

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



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17 *guttata*) Off Southern California in 2017

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82 **Executive Summary**

executive-summary

83 **Stock**

stock

84 This assessment reports the status of the California scorpionfish (*Scorpaena guttata*) resource
85 in U.S. waters off the coast of the California, Oregon, and Washington using data through
86 2016. Etc...

87 **Catches**

catches

88 Catch figure(s) with fleets: (Figures a-c)

89 Catch table: (Table a)

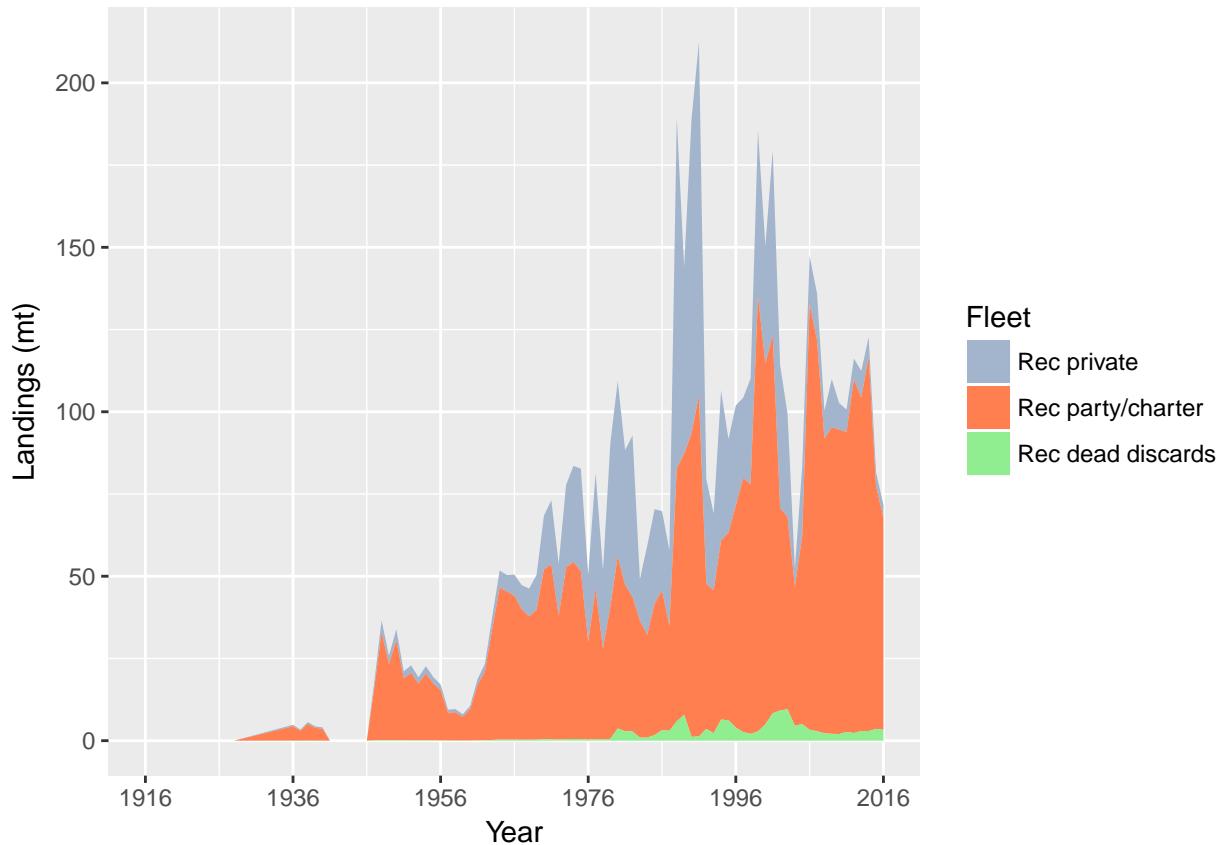


Figure a: California scorpionfish landings history for the recreational fleets. `fig:Exec_catch1`

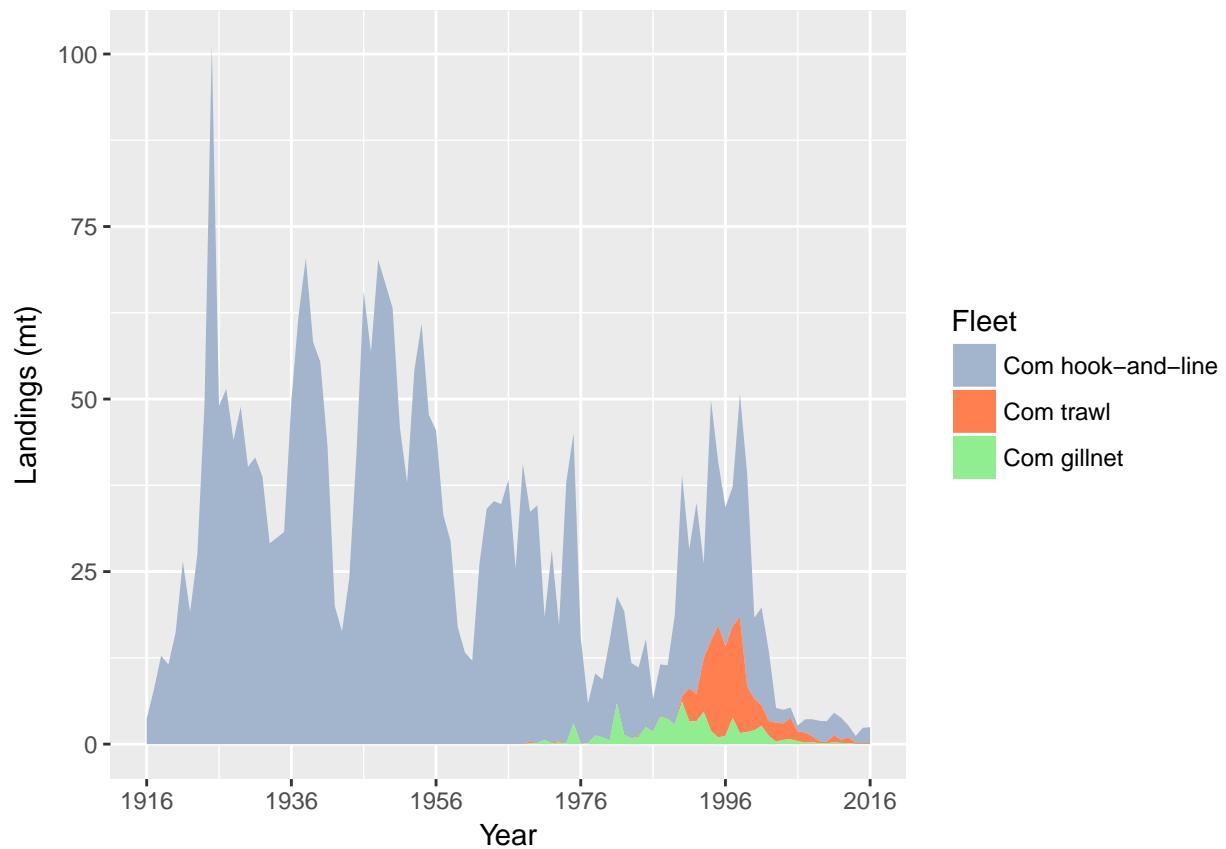


Figure b: Stacked line plot of California scorpionfish landings history for the commercial fleets. [fig:Exec_catch2](#)

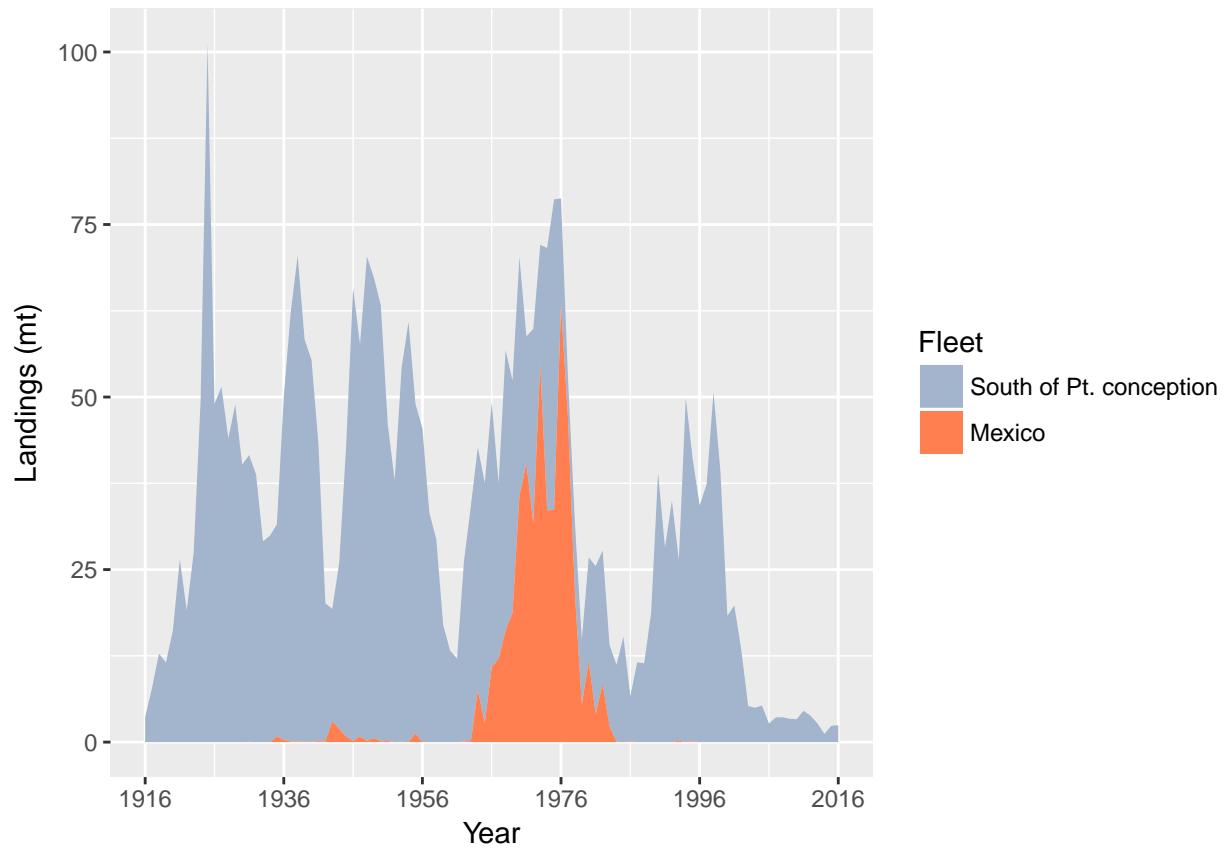


Figure c: Stacked line plot of California scorpionfish landings history by region, north of Pt. Conception, between Pt. Conception and the U.S.-Mexico border, and Mexican waters. [fig:Exec_catch3](#)

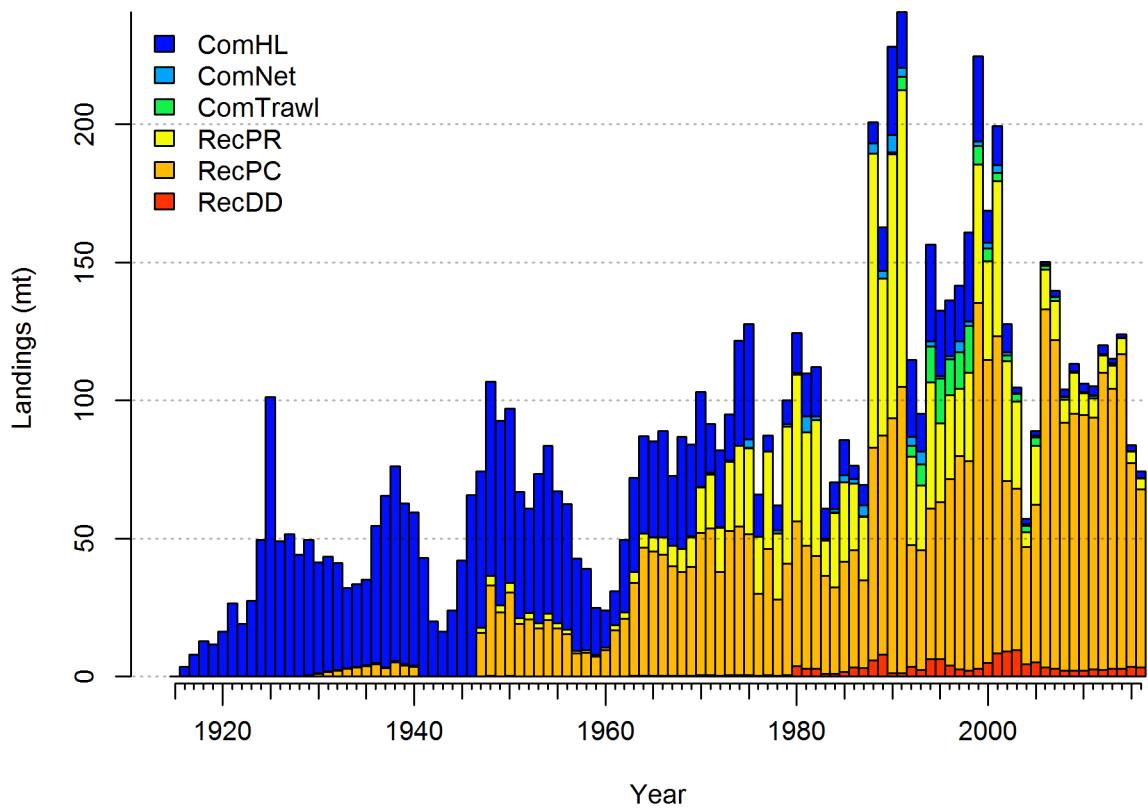


Figure d: Landings history of California scorpionfish in the base model. [fig:r4ss_catches](#)

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

Year	Rec.	Rec.	Rec. Dead	Com.	Com.	Com.	Total
	Private	Party/Charter	Discards	Hook-and-line	Trawl	Gillnet	
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

90 Data and Assessment

data-and-assessment

91 California scorpionfish was assessed in 2005 (Maunder et al. 2005) using Stock Synthesis
 92 II version 1.18. This assessment uses the newest version of Stock Synthesis (3.30.0.4). The
 93 model begins in 1916, and assumes the stock was at an unfished equilibrium that year.

94 Map of assessment region: (Figure e).

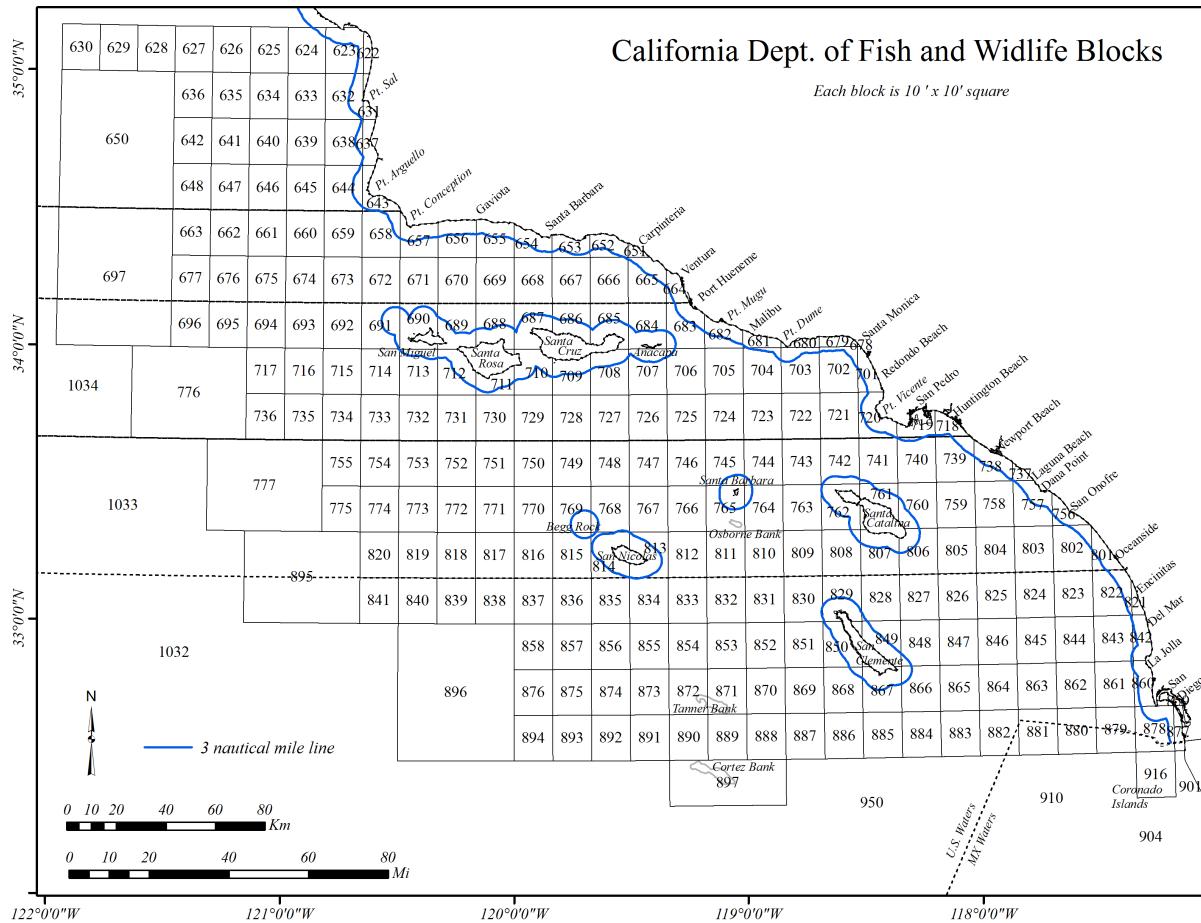


Figure e: Map depicting the boundaries for the base-case model. [fig:assess_region_map](#)

95 **Stock Biomass**

stock-biomass

- 96 Spawning output Figure: Figure [f](#)
 97 Spawning output Table(s): Table [b](#)
 98 Relative depletion Figure: Figure [g](#)

99 The estimated relative depletion level (spawning output relative to unfished spawning output)
 100 of the the base-case model in 2016 is 57.8% (~95% asymptotic interval: ± 45.8%-69.8%)
 101 (Figure [g](#)).

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)

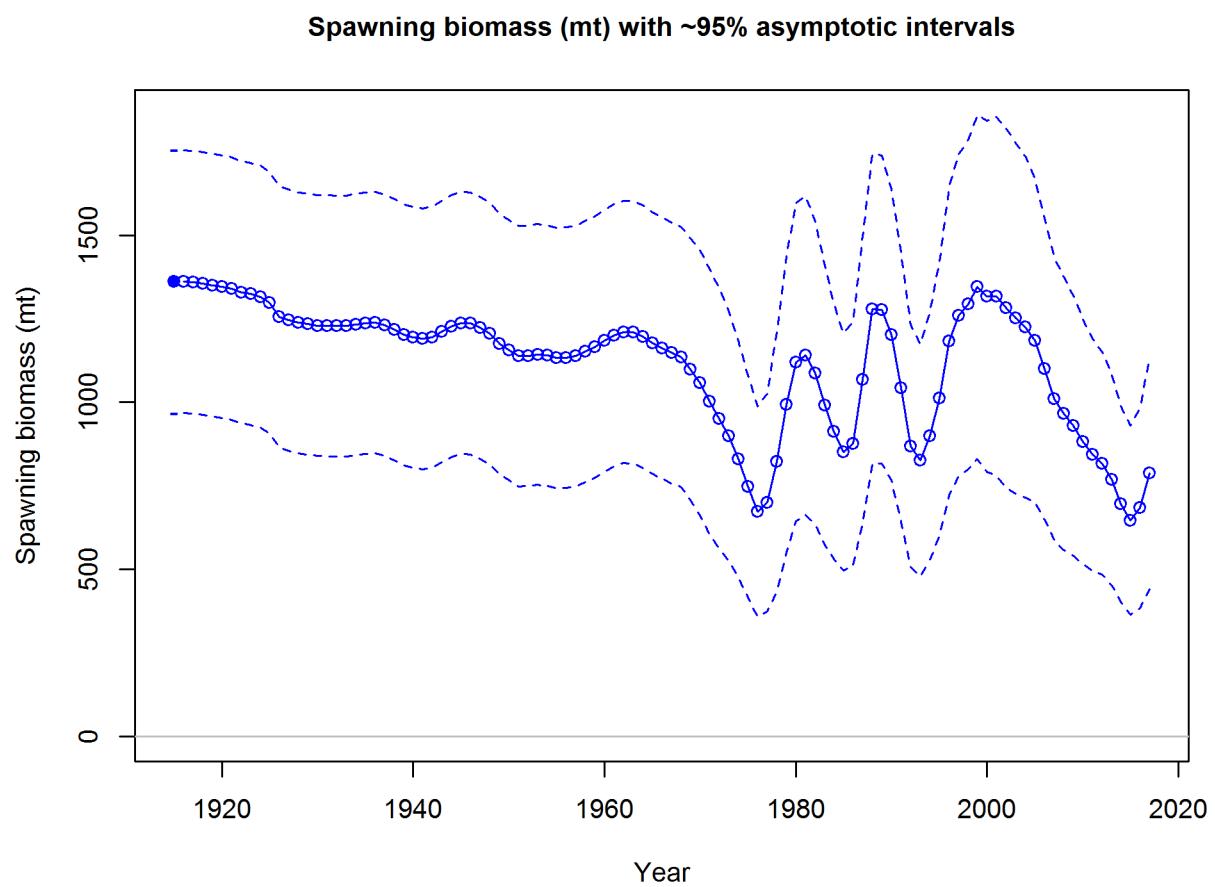


Figure f: Time series of spawning output trajectory (circles and line; median; light broken lines: 95% credibility intervals) for the base case assessment model. | [fig:Spawnbio_all](#)

Spawning depletion with ~95% asymptotic intervals

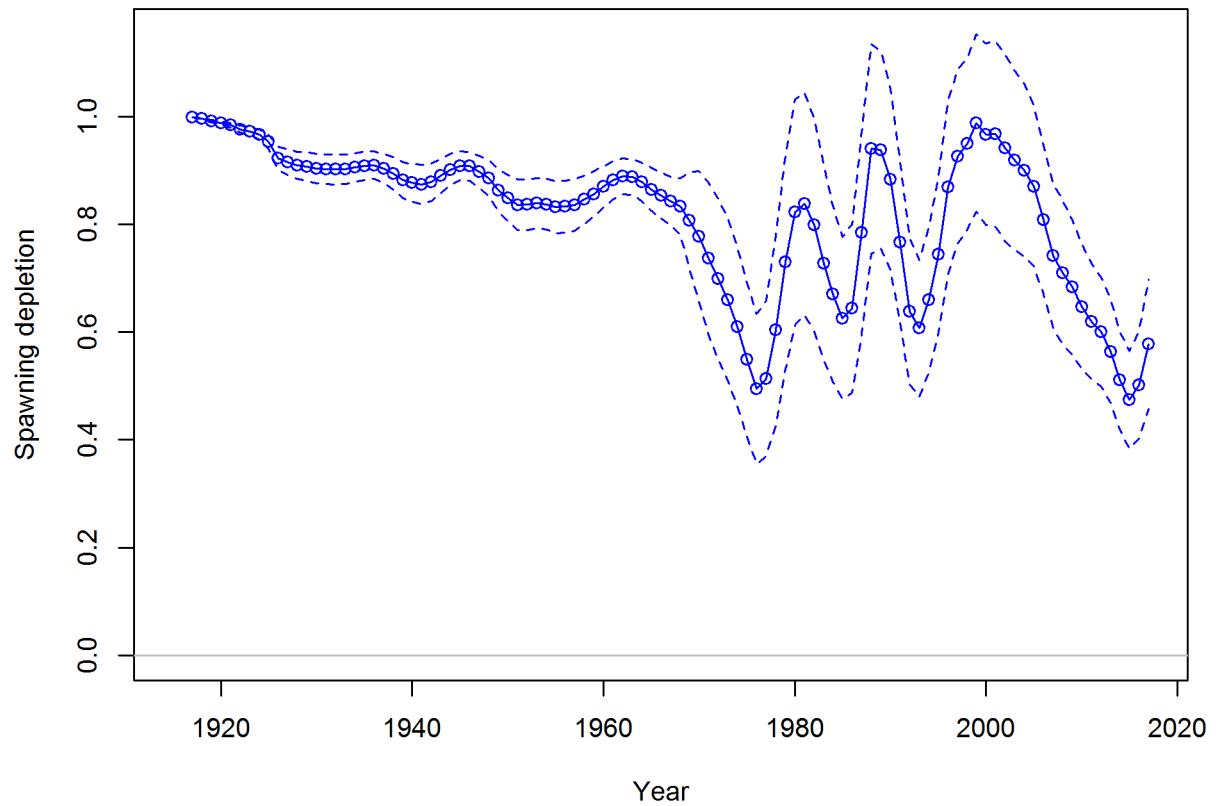


Figure g: Estimated relative depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model. [fig:RelDeplete_all](#)

¹⁰² **Recruitment**

recruitment

¹⁰³ Recruitment Figure: (Figure h)

¹⁰⁴ Recruitment Tables: (Tables c)

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)

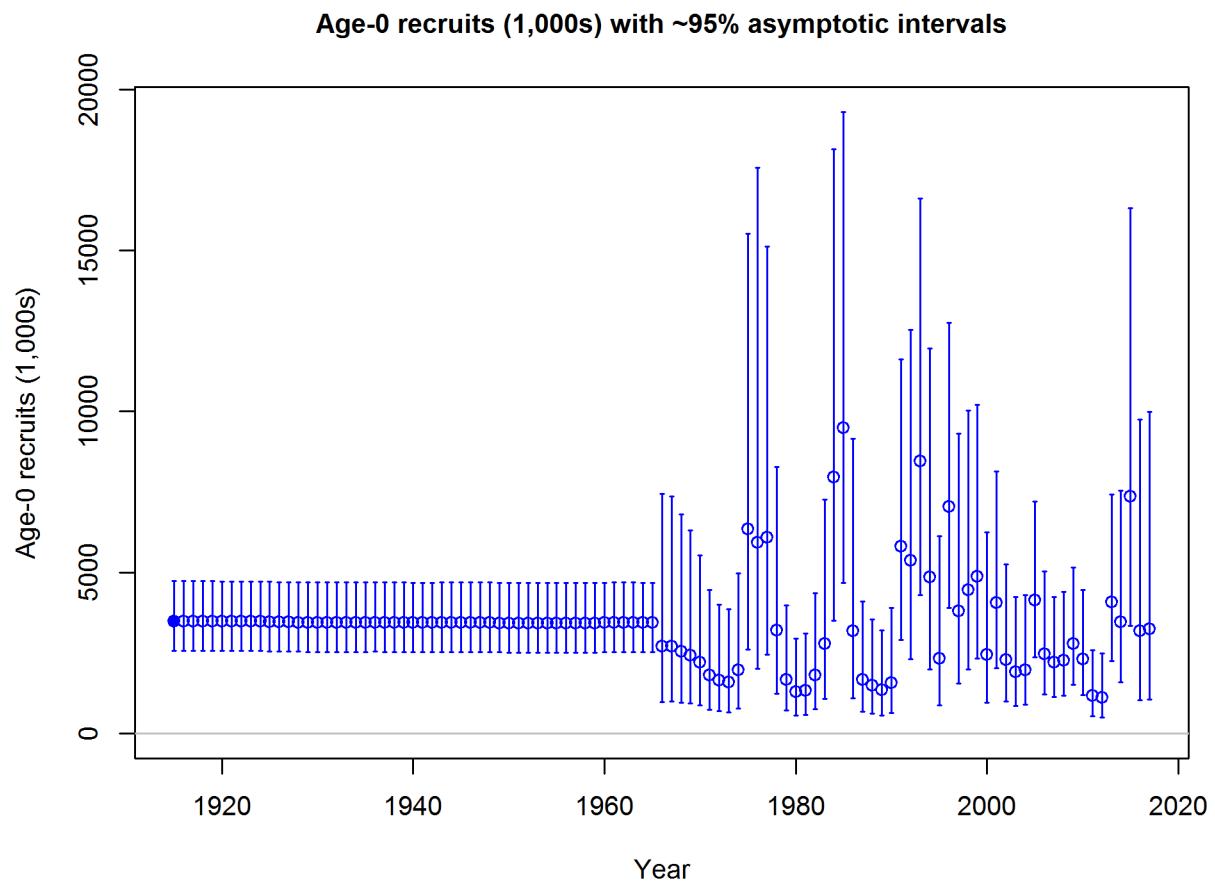


Figure h: Time series of estimated California scorpionfish recruitments for the base-case model with 95% confidence or credibility intervals. [fig:Recruits_all](#)

¹⁰⁵ **Exploitation status**

`exploitation-status`

¹⁰⁶ Exploitation Tables: Table [d](#) Exploitation Figure: Figure [i](#)).

¹⁰⁷ A summary of California scorpionfish exploitation histories for base model is provided as
¹⁰⁸ Figure .

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)

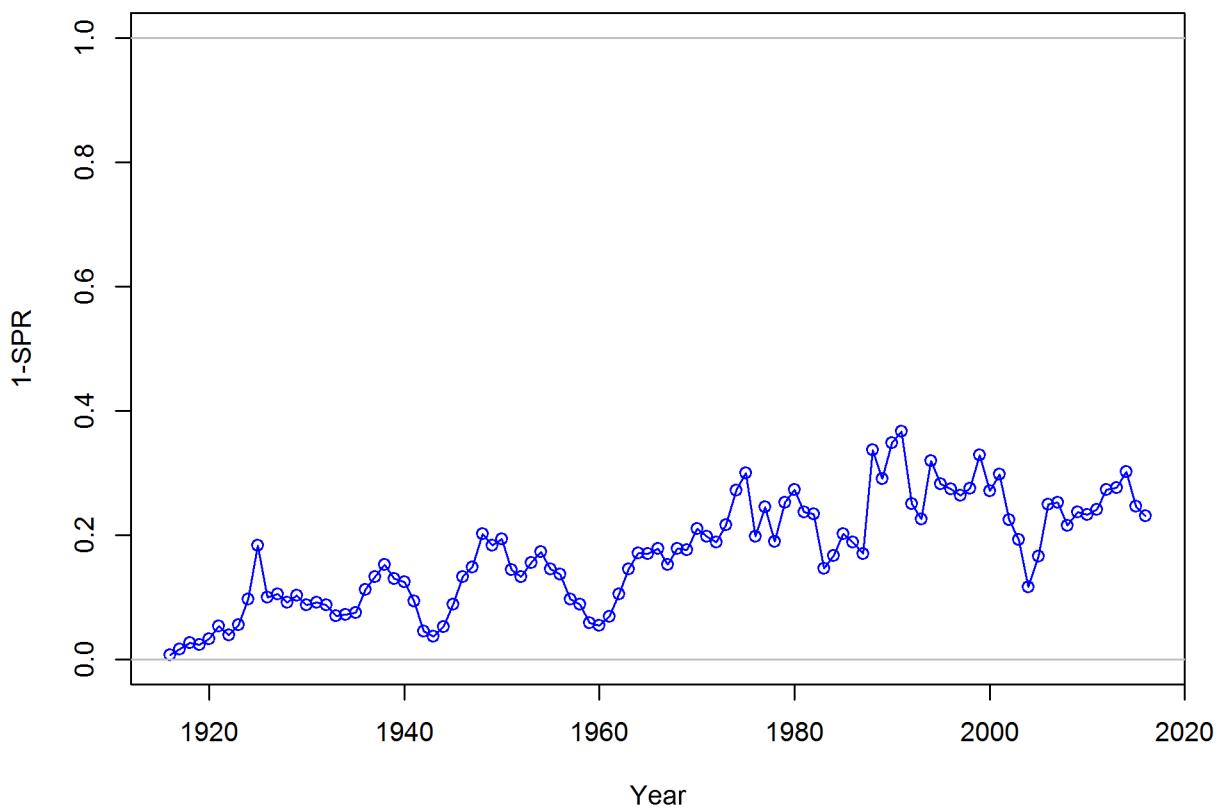


Figure i: Estimated spawning potential ratio (SPR) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing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

109 **Ecosystem Considerations**

ecosystem-considerations

110 In this assessment, ecosystem considerations were. . . .

111 **Reference Points**

reference-points

112 This stock assessment estimates that California scorpionfish in the base model are above the
113 biomass target, but above the minimum stock size threshold. Add sentence about spawning
114 output trend. The estimated relative depletion level for Model 1 in 2016 is 57.8% (~95%
115 asymptotic interval: ± 45.8%-69.8%, corresponding to an unfished spawning output of 787.209
116 mt (~95% asymptotic interval: 440.78-1133.64 mt) of spawning output in the base model
117 (Table e). Unfished age 1+ biomass was estimated to be 2783.7 mt in the base case model.
118 The target spawning output based on the biomass target ($SB_{40\%}$) is 544.6 mt, which gives
119 a catch of 233.9 mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to
120 $SPR_{50\%}$ is 220.1 mt.

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)

¹²¹ Management Performance

management-performance

¹²² Management performance table: Table f

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 terms 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 o 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		-
2008	219		175		-
2009	175		175		-
2010	155		155		-
2011	141	135	135		-
2012	132	126	126		-
2013	126	120	120		-
2014	122	117	117		-
2015	119	114	114		-
2016	117	111	111		-
2017	289	264	150	110	-
2018	278	254	150	110	-

¹²³ Unresolved Problems And Major Uncertainties

unresolved-problems-and-major-uncertainties

¹²⁴ TBD after STAR panel

¹²⁵ Decision Table

decision-table

¹²⁶ OFL projection table: Table g

¹²⁷ Decision table(s) Table h

¹²⁸ Yield curve: Figure \ref{fig:Yield_all}

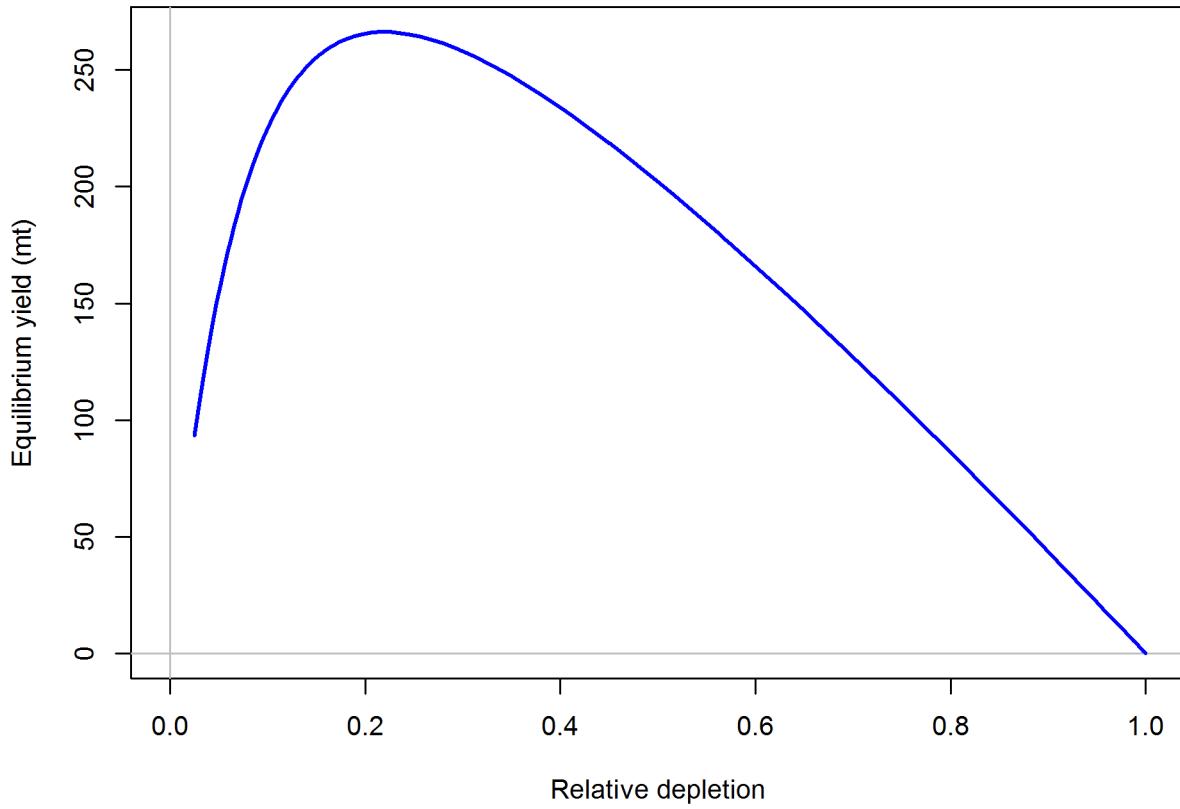


Figure j: Equilibrium yield curve for the base case model. Values are based on the 2016 fishery selectivity and with steepness fixed at... [fig:Yield_all](#)

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

`tab:OFL_projection`

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	tab:base_summary
Total Landings (mt)												
Total Est. Catch (mt)												
OFL (mt)												
ACL (mt)												
$(1-SPR)(1-SPR_{50\%})$	0.43	0.47	0.47	0.48	0.55	0.55	0.60	0.60	0.49	0.49	0.46	
Exploitation rate	0.05	0.06	0.05	0.06	0.07	0.07	0.08	0.08	0.05	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	1556.82	1742.00	
Spawning Output	966.8	930.1	881.1	843.9	817.3	767.9	695.6	646.4	683.6	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)	(363.48-928.25)	(383.62-983.52)	(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	0.5	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)	(0.402-0.602)	(0.458-0.698)	
Recruits	2266.73	2782.03	2308.55	1168.17	1110.63	4078.66	3465.61	7369.42	3173.38	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)	(1593.78-7335.81)	(3330.16-16308.04)	(1032.42-9754.14)	(1032.42-9754.14)	(1057.99-9981.2)	

¹²⁹ **Research And Data Needs**

research-and-data-needs

¹³⁰ We recommend the following research be conducted before the next assessment:

¹³¹ 1. List item No. 1 in the list

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

₁₃₃ **1 Introduction**

introduction

₁₃₄ **1.1 Basic Information and Life History**

basic-information-and-life-history

₁₃₅ California scorpionfish (*Scorpaena guttata*), also known locally as sculpin or spotted scorpionfish, originates from the Greek word for scorpionfishes and *guttata* is Latin for speckled. ₁₃₆ ₁₃₇ California scorpionfish is a medium-bodied fish and like other species in the genus *Scorpaena*, ₁₃₈ it produces a toxin in its dorsal, anal, and pectoral fin spines, which produces intense, painful ₁₃₉ wounds (Love et al. 1987). Scorpionfish are very resistant to hooking mortality and have ₁₄₀ shown survival under extreme conditions.

₁₄₁ Its range extends from central California (Santa Cruz) to the Gulf of California, although ₁₄₂ within U.S. waters they are most common in the Southern California Bight (Eschmeyer et al. ₁₄₃ 1983, Love et al. 1987). The species generally inhabits rocky reefs, caves and crevices, but in ₁₄₄ certain areas and seasons it aggregates over sandy or muddy substrate (Frey 1971, Love et ₁₄₅ al. 1987). California scorpionfish have been observed from the intertidal to 600 ft with a ₁₄₆ preferred depth range from 20-450 ft. Little is known about the aggregating behaviors of ₁₄₇ California scorpionfish. Marine Applied Research and Exploration (MARE) has observed ₁₄₈ California scorpionfish aggregations during the spawning season (June 2014) and also in ₁₄₉ the late fall (November 2012) from video transects in southern California. The November ₁₅₀ spawning aggregation was observed at a small rocky feature near La Jolla and the June ₁₅₁ aggregation was at a sandy area adjacent to the Farnsworth MPAs.

₁₅₂ Males and females show different growth rates, with females growing to a larger size than ₁₅₃ males, and the sexes exhibit different length-weight relationships (Love et al. 1987). Few ₁₅₄ California scorpionfish are mature at one year old (14 cm total length). Fifty-percent of fish ₁₅₅ mature at 17-18 cm (2 years old) and all by 22 cm (4 years old) (Love et al. 1987).

₁₅₆ California scorpionfish feed on a wide variety of mobile prey, including crabs, fishes (e.g., ₁₅₇ include northern anchovy, spotted cusk-eel), octopi, isopods and shrimp, (Taylor 1963, Quast ₁₅₈ 1968, Turner et al. 1969, Love et al. 1987). The species is nocturnal, but have been observed ₁₅₉ feeding during the day. Predation on scorpionfish is believed to be low, but one individual ₁₆₀ was found in the gut of a leopard shark (Love pers comm.).

₁₆₁ **1.2 Early Life History**

early-life-history

₁₆₂ California scorpionfish utilize the “explosive breeding assemblage” reproductive mode in ₁₆₃ which fish migrate to, and aggregate at traditional spawning sites for brief periods (Love ₁₆₄ et al. 1987). California scorpionfish migrate to deeper waters (120-360 ft) to spawn during ₁₆₅ May-August, with peak spawning occurring July. The species is oviparous, producing floating, ₁₆₆ gelatinous egg masses in which the eggs are embedded in a single layer (Orton 1955) and it is

¹⁶⁷ believed that spawning takes place just before, and perhaps after dawn, in the water column
¹⁶⁸ (Love et al. 1987). The same study tagged California scorpionfish and suggests individuals
¹⁶⁹ return to the same spawning site, but information is not available on non-spawning season
¹⁷⁰ site fidelity.

¹⁷¹ Little is known about California scorpionfish larvae. The CalCOFI survey observed 463
¹⁷² California scorpionfish larvae from 1977-2000, with the majority at station close to Oxnard
¹⁷³ (east of the Channel Islands) (Moser et al. 2002). Higher densities of larvae have been
¹⁷⁴ observed in the CalCOFI stations throughout Baja, peaking south of Punta Eugenia from
¹⁷⁵ July to September. The hatching length is reported as 1.9-2.0 mm (Washington et al. 1984)
¹⁷⁶ and transformation length of greater than 1.3 cm (Washington et al. 1984) less than 2.1 cm
¹⁷⁷ (Moser 1996).

¹⁷⁸ 1.3 Map

map

¹⁷⁹ A map showing the scope of the assessment and depicting boundaries for fisheries or data
¹⁸⁰ collection strata is provided in Figure 1.

¹⁸¹ 1.4 Ecosystem Considerations

ecosystem-considerations-1

¹⁸² In this assessment, ecosystem considerations were not explicitly included in the analysis.
¹⁸³ This is primarily due to a lack of relevant data and results of analyses (conducted elsewhere)
¹⁸⁴ that could contribute ecosystem-related quantitative information for the assessment.

¹⁸⁵ 1.5 Fishery Information

fishery-information

¹⁸⁶ The hook-and-line fishery off California developed in the late 19th century (Love et al.
¹⁸⁷ 2002).

¹⁸⁸ The rockfish trawl fishery was established in the early 1940s, when the United States became
¹⁸⁹ involved in World War II and wartime shortage of red meat created an increased demand for
¹⁹⁰ other sources of protein (Harry and Morgan 1961, Alverson et al. 1964).

¹⁹¹ California scorpionfish comprise a minor part of the Californian sport and commercial fisheries
¹⁹² (Love et al. 1987). Historically, California scorpionfish were taken commercially by hook and
¹⁹³ line and, occasionally, by round haul nets (Daugherty 1949). Scorpionfish were commonly
¹⁹⁴ caught around Santa Catalina Island during the late 19th Century with gillnets (Jordan
¹⁹⁵ 1887). The 1937 Bureau of Commercial Fisheries report noted that California scorpionfish
¹⁹⁶ had been a fairly important commercial species for a long time. The species was targeted by
¹⁹⁷ a few fishermen during the summer months, and was also taken as a bycatch in the rockfish

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

202 More recently, commercial bottom longlines have been used to target spawning aggregations
203 offshore of Long Beach (Love et al. 1987). Since the early 1990s, trawl catch has been
204 a substantial component of the commercial catch. Commercial landings have fluctuated
205 substantially over time, which could, in part, be due to changes in targeting and El Nio
206 events (Love et al. 1987). A high proportion of the catch landed in California during the
207 1960s and 1970s was taken from Mexican waters. In recent years, most of the catch has come
208 from around the Los Angeles region. In general, the majority of the commercial catch has
209 come from the Los Angeles region, except in the 1960s and 1970s when the majority of the
210 catch came from the San Diego region and Mexican waters.

211 California scorpionfish is not a major target in the recreational fishery. They are most
212 often taken by boat fishermen, but fairly large numbers are caught from piers, jettys, and
213 rocky shorelines. The Commercial Passenger Fishing Vessel (CPFV; also referred to as
214 the recreational party/charter or PC mode) effort has remained relatively constant over
215 a long period (1959-1998) (Dotson and Charter 2003). However, there appears to be a
216 shift in effort towards less utilized species, such as California scorpionfish, over the past
217 decade (Dotson and Charter 2003). Especially as catch limits for rockfish have become
218 more restricted commercial passenger fishing vessels (CPFV) operators target California
219 scorpionfish spawning aggregations during spring and summer (Love et al. 1987), and also
220 target California scorpionfish in the winter when other fisheries are closed.

221 California scorpionfish become a target species for day boats during the spawning months
222 when spawning aggregations can be located. There are a small number of boats that specialize
223 in targeting these aggregations. The spawning aggregations occur in deeper waters, often
224 times outside of the three nautical mile state jurisdiction. It is also unknown what fraction
225 of the population aggregates during the spawning season, e.g., all mature fish.

226 Aggregate mortality has been far below the Annual Catch Limits (ACL) established by the
227 2005 stock assessment. The ACL projections from the 2005 assessment assumed that the
228 entire ACL was being taken each year and as a result, the ACL for each subsequent year
229 declined despite under-attainment in reality.

230 In addition, in 2014, recreational catch was higher than expected. As a result, in 2014, the
231 combined recreational and commercial catch exceeded the OFL by 2mt (1%) resulting from
232 assumption that the ACL had been attained. Subsequently, action was taken to decrease the
233 recreational season by four months (September 1 - December 31). A catch only update of
234 the stock was undertaken in 2015 (Wallace and Budrick 2015) that imputed the actual catch
235 values since the last assessment, resulting in significant increase in the OFL and ACL.

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

²⁴⁰ The season restriction in the recreational fishery remained in place as a precautionary measure
²⁴¹ until the full assessment is completed to better inform the current status of the stock, catch
²⁴² limits and regulations given the perspective provided.

²⁴³ 1.6 Summary of Management History

[summary-of-management-history](#)

²⁴⁴ Prior to the adoption of the Pacific Coast Groundfish Fishery Management Plan (FMP) in
²⁴⁵ 1982, California scorpionfish (*Scorpaena guttata*) was managed through a regulatory process
²⁴⁶ that included the California Department of Fish and Wildlife (CDFW) along with either
²⁴⁷ the California State Legislature or the Fish and Game Commission (FGC) depending on
²⁴⁸ the sector (recreation or commercial) and fishery. With implementation of the Pacific Coast
²⁴⁹ Groundfish FMP, California scorpionfish came under the management authority of the Pacific
²⁵⁰ Fishery Management Council (PFMC), being incorporated, along with all genera and species
²⁵¹ of the family Scorpidae, into a federal rockfish classification and managed as part of
²⁵² “Remaining Rockfish” under the larger heading of “Other Rockfish” (PFMC (2002, 2004),
²⁵³ Tables 31-39).

²⁵⁴ The ABCs provided by the PFMC’s Groundfish Management Team (GMT) in the 1980’s were
²⁵⁵ based on an analysis of commercial landings from the 1960’s and 1970’s. For this analysis,
²⁵⁶ most of the rockfishes were lumped into one large group. This analysis indicated that the
²⁵⁷ landings for rockfish in the Monterey-Conception area were at or near ABC levels (Pacific
²⁵⁸ Fishery Management Council 1993). To keep landings within these adopted harvest targets,
²⁵⁹ the Pacific Coast Groundfish FMP provided the Council with a variety of management tools
²⁶⁰ including area closures, season closures, gear restrictions, and, for the commercial sector,
²⁶¹ cumulative limits (generally for two-month periods). With the implementation of a federal
²⁶² groundfish restricted access program in 1994, allocations of total catch and cumulative limits
²⁶³ began to be specifically set for open access (including most of California’s commercial fisheries
²⁶⁴ that target California scorpionfish in Southern California) and limited entry fisheries (Figure
²⁶⁵ 3) (Pacific Fishery Management Council 2002, 2004). As a result, in the later 1990’s as
²⁶⁶ commercial landings decreased and recreational harvest became a greater proportion of the
²⁶⁷ available harvest.

²⁶⁸ Beginning in 1997, California scorpionfish was managed as part of the *Sebastodes* complex-
²⁶⁹ south, Other Rockfish category. (*Sebastodes* complex-south included the Eureka, Monterey,
²⁷⁰ and Conception areas while *Sebastodes* complex-north included the Vancouver and Columbia
²⁷¹ areas.) The PFMC’s rockfish management structure changed significantly in 2000 with the
²⁷² replacement of the *Sebastodes* complex -north and -south areas with Minor Rockfish North
²⁷³ (now covering the Vancouver, Columbia, and Eureka areas) and Minor Rockfish South (now
²⁷⁴ Monterey and Conception areas only). The OY for these two groups (which continued to be
²⁷⁵ calculated as 0.50 of the ABC) was further divided (between north and south of 40°10' N.
²⁷⁶ latitude) into nearshore, shelf, and slope rockfish categories with allocations set for Limited
²⁷⁷ Entry and Open Access fisheries within each of these three categories (January 4, 2000, 65
²⁷⁸ FR 221; PFMC (2002), Tables 54-55). Because of its depth range and southern distribution,

²⁷⁹ California scorpionfish was included within the Minor Rockfish South, Other Rockfish ABC
²⁸⁰ and managed under the south of 40°10' N. latitude nearshore rockfish OY and trip limits
²⁸¹ (PFMC ([2002](#)), Table 29).

²⁸² Along with the above changes, in 2000 the southern area divided into two separate management
²⁸³ areas at Point Lopez, 36°00' N. latitude. This was followed in 2001 with the implementation
²⁸⁴ of the northern rockfish and lingcod management area between (40°10' N. latitude) and Point
²⁸⁵ Conception (34°27' N. latitude); and the southern rockfish and lingcod management area
²⁸⁶ between Point Conception and the U.S.- Mexico border. These were later revised starting
²⁸⁷ in 2004 with the northern rockfish and lingcod management area redefined as ocean waters
²⁸⁸ from the Oregon-California border (42°00' N. latitude) to 40°10' N. latitude, the central
²⁸⁹ rockfish and lingcod management area defined as ocean waters from 40°10' N. latitude to
²⁹⁰ Point Conception, and the southern rockfish and management area continuing to be defined
²⁹¹ as ocean waters from Point Conception to the U.S.-Mexico border.

²⁹² Cowcod Conservation Areas (CCAs) also were established in 2001 to reduce fishing effort
²⁹³ in areas with high encounter rates of cowcod rockfish (PFMC ([2002](#)), Table 29). These
²⁹⁴ areas were closed to all recreational and commercial fishing for groundfish except for minor
²⁹⁵ nearshore rockfish¹ (including California scorpionfish) within waters less than 20 fathoms.
²⁹⁶ The California Rockfish Conservation Area (CRCA) was defined as those ocean waters south
²⁹⁷ 40°10' N. latitude to the U.S.-Mexico border with different depth zones specified for the areas
²⁹⁸ north and south of Pt. Reyes (37°59.73' N. latitude).

²⁹⁹ During the late 1990's and early 2000's, major changes also occurred in the way that California
³⁰⁰ managed its nearshore fishery. The Marine Life Management Act (MLMA), which was passed
³⁰¹ in 1998 by the California Legislature and enacted in 1999, required that the FGC adopt
³⁰² an FMP for nearshore finfish. It also gave authority to the FGC to regulate commercial
³⁰³ and recreational nearshore fisheries through FMPs and provided broad authority to adopt
³⁰⁴ regulations for the nearshore fishery during the time prior to adoption of the nearshore finfish
³⁰⁵ FMP. Within this legislation, the Legislature also included commercial size limits for nine
³⁰⁶ nearshore species including California scorpionfish (10-inch minimum size) and a requirement
³⁰⁷ that commercial fishermen landing these nine nearshore species possess a nearshore permit.

³⁰⁸ Following adoption of the Nearshore FMP and accompanying regulations by the FGC in fall
³⁰⁹ of 2002, the FGC adopted regulations in November 2002 which established a set of marine
³¹⁰ reserves around the Channel Islands in Southern California (which became effective April
³¹¹ 2003). The FGC also adopted a nearshore restricted access program in December 2002 (which
³¹² included the establishment of a Deeper Nearshore Permit) to be effective starting in the 2003
³¹³ fishing year.

³¹⁴ Although the Nearshore FMP provided for the management of the nearshore rockfish and
³¹⁵ California scorpionfish, management authority for these species continued to reside with
³¹⁶ the Council. Even so, for the 2003 and subsequent fishery seasons, the State provided
³¹⁷ recommendations to the Council specific to the nearshore species that followed the directives
³¹⁸ set out in the Nearshore FMP. These recommendations, which the Council incorporated into

³¹⁹ the 2003 management specifications, included a recalculated OY for Minor Rockfish South
³²⁰ - Nearshore, division of the Minor Rockfish South - Nearshore into three groups (shallow
³²¹ nearshore rockfish; deeper nearshore rockfish; and California scorpionfish), and specific harvest
³²² targets and recreational and commercial allocations for each of these groups.

³²³ Also, since the enactment of the MLMA, the Council and State in a coordinated effort
³²⁴ developed and adopted various management specifications to keep harvest within the harvest
³²⁵ targets, including seasonal and area closures (e.g. the CCAs; a closure of Cordell Banks
³²⁶ to specific fishing), depth restrictions, minimum size limits, and bag limits to regulate the
³²⁷ recreational fishery and license and permit regulations, finfish trap permits, gear restrictions,
³²⁸ seasonal and area closures (e.g. the RCAs and CCAs; a closure of Cordell Banks to specific
³²⁹ fishing), depth restrictions, trip limits, and minimum size imits to regulate the commercial
³³⁰ fishery.

³³¹ 1.7 Management Performance

management-performance-1

³³² Management performance table: (Table [f](#))

³³³ A summary of these values as well as other base case summary results can be found in Table
³³⁴ [i](#).

³³⁵ 1.8 Fisheries off Mexico

fisheries-off-mexico

³³⁶ The California scorpionfish's range extends into to Abreojos, Baja California.

³³⁷ The species is also found in the northern Gulf of California and Guadalupe Island. No formal
³³⁸ stock assessments have been conducted for California scorpionfish in Mexican waters.

³³⁹ 2 Assessment

assessment

³⁴⁰ 2.1 Data

data

³⁴¹ Data used in the California scorpionfish assessment are summarized in Figure [2](#).

³⁴² A description of each data source is below.

³⁴³ 2.1.1 Commercial Fishery Landings

commercial-fishery-landings

³⁴⁴ Commercial catches of California scorpionfish (often landed as "sculpin") are available back
³⁴⁵ to 1916. Landings from 1916 to 1935 are presented in CDFG Fish Bulletin No. 49 and

³⁴⁶ Bulletin No. 149 provides tabulated data from 1916 to 1968. Over 99% of the commercial
³⁴⁷ catches of California scorpionfish are from south of Pt. Conception.

³⁴⁸ Whenever possible, catches from north of Pt. Conception and also caught in Mexico but
³⁴⁹ landed in the U.S. were excluded from the commercial catch histories.

³⁵⁰ [California Explores the Ocean](#)(CEO) provides landings data taken from the CDFG Fish
³⁵¹ Bulletins in electronic form, as well as electronic copies of all CDFG Fish Bulletins.

³⁵² Statewide annual landings are available for California scorpionfish from 1916 to 1925, and
³⁵³ are assumed to be taken by hook-and-line. Data by area and month are given in a series of
³⁵⁴ bulletins, each bulletin usually providing information for a single year. Data by region and
³⁵⁵ month is available for 1926 to 1986. The Santa Barbara region includes San Luis Obispo,
³⁵⁶ Santa Barbara and Ventura counties. Catches from this region were included in the catch
³⁵⁷ history and comprised less than 10 mt for the period from 1926-1968 (the period when data
³⁵⁸ at the regional scale are available).

³⁵⁹ Catches from Mexico can be separated from the total catch starting in 1931, although the
³⁶⁰ CDFG Bulletins do not report catches originating from Mexican waters available for all years,
³⁶¹ e.g., 1932-1934. It is assumed that before 1931 there was no catch taken from Mexican waters
³⁶² landed in California.

³⁶³ The [CALCOM](#) database was queried (March 7, 2017) for commercial landing estimates of
³⁶⁴ California scorpionfish in California, 1969-2016. Landings were stratified by year, quarter,
³⁶⁵ live/dead, market category, gear group, port complex, and source of species composition
³⁶⁶ data (actual port samples, borrowed samples, or assumed nominal market category). All
³⁶⁷ CALCOM California scorpionfish landing data are either actual port samples or the nominal
³⁶⁸ California scorpionfish market category. However, catches in CALCOM do not separate out
³⁶⁹ catches originating from Mexican waters and landed at U.S. ports.

³⁷⁰ The Commercial Fisheries Information System (CFIS; maintained by CDFW) contains
³⁷¹ California catch in pounds by gear and port for 1969 to 2016 (Figures). The CFIS data come
³⁷² from landing receipts or “fish tickets” filled out by the markets or fish buyers as required by
³⁷³ the state for all commercial landings. The fish tickets include the CDFW block in which the
³⁷⁴ majority of the landings were caught.

³⁷⁵ Landings with a block solely in Mexican waters (blocks >900) were removed from the catch
³⁷⁶ history. Landings with reported blocks 877-882 with area in both U.S. and Mexican waters
³⁷⁷ were retained in the catch histories. The commercial catch is dominated by the hook-and-line
³⁷⁸ fishery (89% of total catches).

³⁷⁹ The catch by reported gear types: hook-and-line, fish pot, trawl, gill net, and other can be
³⁸⁰ found in Table 1. Catch taken by fish pot and other gears is added to the hook-and-line
³⁸¹ catch in the stock assessment (30.6 mt from fish pot and 93.9 mt from other gears).

³⁸² In the assessment, catch for 1916 to 1968 is taken from the CDFG Fish Bulletins. Catch by
³⁸³ gear for 1969 to 2004 is taken from CFIS.

384 **2.1.2 Commercial Discards**

commercial-discards

385 Information on commercial discards from the West Coast Groundfish Observer Program
386 (WCGOP) are available starting in 2004. The commercial fishery for California scorpionfish
387 has been minimal since the early 2003 (averaging 3.5 mt per year). The available length
388 composition data from the observed discards is minimal, with 151 fish measured from 2004-
389 2015, and less than half a metric ton. Given the discard mortality of only 7%, and the small
390 total catches in the recent years, discards from the commercial fleet are not considered in the
391 assessment.

392 **2.2 Commercial Fishery Length And Age Data**

commercial-fishery-length-and-age-data

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

399 The CDFW conducted a market study from 1990-2004 in southern California (Laughlin
400 and Ugoretz 1998) to monitor and summarize local commercial catches. The ports sampled
401 included San Diego, Santa Barbara/Ventura and Long Beach/San Pedro. Very few of the
402 samples from Santa Barbara and San Diego (4 samples each from the hook-and-line and
403 trawl fisheries Santa Barbara, and 1 sample from the hook-and-line fishery in San Diego)
404 reported California scorpionfish, and are excluded from the length composition data.

405 Length composition for California scorpionfish are available from the Long Beach samples for
406 the hook-and-line (Table 2), gillnet (Table 3), and trawl fisheries (Table 4). Length samples
407 from both groundfish (otter) trawls and single-rigged shrimp trawls were available from the
408 market study. The average size of fish from the otter trawls (26.5 cm) was smaller than from
409 the shrimp trawl samples (28.1 cm). Over 70% of California scorpionfish catch from the
410 trawl sector was landed from single-rigged shrimp trawls, which best represent the length
411 composition of the trawl fleet (CALCOM).

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

414 $\text{Input effN} = N_{\text{trips}} + 0.138 * N_{\text{fish}}$ if $N_{\text{fish}}/N_{\text{trips}}$ is < 44

415 $\text{Input effN} = 7.06 * N_{\text{trips}}$ if $N_{\text{fish}}/N_{\text{trips}}$ is ≥ 44

416 **2.2.1 Sport Fishery Removals and Discards**

sport-fishery-removals-and-discards

417 Data used in reconstructing the retained catch and discarded mortality for California scor-
418 pionfish in the California recreational fishery are from the Commercial Passenger Fishing
419 Vessel (CPFV) Logbooks (1932-2017), the Marine Recreational Fishery Statistical Survey
420 (MRFSS, 1980-2003) and the California Recreational Fishery Survey (CRFS, 2004-2017).
421 Total catch was accounted for including retained catch as well as the estimate of fish dis-
422 carded dead assuming a 7% discard mortality rate approved for use in management in the
423 regulatory specifications for 2009-2010 (Pacific Fishery Management Council 2008). The
424 MRFSS and CRFS data provide estimates of mortality for four fishing “modes” including
425 the Party/Charter Boat, Private/Rental Boat, Man Made (piers and jetties etc.) and Beach
426 and Bank modes.

427 While estimates of mortality from the Party/Charter (PC) boat mode is available from the
428 MRFSS and CRFS surveys for the Party/Charter Boat mode for 1980-2017, estimates from
429 the CRFS data from 2011-2017 and data from CPFV Logbook for 1932-2010 were used to
430 represent catch from this mode. The Party/Charter Phone Survey was used to estimate
431 effort used in producing effort estimates for CRFS between 2004 and 2010, which was subject
432 to negative bias due to the low of participation in the survey south of Point Conception.
433 The Coastal County Household Telephone Survey was used to estimate fishing effort for
434 the MRFSS survey from 1980-2003 and was subject to potential positive avidity bias in
435 participation by those contacted by the survey. As a result, the CPFV logbooks provided the
436 reported number of retained and discarded California scorpionfish used to estimate mortality
437 from 1932-2010.

438 This is consistent with the catch based update conducted in 2015 as well as the original
439 assessment, both of which used estimates of catch from logbooks to represent catch in the
440 PC mode with the exception of the years after 2011 when effort estimates used in CRFS
441 estimates were derived from logbooks.

442 An under-reporting adjustment reflecting an average 20% of logs not being submitted was
443 applied to all estimates for the PC mode from 1932-2010. Annual average weights from this
444 mode for retained catch from the MRFSS or CRFS estimates for 1980-2010 and average
445 weight from 1980-1984 was applied to the preceding years. To estimate discard mortality
446 for the PC mode, the annual average weight was applied in respective years from lengths
447 collected sampling onboard CPFVs by the CRFS survey for 2004-2010 were applied to the
448 number of discards from the CPFV logbooks and the average weight over this entire period
449 were applied to the preceding years for 1995-2003. For the period between 1980 and 1994,
450 the MRFSS estimates for discards were used to reflect discarding due to the paucity of data
451 on the number of discards from PC logbooks prior to 1995.

452 For all other modes, the MRFSS (1980-2003) and CRFS (2004-2017) based estimates of
453 retained catch and discard mortality were used. There was a lapse in MRFSS sampling from
454 1990 through 1992, for which retained catch and discard mortality were estimated using the
455 average of values three years before and three years after the lapse for all modes other than

456 the PC mode. For the PC mode, estimates of numbers of fish were available from logbook
457 data and average weight from the three years before and after this period were applied to
458 provide estimates for the PC mode.

459 Estimates of retained catch and discards were not available from the non-PC modes prior
460 to 1980, thus the ratio of catch in the PC mode to the other modes for 1980 through 1985
461 was used to provide an estimate of catch in the other modes in the years 1932-1979. In the
462 case of the PR mode, a linear ramp in the ratio adjustment between PC and PR modes was
463 applied between 1966 and 1979 from 0.55 in 1980 to 0.10 in 1965, reflecting the increase in
464 the relative proportion of catch contributed by the PR mode with time as more individuals
465 anglers purchased vessels, as recommended in the California Catch Reconstruction (Ralston
466 et al. 2010), and the ratio of 0.10 was assumed for all years prior. The ratio of PC estimates
467 to the MM and BB modes was assumed to constant and the average between 1980 and 1989
468 was applied from 1932 to 1979. Catch estimates from CPFV logbooks were not available
469 during the World War II era from 1941 until 1946 and catch was assumed to be zero for all
470 modes during this period. Estimates for retained catch and discarded mortality for 1935 to
471 1928 were estimated using a linear ramp from the value for 1928 to zero in 1936 for the PC
472 mode and ratios PC compared to other modes were used to proxy estimates for other modes
473 based on the resulting ramped values for the PC mode. The final time series of landings and
474 discard mortality are in Table 5.

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

476 2.2.2 Fishery-dependent Data Sources

`fishery-dependent-data-sources`

477 CRFS Private Boat Dockside Intercept Survey

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

493 The survey records the number of contributing anglers (number of anglers on the vessel for
494 the private mode), but does not contain data on hours fished. For this index, angler-day
495 was the assumed effort. The data were filtered to trips fishing with hook-and-line gear in
496 southern California. Trips with a primary fishing area of Mexico were also removed. The
497 CRFS dockside private boat records with these broad filters include 44,128 trips of which
498 3,802 caught California scorpionfish (8.6%).

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

508 Coefficients from the Stephens-MacCall analysis (a binomial GLM) are positive for species
509 which co-occur with California scorpionfish, and negative for species that are not caught with
510 California scorpionfish (Figure 5). Potentially informative species for the Stephens-MacCall
511 analysis were limited to species caught in at least one percent of all trips and caught in at
512 least five years. Some of these never occurred with California scorpionfish (strong ‘counter-
513 indicators’) and records with these species were removed from the data prior to estimation
514 of the index. Strong counter-indicators for the CRFS private boat index included yellowfin
515 tuna and dolphinfish.

516 A total of 8,590 trips were retained following the Stephens-MacCall filter, with 3,056 all
517 positive California scorpionfish trips retained. The California scorpionfish recreational fishery
518 in the southern management area was closed for eight months in 2004 and nine months in
519 2005. The majority of records from 2004 and 2005 are from the period when the fishery
520 was closed and were removed from the analysis (Figure 4). Records from months with the
521 fishery was closed from 2006-2016 were also excluded from the index since this index relies
522 on sampler-examined retained catch.

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

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

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

536 Biological samples from trips retaining California scorpionfish were collected during the
537 dockside surveys. Lengths of California scorpionfish from 1980-2016 for the private mode
538 were provided by RecFIN by Edward Hibsch (PSMFC) on November 29, 2016. Length
539 measurements from the private mode were provided directly from CDFW for the years
540 2004-2016 Table 9. The number of trips is the number of unique ID_CODEs from RecFIN for
541 1980-2003. Starting in 2004 with the CRFS program, the number of unique trips sampled in
542 the private boat mode was recorded. The recreational private fleet tends to select larger fish
543 than the recreational party/charter fleet, which is one reason the private and party/charter
544 fleets were maintained as two separate fleets in the base model. No length data for discarded
545 fish from the recreational private mode fleet are available.

546 CRFS CPFV Logbook Index

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

557 The number of anglers on board the vessel and the hours fished are included in the database
558 for all years. Only retained fish are included in the index of abundance the unit of effort
559 is angler hours. A number of data filters were applied to the data to account for possible
560 mis-reporting, e.g., trips reporting retained California scorpionfish in top 1% of the data
561 (>325 fish). Trips fishing outside of California scorpionfish habitat (reported as targeting
562 pelagic species) or trips reporting a block with a minimum depth deeper than 140 m were
563 also filtered out.

564 Because California scorpionfish is not a primary target species, boats with fewer than 10
565 trips retaining California scorpionfish were removed from the analysis. Data were also filtered
566 to only include catches reported from blocks South of Pt. Conception and north of the U.S.-
567 Mexico border (Figure 1), and blocks with at least 100 trips retaining California scorpionfish
568 and a total of 500 trips. A full description of the data filters is in Table 10. A total of
569 432,868 trips were retained for the index of abundance, 202,937 of which caught California
570 scorpionfish.

571 Two different area factors were considered for the standardization, block and region.
572 The 60 retained blocks were split into nearshore regions north and south of San Pedro and

573 the northern and southern islands, for four regions. Both a delta model and a negative
574 binomial model were considered for index standardization. However, due to the large number
575 of records, the traditional jackknife routine to estimate uncertainty was not possible.

576 California scorpionfish were present in 47% of all trips, and standardized with a negative
577 binomial model. Factors considered were *year*, *month*, and *area* (either block or region). A
578 model with blocks and was selected over a model with region by 39,180 AIC. The final model
579 includes *year*, *month*, and *block* with a log link and effort as an offset (Table 11).

580 The standardized index shows a cyclic pattern, with period of higher CPUE (late 1980's to
581 early 1990's and late 1990s) and has shown a general downward trend since 2008 (Figure 12).
582 An interesting note is the similarity in standardized CPUE between the CPFV logbook index
583 and the CPFV dockside index (not used in the stock assessment model) from 1992-1997 (for
584 a Stephens-MacCall threshold of 0.1) (Figure 11).

585 MRFSS Party/Charter Boat Dockside Index

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

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

614 Data for dockside sampling of 6,295 commercial passenger fishing vessel (CPFV) trips south
615 of Point Conception by the Marine Recreational Fishery Statistical Survey (MRFSS) were
616 filtered using the Stephens-McCall method to identify trips with catch associated with
617 California scorpionfish and the resulting trips analyzed in a delta-GLM including year and
618 county to produce annual indices of abundance for the period 1980 through 1998 . To
619 eliminate trips targeting species caught near the surface for all or part of the trip where
620 California scorpionfish do not occur, prior applying the Stephens-MacCall filter, trips with
621 catch of bluefin tuna, yellowfin tuna, dorado, Pacific bonito, skipjack, albacore, chinook
622 salmon, coho salmon and bigeye tuna were removed. Trips with catch of yellowtail amberjack
623 were also removed since effort on such trips can often be focused in the surface and mid-water
624 where California scorpionfish do not occur. In addition, trips with aggregate effort less below
625 and above 95% percentile (less than 2 and over 109.5 hours) were removed to exclude trips
626 for which either too little effort was exerted to be informative or longer trips that may make
627 an excessive contribution to the effort likely distributed over a number of targets only some
628 of which may co-occur with California scorpionfish biasing low the resulting CPUE. Lastly,
629 trips in Santa Barbara County were removed due the low number of positive samples for
630 California scorpionfish since it resides in the northern extent of their range and this is a
631 transition zone between biogeographic provinces in which the presence of more northerly
632 distributed species could adversely affect the ability of the Stephens-MacCall filtering method
633 to identify co-occurring species. Each of these filtering steps and the resulting number of
634 trips remaining in the sampling frame are provided in Table 13.

635 Removal of the aforementioned trips resulted in a total of 3,968 trips to which the Stephens-
636 MacCall filtering method was applied. Species that composed less than 5% of the catch
637 were excluded from analysis to prevent these uncommon species from affecting correlations
638 identified using the algorithm. Chub mackerel, Pacific mackerel and barracuda were removed
639 as potential predictor species despite having weak positive correlations with California
640 scorpionfish since they are predominantly pelagic and their co-occurrence is not expected to
641 be predictive. As expected, positive indicators of California scorpionfish trips include several
642 species of nearshore rockfish, California sheephead, California halibut, Pacific sanddabs and
643 seabasses and counter-indicators include several species of deep-water rockfish (Figure 9).
644 While the filter is useful in identifying co-occurring or non-occurring species assuming all
645 effort was exerted in pursuit of a single target, the targeting of more than one target species
646 can result in co-occurrence of species in the catch that do not truly co-occur in terms of
647 habitat associations informative for an index of abundance, presenting a confounding influence
648 in selecting trips using the methods employed. Thus the filtering is intended to remove those
649 trips for which effort was targeted in deeper water than California scorpionfish commonly
650 occur.

651 Two levels of filtering were applied using the Stephens-MacCall Filter. The Stephens-MacCall
652 filtering method identified the probability of occurrence (in this case 0.27) at which the rate
653 of false positives and false negatives for the presence of California scorpionfish were equal as
654 a heuristic for selecting a threshold for trips in appropriate habitat to be included in analysis.
655 The trips from this criteria for selection was compared to an alternative method including
656 the false positive trips as well as all positive trips for California scorpionfish supported by

the assumption that if California scorpionfish were caught in such trips, they must constitute appropriate habitat justifying their inclusion. In addition, the false positives from a lower probability of occurrence (0.10) that was considered to reflect a less stringent threshold inclusive of more trips including a higher proportion of the false positive trips combined with the positive trips from the entire data set was evaluated for comparison.

Catch per angler hour (CPUE; number of fish per angler hour) was modelled using a delta model (Lo et al. 1992, Stefnsson 1996). Model selection using Akaike Information Criterion (AIC) and Bayesian Information Criteria (BIC) supported inclusion of year and region effects in both the binomial and lognormal components of the index for both the model with false positives from the 0.27 threshold and the 0.10 threshold. The addition of month effects (to allow for seasonal changes in CPUE) did not improve model fit in the lognormal model, but the full model including month, year and county was supported for the binomial model (Table 2). The difference in AIC values for the full model compared to the model with only year and county was greater for the binomial model (201.5) favoring the full modal compared to the small difference for the lognormal model favoring the model with only year and county (8.3). As a result, the full model including year, county and month effects was selected for further analysis.

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

The percentage of trips that caught California scorpionfish was 20.8% (828/3,968) prior to filtering with the Stephens-MacCall method, and 71.0% (828/1,167) with the filter set to 0.27 and 26.7% (828/3,099) with the filter set to 0.10, filtered data set. Residual-based model diagnostics for the positive component of the index suggest the data generally met the assumptions of the GLM (Figure 10). The resulting index is highly variable for both thresholds, with consistent peaks in 1984 and 1998 (Figure 11). Application of the 0.27 threshold holds the potential of biasing the resulting index values high by excluding false positive trips while including positive trips with equivalent probability of encountering California scorpionfish. The 0.1 threshold removes a high proportion of trips with shelf rockfish species indicative of effort exerted in deeper depths than are commonly occupied by California scorpionfish, while retaining false positive trips with equivalent probabilities of capture to true positives and thus was retained for further analysis.

The resulting jackknifed mean index values, standard error, coefficient of variation and confidence intervals for the 0.1 threshold model, excluding 1989, with year, month and county effects are provided in Table 14.

The results of the models with each of the thresholds provided similar trends seen in Figure

698 Figure 11 along with the results from the CPFV logbook index. The trends differ from those
699 resulting from the CPFV logbook index early in the time series, but both show an increase
700 in the mid to late 1990s. The PC dockside index was excluded from further analysis in the
701 model given that the CPFV logbook index represents the same sector of the fishery and
702 presumably contains data from some of the same trips, utilizes data for many thousands
703 more trips, and provides data from 1989 to 1992 omitted from the MRFSS data as a result
704 of filtering out 1989 and a lapse of sampling from 1990-1992.

705 *Party/Charter Dockside Length Measurements*

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

711 Length measurements for California scorpionfish from 1980-2016 were provided from RecFIN
712 by Edward Hibscher (PSMFC) on November 29, 2016. The number of trips from 1980-2003
713 is the number of trips with observer catch of California scorpionfish as outlined in the
714 Supplemental Material (“Identifying Trips in RecFIN”). However, the algorithm used to
715 determine the number of trips has not been applied to RecFIN data past 2003. The number
716 of trips for 2004 and 2005, was taken as the ratio of the number of interviews (ID_CODE) in
717 RecFIN to the number of known trips for years with complete data. The number of individual
718 ID_CODEs was reduced by 38% for 2004 and 2005, and gives reasonable sample
719 sizes. From 2004-2016 the number of trips from which the samples were taken is known.

720 From 1985-1987 Ally et al. (1991) conducted an onboard observer program in southern
721 California, and measured both retained and discarded fish. Additional unpublished years
722 (1984, 1988-1999) from this onboard observer sampling program were provided by CDFW
723 (Paulo Serpa). From 1984-1989, the onboard observer program measured 11,892 retained
724 California scorpionfish compared to the 1,981 measurements in RecFIN. It is almost certain,
725 but cannot be verified, that some of the lengths from the onboard observer program were
726 input in RecFIN. Therefore, the onboard observer measurements from 1984-1989 are used
727 instead of those from RecFIN for these years.

728 **Onboard Observer Party/Charter Boat**

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

738 CDFW implemented a regulation of three hooks in 2000, which was reduced to (and remains
739 at) two hooks in 2001. CDFW also implemented a 10 inch size limit for California scorpionfish
740 in 2000. The length composition of retained in discarded California scorpionfish (both before
741 and after the minimum size restriction). Prior to 2001, there were no depth restrictions for
742 the southern California recreational fishery. Given these regulation changes, the data from
743 1999 and 2000 are excluded from the index.

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

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

755 Prior to any analyses, drifts with erroneous or missing data were removed from the data
756 considered for the California scorpionfish index. The locations of positive encounters (retained
757 + discarded) were mapped, using the drift starting locations. Regions of suitable habitat were
758 defined by creating detailed hulls (similar to an alpha hull) with a 0.01 decimal degree buffer
759 around a location or cluster of locations.

760 Any portion of a region that intersected with land was removed. Drifts that did not intersect
761 with one of these areas were considered structural zeroes, i.e., outside of the species habitat,
762 and not used in analyses.

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

769 Drift locations within the Cowcod Conservation Area (CCA) or in Mexican waters were also
770 filtered out of the dataset. The years 1999 and 2000 were removed from the index due to
771 changes in hook and gear regulations during those years. California adopted a 3-hook and
772 1-line regulation in 2000, which changed to 2-hooks and 1-line in 2001. California scorpionfish
773 is not a common target species for the CPFV fleet, but if often a fallback species, for trips
774 targeting seabass or rockfish. California scorpionfish are targeted more often in January
775 and February when the rockfish/cabezon/greenling complex is closed. Boat identifiers were
776 available for all trips in the onboard observer database. Approximately 1,000 drifts were
777 filtered out after accounting for boats that were identified as not encountering scorpionfish

778 (Table 16. A total of 26,733 drifts for the analysis were retained. Of these, 5,507 encountered
779 scorpionfish, with 3,249 discarding California scorpionfish and 3,867 retaining California
780 scorpionfish.

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

786 *Onboard Obsever Discarded Catch Index*

787 Covariates considered in the full model included *year*, *area* (5 levels), *month* (12 levels), and
788 *20 m depth bins* (5 levels). All covariates were specified as categorical variables. A lognormal
789 model for the positives was selected by AIC over a gamma model (delta-AIC of 482.28).
790 Model selection for both the lognormal and binomial models retained all covariates (Table
791 17). The Q-Q plot for the positive catch lognormal model looks reasonable (Figure 13). The
792 final index shows a lower CPUE of the discards in 2001 and an increase from 2002-2005 when
793 the California scorpionfish recreational fishery was restricted by depth or closed (Table 18
794 and Figure 14). The relative CPUE of the discards decreases from 2006 to 2015.

795 *Discarded Catch Length Composition*

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

803 The discard length composition reflects the California scorpionfish seasonal closures from
804 2002-2005. Anglers encountered and discarded fish greater than the size limit of 10 inches
805 during these years. When the fishery is open, anglers are most often only discarded California
806 scorpionfish that are smaller than the legal size. This also holds true for the length composition
807 of discarded California scorpionfish in the 1980s before there was a size limit.

808 *Onboard Obsever Retained Catch Index*

809 The index of relative abundance using the retained-only catch from the onboard observer
810 program is a separate survey fleet in the base model and has no lengths associated with it.
811 Covariates considered in the full model included *year*, *area* (5 levels), *month* (12 levels), and
812 *20 m depth bins* (5 levels). All covariates were specified as categorical variables. The final
813 model includes A lognormal model was selected by AIC over a gamma model for the positives
814 (delta-AIC of 534.9).Model selection for both the lognormal and binomial models retained all

815 covariates (Table 20). The Q-Q plot for the positive catch lognormal model looks reasonable
816 (Figure 16). The final index shows a lower CPUE of the retained catch from 2002 and 2003
817 (Table 21 and Figure 17). The relative CPUE of the retained catch shows a decline from
818 2007-2015, and an increase in 2016.

819 **2.2.3 Fishery-Independent Data Sources**

fishery-independent-data-sources

820 **Sanitation Districts Trawl Survey**

821 Sanitation districts that discharge into coastal waters are required to conduct trawls to monitor
822 the demersal fish community in the vicinity of the discharge sites part of their National
823 Pollutant Discharge Elimination System (NPDES) permits, issued by the Environmental
824 Protection Agency. All sanitation districts holding NPDES permits in southern California
825 were contacted for trawl data. The two northernmost districts, Goleta and the City of
826 Oxnard, provided data (via Aquatic Bioassay & Consulting Laboratories, Inc.), but California
827 scorpionfish have not been encountered in either district's trawl surveys. The four other
828 sanitation districts, Orange County, City of Los Angeles, Los Angeles County, and the City
829 of San Diego all encounter California scorpionfish and provided trawl data.

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

833 *Orange County* The Orange County Sanitation District provided trawl data from 1970-
834 2015 (Jeff Armstrong, Orange County Sanitation District). The trawl net is a 7.6 m wide
835 Marinovich, semi-balloon otter trawl (2.54 cm mesh) with a 0.64 cm mesh cod-end liner.
836 Fixed stations are sampled either annually (summer) or semi-annually in the winter and
837 summer, Quarters 1 and 3 (Jan-March and July-September). From 1970-1985 Quarter 2,
838 trawl effort was based on a 10 minute tow time. As of 1985 Quarter 3, trawls were towed a
839 distance of 450 m. Tow time was no available for approximately half of the tows from 1985
840 Quarter 3 to 2016, and was imputed based on the mean tow time of the sampling station.

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

846 *City of Los Angeles* The City of Los Angeles Sanitation District provided trawl data from
847 1986-2016 (Craig Campbell, Lost Angeles City). The City of Los Angeles follows the same
848 sampling protocols as the Southern California Bight Regional Monitoring Program trawl
849 survey. Stations within Los Angeles Harbor were excluded from the dataset. Years with
850 fewer than ten total hauls were removed from the analysis (1986, 1987, and 1992), as were

station sampled in fewer than 10 years. Ten stations (A1, A3, C1, C3, C6, C9A, D1T, Z2, Z3, Z4), total 921 hauls, were retained for the index of abundance.

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

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

City of San Diego The City of San Diego Sanitation District conducts trawls for two permits (Point Loma Ocean Outfall and South Bay Ocean Outfall) and provided data from 1985-2015 (Ami Latker and Robin Gartman, City of San Diego Public Utilities Department).

Stations sampled in fewer than 15 years were filtered from the dataset. Fourteen stations from the Point Loma Ocean Outfall (SD1-SD14) and five stations from the South Bay Ocean Outfall were retained (SD17-21), totaling 1,180 hauls. A tow time of 10 minutes is assumed for all trawls. All California scorpionfish encountered were measured to the nearest cm (standard length).

Sanitation Districts Index Standardization

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

The data were filtered for each sanitation district independently. The filters applied are described in the sections above and summarized in Table 22. The covariates considered for the lognormal and binomial models were *year* (47 levels), *quarter* (4 levels), and *station* (52 levels). A lognormal model for the positives was select over a gamma model by a delta AIC of 619. AIC model select was used for both the lognormal and binomial models and all three covariates were selected for both (Table ??). The standardized index shows a large spike in

relative CPUE in 1981, bounces around within a range of 0.1 to 0.25 from 1989 to 2009, and then declines until 2013 (Figure 18). The last three years of the index show an increase in relative abundance. The final standardized index and log-standard error can be found in Table 24. We did explore standardizing the indices independently. However, this results in a loss of data, as some sanitation district had low sample sizes in some years. The general trend in relative CPUE is similar across sanitation districts.

Sanitation Districts Length Composition

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

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

NWFSC Trawl Survey Index

The Northwest Fishery Science Center has conducted combined shelf and slope trawl surveys (hereafter referred as NWFSC trawl survey) since 2003, based on a random-grid design from depths of 55 to 1280 meters. Additional details on this survey and design are available in the abundance and distribution reports by Keller et al. (2008). Spatial locations of raw catch rates (in log scale) are shown in Figure 24.

The proportions of positive catch haul and the raw catch rates of positive hauls by depth and latitude are shown in Figure 24 and Figure 25, respectively. These figures show that more scorpionfish were caught at shallow depth zones and in the southern latitude zones. Box plots of length summary data by depth and sex (Figure 27) and by latitude and sex (Figure 27) show no evidences of different spatial distributions (by depth and latitude) by length or by sex.

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

Summaries of age data by year and sex are presented in Table 30. There were more males (n = 529) being aged than females (n = 340), presumably indicating that there are more males

than females in the populations. The table also shows that mean ages and mean lengths for both sexes decreased in recent years. Table 31 show five percentiles of fish aged by sex, indicating more older males in the population. All aged data from the survey were used as conditional age-at-length matrix in the assessment model. The mean age-at-length indicates males and females to have similar growth patterns until around age three, at which time, females are larger than males (Table 32).

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

CSUN/VRG Gillnet Survey Index

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

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

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

The survey measured (standard length) every California scorpionfish encountered, totalling 1,130 fish. The majority of fish encountered were between 14 and 33 cm total length, with no strong trends or patterns in age classes during the time period (Figure 36)

Southern California Bight Regional Monitoring Project Trawl Survey

The southern California Coast Water Research Project SCCWRP consists of over 60 agencies in southern California that conduct monitoring of aquatic environments. One of the monitoring

966 programs in the Southern California Bight (SCB) is a trawl survey conducted every five years.
967 The pilot year of the survey was 1994. Data from each of the survey years (1994, 1998, 2003,
968 2008, and 2013) were provided by the SCCWRP (Shelly Moore).

969 In each of the five years of the study, sampling stations were chosen via a stratified random
970 sampling design (Bight '98 Steering Committee 1998). All participating agencies follow the
971 same protocols (net is towed 10 minutes at a speed of 1.0 m/sec) and use the same net
972 (semiballoon otter trawl). All fish and invertebrates are identified, counted, batch-weighed,
973 and measured (standard length to the nearest cm).

974 A series of data filters were applied to the dataset (Table 37).
975 Only two scorpionfish were encountered in hauls deeper than 450 m. Ninety-five percent of
976 the data were retained for hauls in shallower than 97 m, which was set as a filter. Stations
977 in harbors (2/114 positive hauls), north of Ventura (6/190 positive hauls) and the islands
978 (16/117 positive hauls) were excluded due to low encounters of California scorpionfish. The
979 final dataset included 398 hauls, 129 of which encountered California scorpionfish. The unit
980 of effort for this survey is in kg per tow time (minutes).

981 Covariates considered for the delta-GLM model were *year* (5 levels), *area* (4 regions), and
982 *month* (3 levels; July-September). Sampling stations were assigned to one of four regions, 1)
983 Ventura to Long Beach, 2) Long Beach to Dana Point, 3) Dana Point to San Diego, and 4)
984 San Diego to the U.S./Mexico Border. A lognormal model was selected over a gamma model
985 for the positives by a delta AIC of 30. Depth (20-m depth bins) were considered, but none
986 of the levels were significant in a full lognorml or binomial model and was not considered
987 further. AIC selection for both the lognormal and binomial models selected all covariates
988 for the final model (Table 38). The Q-Q plot used to evaluate the goodness-of-fit of the
989 lognormal portion of the model is in Figures 33.

990 The standardized index of abundance indicates higher relative CPUE in 1994 and 2003, with
991 the other three years lower (Figure 34). The fact that the survey is conducted every five years
992 (4 years between the pilot and the 1998 survey), may preclude drawing any firm conclusions
993 on trends in abundance from this data.

994 The survey measured a total of 427 fish, with the last two years of the survey (2008 and
995 2013) only encountering 25 and 53 California scorpionfish, respectively.
996 However, the smallest fish observed in this survey were in 2013 (Figure 35).

997 *Generating Station Impingement Surveys*

998 Data from the southern California generating station surveys were provided by Eric Miller
999 (MBC Applied Environmental Sciences). The generating stations all draw in seawater
1000 through an intake system for once-through cooling water. There are five generating stations
1001 that conduct normal operation and heat treatment surveys with observations of California
1002 scorpionfish: Scattergood Generating Station (SGS), El Segundo Generating Station (ESGS),
1003 Redondo Beach Generating Station (RBGS), Huntington Beach Generating Station (HBGS),

1004 and San Onofre Generation Station (SONGS). Each generating station draws in water from
1005 different depths and distances from shore: SGS draws from 500 m offshore at 6 m depth,
1006 ESBS draws from 700 m offshore at 9.8 m depth, RBGS draws from 289 m offshore at 13.7 m
1007 depth, HBGS draws from 500 m offshore at 5 m depth, and SONGS has two intake systems
1008 960 m and 900 m offshore and at 9 m and 8 m depth, respectively (Miller et al. 2009).

1009 The two surveys conducted are normal operations surveys and heat treatment surveys. For
1010 normal operations surveys, the intake screens are rotated and cleaned to start the survey. All
1011 of the impinged fish are washed off the screen at this time and discarded. When the intake
1012 screens stop running, the survey begins. The generating station then operates as normal for
1013 24 hours, which includes operating and washing the screens as usual (typically every eight
1014 hours). The screens are then operated and washed again after a second 24 hours has elapsed.
1015 Any specimens washed off the screens during the 48 hour study period are retained. The total
1016 sample is processed to identify, count, weigh, measure the fish and macroinvertebrates. There
1017 is often no information on the water flow collected during the 48 hour period of the normal
1018 operations survey. Most fish enter the generating station and swim in the sedimentation
1019 basin until either getting exhausted or impinged. The SONGS generating station also has a
1020 fish elevator that releases a fraction of the fish back to the ocean.

1021 At each generating station, cooling water, i.e., seawater, is pumped into the generating station
1022 where it reaches a sedimentation basin. Water flow is uni-directional, and fish can reside
1023 in this area, but not escape. During a heat treatment, water in the sedimentation basin is
1024 heated to over 38 degrees Celsius, killing all fish and invertebrates, and impinging them on
1025 the travelling screens.

1026 The screens are operated and washed off per normal operating procedures right up until the
1027 heat treatment takes place. Therefore, only the fish remaining in the sedimentation basin
1028 and those impinged since the last screen rotation are counted in the heat treatment survey.
1029 The total flow between heat treatments has previously been used to standardize indices in
1030 previous reports. However, this is not representative of the flow relating to fish impinged
1031 during the heat treatment. The water flows vary widely among heat treatments, time of
1032 year (higher in summer when energy demands increase), and generating stations. Therefore,
1033 the generating station impingement surveys were not used to develop indices of abundance.
1034 However, length composition data from the impingement surveys were used.

1035 The length composition data from the impingement show a higher proportion of smaller (<10
1036 cm) fish since 2012 (Figure 37)

1037 *California Cooperative Oceanic Fisheries Investigations (CalCOFI) Survey* UCSD Scripps
1038 Institution of Oceanography, CDFG, and the National Marine Fisheries Service have carried
1039 out a plankton survey on a regular basis since 1951 (Moser et al. n.d.). Prior to 1965,
1040 *Scorpaena* samples were not speciated.

1041 California scorpionfish larvae encounters from CalCOFI surveys were provided by Noelle
1042 Bowlin (NMFS SWFSC). Only 16 positive bongo tows in the core area (lines 77-93) encountered
1043 California scorpionfish. The majority of the 335 positive bongo tows occurred in Mexico,

1044 south of Punta Eugenia Baja California and are likely a combination of California scorpionfish
1045 and other *Scorpaena* species. The California scorpionfish egg masses are encountered in
1046 the CalCOFI surveys, but because California scorpionfish is not a target species they are
1047 entered in the database as “unidentified eggs” (William Watson, NMFS SWFSC). An index
1048 of abundance was not developed for the CalCOFI data due to the small sample sizes.

1049 **2.2.4 Biological Parameters and Data**

biological-parameters-and-data

1050 Conversion factors California scorpionfish do not have a forked tail, therefore total length
1051 and fork length are equal. Love et al. (1987) provide conversion factors between standard
1052 length (SL) and total length (TL). $TL = 1.21SL + 1.02$ and $SL = 0.82TL - 0.69$.

1053 Standard and total lengths of 163 California scorpionfish were available from a halibut trawl
1054 survey in southern California (Steve Wertz, CDFW). The conversion from SL to TL from
1055 these data was estimated at $TL = 1.2225SL + 0.7773$.

1056 The conversion originating from the halibut trawl data was used in this assessment due to
1057 the fact that the original data from Love et al. (1987) are not available.

1058 The majority of available length composition data were measured to total length, except
1059 for three of the sanitation district trawl surveys, the Southern California Bight Regional
1060 Monitoring Program trawl survey, and the CSUN/VRG gillnet survey (gillnet survey).
1061 Maunder et al. (2005) converted all data to standard length due to clumping of data when
1062 length data are only available to the nearest centimeter. However, the same is true for the
1063 conversion from TL to SL when data are available to the nearest centimeter. All length data
1064 for this assessment are in TL. The Sanitation District of Orange county and the VRG gillnet
1065 study measured SL to the nearest mm.

1066 To avoid missing length bins (specifically 18, 23, 29 cm) in the conversion from SL to TL,
1067 0.5 was first subtracted from each SL and a random uniform number ($U[0, 1]$) was added to
1068 the SL measurement. All TL measurements were rounded to the nearest length centimeter
1069 length bin. A comparison of the length distributions

1070 **Length And Age Compositions**

1071 Include: Sample size information for length and age composition data by area, year, gear,
1072 market category, etc., including both the number of trips and fish sampled.

1073 Length compositions were provided from the following sources:

- 1074 • CDFW market category study (*commercial dead fish*, 1996-2003)
- 1075 • CALCOM (*commercial dead fish*, 2013-2016)
- 1076 • CDFW onboard observer (*recreational charter discards*, 2003-2016)
- 1077 • Ally onboard observer study (*recreational charter discards*, 1984-1989)

- California recreational sources combined (*recreational charter retained catch*)
 - CDFW and Ally onboard observer surveys (1984-1989)
 - Collins and Crooke onboard observer surveys (1975-1978)
 - MRFSS (1980-2003)
 - CRFS (2004-2014)
- California recreational sources combined (*private mode retained catch*)
 - MRFSS (1980-2003)
 - CRFS (2004-2016)
- Sanitation district trawl surveys (*research*, 1970-2016)
- CSUN/VRG gillnet survey (*research*, 1995-2008)
- Power plant impingement surveys (*research*, 1974-2016)
- Southern California Bight trawl survey (*research*, 1994, 1998, 2003, 2008, 2013)

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

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

Commercial: PacFIN

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

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

Sex-specific length-at-age was initially estimated external to the population dynamics models using the von Bertalanffy growth curve (Bertalanffy 1938), $L_i = L_\infty e^{(-k[t-t_0])}$, where L_i is the length (cm) at age i , t is age in years, k is rate of increase in growth, t_0 is the intercept, and L_∞ is the asymptotic length.

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

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

Age-composition data used in the model were all from the NWFSC trawl survey and were from otoliths reads aged by the Cooperative Ageing Project (CAP) in Newport, Oregon. All of the otolith reads were from Age Reader A, and double reads were read by Age Reader B.

1115 Ageing error was estimated using publicly available software (Thorson et al. 2012).
1116 The software setting for bias and standard deviation were the same for both readers, unbiased
1117 and curvilinear increase in standard deviation with age, respectively (Figure 44). Two fish
1118 with estimated age greater than 21 (plus group age) were excluded from the ageing error
1119 estimation. The resulting estimate indicated a standard deviation in age readings increasing
1120 from 0.001 years to a standard deviation of 1.79 years at age 22.

1121 Weight-Length

1122 The weight-length relationship is based on the standard power function: $W = \alpha(L^\beta)$ where
1123 W is individual weight (kg), L is length (cm), and α and β are coefficients used as constants.

1124 Sex-specific weight-length relationships were estimated from the NWFSC trawl survey data.
1125 Length and weight data were available for 340 females and 530 males. The estimated
1126 parameters for females are $\alpha = 1.553983e^{-05}$ and $\beta = 3.057654$, and for males $\alpha = 1.9104e^{-05}$
1127 and $\beta = 2.980548$. Love et al. (1987) found males to be heavier at a given length than
1128 females, whereas the NWFSC data suggest the opposite (Figure 45).

1129 The original data from Love et al. (1987) are no longer available (Milton Love, personal
1130 communication, UC Santa Barbara) to re-examine the trends. The weight-length relationships
1131 estimated from the NWFSC survey are consistent with the sex-specific growth rates and are
1132 used in the assessment model.

1133 Sex Ratio, Maturity, and Fecundity

1134 The NWFSC trawl survey is the only study available with raw data on sex ratios by age.
1135 Across all ages, the sex ratio from the aged California scorpionfish from the NWFSC trawl
1136 survey was 60% males and 40% females. At age-1, 39% of the aged fish were female (29 of
1137 85), but the sex of 10 fish was unknown. For ages two to five, the percent of female fish
1138 ranged from 45-54%, with aged fish older than five dominated by males. The assessment
1139 assumed a sex ratio at birth was 1:1. The NWFSC trawl survey samples a minimum depth
1140 of 55 m and no information on sex ratios was available from other surveys.

1141 Love et al. (1987) conducted the only published life history study of California scorpionfish,
1142 but did not report information on sex ratios. Differing numbers of sample sizes (males and
1143 females) were used for each part of the study (ex. maturity and length-at-age). The raw data
1144 from this study are no longer available, and we were not able to determine raw sample sizes
1145 by sex.

1146 No new data on maturity or fecundity for California scorpionfish are available since the
1147 publication of the 2005 stock assessment. Love et al. (1987) found few California scorpionfish
1148 to be mature at age-1, 50% of males were mature at 17 cm TL and over 50% of females were
1149 mature by 18 cm TL, or two years of age. All fish were mature by 22 cm TL. This assessment

1150 used size at 50% maturity for females of 18 cm TL, with maturity asymptotic to 1.0 for
1151 larger fish.

1152 The 2005 assessment model combined information from estimated linear gonadal somatic
1153 index and maturity based on standard length (Maunder et al. 2005). However, the study
1154 used to estimate the GSI, was a halibut targeted study using a mesh size of xxx (Steven
1155 Wertz, personal communication, CDFW). This assessment assumed linear relationship for
1156 eggs per kilogram.

1157 **Natural Mortality** Hamel (2015) developed a method for combining meta-analytic ap-
1158 proaches to relating the natural mortality rate M to other life-history parameters such as
1159 longevity, size, growth rate and reproductive effort, to provide a prior on M . In that same
1160 issue of ICESJMS, Then et al. (2015), provided an updated data set of estimates of M and
1161 related life history parameters across a large number of fish species, from which to develop
1162 an M estimator for fish species in general. They concluded by recommending M estimates
1163 be based on maximum age alone, based on an updated Hoenig non-linear least squares
1164 (nls) estimator $M = 4.899 * A_{max}^{-0.916}$. The approach of basing M priors on maximum age
1165 alone was one that was already being used for west coast rockfish assessments. However,
1166 in fitting the alternative model forms relating $-0.916M$ to A_{max} , Then et al. (2015) did
1167 not consistently apply their transformation. In particular, in real space, one would expect
1168 substantial heteroscedasticity in both the observation and process error associated with the
1169 observed relationship of M to A_{max} . Therefore, it would be reasonable to fit all models under
1170 a log transformation. This was not done. Reevaluating the data used in Then et al. (2015) by
1171 fitting the one-parameter A_{max} model under a log-log transformation (such that the slope is
1172 forced to be -1 in the transformed space (as in Hamel (2015)), the point estimate for M is:

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

1173 The above is also the median of the prior. The prior is defined as a lognormal with mean
1174 $\ln \frac{5.4}{A_{max}}$ and SE = 0.4384343. Using a maximum age of 21 the point estimate and median of
1175 the prior is 0.2545, which is used as a prior for females in the assessment model.

1176 **2.2.5 Environmental Or Ecosystem Data Included In The Assessment**
environmental-or-ecosystem-data-included-in-the-assessment

1177 **2.3 History Of Modeling Approaches Used For This Stock**
history-of-modeling-approaches-used-for-this-stock

1178 **2.3.1 Previous Assessments**
previous-assessments

1179 California scorpionfish was first assessed in 2005 (Maunder et al. 2005) using SS2 (version
1180 1.18).

1181 The 2005 model was a one-area model for the population south of Pt. Conception to the
1182 U.S.-Mexico border. The assessment was sensitive to the inclusion of the sanitation district
1183 index of abundance and the STAT team provided reference points for a model that included
1184 the sanitation index and one excluding it. The stock was found to be at 80% of unfished
1185 levels for the model with the sanitation index and 58% for the model without the sanitation
1186 index.

1187 The 2015 catch-only projections used the same version of SS2 as the 2005 assessment model.
1188 The 2005 model assumed removals equivalent to the ACL in all years from 2004-2016. The
1189 2015 model included catch estimates from 2004-2014, and the ACLs for 2015 and 2016 were
1190 assumed to be attained. Maunder et al. (2005) assumed no discard mortality, while the 2015
1191 update applied a 7% discard mortality rate derived by the Groundfish Management Team
1192 (GMT) (2009-2010 SPEX EIS, Chapter 4, pg. 290) was applied to the estimate of discards to
1193 provide an estimate of discard mortality for the recreational fleet.

1194 **2.3.2 2005 Assessment Recommendations**
assessment-recommendations

1195 Include: Response to STAR panel recommendations from the most recent previous assessment.

1196 **Recommendation 1:** The sanitation surveys conducted to track the impact
1197 of sewage outfall provided a fishery independent index of abundance for
1198 scorpionfish. This data source should be more fully explored for other
1199 near-shore species of recreational or commercial interest. Methods should
1200 be developed to produce a more statistically rigorous index from the
1201 separate surveys.

1202
1203 STAT response: Data from all sanitation districts in southern California were obtained
1204 for this assessment. All of the data were pooled across surveys to develop one index of
1205 abundance using the delta-GLM method

1206 **Recommendation 2:** An age, growth and maturity study for scorpionfish is
1207 needed. Although there has been previous research on scorpionfish age and

1208 growth, the available information is not appropriate for stock assessment
1209 modeling.

1210
1211 STAT response: Age data are available from the NWFSC trawl survey from 2005-2016.
1212 There have been no additional studies on growth or maturity for California scorpionfish
1213 since the 2005 assessment.

1214 **Recommendation 3:** Location information for the historic groundfish data of all
1215 species is currently available, in hard copy form only, from the California
1216 Department of Fish and Game. Putting this information into electronic
1217 format would greatly improve the ability to assign catches of all species to
1218 specific stocks on a trip-by-trip basis.

1219
1220 STAT response: The location-specific catches referred to above have been key-punched
1221 and are available in electronic form from the SWFSC, Santa Cruz.

1222 **Recommendation 4:** The SS2 model should be modified to allow for projections
1223 of user-specified recruitment at user defined values. It would be most
1224 helpful if the default harvest policies were then recalculated automatically
1225 for these user-specified recruitments.

1226
1227 STAT response: The status of this within Stock Synthesis is unknown.

1228 2.4 Model Description

model-description

1229 2.4.1 Transition To The Current Stock Assessment

transition-to-the-current-stock-assessment

1230 The first formal stock assessment for California scorpionfish was conducted in 2005 (Maunder
1231 et al. 2005). The 2005 model conducted in SS2 version 1.18 was first transitioned to SS3.24z
1232 as a bridge model, before moving forward to SS3.30. During the model transition to SS3.24z
1233 and error was found in the 2005 model. The harvest rate was estimated at the upper limit of
1234 0.9 and could not remove all of the input catch 46.

1235 The older SS2 output did not include separate columns for the observed (input) catch and
1236 dead removals by the model (output), which would have prevented the 2005 STAT team from
1237 discovering that the two time series differed 47. The recreational fishery selects the largest
1238 fish and removes the highest biomass of California scorpionfish. When the harvest rate hit
1239 the upper bounds as in the 1970s, there were not enough fish estimated in the population to
1240 support the large removals, i.e., stock estimated at 500 mt and the recreational catch was
1241 100 mt. The stock was not productive enough to sustain the observed catch. A comparison
1242 of time series from the 2005 model, the SS3.24z transition model, and the base model from
1243 this assessment are in Figure 48

1244 Below, we describe the most important changes made since the last full assessment in 2005
1245 and explain rationale for each change. Some of these items are changes due to structure
1246 changes with Stock Synthesis, and some denote parameters chosen for options that were not
1247 available in SS2 (version 1.18).

1248 Changes in the bridge model from from SS2 version 1.8 to SS3.24z and SS3.30

1249 The way growth is modeled for age-0 fish changed. More recent versions of Stock Synthesis
1250 model length-at-age for fish below the first reference age (A_{min}) as linearly increasing from
1251 the initial length bin to the length given by the L_{at_Amin} parameter. Since small California
1252 scorpionfish are selected in the sanitation district survey data, the change in modeled growth
1253 has the potential to affect estimates of recruitment. We took the following approach in order
1254 to mimic the methods of SS2 version 1.8:

1255 1. Change A_{min} from 1 to 0.

1256 2. Replace initial value of length at minimum age for females with 7.26567 (the Length
1257 begin value for age 0 from the SS2.rep file).

1258 3. Replace initial value of length at minimum age for males with 0.35366 (=
1259 $\ln(10.3483/7.26567)$, the log of the ratio of Male to Female length at age 0 from the
1260 SS2.rep file)

1261 This assessment aggregated the catches from the commercial fish pot fleet with the hook-
1262 and-line fleet. There were no measured California scorpionfish from the fish pot fleet and
1263 overall catches were minimal. The commercial trawl and gill net fleets were disaggregated as
1264 in the 2005 model. The current model also assumes no discards in the commercial fishery.
1265 The previous assessment combined the recreational party/charter and private modes into a
1266 single fishery. This assessment disaggregates the two sectors of the recreational fishery and
1267 adds a fleet to represent the discards (party/charter and private modes combined) from the
1268 recreational fleet

1269 The 2005 model was a length-based model. This assessment uses conditional age-at-length
1270 from fish aged from the NWFSC trawl survey.

1271 The historical commercial catches were the same as those used in the previous assessment
1272 and were updated using CFIS data from 2005-2016. The CFIS database was used instead of
1273 CALCOM because landings in CALCOM included catches from Mexican waters.

1274 The recreational catches differed from the catch history used in the previous assessment. In
1275 2010 a catch reconstruction was completed for California (Ralston et al 2010). Methods
1276 provided were applied in reconstructing the catch of California scorpionfish for this assessment.
1277 Both assessments utilized similar data sources including CPFV logbooks and MRFSS data
1278 providing catch estimates, with the addition of data from the CRFS program for 2004-2016.

1279 The main difference resides with accounting for discard mortality as well as landed catch
1280 allowing discards to be modeled as a separate fleet making use of length distribution data for
1281 discards for 2003-2016. In addition, the recreational catch time series terminated in 1928 for
1282 the current assessment, as specified for rockfish catch reconstructions in the historical catch
1283 reconstruction document, rather than in 1916. The ratio of catches for the party-charter boat
1284 mode to the private and rental boat mode from the MRFSS period were used in combination
1285 with catch estimates from the CPFV logbook estimates back to 1932 in both assessments to
1286 approximate mortality the private rental boat mode prior to 1980. A ramp accounting for
1287 the increase relative contribution of the private boat mode relative to the party charter mode
1288 from the mid 1965 to 1980, as conducted for rockfish in the historical catch reconstruction
1289 document. A constant ratio of catch compared to the party charter boat mode was applied
1290 for man-made and beach and bank modes to provide an estimate of catch back to 1936 as was
1291 done for the private and rental boat mode in the previous assessment. The CPFV logbook
1292 data terminated in 1935 and a linear ramp was used to approximate catch from 1936 back to
1293 zero in 1928 for each mode as compared to 1916 in the 2005 assessment.

1294 The bias adjustment for recruitment deviations did not exist in SS2 (version 1.198). We set
1295 1965-2015 as the range of years with full bias adjustment in SS3.24z to span the time series
1296 that was modeled.

1297 Length composition data was updated and sources added for this assessment. The 2005
1298 assessment used the same source for length compositions for the commercial fisheries, the
1299 CDFW market category study. The length compositions from CALCOM were all from single
1300 trips within a year and are not used in the assessment. The measured fish from RecFIN
1301 (dockside intercept surveys) were disaggregated to the party/charter and private modes.
1302 Preliminary analyses indicated the recreational private and rental boat mode selects larger
1303 fish than the party and charter boat mode (add plot).

1304 The 2005 assessment converted all length parameters to SL, which prevented comparisons
1305 with some of the growth parameters. The values in the SS files from the previous assessment
1306 also did not match those in the written document. The current model uses TL for all length
1307 compositions and growth parameters.

1308 The previous assessment modeled selectivity using the double logistic, with defined peak, and
1309 smooth joiners for all fleets with estimated selectivity. Two parameters were estimated for
1310 each selectivity curve, the size at which selectivity is halfway between the selectivity at length
1311 bin = 1 and one, and the slope of the left side of the selectivity curve. This selectivity pattern
1312 has since been discontinued in SS. All of the double logistic selectivity patterns in the 2005
1313 assessment were asymptotic and are the same in this assessment. Selectivity in this model is
1314 assumed to be length-based and is modeled as double-normal for all fleets that were also in
1315 the previous assessment. This assessment mirrors the selectivity for the trawl and gill net
1316 commercial fisheries to the commercial hook-and-line fishery. The 2005 assessment included
1317 two surveys, the CPFV logbook and sanitation district surveys. The length composition
1318 measurement for the CPFV logbook survey are from the dockside intercept surveys in RecFIN
1319 and were updated to double normal selectivity in this model.

1320 The time blocks for the commercial fishery is the same as in the previous assessment (1916-
1321 1998 and 1999-2017). There have been no additional major changes to the commercial
1322 regulations since the 10-inch minimum size limit and the catches from the commercial fleets in
1323 the last 10 years have been minimal compared to historical catches. The time blocks for the
1324 recreational fleets were updated to include a third time block from 2000-2005, when closures
1325 of the recreational fishery fluctuated annually. Since 2006, the recreational regulations have
1326 remained fairly consistent.

1327 The 2005 assessment considered six candidate indices of abundance (fishery-dependent: CPFV
1328 logbook, CDFW monthly block summaries, RecFIN dockside intercept survey, trawl logbook;
1329 fishery-independent: sanitation survey, CalCOFI, but only included two in the final model
1330 (CPFV logbook and sanitation district surveys). The sanitation district survey ended up
1331 being the basis for the decision table in the 2005 assessment, with more weight given to the
1332 model with/without the sanitation district survey. All indices were re-evaluated and updated
1333 through 2016 for this assessment. As in the 2005 assessment, we did not consider the CaCOFI
1334 index, CDFW monthly block summaries, or the trawl survey for the current model. The
1335 current model includes four fishery-dependent indices and four fishery-independent indices.
1336 The RecFIN party/charter mode dockside intercept survey was not available at the trip-level
1337 in 2005 and it is unclear how the 2005 assessment treated data record entries from RecFIN;
1338 however, the RecFIN index was sensitive to the. The RecFIN private mode index is currently
1339 only available at the trip-level for the CRFS sampling period, 2004-2016. The onboard
1340 observer database was also not available for the 2005 assessment and is used here as both
1341 retained-only and discard-only indices. The CPFV logbook data was updated and reevaluated
1342 from the 2005 assessment.

1343 The fishery-independent indices are all new for this assessment, except for the sanitation
1344 districts trawl surveys.

1345 Maturity was changed for this assessment. The Love et al. (1987) study is the only study
1346 that estimated the maturity ogive. The CDFW cross-shelf halibut survey used in the 2005
1347 assessment to estimate the GSI were not used in this study as GSI is an indicator of fecundity.
1348 No information on fecundity is available for California scorpionfish. This assessment uses the
1349 assumption that eggs are equivalent to spawning biomass.

1350 In this assessment, steepness was set at 0.718, the mean of the beta prior developed from
1351 a meta-analysis of West Coast groundfish and updated in 2017 (James Thorson, personal
1352 communication, NWFSC, NOAA).

1353 The prior for female natural mortality was updated to the median of the prior from a meta-
1354 analysis conducted by Owen Hamel (personal communication, NWFSC, NOAA).
1355 Assuming a maximum age of 21 years, the median of the prior is 0.2547, close to the fixed
1356 value for younger fish in the 2005 assessment of 0.25.

1357 Due to the fact that the 2005 model was erroneous, a bridge from the 2014 catch update,
1358 which used SS2 version 1.8 and the 2005 model, was not developed.

¹³⁵⁹ Changes in the bridge model from from the SS3.24z model closely matched with the SS2
¹³⁶⁰ version 1.8 model to SS3.30.

¹³⁶¹ 2.4.2 Summary of Data for Fleets and Areas

^{summary-of-data-for-fleets-and-areas}

¹³⁶² There are twelve fleets in the base model. They include:

¹³⁶³ *Commercial*: The commercial fleets include three separate fleets, one each for the hook-and-
¹³⁶⁴ line, gillnet, and trawl fisheries. The catch from all other commercial gears is included in the
¹³⁶⁵ hook-and-line catch.

¹³⁶⁶ *Recreational*: The recreational fleets include three separate fleets, one each for retained catch
¹³⁶⁷ from the recreational party/charter boat and private boat modes, and one for the dead
¹³⁶⁸ discards from the recreational party/charter boat and private boat modes combined.

¹³⁶⁹ *Research*: There are six sources of fishery-independent data available for California scorpiofish,
¹³⁷⁰ including the sanitation district trawl surveys, NWFSC trawl survey, the CSUN/VRG
¹³⁷¹ gillnet survey, the generating stations surveys, Southern California Bight regional monitoring
¹³⁷² trawl survey, and the recreational party/charter onboard observer retained-only catch data.

¹³⁷³ 2.4.3 Other specifications

^{other-specifications}

¹³⁷⁴ Stock synthesis has a broad suite of structural options available. Where possible, the ‘default’
¹³⁷⁵ or most commonly used approaches are applied to this stock assessment.

¹³⁷⁶ The assessment is sex-specific, including the estimation of separate growth curves, and natural
¹³⁷⁷ mortality. Sex-specific length-weight parameters were input as fixed values. The assessment
¹³⁷⁸ only tracks female spawning biomass for use in calculating stock status.

¹³⁷⁹ The selectivity for the generation station impingement surveys was set to 1.0 for all sizes
¹³⁸⁰ (SS pattern 0). As an example, the cooling intake pipes at SONGS are 18-foot in diameter
¹³⁸¹ and draw in seawater at a rate of hundreds of thousands of gallons per minute. The water
¹³⁸² flow once in the generating station is one directional and organisms cannot escape, unless
¹³⁸³ removed via a fish return system.

¹³⁸⁴ The time-series of landings begins in 1916 for the commercial fleet and in 1929 for the
¹³⁸⁵ recreational fleet. This captures the inception of the fishery, so the stock is assumed to be in
¹³⁸⁶ equilibrium at the beginning of the modeled period.

¹³⁸⁷ The internal population dynamics model tracks ages 0-21, where age 21 is the ‘plus-group.’
¹³⁸⁸ There are relatively few observations in the age compositions that are greater than age 21.

1389 The following likelihood components are included in this model: catch, indices, discards,
1390 length compositions, age compositions, recruitments, parameter priors, and parameter soft
1391 bounds. See the SS technical documentation for details (Methot 2015).

1392 Electronic SS model files including the data, control, starter, and forecast files can be found
1393 on the [PFMC ftp site](#).

1394 2.4.4 Modeling Software

modeling-software

1395 The STAT team used Stock Synthesis 3 version 3.30.0.4 by Dr. Richard Methot at the NWFSC.
1396 This most recent version was used, since it included improvements and corrections to older
1397 versions. The r4SS package (GitHub release number v1.27.0) was used to post-processing
1398 output data from Stock Synthesis.

1399 2.4.5 Data Weighting

data-weighting

1400 Length composition and conditional-age-at-length (CAAL) compositions sample sizes for the
1401 base model were tuned by the “Francis method,” based on equation TA1.8 in Francis
1402 (2011), and implemented in the r4ss package. This approach involves comparing the residuals
1403 in the model’s expected mean length with respect to the observed mean length and associated
1404 uncertainty derived from the composition vectors and their associated input sample sizes.
1405 The sample sizes are then tuned so that the observed and expected variability are consistent.
1406 After adjustment to the sample sizes, models were not re-tuned if the bootstrap uncertainty
1407 value around the tuning factor overlapped 1.0.

1408 As outlined in the Best Practices, a sensitivity run was conducted with length and conditional-
1409 age-at-length (CAAL) compositions were re-weighted using the Ianelli-McAllister harmonic
1410 mean method (McAllister and Ianelli 1997).

1411 Extra variability parameters were estimated and added to the input variance for all surveys
1412 and CPUE indices.

1413 2.4.6 Priors

priors

1414 The log-normal prior for female natural mortality were based on a meta-analysis completed
1415 by Hamel (2015), as described under “Natural Mortality.” Female natural mortality was
1416 fixed at the median of the prior, 0.257 for an assumed maximum age of 21. An uninformative
1417 prior was used for the male offset natural mortality, which was estimated.

1418 The prior for steepness (h) assumes a beta distribution with parameters based on an update
1419 for the Thorson-Dorn rockfish prior (Dorn, M. and Thorson, J., pers. comm.), which was

1420 endorsed by the Science and Statistical Committee in 2017. The prior is a beta distribution
1421 with $mu=0.718$ and $sigma=0.158$. Steepness is fixed in the base model at the mean of the
1422 prior. The priors were applied in sensitivity analyses where these parameters were estimated.

1423 **2.4.7 Estimated And Fixed Parameters**

estimated-and-fixed-parameters

1424 A full list of all estimated and fixed parameters is provided in Tables 40. Time-invariant,
1425 sex-specific growth is estimated in this assessment, with all SS growth parameters being
1426 estimated. The log of the unexploited recruitment level for the Beverton-Holt stock-recruit
1427 function is treated as an estimated parameter. Annual recruitment deviations are estimated
1428 beginning in 1985, just after the first sets of length composition data enter the model. The
1429 survey catchability parameters are calculated analytically (set as scaling factors) such that the
1430 estimate is median unbiased, which is comparable to the way q is treated in most groundfish
1431 assessments.

1432 The base model has a total of 102 estimated parameters in the following categories:

1433 equilibrium recruitment((0)) and 54 recruitment deviations, 9 growth parameters 8 index
1434 extra standard deviation parameter, and 31 selectivity parameters.

1435 The estimated parameters are described in greater detail below and a full list of all estimated
1436 and parameters is provided in Table 40.

1437 *Growth* Five growth parameters were estimated for females: 3 von Bertalanffy parameters
1438 and 2 parameters for CV as a function of length at age related to variability in length at age
1439 for small and large fish.

1440 Four parameters are estimated for male growth as offset from female growth. The length at
1441 Amin was set equal to the female estimate.

1442 *Natural Mortality*_Natural mortality is fixed for females at the value provided by the Hamel
1443 (Hamel 2015) analysis described above. Natural mortality for males is estimated as an offset
1444 from the fixed female natural mortality.

1445 *Selectivity*_Selectivity for all fleets (except the impingement survey) was estimated as double-
1446 normal. The recreational dead discard fleet has a dome-shaped selectivity and all 6 parameters
1447 were estimable.

1448 For all fleets where the estimated parameters were asymptotic, parameters related to the
1449 dome were fixed, leaving only the position of the peak, the ascending slope, and selectivity at
1450 the first length bin as estimated parameters. Ten selectivity parameters related to the time
1451 blocks were also estimated.

1452 *Other Estimated Parameters*_Log(R0) is the equilibrium recruitment, which is estimated.

1453 Recruitment deviations for the base model are estimated from 1984 to 2015. The base model
1454 also included estimated recruitment deviations for the forecast years, although these have no
1455 impact on the model estimates for the current year.

1456 A number of alternate model were explored before the final base model was reached.
1457 Many variations of the base case model were explored during this analysis. Sensitivities
1458 to asymptotic vs. domed selectivity were explored for the appropriate fisheries, e.g. trawl
1459 and gill net fisheries, as well as estimating selectivity and mirroring fleet selectivities. Time
1460 blocked selectivity without the time block from 2005-2015 for the recreational fisheries was
1461 investigated. We also considered a model with an additional time block for the commercial
1462 fishery, but the length composition data were sparse.

1463 This assessment includes discards for the recreational fleet, so time was spent investigating
1464 changes in selectivity and the most prudent way to incorporate discards.
1465 Length composition of discards from two recreational party/charter onboard observer programs
1466 and

1467 Sensitivities to estimates of female natural mortality were explored by fixing other key
1468 parameters, i.e., steepness. Male natural mortality is still reasonably well estimated, but
1469 the estimates of $\ln R_0$ and female M are not well estimated. The previous assessment fixed
1470 female and male M , where male M was an offset. The previous model had two breakpoints
1471 for natural mortality, but the natural mortality for older fish was set to the same as for
1472 younger fish. This model uses one parameter for natural mortality for each sex.

1473 Much time was also spent tuning the advanced recruitment bias adjustment options, which
1474 are new to SS 3.30. Sensitivities were performed to each of the thirteen advanced options for
1475 recruitment, e.g., early recruitment deviation start year, early recruitment deviation phase,
1476 years with bias adjustments, and maximum bias adjustment. The final base model

1477 Several models were also investigated where steepness was either estimated, fixed at the prior,
1478 or an alternate value.

1479 Sensitivities of the model to the spawning and settlement months were also explored.
1480 The base model originally set spawning month to June and settlement month to July.
1481 California scorpionfish are summer spawners and settle at a small size. However, a potential
1482 bug in how recruits move into the numbers-at-age matrix was discovered (Richard Methot,
1483 personal communication, NWFSC). The final base model sets both the spawning month
1484 and settlement month to January, which is the equivalent to the settings available in
1485 SS3.24z. Parameters for extra standard deviation were added to all survey indices in the model
1486 because they were not exceptionally well fit by the models considered.

1487 Other Fixed Parameters The stock-recruitment steepness is fixed at the SSC approved
1488 steepness prior for rockfish of 0.718. The initial recommendation for steepness was to explore
1489 the available estimates of steepness from Myers et al. (1999).

1490 Myers (Myers et al. 1999) provides estimates of steepness for three species in the family

1491 Scorpidae, of which California scorpionfish is a member: chilipepper (*Sebastodes goodei*),
1492 0.35; Pacific ocean perch (*Sebastodes alutus*) 0.43; and deepwater redfish (*Sebastodes mentella*),
1493 0.47. The estimate of steepness for the family was 0.48. Information for steepness is not
1494 available for California scorpionfish and there is little information from related species that
1495 could be considered as a good proxy. A value of 0.718 (the updated 2017 prior) was assumed
1496 for the assessment.

1497 2.5 Model Selection and Evaluation

model-selection-and-evaluation

1498 2.5.1 Key Assumptions and Structural Choices

key-assumptions-and-structural-choices

1499 Key assumptions in the model were that the population is a single-stock in the southern
1500 California Bight. No information is available on the portion of the population in Mexican
1501 waters. The San Diego recreational party/charter fleet is known to fish for California
1502 scorpionfish at the Coronado Island in Mexican waters. All catches from Mexican waters and
1503 landed in the U.S. were removed from the base model data streams.

1504 Female natural mortality and steepness are both fixed in the base model, and sensitivities
1505 were conducted estimating these parameters. Structurally, the model assumed that the
1506 landings from each fleet were representative of the population in southern California and
1507 fishing mortality prior to 1916 was negligible. It is also assumed that commercial discards
1508 have been negligible and are not included in the base model.

1509 2.5.2 Alternate Models Considered

alternate-models-considered

1510 Include: Summary of alternate model configurations that were tried but rejected.

1511 2.5.3 Convergence

convergence

1512 Model convergence was determined by starting the minimization process from dispersed values
1513 of the maximum likelihood estimates to determine if the model found a better minimum.
1514 Jitter is a SS option that generates random starting values from a normal distribution
1515 logically transformed into each parameter's range (Methot 2015). This was repeated 100
1516 times and the minimum was reached in 35% of the runs (Table 42).

1517 The model did not experience convergence issues, e.g., final gradient was below 0.0001, when
1518 reasonable starting values were used and there were no difficulties in inverting the Hessian
1519 to obtain estimates of variability. We did sensitivity runs for convergence by changing the
1520 phases for key estimated parameters and the total log-likelihood did not change nor the
1521 parameter estimates.

1522 **2.6 Response To The Current STAR Panel Requests**
1523 response-to-the-current-star-panel-requests

1524
1525 **Request No. 1: Add after STAR panel.**

1526 **Rationale:** Add after STAR panel.

1527 **STAT Response:** Add after STAR panel.

1528 **Request No. 2: Add after STAR panel.**

1529 **Rationale:** Add after STAR panel.

1530 **STAT Response:** Add after STAR panel.

1531 **Request No. 3: Add after STAR panel.**

1532 **Rationale:** Add after STAR panel.

1533 **STAT Response:** Add after STAR panel.

1534 **Request No. 4: Example of a request that may have a list:**

1535

- 1536 • **Item No. 1**
- 1537 • **Item No. 2**
- 1538 • **Item No. 3, etc.**

1539 **Rationale:** Add after STAR panel.

1540 **STAT Response:** Continue requests as needed.

1541 **2.7 Model 1**

model-1

1542 **2.7.1 Model 1 Base Case Results**

model-1-base-case-results

1543 The base model parameter estimates and their approximate asymptotic standard errors are
1544 shown in Table 40 and the likelihood components are in Table ???. Estimates of derived
1545 reference points and approximate 95% asymptotic confidence intervals are shown in Table e.
1546 Time-series of estimated stock size over time are shown in Table 44.

1547 The base model is sex-specific for all biological parameters. Key productivity parameters
1548 are fixed at measures of central tendency from prior distributions endorsed by the PFMC's
1549 SSC due to the models' inability to estimate reasonable parameter values. Specifically,
1550 steepness of the assumed Beverton-Holt stock-recruitment relationship was fixed at 0.718. In
1551 the final base models the instantaneous rate of annual natural mortality was fixed at 0.2547
1552 for females, and estimated as 0.2078 for males.

1554 **2.7.2 Parameter Estimates**

parameter-estimates

1555 The base model produces reasonable estimates of growth parameters, for both males and
1556 females (Figure 42). The von Bertalanffy growth coefficient k for females was estimated
1557 close to the external estimate, 0.2496 externally and 0.2494 within SS. For males, the von
1558 Bertalanffy k parameter was estimated at 0.2325 externally and 0.2234 within SS. The female
1559 estimated $\$L_{\{\inf\}}$ was 33.46 and 27.538 for males.
1560 Females grow faster than male and reach a maximum size greater than the males.

1561 Selectivity curves were estimated for the fishery and survey fleets. The estimated selectivities
1562 for all fleets within the model are shown in Figure ???. The commercial fishery selectivities
1563 are all asymptotic with the trawl and gillnet fisheries mirroring the hook-and-line fishery.
1564 Maximum selectivity for the commercial fleet is reached at about 26 cm from 1916-1998 and
1565 28 cm from 1999-2016 (Figure ??).

1566 The shift in selectivity is due to the implementation of the 10-inch size limit for the commercial
1567 fishery in 1999. The recreational private mode sector selects the largest fish, with full selectivity
1568 at 41 cm. The time blocked selectivity does not show a major shift in selectivity when the
1569 fishery was closed for portions of 2001-2005 (Figure ??). This can be explained by the fact
1570 the length composition data from the dockside intercept survey contains a large number of
1571 observed fish when the fishery was closed. The recreational private mode also selects the
1572 largest fish, and there is no available information on discards from this fleet. There is a
1573 distinct shift in the selectivity for the retained-catch recreational party/charter fleet, with the
1574 onboard observer retained-catch fleet mirrored to the other recreational party/charter fleet.
1575 Prior to the implementation of a 10-in minimum size limit the size at maximum selectivity
1576 was 36 cm, from 2001-2005 it was 31 cm and since 2006 the size at maximum selectivity
1577 is at 26 cm (Figure ??). The recreational party/charter mode discard-catch dome-shaped
1578 selectivity reflects the discarding of small fish due to the size limit and also the discarding of
1579 smaller fish prior to the 10-in minimum size limit due to angler preference for larger fish.

1580 All of the survey selectivity curves were asymptotic and none had time blocks.
1581 The southern California Bight regional monitoring trawl survey uses the same gear as the
1582 sanitation district trawls survey. All of the three trawl surveys reach full selectivity around
1583 24 cm. The selectivity for the gill net survey is mirrored to the trawl survey because small
1584 1"-2" mesh sizes were used.

1585 The additional survey variability (process error added directly to each year's input variability)
1586 for all surveys was estimated within the model. The model estimated a small added variances
1587 for the recreational private mode of 0.013 and the recreational party/charter discard fleet of
1588 0.077.
1589 The estimated added variance was highest for the recreational party/charter retained-catch
1590 fleet (0.268), the sanitation district survey (0.225), and the NWFSC trawl survey (0.25).

1591 Recruitment deviations were estimated from 1965 to 2015 (Figure ??) . Estimates of
1592 recruitment suggest that the California scorpionfish population is characterized by variable
1593 recruitment with occasional strong recruitments and periods of low recruitment (Figures ??

1594 and ??). The four lowest recruitments (in ascending order) occurred in 2012, 2011, 1981, and
1595 1973. There are large estimates of recruitment in 1985, 1993, and 2015. The 2015 recruitment
1596 event can be observed in the length and conditional length at age compositions from the
1597 survey data.

1598 The stock-recruit curve resulting from a fixed value of steepness is shown in Figure ??
1599 with estimated recruitments also shown. The stock is predicted to have never fallen to low
1600 enough levels that the steepness is obvious. Steepness was not estimated in this model, but
1601 sensitivities to an alternative value of steepness is discussed below.

1602 2.7.3 Fits to the Data

fits-to-the-data

1603 Model fits to the indices of abundance, fishery length composition, survey length composition,
1604 and conditional age-at-length observations from the NWFSC trawl survey are all discussed
1605 below.

1606 The fits to the four fishery CPUE and four survey indices are shown in Figures
1607 ([\ref{fig:index5_logcpuefit_RecPR - 34}](#)). Extra standard error was estimated for all eight of
1608 the indices. The indices for the recreational private mode and dead-discard fleets were fit
1609 relatively well by the model. The recreational party/charter retained-catch index was fit
1610 moderately well in parts of the time series, but did not capture the increases observed in the
1611 late 1990s. The extra variability added to this index was also large. The onboard observer
1612 retained-only catch index was fit well by the model except for the two lowest years, 2003 and
1613 2015.

1614 The sanitation district index was fit well by the model, except for the highest four years from
1615 1979-1982, where the fit is estimated lower than the the added uncertainty.

1616 The NWFSC trawl survey index is flat and fit well by the model, except for in 2013, the
1617 highest year in the index, with also high uncertainty. The gill net survey was not well fit by
1618 the model and did not capture the trend observed in the standardized index. The Southern
1619 California Bight trawl survey, conducted every 5 years, was also not well fit by the model.
1620 The standardized index from the Bight trawl survey showed peaks in 1994 and 2004, which
1621 were not fit by the model.

1622 Fits to the length data are shown based on the proportions of lengths observed by year and
1623 the Pearson residuals-at-length for all fleets. Detailed fits to the length data by year and
1624 fleet are provided in Appendix ???. Aggregate fits by fleet are shown in Figure ???. Overall,
1625 the length composition data for the commercial hook-and-line, commercial trawl, sanitation
1626 survey, recreational private, and party/charter fleets all fit well. The fits to the recreational
1627 discard fleet by year were variable, and were worse in years with small sample sizes; however,
1628 the aggregate fit is reasonable. The sample sizes by year for each of the gill net, impingement,
1629 and Bight trawl surveys were small compared to the fisheries. The fit to the data varies by
1630 year and does not capture the high proportion of small fish observed in the impingement
1631 survey, especially in 2013.

1632 Fits to the aggregated and yearly length composition data from the gillnet fishery are not
1633 well fit. The selectivity for this fishery is mirrored to the commercial hook-and-line fishery
1634 and the sample sizes of the number of measured fish and trips is small compared to other
1635 fleets. California scorpionfish are also not a target species for the gill net fishery, but are
1636 retained most commonly by the sea bass and halibut fisheries as bycatch. The minimum
1637 mesh size for the gill net fishery ranges from 3.5 - 6 inches depending on the year and season.

1638 The NWFSC trawl survey lengths were well estimated for males and females in aggregate by
1639 the model. California scorpionfish are not one of the more common species observed in this
1640 survey, with sample size all under 10 hauls per year.

1641 The observed and expected conditional age-at-length fits are shown in Figures ?? - ?? for
1642 the NWFSC trawl survey observations. The fits generally match the observations for fish
1643 smaller than 30 cm. Some outliers are apparent with large residuals.

1644 The age data were also weighted according to Francis weighting which adjust the weight
1645 given to a data set based on the fit to the mean age by year. The mean ages from the fishery
1646 appear to have declined in recent years which could be due to incoming cohorts (Figure ??).
1647 Smaller fish were also observed in the sanitation and impingement surveys in the (Figures ??
1648 and ??). The mean length in the recreational private and party/charter fleets increased over
1649 time (Figures ?? and ??).

1650 **2.7.4 Model 1 Uncertainty and Sensitivity Analyses** model-1-uncertainty-and-sensitivity-analyses

1651 A number of sensitivity analyses were conducted, including:

- 1652 1. Data weighting according to the harmonic mean.
- 1653 2. Removal of one index at a time
- 1654 3. Dome-shaped selectivity for the NWFSC trawl survey and gill net survey
- 1655 4. Estimating natural female mortality
- 1656 5. Estimating steepness
- 1657 6.
- 1658 7.

1659 Table 43

1660 **2.7.5 Model 1 Retrospective Analysis**

model-1-retrospective-analysis

1661 A 4-year retrospective analysis was conducted by running the model using data only through
1662 2012, 2013, 2014, and 2015, progressively. The initial population size and estimation of trends
1663 in spawning biomass in the retrospective runs were slightly lower than the base model (Figure
1664 ??). The initial scale of the spawning population was basically unchanged for all of these
1665 retrospectives.

1666 The recruitment deviations in the more recent years shrink towards zero the more years are
1667 removed from the model (Figure ??).

1668 **2.7.6 Model 1 Likelihood Profiles**

model-1-likelihood-profiles

1669 Likelihood profiles were conducted for R_0 , steepness, and over natural mortality values
1670 separately. These likelihood profiles were conducted by fixing the parameter at specific values
1671 and estimated the remaining parameters based on the fixed parameter value.

1672 In regards to values of R_0 , the negative log-likelihood was minimized at approximately $\log(R_0)$
1673 of 8.0 (Table ??). The recreational private mode fishery minimized at a smaller value of R_0
1674 whereas the gillnet survey, recreational discard and commercial gillnet fisheries indicated a
1675 higher value of R_0 (Figure ??). The age and recruitment data indicated a higher value of R_0
1676 and were minimized at the highest value in the profile (Figure ??).

1677 Over the range of values of R_0 , depletion ranged from 0.53-0.70 (Figure ??).

1678 For steepness, the negative log-likelihood was essentially flat between values of 0.57-0.87
1679 (Figure ?? and Table ??).

1680 Likelihood components by data source show that the fishery age data support a low steepness
1681 value, but the other data sources higher value for steepness. The impingement, sanitation,
1682 and recreational private mode fleets support higher values of steepness while the other surveys
1683 are relatively uninformative. The relative depletion for California scorpionfish changes very
1684 little (0.51-0.60) across different assumed values of steepness (Figure ??).

1685 The negative log-likelihood was minimized at a natural mortality value of 0.38, the profile
1686 is relatively flat for the priors, index data, and recruitment (Figure ??). The age data
1687 likelihood contribution was minimized at natural mortality values ranging from 0.035-0.40,
1688 and the length data contribution was minimized as the largest value of M run, 0.40 (Table
1689 ??). The impingement survey was the only fleet for which the likelihood profile over M was
1690 not relatively flat (Figure ??)The relative depletion for California scorpionfish ranged from
1691 0.48-0.80 across alternative values of natural mortality (Figure ??).

1692 **2.7.7 Model 1 Reference Points**

model-1-reference-points

1693 Reference points were calculated using the estimated selectivities and catch distribution
1694 among fleets in the most recent year of the model, (2015). Sustainable total yield (landings
1695 plus discards) were 220.1 mt when using an $SPR_{50\%}$ reference harvest rate and with a 95%
1696 confidence interval of (156-284.1) mt based on estimates of uncertainty. The spawning output
1697 equivalent to 40% of the unfished spawning output ($SB_{40\%}$) was 544.6 millions of eggs.

1698 The predicted spawning output from the base model shows an initial decline starting in
1699 1970, with two years of low spawning biomass in 1976 and 1977. From the late 1970s to the
1700 mid-2000's the population follows a cyclical pattern (driven by recruitment pulses) and then
1701 declines until 2015. The last two years of the model indicate an increase in spawning output.
1702 (Figure ??). Since 2015, the spawning output has been increased due to lower catches and a
1703 high recruitment pulse in 2015. The 2016 spawning output relative to unfished equilibrium
1704 spawning output is above the target of 40% of unfished spawning output (Figure ??). The
1705 fishing intensity, $(1 - SPR)/(1 - SPR_{50\%})$, has been well below the management target for
1706 the entire time series of the model.

1707 Table ?? shows the full suite of estimated reference points for the base model and Figure ??
1708 shows the equilibrium curve based on a steepness value fixed at .

1709 Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to shows the full suite of
1710 estimated reference points for the northern area model and Figure j shows the equilibrium
1711 yield curve.

1712 **3 Harvest Projections and Decision Tables**

harvest-projections-and-decision-tables

1713 The forecasts of stock abundance and yield were developed using the final base model. The
1714 total catches in 2017 and 2018 are set to the PFMC adopted California scorpionfish ACLs
1715 (Table \ref{tab:mnmgt.perform}). CDFW allocated 75% of the ACL to the recreational
1716 fisheries and 25% to the commercial fisheries. The catches were divided among the fleets
1717 within each the commercial and recreational fisheries by taking the ratio of the average
1718 catches from 2012-2016. The average of 2012-2016 catch by fleet was used to distribute
1719 catches in forecasted years. The research catch harvest guideline for 2017-2018 was set at
1720 0.2 mt. The average research catch from the NWFSC trawl survey averaged 0.077 mt from
1721 2012-2016, which was used in the forecast.

1722 **Model 1 Projections and Decision Table (groundfish only)** Table 45

1723 Table h

1724 4 Regional Management Considerations

regional-management-considerations

1725 While the proportion of the stock residing within U.S. waters is unknown, the assessment
1726 provides an adequate geographic representation of portion assessed for management purposes.
1727 Collaboration with Mexico in conducting future assessments may be mutually beneficial. No
1728 genetic information is available to inform whether separate stocks or population structure
1729 pertinent to management exists. Given the relatively small area in the waters off of California
1730 where this species occurs south of Point Conception, there is relatively little concern regarding
1731 exploitation in proportion to the regional distribution of abundance in the area assessed in
1732 this study.

1733 While the species does aggregate during the spawning season making harvest of the stock
1734 more efficient during this period, removals have been well within the harvest limits and the
1735 stock has not been overfished or subject to overfishing as a whole.

1736 Routine sampling of commercial and recreational fisheries provides mortality estimates to
1737 monitor catch during the course of season to prevent overfishing should effort increase in
1738 the future. Analysis of CPUE of areas known to be spawning aggregations over time using
1739 data from sampling on board CPFVs and comparison to the trajectory of the population as
1740 a whole could provide information in determining whether localized depletion is occurring.
1741 Eggs and larvae are expected to travel substantial distance before settling, thus such areas
1742 should be repopulated from adjacent areas. Time/area closures could be considered where
1743 deemed beneficial in maintaining a minimum CPUE the remainder of the year, but are not
1744 necessary to keep aggregate harvest within the current harvest limits.

1745 5 Research Needs

research-needs

1746 There are a number of areas of research that could improve the understand and the stock
1747 assessment for California scorpionfish. Below are issues identified by the STAT team:

1748 1. **Natural mortality:** Both female natural mortality and steepness were fixed in the
1749 base model. The collection of age data for older females may improve the ability to
1750 estimate female natural mortality in the model. The NWFSC trawl survey was the
1751 only available source of age data for this assessment, of which there were a number of
1752 age-1 fish and the data were dominated by males.

1753 2. **Steepness:**

1754 3. **Stock in Mexico:** No available information on the status of California scorpionfish in
1755 Mexico could be found. A number of emails were sent to researchers in Mexico and
1756 none were returned. It is known that a portion of the stock resides in Mexico and that
1757 boat leaving from San Diego target California scorpionfish off the Coronado Islands.

- 1758 4. **Sex ratio:** The sex ratio in both Love et al. [@Love1987] and samples from the NWFSC
1759 trawl survey were skewed towards males. Data on sex ratios from the recreational or
1760 commercial fisheries would help in determining the sex ratio of the population.
- 1761 5. **Aggregating behavior:** Little is known about the aggregating behavior of California
1762 scorpionfish. California scorpionfish are known to aggregate in both the spawning
1763 and non-spawning seasons. The location and timing of the aggregations would aid in
1764 modelling the high catch events.

1765 6 Acknowledgments

acknowledgments

1766 Include: STAR panel members and affiliations as well as names and affiliations of persons
1767 who contributed data, advice or information but were not part of the assessment team. Not
1768 required in draft assessment undergoing review. We thank Kevin Lee for the use of the cover
1769 photo for this document.

1770 **7 Tables**

tables

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

Year	Hook-and-line	Trawl	Gillnet	Mexico	Total U.S. 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
1952	37.93	0.00	0.00	0.00	37.93	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	Trawl	Gillnet	Mexico	Total U.S. Removals	Source
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
1990	32.07	0.78	6.17	0.00	39.01	CFIS
1991	20.12	4.80	3.29	0.00	28.20	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	Trawl	Gillnet	Mexico	Total U.S. Removals	Source
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

tab:CommCatches

Table 2: The annual number of California scorpionfish sampled from the the commercial hook-and-line fleet for lengths.

Year	Fish	Trips	Sample size	Mean length (cm)	tab:ComHL_lengthsample
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.

Year	Fish	Trips	Sample size	Mean length (cm)	tab:ComNet_lengthsample
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.

Year	Fish	Trips	Sample size	Mean length (cm)	tab:ComTrawl_lengthsample
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 7to 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 7to 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 7to 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.

tab:Fleet4_RecPR_dockside_filter			
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 $\geq 1\%$ 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	tab:Fleet5_RecPC_CPFVlogbook_aic
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	NA	NA	tab:Fleet5_RecPC_CPFVlogbook_index
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	tab:Fleet5_RecPC_dockside_filter
		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	tab:Fleet5_RecPC_dockside_aic
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.

tab:Fleet5_lengthsample

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.

`tab:Fleet6_lengthsample`

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.

`tab:Fleet12_RecPC_onboard_aic`

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				
	Tow distance 100-599 m (target tow distance 400 m)			1,490		
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.

tab:Fleet7_Sanitation_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: sdfdsf

Year	Fish	Trips	Mean length (cm)	NA	NA	tab:Fleet7_lengthdepth
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: sdf

Program	0-24 m	25-49 m	50-74m	100+ m	Total	NA	NA	tab:Fleet7_lengths
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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	25.68					
2013	11	11	23.71					
2014	40	36	25.84					
2015	59	46	22.92					
2016	31	28	19.53					

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

Depth zone (m)	Total catch (kg)	Raw CPUE (kg/ha)	tab:Fleet8_NWFSCtrawl_catchdepth
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)	tab:Fleet8_NWFSCtrawl_catchlat
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: 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	tab:Fleet11_SCBSurvey_filter	
		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 recreational private mode dockside 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: The recreational private mode dockside sample index.

Year	Index	Log-scale SE	NA	NA
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: 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)	OK	0.157	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

Continued on next page

Table 40: 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_ComTrawl(3)	1.000	-2	(1, 45)	OK		None
131	SizeSel_P2_ComTrawl(3)	45.000	-3	(1, 45)	OK		None

Continued on next page

Table 40: 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	0.633	None
155	SizeSel_P6.Sanitation(7)	10.000	-3	(-5, 11)	OK	None	None
156	SizeSel_P1.NWFSCTrawl(8)	24.335	4	(13, 44)	OK	None	None
157	SizeSel_P2.NWFSCTrawl(8)	15.000	-3	(-10, 16)	OK	0.557	None
158	SizeSel_P3.NWFSCTrawl(8)	3.658	4	(-1, 10)	OK	0.557	None

Continued on next page

Table 40: 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

tab-model-params

Table 41: Summary of the biomass/abundance time series used in the stock assessment.

Fleet	Years	Name	Fishery ind.	Filtering	Method	<small>tab:Index_summary</small>
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	delta-GLM (bin-lognormal)	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 Bight 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 42: Results from 100 jitters from each of the three models.

Status	Model.1	tab:jitter
Minimum likelihood	1097.50	
Maximum likelihood	1153.34	
Likelihood difference	55.84	
Minimum MGC	0.00	
Maximum MGC	0.07	
Depletion at minimum likelihood percent	52.71	
Depletion at maximum likelihood percent	77.55	
Difference in depletion percent	24.84	
Number of jitters	100.00	
Prop of runs at mimimum likelihood	0.35	
Proportion of runs at maximum likelihood	0.01	

Table 44: 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	0.00	3482	4	0.00	0.99
1917	2781	1360	1.00	3482	8	0.00	0.98
1918	2774	1356	1.00	3481	13	0.00	0.97
1919	2765	1350	0.99	3479	12	0.00	0.98
1920	2757	1346	0.99	3478	16	0.01	0.97
1921	2747	1340	0.98	3477	26	0.01	0.95
1922	2730	1330	0.98	3474	19	0.01	0.96
1923	2721	1325	0.97	3473	27	0.01	0.94
1924	2707	1316	0.97	3471	49	0.02	0.90
1925	2676	1298	0.95	3466	101	0.04	0.82
1926	2606	1256	0.92	3454	49	0.02	0.90
1927	2589	1247	0.92	3451	51	0.02	0.89
1928	2573	1238	0.91	3449	44	0.02	0.91
1929	2566	1235	0.91	3448	50	0.02	0.90
1930	2556	1230	0.90	3446	41	0.02	0.91
1931	2555	1229	0.90	3446	43	0.02	0.91
1932	2552	1228	0.90	3446	41	0.02	0.91
1933	2551	1228	0.90	3446	32	0.01	0.93
1934	2559	1233	0.91	3447	34	0.01	0.93
1935	2564	1237	0.91	3448	35	0.01	0.93
1936	2568	1239	0.91	3449	55	0.02	0.89
1937	2554	1231	0.90	3446	66	0.03	0.87
1938	2533	1218	0.89	3442	76	0.03	0.85
1939	2506	1201	0.88	3437	63	0.03	0.87
1940	2493	1194	0.88	3435	59	0.02	0.88
1941	2486	1190	0.87	3434	43	0.02	0.91
1942	2493	1195	0.88	3436	20	0.01	0.95
1943	2519	1212	0.89	3441	16	0.01	0.96
1944	2545	1228	0.90	3446	24	0.01	0.95
1945	2561	1237	0.91	3448	42	0.02	0.91
1946	2559	1236	0.91	3448	66	0.03	0.87
1947	2537	1223	0.90	3444	74	0.03	0.85
1948	2511	1206	0.89	3439	107	0.04	0.80
1949	2463	1175	0.86	3429	93	0.04	0.82
1950	2433	1156	0.85	3423	97	0.04	0.81
1951	2405	1138	0.84	3417	67	0.03	0.86
1952	2405	1139	0.84	3417	61	0.03	0.87
1953	2410	1143	0.84	3418	73	0.03	0.84
1954	2405	1140	0.84	3417	84	0.03	0.83
1955	2391	1132	0.83	3415	67	0.03	0.85

Table 44: 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	0.83	3415	63	0.03	0.86
1957	2399	1138	0.84	3417	43	0.02	0.90
1958	2420	1152	0.85	3421	39	0.02	0.91
1959	2442	1166	0.86	3426	25	0.01	0.94
1960	2472	1184	0.87	3432	24	0.01	0.95
1961	2499	1201	0.88	3437	31	0.01	0.93
1962	2518	1211	0.89	3440	50	0.02	0.89
1963	2518	1210	0.89	3440	72	0.03	0.85
1964	2499	1197	0.88	3436	87	0.03	0.83
1965	2472	1177	0.86	3430	85	0.03	0.83
1966	2449	1162	0.85	2698	89	0.04	0.82
1967	2404	1148	0.84	2698	73	0.03	0.85
1968	2359	1135	0.83	2550	87	0.04	0.82
1969	2287	1099	0.81	2420	84	0.04	0.82
1970	2207	1058	0.78	2202	103	0.05	0.79
1971	2102	1003	0.74	1816	91	0.04	0.80
1972	1993	951	0.70	1655	82	0.04	0.81
1973	1881	899	0.66	1593	95	0.05	0.78
1974	1753	831	0.61	1964	122	0.07	0.73
1975	1618	748	0.55	6349	128	0.08	0.70
1976	1639	673	0.49	5926	66	0.04	0.80
1977	1812	699	0.51	6088	87	0.05	0.76
1978	2047	822	0.60	3199	62	0.03	0.81
1979	2250	994	0.73	1674	100	0.04	0.75
1980	2321	1121	0.82	1280	124	0.05	0.73
1981	2271	1140	0.84	1334	110	0.05	0.76
1982	2158	1088	0.80	1814	112	0.05	0.77
1983	2014	991	0.73	2789	61	0.03	0.85
1984	1931	914	0.67	7963	70	0.04	0.83
1985	2034	852	0.63	9488	86	0.04	0.80
1986	2312	877	0.64	3171	76	0.03	0.81
1987	2531	1068	0.78	1658	69	0.03	0.83
1988	2648	1280	0.94	1480	201	0.08	0.66
1989	2551	1278	0.94	1340	163	0.06	0.71
1990	2397	1202	0.88	1561	228	0.10	0.65
1991	2146	1044	0.77	5803	241	0.11	0.63
1992	2013	869	0.64	5373	115	0.06	0.75
1993	2064	827	0.61	8446	95	0.05	0.77
1994	2299	899	0.66	4861	156	0.07	0.68
1995	2476	1013	0.74	2324	133	0.05	0.72

Table 44: 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	0.87	7047	136	0.05	0.73
1997	2750	1261	0.93	3793	142	0.05	0.74
1998	2835	1294	0.95	4453	161	0.06	0.73
1999	2880	1346	0.99	4882	225	0.08	0.67
2000	2869	1317	0.97	2438	169	0.06	0.73
2001	2826	1318	0.97	4063	199	0.07	0.70
2002	2759	1282	0.94	2286	128	0.05	0.78
2003	2686	1251	0.92	1898	105	0.04	0.81
2004	2578	1226	0.90	1961	57	0.02	0.88
2005	2472	1185	0.87	4127	89	0.04	0.83
2006	2390	1101	0.81	2465	150	0.06	0.75
2007	2247	1010	0.74	2197	140	0.06	0.75
2008	2117	967	0.71	2267	104	0.05	0.78
2009	2022	930	0.68	2782	113	0.06	0.76
2010	1939	881	0.65	2309	106	0.05	0.77
2011	1864	844	0.62	1168	105	0.06	0.76
2012	1758	817	0.60	1111	120	0.07	0.73
2013	1620	768	0.56	4079	115	0.07	0.72
2014	1571	696	0.51	3466	124	0.08	0.70
2015	1557	646	0.47	7369	84	0.05	0.75
2016	1742	684	0.50	3173			

tab:Timeseries_mod1

Table 43: Sensitivity of the base model to dropping or down-weighting data sources and alternative assumptions about growth.

Label	Base (Francis weights)	Harmonic weights)	Drop index	Drop ages	Down- weight lengths	Free size	Free CV	External growth
TOTAL_like	-	-	-	-	-	-	-	-
Catch_like	-	-	-	-	-	-	-	-
Equil_catch_like	-	-	-	-	-	-	-	-
Survey_like	-	-	-	-	-	-	-	-
Length_comp_like	-	-	-	-	-	-	-	-
Age_comp_like	-	-	-	-	-	-	-	-
Parm_priors_like	-	-	-	-	-	-	-	-
SSB_Unfished_thousand_mt	-	-	-	-	-	-	-	-
TotBio_Unfished	-	-	-	-	-	-	-	-
SmryBio_Unfished	-	-	-	-	-	-	-	-
Recr_Unfished_billions	-	-	-	-	-	-	-	-
SSB_Btgt_thousand_mt	-	-	-	-	-	-	-	-
SPR_Btgt	-	-	-	-	-	-	-	-
Fstd_Btgt	-	-	-	-	-	-	-	-
TotYield_Btgt_thousand_mt	-	-	-	-	-	-	-	-
SSB_SPRtgt_thousand_mt	-	-	-	-	-	-	-	-
Fstd_SPRtgt	-	-	-	-	-	-	-	-
TotYield_SPRtgt_thousand_mt	-	-	-	-	-	-	-	-
SSB_MSY_thousand_mt	-	-	-	-	-	-	-	-
SPR_MSY	-	-	-	-	-	-	-	-
Fstd_MSY	-	-	-	-	-	-	-	-
TotYield_MSY_thousand_mt	-	-	-	-	-	-	-	-
RetYield_MSY	-	-	-	-	-	-	-	-
Bratio_2015	-	-	-	-	-	-	-	-
F_2015	-	-	-	-	-	-	-	-
SPRratio_2015	-	-	-	-	-	-	-	-
Recr_2015	-	-	-	-	-	-	-	-
Recr_Virgin_billions	-	-	-	-	-	-	-	-
L_at_Amin_Fem_GP_1	-	-	-	-	-	-	-	-
L_at_Amax_Fem_GP_1	-	-	-	-	-	-	-	-
VonBert_K_Fem_GP_1	-	-	-	-	-	-	-	-
CV_young_Fem_GP_1	-	-	-	-	-	-	-	-
CV_old_Fem_GP_1	-	-	-	-	-	-	-	-

Table 45: Projection of potential OFL, spawning biomass, and depletion for the base case model.

Yr	OFL contribution (mt)	ACL landings (mt)	Age 5+ biomass (mt)	Spawning Biomass (mt)	tab:Forecast_mod1
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

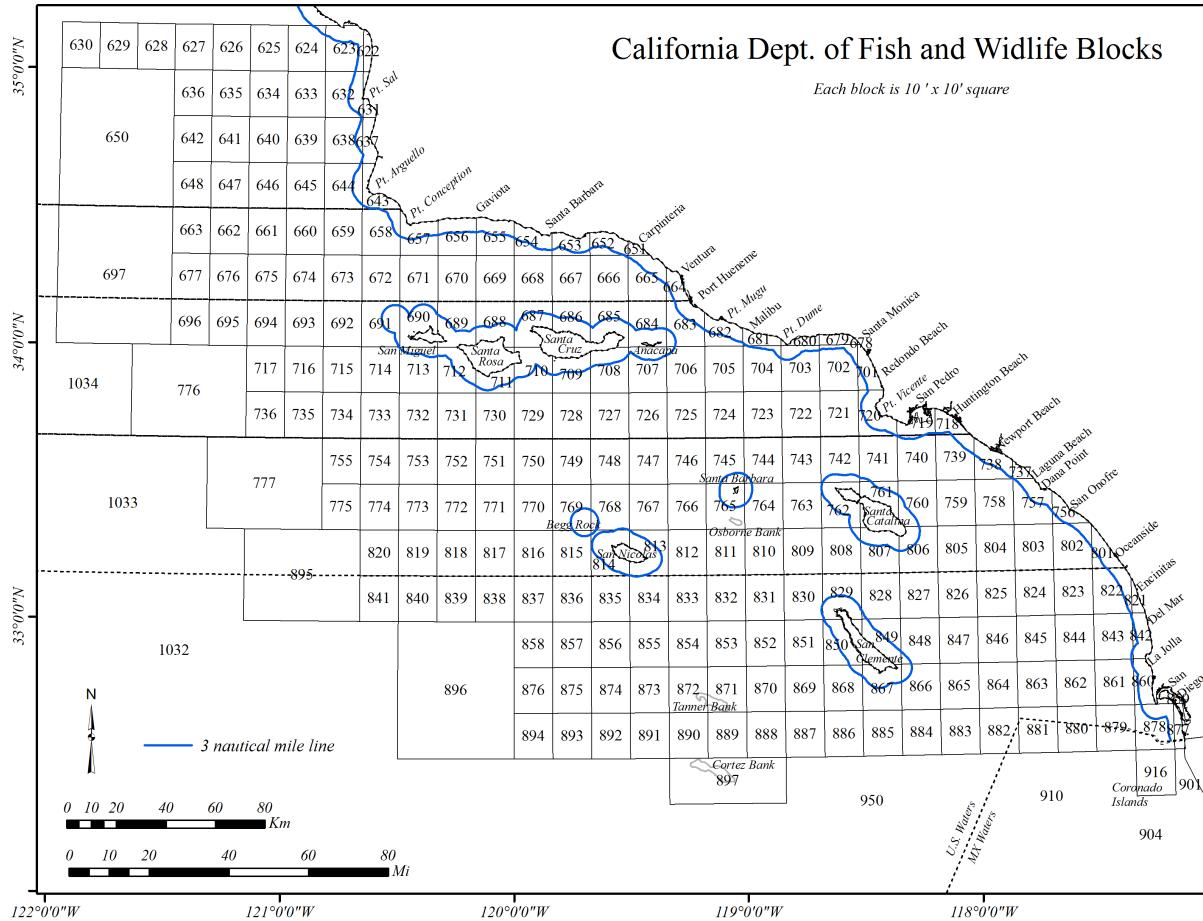


Figure 1: Map showing the state boundary lines for management of the recreational fishing fleets. CRFS Districts 1-6 in California are presented as well as the WDFW Recreational Management Areas in Washington. Florence, OR is shown as a potential location of model stratification.^{fig:boundary_map}

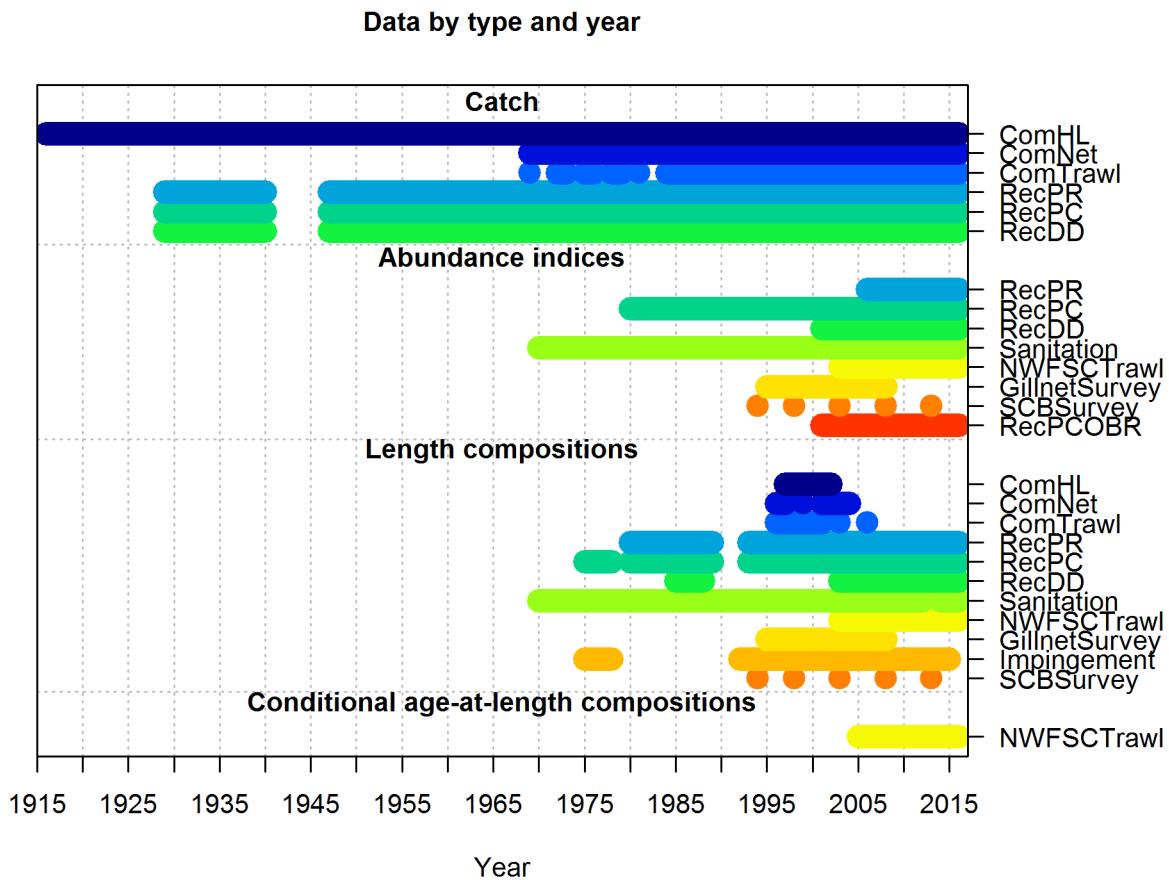


Figure 2: Summary of data sources used in the base model. fig:data_plot

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 3: 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. ^{fig:Com_regs}

	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 4: 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. fig:recregs

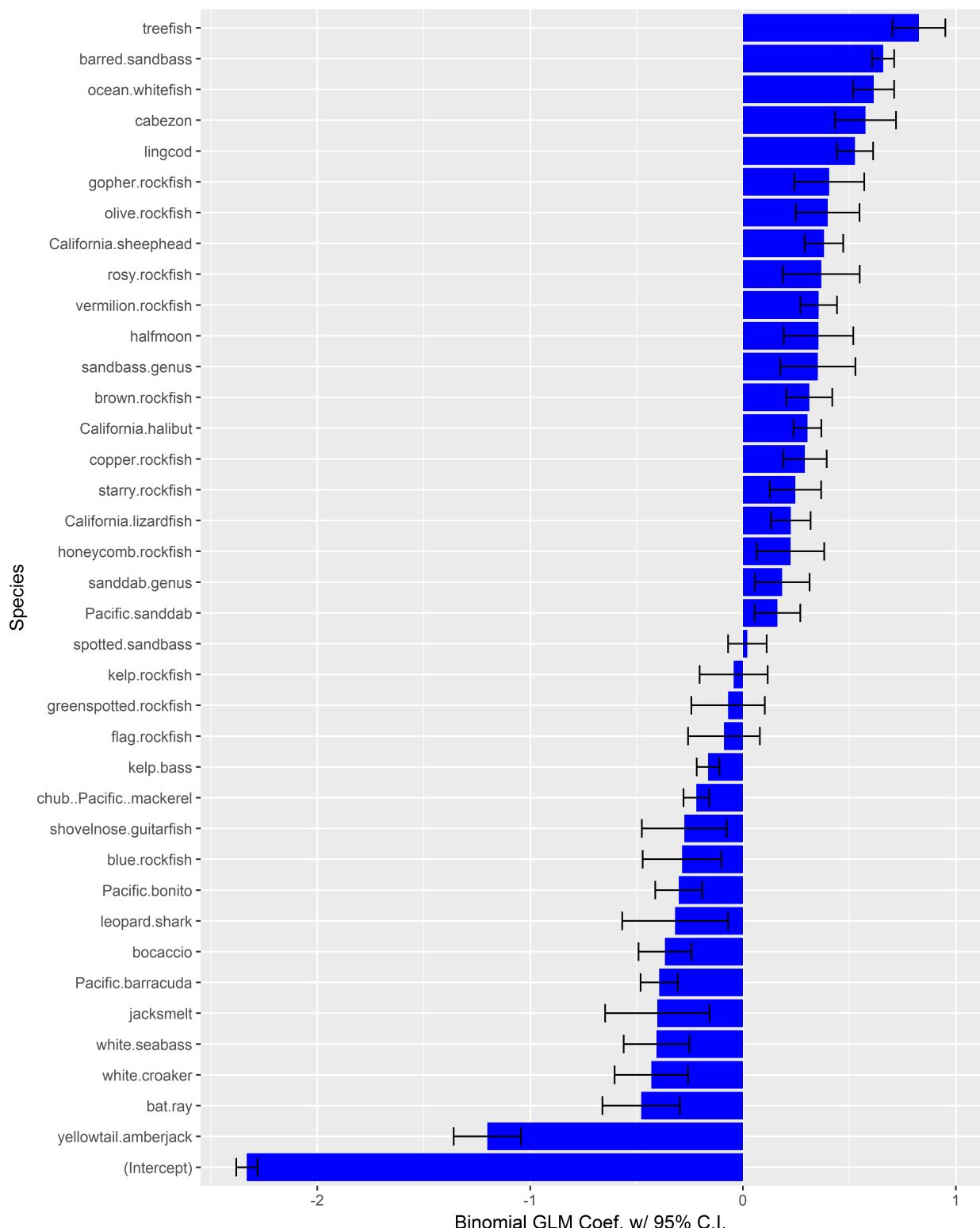


Figure 5: Species coefficients from the binomial GLM for presence/absence of California scorpionfish in the Marine Recreational Fisheries Statistics Survey (MRFSS) private mode dockside survey data set. Horizontal bars are 95% confidence intervals. fig:Fleet4_RecPR_dockside_SM

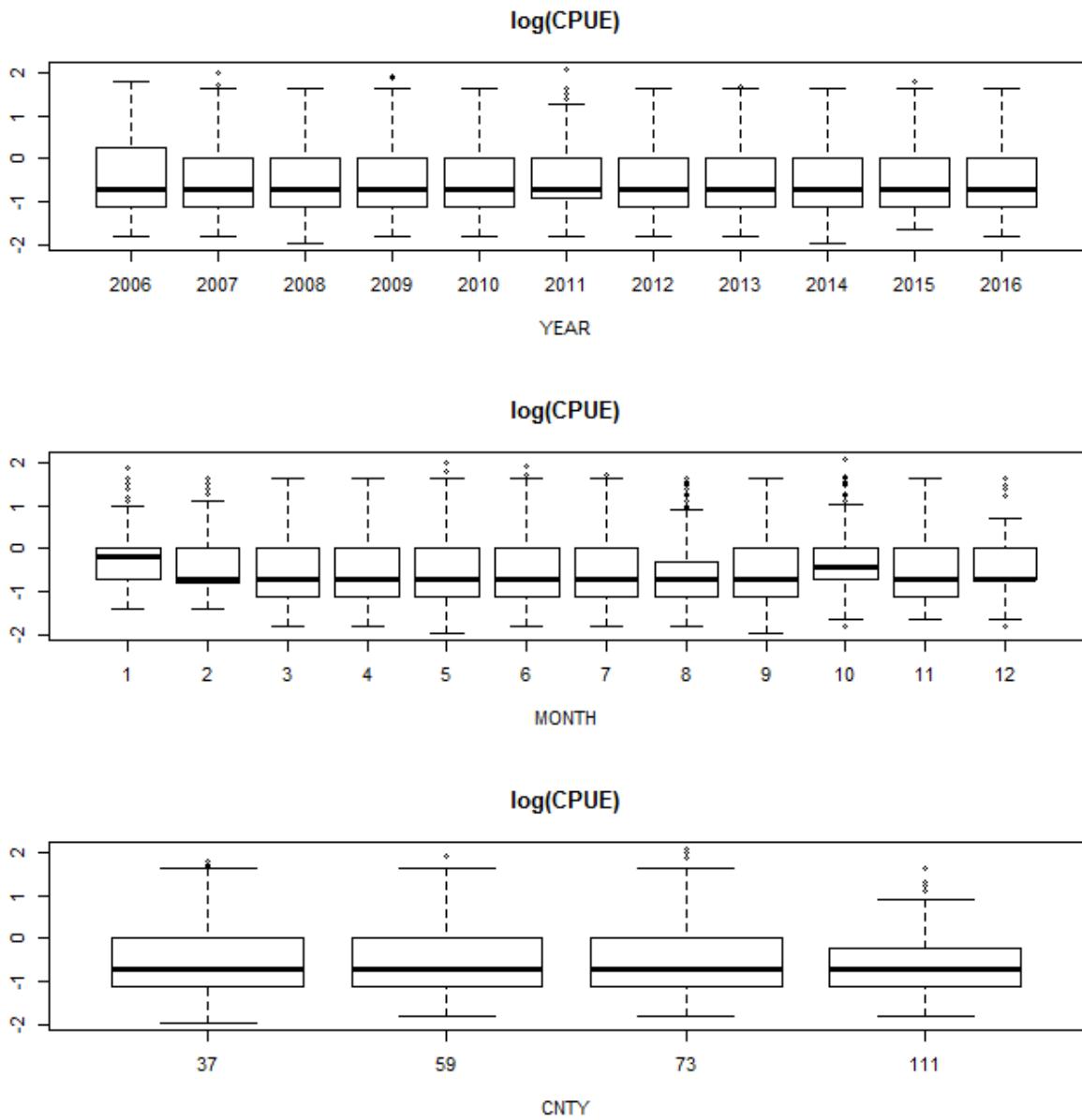


Figure 6: Boxplots of the raw log CPUE by year for each of the three factors considered in the deltaGLM model, county, month and year. [fig:Fleet4_RecPR_docksides_lograwCPUE](#)

Normal Q-Q Plot

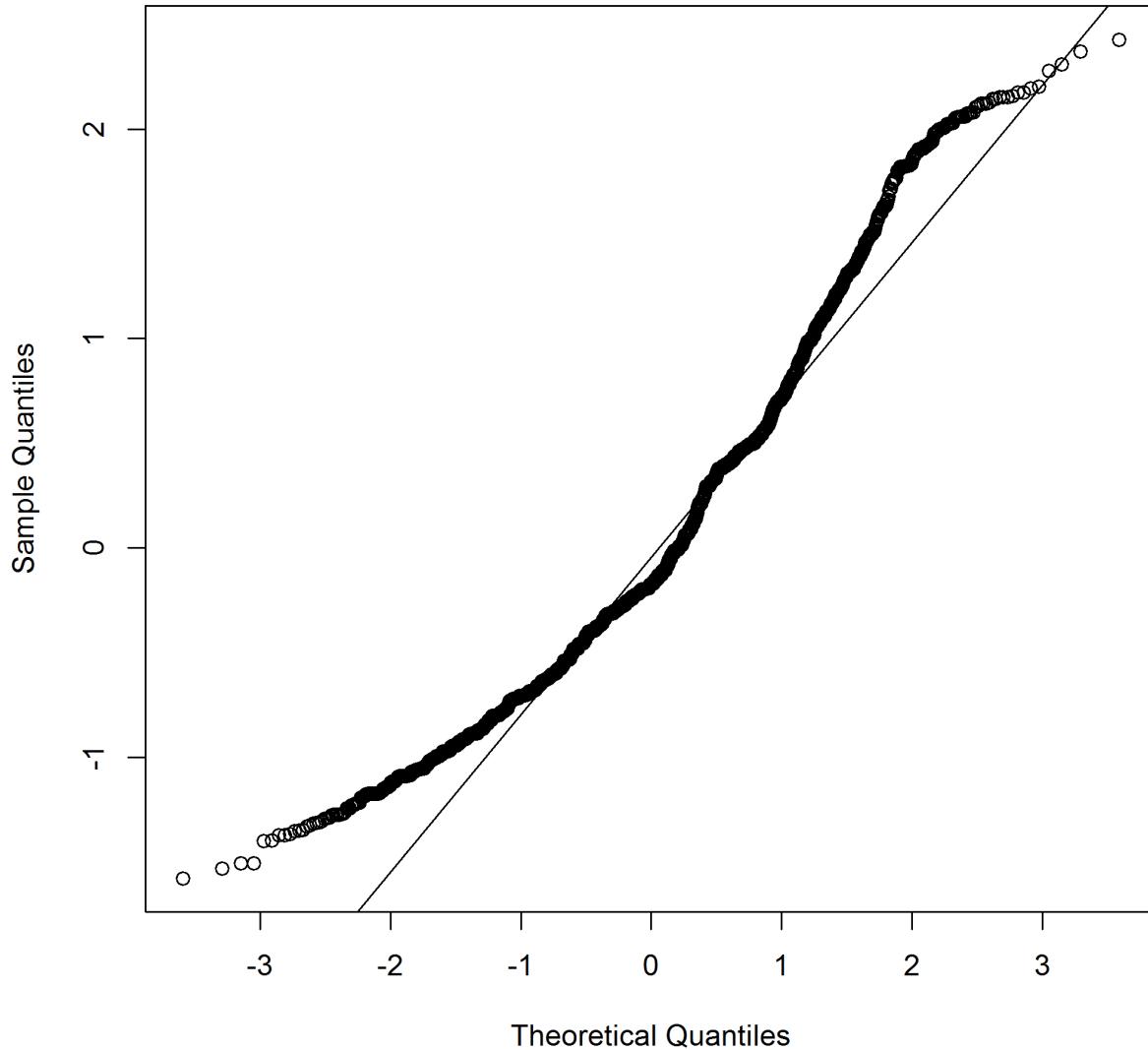


Figure 7: Q-Q plot used to evaluate the fit of the lognormal (positive encounters) of California scorpionfish from the Marine Recreational Fisheries Statistics Survey (MRFSS) private mode dockside survey data set. fig:Fleet4_RecPR_dockside_QQ

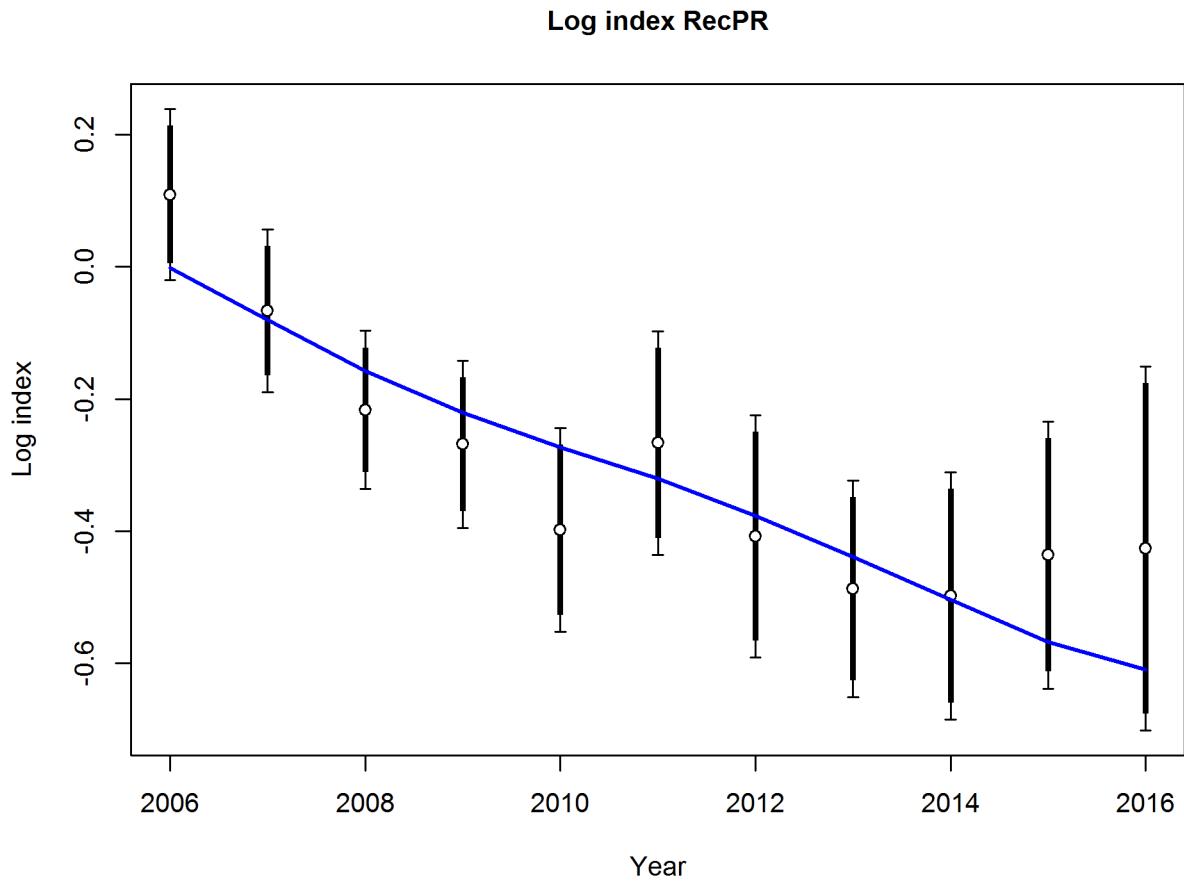


Figure 8: Fit to log index data on log scale for the recreational CPFV logbook retained catches. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. fig:index5_logcpuefit

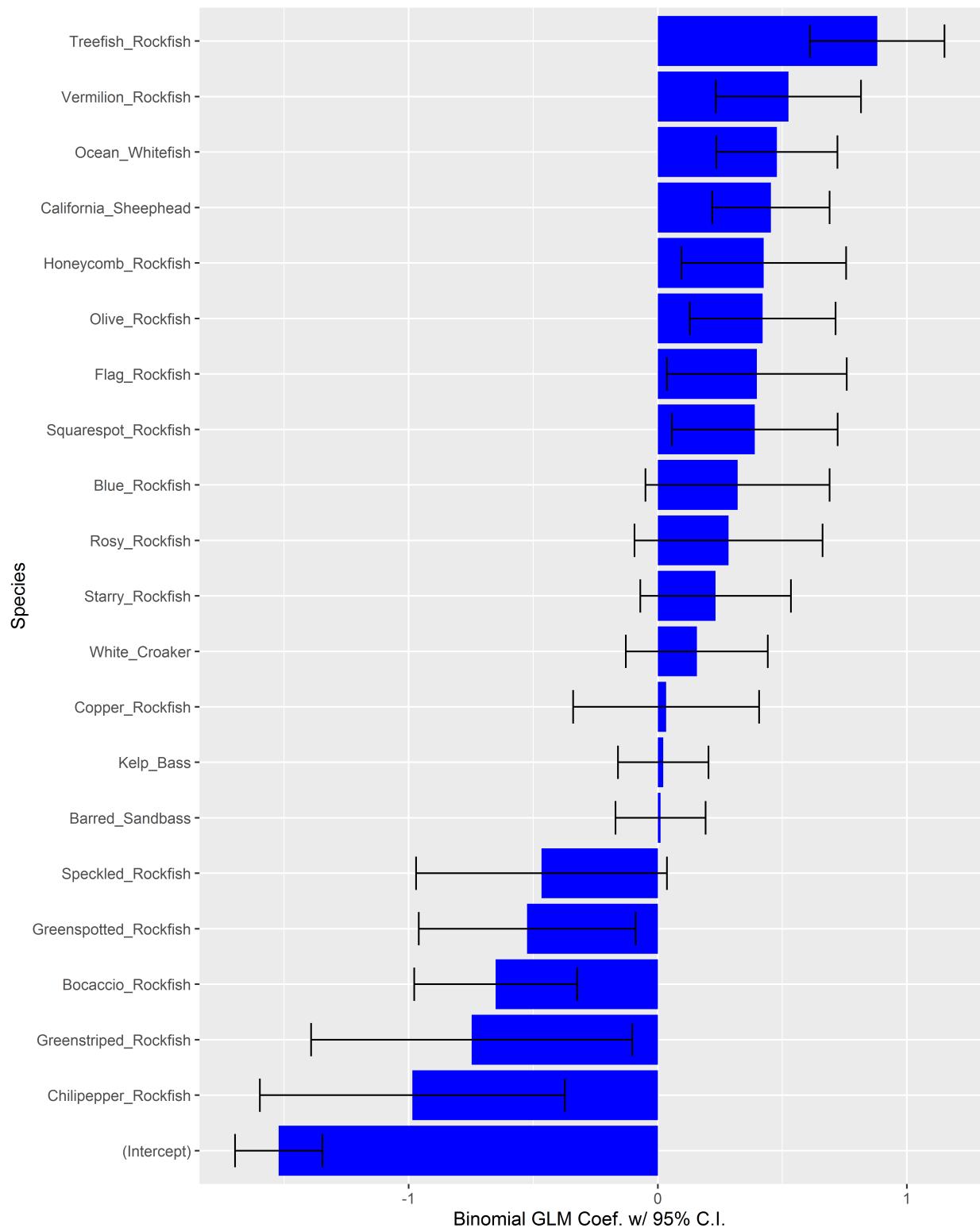


Figure 9: Species coefficients from the binomial GLM for presence/absence of California scorpionfish in the Marine Recreational Fisheries Statistics Survey (MRFSS) party/charter mode dockside survey data set. Horizontal bars are 95% confidence intervals. [fig:Fleet5_RecPC_dockside](#)

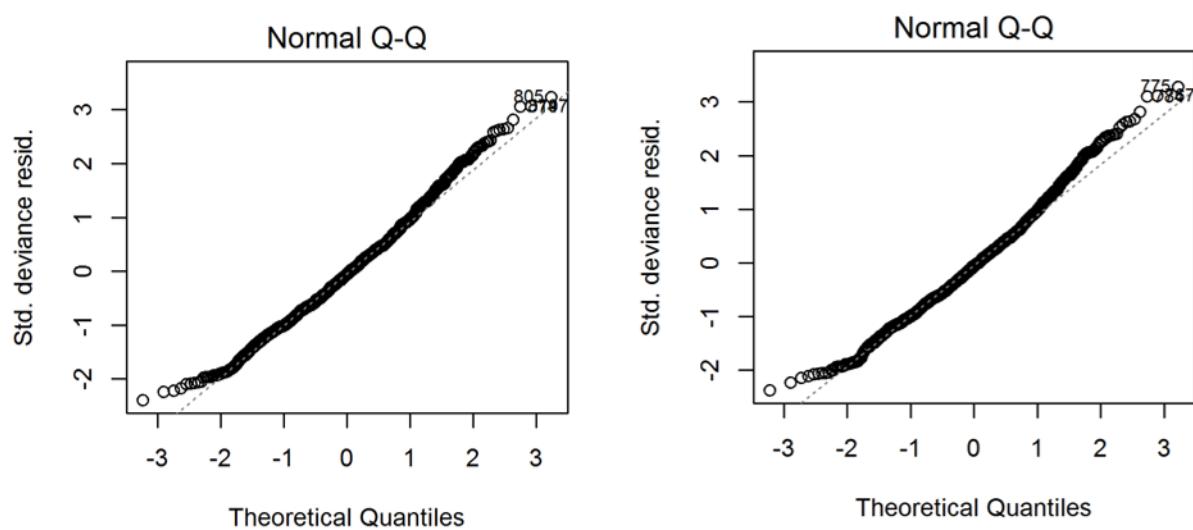


Figure 10: Q-Q plot used to validate the goodness of fit of the lognormal portion (positive catch) of the Marine Recreational Fisheries Statistics Survey (MRFSS) party/charter dockside survey, for thresholds of 0.27 (left) and 0.10 (right) from the Stephens-MacCall filter. fig:Fleet5_RecPC_

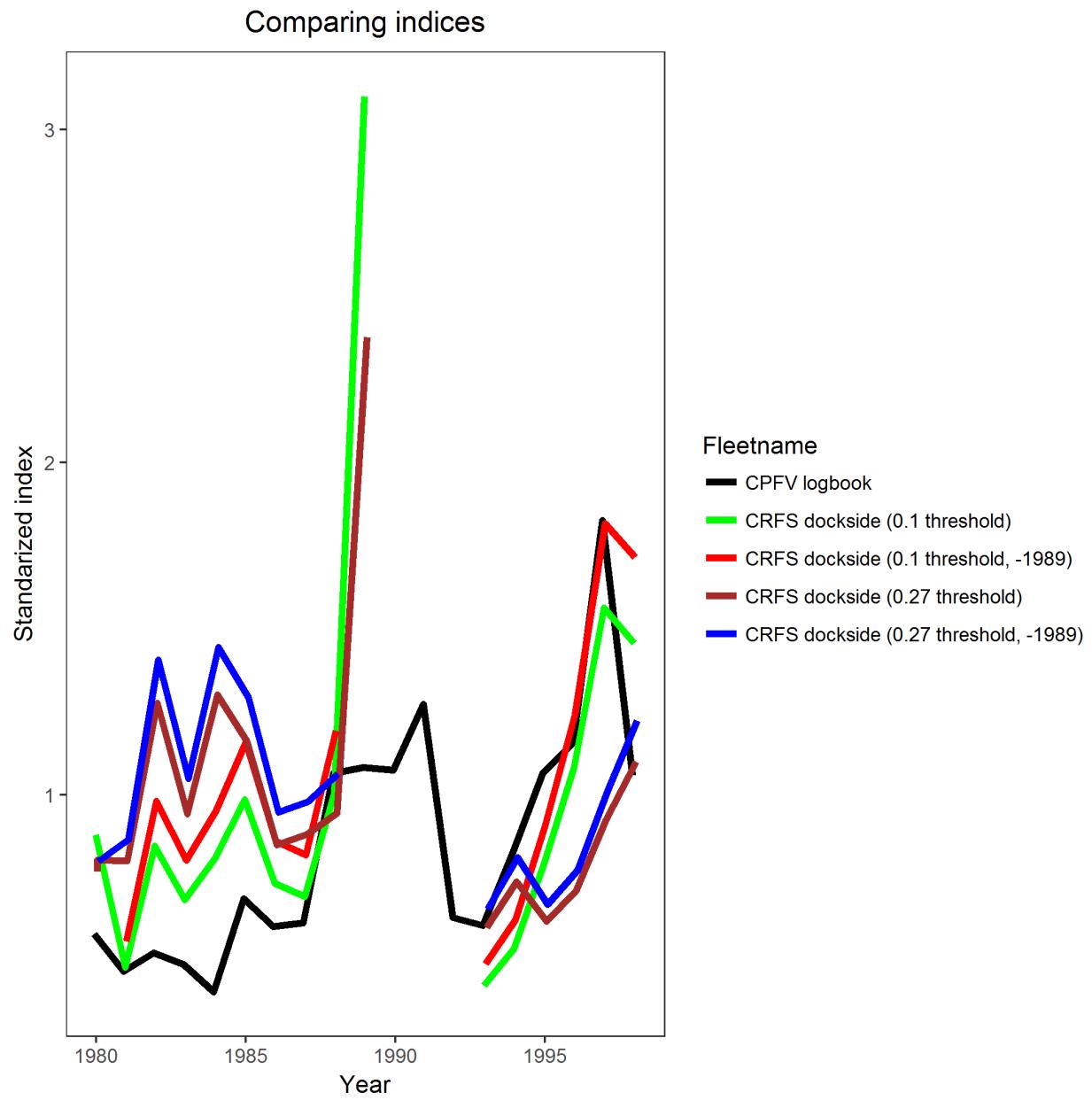


Figure 11: Comparison of standardized indices using two different threshold levels (0.27 and 0.1) from the Stephens-MacCall filtering, and including or excluding the year 1989.

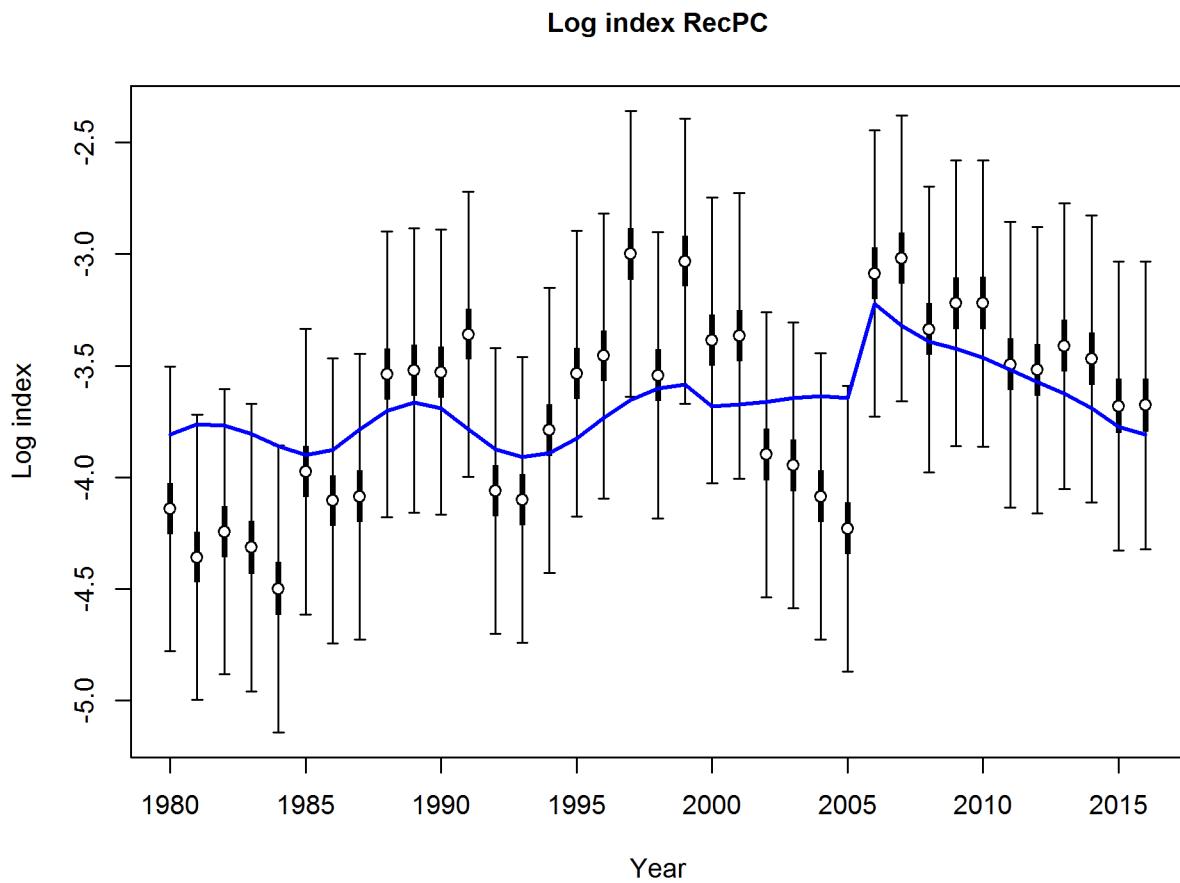


Figure 12: Fit to log index data on log scale for the recreational CPFV logbook retained catches. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. fig:index5_logcpuefit

Normal Q-Q Plot

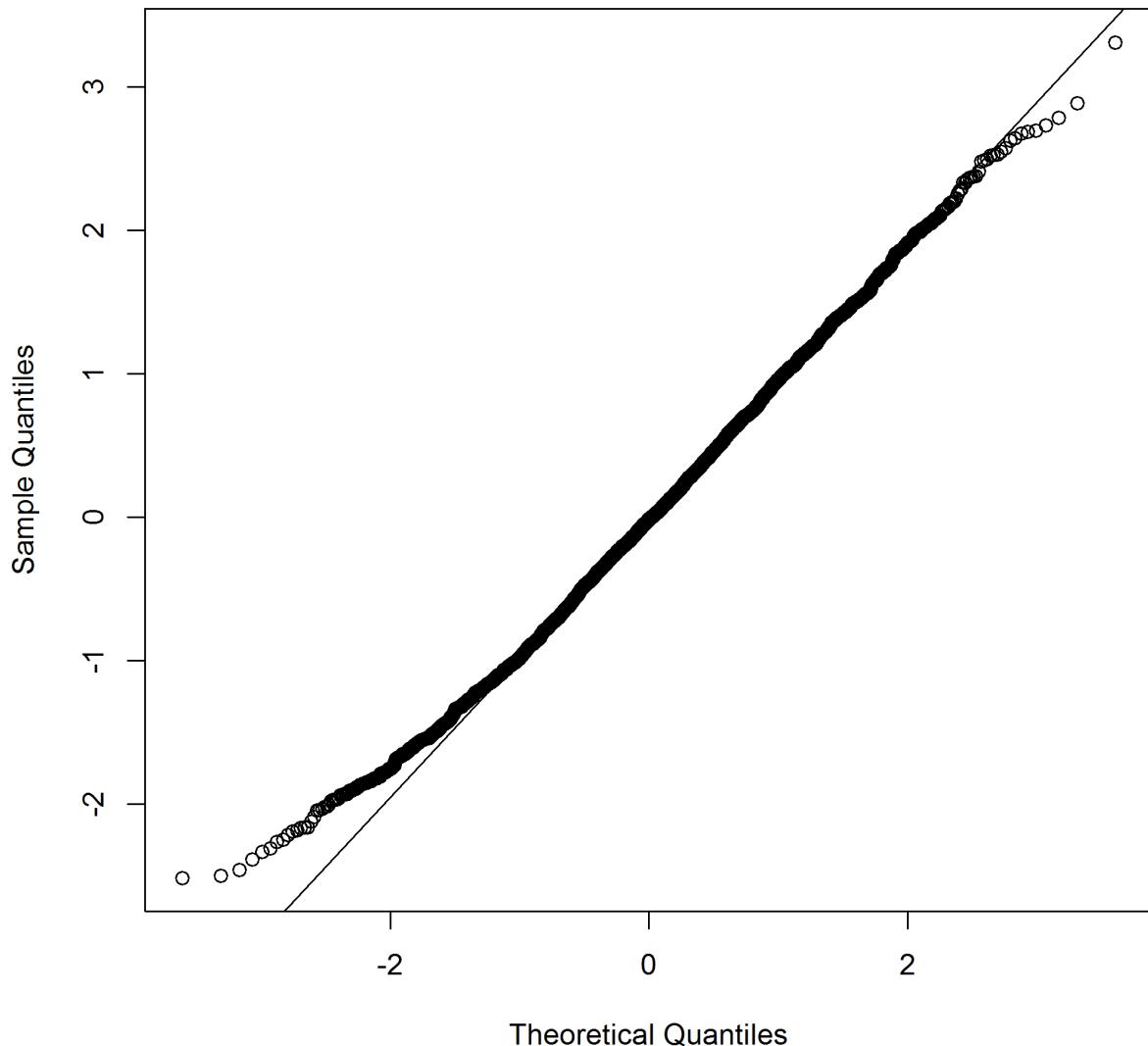


Figure 13: Q-Q plot used to validate the goodness of fit of the lognormal model for the CPFV onboard observer discarded only catch. [Fig:Fleet6_RecDD_QQ](#)

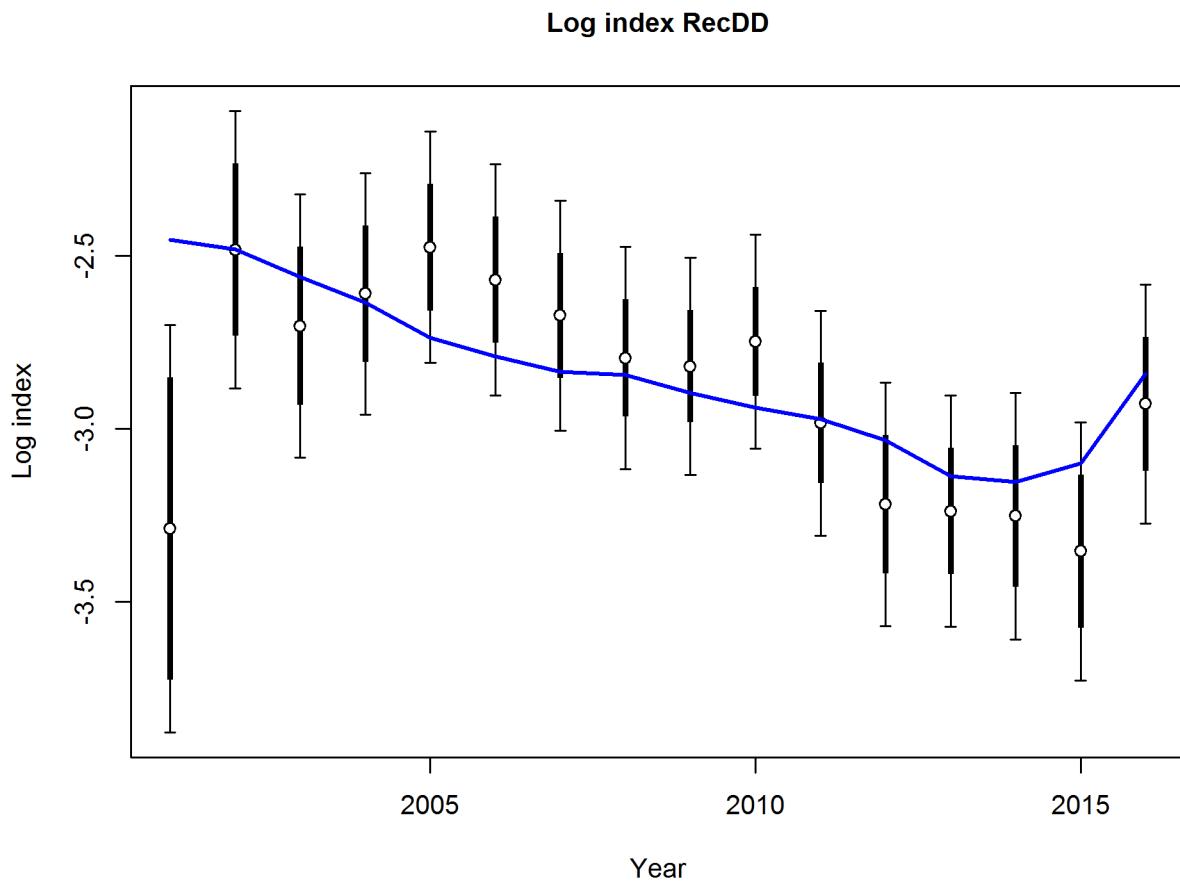


Figure 14: Fit to log index data on log scale for the recreational CPFV onboard observer discarded catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.
`fig:Fleet6_index5_logcpuefit_RecDD`

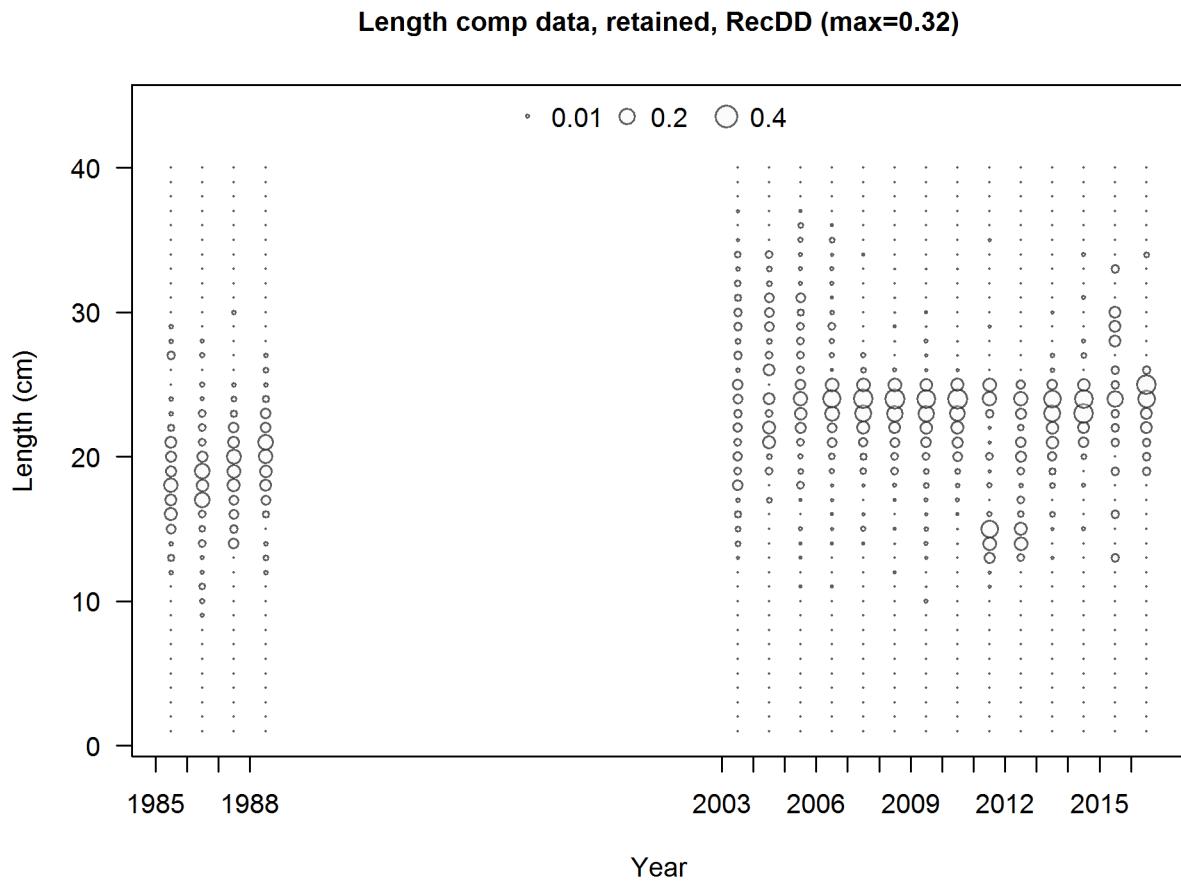


Figure 15: Length frequency distributions from the sanitation districts trawl surveys. `fig:Fleet6_comp`

Normal Q-Q Plot

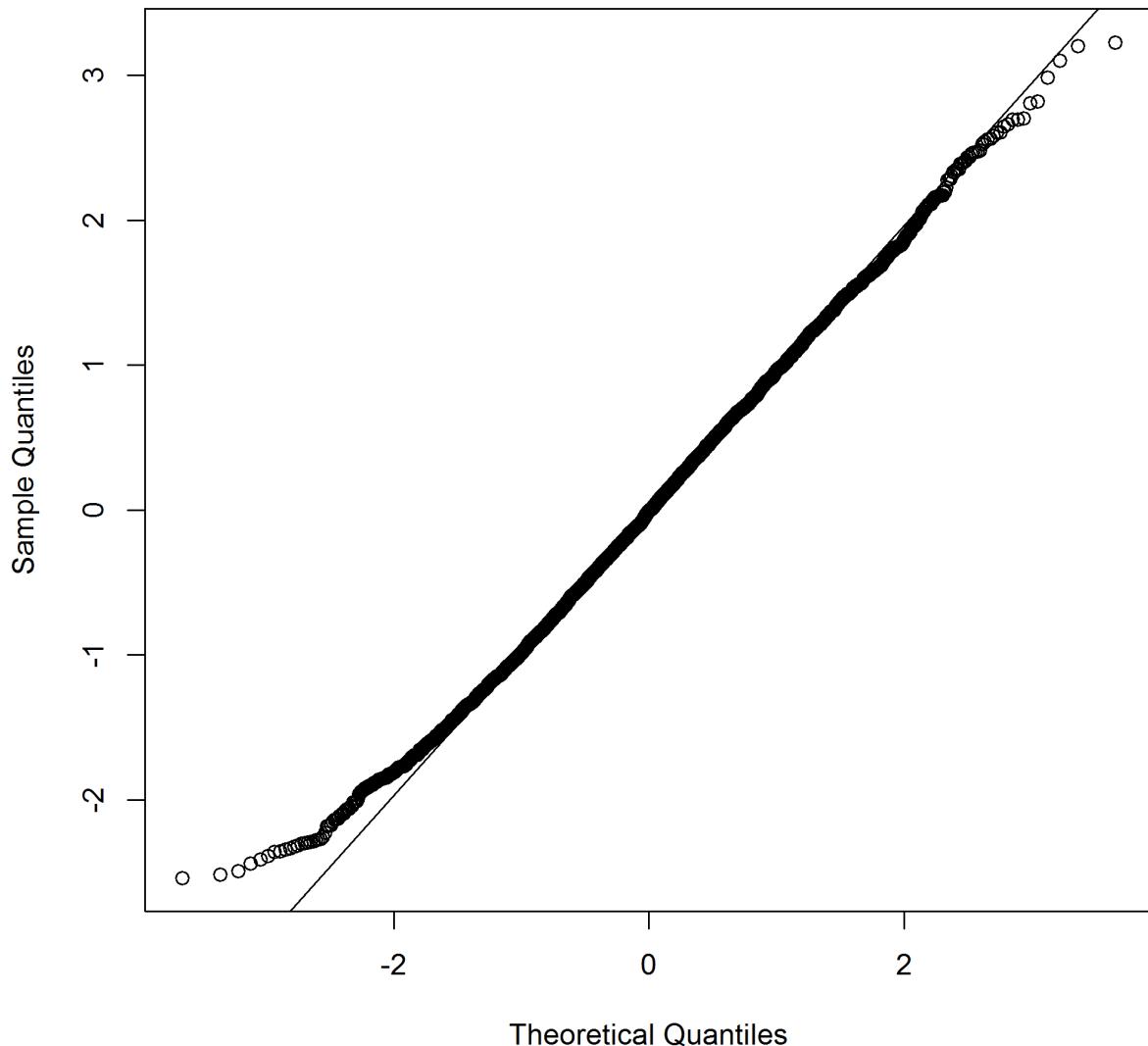


Figure 16: Q-Q plot used to validate the goodness of fit of the lognormal model for the CPFV onboard observer retained only catch. [fig:Fleet12_RecPCOB_R_QQ](#)

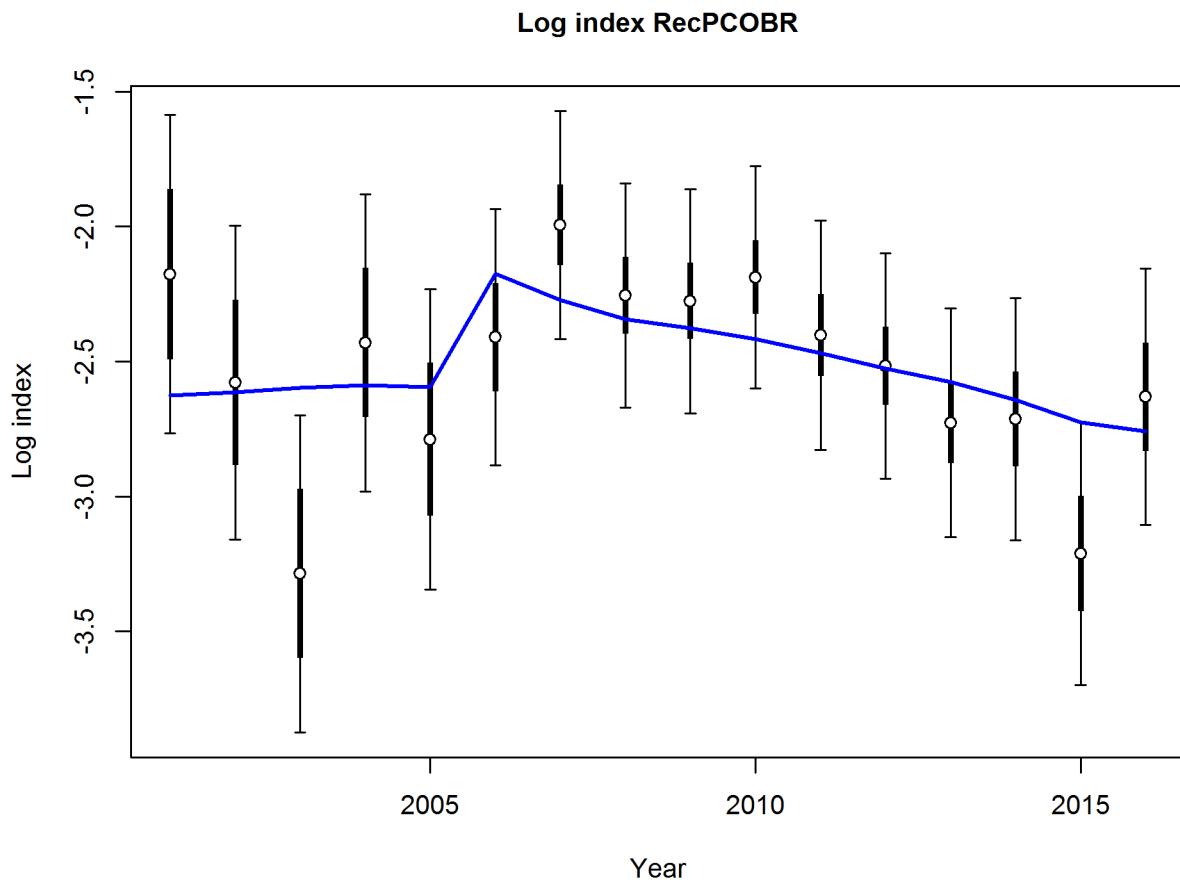


Figure 17: Fit to log index data on log scale for the recreational CPFV onboard observer retained catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.
`fig:Fleet12_index5_logcpuefit_RecPCOBR`

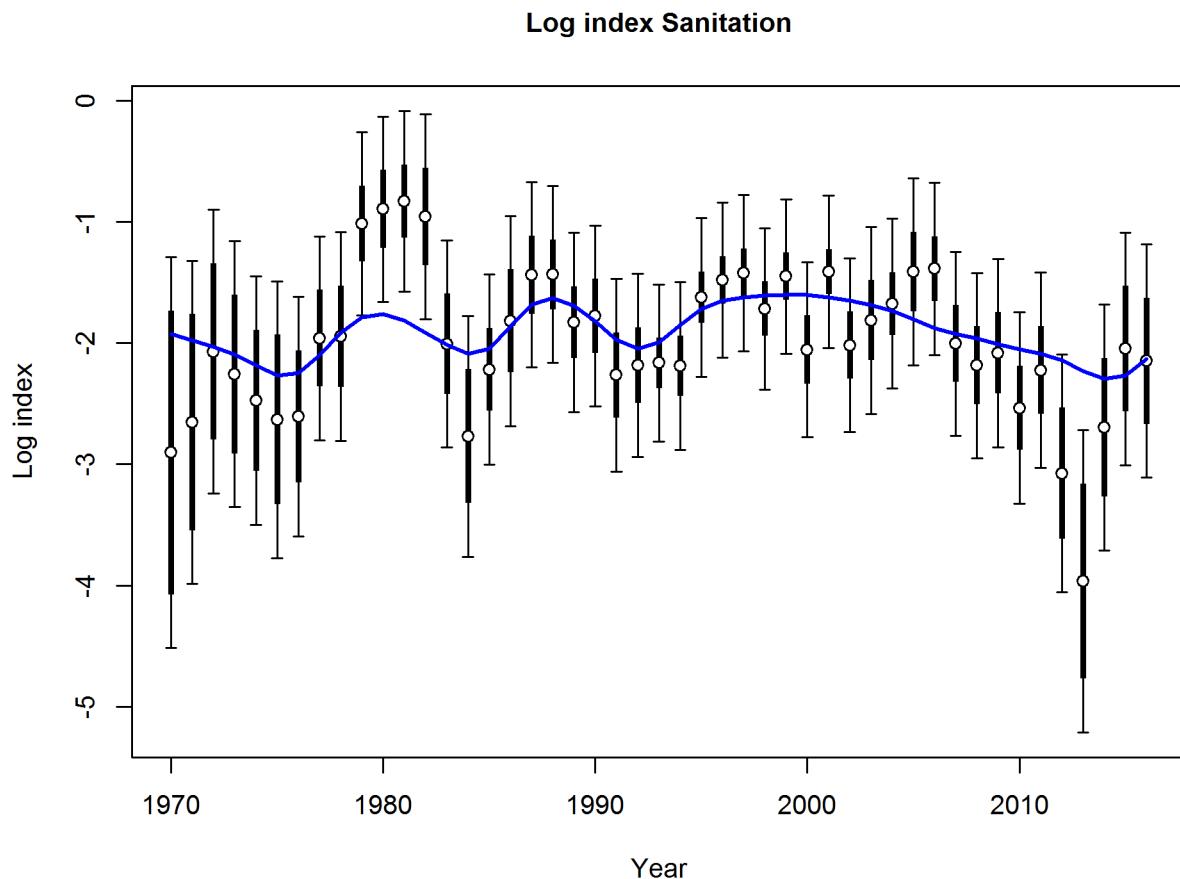


Figure 18: Fit to log index data on log scale for the recreational CPFV onboard observer discarded catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.
`fig:index5_logcpuefit_Sanitation`

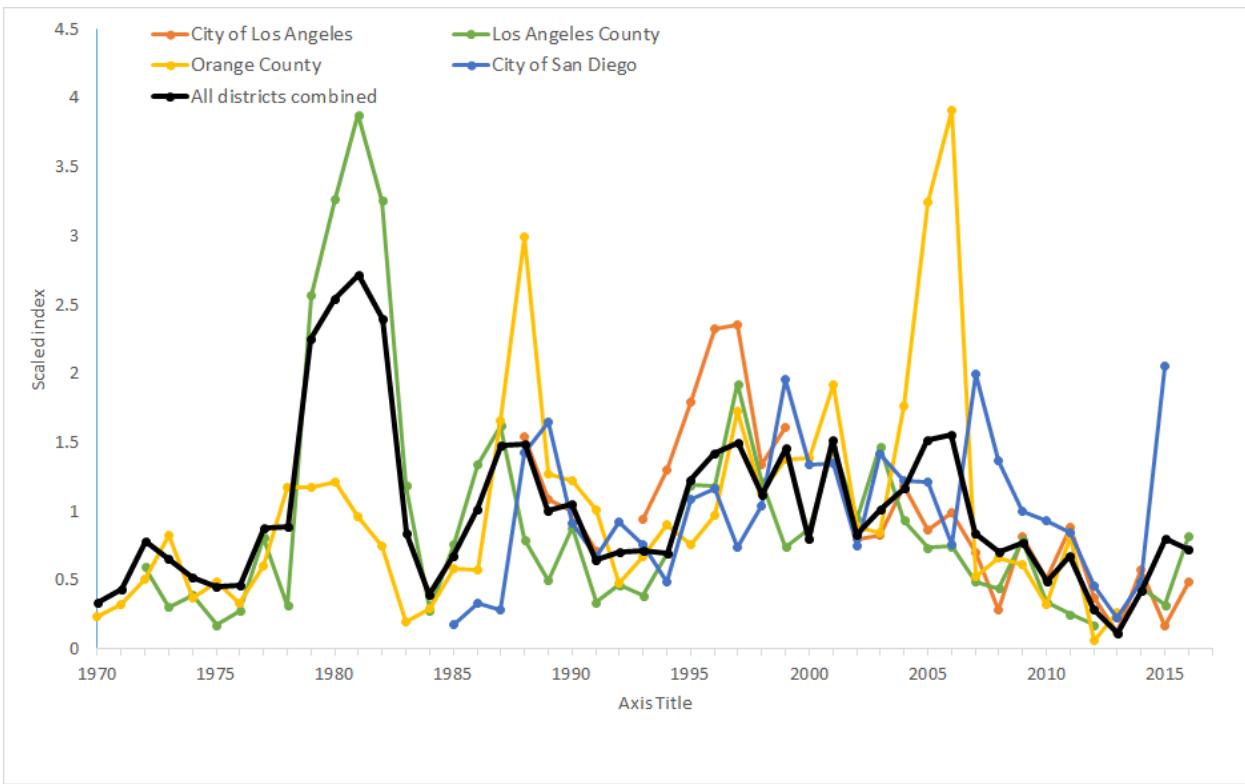


Figure 19: Comparison of standardized indices for each sanitation district independently and with data from all sanitation districts combined. [fig:Fleet7_Sanitation_indexcompare](#)

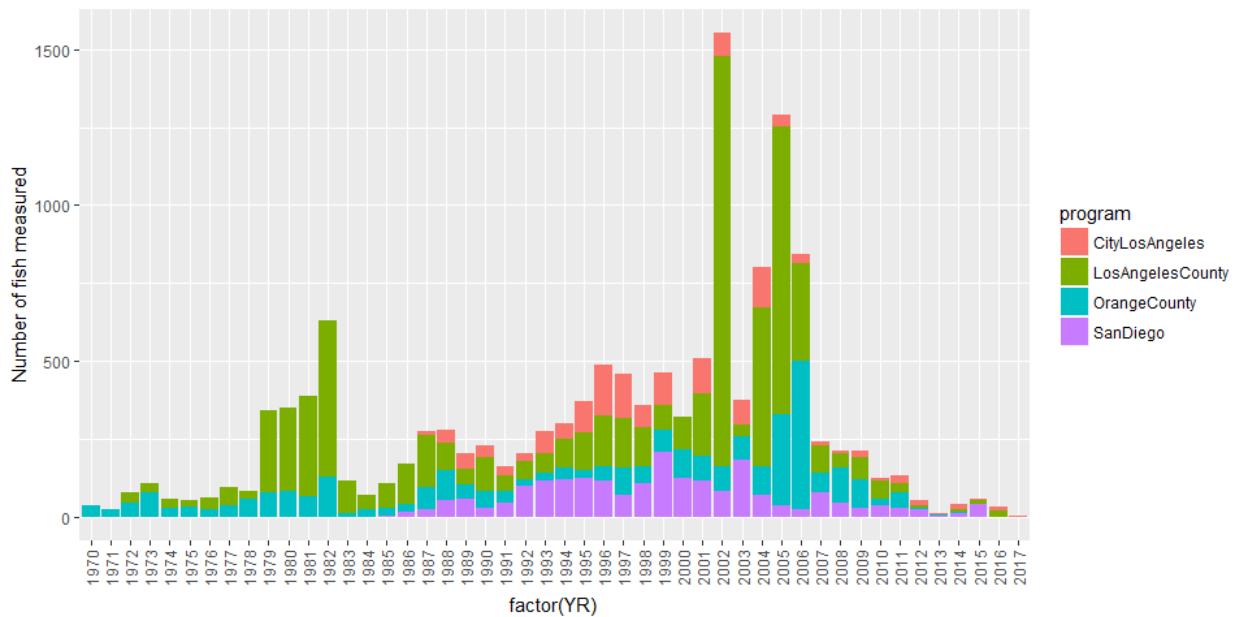


Figure 20: Sample sizes of measured California scorpionfish by sanitation district and year. [fig:Fleet7_Sa](#)

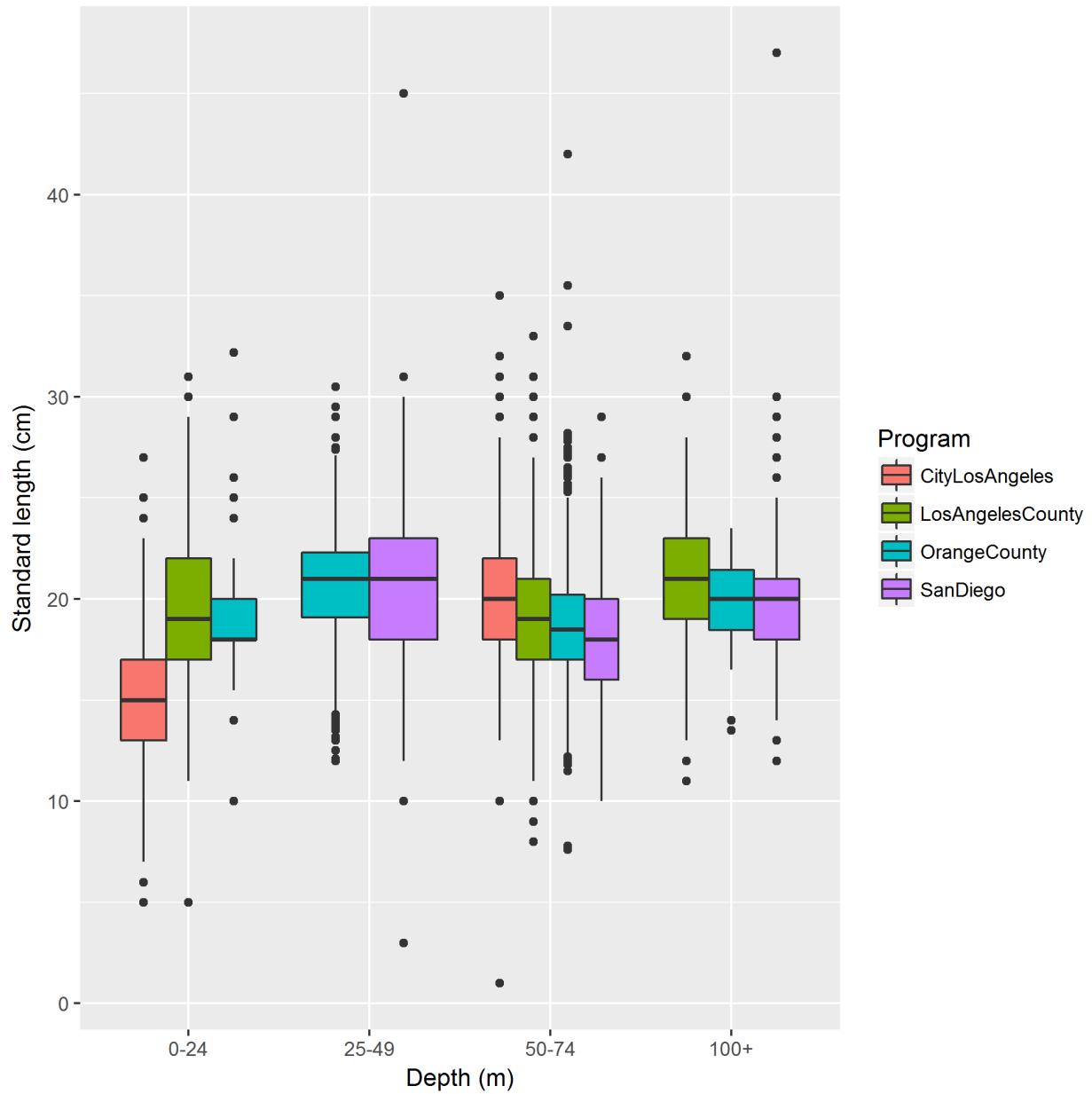


Figure 21: Boxplots of measured California scorpionfish from the sanitation district surveys by program and 25 m depth bins. [fig:Fleet7_Sanitation_Lengthboxplots](#)

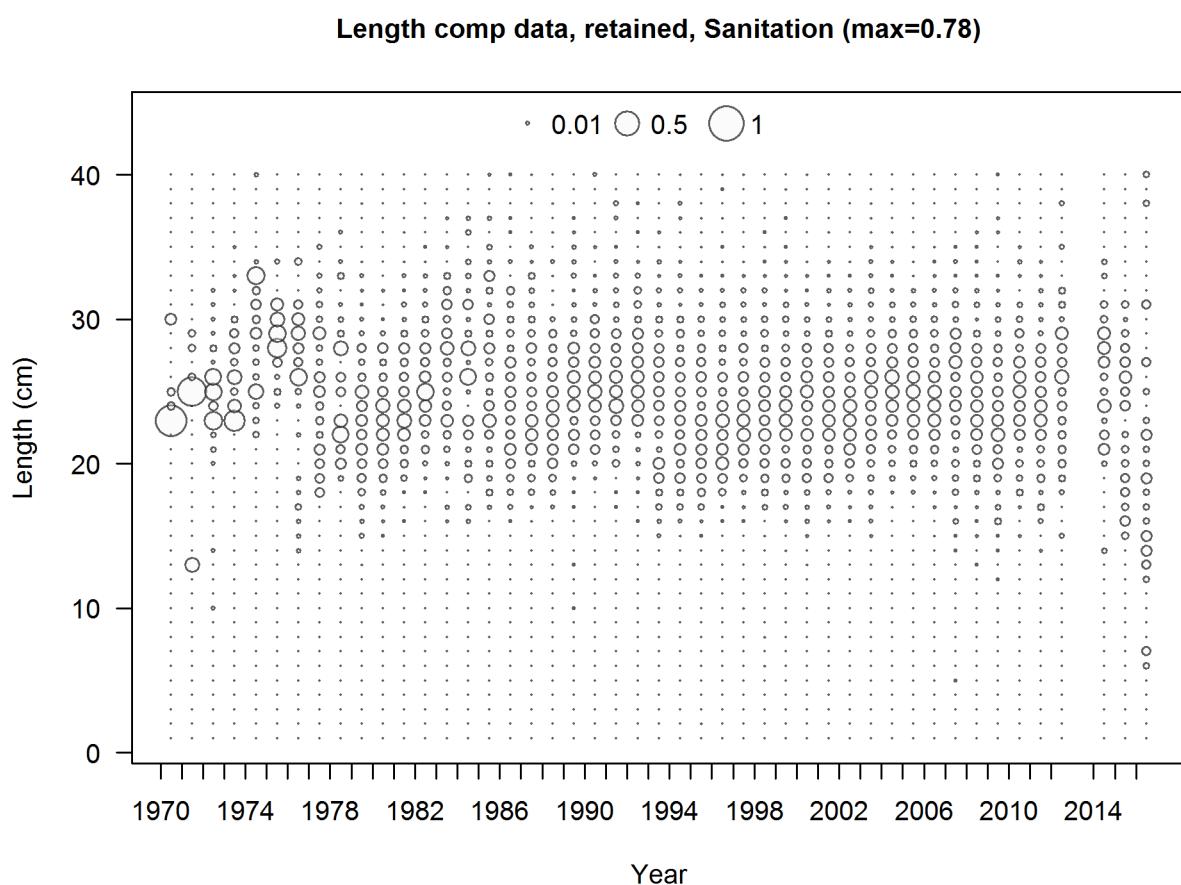


Figure 22: Length frequency distributions from the sanitation districts trawl surveys. fig:Fleet7_comp

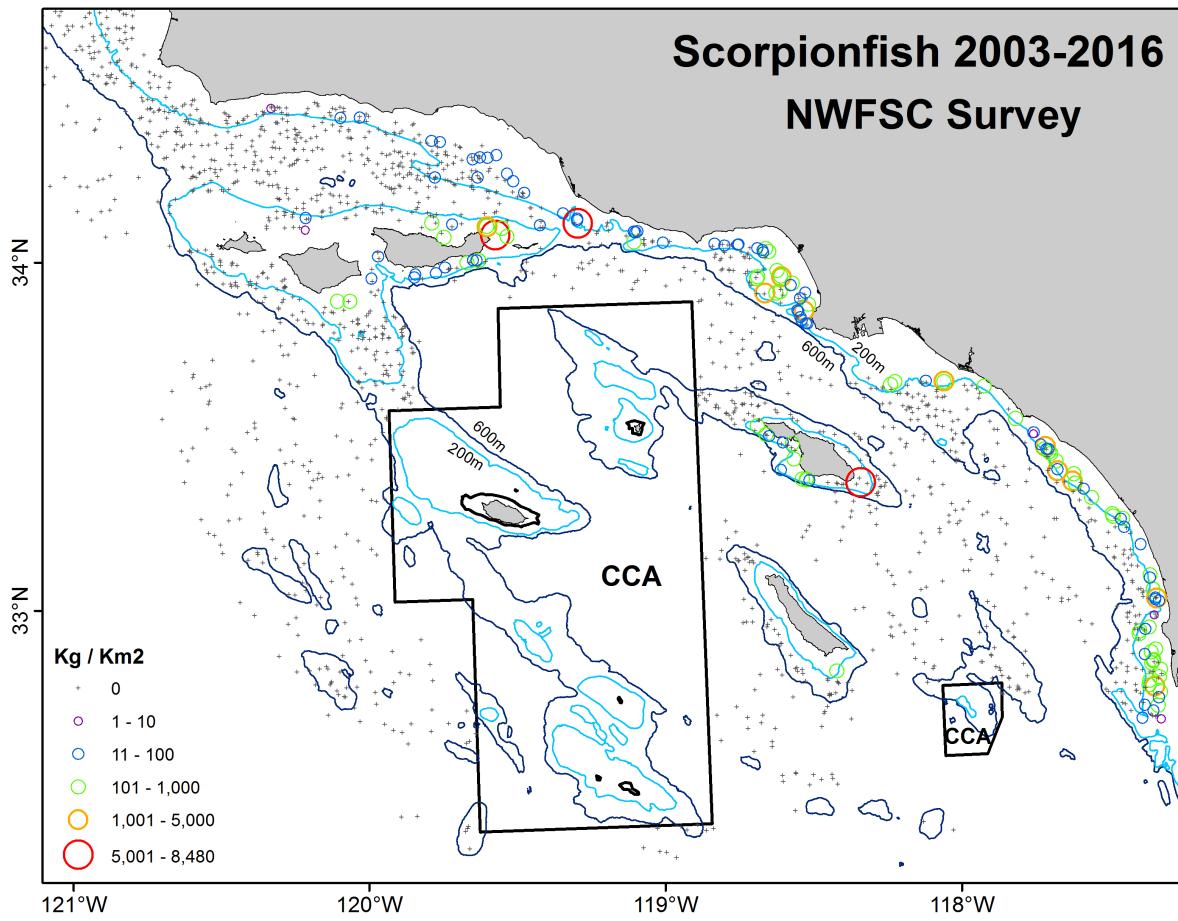


Figure 23: Spatial distribution of raw catch rates of Scorpionfish from NWFSC trawl survey between 2003 and 2016. Depth contour lines of 200m and 600m and the CAC areas are shown. Note that sizes and colors of circles represent catch rate in log scales (Credit of Rebecca Miller, SWFSC). [fig:Fleet8_NWFSCtrawl_map](#)

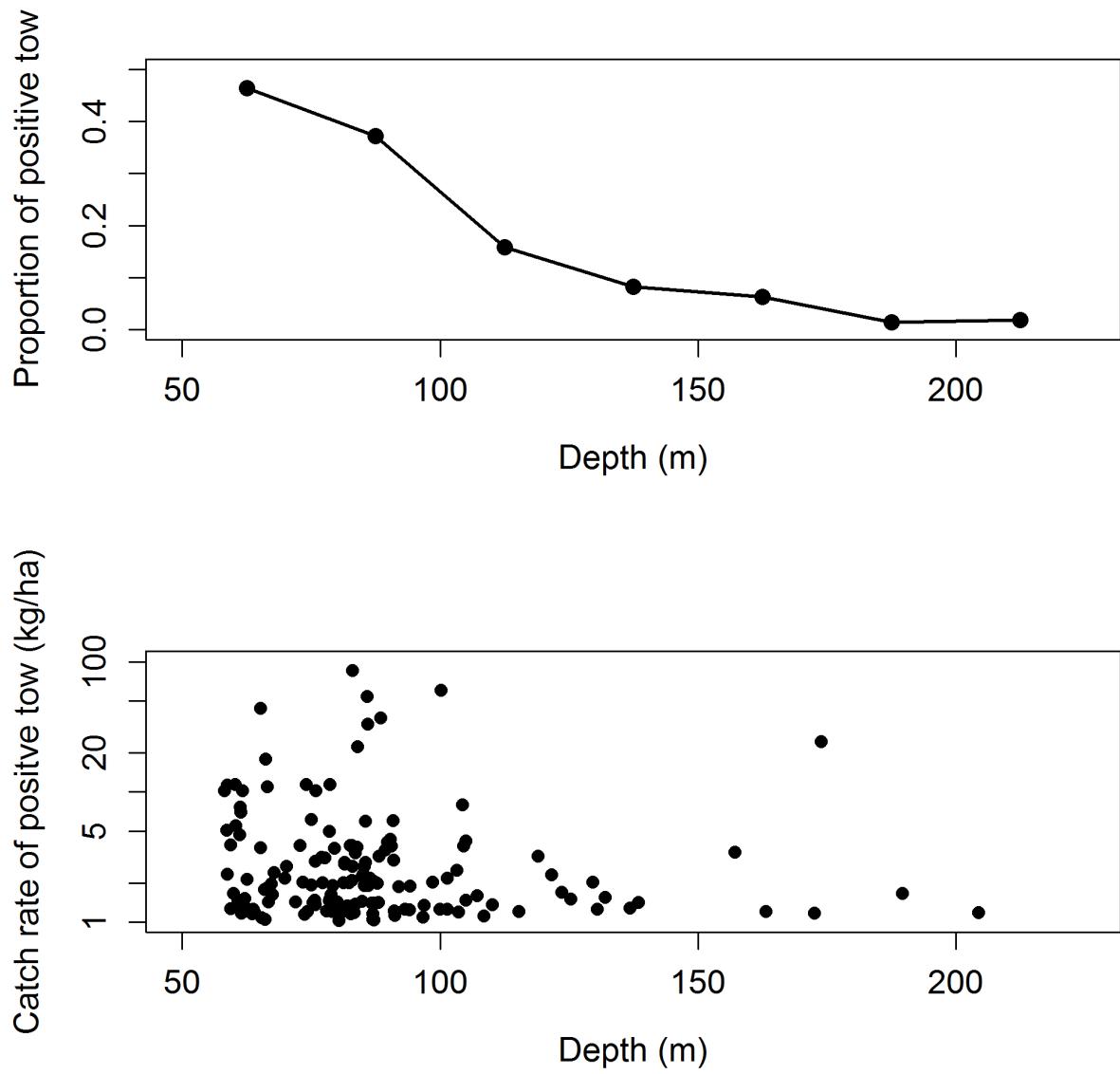


Figure 24: Plots of the proportion of positive tows (top panel) and the raw catch rates of positive tows (bottom panel) by depth zones (25 m interval) for NWFSC trawl survey. fig:Fleet8_NWFSC

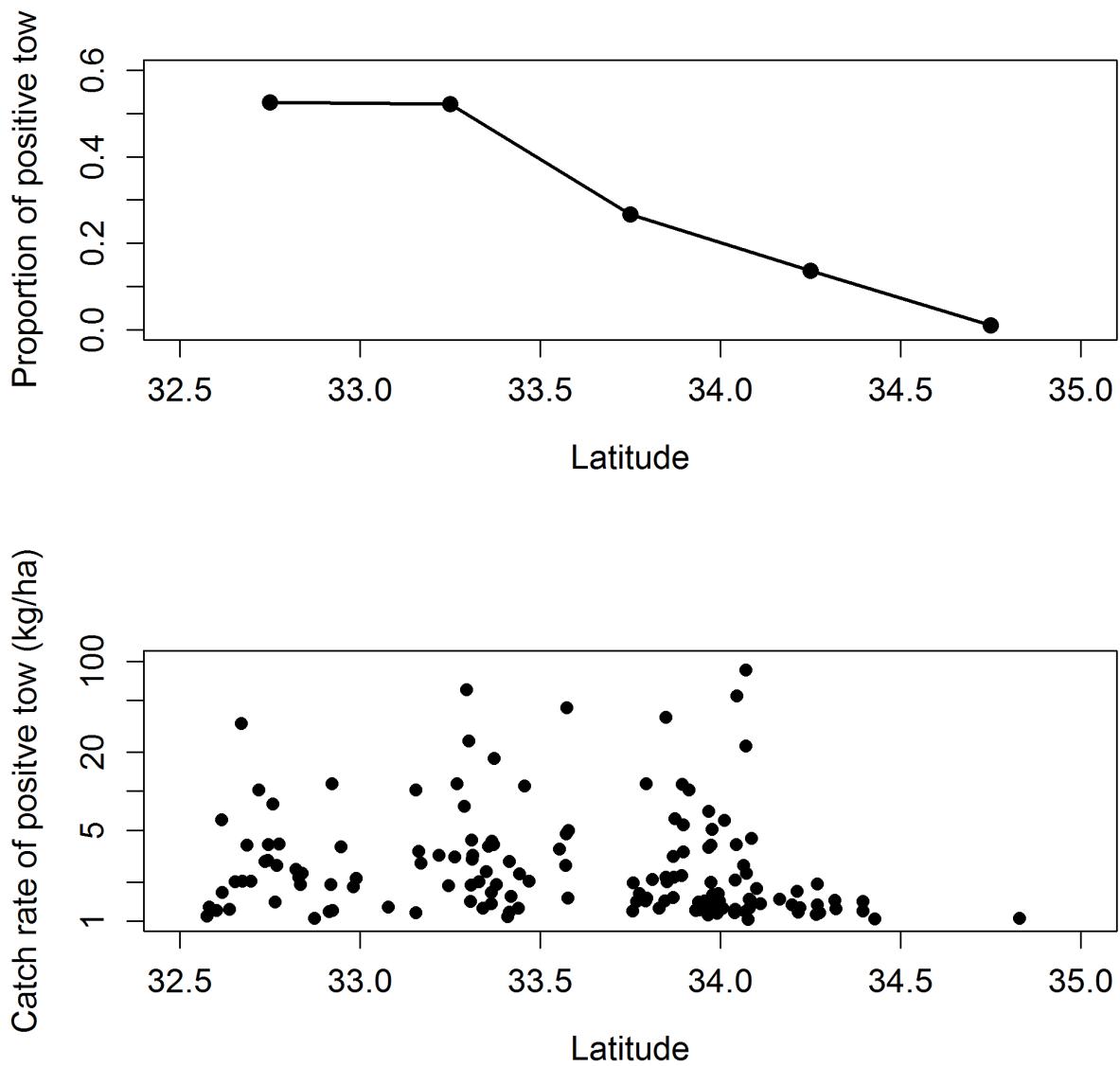


Figure 25: Plots of the proportion of positive tows (top panel) and the raw catch rates of positive tows (bottom panel) by latitude zones (0.5 degree interval) for NWFSC trawl survey.
`fig:Fleet8_NWFSCtrawl_poslat`

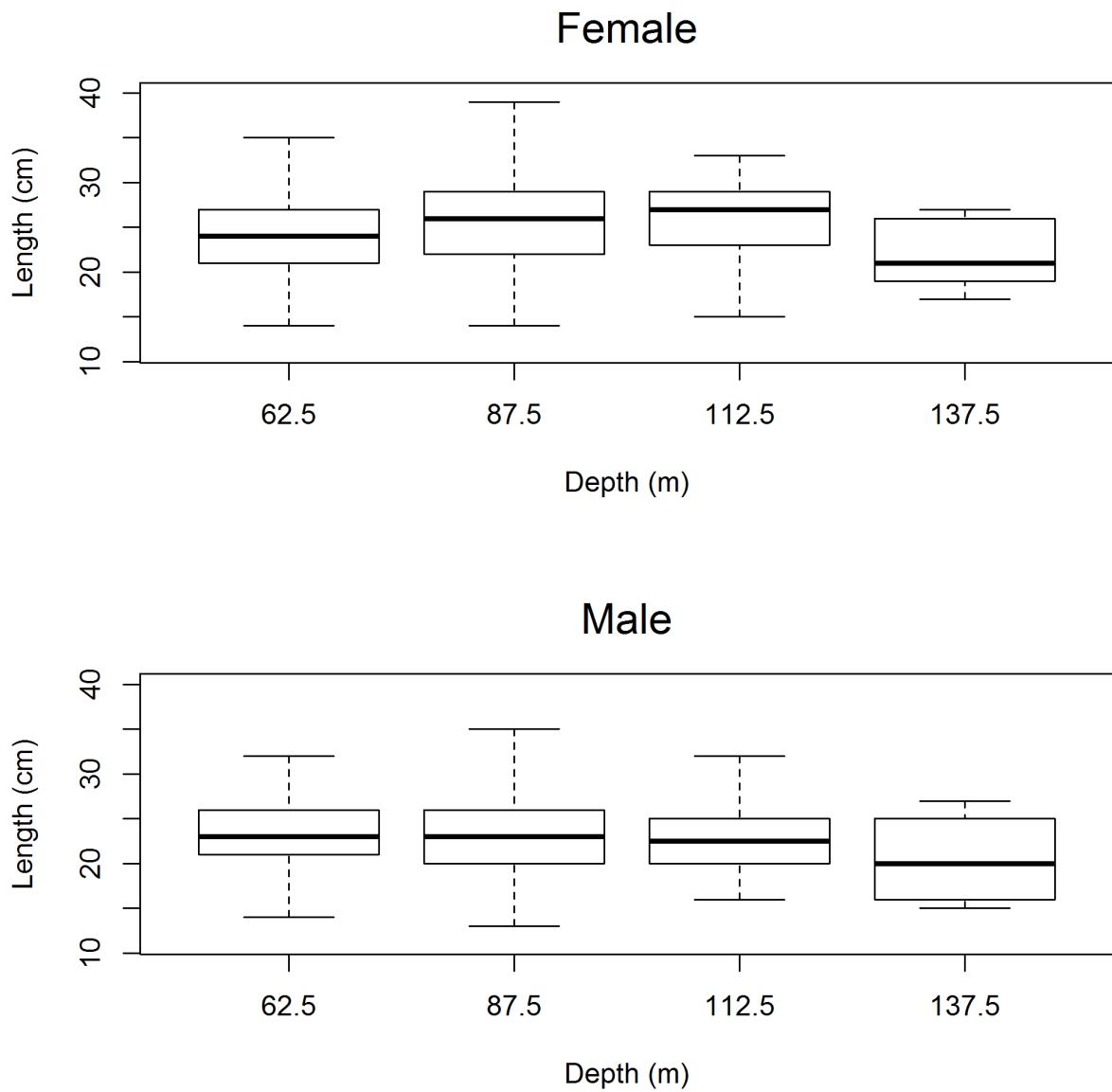


Figure 26: Comparison box plots of raw length data from NWFSC trawl survey by depth zone and sex. [fig:Fleet8_NWFSCtrawl_lengthdepth](#)

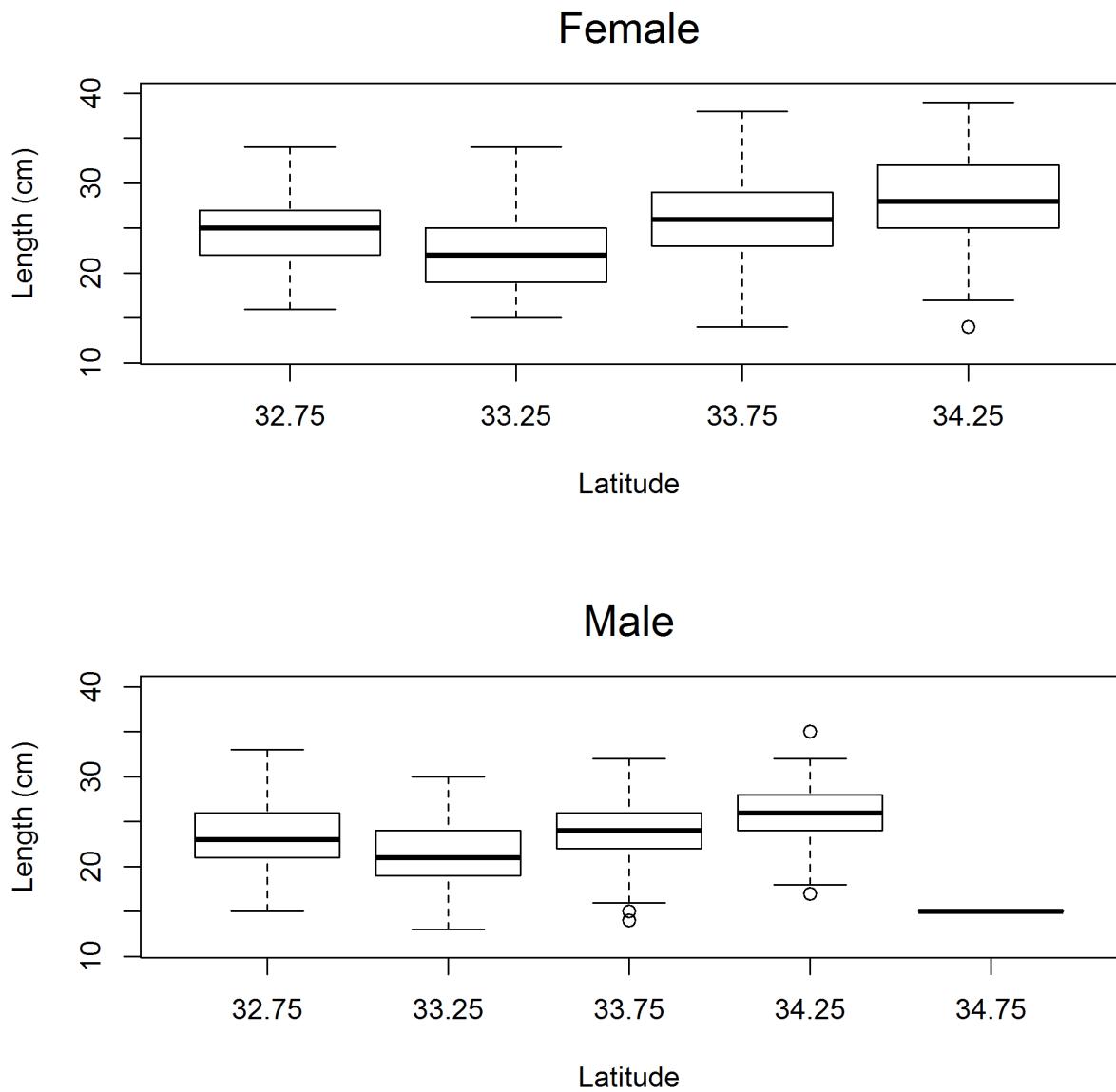


Figure 27: Comparison box plots of raw length data from NWFSC trawl survey by latitude zone and sex. fig:Fleet8_NWFSCtrawl_lengthlat

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

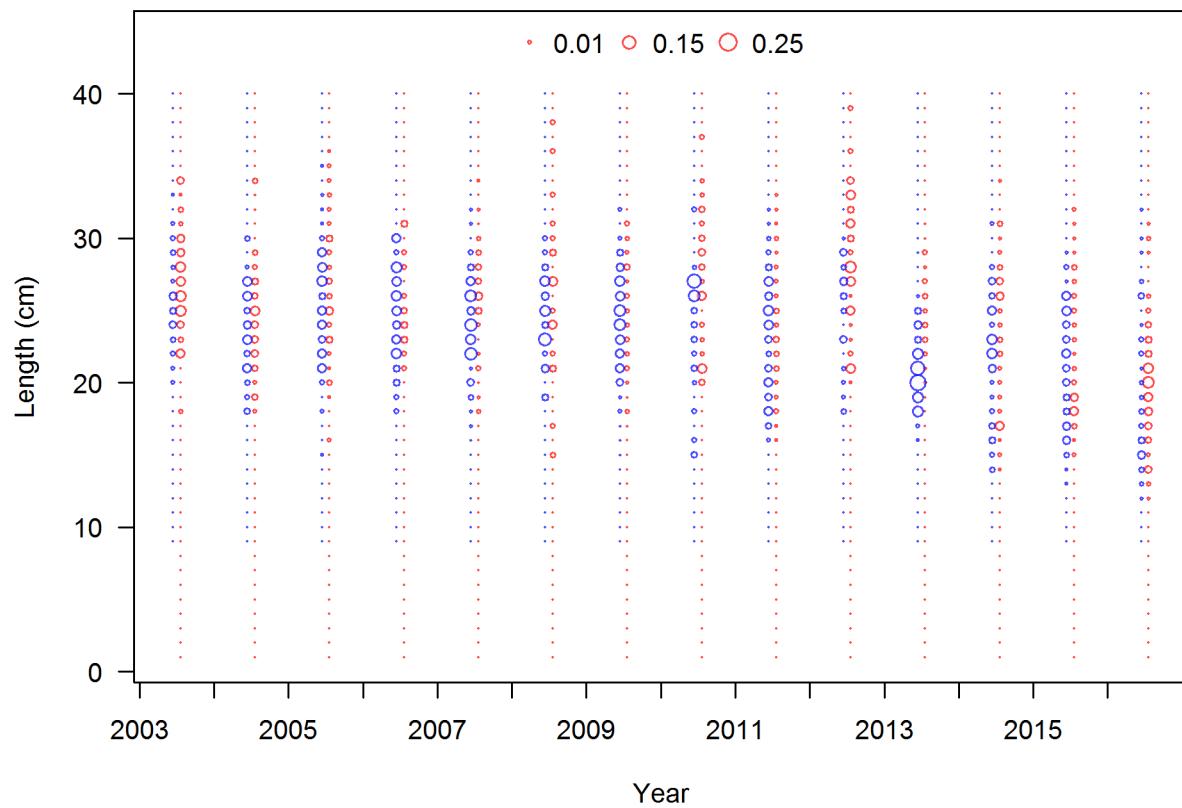


Figure 28: Length frequency distributions of females (red) and male (blue) from the NWFSC trawl survey between 2003 and 2016. [fig:Fleet8_comp_1endat_bubf1t8mkt0](#)

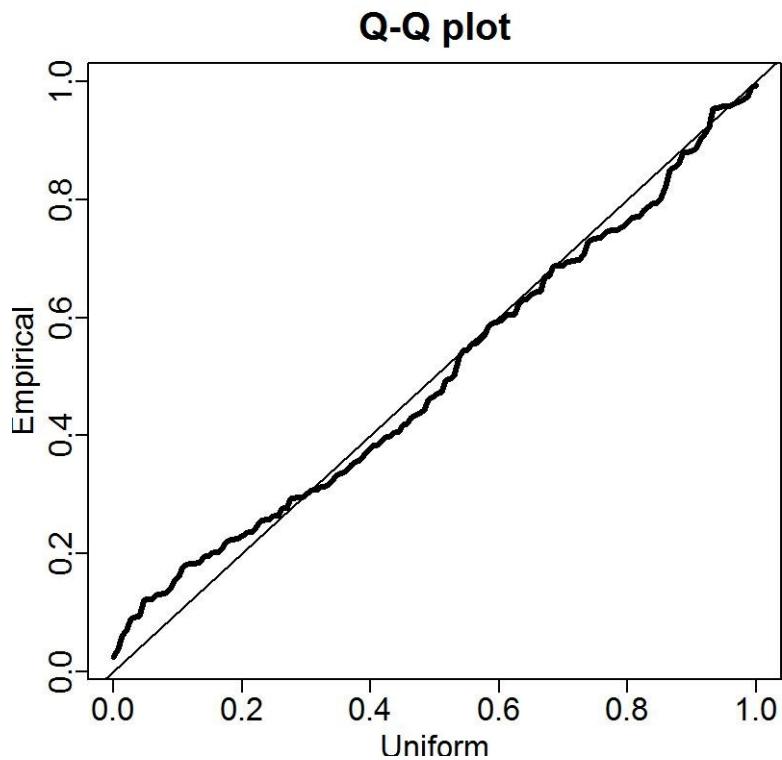


Figure 29: Q-Q plot used to validate the goodness of fit of the VAST analysis for the NWFSC trawl survey between 2003 and 2016. fig:Fleet8_NWFSCtrawl_QQ

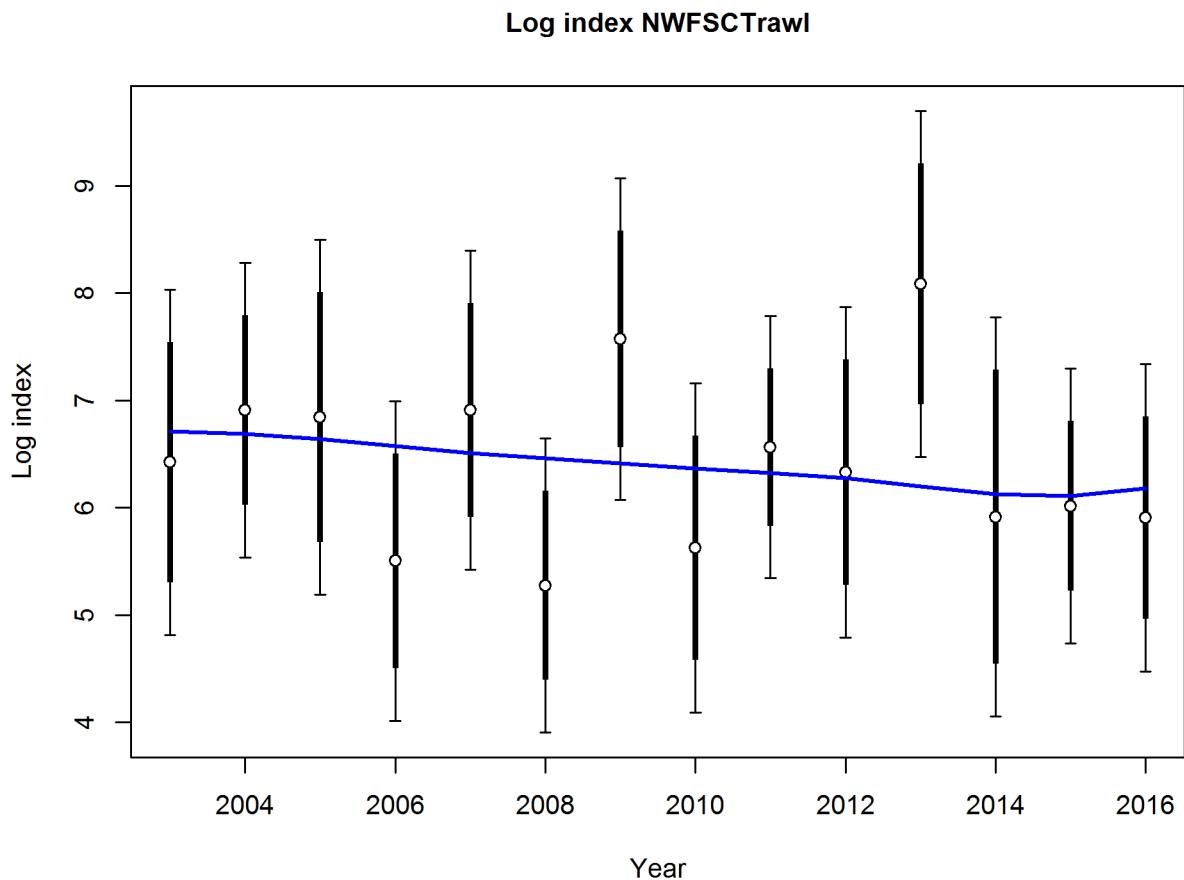


Figure 30: Fit to log index data on log scale for the NWFSC trawl survey from the VAST analysis from 2003-2016. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.
`fig:index5_logcpuefit_NWFSCtrawl`

Normal Q-Q Plot

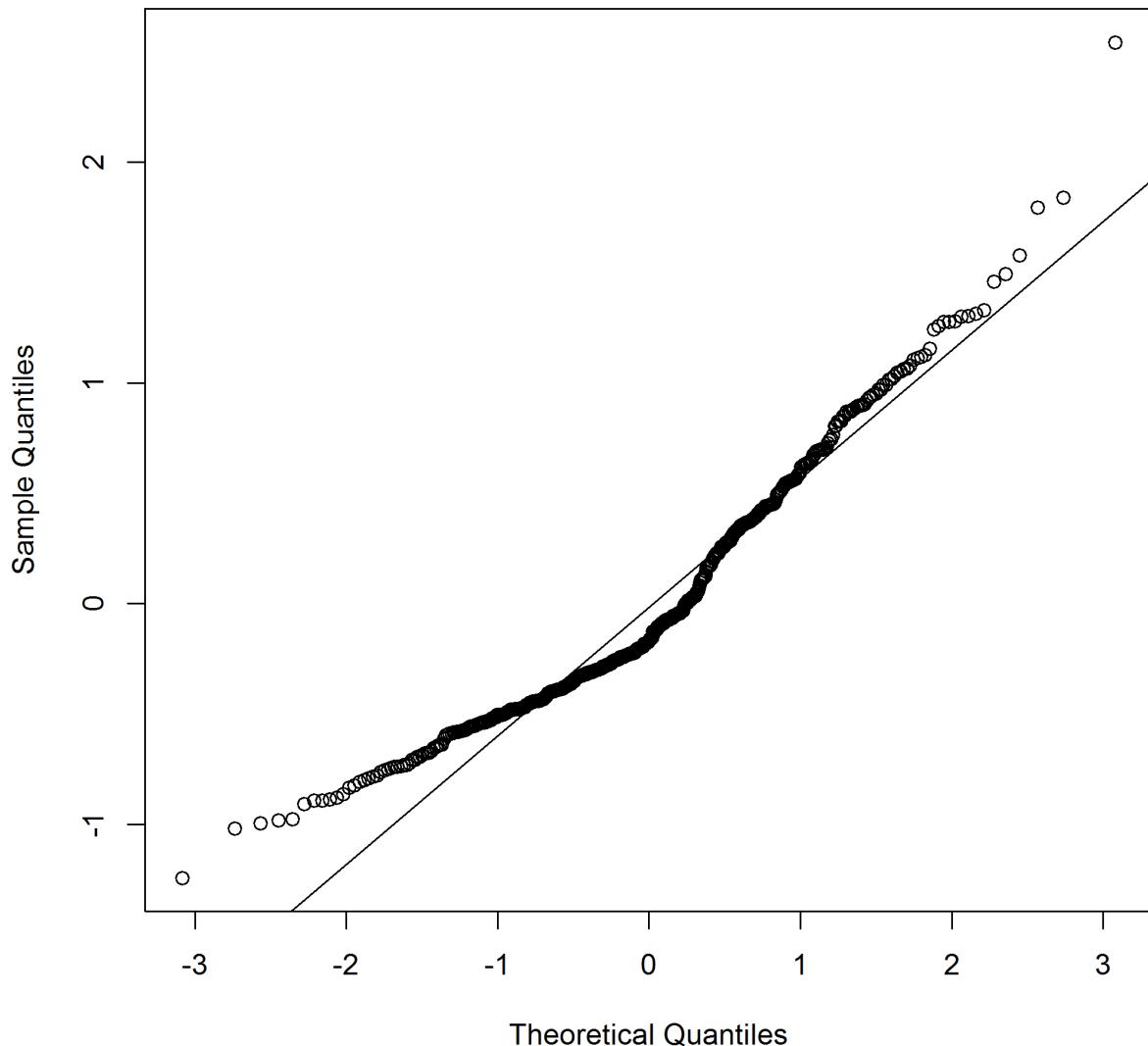


Figure 31: Q-Q plot used to validate the goodness of fit of the lognormal model for the CSUN/VRG gillnet survey from 1995-2008. fig:Fleet9_GillnetSurvey_QQ

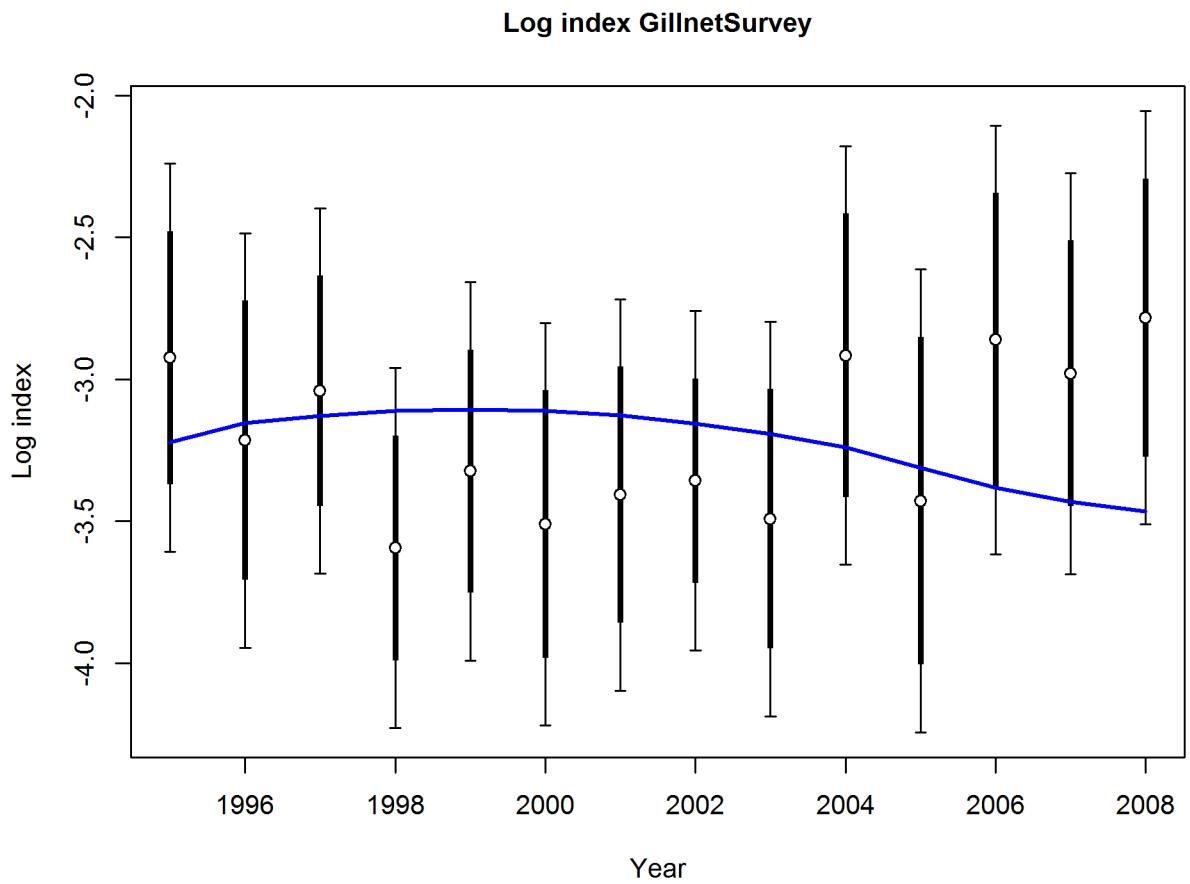


Figure 32: Fit to log index data on log scale for the recreational CSUN/VRG gillnet survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

Normal Q-Q Plot

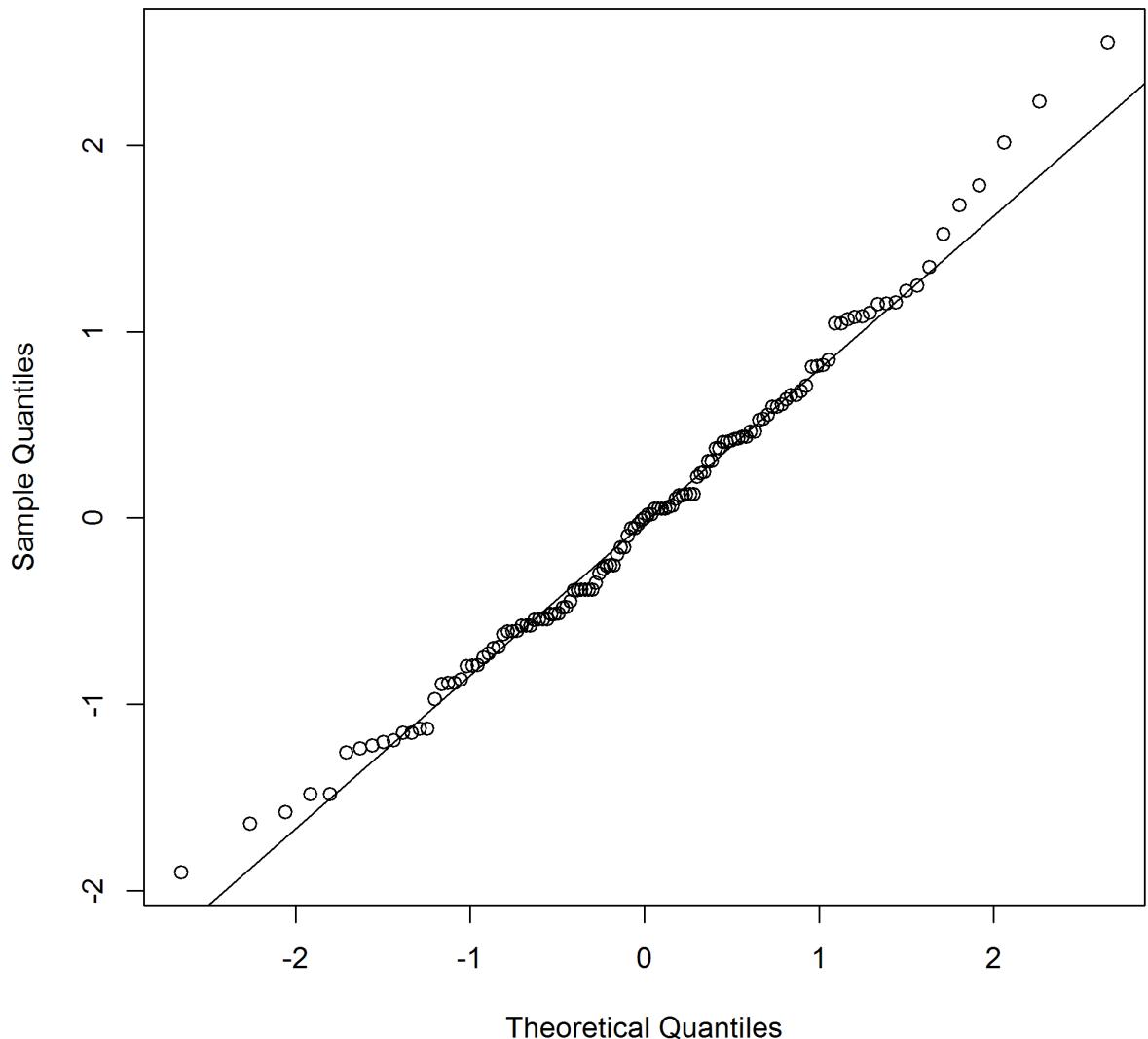


Figure 33: Q-Q plot used to validate the goodness of fit of the lognormal model for the Southern California Bight monitoring program trawl survey. [fig:Fleet11_SCBsurvey_QQ](#)

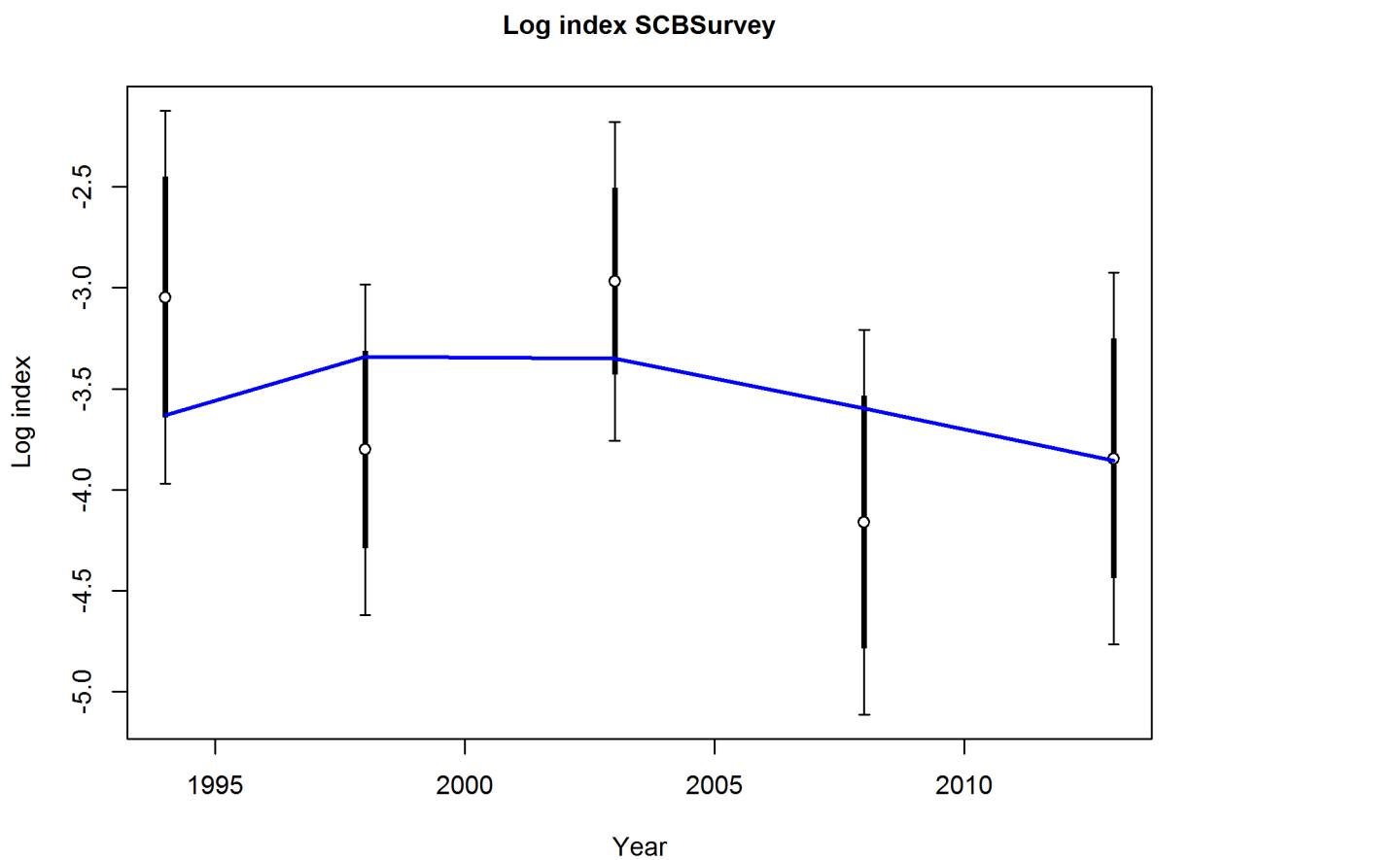


Figure 34: Fit to log index data on log scale for the recreational Southern California Bight trawl survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. fig:index5_log

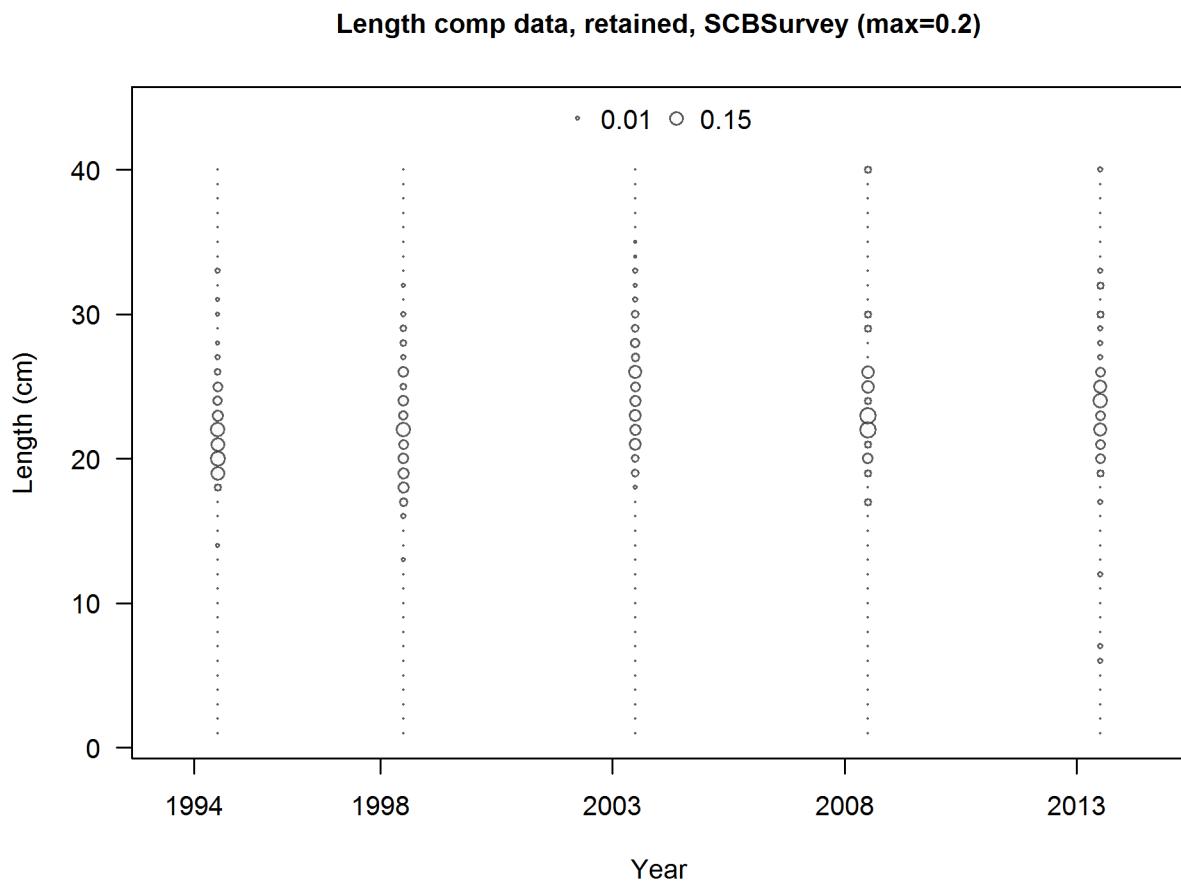


Figure 35: Length frequency distributions from the Southern California Bight regional monitoring program trawl surveys. | [fig:Fleet11_SCBSurvey_Lendat_bubflt11mkt2](#)

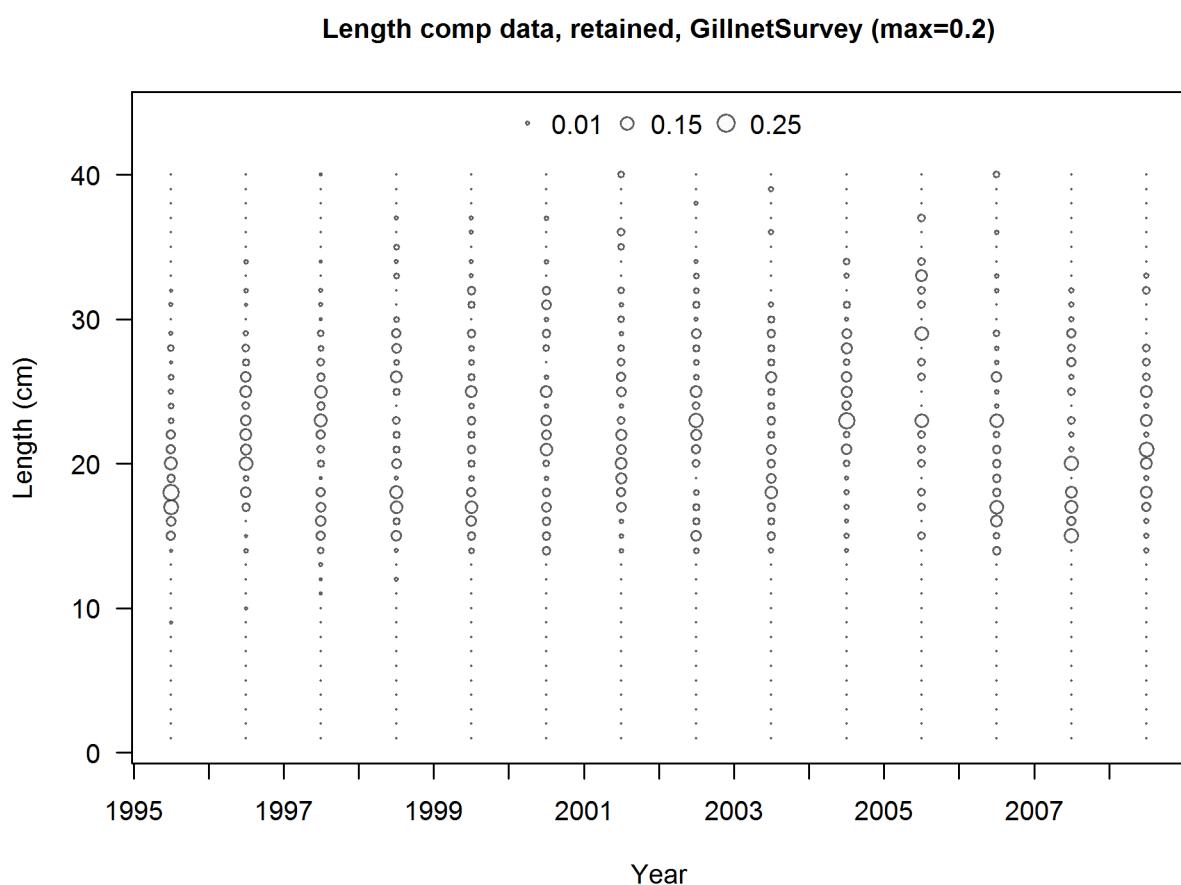


Figure 36: Length frequency distributions from the Impingement surveys. fig:Fleet9_GillnetSu

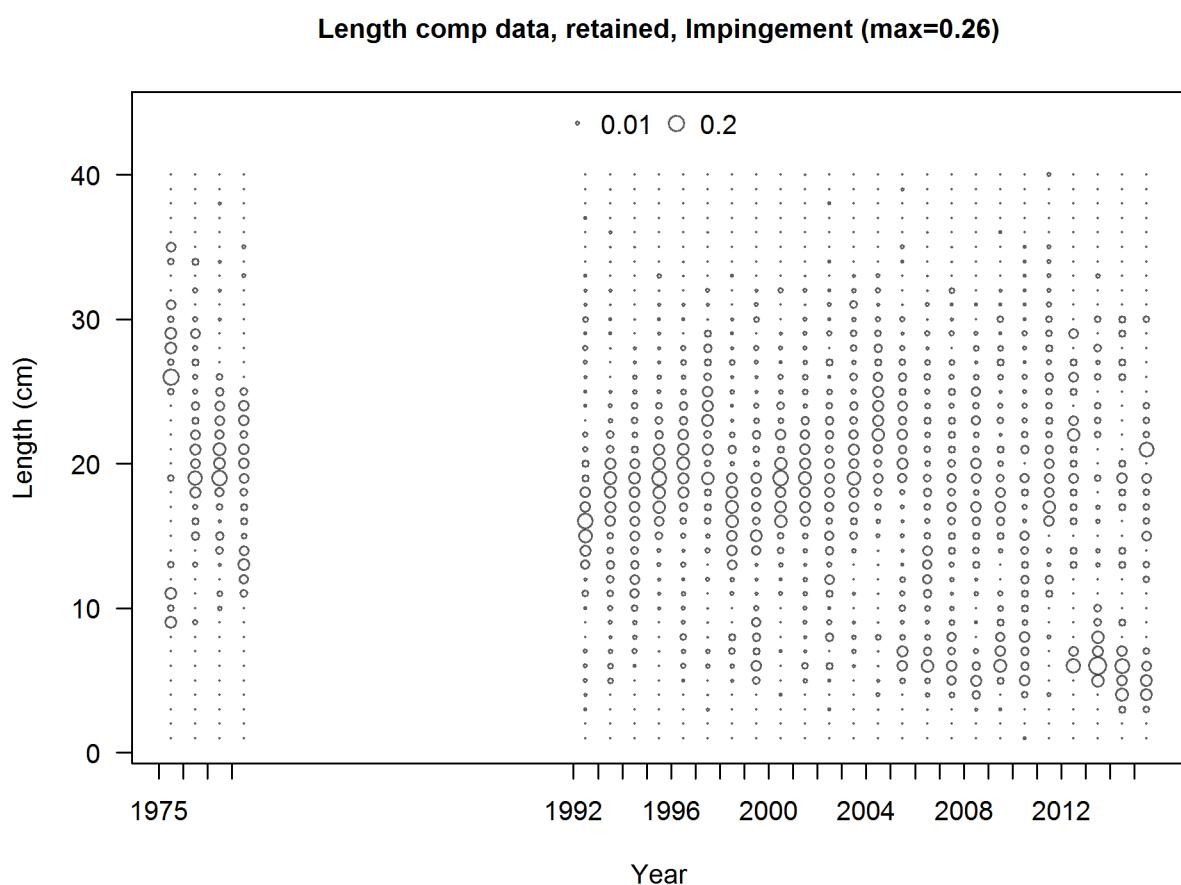


Figure 37: Length frequency distributions from the Impingement surveys. `fig:Fleet10_comp_len`

Length comp data, aggregated across time by fleet

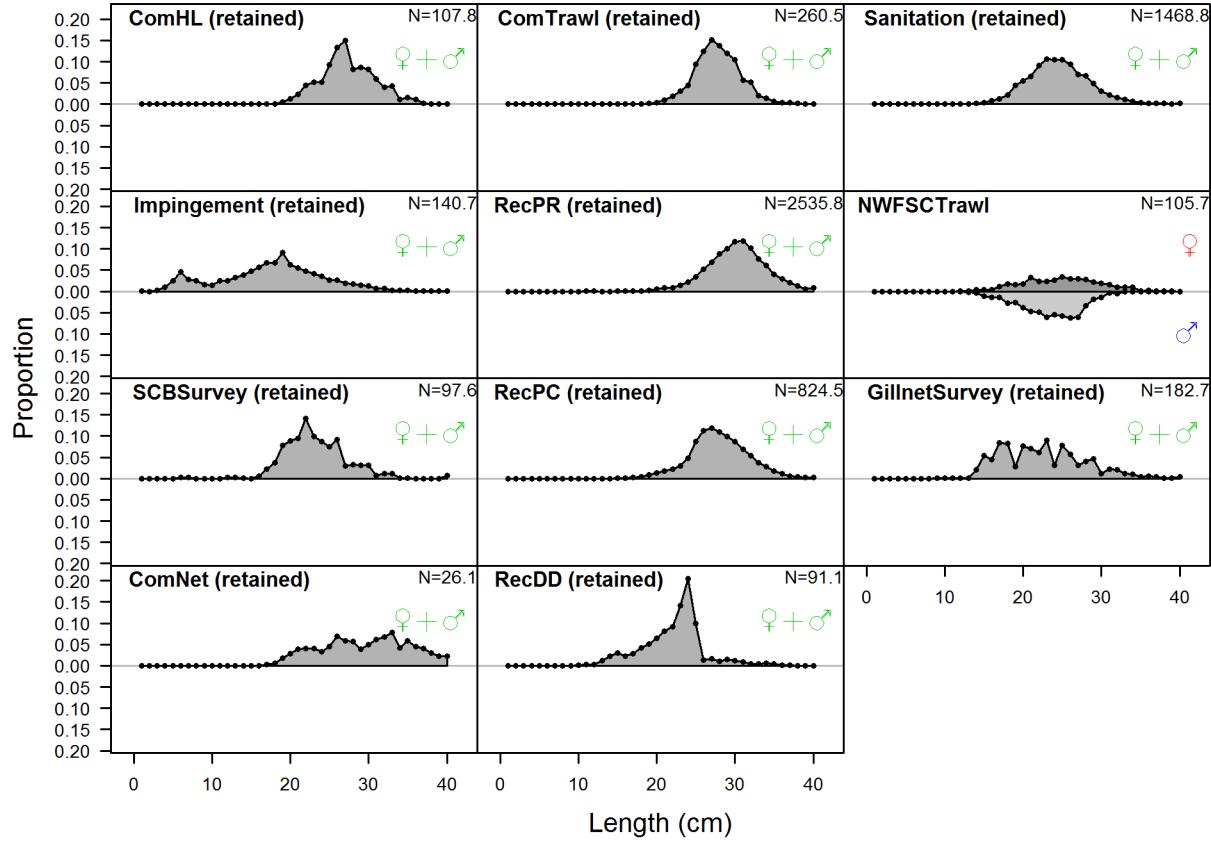


Figure 38: Length comp data, aggregated across time by fleet. Labels ‘retained’ and ‘discard’ indicate discarded or retained sampled for each fleet. Panels without this designation represent the whole catch. [fig:comp_lendat_aggregated_across_time](#)

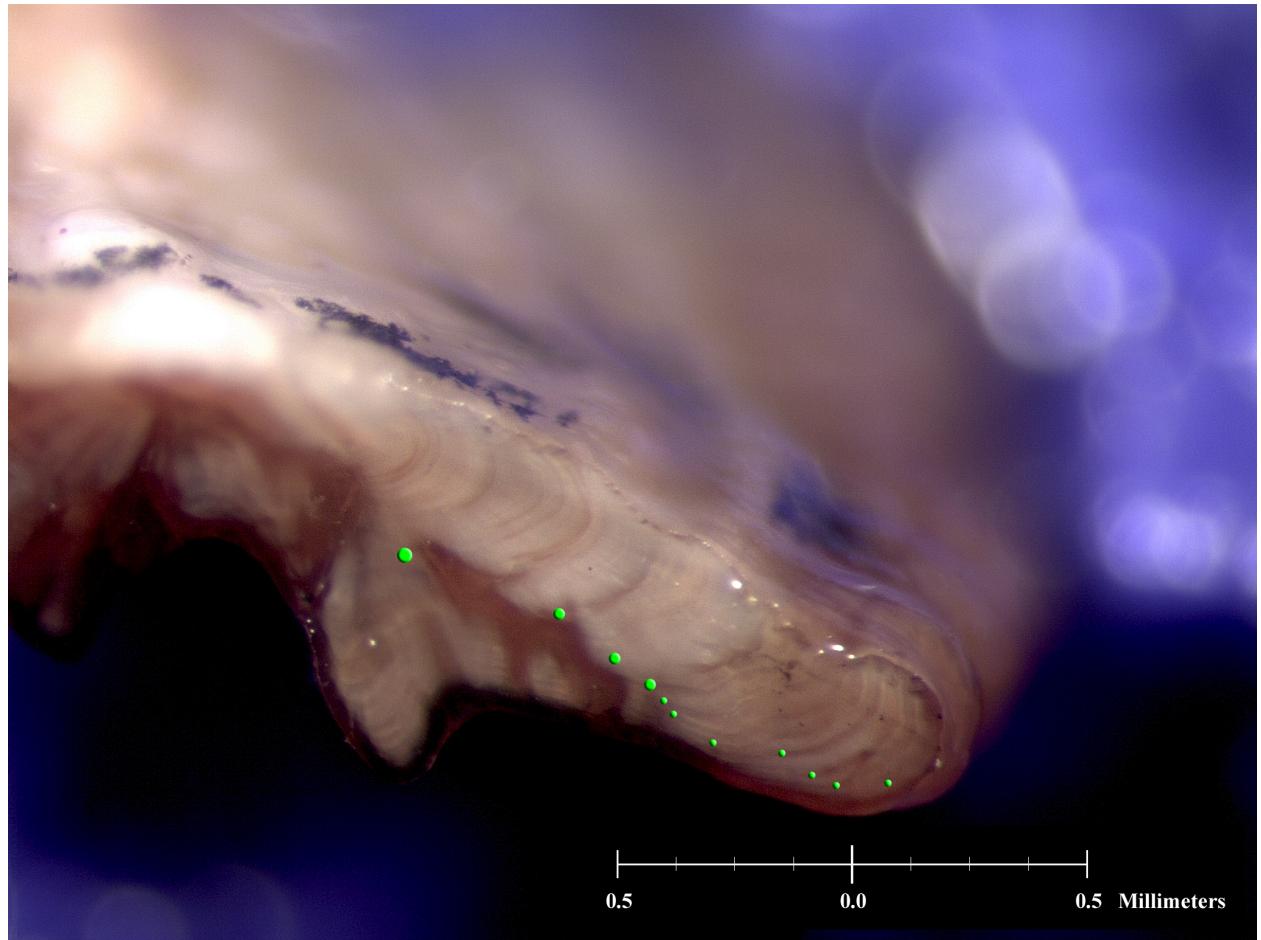


Figure 39: Cross-section of broken and burned California scorpionfish otolith showing. The green dots indicate the number of increments (photo courtesy Lance Sullivan, NWFSC). fig:otolith1

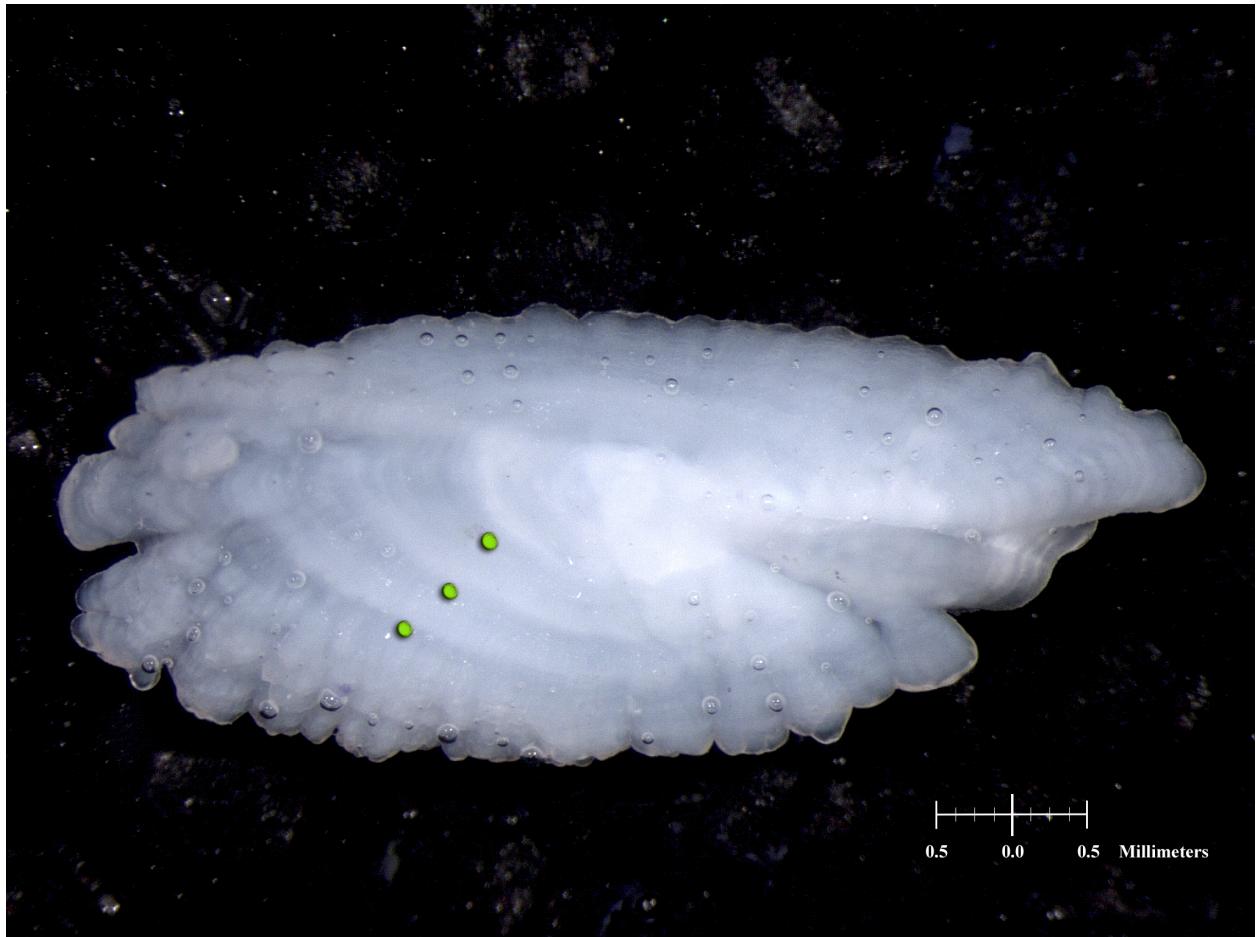
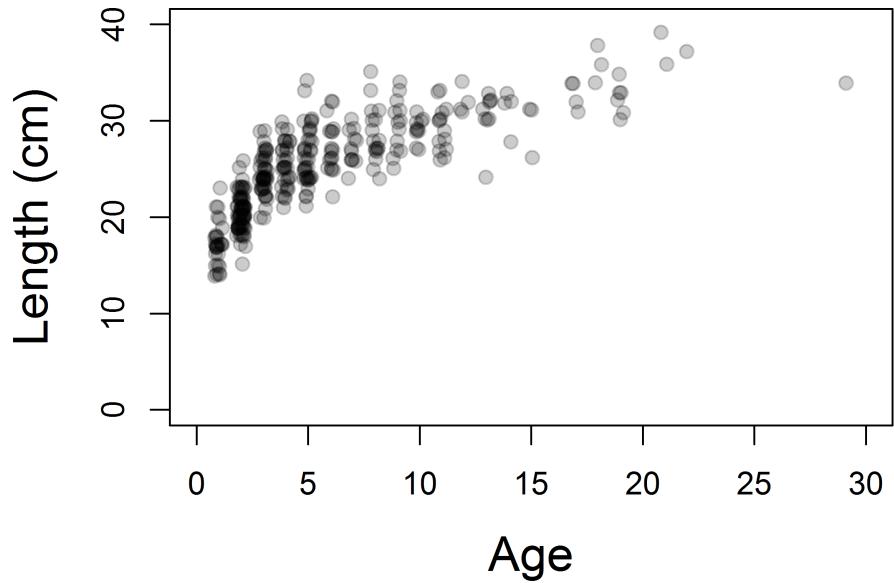


Figure 40: California scorpionfish otolith (photo courtesy Lance Sullivan, NWFSC). fig:otolith2

Female



Male

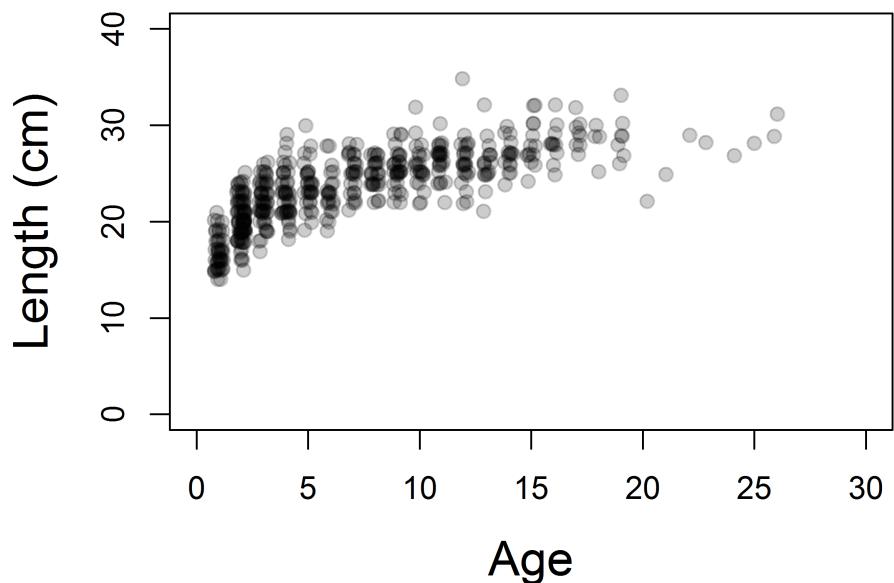
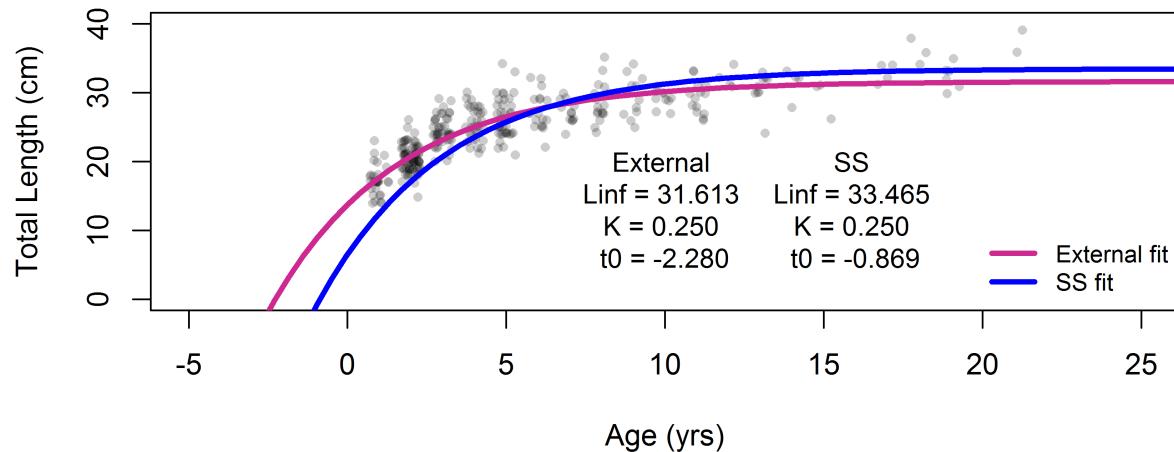


Figure 41: Length at age by sex for California scorpionfish collected from the NWFSC trawl survey. [fig:AgeLength](#)

Female



Male

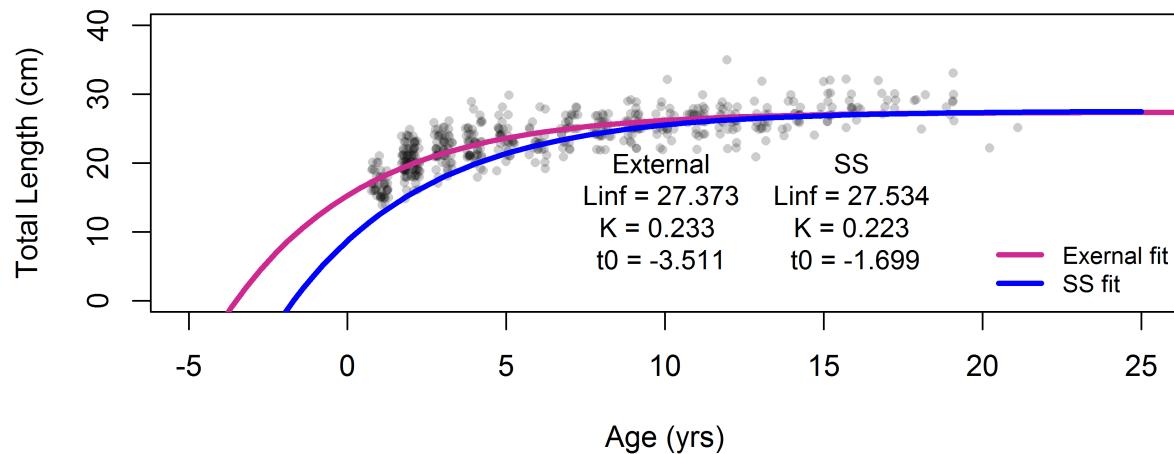


Figure 42: Fitted (external to SS) von Bertalanffy growth by sex for California scorpionfish collected from the NWFSC trawl survey. [fig:vonB_compare](#)

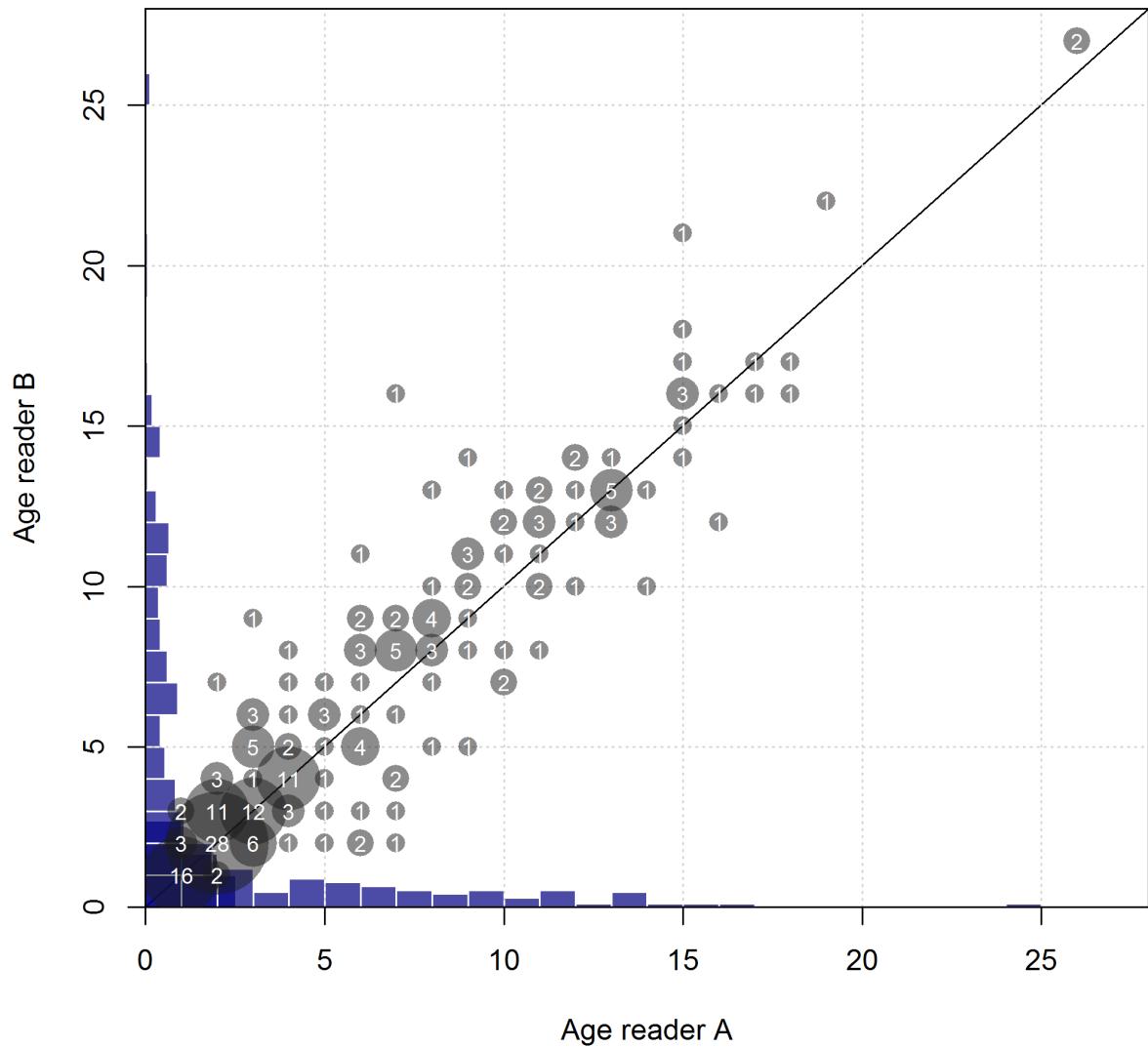


Figure 43: Aging precision between two current age readers at the NWFSC. [fig:Fleet8_NWFSCtra](#)

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

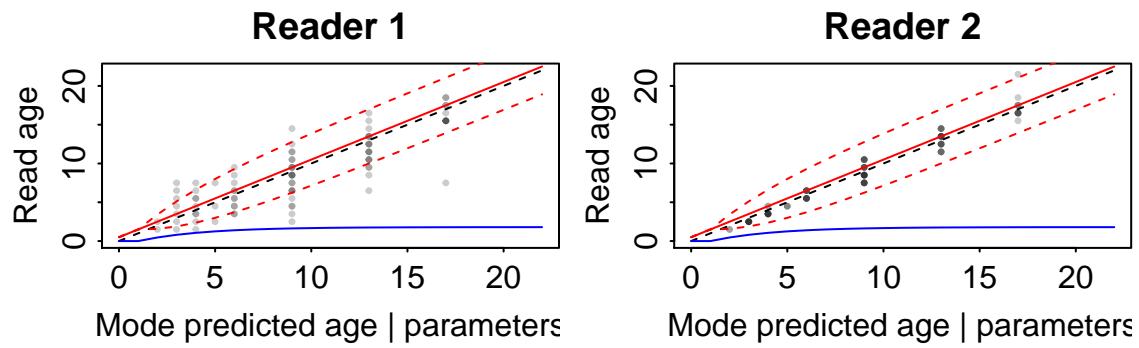


Figure 44: True versus predicted age for two current age readers at the NWFSC from the ageing error software with unbiased reads and curvilinear standard deviation for both readers.
fig:Fleet8_NWFSCtrawl_ageerror2

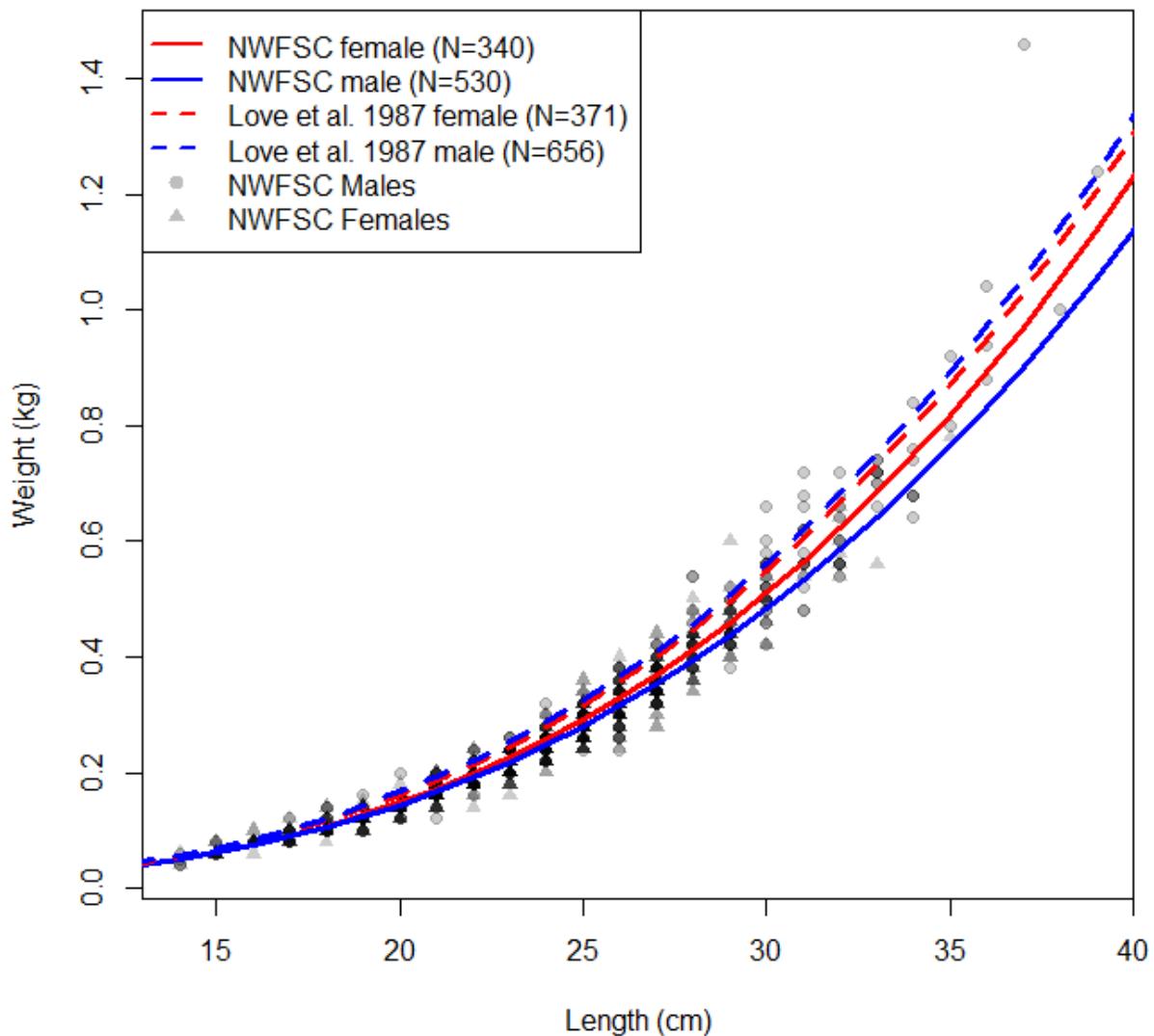


Figure 45: Comparison of the California scorpionfish weight-length curves from Love et al. (1987) and those estimated from the NWFSC trawl survey. [fig:Length_weight](#)

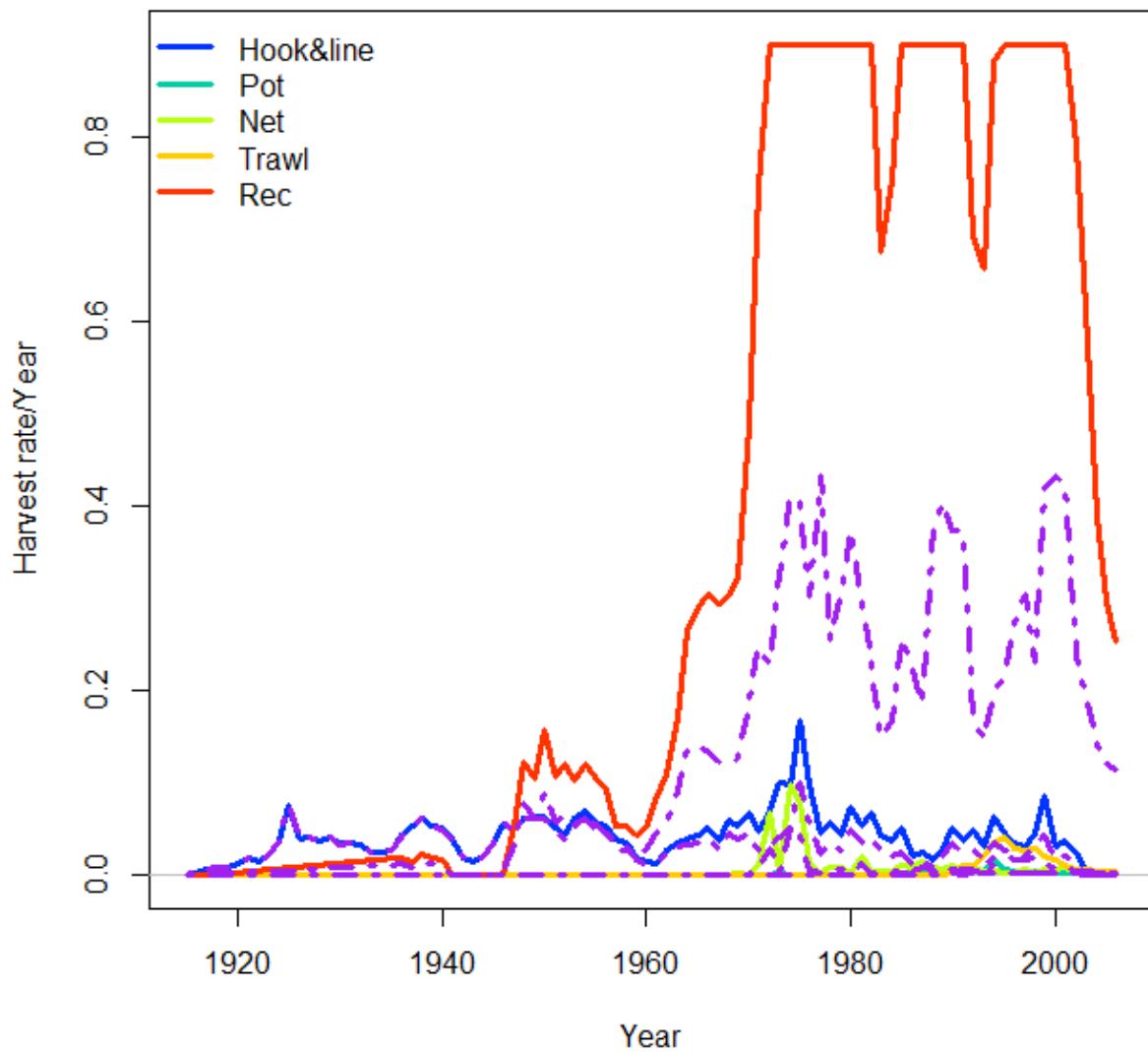


Figure 46: Time series of harvest rates by fleet from the 2005 model where the harvest rate for the recreational fleet hit the boundary of 0.9. [fig:bridge_harvestrate](#)

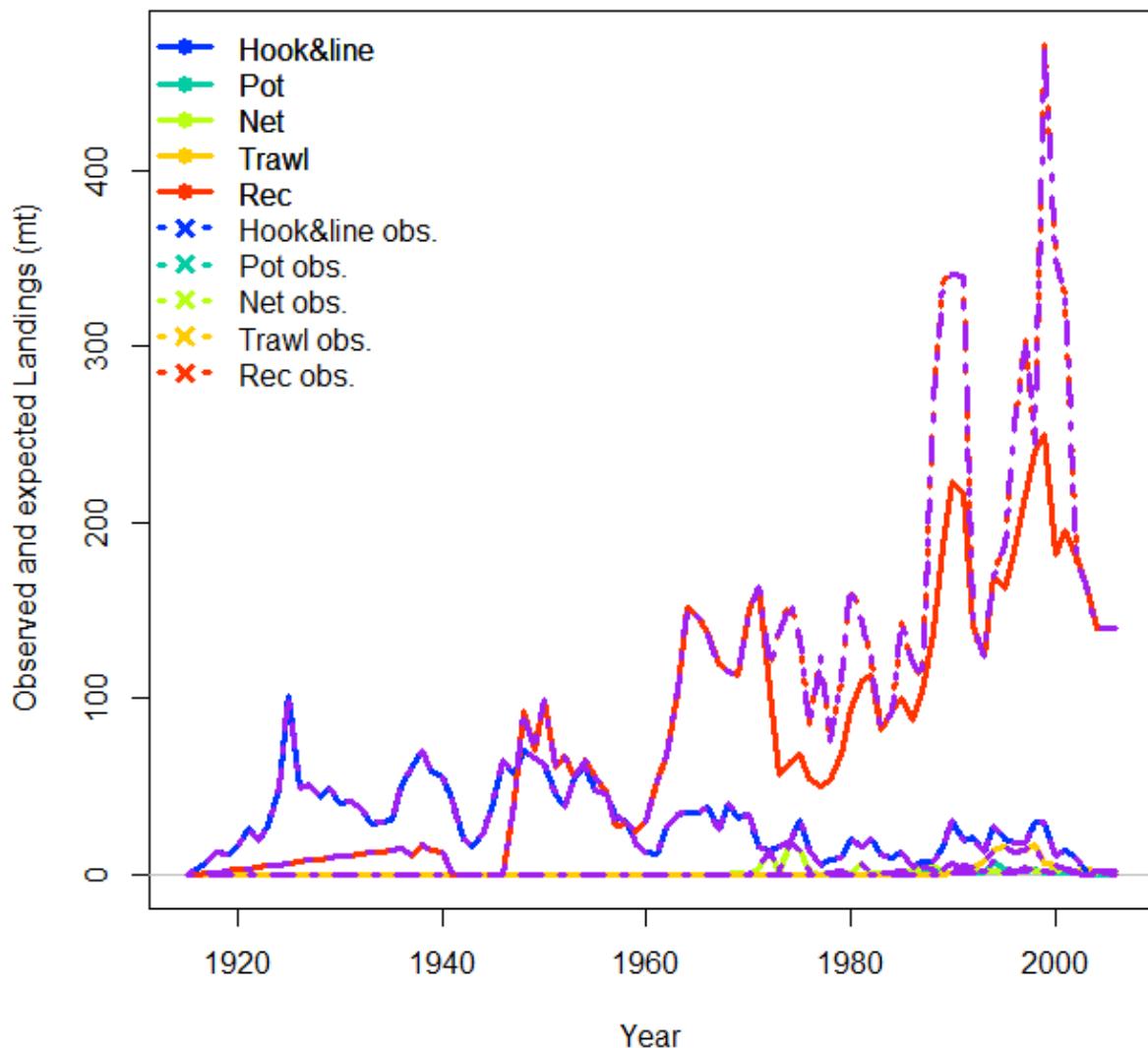


Figure 47: Time series of observed and expected landings by fleet from the 2005 model. The model was not able to remove all of the recreational catches starting around 1970. [fig:bridge_catch](#)

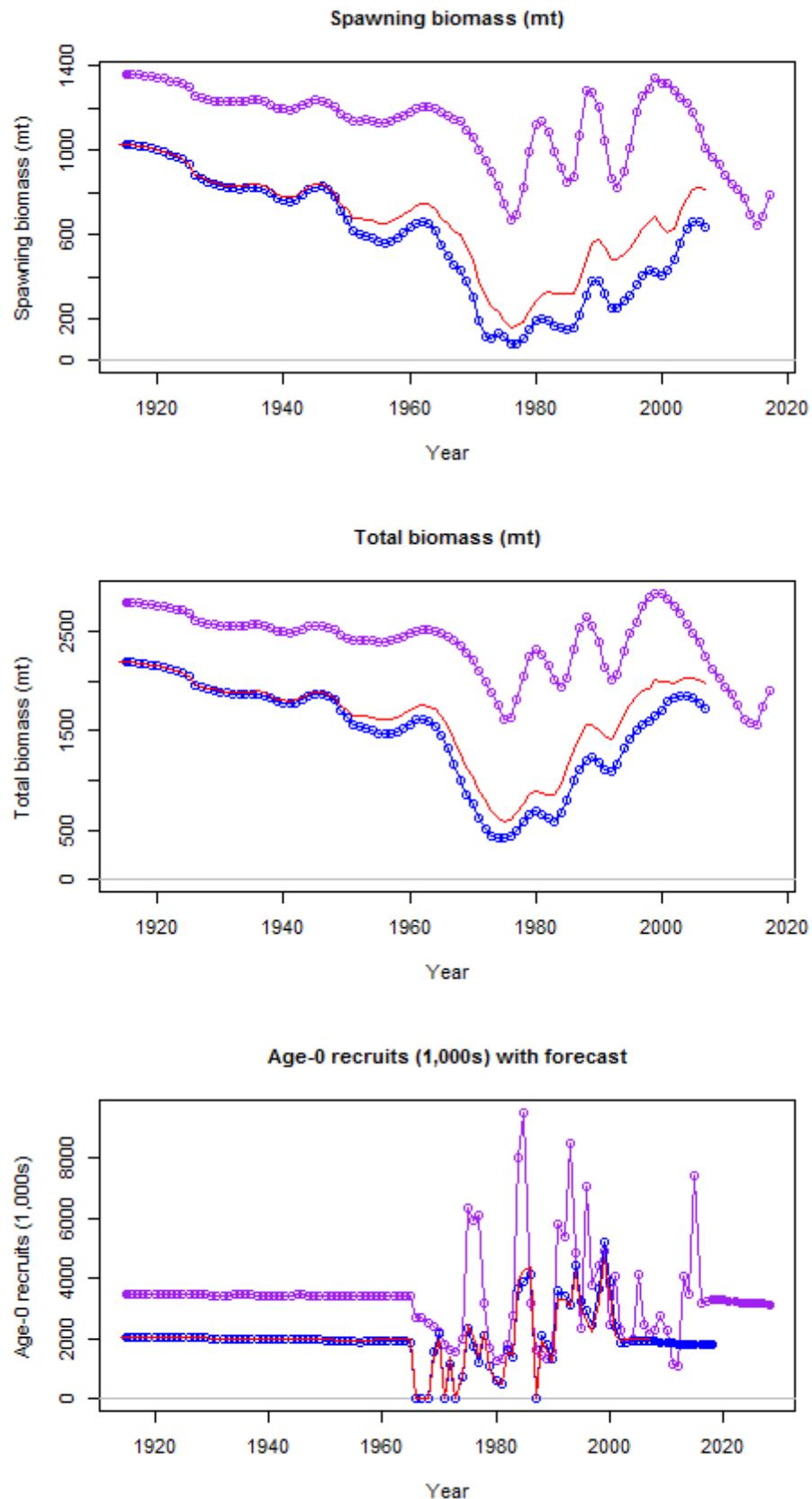


Figure 48: Comparison of spawning output, total biomass, and recruits from the 2005 model (solid red lines) using SS2, the 2005 model converted to SS3.24z (blue lines), and the base model from this assessment (purple lines). Note: The 2005 assessment was found to have an error, and therefore the time series for the model to SS3.24 will not match perfectly. fig:bridge_timeser

1772 References

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