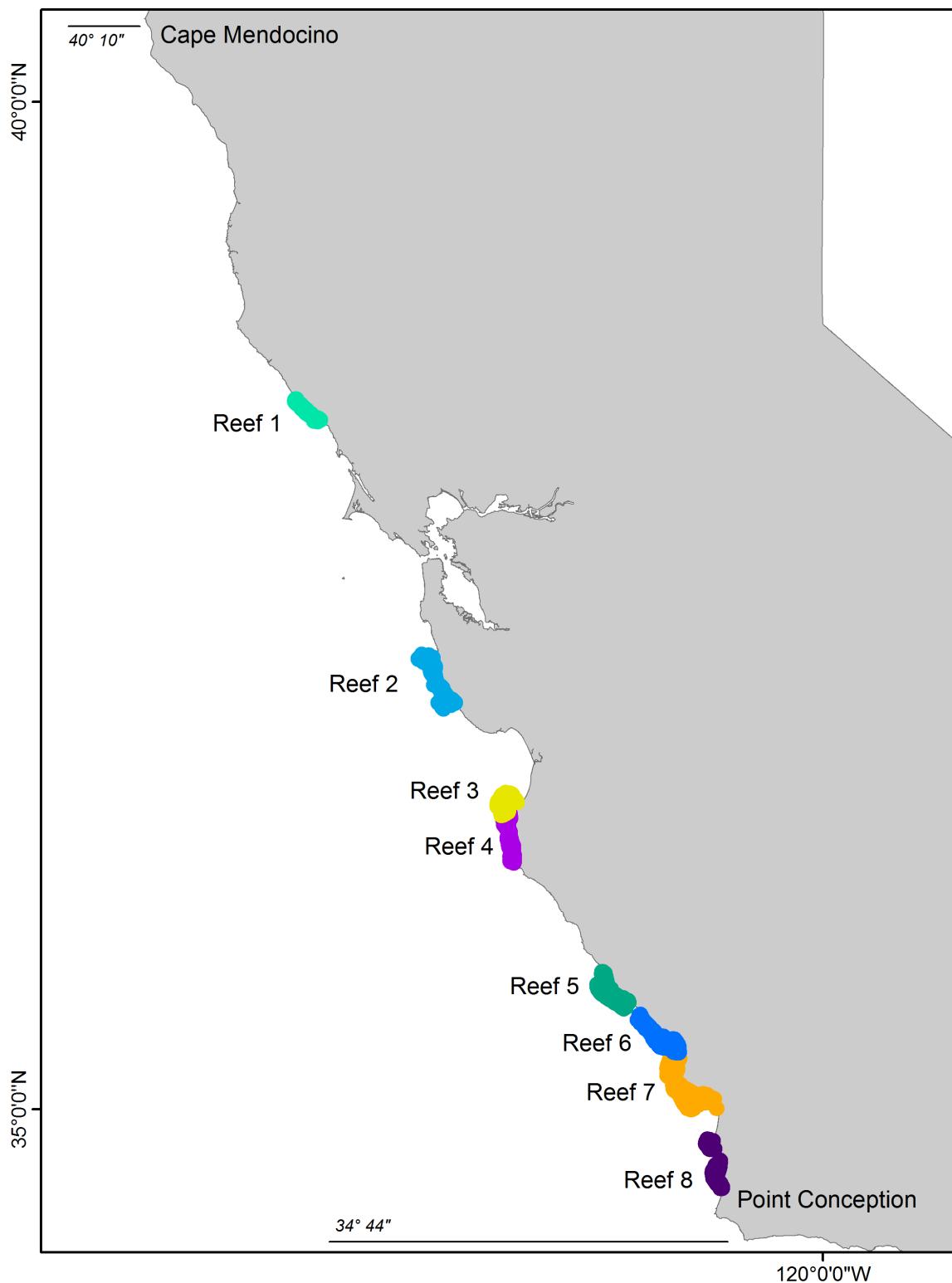


Figure 20: Map of the reefs used in the Deb Wilson-Vandenberg CPFV onboard observer survey index of abundance. [fig:DebWV\\_sites](#)

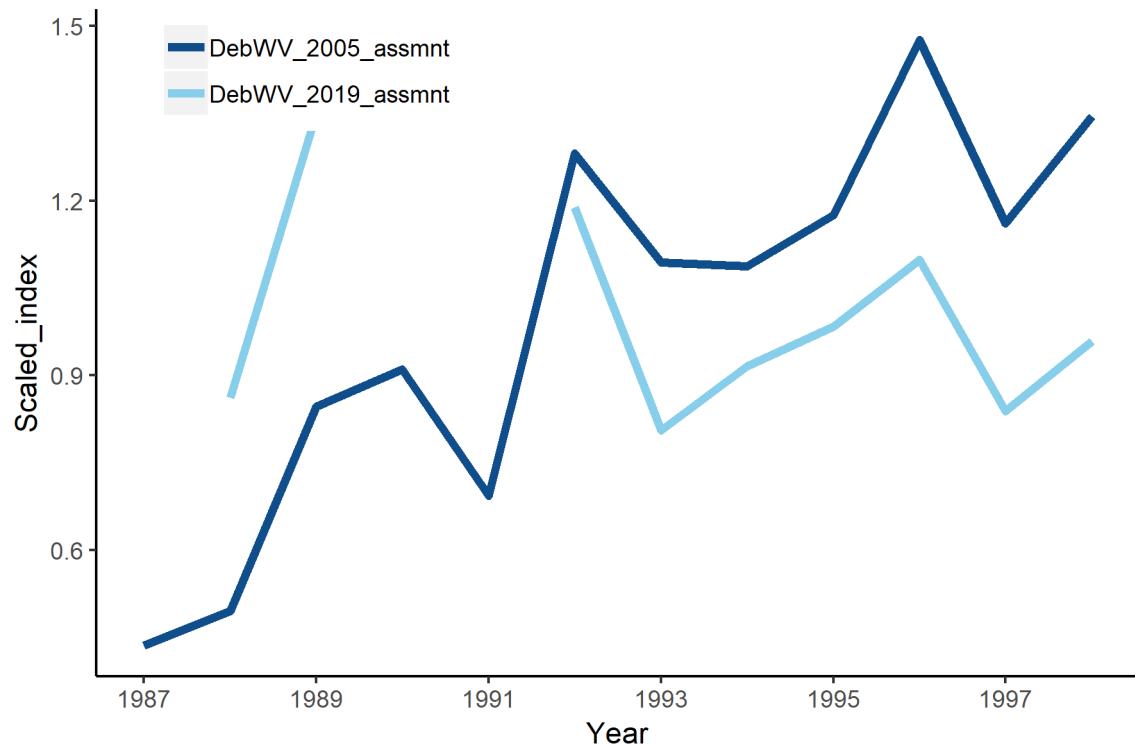


Figure 21: Comparison of the index developed for the Deb Wilson-Vandenberg CPFV onboard observer survey from the 2005 assessment and for the 2019 assessment. fig:DebWV\_index\_compare

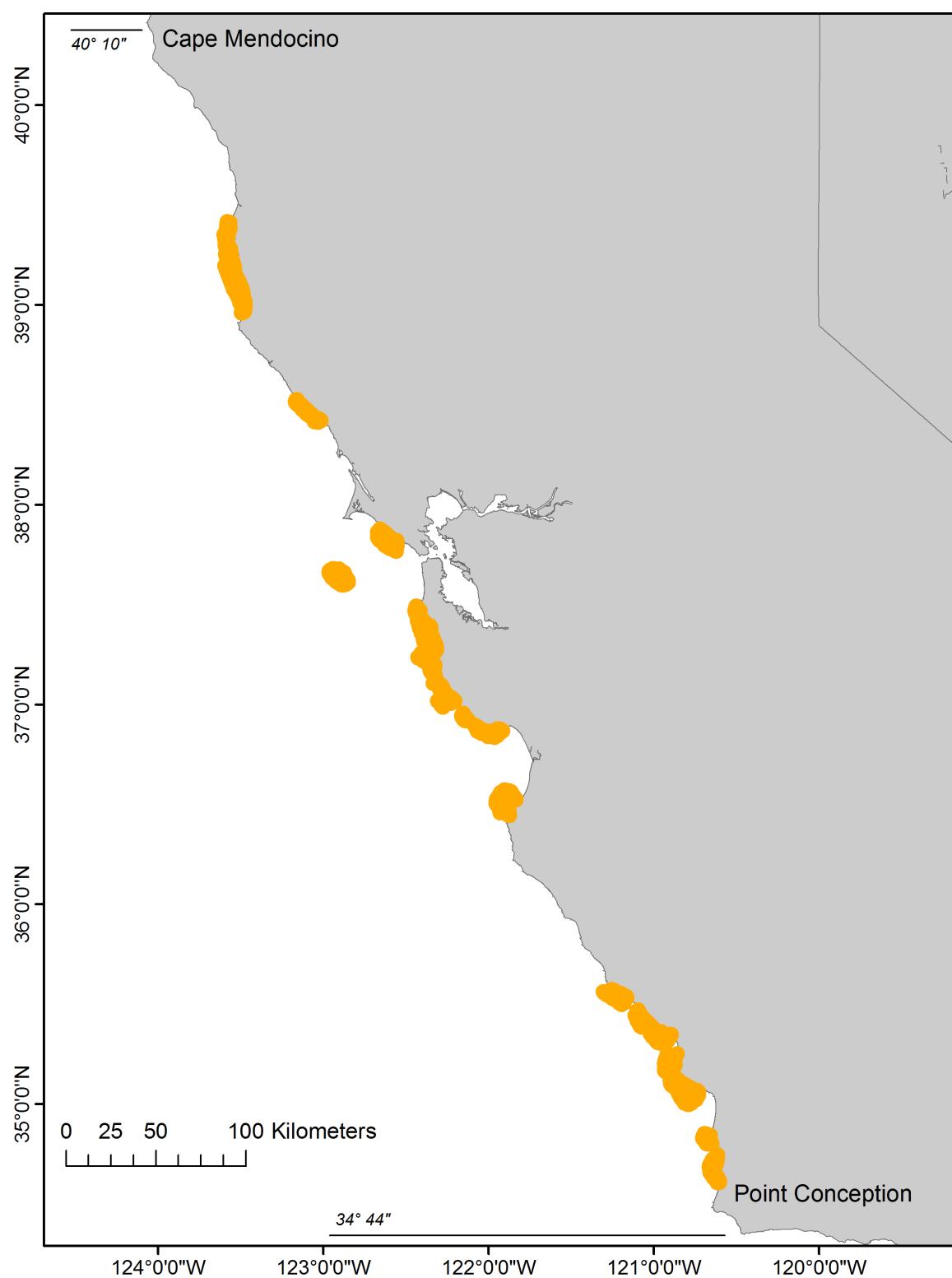


Figure 22: Map of the reefs selected for the final index for the onboard observer surveys (CDFW and Cal Poly) north of Point Conception

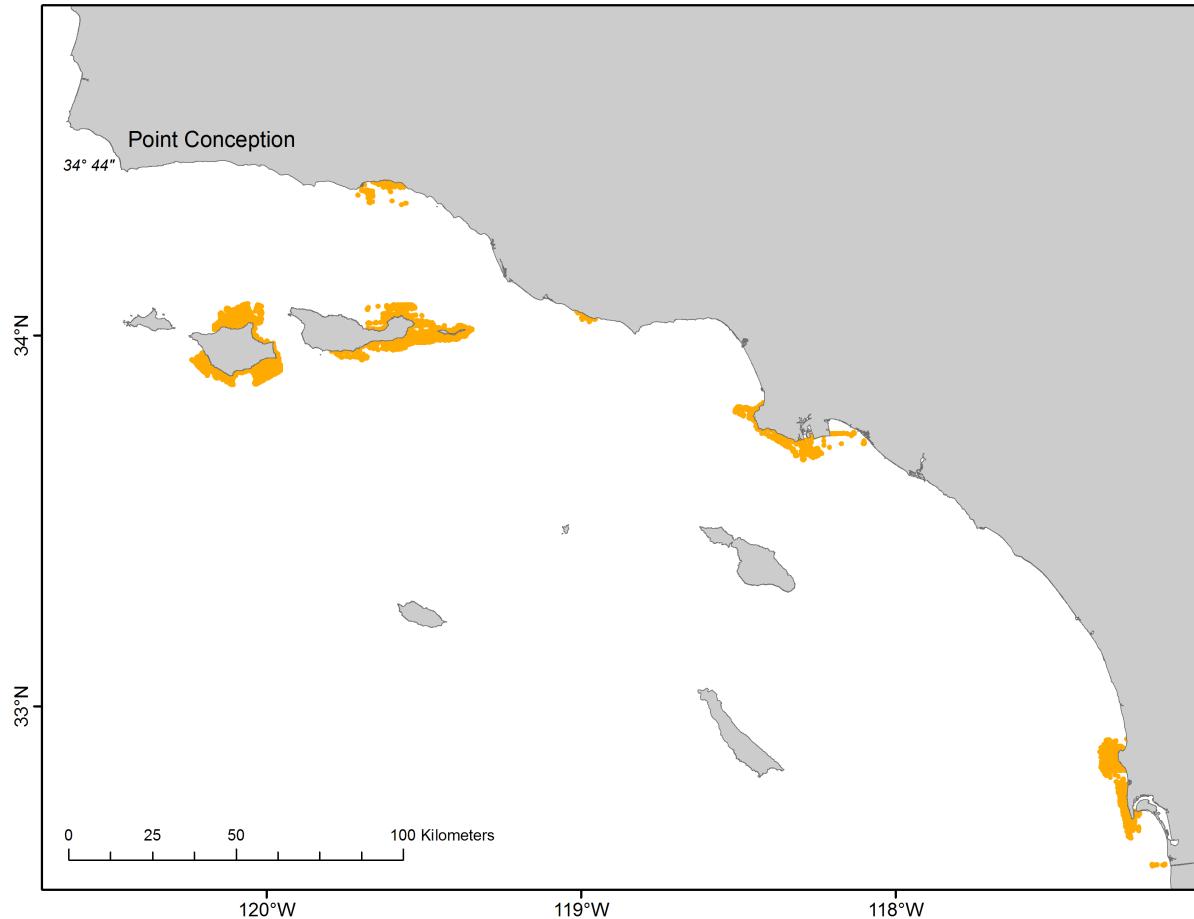


Figure 23: Map of the reefs selected for the final index for the CDFW onboard observer survey south of Point Conception

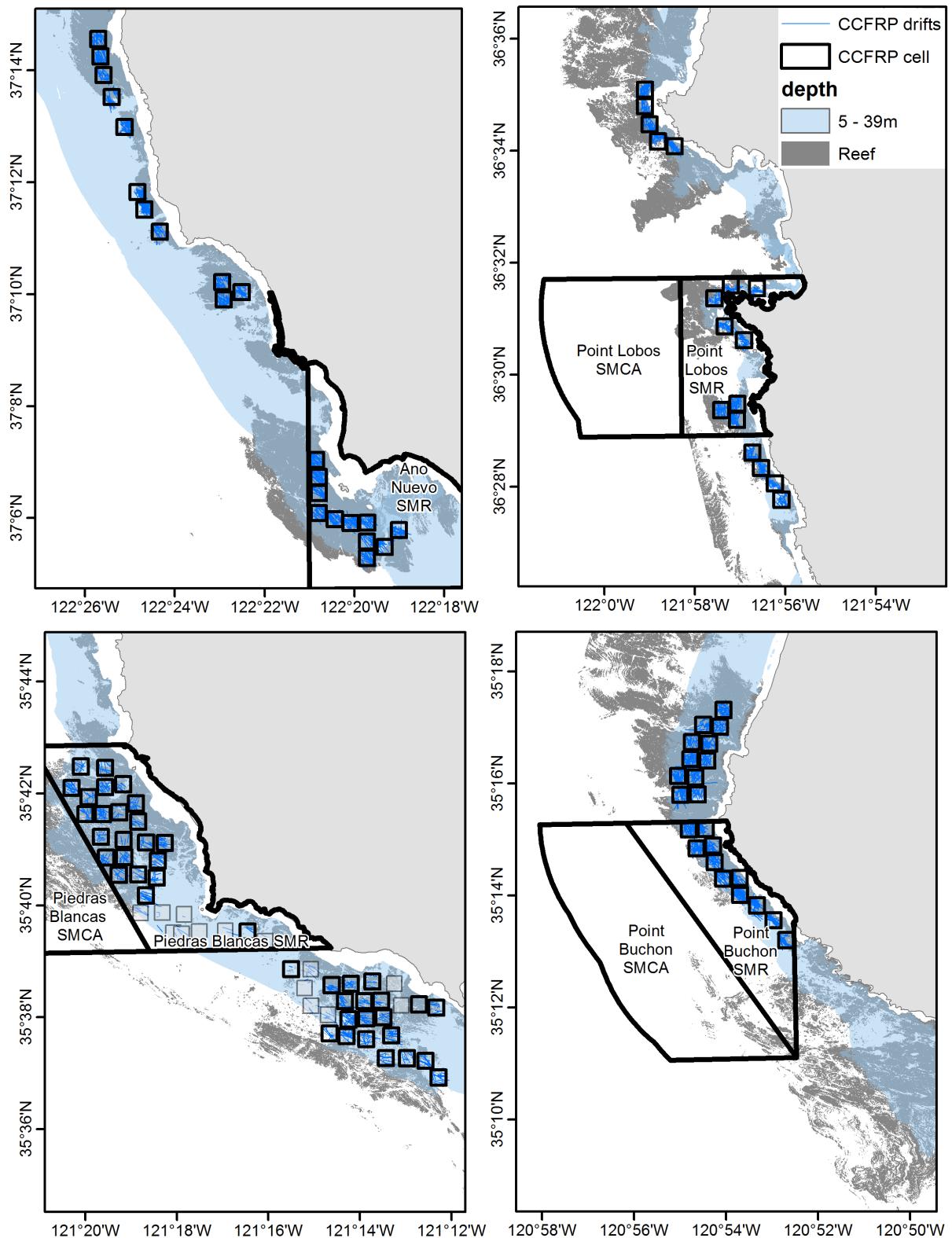


Figure 24: Map of the four MPAs sampled consistently through time for the CCFRP fishery-independent survey. [fig:CCFRP\\_sites](#)

### MLEs vs. Posterior Medians

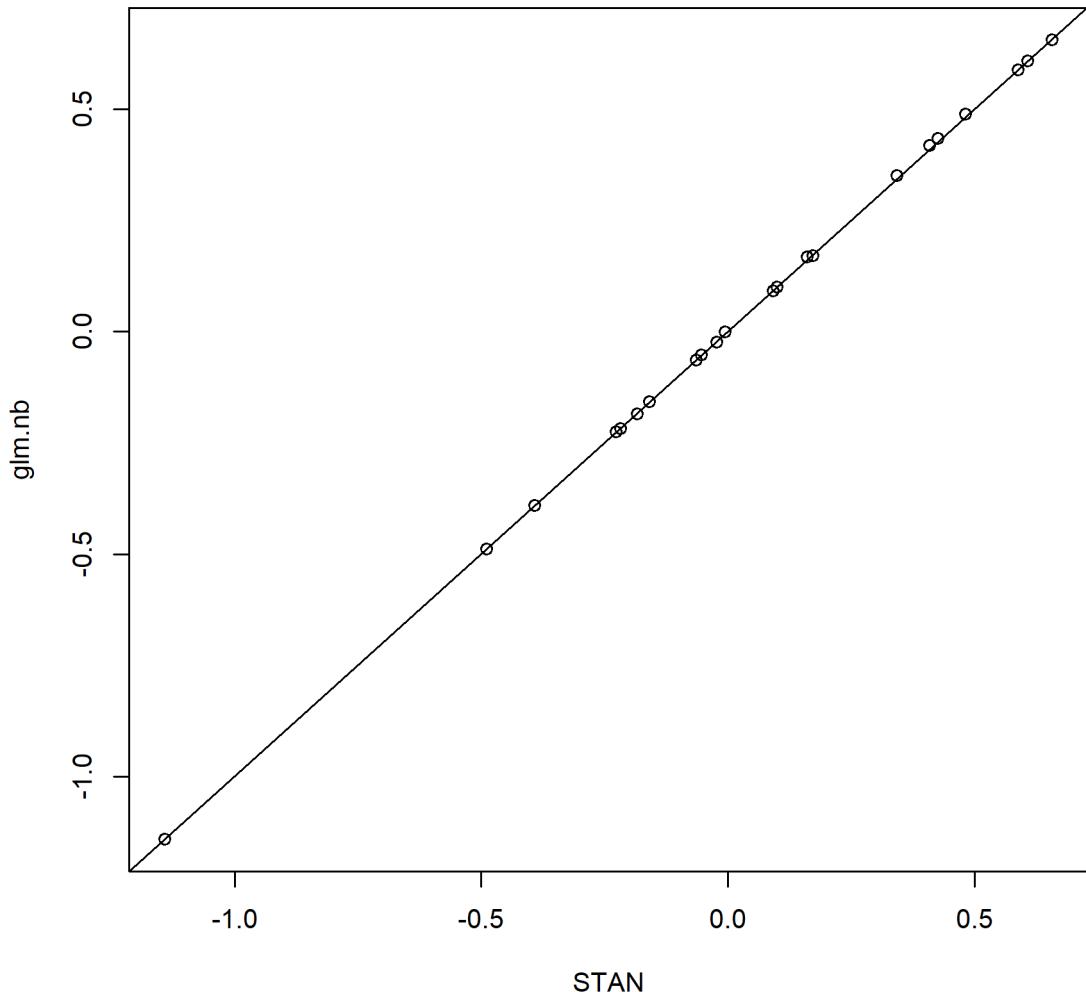


Figure 25: Comparison of negative binomial predictions (CPUE) to observed means in each stratum (year) for the CCFRP index. The 1:1 plot is for reference. [fig:Fleet9\\_MLE\\_stan](#)

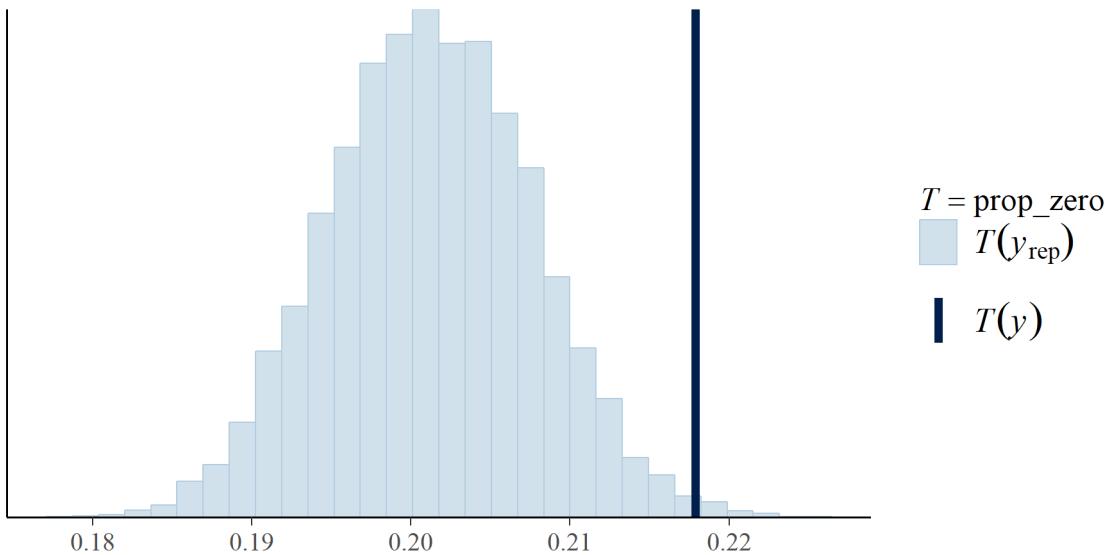


Figure 26: Posterior predictive distribution of the proportion of zero observations in replicate data sets generated by the negative binomial model for the CCFRP index. [fig:Fleet9\\_prop\\_zero\\_STAN](#)

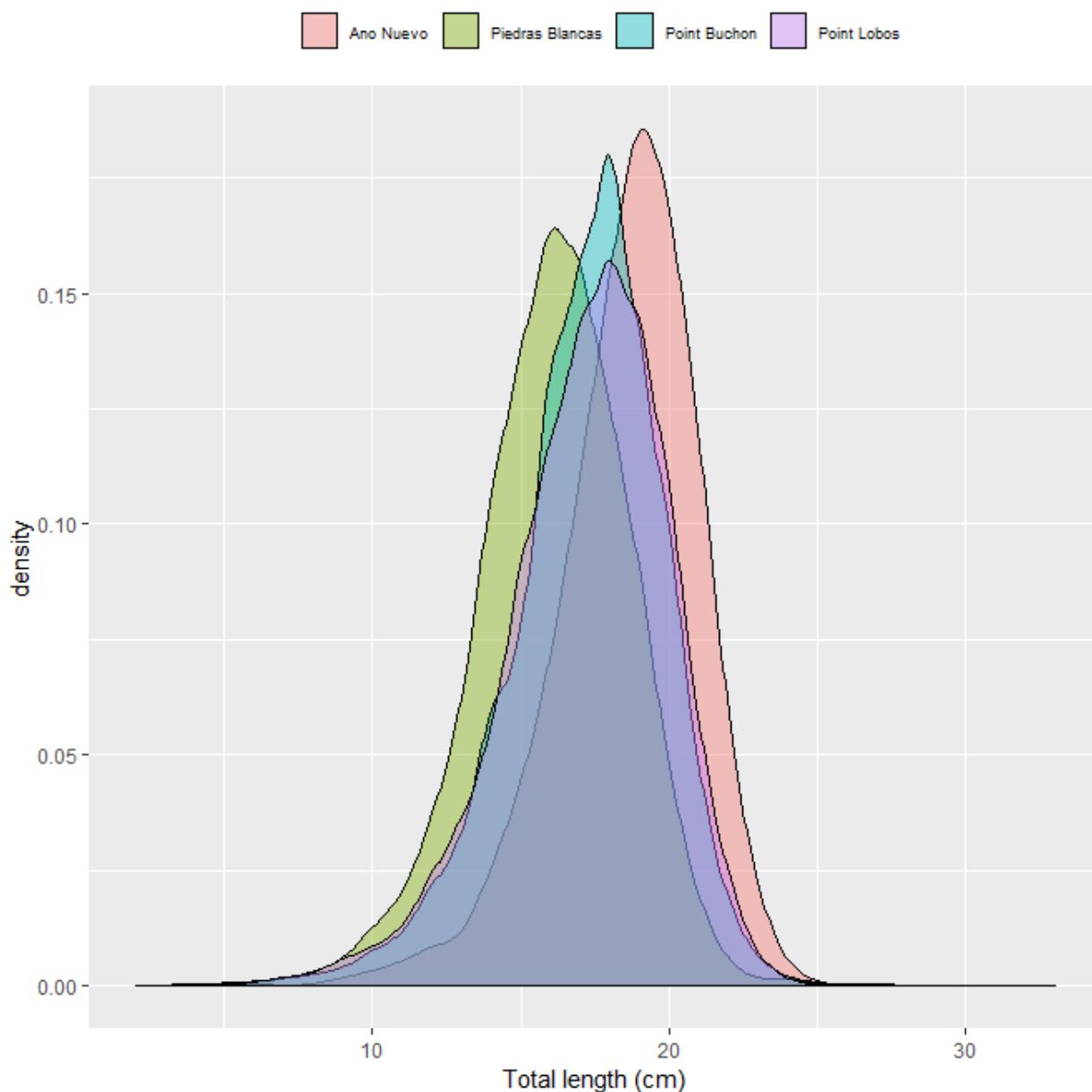


Figure 27: Length distributions of GBYR for the four MPAs sampled by the CCFRP survey used in this assessment. | [CCFRP\\_lengths\\_by\\_site](#)

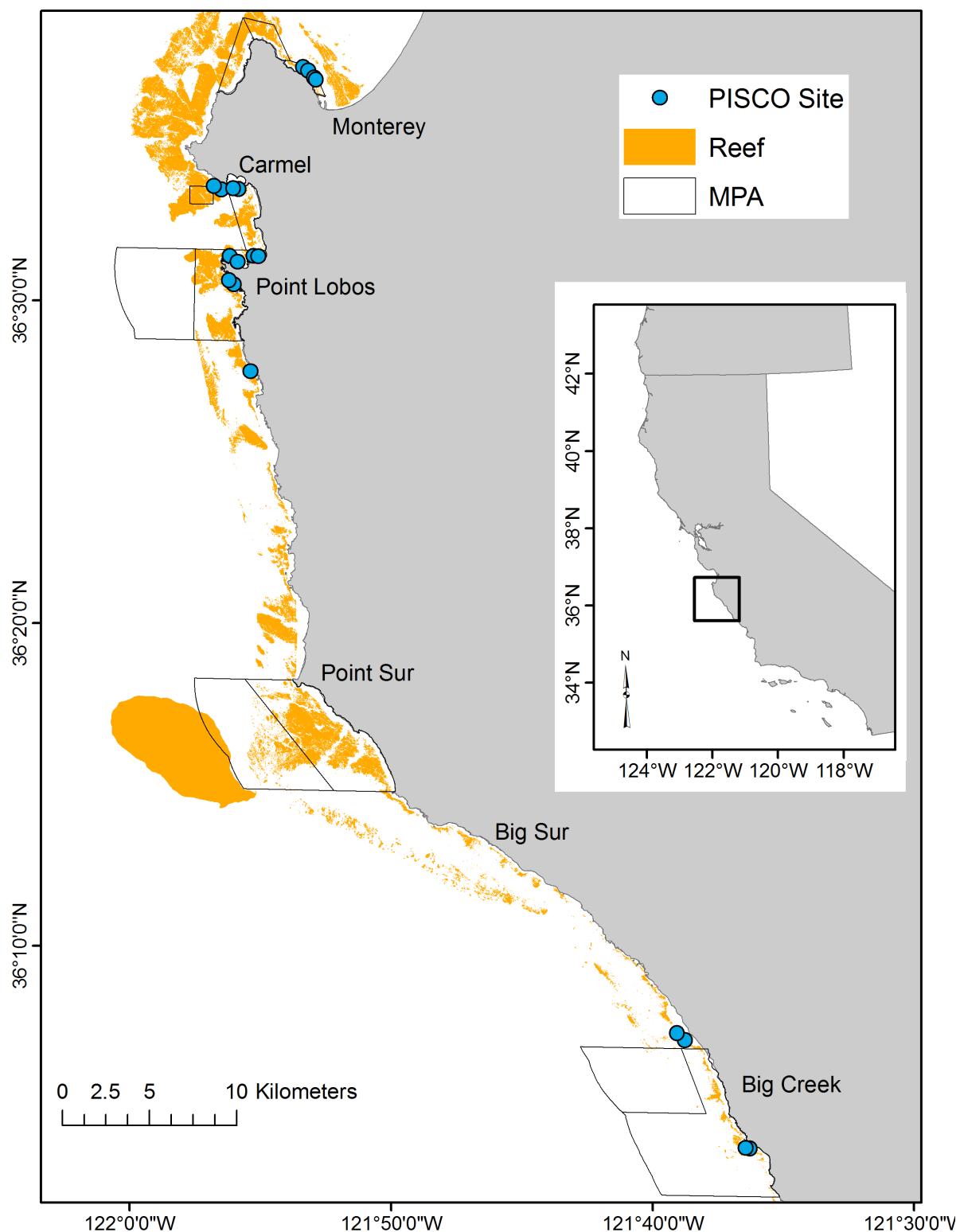


Figure 28: Map of the sites sampled consistently through time for the PISCO kelp forest fish survey. | [fig:PISCO\\_sites](#)

### MLEs vs. Posterior Medians

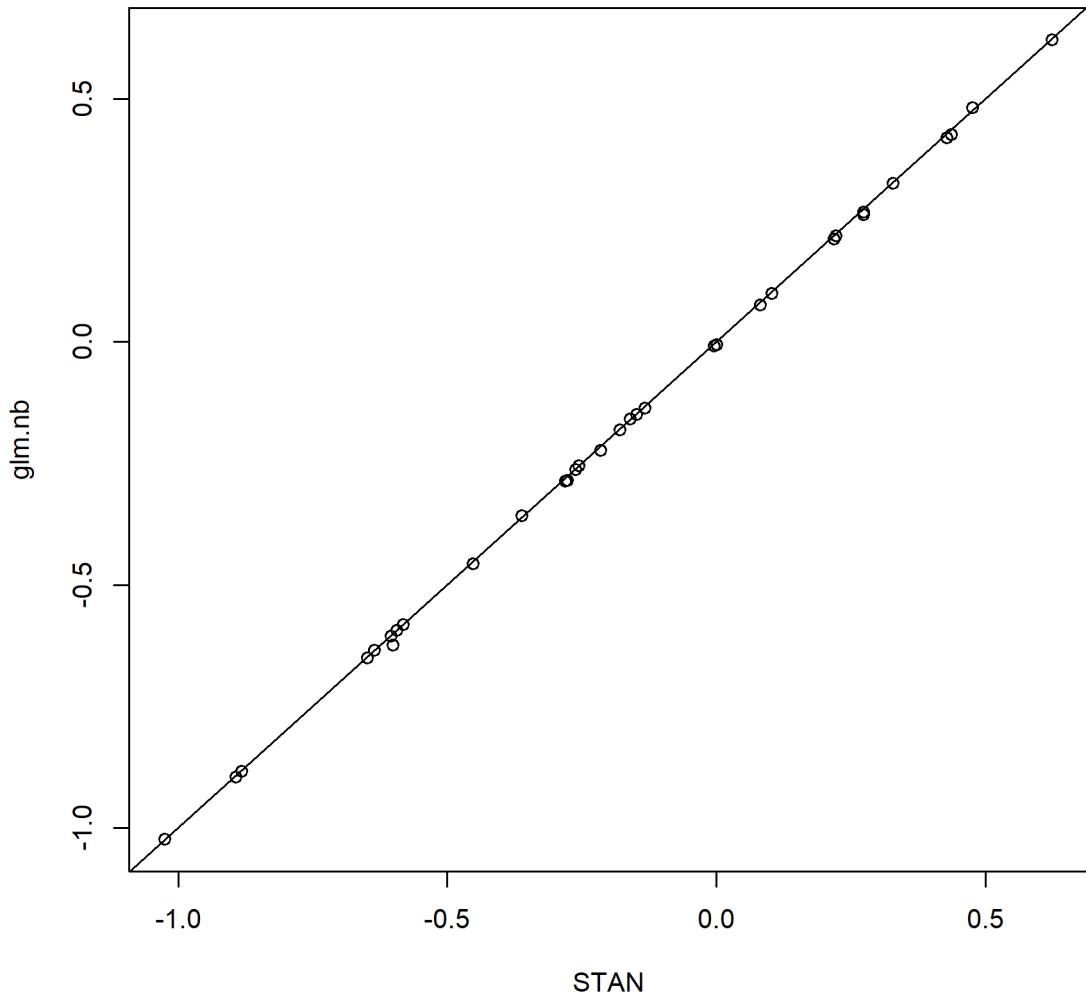


Figure 29: Comparison of negative binomial predictions (CPUE) to observed means in each stratum (year) for the PISCO kelp forest fish survey index. The 1:1 plot is for reference. [fig:Fleet8\\_MLE](#)

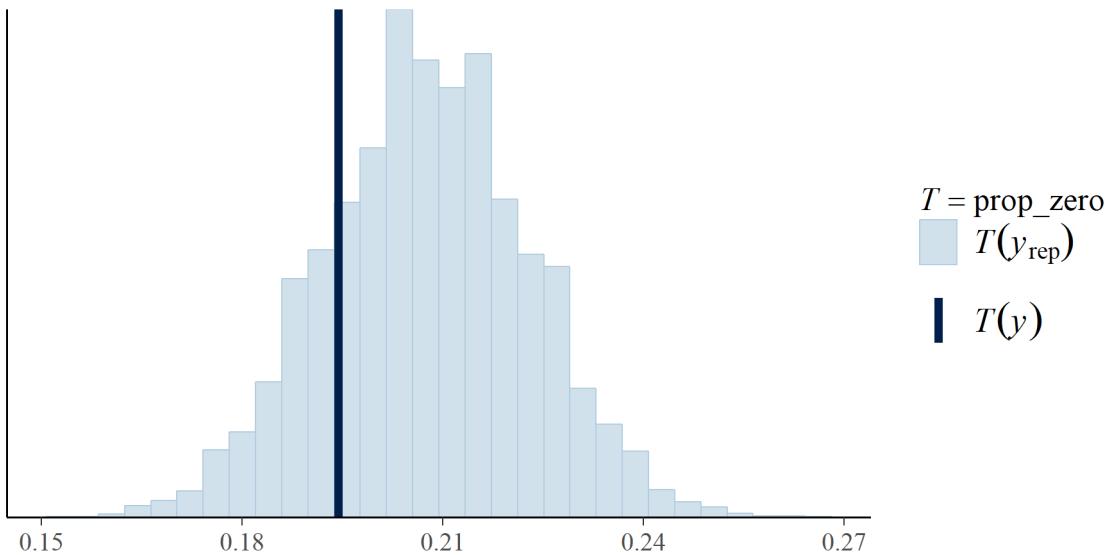


Figure 30: Posterior predictive distribution of the proportion of zero observations in replicate data sets generated by the negative binomial model for the PISCO kelp forest fish survey. [fig:Fleet8\\_pr](#)

### MLEs vs. Posterior Medians

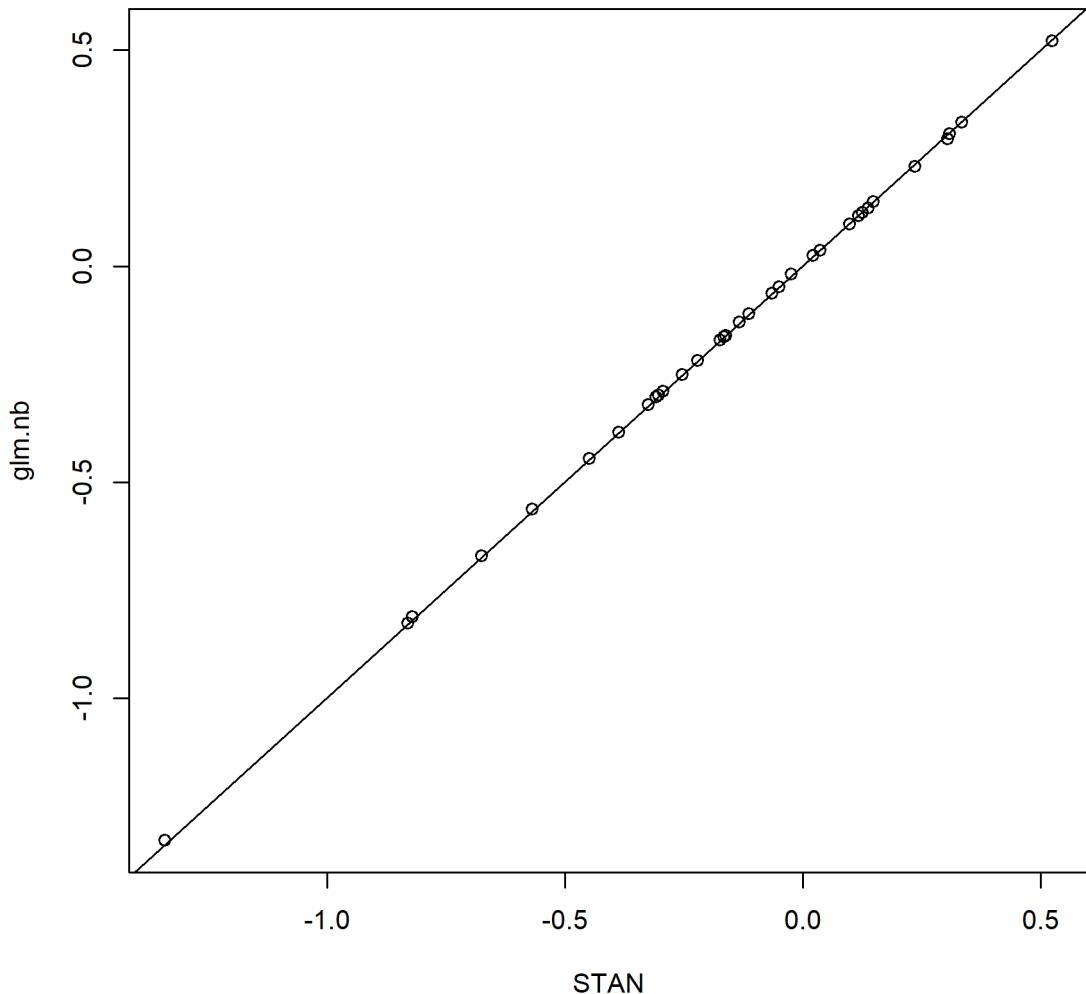


Figure 31: Comparison of negative binomial predictions (CPUE) to observed means in each stratum (year) for the PISCO kelp forest fish survey index for fish 15 cm and larger. The 1:1 plot is for reference. fig:Fleet81large\_MLE\_stan

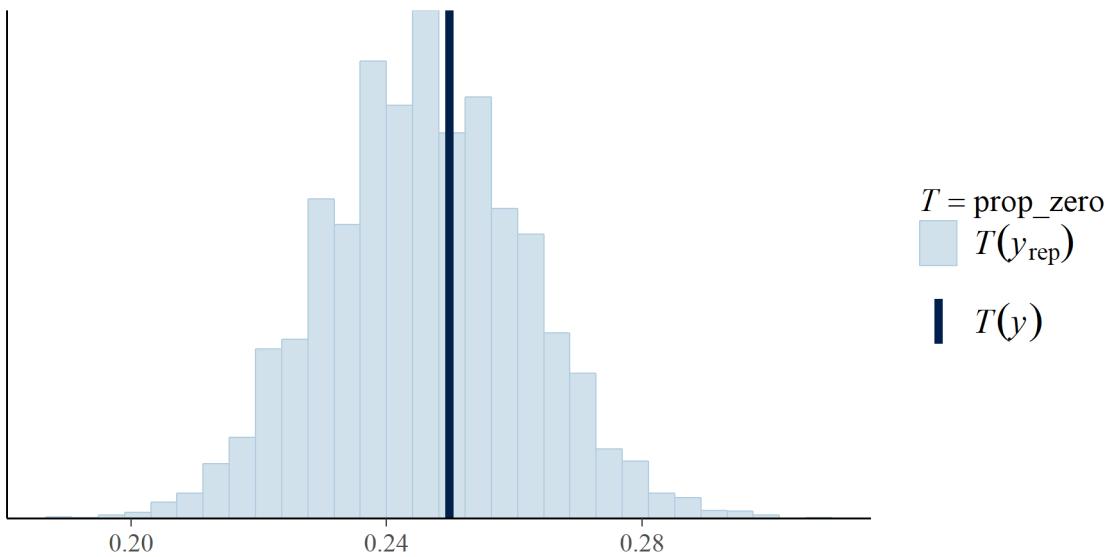


Figure 32: Posterior predictive distribution of the proportion of zero observations in replicate data sets generated by the negative binomial model for the PISCO kelp forest fish survey for fish 15 cm and larger. [fig:Fleet8large\\_prop\\_zero\\_STAN](#)

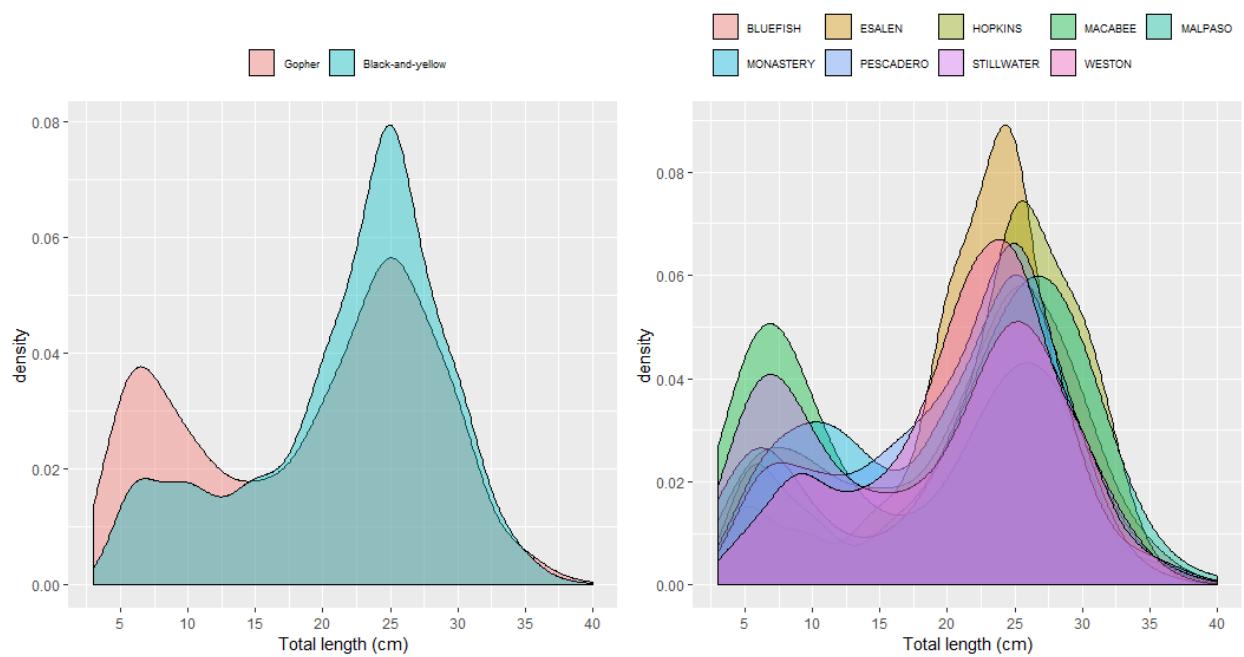


Figure 33: Plots of the length distributions from the PISCO kelp forest fish survey by species (left) and for combined species by site (right) for sites included in the final index of abundance.  
`fig:PISCO_lengths`

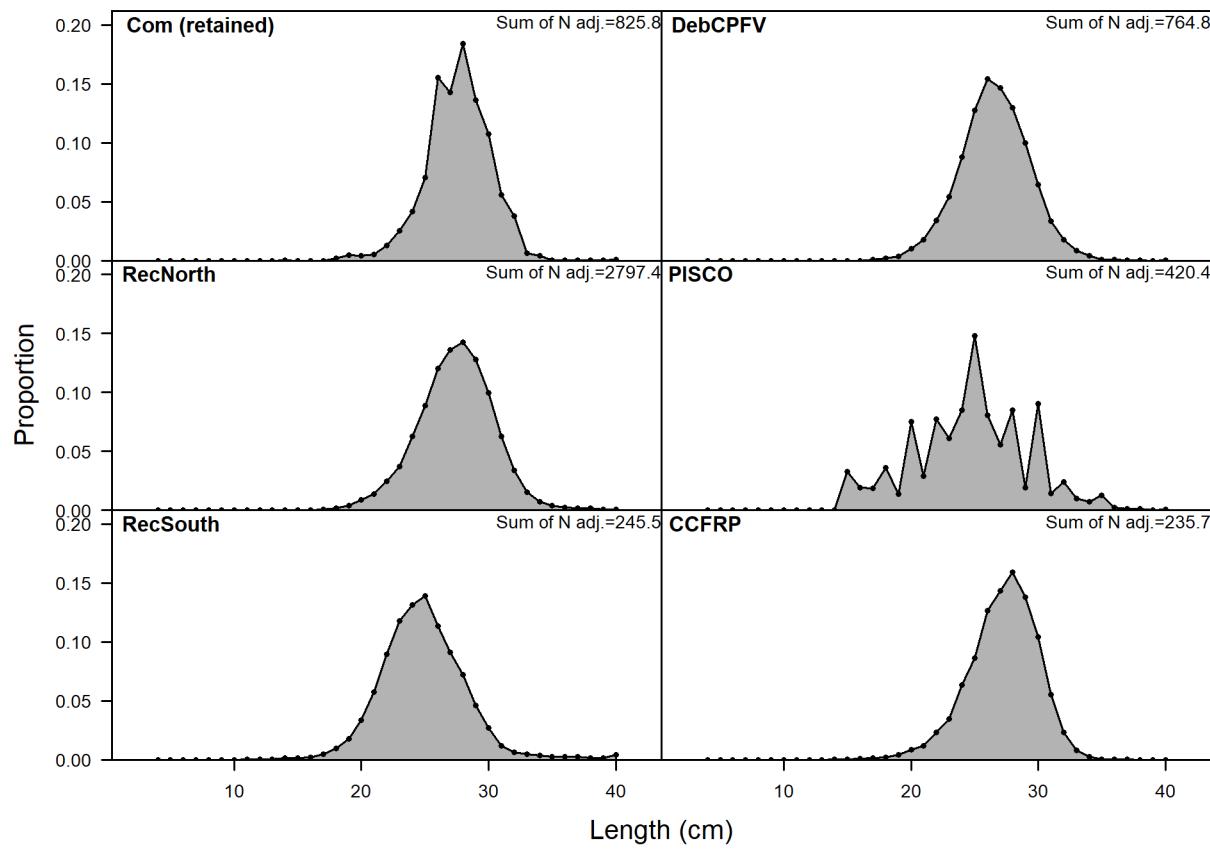


Figure 34: Length comp data, aggregated across time by fleet. Labels ‘retained’ and ‘discard’ indicate discarded or retained sampled for each fleet. Panels without this designation represent the whole catch. [fig:comp\\_lendat\\_aggregated\\_across\\_time](#)

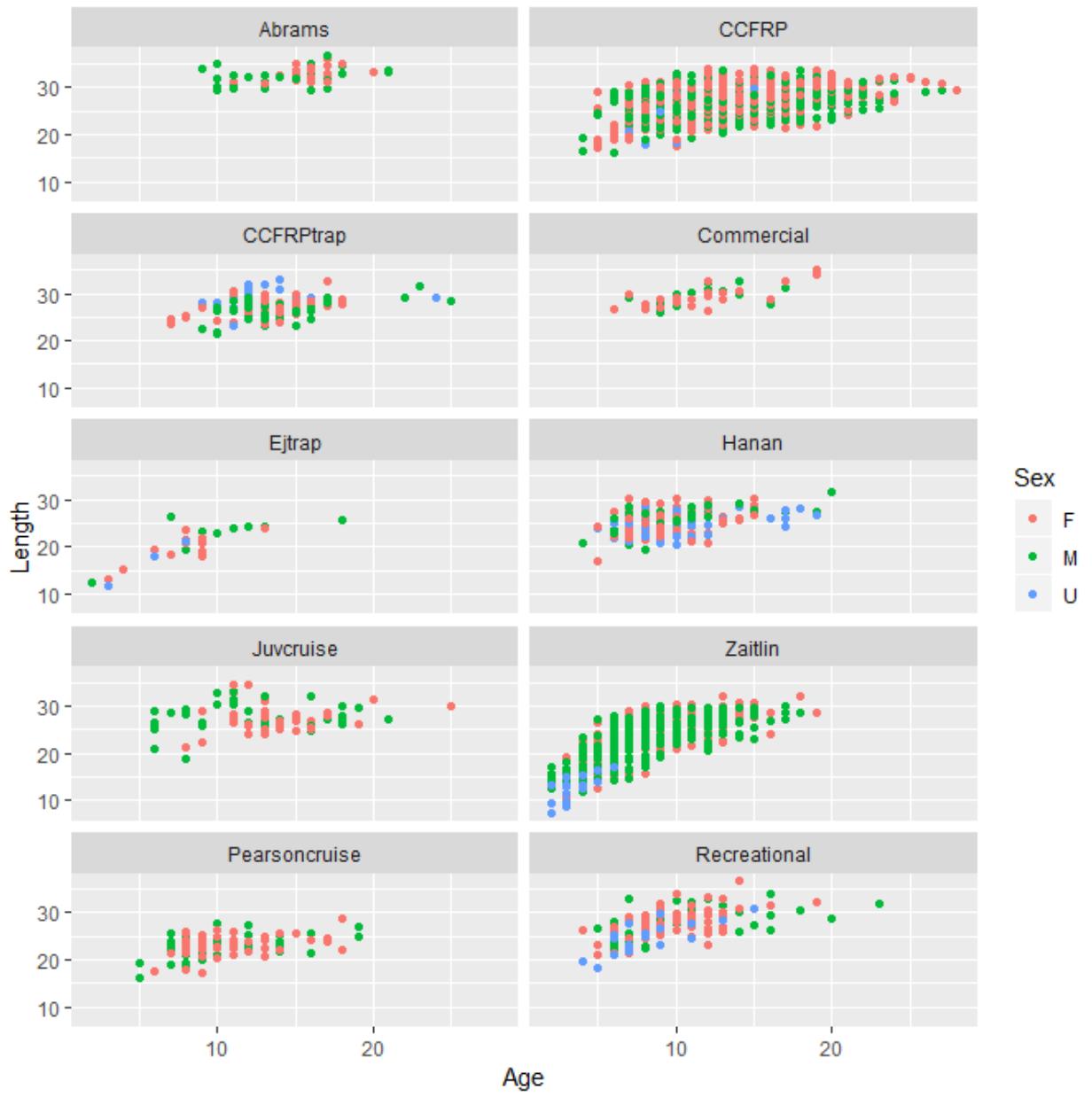


Figure 35: Available length-at-age data for gopher and black-and-yellow rockfish by sex and data source. The Zaitlin study is all black-and-yellow rockfish. The remaining plots represent gopher rockfish

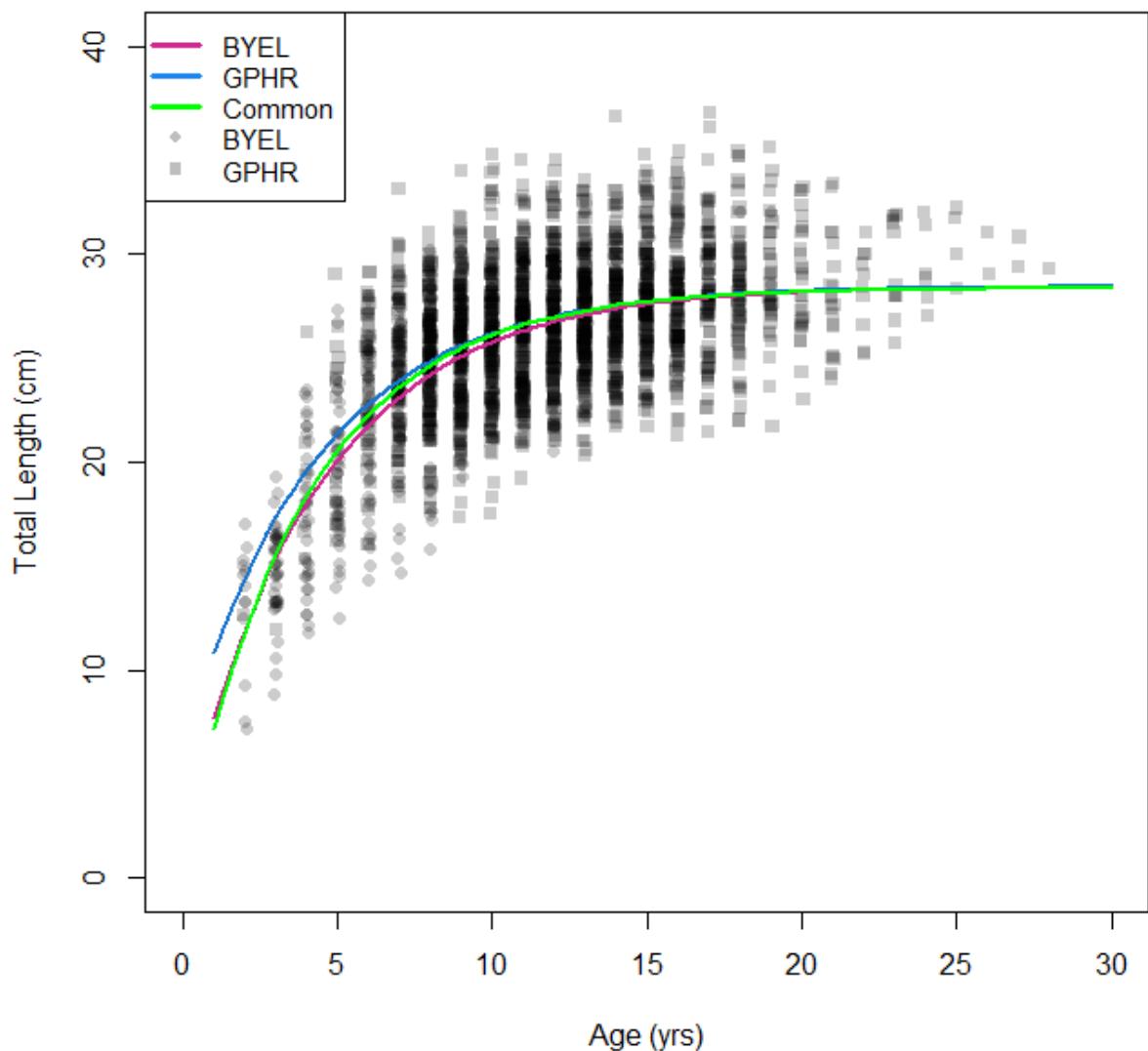


Figure 36: External estimates of growth for gopher and black-and-yellow rockfish from fits to von Bertalanffy growth models. | [Growth\\_by\\_species](#)

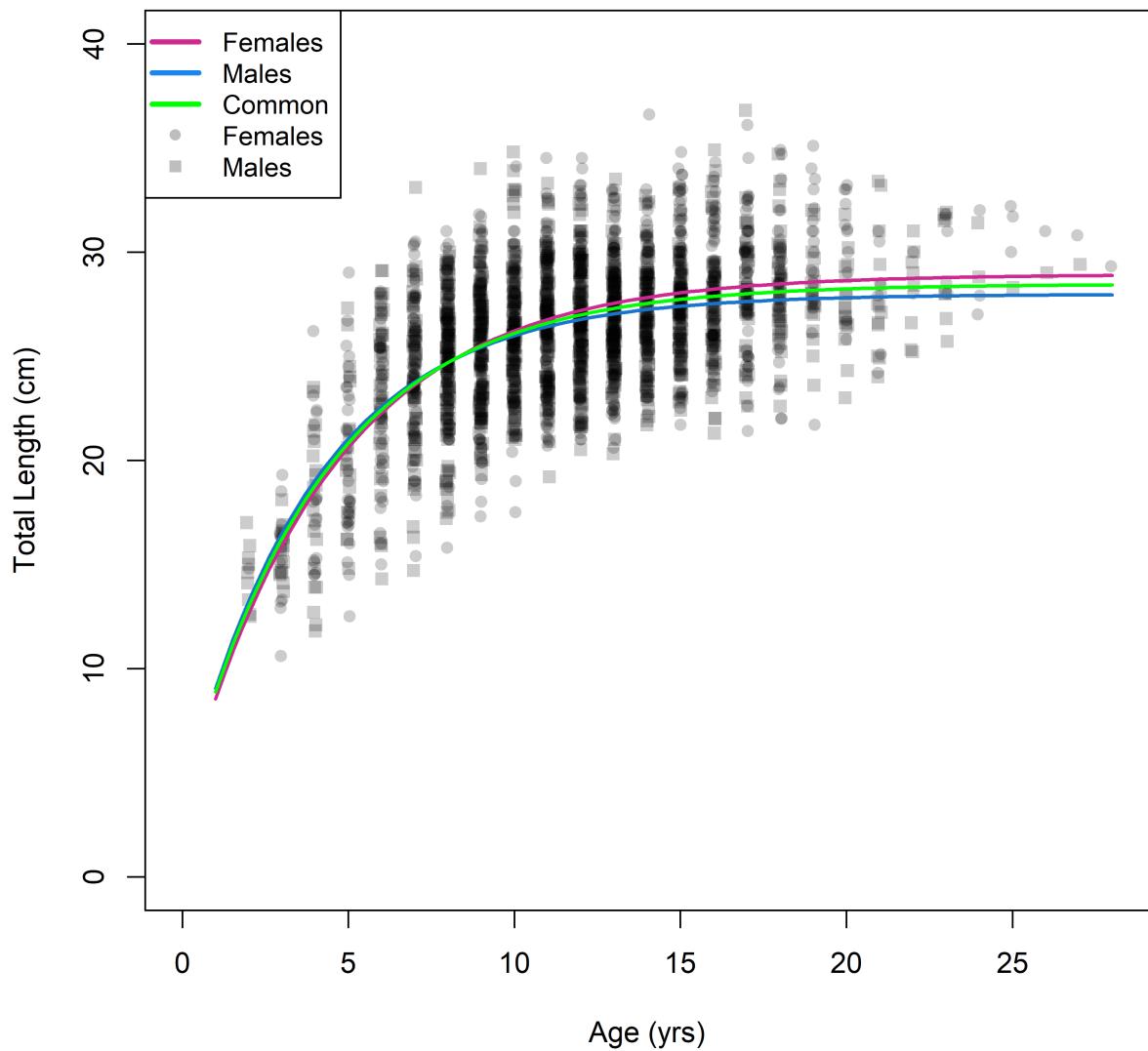


Figure 37: External estimates of growth for GBYR combined by sex from fits to von Bertalanffy growth models. |  
 $\text{Growth\_by\_sex}$

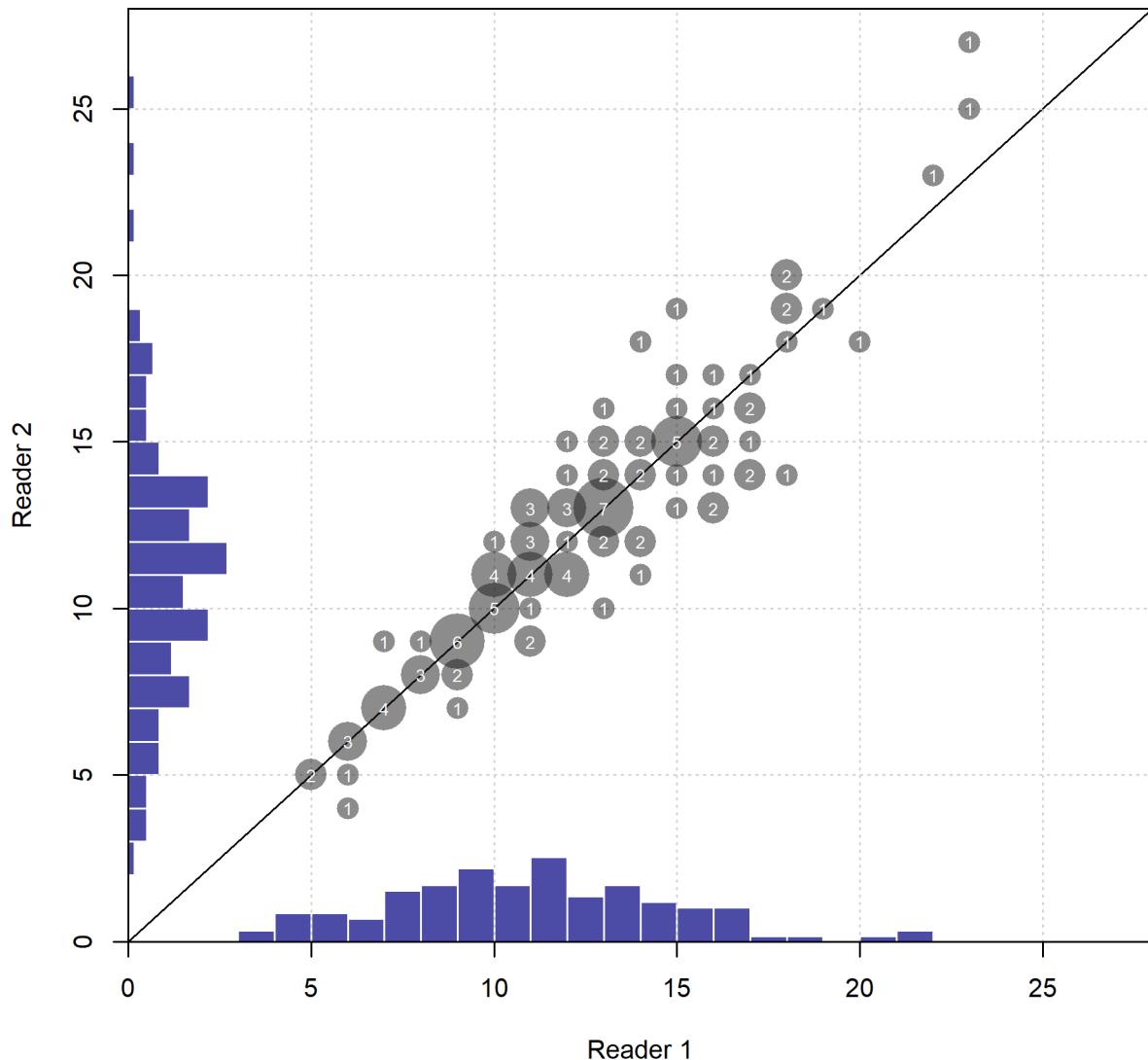


Figure 38: Aging precision between initial and blind double reads for GBYR. Numbers in the bubbles are the sample sizes of otoliths cross-read. [fig:GBY\\_age\\_error](#)

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

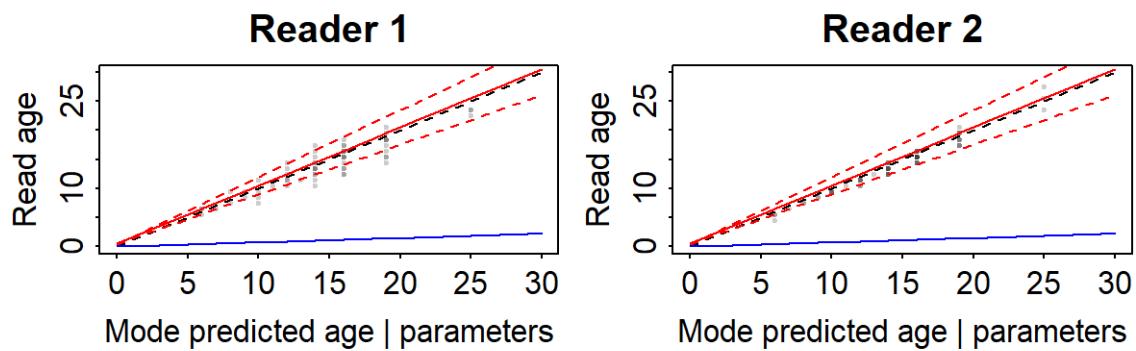


Figure 39: True versus predicted age for two current age readers at the NWFSC from the ageing error software with unbiased reads and curvilinear standard deviation for both readers.  
fig:GBY\_age\_error2

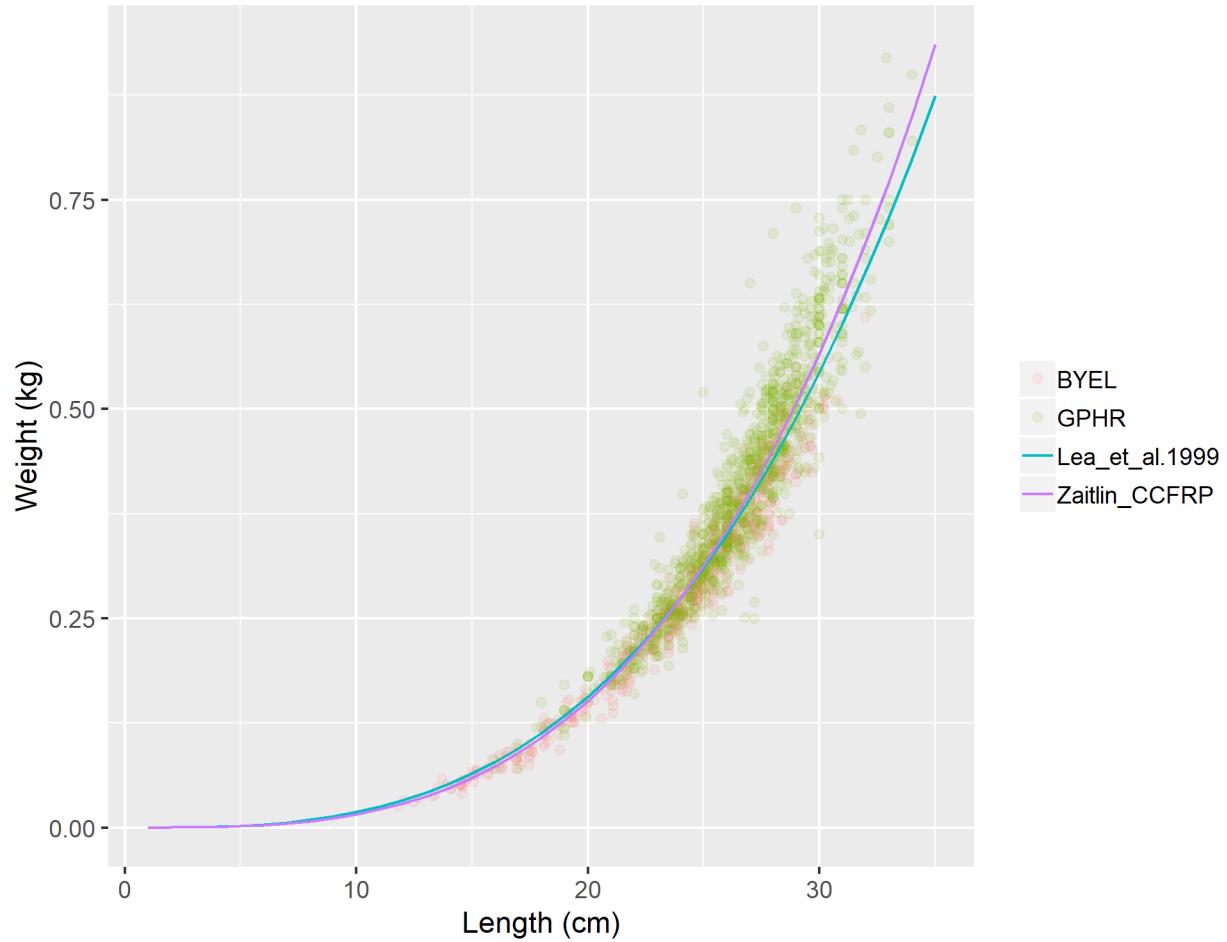


Figure 40: Comparison of the gopher rockfish weight-length curves from Lee et al. (1999) and the estimated from black-and-yellow rockfishes from Zaitlin (1986), and gopher rockfishes from Loury (2011) and Meyers-Cherry(2014). The estimated curve from the current data is used in this assessment. [fig:GBY\\_weight\\_length](#)

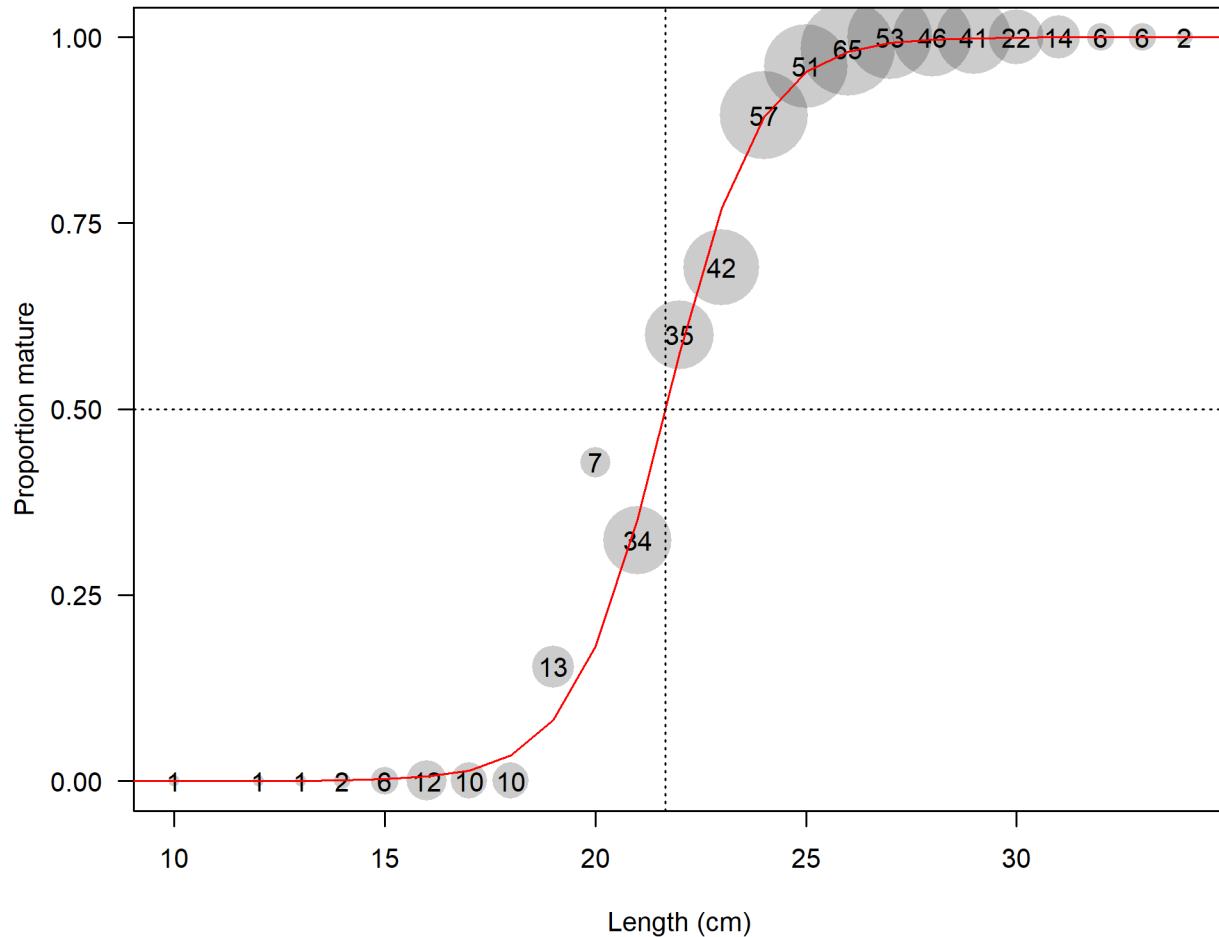


Figure 41: Maturity ogive for females estimated from black-and-yellow rockfish from Zaitlin (1986) and gopher rockfish from Meyers-Cherry (2014). Sample sizes at a given length are shown in the circles. | [fig:GBY\\_maturity\\_ogive](#)

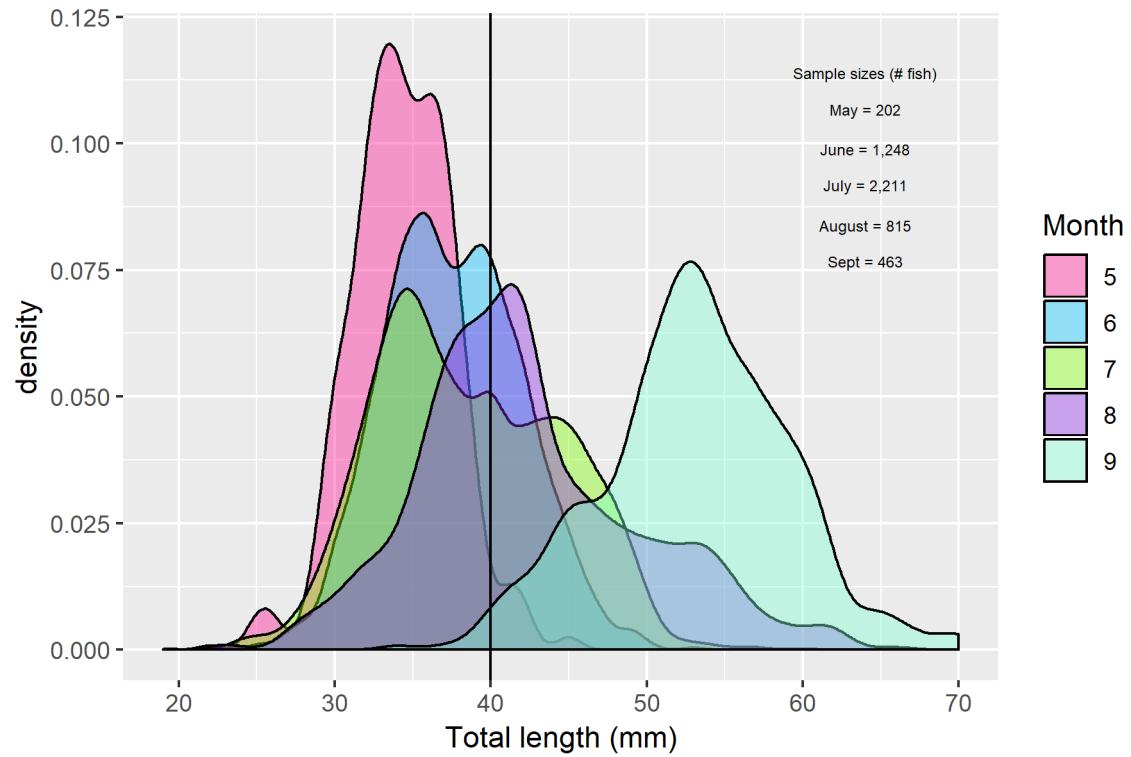


Figure 42: Length distribution by month for GBYR captured using a sampling tool called a Standard Monitoring Unit for the Recruitment of Fishes (SMURFs) from the UCSC-PISCO kelp forest fish survey, specifically as part of Diana Baetscher's dissertation work (Baetscher 2019). [fig:SMURF\\_lengths](#)

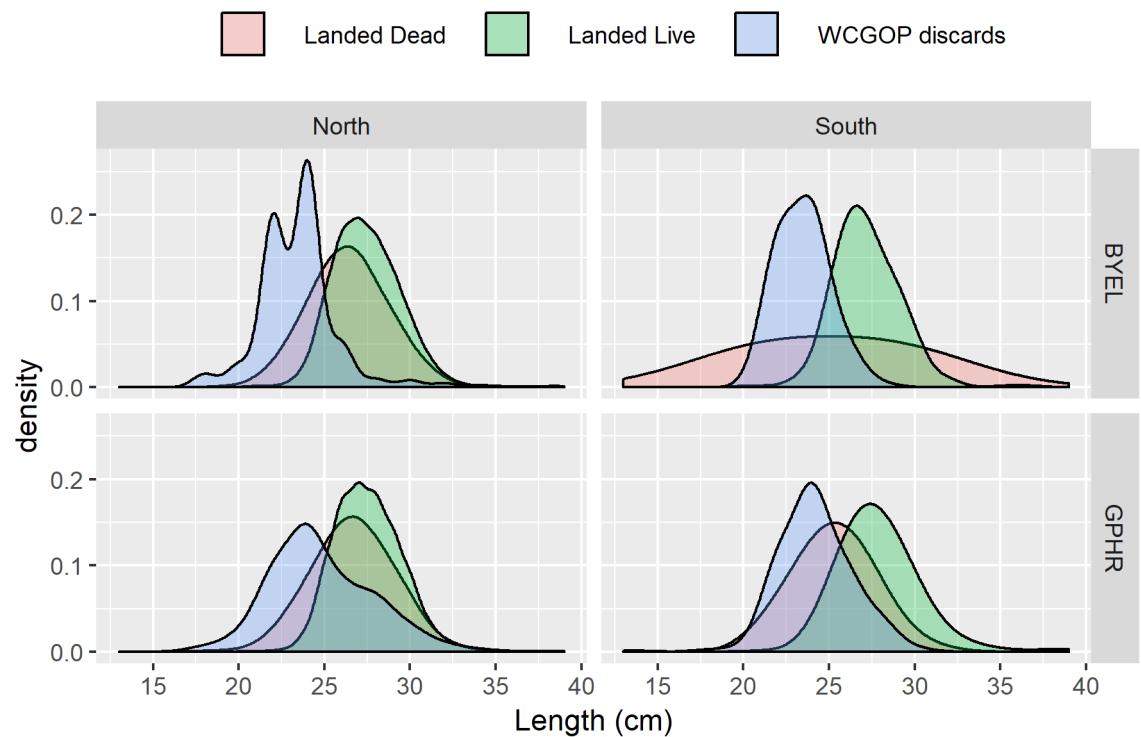


Figure 43: Length distributions of gopher and black-and-yellow rockfish for the commercial fleet and WCGOP discards north and south of Point Conception. The commercial landings were also separated between fish landed live and fish landed dead for this figure. [fig:Comm\\_lengths\\_justin](#)

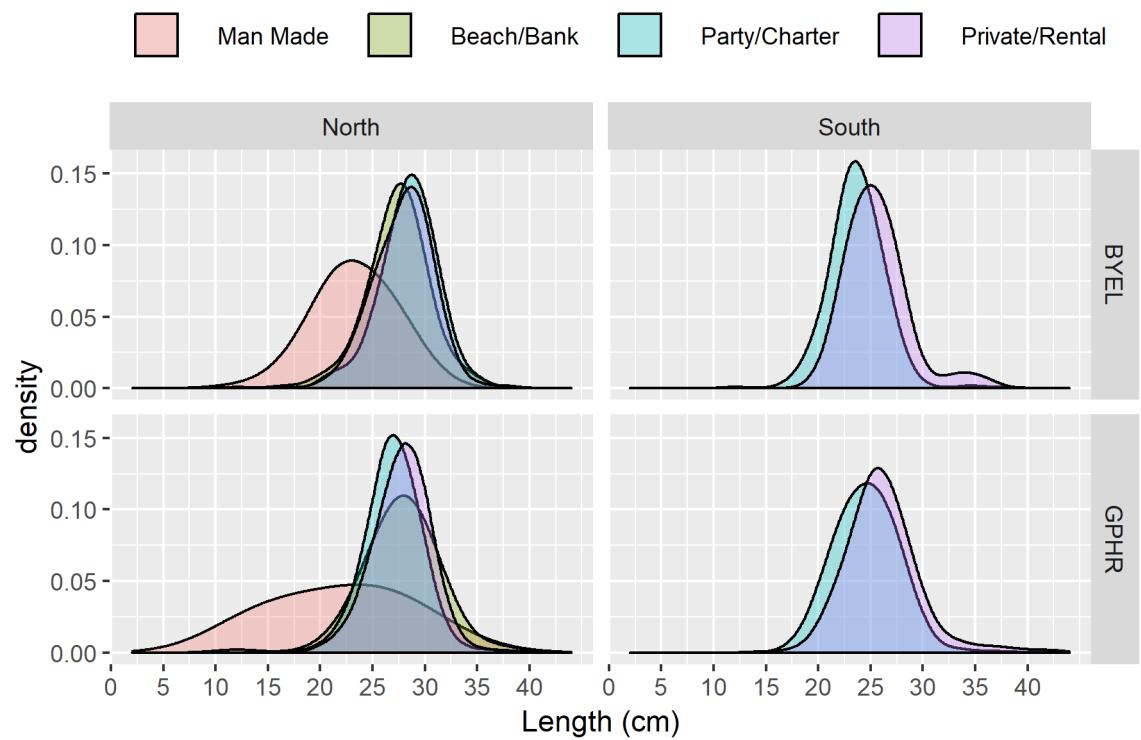


Figure 44: Length distributions of gopher and black-and-yellow rockfish for the recreational fleet north and south of Point Conception and by mode. fig:Rec\_lengths\_justification

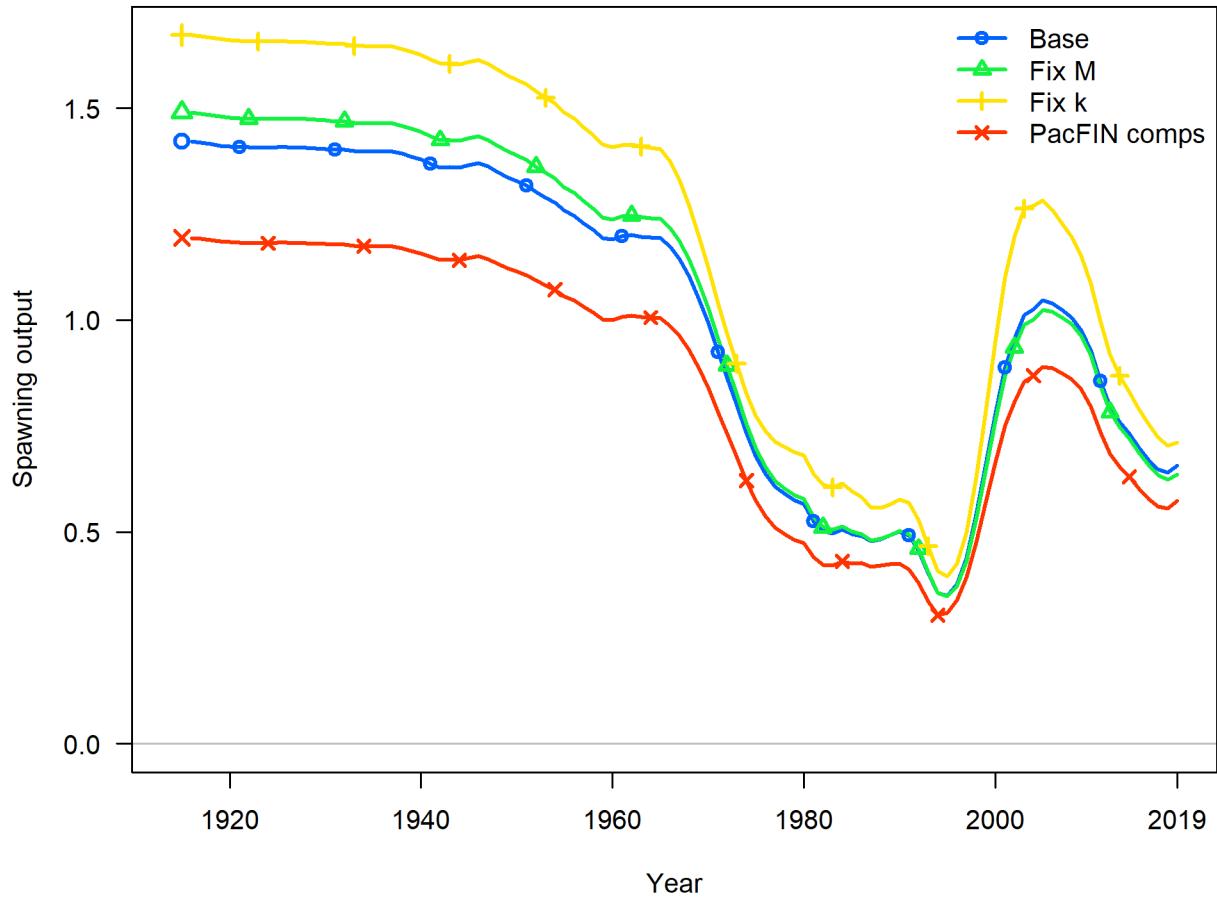


Figure 45: Sensitivity of the spawning biomass to fixing natural mortality to the prior, fixing the von Bertalanffy  $k$  parameter to the external estimate, or using commercial PacFIN length composition data instead of CALCOM, as compared to the pre-STAR base model. [fig:sensitivity1\\_spaw](#)

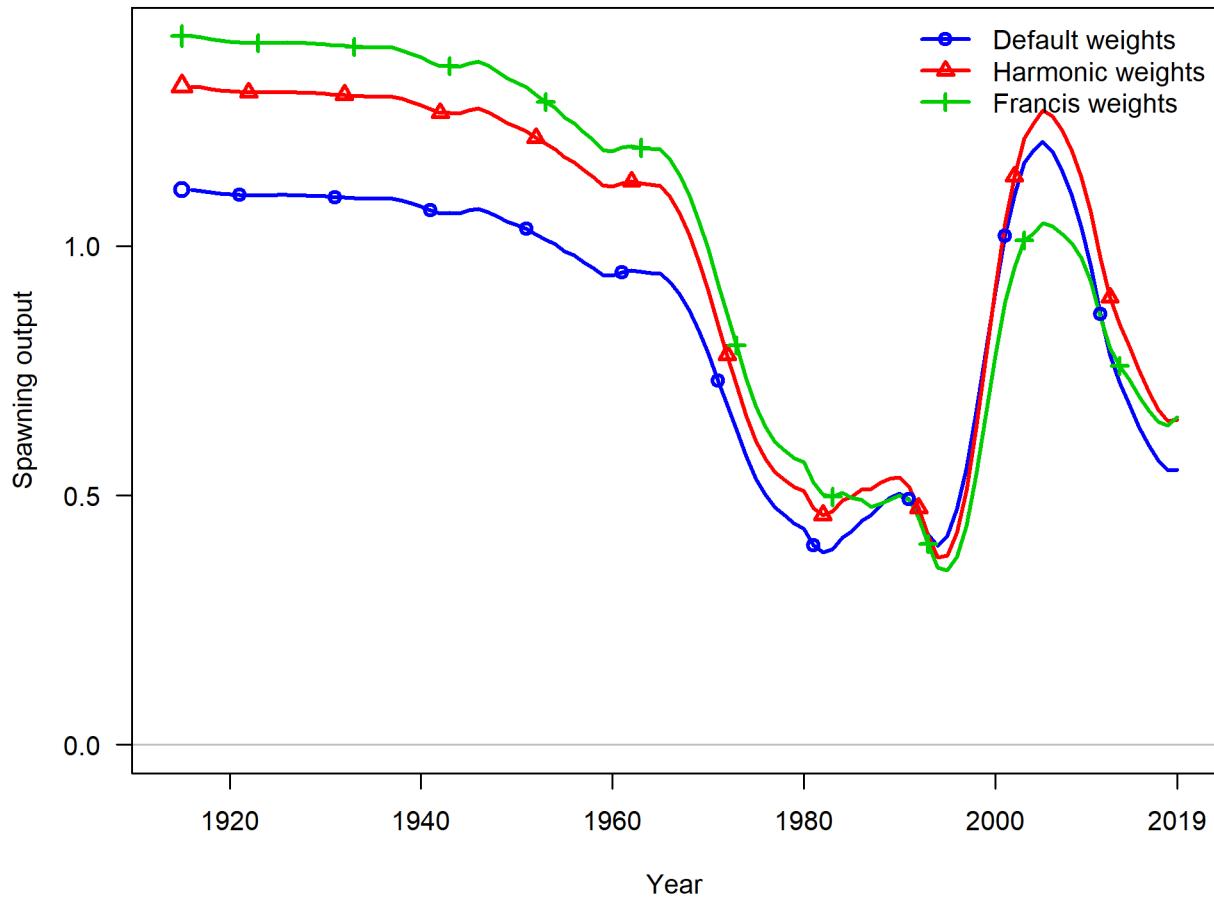


Figure 46: Sensitivity of the spawning biomass to either the default weight of composition data, the harmonic mean, or Francis weights. [fig:sensitivity2\\_spawnbio](#)

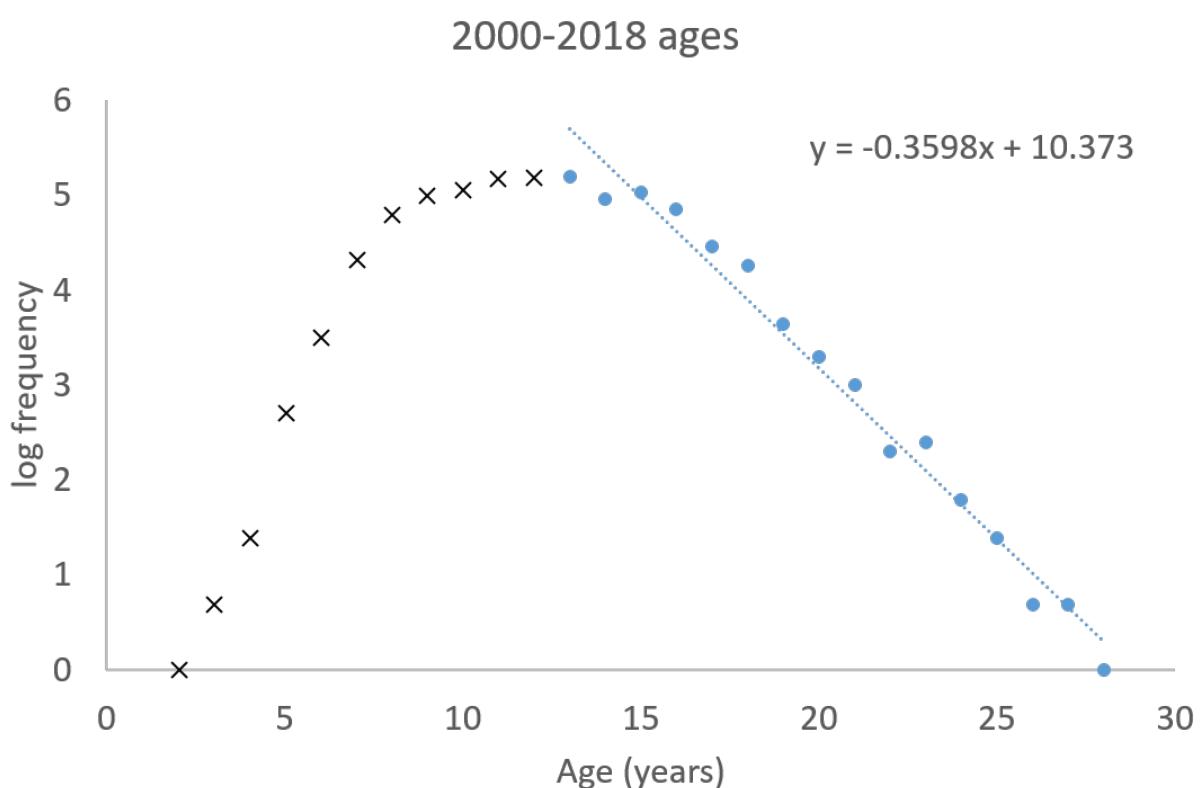
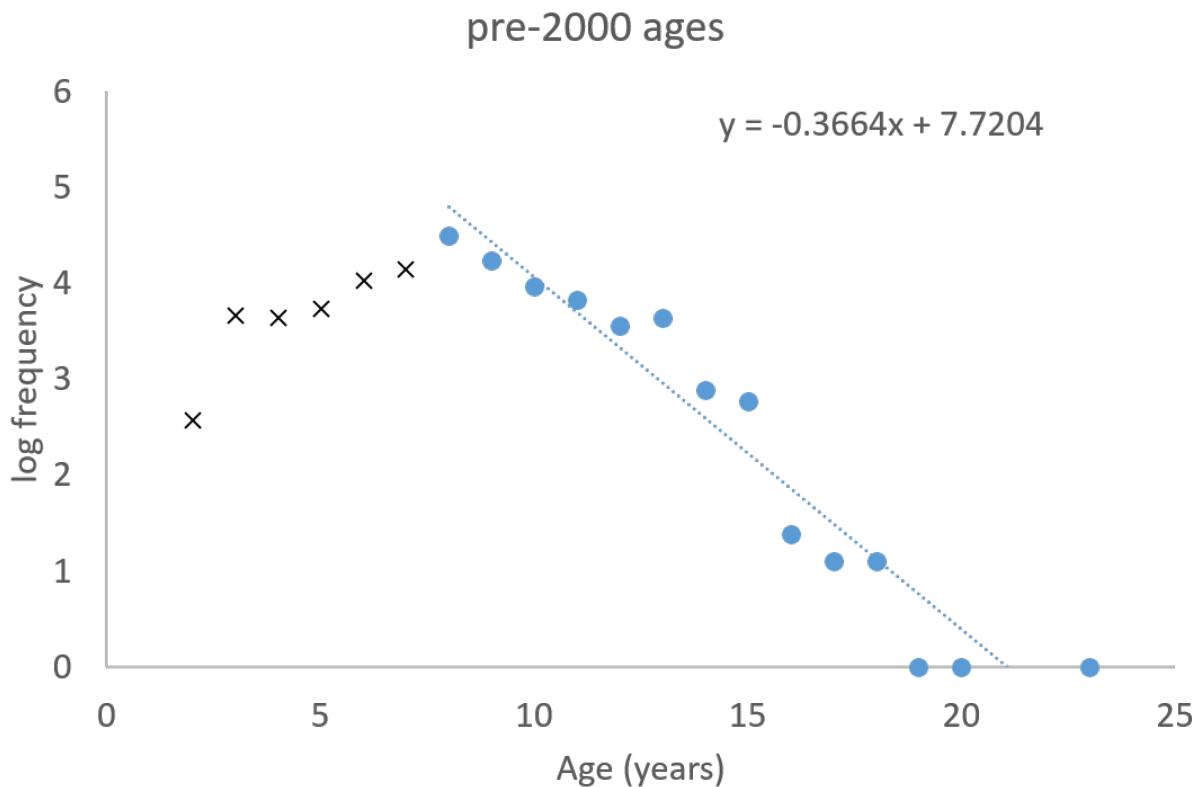


Figure 47: Catch curve analysis for age data prior to 2000 and for 2000-2018.

fig:STAR\_request1

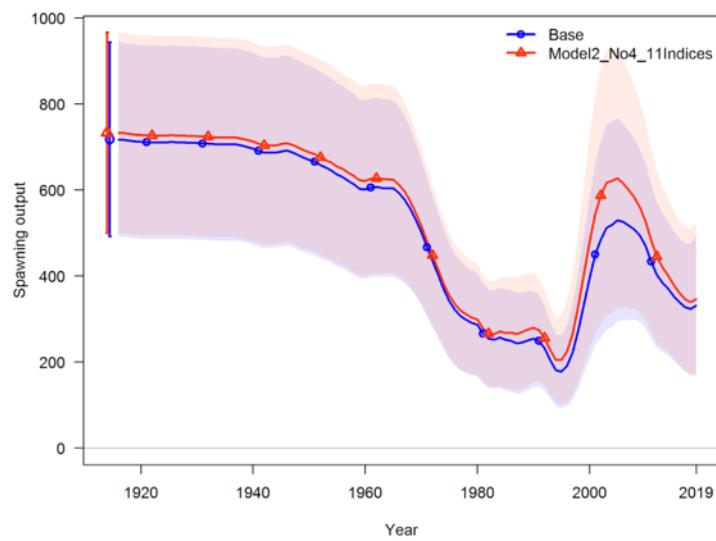
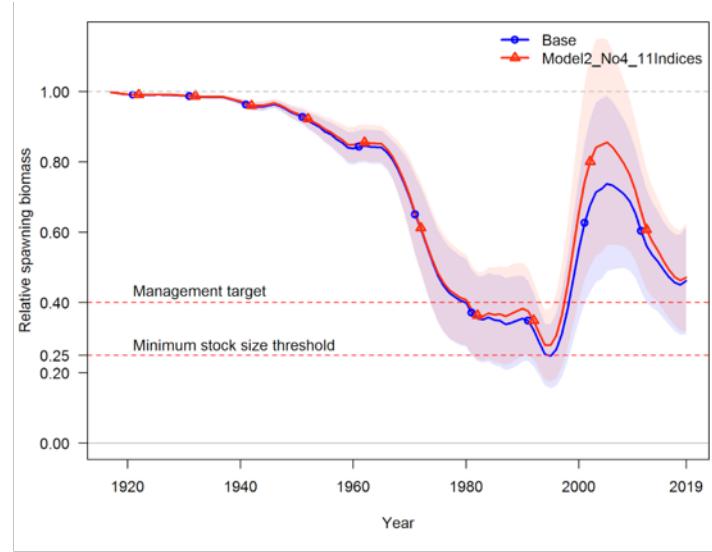


Figure 48: Comparison of time series of relative and absolute spawning output from pre-STAR base model and the model from request 2 removing southern indices. [fig:STAR\\_request2](#)

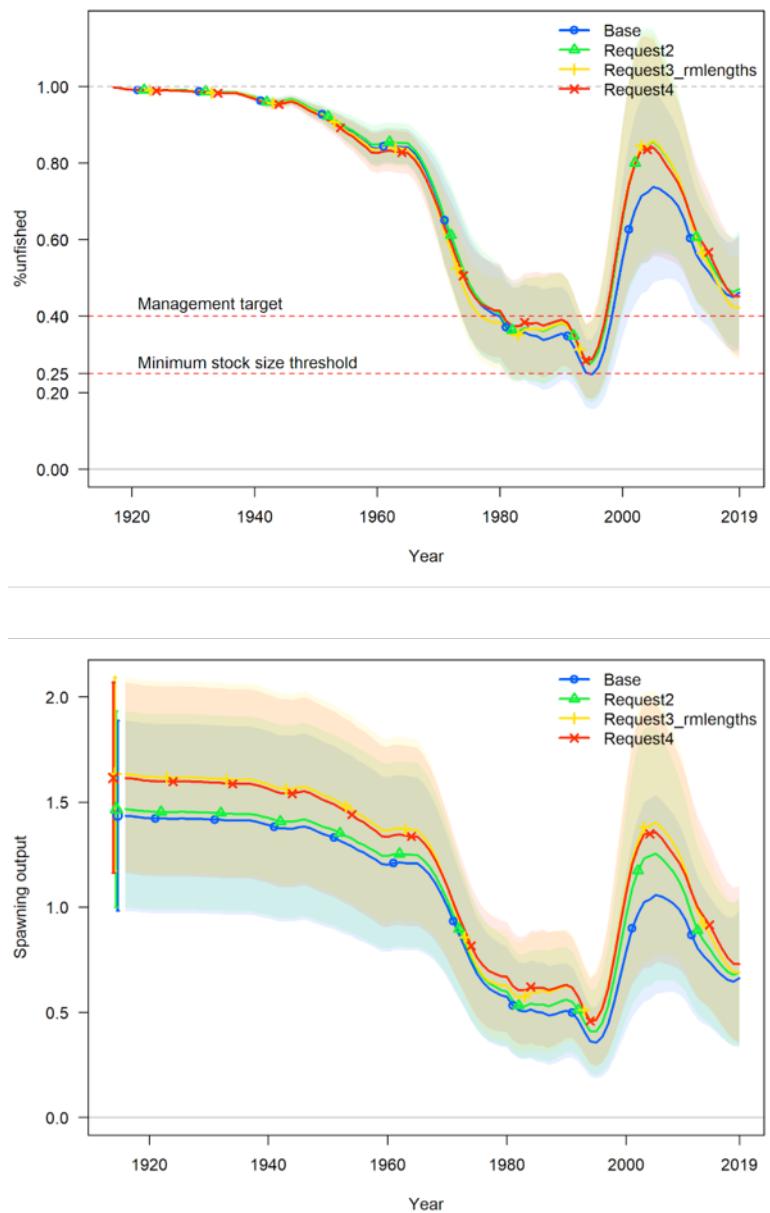


Figure 49: Comparison of time series of relative and absolute spawning output from pre-STAR base model and models from requests 2, 3a and 4. [fig:STAR\\_requests3](#)

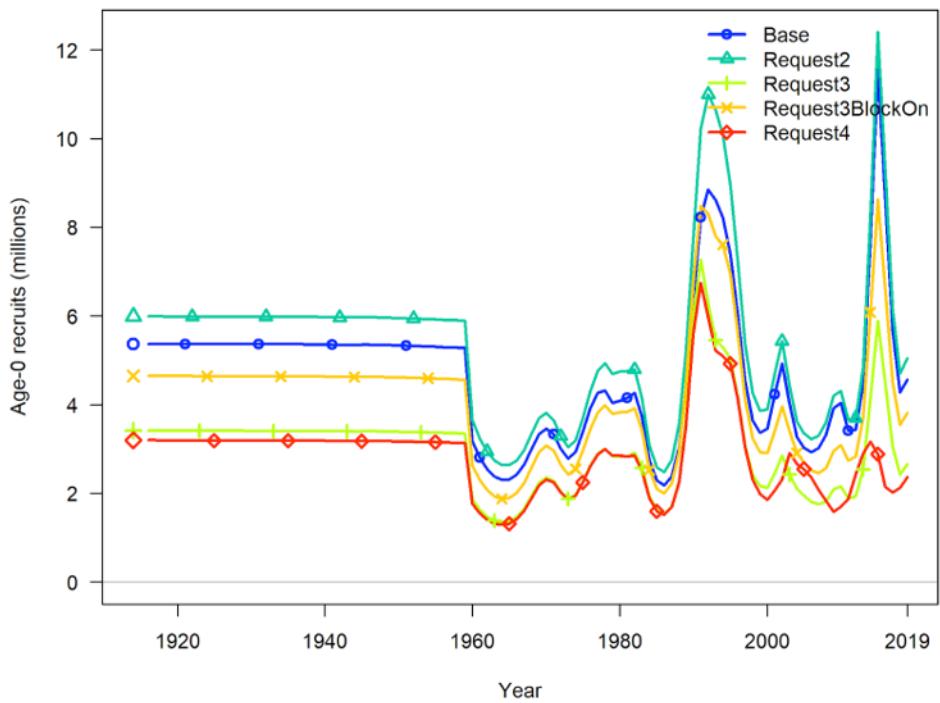


Figure 50: Comparison of time series of recruits from pre-STAR base model and models from requests 2, 3a and 4a. [fig:STAR\\_request4](#)

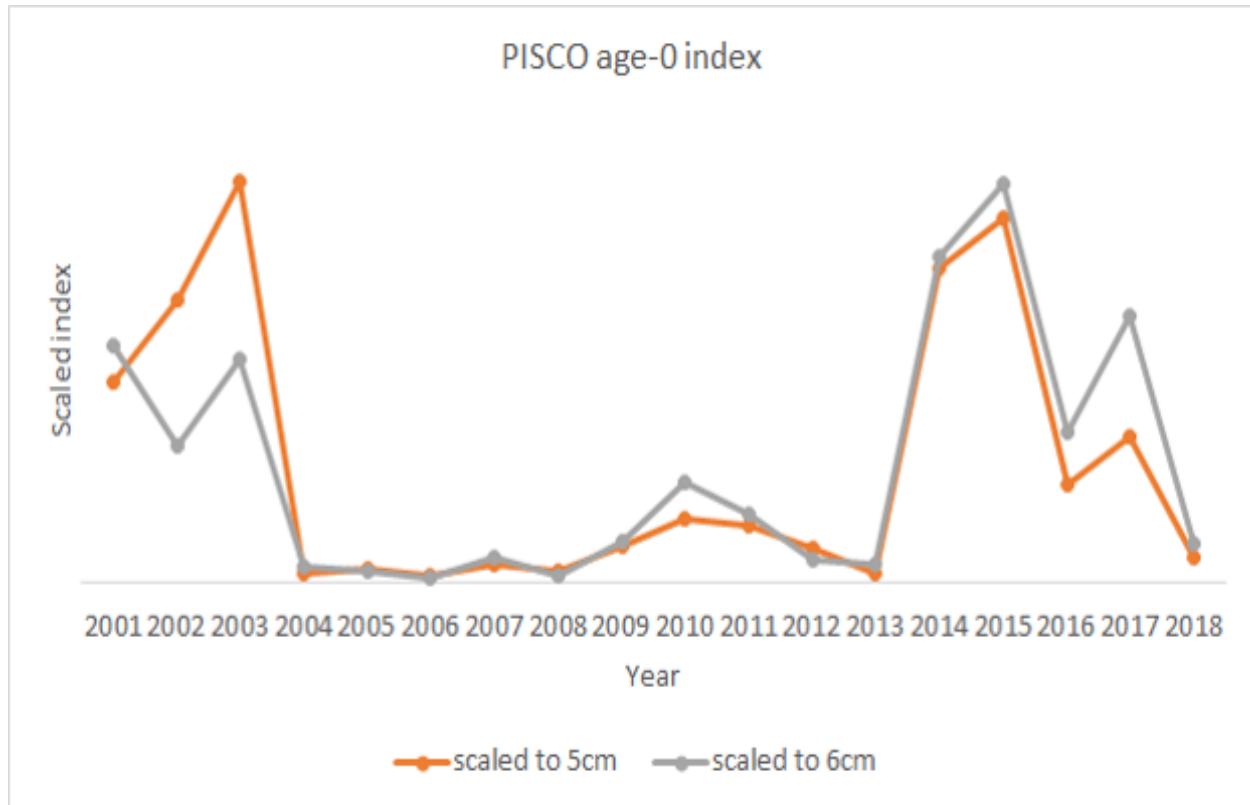


Figure 51: The PISCO recruitment index based upon observed individuals of 4 and 5 cm (“scaled to 5cm”) or 4, 5a and 6 cm (“scaled to 6 cm”).

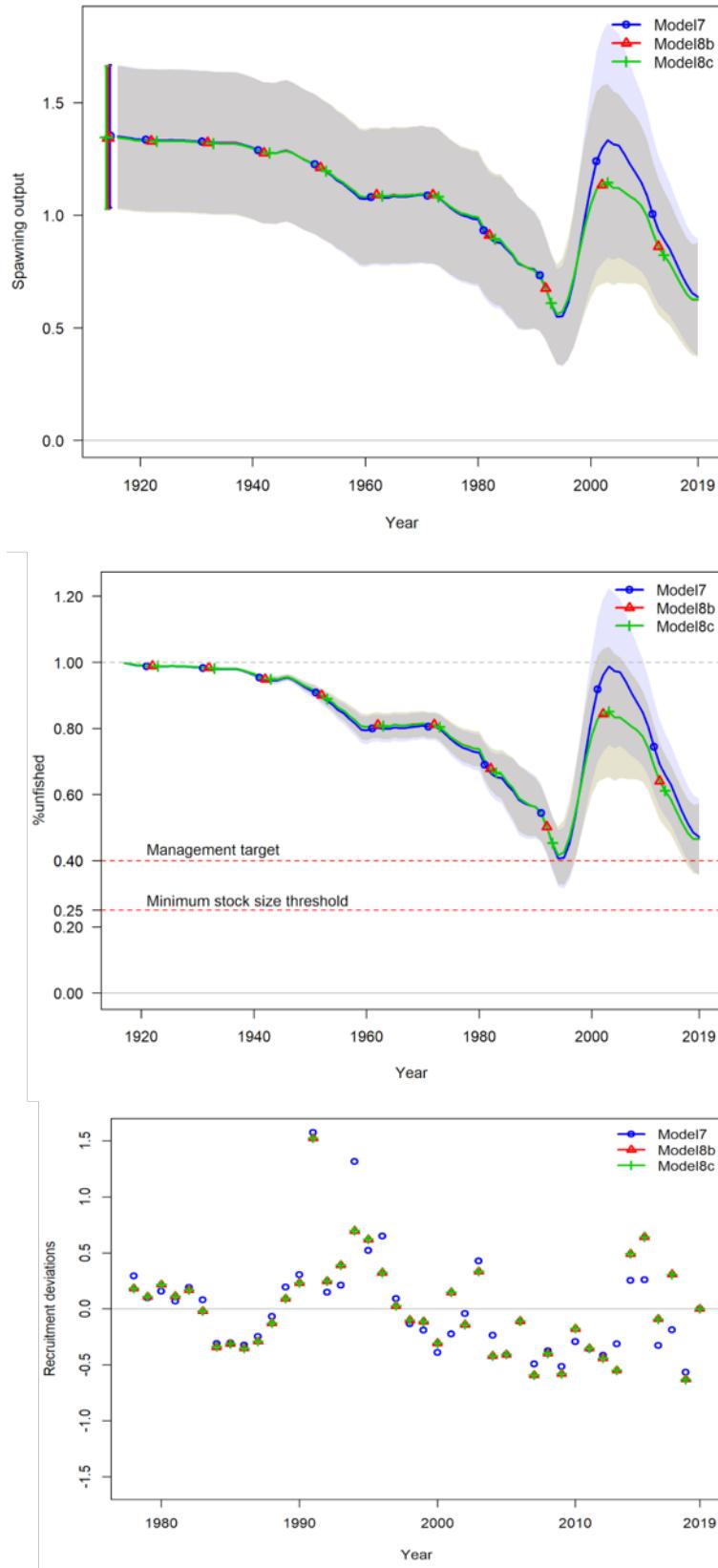


Figure 52: Results of request 7 and 8. Time series of absolute (top) and relative (middle) spawning output and recruitment deviations (now staring in 1978; bottom). [fig:STAR\\_request8\\_2](#)

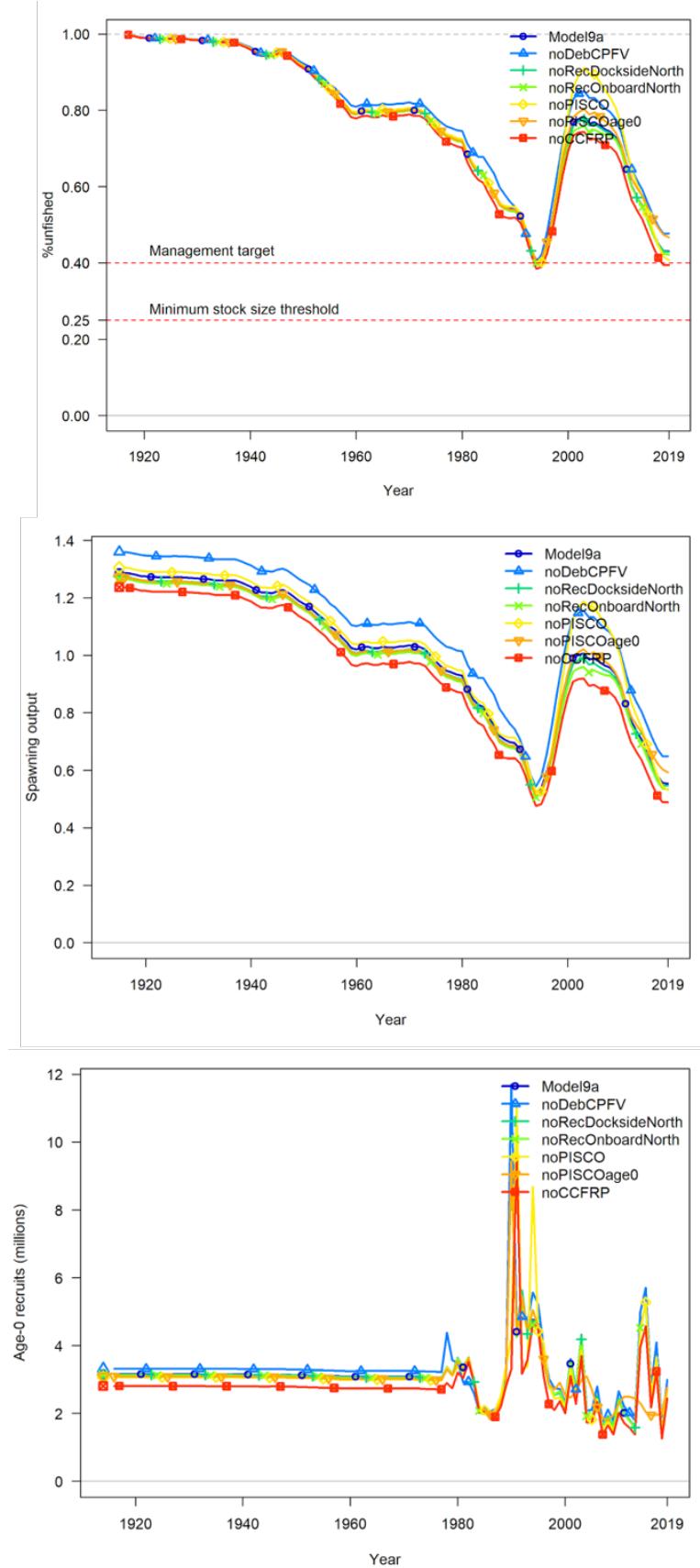


Figure 53: . Results of request 10, drop-1-out analysis. Time series of relative (top) and absolute (middle) spawning output and recruitment estimates (now starting in 1978; bottom).  
 fig:STAR\_request10

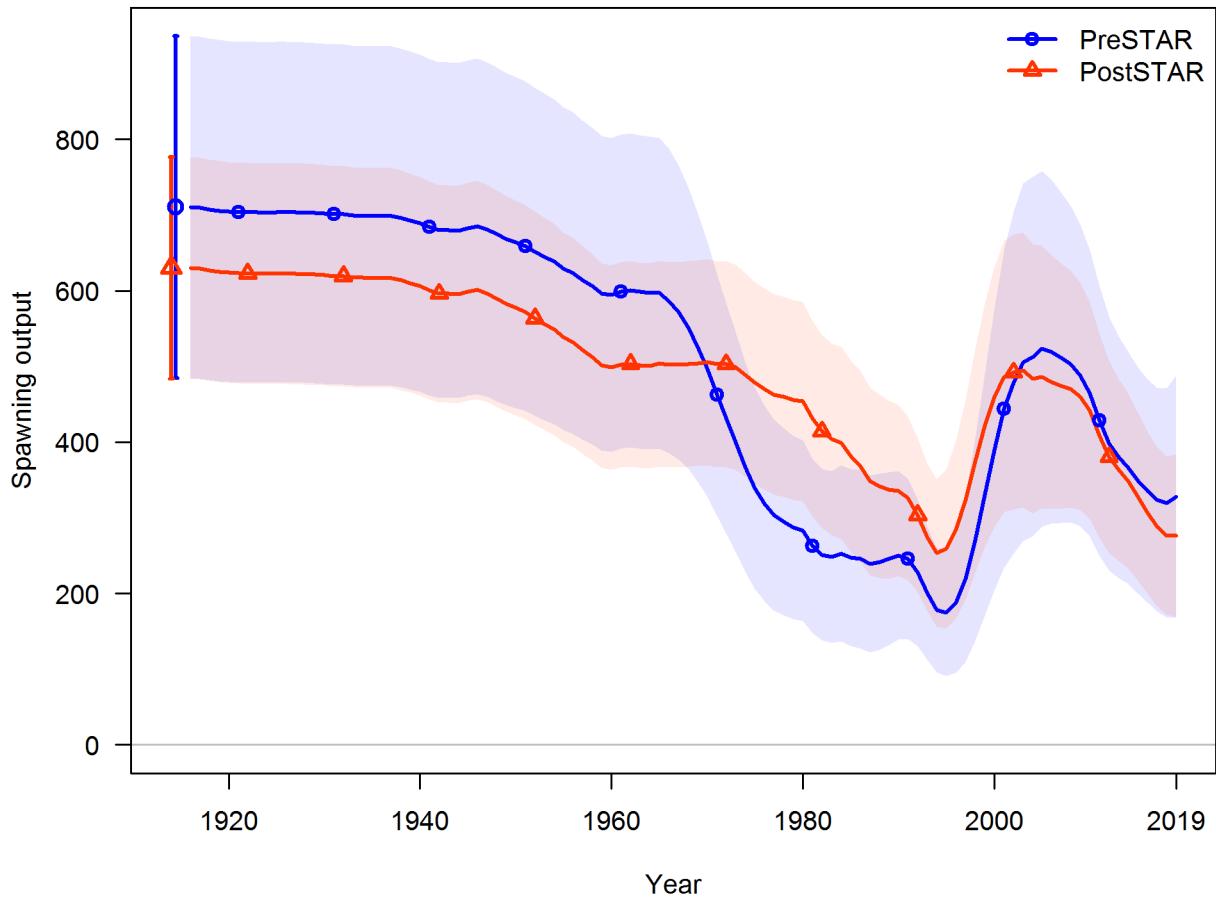


Figure 54: Comparison of the spawning output between the pre-STAR panel base model and the post-STAR model base. [fig:preSTAR\\_postSTAR\\_compare\\_spawnbio](#)

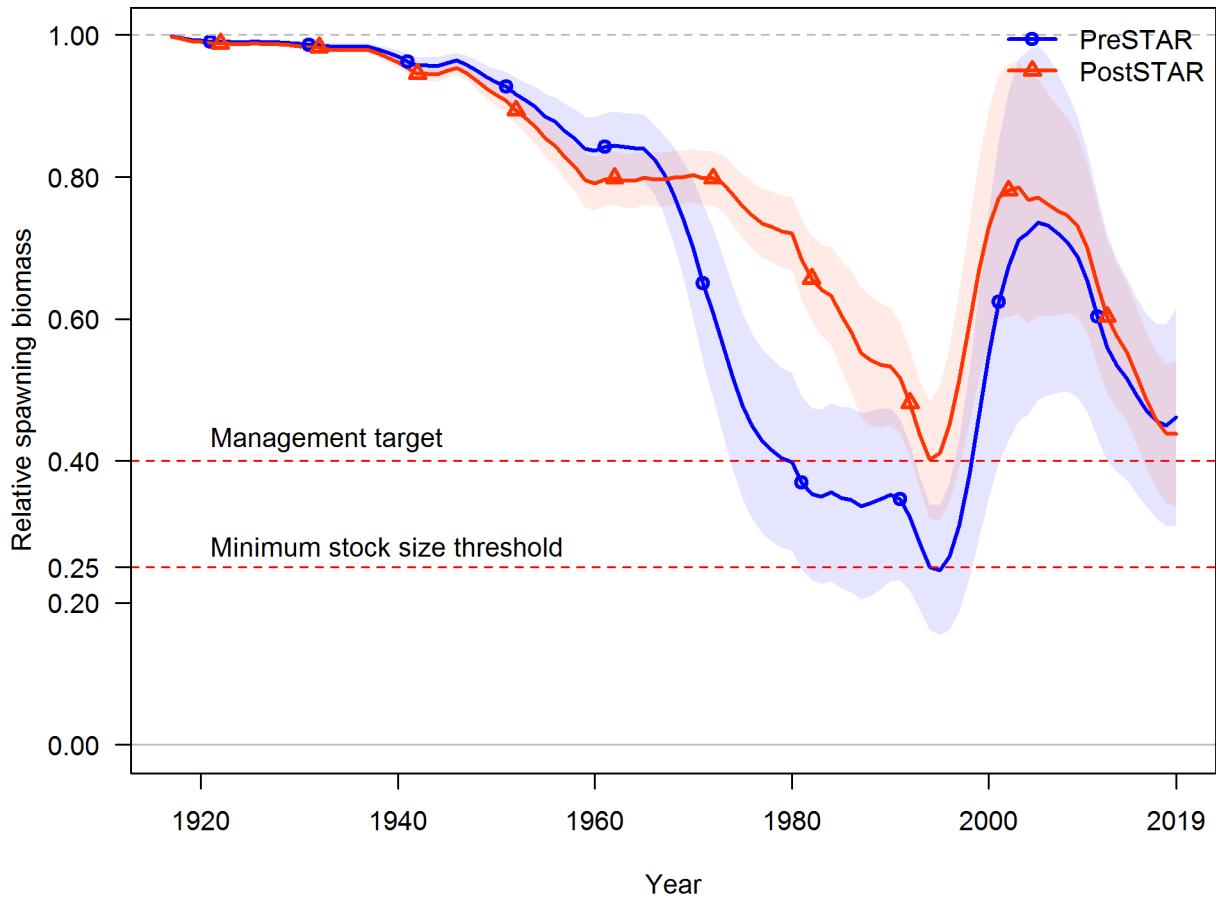


Figure 55: Comparison of the relative spawning output (depletion) between the pre-STAR panel base model and the post-STAR model base. [fig:preSTAR\\_postSTAR\\_compare\\_Bratio](#)

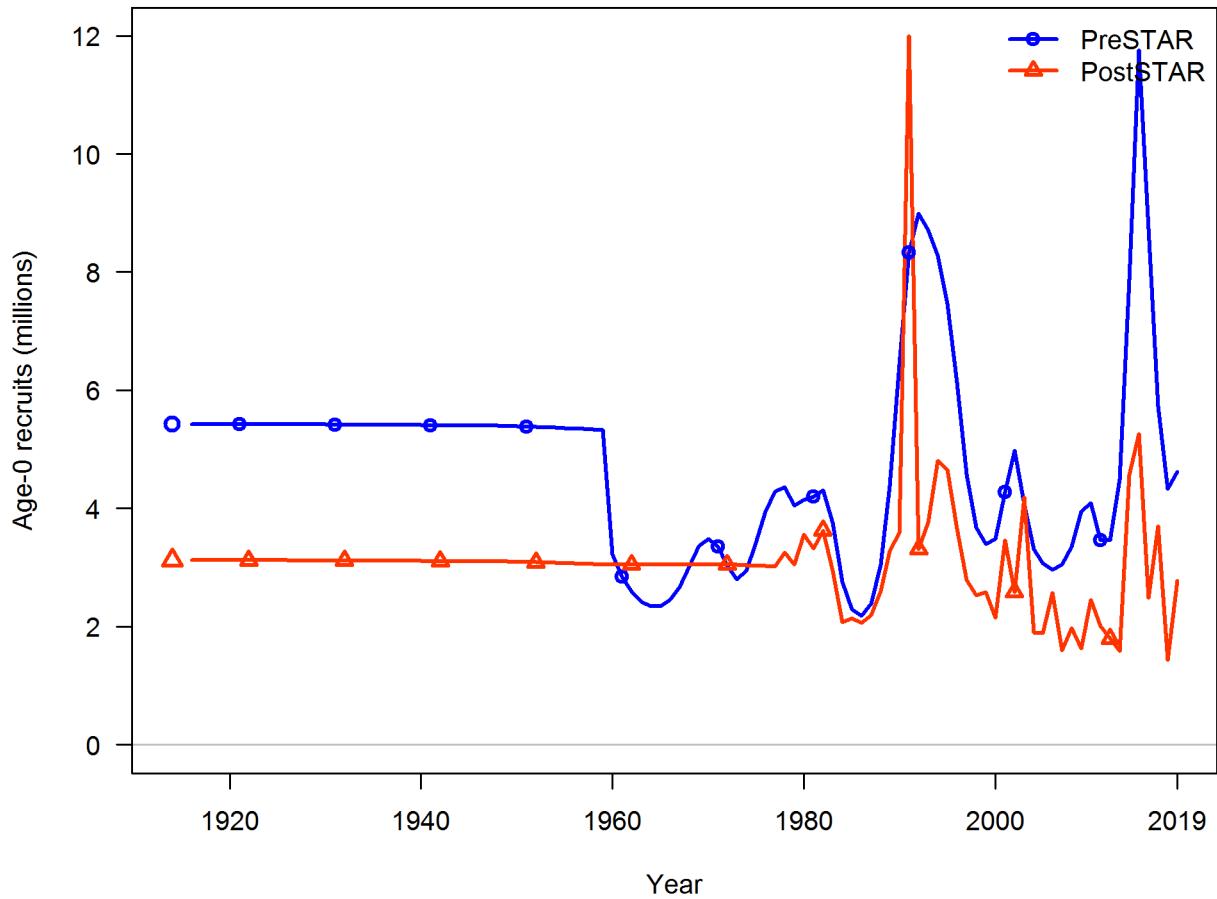
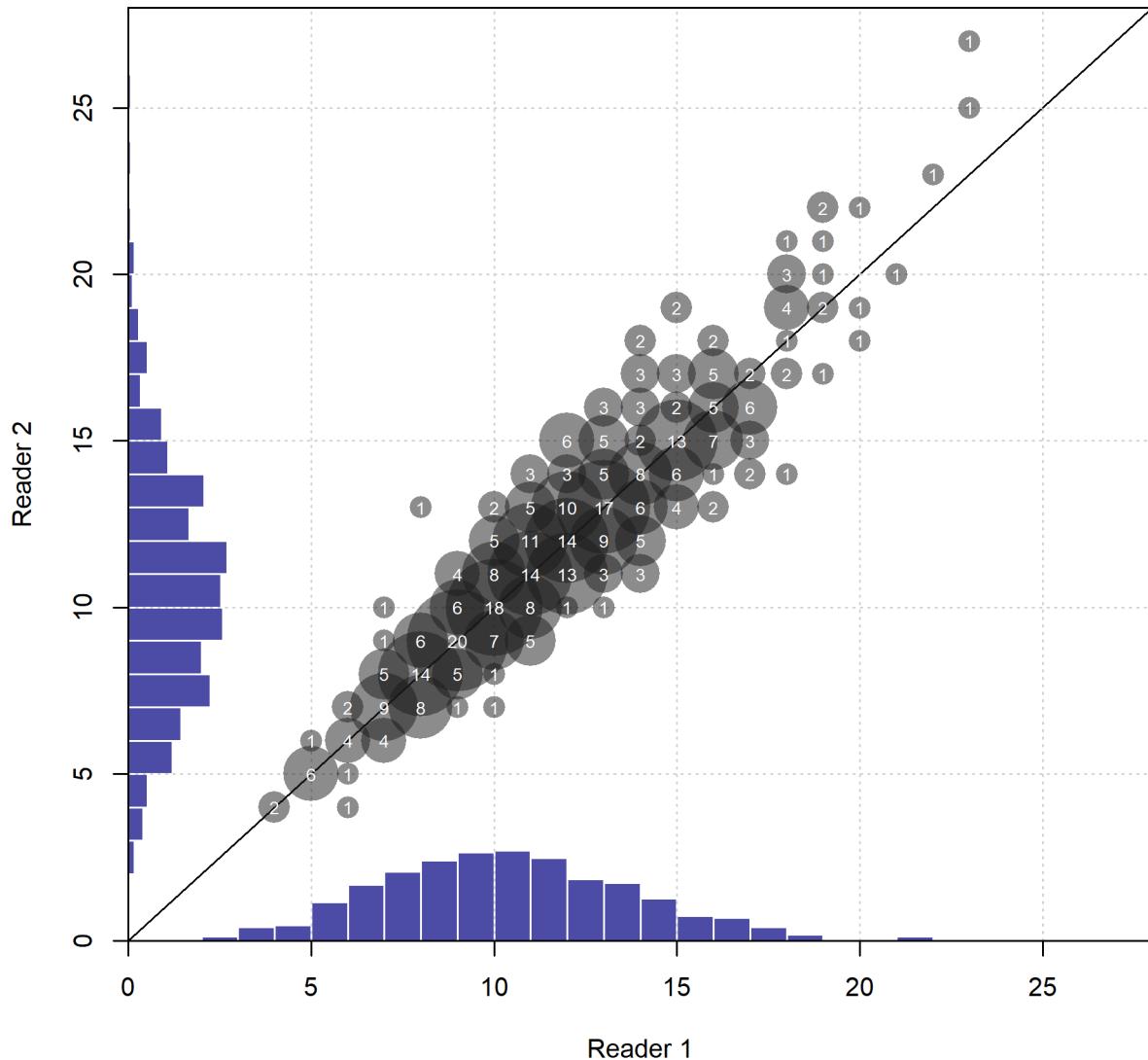


Figure 56: Comparison of the age-0 recruits between the pre-STAR panel base model and the post-STAR model base. [fig:preSTAR\\_postSTAR\\_compare\\_recruit](#)



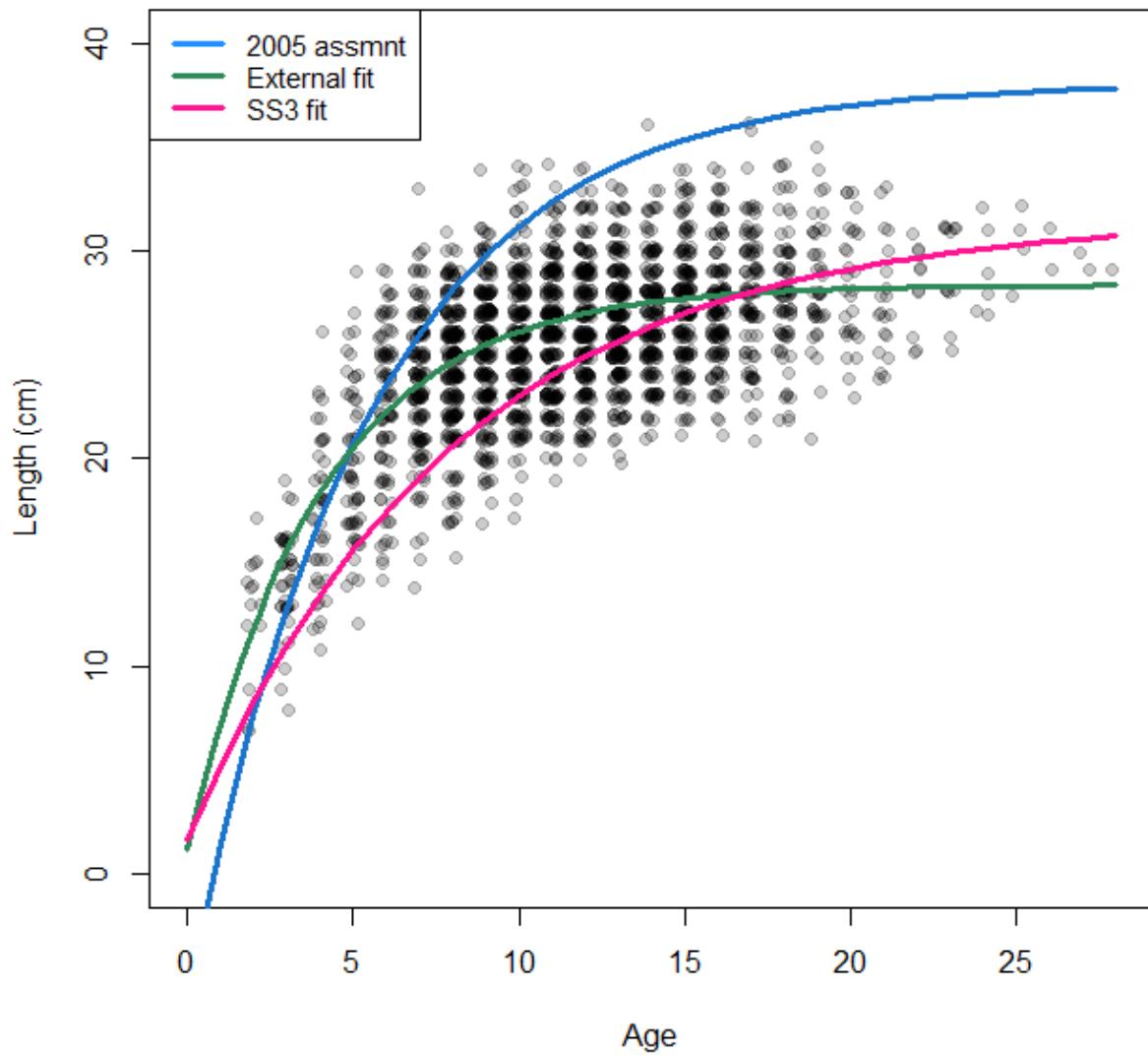


Figure 58: Estimates of growth for GBYR from the 2005 assessment, external fit to the CAAL data used in this assessment and the internal SS estimate of growth for this assessment. All growth curves were estimated using the Schnute parameterization of the von Bertalanffy growth curve. [fig:growth\\_compare](#)

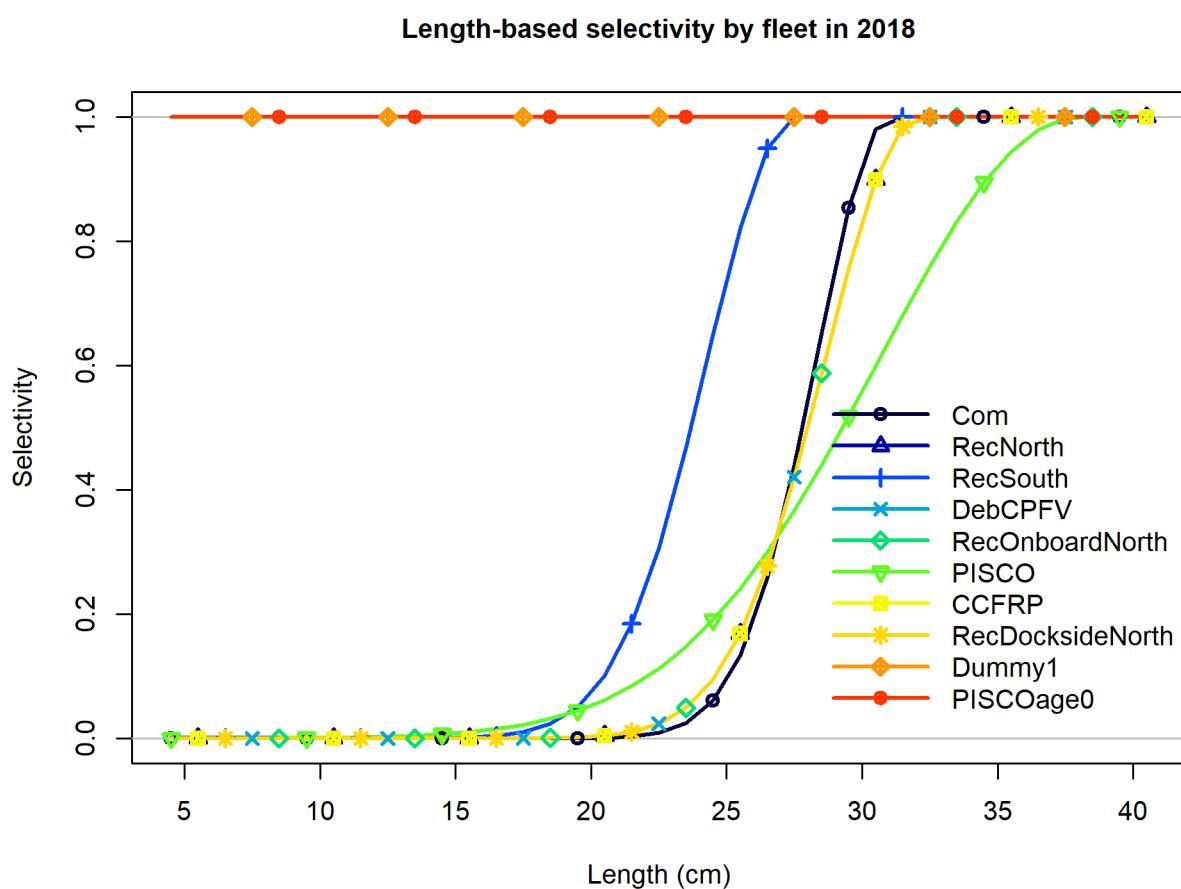


Figure 59: Selectivity at length for all of the fleets in the base model. fig:sel01\_multiple\_fle

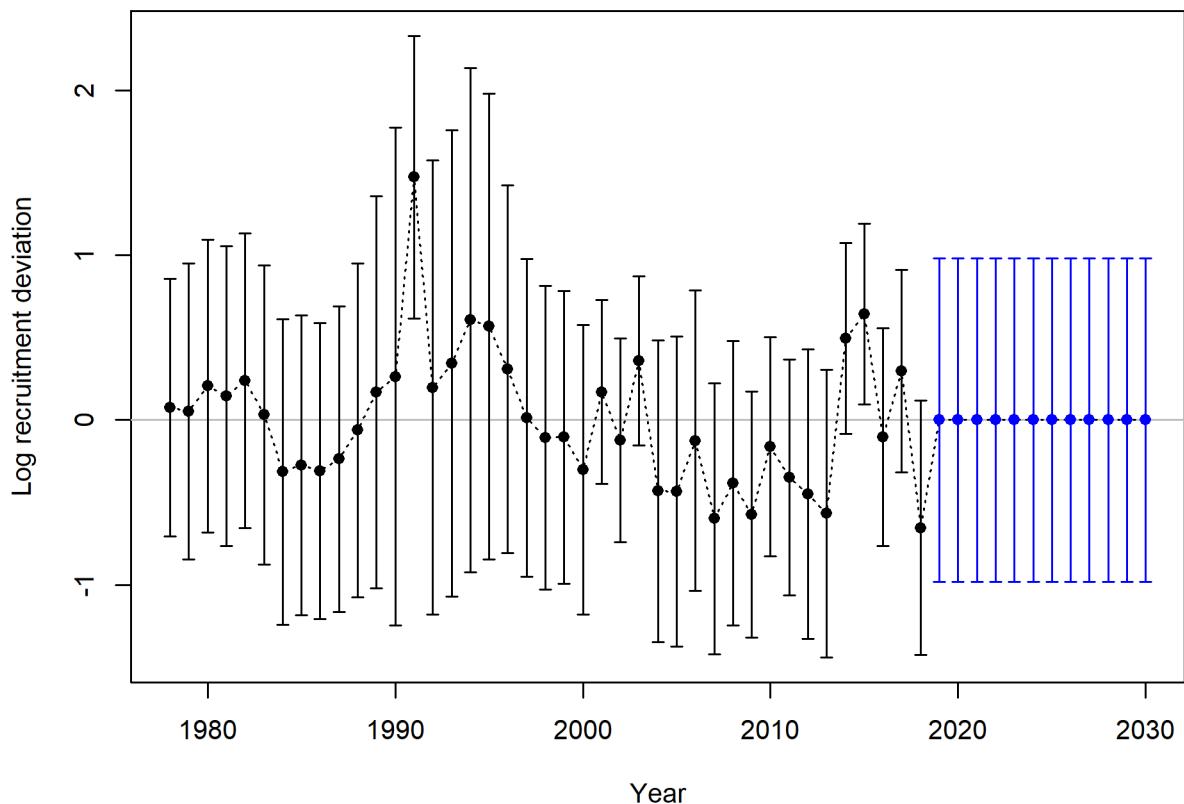


Figure 60: Estimated time-series of recruitment deviations for GBYR with 95% intervals. fig:recdevs2

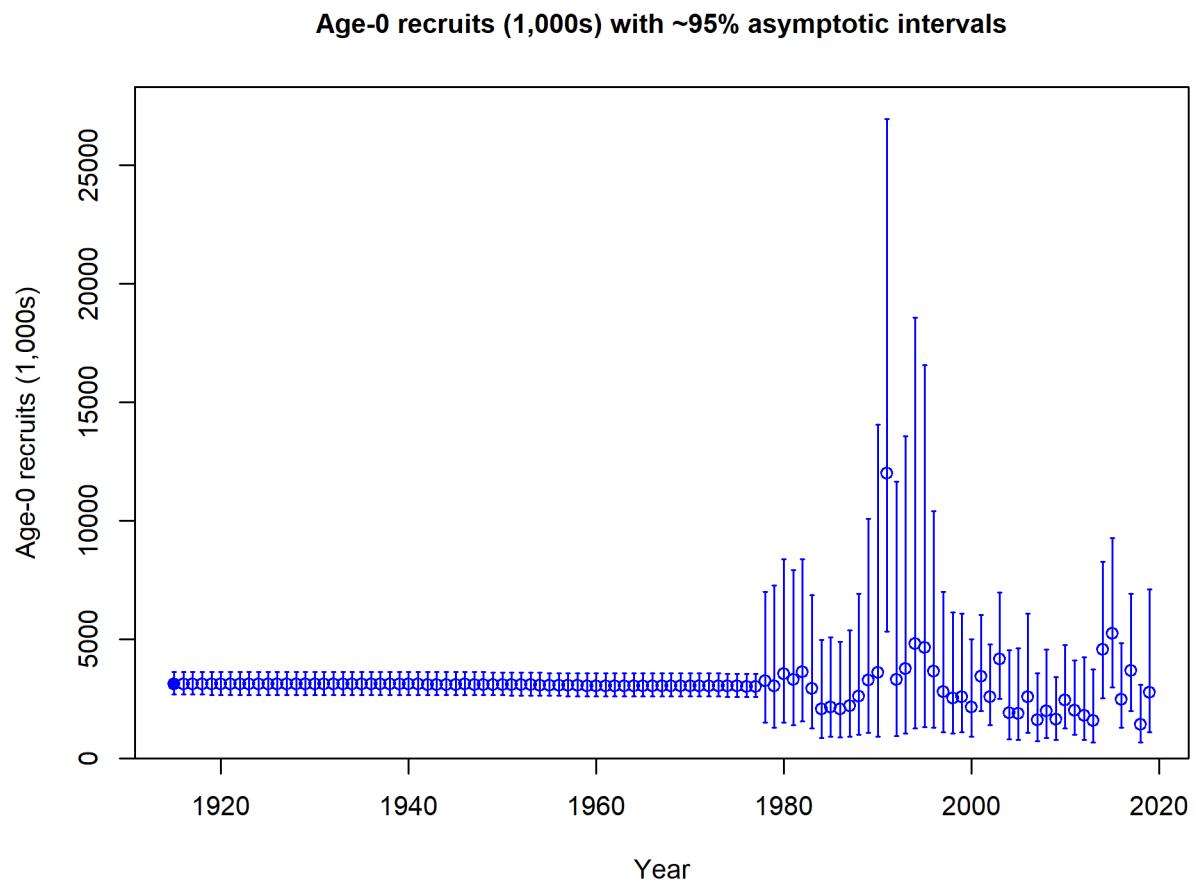


Figure 61: Time series of estimated GBYR recruitments for the base-case model with 95% confidence or credibility intervals. [fig:Recruit\\_mod1](#)

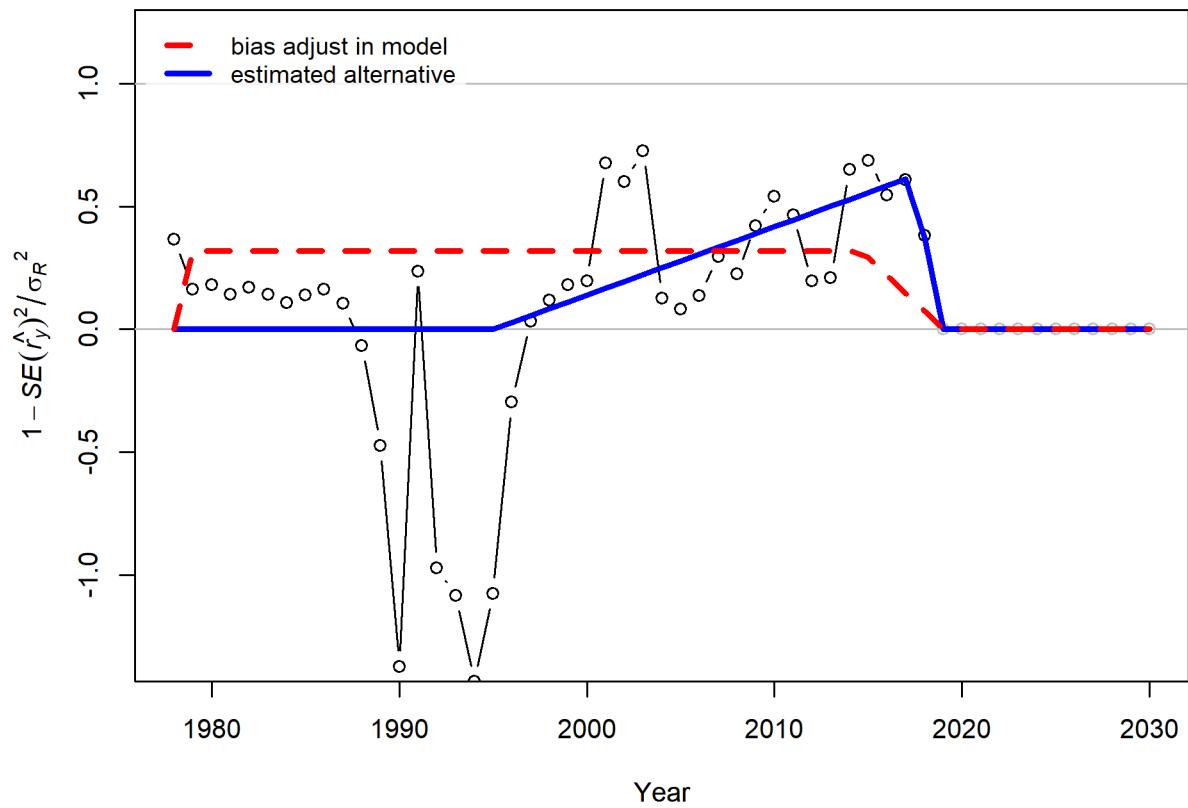


Figure 62: Bias adjustment for recruitment deviations. Points are transformed variances. Red line shows current settings for bias adjustment specified in the control file. Blue line shows the least squares estimate of alternative bias adjustment relationship for recruitment deviations.

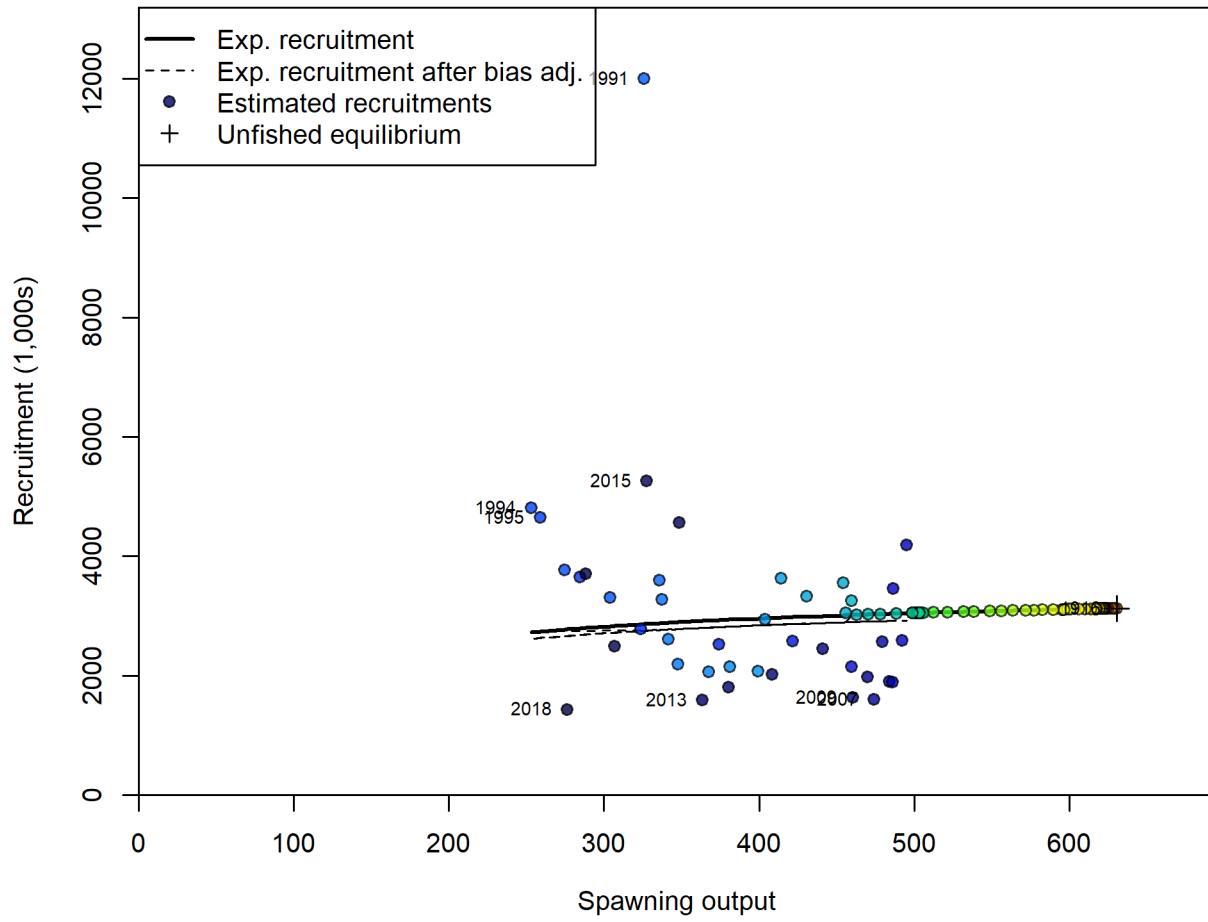


Figure 63: Estimated recruitment (red circles) and the assumed stock-recruit relationship (black line) for GBYR. The green line shows the effect of the bias correction for the lognormal distribution. [fig:SR\\_curve2](#)

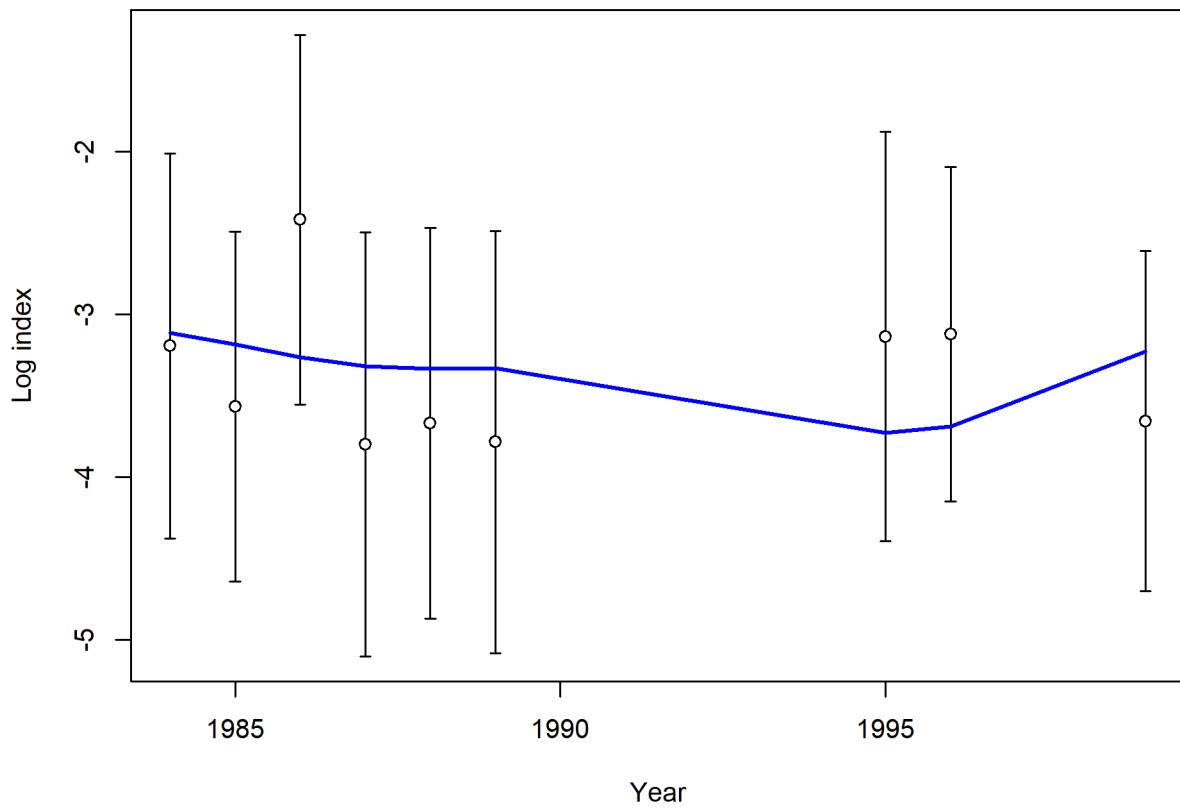


Figure 64: Fit to log index data on log scale for the recreational MRFSS dockside CPFV fishery north of Point Conception. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. [fig:index5\\_logcpuefit\\_RecDocksideNorth](#)

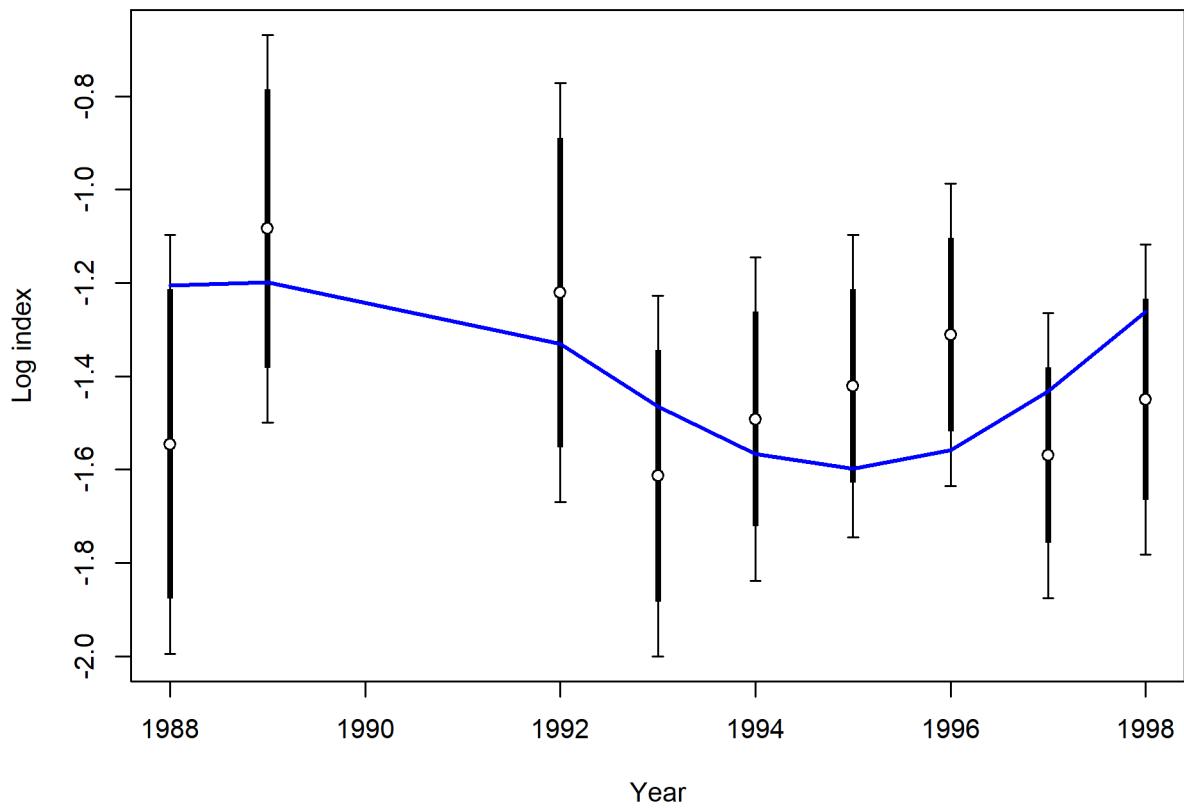


Figure 65: Fit to log index data on log scale for the recreational Deb's CPFV onboard observer program, representing north of Point Conception. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. [fig:index5\\_logcpuefit\\_DebCPFV](#)

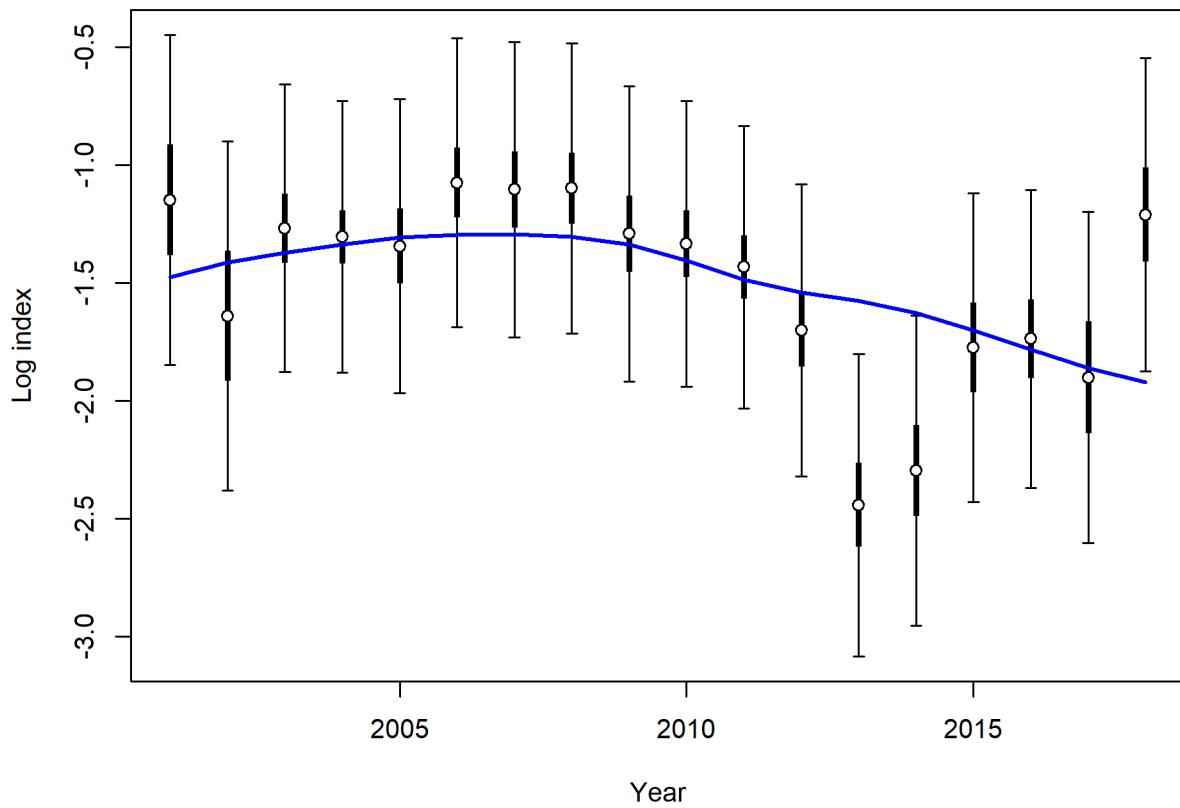


Figure 66: Fit to log index data on log scale for the CRFS/Cal Poly CPFV onboard observer survey north of Point Conception. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. [fig:index5\\_logcpuefit\\_RecOnboardNorth](#)

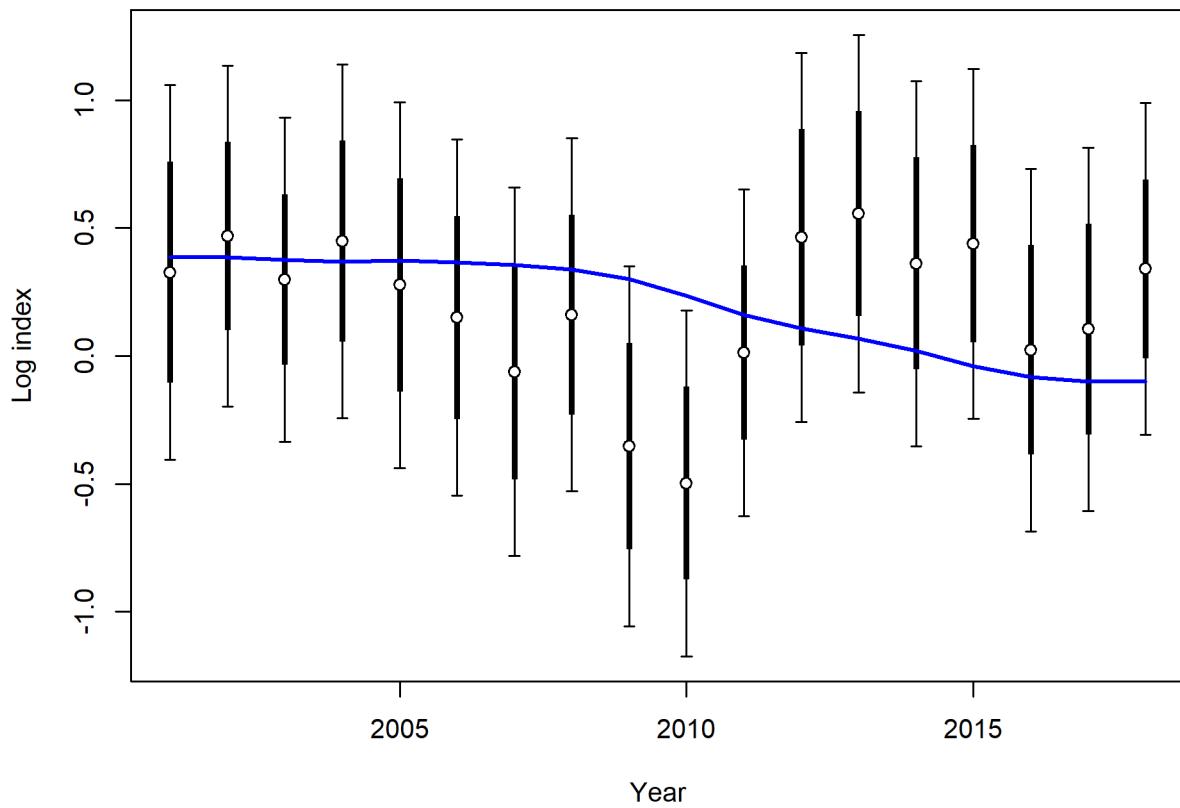


Figure 67: Fit to log index data on log scale for the fishery-independent PISCO kelp forest fish survey for fish 15 cm and larger. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. | [fig:index5\\_logcpuefit\\_PISCO](#)

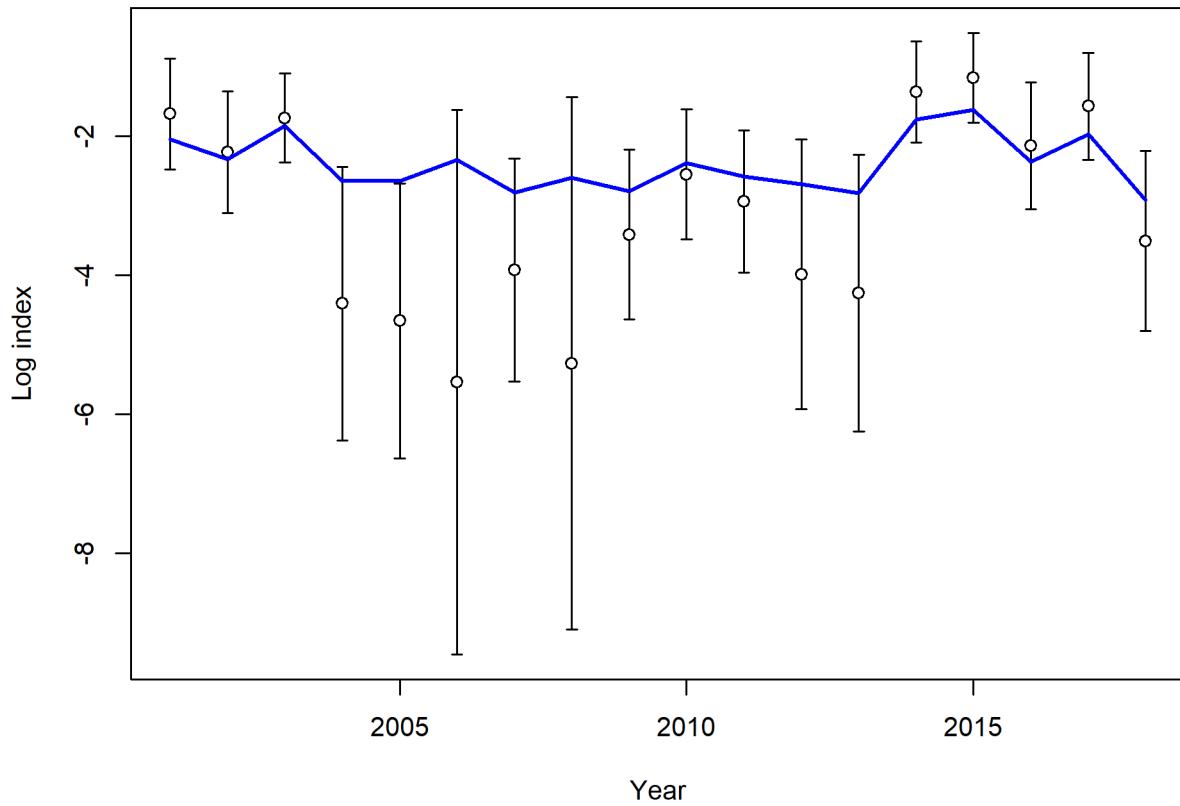


Figure 68: Fit to log index data on log scale for the fishery-independent PISCO age-0 (6 cm or less) kelp forest fish survey for fish 15 cm and larger. Lines indicate 95% uncertainty interval around index values. [fig:index5\\_logcpuefit\\_PISCOage0](#)

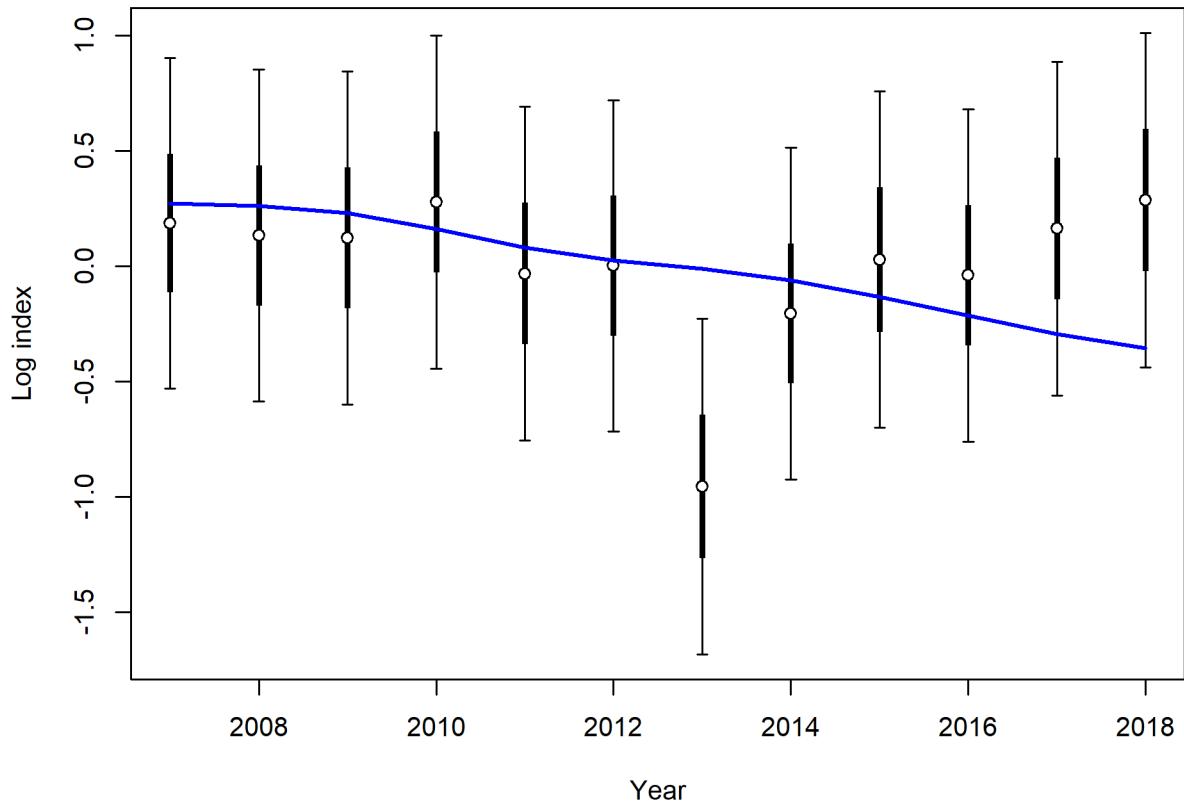


Figure 69: Fit to log index data on log scale for the fishery-independent CCFRP hook-and-line survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. fig:index5\_logcpuefit

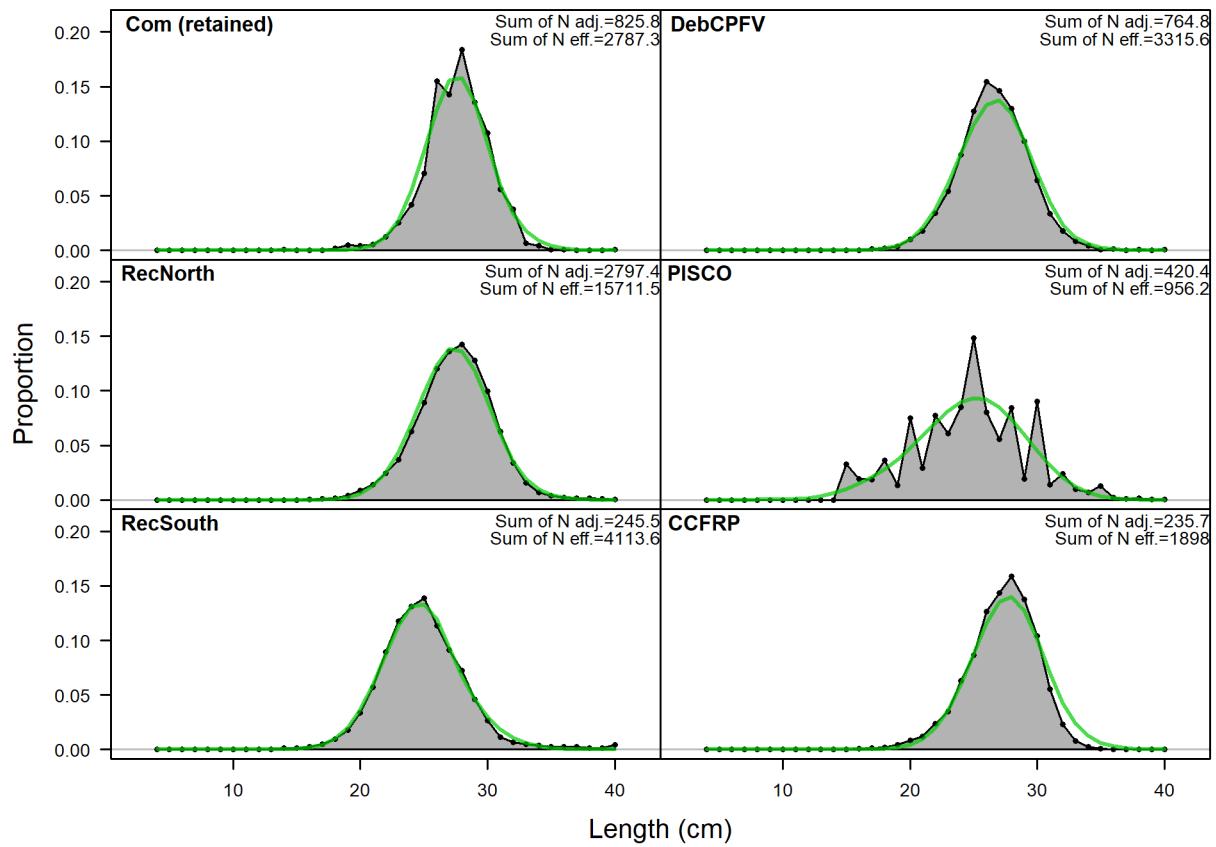


Figure 70: Length compositions aggregated across time by fleet. [fig:comp\\_lenfit\\_\\_aggregat](#)

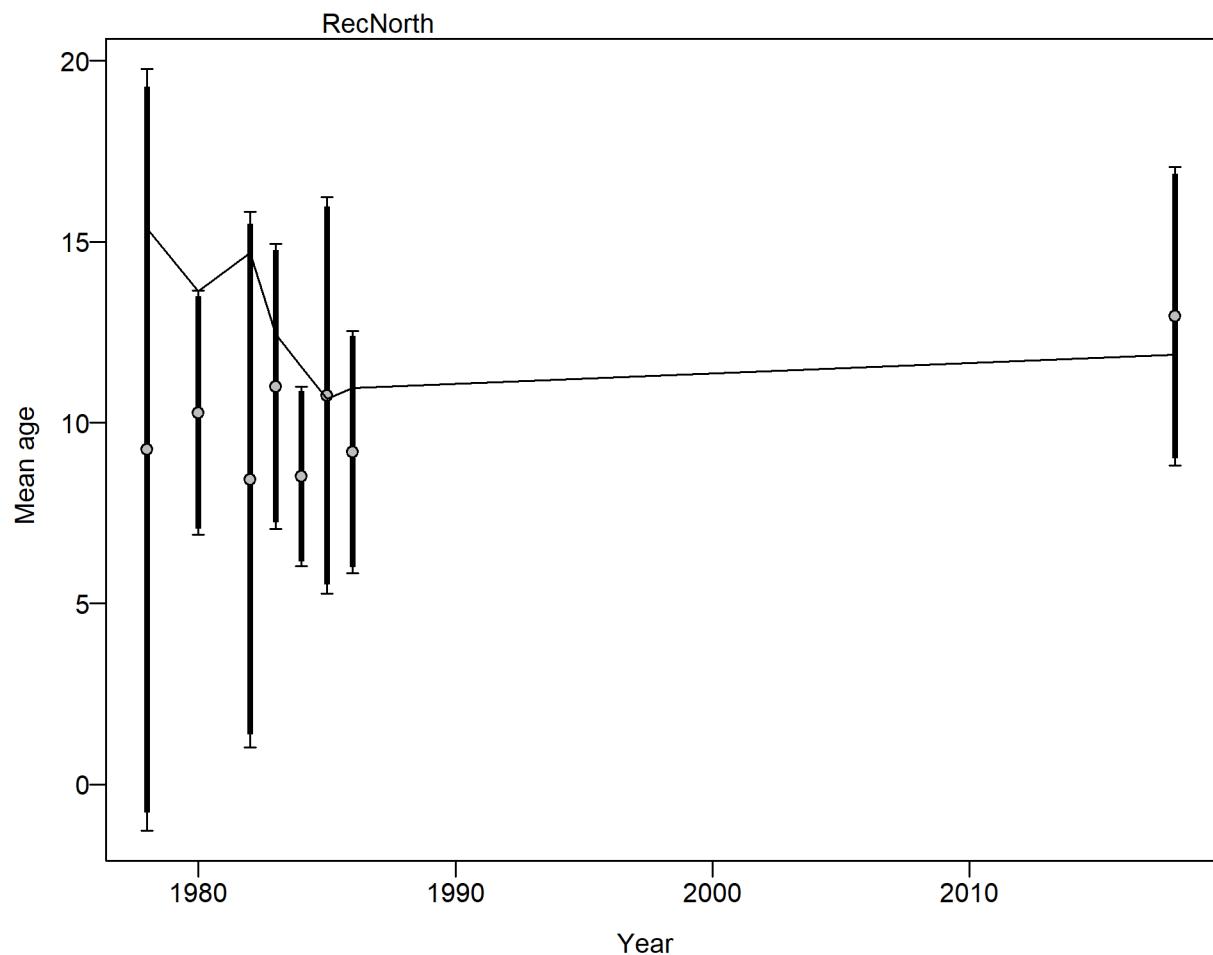


Figure 71: Mean age for the recreational fishery (ages from north of Point Conception only) with 95% confidence intervals based on current sample sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% interval) is 0.182 (0.588-3.588). For more info, see Francis et al. (2011). [fig:comp\\_condAALfit\\_data\\_weighting\\_TA1.8\\_condAgeRecNorth](#)

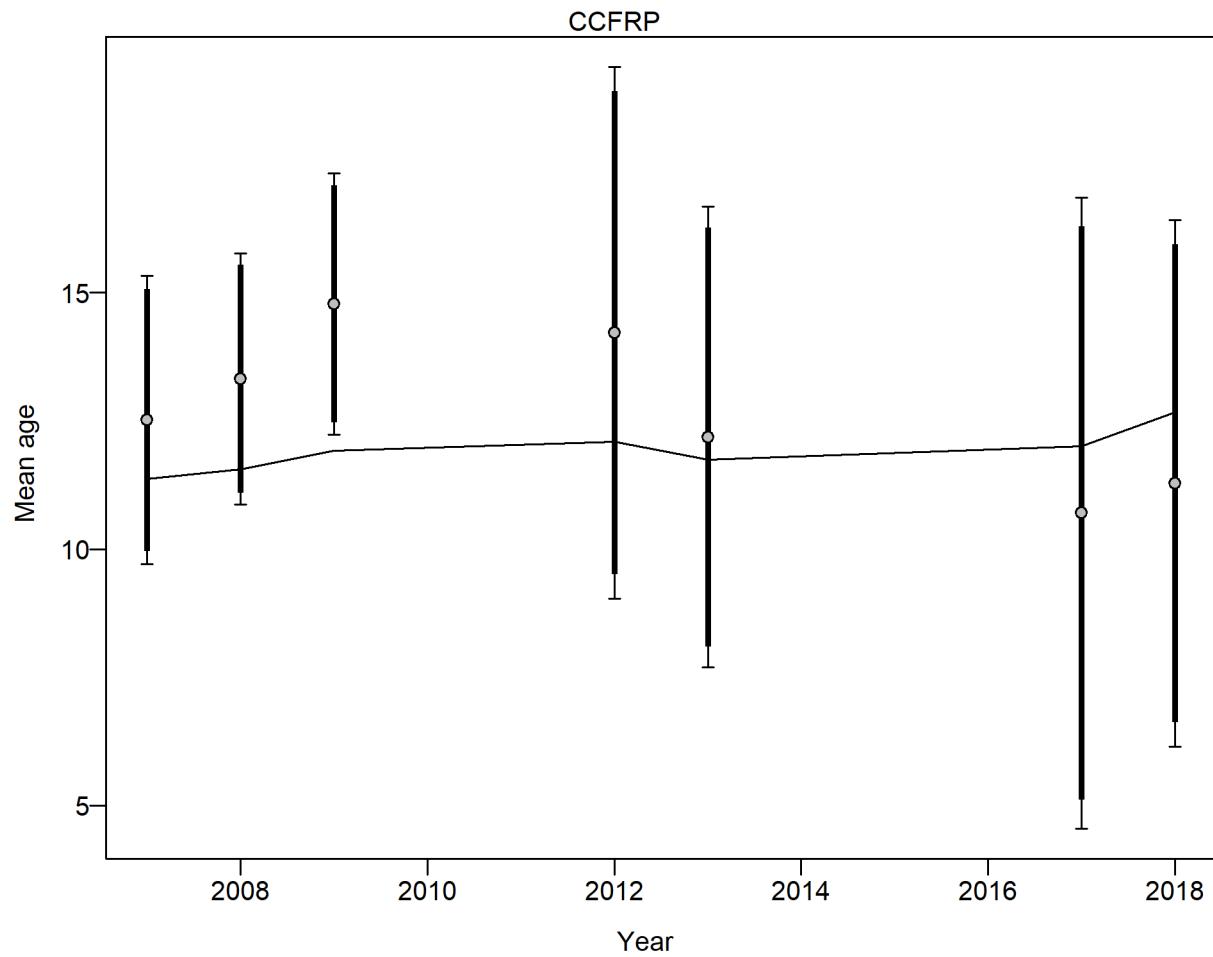


Figure 72: Mean age for the CCFRP survey with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% interval) is 0.023 (0.511-3.745). For more info, see Francis et al. (2011). [fig:comp\\_condAALfit\\_data\\_weighting\\_TA1](#)

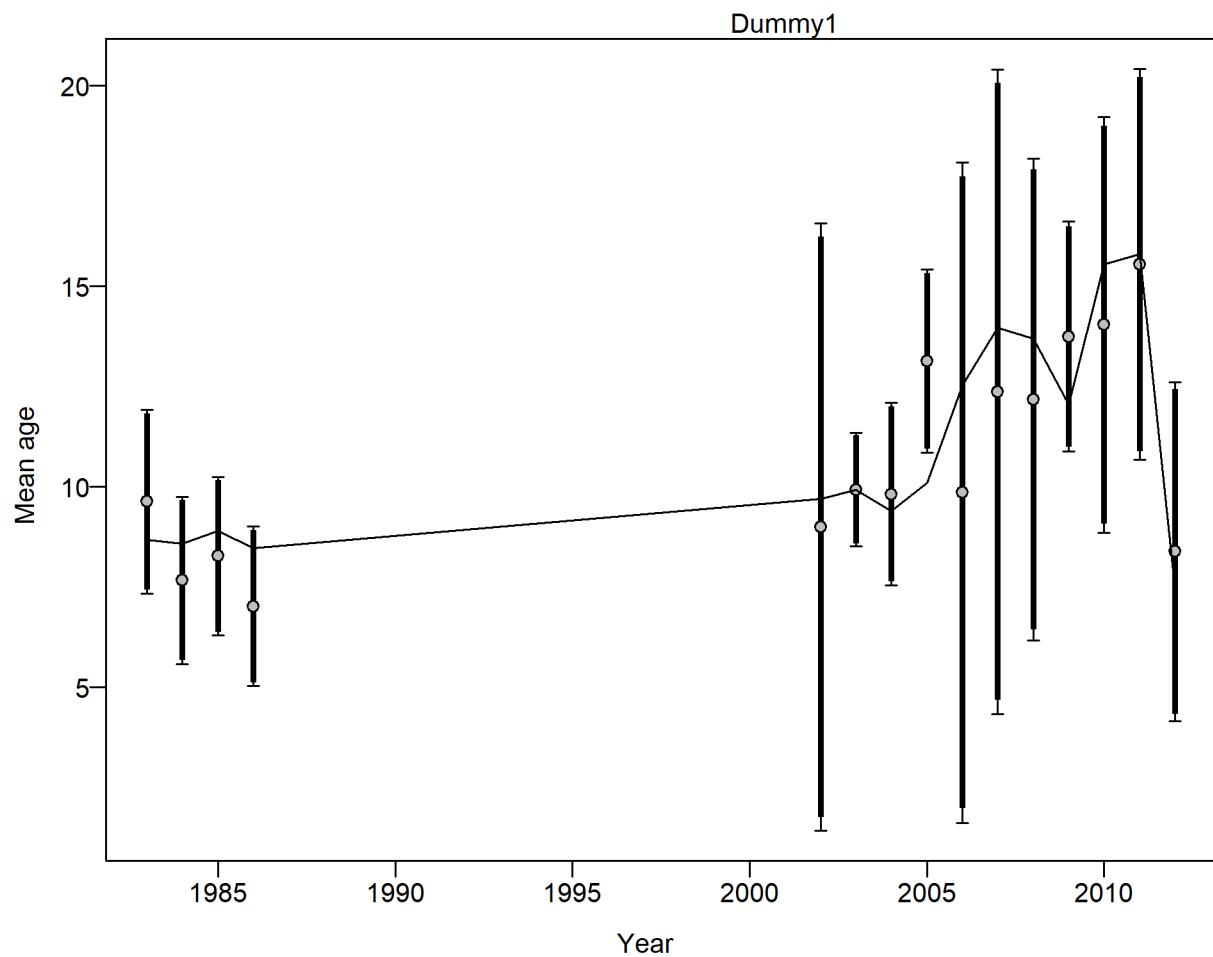


Figure 73: Mean age for the ‘dummy’ fleet with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% interval) is 0.065 (0.507-3.692). For more info, see Francis et al. (2011). [fig:comp\\_condAALfit\\_data\\_weighting\\_TA1](#)

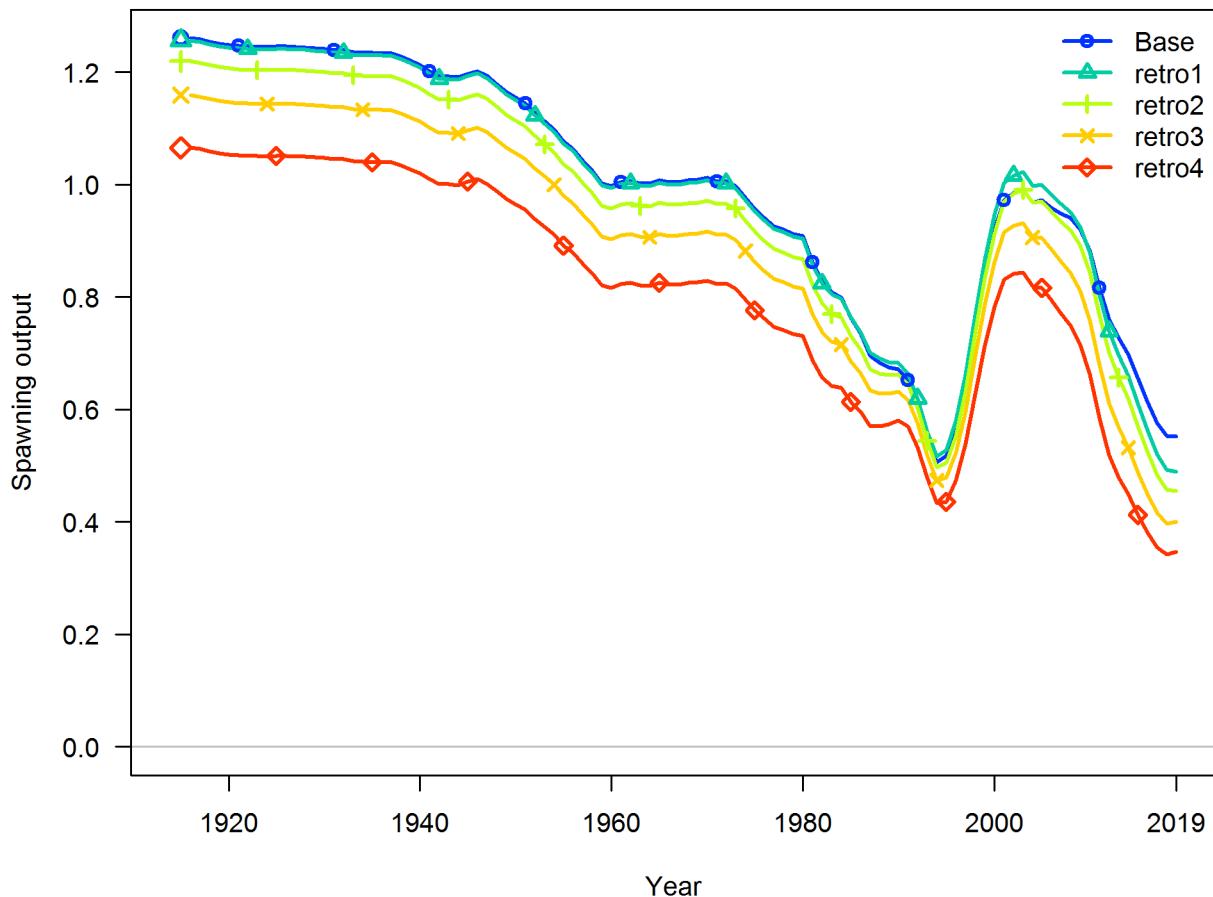


Figure 74: Retrospective pattern for spawning output. `fig:retro_spawnb`

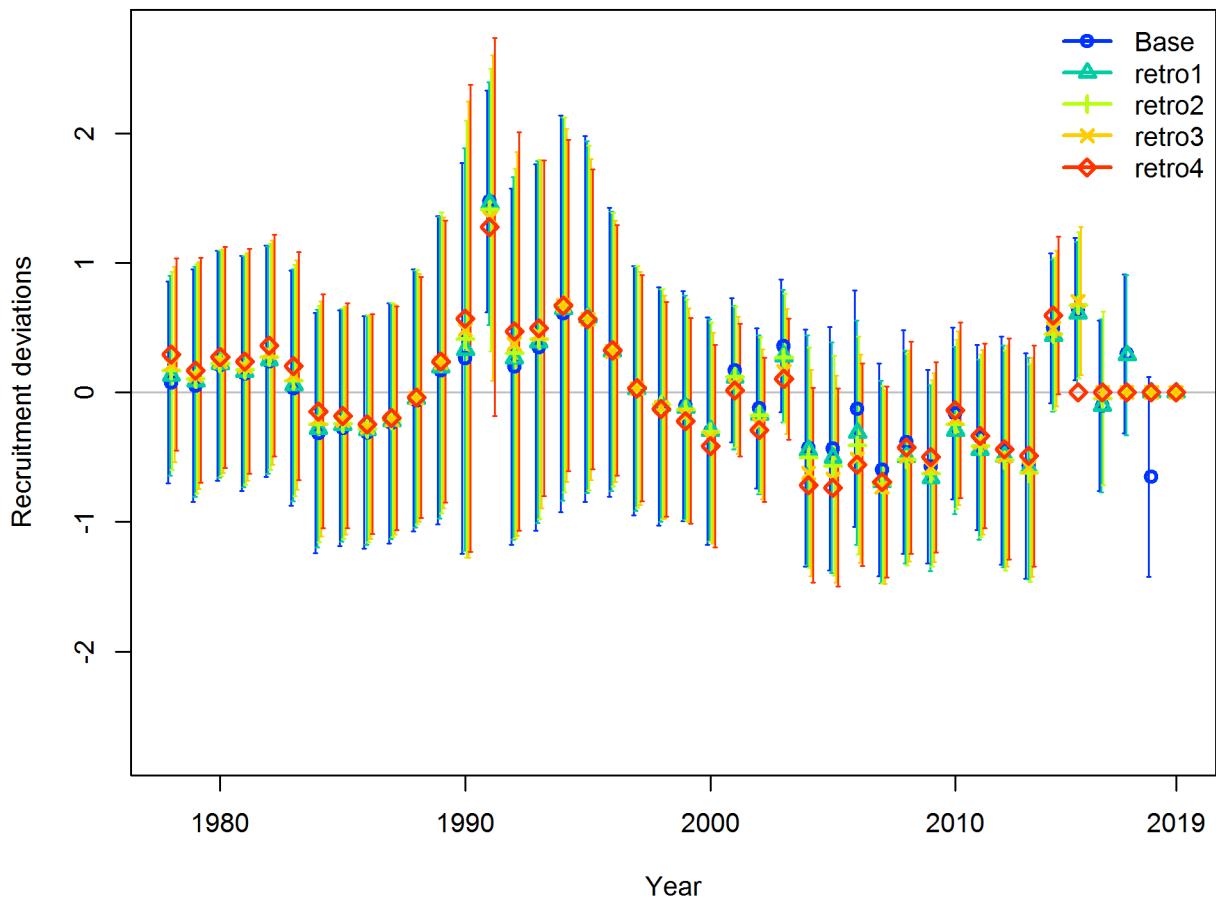


Figure 75: Retrospective pattern for estimated recruitment deviations. fig:retro\_recdev

### Changes in survey likelihoods

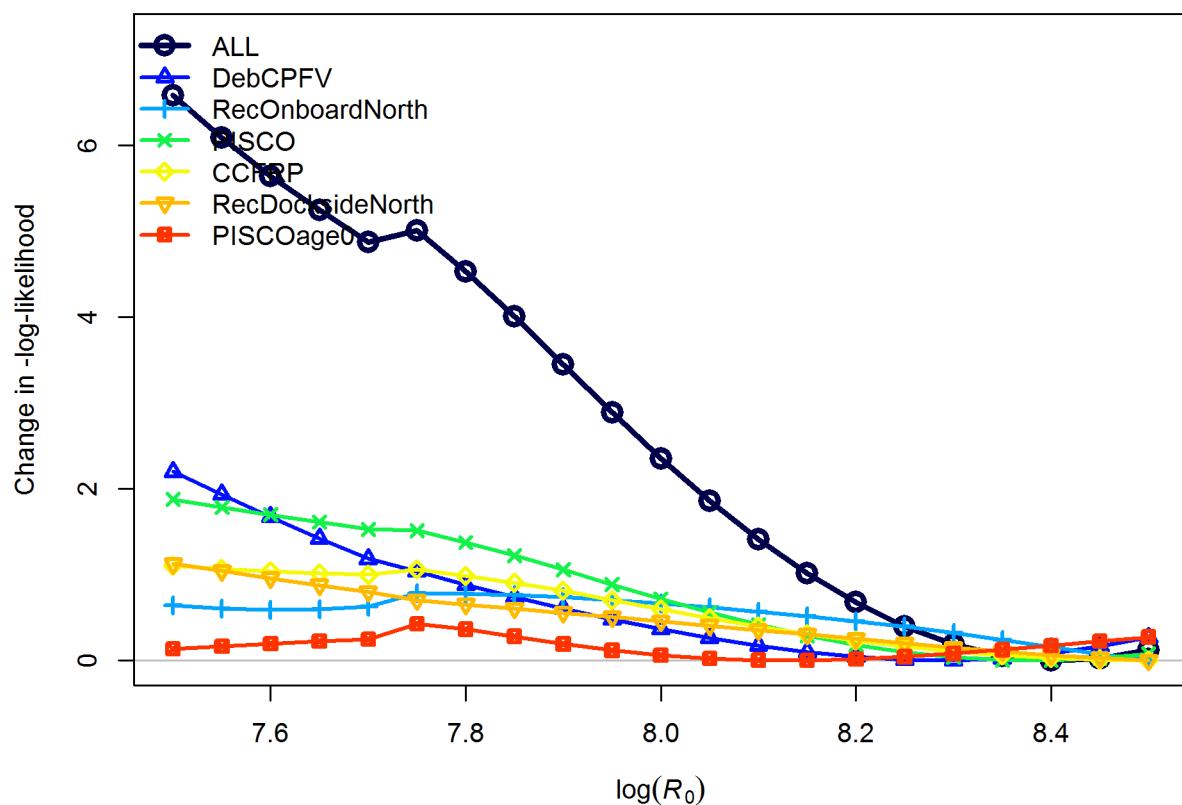


Figure 76: Likelihood profile for  $R_0$  values across surveys. [fig:profile\\_R0\\_piner2](#)

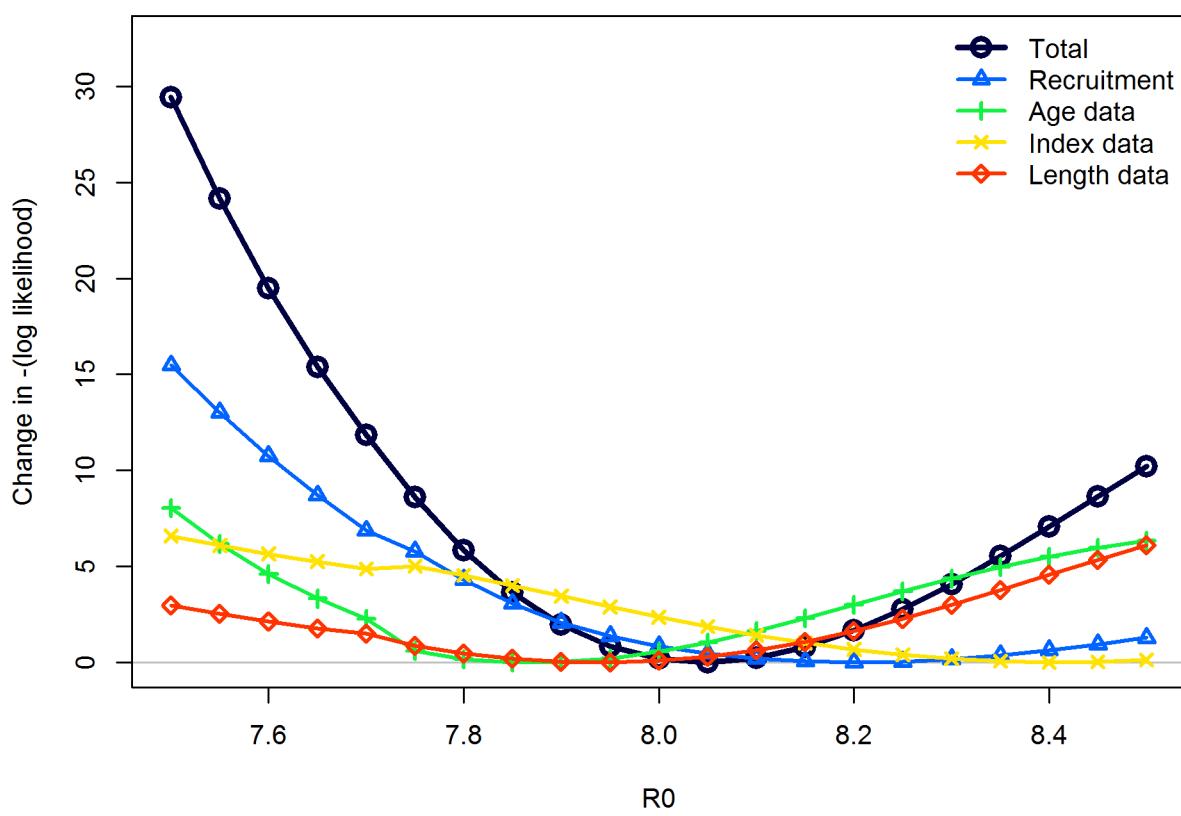


Figure 77: Likelihood profile across  $R_0$  values for each data type. `fig:profile_R0_like`

### Changes in length-composition likelihoods by fleet

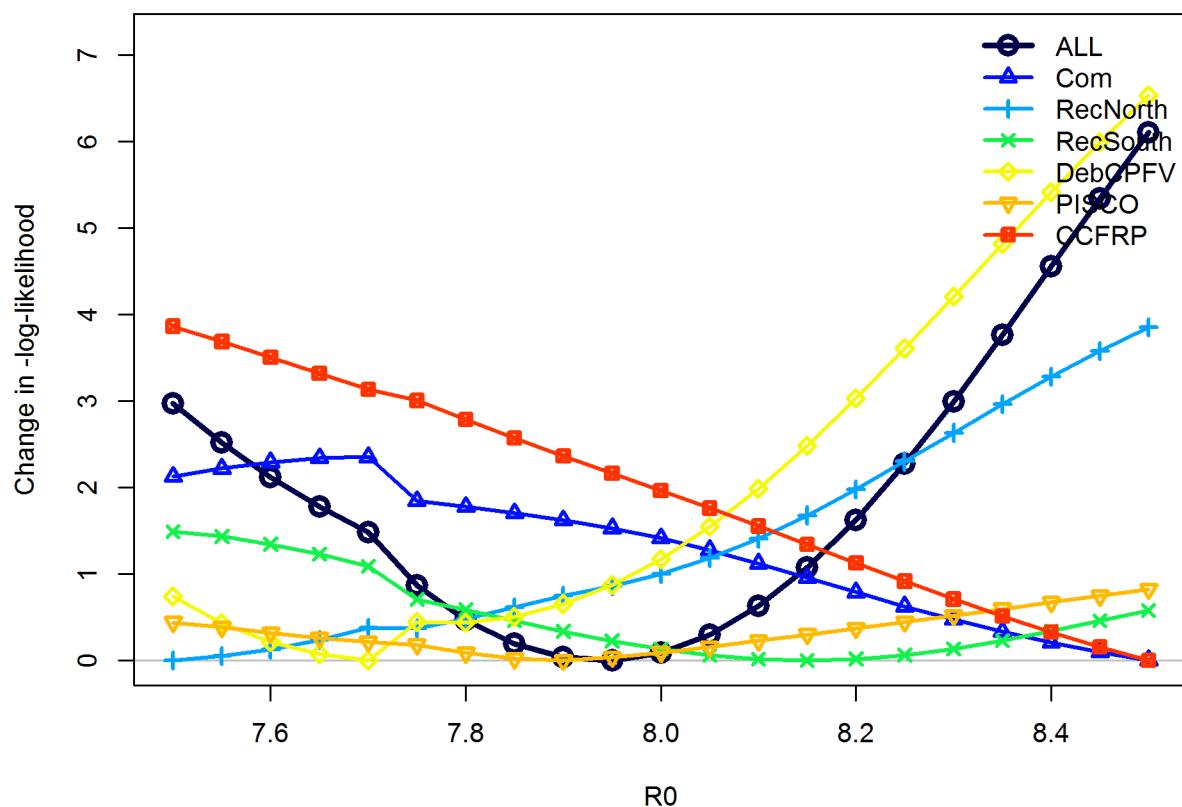


Figure 78: Likelihood profile across  $R_0$  values of length composition by fleet. fig:profile\_R0\_pine

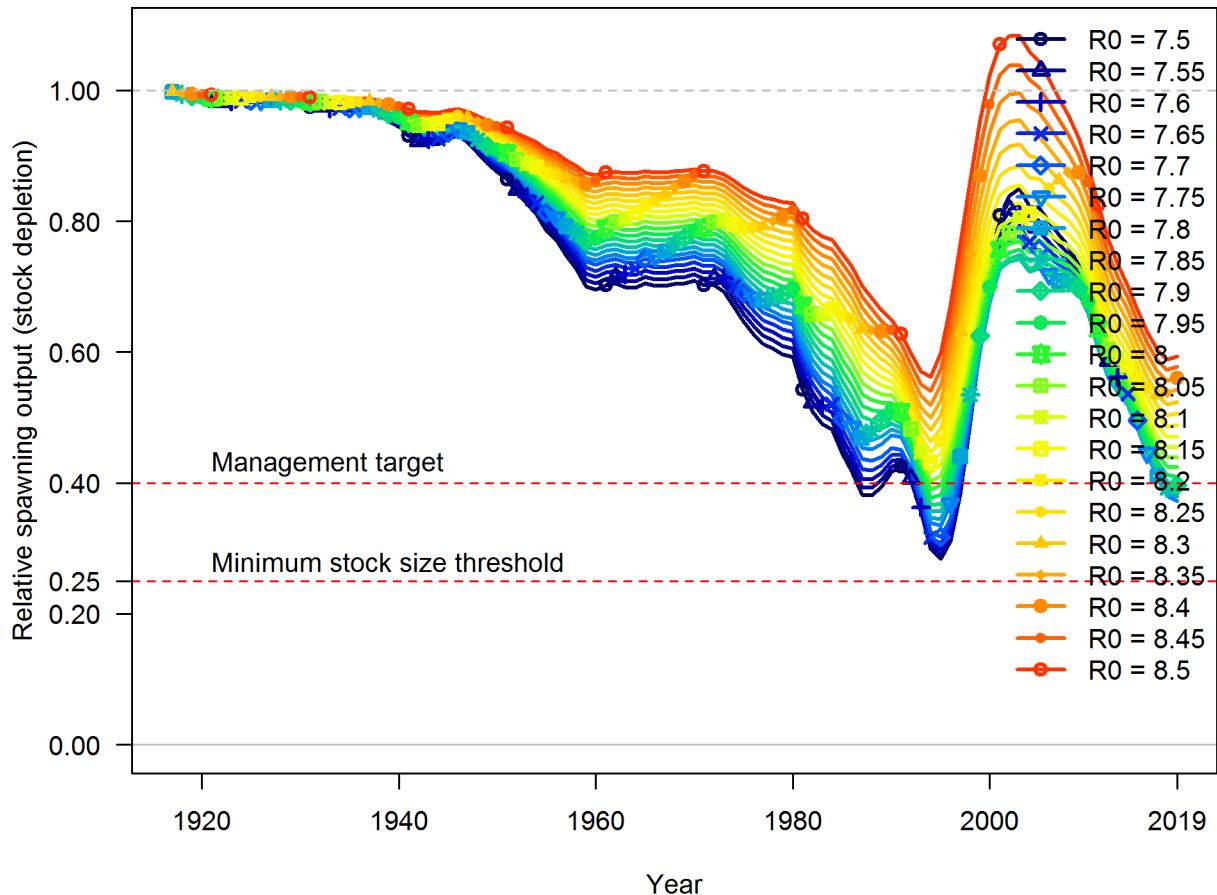


Figure 79: Trajectories of depletion across values of  $R_0$ . [fig:profile\\_R0\\_depl](#)

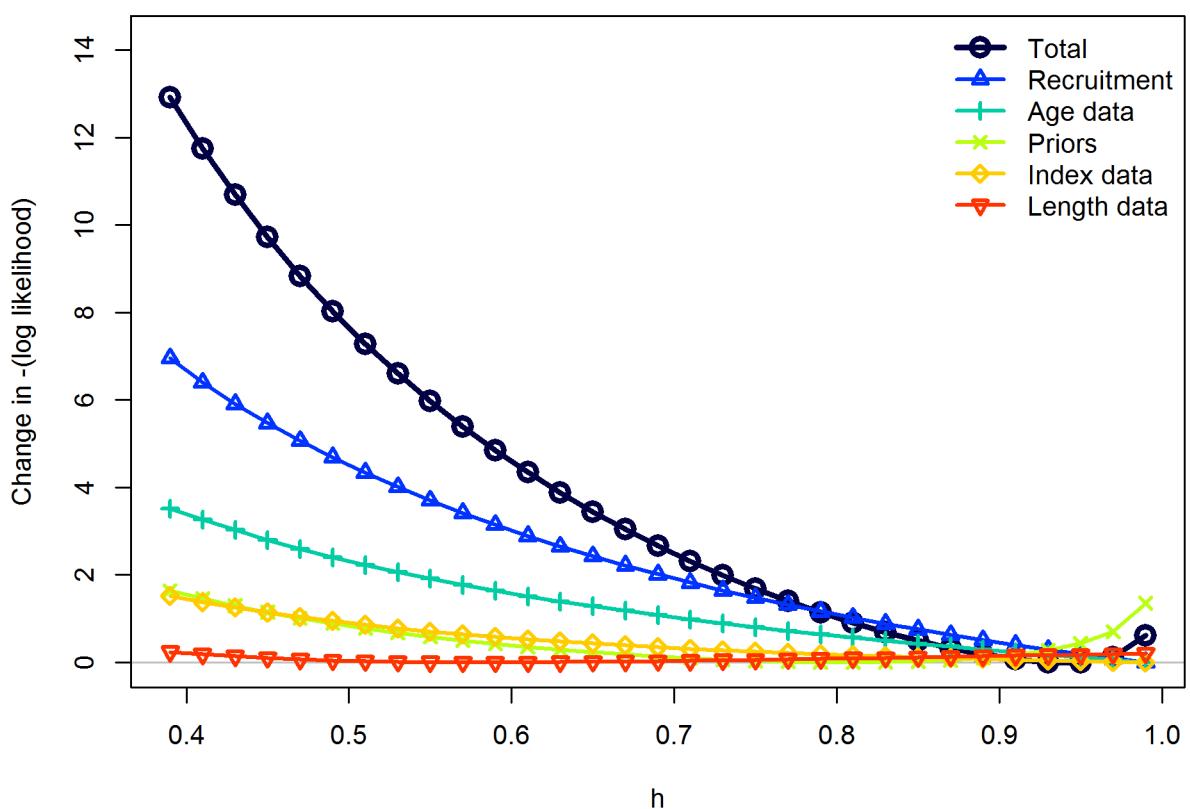


Figure 80: Likelihood profile across steepness values for each data type. [fig:profile\\_h\\_like](#)

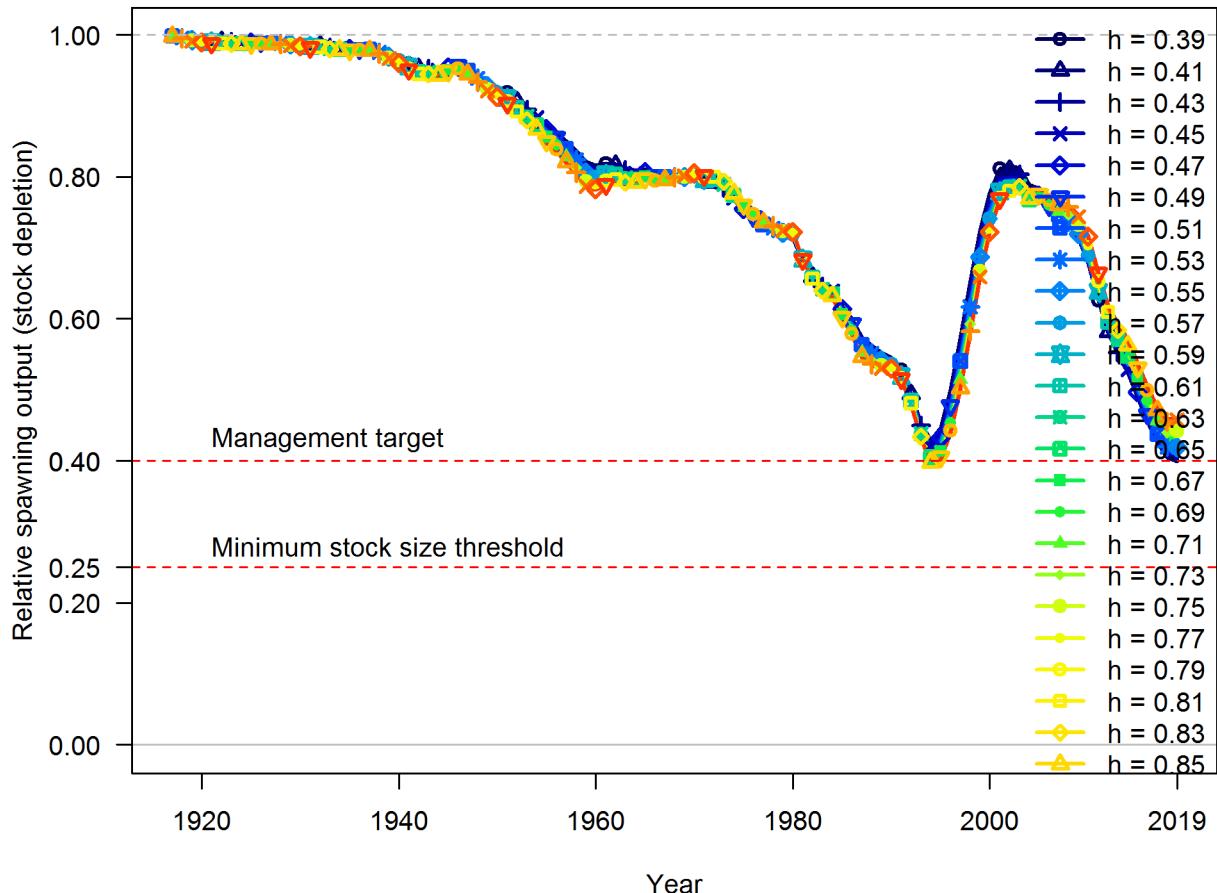


Figure 81: Trajectories of depletion across values of steepness. [fig:profile\\_h\\_depl](#)

### Changes in length-composition likelihoods by fleet

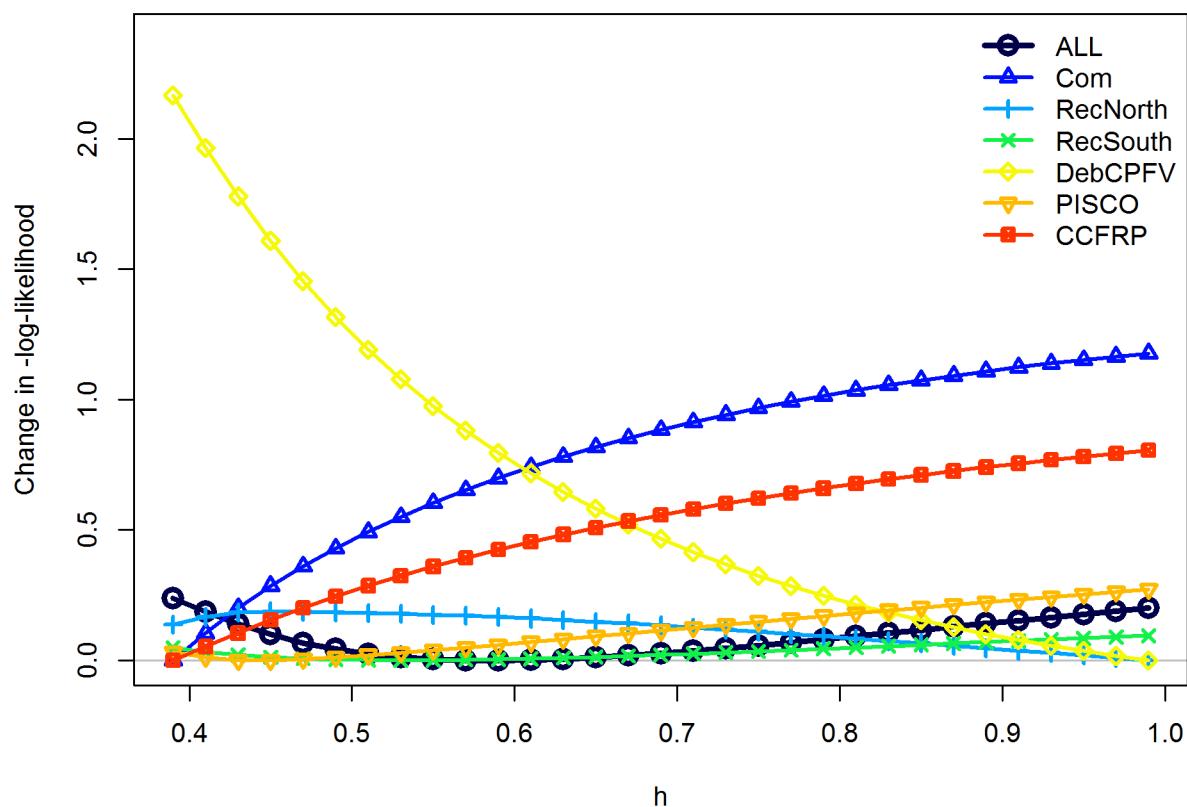


Figure 82: Likelihood profile across steepness values by fleet length composition. [fig:profile\\_h\\_pin](#)

### Changes in survey likelihoods

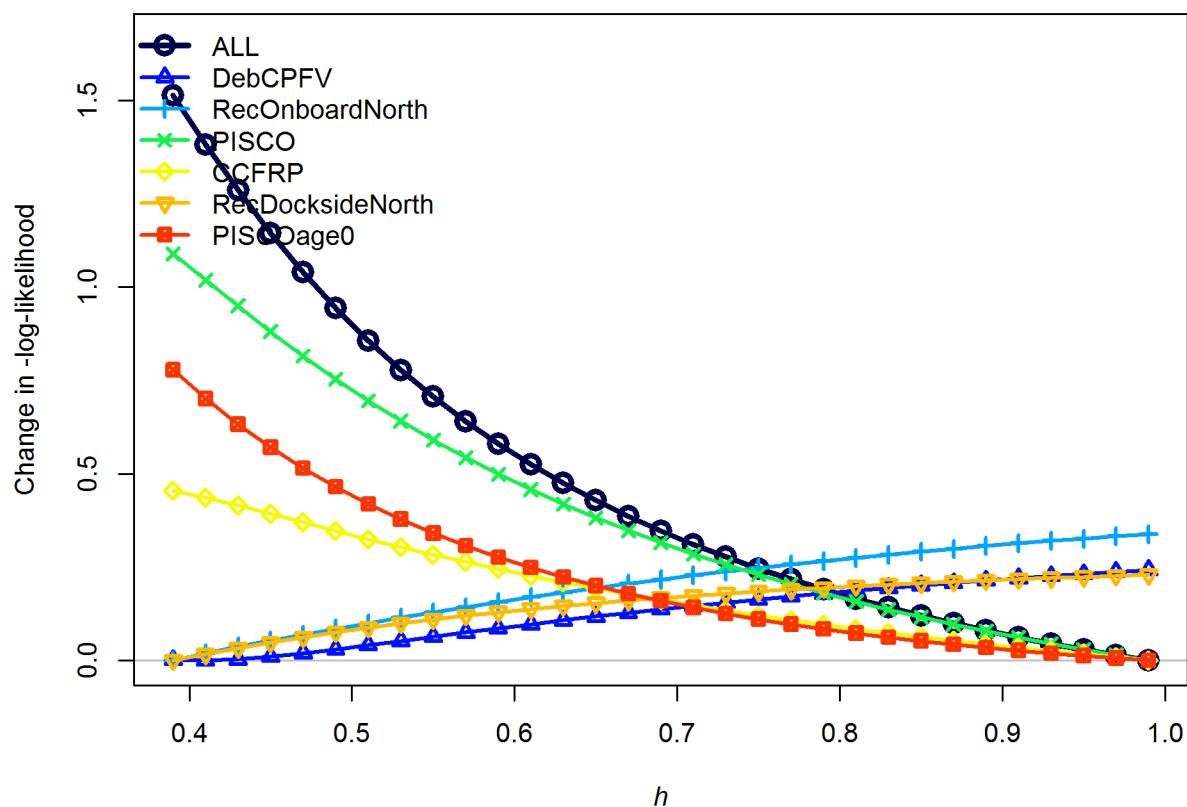


Figure 83: Likelihood profile across steepness values by surveys. [fig:profile\\_h\\_piner2](#)

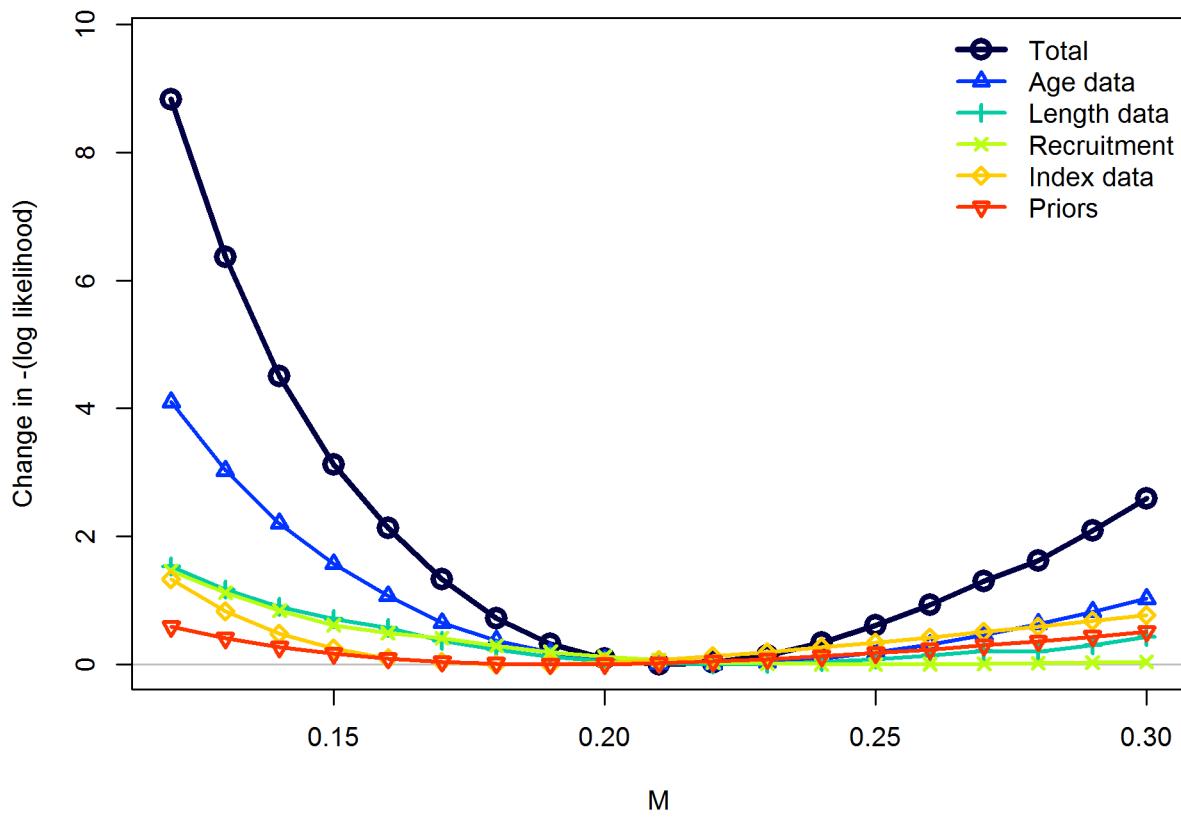


Figure 84: Likelihood profile across female natural mortality values for each data type. `fig:profile_m`

### Changes in length-composition likelihoods by fleet

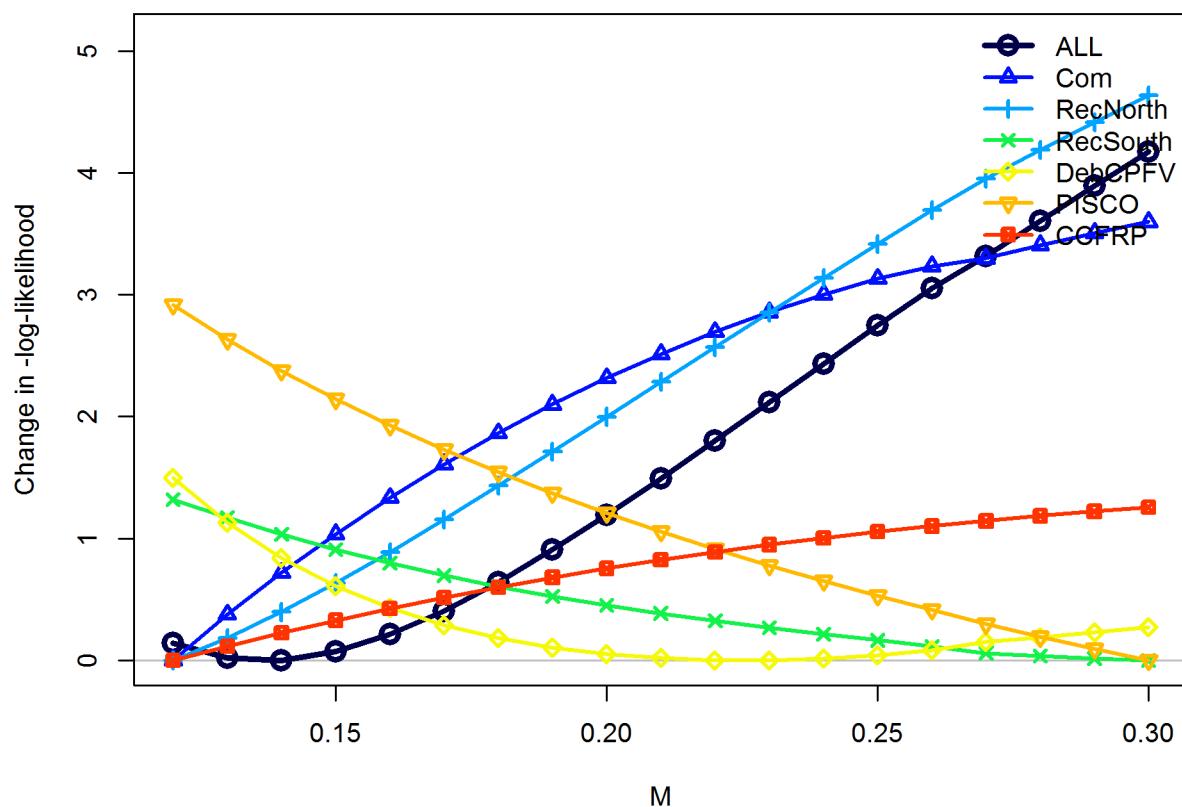


Figure 85: Likelihood profile across female natural mortality values by length composition. fig:profile\_m

### Changes in survey likelihoods

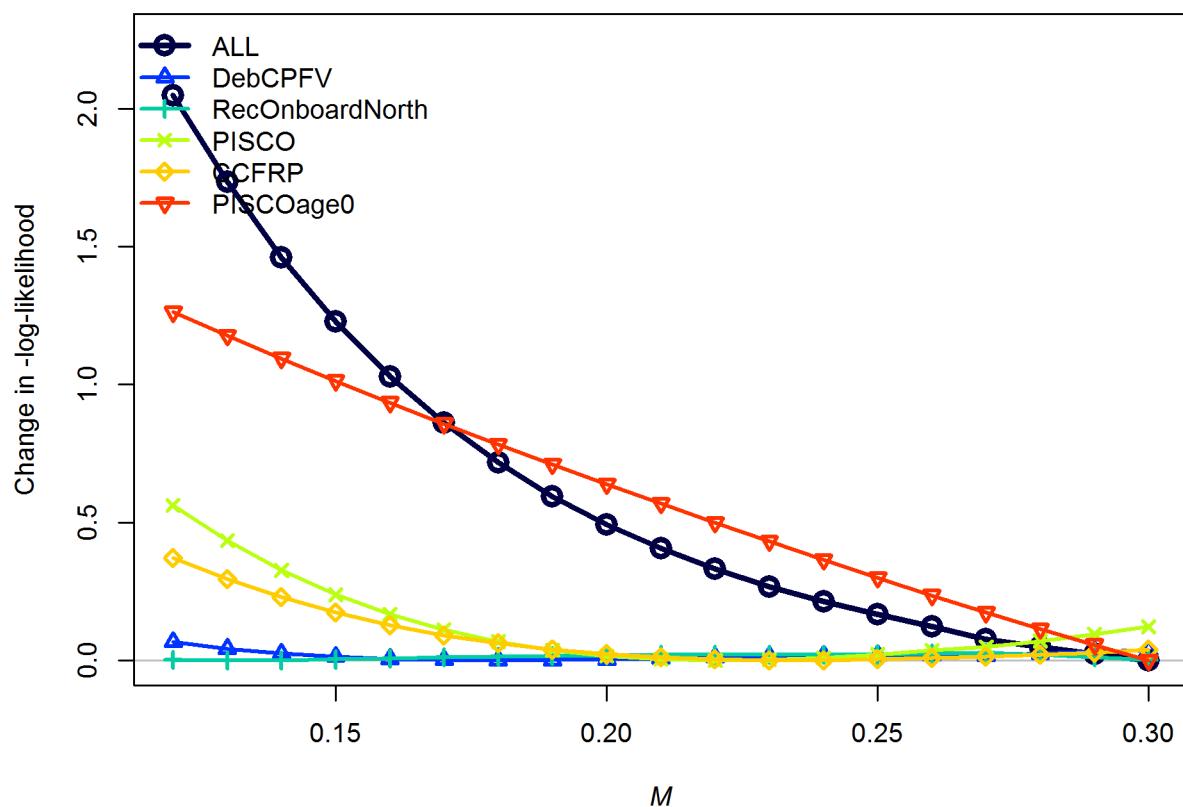


Figure 86: Likelihood profile across female natural mortality values by surveys. [fig:profile\\_m\\_pine](#)

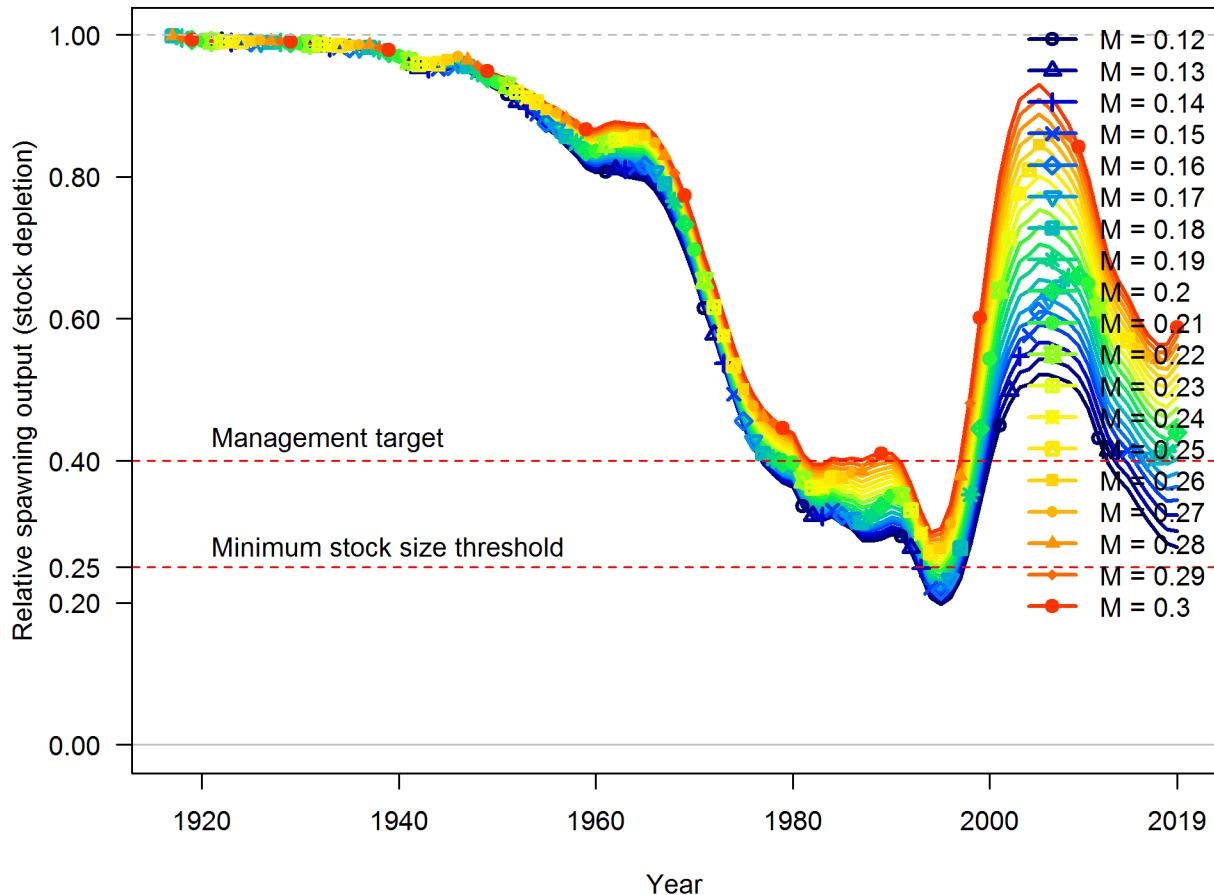


Figure 87: Trajectories of depletion across values of female natural mortality. `fig:profile_m_depl`

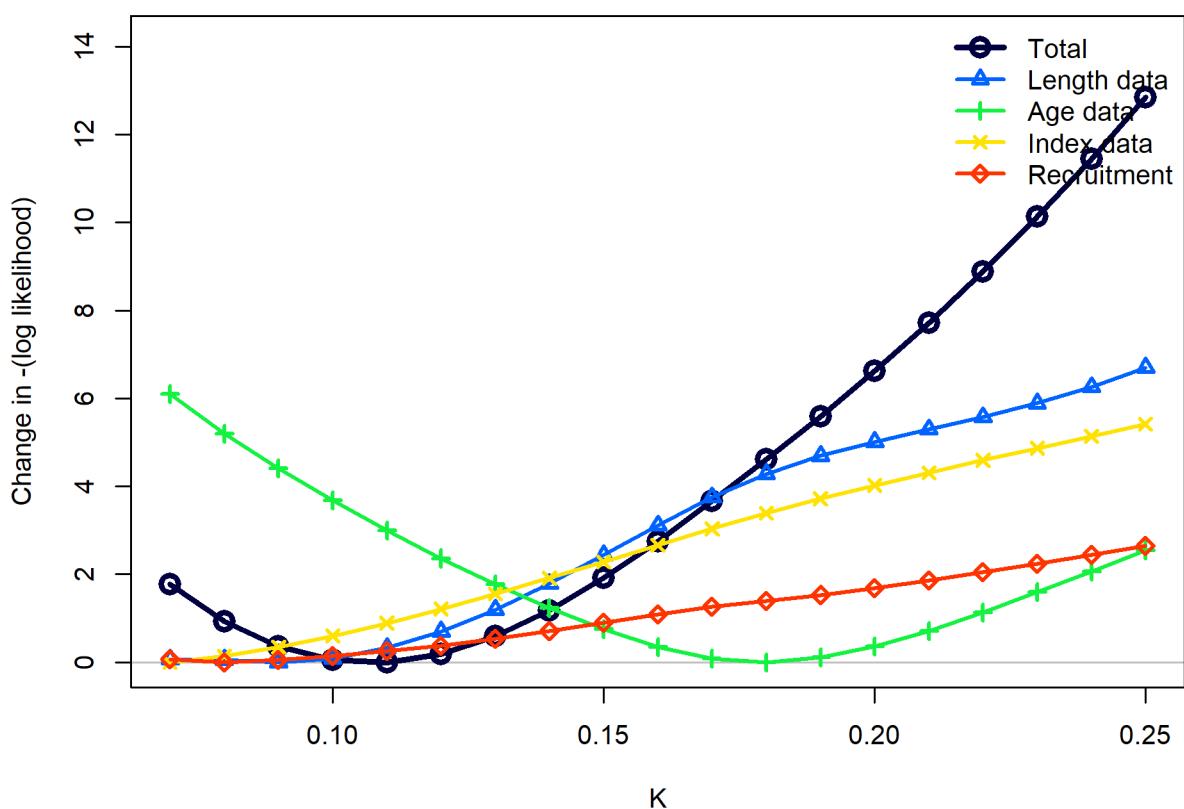


Figure 88: Likelihood profile across the growth parameter  $k$  for each data type. `fig:profile_k_like`

### Changes in age comp likelihoods

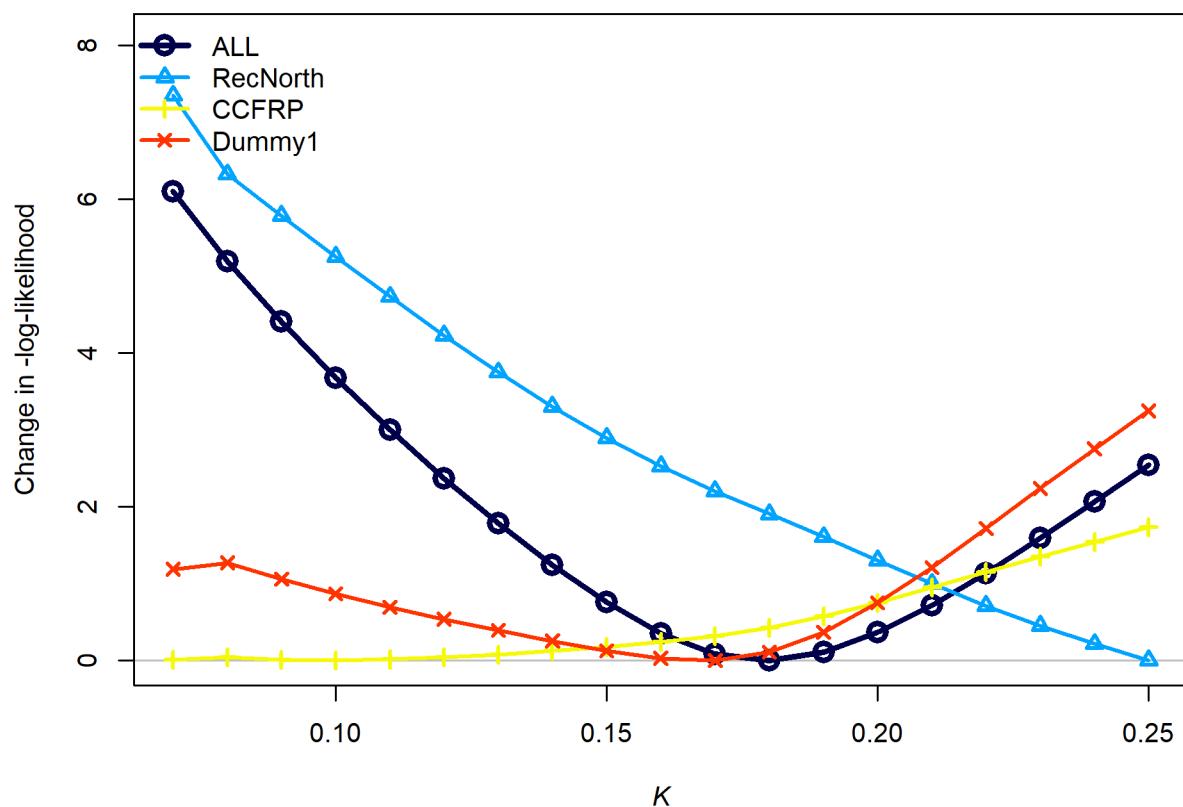


Figure 89: Likelihood profile across the growth parameter  $k$  by age composition. [fig:profile\\_k\\_pin](#)

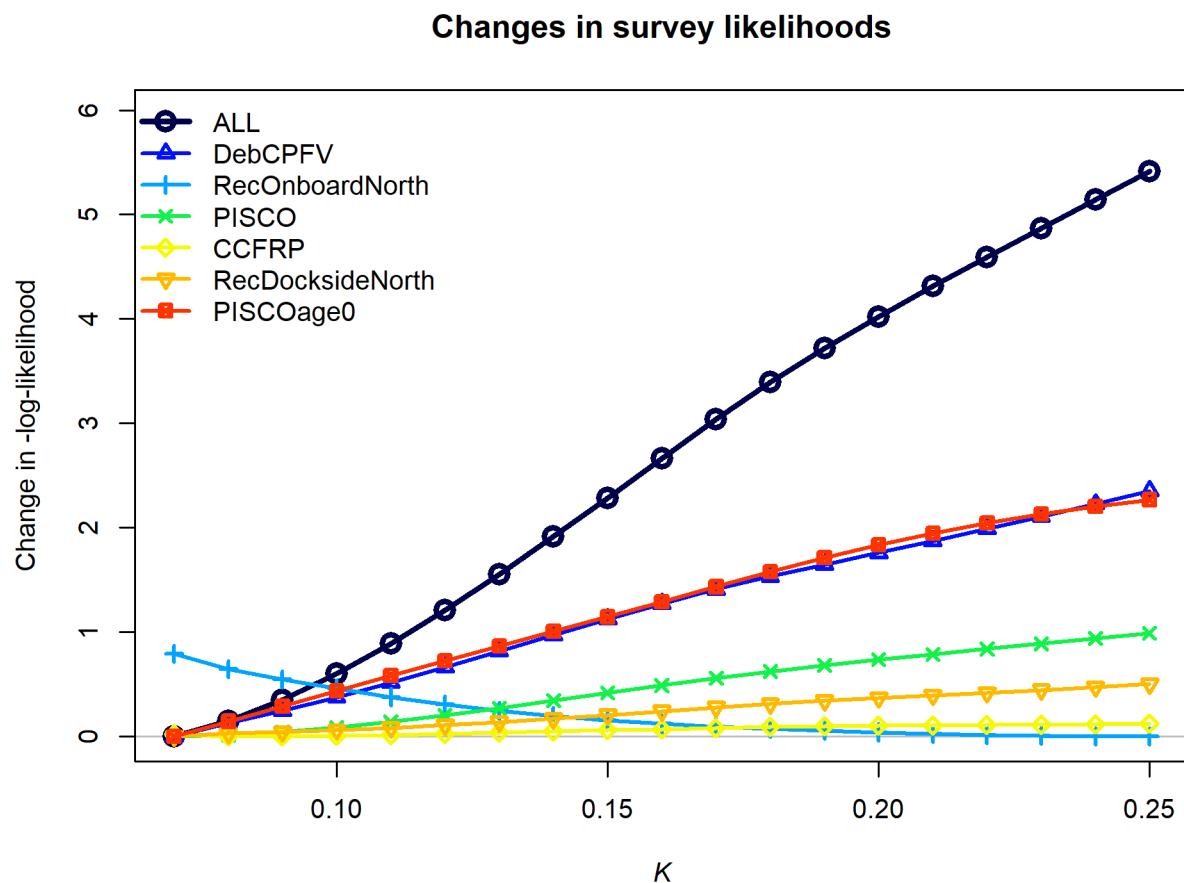


Figure 90: Likelihood profile across the growth parameter  $k$  by surveys. `fig:profile_k_piner2`

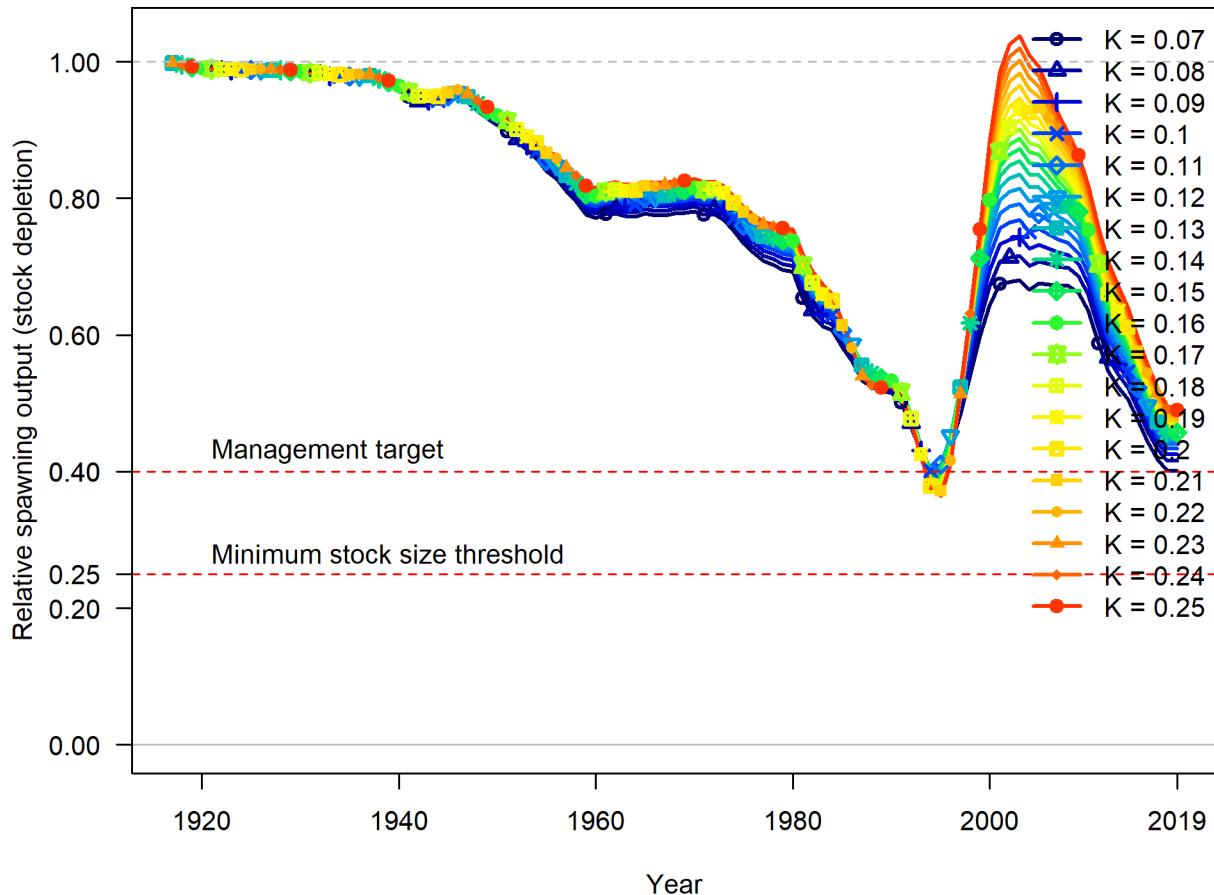


Figure 91: Trajectories of depletion across values of the growth parameter  $k$ . `fig:profile_k_depl`

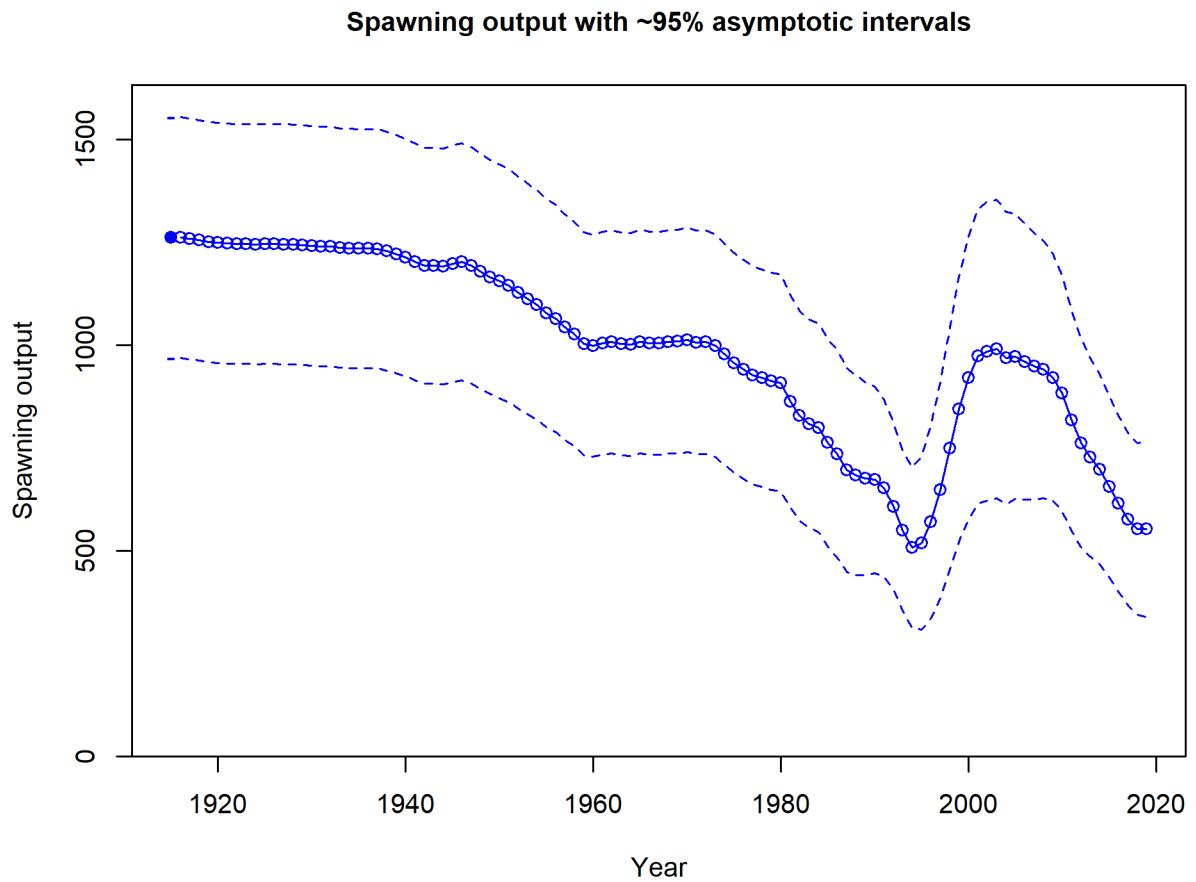


Figure 92: Estimated spawning output with approximate 95% asymptotic intervals. fig:ts7\_Spawning

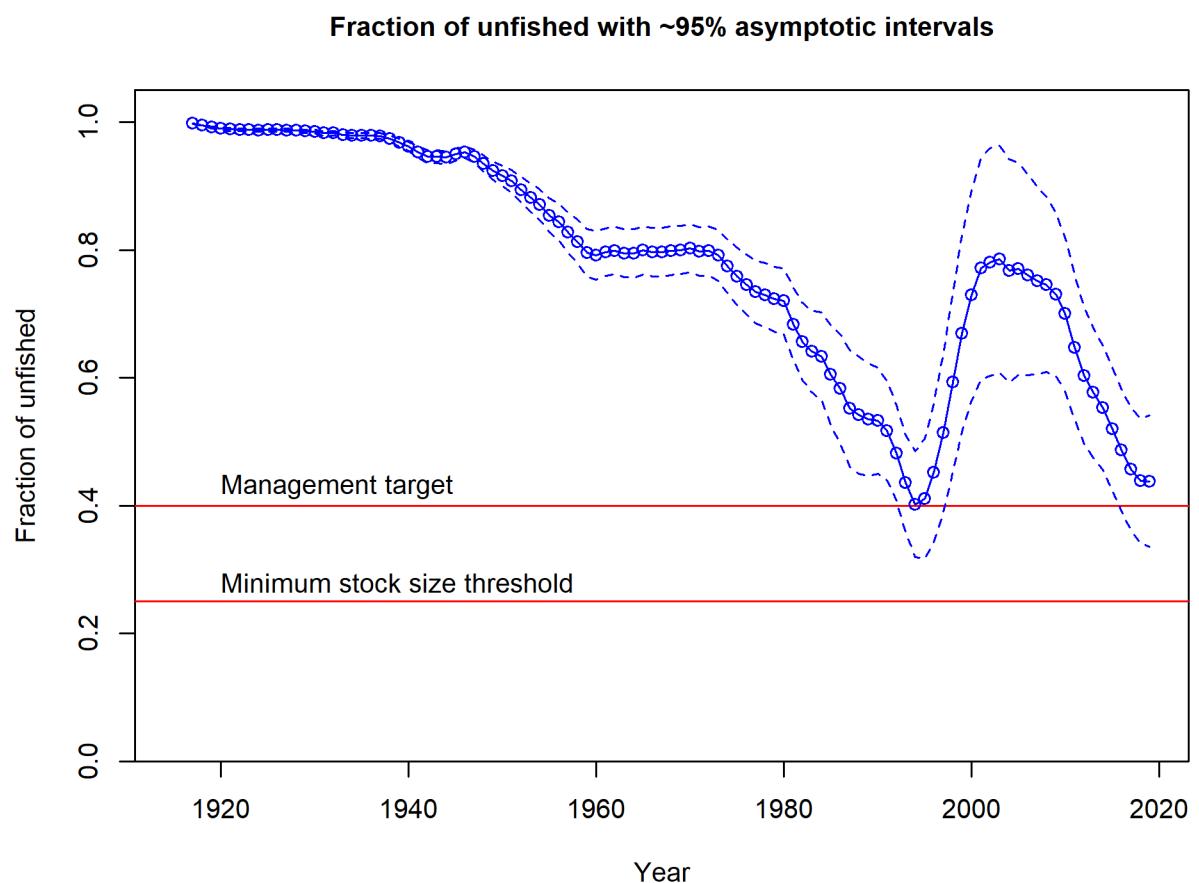


Figure 93: Estimated spawning depletion with approximate 95% asymptotic intervals. fig:ts9\_unfisher

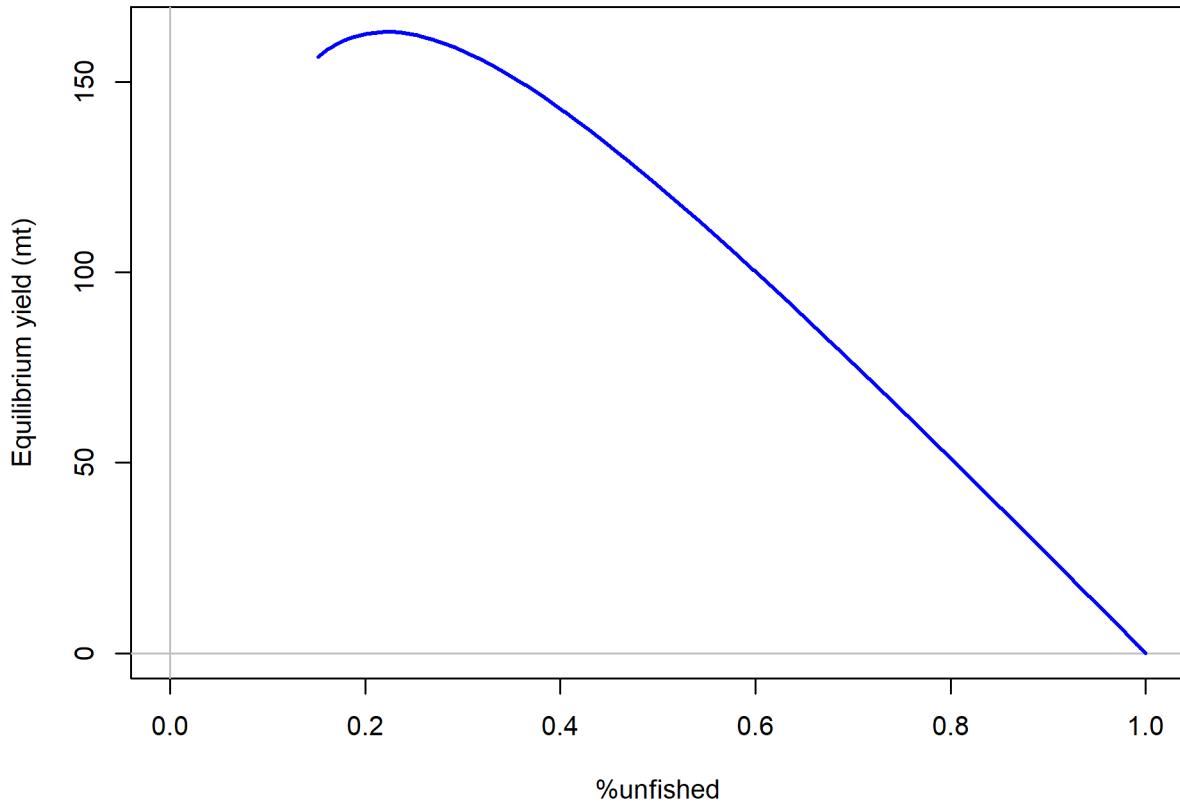


Figure 94: Equilibrium yield curve for the base case model. Values are based on the 2018 fishery selectivity and with steepness fixed at 0.718. | [fig:yield1-yield\\_curve](#)

<sup>2097</sup> **Appendix A. California's Commercial Fishery Regula-**  
<sup>2098</sup> **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<sup>fig:Comm\_regs1</sup>

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<sup>fig:Comm\_regs2</sup>

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<sup>fig:Comm\_regs3</sup>

2099    **Appendix B. California's Recreational Fishery Regula-**  
2100    **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<sup>fig:Rec\_regs1</sup>

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<sup>fig:Rec\_regs3</sup>

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<sup>fig:Rec\_reg4</sup>

2101 **Appendix C. Detailed fits to length composition data**

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

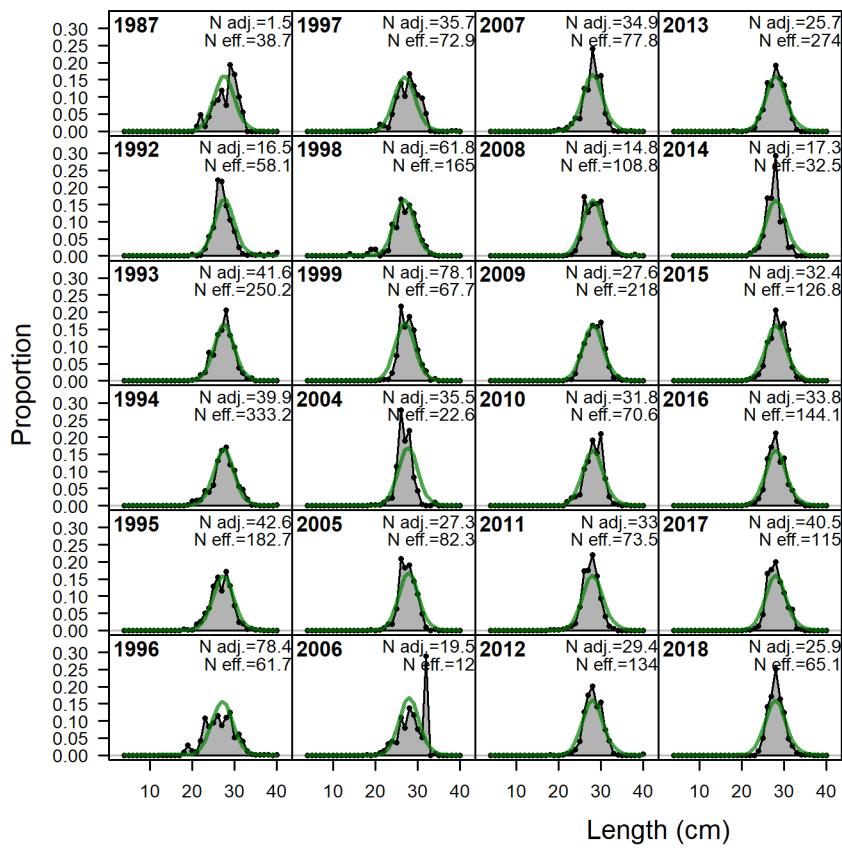


Figure C2: Length comps, retained, Com. 'N adj.' is the input sample size after data\_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister\_Iannelli tuning method. [fig:mod1\\_1\\_comp\\_1enfit\\_fltimkt2](#)

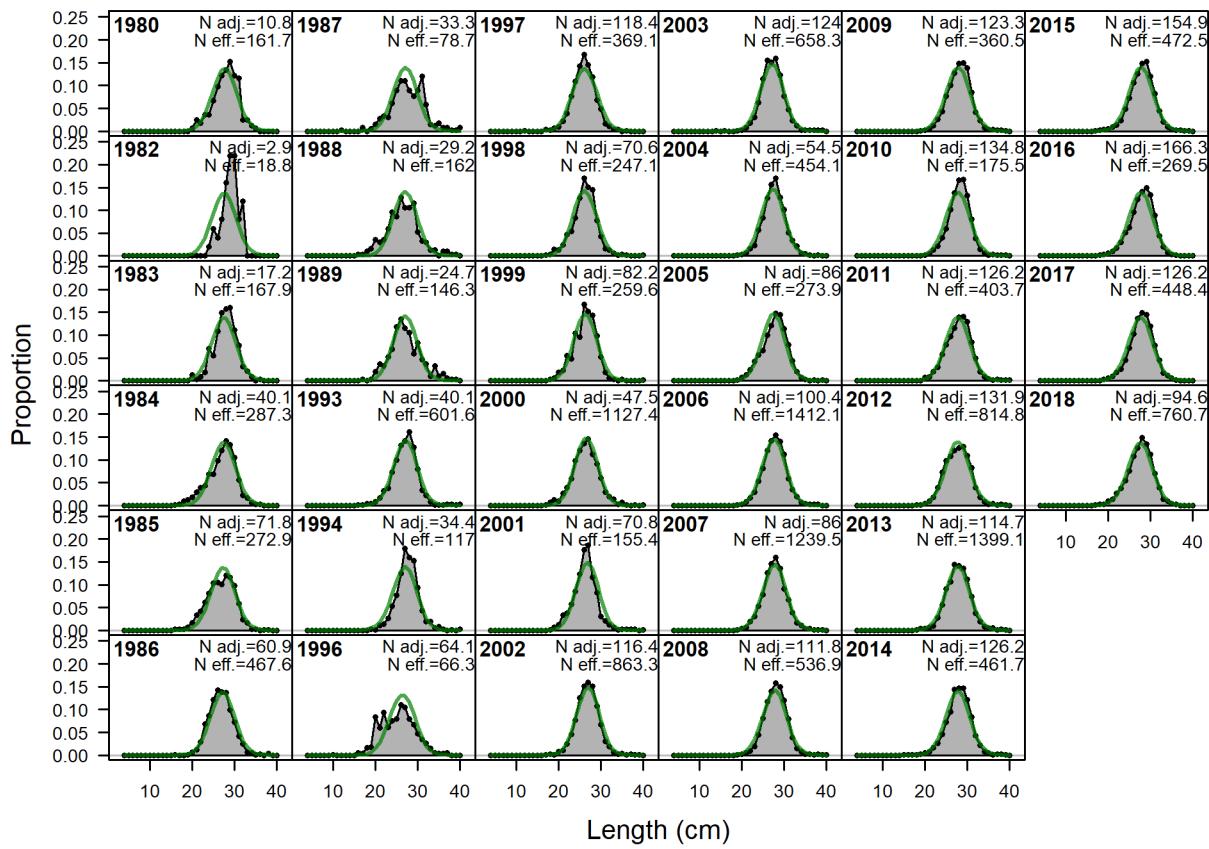


Figure C3: Length comps, whole catch, RecNorth. ‘N adj.’ is the input sample size after data\_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Iannelli tuning method. |  
fig:mod1\_2\_comp\_lenfit\_f1t2mkto

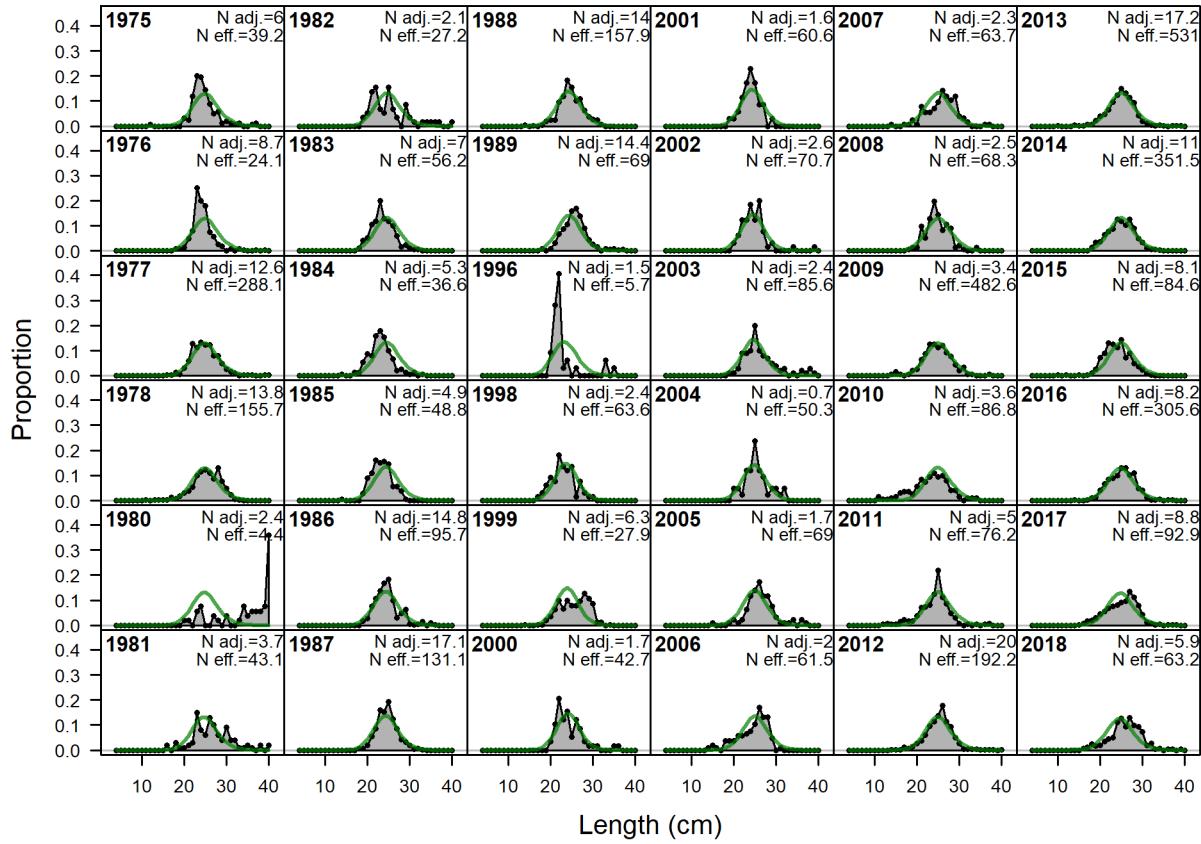


Figure C4: Length comps, whole catch, RecSouth. 'N adj.' is the input sample size after data\_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister\_Iannelli tuning method. |  
fig:mod1\_3\_comp\_lenfit\_f1t3mkto

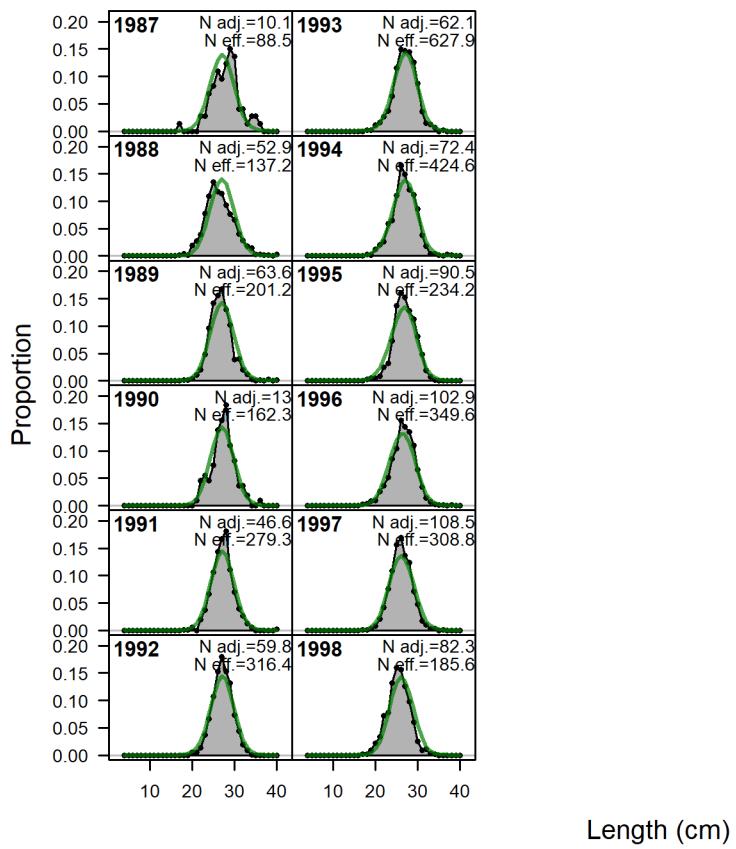


Figure C5: Length comps, whole catch, DebCPFV. ‘N adj.’ is the input sample size after data\_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister\_Iannelli tuning method. | [fig:mod1\\_4\\_comp\\_lenfit\\_f1t4mkt0](#)

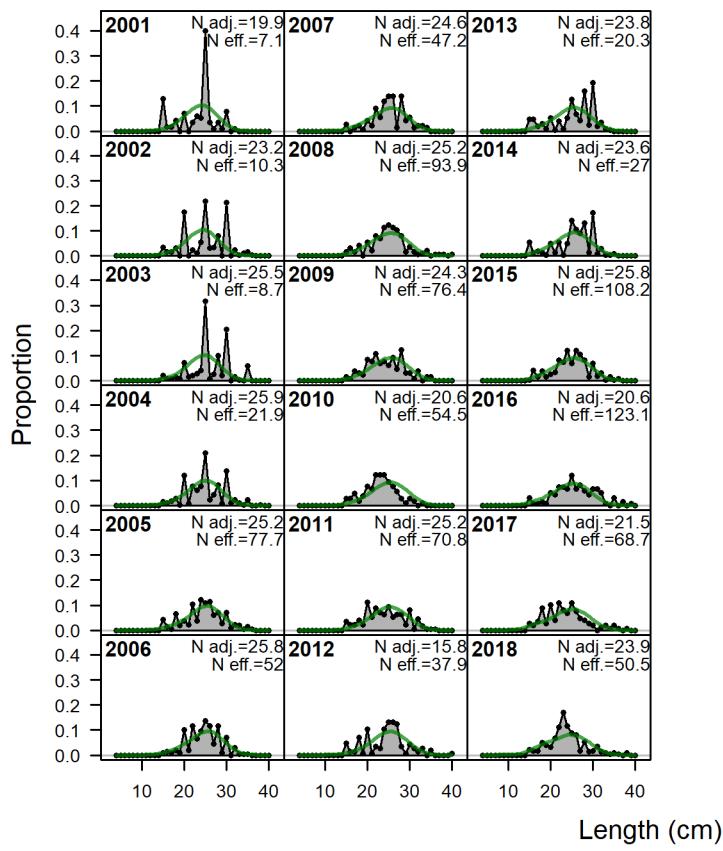


Figure C6: Length comps, whole catch, PISCO. 'N adj.' is the input sample size after data\_weighting adjustment. N\_eff. is the calculated effective sample size used in the McAllister\_Iannelli tuning method.

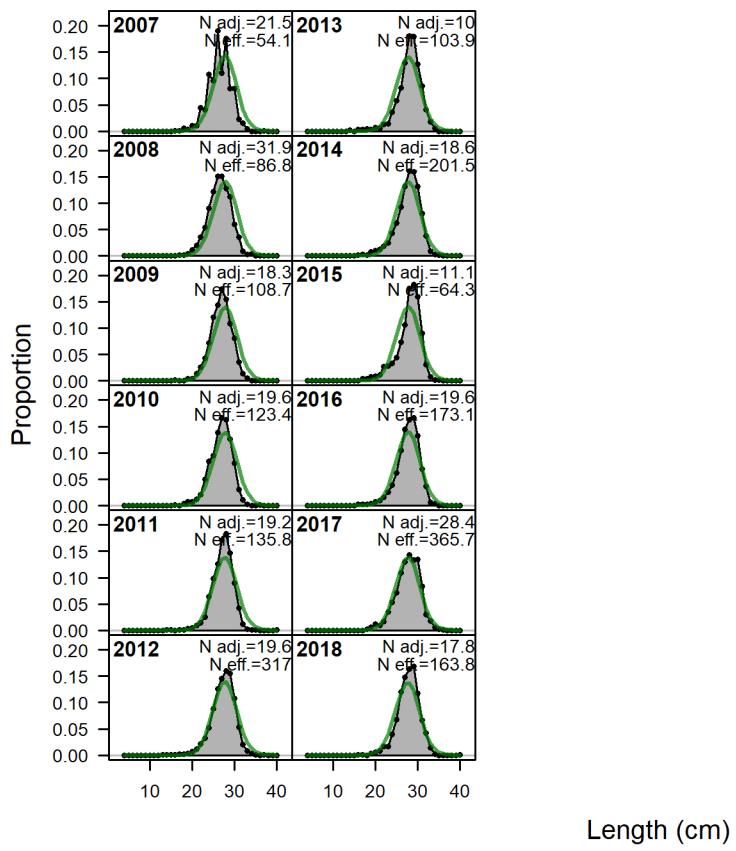


Figure C7: Length comps, whole catch, CCFRP. 'N adj.' is the input sample size after data\_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister\_Iannelli tuning method. | [fig:mod1\\_6\\_comp\\_lenfit\\_flt7mkt0](#)

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