

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)

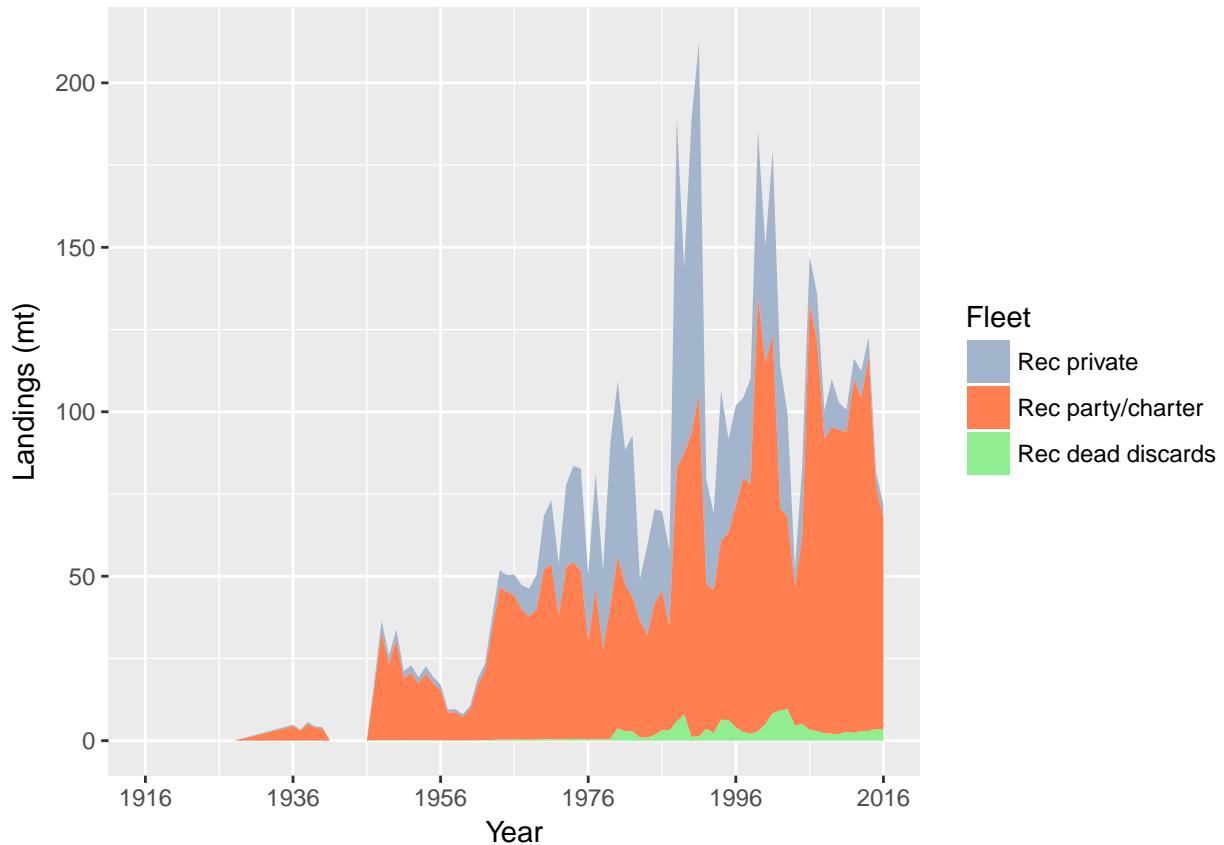


Figure a: California scorpionfish landings history for the recreational fleets. `fig:Exec_catch1`

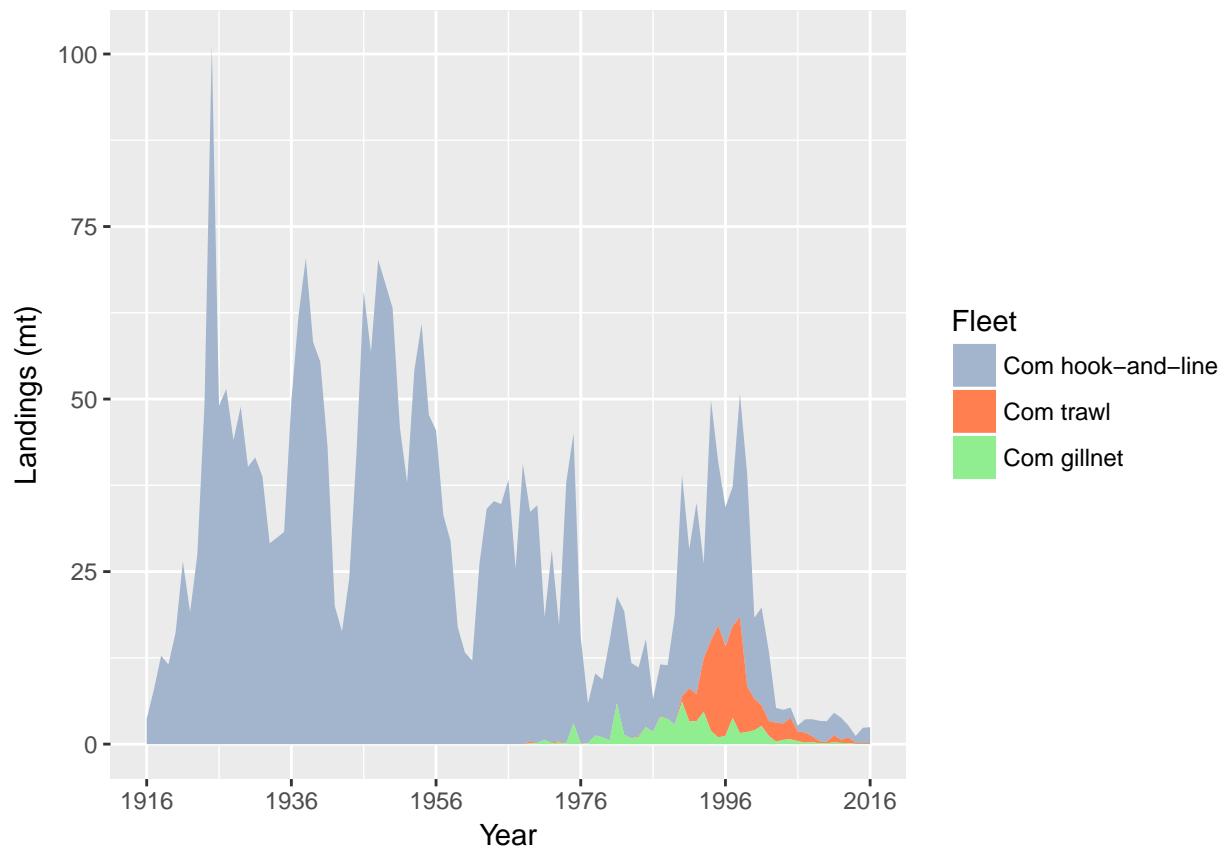


Figure b: Stacked line plot of California scorpionfish landings history for the commercial fleets. fig:Exec_catch2

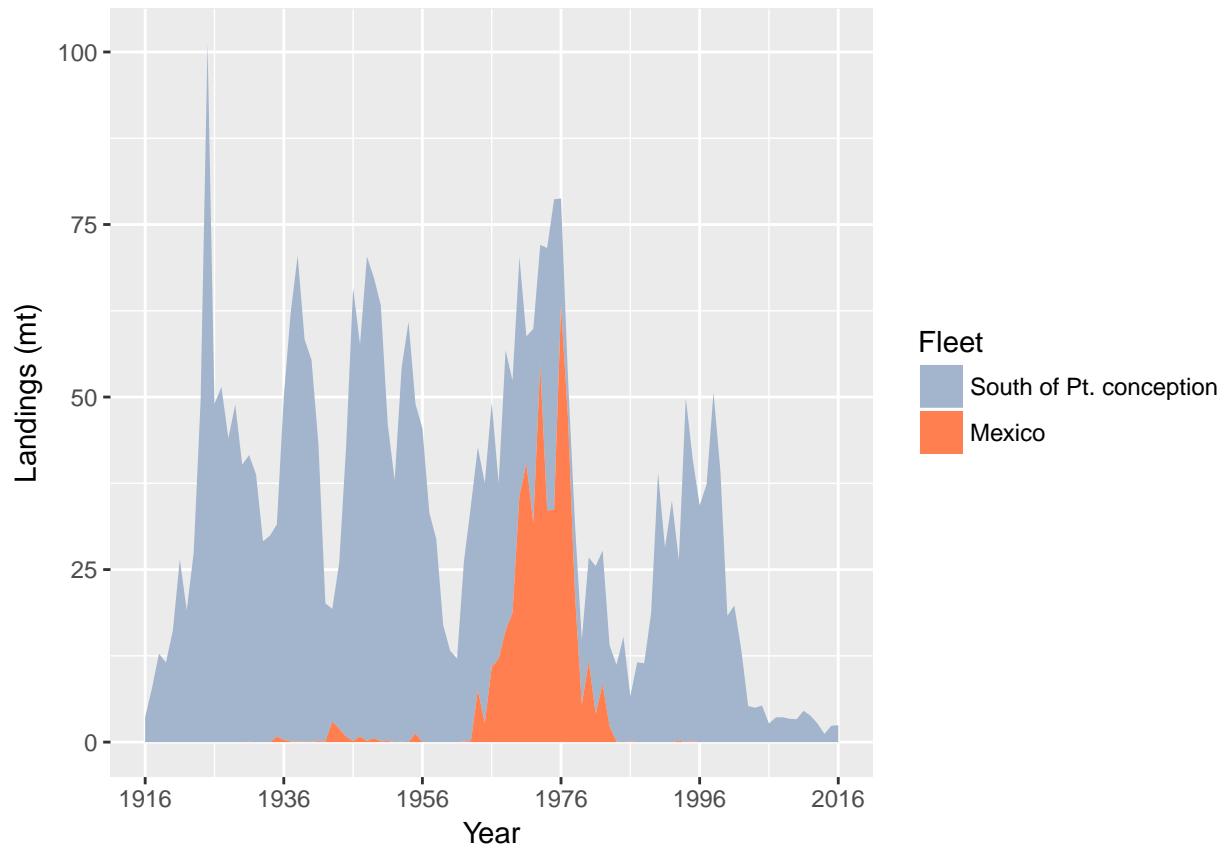


Figure c: Stacked line plot of California scorpionfish landings history by region, north of Pt. Conception, between Pt. Conception and the U.S.-Mexico border, and Mexican waters. [fig:Exec_catch3](#)

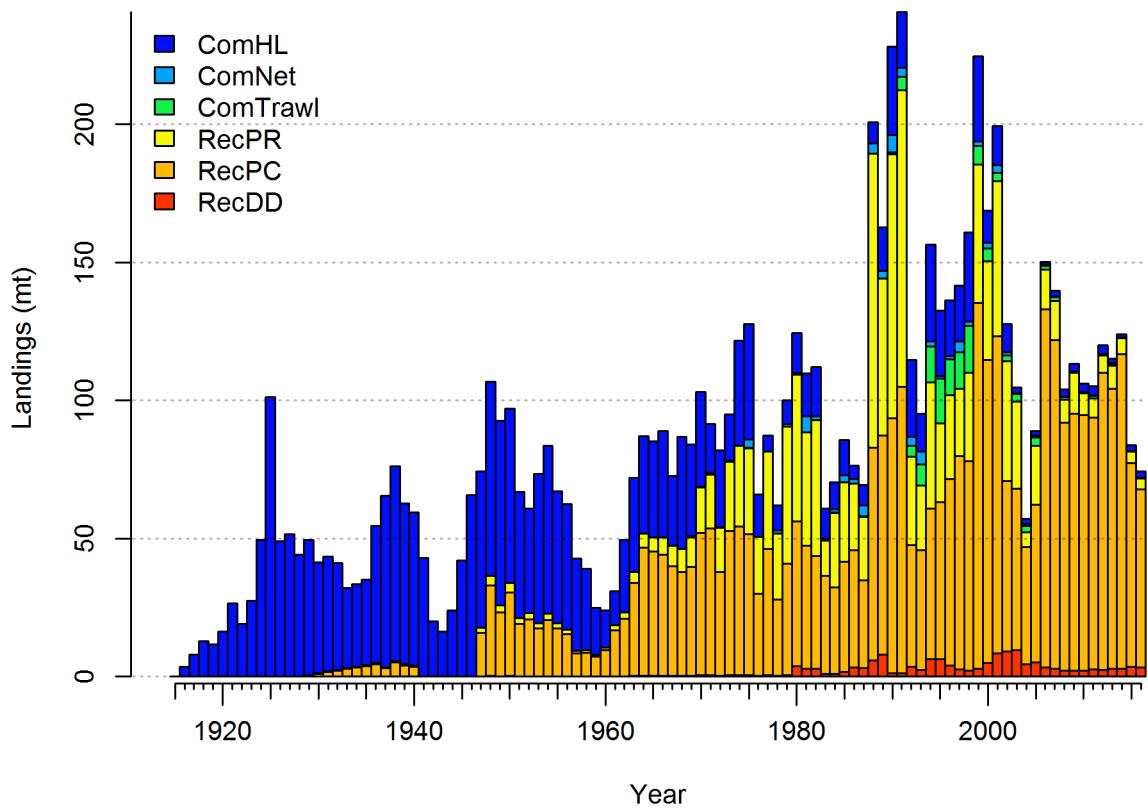


Figure d: Landings history of California scorpionfish in the base model. [fig:r4ss_catches](#)

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).

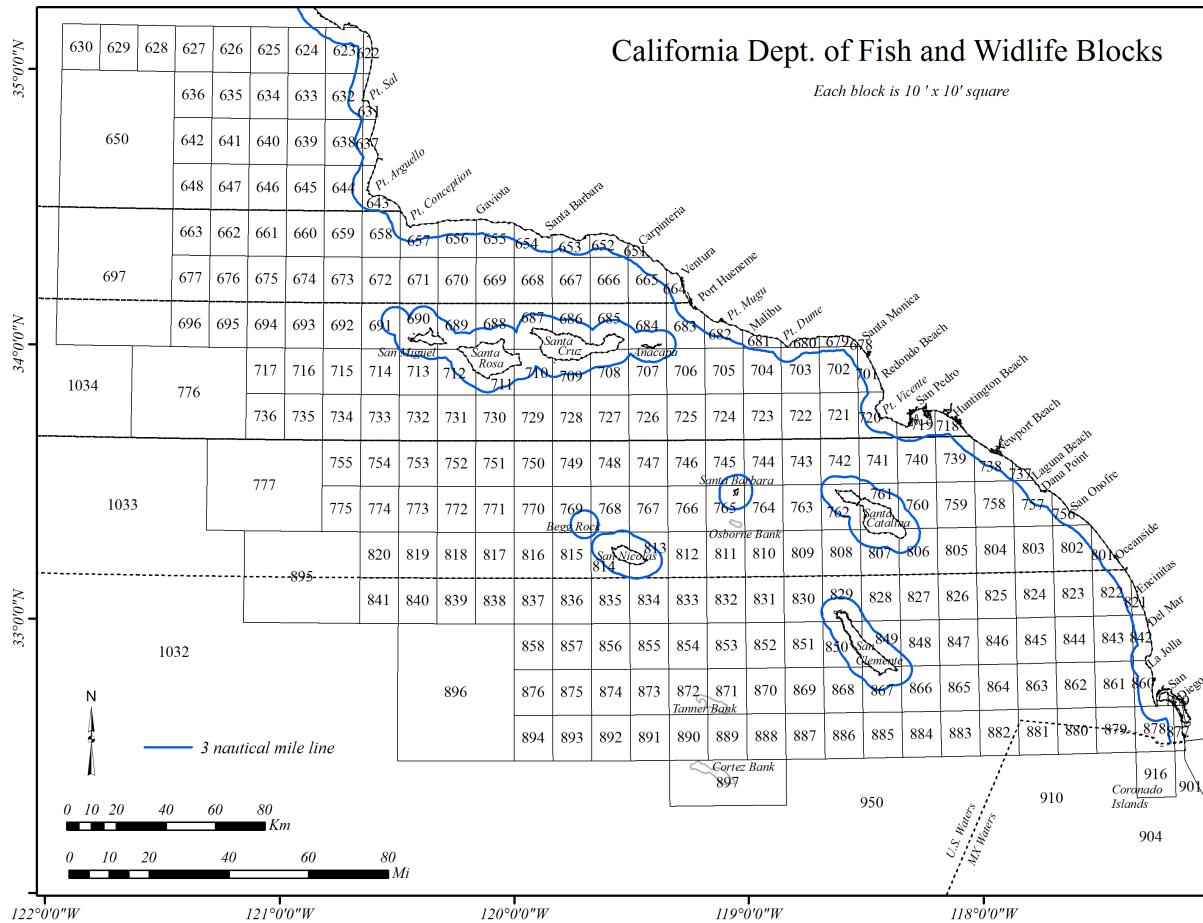


Figure e: Map depicting the boundaries for the base-case model. [fig:assess_region_map](#)

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 55.6% (~95% asymptotic interval: ± 40.5%-70.7%)
 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	649.288	(339.09-959.49)	0.731	(0.554-0.908)
2009	632.086	(332.7-931.47)	0.712	(0.542-0.881)
2010	599.904	(317.76-882.05)	0.676	(0.518-0.833)
2011	570.013	(305.72-834.31)	0.642	(0.498-0.786)
2012	546.582	(296.38-796.78)	0.616	(0.484-0.747)
2013	511.635	(276.25-747.02)	0.576	(0.454-0.698)
2014	467.039	(249.44-684.64)	0.526	(0.413-0.639)
2015	425.087	(219.81-630.37)	0.479	(0.367-0.59)
2016	431.582	(218.81-644.35)	0.486	(0.366-0.606)
2017	493.509	(242.88-744.14)	0.556	(0.405-0.707)

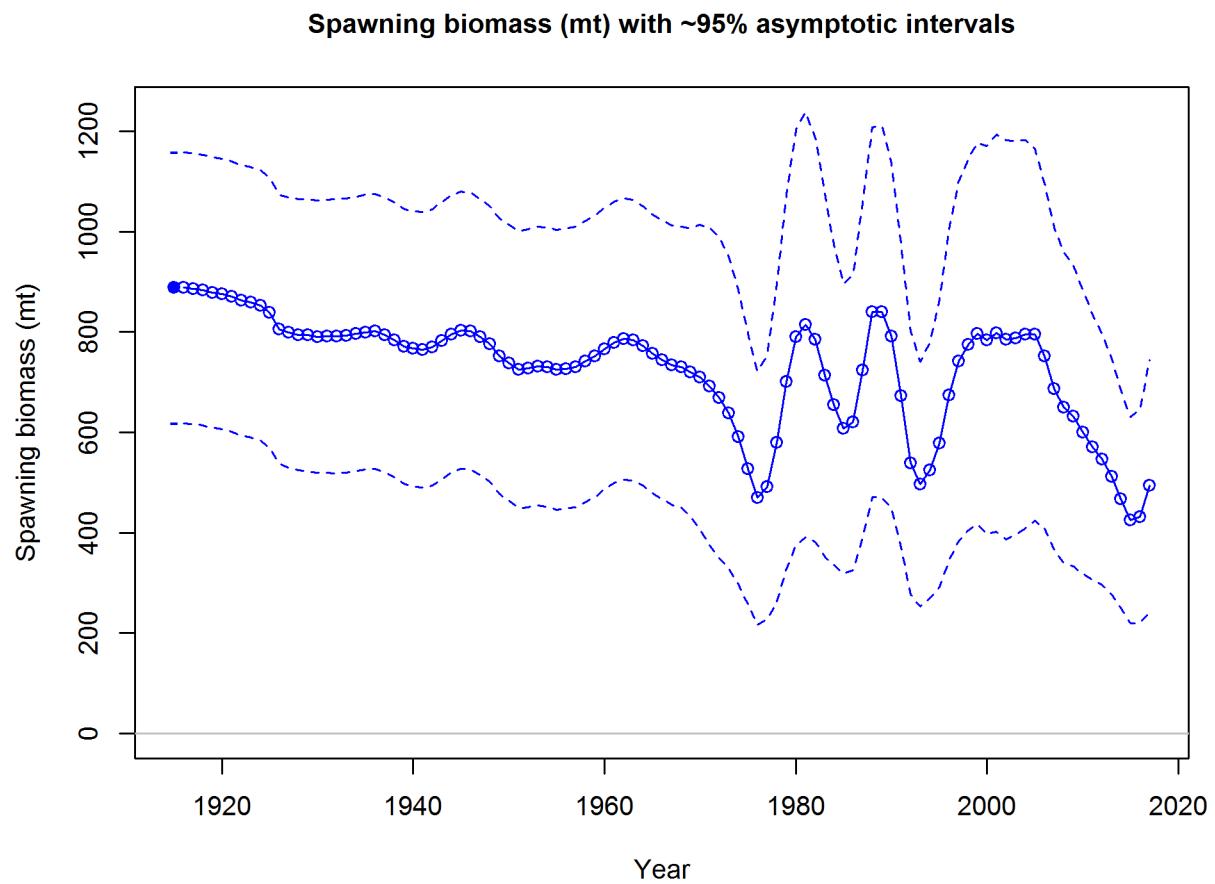


Figure f: Time series of spawning output trajectory (circles and line; median; light broken lines: 95% credibility intervals) for the base case assessment model. | [fig:Spawnbio_all](#)

Spawning depletion with ~95% asymptotic intervals

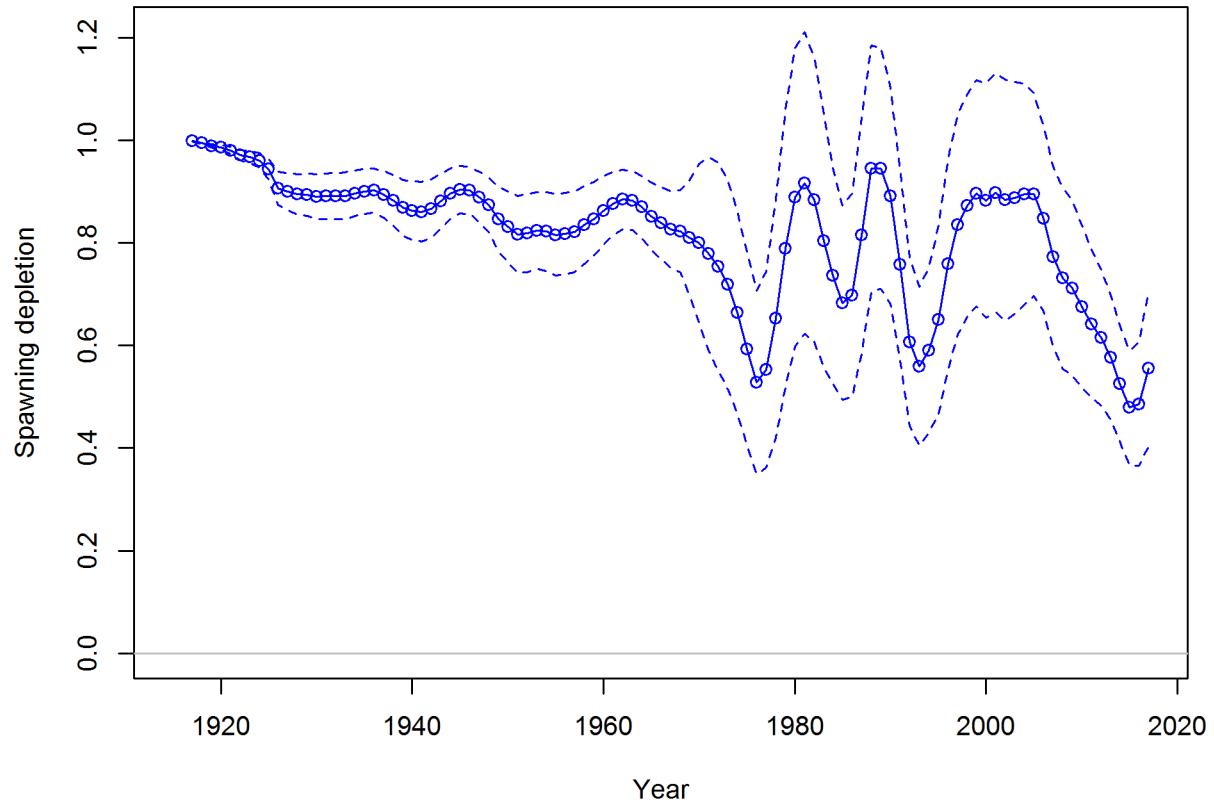


Figure g: Estimated relative depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model. [fig:RelDeplete_all](#)

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	2075.83	(890.89 - 4836.82)
2009	3042.65	(1409.75 - 6566.92)
2010	2050.82	(836.7 - 5026.71)
2011	1178.75	(455.92 - 3047.56)
2012	1296.70	(508.76 - 3304.96)
2013	3459.48	(1487.4 - 8046.27)
2014	3795.50	(1434.21 - 10044.44)
2015	7788.63	(2862.54 - 21191.93)
2016	2994.58	(886.82 - 10111.95)
2017	3064.95	(907.96 - 10346.18)

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

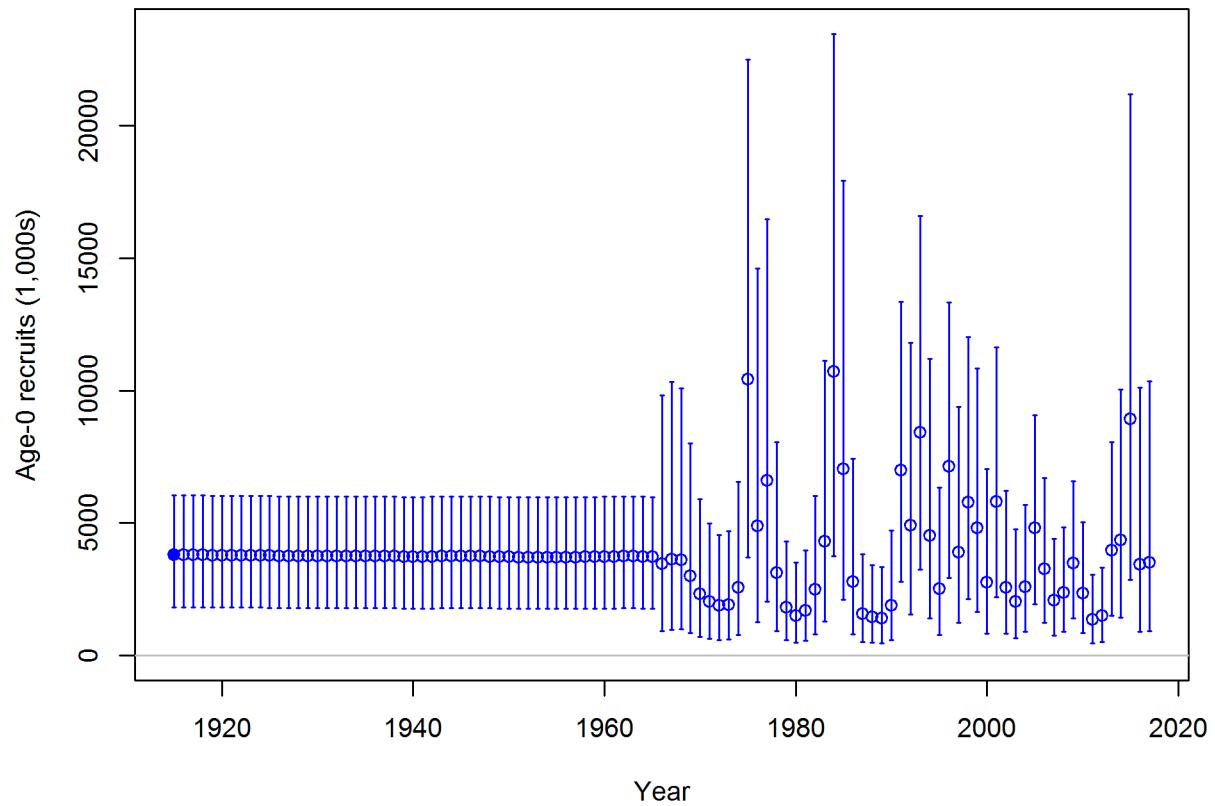


Figure h: Time series of estimated California scorpionfish recruitments for the base-case model with 95% confidence or credibility intervals. [fig:Recruits_all](#)

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	0.53	(0.29-0.78)	0.08	(0.04-0.11)
2008	0.46	(0.23-0.69)	0.06	(0.03-0.09)
2009	0.50	(0.26-0.75)	0.07	(0.04-0.1)
2010	0.49	(0.26-0.73)	0.07	(0.04-0.1)
2011	0.51	(0.27-0.75)	0.07	(0.04-0.1)
2012	0.57	(0.32-0.83)	0.08	(0.05-0.12)
2013	0.58	(0.32-0.84)	0.09	(0.05-0.13)
2014	0.64	(0.37-0.91)	0.10	(0.05-0.14)
2015	0.53	(0.28-0.78)	0.07	(0.03-0.1)
2016	0.50	(0.26-0.74)	0.05	(0.02-0.08)

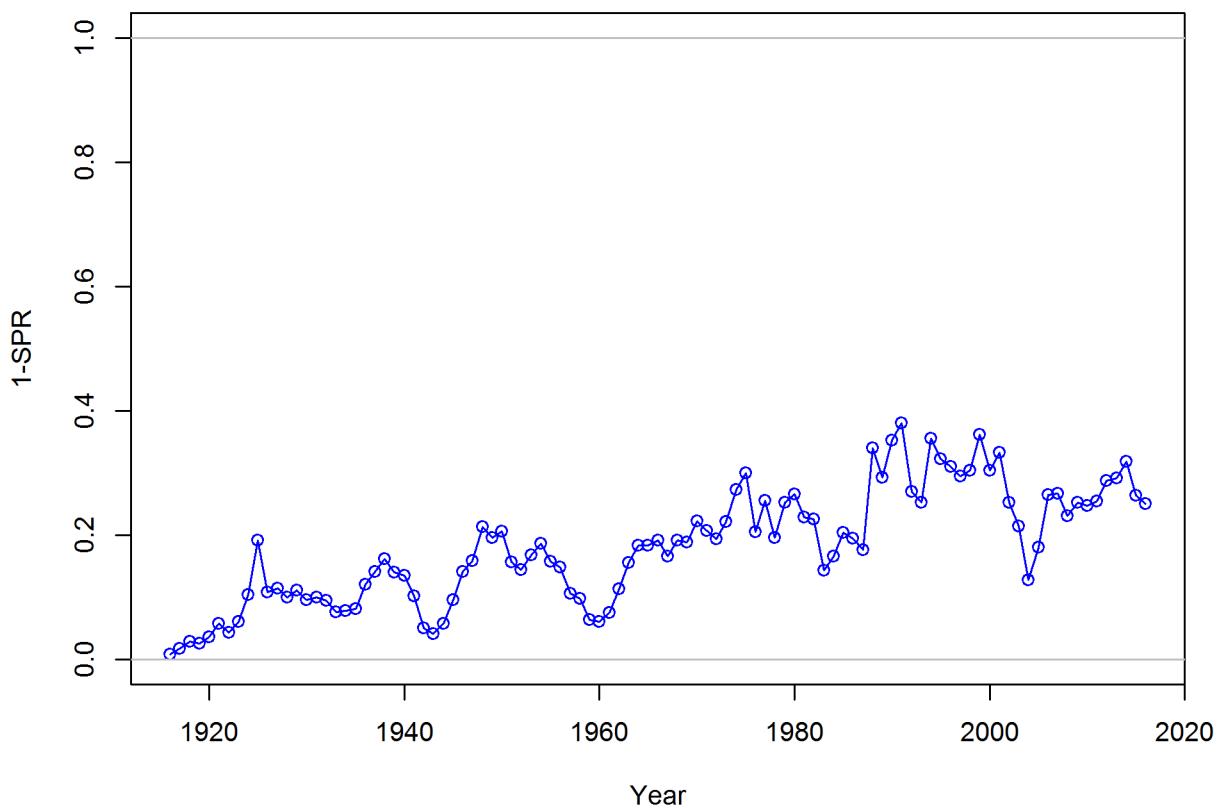


Figure i: Estimated spawning potential ratio (SPR) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the SPR_{50%} harvest rate. The last year in the time series is 2016. | [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 55.6% (~95%
115 asymptotic interval: ± 40.5%-70.7%, corresponding to an unfished spawning output of 493.509
116 mt (~95% asymptotic interval: 242.88-744.14 mt) of spawning output in the base model
117 (Table e). Unfished age 1+ biomass was estimated to be 2218.6 mt in the base case model.
118 The target spawning output based on the biomass target ($SB_{40\%}$) is 355.2 mt, which gives
119 a catch of 218.4 mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to
120 $SPR_{50\%}$ is 205.4 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)	888	(617.9-1158.1)
Unfished age 1+ biomass (mt)	2218.6	(1480.3-2956.8)
Unfished recruitment (R0, thousands)	3305.4	(1266.9-5343.9)
Spawning output(2016 mt)	431.6	(218.8-644.3)
Depletion (2016)	0.486	(0.3659-0.6062)
Reference points based on $SB_{40\%}$		
Proxy spawning output ($B_{40\%}$)	355.2	(247.1-463.3)
SPR resulting in $B_{40\%}$ ($SPR_{B40\%}$)	0.4589	(0.4589-0.4589)
Exploitation rate resulting in $B_{40\%}$	0.1933	(0.1602-0.2264)
Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt)	218.4	(116.2-320.6)
Reference points based on SPR proxy for MSY		
Spawning output	395.7	(275.3-516)
SPR_{proxy}	0.5	
Exploitation rate corresponding to SPR_{proxy}	0.1679	(0.1391-0.1968)
Yield with SPR_{proxy} at SB_{SPR} (mt)	205.4	(109.7-301.1)
Reference points based on estimated MSY values		
Spawning output at MSY (SB_{MSY})	207.2	(144.7-269.6)
SPR_{MSY}	0.3086	(0.2944-0.3228)
Exploitation rate at MSY	0.3238	(0.2645-0.3831)
MSY (mt)	245.5	(128.6-362.5)

₁₂₁ **Management Performance**

management-performance

₁₂₂ Management performance table: Table f

Table f: Recent trend in total catch and commercial landings (mt) relative to the management guidelines. Estimated total catch reflect the commercial landings plus the model estimated discarded biomass.

Year	OFL (mt; ABC prior to 2011)	ABC (mt)	ACL (mt; OY prior to 2011)	Estimated total catch (mt)
2007	-	-	-	-
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	-	-	-	-
2014	-	-	-	-
2015	-	-	-	-
2016	-	-	-	-
2017	-	-	-	-
2018	-	-	-	-

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}

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

tab:OFL_projection

Year	OFL
2017	252.19

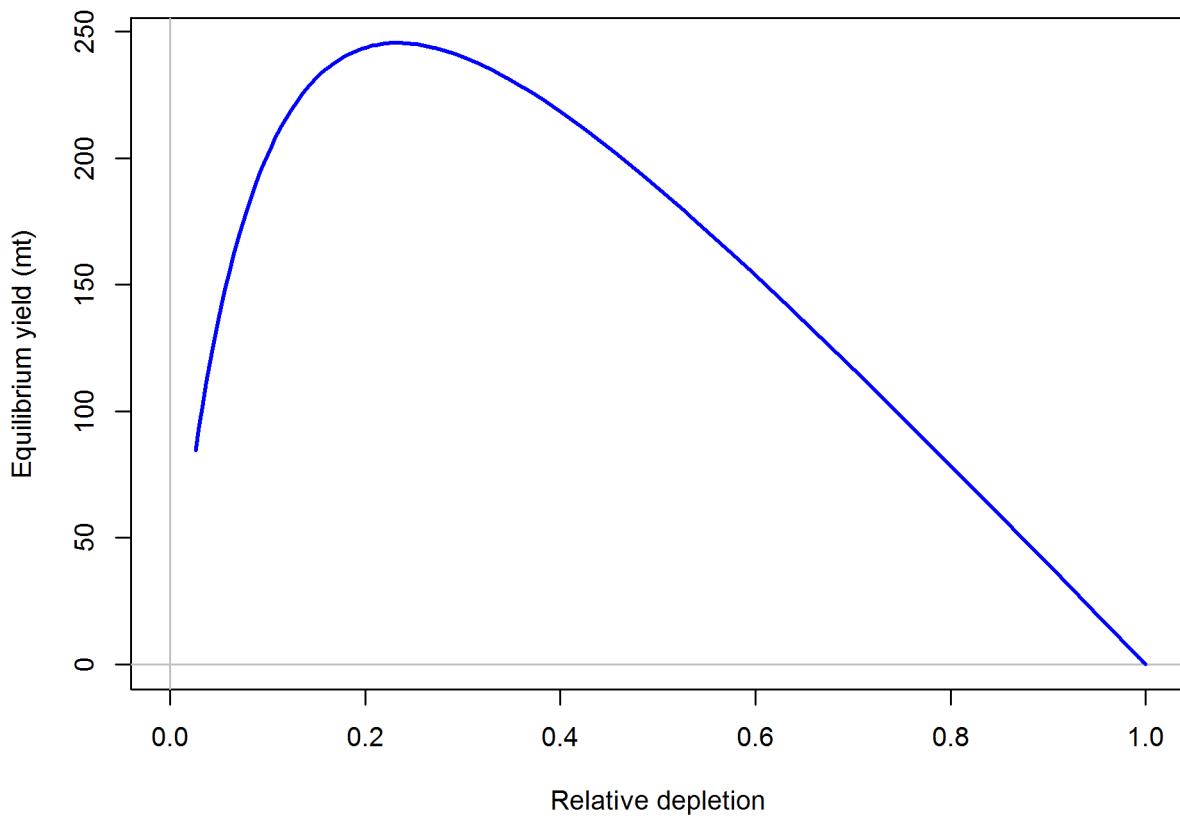


Figure j: Equilibrium yield curve for the base case model. Values are based on the 2016 fishery selectivity and with steepness fixed at... fig:Yield_all

Table 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
Landings (mt)											
Total Est. Catch (mt)											
OFL (mt)											
ACL (mt)											
(1-SPR)(1-SPR _{50%})	0.46	0.50	0.49	0.51	0.57	0.58	0.64	0.53	0.50		
Exploitation rate	0.06	0.07	0.07	0.07	0.08	0.09	0.10	0.07	0.05		
Age 1+ biomass (mt)	1839.96	1739.47	1660.78	1593.86	1527.58	1438.13	1321.18	1257.36	1245.66		
Spawning Output	649.3	632.1	599.9	570.0	546.6	511.6	467.0	425.1	431.6		
95% CI	(339.09-959.49)	(332.7-331.47)	(317.76-882.05)	(305.72-834.31)	(296.38-796.78)	(276.25-747.02)	(249.44-684.64)	(219.81-630.37)	(218.81-644.35)	(242.88-744.14)	
Depletion	0.7	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.6	
95% CI	(0.554-0.908)	(0.542-0.881)	(0.518-0.833)	(0.498-0.786)	(0.484-0.747)	(0.454-0.698)	(0.413-0.639)	(0.367-0.59)	(0.366-0.606)	(0.405-0.707)	
Recruits	2075.83	3042.65	2050.82	1178.75	1296.70	3459.48	3795.50	7788.63	2994.58	3064.95	
95% CI	(890.89 - 4836.82)	(1409.75 - 6566.92)	(836.7 - 5026.71)	(455.92 - 3047.56)	(508.76 - 3304.96)	(1487.4 - 8046.27)	(1434.21 - 10044.44)	(2862.54 - 21191.93)	(886.82 - 10111.95)	(907.96 - 10346.18)	

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 California scorpionfish is a medium-bodied fish and like other species in the genus *Scorpaena*,
₁₃₇ it produces a toxin in its dorsal, anal, and pectoral fin spines, which produces intense, painful
₁₃₈ wounds (Love et al. 1987). Scorpionfish are very resistant to hooking mortality and have
₁₃₉ shown survival under extreme conditions.
₁₄₀

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.

₁₄₇ Males and females show different growth rates, with females growing to a larger size than
₁₄₈ males, and the sexes exhibit different length-weight relationships (Love et al. 1987). Few
₁₄₉ California scorpionfish are mature at one year old (14 cm total length). Fifty-percent of fish
₁₅₀ mature at 17-18 cm (2 years old) and all by 22 cm (4 years old) (Love et al. 1987).

₁₅₁ California scorpionfish feed on a wide variety of mobile prey, including crabs, fishes (e.g.,
₁₅₂ include northern anchovy, spotted cusk-eel), octopi, isopods and shrimp, (Taylor 1963, Quast
₁₅₃ 1968, Turner et al. 1969, Love et al. 1987). The species is nocturnal, but have been observed
₁₅₄ feeding during the day. Predation on scorpionfish is believed to be low, but one individual
₁₅₅ was found in the gut of a leopard shark (Love pers comm.).

₁₅₆ **1.2 Early Life History**

early-life-history

₁₅₇ California scorpionfish utilize the “explosive breeding assemblage” reproductive mode in
₁₅₈ which fish migrate to, and aggregate at traditional spawning sites for brief periods (Love
₁₅₉ et al. 1987). California scorpionfish migrate to deeper waters (120-360 ft) to spawn during
₁₆₀ May-August, with peak spawning occurring July. The species is oviparous, producing floating,
₁₆₁ gelatinous egg masses in which the eggs are embedded in a single layer (Orton 1955). and
₁₆₂ it is believed that spawning takes place just before, and perhaps after dawn, in the water
₁₆₃ column (Love et al. 1987). Tagging data suggest California scorpionfish return to the same
₁₆₄ spawning site, but information is not available on non-spawning season site fidelity.

₁₆₅ Little is known about California scorpionfish larvae. The CalCOFI survey observed 463
₁₆₆ California scorpionfish larvae from 1977-2000, with the majority at station close to Oxnard

¹⁶⁷ (east of the Channel Islands) (Moser et al. 2002). Higher densities of larvae have been
¹⁶⁸ observed in the CalCOFI stations throughout Baja, peaking south of Punta Eugenia from
¹⁶⁹ July to September. The hatching length is reported as 1.9-2.0 mm (Washington et al. 1984)
¹⁷⁰ and transformation length of greater than 1.3 cm (Washington et al. 1984) less than 2.1 cm
¹⁷¹ (Moser 1996).

¹⁷² 1.3 Map

map

¹⁷³ A map showing the scope of the assessment and depicting boundaries for fisheries or data
¹⁷⁴ collection strata is provided in Figure 1.

¹⁷⁵ 1.4 Ecosystem Considerations

ecosystem-considerations-1

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

¹⁷⁹ 1.5 Fishery Information

fishery-information

¹⁸⁰ The hook-and-line fishery fishery off California developed in the late 19th century (Love et al.
¹⁸¹ 2002).
¹⁸² The rockfish trawl fishery was established in the early 1940s, when the United States became
¹⁸³ involved in World War II and wartime shortage of red meat created an increased demand for
¹⁸⁴ other sources of protein (Harry and Morgan 1961, Alverson et al. 1964).

¹⁸⁵ California scorpionfish comprise a minor part of the Californian sport and commercial fisheries
¹⁸⁶ (Love et al. 1987). Historically, California scorpionfish were taken commercially by hook and
¹⁸⁷ line and, occasionally, by round haul nets (Daugherty 1949). Scorpionfish were commonly
¹⁸⁸ caught around Santa Catalina Island during the late 19th Century with gillnets (Jordan
¹⁸⁹ 1887). The 1937 Bureau of Commercial Fisheries report noted that California scorpionfish
¹⁹⁰ had been a fairly important commercial species for a long time. The species was targeted by
¹⁹¹ a few fishermen during the summer months, and was also taken as a bycatch in the rockfish
¹⁹² fisheries. By 1949, Bureau of Marine Fisheries reported
¹⁹³ “[Scorpionfish] will even come to the surface to lights at night” and were also taken in round
¹⁹⁴ haul nets. At that time, scorpionfish were rarely targeted by fishermen except by a few
¹⁹⁵ specialists.

¹⁹⁶ More recently, commercial bottom longlines have been used to target spawning aggregations
¹⁹⁷ offshore of Long Beach (Love et al. 1987). Since the early 1990s, trawl catch has been

198 a substantial component of the commercial catch. Commercial landings have fluctuated
199 substantially over time, which could, in part, be due to changes in targeting and El Nio
200 events (Love et al. 1987). A high proportion of the catch landed in California during the
201 1960s and 1970s was taken from Mexican waters. In recent years, most of the catch has come
202 from around the Los Angeles region. In general, the majority of the commercial catch has
203 come from the Los Angeles region, except in the 1960s and 1970s when the majority of the
204 catch came from the San Diego region and Mexican waters.

205 They are most often taken by boat fishermen, but fairly large numbers are caught from
206 piers, jettys, and rocky shorelines. The CPFV effort has remained relatively constant over
207 a long period (1959-1998) (Dotson and Charter 2003). However, there appears to be a
208 shift in effort towards less utilized species, such as California scorpionfish, over the past
209 decade (Dotson and Charter 2003). Especially as catch limits for rockfish have become
210 more restricted commercial passenger fishing vessels (CPFV) operators target California
211 scorpionfish spawning aggregations during spring and summer (Love et al. 1987), and also
212 target California scorpionfish in the winter when other fisheries are closed.

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

218 Aggregate mortality has been far below the Annual Catch Limits (ACL) established by the
219 2005 stock assessment. The ACL projections from the 2005 assessment assumed that the
220 entire ACL was being taken each year and as a result, the ACL for each subsequent year
221 declined despite under-attainment in reality.

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

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

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

235 1.6 Summary of Management History

summary-of-management-history

236 Prior to the adoption of the Pacific Coast Groundfish Fishery Management Plan (FMP) in
237 1982, California scorpionfish (*Scorpaena guttata*) was managed through a regulatory process
238 that included the California Department of Fish and Wildlife (CDFW) along with either
239 the California State Legislature or the Fish and Game Commission (FGC) depending on
240 the sector (recreation or commercial) and fishery. With implementation of the Pacific Coast
241 Groundfish FMP, California scorpionfish came under the management authority of the Pacific
242 Fishery Management Council (PFMC), being incorporated, along with all genera and species
243 of the family Scorpaenidae, into a federal rockfish classification and managed as part of
244 “Remaining Rockfish” under the larger heading of “Other Rockfish” (PFMC (2002, 2004),
245 Tables 31-39).

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

260 Beginning in 1997, California scorpionfish was managed as part of the *Sebastodes* complex-
261 south, Other Rockfish category. (*Sebastodes* complex-south included the Eureka, Monterey,
262 and Conception areas while *Sebastodes* complex-north included the Vancouver and Columbia
263 areas.) The PFMC’s rockfish management structure changed significantly in 2000 with the
264 replacement of the *Sebastodes* complex -north and -south areas with Minor Rockfish North
265 (now covering the Vancouver, Columbia, and Eureka areas) and Minor Rockfish South (now
266 Monterey and Conception areas only). The OY for these two groups (which continued to be
267 calculated as 0.50 of the ABC) was further divided (between north and south of 40°10' N.
268 latitude) into nearshore, shelf, and slope rockfish categories with allocations set for Limited
269 Entry and Open Access fisheries within each of these three categories (January 4, 2000, 65
270 FR 221; PFMC (2002), Tables 54-55). Because of its depth range and southern distribution,
271 California scorpionfish was included within the Minor Rockfish South, Other Rockfish ABC
272 and managed under the south of 40°10' N. latitude nearshore rockfish OY and trip limits
273 (PFMC (2002), Table 29).

274 Along with the above changes, in 2000 the southern area divided into two separate management
275 areas at Point Lopez, 36°00' N. latitude. This was followed in 2001 with the implementation

276 of the northern rockfish and lingcod management area between (40°10' N. latitude) and Point
277 Conception (34°27' N. latitude); and the southern rockfish and lingcod management area
278 between Point Conception and the U.S.- Mexico border. These were later revised starting
279 in 2004 with the northern rockfish and lingcod management area redefined as ocean waters
280 from the Oregon-California border (42°00' N. latitude) to 40°10' N. latitude, the central
281 rockfish and lingcod management area defined as ocean waters from 40°10' N. latitude to
282 Point Conception, and the southern rockfish and management area continuing to be defined
283 as ocean waters from Point Conception to the U.S.-Mexico border.

284 Cowcod Conservation Areas (CCAs) also were established in 2001 to reduce fishing effort for
285 cowcod rockfish (PFMC (2002), Table 29). These areas were closed to all recreational and
286 commercial fishing for groundfish except for minor nearshore rockfish1 (including California
287 scorpionfish) within waters less than 20 fathoms. In addition, Rockfish Conservation Areas
288 (RCAs) were established in 2003 to allow for the closure of specific area and depth ranges
289 along the West Coast for the purpose of reducing fishing effort for shelf and slope rockfish.
290 The California Rockfish Conservation Area (CRCA) was defined as those ocean waters south
291 40°10' N. latitude to the U.S.-Mexico border with different depth zones specified for the areas
292 north and south of Pt. Reyes (37°59.73' N. latitude).

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

302 Following adoption of the Nearshore FMP and accompanying regulations by the FGC in fall
303 of 2002, the FGC adopted regulations in November 2002 which established a set of marine
304 reserves around the Channel Islands in Southern California (which became effective April
305 2003) and adopted a nearshore restricted access program in December 2002 (which included
306 the establishment of a Deeper Nearshore Permit) to be effective starting in the 2003 fishing
307 year.

308 Although the Nearshore FMP provided for the management of the nearshore rockfish and
309 California scorpionfish, management authority for these species continued to reside with
310 the Council. Even so, for the 2003 and subsequent fishery seasons, the State provided
311 recommendations to the Council specific to the nearshore species that followed the directives
312 set out in the Nearshore FMP. These recommendations, which the Council incorporated into
313 the 2003 management specifications, included a recalculated OY for Minor Rockfish South
314 - Nearshore, division of the Minor Rockfish South - Nearshore into three groups (shallow
315 nearshore rockfish; deeper nearshore rockfish; and California scorpionfish), and specific harvest
316 targets and recreational and commercial allocations for each of these groups.

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

325 1.7 Management Performance

management-performance-1

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

329 1.8 Fisheries off Mexico

fisheries-off-mexico

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

333 2 Assessment

assessment

334 2.1 Data

data

335 Data used in the California scorpionfish assessment are summarized in Figure [2](#).
336 A description of each data source is below.

337 2.1.1 Commercial Fishery Landings

commercial-fishery-landings

338 Commercial catches of California scorpionfish (often landed as “sculpin”) are available back
339 to 1916. Landings from 1916 to 1935 are presented in CDFG Fish Bulletin No. 49 and
340 Bulletin No. 149 provides tabulated data from 1916 to 1968. Over 99% of the commercial
341 catches of California scorpionfish are from south of Pt. Conception.
342 Whenever possible, catches from north of Pt. Conception and also caught in Mexico but
343 landed in the U.S. were excluded from the commercial catch histories.

³⁴⁴ California Explores the Ocean(CEO) provides landings data taken from the CDFG Fish
³⁴⁵ Bulletins in electronic form, as well as electronic copies of all CDFG Fish Bulletins.

³⁴⁶ Statewide annual landings are available for California scorpionfish from 1916 to 1925, and
³⁴⁷ are assumed to be taken by hook-and-line. Data by area and month are given in a series of
³⁴⁸ bulletins, each bulletin usually providing information for a single year. Data by region and
³⁴⁹ month is available for 1926 to 1986. The Santa Barbara region includes San Luis Obispo,
³⁵⁰ Santa Barbara and Ventura counties. Catches from this region were included in the catch
³⁵¹ history and comprised less than 10 mt for the period from 1926-1968 (the period when data
³⁵² at the regional scale are available).

³⁵³ Catches from Mexico can be separated from the total catch starting in 1931, although the
³⁵⁴ CDFG Bulletins do not report catches originating from Mexican waters available for all years,
³⁵⁵ e.g., 1932-1934. It is assumed that before 1931 there was no catch taken from Mexican waters
³⁵⁶ landed in California.

³⁵⁷ The CALCOM database was queried (March 7, 2017) for commercial landing estimates of
³⁵⁸ California scorpionfish in California, 1969-2016. Landings were stratified by year, quarter,
³⁵⁹ live/dead, market category, gear group, port complex, and source of species composition
³⁶⁰ data (actual port samples, borrowed samples, or assumed nominal market category). All
³⁶¹ CALCOM California scorpionfish landing data are either actual port samples or the nominal
³⁶² California scorpionfish market category. However, catches in CALCOM do not separate out
³⁶³ catches originating from Mexican waters and landed at U.S. ports.

³⁶⁴ The Commercial Fisheries Information System (CFIS; maintained by CDFW) contains
³⁶⁵ California catch in pounds by gear and port for 1969 to 2016 (Figures). The CFIS data come
³⁶⁶ from landing receipts or “fish tickets” filled out by the markets or fish buyers as required by
³⁶⁷ the state for all commercial landings. The fish tickets include the CDFW block in which the
³⁶⁸ majority of the landings were caught.

³⁶⁹ Landings with a block solely in Mexican waters (blocks >900) were removed from the catch
³⁷⁰ history. Landings with reported blocks 877-882 with area in both U.S. and Mexican waters
³⁷¹ were retained in the catch histories. The commercial catch is dominated by the hook-and-line
³⁷² fishery (89% of total catches).

³⁷³ The catch by reported gear types: hook-and-line, fish pot, trawl, gill net, and other can be
³⁷⁴ found in Table 1. Catch taken by fish pot and other gears is added to the hook-and-line
³⁷⁵ catch in the stock assessment (30.6 mt from fish pot and 93.9 mt from other gears).

³⁷⁶ In the assessment, catch for 1916 to 1968 is taken from the CDFG Fish Bulletins. Catch by
³⁷⁷ gear for 1969 to 2004 is taken from CFIS.

³⁷⁸ 2.1.2 Commercial Discards

commercial-discards

³⁷⁹ Information on commercial discards from the West Coast Groundfish Observer Program
³⁸⁰ (WCGOP) are available starting in 2004. The commercial fishery for California scorpionfish

381 has been minimal since the early 2003 (averaging 3.5 mt per year). The available length
382 composition data from the observed discards is minimal, with 151 fish measured from 2004-
383 2015, and less than half a metric ton. Given the discard mortality of only 7%, and the small
384 total catches in the recent years, discards from the commercial fleet are not considered in the
385 assessment.

386 2.1.3 Sport Fishery Removals and Discards

sport-fishery-removals-and-discards

387 Data used in reconstructing the retained catch and discarded mortality for California scorpionfish
388 in the California recreational fishery are from the Commercial Passenger Fishing
389 Vessel (CPFV) Logbooks (1932-2017), the Marine Recreational Fishery Statistical Survey
390 (MRFSS, 1980-2003) and the California Recreational Fishery Survey (CRFS, 2004-2017).

391 Total catch was accounted for including retained catch as well as the estimate of fish dis-
392 carded dead assuming a 7% discard mortality rate approved for use in management in the
393 regulatory specifications for 2009-2010 (Pacific Fishery Management Council [2008](#)). The
394 MRFSS and CRFS data provide estimates of mortality for four fishing “modes” including
395 the Party/Charter Boat, Private/Rental Boat, Man Made (piers and jetties etc.) and Beach
396 and Bank modes.

397 While estimates of mortality from the Party/Charter (PC) boat mode is available from the
398 MRFSS and CRFS surveys for the Party/Charter Boat mode for 1980-2017, estimates from
399 the CRFS data from 2011-2017 and data from CPFV Logbook for 1932-2010 were used to
400 represent catch from this mode. The Party/Charter Phone Survey was used to estimate
401 effort used in producing effort estimates for CRFS between 2004 and 2010, which was subject
402 to negative bias due to the low of participation in the survey south of Point Conception.
403 The Coastal County Household Telephone Survey was used to estimate fishing effort for
404 the MRFSS survey from 1980-2003 and were subject to potential positive avidity bias in
405 participation by those contacted by the survey. As a result, the CPFV logbooks were used
406 to provide the reported number of retained and discarded California scorpionfish used to
407 estimate mortality from 1932-2010.

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

412 An underreporting adjustment reflecting an average 20% of logs not being submitted was
413 applied to all estimates for the PC mode from 1932-2010. Annual average weights from this
414 mode for retained catch from the MRFSS or CRFS estimates for 1980-2010 and average
415 weight from 1980-1984 was applied to the preceding years. To estimate discard mortality
416 for the PC mode, the annual average weight determined from lengths collected sampling
417 onboard CPFVs by the CRFS survey for 2004-2010 were applied to the number of discards
418 from the CPFV logbooks and the average weight over this entire period were applied to the
419 preceding years for 1995-2003. For the period between 1980 and 1994, the MRFSS estimates

420 for discards were used to reflect discarding due to the paucity of data on the number of
421 discards from PC logbooks prior to 1995.

422 For all other modes, the MRFSS (1980-2003) and CRFS (2004-2017) based estimates of
423 retained catch and discard mortality were used. There was a lapse in MRFSS sampling
424 from 1990 through 1992, which for which retained catch and discard mortality was estimated
425 using the average of values three years before and three years after the lapse for all modes
426 other than the PC mode. For the PC mode, estimates of numbers of fish were available
427 from logbook data and average weight from the three years before and after this period were
428 applied to provide estimates for the PC mode.

429 Estimates of retained catch and discards were not available from the non-PC modes prior
430 to 1980, thus the ratio of catch in the PC mode to the other modes for 1980 through 1985
431 was used to provide an estimate of catch in the other modes in the years 1932-1979. In the
432 case of the PR mode, a linear ramp in the ratio adjustment between PC and PR modes was
433 applied between 1979 and 1966 from 0.55 in 1980 to 0.10 in 1965, reflecting the increase in
434 the relative proportion of catch contributed by the PR mode with time as more individuals
435 anglers purchased vessels, as recommended in the California Catch Reconstruction (Ralston
436 et al. 2010), and the ratio of 0.10 was assumed for all years prior. The ratio of PC estimates
437 to the MM and BB modes was assumed to constant and the average between 1980 and 1989
438 was applied from 1979 to 1932. Catch estimates from CPFV logbooks were not available
439 during the World War II era from 1941 until 1946 and catch was assumed to be zero for all
440 modes during this period. Estimates for retained catch and discarded mortality for 1935 to
441 1928 were estimated using a linear ramp from the value for 1936 to zero in 1928 for the PC
442 mode and ratios PC compared to other modes were used to proxy estimates for other modes
443 based on the resulting ramped values for the PC mode. The final time series of retained and
444 discarded landings is in Table 2.

445 2.1.4 Fishery-dependent Abundance Indices

fishery-dependent-abundance-indices

446 MRFSS Dockside Private Boat Index

447 The CDFW provided the CRFS private boat dockside sampling fisheries data from 2004
448 to 2016. The data went through several data quality checks to identify the best subset of
449 available data that are consistent over the time series and provide a representative relative
450 index of abundance once standardized. The dockside sampling of the private mode (PR mode
451 in RecFIN) consists of samples from a primary series of ports (PR1) where the majority
452 of fishing effort for this mode originates and a secondary series of ports with historically
453 low effort (PR2). Only PR1 samples were used for this index as the sampling forms for
454 the PR2 index have changed over time and the data could not reliably be collapsed to the
455 trip level. The dockside data consist of two types of data; Type 2 data contain records of
456 angler-reported catch, i.e., catch that was not observed by the sampler and Type 3 data
457 includes sampler-examined retained catch. Of the Type 2 reported catch for scorpionfish, less

458 than one percent were reported “thrown back dead” and five percent reported as retained
459 to eat. Given that the reported retained catch is a small fraction of the catch overall and
460 discard mortality of California scorpionfish is low, only the Type 3 examined catch are used
461 in the index.

462 The survey records the number of contributing anglers (number of anglers on the vessel for
463 the private mode), but does not contain data on hours fished. For this index, angler-day
464 was the assumed effort. The data were filtered to trips fishing with hook-and-line gear in
465 southern California. Trips with a primary fishing area of Mexico were also removed. The
466 CRFS dockside private boat records with these broad filters include 44,128 trips of which
467 3,802 caught California scorpionfish (8.6%).

468 The Stephens-MacCall approach was used to identify trips with a high probability of catching
469 California scorpionfish (Stephens and MacCall 2004). Prior to using the Stephens-MacCall
470 approach to select relevant trips a number of other filters were applied to the data to minimize
471 variability in CPUE estimates. Over the course of the time series only 45 trips from Santa
472 Barbara county encountered California scorpionfish, ranging from 0-10 trips a year. The
473 Stephens-MacCall approach was applied with and without trips from Santa Barbara and the
474 same species were identified as indicators and counter-indicators. For the final model prior to
475 Stephens-MacCall, trips from Santa Barbara were excluded, leaving 41,235 trips, and 3,747
476 of those caught California scorpionfish (Table 3).

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

485 A total of 6,673 trips were retained following the Stephens-MacCall filter, with all positive
486 California scorpionfish trips retained. The California scorpionfish recreational fishery in the
487 southern management area was closed for eight months in 2004 and nine months in 2005. The
488 majority of records from 2004 and 2005 are from the period when the fishery was closed and
489 were removed from the analysis (Figure 3). Records from months with the fishery was closed
490 from 2006-2016 were also excluded from the index since this index relies on sampler-examined
491 retained catch.

492 Catch per unite effort was modeled using a delta-GLM approach, where the catch occurrence
493 (binomial) component was modeled using a logit link function and the positive catch compo-
494 nent was modeled after log-transformation of the response variable, according to a normal
495 distribution with an identity link function. The units for CPUE are fish landed/anglers. A
496 gamma distribution for the positive catch component was also explored, but model selection
497 favored the lognormal model.

498 Model selection procedures selected the covariates *2-month wave* and *county* as important
499 for both the catch occurrence and positive catch component models for all data sets, along
500 with the categorical year factor used for the index of abundance (Table 4). The final index
501 indicates a decrease in relative abundance from 2006 to 2010, at which point the index is
502 relatively flat (Figure 5).

503 CRFS Dockside Party/Charter Boat Index

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

514 The number of anglers on board the vessel and the hours fished are included in the database
515 for all years. Only retained fish are included in the index of abundance the the unit of effort
516 is angler hours. A number of data filters were applied to the data to account for possible
517 mis-reporting, e.g., trips reporting retained California scorpionfish in top 1% of the data
518 (>325 fish). Trips fishing outside of California scorpionfish habitat (reported as targeting
519 pelagic species) or trips reporting a block with a minimum depth deeper than 140 m were
520 also filtered out.

521 Because California scorpionfish is not a primary target species, boats with fewer than 10
522 trips retaining California scorpionfish were removed from the analysis. Data were also
523 filtered to only include catches reported from blocks South of Pt. Conception and north of
524 the U.S.-Mexico border (Figure 1, and blocks with at least 100 trips retaining California
525 scorpionfish and a total of 500 trips. A full description of the data filters is in Table 6. A
526 total of 432,868 trips were retained for the index of abundance, 202,937 of which caught
527 California scorpionfish.

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

533 California scorpionfish were present in 47% of all trips, which warrants the use of a negative
534 binomial model. Factors considered were *year*, *month*, and *area* (either block or region). A
535 model with blocks and was selected over a model with region by 39,180 AIC. The final model
536 includes *year*, *month*, and *block* with a log link and effort as an offset (Table 7).

537 The standardized index shows a cyclic pattern, with period of higher CPUE (late 1980's to

538 early 1990's and late 1990s) and has shown a general downward trend since 2008 (Figure 9).
539 An interesting note is the similarity in standardized CPUE between the CPFV logbook index
540 and the CPFV dockside index (not used in the stock assessment model) from 1992-1997 (for
541 a Stephens-MacCall threshold of 0.1) (Figure 8).

542 **Party/Charter Boat Logbook Index**

543 **Onboard Observer Party/Charter Boat Index**

544 California implemented a statewide Onboard Observer Sampling Program in 1999, and began
545 measuring discarded fish in 2003 (Monk et al. 2014). The goal of the Onboard Observer
546 Sampling Program is to collect data including charter boat fishing locations, catch and
547 discard of observed fish by species, and lengths of discarded fish. The program samples the
548 commercial passenger fishing vessel (CPFV), i.e., charter boat or for-hire fleet and collects
549 drift-specific information at each fishing stop on an observed trip.

550 At each fishing stop recorded information includes start and end times, start and end location
551 (latitude/longitude), start and end depth, number of observed anglers (a subset of the total
552 anglers), and the catch (retained and discarded) by species of the observed anglers.

553 CDFW implemented a regulation of three hooks in 2000, which was reduced to (and remains
554 at) two hooks in 2001. CDFW also implemented a 10 inch size limit for California scorpionfish
555 in 2000. The length composition of retained in discarded California scorpionfish (both before
556 and after the minimum size restriction). Prior to 2001, there were no depth restrictions for
557 the southern California recreational fishery. Given these regulation changes, the data from
558 1999 and 2000 are excluded from the index.

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

567 Prior to any analyses, drifts with erroneous or missing data were removed from the data
568 considered for the California scorpionfish index. Both of the indices derived from this dataset
569 were standardized using a delta-GLM modeling approach (Lo et al. 1992).

570 The locations of positive encounters were mapped, using the drift starting locations.
571 Regions of suitable habitat were defined by creating detailed hulls (similar to an alpha hull)
572 with a 0.01 decimal degree buffer around a location or cluster of locations.
573 Any portion of a region that intersected with land was removed. As an example of the buffers,
574 a region with only one positive encounter has an ellipsoid area of 3.22km². Each drift (both
575 positive and zero-catch) was assigned to the region with which it intersected. Drifts that

576 did not intersect with a region were considered structural zeroes, i.e., outside of the species
577 habitat, and not used in analyses.

578 **California CRFS Party/Charter Boat Index (Dockside)**

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

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

607 Data for dockside sampling of 6295 commercial passenger fishing vessel (CPFV) trips south
608 of Point Conception by the Marine Recreational Fishery Statistical Survey (MRFSS) were
609 filtered using the Stephens-McCall method to identify trips with catch associated with
610 California scorpionfish and the resulting trips analyzed in a delta-GLM including year and
611 county to produce annual indices of abundance for the period 1980 through 1998 . To
612 eliminate trips targeting species caught near the surface for all or part of the trip where
613 California scorpionfish do not occur, prior applying the Stephens-MacCall filter, trips with
614 catch of bluefin tuna, yellowfin tuna, dorado, Pacific bonito, skipjack, albacore, chinook
615 salmon, coho salmon and bigeye tuna were removed. Trips with catch of yellowtail amberjack
616 were also removed since effort on such trips can often be focused in the surface and midwater

617 where California scorpionfish do not occur. In addition, trips with aggregate effort less below
618 and above 95% percentile (less than 2 and over 109.5 hours) were removed to exclude trips
619 for which either too little effort was exerted to be informative or longer trips that may make
620 an excessive contribution to the effort likely distributed over a number of targets only some
621 of which may co-occur with California scorpionfish biasing low the resulting CPUE. Lastly,
622 trips in Santa Barbara County were removed due the low number of positive samples for
623 California scorpionfish since it resides in the northern extent of their range and this is a
624 transition zone between biogeographic provinces in which the presence of more northerly
625 distributed species could adversely affect the ability of the Stephens-MacCall filtering method
626 to identify co-occurring species.

627 Removal of the aforementioned trips resulted in a total of 3968 trips to which the Stephens-
628 MacCall filtering method was applied. Species that composed less than 5% of the catch
629 were excluded from analysis to prevent these uncommon species from affecting correlations
630 identified using the algorithm. Chub mackerel, Pacific mackerel and barracuda were removed
631 as potential predictor species despite having weak positive correlations with California
632 scorpionfish since they are predominantly pelagic and their co-occurrence is not expected to
633 be predictive. As expected, positive indicators of California scorpionfish trips include several
634 species of nearshore rockfish, California sheephead, California halibut, Pacific sanddabs and
635 seabasses and counter-indicators include several species of deep-water rockfish (Figure 6).
636 While the filter is useful in identifying co-occurring or non-occurring species assuming all
637 effort was exerted in pursuit of a single target, the targeting of more than one target species
638 can result in co-occurrence of species in the catch that do not truly co-occur in terms of
639 habitat associations informative for an index of abundance, presenting a confounding influence
640 in selecting trips using the methods employed.

641 Two levels of filtering were applied using the Stephens- MacCall Filter. The Stephens-MacCall
642 filtering method identified the probability of occurrence (in this case 0.27) at which the rate
643 of false positives and false negatives for the presence of California scorpionfish were equal as
644 a heuristic for selecting a threshold for trips in appropriate habitat to be included in analysis.
645 The trips from this criteria for selection was compared to an alternative method including
646 the false positive trips as well as all positive trips for California scorpionfish supported by
647 the assumption that if California scorpionfish were caught in such trips, they must constitute
648 appropriate habitat justifying their inclusion. In addition, the false positives from a lower
649 probability of occurrence (0.10) that was considered to reflect a less stringent threshold
650 inclusive of more trips including a higher proportion of the false positive trips combined with
651 the positive trips from the entire data set was evaluated for comparison.

652 CPUE (number of fish per angler hour) was modelled using a “delta-GLM” model (Lo et
653 al. 1992, Stefnsson 1996). Model selection using Akaike Information Criterion (AIC) and
654 Bayesian Information Criteria (BIC) supported inclusion of year and region effects in both
655 the binomial and lognormal components of the index for both the model with false positives
656 from the 0.27 threshold and the 0.10 threshold. The addition of month effects (to allow for
657 seasonal changes in CPUE) did not improve model fit. The lognormal model was employed as
658 a result of the lower AIC values compared to the binomial model. The resulting index values

for 1989 were anomalously high compared to other years. In addition, the less stringent filter of 0.10 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% (828/3968) prior to filtering with the Stephens-MacCall method, and 71.0% (828/1167) with the filter set to 0.27 and 26.7% (828/3099) 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 7). The resulting index is highly variable for both thresholds, with consistent peaks in 1984 and 1998 (Figure 8).

The results of the models with each of the thresholds provided similar trends seen in Figure 4 along with the results from the CPFV logbook index. The trends differ from those resulting from the CPFV logbook index early in the time series, but both show an increase in the mid to late 1990s. The PC dockside index was excluded from further analysis in the model given that the PC logbook index represents the same sector of the fishery and presumably contains data from some of the same trips, utilizes data for many thousands more trips, and provides data from 1989 to 1992 omitted from the MRFSS data as a result of filtering out 1989 and a lapse of sampling from 1990-1992.

2.1.5 Fishery-Independent Abundance Indices

`fishery-independent-abundance-indices`

Sanitation Districts Trawl Survey Index

Sanitation districts in southern California are required to conduct trawls as part of their National Pollutant Discharge Elimination System (NPDES) permits. All sanitation districts in southern California were contacted for data series. The two northernmost districts Goleta and the City of Oxnard provided data, but no scorpionfish have been observed in either trawl survey. The four other sanitation districts, Orange County, City of Los Angeles, Los Angeles County, and the City of San Diego all encounter California scorpionfish.

Orange County Orange County Sanitation District provided trawl data from 1970-2015, and the majority of sampling occurred in Quarter 1 and 3 (Jan-March and July-September). From 1970-1985 Quarter 2, sampling was based on a 10 minute tow time. As of 1985 Quarter 3 sampling was based upon a towed distance of 450m. Tow time was missing for approximately half of the tows from 1985 Quarter 3 to present, and was imputed based on the mean tow time of the sampling station. Two stations were removed that were frequently sampled, but observed very few scorpionfish. Eleven stations (T0-T6,T10-T13) with long time series and 1,490 tows were retained for the analysis .

697 City of Los Angeles (Hyperion) The City of Los Angeles Sanitation District provided trawl
698 data from 1986-2016.

699 Years with fewer than ten samples were removed from the analysis (1986, 1987, and 1992).
700 Tow times were recorded starting in 1999, and assumed to be 10 minutes prior to 1999.
701 Stations sampled at least ten years were retained, which resulted in ten stations (A1, A3,
702 C1, C3, C6, C9A, D1T, Z2, Z3, Z4; 921 hauls) for the analysis. Haul depth was missing for
703 approximately half of the stations, and was imputed as the mean depth of other tows at
704 that station.

705 Los Angeles County (Palos Verdes) The Sanitation Districts of Los Angeles County provided
706 trawl data from 1972-2016 with quarterly sampling. Stations sampled in fewer than 10 years
707 or at 305m where California scorpionfish were never observed were removed from the analysis.
708 Non-standard and special study trawls were also removed, e.g., night trawl study in 1987.
709 Hauls were based on a 10 minute tow time. Twelve stations (stations at 23m, 61m, and 137m
710 for T0,T1,T4,T5) containing 1,848 tows were retained after initial filtering.

711 City of San Diego The City of San Diego Sanitation provided trawl data from 1985-2015.
712 Stations sampled in at least 15 years were retained for analysis, resulting in 14 stations
713 (SD1-SD14, SD17-21) and a total of 1,180 tows. A ten minute tow time is assumed for all
714 trawls.

715 NWFSC Trawl Survey Index

716 The Northwest Fishery Science Center has conducted combined shelf and slope trawl surveys
717 (hereafter referred as NWFSC trawl survey) since 2003, based on a random-grid design from
718 depths of 55 to 1280 meters. Additional details on this survey and design are available in the
719 abundance and distribution reports by Keller et al. (2008). Spatial locations of raw catch
720 rates (in log scale) are shown in Figure X1.

721 The proportions of positive catch haul and the raw catch rates of positive hauls by depth and
722 latitude are shown in Figure 14 and Figure 15, respectively. These figures show that more
723 scorpionfish were caught at shallow depth zones and in the southern latitude zones. Box
724 plots of length summary data by depth and sex (Figure 17) and by latitude and sex (Figure
725 17) show no evidences of different spatial distributions (by depth and latitude) by length or
726 by sex.

727 The numbers of total hauls and percentages of positive catch hauls by depth and latitude
728 zones are presented in Tables 17 and 18, respectively. Summaries of raw catch data by year
729 are listed in Table 19. Overall, catches of scorpionfish by the survey were very low with
730 less than 1mt fish caught during the entire 14 years of the survey. Bubble plots of length
731 frequency distribution by year and sex are presented in Figure 18.

732 Summaries of age data by year and sex are presented in Table 20. There were more males (n
733 = 529) being aged than females (n = 340), presumably indicating that there are more males
734 than females in the populations. The table also shows that mean ages and mean lengths
735 for both sexes decreased in recent years. Table 21 show five percentiles of fish aged by sex,

⁷³⁶ indicating more older males in the population. All aged data from the survey were used as
⁷³⁷ conditional age-at-length matrix in the assessment model.

⁷³⁸ Total biomass estimates from the survey were analyzed using the VAST program (Thorson
⁷³⁹ and Barnett 2017). The Q-Q goodness of fit plot and time series of total biomass estimates
⁷⁴⁰ are shown in Figures 19 and 20, respectively. The Q-Q plots shows generally good of fits
⁷⁴¹ and the time series of biomass estimates indicates no significant trend with relatively large
⁷⁴² uncertainties from the survey. The final survey index and log standard error used in the
⁷⁴³ assessment model are in Table 22.

⁷⁴⁴ CSUN/VRG Gillnet Survey Index

⁷⁴⁵ The CSUN/VRG gillnet survey was conducted from 1995-2008. Sites along the coast from
⁷⁴⁶ Santa Barbara to Newport were consistently sampled for the time series, as well as Catalina
⁷⁴⁷ Island. Gillnet sets from within Marina Del Rey and Catalina Harbor were removed from the
⁷⁴⁸ analysis.

⁷⁴⁹ Gillnets were All gillnets were the same length with six-25' panels (150' in length).
⁷⁵⁰ The majority of samples were collected using a net with 1", 1.5", 2" square mesh, each mesh
⁷⁵¹ was on 2 panels.

⁷⁵² Perp/para was whether or not the net was set perpendicular or parallel to shore.

⁷⁵³ Southern California Bight 2013 Regional Monitoring Project Trawl Survey Index

⁷⁵⁴ 2.1.6 Other data sources considered

`other-data-sources-considered`

⁷⁵⁵ *Northwest Fisheries Science Center (NWFSC) shelf-slope survey*

⁷⁵⁶ This survey is referred to as the “combo,” conducted annually since 2003.

⁷⁵⁷ The survey consistently covered depths between 30 and 700 fm.

⁷⁵⁸ *Alaska Fisheries Science Center (AFSC) shelf survey*

⁷⁵⁹ The survey, often referred to as the “triennial” survey was conducted every third year between
⁷⁶⁰ 1977 and (and conducted in 2004 by the NWFSC using the same protocols). The triennial
⁷⁶¹ survey trawls in depths of 30 to 275 fm.

⁷⁶² *California Cooperative Oceanic Fisheries Investigations (CalCOFI) Survey* Only 16 positive
⁷⁶³ tows in the core area (lines 77-93) of California scorpionfish.

⁷⁶⁴ The majority of the 335 positive tows occurred in Mexico, south of Punta Eugenia Baja
⁷⁶⁵ California and are likely a combination of California scorpionfish and other *Scorpaena* species.
⁷⁶⁶ Prior to 1965, *Scorpaena* samples were not speciated.

⁷⁶⁷ *Generating Station Impingement Surveys*

768 Data from the southern California generating station surveys were provided by Eric Miller
769 (xxx). There are five generating stations that conduct normal operation and heat treatment
770 surveys: Scattergood Generating Station (SGS), El Segundo Generation Station (ESGS),
771 Redondo Beach Generating Station (RBGS), Huntington Beach Generatig Station (HBGS),
772 and San Onofre Generatin Station (SONGS).

773 The generating stations all draw in seawater through an intake system for once-through
774 cooling water. Each generating station draws in water from different depths and distances
775 from shore: SGS draws from 500 m offshore at 6 m depth, ESBS draws from 700 m offshore
776 at 9.8 m depth, RBGS draws from 289 m offshore at 13.7 m depth, HBGS draws from 500 m
777 offshore at 5 m depth, and SONGS has two intake systems 960 m and 900 m offshore and at
778 9 m and 8m depth, respectively (Miller et al. 2009).

779 The two surveys conducted are normal operations surveys and heat treatment surveys. For
780 normal operations surveys, the intake screens are rotated and cleaned to start the survey. All
781 of the impinged fish are washed off the screen at this time and discarded. when the intake
782 screens stop running, the survey begins. The generating station then operates as normal for
783 24 hours, which includes operating and washing the screens as usual (typically every eight
784 hours). The screens are then operated and washed again after a second 24 hours has elapsed.
785 Any specimens washed off the screens during the 48 hour study period are retained. The
786 total sample is processed to identify, count, weigh, measure the fish and macroinvertebrates.
787 There is no information on the water flow collected during the 48 hour period of the normal
788 operations survey. Most fish enger the the generating station and swim in the forebay until
789 either getting exhausted or impinged. Does that sound about right?

790 During a heat treatment,

791 data, it's my understanding that the screens are rotated and washed off per normal operating
792 procedures right up until the heat treatment takes place. Therefore, only the fish remaining
793 in the forebay and those impinged since the last screen rotation are counted in the heat
794 treatment. The flow between heat treatments has previously been used to standardize the
795 catch. However, I don't see that as very useful since the fish killed in the heat treatment are
796 not the total representative sample since the last heat treatment

797 2.1.7 Biological Parameters and Data

biological-parameters-and-data

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

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

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

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

814 To avoid missing length bins (specifically 18, 23, 29cm) in the conversion from SL to TL,
815 0.5 was first subtracted from each SL and a random uniform number ($U[0,1]$) was added to
816 the SL measurement. All TL measurements were rounded to the nearest length centimeter
817 length bin. A comparison of the length distributions

818 Length And Age Compositions

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

821 Length compositions were provided from the following sources, with brief descriptions below:

- 822 • CDFW market category study (*commercial dead fish*, 1996-2003)
- 823 • CALCOM (*commercial dead fish*, 2013-2016)
- 824 • CDFW onboard observer (*recreational charter discards*, 2003-2016)
- 825 • Ally onboard observer study (*recreational charter discards*, 1984-1989)
- 826 • California recreational sources combined (*recreational charter retained catch*)
 - 827 – CDFW and Ally onboard observer surveys (1984-1989)
 - 828 – Collins and Crooke onboard observer surveys (1975-1978)
 - 829 – MRFSS (1980-2003)
 - 830 – CRFS (2004-2014)
- 831 • California recreational sources combined (*private mode retained catch*)
 - 832 – MRFSS (1980-2003)
 - 833 – CRFS (2004-2016)
- 834 • Sanitation district trawl surveys (*research*, 1970-2016)
- 835 • CSUN/VRG gillnet survey (*research*, 1995-2008)
- 836 • Power plant impingement surveys (*research*, 1974-2016)
- 837 • Southern California Bight trawl survey (*research*, 1994, 1998, 2003, 2008, 2013)

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

842 *Commercial: PacFIN*

843 *Research: NWFSC shelf-slope survey*

844 *Research: NWFSC slope survey*

845 **Age Structures** Age data were provided from the NWFSC trawl survey from 2005-2016.

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

850 Aging Precision And Bias

851 Weight-Length

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

854 Maturity And Fecundity

855 **Natural Mortality** Hamel (2015) developed a method for combining meta-analytic ap-
856 proaches to relating the natural mortality rate M to other life-history parameters such as
857 longevity, size, growth rate and reproductive effort, to provide a prior on M . In that same
858 issue of ICESJMS, Then et al. (2015), provided an updated data set of estimates of M and
859 related life history parameters across a large number of fish species, from which to develop
860 an M estimator for fish species in general. They concluded by recommending M estimates
861 be based on maximum age alone, based on an updated Hoenig non-linear least squares
862 (nls) estimator $M = 4.899 * A_{max}^{-.916}$. The approach of basing M priors on maximum age
863 alone was one that was already being used for west coast rockfish assessments. However,
864 in fitting the alternative model forms relating $-.916M$ to A_{max} , Then et al. (2015) did
865 not consistently apply their transformation. In particular, in real space, one would expect
866 substantial heteroscedasticity in both the observation and process error associated with the
867 observed relationship of M to A_{max} . Therefore, it would be reasonable to fit all models under
868 a log transformation. This was not done. Reevaluating the data used in Then et al. (2015) by
869 fitting the one-parameter A_{max} model under a log-log transformation (such that the slope is
870 forced to be -1 in the transformed space (as in Hamel (2015)), the point estimate for M is:

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

871 The above is also the median of the prior. The prior is defined as a lognormal with mean
872 $\ln \frac{5.4}{A_{max}}$ and SE = 0.4384343. Using a maximum age of 21 the point estimate and median of
873 the prior is 0.2545, which is used as a prior for females in the assessment model.

874 **Sex ratios**

875 **2.1.8 Environmental Or Ecosystem Data Included In The Assessment**
[environmental-or-ecosystem-data-included-in-the-assessment](#)

876 **2.2 History Of Modeling Approaches Used For This Stock**
[history-of-modeling-approaches-used-for-this-stock](#)

877 **2.2.1 Previous Assessments**

[previous-assessments](#)

878 **2.2.2 2005 Assessment Recommendations**

[assessment-recommendations](#)

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

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

886
887 STAT response: Data from all sanitation districts in southern California were obtained
888 for this assessment. All of the data were pooled across surveys to develop one index of
889 abundance using the delta-GLM method

890 **Recommendation 2:** An age, growth and maturity study for scorpionfish is
891 needed. Although there has been previous research on scorpionfish age and
892 growth, the available information is not appropriate for stock assessment
893 modeling.

894
895 STAT response: Age data are available from the NWFSC trawl survey from 2005-2016.
896 There have been no additional studies on growth or maturity for California scorpionfish
897 since the 2005 assessment.

898 **Recommendation 3:** Location information for the historic groundfish data of all
899 species is currently available, in hard copy form only, from the California
900 Department of Fish and Game. Putting this information into electronic

format would greatly improve the ability to assign catches of all species to specific stocks on a trip-by-trip basis.

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

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

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

2.3 Model Description

[model-description](#)

2.3.1 Transition To The Current Stock Assessment

[transition-to-the-current-stock-assessment](#)

Include: Complete description of any new modeling approaches

Below, we describe the most important changes made since the last full assessment and explain rationale for each change.:

1. Change No. 1. *Rationale:* blah blah blah.

2. Change No. 2. *Rationale:* blah blah blah.

3. Change No. 3. *Rationale:* Continue list as needed.

2.3.2 Definition of Fleets and Areas

[definition-of-fleets-and-areas](#)

We generated data sources for each of the models. Fleets by model include:

Model Region 1 or remove this line if only one model

Commercial: The commercial fleets include...

Recreational: The recreational fleets include...

Research: Research derived-data include...

926 **2.3.3 Summary of Data for Fleets and Areas**
summary-of-data-for-fleets-and-areas

927 **2.3.4 Modeling Software**
modeling-software

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

932 **2.3.5 Data Weighting**
data-weighting

933 Citation for Francis method (Francis 2011)
934 Citation for Ianelli-McAllister harmonic mean method (McAllister and Ianelli 1997)

935 **2.3.6 Priors**
priors

936 Citation for Hamel prior on natural mortality (Hamel 2015)

937 **2.3.7 General Model Specifications**
general-model-specifications

938 Model data, control, starter, and forecast files can be found in Appendices A-D.

939 **2.3.8 Estimated And Fixed Parameters**
estimated-and-fixed-parameters

940 A full list of all estimated and fixed parameters is provided in Tables. . . . Estimated and fixed
941 parameters tables currently read in from .csv file, EXAMPLE: Table ??

942 **2.4 Model Selection and Evaluation**
model-selection-and-evaluation

943 **2.4.1 Key Assumptions and Structural Choices**
key-assumptions-and-structural-choices

944 Include: Evidence of search for balance between model realism and parsimony.
945 Comparison of key model assumptions, include comparisons based on nested models (e.g.,
946 asymptotic vs. domed selectivities, constant vs. time-varying selectivities).

947 **2.4.2 Alternate Models Considered**

alternate-models-considered

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

949 **2.4.3 Convergence**

convergence

950 Include: Randomization run results or other evidence of search for global best estimates.

951 Convergence testing through use of dispersed starting values often requires extreme values to
952 actually explore new areas of the multivariate likelihood surface. Jitter is a SS option that
953 generates random starting values from a normal distribution logically transformed into
954 each parameter's range (Methot 2015). Table 31 shows the results of running 100 jitters for
955 each pre-STAR base model....

956 **2.5 Response To The Current STAR Panel Requests**

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

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

958

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

960

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

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

962

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

964

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

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

966

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

968

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

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

970

- 971 • **Item No. 1**
- 972 • **Item No. 2**
- 973 • **Item No. 3, etc.**

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

975

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

976 **2.6 Model 1**

model-1

977 **2.6.1 Model 1 Base Case Results**

model-1-base-case-results

978 Table ??

979 **2.6.2 Model 1 Uncertainty and Sensitivity Analyses**

model-1-uncertainty-and-sensitivity-analyses

980 Table 32

981 **2.6.3 Model 1 Retrospective Analysis**

model-1-retrospective-analysis

982 **2.6.4 Model 1 Likelihood Profiles**

model-1-likelihood-profiles

983 **2.6.5 Model 1 Harvest Control Rules (CPS only)**

model-1-harvest-control-rules-cps-only

984 **2.6.6 Model 1 Reference Points (groundfish only)**

model-1-reference-points-groundfish-only

985 Intro sentence or two....(Table 33).

986 Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is 205.4 mt.
987 Table e shows the full suite of estimated reference points for the northern area model and
988 Figure j shows the equilibrium yield curve.

989 **3 Harvest Projections and Decision Tables**

harvest-projections-and-decision-tables

990 Table f

991 **Model 1 Projections and Decision Table (groundfish only) (Table 34**

992 Table h

993 **Model 2 Projections and Decision Table (groundfish only)**

994 **Model 3 Projections and Decision Table (groundfish only)**

4 Regional Management Considerations

`regional-management-considerations`

- 996 1. For stocks where current practice is to allocate harvests by management area, a
997 recommended method of allocating harvests based on the distribution of biomass should
998 be provided. The MT advisor should be consulted on the appropriate management
999 areas for each stock.
- 1000 2. Discuss whether a regional management approach makes sense for the species from a
1001 biological perspective.
- 1002 3. If there are insufficient data to analyze a regional management approach, what are the
1003 research and data needs to answer this question?

5 Research Needs

`research-needs`

- 1004 1. Research need No. 1
- 1005 2. Research need No. 2
- 1006 3. Research need No. 3
- 1007 4. etc.

6 Acknowledgments

`acknowledgments`

- 1008 1010 Include: STAR panel members and affiliations as well as names and affiliations of persons
1011 who contributed data, advice or information but were not part of the assessment team. Not
1012 required in draft assessment undergoing review. We thank Kevin Lee for the use of the cover
1013 photo for this document.

7 Tables

tables

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

Year	Hook-and-line	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: 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 2: 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 2: 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 3: 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	4,873

Table 4: 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 5: 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 6: 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	tab:Fleet5_RecPC_CPFVlogbook_filter
		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 7: AIC values for each model in the recreational CPFV logbook sample index.

Model	tab:Fleet5_RecPC_CPFVlogbook_aic
Negative Binomial	
Year	1918470
Year+ Month	1901592
Year + Block	1872224
Year+ Month + Block	1854652

Table 8: The recreational CPFV logbook sample index.

Year	Index	Log-scale SE	NA	NA
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 9: 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 trips)	Sample size (no. of trips)
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 10: 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 11: 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 12: AIC values for each model in the The recreational CPFV onboard observer retained-only catch index.

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

Table 13: 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 14: 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 15: 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 16: 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 17: 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 18: 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 19: 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 20: 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	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 21: 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 22: 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 23: 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 24: 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 25: 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 26: 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, south of Ventura and islands (few scorpionfish)	129	398

Table 27: 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 28: 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 29: 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	0.298	2	(0.01, 1) (2, 30)	OK	0.030	Log_Norm (-1.3581, 0.438438)
2	Lat_Amin_Fem_GP_1	7.228	2	(30, 50)	OK	1.410	None
3	Lat_Amax_Fem_GP_1	33.194	2	(0.05, 0.5)	OK	1.295	None
4	VonBert_K_Fem_GP_1	0.247	2	(0.02, 0.5)	OK	0.053	None
5	CV_young_Fem_GP_1	0.328	3	(0.02, 0.75)	OK	0.036	None
6	CV_old_Fem_GP_1	0.104	3	(-3, 3)	OK	0.016	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	17.188	-3	(-3, 3)	None	None	None
10	Mat_slope_Fem	-0.466	-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)	OK	0.066	Normal (0, 99)
13	NatM_p_1_Mal_GP_1	-0.204	2	(-3, 3)	OK	0.190	None
14	Lat_Amin_Mal_GP_1	0.667	2	(-3, 3)	OK	0.043	None
15	Lat_Amax_Mal_GP_1	-0.180	2	(-3, 3)	OK	0.222	None
16	VonBert_K_Mal_GP_1	0.101	2	(-3, 3)	OK	0.279	None
17	CV_young_Mal_GP_1	-1.487	3	(-3, 3)	OK	0.188	None
18	CV_old_Mal_GP_1	0.085	3	(-3, 3)	OK	None	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	0.315	Full_Beta (0.718, 0.158)
26	SR_LN(R0)	8.103	1	(0, 31)	OK	0.315	None
27	SR_BH_stEEP	0.718	-2	(0.21, 0.99)	None	None	None
28	SR_sigmar	0.600	-2	(0, 2)	None	None	None
29	SR_regime	0.000	-4	(-5, 5)	None	None	None

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Table 29: 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
84	InitF_seas_1_ftt_1ComHL	0.000	-1	(0, 1)			Normal (0.01, 1000)
85	LnQ_base_RecPR(4)	-6.411	-1	(-15, 15)	OK	0.025	None
86	Q_extraSD_RecPR(4)	0.019	4	(0.001, 1)			None
87	LnQ_base_RecPC(5)	-10.929	-1	(-15, 15)			None
88	Q_extraSD_RecPC(5)	0.372	4	(0.001, 1)	OK	0.056	None
89	LnQ_base_RecDD(6)	-10.809	-1	(-15, 15)			None
90	Q_extraSD_RecDD(6)	0.055	4	(0.001, 1)	OK	0.045	None
91	LnQ_base_Sanitation(7)	-10.227	-1	(-15, 15)			None
92	Q_extraSD_Sanitation(7)	0.211	4	(0.001, 1)	OK	0.046	None
93	LnQ_base_NWFSCTrawl(8)	-0.732	-1	(-15, 15)			None
94	Q_extraSD_NWFSCTrawl(8)	0.244	4	(0.001, 1)	OK	0.144	None
95	LnQ_base_GillnetSurvey(9)	-11.700	-1	(-15, 15)			None
96	Q_extraSD_GillnetSurvey(9)	0.100	4	(0.001, 1)	OK	0.067	None
97	LnQ_base_SCBSurvey(11)	-10.682	-1	(-15, 15)			None
98	Q_extraSD_SCBSurvey(11)	0.188	4	(0.001, 1)	OK	0.151	None
99	LnQ_base_RecPCOBR(12)	-9.830	-1	(-15, 15)			None
100	Q_extraSD_RecPCOBR(12)	0.218	4	(0.001, 1)	OK	0.063	None
101	SizeSel_P1_ComHL(1)	32.676	4	(13, 44)	OK	2.046	None
102	SizeSel_P2_ComHL(1)	15.000	-3	(-10, 16)			None
103	SizeSel_P3_ComHL(1)	3.945	4	(-1, 10)	OK	0.358	None
104	SizeSel_P4_ComHL(1)	15.000	-3	(-1, 16)			None
105	SizeSel_P5_ComHL(1)	-16.478	5	(-25, -1)	OK	113.849	None
106	SizeSel_P6_ComHL(1)	10.000	-3	(-5, 11)			None
107	SizeSel_P1_ComNet(2)	1.000	-2	(1, 45)			None
108	SizeSel_P2_ComNet(2)	45.000	-3	(1, 45)			None
109	SizeSel_P1_ComTrawl(3)	1.000	-2	(1, 45)			None

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Table 29: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD)).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
110	SizeSel_P2_ComTrawl(3)	45.000	-3	(1, 45)	OK	1.547	None
111	SizeSel_P1_RecPR(4)	39.065	4	(13, 44)	OK	1.547	None
112	SizeSel_P2_RecPR(4)	15.000	-3	(-10, 16)	OK	0.158	None
113	SizeSel_P3_RecPR(4)	4.242	4	(-1, 10)	OK	0.158	None
114	SizeSel_P4_RecPR(4)	15.000	-3	(-1, 16)	OK	0.158	None
115	SizeSel_P5_RecPR(4)	-8.383	5	(-25, -1)	OK	0.638	None
116	SizeSel_P6_RecPR(4)	10.000	-3	(-5, 11)	OK	0.638	None
117	SizeSel_P1_RecPC(5)	35.668	4	(13, 44)	OK	1.218	None
118	SizeSel_P2_RecPC(5)	15.000	-3	(-10, 16)	OK	1.218	None
119	SizeSel_P3_RecPC(5)	4.270	4	(-1, 10)	OK	0.164	None
120	SizeSel_P4_RecPC(5)	15.000	-3	(-1, 16)	OK	0.164	None
121	SizeSel_P5_RecPC(5)	-8.373	5	(-25, -1)	OK	1.683	None
122	SizeSel_P6_RecPC(5)	10.000	-3	(-5, 11)	OK	1.683	None
123	SizeSel_P1_RecDD(6)	24.543	4	(13, 44)	OK	0.094	None
124	SizeSel_P2_RecDD(6)	-11.346	3	(-15, 16)	OK	56.497	None
125	SizeSel_P3_RecDD(6)	2.606	4	(-1, 10)	OK	0.506	None
126	SizeSel_P4_RecDD(6)	-8.688	3	(-20, 5)	OK	77.743	None
127	SizeSel_P5_RecDD(6)	-2.188	5	(-25, 3)	OK	0.438	None
128	SizeSel_P6_RecDD(6)	-1.402	3	(-5, 11)	OK	0.486	None
129	SizeSel_P1_Sanitation(7)	26.615	4	(13, 44)	OK	0.848	None
130	SizeSel_P2_Sanitation(7)	15.000	-3	(-10, 16)	OK	0.848	None
131	SizeSel_P3_Sanitation(7)	3.730	4	(-1, 10)	OK	0.137	None
132	SizeSel_P4_Sanitation(7)	15.000	-3	(-1, 16)	OK	0.137	None
133	SizeSel_P5_Sanitation(7)	-5.316	4	(-25, 5)	OK	0.715	None
134	SizeSel_P6_Sanitation(7)	10.000	-3	(-5, 11)	OK	0.715	None
135	SizeSel_P1_NWFSCTrawl(8)	26.558	4	(13, 44)	OK	2.160	None
136	SizeSel_P2_NWFSCTrawl(8)	15.000	-3	(-10, 16)	OK	2.160	None

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Table 29: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD)).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
137	SizeSel_P3_NWFSTrawl(8)	4.014	4	(-1, 10)	OK	0.417	None
138	SizeSel_P4_NWFSTrawl(8)	15.000	-3	(-1, 16)	None	None	None
139	SizeSel_P5_NWFSTrawl(8)	-13.435	4	(-25, 5)	OK	153.055	None
140	SizeSel_P6_NWFSTrawl(8)	10.000	-3	(-5, 11)	None	None	None
141	SizeSel_P1_GillnetSurvey(9)	1.000	-2	(1, 45)	None	None	None
142	SizeSel_P2_GillnetSurvey(9)	45.000	-3	(1, 45)	None	None	None
143	SizeSel_P1_SCBSurvey(11)	1.000	-2	(1, 45)	None	None	None
144	SizeSel_P2_SCBSurvey(11)	45.000	-3	(1, 45)	None	None	None
145	SizeSel_P1_RecPCOBR(12)	1.000	-2	(1, 45)	None	None	None
146	SizeSel_P2_RecPCOBR(12)	45.000	-3	(1, 45)	None	None	None
147	SizeSel_P1_ComHL(1)_BLK1rep1_1999	28.995	5	(13, 44)	OK	0.576	None
148	SizeSel_P3_ComHL(1)_BLK1rep1_1999	2.133	5	(-1, 10)	OK	0.253	None
149	SizeSel_P1_RecPR(4)_BLK2rep1_2000	35.437	5	(13, 44)	OK	0.557	None
150	SizeSel_P3_RecPR(4)_BLK2rep1_2000	3.344	5	(-1, 10)	OK	0.102	None
151	SizeSel_P1_RecPC(5)_BLK2rep1_2000	27.962	5	(13, 44)	OK	0.523	None
152	SizeSel_P3_RecPC(5)_BLK2rep1_2000	1.630	5	(-1, 10)	OK	0.316	None

tab-model-params

Table 30: 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 31: Results from 100 jitters from each of the three models.

Status	Model.1	Model.2	Model.3	tab:jitter
Returned to base case	-	-	-	
Found local minimum	-	-	-	
Found better solution	-	-	-	
Error in likelihood	-	-	-	
Total	100	100	100	

Table 33: 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	2205	888	1.00	3305	4	0.00	0.99
1917	2190	886	1.00	3305	8	0.00	0.98
1918	2172	883	0.99	3304	13	0.01	0.97
1919	2176	879	0.99	3302	12	0.01	0.97
1920	2160	875	0.99	3301	16	0.01	0.96
1921	2124	871	0.98	3299	26	0.01	0.94
1922	2148	863	0.97	3296	19	0.01	0.96
1923	2119	859	0.97	3295	27	0.01	0.94
1924	2047	853	0.96	3292	49	0.02	0.90
1925	1898	838	0.94	3286	101	0.05	0.81
1926	2039	805	0.91	3272	49	0.02	0.89
1927	2029	799	0.90	3270	51	0.03	0.89
1928	2053	794	0.89	3268	44	0.02	0.90
1929	2034	794	0.89	3267	50	0.02	0.89
1930	2061	791	0.89	3266	41	0.02	0.90
1931	2054	791	0.89	3266	43	0.02	0.90
1932	2062	791	0.89	3266	41	0.02	0.90
1933	2094	792	0.89	3267	32	0.02	0.92
1934	2090	796	0.90	3269	34	0.02	0.92
1935	2085	799	0.90	3270	35	0.02	0.92
1936	2020	801	0.90	3271	55	0.03	0.88
1937	1983	794	0.89	3268	66	0.03	0.86
1938	1949	784	0.88	3263	76	0.04	0.84
1939	1987	771	0.87	3257	63	0.03	0.86
1940	1995	767	0.86	3255	59	0.03	0.87
1941	2049	764	0.86	3254	43	0.02	0.90
1942	2136	769	0.87	3256	20	0.01	0.95
1943	2151	783	0.88	3262	16	0.01	0.96
1944	2123	796	0.90	3268	24	0.01	0.94
1945	2060	803	0.90	3271	42	0.02	0.90
1946	1984	801	0.90	3271	66	0.03	0.86
1947	1957	789	0.89	3265	74	0.04	0.84
1948	1866	776	0.87	3259	107	0.05	0.79
1949	1894	752	0.85	3248	93	0.05	0.80
1950	1877	738	0.83	3241	97	0.05	0.79
1951	1962	725	0.82	3234	67	0.04	0.84
1952	1982	727	0.82	3235	61	0.03	0.86
1953	1942	732	0.82	3238	73	0.04	0.83
1954	1911	730	0.82	3237	84	0.04	0.81
1955	1960	724	0.82	3234	67	0.04	0.84

Table 33: 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	1975	726	0.82	3235	63	0.03	0.85
1957	2044	730	0.82	3237	43	0.02	0.89
1958	2060	741	0.83	3242	39	0.02	0.90
1959	2115	752	0.85	3248	25	0.01	0.94
1960	2122	766	0.86	3255	24	0.01	0.94
1961	2098	779	0.88	3261	31	0.02	0.92
1962	2035	786	0.88	3264	50	0.02	0.89
1963	1966	784	0.88	3263	72	0.04	0.84
1964	1921	772	0.87	3257	87	0.04	0.82
1965	1921	757	0.85	3250	85	0.04	0.82
1966	1906	745	0.84	3011	89	0.05	0.81
1967	1951	734	0.83	3159	73	0.04	0.83
1968	1907	730	0.82	3142	87	0.05	0.81
1969	1913	719	0.81	2611	84	0.04	0.81
1970	1859	710	0.80	2026	103	0.06	0.78
1971	1888	691	0.78	1770	91	0.05	0.79
1972	1908	669	0.75	1634	82	0.05	0.81
1973	1866	639	0.72	1668	95	0.06	0.78
1974	1774	590	0.66	2234	122	0.08	0.73
1975	1726	527	0.59	9115	128	0.09	0.70
1976	1895	469	0.53	4264	66	0.05	0.80
1977	1817	491	0.55	5776	87	0.05	0.74
1978	1914	580	0.65	2712	62	0.03	0.80
1979	1827	701	0.79	1573	100	0.05	0.75
1980	1797	789	0.89	1311	124	0.06	0.73
1981	1857	814	0.92	1470	110	0.05	0.77
1982	1863	785	0.88	2173	112	0.06	0.77
1983	1993	714	0.80	3754	61	0.04	0.86
1984	1961	654	0.74	9362	70	0.04	0.83
1985	1896	607	0.68	6138	86	0.05	0.80
1986	1910	620	0.70	2417	76	0.04	0.81
1987	1942	724	0.82	1380	69	0.03	0.82
1988	1673	840	0.95	1263	201	0.09	0.66
1989	1744	840	0.95	1230	163	0.08	0.71
1990	1646	792	0.89	1644	228	0.12	0.65
1991	1598	672	0.76	6094	241	0.15	0.62
1992	1776	539	0.61	4277	115	0.08	0.73
1993	1807	497	0.56	7345	95	0.06	0.75
1994	1623	524	0.59	3943	156	0.09	0.64
1995	1681	578	0.65	2201	133	0.07	0.68

Table 33: 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	1708	675	0.76	6236	136	0.07	0.69
1997	1733	742	0.84	3406	142	0.07	0.70
1998	1718	775	0.87	5046	161	0.07	0.70
1999	1625	797	0.90	4199	225	0.10	0.64
2000	1736	784	0.88	2408	169	0.08	0.70
2001	1689	798	0.90	5059	199	0.09	0.67
2002	1825	785	0.88	2236	128	0.06	0.75
2003	1880	788	0.89	1770	105	0.05	0.79
2004	2013	795	0.90	2263	57	0.03	0.87
2005	1935	795	0.89	4199	89	0.04	0.82
2006	1792	752	0.85	2856	150	0.08	0.73
2007	1789	687	0.77	1815	140	0.08	0.73
2008	1849	649	0.73	2076	104	0.06	0.77
2009	1817	632	0.71	3043	113	0.07	0.75
2010	1821	600	0.68	2051	106	0.07	0.75
2011	1808	570	0.64	1179	105	0.07	0.75
2012	1752	547	0.62	1297	120	0.08	0.71
2013	1745	512	0.58	3459	115	0.09	0.71
2014	1697	467	0.53	3796	124	0.10	0.68
2015	1787	425	0.48	7789	84	0.07	0.74
2016	1811	432	0.49	2995			

tab:Timeseries_mod1

Table 32: 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_Umfished_thousand_mt	-	-	-	-	-	-	-	-
TotBio_Umfished	-	-	-	-	-	-	-	-
SmryBio_Umfished	-	-	-	-	-	-	-	-
Recr_Umfished_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 34: 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)	<small>tab:Forecast_mod1</small>
2017	252.19	252.19	1604.93	493.51	0.56

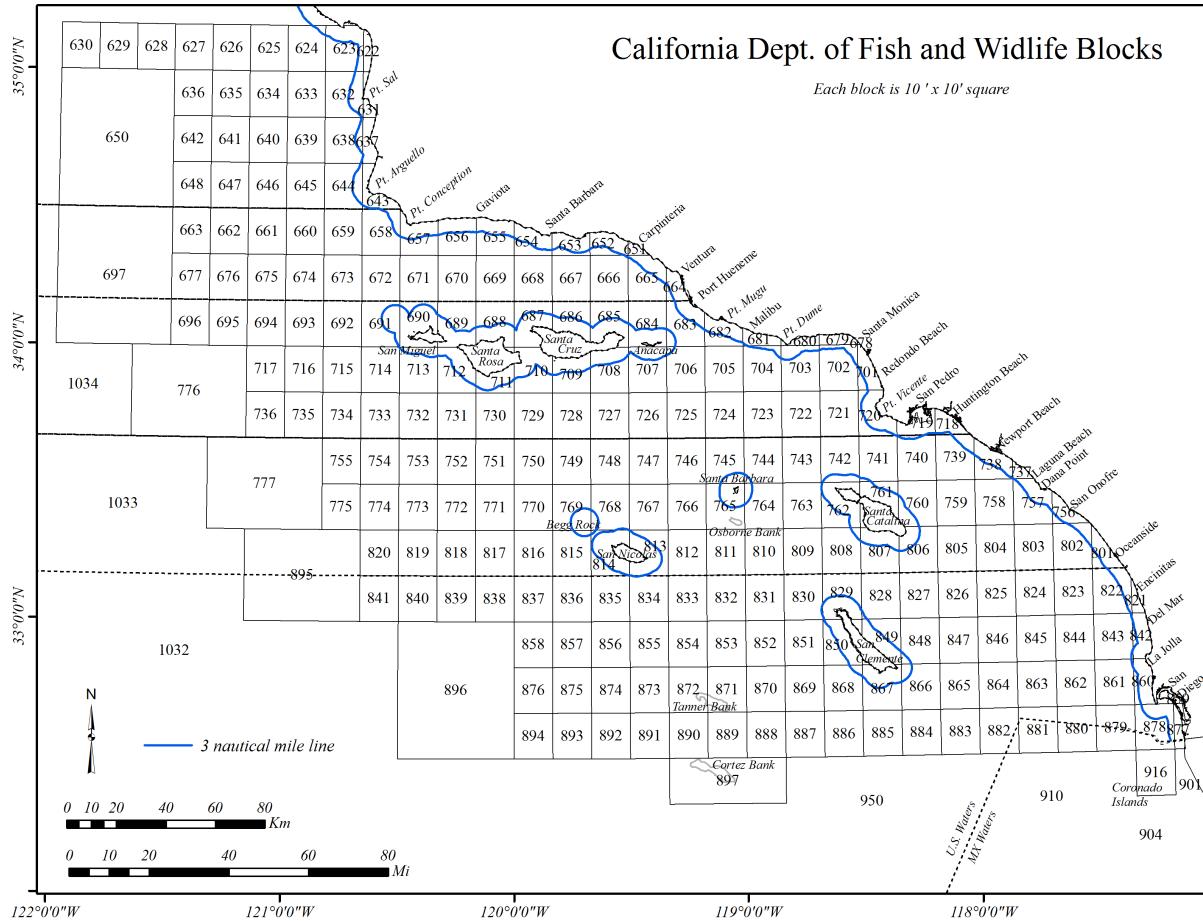


Figure 1: Map showing the state boundary lines for management of the recreational fishing fleets. CRFS Districts 1-6 in California are presented as well as the WDFW Recreational Management Areas in Washington. Florence, OR is shown as a potential location of model stratification.^{fig:boundary_map}

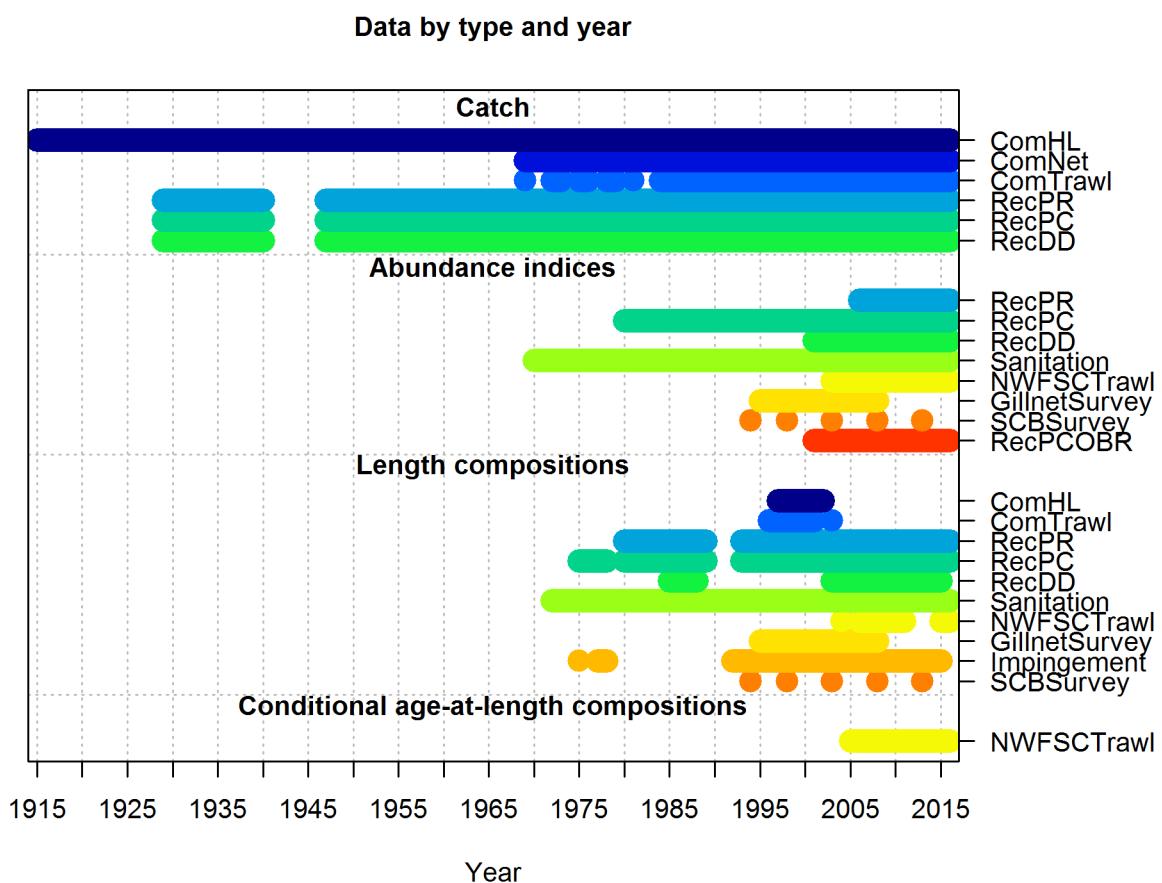


Figure 2: Summary of data sources used in the base model. `fig:data_plot`

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
1999												
2000												
2001	20	20								20	20	
2002							20	20	20	20		
2003	20	20					20	20	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 3: A summary of the monthly recreational regulations for California scorpionfish in southern California. Open cells 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](#)

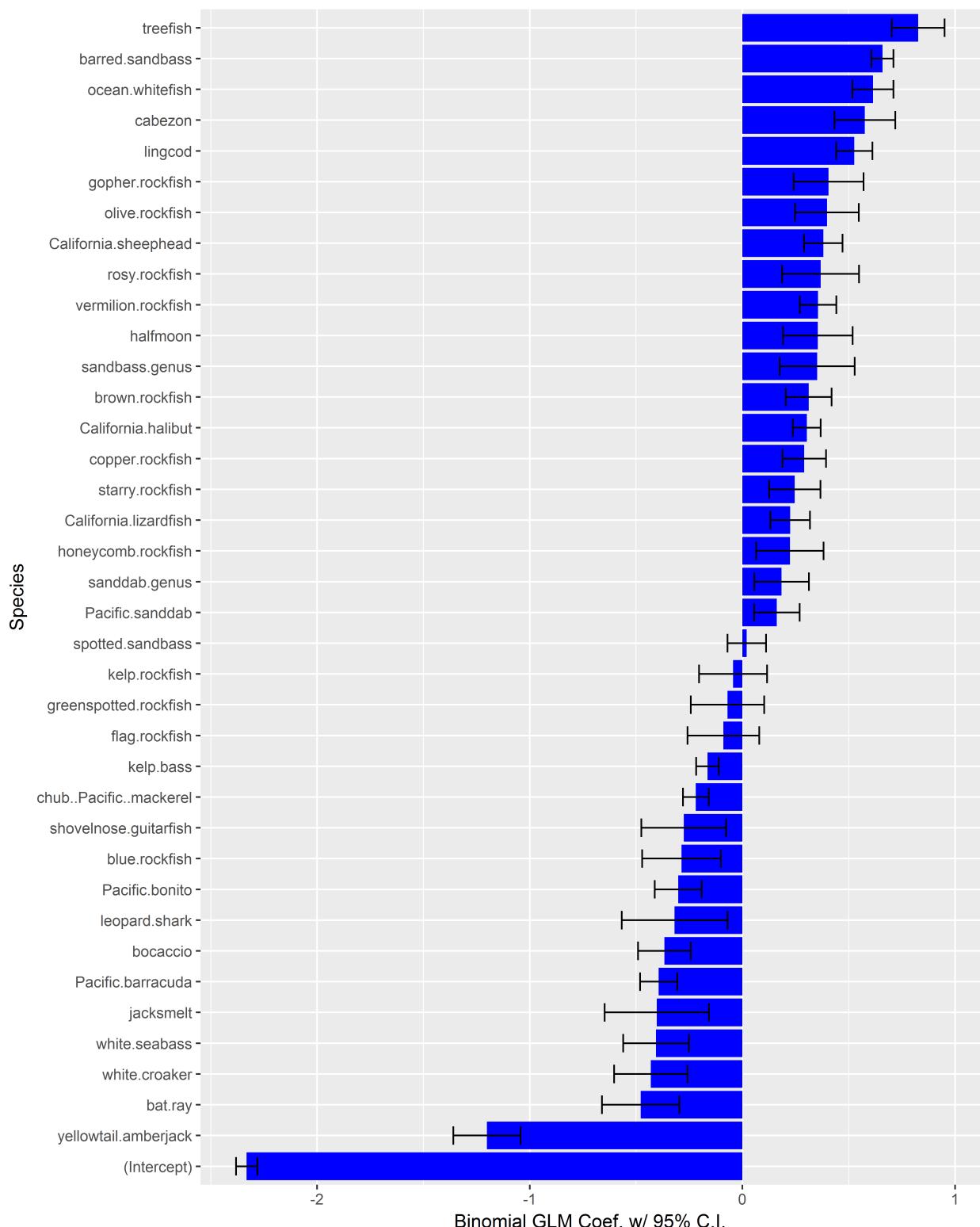


Figure 4: Species coefficients from the binomial GLM for presence/absence of California scorpionfish in the Marine Recreational Fisheries Statistics Survey (MRFSS) private mode dockside survey data set. Horizontal bars are 95% confidence intervals. fig:Fleet4_RecPR_dockside_SM

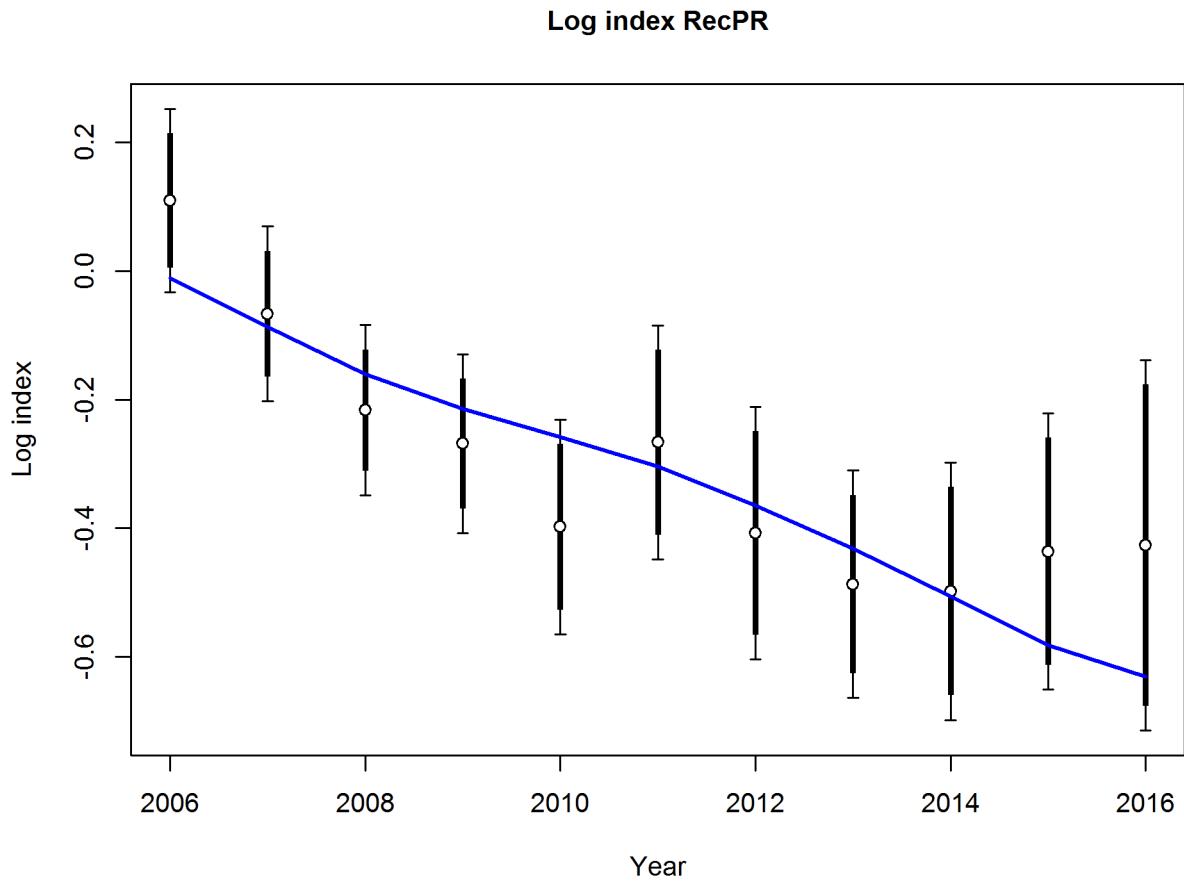


Figure 5: Fit to log index data on log scale for the recreational CPFV logbook retained catches. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. fig:index5_logcpuefit

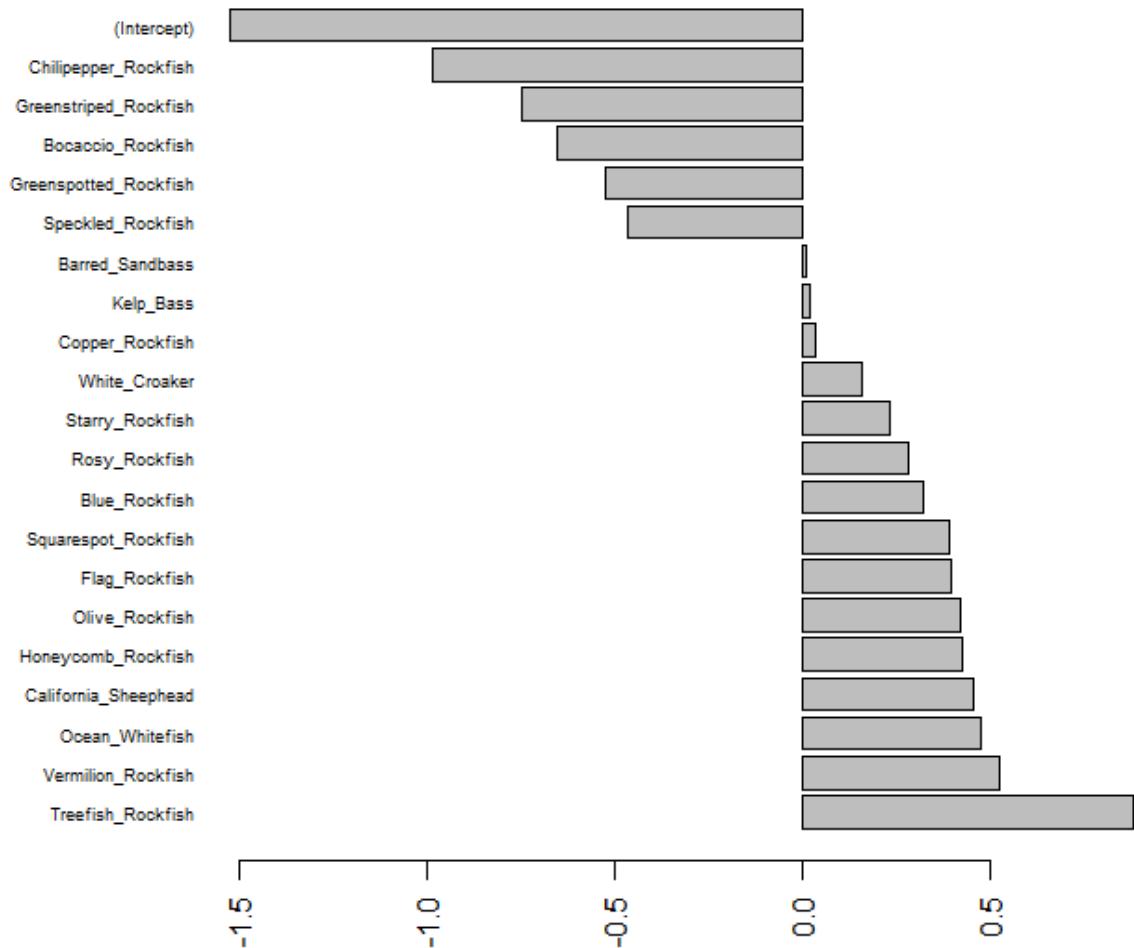


Figure 6: Species coefficients from the binomial GLM for presence/absence of California scorpionfish in the Marine Recreational Fisheries Statistics Survey (MRFSS) party/charter mode dockside survey data set. Horizontal bars are 95% confidence intervals. [fig:Fleets5_RecPC_dockside](#)

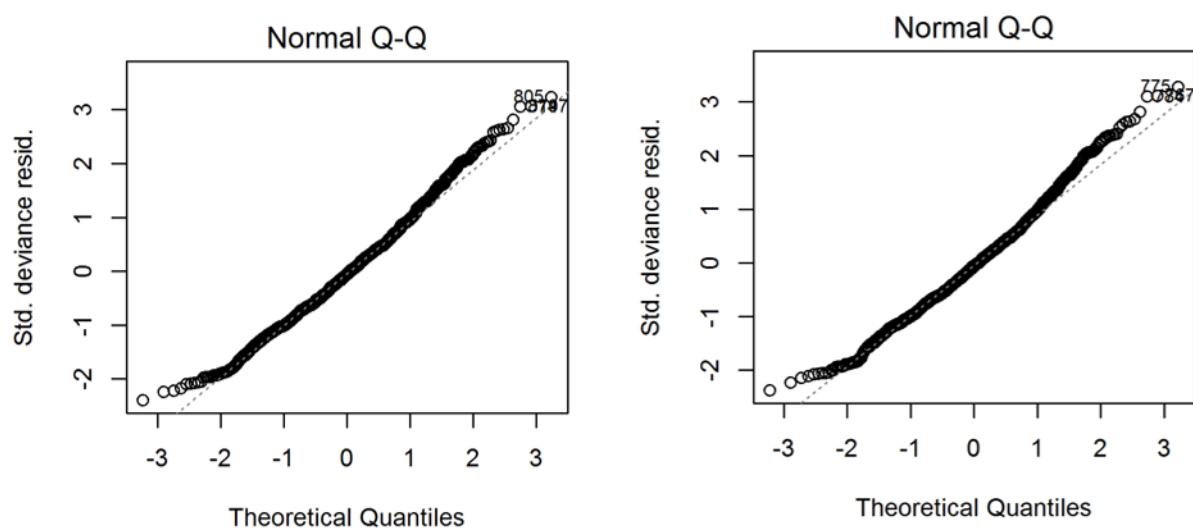


Figure 7: Q-Q plot used to validate the goodness of fit of the lognormal portion (positive catch) of the Marine Recreational Fisheries Statistics Survey (MRFSS) party/charter dockside survey, for thresholds of 0.27 (left) and 0.10 (right) from the Stephens-MacCall filter. fig:Fleet5_RecPC_

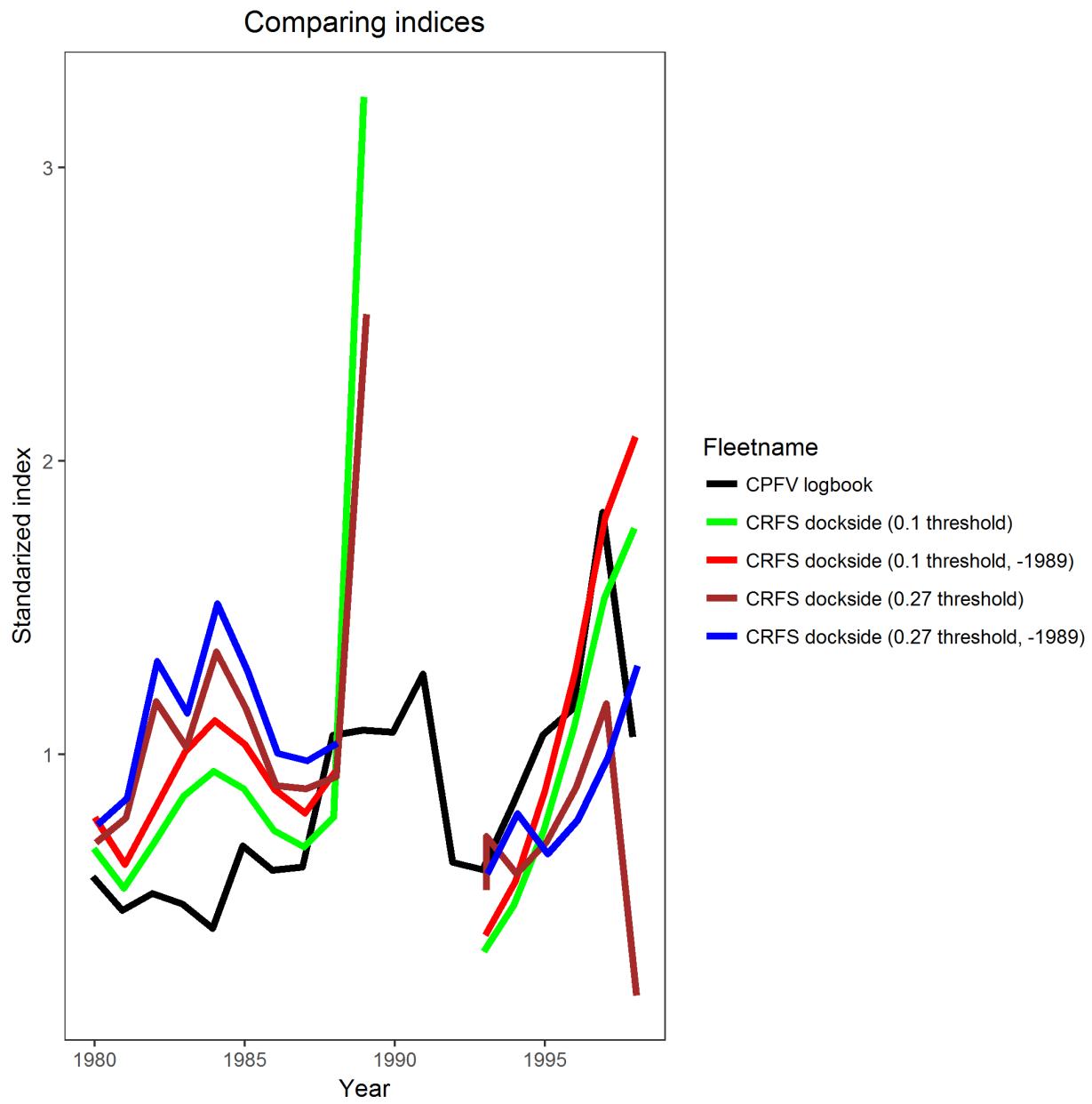


Figure 8: Comparison of standardized indices using two different threshold levels (0.27 and 0.1) from the Stephens-MacCall filtering, and including or excluding the year 1989.

Log index RecPC

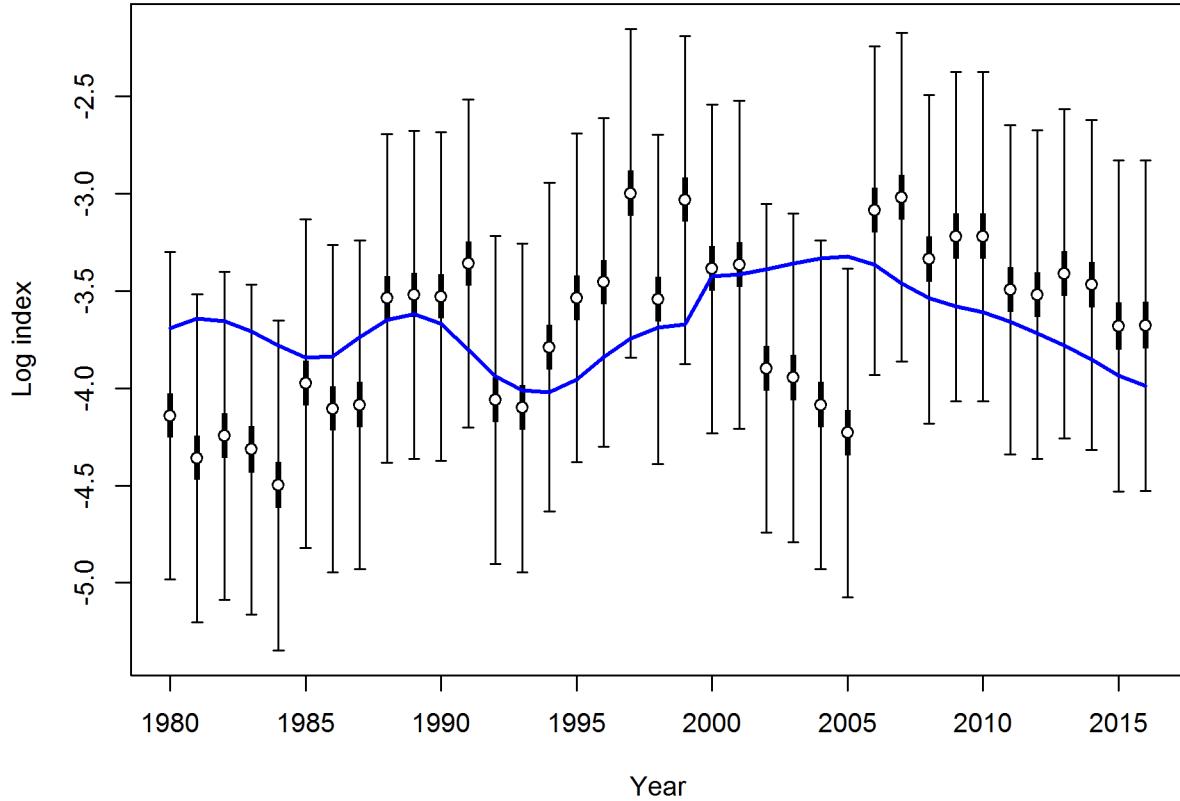


Figure 9: Fit to log index data on log scale for the recreational CPFV logbook retained catches. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. fig:index5_logcpuefit

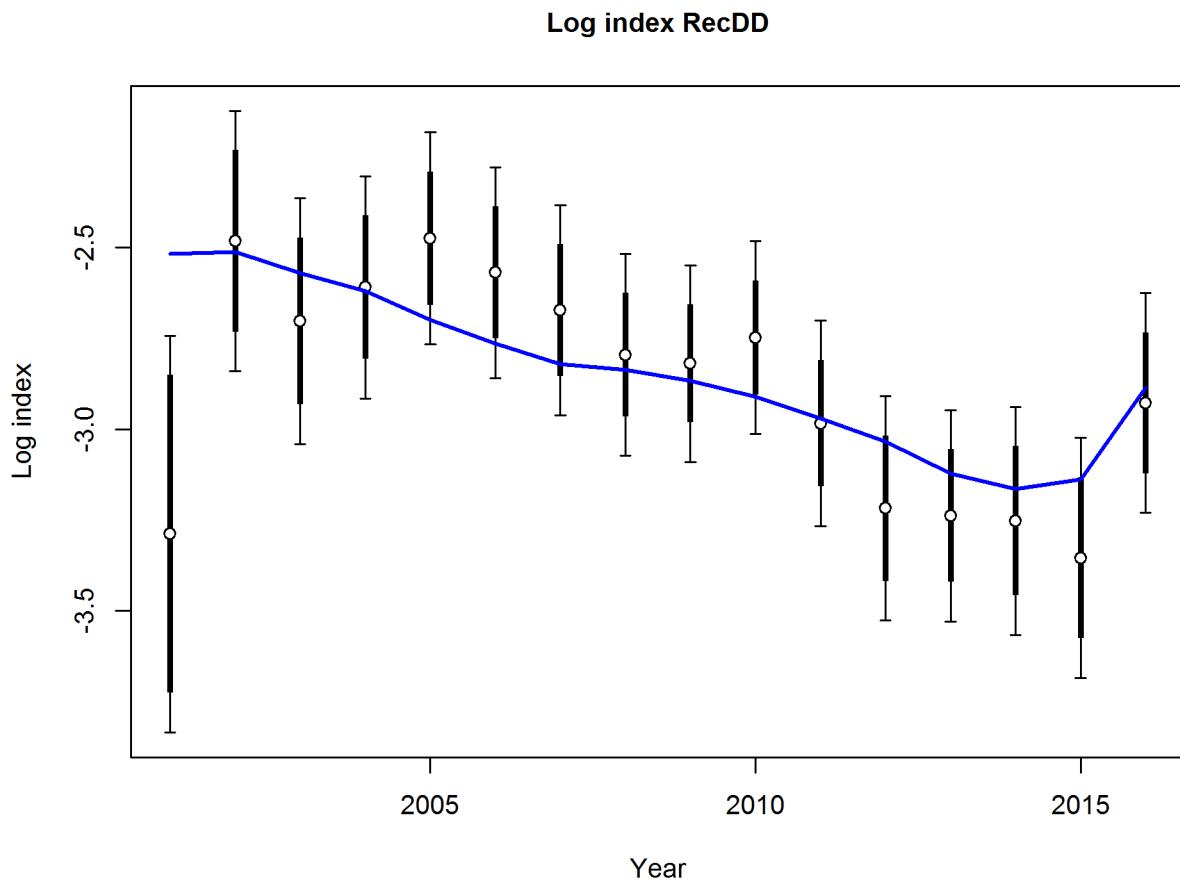


Figure 10: Fit to log index data on log scale for the recreational CPFV onboard observer discarded catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

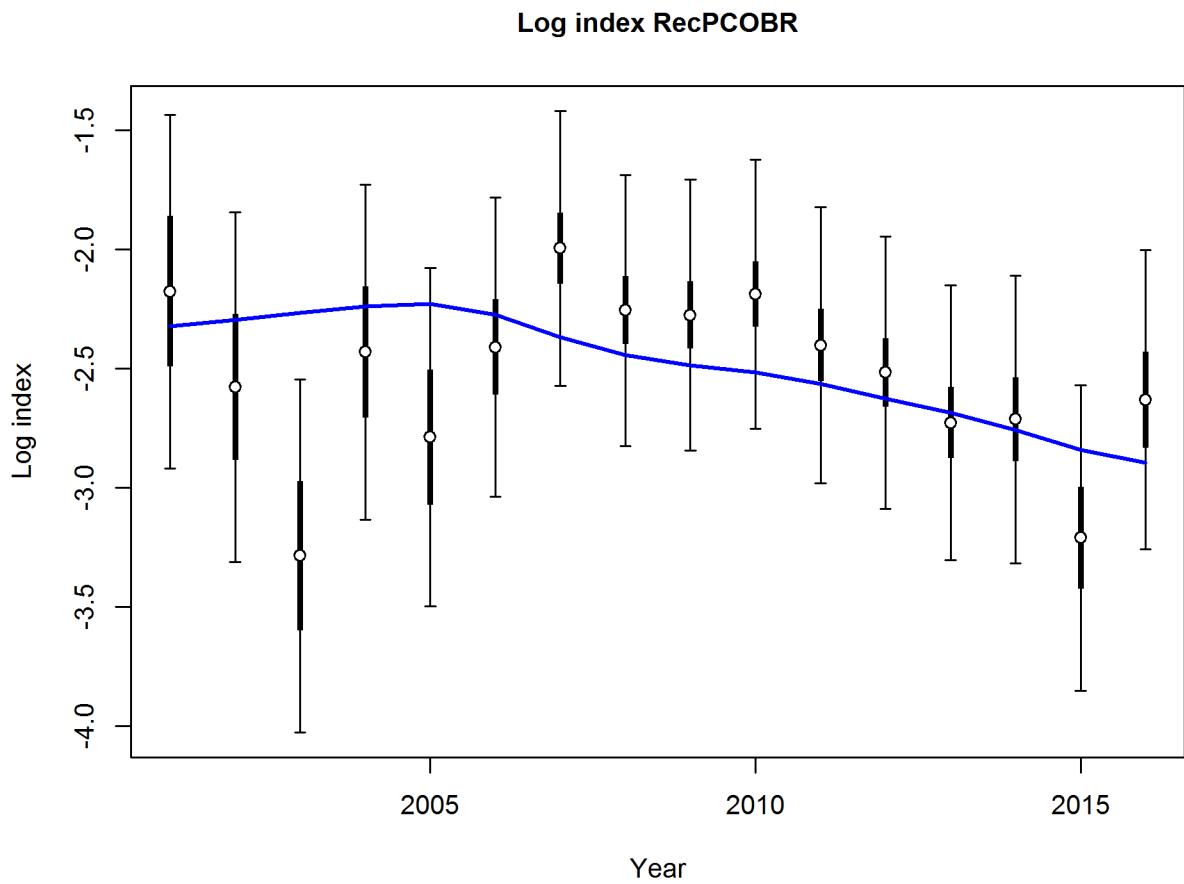


Figure 11: Fit to log index data on log scale for the recreational CPFV onboard observer retained catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.
fig:index5_logcpuefit_RecPCOB

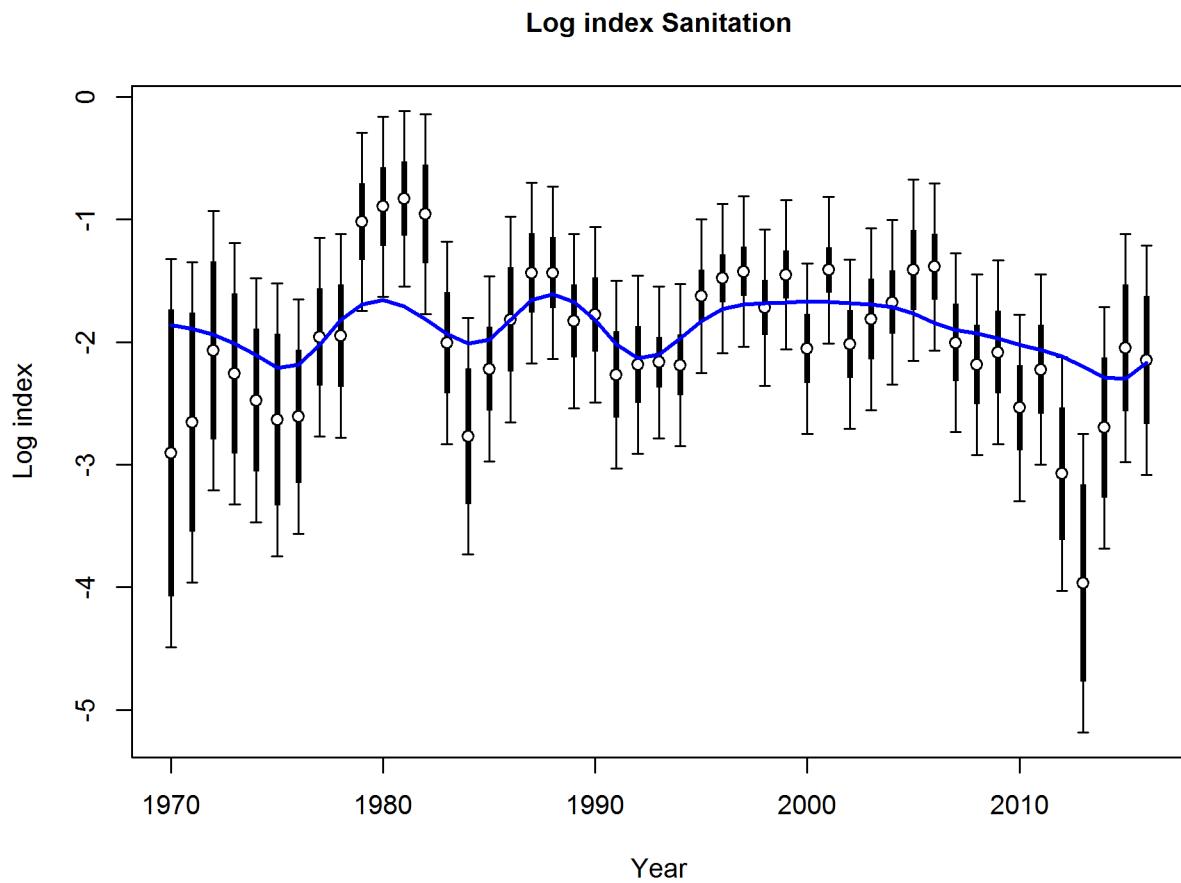


Figure 12: Fit to log index data on log scale for the recreational CPFV onboard observer discarded catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.
`fig:index5_logcpuefit_Sanitation`

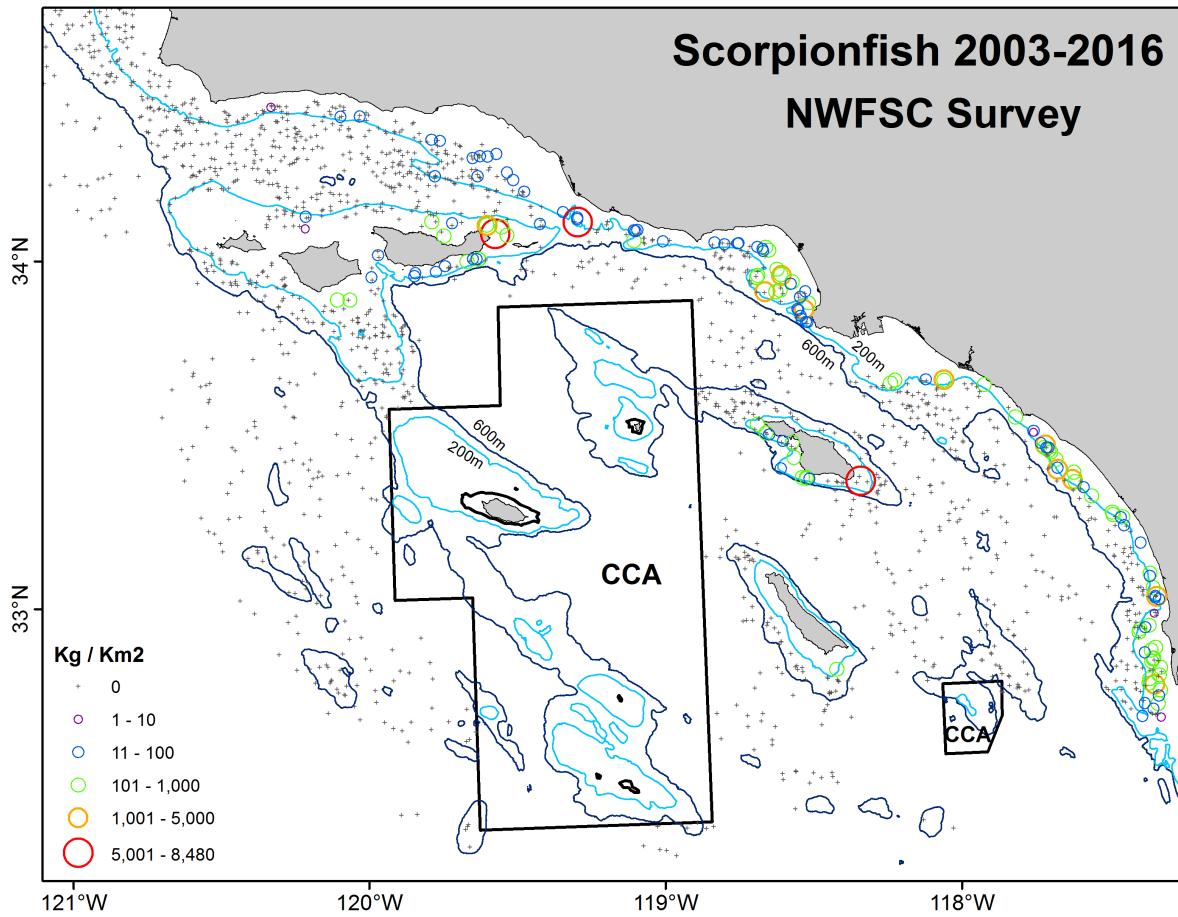


Figure 13: Spatial distribution of raw catch rates of Scorpionfish from NWFSC trawl survey between 2003 and 2016. Depth contour lines of 200m and 600m and the CAC areas are shown. Note that sizes and colors of circles represent catch rate in log scales (Credit of Rebecca Miller, SWFSC). [fig:Fleet8_NWFSCtrawl_map](#)

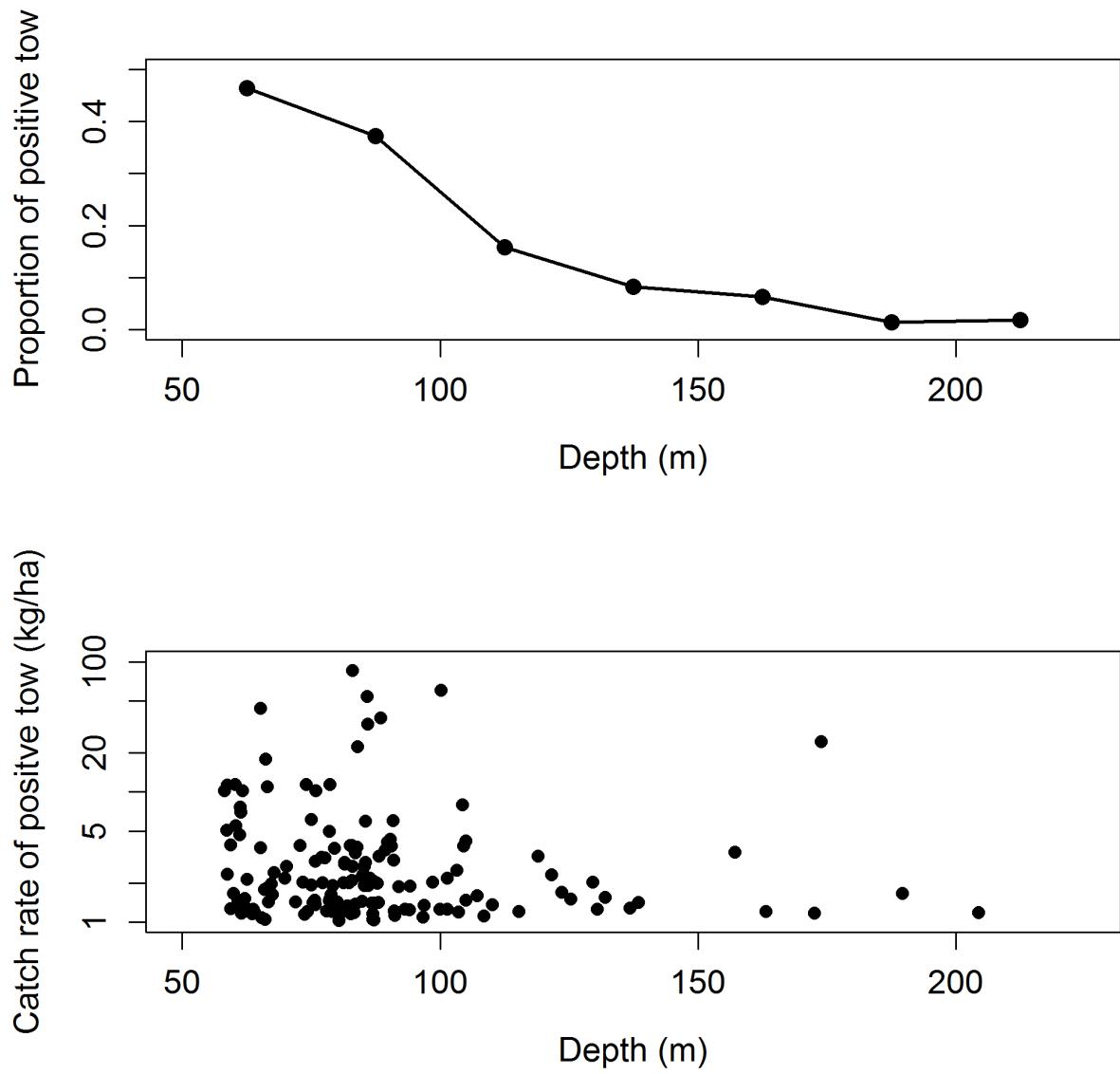


Figure 14: Plots of the proportion of positive tows (top panel) and the raw catch rates of positive tows (bottom panel) by depth zones (25 m interval) for NWFSC trawl survey. fig:Fleet8_NWFSC

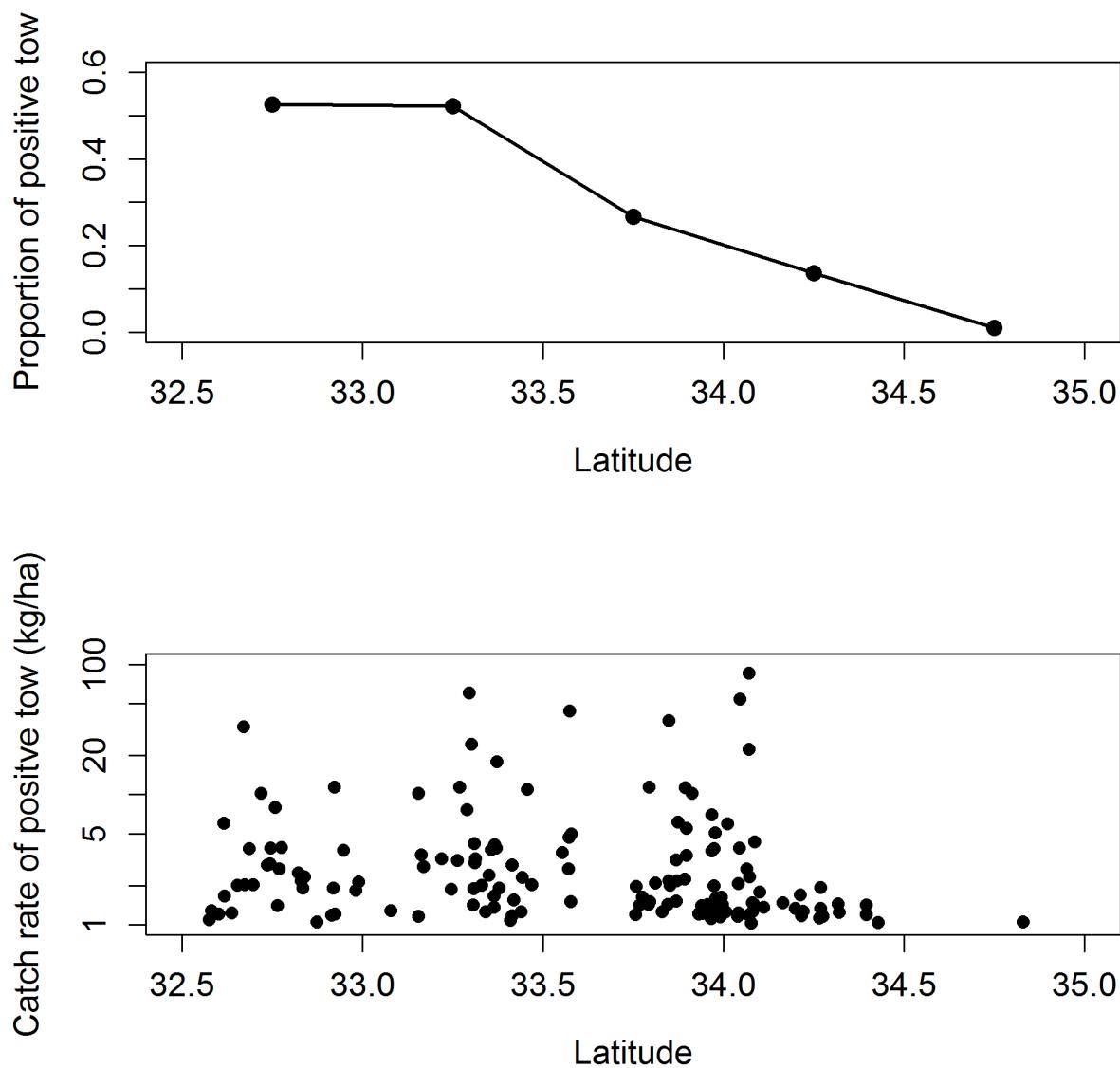


Figure 15: Plots of the proportion of positive tows (top panel) and the raw catch rates of positive tows (bottom panel) by latitude zones (0.5 degree interval) for NWFSC trawl survey.
`fig:Fleet8_NWFSCtrawl_poslat`

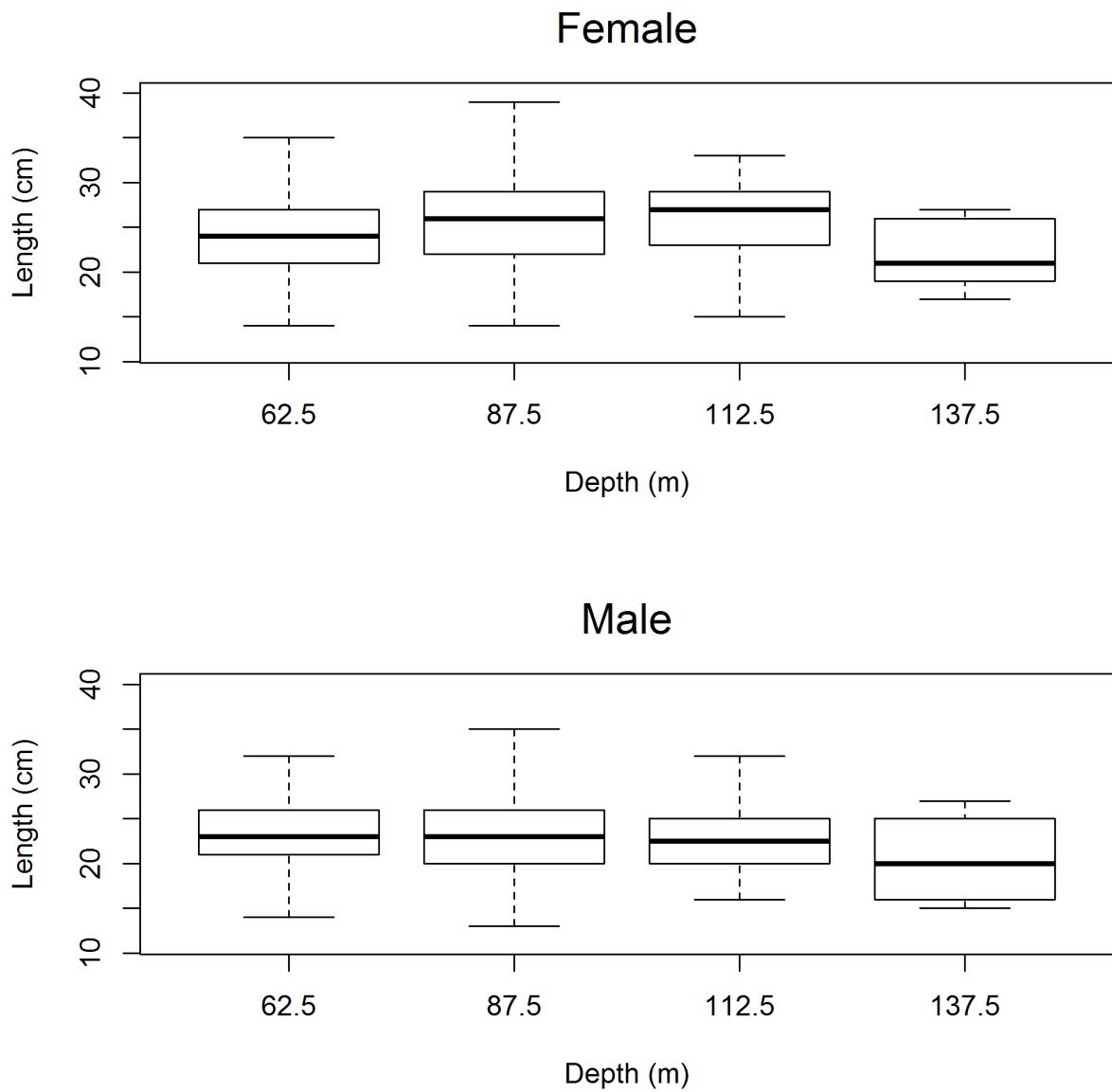


Figure 16: Comparison box plots of raw length data from NWFSC trawl survey by depth zone and sex. [fig:Fleet8_NWFSCtrawl_lengthdepth](#)

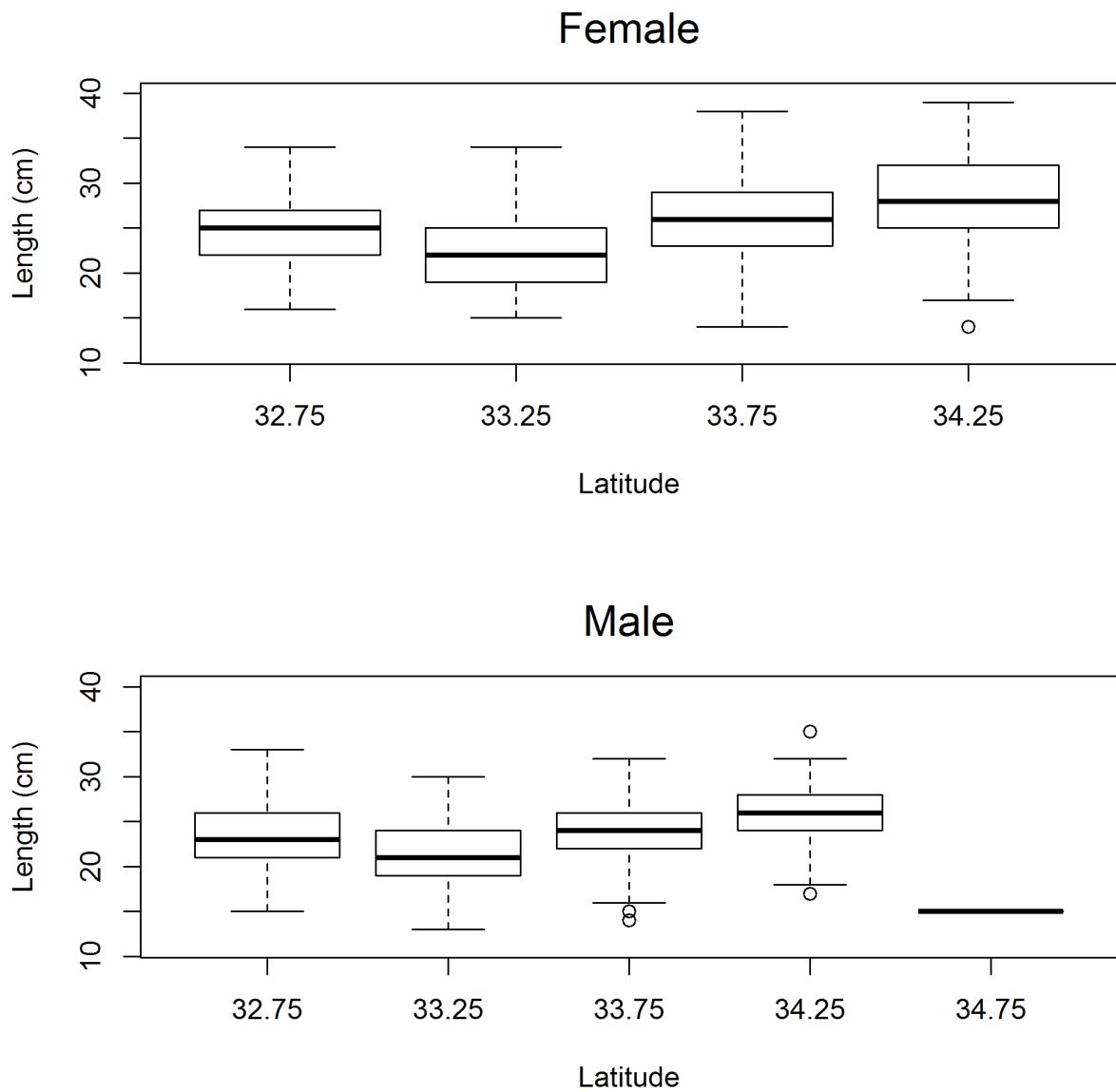


Figure 17: Comparison box plots of raw length data from NWFSC trawl survey by latitude zone and sex. fig:Fleet8_NWFSCtrawl_lengthlat

Length comp data, whole catch, NWFSC Trawl (max=0.15)

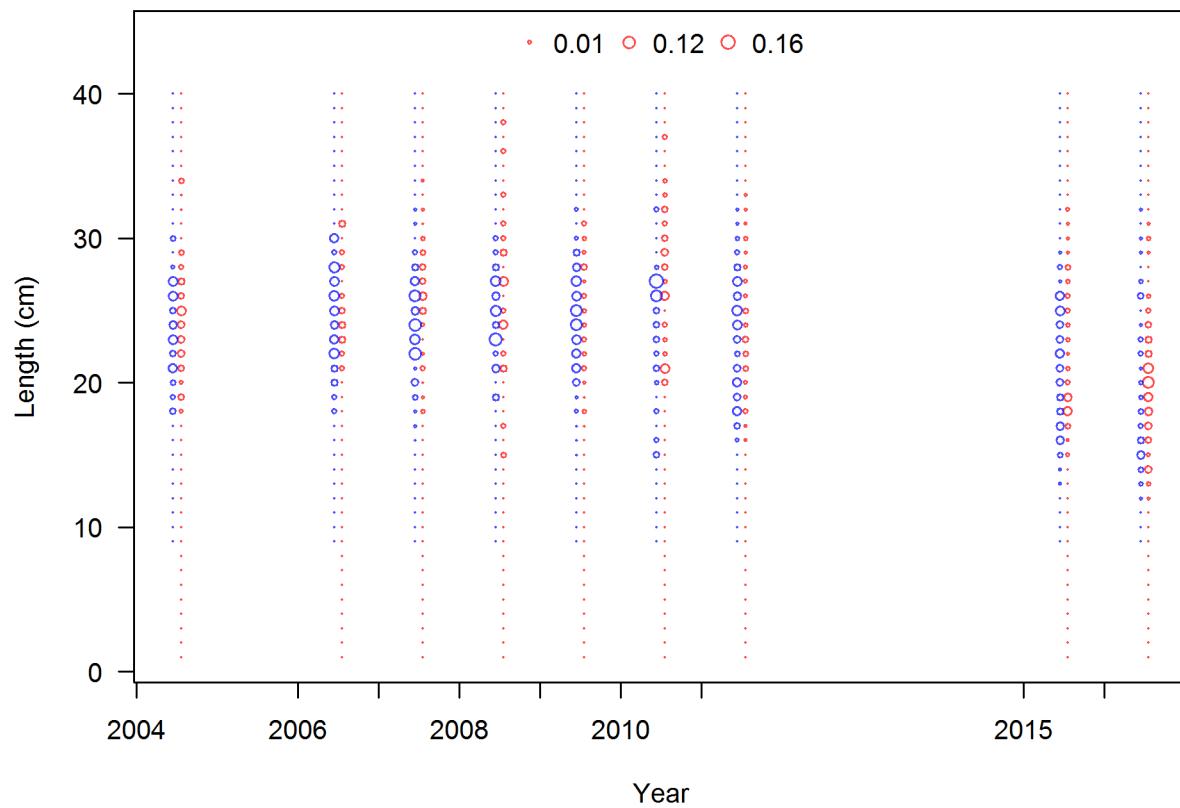


Figure 18: Length frequency distributions of females (red) and male (blue) from the NWFSC trawl survey between 2003 and 2016. | [fig:Fleet8_comp_1endat_bubflt8mkt0](#)

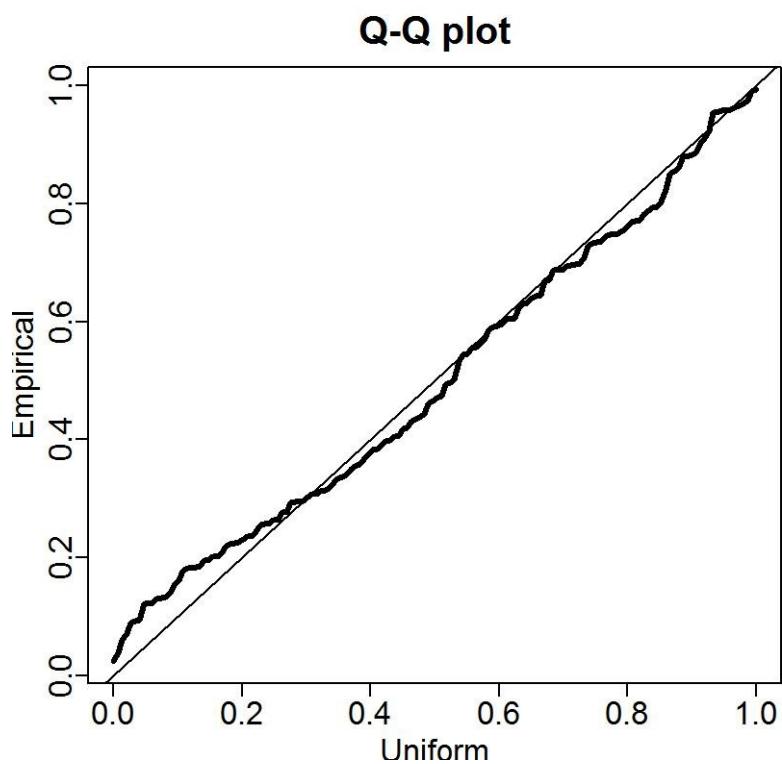


Figure 19: Q-Q plot used to validate the goodness of fit of the VAST analysis for the NWFSC trawl survey between 2003 and 2016. fig:Fleet8_NWFSCtrawl_QQ

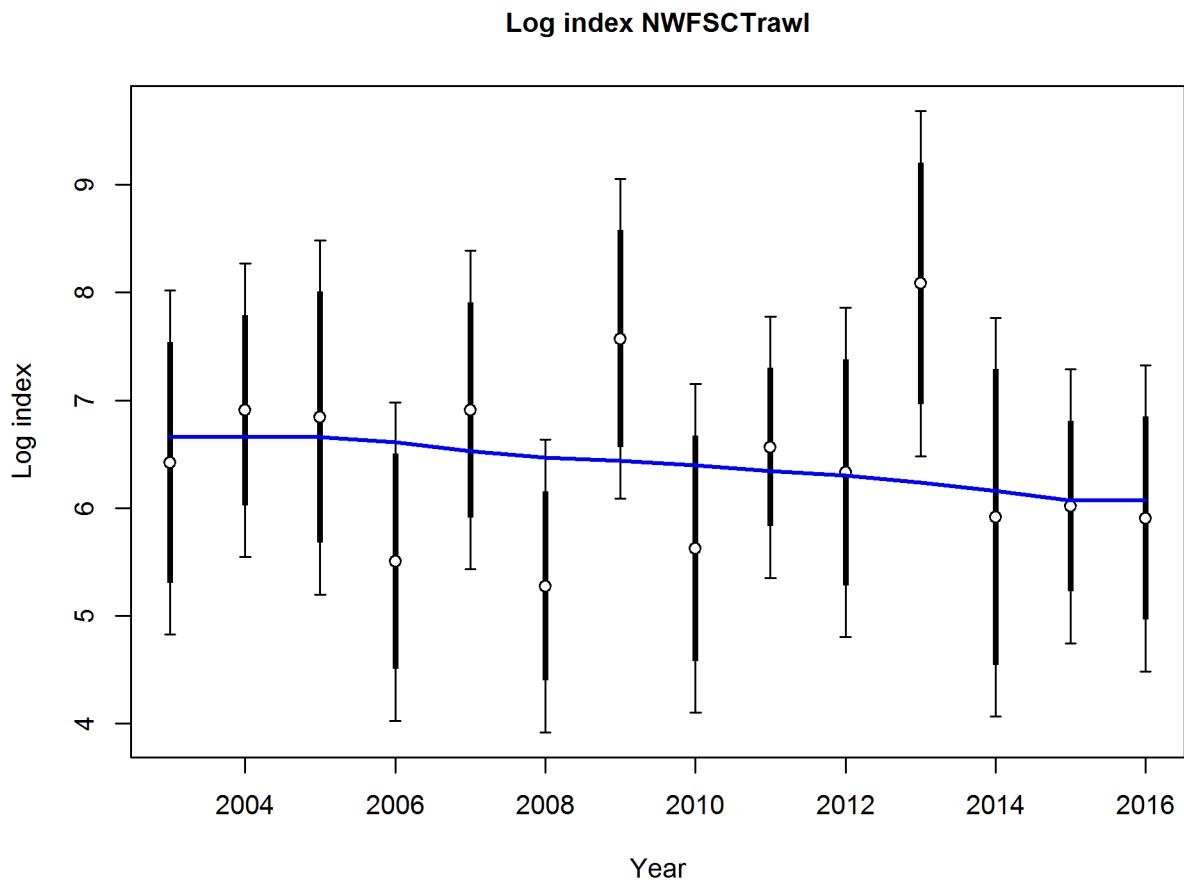


Figure 20: Fit to log index data on log scale for the NWFSC trawl survey from the VAST analysis from 2003-2016. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.
`fig:index5_logcpuefit_NWFSCtrawl`

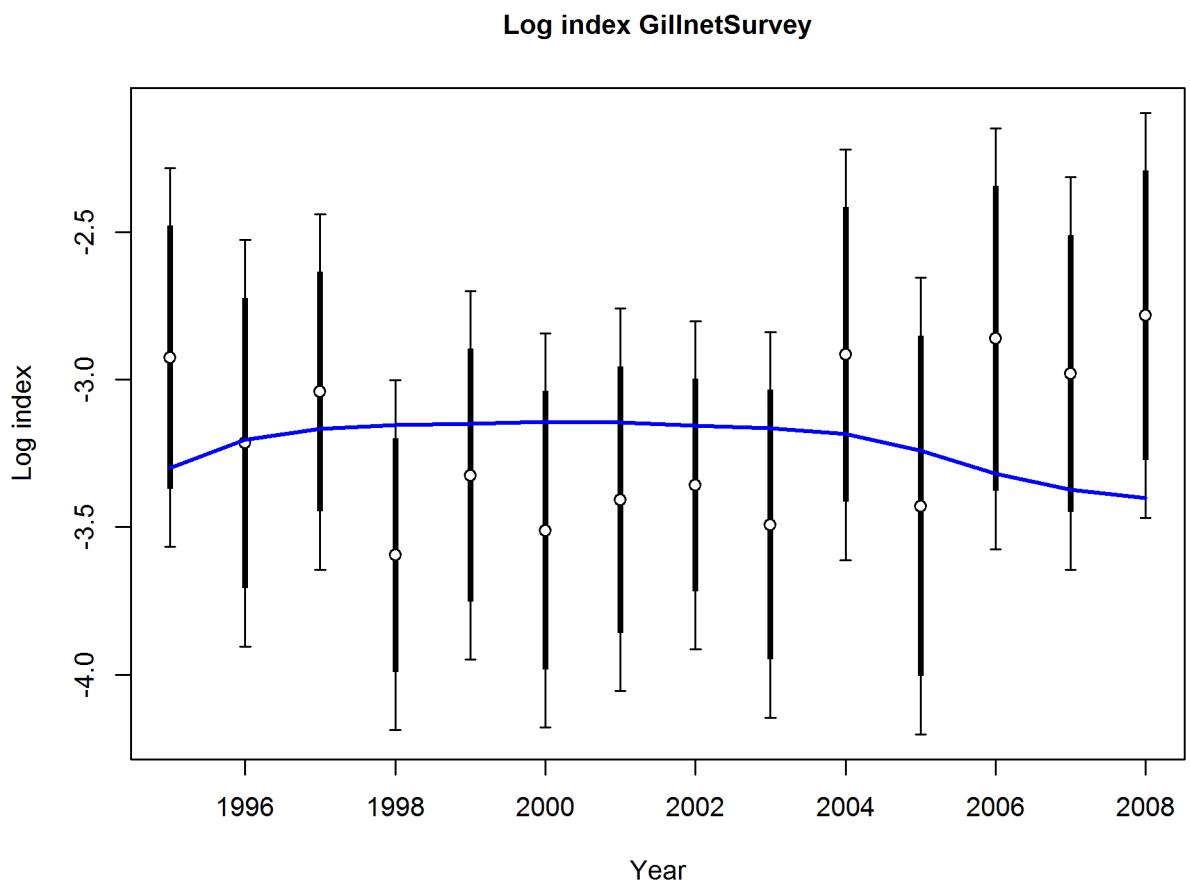


Figure 21: Fit to log index data on log scale for the recreational CSUN/VRG gillnet survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

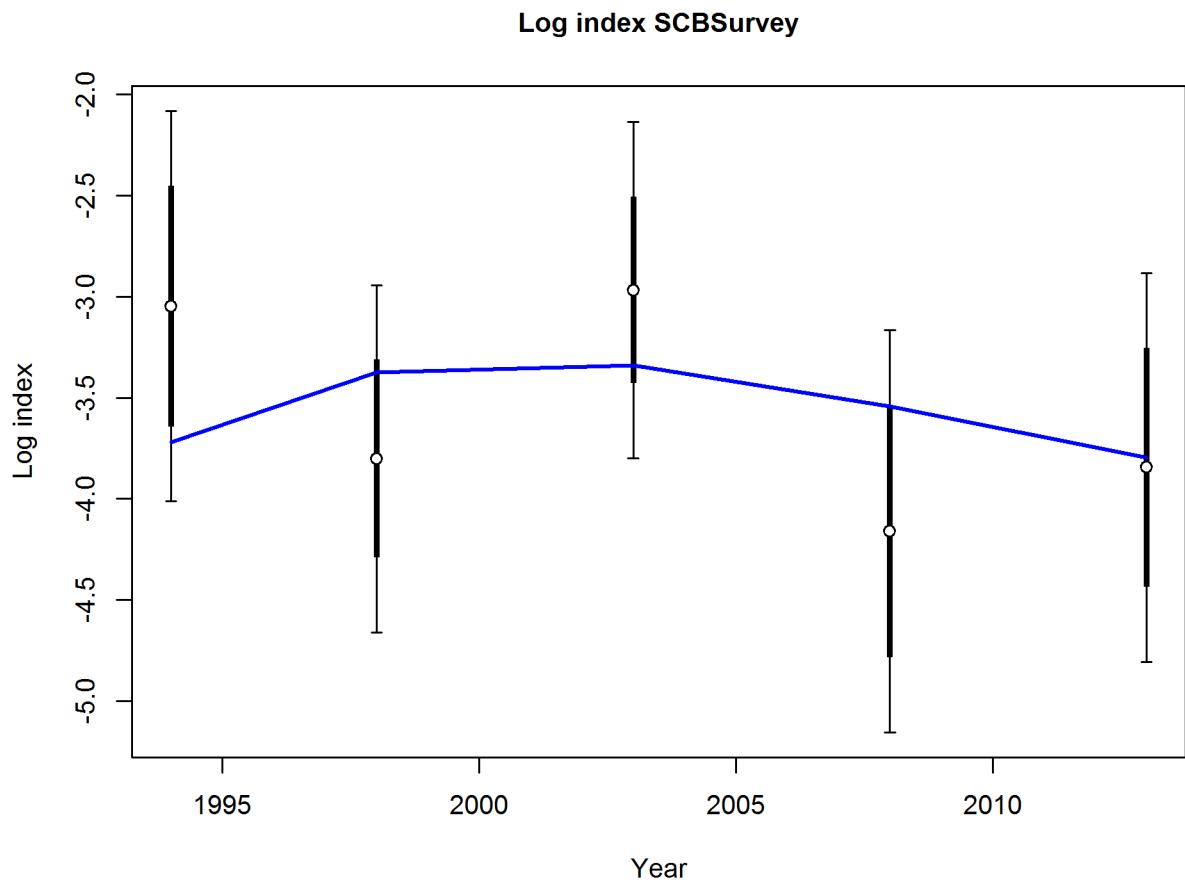


Figure 22: Fit to log index data on log scale for the recreational Southern California Bight trawl survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. fig:index5_log

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