Stock Assessment Update: Status of Bocaccio, *Sebastes paucispinis*, in the Conception, Monterey and Eureka INPFC areas for 2017

by
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Table of Contents

Executive Summary

Stock

This update assessment reports the status of the Bocaccio rockfish (*Sebastes paucispinis*) off of the West Coast of the United States, from the U.S.-Mexico border to Cape Blanco, Oregon (representing the Conception, Monterey and Eureka INPFC areas which is all U.S. waters south of 40^{o}10'N latitude), and it is an update of the 2015 benchmark assessment (He et al. 2015). Although the range of Bocaccio extends considerably further north, there is some evidence that there are two demographic clusters centered around southern/central California and the West Coast of British Columbia, with a relative rarity of Bocaccio (particularly smaller fish) in the region between Cape Mendocino and the mouth of the Columbia River. This is supported by apparent differences in growth, maturity and longevity, although genetic evidence seems to indicate a single West Coast population. Within the stock area, there is also evidence of limited demographic separation, which is treated through some separation of fleets and data. These and other issues related to stock identification and relative levels of demographic mixing and isolation remain important research questions for future assessments.

Catches

Bocaccio rockfish have long been one of the most important targets of both commercial and recreational fisheries in California waters, accounting for between 25 and 30% of the commercial rockfish (*Sebastes*) historical catch over the past century. However, this percentage has declined in recent years as a result of stock declines, management actions and the development of alternative fisheries (particularly the widow rockfish fishery in the early 1980s). The catch history for this assessment begins in 1892, and relies heavily on the catch reconstruction efforts and products recently developed for historical California groundfish landings. Total catches, including both commercial and recreational fisheries, have been low in recent years as compared to those in the late period of the last century (Figure 1 and Table 1).

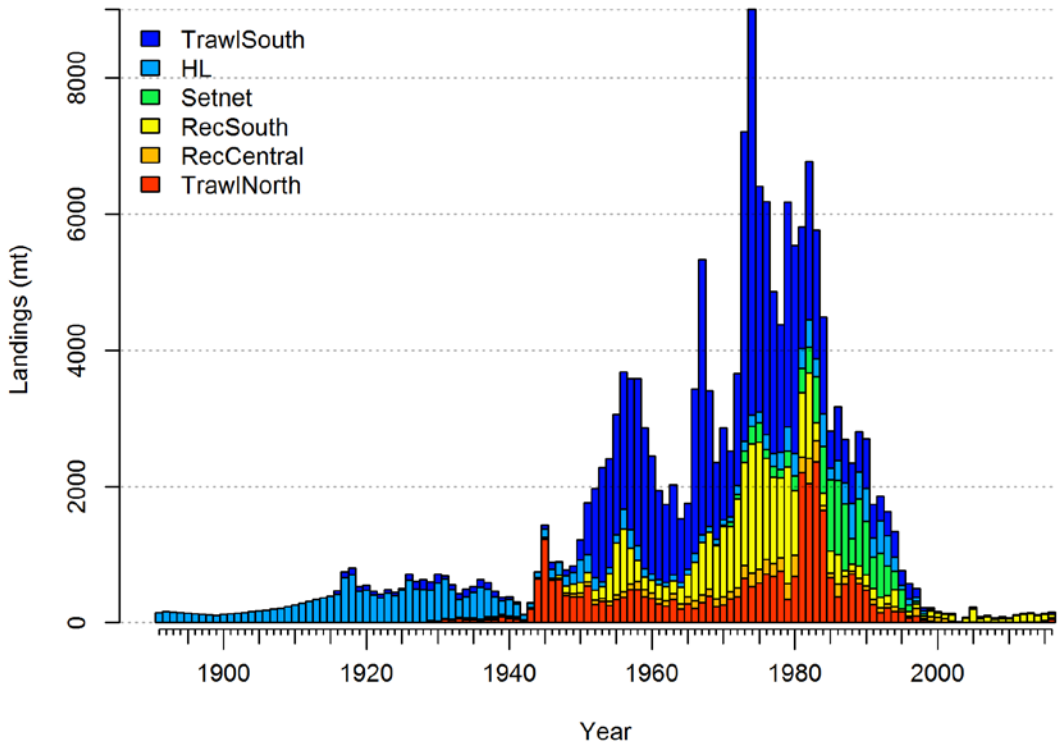

Figure 1. Time series of total catches of Bocaccio (in metric tons) and catches by six fisheries from 1892 to 2016 (HL = hook-and-line fishery).

Table 1: Estimated recent catches (mt) of Bocaccio from six fisheries and sum of annual total catches.

Year	Trawl south	Hook-and-line	Setnet	Recreational south	Recreational central	Trawl north	Total
2007	5.2	10.9	0	80.2	9.3	1.5	107.1
2008	7.5	3.8	0	49.3	3.7	4.4	68.7
2009	19.8	2.7	0	52	8.8	1.4	84.6
2010	12.9	1.8	0	50.1	6.5	2.1	73.4
2011	7.9	2.5	0	99.3	4.1	1.9	115.7
2012	11.4	3.5	0	119.1	5.7	2	141.7
2013	14.3	3.9	0	125.9	5	1.3	150.4
2014	6.4	6.6	0	93.4	6.1	6.5	119
2015	11	7.9	0	82.9	7.5	30	139.4
2016	31.6	0.7	0	57.9	10.1	56.9	157.2

Data and assessment

The last benchmark assessment of Bocaccio rockfish was done in 2015 in Stock Synthesis 3 (version 3.24U; He et al. 2015), and this update assessment uses the same version of the Stock Synthesis 3 software. This assessment update uses the same modeling framework, including the fleet and survey structures, data inputs and analysis, and sensitivity analysis and data-weighting schemes, as in the 2015 assessment. The model includes catch and length-frequency from six fisheries, two trawl fisheries (north and south of 38° N, labelled as “TrawlSouth” and “TrawlNorth”, respectively), a hook-and-line fishery (labelled as “HL”), a set net (gillnet, labelled as “Setnet”) fishery and recreational fisheries south and north of Point Conception, CA (labelled as “RecSouth” and “RecCentral”). Age data are unchanged from the 2015 assessment. Fisheries-dependent relative abundance (CPUE) indices from both trawl fisheries (one index) and recreational fisheries (five indices) are included. Fisheries-independent data used in the past assessments and continued here include the CalCOFI larval abundance time series and the triennial trawl survey index; the NWFSC trawl survey (also referred to as combo trawl survey); the NWFSC Southern California Bight hook-and-line survey; and the coast wide pelagic juvenile index. The growth and natural mortality rates are estimated in the base model, while steepness is fixed at an updated prior value of 0.718 (Thorson, NWFSC, personal communication), which is less than the value (0.773) used in the 2015 assessment.

Stock biomass and spawning output

The spawning output was estimated to be very slightly below the estimated unfished levels in the beginning of the modeled period, due to very moderate fishing pressure that began no later than the 1850s. The spawning output trajectory continues to show a very moderate decline until about 1950, but is estimated to have declined steeply from the early 1950s through the early 1960s as catches rose from several hundred to several thousand tons. The biomass increased sharply thereafter, as a result of one or several very strong recruitment events in the early 1960s, exceeding the mean unfished biomass level through the early 1970s. During that time, catches climbed rapidly to their peak levels, which were associated with high fishing mortality rates and a subsequent rapid drop in spawning output. Fishing mortality remained high throughout the 1980s and 1990s, even as catches, biomass and spawning output declined rapidly. Fishing mortality declined towards the end of the 1990s, in response to severe management restrictions and coincident with a series of several strong year classes (following a decade of very poor recruitment) that began in 1999. Since the early 2000s, spawning output has been increasing steadily. The base model estimates increasing trends of total biomass and spawning outputs, and a current (2017) depletion level of 48.6% (Figures 2-4 and Table 2).

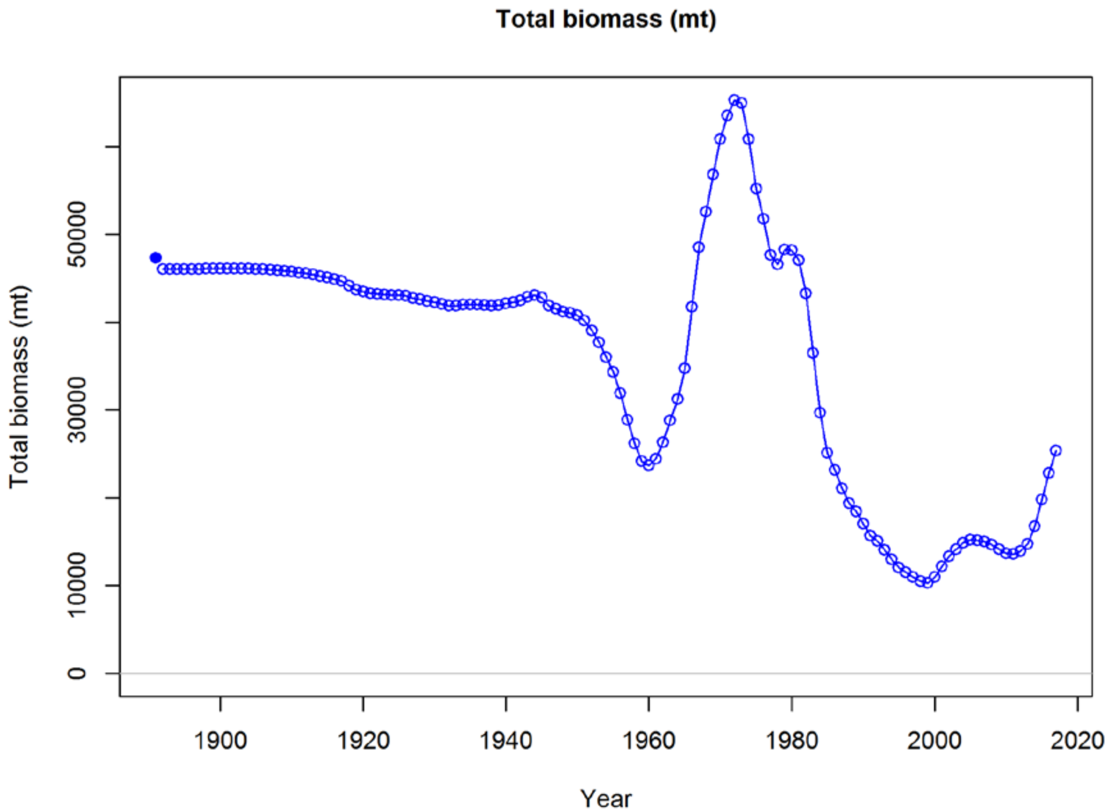

Figure 2. Estimated total biomass (defined as biomass for all fish age 1 and older).

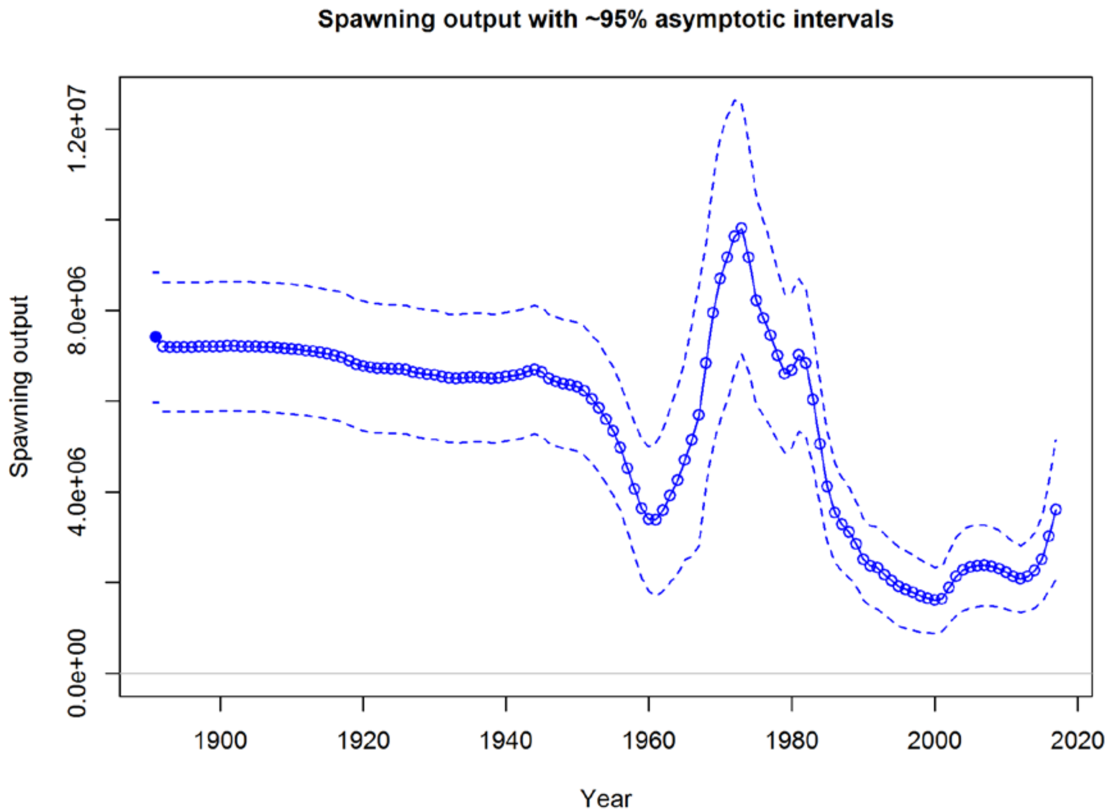

Figure 3. Estimated spawning output (10^6 larvae) with 95% confident intervals.

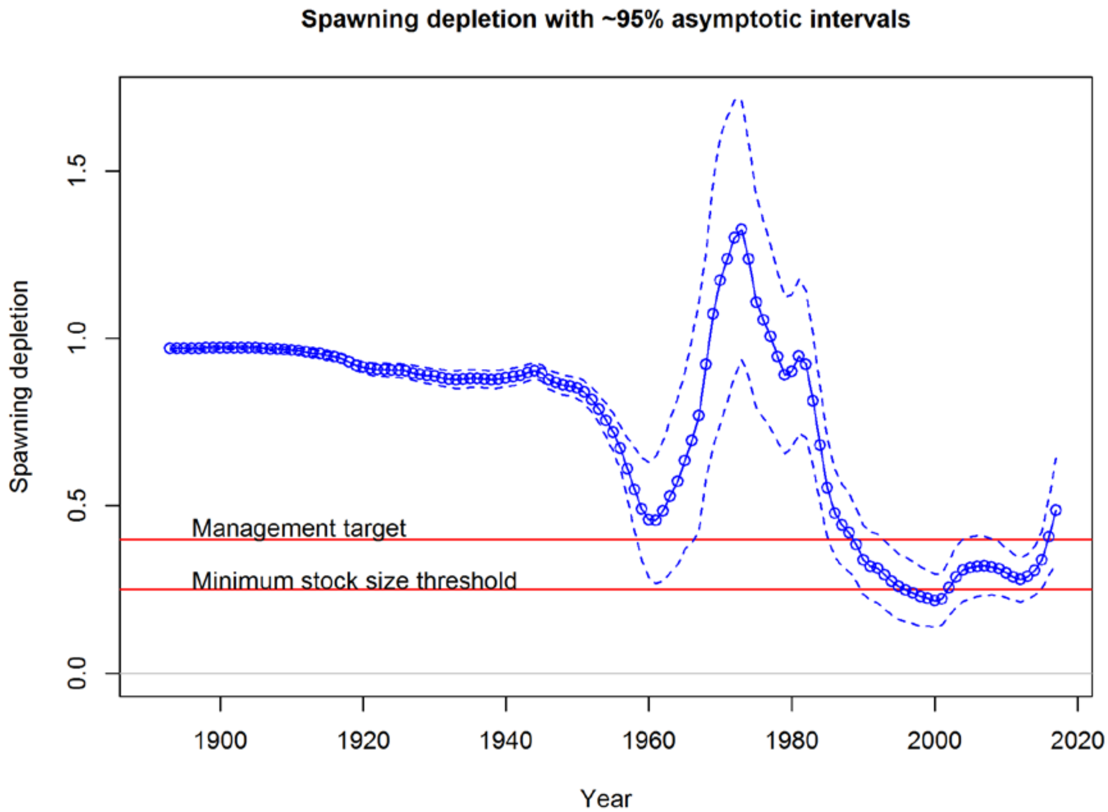

Figure 4. Estimated stock depletion with 95% asymptotic intervals.

Table 2: Estimated recent trends in estimated spawning outputs, recruitment, and stock depletion.

Year	Spawning output (10^6 larvae)	~95% confident interval	Recruitment (10^6)	~95% confident interval	Stock depletion (%)	~95% confident interval
2007	2379	1489 - 3270	1193	635 - 2239	32.1	23.3 - 40.9
2008	2356	1487 - 3226	978	500 - 1913	31.8	23.4 - 40.2
2009	2306	1465 - 3146	1949	1092 - 3480	31.1	23.1 - 39.1
2010	2223	1420 - 3025	5459	3214 - 9273	30.0	22.5 - 37.4
2011	2128	1366 - 2890	4594	2532 - 8332	28.7	21.8 - 35.7
2012	2075	1336 - 2814	2831	1454 - 5509	28.0	21.4 - 34.6
2013	2137	1374 - 2899	15582	8561 - 28358	28.8	22.1 - 35.6
2014	2270	1447 - 3093	7744	3606 - 16630	30.6	23.3 – 38.0
2015	2505	1570 - 3439	4223	1715 - 10400	33.8	25.3 - 42.3
2016	3022	1821 - 4224	2430	843 - 7004	40.8	29.2 - 52.3
2017	3603	2066 - 5139	6220	1194 - 32412	48.6	33.1 - 64.1

Recruitment

Recruitment for Bocaccio is highly variable, with a small number of year classes tending to dominate the catch in any given fishery or region. Recruitment appears to have been at very low levels throughout most of the 1990s, but several recent year classes (1999, 2010, and 2013) have been strong, particularly relative to spawner abundance, and have resulted in sharp increases in abundance and spawning output. The 2013 recruitment was estimated to be high in the 2015 assessment, and recent length composition and index data are consistent with this year class being among the strongest in the past two decades. Thus, this and other strong year classes (such as 2010) are expected to lead to continued increasing biomass levels over the next few years (Figure 5 and Table 2).

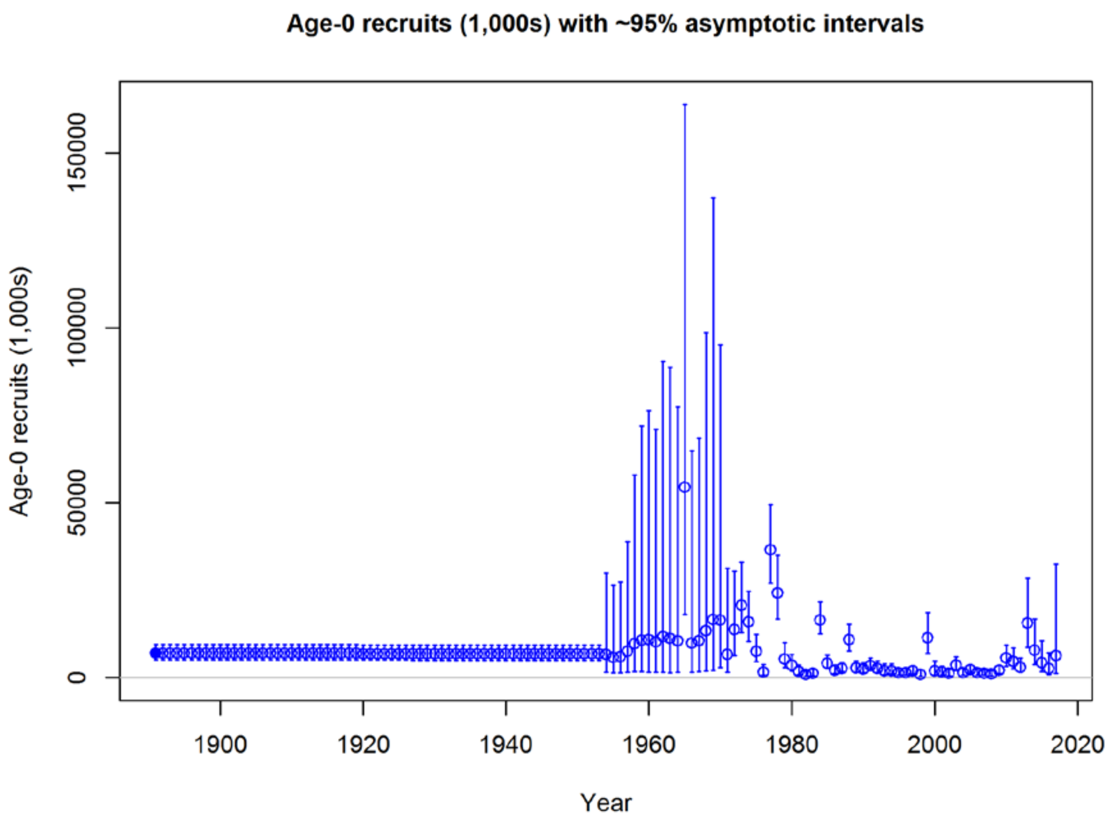

Figure 5. Estimated annual recruits with 95% asymptotic intervals.

Exploitation status

The 2017 spawning output is estimated to be at 48.6% of the unfished spawning output (Table 2). The base model indicates that the exploitation rates for Bocaccio rockfish has remained at low levels since the turn of the millennia, and the population has been increasing accordingly (Figure 6 to Figure 8, and Table 1).

Table 3: Recent trend in harvest rate (proportion of catch over total biomass) and spawning potential ratio (SPR).

Year	Harvest rate	SPR (%)
2007	0.0071	91.2
2008	0.0047	93.8
2009	0.0060	92.1
2010	0.0054	92.2
2011	0.0086	88.0
2012	0.0102	89.0
2013	0.0103	90.4
2014	0.0071	93.7
2015	0.0071	94.5
2016	0.0069	94.5

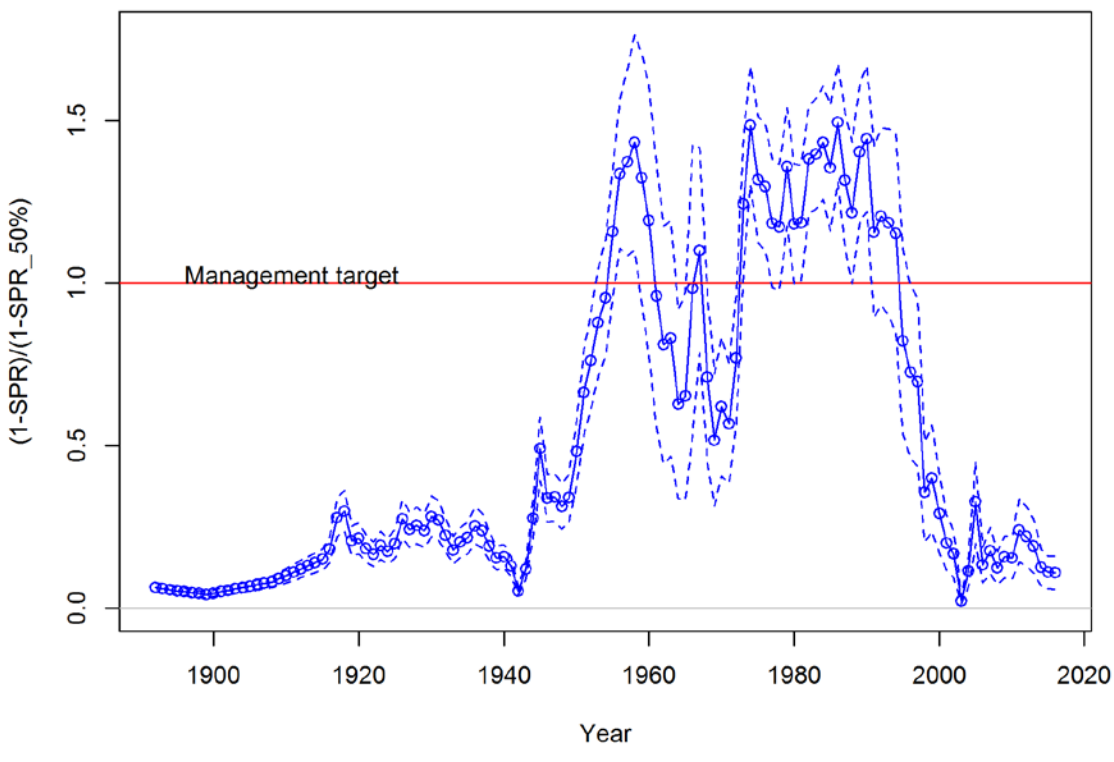

Figure 6. Time series of relative SPR with the target level of 50% for the base model. Values of relative SPR about 1.0 (red line, management target) indicate harvests in excess of the current overfishing proxy.

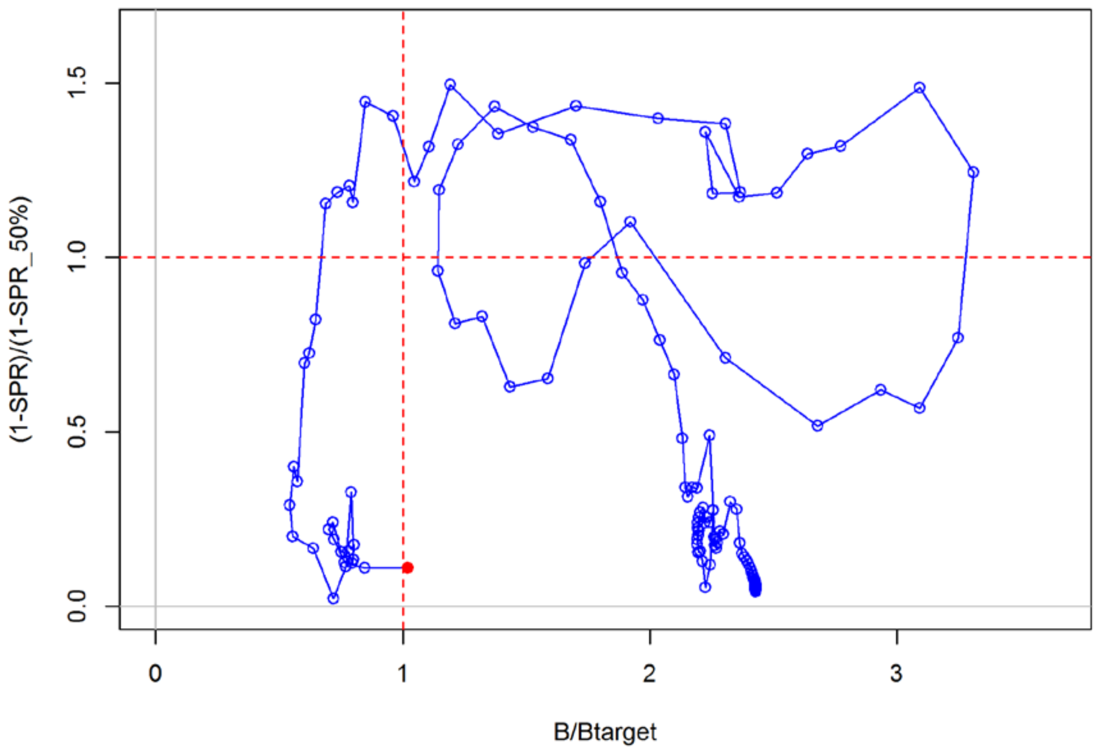

Figure 7. Phase plot of relative SPR with the target level of 50% versus relative stock depletion (labelled as B/Btarget) for the base model. Relative stock depletion is the spawning output divided by the spawning output corresponding to 40% of the unfished spawning output. The red end point indicates the year 2016.

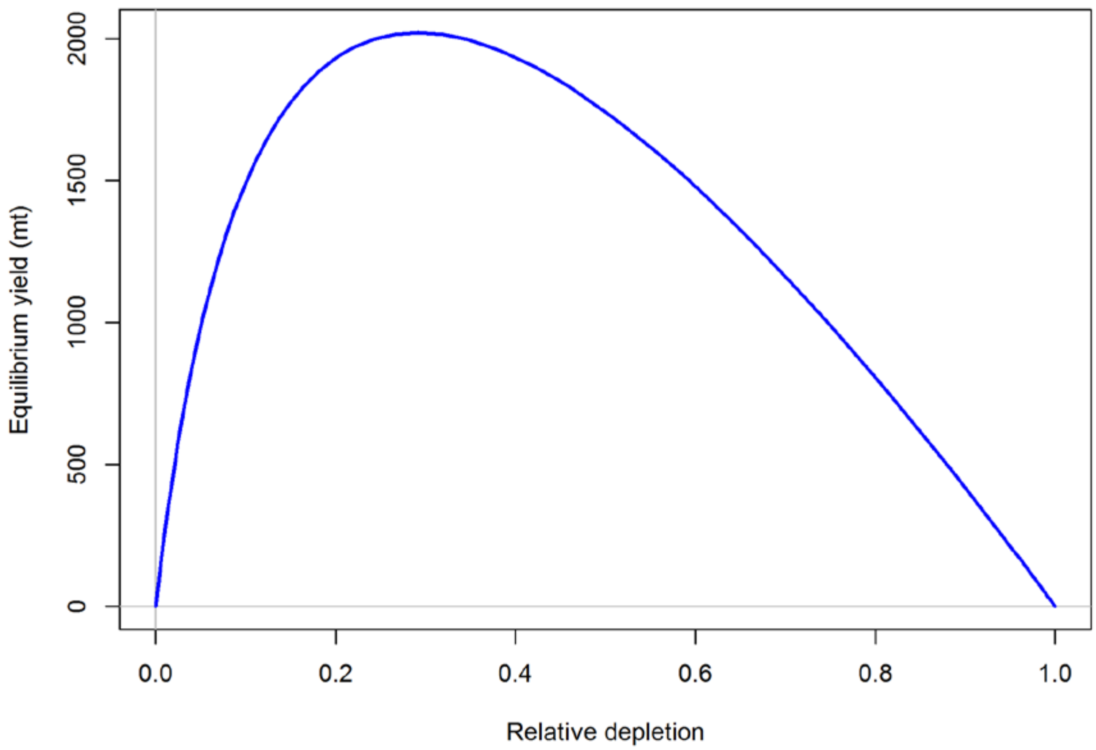

Figure 8. Equilibrium yield curve for the base model.

Ecosystem considerations

Bocaccio are an important component of coastal food webs by virtue of being both fairly abundant (historically more so) and very piscivorous. Although there are no published quantitative food habits studies of this species, they have long been described as primarily piscivorous, and young Bocaccio are known to prey on other young-of-year (YOY) rockfish, surfperch, jack mackerel and other small inshore fish species (Phillips 1964, Nelson 2001). The high recruitment variability exhibited by this species may serve to constrain or limit recruitment of co-occurring species at times, and the dynamics of this interaction could be revealing with respect to patterns of recruitment variability observed in other species. Adults in deeper waters feed on small rockfish, Pacific hake, sablefish, anchovies, mesopelagic fishes, and squids, particularly California market squids. The assessment model does not include any explicit mechanisms to account for ecosystem changes that might impact the Bocaccio stock.

Reference points

Summary of reference points for the base model is presented in Table 4, including the unfished summary biomass, unfished spawning output, mean unfished recruitment and the proxy estimates for MSY based on the $SPR_{50\%}$ rate as well as the fishing mortality rate associated with a spawning stock output of 40% of the unfished level and with MSY estimated based on the spawner/recruit relationship and yield curve. The corresponding yields for these three estimates vary between 1,857 mt based on the SPR target and 2,158 mt based on the MSY estimate. The unfished total biomass is estimated to be 47,268 mt, which was similar to that estimated in the 2015 assessment

(45,476 mt). Unfished spawning output and virgin recruitment are also comparable with those in the 2013 assessment update.

Table 4: Summary of reference points for the base model.

Quantity	Estimate	Low 2.5% limit	High 97.5% limit
Unfished Spawning output (10^6 larvae)	7411	5977	8845
Unfished age 1+ biomass (mt)	47268	38348	56188
Unfished recruitment (R_0)	6865	5011	9405
Depletion (2017)	48.6%	33.1%	64.1%
Reference points based on $SB_{40\%}$			
Proxy spawning biomass ($B_{40\%}$)	2964	2391	3538
SPR resulting in $B_{40\%}$ ($SPR_{50\%}$)	0.459	0.459	0.459
Exploitation rate resulting in $B_{40\%}$	0.093	0.081	0.106
Yield with SPR at $B_{40\%}$ (mt)	1934	1462	2406
Reference points based on SPR proxy for MSY			
Spawning biomass	3302	2663	3941
SPR_{proxy}	50%		
Exploitation rate corresponding to SPR_{proxy}	0.082	0.071	0.092
Yield with SPR_{proxy} at SB_{SPR} (mt)	1857	1406	2309
Reference points based on estimated MSY values			
Spawning biomass at MSY (SB_{MSY})	2158	1736	2579
SPR_{MSY}	0.361	0.357	0.365
Exploitation rate corresponding to SPR_{MSY}	0.129	0.112	0.146
MSY (mt)	2021	1525	2517

Management performance

Bocaccio rockfish were formally designated as overfished in March of 1999, after the groundfish FMP was amended to incorporate the mandates of the Sustainable Fisheries Act reauthorization to the MSFCMA. The rebuilding policy adopted by the PFMC held the rebuilding optimum yield (OY) constant at 100 MT for the years 2000-2002, with the intention of switching to a constant fishing rate policy beginning in 2003. However, due to an extremely pessimistic 2002 assessment, the 2003 OY was set to 20 tons. A more optimistic assessment in 2003 led to a 2004 OY of 199 tons. The OY or more recently ACL values have been set at a range of values between 218 and 362 tons since then (Table 5), with estimated catches (including discards) typically observed to be less than half of the adopted values in most years since 2005. A summary of recent catches, regulations, and stock status between 2005 and 2017 is presented in Table 5. A summary of catch distribution data as the basis for the apportionment of Bocaccio ACL and OFL estimates North and South of 40°10’ N latitude is listed in Appendix C in the 2015 stock assessment (He et al. 2015).

Unresolved problems and major uncertainties

For this assessment, steepness (h) is treated as fixed, with natural mortality (M) estimated, as in the 2015 base model. Sensitivity analyses conducted for the 2015 base model (and for other stocks) demonstrate considerable covariance among these two parameters, such that there is rarely adequate data to reliably estimate both simultaneously. Moreover, because Bocaccio exhibit very large recruitment variability, estimations of the stock-recruitment relationship for this species are highly uncertain.

Abundance trends in this population are driven to a large extent by strong year classes, for which the relative magnitude may not be apparent for several years. The 2015 assessment indicated a very strong 2013 year class, although the magnitude of that year class was difficult to evaluate at that time. Length composition data in this update are consistent with a very large 2013 year class, although the true magnitude of the year class may not be obvious until more data are available. Similarly, an abundance of pelagic YOY rockfish has been noted in several surveys and in anecdotal accounts in the 2014-2016 period, although it remains to be seen whether strong recruitment will materialize in the populations.

Decision table

The decision table in the 2015 assessment was based on two major sources of uncertainties and four forecast catch streams (Table 6 in He et al. 2016). The basis for the alternative states of nature were a combination of steepness values and relative strength of the 2013 year class. As this year class is better resolved in this assessment, the updated decision table states of nature are limited to the steepness values associated with the 2015 assessment.

Three catch streams, which are similarly defined in the 2015 assessment, were included for each scenario, with the adopted ACL values used for 2017-2018 used for each one. The low catch stream was represented by status quo catches (average of total catch in 2012-2016 period), the catches associated with the adopted rebuilding SPR rate (0.777) in the low productivity scenario, the catches associated with the rebuilding SPR rate in the base model scenario, and the base model estimate of ACL catches under the SPR=0.50 harvest rate policy. Table 6 shows time series of spawning output and stock depletion for all nine scenarios for three states of natures and three catch streams. Under the most pessimistic scenario (high catches and low *h* value, lower left column in the Table), the stock is estimated to fall below the management target in 2023. For all other scenarios, the stock is estimated to be above the management target level for all years. Projections of ACL and OFL from 2017 to 2026 based on current control rule are listed in Table 6a.

Research and data needs

Stock structure and stock boundaries for Bocaccio rockfish on the West Coast remain an important issue to consider with respect to both future assessments and future management actions.

Since large scale area closures and other management actions were initiated in 2001, the spatial distributions of fishing effort (fishing mortality) have changed over both large and small spatial scales. This confounds the interpretation of survey indices for surveys that do not sample in the Cowcod Conservation Areas (CCAs), although the decision to begin sampling for the NWFSC hook and line survey within the CCAs should begin to address this issue with time.

Recently updated reproductive biology data (maturity and fecundity) show some differences in length and weight specific fecundity in Bocaccio from those used in the past assessments. Regional differences (southern and northern California, as well as southern Oregon), and multiple brood spawning, are poorly understood.

Information regarding diet and movement patterns associated with habitat and prey abundance are key in order to further understand their roles in the ecosystem of the California waters. Northward migratory behaviors of juvenile and young adults are indicated by length frequency data, but such behaviors are also poorly understood.

Table 5: Summary table of recent catches, regulations, and stock status between 2007 and 2017.

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Commercial landings (mt)	18	16	24	17	12	17	20	20	49	89	
Estimated total catch (mt)	107	69	85	73	116	142	150	119	139	157	
OFL (mt)	602	618	793	793	737	732	884	881	1444	1351	2139
ACL (mt)	218	218	288	288	263	274	320	337	349	362	790
1-SPR (%)	91.2	93.8	92.1	92.2	88.0	89.0	90.4	93.7	94.5	94.5	
Exploitation rate	0.007	0.005	0.006	0.005	0.009	0.010	0.010	0.007	0.007	0.007	
Age 0+ biomass (mt)	14983	14623	14122	13583	13520	13915	14533	16669	19701	22816	25293
Spawning output (10^6 larvae)	2379	2356	2306	2223	2128	2075	2137	2270	2505	3022	3603
Spawning output (low 2.5%)	1489	1487	1465	1420	1366	1336	1374	1447	1570	1821	2066
Spawning output (high 97.5%)	3270	3226	3146	3025	2890	2814	2899	3093	3439	4224	5139
Recruitment	1193	978	1949	5459	4594	2831	15582	7744	4223	2430	6220
Recruitment (low 2.5%)	635	500	1092	3214	2532	1454	8561	3606	1715	843	1194
Recruitment (high 97.5%)	2239	1913	3480	9273	8332	5509	28358	16630	10400	7004	32412
Depletion (%)	32.1	31.8	31.1	30.0	28.7	28.0	28.8	30.6	33.8	40.8	48.6
Depletion (low 2.5%)	23.3	23.4	23.1	22.5	21.8	21.4	22.1	23.3	25.3	29.2	33.1
Depletion (high 97.5%)	40.9	40.2	39.1	37.4	35.7	34.6	35.6	38.0	42.3	52.3	64.1

Table 6: Decision table based on three states of nature and three alternative future catch streams. States of nature are defined as low recruitment potential (*h*=0.545) and high recruitment potential (h=0.845). Both *h* values are offsets by -0.055 from those used in the 2015 settings of the state of nature, due to that the *h* prior (0.718) used in this assessment is 0.055 less than that used in the 2015 assessment (0.773). Also, the low/high 2013 recruitment was used as factor in the settings of state of nature in the 2015 assessment, but it is not considered here because the 2013 recruitment has been estimated to be high in this assessment. Spawning output has units of billions of larvae.

			State of nature					
			Low state of nature (*h* = 0.545)		Base (*h*=0.718)		High state of nature (*h* = 0.845)	
Management decision	Year	Catch (mt)	Spawning output	Depletion (%)	Spawning output	Depletion (%)	Spawning output	Depletion (%)
Average catch (2012-2016)	2017	790	3.27	40.1	3.60	48.6	3.82	53.6
	2018	741	3.54	43.3	3.93	53.1	4.19	58.8
	2019	142	3.65	44.7	4.10	55.3	4.38	61.4
	2020	142	3.83	46.9	4.31	58.1	4.60	64.5
	2021	142	4.04	49.5	4.53	61.1	4.82	67.5
	2022	142	4.26	52.2	4.75	64.1	5.03	70.5
	2023	142	4.49	55.0	4.97	67.1	5.23	73.3
	2024	142	4.71	57.8	5.18	69.9	5.41	75.9
	2025	142	4.94	60.5	5.37	72.5	5.59	78.3
	2026	142	5.15	63.2	5.56	75.0	5.74	80.5
	2027	142	5.36	65.7	5.73	77.3	5.88	82.5
	2028	142	5.56	68.2	5.88	79.4	6.01	84.2
Base model rebuilding SPR (0.777) catches	2017	790	3.27	40.1	3.60	48.6	3.82	53.6
	2018	741	3.54	43.3	3.93	53.1	4.19	58.8
	2019	764	3.65	44.7	4.10	55.3	4.38	61.4
	2020	781	3.74	45.8	4.22	56.9	4.50	63.2
	2021	803	3.84	47.1	4.33	58.5	4.62	64.8
	2022	824	3.95	48.4	4.44	60.0	4.72	66.2
	2023	843	4.06	49.7	4.54	61.3	4.80	67.3
	2024	860	4.16	51.0	4.63	62.5	4.87	68.3
	2025	875	4.26	52.2	4.71	63.5	4.93	69.1
	2026	888	4.36	53.4	4.78	64.5	4.97	69.7
	2027	899	4.45	54.5	4.84	65.3	5.02	70.3
	2028	910	4.53	55.5	4.90	66.1	5.05	70.7
Base model ACL catch (SPR=0.5 with P*=0.45 and sigma=0.36)	2017	790	3.27	40.1	3.60	48.6	3.82	53.6
	2018	741	3.54	43.3	3.93	53.1	4.19	58.8
	2019	2097	3.65	44.7	4.10	55.3	4.38	61.4
	2020	2011	3.54	43.5	4.02	54.3	4.31	60.4
	2021	1978	3.45	42.3	3.93	53.1	4.22	59.2
	2022	1957	3.35	41.1	3.84	51.8	4.11	57.7
	2023	1939	3.25	39.9	3.73	50.4	4.00	56.1
	2024	1923	3.16	38.7	3.63	49.0	3.88	54.4
	2025	1909	3.07	37.6	3.53	47.7	3.76	52.8
	2026	1897	2.98	36.5	3.44	46.4	3.66	51.3
	2027	1887	2.90	35.5	3.36	45.3	3.56	50.0
	2028	1878	2.82	34.6	3.28	44.2	3.47	48.7

Table 6a. Projections of ACL and OFL from 2017 to 2028. Both ACLs and OFLs for 2017 and 2018 (bold and italic) are from current regulations. ACLs from 2019 to 2026 are from the forecast with SPR = 0.5 and ACL = ABC (P*=0.45).

Year	ACL (mt)	OFL (mt)
2017	***790***	***2233***
2018	***741***	***2201***
2019	2097	2194
2020	2011	2104
2021	1978	2069
2022	1957	2047
2023	1939	2028
2024	1923	2011
2025	1909	1997
2026	1897	1984
2027	1887	1974
2028	1878	1964

1 Introduction

1.1 Basic Information

The name Bocaccio is derived from the Italian for "bigmouth," Bocaccio were also often called "bocacc" by early Italian fishermen, "merou" by Portuguese fishermen, "jack" by some American fishermen, and "andygumps" by some British Columbia fishermen. Additional alternate names include "tomcod," for young Bocaccio caught around wharfs; "salmon grouper", "longjaw", and many others (Love et al. 2002). The genus, *Sebastes*, is Latin for magnificent, of course, and the species name, *paucispinis*, is a reference to the paucity of head spines relative to most other species of *Sebastes*. Both juvenile and adult stages grow rapidly, although growth slows considerably in mature adults; maximum reported sizes are 91 cm and approximately 8 kg. In an extensive review of phylogenetic relationships among *Sebastes*, Hyde and Vetter (2007) found that Bocaccio were most closely related to both chilipepper (*S. goodei*) and shortbelly (*S. jordani*) rockfish, although that lineage dated back approximately 6 million years. Adult systematics are described in more detail in Phillips (1939; 1964) and Love et al. (2002); larval distribution and descriptions are provided by Moser (1977; 1991); and pelagic juvenile life history stages and growth are described in Woodbury and Ralston (1991).

1.2 Life History, Stock Distribution, Habitat Preferences and Movement patterns

The distribution of Bocaccio has been described as ranging from Stepovak Bay on the Alaskan Peninsula (as well as Kodiak Island, Alaska) to Punta Blanca, Baja California (Miller and Lea 1972; Eschmeyer et al. 1983; Love et al. 2002). The species is abundant off southern and central California, uncommon between Cape Mendocino and the Oregon/Washington border, and moderately abundant from the Oregon-Washington border into Queen Charlotte Sound and Hecata Strait, British Columbia. In this update assessment, we maintain the tradition of distinguishing the southern Bocaccio population unit from the northern unit, and, as in the 2015 assessment, we suggest that the geographic range of the southern Bocaccio stock corresponds to the waters south of Cape Blanco, Oregon (the northern boundary of the Eureka INPFC area), to the U.S./Mexico border. This is consistent with the suggestion of a break in population distribution based on both historical and recent abundance data, the paucity of data in the northern part of the range, and a long history of previous assessments.

1.3 Ecosystem Considerations

Bocaccio are an important component of coastal food webs by virtue of being both fairly abundant (historically more so) and very piscivorous. Although there are no published quantitative food habits studies of this species, they have long been described as primarily piscivorous, and young Bocaccio are known to prey on other young-of-year (YOY) rockfish, surfperch, jack mackerel and other small inshore fish species (Phillips 1964, Nelson 2001). The high recruitment variability exhibited by this species may serve to constrain or limit recruitment of co-occurring species at times, and the dynamics of this interaction could be revealing with respect to patterns of recruitment variability observed in other species. Adults in deeper waters feed on small rockfish, Pacific hake, sablefish, anchovies, mesopelagic fishes, and squids, particularly California market squids.

Pelagic juveniles are preyed upon by a wide range of predators, including seabirds, salmon, lingcod, and marine mammals (Sydeman et al. 2001). Predators of larger adults are likely limited to larger piscivorous fishes, sharks and marine mammals, although few studies have identified rockfish prey to the species level.

Ongoing investigations into the reproductive ecology of Bocaccio suggest that reproductive output is likely to be more variable from year to year than previously thought, likely through both size-dependent and interannual variability in the frequency of multiple broods. Environmentally driven changes in relative fecundity could also have important implications for estimating both historical and future relative spawning abundance under climate change scenarios, as could environmentally driven differences in year to year recruitment success. However, the previous stock assessment model, which this current assessment updates, did not include any environmentally driven aspects in the stock's population dynamics.

1.4 Management History and Performance

The 2015 Assessment provided a detailed review of the management history of this stock, and readers are referred to that document for more information. The updated history of management measures affecting the Bocaccio fishery is also listed in Appendix A. Recent management performance of the fishery is shown in Table 5 in the Executive Summary.

1.5 Fisheries off Canada, Alaska, and Mexico

Readers are again referred to the 2015 assessment for a more complete summary of fisheries and data availability off of Canada, Alaska and Mexico. In short, there is a fair amount of data and information on the status of Bocaccio in Canadian waters, where landings have ranged from several hundred to over 1,000 mt per year in recent decades and several assessments have been conducted over recent decades (e.g., DFO 2012). Considerably less is known about the abundance and distribution of Bocaccio at the southern end of their range, although based on an analysis of CalCOFI larval abundance data from the 1950s and 1960s (CalCOFI cruises ceased to sample Mexican waters in the 1970s), MacCall (2003) estimated that approximately 4.6 percent of larvae were encountered in Mexican waters, 46 percent in southern California waters, and 50 percent in central/northern California waters (from Pt. Conception to Bodega Bay). As Mexican oceanographers have begun occupying the historical CalCOFI stations off of the Baja Peninsula in recent monitoring efforts, the potential to include or analyze data from these efforts should be revisited in the future.

2 Assessment

2.1 Data

A summary of key data sources and time periods of each data set are presented in Figure 10. Details of each data set are described in the corresponding sections below. This assessment update includes the following additional data to the 2015 assessment:

1) Recreational fishery catches, which have been main sources of fishing mortality in recent years, for 2015 and 2016 obtained from the GMT score card estimates;
2) Commercial fishery catches obtained from the WCGOP total mortality estimates, which include updates for the 2014 estimates and new 2015 estimates. The 2016 estimates are taken from CalCOM estimates as they are not yet available from the WCGOP;
3) New index data include: 1) CalCOFI data for 2015; 2) NWFSC hook-and-line survey for 2015 and 2016; 3) NWFSC bottom trawl survey data for 2015; 4) pelagic juvenile trawl survey data for 2015 and 2016; and 6) California CPFV recreational onboard survey for southern and northern California for 2015 and 2016.

4) Commercial fishery length composition data from trawl and hook-and-line fisheries for 2015 and 2016, and survey length composition data from the NWFSC hook-and-line survey for 2015 and 2016 and from the NWFSC bottom trawl survey for 2016.

No new age data are included in the assessment update as there have been no new fish aged since the 2015 assessment.

2.1.1 Fishery fleets and catches

There are six fishery fleets defined in this assessment: (1) the southern and south-central California trawl fishery, including all trawl-caught fish landed south of 38° N ("TrawlSouth"); (2) the hook-and-line fishery ("HL"); (3) the setnet fishery (most gillnet, "Setnet"); (4) the southern California (all catches south of Point Conception) recreational fishery ("RecSouth"); (5) the central and northern California recreational fishery, including any southern Oregon recreational catches ("RecCentral"); and (6) the northern California (north of 38° N) and southern Oregon trawl fishery ("TrawlNorth"). Bocaccio have long been described as one of the dominant rockfish species for both commercial and recreational fisheries throughout California. Although landings of many California groundfish are typically reported in single species market categories, group market categories have been the most common approach for sorting rockfish catches in California, with a trend towards single species categories in recent years due to regulatory constraints. Recent trends in commercial catches and estimated total catch relative to the management guidelines are listed in Table 5. Estimated annual catches by each fleet, along with total annual catches, are presented in Figure 11 and Table 7.

2.1.1.1 Commercial fishery catches

Bocaccio have long been one of the most important rockfish species in California fisheries, having been described as a "common market fish" in California fish markets as early as the 1850s (Jordan 1884). Commercial catches of Bocaccio reached their highest level in the late 1970's, ranging between 2,000 to 5,000 mt, but have been very low (less than 100 mt) since the late 1990s (Figure 11). Detailed descriptions of commercial fisheries are provided in previous assessments (Field et al. 2009, He et al. 2015). Catches for 2002 through 2015 were taken from West Coast Groundfish Observer Program (WCGOP) total mortality estimates (e.g., Bellman et al. 2010, Sommers et al. 2014). Catches between 1892 and 2013 are the same as in the 2015 assessment. Catches between 2014 and 2015 were updated using the estimates provided by the WCGOP total mortality reports, and catches for 2016 were taken from the information provided by the GMT report (March 2017, http://www.pcouncil.org/wp-content/uploads/2017/03/I3a_Sup_GMT_Rpt2_Inseason_Mar2017BB.pdf) and downloaded information from the PacFIN (Table 7).

For the 2014 and 2015 WCGOP mortality estimates, the total mortalities are reported for the entire region of the U.S. north of 40'10º N, which includes catches outside of the assessment area. We based catches from the areas between 40'10º N and 43º N on WCGOP estimates of total mortality north of 40'10º N multiplied by the ratio of landings from PacFIN data between two areas (between 40'10º N and 43º N, and all areas north of 43º N). Overall, commercial catches from areas between 40'10º N and 43º N are very small (0.16 and 1.19 mt for 2014 and 2015, respectively). The GMT report for 2016 only contains estimates from areas of south of 40'10º N (total 154.5 mt, including recreational catch). Additional catches from areas between 40'10º N and 43º N were downloaded from the PacFIN (3.03 mt) and were added to the 2016 GMT estimates. Because both WCGOP and GMT only report total mortality for trawl fisheries, they were proportionally allocated to the "TrawlSouth" and "TrawlNorth" fisheries each year by using proportions estimated from the CalCOM data base.

2.1.1.2 Recreational fishery catches

Details of Bocaccio catches in recreational fisheries between 1892 and 2014 are in the 2015 assessment report. Only catches between 2015 and 2016 were updated in this report, and they are taken from the GMT scorecards, as reported in the Recreational Fisheries Information Network (RecFIN). These estimates are the very same as in the 2015 WCGOP report and in the March 2017 GMT report (Table 7).

2.1.2 Biology data and parameters

2.1.2.1 Length-weight, maturity, and fecundity relationships

All these biological parameters were re-examined and re-estimated in the 2015 assessment (details in He et al. 2015). As they are all fixed parameters, they are all unchanged in this assessment update.

2.1.2.2 Growth

The stock synthesis approach uses the Schnute (1981) parameterization of the von Bertalanffy growth equation (Methot and Wetzel 2013). Bocaccio have long been described as having very rapid growth during the early years of life, which can be tracked by the progression of strong cohorts in fisheries length frequency data. Past assessments have typically estimated the growth coefficient (K) internally, while fixing L_{min} and L_{max} based on the length frequency data (MacCall et al. 2002; MacCall 2003). In the 2015 assessment, however, L_{max} was estimated internally. Because no new age data were added in this assessment, growth was estimated in the same way as in the 2015 assessment.

2.1.2.3 Natural mortality (*M*)

Settings for natural mortality (M) estimates were set to be the same as in the 2015 assessment (He et al. 2015). There is no age or time varying M and M is also set to be the same for both sexes. The prior for M is updated using an updated method developed by O. Hamel of the NWFSC for the 2017 assessment. The prior is defined as a lognormal with mean $\ln(5.4/Amax)$ and SE = 0.4384343. Using a maximum age of 31 years ($Amax$ = 31), the point estimate and median of the prior is -1.7476. As in the 2015 assessment, M is internally estimated with the prior.

2.1.2.4 Ageing data

Considerable effort was expended to develop age determination criteria and conduct production aging for the 2015 assessment (Pearson et al. 2015). That assessment included over 8,000 age samples selected from available otoliths, the greatest fraction coming from commercial trawl fisheries, a smaller fraction from commercial fixed gear and setnet fisheries, and nearly 3,000 from the NWFSC bottom trawl survey. All age data were treated as conditional age-at-length data in the 2015 assessment. No new age data are included in this assessment update.

2.1.3 Fishery independent data

2.1.3.1 CalCOFI larval abundance data

Details on the CalCOFI (California Cooperative Oceanic Fisheries Investigations) are in the previous assessments (Field et al. 2009, He et al. 2015). For this assessment update, the CalCOFI larval abundance time series was updated with a small number of observations from (late) 2014 and new data from spring (April) surveys in 2015 and 2016. The index (Table 8) was developed with the same modeling approach, a Delta-GLM with a lognormal error distribution for positive observations and a c log log link for the binomial portion of the model, with the main (fixed) effects of interest being year (adjusted to spawning season), month and line-station effects. As in the 2015 assessment, the index is treated as a relative index of population larval (spawning) output. The 2014 year effect changed very slightly in response to new data, the 2015 year effect was a fairly high point, and the 2016 year effect could not be estimated due to a lack of positive observations. Both the 2015 and 2016 estimates should be considered very uncertain and preliminary, as they do not include data from the peak of the spawning season in bocaccio (winter months, particularly January and February; see Figure 12 and Figure 13). These data have been collected, but the ichthyoplankton data have not been identified to the species level due to greater priority placed in the Spring CalCOFI data to inform anchovy larval abundance index development.

2.1.3.2 Triennial trawl survey

Since no new data are available from this survey, the same length composition data and estimated survey index used on the 2015 assessment are used in this assessment.

2.1.3.3 Northwest Fishery Science Center (NWFSC) trawl survey

The Northwest Fishery Science Center has conducted combined shelf and slope trawl surveys (hereafter referred as NWFSC trawl survey) since 2003, based on a random-grid design from depths of 55 to 1,280 meters. Additional details on this survey and design are available in the abundance and distribution reports by Keller et al. (2008). Spatial locations of raw catch rates (in log scale) are shown in Figure 14. Spatial locations of raw catch rates from 2015 and 2016 are also shown separately in Figure 15a and Figure 15b, which show that catches from 2016 were exceptionally high in comparison to those from 2015.

Two more years of data (2015 and 2016) from this survey are used in this assessment. For the index data, we use the VAST program (J. Thorson, NWFSC, personal communication, Thorson 2015) to analyze the data, and the derived index is used in the base model (Table 9). For comparisons, we also used the same Delta GLMM method used in the 2015 assessment to derive an alternative index series. Additional analysis is also conducted using the VAST program but with non-spatial settings (J. Thorson, personal communication). Comparisons of these three indices are presented in Figure 16, and the VAST outputs of Q-Q plot and index series are presented in Figure 17 and Figure 18. Time trends from these three indices are similar but the estimates for 2016 (unusual high abundance) differ substantially among the three methods. However, a sensitivity analysis (see the Sensitivity Analysis section) shows effects of differences among these three indices on the assessment outputs are very small.

Length composition data from the latest two years are analyzed using the same method as in the 2015 assessment, including using the same expansion method used in the 2015 stock assessment. Numbers of trawl tows, fish measured, and effective sample sizes, which are also derived and analyzed using the same method as in the 2015 assessment, are shown in Table 9a. Figure 19 shows there were two strong year classes (2010 and 2013) that dominated catches in recent years. Length frequency distributions by sex and year for two regions (south and north of Point Conception) are presented in Figures 19a and 19b. These figures show again that both 2010 and 2013 year-classes were well presented in the trawl survey. However, the 2013 year-class was not well represented in the data south of Point Conception in 2016, although it was observed in the length frequency data north of Conception in the entire 2014-2016 period (Figure 19b).

2.1.3.4 NWFSC Southern California Bight hook-and-line survey

Since 2004 the NWFSC has conducted a hook-and-line survey (here after referred as NWFSC hook-and-line survey) for rockfish in the region south of Point Conception, using essentially recreational gear types, surveying locations that are either likely or known sites where recreational fishing occurs, and chartering recreational (CPFV) vessels to conduct the survey (Harms et al. 2008; Harms et al. 2010). Importantly, the survey data used in this assessment do not include fishing sites within the Cowcod Conservation Areas (CCA)--a large region closed to commercial and recreational fishing in order to rebuild the cowcod (*S. levis*)--because the survey only started to collect data inside the CCA in 2014. Consequently, the trends inferred from this index should be interpreted with some caution.

Bocaccio are among the most frequently encountered species in the survey, representing approximately 25% of all fishes encountered. Harms et al. (2010) standardized catch rates of Bocaccio rockfish using a Bayesian Generalized Linear Model to account for site, fishing time, survey vessel, angler, and other statistically significant effects. Their results are moderately indicative of a downward trend in the biomass vulnerable to this survey from 2004 to 2010, show an increasing trend between 2011 and 2013, and then again show a downward trend between 2014 and 2016 (Figure 20).

Length-frequency plot and numbers of length samples are presented in Figure 21 and Table 10, respectively. As with the NWFSC trawl survey and the southern recreational fishery length frequency data, the length-frequency distributions are dominated by the 1999 year class from 2004-2006, with signs of the incoming 2003 year class and relatively strong 2005 year class. The last six years of data also clearly show strong 2010 year class. However, the 2013 year class, which is shown to be a strong year class in other fisheries and survey data, are not strongly represented in this survey.

2.1.3.5 Power plant recruitment index (Southern California)

An index of juvenile (age-0) abundance based on power plant impingement data has been used in previous assessments, including the 2011, 2013, and 2015 models. This index represents data collected from coastal cooling water intakes at Southern California electrical generating stations from 1972 to the present. These data have been previously described by Love et al. (1998), Miller et al. (2009), and Field et al. (2010), with respect to trends in abundance of *Sebastes* species, queenfish *(Seriphus politus*), and bocaccio, respectively. Since there are no new data available for this assessment, the same index used in the 2015 assessment is used in this assessment update.

2.1.3.6 Pelagic juvenile trawl survey

Past Bocaccio stock assessments, including the 2015 base model (He et al. 2015), have used an index of age-0 abundance as a recruitment indicator based on combined SWFSC/NWFSC pelagic young-of-the-year (YOY) rockfish surveys. In preparing the indices for the 2017 assessment cycle, the code for developing the indices was migrated from SAS to the R programming language to facilitate future rapid computation of indices, and in doing so, a minor, but non-trivial, error was found in how the indices were compiled. Specifically, the model as previously run summed across latitude (bins) parameters in log space, and then back-transformed the sum for each year. The more appropriate approach is to back-transform the latitude bin results and then sum across latitudes within each year, in order to arrive at an estimate in arithmetic space. The issue is described in greater detail in the Appendix B that documents the methods and summarizes the results. As the “corrected” index is essentially flat (despite recognition that recruitment has been highly variable over the last 10 years as seen in compositional data) (Figure 24), we developed additional indices based on delta-GLM models and the VAST software package (using VAST version VAST_v2_0_0), we use these and the unaltered index from the 2015 assessment as sensitivity tests. Additional considerations regarding new means of developing the recruitment indices are discussed in the Appendix B.

2.1.4 Fishery dependent data

2.1.4.1 Northern California trawl CPUE indices

Ralston (1999) developed a CPUE index of Bocaccio abundance based on California trawl logbooks that was initially used in the assessment (Figure 25). Because the logbooks do not identify most individual species such as Bocaccio, Ralston applied species compositions from local port sampling to the overall catch rates of rockfish from the trawl logbooks. The 2015 assessment used Ralston's "area-weighted" index of Bocaccio CPUE and the associated standard errors (average CV is 32%). The same index is used in this assessment.

2.1.4.2 Recreational fishery CPUE indices

Recreational CPUE indices were developed for the 2003 assessment (MacCall 2003) using catch and effort data from two sources, the RecFIN database (Wade Van Buskirk, Pers. Comm.) and the Northern California party boat monitoring conducted by CDFG (Deb Wilson-Vandenberg, Pers. Comm.). Developments of these indices were described in detail in the 2015 assessment. The time ranges for these indices are from 1980 to 2002 (Figure 26 and Figure 27). As there are no new data or developments for these indices, the same indices used in the 2015 assessment are used in this assessment.

2.1.4.3 California CPFV recreational fishery survey

In addition to the indices derived from the MRFSS (Marine Recreational Fisheries Statistics Survey) data, the California Department of Fish and Wildlife (CDFW) conducted on-board monitoring of party boat catches (Commercial Passenger Fishing Vessel survey, hereafter referred to as CPFV survey) in central California from 1988 to 1998 and from both southern and central/northern California from 2004 to 2016. Detailed descriptions of these surveys were presented in the 2015 assessment.

The first index (from 1988 to 1998, labelled as "CDFWEarlyOB") is unchanged from the 2015 assessment (Figure 28) as there are no new data available. The length composition data from this survey are also unchanged (Figure 29).

The second set of indices (labelled as "RecSouthOB", and "RecCentralOB") are updated using the same analytic program as in the 2015 assessment (Figure 30 and Figure 31). The "RecSouthOB" shows a somewhat decreasing trend in CPUE in the last two years (2015 and 2016), while the "RecCentralOB" shows an increasing trend in the last two years. The length composition data from both surveys from 2015 to 2016 were updated using the same procedures as in the 2015 assessment. A summary of the annual number of sampling trips and numbers of fish measured are presented in Table 11, and length composition data are plotted in Figure 32 and Figure 33. Both figures show a relatively strong 2013 year class.

2.1.4.4 Fishery length composition data

The length composition of commercial landings (here broken out into trawl, hook-and-line (HL), and set net fisheries) were obtained from the CalCOM database, and cover the years 1977-2016, although there were some years with no data or only small samples. The same analytic procedures used in the 2015 assessment are used in this assessment. The expansion of length frequency data was carefully evaluated in 2009 and since then the same expansion method, to account for fish that were caught but not measured for length, has been adapted and used, including the 2015 and this assessments. Summary of annual sample trips and numbers of fish measured for these fisheries are presented in Table 12 to Table 14, and length composition data are plotted in Figure 34 to Figure 37. As in the length composition data from the recreational fisheries, the plots also show strong 2013 year class (all but the setnet fishery which has no data for recent years).

2.2 History of Modeling Approaches and Transitions to Current SS Program

2.2.1 Previous assessments

The stock was first assessed in 1985, and since then it has been fully assessed or updated 12 times. The stock was declared to be overfished in 1999. Subsequently, the stock was fully assessed 2002 and 2003 and 2009, and updated in 2005, 2007, 2011 and 2013 (Field et al. 2009, Field 2011, Field 2013). The last full assessment was conducted in 2015 (He et al. 2015).

A stock assessment conducted in 1996 (Ralston et al. 1996) indicated that the stock was in severe decline, and the stock was formally designated as overfished after the groundfish FMP was amended to incorporate the mandates of the Sustainable Fisheries Act reauthorization to the MSFCMA in 1999. Both catch limits and catches had already been declining prior to that time period. The stock has been regularly assessed and catches sharply curtailed since that time, with either full or update assessments occurring no less frequently than every two years (see detailed review in He et al. 2015). The 2009 assessment (Field et al. 2009) used Stock Synthesis 3 (version 3.03a); expanded the northern boundary of the area modeled from Cape Mendocino, CA to Cape Blanco, OR; and began the model at 1892 rather than 1950. That model included catch and length-frequency from six fisheries, two trawl fisheries (north and south of 38° N), a hook-and-line fishery, a set net (gillnet) fishery, and recreational fisheries south and north of Point Conception, CA. Fisheries-dependent relative abundance (CPUE) indices, unchanged from the 2003 assessment, were used for the trawl fishery and the two recreational fisheries; a recruitment (age-0) index based on recreational pier fishing was also included, revised from the 2003 assessment. As in the 2003 assessment (and subsequent updates), the CalCOFI larval abundance time series and the triennial trawl survey index were used as fisheries independent survey data, and new fisheries independent indices included the NWFSC trawl survey, the NWFSC Southern California Bight hook and line survey, and a revised (coast wide) pelagic juvenile index. Steepness was estimated with an informative prior to be 0.57. Biomass and spawning output trajectories in the 2009 model were very comparable to those in previous (2003-2007) models, with low abundance in the 1950s, a series of strong recruitments in the 1950s, and high abundance through the early 1970s, when catches began to climb rapidly to their peak levels. This then was associated with high fishing mortality rates and a rapid drop in spawning output through the 1980s and 1990s, even as catches followed the decline in abundance. In response to severe management restrictions, and coincident with very strong recruitment in 1999 (following a decade of very poor recruitment through the 1990-1998 period), spawning output was estimated to be increasing steadily. The 2009 base model estimated the depletion to be 28% of unfished larval output with a corresponding SPR of 0.95 and forecasted a continued increase in spawning output.

The 2015 assessment was a full stock assessment (He et al. 2015) and was reviewed by a STAR Panel and approved by the PFMC for fishery management. The basic model structure of the 2015 assessment included catch and length-frequency from six fisheries, two trawl fisheries (north and south of 38° N), a hook-and-line fishery, a set net (gillnet) fishery, and recreational fisheries south and north of Point Conception, CA. The CalCOFI larval abundance time series, triennial trawl survey index, NWFSC combined shelf-slope trawl survey index, the NWFSC Southern California Bight hook and line survey, and a coast wide pelagic juvenile index were all included in the 2015 (and most previous) assessments. The 2015 model diverged from previous models in several substantive ways, with the inclusion of age composition information and the subsequent estimation of natural mortality and growth internally (in most previous models, most growth parameters and natural mortality rates were fixed). As a consequence, the steepness (*h*) parameter was fixed at the point estimate of the meta-analysis prior as the STAT and STAR Panel agreed that estimating both M and h was not warranted given the available data. This also reflected a shift from previous models, which had typically estimated h. Double-normal selectivity functions, previously unavailable in the SS program, were used in nearly all fisheries and surveys for the 2015 model, and the Francis data weighting method was also used in the assessment. Overall trends in stock biomass and spawning outputs estimated in the 2015 assessment were similar to those in the 2009 assessment. The stock depletion in 2015 was estimated to be 36.8% (He et al. 2015). In 2015, the Council adopted the assessment, and the ACLs for 2017 and 2018 were set to be 790 mt and 741 mt, respectively, which are higher than actual catches in those recent years (less than 150 mt).

2.2.2 Transition to current SS model, changes in model structure, and additions of new data

As this is an update assessment, no change in model structure and basic modeling approach have been made. Additional data, including new data analysis methods, are as follows:

1) New data from 2015 and 2016, including catches, length compositions, and indices, have been included in this assessment;
2) Some of the data for 2014, which were not available in the 2015 assessment, have also been re-analyzed and added into this assessment update. This includes estimates of total mortality in 2014 from the WCGOP program.
3) The new spatial analytic tool (VAST package, developed by J. Thorson of NWFSC) is used to analysis the NWFSC bottom trawl survey index. The model outputs from using VAST index are compared to the index derived from the same method used in the 2015 assessment in the sensitivity analysis.

2.2.3 Responses to 2015 STAR Panel recommendations

The 2015 STAR Panel provided the following recommendations for future research and data collection. As relatively little time has passed since that assessment, and as most of these investigations would be outside of the scope for an assessment update, there has been little progress made thus far on most of these recommendations:

1. An objective procedure for evaluating the stock boundaries is needed for all rockfish (and potentially other west coast assessments). Such a procedure would more directly point to directions for future research or collaboration across national/international political boundaries.
   No progress has been made in this area.

2. Explore better ways to model productivity for stocks like bocaccio that exhibit large episodic recruitment patterns. Lognormal distributions are not a good way to model the recruitment variability for such stocks.
   There are some recent research and workshops aimed to improve estimations of productivity of fish stocks with high variability in recruitments. A simulation study (He and Field, unpublished manuscript) has been conducted to evaluate effects of recruitment variability on stock assessment outputs.

3. The strength of recent recruitments is a major uncertainty for bocaccio. Technical methods for capturing and propagating this uncertainty are needed in stock synthesis (especially for axes of uncertainty), perhaps by an improved procedure to fix particular recent recruitment deviations.
   No progress has been made in this area.

4. The relationship between stock size and spawning output is critical for interpretation of the CalCOFI index, which is perhaps the most useful index in the bocaccio assessment. Research is needed to better quantify spawning output. This research could include

evaluation of environmental correlations of spawning output, and studies of both the prevalence, and the potential demographic and environmental drivers of multiple broods (multiple spawning events by an individual fish within a given spawning season).
There has been ongoing progress to understand and quantify the effects of multiple brooding in chilipepper rockfish, a closely related species, and some additional data collection for bocaccio, but no results are available at the present time.

5. The Panel recommends continued processing of historical CalCOFI samples from northern transects in the early 1950s through the late 1960s. These data would add to the index used in the assessment model, and improve understanding of spatial patterns in population dynamics.
No progress has been made in this area.

6. A data workshop prior to STAR panel reviews, perhaps for all rockfish stocks due for assessment, should be scheduled to examine assessment information across a broad range of species. The workshop could document protocols used to compile data sets for stock assessment, establish agreed procedures for standardization of abundance indices, and develop alternative data series that capture uncertainty–particularly for historical catch and discards.
An assessment planning workshop was held in anticipation of the 2017 assessment cycle, but appropriately focused on data availability for stocks undergoing full assessments in 2017.

7. Several estimated selectivity patterns in the bocaccio assessment are very unusual. The NWFSC trawl survey has a curiously flat selection pattern at young ages, and triennial survey has a strongly peaked selectivity at young ages. Research into alternative ways to model the selection pattern of these surveys is needed. Possible approaches include 1) use of age-specific natural mortality, 2) splitting the surveys into separate indices for juveniles (age 0 and/or1) and older fish.
Since this is an update assessment, no attempt has been made to address this recommendation.

8. Available information indicates that the CCAs are a center of abundance for bocaccio. Surveying inside the CCA during the NMFSC hook and line surveys should be continued, though several years of data will be required before the information can be used to inform the assessment. Consideration should also be given to extending the NWFSC trawl survey into the CCAs. A simple analysis of potential catch rates of cowcod, and the impact of survey take on stock rebuilding, would allow the benefits of surveying inside CCA to be compared to potential costs.
There have been some data collections by the NWFSC hook survey inside the CCA since 2014. Because time period of data collection is short and this is an update assessment, no data from inside the CCA have been used in this assessment.

9. Age data from the NWFSC hook and line survey would increase the utility of the survey for assessment of bocaccio by better defining the selectivity pattern for large fish.
No new age data from any sources are available for this assessment update. However, it remains as one of top priorities in research in the near future.

2.3 Model Description

This assessment is an update assessment model from the 2015 stock assessment model (He et al. 2015). All model structures, data preparations, and modeling processes are the same as used in the 2015 assessment. The only major changes are inclusions of new data (catches, indices, length and age compositions) from the last two years (2015 and 2016). Also, preparation of the pelagic juvenile survey index was different from the 2015 assessment (see Appendix B for detail).

2.3.1 Modeling software

The modeling software used in this assessment is Stock Synthesis 3 (SS3, version 3.24U, 8/29/2014), developed by Richard Methot (Methot and Wetzel 2013), which is the same SS3 version used in the 2015 assessment. R programs developed at the NWFSC, including Rsoftware packages for delta-GLMM, ageing error analysis, and r4ss software (Taylor et al. 2016, https://github.com/r4ss) were used in analyzing data and producing graphics for this assessment.

2.3.2 Basic model structures and general model specifications

This assessment is based on an age-structured population model, commonly used in U.S. West Coast groundfish stock assessments. The population model has two sexes with a range of ages between 0 and 21 years old (age-plus group) and with a range of length bins between 10 cm to 76 cm at 2 cm interval. There are six fishing fleets and ten survey indices.

The general model specifications are very similar to the 2009 assessment and are unchanged from the 2015 assessment (last full assessment). Details on additional data to the 2015 assessment are described in the previous sections.

2.3.3 Estimated and fixed parameters

There are a total of 162 parameters being estimated in the base model. Major estimated parameters include logarithm of virgin recruitment (*lnR0*), steepness (*h*), growth parameters (L_1 *[same for both sexes]*, L_2, K for both sexes), recruitment deviation parameters and extra standard deviations (SD) for index catchability coefficients. Details on each category of parameters (life history, stock-recruitment, and selectivity) are described below.

2.3.3.1 Parameter priors

Uninformative uniform priors are used on all parameters except natural mortality (*M*) and steepness (*h*). Priors for *M* (mean = 0.174, SD = 0.438) are provided by O. Hamel (NWFSC, personal comm.). The priors are slightly different from those used in the 2015 assessment (mean = 0.128, SD = 0.517) because only maximum ages are used in the current method while the 2015 method includes other factors such as fecundity and environmental information. The prior used for *h* was updated and provided by J. Thorson (NWFSC, personal comm.), and has mean of 0.718 and standard deviation of 0.158. Both priors were approved by the SSC for the 2017 assessment cycle.

2.3.3.2 Life history, stock-recruitment, and selectivity parameters

All parameters for the length-weight relationships, maturity, and fecundity are externally estimated and fixed in the base model, and are unchanged from the 2015 assessment. Natural mortality rates (*M*) are set to be same for both sexes and estimated internally with the priors in the base model. All growth parameters are sex-specific and are internally estimated, with the exception of L_1 for males, which is set to be the same as for females.

The stock-recruit relationship is modeled as the Beverton-Holt function with two parameters (*lnR0* and *h*). The virgin recruitment parameter (*lnR0*) is internally estimated while the steepness parameter (*h*) is fixed at a prior value of 0.718. Recruitment deviations are estimated between

1954 and 2015. The standard deviation for recruitment deviations (σ_R) is fixed at 1.0, the same value used since the 2002 assessment, and is slightly less than the RMSE value (1.01) of estimated main recruitment deviations. A bias correction procedure, developed by Methot and Taylor (2011) and availed in the r4ss program, is used. This procedure provides five ramp parameters to approximate unbiased estimates of log-normally distributed recruitments.

Selectivity functions for fisheries and surveys are all length-based and modeled as double-normal selectivity specified in the SS software with exceptions for the CalCOFI index (as function of spawning biomass) , the pelagic juvenile trawl survey index (recruitment, age-0 abundance), and the power plan impingement index (recruitment, age-0 abundance). The double-normal function has six parameters and is very flexible, as it can effectively model both asymptotic and dome-shaped selectivity. No sex offsets are used, so that both females and males are subject to the same selectivity in all fisheries and surveys. The same shapes of selectivity used in the 2009 assessment are employed in this assessment. A time block is used for four fisheries (two trawl and two recreational fisheries) from 2003 to 2016 to reflect management changes during the time period.

2.4 Model Selection and Evaluation

2.4.1 Key assumptions and data weighting

Key assumptions for the base model include the two most important functions (1) constant natural mortality for all ages and sexes for the whole time period; and (2) Beverton-Holt stock-recruit relationship, with steepness parameters being fixed at prior (0.718) in the base model.

A few alternative data-weighting methods were exploited in the 2015 assessment and during the 2015 STAR Panel review, including using harmonic mean and the Francis methods. This update assessment uses the same weighting method as in the 2015 base model (adopted in the 2015 STAR Panel review), in which we used the Francis weighing method for the length composition data and the harmonic mean weighting method for the CAAL data.

2.4.2 Model convergence, jitter and phase analysis runs

The base model converged well and seems to be relatively stable with maximum gradient component being less than 0.0001 in almost all runs. All estimated parameters are within reasonable ranges, and the SS3 program produces no warning. A jitter analysis of $N = 50$ with a jitter setting of 0.05 (randomly jitter initial parameter values by 5% of their standard deviations) has 70% of repeated runs converged at the same minimum negative log likelihood value as the base model (Table 15). There are a couple of repeated runs with log likelihood values that drifted by 1.28 likelihood unit. These runs, however, appeared to have minimum effects on the model outputs (less than 1.0% difference in the estimated stock depletions). A phase analysis was done by alternating parameter estimation phases for different parameters, and the analysis indicated no effects on the model outputs.

2.5 Response to 2017 SSC Update Assessment Review

The SSC noted that the approach used to update the pre-recruit (age 0) trawl survey index was changed from the previous assessment to correct a methodological error, although there was little impact on the results. Ongoing efforts to develop a more robust method for developing the index were discussed and should be anticipated in future assessments. Similarly, it was noted as interesting that the NWFSC hook and line survey data were consistent with a strong 2010 year class, but not with a strong 2013 year class (both of which were evident from other data sources). This too was noted as something worth greater investigation in future updates or full assessments.

Two additional suggestions by the SSC (add results for steepness = 0.718 to Table 19 and clarify which version of VAST was used for the base model) were addressed and added to the document.

2.6 Base-Model Results

Table 16 details all of the common parameters used in the base model, except estimated recruitment deviations that are listed separately in Table 17. Both tables also show the same sets of parameters estimated in the 2015 assessment model. The input files for the base model to the SS program are available upon request. All estimated parameter values, as well as estimated standard deviations (SD), are comparable between this and the 2015 assessment. Status of all actively estimated parameters show that all these parameters are within defined boundaries (not too close to lower or upper boundaries), although standard deviations (SD) of some parameters are large. Estimated growth functions for both sexes and related CVs are shown in Figure 38.

Fits to the relative abundance indices (in log space) for all of the indices used in the model are shown in Figure 39 to Figure 49. As in the 2015 assessment, fits to the CPUE indices were generally reasonable in most indices. Both the NWFSC hook-and-line and bottom trawl surveys show increasing trends in recent years (Figures 45 and 46). The 2016 index from the NWFSC bottom trawl survey is the highest since the start of the survey in 2003. However, the 2015 and 2016 indices from the NWFSC hook-and-line survey are lower than those in the previous years (2011 to 2014). This is not consistent with the model estimated increasing population trend for these years. As discussed in the data section (also see the length composition discussion below), this discrepancy could be due to the fact that the 2013 year-class was not well represented in the survey. This lack of fit also occurs in the 2015 and 2016 indices from the southern California onboard recreational CPUE, in which the index values are also lower than expected, especially in 2016 (Figure 48). However, it should also be noted that throughout the history of assessments for this stock, conflicting signals in different indices are common. In fact, variable weighting of conflicting data sources has historically been used to bracket uncertainty in this assessment.

All estimated selectivity functions are generally well estimated and show very similar patterns as in the 2015 assessment (Figure 50 to Figure 65). All selectivity curves are estimated to be dome-shaped, except for the late time period of the northern California trawl fishery (Figure 59).

In general, as in the 2015 assessment, the length composition data fit reasonably well in most fishing fleets and surveys (Figure 66 to Figure 78). The length composition data and the model fits to the data from several fishing fleets and surveys, including both trawl fisheries (Figure 67 and Figure 72), both recreational fisheries (Figure 70 and Figure 71), and the NWFSC trawl survey (Figure 76), indicate a very strong 2013 year-class, which corresponds well with the high recruitment in 2013 estimated by the base model.

As mentioned in the data section, the 2013 year-class was not well represented in the NWFSC Hook-and-line survey. As the result, there is a poor fit to the length composition data from this survey in the later years (especially in 2015 and 2016, Figure 75). The reason for this lack of fit are not evident, possibly due to some large fish moving out of the area. Young (first several years of life) bocaccio are known to disperse over respectable distances, and it is also possible that the unusual ocean conditions of 2015-2016 triggered unusual movement patterns in this cohort.

Since no new age data are included in this assessment update, and estimated growth and natural mortality parameters have changed very little from the 2015 assessment, fits to the CAAL data for all fishing fleets and surveys are not updated here but are available in the r4ss output files.

The base model results for time series of fishing mortality and 1-SPR, summary biomass, spawning output, stock depletion, and age-0 recruitment and recruitment deviations are shown from Figure 79 to Figure 84 and are listed in Table 18. The stock-recruit curve and the estimated recruitment bias adjustments are shown as Figure 85 and Figure 86. The estimated numbers of fish by age, sex and year are presented in Appendix C. The initial unfished summary (age 1+) biomass is estimated to be 45,988 mt, with a spawning output (SSB_0) of 7,195 x 10^6 larvae and mean age-0 recruitment (R_0) of 6,845 x 10^3 recruits. The estimated natural mortality (M) for the base model was 0.180.

The summary biomass, spawning output, and recruitment in 1892 (when the catch history begins) are slightly below the estimated unfished levels due to the presumed existence of a very moderate fishery beginning in the 1850s. The population trajectory exhibited a very moderate decline until about 1950, and then declined steeply as catches rose from several hundred to several thousand metric tons. The local minimum of the unfished spawning output occurred in 1961, and was associated with harvest rates significantly above the (current) target levels. The biomass increased sharply thereafter as a result of one or several very strong recruitment events in the early 1960s (informed primarily by the CalCOFI time series). The biomass exceeded the mean unfished biomass level through the early 1970s, when catches again began to climb rapidly to their peak levels, associated with high (SPR of less than 0.2) fishing mortality rates and a rapid drop in biomass. The estimated biomass and spawning output continued to decline from the mid-1970 to the early 2000s because of high catches from fisheries, and they reached their the lowest levels in 2000. Since then, the biomass and spawning outputs have been steadily increasing. The model estimates a strong 2013 recruitment (Table 18, Figure 83 to Figure 85), and this is a key factor in determining increases of biomass and spawning outputs in the recent years. The base model estimates a current (2017) stock depletion level of 48.6% and a 2016 SPR of 94.5%.

2.7 Uncertainty and Sensitivity Analyses

2.7.1 Likelihood profiles on key assessment parameters

2.7.1.1 Likelihood profile on steepness (*h*)

A profile of steepness was conducted on a range between 0.35 and 0.975; the outputs are shown from Figure 87 to Figure 90. Summary outputs from the selected profile runs are shown in Table 19. The profile of steepness shows that the best fit occurs at h around 0.525, and the model is not very informative on estimating steepness (small differences in log likelihoods). However, as seen in the figures, different components have different effects on estimating steepness values. In general, CAAL data and parameter priors have better fits with high steepness values; length composition and recruitment data have better fits with low steepness values; and index data have better fits at intermediate steepness values. The estimated growth parameters remain very similar with regards to changes in steepness. As expected, the stock is less depleted with higher steepness values (Figure 89 and Table 19).

2.7.1.2 Likelihood profile on natural mortality (*M*)

A profile of natural mortality (M) was conducted on a range between 0.10 and 0.27; outputs are shown as Figure 91 to Figure 94 and summary outputs from selected profile runs are shown in Table 20. The results indicate that the model has a better fit with M around 0.18. The results show that different components have different effects on estimating natural mortality. Both length and index data have better fits with natural mortality around 0.16, while recruitment estimates have better fits at higher natural mortality values. The estimated growth parameters are relatively insensitive to changes in steepness.

2.7.1.3 Likelihood profile on virgin recruitment (*$ln(R_0)$*)

A profile of the logarithm of virgin recruitment (*$ln(R_0)$*) was conducted on a range between 8.2 and 9.6; outputs are shown as Figure 95 to Figure 98, and summary outputs from selected profile runs are shown in Table 21. The results indicate that the model has a best fit with *$ln(R_0)$* around 8.8. The results show that different components have different effects on estimating natural mortality. Recruitments have better fits with high *$ln(R_0)$* values, while both index and length data have better fits at low values of *$ln(R_0)$*. The estimated growth parameters remain very similar with changes in *$ln(R_0)$*.

2.7.2 Sensitivity analysis

2.7.2.1 Sensitivity to estimates of NWFSC trawl survey indices using different analytic methods

The base model uses the VAST program to analyze the index, which is a program developed by J. Thorson of the NWFSC. The program is a spatial and temporal explicit Delta GLMM method and differs from a similar but non-spatial method used in the 2015 assessment. The VAST program is also capable of analyzing data in non-spatial explicit setting (J. Thorson, personal communication). We used these three comparable methods to analyze the NWFSC trawl survey data, and outputs from these three methods are compared and presented in Table 22 and Figure 99 to Figure 101. The results show that the assessment outputs are very similar among the three methods, although the non-spatial Delta GLMM method seems to have better overall fits (smaller total negative log-likelihood value, Table 22).

2.7.2.2 Sensitivity to estimates of juvenile survey indices using different analytic methods

The base model uses an ANOVA method to analyze the juvenile survey index (Appendix A). Although this index was intended to be a strict "update" from the 2015 index, a correction in the estimation method for the juvenile survey index resulted in an extremely flat (uninformative) index, which is (predictably) very poorly fit to the recruitments estimated by the model. A sensitivity analysis was conducted to compare the outputs from this method with two other methods: (1) the juvenile survey index used in the 2015 assessment, which does not include the last two years (2015 and 2016) data and did not include the "correction" to the ANOVA estimation; and (2) the same VAST procedure used in the NWFSC trawl survey data. The VAST method is promising and is likely to provide a more robust approach for developing pelagic YOY indices for future assessments. However, the method has not been rigorously reviewed with respect to applications to the pelagic YOY data and currently cannot account for temporal changes (period effects) that are included in the ANOVA. The outputs from this sensitivity analysis are compared and presented in Table 23 and Figure 102 to Figure 104. The results show that the model with the 2015 index estimates a slightly more depleted stock (stock depletion = 46.6% vs 48.6% in the base model), while the model with the VAST index estimates more optimistic stock status (stock depletion = 56.9%). Despite unusually high abundance of pelagic YOY from 2014-2016 (Sakuma et al. 2016), analysis of the pelagic YOY data using any of these varied approaches does not indicate either very strong or very weak year classes in recent years. Given the results of these sensitivity analyses and based on the observation that analysis of the pelagic YOY data using any of these varied approaches does not indicate either very strong or very weak year classes in recent years, despite unusually high abundance of pelagic YOY generally from 2014-2016 (Sakuma et al. 2016), the model should not be sensitive to the YOY index in this update. However, the modeling approach for the index should be revisited prior to the next full assessment or update.

2.7.3 Retrospective analysis

The retrospective analyses (Figure 105 to Figure 107, Table 24) do not seem to show a major shift in perception of stock status when data from the last one to four years are removed, indicating that there are no significant biases in model estimation with or without data from recent years. Estimates of both natural mortality (*M*) and log-virgin recruitment (lnR0) are very similar, and all runs with less data from recent years show that the stock is less depleted in 2017 (stock depletion greater than 48.6%).

2.7.4 Comparisons to the 2015 assessment

Comparisons of time series of the spawning outputs and stock depletions between the base model in this assessment and the 2015 assessment are presented in Figure 108. Comparisons of the 2015 assessment biomass estimates with previous assessments are presented in Figure 109. Overall, two time series are similar with the estimated virgin spawning output slightly higher than that in the 2015 assessment.

3 Reference Points

A summary of reference points for the base model is presented in Table 25, including the unfished summary biomass, unfished spawning output, mean unfished recruitment and the proxy estimates for MSY based on the $SPR_{50\%}$ rate as well as the fishing mortality rate associated with a spawning stock output of 40% of the unfished level and with MSY estimated based on the spawner/recruit relationship and yield curve. The corresponding yields for these three estimates vary between 1,857 mt based on the SPR target and 2,158 mt based on the MSY estimate. The unfished total biomass is estimated to be 47,268 mt, which was similar to that estimated in the 2015 assessment. Summary of recent trend in catches, regulations, and stock status is presented in Table 26.

4 Harvest Projections and Decision Tables

Harvest projections and a decision table based on four future catch scenarios (four catch streams) are presented in detail in the Decision table section in the Executive Summary. A projection of annual ACL and OFL between 2019 and 2026 based on the current base model is presented in Table 26a.

5 Regional Management Considerations

As described in the 2009 assessment, the stock structure for Bocaccio is poorly understood. The decision to extend the boundaries of what we consider to be the southern subpopulation from Cape Mendocino to Cape Blanco was based on the observation that catches (both fishery and survey-derived) do not end abruptly at Cape Mendocino, but rather tend to taper off to the north. As such, the fish in this region were more likely to originate from the southern subpopulation than the subpopulation distributed to the north. However, either boundary is imperfect. There is clearly a need to devote additional effort into understanding population structure and connectivity, and to evaluating trends in abundance in the waters of the Pacific Northwest, as discussed in the research needs section below.

6 Research Needs

Stock structure for Bocaccio on the West Coast remains an important issue to consider in future assessments, as well as for management. This assessment does not address population abundance levels or trends in the Columbia or U.S. Vancouver INPFC areas, which might be considered more likely to be comparable to those observed in Canadian waters than waters south of Cape Blanco. As noted in the 2015 STAR Panel report, improved means for evaluating stock boundaries is needed for all rockfish (and potentially other West Coast assessments).

Since large scale area closures and other management actions were initiated in 2001, the spatial distributions of fishing effort (fishing mortality) have changed over both large and small spatial scales. Not only has this effectively truncated several abundance indices (recreational CPUE), this confounds the interpretation of survey indices for surveys that do not sample in the Cowcod Conservation Areas (CCAs) as it follows that fishing mortality is greater on the fraction of the stock currently outside of the CCAs. Exploration of the potential spatial differences in relative abundance and population trends on both fine and broad spatial scales should continue.

Regional differences (southern and northern California, as well as southern Oregon) in growth, maturity, fecundity and the probability of females producing multiple broods in a given spawning season have been recognized but are poorly quantified. It is also apparent that multiple broods are more likely to result from larger, older individuals, which has implications on the shape of the size-dependent fecundity relationship used in this model. Environmentally driven changes in relative fecundity, particularly if manifest through the likelihood of producing multiple broods, could also have important implications for estimating both historical and future relative spawning abundance. Analysis of these factors remains ongoing.

Continued evaluation of the coastwide pelagic juvenile index (as well as other sources of recruitment information) is ongoing, particularly with respect to the spatial and temporal nature of the current coastwide survey for pelagic YOY, and towards an improved understanding of the physical mechanisms that relate to variability in cohort strength.

As Bocaccio is one of the most abundant and important piscivorous rockfish species, and its interactions with other predator and prey species are poorly known, dietary studies along with its movement patterns that are associated with habitats and prey abundance are key information to further understand its roles in the ecosystem in California waters.

Northward migratory behaviors of juvenile and young adults are indicated by length frequency data, but such behaviors are also poorly understood. Studies on the behaviors and their associations with oceanographic or other ecological factors can help future assessments in defining stock structure as well as explaining high variability in stock recruitments.

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9 List of Auxiliary files

1. Starter.ss
2. Forecast.ss
3. Boc1.dat
4. Boc1.ctl
5. PredictedNumber_byAgeSex_Boc2017.docx

10 Tables

Table 7: Estimated catches (mt) of Bocaccio from six fisheries and sum of annual total catches.

Year	Trawl south	Hook-and-line	Setnet	Recreational south	Recreational central	Trawl north	Total
1892	0	167	0	0	0	0	167
1893	0	157	0	0	0	0	158
1894	0	148	0	0	0	0	148
1895	0	139	0	0	0	0	139
1896	0	131	0	0	0	0	131
1897	0	123	0	0	0	0	123
1898	0	115	0	0	0	0	116
1899	0	108	0	0	0	0	108
1900	0	119	0	0	0	0	119
1901	0	131	0	0	0	0	131
1902	0	142	0	0	0	0	142
1903	0	154	0	0	0	0	154
1904	0	165	0	0	0	0	165
1905	0	176	0	0	0	0	176
1906	0	188	0	0	0	0	188
1907	0	199	0	0	0	0	199
1908	0	210	0	0	0	0	210
1909	0	237	0	0	0	0	237
1910	0	263	0	0	0	0	263
1911	0	289	0	0	0	0	289
1912	0	316	0	0	0	0	316
1913	0	342	0	0	0	0	342
1914	0	368	0	0	0	0	368
1915	0	395	0	0	0	0	395
1916	55	419	0	0	0	0	474
1917	86	661	0	0	0	0	747
1918	97	701	0	0	0	1	799
1919	66	463	0	0	0	0	529
1920	68	482	0	0	0	0	550
1921	56	406	0	0	0	0	463
1922	49	367	0	0	0	0	417
1923	55	434	0	0	0	0	489
1924	37	405	0	0	0	0	443
1925	30	475	0	0	0	1	506
1926	83	627	0	0	0	1	711

Table 7 (continued): Estimated catches (mt) of Bocaccio from six fisheries and sum of annual total catches.

Year	Trawl south	Hook-and-line	Setnet	Recreational south	Recreational central	Trawl north	Total
1927	111	497	0	0	0	2	610
1928	151	483	0	2	2	1	639
1929	119	441	0	4	5	28	598
1930	136	551	0	6	6	17	715
1931	46	578	0	8	7	50	689
1932	69	431	0	10	9	37	556
1933	90	257	0	12	11	59	429
1934	109	317	0	14	13	42	494
1935	91	369	0	16	15	43	534
1936	108	474	0	16	17	18	632
1937	92	408	0	28	20	41	589
1938	76	295	0	22	19	48	461
1939	50	200	0	20	17	86	373
1940	46	238	0	14	24	61	383
1941	32	187	0	13	22	54	310
1942	8	72	0	7	12	28	127
1943	8	70	0	7	11	204	300
1944	3	84	0	5	9	647	748
1945	55	127	0	7	12	1229	1430
1946	112	122	0	12	21	623	891
1947	6	198	0	37	17	639	897
1948	82	150	0	102	34	404	772
1949	94	177	0	133	44	387	834
1950	304	328	0	157	54	380	1222
1951	765	262	0	136	63	538	1764
1952	1311	181	0	152	55	274	1973
1953	1678	70	0	171	47	314	2281
1954	1598	89	0	411	58	255	2411
1955	1765	123	0	761	69	345	3062
1956	2006	300	0	917	77	379	3680
1957	2219	271	0	530	77	488	3585
1958	2460	214	0	301	123	490	3588
1959	2063	125	0	178	103	387	2855
1960	1732	93	0	185	81	358	2449
1961	1297	81	0	212	68	277	1935

Table 7 (continued): Estimated catches (mt) of Bocaccio from six fisheries and sum of annual total catches.

Year	Trawl south	Hook-and-line	Setnet	Recreational south	Recreational central	Trawl north	Total
1962	1147	68	0	204	80	243	1743
1963	1314	85	0	194	89	339	2021
1964	943	70	0	244	75	200	1533
1965	966	81	0	319	107	281	1753
1966	2410	130	0	564	118	206	3428
1967	4036	118	0	770	111	300	5336
1968	1996	81	0	832	104	396	3410
1969	1133	78	17	785	111	236	2359
1970	1341	82	15	1039	118	262	2858
1971	961	82	59	967	104	346	2519
1972	1648	123	71	1309	123	387	3661
1973	4537	152	167	1511	186	654	7207
1974	5956	164	262	1893	201	530	9005
1975	3316	158	285	1865	200	586	6411
1976	3425	219	123	1489	216	714	6186
1977	2381	189	158	1265	194	678	4865
1978	1879	248	125	1174	196	761	4382
1979	3299	351	235	1714	230	342	6172
1980	3055	335	216	943	317	677	5543
1981	1779	300	356	941	230	2205	5812
1982	2328	393	387	1249	371	2043	6772
1983	1891	268	671	266	308	2366	5770
1984	1421	480	685	182	67	1655	4491
1985	545	163	1047	325	68	664	2811
1986	789	288	1092	435	176	387	3168
1987	643	307	976	92	106	569	2693
1988	590	523	370	107	44	712	2346
1989	593	395	983	183	82	572	2808
1990	724	487	783	160	68	476	2699
1991	498	271	468	160	68	273	1739
1992	360	479	640	160	68	149	1857
1993	358	444	432	118	68	216	1635
1994	377	211	263	253	68	170	1341
1995	215	69	281	35	3	165	768
1996	226	93	92	69	32	67	578

Table 7 (continued): Estimated catches (mt) of Bocaccio from six fisheries and sum of annual total catches.

Year	Trawl south	Hook-and-line	Setnet	Recreational south	Recreational central	Trawl north	Total
1997	136	58	35	73	112	96	509
1998	41	42	39	34	26	33	215
1999	19	21	7	81	61	31	220
2000	14	7	1	60	75	8	164
2001	9	8	1	64	54	6	141
2002	28	0	0	86	9	21	144
2003	5	0	0	12	0	0	17
2004	14	2	0	61	2	4	83
2005	25	2	0	192	11	0	230
2006	16	10	0	52	12	1	91
2007	5	11	0	80	9	1	107
2008	8	4	0	49	4	4	68
2009	20	3	0	52	9	1	85
2010	13	2	0	50	7	2	73
2011	8	2	0	99	4	2	116
2012	11	3	0	119	6	2	142
2013	14	4	0	126	5	1	150
2014	6	7	0	93	6	7	119
2015	11	8	0	83	8	30	139
2016	32	1	0	58	10	57	157

Table 8: Number of positive samples, total available samples (in the November-May time period) and percent positive tows for the CalCOFI Ichthyoplankton data, 1981-2016 (see 2015 assessment for corresponding data from 1951-1980). Note that 2015 data are from spring (April) surveys only, winter (January-February) data have not yet been processed.

Year	South positives	Total	% pos	North positives	Total	% pos
1981	25	270	9%	16	130	12%
1982	0	85	0%	0	42	0%
1983	6	83	7%	2	44	4%
1984	31	165	18%	17	107	15%
1985	5	86	5%			
1986	6	131	4%			
1987	9	135	6%			
1988	19	142	13%			
1989	13	96	13%			
1990	9	135	6%			
1991	21	135	15%			
1992	17	91	18%			
1993	4	96	4%			
1994	13	146	8%	0	15	0%
1995	2	89	2%			
1996	19	92	20%			
1997	9	97	9%			
1998	5	120	4%	0	19	0%
1999	8	118	6%			
2000	8	96	8%			
2001	6	93	6%			
2002	10	118	8%			
2003	14	143	9%	4	46	8%
2004	11	99	11%	3	46	6%
2005	16	146	10%	1	44	2%
2006	13	149	8%	4	28	14%
2007	11	108	10%	4	10	40%
2008	13	176	7%	1	20	5%
2009	28	484	5%	1	35	2%
2010	10	149	6%	3	21	14%
2011	17	142	11%	3	43	6%
2012	11	161	6%	1	15	6%
2013	10	155	6%	0	30	0%
2014	5	80	6%	2	52	3%
2015	***8***	***49***	***16%***	***3***	***23***	***13%***
2016	***0***	***48***	***0%***	***0***	***30***	***0%***

Table 9: Summary statistics of raw numbers of hauls and catches and estimated biomass of Bocaccio and CVs using designed based estimate and VAST analysis for NWFSC trawl survey between 2003 and 2016. Raw CPUE are expressed in catches of kg per haul.

Year	n	Total catch (kg)	Raw CPUE	Design based biomass (mt)	Design based standard error (ln)	VAST biomass (mt)	VAST standard error (ln)
2003	541	184	0.341	1374.9	0.2901	1636.1	0.3132
2004	470	929	1.976	9086.2	0.4009	6879.7	0.3421
2005	637	385	0.604	2939.0	0.4221	2455.1	0.2855
2006	641	349	0.544	1960.4	0.4088	2333.1	0.3623
2007	688	226	0.328	1787.5	0.4795	1775.4	0.3793
2008	681	251	0.369	1604.2	0.4448	1688.7	0.3498
2009	682	103	0.151	772.1	0.3170	835.7	0.3667
2010	714	87	0.121	672.6	0.2664	657.6	0.3097
2011	697	76	0.110	536.3	0.3356	680.5	0.3989
2012	701	1353	1.930	8454.5	0.6071	5716.8	0.3228
2013	471	485	1.029	6816.2	0.3919	4429.8	0.2788
2014	685	1778	2.595	10865.2	0.6475	6366.5	0.2447
2015	672	609	0.906	4602.7	0.3406	3808.1	0.2586
2016	692	3709	5.360	38090.6	0.5076	17884.4	0.2728

Table 9a. Summary of annual numbers of tows; fish measured for length compositions; and computed effective sample sizes for sexed fish from NWFSC trawl survey between 2003 and 2006. Effective sample size is computed using the same method as in the 2015 assessment (i.e. Stewart method for computing length composition data for surveys).

Year	No. tow	No. fish	Effective sample size
2003	38	107	45.56
2004	29	480	62.94
2005	40	270	59.09
2006	38	262	56.52
2007	30	157	41.10
2008	26	111	33.85
2009	24	100	31.07
2010	37	272	56.23
2011	22	105	29.42
2012	48	817	105.76
2013	47	837	106.18
2014	95	1018	166.97
2015	58	696	107.21
2016	81	1447	183.30

Table 10 Summary of annual numbers of sampling trips, defined by vessel/date counts; fish measured for length composition; and computed effective sample sizes for sexed fish from the NWFSC hook-and-line survey. Effective sample size is computed using the same method as in the 2015 assessment (i.e. Stewart method for computing length composition data for surveys).

Year	Number of trip	Number of fish measured	Effective sample size
2004	19	786	127.47
2005	20	659	110.94
2006	22	728	122.46
2007	19	641	107.46
2008	22	665	113.77
2009	20	590	101.42
2010	22	269	59.12
2011	22	769	128.12
2012	23	1079	171.90
2013	27	1132	183.22
2014	23	1033	165.55
2015	21	1013	160.80
2016	27	773	133.67

Table 11: Summary of annual numbers of sampling trips, defined by month-site counts; fish measured for length compositions; and computed effective sample sizes for unsexed fish from two recreational fisheries. Effective sample sizes were calculated using Ian Stewart's method, and maximum effective size was set to be 400. Effective sample size is computed using the same method as in the 2015 assessment (i.e. Stewart method for computing length composition data for surveys).

	Recreational south			Recreational central		
Year	N sample	N fish	Effective sample size	N sample	N fish	Effective sample size
1980	494	2606	400	318	252	318
1981	388	2233	388	56	252	56
1982	332	1828	332	73	311	73
1983	134	706	134	79	359	79
1984	123	594	123	66	187	66
1985	311	1338	311	367	558	367
1986	220	1299	220	332	944	332
1987	39	132	39	52	225	52
1988	29	79	29	25	57	25
1989	98	490	98	33	119	33
1993	57	211	57	31	75	31
1994	80	377	80	27	57	27
1995	18	35	18	26	74	26
1996	41	116	41	65	244	65
1997	19	54	19	136	699	136
1998	44	106	44	70	296	70
1999	501	463	400	128	639	128
2000	325	525	325	62	272	62
2001	83	380	83	62	326	62
2002	311	726	311	30	179	30
2003	32	124	32			
2004	755	914	400	29	80	29
2005	812	1470	400	64	274	64
2006	911	1882	400	78	281	78
2007	1073	2148	400	332	266	332
2008	1059	1817	400	59	165	59
2009	953	2095	400	69	215	69
2010	960	1877	400	53	185	53
2011	1066	3250	400	353	187	353
2012	840	3812	400	52	148	52
2013	960	4235	400	36	67	36
2014	770	2901	400	45	111	45
2015	178	2383	400	42	137	61
2016	147	1397	400	36	93	49

Table 12: Summary of annual numbers of sampling trips, defined by port complex-day counts; fish measured for length compositions; and computed effective sample sizes for sexed fish from two commercial trawl fisheries. Effective sample sizes were calculated using Ian Stewart's method, and maximum effective size was set to be 400 (the same method used in the 2015 assessment). Note that only annual samples with N fish greater than 30 were used in the assessment model.

	Trawl south			Trawl north		
Year	N sample	N fish	Effective sample size	N sample	N fish	Effective sample size
1977				45	300	317.7
1978	56	963	395.4	81	583	400.0
1979	58	1085	400.0	40	170	63.5
1980	100	992	400.0	108	725	400.0
1981	77	631	400.0	93	792	400.0
1982	117	1492	400.0	117	1118	400.0
1983	116	1524	400.0	143	1146	400.0
1984	157	1799	400.0	100	890	400.0
1985	159	1151	400.0	97	593	400.0
1986	100	1891	400.0	74	543	400.0
1987	92	1748	400.0	87	975	400.0
1988	86	1180	400.0	67	522	400.0
1989	81	721	400.0	56	351	395.4
1990	96	1496	400.0	63	398	400.0
1991	89	1911	400.0	38	556	114.7
1992	64	1370	400.0	12	210	41.0
1993	46	1063	324.8	11	230	42.7
1994	16	313	59.2	14	272	51.5
1995	11	240	44.1	17	154	38.3
1996	23	349	71.2	6	59	14.1
1997	21	352	69.6	6	70	15.7
1998	19	281	57.8	7	106	21.6
1999	18	417	75.5	5	21	7.9
2000	4	53	11.3	5	65	14.0
2001	11	372	62.3	4	16	6.2
2002	14	160	36.1	6	107	20.8
2003	1	2	1.3			
2004	13	118	29.3			
2005	1	4	1.6	1	2	1.3
2006						
2007	3	10	4.4	2	2	2.3
2008	1	2	1.3	4	16	6.2
2009	2	2	2.3			
2010				2	6	2.8
2011						
2012	12	122	28.8			
2013	5	43	10.9	6	8	7.1
2014	1	25	4.5	5	5	5.7
2015	4	72	13.9	10	149	30.6
2016	3	90	15.4	14	244	47.7

Table 13: Summary of annual numbers of sampling trips, defined by port complex-day counts; fish measured for length compositions; and computed effective sample sizes for unsexed fish from two commercial trawl fisheries. Effective sample sizes were calculated using Ian Stewart's method, and maximum effective size was set to be 400 (the same method used in the 2015 assessment). Note that only annual samples with N fish greater than 30 were used in the assessment model.

	Trawl south			Trawl north		
Year	N sample	N fish	Effective sample size	N sample	N fish	Effective sample size
1977				1	4	1.6
1978	17	201	44.7			
1979	39	235	71.4	1	1	1.1
1980	6	9	7.2	18	73	28.1
1981	5	5	5.7	1	1	1.1
1982	1	1	1.1			
1983	4	85	15.7			
1984	7	111	22.3			
1985	5	26	8.6	1	3	1.4
1986	13	22	16.0			
1987	5	99	18.7			
1988	4	6	4.8			
1989	12	24	15.3			
1990	25	100	38.8			
1991	9	68	18.4			
1992	4	72	13.9			
1993	25	350	73.3			
1994	33	468	97.6	3	73	13.1
1995	28	352	76.6	1	1	1.1
1996	15	200	42.6	4	62	12.6
1997	27	567	105.2	1	15	3.1
1998	6	54	13.5			
1999	3	4	3.6	1	5	1.7
2000	5	37	10.1			
2001	10	158	31.8	1	16	3.2
2002	3	48	9.6	3	60	11.3
2003						
2004	2	5	2.7			
2005						
2006						
2007	1	1	1.1			
2008	1	1	1.1			
2009				1	16	3.2
2010				1	17	3.3
2011	4	30	8.1	3	14	4.9
2012	7	75	17.4	5	110	20.2
2013	9	125	26.3	4	147	24.3
2014	9	318	52.9	215	5	34.7
2015	10	342	57.2	247	14	48.1
2016	8	228	40.5	277	12	50.2

Table 14: Summary of annual numbers of sampling trips, defined by port complex-day counts; fish measured for length compositions; and computed effective sample sizes for unexsed fish from commercial hook-and-line and set net fisheries. Effective sample sizes were calculated using Ian Stewart's method and maximum effective size was set to be 400. Note that only annual samples with N fish greater than 30 were used in the assessment model.

	Hook-and-line			Setnet		
Year	N sample	N fish	Effective sample size	N sample	N fish	Effective sample size
1979	20	541	94.7			
1980	5	183	30.3			
1981	12	260	47.9			
1982	12	244	45.7			
1983	5	113	20.6	15	338	61.6
1984	12	151	32.8	69	947	400.0
1985	11	131	29.1	100	1156	400.0
1986	16	245	49.8	25	372	76.3
1987	6	64	14.8	18	207	46.6
1988	6	80	17.0	19	252	53.8
1989	18	324	62.7	17	99	30.7
1990	8	89	20.3	17	40	22.5
1991	9	143	28.7	8	137	26.9
1992	38	375	89.8	13	163	35.5
1993	48	547	338.9	19	486	86.1
1994	41	347	88.9	32	675	125.2
1995	22	179	46.7	30	498	98.7
1996	40	473	105.3	22	233	54.2
1997	24	259	59.7	9	105	23.5
1998	21	306	63.2	7	112	22.5
2001	8	108	22.9			
2002	4	61	12.4			
2006	6	45	12.2			
2007	5	42	10.8			
2008	8	20	10.8			
2009	11	41	16.7			
2010	9	35	13.8			
2011	7	24	10.3			
2012	6	48	12.6			
2013	8	110	23.2			
2014	29	488	96.3			
2015	20	171	43.6			
2016	22	94	35.0			

Table 15: Summary of jitter analysis of the base model to test the model stability.

Variable	Value
Minimum likelihood	3068.58
Maximum likelihood	3069.86
Likelihood difference between min. and max. likelihood	1.28
Minimum MGC (maximum gradient component)	2.10317E-05
Maximum MGC (maximum gradient component)	0.000786072
Stock depletion at min likelihood (%)	48.6136
Stock depletion at max likelihood (%)	48.5194
Depletion difference (%) between min and max likelihood	-0.0942
Number of jitter runs	50
Proportion of runs at minimum likelihood	0.7
Proportion of runs at maximum likelihood	0.02

Table 16: List of parameters used in the base model, including those estimated in the 2015 base model, estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds), estimated values and standard deviations (SD). Recruitment deviations are actively estimated parameters but are not listed here (plotted in figures). Bold parameters are exponential offset parameters from females.

No.	Parameter label	Phase	Active-count	Status	Value (2015)	SD (2015)	Value (2017)	SD (2017)
1	NatM_p_1_Fem_GP_1	2	1	OK	0.178	0.013	0.18	0.013
2	L_at_Amin_Fem_GP_1	2	2	OK	18.377	0.355	18.056	0.325
3	L_at_Amax_Fem_GP_1	2	3	OK	67.34	0.659	67.51	0.651
4	VonBert_K_Fem_GP_1	2	4	OK	0.226	0.007	0.226	0.007
5	CV_young_Fem_GP_1	6	5	OK	0.118	0.006	0.117	0.006
6	CV_old_Fem_GP_1	6	6	OK	0.077	0.004	0.077	0.003
7	**NatM_p_1_Mal_GP_1**	**-2**			**0**		**0**	
8	**L_at_Amin_Mal_GP_1**	**-2**			**0**		**0**	
9	**L_at_Amax_Mal_GP_1**	**2**	**7**	**OK**	**-0.083**	**0.01**	**-0.085**	**0.01**
10	**VonBert_K_Mal_GP_1**	**2**	**8**	**OK**	**0.081**	**0.031**	**0.085**	**0.03**
11	**CV_young_Mal_GP_1**	**6**	**9**	**OK**	**-0.074**	**0.06**	**-0.07**	**0.063**
12	**CV_old_Mal_GP_1**	**6**	**10**	**OK**	**0.003**	**0.06**	**0.003**	**0.06**
13	Wtlen_1_Fem	-3			0		0	
14	Wtlen_2_Fem	-3			3.114		3.114	
15	Mat50%_Fem	-3			37.7		37.7	
16	Mat_slope_Fem	-3			-0.334		-0.334	
17	Eggs/kg_inter_Fem	-3			254.9		254.9	
18	Eggs/kg_slope_wt_Fem	-3			20		20	
19	Wtlen_1_Mal	-3			0		0	
20	Wtlen_2_Mal	-3			3.114		3.114	
21	SR_LN(R0)	1	11	OK	8.769	0.164	8.834	0.162
22	SR_BH_steep	-2			0.773		0.718	

Table (continued): List of parameters used in the base model, including those estimated in the 2015 base model, estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds), and estimated values and standard deviations (SD). Recruitment deviations are actively estimated parameters but are not listed here (plotted in figures).

No.	Parameter label	Phase	Active-count	Status	Value (2015)	SD (2015)	Value (2017)	SD (2017)
23	SR_sigmaR	-4			1		1	
24	InitF_1TrawlSouth	-1			0		0	
25	InitF_2HL	1	83	OK	0.006	0.001	0.006	0.001
26	InitF_3Setnet	-1			0		0	
27	InitF_4RecSouth	-1			0		0	
28	InitF_5RecCentral	-1			0		0	
29	InitF_6TrawlNorth	-1			0		0	
30	Q_extraSD_1_TrawlSouth	4	84	OK	0.045	0.077	0.049	0.078
31	Q_extraSD_4_RecSouth	4	85	OK	0.328	0.104	0.328	0.104
32	Q_extraSD_5_RecCentral	5	86	OK	0.397	0.106	0.395	0.106
33	Q_extraSD_7_CalCOFI	4	87	OK	0.141	0.046	0.16	0.048
34	Q_extraSD_9_CDFWEarlyOB	4	88	OK	0.262	0.09	0.263	0.09
35	Q_extraSD_10_NWFSCHook	4	89	OK	0.228	0.067	0.308	0.089
36	Q_extraSD_11_NWFSCTrawl	4	90	OK	0.014	0.108	0.366	0.134
37	Q_extraSD_12_Juvenile	4	91	OK	0.334	0.153	0.586	0.196
38	Q_extraSD_14_PPIndex	4	92	OK	0.387	0.118	0.402	0.12
39	Q_extraSD_17_RecSouthOB	4	93	OK	0.272	0.08	0.55	0.136
40	Q_extraSD_18_RecCentralOB	4	94	OK	0.254	0.101	0.294	0.104
41	SizeSel_1P_1_TrawlSouth	3	95	OK	43.58	1.006	43.522	0.97
42	SizeSel_1P_2_TrawlSouth	4	96	OK	-11.864	122.792	-11.946	121.097
43	SizeSel_1P_3_TrawlSouth	4	97	OK	4.429	0.169	4.418	0.164
44	SizeSel_1P_4_TrawlSouth	4	98	OK	4.461	0.35	4.481	0.331

Table (continued): List of parameters used in the base model, including those estimated in the 2015 base model, estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds), and estimated values and standard deviations (SD). Recruitment deviations are actively estimated parameters but are not listed here (plotted in figures).

No.	Parameter label	Phase	Active-count	Status	Value (2015)	SD (2015)	Value (2017)	SD (2017)
45	SizeSel_1P_5_TrawlSouth	4	99	OK	-16.213	224.045	-16.319	218.566
46	SizeSel_1P_6_TrawlSouth	4	100	OK	-1.435	0.342	-1.499	0.339
47	SizeSel_2P_1_HL	3	101	OK	50.07	1.691	49.98	1.587
48	SizeSel_2P_2_HL	3	102	OK	-11.301	145.083	-11.239	147.023
49	SizeSel_2P_3_HL	3	103	OK	4.844	0.259	4.919	0.21
50	SizeSel_2P_4_HL	3	104	OK	4.013	0.759	4.059	0.717
51	SizeSel_2P_5_HL	3	105	OK	-7.73	11.299	-11.75	55.302
52	SizeSel_2P_6_HL	3	106	OK	-0.679	0.554	-0.732	0.543
53	SizeSel_3P_1_Setnet	3	107	OK	47.627	1.091	47.572	1.08
54	SizeSel_3P_2_Setnet	3	108	OK	-12.152	121.145	-12.18	120.473
55	SizeSel_3P_3_Setnet	3	109	OK	3.615	0.312	3.605	0.311
56	SizeSel_3P_4_Setnet	3	110	OK	3.892	0.479	3.903	0.467
57	SizeSel_3P_5_Setnet	3	111	OK	-6.349	1.529	-6.368	1.526
58	SizeSel_3P_6_Setnet	3	112	OK	-1.813	0.505	-1.869	0.506
59	SizeSel_4P_1_RecSouth	3	113	OK	37.874	1.068	37.605	1.236
60	SizeSel_4P_2_RecSouth	3	114	OK	-10.898	161.492	-3.71	2.583
61	SizeSel_4P_3_RecSouth	3	115	OK	4.651	0.166	4.604	0.185
62	SizeSel_4P_4_RecSouth	3	116	OK	5.58	0.212	5.479	0.286
63	SizeSel_4P_5_RecSouth	3	117	OK	-6.987	2.25	-6.928	2.302
64	SizeSel_4P_6_RecSouth	3	118	OK	-3.566	1.187	-3.555	1.215
65	SizeSel_5P_1_RecCentral	3	119	OK	46.921	2.349	46.719	2.434
66	SizeSel_5P_2_RecCentral	3	120	OK	-11.254	146.445	-11.18	149.249

Table (continued): List of parameters used in the base model, including those estimated in the 2015 base model, estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds), and estimated values and standard deviations (SD). Recruitment deviations are actively estimated parameters but are not listed here (plotted in figures).

No.	Parameter label	Phase	Active-count	Status	Value (2015)	SD (2015)	Value (2017)	SD (2017)
67	SizeSel_5P_3_RecCentral	3	121	OK	5.523	0.251	5.499	0.26
68	SizeSel_5P_4_RecCentral	3	122	OK	3.787	1.324	3.911	1.295
69	SizeSel_5P_5_RecCentral	3	123	OK	-5.679	1.8	-5.399	1.666
70	SizeSel_5P_6_RecCentral	3	124	OK	0.238	0.479	0.15	0.473
71	SizeSel_6P_1_TrawlNorth	3	125	OK	45.38	1.156	45.322	1.089
72	SizeSel_6P_2_TrawlNorth	4	126	OK	-0.964	0.564	-0.989	0.513
73	SizeSel_6P_3_TrawlNorth	4	127	OK	3.761	0.262	3.751	0.248
74	SizeSel_6P_4_TrawlNorth	4	128	OK	3.021	1.444	3.126	1.26
75	SizeSel_6P_5_TrawlNorth	4	129	OK	-9.02	5.591	-9.012	5.216
76	SizeSel_6P_6_TrawlNorth	4	130	OK	0.282	0.471	0.173	0.441
77	SizeSel_8P_1_Triennial	2	131	OK	27.611	2.388	27.715	2.508
78	SizeSel_8P_2_Triennial	2	132	OK	-12.31	117.597	-12.211	119.817
79	SizeSel_8P_3_Triennial	2	133	OK	1.832	1.744	1.857	1.773
80	SizeSel_8P_4_Triennial	2	134	OK	-8.5	257.144	-8.494	257.144
81	SizeSel_8P_5_Triennial	-4			-999		-999	
82	SizeSel_8P_6_Triennial	2	135	OK	-0.926	0.677	-0.917	0.685
83	SizeSel_9P_1_CDFWEarlyOB	-3			-1		-1	
84	SizeSel_9P_2_CDFWEarlyOB	-3			-1		-1	
85	SizeSel_10P_1_NWFSCHook	3	136	OK	44.76	3.47	49.386	3.742
86	SizeSel_10P_2_NWFSCHook	3	137	OK	-1.533	1.712	-4.365	14.307
87	SizeSel_10P_3_NWFSCHook	3	138	OK	4.734	0.438	5.195	0.405
88	SizeSel_10P_4_NWFSCHook	3	139	OK	4.332	1.513	4.348	1.223

Table (continued): List of parameters used in the base model, including those estimated in the 2015 base model, estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds), and estimated values and standard deviations (SD). Recruitment deviations are actively estimated parameters but are not listed here (plotted in figures).

No.	Parameter label	Phase	Active-count	Status	Value (2015)	SD (2015)	Value (2017)	SD (2017)
89	SizeSel_10P_5_NWFSCHook	3	140	OK	-12.05	54.771	-12.068	54.56
90	SizeSel_10P_6_NWFSCHook	3	141	OK	-2.026	1.468	-2.024	1.598
91	SizeSel_11P_1_NWFSCTrawl	3	142	OK	23.212	0.839	23.167	1.429
92	SizeSel_11P_2_NWFSCTrawl	3	143	OK	-11.613	135.026	-10.865	162.229
93	SizeSel_11P_3_NWFSCTrawl	3	144	OK	-4.71	7.632	-4.228	20.482
94	SizeSel_11P_4_NWFSCTrawl	3	145	OK	6.528	0.919	6.341	0.46
95	SizeSel_11P_5_NWFSCTrawl	3	146	OK	0.482	0.88	-0.247	0.519
96	SizeSel_11P_6_NWFSCTrawl	3	147	OK	-2.255	2.542	-2.984	2.054
97	SizeSel_15P_1_Free1	-3			-1		-1	
98	SizeSel_15P_2_Free1	-3			-1		-1	
99	SizeSel_16P_1_MirrorRecS	-3			-1		-1	
100	SizeSel_16P_2_MirrorRecS	-3			-1		-1	
101	SizeSel_17P_1_RecSouthOB	-3			-1		-1	
102	SizeSel_17P_2_RecSouthOB	-3			-1		-1	
103	SizeSel_18P_1_RecCentralOB	-3			-1		-1	
104	SizeSel_18P_2_RecCentralOB	-3			-1		-1	
105	SizeSel_1P_1_TrawlSouth_BLK1	2	148	OK	59.865	6.167	62.97	10.701
106	SizeSel_1P_3_TrawlSouth_BLK1	4	149	OK	5.578	0.538	6.343	0.654
107	SizeSel_1P_4_TrawlSouth_BLK1	4	150	OK	4.128	7.839	3.193	7.385
108	SizeSel_1P_6_TrawlSouth_BLK1	4	151	OK	0.393	5.177	0.154	4.102
109	SizeSel_4P_1_RecSouth_BLK1	2	152	OK	38.2	0.857	36.794	1.139
110	SizeSel_4P_3_RecSouth_BLK1	4	153	OK	4.305	0.16	4.189	0.208

Table (continued): List of parameters used in the base model, including those estimated in the 2015 base model, estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds), and estimated values and standard deviations (SD). Recruitment deviations are actively estimated parameters but are not listed here (plotted in figures).

No.	Parameter label	Phase	Active-count	Status	Value (2015)	SD (2015)	Value (2017)	SD (2017)
111	SizeSel_4P_4_RecSouth_BLK1	4	154	OK	4.769	0.185	4.835	0.275
112	SizeSel_4P_6_RecSouth_BLK1	4	155	OK	-3.868	0.704	-3.943	0.841
113	SizeSel_5P_1_RecCentral_BLK1	2	156	OK	44.168	2.436	44.559	2.494
114	SizeSel_5P_3_RecCentral_BLK1	4	157	OK	4.66	0.379	4.804	0.384
115	SizeSel_5P_4_RecCentral_BLK1	4	158	OK	4.357	0.999	4.437	0.978
116	SizeSel_5P_6_RecCentral_BLK1	4	159	OK	-0.889	0.591	-0.985	0.632
117	SizeSel_6P_1_TrawlNorth_BLK1	2	160	OK	46.789	9.295	46.76	7.383
118	SizeSel_6P_3_TrawlNorth_BLK1	4	161	OK	4.893	1.166	5.323	0.802
119	SizeSel_6P_4_TrawlNorth_BLK1	4	162	OK	-0.027	113.354	-0.221	114.679
120	SizeSel_6P_6_TrawlNorth_BLK1	4	163	OK	8.452	31.433	8.711	27.499
121	SizeSel_8P_1_Triennial_BLK2	2	164	OK	22.93	0.136	22.919	0.14
122	SizeSel_8P_3_Triennial_BLK2	4	165	OK	1.216	0.806	1.258	0.807
123	SizeSel_8P_4_Triennial_BLK2	4	166	OK	-7.552	46.594	-7.276	49.01
124	SizeSel_8P_6_Triennial_BLK2	4	167	OK	-1.929	0.57	-1.945	0.571

Table 17: Time series of estimated recruitment deviations and associated standard deviation (SD) from the base model. The same set of parameter estimates from the 2015 base model are also included for comparisons.

Year	Recruitment deviation (2015)	SD (2015)	Recruitment deviation (2017)	SD (2017)
1954	0.0519	0.9063	-0.0203	0.9007
1955	-0.1069	0.9017	-0.1339	0.8958
1956	-0.1047	0.9134	-0.1096	0.9125
1957	0.1553	1.0120	0.1452	1.0086
1958	0.4388	1.1598	0.4128	1.1483
1959	0.5555	1.2655	0.5386	1.2564
1960	0.5575	1.3145	0.5531	1.3112
1961	0.4968	1.2841	0.5000	1.2864
1962	0.6382	1.4262	0.6193	1.4105
1963	0.5897	1.4749	0.5598	1.4351
1964	0.5906	1.3561	0.4929	1.2991
1965	2.0962	0.6816	2.1241	0.6389
1966	0.4350	1.2027	0.3863	1.2045
1967	0.4710	1.1677	0.4455	1.1946
1968	0.6820	1.2749	0.6717	1.3370
1969	0.8726	1.4336	0.8712	1.4887
1970	0.9138	1.0782	0.8482	1.1246
1971	0.0880	0.9147	0.0296	0.9108
1972	1.2001	0.4180	1.1269	0.4180
1973	1.5726	0.2438	1.5265	0.2382
1974	1.3384	0.2129	1.2755	0.2112
1975	0.6071	0.2485	0.5209	0.2512
1976	-0.9750	0.4305	-1.0351	0.4318
1977	2.1224	0.1389	2.1269	0.1369
1978	1.7898	0.1867	1.7204	0.1935
1979	0.2753	0.3091	0.2071	0.3166
1980	-0.1023	0.3039	-0.2070	0.3180
1981	-0.8625	0.3550	-0.9195	0.3573
1982	-1.6881	0.4540	-1.7457	0.4543
1983	-1.3287	0.3591	-1.3496	0.3560
1984	1.3864	0.0939	1.3723	0.0943
1985	0.0846	0.1928	0.0088	0.1996

Table (continued): Time series of estimated recruitment deviations and associated standard deviation (SD) from the base model. The same set of parameter estimates from the 2015 base model are also included for comparisons.

Year	Recruitment deviation (2015)	SD (2015)	Recruitment deviation (2017)	SD (2017)
1986	-0.6327	0.2502	-0.6608	0.2509
1987	-0.4195	0.2182	-0.4073	0.2152
1988	1.0277	0.1027	1.0346	0.1041
1989	-0.3349	0.2530	-0.3681	0.2606
1990	-0.4477	0.2260	-0.4222	0.2241
1991	-0.0778	0.1874	-0.0647	0.1888
1992	-0.3329	0.2588	-0.3426	0.2660
1993	-0.7308	0.3646	-0.6868	0.3578
1994	-0.5959	0.3013	-0.5978	0.3034
1995	-1.0128	0.3223	-1.0046	0.3272
1996	-1.0728	0.3145	-0.9804	0.3153
1997	-0.7865	0.2594	-0.6452	0.2642
1998	-1.6198	0.4730	-1.4339	0.4816
1999	1.1694	0.1414	1.2519	0.1482
2000	-0.6455	0.4279	-0.5495	0.4489
2001	-1.0639	0.3828	-0.8299	0.3777
2002	-1.2329	0.3321	-1.1439	0.3451
2003	-0.0495	0.1694	-0.0119	0.1769
2004	-0.9783	0.2641	-0.9855	0.2910
2005	-0.5385	0.1905	-0.5404	0.2035
2006	-1.0187	0.2475	-1.0236	0.2694
2007	-1.0755	0.2303	-1.1042	0.2495
2008	-1.2692	0.2592	-1.3008	0.2789
2009	-0.5264	0.2041	-0.6049	0.2147
2010	0.4848	0.1747	0.4345	0.1765
2011	0.4445	0.2218	0.2736	0.2237
2012	-0.0147	0.2866	-0.2036	0.2723
2013	1.7816	0.2671	1.4939	0.2216
2014	-0.4022	0.4518	0.7786	0.3302
2015			0.1473	0.4219
2016			-0.5504	0.5385

Table 18: Time series of estimated key summary outputs from the base model.

No.	Age 1+ biomass (mt)	Spawning output (10^6 larvae)	Stock depletion (%)	Age-0 recruits	Total catch (mt)	SPR (%)	Relative exploitation rate (%)
1892	45988	7195	97.1	6845	167	96.8	0.4
1893	45971	7192	97.0	6845	158	97.0	0.3
1894	45962	7192	97.0	6845	148	97.2	0.3
1895	45959	7192	97.0	6845	139	97.3	0.3
1896	45965	7193	97.1	6845	131	97.5	0.3
1897	45976	7194	97.1	6845	123	97.6	0.3
1898	45993	7197	97.1	6845	116	97.8	0.3
1899	46016	7201	97.2	6846	108	97.9	0.2
1900	46044	7205	97.2	6846	119	97.7	0.3
1901	46058	7208	97.3	6846	131	97.5	0.3
1902	46058	7208	97.3	6846	142	97.3	0.3
1903	46046	7206	97.2	6846	154	97.1	0.3
1904	46023	7203	97.2	6846	165	96.8	0.4
1905	45989	7197	97.1	6845	176	96.6	0.4
1906	45946	7191	97.0	6845	188	96.4	0.4
1907	45895	7182	96.9	6844	199	96.2	0.4
1908	45836	7173	96.8	6843	210	96.0	0.5
1909	45772	7162	96.6	6842	237	95.5	0.5
1910	45687	7149	96.5	6841	263	95.0	0.6
1911	45583	7132	96.2	6839	289	94.5	0.6
1912	45462	7112	96.0	6837	316	94.0	0.7
1913	45324	7090	95.7	6835	342	93.5	0.8
1914	45174	7065	95.3	6832	368	93.0	0.8
1915	45010	7038	95.0	6830	395	92.5	0.9
1916	44836	7010	94.6	6827	474	90.9	1.1
1917	44596	6971	94.1	6823	747	86.1	1.7
1918	44097	6893	93.0	6815	799	85.1	1.8
1919	43581	6810	91.9	6806	529	89.7	1.2
1920	43380	6774	91.4	6802	550	89.2	1.3
1921	43187	6741	91.0	6799	463	90.8	1.1
1922	43109	6725	90.7	6797	417	91.7	1.0
1923	43096	6720	90.7	6797	489	90.4	1.1
1924	43021	6706	90.5	6795	443	91.3	1.0
1925	43004	6701	90.4	6795	506	90.1	1.2
1926	42930	6688	90.2	6793	711	86.3	1.7

Table (continued): Time series of estimated key summary outputs from the base model.

Year	Age 1+ biomass (mt)	Spawning output (10^6 larvae)	Stock depletion (%)	Age-0 recruits	Total catch (mt)	SPR (%)	Relative exploitation rate (%)
1927	42655	6645	89.7	6788	610	88.0	1.4
1928	42496	6619	89.3	6786	639	87.3	1.5
1929	42319	6591	88.9	6782	598	88.1	1.4
1930	42200	6571	88.7	6780	715	85.9	1.7
1931	41974	6534	88.2	6776	689	86.5	1.6
1932	41797	6504	87.8	6772	556	88.8	1.3
1933	41774	6497	87.7	6772	429	91.1	1.0
1934	41888	6513	87.9	6774	494	89.9	1.2
1935	41935	6520	88.0	6774	534	89.2	1.3
1936	41939	6520	88.0	6774	632	87.3	1.5
1937	41842	6506	87.8	6773	589	88.1	1.4
1938	41792	6498	87.7	6772	461	90.5	1.1
1939	41875	6509	87.8	6773	373	92.3	0.9
1940	42047	6535	88.2	6776	383	92.1	0.9
1941	42202	6559	88.5	6779	310	93.6	0.7
1942	42421	6593	89.0	6783	127	97.3	0.3
1943	42811	6655	89.8	6789	300	94.1	0.7
1944	43005	6686	90.2	6793	748	86.2	1.7
1945	42738	6644	89.6	6788	1430	75.5	3.3
1946	41803	6495	87.6	6772	891	83.1	2.1
1947	41452	6437	86.9	6765	897	83.0	2.2
1948	41129	6382	86.1	6758	772	84.3	1.9
1949	40950	6353	85.7	6755	834	83.0	2.0
1950	40719	6317	85.2	6751	1222	75.9	3.0
1951	40098	6224	84.0	6739	1764	66.8	4.4
1952	38938	6047	81.6	6717	1973	61.9	5.1
1953	37584	5843	78.8	6689	2281	56.1	6.1
1954	35957	5594	75.5	6520	2411	52.2	6.7
1955	34242	5332	72.0	5784	3062	42.0	8.9
1956	31818	4978	67.2	5871	3680	33.2	11.6
1957	28746	4523	61.0	7470	3585	31.4	12.5
1958	26045	4064	54.8	9598	3588	28.4	13.8
1959	23991	3629	49.0	10672	2855	33.8	11.9
1960	23553	3402	45.9	10698	2449	40.4	10.4
1961	24330	3387	45.7	10137	1935	52.0	8.0

Table (continued): Time series of estimated key summary outputs from the base model.

Year	Age 1+ biomass (mt)	Spawning output (10^6 larvae)	Stock depletion (%)	Age-0 recruits	Total catch (mt)	SPR (%)	Relative exploitation rate (%)
1962	26159	3590	48.4	11547	1743	59.5	6.7
1963	28635	3916	52.8	11048	2021	58.5	7.1
1964	31063	4251	57.4	10474	1533	68.6	4.9
1965	34002	4702	63.5	54356	1753	67.4	5.2
1966	41642	5148	69.5	9685	3428	50.8	8.2
1967	48386	5696	76.9	10411	5336	45.0	11.0
1968	52405	6840	92.3	13330	3410	64.4	6.5
1969	56582	7942	107.2	16516	2359	74.1	4.2
1970	60666	8698	117.4	16270	2858	69.0	4.7
1971	63493	9166	123.7	6604	2519	71.6	4.0
1972	65127	9629	129.9	13721	3661	61.6	5.6
1973	64669	9811	132.4	20490	7207	37.8	11.1
1974	60686	9169	123.7	15858	9005	25.7	14.8
1975	55115	8215	110.8	7387	6411	34.1	11.6
1976	51782	7823	105.6	1552	6186	35.2	11.9
1977	47178	7453	100.6	36474	4865	40.8	10.3
1978	46287	7001	94.5	24140	4382	41.4	9.5
1979	48185	6598	89.0	5282	6172	32.1	12.8
1980	48132	6679	90.1	3495	5543	40.9	11.5
1981	47004	7015	94.7	1723	5812	40.7	12.4
1982	43286	6834	92.2	752	6772	30.9	15.6
1983	36470	6027	81.3	1102	5770	30.1	15.8
1984	29480	5046	68.1	16386	4491	28.4	15.2
1985	25077	4109	55.4	4064	2811	32.3	11.2
1986	23125	3537	47.7	2026	3168	25.3	13.7
1987	21026	3277	44.2	2573	2693	34.1	12.8
1988	19246	3104	41.9	10762	2346	39.2	12.2
1989	18378	2844	38.4	2598	2808	29.8	15.3
1990	17022	2514	33.9	2392	2699	27.7	15.9
1991	15642	2363	31.9	3367	1739	42.1	11.1
1992	15040	2323	31.4	2539	1857	39.7	12.3
1993	14040	2179	29.4	1769	1635	40.7	11.6
1994	12990	2036	27.5	1898	1341	42.3	10.3
1995	12034	1916	25.8	1242	768	58.9	6.4
1996	11474	1845	24.9	1258	578	63.7	5.0

Table (continued): Time series of estimated key summary outputs from the base model.

Year	Age 1+ biomass (mt)	Spawning output (10^6 larvae)	Stock depletion (%)	Age-0 recruits	Total catch (mt)	SPR (%)	Relative exploitation rate (%)
1997	10953	1781	24.0	1740	509	65.2	4.6
1998	10453	1703	23.0	779	215	82.2	2.1
1999	10150	1655	22.3	11329	220	80.0	2.2
2000	10952	1609	21.7	1853	164	85.5	1.5
2001	12140	1641	22.1	1409	141	90.1	1.2
2002	13312	1891	25.5	1076	144	91.7	1.1
2003	14101	2133	28.8	3455	17	98.9	0.1
2004	14828	2279	30.8	1328	83	94.3	0.6
2005	15163	2342	31.6	2088	230	83.7	1.5
2006	15117	2370	32.0	1292	91	93.4	0.6
2007	14983	2379	32.1	1193	107	91.2	0.7
2008	14623	2356	31.8	978	69	93.8	0.5
2009	14122	2306	31.1	1949	85	92.1	0.6
2010	13583	2223	30.0	5459	73	92.2	0.5
2011	13520	2128	28.7	4594	116	88.0	0.9
2012	13915	2075	28.0	2831	142	89.0	1.0
2013	14533	2137	28.8	15582	150	90.4	1.0
2014	16669	2270	30.6	7744	119	93.7	0.7
2015	19701	2505	33.8	4223	139	94.5	0.7
2016	22816	3022	40.8	2430	157	94.5	0.7
2017	25293	3603	48.6	6220			

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

	h = 0.350	*h* = 0.500	*h* = 0.650	*h* = 0.718	*h* = 0.725	*h* = 0.850	*h* = 0.975
M (both sexes)	0.203	0.189	0.182	0.180	0.180	0.179	0.179
Steepness	**0.350**	**0.500**	**0.650**	**0.718**	**0.725**	**0.850**	**0.975**
lnR0	9.398	9.065	8.882	8.834	8.83	8.783	8.767
Depletion (%)	29.617	37.863	45.496	48.614	48.921	53.785	57.556
SPR ratio	0.087	0.082	0.076	0.073	0.073	0.069	0.065
Female Lmin	18.031	18.048	18.057	18.056	18.056	18.053	18.049
Female Lmax	67.618	67.548	67.514	67.51	67.51	67.518	67.532
Female K	0.226	0.226	0.226	0.226	0.226	0.226	0.226
Male Lmin (offset)	0	0	0	0	0	0	0
Male Lmax (offset)	-0.087	-0.086	-0.085	-0.0852	-0.085	-0.085	-0.085
Male K (offset)	0.088	0.086	0.085	0.0853	0.085	0.085	0.086
Negative log-likelihood							
TOTAL	3069.52	3067.43	3068.02	3068.58	3068.65	3069.89	3071.96
Catch	0	0	0	0	0	0	0
Equil_catch	0	0	0	0	0	0	0
Survey	-5.285	-7.045	-7.266	-7.08	-7.05	-6.443	-5.712
Length_comp	768.86	769.06	769.23	769.318	769.329	769.431	769.469
Age_comp	2281.44	2281.14	2281.01	2280.90	2280.89	2280.69	2280.52
Recruitment	22.279	23.319	24.709	25.267	25.315	26.107	26.64
Forecast_Recruitment	0.122	0.161	0.157	0.151	0.151	0.14	0.132
Parm_priors	2.081	0.77	0.156	-0.003	-0.009	-0.063	0.884
Parm_softbounds	0.02	0.02	0.02	0.021	0.021	0.021	0.021

Table 20: 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.

	M = 0.10	M = 0.15	M = 0.18	M = 0.20	M = 0.23	M = 0.27
M (both sexes)	**0.10**	**0.15**	**0.18**	**0.2**	**0.23**	**0.27**
Steepness	0.718	0.718	0.718	0.718	0.718	0.718
lnR0	8.095	8.535	8.834	9.046	9.414	10.087
Depletion (%)	27.564	40.587	48.611	55.393	62.074	69.467
SPR ratio	0.149	0.096	0.073	0.058	0.043	0.025
Female Lmin	18.143	18.088	18.056	18.046	18.019	17.969
Female Lmax	67.228	67.501	67.51	67.455	67.361	67.133
Female K	0.229	0.227	0.226	0.226	0.226	0.227
Male Lmin (offset)	0	0	0	0	0	0
Male Lmax (offset)	-0.076	-0.083	-0.085	-0.087	-0.088	-0.089
Male K (offset)	0.061	0.078	0.085	0.09	0.096	0.103
Negative log-likelihood						
TOTAL	3096.57	3071.73	3068.58	3069.37	3074.02	3084.25
Catch	0	0	0	0	0	0
Equil_catch	0	0	0	0	0	0
Survey	0.033	-7.763	-7.077	-5.061	-2.099	2.535
Length_comp	771.338	768.767	769.321	769.272	771.086	773.622
Age_comp	2293.95	2284.14	2280.9	2279.9	2280.02	2283.16
Recruitment	30.239	26.339	25.263	25.044	24.651	24.252
Forecast_Recruitment	0.191	0.166	0.151	0.136	0.134	0.137
Parm_priors	0.801	0.058	0.003	0.05	0.201	0.5
Parm_softbounds	0.019	0.02	0.021	0.027	0.031	0.041

Table 21: Summaries of key assessment outputs and likelihood values from selected likelihood profile runs on virgin recruitment (lnR0). Note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for the year of 2017.

	lnR0 = 8.2	lnR0 = 8.4	lnR0 = 8.6	lnR0 = 8.75	lnR0 = 9.0	lnR0 = 9.6
M (both sexes)	0.140	0.152	0.165	0.181	0.191	0.222
Steepness	0.718	0.718	0.718	0.718	0.718	0.718
lnR0	**8.2**	**8.4**	**8.6**	**8.85**	**9**	**9.6**
Depletion (%)	35.242	38.145	42.491	49.083	54.84	67.557
SPR ratio	0.147	0.121	0.096	0.072	0.058	0.032
Female Lmin	18.137	18.112	18.085	18.054	18.045	17.974
Female Lmax	67.407	67.44	67.477	67.512	67.499	67.439
Female K	0.227	0.227	0.226	0.226	0.226	0.228
Male Lmin (offset)	0	0	0	0	0	0
Male Lmax (offset)	-0.081	-0.082	-0.084	-0.085	-0.086	-0.087
Male K (offset)	0.074	0.077	0.081	0.086	0.088	0.092
Negative log-likelihood						
TOTAL	3077.84	3072.81	3069.75	3068.59	3068.87	3074.35
Catch	0	0	0	0	0	0
Equil_catch	0	0	0	0	0	0
Survey	-9.876	-9.778	-8.902	-6.926	-4.911	1.556
Length_comp	767.983	768.173	768.573	769.387	769.1	771.66
Age_comp	2287.05	2284.77	2282.8	2280.79	2279.83	2278.08
Recruitment	32.336	29.375	27.07	25.165	24.673	22.764
Forecast_Recruitment	0.204	0.196	0.176	0.149	0.128	0.105
Parm_priors	0.127	0.047	0.008	0.004	0.023	0.153
Parm_softbounds	0.019	0.02	0.02	0.021	0.026	0.029

Table 22: Summaries of key assessment outputs and likelihood values from sensitivity analysis from three methods of analyzing the NWFSC survey index. Note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for year of 2017.

Method	Base (VAST spatial)	VAST non-spatial	Delta GLMM
M (both sexes)	0.180	0.180	0.180
Steepness	0.718	0.718	0.718
lnR0	8.834	8.833	8.831
Depletion (%)	48.614	48.563	46.855
SPR ratio	0.073	0.073	0.079
Female Lmin	18.056	18.058	18.063
Female Lmax	67.51	67.507	67.51
Female K	0.226	0.226	0.226
Male Lmin (offset)	0	0	0
Male Lmax (offset)	-0.085	-0.085	-0.085
Male K (offset)	0.085	0.085	0.085
Negative log-likelihood			
TOTAL	3068.58	3071.25	3063.39
Catch	0	0	0
Equil_catch	0	0	0
Survey	-7.079	-4.494	-13.53
Length_comp	769.318	769.393	770.783
Age_comp	2280.9	2280.95	2280.91
Recruitment	25.267	25.231	25.024
Forecast_Recruitment	0.151	0.153	0.176
Parm_priors	0.003	0.003	0.003
Parm_softbounds	0.021	0.021	0.02

Table 23: Summaries of key assessment outputs and likelihood values from three methods of analyzing the juvenile survey index. Note that likelihood values are not comparable because different data are used, and they are listed here for references only. Also note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for year of 2017. The 2015 index is the same index used in the 2015 assessment (no 2016 and 2017 data).

Method	Base (ANOVA index)	2015 index	2017 VAST index
M (both sexes)	0.180	0.180	0.182
Steepness	0.718	0.718	0.718
lnR0	8.834	8.833	8.875
Depletion (%)	48.614	46.649	56.901
SPR ratio	0.073	0.078	0.052
Female Lmin	18.056	18.088	18.021
Female Lmax	67.51	67.513	67.516
Female K	0.226	0.226	0.226
Male Lmin (offset)	0	0	0
Male Lmax (offset)	-0.085	-0.085	-0.086
Male K (offset)	0.085	0.085	0.087
Negative log-likelihood			
TOTAL	3068.58	3065.37	3072.36
Catch	0	0	0
Equil_catch	0	0	0
Survey	-7.079	-11.757	-0.158
Length_comp	769.318	771.72	763.029
Age_comp	2280.9	2280.27	2282.59
Recruitment	25.267	24.971	26.869
Forecast_Recruitment	0.151	0.142	0.004
Parm_priors	0.003	0.003	0.005
Parm_softbounds	0.021	0.02	0.025

Table 24: Summaries of key assessment outputs and likelihood values from retrospective analysis from all data to four years of less data. Note that likelihood values are not comparable because different data are used, and they are listed here for references only. Also note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for year of 2017.

Year of data available	Base (all data)	One year less data	Two year less data	Three year less data	Four year less data
M (both sexes)	0.180	0.181	0.181	0.180	0.180
Steepness	0.718	0.718	0.718	0.718	0.718
lnR0	8.83423	8.84039	8.82646	8.81304	8.83647
Depletion (%)	48.6136	53.3997	59.7705	48.8756	62.8339
SPR ratio	0.072975	0.068159	0.058882	0.093998	0.069282
Female Lmin	18.056	18.1056	18.1987	19.2158	20.0257
Female Lmax	67.5104	67.4438	67.3823	67.6708	68.4164
Female K	0.226191	0.22627	0.226738	0.220043	0.210578
Male Lmin (offset)	0	0	0	0	0
Male Lmax (offset)	-0.0852	-0.08514	-0.08494	-0.08673	-0.09361
Male K (offset)	0.085304	0.086211	0.08597	0.080277	0.087442
Negative log-likelihood					
TOTAL	3068.58	3031.27	2999.78	2892.18	2789.81
Catch	3.05E-10	3.06E-10	3.32E-10	3.07E-10	3.06E-10
Equil_catch	8.27E-15	1.65E-13	1.35E-13	1.59E-13	3.61E-13
Survey	-7.079	-14.159	-18.7315	-28.2814	-26.9726
Length_comp	769.318	741.702	717.678	701.563	678.135
Age_comp	2280.9	2278.27	2274.33	2194.57	2112.7
Recruitment	25.2667	25.4299	26.4734	24.2968	25.9179
Forecast_Recruitment	0.151482	1.04E-18	1.01E-16	2.35E-15	2.51E-11
Parm_priors	0.002828	0.004181	0.00372	0.002653	0.003019
Parm_softbounds	0.020511	0.026544	0.026027	0.024348	0.025564

Table 25: Summary of reference points for the base model.

Quantity	Estimate	Low 2.5% limit	High 97.5% limit
Unfished Spawning output (10^6 larvae)	7411	5977	8845
Unfished age 1+ biomass (mt)	47268	38348	56188
Unfished recruitment (R_0)	6865	5011	9405
Depletion (2017)	48.6%	33.1%	64.1%
Reference points based on $SB_{40\%}$			
Proxy spawning biomass ($B_{40\%}$)	2964	2391	3538
SPR resulting in $B_{40\%}$ ($SPR_{50\%}$)	0.459	0.459	0.459
Exploitation rate resulting in $B_{40\%}$	0.093	0.081	0.106
Yield with SPR at $B_{40\%}$ (mt)	1934	1462	2406
Reference points based on SPR proxy for MSY			
Spawning biomass	3302	2663	3941
SPR_{proxy}	50%		
Exploitation rate corresponding to SPR_{proxy}	0.082	0.071	0.092
Yield with SPR_{proxy} at SB_{SPR} (mt)	1857	1406	2309
Reference points based on estimated MSY values			
Spawning biomass at MSY (SB_{MSY})	2158	1736	2579
SPR_{MSY}	0.361	0.357	0.365
Exploitation rate corresponding to SPR_{MSY}	0.129	0.112	0.146
MSY (mt)	2021	1525	2517

Table 26: Summary table of recent catches, regulations, and stock status between 2007 and 2017.

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Commercial landings (mt)	18	16	24	17	12	17	20	20	49	89	
Estimated total catch (mt)	107	69	85	73	116	142	150	119	139	157	
OFL (mt)	602	618	793	793	737	732	884	881	1444	1351	2039
ACL (mt)	218	218	288	288	263	274	320	337	349	362	790
1-SPR (%)	91.2	93.8	92.1	92.2	88.0	89.0	90.4	93.7	94.5	94.5	
Exploitation rate	0.007	0.005	0.006	0.005	0.009	0.010	0.010	0.007	0.007	0.007	
Age 0+ biomass (mt)	14983	14623	14122	13583	13520	13915	14533	16669	19701	22816	25293
Spawning output (10^6 larvae)	2379	2356	2306	2223	2128	2075	2137	2270	2505	3022	3603
Spawning output (low 2.5%)	1489	1487	1465	1420	1366	1336	1374	1447	1570	1821	2066
Spawning output (high 97.5%)	3270	3226	3146	3025	2890	2814	2899	3093	3439	4224	5139
Recruitment	1193	978	1949	5459	4594	2831	15582	7744	4223	2430	6220
Recruitment (low 2.5%)	635	500	1092	3214	2532	1454	8561	3606	1715	843	1194
Recruitment (high 97.5%)	2239	1913	3480	9273	8332	5509	28358	16630	10400	7004	32412
Depletion (%)	32.1	31.8	31.1	30.0	28.7	28.0	28.8	30.6	33.8	40.8	48.6
Depletion (low 2.5%)	23.3	23.4	23.1	22.5	21.8	21.4	22.1	23.3	25.3	29.2	33.1
Depletion (high 97.5%)	40.9	40.2	39.1	37.4	35.7	34.6	35.6	38.0	42.3	52.3	64.1

Table 26a. Projections of ACL and OFL from 2017 to 2026. Both ACLs and OFLs for 2017 and 2018 (bold and italic) are from current regulations. ACLs from 2019 to 2026 are from the forecast with SPR = 0.5 and ACL = ABC (P*=0.45).

Year	ACL (mt)	OFL (mt)
2017	***790***	***2233***
2018	***741***	***2201***
2019	2101	2194
2020	2043	2133
2021	2011	2100
2022	1986	2074
2023	1964	2051
2024	1945	2031
2025	1928	2013
2026	1914	1998

11 Figures

Figure 9. Map of the West Coast INPFC management areas. This assessment covers the Bocaccio stock in the Eureka, Monterey and Conception management areas (adapted from Field et al., 2009).

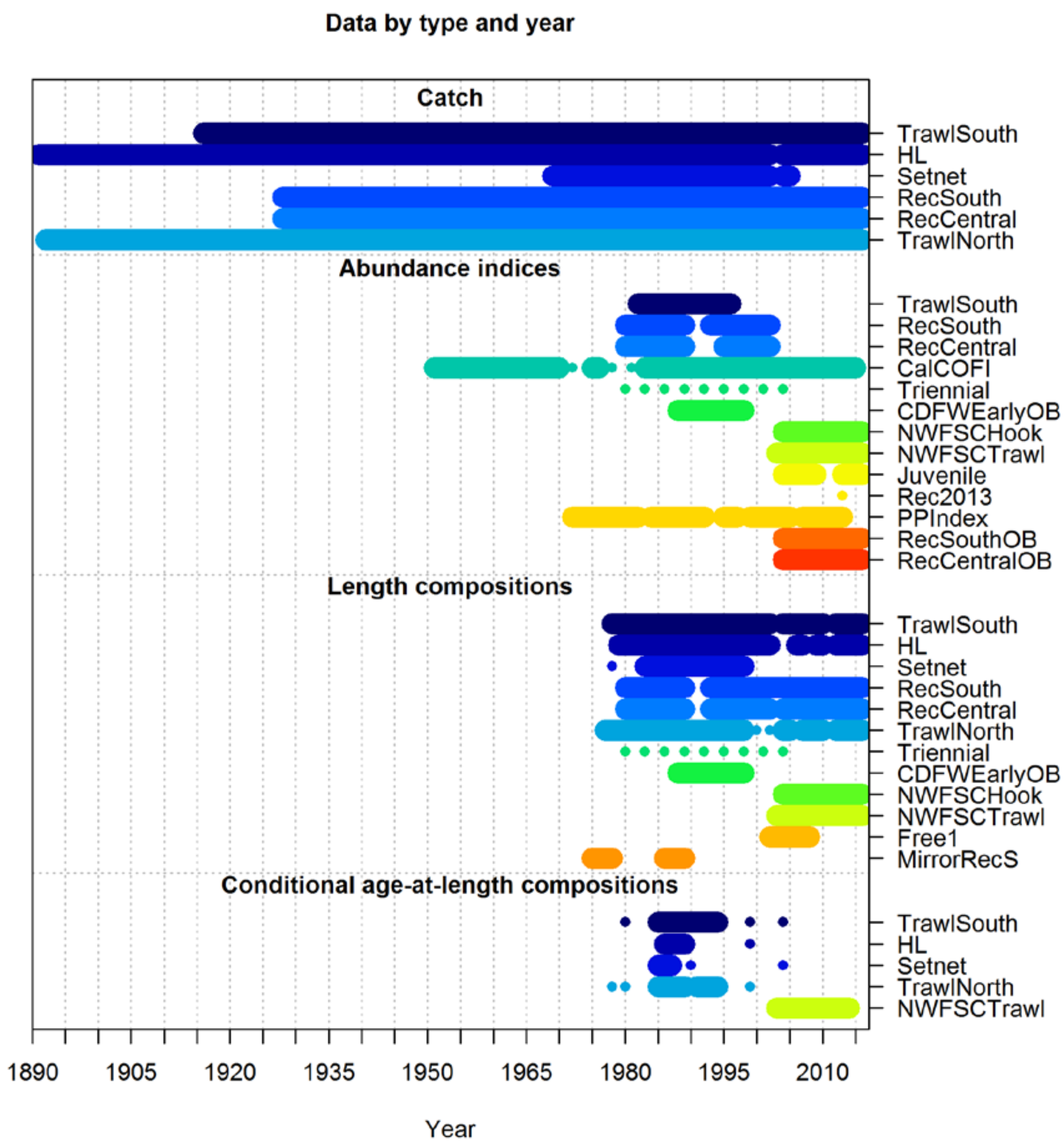


Figure 10. Summary of available data sources for the assessment.

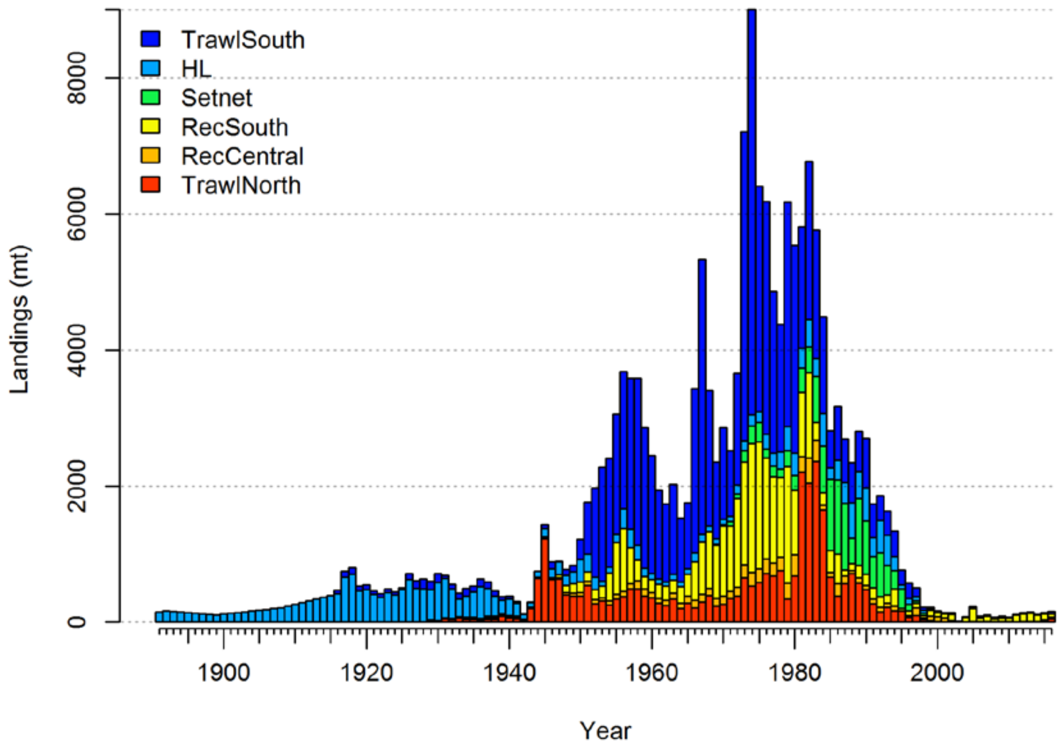
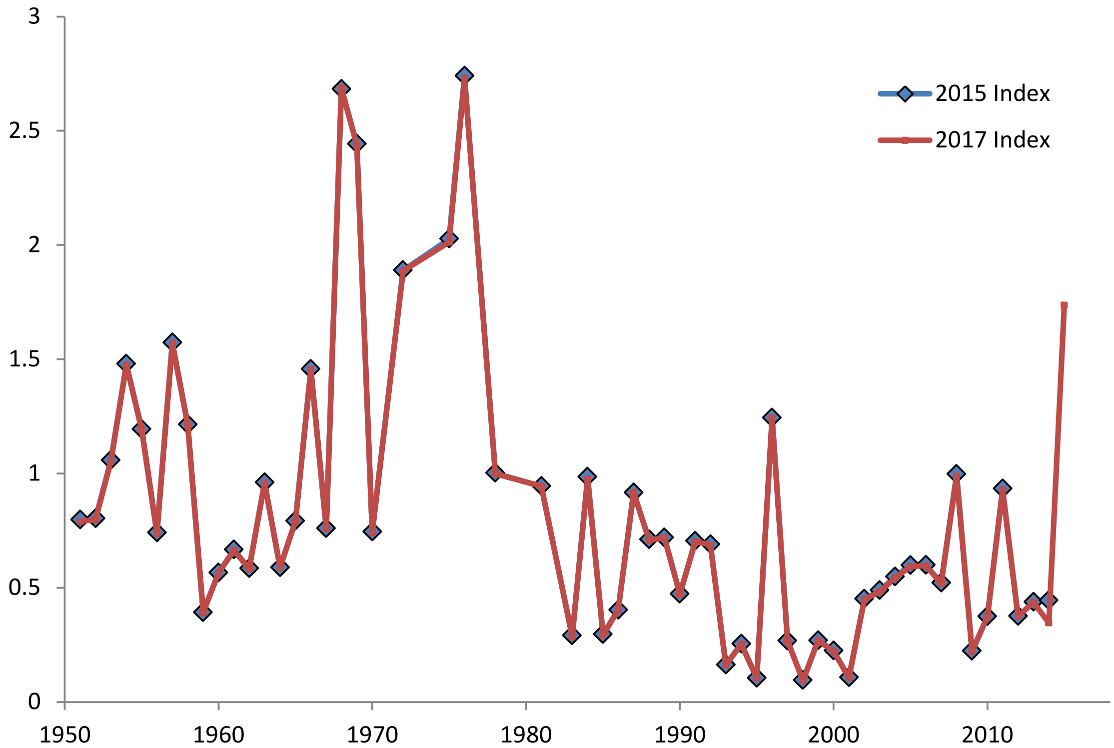


Figure 11. Time series of total catches (labelled as landing) and catches by six fisheries from 1892 to 2016.



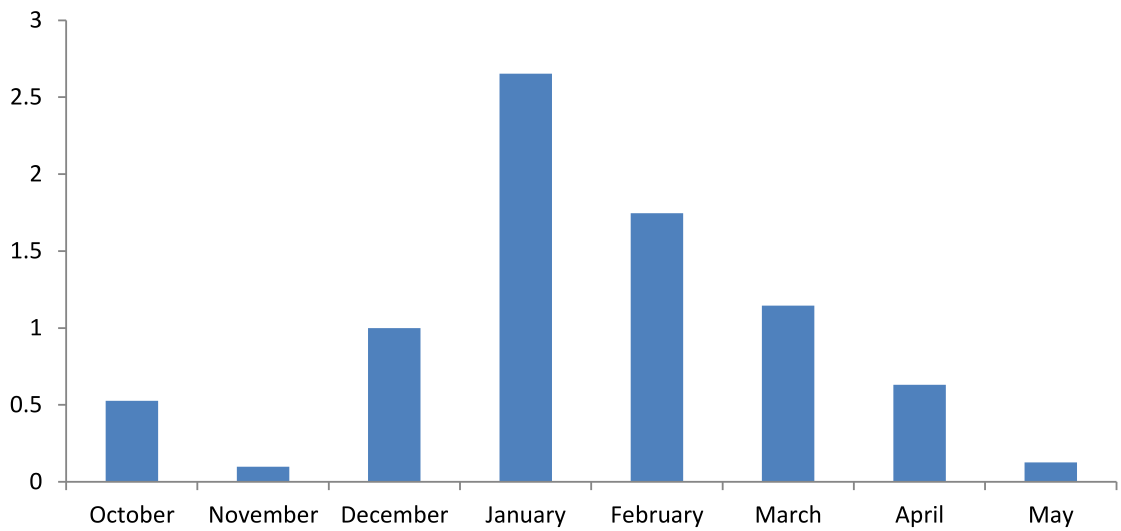


Figure 12. Comparison of CalCOFI 2015 model index (data for nearly all tows through 2014) and CalCOFI 2017 (this update) model index (data for 2015 and 2016 for Spring/April cruises only, winter data have not yet been processed).

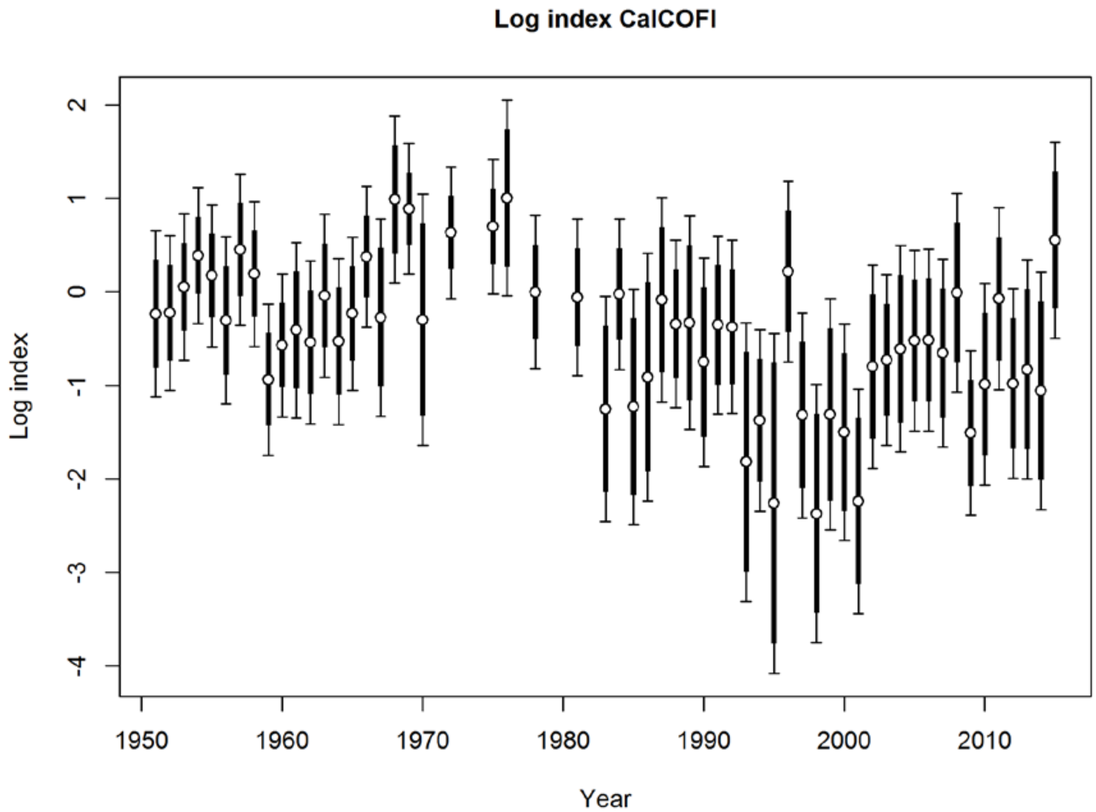


Figure 13. CalCOFI larval abundance indices (in log scale), with asymptotic standard errors based on a jackknife routine.

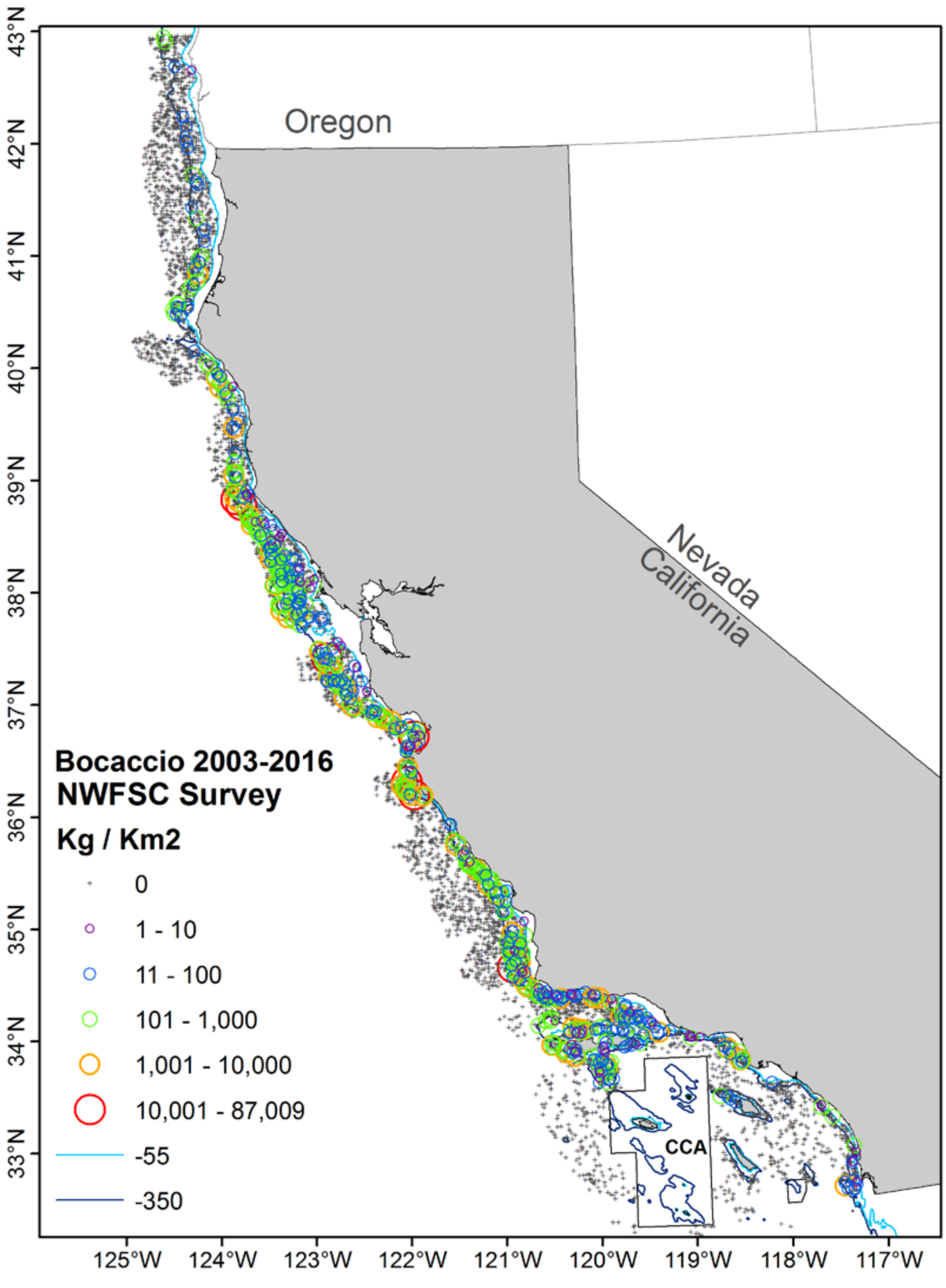


Figure 14. Spatial distribution of raw catch rates of Bocaccio from NWFSC trawl survey between 2003 and 2016. Depth contour lines of 55m and 350m and the CCA area are shown. Note that sizes and color of circles represent catch rate in log scales (Credit of Rebecca Miller, SWFSC).

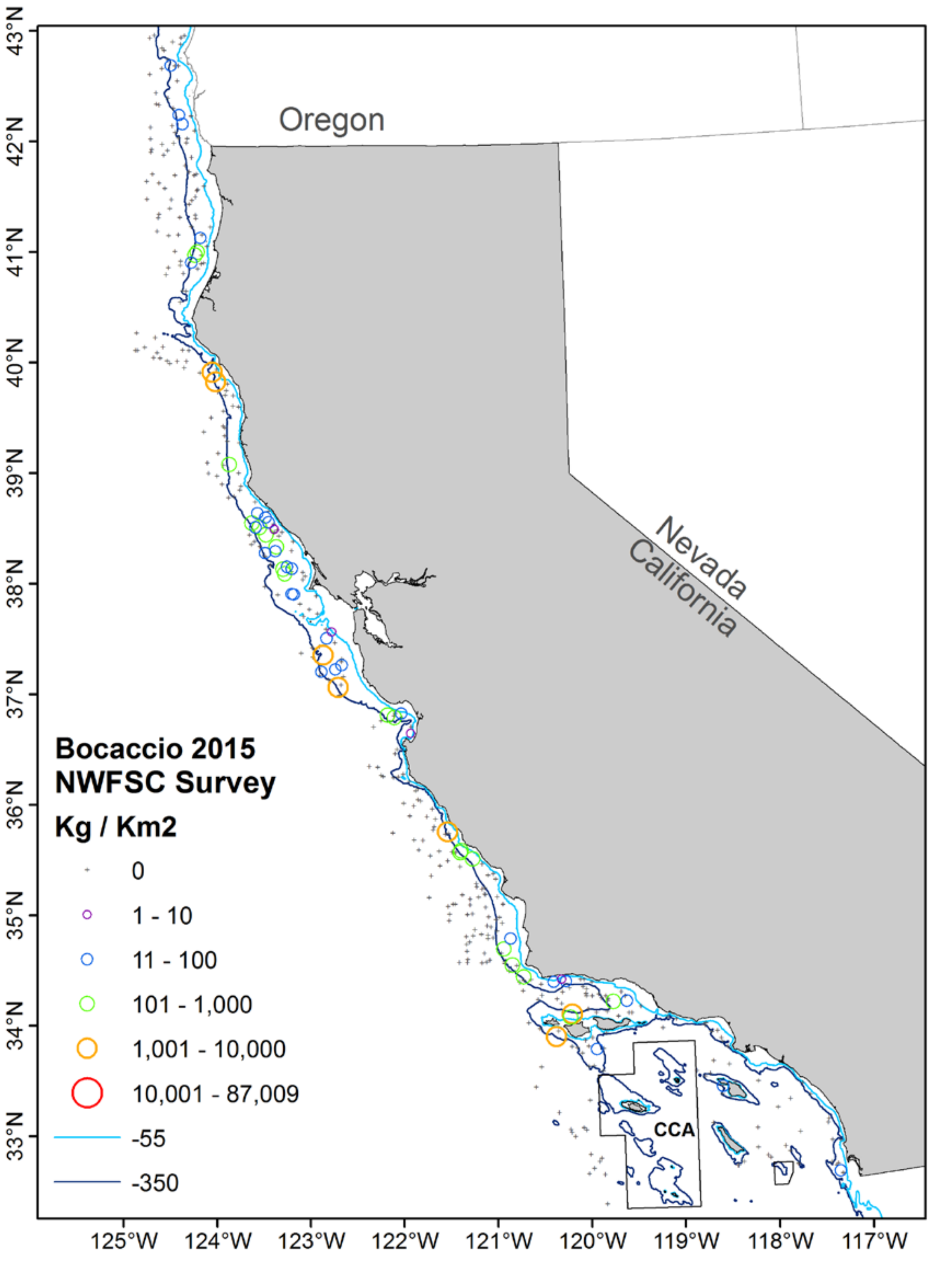


Figure 15 (a). Spatial distribution of raw catch rates of Bocaccio from NWFSC trawl survey in 2015. Depth contour lines of 55m and 350m and the CCA area are shown. Note that sizes and color of circles represent catch rate in log scales (Credit of Rebecca Miller, SWFSC).

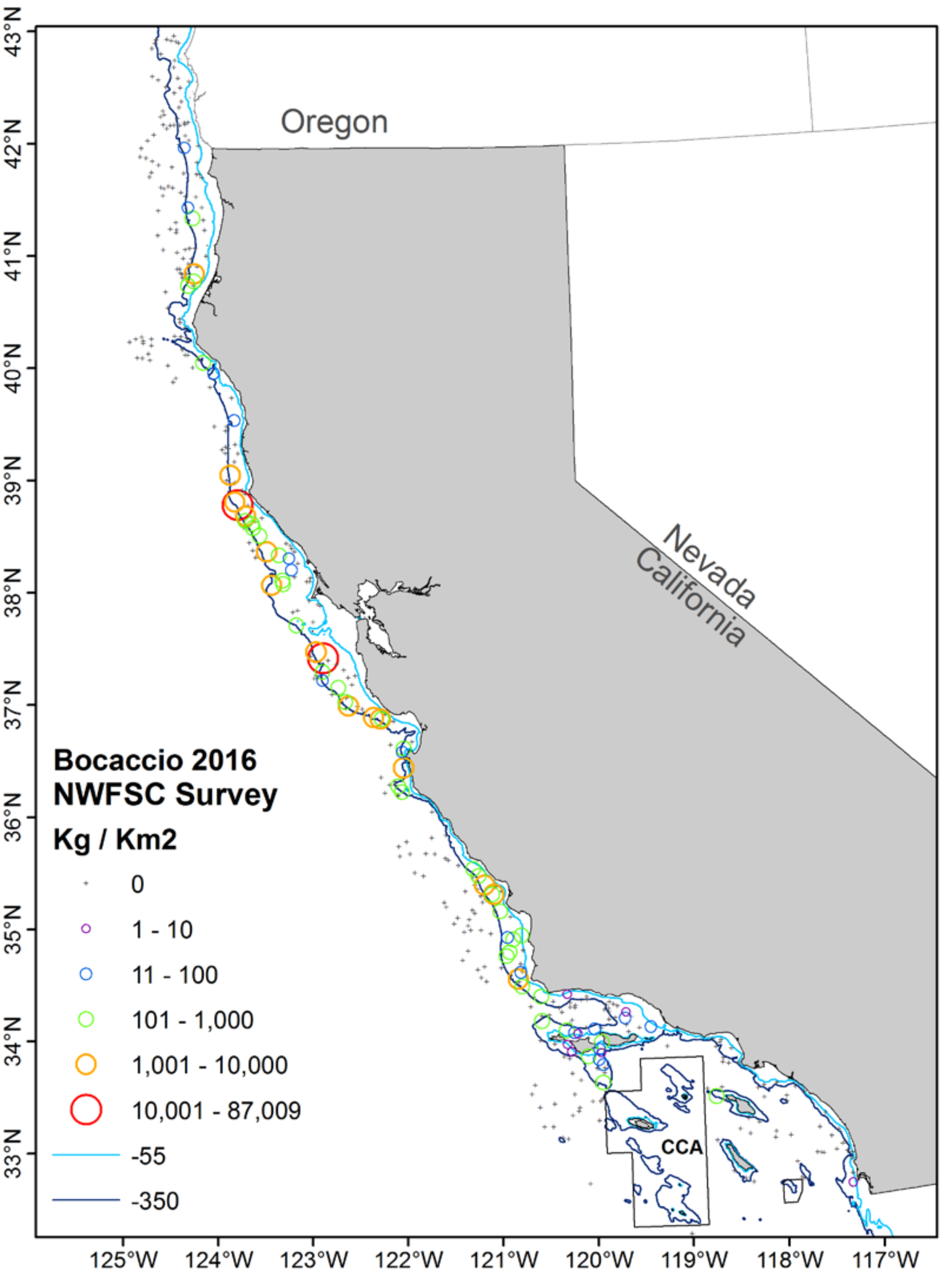


Figure 15 (b). Spatial distribution of raw catch rates of Bocaccio from NWFSC trawl survey in 2016. Depth contour lines of 55m and 350m and the CCA area are shown. Note that sizes and color of circles represent catch rate in log scales (Credit of Rebecca Miller, SWFSC).

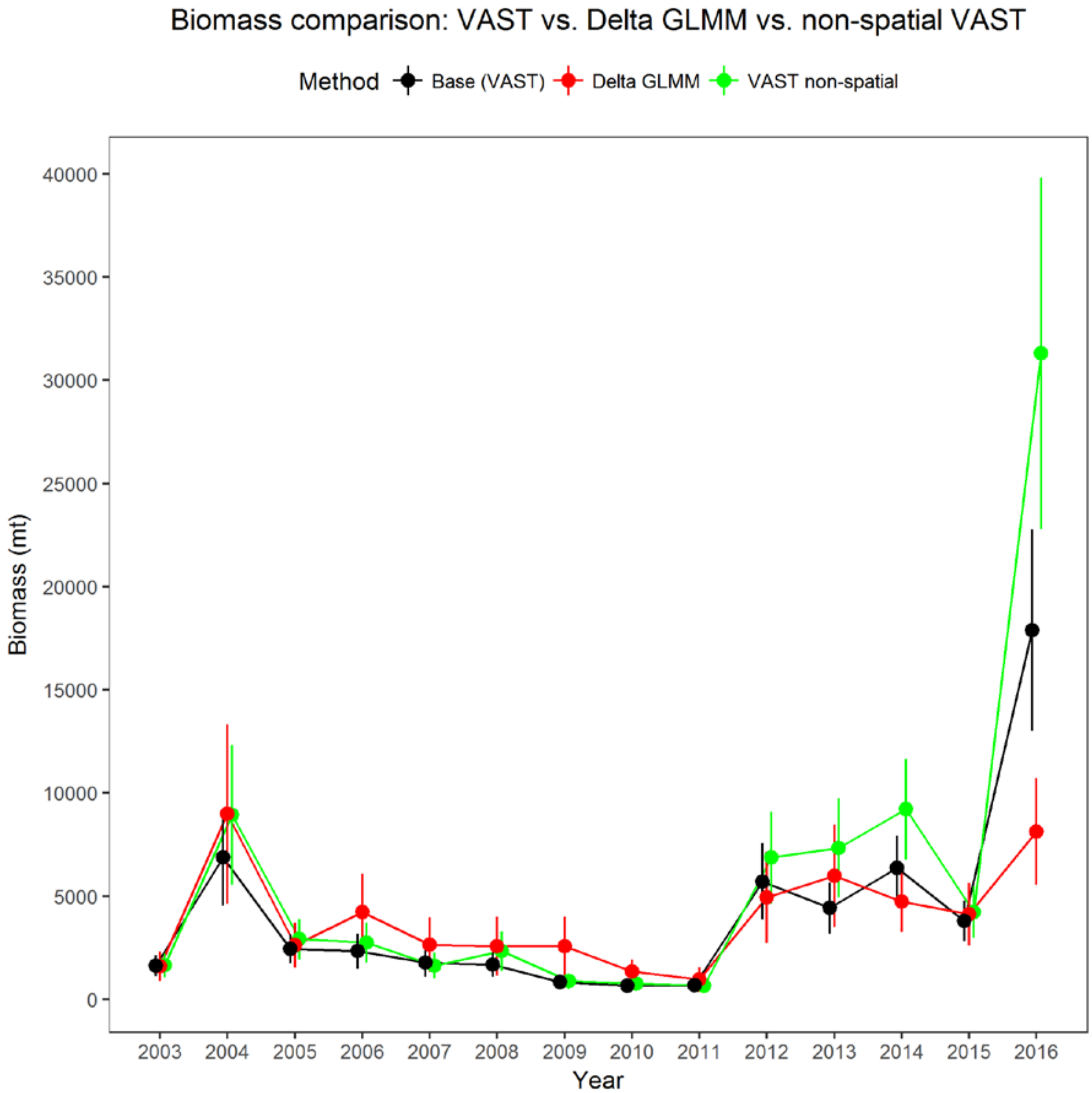


Figure 16. Comparison plot of estimated biomass among three methods of estimating biomass for the NWFSC bottom trawl survey between 2003 and 2016. The VAST (spatial) estimates are used in the base model. The Delta GLMM (non-spatial) were used in the 2015 assessment. The estimates of non-spatial VAST are also included for comparisons. Sensitivity analysis of using each indices are provided in the Uncertainty and Sensitivity Analysis section.

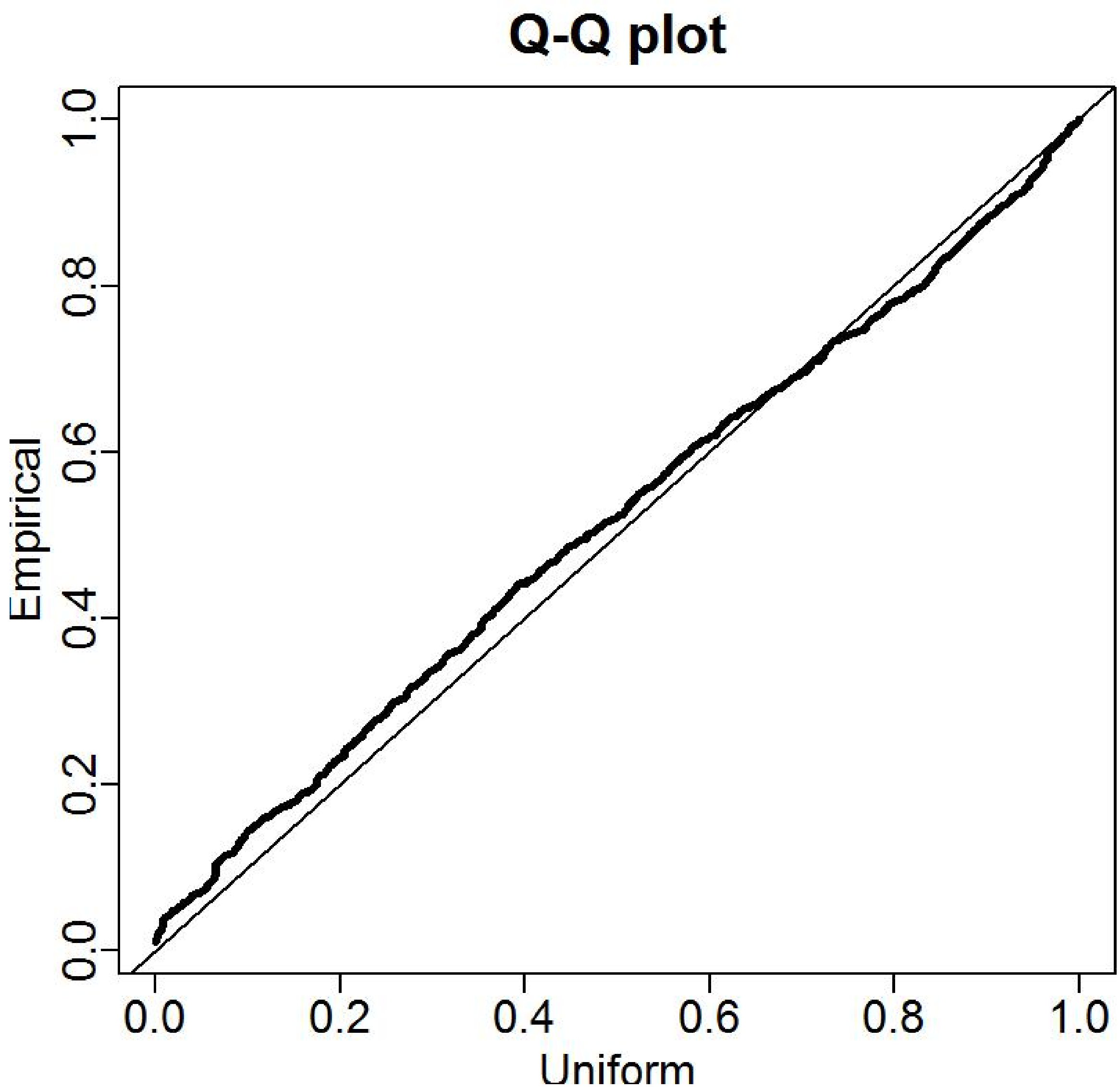


Figure 17. A Bayesian Q-Q plot used to validate the goodness of fit of the VAST analysis for the NWFSC trawl survey between 2003 and 2014.

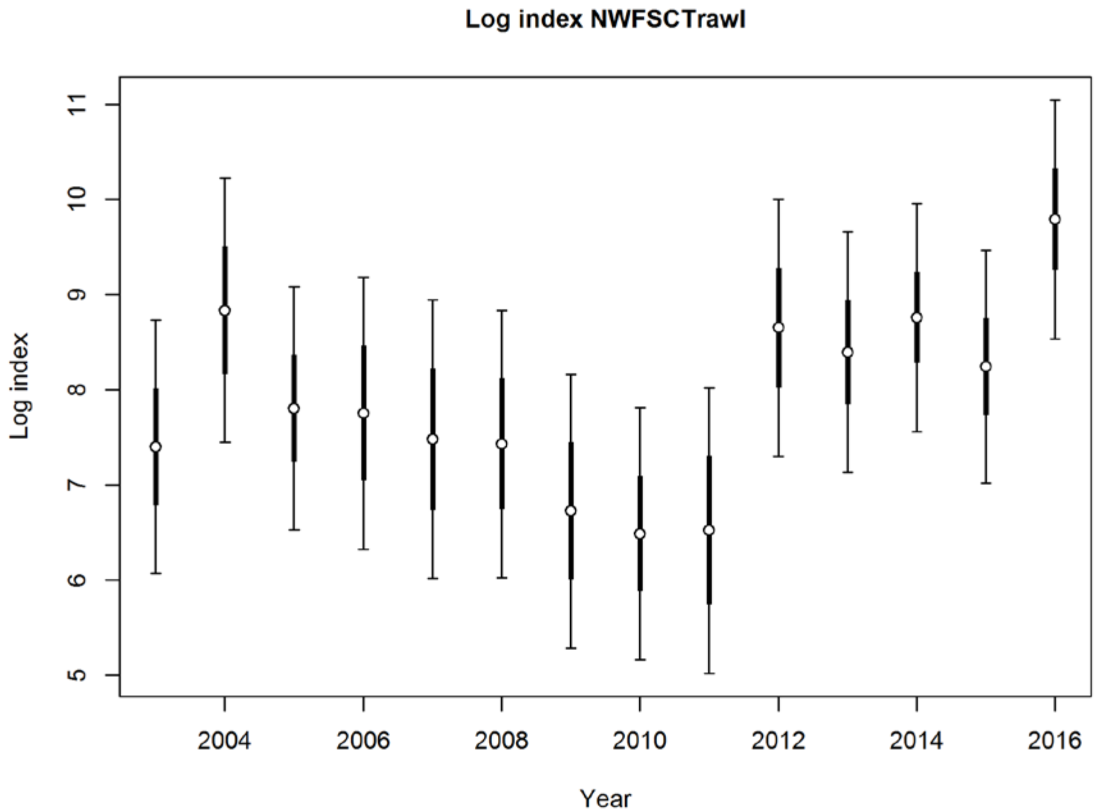


Figure 18. Estimated biomass (mt in log scale) from the VAST analysis for NWFSC trawl survey between 2003 and 2016.

Figure 19. Plots of length frequency distributions of females (red) and males (blue) from the NWFSC trawl survey between 2003 and 2016.

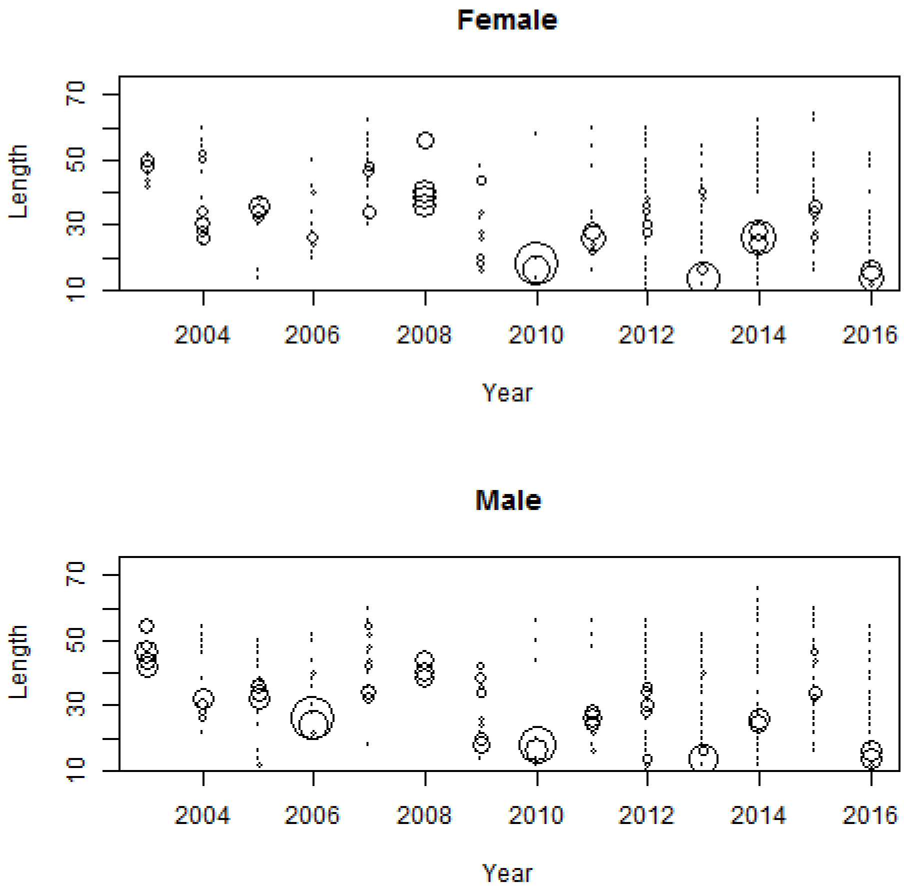
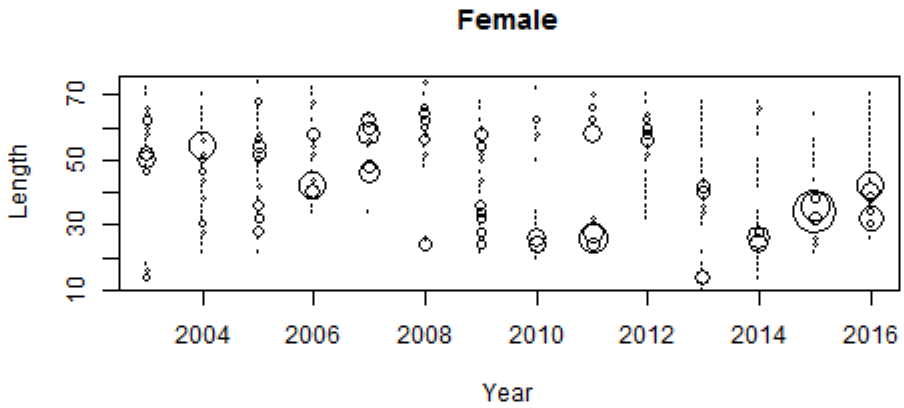


Figure 19a. Plots of length frequency distributions of females (Top) and males (bottom) from the NWFSC trawl survey from south of Point Conception areas between 2003 and 2016.



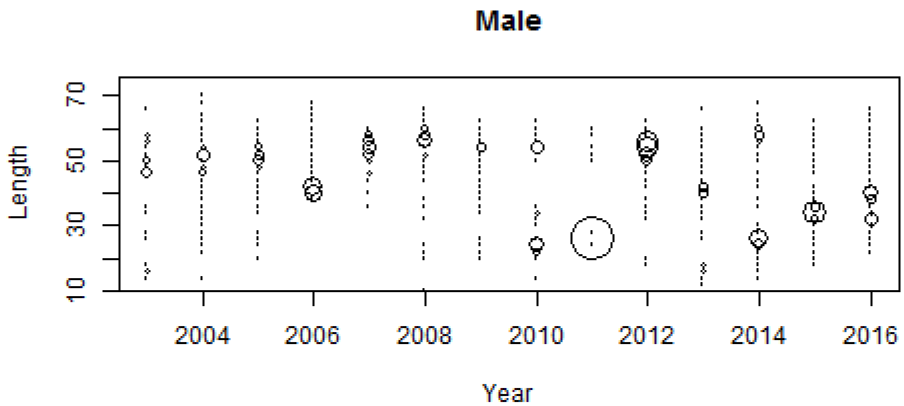


Figure 19b. Plots of length frequency distributions of females (Top) and males (bottom) from the NWFSC trawl survey from north of Point Conception areas between 2003 and 2016.

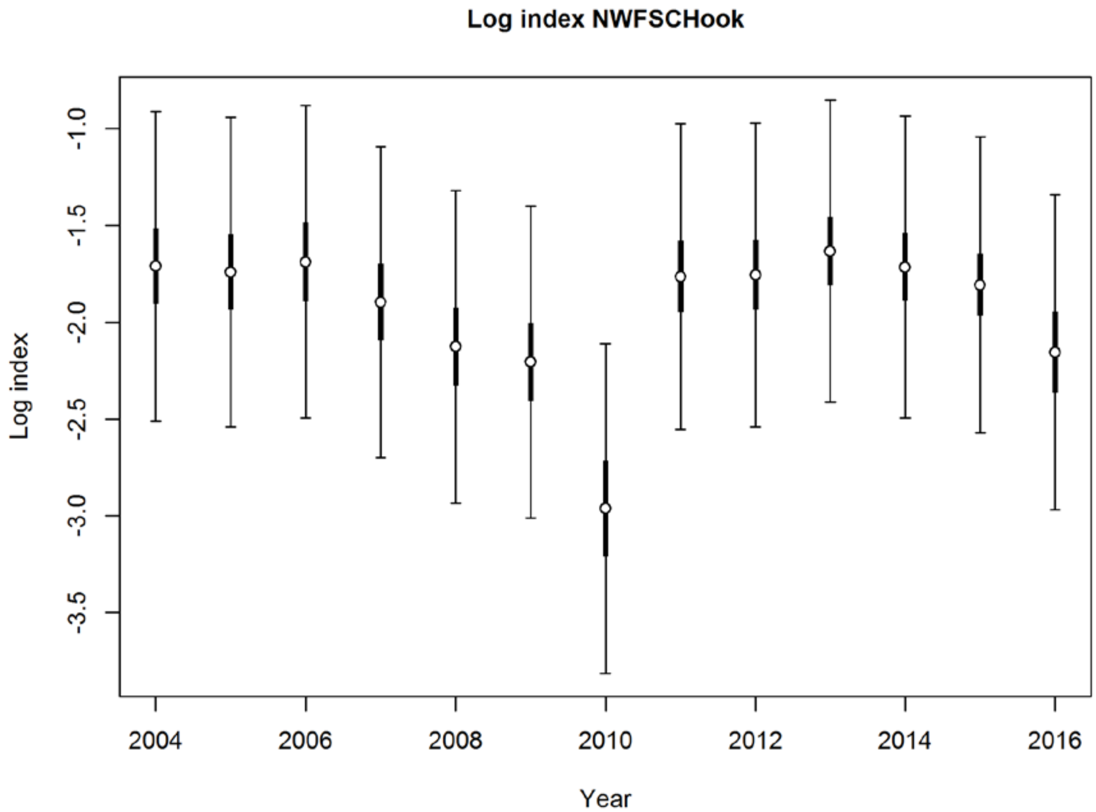


Figure 20. CPUE indices of Bocaccio abundance from the NWFSC hook-and-line survey in the California Bight.

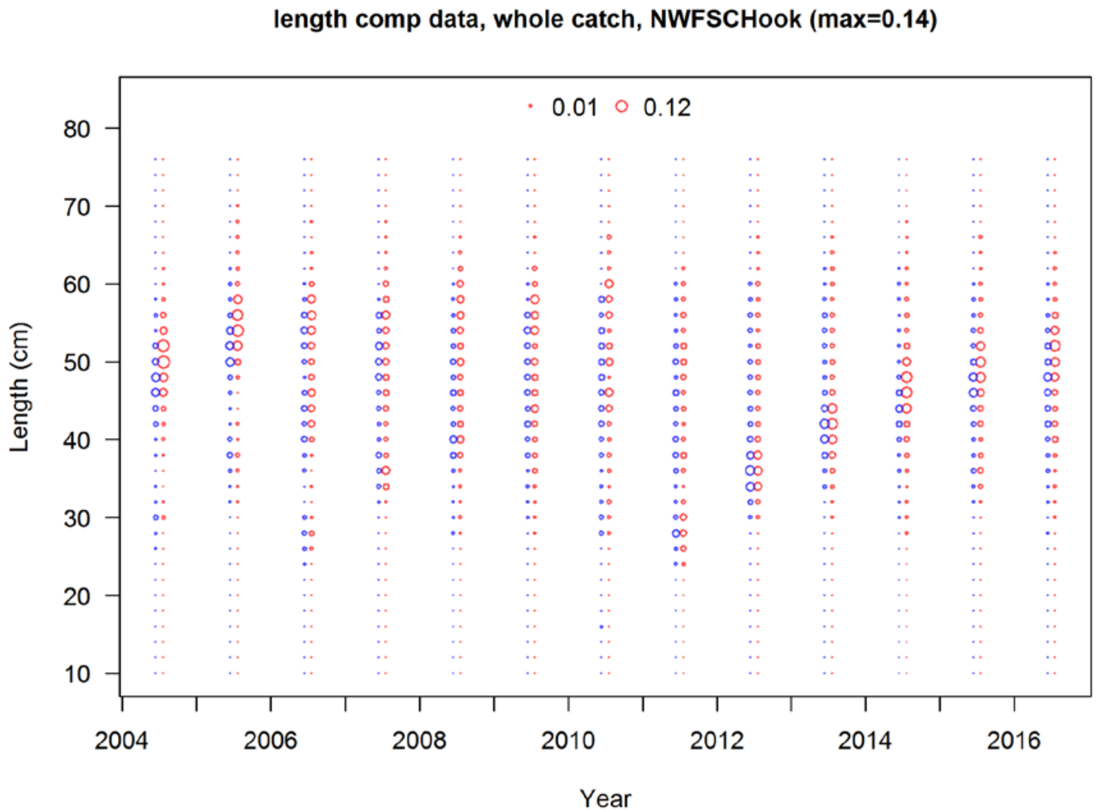


Figure 21. Plots of length frequency distributions of females (red) and males (blue) from the NWFSC hook-and-line survey between 2004 and 2014.

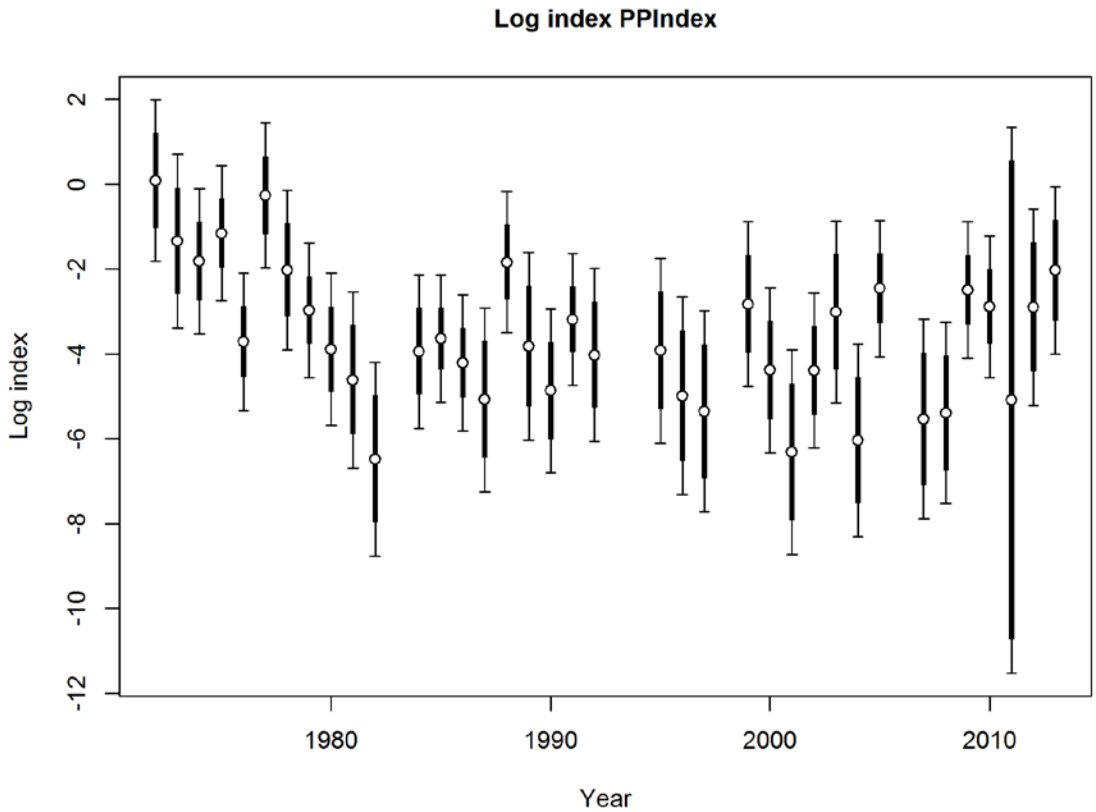


Figure 22. Juvenile indices (in log scale) of Bocaccio recruitment from the power plant impingement.

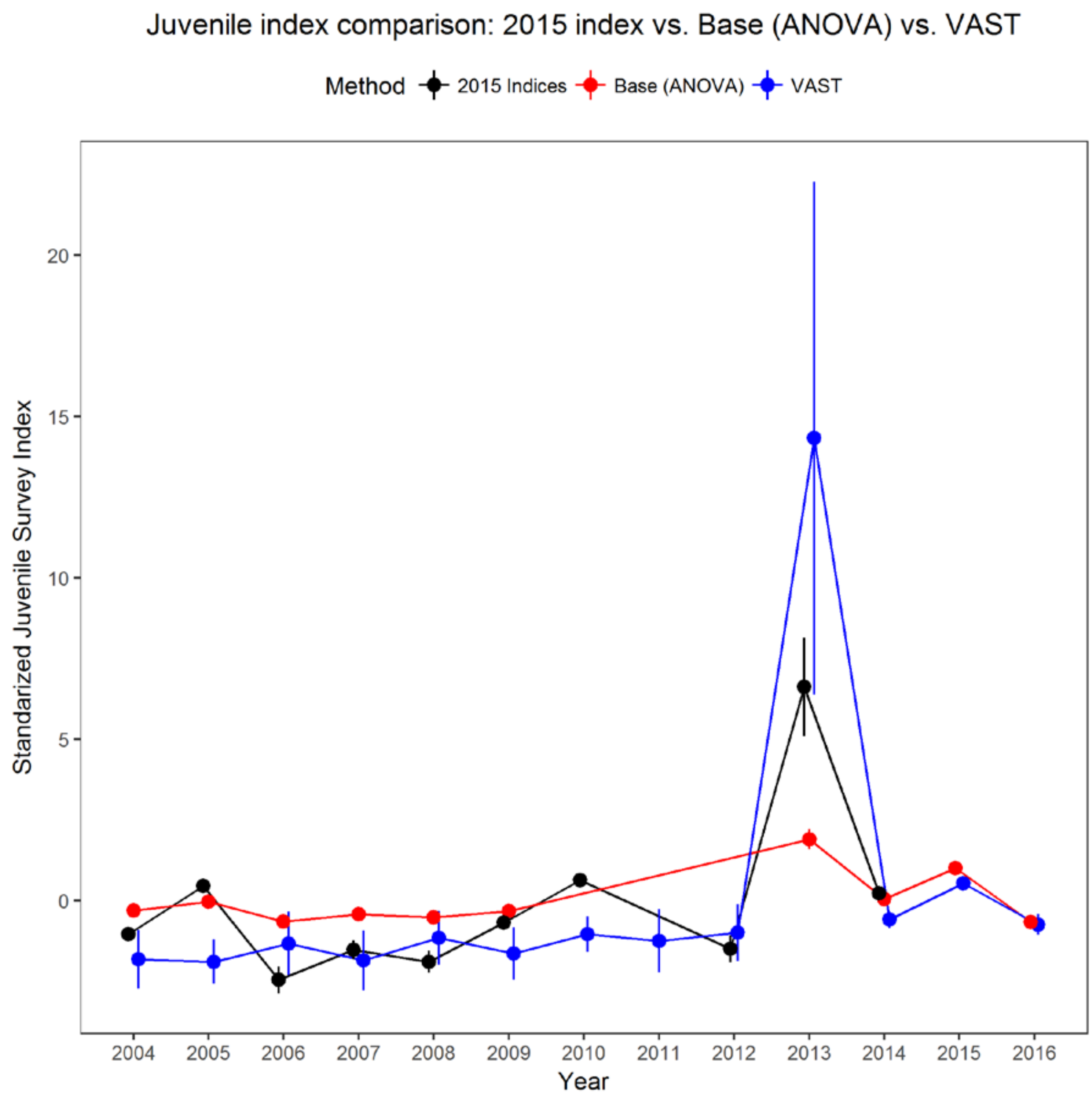


Figure 23. Comparison plot of estimated juvenile survey indices (standardized) among three methods of estimating the juvenile trawl survey indices between 2004 and 2016. The ANOVA estimates are used in the base model. The 2015 index is only between 2004 and 2014. The estimates using VAST are also included for comparisons. Sensitivity analysis of using each indices are provided in the Uncertainty and Sensitivity Analysis section.

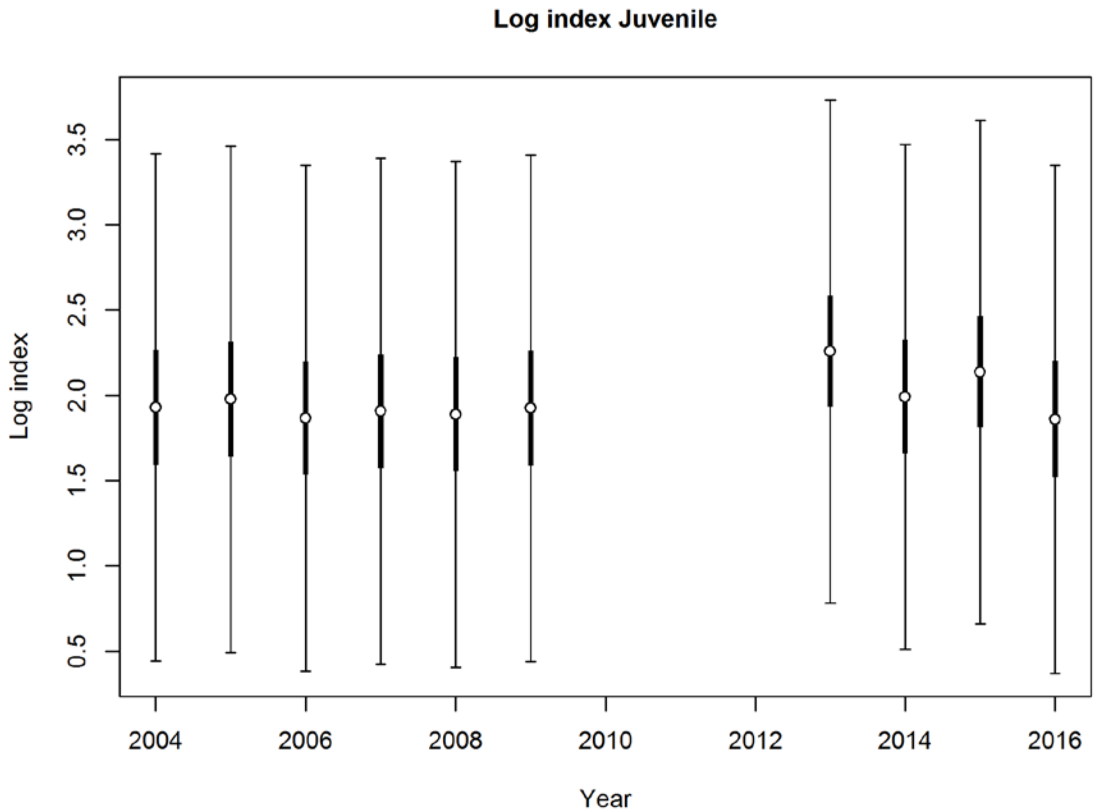


Figure 24. Juvenile indices (in log scale) of Bocaccio from the pelagic juvenile trawl survey.

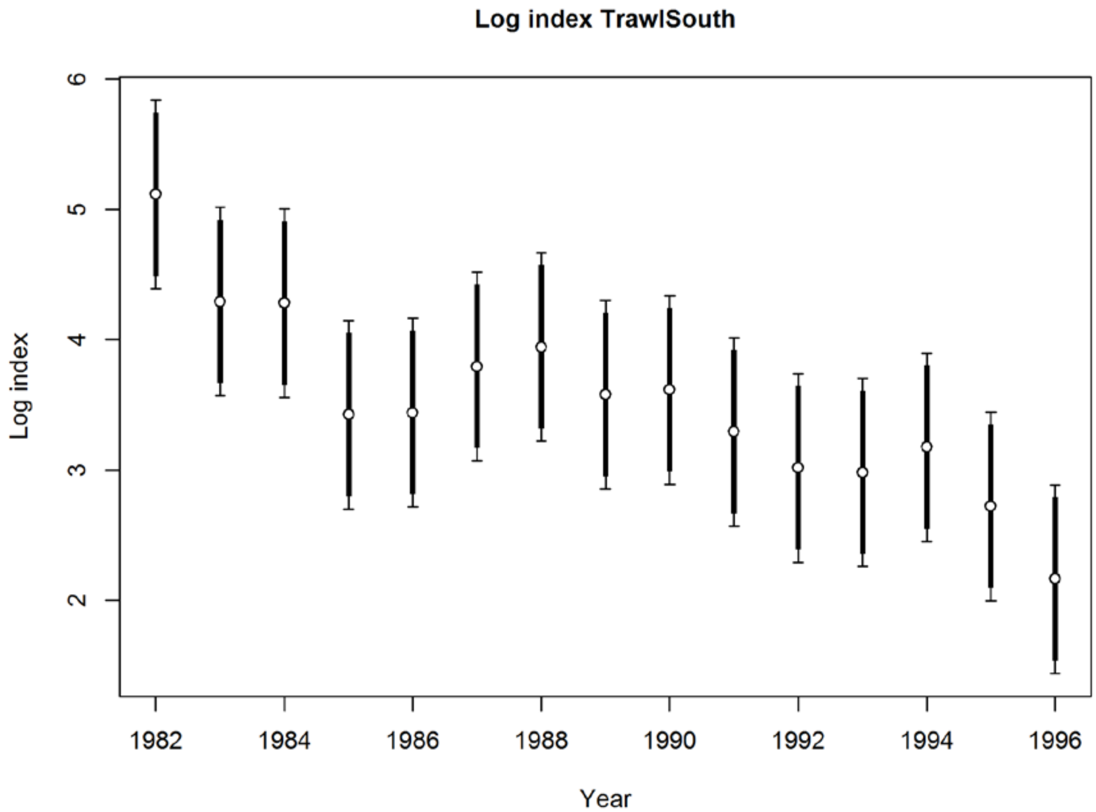


Figure 25. Trawl fishery CPUE index (in log scale) of Bocaccio abundance developed in Ralston (1998).

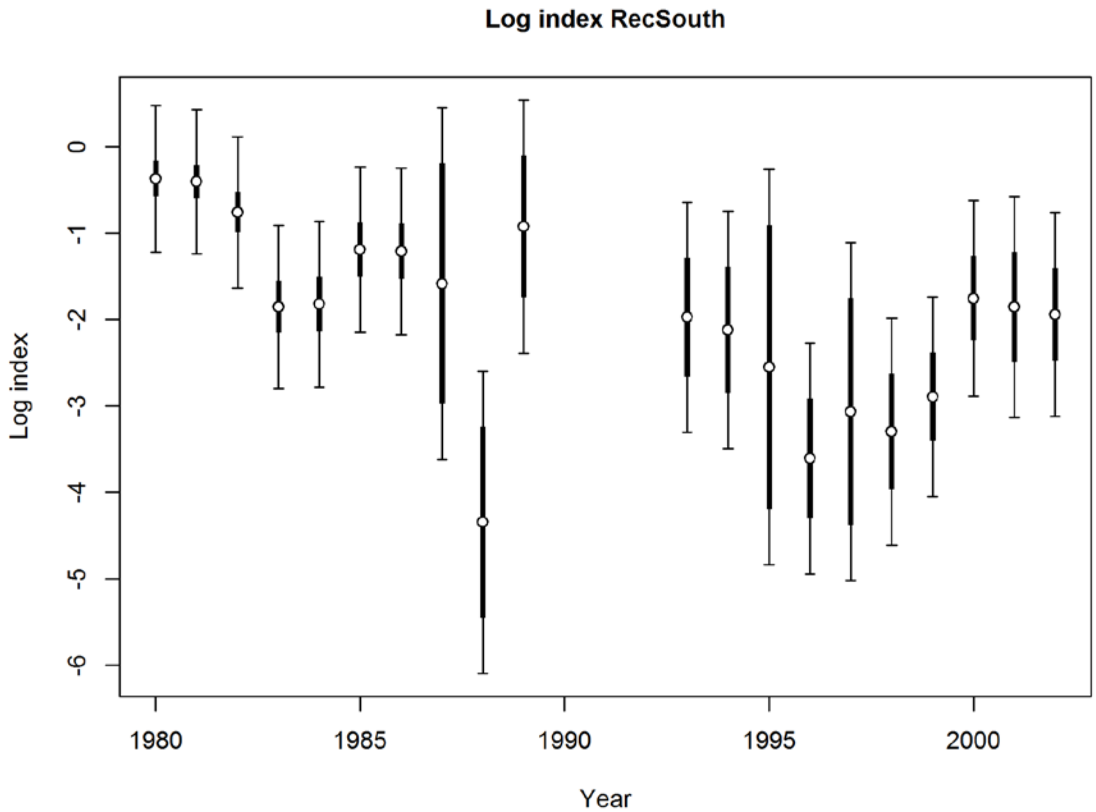


Figure 26. CPUE indices of Bocaccio abundance from the southern California recreational fishery.

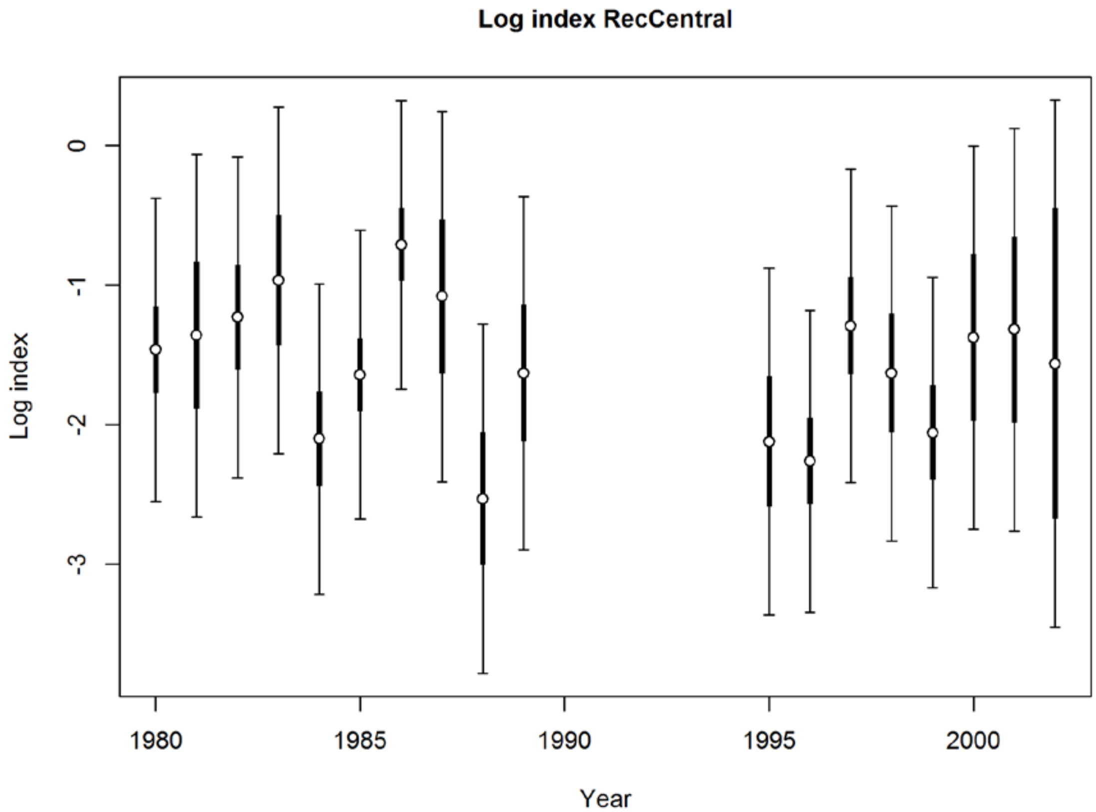


Figure 27. CPUE indices of Bocaccio abundance from the central California recreational fishery.

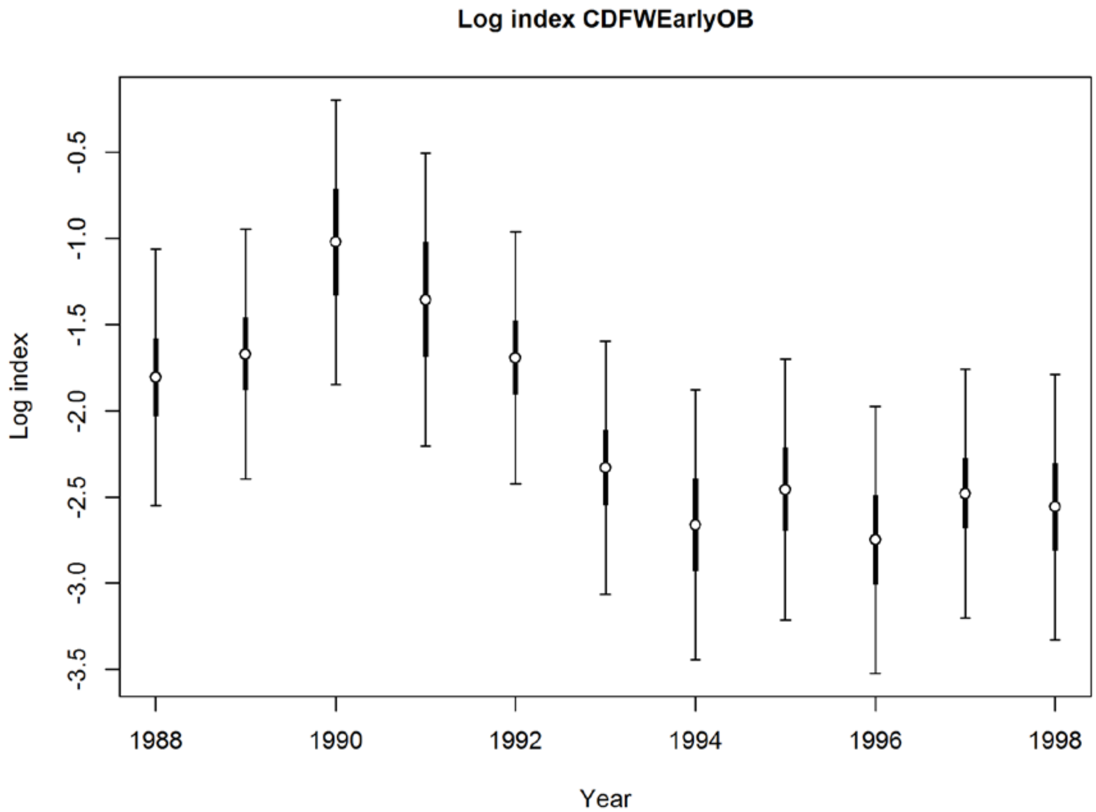


Figure 28. CPUE indices of Bocaccio abundance from the early years of the southern California onboard recreational survey.

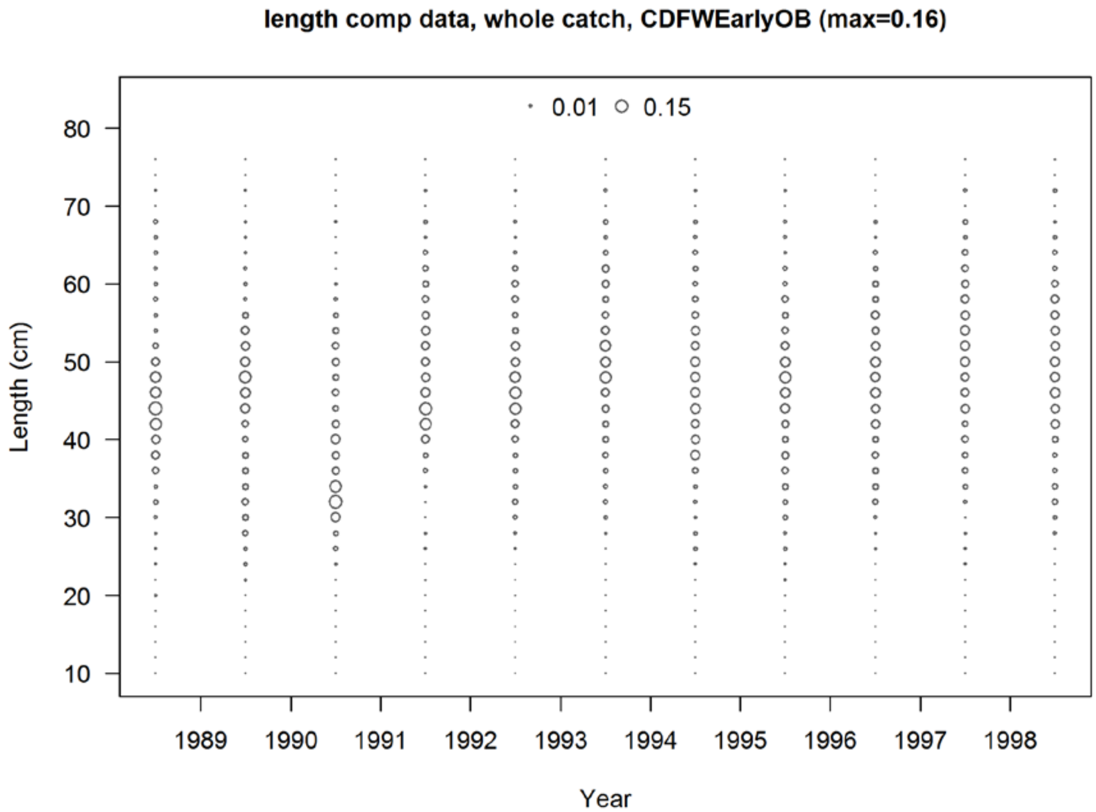


Figure 29. Plots of length frequency distributions of unsexed fish from the CFGCPUE survey between 1987 and 1998.

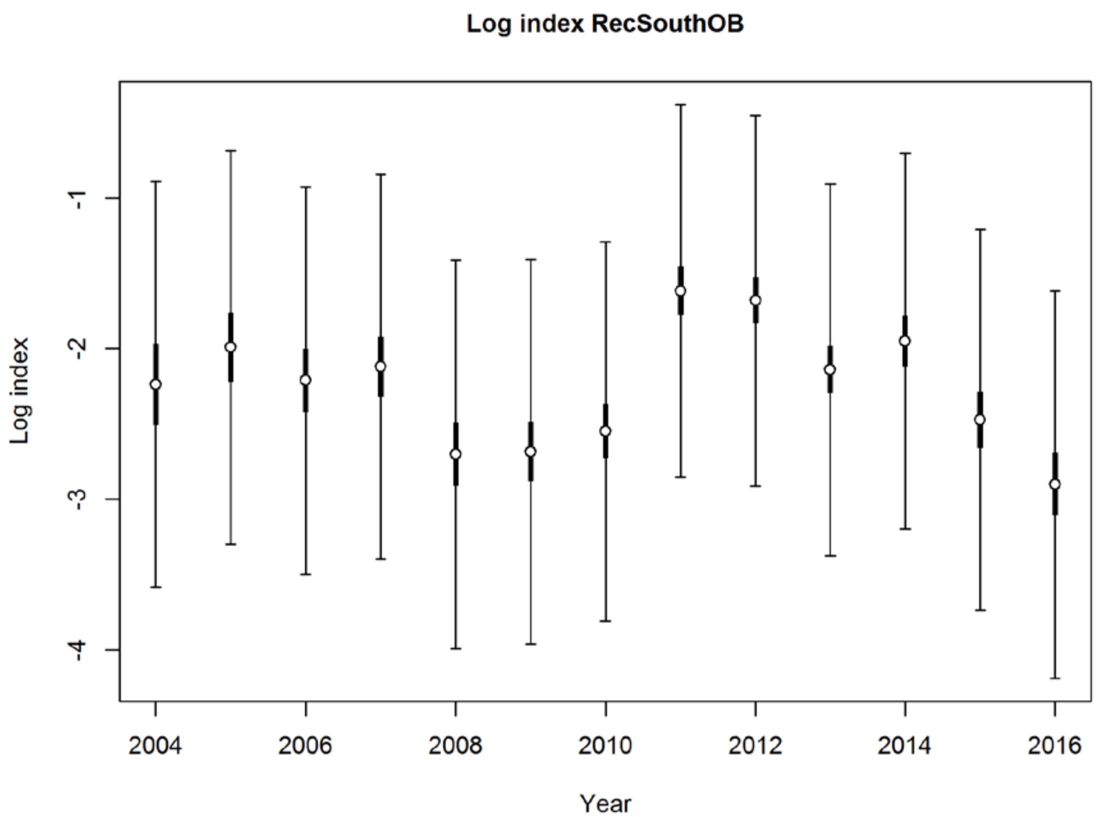


Figure 30. CPUE indices of Bocaccio abundance from the southern California onboard recreational survey.

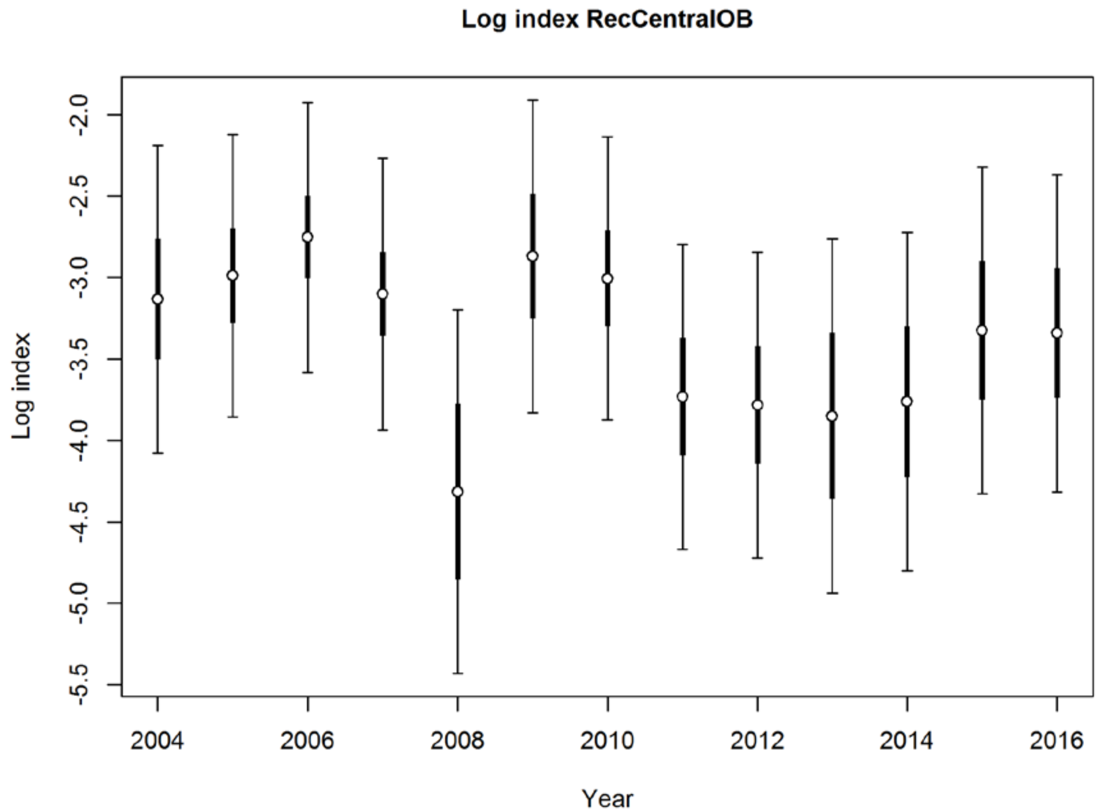


Figure 31. CPUE indices of Bocaccio abundance from the central California onboard recreational survey.

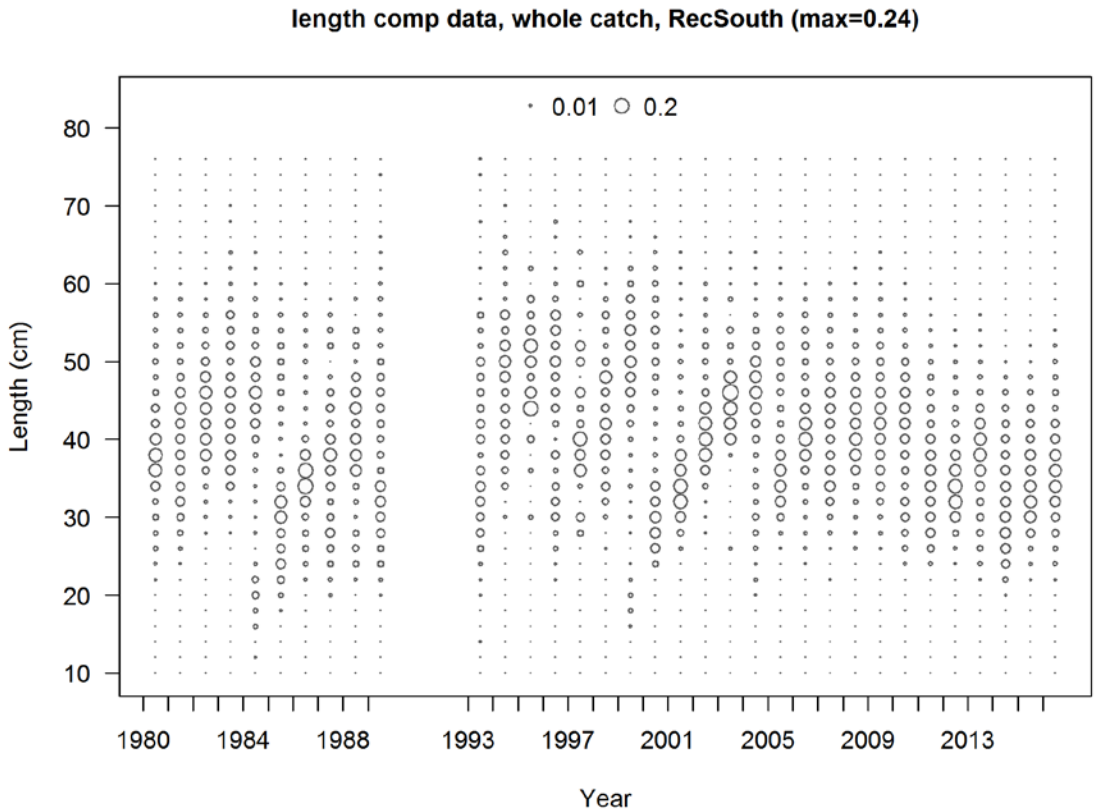


Figure 32. Plots of length frequency distributions of unsexed fish from the Southern California recreational fishery between 1980 and 2016.

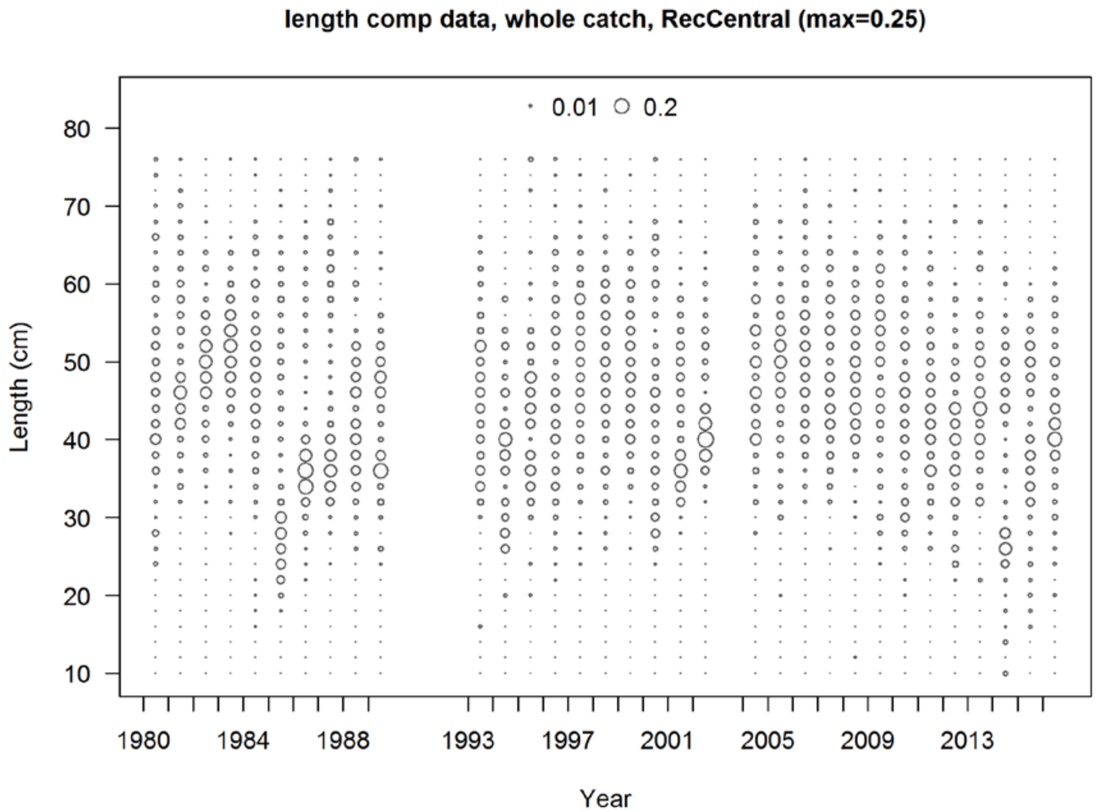


Figure 33. Plots of length frequency distributions of unsexed fish from the central California recreational fishery between 1980 and 2016.

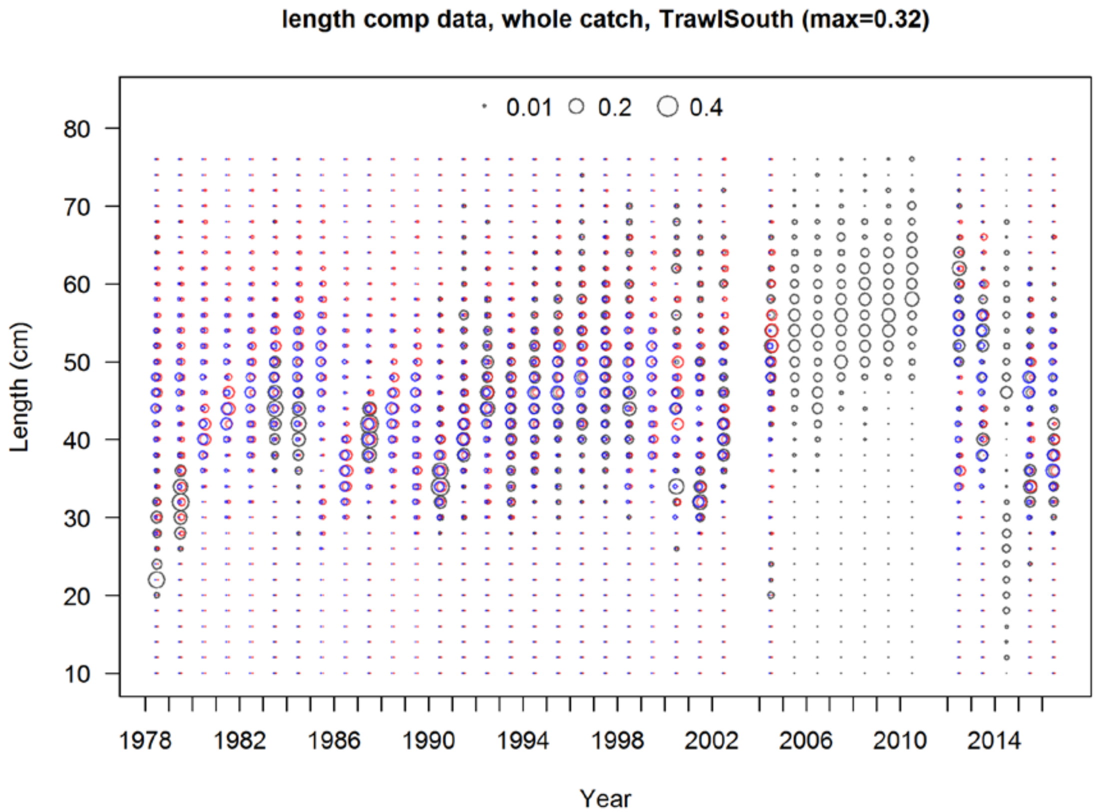


Figure 34. Plots of length frequency distributions of females (red), males (blue), and unsexed (black) fish from the Southern California trawl fishery between 1978 and 2016.

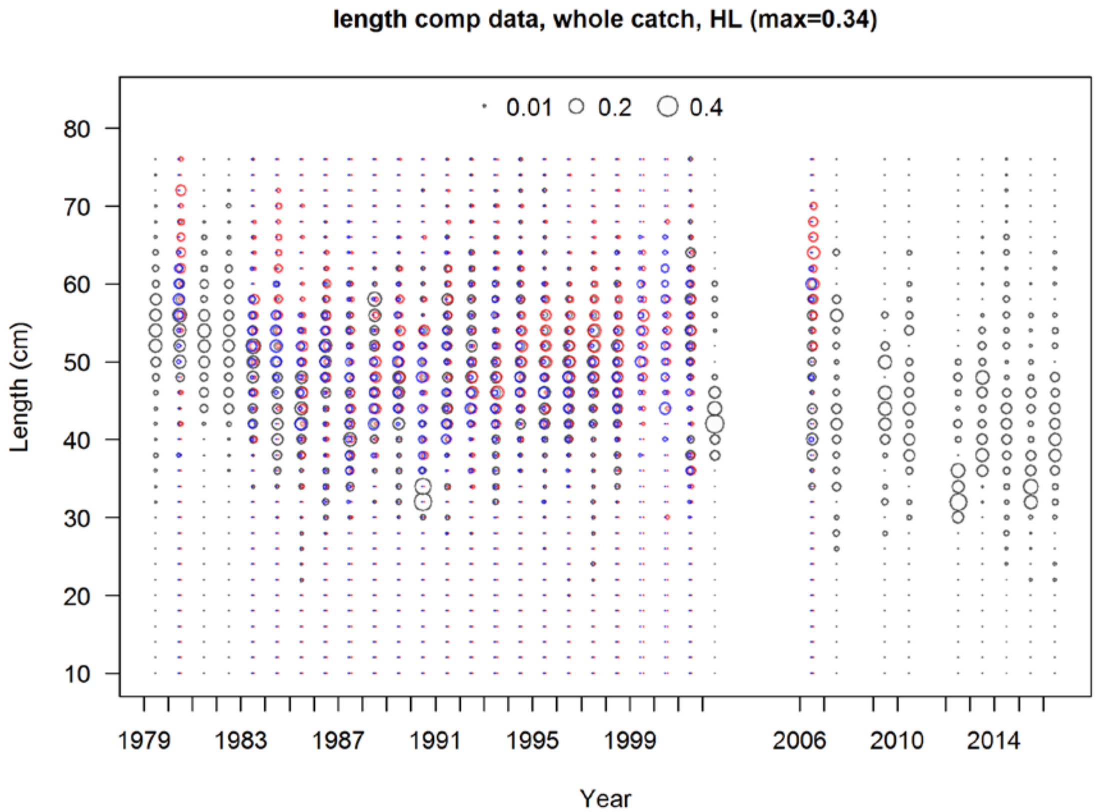


Figure 35. Plots of length frequency distributions of females (red), males (blue), and unsexed (black) fish from the hook-and-line fishery between 1979 and 2016.

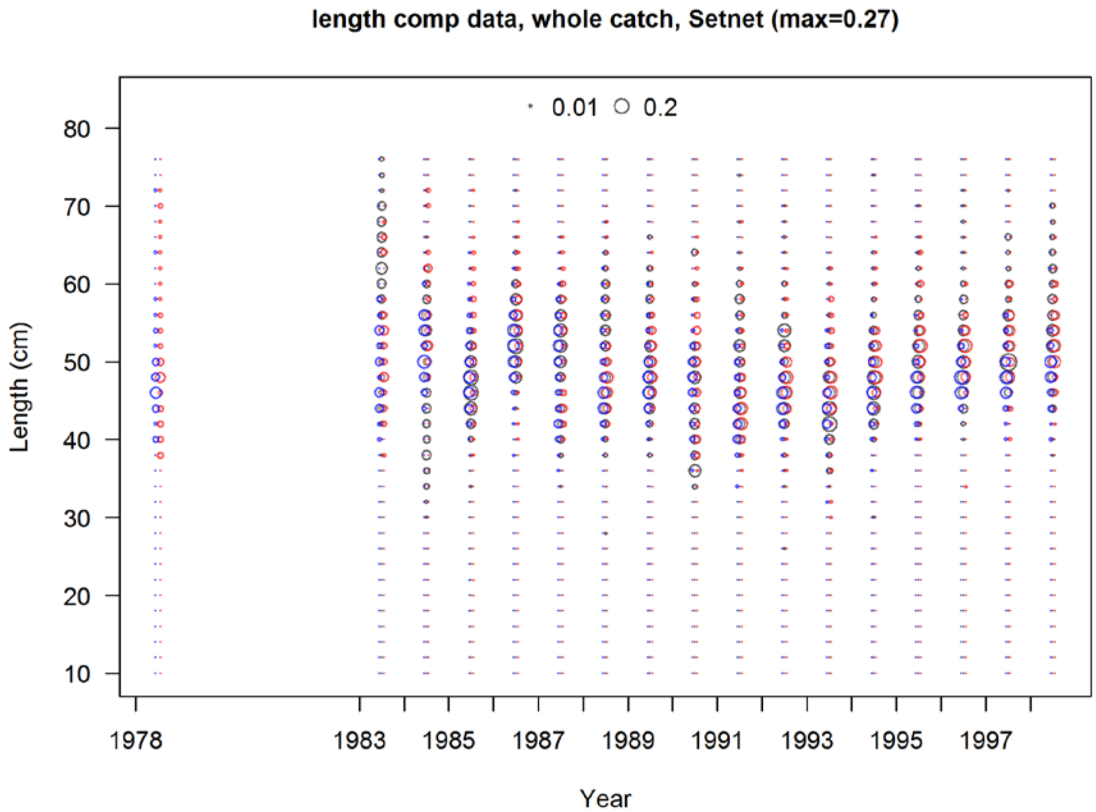


Figure 36. Plots of length frequency distributions of females (red), males (blue), and unsexed (black) fish from the setnet fishery between 1978 and 1998.

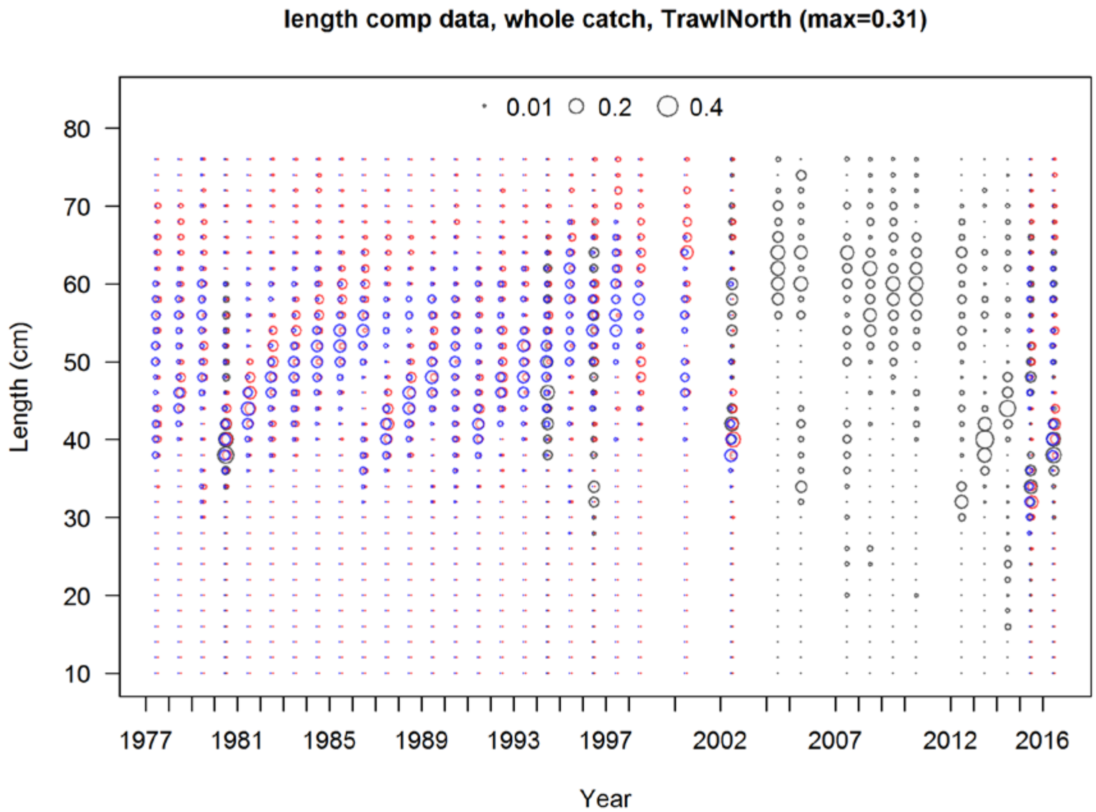


Figure 37. Plots of length frequency distributions of females (red), males (blue), and unsexed (black) fish from the Northern California trawl fishery between 1977 and 2016.

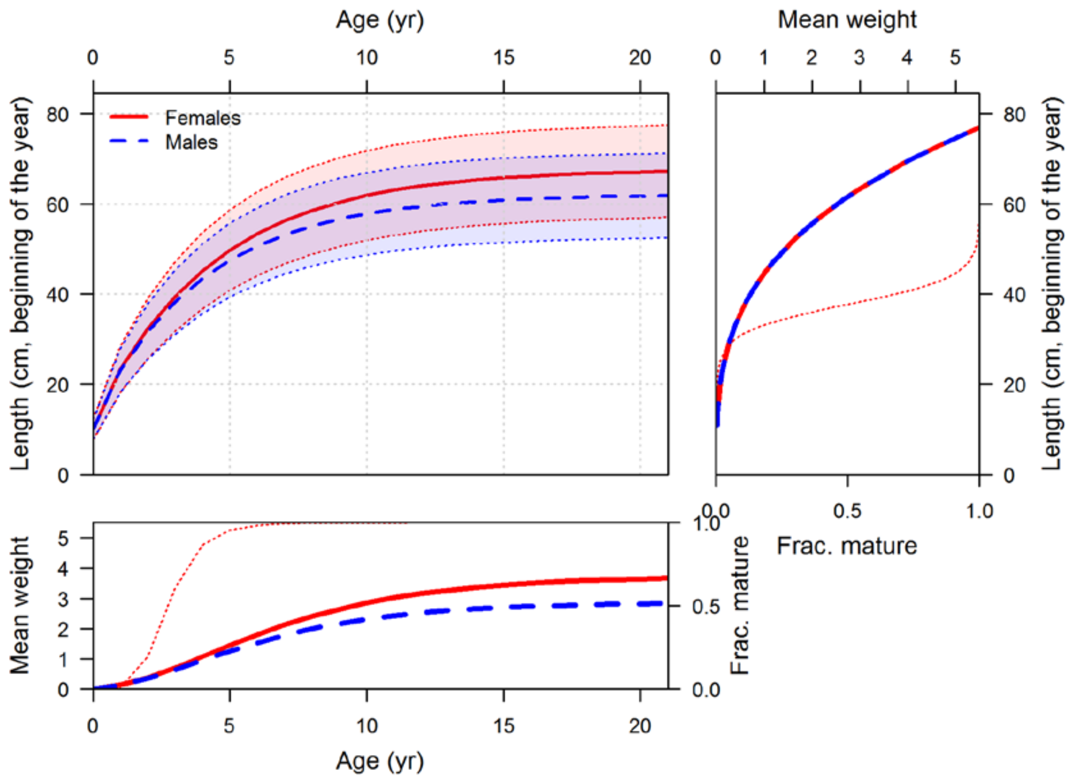


Figure 38. Estimated growth functions for both sexes and their variability. Top left: growth functions by sex; Top right: CV and SD by length; Bottom: CV and SD by age.

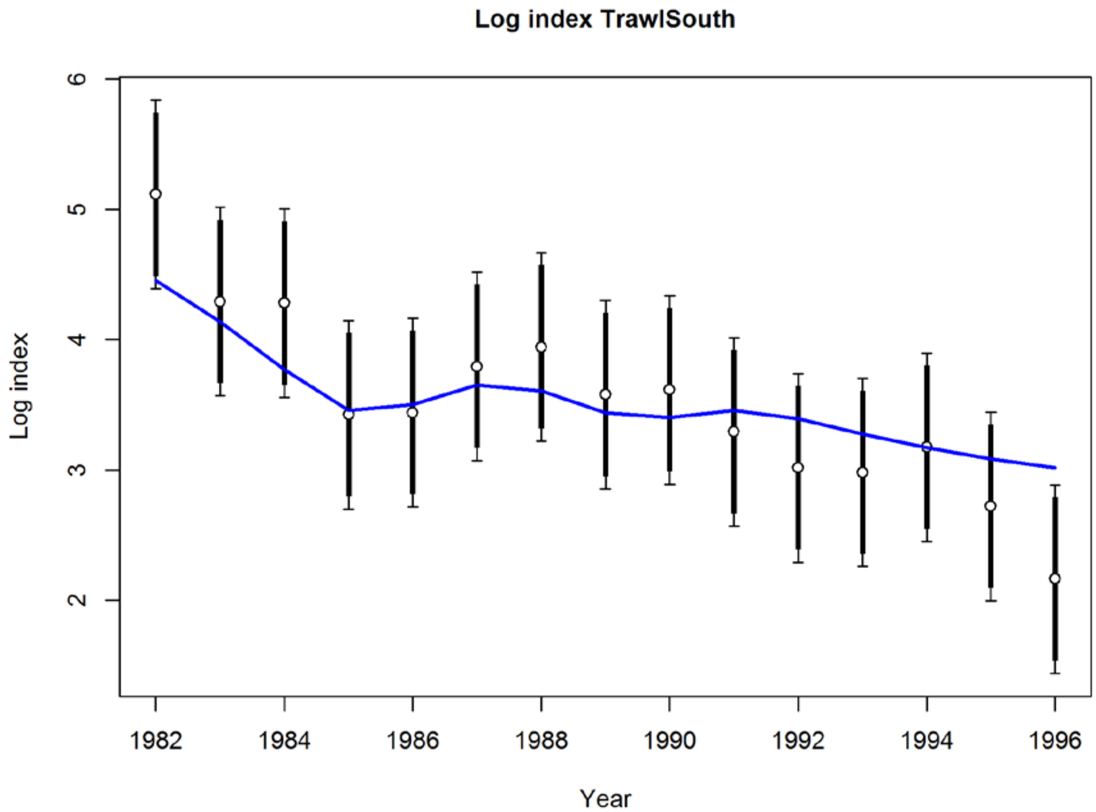


Figure 39. Observed and expected indices (in log scale) for the Southern California trawl fishery.

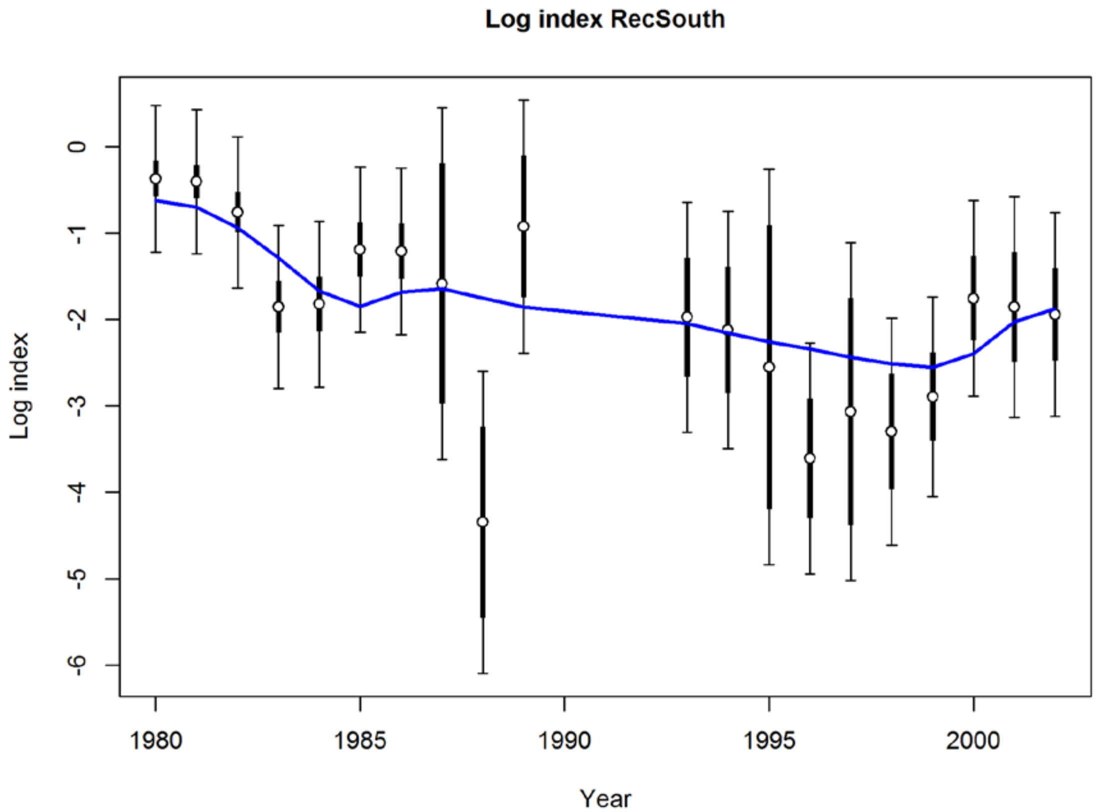


Figure 40. Observed and expected indices (in log scale) for the Southern California recreational fishery.

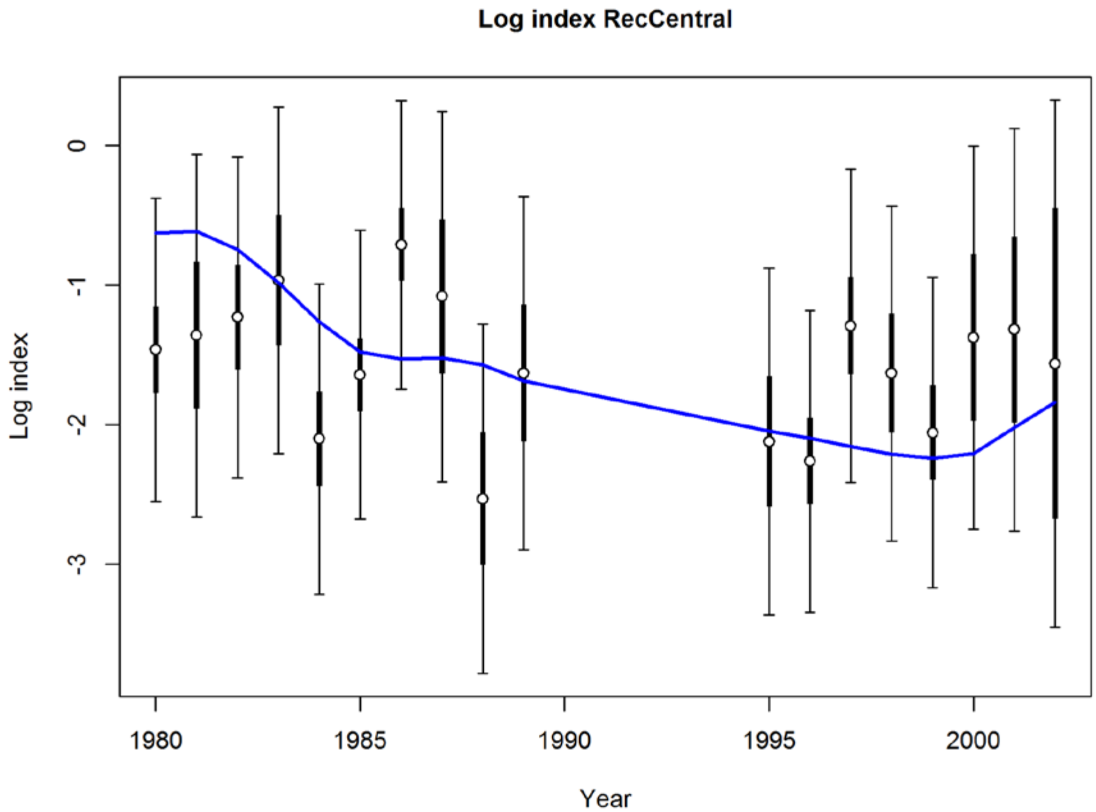


Figure 41. Observed and expected indices (in log scale) for the Central California recreational fishery.

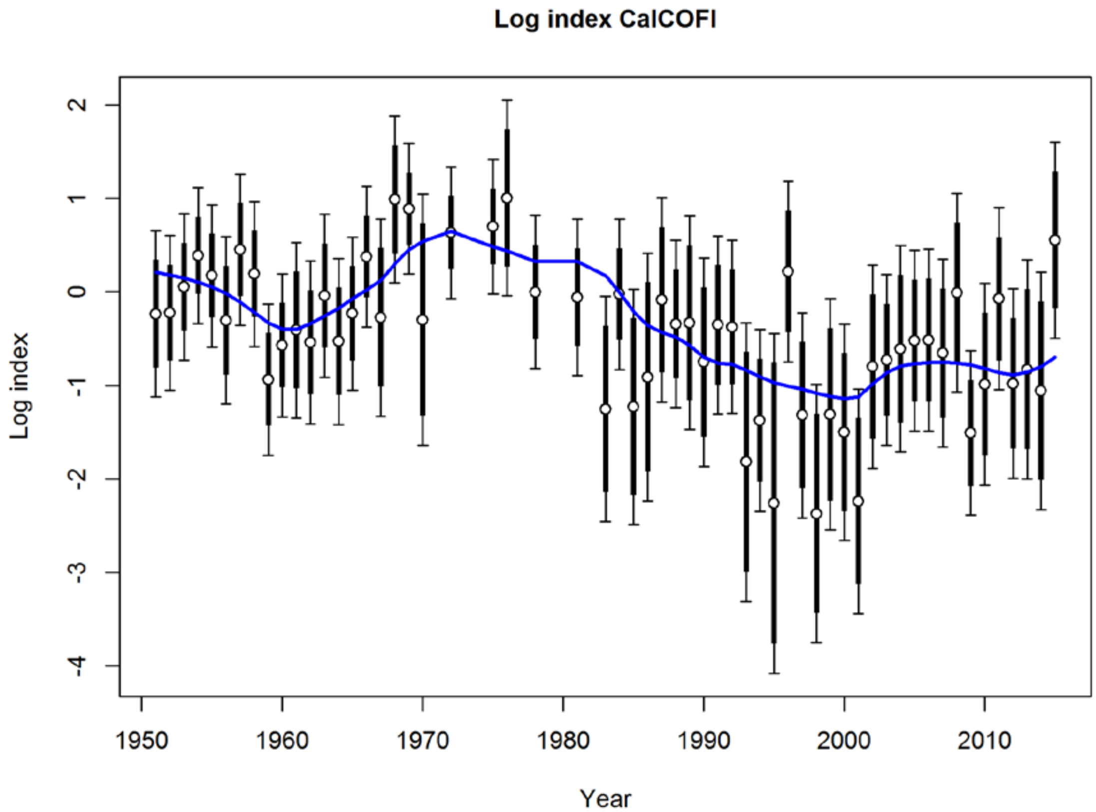


Figure 42. Observed and expected indices (in log scale) for the CalCOFI survey.

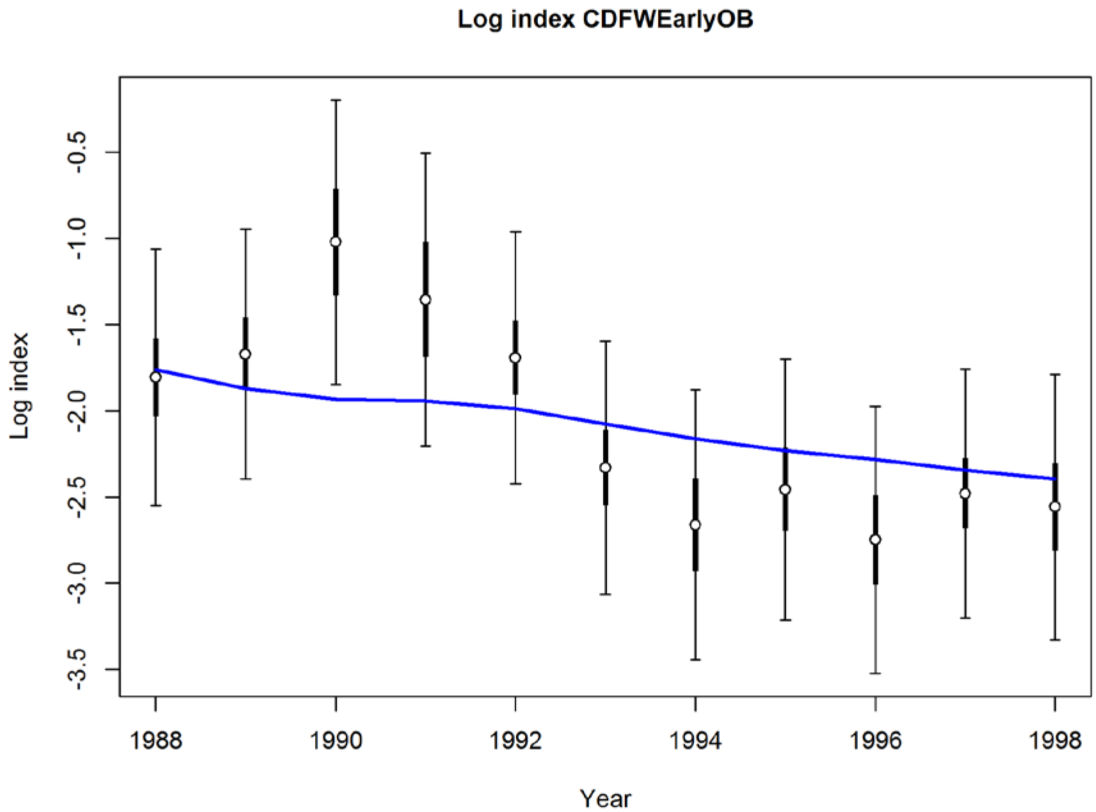


Figure 43. Observed and expected indices (in log scale) for the CDFW early year onboard observer indices.

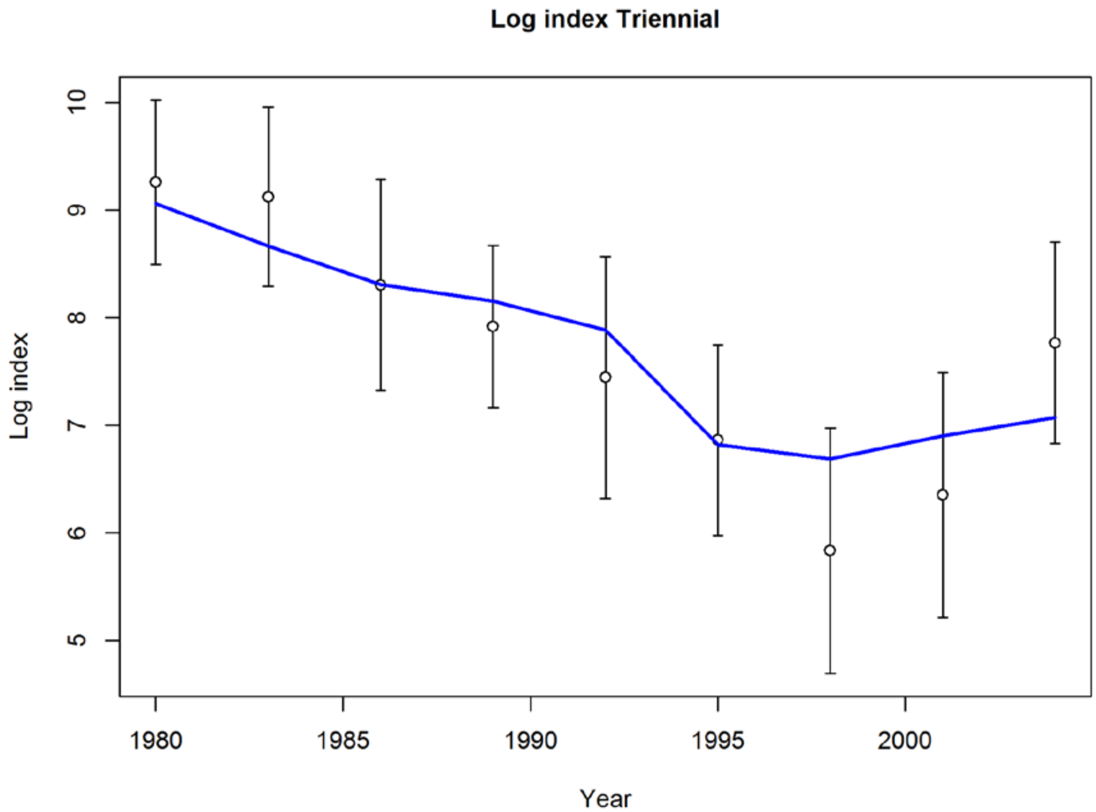


Figure 44. Observed and expected indices (in log scale) for the triennial trawl survey.

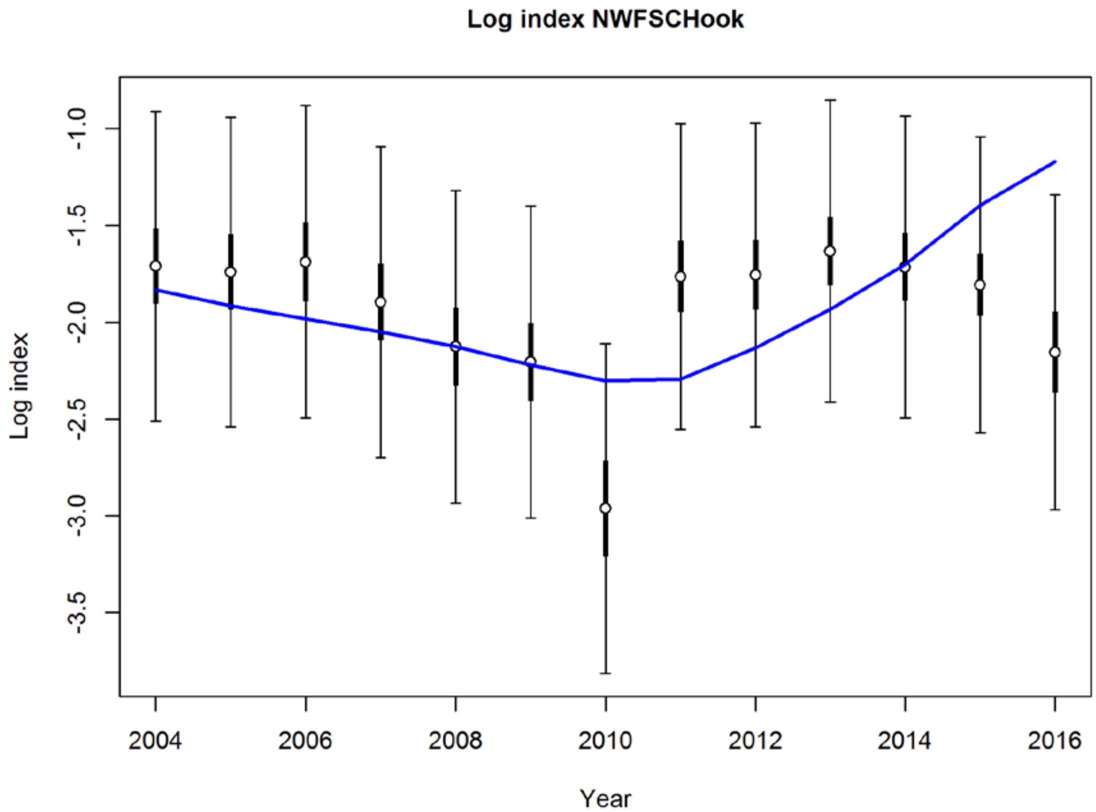


Figure 45. Observed and expected indices (in log scale) for the NWFSC hook-and-line survey.

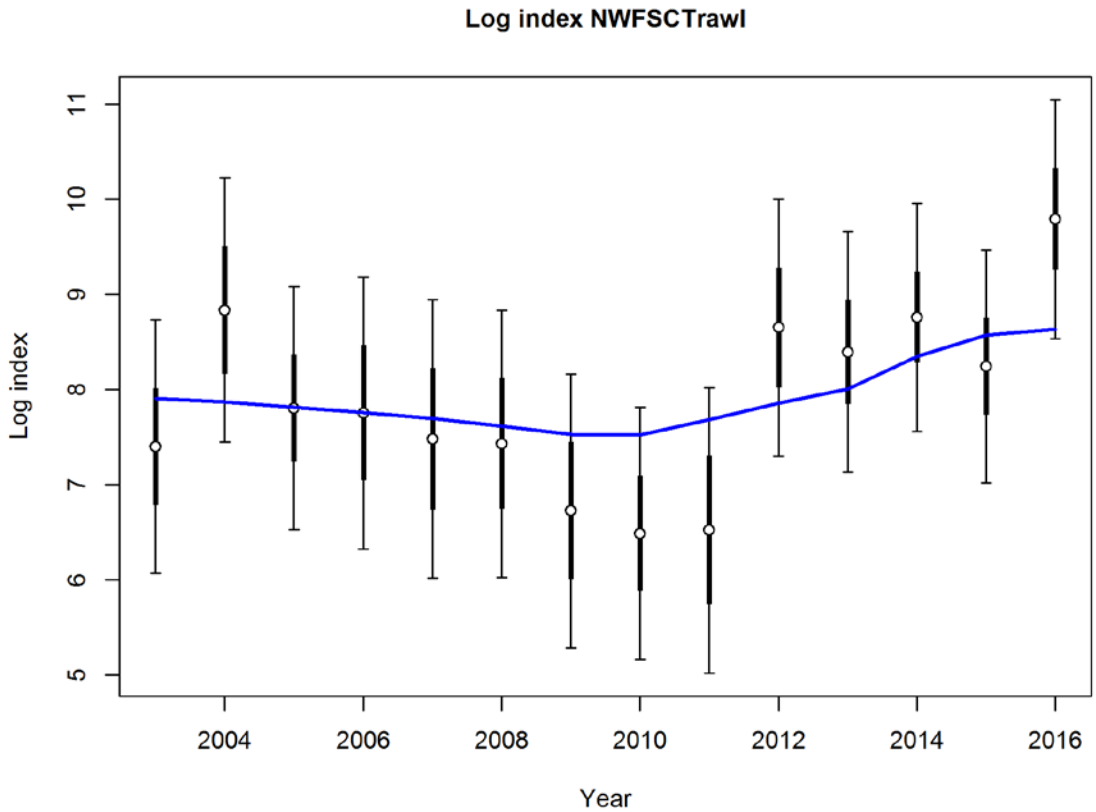


Figure 46. Observed and expected indices (in log scale) for the NWFSC trawl survey.

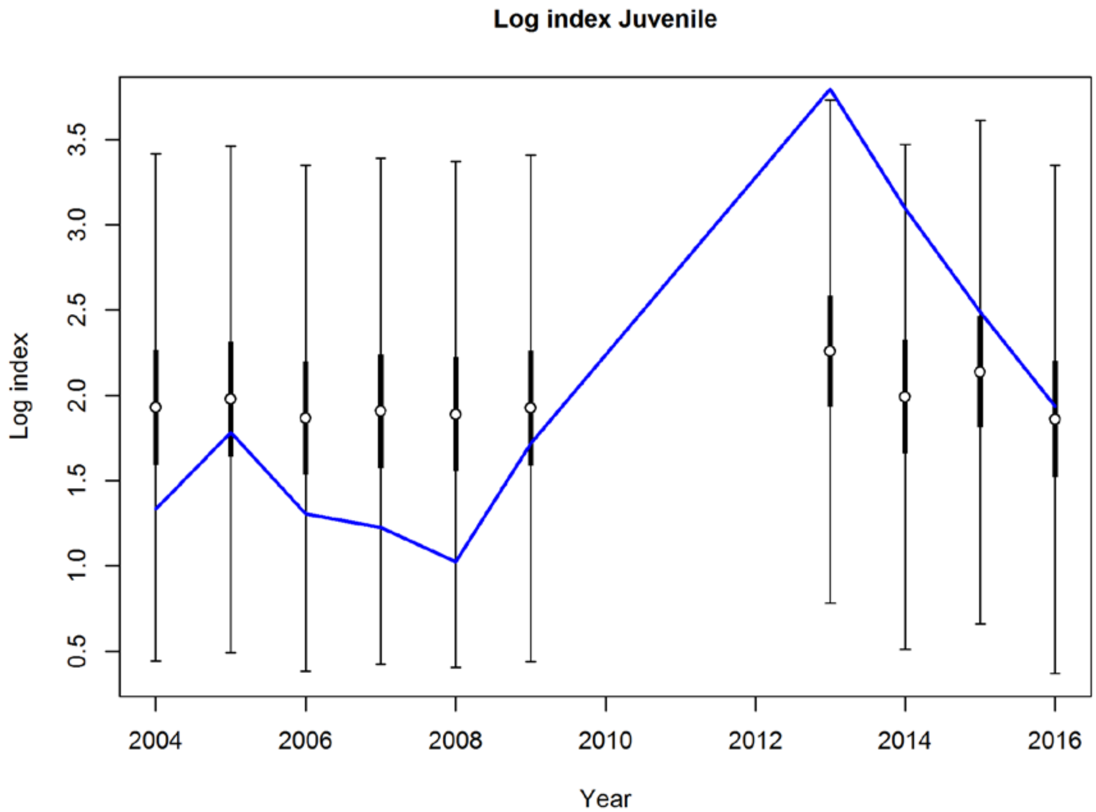


Figure 47. Observed and expected indices (in log scale) for pelagic juvenile trawl survey.

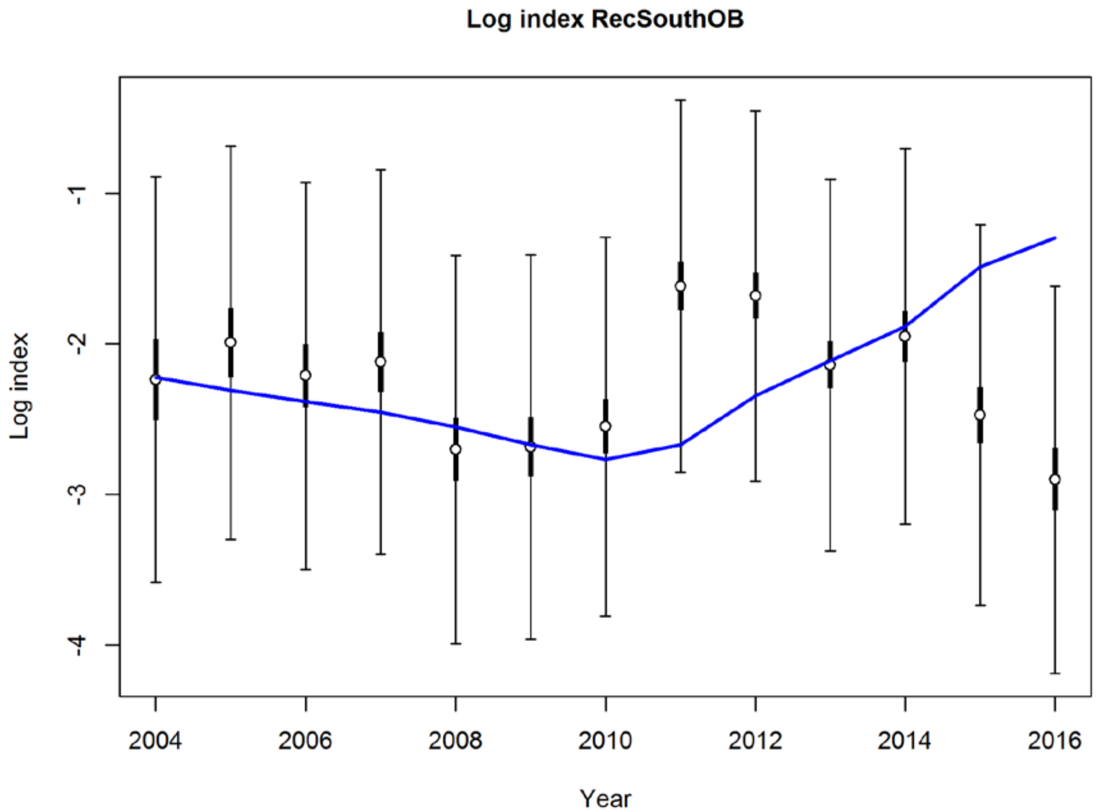


Figure 48. Observed and expected indices (in log scale) for the southern California onboard recreational CPUE indices.

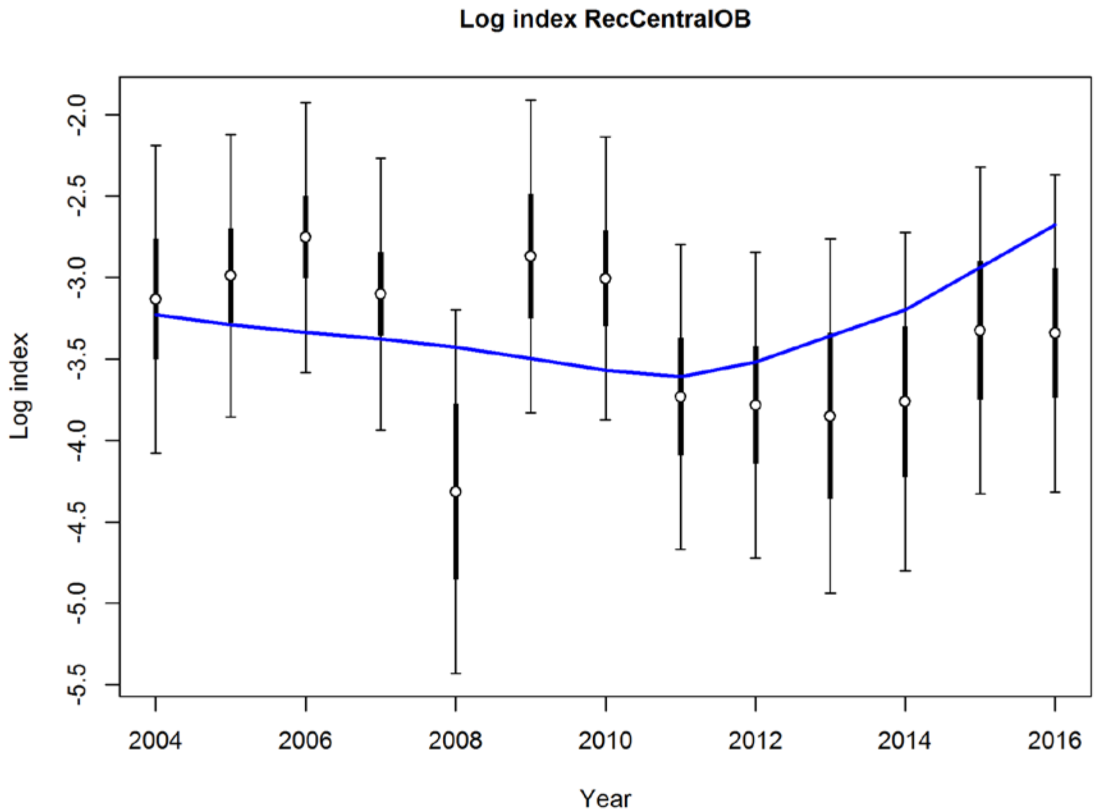


Figure 49. Observed and expected indices (in log scale) for the central California onboard recreational CPUE indices.

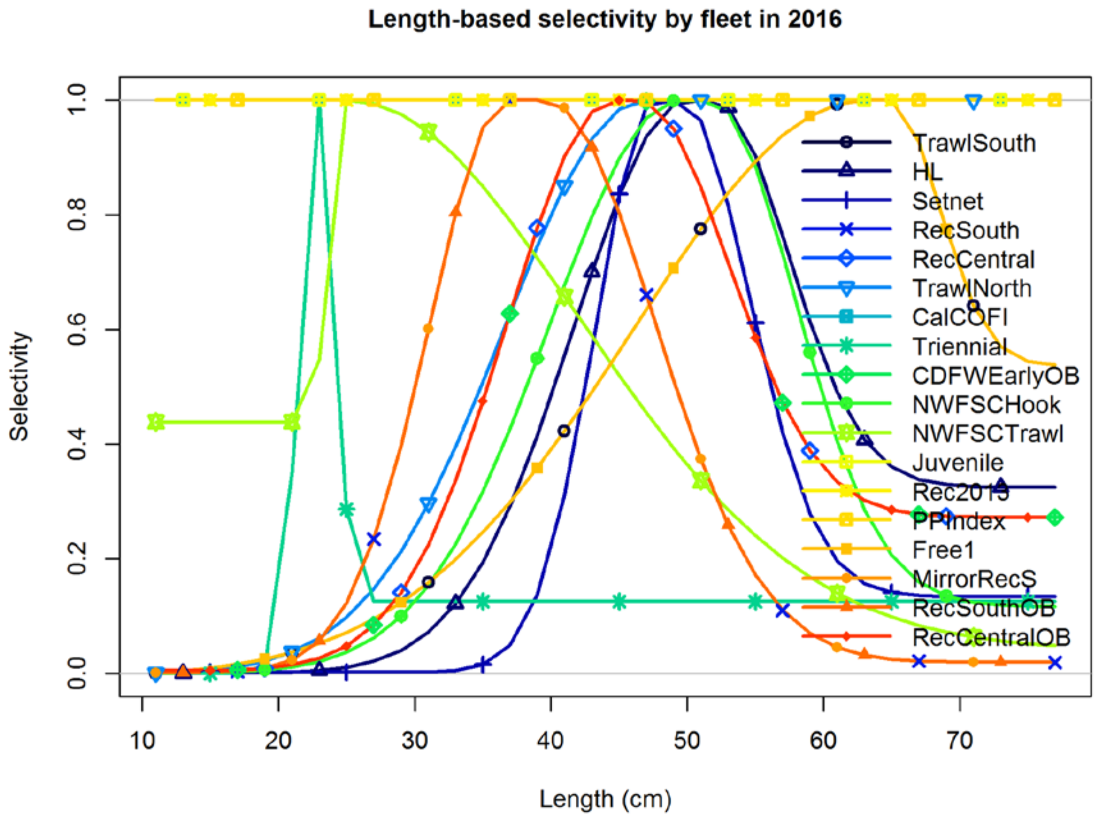


Figure 50. Estimated length selectivity functions for all fishery fleets and surveys in 2014 (the last year that these functions were estimated in the assessment model).

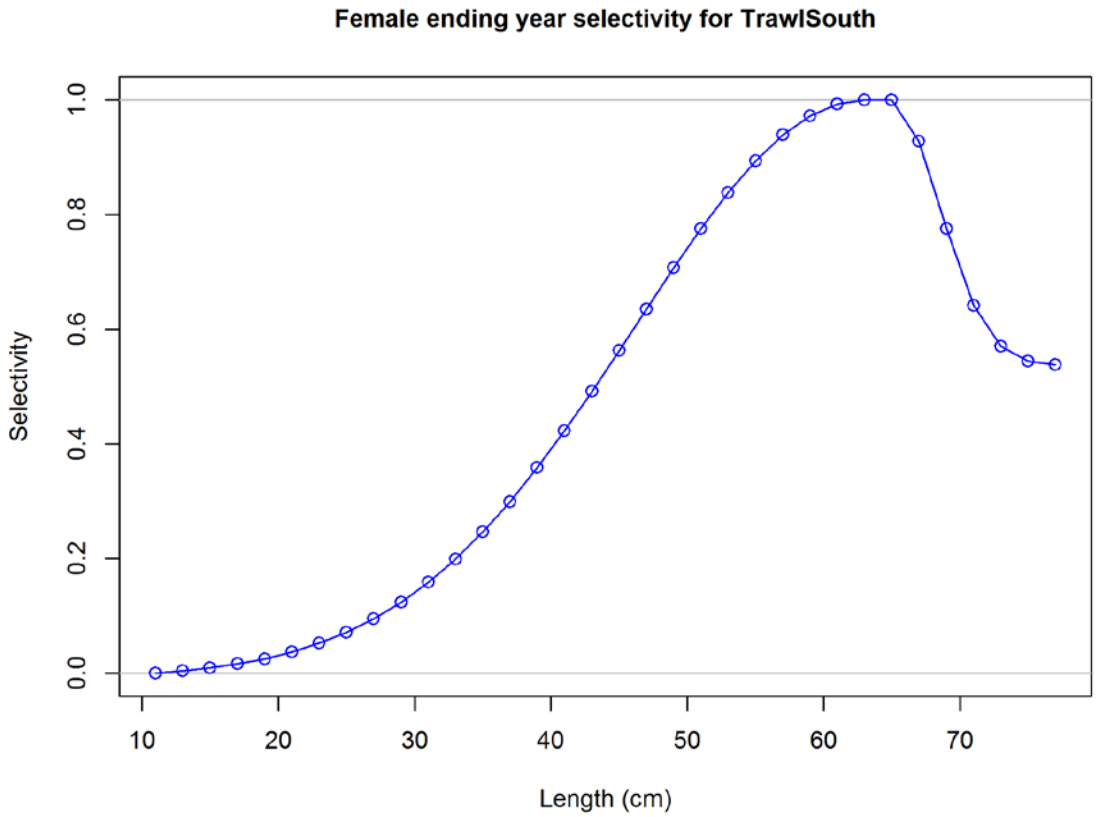


Figure 51. Estimated the ending year length selectivity function for the southern California trawl fishery (same for both sexes).

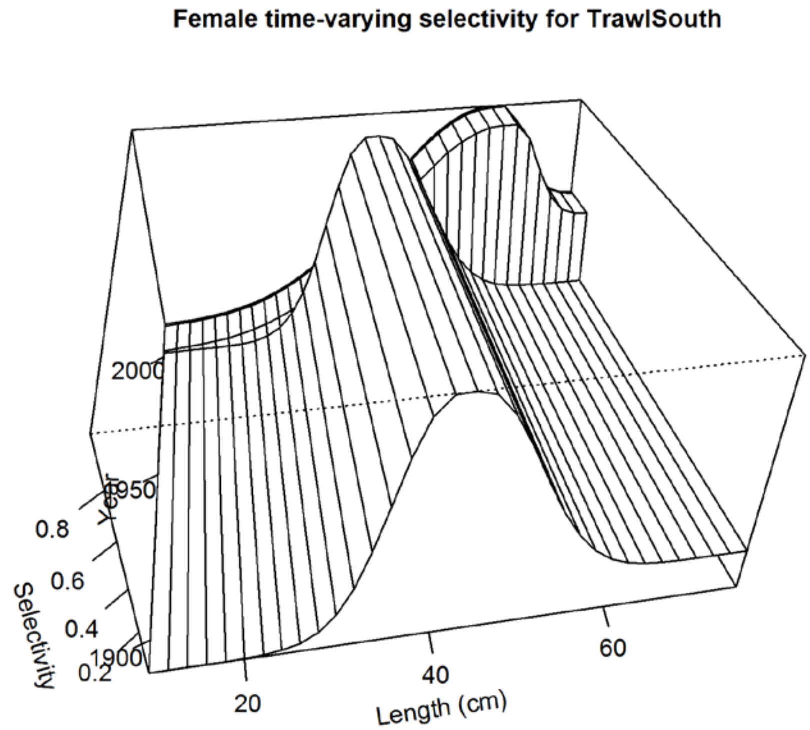


Figure 52. Estimated time varying (block in 2001) length selectivity functions for the southern California trawl fishery (same for both sexes).

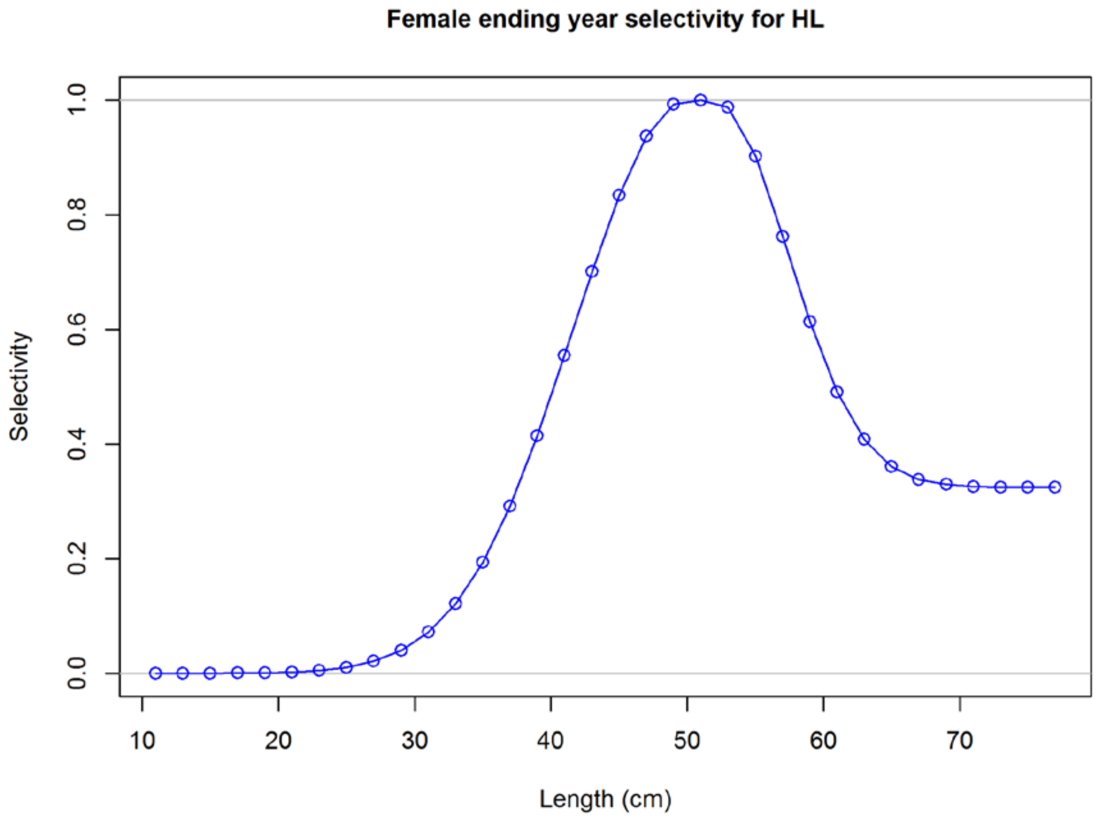


Figure 53. Estimated length selectivity function for the hook-and-line fishery (same for both sexed).

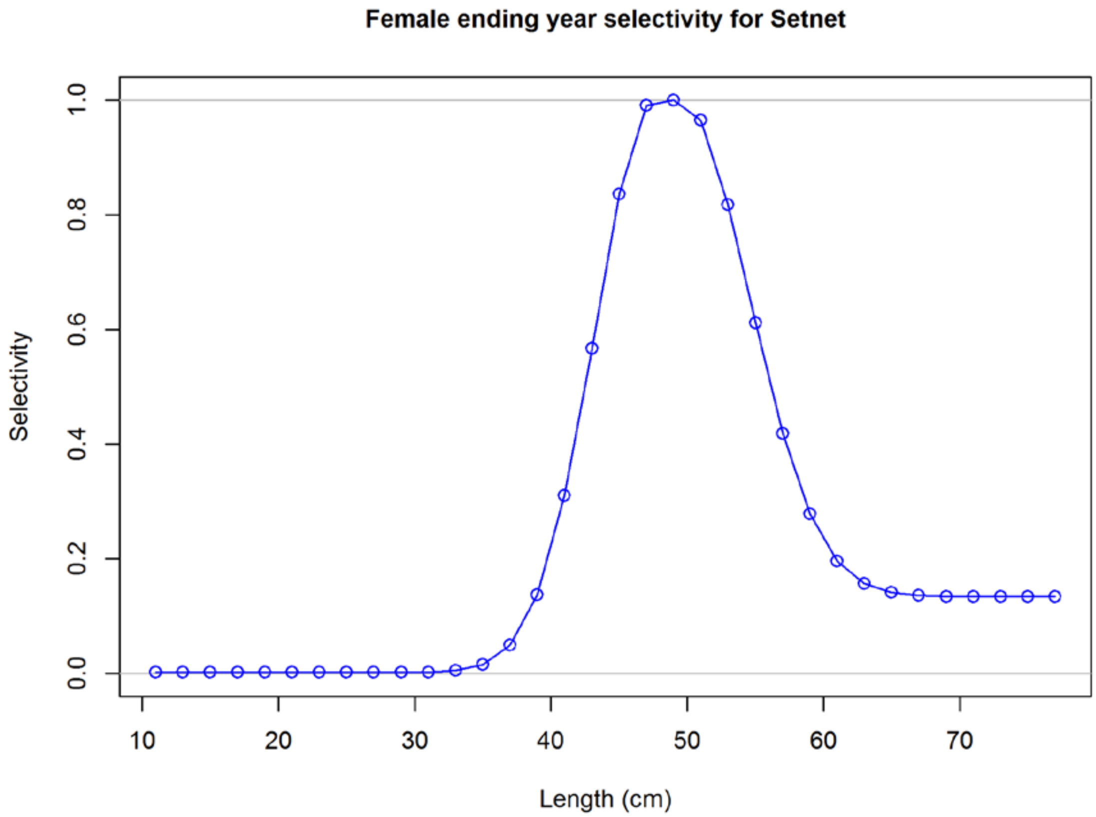


Figure 54. Estimated length selectivity functions for the setnet fishery (same for both sexed).

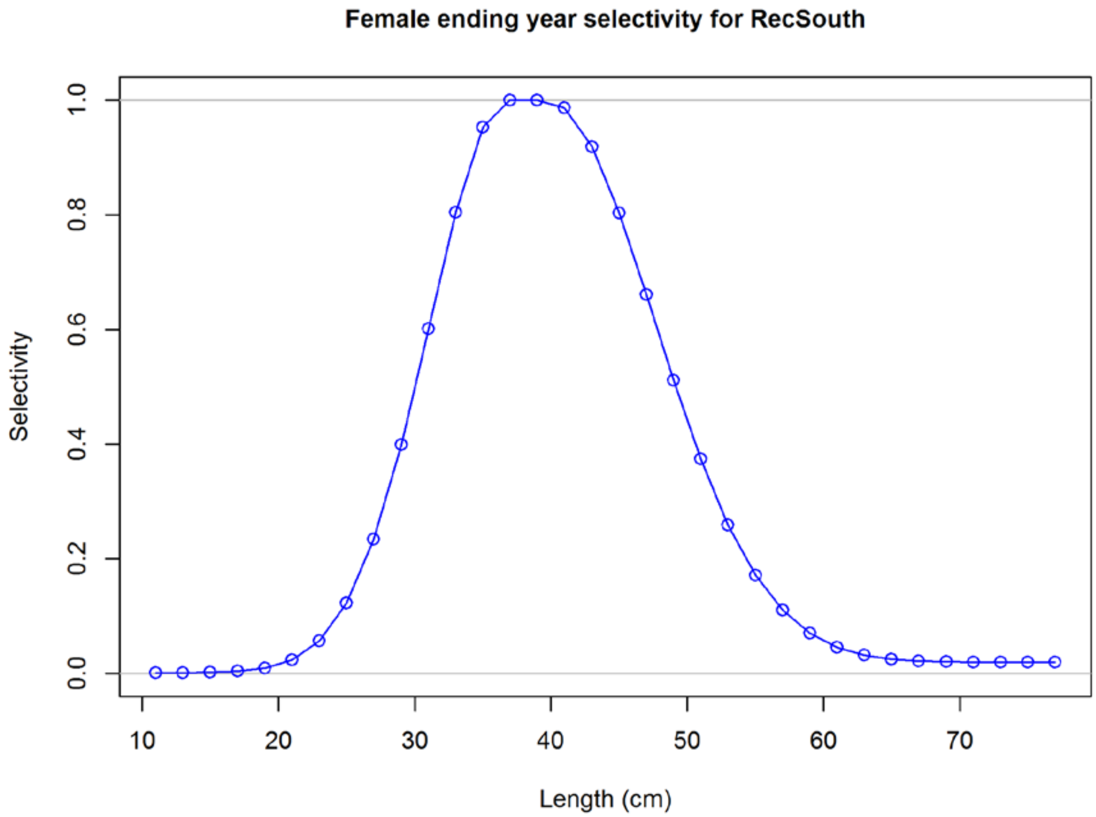


Figure 55. Estimated length selectivity function for the southern California recreational fishery (unsexed data for this fishery) in 2016.

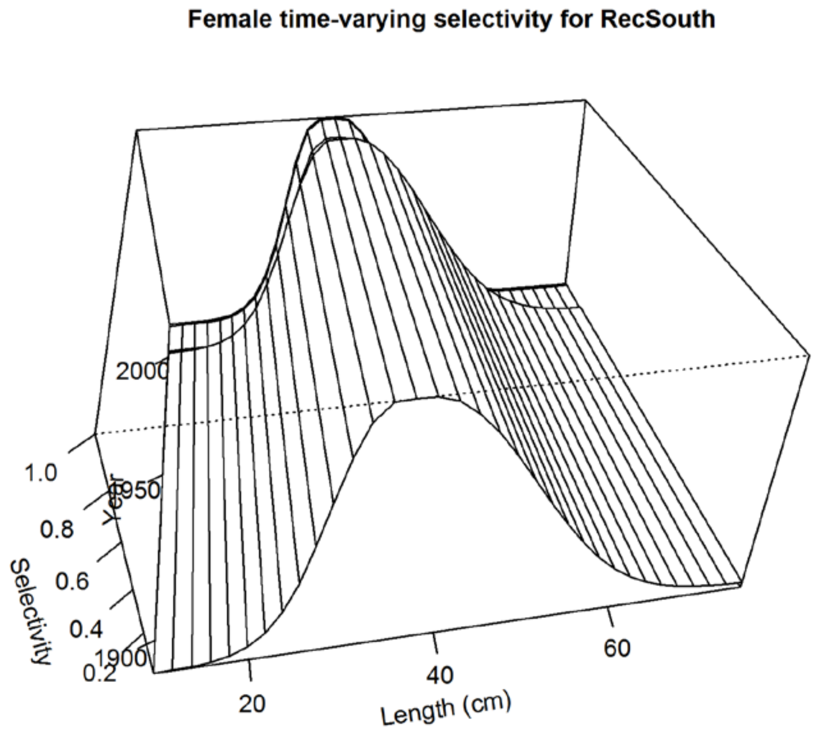


Figure 56. Estimated time varying (block in 2001) length selectivity functions for the central California recreational fishery.

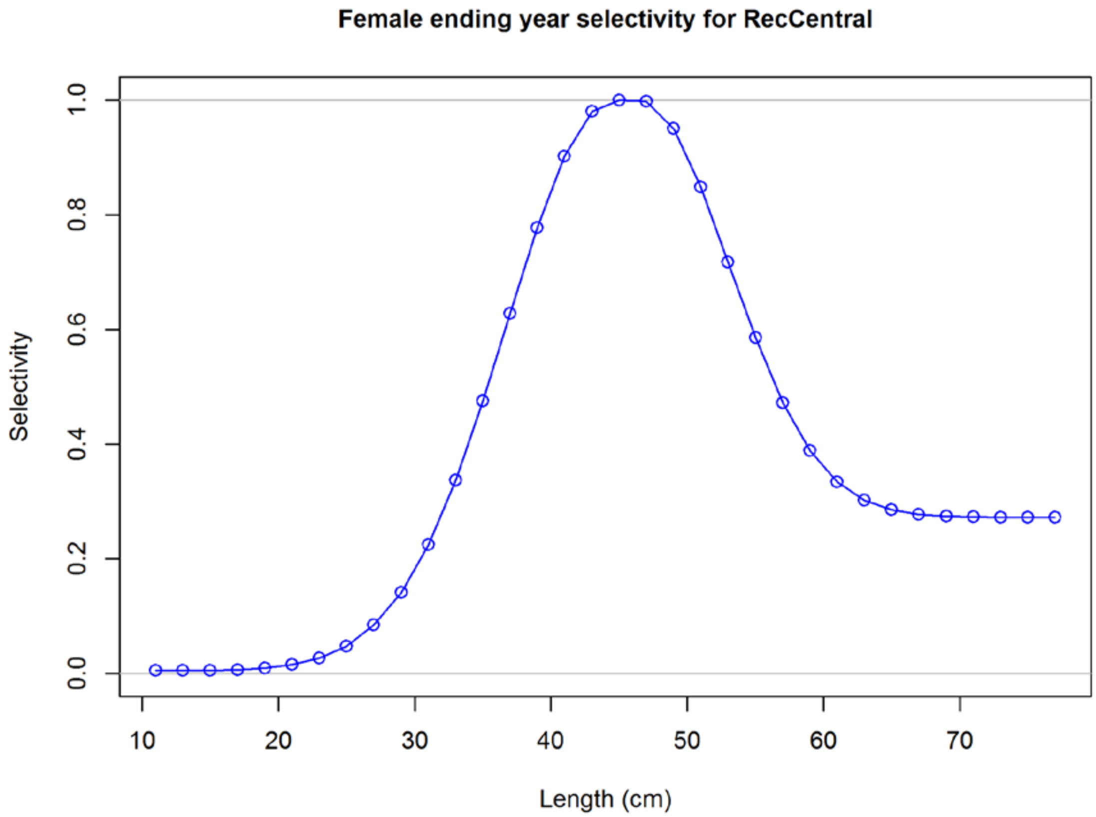


Figure 57. Estimated length selectivity function for the central California recreational fishery in 2016.

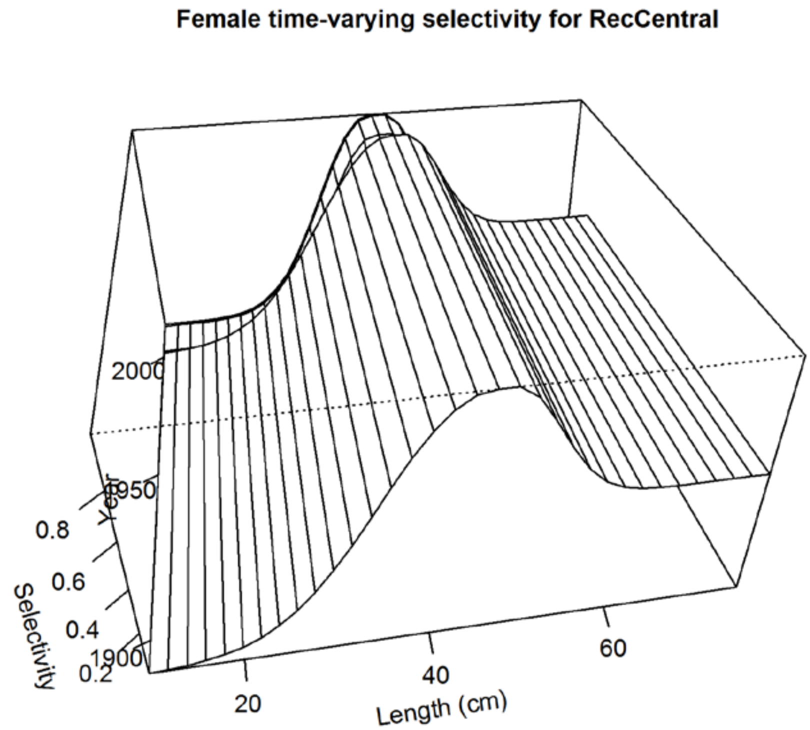


Figure 58. Estimated time varying (block in 2001) length selectivity function for the northern California trawl fishery.

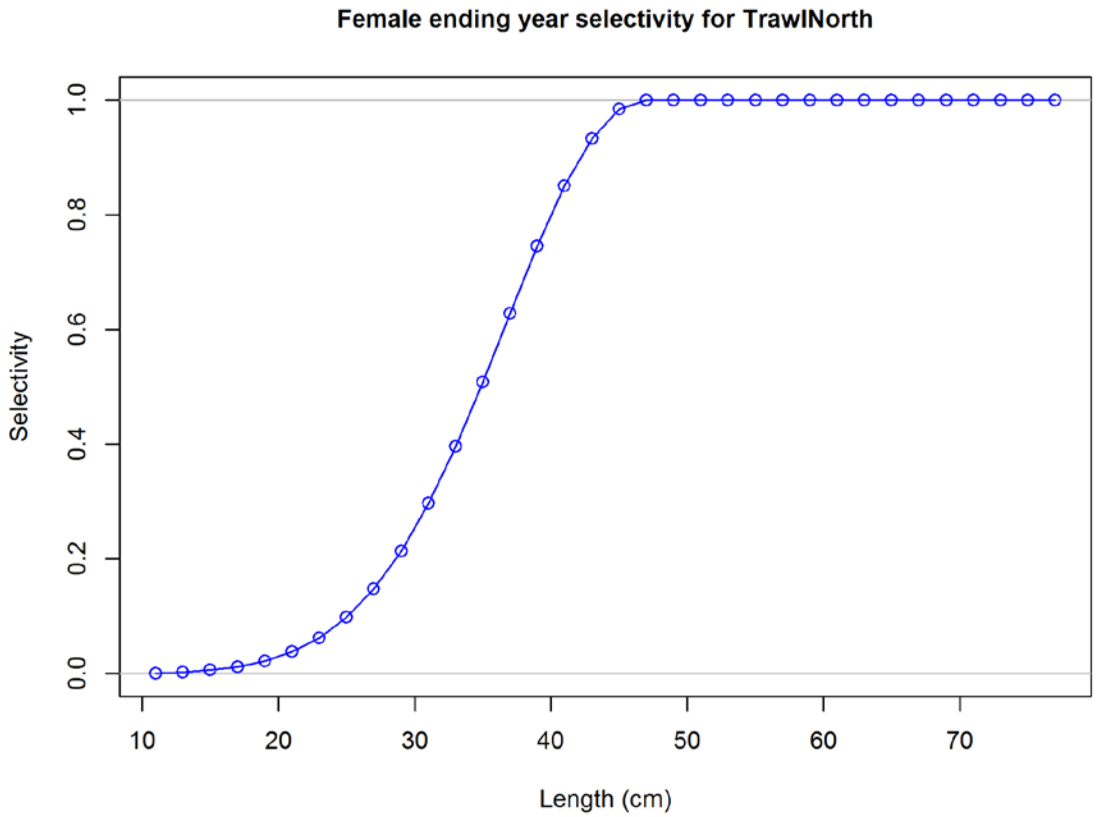


Figure 59. Estimated length selectivity function for the northern California trawl fishery in 2014.

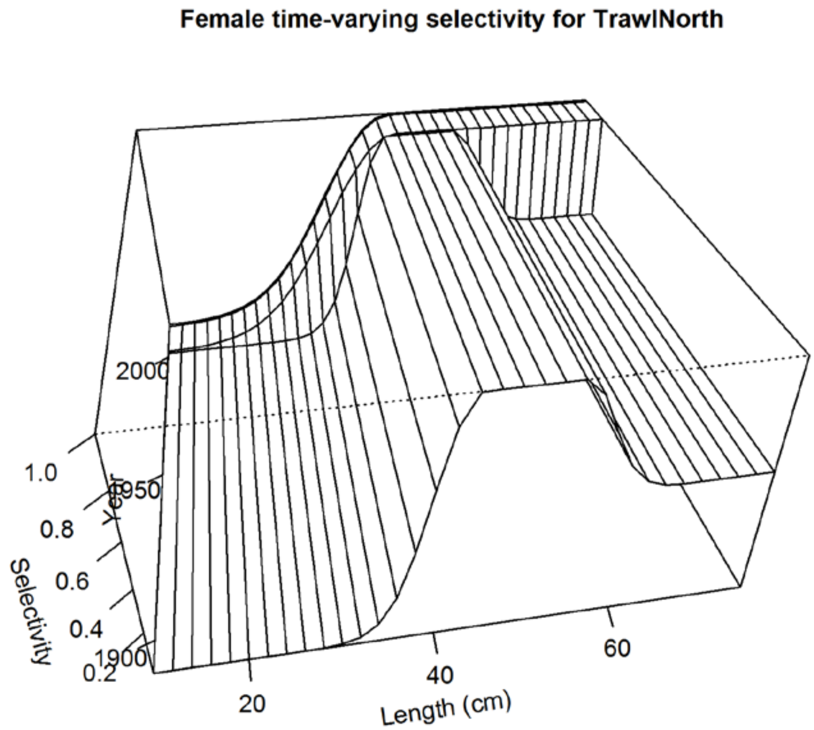


Figure 60. Estimated time varying (block in 2001) length selectivity function for the northern California trawl fishery.

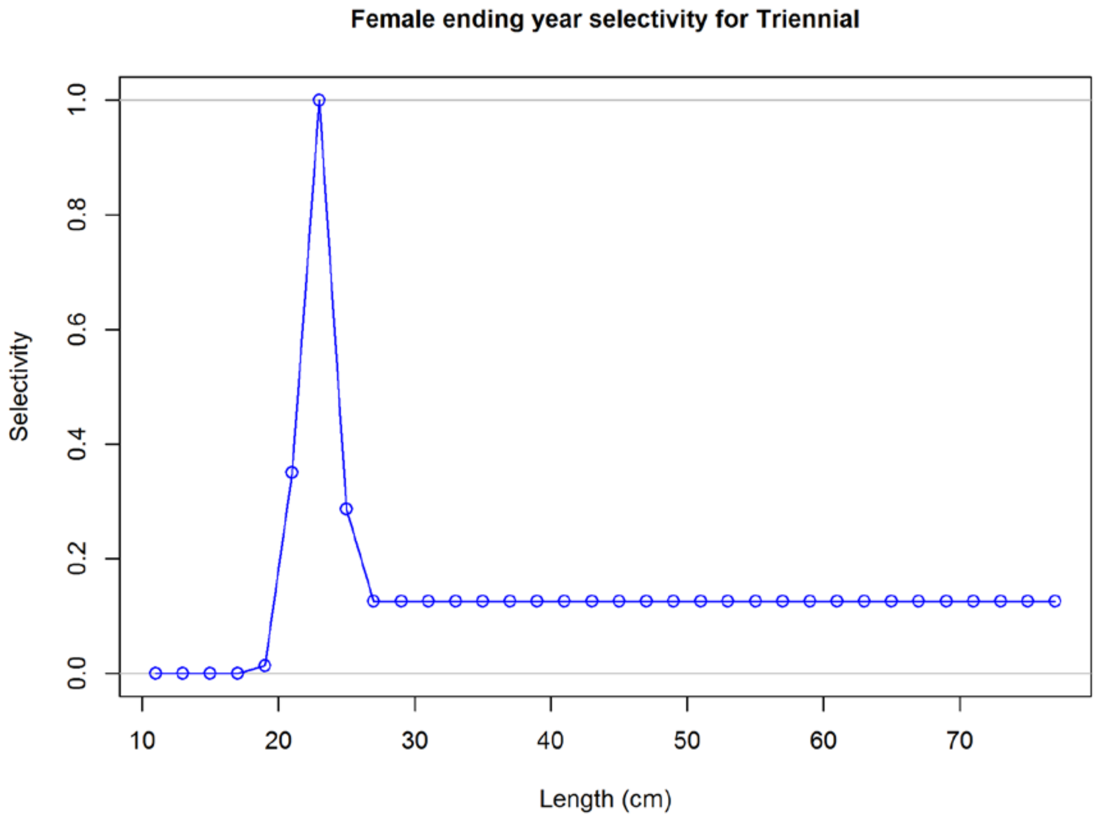


Figure 61. Estimated length-based selectivity functions for the triennial trawl survey.

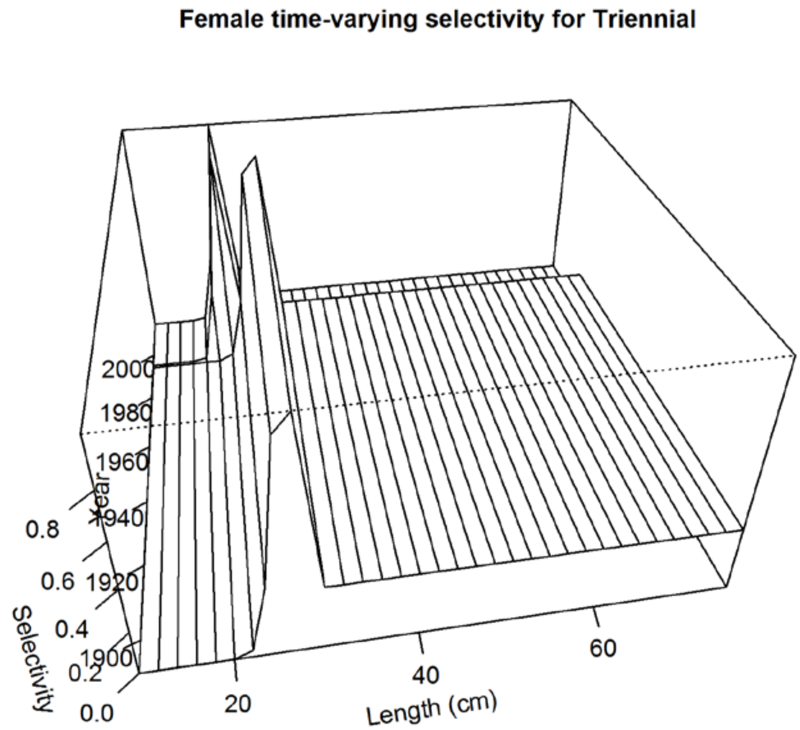


Figure 62. Estimated time varying (block in 1995) length selectivity function for the triennial trawl survey.

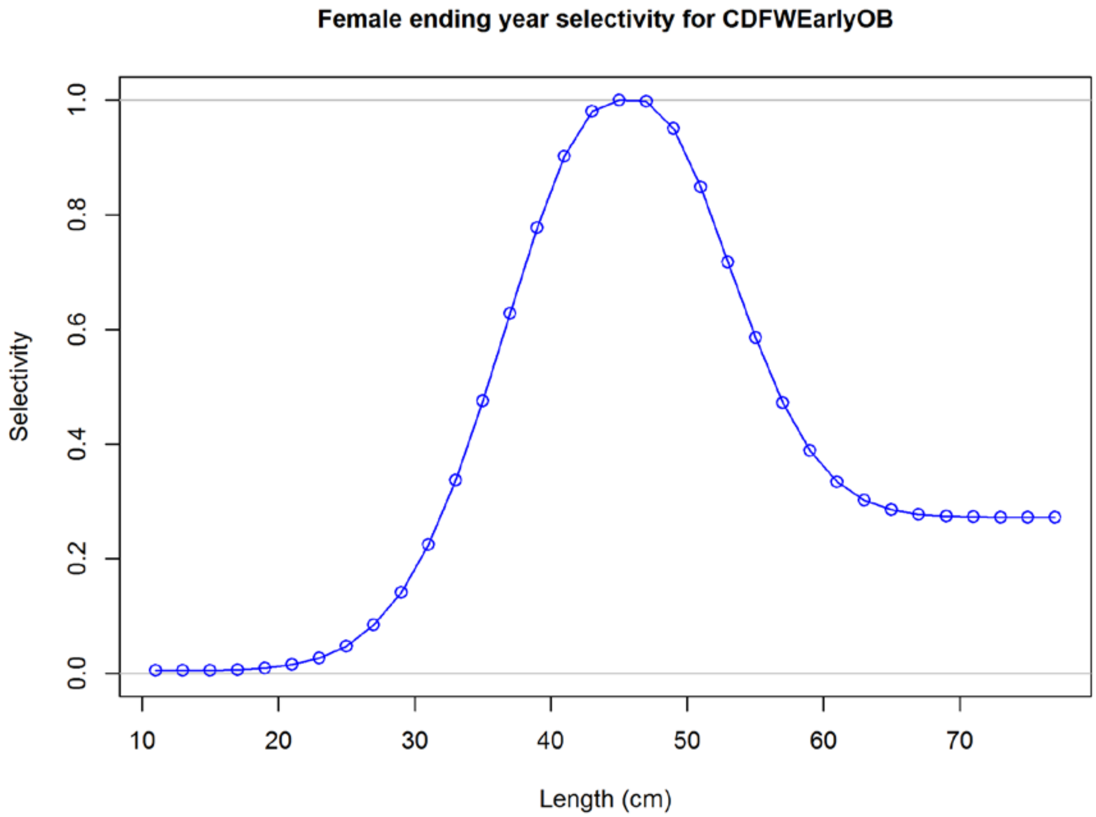


Figure 63. Estimated length-based selectivity functions the early years of the CDFW CPUE survey.

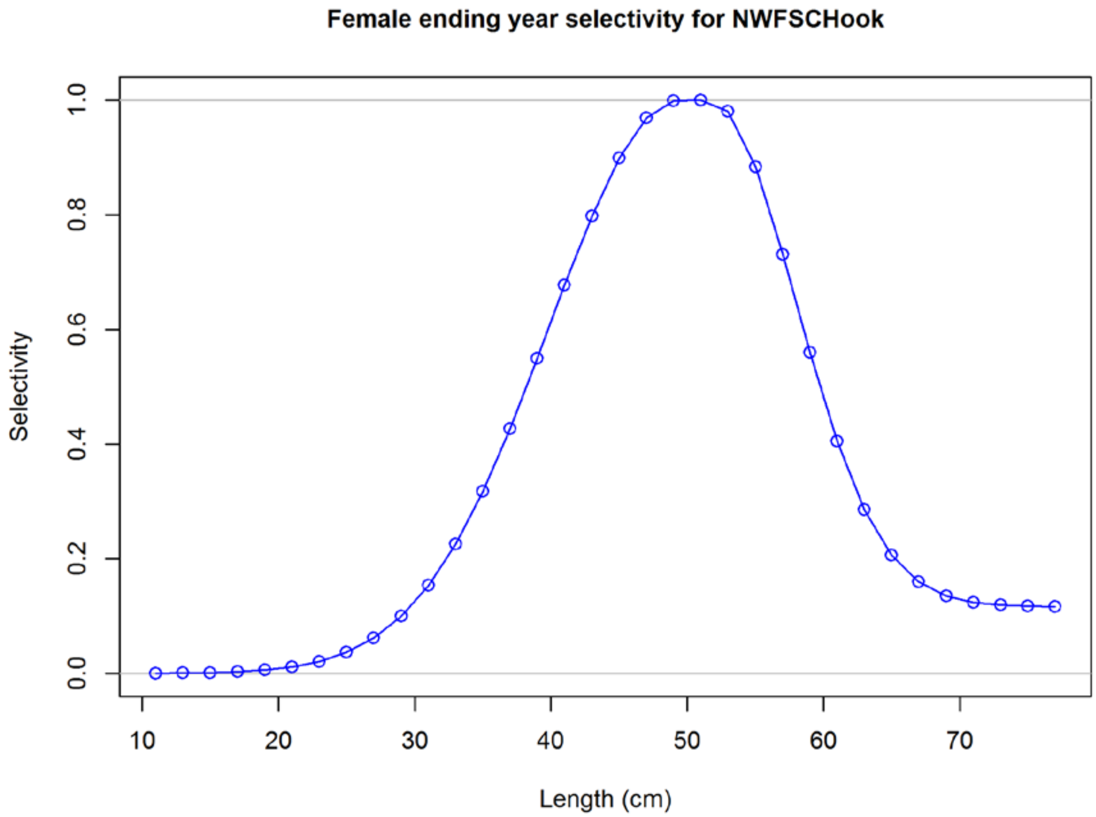


Figure 64. Estimated length selectivity functions for the southern California trawl fishery.

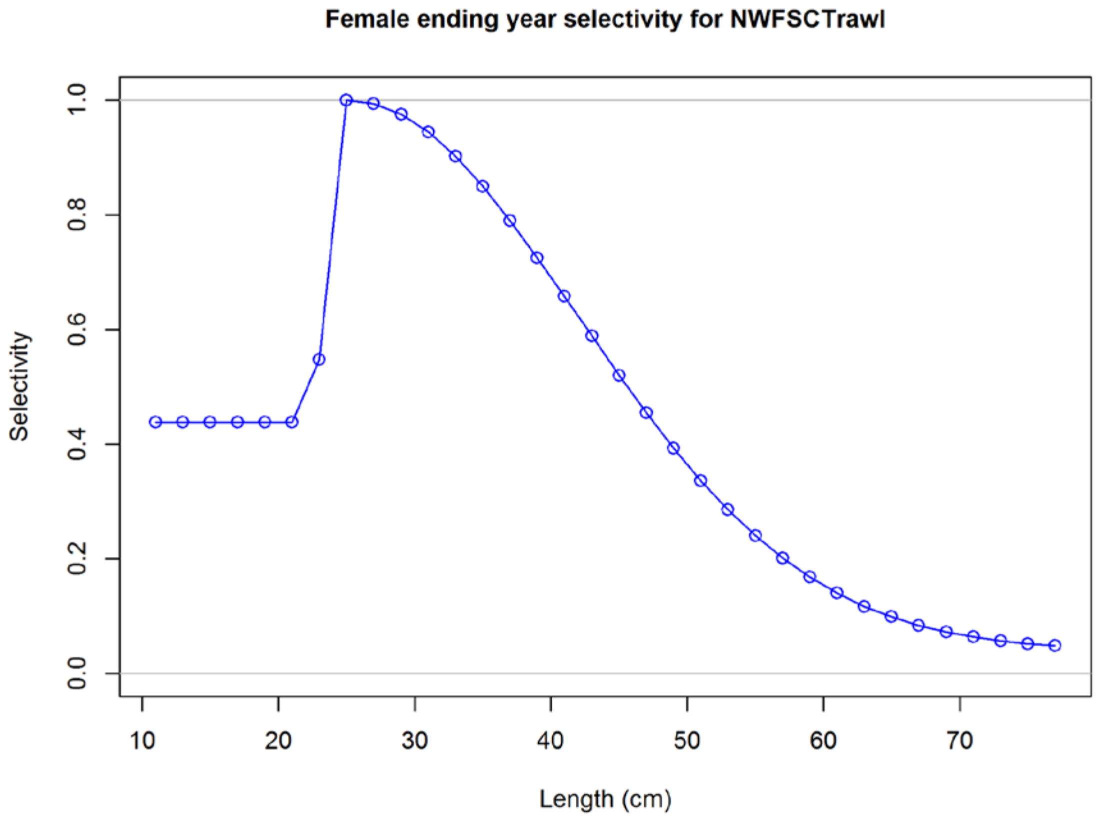


Figure 65. Estimated length selectivity functions for the southern California trawl fishery.

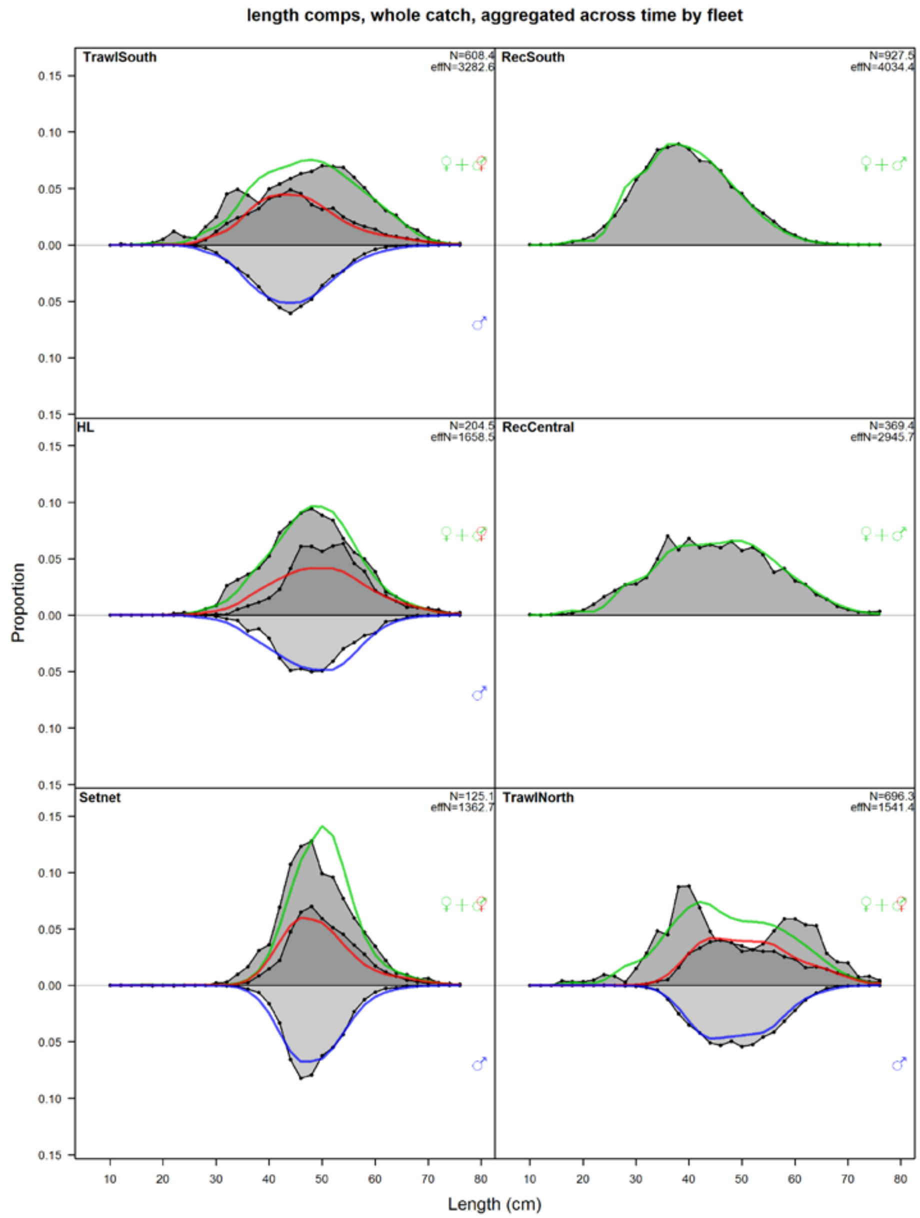


Figure 66. Observed and expected length composition by sex (female, male, and/or unsexed) by fleets aggregated over all years.

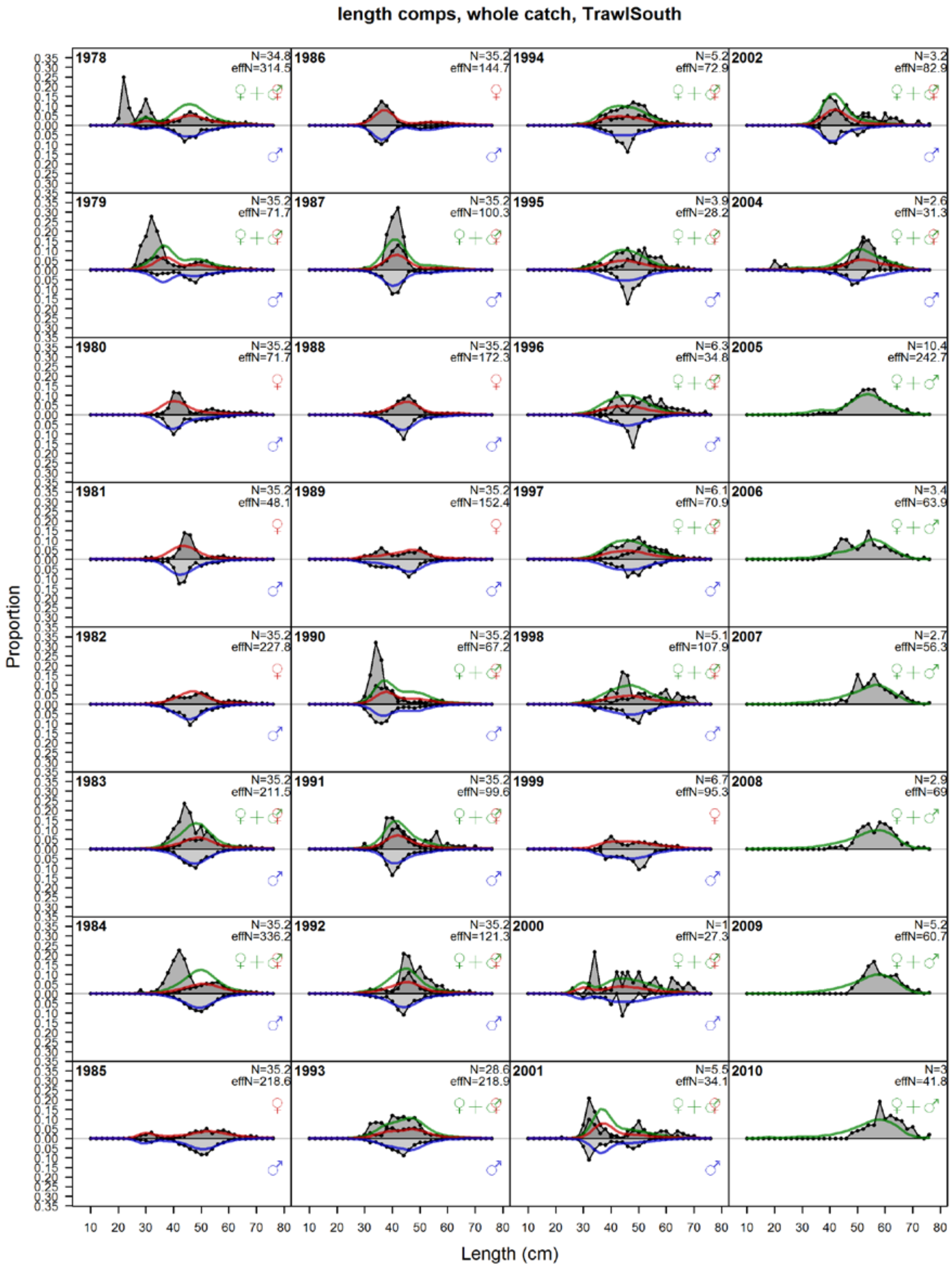


Figure 67. Observed and expected length composition by sex (female, male, and/or unsexed) for the Southern California trawl fishery.

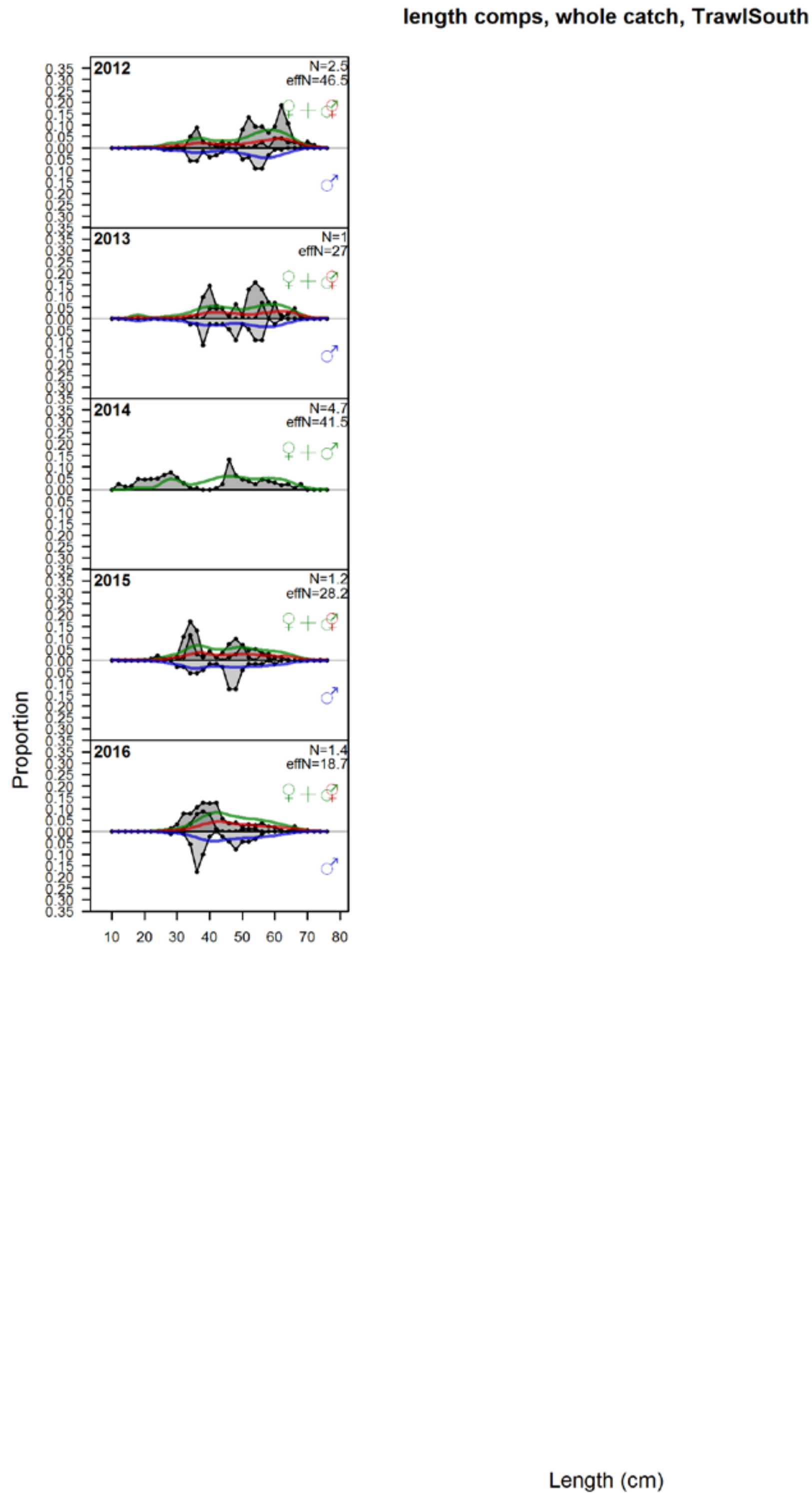


Figure (continued). Observed and expected length composition by sex (female, male, and/or unsexed) for the Southern California trawl fishery.

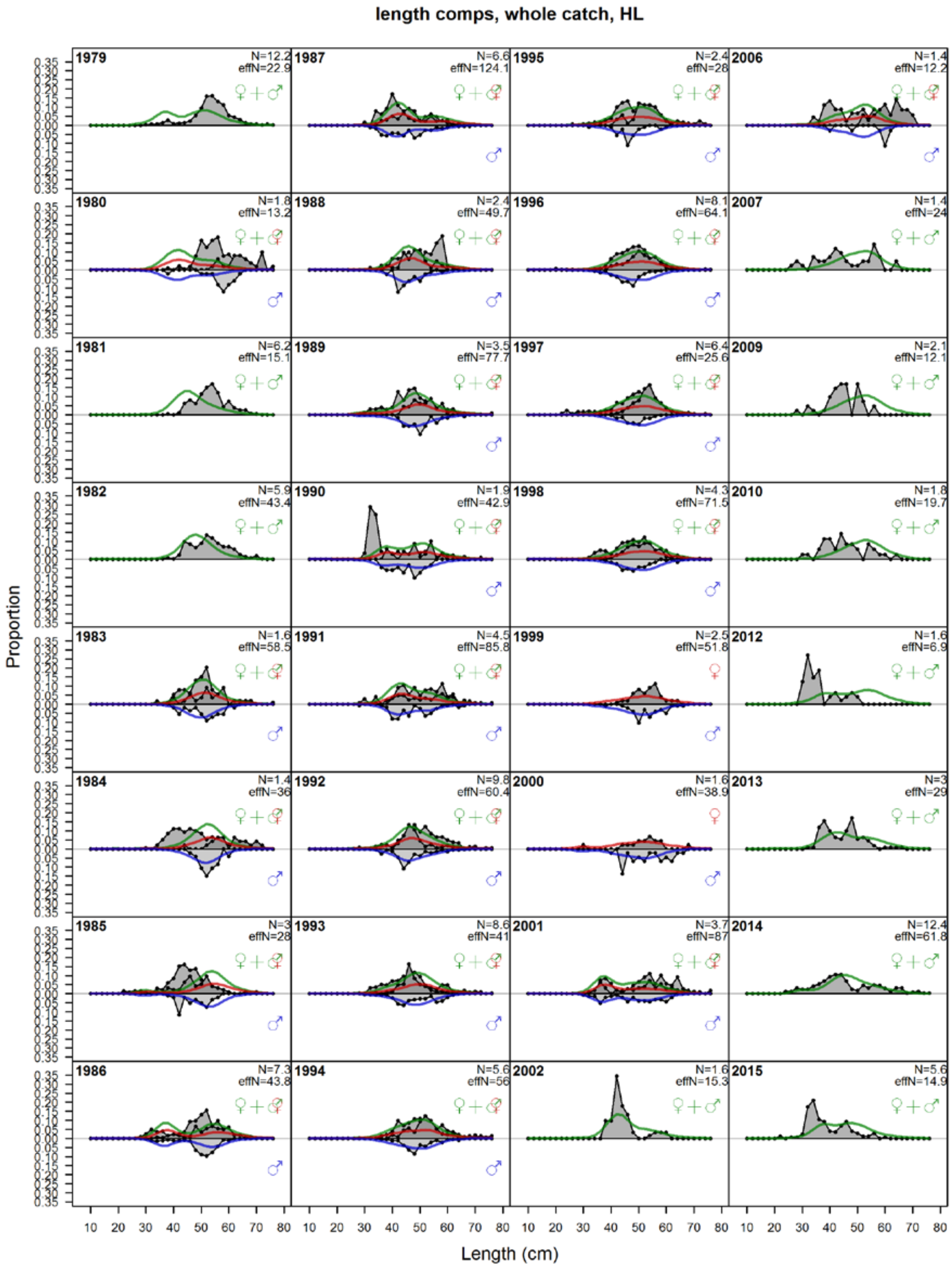


Figure 68. Observed and expected length composition by sex (female, male, and/or unsexed) for the hook-and-line fishery.

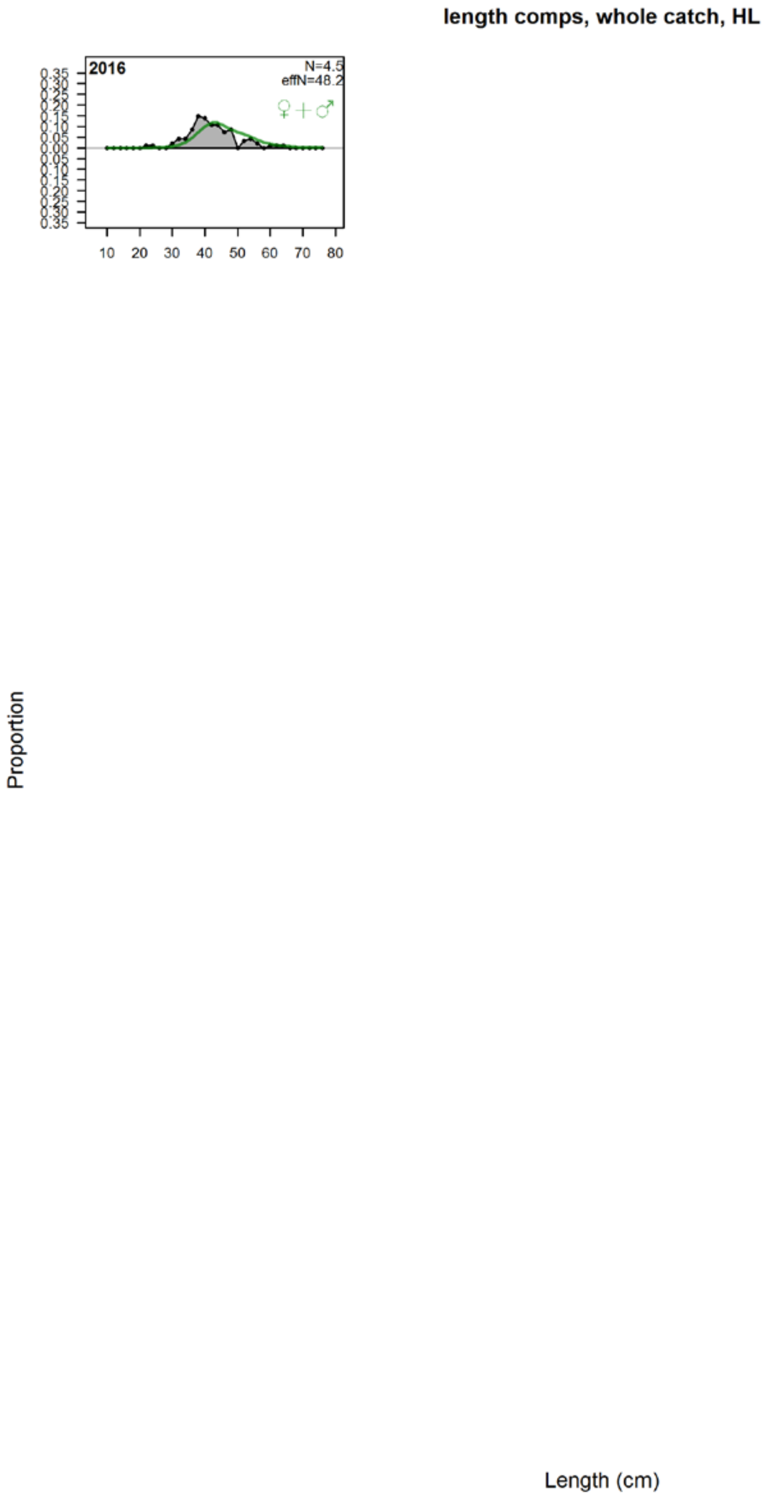


Figure (continued). Observed and expected length composition by sex (female, male, and/or unsexed) for the hook-and-line fishery.

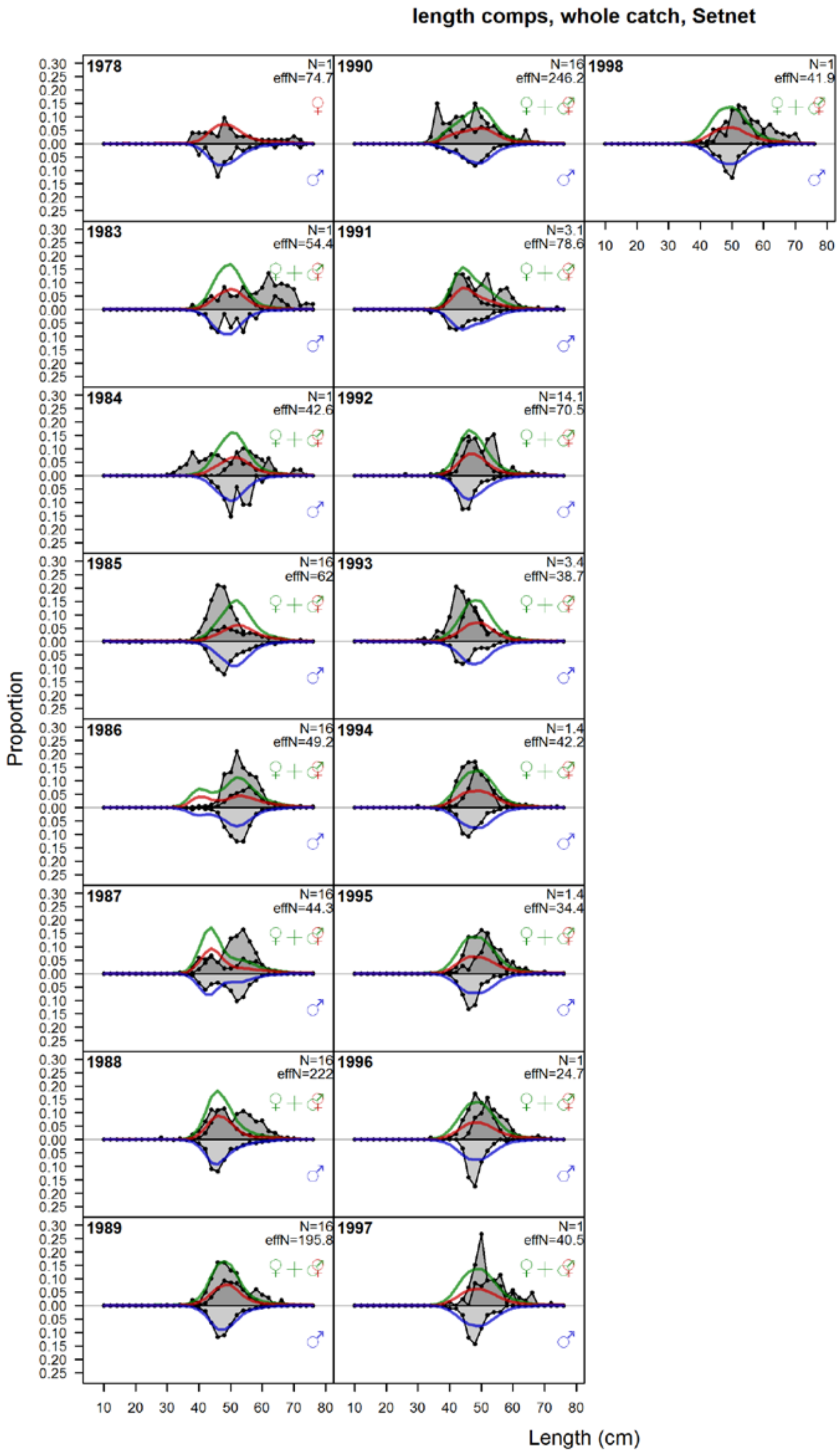


Figure 69. Observed and expected length composition by sex (female, male, and/or unsexed) for the setnet fishery.

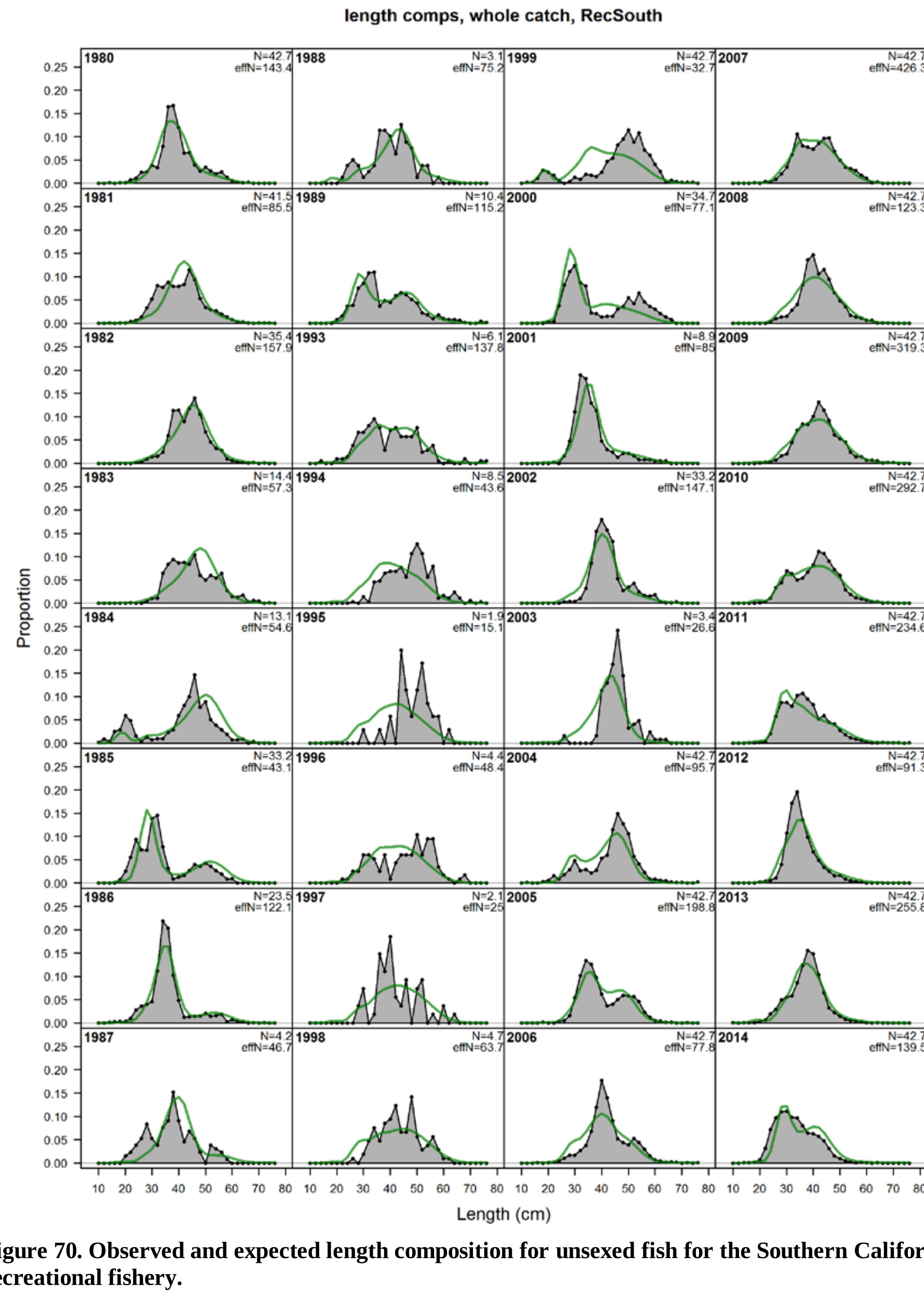


Figure 70. Observed and expected length composition for unsexed fish for the Southern California recreational fishery.

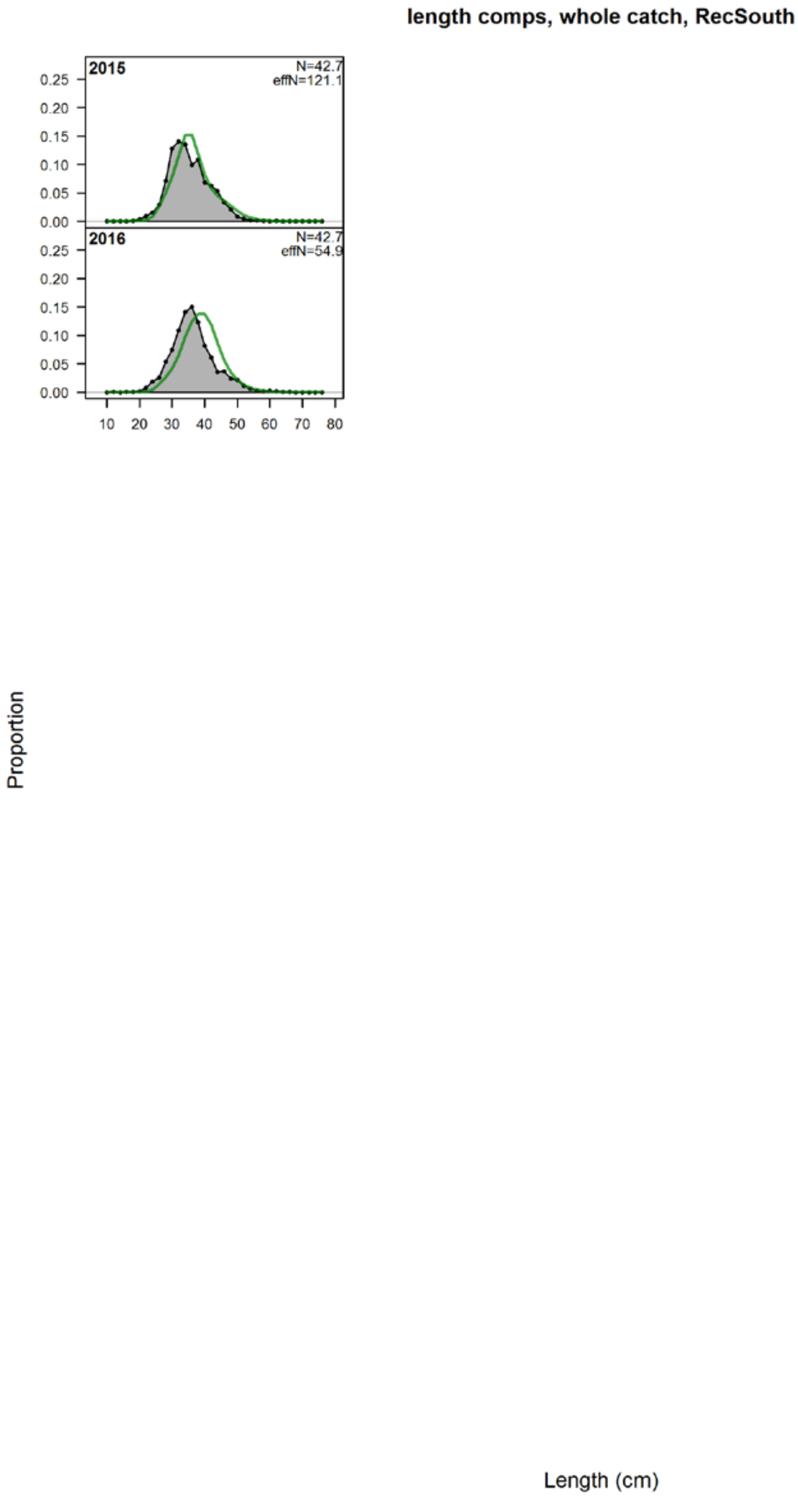


Figure. (Continued) Observed and expected length composition for unsexed fish for the Southern California recreational fishery.

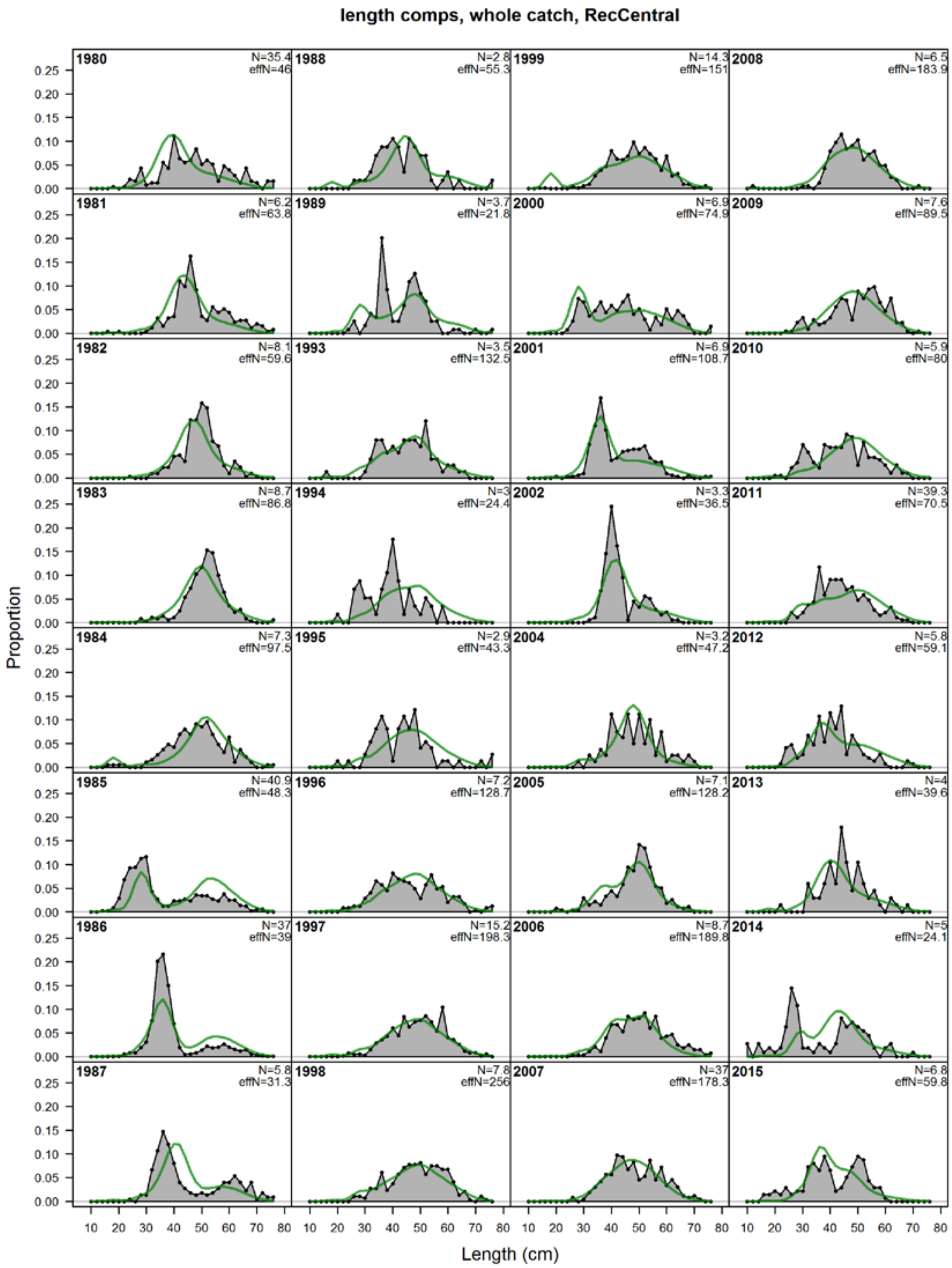


Figure 71. Observed and expected length composition for unsexed fish for the Central California recreational fishery.

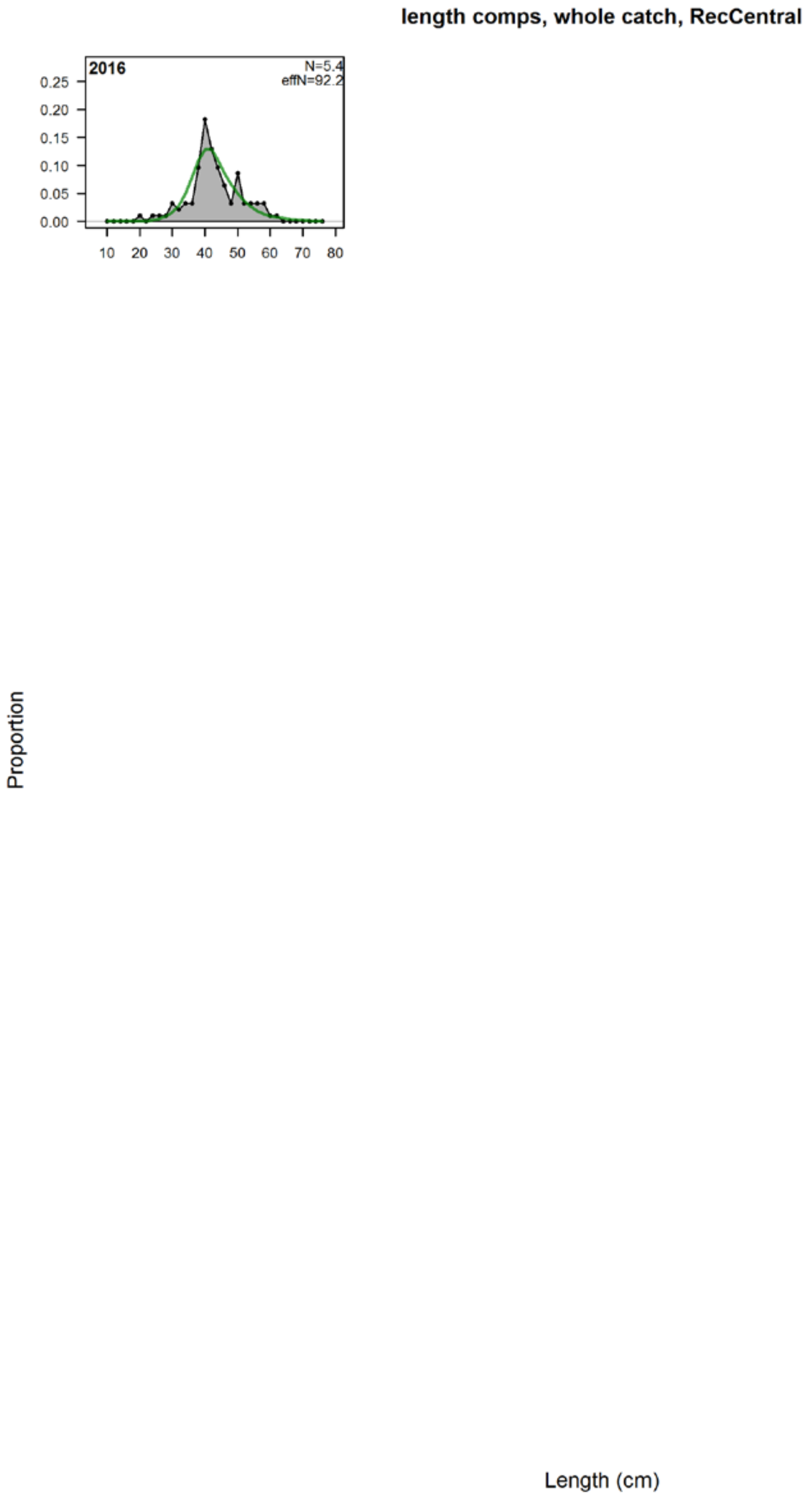


Figure. (continued) Observed and expected length composition for unsexed fish for the Central California recreational fishery.

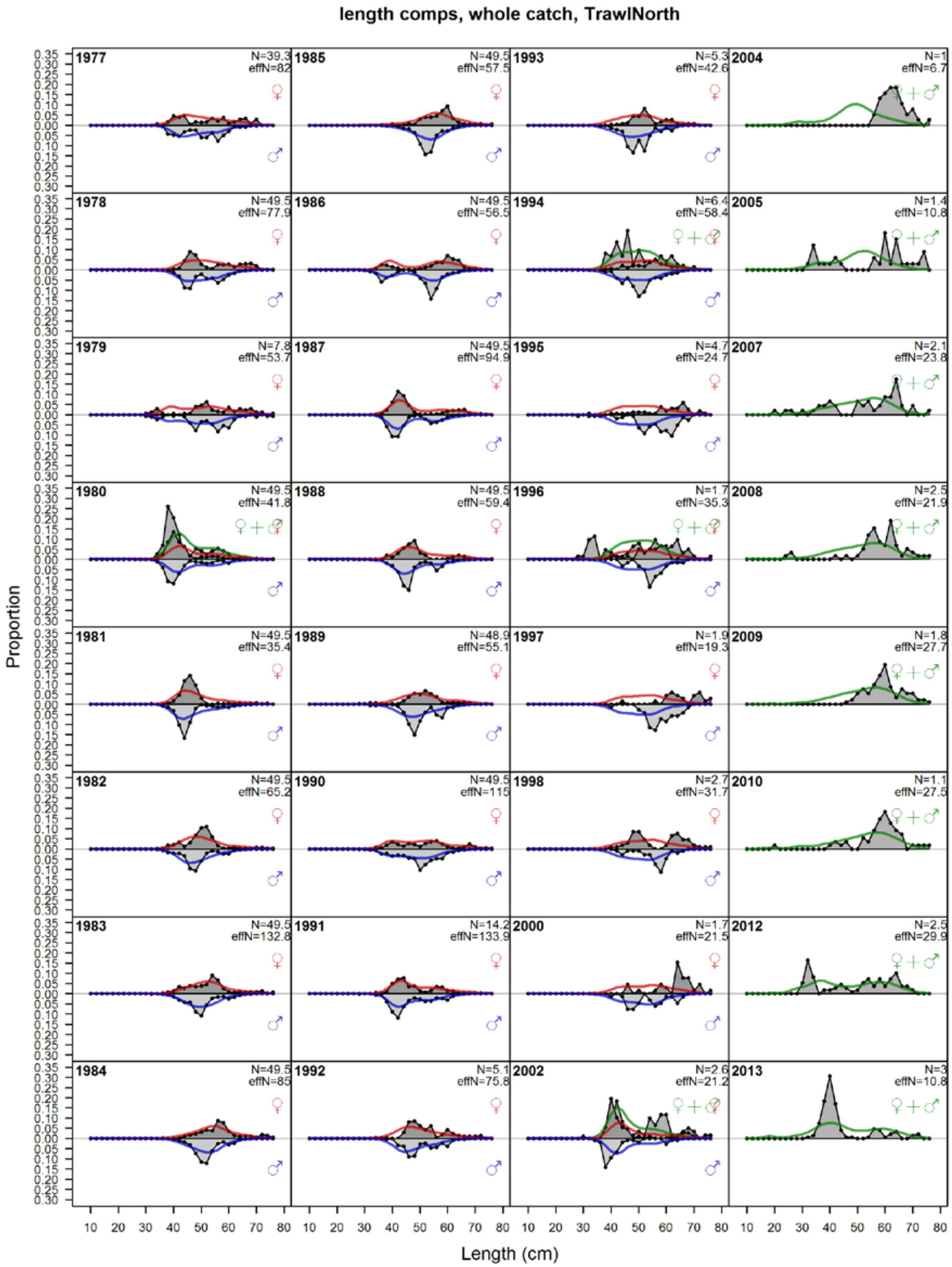


Figure 72. Observed and expected length composition by sex (female, male, and/or unsexed) by the Central California trawl fishery.

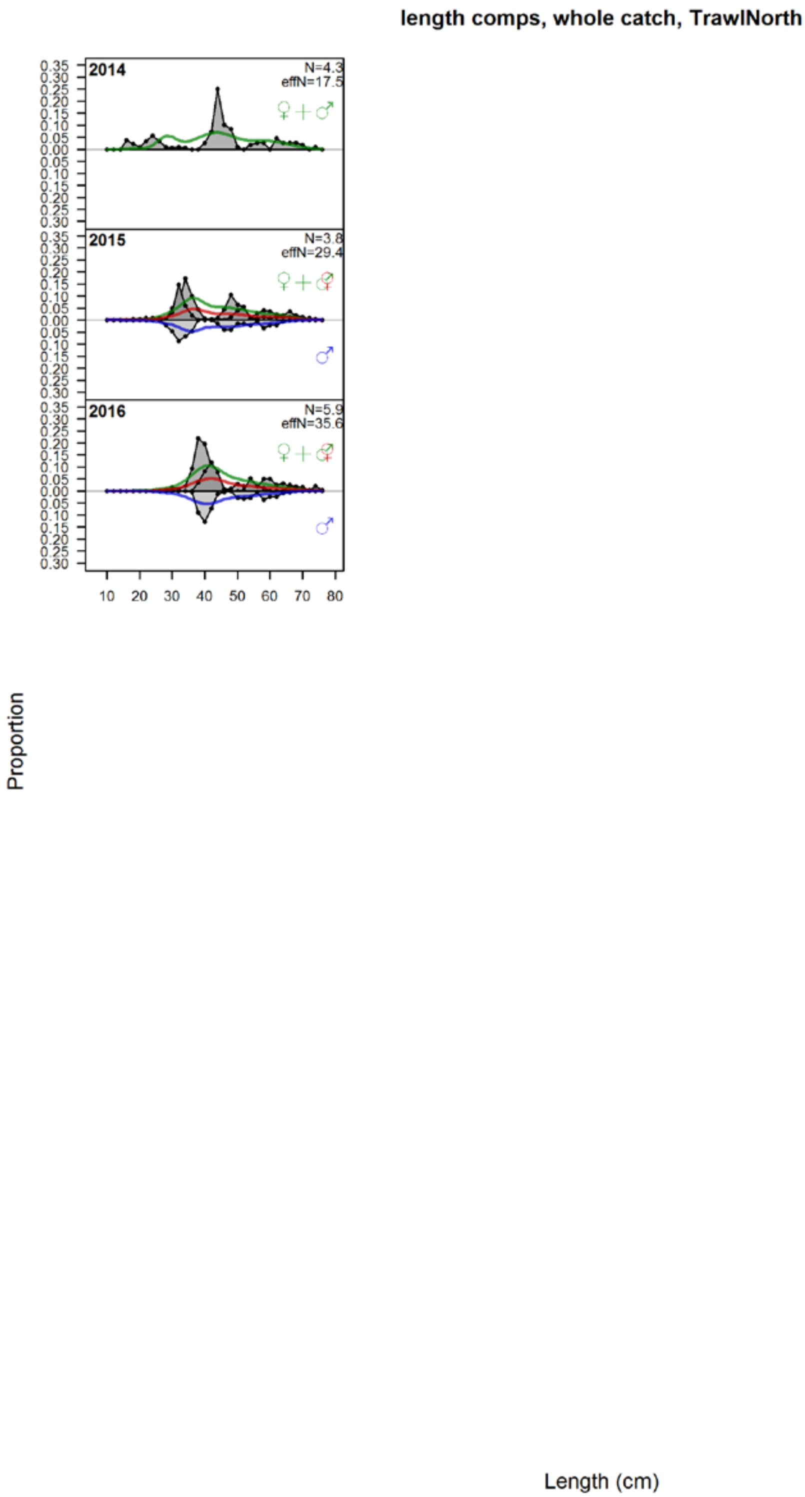


Figure (continued). Observed and expected length composition by sex (female, male, and/or unsexed) by the Central California trawl fishery.

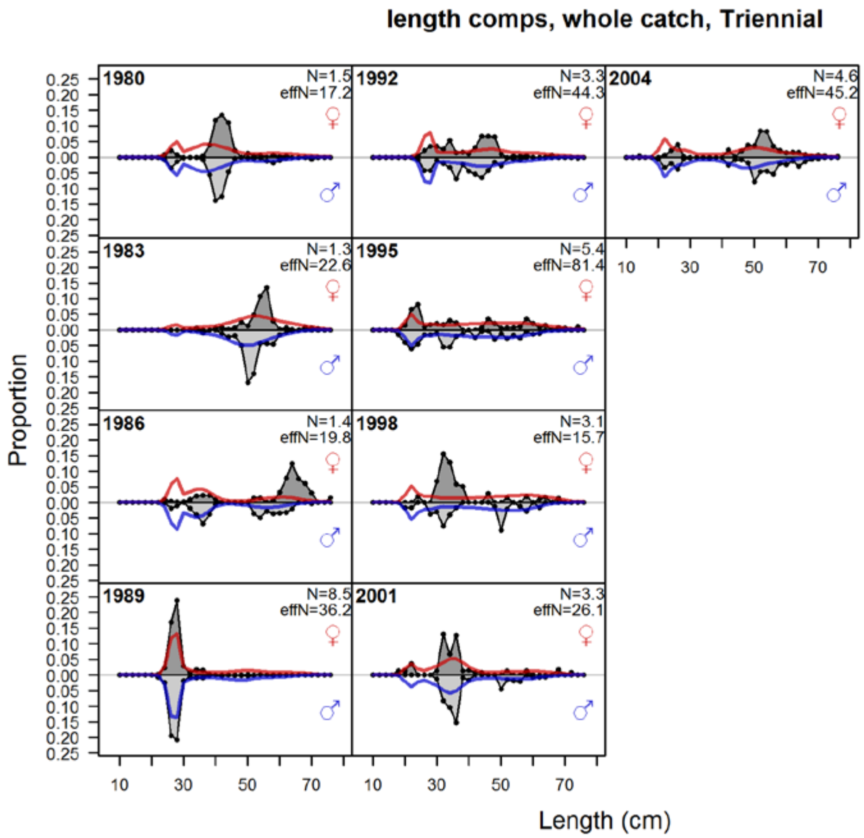


Figure 73. Observed and expected length composition by sex (female, male, and/or unsexed) for the triennial trawl survey.

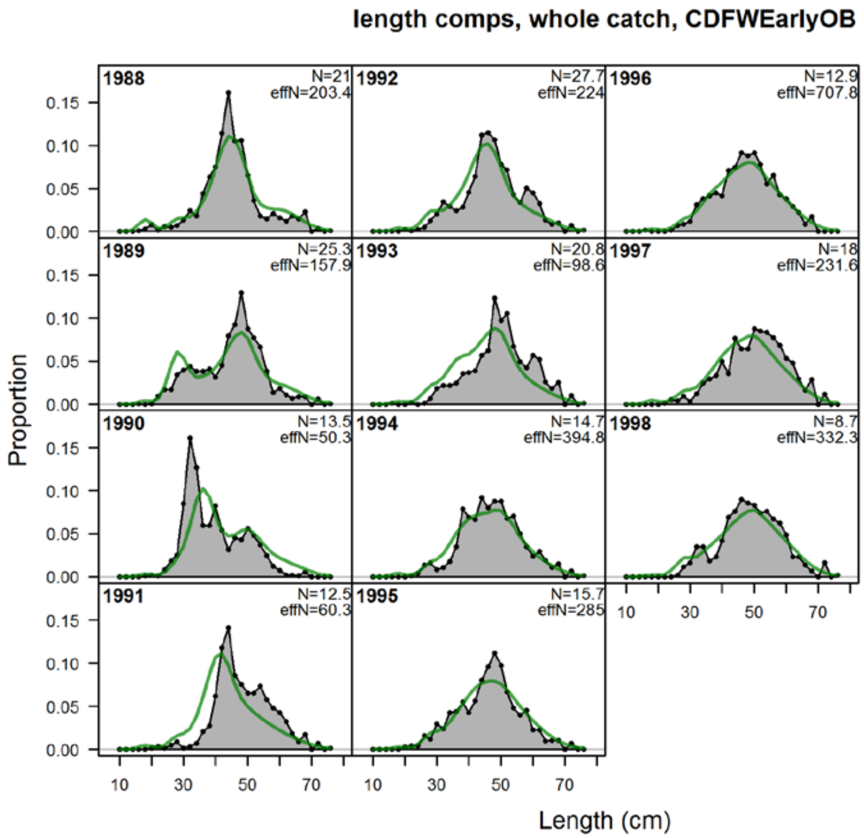


Figure 74. Observed and expected length composition for unsexed fish the early years of the CDFW CPUE survey.

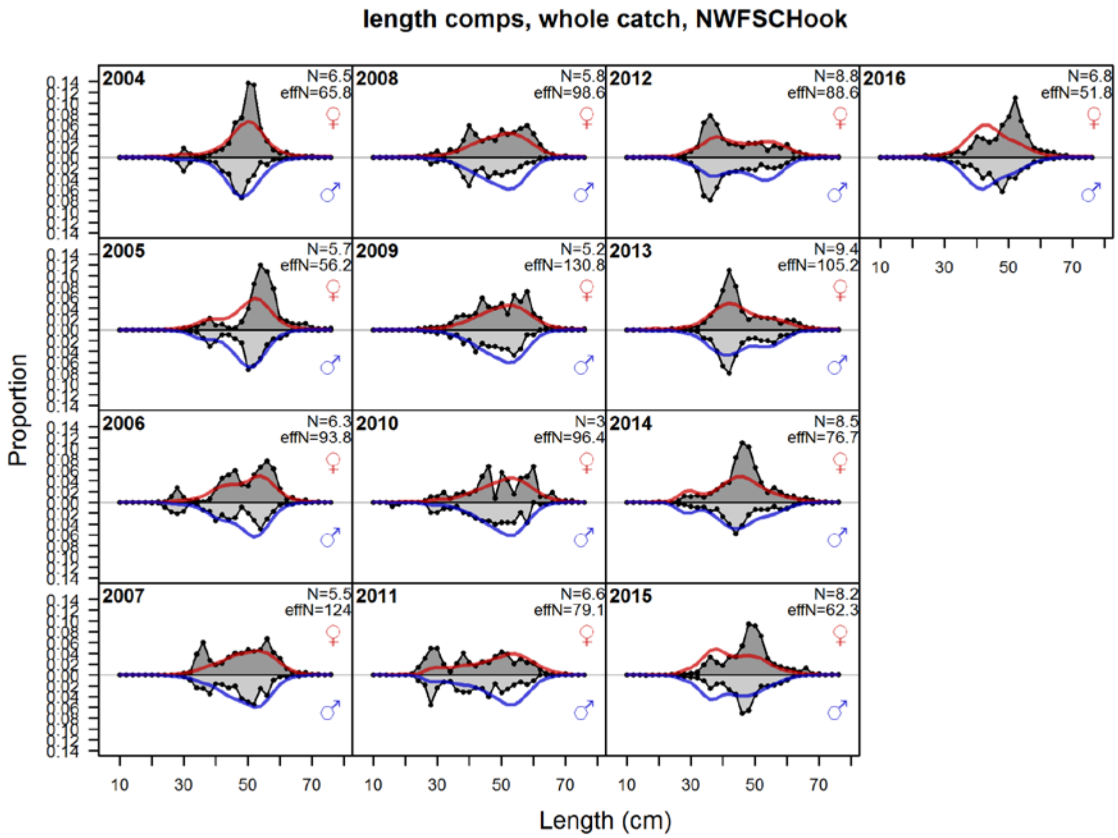


Figure 75. Observed and expected length composition by sex (female, male, and/or unsexed) for the NWFSC hook-and-line survey.

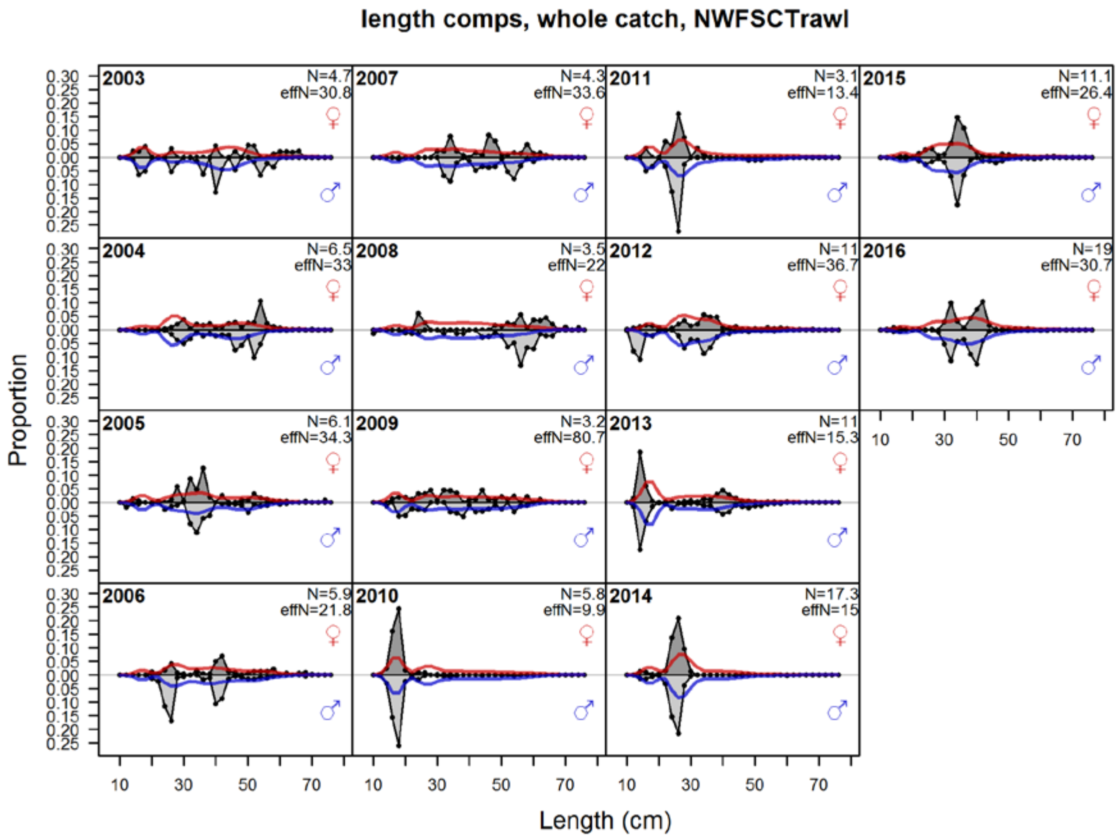


Figure 76. Observed and expected length composition by sex (female and male) for the NWFSC survey.

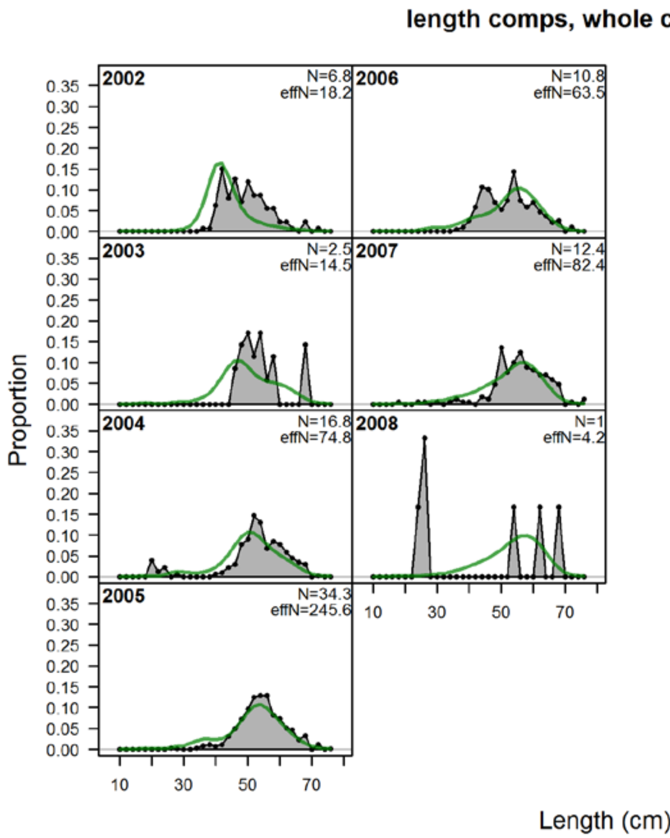


Figure 77. Observed and expected length composition for unsexed fish for the Free1 length composition. Note that the data are not included in likelihood computation. Note that this figure is only for showing fits to the data as the data were not included in the likelihood calculation.

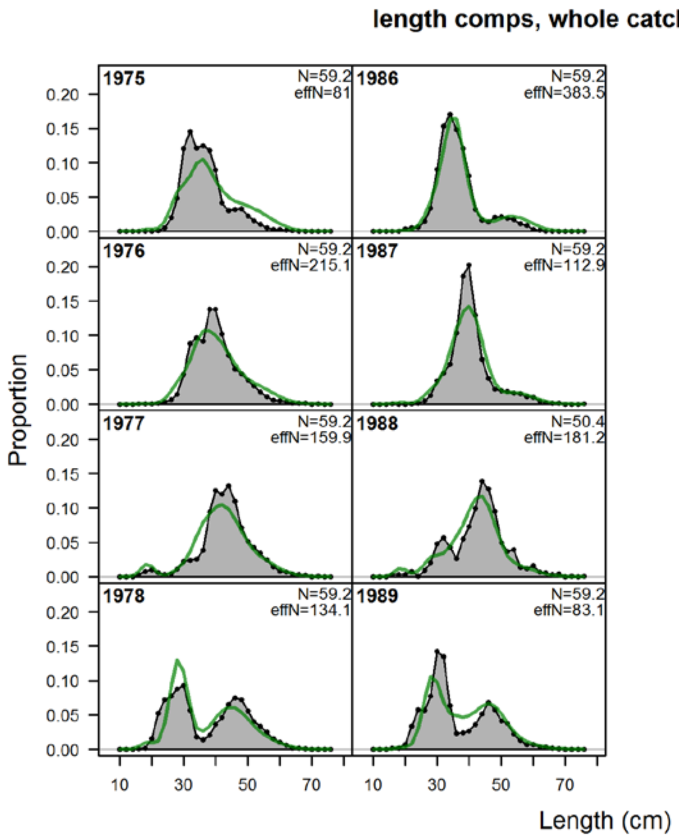
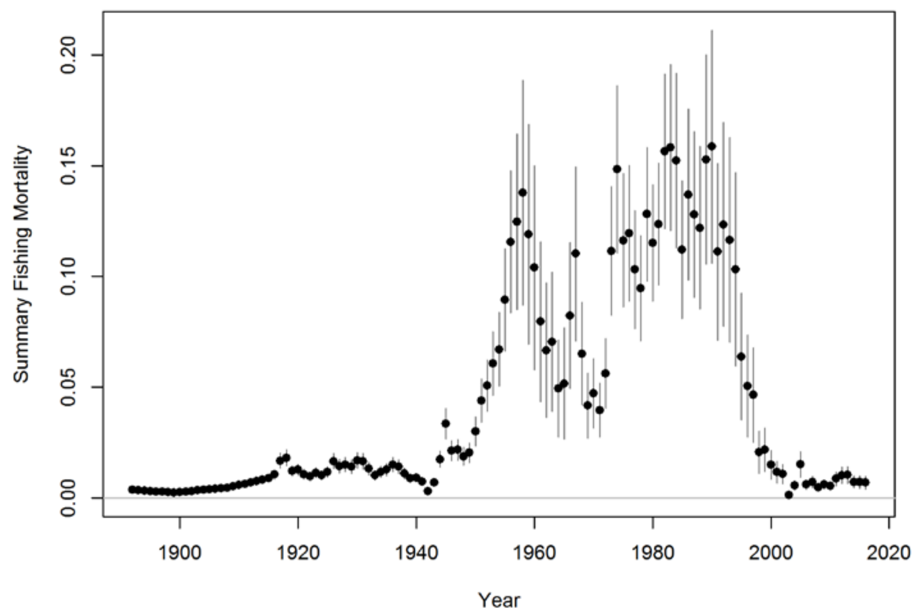


Figure 78. Observed and expected length composition for unsexed fish for the MirrorRecS length data.



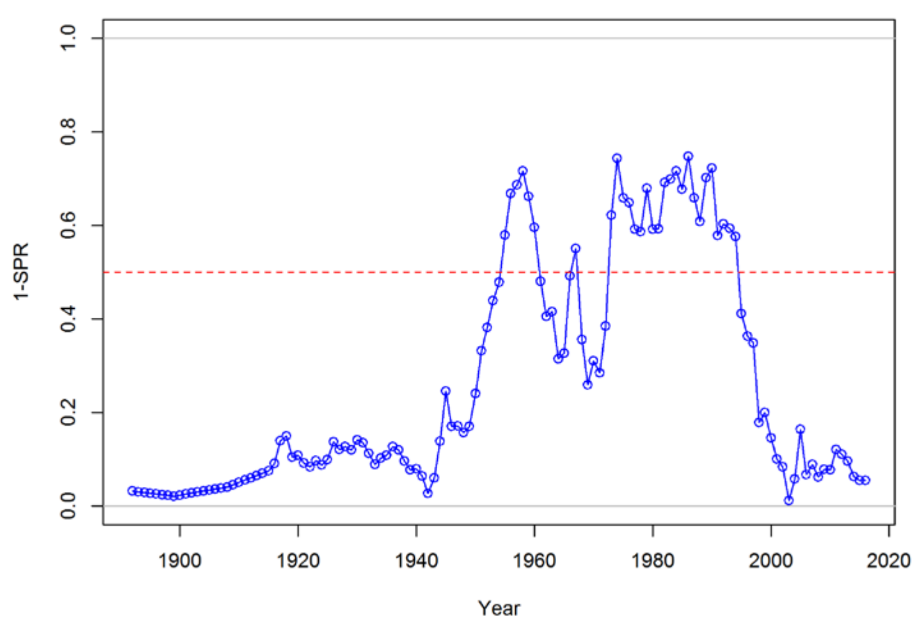


Figure 79. Estimated time series of total fishing mortality (top) and 1-SPR (bottom).

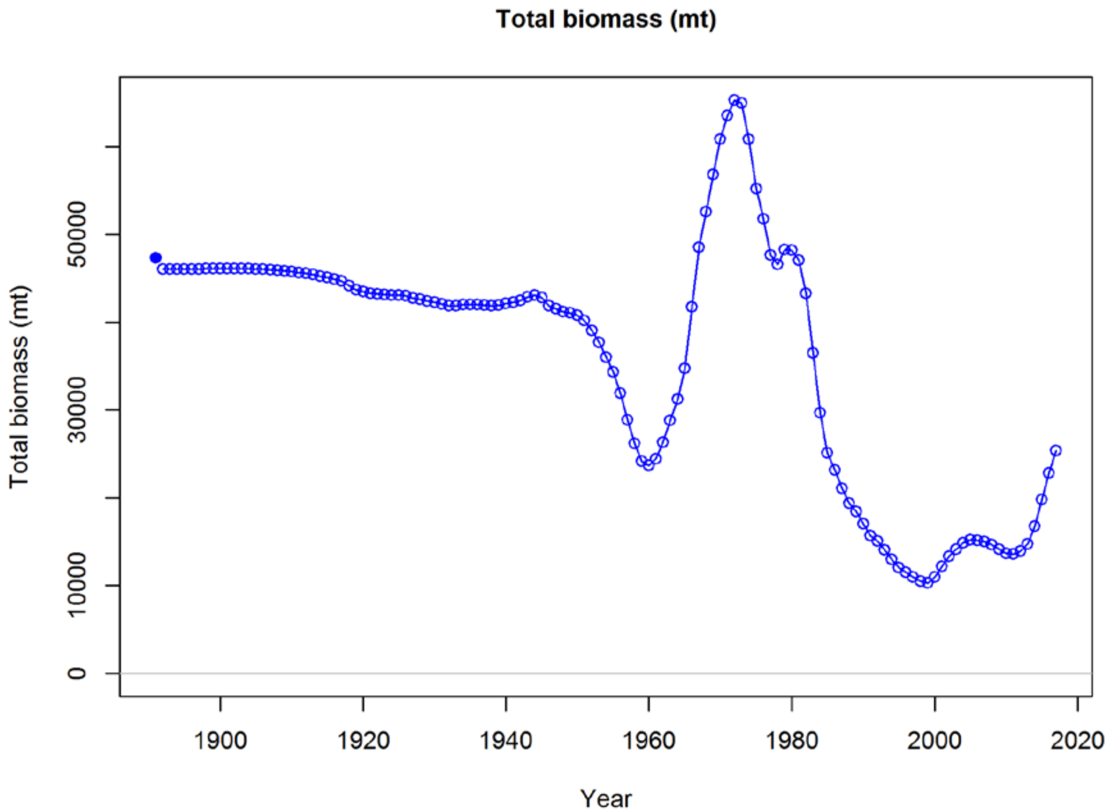


Figure 80. Estimated total biomass (defined as biomass for all fish age 1 and older).

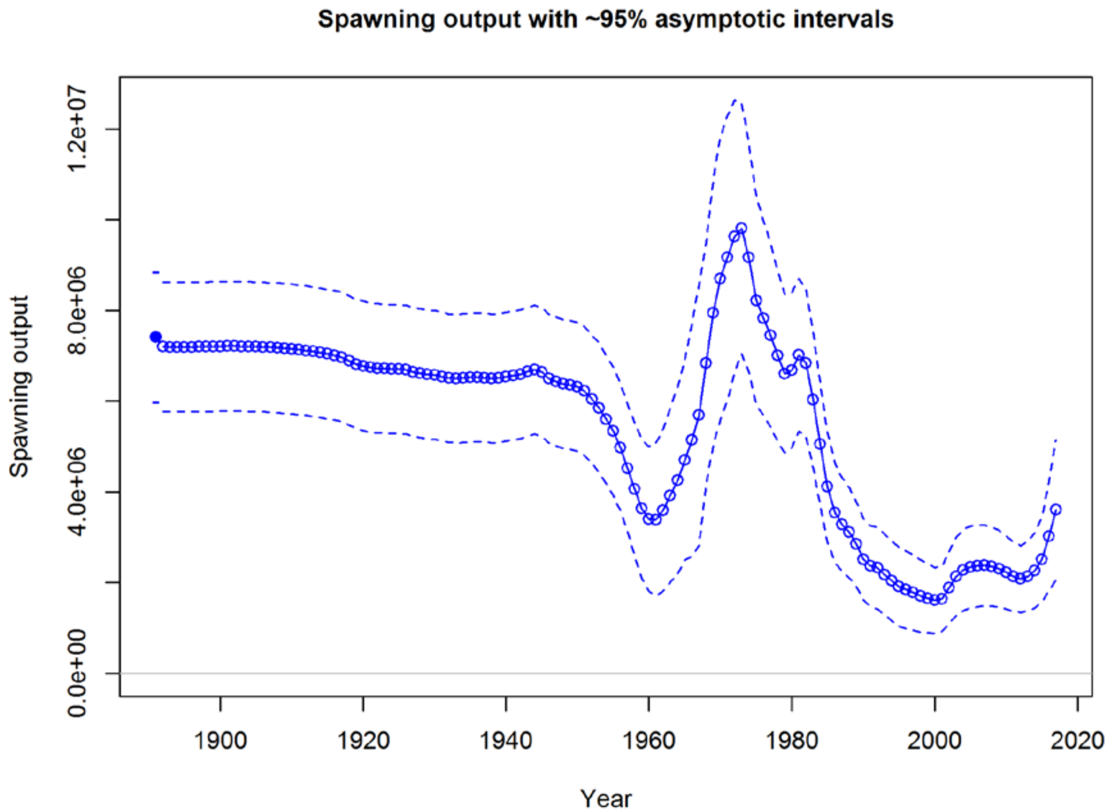


Figure 81. Estimated spawning output (10^3 larvae) with 95% confident intervals.

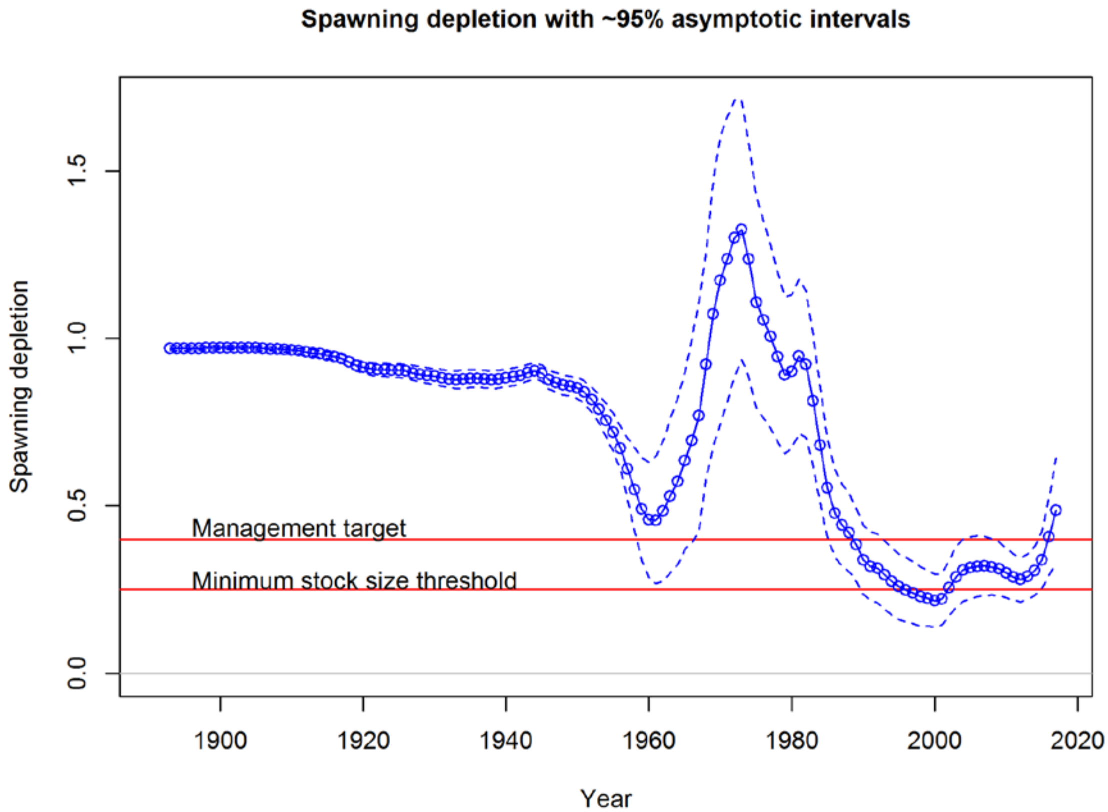


Figure 82. Estimated stock depletion with 95% asymptotic intervals.

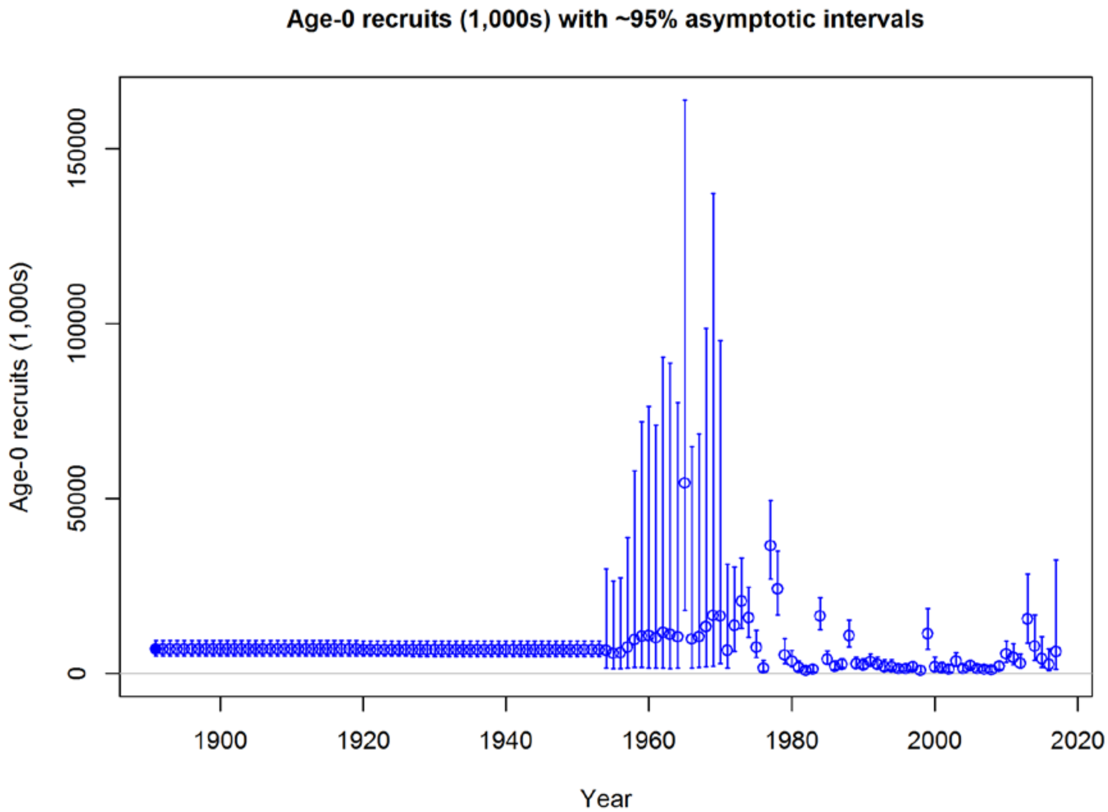


Figure 83. Estimated annual recruits with 95% asymptotic intervals.

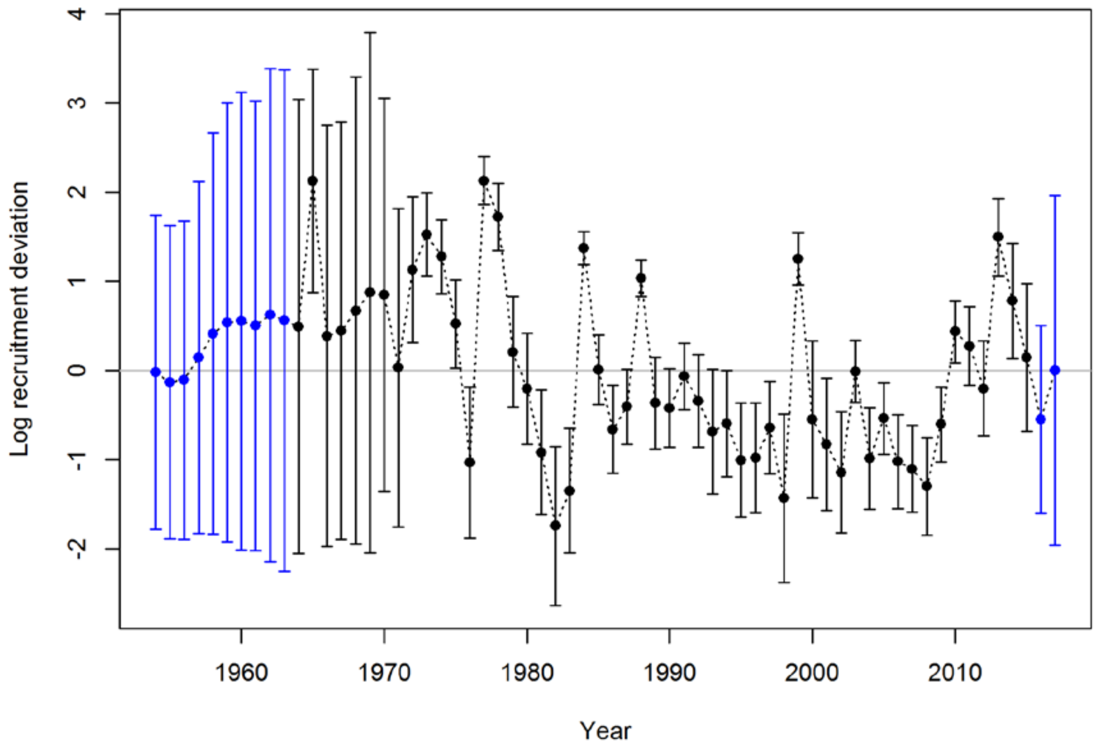


Figure 84. Estimated annual recruitment deviations (dots) and 95% confidence intervals for main recruitment deviation time period (black) and the early and late recruitment deviation time periods (blue).

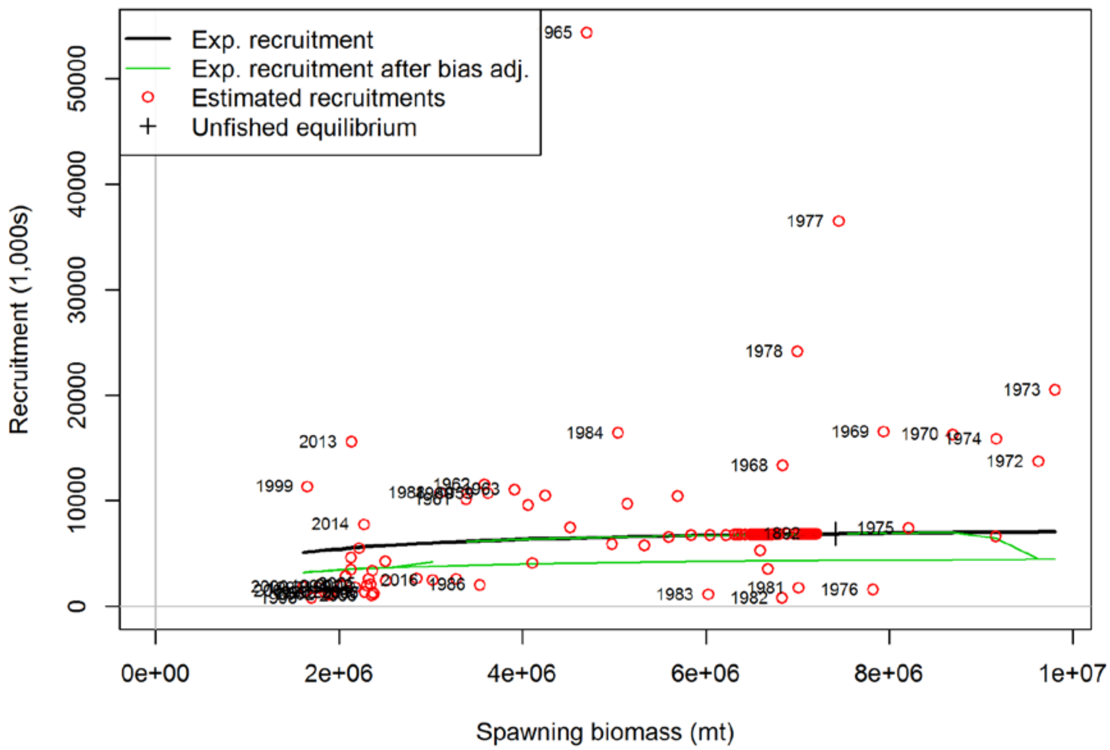


Figure 85. Estimated stock-recruitments relationship. Note that the label for x-axis should be "Spawning output".

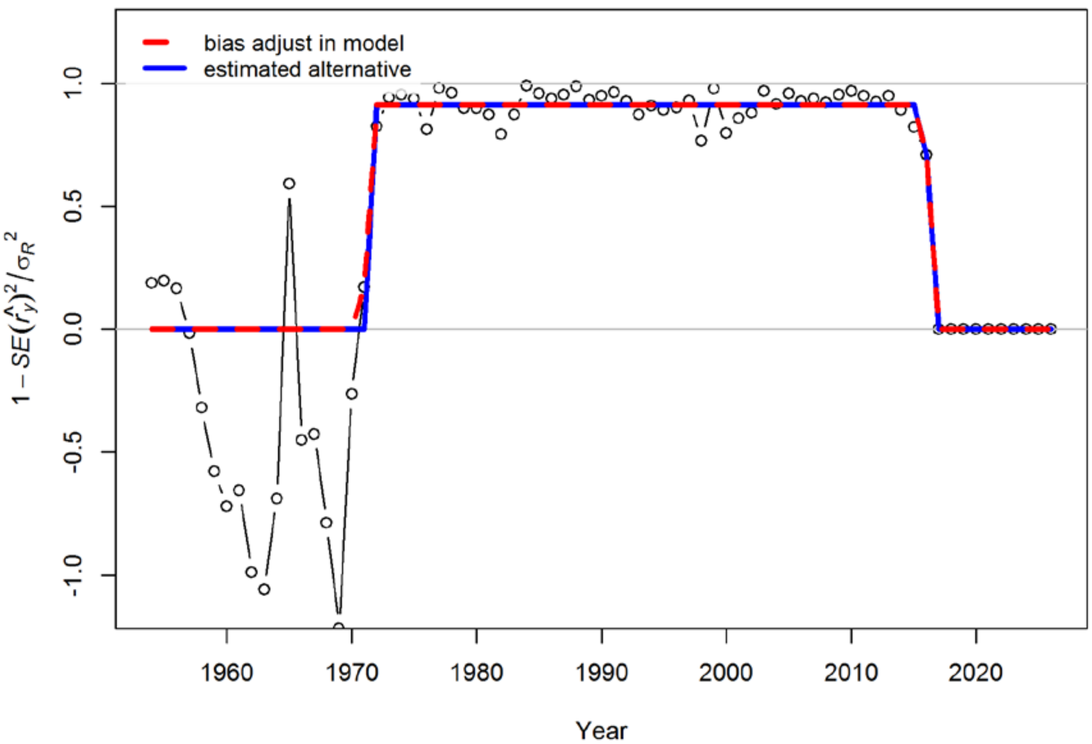


Figure 86. Estimated time series of recruitment bias adjustments showing that bias adjustments used in the base model are similar to those calculated using the method provided by Methot and Taylor (2011).

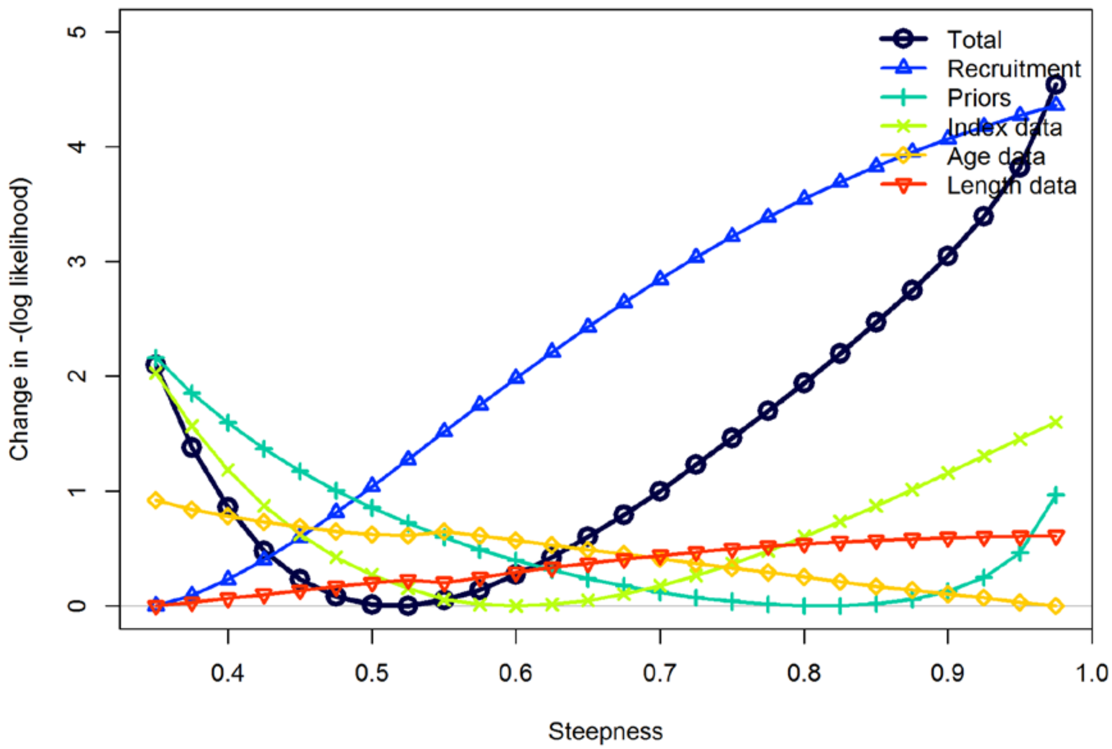


Figure 87. Likelihood profile for total and each data component at different values of steepness parameter.

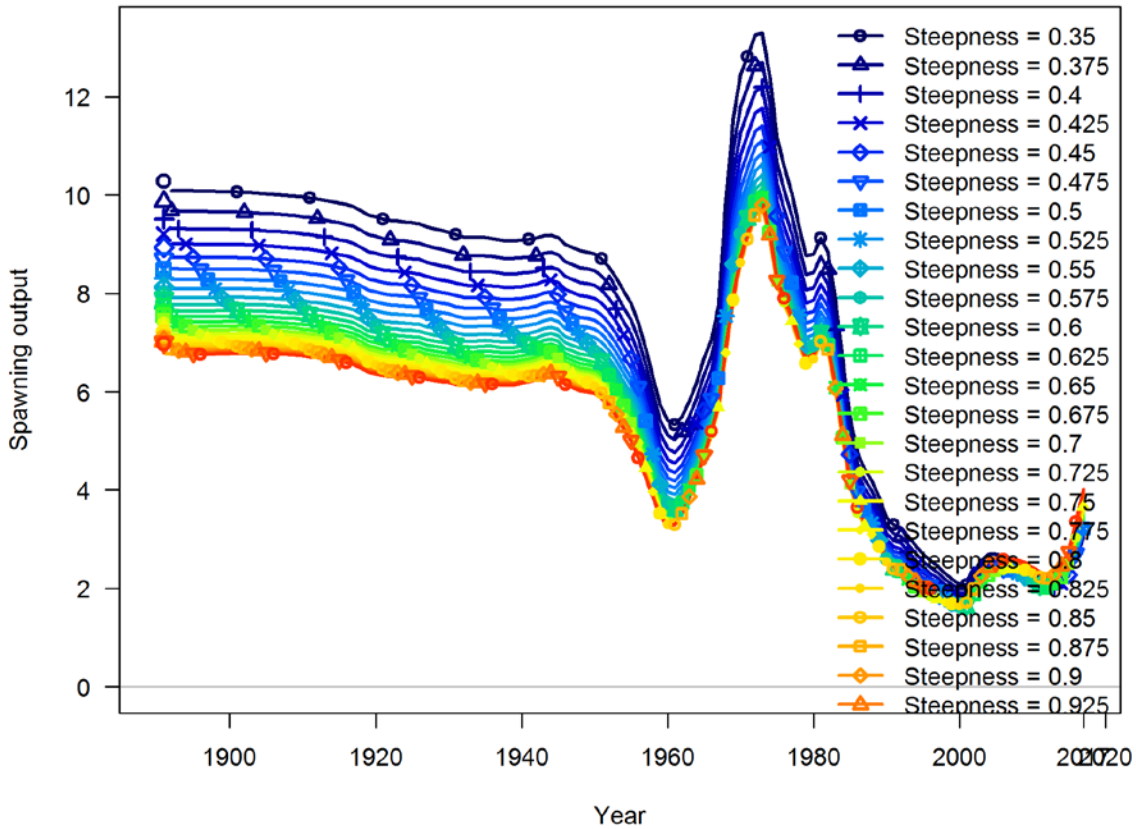


Figure 88. Time series of spawning outputs (billions of larvae) at different values of steepness parameter.

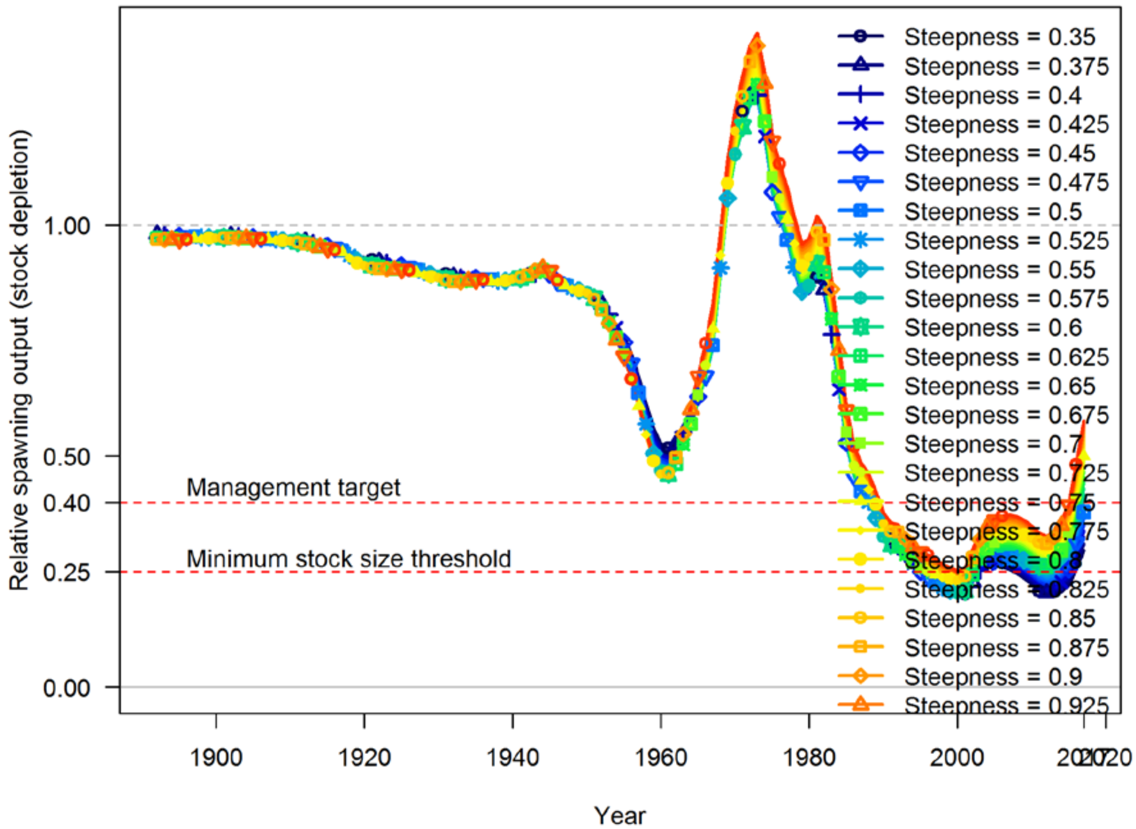


Figure 89. Time series of stock depletion at different values of steepness parameter.

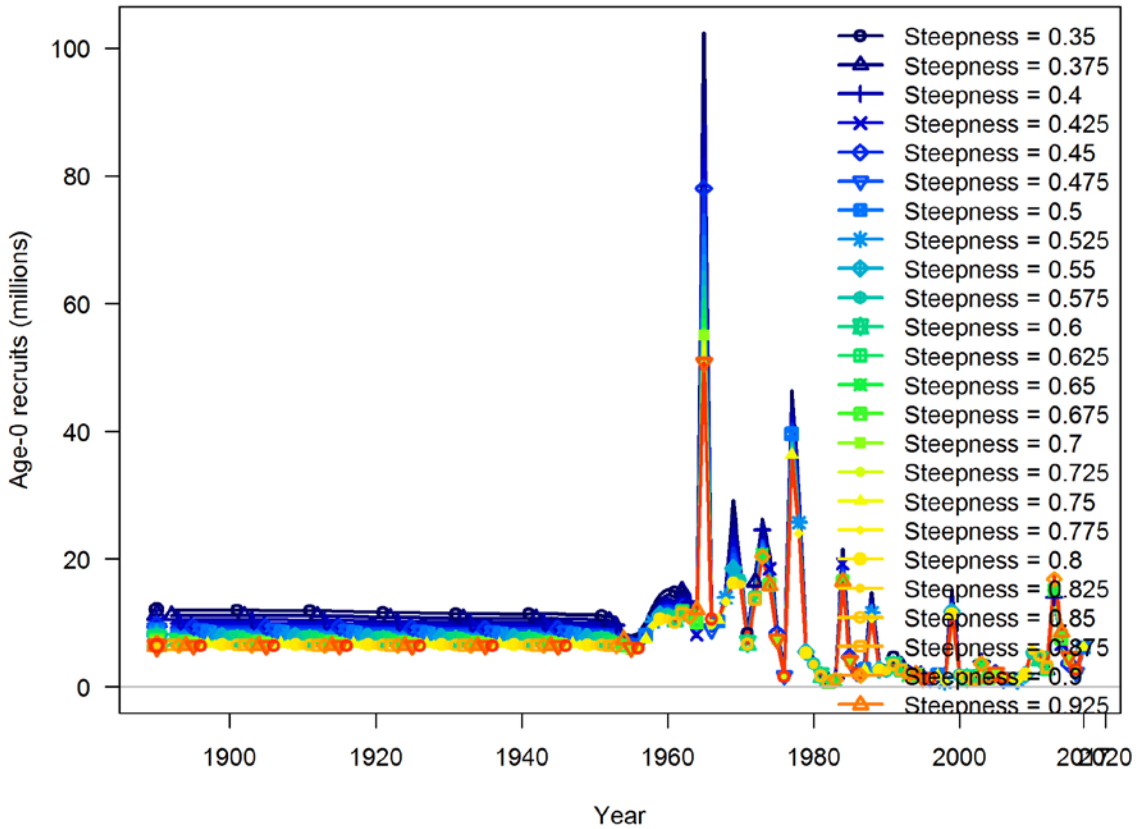


Figure 90. Time series of recruitment at different values of steepness parameter.

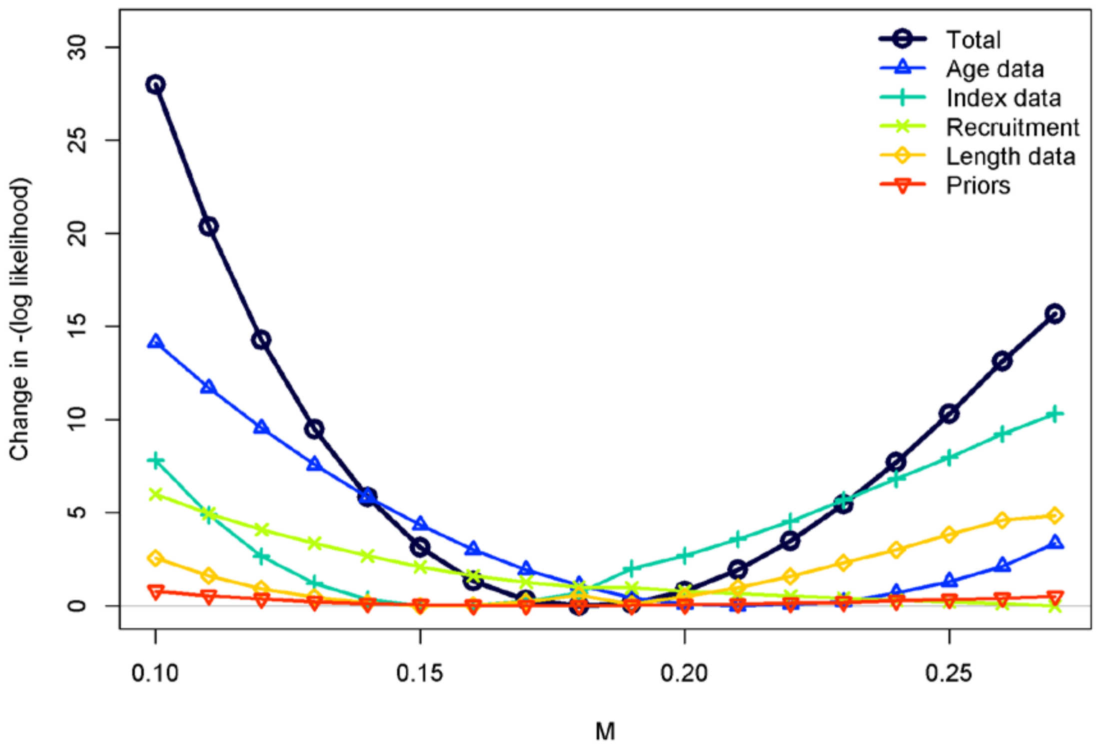


Figure 91. Likelihood profile for total and each data component at different values of female natural mortality parameter.

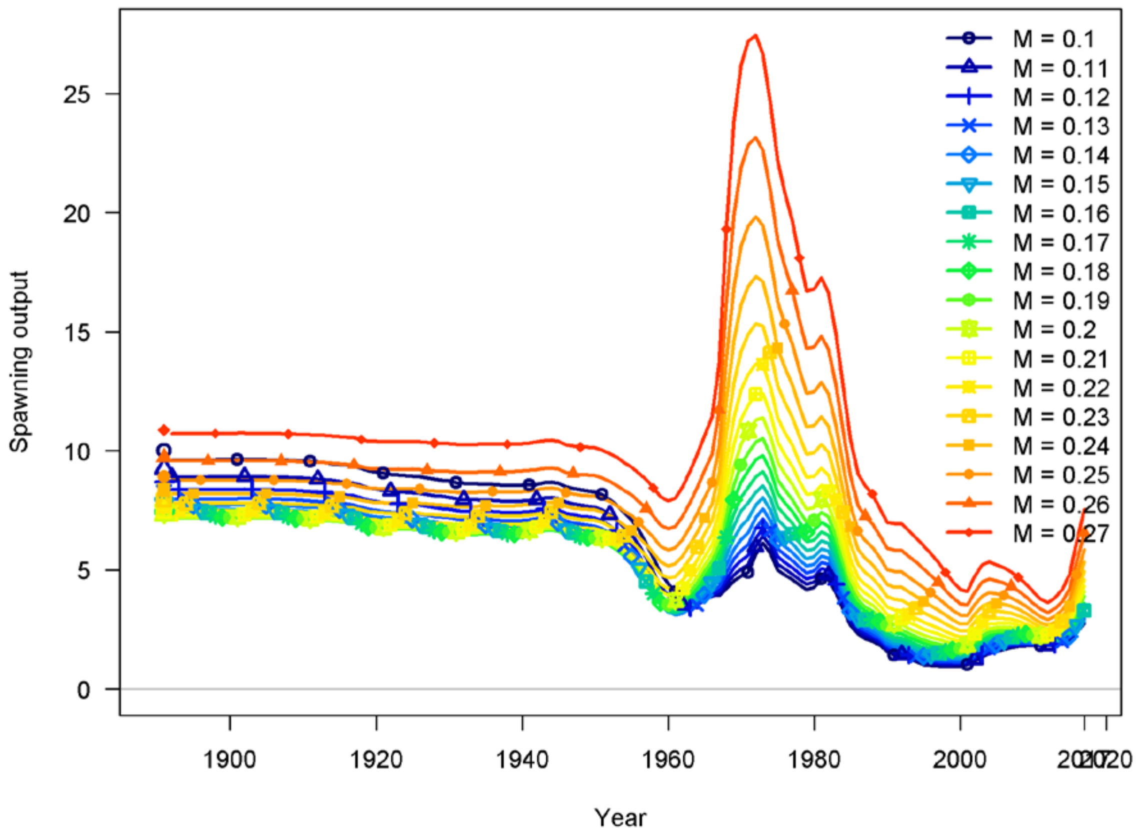


Figure 92. Time series of spawning outputs (billions of larvae) at different values of female natural mortality parameter.

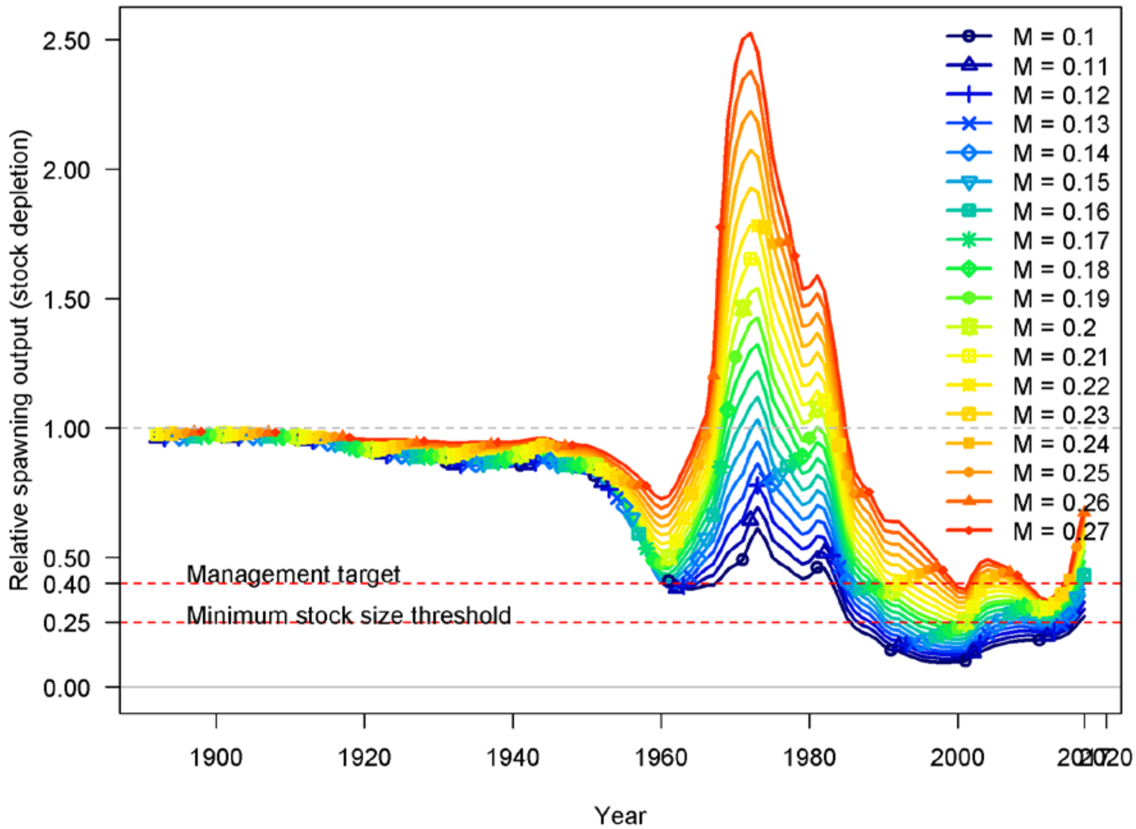


Figure 93. Time series of stock depletion (relative spawning biomass) at different values of female natural mortality parameter.

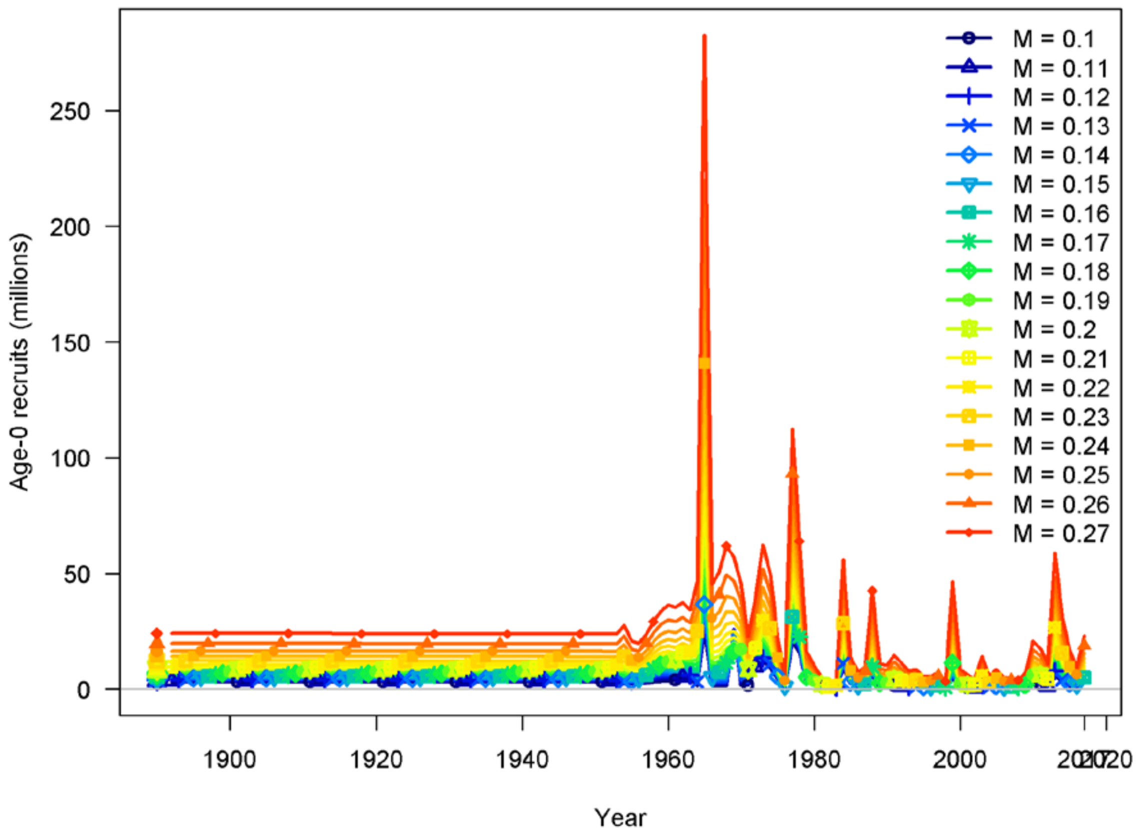


Figure 94. Time series of recruitment at different values of female natural mortality parameter.

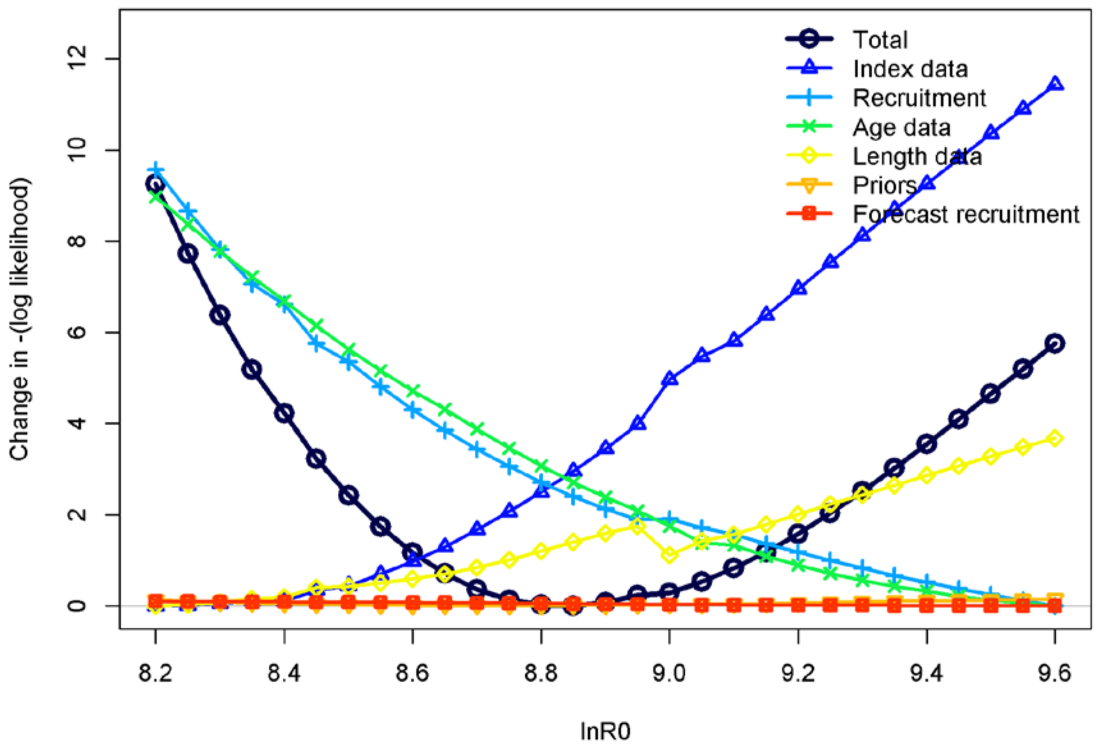


Figure 95. Likelihood profile for total and each data component at different values of logarithms virgin recruitment parameter.

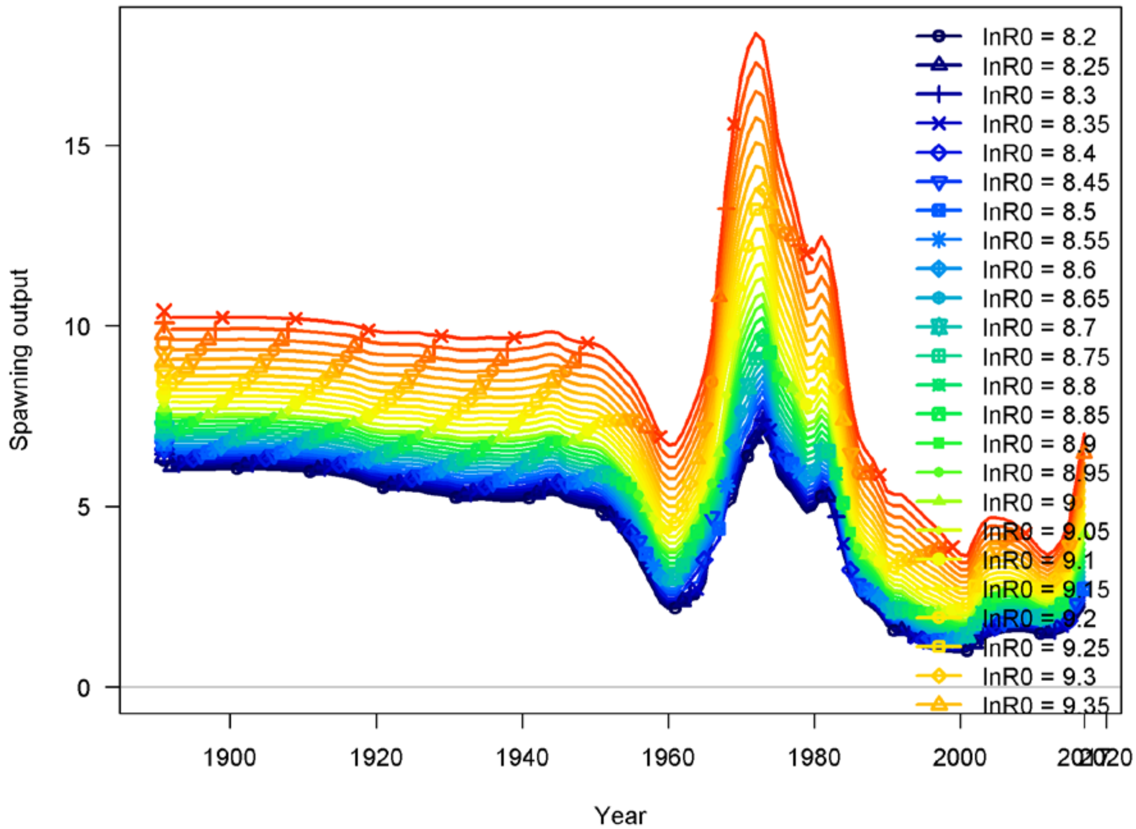


Figure 96. Time series of spawning outputs (billions of larvae) at different values of logarithms virgin recruitment parameter.

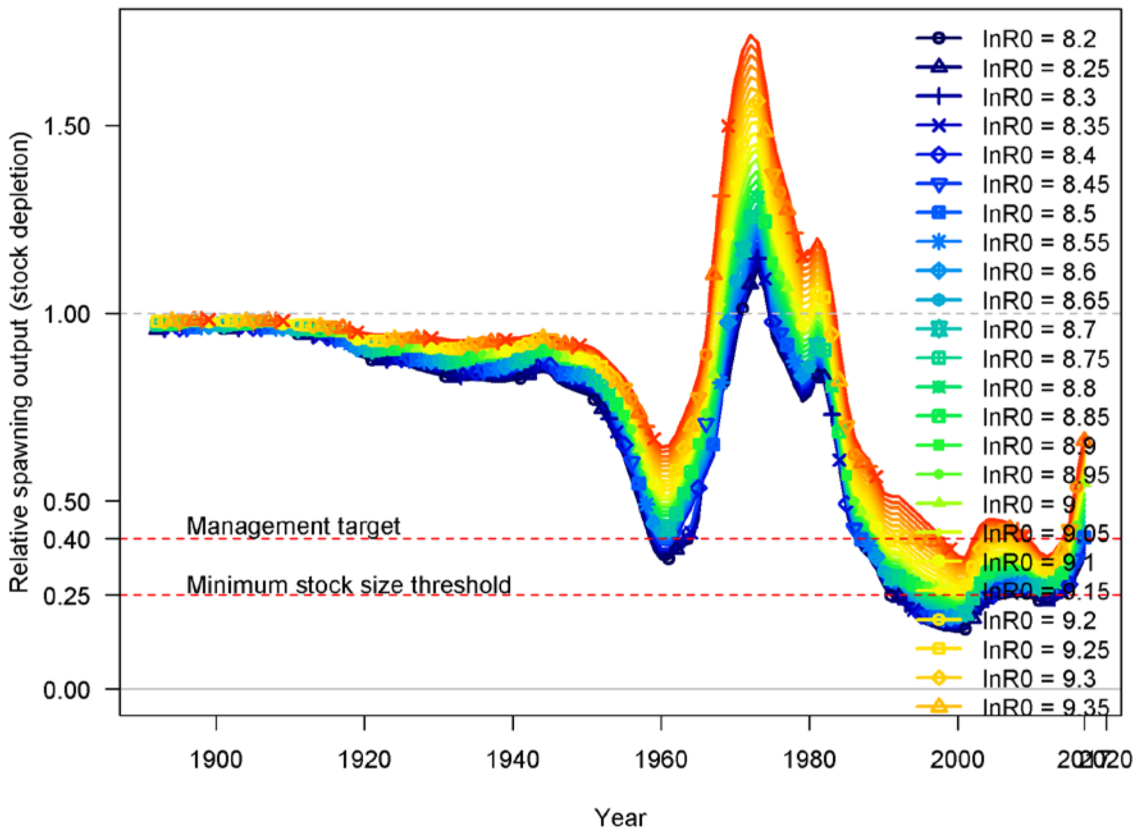


Figure 97. Time series of stock depletion (relative spawning biomass) at different values of logarithms virgin recruitment parameter.

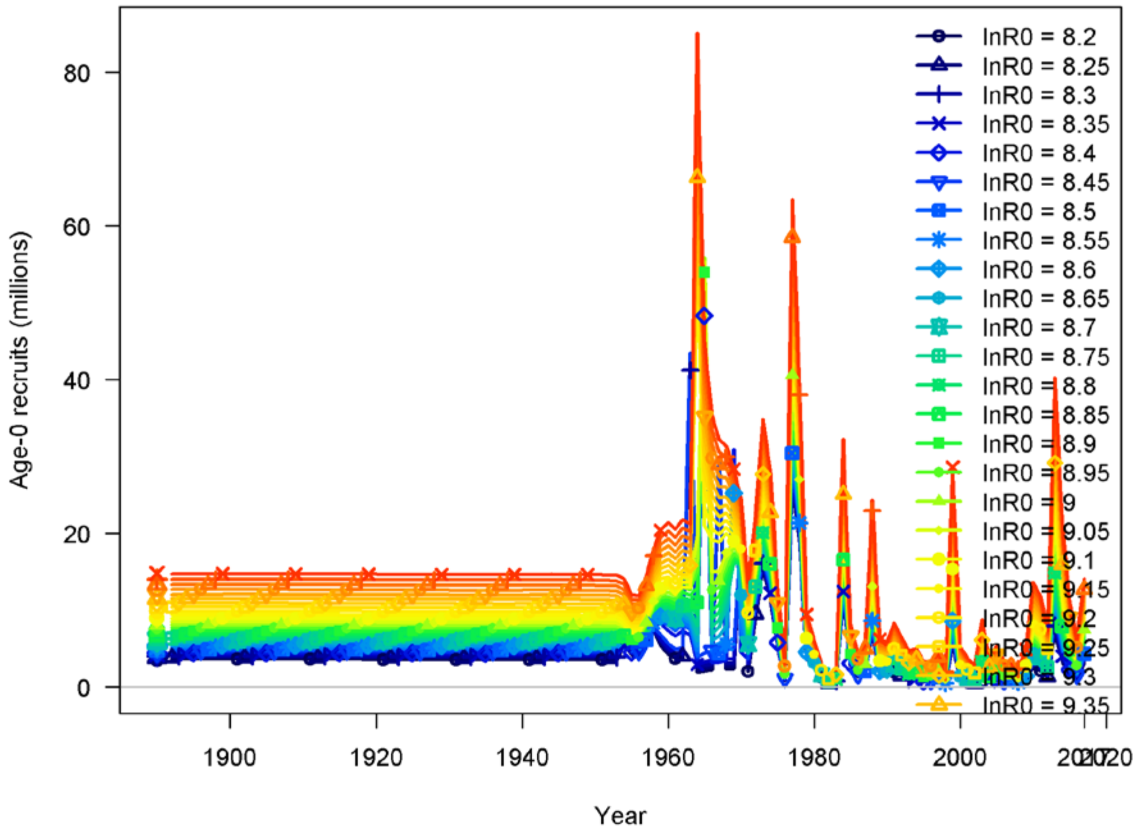


Figure 98. Time series of recruitment at different values of logarithms virgin recruitment parameter.

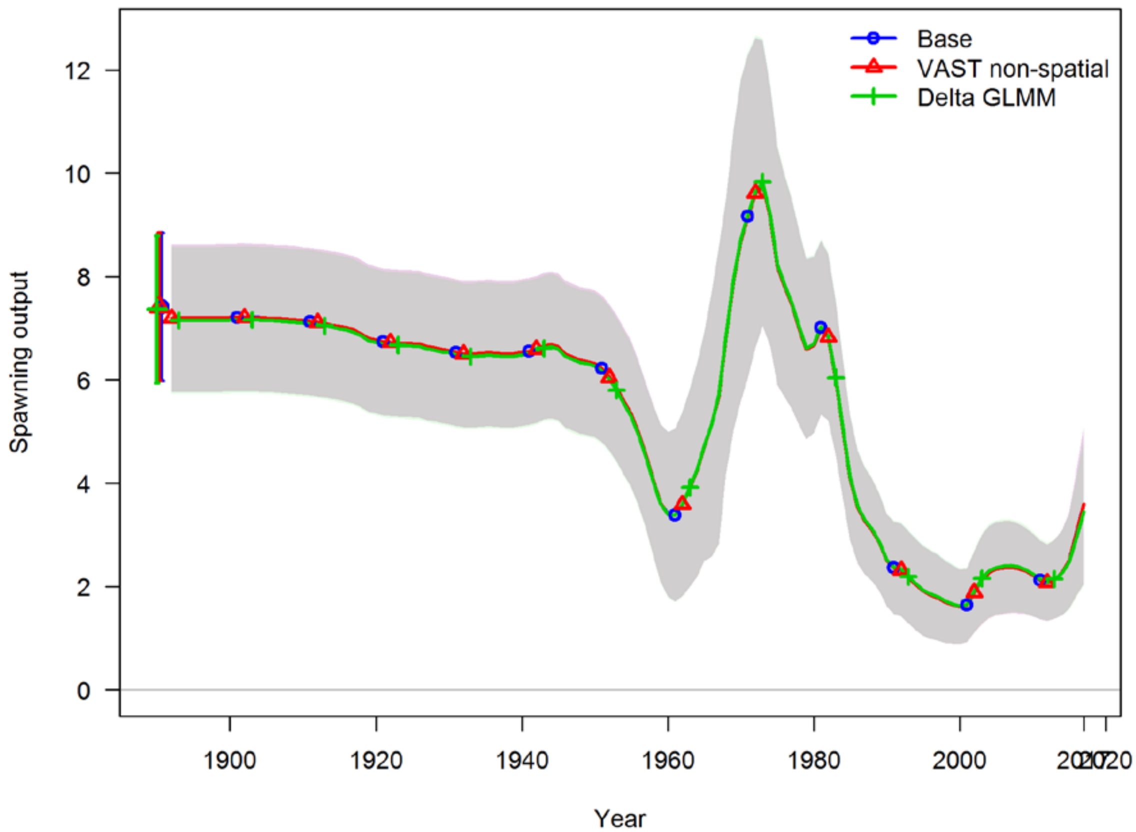


Figure 99. Time series of spawning outputs (billions of larvae) and their 95 percentiles for model runs with three different NWFSC bottom trawl survey indices.

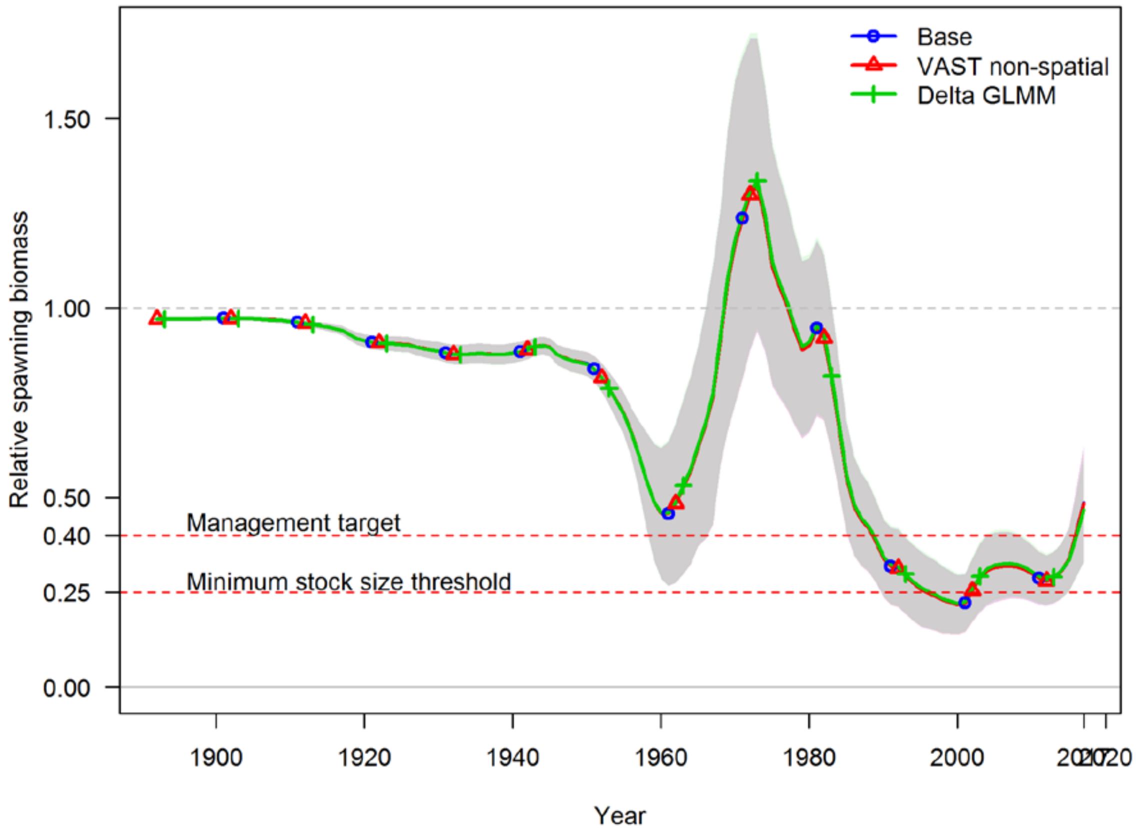


Figure 100. Time series of stock depletion and their 95 percentiles for model runs with three different NWFSC bottom trawl survey indices.

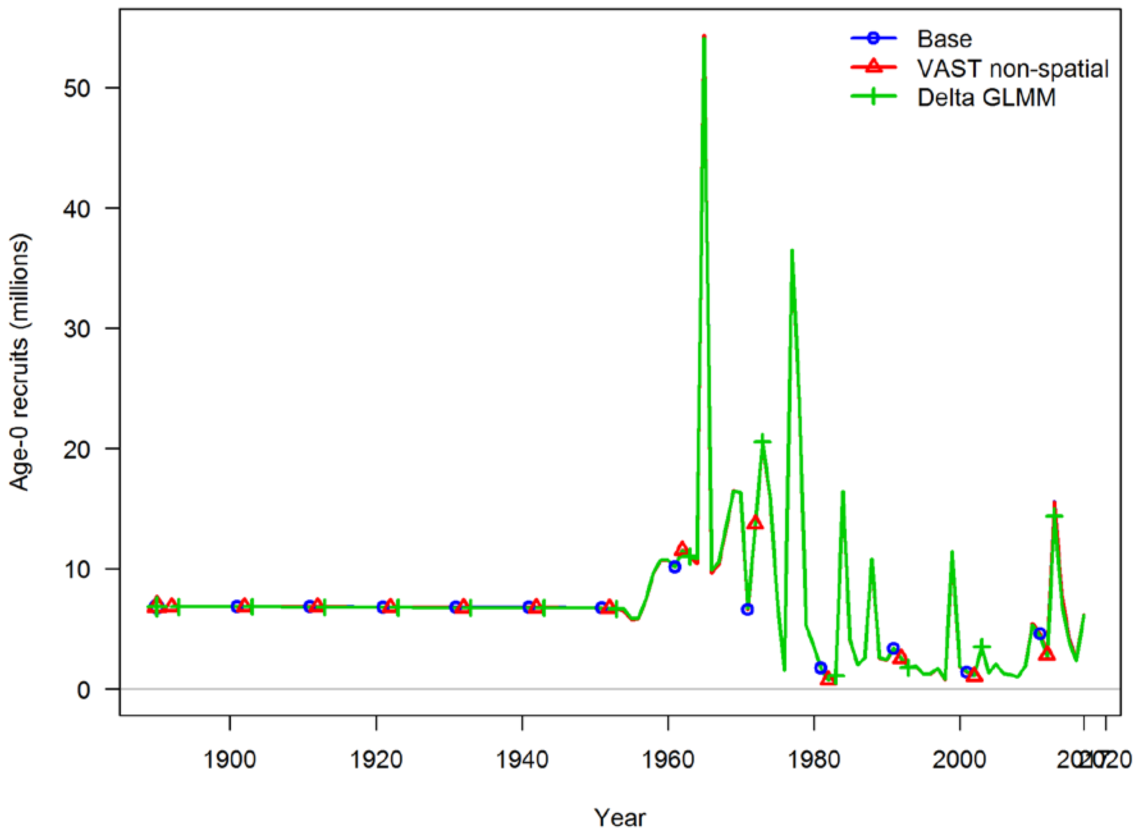


Figure 101. Time series of stock recruitments for model runs with three different NWFSC bottom trawl survey indices.

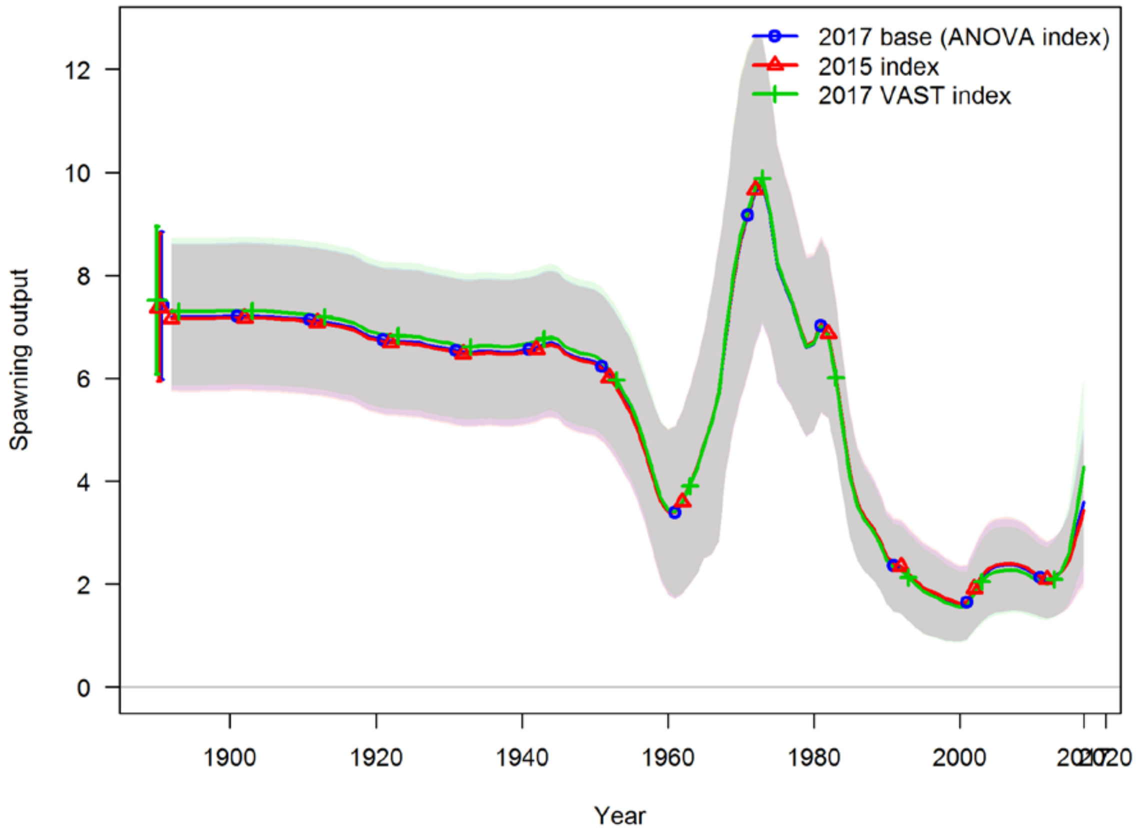


Figure 102. Time series of spawning outputs (billions of larvae) and their 95 percentiles for model runs with three different juvenile survey indices.

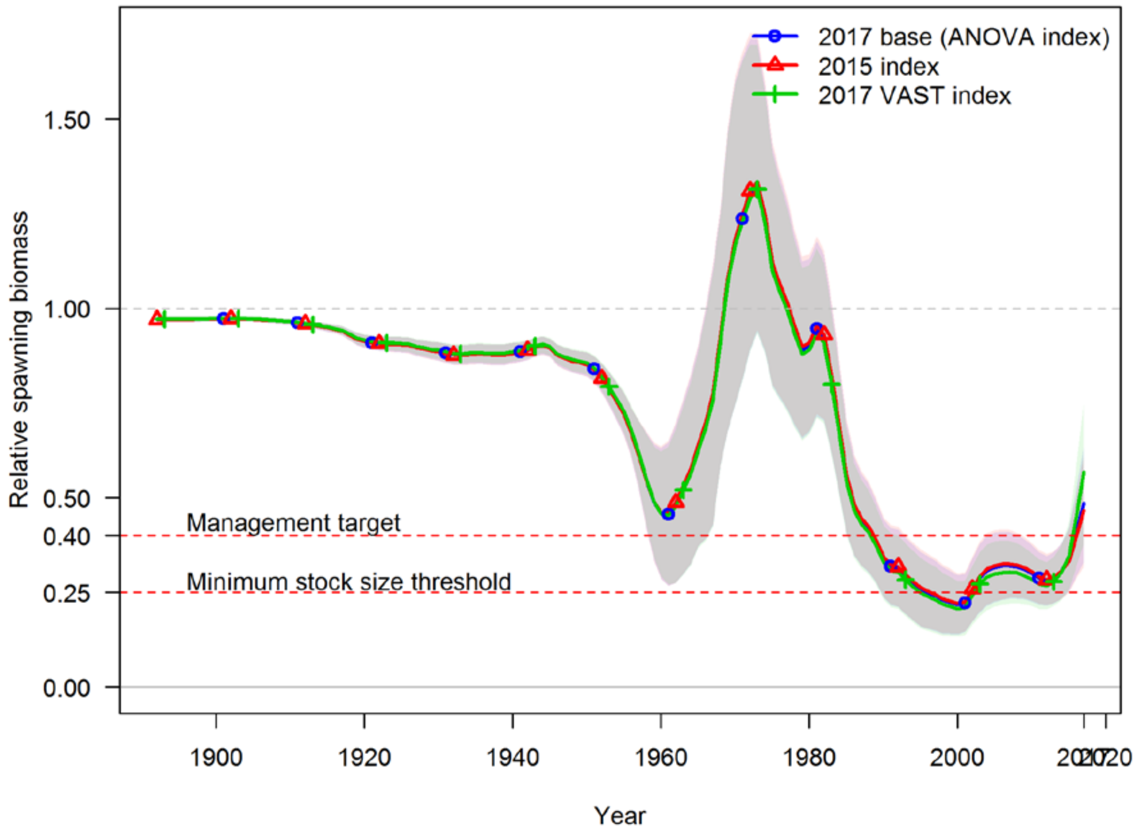


Figure 103. Time series of stock depletion and their 95 percentiles for model runs with three different juvenile survey indices.

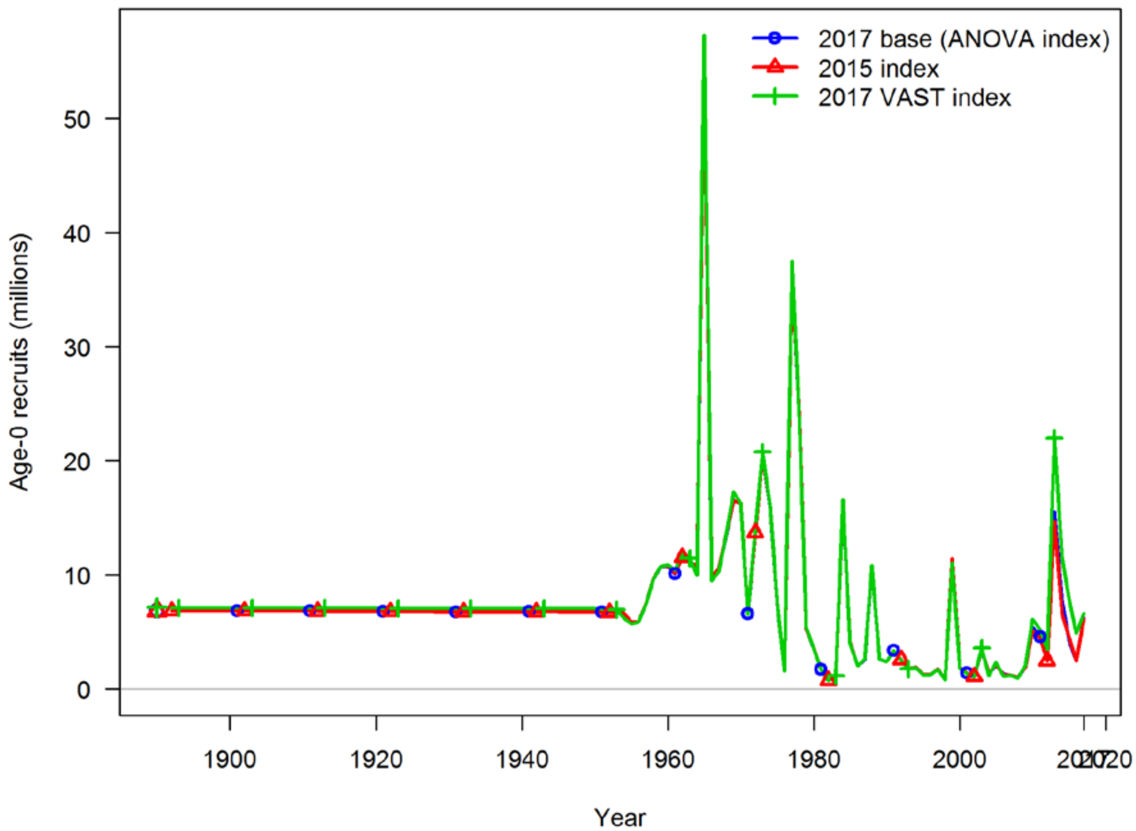


Figure 104. Time series of stock recruitments for model runs with three different juvenile survey indices.

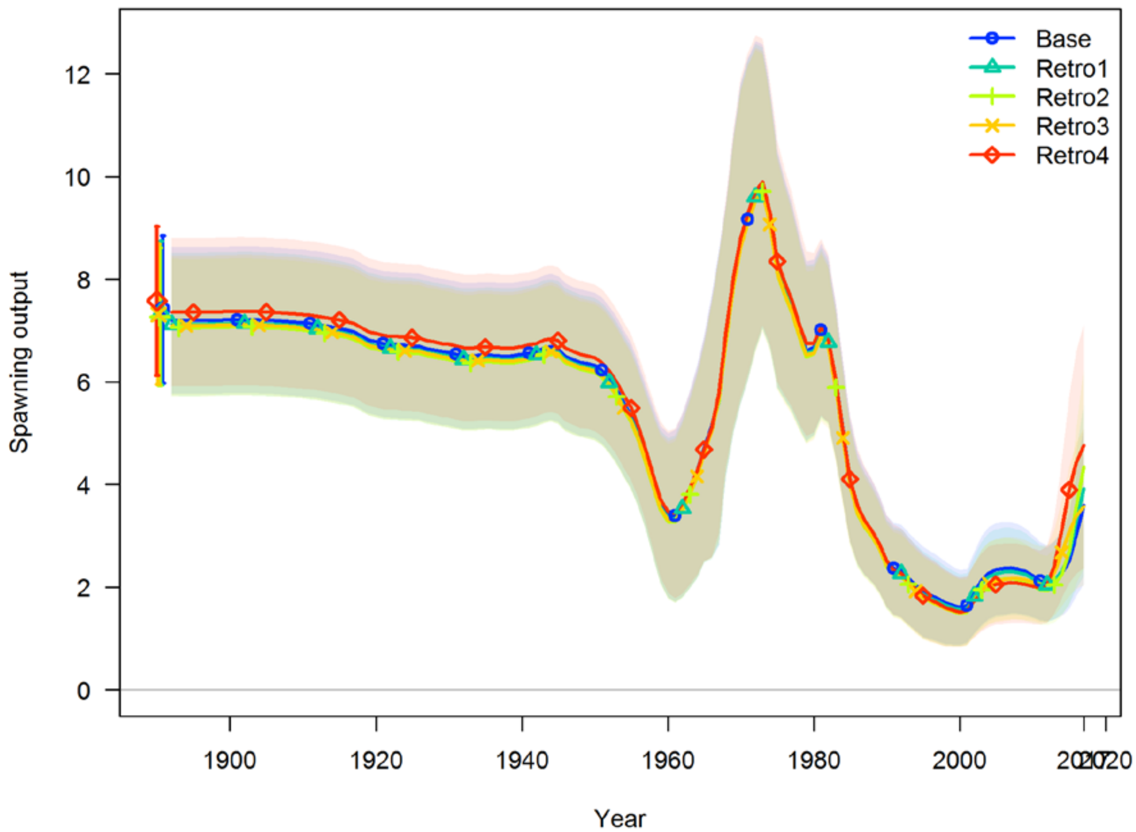


Figure 105. Time series of spawning outputs (billions of larvae) their 95 percentiles from retrospective analysis to four less years of data. In each of retrospective run, data from specified year (or years) are not used with all other model structures unchanged. Stock status from those year(s) without data are computed as they are "forecast" year(s).

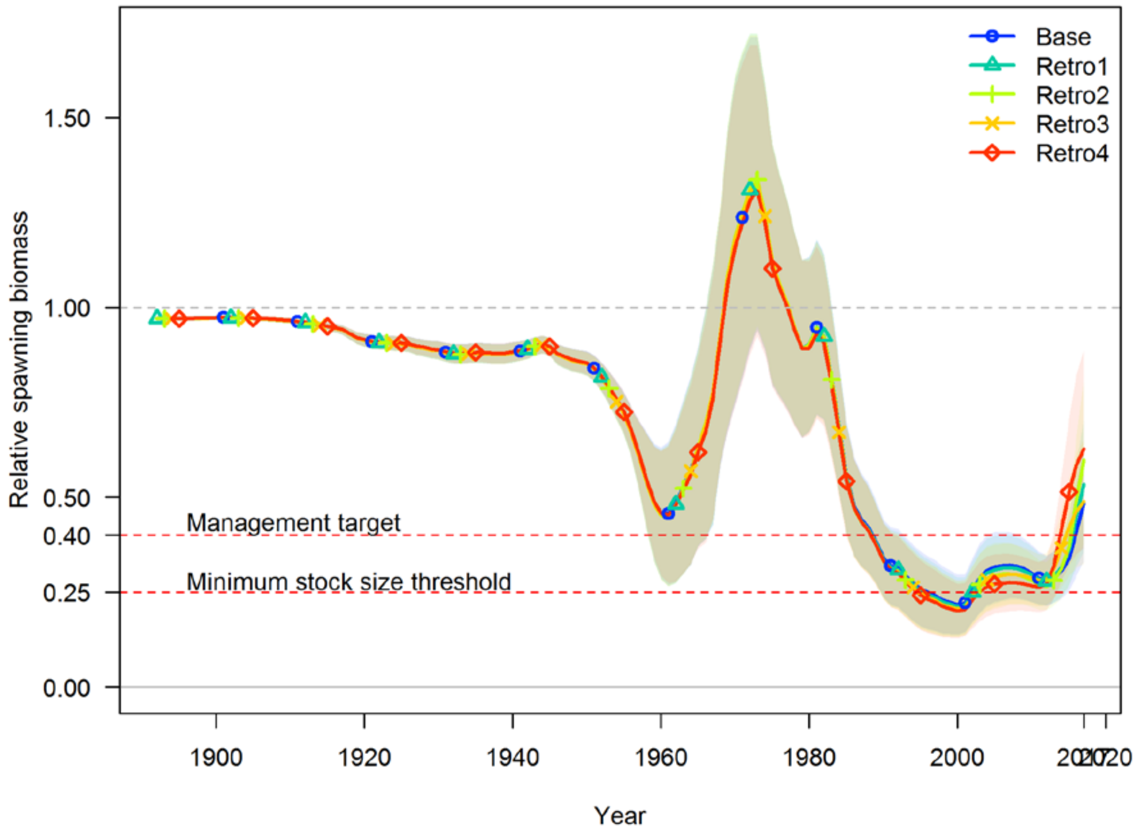


Figure 106. Time series of stock depletion (relative spawning biomass) and their 95 percentiles from retrospective analysis to four less years of data. In each of retrospective run, data from specified year (or years) are not used with all other model structures unchanged. Stock status from those year(s) without data are computed as they are "forecast" year(s).

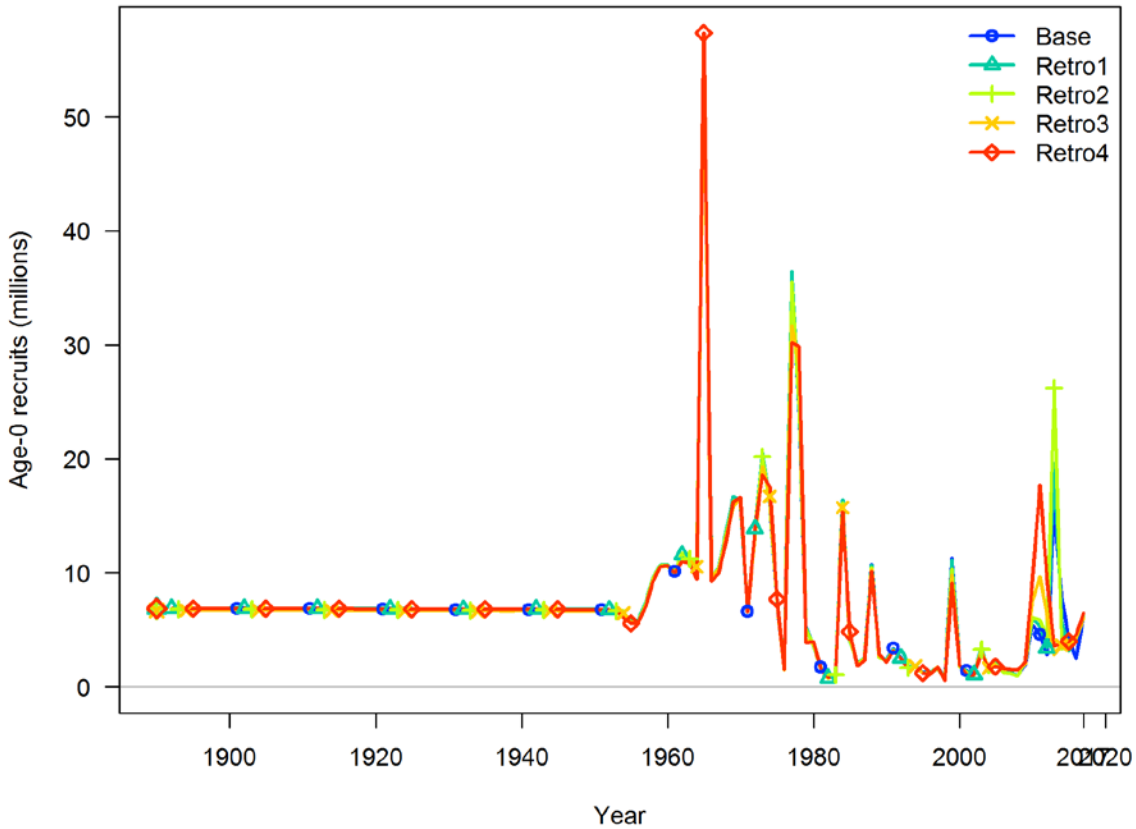
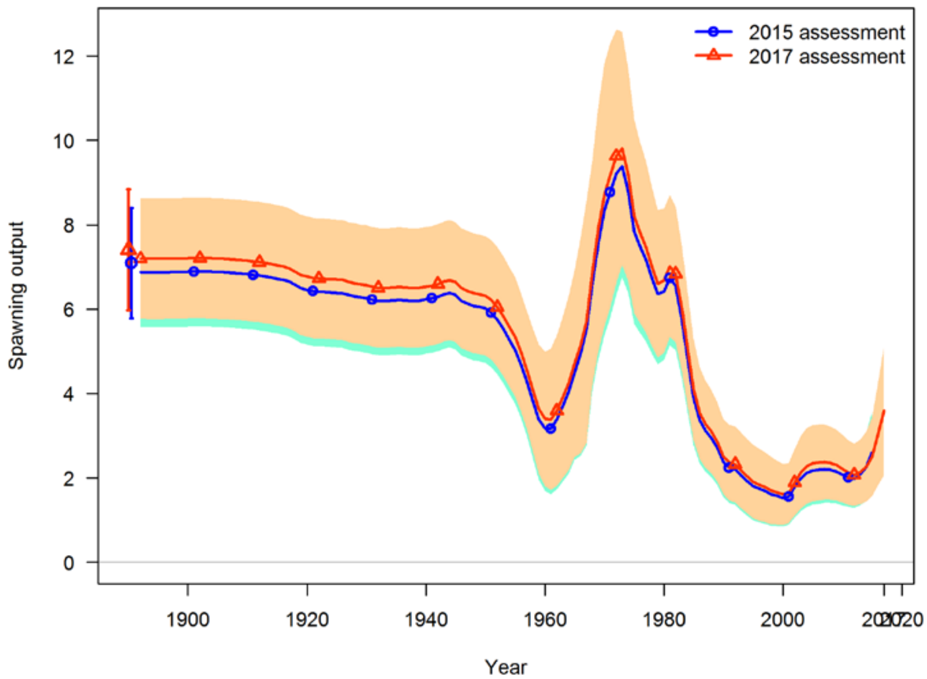


Figure 107. Time series of recruitment from retrospective analysis to four less years of data. In each of retrospective run, data from specified year (or years) are not used with all other model structures unchanged. Stock status from those year(s) without data are computed as they are "forecast" year(s).



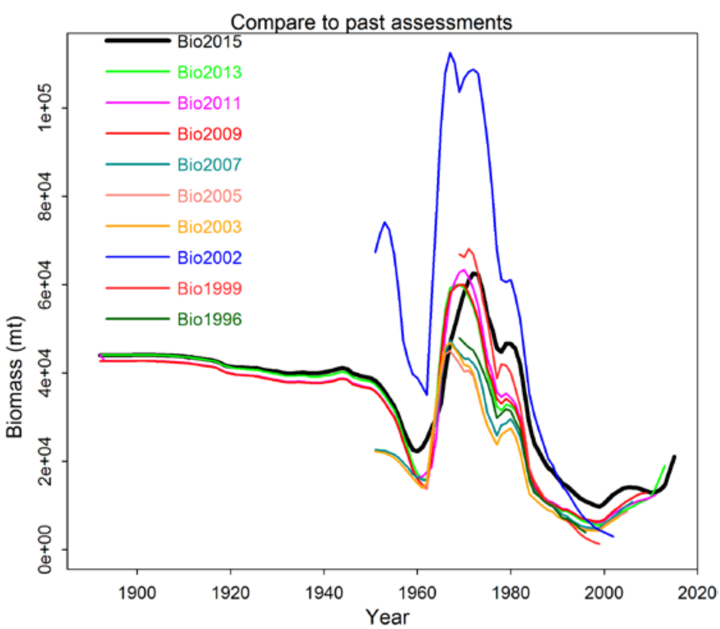


Figure 108. Comparisons of time series of spawning output with 2015 stock assessments (top panel). For reference, comparisons of spawning biomass among all previous assessments are also plotted (bottom panel).

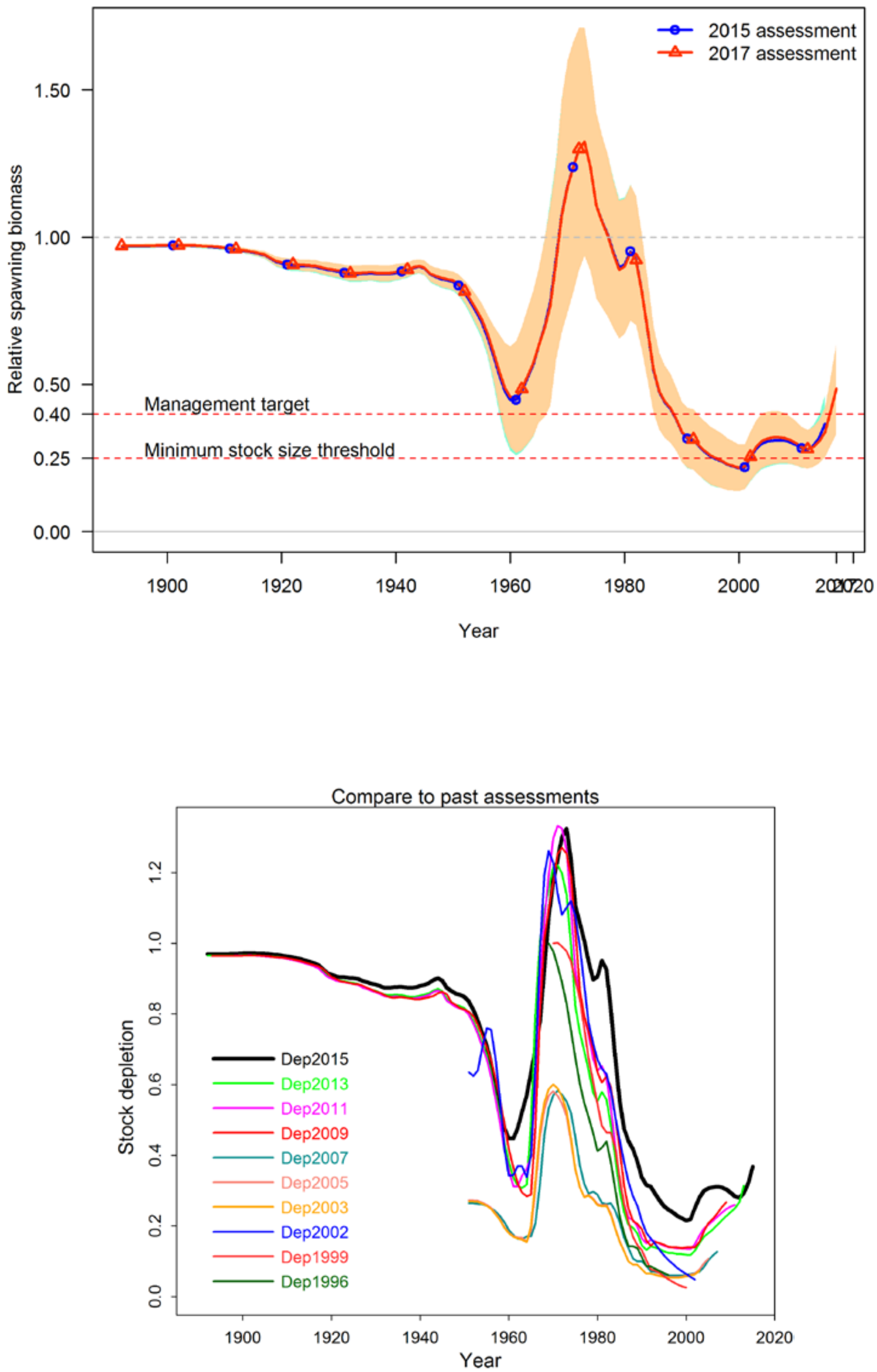


Figure 109. Comparisons of time series of stock depletion with 2015 stock assessments (top panel). For reference, comparisons of stock depletion among all previous assessments are also plotted (bottom panel).

Appendix A. History of Management Measures Affecting the Bocaccio Fishery

This table is downloaded from the fishery regulation website and contains all regulations related to Bocaccio from south of Cape Blanco (provided by John DeVore of the PFMC)

Regulation date	Location ID	Regulation
9/10/1983	4300 South	Continued 40,000-pound trip limit on Sebastes complex south of 43N latitude; no limit on number of trips.
1/1/1984	4300 South	Continued 40,000-pound trip limit on Sebastes complex south of 4300 (changed to 4250 on February, 12, 1984); no limit on trip frequency.
5/6/1984	ALL	Specified that fishing for groundfish on a Sebastes complex trip may occur on only one side of Cape Blanco (4250), which allows southern caught fish to be landed north of Cape Blanco using the southern trip limit of 40,000 pounds with appropriate declaration of intent.
5/6/1984	Eureka Monterey Conception	Recommended no change in Sebastes complex trip limit of 40,000 pounds in the Eureka, Monterey, and Conception areas.
8/1/1984	ALL	Vessel operators on combined groundfish/Sebastes complex trips allowed to fish on both sides of a line at 4250 N latitude (Cape Blanco), but landings of Sebastes complex in excess of 3,000 pounds controlled by the trip limit/trip frequency in effect north of the line (Vancouver and Columbia areas). Appropriate advance declaration of intent required.
1/10/1985	ALL	If fishers fish on both sides of the Cape Blanco line during a trip, the northern limit on Sebastes complex applies.
1/10/1985	ALL	Landings of Sebastes complex and widow rockfish smaller than 3,000 pounds unrestricted.
1/10/1985	Cape Blanco South	For Sebastes complex south of Cape Blanco, established a 40,000-pound trip limit without a trip frequency.
9/1/1985	ALL	Changed the management boundary line separating northern and southern trip limits for the Sebastes complex from Cape Blanco (4250' N latitude) northward 30 miles to the north jetty at Coos Bay (4322' N latitude).
1/1/1986	ALL	For Sebastes complex north of Coos Bay, established 25,000-pound weekly trip limit of which no more than 10,000 pounds may be yellowtail rockfish (or 50,000

Regulation date	Location ID	Regulation
		pounds biweekly of which no more than 20,000 pounds may be yellowtail rockfish, or 12,500 pounds twice per week of which no more than 5,000 pounds may be yellowtail rockfish; biweekly and twice weekly landings require appropriate declaration to state in which fish are landed). For Sebastes complex south of Coos Bay, established 40,000-pound trip limit; no trip frequency. Landings of less than 3,000 pounds of Sebastes complex and widow rockfish unrestricted. Fishers fishing the Sebastes complex on both sides of the Coos Bay line during a trip must conform with the northern (more restrictive) trip limit.
1/1/1987	Coos Bay South	For Sebastes complex south of Coos Bay, established 40,000-pound trip limit; no trip frequency limit.
5/3/1987	ALL	Changed the definition of fishing week from Sunday through Saturday to Wednesday through Tuesday for Sebastes complex and widow rockfish.
1/1/1988	ALL	For Sebastes complex north of Coos Bay, established a 25,000-pound weekly trip limit of which no more than 10,000 pounds may be yellowtail rockfish (or 50,000 pounds biweekly of which no more than 20,000 pounds may be yellowtail rockfish, or 12,500 pounds twice per week, of which no more than 5,000 pounds may be yellowtail rockfish; biweekly and twice weekly landings require appropriate declaration to state in which fish are landed). No restriction on landings less than 3,000 pounds. For Sebastes complex south of Coos Bay, established a 40,000-pound trip limit; no trip frequency restriction.
1/1/1989	Coos Bay South	For Sebastes complex south of Coos Bay, established a 40,000-pound trip limit; no trip frequency restriction.
7/26/1989	ALL	Reduced the trip limit for yellowtail rockfish to 3,000 pounds or 20% of the Sebastes complex, whichever is greater.
1/1/1990	Coos Bay South	For Sebastes complex south of Coos Bay, established the trip limit at 40,000 pound; no trip frequency restriction.
7/25/1990	ALL	Reduced the weekly trip limit for yellowtail rockfish caught with any gear north of Coos Bay to 3,000 pounds or 20% of the Sebastes complex, whichever is greater. Biweekly and twice weekly landing options remain in effect.
1/1/1991	Coos Bay South	For Sebastes complex south of Coos Bay, the trip limit established at 25,000 pounds, including no more than 5,000 pounds of Bocaccio; no trip frequency

Regulation date	Location ID	Regulation
		restriction; harvest guideline for bocaccio set at 1,100 mt (ABC = 800 mt).
1/1/1992	4030 South	For the Sebastes complex, established a cumulative landing limit per specified 2 week period of 50,000 pounds. Within this 50,000 pounds, no more than no more than 10,000 pounds cumulative may be Bocaccio landed south of Cape Mendocino, California (4030 latitude). All landings count toward the 50,000-pound limit.
1/1/1993	4030 South	For Sebastes complex established a cumulative landing limit per specified 2-week period of 50,000 pounds. Within this 50,000 pounds, no more than 10,000 pounds cumulative may be Bocaccio caught south of Cape Mendocino, California (4030 latitude). All landings count toward the cumulative limits. If a vessel fishes in the more restrictive area at any time during the 2-week period, the more restrictive limit applies for that vessel.
1/1/1993	Cape Mendocino Coos Bay	For Sebastes complex established a cumulative landing limit per specified 2-week period of 50,000 pounds between Cape Mendocino and Coos Bay. All landings count toward the cumulative limits. If a vessel fishes in the more restrictive area at any time during the 2-week period, the more restrictive limit applies for that vessel.
10/6/1993	4030 South	Increased the cumulative trip limit for Bocaccio caught south of Cape Mendocino, California from 10,000 pounds to 15,000 pounds per 2-week period.
1/1/1994	4030 South	For Sebastes complex, Bocaccio and yellowtail, cumulative limit of 80,000 pounds per calendar month, no more than 30,000 pounds may be Bocaccio caught south of Cape Mendocino, California (4030 latitude).
9/1/1994	4030 South	Increased the cumulative trip limit for the Sebastes complex caught south of Cape Mendocino, California (4030 latitude) in the limited entry groundfish fishery from 80,000 pounds to 100,000 pounds per calendar month.
1/1/1995	4030 4530	Cumulative limit for Sebastes Complex of 50,000 pounds per month between Cape Lookout and Cape Mendocino, California (4030 latitude), no more than 30,000 pounds may be yellowtail rockfish
1/1/1995	4030 South	For Sebastes complex, cumulative limit of 100,000 pounds per month south of Cape Mendocino.
1/1/1995	4030 South	For Bocaccio, the cumulative limit is 30,000 pounds per month south of Cape Mendocino, and no limit

Regulation date	Location ID	Regulation
		north of Cape Mendocino (other than the limit on the Sebastes complex).
5/1/1995	Cape lookout South	For Sebastes complex, Bocaccio and yellowtail, cumulative limit of 80,000 pounds per calendar month, no more than 30,000 pounds may be yellowtail rockfish caught south of Cape Lookout.
8/1/1995	ALL	Increased the monthly cumulative trip limit for canary rockfish from 6,000 pounds (2,722 kg) to 9,000 pounds (4,082 kg). The Sebastes complex limit was not increased.
1/1/1996	ALL	for fishing in areas with different trip limits for the same species: Trip limits for a species or species complex may differ in different geographic areas along the coast. The following "crossover" provisions apply to all vessels (limited entry and open access) operating in different geographical areas with different cumulative or "per trip" limits for the same species, except for species with daily-trip-limits (nontrawl sablefish, open access thornyhead), black rockfish off Washington State, or those otherwise exempted by a State declaration procedure (yellowtail rockfish and the Sebastes complex off Washington and Oregon).
1/1/1996	ALL	Sebastes complex and Bocaccio 200,000 pounds per 2-months south of Cape Mendocino. For Bocaccio, the cumulative limit is 60,000 pounds per 2-months south of Cape Mendocino, and no limit north of Cape Mendocino (other than the limit on the Sebastes complex).
1/1/1996	Cape Lookout Cape Mendocino	Sebastes complex and yellowtail 100,000 pounds per 2-months between Cape Lookout and Cape Mendocino, California (4030 latitude), no more than 70,000 pounds may be yellowtail rockfish caught between Cape Lookout and Cape Mendocino
11/1/1996	Cape Lookout Cape Mendocino	The cumulative trip limit for the Sebastes complex taken between Cape Mendocino and Cape Lookout is 50,000 pounds per month, of which no more than 35,000 pounds may be yellowtail rockfish and no more than 9,000 pounds may be canary rockfish
1/1/1997	4030 South	measures for open access gear except trawls (may not exceed 50% of any two-month cumulative limit or any other limit for the limited entry fishery for any groundfish species or complex that applies to the same area or gear): Rockfish cumulative limit of 40,000 pounds per month which includes, south of Cape Mendocino, a trip limit of 300 pounds Bocaccio not to

Regulation date	Location ID	Regulation
		exceed 2,000 pounds cumulative per month. Setnets, which are legal gear only south of 3800 latitude, will be subject to the 40,000-pound monthly cumulative limit but not the per trip limit, and will have a cumulative limit of 4,000 pounds of Bocaccio per month
5/1/1997	4030 South	Sebastes Complex (Including Yellowtail Rockfish and Bocaccio) reduced the two-month cumulative limit on Bocaccio to 10,000 pounds south of Cape Mendocino.
5/1/1997	4030 South	Open Access south of Cape Mendocino, trip limit reduction for hook-and-line and trap gear for Bocaccio from 300 pounds to 250 pounds with no change to the monthly trip limit (2000 pounds).
10/1/1997	4030 South	changed from two-month limits to one-month limits for Sebastes complex 75,000 pounds south of Cape Mendocino, no more than 5,000 pounds of which may be Bocaccio south of Cape Mendocino, and no more than 10,000 pounds of which may be canary rockfish coastwide
10/1/1997	ALL	Sebastes complex coastwide no more than 10,000 pounds of which may be canary rockfish
1/1/1998	4030 South	Sebastes Complex (Including yellowtail, canary and Bocaccio rockfish): limited entry fishery Cumulative limit of 150,000 pounds per two-months south of Cape Mendocino. For Bocaccio, the cumulative limit is 2,000 pounds per two-months south of Cape Mendocino, and no limit north
1/1/1998	ALL	for open access gear except trawls Open access landings may not exceed 50% of any two-month cumulative limit or any other limit for the limited entry fishery for any groundfish species or complex that applies to the same area, unless specifically authorized (as for Bocaccio caught with setnets and lingcod).
1/1/1998	ALL	Rockfish: for open access gear except trawls , For rockfish, a cumulative limit of 40,000 pounds per month coastwide, including a trip limit for hook-and-line and pot gear of 10,000 pounds of rockfish per trip, which includes, south of Cape Mendocino, a trip limit of 250 pounds Bocaccio not to exceed 1,000 pounds cumulative per month. Setnets, which are legal gear only south of 3800 latitude, are subject to the 40,000-pound monthly cumulative limit, but not the per-trip limit, and have a cumulative limit of 2,000 pounds of Bocaccio per month.

Regulation date	Location ID	Regulation
5/1/1998	4030 South	Bocaccio, South of Cape Mendocino: increase the per-trip limit to 500 pounds, retaining the one-month cumulative limit of 1,000 pounds.
7/1/1998	4030 South	Limited Entry Sebastes Complex: south of Cape Mendocino, decreased the 2-month cumulative limit to 40,000 pounds.
7/1/1998	ALL	Open Access Rockfish: removed overall rockfish monthly limit and replaced it with limits for component rockfish species: for Sebastes complex, monthly cumulative limit is 33,000 pounds, for widow rockfish, monthly cumulative trip limit is 3,000 pounds, for Pacific Ocean Perch, monthly cumulative trip limit is 4,000 pounds.
10/1/1998	4030 South	Sebastes complex South of Cape Mendocino: Limited Entry: decreased monthly limit to 15,000 pounds.
1/1/1999	3800 South	for open access gear: Bocaccio: setnet and trammel net gears, legal only south of 3800 N latitude, 1,000 pounds per month.
1/1/1999	4030 South	for the limited entry fishery Sebastes Complex (including Yellowtail Rockfish, Canary Rockfish, and Bocaccio):South of Cape Mendocino, California, Phase1: 13,000 pounds per period; Phase 2: 6,500 pounds per period; Phase 3: 5,000 pounds per period.
1/1/1999	4030 South	for the limited entry fishery Sebastes Complex (including Yellowtail Rockfish, Canary Rockfish, and Bocaccio):Bocaccio: south of Cape Mendocino, Phase 1: 750 pounds per month; Phase 2: 750 pounds per month; Phase 3: 750 pounds per month
1/1/1999	4030 South	for open access gear: Sebastes complex: south of Cape Mendocino, 2,000 pounds per month.
1/1/1999	ALL	for the limited entry fishery A new three phase cumulative limit period system is introduced for 1999. Phase 1 is a single cumulative limit period that is 3 months long, from January 1 - March 31. Phase 2 has 3 separate 2 month cumulative limit periods of April 1 - May 31, June 1 - July 31, and August 1 - September 30. Phase 3 has 3 separate 1 month cumulative limit periods of October 1-31, November 1-30, and December 1-31. For all species except Pacific ocean perch and Bocaccio, there will be no monthly limit within the cumulative landings limit periods. An option to apply cumulative trip limits lagged by 2 weeks (from the 16th to the 15th) was made available to limited entry trawl vessels when their permits were renewed for 1999. Vessels that are authorized to operate in this

Regulation date	Location ID	Regulation
		"B" platoon may take and retain, but may not land, groundfish during January 1-15, 1999.
1/1/1999	ALL	for the limited entry fishery Sebastes Complex (including Yellowtail Rockfish, Canary Rockfish, and Bocaccio):Canary Rockfish: coastwide, Phase 1: 9,000 pounds per period; Phase 2: 9,000 pounds per period; Phase 3: 3,000 pounds per period
1/1/1999	ALL	for open access gear: Bocaccio: 500 pounds per month, except for setnet and trammel net gears.
4/1/1999	4030 South	For “A” Platoon Vessels: Limited Entry Canary Rockfish: south of Cape Mendocino, decreased 2-month cumulative limit from 9,000 pounds to 6,500 pounds. Landings of canary rockfish south of Cape Mendocino are limited by and count against the overall Sebastes complex 2-month cumulative limit south of Cape Mendocino, which is 6,500 pounds.
4/1/1999	ALL	For “A” Platoon Vessels: Limited Entry and Open Access Sebastes complex: north and south of Cape Mendocino, if a vessel takes and retains, possesses, or lands any splitnose or chilipepper rockfish south of Cape Mendocino, then the more restrictive Sebastes complex cumulative trip limit applies throughout the same cumulative limit period, no matter where the Sebastes complex is taken and retained, possessed, or landed.
4/16/1999	4030 South	For “B” Platoon Vessels: Limited Entry and Open Access Sebastes complex: north and south of Cape Mendocino, if a vessel takes and retains, possesses, or lands any splitnose or chilipepper rockfish south of Cape Mendocino, then the more restrictive Sebastes complex cumulative trip limit applies throughout the same cumulative limit period, no matter where the Sebastes complex is taken and retained, possessed, or landed.
4/16/1999	4030 South	For ”B” Platoon Vessels: Limited Entry Canary Rockfish: south of Cape Mendocino, decreased 2-month cumulative limit from 9,000 pounds to 6,500 pounds. Landings of canary rockfish south of Cape Mendocino are limited by and count against the overall Sebastes complex 2-month cumulative limit south of Cape Mendocino, which is 6,500 pounds.
6/1/1999	4030 South	Limited Entry, Platoon ”A”: Sebastes complex: south of Cape Mendocino, limited entry 2 month cumulative trip limit for the periods June 1 through July 31 and August 1 through September 30 decreased from 6,500

Regulation date	Location ID	Regulation
		pounds to 3,500 pounds, within which: (1) Bocaccio monthly trip limit of 750 pounds decreased and changed to a 2-month cumulative trip limit of 1,000 pounds with a 500 pounds per trip limit, and (2) canary rockfish 2-month cumulative trip limit decreased to 3,500 pounds.
6/1/1999	4030 South	Limited Entry, Platoon ”B”: Sebastes complex: south of Cape Mendocino, limited entry 2 month cumulative trip limit for the periods June 1 through July 31 and August 1 through September 30 decreased from 6,500 pounds to 3,500 pounds, within which: (1) Bocaccio monthly trip limit of 750 pounds decreased and changed to a 2-month cumulative trip limit of 1,000 pounds with a 500 pounds per trip limit, and (2) canary rockfish 2-month cumulative trip limit decreased to 3,500 pounds.
10/1/1999	4030 South	Limited Entry Sebastes Complex, “A” platoon: decreased 1-month cumulative trip limits from 5,000 pounds (south of Cape Mendocino) to a coastwide limit of 500 pounds per month.
10/1/1999	ALL	Limited Entry, “A” platoon: The 1-month cumulative trip limits for canary rockfish, coastwide; Bocaccio, south of Cape Mendocino; and other species in the Sebastes complex, which count together towards the overall Sebastes complex limit, may not exceed the 500-pound cumulative monthly limit.
10/16/1999	4030 South	Limited Entry Sebastes Complex, “B” platoon: decreased 1-month cumulative trip limits from 5,000 pounds (south of Cape Mendocino) to a coastwide limit of 500 pounds per month.
10/16/1999	ALL	Limited Entry, “B” platoon: The 1-month cumulative trip limits for canary rockfish, coastwide; Bocaccio, south of Cape Mendocino; and other species in the Sebastes complex, which count together towards the overall Sebastes complex limit, may not exceed the 500-pound cumulative monthly limit.
1/1/2000	3600 4010	Bocaccio, limited entry fixed gear, 300 lbs per month
1/1/2000	3600 4010	Bocaccio, Open Access gear except exempted trawl, 200 lbs per month
1/1/2000	3600 South	Bocaccio, limited entry fixed gear, closed
1/1/2000	3600 South	Bocaccio, Open Access gear except exempted trawl, closed
1/1/2000	4010 South	Limited entry trawl, small footrope or midwater trawl only, Bocaccio, 300 lbs per month

Regulation date	Location ID	Regulation
3/1/2000	3600 4010	Bocaccio, Open Access gear except exempted trawl, closed
3/1/2000	3600 4010	Bocaccio, limited entry fixed gear, closed
3/1/2000	3600 South	Bocaccio, Open Access gear except exempted trawl, 200 lbs per month
3/1/2000	3600 South	Bocaccio, limited entry fixed gear, 300 lbs per month
5/1/2000	3600 4010	Bocaccio, limited entry fixed gear, 500 lbs per month
5/1/2000	3600 4010	Bocaccio rockfish, Open Access gear except exempted trawl, 200 lbs per month
5/1/2000	3600 South	Bocaccio, limited entry fixed gear, 500 lbs per month
5/1/2000	4010 South	Limited entry trawl, small footrope or midwater trawl only, Bocaccio, 500 lbs per month
11/1/2000	3600 4010	Bocaccio, limited entry fixed gear, 300 lbs per month
11/1/2000	3600 South	Bocaccio, limited entry fixed gear, 300 lbs per month
11/1/2000	4010 South	Limited entry trawl, small footrope or midwater trawl only, Bocaccio, 300 lbs per month
1/1/2001	3427 4010	Bocaccio, open access, 200 lbs per month
1/1/2001	3427 4010	Bocaccio, limited entry fixed gear, 300 lbs per month
1/1/2001	3427 South	Bocaccio, limited entry fixed gear, closed
1/1/2001	3427 South	Bocaccio, open access, closed
1/1/2001	4010 South	Bocaccio, limited entry trawl, small footrope or midwater trawl only, 300 lbs per month
3/1/2001	3427 4010	Bocaccio, open access, closed
3/1/2001	3427 South	Bocaccio, open access, 200 lbs per month
4/1/2001	3427 4010	Bocaccio, limited entry fixed gear, closed
4/1/2001	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per month
5/1/2001	4010 South	Bocaccio, limited entry trawl, small footrope or midwater trawl only, 500 lbs per month
7/1/2001	3427 4010	Bocaccio, open access, 200 lbs per month
7/1/2001	3427 4010	Bocaccio, limited entry fixed gear, 500 lbs per month
7/1/2001	3427 South	Bocaccio, open access, 200 lbs per month
10/1/2001	4010 South	Bocaccio, limited entry trawl, small footrope or midwater trawl only, 300 lbs per month
11/1/2001	3427 4010	Bocaccio, limited entry fixed gear, 300 lbs per month
1/1/2002	3427 4010	Bocaccio, open access, 200 lbs per month
1/1/2002	3427 4010	Bocaccio, limited entry fixed gear, 200 lbs per month
1/1/2002	3427 South	Bocaccio, open access, closed
1/1/2002	3427 South	Bocaccio, limited entry fixed gear, closed
1/1/2002	4010 South	Bocaccio, limited entry trawl, midwater or small footrope only, 600 lbs per 2 months
3/1/2002	3427 4010	Bocaccio, limited entry fixed gear, closed
3/1/2002	3427 4010	Bocaccio, open access, closed

Regulation date	Location ID	Regulation
3/1/2002	3427 South	Bocaccio, limited entry fixed gear, 200 lbs per month
3/1/2002	3427 South	Bocaccio, open access, 200 lbs per month
5/1/2002	4010 South	Bocaccio, limited entry trawl, midwater or small footrope only, 1000 lbs per 2 months
7/1/2002	3427 4010	Bocaccio, open access, 200 lbs per month
7/1/2002	3427 4010	Bocaccio, limited entry fixed gear, 200 lbs per month
9/1/2002	3427 4010	Bocaccio, limited entry fixed gear, closed
9/1/2002	3427 4010	Bocaccio, open access, closed
11/1/2002	3427 South	Bocaccio, open access, closed
11/1/2002	3427 South	Bocaccio, limited entry fixed gear, closed
11/1/2002	4010 South	Bocaccio, limited entry trawl, midwater or small footrope only, 600 lbs per 2 months
1/1/2003	4010 North	minor shelf rockfish north including widow, yellowtail, Bocaccio and chilipepper, open access gears, 200 lbs per month
1/1/2003	4010 North	minor shelf rockfish north including widow, yellowtail, Bocaccio and chilipepper, limited entry fixed gear, 200 lbs per month
1/1/2003	4010 North	minor shelf rockfish north and widow rockfish, chilipepper and Bocaccio, Limited entry trawl gear, small footrope or midwater trawl only, 300 lbs per month
1/1/2003	4010 South	Bocaccio, open access gear, closed
1/1/2003	4010 South	Bocaccio, limited entry fixed gear, closed
1/1/2003	4010 South	Bocaccio, limited entry trawl, small footrope or midwater trawl only, closed
5/1/2003	4010 North	minor shelf rockfish north and widow rockfish and chilipepper and Bocaccio, Limited entry trawl gear, small footrope or midwater trawl only, 1000 lbs per month no more than 200 lbs per month may be yelloweye rockfish
11/1/2003	4010 North	minor shelf rockfish north and widow rockfish and chilipepper and Bocaccio, Limited entry trawl gear, small footrope or midwater trawl only, 300 lbs per month
1/1/2004	3427 4010	Bocaccio, limited entry fixed gear, 200 lbs per 2 months
1/1/2004	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
1/1/2004	3427 South	Bocaccio, open access gear, closed
1/1/2004	3427 South	Bocaccio, limited entry fixed gear, closed
1/1/2004	4010 North	minor shelf rockfish north including widow rockfish, yellowtail rockfish, Bocaccio, and chilipepper rockfish, open access gear, 200 lbs per month

Regulation date	Location ID	Regulation
1/1/2004	4010 North	minor shelf rockfish north including widow, Bocaccio, chilipepper and yellowtail rockfish, limited entry fixed gear, 200 lbs per month
1/1/2004	4010 North	minor shelf rockfish north including widow, Bocaccio and chilipepper, large footrope, limited entry trawl, closed
1/1/2004	4010 North	minor shelf rockfish north including widow, Bocaccio and chilipepper, small footrope, limited entry trawl, 300 lbs per month
1/1/2004	4010 South	Bocaccio, limited entry trawl, large footrope or midwater trawl, 100 lbs per month
1/1/2004	4010 South	Bocaccio, limited entry trawl, small footrope, closed
3/1/2004	3427 4010	Bocaccio, open access gear, closed
3/1/2004	3427 4010	Bocaccio, limited entry fixed gear, closed
3/1/2004	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
3/1/2004	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2004	3427 4010	Bocaccio, limited entry fixed gear, 100 lbs per 2 months
5/1/2004	3427 4010	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2004	4010 North	minor shelf rockfish north including widow, Bocaccio and chilipepper, small footrope, limited entry trawl, 1000 lbs per month, no more than 200 lbs per month of yelloweye rockfish
7/1/2004	3427 4010	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
7/1/2004	4010 North	minor shelf rockfish north including widow, Bocaccio and chilipepper, large footrope, limited entry trawl, 300 lbs per 2 months
7/1/2004	4010 South	Bocaccio, limited entry trawl, large footrope or midwater trawl, 300 lbs per 2 months
9/1/2004	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
11/1/2004	4010 North	minor shelf rockfish north including widow, Bocaccio and chilipepper, large footrope, limited entry trawl, 300 lbs per 2 months
11/1/2004	4010 North	minor shelf rockfish north including widow, Bocaccio and chilipepper, small footrope, limited entry trawl, 300 lbs per month
11/1/2004	4010 South	Bocaccio, limited entry trawl, large footrope or midwater trawl, 300 lbs per 2 months
11/1/2004	4010 South	Bocaccio, limited entry trawl, small footrope, 300 lbs per 2 months
1/1/2005	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months

Regulation date	Location ID	Regulation
1/1/2005	3427 4010	Bocaccio, limited entry fixed gear, 200 lbs per 2 months
1/1/2005	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
1/1/2005	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
1/1/2005	4010 North	minor shelf rockfish north including shortbelly, widow, yellowtail, Bocaccio, chilipepper and cowcod, open access gears, 200 lbs per month
1/1/2005	4010 North	minor shelf rockfish north including shortbelly, widow, Bocaccio, chilipepper, cowcod, and yelloweye rockfish, limited entry trawl gear, midwater trawl for widow rockfish, before the primary whiting season - closed; during the primary whiting season , in trips with at least 10000 lbs of whiting - combined widow rockfish and yellowtail rockfish 500 lbs per trip with a cumulative limit of 1500 lbs of widow rockfish per month. Midwater trawl permitted in the RCA. After the primary whiting season - closed
1/1/2005	4010 North	minor shelf rockfish north including shortbelly, widow, Bocaccio, chilipepper, cowcod, and yelloweye rockfish, limited entry trawl gear, large and small footrope, 300 lbs per 2 months
1/1/2005	4010 North	minor shelf rockfish north including shortbelly, widow, Bocaccio, chilipepper, cowcod, and yelloweye rockfish, limited entry trawl gear, selective flatfish gear, 300 lbs per month
1/1/2005	4010 North	minor shelf rockfish north including shortbelly, widow, yellowtail, chilipepper, Bocaccio, and cowcod, limited entry fixed gear, 200 lbs per month
1/1/2005	4010 North	minor shelf rockfish north including shortbelly, widow, Bocaccio, chilipepper, cowcod, and yelloweye rockfish, limited entry trawl gear, multiple bottom trawl gear, 300 lbs per month
1/1/2005	4010 South	Bocaccio, limited entry trawl, large footrope or midwater trawl, 300 lbs per 2 months
1/1/2005	4010 South	Bocaccio, limited entry trawl, small footrope trawl, closed
3/1/2005	3427 4010	Bocaccio, limited entry fixed gear, closed
3/1/2005	3427 4010	Bocaccio, open access gear, closed
3/1/2005	3427 South	Bocaccio, limited entry fixed gear, closed
3/1/2005	3427 South	Bocaccio, open access gear, closed
5/1/2005	3427 4010	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2005	3427 4010	Bocaccio, limited entry fixed gear, 100 lbs per 2 months

Regulation date	Location ID	Regulation
5/1/2005	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2005	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
5/1/2005	4010 North	minor shelf rockfish north including shortbelly, widow, Bocaccio, chilipepper, cowcod, and yelloweye rockfish, limited entry trawl gear, multiple bottom trawl gear, 300 lbs per 2 months of which no more than 200 lbs per month may be yelloweye rockfish
5/1/2005	4010 North	minor shelf rockfish north including shortbelly, widow, Bocaccio, chilipepper, cowcod, and yelloweye rockfish, limited entry trawl gear, selective flatfish gear, 1000 lbs per month no more than 200 lbs per month of which may be yelloweye rockfish
7/1/2005	3427 4010	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
9/1/2005	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
11/1/2005	4010 North	minor shelf rockfish north including shortbelly, widow, Bocaccio, chilipepper, cowcod, and yelloweye rockfish, limited entry trawl gear, selective flatfish gear, 300 lbs per month
11/1/2005	4010 North	minor shelf rockfish north including shortbelly, widow, Bocaccio, chilipepper, cowcod, and yelloweye rockfish, limited entry trawl gear, multiple bottom trawl gear, 300 lbs per month
1/1/2006	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
1/1/2006	3427 4010	Bocaccio, limited entry fixed gear, 200 lbs per 2 months
1/1/2006	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
1/1/2006	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
1/1/2006	4010 North	minor shelf rockfish north including shortbelly, widow rockfish, yelloweye, Bocaccio, chilipepper, and cowcod, limited entry trawl, selective flatfish trawl gear, 300 lbs per month
1/1/2006	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yellowtail rockfish, open access gear, 200 lbs per month
1/1/2006	4010 North	minor shelf rockfish north including shortbelly, widow, yellowtail, Bocaccio, chilipepper, and cowcod, limited entry fixed gear, 200 lbs per month
1/1/2006	4010 North	minor shelf rockfish north including shortbelly, widow rockfish, yelloweye, Bocaccio, chilipepper, and cowcod, limited entry trawl, large and small footrope gear, 150 lbs per month

Regulation date	Location ID	Regulation
1/1/2006	4010 North	minor shelf rockfish north including shortbelly, widow rockfish, yelloweye, Bocaccio, chilipepper, and cowcod, limited entry trawl, multiple bottom trawl gear, 300 lbs per month
1/1/2006	4010 South	Bocaccio, limited entry trawl, large footrope and midwater trawl, 150 lbs per month
1/1/2006	4010 South	Bocaccio, limited entry trawl, small footrope, closed
3/1/2006	3427 4010	Bocaccio, limited entry fixed gear, closed
3/1/2006	3427 4010	Bocaccio, open access gear, closed
3/1/2006	3427 South	Bocaccio, limited entry fixed gear, closed
3/1/2006	3427 South	Bocaccio, open access gear, closed
3/1/2006	4010 North	minor shelf rockfish north including shortbelly, widow rockfish, yelloweye, Bocaccio, chilipepper, and cowcod, limited entry trawl, large and small footrope gear, 300 lbs per 2 months
3/1/2006	4010 South	Bocaccio, limited entry trawl, large footrope and midwater trawl, 300 lbs per 2 months
5/1/2006	3427 4010	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2006	3427 4010	Bocaccio, limited entry fixed gear, 100 lbs per 2 months
5/1/2006	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2006	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
5/1/2006	4010 North	minor shelf rockfish north including shortbelly, widow rockfish, yelloweye, Bocaccio, chilipepper, and cowcod, limited entry trawl, selective flatfish trawl gear, 1000 lbs per month, no more than 200 lbs per month of which may be yelloweye rockfish
5/1/2006	4010 North	minor shelf rockfish north including shortbelly, widow rockfish, yelloweye, Bocaccio, chilipepper, and cowcod, limited entry trawl, multiple bottom trawl gear, 300 lbs per 2 months, no more than 200 lbs per 2 months of which may be yelloweye rockfish
7/1/2006	3427 4010	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
9/1/2006	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
11/1/2006	4010 North	minor shelf rockfish north including shortbelly, widow rockfish, yelloweye, Bocaccio, chilipepper, and cowcod, limited entry trawl, selective flatfish trawl gear, 300 lbs per month
11/1/2006	4010 North	minor shelf rockfish north including shortbelly, widow rockfish, yelloweye, Bocaccio, chilipepper, and cowcod, limited entry trawl, multiple bottom trawl gear, 300 lbs per month

Regulation date	Location ID	Regulation
1/1/2007	3427 4010	Bocaccio, limited entry fixed gear, 200 lbs per 2 months
1/1/2007	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
1/1/2007	3427 South	Bocaccio limited, limited entry fixed gear, 300 lbs per 2 months
1/1/2007	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
1/1/2007	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yellowtail, limited entry fixed gear, 200 lbs per month
1/1/2007	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow and yellowtail, open access gears, 200 lbs per month
1/1/2007	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, large and small footrope gear, 300 lbs per 2 months
1/1/2007	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, selective flatfish trawl, 300 lbs per month
1/1/2007	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, multiple bottom trawl gear, 300 lbs per month
1/1/2007	4010 South	Bocaccio, limited entry trawl, large footrope or midwater trawl, 300 lbs per 2 months
1/1/2007	4010 South	Bocaccio, limited entry trawl, small footrope trawl, closed
3/1/2007	3427 4010	Bocaccio, open access gear, closed
3/1/2007	3427 4010	Bocaccio, limited entry fixed gear, closed
3/1/2007	3427 South	Bocaccio, open access gear, closed
3/1/2007	3427 South	Bocaccio limited, limited entry fixed gear, closed
5/1/2007	3427 4010	Bocaccio, limited entry fixed gear, 100 lbs per 2 months
5/1/2007	3427 4010	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2007	3427 South	Bocaccio limited, limited entry fixed gear, 300 lbs per 2 months
5/1/2007	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2007	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, multiple bottom trawl gear, 300 lbs per month, no more than 200 lbs per month of which may be yelloweye rockfish

Regulation date	Location ID	Regulation
5/1/2007	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, selective flatfish trawl, 1000 lbs per month, no more than 200 lbs per month of which may be yelloweye rockfish
7/1/2007	3427 4010	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
9/1/2007	3427 4010	Bocaccio, limited entry fixed gear, Bocaccio included in minor shelf south rockfish limits
9/1/2007	3427 4010	minor shelf rockfish south including yellowtail, shortbelly and widow rockfish, limited entry fixed gear, 500 lbs per 2 months (including Bocaccio)
9/1/2007	3427 4010	minor shelf rockfish south including yellowtail, shortbelly, Bocaccio and widow rockfish, limited entry fixed gear, 3000 lbs per 2 months
9/1/2007	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
11/1/2007	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, selective flatfish trawl, 300 lbs per month
11/1/2007	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, multiple bottom trawl gear, 300 lbs per month
1/1/2008	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
1/1/2008	3427 4010	minor shelf rockfish south including yellowtail, shortbelly, Bocaccio, chilipepper and widow rockfish, limited entry fixed gear, 2500 lbs per 2 months of which no more than 500 lbs per 2 months may be species other than chilipepper
1/1/2008	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
1/1/2008	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
1/1/2008	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, large and small footrope gear, 300 lbs per 2 months
1/1/2008	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, selective flatfish trawl, 300 lbs per month
1/1/2008	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow and yellowtail, open access gears, 200 lbs per month

Regulation date	Location ID	Regulation
1/1/2008	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yellowtail, limited entry fixed gear, 200 lbs per month
1/1/2008	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, multiple bottom trawl gear, 300 lbs per month
1/1/2008	4010 South	Bocaccio, limited entry trawl, large footrope or midwater trawl, 300 lbs per 2 months
1/1/2008	4010 South	Bocaccio, limited entry trawl, small footrope trawl, closed
3/1/2008	3427 4010	Bocaccio, open access gear, closed
3/1/2008	3427 South	Bocaccio, limited entry fixed gear, closed
3/1/2008	3427 South	Bocaccio, open access gear, closed
5/1/2008	3427 4010	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2008	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2008	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
5/1/2008	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, selective flatfish trawl, 1000 lbs per month, no more than 200 lbs per month of which may be yelloweye rockfish
5/1/2008	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, multiple bottom trawl gear, 300 lbs per month, no more than 200 lbs per month of which may be yelloweye rockfish
9/1/2008	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
11/1/2008	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, selective flatfish trawl, 300 lbs per month
11/1/2008	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, multiple bottom trawl gear, 300 lbs per month
1/1/2009	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
1/1/2009	3427 4010	minor shelf rockfish south including yellowtail, shortbelly, Bocaccio, chilipepper and widow rockfish, limited entry fixed gear, 2500 lbs per 2 months of which no more than 500 lbs per 2 months may be species other than chilipepper
1/1/2009	3427 South	Bocaccio, open access gear, 100 lbs per 2 months

Regulation date	Location ID	Regulation
1/1/2009	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
1/1/2009	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, large and small footrope gear, 300 lbs per 2 months
1/1/2009	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, selective flatfish trawl, 300 lbs per month
1/1/2009	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, multiple bottom trawl gear, 300 lbs per month
1/1/2009	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yellowtail, limited entry fixed gear, 200 lbs per month
1/1/2009	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow and yellowtail, open access gears, 200 lbs per month
1/1/2009	4010 South	Bocaccio, limited entry trawl, large footrope or midwater trawl, 300 lbs per 2 months
1/1/2009	4010 South	Bocaccio, limited entry trawl, small footrope trawl, closed
3/1/2009	3427 4010	Bocaccio, open access gear, closed
3/1/2009	3427 South	Bocaccio, limited entry fixed gear, closed
3/1/2009	3427 South	Bocaccio, open access gear, closed
5/1/2009	3427 4010	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2009	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2009	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
5/1/2009	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, multiple bottom trawl gear, 300 lbs per month, no more than 200 lbs per month of which may be yelloweye rockfish
5/1/2009	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, selective flatfish trawl, 1000 lbs per month, no more than 200 lbs per month of which may be yelloweye rockfish
9/1/2009	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
11/1/2009	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye,

Regulation date	Location ID	Regulation
		limited entry trawl, selective flatfish trawl, 300 lbs per month
11/1/2009	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, multiple bottom trawl gear, 300 lbs per month
1/1/2010	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
1/1/2010	3427 4010	minor shelf rockfish south including yellowtail, shortbelly, Bocaccio, chilipepper and widow rockfish, limited entry fixed gear, 2500 lbs per 2 months of which no more than 500 lbs per 2 months may be species other than chilipepper
1/1/2010	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
1/1/2010	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
1/1/2010	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, large and small footrope gear, 300 lbs per 2 months
1/1/2010	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, selective flatfish trawl, 300 lbs per month
1/1/2010	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, multiple bottom trawl gear, 300 lbs per month
1/1/2010	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow and yellowtail, open access gears, 200 lbs per month
1/1/2010	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yellowtail, limited entry fixed gear, 200 lbs per month
1/1/2010	4010 South	Bocaccio, limited entry trawl, large footrope or midwater trawl, 300 lbs per 2 months
1/1/2010	4010 South	Bocaccio, limited entry trawl, small footrope trawl, closed
3/1/2010	3427 4010	Bocaccio, open access gear, closed
3/1/2010	3427 South	Bocaccio, limited entry fixed gear, closed
3/1/2010	3427 South	Bocaccio, open access gear, closed
5/1/2010	3427 4010	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2010	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2010	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months

Regulation date	Location ID	Regulation
5/1/2010	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, multiple bottom trawl gear, 300 lbs per month, no more than 200 lbs per month of which may be yelloweye rockfish
5/1/2010	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, selective flatfish trawl, 1000 lbs per month, no more than 200 lbs per month of which may be yelloweye rockfish
9/1/2010	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
11/1/2010	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, selective flatfish trawl, 300 lbs per month
11/1/2010	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yelloweye, limited entry trawl, multiple bottom trawl gear, 300 lbs per month
1/1/2011	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
1/1/2011	3427 4010	minor shelf rockfish south including yellowtail, shortbelly, Bocaccio, chilipepper and widow rockfish, limited entry fixed gear, 2500 lbs per 2 months of which no more than 500 lbs per 2 months may be species other than chilipepper
1/1/2011	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
1/1/2011	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
1/1/2011	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yellowtail, limited entry fixed gear, 200 lbs per month
1/1/2011	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow and yellowtail, open access gears, 200 lbs per month
1/1/2011	ALL	Bocaccio managed in part by IFQ
3/1/2011	3427 4010	Bocaccio, open access gear, closed
3/1/2011	3427 South	Bocaccio, limited entry fixed gear, closed
3/1/2011	3427 South	Bocaccio, open access gear, closed
5/1/2011	3427 4010	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2011	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2011	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
9/1/2011	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
1/1/2012	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months

Regulation date	Location ID	Regulation
1/1/2012	3427 4010	minor shelf rockfish south including yellowtail, shortbelly, Bocaccio, chilipepper and widow rockfish, limited entry fixed gear, 2500 lbs per 2 months of which no more than 500 lbs per 2 months may be species other than chilipepper
1/1/2012	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
1/1/2012	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
1/1/2012	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yellowtail, limited entry fixed gear, 200 lbs per month
1/1/2012	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow and yellowtail, open access gears, 200 lbs per month
3/1/2012	3427 4010	Bocaccio, open access gear, closed
3/1/2012	3427 South	Bocaccio, limited entry fixed gear, closed
3/1/2012	3427 South	Bocaccio, open access gear, closed
5/1/2012	3427 4010	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2012	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2012	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
9/1/2012	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
9/1/2012	3427 South	Bocaccio, limited entry fixed gear, 500 lbs per 2 months
1/1/2013	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
1/1/2013	3427 4010	minor shelf rockfish south including yellowtail, shortbelly, Bocaccio, chilipepper and widow rockfish, limited entry fixed gear, 2500 lbs per 2 months of which no more than 500 lbs per 2 months may be species other than chilipepper
1/1/2013	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
1/1/2013	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
1/1/2013	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow, and yellowtail, limited entry fixed gear, 200 lbs per month
1/1/2013	4010 North	minor shelf rockfish north including Bocaccio, chilipepper, cowcod, shortbelly, widow and yellowtail, open access gears, 200 lbs per month
3/1/2013	3427 4010	Bocaccio, open access gear, closed
3/1/2013	3427 South	Bocaccio, limited entry fixed gear, closed
3/1/2013	3427 South	Bocaccio, open access gear, closed
5/1/2013	3427 4010	Bocaccio, open access gear, 100 lbs per 2 months

Regulation date	Location ID	Regulation
5/1/2013	3427 South	Bocaccio, open access gear, 100 lbs per 2 months
5/1/2013	3427 South	Bocaccio, limited entry fixed gear, 300 lbs per 2 months
7/1/2013	3427 South	Bocaccio, limited entry fixed gear, 500 lbs per 2 months
7/1/2013	3427 South	Bocaccio, open access gear, 200 lbs per 2 months
9/1/2013	3427 4010	Bocaccio, open access gear, 200 lbs per 2 months
1/1/2014	3427 4010	non-trawl, limited entry, minor shelf rockfish including shortbelly, widow, and yellowtail rockfish, Bocaccio, chilipepper, 2500 lbs per 2 months of which no more than 500 lbs may be species other than chilipepper
1/1/2014	3427 4010	non-trawl, open access, Bocaccio, 200 lbs per 2 months
1/1/2014	3427 South	non-trawl, limited entry, Bocaccio, 300 lbs per 2 months
1/1/2014	3427 South	non-trawl, open access, Bocaccio, 100 lbs per 2 months
1/1/2014	4010 North	non-trawl, limited entry, minor shelf rockfish including shortbelly, widow, and yellowtail rockfish, Bocaccio, chilipepper, and cowcod, 200 lbs per month
1/1/2014	4010 North	non-trawl, open access, minor shelf rockfish including shortbelly, widow, yellowtail, Bocaccio, chilipepper rockfish, and cowcod, 200 lbs per month
3/1/2014	3427 4010	non-trawl, open access, Bocaccio, closed
3/1/2014	3427 South	non-trawl, open access, Bocaccio, closed
3/1/2014	3427 South	non-trawl, limited entry, Bocaccio, closed
5/1/2014	3427 4010	non-trawl, open access, Bocaccio, 100 lbs per 2 months
5/1/2014	3427 South	non-trawl, limited entry, Bocaccio, 300 lbs per 2 months
5/1/2014	3427 South	non-trawl, open access, Bocaccio, 100 lbs per 2 months
7/1/2014	3427 South	non-trawl, open access, Bocaccio, 200 lbs per 2 months
7/1/2014	3427 South	non-trawl, limited entry, Bocaccio, 500 lbs per 2 months
9/1/2014	3427 4010	non-trawl, open access, Bocaccio, 200 lbs per 2 months
1/1/2015	3427 4010	non-trawl, limited entry, minor shelf rockfish including shortbelly, widow, and yellowtail rockfish, Bocaccio, chilipepper, 2500 lbs per 2 months of which no more than 500 lbs may be species other than chilipepper
1/1/2015	3427 4010	non-trawl, open access, Bocaccio, 200 lbs per 2 months

Regulation date	Location ID	Regulation
1/1/2015	3427 South	non-trawl, limited entry, Bocaccio, 750 lbs per 2 months
1/1/2015	3427 South	non-trawl, open access, Bocaccio, 250 lbs per 2 months
1/1/2015	4010 North	non-trawl, limited entry, minor shelf rockfish including shortbelly, widow, and yellowtail rockfish, Bocaccio, chilipepper, and cowcod, 200 lbs per month
1/1/2015	4010 North	non-trawl, open access, minor shelf rockfish including shortbelly, widow, yellowtail, Bocaccio, chilipepper rockfish, and cowcod, 200 lbs per month
3/1/2015	3427 4010	non-trawl, open access, Bocaccio, closed
3/1/2015	3427 South	non-trawl, open access, Bocaccio, closed
3/1/2015	3427 South	non-trawl, limited entry, Bocaccio, closed
5/1/2015	3427 4010	non-trawl, open access, Bocaccio, 100 lbs per 2 months
5/1/2015	3427 South	non-trawl, limited entry, Bocaccio, 750 lbs per 2 months
5/1/2015	3427 South	non-trawl, open access, Bocaccio, 250 lbs per 2 months
9/1/2015	3427 4010	non-trawl, open access, Bocaccio, 200 lbs per 2 months
1/1/2016	3427 4010	non-trawl, limited entry, minor shelf rockfish including shortbelly, widow, and yellowtail rockfish, Bocaccio, chilipepper, 2500 lbs per 2 months of which no more than 500 lbs may be species other than chilipepper
1/1/2016	3427 4010	non-trawl, open access, Bocaccio, 200 lbs per 2 months
1/1/2016	3427 South	non-trawl, limited entry, Bocaccio, 750 lbs per 2 months
1/1/2016	3427 South	non-trawl, open access, Bocaccio, 250 lbs per 2 months
1/1/2016	4010 North	non-trawl, limited entry, minor shelf rockfish including shortbelly, widow, and yellowtail rockfish, Bocaccio, chilipepper, and cowcod, 200 lbs per month
1/1/2016	4010 North	non-trawl, open access, minor shelf rockfish including shortbelly, widow, yellowtail, Bocaccio, chilipepper rockfish, and cowcod, 200 lbs per month
3/1/2016	3427 4010	non-trawl, open access, Bocaccio, closed
3/1/2016	3427 South	non-trawl, open access, Bocaccio, closed
3/1/2016	3427 South	non-trawl, limited entry, Bocaccio, closed
5/1/2016	3427 4010	non-trawl, open access, Bocaccio, 100 lbs per 2 months
5/1/2016	3427 South	non-trawl, limited entry, Bocaccio, 750 lbs per 2 months

Regulation date	Location ID	Regulation
5/1/2016	3427 South	non-trawl, open access, Bocaccio, 250 lbs per 2 months
9/1/2016	3427 4010	non-trawl, open access, Bocaccio, 200 lbs per 2 months

Appendix B. Coastwide Pre-Recruit Indices from SWFSC and NWFSC/PWCC Midwater trawl Surveys (2001-2016)

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Introduction

This document provides an update of coastwide pre-recruit indices of abundance developed for past stock assessment cycles (Ralston et al. 2015), using data collected during SWFSC, NWFSC and PWCC/NWFSC midwater trawl surveys for young-of-the-year (YOY) pelagic juvenile groundfish. Due to time constraints and complications related to the discovery of a problem in how past indices were developed, this document reports indices for only a handful of those species typically evaluated, with a focus on those being assessed for the 2017 assessment cycle (bocaccio, blue/deacon and yellowtail) and one relatively abundant species from which to evaluate the consequences of the computational issues in past indices (shortbelly rockfish). Some preliminary explorations of an alternative means of developing indices are also included for consideration in review panels of those assessments.

In recent stock assessment cycles, these indices have been developed with guidance from the 2006 Pre-Recruit Survey Workshop (Hastie and Ralston 2007), such that data collected by these different surveys using identical gear and methods could be pooled to develop "coastwide" indices of abundance for YOY *Sebastes* spp. (see Ralston et al. 2013, Ralston and Stewart 2013 and Sakuma et al. 2016 for reviews of data, methods, vessel comparison and select results). This was in recognition that the data collected over a longer time period (1983-present) from the "core" area of the SWFSC survey were likely to present a biased and/or imprecise representation of coastwide YOY abundance due to significant interannual shifts in the spatial distribution of pelagic juvenile YOY (Ralston and Stewart 2013). However, variable ship availability and survey effort make the development of truly "coastwide" indices for some years impossible.

Data Analysis

As in recent assessment cycles, we used only years with the most comprehensive coverage to evaluate the spatial scope appropriate for each individual stock for which an index might be developed. Figure 1 shows haul locations for the different surveys over time, for the SWFSC (1983-2016, fixed stations), NWFSC (2011, 2013-2016, fixed stations) and PWCC/NWFSC (no fixed stations) datasets. Table 1 shows the total number of hauls by 2° latitude bins (the reported latitude in the Table represents the "mean" latitude for that bin, such that latitude 46 includes hauls from 45°- 47° N) for all of the survey data when pooled together. As the years 2004-2009 and 2013-2016 included very comprehensive coastwide coverage (albeit with very little data north of 47°N), these years were used to develop “climatologies” of the spatial distribution of the catch, in order to evaluate where the majority of the catch by species took place, so that “coastwide” indices could be crafted for southerly and northerly distributed species. This time period included years of very high (2009, 2013-2016) as well as very low (but spatially variable, 2005- 2007) abundance, and thus should provide a reasonable characterization of the spatial distributions of most species.

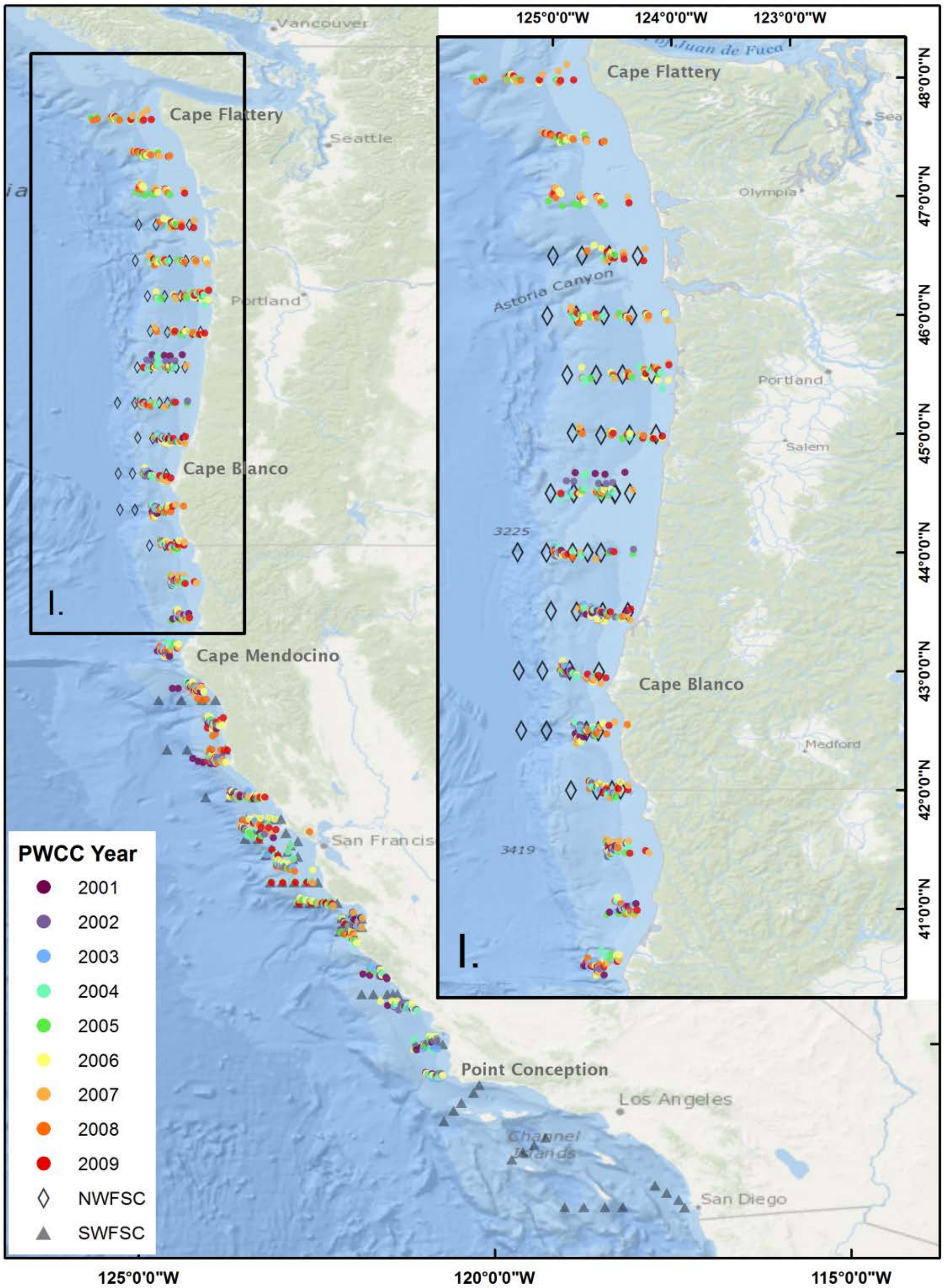

Figure 1: Station and haul locations for SWFSC, NWFSC and PWCC/NWFSC midwater trawl surveys.

Table 1: Number of hauls by year and latitude bin used to develop climatologies of spatial abundance (data prior to 2001 excluded).

only northern species
all species
only southern species

year	latbin 32	34	36	38	40	42	44	46	48	Total
2001		6	68	53	17	17	19			180
2002		6	63	52	19	21	17			178
2003		8	72	71	20	20	19			210
2004	8	27	76	74	28	20	25	20		278
2005	13	27	92	61	35	17	22	21	12	300
2006	14	24	83	86	40	21	20	22	13	323
2007	11	17	78	85	37	25	21	23	16	313
2008	13	20	43	43	37	21	22	18	15	232
2009	7	19	59	79	30	24	23	23	16	280
2010	6	15	44	52	16					133
2011			29	30	19	22	28	24	13	165
2012	3	13	51	27						94
2013	7	21	51	39	17	16	21	13		185
2014	5	13	54	57	16	15	18	9		187
2015	13	25	56	44	18	19	17	13		205
2016	12	26	56	35	6	9	20	12		176

The results of the exploration of catch rate climatologies indicated that some fairly rational generalizations could be made regarding the spatial survey extent that might represent "coastwide" coverage for the different species of rockfish. Specifically, for the "northern" species, widow rockfish (*S. entomelas*), yellowtail rockfish (*S. flavidus*), black rockfish (*S. melanops*), and canary rockfish (*S. pinniger*), the data from the years of the best truly coastwide coverage indicate that 99.7 to 100% of population abundance, as measured by spatial integration of average catch-per-unit-effort (fish·tow^{-1}), has occurred within the 36 - 46° N latitudinal bins, representing the area between 35° and 47° N (Table 2). Thus, the best spatial coverage for these species are the years 2004-2009, 2011 and 2013-2016, as reflected by the indices developed for the 2015 assessment cycle (Ralston et al. 2015). By contrast, for blue/deacon rockfish (which have not historically been differentiated to the species level in this survey), catches were very uncommon north of 44 N, and consequently years in which the survey evaluated the region between 36 to 44 could be used for an index.

Similarly, for the "southern" species, chilipepper (*S. goodei*), squarespot rockfish (*S. hopkinsi*), shortbelly rockfish (*S. jordani*), bocaccio (*S. paucispinis*), and stripetail rockfish (*S. saxicola*), between 95 and 100% of the integrated abundance took place within or below the 40° latitude bin (e.g., latitudes 41° and south), although for bocaccio this range extended to the 42° N latitude bin with the addition of 2015-16 data. Thus, the indices developed for the 2017 assessment cycle were limited to those years that included the 32-34 latitude bins up through 42°N for bocaccio; namely 2004-2009, 2013-2016.

Prior to developing the Pre-Recruit index, the raw catch rate data were converted to standard age fish, due to substantial interannual variation in the size distribution of fish collected. To accomplish this, the length of each specimen of a species in a haul was converted to an estimated age using a linear regression of age $N = a + b \times SL$, where N is estimated age in days and SL is standard length (mm). Data used to fit all species-year regressions were generated by sub-sampling fish and counting daily otolith increments (see Woodbury and Ralston 1991). The contribution of each fish in a given haul was then age-adjusted according to:

$$N^{*}_{h,t} = N_{h,t} \exp[-M(100 - t_{hat}]$$

Where N^{*} is the number of fish in 100 day old equivalents, $N_{h,t}$, is the number of fish from haul h of estimated age t and M is the natural mortality rate of pelagic juvenile rockfish (0.04 day^{-1}; see Ralston and Howard 1995, Ralston et al. 2013). Standardized abundances were obtained by summing the number of 100 day old equivalent fishes within a haul. This effectively standardizes the contribution of all fish to a common age of 100 days, i.e., younger fish are downweighted and older fish are up-weighted. The number of age observations for each species is available in the 2015 documentation.

Following discussions during the 2006 Pre-Recruit Survey Workshop related to the strengths and weaknesses of alternative analytical approaches, indices distributed to stock assessment authors in recent assessment cycles (Ralston 2010, Sakuma and Ralston 2012) have been based on an ANOVA index, primarily because of its ability to best account for significant year x latitude interactions, and we continue this practice here. The specific form of the ANOVA mixed-effects model is:

$$\log(C_{i,j,k,l,m,n}+1) = Y_i \times L_j + Z_k + D_l + V_m + \varepsilon_{i,j,k,l,m,n}$$

with all independent variables treated as categorical. Specifically Y_i is a fixed year effect $\{Y_i \in 2001, 2002, \ldots, 2016\}$, L_j is a fixed latitudinal effect $\{L_j \in 32, 34, \ldots, 40\}$, Z_k is a fixed depth effect $\{Z_k \leq 160$ m or $Z > 160$ m$\}$, D_l is a fixed calendar date effect $\{D_l \in 120, 130, \ldots, 170\}$, V_m is a random vessel effect $[V_m \sim N(0,\sigma_v)]$, and $\varepsilon_{i,j,k,l,m,n}$ is normal error term $[\varepsilon \sim N(0,\sigma_\varepsilon)]$ for the n^{th} observation in a stratum. As in the case of the traditional ANOVA model, interactions between latitude and year were explicitly modeled.

Prior to this year, the model was fit to the data using PROC MIXED (SAS Institute Inc. 2004) and the year:latitude parameter estimates were bias-corrected, integrated over latitude, and error estimates summarized in a manner directly analogous to the traditional ANOVA approach. This year the code for developing the indices was migrated from SAS to the R programming language to facilitate future rapid computation of indices. In doing so, a non-trivial issue was discovered related to how the indices were compiled from the year:latitude results. Specifically, the model as previously run summed across latitude parameters in log space, and then backtransformed the sum for each year estimate. However, upon greater consideration it was determined that the appropriate approach is to back-transform the latitude bin results and then sum across latitudes within each year, to produce the annual index in arithmetic space. The use of log(C+1) as a response variable also introduces minor complications with respect to back-transformation to obtain means on the arithmetic scale.

As a consequence of the conflicting time series produced by these two slightly different approaches, we also developed indices based on the well-established delta-GLM model (Lo et al. 1992, Stefánsson, 1996) for these four stocks (as done in earlier assessment cycles as well as Ralston et al. 2013). This model has the greatest potential, in our view, to provide a stopgap approach to developing a YOY index until a deeper modeling exploration can be conducted. The delta-GLM components (binomial and positive models) both contained categorical covariates as described for the ANOVA, above. The delta-GLM was fit using the "rstanarm" package in R to obtain Bayesian posterior distributions of the delta-GLM index. Finally, we also report the resulting indices developed when using the VAST software package (Thorson et al. 2015) on the same data.

Results

We report results of the four modeling approaches (past implementation of the ANOVA approach, "corrected" ANOVA approach, delta-GLM, and VAST) for bocaccio (update assessment) and blue/deacon and yellowtail rockfish (full assessments). We also report results for shortbelly rockfish as this species is the most frequently encountered rockfish in the surveys, has a broad spatial distribution, and thus should provide a better basis for understanding differences in modeling results among these species.

These results are shown in Figure 2, and Table 2 provides the numerical values and the associated CVs. Importantly, upon making the correction to the calculation of the ANOVA indices, the indices for several species appear unusually "flat," particularly for bocaccio but for other species as well, suggesting that even this corrected approach is far less than an ideal means of deriving these indices. Most likely it is the log(catch+1) transformation, which is used to address the issue of large numbers of zeros in the data, that is leading to poor performance of this modeling approach, which was masked by the increased variability in the indices when the summation was done inappropriately.

Relative to the corrected ANOVA, both the delta-GLM and VAST approaches show considerably greater variability in the indices, with high and low values typically ranging from one to several orders of magnitude among different years. Differences in interannual variability between indices derived from the ANOVA and delta-type models (delta-GLM and VAST) also depend on the number of zeros in the data. For example, the corrected ANOVA approach is extremely flat relative to the other two approaches for bocaccio, a species that is fairly rare in these surveys (present in 8.5% of hauls in the nominal range during the 2001-2016 period). However, the ANOVA begins to resemble both the Delta-GLM and the VAST indices for shortbelly rockfish, a species present in a far greater fraction of hauls (34% of hauls in the nominal range during the 2001-2016 period). This lends additional support for the concerns that the log(catch+1) transformation used in the ANOVA method is inappropriate for those species that are rarely encountered in the survey.

Despite these challenges, there are some clear indications in the data, as illustrated in all modeling approaches, of very strong recruitment for some stocks and years, particularly in 2013 for all of these stocks. Such signals were also evident in the 2015 chilipepper assessment update (Field et al. 2015) as well as the 2015 bocaccio assessment (He et al. 2015) and the pending update. Given the consistency of this strong year class with recent observations, the indices should provide some utility for full assessments of blue and yellowtail rockfish this assessment cycle.

Discussion

For bocaccio, the “corrected” ANOVA result is the most consistent with the intent of what had been done in prior assessments, despite the fact that it does not indicate recruitment variability of the magnitude expected from other sources of data (e.g., fishery and survey length frequency data). Consequently, the bocaccio assessment also includes sensitivity analyses that use both the same index (not extended in time) from the 2015 model (the nominally incorrect ANOVA) as well as the indices developed using the delta-GLM and VAST approaches. As none of these approaches suggest unusually strong recruitment since the 2013 year class, which is now largely informed by length composition and other data sources, we think this is a reasonable short-term fix for the purposes of an update.

For the full assessments being conducted in 2017 (blue/deacon, yellowtail rockfish), our current preference would be to use the delta-GLM results. However, the results presented here will need to be refined for the appropriate spatial strata associated with assessment boundaries, and will likely require some additional exploration and documentation. For example, the current VAST outputs include all years regardless of the spatial coverage of the survey, which is inconsistent with previous approaches and should be interpreted with caution (we may have revised in time). The VAST indices also do not include a within-year temporal effect (period effect) to account for the seasonality of sampling, which has varied in surveys throughout the years and has been demonstrated to be an important factor for many species. Consequently, both the delta-GLM and the VAST these results should be considered preliminary, and can be revised and considered in greater detail prior to the full STAR Panels for those two species.

Our intent is to return to alternative means of developing indices, including evaluation delta-GLM models (including the VAST geostatistical approach) as more robust approaches for developing YOY recruitment indices to support West Coast rockfish assessments. Ongoing analyses indicate that in fact there is likely to be considerably more coherence in YOY abundance trends than earlier envisioned, and that the 2005-2006 period was atypical with respect to strong differences in abundance between the historical core survey area and coastwide abundance trends.

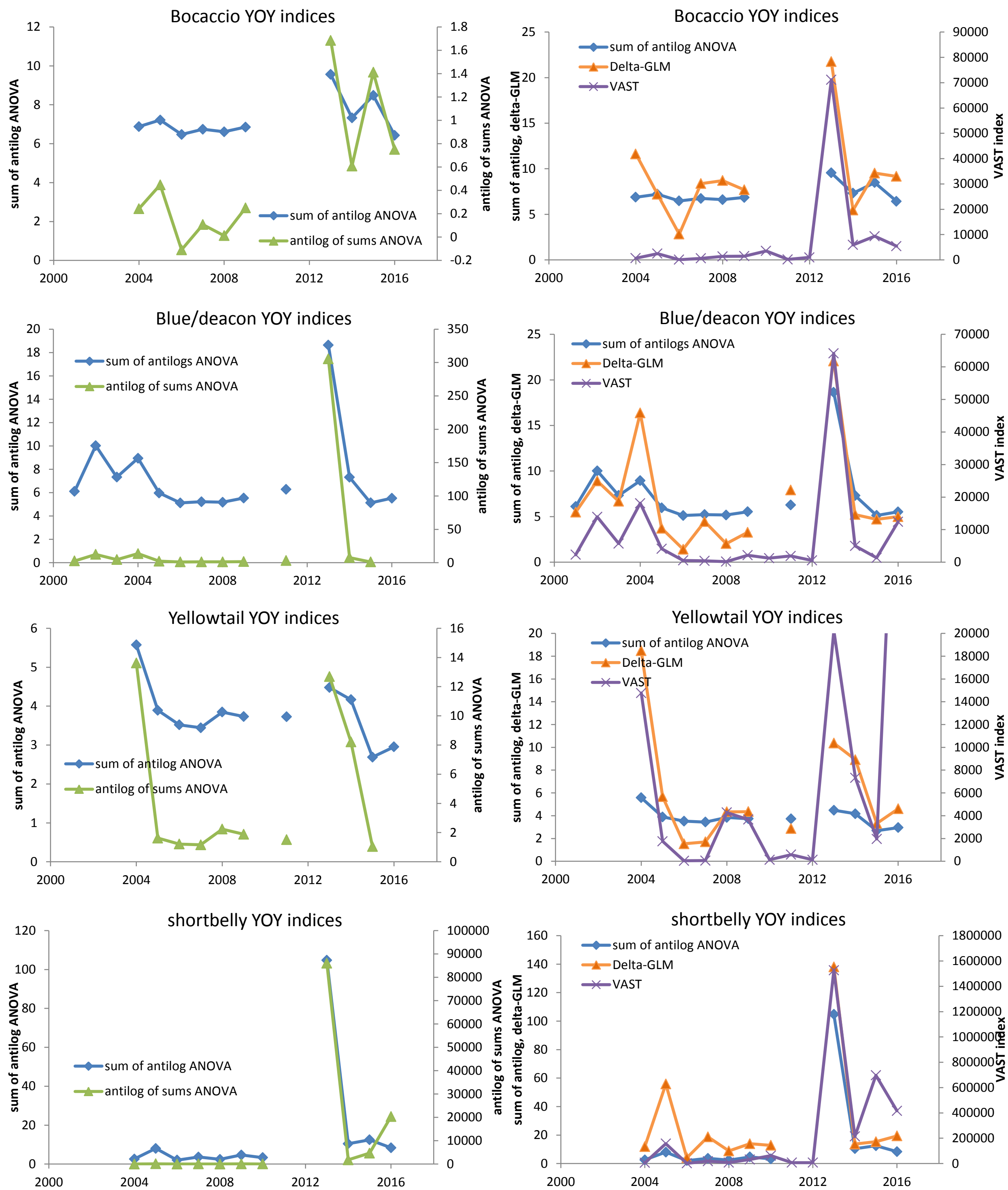

Figure 2: Comparisons of the two ANOVA based indices (using sum of the antilog values or the antilog of the sum of values for the year:latitude interaction model) for YOY rockfish (left panels) and of ANOVA, Delta-GLM and VAST indices for YOY rockfish indices (right panels).

Table 2: Index values and estimated coefficients of variation (CVs) from alternative approaches to developing YOY indices.

Bocaccio	sum antilog ANOVA		antilog sums ANOVA		Delta-GLM		VAST	
	Index	CV	Index	CV	Index	CV	Index	CV
2004	6.878	0.172	1.405	0.256	11.622	0.318	703	0.504
2005	7.216	0.171	1.724	0.237	7.193	0.318	2484	0.364
2006	6.471	0.17	0.987	0.228	2.831	0.46	97	0.75
2007	6.739	0.17	1.227	0.243	8.368	0.349	641	0.499
2008	6.613	0.17	1.115	0.246	8.705	0.355	1377	0.721
2009	6.852	0.171	1.414	0.286	7.692	0.413	1493	0.498
2010							3549	0.54
2011							184	0.791
2012							989	0.887
2013	9.556	0.166	5.94	0.299	21.754	0.378	71157	0.554
2014	7.327	0.169	2.023	0.321	5.458	0.367	5945	0.436
2015	8.481	0.166	4.521	0.251	9.523	0.302	9366	0.33
2016	6.43	0.174	2.333	0.555	9.169	0.438	5430	0.433

Blue/Deacon	sum antilog ANOVA		antilog sums ANOVA		Delta-GLM		VAST	
	Index	CV	Index	CV	Index	CV	Index	CV
2001	6.104	0.279	2.659	0.503	5.482	0.299	2288	0.436
2002	10.024	0.278	12.423	0.495	8.912	0.257	13937	0.289
2003	7.327	0.278	4.685	0.488	6.674	0.244	5729	0.387
2004	8.946	0.278	13.53	0.469	16.367	0.26	18113	0.291
2005	5.97	0.28	2.306	0.473	3.718	0.279	4132	0.311
2006	5.119	0.278	1.16	0.464	1.421	1.553	542	0.855
2007	5.218	0.277	1.274	0.461	4.456	0.375	420	0.52
2008	5.177	0.279	1.225	0.477	2.034	0.526	192	0.629
2009	5.534	0.275	1.683	0.466	3.278	0.314	2129	0.29
2010							1240	0.769
2011	6.283	0.281	3.102	0.5	7.909	0.42	1913	0.557
2012							542	0.855
2013	18.645	0.272	305.436	0.712	22.066	0.328	64142	0.203
2014	7.316	0.271	7.709	0.685	5.221	0.361	5002	0.352
2015	5.129	0.235	1.182	0.637	4.703	0.428	1340	0.54
2016	5.526	0.385	0	0	4.995	0.549	12412	0.475

Yellowtail	sum antilog ANOVA		antilog sums ANOVA		Delta-GLM		VAST	
	Index	CV	Index	CV	Index	CV	Index	CV
2004	5.575	0.314	13.624	0.33	18.472	0.316	14765	0.283
2005	3.892	0.314	1.62	0.333	5.669	0.328	1756	0.357
2006	3.518	0.313	1.214	0.327	1.531	0.72	45	1.078
2007	3.442	0.314	1.159	0.325	1.7	0.69	57	1.057
2008	3.846	0.314	2.239	0.335	4.341	0.324	4280	0.485
2009	3.732	0.31	1.884	0.328	4.354	0.315	3663	0.654
2010							129	0.993
2011	3.726	0.315	1.52	0.35	2.866	0.563	585	0.984
2012							129	0.993
2013	4.477	0.238	12.694	0.487	10.366	0.42	20243	0.474
2014	4.167	0.236	8.213	0.471	8.912	0.444	7323	0.359
2015	2.689	0.21	1.041	0.442	3.315	0.645	1957	0.577
2016	2.954	0.29	0	0	4.603	0.614	42874	0.432

Shortbelly	sum antilog ANOVA		antilog sums ANOVA		Delta-GLM		VAST	
	Index	CV	Index	CV	Index	CV	Index	CV
2004	2.602	0.827	10.099	0.67	11.849	0.666	6091	0.467
2005	8.011	0.854	106.005	0.592	55.807	0.528	157359	0.303
2006	2.04	0.812	3.018	0.578	4.066	0.863	1962	0.576
2007	3.625	0.837	17.624	0.64	18.742	0.62	18509	0.406
2008	2.416	0.81	6.573	0.636	8.838	0.739	7666	0.352
2009	4.676	0.825	79.865	0.826	13.902	0.61	32000	0.402
2010	3.323	0.9	27.044	0.853	12.817	0.931	62008	0.412
2011							7550	1.186
2012							7550	1.186
2013	104.757	1.662	85988.419	0.794	138.074	0.437	1526456	0.287
2014	10.426	1.667	1792.581	0.9	13.662	0.525	214435	0.388
2015	12.477	1.624	4677.989	0.68	15.331	0.45	697206	0.295
2016	8.375	0.468	20330.549	0.838	19.365	0.595	416177	0.366

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Appendix C. Numbers of fish (1000s') by year, sex and age from the base model (1 = female; 2 = male). Numbers in the last column are sums of fish aged 17 and older.

Year.	Sex	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17+
1892	1	3127	2619	2186	1820	1514	1258	1046	870	724	602	502	418	348	290	241	201	167	839
1892	2	3127	2619	2186	1822	1515	1260	1047	870	723	601	500	416	346	288	240	200	166	828
1893	1	3127	2612	2186	1820	1514	1258	1046	870	724	602	502	418	348	290	241	201	167	838
1893	2	3127	2612	2186	1821	1515	1259	1046	870	723	601	500	416	346	288	240	200	166	828
1894	1	3127	2612	2179	1821	1514	1258	1046	869	723	602	501	418	348	290	241	201	167	838
1894	2	3127	2612	2180	1822	1515	1259	1046	870	723	601	500	416	346	288	240	200	166	828
1895	1	3127	2612	2179	1816	1515	1259	1046	870	724	602	502	418	348	290	241	201	167	839
1895	2	3127	2612	2180	1817	1516	1260	1047	870	723	601	500	416	346	288	240	200	166	828
1896	1	3127	2612	2180	1816	1511	1260	1047	870	724	603	502	418	348	290	241	201	168	839
1896	2	3127	2612	2180	1817	1512	1261	1048	871	724	602	501	416	347	288	240	200	166	828
1897	1	3127	2612	2180	1816	1512	1257	1048	871	725	603	502	418	348	290	242	201	168	839
1897	2	3127	2612	2180	1817	1513	1258	1049	871	724	602	501	417	347	289	240	200	166	828
1898	1	3128	2612	2180	1817	1512	1258	1046	872	725	604	502	418	348	290	242	201	168	839
1898	2	3128	2612	2180	1818	1513	1259	1046	872	725	603	501	417	347	289	240	200	166	829
1899	1	3128	2612	2180	1817	1513	1258	1047	871	726	604	503	419	349	290	242	201	168	840
1899	2	3128	2612	2180	1818	1514	1259	1047	871	726	604	502	418	347	289	241	200	167	830
1900	1	3128	2612	2180	1817	1513	1259	1047	871	725	605	504	419	349	291	242	202	168	840
1900	2	3128	2612	2180	1818	1514	1260	1048	872	725	605	503	418	348	289	241	200	167	830
1901	1	3128	2612	2180	1817	1512	1258	1047	872	726	604	504	420	349	291	242	202	168	840
1901	2	3128	2612	2180	1818	1513	1259	1048	872	725	603	503	419	348	290	241	200	167	831
1902	1	3128	2612	2180	1816	1512	1258	1047	871	726	604	503	420	350	291	242	202	168	841
1902	2	3128	2612	2180	1817	1513	1259	1047	871	725	603	502	419	348	290	241	201	167	831

Table (continued).

Year.	Sex	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17+
1903	1	3128	2612	2180	1816	1511	1256	1045	870	725	604	503	419	350	291	242	202	168	841
1903	2	3128	2612	2180	1817	1512	1258	1046	870	725	603	502	418	349	290	241	201	167	831
1904	1	3128	2612	2180	1816	1510	1255	1044	869	724	603	503	419	349	291	243	202	168	841
1904	2	3128	2612	2180	1817	1511	1257	1045	869	724	602	502	418	348	290	241	201	167	831
1905	1	3128	2612	2179	1815	1509	1254	1043	868	723	603	502	419	349	291	243	202	168	841
1905	2	3128	2612	2180	1816	1511	1256	1044	868	722	601	501	417	347	289	241	201	167	831
1906	1	3127	2612	2179	1814	1508	1253	1042	867	722	601	501	418	348	290	242	202	168	841
1906	2	3127	2612	2180	1816	1510	1254	1042	866	721	600	500	416	347	289	241	201	167	831
1907	1	3127	2611	2179	1814	1507	1252	1040	865	720	600	500	417	348	290	242	201	168	840
1907	2	3127	2612	2179	1815	1509	1253	1041	865	719	599	499	416	346	288	240	200	167	830
1908	1	3126	2611	2178	1813	1506	1251	1039	864	719	599	499	416	347	290	241	201	168	839
1908	2	3126	2611	2179	1815	1508	1252	1040	864	718	597	497	414	345	288	240	200	166	829
1909	1	3126	2611	2178	1812	1505	1249	1037	862	717	598	498	415	346	289	241	201	167	838
1909	2	3126	2611	2178	1814	1507	1251	1038	862	717	596	496	413	344	287	239	199	166	828
1910	1	3125	2610	2177	1811	1503	1247	1035	860	716	596	497	414	345	288	240	200	167	838
1910	2	3125	2610	2178	1812	1505	1249	1036	860	715	594	495	412	343	286	238	199	166	827
1911	1	3125	2610	2176	1809	1501	1244	1032	858	714	594	495	413	344	287	239	200	167	835
1911	2	3125	2610	2177	1811	1503	1246	1033	858	712	592	493	410	342	285	237	198	165	822
1912	1	3124	2609	2176	1808	1498	1241	1029	855	711	592	493	411	343	286	238	199	166	832
1912	2	3124	2609	2176	1810	1501	1243	1030	855	710	590	491	409	340	283	236	197	164	821
1913	1	3123	2608	2175	1806	1496	1238	1026	852	708	590	491	409	341	285	237	198	165	831
1913	2	3123	2608	2175	1809	1499	1241	1027	851	707	587	488	407	339	282	235	196	163	817
1914	1	3122	2607	2174	1805	1494	1235	1022	848	705	587	489	408	340	283	236	197	164	827
1914	2	3122	2607	2174	1807	1497	1238	1024	848	703	584	486	404	337	280	234	195	162	813
1915	1	3120	2606	2172	1803	1491	1232	1019	845	702	584	486	405	338	282	235	196	164	824
1915	2	3120	2606	2173	1806	1494	1235	1021	845	700	581	483	402	335	279	232	194	161	808
1916	1	3119	2605	2170	1799	1487	1228	1015	841	698	581	483	403	336	280	234	195	163	820
1916	2	3119	2605	2171	1802	1490	1231	1016	840	696	578	480	399	332	277	231	192	160	803
1917	1	3117	2603	2164	1789	1474	1216	1006	833	692	575	479	399	333	278	232	193	161	814
1917	2	3117	2603	2166	1792	1478	1219	1006	832	689	572	475	395	329	274	228	190	158	795

Table (continued).

Year.	Sex	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17+
1918	1	3114	2601	2161	1779	1458	1199	991	822	683	568	473	395	329	275	229	191	160	805
1918	2	3114	2602	2164	1785	1464	1203	991	819	679	563	468	389	324	270	225	187	156	784
1919	1	3110	2599	2163	1783	1456	1190	980	811	675	562	468	390	326	272	227	189	158	799
1919	2	3110	2599	2165	1787	1463	1195	981	809	670	556	462	384	320	267	222	185	154	775
1920	1	3108	2596	2162	1787	1464	1194	977	805	669	557	464	387	323	270	225	188	157	792
1920	2	3108	2596	2163	1791	1470	1199	979	805	665	551	458	381	317	264	220	183	153	767
1921	1	3106	2595	2160	1787	1469	1201	980	804	664	552	460	384	320	267	223	186	156	786
1921	2	3106	2595	2162	1791	1474	1206	984	804	661	547	454	378	314	262	218	182	151	761
1922	1	3105	2593	2160	1788	1472	1208	989	808	664	549	457	381	318	266	222	185	155	782
1922	2	3105	2593	2161	1792	1477	1212	992	809	662	545	452	375	312	260	216	180	150	756
1923	1	3105	2592	2158	1787	1472	1210	994	815	667	549	455	378	316	264	220	184	153	776
1923	2	3105	2593	2159	1790	1477	1214	996	816	667	546	450	373	310	258	215	179	149	750
1924	1	3105	2592	2158	1786	1471	1210	995	819	672	552	454	376	313	262	219	182	152	772
1924	2	3105	2593	2159	1789	1475	1213	997	819	671	549	450	372	308	256	213	178	148	744
1925	1	3104	2592	2158	1785	1470	1209	995	820	676	556	456	376	312	260	217	181	151	765
1925	2	3104	2592	2159	1789	1474	1212	997	820	674	553	453	372	307	254	212	176	147	738
1926	1	3104	2591	2153	1779	1463	1202	989	816	674	557	458	377	310	258	215	179	150	759
1926	2	3104	2591	2155	1783	1468	1206	991	815	672	553	454	372	306	253	210	174	145	730
1927	1	3102	2590	2153	1774	1455	1194	982	810	670	555	459	378	311	256	213	177	148	752
1927	2	3102	2591	2155	1779	1460	1198	983	809	667	551	454	373	306	252	208	173	144	722
1928	1	3100	2588	2151	1773	1451	1188	976	805	666	552	458	379	312	257	212	176	147	745
1928	2	3100	2589	2153	1777	1457	1192	978	804	663	547	452	373	307	252	207	171	142	713
1929	1	3099	2587	2150	1772	1450	1185	972	801	662	549	456	378	313	258	212	175	145	738
1929	2	3099	2588	2152	1777	1456	1190	974	800	659	544	450	372	307	253	208	171	141	705
1930	1	3098	2586	2148	1769	1448	1183	969	796	658	545	453	376	312	259	213	176	145	731
1930	2	3098	2586	2150	1774	1453	1187	970	795	654	540	446	370	306	253	208	171	141	697
1931	1	3096	2585	2148	1767	1444	1179	965	792	653	541	449	373	310	257	213	176	145	724
1931	2	3096	2585	2150	1773	1450	1184	966	791	650	535	442	366	303	251	208	171	141	691
1932	1	3094	2584	2149	1772	1448	1180	964	791	651	538	446	370	308	256	213	176	146	719
1932	2	3094	2584	2151	1776	1454	1185	967	790	648	533	440	364	301	250	207	171	141	685

Table (continued).

Year.	Sex	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17+
1933	1	3094	2583	2149	1776	1456	1188	969	793	652	538	445	369	307	255	212	176	146	717
1933	2	3094	2583	2151	1780	1462	1193	972	794	650	533	439	363	300	249	206	171	141	683
1934	1	3095	2582	2147	1775	1460	1196	977	799	655	539	445	368	306	254	211	176	146	715
1934	2	3095	2582	2149	1778	1464	1200	980	799	654	535	440	362	299	248	206	170	141	682
1935	1	3095	2583	2146	1772	1457	1197	982	804	658	541	446	368	305	253	210	175	146	714
1935	2	3095	2583	2148	1775	1461	1200	984	804	657	538	441	363	299	247	205	170	141	682
1936	1	3095	2582	2145	1768	1451	1191	980	807	662	543	447	368	304	252	209	174	145	711
1936	2	3095	2583	2147	1772	1456	1195	981	806	660	540	442	363	299	246	204	169	140	679
1937	1	3094	2582	2145	1766	1447	1185	975	804	663	545	448	369	304	251	208	173	144	710
1937	2	3094	2583	2147	1771	1452	1189	976	803	660	541	444	364	299	246	203	168	139	675
1938	1	3094	2582	2146	1770	1450	1186	973	802	663	547	451	370	305	252	208	172	143	706
1938	2	3094	2582	2148	1774	1455	1190	974	801	659	543	446	366	300	247	203	168	139	673
1939	1	3094	2582	2149	1776	1458	1193	977	803	663	548	453	373	307	253	209	173	143	705
1939	2	3094	2582	2150	1779	1463	1197	979	802	660	544	448	369	302	248	204	168	139	672
1940	1	3096	2583	2149	1779	1465	1202	984	807	664	549	455	376	310	255	210	173	143	705
1940	2	3096	2583	2150	1782	1469	1205	986	807	662	545	450	371	305	250	206	169	139	672
1941	1	3097	2584	2151	1782	1470	1209	992	814	668	550	455	377	312	257	211	174	144	704
1941	2	3097	2584	2152	1784	1473	1212	994	814	667	548	451	373	307	253	207	170	140	673
1942	1	3099	2586	2155	1789	1478	1218	1002	823	676	555	457	378	314	259	214	176	145	707
1942	2	3099	2586	2156	1791	1481	1221	1004	824	676	554	455	375	309	255	210	172	142	675
1943	1	3102	2588	2156	1792	1485	1226	1011	832	684	562	461	380	315	261	216	178	146	707
1943	2	3102	2588	2157	1793	1486	1228	1013	833	684	561	460	378	311	257	212	174	143	681
1944	1	3104	2590	2154	1782	1474	1219	1008	832	686	564	464	381	314	260	216	178	147	707
1944	2	3104	2590	2155	1785	1476	1221	1009	832	685	563	462	379	311	257	212	175	144	680
1945	1	3101	2591	2148	1761	1442	1189	985	816	676	558	460	378	311	257	213	176	146	698
1945	2	3101	2591	2152	1768	1448	1191	985	814	673	555	457	375	308	253	209	173	142	671
1946	1	3094	2588	2151	1761	1423	1160	957	795	661	549	454	375	309	254	210	174	144	690
1946	2	3094	2589	2154	1769	1433	1165	957	792	657	544	449	370	304	250	206	170	140	662
1947	1	3091	2582	2150	1766	1431	1153	941	779	649	541	449	372	307	253	208	172	143	686
1947	2	3091	2582	2152	1773	1440	1161	944	777	644	534	443	366	302	249	204	168	139	658

Table (continued).

Year.	Sex	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17+
1948	1	3087	2576	2140	1765	1438	1162	938	767	636	531	443	369	306	253	208	171	142	681
1948	2	3087	2577	2142	1770	1445	1169	943	767	632	525	436	362	300	247	204	167	138	654
1949	1	3086	2572	2131	1751	1434	1167	945	765	628	522	436	364	303	252	208	171	141	679
1949	2	3086	2573	2133	1756	1440	1172	949	767	625	516	429	357	297	246	203	167	137	649
1950	1	3084	2568	2116	1727	1408	1154	943	767	623	513	427	357	299	249	207	171	141	674
1950	2	3084	2569	2120	1734	1414	1157	943	766	621	507	420	350	291	242	201	166	136	643
1951	1	3078	2564	2096	1686	1361	1112	917	755	618	504	416	347	291	243	203	168	139	666
1951	2	3078	2565	2102	1695	1367	1112	913	749	612	497	408	338	282	235	196	162	134	633
1952	1	3068	2555	2073	1639	1299	1053	871	726	603	496	406	336	281	236	197	165	137	653
1952	2	3068	2557	2083	1653	1307	1052	862	715	591	485	396	326	271	226	189	157	131	618
1953	1	3055	2543	2048	1591	1236	988	815	684	576	482	398	327	271	227	191	160	133	641
1953	2	3055	2546	2060	1608	1246	985	802	666	558	465	384	315	260	216	181	151	126	602
1954	1	2977	2523	2020	1548	1179	926	755	634	539	458	385	319	263	218	183	154	129	625
1954	2	2977	2526	2033	1567	1190	923	741	612	515	435	365	303	249	206	172	144	121	581
1955	1	2640	2441	1960	1480	1113	861	694	579	494	424	363	306	255	210	175	146	123	605
1955	2	2640	2446	1976	1500	1124	858	678	554	465	396	337	285	237	196	162	136	114	555
1956	1	2679	2152	1850	1374	1013	779	623	517	440	380	329	284	240	201	166	138	116	578
1956	2	2679	2157	1870	1398	1024	773	604	489	408	348	299	257	218	182	151	125	105	520
1957	1	3410	2192	1624	1266	908	685	547	453	385	333	291	254	220	187	156	129	108	544
1957	2	3410	2197	1646	1296	923	678	526	423	351	298	258	224	193	165	138	115	96	478
1958	1	4382	2795	1653	1098	820	601	472	392	333	288	252	222	195	169	144	121	100	506
1958	2	4382	2802	1677	1129	838	598	452	362	299	253	218	190	166	144	124	104	86	435
1959	1	4874	3607	2141	1136	717	544	415	339	288	250	218	193	170	150	130	111	93	470
1959	2	4874	3614	2169	1170	738	546	400	312	256	216	185	161	141	124	108	93	78	394
1960	1	4886	4022	2810	1524	773	494	388	306	255	220	192	169	150	133	117	102	87	444
1960	2	4886	4028	2840	1565	798	501	379	285	227	189	161	140	122	108	95	83	71	365
1961	1	4630	4043	3192	2084	1090	558	366	294	235	198	173	151	134	119	106	93	81	421
1961	2	4630	4048	3217	2127	1121	569	363	280	214	173	145	125	108	95	84	74	65	343
1962	1	5274	3838	3245	2440	1554	819	427	285	231	187	158	138	122	108	96	85	75	406
1962	2	5274	3842	3264	2476	1588	835	429	278	217	167	136	115	99	86	76	67	59	326

Table (continued).

Year.	Sex	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17+
1963	1	5047	4374	3086	2499	1843	1183	633	335	225	185	150	127	111	98	87	77	69	390
1963	2	5047	4378	3103	2529	1871	1199	637	331	217	170	132	107	91	79	68	60	53	308
1964	1	4784	4190	3547	2413	1916	1420	923	501	267	181	149	121	103	90	79	70	63	373
1964	2	4784	4192	3562	2439	1941	1432	926	497	261	172	136	105	86	73	63	55	48	292
1965	1	24830	3969	3397	2792	1876	1498	1123	738	403	216	147	121	98	84	73	65	57	355
1965	2	24830	3972	3410	2815	1896	1509	1122	732	396	209	138	109	85	70	59	51	45	277
1966	1	4423	20506	3151	2589	2104	1430	1162	883	586	322	174	118	98	80	68	59	52	334
1966	2	4423	20533	3171	2612	2117	1431	1153	869	572	312	165	110	87	68	56	47	41	258
1967	1	4754	3647	16069	2320	1864	1538	1073	891	688	461	255	138	94	78	64	54	48	311
1967	2	4755	3653	16207	2352	1878	1527	1051	864	661	440	242	129	86	68	53	44	37	236
1968	1	6088	3937	2924	12207	1713	1388	1170	832	701	546	368	205	111	76	63	51	44	290
1968	2	6088	3940	2941	12402	1739	1385	1143	800	666	515	345	191	102	68	54	42	35	219
1969	1	7543	5049	3195	2308	9515	1343	1101	937	672	569	445	300	167	91	62	51	42	273
1969	2	7544	5052	3206	2329	9667	1356	1089	906	638	535	415	279	154	83	55	44	34	206
1970	1	7430	6242	4079	2523	1811	7522	1073	887	760	547	464	364	246	137	74	51	42	260
1970	2	7430	6247	4093	2538	1826	7598	1074	869	727	515	433	337	227	126	67	45	36	197
1971	1	3016	6153	5049	3216	1973	1426	5989	862	718	618	446	380	298	202	112	61	42	247
1971	2	3016	6157	5066	3236	1983	1429	5997	855	696	586	416	351	273	184	102	55	36	190
1972	1	6265	2489	4925	3932	2489	1541	1128	4789	695	582	503	364	310	243	165	92	50	237
1972	2	6265	2491	4946	3957	2500	1538	1119	4738	680	557	471	336	283	221	149	83	44	184
1973	1	9354	5131	1919	3595	2841	1833	1164	869	3745	548	462	401	291	248	195	132	74	231
1973	2	9354	5142	1936	3632	2847	1814	1137	843	3621	525	434	368	264	223	175	118	65	182
1974	1	7236	7592	3802	1290	2349	1910	1287	847	649	2846	421	357	312	227	194	153	104	239
1974	2	7237	7616	3856	1317	2363	1870	1229	795	605	2650	390	325	278	200	170	133	90	189
1975	1	3370	5893	5709	2569	833	1552	1320	926	627	490	2175	324	277	242	177	152	119	269
1975	2	3371	5908	5784	2641	850	1528	1247	848	565	439	1951	290	244	209	151	129	101	213
1976	1	708	2752	4468	3965	1729	572	1105	971	697	480	379	1692	254	217	190	139	119	307
1976	2	708	2759	4521	4060	1774	573	1056	886	617	418	328	1475	220	186	161	116	99	243
1977	1	16649	579	2116	3174	2726	1208	413	821	737	537	373	296	1329	200	171	150	110	337
1977	2	16650	580	2138	3244	2790	1221	403	761	651	461	315	250	1129	169	143	124	90	266

Table (continued).

Year.	Sex	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17+
1978	1	11019	13639	447	1525	2226	1940	884	310	628	571	419	293	233	1051	158	136	119	355
1978	2	11019	13665	452	1554	2274	1959	873	294	566	491	351	242	193	874	131	111	97	278
1979	1	2410	8976	10318	313	1040	1549	1396	655	234	482	442	327	229	183	827	124	107	376
1979	2	2410	9000	10434	319	1058	1555	1371	626	215	421	369	266	184	148	672	101	86	289
1980	1	1596	1981	6926	7285	212	717	1105	1027	493	179	372	344	255	180	144	651	98	381
1980	2	1596	1985	7003	7454	217	717	1078	976	456	159	315	279	202	141	113	517	78	290
1981	1	786	1315	1557	5052	5111	150	519	820	777	378	138	289	268	200	141	113	511	377
1981	2	786	1317	1570	5167	5247	151	509	779	718	340	120	239	213	155	108	87	398	284
1982	1	343	643	1010	1108	3459	3525	106	377	608	584	287	106	222	207	154	109	87	689
1982	2	343	644	1021	1131	3547	3576	104	359	560	523	250	89	178	160	116	81	66	516
1983	1	503	283	496	702	728	2286	2404	74	272	447	435	215	80	168	157	117	83	591
1983	2	503	283	502	722	747	2314	2372	71	249	396	375	181	65	131	117	86	60	434
1984	1	7484	415	219	347	457	472	1530	1666	53	197	329	323	160	60	126	118	88	510
1984	2	7484	416	222	358	474	479	1505	1581	48	173	280	268	130	47	95	86	63	363
1985	1	1855	6166	325	155	226	296	316	1065	1195	39	147	247	244	122	45	96	90	458
1985	2	1855	6175	329	160	237	304	312	1005	1084	34	123	202	195	95	34	70	63	315
1986	1	924	1522	4757	226	99	144	196	219	763	877	29	110	187	186	93	35	74	423
1986	2	924	1525	4814	233	104	149	194	205	681	754	24	89	146	142	70	25	52	281
1987	1	1175	766	1201	3381	146	63	94	134	156	557	651	21	83	142	141	71	26	381
1987	2	1175	767	1214	3495	153	65	94	127	138	472	533	17	64	107	104	51	18	248
1988	1	4916	974	611	890	2333	99	43	67	98	116	420	495	16	64	109	109	55	317
1988	2	4916	975	616	913	2446	103	44	65	89	99	343	391	12	48	80	78	39	202
1989	1	1186	4062	768	440	598	1559	68	31	49	73	87	318	377	12	49	84	84	285
1989	2	1186	4067	775	452	621	1620	69	30	45	63	71	250	287	9	35	59	58	179
1990	1	1092	979	3176	541	284	380	1024	46	22	35	53	65	239	284	9	37	64	282
1990	2	1092	981	3212	558	296	391	1030	45	20	31	44	51	180	208	6	26	43	175
1991	1	1537	903	779	2326	366	188	259	722	33	16	26	40	49	183	219	7	28	268
1991	2	1537	904	785	2392	383	196	260	699	31	14	22	32	37	133	155	5	19	164
1992	1	1159	1272	720	578	1632	255	134	190	541	25	12	20	31	38	143	172	5	233
1992	2	1159	1273	725	591	1695	265	136	184	506	23	10	17	24	28	101	118	3	140

Table (continued).

Year.	Sex	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17+
1993	1	808	959	1013	535	406	1132	180	98	141	411	19	9	16	24	30	112	134	186
1993	2	808	960	1021	547	419	1170	184	96	133	371	17	8	12	18	21	77	90	112
1994	1	866	665	758	753	379	286	814	133	73	108	317	15	7	12	19	23	88	254
1994	2	866	666	763	767	390	293	824	132	70	98	278	13	6	9	14	16	59	155
1995	1	567	720	537	578	551	276	212	617	102	57	85	251	12	6	10	15	19	273
1995	2	567	721	540	588	565	283	214	611	99	53	75	215	10	4	7	11	13	169
1996	1	574	470	586	422	442	419	213	165	488	82	46	68	202	9	4	8	12	238
1996	2	574	471	588	428	452	429	215	165	475	77	42	60	171	8	3	6	9	145
1997	1	794	476	382	461	326	342	328	168	132	392	66	37	55	164	8	3	6	203
1997	2	794	476	383	465	331	348	332	168	129	376	61	33	48	137	6	3	4	124
1998	1	356	661	391	307	365	258	272	263	136	107	319	53	30	45	134	6	3	171
1998	2	356	661	392	309	369	261	275	264	135	104	303	50	27	39	111	5	2	104
1999	1	5174	295	542	317	247	294	209	222	215	111	88	262	44	25	37	110	5	143
1999	2	5174	295	543	318	249	297	211	223	215	110	85	248	41	22	32	91	4	88
2000	1	846	4300	242	441	257	201	240	171	182	177	92	72	216	36	20	30	91	122
2000	2	846	4302	243	442	258	202	241	172	182	176	90	70	204	33	18	26	75	75
2001	1	643	704	3551	198	360	210	165	197	141	150	146	76	60	179	30	17	25	177
2001	2	643	704	3555	199	361	211	165	198	141	150	145	74	57	168	27	15	21	124
2002	1	491	535	582	2921	163	296	173	136	163	117	125	121	63	50	149	25	14	169
2002	2	491	536	583	2926	163	297	173	136	163	117	124	120	61	48	140	23	12	121
2003	1	1578	410	445	482	2419	135	246	144	113	136	97	104	101	52	41	124	21	151
2003	2	1578	410	446	483	2422	135	246	144	113	136	97	103	100	51	40	116	19	112
2004	1	606	1315	340	369	401	2011	112	205	120	94	113	81	86	84	43	34	103	142
2004	2	606	1315	340	369	401	2012	112	205	120	94	113	81	86	83	42	33	97	108
2005	1	953	502	1072	276	302	329	1663	93	170	100	78	94	67	72	70	36	28	206
2005	2	953	503	1073	276	301	328	1658	93	169	99	78	94	67	71	69	35	27	170
2006	1	590	794	413	870	225	247	271	1376	77	141	83	65	78	56	60	58	30	195
2006	2	590	794	414	872	224	246	270	1367	77	140	82	65	78	56	59	57	29	166
2007	1	544	490	654	339	716	185	205	225	1144	64	117	69	54	65	47	50	48	188
2007	2	544	491	655	339	716	185	203	223	1134	64	116	68	54	65	46	49	48	161

Table (continued).

Year.	Sex	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17+
2008	1	446	453	405	537	278	591	154	170	187	952	53	98	57	45	54	39	41	196
2008	2	446	453	405	537	279	590	152	168	185	942	53	97	57	45	54	38	41	174
2009	1	890	371	374	333	442	230	490	127	141	156	793	44	81	48	37	45	32	197
2009	2	890	371	375	333	442	230	488	126	139	154	783	44	80	47	37	45	32	179
2010	1	2494	741	306	307	274	365	191	407	106	117	130	660	37	68	40	31	37	193
2010	2	2494	741	306	307	273	364	190	404	105	116	128	651	36	67	39	31	37	175
2011	1	2098	2070	607	249	251	225	302	158	338	88	98	108	550	31	56	33	26	191
2011	2	2098	2071	608	250	251	224	300	157	335	87	96	106	542	30	56	32	26	177
2012	1	1293	1742	1694	492	203	206	186	250	131	281	73	81	90	458	25	47	27	181
2012	2	1293	1743	1697	493	203	205	184	248	130	278	72	80	88	450	25	46	27	168
2013	1	7119	1074	1431	1380	402	167	170	154	208	109	234	61	68	75	381	21	39	173
2013	2	7119	1075	1433	1382	402	166	169	152	205	108	230	60	66	73	374	21	38	162
2014	1	3538	5928	887	1173	1133	332	138	141	128	173	91	195	51	56	62	318	17	177
2014	2	3538	5930	888	1174	1133	330	137	140	126	170	89	192	50	55	61	312	17	169
2015	1	1929	2949	4914	732	968	938	275	115	117	106	144	75	162	42	47	52	265	162
2015	2	1929	2950	4918	733	969	937	274	114	116	105	141	74	159	41	46	51	259	153
2016	1	1110	1609	2450	4068	606	802	778	228	95	97	88	119	63	135	35	39	43	355
2016	2	1110	1609	2451	4072	606	803	777	227	94	96	87	118	62	132	34	38	42	344
2017	1	2842	925	1336	2031	3373	503	667	647	190	79	81	73	99	52	112	29	32	331
2017	2	2842	925	1337	2032	3375	503	666	646	189	78	80	72	98	51	110	28	31	321