

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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2019-06-25

- ¹⁹ This report may be cited as:
- ²⁰ Monk, M. H. and X. He. 2019. The Combined Status of Gopher *Sebastodes carnatus* and
- ²¹ Black-and-Yellow Rockfishes *Sebastodes chrysomelas* in U.S. Waters Off California in 2019. Pacific
- ²² Fishery Management Council, Portland, OR. Available from
- ²³ <http://www.pcouncil.org/groundfish/stock-assessments/>

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

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⁹⁶ **Executive Summary**

executive-summary

⁹⁷ **Stock**

stock

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

¹⁰⁰ **Catches**

catches

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

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

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



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

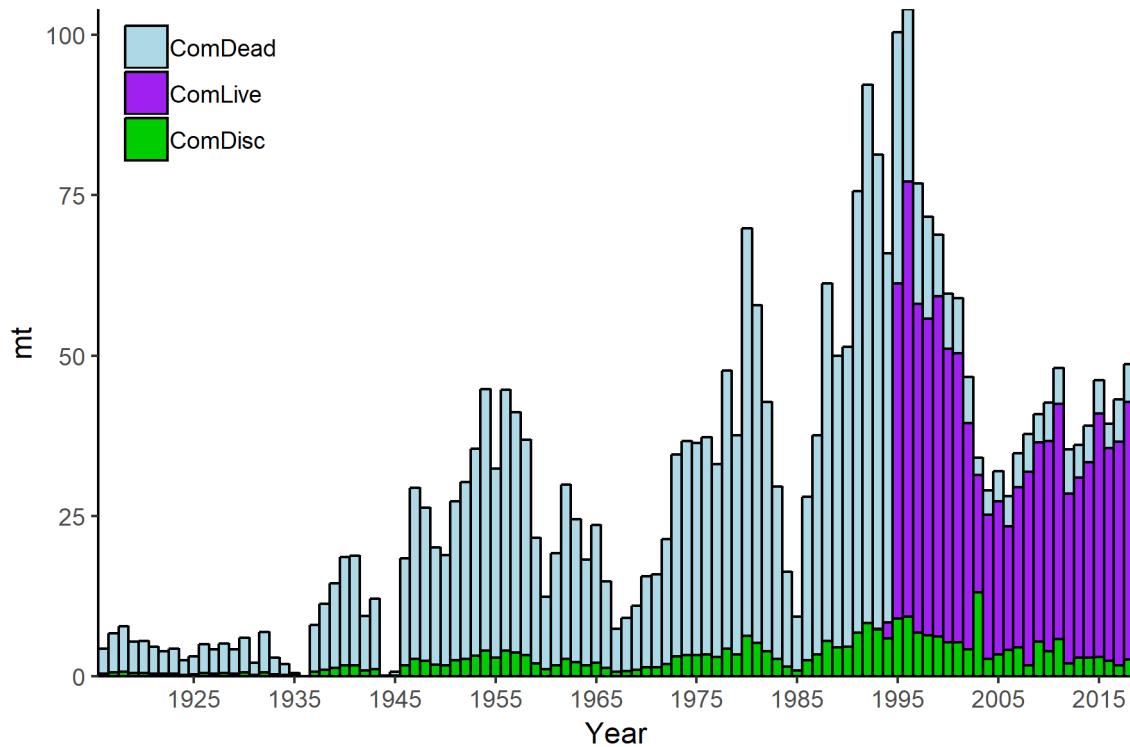


Figure b: Catch history of GBYR for the commercial fleet by dead and live landings, and discards. Catches in 1936 and 1946 were minimal. ^{fig:Exec_catch2}

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

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

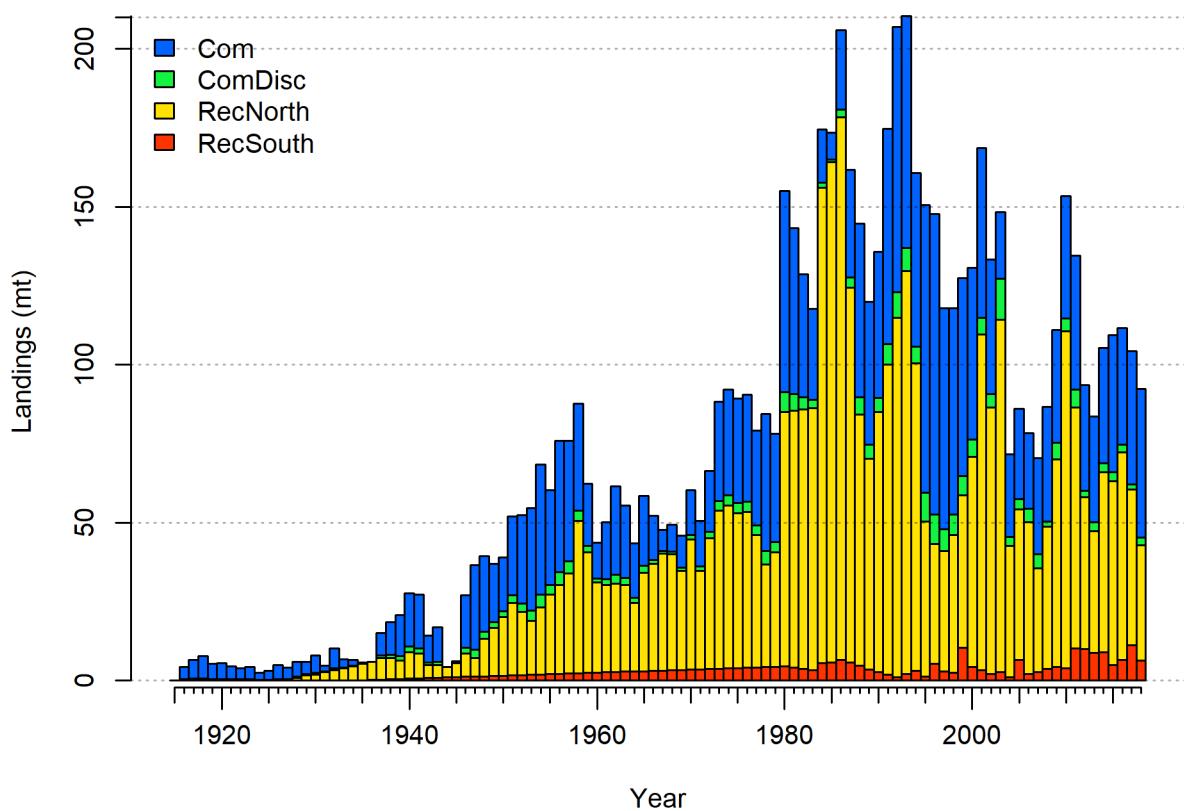


Figure c: Catch history of GBYR in the model. [fig:r4ss_catches](#)

¹⁰⁸ **Data and Assessment**

data-and-assessment

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

¹¹² (Figure d).

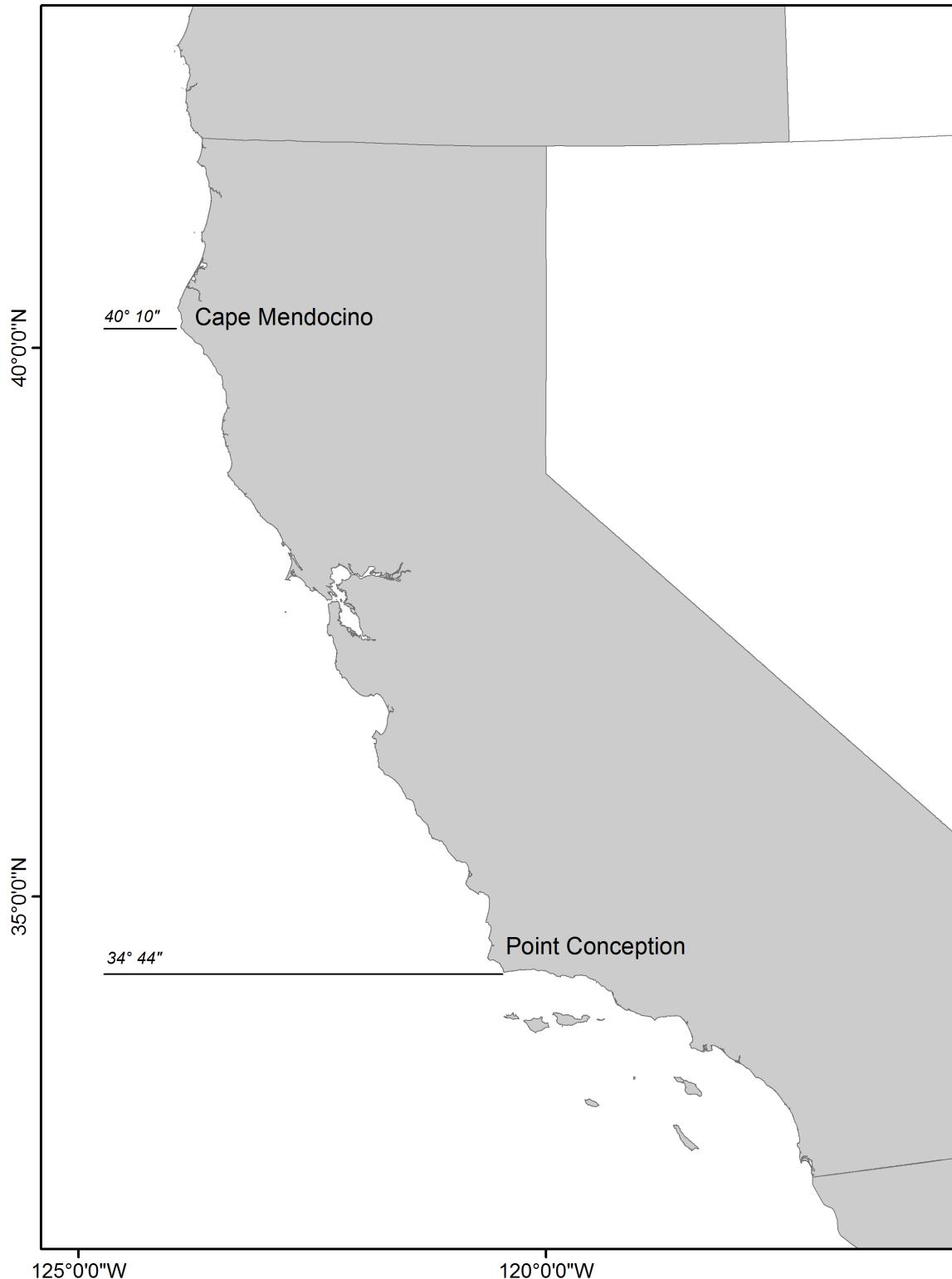


Figure d: Map depicting the core distribution of gopher and black-and-yellow rockfishes. The stock assessment is bounded at Cape Mendocino in the north to the U.S./Mexico border in the south. [fig:assess_region_map](#)

¹¹³ **Stock Biomass**

stock-biomass

¹¹⁴ (Figure e and Table b).

¹¹⁵ The 2018 estimated spawning biomass relative to unfished equilibrium spawning biomass is
¹¹⁶ above the target of 40% of unfished spawning biomass at 4 520% (95% asymptotic interval:
¹¹⁷ ± 3 000% - 6 050%) (Figure f). Approximate confidence intervals based on the asymptotic
¹¹⁸ variance estimates show that the uncertainty in the estimated spawning biomass is high.

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

Year	Spawning Output (million eggs)	~ 95% confidence interval	Estimated depletion	~ 95% confidence interval
2010	834	520 - 1149	63.32	45.47 - 81.16
2011	764	469 - 1060	58.03	41.45 - 74.61
2012	707	429 - 985	53.69	38.2 - 69.18
2013	676	410 - 942	51.33	36.74 - 65.91
2014	654	397 - 911	49.64	35.74 - 63.55
2015	625	374 - 877	47.48	33.95 - 61.01
2016	602	352 - 852	45.71	32.24 - 59.18
2017	585	332 - 838	44.41	30.69 - 58.12
2018	580	320 - 841	44.06	29.81 - 58.32
2019	596	320 - 872	45.25	29.99 - 60.5

Spawning output with ~95% asymptotic intervals

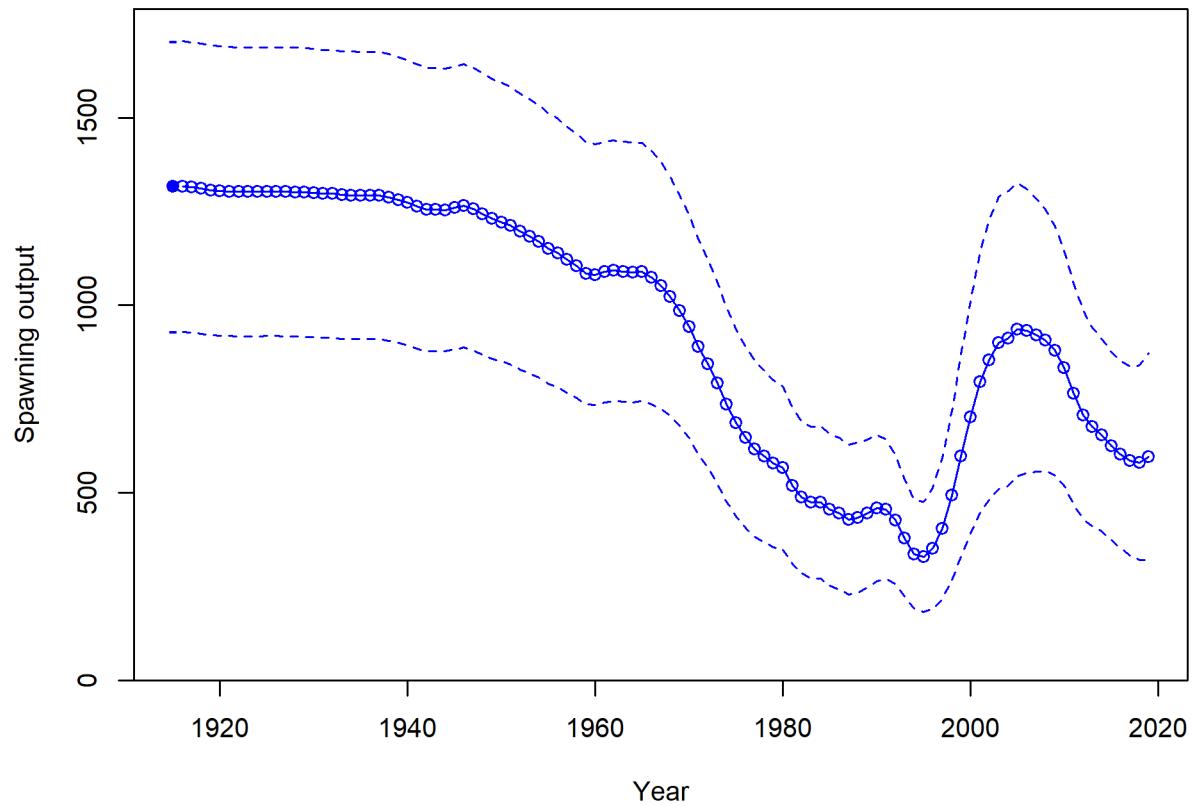


Figure e: Time series of spawning biomass trajectory (circles and line; median; light broken lines: 95% credibility intervals) for the base case assessment model. | [fig:Spawnbio_all](#)

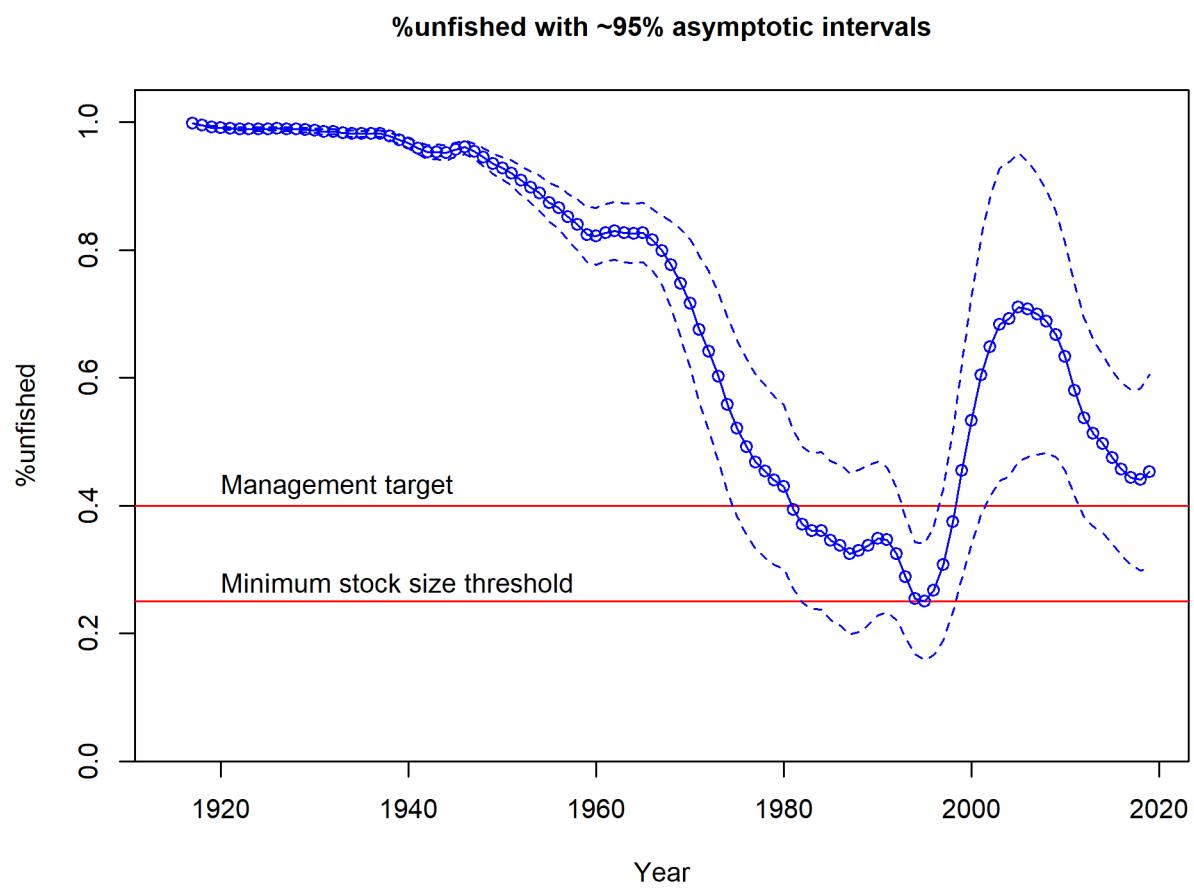


Figure f: Estimated percent depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model. fig:Re1Deplete_all

¹¹⁹ **Recruitment**

recruitment

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

Table c: Recent recruitment for the GBYR assessment.

Year	Estimated Recruitment (1,000s)	~ 95% confidence interval
2010	3680	1452 - 9327
2011	3319	1277 - 8625
2012	3393	1279 - 9001
2013	4194	1580 - 11131
2014	6319	2385 - 16738
2015	8445	3154 - 22610
2016	6941	2564 - 18788
2017	5137	1845 - 14301
2018	4177	1469 - 11875
2019	4276	1486 - 12305

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

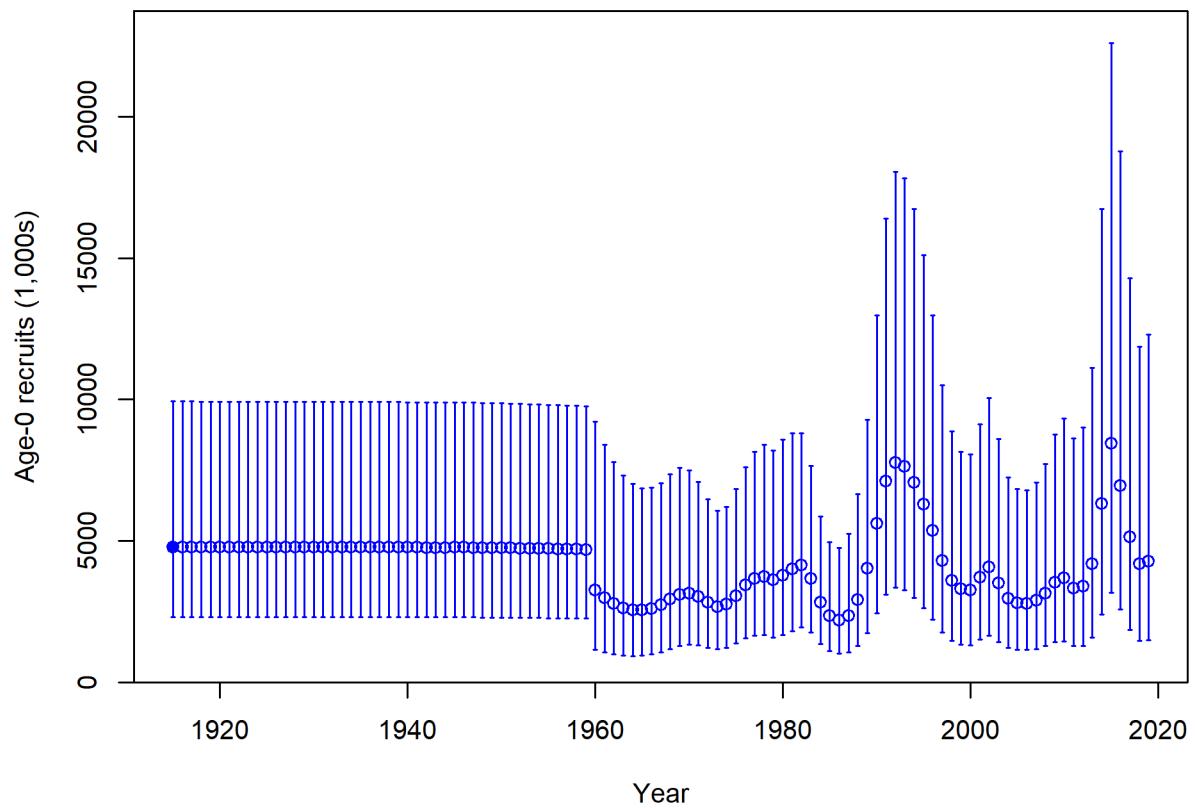


Figure g: Time series of estimated GBYR recruitments for the base-case model with 95% confidence or credibility intervals. [fig:Recruits_all](#)

₁₂₁ **Exploitation status**

exploitation-status

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

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

Year	Fishing intensity	~ 95% confidence interval	Exploitation rate	~ 95% confidence interval
2009	0.61	0.38 - 0.83	0.08	0.05 - 0.1
2010	0.74	0.5 - 0.99	0.11	0.07 - 0.15
2011	0.74	0.49 - 0.99	0.10	0.06 - 0.14
2012	0.63	0.4 - 0.87	0.08	0.05 - 0.1
2013	0.61	0.38 - 0.84	0.07	0.04 - 0.1
2014	0.71	0.46 - 0.96	0.09	0.05 - 0.12
2015	0.74	0.49 - 0.99	0.09	0.05 - 0.13
2016	0.77	0.51 - 1.04	0.09	0.05 - 0.13
2017	0.77	0.5 - 1.04	0.08	0.04 - 0.12
2018	0.73	0.46 - 1	0.07	0.03 - 0.1

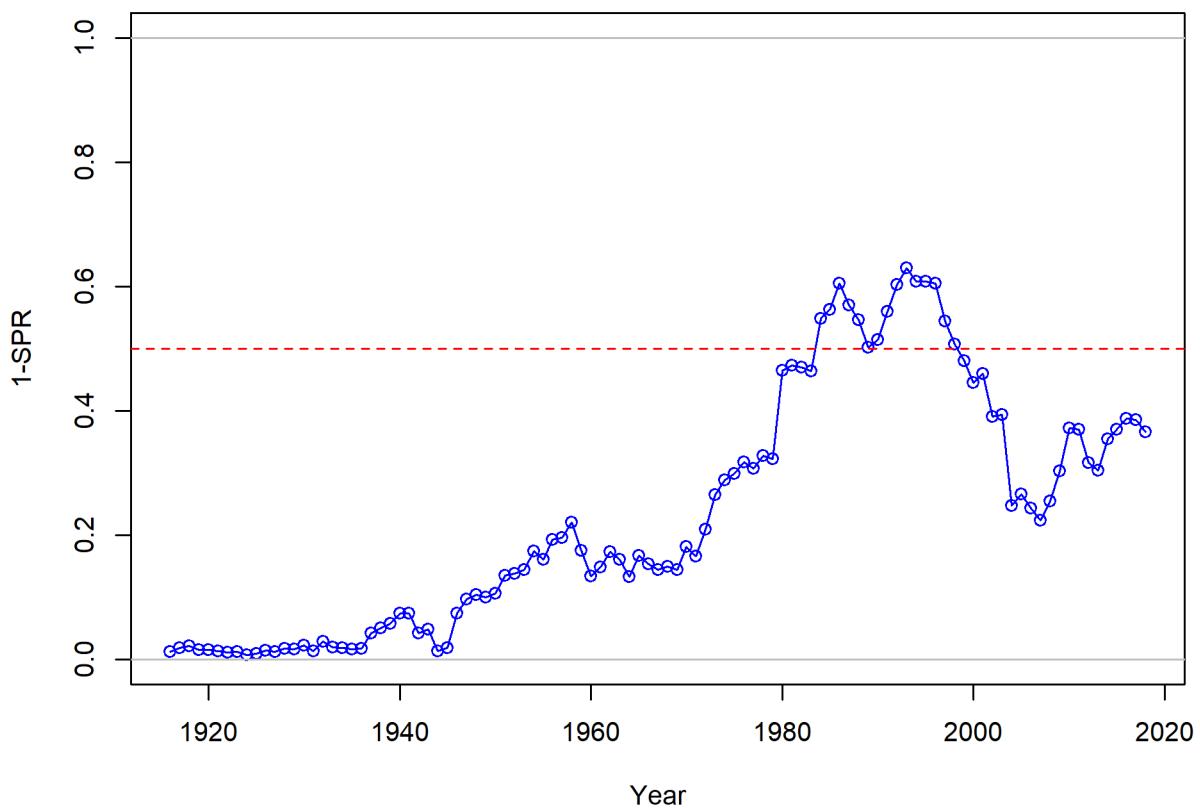


Figure h: Estimated spawning potential ratio (SPR) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing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

¹²⁴ **Ecosystem Considerations**

ecosystem-considerations

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

¹²⁸ **Reference Points**

reference-points

- ¹²⁹ This stock assessment estimates that GBYR in the model is above the biomass target
¹³⁰ ($SB_{40\%}$), and well above the minimum stock size threshold ($SB_{25\%}$). The estimated rel-
¹³¹ ative depletion level for the base model in 2019 is 4 520% (95% asymptotic interval: ± 3
¹³² 000% - 6 050%, corresponding to an unfished spawning biomass of 596 million eggs (95%
¹³³ asymptotic interval: 320 - 872 million eggs) of spawning biomass in the base model (Table
¹³⁴ e). Unfished age 1+ biomass was estimated to be 2,149 mt in the base case model. The
¹³⁵ target spawning biomass ($SB_{40\%}$) is 527 million eggs, which corresponds with an equilibrium
¹³⁶ yield of 179 mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$
¹³⁷ is 167 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)	1,317	930	1,705
Unfished age 1+ biomass (mt)	2,149	1,664	2,634
Unfished recruitment (R_0)	4,784	1,164	8,404
Spawning output(2018 million eggs)	580	320	841
Depletion (2018)	0.441	0.298	0.583
Reference points based on SB_{40%}			
Proxy spawning output ($B_{40\%}$)	527	428	626
SPR resulting in $B_{40\%}$ ($SPR_{B40\%}$)	0.458	0.458	0.458
Exploitation rate resulting in $B_{40\%}$	0.151	0.107	0.195
Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt)	179	108	251
Reference points based on SPR proxy for MSY			
Spawning output	588	477	698
SPR_{proxy}	0.5		
Exploitation rate corresponding to SPR_{proxy}	0.131	0.094	0.169
Yield with SPR_{proxy} at SB_{SPR} (mt)	167	101	233
Reference points based on estimated MSY values			
Spawning output at MSY (SB_{MSY})	279	226	333
SPR_{MSY}	0.289	0.278	0.299
Exploitation rate at MSY	0.266	0.194	0.339
Dead Catch MSY (mt)	210	121	299
Retained Catch MSY (mt)	210	121	299

¹³⁸ Management Performance

management-performance

¹³⁹ Table f

¹⁴⁰ Unresolved Problems and Major Uncertainties

unresolved-problems-and-major-uncertainties

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

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

¹⁴¹ Decision Table

decision-table

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

Year	OFL
2019	180.21
2020	168.28
2021	167.05
2022	174.54
2023	187.31
2024	200.67
2025	210.28
2026	213.76
2027	211.19
2028	204.47
2029	196.15
2030	188.32

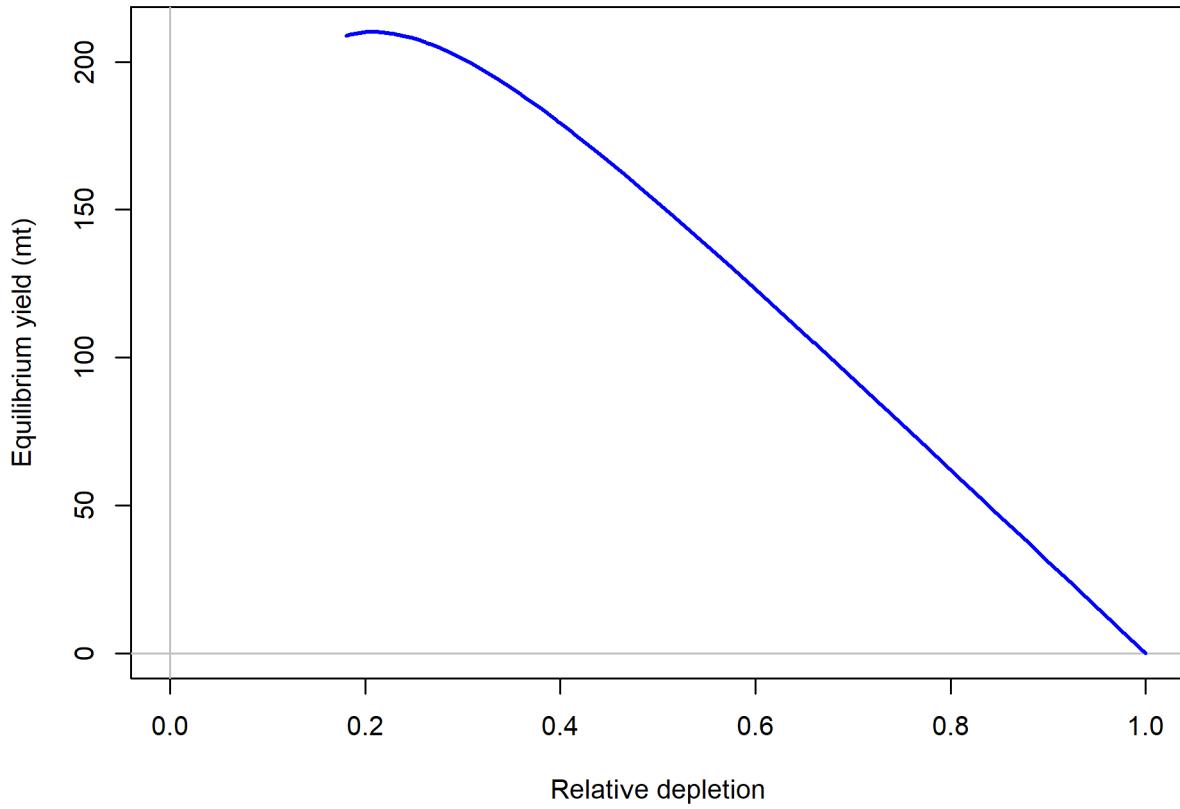


Figure i: Equilibrium yield curve for the base case model. Values are based on the 2018 fishery selectivity and with steepness fixed at 0.718. [fig:Yield_all]

Table h: Summary of 10-year projections beginning in 2020 for alternate states of nature based on an axis of uncertainty for the model. Columns range over low, mid, and high states of nature, and rows range over different assumptions of catch levels. An entry of “-” indicates that the stock is driven to very low abundance under the particular scenario.

		States of nature					
		Low M 0.05		Base M 0.07		High M 0.09	
	Year	Catch	Spawning Output	Depletion	Spawning Output	Depletion	Spawning Output
40-10 Rule, Low M	2019	-	-	-	-	-	-
	2020	-	-	-	-	-	-
	2021	-	-	-	-	-	-
	2022	-	-	-	-	-	-
	2023	-	-	-	-	-	-
	2024	-	-	-	-	-	-
	2025	-	-	-	-	-	-
	2026	-	-	-	-	-	-
	2027	-	-	-	-	-	-
	2028	-	-	-	-	-	-
40-10 Rule	2019	-	-	-	-	-	-
	2020	-	-	-	-	-	-
	2021	-	-	-	-	-	-
	2022	-	-	-	-	-	-
	2023	-	-	-	-	-	-
	2024	-	-	-	-	-	-
	2025	-	-	-	-	-	-
	2026	-	-	-	-	-	-
	2027	-	-	-	-	-	-
	2028	-	-	-	-	-	-
40-10 Rule, High M	2019	-	-	-	-	-	-
	2020	-	-	-	-	-	-
	2021	-	-	-	-	-	-
	2022	-	-	-	-	-	-
	2023	-	-	-	-	-	-
	2024	-	-	-	-	-	-
	2025	-	-	-	-	-	-
	2026	-	-	-	-	-	-
	2027	-	-	-	-	-	-
	2028	-	-	-	-	-	-
Average Catch	2019	-	-	-	-	-	-
	2020	-	-	-	-	-	-
	2021	-	-	-	-	-	-
	2022	-	-	-	-	-	-
	2023	-	-	-	-	-	-
	2024	-	-	-	-	-	-
	2025	-	-	-	-	-	-
	2026	-	-	-	-	-	-
	2027	-	-	-	-	-	-
	2028	-	-	-	-	-	-

Table i: Base case results summary.

	Quantity	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Landings (mt)											
Total Est. Catch (mt)											
OFL (mt)											
ACL (mt)											
(1-SPR)(1-SPR _{50%})	0.74	0.74	0.63	0.61	0.71	0.74	0.77	0.77	0.77	0.73	
Exploitation rate	0.11	0.10	0.08	0.07	0.09	0.09	0.09	0.09	0.08	0.07	
Age 1+ biomass (mt)	1454.47	1385.60	1298.92	1236.26	1210.39	1198.97	1188.32	1203.33	1250.27	1329.14	
Spawning Output	834	764	707	676	654	625	602	585	580	596	
95% CI	520 - 1149	469 - 1060	429 - 985	410 - 942	397 - 911	374 - 877	352 - 852	332 - 838	320 - 841	320 - 872	
Depletion	63.3	58.0	53.7	51.3	49.6	47.5	45.7	44.4	44.1	45.2	
95% CI	45.47 - 81.16	41.45 - 74.61	38.2 - 69.18	36.74 - 65.91	35.74 - 63.55	33.95 - 61.01	32.24 - 59.18	30.69 - 58.12	29.81 - 58.32	29.99 - 60.5	
Recruits	3680	3319	3393	4194	6319	8445	6941	5137	4177	4276	
95% CI	1452 - 9327	1277 - 8625	1279 - 9001	1580 - 11131	2385 - 16738	3154 - 22610	2564 - 18788	1845 - 14301	1469 - 11875	1486 - 12305	

¹⁴² **Research and Data Needs**

research-and-data-needs

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

¹⁴⁴ 1. xxxx:

¹⁴⁵ 2. xxxx:

¹⁴⁶ 3. xxxx:

¹⁴⁷ 4. xxxx:

¹⁴⁸ 5. xxxx:

¹⁴⁹ **1 Introduction**

introduction

¹⁵⁰ **1.1 Basic Information and Life History**

basic-information-and-life-history

¹⁵¹ *Population Structure and Complex Assessment Considerations*

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

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

¹⁸⁴ Most recently, an analysis of microhaplotypes by Baetscher (2019) observed a higher fre-
¹⁸⁵ quency of mis-assignments of individuals to between gopher and black-and-yellow rockfishes
¹⁸⁶ compared to all other pairs of species in the genus *Sebastodes*. In addition, comparisons of F_{ST}

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

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

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

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

Both species are primarily nocturnal feeders, with similar diets composed primarily of crabs and shrimp, supplemented by fish and cephalopods (Larson 1972, 1985, Love et al. 2002). Loury et al. (2015) found no significant differences in the diet of gopher rockfish inside and outside the 35 year old Point Lobos Marine Protected Area (MPA). She did find the diet of gopher rockfish at Año Nuevo (shallower and north of Point Lobos) was dominated by crabs and dominated by brittle stars at southern, deeper study locations. Zuercher (2019) examined the diets of a suite of nearshore rockfish species including black-and-yellow and found that

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

231 1.2 Early Life History

early-life-history

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

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

248 1.3 Map

map

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

252 1.4 Ecosystem Considerations

ecosystem-considerations-1

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

256 1.5 Fishery Information

fishery-information

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

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

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

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

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

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

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

302 1.6 Summary of Management History

summary-of-management-history

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

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

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

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

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

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

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

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

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

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

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

381 1.7 Management Performance

management-performance-1

382 NEED TO FINISH

383 The contribution of GBYR to the minor nearshore rockfish OFLs is currently derived from
384 two sources: 1) forecasts from Key et al. ([2005](#)), from Cape Mendocino to Point Conception,
385 and 2) a Depletion Corrected Average Catch (DCAC (MacCall [2009](#))) for the area south of
386 Point Conception. The total mortality of the minor nearshore rockfish has been below the
387 ACL in all years (2011-2016). A summary of these values as well as other base case summary
388 results can be found in Table [f](#).

389 1.8 Fisheries Off Mexico or Canada

fisheries-off-mexico-or-canada

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

397 2 Assessment

assessment

398 2.1 Data

data

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

401 2.1.1 Commercial Fishery Landings

commercial-fishery-landings

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

403 Commercial fishery landings for gopher and black-and-yellow rockfishes have not been re-
404 ported consistently by species throughout the available catch history (Figure 2). The period
405 from 1916-1935 indicates that only black-and-yellow rockfish were landed in the commer-
406 cial fishery, which then switched to predominately gopher rockfish from 1937-1984. From
407 1985-1988 the landings data suggest that only black-and-yellow rockfish were landed and
408 not until 1995 are both species well-represented in the catches. There is no way to tease
409 apart the historical catches by species and even across north and south of Point Conception
410 prior to about 1995. This precludes the ability to model the catch histories for either species
411 accurately. Given these constraints, all commercial data were combined to represent one
412 commercial fleet in the assessment. Additional details regarding this decision are described
413 below.

414 The stock assessment of gopher rockfish in 2005 did not include black-and-yellow rockfish
415 landings. A comparison of recreational and commercial landings from the 2005 assessment
416 to those used in this assessment suggest the 2005 assessment may have included some black-
417 and-yellow rockfish landings (Figure 6). The 2005 assessment estimated recreational landings
418 from 1969-1980 based on a ratio of commercial to recreational landings, whereas this as-
419 sessment makes use of the California Catch Reconstruction landings estimates (Ralston et
420 al. 2010).

421 *Commercial Landings Data Sources*

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

431 Contemporary landings were extracted from two data sources, the California Cooperative
432 Groundfish Survey, [CALCOM](#)) and the Pacific Fisheries Information Network ([PacFIN](#))
433 landings database. Both databases are based on the same data sources (CALCOM landing
434 receipts), but apply a catch expansion based on different algorithms. CALCOM collects
435 information including species composition data (i.e. the proportion of species landed in a
436 sampling stratum), and landing receipts (sometimes called “fish tickets”) that are a record
437 of pounds landed in a given stratum. Strata in California are defined by market category,
438 year, quarter, gear group, port complex, and disposition (live or dead). Although many

market categories are named after actual species, catch in a given market category can consist of several species. These data form the basis for the “expanded” landings, i.e., species composition data collected by port samplers were used to allocate pounds recorded on landing receipts to species starting in 1978. Use of the “Gopher Rockfish” or the “Black-and-Yellow Rockfish” categories alone to represent actual landings of GBY would not be accurate.

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

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

2.1.2 Commercial Discards

commercial-discards

The West Coast Groundfish Observer Program (WCGOP) provides observer data on discarding across fishery sectors back to 2003. Gopher and black-and-yellow rockfishes have species-specific depth-stratified commercial fishery discard mortality rates (Pacific Fishery Management Council 2018). In consultation with WCGOP staff, the STAT used estimates of total discard mortality from WCGOP’s Groundfish Expanded Mortality Multiyear (GEMM) report. WCGOP observes between 1-5% of nearshore fixed gear landings annually south of 40°10' N. latitude (coverage rates available [here](#)). The expanded estimates of total discard weight by species is calculated as the ratio of the observed discard weight of the individual species divided by the observed landed weight from PacFIN landing receipts. WCGOP discard estimates for the nearshore fixed gear fishery take into account the depth distribution of landings in order to appropriately apply the depth-stratified discard mortality rates by species (Somers et al. 2018). The discard mortality for 2018 was estimated as an average of the discard mortality from 2013-2017. Discard mortality was estimated from the period

⁴⁷⁸ prior to WCGOP discard estimates (1916-2002) based on the average discard mortality rate
⁴⁷⁹ from 2003-2016 (2017 was excluded because 2017 discard mortality was disproportionately
⁴⁸⁰ higher than all other years) (Table 1).

⁴⁸¹ **2.1.3 Commercial Fishery Length and Age Data**
commercial-fishery-length-and-age-data

⁴⁸² Biological data from the commercial fisheries that caught GBYR were extracted from CAL-
⁴⁸³ COM on 9 May 2019. The CALCOM length composition data were catch-weighted to
⁴⁸⁴ “expanded” length the raw length composition data (Table 2). The 2005 assessment used
⁴⁸⁵ commercial length composition information from CALCOM, but did not include black-and-
⁴⁸⁶ yellow rockfish and is not directly comparable. The 2005 assessment used 2 cm length bins
⁴⁸⁷ from 16-40 cm, where this assessment uses 1 cm length bins from 4-40 cm. Sex was not
⁴⁸⁸ available for the majority (99.5%) of the commercial length, and the assessment did not
⁴⁸⁹ find sexual dimorphism in growth for either species. We aggregated the commercial length
⁴⁹⁰ composition among all gears and regions south of Cape Mendocino.

⁴⁹¹ Discard length compositions from WCGOP (2003-2017) were expanded based on the the
⁴⁹² discard estimates and were aggregated for all regions south of Cape Mendocino and across
⁴⁹³ all fixed gear fisheries.

⁴⁹⁴ A total of 46 ages were available for gopher rockfish from the commercial fisheries 2009-2011,
⁴⁹⁵ 2016, and 2018. Though sparse, the data were included as conditional age-at-length for the
⁴⁹⁶ commercial fleet.

⁴⁹⁷ The input sample sizes for commercial length composition data were calculated via the
⁴⁹⁸ Stewart Method for fisheries (Ian Stewart, personal communication, IPHC):

$$499 \quad \text{Input effN} = N_{\text{trips}} + 0.138 * N_{\text{fish}} \text{ if } N_{\text{fish}}/N_{\text{trips}} < 44$$

$$500 \quad \text{Input effN} = 7.06 * N_{\text{trips}} \text{ if } N_{\text{fish}}/N_{\text{trips}} \geq 44$$

⁵⁰¹ Commercial length composition data are made available from PacFIN and the expanded
⁵⁰² catch-weight length compositions were provided by Andi Stephens (NWFSC) processed
⁵⁰³ through the [PacFIN Utilities](#) package. We compares differences between the catch-weighted
⁵⁰⁴ length composition expansions from CALCOM and PacFIN. We were unable to reconcile the
⁵⁰⁵ difference between the two data sets. Sample sizes became more similar if the PacFIN data
⁵⁰⁶ were restricted to the same market categories used by CALCOM in the expansion. However,
⁵⁰⁷ both data sets apply other filters that we did not have time to explore. For instance, in the
⁵⁰⁸ year 2000, 290 more fish were used in the CALCOM expansion than in PacFIN, but in 2002,
⁵⁰⁹ 150 more fish were used in the PacFIN expansions that were not used in CALCOM. Given
⁵¹⁰ these caveats, Figure 8 shows the percent difference in the expanded length comps within
⁵¹¹ a year. The biggest difference is in length bin 32 in 2006. However, the same number of

512 fish and samples were used to expand the 2006 lengths in both databases, indicating there
513 are also fundamental differences in how the data are treated. Full documentation is not
514 available for the PacFIN length composition expansion program. The base model for this
515 assessment uses the CALCOM length composition data as described above, but a sensitivity
516 was conducted using the PacFIN length composition data.

517 2.1.4 Recreational Fishery Landings and Discards *recreational-fishery-landings-and-discards*

518 *Historical recreational landings and discard, 1928-1980*

519 Ralston et al. (2010) reconstructed estimates of recreational rockfish catch and discard in
520 California, 1928-1980. Reported landings of total rockfish were allocated to species based
521 on several sources of species composition data. Estimates of GBYR landings and discard
522 (combined) from 1928-1979 are available from the SWFSC. For this assessment, historical
523 recreational catch was stratified by year and area (north and south of Point Conception).
524 The catches of GBYR reported in Ralston et al. (2010) are higher by an order of magnitude
525 than expected given the more recent catches of GBYR in the MRFSS and CRFS eras south
526 of Point Conception (Figure 9). The recreational catches estimated by Ralston et al. (2010)
527 were discussed with the paper's co-authors and also Commercial Passenger Fishing Vessel
528 (CPFV), i.e., party/charter mode, captains in California. A consensus was reached that
529 the estimated landings did not accurately represent the historical GBYR landings and an
530 alternative catch stream should be developed. One possibility for the inflated catches of
531 GBYR in southern California is that all nearshore shallow species were combined and all
532 of the nearshore deep species were combined and a constant relative fraction between the
533 two was used to assign catches to each combination of CDFW fishing block and year. The
534 fraction of GBYR within the nearshore shallow species group was likely overestimated.

535 The California Catch Reconstruction applied a linear ramp from 1928-1936 that was
536 not altered in this assessment. From 1937-1979 a linear ramp was developed from the
537 1936 estimate to the average recreational landing from 1980 and 1983 (1981-1982 catches
538 interpolated as described in the next section) of 4.3 mt. The recreational catches north of
539 Point Conception were not altered from the original catch reconstruction. The resulting
540 alternate recreational catch streams are in (Table 3 and Figure 10).

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

542 From 1980-2003, the Marine Recreational Fisheries Statistics Survey (MRFSS) executed a
543 dockside (angler intercept) sampling program in Washington, Oregon, and California (see
544 Holliday et al. (1984) for a description of methods). Data from this survey are available from
545 the Recreational Fisheries Information Network [RecFIN](#). RecFIN serves as a repository for
546 recreational fishery data for California, Oregon, and Washington. Catch estimates for years
547 1980-2003 were downloaded on 23 March 2019, and are consistent from 1992-2004 with the
548 previous assessment (Key et al. 2005) (Figure 6).

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

564 Catches from north of Cape Mendocino were removed based on a CRFS-era average of frac-
565 tion of recreational landings north of Cape Mendocino by mode (3.3% of shore-based, 0.1% of
566 CPFV, and 0.2% of private/rental were removed). From 1980-1989, San Luis Obispo County
567 was sampled as part of Southern California (personal observation from MRFSS Type 3 sam-
568 pler examined catch where county is available for 1980-2004). This assessment separates the
569 recreational fleet at Point Conception. Recreational landings were re-allocated from southern
570 California from 1980-1992 by fleet based on the average proportion of recreational landings
571 in northern California from 1996-2004 (after sampling of the CPFV fleet in northern Cali-
572 fornia resumed). The average proportion re-allocated from southern to northern California
573 for the CPFV mode was 85%, 97% for the private/rental mode, and 81% for the shore-based
574 modes. Data were pooled over all years and modes to estimate the landings re-allocation
575 for the shore-based modes. Total recreational landings for 1981 and 1982 were 18.8 mt and
576 18.6 mt, respectively. These landings were >60 mt lower than any of the neighboring years.
577 Landings from 1981-1982 were interpolated from the 1980 and 1983 landings.

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

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

588 *Recreational Discards*

589 Recreational discards were only added to the California Catch Reconstruction landings, as

590 Ralston et al. (2010) did not address discards for the recreational reconstruction. Recreational
591 removals from the California Department of Fish and Wildlife MRFSS era (1980-
592 2003) includes catch type A + B1. Catch type A refers to estimates of catch based on
593 sampler-examined catch. Catch type B1 includes mainly angler-reported discard, but also
594 angler-reported retained fish that were unavailable to the sampler during the interview (e.g.,
595 fillets). The CRFS era removals account for depth-stratified discard mortality rate and the
596 catch time series includes both retained and discarded catch (total mortality). We calculated
597 the ratio of dead discards to total mortality from the CRFS era by region and mode. The
598 region average across modes was applied to the California Catch Reconstruction as a con-
599 stant. The result added 4.68% annually to recreational removals north of Point Conception
600 and 4.05% annually to the removals South of Point Conception). The final time series of
601 landings and discard mortality are in Table 3.

602 2.1.5 Recreational Fishery Length and Age Data

[recreational-fishery-length-and-age-data](#)

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

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

611 *CPFV length composition data, 1959-1978*

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

623 Collins and Crooke (n.d.) conducted an onboard observer survey of the CPFV fleet in
624 southern California from 1975-1978. A total of 1,308 GBYR lengths were available from
625 the study and were assumed to all be from retained fish. Ally et al. (1991) conducted an
626 onboard observer program of the CPFV fleet from 1985-1987 in southern California. Because

627 MRFSS data were available for this time period as well and represents multiple recreational
628 modes, the Ally et al. (1991) length data were not used in the assessment.

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

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

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

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

652 **2.1.6 Fishery-Dependent Indices of Abundance**
fishery-dependent-indices-of-abundance

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

656 **MRFSS Dockside CPFV Index**

657 From 1980 to 2003 the MRFSS program conducted dockside intercept surveys of recreational
658 fishing fleet. The program was temporarily suspended from 1990-1992 due to lack of fund-
659 ing. For purposes of this assessment, the MRFSS time series was truncated at 1998 due to
660 sampling overlap with the onboard observer program (i.e., the same observer samples the
661 catch while onboard the vessel and also conducts the dockside intercept survey for the same

662 vessel). Each entry in the RecFIN Type 3 database corresponds to a single fish examined
663 by a sampler at a particular survey site. Since only a subset of the catch may be sampled,
664 each record also identifies the total number of that species possessed by the group of anglers
665 being interviewed. The number of anglers and the hours fished are also recorded. The data,
666 as they exist in RecFIN, do not indicate which records belong to the same boat trip. A
667 description of the algorithms and process used to aggregate the RecFIN records to the trip
668 level is outlined Supplemental Materials (“Identifying Trips in RecFIN”).

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

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

680 The species composition of catch in California varies greatly with latitude.
681 Therefore, Stephens-MacCall filtering was applied independently for north and south of Point
682 Conception. Separate indices were also developed to represent two recreational fleets in the
683 model.

684 Since recreational fishing trips target a wide variety of species, standardization of the catch
685 rates requires selecting trips that are likely to have fished in habitats containing GBYR. The
686 Stephens-MacCall (2004) filtering approach was used to identify trips with a high probability
687 of catching GBYR, based on the species composition of the catch in a given trip. Prior to
688 applying the Stephens-MacCall filter, we identified potentially informative predictor species,
689 i.e., species with sufficient sample sizes and temporal coverage (at least 30 positive trips
690 total) to inform the binomial model. Coefficients from the Stephens-MacCall analysis (a
691 binomial GLM) are positive for species which co-occur with GBYR, and negative for species
692 that are not caught with GBYR. Each of these filtering steps and the resulting number of
693 trips remaining in the sampling frame are provided in Table 16.

694 *MRFSS Filtering and Index Standardization for North of Point Conception.* Prior to the
695 Stephens-MacCall filter, a total of 2,788 trips were retained for the analysis. As expected,
696 positive indicators of GBYR trips include several species of nearshore rockfish, treefish, kelp
697 rockfish, and blue rockfish, and the strongest counter-indicator was striped bass (Figure
698 13). While the filter is useful in identifying co-occurring or non-occurring species assuming
699 all effort was exerted in pursuit of a single target, the targeting of more than one target
700 species can result in co-occurrence of species in the catch that do not truly co-occur in
701 terms of habitat associations informative for an index of abundance. Stpehens and MacCall

702 (Stephens and MacCall 2004) recommended including all trips above a threshold where the
703 false negatives and false positives are equally balanced. However, this does not have any
704 biological relevance and for this data set, we assume that if a GBYR was landed, the anglers
705 had to have fished in appropriate habitat, especially given how territorial GBYR and both
706 species are strongly associated with rocky habitat.

707 Two levels of possible filtering were applied using the Stephens-MacCall filter (Table
708 ??tab:Fleet10_11_Filter}). The Stephens-MacCall filtering method identified the probability
709 of occurrence (in this case 0.4) at which the rate of “false positives” equals “false negatives.”
710 The trips selected using this criteria were compared to an alternative method including
711 all the “false positive” trips, regardless of the probability of encountering GBYR (Table
712 19). This assumes that if GBYR were caught, the anglers must have fished in appropriate
713 habitat during the trip. The catch included in this index is “sampler-examined” and the
714 samplers are well trained in species identification. The last filter applied was to exclude
715 years after 1999 due to a number of regulation changes, and years in which there were less
716 than 20 observed trips. The final index is represented by 544 trips, 220 of which encountered
717 GBYR.

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

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

733 *MRFSS Filtering and Index Standardization for South of Point Conception.* Prior to the
734 Stephens-MacCall filter, a total of 7,334 trips were available for the analysis. As expected,
735 positive indicators of GBYR trips included several nearshore species, e.g., kelp rockfish,
736 treefish, and black croaker, while the strongest counter-indicator was opaleye (Figure 17).
737 While the filter is useful in identifying co-occurring or non-occurring species assuming all
738 effort was exerted in pursuit of a single target, the targeting of more than one target species
739 can result in co-occurrence of species in the catch that do not truly co-occur in terms of
740 habitat associations informative for an index of abundance.

741 For consistency with the methods used north of Point Conception (Table 16) the index
742 includes the trips identified as “false positives” from the Stephens-MacCall filtering that had

⁷⁴³ a lower threshold level of 0.22 (Table 20). The last filter applied was to exclude years after
⁷⁴⁴ 1999 due to a number of regulation changes, and years in which there were less than 20
⁷⁴⁵ observed trips. The final index is represented by 475 trips, 342 of which encountered GBYR.

⁷⁴⁶ Catch per angler hour (CPUE; number of fish per angler hour) was modelled using the delta-
⁷⁴⁷ GLM approach (Lo et al. 1992, Stefánsson 1996). A negative binomial model was explored,
⁷⁴⁸ but the proportion of zeroes was not well estimated in the negative binomial models. This
⁷⁴⁹ is likely due to the facts that MRFSS sampling effort was higher south of Point Conception,
⁷⁵⁰ and GBYR are also rare south of Point Conception, both leading to a higher proportion of
⁷⁵¹ zeroes in the trip data than for north of Point Conception.

⁷⁵² Model selection using Akaike Information Criterion (AIC) supported inclusion of year, region,
⁷⁵³ area_x, and 2-month waves. Counties were grouped into three regions, Santa Barbara to
⁷⁵⁴ Ventura counties, Los Angeles and Orange counties, and San Diego county for both the
⁷⁵⁵ positive observation model and the binomial model. Area_x is a measure of distance from
⁷⁵⁶ shore, a categorical variable indicating whether most of the fishing occurred inside or outside
⁷⁵⁷ three nautical miles from shore.

⁷⁵⁸ The resulting index for south of Point Conception represents different years than the index for
⁷⁵⁹ north of Point Conception (Table 6). The index starts in 1980 with continuous data through
⁷⁶⁰ 1986, and three additional years in 1996, 1998 and 1999. The index increases through 1983
⁷⁶¹ and a marked decrease to 1986. The index for the three years in the 1990s does not exhibit
⁷⁶² any significant trend.

⁷⁶³ CPFV Onboard Observer Surveys

⁷⁶⁴ Onboard observer survey data were available from three sources for this assessment, 1)
⁷⁶⁵ a CDFW survey in central California from 1987-1998 (referred to as the Deb Wilson-
⁷⁶⁶ Vandenberg onboard observer survey, (Reilly et al. 1998)), 2) the CDFW CPFV onboard
⁷⁶⁷ observer survey from 1999-2018, and 3) a Cal Poly survey from 2003-2018. During an on-
⁷⁶⁸ board observer trip the sampler rides along on the CPFV and records location-specific catch
⁷⁶⁹ and discard information to the species level for a subset of anglers onboard the vessel. The
⁷⁷⁰ subset of observed anglers is usually a maximum of 15 people the observed anglers change
⁷⁷¹ during each fishing stop. The catch cannot be linked to an individual, but rather to a specific
⁷⁷² fishing location. The sampler also records the starting and ending time, number of anglers
⁷⁷³ observed, starting and ending depth, and measures discarded fish.
⁷⁷⁴ The fine-scale catch and effort data allow us to better filter the data for indices to fishing
⁷⁷⁵ stops within suitable habitat for the target species.

⁷⁷⁶ California implemented a statewide sampling program in 1999 (Monk et al. 2014). California
⁷⁷⁷ Polytechnic State University (Cal Poly) has conducted an independent onboard sampling
⁷⁷⁸ program as of 2003 for boats in Port San Luis and Morro Bay, and follows the protocols
⁷⁷⁹ established in Reilly et al. (1998). Cal Poly has modified protocols reflect sampling changes
⁷⁸⁰ that CDFW has also adopted, e.g., observing fish as they are encountered instead of at the
⁷⁸¹ level of a fisher's bag. Therefore, the Cal Poly data area incorporated in the same index as

782 the CDFW data from 1999-2018. The only difference is that Cal Poly measures the lenght
783 of both retained and discarded fish.

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

787 *Deb Wilson-Vandenberg Onboard Observer Index Filtering and Standardization.* The specific
788 fishing locations at each fishing stop were recorded at a finer scale than the catch data for
789 this survey. We aggregated the relevant location information (time and number of observed
790 anglers) to match the available catch information. Between April 1987 and July 1992 the
791 number of observed anglers was not recorded for each fishing stop, but the number of anglers
792 aboard the vessel is available. We imputed the number of observed anglers using the number
793 of anglers aboard the vessel and the number of observed anglers at each fishing stop from
794 the August 1992-December 1998 data (see Supplemental materials for details). In 1987,
795 trips were only observed in Monterey, CA and were therefore excluded from the analysis.
796 The years 1990 and 1991 were also removed for low sample sizes. Final data filters included
797 removing reefs that never encountered GBYR, drifts that had fishing times outside 95% of
798 the data, and fishing stops with depths <9 m and >69m. The final data set contained 2,411
799 fishing stops, with 1,096 of those encountering GBYR (Figure 18).

800 The index was fit using a delta-GLM model, with a lognormal model (AIC: 1,088) selected
801 over a gamma model (AIC: 1,143) for the positive encounters. Covariates considered in
802 the full model included year, depth, and month (Table 8). The model selected by AIC for
803 both the lognormal and binomial components of the delta-GLM included year, depth and
804 reef. Depth was included in 10 m depth bins and eight reefs were select in the final model
805 (Figure coming). The final index did not indicate an increasing trend that was seen in the
806 2005 gopher rockfish assessment using the same data set (Figure 19). A number of reasons
807 include that finer-scale location data was keypunched in 2012 for this survey, the index in
808 this assessment includes black-and-yellow rockfish, and different filters were applied to the
809 data. However, the the same peaks and decreases in the two indices are present.

810 *CDFW and Cal Poly Onboard Observer Index Filtering and Standardization* As described
811 above the CDFW and Cal Poly onboard observer programs are identical in that the same
812 protocols are followed. The only difference is that Cal Poly measures both retained and
813 discarded fish from the observed anglers. CDFW measures discarded fish only from the
814 observed anglers, and measures retained fish as part of the angler interview at the bag level.
815 Cal Poly has also begun collecting otoliths during the onboard observer trips, which are used
816 as conditional age-at-length data the recreational fishery north of Point Conception in this
817 assessment.

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

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

826 Initial filters were applied to the entire data set, north and south of Point Conception com-
827 bined. After an initial clean-up of the data, 67,850 drifts remained, with GBYR present in
828 9,317 (Table 9). This was reduced to 25,427 drifts GBYR present in 7,250 drifts) after fil-
829 tering the data to remove potential outliers in the time fished and observed anglers, limiting
830 the data to reefs that observed GBYR and were sampled in at least 2/3 of all years, and to
831 drifts with starting locations within 1,000 m of a reef.

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

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

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

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

849 *Filtering and Index Standardization for south of Point Conception* The bathymetric data is
850 not available at as fine-scale resolution for the Southern California Bight and more of the
851 trips and drifts target mid-water species, including mid-water rockfish (Table 9). Therefore,
852 instead of using distance to reef as a filter, we filtered the data to drifts that encountered
853 20% or more groundfish. This resulted in the total number of drifts decreasing from 11,635
854 to 5,495, but only decreased the number of drifts encountering GBYR from 1,277 to 1,171.
855 A final check was made to ensure all reefs were sampled in at least 2/3 of all years, leaving
856 5,440 drift for the final index, of which 1,132 encountered GBYR (Figure 21).

857 The index of abundance was modeled with the a delta-GLM modeling approach, with year,
858 month, 10 m depth bins from 10-59 m, and four reefs as possible covariates. A lognormal
859 model (AIC: 162) was selected over a gamma (AIC: 277) for the positive observations using
860 AIC. A model with year, depth and reef was selected by AIC for both the lognormal and

binomial components of the delta-GLM. The index indicates a relatively stable trend from 2001-2004 and a steady increase from 2005-2017.

863 2.1.7 Fishery-Dependent Indices: Available Length and Age Data

[fishery-dependent-indices-available-length-and-age-data](#)

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

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

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

880 2.1.8 Fishery-Independent Data Sources fishery-independent-data-sources

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

883 California Collaborative Fisheries Research Project

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

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

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

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

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

924 *CCFRP Length Measurements and Available Ages*

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

930 Conditional age-at-length data were also incorporated into the assessment from the CCFRP
931 program, including two master’s theses that are products of the CCFRP. Erin Loury (Loury

932 2011) collected gopher rockfish otoliths as part of her thesis work from 2007-2009 that in-
933 cluded specimens from both inside and outside the MPAs. Natasha Meyers-Cherry (Meyers-
934 Cherry 2014) conducted another thesis focused on the life history of gopher rockfish and
935 collected otoliths from 2011-2012, also both inside and outside the MPAs. Both MLML and
936 Cal Poly began routinely collecting otoliths from a select number of fish in 2017 as part of
937 the CCFRP program. Also included in the conditional age-at-length dat for this fleet are
938 otoliths collected in 2018 by the University of California Davis Bodega Marine Lab CCFRP
939 program.

940 Partnership for Interdisciplinary Studies of Coastal Oceans

941 The Partnership for Interdisciplinary Studies of Coastal Oceans, [PISCO-UCSC](#), conducts
942 a number of surveys to monitor the kelp forests, one of which is a kelp forest fish survey.
943 PISCO has monitored fish population in the 0-20 m depth range as part of the Marine Life
944 Protection Act (MLPA) since 1998. Paired sites inside and outside MPAs are surveyed to
945 monitor the long-term dynamics of the kelp forest ecosystem and provide insight into the
946 effect of MPAs on kelp forest species. PISCO conducts the fish surveys from late July through
947 September. At each site, benthic, midwater, and canopy scuba transects are conducted at
948 5, 10, 15, and 20 m depth. All divers are trained in species identification. Along each 30
949 m transect, divers enumerate all identifiable non-cryptic fish, and measure total length to
950 the nearest centimeter. PISCO surveys are conducted by the University of California Santa
951 Cruz (UCSC) in central California and through the University of California Santa Barbara
952 in southern California. All PISCO data were provided by Dan Malone (UCSC).

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

962 We modeled number of fish observed per transect(s) using maximum likelihood and Bayesian
963 negative binomial regression. Models incorporating temporal (year, month) and geographic
964 (site and zone) factors were evaluated. The zone is a factor indicating the depth stratification
965 at a site, i.e., 5 m, 10 m, 15 m, or 20 m targeted bottom depth.. Based on AIC values from
966 maximum likelihood fits (Table 13), a main effects model including all factors (year, month,
967 site and zone) was fit in the “rstanarm” R package (version 2.18.2). Diagnostic checks of the
968 Bayesian model fit (Neff, Rhat, and Monte Carlo standard error values) were all reasonable.
969 Predicted means by stratum (Year) were strongly correlated with observed means, suggesting
970 a reasonable fit to the data (Figure 27). The NB model generated data sets with roughly
971 16-25% zeros, compared to the observed 23% (Figure 28).

972 The final index decreases from 2001 to the late 2000s, with lower estiamtes of relative abundance
973 from 2005-2010. From 2010 to 2015, the index increaes and peaks in 2015, before
974 the decreasing trends from 2016-2018. The pattern observed in this index indicates almost
975 an counter trend to that observed in the onboard observer and CCFRP indices for north of
976 Point Conception (Figure 11). The PISCO survey is sampling different habitat types than
977 the other two surveys, and covers much shallower depths.

978 *PISCO Length Measurements*

979 Every GBYR observed by PISCO divers except one, had an associated length measurement
980 ($N = 11,965$). Divers measure fish to the nearest centimeter, and are trained to measure fish
981 underwater and be aware of possible biases, e.g., ambient light, body color, visibility, and
982 body shape. Both juvenile and adult GBYR were observed in the PISCO kelp forest fish
983 survey data (Figure 29). Of note is the similarity in length distibutions both between the
984 species and for the two species combined across sites. Fish in the 10-17 cm size range (ap-
985 proximately) are not observed in this survey. There is significant post-settlement mortality
986 for both species, which is thought to be due to density-dependent predation (Johnson 2006,
987 2007). Secondly, both species are cryptic and observed more often at night than during the
988 day (Mark Carr, PISCO-UCSC, personal communication).

989 **2.1.9 Biological Parameters and Data**

biological-parameters-and-data

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

993 (Table 4)

994 **Length and Age Compositions**

995 Length compositions were provided from the following sources:

- 996 • CALCOM (*commercial retained dead fish*, 1987, 1992-2018)
- 997 • WCGOP (*commercial discarded fish*, 2004-2018)
- 998 • Deb Wilson-Vandenber's onboard observer survey (*recreational charter retained and*
999 *discarded catch*, 1987-1998)
- 1000 • California recreational sources combined (*recreational charter retained catch*)
 - 1001 – Miller and Gotshall dockside survey (1959-1966)
 - 1002 – Ally et al. onboard observer survey (1985-1987)
 - 1003 – Collins and Crooke onboard observer survey (1975-1978)
 - 1004 – MRFSS dockside survey (1980-2003)
 - 1005 – CRFS onboard and dockside survey (2004-2018)
- 1006 • PISCO dive survey (*research*, 2001-2018)

- 1007 • CCFRP hook-and-line survey (*research*, 2007-2018)

1008 The length composition of all fisheries aggregated across time by fleet is in Figure 30. De-
1009 scriptions and details of the length composition data are in the above section for each fleet
1010 or survey.

1011 Age Structures

1012 A total of 2,467 otoliths were incorporated in this assessment and a summary by source can
1013 be found in Table 21. Gopher rockfish comprised 80% of the samples (946 females, 901 males,
1014 121 unknown sex), and all but a few black-and-yellow rockfish (247 females, 232 males, 20
1015 unknown sex) came from a directed study by Jody Zaitlin (1986) (Figure 31).

1016 Of the available ages, 91% were collected during fishery-independent surveys.

1017 An additional 36 otoliths were collected by Cal Poly during their CPFV onboard observer
1018 survey in 2018. The remaining 7.5% were from commercial port samples or recreational
1019 dockside surveys. Black-and-yellows represent 20% of the samples collected, and are mainly
1020 derived from Ralph Larson's work in Monterey Bay.

1021 All otoliths were read by Don Pearson (NMFS SWFSC, now retired) and ages ranged from
1022 1-28. The aged black-and-yellow rockfish ranged in length from 7-32 cm with a mean of 24
1023 cm and gopher rockfish ranged in length from 11-36 cm, with a mean of 26. In terms of
1024 ages, the black-and-yellow rockfish ranged from 2-19 and gophers from 2-28. Fits to the von
1025 Bertalanffy growth curve (Bertalanffy 1938), $L_i = L_\infty e^{(-k[t-t_0])}$, where L_i is the length (cm)
1026 at age i , t is age in years, k is rate of increase in growth, t_0 is the intercept, and L_∞ is the
1027 asymptotic length, were explore by species and sex.

1028 No significant differences were found in growth between males and females, or between gopher
1029 and black-and-yellow rockfishes.

1030 Aging Precision and Bias

1031 Uncertainty in ageing error was estimated using a collection of xxx gopher and black-and-
1032 yellow rockfish scorpionfish otoliths with two age reads (Figure 33). Age-composition data
1033 used in the model were from a number of sources described above. All otoliths were read by
1034 Don Pearson (NMFS SWFSC, no retired) who also conducted all blink double reads.

1035 Ageing error was estimated using publicly available software (Thorson et al. 2012). The
1036 software setting for bias was set to unbiased since the same reader conducted the first and
1037 second readings. The best fit model chose by AIC for the standard deviation was a constant
1038 coefficient of variation for reader one ad mirrored for reader two (Figure 34).

1039 The resulting estimate indicated a standard deviation in age readings increasing from 0.74
1040 years at age 0 to a standard deviation of 2.07 years at age 28, the first year of the plus group
1041 in the assessment model.

1042 **Weight-Length**

1043 The weight-length relationship is based on the standard power function: $W = \alpha(L^\beta)$ where
1044 W is individual weight (kg), L is length (cm), and α and β are coefficients used as constants.

1045 The weight-length relationships was estimated from the three studies, Loury (2011), Meyers-
1046 Cherry (2014) (both gopher rockfish only from CCFRP) and Zaitlin (Zaitlin 1986) (black-
1047 and-yellow rockfish only). Only one weight-length relationship was estimated for the GBYR
1048 complex. The estimated parameters are $\alpha = 8.84e^{-006}$ and $\beta = 3.25584$. The estimated
1049 relationship is similar to that estimated by Lea et al. (1999) for gopher rockfish (Figure
1050 35). The weight-length relationship estimated here was used in the assessment model to
1051 best represent the GBYR complex.

1052 **Sex Ratio, Maturity, and Fecundity**

1053 The sex ratio for GBYR is assumed to be 50:50 as there is no evidence to suggest otherwise.

1054 Zaitlin (1986) found that females reached 50% maturity at 17.5 cm or 4 years of age in
1055 Central California and were 100% mature by age 6, with the same age of maturity found
1056 in southern California though individuals were smaller at age; all ages from this study were
1057 surface ages and have been re-read for this assessment. Echeverria (1987) estimated maturity
1058 for 17 rockfish species in central California. She found the size at first maturity and the size
1059 at 50% maturity for male and female gopher rockfish to be 17 cm total length, and 100%
1060 mature by 21 cm. Black-and-yellow rockfish males and females were first mature at 14 cm,
1061 50% of females were mature at 15 cm, 50% of males mature at 16 cm. Male black-and-yellow
1062 rockfish were 100% mature at 20 cm and females at 19 cm. In southern California waters,
1063 both males and females were found to reach first maturity at 13 cm total length (Larson
1064 1980). We did not have any samples from southern California to re-analyze the maturity
1065 ogive for that portion of the population.

1066 The maturity data from Zaitlin (1986) (422 black-and-yellow rockfish) were re-analyzed along
1067 with samples from Meyers-Cherry (2014) (115 gopher rockfish). Combining the two dataset
1068 provided an updated maturity ogive for the GBYR complex females (Figure 32). The first
1069 observed mature fish was 19 cm and the length at 50% was 21.66 cm, larger than suggested
1070 from the studies in the 1980s. Using only the gopher data, 50% was estimated at 23.33 cm
1071 and for black-and-yellow rockfish at 21.26 cm. An important note is that the smaller fish
1072 from these studies were black-and-yellow rockfish and the larger fish were gopher rockfish.
1073 Alhtough not used in this assessment, the estimate of 50% maturity for 23 GBYR from
1074 these studies was 21.88 cm. The age at 50% mature increased in this assessment to 21.66
1075 cm, which is 3.96 cm larger than the value used int eh 2005 assessment.

1076 Mature females in central California release larvae between January and July, peaking in
1077 February, March, and May (Larson 1980, Lea et al. 1999, Love et al. 2002). Both species of
1078 GBYR release one brood per season (Love et al. 2002). Black-and-yellow rockfish females

1079 can produce 25,000 - 450,000 eggs spawning from January to May. Gopher rockfish females
1080 ranging between 176 and 307 grams carry approximately 249 eggs per gram of body weight
1081 (MacGregor 1970). The fecundity estimates used in this assessment were provided by E.J.
1082 Dick (NMFS SWFSC) from a meta-analysis of fecundity in the genus *Sebastodes* (Dick et al.
1083 2017).

1084 **Natural Mortality**

1085 Hamel (2015) developed a method for combining meta-analytic approaches to relating the
1086 natural mortality rate M to other life-history parameters such as longevity, size, growth
1087 rate and reproductive effort, to provide a prior on M . In that same issue of ICESJMS,
1088 Then et al. (2015), provided an updated data set of estimates of M and related life history
1089 parameters across a large number of fish species, from which to develop an M estimator
1090 for fish species in general. They concluded by recommending M estimates be based on
1091 maximum age alone, based on an updated Hoenig non-linear least squares (nls) estimator
1092 $M = 4.899 * A_{max}^{-0.916}$. The approach of basing M priors on maximum age alone was one that
1093 was already being used for west coast rockfish assessments. However, in fitting the alternative
1094 model forms relating $-0.916M$ to A_{max} , Then et al. (2015) did not consistently apply their
1095 transformation. In particular, in real space, one would expect substantial heteroscedasticity
1096 in both the observation and process error associated with the observed relationship of M to
1097 A_{max} . Therefore, it would be reasonable to fit all models under a log transformation. This
1098 was not done. Reevaluating the data used in Then et al. (2015) by fitting the one-parameter
1099 A_{max} model under a log-log transformation (such that the slope is forced to be -1 in the
1100 transformed space (as in Hamel (2015)), the point estimate for M is:

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

1101 The above is also the median of the prior. The prior is defined as a lognormal with mean
1102 $\ln \frac{5.4}{A_{max}}$ and SE = 0.4384343 (Owen Hamel, personal communication, NMFS). Using a max-
1103 imum age of 28 the point estimate and median of the prior is 0.211138, which is used as a
1104 prior for in the assessment model.

1105 **2.1.10 Environmental or Ecosystem Data Included in the Assessment**
environmental-or-ecosystem-data-included-in-the-assessment

1106 In this assessment, neither environmental nor ecosystem considerations were explicitly in-
1107 cluded in the analysis. This is primarily due to a lack of relevant data and results of analyses
1108 (conducted elsewhere) that could contribute ecosystem-related quantitative information for
1109 the assessment.

1110 **2.2 Previous Assessments**

previous-assessments

1111 **2.2.1 History of Modeling Approaches Used for this Stock**

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

1112 This is the first full assessment for black-and-yellow rockfish. Black-and-yellow rockfish was
1113 assessed coastwide as a data poor species using Depletion-Based Stock Reduction Analaysis
1114 (DB-SRA) (Dick and MacCall 2010). The DB-SRA model assigned a 40% probability that
1115 the then recent (2008-2009) catch exceeded the 2010 OFL.

1116 Gopher rockfish south of Point Conception was assessed as a data poor species in 2010 (Dick
1117 and MacCall 2010). A Depletion-Corrected Average Catch (DCAC) model was used due to
1118 time constraints. The mean yield? (OFL?) from the DCAC distribution was 25.5.

1119 Gopher rockfish north of Point Conception ($34^{\circ}27'$ N. latitude) was first assessed a full stock
1120 assessment in 2005 (Key et al. 2005) using SS2 (verion 1.19). The assessment was sensitive
1121 to the CPFV onboard observer index of abundance (referred to as Deb Wilson-Vandenber's
1122 onboard observer index in this assessment). THe final decision table was based around the
1123 emphasis given to the index, with a value of 5 given a 40% probability and used in the
1124 baseline model. The stock was found to be at 97% depletion.

1125 **2.2.2 2005 Assessment Recommendations**

assessment-recommendations

1126 The 2005 STAR panel only had one recommendation specific to gopher rockfish. However,
1127 they had a number of generic rockfish recommendations that can be found in the STAR
1128 panel report available [here](#).

1129 **Recommendation 1: Additional length and age composition data should be
1130 collected for gopher rockfish. This would help to characterize spatial and
1131 possibly temporal variation in growth**

1132
1133 2019 STAT response: Additional age and length data have been collected from a num-
1134 ber of sources, the majority of which have been fishery-independent studies, including
1135 two master's theses focused on gopher rockfish. Only a handful of otoliths have been
1136 collected for gopher rockfish south of Point Conception. Additional length composition
1137 data are available since the last assessment.

1138 **2.3 Model Description**

model-description

1139 The mode descriptions in the following sections reflect decisions and modelling choices the
1140 STAT team made prior to the STAR panel. Changes from the pre-STAR base model to the

1141 final post-STAR base model are documented in the “Responses to the Current STAR Panel
1142 Requests” section. None of the data changed during the STAR panel, and the figures and
1143 tables reflect the post-STAR final base model.

1144 2.3.1 Transition to the Current Stock Assessment 1145 transition-to-the-current-stock-assessment

1146 The first formal stock assessment for gopher rockfish was conducted in 2005 (Key et al.
1147 2005). There are two major differences between the 2005 assessment this assessment, 1) this
1148 assessment models gopher and black-and-yellow rockfish as a complex, and 2) this assessment includes the area south of Point Conception.

1149 The 2005 model conducted in SS2 version 1.19 was first transitioned to SS3.24z as a bridge
1150 model, before moving forward to SS3.30. Below, we describe the most important changes
1151 made since the last full assessment in 2005 and explain rationale for each change. Some of
1152 these items are changes due to structure changes with Stock Synthesis, and some denote
1153 parameters chosen for options that were not available in SS2 (version 1.19).

1154 Changes in the bridge model from SS2 version 1.9 to SS3.24z and SS3.30.13.08 include:

1155 The way growth is modeled for age-0 fish has changed. More recent versions of Stock Synthesis
1156 model length-at-age for fish below the first reference age (A_{min}) as linearly increasing
1157 from the initial length bin to the length given by the $L_{at_A_{min}}$ parameter. The minimum
1158 population length bin was reduced from 10 cm in the 2005 assessment to 4 cm in this assessment.
1159 The timing of settlement was set at July to reflect the month at which the young-of-the-year are expected to be at 4 cm (Figure ??). The length data leading to this
1160 decision were provided by Diana Baetscher (UCSC) and were collected via Standard Monitoring Unit for the Recruitment of Fishes (SMURFs) from the UCSC-PISCO kelp forest fish
1161 survey as part of her dissertation work on GBYR (Baetscher 2019).

1162 This stock assessment retains a single fleet for the commercial fishery, and also includes
1163 a commercial discard fleet. Data on commercial discards were not available for and not
1164 included in the 2005 assessment. The decision to retain one commercial fleet was made by
1165 examining the length distributions across species, fishing gears, and space, i.e., north and
1166 south of Point Conception (Figure 36). There is very little difference between the length
1167 composition of gopher and black-and-yellow rockfish landed in the commercial fleet north
1168 of Point Conception which contributed 97% of the commercial landings from 1978-2018.
1169 The length distributions suggest that gopher rockfish south of Point Conception landed
1170 dead south of Point Conception are slightly smaller on average than north of Point
1171 Conception. However, there is not enough data available to justify splitting the commercial
1172 fishery north and south of Point Conception. The length compositions of discarded fish are
1173 small in all four of the subplots, suggesting size-based discarding. Because Stock Synthesis
1174 is not set up to handle depth-dependent discard mortality rates and we’re modelling two
1175 species as a complex with differing depth-dependent discard mortality rates, the time series
1176 of commercial discards was incorporated as a fleet.

1179 This assessment incorporates the area south of Point Conception, which was previously
1180 excluded from the 2005 assessment. The length composition data suggested that while the
1181 lengths of gopher and black-and-yellow rockfish were similar, fish encountered south of Point
1182 Conception were smaller (Figure 37). The recreational catches from the man made mode
1183 are negligible and did not influence the decision to split the fleet at Point Conception. The
1184 similarity of the length distributions between species and among modes within a region were
1185 similar and justified one recreational fleet.

1186 The 2005 model was a length-based model. This assessment uses conditional age-at-length
1187 from fish aged from a number of sources (Table 21).

1188 Differences in both the recreational and commercial catches used in this assessment are
1189 described in detail in the 1.5 section.

1190 The bias adjustment for recruitment deviations did not exist in SS2 (version 1.19). We set
1191 1973-2012 as the range of years with full bias adjustment to span the time series that was
1192 modeled.

1193 2.3.2 Summary of Data for Fleets and Areas

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

1194 There are 12 fleets in the base model. They include:

1195 *Commercial*: The commercial fleets include two separate fleets, one for GBYR landed (all
1196 gears combined), and one for commercial dead discards.

1197 *Recreational*: The recreational fleets include two fleets, one for north of Point Conception
1198 and one for south of Point Conception (all mode combined).

1199 *Fishery-Dependent Surveys*: There are five fishery-dependent survey fleets, one each for
1200 north and south of Point Conception from the MFRSS CPFV dockside survey, one each
1201 for north and south of Point Conception from the CDFW/Cal Poly onboard observer survey,
1202 and one from the Deb Wilson-Vandenberg CPFV onboard observer survey that represents
1203 north of Point Conception only.

1204 *Research*: There are third main sources of fishery-independent data available the CCFRP
1205 survey the PISCO kelp forest fish survey. A third survey fleet is included as a “dummy”
1206 fleet to allow incorporation of additional conditional age-at-length composition data from the
1207 Zaitlin and Abrams theses. This dummy fleet does not have any length or catches associated
1208 with it.

1209 **2.3.3 Other Specifications**

other-specifications

1210 **2.3.4 Modeling Software**

modeling-software

1211 The STAT team used Stock Synthesis 3 version 3.30.13.08 by Dr. Richard Methot at the
1212 NWFSC. This most recent version was used, since it included improvements and corrections
1213 to older versions. The r4SS package (GitHub release number v1.35.1) was used to post-
1214 process output data from Stock Synthesis.

1215 **2.3.5 Data Weighting**

data-weighting

1216 **2.3.6 Priors**

priors

1217 The log-normal prior for female natural mortality were based on a meta-analysis completed
1218 by Hamel (2015), as described under “Natural Mortality.” Female natural mortality was fixed
1219 at the median of the prior, 0.xxx for an assumed maximum age of xx. An uninformative
1220 prior was used for the male offset natural mortality, which was estimated.

1221 The prior for steepness (h) assumes a beta distribution with parameters based on an update
1222 for the Thorson-Dorn rockfish prior (Dorn, M. and Thorson, J., pers. comm.), which was
1223 endorsed by the Science and Statistical Committee in 2018. The prior is a beta distribution
1224 with $mu=0.xxx$ and $sigma=0.xxx$. Steepness is fixed in the base model at the mean of the
1225 prior. The priors were applied in sensitivity analyses where these parameters were estimated.

1226 **2.3.7 Estimated and Fixed Parameters**

estimated-and-fixed-parameters

1227 A full list of all estimated and fixed parameters is provided in Tables 23.

1228 The base model has a total of xxx estimated parameters in the following categories:

1229 • XXX,

1230 • XXX

1231 • XXX, and

1232 • XXX selectivity parameters

₁₂₃₃ The estimated parameters are described in greater detail below and a full list of all estimated
₁₂₃₄ and parameters is provided in Table 23.

₁₂₃₅ *Growth.*

₁₂₃₆ *Natural Mortality.*

₁₂₃₇ *Selectivity.*

₁₂₃₈ *Other Estimated Parameters.*

₁₂₃₉ *Other Fixed Parameters.*

₁₂₄₀ 2.4 Model Selection and Evaluation

model-selection-and-evaluation

₁₂₄₁ 2.4.1 Key Assumptions and Structural Choices

key-assumptions-and-structural-choices

₁₂₄₂ 2.4.2 Alternate Models Considered

alternate-models-considered

₁₂₄₃ 2.4.3 Convergence

convergence

₁₂₄₄ 2.5 Response to the Current STAR Panel Requests

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

₁₂₄₅ To be populated after the STAR panel.

₁₂₄₆ Request No. 1:

₁₂₄₇

Rationale: xxx

₁₂₄₉ **STAT Response:** xxx

₁₂₅₀ Request No. 2:

₁₂₅₁

Rationale: xxx

₁₂₅₃ **STAT Response:** xxx

₁₂₅₄ Request No. 3:

₁₂₅₅

Rationale: x.

₁₂₅₇ **STAT Response:** xxx

1258 **Request No. 4:**

1259

1260 **Rationale:** xxx

1261 **STAT Response:** xxx

1262 **Request No. 5:**

1263

1264 **Rationale:** xxx

1265 **STAT Response:** xxx

1266 **2.6 Base Case Model Results**

base-case-model-results

1267 The following description of the model results reflects a base model that incorporates all of
1268 the changes made during the STAR panel (see previous section). The base model parameter
1269 estimates and their approximate asymptotic standard errors are shown in Table 23 and the
1270 likelihood components are in Table 24. Estimates of derived reference points and approximate
1271 95% asymptotic confidence intervals are shown in Table e. Time-series of estimated stock
1272 size over time are shown in Table 25.

1273 **2.6.1 Parameter Estimates**

parameter-estimates

1274 The additional survey variability (process error added directly to each year's input variabil-
1275 ity) for all surveys was estimated within the model.

1276 (Figure ??).

1277 The stock-recruit curve ... Figure 40 with estimated recruitments also shown.

1278 **2.6.2 Fits to the Data**

fits-to-the-data

1279 Model fits to the indices of abundance, fishery length composition, survey length composition,
1280 and conditional age-at-length observations are all discussed below.

1281 ??

1282 **2.6.3 Uncertainty and Sensitivity Analyses**
uncertainty-and-sensitivity-analyses

1283 A number of sensitivity analyses were conducted, including:

- 1284 1. Sensitivity 1
- 1285 2. Sensitivity 2
- 1286 3. Sensitivity 3
- 1287 4. Sensitivity 4
- 1288 5. Sensitivity 5, etc/

1289 **2.6.4 Retrospective Analysis**

retrospective-analysis

1290 **2.6.5 Likelihood Profiles**

likelihood-profiles

1291 **2.6.6 Reference Points**

reference-points-1

1292 Reference points were calculated using the estimated selectivities and catch distribution
1293 among fleets in the most recent year of the model, (2017). Sustainable total yield (landings
1294 plus discards) were 167 mt when using an $SPR_{50\%}$ reference harvest rate and with a 95%
1295 confidence interval of 101 mt based on estimates of uncertainty. The spawning biomass
1296 equivalent to 40% of the unfished level ($SB_{40\%}$) was 527 mt.

1297 (Figure 50

1298 The 2018 spawning biomass relative to unfished equilibrium spawning biomass is
1299 above/below the target of 40% of unfished levels (Figure ??). The relative fishing intensity,
1300 $(1 - SPR)/(1 - SPR_{50\%})$, has been xxx the management target for the entire time series
1301 of the model.

1302 Table e shows the full suite of estimated reference points for the base model and Figure 52
1303 shows the equilibrium curve based on a steepness value xxx.

1304 **3 Harvest Projections and Decision Tables**

harvest-projections-and-decision-tables

1305 This section will be completed at or after the STAR panel.

1306 **4 Regional Management Considerations**

regional-management-considerations

1307 While the proportion of the stock residing within U.S. waters is unknown, the assessment
1308 provides an adequate geographic representation of the portion assessed for management
1309 purposes. There is little evidence that black-and-yellow rockfish extend into Mexico, and
1310 the proportion of gopher rockfish residing south of Pt. Conception is small. while there
1311 has been work on the genetic structure of the two species, there has not been work done
1312 within species to inform whether or not there is genetic spatial structure to the population.
1313 Given the relatively small area in the waters of California where these species occur, there
1314 is relatively little concern regarding exploitation in proportion to the regional distribution
1315 of abundance in the area assessed in this study.

1316 The state of California implements regional management for the recreational fleet in the
1317 form of five regions. Neither gopher nor black-and-yellow rockfish are a large component
1318 of the total recreational landings and are managed as part of a shallow nearshore rockfish
1319 complex. Current regional management appears appropriate for these species.

1320 **5 Research Needs**

research-needs

1321 This section will be completed at or after the STAR panel.

1322 **6 Acknowledgments**

acknowledgments

1323 This section will be completed at or after the STAR panel.

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

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

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

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

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

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

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tab:Rec_removal

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

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

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

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

Table 4: Length composition sample sizes for survey data.

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

Table 5: Summary of indices used in this assessment.

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

Table 6: Index inputs.

tab:Indices

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

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

Filter	tab:Fleet5_Filter	Drifts	Positive Drifts
Remove errors, missing data		6691	1470
Remove 1987 (sampled only MNT), 1990-1991 low sample sizes		4283	1372
Remove reefs that never encountered GBY		4022	1372
Remove lower and upper 2.5% of time fished		3762	1300
Remove depth less than 9 m and greater than 69 m		3515	1279
Remove reefs with low sample rates		2411	1096

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

Model	Lognormal	Binomial	tab:Fleet5_AIC
Year	2834	3330	
Year + Depth	2781	2906	
Year + Reef	2716	2880	
Year + Month	2839	3286	
Year + Depth + Reef	2625	2488	
Year + Month+ Reef	2725	2844	
Year + Depth + Month	2780	2902	
Year+ Depth+Month+Reef	2632	2479	

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

Filter	Drifts	Positive Drifts	tab:Fleet6_7_Filter
Data from SQL filtered for missing data	67850	9317	
Remove years prior to 2001 and north of Cape Mendocino	64448	9129	
Depth, remove 1% data on each tail of positive catches	50846	8955	
Time fished, remove 1% data on each tail	50100	8903	
Observed anglers, remove 1% data on each tail	48089	8774	
Limit to reefs observering gopher/byel in at least 20 drifts	29639	8025	
Limit to reefs sampled in at least 2/3 of all years	32672	7517	
Limit to drifts within 1000 m of a reef	27355	7358	
Put depth in 10m depth bins, remove 0-9 and 60-69 m bins	25427	7250	
Start of north filtering	13792	6036	
Filter to drifts within 43 m of a reef, 97% quantile	13145	5854	
Make sure reefs still sampled at least 2/3 of years	12965	5796	
Start of south filtering	11635	1277	
Filter to drifts with $\geq=20\%$ groundfish and recheck reefs	5495	1171	
Make sure reefs still sampled at least 2/3 of years	5440	1132	

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

Model	Lognormal	Binomial	tab:Fleet6_AIC
Year	14135	17531	
Year + Month	14120	17529	
Year + Depth	13953	17025	
Year + Reef	14126	17293	
Year + Month + Depth	13951	17027	
Year + Month + Depth + Reef	13921	16674	

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

Model	Lognormal	Binomial	tab:Fleet7_AIC
Year	2798	5490	
Year + Month	2799	5487	
Year + Depth	2744	5159	
Year + Reef	2653	5390	
Year + Depth + Reef	2652	5071	
Year + Depth + Reef + Month	2663	5072	

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

Filter	Transects	Positive Transects	tab:Fleet8_Filter
Remove missing data and retain only bottom transects	22,055	6,330	
Remove month of June - few samples	21,941	6,318	
Remove dives earlier than 2004 for UCSB and 2001 for UCSC	20,659	6,165	
Keep sites sampled in at least half of all years (UCSC and UCSB separate)	14,721	4,097	
Keep sites observing GBYR in at least half of all years	12,139	4,002	
Remove transects denoted as old, no longer sampled	10,712	3,268	
Subset to just UCSC sites	5,686	2,939	
Use only consistently sampled sites	3,231	1,729	
Collapse repeated transects	1,928	1,487	

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

Model	AIC	tab:Fleet8_AIC
Year	5,687	
Year + Month	5,672	
Year + Month + Site	5,623	
Year + Month + Site + Zone	5,512	

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

Filter	Drifts	Positive Drifts	tab:Fleet9_Filter
All data	5,886	Drift and catch data not merged	
Remove missing data and cells not sampled consistently at Piedras Blancas	4,942	3,857	
Remove cells that never encountered GBYR	4,934	3,857	
Remove depth bins with little or no sampling (keep 5-39 m)	4,920	3,848	

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

`tab:Fleet9_AIC`

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

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

`tab:Fleet10_11_Filter`

Filter	Trips	Positive Trips
All data	10,392	1,061
Remove north of Cape Mendocino	10,327	1,061
Remove trips targetting offshore species	10,122	1,061
Start northern filtering	2,788	620
Remove species that never co-occur and not present in at least 1% of all	2,788	620
Stephens-MacCall filter (keep all positives - selected filter)	806	620
Alternate Stephens-MacCall filter (keep only above threshold)	623	437
Remove years after 1999 due to regulation changes and with fewer than 20 trips	544	220
Start southern filtering	7,334	441
Remove species that never co-occur and not present in at least 1% of all	7,334	441
Stephens-MacCall filter (keep all positives - selected filter)	687	441
Alternate Stephens-MacCall filter (keep only above threshold)	430	184
Remove years after 1999 due to regulation changes and with fewer than 20 trips	475	342

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

Model	AIC	tab:Fleet10_AIC
Year	1,481	
Year + Region	1,429	
Year + Region + Area_X	1,403	
Year + Region + Area_X + Wave	1,397	

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

Model	Lognormal	Binomial	tab:Fleet11_AIC
Year	911	552	
Year+ Wave	908	538	
Year + Wave + Area_X	905	540	
Year + Wave + Area_X + SubRegion	903	537	
Year + Wave + SubRegion	908	536	

Table 19: Contingency table for the Stephens-MacCall filtering for the MRFSS dockside CPFV index for GBYR north of Pt. Conception.

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

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

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

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

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

Table 22: Results from 100 jitters from the base case model.

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

Table 23: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD)).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
1	NatM_p_1_Fem_GP_1	0.211	2	(0.05, 0.4) (4, 50)	OK	0.029	Log_Norm (-1.6458, 0.4384)
2	Lat_Amin_Fem_GP_1	9.590	3	(4, 50)	OK	0.725	None
3	Lat_Amax_Fem_GP_1	28.549	3	(20, 60)	OK	0.883	None
4	VonBert_K_Fem_GP_1	0.129	3	(0.01, 0.3)	OK	0.028	None
5	CV_young_Fem_GP_1	0.258	3	(0.05, 0.5)	OK	0.032	None
6	CV_old_Fem_GP_1	0.117	3	(0.03, 0.3)	OK	0.013	None
7	Wtlen_1_Fem_GP_1	0.000	-3	(-3, 3)	None	None	None
8	Wtlen_2_Fem_GP_1	3.256	-3	(2, 4)	None	None	None
9	Mat50%_Fem_GP_1	21.666	-3	(-3, 3)	None	None	None
10	Mat_slope_Fem_GP_1	-0.906	-3	(-6, 3)	None	None	None
11	Eggs/kg_inter_Fem_GP_1	1.000	-3	(-3, 3)	None	None	None
12	Eggs/kg_slope_wt_Fem_GP_1	0.000	-3	(-3, 3)	None	None	None
13	CohortGrowDev	1.000	-1	(0.1, 10)	None	None	None
14	FracFemale_GP_1	0.500	-4	(0.000001, 0.999999)	OK	0.386	None
15	SR_LN(R0)	8.473	1	(2, 15)	OK	0.386	None
16	SR_BH_stEEP	0.720	-1	(0.2, 1)	None	Full_Beta (0.72, 0.16)	None
17	SR_sigmaR	0.400	-2	(0, 2)	None	None	None
18	SR_regime	0.000	-4	(-5, 5)	None	None	None
19	SR_autocorr	0.678	4	(-1, 1)	OK	0.106	None
103	LnQ_base_DebCPFV(5)	-6.982	-1	(-15, 15)	None	None	None
104	Q_extraSD_DebCPFV(5)	0.071	4	(0.0001, 2)	OK	0.048	None
105	LnQ_base_RecOnboardNorth(6)	-7.718	-1	(-15, 15)	None	None	None
106	Q_extraSD_RecOnboardNorth(6)	0.230	4	(0.0001, 2)	OK	0.056	None
107	LnQ_base_RecOnboardSouth(7)	-10.300	-1	(-15, 15)	None	None	None
108	Q_extraSD_RecOnboardSouth(7)	0.597	4	(0.0001, 2)	OK	0.148	None
109	LnQ_base_PISCO(8)	-7.605	-1	(-15, 15)	None	None	None

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Table 23: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD)).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
110	Q_extraSD_PISCO(8)	0.209	4	(0.0001, 2)	OK	0.074	None
111	LnQ_base_CCFRP(9)	-6.449	-1	(-15, 15)	OK	0.074	None
112	Q_extraSD_CCFRP(9)	0.185	4	(0.0001, 2)	OK	0.074	None
113	LnQ_base_RecDocksideNorth(10)	-8.798	-1	(-15, 15)	None	None	None
114	Q_extraSD_RecDocksideNorth(10)	0.000	-4	(0.0001, 2)	None	None	None
115	LnQ_base_RecDocksideSouth(11)	-9.771	-1	(-15, 15)	None	None	None
116	Q_extraSD_RecDocksideSouth(11)	0.276	4	(0.0001, 2)	OK	0.108	None
117	Size_DbIN_peak_Com(1)	32.339	1	(19, 38)	OK	0.716	None
118	Size_DbIN_top_logit_Com(1)	8.000	-5	(-5, 10)	None	None	None
119	Size_DbIN_ascend_se_Com(1)	3.124	5	(-9, 10)	OK	0.126	None
120	Size_DbIN_descend_se_Com(1)	5.000	-5	(-9, 9)	None	None	None
121	Size_DbIN_start_logit_Com(1)	-11.708	5	(-15, -5)	OK	1.749	None
122	Size_DbIN_end_logit_Com(1)	10.000	-5	(-5, 15)	None	None	None
123	Size_DbIN_peak_ComDisc(2)	25.041	2	(19, 38)	OK	0.449	None
124	Size_DbIN_top_logit_ComDisc(2)	-9.378	5	(-15, 10)	OK	78.881	None
125	Size_DbIN_ascend_se_ComDisc(2)	2.035	5	(-9, 10)	OK	0.220	None
126	Size_DbIN_descend_se_ComDisc(2)	5.469	5	(-9, 9)	OK	1.896	None
127	Size_DbIN_start_logit_ComDisc(2)	-14.117	5	(-15, -5)	OK	20.152	None
128	Size_DbIN_end_logit_ComDisc(2)	-999.000	-5	(-5, 10)	None	None	None
129	Size_DbIN_peak_RecNorth(3)	32.379	3	(19, 39)	OK	0.404	None
130	Size_DbIN_top_logit_RecNorth(3)	8.000	-5	(-5, 10)	None	None	None
131	Size_DbIN_ascend_se_RecNorth(3)	3.264	5	(-9, 10)	OK	0.072	None
132	Size_DbIN_descend_se_RecNorth(3)	5.000	-5	(-9, 9)	None	None	None
133	Size_DbIN_start_logit_RecNorth(3)	-11.972	5	(-15, -5)	OK	1.526	None
134	Size_DbIN_end_logit_RecNorth(3)	10.000	-5	(-5, 15)	None	None	None
135	Size_DbIN_peak_RecSouth(4)	27.732	4	(19, 38)	OK	1.212	None
136	Size_DbIN_top_logit_RecSouth(4)	8.000	-5	(-5, 10)	None	None	None

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Table 23: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD)).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
137	Size_DbIN_ascend_se_RecSouth(4)	3.212	5	(-9, 10)	OK	0.265	None
138	Size_DbIN_descend_se_RecSouth(4)	5.000	-5	(-9, 9)	None	None	None
139	Size_DbIN_start_logit_RecSouth(4)	-8.820	5	(-15, -5)	OK	2.760	None
140	Size_DbIN_end_logit_RecSouth(4)	10.000	-5	(-5, 15)	None	None	None
141	Size_DbIN_peak_DbCPFV(5)	30.894	5	(19, 38)	OK	0.617	None
142	Size_DbIN_top_logit_DbCPFV(5)	8.000	-5	(-5, 10)	None	None	None
143	Size_DbIN_ascend_se_DbCPFV(5)	2.999	5	(-9, 10)	OK	0.117	None
144	Size_DbIN_descend_se_DbCPFV(5)	5.000	-5	(-9, 9)	None	None	None
145	Size_DbIN_start_logit_DbCPFV(5)	-17.851	5	(-20, -5)	OK	38.084	None
146	Size_DbIN_end_logit_DbCPFV(5)	10.000	-5	(-5, 15)	None	None	None
147	SizeSel_P1_RecOnboardNorth(6)	-1.000	-5	(-1, 10)	None	None	None
148	SizeSel_P2_RecOnboardNorth(6)	-1.000	-5	(-1, 10)	None	None	None
149	SizeSel_P1_RecOnboardSouth(7)	-1.000	-5	(-1, 10)	None	None	None
150	SizeSel_P2_RecOnboardSouth(7)	-1.000	-5	(-1, 10)	None	None	None
151	Size_DbIN_peak_PISCO(8)	30.452	5	(19, 38)	OK	2.149	None
152	Size_DbIN_top_logit_PISCO(8)	8.000	-5	(-15, 10)	None	None	None
153	Size_DbIN_ascend_se_PISCO(8)	3.907	5	(-9, 10)	OK	0.362	None
154	Size_DbIN_descend_se_PISCO(8)	5.000	-5	(-9, 9)	None	None	None
155	Size_DbIN_start_logit_PISCO(8)	-2.801	5	(-15, 15)	OK	0.604	None
156	Size_DbIN_end_logit_PISCO(8)	10.000	-5	(-5, 15)	None	None	None
157	Size_DbIN_peak_CCFRP(9)	31.050	5	(19, 38)	OK	0.623	None
158	Size_DbIN_top_logit_CCFRP(9)	-10.648	5	(-15, 10)	OK	6.5.029	None
159	Size_DbIN_ascend_se_CCFRP(9)	3.135	5	(-9, 10)	OK	0.149	None
160	Size_DbIN_descend_se_CCFRP(9)	1.643	5	(-15, 9)	OK	0.802	None
161	Size_DbIN_start_logit_CCFRP(9)	-999.000	-5	(-15, -5)	None	None	None
162	Size_DbIN_end_logit_CCFRP(9)	-999.000	-5	(-5, 10)	None	None	None
163	SizeSel_P1_RecDocksideNorth(10)	-1.000	-5	(-1, 10)	None	None	None

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Table 23: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD)).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
164	SizeSel_P2_RecDocksideNorth(10)	-1.000	-5	(-1, 10)			None
165	SizeSel_P1_RecDocksideSouth(11)	-1.000	-5	(-1, 10)			None
166	SizeSel_P2_RecDocksideSouth(11)	-1.000	-5	(-1, 10)			None
167	Size_DblIN_peak_Com(1)_BLK1rep1_1999	28.891	6	(19, 38)	OK	0.328	None
168	Size_DblIN_ascend_se_Com(1)_BLK1rep1_1999	1.585	6	(-9, 10)	OK	0.167	None
169	Size_DblIN_start_logit_Com(1)_BLK1rep1_1999	-11.860	6	(-15, -5)	OK	3.470	None

tab-model-params

Table 24: Likelihood components from the base model.

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

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

Year	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative exploitation rate	SPR
1916	2156	1317	0.000	4784	4	0.00	0.99
1917	2154	1315	0.998	4783	7	0.00	0.98
1918	2150	1311	0.995	4782	8	0.00	0.98
1919	2146	1307	0.993	4780	5	0.00	0.98
1920	2144	1306	0.991	4780	5	0.00	0.98
1921	2142	1304	0.990	4779	5	0.00	0.99
1922	2141	1303	0.989	4779	4	0.00	0.99
1923	2141	1303	0.989	4779	4	0.00	0.99
1924	2140	1303	0.989	4779	2	0.00	0.99
1925	2141	1303	0.989	4779	3	0.00	0.99
1926	2141	1304	0.990	4779	5	0.00	0.99
1927	2140	1303	0.989	4779	4	0.00	0.99
1928	2140	1302	0.989	4779	6	0.00	0.98
1929	2138	1301	0.988	4778	6	0.00	0.98
1930	2137	1300	0.987	4778	8	0.00	0.98
1931	2135	1298	0.985	4777	5	0.00	0.99
1932	2135	1298	0.985	4777	10	0.00	0.97
1933	2131	1294	0.983	4776	7	0.00	0.98
1934	2130	1294	0.982	4775	7	0.00	0.98
1935	2130	1293	0.982	4775	6	0.00	0.98
1936	2130	1293	0.982	4775	6	0.00	0.98
1937	2130	1293	0.982	4775	15	0.01	0.96
1938	2124	1288	0.978	4773	18	0.01	0.95
1939	2117	1281	0.973	4771	21	0.01	0.94
1940	2109	1274	0.967	4768	28	0.01	0.93
1941	2098	1264	0.959	4764	27	0.01	0.93
1942	2088	1255	0.953	4761	14	0.01	0.96
1943	2089	1255	0.953	4761	17	0.01	0.95
1944	2088	1254	0.952	4761	4	0.00	0.99
1945	2094	1261	0.957	4763	6	0.00	0.98
1946	2099	1265	0.961	4765	27	0.01	0.93
1947	2090	1257	0.954	4762	37	0.02	0.90
1948	2076	1244	0.945	4757	39	0.02	0.90
1949	2061	1231	0.935	4752	37	0.02	0.90
1950	2051	1222	0.927	4748	39	0.02	0.89
1951	2041	1212	0.920	4744	52	0.03	0.86
1952	2024	1197	0.908	4738	52	0.03	0.86

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

Year	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative exploitation rate	SPR
1953	2009	1183	0.898	4732	55	0.03	0.86
1954	1995	1170	0.888	4726	68	0.03	0.83
1955	1974	1152	0.874	4718	60	0.03	0.84
1956	1961	1140	0.865	4713	76	0.04	0.81
1957	1940	1122	0.851	4704	76	0.04	0.80
1958	1922	1106	0.839	4696	88	0.05	0.78
1959	1899	1085	0.824	4687	62	0.03	0.82
1960	1893	1082	0.821	3255	44	0.02	0.87
1961	1897	1090	0.827	2975	50	0.03	0.85
1962	1888	1093	0.830	2772	61	0.03	0.83
1963	1859	1089	0.827	2630	56	0.03	0.84
1964	1820	1088	0.826	2552	43	0.02	0.87
1965	1775	1089	0.827	2542	58	0.03	0.83
1966	1710	1074	0.815	2600	52	0.03	0.85
1967	1643	1052	0.799	2731	48	0.03	0.86
1968	1575	1023	0.777	2930	49	0.03	0.85
1969	1508	985	0.748	3104	46	0.03	0.86
1970	1447	943	0.716	3149	60	0.04	0.82
1971	1384	890	0.676	3036	51	0.04	0.83
1972	1337	844	0.641	2816	66	0.05	0.79
1973	1288	793	0.602	2664	88	0.07	0.74
1974	1233	735	0.558	2747	92	0.07	0.71
1975	1184	686	0.521	3062	89	0.08	0.70
1976	1144	647	0.492	3430	91	0.08	0.68
1977	1111	616	0.468	3674	79	0.07	0.69
1978	1094	597	0.454	3732	84	0.08	0.67
1979	1083	579	0.439	3610	78	0.07	0.68
1980	1086	566	0.430	3787	155	0.14	0.53
1981	1052	519	0.394	3993	143	0.14	0.53
1982	1037	488	0.370	4134	129	0.12	0.53
1983	1041	474	0.360	3670	118	0.11	0.54
1984	1058	475	0.360	2819	174	0.17	0.45
1985	1045	455	0.346	2339	173	0.17	0.44
1986	1032	445	0.338	2191	206	0.20	0.39
1987	995	428	0.325	2350	162	0.16	0.43
1988	975	433	0.329	2918	145	0.15	0.45
1989	957	445	0.337	4015	120	0.13	0.50

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

Year	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative exploitation rate	SPR
1990	949	459	0.348	5623	136	0.14	0.49
1991	939	456	0.346	7114	175	0.19	0.44
1992	927	427	0.324	7774	207	0.23	0.40
1993	931	379	0.288	7619	210	0.23	0.37
1994	972	336	0.255	7063	161	0.17	0.39
1995	1075	329	0.250	6297	150	0.14	0.39
1996	1205	352	0.267	5358	148	0.12	0.39
1997	1342	404	0.307	4289	118	0.09	0.46
1998	1485	494	0.375	3604	118	0.08	0.49
1999	1601	598	0.454	3302	127	0.08	0.52
2000	1678	702	0.533	3250	131	0.08	0.55
2001	1717	795	0.604	3702	169	0.10	0.54
2002	1703	853	0.648	4080	133	0.08	0.61
2003	1683	900	0.683	3497	148	0.09	0.61
2004	1637	912	0.692	2963	72	0.04	0.75
2005	1625	935	0.710	2793	86	0.05	0.73
2006	1592	932	0.708	2782	78	0.05	0.76
2007	1555	921	0.699	2887	70	0.05	0.78
2008	1514	907	0.688	3137	87	0.06	0.75
2009	1460	879	0.667	3534	111	0.08	0.70
2010	1391	834	0.633	3680	153	0.11	0.63
2011	1304	764	0.580	3319	135	0.10	0.63
2012	1242	707	0.537	3393	94	0.08	0.68
2013	1217	676	0.513	4194	84	0.07	0.70
2014	1209	654	0.496	6319	105	0.09	0.65
2015	1202	625	0.475	8445	109	0.09	0.63
2016	1214	602	0.457	6941	112	0.09	0.61
2017	1258	585	0.444	5137	104	0.08	0.61
2018	1336	580	0.441	4177	92	0.07	0.63
2019	1433	596	0.452	4276			

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

Label	Base (Francis weights)	Default weights	Harmonic mean weights	Estimate equal M and h	Drop PR data	Drop PC data	tab:Sensitivity_model1
TOTAL_like	-	-	-	-	-	-	-
Catch_like	-	-	-	-	-	-	-
Equil_catch_like	-	-	-	-	-	-	-
Survey_like	-	-	-	-	-	-	-
Length_comp_like	-	-	-	-	-	-	-
Age_comp_like	-	-	-	-	-	-	-
Parm_priors_like	-	-	-	-	-	-	-
SSB_Unfished_thousand_mt	-	-	-	-	-	-	-
TotBio_U_nfished	-	-	-	-	-	-	-
SmryBio_Unfished	-	-	-	-	-	-	-
Recr_Unfished_billions	-	-	-	-	-	-	-
SSB_Btgt_thousand_mt	-	-	-	-	-	-	-
SPR_Btgt	-	-	-	-	-	-	-
Fstd_Btgt	-	-	-	-	-	-	-
TotYield_Btgt_thousand_mt	-	-	-	-	-	-	-
SSB_SPRtgt_thousand_mt	-	-	-	-	-	-	-
Fstd_SPRtgt	-	-	-	-	-	-	-
TotYield_SPRtgt_thousand_mt	-	-	-	-	-	-	-
SSB_MSY_thousand_mt	-	-	-	-	-	-	-
SPR_MSY	-	-	-	-	-	-	-
Fstd_MSY	-	-	-	-	-	-	-
TotYield_MSY_thousand_mt	-	-	-	-	-	-	-
RetYield_MSY	-	-	-	-	-	-	-
Bratio_2015	-	-	-	-	-	-	-
F_2015	-	-	-	-	-	-	-
SPRratio_2015	-	-	-	-	-	-	-
Recr_2015	-	-	-	-	-	-	-
Recr_Virgin_billions	-	-	-	-	-	-	-
L_at_Amin_Fem_GP_1	-	-	-	-	-	-	-
L_at_Amax_Fem_GP_1	-	-	-	-	-	-	-
VonBert_K_Fem_GP_1	-	-	-	-	-	-	-
CV_young_Fem_GP_1	-	-	-	-	-	-	-
CV_old_Fem_GP_1	-	-	-	-	-	-	-

Table 27: Summary of the biomass/abundance time series used in the stock assessment.

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

Table 28: Summaries of key assessment outputs and likelihood values from the retrospective analysis. Note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for the year of 2017. The base model includes all of the data. Retro1 removes the last year of data (2016), Retro2 removes the last two years of data, Retro3 removes three years and Retro4 removes four years.

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

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

	Label	R07400	R07800	R08200	R08600	R09000	h0410	h0570	h0710	h0870	h0990	tab:1like_profiles
Female M	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	
Steepness	0.72	0.72	0.72	0.72	0.72	0.72	0.41	0.57	0.71	0.87	0.99	
lnR0	7.40	7.80	8.20	8.60	9.00	9.00	8.34	8.21	8.16	8.13	8.11	
Total biomass (m)	1623.19	2113.03	2894.72	4173.95	6142.97	6142.97	3313.42	2943.85	2802.69	2712.12	2667.97	
Depletion (%)	46.83	49.83	58.31	66.23	71.80	71.80	51.20	55.27	57.32	58.81	59.60	
SPR ratio	1.05	0.91	0.70	0.49	0.34	0.34	0.68	0.71	0.72	0.72	0.73	
Female Lmin	12.16	12.41	12.43	12.39	12.36	12.36	12.43	12.44	12.43	12.43	12.43	
Female Lmax	34.29	33.83	33.26	32.76	32.42	32.42	33.19	33.28	33.31	33.33	33.34	
Female K	0.24	0.25	0.25	0.26	0.26	0.26	0.25	0.25	0.25	0.25	0.25	
Male Lmin (offset)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Male Lmax (offset)	-0.18	-0.17	-0.16	-0.15	-0.15	-0.15	-0.16	-0.16	-0.16	-0.16	-0.16	
Male K (offset)	-0.22	-0.31	-0.29	-0.24	-0.21	-0.21	-0.27	-0.29	-0.29	-0.30	-0.30	
Negative log-likelihood												
TOTAL	1117.15	1101.02	1097.33	1099.69	1102.95	1102.95	1101.35	1098.58	1097.35	1096.72	1100.21	
Catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Equil_catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Survey	-100.10	-99.20	-97.99	-97.00	-96.37	-96.37	-98.27	-98.18	-98.12	-98.06	-98.03	
Length_comp	761.18	760.12	763.44	767.61	770.76	770.76	765.11	763.69	763.05	762.58	762.33	
Age_comp	437.32	427.37	421.09	418.57	417.98	417.98	420.58	421.24	421.51	421.68	421.77	
Recruitment	18.74	12.72	10.80	10.50	10.58	10.58	12.55	11.40	10.90	10.56	10.38	
Forecast_Recruitment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Parm_priors	0.00	0.00	0.00	0.00	0.00	0.00	1.38	0.42	0.01	-0.04	3.76	
Parm_softbounds	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
Parm_devs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Crash_Pen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

Table 30: Summaries of key assessment outputs and likelihood values from selected likelihood profile runs on female natural mortality. Note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for the year of 2017.

Label	M0220	M0260	M0300	M0350	M0400
Female M	0.22	0.26	0.30	0.35	0.40
Steepness	0.72	0.72	0.72	0.72	0.72
InR0	7.67	8.20	8.95	12.21	31.00
Total biomass (m)	2259.39	2861.79	4632.81	89473.50	975357000000.00
Depletion (%)	47.72	58.15	68.08	79.27	79.74
SPR ratio	0.97	0.70	0.41	0.02	0.00
Female Lmin	12.39	12.44	12.43	12.39	12.24
Female Lmax	33.23	33.31	33.31	33.25	33.73
Female K	0.25	0.25	0.25	0.25	0.24
Male Lmin (offset)	0.00	0.00	0.00	0.00	0.00
Male Lmax (offset)	-0.16	-0.16	-0.15	-0.15	-0.15
Male K (offset)	-0.27	-0.30	-0.31	-0.32	-0.36
Negative log-likelihood					
TOTAL	1102.66	1096.96	1092.96	1089.92	1091.52
Catch	0.00	0.00	0.00	0.00	0.00
Equil_catch	0.00	0.00	0.00	0.00	0.00
Survey	-97.79	-98.14	-98.33	-98.33	-98.95
Length_comp	765.50	762.85	760.88	759.19	755.26
Age_comp	422.97	421.41	420.05	418.75	425.16
Recruitment	11.91	10.82	10.30	10.05	9.54
Forecast_Recruitment	0.00	0.00	0.00	0.00	0.00
Parm_priors	0.06	0.00	0.06	0.25	0.51
Parm_softbounds	0.01	0.01	0.01	0.00	0.00
Parm_devs	0.00	0.00	0.00	0.00	0.00
Crash_Pen	0.00	0.00	0.00	0.00	0.00

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

Yr	OFL contribution (mt)	ACL landings (mt)	Age 5+ biomass (mt)	Spawning Biomass (mt)	tab:Forecast_mod1
2019	180.214	180.214	1425.960	596.045	0.452
2020	168.285	168.285	1466.470	596.045	0.452
2021	167.052	167.052	1506.630	596.045	0.452
2022	174.540	174.540	1535.160	596.045	0.452
2023	187.307	187.307	1546.310	596.045	0.452
2024	200.668	200.668	1538.850	596.045	0.452
2025	210.285	210.285	1515.250	596.045	0.452
2026	213.765	213.765	1480.850	596.045	0.452
2027	211.189	211.190	1442.300	596.045	0.452
2028	204.471	204.472	1405.670	596.045	0.452
2029	196.145	196.145	1375.030	596.045	0.452
2030	188.320	188.320	1351.970	596.045	0.452

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figures

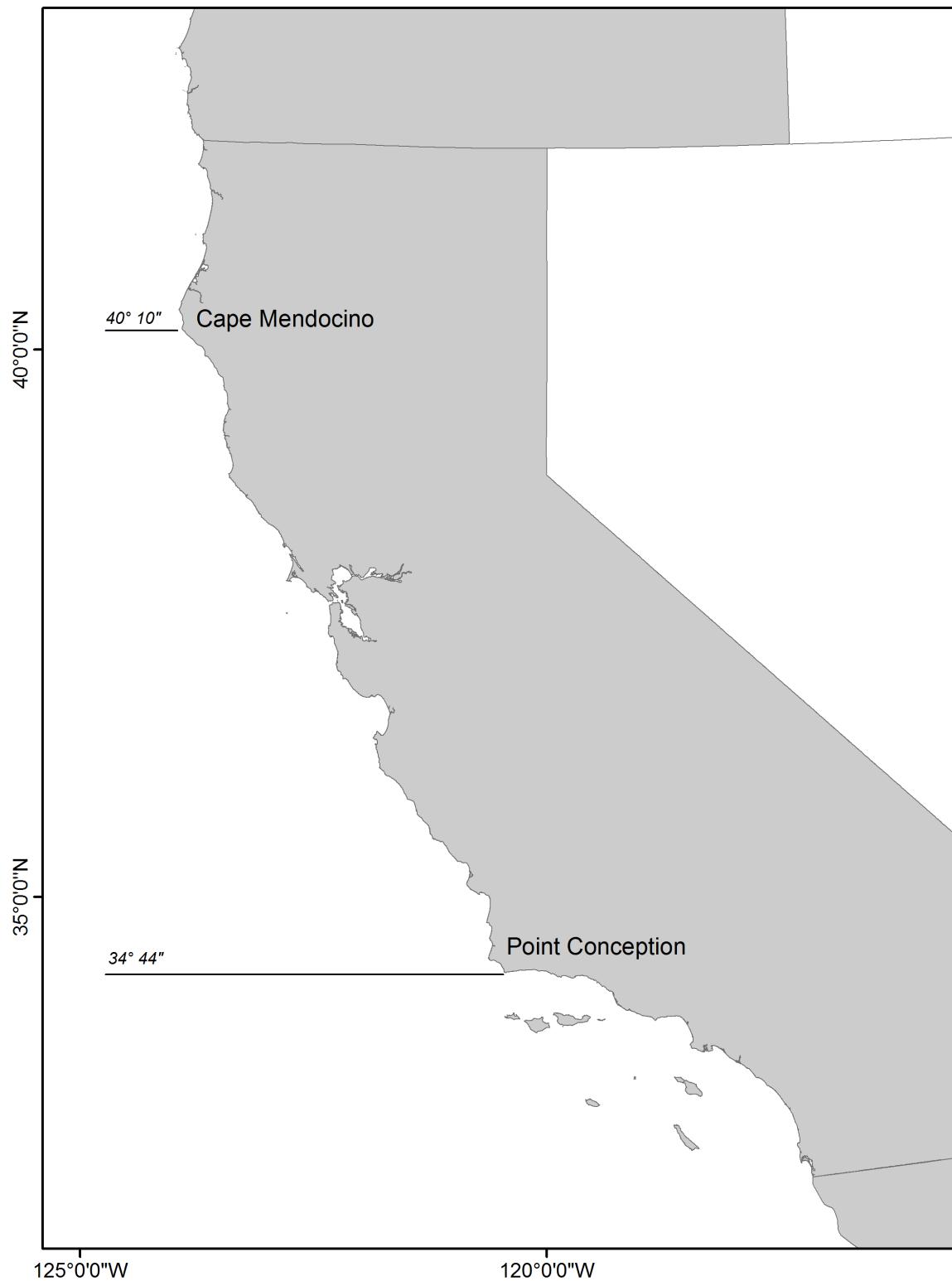


Figure 1: Map showing the management area for gopher and black-and-yellow rockfish from Cape Mendocino to the U.S.-Mexico border. fig:assess_region_map1

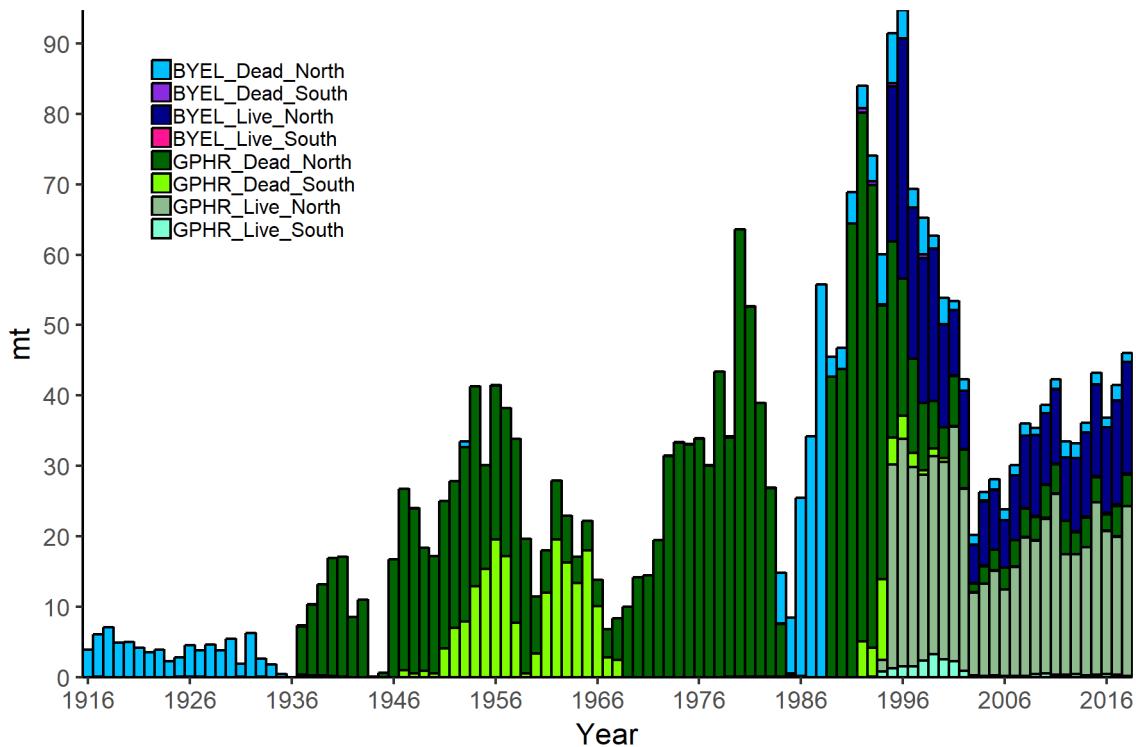


Figure 2: Commercial landings for gopher (GPHR) and black-and-yellow (BYEL) rockfishes landed live and dead north and south of Point Conception. All catch time series were combined for the assessment into one commercial fleet.

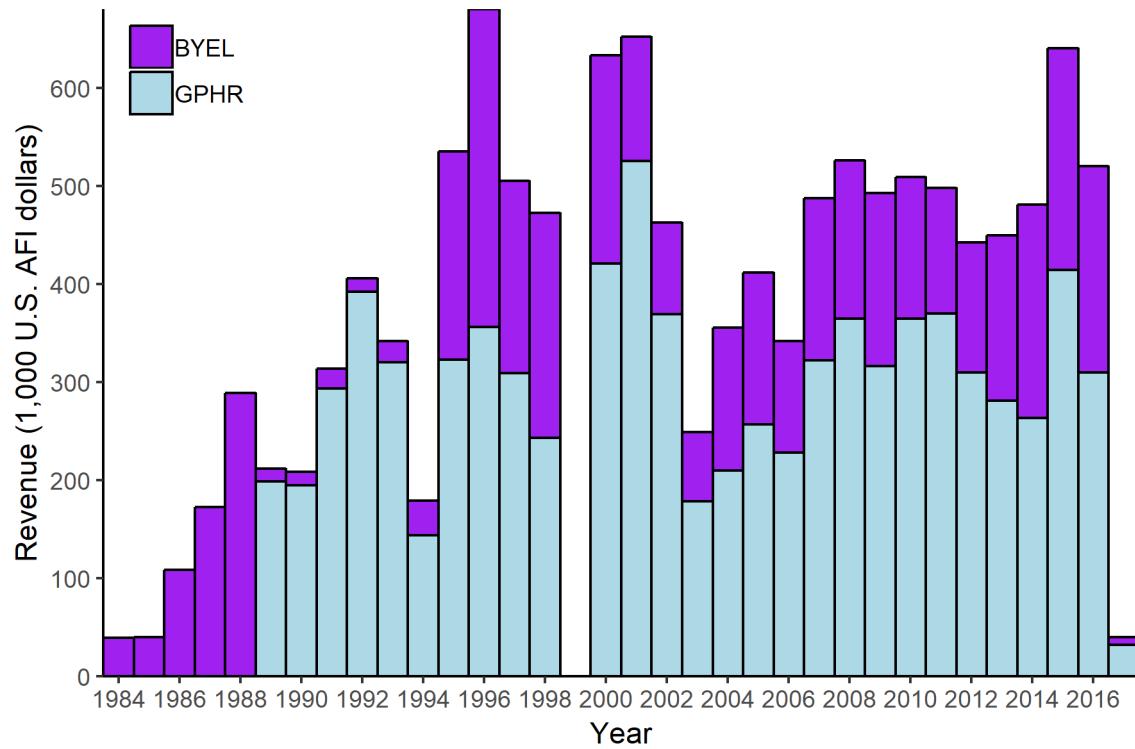


Figure 3: Annual ex-vessel revenue, adjusted for inflation (AFI) in thousands of dollars for gopher and black-and-yellow rockfish. [fig:GBY_revenue](#)

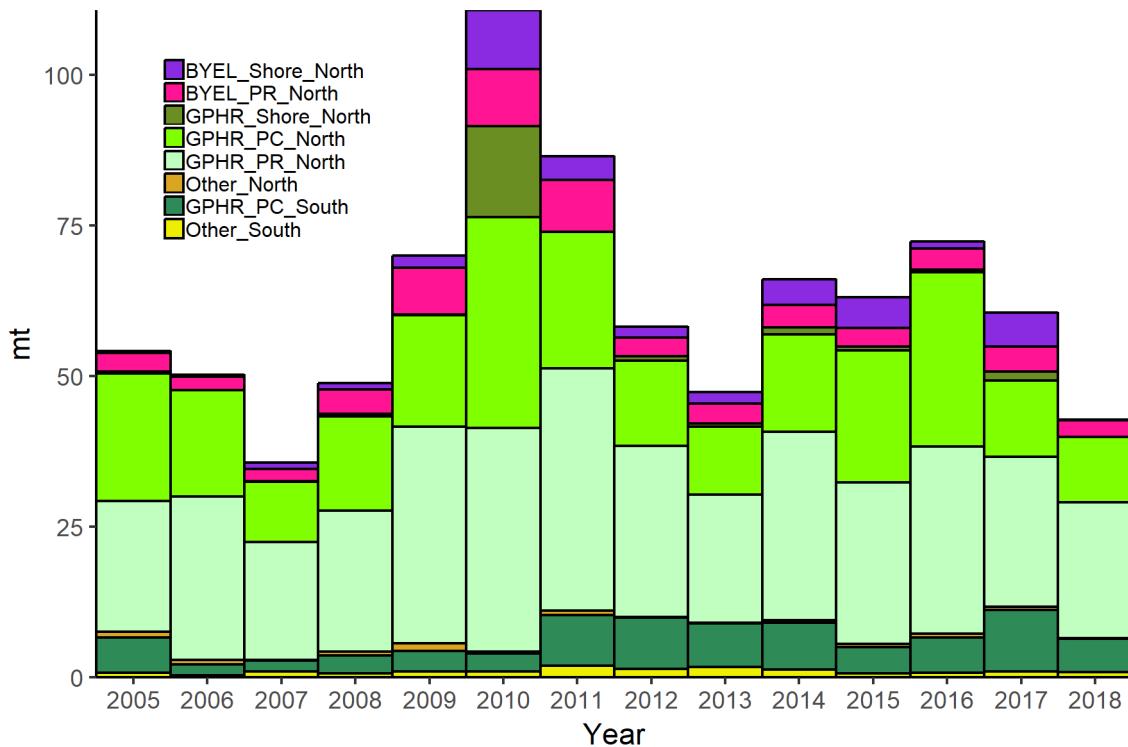


Figure 4: Recreational total mortality for gopher rockfish (GPHR) and black-and-yellow (BYEL) rockfish from the CDFW CRFS sampling era by mode and split north and south of Point Conception. fig:CFRS_catches

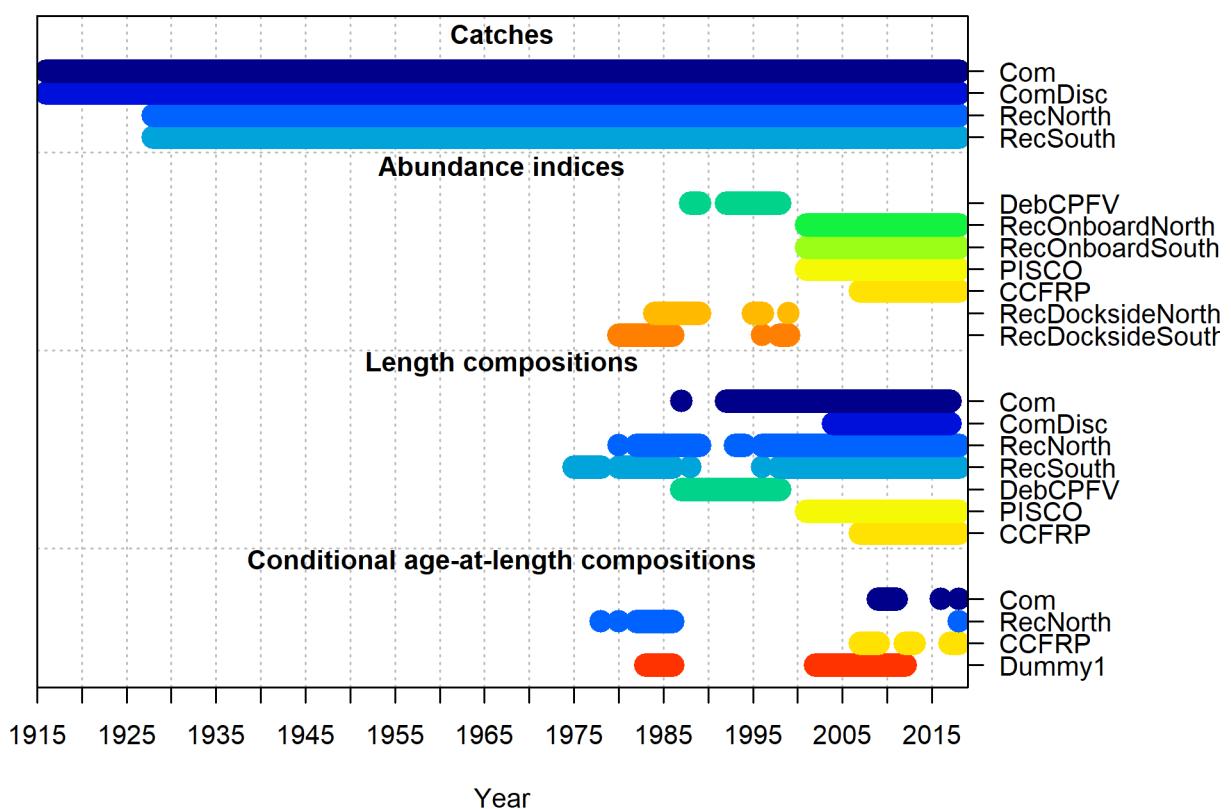


Figure 5: Summary of data sources used in the model. `fig: data_plot`

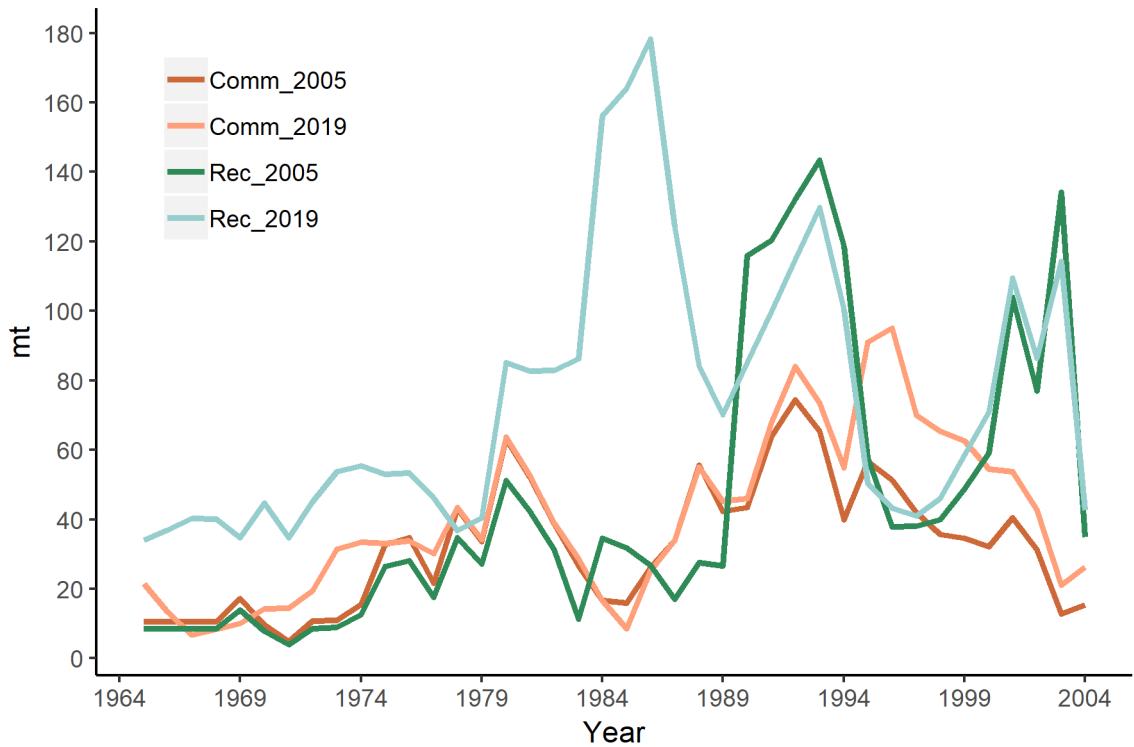


Figure 6: Comparison of the recreational and commercial fishery landings from the 2005 assessment to this 2019 assessment. Note that the 2019 assessment includes both gopher and black-and-yellow rockfish where the 2005 assessment represents gopher rockfish only. The 2005 assessment also did not include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

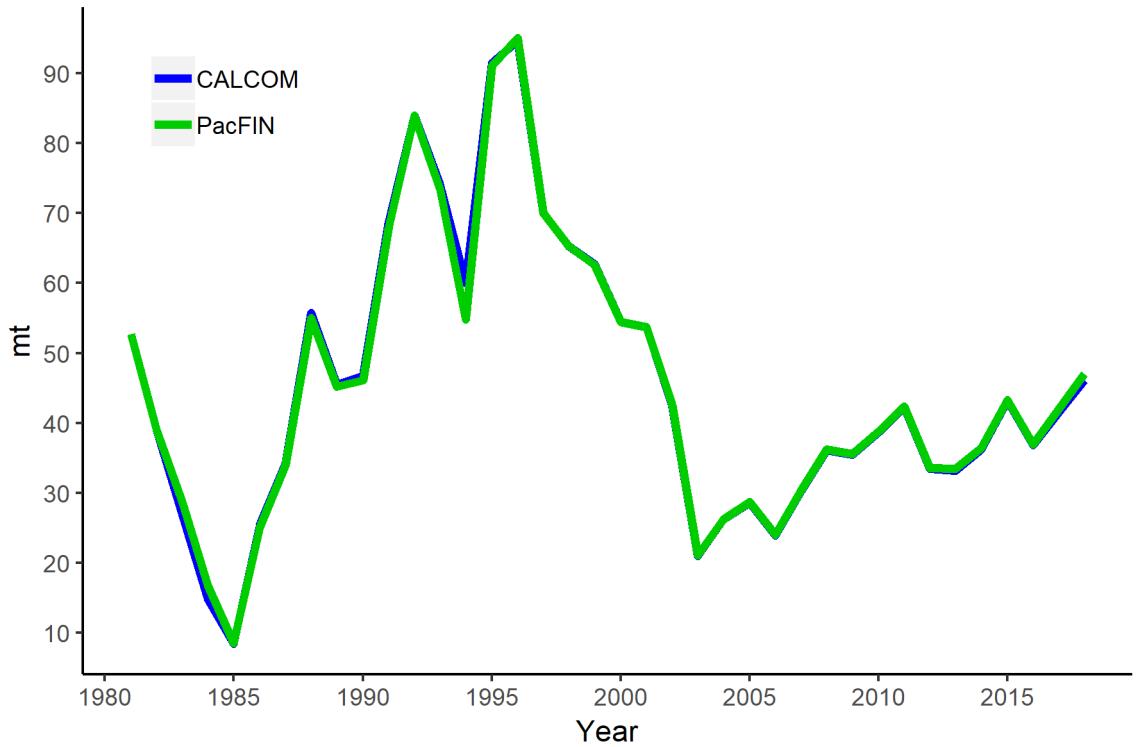


Figure 7: Commercial landings estimates from CALCOM add PacFIN. fig:Calcom_vs_Pacfin

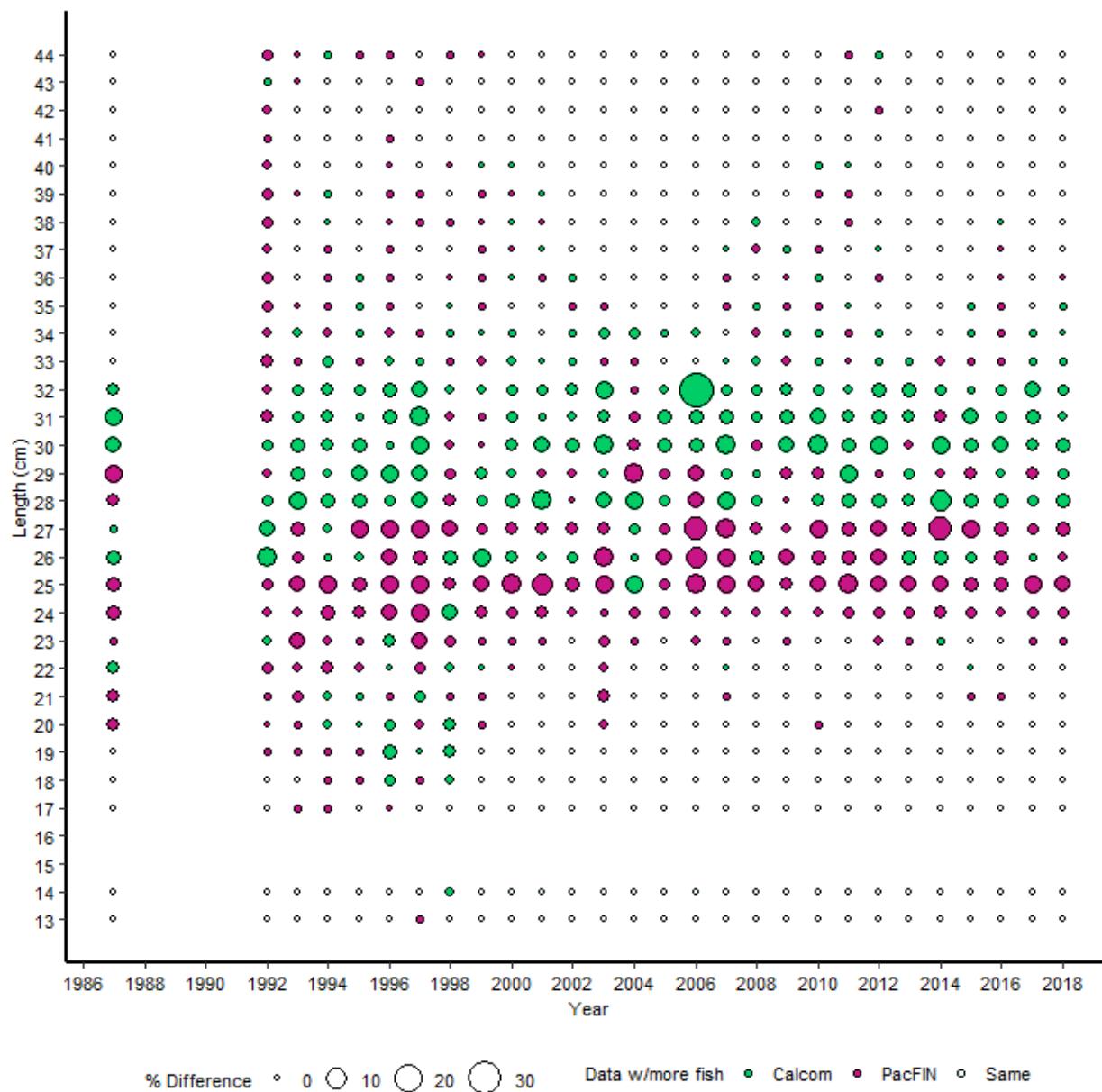


Figure 8: Percent differences in the expanded length compositions by year from CALCOM and PacFIN. The same market categories were used for each dataset, but each database was subject to further independent filtering criteria and expansion algorithms. fig:Calcom_vs_pacfin_length

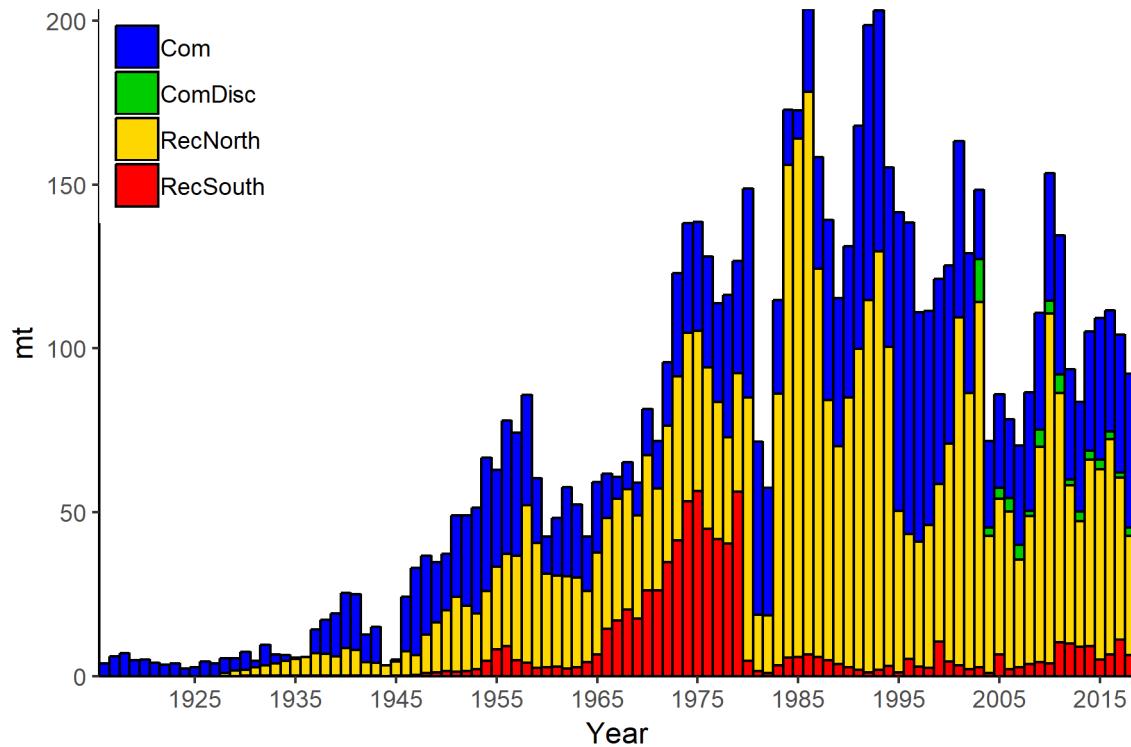


Figure 9: Commercial and recreational landings estimates prior to any data modification or interpolation to the recreational catches or hindcasting of commercial discards. [fig:Catches_original](#)

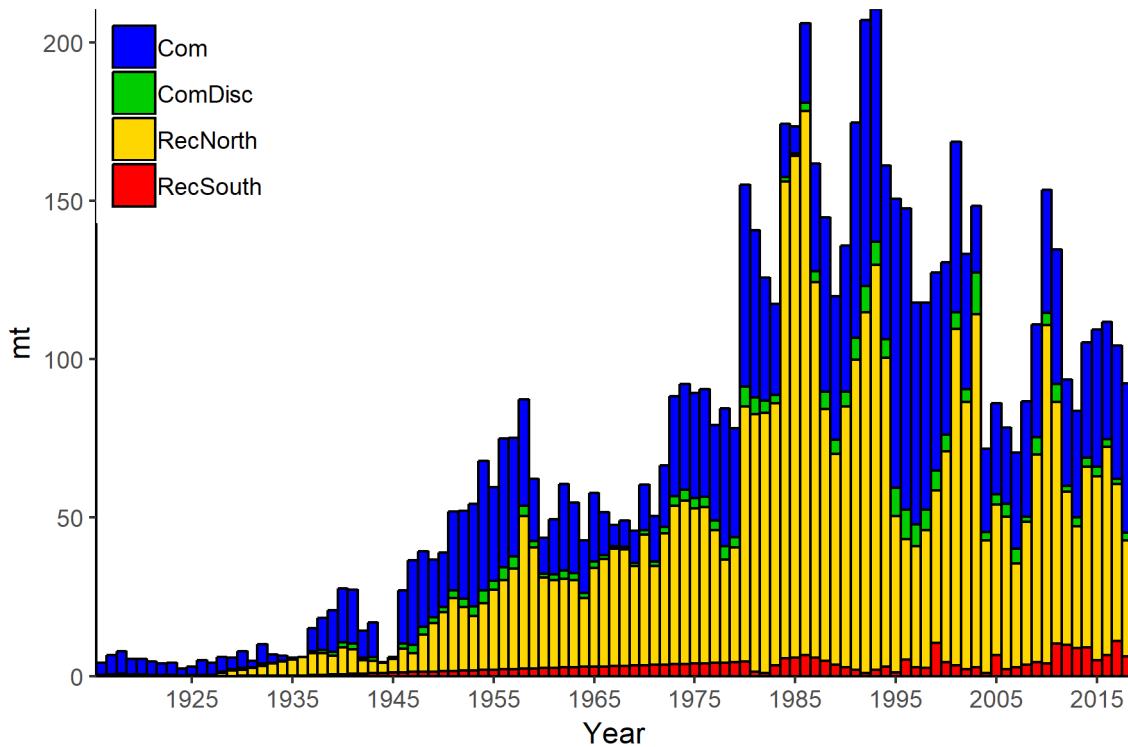


Figure 10: Commercial and recreational landings estimates after data modification and interpolations were made to the recreational catches and commercial discards. [fig:Catches_alternate](#)

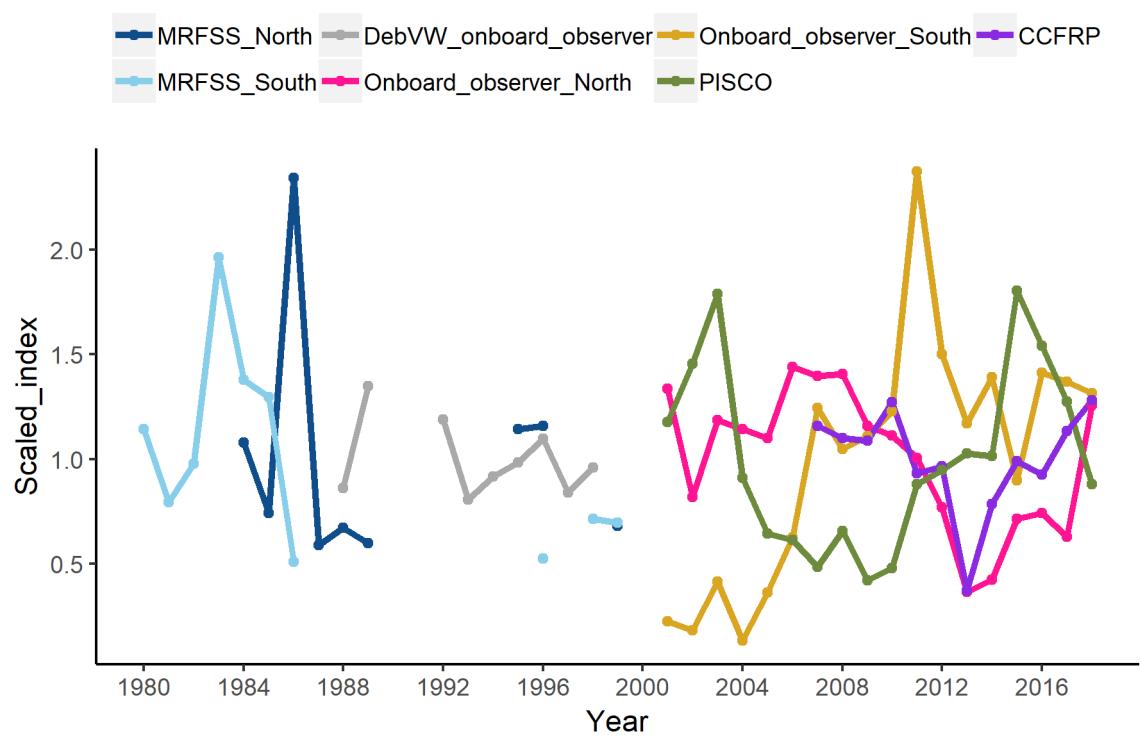


Figure 11: Comparison of all indices of abundance (scaled to their means). fig:All_index_compar

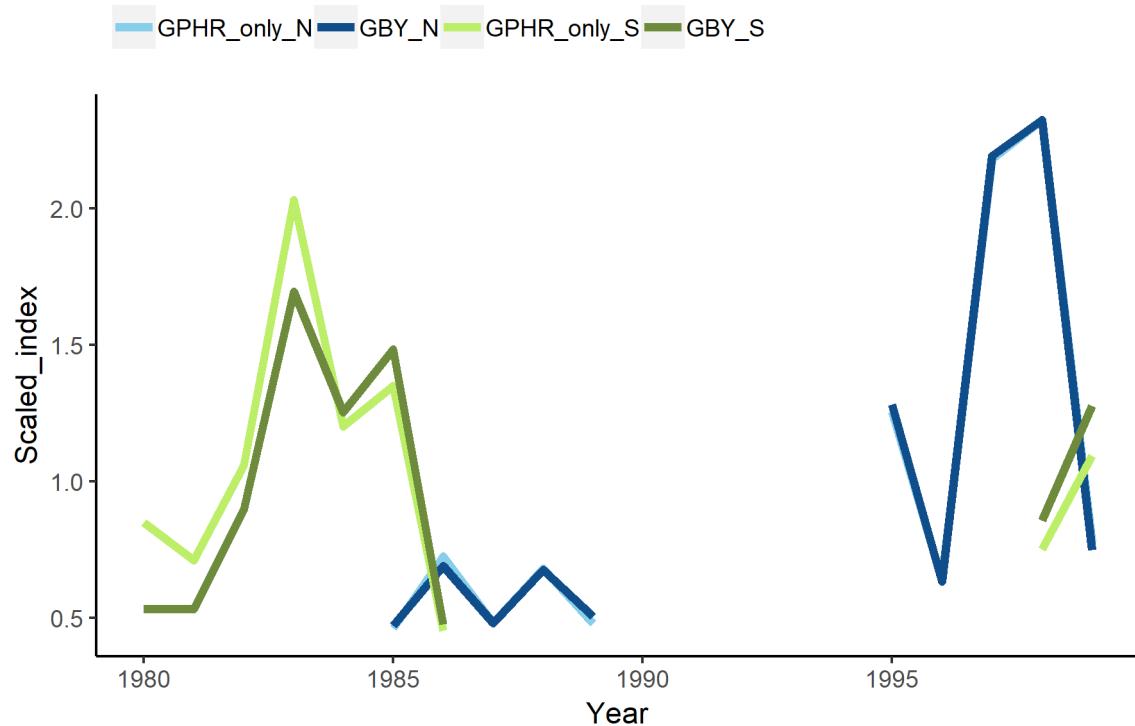


Figure 12: Comparison of indices of abundance (scaled to their means) for the MRFSS dockside CPFV survey between a gopher-only and GBYR complex index for north and south of Point Conception. [fig:MRFSS_index_compare]

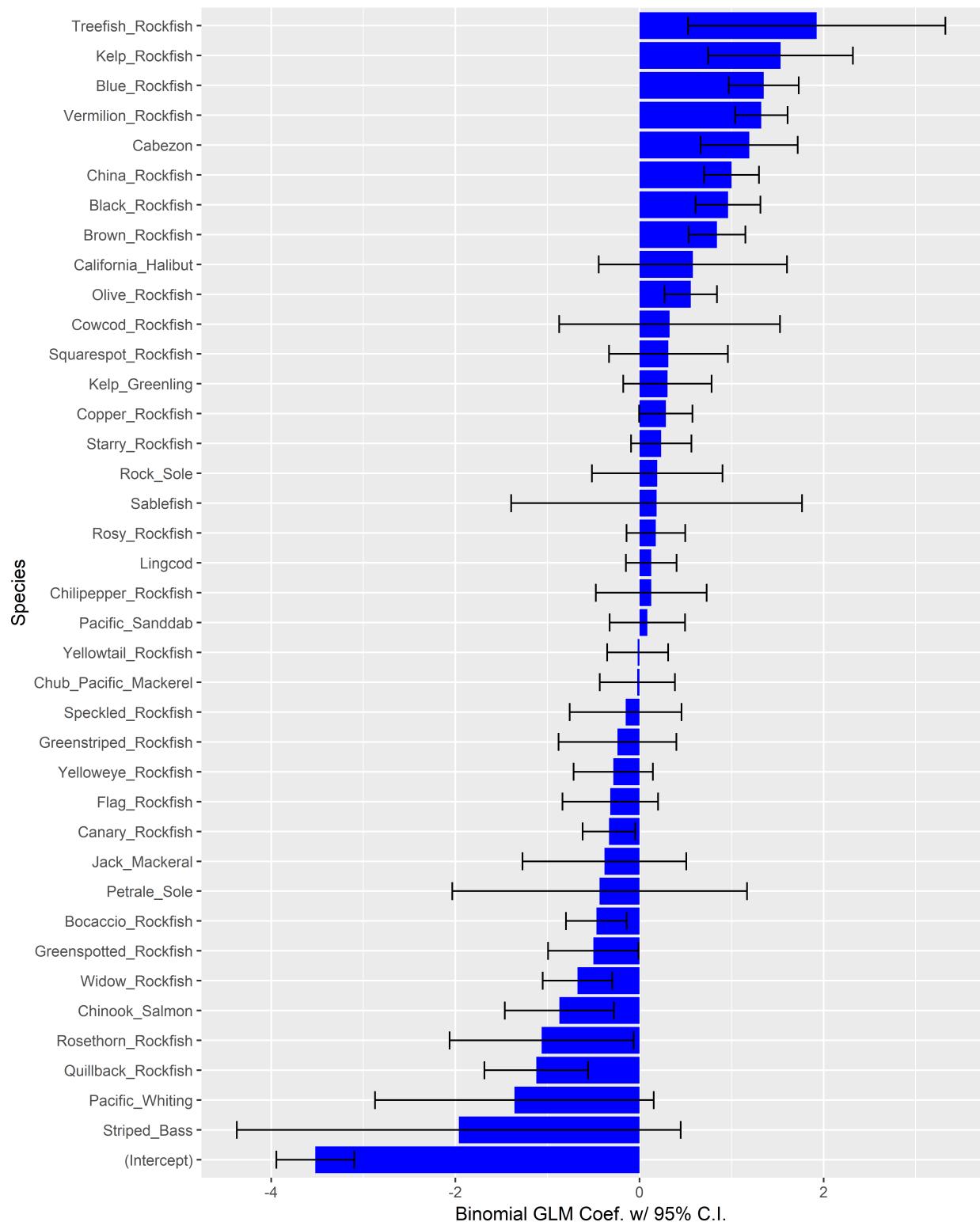


Figure 13: Species coefficients from the binomial GLM for presence/absence of GBYR in the Marine Recreational Fisheries Statistics Survey (MRFSS) CPFV mode dockside survey data set north of Point Conception. Horizontal bars are 95% confidence intervals. fig:Fleet10_SM_filter

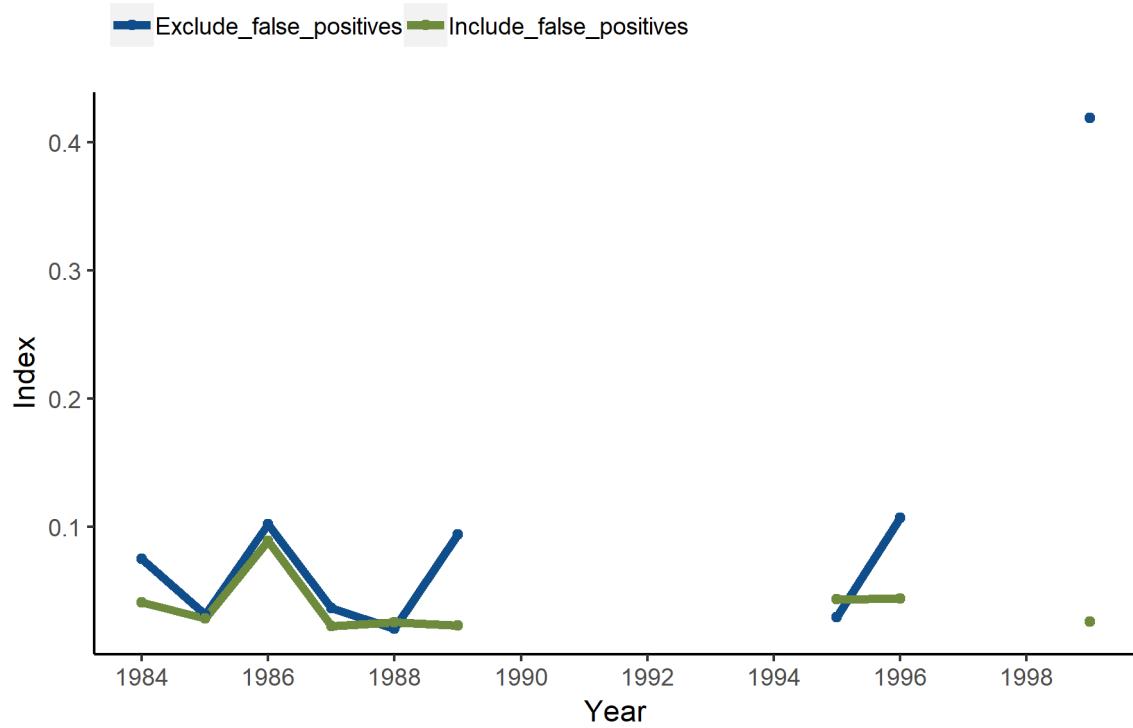


Figure 14: Comparisons of the indices of abundance for GBYR north of Point Conception from the MRFSS dockside CPVS survey that either include or exclude the trips identified as false positives from the Stephens-MacCall filter. [fig:MRFSS_index_N_SM_falsepos](#)

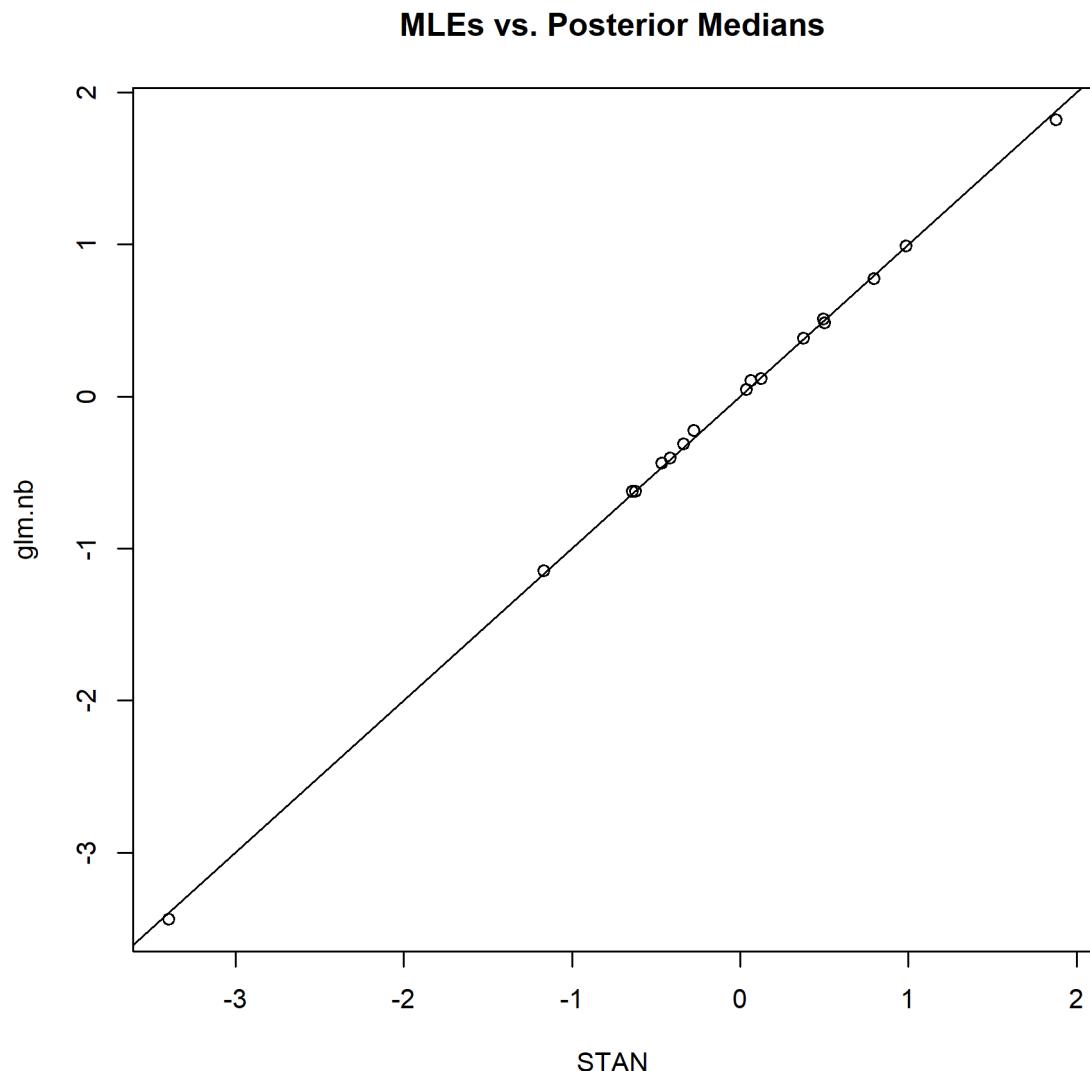


Figure 15: Comparison of negative binomial predictions (CPUE) to observed means in each stratum (year). MRFSS CPFV dockside index north of Point Conception. The 1:1 plot is for reference.

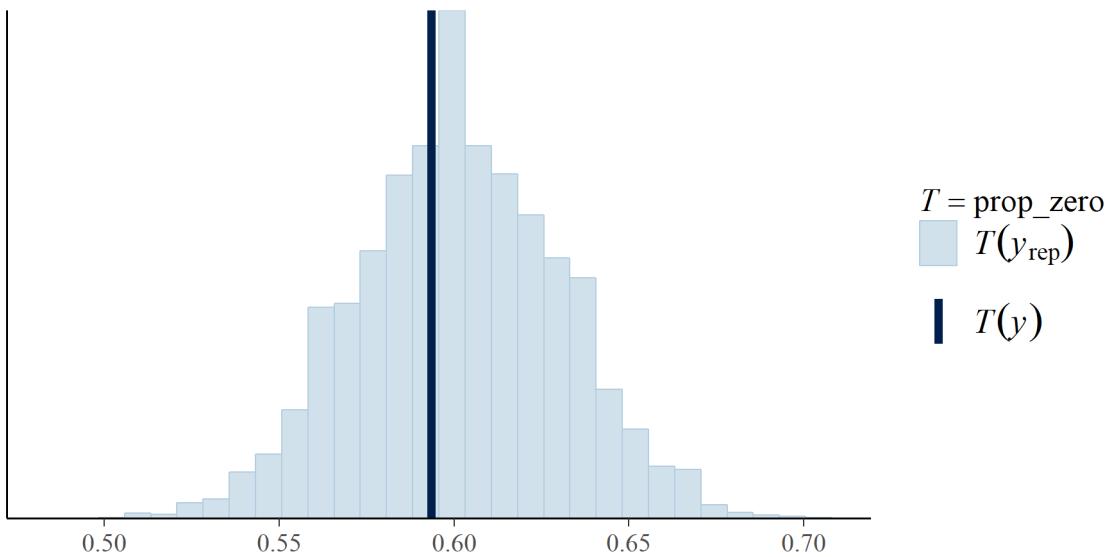


Figure 16: Posterior predictive distribution of the proportion of zero observations in replicate data sets generated by the negative binomial model for MRFSS dockside CPFV index north of Point Conception. [fig:Fleet10_prop_zero_STAN](#)

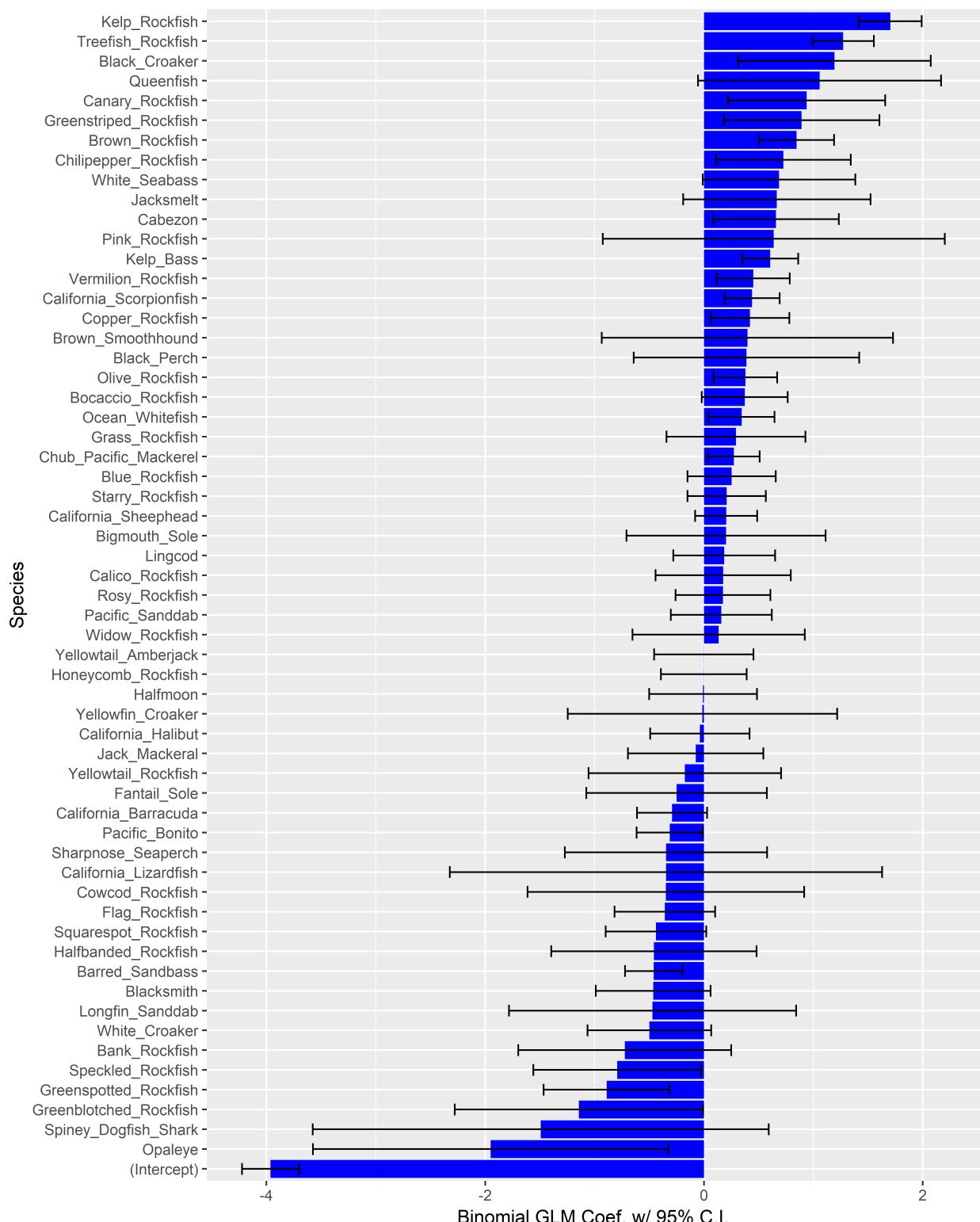


Figure 17: Species coefficients from the binomial GLM for presence/absence of GBYR in the Marine Recreational Fisheries Statistics Survey (MRFSS) CPFV mode dockside survey data set north of Point Conception. Horizontal bars are 95% confidence intervals. fig:Fleet11_SM_filter

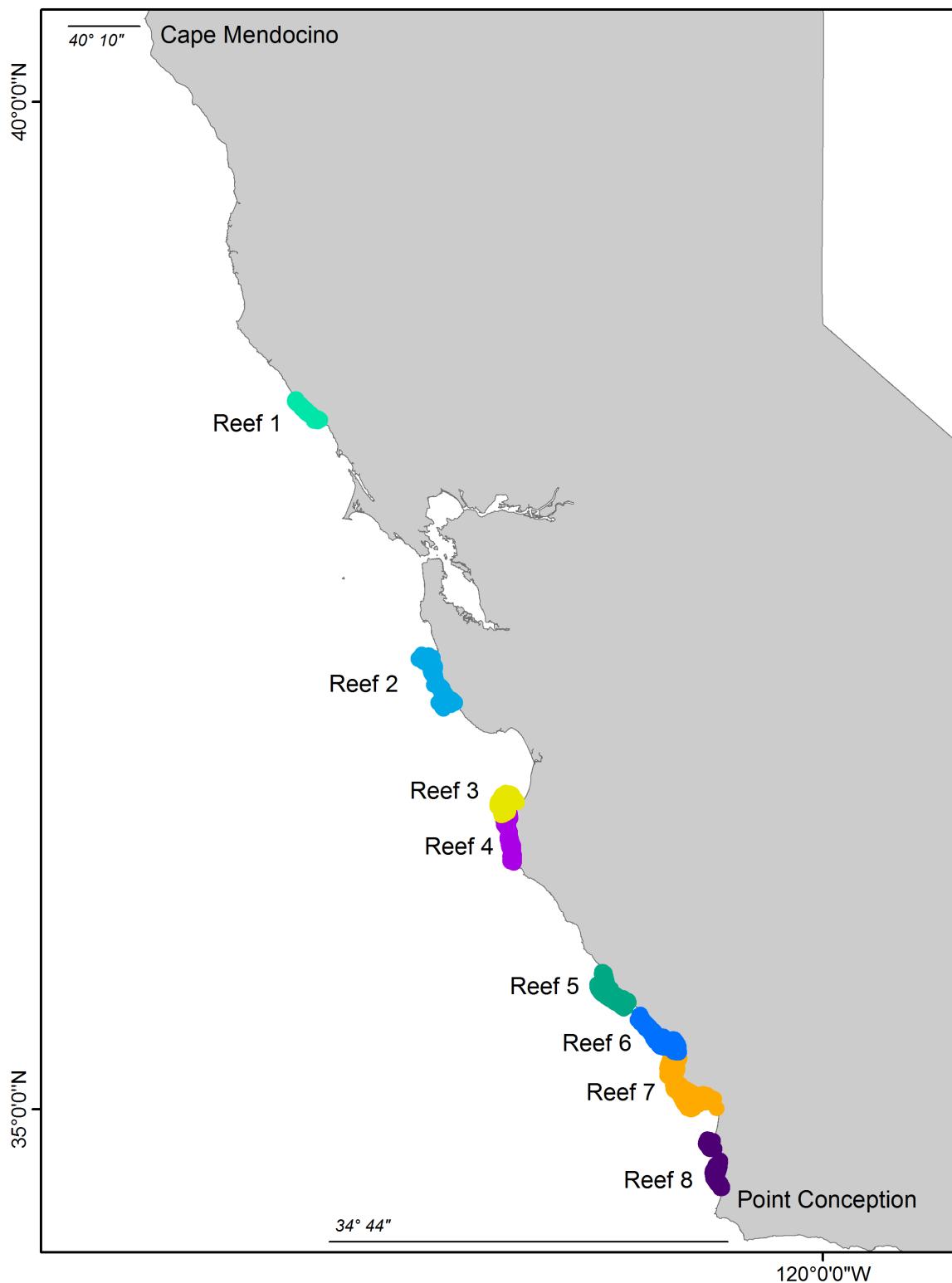


Figure 18: Map of the reefs used in the Deb Wilson-Vandenbervy CPFV onboard observer survey index of abundance. [fig:DebWV_sites](#)

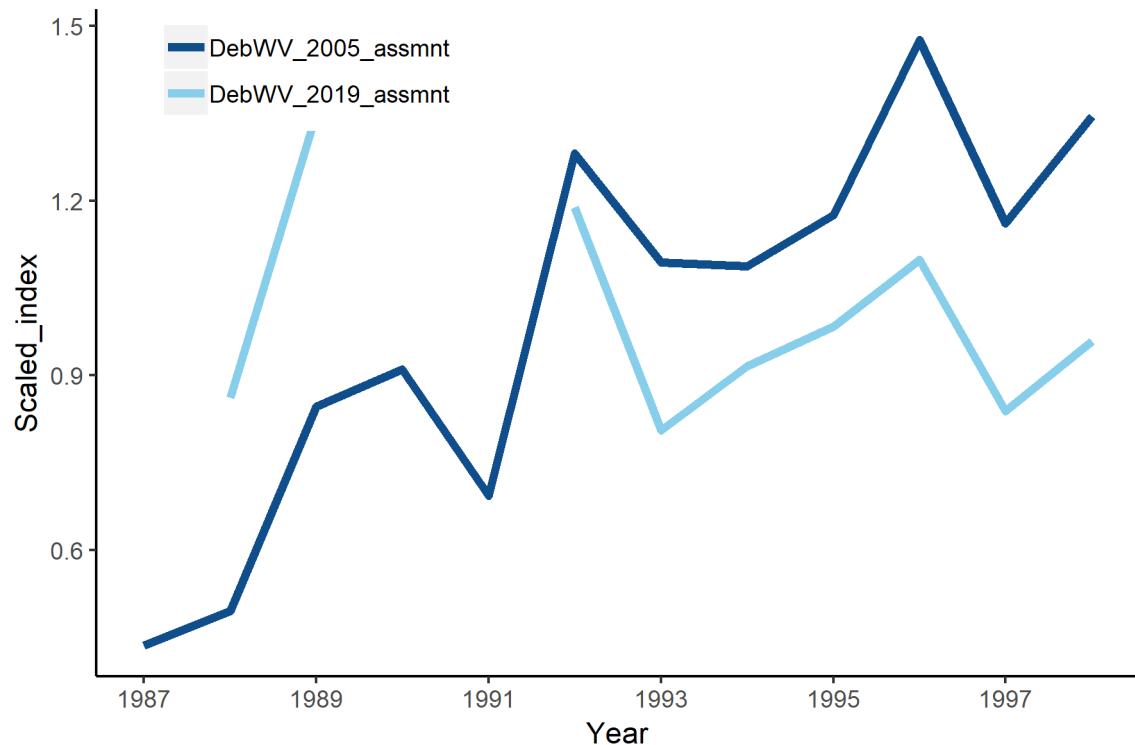


Figure 19: Comparison of the index developed for the Deb Wilson-Vandenberg CPFV onboard observer survey from the 2005 assessment and for the 2019 assessment. | Fig:DebWV_index_compare

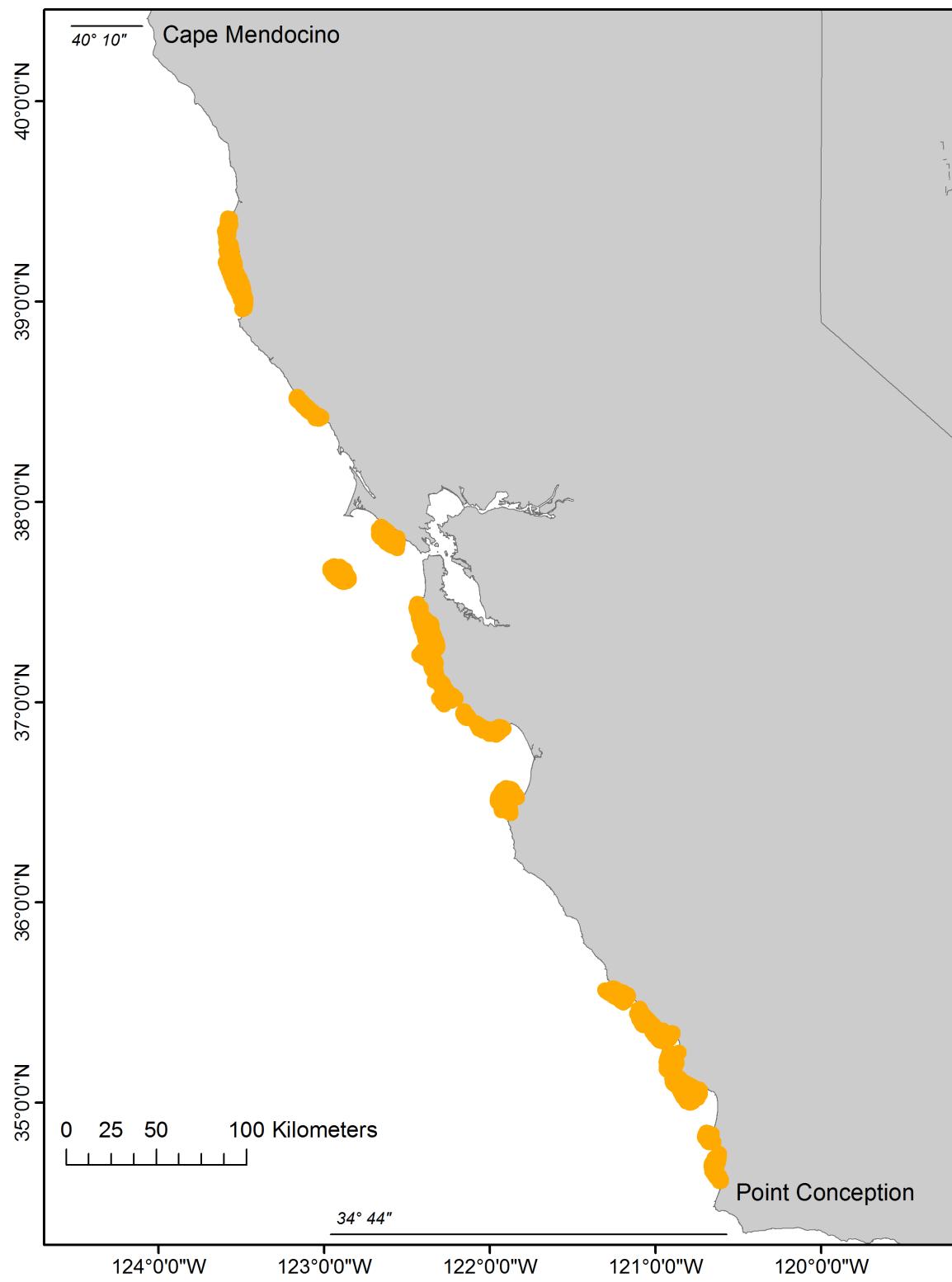


Figure 20: Map of the reefs selected for the final index for the onboard observer surveys (CDFW and Cal Poly) north of Point Conception

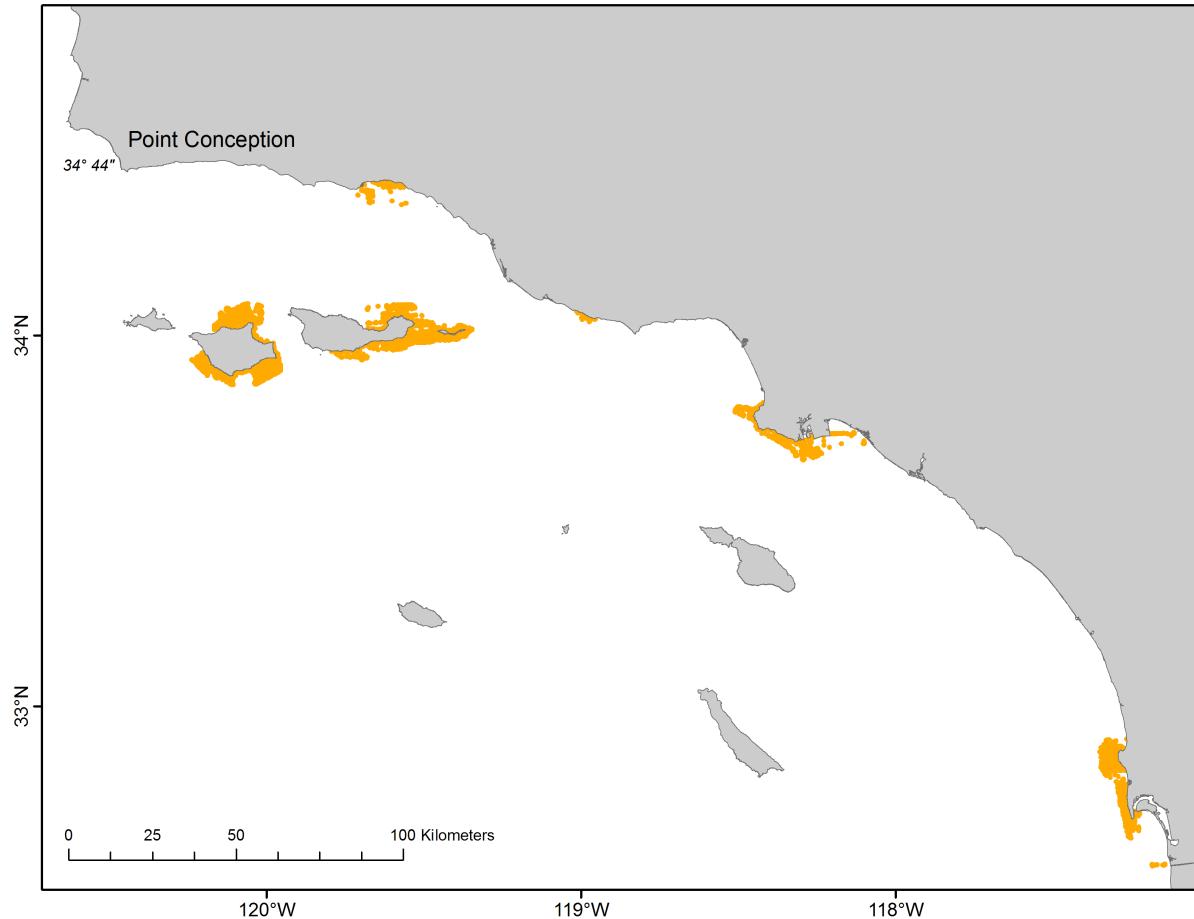


Figure 21: Map of the reefs selected for the final index for the CDFW onboard observer survey south of Point Conception | [fig:Unboard_observer_south_sites](#)

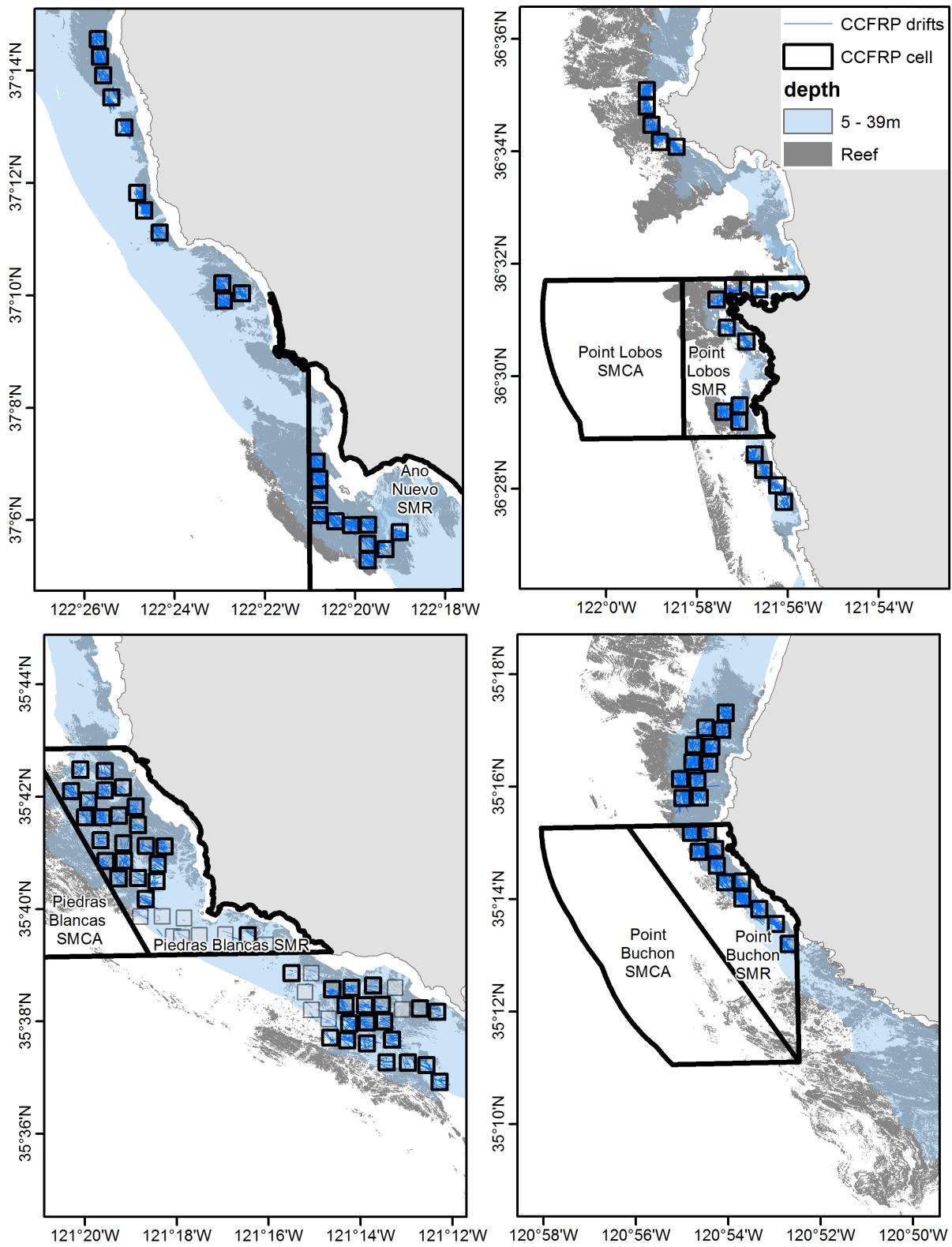


Figure 22: Map of the four MPAs sample consistently through time for the CCFRP fishery-independent survey. [fig:CCFRP_sites](#)

MLEs vs. Posterior Medians

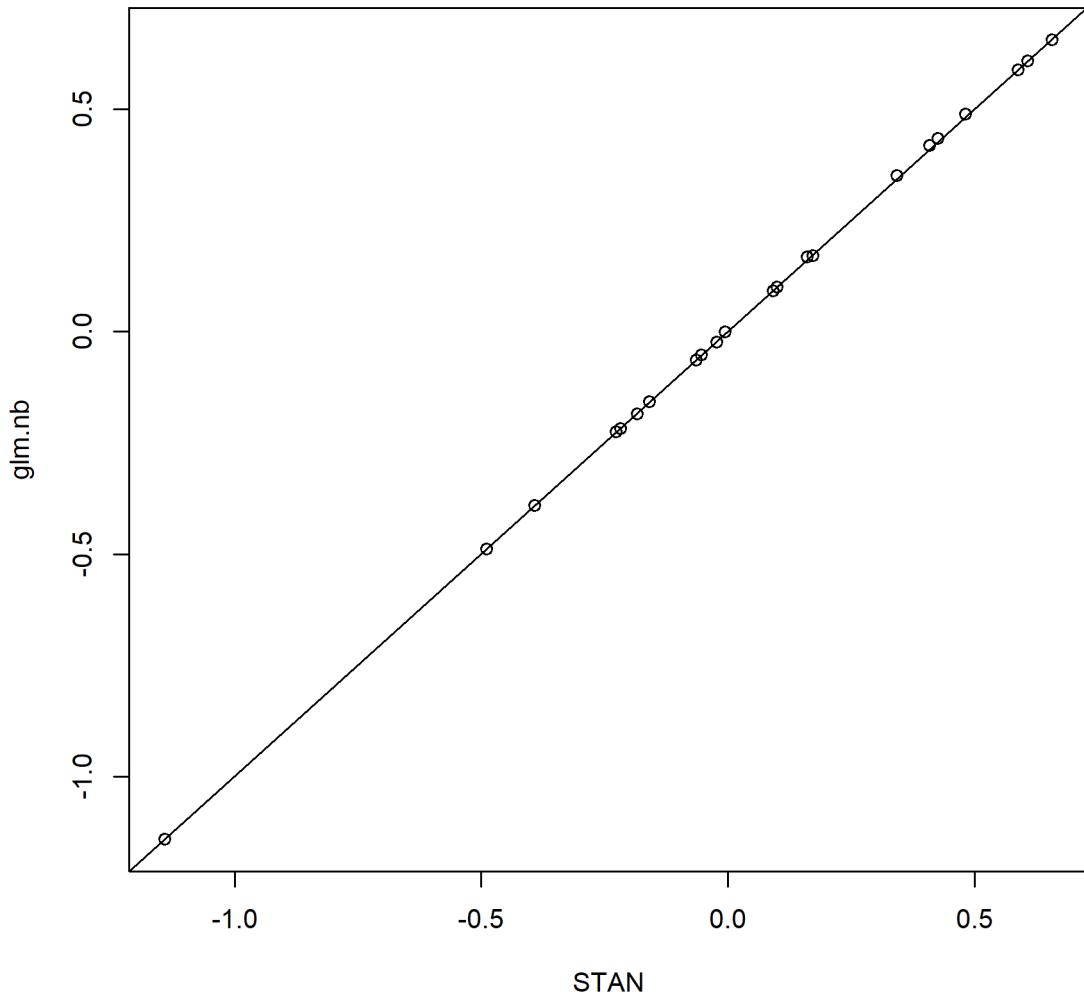


Figure 23: Comparison of negative binomial predictions (CPUE) to observed means in each stratum (year) for the CCFRP index. The 1:1 plot is for reference. [fig:Fleet9_MLE_stan](#)

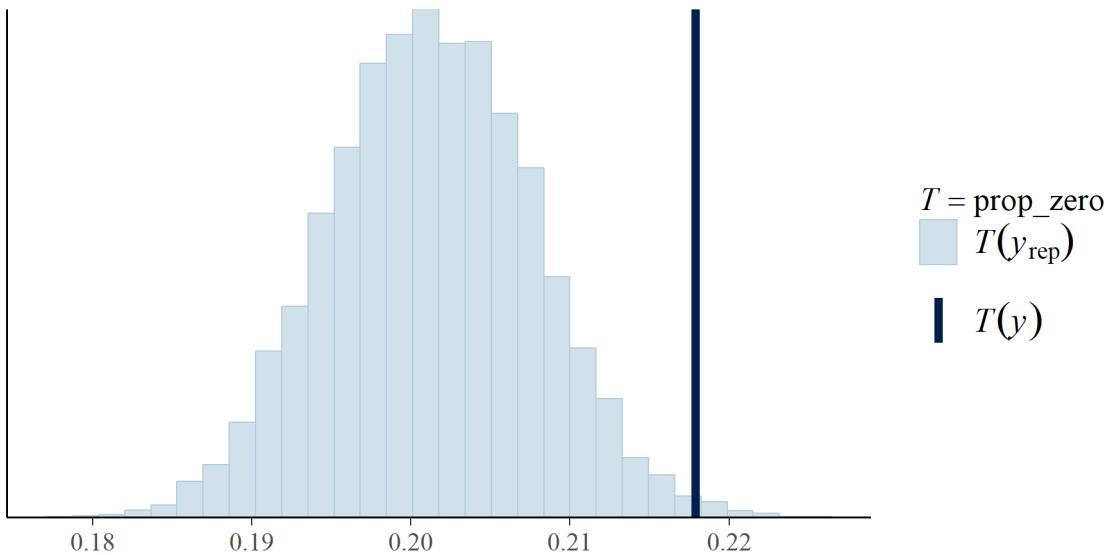


Figure 24: Posterior predictive distribution of the proportion of zero observations in replicate data sets generated by the negative binomial model for the CCFRP index. [fig:Fleet9_prop_zero_STAN](#)

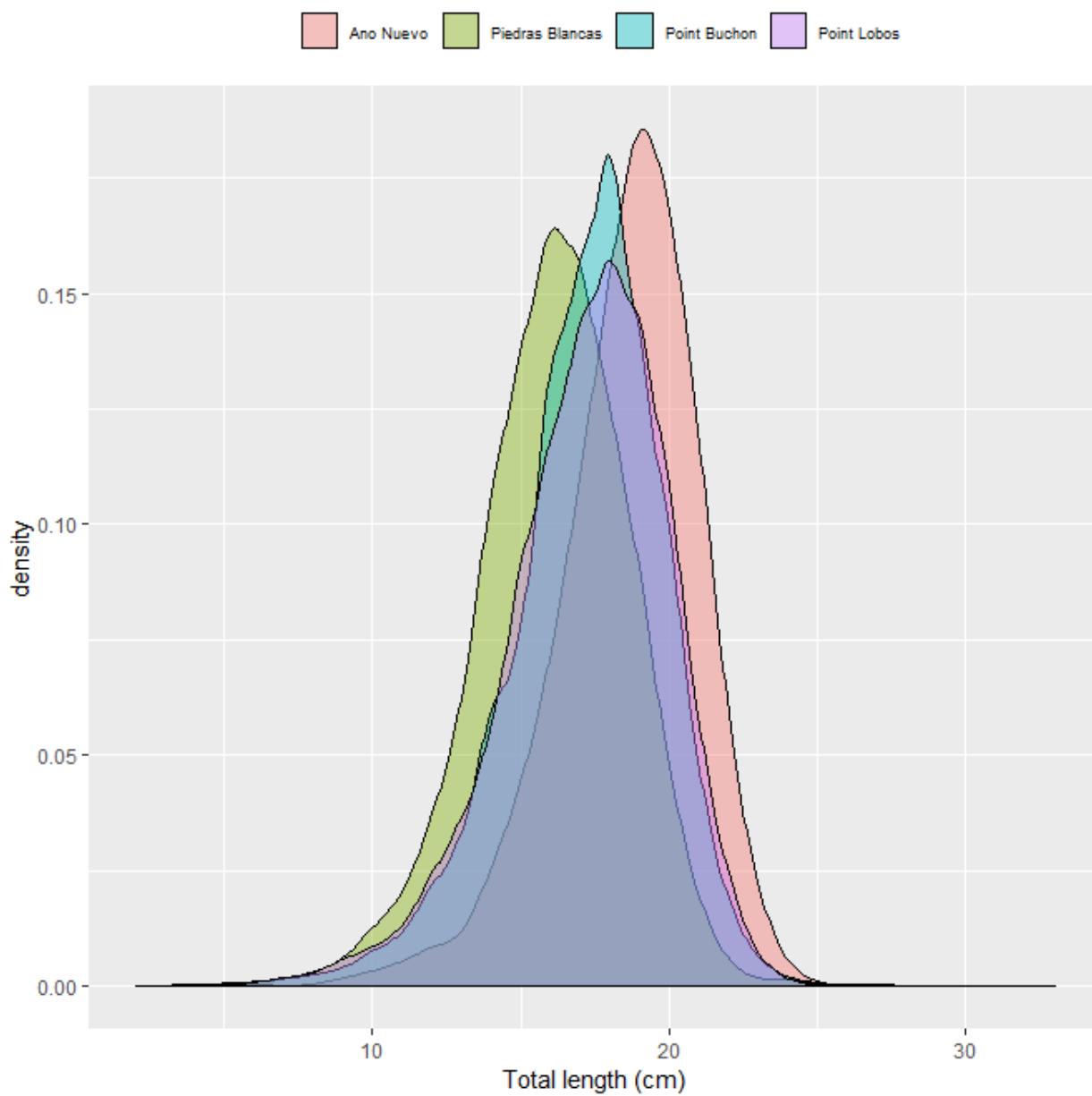


Figure 25: Length distributions of GBYR for the four MPAs sampled by the CCFRP survey used in this assessment. | [CCFRP_lengths_by_site](#)

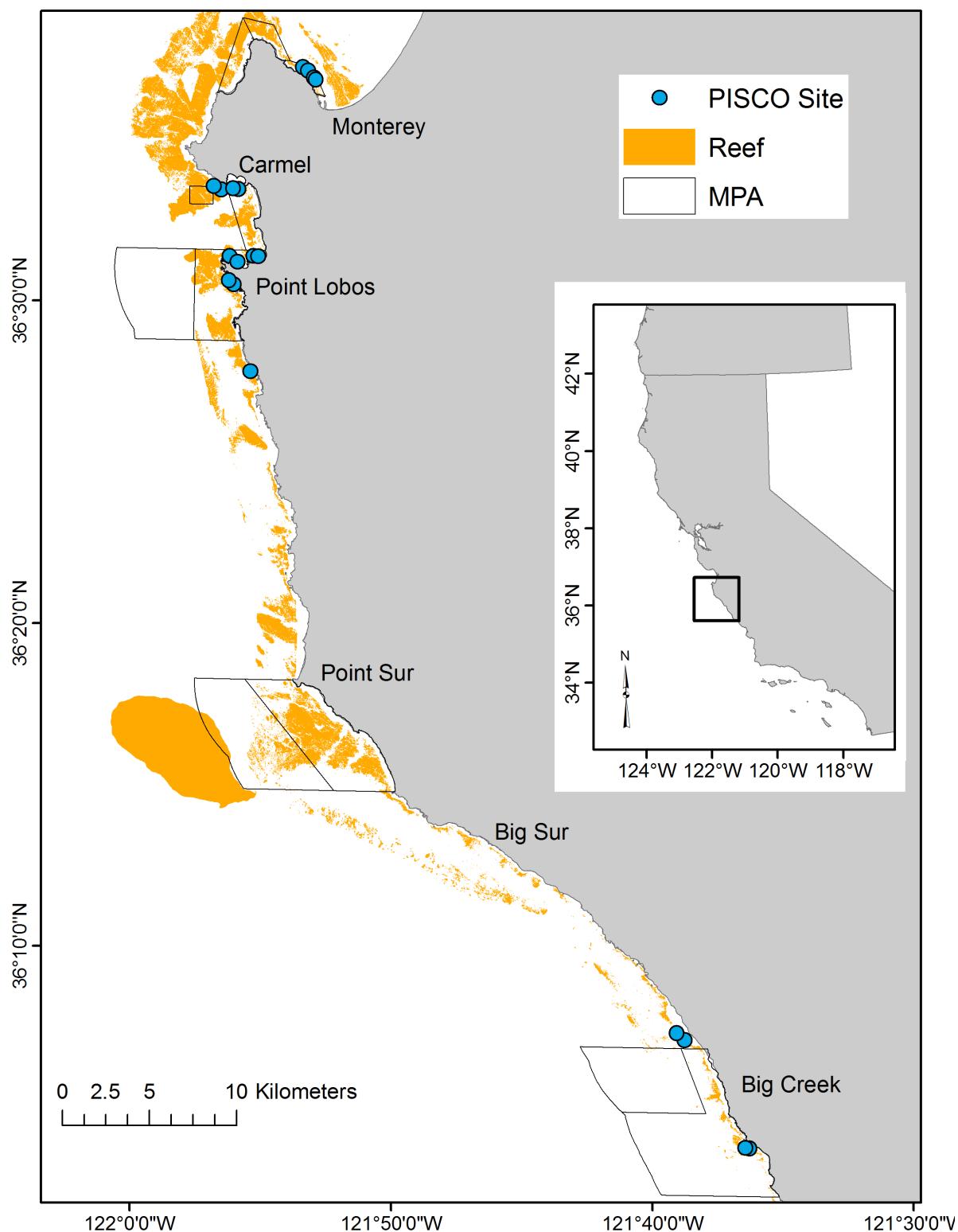


Figure 26: Map of the sites sampled consistently through time for the PISCO kelp forest fish survey. | [fig:PISCO_sites](#)

MLEs vs. Posterior Medians

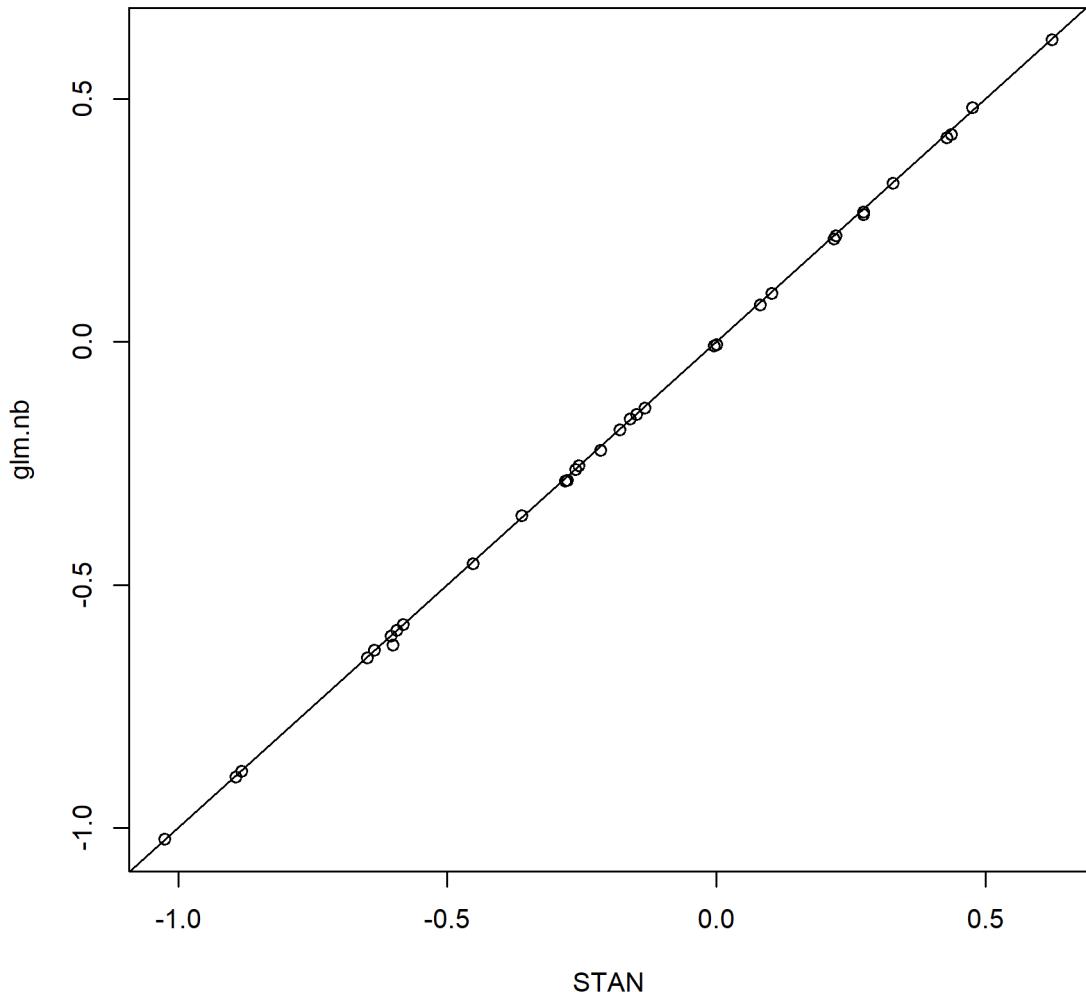


Figure 27: Comparison of negative binomial predictions (CPUE) to observed means in each stratum (year) for the PISCO kelp forest fish survey index. The 1:1 plot is for reference. [fig:Fleet8_MLE](#)

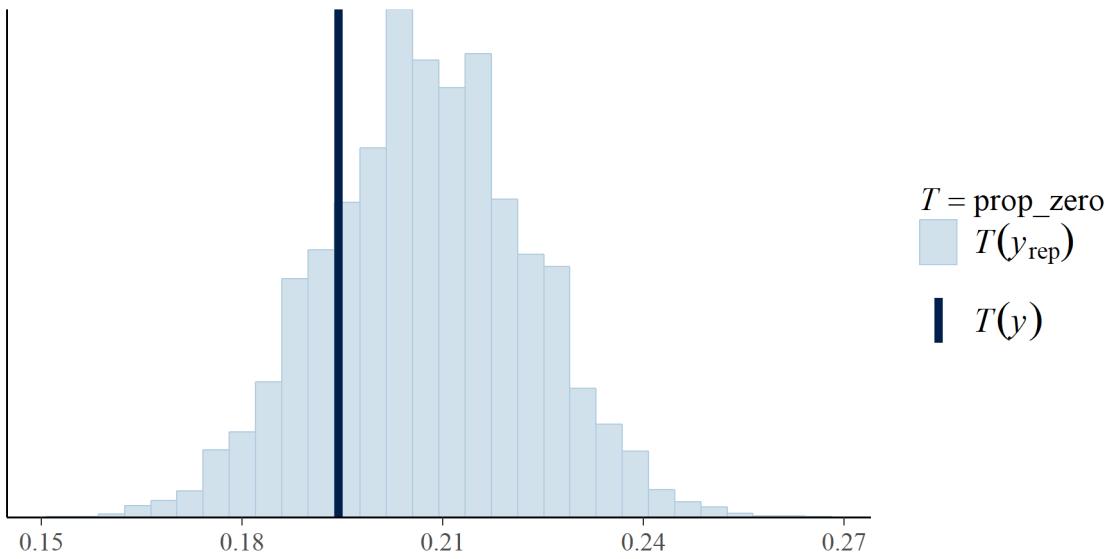


Figure 28: Posterior predictive distribution of the proportion of zero observations in replicate data sets generated by the negative binomial model for the PISCO kelp forest fish survey. [fig:Fleet8_pr](#)

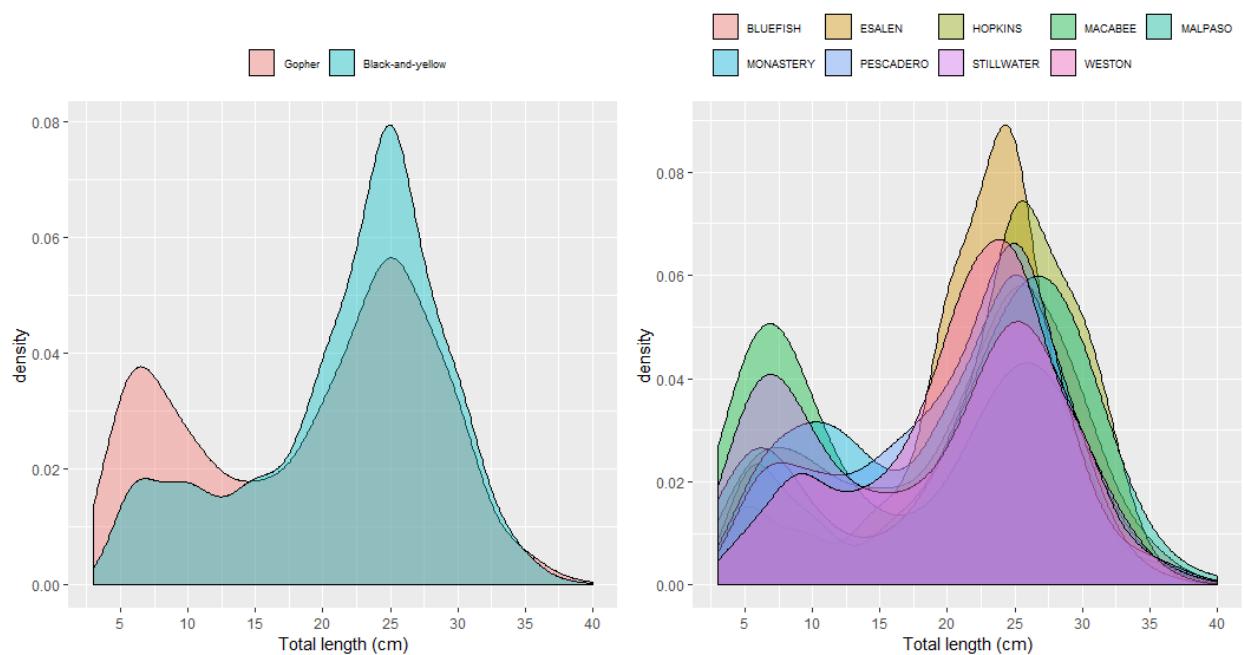


Figure 29: Plots of the length distributions from the PISCO kelp forest fish survey by species (left) and for combined species by site (right) for sites included in the final index of abundance. [fig:PISCO_Lengths](#)

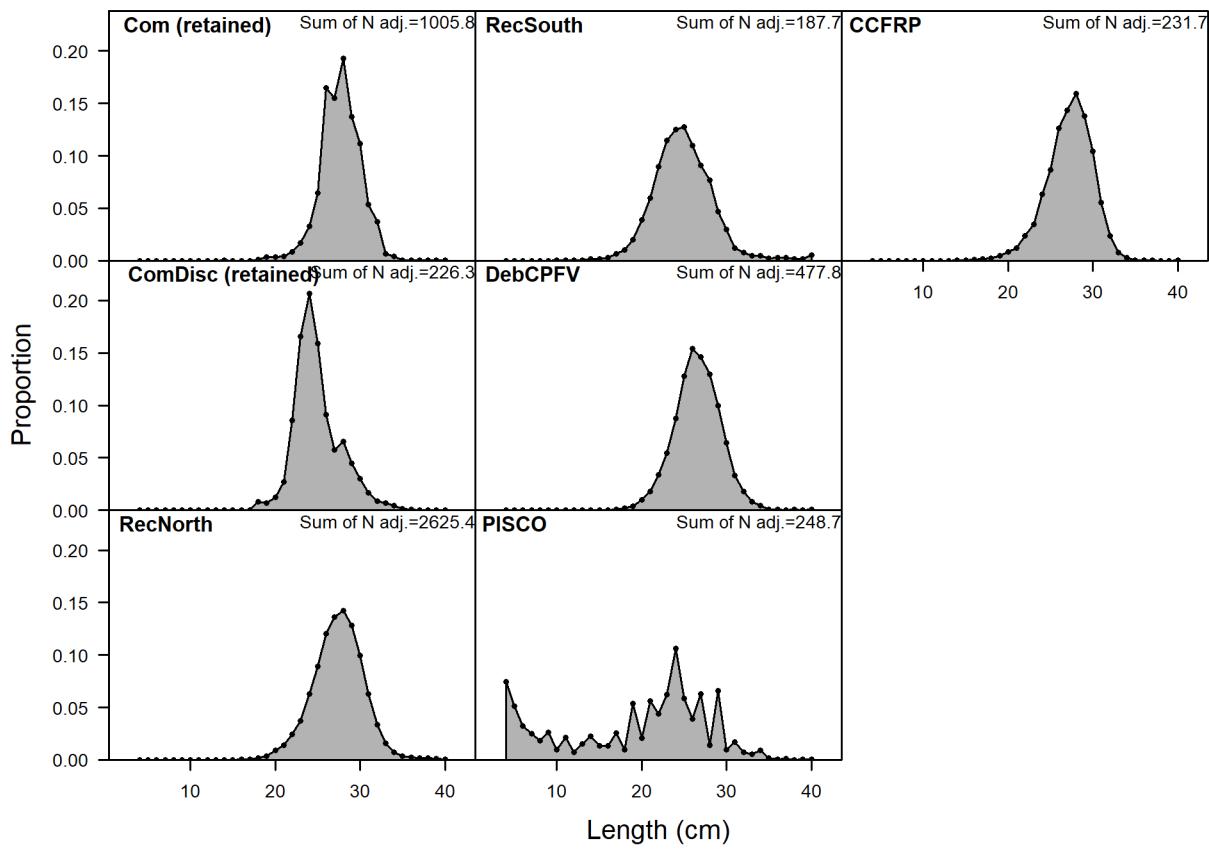


Figure 30: Length comp data, aggregated across time by fleet. Labels ‘retained’ and ‘discard’ indicate discarded or retained sampled for each fleet. Panels without this designation represent the whole catch.

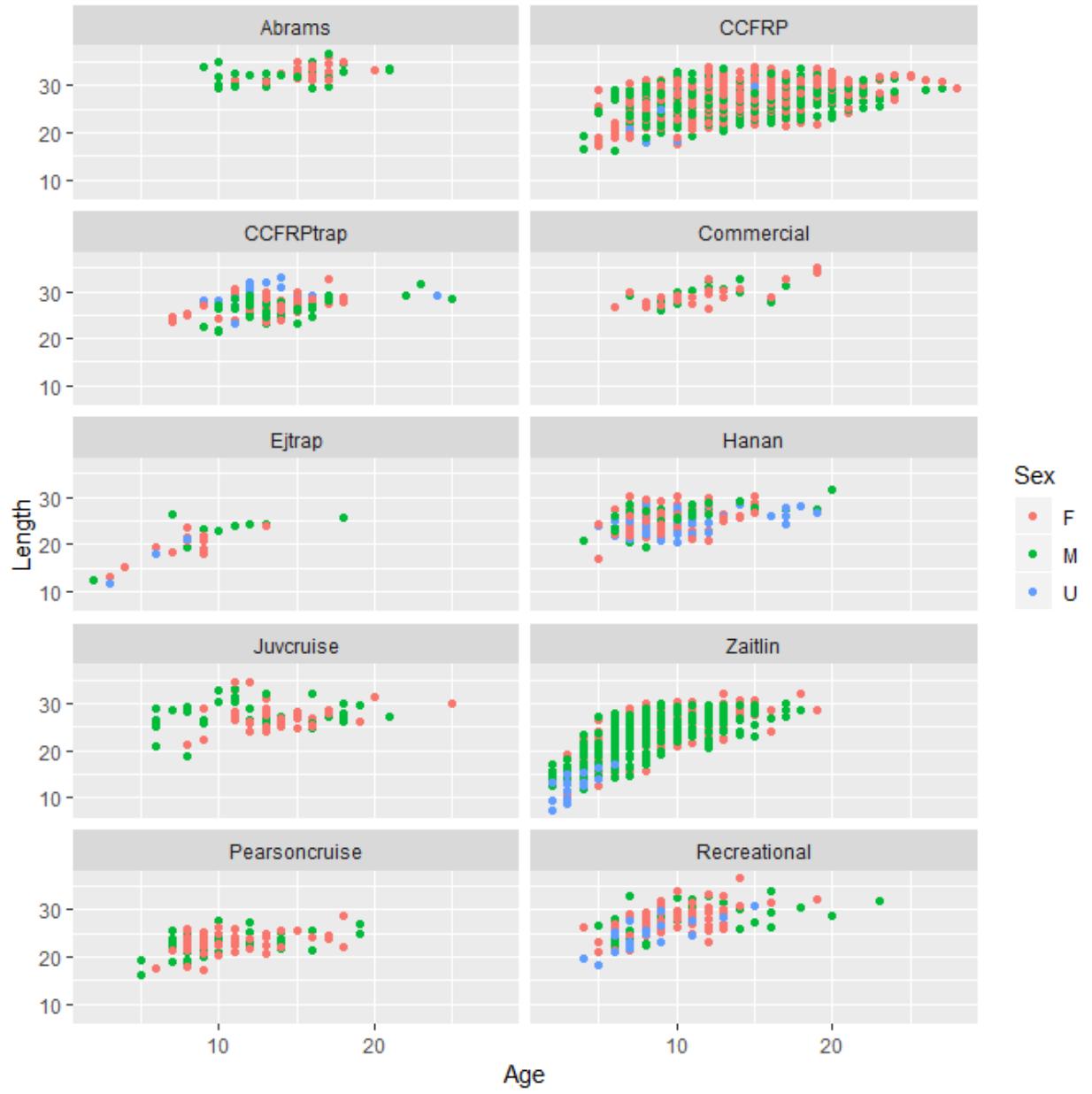


Figure 31: Available length-at-age data for gopher and black-and-yellow rockfish by sex and data source. The Zaitlin study is all black-and-yellow rockfish. The remaining plots represent gopher rockfish ^{fig:growth_samples}

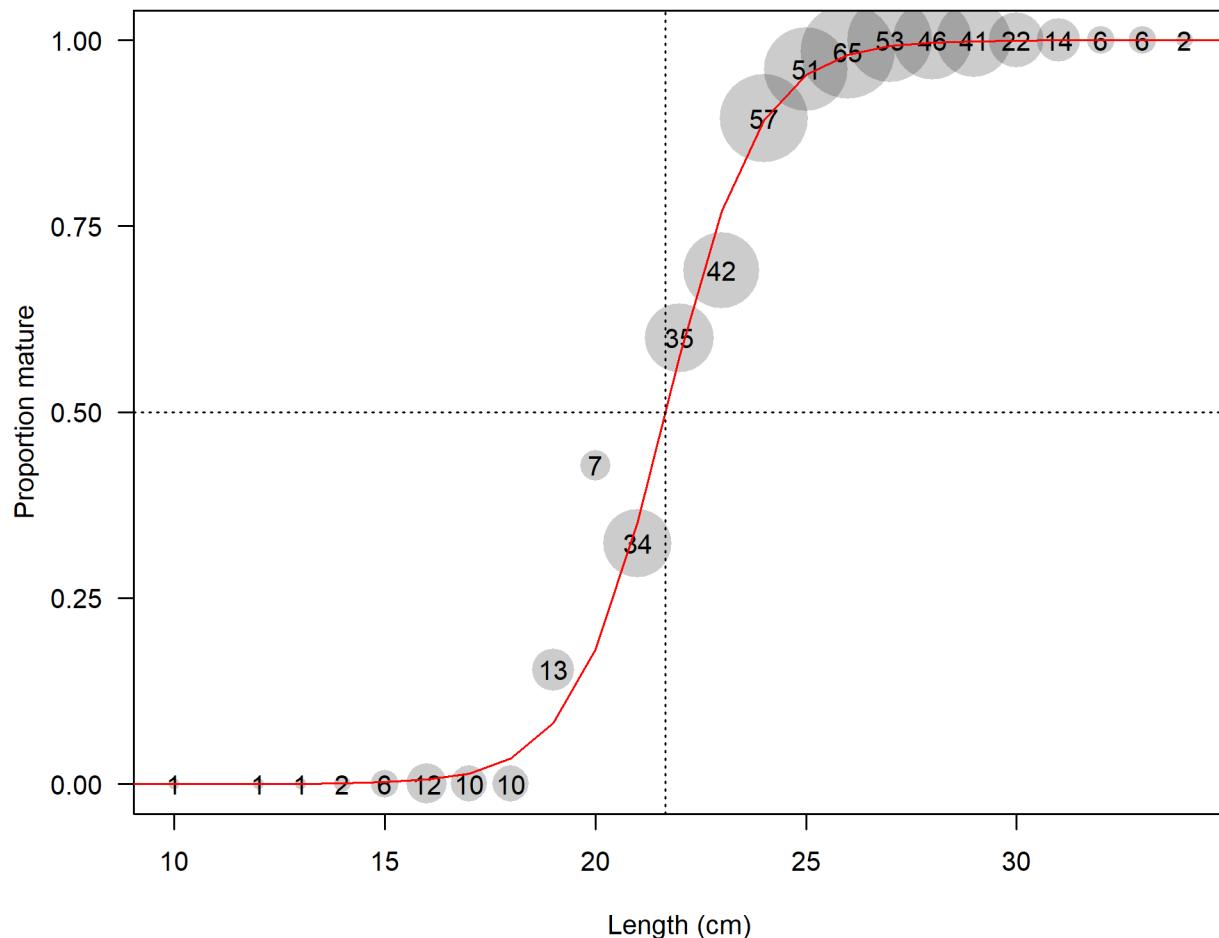


Figure 32: Maturity ogive for females estimated from black-and-yellow rockfish from Zaitlin (1986) and gopher rockfish from Meyers-Cherry (2014). Sample sizes at a given length are shown in the circles. [fig:GBY_maturity_ogive](#)

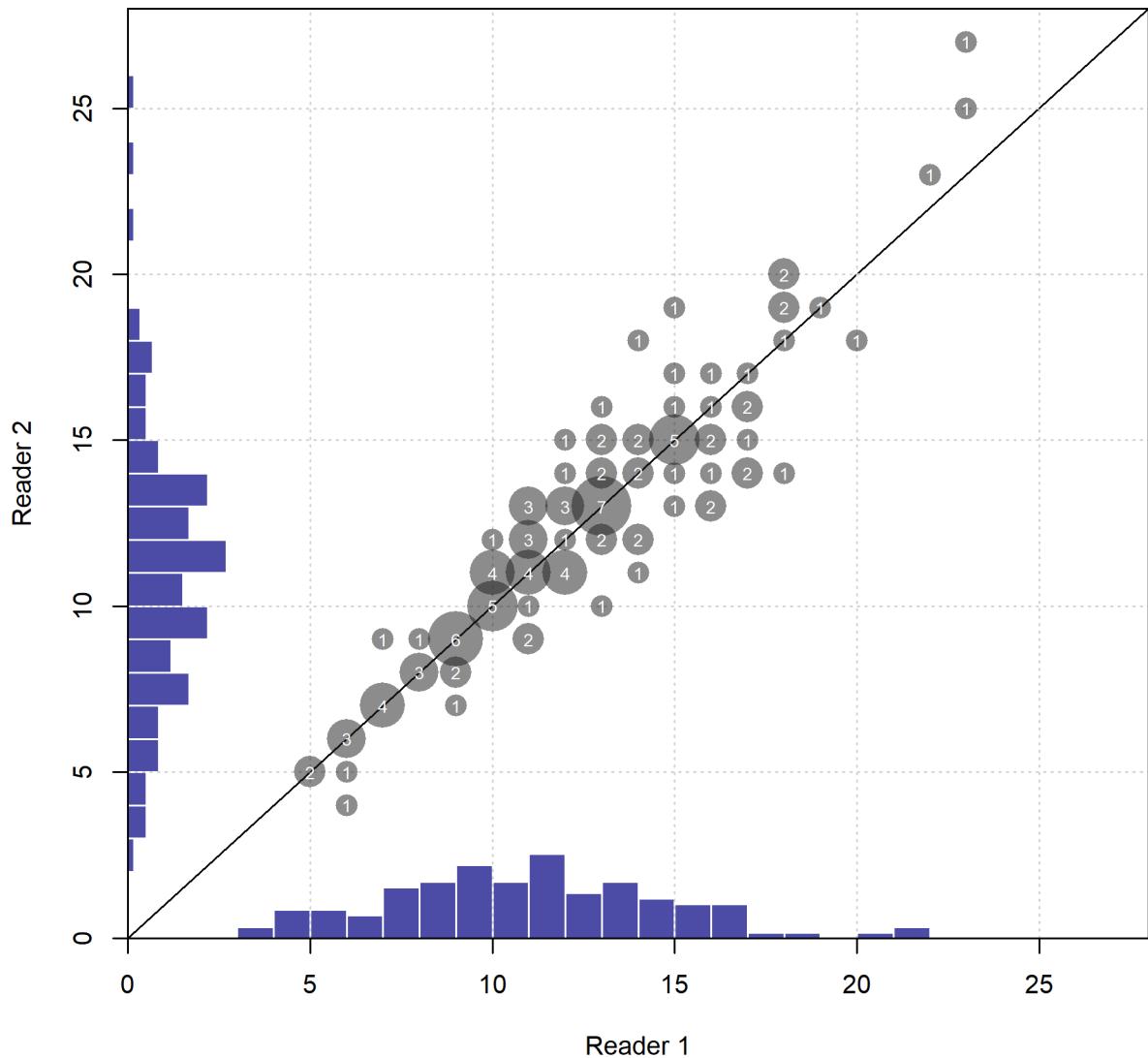


Figure 33: Aging precision between initial and blind double reads for GBYR. Numbers in the bubbles are the sample sizes of otoliths cross-read. [fig:GBY_age_error](#)

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

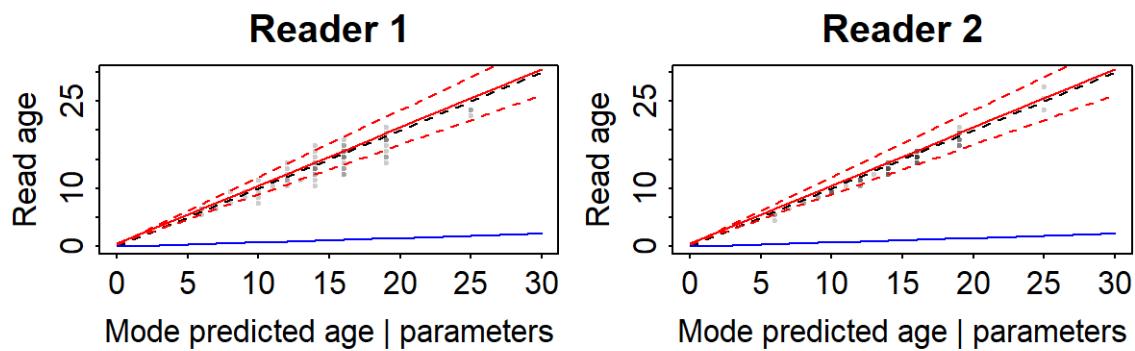


Figure 34: True versus predicted age for two current age readers at the NWFSC from the ageing error software with unbiased reads and curvilinear standard deviation for both readers.
fig:GBY_age_error2

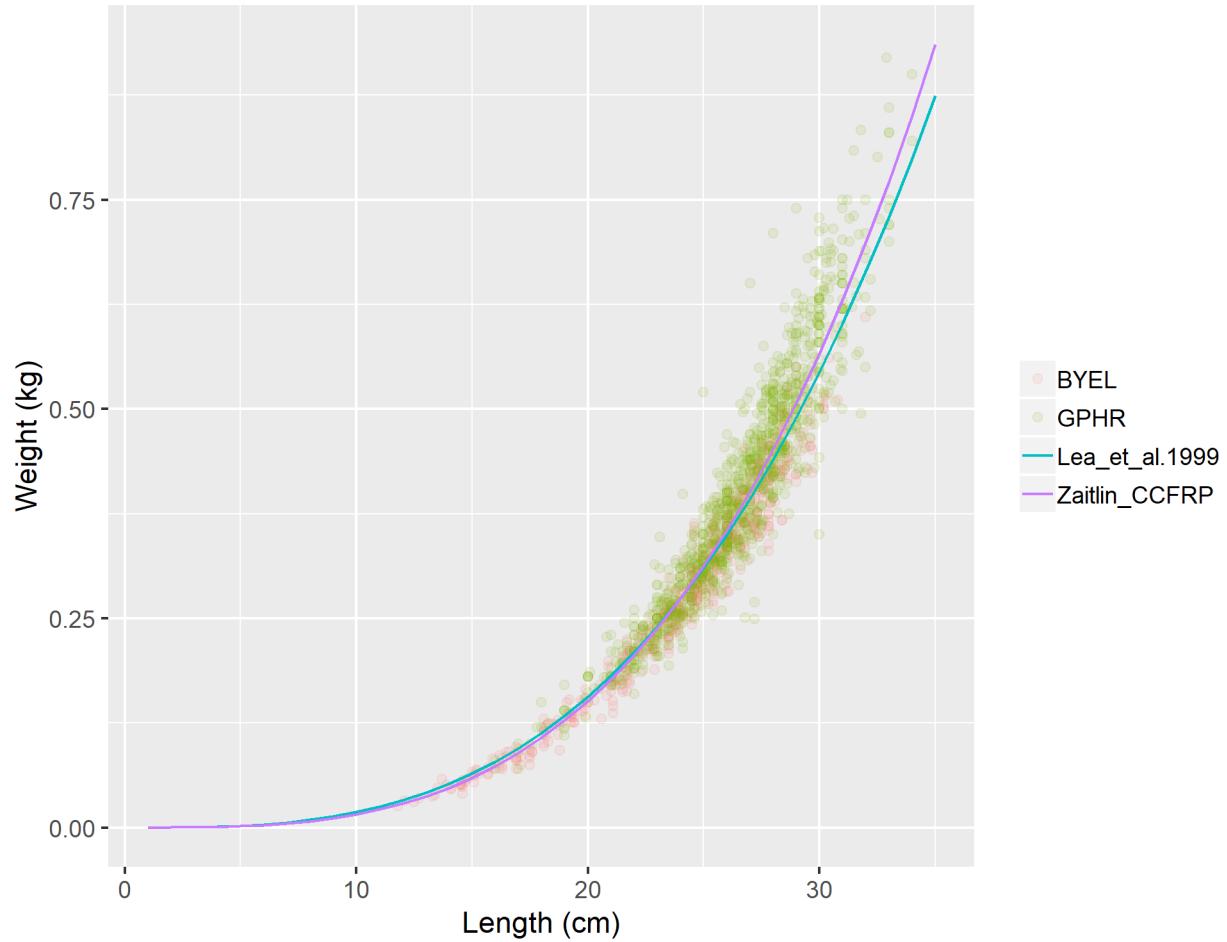
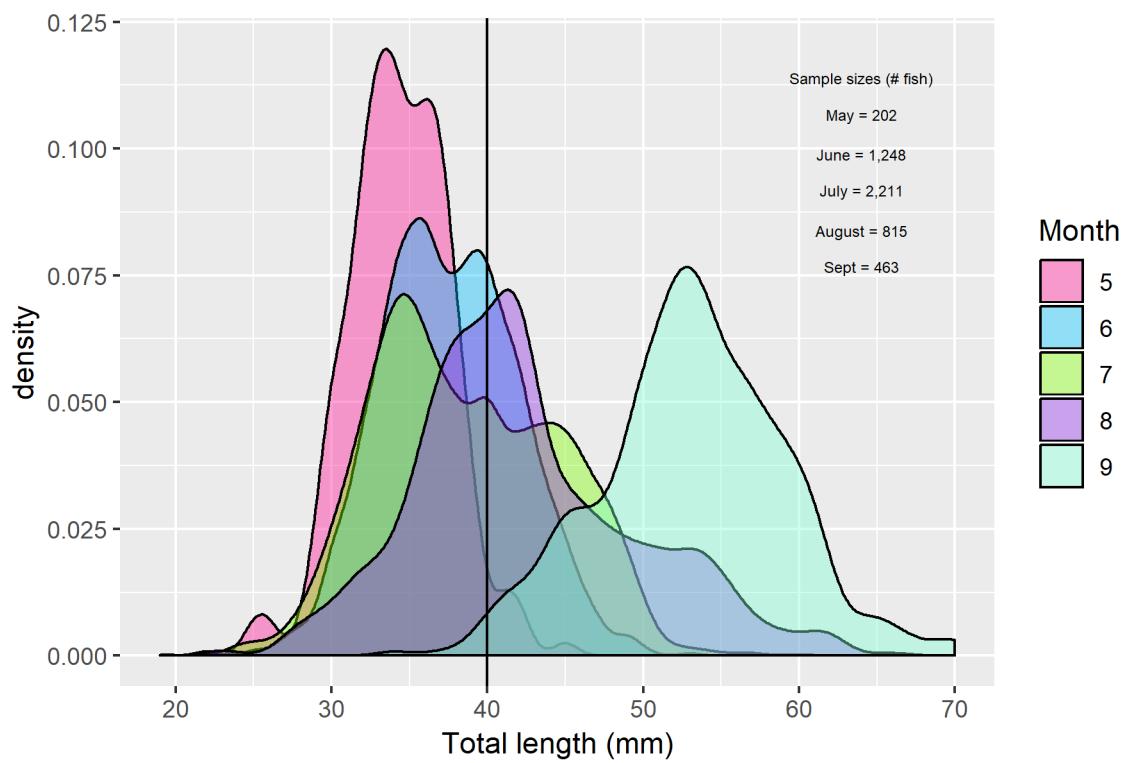


Figure 35: Comparison of the gopher rockfish weight-length curves from Lee et al. (1999) and the estimated from black-and-yellow rockfishes from Zaitlin (1986), and gopher rockfishes from Loury (2011) and Meyers-Cherry(2014). The estimated curve from the current data is used in this assessment. [fig:GBY_weight_length](#)



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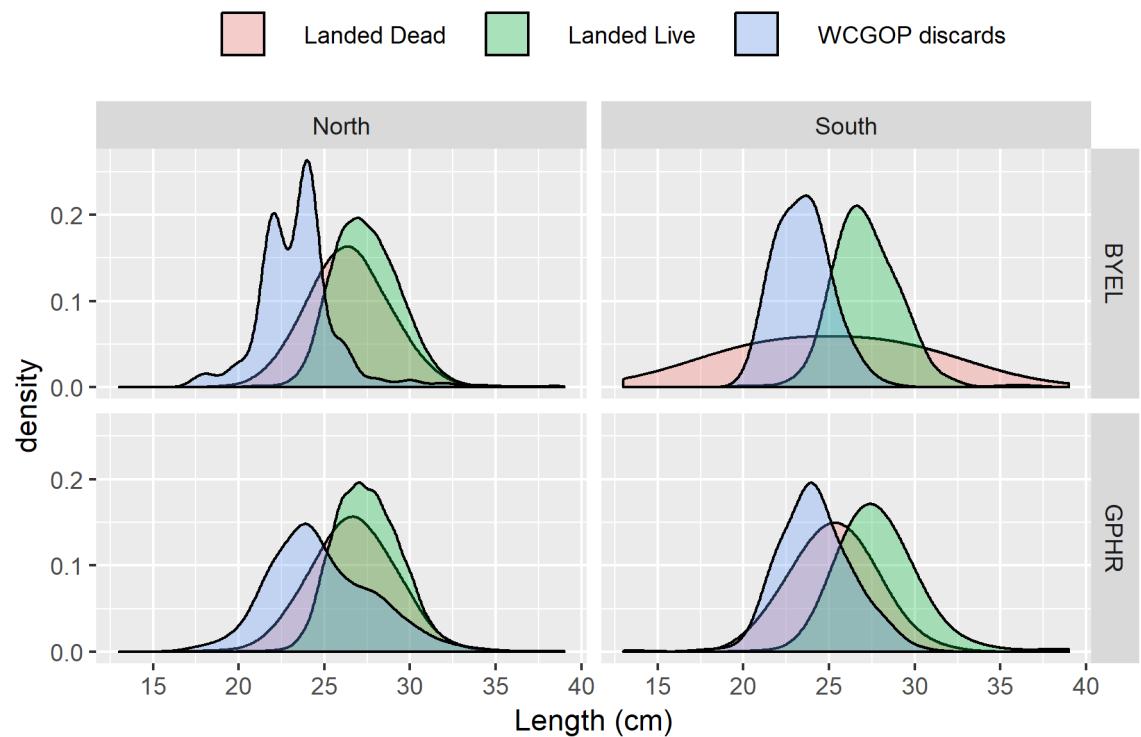


Figure 36: Length distributions of gopher and black-and-yellow rockfish for the commercial fleet and WCGOP discards north and south of Point Conception. The commercial landings were also separated between fish landed live and fish landed dead for this figure. [fig:Comm_lengths_justified](#)

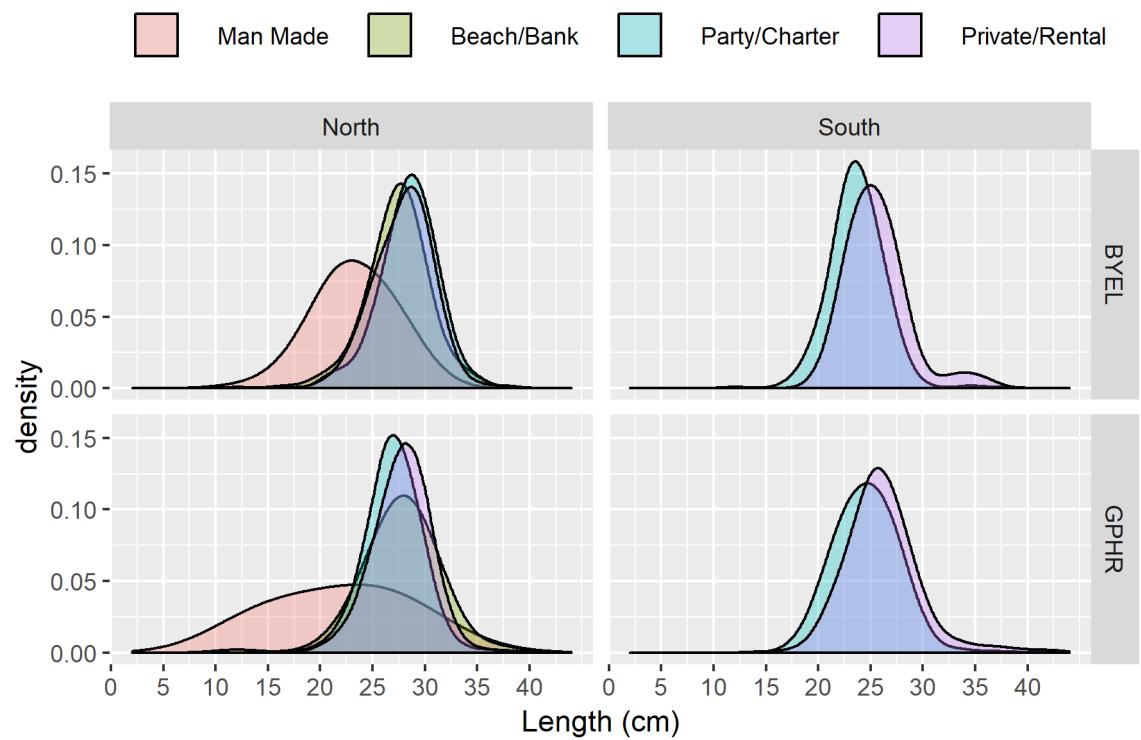


Figure 37: Length distributions of gopher and black-and-yellow rockfish for the recreational fleet north and south of Point Conception and by mode. fig:Rec_lengths_justification

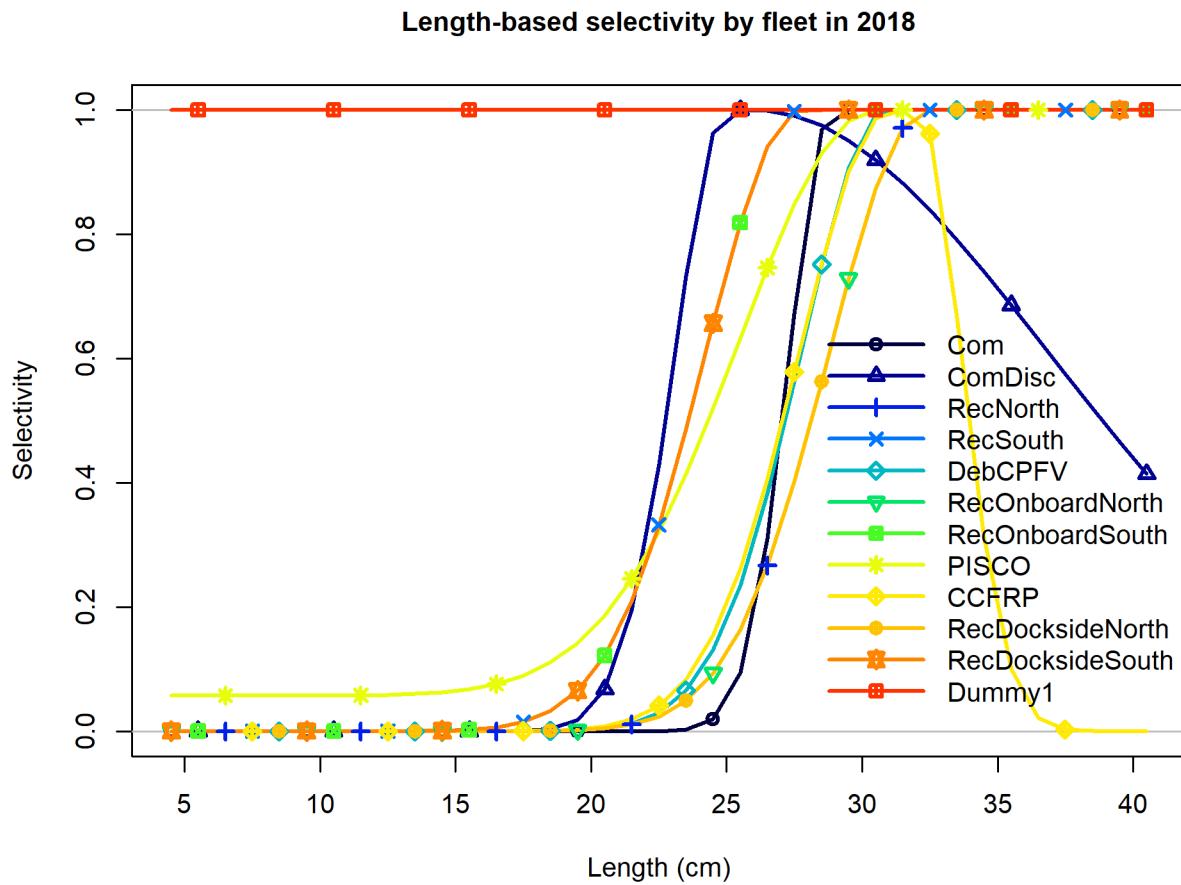


Figure 38: Selectivity at length for all of the fleets in the base model. fig:sel01_multiple_fle

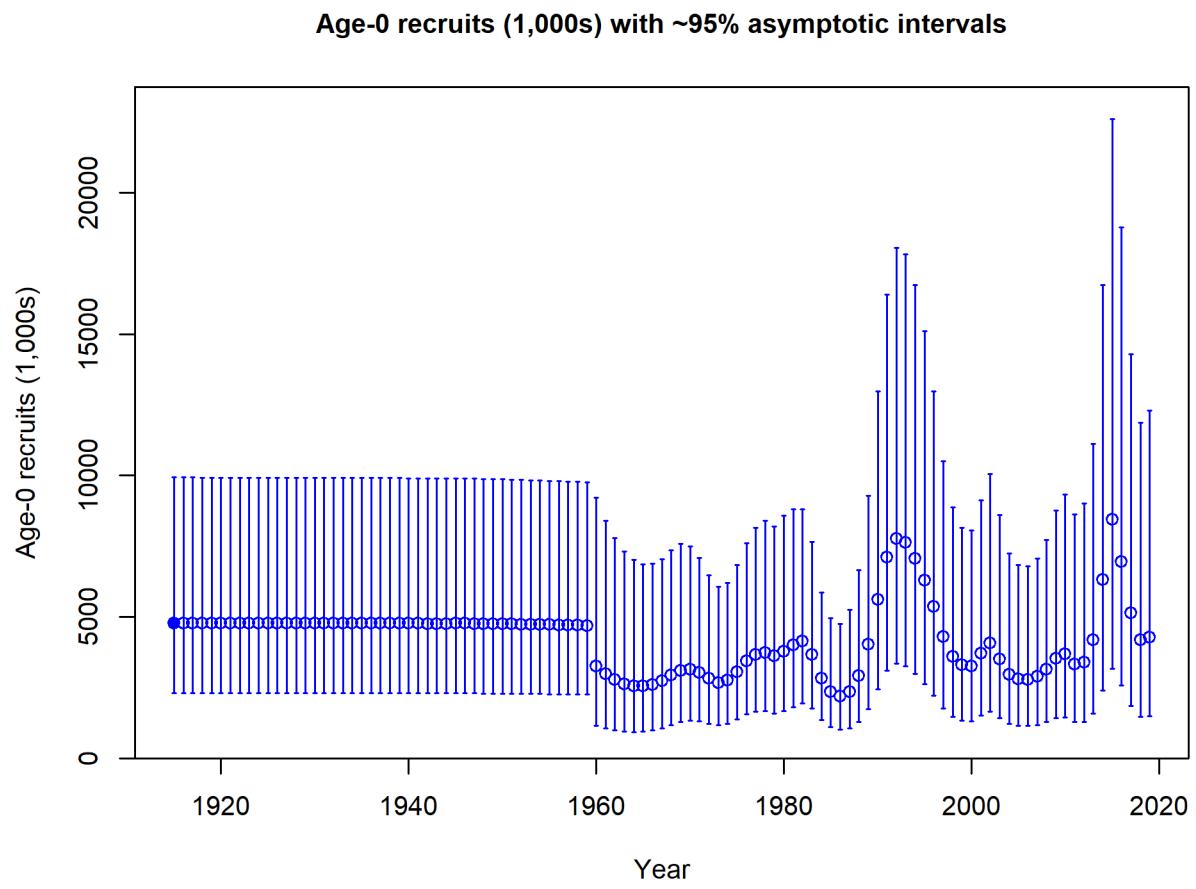


Figure 39: Time series of estimated GBYR recruitments for the base-case model with 95% confidence or credibility intervals. fig:Recruit_mod1

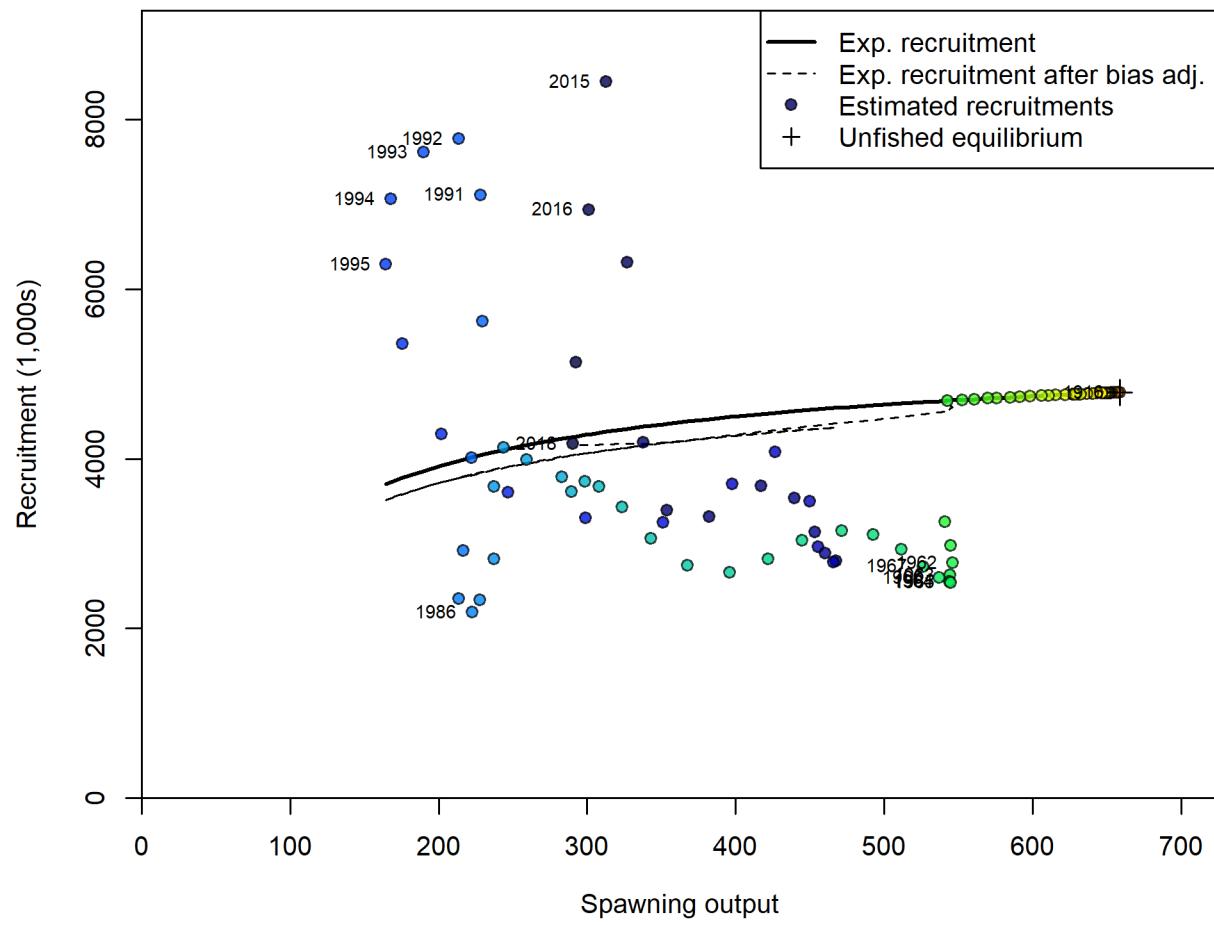
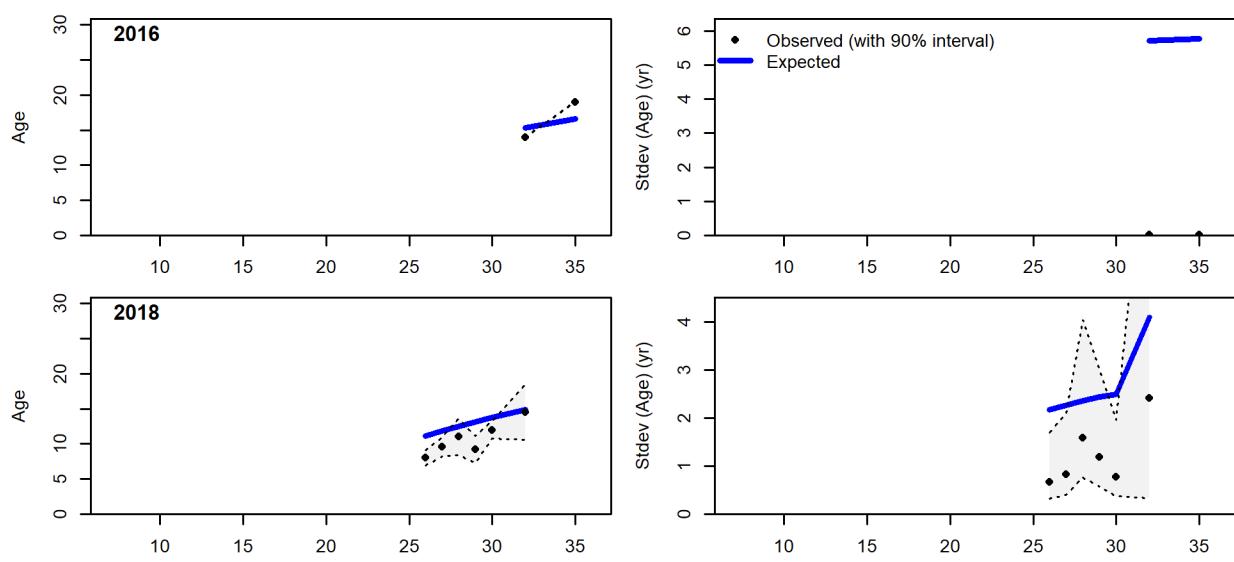


Figure 40: Estimated recruitment (red circles) and the assumed stock-recruit relationship (black line) for GBYR. The green line shows the effect of the bias correction for the lognormal distribution. ^{fig:SR_curve2}



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Figure continued from previous page

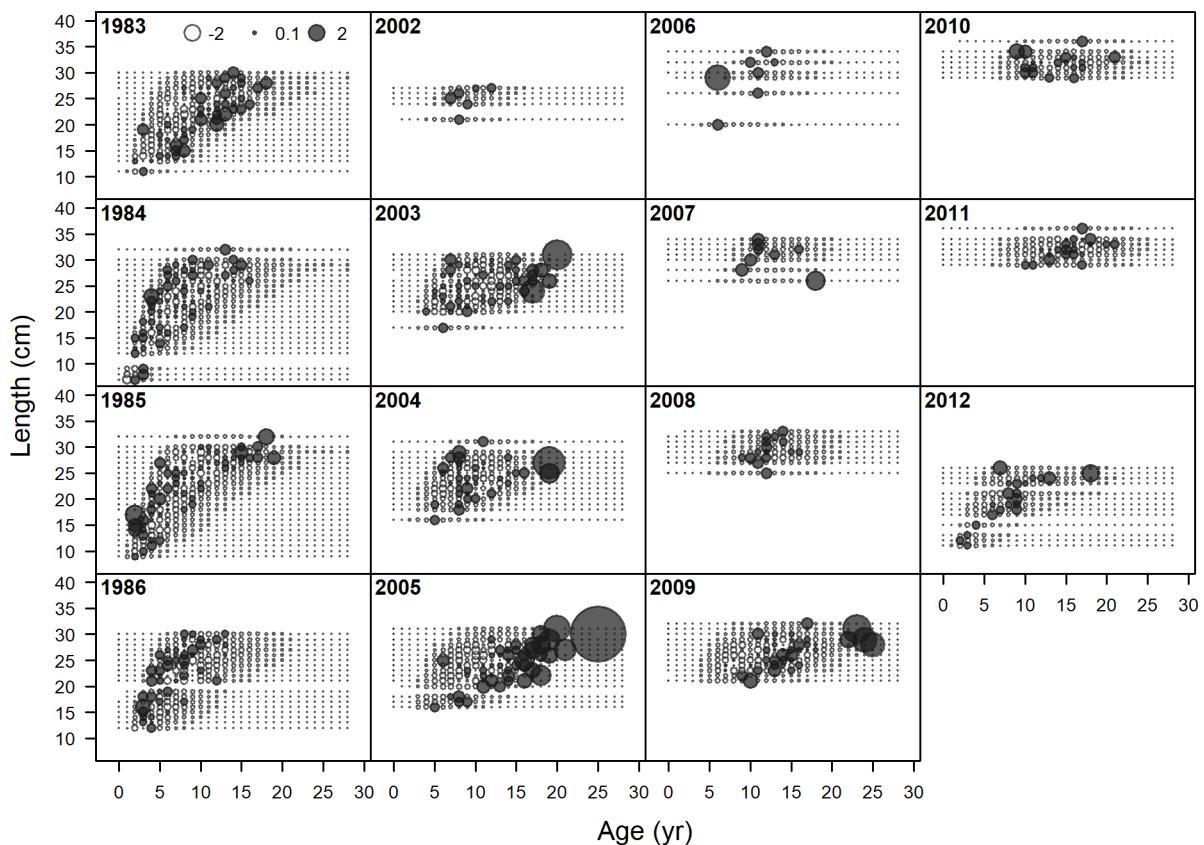


Figure 41: Pearson residuals, whole catch, Dummy1 (max=22.55) `fig:mod1_4_comp_condAALf`

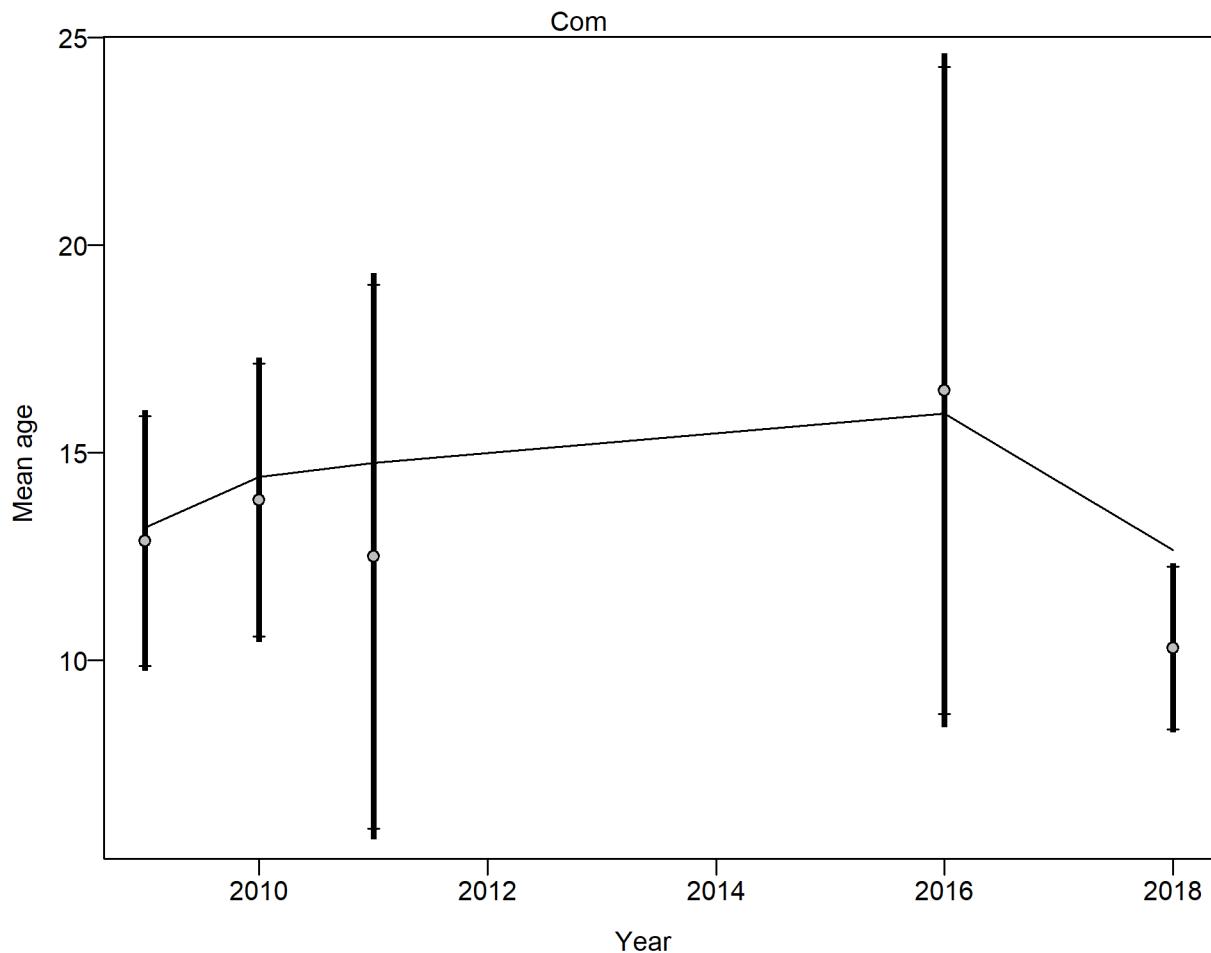


Figure 42: Mean age from conditional data (aggregated across length bins) for Com with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% interval) for conditional age_at_length data from Com: 1.0859 (0.6193_33.7322) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod1_5_com

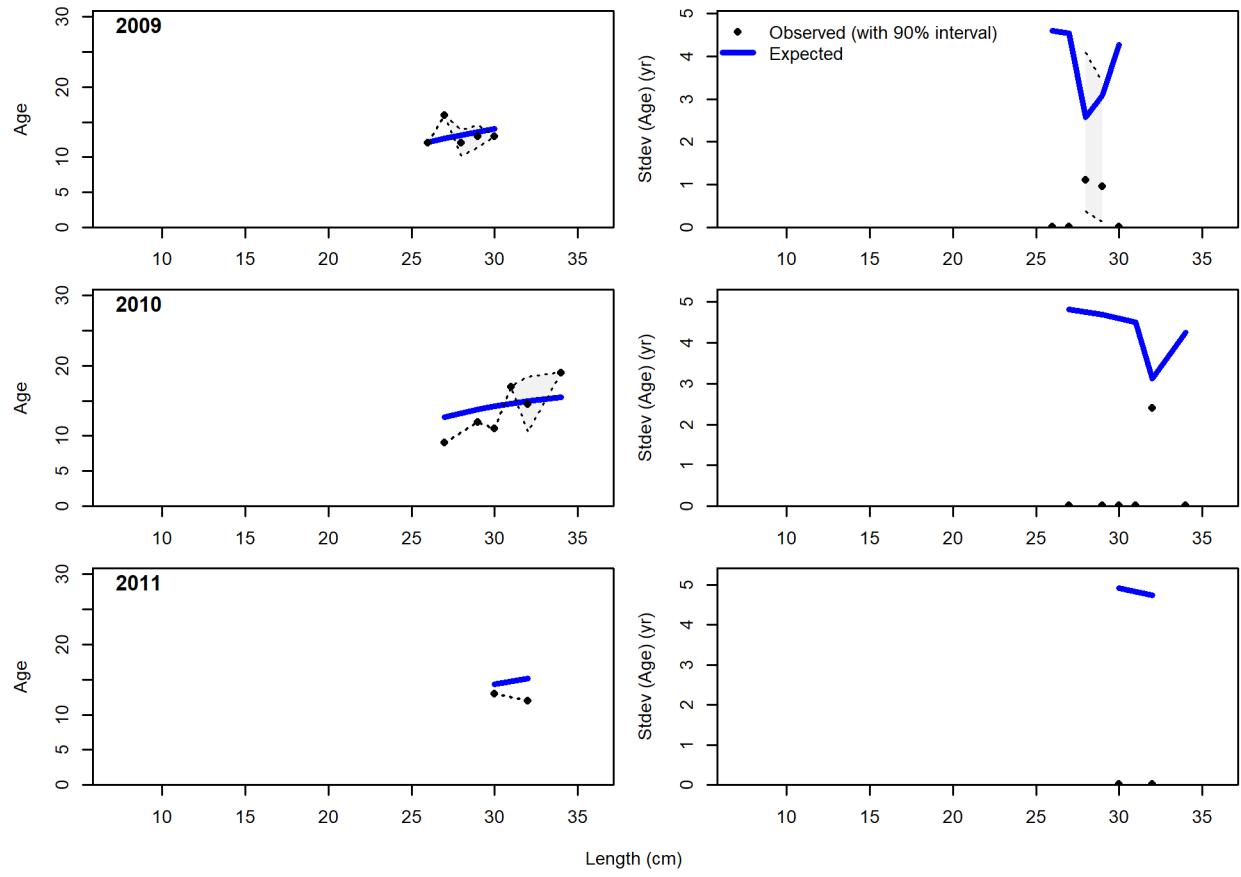


Figure 43: Conditional AAL plot, whole catch, Com (plot 1 of 2) These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.) with 90% CIs based on the chi_square distribution. [fig:mod1_6_comp_cond](#)

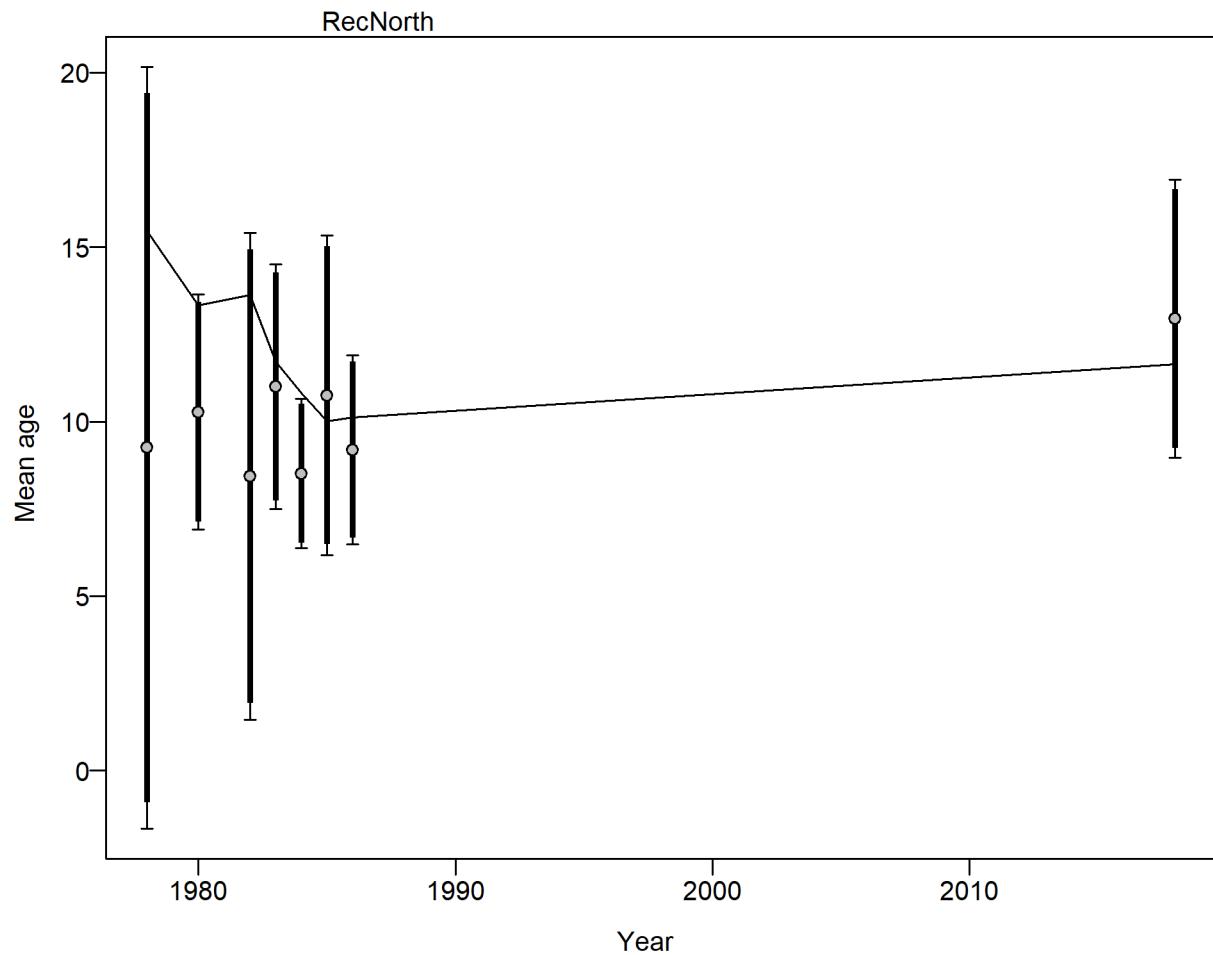


Figure 44: Mean age from conditional data (aggregated across length bins) for RecNorth with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% interval) for conditional age_at_length data from RecNorth: 0.8677 (0.589_3.1055) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod1_8_com

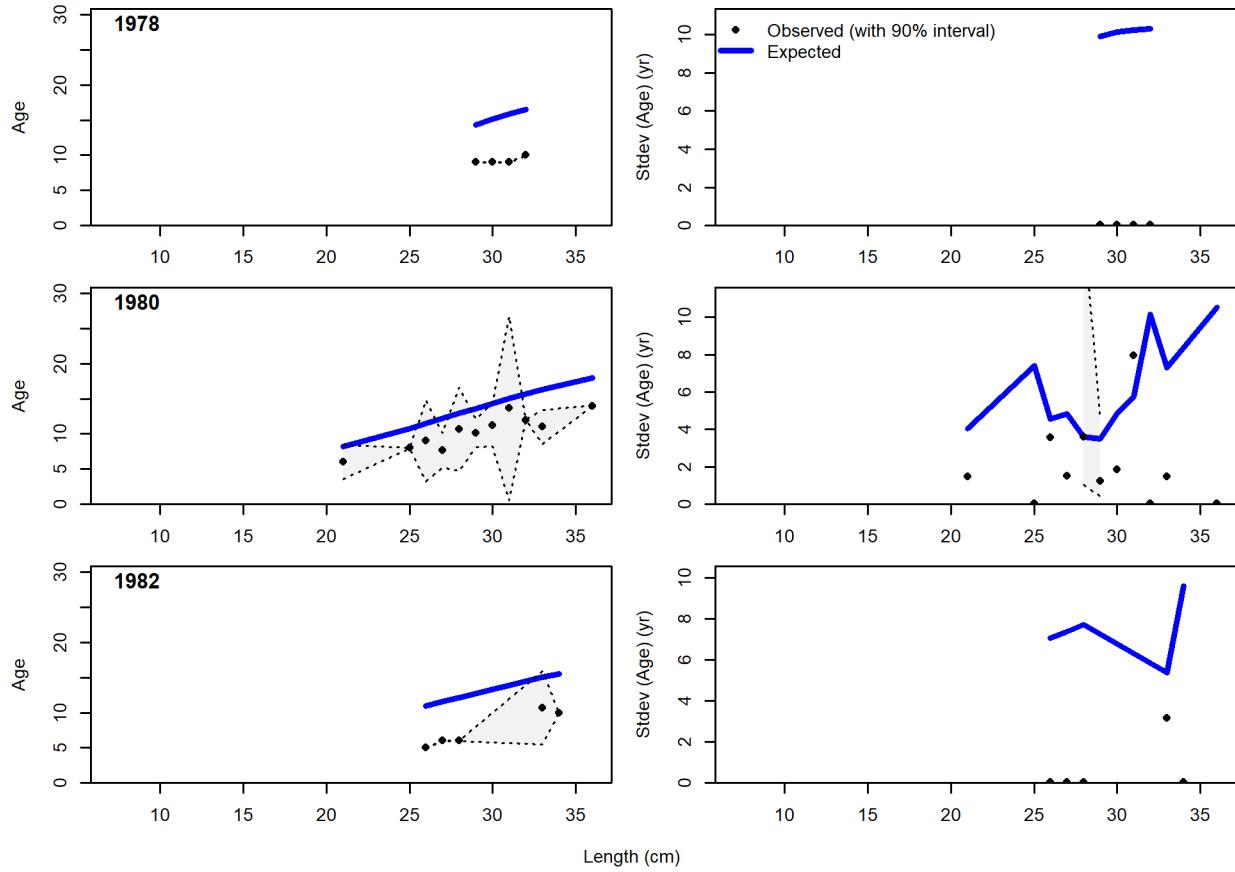
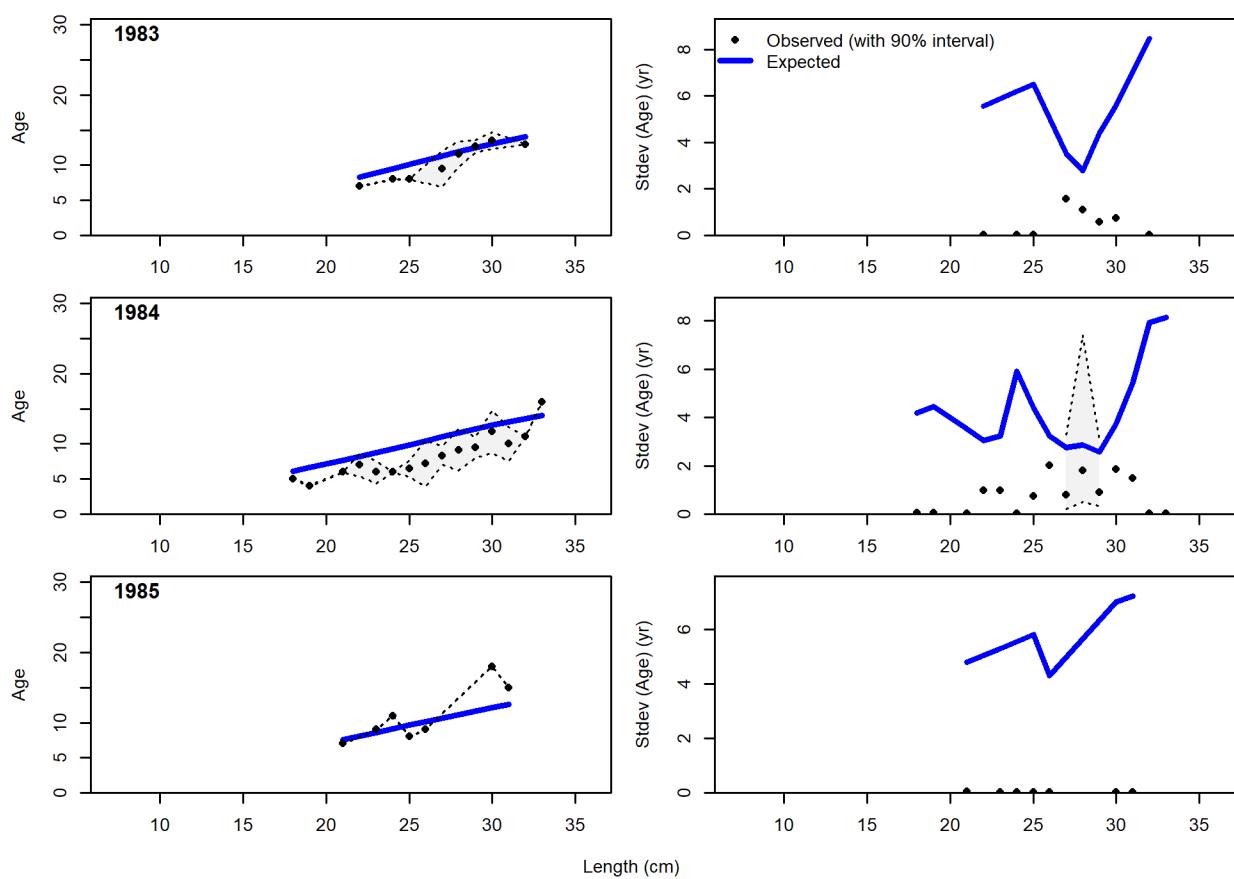


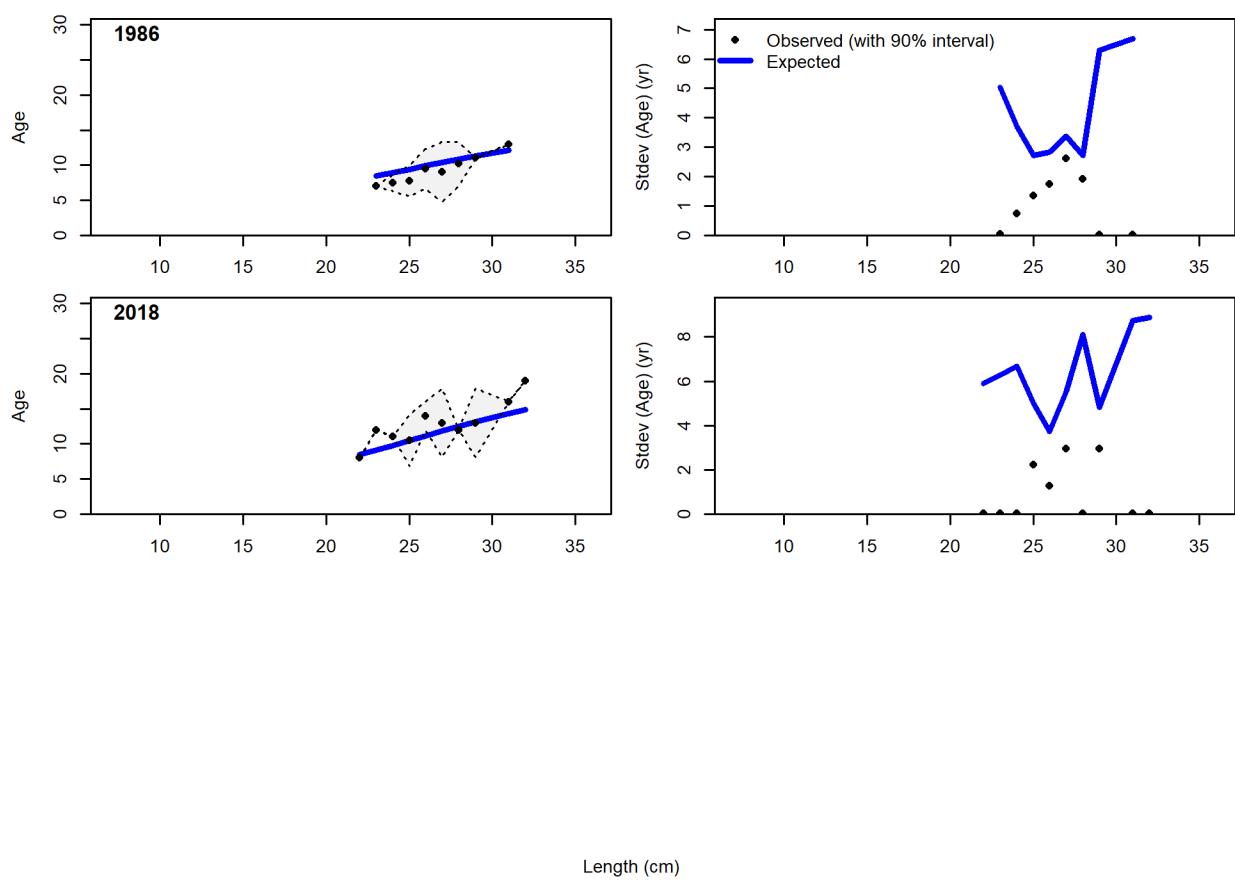
Figure 45: Conditional AAL plot, whole catch, RecNorth (plot 1 of 3) These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.) with 90% CIs based on the chi_square distribution.



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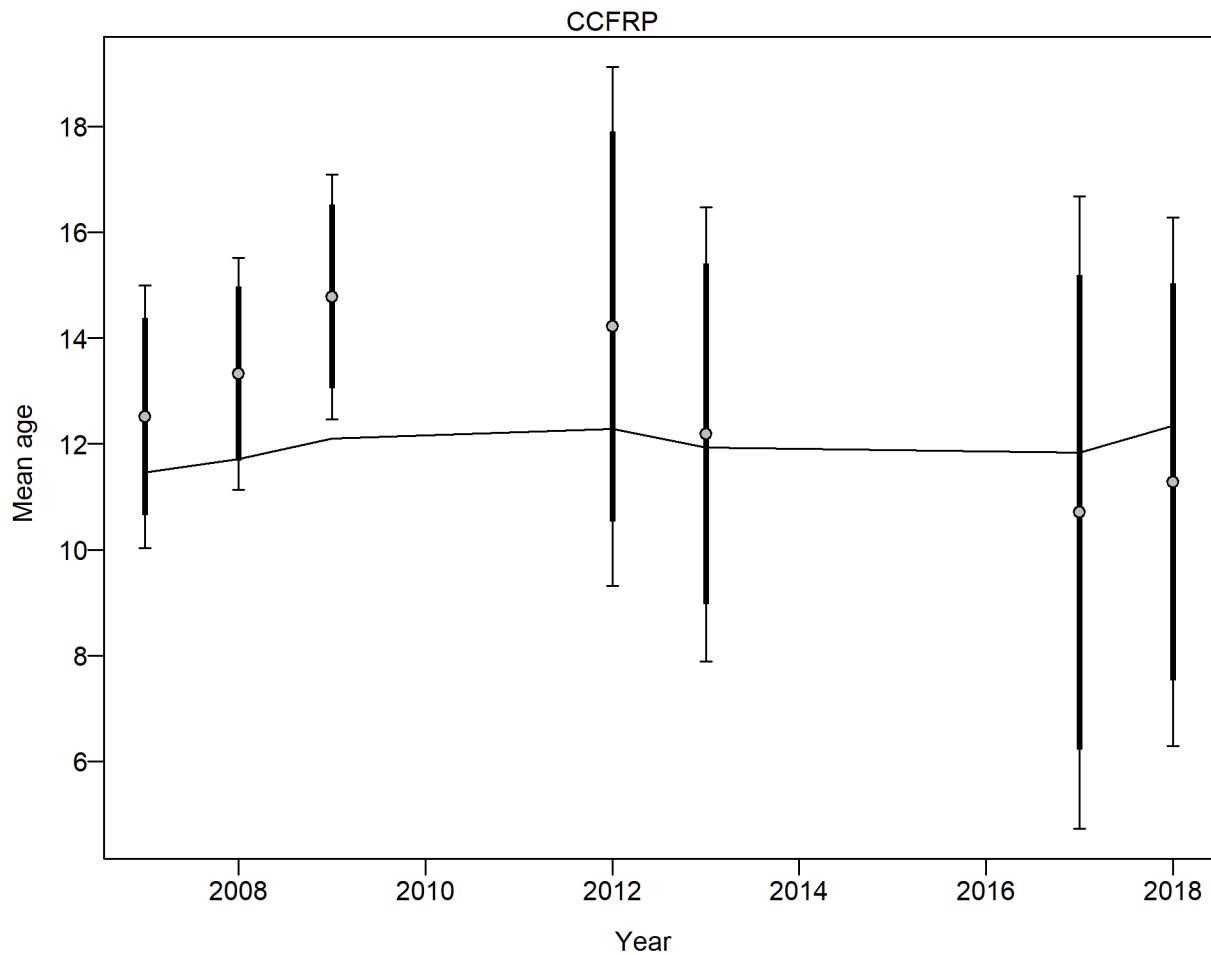


Figure 46: Mean age from conditional data (aggregated across length bins) for CCFRP with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% interval) for conditional age_at_length data from CCFRP: 0.5645 (0.344_2.4444) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod1_12_c...

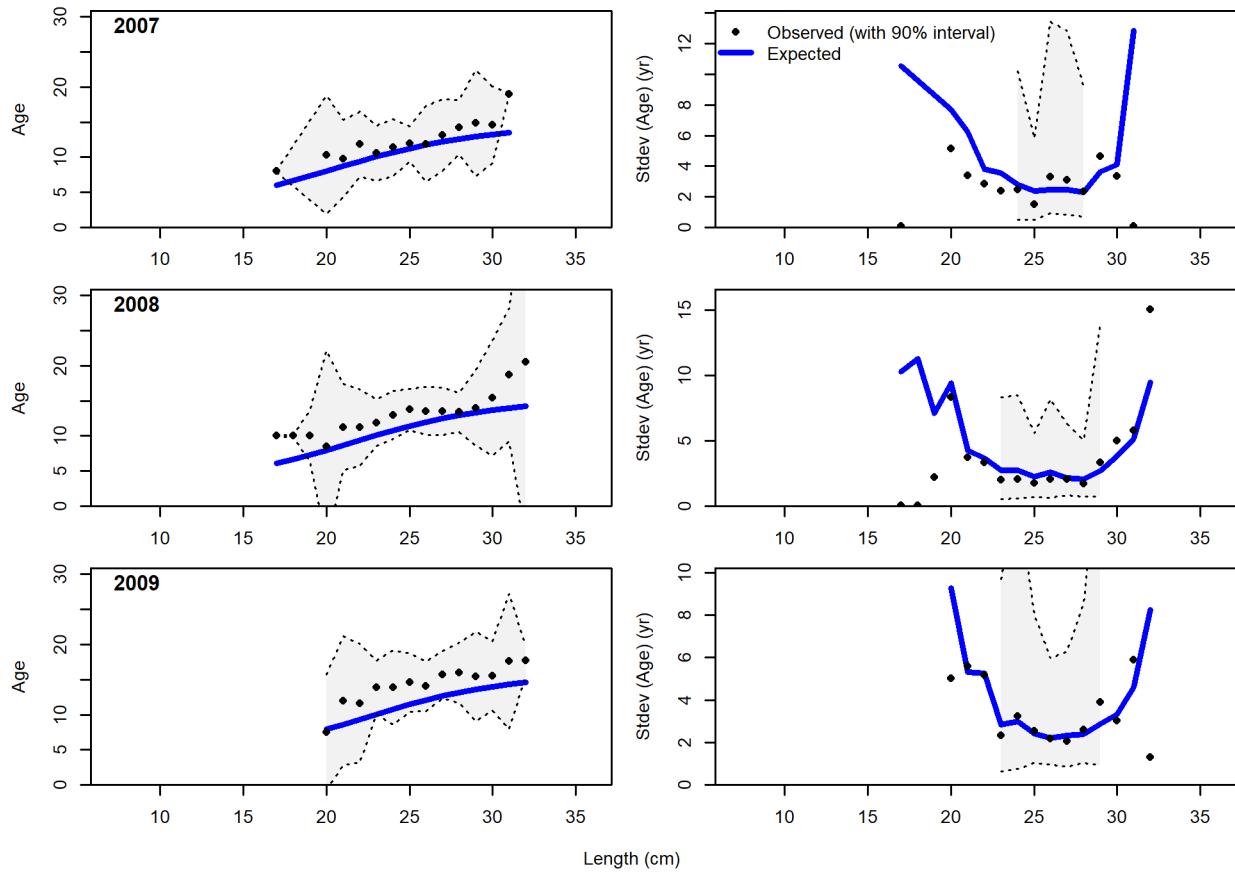
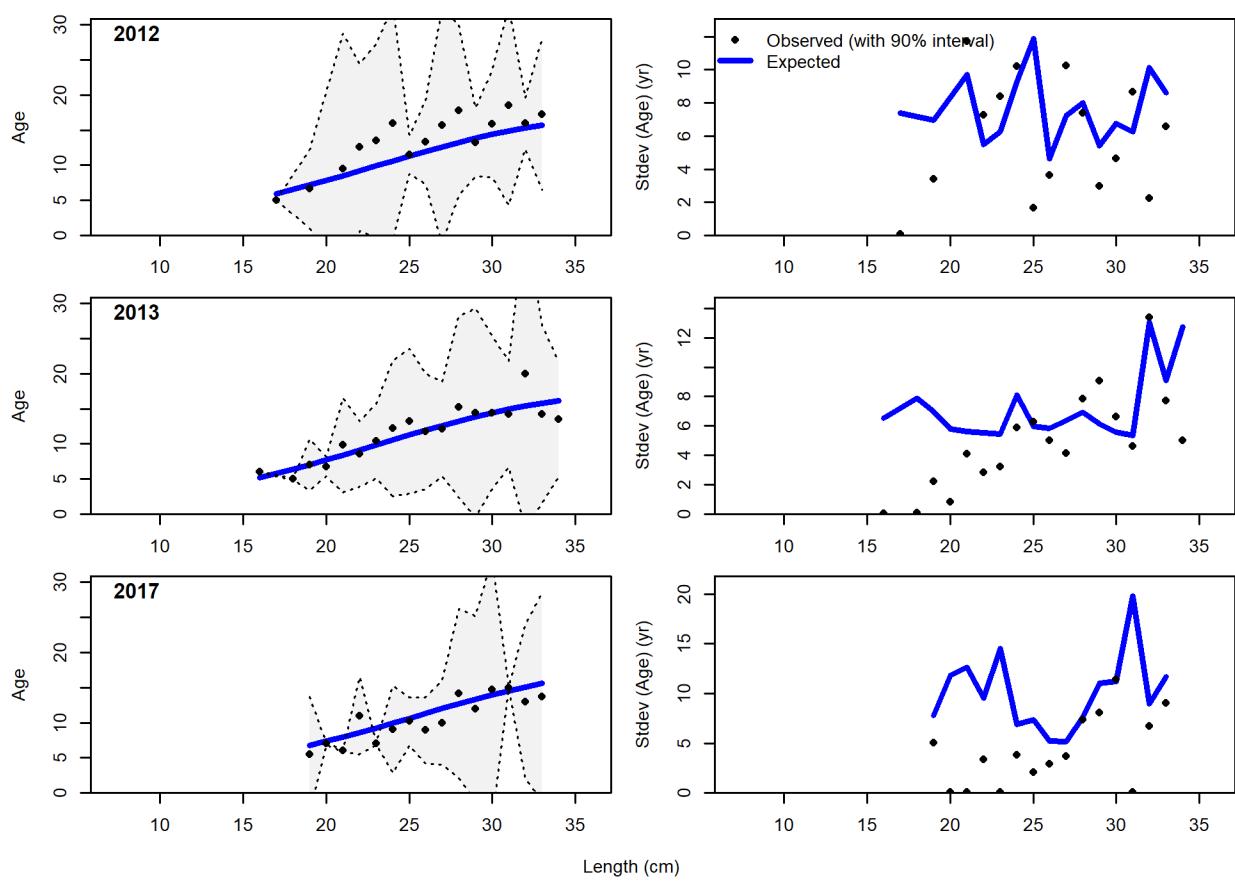


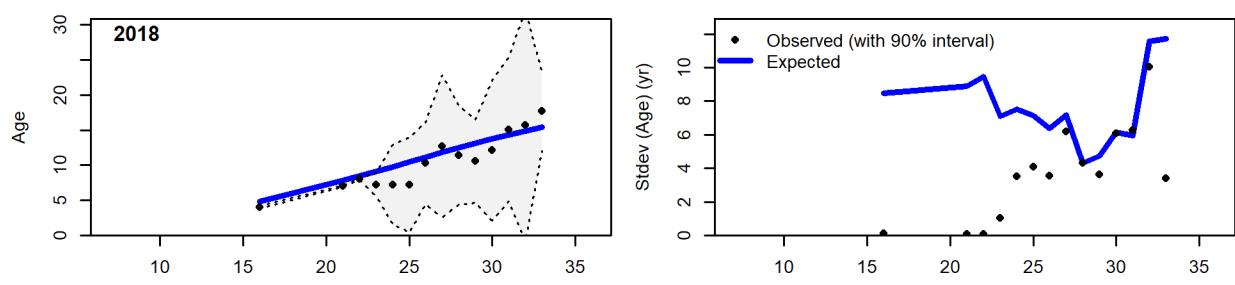
Figure 47: Conditional AAL plot, whole catch, CCFRP (plot 1 of 3) These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.) with 90% CIs based on the chi_square distribution. fig:mod1_13_c



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Length (cm)

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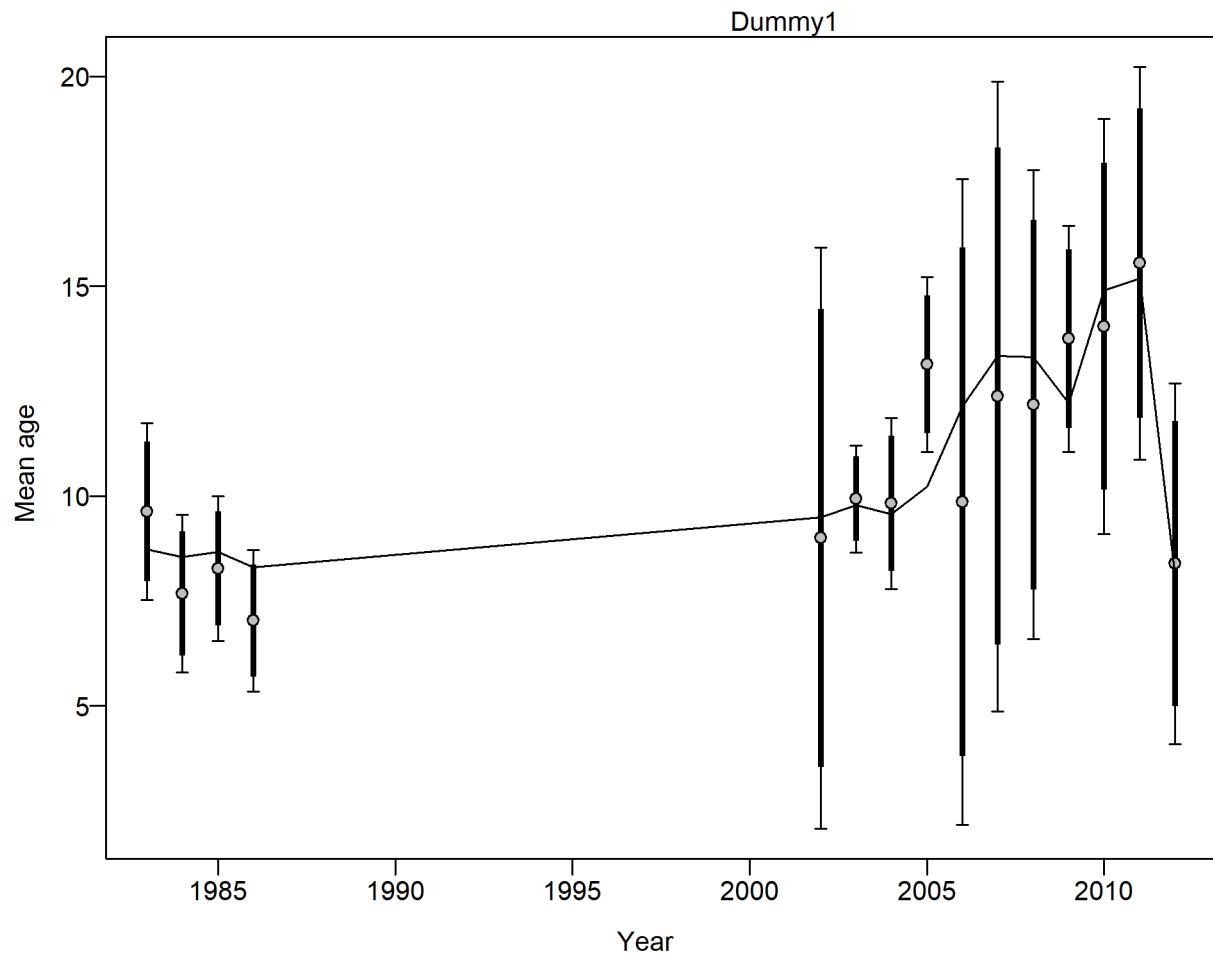


Figure 48: Mean age from conditional data (aggregated across length bins) for Dummy1 with 95% confidence intervals based on current samples sizes. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% interval) for conditional age_at_length data from Dummy1: 0.6218 (0.324_3.077) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod1_16_co

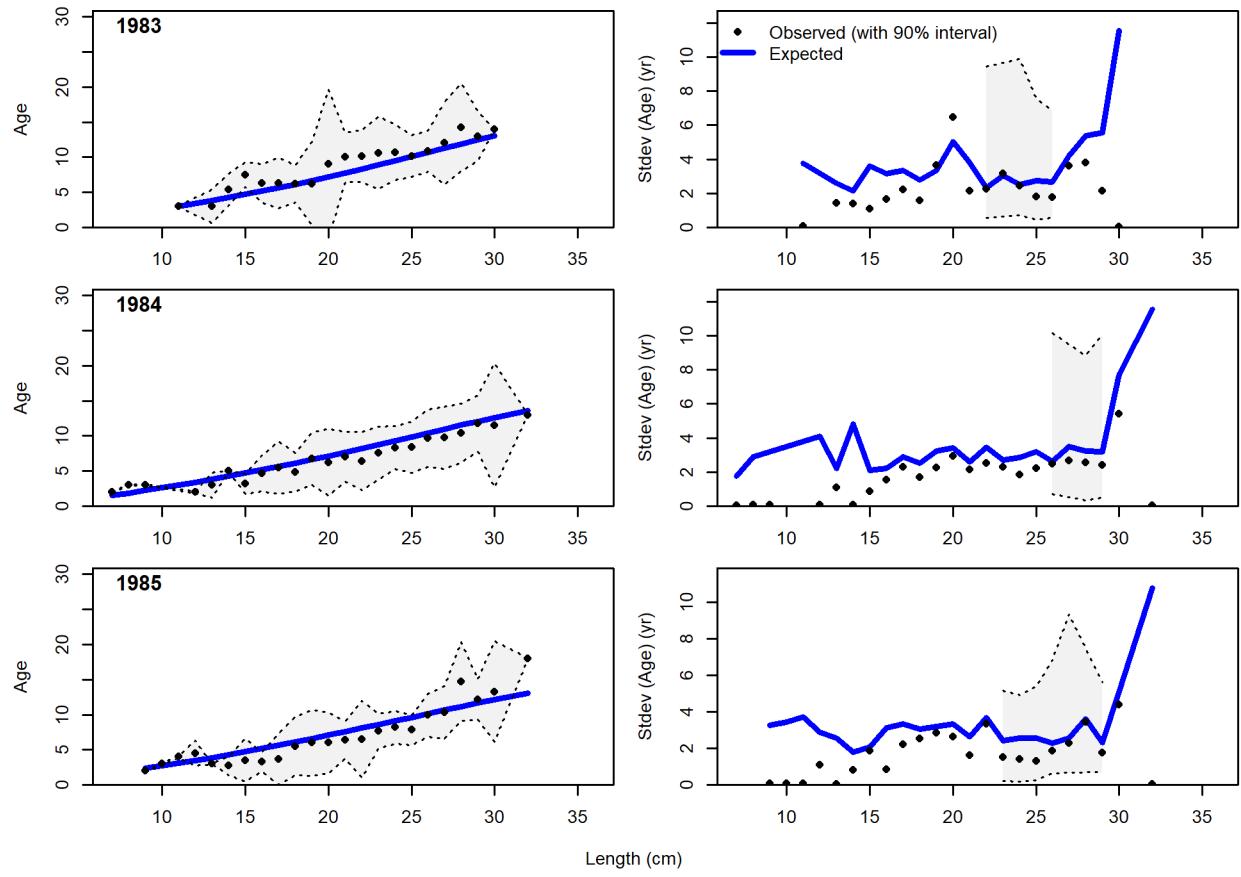
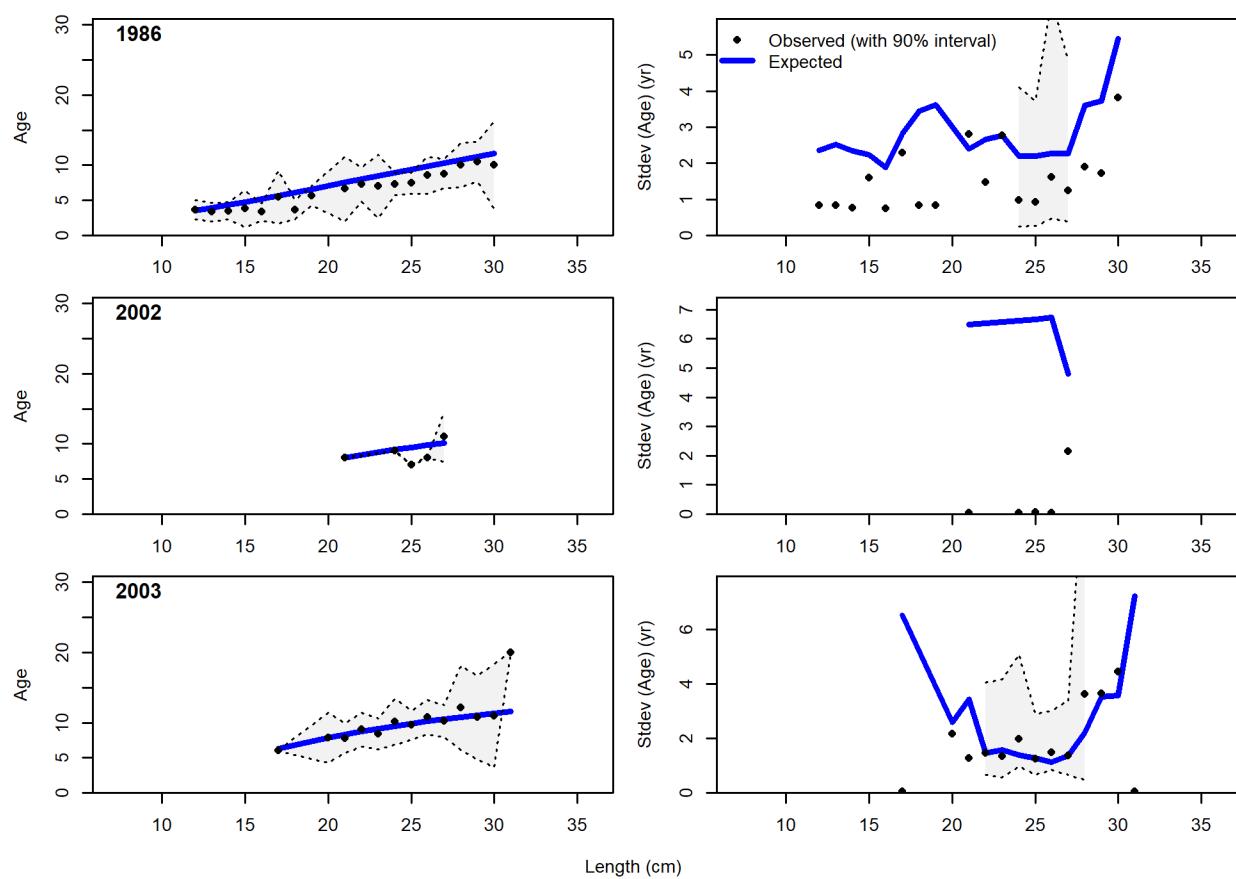


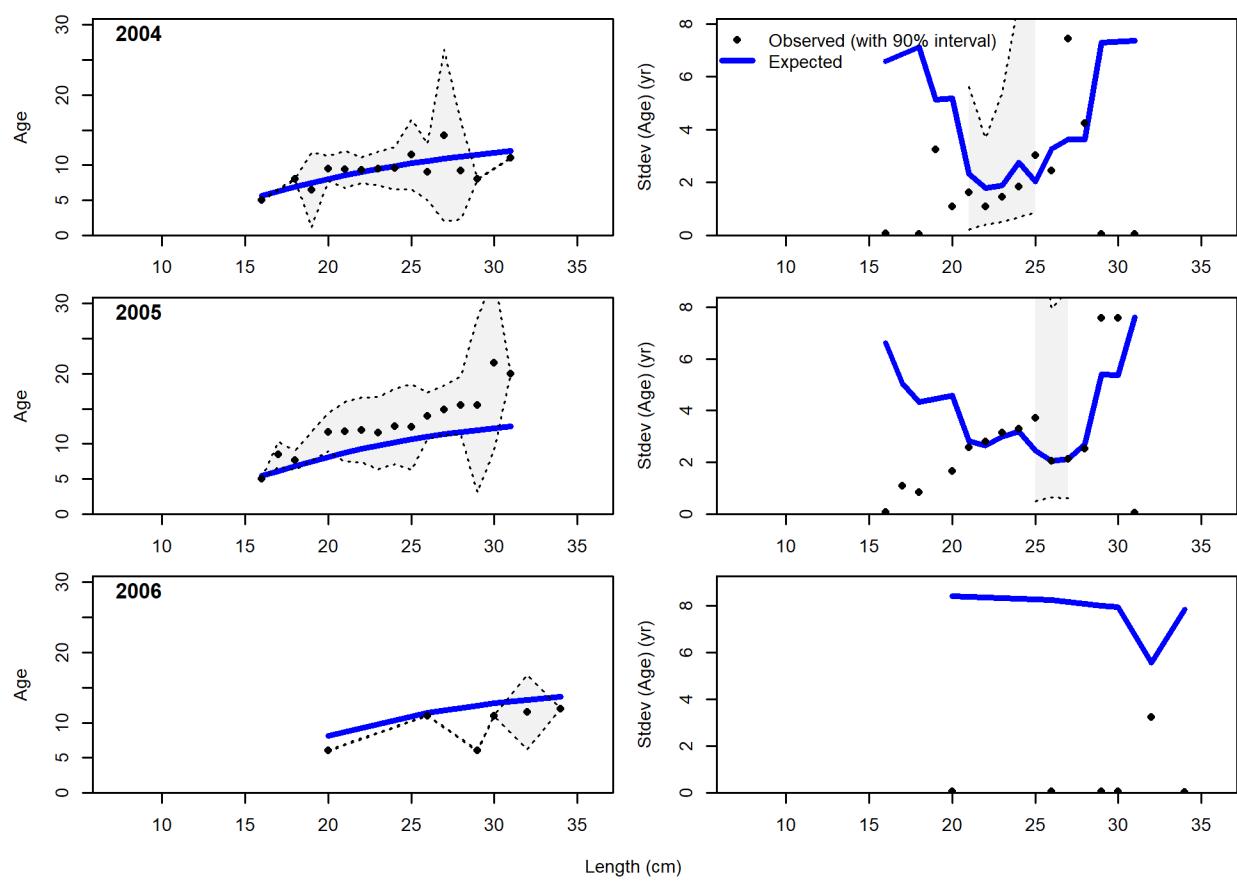
Figure 49: Conditional AAL plot, whole catch, Dummy1 (plot 1 of 5) These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.) with 90% CIs based on the chi_square distribution. fig:mod1_17_c



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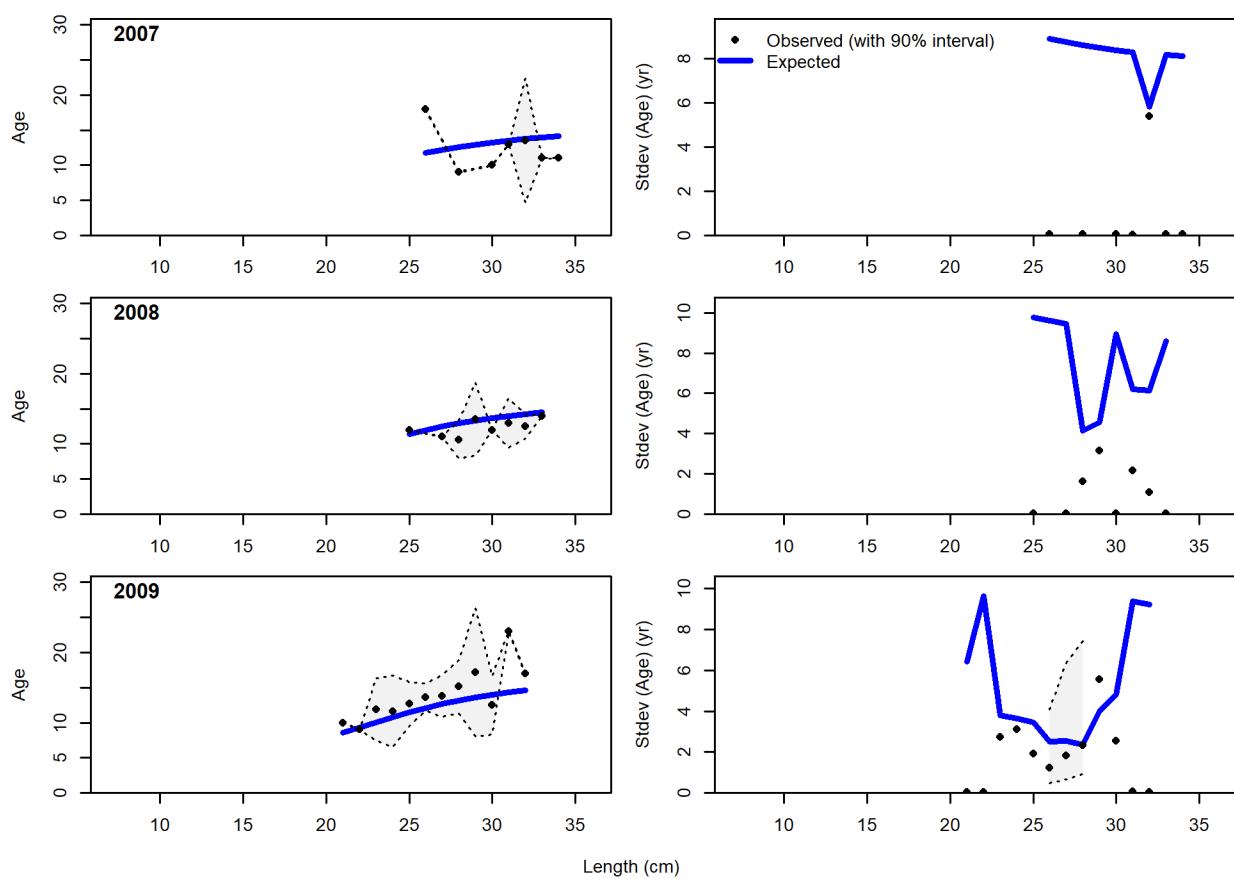
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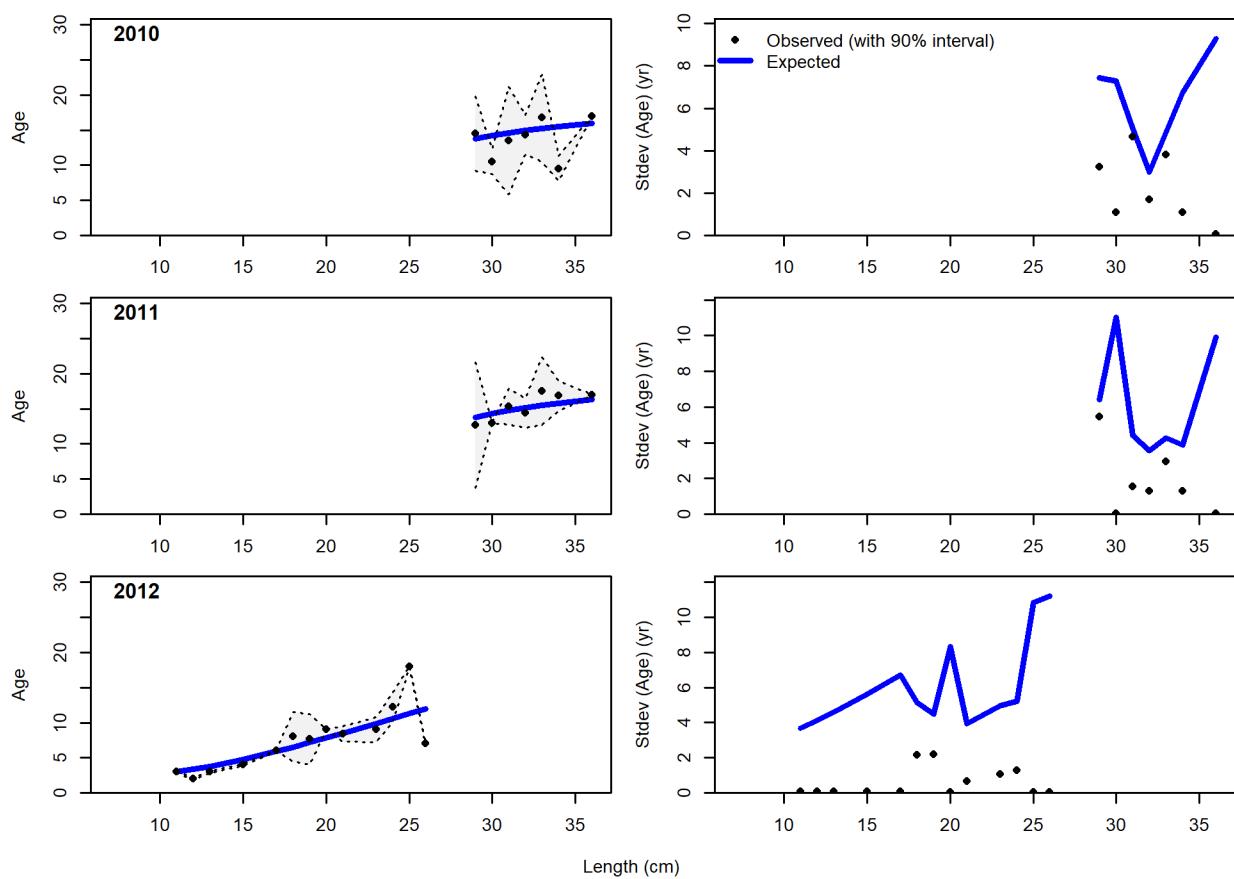
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1347 j!*****h Likelihood profile FIGURES***** -j

1348 j!***** -j

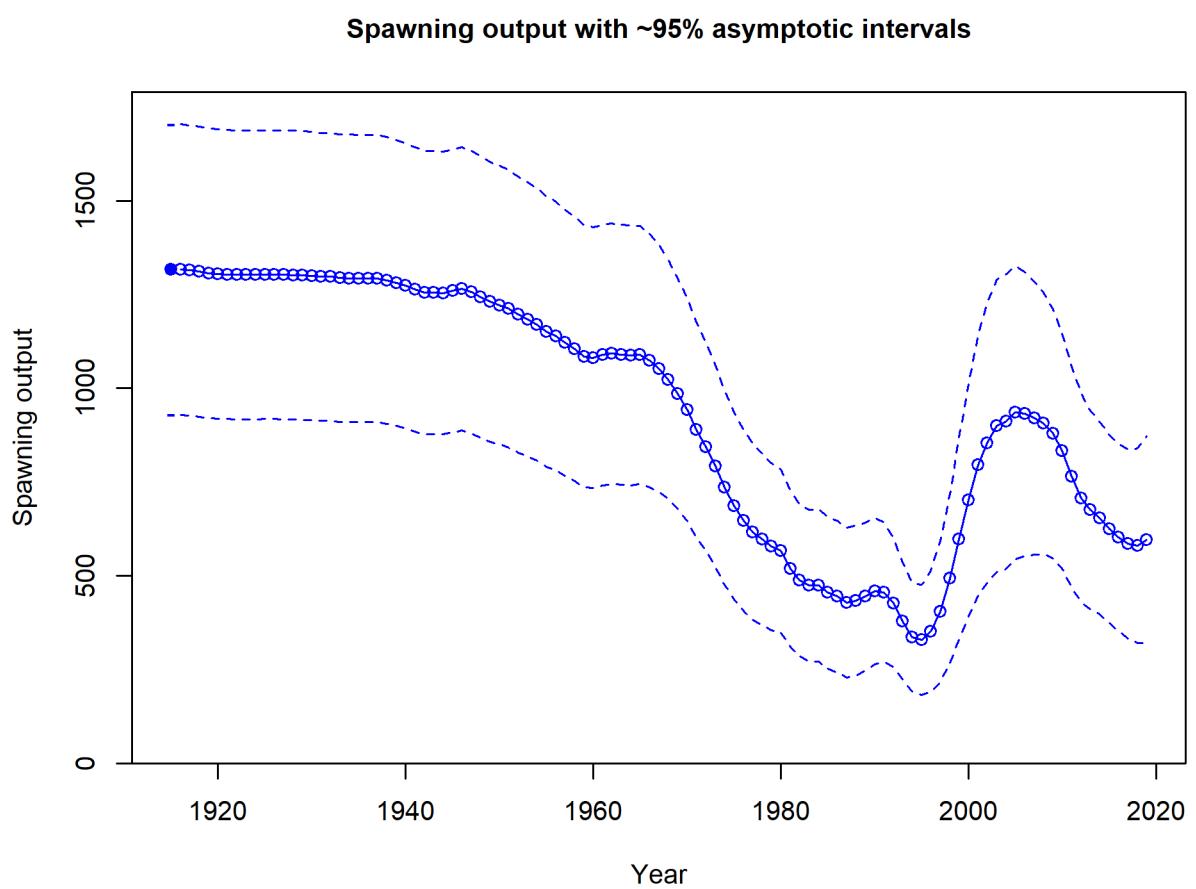


Figure 50: Estimated spawning biomass (mt) with approximate 95% asymptotic intervals. fig:ts7_Spawn

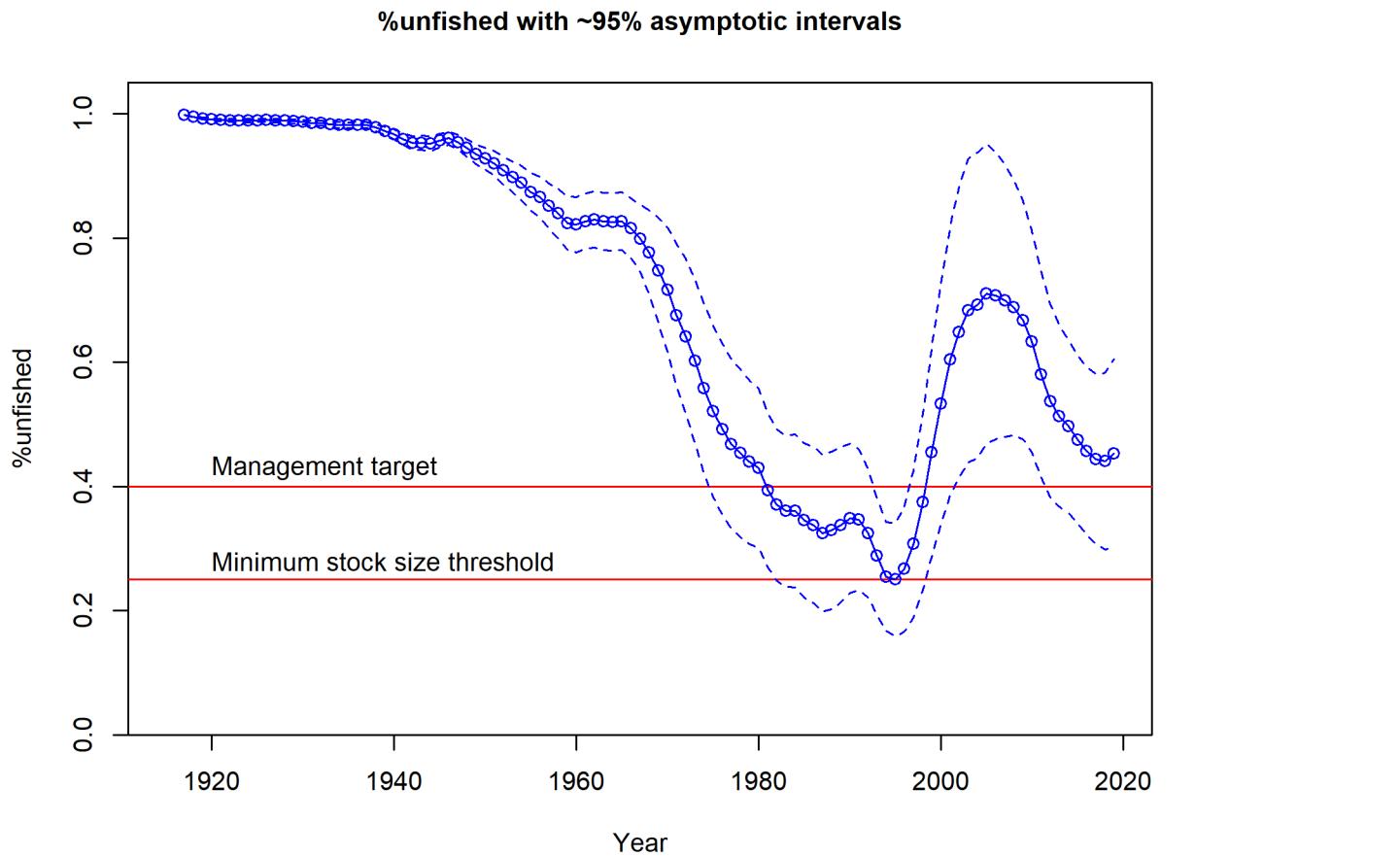


Figure 51: Estimated spawning depletion with approximate 95% asymptotic intervals. fig:ts9_unfish

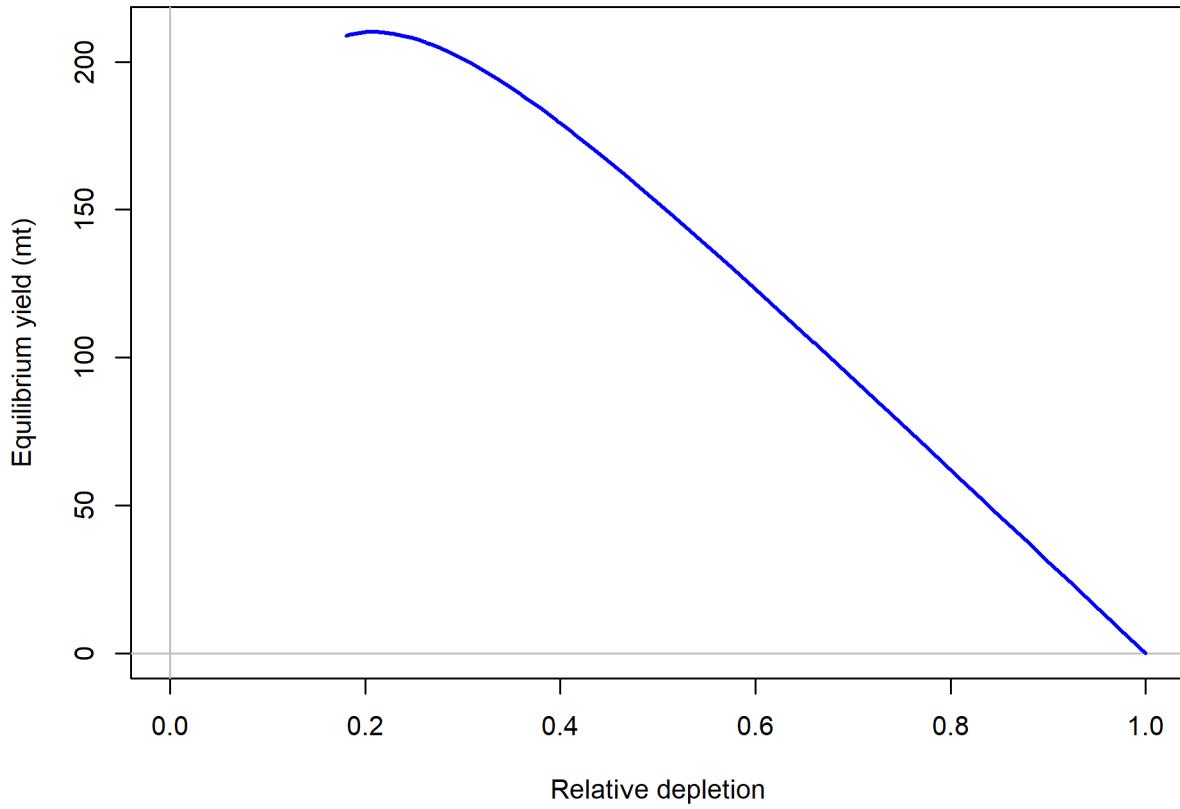


Figure 52: Equilibrium yield curve for the base case model. Values are based on the 2018 fishery selectivity and with steepness fixed at 0.718. |
fig:yield1_yield_curve

1350 **Appendix A. California's Commercial Fishery Regula-**
1351 **tions**

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

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

Figure A2^{fig:Comm_regs1}

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

Figure A3^{fig:Comm_regs2}

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

Figure A4^{fig:Comm_regs3}

¹³⁵² **Appendix B. California's Recreational Fishery Regulations**

¹³⁵³ appendix-b.-californias-recreational-fishery-regulations

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

Figure B2^{fig:Rec_regs1}

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

Figure B3
fig:Rec_regs2

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

Figure B4^{fig:Rec_regs3}

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

Figure B5^{fig:Rec_reg4}

1354 **Appendix C. Detailed fits to length composition data**

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

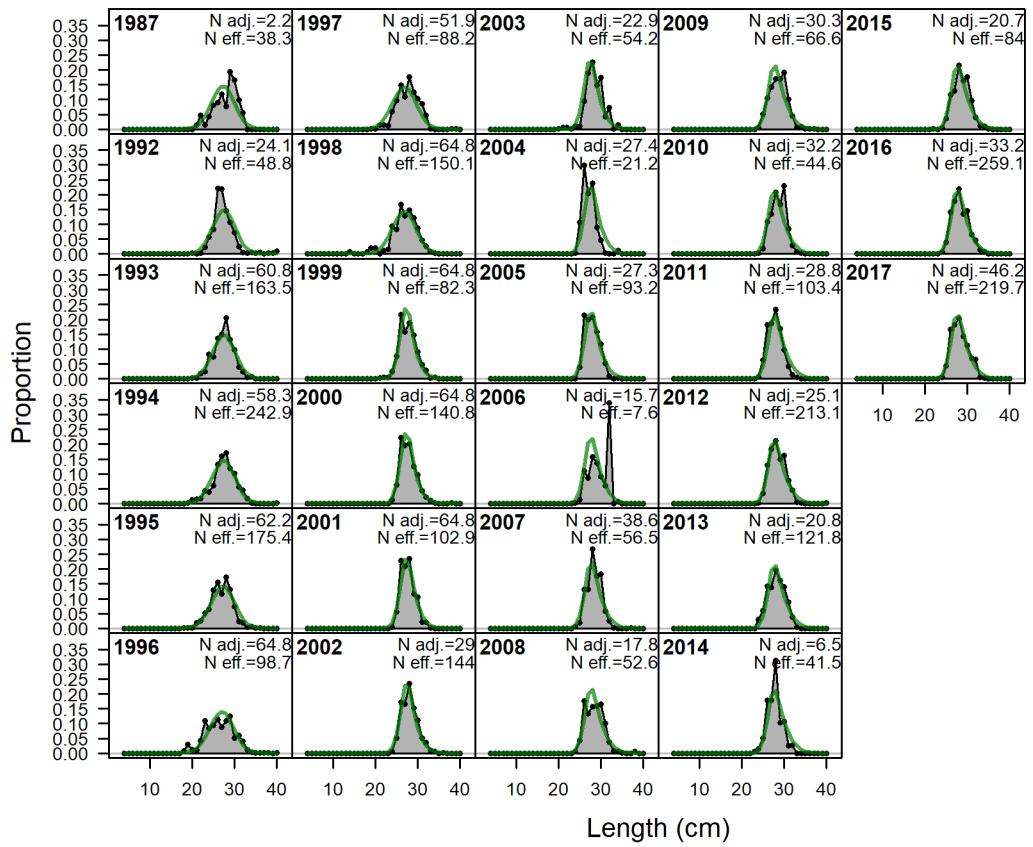


Figure C2: Length comps, retained, Com. ‘N adj.’ is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAlister_Iannelli tuning method. [fig:mod1_1_comp_1enfit_fltimkt2](#)

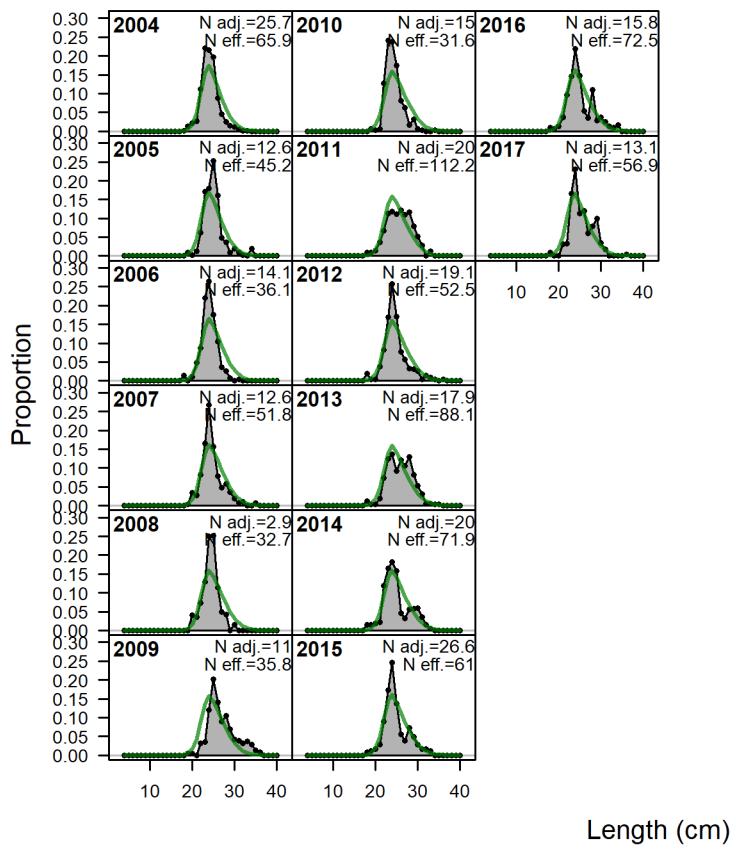


Figure C3: Length comps, retained, ComDisc. ‘N adj.’ is the input sample size after data_weighting adjustment. N_eff. is the calculated effective sample size used in the McAlister_Iannelli tuning method. ^{fig:mod1_2_comp_1enfit_flt2mkt2}

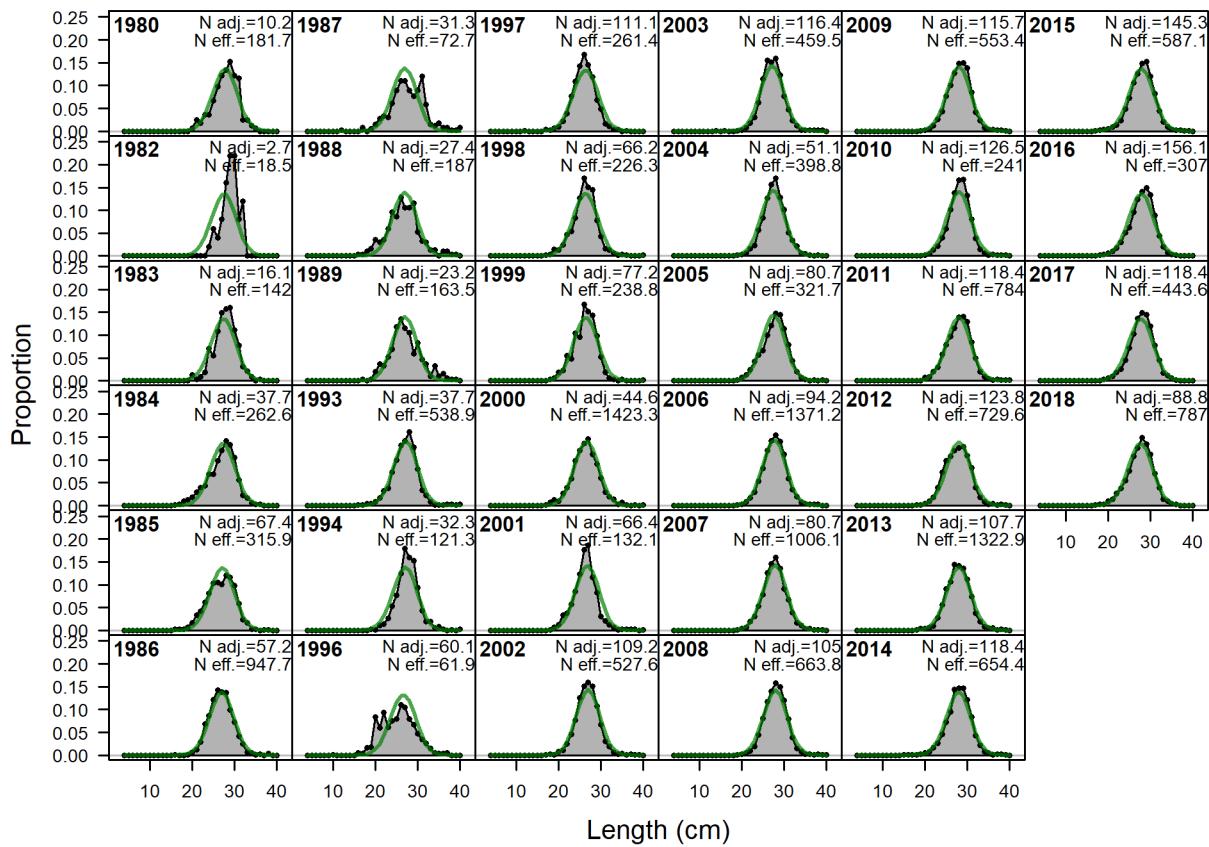


Figure C4: Length comps, whole catch, RecNorth. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method. | [fig:mod1_3_comp_lenfit_flt3mkto](#)

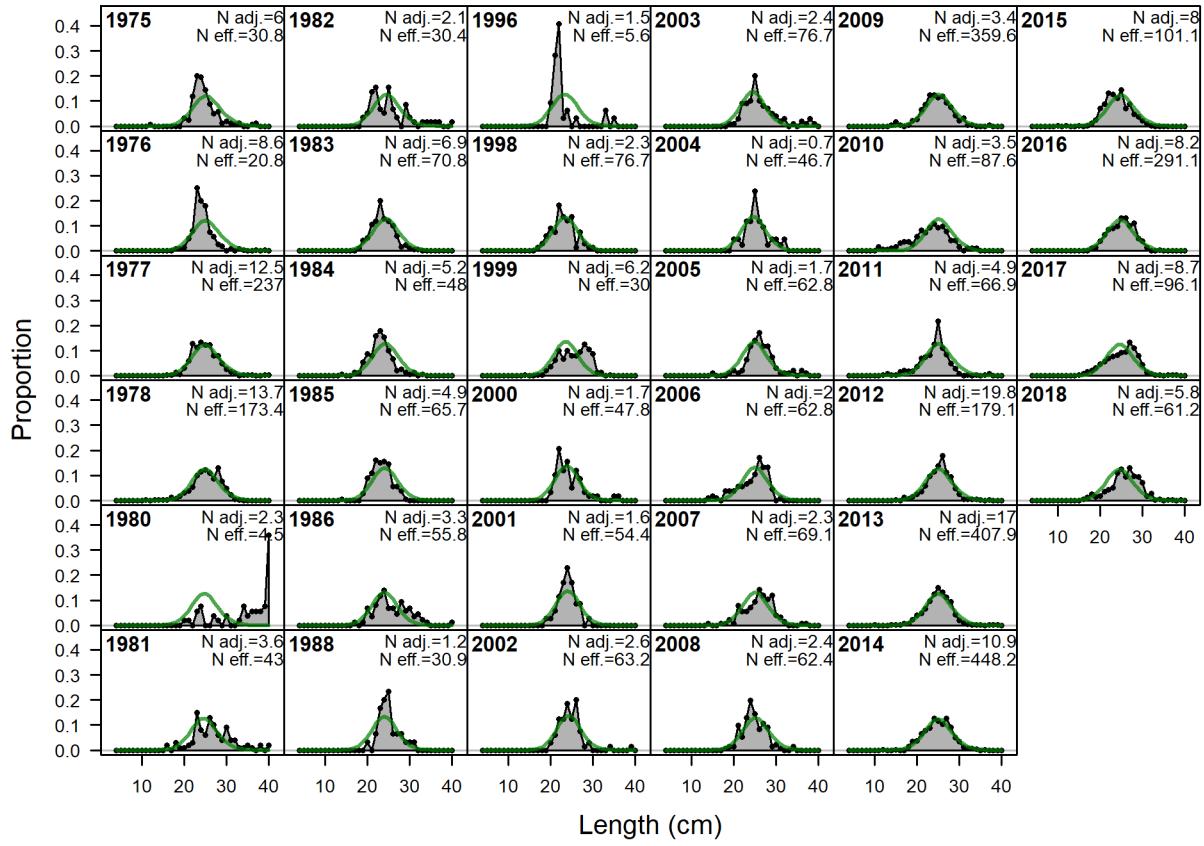


Figure C5: Length comps, whole catch, RecSouth. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method. | [fig:mod1_4_comp_lenfit_flt4mkt0](#)

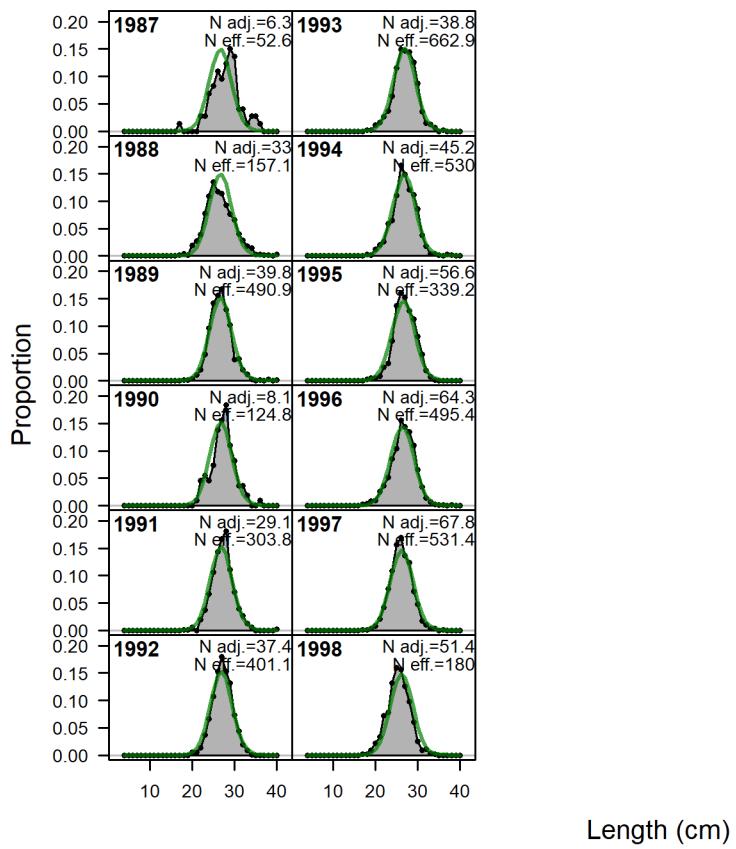


Figure C6: Length comps, whole catch, DebCPFV. 'N adj.' is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAllister_Iannelli tuning method. | [fig:mod1_5_comp_lenfit_flt5mkto](#)

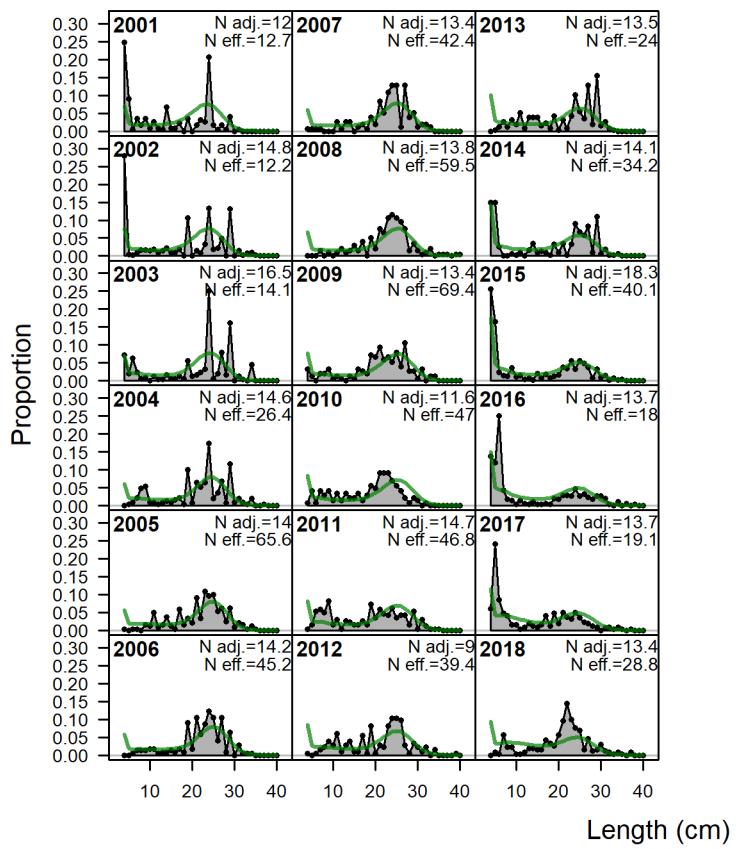


Figure C7: Length comps, whole catch, PISCO. ‘N adj.’ is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAlister_Iannelli tuning method. [fig:mod1_6_comp_1enfit_flt8mkt0](#)

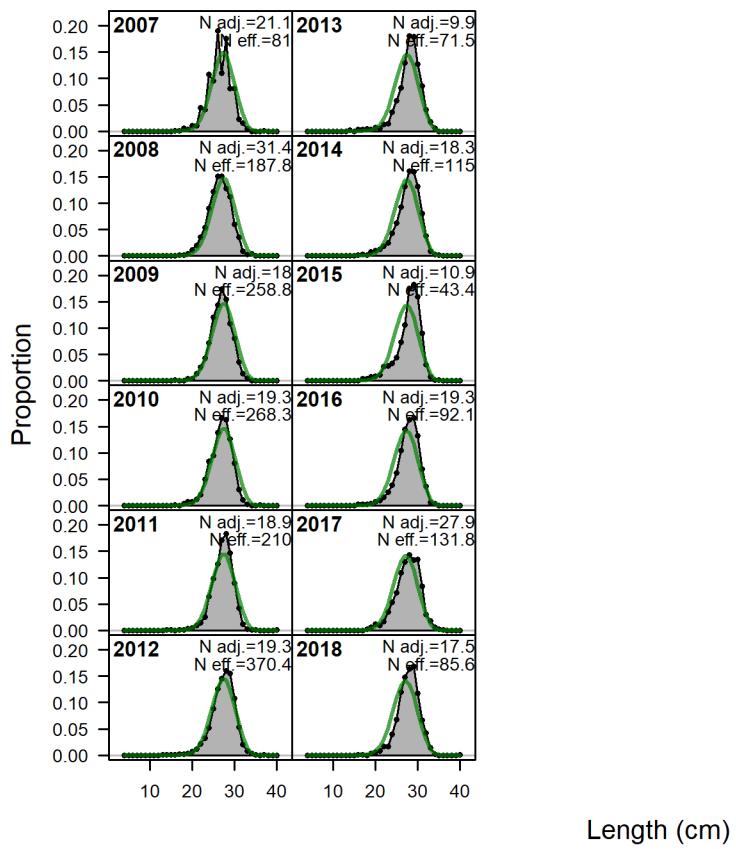


Figure C8: Length comps, whole catch, CCFRP. ‘N adj.’ is the input sample size after data_weighting adjustment. N eff. is the calculated effective sample size used in the McAlister_Iannelli tuning method. [fig:mod1_7_comp_1enfit_flt9mkt0](#)

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