

¹ Status of California Scorpionfish (*Scorpaena*
² *guttata*) Off Southern California in 2017



³ Melissa H. Monk¹

⁴ Xi He¹

⁵ John Budrick²

⁶ ⁷ ¹Southwest Fisheries Science Center, U.S. Department of Commerce, National Oceanic and
⁸ Atmospheric Administration, National Marine Fisheries Service, 110 Shaffer Road, Santa Cruz,
⁹ California 95060

¹⁰ ²California Department of Fish and Wildlife, 350 Harbor Blvd., Belmont, California 94002

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⁸² **Executive Summary**

⁸³ **Stock**

⁸⁴ This assessment reports the status of the California scorpionfish (*Scorpaena guttata*) resource
⁸⁵ in U.S. waters off the coast of southern California (south of Pt. Conception) using data
⁸⁶ through 2016. California scorpionfish are most abundant in the southern California Bight
⁸⁷ and their range extends to Punta Eugena, Mexico, about halfway down the Baja peninsula.
⁸⁸ Catches from Mexico were not included in this assessment, and catches from Mexican waters
⁸⁹ that were landed in the U.S. were excluded from the catch histories.

⁹⁰ **Catches**

⁹¹ Information on historical landings of California scorpionfish are available back to 1916, with
⁹² the assumption that from 1916 to 1968 all of the commercial landings were caught by hook-
⁹³ and-line (Table [a](#)). Commercial landings were small during the years of World War II, ranging
⁹⁴ between 16 to 63 metric tons (mt) per year. The recreational fleets began ramping up in the
⁹⁵ 1960s and have dominated the catch since then (Figures [a-c](#)). The party/charter fleet has
⁹⁶ been the major component of the recreational sector since the early 2000's.

⁹⁷ The catches from the commercial fleets have been small in the last decade, ranging from 1.19 to
⁹⁸ 4.54 mt per year (Figure [d](#)). Since 2000, annual total landings of California scorpionfish have
⁹⁹ ranged between 57-199 mt, with landings in 2016 totaling 74 mt.

¹⁰⁰ California scorpionfish is not a major component of the commercial or recreational fisheries in
¹⁰¹ southern California. There is little discarding of the species in the commercial fisheries
¹⁰² and the discard mortality rate for the recreational fisheries is estimated to be 7%. The peak
¹⁰³ in discards from 2001-2005 was due to the closure of California scorpionfish fishery between
¹⁰⁴ two and ten months of the year during that period.

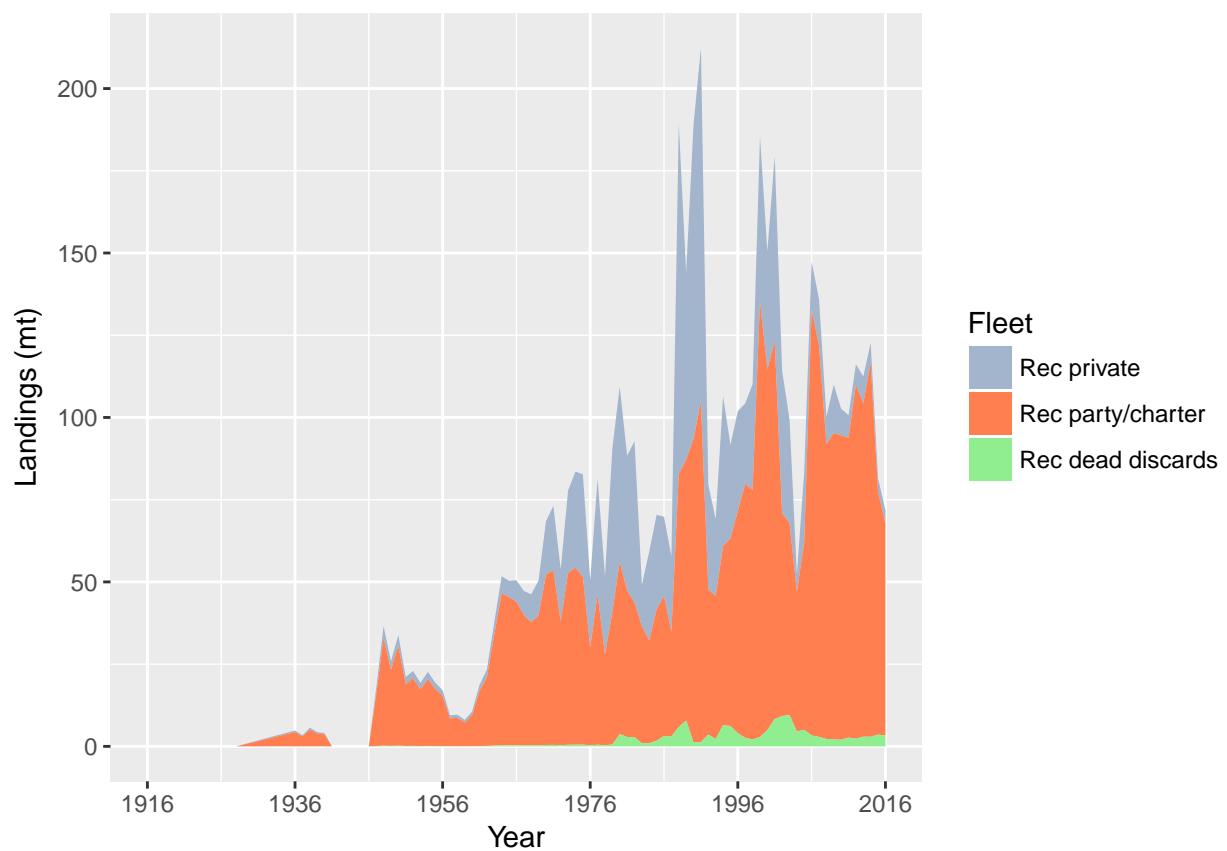


Figure a: California scorpionfish catch history for the recreational fleets.

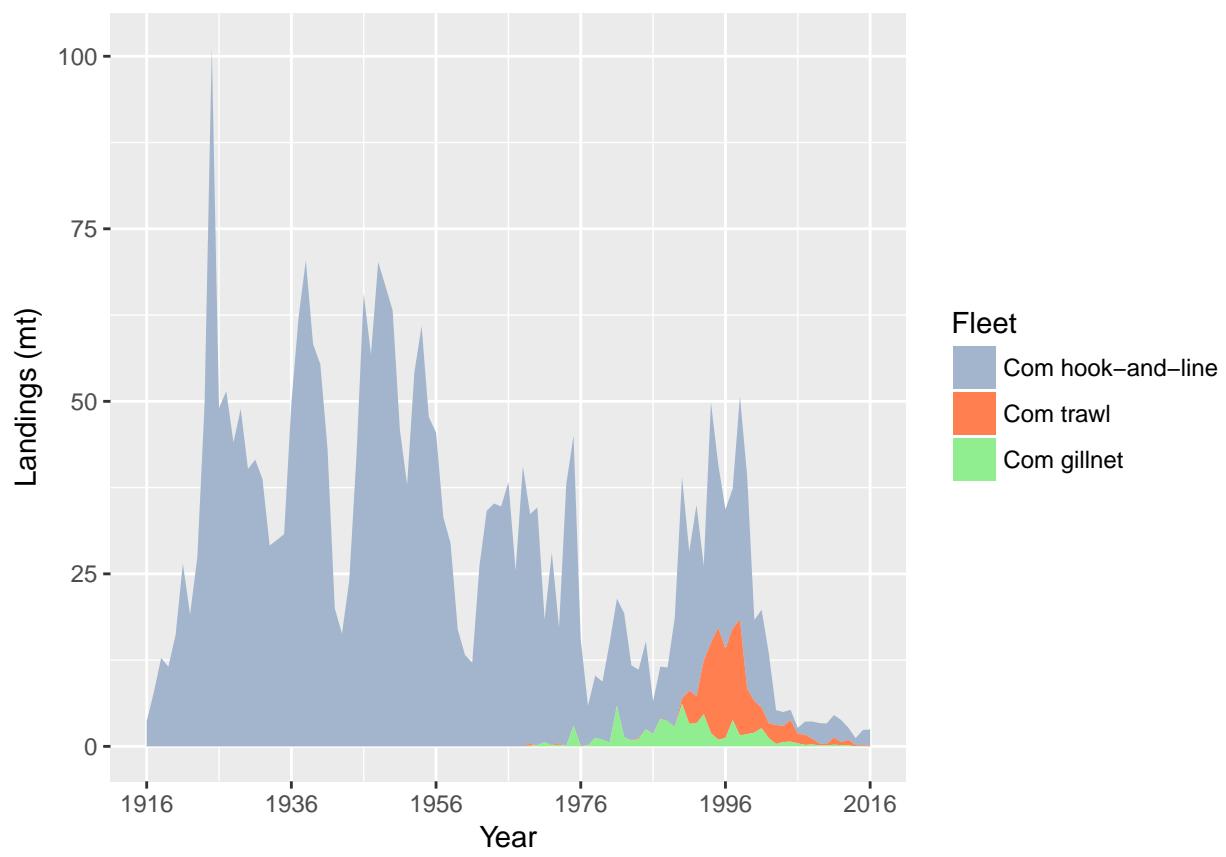


Figure b: Stacked line plot of California scorpionfish catch history for the commercial fleets.

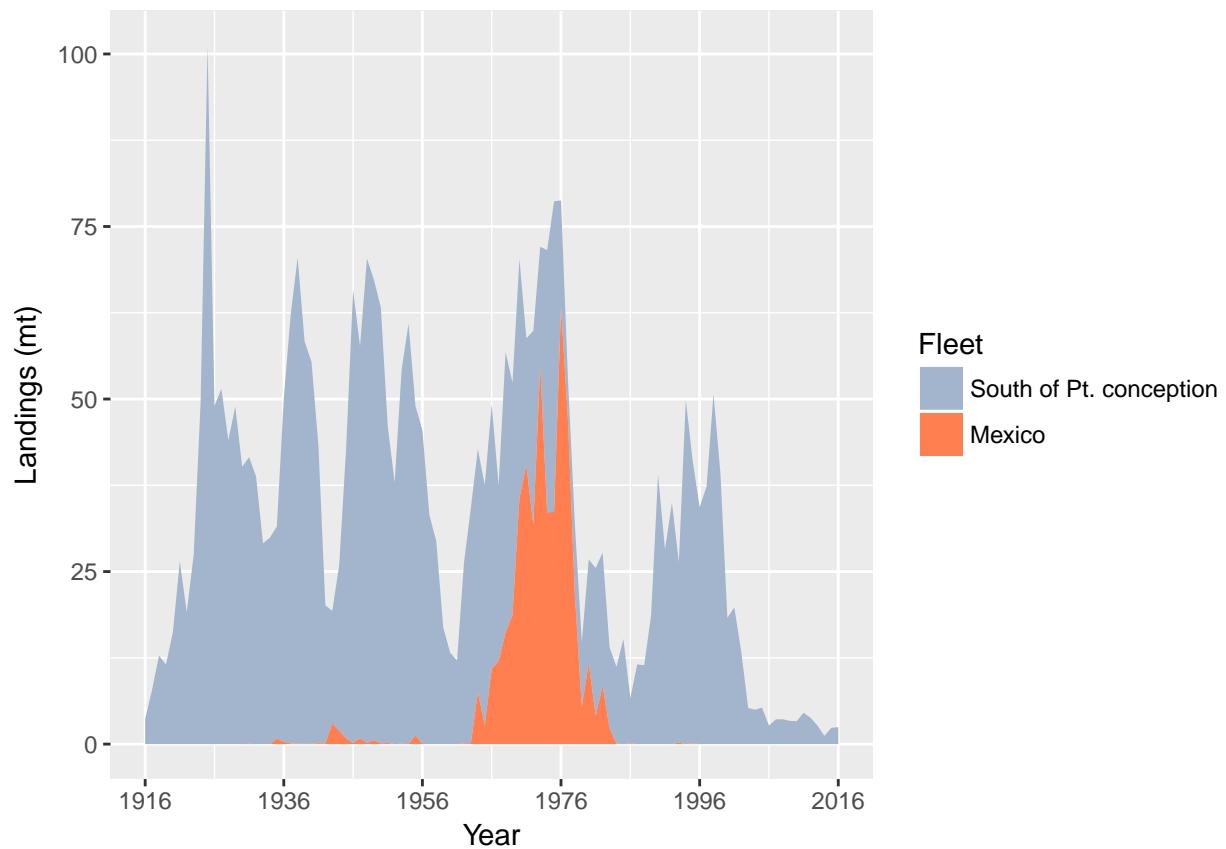


Figure c: Stacked line plot of California scorpionfish catch history from Pt. Conception to the U.S.-Mexico border and catches from Mexican waters.

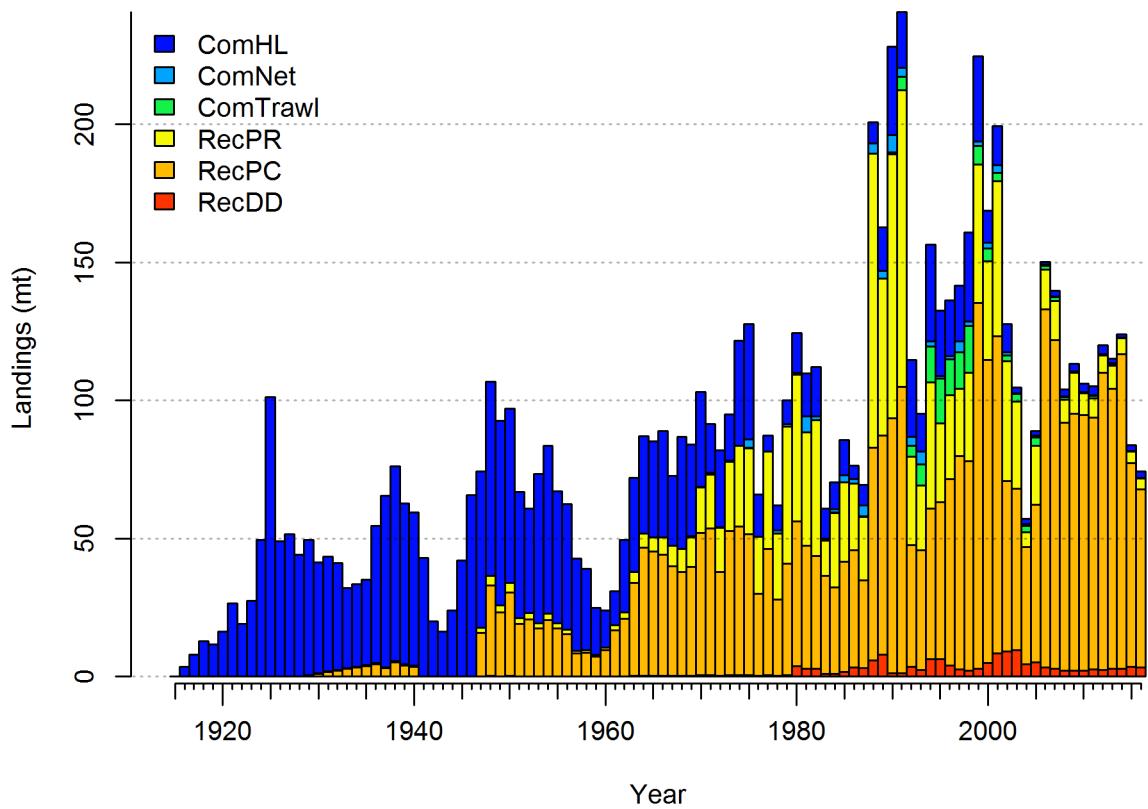


Figure d: Catch history of California scorpionfish in the base model.

Table a: Recent California scorpionfish landings (mt) by recreational (Rec.) and commercial (Com.) fleets.

Year	Rec. Private	Rec. Party/Charter	Rec. Dead Discards	Com. Hook-and-line	Com. Trawl	Com. Gillnet	Total
2007	14.24	118.87	2.89	1.90	1.48	0.21	139.58
2008	8.38	89.65	2.25	2.46	0.86	0.28	103.89
2009	14.68	93.16	2.09	2.97	0.27	0.13	113.31
2010	8.07	92.55	2.03	2.99	0.18	0.14	105.97
2011	6.84	91.18	2.66	3.24	1.05	0.24	105.21
2012	6.22	107.63	2.34	3.22	0.43	0.18	120.00
2013	8.18	101.31	2.94	1.73	0.83	0.14	115.14
2014	5.88	113.83	2.93	1.03	0.13	0.04	123.82
2015	4.15	73.78	3.59	2.21	0.13	0.03	83.89
2016	3.86	64.56	3.29	2.32	0.13	0.00	74.16

105 Data and Assessment

106 California scorpionfish was last assessed in 2005 . This assessment uses the newest version
 107 of Stock Synthesis (3.30.05). The model begins in 1916, and assumes the stock was at an
 108 unfished equilibrium that year.

109 This a new full assessment for California scorpionfish, which was last assessed in 2005
 110 (Maunder et al. 2005) using Stock Synthesis II version 1.18. In this assessment, aspects
 111 of the model including landings, data, and modelling assumptions were re-evaluated. The
 112 assessment was conducted using the length- and age-structured modeling software Stock
 113 Synthesis (version 3.30.05). The population was modeled allowing separate growth and
 114 mortality parameters for each sex (a two-sex model) from 1916 to 2016, and forecast beyond
 115 2016.

116 All of the data sources for California scorpionfish have been re-evaluated for 2016, including
 117 the historical fishery catch-per-unit effort time-series. The landings history has been updated
 118 and extended back to 1916. Harvest was negligible prior to that year. Survey data from five
 119 sources were used to develop indices of abundance: 1) sanitation district trawl surveys, 2)
 120 the NWFSC trawl survey, 3) a fishery-independent gill net survey, 4) the Southern California
 121 Bight regional monitoring program trawl survey, and 5) the onboard observer survey for
 122 retained catch. Length and conditional age-at-length compositions were also created for each
 123 fishery-dependent and -independent data source, including a generating station impingement
 124 survey that did not have an associated index of abundance.

125 The definition of fishing fleets have changed from those in the 2005 assessment.

126 Six fishing fleets were specified within the model: 1) a combined hook-and-line, fish pot, and
 127 “other” fishery fleet where only a small fraction of California scorpionfish, 2) the commercial
 128 gill net fleet, 3) the commercial trawl fleet, 4) the recreational party/charter boat fleet

¹²⁹ (retained catch only), 5) the recreational private boat fleet (retained catch only), and 6) a
¹³⁰ discard fleet that combined the estimated discards from the recreational party/charter and
¹³¹ private boat fleets

¹³² The assessment uses landings data; catch-per-unit-effort and survey indices; length or age
¹³³ composition data for each year and fishery or survey (with conditional age-at-length compo-
¹³⁴ sition data for the NWFSC trawl survey); information on weight-at-length; and estimates
¹³⁵ of ageing error. Recruitment at “equilibrium spawning output”, length-based selectivity of
¹³⁶ the fisheries and surveys, retention of the fishery, catchability of the surveys, growth, the
¹³⁷ time-series of spawning output, age and size structure, and current and projected future stock
¹³⁸ status are outputs of the model. Natural mortality and steepness were fixed in the final model.
¹³⁹ This was done due to relatively flat likelihood surfaces, such that fixing parameters and then
¹⁴⁰ varying them in sensitivity analyses was deemed the best way to characterize uncertainty.

¹⁴¹ Although there are many types of data available for California scorpionfish since the 1980s
¹⁴² which were used in this assessment, there is little information about steepness and natural
¹⁴³ mortality. Estimates of steepness are uncertain partly because of highly variable recruitment.
¹⁴⁴ Uncertainty in natural mortality is common in many fish stock assessments even when length
¹⁴⁵ and age data are available.

¹⁴⁶ A number of sources of uncertainty are explicitly included in this assessment. This assessment
¹⁴⁷ includes gender differences in growth, an updated length-weight curve, and new conditional
¹⁴⁸ length at age data. One of the largest sources of uncertainty that is not considered in the
¹⁴⁹ current model is the proportion of the stock in Mexico and the connectivity between the
¹⁵⁰ portion of the fishery in Mexican and U.S. waters.

¹⁵¹ A base model was selected which best captures the central tendency for those sources of
¹⁵² uncertainty considered in the model for the California scorpionfish stock in southern California
¹⁵³ (Figure e).

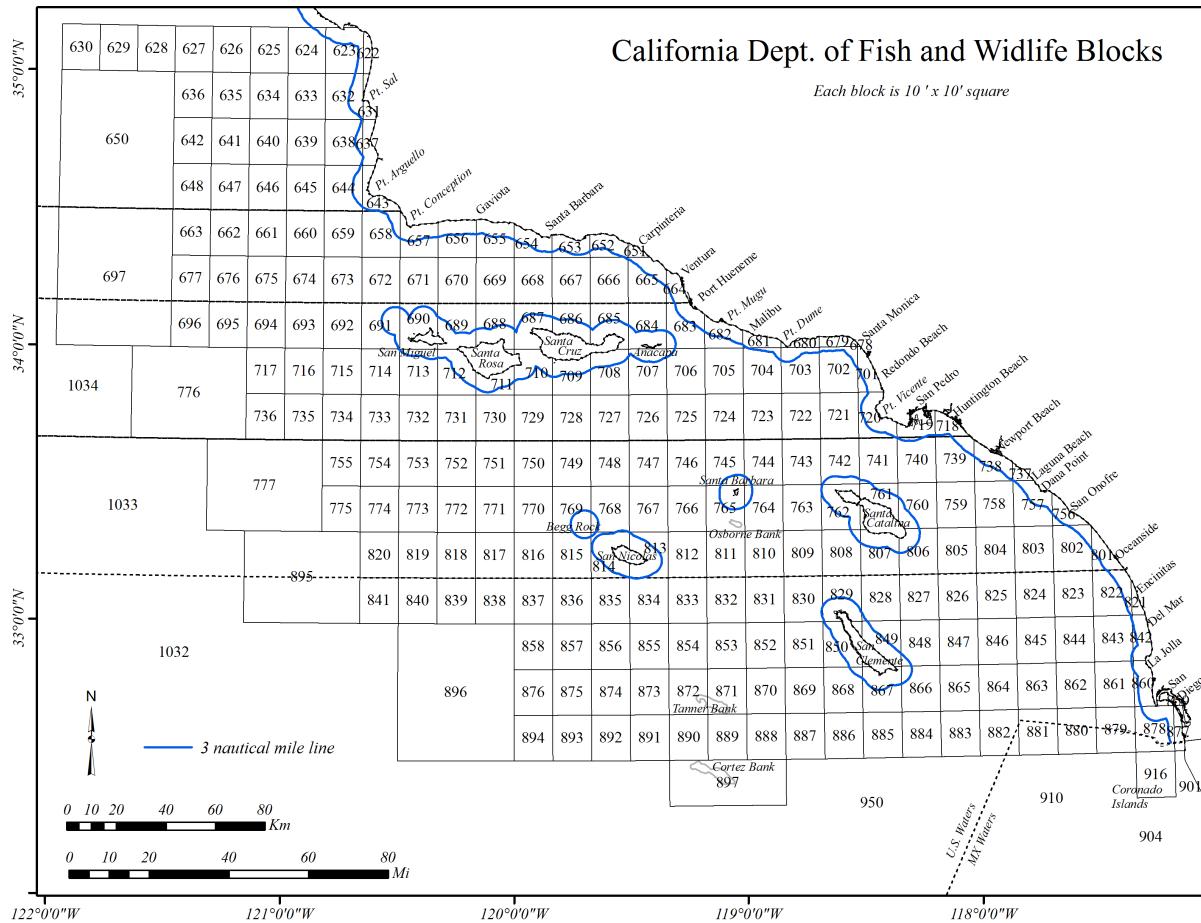


Figure e: Map depicting the boundaries for the base-case model.

¹⁵⁴ **Stock Biomass**

¹⁵⁵ The predicted spawning output from the base model generally showed a slight decline prior
¹⁵⁶ to 1965, when information on recruitment variability was available (Figure [f](#) and Table [b](#)).
¹⁵⁷ A short, but sharp decline occurred between 1965 and 1985, followed by a period cyclical
¹⁵⁸ spawning output and a decline from 2000 to 2015. The stock showed increases in stock size
¹⁵⁹ in 2015 due to a combination of strong recruitment and smaller catches in 2015 and 2016.
¹⁶⁰ The 2016 estimated spawning output relative to unfished equilibrium spawning output is
¹⁶¹ above the target of 40% of unfished spawning output at 57.8% (~95% asymptotic interval: ±
¹⁶² 45.8%-69.8%) (Figure [g](#)). Approximate confidence intervals based on the asymptotic variance
¹⁶³ estimates show that the uncertainty in the estimated spawning output is high.

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

Year	Spawning Output (mt)	~ 95% confidence interval	Estimated depletion	~ 95% confidence interval
2008	966.751	(557.5-1376)	0.710	(0.577-0.843)
2009	930.122	(541.36-1318.88)	0.683	(0.558-0.808)
2010	881.084	(514.78-1247.39)	0.647	(0.531-0.763)
2011	843.890	(496.37-1191.41)	0.620	(0.512-0.728)
2012	817.262	(484.55-1149.97)	0.600	(0.499-0.701)
2013	767.890	(452.31-1083.47)	0.564	(0.468-0.66)
2014	695.630	(401.97-989.29)	0.511	(0.42-0.602)
2015	646.363	(363.48-929.25)	0.475	(0.384-0.565)
2016	683.571	(383.62-983.52)	0.502	(0.402-0.602)
2017	787.209	(440.78-1133.64)	0.578	(0.458-0.698)

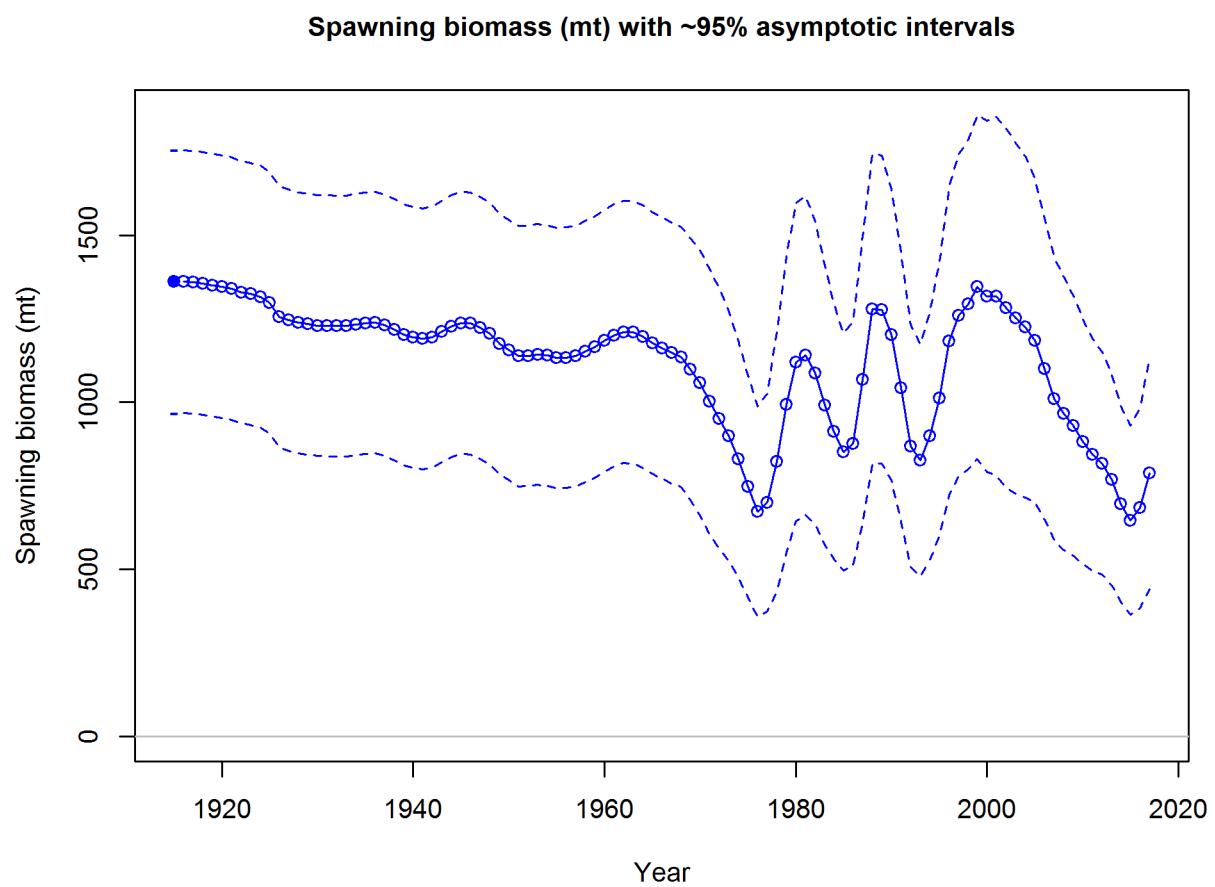


Figure f: Time series of spawning output trajectory (circles and line: median; light broken lines: 95% credibility intervals) for the base case assessment model.

Spawning depletion with ~95% asymptotic intervals

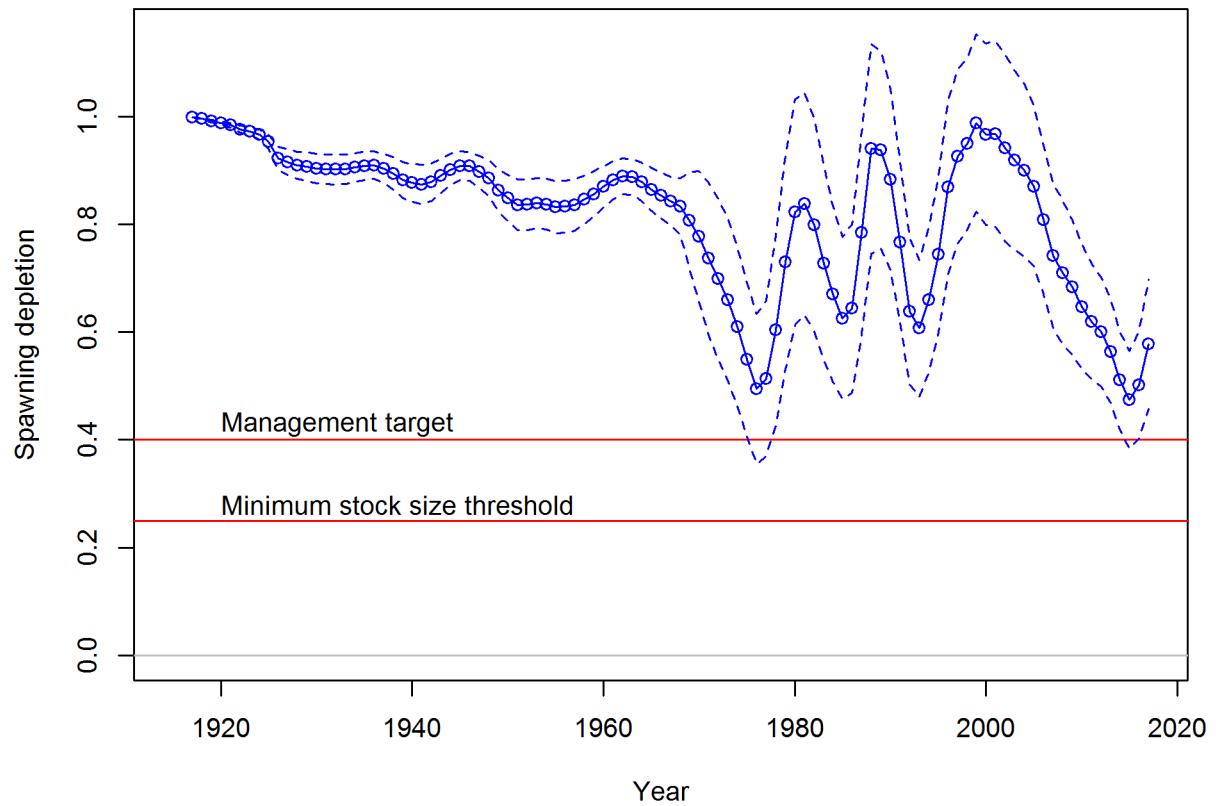


Figure g: Estimated relative depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model.

¹⁶⁴ **Recruitment**

¹⁶⁵ Recruitment deviations were estimated from 1965-2016 (Figure [h](#) and Table [c](#)). Historically,
¹⁶⁶ there are estimates of large recruitment from 1975-1977, 1984-1985 and in 1993 and 1996.
¹⁶⁷ There is early evidence of a strong recruitment in 2013. The four lowest recruitment estimated
¹⁶⁸ within the model (in ascending order) occurred in 2012, 2011, 1989, and 1988.

Table c: Recent recruitment for the base model.

Year	Estimated Recruitment (1,000s)	~ 95% confidence interval
2008	2266.73	(1167.95 - 4399.23)
2009	2782.03	(1500.8 - 5157.05)
2010	2308.55	(1197.59 - 4450.1)
2011	1168.17	(529.31 - 2578.13)
2012	1110.63	(497.23 - 2480.76)
2013	4078.66	(2241.3 - 7422.24)
2014	3465.61	(1593.78 - 7535.81)
2015	7369.42	(3330.16 - 16308.04)
2016	3173.38	(1032.42 - 9754.14)
2017	3249.61	(1057.99 - 9981.2)

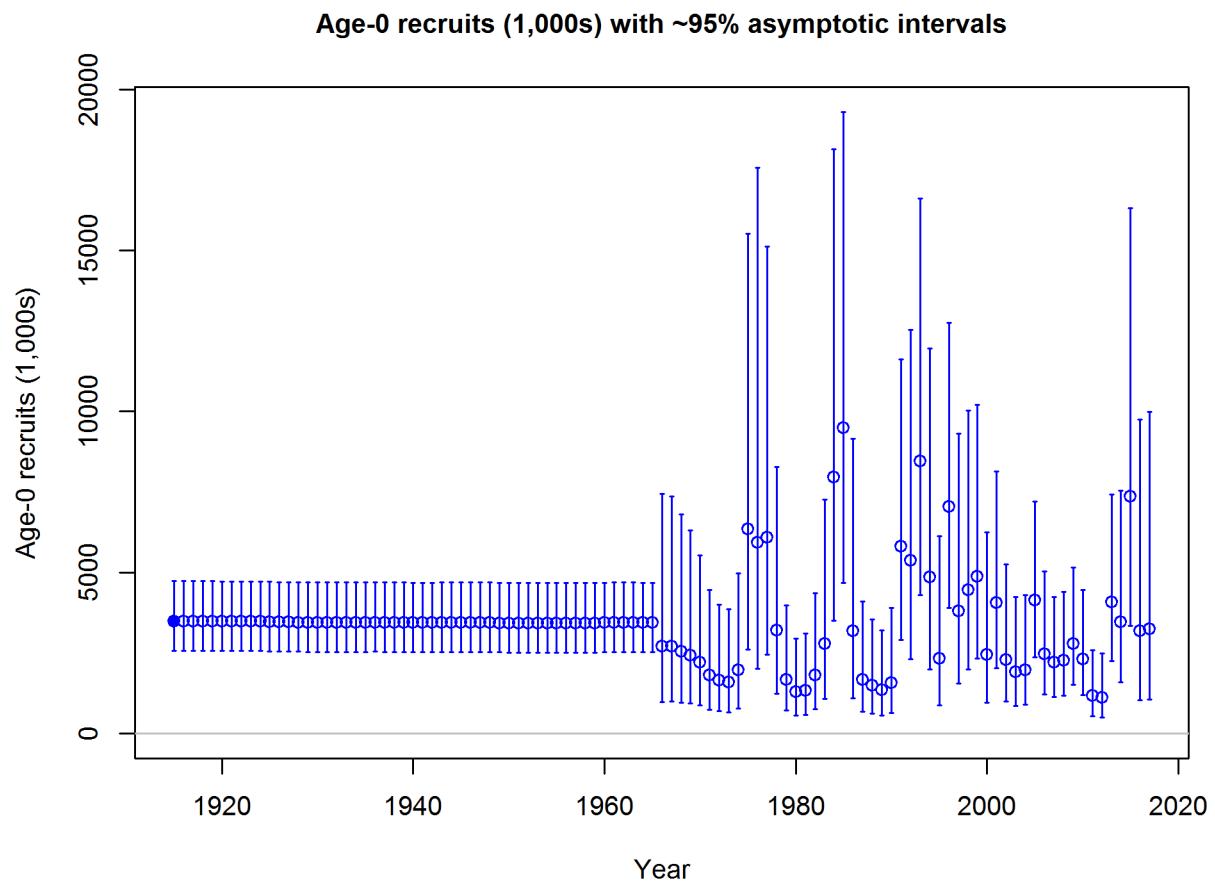


Figure h: Time series of estimated California scorpionfish recruitments for the base-case model with 95% confidence or credibility intervals.

¹⁶⁹ **Exploitation status**

¹⁷⁰ Harvest rates estimated by the base model for Washington have never exceeded management
¹⁷¹ target levels (Table d and Figure i). Recent harvest rates for California scorpionfish have been
¹⁷² relatively constant for the last decade. The estimated relative depletion is currently greater
¹⁷³ than the 40% unfished spawning output target. Recent exploitation rates on California
¹⁷⁴ scorpionfish were predicted to be significantly below target levels.

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

Year	Fishing intensity	~ 95% confidence interval	Exploitation rate	~ 95% confidence interval
2007	0.50	(0.35-0.66)	0.06	(0.04-0.09)
2008	0.43	(0.29-0.57)	0.05	(0.03-0.07)
2009	0.47	(0.32-0.62)	0.06	(0.04-0.08)
2010	0.47	(0.32-0.61)	0.05	(0.03-0.07)
2011	0.48	(0.33-0.63)	0.06	(0.04-0.08)
2012	0.55	(0.39-0.71)	0.07	(0.04-0.09)
2013	0.55	(0.39-0.72)	0.07	(0.04-0.1)
2014	0.60	(0.43-0.78)	0.08	(0.05-0.11)
2015	0.49	(0.33-0.65)	0.05	(0.03-0.08)
2016	0.46	(0.31-0.62)	0.04	(0.03-0.06)

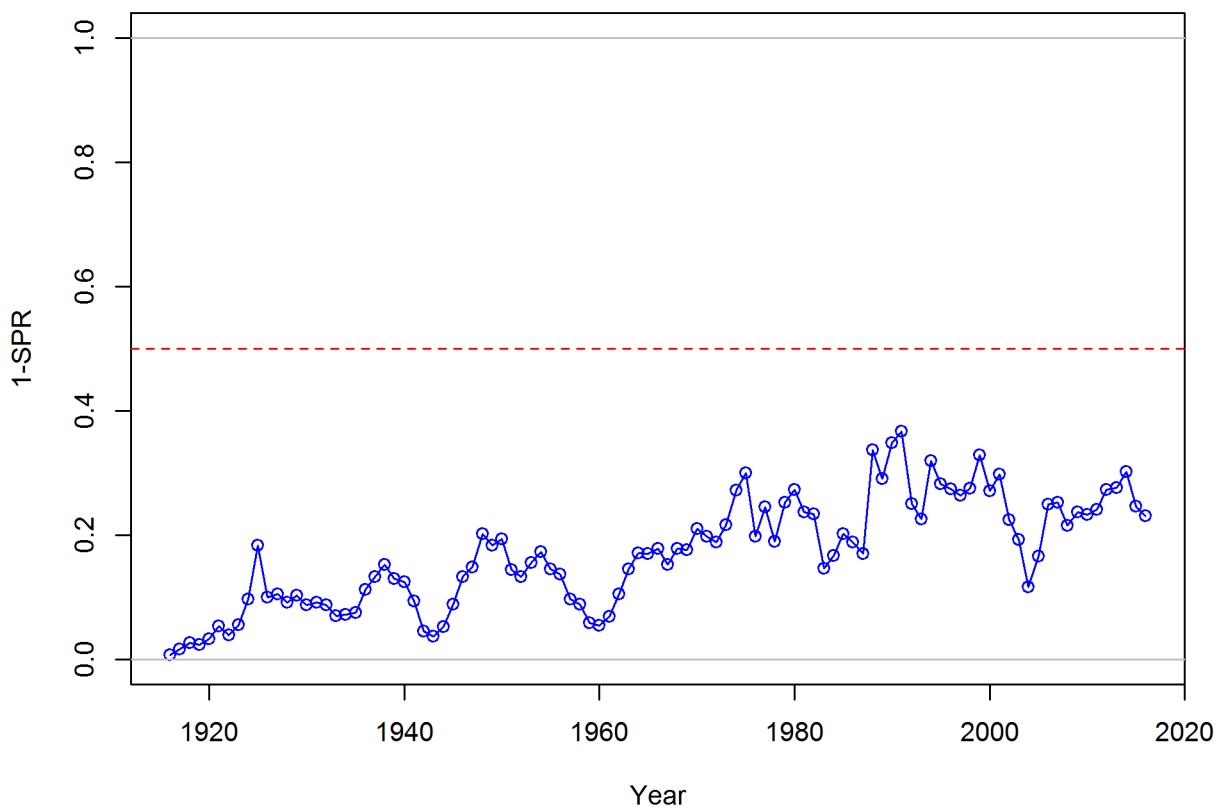


Figure i: Estimated spawning potential ratio (SPR) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the SPR_{50%} harvest rate. The last year in the time series is 2016.

¹⁷⁵ **Ecosystem Considerations**

- ¹⁷⁶ In this assessment, ecosystem considerations were not explicitly included in the analysis.
¹⁷⁷ This is primarily due to a lack of relevant data and results of analyses (conducted elsewhere)
¹⁷⁸ that could contribute ecosystem-related quantitative information for the assessment.

¹⁷⁹ **Reference Points**

- ¹⁸⁰ This stock assessment estimates that California scorpionfish in the base model is above the
¹⁸¹ biomass target, and well above the minimum stock size threshold. The estimated relative
¹⁸² depletion level for the base model in 2016 is 57.8% (~95% asymptotic interval: $\pm 45.8\%-69.8\%$,
¹⁸³ corresponding to an unfished spawning output of 787.209 mt (~95% asymptotic interval:
¹⁸⁴ 440.78-1133.64 mt) of spawning output in the base model (Table [e](#)). Unfished age 1+ biomass
¹⁸⁵ was estimated to be 2783.7 mt in the base case model. The target spawning output based
¹⁸⁶ on the biomass target ($SB_{40\%}$) is 544.6 mt, which corresponds with an equilibrium yield of
¹⁸⁷ 233.9 mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is
¹⁸⁸ 220.1 mt (Figure [j](#)).

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

Quantity	Estimate	95% Confidence Interval
Unfished spawning output (mt)	1361.6	(968.3-1754.9)
Unfished age 1+ biomass (mt)	2783.7	(2020.6-3546.7)
Unfished recruitment (R0, thousands)	3482.3	(2412.1-4552.6)
Spawning output(2016 mt)	683.6	(383.6-983.5)
Depletion (2016)	0.502	(0.4024-0.6017)
Reference points based on SB_{40%}		
Proxy spawning output ($B_{40\%}$)	544.6	(387.3-701.9)
SPR resulting in $B_{40\%}$ ($SPR_{B40\%}$)	0.4589	(0.4589-0.4589)
Exploitation rate resulting in $B_{40\%}$	0.1744	(0.1612-0.1876)
Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt)	233.9	(165.8-302)
Reference points based on SPR proxy for MSY		
Spawning output	606.7	(431.4-781.9)
SPR_{proxy}	0.5	
Exploitation rate corresponding to SPR_{proxy}	0.1504	(0.1393-0.1616)
Yield with SPR_{proxy} at SB_{SPR} (mt)	220.1	(156-284.1)
Reference points based on estimated MSY values		
Spawning output at MSY (SB_{MSY})	300.1	(212-388.3)
SPR_{MSY}	0.297	(0.2867-0.3073)
Exploitation rate at MSY	0.327	(0.2949-0.3591)
MSY (mt)	266.3	(188.6-344)

¹⁸⁹ Management Performance

¹⁹⁰ California scorpionfish has been managed as a single-species outside of a complex since 2003.
¹⁹¹ The estimated catch of California scorpionfish north below the ACL in all years (2007-2017)
¹⁹² except for in 2014 when the catch exceeded the ACL (and ABC) by 6.8 mt. A summary of
¹⁹³ these values as well as other base case summary results can be found in Table f.

¹⁹⁴ Unresolved Problems And Major Uncertainties

¹⁹⁵ TBD after STAR panel

Table f: Recent trend in total catch (mt) relative to the harvest specifications. Estimated total catch reflect the commercial and recreational removals. The OFL was termed the ABC prior to implementation of the FMP Amendment 23 in 2011. Likewise, the ACL was termed OY prior to 2011 and the ABC was redefined to reflect the uncertainty in estimating the OFL.

Year	OFL (mt; ABC prior to 2011)	ABC (mt)	ACL (mt; OY prior to 2011)	ACT	Estimated total catch (mt)
2007	219		175		139.583
2008	219		175		103.887
2009	175		175		113.318
2010	155		155		105.968
2011	141	135	135		105.215
2012	132	126	126		120.008
2013	126	120	120		115.142
2014	122	117	117		123.822
2015	119	114	114		83.8908
2016	117	111	111		74.1613
2017	289	264	150	110	-
2018	278	254	150	110	-

¹⁹⁶ Decision Table

¹⁹⁷ The forecasted projections of the OFL for each model are presented in Table [g](#) and will be
¹⁹⁸ finalized after the STAR panel.

¹⁹⁹ Decision table to be added after the STAR panel (Table [h](#)).

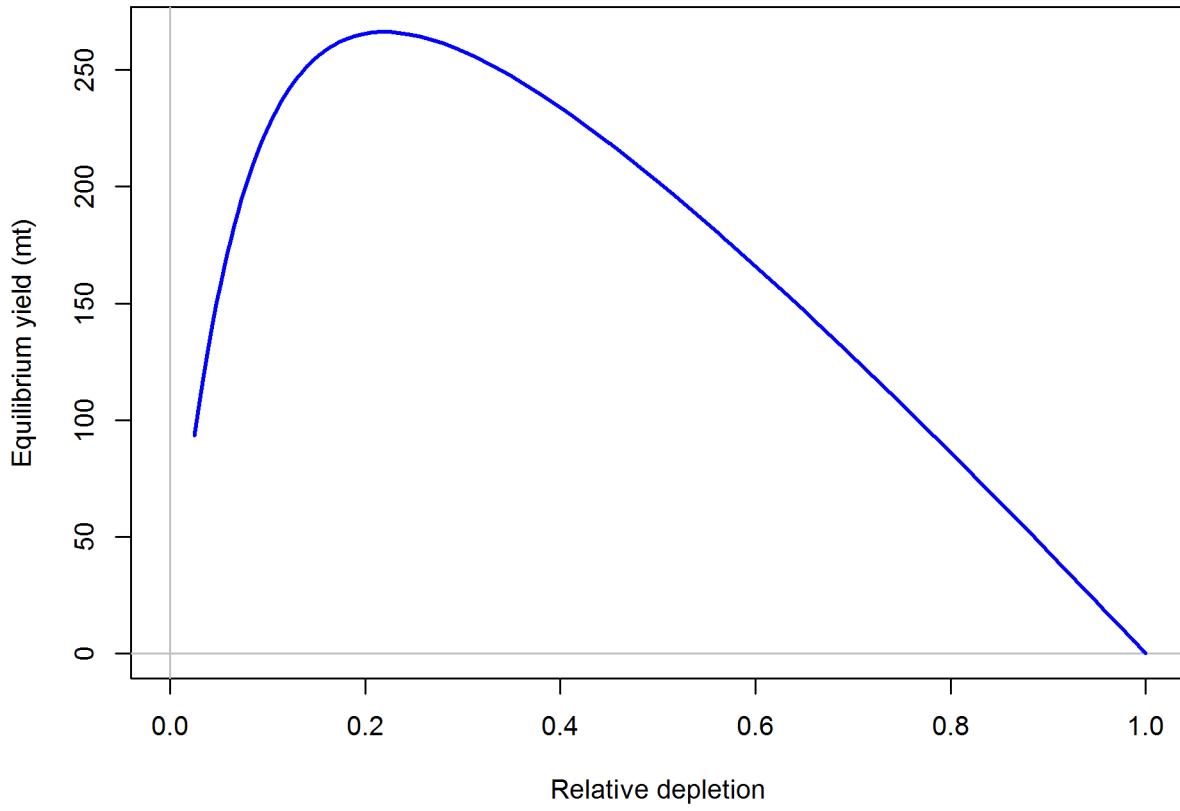


Figure j: Equilibrium yield curve for the base case model. Values are based on the 2016 fishery selectivity and with steepness fixed at 0.718.

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

Year	OFL
2017	283.53
2018	279.14
2019	295.36
2020	298.92
2021	290.45
2022	279.50
2023	269.81
2024	261.91
2025	255.54
2026	250.40
2027	246.26
2028	242.98

Table h: Summary of 10-year projections beginning in 2018 for alternate states of nature based on an axis of uncertainty for the base model. Columns range over low, mid, and high states of nature, and rows range over different assumptions of catch levels. An entry of “-” indicates that the stock is driven to very low abundance under the particular scenario.

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

Table i: Base case results summary.

	Quantity	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Laudlings (mt)											
Total Est. Catch (mt)											
OFL (mt)											
ACL (mt)											
$(1-SPR)(1-SPB_{0.0\%})$	0.43	0.47	0.47	0.48	0.48	0.55	0.55	0.60	0.49	0.46	
Exploitation rate	0.05	0.06	0.05	0.06	0.07	0.07	0.07	0.08	0.05	0.04	
Age 1+ biomass (mt)	2247.21	2116.80	2021.34	1938.81	1863.99	1758.27	1619.97	1571.00	1556.82	1742.00	
Spawning Output	966.8	930.1	881.1	843.9	817.3	767.9	695.6	646.4	683.6	787.2	
95% CI	(557.5-1376)	(541.36-1318.88)	(514.78-1247.39)	(496.37-1191.41)	(484.55-1149.97)	(452.31-1083.47)	(401.97-989.29)	(363.48-924.25)	(383.62-983.52)	(440.78-1133.64)	
Depletion	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.6	
95% CI	(0.577-0.843)	(0.558-0.808)	(0.531-0.763)	(0.512-0.728)	(0.499-0.701)	(0.468-0.66)	(0.42-0.602)	(0.384-0.565)	(0.402-0.602)	(0.458-0.698)	
Recruits	2266.73	2782.03	2308.55	1168.17	1110.63	4078.66	3465.61	7369.42	3173.38	3249.61	
95% CI	(1167.95 - 4399.23)	(1500.8 - 5157.05)	(1197.59 - 4450.1)	(529.31 - 2578.13)	(497.23 - 2480.76)	(2241.3 - 7422.24)	(1593.78 - 7355.81)	(3330.16 - 16308.04)	(1032.42 - 9754.14)	(1057.99 - 9981.2)	

²⁰⁰ **Research And Data Needs**

²⁰¹ We recommend the following research be conducted before the next assessment:

²⁰² 1. List item No. 1 in the list

²⁰³ 2. List item No. 2 in the list, etc.

204 **1 Introduction**

205 **1.1 Basic Information and Life History**

206 California scorpionfish (*Scorpaena guttata*), also known locally as sculpin or spotted scorp-
207 onfish, originates from the Greek word for scorpionfishes and *guttata* is Latin for speckled.
208 California scorpionfish is a medium-bodied fish and like other species in the genus *Scorpaena*,
209 it produces a toxin in its dorsal, anal, and pectoral fin spines, which produces intense, painful
210 wounds (Love et al. 1987). Scorpionfish are very resistant to hooking mortality and have
211 shown survival under extreme conditions.

212 Its range extends from central California (Santa Cruz) to the Gulf of California, although
213 within U.S. waters they are most common in the Southern California Bight (Eschmeyer et al.
214 1983, Love et al. 1987). The species generally inhabits rocky reefs, caves and crevices, but in
215 certain areas and seasons it aggregates over sandy or muddy substrate (Frey 1971, Love et
216 al. 1987). California scorpionfish have been observed from the intertidal to 600 ft with a
217 preferred depth range from 20-450 ft. Little is known about the aggregating behaviors of
218 California scorpionfish. Marine Applied Research and Exploration (MARE) has observed
219 California scorpionfish aggregations during the spawning season (June 2014) and also in
220 the late fall (November 2012) from video transects in southern California. The November
221 spawning aggregation was observed at a small rocky feature near La Jolla and the June
222 aggregation was at a sandy area adjacent to the Farnsworth MPAs (Andy Lauerman, MARE,
223 personal communication).

224 Males and females show different growth rates, with females growing to a larger size than
225 males, and the sexes exhibit different length-weight relationships (Love et al. 1987). Few
226 California scorpionfish are mature at one year old (14 cm total length). Fifty-percent of fish
227 mature at 17-18 cm (2 years old) and all by 22 cm (4 years old) (Love et al. 1987).

228 California scorpionfish feed on a wide variety of mobile prey, including crabs, fishes (e.g.,
229 include northern anchovy, spotted cusk-eel), octopi, isopods and shrimp, (Taylor 1963, Quast
230 1968, Turner et al. 1969, Love et al. 1987). The species is nocturnal, but have been observed
231 feeding during the day. Predation on scorpionfish is believed to be low, but one individual
232 was found in the gut of a leopard shark (Milton Love, personal communication, UC Santa
233 Barbara).

234 **1.2 Early Life History**

235 California scorpionfish utilize the “explosive breeding assemblage” reproductive mode in
236 which fish migrate to, and aggregate at traditional spawning sites for brief periods (Love
237 et al. 1987). California scorpionfish migrate to deeper waters (120-360 ft) to spawn during
238 May-August, with peak spawning occurring July. The species is oviparous, producing floating,

²³⁹ gelatinous egg masses in which the eggs are embedded in a single layer (Orton 1955) and it is
²⁴⁰ believed that spawning takes place just before, and perhaps after dawn, in the water column
²⁴¹ (Love et al. 1987). The same study tagged California scorpionfish and suggests individuals
²⁴² return to the same spawning site, but information is not available on non-spawning season
²⁴³ site fidelity.

²⁴⁴ Little is known about California scorpionfish larvae. The CalCOFI survey observed 463
²⁴⁵ California scorpionfish larvae from 1977-2000, with the majority at station close to Oxnard
²⁴⁶ (east of the Channel Islands) (Moser et al. 2002). Higher densities of larvae have been
²⁴⁷ observed in the CalCOFI stations throughout Baja, peaking south of Punta Eugenia from
²⁴⁸ July to September. The hatching length is reported as 1.9-2.0 mm (Washington et al. 1984)
²⁴⁹ and transformation length of greater than 1.3 cm (Washington et al. 1984) less than 2.1 cm
²⁵⁰ (Moser 1996).

²⁵¹ 1.3 Map

²⁵² A map showing the scope of the assessment and depicting boundaries for fisheries or data
²⁵³ collection strata is provided in Figure 1.

²⁵⁴ 1.4 Ecosystem Considerations

²⁵⁵ In this assessment, ecosystem considerations were not explicitly included in the analysis.
²⁵⁶ This is primarily due to a lack of relevant data and results of analyses (conducted elsewhere)
²⁵⁷ that could contribute ecosystem-related quantitative information for the assessment.

²⁵⁸ 1.5 Fishery Information

²⁵⁹ The hook-and-line fishery fishery off California developed in the late 19th century (Love et al.
²⁶⁰ 2002). The rockfish trawl fishery was established in the early 1940s, when the United States
²⁶¹ became involved in World War II and wartime shortage of red meat created an increased
²⁶² demand for other sources of protein (Harry and Morgan 1961, Alverson et al. 1964).

²⁶³ California scorpionfish comprise a minor part of the Californian sport and commercial fisheries
²⁶⁴ (Love et al. 1987). Historically, California scorpionfish were taken commercially by hook and
²⁶⁵ line and, occasionally, by round haul nets (Daugherty 1949). Scorpionfish were commonly
²⁶⁶ caught around Santa Catalina Island during the late 19th Century with gill nets (Jordan
²⁶⁷ 1887). The 1937 Bureau of Commercial Fisheries report noted that California scorpionfish
²⁶⁸ had been a fairly important commercial species for a long time. The species was targeted by
²⁶⁹ a few fishermen during the summer months, and was also taken as a bycatch in the rockfish

fisheries. By 1949, Bureau of Marine Fisheries reported “[Scorpionfish] will even come to the surface to lights at night” and were also taken in round haul nets. At that time, scorpionfish were rarely targeted by fishermen except by a few specialists.

More recently, commercial bottom longlines have been used to target spawning aggregations offshore of Long Beach (Love et al. 1987). Since the early 1990s, trawl catch has been a substantial component of the commercial catch. Commercial landings have fluctuated substantially over time, which could, in part, be due to changes in targeting and El Niño events (Love et al. 1987). A high proportion of the catch landed in California during the 1960s and 1970s was taken from Mexican waters. In recent years, most of the catch has come from around the Los Angeles region. In general, the majority of the commercial catch has come from the Los Angeles region, except in the 1960s and 1970s when the majority of the catch came from the San Diego region and Mexican waters.

California scorpionfish are most often taken by boat fishermen, but fairly large numbers are caught from piers, jettys, and rocky shorelines in the recreational fishery. The Commercial Passenger Fishing Vessel (CPFV; also referred to as the recreational party/charter or PC mode) effort has remained relatively constant over a long period (1959-1998) (Dotson and Charter 2003). However, there appears to be a shift in effort towards less utilized species, such as California scorpionfish, over the past decade (Dotson and Charter 2003). Especially as catch limits for rockfish have become more restricted commercial passenger fishing vessels (CPFV) operators target California scorpionfish spawning aggregations during spring and summer (Love et al. 1987), and also target California scorpionfish in the winter when other fisheries are closed. California scorpionfish become a target species for day boats during the spawning months when spawning aggregations can be located. There are a small number of boats that specialize in targeting these aggregations. The spawning aggregations occur in deeper waters, often times outside of the three nautical mile state jurisdiction. It is also unknown what fraction of the population aggregates during the spawning season, e.g., all mature fish.

Aggregate mortality has been far below the Annual Catch Limits (ACL) established by the 2005 stock assessment. The ACL projections from the 2005 assessment assumed that the entire ACL was being taken each year and as a result, the ACL for each subsequent year declined despite under-attainment in reality. In addition, in 2014, recreational catch was higher than expected. As a result, in 2014, the combined recreational and commercial catch exceeded the OFL by 2mt (1%) resulting from assumption that the ACL had been attained. Subsequently, action was taken to decrease the recreational season by four months (September 1 - December 31). A catch only update of the stock was undertaken in 2015 (Wallace and Budrick 2015) that imputed the actual catch values since the last assessment, resulting in significant increase in the OFL and ACL.

Retrospectively, the catch in 2014 was well below the OFL as well as the ACL that would have been in place had the ACL values from the actual attainment been in place in 2014. Thus the stock has not been subject to overfishing since the original assessment or been in an overfished condition historically and is considered healthy.

The season restriction in the recreational fishery remained in place as a precautionary measure

³¹² until the full assessment is completed to better inform the current status of the stock, catch
³¹³ limits and regulations given the perspective provided.

³¹⁴ 1.6 Summary of Management History

³¹⁵ Prior to the adoption of the Pacific Coast Groundfish Fishery Management Plan (FMP) in
³¹⁶ 1982, California scorpionfish (*Scorpaena guttata*) was managed through a regulatory process
³¹⁷ that included the California Department of Fish and Wildlife (CDFW) along with either
³¹⁸ the California State Legislature or the Fish and Game Commission (FGC) depending on
³¹⁹ the sector (recreation or commercial) and fishery. With implementation of the Pacific Coast
³²⁰ Groundfish FMP, California scorpionfish came under the management authority of the Pacific
³²¹ Fishery Management Council (PFMC), being incorporated, along with all genera and species
³²² of the family Scorpaenidae, into a federal rockfish classification and managed as part of
³²³ “Remaining Rockfish” under the larger heading of “Other Rockfish” (PFMC (2002, 2004),
³²⁴ Tables 31-39).

³²⁵ The ABCs provided by the PFMC’s Groundfish Management Team (GMT) in the 1980’s were
³²⁶ based on an analysis of commercial landings from the 1960’s and 1970’s. For this analysis,
³²⁷ most of the rockfishes were lumped into one large group. This analysis indicated that the
³²⁸ landings for rockfish in the Monterey-Conception area were at or near ABC levels (Pacific
³²⁹ Fishery Management Council 1993). To keep landings within these adopted harvest targets,
³³⁰ the Pacific Coast Groundfish FMP provided the Council with a variety of management tools
³³¹ including area closures, season closures, gear restrictions, and, for the commercial sector,
³³² cumulative limits (generally for two-month periods). With the implementation of a federal
³³³ groundfish restricted access program in 1994, allocations of total catch and cumulative limits
³³⁴ began to be specifically set for open access (including most of California’s commercial fisheries
³³⁵ that target California scorpionfish in Southern California) and limited entry fisheries (Figure
³³⁶ 2) (Pacific Fishery Management Council 2002, 2004). As a result, in the later 1990’s as
³³⁷ commercial landings decreased and recreational harvest became a greater proportion of the
³³⁸ available harvest.

³³⁹ Beginning in 1997, California scorpionfish was managed as part of the *Sebastodes* complex-
³⁴⁰ south, Other Rockfish category. *Sebastodes* complex-south included the Eureka, Monterey,
³⁴¹ and Conception areas while *Sebastodes* complex-north included the Vancouver and Columbia
³⁴² areas.) The PFMC’s rockfish management structure changed significantly in 2000 with the
³⁴³ replacement of the *Sebastodes* complex -north and -south areas with Minor Rockfish North
³⁴⁴ (now covering the Vancouver, Columbia, and Eureka areas) and Minor Rockfish South (now
³⁴⁵ Monterey and Conception areas only). The OY for these two groups (which continued to be
³⁴⁶ calculated as 0.50 of the ABC) was further divided (between north and south of 40°10' N.
³⁴⁷ latitude) into nearshore, shelf, and slope rockfish categories with allocations set for Limited
³⁴⁸ Entry and Open Access fisheries within each of these three categories (January 4, 2000, 65
³⁴⁹ FR 221; PFMC (2002), Tables 54-55). Because of its depth range and southern distribution,
³⁵⁰ California scorpionfish was included within the Minor Rockfish South, Other Rockfish ABC

³⁵¹ and managed under the south of 40°10' N. latitude nearshore rockfish OY and trip limits
³⁵² (PFMC ([2002](#)), Table 29).

³⁵³ Along with the above changes, in 2000 the southern area divided into two separate management
³⁵⁴ areas at Point Lopez, 36°00' N. latitude. This was followed in 2001 with the implementation
³⁵⁵ of the northern rockfish and lingcod management area between (40°10' N. latitude) and Point
³⁵⁶ Conception (34°27' N. latitude); and the southern rockfish and lingcod management area
³⁵⁷ between Point Conception and the U.S.- Mexico border. These were later revised starting
³⁵⁸ in 2004 with the northern rockfish and lingcod management area redefined as ocean waters
³⁵⁹ from the Oregon-California border (42°00' N. latitude) to 40°10' N. latitude, the central
³⁶⁰ rockfish and lingcod management area defined as ocean waters from 40°10' N. latitude to
³⁶¹ Point Conception, and the southern rockfish and management area continuing to be defined
³⁶² as ocean waters from Point Conception to the U.S.-Mexico border.

³⁶³ Cowcod Conservation Areas (CCAs) also were established in 2001 to reduce fishing effort
³⁶⁴ in areas with high encounter rates of cowcod rockfish (PFMC ([2002](#)), Table 29). These
³⁶⁵ areas were closed to all recreational and commercial fishing for groundfish except for minor
³⁶⁶ nearshore rockfish¹ (including California scorpionfish) within waters less than 20 fathoms.
³⁶⁷ The California Rockfish Conservation Area (CRCA) was defined as those ocean waters south
³⁶⁸ 40°10' N. latitude to the U.S.-Mexico border with different depth zones specified for the areas
³⁶⁹ north and south of Pt. Reyes (37°59.73' N. latitude).

³⁷⁰ During the late 1990's and early 2000's, major changes also occurred in the way that California
³⁷¹ managed its nearshore fishery. The Marine Life Management Act (MLMA), which was passed
³⁷² in 1998 by the California Legislature and enacted in 1999, required that the FGC adopt
³⁷³ an FMP for nearshore finfish. It also gave authority to the FGC to regulate commercial
³⁷⁴ and recreational nearshore fisheries through FMPs and provided broad authority to adopt
³⁷⁵ regulations for the nearshore fishery during the time prior to adoption of the nearshore finfish
³⁷⁶ FMP. Within this legislation, the Legislature also included commercial size limits for nine
³⁷⁷ nearshore species including California scorpionfish (10-inch minimum size) and a requirement
³⁷⁸ that commercial fishermen landing these nine nearshore species possess a nearshore permit.

³⁷⁹ Following adoption of the Nearshore FMP and accompanying regulations by the FGC in fall
³⁸⁰ of 2002, the FGC adopted regulations in November 2002 which established a set of marine
³⁸¹ reserves around the Channel Islands in Southern California (which became effective April
³⁸² 2003). The FGC also adopted a nearshore restricted access program in December 2002 (which
³⁸³ included the establishment of a Deeper Nearshore Permit) to be effective starting in the 2003
³⁸⁴ fishing year.

³⁸⁵ Although the Nearshore FMP provided for the management of the nearshore rockfish and
³⁸⁶ California scorpionfish, management authority for these species continued to reside with
³⁸⁷ the Council. Even so, for the 2003 and subsequent fishery seasons, the State provided
³⁸⁸ recommendations to the Council specific to the nearshore species that followed the directives
³⁸⁹ set out in the Nearshore FMP. These recommendations, which the Council incorporated into
³⁹⁰ the 2003 management specifications, included a recalculated OY for Minor Rockfish South

³⁹¹ - Nearshore, division of the Minor Rockfish South - Nearshore into three groups (shallow
³⁹² nearshore rockfish; deeper nearshore rockfish; and California scorpionfish), and specific harvest
³⁹³ targets and recreational and commercial allocations for each of these groups.

³⁹⁴ Also, since the enactment of the MLMA, the Council and State in a coordinated effort
³⁹⁵ developed and adopted various management specifications to keep harvest within the harvest
³⁹⁶ targets, including seasonal and area closures (e.g. the CCAs; a closure of Cordell Banks
³⁹⁷ to specific fishing), depth restrictions, minimum size limits, and bag limits to regulate the
³⁹⁸ recreational fishery and license and permit regulations, finfish trap permits, gear restrictions,
³⁹⁹ seasonal and area closures (e.g. the RCAs and CCAs; a closure of Cordell Banks to specific
⁴⁰⁰ fishing), depth restrictions, trip limits, and minimum size limits to regulate the commercial
⁴⁰¹ fishery.

⁴⁰² 1.7 Management Performance

⁴⁰³ Management performance table: (Table [f](#))
⁴⁰⁴ A summary of these values as well as other base case summary results can be found in Table
⁴⁰⁵ [i](#).

⁴⁰⁶ 1.8 Fisheries off Mexico

⁴⁰⁷ The California scorpionfish's range extends into Abreojos, Baja California.
⁴⁰⁸ The species is also found in the northern Gulf of California and Guadalupe Island. No formal
⁴⁰⁹ stock assessments have been conducted for California scorpionfish in Mexican waters.

⁴¹⁰ 2 Assessment

⁴¹¹ 2.1 Data

⁴¹² Data used in the California scorpionfish assessment are summarized in Figure [3](#).
⁴¹³ A description of each data source is below.

⁴¹⁴ 2.1.1 Commercial Fishery Landings

⁴¹⁵ Commercial catches of California scorpionfish (often landed as "sculpin") are available back
⁴¹⁶ to 1916. Landings from 1916 to 1935 are presented in CDFG Fish Bulletin No. 49 and

417 Bulletin No. 149 provides tabulated data from 1916 to 1968. Over 99% of the commercial
418 catches of California scorpionfish are from south of Pt. Conception.

419 Whenever possible, catches from north of Pt. Conception and also caught in Mexico but
420 landed in the U.S. were excluded from the commercial catch histories.

421 [California Explores the Ocean](#)(CEO) provides landings data taken from the CDFG Fish
422 Bulletins in electronic form, as well as electronic copies of all CDFG Fish Bulletins.

423 Statewide annual commercial landings are available for California scorpionfish from 1916 to
424 1925, and are assumed to be taken by hook-and-line. Data by area and month are given in
425 a series of bulletins, each bulletin usually providing information for a single year. Data by
426 region and month is available for 1926 to 1986. The Santa Barbara region includes San Luis
427 Obispo, Santa Barbara and Ventura counties. Catches from this region were included in the
428 catch history and comprised less than 10 mt for the period from 1926-1968 (the period when
429 data at the regional scale are available).

430 Catches from Mexico can be separated from the total catch starting in 1931, although the
431 CDFG Bulletins do not report catches originating from Mexican waters available for all years,
432 e.g., 1932-1934. It is assumed that before 1931 there was no catch taken from Mexican waters
433 landed in California.

434 The [CALCOM](#) database was queried (March 7, 2017) for commercial landing estimates of
435 California scorpionfish in California, 1969-2016. Landings were stratified by year, quarter,
436 live/dead, market category, gear group, port complex, and source of species composition
437 data (actual port samples, borrowed samples, or assumed nominal market category). All
438 CALCOM California scorpionfish landing data are either actual port samples or the nominal
439 California scorpionfish market category. However, catches in CALCOM do not separate out
440 catches originating from Mexican waters and landed at U.S. ports.

441 The Commercial Fisheries Information System (CFIS; maintained by CDFW) contains
442 California catch in pounds by gear and port for 1969 to 2016. The CFIS data come from
443 landing receipts or “fish tickets” filled out by the markets or fish buyers as required by the
444 state for all commercial landings. The fish tickets include the CDFW block in which the
445 majority of the landings were caught. Landings reported from a block solely in Mexican
446 waters (blocks >900) were removed from the catch history. Landings with reported blocks
447 877-882 with area in both U.S. and Mexican waters were retained in the catch histories.

448 The commercial catch is dominated by the hook-and-line fishery (89% of total catches).
449 The catch by reported gear types: hook-and-line, fish pot, trawl, gill net, and other can be
450 found in Table 1. Catch taken by fish pot and other gears is added to the hook-and-line
451 catch in the stock assessment (30.6 mt from fish pot and 93.9 mt from other gears).

452 In the assessment, catch for 1916 to 1968 is taken from the CDFG Fish Bulletins. Catch by
453 gear for 1969 to 2004 is taken from CFIS.

454 **2.1.2 Commercial Discards**

455 Information on commercial discards from the West Coast Groundfish Observer Program
456 (WCGOP) are available starting in 2004. The commercial fishery for California scorpionfish
457 has been minimal since the early 2003 (averaging 3.5 mt per year). The available length
458 composition data from the observed discards is minimal, with 151 fish measured from 2004-
459 2015, and less than half a metric ton. Given the discard mortality of only 7%, and the small
460 total catches in the recent years, discards from the commercial fleet are not considered in the
461 assessment.

462 **2.2 Commercial Fishery Length And Age Data**

463 Biological data from commercial fisheries that caught California scorpionfish were extracted
464 from CALCOM on March 7, 2017. Samples from the hook and line fishery were available
465 from 1999 (1 trip) and 2013-2015 (1 trip per year), and for 1999 (1 trip) and 2006 (2 trips)
466 from the trawl fishery. A total of 87 fish were measured and length compositions were based
467 on expanded catch-weighted landings. The samples from 1999 for both fisheries were replaced
468 by samples from the market category study described below.

469 The CDFW conducted a market study from 1990-2004 in southern California (Laughlin
470 and Ugoretz 1998) to monitor and summarize local commercial catches. The ports sampled
471 included San Diego, Santa Barbara/Ventura and Long Beach/San Pedro. Very few of the
472 samples from Santa Barbara and San Diego (4 samples each from the hook-and-line and
473 trawl fisheries Santa Barbara, and 1 sample from the hook-and-line fishery in San Diego)
474 reported California scorpionfish, and are excluded from the length composition data.
475 Length composition for California scorpionfish are available from the Long Beach samples for
476 the hook-and-line (Table 2), gillnet (Table 3), and trawl fisheries (Table 4). Length samples
477 from both groundfish (otter) trawls and single-rigged shrimp trawls were available from the
478 market study. The average size of fish from the otter trawls (26.5 cm) was smaller than from
479 the shrimp trawl samples (28.1 cm). Over 70% of California scorpionfish catch from the
480 trawl sector was landed from single-rigged shrimp trawls, which best represent the length
481 composition of the trawl fleet (CALCOM).

482 The input sample sizes were calculated via the Stewart Method (Ian Stewart, personal
483 communication, IPHC):

484
$$\text{Input effN} = N_{\text{trips}} + 0.138 * N_{\text{fish}} \text{ if } N_{\text{fish}}/N_{\text{trips}} \text{ is } < 44$$

485
$$\text{Input effN} = 7.06 * N_{\text{trips}} \text{ if } N_{\text{fish}}/N_{\text{trips}} \text{ is } \geq 44$$

486 **2.2.1 Sport Fishery Removals and Discards**

487 Data used in reconstructing the retained catch and discarded mortality for California scor-
488 pionfish in the California recreational fishery are from the Commercial Passenger Fishing
489 Vessel (CPFV) Logbooks (1932-2017), the Marine Recreational Fishery Statistical Survey
490 (MRFSS, 1980-2003) and the California Recreational Fishery Survey (CRFS, 2004-2017).

491 Total catch was accounted for including retained catch as well as the estimate of fish discarded
492 dead assuming a 7% discard mortality rate approved for use in management in the regulatory
493 specifications for 2009-2010 (Pacific Fishery Management Council 2008). The MRFSS and
494 CRFS data provide estimates of mortality for four fishing “modes” including the party/charter
495 Boat, Private/Rental Boat, Man Made (piers and jetties etc.) and Beach and Bank modes.

496 While estimates of mortality from the party/charter (PC) boat mode is available from the
497 MRFSS and CRFS surveys for the party/charter Boat mode for 1980-2017, estimates from
498 the CRFS data from 2011-2017 and data from CPFV Logbook for 1932-2010 were used to
499 represent catch from this mode. The party/charter Phone Survey was used to estimate effort
500 used in producing effort estimates for CRFS between 2004 and 2010, which was subject
501 to negative bias due to the low of participation in the survey south of Point Conception.
502 The Coastal County Household Telephone Survey was used to estimate fishing effort for
503 the MRFSS survey from 1980-2003 and was subject to potential positive avidity bias in
504 participation by those contacted by the survey. As a result, the CPFV logbooks provided the
505 reported number of retained and discarded California scorpionfish used to estimate mortality
506 from 1932-2010. This is consistent with the catch based update conducted in 2015 as well as
507 the original assessment, both of which used estimates of catch from logbooks to represent
508 catch in the PC mode with the exception of the years after 2011 when effort estimates used
509 in CRFS estimates were derived from logbooks.

510 An under-reporting adjustment reflecting a lack of reporting of 20% of all log books as
511 applied in the previous assessment (Maunder 2005) was confirmed as the approximate
512 level of underreporting in conversation with the CRFS program (Connie Ryan, personal
513 communication, CDFW) and applied to estimates from the logbooks for 1936 to 2010. Annual
514 average weights from this mode for retained catch from the MRFSS or CRFS estimates for
515 1980-2010 and average weight from 1980-1984 was applied to the preceding years. To estimate
516 discard mortality for the PC mode, the annual average weight was applied in respective years
517 from lengths collected sampling onboard CPFVs by the CRFS survey for 2004-2010 were
518 applied to the number of discards from the CPFV logbooks and the average weight over
519 this entire period were applied to the preceding years for 1995-2003. For the period between
520 1980 and 1994, the MRFSS estimates for discards were used to reflect discarding due to the
521 paucity of data on the number of discards from PC logbooks prior to 1995.

522 For all other modes, the MRFSS (1980-2003) and CRFS (2004-2017) based estimates of
523 retained catch and discard mortality were used. There was a lapse in MRFSS sampling from
524 1990 through 1992, for which retained catch and discard mortality were estimated using the
525 average of values three years before and three years after the lapse for all modes other than
526 the PC mode. For the PC mode, estimates of numbers of fish were available from logbook

527 data and average weight from the three years before and after this period were applied to
528 provide estimates for the PC mode.

529 Estimates of retained catch and discards were not available from the non-PC modes prior
530 to 1980, thus the ratio of catch in the PC mode to the other modes for 1980 through 1985
531 was used to provide an estimate of catch in the other modes in the years 1932-1979. In the
532 case of the PR mode, a linear ramp in the ratio adjustment between PC and PR modes was
533 applied between 1966 and 1979 from 0.55 in 1980 to 0.10 in 1965, reflecting the increase in
534 the relative proportion of catch contributed by the PR mode with time as more individuals
535 anglers purchased vessels, as recommended in the California Catch Reconstruction (Ralston
536 et al. 2010), and the ratio of 0.10 was assumed for all years prior. The ratio of PC estimates
537 to the MM and BB modes was assumed to constant and the average between 1980 and 1989
538 was applied from 1932 to 1979. Catch estimates from CPFV logbooks were not available
539 during the World War II era from 1941 until 1946 and catch was assumed to be zero for all
540 modes during this period. Estimates for retained catch and discarded mortality for 1928 to
541 3528 were estimated using a linear ramp from the value for 1936 to zero in 1928 for the PC
542 mode and ratios PC compared to other modes were used to proxy estimates for other modes
543 based on the resulting ramped values for the PC mode. The final time series of landings and
544 discard mortality are in Table 5.

545 Biological samples from the recreational fleets are desired in the sections below.

546 2.2.2 Fishery-dependent Data Sources

547 CRFS Private Boat Dockside Intercept Survey

548 The CDFW provided the CRFS private boat dockside sampling fisheries data from 2004
549 to 2016. The data went through several data quality checks to identify the best subset of
550 available data that are consistent over the time series and provide a representative relative
551 index of abundance once standardized. The dockside sampling of the private mode (PR mode
552 in RecFIN) consists of samples from a primary series of ports (PR1) where the majority
553 of fishing effort for this mode originates and a secondary series of ports with historically
554 low effort (PR2). Only PR1 samples were used for this index as the sampling forms for
555 the PR2 index have changed over time and the data could not reliably be collapsed to the
556 trip level. The dockside data consist of two types of data; Type 2 data contain records of
557 angler-reported catch, i.e., catch that was not observed by the sampler and Type 3 data
558 includes sampler-examined retained catch. Of the Type 2 reported catch for scorpionfish, less
559 than one percent were reported “thrown back dead” and five percent reported as retained
560 to eat. Given that the reported retained catch is a small fraction of the catch overall and
561 discard mortality of California scorpionfish is low, only the Type 3 examined catch are used
562 in the index.

563 The survey records the number of contributing anglers (number of anglers on the vessel for
564 the private mode), but does not contain data on hours fished. For this index, angler-day

565 was the assumed effort. The data were filtered to trips fishing with hook-and-line gear in
566 southern California. Trips with a primary fishing area of Mexico were also removed. The
567 CRFS dockside private boat records with these broad filters include 44,128 trips of which
568 3,802 caught California scorpionfish (8.6%).

569 The Stephens-MacCall approach was used to identify trips with a high probability of catching
570 California scorpionfish (Stephens and MacCall 2004). Prior to using the Stephens-MacCall
571 approach to select relevant trips a number of other filters were applied to the data to minimize
572 variability in CPUE estimates. Over the course of the time series only 45 trips from Santa
573 Barbara county encountered California scorpionfish, ranging from 0-10 trips a year. The
574 Stephens-MacCall approach was applied with and without trips from Santa Barbara and the
575 same species were identified as indicators and counter-indicators. For the final model prior to
576 Stephens-MacCall, trips from Santa Barbara were excluded, leaving 41,235 trips, and 3,747
577 of those caught California scorpionfish (Table 6).

578 Coefficients from the Stephens-MacCall analysis (a binomial GLM) are positive for species
579 which co-occur with California scorpionfish, and negative for species that are not caught with
580 California scorpionfish (Figure 4). Potentially informative species for the Stephens-MacCall
581 analysis were limited to species caught in at least one percent of all trips and caught in at
582 least five years. Some of these never occurred with California scorpionfish (strong ‘counter-
583 indicators’) and records with these species were removed from the data prior to estimation
584 of the index. Strong counter-indicators for the CRFS private boat index included yellowfin
585 tuna and dolphinfish.

586 A total of 8,590 trips were retained following the Stephens-MacCall filter, with 3,056 all
587 positive California scorpionfish trips retained. The California scorpionfish recreational fishery
588 in the southern management area was closed for eight months in 2004 and nine months in
589 2005. The majority of records from 2004 and 2005 are from the period when the fishery
590 was closed and were removed from the analysis (Figure 5). Records from months with the
591 fishery was closed from 2006-2016 were also excluded from the index since this index relies
592 on sampler-examined retained catch.

593 Catch per unit effort was modeled using a delta-GLM approach, where the catch occurrence
594 (binomial) component was modeled using a logit link function and the positive catch compo-
595 nent was modeled after log-transformation of the response variable, according to a normal
596 distribution with an identity link function. The units for CPUE are fish landed/anglers. A
597 gamma distribution for the positive catch component was also explored, but model selection
598 favored the lognormal model. The raw CPUE of factors considered in the model by year are
599 shown in Figure 6.

600 Model selection procedures selected the covariates *2-month wave* and *county* as important
601 for both the catch occurrence and positive catch component models for all data sets, along
602 with the categorical year factor used for the index of abundance (Table 7).

603 The Q-Q goodness of fit plot for the lognormal portion of the model shows a moderate fit to
604 the data (Figure 7). The final index indicates a decrease in relative abundance from 2006 to
605 2010, at which point the index is relatively flat (Figure 8 and Table 8).

606 Biological samples from trips retaining California scorpionfish were collected during the
607 dockside surveys. Lengths of California scorpionfish from 1980-2016 for the private mode
608 were provided by RecFIN by Edward Hibsch (PSMFC) on November 29, 2016. Length
609 measurements from the private mode were provided directly from CDFW for the years
610 2004-2016 Table 9. The number of trips is the number of unique ID_CODEs from RecFIN for
611 1980-2003. Starting in 2004 with the CRFS program, the number of unique trips sampled in
612 the private boat mode was recorded. The recreational private fleet tends to select larger fish
613 than the recreational party/charter fleet, which is one reason the private and party/charter
614 fleets were maintained as two separate fleets in the base model. No length data for discarded
615 fish from the recreational private mode fleet are available.

616 CRFS CPFV Logbook Index

617 CPFV operators have been required to submit written catch logs with daily trips records of
618 catches to CDFW since 1935. The logbook data from 1936-1979 are available as monthly
619 summaries, which do not contain the level of detail needed for an index of abundance. CDFW
620 provided the CPFV logbook data from 1980-2016 (Charlene Calac, CDFW). Logbook data
621 from 1980-2016 contain records for each trip, including the fishing date, port of landing,
622 vessel name and number, CDFG block area fished (Figure 1), angler effort, number of fish
623 kept and discarded by species. As of 1994, operators were required to report the number
624 of fish discarded and lost to seals. Prior to 1994, it is assumed that all reported fish were
625 retained. Details and additional information on the historical logbook database can be found
626 in Hill and Schneider (1999).

627 The number of anglers on board the vessel and the hours fished are included in the database
628 for all years. Only retained fish are included in the index of abundance the unit of effort
629 is angler hours. A number of data filters were applied to the data to account for possible
630 mis-reporting, e.g., trips reporting retained California scorpionfish in top 1% of the data
631 (>325 fish). Trips fishing outside of California scorpionfish habitat (reported as targeting
632 pelagic species) or trips reporting a block with a minimum depth deeper than 140 m were
633 also filtered out.

634 Because California scorpionfish is not a primary target species, boats with fewer than 10
635 trips retaining California scorpionfish were removed from the analysis. Data were also filtered
636 to only include catches reported from blocks South of Pt. Conception and north of the U.S.-
637 Mexico border (Figure 1), and blocks with at least 100 trips retaining California scorpionfish
638 and a total of 500 trips. A full description of the data filters is in Table 10. A total of
639 432,868 trips were retained for the index of abundance, 202,937 of which caught California
640 scorpionfish.

641 Two different area factors were considered for the standardization, block and region.
642 The 60 retained blocks were split into nearshore regions north and south of San Pedro and
643 the northern and southern islands, for four regions. Both a delta model and a negative
644 binomial model were considered for index standardization. However, due to the large number
645 of records, the traditional jackknife routine to estimate uncertainty was not possible.

646 California scorpionfish were present in 47% of all trips, and standardized with a negative
647 binomial model. Factors considered were *year*, *month*, and *area* (either block or region). A
648 model with blocks and was selected over a model with region by 39,180 AIC. The final model
649 includes *year*, *month*, and *block* with a log link and effort as an offset (Table 11).
650 The standardized index shows a cyclic pattern, with period of higher CPUE (late 1980's to
651 early 1990's and late 1990s) and has shown a general downward trend since 2008 (Figure
652 9 and Table 12). An interesting note is the similarity in standardized CPUE between the
653 CPFV logbook index and the CPFV dockside index (not used in the stock assessment model)
654 from 1992-1997 (for a Stephens-MacCall threshold of 0.1) (Figure 10).

655 MRFSS Party/Charter Boat Dockside Index

656 From 1980 to 2003 the MRFSS program sampled landings at dockside (called an “intercept”)
657 upon termination of recreational fishing trips. The program was temporarily suspended
658 from 1990-1992 due to lack of funding. For purposes of this assessment, the MRFSS time
659 series is truncated at 1998 due to overlap with an alternative index used to represent 1999
660 onward using onboard sampling data making analysis using the dockside data redundant
661 (see “Recreational Onboard Observer Surveys”). Only trips south of Point Conception were
662 included in the analysis as California scorpionfish are exceedingly uncommon in the catch to
663 the north. The California party and charter boat (a.k.a. “PC mode,” commercial passenger
664 fishing vessel, or CPFV) samples used in the present analysis provide catch and effort data
665 aggregated at the trip level. Each entry in the RecFIN Type 3 database corresponds to a
666 single fish examined by a sampler at a particular survey site. Since only a subset of the catch
667 may be sampled, each record also identifies the total number of that species possessed by
668 the group of anglers being interviewed. The number of anglers and the hours fished are also
669 recorded. Unfortunately the Type 3 data do not indicate which records belong to the same
670 boat trip. Because our aim is to obtain a measure of catch per unit effort (fish per angler
671 hour), it is necessary to separate the records into individual trips. For this reason trips must
672 be inferred from the RecFIN data. This is a lengthy process, and is outlined in Supplemental
673 Materials (“Identifying Trips in RecFIN”).

674 Since recreational fishing trips target a wide variety of species, standardization of the catch
675 rates requires selecting trips that are likely to have fished in habitats containing California
676 scorpionfish. The method of Stephens and MacCall (2004) was used to identify trips with a
677 high probability of catching California scorpionfish, based on the species composition of the
678 catch in a given trip. Prior to applying the Stephens-MacCall filter, we identified potentially
679 informative “predictor” species , i.e., those with sufficient sample sizes and temporal coverage
680 (at least 30 positive trips total, distributed across at least 10 years of the index) to inform
681 the binomial model. Coefficients from the Stephens-MacCall analysis (a binomial GLM) are
682 positive for species which co-occur with California scorpionfish, and negative for species that
683 are not caught with California scorpionfish.

684 Data for dockside sampling of 6,295 commercial passenger fishing vessel (CPFV) trips south
685 of Point Conception by the Marine Recreational Fishery Statistical Survey (MRFSS) were
686 filtered using the Stephens-McCall method to identify trips with catch associated with

687 California scorpionfish and the resulting trips analyzed in a delta-GLM including year and
688 county to produce annual indices of abundance for the period 1980 through 1998. To eliminate
689 trips targeting species caught near the surface for all or part of the trip where California
690 scorpionfish do not occur, prior applying the Stephens-MacCall filter, trips with catch of
691 bluefin tuna, yellowfin tuna, dorado, Pacific bonito, skipjack, albacore, chinook salmon, coho
692 salmon and bigeye tuna were removed. Trips with catch of yellowtail amberjack were also
693 removed since effort on such trips can often be focused in the surface and mid-water where
694 California scorpionfish do not occur. In addition, trips with aggregate effort below and
695 above 95% percentile (less than 2 and over 109.5 hours) were removed to exclude trips for
696 which either too little effort was exerted to be informative or longer trips that may make
697 an excessive contribution to the effort likely distributed over a number of targets only some
698 of which may co-occur with California scorpionfish biasing low the resulting CPUE. Lastly,
699 trips in Santa Barbara County were removed due the low number of positive samples for
700 California scorpionfish since it resides in the northern extent of their range and this is a
701 transition zone between biogeographic provinces in which the presence of more northerly
702 distributed species could adversely affect the ability of the Stephens-MacCall filtering method
703 to identify co-occurring species. Each of these filtering steps and the resulting number of
704 trips remaining in the sampling frame are provided in Table 13.

705 Removal of the aforementioned trips resulted in a total of 3,968 trips to which the Stephens-
706 MacCall filtering method was applied. Species that composed less than 5% of the catch
707 were excluded from analysis to prevent these uncommon species from affecting correlations
708 identified using the algorithm. Chub mackerel, Pacific mackerel and barracuda were removed
709 as potential predictor species despite having weak positive correlations with California
710 scorpionfish since they are predominantly pelagic and their co-occurrence is not expected to
711 be predictive. As expected, positive indicators of California scorpionfish trips include several
712 species of nearshore rockfish, California sheephead, California halibut, Pacific sanddabs and
713 seabasses and counter-indicators include several species of deep-water rockfish (Figure 11).
714 While the filter is useful in identifying co-occurring or non-occurring species assuming all
715 effort was exerted in pursuit of a single target, the targeting of more than one target species
716 can result in co-occurrence of species in the catch that do not truly co-occur in terms of
717 habitat associations informative for an index of abundance, presenting a confounding influence
718 in selecting trips using the methods employed. Thus the filtering is intended to remove those
719 trips for which effort was targeted in deeper water than California scorpionfish commonly
720 occur.

721 Two levels of filtering were applied using the Stephens-MacCall Filter. The Stephens-MacCall
722 filtering method identified the probability of occurrence (in this case 0.27) at which the rate
723 of false positives and false negatives for the presence of California scorpionfish were equal as
724 a heuristic for selecting a threshold for trips in appropriate habitat to be included in analysis.
725 The trips from this criteria for selection was compared to an alternative method including
726 the false positive trips as well as all positive trips for California scorpionfish supported by
727 the assumption that if California scorpionfish were caught in such trips, they must constitute
728 appropriate habitat justifying their inclusion. In addition, the false positives from a lower
729 probability of occurrence (0.10) that was considered to reflect a less stringent threshold

730 inclusive of more trips including a higher proportion of the false positive trips combined with
731 the positive trips from the entire data set was evaluated for comparison.

732 Catch per angler hour (CPUE; number of fish per angler hour) was modelled using a delta
733 model (Lo et al. 1992, Stefnsson 1996). Model selection using Akaike Information Criterion
734 (AIC) and Bayesian Information Criteria (BIC) supported inclusion of year and region effects
735 in both the binomial and lognormal components of the index for both the model with false
736 positives from the 0.27 threshold and the 0.10 threshold. The addition of month effects (to
737 allow for seasonal changes in CPUE) did not improve model fit in the lognormal model, but
738 the full model including month, year and county was supported for the binomial model (Table
739 14). The difference in AIC values for the full model compared to the model with only year
740 and county was greater for the binomial model (201.5) favoring the full modal compared to
741 the small difference for the lognormal model favoring the model with only year and county
742 (8.3). As a result, the full model including year, county and month effects was selected for
743 further analysis.

744 The resulting index values for 1989 were anomalously high compared to other years. In
745 addition, the less stringent filter of 0.1 resulted in a higher index value than 0.27, which was
746 antithetical to the expectation that including trips with fewer positive trips would decrease
747 the CPUE. Further examination of the number of California scorpionfish per trip by year
748 showed a lower number of trips for this year than others and a lower proportion of low catch
749 trips explaining why exclusion of low catch trips through application of the 0.27 index reduced
750 the relative magnitude of the 1989 index value relative to other years. As a result of this
751 anomalous result and the low sample size, trips from 1989 were excluded from analysis.

752 The percentage of trips that caught California scorpionfish was 20.8% (828/3,968) prior to
753 filtering with the Stephens-MacCall method, and 71.0% (828/,1167) with the filter set to
754 0.27 and 26.7% (828/3,099) with the filter set to 0.10, filtered data set. Residual-based
755 model diagnostics for the positive component of the index suggest the data generally met the
756 assumptions of the GLM (Figure 12). The resulting index is highly variable for both thresholds,
757 with consistent peaks in 1984 and 1998 (Figure 10). Application of the 0.27 threshold holds
758 the potential of biasing the resulting index values high by excluding false positive trips while
759 including positive trips with equivalent probability of encountering California scorpionfish.
760 The 0.1 threshold removes a high proportion of trips with shelf rockfish species indicative of
761 effort exerted in deeper depths than are commonly occupied by California scorpionfish, while
762 retaining false positive trips with equivalent probabilities of capture to true positives and
763 thus was retained for further analysis. The resulting jackknifed mean index values, standard
764 error, coefficient of variation and confidence intervals for the 0.1 threshold model, excluding
765 1989, with year, month and county effects are provided in Table 14.

766 The results of the models with each of the thresholds provided similar trends seen in Figure
767 Figure 10 along with the results from the CPFV logbook index. The trends differ from those
768 resulting from the CPFV logbook index early in the time series, but both show an increase
769 in the mid to late 1990s. The PC dockside index was excluded from further analysis in the
770 model given that the CPFV logbook index represents the same sector of the fishery and

771 presumably contains data from the some of the same trips, utilizes data for many thousands
772 more trips, and provides data from 1989 to 1992 omitted from the MRFSS data as a result
773 of filtering out 1989 and a lapse of sampling from 1990-1992.

774 *Party/Charter Dockside Length Measurements*

775 The retained catch for the recreational party/charter mode has been measured during the
776 dockside interviews since 1980, and also by two different onboard observer programs in
777 southern California by Collins and Crooke (n.d.) a combination of unpublished data and
778 a study by Ally et al. (1991) from 1984-1989 (Table 15). The length measurements from
779 Collins and Crooke (n.d.) are assumed to all be from retained fish.

780 Length measurements for California scorpionfish from 1980-2016 were provided from RecFIN
781 by Edward Hirsch (PSMFC) on November 29, 2016. The number of trips from 1980-2003
782 is the number of trips with observer catch of California scorpionfish as outlined in the
783 Supplemental Material (“Identifying Trips in RecFIN”). However, the algorithm used to
784 determine the number of trips has not been applied to RecFIN data past 2003. The number
785 of trips for 2004 and 2005, was taken as the ratio of the number of interviews (ID_CODE) in
786 RecFIN to the number of known trips for years with complete data. The number of individual
787 ID_CODEs was reduced reduced by 38% for 2004 and 2005, and gives reasonable sample
788 sizes. From 2004-2016 the number of trips from which the samples were taken is known.

789 From 1985-1987 Ally et al. (1991) conducted an onboard observer program in southern
790 California, and measured both retained and discarded fish. Additional unpublished years
791 (1984, 1988-1999) from this onboard observer sampling program were provided by CDFW
792 (Paulo Serpa). From 1984-1989, the onboard observer program measured 11,892 retained
793 California scorpionfish compared to the 1,981 measurements in RecFIN. It is almost certain,
794 but cannot be verified, that some of the lengths from the onboard observer program were
795 input in RecFIN. Therefore, the onboard observer measurements from 1984-1989 are used
796 instead of those from RecFIN for these years.

797 **Onboard Observer Party/Charter Boat**

798 California implemented a statewide Onboard Observer Sampling Program in 1999, and began
799 measuring discarded fish in 2003 (Monk et al. 2014). The goal of the Onboard Observer
800 Sampling Program is to collect data including charter boat fishing locations, catch and discard
801 of observed fish by species, and lengths of discarded fish. The program samples the commercial
802 passenger fishing vessel (CPFV), i.e., charter boat or for-hire fleet and collects drift-specific
803 information at each fishing stop on an observed trip. At each fishing stop recorded information
804 includes start and end times, start and end location (latitude/longitude), start and end
805 depth, number of observed anglers (a subset of the total anglers), and the catch (retained
806 and discarded) by species of the observed anglers.

807 CDFW implemented a regulation of three hooks in 2000, which was reduced to (and remains
808 at) two hooks in 2001. CDFW also implemented a 10 inch size limit for California scorpionfish

809 in 2000. The length composition of retained in discarded California scorpionfish (both before
810 and after the minimum size restriction). Prior to 2001, there were no depth restrictions for
811 the southern California recreational fishery. Given these regulation changes, the data from
812 1999 and 2000 are excluded from the index.

813 From 2002 to 2005, the California scorpionfish fishery was closed from four to nine months of
814 the year. During these years, California scorpionfish were still encountered, but all discarded.
815 The onboard observer program provides the only available information on discards because
816 the sampler records both the retained and discarded catch at each fishing stop. The onboard
817 observer data are used to create two indices of abundance, one using only the discarded catch
818 and one using only the retained catch. The index of discarded catch is used as an index of
819 abundance for the recreational discard fleet, and the index derived from the retained catch is
820 treated a survey in the assessment model.

821 The entire dataset was filtered as one, regardless of retained or discarded, due to the fact that
822 discarding can occur for a number of reasons, e.g., angler preference, size limit, bag limit,
823 etc., and California scorpionfish are often retained and discarded on the same fishing drift.

824 Prior to any analyses, drifts with erroneous or missing data were removed from the data
825 considered for the California scorpionfish index. The locations of positive encounters (retained
826 + discarded) were mapped, using the drift starting locations. Regions of suitable habitat were
827 defined by creating detailed hulls (similar to an alpha hull) with a 0.01 decimal degree buffer
828 around a location or cluster of locations. Any portion of a region that intersected with land
829 was removed. Drifts that did not intersect with one of these areas were considered structural
830 zeroes, i.e., outside of the species habitat, and not used in analyses.

831 Five areas were retained based on sample sizes, 1) nearshore area from the U.S./Mexico
832 border to Oceanside, 2) nearshore Oceanside to Newport Beach, 3) Newport Beach to Palos
833 Verdes, 4) Palos Verdes to Point Magu, and 4) drifts from Santa Cruz Island, Santa Barbara
834 and Anacapa Islands, Santa Catalina Island, and San Clemente Islands were combined.
835 Drifts encountering California scorpionfish north of Point Magu were rare (<5% positive
836 encounters).

837 Drift locations within the Cowcod Conservation Area (CCA) or in Mexican waters were also
838 filtered out of the dataset. The years 1999 and 2000 were removed from the index due to
839 changes in hook and gear regulations during those years. California adopted a 3-hook and
840 1-line regulation in 2000, which changed to 2-hooks and 1-line in 2001. California scorpionfish
841 is not a common target species for the CPFV fleet, but if often a fallback species, for trips
842 targeting seabass or rockfish. California scorpionfish are targeted more often in January
843 and February when the rockfish/cabezon/greenling complex is closed. Boat identifiers were
844 available for all trips in the onboard observer database. Approximately 1,000 drifts were
845 filtered out after accounting for boats that were identified as not encountering scorpionfish
846 (Table 16). A total of 26,733 drifts for the analysis were retained. Of these, 5,507 encountered
847 scorpionfish, with 3,249 discarding California scorpionfish and 3,867 retaining California
848 scorpionfish.

849 The drift-level effort cannot be parsed out between the retained and discarded catch. The
850 effort represents the total angler hours fished by the subset of observed anglers for a particular
851 drift, and is the same for both the discard-only and retained-only indices. Both of the indices
852 derived from this dataset were standardized using a delta modeling approach (Lo et al. 1992).

853 *Onboard Obsever Discarded Catch Index*

854 Covariates considered in the full model included *year*, *area* (5 levels), *month* (12 levels), and
855 *20 m depth bins* (5 levels). All covariates were specified as categorical variables. A lognormal
856 model for the positives was selected by AIC over a gamma model (delta-AIC of 482.28).
857 Model selection for both the lognormal and binomial models retained all covariates (Table
858 17). The Q-Q plot for the positive catch lognormal model looks reasonable (Figure 13). The
859 final index shows a lower CPUE of the discards in 2001 and an increase from 2002-2005 when
860 the California scorpionfish recreational fishery was restricted by depth or closed (Table 18
861 and Figure 14). The relative CPUE of the discards decreases from 2006 to 2015.

862 *Discarded Catch Length Composition*

863 As of 2003, Onboard Observer program has taken length measurements for discarded fish.
864 The retained catch is measured during the dockside (angler intercept) surveys, and cannot
865 necessarily be matched to a trip with the discard lengths prior to 2012. Additional discarded
866 length measurements were available from both CDFW unpublished data (1984, 1988-1989)
867 and the Ally et al. (1991) onboard observer program from 1985-1987. The sample sizes of
868 measured discarded fish in the 1980s is small. The mean length of discarded fish is smaller
869 than for years when the length restriction was in place (Table 19 and Figure 15).

870 The discard length composition reflects the California scorpionfish seasonal closures from
871 2002-2005. Anglers encountered and discarded fish greater than the size limit of 10 inches
872 during these years. When the fishery is open, anglers are most often only discarded California
873 scorpionfish that are smaller than the legal size. This also holds true for the length composition
874 of discarded California scorpionfish in the 1980s before there was a size limit.

875 *Onboard Obsever Retained Catch Index*

876 The index of relative abundance using the retained-only catch from the onboard observer
877 program is a separate survey fleet in the base model and has no lengths associated with it.
878 Covariates considered in the full model included *year*, *area* (5 levels), *month* (12 levels), and
879 *20 m depth bins* (5 levels). All covariates were specified as categorical variables. The final
880 model includes A lognormal model was selected by AIC over a gamma model for the positives
881 (delta-AIC of 534.9).Model selection for both the lognormal and binomial models retained all
882 covariates (Table 20). The Q-Q plot for the positive catch lognormal model looks reasonable
883 (Figure 16). The final index shows a lower CPUE of the retained catch from 2002 and 2003
884 (Table 21 and Figure 17). The relative CPUE of the retained catch shows a decline from
885 2007-2015, and an increase in 2016.

886 **2.2.3 Fishery-Independent Data Sources**

887 **Sanitation Districts Trawl Survey**

888 Sanitation districts that discharge into coastal waters are required to conduct trawl surveys
889 to monitor the demersal fish community in the vicinity of the discharge sites as a condition
890 of their National Pollutant Discharge Elimination System (NPDES) permits, issued by
891 the Environmental Protection Agency. All sanitation districts holding NPDES permits in
892 southern California were contacted for trawl data. The two northernmost districts, Goleta
893 and the City of Oxnard, provided data (via Aquatic Bioassay & Consulting Laboratories,
894 Inc.), but California scorpionfish have not been encountered in either district's trawl surveys.
895 The four other sanitation districts, Orange County, City of Los Angeles, Los Angeles County,
896 and the City of San Diego all encounter California scorpionfish and provided trawl data.

897 A description of the data provided by each sanitation district is provided. In contrast to the
898 inverse variance weighted index from the 2005 assessment, trawls from all sanitation districts
899 were combined to develop a single index of abundance.

900 *Orange County* The Orange County Sanitation District provided trawl data from 1970-
901 2015 (Jeff Armstrong, Orange County Sanitation District). The trawl net is a 7.6 m wide
902 Marinovich, semi-balloon otter trawl (2.54 cm mesh) with a 0.64 cm mesh cod-end liner.
903 Fixed stations are sampled either annually (summer) or semi-annually in the winter and
904 summer, Quarters 1 and 3 (Jan-March and July-September). From 1970-1985 Quarter 2,
905 trawl effort was based on a 10 minute tow time. As of 1985 Quarter 3, trawls were towed a
906 distance of 450 m. Tow time was no available for approximately half of the tows from 1985
907 Quarter 3 to 2016, and was imputed based on the mean tow time of the sampling station.

908 Eleven stations (T0-T6,T10-T13) sampled in at least 11 years and with California scorpionfish
909 present in at least 5% of trawls were retained for the analysis (1,490 trawls). For hauls with
910 fewer than 30 California scorpionfish, each fish was measured to the nearest mm (standard
911 length). In hauls with more than 30 California scorpionfish, they were tallied by size class
912 (nearest cm). Six hauls, all from station T3, caught more than 30 California scorpionfish.

913 *City of Los Angeles* The City of Los Angeles Sanitation District provided trawl data from
914 1986-2016 (Craig Campbell, Lost Angeles City). The City of Los Angeles follows the same
915 sampling protocols as the Southern California Bight Regional Monitoring Program trawl
916 survey. Stations within Los Angeles Harbor were excluded from the dataset. Years with
917 fewer than ten total hauls were removed from the analysis (1986, 1987, and 1992), as were
918 station sampled in fewer than 10 years. Ten stations (A1, A3, C1, C3, C6, C9A, D1T, Z2,
919 Z3, Z4), total 921 hauls, were retained for the index of abundance.

920 Tow times were recorded starting in 1999, and assumed to be 10 minutes prior to 1999. Haul
921 depth was missing for approximately half of the hauls, and was imputed as the mean depth
922 of other hauls at that station. All California scorpionfish encountered were measured to the
923 nearest cm (standard length).

924 *Los Angeles County* The Sanitation Districts of Los Angeles County provided quarterly trawl
925 data from 1972-2016 (Shelly Walther, Sanitation Districts of Los Angeles County) and follow
926 the same sampling protocols as the Southern California Bight Regional Monitoring Program
927 trawl survey stations sampled in fewer than 10 years or at 305 m where California scorpionfish
928 were never observed were removed from the analysis. Non-standard and special study trawls
929 were also removed, e.g., night trawl study in 1987. Hauls were based on a 10 minute tow
930 time and that is assumed as the effort for all hauls. Twelve stations (stations at 23m, 61m,
931 and 137m for T0, T1, T4, T5), totaling 1,848 hauls were retained after initial filtering. All
932 California scorpionfish encountered were measured to the nearest cm (standard length).

933 *City of San Diego* The City of San Diego Sanitation District conducts trawls for two permits
934 (Point Loma Ocean Outfall and South Bay Ocean Outfall) and provided data from 1985-2015
935 (Ami Latker and Robin Gartman, City of San Diego Public Utilities Department).
936 Stations sampled in fewer than 15 years were filtered from the dataset. Fourteen stations
937 from the Point Loma Ocean Outfall (SD1-SD14) and five stations from the South Bay Ocean
938 Outfall were retained (SD17-21), totaling 1,180 hauls. A tow time of 10 minutes is assumed
939 for all trawls. All California scorpionfish encountered were measured to the nearest cm
940 (standard length).

941 *Sanitation Districts Index Standardization*

942 Trawls from all sanitation districts were combined to standardize the index of relative
943 abundance. This is in contrast to the 2005 assessment that standardized each of the
944 sanitation district indices independently and combined them using an inverse variance
945 weighting approach (Maunder et al. 2005). One reason for this was that the 2005 base model
946 going into the STAR panel was five sub-models for the southern California Bight. Taking
947 into consideration that the 2017 base model is a one-area model, all of the sanitation districts
948 follow the same sampling protocols and the sampling design is a fixed station approach, the
949 decision was made to develop a single index. The index was standardized using a delta-GLM
950 approach.

951 The data were filtered for each sanitation district independently. The filters applied are
952 described in the sections above and summarized in Table 22. The covariates considered for
953 the lognormal and binomial models were *year* (47 levels), *quarter* (4 levels), and *station* (52
954 levels). A lognormal model for the positives was select over a gamma model by a delta AIC
955 of 619. AIC model select was used for both the lognormal and binomial models and all three
956 covariates were selected for both (Table 23). The standardized index shows a large spike
957 in relative CPUE in 1981, varies within a range of 0.1 to 0.25 from 1989 to 2009, and then
958 declines until 2013 (Figure 18). The last three years of the index show an increase in relative
959 abundance. The final standardized index and log-standard error can be found in Table 24.
960 We did explore standardizing the indices independently. However, this results in a loss of
961 data, as some sanitation district had low sample sizes in some years. The general trend in
962 relative CPUE is similar across sanitation districts (Figures 19).

963 *Sanitation Districts Length Composition*

964 Each district measures every fish encountered in their survey. Orange County Sanitation
965 District was the only program sampling in 1970 and 1971 and encountered a small number of
966 California scorpionfish in those years (Figure 20). Los Angeles County has has encountered
967 pulses of large numbers of California scorpionfish in 2002, 2004 and 2005. Figure 21 shows
968 the distribution of lengths for California scorpionfish by 25 m depth bins and Sanitation
969 District. The median length
970 of fish from the City of Los Angeles trawls is smaller than the other two districts. However,
971 there are only 120 in that depth bin, compared to 1,372 fish in the 50-74 m depth bin for the
972 City of Los Angeles (Table 25).

973 The length composition indicates a fairly consistent size range of fish encountered in the trawl
974 surveys, with a handful of smaller fish in 2016 (Figure 22). Length measurements from all
975 5,525 hauls of the sanitation districts were combined across sanitation districts. The number
976 of California scorpionfish was slowest during the first few years of the time series, and also
977 declines starting in 2012 (Table 26).

978 NWFSC Trawl Survey Index

979 The Northwest Fishery Science Center has conducted combined shelf and slope trawl surveys
980 (hereafter referred as NWFSC trawl survey) since 2003, based on a random-grid design from
981 depths of 55 to 1280 meters. Additional details on this survey and design are available in
982 the abundance and distribution reports by Keller et al. (2008). The haul locations and raw
983 catch rates (in log scale) are shown in Figure 23.

984 The proportions of positive catch haul and the raw catch rates of positive hauls by depth and
985 latitude are shown in Figure 23 and Figure 25, respectively. These figures show that more
986 scorpionfish were caught at shallow depth zones and in the southern latitude zones. Box
987 plots of length summary data by depth and sex (Figure 27) and by latitude and sex (Figure
988 27) show no evidences of different spatial distributions (by depth and latitude) by length or
989 by sex.

990 The numbers of total hauls and percentages of positive catch hauls by depth and latitude
991 zones are presented in Tables 27 and 28, respectively. Summaries of raw catch data by year
992 are listed in Table 29. Overall, catches of scorpionfish by the survey were very low with
993 less than 1mt fish caught during the entire 14 years of the survey. Bubble plots of length
994 frequency distribution by year and sex are presented in Figure 28.

995 Summaries of age data by year and sex are presented in Table 30. There were more males (n
996 = 529) being aged than females (n = 340), presumably indicating that there are more males
997 than females in the populations. The table also shows that mean ages and mean lengths
998 for both sexes decreased in recent years. Table 31 show five percentiles of fish aged by sex,
999 indicating more older males in the population. All aged data from the survey were used as
1000 conditional age-at-length matrix in the assessment model. The mean age-at-length indicates
1001 males and females to have similar growth patterns until around age three, at which time,
1002 females are larger than males (Table 32).

1003 Total biomass estimates from the survey were analyzed using the VAST program (Thorson
1004 and Barnett 2017). The Q-Q goodness of fit plot and time series of total biomass estimates
1005 are shown in Figures 29 and 30, respectively. The Q-Q plots shows generally good fits
1006 and the time series of biomass estimates indicates no significant trend with relatively large
1007 uncertainties from the survey. The final survey index and log standard error used in the
1008 assessment model are in Table 33.

1009 CSUN/VRG Gillnet Survey Index

1010 California State University Northridge with Vantuna Research Group (CSUN/VRG) con-
1011 ducted a gillnet survey from 1995-2008 (Daniel Pondela, VRG). Sites along the coast from
1012 Santa Barbara to Newport were consistently sampled for the time series, as well as Catalina
1013 Island. Gillnet sets from within Marina Del Rey and Catalina Harbor were removed from the
1014 analysis.

1015 All gillnets were the same length with six-25' panels (150' in length).
1016 The standard sampling gillnet had 1“, 1.5“, 2 square mesh, with each mesh on two panels.
1017 Samples were excluded if they were collected using a net other than the standard sampling
1018 gear. Other data filters included remove months that were not consistently sampled (Table
1019 34).

1020 Five covariates were considered in the model standardization, *year* (14 levels), *month* (8
1021 levels), *site* (8 levels indicating the sampling site location), *float* (2 levels indicate if floats
1022 were used on the gillnet), and *perp/para* (2 levels indicate if the net was set perpendicular or
1023 parallel to shore). A lognormal was select over a gamma model for the positive encounters by
1024 a delta AIC of 108.29. Covariates selected via AIC for both the lognormal binomial models
1025 included *year*, *site*, and *perp/para* (Table 35, Figure 31). The standardized index decreases
1026 from 1995-1998 and remains flat until through the early 2000's with three high years at the
1027 end of the time series (Figure 32).

1028 The survey measured (standard length) every California scorpionfish encountered, totalling
1029 1,130 fish. The majority of fish encountered were between 14 and 33 cm total length, with no
1030 strong trends or patterns in age classes during the time period (Figure 33)

1031 Southern California Bight Regional Monitoring Project Trawl Survey

1032 The southern California Coast Water Research Project SCCWRP consists of over 60 agencies
1033 in southern California that conduct monitoring of aquatic environments. One of the monitoring
1034 programs in the Southern California Bight (SCB) is a trawl survey conducted every five years.
1035 The pilot year of the survey was 1994. Data from each of the survey years (1994, 1998, 2003,
1036 2008, and 2013) were provided by the SCCWRP (Shelly Moore).

1037 In each of the five years of the study, sampling stations were chosen via a stratified random
1038 sampling design (Bight '98 Steering Committee 1998). All participating agencies follow the
1039 same protocols (net is towed 10 minutes at a speed of 1.0 m/sec) and use the same net

1040 (semiballoon otter trawl). All fish and invertebrates are identified, counted, batch-weighed,
1041 and measured (standard length to the nearest cm).

1042 A series of data filters were applied to the dataset (Table 37). Only two scorpionfish were
1043 encountered in hauls deeper than 450 m. Ninety-five percent of the data were retained for
1044 hauls in shallower than 97 m, which was set as a filter. Stations in harbors (2/114 positive
1045 hauls), north of Ventura (6/190 positive hauls) and the islands (16/117 positive hauls) were
1046 excluded due to low encounters of California scorpionfish. The final dataset included 398
1047 hauls, 129 of which encountered California scorpionfish. The unit of effort for this survey is
1048 in kg per tow time (minutes).

1049 Covariates considered for the delta-GLM model were *year* (5 levels), *area* (4 regions), and
1050 *month* (3 levels; July-September). Sampling stations were assigned to one of four regions, 1)
1051 Ventura to Long Beach, 2) Long Beach to Dana Point, 3) Dana Point to San Diego, and 4)
1052 San Diego to the U.S./Mexico Border. A lognormal model was selected over a gamma model
1053 for the positives by a delta AIC of 30. Depth (20-m depth bins) were considered, but none
1054 of the levels were significant in a full lognorml or binomial model and was not considered
1055 further. AIC selection for both the lognormal and binomial models selected all covariates
1056 for the final model (Table 38). The Q-Q plot used to evaluate the goodness-of-fit of the
1057 lognormal portion of the model is in Figures 34.

1058 The standardized index of abundance indicates higher relative CPUE in 1994 and 2003, with
1059 the other three years lower (Figure 35). The fact that the survey is conducted every five years
1060 (4 years between the pilot and the 1998 survey), may preclude drawing any firm conclusions
1061 on trends in abundance from this data.

1062 The survey measured a total of 427 fish, with the last two years of the survey (2008 and
1063 2013) only encountering 25 and 53 California scorpionfish, respectively.
1064 However, the smallest fish observed in this survey were in 2013 (Figure 36).

1065 Generating Station Impingement Surveys

1066 Data from the southern California generating station surveys were provided by Eric Miller
1067 (MBC Applied Environmental Sciences). The generating stations all draw in seawater
1068 through an intake system for once-through cooling water. There are five generating stations
1069 that conduct normal operation and heat treatment surveys with observations of California
1070 scorpionfish: Scattergood Generating Station (SGS), El Segundo Generating Station (ESGS),
1071 Redondo Beach Generating Station (RBGS), Huntington Beach Generating Station (HBGS),
1072 and San Onofre Generation Station (SONGS). Each generating station draws in water from
1073 different depths and distances from shore: SGS draws from 500 m offshore at 6 m depth,
1074 ESGS draws from 700 m offshore at 9.8 m depth, RBGS draws from 289 m offshore at 13.7 m
1075 depth, HBGS draws from 500 m offshore at 5 m depth, and SONGS has two intake systems
1076 960 m and 900 m offshore and at 9 m and 8 m depth, respectively (Miller et al. 2009).

1077 The two surveys conducted are normal operations surveys and heat treatment surveys. For
1078 normal operations surveys, the intake screens are rotated and cleaned to start the survey. All

1079 of the impinged fish are washed off the screen at this time and discarded. When the intake
1080 screens stop running, the survey begins. The generating station then operates as normal for
1081 24 hours, which includes operating and washing the screens as usual (typically every eight
1082 hours). The screens are then operated and washed again after a second 24 hours has elapsed.
1083 Any specimens washed off the screens during the 48 hour study period are retained. The total
1084 sample is processed to identify, count, weigh, measure the fish and macroinvertebrates. There
1085 is often no information on the water flow collected during the 48 hour period of the normal
1086 operations survey. Most fish enter the the generating station and swim in the sedimentation
1087 basin until either getting exhausted or impinged. The SONGS generating station also has a
1088 fish elevator that releases a fraction of the fish back to the ocean.

1089 At each generating station, cooling water, i.e., seawater, is pumped into the generating station
1090 where it reaches a sedimentation basin. Water flow is uni-directional, and fish can reside
1091 in this area, but not escape. During a heat treatment, water in the sedimentation basin is
1092 heated to over 38 degrees Celsius, killing all fish and invertebrates, and impinging them on
1093 the travelling screens.

1094 The screens are operated and washed off per normal operating procedures right up until the
1095 heat treatment takes place. Therefore, only the fish remaining in the sedimentation basin
1096 and those impinged since the last screen rotation are counted in the heat treatment survey.
1097 The total flow between heat treatments has previously been used to standardize indices in
1098 previous reports. However, this is not representative of the flow relating to fish impinged
1099 during the heat treatment. The water flows vary widely among heat treatments, time of
1100 year (higher in summer when energy demands increase), and generating stations. Therefore,
1101 the generating station impingement surveys were not used to develop indices of abundance.
1102 However, length composition data from the impingement surveys were used.

1103 The length composition data from the impingement show a higher proportion of smaller (<10
1104 cm) fish since 2012 (Figure 37)

1105 *California Cooperative Oceanic Fisheries Investigations (CalCOFI) Survey* UCSD Scripps
1106 Institution of Oceanography, CDFG, and the National Marine Fisheries Service have carried
1107 out a plankton survey on a regular basis since 1951 (Moser et al. n.d.). Prior to 1965,
1108 *Scorpaena* samples were not speciated.

1109 California scorpionfish larvae encounters from CalCOFI surveys were provided by Noelle
1110 Bowlin (NMFS SWFSC). Only 16 positive bongo tows in the core area (lines 77-93) encoun-
1111 tered California scorpionfish. The majority of the 335 positive bongo tows occurred in Mexico,
1112 south of Punta Eugenia Baja California and are likely a combination of California scorpionfish
1113 and other *Scorpaena* species. The California scorpionfish egg masses are encountered in
1114 the CalCOFI surveys, but because California scorpionfish is not a target species they are
1115 entered in the database as “unidentified eggs” (William Watson, NMFS SWFSC). An index
1116 of abundance was not developed for the CalCOFI data due to the small sample sizes.

1117 **2.2.4 Biological Parameters and Data**

1118 California scorpionfish do not have a forked tail, therefore total length and fork length are
1119 equal. Love et al. (1987) provide conversion factors between standard length (SL) and total
1120 length (TL): $TL = 1.21SL + 1.02$ and $SL = 0.82TL - 0.69$.

1121 Standard and total lengths of 163 California scorpionfish were available from a halibut trawl
1122 survey in southern California (Steve Wertz, CDFW). The conversion from SL to TL from
1123 these data was estimated at $TL = 1.2225SL + 0.7773$.

1124 The conversion originating from the halibut trawl data was used in this assessment due to the
1125 fact that the original data from Love et al. (1987) are not available. The majority of available
1126 length composition data were measured to total length, except for three of the sanitation
1127 district trawl surveys, the Southern California Bight Regional Monitoring Program trawl
1128 survey, and the CSUN/VRG gillnet survey (gillnet survey). Maunder et al. (2005) converted
1129 all data to standard length due to clumping of data when length data are only available to
1130 the nearest centimeter. However, the same is true for the conversion from TL to SL when
1131 data are available to the nearest centimeter. All length data for this assessment are in TL.
1132 The Sanitation District of Orange county and the VRG gillnet study measured SL to the
1133 nearest mm.

1134 To avoid missing length bins (specifically 18, 23, 29 cm) in the conversion from SL to TL,
1135 0.5 was first subtracted from each SL and a random uniform number ($U[0, 1]$) was added to
1136 the SL measurement. All TL measurements were rounded to the nearest length centimeter
1137 length bin. A comparison of the length distributions

1138 **Length And Age Compositions**

1139 Include: Sample size information for length and age composition data by area, year, gear,
1140 market category, etc., including both the number of trips and fish sampled.

1141 Length compositions were provided from the following sources:

- 1142 • CDFW market category study (*commercial dead fish*, 1996-2003)
- 1143 • CALCOM (*commercial dead fish*, 2013-2016)
- 1144 • CDFW onboard observer (*recreational charter discards*, 2003-2016)
- 1145 • Ally onboard observer study (*recreational charter discards*, 1984-1989)
- 1146 • California recreational sources combined (*recreational charter retained catch*)
 - 1147 – CDFW and Ally onboard observer surveys (1984-1989)
 - 1148 – Collins and Crooke onboard observer surveys (1975-1978)
 - 1149 – MRFSS (1980-2003)
 - 1150 – CRFS (2004-2014)
- 1151 • California recreational sources combined (*private mode retained catch*)
 - 1152 – MRFSS (1980-2003)
 - 1153 – CRFS (2004-2016)
- 1154 • Sanitation district trawl surveys (*research*, 1970-2016)

- 1155 • CSUN/VRG gillnet survey (*research*, 1995-2008)
 1156 • Power plant impingement surveys (*research*, 1974-2016)
 1157 • Southern California Bight trawl survey (*research*, 1994, 1998, 2003, 2008, 2013)

1158 The length composition of all fisheries aggregated across time by fleet is in Figure 38.
 1159 Descriptions and details of the length composition data are in the above section for each fleet
 1160 or survey.

1161 *Recreational: California MRFSS And CRFS Length Composition Data* Individual fish lengths
 1162 recorded by MRFSS (1980-2003) and CRFS (2004-2011) samplers were downloaded from the
 1163 RecFIN website (www.recfin.org). CRFS data from 2012-2014 were obtained directly from
 1164 CDFW.

1165 **Age Structures** Age data were provided from the NWFSC trawl survey from 2005-2016, and
 1166 all of the otoliths collected from the survey were aged. Figures 39 and 40 provide examples
 1167 of California scorpionfish otoliths read (including double-reads) by the Cooperative Ageing
 1168 Project (CAP) in Newport, Oregon.

1169 A total of 879 otoliths were read, and ranged from 0-29 years of age. Fewer thana 1% (8 fish)
 1170 were aged 22 years or older, and only one age-0 fish was in the sample (Figure 41).

1171 Males and females exhibit different growth patterns with females growing to be larger at a
 1172 smaller age (Figure 41). Sex-specific length-at-age was initially estimated external to the
 1173 population dynamics models using the von Bertalanffy growth curve (Bertalanffy 1938),
 1174 $L_i = L_\infty e^{(-k[t-t_0])}$, where L_i is the length (cm) at age i , t is age in years, k is rate of increase
 1175 in growth, t_0 is the intercept, and L_∞ is the asymptotic length.

1176 The external parameter estimates for females were $L\infty = 31.613$, $k = 0.250$, $t_0 = -2.280$, and
 1177 for males $L\infty = 27.374$, $k = 0.233$, $t_0 = -2.092$ (Figure 42).

1178 **Aging Precision And Bias** Uncertainty in ageing error was estimated using a collection
 1179 of 200 California scorpionfish otoliths with two age reads (43).

1180 Age-composition data used in the model were all from the NWFSC trawl survey and were
 1181 from otoliths reads aged by the Cooperative Ageing Project (CAP) in Newport, Oregon. All
 1182 of the otolith reads were from Age Reader A, and double reads were read by Age Reader B.
 1183 Ageing error was estimated using publicly available software (Thorson et al. 2012).
 1184 The software setting for bias and standard deviation were the same for both readers, unbiased
 1185 and curvilinear increase in standard deviation with age, respectively (Figure 44). Two fish
 1186 with estimated age greater than 21 (plus group age) were exluded from the ageing error
 1187 estimation. The resulting estimate indicated a standard deviation in age readings increasing
 1188 from 0.001 years to a standard deviation of 1.79 years at age 22.

1189 **Weight-Length**

1190 The weight-length relationship is based on the standard power function: $W = \alpha(L^\beta)$ where
1191 W is individual weight (kg), L is length (cm), and α and β are coefficients used as constants.

1192 Sex-specific weight-length relationships were estimated from the NWFSC trawl survey data.
1193 Length and weight data were available for 340 females and 530 males. The estimated
1194 parameters for females are $\alpha = 1.553983e^{-05}$ and $\beta = 3.057654$, and for males $\alpha = 1.9104e^{-05}$
1195 and $\beta = 2.980548$. Love et al. (1987) found males to be heavier at a given length than
1196 females, whereas the NWFSC data suggestes the opposite (Figure 45).

1197 The original data from Love et al. (1987) are no longer available (Milton Love, personal
1198 communication, UC Santa Barbara) to re-examine the trends. The weight-length relationships
1199 estimated from the NWFSC survey are consistent with the sex-specific growth rates and are
1200 used in the assessment model.

1201 Sex Ratio, Maturity, and Fecundity

1202 The NWFSC trawl survey is the only study available with raw data on sex ratios by age.
1203 Across all ages, the sex ratio from the aged California scorpionfish from the NWFSC trawl
1204 survey was 60% males and 40% females (Figure 46). At age-1, 39% of the aged fish were
1205 female (29 of 85), but the sex of 10 fish was unknown. For ages two to five, the percent of
1206 female fish ranged from 45-54%, with aged fish older than five dominated by males. The
1207 assessment assumed a sex ratio at birth was 1:1. The NWFSC trawl survey samples a
1208 minimum depth of 55 m and no information on sex ratios was available from other surveys.

1209 Love et al. (1987) conducted the only published life history study of California scorpionfish,
1210 but did not report information on sex ratios. Differing numbers of sample sizes (males and
1211 females) were used for each part of the study (ex. maturity and length-at-age). The raw data
1212 from this study are no longer available, and we were not able to determine raw samples sizes
1213 by sex.

1214 No new data on maturity or fecundity for California scorpionfish are available since the
1215 publication of the 2005 stock assessment. Love et al. (1987) found few California scorpionfish
1216 to be mature at age-1, 50% of males were mature at 17 cm TL and over 50% of females were
1217 mature by 18 cm TL, or two years of age. All fish were mature by 22 cm TL. This assessment
1218 used size at 50% maturity for females of 18 cm TL, with maurity asmyptotign to 1.0 for
1219 larger fish.

1220 The 2005 assessment model combined information from estimated linear gonadal somatic
1221 index and maturity based on standard length (Maunder et al. 2005). However, the study used
1222 to estimate the GSI, was a halibut targeted trawl study using a mesh size of 10.2 cm (Steven
1223 Wertz, personal communication, CDFW). This assessment assumed linear relationship for
1224 eggs per kilogram.

1225 **Natural Mortality** Hamel (2015) developed a method for combining meta-analytic ap-

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

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

The above is also the median of the prior. The prior is defined as a lognormal with mean
 $\ln \frac{5.4}{A_{max}}$ and SE = 0.4384343. Using a maximum age of 21 the point estimate and median of
 the prior is 0.2545, which is used as a prior for females in the assessment model.

2.2.5 Environmental Or Ecosystem Data Included In The Assessment

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

2.3 History Of Modeling Approaches Used For This Stock

2.3.1 Previous Assessments

California scorpionfish was first assessed in 2005 (Maunder et al. 2005) using SS2 (version
 1.18). The 2005 model was a one-area model for the population south of Pt. Conception
 to the U.S.-Mexico border. The assessment was sensitive to the inclusion of the sanitation
 district index of abundance and the STAT team provided reference points for a model that
 included the sanitation index and one excluding it. The stock was found to be at 80% of

1256 unfished levels for the model with the sanitation index and 58% for the model without the
1257 sanitation index. The 2015 catch-only projections used the same version of SS2 as the 2005
1258 assessment model.

1259 The 2005 model assumed removals equivalent to the ACL in all years from 2004-2016. The
1260 2015 model included catch estimates from 2004-2014, and the ACLs for 2015 and 2016 were
1261 assumed to be attained. Maunder et al. (2005) assumed no discard mortality, while the 2015
1262 update applied a 7% discard mortality rate derived by the Groundfish Management Team
1263 (GMT) (2009-2010 SPEX EIS, Chapter 4, pg. 290) was applied to the estimate of discards to
1264 provide an estimate of discard mortality for the recreational fleet.

1265 2.3.2 2005 Assessment Recommendations

1266 Include: Response to STAR panel recommendations from the most recent previous assessment.

1267 **Recommendation 1:** The sanitation surveys conducted to track the impact
1268 of sewage outfall provided a fishery independent index of abundance for
1269 scorpionfish. This data source should be more fully explored for other
1270 near-shore species of recreational or commercial interest. Methods should
1271 be developed to produce a more statistically rigorous index from the
1272 separate surveys.

1273
1274 STAT response: Data from all sanitation districts in southern California were obtained
1275 for this assessment. All of the data were pooled across surveys to develop one index of
1276 abundance using the delta-GLM method

1277 **Recommendation 2:** An age, growth and maturity study for scorpionfish is
1278 needed. Although there has been previous research on scorpionfish age and
1279 growth, the available information is not appropriate for stock assessment
1280 modeling.

1281
1282 STAT response: Age data are available from the NWFSC trawl survey from 2005-2016.
1283 There have been no additional studies on growth or maturity for California scorpionfish
1284 since the 2005 assessment.

1285 **Recommendation 3:** Location information for the historic groundfish data of all
1286 species is currently available, in hard copy form only, from the California
1287 Department of Fish and Game. Putting this information into electronic
1288 format would greatly improve the ability to assign catches of all species to
1289 specific stocks on a trip-by-trip basis.

1290
1291 STAT response: The location-specific catches referred to above have been key-punched
1292 and are available in electronic form from the SWFSC, Santa Cruz.

1293 **Recommendation 4:** The SS2 model should be modified to allow for projections
1294 of user-specified recruitment at user defined values. It would be most
1295 helpful if the default harvest policies were then recalculated automatically
1296 for these user-specified recruitments.

1297

1298 STAT response: The status of this within Stock Synthesis is unknown.

1299 2.4 Model Description

1300 2.4.1 Transition To The Current Stock Assessment

1301 The first formal stock assessment for California scorpionfish was conducted in 2005 (Maunder
1302 et al. 2005). The 2005 model conducted in SS2 version 1.18 was first transitioned to SS3.24z
1303 as a bridge model, before moving forward to SS3.30. During the model transition to SS3.24z
1304 and error was found in the 2005 model. The harvest rate was estimated at the upper limit of
1305 0.9 and could not remove all of the input catch (Figure 47).

1306 The older SS2 output did not include separate columns for the observed (input) catch and
1307 dead removals by the model (output), which would have prevented the 2005 STAT team from
1308 discovering that the two time series differed (Figure 48). The recreational fishery selects the
1309 largest fish and removes the highest biomass of California scorpionfish. When the harvest rate
1310 hit the upper bounds as in the 1970s, there were not enough fish estimated in the population
1311 to support the large removals, i.e., stock estimated at 500 mt and the recreational catch was
1312 100 mt. The stock was not productive enough to sustain the observed catch. A comparison
1313 of time series from the 2005 model, the SS3.24z transition model, and the base model from
1314 this assessment are in Figure 49.

1315 Below, we describe the most important changes made since the last full assessment in 2005
1316 and explain rationale for each change. Some of these items are changes due to structure
1317 changes with Stock Synthesis, and some denote parameters chosen for options that were not
1318 available in SS2 (version 1.18).

1319 Changes in the bridge model from from SS2 version 1.8 to SS3.24z and SS3.30

1320 The way growth is modeled for age-0 fish changed. More recent versions of Stock Synthesis
1321 model length-at-age for fish below the first reference age (A_{min}) as linearly increasing from
1322 the initial length bin to the length given by the L_{at_Amin} parameter. Since small California
1323 scorpionfish are selected in the sanitation district survey data, the change in modeled growth
1324 has the potential to affect estimates of recruitment. We took the following approach in order
1325 to mimic the methods of SS2 version 1.8:

- 1326 1. Change A_{min} from 1 to 0.

1327 2. Replace initial value of length at minimum age for females with 7.26567 (the Length
1328 begin value for age 0 from the SS2.rep file).

1329 3. Replace initial value of length at minimum age for males with 0.35366 (=
1330 LN(10.3483/7.26567), the log of the ratio of Male to Female length at age 0 from the
1331 SS2.rep file)

1332 This assessment aggregated the catches from the commercial fish pot fleet with the hook-
1333 and-line fleet. There were no measured California scorpionfish from the fish pot fleet and
1334 overall catches were minimal. The commercial trawl and gill net fleets were disaggregated as
1335 in the 2005 model. The current model also assumes no discards in the commercial fishery.
1336 The previous assessment combined the recreational party/charter and private modes into a
1337 single fishery. This assessment disaggregates the two sectors of the recreational fishery and
1338 adds a fleet to represent the discards (party/charter and private modes combined) from the
1339 recreational fleet

1340 The 2005 model was a length-based model. This assessment uses conditional age-at-length
1341 from fish aged from the NWFSC trawl survey.

1342 The historical commercial catches were the same as those used in the previous assessment
1343 and were updated using CFIS data from 2005-2016. The CFIS database was used instead of
1344 CALCOM because landings in CALCOM included catches from Mexican waters.

1345 The recreational catches differed from the catch history used in the previous assessment. In
1346 2010 a catch reconstruction was completed for California (Ralston et al. 2010). Methods
1347 provided were applied in reconstructing the catch of California scorpionfish for this assessment.
1348 Both assessments utilized similar data sources including CPFV logbooks and MRFSS data
1349 providing catch estimates, with the addition of data from the CRFS program for 2004-2016.
1350 The main difference resides with accounting for discard mortality as well as landed catch
1351 allowing discards to be modeled as a separate fleet making use of length distribution data for
1352 discards for 2003-2016. In addition, the recreational catch time series terminated in 1928 for
1353 the current assessment, as specified for rockfish catch reconstructions in the historical catch
1354 reconstruction document, rather than in 1916. The ratio of catches for the party-charter boat
1355 mode to the private and rental boat mode from the MRFSS period were used in combination
1356 with catch estimates from the CPFV logbook estimates back to 1932 in both assessments to
1357 approximate mortality the private rental boat mode prior to 1980. A ramp accounting for
1358 the increase relative contribution of the private boat mode relative to the party charter mode
1359 from the mid 1965 to 1980, as conducted for rockfish in the historical catch reconstruction
1360 document. A constant ratio of catch compared to the party charter boat mode was applied
1361 for man-made and beach and bank modes to provide an estimate of catch back to 1936 as was
1362 done for the private and rental boat mode in the previous assessment. The CPFV logbook
1363 data terminated in 1935 and a linear ramp was used to approximate catch from 1936 back to
1364 zero in 1928 for each mode as compared to 1916 in the 2005 assessment.

1365 The bias adjustment for recruitment deviations did not exist in SS2 (version 1.198). We set
1366 1965-2015 as the range of years with full bias adjustment in SS3.24z to span the time series
1367 that was modeled.

1368 Length composition data was updated and sources added for this assessment. The 2005
1369 assessment used the same source for length compositions for the commercial fisheries, the
1370 CDFW market category study. The length compositions from CALCOM were all from single
1371 trips within a year and are not used in the assessment. The measured fish from RecFIN
1372 (dockside intercept surveys) were disaggregated to the party/charter and private modes.
1373 Preliminary analyses indicated the recreational private and rental boat mode selects larger
1374 fish than the party and charter boat mode (add plot).

1375 The 2005 assessment converted all length parameters to SL, which prevented comparisons
1376 with some of the growth parameters. The values in the SS files from the previous assessment
1377 also did not match those in the written document. The current model uses TL for all length
1378 compositions and growth parameters.

1379 The previous assessment modeled selectivity using the double logistic, with defined peak, and
1380 smooth joiners for all fleets with estimated selectivity. Two parameters were estimated for
1381 each selectivity curve, the size at which selectivity is halfway between the selectivity at length
1382 bin = 1 and one, and the slope of the left side of the selectivity curve. This selectivity pattern
1383 has since been discontinued in SS. All of the double logistic selectivity patterns in the 2005
1384 assessment were asymptotic and are the same in this assessment. Selectivity in this model is
1385 assumed to be length-based and is modeled as double-normal for all fleets that were also in
1386 the previous assessment. This assessment mirrors the selectivity for the trawl and gill net
1387 commercial fisheries to the commercial hook-and-line fishery. The 2005 assessment included
1388 two surveys, the CPFV logbook and sanitation district surveys. The length composition
1389 measurement for the CPFV logbook survey are from the dockside intercept surveys in RecFIN
1390 and were updated to double normal selectivity in this model.

1391 The time blocks for the commercial fishery is the same as in the previous assessment (1916-
1392 1998 and 1999-2017). There have been no additional major changes to the commercial
1393 regulations since the 10-inch minimum size limit and the catches from the commercial fleets in
1394 the last 10 years have been minimal compared to historical catches. The time blocks for the
1395 recreational fleets were updated to include a third time block from 2000-2005, when closures
1396 of the recreational fishery fluctuated annually. Since 2006, the recreational regulations have
1397 remained fairly consistent.

1398 The 2005 assessment considered six candidate indices of abundance (fishery-dependent: CPFV
1399 logbook, CDFW monthly block summaries, RecFIN dockside intercept survey, trawl logbook;
1400 fishery-independent: sanitation survey, CalCOFI, but only included two in the final model
1401 (CPFV logbook and sanitation district surveys). The sanitation district survey ended up
1402 being the basis for the decision table in the 2005 assessment, with more weight given to
1403 the model without the sanitation district survey. All indices were re-evaluated and updated
1404 through 2016 for this assessment. As in the 2005 assessment, we did not consider the CaCOFI

1405 index, CDFW monthly block summaries, or the trawl survey for the current model. The
1406 current model includes four fishery-dependent indices and four fishery-independent indices.
1407 The RecFIN party/charter mode dockside intercept survey was not available at the trip-level
1408 in 2005 and it is unclear how the 2005 assessment treated data record entries from RecFIN;
1409 however, the RecFIN index was sensitive to the. The RecFIN private mode index is currently
1410 only available at the trip-level for the CRFS sampling period, 2004-2016. The onboard
1411 observer database was also not available for the 2005 assessment and is used here as both
1412 retained-only and discard-only indices. The CPFV logbook data was updated and reevaluated
1413 from the 2005 assessment.

1414 The fishery-independent indices are all new for this assessment, except for the sanitation
1415 districts trawl surveys.

1416 Maturity was changed for this assessment. The Love et al. (1987) study is the only study
1417 that estimated the maturity ogive. The CDFW cross-shelf halibut survey used in the 2005
1418 assessment to estimate the GSI were not used in this study as GSI is an indicator of fecundity.
1419 No information on fecundity is available for California scorpionfish. This assessment uses the
1420 assumption that eggs are equivalent to spawning biomass.

1421 In this assessment, steepness was set at 0.718, the mean of the beta prior developed from
1422 a meta-analysis of West Coast groundfish and updated in 2017 (James Thorson, personal
1423 communication, NWFSC, NOAA).

1424 The prior for female natural mortality was updated to the median of the prior from a meta-
1425 analysis conducted by Owen Hamel (personal communication, NWFSC, NOAA).

1426 Assuming a maximum age of 21 years, the median of the prior is 0.2547, close to the fixed
1427 value for younger fish in the 2005 assessment of 0.25.

1428 Due to the fact that the 2005 model was erroneous, a bridge from the 2014 catch update,
1429 which used SS2 version 1.8 and the 2005 model, was not developed.

1430 Changes in the bridge model from from the SS3.24z model closely matched with the SS2
1431 version 1.8 model to SS3.30.

1432 **2.4.2 Summary of Data for Fleets and Areas**

1433 There are twelve fleets in the base model. They include:

1434 *Commercial*: The commercial fleets include three separate fleets, one each for the hook-and-
1435 line, gillnet, and trawl fisheries. The catch from all other commercial gears is included in the
1436 hook-and-line catch.

1437 *Recreational*: The recreational fleets include three separate fleets, one each for retained catch
1438 from the recreational party/charter boat and private boat modes, and one for the dead
1439 discards from the recreational party/charter boat and private boat modes combined.

¹⁴⁴⁰ *Research:* There are six sources of fishery-independent data available for California scorpions, including the sanitation district trawl surveys, NWFSC trawl survey, the CSUN/VRG
¹⁴⁴¹ gillnet survey, the generating stations surveys, Southern California Bight regional monitoring
¹⁴⁴² trawl survey, and the recreational party/charter onboard observer retained-only catch data.
¹⁴⁴³

¹⁴⁴⁴ 2.4.3 Other specifications

¹⁴⁴⁵ Stock synthesis has a broad suite of structural options available. Where possible, the ‘default’
¹⁴⁴⁶ or most commonly used approaches are applied to this stock assessment.

¹⁴⁴⁷ The assessment is sex-specific, including the estimation of separate growth curves, and natural
¹⁴⁴⁸ mortality. Sex-specific length-weight parameters were input as fixed values. The assessment
¹⁴⁴⁹ only tracks female spawning biomass for use in calculating stock status.

¹⁴⁵⁰ The selectivity for the generation station impingement surveys was set to 1.0 for all sizes
¹⁴⁵¹ (SS pattern 0). As an example, the cooling intake pipes at SONGS are 18-foot in diameter
¹⁴⁵² and draw in seawater at a rate of hundreds of thousands of gallons per minute. The water
¹⁴⁵³ flow once in the generating station is one directional and organisms cannot escape, unless
¹⁴⁵⁴ removed via a fish return system. Flow rates for the cooling water intake range from 0.27-1.2
¹⁴⁵⁵ m/s (MBC 2005, 2007, Electric Power Research Institute 2008) and would not allow a fish of
¹⁴⁵⁶ any size evade intake cooling pipes.

¹⁴⁵⁷ The length composition data for some years and fleets was small, and may not have been
¹⁴⁵⁸ representative of the total catch. Length composition data were removed from the model if
¹⁴⁵⁹ less than one trip sampled and fewer than 20 fish were measured in a given year and fleet.
¹⁴⁶⁰ From 1985-1989, two surveys measured fish from the recreational party/charter fleet, the
¹⁴⁶¹ Ally et al. (Ally et al. 1991) onboard observer survey and the dockside intercept survey. The
¹⁴⁶² number of trips and fish sampled by the onboard observer survey was far greater than the
¹⁴⁶³ RecFIN survey and were used in the model.

¹⁴⁶⁴ The time-series of landings begins in 1916 for the commercial fleet and in 1929 for the
¹⁴⁶⁵ recreational fleet. This captures the inception of the fishery, so the stock is assumed to be in
¹⁴⁶⁶ equilibrium at the beginning of the modeled period.

¹⁴⁶⁷ The internal population dynamics model tracks ages 0-21, where age 21 is the ‘plus-group.’
¹⁴⁶⁸ There are relatively few observations in the age compositions that are greater than age 21.

¹⁴⁶⁹ The following likelihood components are included in this model: catch, indices, discards,
¹⁴⁷⁰ length compositions, age compositions, recruitments, parameter priors, and parameter soft
¹⁴⁷¹ bounds. See the SS technical documentation for details (Methot 2015).

¹⁴⁷² Electronic SS model files including the data, control, starter, and forecast files can be found
¹⁴⁷³ on the [PFMC ftp site](#).

1474 **2.4.4 Modeling Software**

1475 The STAT team used Stock Synthesis 3 version 3.30.0.4 by Dr. Richard Methot at the NWFSC.
1476 This most recent version was used, since it included improvements and corrections to older
1477 versions. The r4SS package (GitHub release number v1.27.0) was used to post-processing
1478 output data from Stock Synthesis.

1479 **2.4.5 Data Weighting**

1480 Length composition and conditional-age-at-length (CAAL) compositions sample sizes for the
1481 base model were tuned by the “Francis method,” based on equation TA1.8 in Francis
1482 (2011), and implemented in the r4ss package. This approach involves comparing the residuals
1483 in the model’s expected mean length with respect to the observed mean length and associated
1484 uncertainty derived from the composition vectors and their associated input sample sizes.
1485 The sample sizes are then tuned so that the observed and expected variability are consistent.
1486 After adjustment to the sample sizes, models were not re-tuned if the bootstrap uncertainty
1487 value around the tuning factor overlapped 1.0.

1488 As outlined in the Best Practices, a sensitivity run was conducted with length and conditional-
1489 age-at-length (CAAL) compositions were re-weighted using the Ianelli-McAllister harmonic
1490 mean method (McAllister and Ianelli 1997).

1491 Extra variability parameters were estimated and added to the input variance for all surveys
1492 and CPUE indices.

1493 **2.4.6 Priors**

1494 The log-normal prior for female natural mortality were based on a meta-analysis completed
1495 by Hamel (2015), as described under “Natural Mortality.” Female natural mortality was
1496 fixed at the median of the prior, 0.257 for an assumed maximum age of 21. An uninformative
1497 prior was used for the male offset natural mortality, which was estimated.

1498 The prior for steepness (h) assumes a beta distribution with parameters based on an update
1499 for the Thorson-Dorn rockfish prior (Dorn, M. and Thorson, J., pers. comm.), which was
1500 endorsed by the Science and Statistical Committee in 2017. The prior is a beta distribution
1501 with $mu=0.718$ and $sigma=0.158$. Steepness is fixed in the base model at the mean of the
1502 prior. The priors were applied in sensitivity analyses where these parameters were estimated.

1503 **2.4.7 Estimated And Fixed Parameters**

1504 A full list of all estimated and fixed parameters is provided in Tables 41. Time-invariant,
1505 sex-specific growth is estimated in this assessment, with all SS growth parameters being
1506 estimated. The log of the unexploited recruitment level for the Beverton-Holt stock-recruit
1507 function is treated as an estimated parameter. Annual recruitment deviations are estimated
1508 beginning in 1985, just after the first sets of length composition data enter the model. The
1509 survey catchability parameters are calculated analytically (set as scaling factors) such that the
1510 estimate is median unbiased, which is comparable to the way q is treated in most groundfish
1511 assessments.

1512 The base model has a total of 102 estimated parameters in the following categories:

- 1513 • Equilibrium recruitment (R_0) and 54 recruitment deviations,
- 1514 • Nine growth parameters
- 1515 • Eight index extra standard deviation parameter, and
- 1516 • 31 selectivity parameters

1517 The estimated parameters are described in greater detail below and a full list of all estimated
1518 and parameters is provided in Table 41.

1519 *Growth.* Five growth parameters were estimated for females: 3 von Bertalanffy parameters
1520 and 2 parameters for CV as a function of length at age related to variability in length at age
1521 for small and large fish.

1522 Four parameters are estimated for male growth as offset from female growth. The length at
1523 Amin was set equal to the female estimate.

1524 *Natural Mortality.* Natural mortality is fixed for females at the value provided by the Hamel
1525 (Hamel 2015) analysis described above. Natural mortality for males is estimated as an offset
1526 from the fixed female natural mortality.

1527 *Selectivity.* Selectivity for all fleets (except the impingement survey) was estimated as
1528 double-normal. The recreational dead discard fleet has a dome-shaped selectivity and all 6
1529 parameters were estimable.

1530 For all fleets where the estimated parameters were asymptotic, parameters related to the
1531 dome were fixed, leaving only the position of the peak, the ascending slope, and selectivity at
1532 the first length bin as estimated parameters. Ten selectivity parameters related to the time
1533 blocks were also estimated.

1534 *Other Estimated Parameters.* Recruitment deviations for the base model are estimated from
1535 1984 to 2015. The base model also included estimated recruitment deviations for the forecast
1536 years, although these have no impact on the model estimates for the current year.

1537 A number of alternate model were explored before the final base model was reached.
1538 Many variations of the base case model were explored during this analysis. Sensitivities
1539 to asymptotic vs. domed selectivity were explored for the appropriate fisheries, e.g. trawl
1540 and gill net fisheries, as well as estimating selectivity and mirroring fleet selectivities. Time
1541 blocked selectivity without the time block from 2005-2015 for the recreational fisheries was
1542 investigated. We also considered a model with an additional time block for the commercial
1543 fishery, but the length composition data were sparse.

1544 This assessment includes discards for the recreational fleet, so time was spent investigating
1545 changes in selectivity and the most prudent way to incorporate discards.
1546 Length composition of discards from two recreational party/charter onboard observer programs
1547 and

1548 Sensitivities to estimates of female natural mortality were explored by fixing other key
1549 parameters, i.e., steepness. Male natural mortality is still reasonably well estimated, but
1550 the estimates of $\ln R_0$ and female M are not well estimated. The previous assessment fixed
1551 female and male M , where male M was an offset. The previous model had two breakpoints
1552 for natural mortality, but the natural mortality for older fish was set to the same as for
1553 younger fish. This model uses one parameter for natural mortality for each sex.

1554 Much time was also spent tuning the advanced recruitment bias adjustment options, which
1555 are new to SS 3.30. Sensitivities were performed to each of the thirteen advanced options for
1556 recruitment, e.g., early recruitment deviation start year, early recruitment deviation phase,
1557 years with bias adjustments, and maximum bias adjustment. The final base model sets the
1558 first year of recruitment deviations just prior to when length composition are available.

1559 Several models were also investigated where steepness was either estimated, fixed at the prior,
1560 or an alternate value.

1561 Sensitivities of the model to the spawning and settlement months were also explored.
1562 The base model originally set spawning month to June and settlement month to July.
1563 California scorpionfish are summer spawners and settle at a small size. However, a potential
1564 bug in how recruits move into the numbers-at-age matrix was discovered (Richard Methot,
1565 personal communication, NWFSC). The final base model sets both the spawning month
1566 and settlement month to January, which is the equivalent to the settings available in
1567 SS3.24z. Parameters for extra standard deviation were added to all survey indices in the model
1568 because they were not exceptionally well fit by the models considered.

1569 *Other Fixed Parameters.* The stock-recruitment steepness is fixed at the SSC approved
1570 steepness prior for rockfish of 0.718. The initial recommendation for steepness was to explore
1571 the available estimates of steepness from Myers et al. (1999). Myers (Myers, R.A., Bowen,

1572 K.G., and Barrowman 1999) provides estimates of steepness for three species in the family
1573 Scorpaenidae, of which California scorpionfish is a member: chilipepper (*Sebastes goodei*),
1574 0.35; Pacific ocean perch (*Sebastes alutus*) 0.43; and deepwater redfish (*Sebastes mentella*),
1575 0.47. The estimate of steepness for the family was 0.48. Information for steepness is not
1576 available for California scorpionfish and there is little information from related species that
1577 could be considered as a good proxy. A value of 0.718 (the updated 2017 prior) was assumed
1578 for the assessment.

1579 2.5 Model Selection and Evaluation

1580 2.5.1 Key Assumptions and Structural Choices

1581 Key assumptions in the model were that the population is a single-stock in the southern
1582 California Bight. No information is available on the portion of the population in Mexican
1583 waters. The San Diego recreational party/charter fleet is known to fish for California
1584 scorpionfish at the Coronado Island in Mexican waters. All catches from Mexican waters and
1585 landed in the U.S. were removed from the base model data streams.

1586 Female natural mortality and steepness are both fixed in the base model, and sensitivities
1587 were conducted estimating these parameters. Structurally, the model assumed that the
1588 landings from each fleet were representative of the population in southern California and
1589 fishing mortality prior to 1916 was negligible. It is also assumed that commercial discards
1590 have been negligible and are not included in the base model.

1591 2.5.2 Alternate Models Considered

1592 Due to the error in the 2005 model, the population from the base case of this assessment is
1593 larger in scale. The majority of the alternate models considered were to estimate parameters,
1594 such as natural mortality and steepness.

1595 The base model is age structured, but 60% of those ages are from males, and a number of
1596 ages were from younger fish. Models that attempted to estimate female natural mortality
1597 were considered. However, female natural mortality was estimated at 0.38, much too high to be
1598 considered a reasonable value. The age data needed to estimate natural mortality (especially
1599 for older fish) is not yet available. Male natural mortality was estimatable as an offset from
1600 female natural mortality.

1601 Runs of the base case model estimating steepness were also considered, when female natural
1602 mortality was fixed. Steepness was estiamted at approximately 0.8. No data exist to inform
1603 this parameter for California scorpionsh, and the decision was made to fix steepness at the
1604 mean of the prior developed from a meta-anaylsis of West Coast groundfish.

1605 Additional models considered and run for sensitivity analyses can be found in the Sensitivity
1606 Analysis Section of this document.

1607 **2.5.3 Convergence**

1608 Model convergence was determined by starting the minimization process from dispersed values
1609 of the maximum likelihood estimates to determine if the model found a better minimum.
1610 Jitter is a SS option that generates random starting values from a normal distribution
1611 logistically transformed into each parameter's range (Methot 2015). This was repeated 100
1612 times and the minimum was reached in 45% of the runs (Table 40).
1613 The model did not experience convergence issues, e.g., final gradient was below 0.0001, when
1614 reasonable starting values were used and there were no difficulties in inverting the Hessian
1615 to obtain estimates of variability. We did sensitivity runs for convergence by changing the
1616 phases for key estimated parameters and the total log-likelihood did not change nor the
1617 parameter estimates.

1618 **2.6 Response To The Current STAR Panel Requests**

1619 **Request No. 1: Add after STAR panel.**

1620

1621 **Rationale:** Add after STAR panel.

1622 **STAT Response:** Add after STAR panel.

1623 **Request No. 2: Add after STAR panel.**

1624

1625 **Rationale:** Add after STAR panel.

1626 **STAT Response:** Add after STAR panel.

1627 **Request No. 3: Add after STAR panel.**

1628

1629 **Rationale:** Add after STAR panel.

1630 **STAT Response:** Add after STAR panel.

1631 **2.7 Base Case Model Results**

1632 The base model parameter estimates and their approximate asymptotic standard errors are
1633 shown in Table 41 and the likelihood components are in Table 42. Estimates of derived

¹⁶³⁴ reference points and approximate 95% asymptotic confidence intervals are shown in Table e.
¹⁶³⁵ Time-series of estimated stock size over time are shown in Table 43.

¹⁶³⁶ The base model is sex-specific for all biological parameters. Key productivity parameters
¹⁶³⁷ are fixed at measures of central tendency from prior distributions endorsed by the PFMC's
¹⁶³⁸ SSC due to the models' inabilities to estimate reasonable parameter values. Specifically,
¹⁶³⁹ steepness of the assumed Beverton-Holt stock-recruitment relationship was fixed at 0.718. In
¹⁶⁴⁰ the final base models the instantaneous rate of annual natural mortality was fixed at 0.2547
¹⁶⁴¹ for females, and estimated as 0.2078 for males.

¹⁶⁴² 2.7.1 Parameter Estimates

¹⁶⁴³ The base model produces reasonable estimates of growth parameters, for both males and
¹⁶⁴⁴ females (Figure 42). The von Bertalanffy growth coefficient k for females was estimated
¹⁶⁴⁵ close to the external estimate, 0.2496 externally and 0.2494 within SS. For males, the von
¹⁶⁴⁶ Bertalanffy k parameter was estimated at 0.2325 externally and 0.2234 within SS. The female
¹⁶⁴⁷ estimated L_{∞} was 33.46 and 27.538 for males.

¹⁶⁴⁸ Females grow faster than male and reach a maximum size greater than the males.

¹⁶⁴⁹ Selectivity curves were estimated for the fishery and survey fleets. The estimated selectivities
¹⁶⁵⁰ for all fleets within the model are shown in Figure 50. The commercial fishery selectivities
¹⁶⁵¹ are all asymptotic with the trawl and gillnet fisheries mirroring the hook-and-line fishery.
¹⁶⁵² Maximum selectivity for the commercial fleet is reached at about 26 cm from 1916-1998 and
¹⁶⁵³ 28 cm from 1999-2016 (Figure 51). The shift in selectivity is due to the implementation
¹⁶⁵⁴ of the 10-inch size limit for the commercial fishery in 1999. The recreational private mode
¹⁶⁵⁵ sector selects the largest fish, with full selectivity at 41 cm. The time blocked selectivity does
¹⁶⁵⁶ not show a major shift in selectivity when the fishery was closed for portions of 2001-2005
¹⁶⁵⁷ (Figure 52). This can be explained by the fact the length composition data from the dockside
¹⁶⁵⁸ intercept survey contains a large number of observed fish when the fishery was closed. The
¹⁶⁵⁹ recreational private mode also selects the largest fish, and there is no available information
¹⁶⁶⁰ on discards from this fleet. There is a distinct shift in the selectivity for the retained-catch
¹⁶⁶¹ recreational party/charter fleet, with the onboard observer retained-catch fleet mirrored to
¹⁶⁶² the other recreational party/charter fleet. Prior to the implementation of a 10-in minimum
¹⁶⁶³ size limit the size at maximum selectivity was 36 cm, from 2001-2005 it was 31 cm and since
¹⁶⁶⁴ 2006 the size at maximum selectivity is at 26 cm (Figure 53). The recreational party/charter
¹⁶⁶⁵ mode discard-catch dome-shaped selectivity reflects the discarding of small fish due to the
¹⁶⁶⁶ size limit and also the discarding of smaller fish prior to the 10-in minimum size limit due to
¹⁶⁶⁷ angler preference for larger fish. The selectivity of the discard fleet does not go to 0, because
¹⁶⁶⁸ some larger fish are still discarded, either due to angler preference, bag limits, and/or fishery
¹⁶⁶⁹ closure. The onboard observer data also indicates that there are higher discards when an
¹⁶⁷⁰ aggregation of California scorpionfish was found, i.e., hundreds of fish may be caught at a
¹⁶⁷¹ single fishing stop and some are discarded.

1672 All of the survey selectivity curves were asymptotic and none had time blocks. The southern
1673 California Bight regional monitoring trawl survey uses the same gear as the sanitation district
1674 trawls survey. All of the three trawl surveys reach full selectivity around 24 cm. The selectivity
1675 for the gill net survey is mirrored to the trawl survey because small 1"-2" mesh sizes were
1676 used.

1677 The additional survey variability (process error added directly to each year's input variability)
1678 for all surveys was estimated within the model. The model estimated a small added variances
1679 for the recreational private mode of 0.013 and the recreational party/charter discard fleet of
1680 0.077. The estimated added variance was highest for the recreational party/charter retained-
1681 catch fleet (0.268), the sanitation district survey (0.225), and the NWFSC trawl survey
1682 (0.25).

1683 Recruitment deviations were estimated from 1965 to 2015 (Figure 54). Estimates of re-
1684 cruitment suggest that the California scorpionfish population is characterized by variable
1685 recruitment with occasional strong recruitments and periods of low recruitment (Figures 55
1686 and 54). The four lowest recruitments (in ascending order) occurred in 2012, 2011, 1981, and
1687 1973. There are large estimates of recruitment in 1985, 1993, and 2015. The 2015 recruitment
1688 event can be observed in the length and conditional length at age compositions from the
1689 survey data.

1690 The stock-recruit curve resulting from a fixed value of steepness is shown in Figure 56
1691 with estimated recruitments also shown. The stock is predicted to have never fallen to low
1692 enough levels that the steepness is obvious. Steepness was not estimated in this model, but
1693 sensitivities to an alternative value of steepness is discussed below.

1694 2.7.2 Fits to the Data

1695 Model fits to the indices of abundance, fishery length composition, survey length composition,
1696 and conditional age-at-length observations from the NWFSC trawl survey are all discussed
1697 below.

1698 The fits to the four fishery CPUE and four survey indices are shown in Figures 57 - 64. Extra
1699 standard error was estimated for all eight of the indices. The indices for the recreational
1700 private mode and dead-discard fleets were fit relatively well by the model. The recreational
1701 party/charter retained-catch index was fit moderately well in parts of the time series, but
1702 did not capture the increases observed in the late 1990s. The extra variability added to this
1703 index was also large. The onboard observer retained-only catch index was fit well by the
1704 model except for the two lowest years, 2003 and 2015.

1705 The sanitation district index was fit well by the model, except for the highest four years from
1706 1979-1982, where the fit is estimated lower than the the added uncertainty.

1707 The NWFSC trawl survey index is flat and fit well by the model, except for in 2013, the

1708 highest year in the index, with also high uncertainty. The gill net survey was not well fit by
1709 the model and did not capture the trend observed in the standardized index. The Southern
1710 California Bight trawl survey, conducted every 5 years, was also not well fit by the model.
1711 The standardized index from the Bight trawl survey showed peaks in 1994 and 2004, which
1712 were not fit by the model.

1713 Fits to the length data are shown based on the proportions of lengths observed by year and
1714 the Pearson residuals-at-length for all fleets. Detailed fits to the length data by year and
1715 fleet are provided in Appendix 8. Aggregate fits by fleet are shown in Figure 65. Overall,
1716 the length composition data for the commercial hook-and-line, commercial trawl, sanitation
1717 survey, recreational private, and party/charter fleets all fit well. The fits to the recreational
1718 discard fleet by year were variable, and were worse in years with small sample sizes; however,
1719 the aggregate fit is reasonable. The sample sizes by year for each of the gill net, impingement,
1720 and Bight trawl surveys were small compared to the fisheries. The fit to the data varies by
1721 year and does not capture the high proportion of small fish observed in the impingement
1722 survey, especially in 2013.

1723 Fits to the aggregated and yearly length composition data from the gillnet fishery are not
1724 well fit. The selectivity for this fishery is mirrored to the commercial hook-and-line fishery
1725 and the sample sizes of the number of measured fish and trips is small compared to other
1726 fleets. California scorpionfish are also not a target species for the gill net fishery, but are
1727 retained most commonly by the sea bass and halibut fisheries as bycatch. The minimum
1728 mesh size for the gill net fishery ranges from 3.5 - 6 inches depending on the year and season.

1729 The NWFSC trawl survey lengths were well estimated for males and females in aggregate by
1730 the model. California scorpionfish are not one of the more common species observed in this
1731 survey, with sample size all under 10 hauls per year.

1732 The observed and expected conditional age-at-length fits are shown in Figure 66 for the
1733 NWFSC trawl survey observations. The fits generally match the observations for fish smaller
1734 than 30 cm. Some outliers are apparent with large residuals.

1735 The age data were also weighted according to Francis weighting which adjust the weight
1736 given to a data set based on the fit to the mean age by year. The mean ages from the fishery
1737 appear to have declined in recent years which could be due to incoming cohorts (Figure 67).
1738 Smaller fish were also observed in the sanitation and impingement surveys in the (Figures
1739 68 and 69). The mean length in the recreational private and party/charter fleets increased
1740 over time (Figures 70 and 71). The length composition of the recreational fleet discards was
1741 smaller in the 1980's and hovers around the 10-in minimum size limit in the 2000's (Figure
1742 72).

1743 2.7.3 Uncertainty and Sensitivity Analyses

1744 A number of sensitivity analyses were conducted, including:

- 1745 1. Data weighting according to the harmonic mean.
- 1746 2. Removal of the sanitation district index (axis of uncertainty from the 2005 assessment)
- 1747 3. Dome-shaped selectivity for the NWFSC trawl survey and gill net survey - TBD
- 1748 4. Estimating natural female mortality
- 1749 5. Estimating steepness - TBD
- 1750 6. Assume the same fixed natural mortality for males and females
- 1751 7. Remove each index, one at a time - TBD

1752 A number of changes were made since the 2005 assessment, and sensitivities to the current
1753 base model included changing or fixing a number of parameters to the same as the 2005
1754 assessment, as well as a number of sensitivities to modelling choices made in developing the
1755 current base model (Table 44).

1756 Data weighting is an area of uncertainty for stock assessment and research is ongoing to
1757 determine the effects of data weighting and the most appropriate initial sample sizes for
1758 length and age composition data. A model run with default weighting increased the total
1759 likelihood by 2,692 and resulted in a final depletion of 0.771. The base model used the Stewart
1760 sample sizes for the fishery data and number of trips for all survey sample sizes. Weighting
1761 the data by the harmonic mean resulted in a model with a total likelihood between the base
1762 model, which uses the Francis method for weighting, and the model with default weights.
1763 The Francis weights in the base model were stable, and did not tend to serially decrease
1764 (downweight) any of the datasets, which has been seen in other assessments.

1765 The sanitation district index was the axis of uncertainty in the 2005 assessment. The
1766 current assessment has a number of new data sources, including new indices, length data,
1767 and conditional age-at-length data available. Removing the sanitation index and length
1768 composition data from the current base model did not have a large effect on the model.
1769 Depletion dropped from 0.574 to 0.53, but this is a fairly small change compared to the effect
1770 on the 2005 model.

1771 The 2005 assessment fixed natural mortality at 0.25 for males and females, and steepness at
1772 0.7. A sensitivity of fixing male and female natural mortality to 0.257, increased depletion
1773 from 0.574 to 0.594, but did not have a large overall effect on the model.

1774 2.7.4 Retrospective Analysis

1775 A 4-year retrospective analysis was conducted by running the model using data only through
1776 2012, 2013, 2014, and 2015, progressively (Table 46). The initial population size and estimation

1777 of trends in spawning biomass in the retrospective runs were slightly lower than the base
1778 model (Figure 73). The initial scale of the spawning population was basically unchanged for
1779 all of these retrospectives.

1780 The recruitment deviations in the more recent years shrink towards zero the more years are
1781 removed from the model (Figure 74).

1782 2.7.5 Likelihood Profiles

1783 Likelihood profiles were conducted for R_0 , steepness, and over natural mortality values
1784 separately. These likelihood profiles were conducted by fixing the parameter at specific values
1785 and estimated the remaining parameters based on the fixed parameter value.

1786 In regards to values of R_0 , the negative log-likelihood was minimized at approximately $\log(R_0)$
1787 of 8.0 (Table 47). The recreational private mode fishery minimized at a smaller value of R_0
1788 whereas the gillnet survey, recreational discard and commercial gillnet fisheries indicated a
1789 higher value of R_0 (Figure 75). The age and recruitment data indicated a higher value of R_0
1790 and were minimized at the highest value in the profile (Figure 76). Over the range of values
1791 of R_0 , depletion ranged from 0.53-0.70 (Figure 77).

1792 For steepness, the negative log-likelihood was essentially flat between values of 0.57-0.87
1793 (Figure 78 and Table 47).

1794 Likelihood components by data source show that the fishery age data support a low steepness
1795 value, but the other data sources higher value for steepness (Figure 79). The impingement,
1796 sanitation, and recreational private mode fleets support higher values of steepness while the
1797 other surveys are relatively uninformative. The relative depletion for California scorpionfish
1798 changes very little (0.51-0.60) across different assumed values of steepness (Figure 80).

1799 The negative log-likelihood was minimized at a natural mortality value of 0.38, the profile
1800 is relatively flat for the priors, index data, and recruitment (Figure 81). The age data
1801 likelihood contribution was minimized at natural mortality values ranging from 0.035-0.40,
1802 and the length data contribution was minimized as the largest value of M run, 0.40 (Table
1803 47). The impingement survey was the only fleet for which the likelihood profile over M was
1804 not relatively flat (Figure 82) The relative depletion for California scorpionfish ranged from
1805 0.48-0.80 across alternative values of natural mortality (Figure 83).

1806 2.7.6 Reference Points

1807 Reference points were calculated using the estimated selectivities and catch distribution
1808 among fleets in the most recent year of the model, (2015). Sustainable total yield (landings
1809 plus discards) were 220.1 mt when using an $SPR_{50\%}$ reference harvest rate and with a 95%
1810 confidence interval of (156-284.1) mt based on estimates of uncertainty. The spawning output
1811 equivalent to 40% of the unfished spawning output ($SB_{40\%}$) was 544.6 millions of eggs.

1812 The predicted spawning output from the base model shows an initial decline starting in
1813 1970, with two years of low spawning biomass in 1976 and 1977. From the late 1970s to the
1814 mid-2000's the population follows a cyclical pattern (driven by recruitment pulses) and then
1815 declines until 2015. The last two years of the model indicate an increase in spawning output.
1816 (Figure 84). Since 2015, the spawning output has been increased due to lower catches and a
1817 high recruitment pulse in 2015. The 2016 spawning output relative to unfished equilibrium
1818 spawning output is above the target of 40% of unfished spawning output (Figure 85). The
1819 fishing intensity, $(1 - SPR)/(1 - SPR_{50\%})$, has been well below the management target for
1820 the entire time series of the model.

1821 Table e shows the full suite of estimated reference points for the base model and Figure 86
1822 shows the equilibrium curve based on a steepness value fixed at .

1823 **3 Harvest Projections and Decision Tables**

1824 The forecasts of stock abundance and yield were developed using the final base model. The
1825 total catches in 2017 and 2018 are set to the PFMC adopted California scorpionfish ACLs
1826 (Table \ref{tab:tab:mnmgt_perform}). CDFW allocated 75% of the ACL to the recreational
1827 fisheries and 25% to the commercial fisheries. The catches were divided among the fleets
1828 within each the commercial and recreational fisheries by taking the ratio of the average
1829 catches from 2012-2016. The average of 2012-2016 catch by fleet was used to distribute
1830 catches in forecasted years. The research catch harvest guideline for 2017-2018 was set at
1831 0.2 mt. The average research catch from the NWFSC trawl survey averaged 0.077 mt from
1832 2012-2016, which was used in the forecast.

1833 **Projections and Decision Table**

1834 Forecasts (Table 48) and decision tables (Table h) to be completed during and/or after the
1835 STAR panel

1836 **4 Regional Management Considerations**

1837 While the proportion of the stock residing within U.S. waters is unknown, the assessment
1838 provides an adequate geographic representation of portion assessed for management purposes.
1839 Collaboration with Mexico in conducting future assessments may be mutually beneficial. No
1840 genetic information is available to inform whether separate stocks or population structure
1841 pertinent to management exists. Given the relatively small area in the waters off of California
1842 where this species occurs south of Point Conception, there is relatively little concern regarding
1843 exploitation in proportion to the regional distribution of abundance in the area assessed in
1844 this study.

1845 While the species does aggregate during the spawning season making harvest of the stock
1846 more efficient during this period, removals have been well within the harvest limits and the
1847 stock has not been overfished or subject to overfishing as a whole.
1848 Routine sampling of commercial and recreational fisheries provides mortality estimates to
1849 monitor catch during the course of season to prevent overfishing should effort increase in
1850 the future. Analysis of CPUE of areas known to be spawning aggregations over time using
1851 data from sampling on board CPFVs and comparison to the trajectory of the population as
1852 a whole could provide information in determining whether localized depletion is occurring.
1853 Eggs and larvae are expected to travel substantial distance before settling, thus such areas
1854 should be repopulated from adjacent areas. Time/area closures could be considered where
1855 deemed beneficial in maintaining a minimum CPUE the remainder of the year, but are not
1856 necessary to keep aggregate harvest within the current harvest limits.

1857 5 Research Needs

1858 There are a number of areas of research that could improve the understand and the stock
1859 assessment for California scorpionfish. Below are issues identified by the STAT team:

- 1860 1. **Natural mortality:** Both female natural mortality and steepness were fixed in the
1861 base model. The collection of age data for older females may improve the ability to
1862 estimate female natural mortality in the model. The NWFSC trawl survey was the
1863 only available source of age data for this assessment, of which there were a number of
1864 age-1 fish and the data were dominated by males.
- 1865 2. **Steepness:** California scorpionfish has not been fished to a level where information on
1866 steepness is available. A meta-analysis for species with similar breeding strategies to
1867 California scorpionfish could be conducted if data are available.
- 1868 3. **Stock in Mexico:** No available information on the status of California scorpionfish in
1869 Mexico could be found. A number of emails were sent to researchers in Mexico and
1870 none were returned. It is known that a portion of the stock resides in Mexico and that
1871 boat leaving from San Diego target California scorpionfish off the Coronado Islands.
- 1872 4. **Sex ratio:** The sex ratio in both Love et al. [@Love1987] and samples from the NWFSC
1873 trawl survey were skewed towards males. Data on sex ratios from the recreational or
1874 commercial fisheries would help in determining the sex ratio of the population.
- 1875 5. **Aggregating behavior:** Little is known about the aggregating behavior of California
1876 scorpionfish. California scorpionfish are known to aggregate in both the spawning
1877 and non-spawning seasons. The location and timing of the aggregations would aid in
1878 modelling the high catch events.

1879 6. **Fecundity/Maturity:** There are currently no estimates of fecundity for California
1880 scorpionfish. Love et al. [@Love1987] has published the only estiamtes of maturity for
1881 California scorpionfish, but the original copies of the data are no long available. Some
1882 data on the spatial distribution of the eggs are available from CalCOFI, but were not
1883 keypunched to the species level. California scorpionfish mature at a young age, and
1884 additional data can help inform the maturity ogive.

1885 6 Acknowledgments

1886 To be added.

7 Tables

Table 1: Commercial removals (mt) from the commercial fisheries. Data sources are the CDFG Fishery Bulletins (available from California Explores the Ocean) and the California Fisheries Information System (CFIS)

Year	Hook-and-line (plus pot and other)	Trawl	Gillnet	Mexico	Total U.S. Commercial Removals	Source
1916	3.64	0.00	0.00	0.00	3.64	CDFG Bulletins
1917	7.90	0.00	0.00	0.00	7.90	CDFG Bulletins
1918	12.81	0.00	0.00	0.00	12.81	CDFG Bulletins
1919	11.54	0.00	0.00	0.00	11.54	CDFG Bulletins
1920	16.18	0.00	0.00	0.00	16.18	CDFG Bulletins
1921	26.48	0.00	0.00	0.00	26.48	CDFG Bulletins
1922	19.11	0.00	0.00	0.00	19.11	CDFG Bulletins
1923	27.43	0.00	0.00	0.00	27.43	CDFG Bulletins
1924	49.47	0.00	0.00	0.00	49.47	CDFG Bulletins
1925	101.20	0.00	0.00	0.00	101.20	CDFG Bulletins
1926	49.02	0.00	0.00	0.00	49.02	CDFG Bulletins
1927	51.46	0.00	0.00	0.00	51.46	CDFG Bulletins
1928	44.04	0.00	0.00	0.00	44.04	CDFG Bulletins
1929	48.90	0.00	0.00	0.00	48.90	CDFG Bulletins
1930	40.19	0.00	0.00	0.00	40.19	CDFG Bulletins
1931	41.54	0.00	0.00	0.05	41.54	CDFG Bulletins
1932	38.78	0.00	0.00	0.00	38.78	CDFG Bulletins
1933	29.10	0.00	0.00	0.00	29.10	CDFG Bulletins
1934	29.91	0.00	0.00	0.00	29.91	CDFG Bulletins
1935	30.76	0.00	0.00	0.79	30.76	CDFG Bulletins
1936	49.75	0.00	0.00	0.34	49.75	CDFG Bulletins
1937	62.19	0.00	0.00	0.09	62.19	CDFG Bulletins
1938	70.44	0.00	0.00	0.05	70.44	CDFG Bulletins
1939	58.29	0.00	0.00	0.06	58.29	CDFG Bulletins
1940	55.37	0.00	0.00	0.03	55.37	CDFG Bulletins
1941	43.07	0.00	0.00	0.14	43.07	CDFG Bulletins
1942	20.00	0.00	0.00	0.11	20.00	CDFG Bulletins
1943	16.32	0.00	0.00	2.98	16.32	CDFG Bulletins
1944	24.03	0.00	0.00	1.95	24.03	CDFG Bulletins
1945	42.13	0.00	0.00	0.81	42.13	CDFG Bulletins
1946	65.63	0.00	0.00	0.16	65.63	CDFG Bulletins
1947	56.79	0.00	0.00	0.84	56.79	CDFG Bulletins
1948	70.17	0.00	0.00	0.18	70.17	CDFG Bulletins
1949	66.72	0.00	0.00	0.58	66.72	CDFG Bulletins
1950	63.16	0.00	0.00	0.12	63.16	CDFG Bulletins
1951	45.85	0.00	0.00	0.16	45.85	CDFG Bulletins

Table 1: Commercial removals (mt) from the commercial fisheries. Data sources are the CDFG Fishery Bulletins (available from California Explores the Ocean) and the California Fisheries Information System (CFIS)

Year	Hook-and-line (plus pot and other)	Trawl	Gillnet	Mexico	Total U.S. Commercial Removals	Source
1952	37.93	0.00	0.00	0.00	37.93	CDFG Bulletins
1953	54.17	0.00	0.00	0.05	54.17	CDFG Bulletins
1954	60.92	0.00	0.00	0.00	60.92	CDFG Bulletins
1955	47.71	0.00	0.00	1.29	47.71	CDFG Bulletins
1956	45.47	0.00	0.00	0.00	45.47	CDFG Bulletins
1957	33.23	0.00	0.00	0.00	33.23	CDFG Bulletins
1958	29.43	0.00	0.00	0.00	29.43	CDFG Bulletins
1959	16.94	0.00	0.00	0.00	16.94	CDFG Bulletins
1960	13.25	0.00	0.00	0.00	13.25	CDFG Bulletins
1961	12.12	0.00	0.00	0.00	12.12	CDFG Bulletins
1962	26.18	0.00	0.00	0.11	26.18	CDFG Bulletins
1963	34.11	0.00	0.00	0.14	34.11	CDFG Bulletins
1964	35.19	0.00	0.00	7.55	35.19	CDFG Bulletins
1965	34.78	0.00	0.00	2.75	34.78	CDFG Bulletins
1966	38.31	0.00	0.00	10.90	38.31	CDFG Bulletins
1967	25.42	0.00	0.00	12.07	25.42	CDFG Bulletins
1968	40.60	0.00	0.00	16.18	40.60	CDFG Bulletins
1969	33.28	0.28	0.10	18.72	33.66	CFIS
1970	34.45	0.00	0.16	35.67	34.62	CFIS
1971	17.76	0.00	0.63	40.41	18.38	CFIS
1972	27.84	0.11	0.13	31.81	28.08	CFIS
1973	16.80	0.17	0.24	54.85	17.21	CFIS
1974	37.94	0.00	0.06	33.59	38.00	CFIS
1975	41.95	0.02	3.03	33.64	45.01	CFIS
1976	15.41	0.06	0.01	63.29	15.49	CFIS
1977	5.75	0.00	0.13	47.07	5.88	CFIS
1978	8.99	0.00	1.26	21.62	10.25	CFIS
1979	8.40	0.00	0.97	5.43	9.37	CFIS
1980	14.47	0.00	0.56	11.72	15.03	CFIS
1981	15.48	0.01	5.93	4.09	21.41	CFIS
1982	17.95	0.00	1.34	8.46	19.29	CFIS
1983	10.91	0.00	0.83	2.31	11.74	CFIS
1984	9.89	0.15	1.07	0.08	11.11	CFIS
1985	12.73	0.02	2.48	0.00	15.24	CFIS
1986	4.76	0.02	1.76	0.11	6.54	CFIS
1987	7.46	0.11	3.99	0.00	11.56	CFIS
1988	7.77	0.00	3.65	0.00	11.42	CFIS
1989	15.87	0.02	2.80	0.00	18.69	CFIS

Table 1: Commercial removals (mt) from the commercial fisheries. Data sources are the CDFG Fishery Bulletins (available from California Explores the Ocean) and the California Fisheries Information System (CFIS)

Year	Hook-and-line (plus pot and other)	Trawl	Gillnet	Mexico	Total U.S. Commercial Removals	Source
1990	32.07	0.78	6.17	0.00	39.01	CFIS
1991	20.12	4.80	3.29	0.00	28.20	CFIS
1992	27.71	3.94	3.33	0.00	34.98	CFIS
1993	13.72	7.76	4.66	0.22	26.14	CFIS
1994	34.85	13.08	1.92	0.00	49.86	CFIS
1995	23.69	16.20	0.98	0.13	40.87	CFIS
1996	20.17	12.97	1.19	0.00	34.33	CFIS
1997	20.22	13.28	3.82	0.00	37.31	CFIS
1998	32.34	16.80	1.59	0.00	50.72	CFIS
1999	30.88	6.56	1.78	0.00	39.22	CFIS
2000	11.74	4.57	2.00	0.00	18.30	CFIS
2001	14.18	2.98	2.64	0.00	19.80	CFIS
2002	10.09	2.16	1.18	0.00	13.43	CFIS
2003	2.13	2.75	0.35	0.00	5.24	CFIS
2004	2.00	2.36	0.62	0.00	4.98	CFIS
2005	1.47	3.12	0.70	0.00	5.29	CFIS
2006	0.86	1.38	0.44	0.00	2.68	CFIS
2007	1.90	1.48	0.21	0.00	3.59	CFIS
2008	2.46	0.86	0.28	0.00	3.61	CFIS
2009	2.97	0.27	0.13	0.00	3.38	CFIS
2010	2.99	0.18	0.14	0.00	3.32	CFIS
2011	3.24	1.05	0.24	0.00	4.54	CFIS
2012	3.22	0.43	0.18	0.00	3.82	CFIS
2013	1.73	0.83	0.14	0.00	2.70	CFIS
2014	1.03	0.13	0.04	0.00	1.19	CFIS
2015	2.21	0.13	0.03	0.00	2.37	CFIS
2016	2.32	0.13	0.00	0.00	2.45	CFIS

Table 2: The annual number of California scorpionfish sampled from the the commercial hook-and-line fleet for lengths. Sample size is calculated using Stewarts method (see text for detail)

Year	Fish	Trips	Sample size	Mean length (cm)
1996	25	1	4.45	22.06
1997	115	6	21.87	26.88
1998	197	16	43.19	25.79
1999	224	15	45.91	28.43
2000	24	2	5.31	27.80
2001	139	10	29.18	29.98
2002	71	7	16.80	28.49
2003	6	1	1.83	32.03
2013	244	1	7.06	29.00
2014	46	1	7.06	29.60
2015	163	1	7.06	29.38

Table 3: The annual number of California scorpionfish sampled from the the commercial gillnet fleet for lengths. Sample size is calculated using Stewarts method (see text for detail)

Year	Fish	Trips	Sample size	Mean length (cm)
1996	37	4	9.11	27.68
1997	310	54	96.78	27.26
1998	13	4	5.79	31.55
1999	21	11	13.90	33.01
2000	15	5	7.07	29.91
2001	209	27	55.84	30.15
2002	59	19	27.14	33.51
2003	51	12	19.04	35.08
2004	33	6	10.55	34.07

Table 4: The annual number of California scorpionfish sampled from the the commercial trawl fleet for lengths. Sample size is calculated using Stewarts method (see text for detail)

Year	Fish	Trips	Sample size	Mean length (cm)
1996	69	9	18.52	26.31
1997	42	6	11.80	26.06
1998	111	12	27.32	26.86
1999	399	49	104.06	28.85
2000	82	6	17.32	27.65
2001	208	21	49.70	28.44
2003	84	14	25.59	29.63
2004	22	1	4.04	28.35
2006	33	2	6.55	28.00

Table 5: Recreational removals (mt) from the party/charter and private vessels. Removals from man-made and beach/bank modes were included in the private mode removals. Dead discards include all modes. CDFW provided all data. Note: A discard mortality rate of seven percent was applied to the dead discard removals.

Year	Private	Party/charter	Dead Discard (all modes)	Total Removals
1929	0.06	0.54	0.00	0.61
1930	0.12	1.08	0.01	1.21
1931	0.18	1.62	0.01	1.81
1932	0.24	2.16	0.01	2.42
1933	0.30	2.70	0.02	3.02
1934	0.36	3.24	0.02	3.63
1935	0.42	3.78	0.03	4.23
1936	0.48	4.33	0.03	4.84
1937	0.34	3.01	0.02	3.37
1938	0.56	5.06	0.04	5.66
1939	0.44	3.90	0.03	4.36
1940	0.40	3.61	0.02	4.04
1941	0.00	0.00	0.00	0.00
1942	0.00	0.00	0.00	0.00
1943	0.00	0.00	0.00	0.00
1944	0.00	0.00	0.00	0.00
1945	0.00	0.00	0.00	0.00
1946	0.00	0.00	0.00	0.00
1947	1.76	15.73	0.11	17.60
1948	3.65	32.67	0.23	36.55
1949	2.58	23.12	0.16	25.86
1950	3.38	30.29	0.21	33.89
1951	2.11	18.84	0.13	21.08
1952	2.29	20.48	0.14	22.91
1953	1.93	17.24	0.12	19.28
1954	2.26	20.27	0.14	22.67
1955	1.93	17.33	0.12	19.38
1956	1.70	15.26	0.11	17.07
1957	0.94	8.44	0.06	9.44
1958	0.96	8.60	0.06	9.62
1959	0.80	7.19	0.05	8.04
1960	1.06	9.47	0.07	10.59
1961	1.86	16.71	0.12	18.69
1962	2.33	20.87	0.14	23.34
1963	3.77	33.75	0.23	37.75
1964	5.16	46.25	0.32	51.73
1965	5.02	45.03	0.31	50.36
1966	6.44	43.74	0.31	50.48
1967	7.34	39.64	0.29	47.27

Table 5: Recreational removals (mt) from the party/charter and private vessels. Removals from man-made and beach/bank modes were included in the private mode removals. Dead discards include all modes. CDFW provided all data. Note: A discard mortality rate of seven percent was applied to the dead discard removals.

Year	Private	Party/charter	Dead	Discard (all modes)	Total	Removals
1968	8.46	37.50		0.29		46.25
1969	10.62	39.47		0.32		50.41
1970	16.32	51.69		0.43		68.44
1971	19.46	53.19		0.46		73.10
1972	15.80	37.62		0.34		53.76
1973	25.01	52.28		0.49		77.78
1974	29.18	53.84		0.52		83.55
1975	31.19	51.01		0.52		82.72
1976	20.44	29.75		0.32		50.50
1977	35.19	45.69		0.51		81.39
1978	23.82	27.63		0.33		51.77
1979	49.76	40.23		0.58		90.57
1980	53.27	52.35		3.72		109.35
1981	41.08	44.42		2.85		88.36
1982	49.04	40.92		2.81		92.77
1983	12.65	35.56		0.93		49.14
1984	27.06	31.25		0.96		59.27
1985	28.77	39.93		1.71		70.41
1986	24.07	42.53		3.19		69.79
1987	23.05	31.78		3.02		57.85
1988	106.56	76.88		5.89		189.34
1989	56.79	79.32		7.90		144.00
1990	95.63	92.27		1.16		189.06
1991	107.40	103.63		1.30		212.34
1992	31.91	44.10		3.60		79.60
1993	23.31	43.49		2.26		69.07
1994	45.62	54.40		6.42		106.45
1995	28.44	57.03		6.21		91.68
1996	30.46	67.48		4.00		101.93
1997	24.39	77.23		2.62		104.24
1998	32.12	75.91		2.08		110.11
1999	50.11	132.50		2.83		185.43
2000	35.86	109.64		4.97		150.47
2001	56.20	114.90		8.33		179.43
2002	43.39	61.57		9.20		114.15
2003	31.49	58.46		9.56		99.52
2004	5.29	42.42		4.53		52.24
2005	21.34	57.15		5.04		83.53
2006	14.44	129.58		3.31		147.33

Table 5: Recreational removals (mt) from the party/charter and private vessels. Removals from man-made and beach/bank modes were included in the private mode removals. Dead discards include all modes. CDFW provided all data. Note: A discard mortality rate of seven percent was applied to the dead discard removals.

Year	Private	Party/charter	Dead	Discard (all modes)	Total	Removals
2007	14.24	118.87		2.89		135.99
2008	8.38	89.65		2.25		100.28
2009	14.68	93.16		2.09		109.93
2010	8.07	92.55		2.03		102.65
2011	6.84	91.18		2.66		100.68
2012	6.22	107.63		2.34		116.18
2013	8.18	101.31		2.94		112.44
2014	5.88	113.83		2.93		122.63
2015	4.15	73.78		3.59		81.52
2016	3.86	64.56		3.29		71.71

Table 6: Recreational private mode dockside data sample sizes at each data filtering step. The bold value indicates the final sample size used for delta-GLM analysis.

Filter	Criteria	Sample size (no. positive trips)	Sample size (no. of trips)
Entire dataset			108,171
General data filters	CRFS-PR1 survey only, Southern California only (sub_reg = 1), Hook and line gear only (geara = 'H'), Ocean only (Area_X = 1 or 2)	3,802	43,956
Region	Remove trips from Santa Barbara	3,757	42,956
Year	Remove 2004-2005; fishery closed majority of year	3,094	33,770
Closed fishery	Remove remaining trips when fishery closed	3,056	32,236
Rare and co-occurring species	Remove trips with yellowfin tuna and dolphinfish and species present in <1% of all trips and in at least 5 years of data	3,056	30,033
Stephens-MacCall	Retain all positive trips, plus "False Positives" (trips predicted to be in California scorpionfish habitat, but with no California scorpionfish retained)	3,056	8,590

Table 7: AIC values for each model in the recreational private mode dockside sample index.

Model	Binomial	Lognormal
Year	6182.366	8103.204
Year + County	5862.9	8003.9
Year + Wave	6091	8092.2
Year + County + Wave	5792.29	8000.45

Table 8: The recreational private mode dockside sample index.

Year	Index	Log-scale SE
2006	1.1154	0.0533
2007	0.9353	0.0500
2008	0.8052	0.0481
2009	0.7645	0.0516
2010	0.6716	0.0657
2011	0.7660	0.0734
2012	0.6651	0.0807
2013	0.6143	0.0708
2014	0.6076	0.0826
2015	0.6465	0.0901
2016	0.6530	0.1275

Table 9: The annual number of California scorpionfish sampled from the the recreational private mode fleet for lengths. Data from 1980-2003 were downloaded from RecFIN and from CDFW for 2004-2016. The number of trips is the number of unique ID Codes from 1980-2003 and the number of trips from 2004-2016.

Year	N.measured	N.trips	Mean.length
1980	132	68	26.57
1981	191	76	25.84
1982	199	90	27.43
1983	63	37	28.21
1984	81	44	28.21
1985	76	40	27.78
1986	34	22	27.03
1987	42	28	27.45
1988	177	65	25.63
1989	136	55	25.35
1993	112	62	28.05
1994	136	67	26.96
1995	102	55	25.79
1996	101	70	26.44
1997	90	55	26.93
1998	116	62	26.80
1999	312	138	27.32
2000	142	70	27.77
2001	96	52	27.70
2002	178	94	28.98
2003	148	82	27.82
2004	286	165	30.58
2005	297	171	31.13
2006	663	314	30.85
2007	412	253	31.47
2008	356	237	30.91
2009	471	280	30.84
2010	241	150	30.39
2011	244	131	30.55
2012	158	95	30.65
2013	226	144	30.72
2014	153	92	30.52
2015	106	68	31.27
2016	89	53	30.51

Table 10: Recreational CPFV logbook sample sizes at each data filtering step. The bold value indicates the final sample size used for delta-GLM analysis.

Filter	Criteria	Sample size (no. of trips)
All CA data	No filter	1,164,662
Gear	Remove trips reported as diving, mooching or trolling	959,740
Effort or missing data	Remove trips with missing effort or species information	930,233
Year	Remove 2017, remaining years 1980-2016	929,781
Region	Remove trips north of Pt. Conception and in Mexico	568,222
Fish encountered	Remove trips reporting number of retained fish greater than in the 99% quantile (>325 fish)	564,433
Target species	Remove trips targeting sharks, striped bass, sturgeon, tun, misc. bay, and potluck	558,872
Single-species trips	Filter trips reporting catches of only species and that one species in <100 trips	558,833
Offshore trips	Remove trips catching yellowtail, tunas, and dolphinfish that were not designated as offshore trips	475,492
Vessel	Remove trips by vessels that had fewer than 10 trips catching scorpionfish	466,023
Anglers	Remove trips with number of anglers < the 1% and > the 99% quantile (retain 5-75 anglers)	452,938
Depth	Remove trips in blocks with a minimum depth of >140m	443,929
Scorpionfish targets	Blocks with at least 100 scorpionfish trips	433,248
Sample size	Blocks with at least 500 trips	432,868

Table 11: AIC values for each model in the recreational CPFV logbook sample index.

Model	Negative Binomial
Year	1918470
Year+ Month	1901592
Year + Block	1872224
Year+ Month + Block	1854652

Table 12: The recreational CPFV logbook sample index.

Year	Index	Log-scale SE
1980	0.0159	0.0579
1981	0.0128	0.0580
1982	0.0143	0.0583
1983	0.0134	0.0610
1984	0.0111	0.0605
1985	0.0188	0.0588
1986	0.0165	0.0579
1987	0.0168	0.0593
1988	0.0291	0.0584
1989	0.0296	0.0581
1990	0.0293	0.0585
1991	0.0348	0.0579
1992	0.0172	0.0587
1993	0.0166	0.0590
1994	0.0226	0.0588
1995	0.0291	0.0587
1996	0.0316	0.0583
1997	0.0498	0.0592
1998	0.0289	0.0595
1999	0.0482	0.0583
2000	0.0338	0.0587
2001	0.0345	0.0586
2002	0.0203	0.0588
2003	0.0193	0.0593
2004	0.0168	0.0595
2005	0.0146	0.0592
2006	0.0457	0.0592
2007	0.0489	0.0589
2008	0.0355	0.0593
2009	0.0399	0.0595
2010	0.0400	0.0597
2011	0.0304	0.0593
2012	0.0296	0.0591
2013	0.0330	0.0592
2014	0.0311	0.0602
2015	0.0252	0.0622
2016	0.0253	0.0615

Table 13: Recreational CPFV dockside sample sizes at each data filtering step. The bold value indicates the final sample size used for delta-GLM analysis.

Filter	Criteria	Sample size (no. of trips)
All southern CA data	No filter	6295
Offshore trips	Remove trips with catch of yellowfin tuna, bluefin tuna, albacore, chinook salmon, coho salmon, bigeye tuna and skipjack	6180
Species	Remove trips with catch of Pacific bonito	4718
County	Remove trips from Santa Barbara County	4338
Effort	Remove trips with lower and upper 2.5% of angler hours (± 2 or ± 109.5).	4117
Second species filter	Remove trips with catch of yellowtail (<i>Seriola lalandi</i>); remove chub/Pacific mackerel and barracuda as predictors	3968
Stephens-MacCall	Retained all trips with California scorpionfish as well as trips identified as false negatives and probability of encounter of 0.10	3176
Year	Removed trips from 1989 due to anomalous results and low sample size	3,099

Table 14: AIC values for each model in the recreational CPFV logbook sample index, including all positive trips and false positive trips selected with a Stephens-MacCall filter threshold encounter probability of 0.1.

Model	Binomial	Lognormal
Year	3516.2	2479.6
Year + Month	3123.2	2488.7
Year + County	3293.3	2436.3
Year + Month + County	3091.8	2444.6

Table 15: The annual number of retained California scorpionfish sampled from the the recreational party/charter mode fleet for lengths. Length measurements from 1980-1983 and 1993-2016 were downloaded from RecFIN. Length measurements from 1984-1989 were from an onboard observer program that measured both retained and discarded fish.

Year	Fish	Trips	Mean length (cm)	Source
1975	935	150	26.84	Collins and Crooke (unpublished)
1976	941	174	27.61	Collins and Crooke (unpublished)
1977	1373	194	26.04	Collins and Crooke (unpublished)
1978	1729	242	26.12	Collins and Crooke (unpublished)
1980	212	45	26.79	MRFSS
1981	187	59	28.36	MRFSS
1982	277	91	27.10	MRFSS
1983	318	113	28.30	MRFSS
1984	472	99	29.18	CDFW (unpublished)
1985	1089	285	28.45	Ally et al. (1991)
1986	955	266	28.02	Ally et al. (1991)
1987	1500	241	26.89	Ally et al. (1991)
1988	3358	289	26.81	CDFW (unpublished)
1989	4518	326	26.30	CDFW (unpublished)
1993	233	62	28.63	MRFSS
1994	201	74	27.82	MRFSS
1995	196	50	27.72	MRFSS
1996	698	82	25.54	MRFSS
1997	373	49	25.09	MRFSS
1998	656	89	28.38	MRFSS
1999	2057	136	27.10	MRFSS
2000	875	87	28.73	MRFSS
2001	479	79	29.82	MRFSS
2002	816	102	29.12	MRFSS
2003	1026	99	28.79	MRFSS
2004	1497	174	28.45	CRFS
2005	1493	163	28.31	CRFS
2006	3054	193	28.58	CRFS
2007	4143	255	28.22	CRFS
2008	4971	328	28.08	CRFS
2009	4118	303	28.36	CRFS
2010	4773	291	28.10	CRFS
2011	2763	265	28.63	CRFS
2012	3440	75	28.47	CRFS
2013	3299	119	28.42	CRFS
2014	2564	82	28.12	CRFS
2015	1734	168	28.33	CRFS
2016	1922	151	28.50	CRFS

Table 16: Recreational onboard observer data sample sizes at each data filtering step. The bold value indicates the final sample size used for delta-GLM analysis. The same sample data were used for the discard-only index and the retained-only catch indices

Filter	Criteria	Sample size (no. positive drifts)	Sample size (no. of drifts)
Initial SQL filtering		6,475	59,192
Habitat filter	Remove drifts >1000 m of alpha hull buffer, remove "reefs" with <0 drifts or 5% positives, or in CCA	6,365	30,987
Exclude 1999 and 2000	Management changes (depth and gear restrictions)	5,986	29,577
Depth	Remove upper and lower 1% of data (retain 26-330ft)	5,921	29,002
Minutes Fished	Remove upper and lower 1% of data (retain 4 - 155 minutes)	5,780	28,460
Observed Anglers	Remove upper and lower 1% of data (retain 4 - 15 anglers)	5,679	27,946
Boats	Include boats encountering scorpionfish in at least 3 years; at least 30 drifts and 10 with scorpionfish	5,509	26,805
Second depth filter	Remove anything >100 m after looking at 20 m depth bins	5,507	26,733

Table 17: AIC values for each model in the The recreational CPFV onboard observer discard-only catch index.

Model	Binomial	Lognormal
Year	19619.56	9177.115
Year + Reef	18677.11	9177.115
Year + Depth	19374.02	8860.893
Year + Depth + Reef	18392.13	8778.47
Year + Month + Reef + Depth	18318.92	8769.844

Table 18: The recreational CPFV onboard observer discard-only catch sample index.

Year	Index	Log-scale SE
2001	0.0373	0.0373
2002	0.0836	0.0834
2003	0.0670	0.0670
2004	0.0736	0.0735
2005	0.0842	0.0840
2006	0.0766	0.0765
2007	0.0691	0.0690
2008	0.0611	0.0610
2009	0.0596	0.0596
2010	0.0640	0.0640
2011	0.0506	0.0506
2012	0.0400	0.0400
2013	0.0392	0.0392
2014	0.0387	0.0386
2015	0.0349	0.0349
2016	0.0535	0.0535

Table 19: The annual number of discarded California scorpionfish sampled from the the recreational party/charter mode fleet for lengths. Length measurements from 2003-2016 were provided by CDFW. Length measurements from 1984-1989 were from an onboard observer program that measured both retained and discarded fish.

Year	N.measured	N.trips	Mean.length	Source
1984	6	5	20.50	CDFW unpublished
1985	55	34	18.87	Ally et al. (1991)
1986	88	30	18.26	Ally et al. (1991)
1987	72	34	19.07	Ally et al. (1991)
1988	70	32	20.03	CDFW unpublished
1989	11	11	22.55	CDFW unpublished
2003	121	41	23.90	Onboard Observer
2004	40	13	25.53	Onboard Observer
2005	161	31	25.12	Onboard Observer
2006	222	58	24.25	Onboard Observer
2007	207	32	22.95	Onboard Observer
2008	455	58	22.95	Onboard Observer
2009	396	75	22.48	Onboard Observer
2010	873	111	22.83	Onboard Observer
2011	103	32	18.82	Onboard Observer
2012	62	18	19.19	Onboard Observer
2013	124	31	22.44	Onboard Observer
2014	73	22	23.42	Onboard Observer
2015	19	10	24.63	Onboard Observer
2016	37	8	23.70	Onboard Observer

Table 20: AIC values for each model in the The recreational CPFV onboard observer retained-only catch index.

Model	Binomial	Lognormal
Year	21826.47	11507.73
Year + Reef	21192.97	11325.43
Year + Depth	21265.79	10704.15
Year + Depth + Reef	20691.44	10619.25
Year + Month + Reef + Depth	20453.43	10599.42

Table 21: The recreational CPFV onboard observer retained-only catch sample index.

Year	Index	Log-scale SE
2001	0.1134	0.1611
2002	0.0759	0.1566
2003	0.0374	0.1600
2004	0.0880	0.1410
2005	0.0615	0.1444
2006	0.0898	0.1025
2007	0.1360	0.0760
2008	0.1048	0.0722
2009	0.1027	0.0723
2010	0.1121	0.0701
2011	0.0905	0.0775
2012	0.0807	0.0736
2013	0.0654	0.0763
2014	0.0663	0.0895
2015	0.0403	0.1088
2016	0.0720	0.1026

Table 22: The trawl sample sizes for each sanitation district at each data filtering step. The bold value indicates the final sample size used for delta-GLM analysis.

Filter	Criteria	City of LA	LA County	Orange County	City of San Diego	Total trawls
General	Erroneous and missing data, harbors or Mexican waters	1,496	2,321	1,671	1,180	6,668
District-specific filters	Stations sampled >29 years or <305 ft		1,848			
	Stations sampled >9 years	930			998	
	Stations sampled >13 years			1,558		
	Stations sampled >11 years					
Station	Stations encountering scorpionfish >4% of trawls	930	1,848	1,500	998	
Tow time and depth	Stations with tow times >4 minutes and <24 ft	921			1,490	
	Tow distance 100-599 m (target tow distance 400 m)					
Final data		921	1,848	1,490	998	5,257

Table 23: AIC values for each model in the sanitation districts trawl sample index.

Model	Binomial	Lognormal
Year	7330.73	6748.7
Year + Quarter	7179.5	6642.7
Year + Station	6321.6	6372.8
Year + Station + Quarter	6130.94	6252.71

Table 24: The sanitation districts trawl sample index.

Year	Index	Log-scale SE
1970	0.0548	0.5975
1971	0.0703	0.4554
1972	0.1261	0.3709
1973	0.1047	0.3344
1974	0.0841	0.2973
1975	0.0719	0.3571
1976	0.0737	0.2780
1977	0.1408	0.2035
1978	0.1426	0.2135
1979	0.3617	0.1598
1980	0.4085	0.1645
1981	0.4360	0.1543
1982	0.3841	0.2056
1983	0.1343	0.2110
1984	0.0627	0.2817
1985	0.1087	0.1745
1986	0.1624	0.2172
1987	0.2377	0.1644
1988	0.2382	0.1471
1989	0.1605	0.1513
1990	0.1691	0.1551
1991	0.1037	0.1801
1992	0.1126	0.1595
1993	0.1147	0.1055
1994	0.1120	0.1267
1995	0.1970	0.1083
1996	0.2276	0.1006
1997	0.2407	0.1036
1998	0.1795	0.1148
1999	0.2343	0.1001
2000	0.1281	0.1439
2001	0.2433	0.0947
2002	0.1329	0.1411
2003	0.1632	0.1688
2004	0.1873	0.1320
2005	0.2435	0.1673
2006	0.2497	0.1368
2007	0.1347	0.1615
2008	0.1126	0.1643
2009	0.1246	0.1717
2010	0.0791	0.1772
2011	0.1081	0.1851
2012	0.0462	0.2760
2013	0.0190	0.4105
2014	0.0674	0.2917
2015	0.1290	0.2641
2016	0.1167	0.2660

Table 25: Number of fish measured by 25 m depth bin and sanitation district

Program	0-24 m	25-49 m	50-74m	100+ m	Total
City of Los Angeles	120	0	1372	0	1492
Los Angeles County	687	0	5879	450	7016
Orange County	161	669	2157	48	3035
City of San Diego	0	404	333	829	1566

Table 26: Sample sizes and mean length by year fo the sanitation district trawl surveys, all sanitation district programs combined

Year	Fish	Trips	Mean length (cm)
1970	36	5	23.80
1971	23	8	23.42
1972	77	28	24.52
1973	108	30	25.31
1974	57	31	29.05
1975	54	25	28.76
1976	61	37	26.88
1977	93	53	24.70
1978	83	32	24.48
1979	340	100	23.15
1980	352	107	23.23
1981	388	97	24.31
1982	631	103	25.43
1983	118	64	26.67
1984	72	41	26.17
1985	109	67	26.46
1986	171	105	24.73
1987	276	143	24.80
1988	278	174	23.94
1989	203	138	25.38
1990	230	120	25.82
1991	162	95	26.03
1992	204	121	26.41
1993	275	155	24.06
1994	299	177	24.01
1995	371	207	23.29
1996	489	215	23.36
1997	458	229	23.94
1998	358	178	23.89
1999	461	240	24.10
2000	319	209	23.84
2001	510	266	24.27
2002	1552	203	23.81
2003	376	206	24.80
2004	801	199	25.25
2005	1292	253	24.92
2006	844	271	24.72
2007	242	152	25.01
2008	212	145	24.43
2009	211	140	23.61
2010	125	89	24.76
2011	131	107	23.87
2012	53	40 ⁶⁸	25.68
2013	11	11 ⁶⁸	23.71
2014	40	36	25.84
2015	59	46	22.92

Table 27: Summaries of catch statistics of California scorpionfish by 25 m interval depth zones from NWFSC trawl survey between 2003 and 2016.

Depth zone (m)	Total catch (kg)	Raw CPUE (kg/ha)
62.50	304.80	1.71
87.50	568.20	1.98
112.50	34.10	0.22
137.50	3.80	0.04
162.50	46.90	0.41
187.50	1.10	0.01
212.50	0.40	0.00

Table 28: Summaries of catch statistics of California scorpionfish by latitude zones from NWFSC trawl survey between 2003 and 2016.

Latitude zone	Total catch (kg)	Raw CPUE (kg/ha)
32.50	156.30	1.59
33.00	274.90	2.60
33.50	257.70	0.93
34.00	270.10	0.73
34.50	0.10	0.00

Table 29: Summaries of haul statistics of California scorpionfish from NWFSC trawl survey between 2003 and 2016.

Year	No. hauls	No. positive hauls	Percent positive hauls	Total catch (kg)	Raw CPUE (kg/ha)
2003	33	9	27.30	28.20	0.51
2004	37	12	32.40	73.20	1.02
2005	37	8	21.60	58.50	0.90
2006	42	11	26.20	15.10	0.23
2007	50	12	24.00	81.30	1.03
2008	51	12	23.50	16.20	0.22
2009	58	10	17.20	217.50	2.60
2010	53	10	18.90	20.00	0.23
2011	51	16	31.40	64.00	0.93
2012	61	9	14.80	102.40	1.07
2013	25	8	32.00	182.70	4.85
2014	49	6	12.20	23.00	0.32
2015	50	14	28.00	52.50	0.59
2016	58	12	20.70	24.70	0.28

Table 30: Summary statistics of age data by year and sex from NWFSC trawl survey between 2005 and 2016. The last raw shows total numbers of fish aged by sex.

Year	Female			Male		
	No. aged	Mean age (year)	Mean length (cm)	No. aged	Mean age (year)	Mean length (cm)
2005	38	7.70	28.30	37	9.20	26.00
2006	12	5.50	25.60	33	8.60	24.40
2007	19	6.60	26.50	49	7.10	24.60
2008	19	5.70	25.80	30	8.00	24.50
2009	33	4.30	24.10	97	7.10	23.20
2010	20	8.50	27.60	22	8.90	24.80
2011	42	4.80	24.40	74	7.60	23.60
2012	30	9.60	28.60	36	9.30	25.00
2013	28	6.30	27.00	39	3.70	22.40
2014	32	5.70	24.40	41	6.00	22.20
2015	20	3.20	20.40	34	5.20	21.30
2016	47	2.70	21.10	37	4.90	20.60
Sum	340			529		

Table 31: Ages at five percentiles by sex from NWFSC trawl survey between 2005 and 2016, indicating more older males in the population.

Percentile	Female age at percentile	Male age at percentile
50.00	4.00	6.00
90.00	12.00	14.20
95.00	15.10	16.60
97.50	19.00	19.00
99.00	20.20	21.70

Table 32: Mean age at length (cm) and number of fish aged by sex for California scorpionfish from the NWFSC trawl survey.

Age	Female		Male	
	Mean length	Fish	Mean length	Fish
1	17.21	29	16.80	46
2	20.47	72	20.25	87
3	24.40	45	22.06	54
4	25.42	33	22.75	44
5	26.32	38	23.72	32
6	27.33	18	23.00	23
7	27.17	12	24.92	26
8	28.53	17	24.93	27
9	29.46	13	25.48	31
10	29.10	10	25.74	23
11	29.21	14	26.32	25
12	32.00	4	26.29	24
13	30.44	9	26.06	17
14	31.25	4	26.88	16
15	29.33	3	28.07	14
16			28.09	11
17	32.75	4	29.13	8
18	36.00	3	28.25	4
19	32.33	6	28.86	7
20			22.00	1
21	37.50	2	25.00	1

Table 33: The NWFSC trawl survey index.

Year	Index	Log-scale SE
2003	615.6453	0.5708
2004	1000.1240	0.4503
2005	936.2185	0.5943
2006	245.5559	0.5092
2007	1001.1330	0.5099
2008	195.6025	0.4484
2009	1940.3440	0.5137
2010	277.3953	0.5338
2011	710.0569	0.3744
2012	561.1833	0.5361
2013	3243.2760	0.5728
2014	370.3868	0.7000
2015	409.8495	0.4045
2016	366.7447	0.4809

Table 34: Recreational private mode dockside data sample sizes at each data filtering step. The bold value indicates the final sample size used for delta-GLM analysis.

Filter	Criteria	Sample size (no. positive trips)	Sample size (no. of trips)
Entire dataset		325	3,558
General data filters	Samples with no net failures	269	3,515
Net type	Samples using a net type 1", 1.5" and 2" mesh	269	2,815
Sites	Sites frequently sampled	266	2,170
Month	Months sampled consistently (April, June, August, October)	259	2,019

Table 35: AIC values for each model in the recreational private mode dockside sample index.

Model	Binomial	Lognormal
Year + month + site + perp_para + floats	1983.12	1008.62
Year + site + perp_para + floats	2000.281	1004.4
Year + month + perp_para + floats	2349.989	1264.8
Year + site + perp_para	2010.078	1004.1

Table 36: The recreational private mode dockside sample index.

Year	Index	Log-scale SE
1995	0.0537	0.0536
1996	0.0401	0.0401
1997	0.0478	0.0477
1998	0.0275	0.0275
1999	0.0360	0.0360
2000	0.0299	0.0299
2001	0.0331	0.0331
2002	0.0348	0.0348
2003	0.0304	0.0304
2004	0.0541	0.0541
2005	0.0324	0.0324
2006	0.0572	0.0572
2007	0.0508	0.0508
2008	0.0618	0.0618

Table 37: Southern California Bight regional monitoring trawl survey data sample sizes at each data filtering step. The bold value indicates the final sample size used for delta-GLM analysis.

Filter	Criteria	Sample size (no. positive trips)	Sample size (no. of trips)
All trawls	No filter	158	944
Depth	Trawls < 98 m (retains 95% of all data)	149	662
Region	Exclude trawls in harbors, north of Ventura and islands (few scorpionfish)	129	398

Table 38: AIC values for each model in the Southern California Bight regional monitoring trawl survey sample index.

Model	Binomial	Lognormal
Year	494.73	339.56
Year + Region	490.24	343.16
Year + Month	493.02	336.68
Year + Month + Region	486.55	337.87

Table 39: Southern California Bight regional monitoring trawl survey sample index.

Year	Index	Log-scale SE
1994	0.0475	0.3042
1998	0.0223	0.2499
2003	0.0514	0.2356
2008	0.0156	0.3187
2013	0.0214	0.3021

Table 40: Results from 100 jitters from the base case model.

Description	Value
Minimum likelihood	1095.94
Maximum likelihood	1111.16
Likelihood difference	15.22
Minimum MGC	0.00
Maximum MGC	0.02
Depletion at minimum likelihood percent	57.43
Depletion at maximum likelihood percent	83.25
Difference in depletion percent	25.82
Number of jitters	100.00
Prop of runs at minimum likelihood	0.45
Proportion of runs at maximum likelihood	0.02

Table 41: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD)).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
1	NatM_p_1_Fem_GP_1	0.257	-3	(0.01, 1) (2, 30)	OK	0.617	Log_Norm (-1.3581, 0.438438)
2	Lat_Amin_Fem_GP_1	12.467	2	(30, 50)	OK	0.721	None
3	Lat_Amax_Fem_GP_1	33.322	2	(0.05, 0.5)	OK	0.024	None
4	VonBert_K_Fem_GP_1	0.249	2	(0.02, 0.5)	OK	0.019	None
5	CV_young_Fem_GP_1	0.088	3	(0.02, 0.75)	OK	0.008	None
6	CV_old_Fem_GP_1	0.113	3	(-3, 3)	None	None	None
7	Wtlen_1_Fem	0.000	-3	(2, 4)	None	None	None
8	Wtlen_2_Fem	3.058	-3	(10, 30)	None	None	None
9	Mat50%_Fem	18.000	-3	(-3, 3)	None	None	None
10	Mat_slope_Fem	-1.200	-3	(-3, 3)	None	None	None
11	Eggs/kg_inter_Fem	1.000	-3	(-3, 3)	None	None	None
12	Eggs/kg_slope_wt_Fem	0.000	-3	(-3, 3)	None	None	None
13	NatM_p_1_Mal_GP_1	-0.213	2	(-1, 1)	OK	0.049	Normal (0, 99)
14	Lat_Amin_Mal_GP_1	0.000	-2	(-3, 3)	None	None	None
15	Lat_Amax_Mal_GP_1	-0.159	2	(-3, 3)	OK	0.026	None
16	VonBert_K_Mal_GP_1	-0.299	2	(-3, 3)	OK	0.185	None
17	CV_young_Mal_GP_1	1.308	3	(-3, 3)	OK	0.218	None
18	CV_old_Mal_GP_1	-0.455	3	(-3, 3)	OK	0.159	None
19	Wtlen_1_Mal	0.000	-5	(0, 1)	None	None	None
20	Wtlen_2_Mal	2.981	-5	(2, 4)	None	None	None
24	CohortGrowDev	1.000	-1	(1, 1)	None	None	None
25	FracFemale_GP_1	0.500	-4	(0.000001, 0.999999)	OK	0.157	Full_Beta (0.718, 0.158)
26	SR_LN(R0)	8.155	1	(0, 31)	None	None	None
27	SR_BH_stEEP	0.718	-2	(0.21, 0.99)	None	None	None
28	SR_sigmar	0.600	-2	(0, 2)	None	None	None
29	SR_regime	0.000	-4	(-5, 5)	None	None	None

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Table 41: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD)).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
30	SR.autocorr	0.000	-3	(0, 0.5)			None
106	LnQ_base_RecPR(4)	-6.777	-1	(-15, 15)	OK	0.020	None
107	Q_extraSD_RecPR(4)	0.013	4	(0.0001, 1)			None
108	LnQ_base_RecPC(5)	-11.225	-1	(-15, 15)	OK	0.047	None
109	Q_extraSD_RecPC(5)	0.268	4	(0.0001, 1)			None
110	LnQ_base_RecDD(6)	-10.896	-1	(-15, 15)	OK	0.044	None
111	Q_extraSD_RecDD(6)	0.077	4	(0.0001, 1)			None
112	LnQ_base_Sanitation(7)	-10.545	-1	(-15, 15)	OK	0.047	None
113	Q_extraSD_Sanitation(7)	0.225	4	(0.0001, 1)			None
114	LnQ_base_NWFSC_Trawl(8)	-1.024	-1	(-15, 15)	OK	0.145	None
115	Q_extraSD_NWFSC_Trawl(8)	0.250	4	(0.0001, 1)			None
116	LnQ_base_GillnetSurvey(9)	-12.050	-1	(-15, 15)	OK	0.069	None
117	Q_extraSD_GillnetSurvey(9)	0.122	4	(0.0001, 1)			None
118	LnQ_base_SCBSSurvey(11)	-11.053	-1	(-15, 15)	OK	0.142	None
119	Q_extraSD_SCBSSurvey(11)	0.167	4	(0.0001, 1)			None
120	LnQ_base_RecPCOBR(12)	-10.173	-1	(-15, 15)	OK	0.046	None
121	Q_extraSD_RecPCOBR(12)	0.140	4	(0.0001, 1)			None
122	SizeSel_P1_CoMHL(1)	26.242	5	(13, 44)	OK	2.113	None
123	SizeSel_P2_CoMHL(1)	15.000	-3	(-10, 16)	OK		None
124	SizeSel_P3_CoMHL(1)	2.839	5	(-1, 10)	OK	0.681	None
125	SizeSel_P4_CoMHL(1)	15.000	-3	(-1, 16)	OK		None
126	SizeSel_P5_CoMHL(1)	-15.935	5	(-25, -1)	OK	121.126	None
127	SizeSel_P6_CoMHL(1)	10.000	-3	(-5, 11)	OK		None
128	SizeSel_P1_CoMNet(2)	1.000	-2	(1, 45)	OK		None
129	SizeSel_P2_CoMNet(2)	45.000	-3	(1, 45)	OK		None
130	SizeSel_P1_CoM_Trawl(3)	1.000	-2	(1, 45)	OK		None
131	SizeSel_P2_CoM_Trawl(3)	45.000	-3	(1, 45)	OK		None

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Table 41: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD)).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
132	SizeSel_P1_RecPR(4)	41.211	5	(13, 44)	OK	2.052	None
133	SizeSel_P2_RecPR(4)	15.000	-3	(-10, 16)	OK	0.163	None
134	SizeSel_P3_RecPR(4)	4.493	5	(-1, 10)	OK	0.163	None
135	SizeSel_P4_RecPR(4)	15.000	-3	(-1, 16)	OK	0.784	None
136	SizeSel_P5_RecPR(4)	-8.341	5	(-25, -1)	OK	0.784	None
137	SizeSel_P6_RecPR(4)	10.000	-3	(-5, 11)	OK	1.354	None
138	SizeSel_P1_RecPC(5)	36.608	5	(13, 44)	OK	1.354	None
139	SizeSel_P2_RecPC(5)	15.000	-3	(-10, 16)	OK	None	None
140	SizeSel_P3_RecPC(5)	4.470	5	(-1, 10)	OK	0.157	None
141	SizeSel_P4_RecPC(5)	15.000	-3	(-1, 16)	OK	None	None
142	SizeSel_P5_RecPC(5)	-8.339	5	(-25, -1)	OK	1.866	None
143	SizeSel_P6_RecPC(5)	10.000	-3	(-5, 11)	OK	0.074	None
144	SizeSel_P1_RecDD(6)	24.530	5	(13, 44)	OK	57.641	None
145	SizeSel_P2_RecDD(6)	-11.237	4	(-15, 16)	OK	0.515	None
146	SizeSel_P3_RecDD(6)	2.718	4	(-1, 10)	OK	65.337	None
147	SizeSel_P4_RecDD(6)	-9.304	4	(-20, 5)	OK	0.469	None
148	SizeSel_P5_RecDD(6)	-2.150	5	(-25, 3)	OK	0.457	None
149	SizeSel_P6_RecDD(6)	-1.709	4	(-5, 11)	OK	0.576	None
150	SizeSel_P1_Sanitation(7)	24.644	4	(13, 44)	OK	None	None
151	SizeSel_P2_Sanitation(7)	15.000	-3	(-10, 16)	OK	0.140	None
152	SizeSel_P3_Sanitation(7)	3.390	4	(-1, 10)	OK	0.633	None
153	SizeSel_P4_Sanitation(7)	15.000	-3	(-1, 16)	OK	2.253	None
154	SizeSel_P5_Sanitation(7)	-4.611	4	(-25, 5)	OK	0.557	None
155	SizeSel_P6_Sanitation(7)	10.000	-3	(-5, 11)	OK	None	None
156	SizeSel_P1_NWFSCCTrawl(8)	24.335	4	(13, 44)	OK	None	None
157	SizeSel_P2_NWFSCCTrawl(8)	15.000	-3	(-10, 16)	OK	None	None
158	SizeSel_P3_NWFSCCTrawl(8)	3.658	4	(-1, 10)	OK	0.557	None

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Table 41: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD)).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
159	SizeSel_P4_NWFSTrawl(8)	15.000	-3	(-1, 16)			None
160	SizeSel_P5_NWFSTrawl(8)	-12.835	4	(-25, 5)	OK	166.534	None
161	SizeSel_P6_NWFSTrawl(8)	10.000	-3	(-5, 11)			None
162	SizeSel_P1_GilnetSurvey(9)	1.000	-2	(1, 45)			None
163	SizeSel_P2_GilnetSurvey(9)	45.000	-3	(1, 45)			None
164	SizeSel_P1_SCBSurvey(11)	1.000	-2	(1, 45)			None
165	SizeSel_P2_SCBSurvey(11)	45.000	-3	(1, 45)			None
166	SizeSel_P1_RecPCOBR(12)	1.000	-2	(1, 45)			None
167	SizeSel_P2_RecPCOBR(12)	45.000	-3	(1, 45)			None
168	SizeSel_P1_CoMHL(1)_BLK1rep1_1999	28.449	6	(13, 44)	OK	0.488	None
169	SizeSel_P3_CoMHL(1)_BLK1rep1_1999	2.009	6	(-1, 10)	OK	0.250	None
170	SizeSel_P1_RecPR(4)_BLK2rep1_2000	36.592	6	(13, 44)	OK	1.031	None
171	SizeSel_P1_RecPR(4)_BLK2rep1_2006	35.816	6	(13, 44)	OK	0.651	None
172	SizeSel_P3_RecPR(4)_BLK2rep1_2000	3.603	6	(-1, 10)	OK	0.165	None
173	SizeSel_P3_RecPR(4)_BLK2rep1_2006	3.463	6	(-1, 10)	OK	0.110	None
174	SizeSel_P1_RecPC(5)_BLK2rep1_2000	31.782	6	(13, 44)	OK	1.371	None
175	SizeSel_P1_RecPC(5)_BLK2rep1_2006	26.886	6	(13, 44)	OK	0.462	None
176	SizeSel_P3_RecPC(5)_BLK2rep1_2000	3.036	6	(-1, 10)	OK	0.418	None
177	SizeSel_P3_RecPC(5)_BLK2rep1_2006	1.065	6	(-1, 10)	OK	0.411	None

Table 42: Likelihood components from the base model.

Likelihood component	Value
TOTAL	1096.53
Catch	0.00
Survey	-98.12
Length composition	762.48
Age composition	420.57
Recruitment	11.59
Forecast recruitment	0.00
Parameter priors	0.00
Parameter soft bounds	0.01

Table 43: Time-series of population estimates from the base-case model.

Yr	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative ex- ploitation rate	SPR
1916	2784	1362	0.000	3482	4	0.00	0.99
1917	2781	1360	0.999	3482	8	0.00	0.98
1918	2774	1356	0.996	3481	13	0.00	0.97
1919	2765	1350	0.992	3479	12	0.00	0.98
1920	2757	1346	0.988	3478	16	0.01	0.97
1921	2747	1340	0.984	3477	26	0.01	0.95
1922	2730	1330	0.977	3474	19	0.01	0.96
1923	2721	1325	0.973	3473	27	0.01	0.94
1924	2707	1316	0.967	3471	49	0.02	0.90
1925	2676	1298	0.953	3466	101	0.04	0.82
1926	2606	1256	0.922	3454	49	0.02	0.90
1927	2589	1247	0.916	3451	51	0.02	0.89
1928	2573	1238	0.909	3449	44	0.02	0.91
1929	2566	1235	0.907	3448	50	0.02	0.90
1930	2556	1230	0.903	3446	41	0.02	0.91
1931	2555	1229	0.903	3446	43	0.02	0.91
1932	2552	1228	0.902	3446	41	0.02	0.91
1933	2551	1228	0.902	3446	32	0.01	0.93
1934	2559	1233	0.906	3447	34	0.01	0.93
1935	2564	1237	0.908	3448	35	0.01	0.93
1936	2568	1239	0.910	3449	55	0.02	0.89
1937	2554	1231	0.904	3446	66	0.03	0.87
1938	2533	1218	0.894	3442	76	0.03	0.85
1939	2506	1201	0.882	3437	63	0.03	0.87
1940	2493	1194	0.877	3435	59	0.02	0.88
1941	2486	1190	0.874	3434	43	0.02	0.91
1942	2493	1195	0.878	3436	20	0.01	0.95
1943	2519	1212	0.890	3441	16	0.01	0.96
1944	2545	1228	0.902	3446	24	0.01	0.95
1945	2561	1237	0.909	3448	42	0.02	0.91
1946	2559	1236	0.908	3448	66	0.03	0.87
1947	2537	1223	0.898	3444	74	0.03	0.85
1948	2511	1206	0.886	3439	107	0.04	0.80
1949	2463	1175	0.863	3429	93	0.04	0.82
1950	2433	1156	0.849	3423	97	0.04	0.81
1951	2405	1138	0.836	3417	67	0.03	0.86
1952	2405	1139	0.837	3417	61	0.03	0.87
1953	2410	1143	0.839	3418	73	0.03	0.84
1954	2405	1140	0.837	3417	84	0.03	0.83
1955	2391	1132	0.832	3415	67	0.03	0.85

Table 43: Time-series of population estimates from the base-case model.

Yr	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative ex- ploitation rate	SPR
1956	2393	1134	0.833	3415	63	0.03	0.86
1957	2399	1138	0.836	3417	43	0.02	0.90
1958	2420	1152	0.846	3421	39	0.02	0.91
1959	2442	1166	0.856	3426	25	0.01	0.94
1960	2472	1184	0.870	3432	24	0.01	0.95
1961	2499	1201	0.882	3437	31	0.01	0.93
1962	2518	1211	0.889	3440	50	0.02	0.89
1963	2518	1210	0.888	3440	72	0.03	0.85
1964	2499	1197	0.879	3436	87	0.03	0.83
1965	2472	1177	0.865	3430	85	0.03	0.83
1966	2449	1162	0.854	2698	89	0.04	0.82
1967	2404	1148	0.843	2698	73	0.03	0.85
1968	2359	1135	0.834	2550	87	0.04	0.82
1969	2287	1099	0.807	2420	84	0.04	0.82
1970	2207	1058	0.777	2202	103	0.05	0.79
1971	2102	1003	0.737	1816	91	0.04	0.80
1972	1993	951	0.698	1655	82	0.04	0.81
1973	1881	899	0.660	1593	95	0.05	0.78
1974	1753	831	0.610	1964	122	0.07	0.73
1975	1618	748	0.550	6349	128	0.08	0.70
1976	1639	673	0.495	5926	66	0.04	0.80
1977	1812	699	0.514	6088	87	0.05	0.76
1978	2047	822	0.604	3199	62	0.03	0.81
1979	2250	994	0.730	1674	100	0.04	0.75
1980	2321	1121	0.823	1280	124	0.05	0.73
1981	2271	1140	0.838	1334	110	0.05	0.76
1982	2158	1088	0.799	1814	112	0.05	0.77
1983	2014	991	0.728	2789	61	0.03	0.85
1984	1931	914	0.671	7963	70	0.04	0.83
1985	2034	852	0.625	9488	86	0.04	0.80
1986	2312	877	0.644	3171	76	0.03	0.81
1987	2531	1068	0.784	1658	69	0.03	0.83
1988	2648	1280	0.940	1480	201	0.08	0.66
1989	2551	1278	0.939	1340	163	0.06	0.71
1990	2397	1202	0.883	1561	228	0.10	0.65
1991	2146	1044	0.767	5803	241	0.11	0.63
1992	2013	869	0.638	5373	115	0.06	0.75
1993	2064	827	0.607	8446	95	0.05	0.77
1994	2299	899	0.660	4861	156	0.07	0.68
1995	2476	1013	0.744	2324	133	0.05	0.72

Table 43: Time-series of population estimates from the base-case model.

Yr	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative ex- ploitation rate	SPR
1996	2581	1184	0.869	7047	136	0.05	0.73
1997	2750	1261	0.926	3793	142	0.05	0.74
1998	2835	1294	0.950	4453	161	0.06	0.73
1999	2880	1346	0.988	4882	225	0.08	0.67
2000	2869	1317	0.967	2438	169	0.06	0.73
2001	2826	1318	0.968	4063	199	0.07	0.70
2002	2759	1282	0.942	2286	128	0.05	0.78
2003	2686	1251	0.919	1898	105	0.04	0.81
2004	2578	1226	0.901	1961	57	0.02	0.88
2005	2472	1185	0.870	4127	89	0.04	0.83
2006	2390	1101	0.808	2465	150	0.06	0.75
2007	2247	1010	0.742	2197	140	0.06	0.75
2008	2117	967	0.710	2267	104	0.05	0.78
2009	2022	930	0.683	2782	113	0.06	0.76
2010	1939	881	0.647	2309	106	0.05	0.77
2011	1864	844	0.620	1168	105	0.06	0.76
2012	1758	817	0.600	1111	120	0.07	0.73
2013	1620	768	0.564	4079	115	0.07	0.72
2014	1571	696	0.511	3466	124	0.08	0.70
2015	1557	646	0.475	7369	84	0.05	0.75
2016	1742	684	0.502	3173	74	0.04	0.77
2017	1905	787	0.578	3250			

Table 44: Sensitivity of the base model to dropping or down-weighting data sources and alternative assumptions about growth.

Label	Base (Francis weights)	Default weights	Harmonic mean weights	Drop sanita- tion data	Assume equal M	Placeholder ^{Placeholder3}
Female natural mortality	0.26	0.26	0.26	0.26	0.26	-
Male natural mortality	0.21	0.21	0.19	0.20	0.26	-
Steepness	0.72	0.72	0.72	0.72	0.72	-
lnR0	8.16	8.26	8.03	8.22	8.45	-
Total Biomass (mt)	2801.84	2870.33	2426.03	3024.20	3144.75	-
Depletion	0.57	0.77	0.65	0.53	0.59	-
SPR ratio	0.72	0.61	0.79	0.70	0.63	-
Female Lmin	12.47	12.33	12.37	12.74	12.01	-
Female Lmax	33.32	33.75	34.57	33.81	32.48	-
Female K	0.25	0.22	0.21	0.24	0.26	-
Male Lmin (offset)	0.00	0.00	0.00	0.00	0.00	-
Male Lmax (offset)	-0.16	-0.17	-0.17	-0.15	-0.14	-
Male K (offset)	-0.30	-0.37	-0.85	-0.47	-0.16	-
Negative log-likelihood						-
No. parameters	113.00	113.00	113.00	109.00	112.00	-
TOTAL	1095.94	3787.10	2301.37	872.09	1106.63	-
Catch	0.00	0.00	0.00	0.00	0.00	-
Equilibrium catch	0.00	0.00	0.00	0.00	0.00	-
Survey	-98.10	-87.72	-88.09	-93.07	-98.41	-
Length composition	762.60	2521.59	1683.31	536.67	764.90	-
Age composition	420.57	1320.79	683.12	419.66	429.62	-
Recruitment	10.87	32.44	23.02	8.83	10.52	-
Forecast Recruitment	0.00	0.00	0.00	0.00	0.00	-
Parameter priors	0.00	0.00	0.00	0.00	0.00	-
Parameter softbounds	0.01	0.01	0.00	0.01	0.00	-
Parameter devs	0.00	0.00	0.00	0.00	0.00	-
Crash Pen	0.00	0.00	0.00	0.00	0.00	-

Table 45: Summary of the biomass/abundance time series used in the stock assessment.

Fleet	Years	Name	Fishery ind.	Filtering	Method	Endorsed
4	2004-2016	Recreational PR dockside CPUE	No	trip, area, regulations, Stephens-MacCall	delta-GLM (bin-lognormal)	SSC
5	1980-2016	CPFV logbook CPUE	No	trip, gear, effort, species, depth, sample size	negative binomial	SSC
6	2002-2016	Onboard observer discard catch CPUE	No	habitat ,regulations, effort, boats	delta-GLM (bin-lognormal)	SSC
7	1970-2016	Sanitation district CPUE	Yes	sample size, depth, tow times	delta-GLM (bin-lognormal)	SSC
8	2003-2016	NWFSC trawl survey CPUE	Yes	depth, area	VAST	SSC
9	1995-2008	CSUN/VRG Gillnet survey CPUE	Yes	gear, site, month	delta-GLM (bin-lognormal)	SSC
11	1994; 1998; 2003; 2008; 2013	Southern California Bright trawl survey CPUE	Yes	depth, area	delta-GLM (bin-lognormal)	SSC
12	2002-2016	Onboard observer retained catch CPUE	No	habitat, regulations, effort, boats	delta-GLM (bin-lognormal)	SSC

Table 46: Summaries of key assessment outputs and likelihood values from the retrospective analysis. Note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for the year of 2017.

Label	Base	Retro1	Retro2	Retro3	Retro4
Female natural mortality	0.26	0.26	0.26	0.26	0.26
Male natural mortality	0.72	0.72	0.72	0.72	0.72
Steepness	8.16	8.08	8.06	8.03	8.07
InR0	2801.84	2583.95	2557.25	2487.92	2638.26
Total Biomass (mt)	57.43	53.92	51.09	51.11	55.23
Depletion	0.72	0.84	0.96	0.96	0.96
SPR ratio	12.47	12.49	12.94	12.67	13.06
Female Lmin	33.32	33.51	33.39	33.37	33.46
Female Lmax	0.25	0.24	0.24	0.24	0.23
Female K	0.00	0.00	0.00	0.00	0.00
Male Lmin (offset)	-0.16	-0.16	-0.15	-0.15	-0.15
Male Lmax (offset)	-0.30	-0.30	-0.44	-0.42	-0.57
Male K (offset)					
Negative log-likelihood	1095.94	1046.89	1008.74	961.28	896.59
No. parameters	0.00	0.00	0.00	0.00	0.00
TOTAL	0.00	0.00	0.00	0.00	0.00
Catch	-98.10	-92.00	-89.11	-81.75	-80.60
Equilibrium catch	762.60	739.38	719.84	699.58	670.14
Survey	420.57	389.68	369.16	335.51	299.18
Length composition	10.87	9.81	8.85	7.93	7.86
Age composition	0.00	0.00	0.00	0.00	0.00
Recruitment	0.00	0.00	0.00	0.00	0.00
Forecast Recruitment	0.01	0.01	0.01	0.01	0.01
Parameter priors	0.00	0.00	0.00	0.00	0.00
Parameter softbounds	0.00	0.00	0.00	0.00	0.00
Parameter devs					
Crash Pen					

Table 47: Summaries of key assessment outputs and likelihood values from selected likelihood profile runs on virgin recruitment ($\ln R_0$). Note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for the year of 2017.

Label	R07200	R07500	R08000	R08500	R08800	h0410	h0570	h0870	h0990	M0220	M026
Female M	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.22	0.2
Steepness	0.72	0.72	0.72	0.72	0.72	0.41	0.57	0.71	0.87	0.99	0.72
lnR0	7.20	7.50	8.00	8.50	8.80	8.33	8.21	8.16	8.12	8.11	7.66
Total biomass (m)	1100.99	1479.13	2399.06	3900.00	5254.49	3281.22	2925.73	2789.28	2701.53	2658.70	2248.53
Depletion (%)	53.15	48.51	53.61	65.83	70.85	51.63	55.70	57.73	59.20	59.97	48.06
SPR ratio	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.9
Female Lmin	11.49	11.74	12.40	12.52	12.51	12.48	12.47	12.47	12.46	12.42	12.4
Female Lmax	34.19	34.02	33.50	32.95	32.71	33.21	33.29	33.32	33.34	33.34	33.3
Female K	0.24	0.24	0.25	0.25	0.26	0.25	0.25	0.25	0.25	0.25	0.2
Male Lmin (offset)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Male Lmax (offset)	-0.19	-0.18	-0.16	-0.15	-0.15	-0.16	-0.16	-0.16	-0.16	-0.16	-0.1
Male K (offset)	-0.06	-0.13	-0.29	-0.27	-0.25	-0.28	-0.29	-0.30	-0.30	-0.27	-0.3
Negative log-likelihood											
TOTAL	1143.29	1117.36	1097.30	1098.47	1101.20	1100.52	1097.80	1096.58	1095.96	1099.46	1101.91
Catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Equil_catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Survey	-100.93	-100.63	-98.82	-96.85	-96.13	-98.27	-98.18	-98.12	-98.07	-98.03	-97.79
Length_comp	759.65	758.27	760.62	766.56	769.44	764.45	763.13	762.51	762.05	761.81	765.05
Age_comp	444.54	436.50	423.26	417.52	416.62	419.73	420.32	420.56	420.73	420.81	421.99
Recruitment	40.03	23.21	12.23	11.24	11.28	13.23	12.11	11.62	11.28	11.11	12.59
Forecast_Recruitment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Parm_priors	0.00	0.00	0.00	0.00	0.00	0.00	1.38	0.42	0.01	-0.04	3.76
Parm_softbounds	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.0
Parm_devs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Crash_Pen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

Table 48: Projection of potential OFL, spawning biomass, and depletion for the base case model.

Yr	OFL contribution (mt)	ACL landings (mt)	Age 5+ biomass (mt)	Spawning Biomass (mt)	Depletion
2017	283.53	261.36	1905.14	787.21	0.58
2018	279.14	257.08	1905.19	849.97	0.62
2019	295.36	271.93	1896.34	857.65	0.63
2020	298.92	275.29	1857.38	827.21	0.61
2021	290.45	267.52	1801.40	783.09	0.58
2022	279.50	257.44	1745.93	743.41	0.55
2023	269.81	248.50	1698.02	713.51	0.52
2024	261.91	241.22	1658.67	692.30	0.51
2025	255.54	235.35	1626.94	677.30	0.50
2026	250.40	230.60	1601.67	666.48	0.49
2027	246.26	226.79	1581.74	658.49	0.48
2028	242.98	223.76	1566.20	652.52	0.48

8 Figures

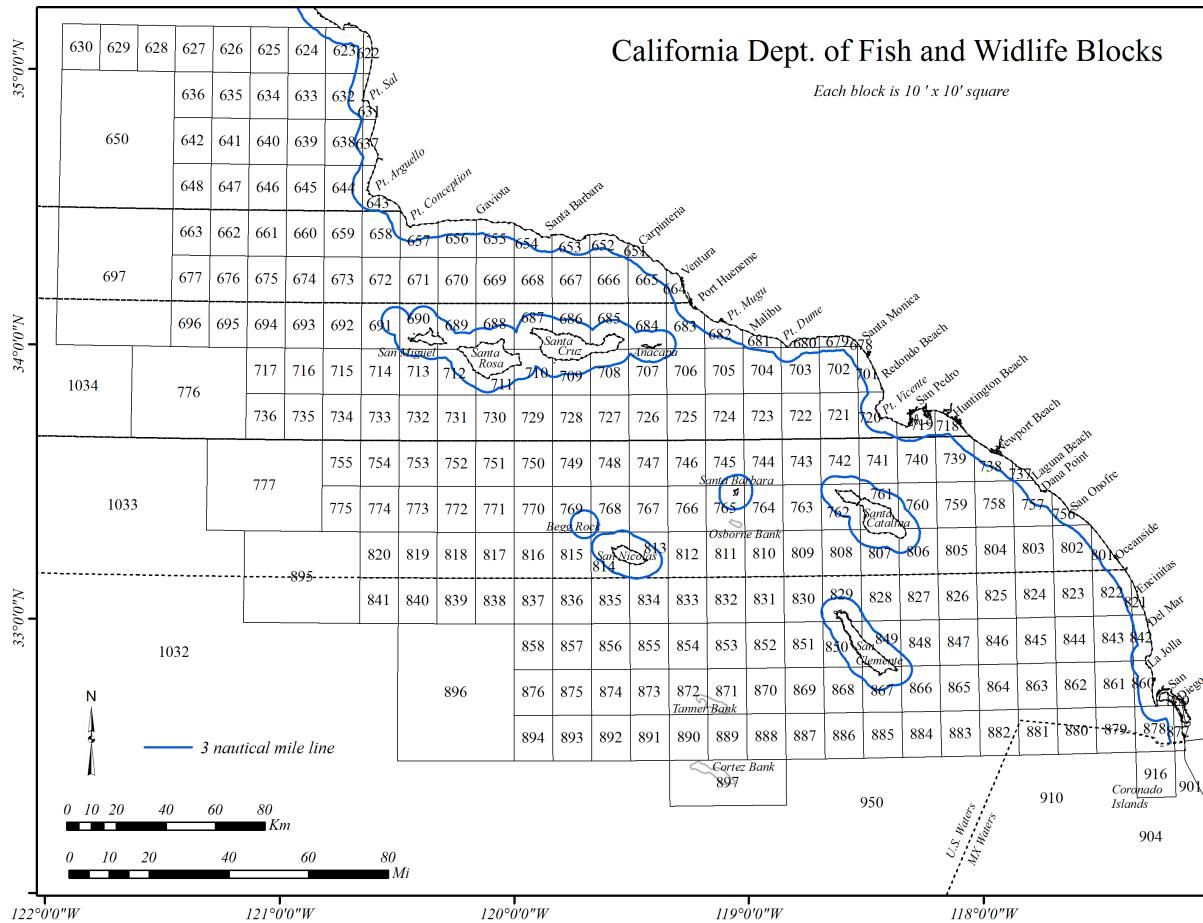


Figure 1: Map showing the state boundary lines for management of the recreational fishing fleets

Year	JAN-FEB	MAR-APR	MAY-JUN	JUL-AUG	SEP-OCT	NOV-DEC
1994						
1995						
1996						
1997						
	LE = 80,000 lb/ month; OA = 40,000 lb/ month					
1998						
1999						
2000	CLOSED					
2001	CLOSED					
2002	CLOSED					
2003	800	CLOSED	800	800	CLOSED	CLOSED
2004	300	CLOSED	300	400	400	300
2005	300	CLOSED	300	400	400	300
2006	300	CLOSED	300	400	400	300
2007	600	CLOSED	600	800	800	600
2008	600	CLOSED	600	800	800	600
2009	600	CLOSED	600	1,200	1,200	1,200
2010	600	CLOSED	600	1,200	1,200	1,200
2011	600	CLOSED	1,200	1,200	1,200	1,200
2012	1,200	CLOSED	1,200	1,200	1,200	1,200
2013	1,200	CLOSED	1,200	1,200	1,200	1,200
2014	1,200	CLOSED	1,200	1,200	1,200	1,200
2015	1,200	CLOSED	1,200	1,200	1,200	1,200
2016	1,200	CLOSED	1,200	1,200	1,200	1,200
2017	1,500	CLOSED	1,500	1,500	1,500	1,500

Figure 2: Commercial fishery regulations pertaining to limited entry (LE) and open access (OA) fisheries in southern California. Blocks with a numeric value indicate the bi-monthly trip limit for both LE and OA fisheries.

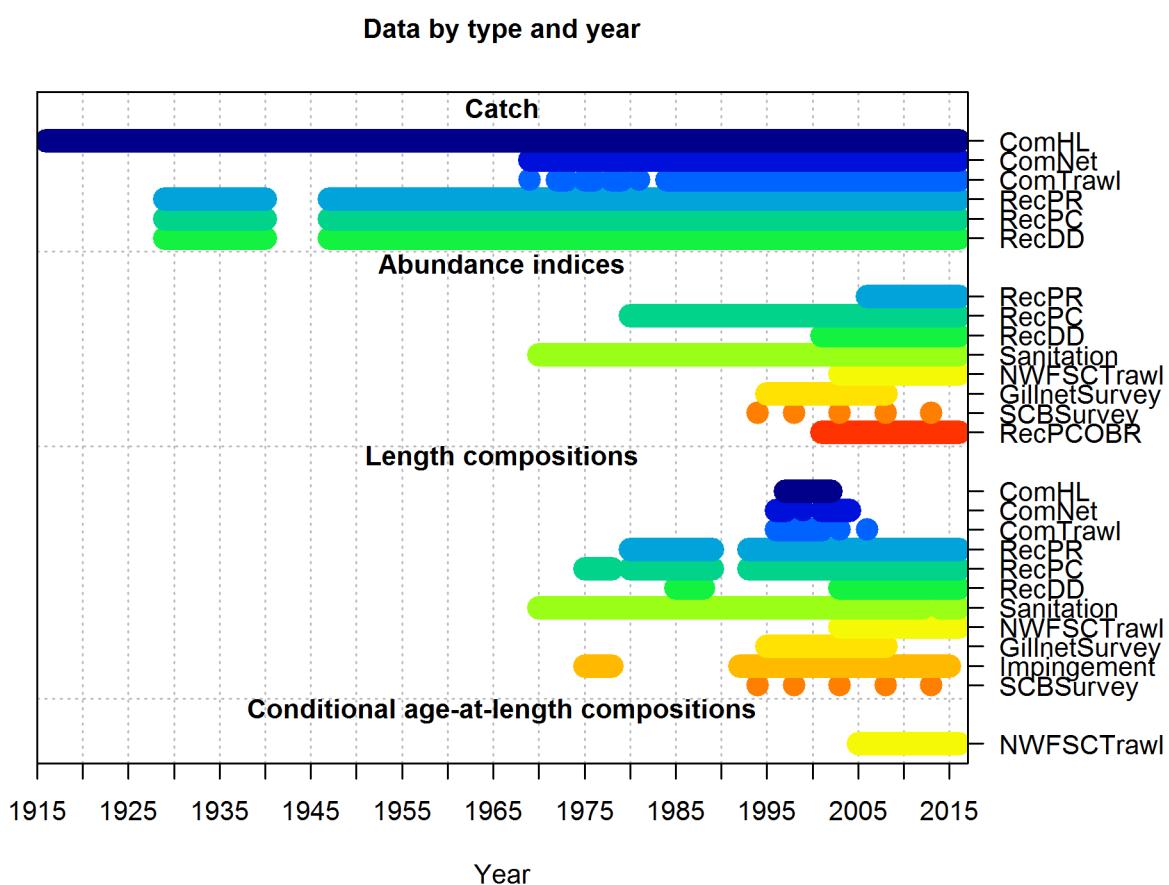


Figure 3: Summary of data sources used in the base model.

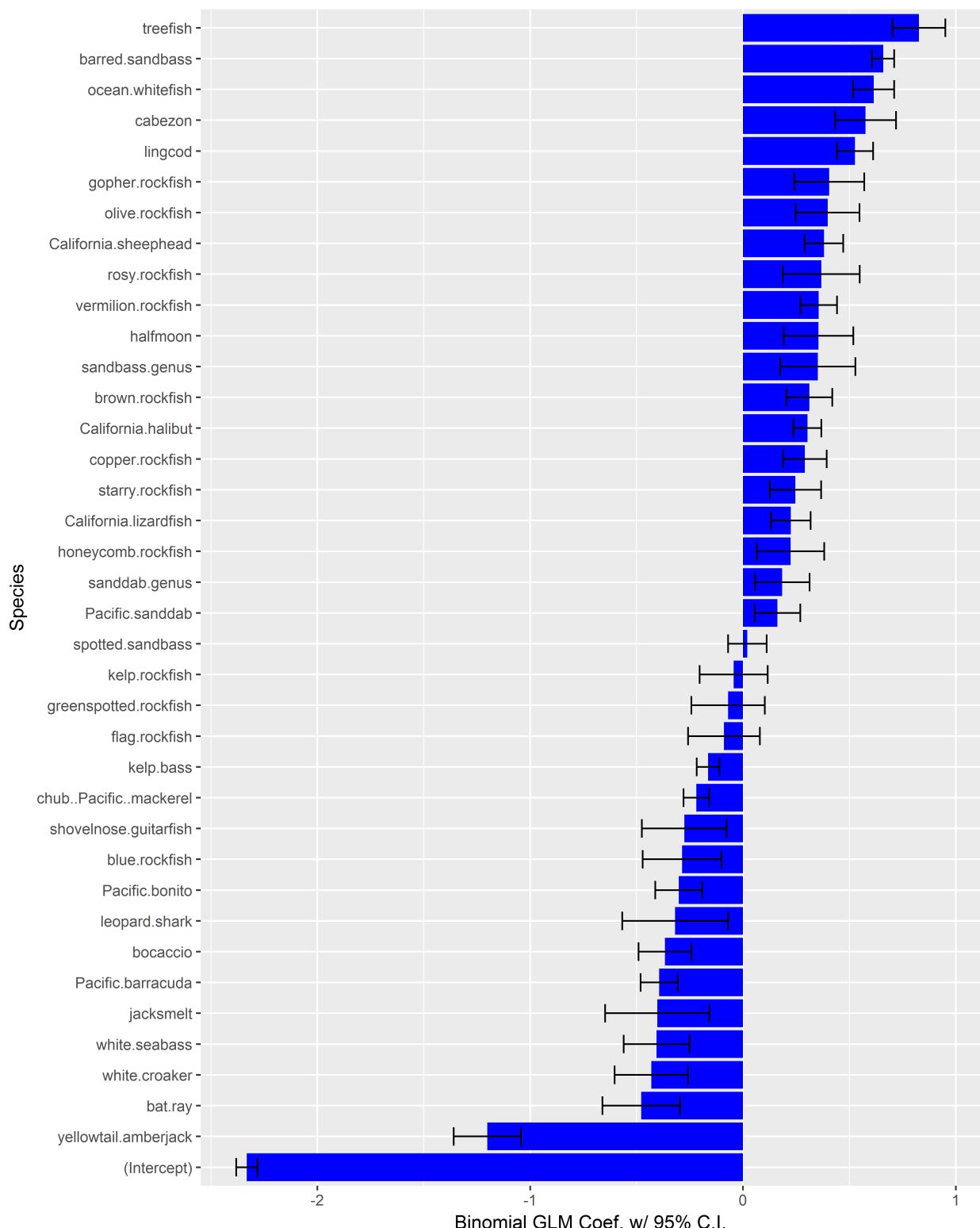


Figure 4: Species coefficients from the binomial GLM for presence/absence of California scorpionfish in the Marine Recreational Fisheries Statistics Survey (MRFSS) private mode dockside survey data set. Horizontal bars are 95% confidence intervals.

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
1999	open	open	open	open	open	open						
2000	open	open	open	open	open	open						
2001	20	20	open	open	open	open	open	open	open	open	20	20
2002			open	open	open	open	20	20	20	20		
2003	20	20					20	20	30	30	30	
2004			60	60							60	60
2005										30	60	60
2006			60	60	60	60	60	60	60	60	60	60
2007	40	40	60	60	60	60	60	60	60	60	60	60
2008	40	40	60	60	60	60	60	60	60	60	60	60
2009	40	40	60	60	60	60	60	60	60	60	60	60
2010	40	40	60	60	60	60	60	60	60	60	60	60
2011	60	60	60	60	60	60	60	60	60	60	60	60
2012	60	60	60	60	60	60	60	60	60	60	50	50
2013	50	50	50	50	50	50	50	50	50	50	50	50
2014	50	50	50	50	50	50	50	50	50	50	50*	
2015	60	60	60	60	60	60	60	60				
2016	60	60	60	60	60	60	60	60				

Figure 5: A summary of the monthly recreational regulations for California scorpionfish in southern California. Cells with “open” indicate no depth restriction, black cells indicate the fishery is closed, and cells with a number indicate the depth restriction in fathoms, e.g., 20 = retained catch allowed in less than 20 fathoms. *Fishery closed on November 15, 2014.

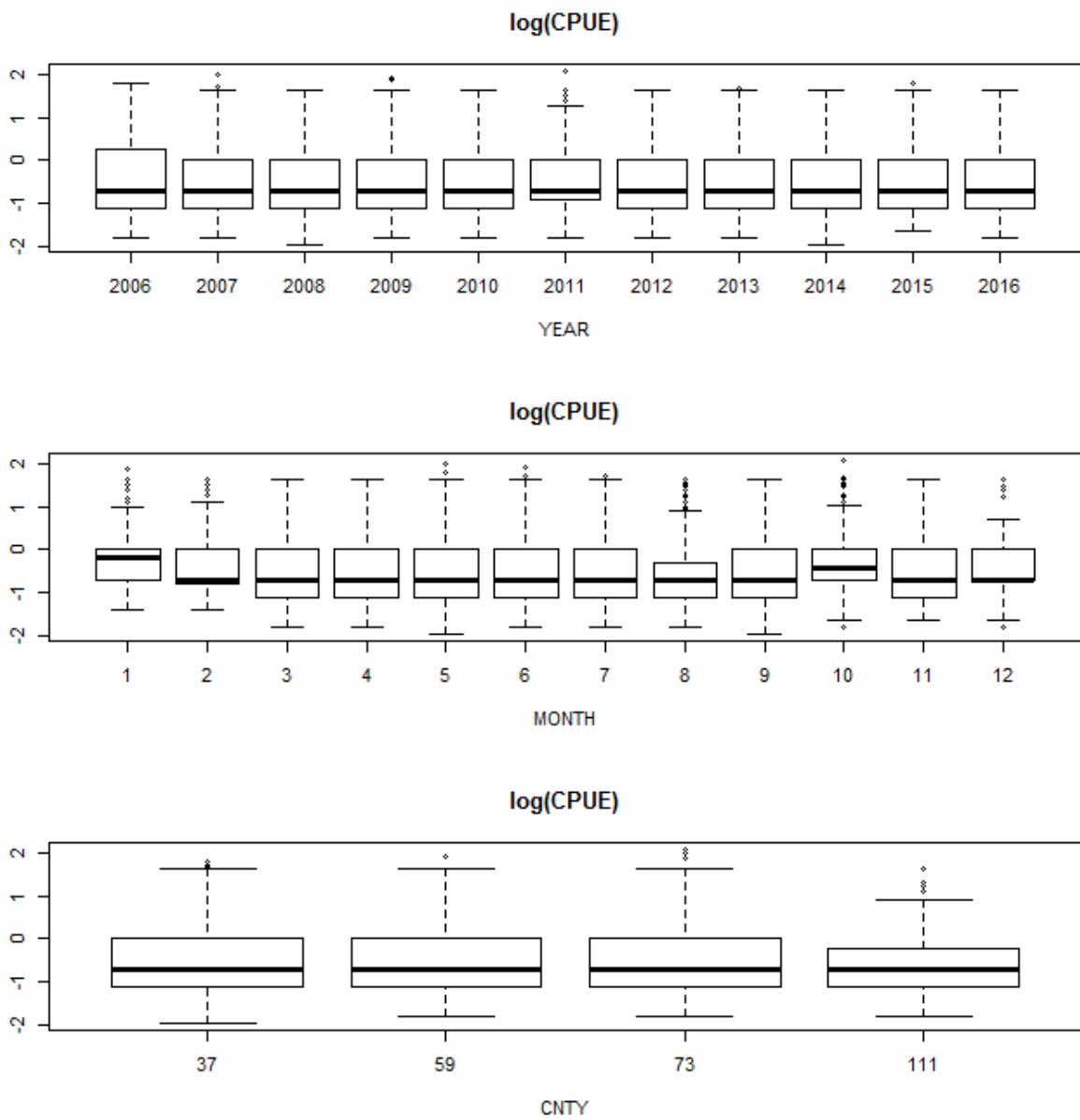


Figure 6: Boxplots of the raw log CPUE by year for each of the three factors considered in the deltaGLM model, county, month and year.

Normal Q-Q Plot

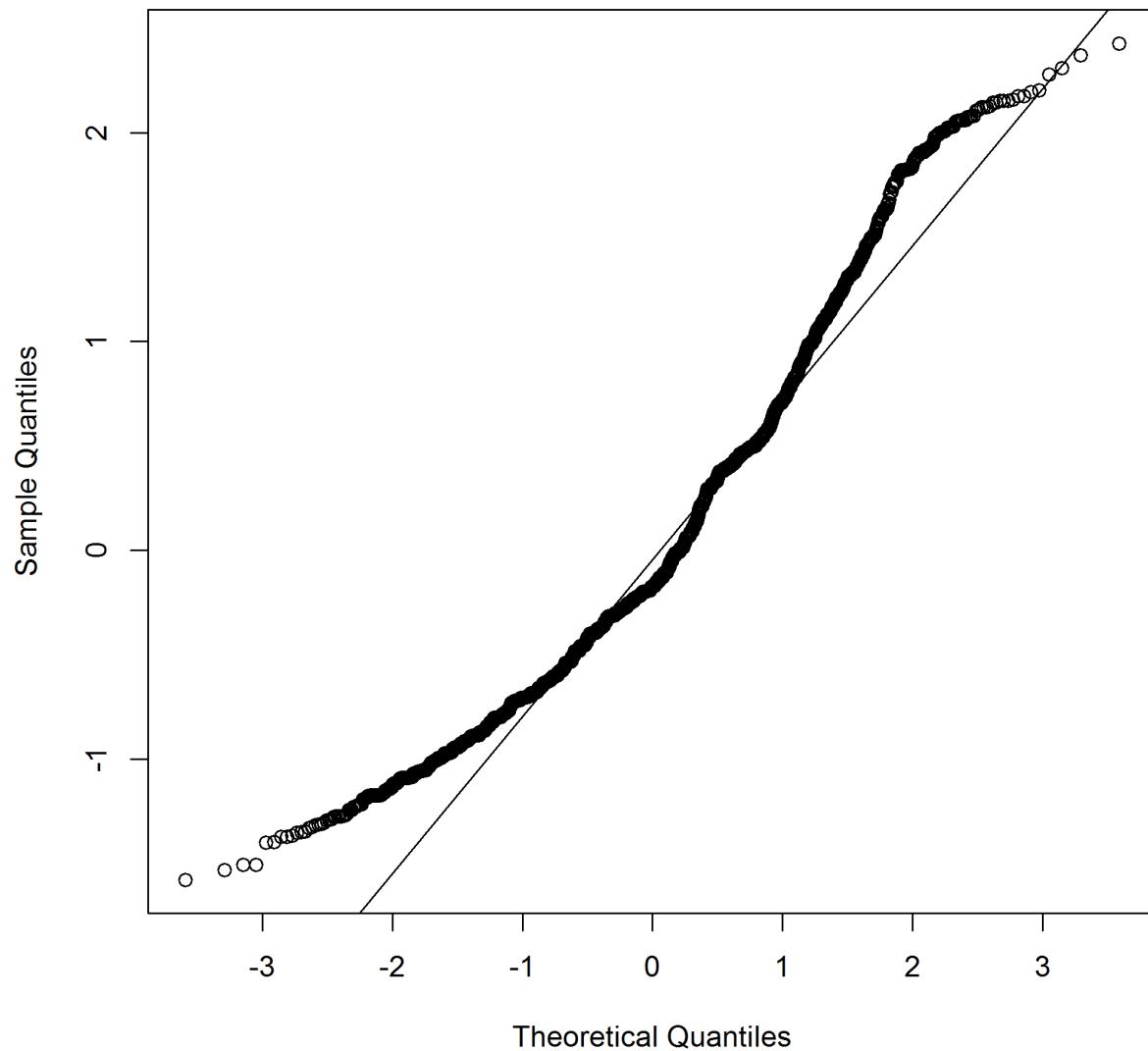


Figure 7: Q-Q plot used to evaluate the fit of the lognmoral (positive encounters) of California scorpionfish from the Marine Recreational Fisheries Statistics Survey (MRFSS) private mode dockside survey data set.

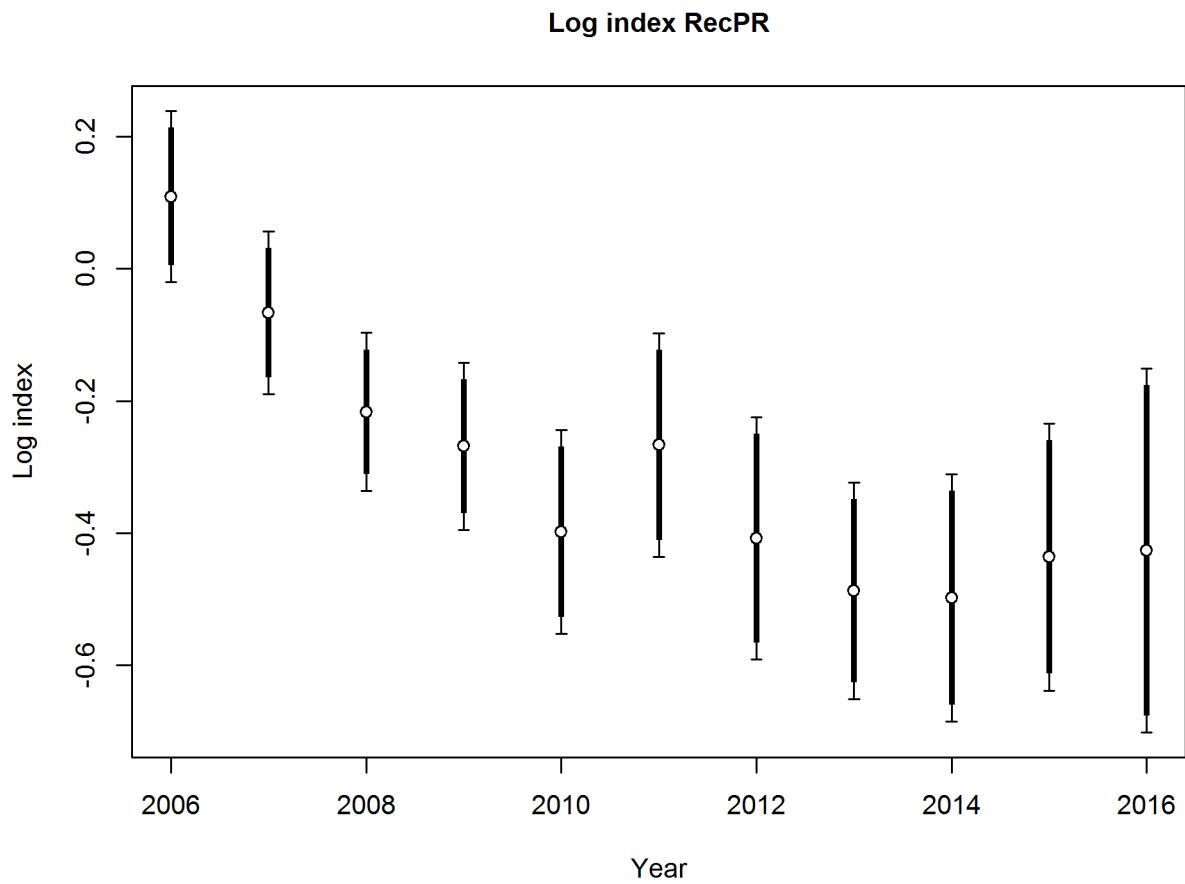


Figure 8: Standardized index on log scale for the recreational CPFV logbook retained catches. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

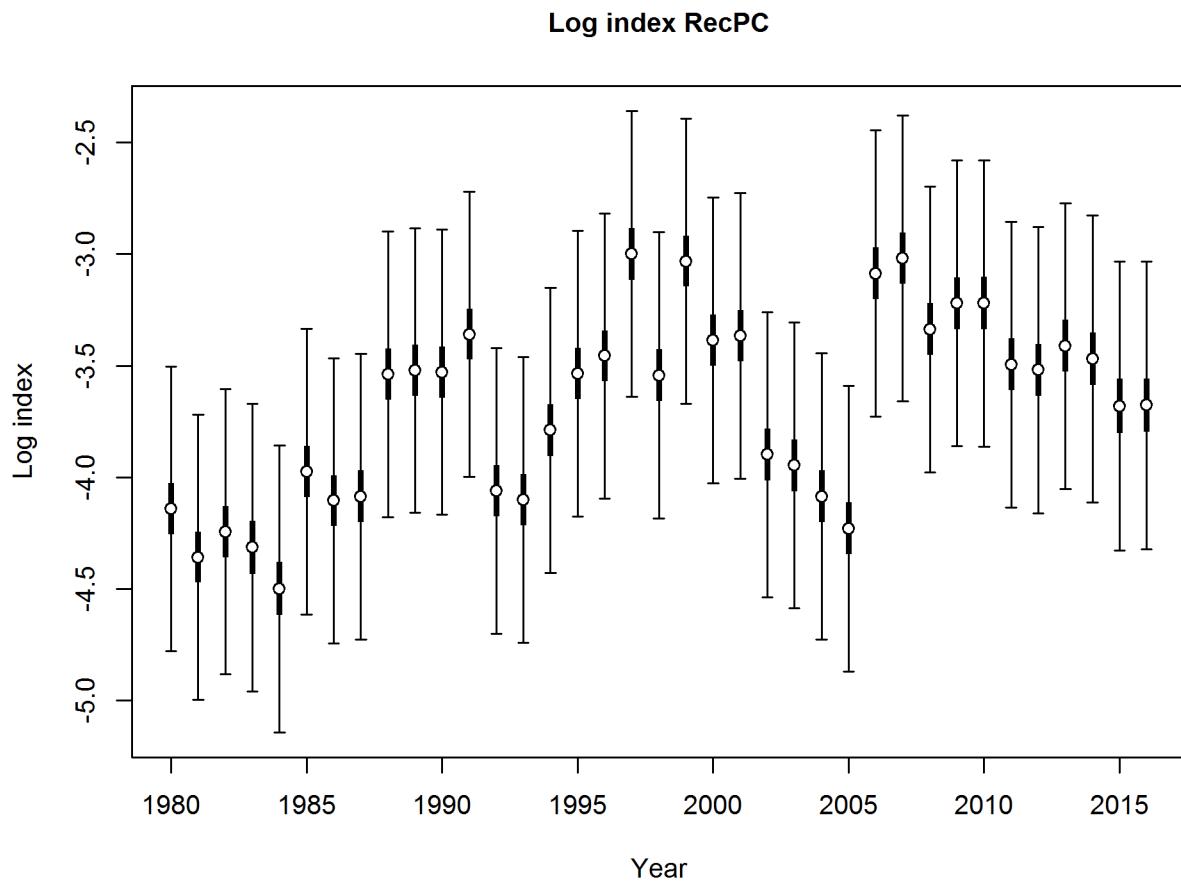


Figure 9: Standardized index on the log scale for the recreational CPFV logbook retained catches. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

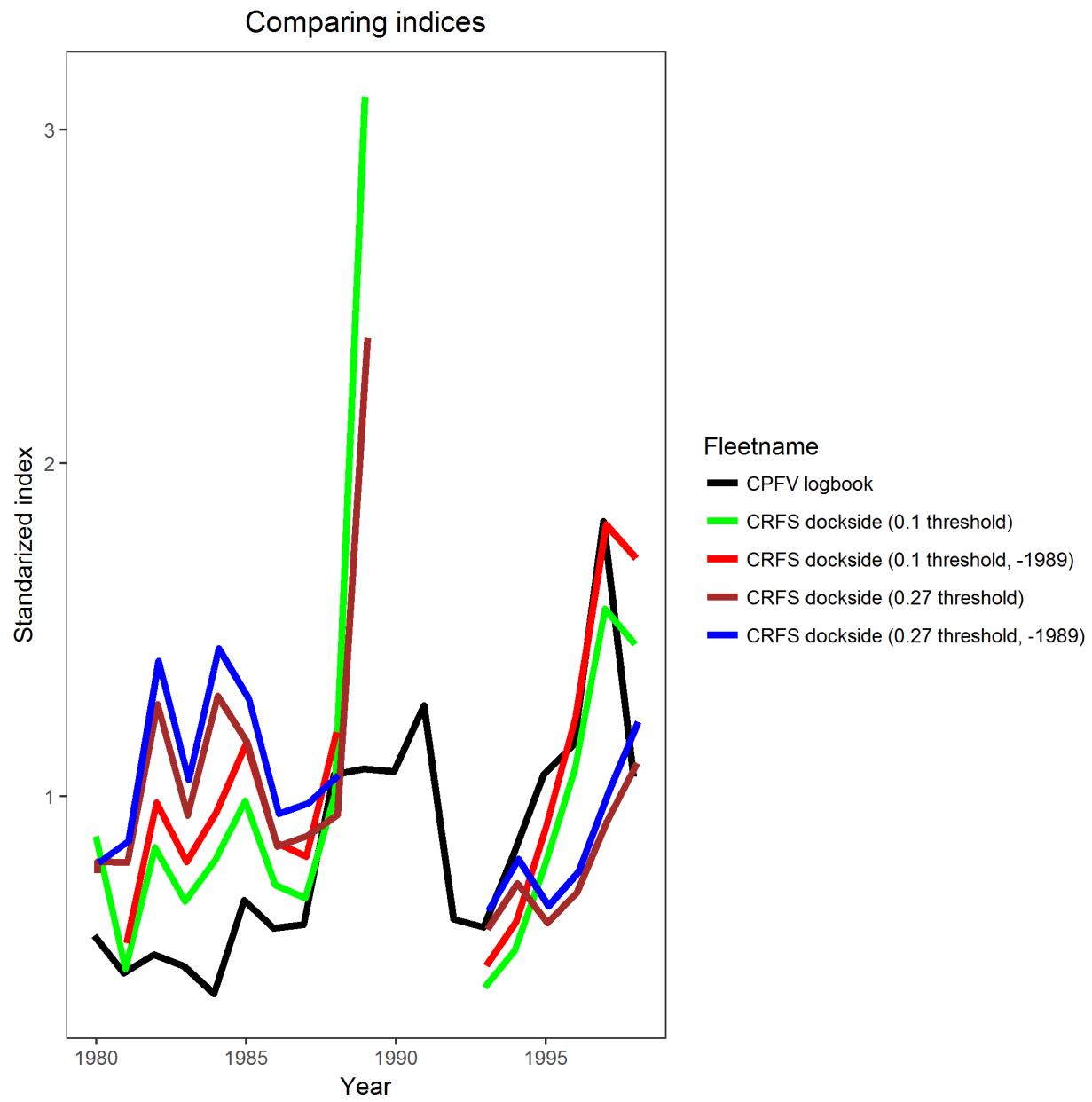


Figure 10: Comparison of standardized indices using two different threshold levels (0.27 and 0.1) from the Stephens-MacCall filtering, and including or excluding the year 1989.

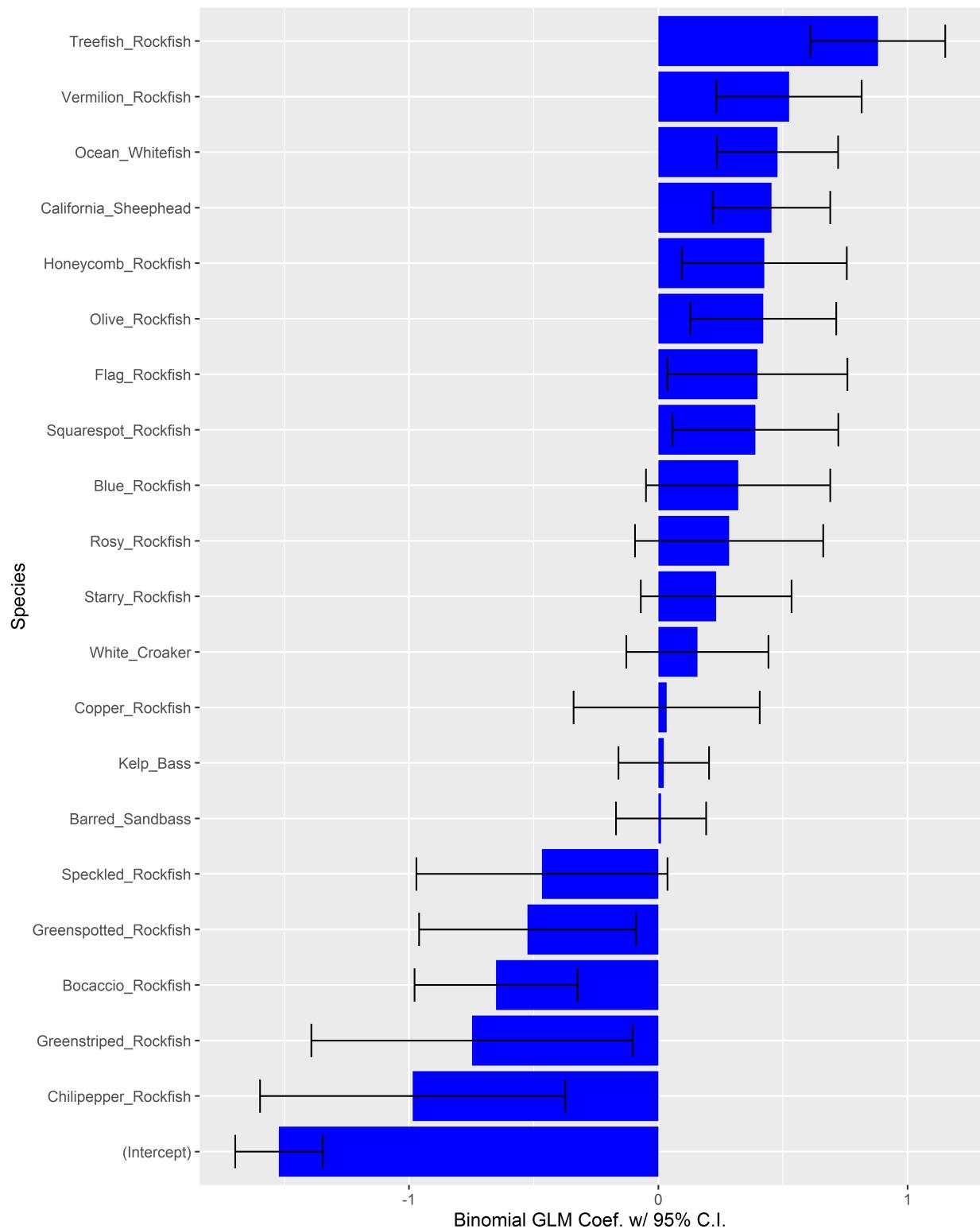


Figure 11: Species coefficients from the binomial GLM for presence/absence of California scorpionfish in the Marine Recreational Fisheries Statistics Survey (MRFSS) party/charter mode dockside survey data set. Horizontal bars are 95% confidence intervals.

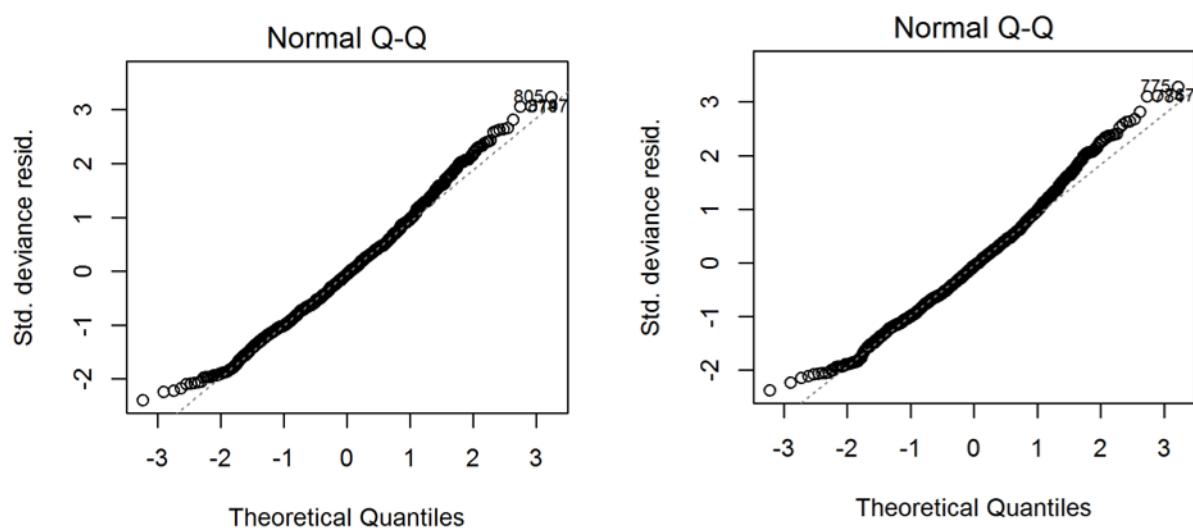


Figure 12: Q-Q plot used to validate the goodness of fit of the lognormal portion (positive catch) of the Marine Recreational Fisheries Statistics Survey (MRFSS) party/charter dockside survey, for thresholds of 0.27 (left) and 0.10 (right) from the Stephens-MacCall filter.

Normal Q-Q Plot

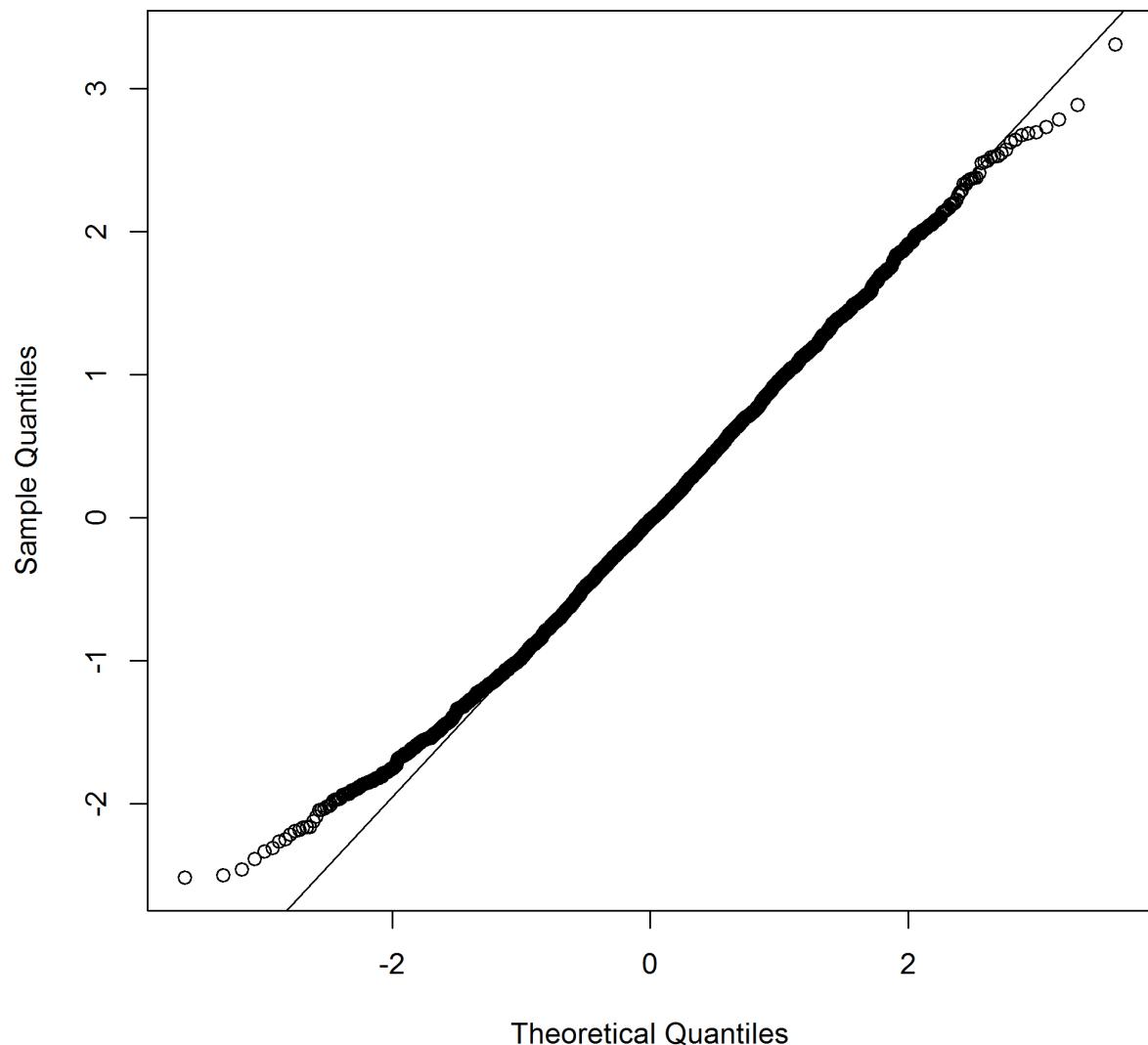


Figure 13: Q-Q plot used to validate the goodness of fit of the lognormal model for the CPFV onboard observer discarded only catch.

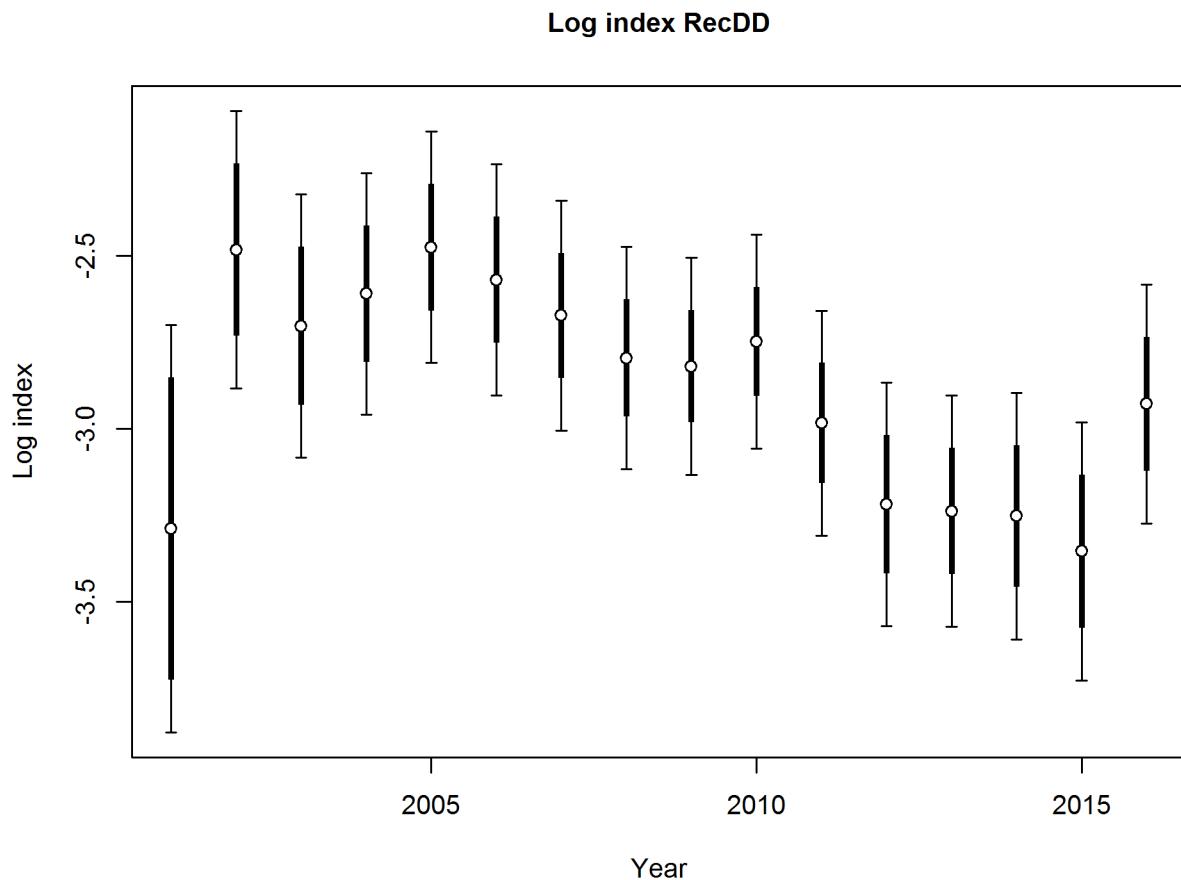


Figure 14: Standardized index on the log scale for the recreational CPFV onboard observer discarded catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

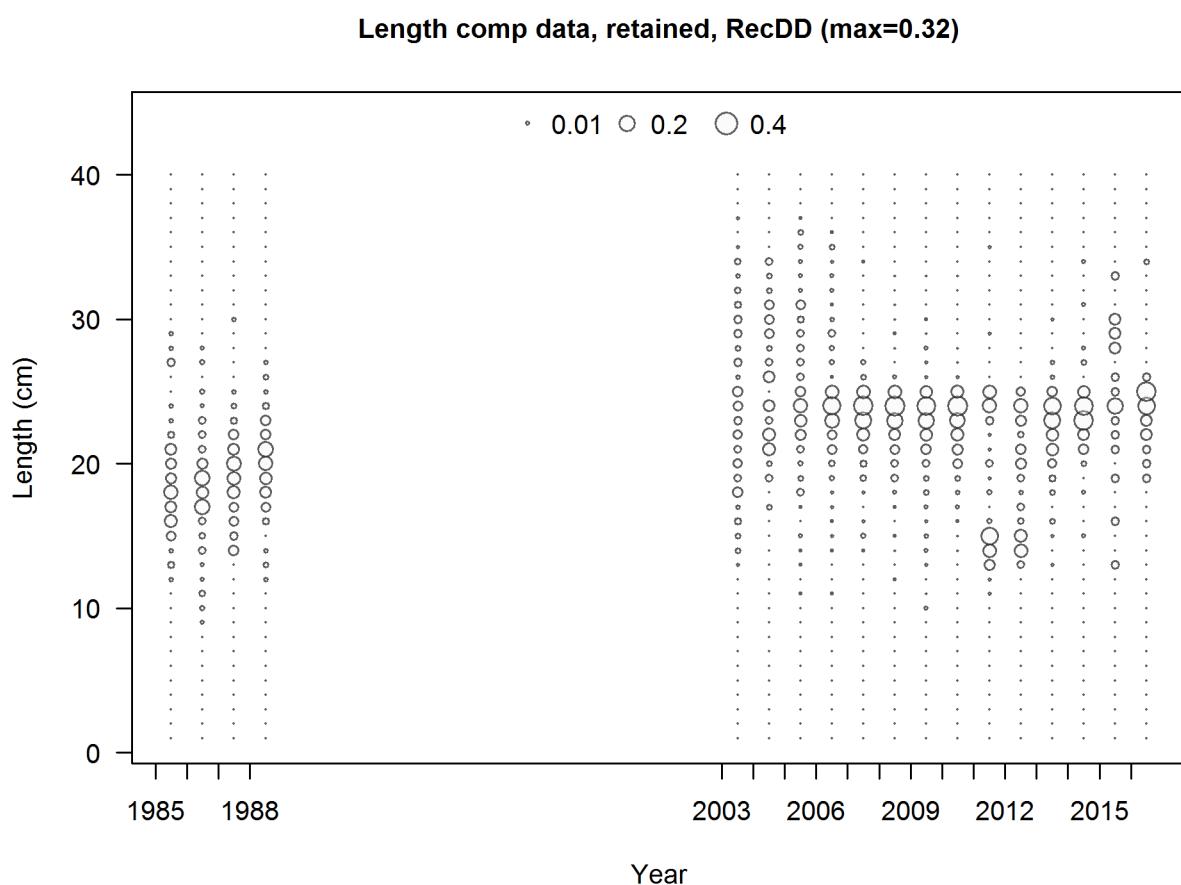


Figure 15: Length frequency distributions from the onboard observer discard-only catch.

Normal Q-Q Plot

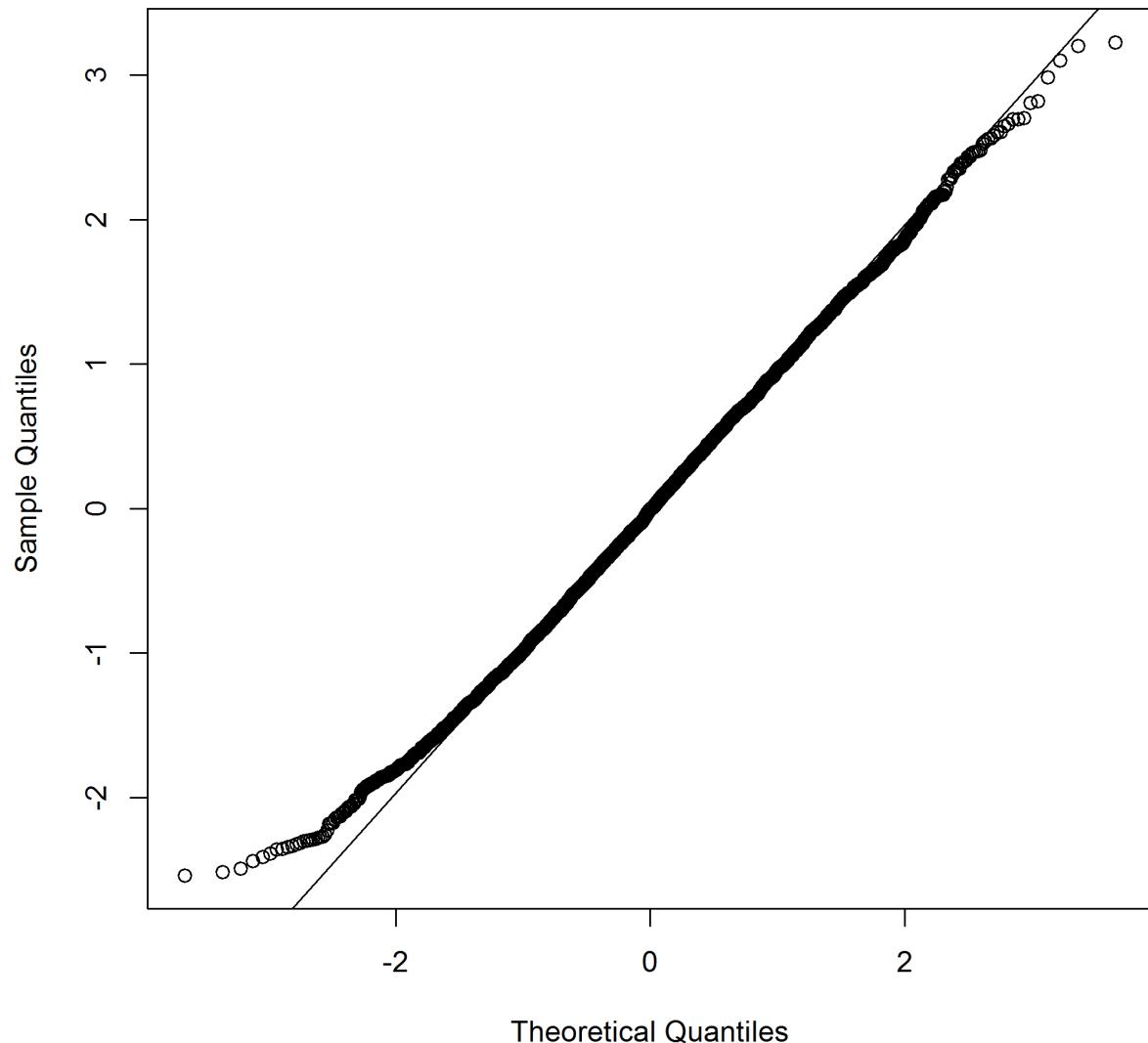


Figure 16: Q-Q plot used to validate the goodness of fit of the lognormal model for the CPFV onboard observer retained only catch.

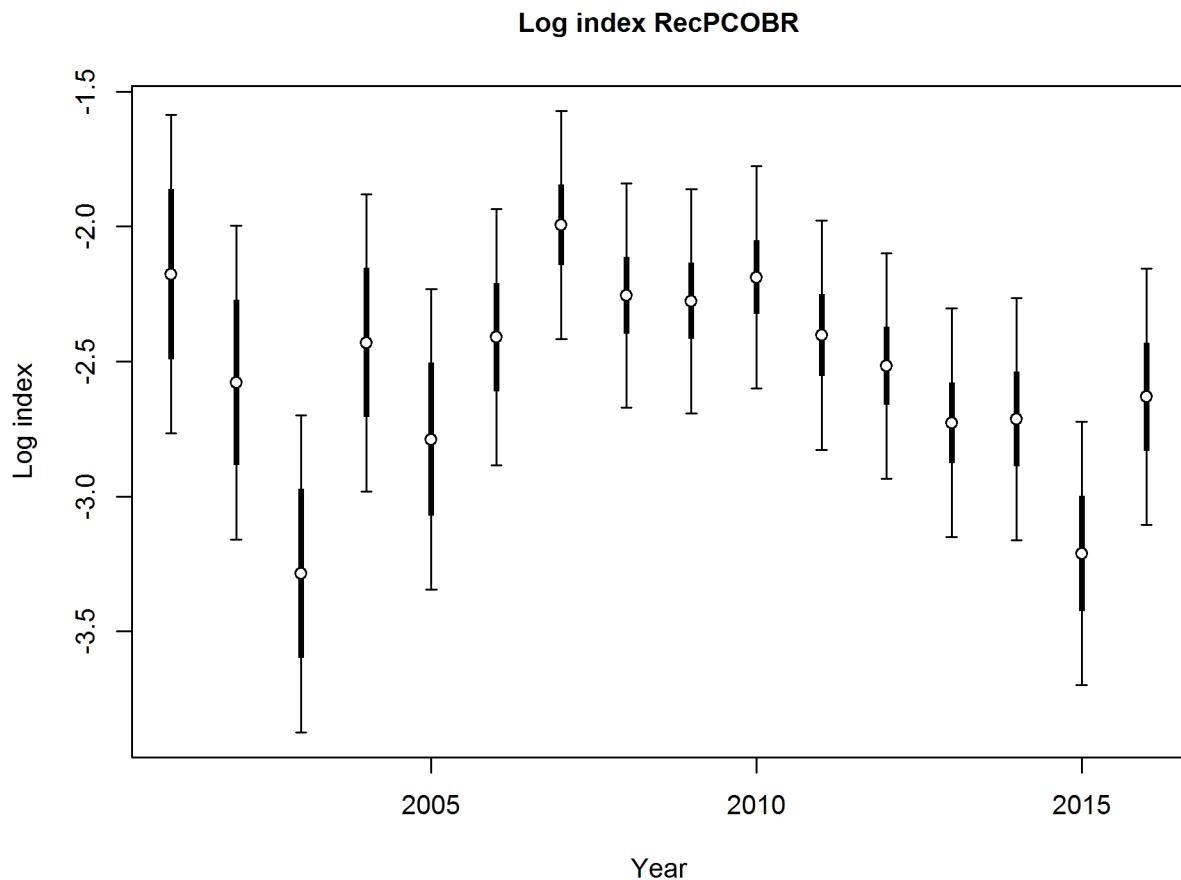


Figure 17: Standardized index on the log scale for the recreational CPFV onboard observer retained catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

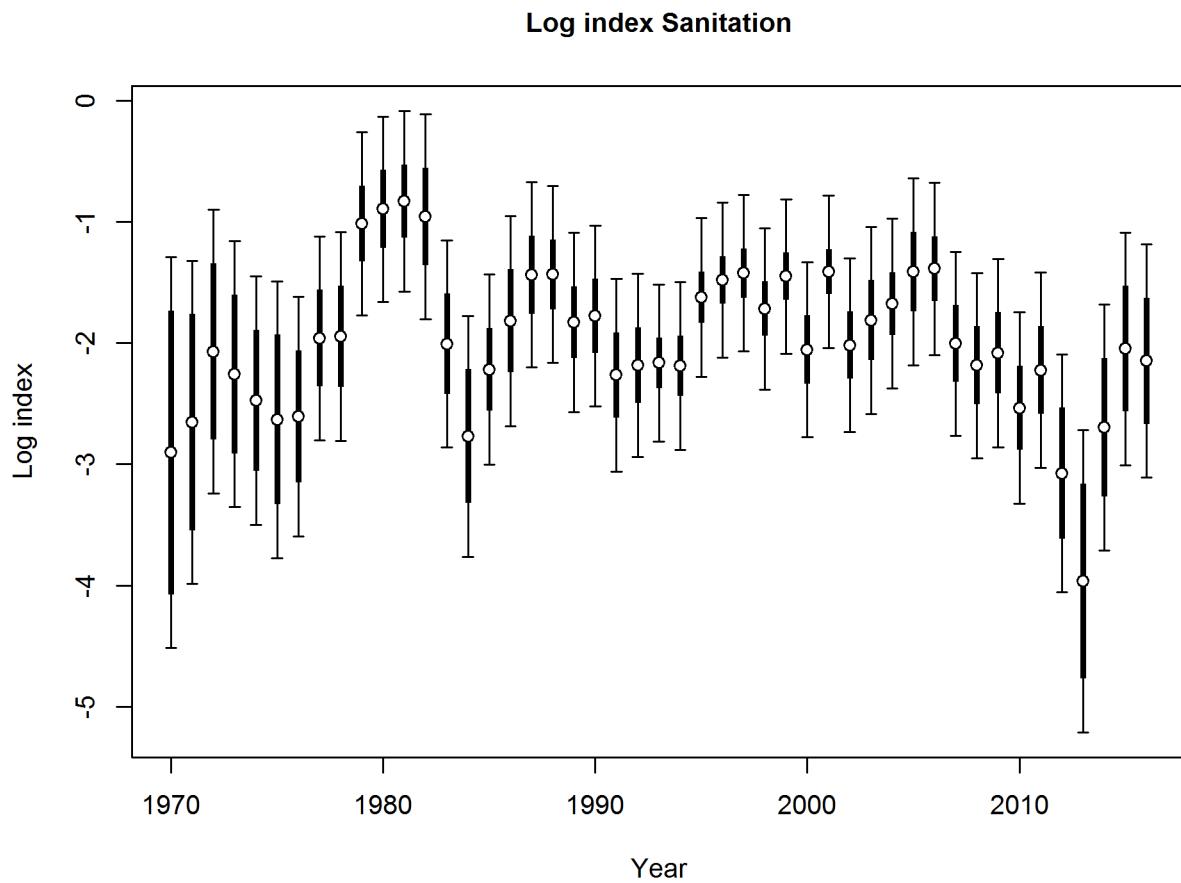


Figure 18: Standardized index on log scale for the sanitation district trawl index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

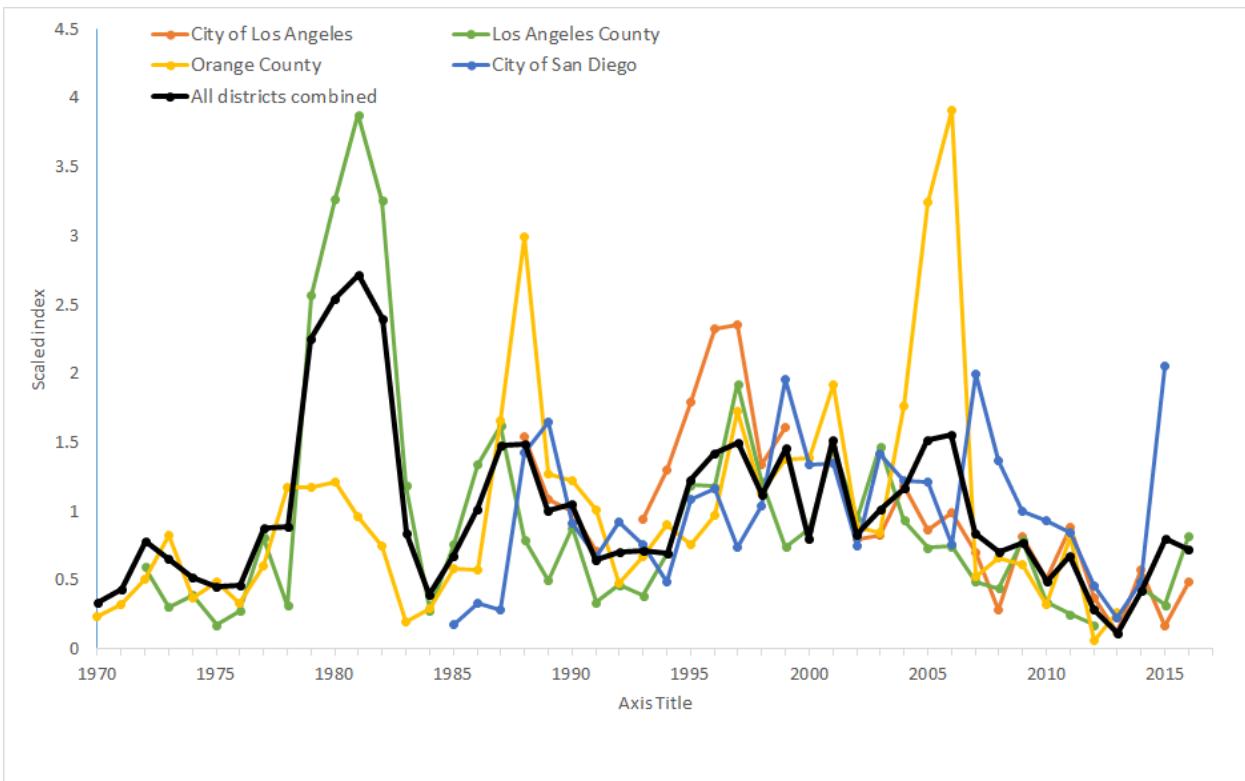


Figure 19: Comparison of standardized indices for each sanitation district independently and with data from all sanitation districts combined.

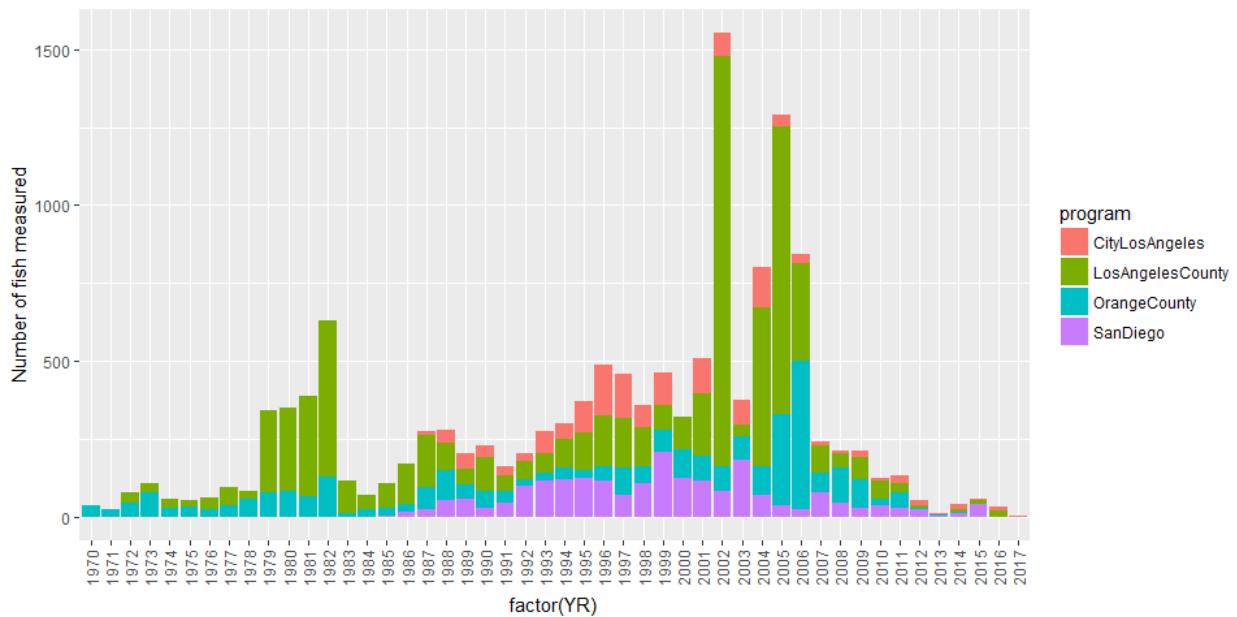


Figure 20: Sample sizes of measured California scorpionfish by sanitation district and year.

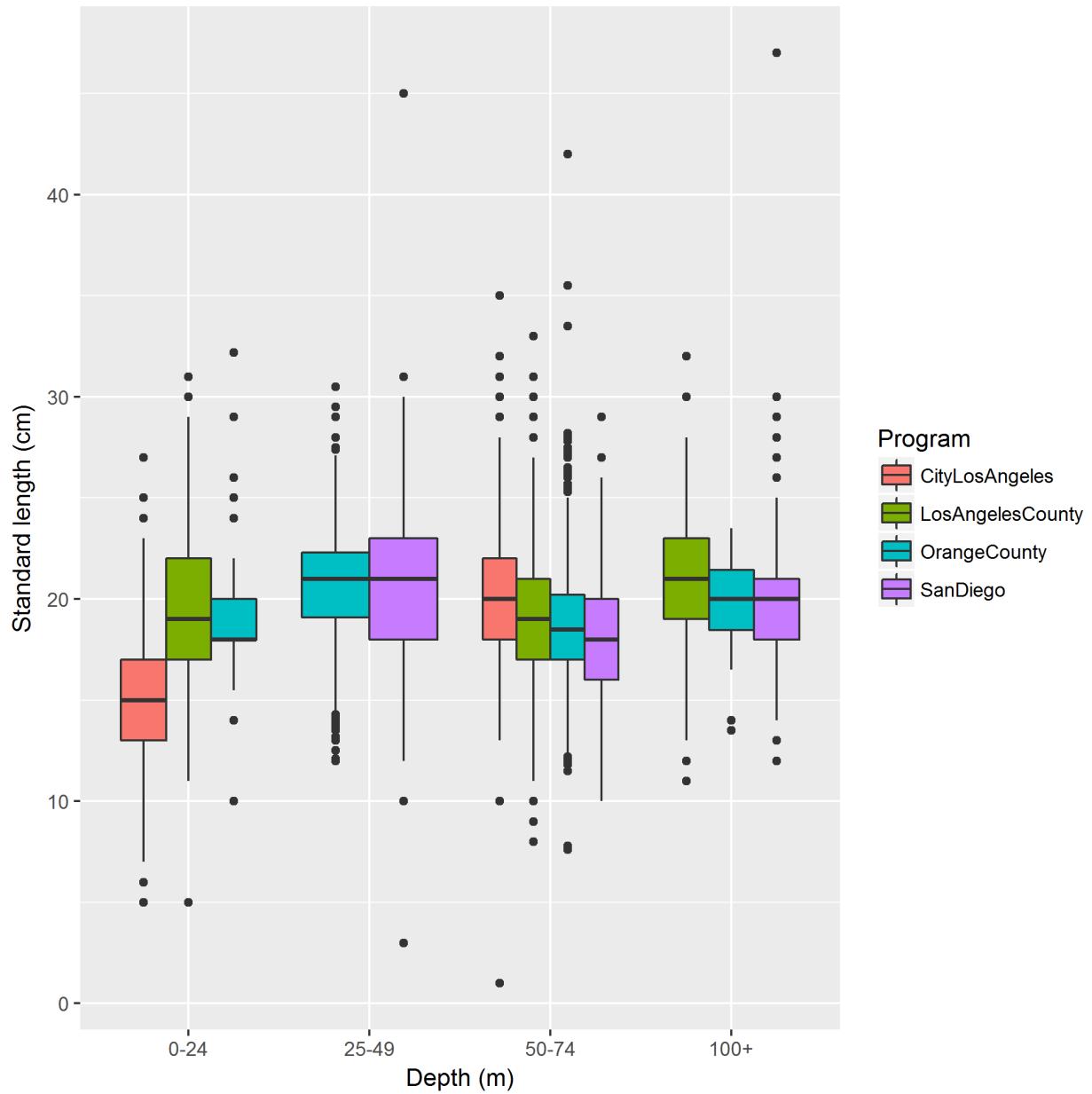


Figure 21: Boxplots of measured California scorpionfish from the sanitation district surveys by program and 25 m depth bins.

Length comp data, retained, Sanitation (max=0.78)

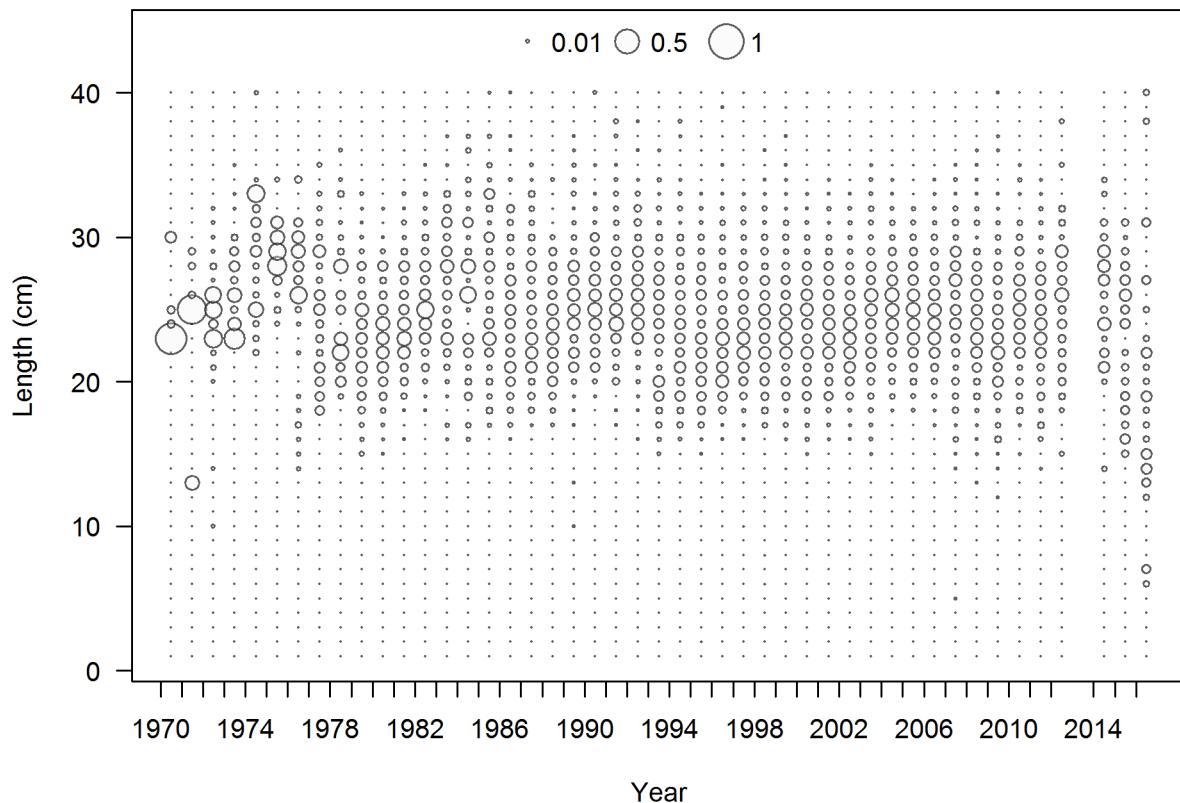


Figure 22: Length frequency distributions from the sanitation districts trawl surveys.

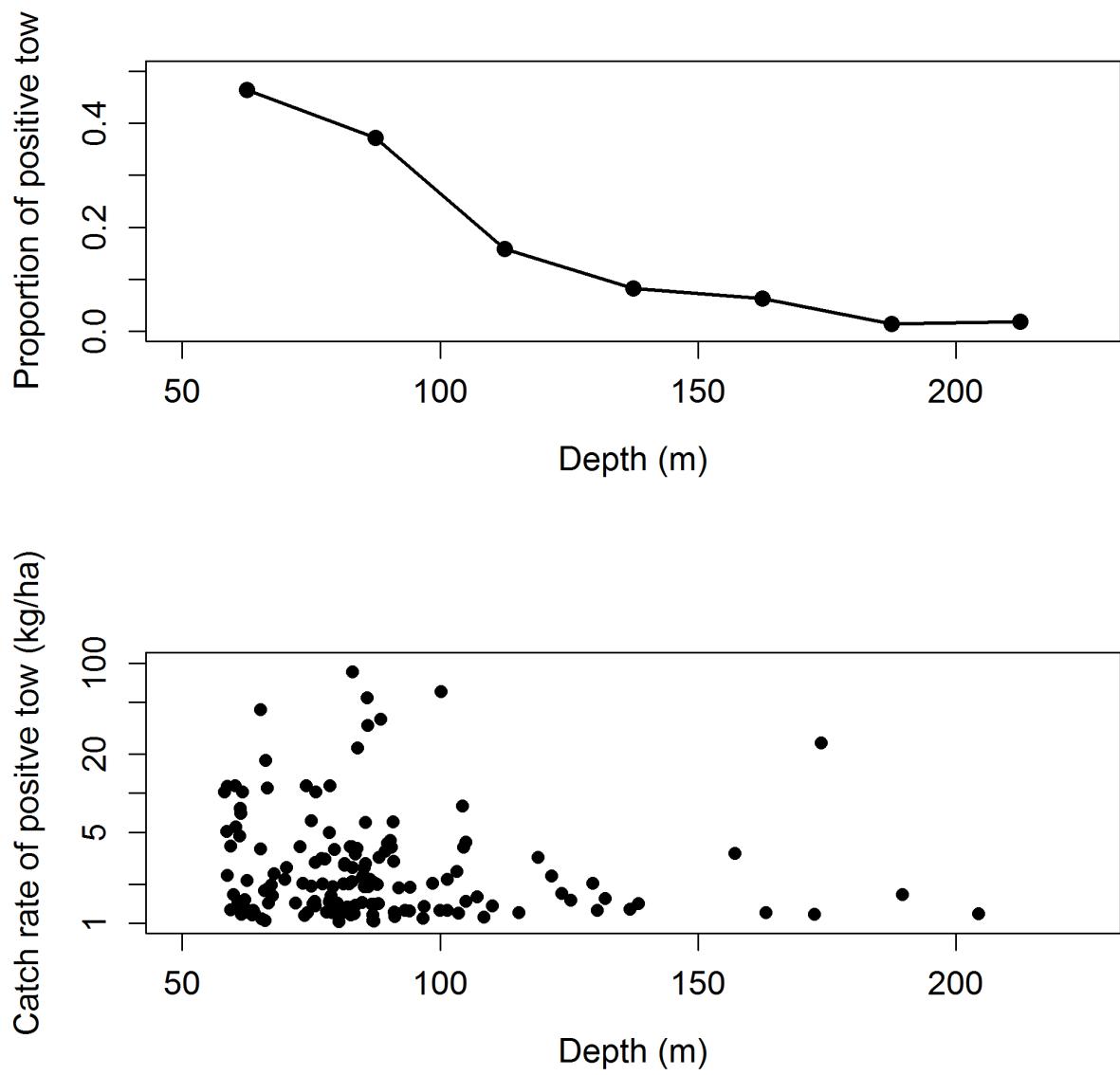


Figure 23: Plots of the proportion of positive tows (top panel) and the raw catch rates of positive tows (bottom panel) by depth zones (25 m interval) for NWFSC trawl survey.

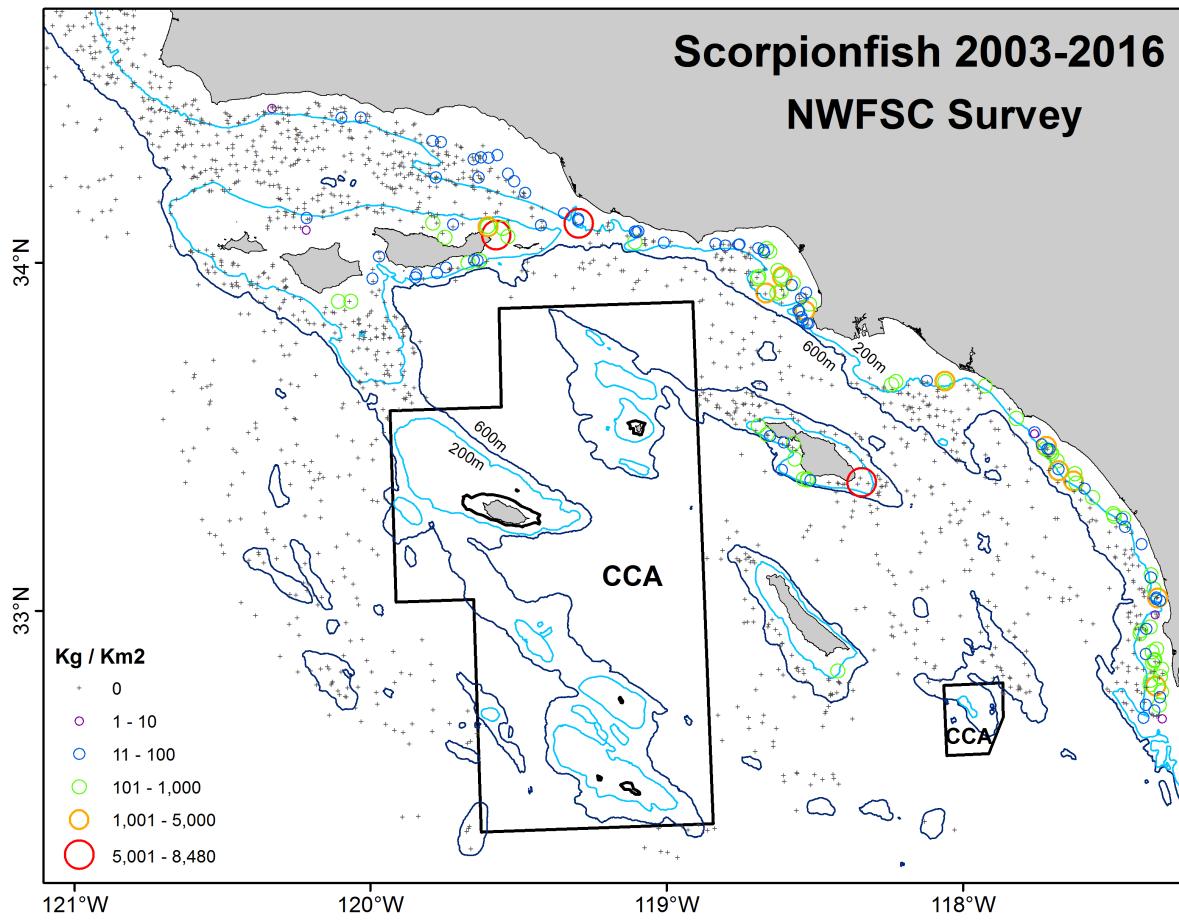


Figure 24: Spatial distribution of raw catch rates of Scorpionfish from NWFSC trawl survey between 2003 and 2016. Depth contour lines of 200m and 600m and the CCA areas are shown. Note that sizes and colors of circles represent catch rate in log scales (Credit of Rebecca Miller, SWFSC).

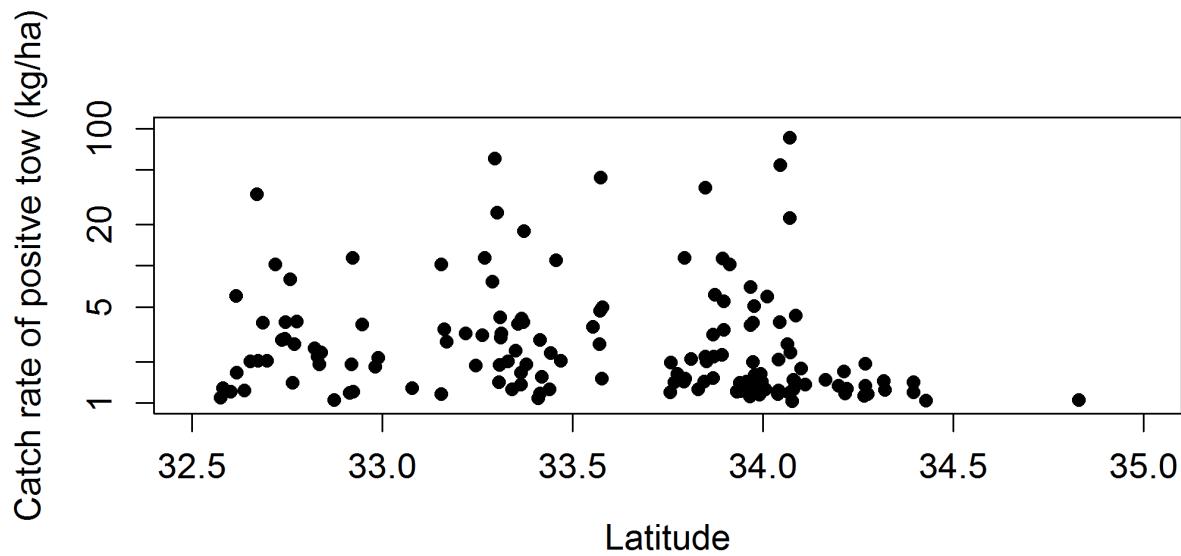
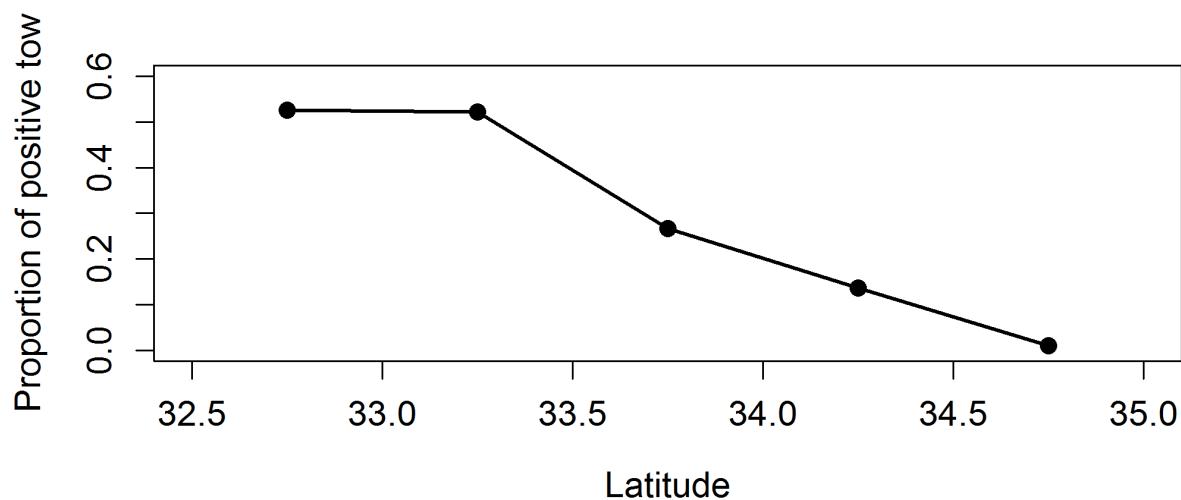


Figure 25: Plots of the proportion of positive tows (top panel) and the raw catch rates of positive tows (bottom panel) by latitude zones (0.5 degree interval) for NWFSC trawl survey.

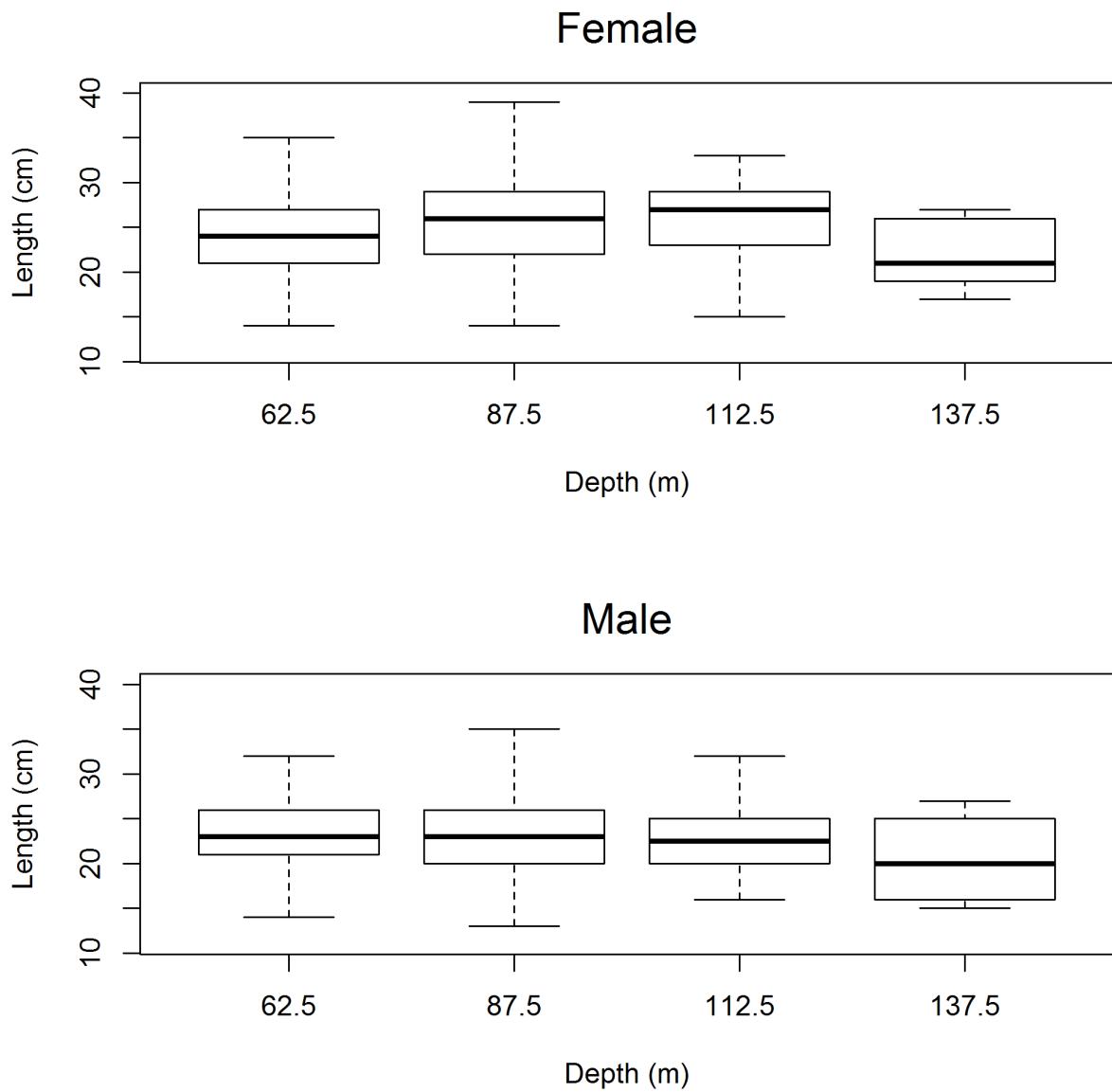


Figure 26: Comparison box plots of raw length data from NWFSC trawl survey by depth zone and sex.

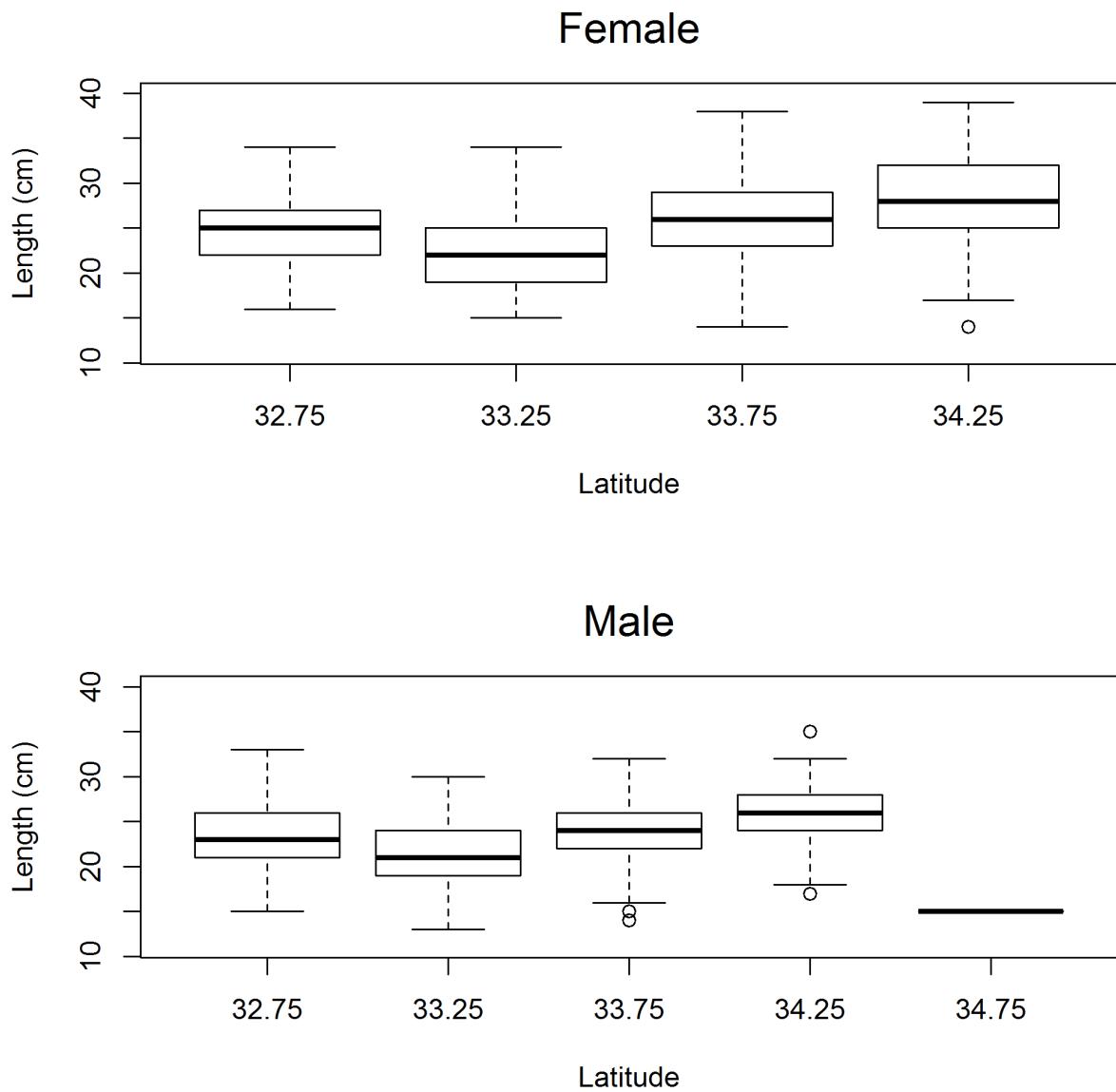


Figure 27: Comparison box plots of raw length data from NWFSC trawl survey by latitude zone and sex.

Length comp data, whole catch, NWFSC Trawl (max=0.21)

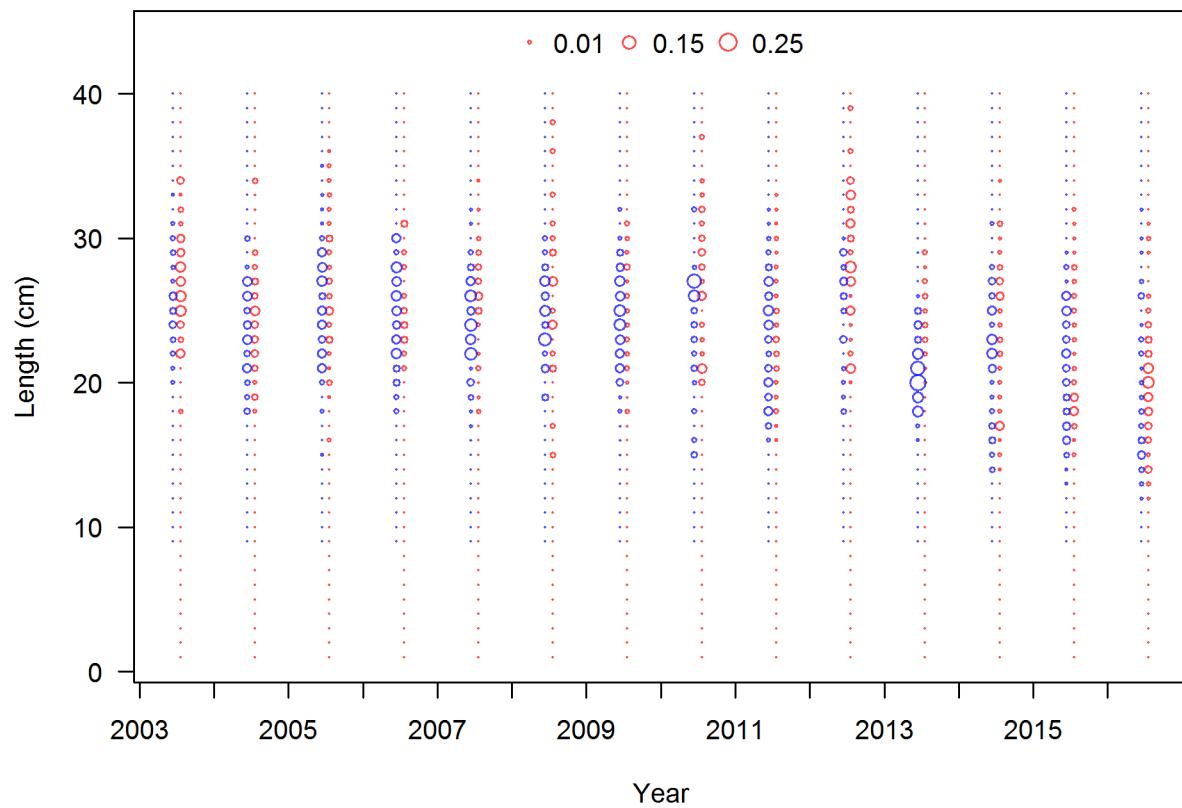


Figure 28: Length frequency distributions of females (red) and male (blue) from the NWFSC trawl survey between 2003 and 2016.

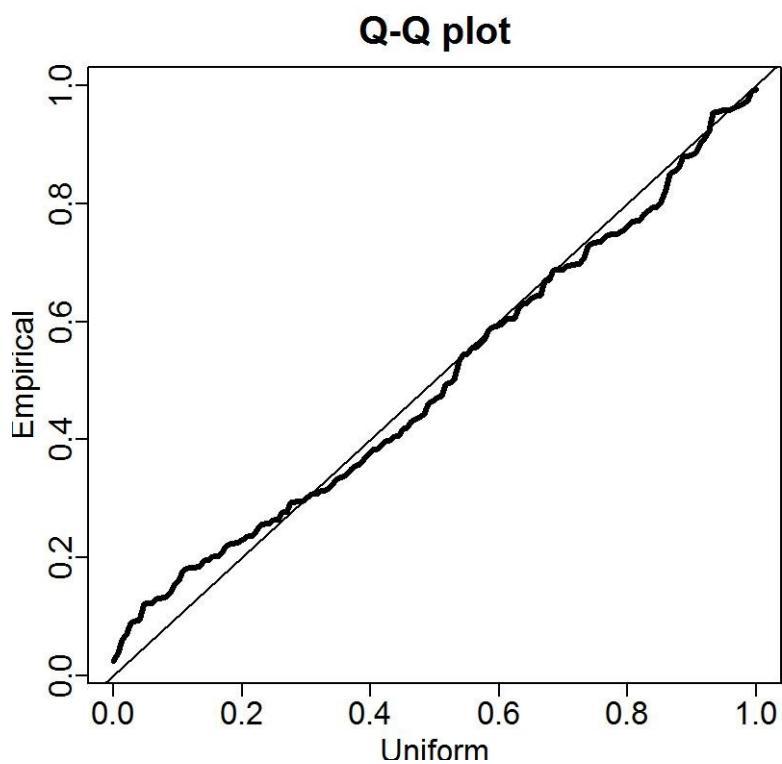


Figure 29: Q-Q plot used to validate the goodness of fit of the VAST analysis for the NWFSC trawl survey between 2003 and 2016.

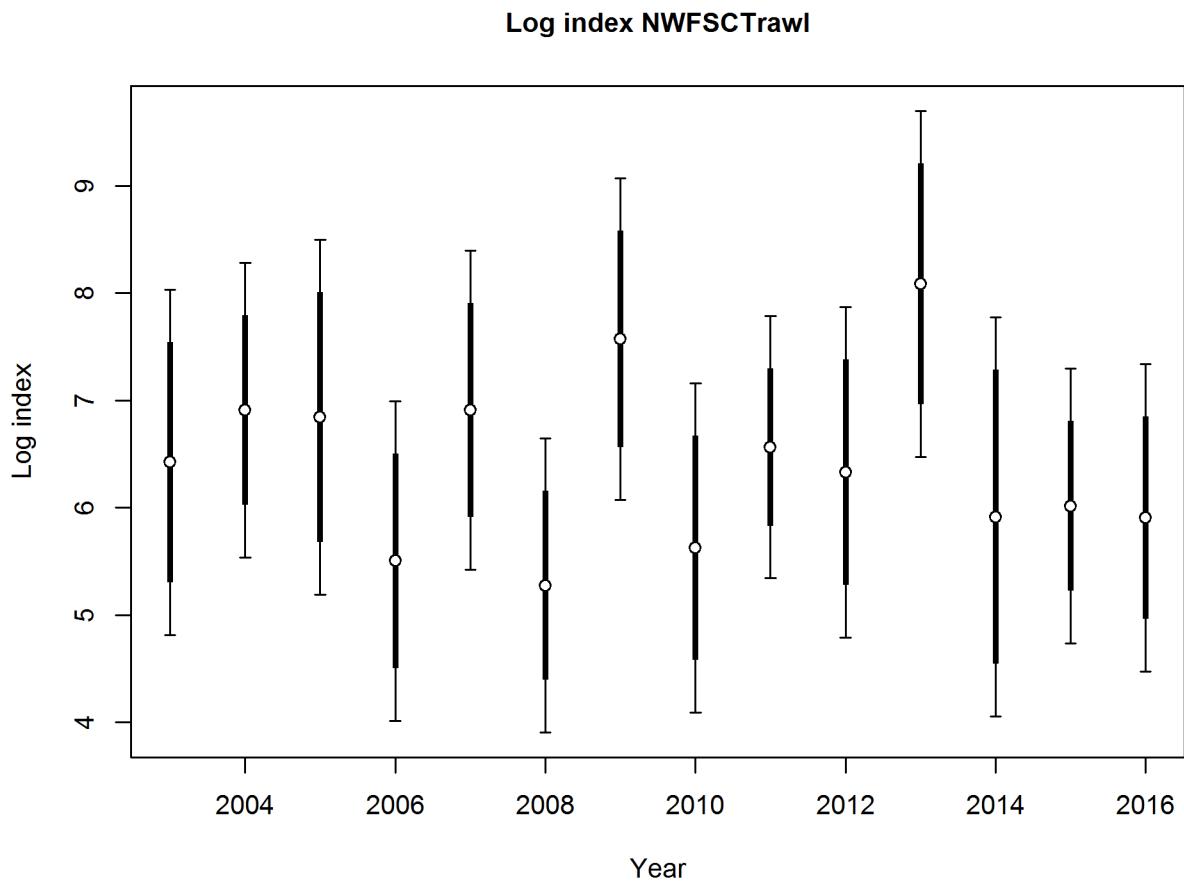


Figure 30: Standardized index on the log scale for the NWFSC trawl survey from the VAST analysis from 2003-2016. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

Normal Q-Q Plot

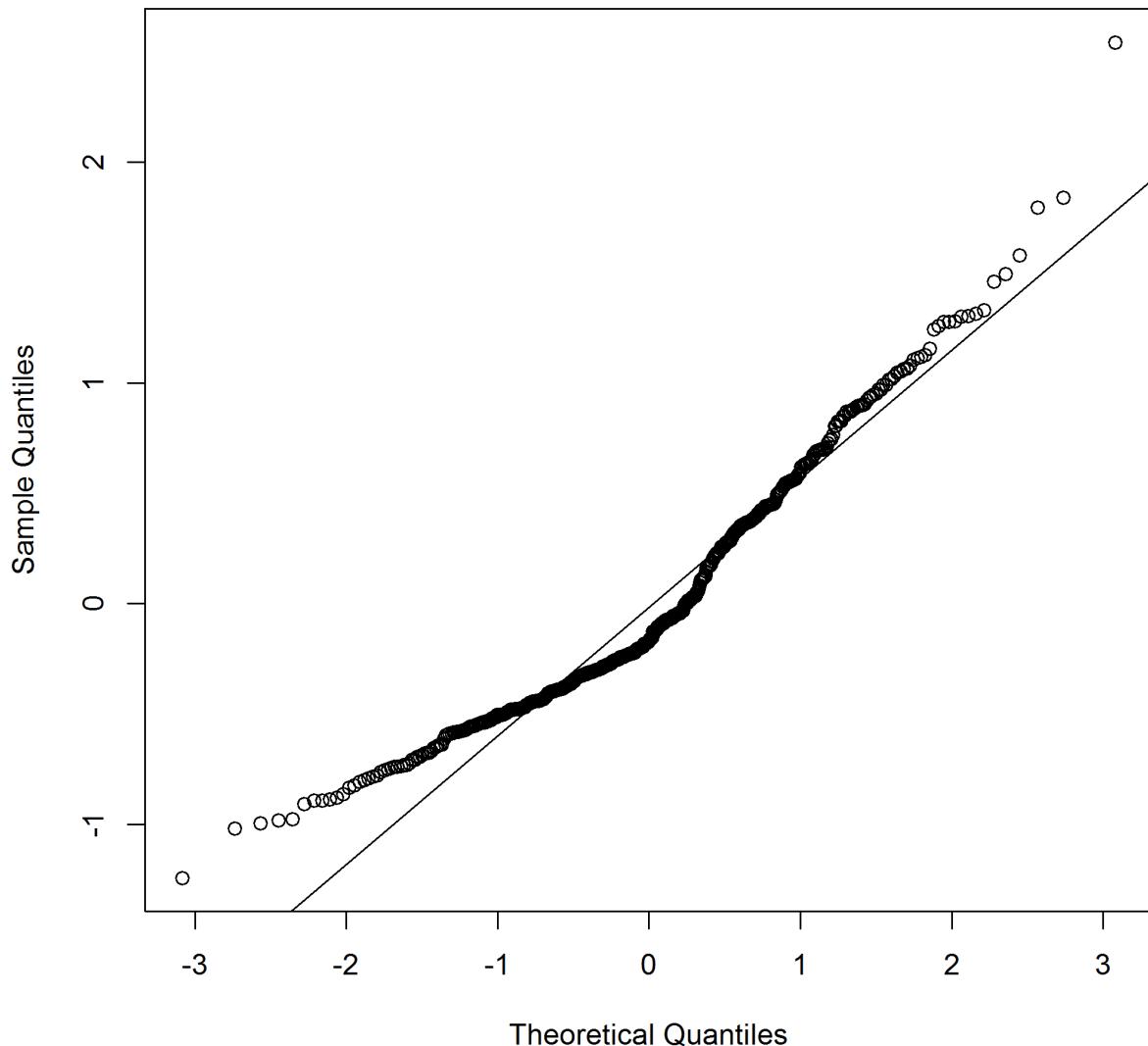


Figure 31: Q-Q plot used to validate the goodness of fit of the lognormal model for the CSUN/VRG gillnet survey from 1995-2008.

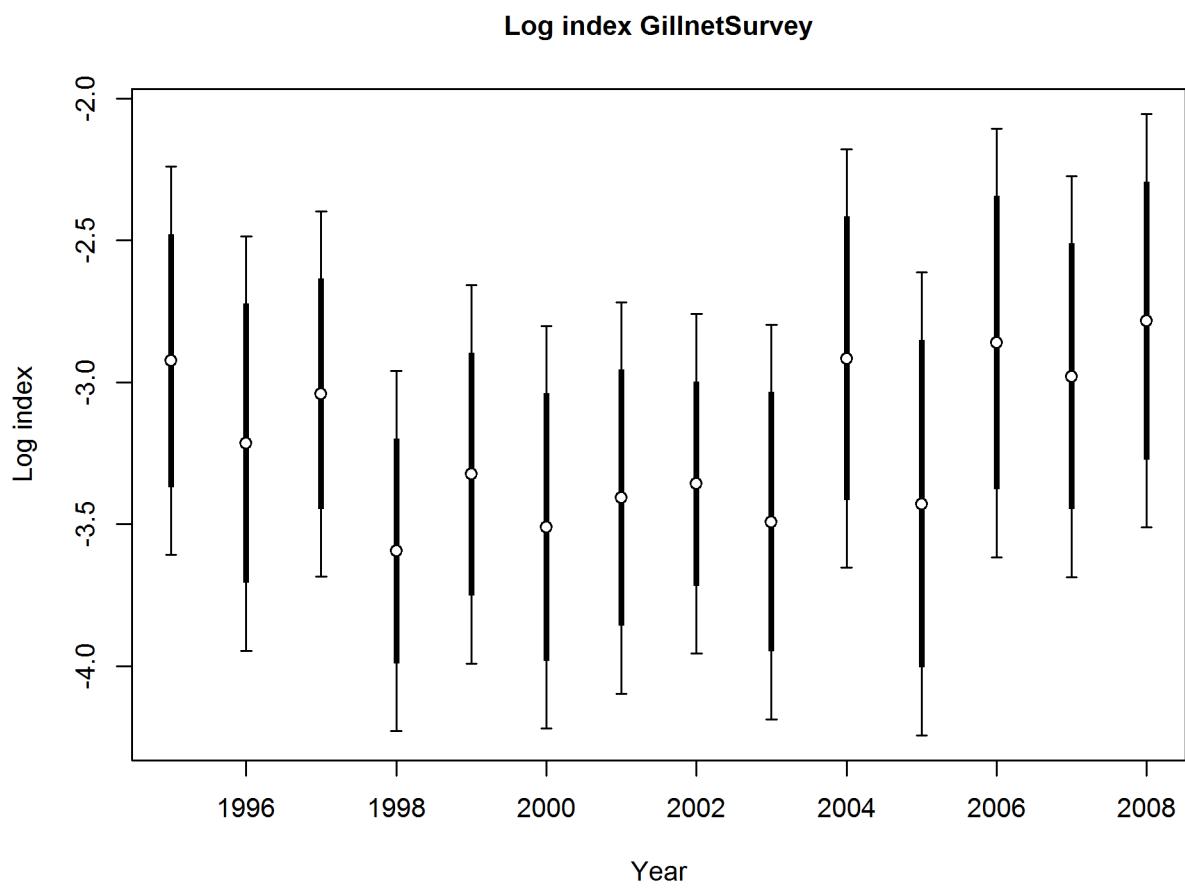


Figure 32: Standardized index on the log scale for the recreational CSUN/VRG gillnet survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

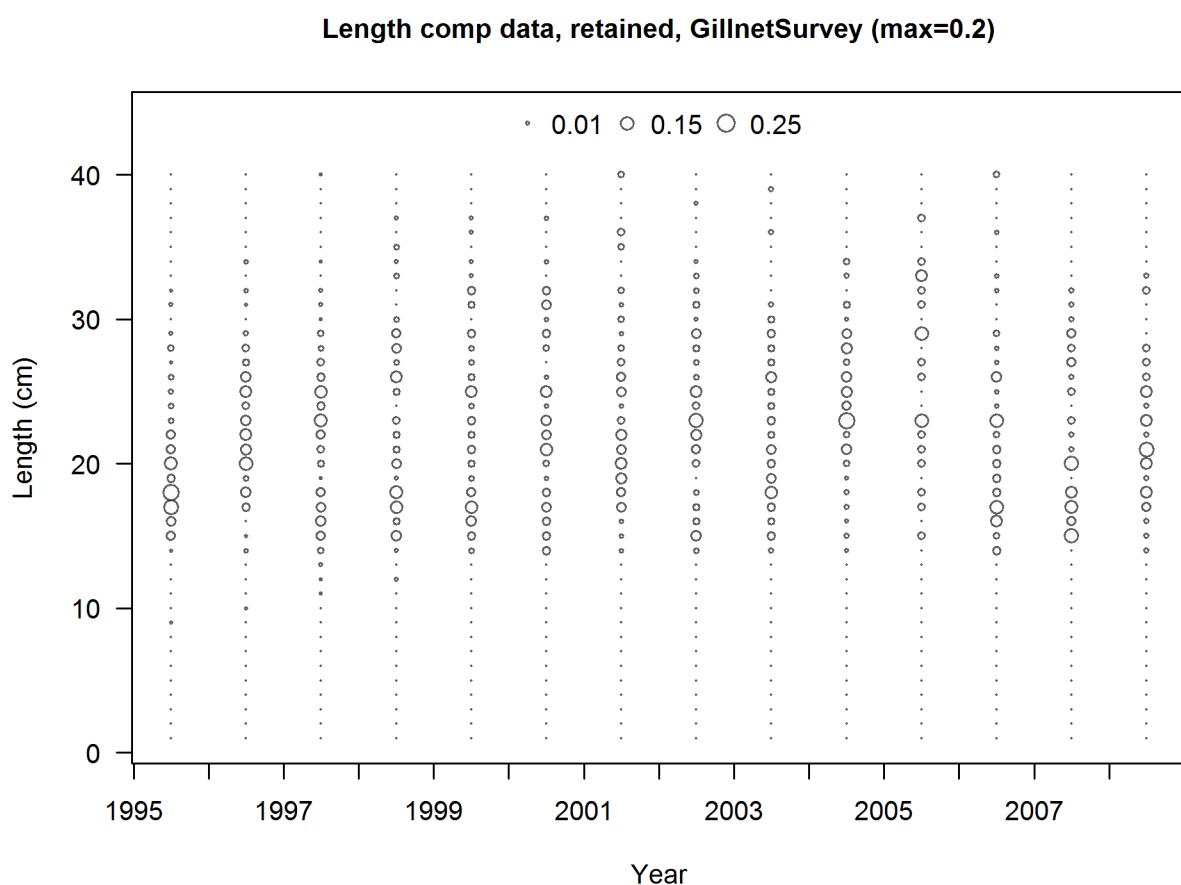


Figure 33: Length frequency distributions from the gill net surveys.

Normal Q-Q Plot

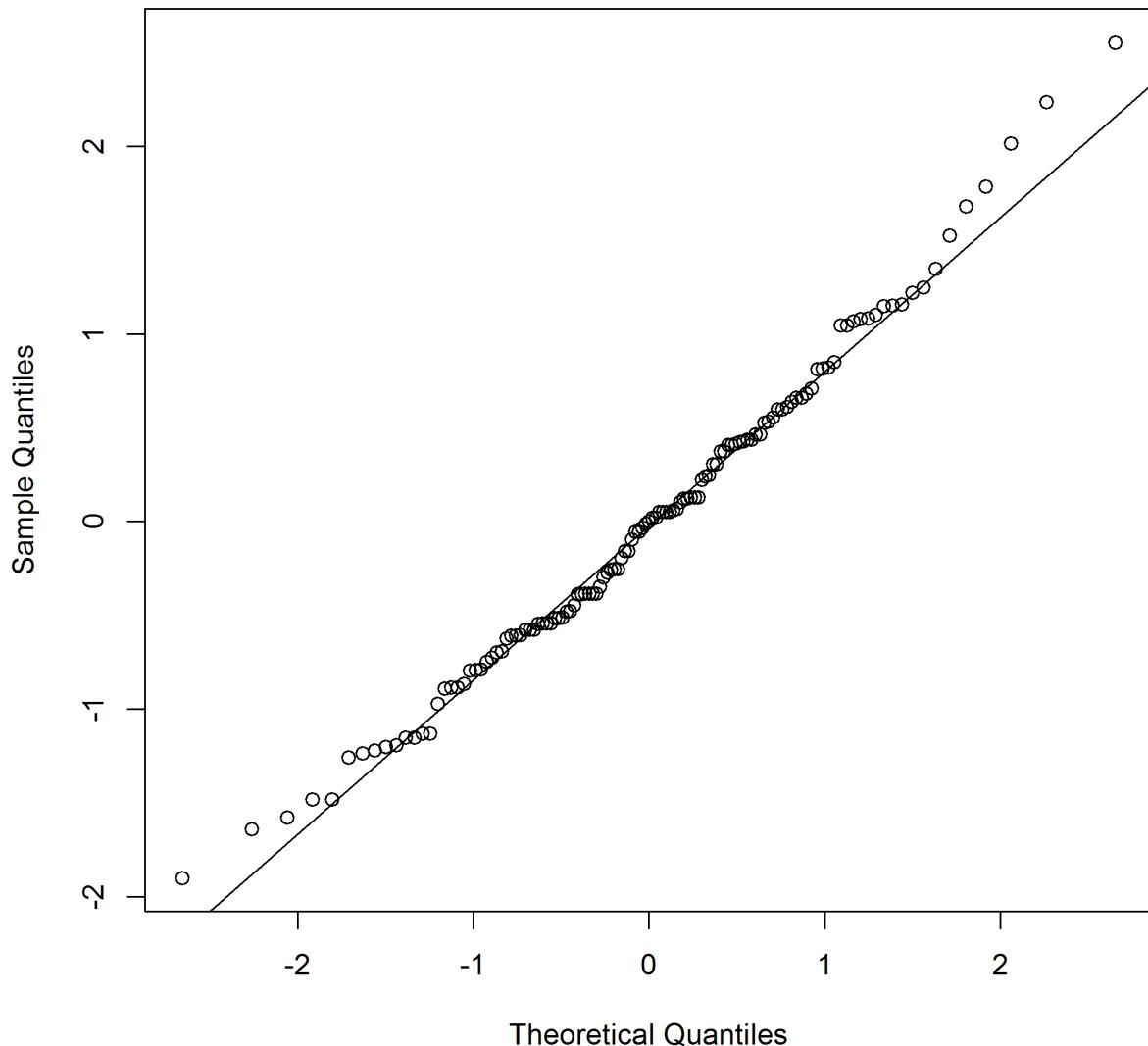


Figure 34: Q-Q plot used to validate the goodness of fit of the lognormal model for the Southern California Bight monitoring program trawl survey.

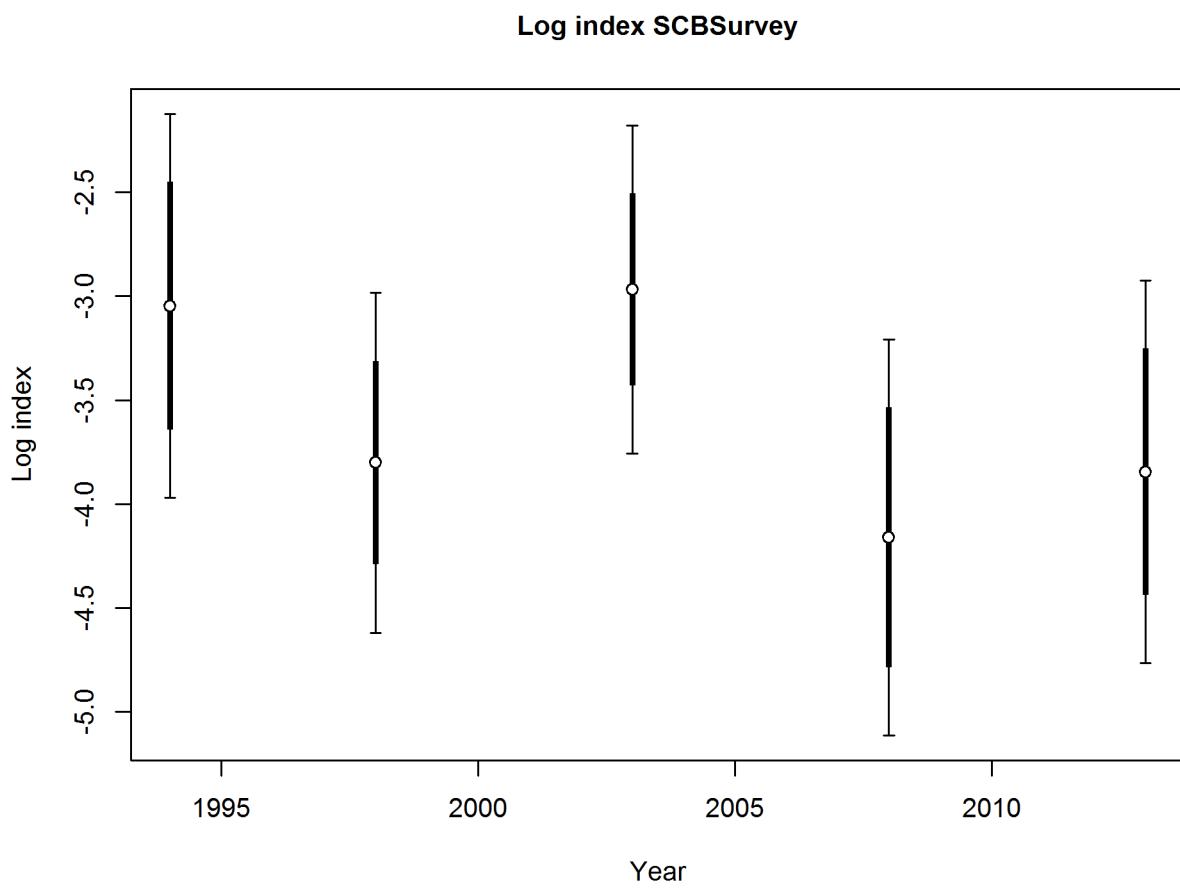


Figure 35: Standardized index on the log scale for the recreational Southern California Bight trawl survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

Length comp data, retained, SCBSurvey (max=0.2)

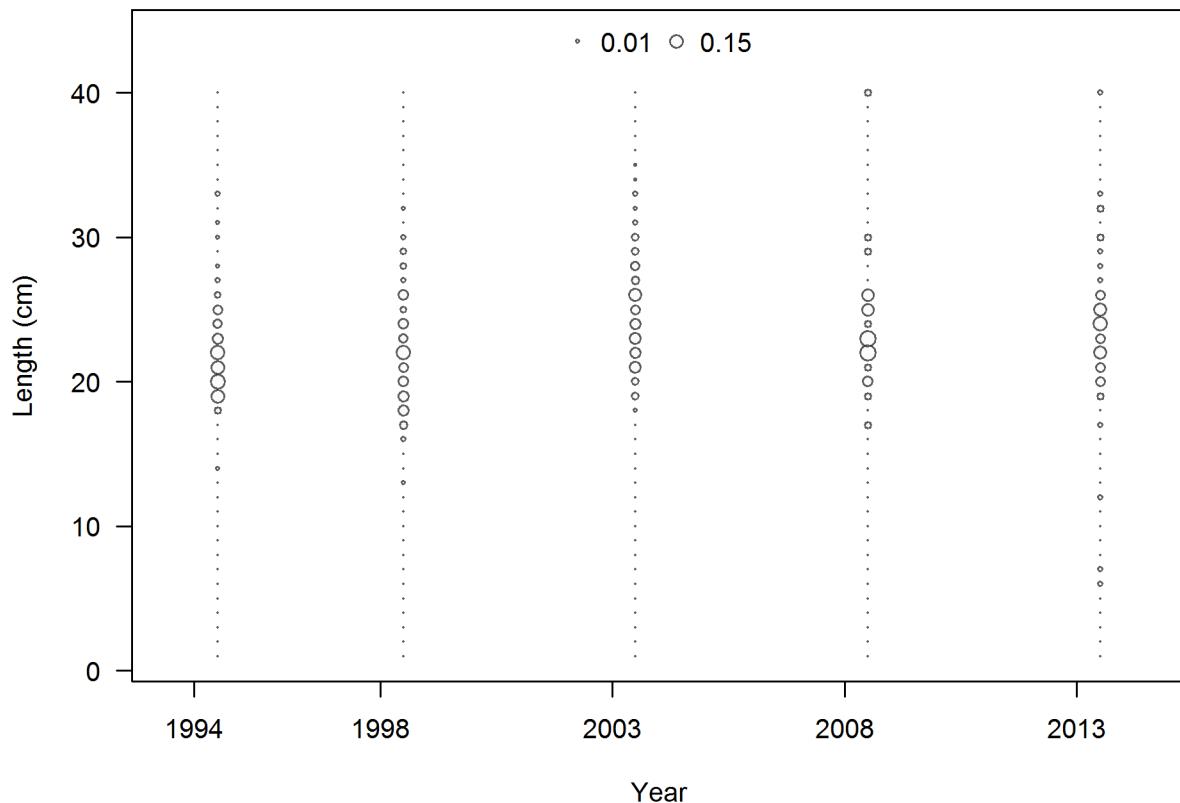


Figure 36: Length frequency distributions from the Southern California Bight regional monitoring program trawl surveys.

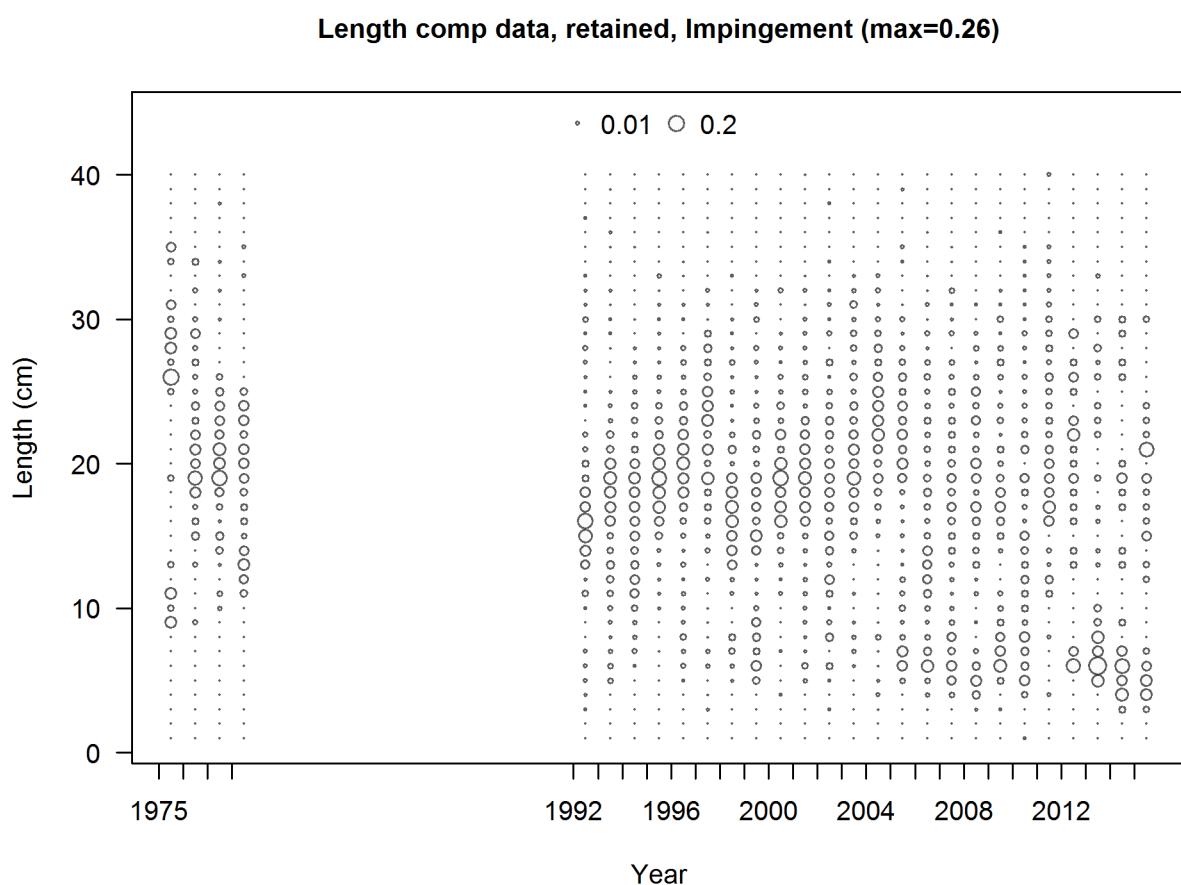


Figure 37: Length frequency distributions from the Impingement surveys.

Length comp data, aggregated across time by fleet

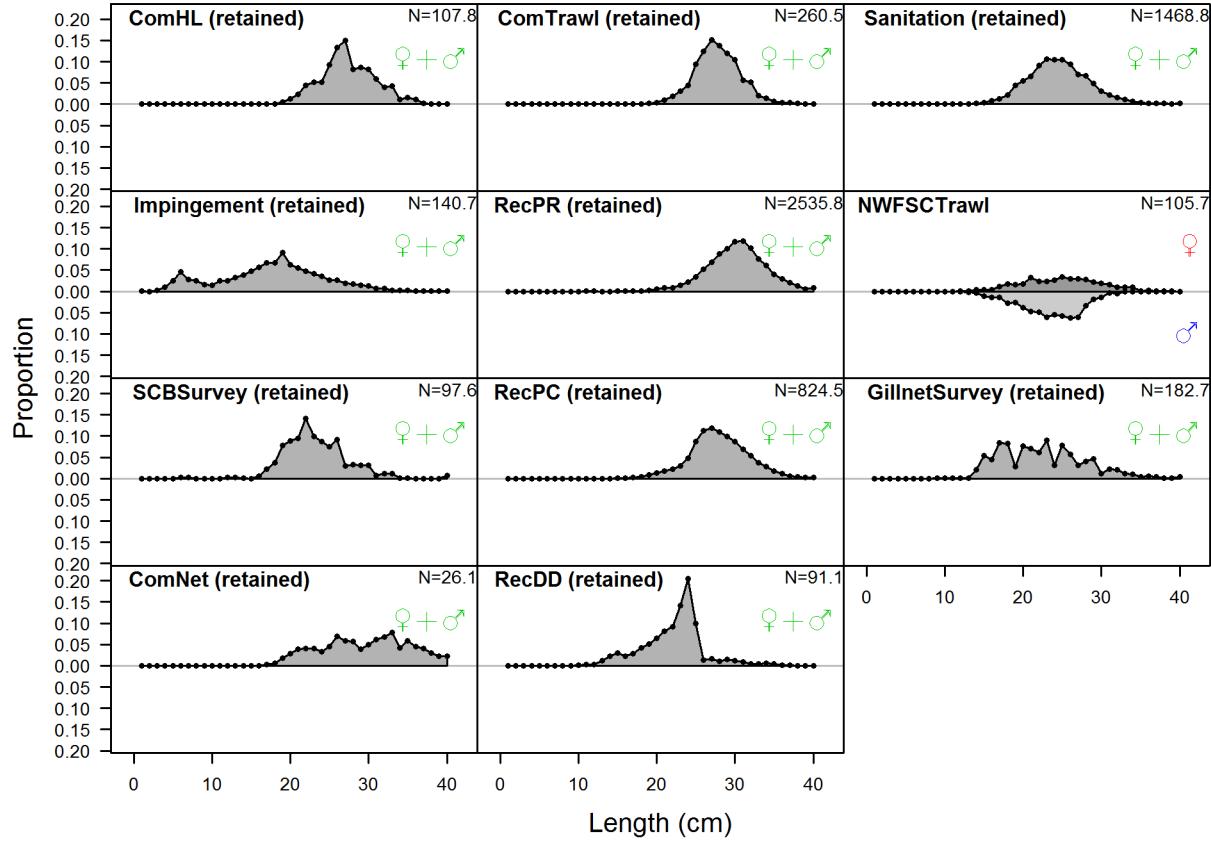


Figure 38: Length comp data, aggregated across time by fleet. Labels ‘retained’ and ‘discard’ indicate discarded or retained sampled for each fleet. Panels without this designation represent the whole catch.

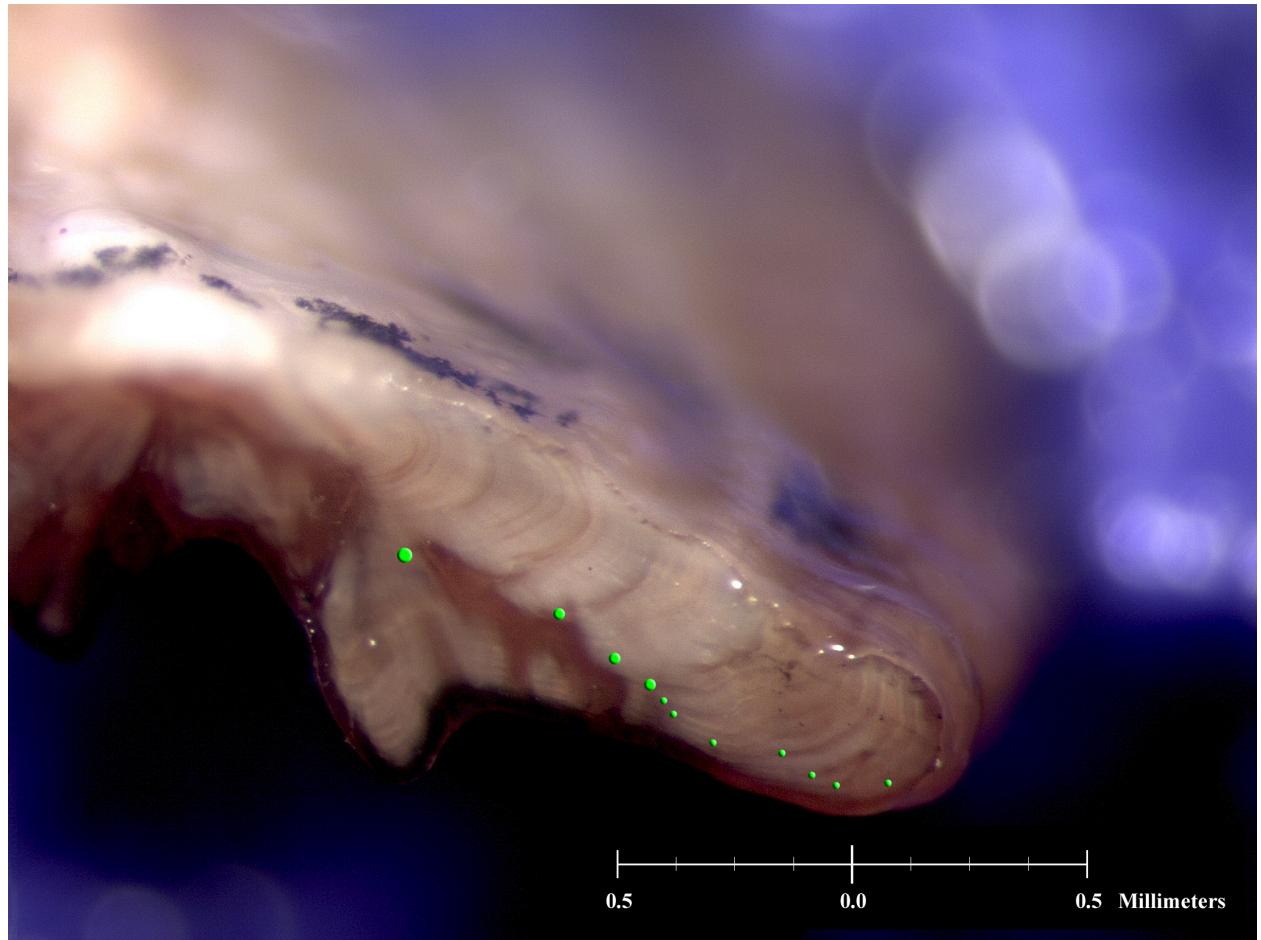


Figure 39: Cross-section of broken and burned California scorpionfish otolith showing. The green dots indicate the number of increments (photo courtesy Lance Sullivan, NWFSC).

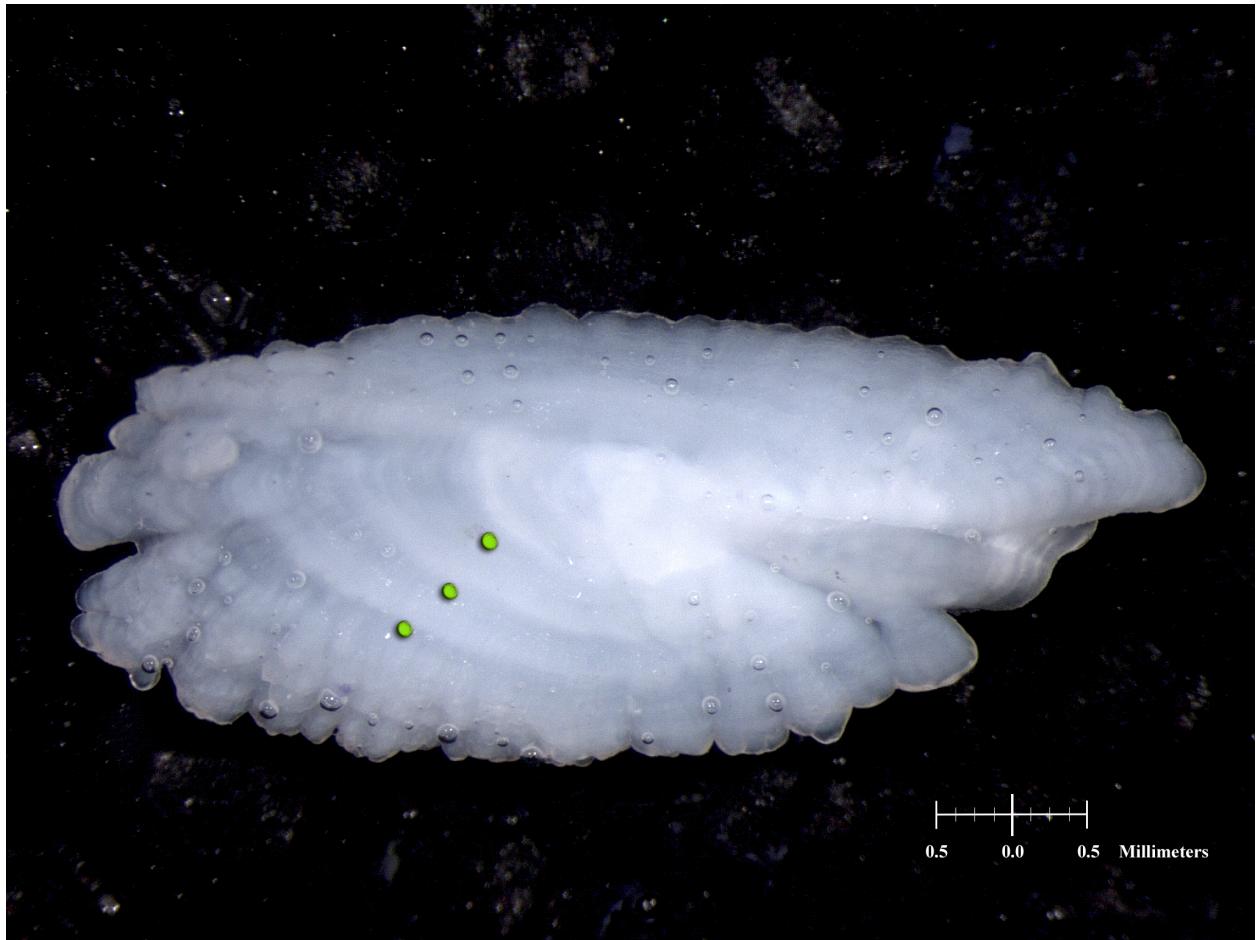


Figure 40: California scorpionfish otolith (photo courtesy Lance Sullivan, NWFSC).

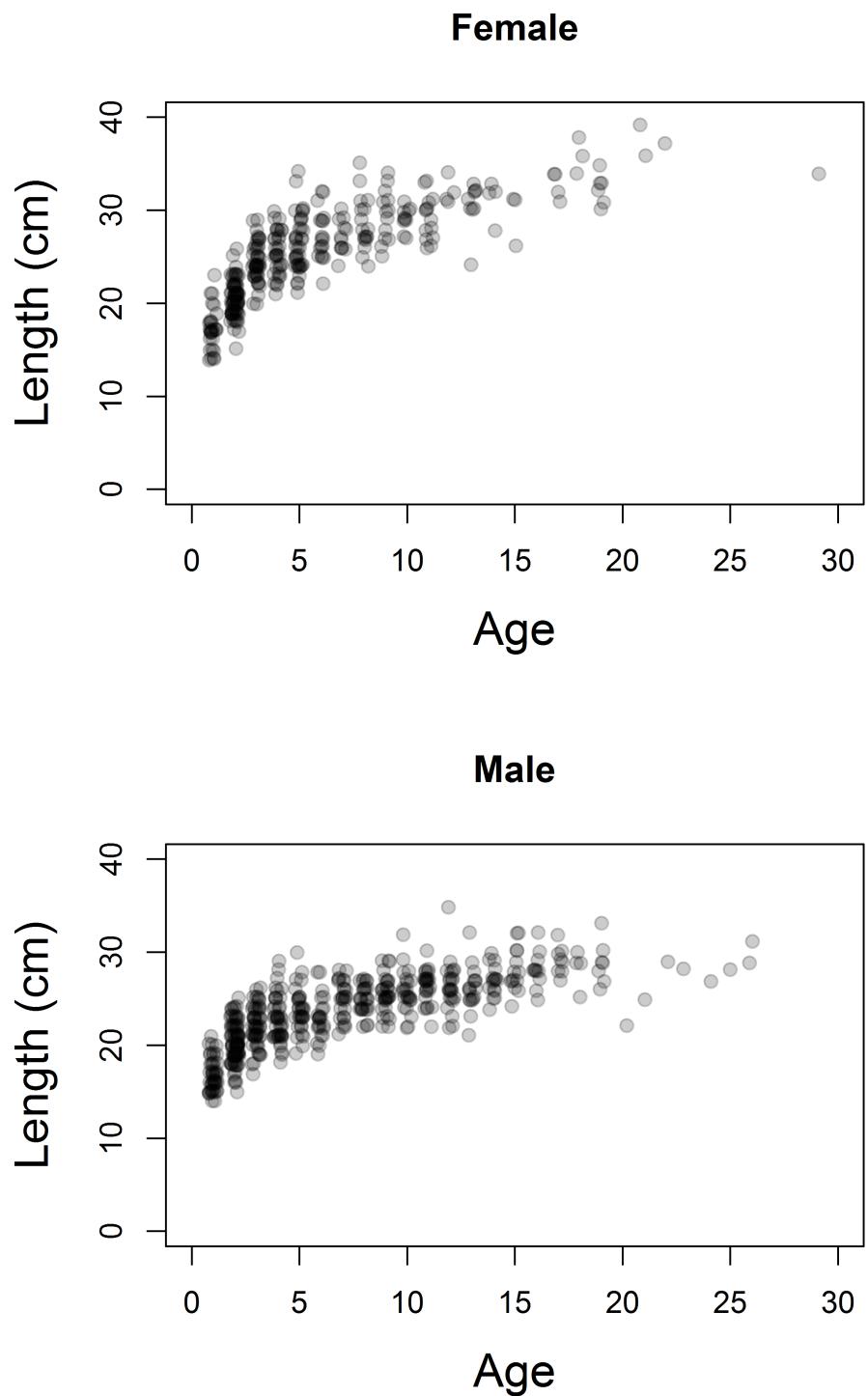
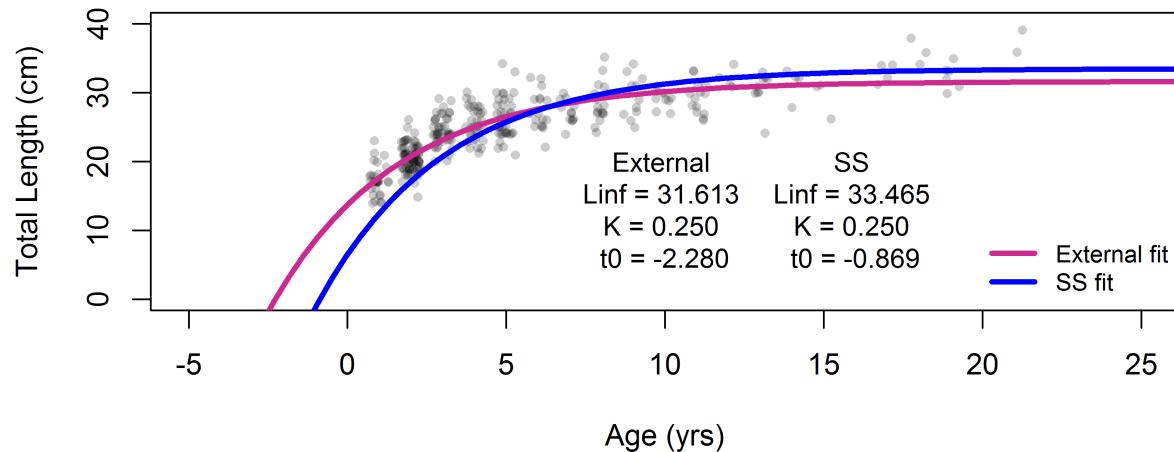


Figure 41: Length at age by sex for California scorpionfish collected from the NWFSC trawl survey.

Female



Male

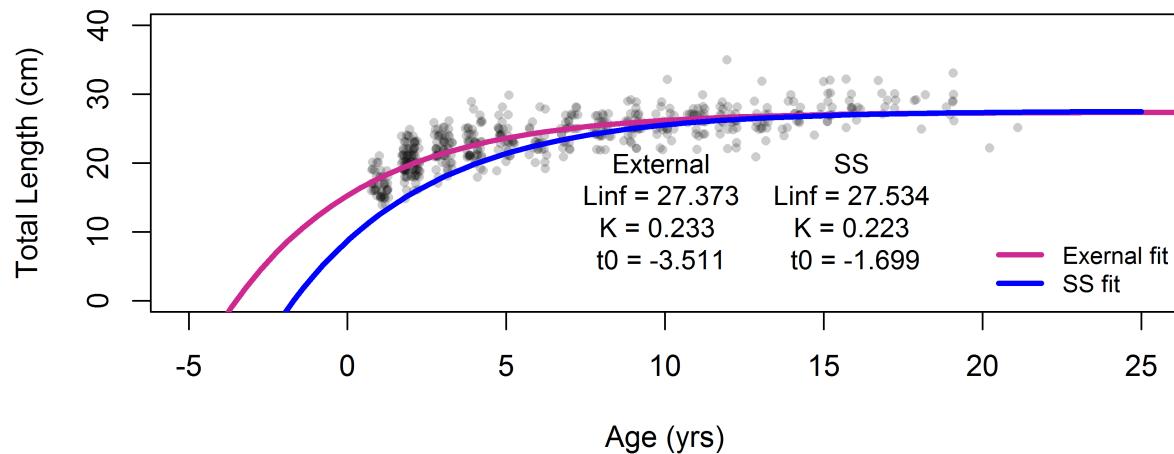


Figure 42: Fitted (external to SS) von Bertalanffy growth by sex for California scorpionfish collected from the NWFSC trawl survey.

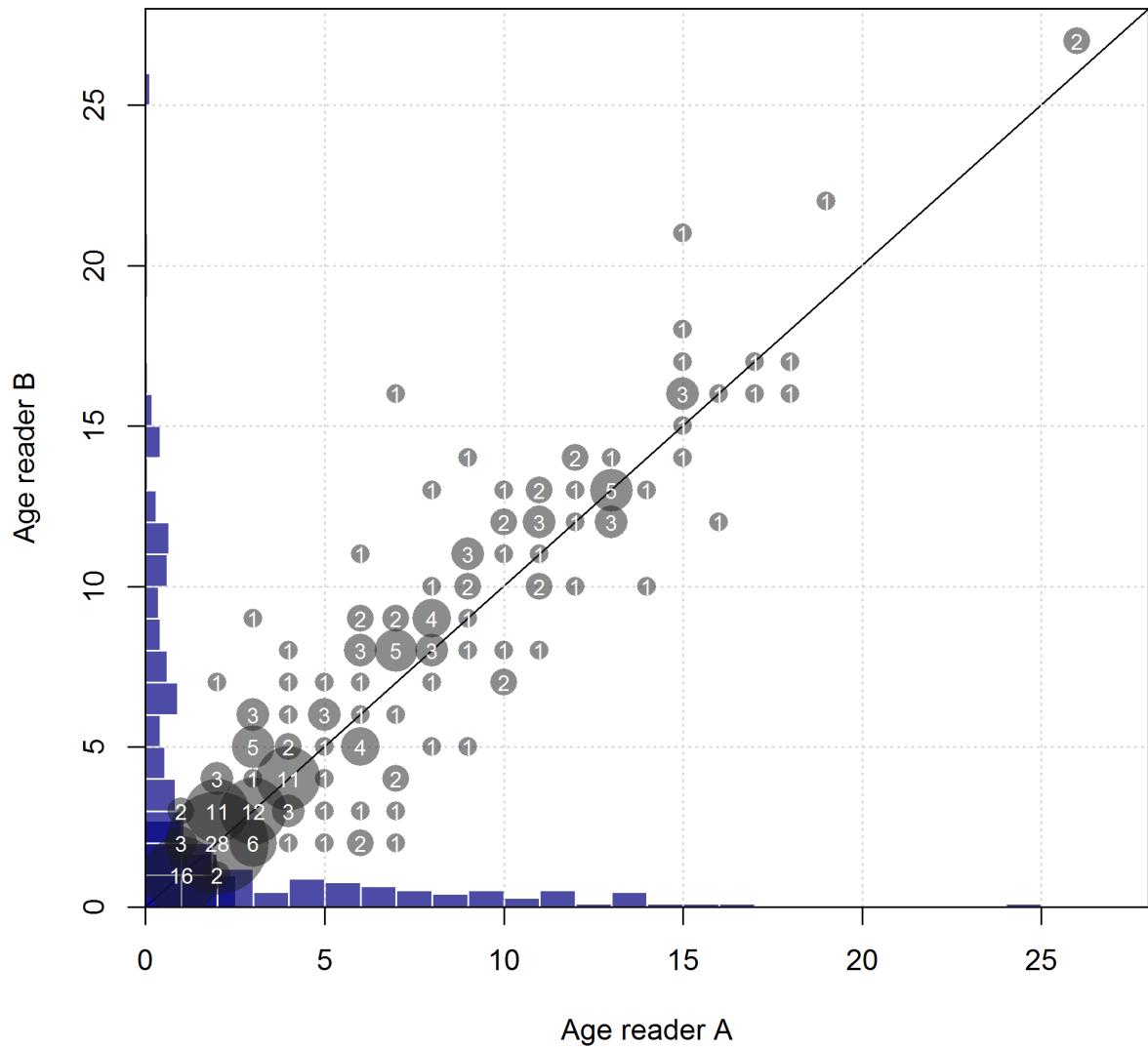


Figure 43: Aging precision between two current age readers at the NWFSC. Numbers in the bubbles are the sample sizes of otoliths cross-read.

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

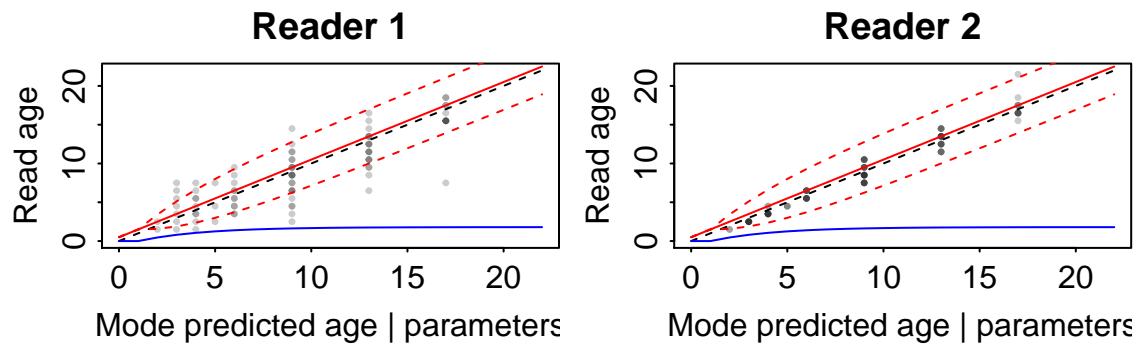


Figure 44: True versus predicted age for two current age readers at the NWFSC from the ageing error software with unbiased reads and curvilinear standard deviation for both readers.

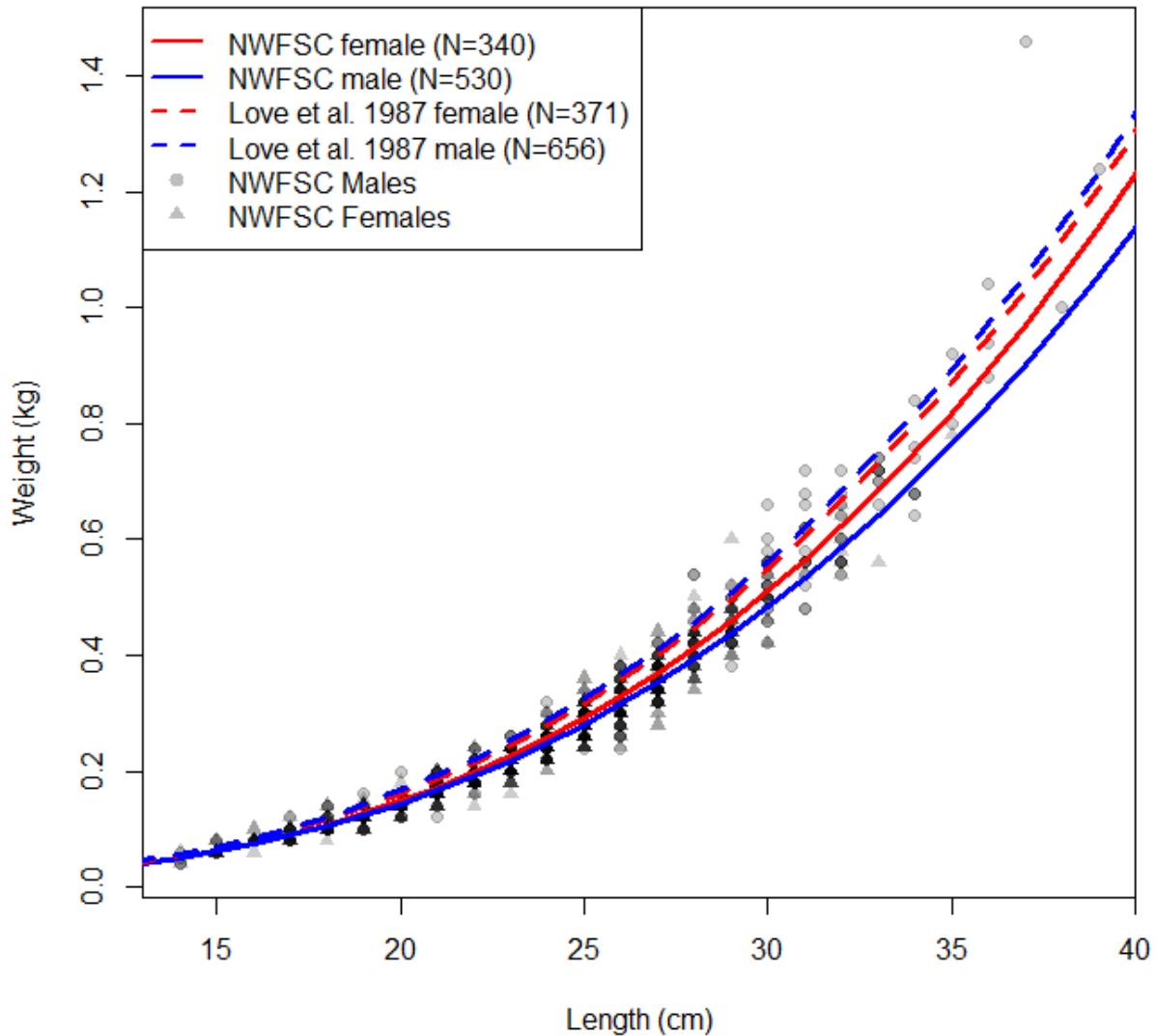


Figure 45: Comparison of the California scorpionfish weight-length curves from Love et al. (1987) and those estimated from the NWFSC trawl survey. The latter is used in this assessment.

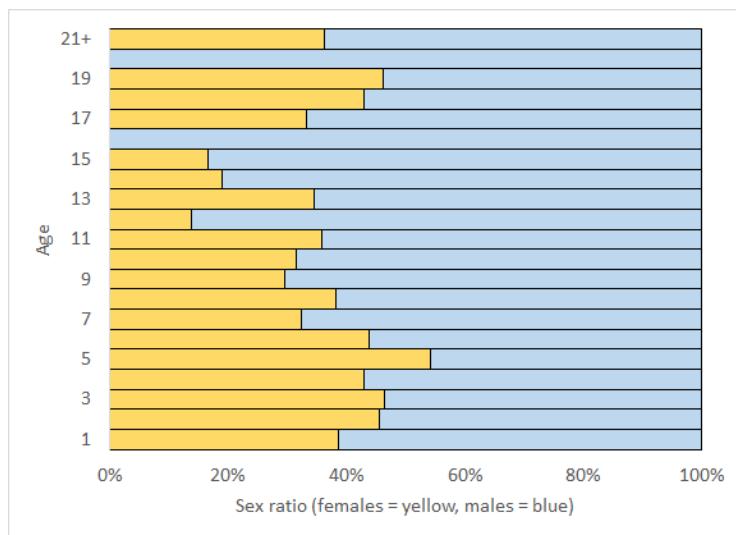


Figure 46: Percent of males and females by age of the fish aged from the NWFSC trawl survey, yellow=females and blue = males.

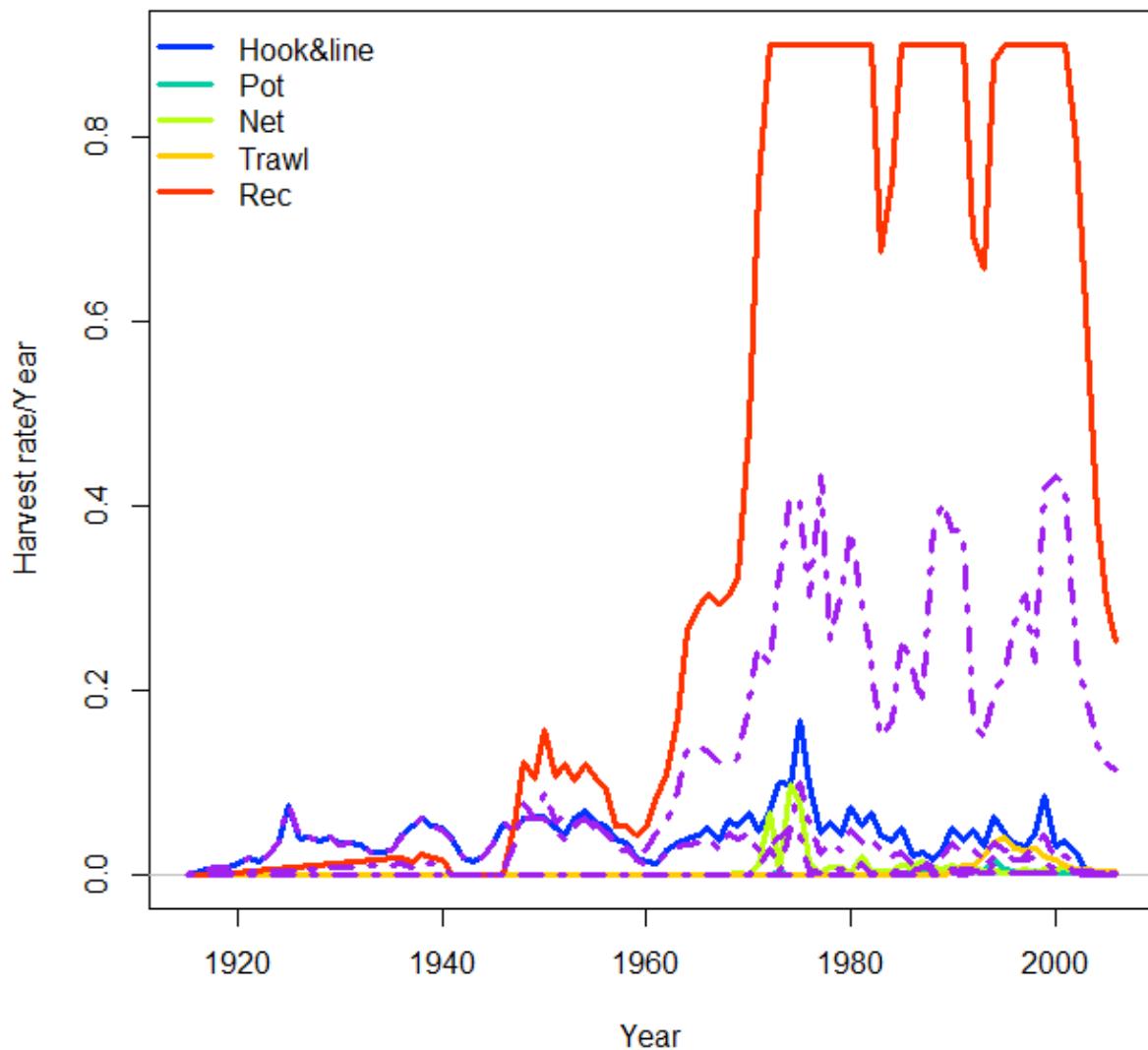


Figure 47: Time series of harvest rates by fleet from the 2005 model where the harvest rate for the recreational fleet hit the boundary of 0.9.

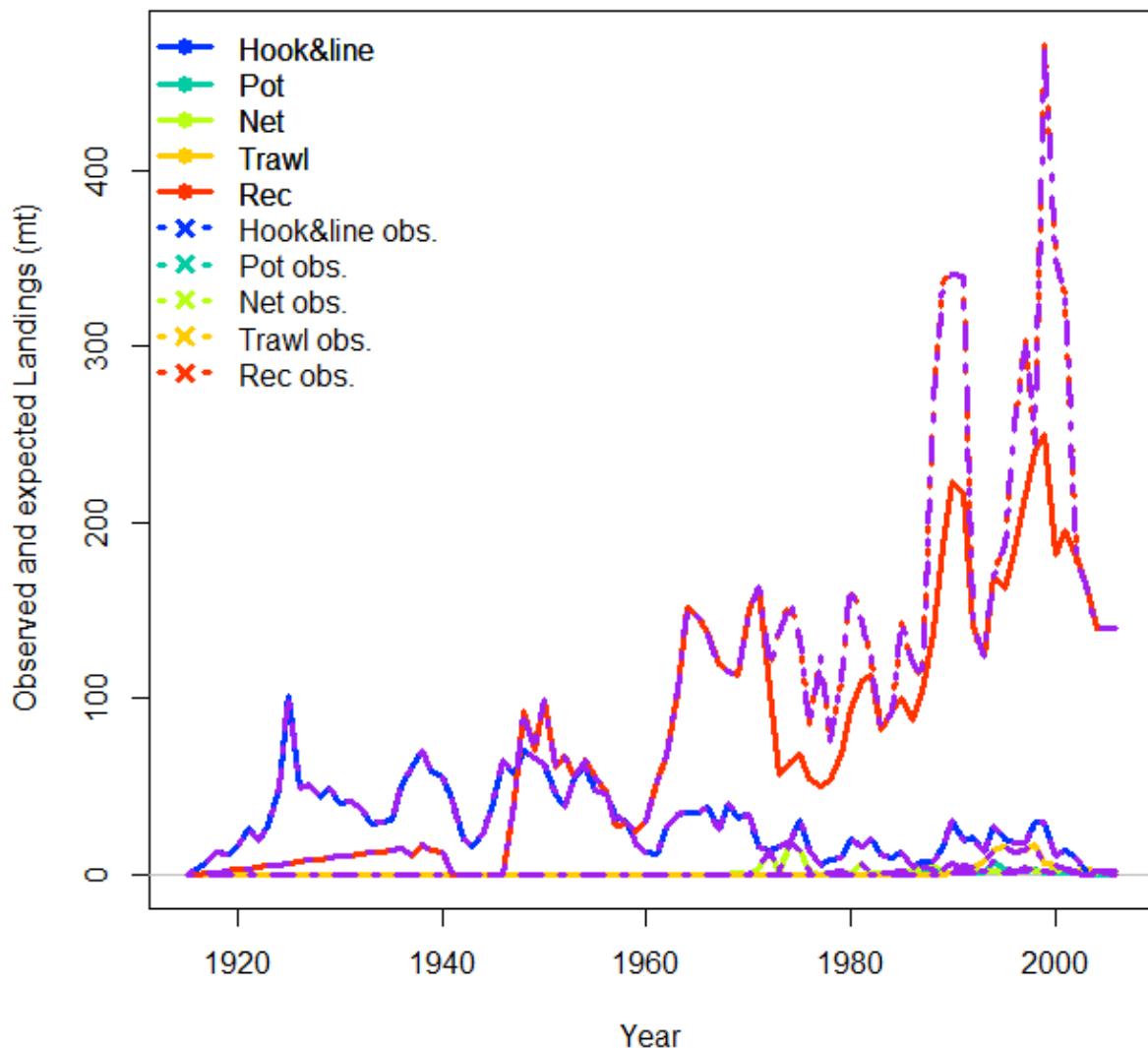


Figure 48: Time series of observed and expected landings by fleet from the 2005 model. The model was not able to remove all of the recreational catches starting around 1970.

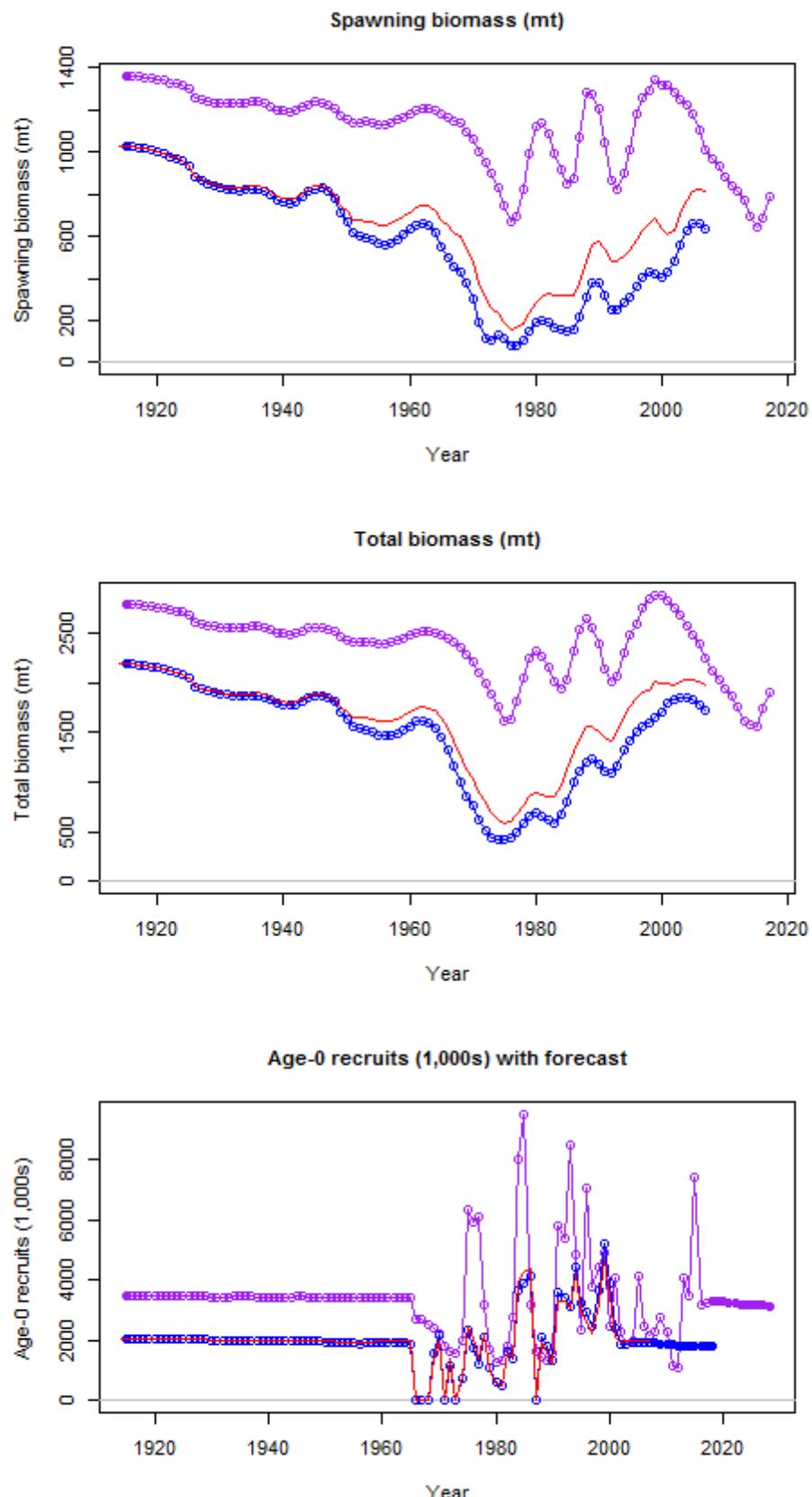


Figure 49: Comparison of spawning output, total biomass, and recruits from the 2005 model (solid red lines) using SS2, the 2005 model converted to SS3.24z (blue lines), and the base model from this assessment (purple lines). Note: The 2005 assessment was found to have an error, and therefore the time series for the model to SS3.24 will not match perfectly.

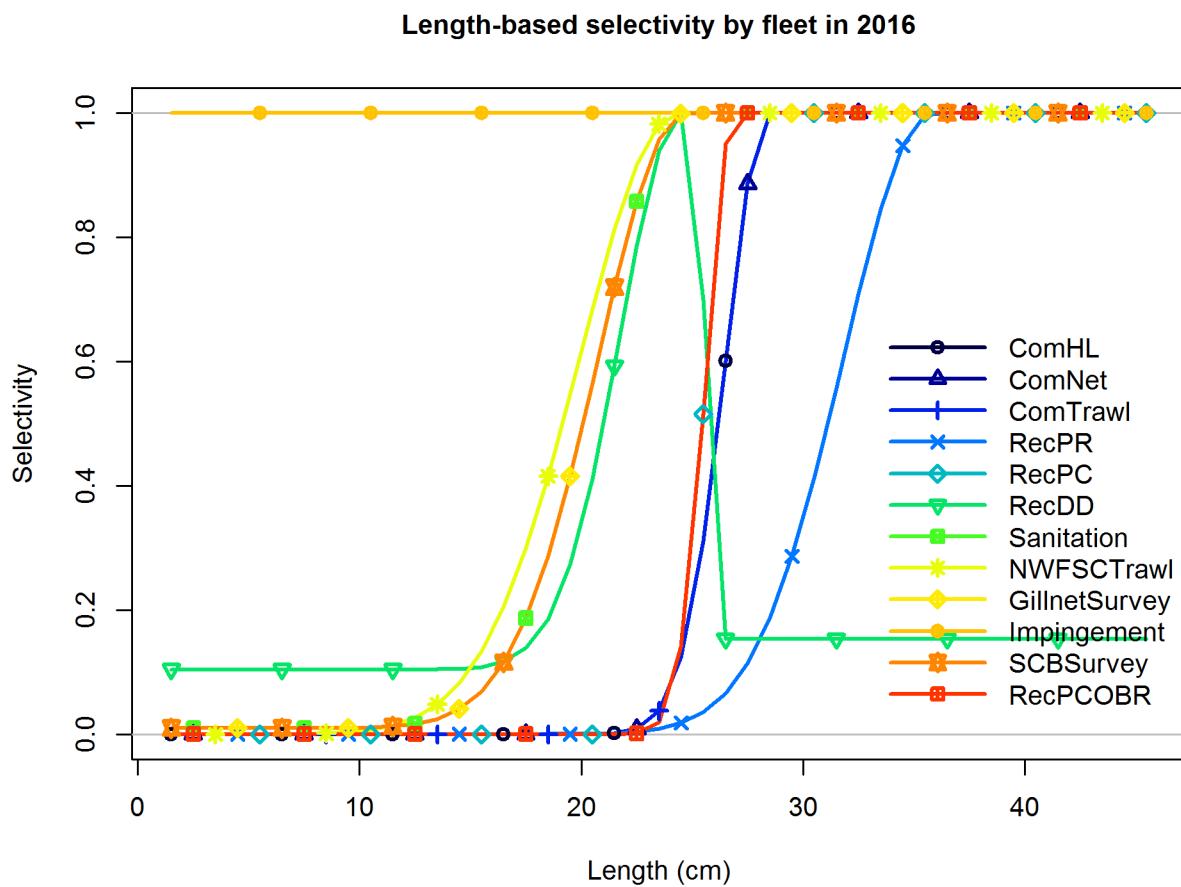


Figure 50: Selectivity at length for all of the fleets in the base model.

Female time-varying selectivity for ComHL

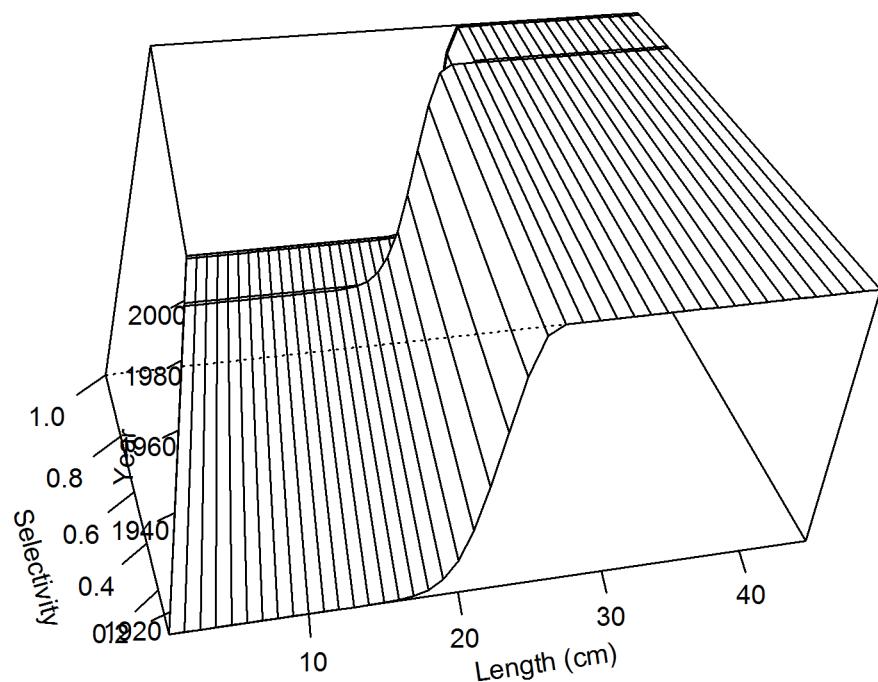


Figure 51: Surface plot of Female time-varying selectivity for the commercial hook-and-line fleet, with time blocks from 1916-1998 and 1999-2016.

Female time-varying selectivity for RecPR

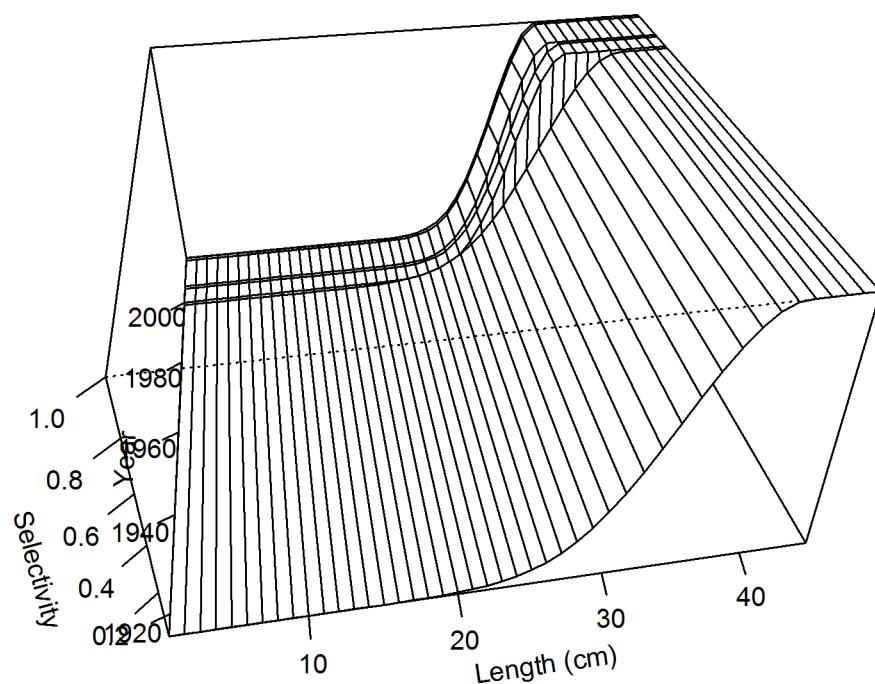


Figure 52: Surface plot of Female time-varying selectivity for the recreational private boat fleet, with time blocks from 1916-2000, 2001-2005, and 2006-2016.

Female time-varying selectivity for RecPC

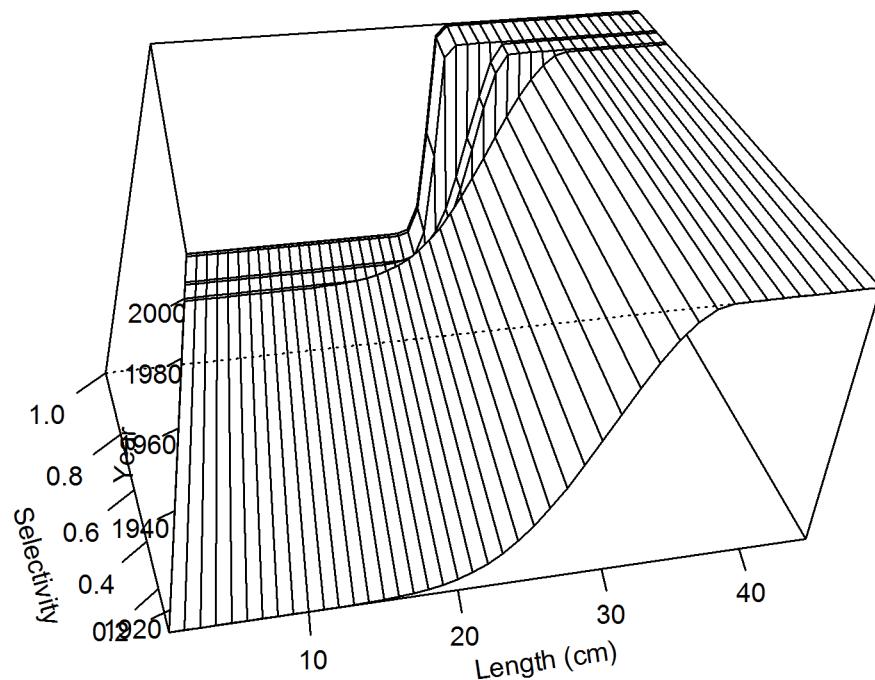


Figure 53: Surface plot of Female time-varying selectivity for the recreational party/charter retained-only catch fleet, with time blocks from 1916-2000, 2001-2005, and 2006-2016.

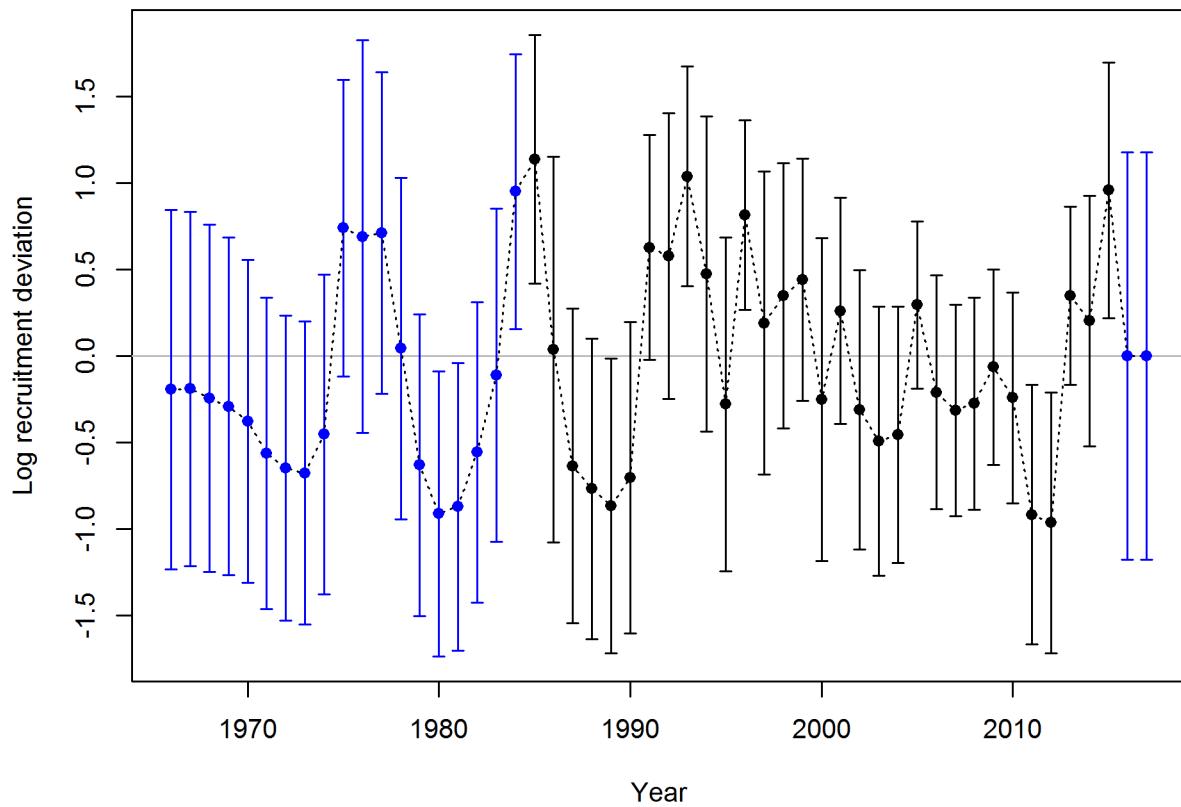


Figure 54: Estimated time-series of recruitment deviations for California scorpionfish with 95% intervals.

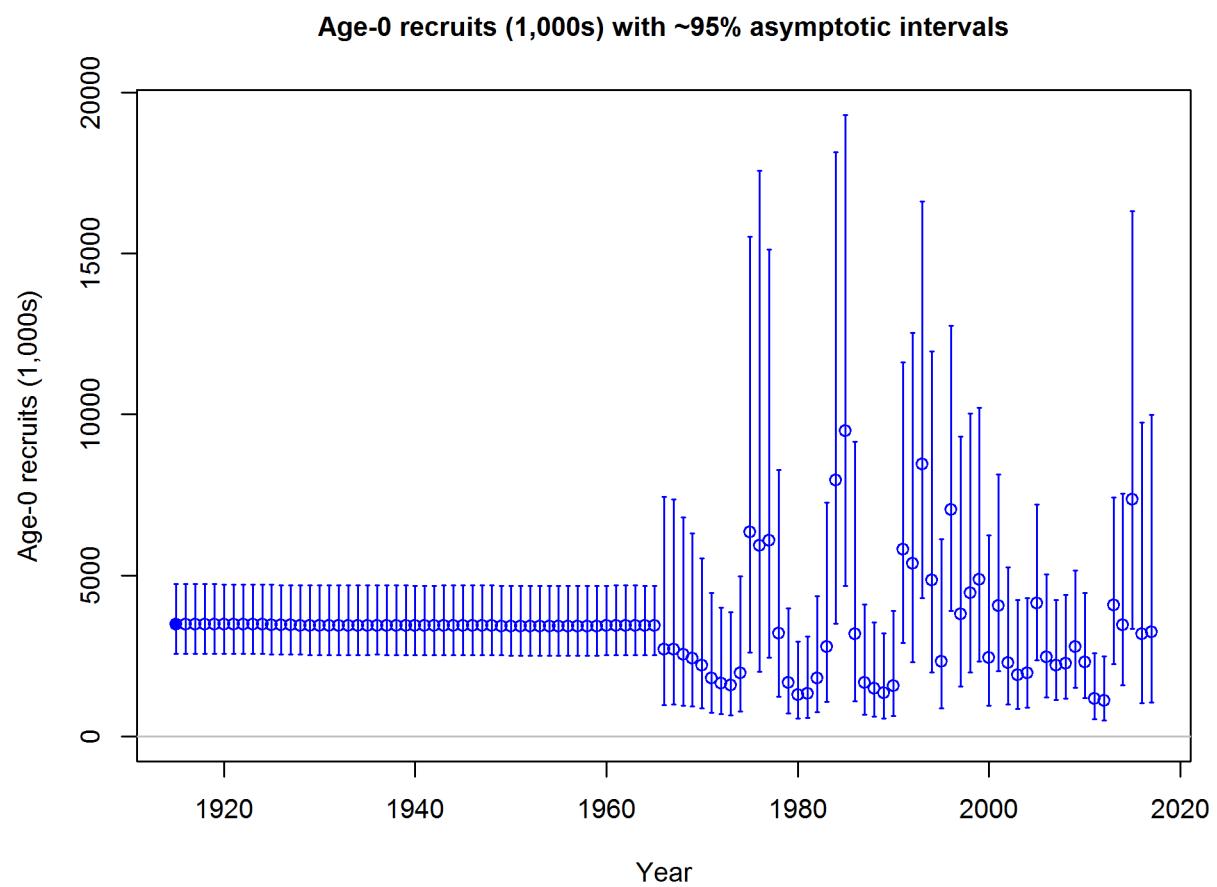


Figure 55: Estimated time-series of recruitment for California scorpionfish.

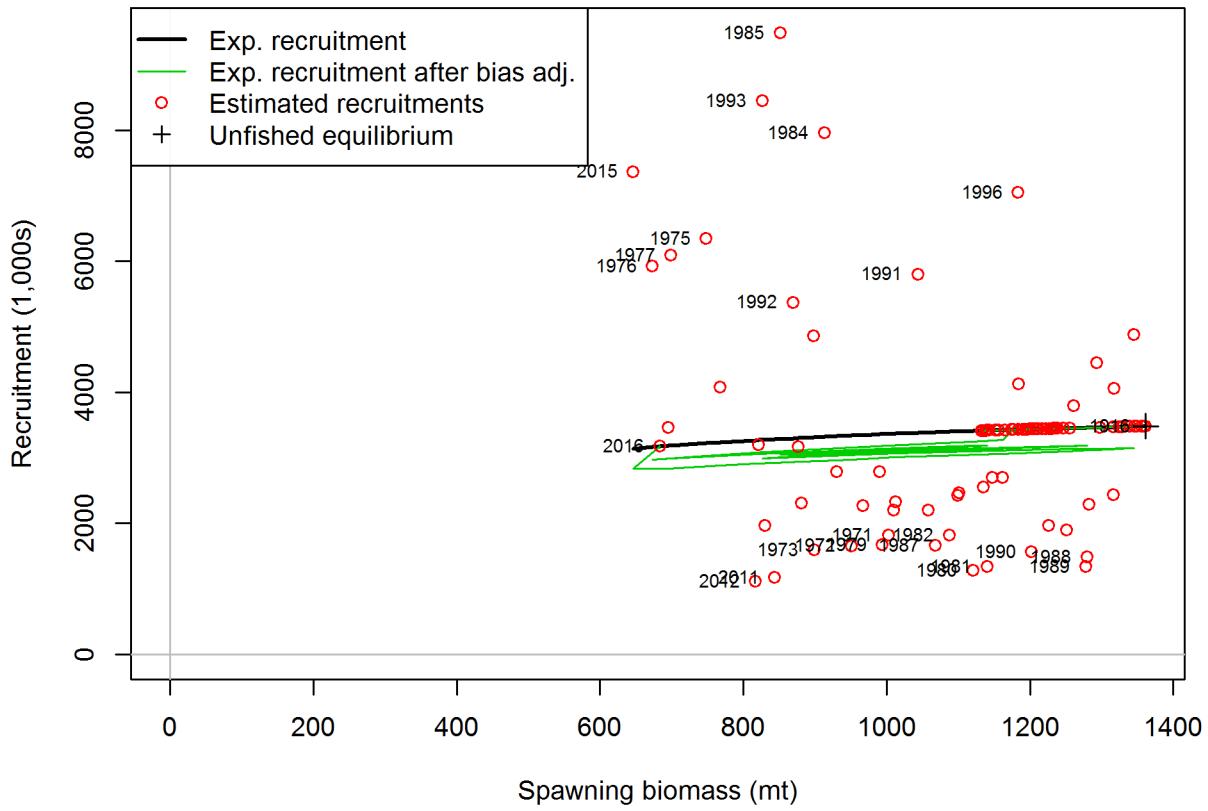


Figure 56: Estimated recruitment (red circles) and the assumed stock-recruit relationship (black line) for California scorpionfish. The green line shows the effect of the bias correction for the lognormal distribution.

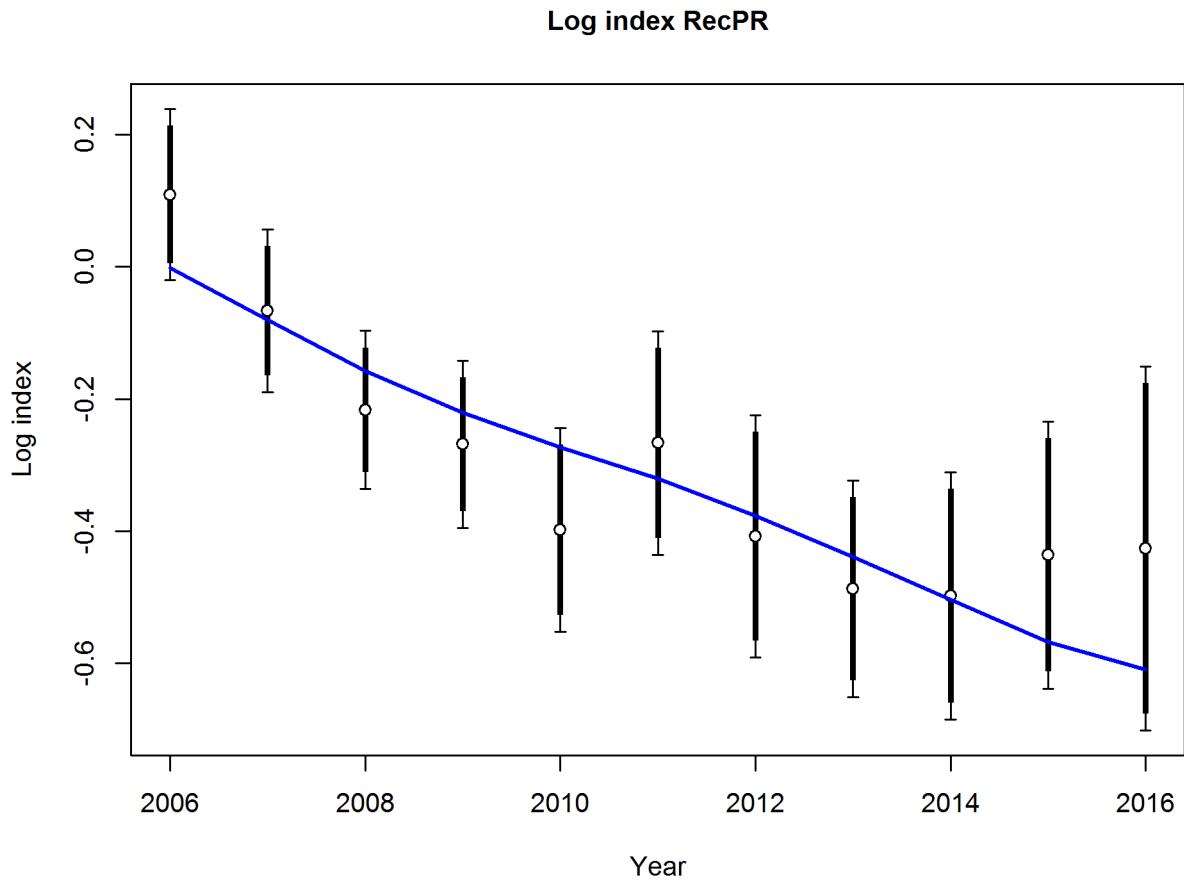


Figure 57: Fit to log index data on log scale for the recreational CPFV logbook retained catches. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

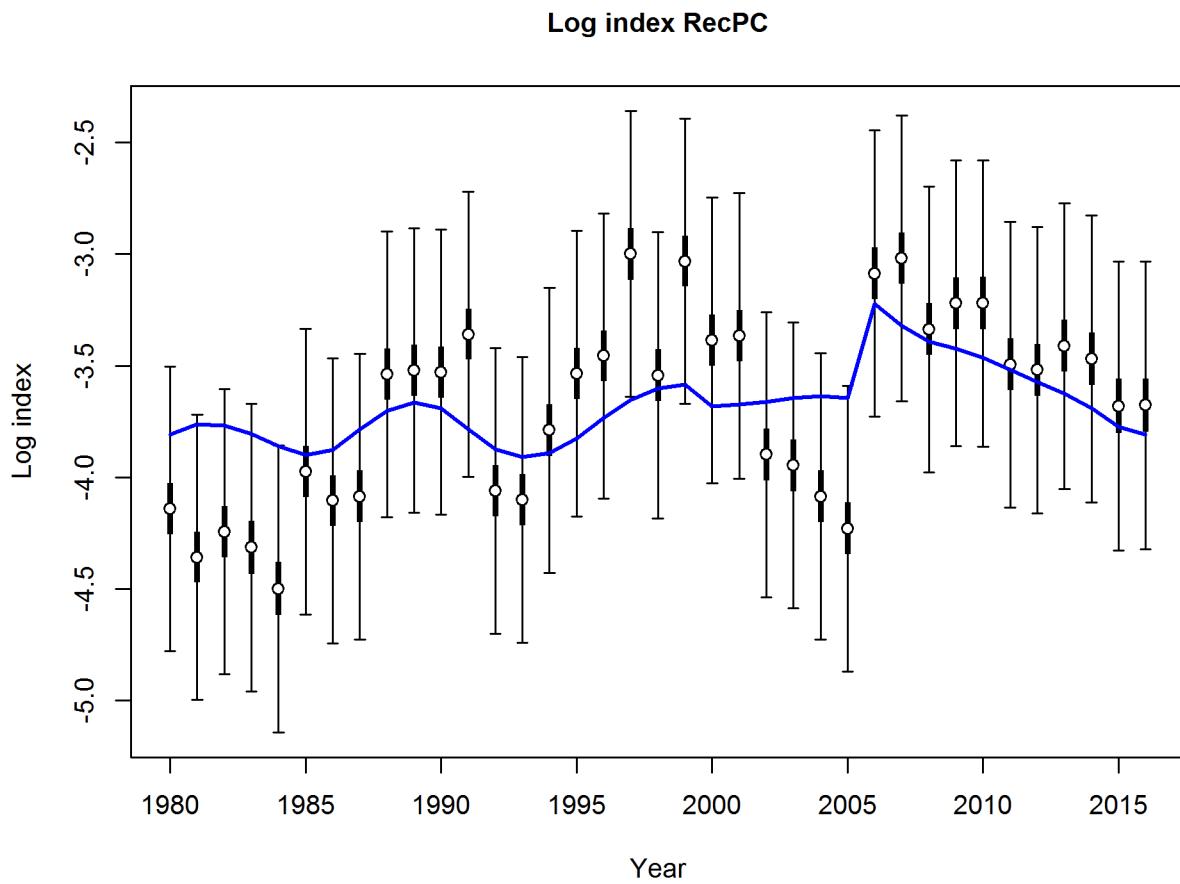


Figure 58: Fit to log index data on log scale for the recreational CPFV logbook retained catches. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

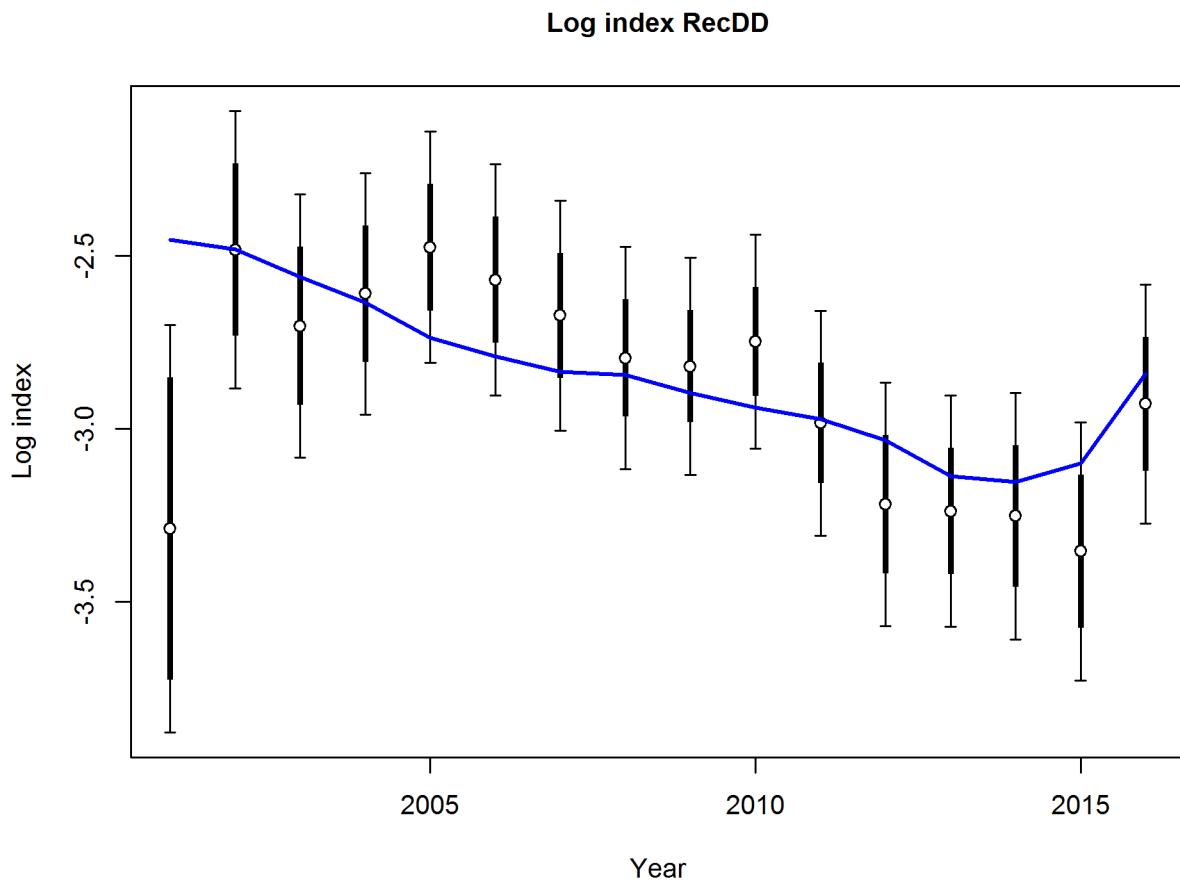


Figure 59: Fit to log index data on log scale for the recreational CPFV onboard observer discard catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

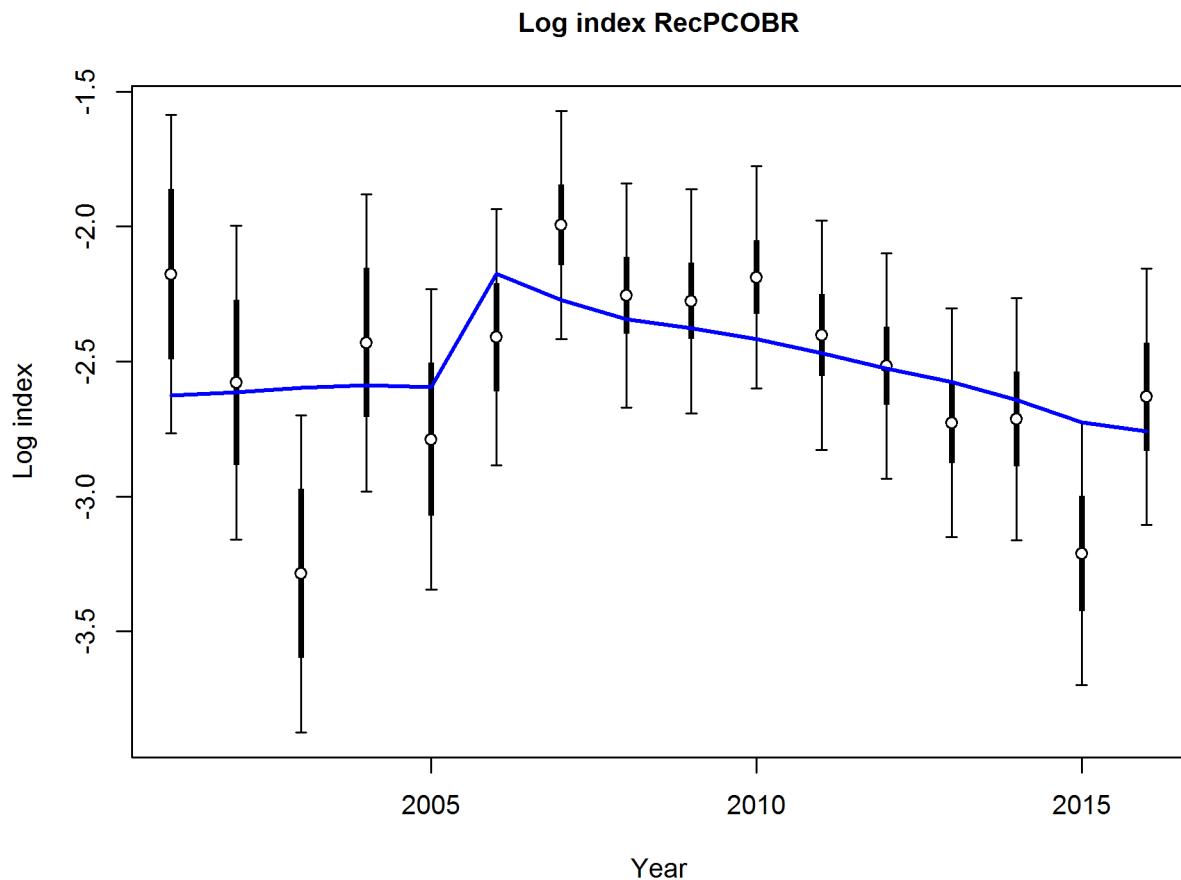


Figure 60: Fit to log index data on log scale for the recreational CPFV onboard observer retained catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

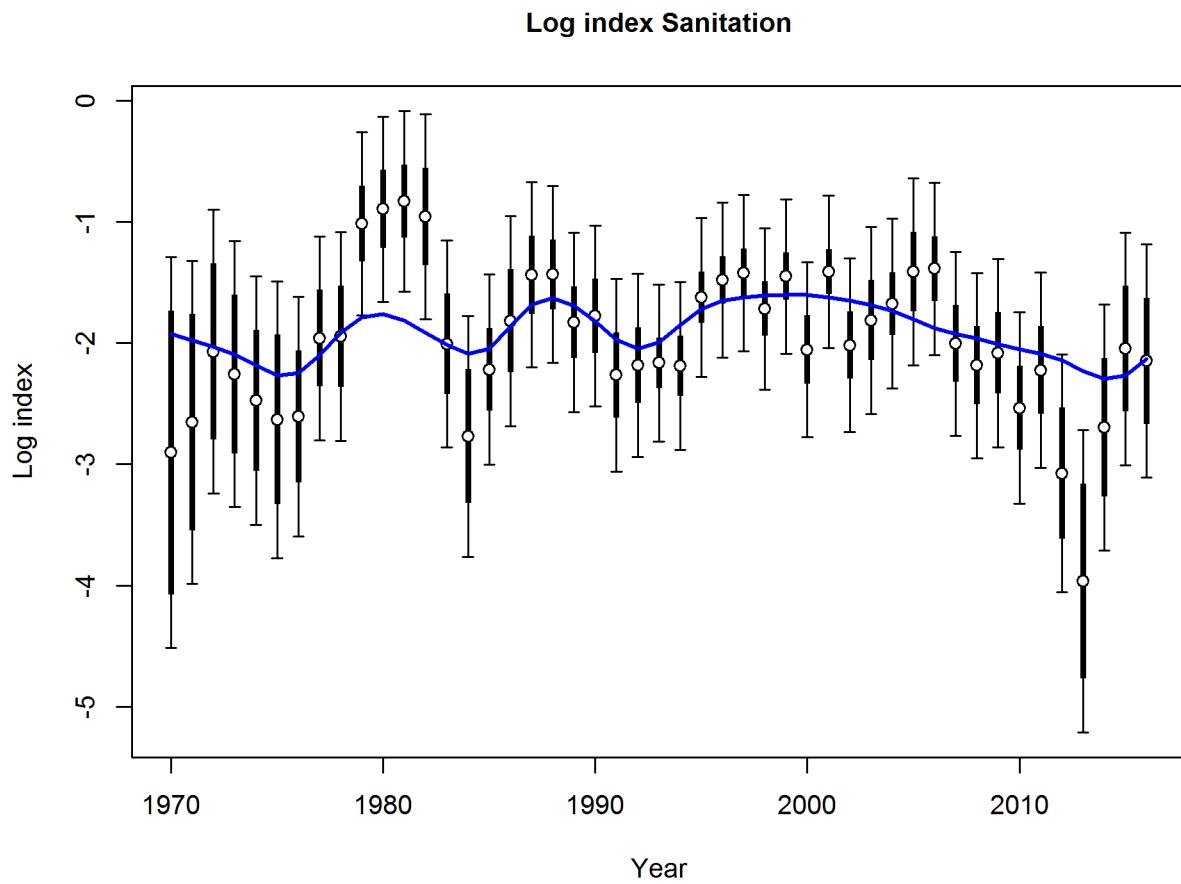


Figure 61: Fit to log index data on log scale for the sanitation district trawl index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

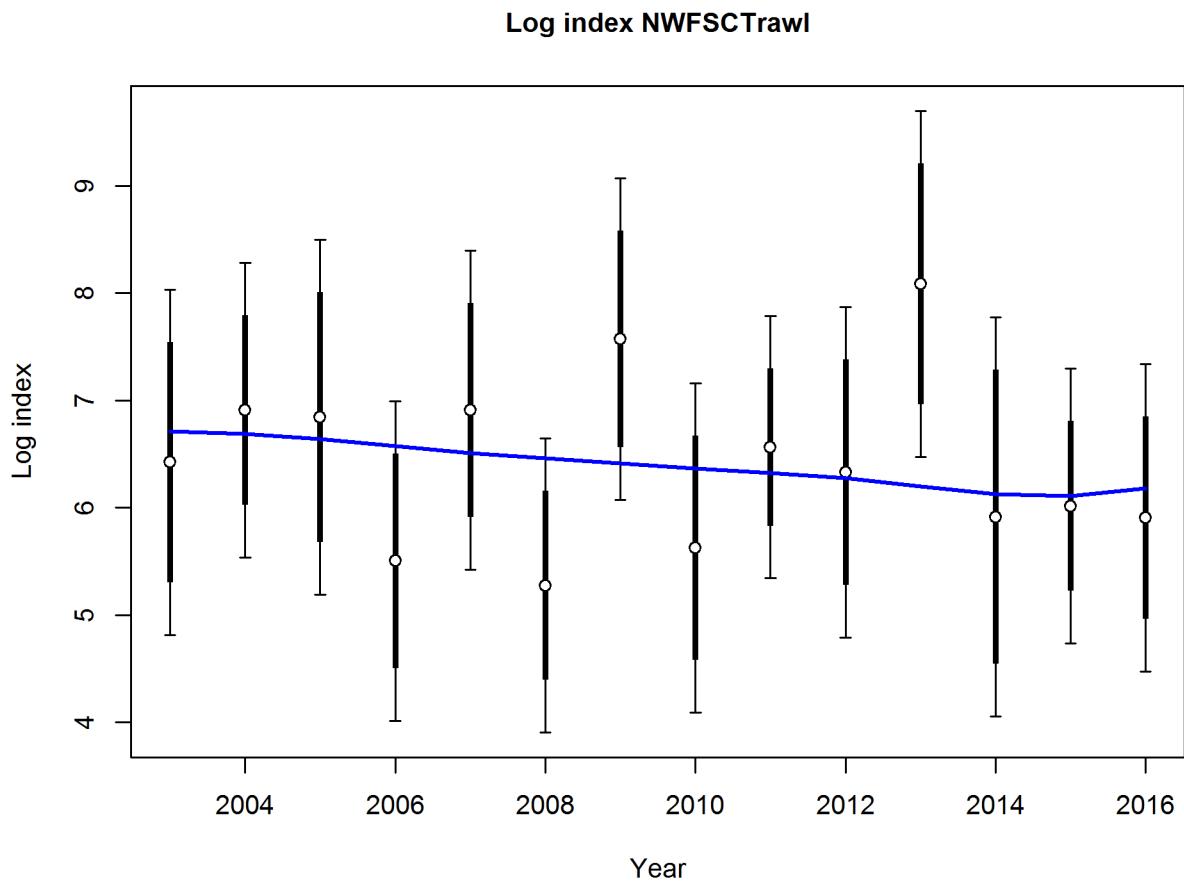


Figure 62: Fit to log index data on log scale for the NWFSC trawl survey from the VAST analysis from 2003-2016. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

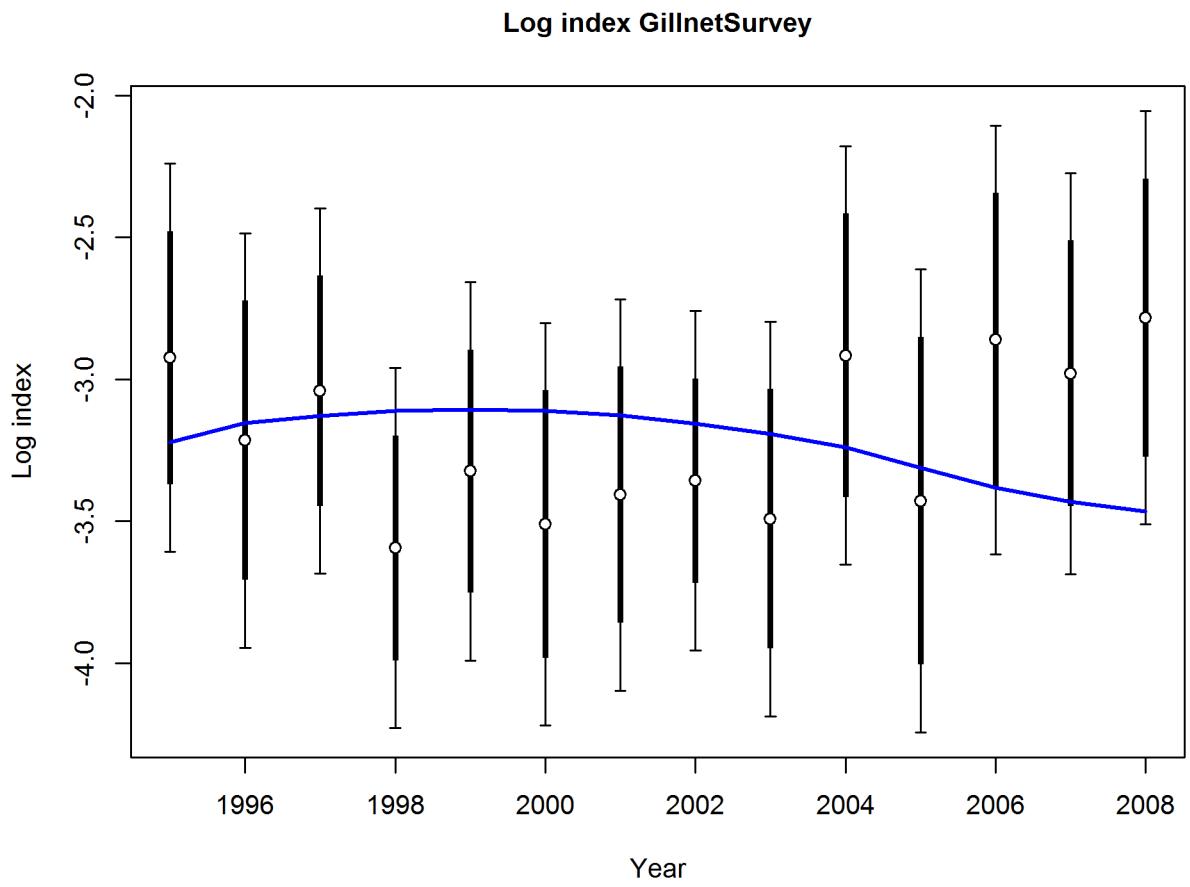


Figure 63: Fit to log index data on log scale for the recreational CSUN/VRG gillnet survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

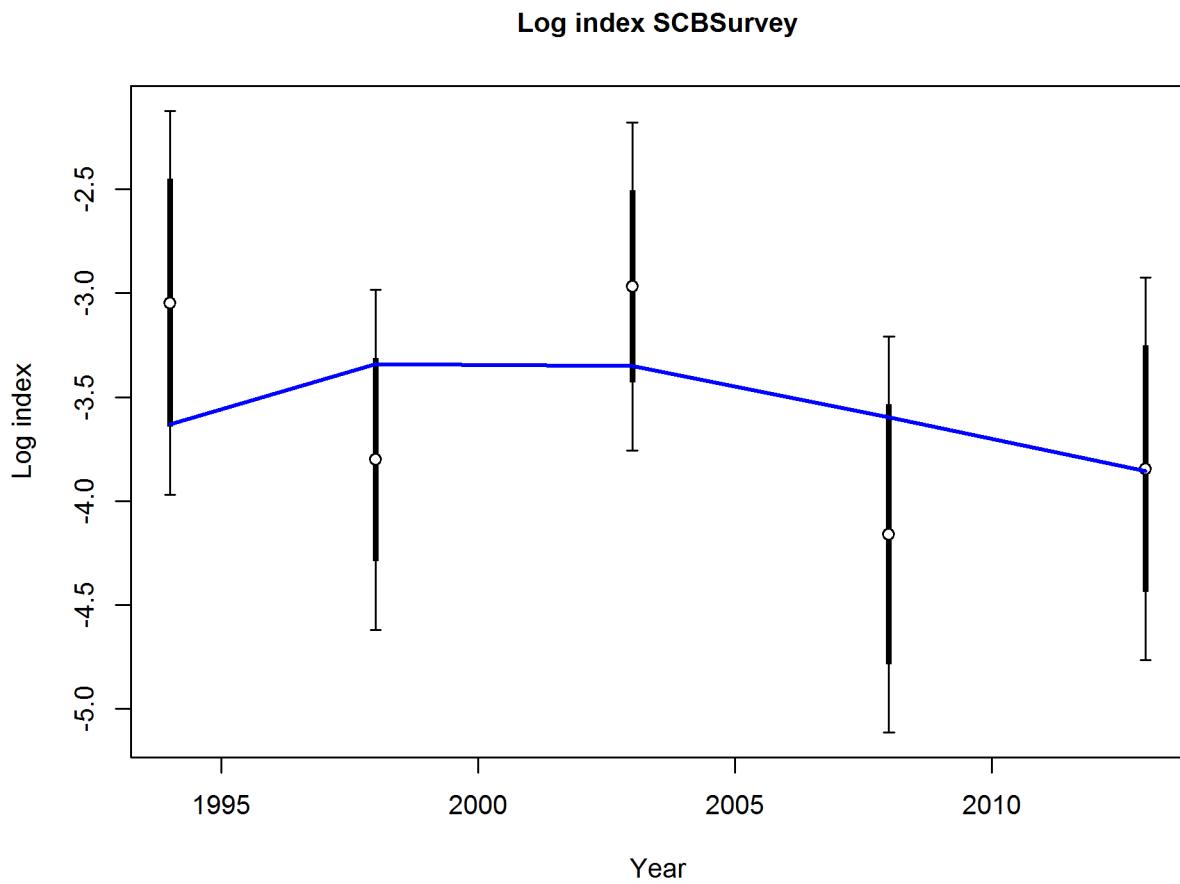


Figure 64: Fit to log index data on log scale for the recreational Southern California Bight trawl survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

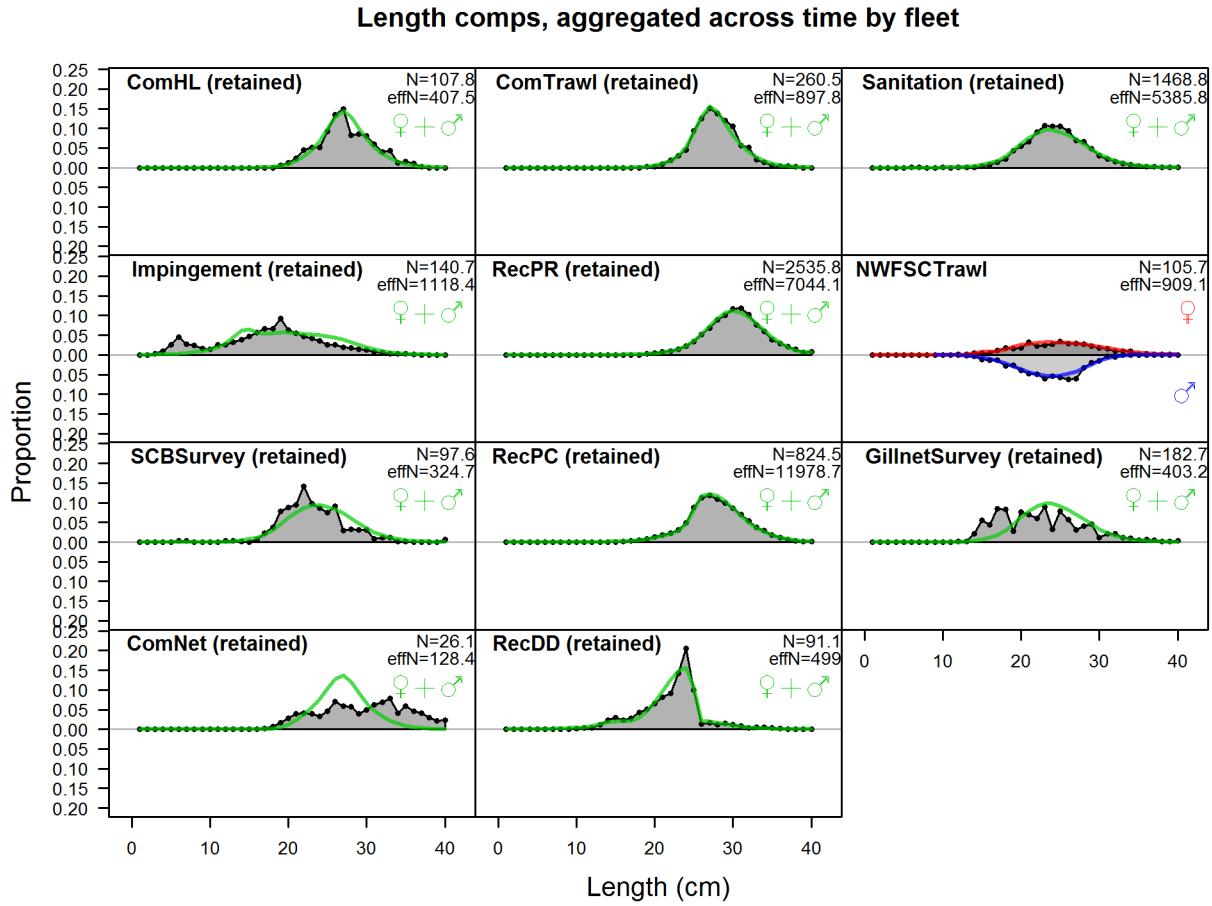


Figure 65: Length compositions aggregated across time by fleet. Labels ‘retained’ and ‘discard’ indicate retained or discarded samples for each fleet. Panels without this designation represent the whole catch.

Conditional AAL plot, whole catch, NWFSC Trawl

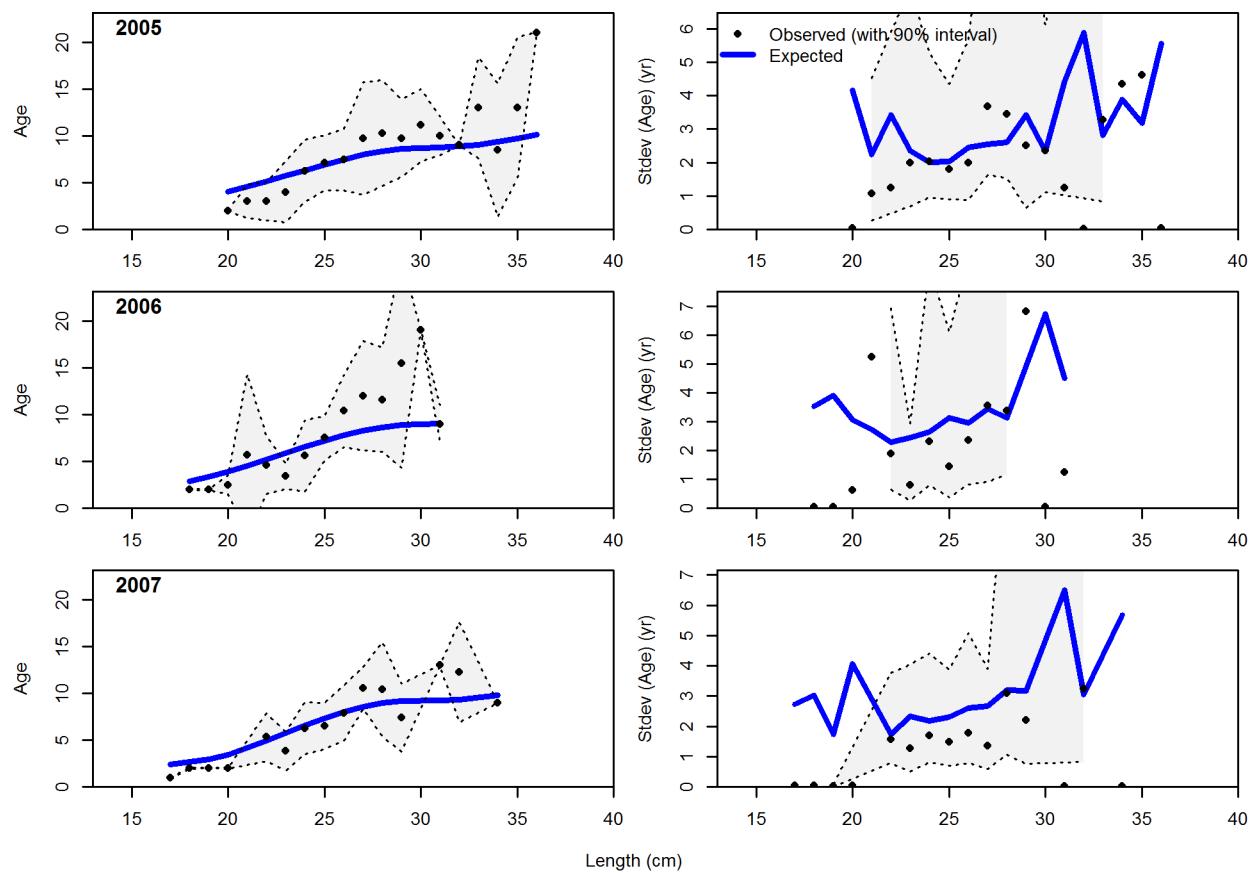
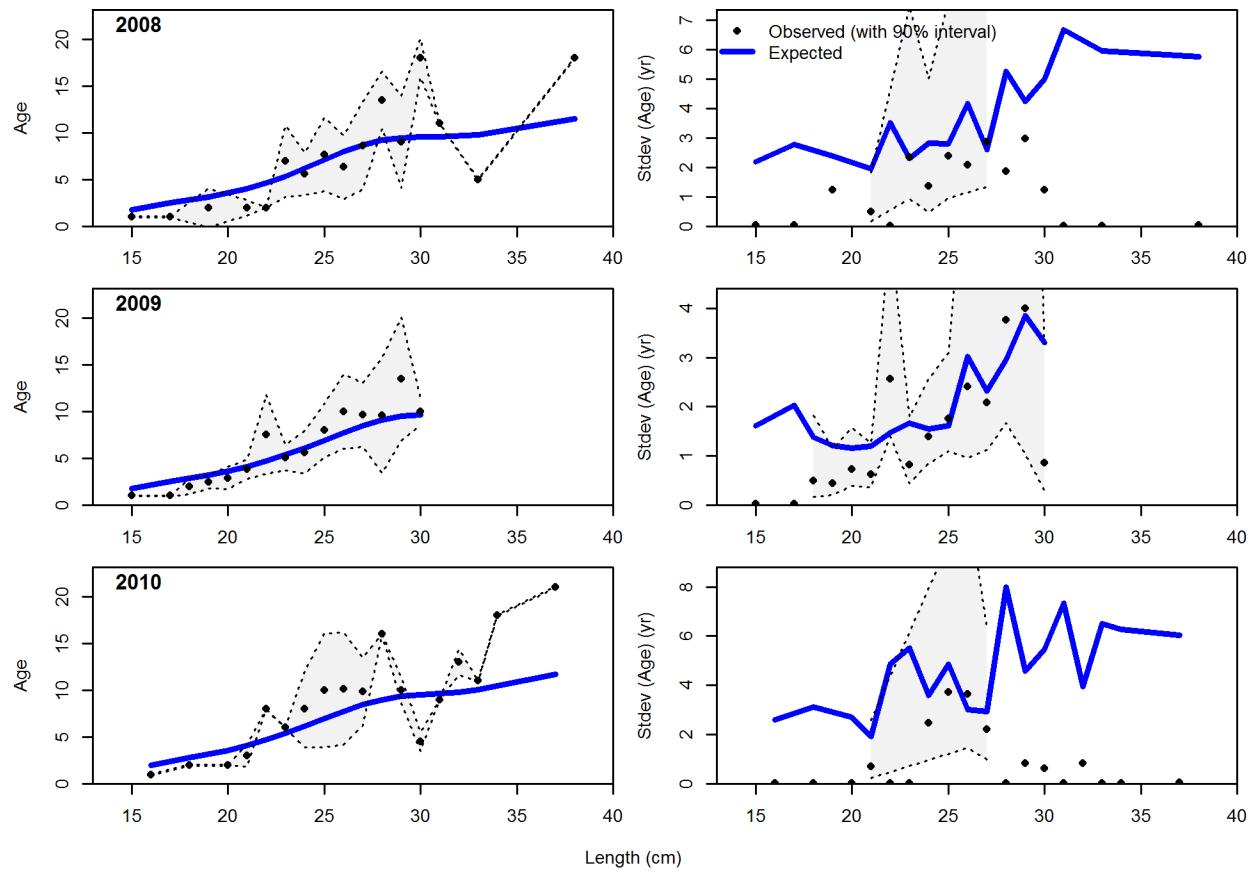


Figure 66: Conditional AAL plot, whole catch, NWFSC Trawl (plot 1 of 4) These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.) with 90% CIs based on the chi_square distribution.

Conditional AAL plot, whole catch, NWFSC Trawl

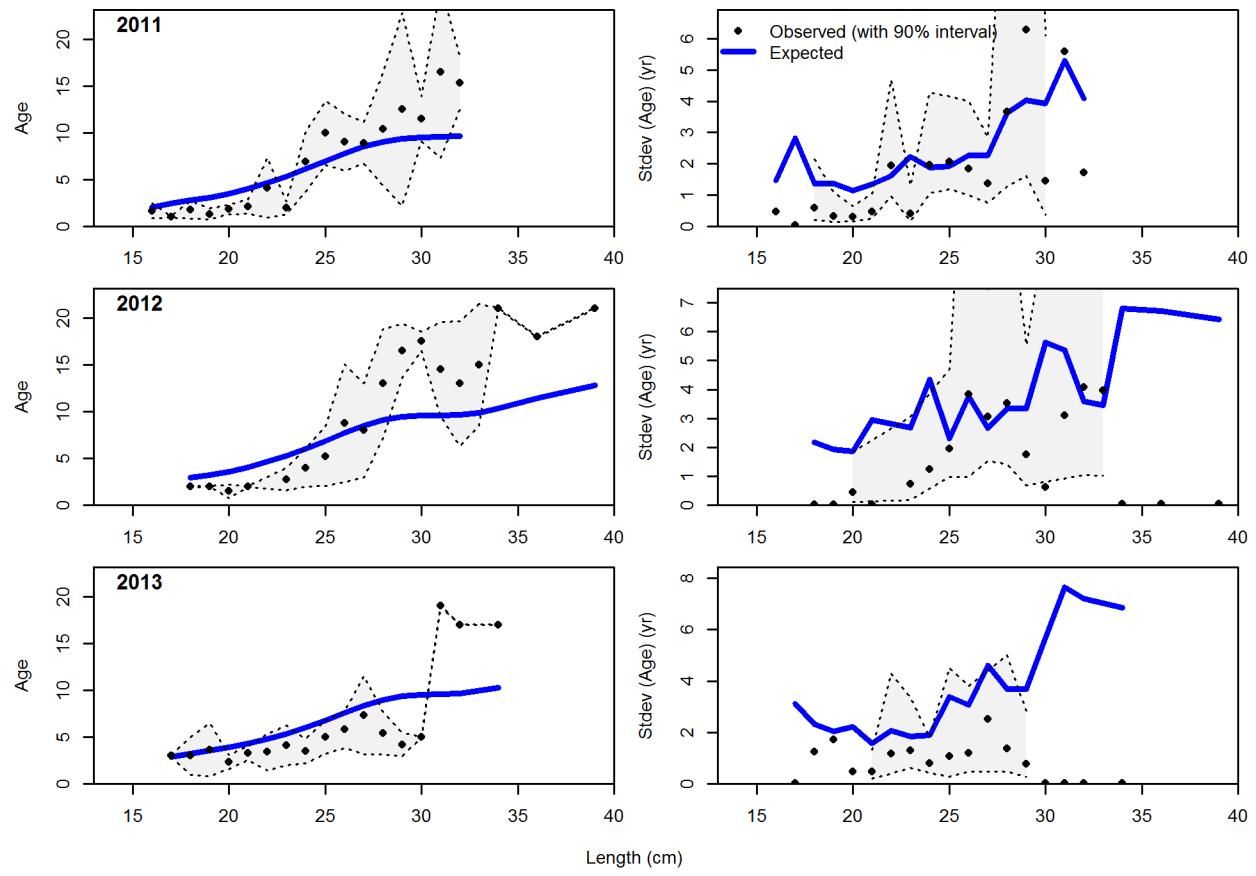


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Conditional AAL plot, whole catch, NWFSC Trawl

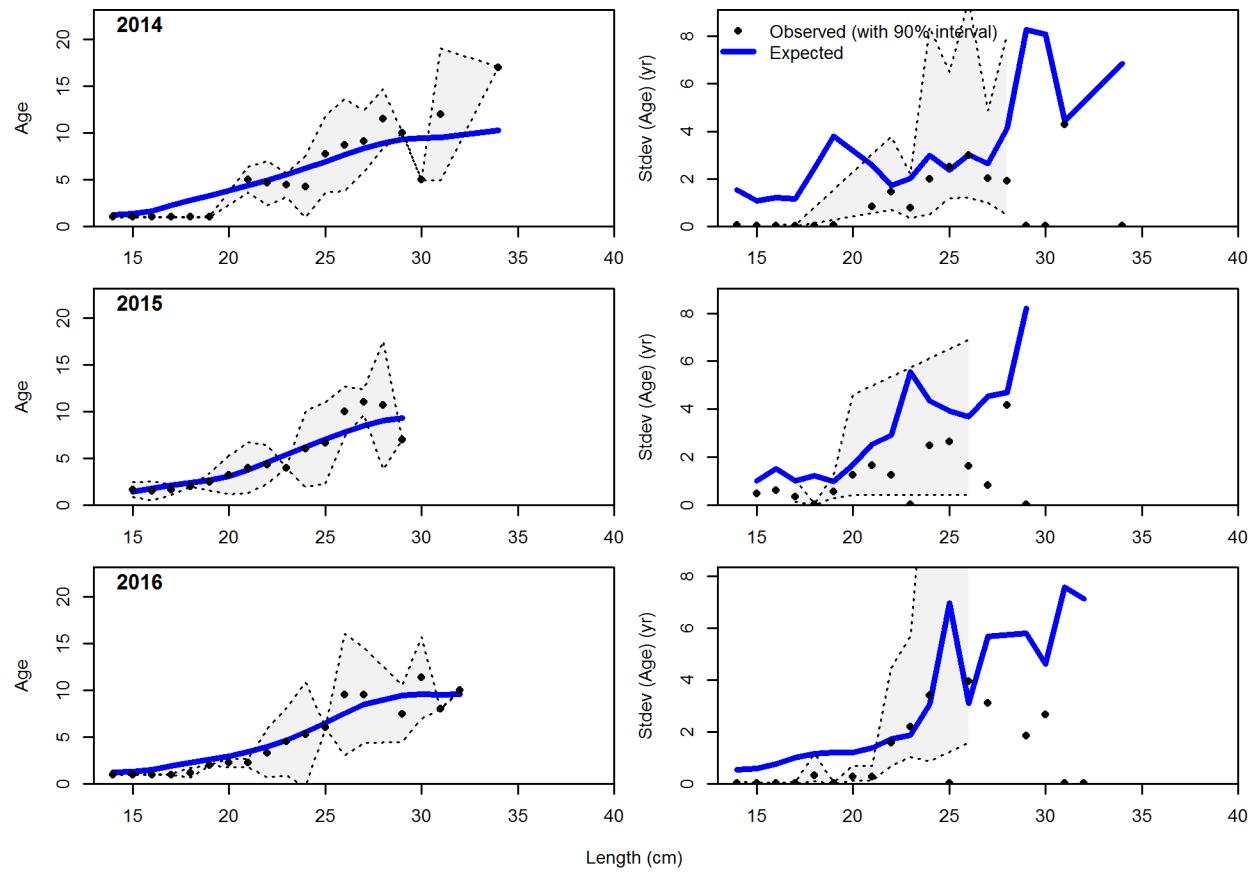


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Conditional AAL plot, whole catch, NWFSC Trawl



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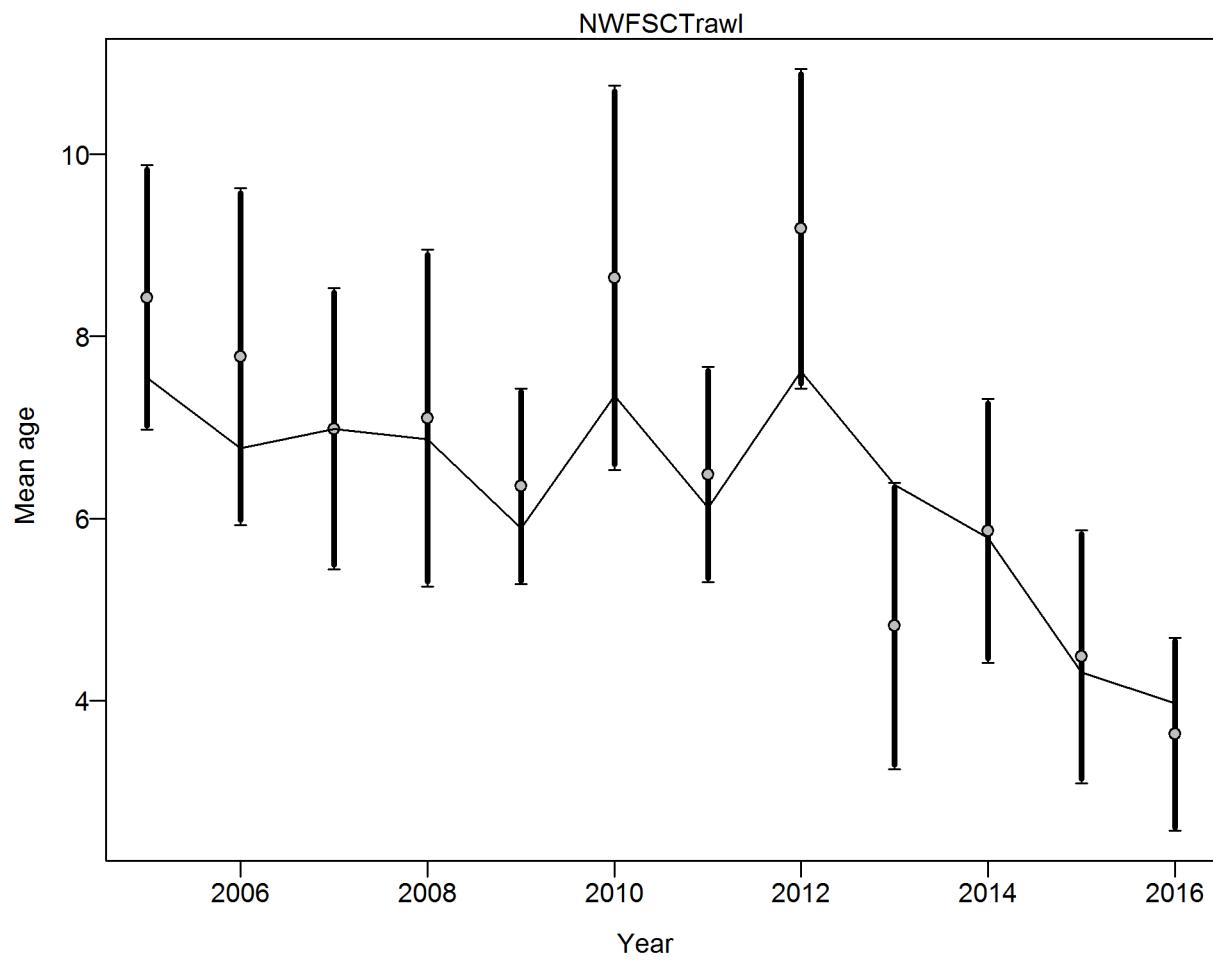


Figure 67: Francis data weighting method TA1.8 for conditional age data from the NWFSC trawl survey. Suggested sample size adjustment (with 95% interval) for conditional age-at-length data from NWFSC trawl is 0.9373 (0.4951-3.7346). For more info, see Francis et al. (2011).

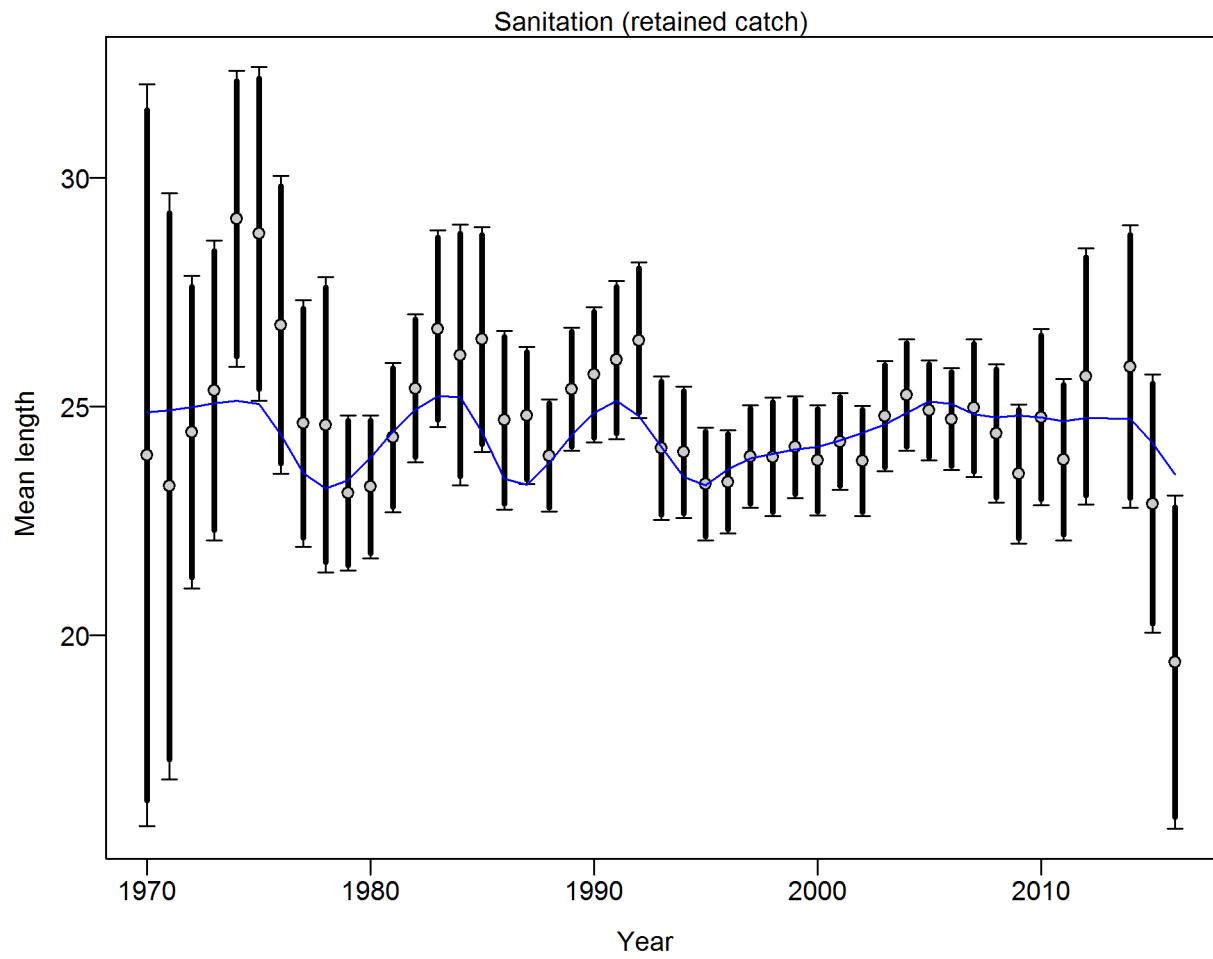


Figure 68: Francis data weighting method TA1.8 for length composition data from the Sanitation district surveys. Suggested sample size adjustment (with 95% interval) for length data from Sanitation surveys is 0.8665 (0.6162-1.3836). For more info, see Francis et al. (2011).

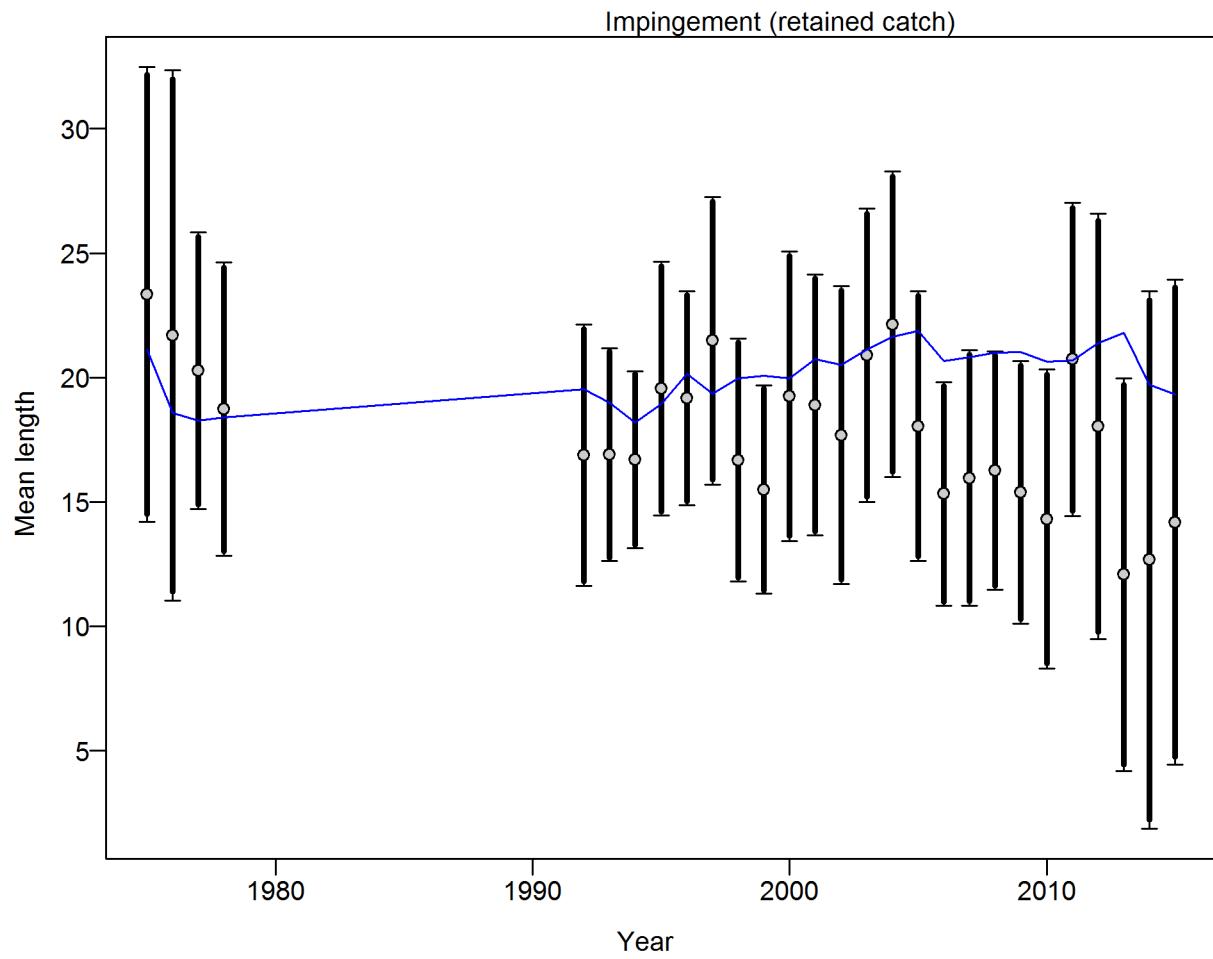


Figure 69: Francis data weighting method TA1.8 for length composition data from the Impingement surveys. Suggested sample size adjustment (with 95% interval) for the length data from the Impingement surveys is 0.9356 (0.7114-1.5026). For more info, see Francis et al. (2011).

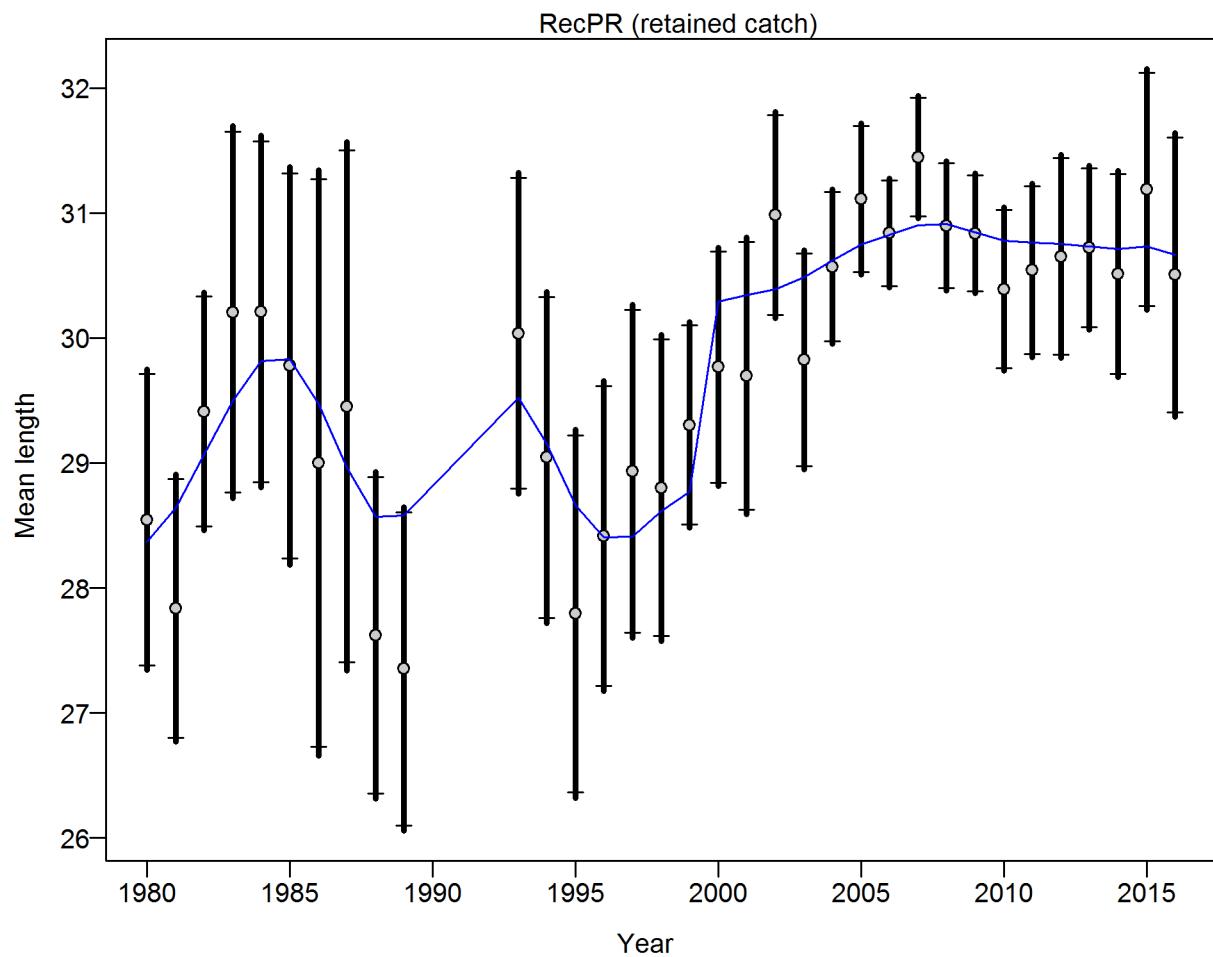


Figure 70: Francis data weighting method TA1.8 for length composition data from the recreational private boat fleet. Suggested sample size adjustment (with 95% interval) for the length data from the recreational private boat fleet is 1.0655 (0.7368-1.7486). For more info, see Francis et al. (2011).

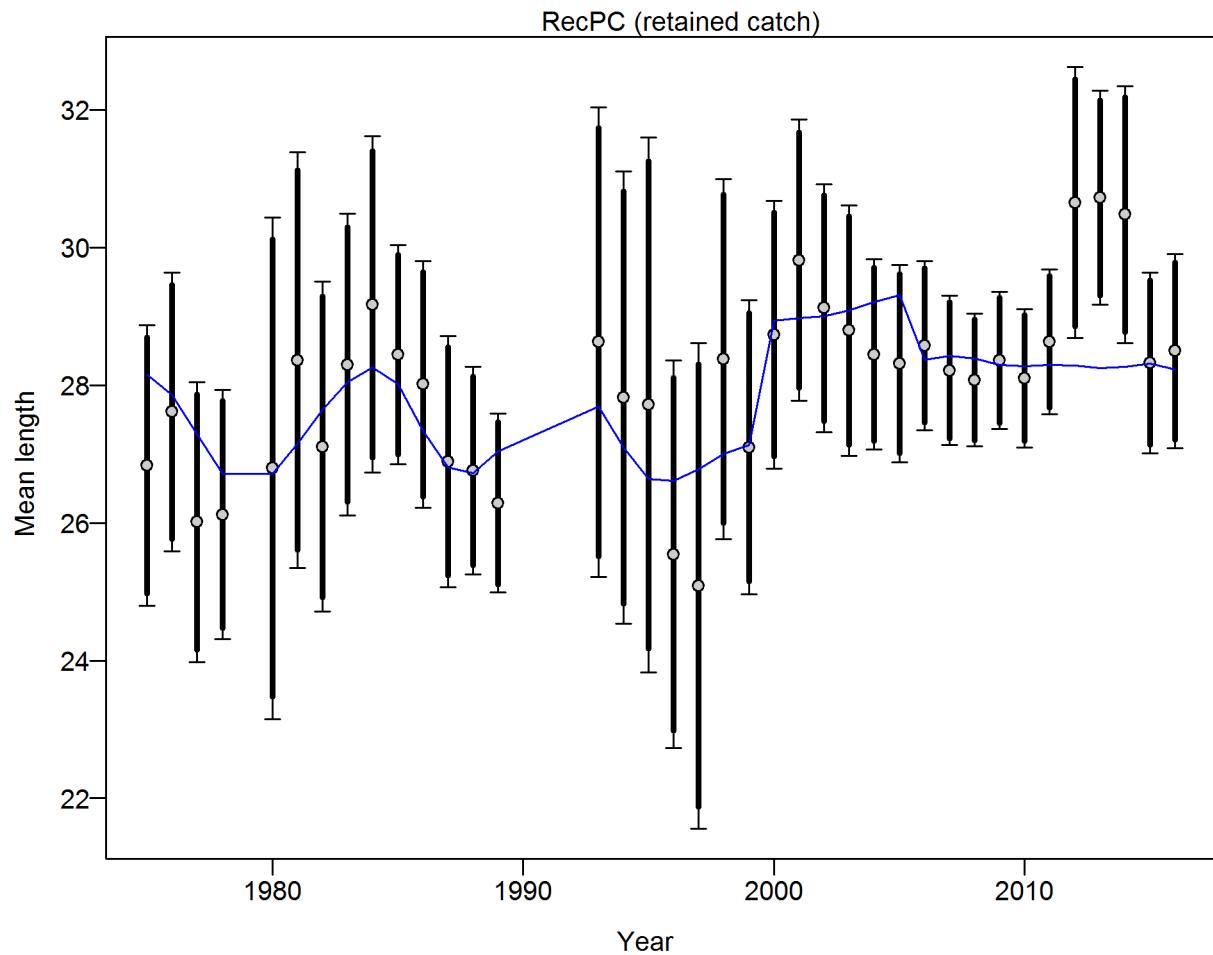


Figure 71: Francis data weighting method TA1.8 for conditional age data from the recreational party/charter retained-catch fleet. Suggested sample size adjustment (with 95% interval) for the length data from the recreational party/charter retained-catch fleet is 0.832 (0.5086-1.8822). For more info, see Francis et al. (2011).

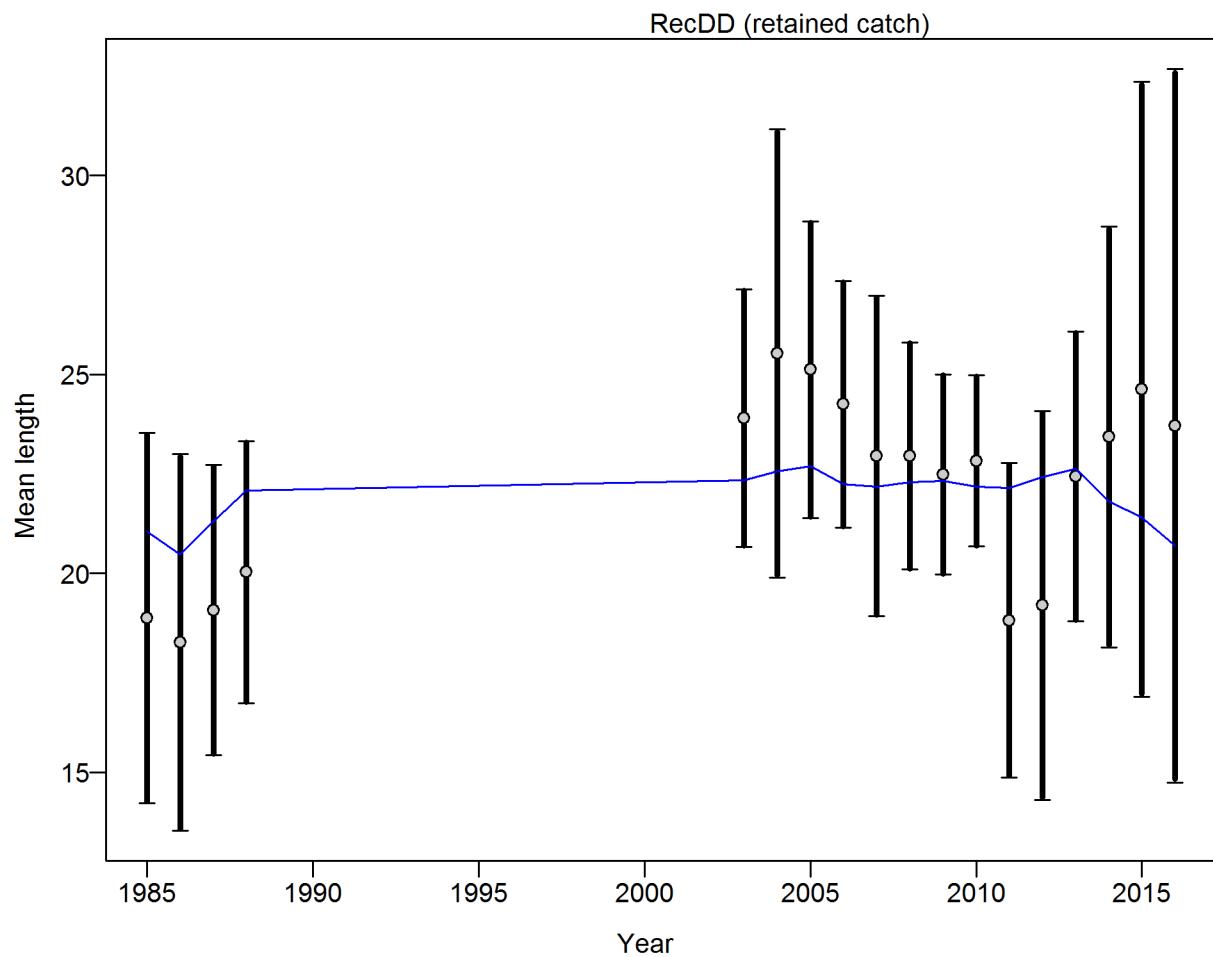


Figure 72: Francis data weighting method TA1.8 for conditional age data from the recreational discard-catch fleet. Suggested sample size adjustment (with 95% interval) for the length data from the recreational discard-catch fleet is 0.9793 (0.7467-1.8748). For more info, see Francis et al. (2011).

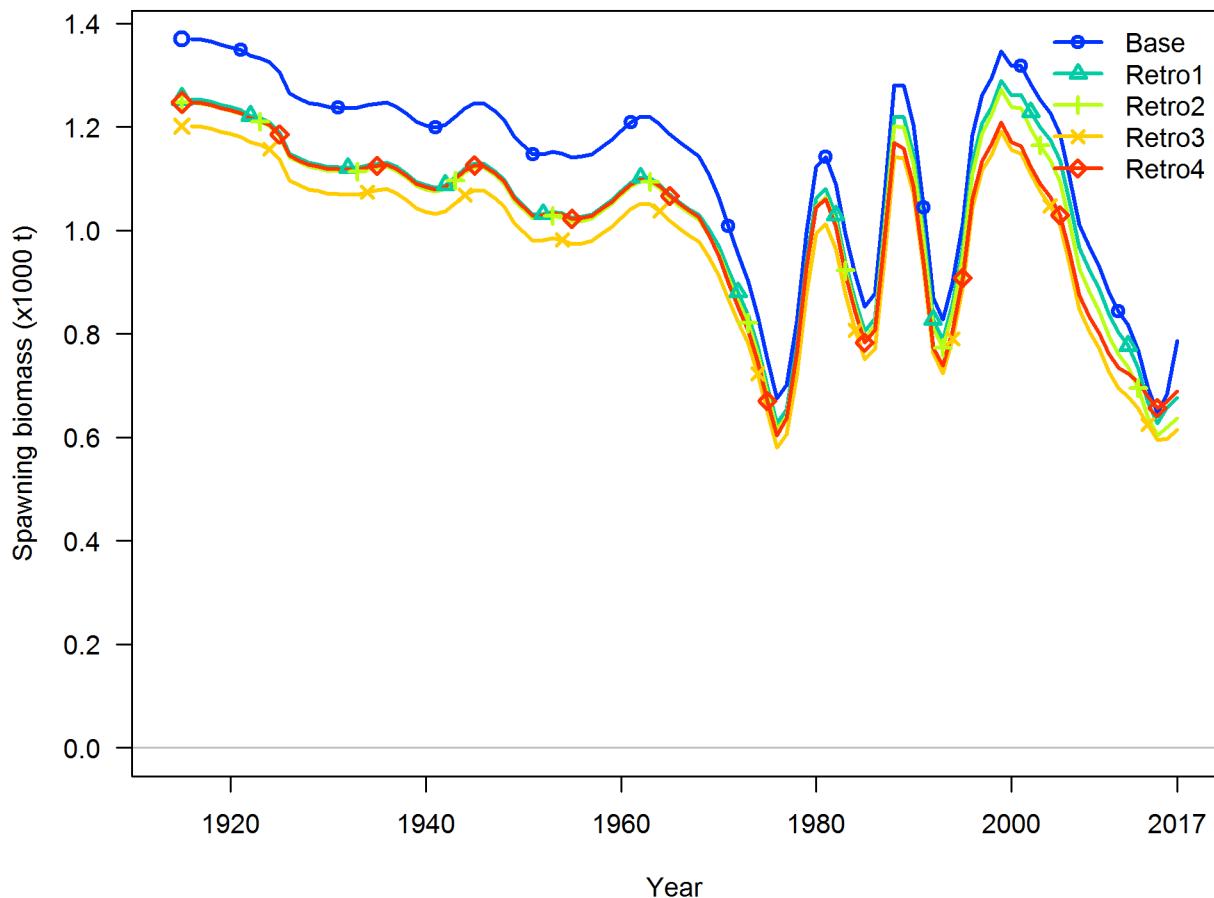


Figure 73: Retrospective pattern for spawning output.

1895 fig:retro_recdev

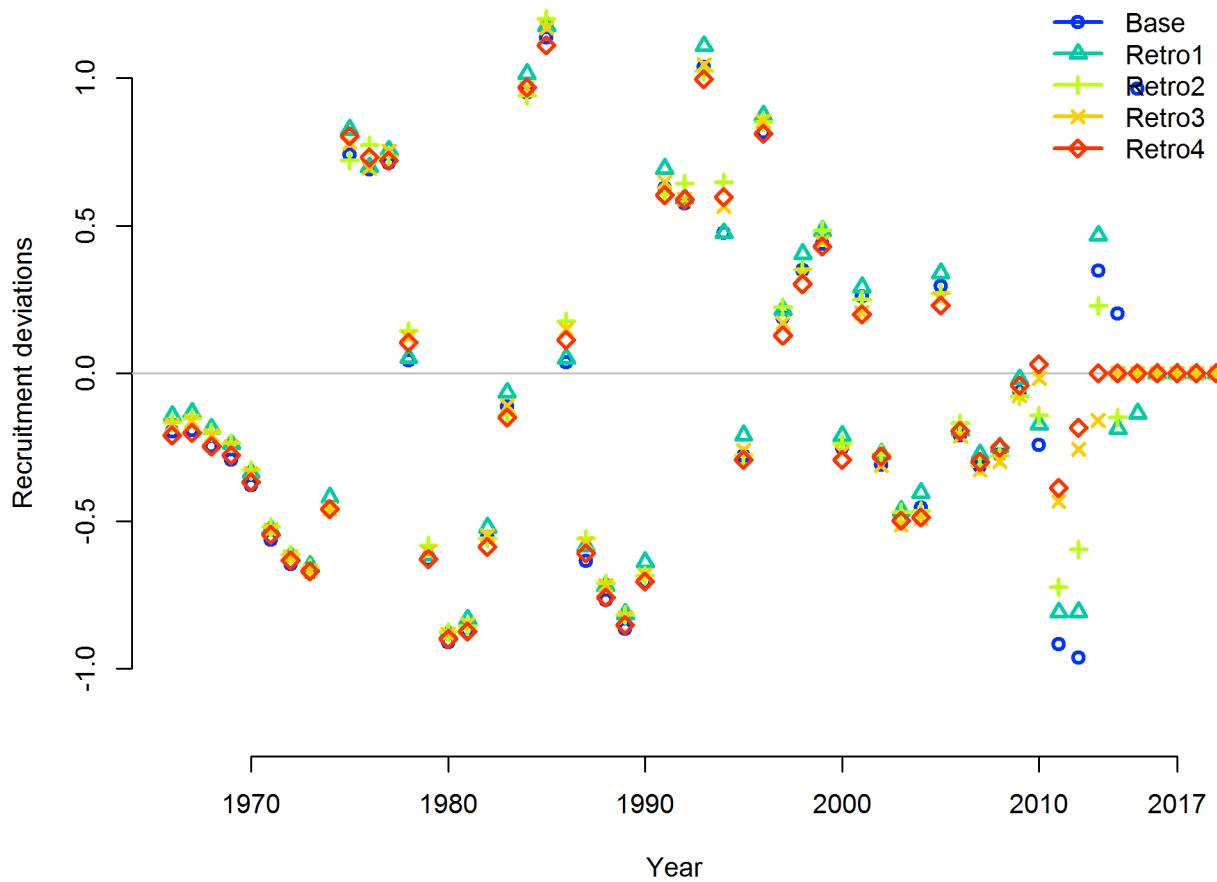


Figure 74: Retrospective pattern for estimated recruitment deviations.

Changes in length-composition likelihoods by fleet

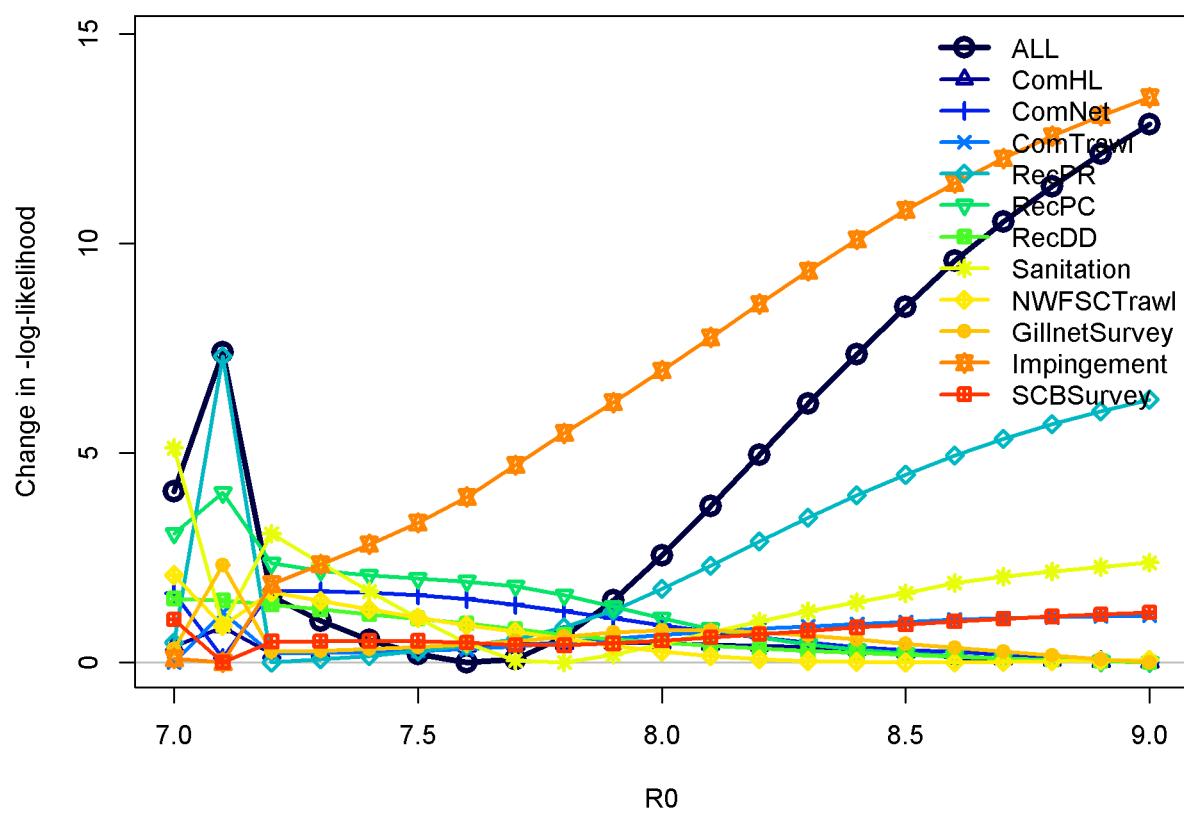


Figure 75: Likelihood profile across R_0 values by fleet.

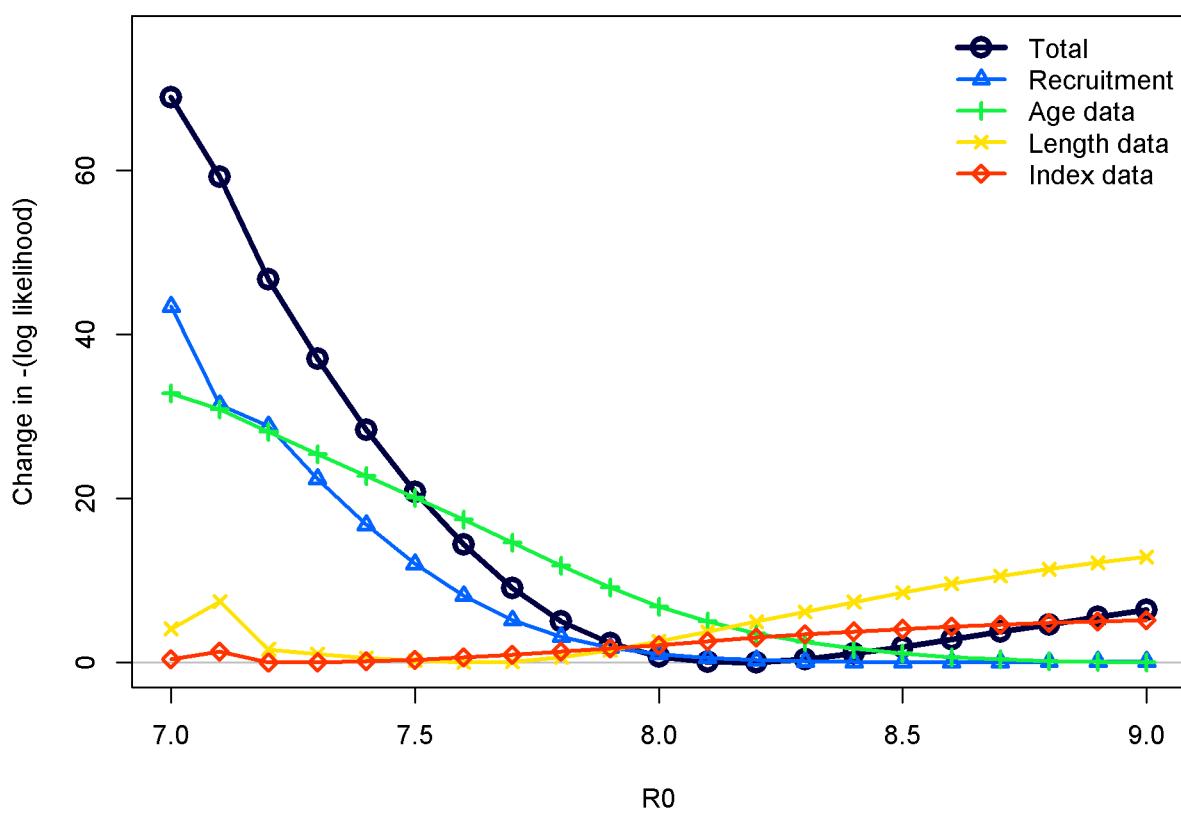


Figure 76: Likelihood profile across R_0 values for each data type.

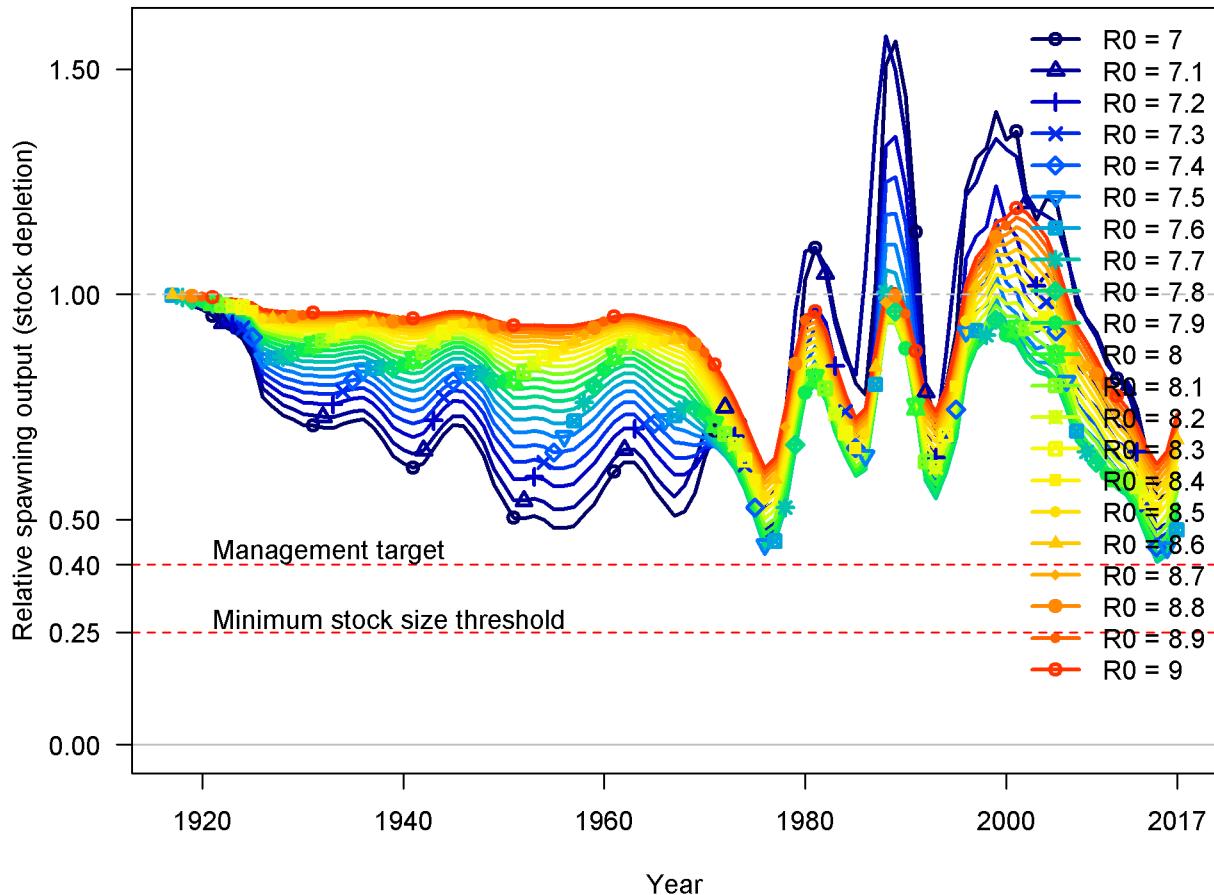


Figure 77: Trajectories of depletion across values of R_0 .

Changes in length-composition likelihoods by fleet

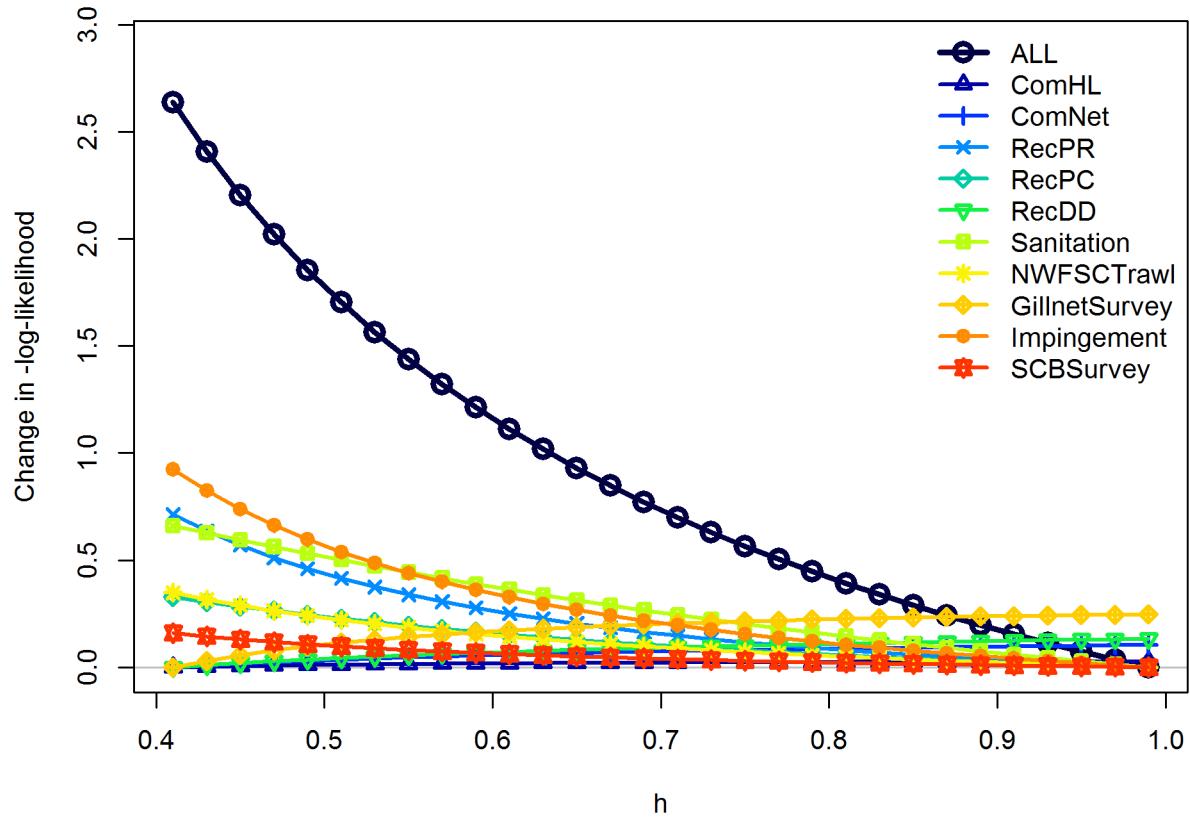


Figure 78: Likelihood profile across steepness values by fleet.

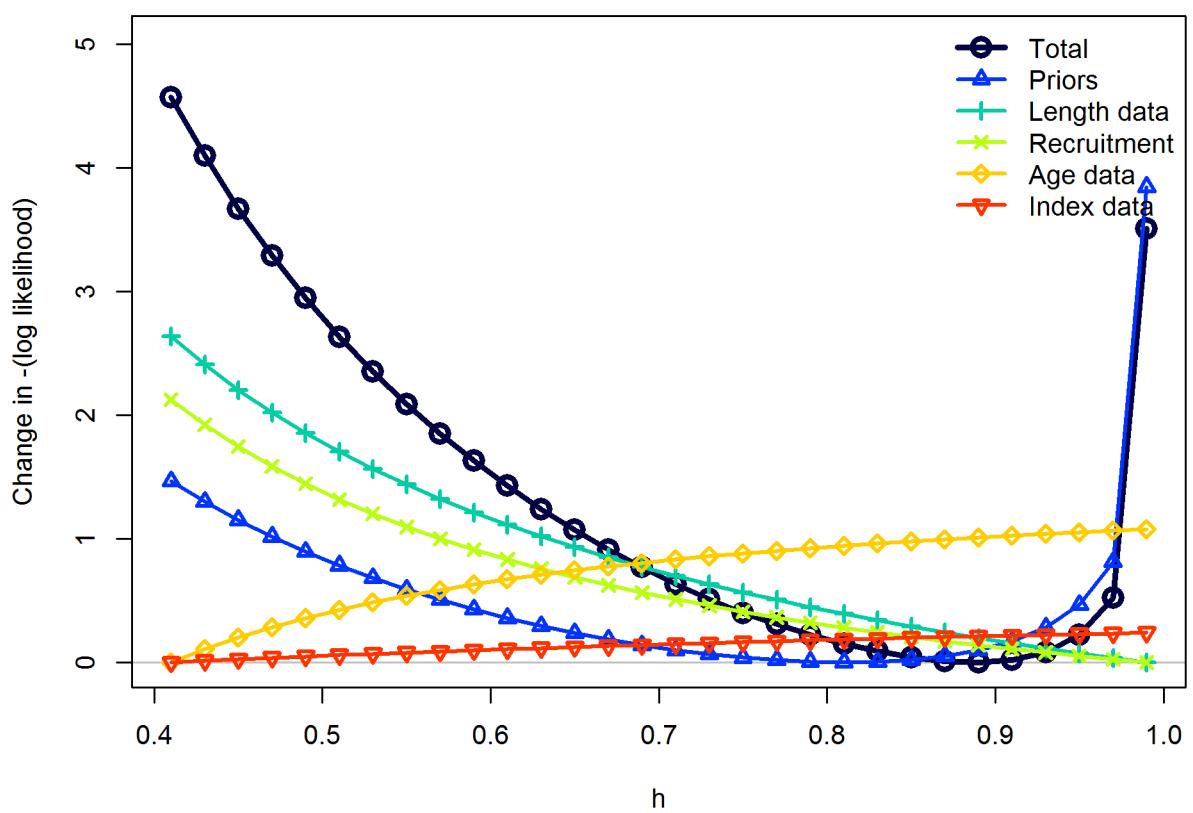


Figure 79: Likelihood profile across steepness values for each data type.

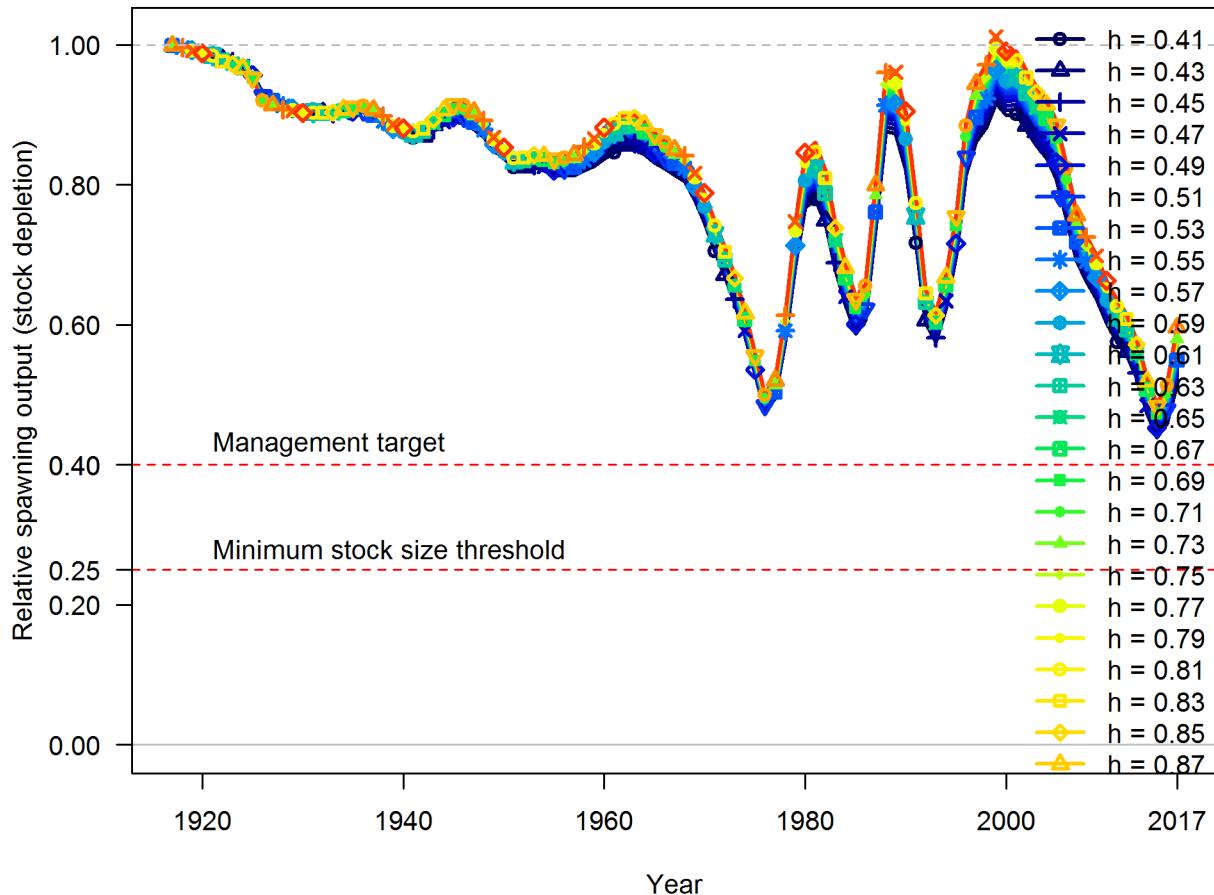


Figure 80: Trajectories of depletion across values of steepness.

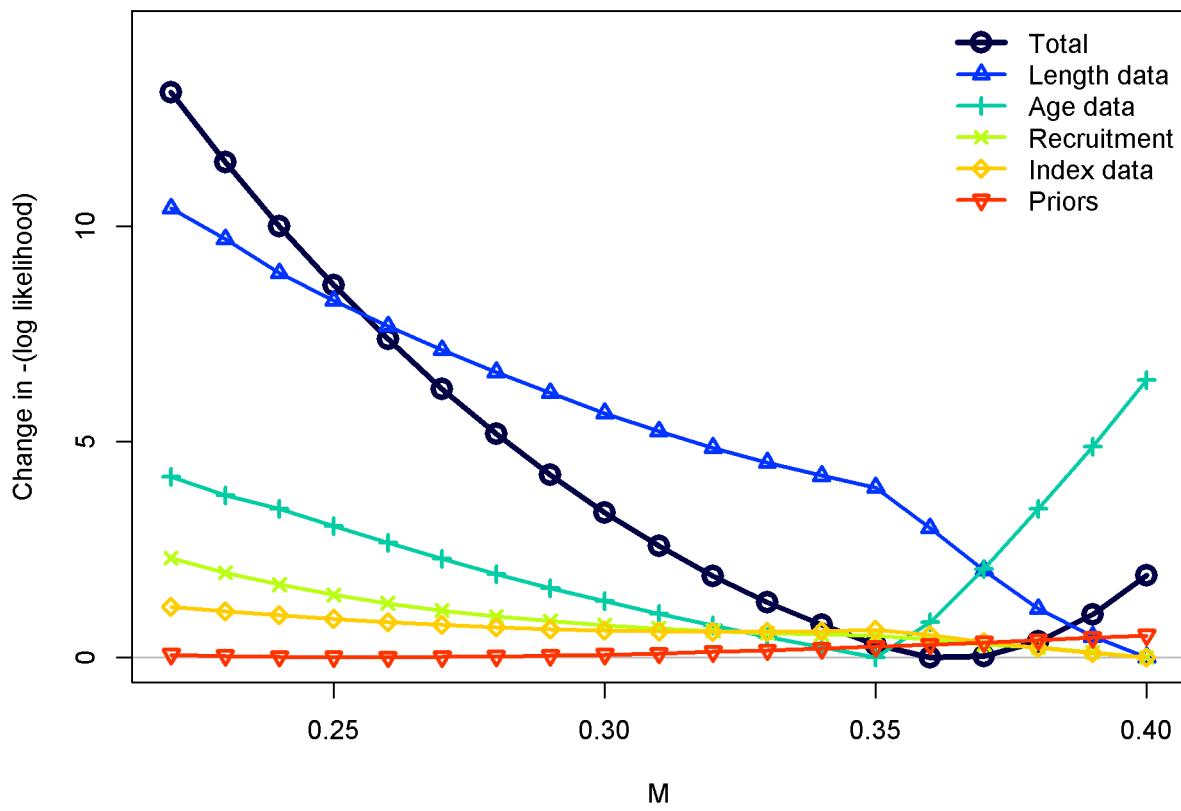


Figure 81: Likelihood profile across female natural mortality values for each data type.

Changes in length-composition likelihoods by fleet

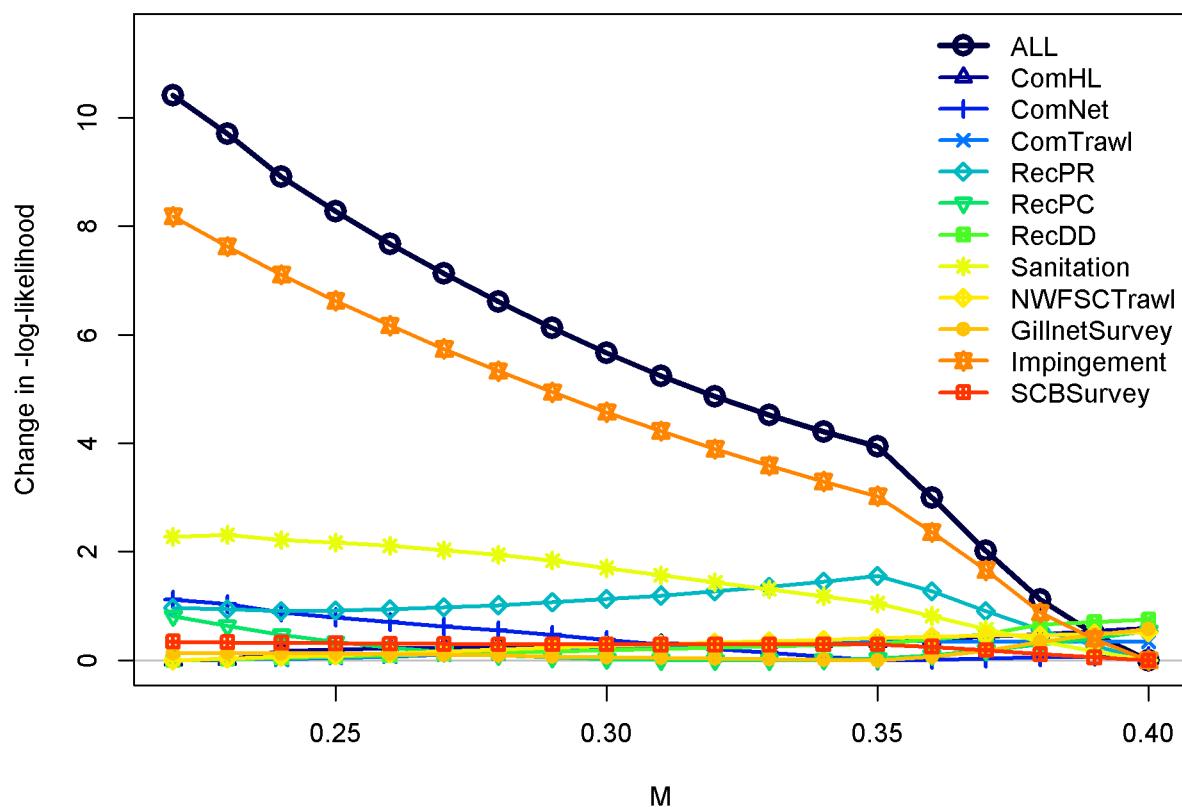


Figure 82: Likelihood profile across female natural mortality values by fleet.

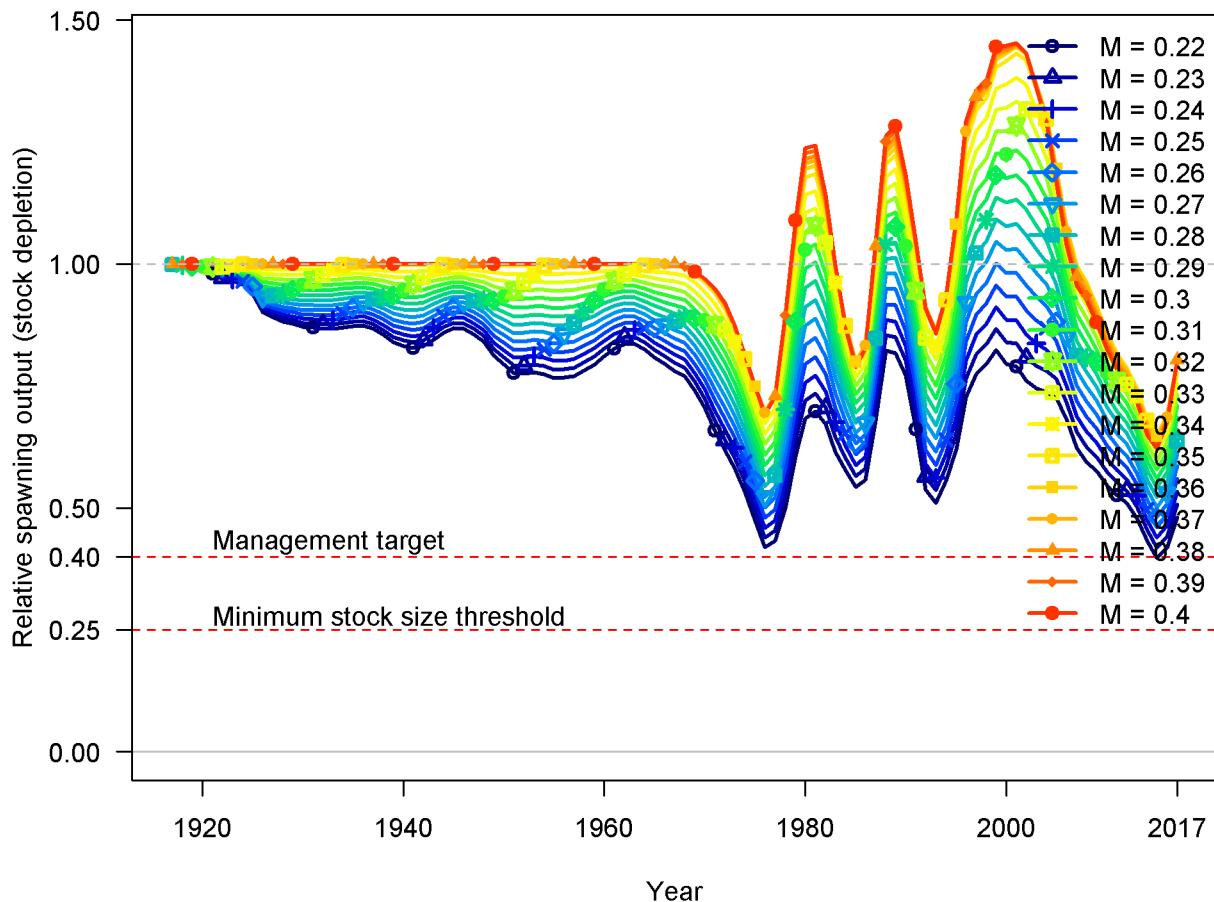


Figure 83: Trajectories of depletion across values of female natural mortality.

Spawning biomass (mt) with ~95% asymptotic intervals

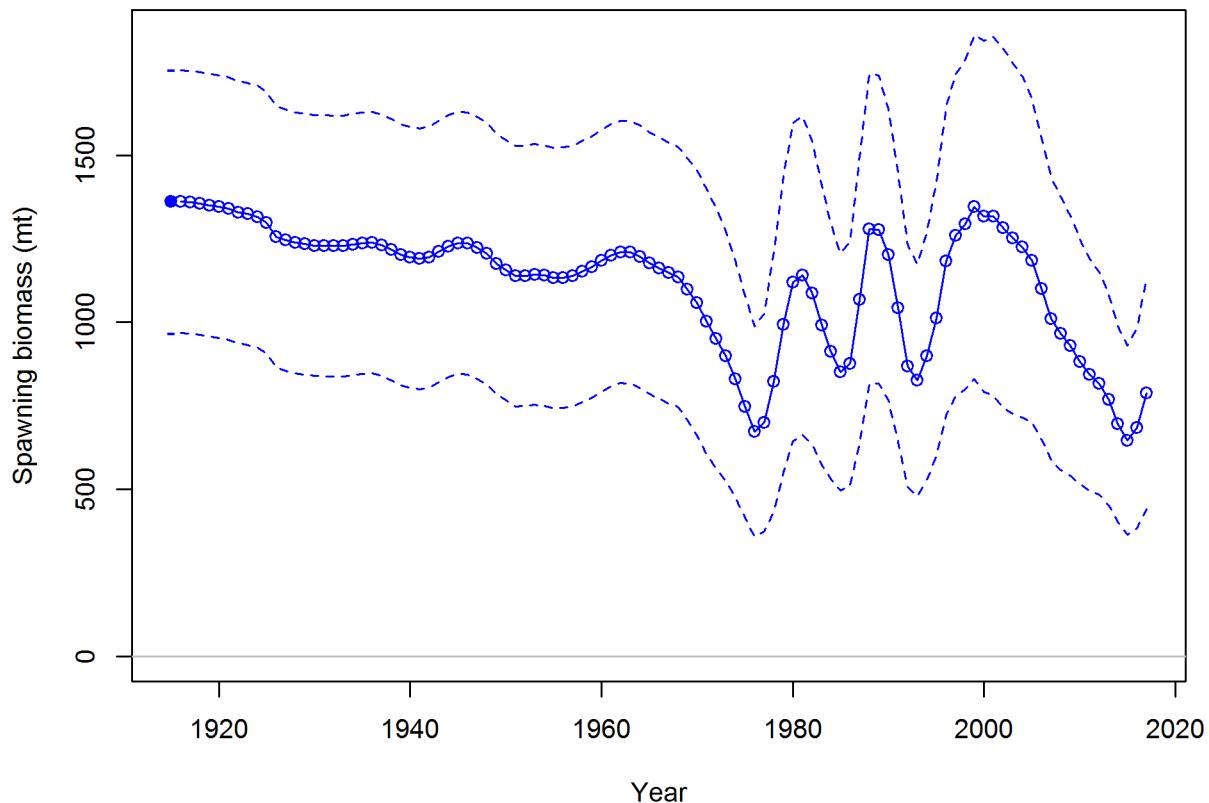


Figure 84: Estimated spawning biomass (mt) with approximate 95% asymptotic intervals.

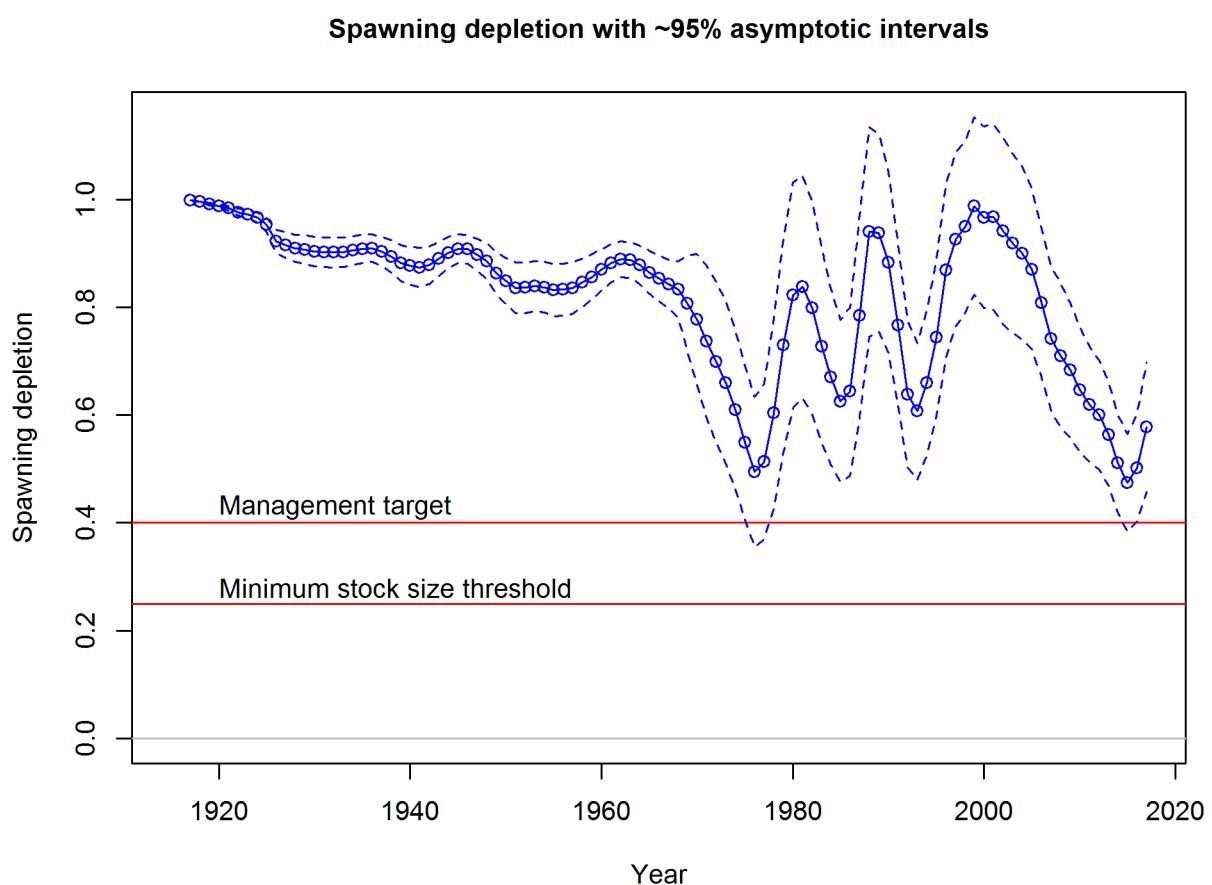


Figure 85: Estimated spawning depletion with approximate 95% asymptotic intervals.

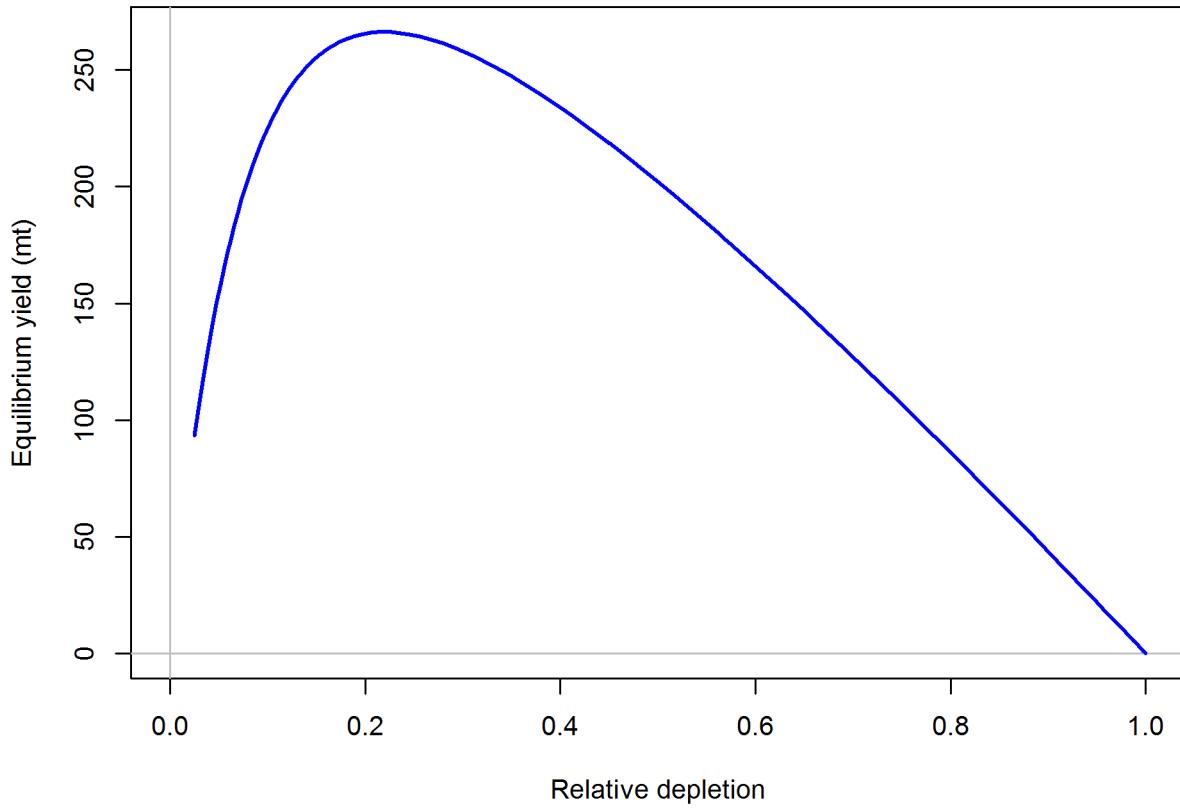


Figure 86: Equilibrium yield curve for the base case model. Values are based on the 2016 fishery selectivity and with steepness fixed at .

1896 **Appendix A. Detailed fits to length composition data**

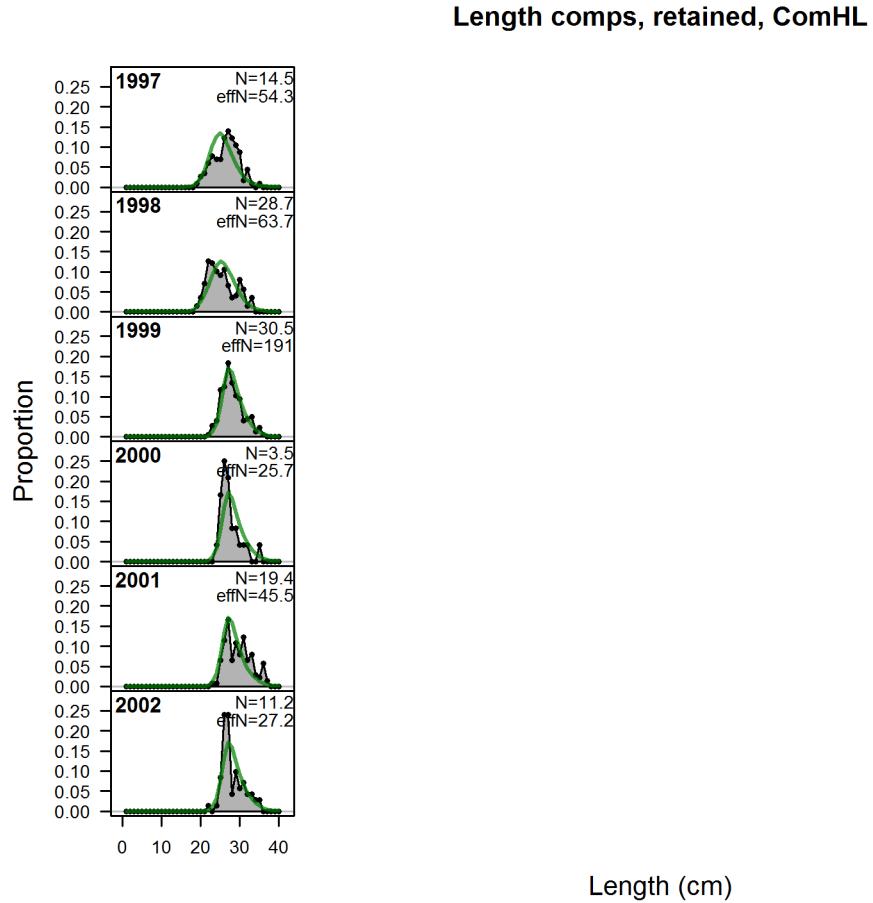


Figure A87: Length comps, retained, ComHL

Length comps, retained, ComNet

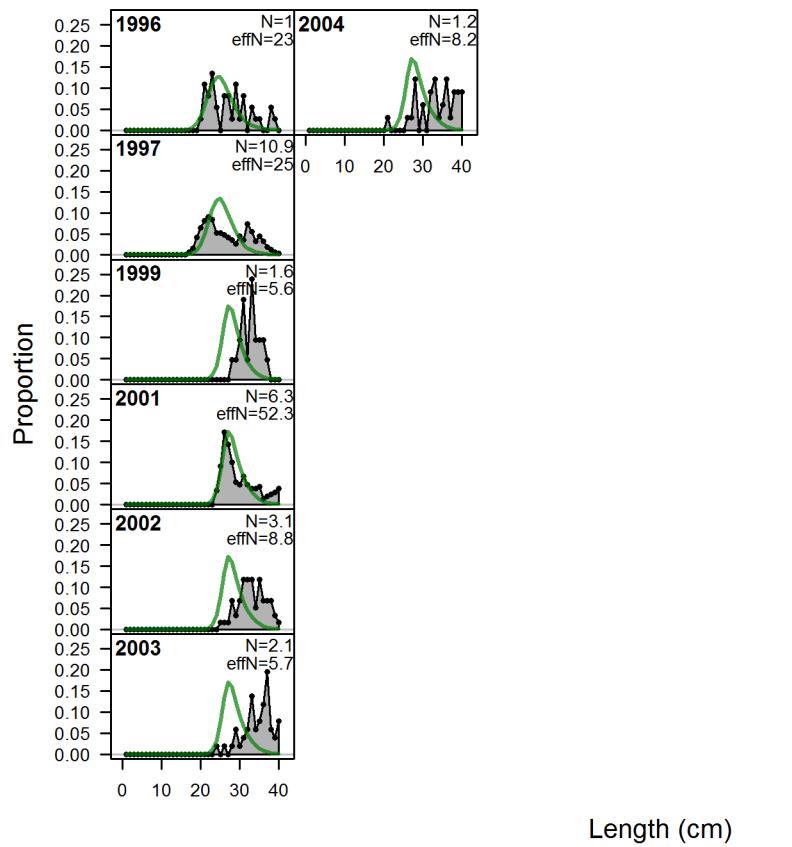


Figure A88: Length comps, retained, ComNet

Length comps, retained, ComTrawl

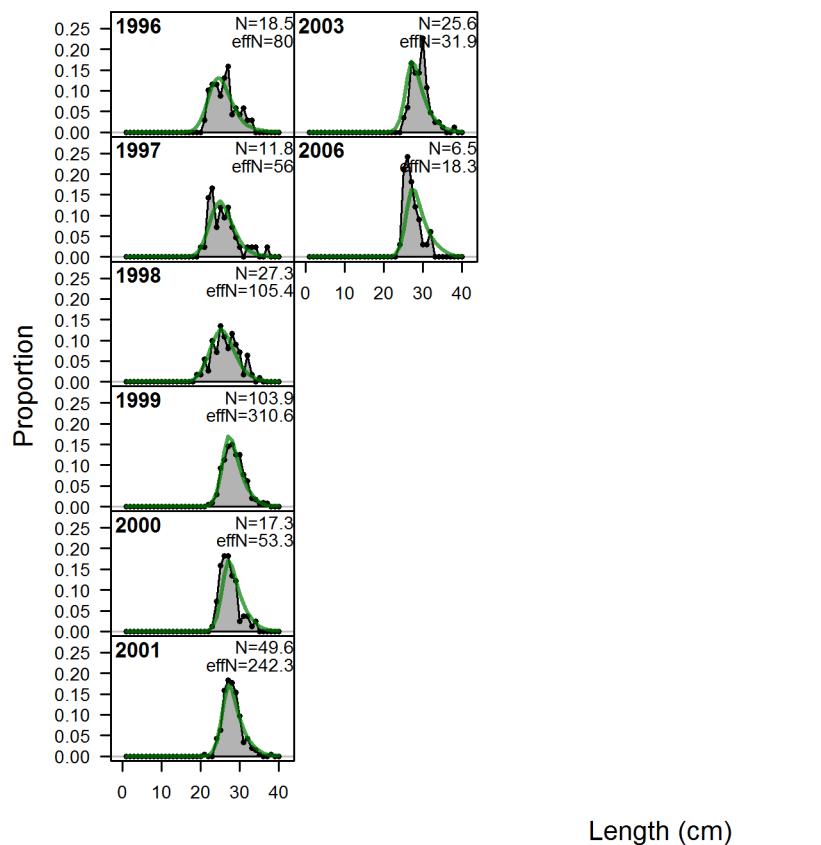


Figure A89: Length comps, retained, ComTrawl

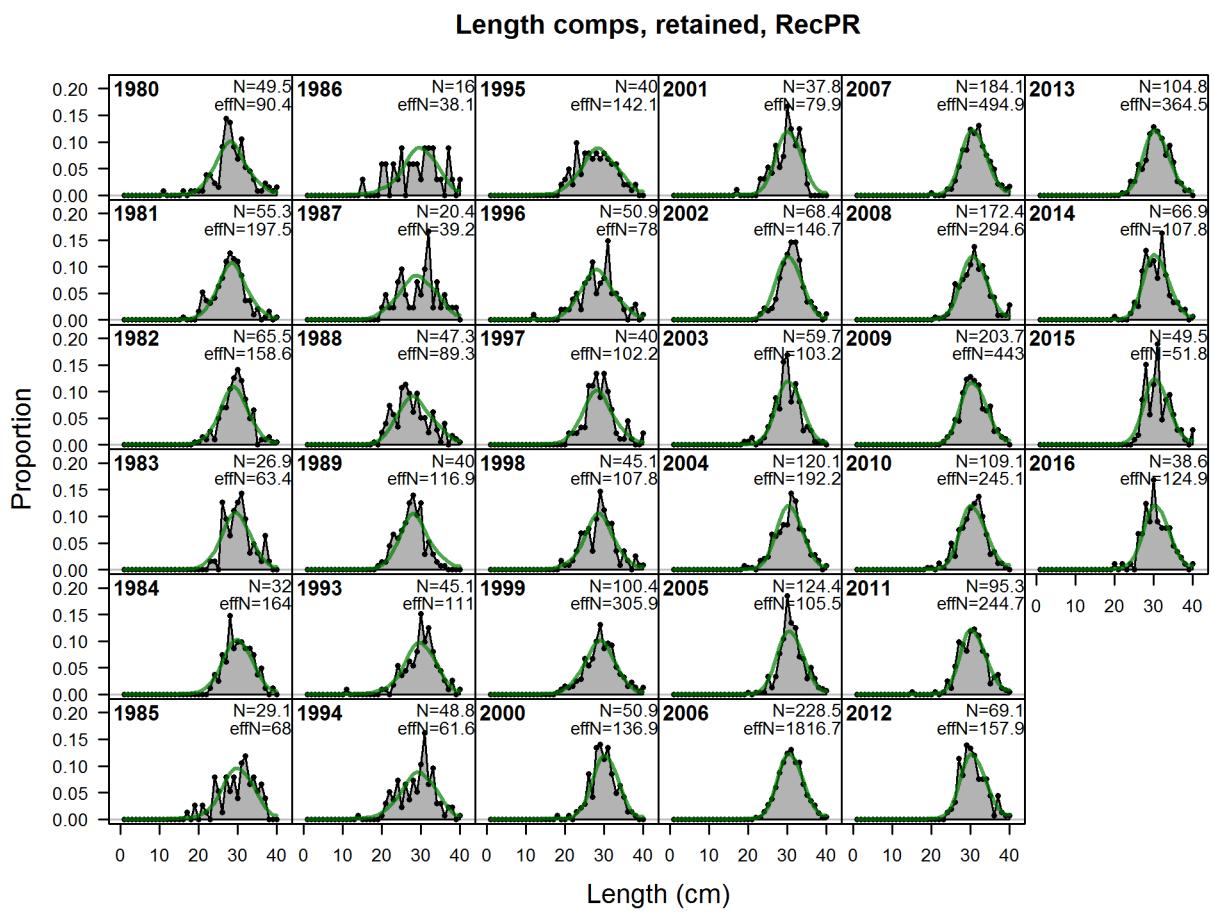


Figure A90: Length comps, retained, RecPR

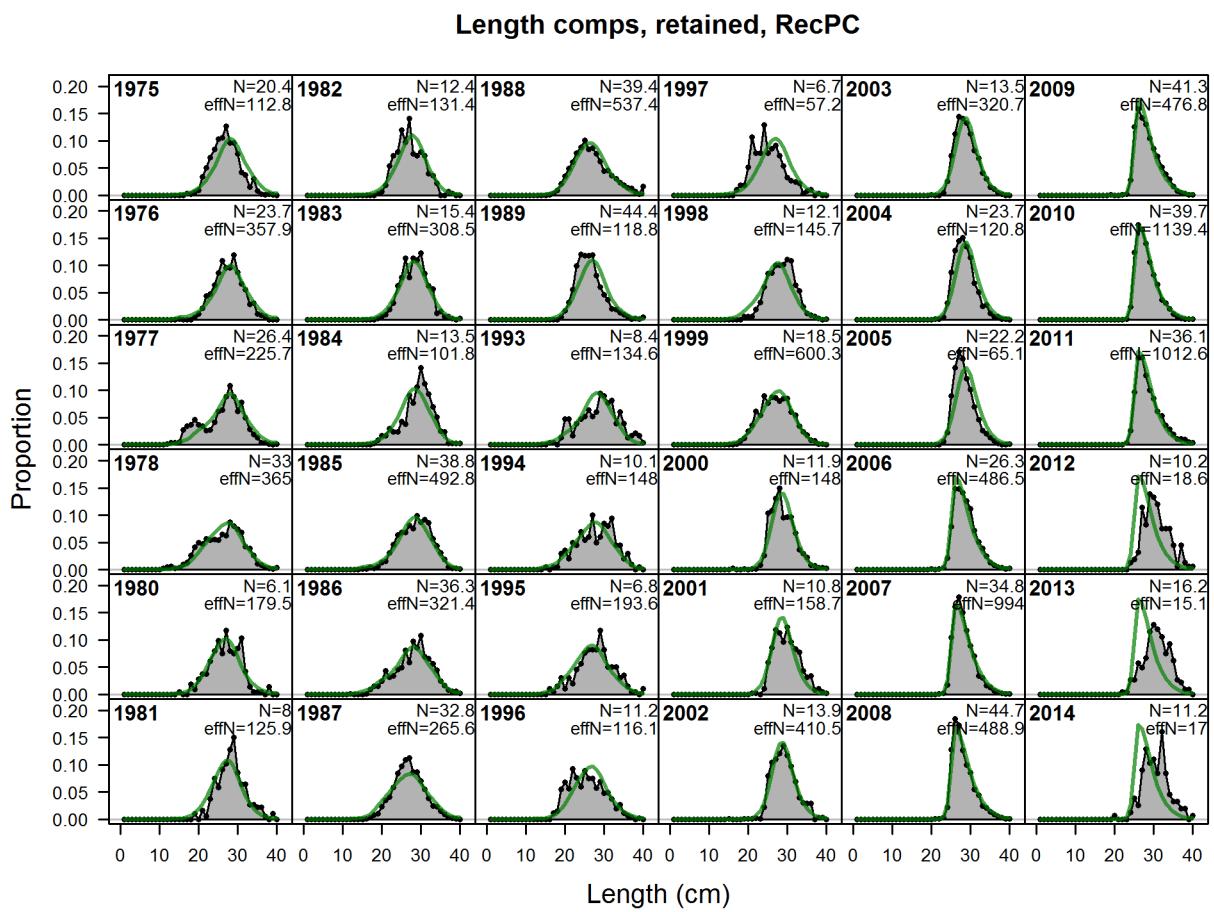
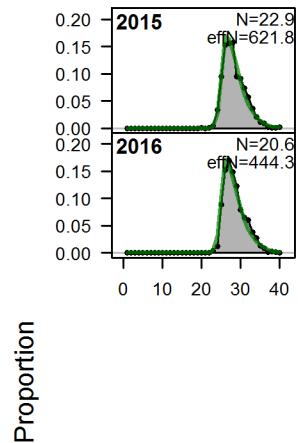


Figure A91: Length comps, retained, RecPC (plot 1 of 2)

Length comps, retained, RecPC



1897

Length (cm)

1898

Figure continued from previous page

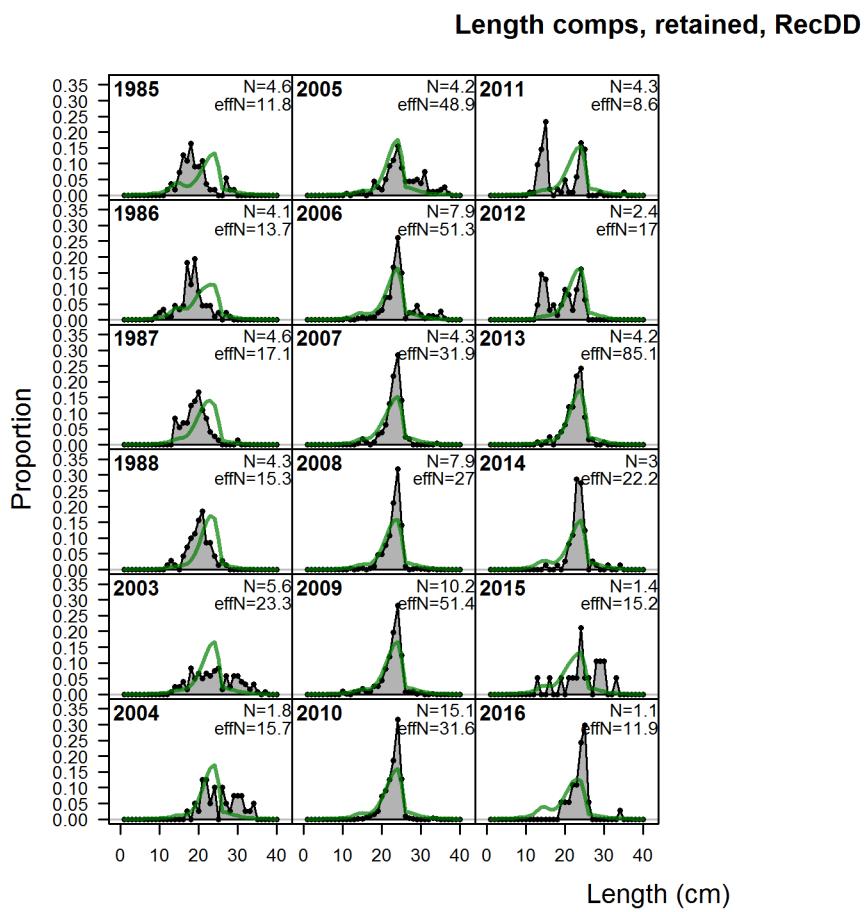


Figure A92: Length comps, retained, RecDD

Length comps, retained, Sanitation

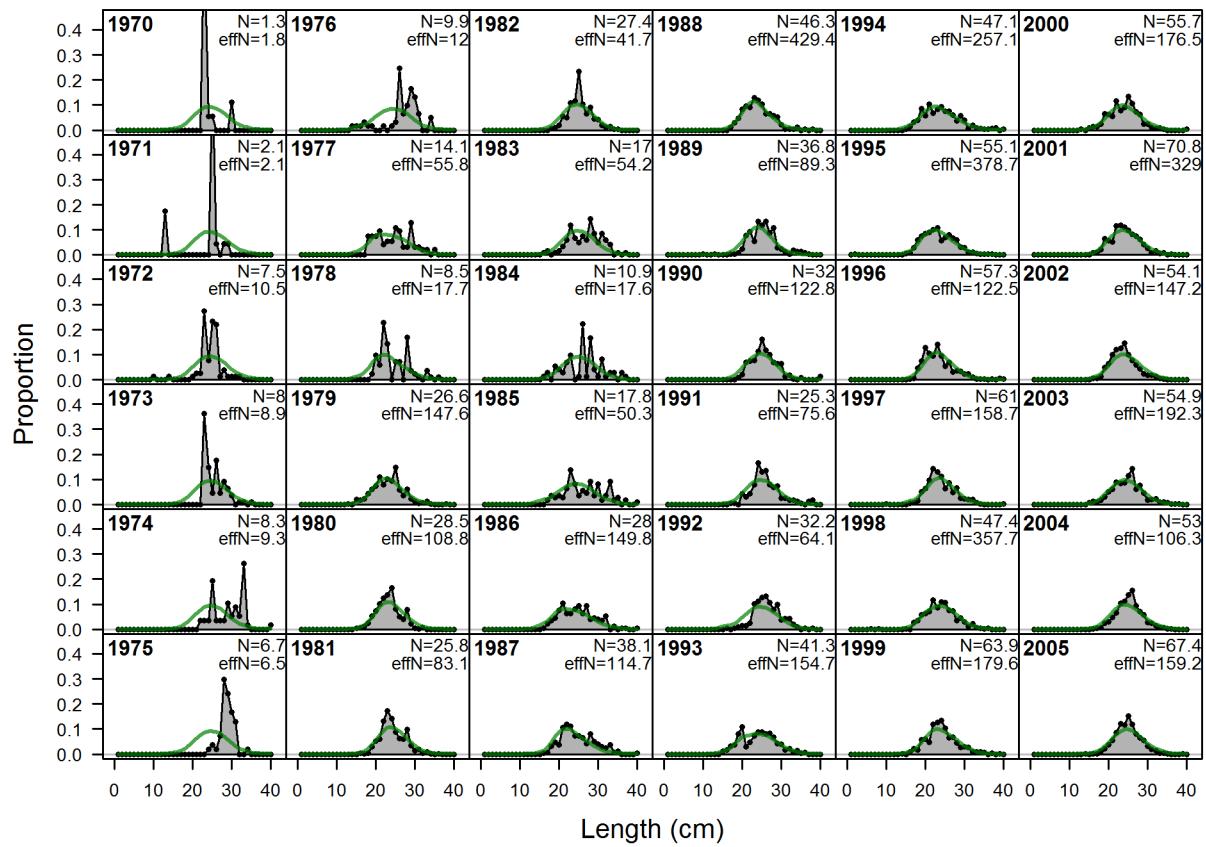
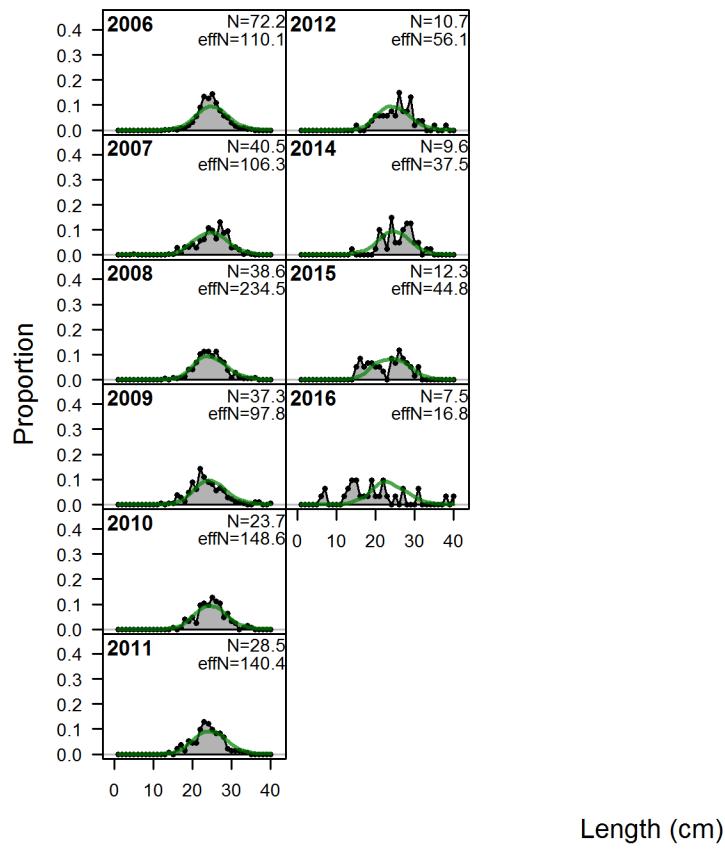


Figure A93: Length comps, retained, Sanitation (plot 1 of 2)

Length comps, retained, Sanitation



1899

1900

Figure continued from previous page

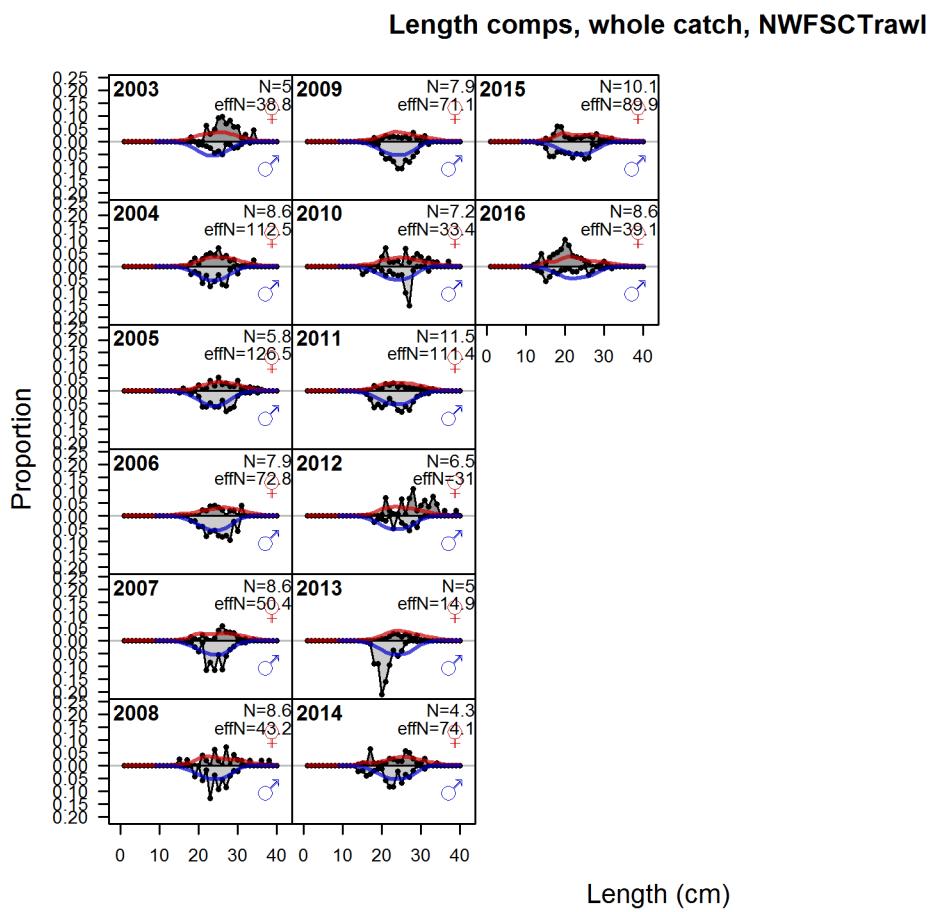


Figure A94: Length comps, whole catch, NWFSC Trawl

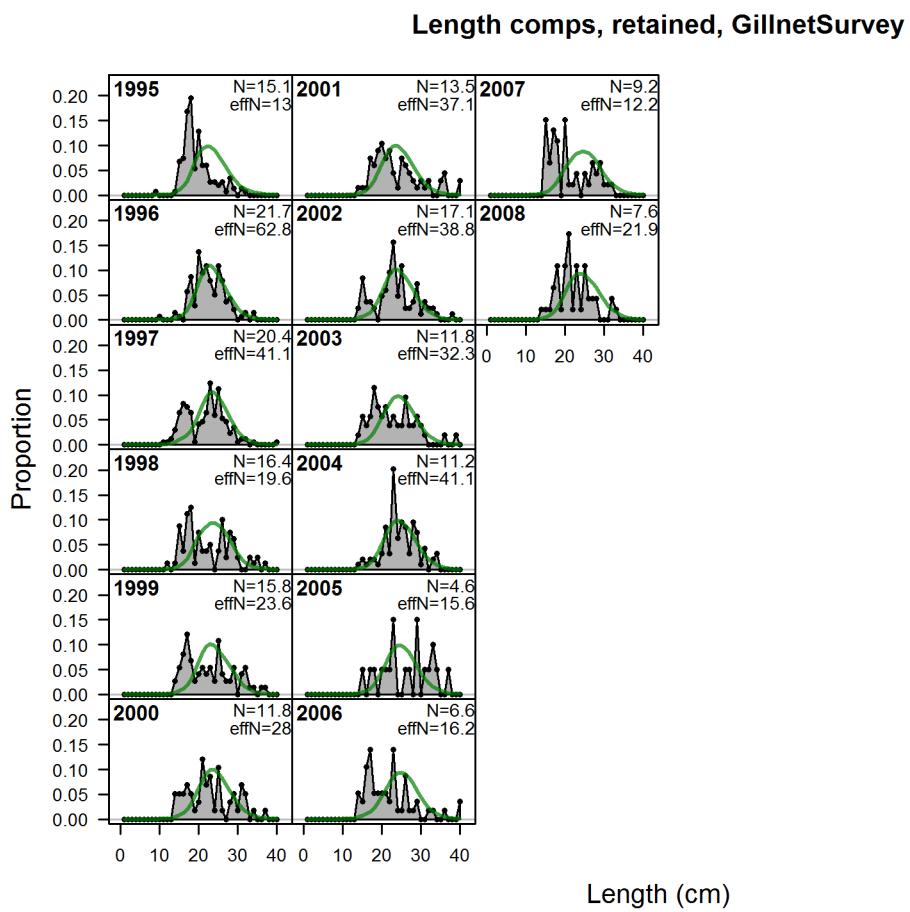


Figure A95: Length comps, retained, GillnetSurvey

Length comps, retained, Impingement

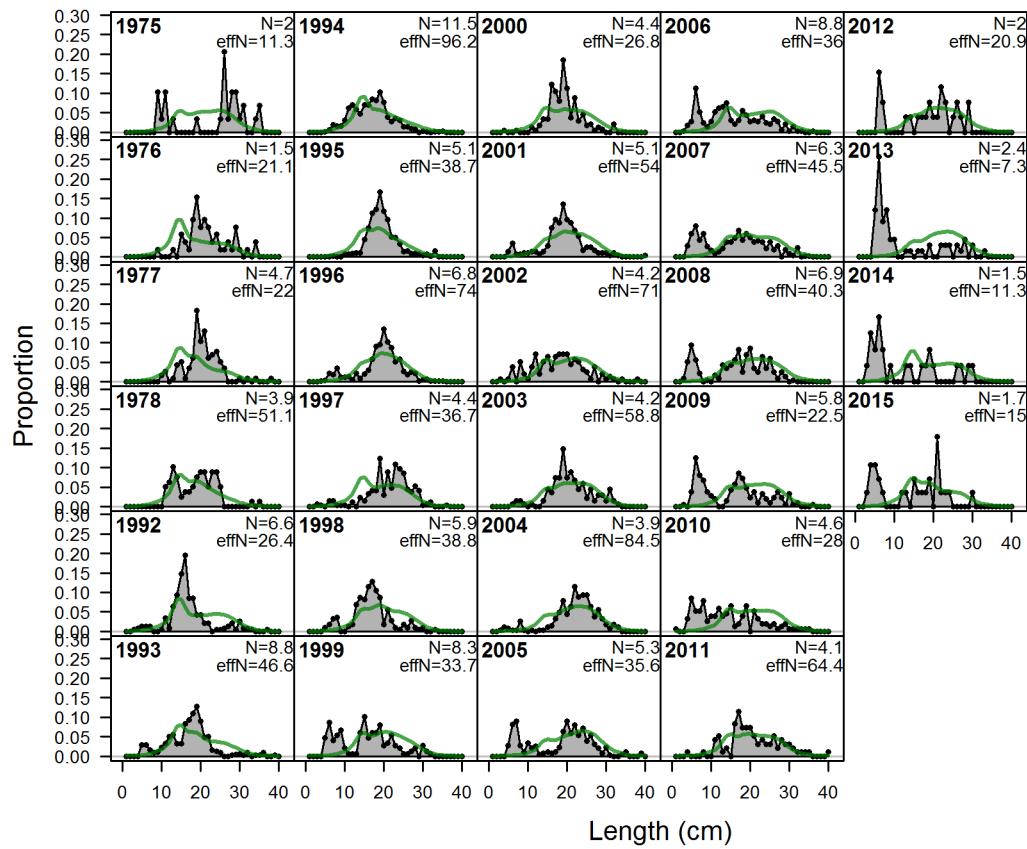


Figure A96: Length comps, retained, Impingement

Length comps, retained, SCBSurvey

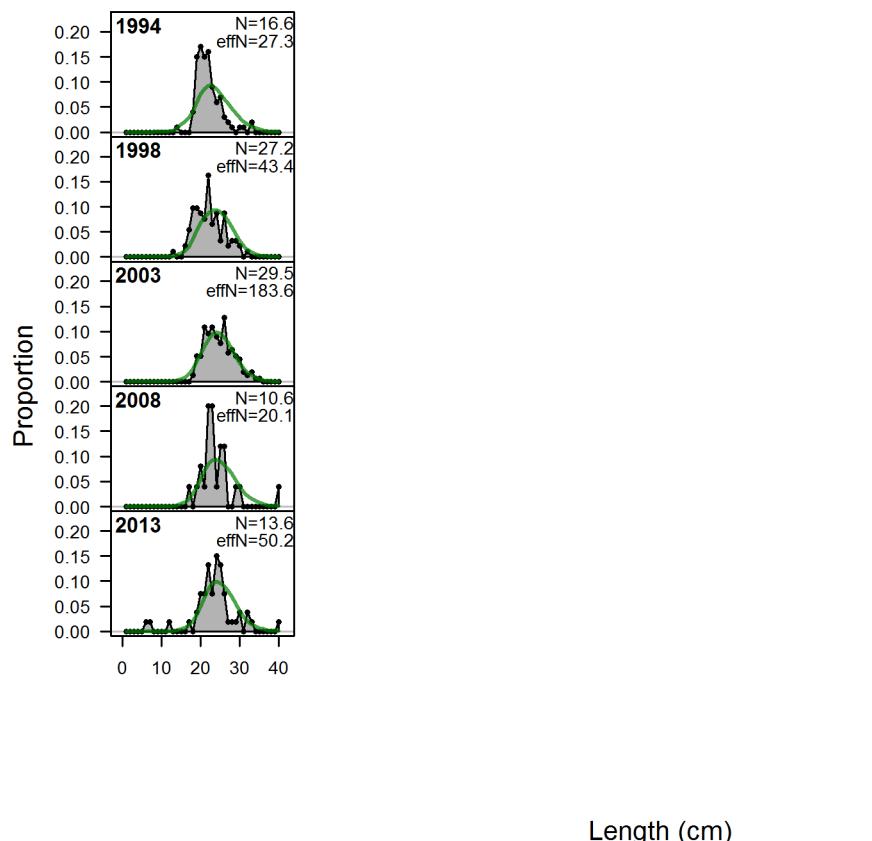


Figure A97: Length comps, retained, SCBSurvey

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