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

Melissa H. Monk[1]
Xi He[1]
John Budrick[2]

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

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

DRAFT SAFE

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

Contents

Executive Summary

executive-summary

Stock

stock

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

Catches

catches

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

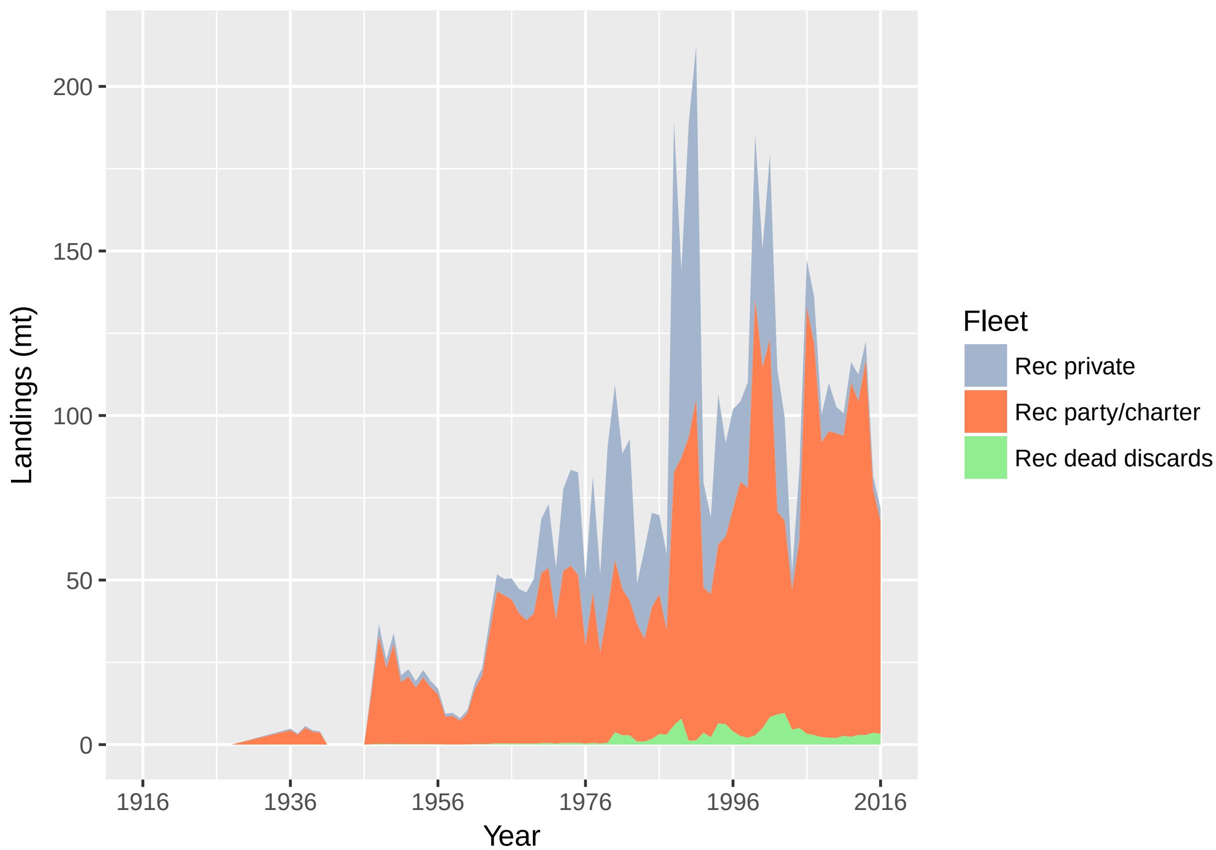

Figure a: California scorpionfish landings history for the recreational fleets. fig:Exec_catch1

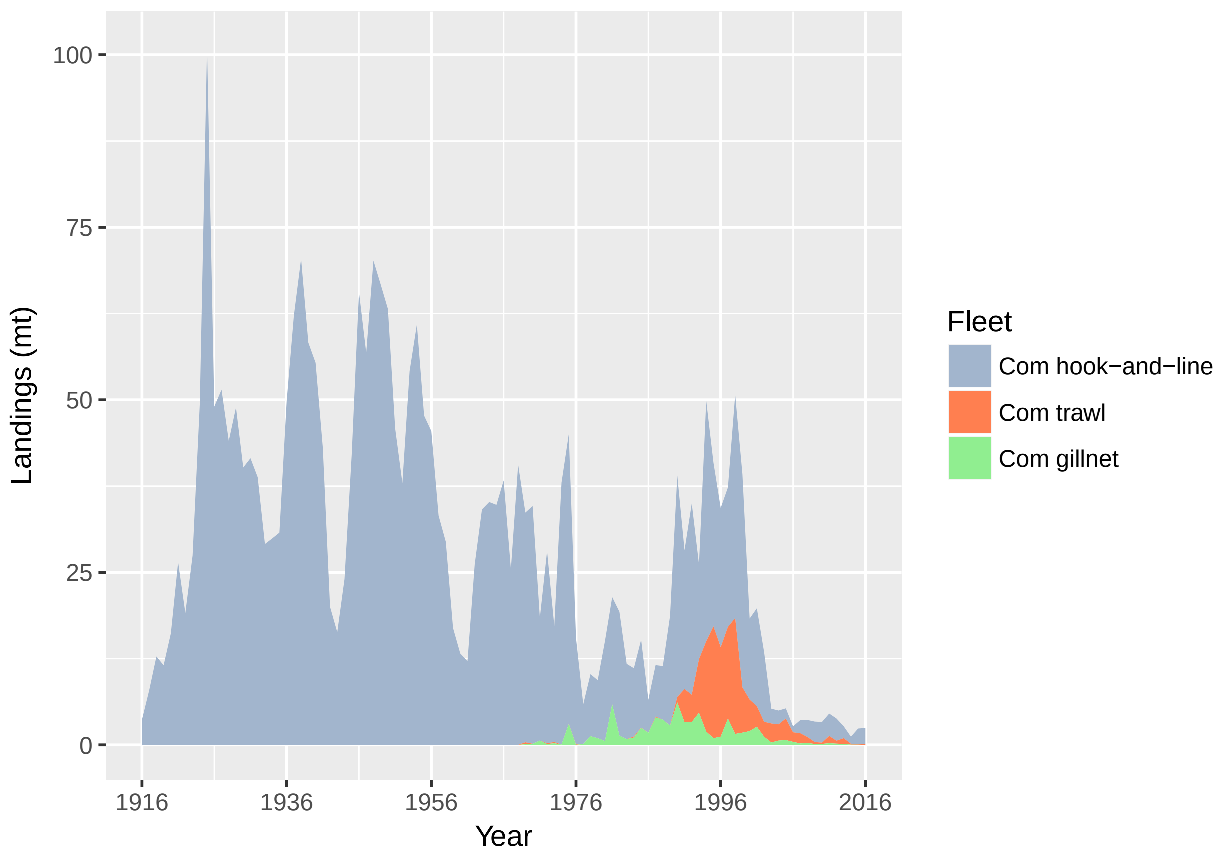

Figure b: Stacked line plot of California scorpionfish landings history for the commercial fleets. [fig:Exec_catch2]

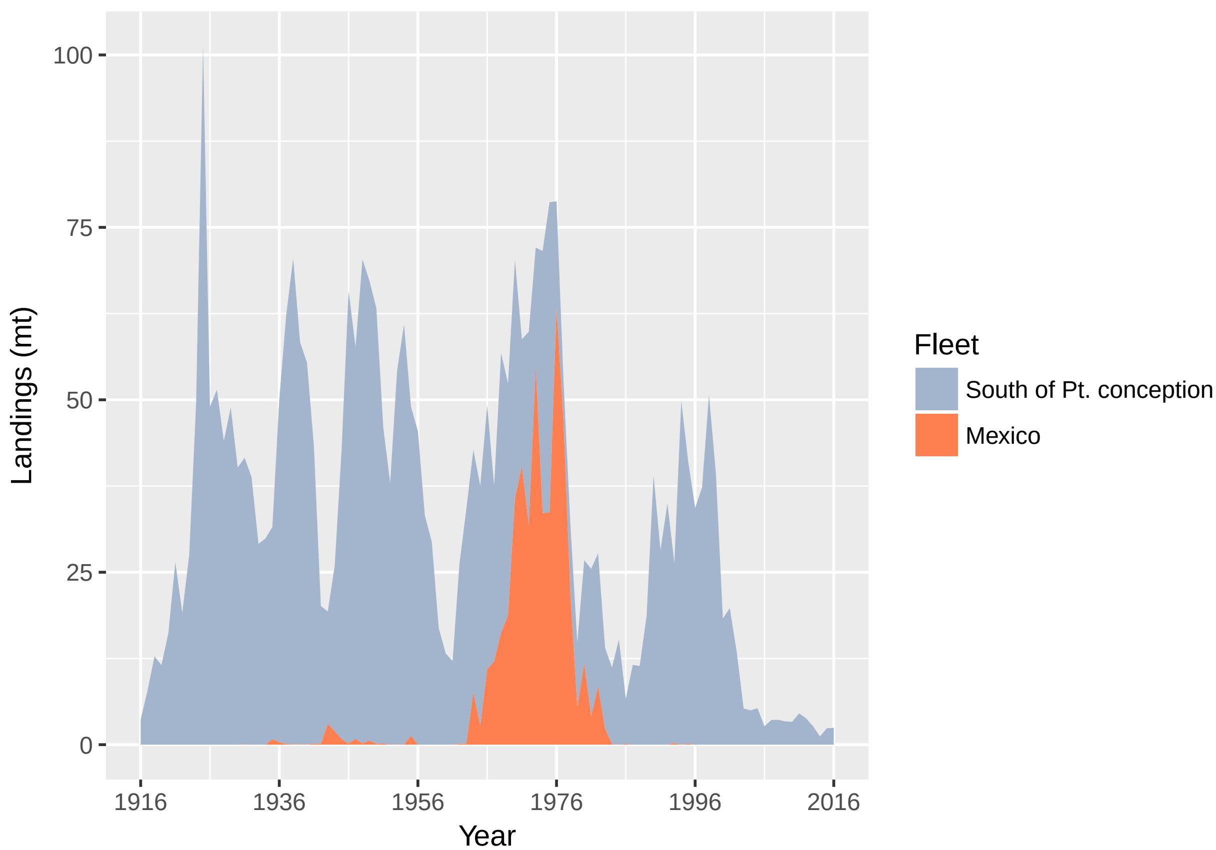

Figure c: Stacked line plot of California scorpionfish landings history by region, north of Pt. Conception, between Pt. Conception and the U.S.-Mexico border, and Mexican waters. fig:Exec_catch3

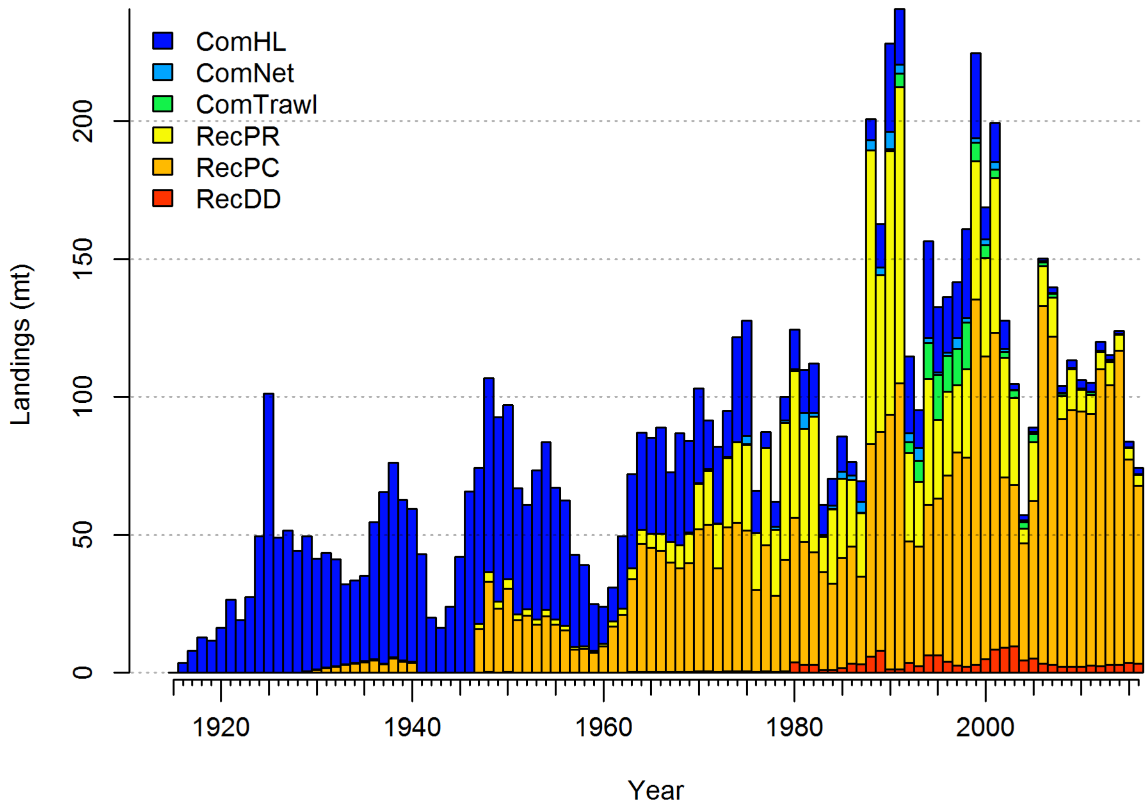

Figure d: Landings history of California scorpionfish in the base model. fig:r4ss_catches

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

tab:Exec_catch

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

Data and Assessment

data-and-assessment

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

Map of assessment region: (Figure e).

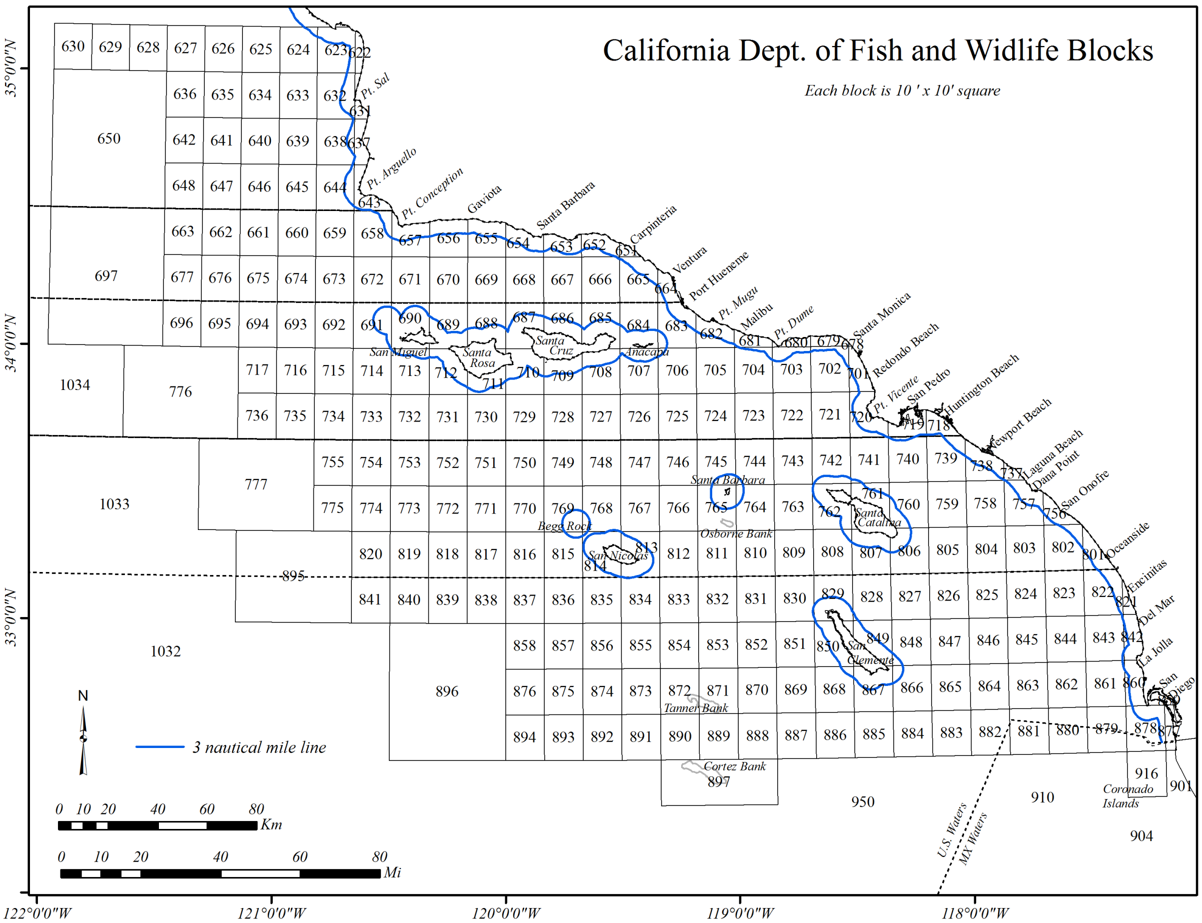

Figure e: Map depicting the boundaries for the base-case model. fig:assess_region_map

Stock Biomass

stock-biomass

Spawning output Figure: Figure f
Spawning output Table(s): Table b
Relative depletion Figure: Figure g

The estimated relative depletion level (spawning output relative to unfished spawning output) of the the base-case model in 2016 is 55.6% (~95% asymptotic interval: ± 40.5%-70.7%) (Figure g).

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

tab:SpawningDeplete_mod1

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)

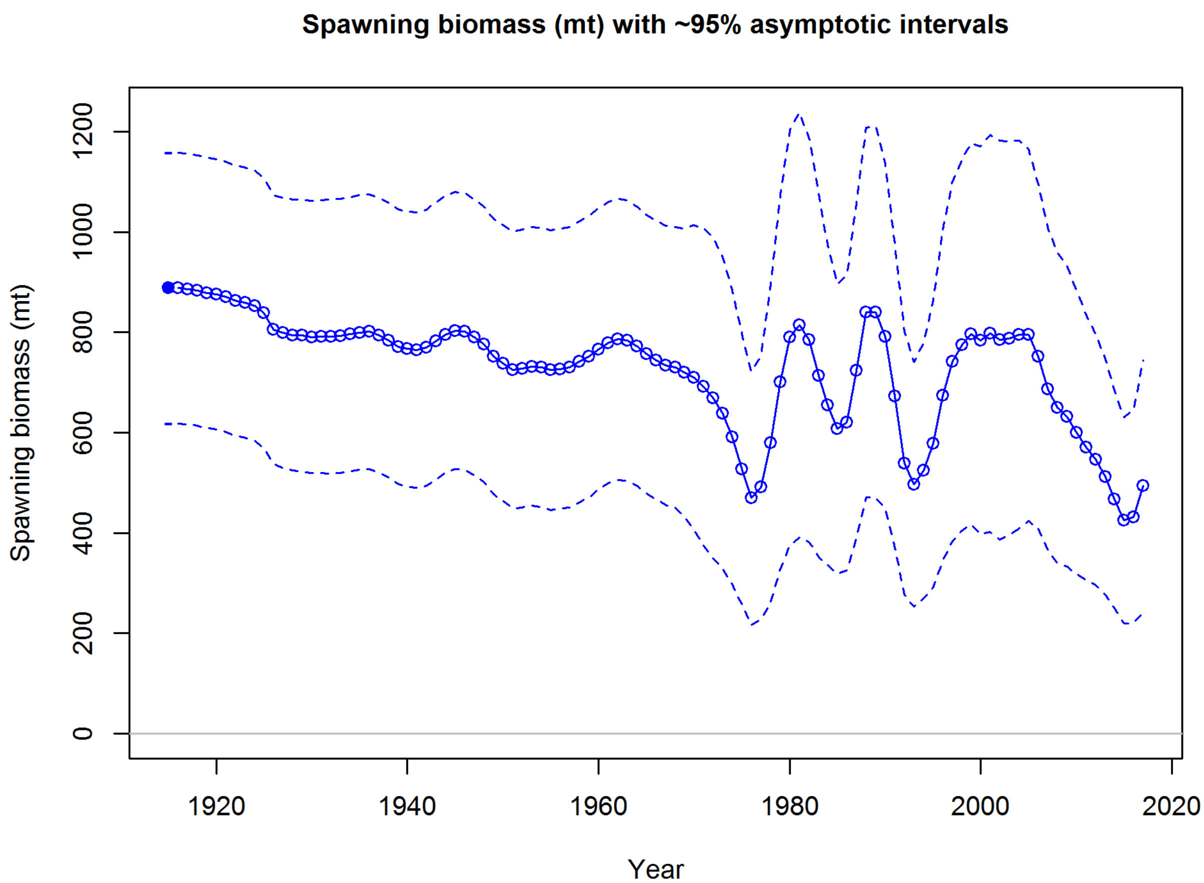

Figure f: Time series of spawning output trajectory (circles and line: median; light broken lines: 95% credibility intervals) for the base case assessment model. fig:Spawnbio_all

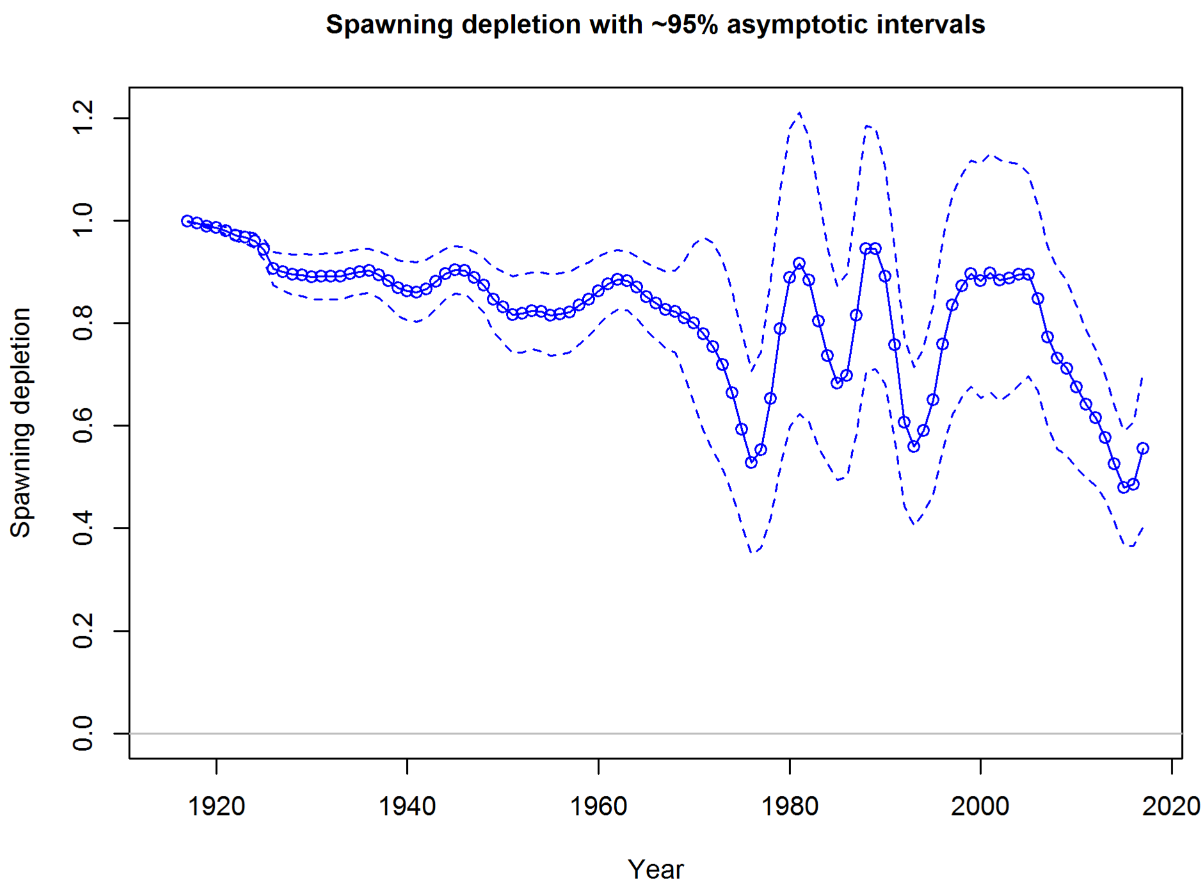

Figure g: Estimated relative depletion with approximate 95% asymptotic confidnce intervals (dashed lines) for the base case assessment model. fig:RelDeplete_all

Recruitment

recruitment

Recruitment Figure: (Figure h)
Recruitment Tables: (Tables c

Table c: Recent recruitment for the base model.

tab:Recruit_mod1

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)

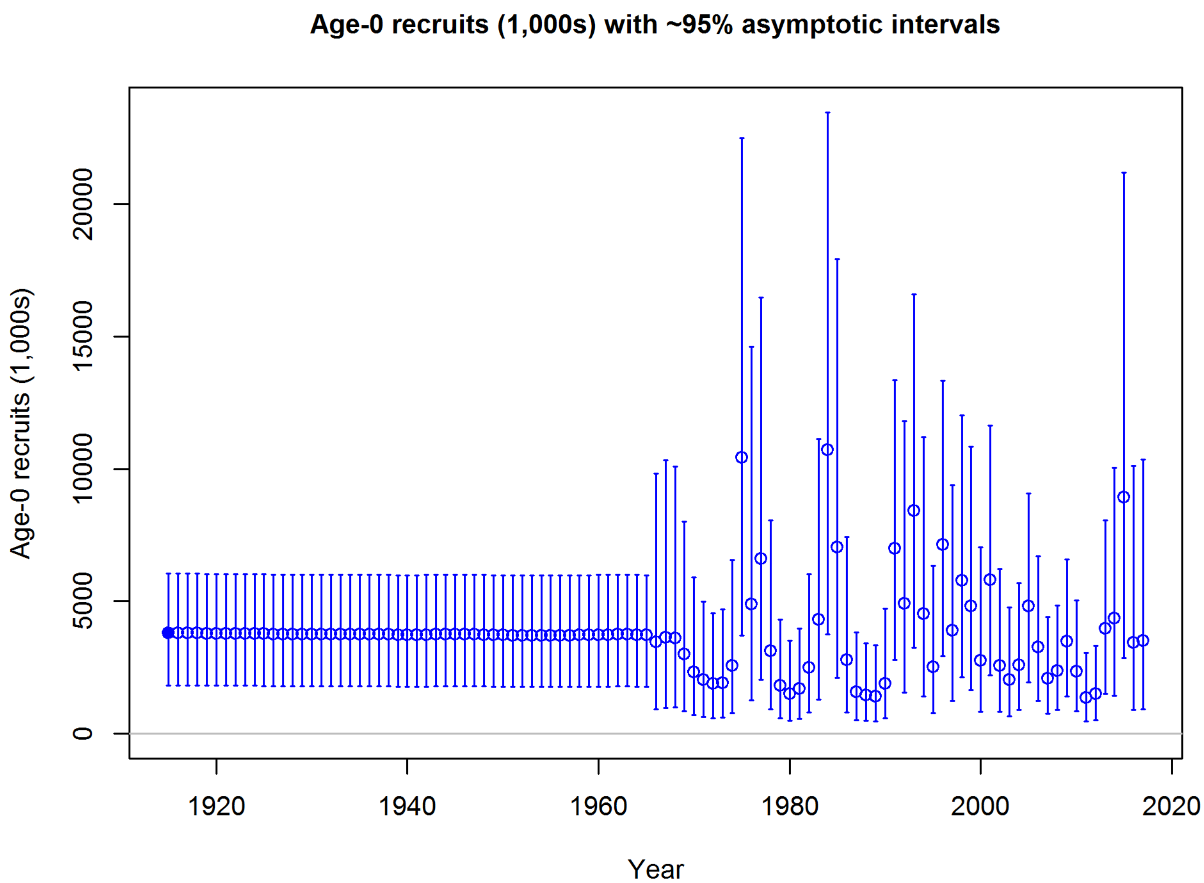

Figure h: Time series of estimated California scorpionfish recruitments for the base-case model with 95% confidence or credibility intervals. fig:Recruits_all

Exploitation status

exploitation-status

Exploitation Tables: Table d Exploitation Figure: Figure i).

A summary of California scorpionfish exploitation histories for base model is provided as 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}.

tab:SPR_Exploit_mod1

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)

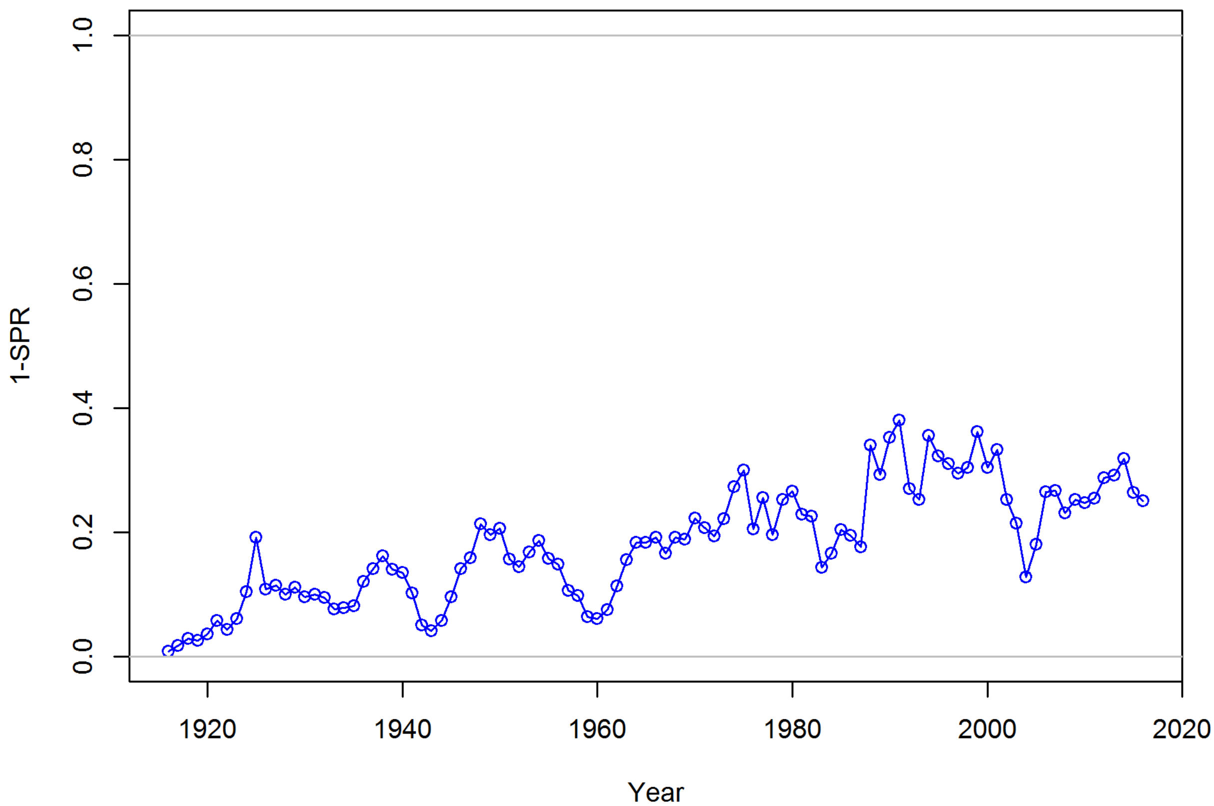

Figure i: Estimated spawning potential ratio (SPR) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing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

Ecosystem Considerations

ecosystem-considerations

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

Reference Points

reference-points

This stock assessment estimates that California scorpionfish in the base model are above the biomass target, but above the minimum stock size threshold. Add sentence about spawning output trend. The estimated relative depletion level for Model 1 in 2016 is 55.6% (~95% asymptotic interval: ± 40.5%-70.7%, corresponding to an unfished spawning output of 493.509 mt (~95% asymptotic interval: 242.88-744.14 mt) of spawning output in the base model (Table e). Unfished age 1+ biomass was estimated to be 2218.6 mt in the base case model. The target spawning output based on the biomass target ($SB_{40\%}$) is 355.2 mt, which gives a catch of 218.4 mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is 205.4 mt.

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

tab:Ref_pts_mod1

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 $\mathbf{SB_{40\%}}$		
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)

Management Performance

management-performance

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.

tab:mnmgt_perform

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	-	-	-	-

Unresolved Problems And Major Uncertainties

unresolved-problems-and-major-uncertainties

TBD after STAR panel

Decision Table

decision-table

OFL projection table: Table g

Decision table(s) Table h

```
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

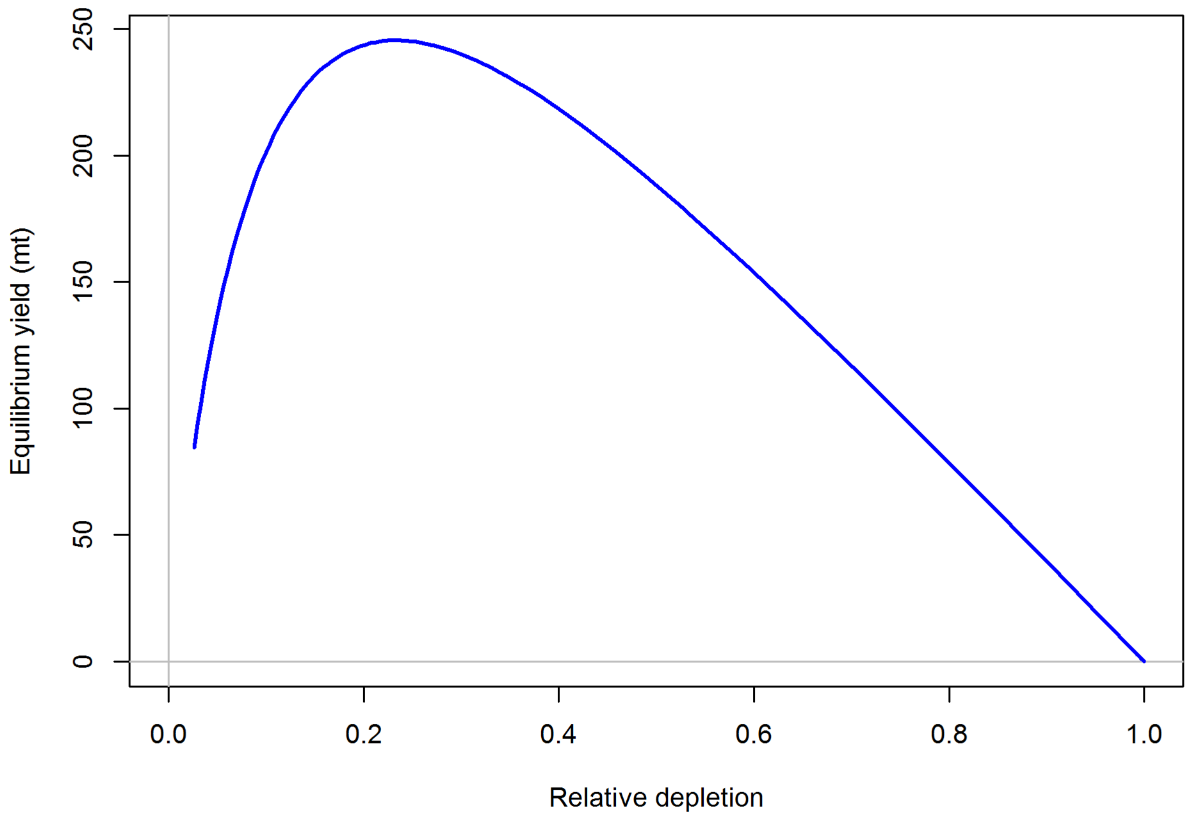

Figure j: Equilibrium yield curve for the base case model. Values are based on the 2016 fishery selectivity and with steepness fixed at... fig:Yield_all

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.

tab:Decision_table_mod1

			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	Depletion
	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
40-10 Rule, Low M	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-
	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
40-10 Rule	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-
	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
40-10 Rule, High M	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-
	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
Average Catch	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-

Table i: Base case results summary.

tab:base_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	1424.08
Spawning Output	649.3	632.1	599.9	570.0	546.6	511.6	467.0	425.1	431.6	493.5
95% CI	(339.09-959.49)	(332.7-931.47)	(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)

Research And Data Needs

research-and-data-needs

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

1. List item No. 1 in the list
2. List item No. 2 in the list, etc.

1 Introduction

introduction

1.1 Basic Information and Life History

basic-information-and-life-history

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

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

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

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

1.2 Early Life History

early-life-history

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

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

1.3 Map

`map`

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

1.4 Ecosystem Considerations

`ecosystem-considerations-1`

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

1.5 Fishery Information

`fishery-information`

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

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

"[Scorpionfish] will even come to the surface to lights at night" and were also taken in round haul nets. At that time, scorpionfish were rarely targeted by fishermen except by a few specialists.

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

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

Aggregate mortality has been far below the Annual Catch Limits (ACL) established by the 2005 stock assessment. The ACL projections from the 2005 assessment assumed that the entire ACL was being taken each year and as a result, the ACL for each subsequent year declined despite under-attainment in reality.
In addition, in 2014, recreational catch was higher than expected. As a result, in 2014, the combined recreational and commercial catch exceeded the OFL by 2mt (1%) resulting from assumption that the ACL had been attained. Subsequently, action was taken to decrease the recreational season by four months (September 1 - December 31). A catch only update of the stock was undertaken in 2015 (Wallace and Budrick 2015) that imputed the actual catch values since the last assessment, resulting in significant increase in the OFL and ACL.
Retrospectively, the catch in 2014 was well below the OFL as well as the ACL that would have been in place had the ACL values from the actual attainment been in place in 2014.
Thus the stock has not been subject to overfishing since the original assessment or been in an overfished condition historically and is considered healthy.
The season restriction in the recreational fishery remained in place as a precautionary measure until the full assessment is completed to better inform the current status of the stock, catch limits and regulations given the perspective provided.

1.6 Summary of Management History

summary-of-management-history

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

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

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

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

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

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

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

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

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

1.7 Management Performance

`management-performance-1`

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

1.8 Fisheries off Mexico

`fisheries-off-mexico`

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

2 Assessment

`assessment`

2.1 Data

`data`

Data used in the California scorpionfish assessment are summarized in Figure 2.
A description of each data source is below.

2.1.1 Commercial Fishery Landings

`commercial-fishery-landings`

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

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

Statewide annual landings are available for California scorpionfish from 1916 to 1925, and are assumed to be taken by hook-and-line. Data by area and month are given in a series of bulletins, each bulletin usually providing information for a single year. Data by region and month is available for 1926 to 1986. The Santa Barbara region includes San Luis Obispo, Santa Barbara and Ventura counties. Catches from this region were included in the catch history and comprised less than 10 mt for the period from 1926-1968 (the period when data at the regional scale are available).
Catches from Mexico can be separated from the total catch starting in 1931, although the CDFG Bulletins do not report catches originating from Mexican waters available for all years, e.g., 1932-1934. It is assumed that before 1931 there was no catch taken from Mexican waters landed in California.

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

The Commercial Fisheries Information System (CFIS; maintained by CDFW) contains California catch in pounds by gear and port for 1969 to 2016 (Figures). The CFIS data come from landing receipts or "fish tickets" filled out by the markets or fish buyers as required by the state for all commercial landings. The fish tickets include the CDFW block in which the majority of the landings were caught.
Landings with a block solely in Mexican waters (blocks >900) were removed from the catch history. Landings with reported blocks 877-882 with area in both U.S. and Mexican waters were retained in the catch histories. The commercial catch is dominated by the hook-and-line fishery (89% of total catches).
The catch by reported gear types: hook-and-line, fish pot, trawl, gill net, and other can be found in Table 1. Catch taken by fish pot and other gears is added to the hook-and-line catch in the stock assessment (30.6 mt from fish pot and 93.9 mt from other gears).

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

2.1.2 Commercial Discards

`commercial-discards`

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

2.1.3 Sport Fishery Removals and Discards

sport-fishery-removals-and-discards

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

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

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

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

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

2.1.4 Fishery-dependent Data Sources

`fishery-dependent-data-sources`

MRFSS Dockside Private Boat Survey

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

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

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

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

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

Catch per unit effort was modeled using a delta-GLM approach, where the catch occurrence (binomial) component was modeled using a logit link function and the positive catch component was modeled after log-transformation of the response variable, according to a normal distribution with an identity link function. The units for CPUE are fish landed/anglers. A gamma distribution for the positive catch component was also explored, but model selection favored the lognormal model. The raw CPUE of factors considered in the model by year are shown in Figure 5.

Model selection procedures selected the covariates *2-month wave* and *county* as important for both the catch occurrence and positive catch component models for all data sets, along with the categorical year factor used for the index of abundance (Table 4).
The Q-Q goodness of fit plot for the lognormal portion of the model shows a moderate fit to the data (Figure 6). final index indicates a decrease in relative abundance from 2006 to 2010, at which point the index is relatively flat (Figure 7).

CRFS CPFV Logbook Index

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

The number of anglers on board the vessel and the hours fished are included in the database for all years. Only retained fish are included in the index of abundance the the unit of effort is angler hours. A number of data filters were applied to the data to account for possible mis-reporting, e.g., trips reporting retained California scorpionfish in top 1% of the data (>325 fish). Trips fishing outside of California scorpionfish habitat (reported as targeting pelagic species) or trips reporting a block with a minimum depth deeper than 140 m were also filtered out.
Because California scorpionfish is not a primary target species, boats with fewer than 10 trips retaining California scorpionfish were removed from the analysis. Data were also filtered to only include catches reported from blocks South of Pt. Conception and north of the U.S.-Mexico border (Figure 1, and blocks with at least 100 trips retaining California scorpionfish and a total of 500 trips. A full description of the data filters is in Table 6. A total of 432,868 trips were retained for the index of abundance, 202,937 of which caught California scorpionfish.

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

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

The standardized index shows a cyclic pattern, with period of higher CPUE (late 1980's to early 1990's and late 1990s) and has shown a general downward trend since 2008 (Figure 11). An interesting note is the similarity in standardized CPUE between the CPFV logbook index and the CPFV dockside index (not used in the stock assessment model) from 1992-1997 (for a Stephens-MacCall threshold of 0.1) (Figure 10).

MRFSS Party/Charter Boat Dockside Index

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

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

Data for dockside sampling of 6295 commercial passenger fishing vessel (CPFV) trips south of Point Conception by the Marine Recreational Fishery Statistical Survey (MRFSS) were filtered using the Stephens-McCall method to identify trips with catch associated with California scorpionfish and the resulting trips analyzed in a delta-GLM including year and county to produce annual indices of abundance for the period 1980 through 1998 . To eliminate trips targeting species caught near the surface for all or part of the trip where California scorpionfish do not occur, prior applying the Stephens-MacCall filter, trips with catch of bluefin tuna, yellowfin tuna, dorado, Pacific bonito, skipjack, albacore, chinook salmon, coho salmon and bigeye tuna were removed. Trips with catch of yellowtail amberjack were also removed since effort on such trips can often be focused in the surface and midwater where California scorpionfish do not occur. In addition, trips with aggregate effort less below and above 95% percentile (less than 2 and over 109.5 hours) were removed to exclude trips for which either too little effort was exerted to be informative or longer trips that may make an excessive contribution to the effort likely distributed over a number of targets only some of which may co-occur with California scorpionfish biasing low the resulting CPUE. Lastly, trips in Santa Barbara County were removed due the low number of positive samples for California scorpionfish since it resides in the northern extent of their range and this is a transition zone between biogeographic provinces in which the presence of more northerly distributed species could adversely affect the ability of the Stephens-MacCall filtering method to identify co-occurring species. Each of these filtering steps and the resulting number of trips remaining in the sampling frame are provided in Table 9.

Removal of the aforementioned trips resulted in a total of 3,968 trips to which the Stephens-MacCall filtering method was applied. Species that composed less than 5% of the catch were excluded from analysis to prevent these uncommon species from affecting correlations identified using the algorithm. Chub mackerel, Pacific mackerel and barracuda were removed as potential predictor species despite having weak positive correlations with California scorpionfish since they are predominantly pelagic and their co-occurrence is not expected to be predictive. As expected, positive indicators of California scorpionfish trips include several species of nearshore rockfish, California sheephead, California halibut, Pacific sanddabs and seabasses and counter-indicators include several species of deep-water rockfish (Figure 8). While the filter is useful in identifying co-occurring or non-occurring species assuming all effort was exerted in pursuit of a single target, the targeting of more than one target species can result in co-occurrence of species in the catch that do not truly co-occur in terms of habitat associations informative for an index of abundance, presenting a confounding influence in selecting trips using the methods employed. Thus the filtering is intended to remove those trips for which effort was targeted in deeper water than California scorpionfish commonly occur.

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

Catch per angler hour (CPUE; number of fish per angler hour) was modelled using a delta model (Lo et al. 1992, Stefnsson 1996). Model selection using Akaike Information Criterion (AIC) and Bayesian Information Criteria (BIC) supported inclusion of year and region effects in both the binomial and lognormal components of the index for both the model with false positives from the 0.27 threshold and the 0.10 threshold. The addition of month effects (to allow for seasonal changes in CPUE) did not improve model fit. The lognormal model was employed as 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 relative index than the 0.27 threshold. 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 threshold reduced the relative magnitude of the 1989 index value relative to other years. As a result of this anomalous result and the low sample size, trips from 1989 were excluded from analysis.

The percentage of trips that caught California scorpionfish was 20.8% (828/3,968) prior to filtering with the Stephens-MacCall method, and 71.0% (828/,1167) with the filter set to 0.27 and 26.7% (828/3,099) with the filter set to 0.10, filtered data set. Residual-based model diagnostics for the positive component of the index suggest the data generally met the assumptions of the GLM (Figure 9). The resulting index is highly variable for both thresholds, with consistent peaks in 1984 and 1998 (Figure 10). Application of the 0.27 threshold holds the potential of biasing the resulting index values high by excluding false positive trips while including positive trips with equivalent probability of encountering California scorpionfish. The 0.1 threshold removes a high proportion of trips with shelf rockfish species indicative of effort exerted in deeper depths than are commonly occupied by California scorpionfish, while retaining false positive trips with equivalent probabilities of capture to true positives. The AIC and values informing selection of the lognormal model including year and county effects is provided in Table 10.

The results of the models with each of the thresholds provided similar trends seen in Figure Figure 10 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 CPFV logbook index represents the same sector of the fishery and presumably contains data from the 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.

Onboard Observer Party/Charter Boat

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

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

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

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

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

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

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

Drift locations within the Cowcod Conservation Area (CCA) or in Mexican waters were also filtered out of the dataset. The years 1999 and 2000 were removed from the index due to changes in hook and gear regulations during those years. California adopted a 3-hook and 1-line regulation in 2000, which changed to 2-hooks and 1-line in 2001. California scorpionfish is not a common target species for the CPFV fleet, but if often a fallback species, for trips targeting seabass or rockfish. California scorpionfish are targeted more often in January and February when the rockfish/cabezon/greenling complex is closed. Boat identifiers were availalbe for all trips in the onboard observer database. Approximately 1,000 drifts were filtered out after accounting for boats that were identified as not encountering scorpionfish (Table 11. A total of 26,733 drifts for the analysis were retained. Of these, 5,507 encountered scorpionfish, with 3,249 discarding California scorpionfish and 3,867 retaining California scorpionfish.

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

Onboard Obsever Discarded Catch Index

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

Onboard Obsever Discarded Catch Length Composition

The Onboard Obsever program only measures discarded fish, as of 2003. The retained catch is measured during the dockside (angler intercept) surveys, and cannot necessarily be matched to a trip with the discard lengths prior to 2012.

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

Onboard Obsever Retained Catch Index

Covariates considered in the full model included *year*, *area* (5 levels), *month* (12 levels), and *20 m depth bins* (5 levels). All covariates were specified as categorical variables. The final model includes A lognormal model was selected by AIC over a gamma model for the positives (delta-AIC of 534.9).Model selection for both the lognormal and binomial models retained all covariates (Table 14). The Q-Q plot for the positive catch lognormal model looks reasonable (Figure 15). The final index shows a lower CPUE of the retained catch from 2002 and 2003 (Table 15 and Figure 16). The relative CPUE of the retained catch shwos a decline from 2007-2015, and an increase in 2016.

2.1.5 Fishery-Independent Data Sources

`fishery-independent-data-sources`

Sanitation Districts Trawl Survey

Sanitation districts in southern California are required to conduct trawls as part of their National Pollutant Discharge Elimination System (NPEDES) 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 .

City of Los Angeles (Hyperion) The City of Los Angeles Sanitation District provided trawl data from 1986-2016.
Years with fewer than ten samples were removed from the analysis (1986, 1987, and 1992). Tow times were recorded starting in 1999, and assumed to be 10 minutes prior to 1999. Stations sampled at least ten years were retained, which resulted in ten stations (A1, A3, C1, C3, C6, C9A, D1T, Z2, Z3, Z4; 921 hauls) for the analysis. Haul depth was missing for approximately half of the stations, and was imputed as the mean depth of of other tows at that station.

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

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

fig:Fleet7_comp_lendat_bubflt10mkt2

NWFSC Trawl Survey Index

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

The proportions of positive catch haul and the raw catch rates of positive hauls by depth and latitude are shown in Figure 21 and Figure 22, respectively. These figures show that more scorpionfish were caught at shallow depth zones and in the southern latitude zones. Box plots of length summary data by depth and sex (Figure 24) and by latitude and sex (Figure 24) show no evidences of different spatial distributions (by depth and latitude) by length or by sex.
The numbers of total hauls and percentages of positive catch hauls by depth and latitude zones are presented in Tables 19 and 20, respectively. Summaries of raw catch data by year are listed in Table 21. Overall, catches of scorpionfish by the survey were very low with less than 1mt fish caught during the entire 14 years of the survey. Bubble plots of length frequency distribution by year and sex are presented in Figure 25.

Summaries of age data by year and sex are presented in Table 22. There were more males (n = 529) being aged than females (n = 340), presumably indicating that there are more males than females in the populations. The table also shows that mean ages and mean lengths for both sexes decreased in recent years. Table 23 show five percentiles of fish aged by sex, indicating more older males in the population. All aged data from the survey were used as conditional age-at-length matrix in the assessment model.

Total biomass estimates from the survey were analyzed using the VAST program (Thorson and Barnett 2017). The Q-Q goodness of fit plot and time series of total biomass estimates are shown in Figures 26 and 27, respectively. The Q-Q plots shows generally good of fits and the time series of biomass estimates indicates no significant trend with relatively large uncertainties from the survey. The final survey index and log standard error used in the assessment model are in Table 24.

CSUN/VRG Gillnet Survey Index

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

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

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

Southern California Bight 2013 Regional Monitoring Project Trawl Survey Index

Generating Station Impingement Surveys

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

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

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

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

The length composition data from the impingement show a higher proportion of smaller (<10 cm) fish since 2012 (Figure 30)

California Cooperative Oceanic Fisheries Investigations (CalCOFI) Survey UCSD Scripps Institution of Oceanography, CDFG, and the National Marine Fisheries Service have carried out a plankton survey on a regular basis since 1951 (Moser et al. 1993). Prior to 1965, *Scorpaena* samples were not speciated.

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

2.1.6 Biological Parameters and Data

`biological-parameters-and-data`

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

Standard and total lengths of 163 California scorpionfish were available from a halibut trawl survey in southern California (Steve Wertz, CDFW). The conversion from SL to TL from these data was estimated at $TL = 1.2225SL + 0.7773$.
The conversion originating from the halibut trawl data was used in this assessment due to the fact that the original data from Love et al. (1987) are not available.

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

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

Length And Age Compositions

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

Length compositions were provided from the following sources:

- CDFW market category study (*commercial dead fish*,1996-2003)
- CALCOM (*commercial dead fish*, 2013-2016)
- CDFW onboard observer (*recreational charter discards*, 2003-2016)
- Ally onboard observer study (*recreational charter discards*, 1984-1989)
- California recreational sources combined (*recreational charter retained catch*)
  - CDFW and Ally onboard observer surveys (1984-1989)
  - Collins and Crooke onboard observer surveys (1975-1978)
  - MRFSS (1980-2003)
  - CRFS (2004-2014)
- California recreational sources combined (*private mode retained catch*)
  - MRFSS (1980-2003)
  - CRFS (2004-2016)
- Sanitation district trawl surveys (*research*, 1970-2016)
- CSUN/VRG gillnet survey (*research*, 1995-2008)
- Power plant impingement surveys (*research*, 1974-2016)
- Southern California Bight trawl survey (*research*, 1994,1998,2003,2008,2013)

The length composition of all fisheries aggregated across time by fleet is in Figure 31. Descriptions and details of the length composition data are in the above section for each fleet or survey.

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

Commercial: PacFIN

Age Structures Age data were provided from the NWFSC trawl survey from 2005-2016. All otoliths collected from the survey were aged

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

Aging Precision And Bias Uncertainty in ageing error was estimated using a collection of 200 California scorpionfish otoliths with two age reads (**??**).
Age-composition data used in the model were all from the NWFSC trawl survey and were from otoliths reads aged by the Cooperative Ageing Project (CAP) in Newport, Oregon. All of the otolith reads were from Age Reader A, and double reads were read by Age Reader 2.

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

Weight-Length

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

Maturity And Fecundity

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

$$M = \frac{5.4}{A_{max}} \tag{1}$$

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

Sex ratios

2.1.7 Environmental Or Ecosystem Data Included In The Assessment

environmental-or-ecosystem-data-included-in-the-assessment

2.2 History Of Modeling Approaches Used For This Stock

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

2.2.1 Previous Assessments

previous-assessments

2.2.2 2005 Assessment Recommendations

assessment-recommendations

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

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

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

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

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

Recommendation 3: Location information for the historic groundfish data of all species is currently available, in hard copy form only, from the California 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-sepciic catches referred to above have been key-punched and are available in electornic 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…

2.3.3 Summary of Data for Fleets and Areas

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

2.3.4 Modeling Software

modeling-software

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

2.3.5 Data Weighting

`data-weighting`

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

2.3.6 Priors

`priors`

Citation for Hamel prior on natural mortality (Hamel 2015)

2.3.7 General Model Specifications

`general-model-specifications`

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

2.3.8 Estimated And Fixed Parameters

`estimated-and-fixed-parameters`

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

2.4 Model Selection and Evaluation

`model-selection-and-evaluation`

2.4.1 Key Assumptions and Structural Choices

`key-assumptions-and-structural-choices`

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

2.4.2 Alternate Models Considered

`alternate-models-considered`

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

2.4.3 Convergence

`convergence`

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

Convergence testing through use of dispersed starting values often requires extreme values to actually explore new areas of the multivariate likelihood surface. Jitter is a SS option that generates random starting values from a normal distribution logistically transformed into each parameter's range (Methot 2015). Table 33 shows the results of running 100 jitters for each pre-STAR base model....

2.5 Response To The Current STAR Panel Requests

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

Request No. 1: Add after STAR panel.

Rationale: Add after STAR panel.

STAT Response: Add after STAR panel.

Request No. 2: Add after STAR panel.

Rationale: Add after STAR panel.

STAT Response: Add after STAR panel.

Request No. 3: Add after STAR panel.

Rationale: Add after STAR panel.

STAT Response: Add after STAR panel.

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

- **Item No. 1**
- **Item No. 2**
- **Item No. 3, etc.**

Rationale: Add after STAR panel.

STAT Response: Continue requests as needed.

2.6 Model 1

`model-1`

2.6.1 Model 1 Base Case Results

`model-1-base-case-results`

Table **??**

2.6.2 Model 1 Uncertainty and Sensitivity Analyses

`model-1-uncertainty-and-sensitivity-analyses`

Table 34

2.6.3 Model 1 Retrospective Analysis

`model-1-retrospective-analysis`

2.6.4 Model 1 Likelihood Profiles

`model-1-likelihood-profiles`

2.6.5 Model 1 Harvest Control Rules (CPS only)

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

2.6.6 Model 1 Reference Points (groundfish only)

`model-1-reference-points-groundfish-only`

Intro sentence or two. . . .(Table 35).

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

3 Harvest Projections and Decision Tables

`harvest-projections-and-decision-tables`

Table f

Model 1 Projections and Decision Table (groundfish only) (Table 36

Table h

Model 2 Projections and Decision Table (groundfish only)

Model 3 Projections and Decision Table (groundfish only)

4 Regional Management Considerations

`regional-management-considerations`

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

5 Research Needs

`research-needs`

1. Research need No. 1
2. Research need No. 2
3. Research need No. 3
4. etc.

6 Acknowledgments

`acknowledgments`

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

7 Tables

tables

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

Year	Hook-and-line	Trawl	Gillnet	Mexico	Total U.S. Removals	Source
1916	3.64	0.00	0.00	0.00	3.64	CDFG Bulletins
1917	7.90	0.00	0.00	0.00	7.90	CDFG Bulletins
1918	12.81	0.00	0.00	0.00	12.81	CDFG Bulletins
1919	11.54	0.00	0.00	0.00	11.54	CDFG Bulletins
1920	16.18	0.00	0.00	0.00	16.18	CDFG Bulletins
1921	26.48	0.00	0.00	0.00	26.48	CDFG Bulletins
1922	19.11	0.00	0.00	0.00	19.11	CDFG Bulletins
1923	27.43	0.00	0.00	0.00	27.43	CDFG Bulletins
1924	49.47	0.00	0.00	0.00	49.47	CDFG Bulletins
1925	101.20	0.00	0.00	0.00	101.20	CDFG Bulletins
1926	49.02	0.00	0.00	0.00	49.02	CDFG Bulletins
1927	51.46	0.00	0.00	0.00	51.46	CDFG Bulletins
1928	44.04	0.00	0.00	0.00	44.04	CDFG Bulletins
1929	48.90	0.00	0.00	0.00	48.90	CDFG Bulletins
1930	40.19	0.00	0.00	0.00	40.19	CDFG Bulletins
1931	41.54	0.00	0.00	0.05	41.54	CDFG Bulletins
1932	38.78	0.00	0.00	0.00	38.78	CDFG Bulletins
1933	29.10	0.00	0.00	0.00	29.10	CDFG Bulletins
1934	29.91	0.00	0.00	0.00	29.91	CDFG Bulletins
1935	30.76	0.00	0.00	0.79	30.76	CDFG Bulletins
1936	49.75	0.00	0.00	0.34	49.75	CDFG Bulletins
1937	62.19	0.00	0.00	0.09	62.19	CDFG Bulletins
1938	70.44	0.00	0.00	0.05	70.44	CDFG Bulletins
1939	58.29	0.00	0.00	0.06	58.29	CDFG Bulletins
1940	55.37	0.00	0.00	0.03	55.37	CDFG Bulletins
1941	43.07	0.00	0.00	0.14	43.07	CDFG Bulletins
1942	20.00	0.00	0.00	0.11	20.00	CDFG Bulletins
1943	16.32	0.00	0.00	2.98	16.32	CDFG Bulletins
1944	24.03	0.00	0.00	1.95	24.03	CDFG Bulletins
1945	42.13	0.00	0.00	0.81	42.13	CDFG Bulletins
1946	65.63	0.00	0.00	0.16	65.63	CDFG Bulletins
1947	56.79	0.00	0.00	0.84	56.79	CDFG Bulletins
1948	70.17	0.00	0.00	0.18	70.17	CDFG Bulletins
1949	66.72	0.00	0.00	0.58	66.72	CDFG Bulletins
1950	63.16	0.00	0.00	0.12	63.16	CDFG Bulletins
1951	45.85	0.00	0.00	0.16	45.85	CDFG Bulletins
1952	37.93	0.00	0.00	0.00	37.93	CDFG Bulletins

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

Year	Hook-and-line	Trawl	Gillnet	Mexico	Total U.S. Removals	Source
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 the CDFG Fishery Bulletins (availabl from California Explores the Ocean) and the California Fisheries Information System (CFIS)

Year	Hook-and-line	Trawl	Gillnet	Mexico	Total U.S. Removals	Source
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

tab:Rec_removal

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 ¡1% of all trips and in at least 5 years of data	3,056	30,033
Stephens-MacCall	Retain all positive trips, plus "False Positives" (trips predicted to be in California scorpionfish habitat, but with no California scorpionfish retained)	3,056	**8,590**

Table 4: AIC values for each model in the recreational private mode dockside sample index.
tab:Fleet4_RecPR_dockside_aic

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.
tab:Fleet4_RecPR_dockside_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.

tab:Fleet5_RecPC_CPFVlogbook_filter

Filter	Criteria	Sample size (no. of trips)
All CA data	No filter	1,164,662
Gear	Remove trips reported as diving, mooching or trolling	959,740
Effort or missing data	Remove trips with missing effort or species information	930,233
Year	Remove 2017, remaining years 1980-2016	929,781
Region	Remove trips north of Pt. Conception and in Mexico	568,222
Fish encountered	Remove trips reporting number of retained fish greater than in the 99% quantile (>325 fish)	564,433
Target species	Remove trips targeting sharkes, 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.

tab:Fleet5_RecPC_CPFVlogbook_aic

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

Table 8: The recreational CPFV logbook sample index.

tab:Fleet5_RecPC_CPFVlogbook_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 CPFV dockside sample sizes at each data filtering step. The bold value indicates the final sample size used for delta-GLM analysis.

tab:Fleet5_RecPC_dockside_filter

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

Table 10: AIC values for each model in the recreational CPFV logbook sample index, including all positive trips and false positive trips selected with a Stephens-MacCall filter threshold encounter probability of 0.1.

tab:Fleet5_RecPC_dockside_aic

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

Table 11: 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

tab:Fleet6_RecDD_onboard_filter

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

Table 12: AIC values for each model in the The recreational CPFV onboard observer discard-only catch index.

tab:Fleet6_RecDD_onboard_aic

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 13: The recreational CPFV onboard observer discard-only catch sample index.
tab:Fleet6_RecDD_onboard_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 14: AIC values for each model in the The recreational CPFV onboard observer retained-only catch index.
tab:Fleet12_RecPC_onboard_aic

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

Table 15: The recreational CPFV onboard observer retained-only catch sample index.
tab:Fleet12_RecPC_onboard_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 16: 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.

tab:Fleet7_Sanitation_filter

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

tab:Fleet7_Sanitation_aic

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 18: 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 19: Summaries of catch statistics of Califronia scorpionfish by depth zones from NWFSC trawl survey between 2003 and 2016.

tab:Fleet8_NWFSCTrawl_catchdepth

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

Table 20: Summaries of catch statistics of Calfironia scorpionfish by latitude zones from NWFSC trawl survey between 2003 and 2016.

tab:Fleet8_NWFSCTrawl_catchlat

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

Table 21: Summaries of haul statistics of California scorpionfish from NWFSC trawl survey between 2003 and 2016.

tab:Fleet8_NWFSCTrawl_summary

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 22: 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.

tab:Fleet8_NWFSCTrawl_agesummary

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

tab:Fleet8_NWFSCTrawl_agepercents

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 24: The NWFSC trawl survey index.

tab:Fleet8_NWFSCTrawl_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 25: 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:Fleet9_GillnetSurvey_filter

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

tab:Fleet9_GillnetSurvey_aic

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 27: The recreational private mode dockside sample index.
tab:Fleet9_GillnetSurvey_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 28: 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:Fleet11_SCBSurvey_filter

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

Table 29: AIC values for each model in the recreational private mode dockside sample index.
tab:Fleet11_SCBSurvey_aic

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 30: The recreational private mode dockside sample index.
tab:Fleet11_SCBSurvey_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 31: 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)	OK	0.030	Log_Norm (-1.3581, 0.438438)
2	L_at_Amin_Fem_GP_1	7.228	2	(2, 30)	OK	1.410	None
3	L_at_Amax_Fem_GP_1	33.194	2	(30, 50)	OK	1.295	None
4	VonBert_K_Fem_GP_1	0.247	2	(0.05, 0.5)	OK	0.053	None
5	CV_young_Fem_GP_1	0.328	3	(0.02, 0.5)	OK	0.036	None
6	CV_old_Fem_GP_1	0.104	3	(0.02, 0.75)	OK	0.016	None
7	Wtlen_1_Fem	0.000	-3	(-3, 3)			None
8	Wtlen_2_Fem	3.058	-3	(2, 4)			None
9	Mat50%_Fem	17.188	-3	(10, 30)			None
10	Mat_slope_Fem	-0.466	-3	(-3, 3)			None
11	Eggs/kg_inter_Fem	1.000	-3	(-3, 3)			None
12	Eggs/kg_slope_wt_Fem	0.000	-3	(-3, 3)			None
13	NatM_p_1_Mal_GP_1	-0.204	2	(-3, 3)	OK	0.066	Normal (0, 99)
14	L_at_Amin_Mal_GP_1	0.667	2	(-3, 3)	OK	0.190	None
15	L_at_Amax_Mal_GP_1	-0.180	2	(-3, 3)	OK	0.043	None
16	VonBert_K_Mal_GP_1	0.101	2	(-3, 3)	OK	0.222	None
17	CV_young_Mal_GP_1	-1.487	3	(-3, 3)	OK	0.279	None
18	CV_old_Mal_GP_1	0.085	3	(-3, 3)	OK	0.188	None
19	Wtlen_1_Mal	0.000	-5	(0, 1)			None
20	Wtlen_2_Mal	2.981	-5	(2, 4)			None
24	CohortGrowDev	1.000	-1	(1, 1)			None
25	FracFemale_GP_1	0.500	-4	(0.000001, 0.999999)			None
26	SR_LN(R0)	8.103	1	(0, 31)	OK	0.315	None
27	SR_BH_steep	0.718	-2	(0.21, 0.99)			Full_Beta (0.718, 0.158)
28	SR_sigmaR	0.600	-2	(0, 2)			None
29	SR_regime	0.000	-4	(-5, 5)			None

Continued on next page

Table 31: 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_flt_1ComHL	0.000	-1	(0, 1)			Normal (0.01, 1000)
85	LnQ_base_RecPR(4)	-6.411	-1	(-15, 15)			None
86	Q_extraSD_RecPR(4)	0.019	4	(0.0001, 1)	OK	0.025	None
87	LnQ_base_RecPC(5)	-10.929	-1	(-15, 15)			None
88	Q_extraSD_RecPC(5)	0.372	4	(0.0001, 1)	OK	0.056	None
89	LnQ_base_RecDD(6)	-10.809	-1	(-15, 15)			None
90	Q_extraSD_RecDD(6)	0.055	4	(0.0001, 1)	OK	0.045	None
91	LnQ_base_Sanitation(7)	-10.227	-1	(-15, 15)			None
92	Q_extraSD_Sanitation(7)	0.211	4	(0.0001, 1)	OK	0.046	None
93	LnQ_base_NWFSCTrawl(8)	-0.732	-1	(-15, 15)			None
94	Q_extraSD_NWFSCTrawl(8)	0.244	4	(0.0001, 1)	OK	0.144	None
95	LnQ_base_GillnetSurvey(9)	-11.700	-1	(-15, 15)			None
96	Q_extraSD_GillnetSurvey(9)	0.100	4	(0.0001, 1)	OK	0.067	None
97	LnQ_base_SCBSurvey(11)	-10.682	-1	(-15, 15)			None
98	Q_extraSD_SCBSurvey(11)	0.188	4	(0.0001, 1)	OK	0.151	None
99	LnQ_base_RecPCOBR(12)	-9.830	-1	(-15, 15)			None
100	Q_extraSD_RecPCOBR(12)	0.218	4	(0.0001, 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

Continued on next page

Table 31: 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)			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)			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)			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)			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)			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)			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)			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)			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)			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)			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)			None

Continued on next page

Table 31: 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_NWFSCTrawl(8)	4.014	4	(-1, 10)	OK	0.417	None
138	SizeSel_P4_NWFSCTrawl(8)	15.000	-3	(-1, 16)			None
139	SizeSel_P5_NWFSCTrawl(8)	-13.435	4	(-25, 5)	OK	153.055	None
140	SizeSel_P6_NWFSCTrawl(8)	10.000	-3	(-5, 11)			None
141	SizeSel_P1_GillnetSurvey(9)	1.000	-2	(1, 45)			None
142	SizeSel_P2_GillnetSurvey(9)	45.000	-3	(1, 45)			None
143	SizeSel_P1_SCBSurvey(11)	1.000	-2	(1, 45)			None
144	SizeSel_P2_SCBSurvey(11)	45.000	-3	(1, 45)			None
145	SizeSel_P1_RecPCOBR(12)	1.000	-2	(1, 45)			None
146	SizeSel_P2_RecPCOBR(12)	45.000	-3	(1, 45)			None
147	SizeSel_P1_ComHL(1)_BLK1repl_1999	28.995	5	(13, 44)	OK	0.576	None
148	SizeSel_P3_ComHL(1)_BLK1repl_1999	2.133	5	(-1, 10)	OK	0.253	None
149	SizeSel_P1_RecPR(4)_BLK2repl_2000	35.437	5	(13, 44)	OK	0.557	None
150	SizeSel_P3_RecPR(4)_BLK2repl_2000	3.344	5	(-1, 10)	OK	0.102	None
151	SizeSel_P1_RecPC(5)_BLK2repl_2000	27.962	5	(13, 44)	OK	0.523	None
152	SizeSel_P3_RecPC(5)_BLK2repl_2000	1.630	5	(-1, 10)	OK	0.316	None

tab:model_params

Table 32: Summary of the biomass/abundance time series used in the stock assessment.

tab:Index_summary

Fleet	Years	Name	Fishery ind.	Filtering	Method	Endorsed
4	2004-2016	Recreational PR dockside CPUE	No	trip, area, regulations, Stephens-MacCall	delta-GLM (bin-lognormal)	SSC
5	1980-2016	CPFV logbook CPUE	No	trip, gear, effort, species, depth, sample size	negative binomial	SSC
6	2002-2016	Onboard observer discard catch CPUE	No	habitat ,regulations, effort, boats	delta-GLM (bin-lognormal)	SSC
7	1970-2016	Sanitation district CPUE	Yes	sample size, depth, tow times	delta-GLM (bin-lognormal)	SSC
8	2003-2016	NWFSC trawl survey CPUE	Yes	depth, area	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 Califrnia 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 33: Results from 100 jitters from each of the three models.

tab:jitter

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

Table 35: 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 exploitation 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 35: 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 exploitation 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 35: 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 exploitation 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 34: Sensitivity of the base model to dropping or down-weighting data sources and alternative assumptions about growth.

`tab:Sensitivity_model1`

Label	Base (Francis weights)	Harmonic mean weights	Drop index	Drop ages	Down-weight lengths	Free size Age0	Free CV Amin	External growth
TOTAL_like	-	-	-	-	-	-	-	-
Catch_like	-	-	-	-	-	-	-	-
Equil_catch_like	-	-	-	-	-	-	-	-
Survey_like	-	-	-	-	-	-	-	-
Length_comp_like	-	-	-	-	-	-	-	-
Age_comp_like	-	-	-	-	-	-	-	-
Parm_priors_like	-	-	-	-	-	-	-	-
SSB_Unfished_thousand_mt	-	-	-	-	-	-	-	-
TotBio_Unfished	-	-	-	-	-	-	-	-
SmryBio_Unfished	-	-	-	-	-	-	-	-
Recr_Unfished_billions	-	-	-	-	-	-	-	-
SSB_Btgt_thousand_mt	-	-	-	-	-	-	-	-
SPR_Btgt	-	-	-	-	-	-	-	-
Fstd_Btgt	-	-	-	-	-	-	-	-
TotYield_Btgt_thousand_mt	-	-	-	-	-	-	-	-
SSB_SPRtgt_thousand_mt	-	-	-	-	-	-	-	-
Fstd_SPRtgt	-	-	-	-	-	-	-	-
TotYield_SPRtgt_thousand_mt	-	-	-	-	-	-	-	-
SSB_MSY_thousand_mt	-	-	-	-	-	-	-	-
SPR_MSY	-	-	-	-	-	-	-	-
Fstd_MSY	-	-	-	-	-	-	-	-
TotYield_MSY_thousand_mt	-	-	-	-	-	-	-	-
RetYield_MSY	-	-	-	-	-	-	-	-
Bratio_2015	-	-	-	-	-	-	-	-
F_2015	-	-	-	-	-	-	-	-
SPRratio_2015	-	-	-	-	-	-	-	-
Recr_2015	-	-	-	-	-	-	-	-
Recr_Virgin_billions	-	-	-	-	-	-	-	-
L_at_Amin_Fem_GP_1	-	-	-	-	-	-	-	-
L_at_Amax_Fem_GP_1	-	-	-	-	-	-	-	-
VonBert_K_Fem_GP_1	-	-	-	-	-	-	-	-
CV_young_Fem_GP_1	-	-	-	-	-	-	-	-
CV_old_Fem_GP_1	-	-	-	-	-	-	-	-

Table 36: Projection of potential OFL, spawning biomass, and depletion for the base case model.

tab:Forecast_mod1

Yr	OFL contriubtion (mt)	ACL landings (mt)	Age 5+ biomass (mt)	Spawning Biomass (mt)	Depletion
2017	252.19	252.19	1604.93	493.51	0.56

8 Figures

figures

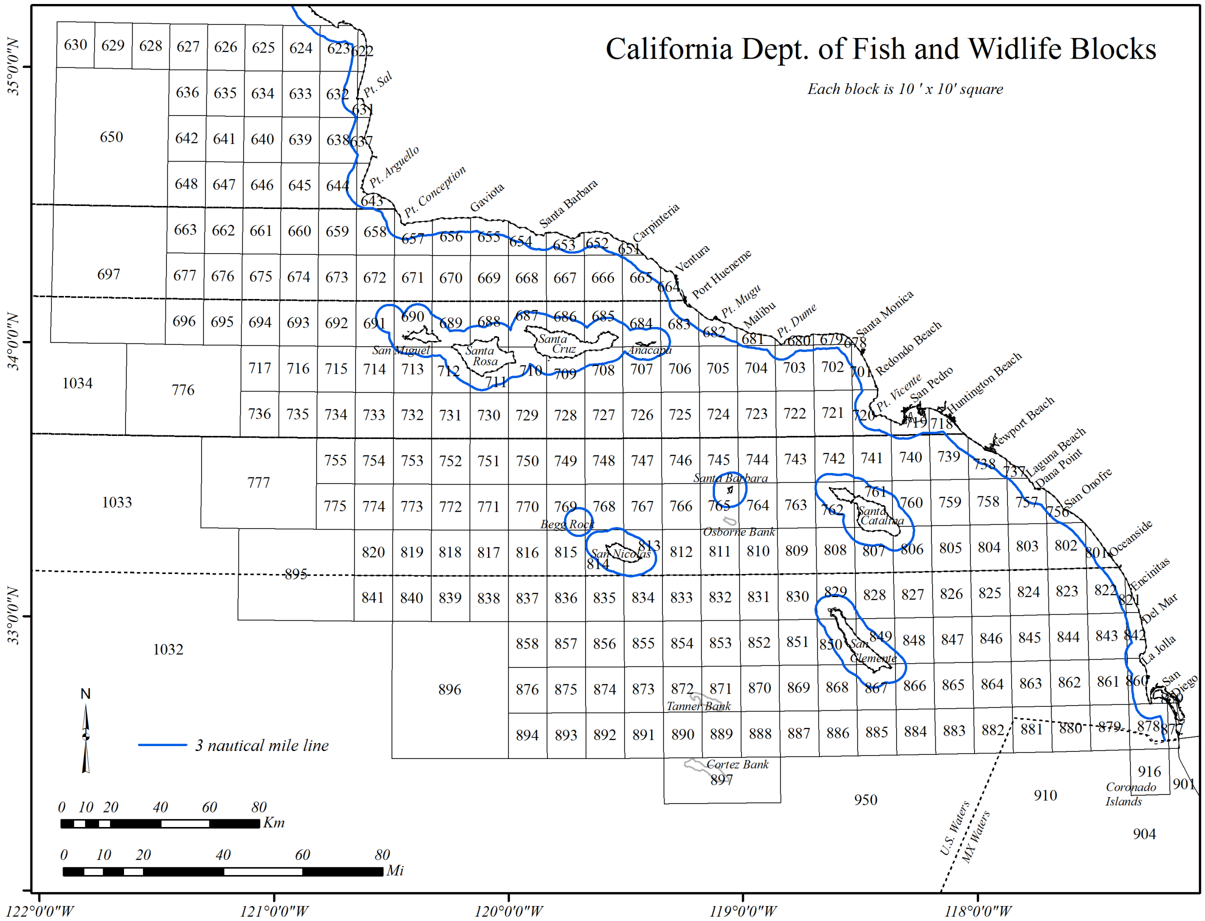

Figure 1: Map showing the state boundary lines for management of the recreational fishing fleets. CRFS Districts 1-6 in California are presented as well as the WDFW Recreational Management Areas in Washington. Florence, OR is shown as a potential location of model stratification. fig:boundary_map

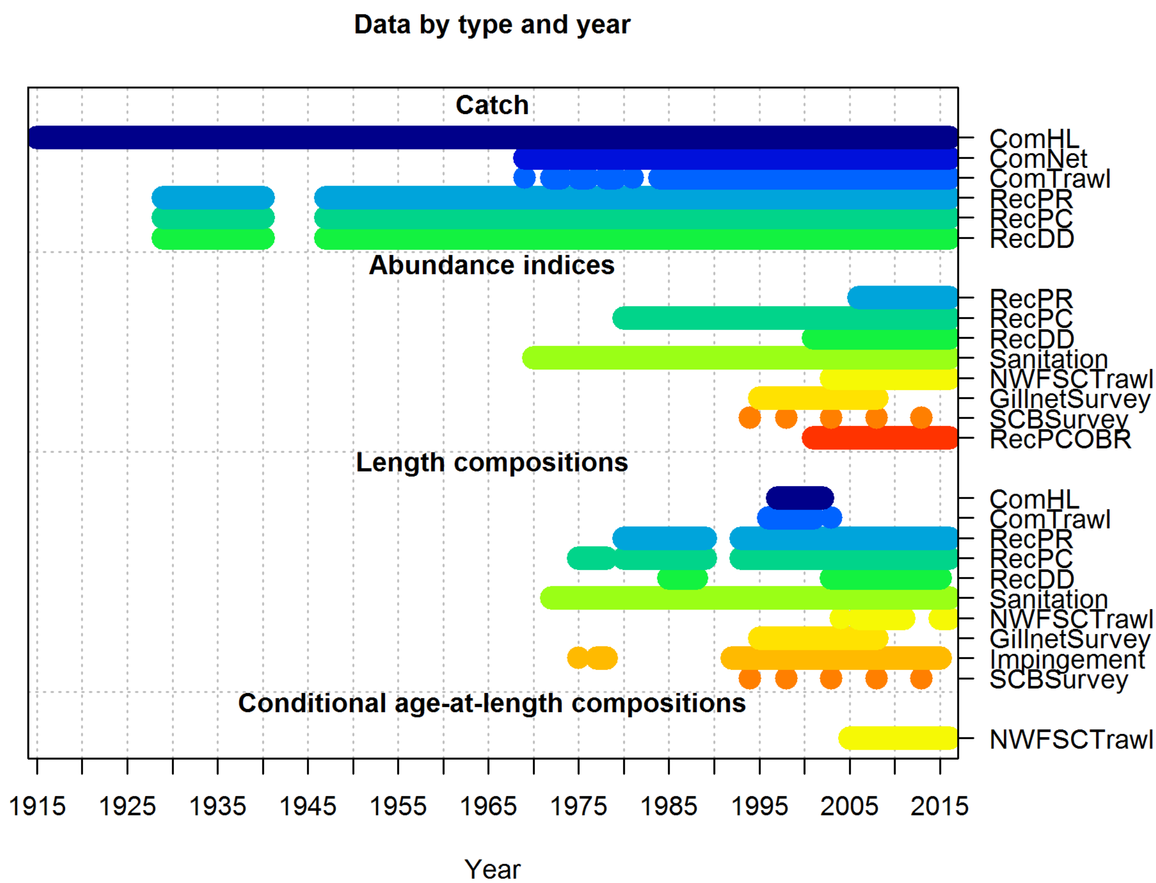

Figure 2: Summary of data sources used in the base model. fig:data_plot

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

Figure 3: A summary of the monthly recreational regulations for California scorpionfish in southern Califoria. cells with "open" indicate no depth restriction, black cells indicate the fishery is closed, and cells with a number indicate the depth restriction in fathoms, e.g., 20 = retained catch allowed in less than 20 fathoms. *Fishery closed on November 15, 2014. fig:recregs

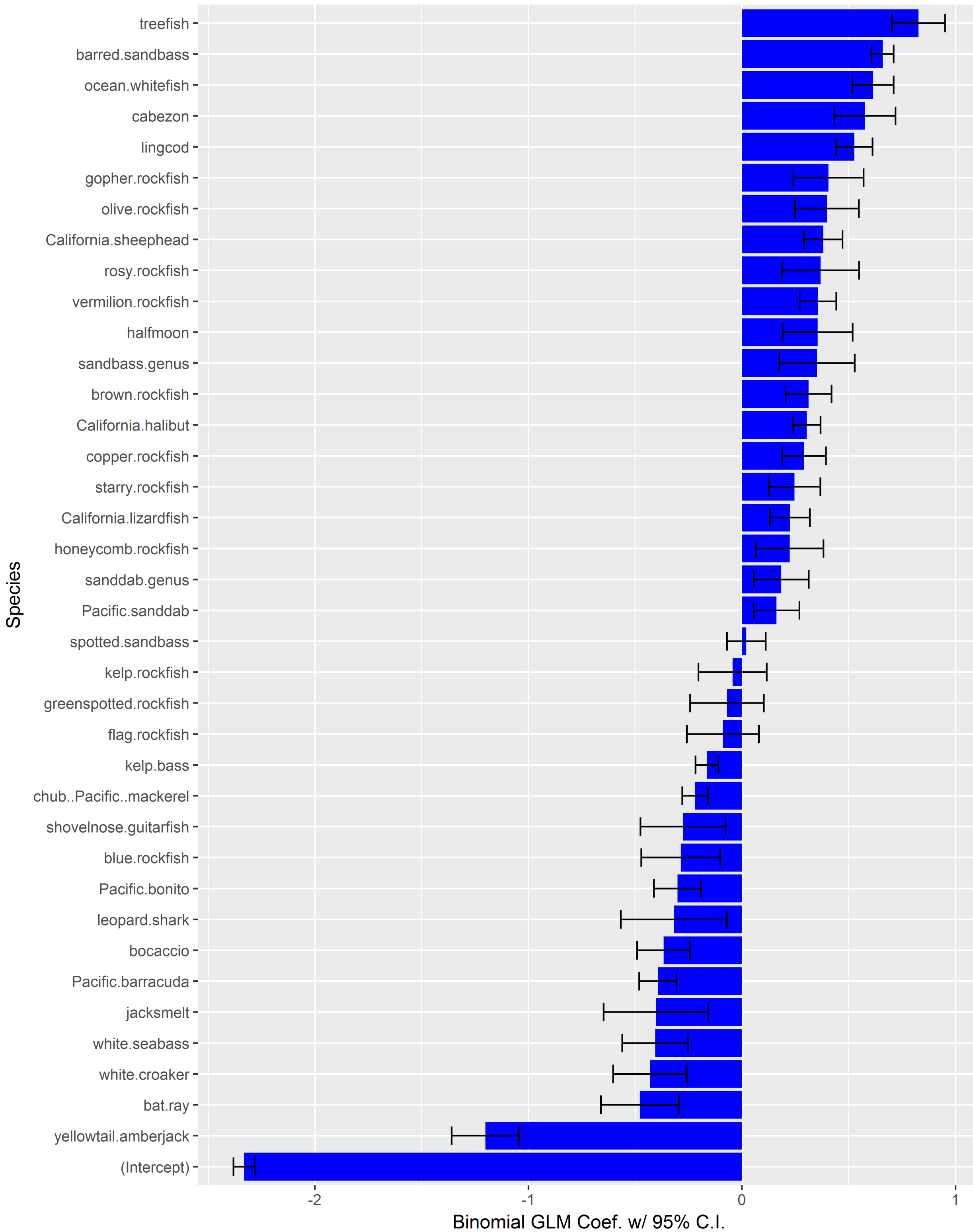

Figure 4: Species coefficients from the binomial GLM for presence/absence of California scorpionfish in the Marine Recreational Fisheries Statistics Survey (MRFSS) private mode dockside survey data set. Horizontal bars are 95% confidence intervals. fig:Fleet4_RecPR_dockside_SM

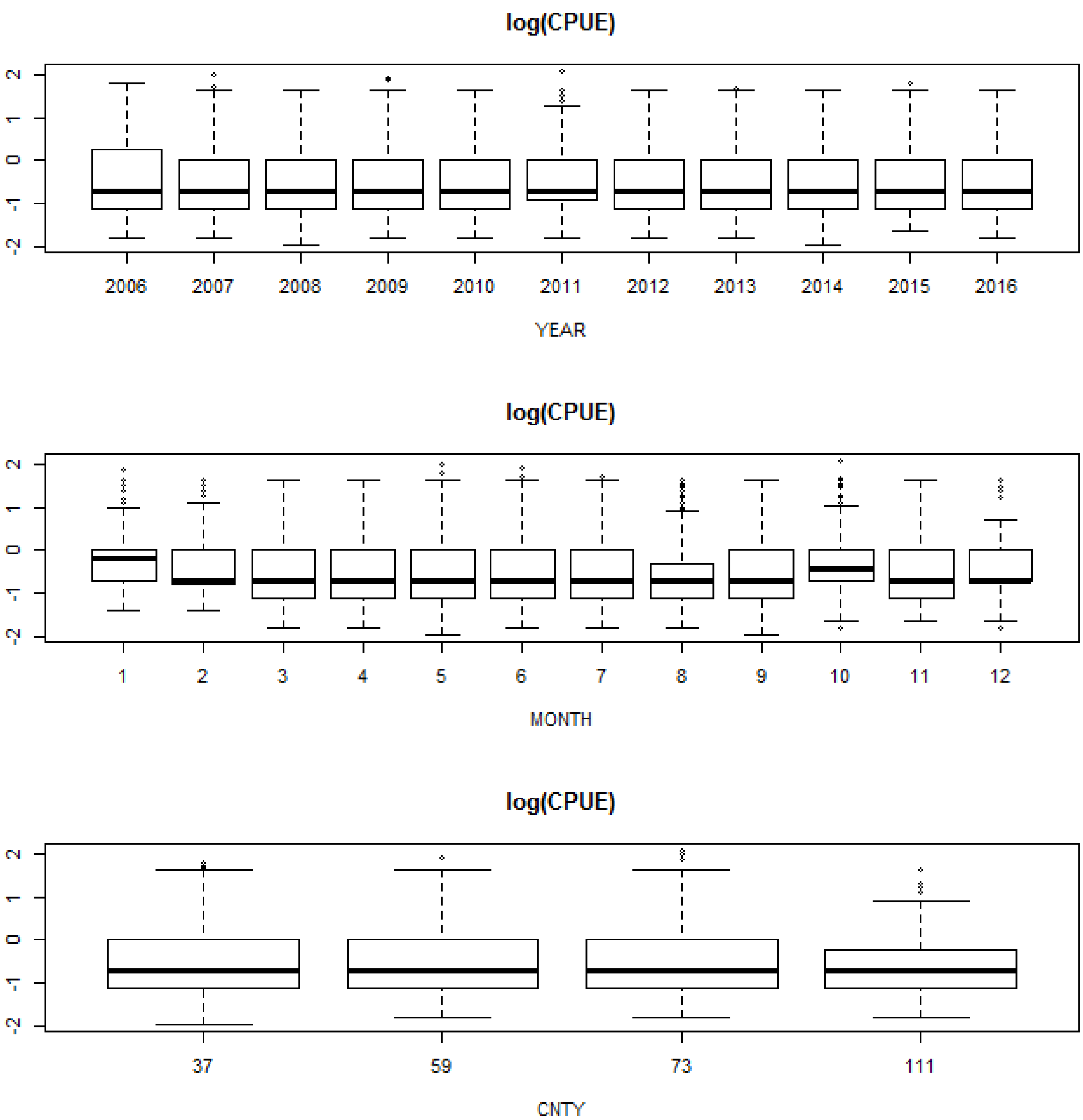

Figure 5: Boxplots of the raw log CPUE by year for each of the three factors considered in the deltaGLM model, county, month and year. fig:Fleet4_RecPR_dockside_lograwCPUE

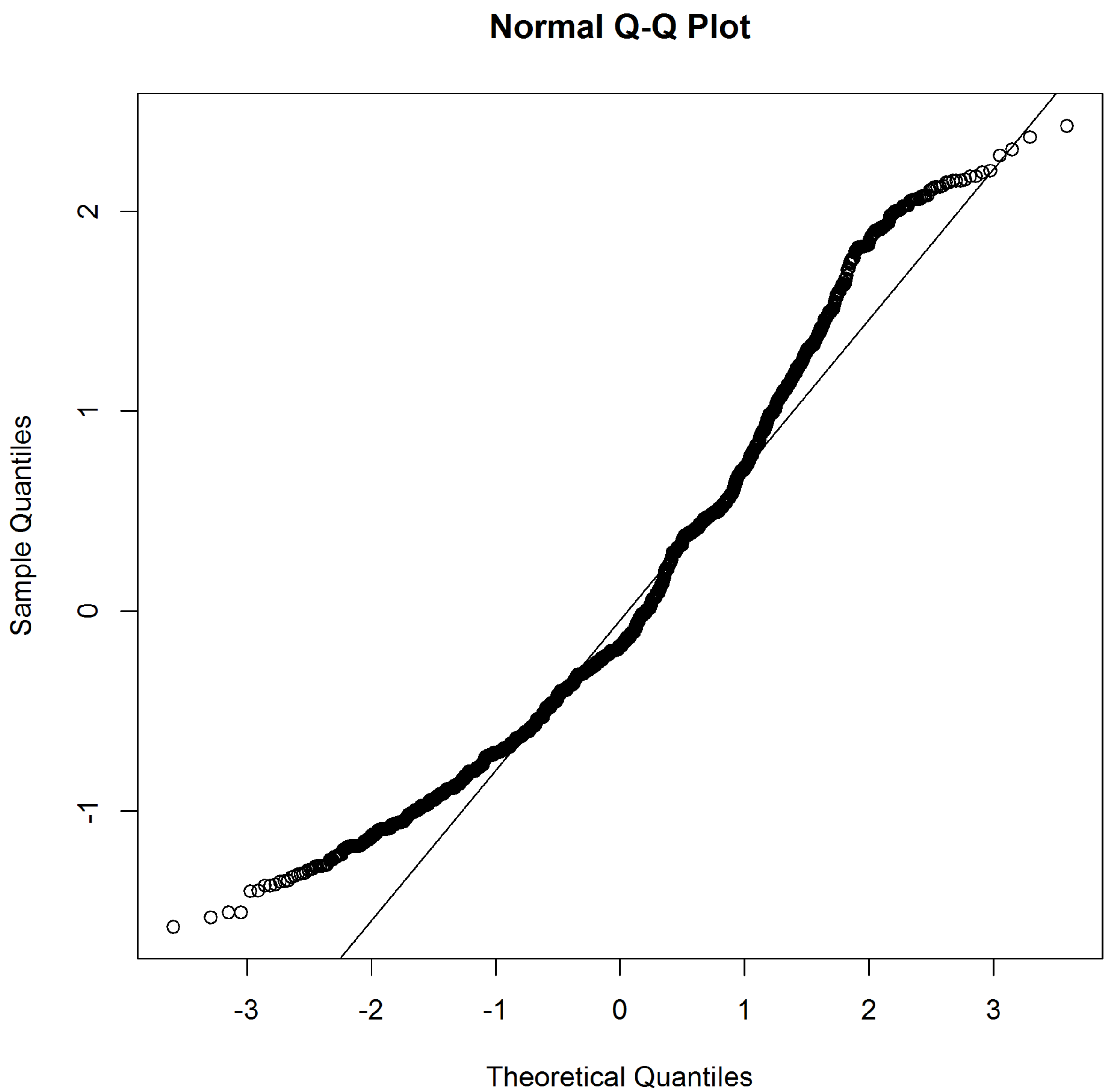

Figure 6: Q-Q plot used to evaluate the fit of the lognmoral (positive encounters) of California scorpionfish from the Marine Recreational Fisheries Statistics Survey (MRFSS) private mode dockside survey data set. fig:Fleet4_RecPR_dockside_QQ

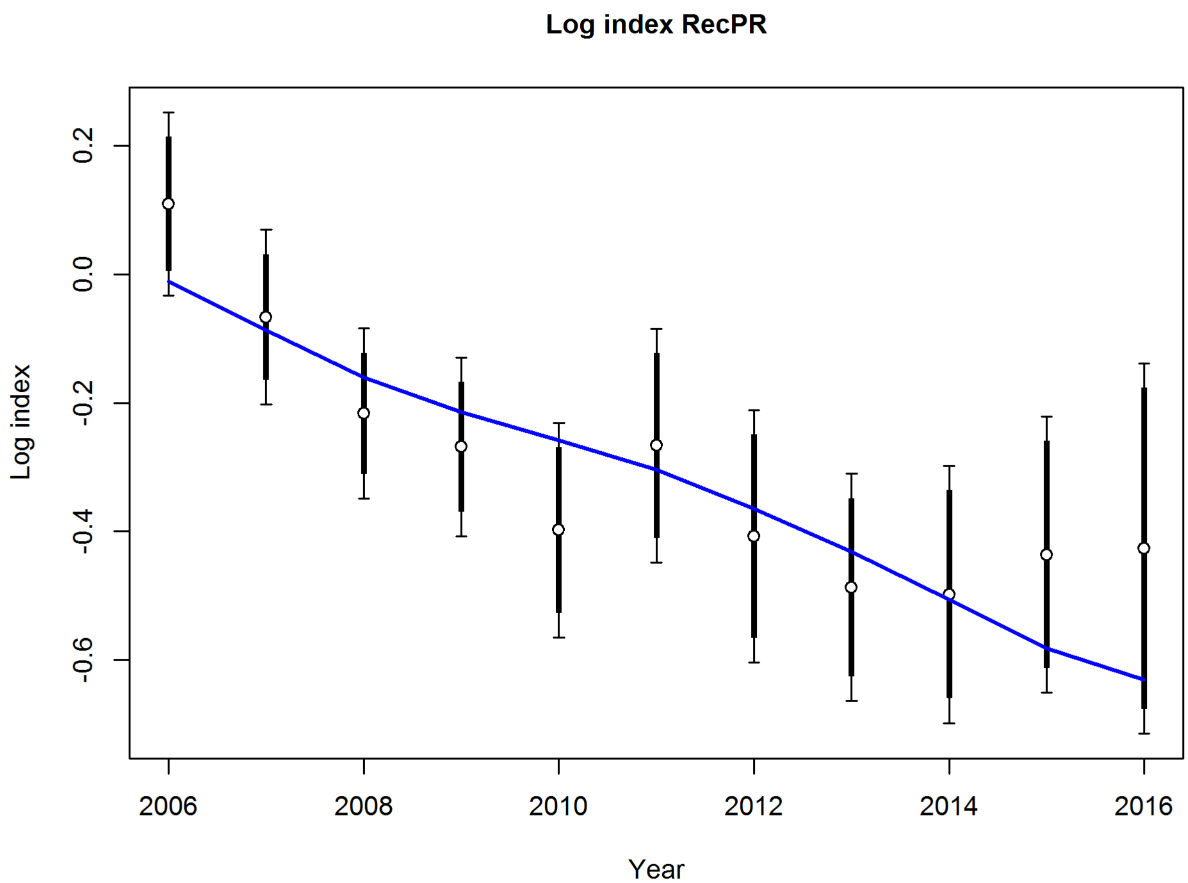

Figure 7: Fit to log index data on log scale for the recreational CPFV logbook retained catches. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. fig:index5_logcpuefit

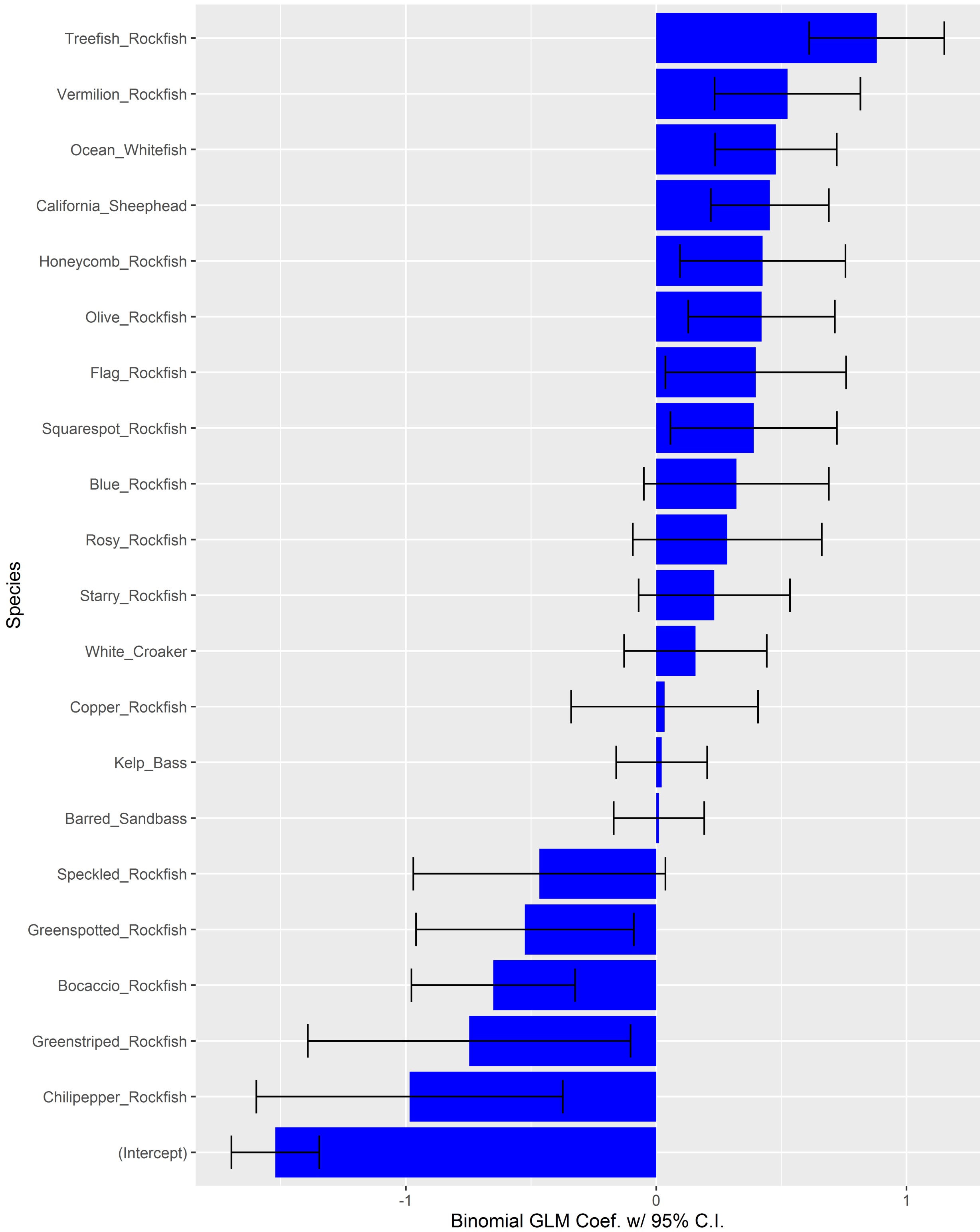

Figure 8: Species coefficients from the binomial GLM for presence/absence of California scorpionfish in the Marine Recreational Fisheries Statistics Survey (MRFSS) party/charter mode dockside survey data set. Horizontal bars are 95% confidence intervals. fig:Fleet5_RecPC_dockside

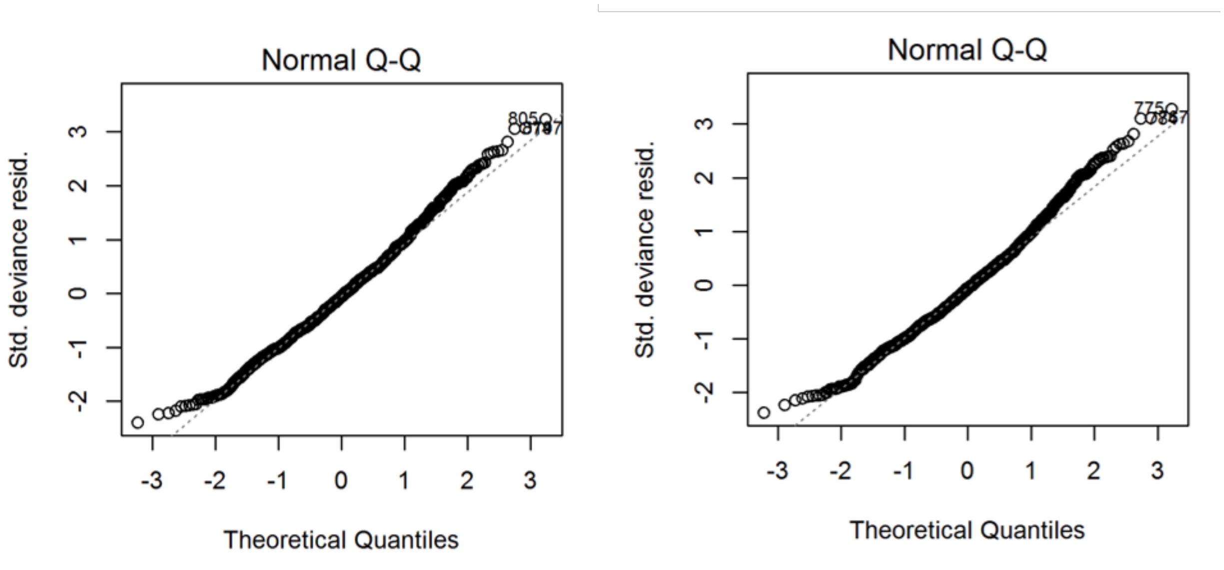

Figure 9: Q-Q plot used to validate the goodness of fit of the lognormal portion (posirive catch) of the Marine Recreational Fisheries Statistics Survey (MRFSS) party/charter dockside survey, for thresholds of 0.27 (left) and 0.10 (right) from the Stephens-MacCall filter. fig:Fleet5_RecPC_

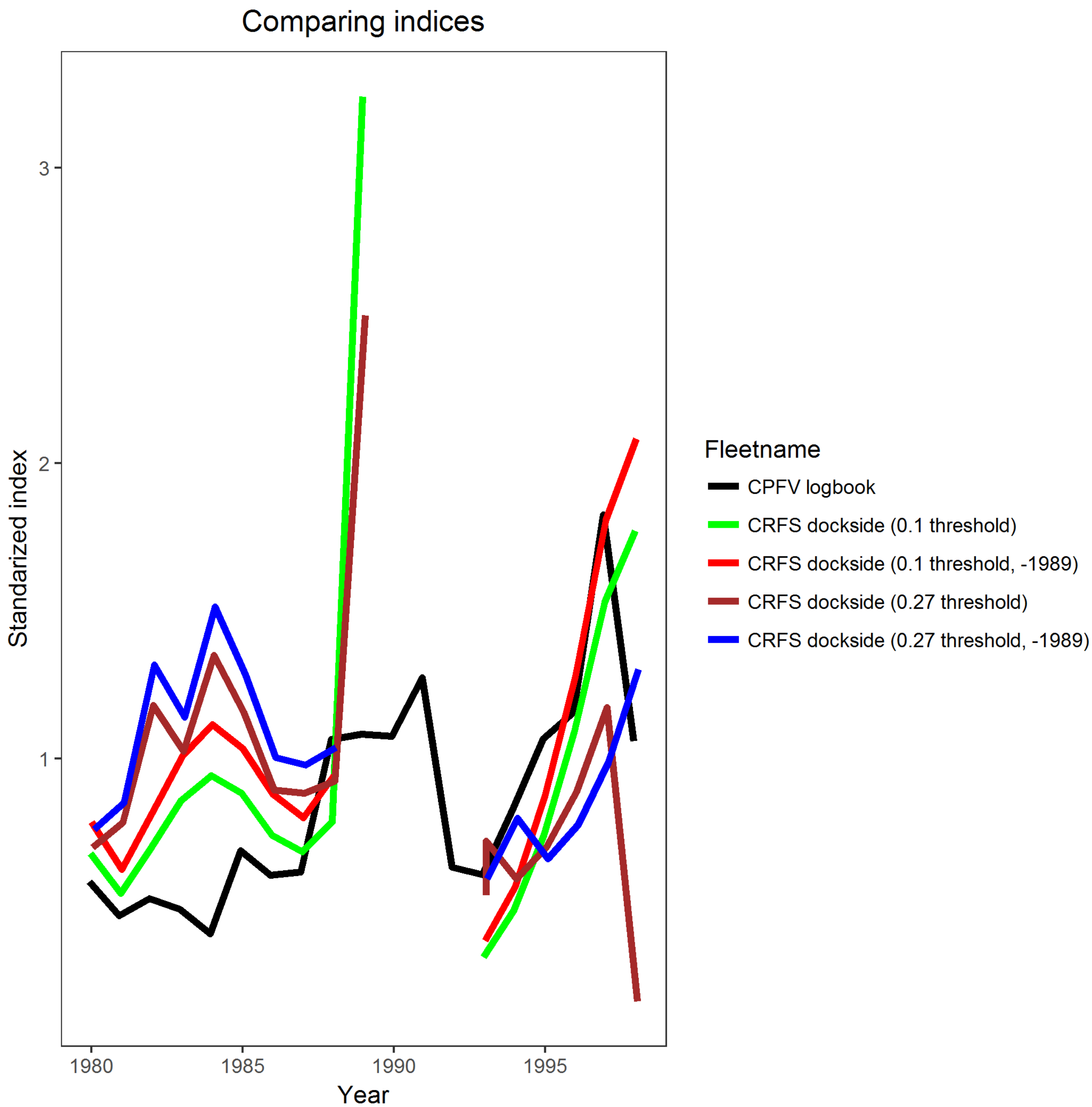

Figure 10: Comparison of standardized indices using two different threshold levels (0.27 and 0.1) from the Stephens-MacCall filtering, and including or excluding the year 1989. fig:Fleet5_RecPC_do

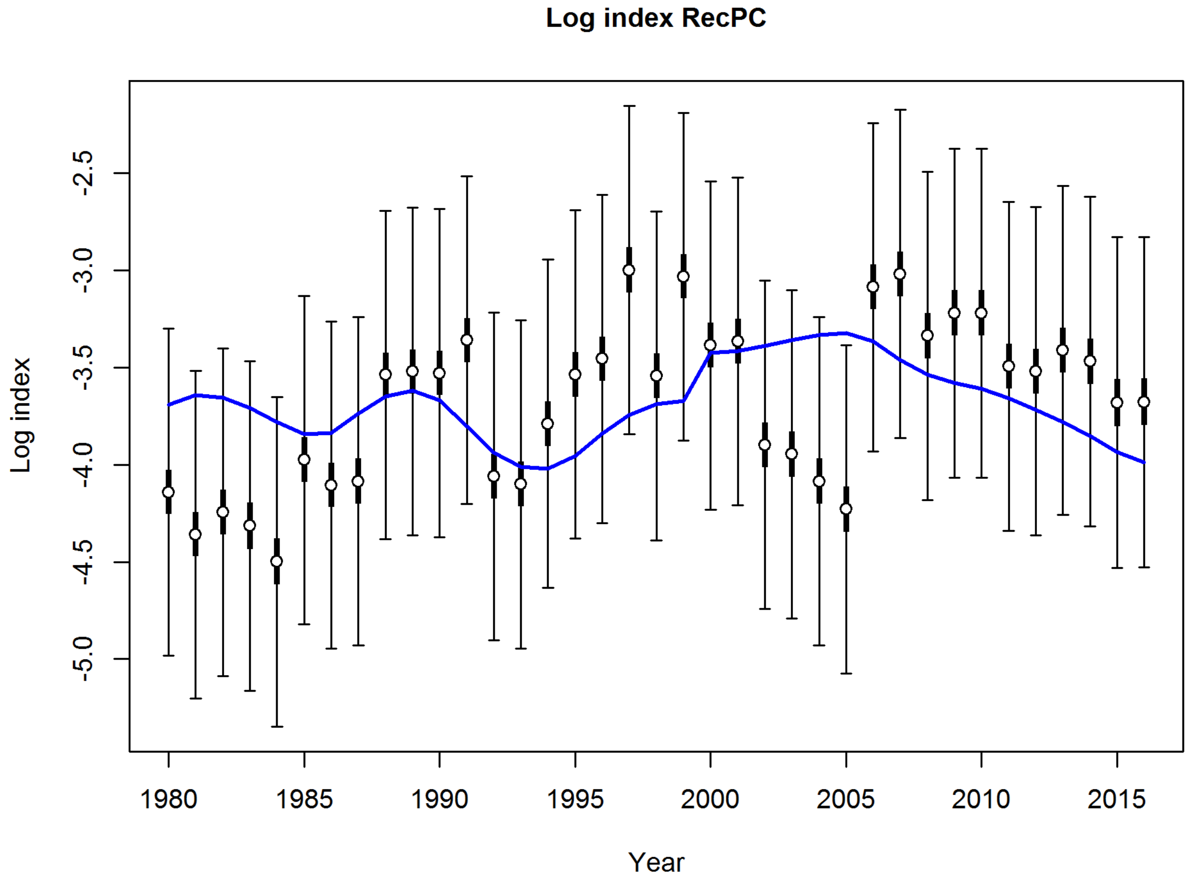

Figure 11: Fit to log index data on log scale for the recreational CPFV logbook retained catches. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. fig:index5_logcpuefit

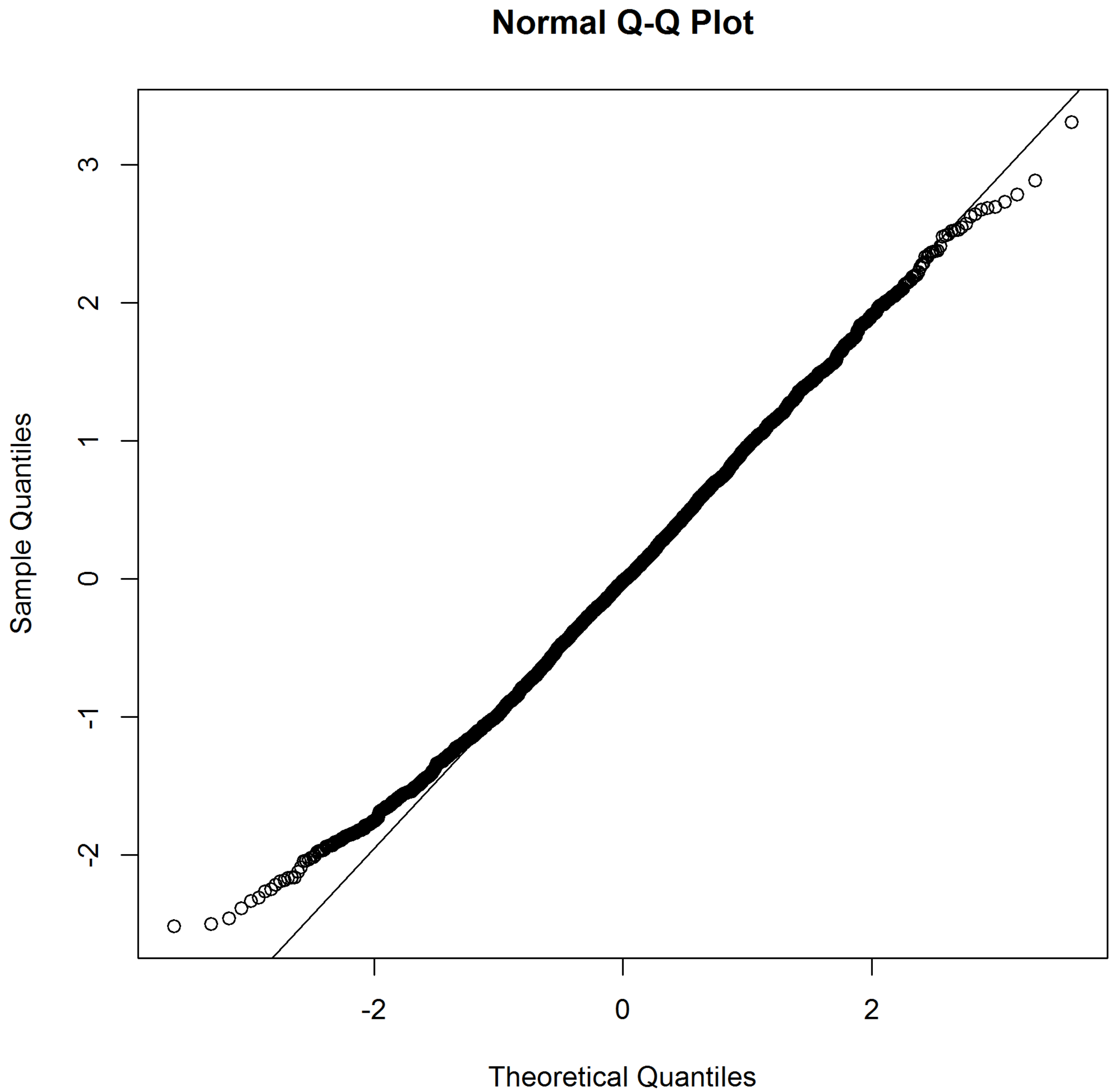

Figure 12: Q-Q plot used to validate the goodness of fit of the lognormal model for the CPFV onboard observer discarded only catch. fig:Fleet6_RecDD_QQ

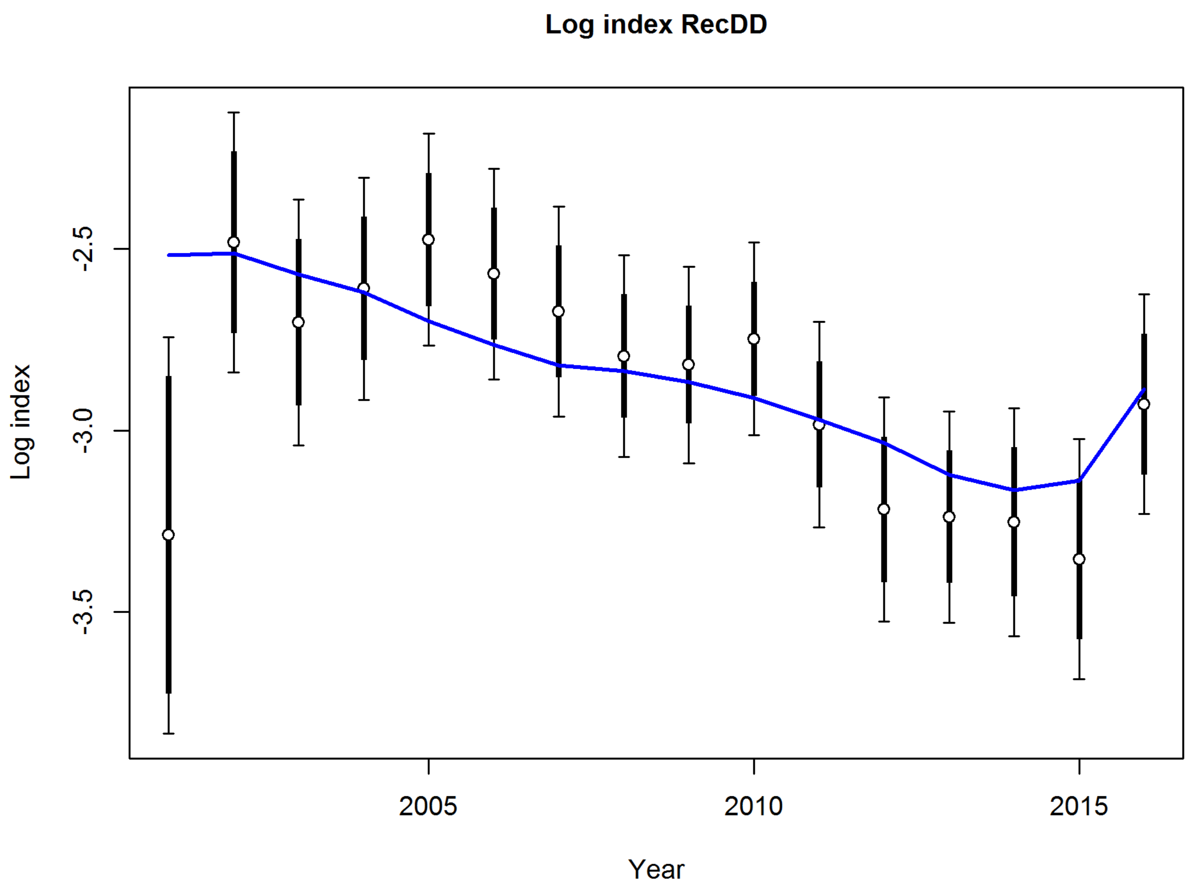

Figure 13: Fit to log index data on log scale for the recreational CPFV onboard oserver discarded catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. fig:Fleet6_index5_logcpuefit_RecDD

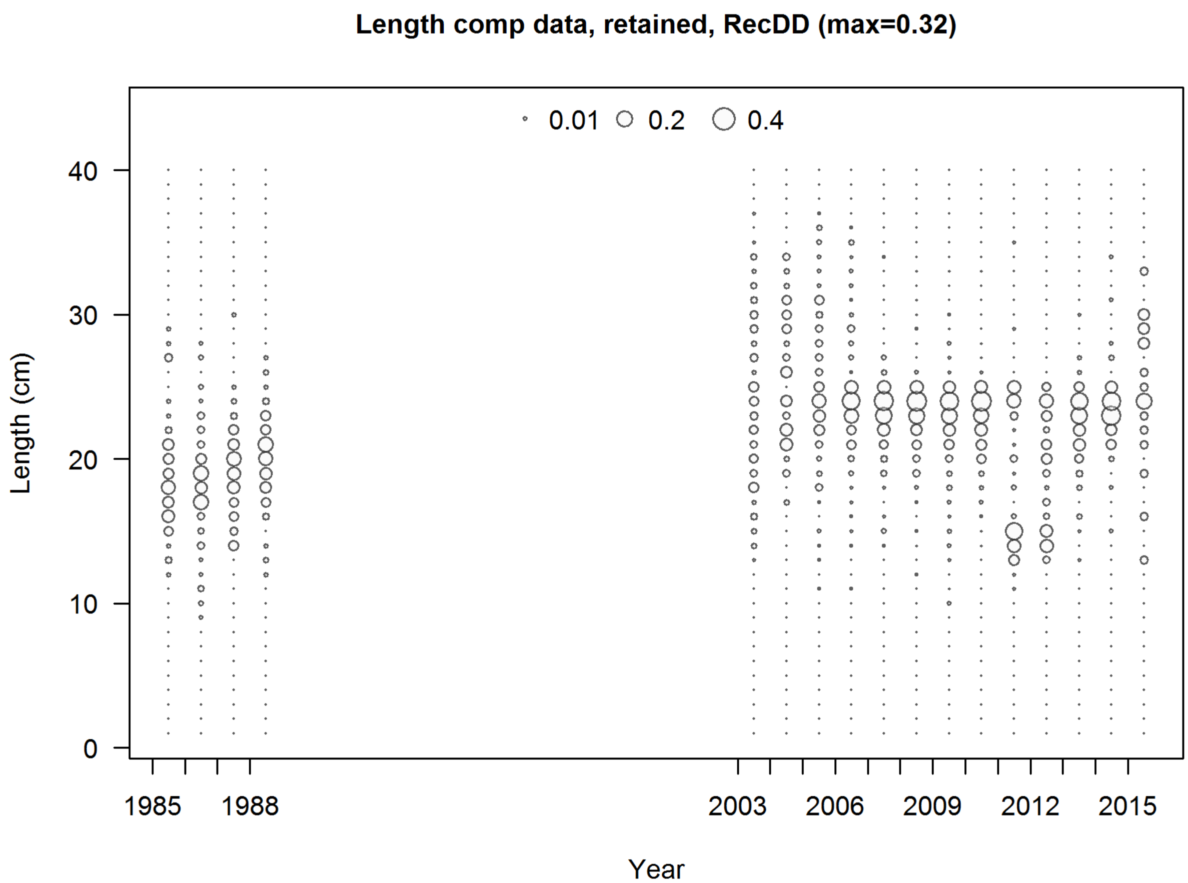

Figure 14: Length frequency distributions from the sanitation disricts trawl surveys. fig:Fleet6_comp

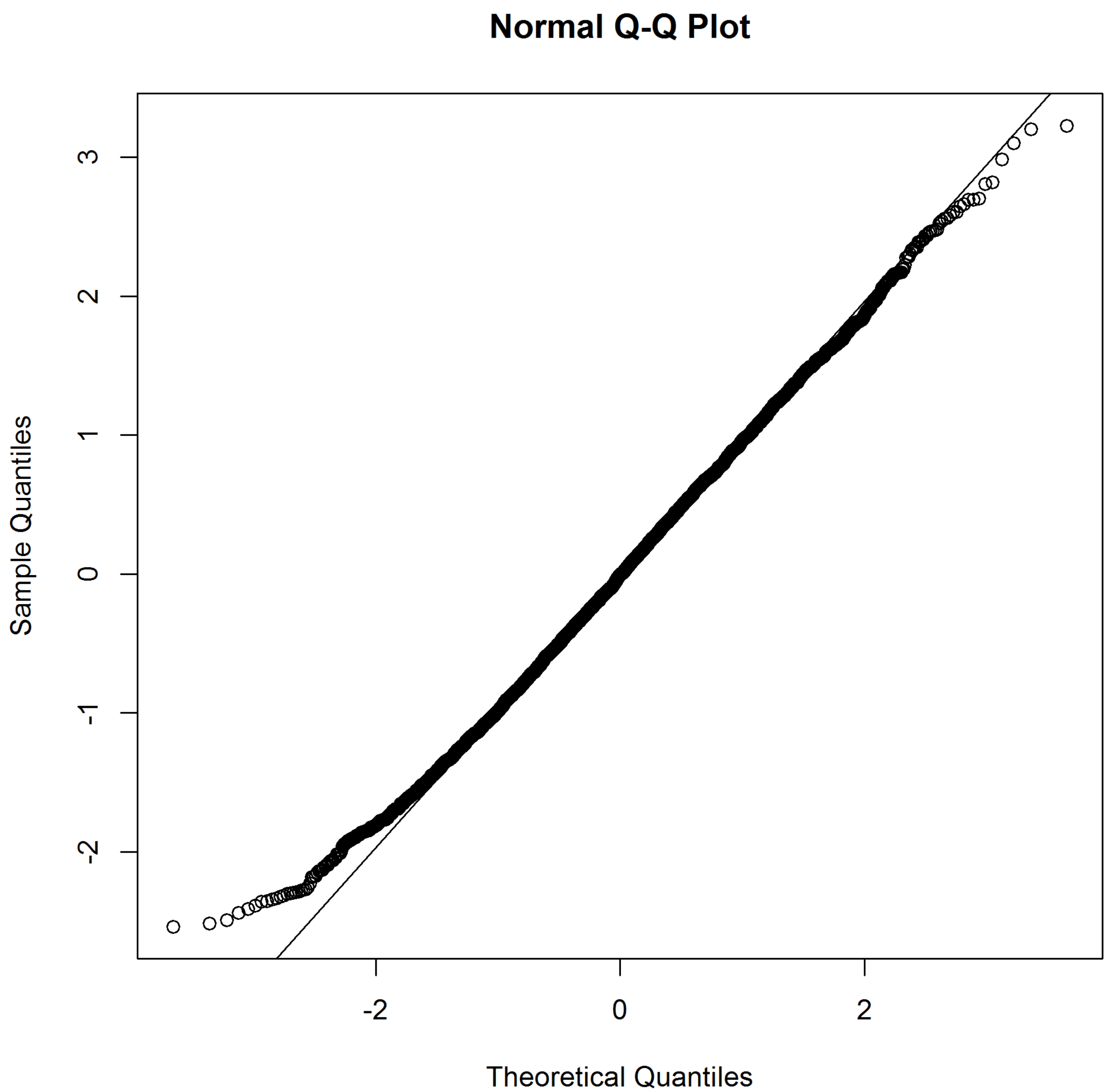

Figure 15: Q-Q plot used to validate the goodness of fit of the lognormal model for the CPFV onboard observer retained only catch. fig:Fleet12_RecPCOBR_QQ

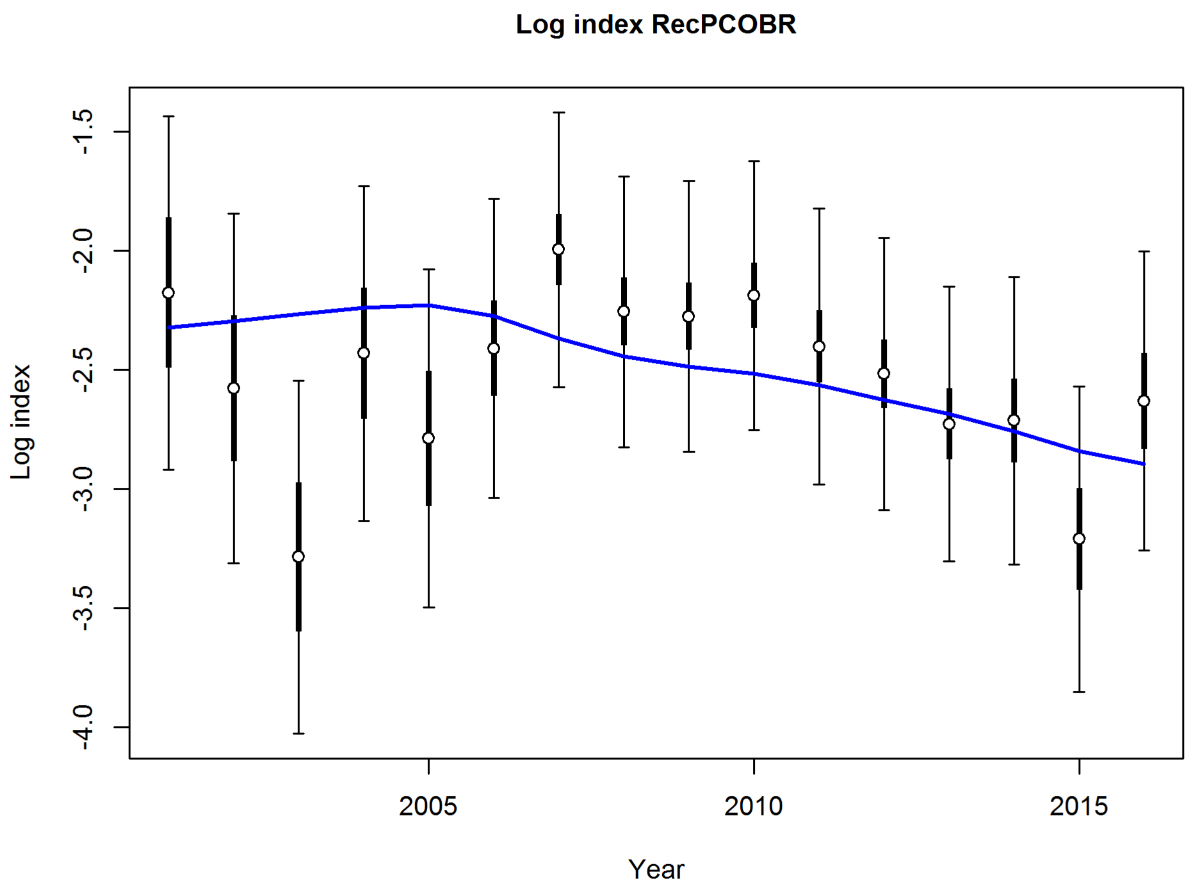

Figure 16: Fit to log index data on log scale for the recreational CPFV onboard oserver retained catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. fig:Fleet12_index5_logcpuefit_RecPCOBR

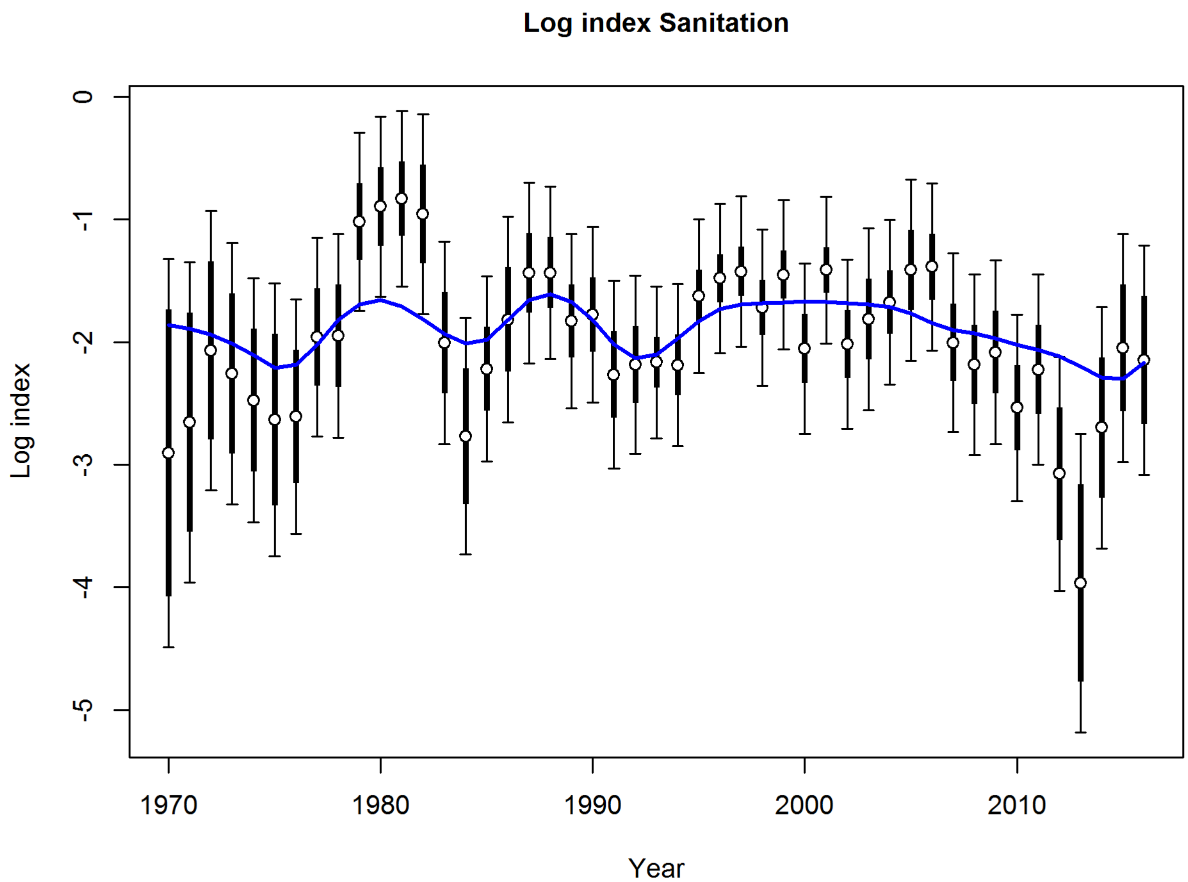

Figure 17: Fit to log index data on log scale for the recreational CPFV onboard oserver discarded catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.
fig:index5_logcpuefit_Sanitation

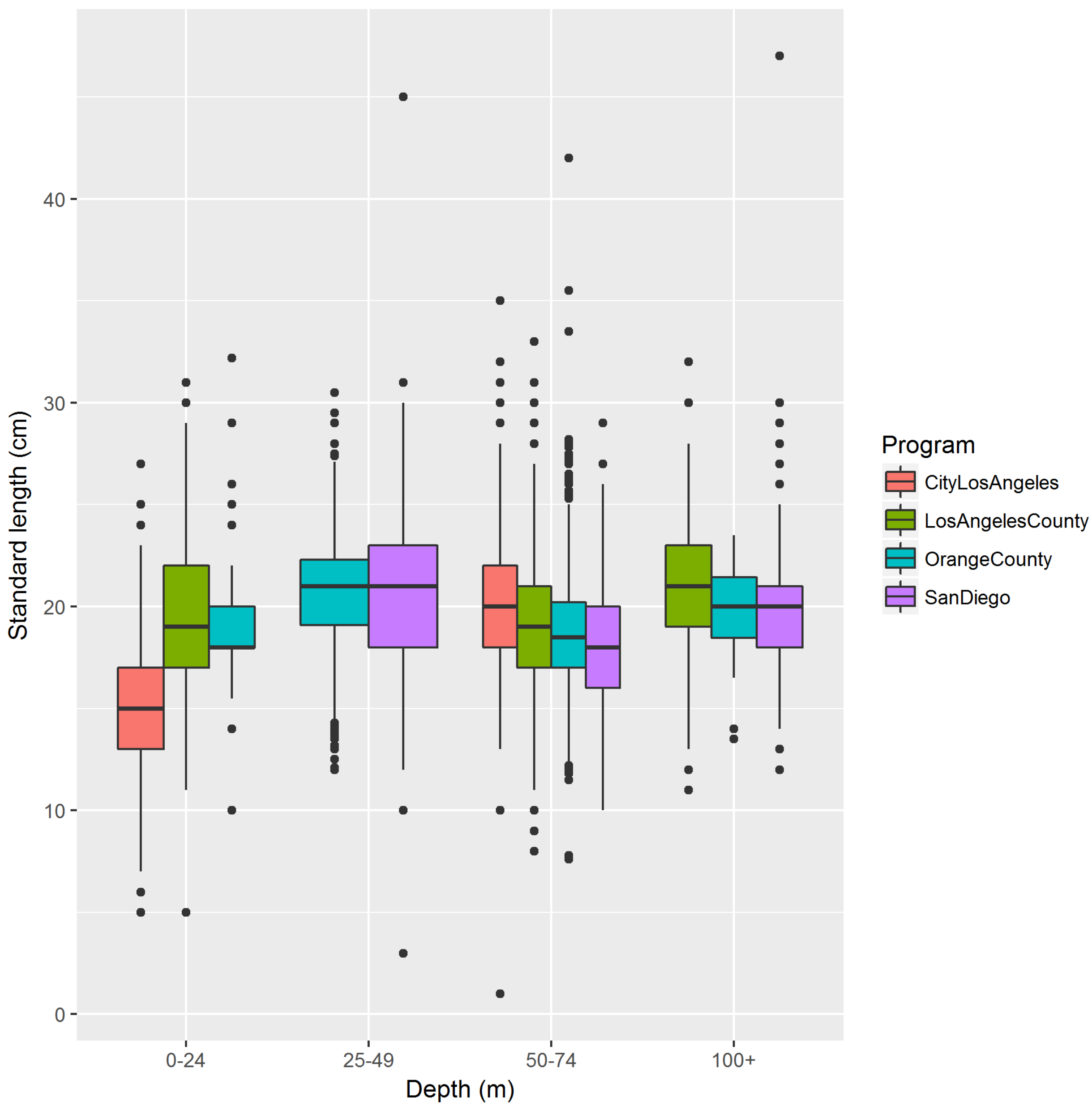

Figure 18: Boxplots of measured California scorpionfish from the sanitation district surveys by program and 25 m depth bins. fig:Fleet7_Sanitation_lengthboxplots

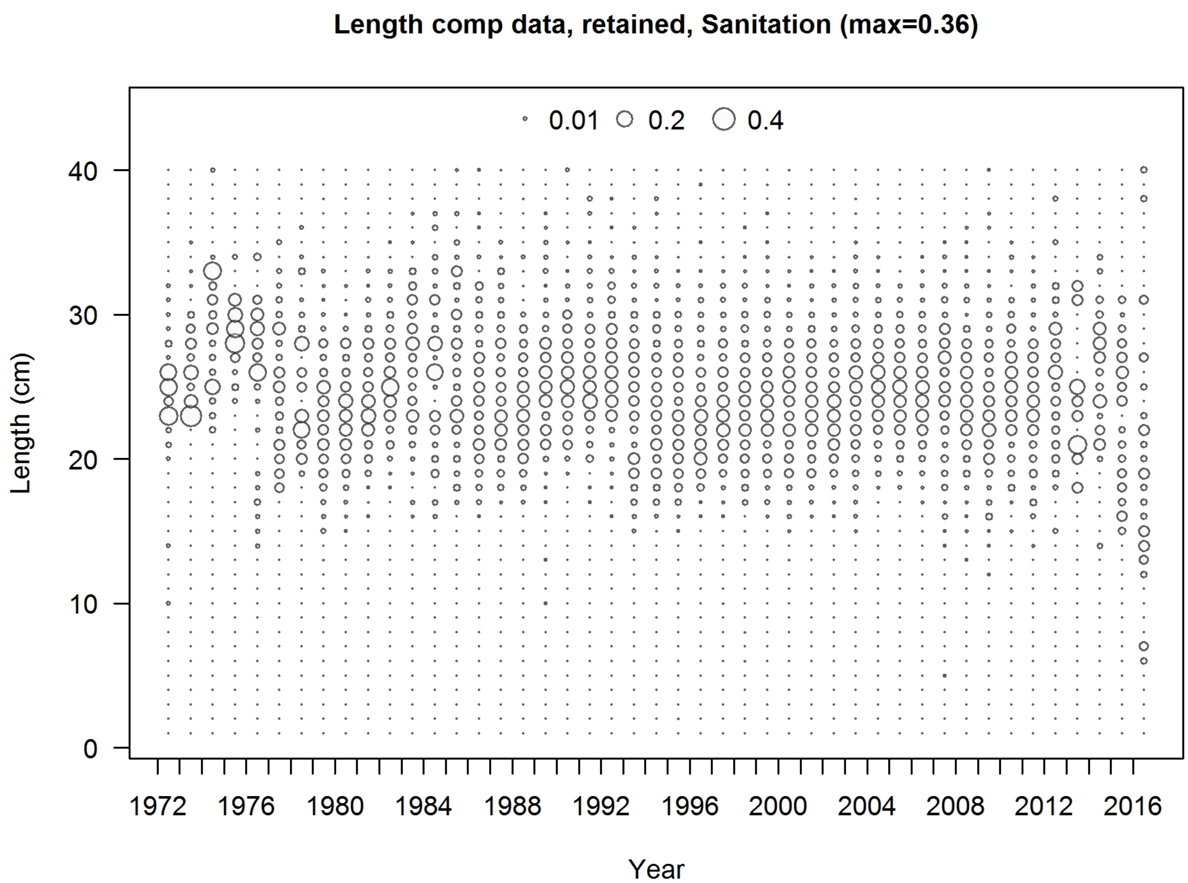

Figure 19: Length frequency distributions from the sanitation disricts trawl surveys. fig:Fleet7_comp_

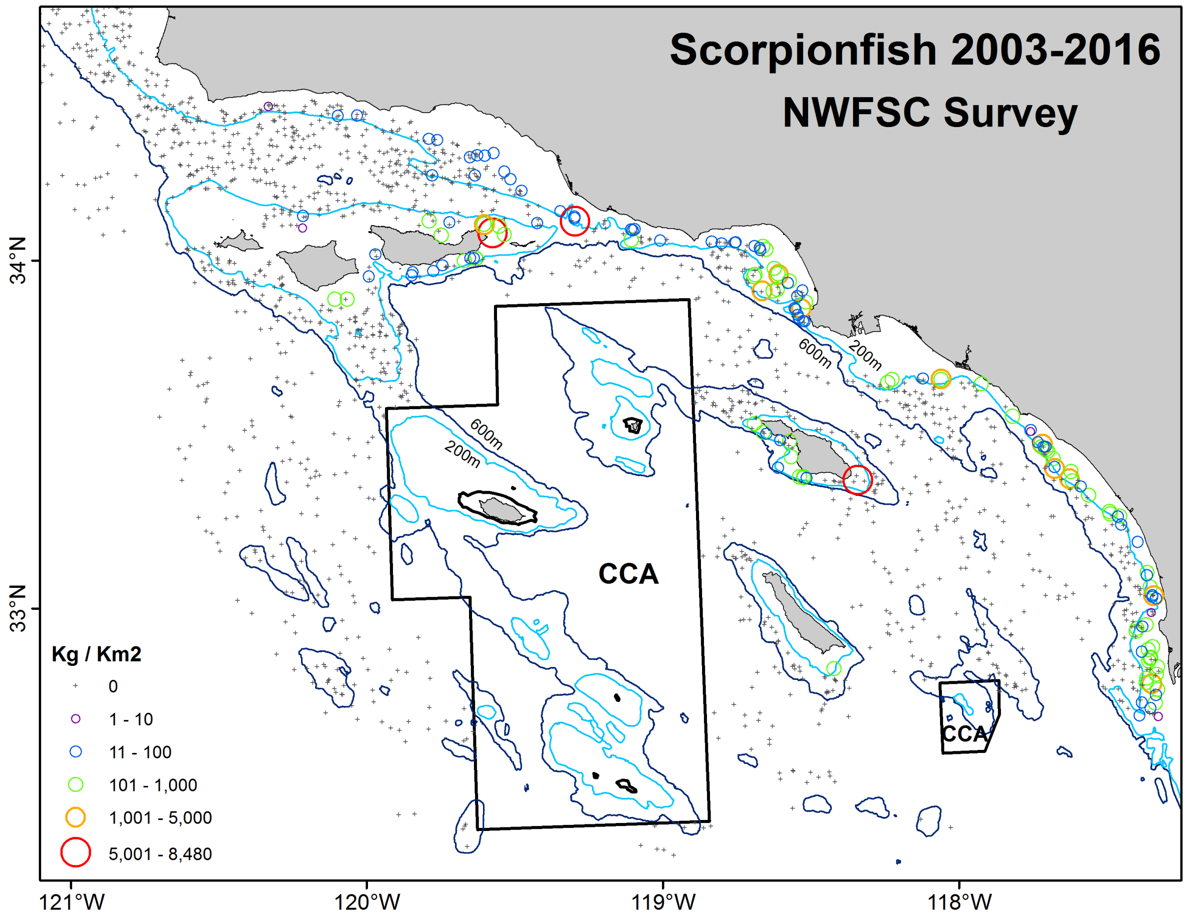

Figure 20: Spatial distribution of raw catch rates of Scorpionfish from NWFSC trawl survey between 2003 and 2016. Depth contour lines of 200m and 600m and the CAC areas are shown. Note that sizes and colors of circles represent catch rate in log scales (Credit of Rebecca Miller, SWFSC). fig:Fleet8_NWFSCtrawl_map

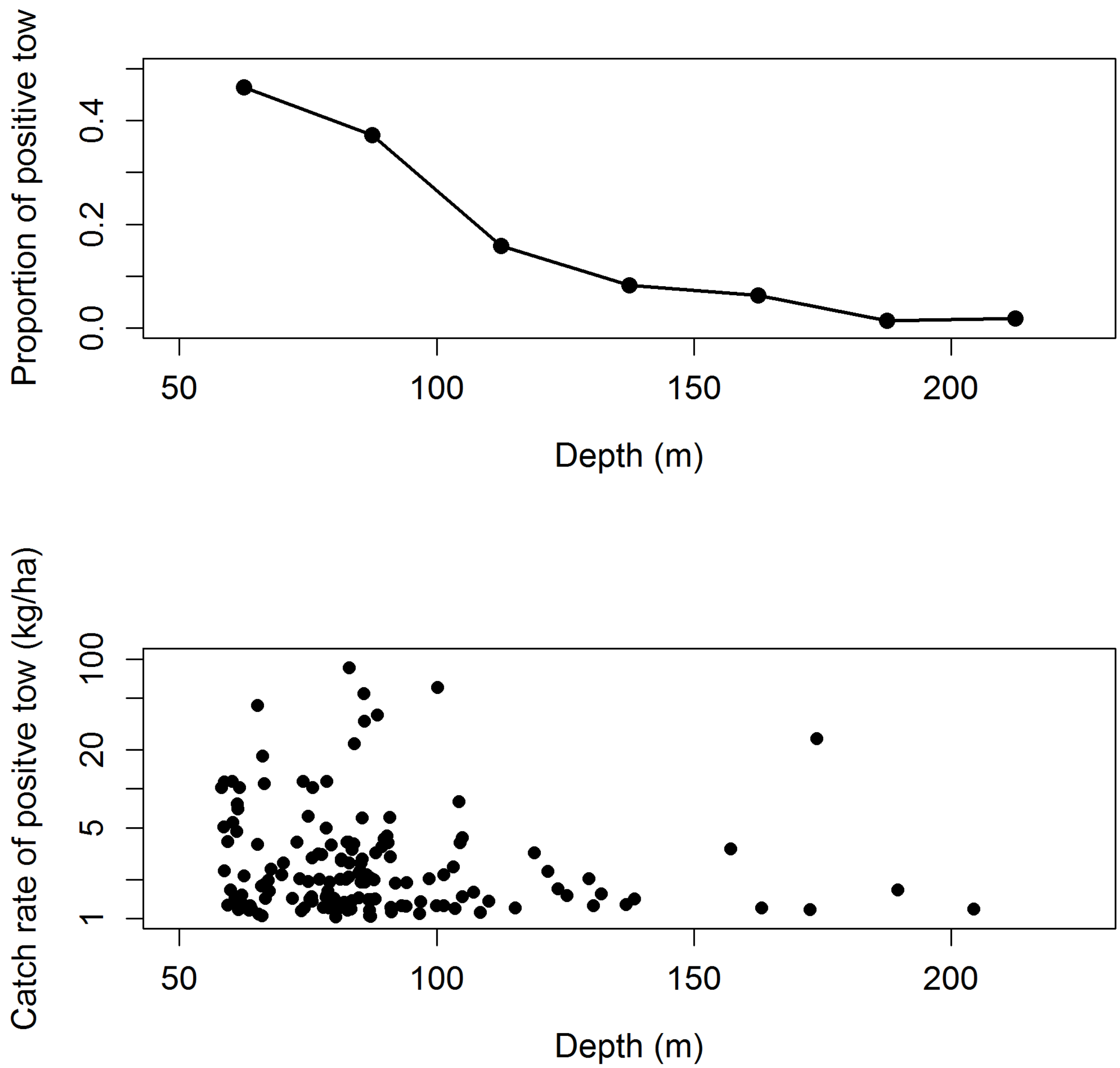

Figure 21: Plots of the proportion of positive tows (top panel) and the raw catch rates of positive tows (bottom panel) by depth zones (25 m interval) for NWFSC trawl survey. fig:Fleet8_NWFSC

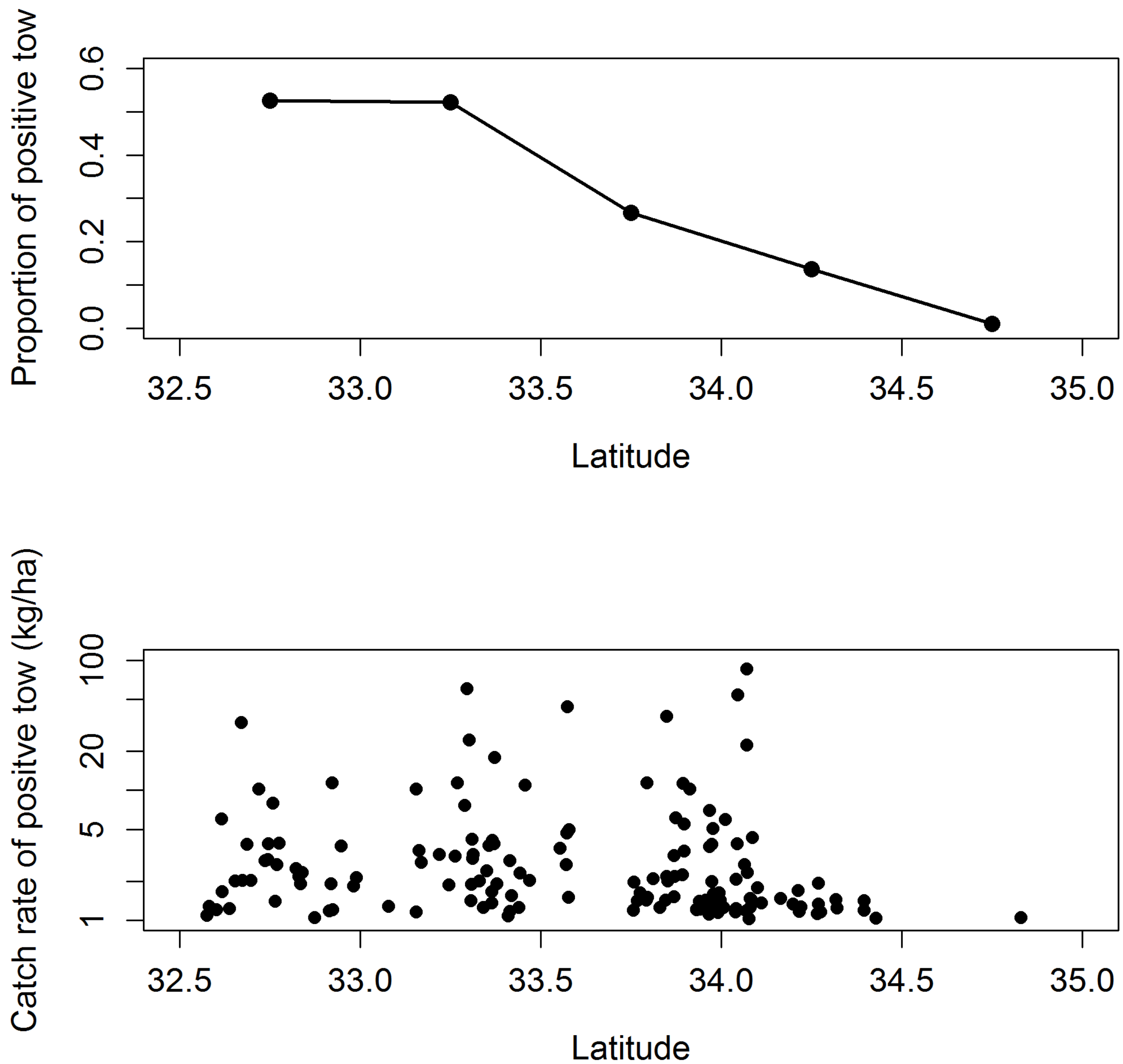

Figure 22: Plots of the proportion of positive tows (top panel) and the raw catch rates of positive tows (bottom panel) by latitude zones (0.5 degree interval) for NWFSC trawl survey.
fig:Fleet8_NWFSCtrawl_poslat

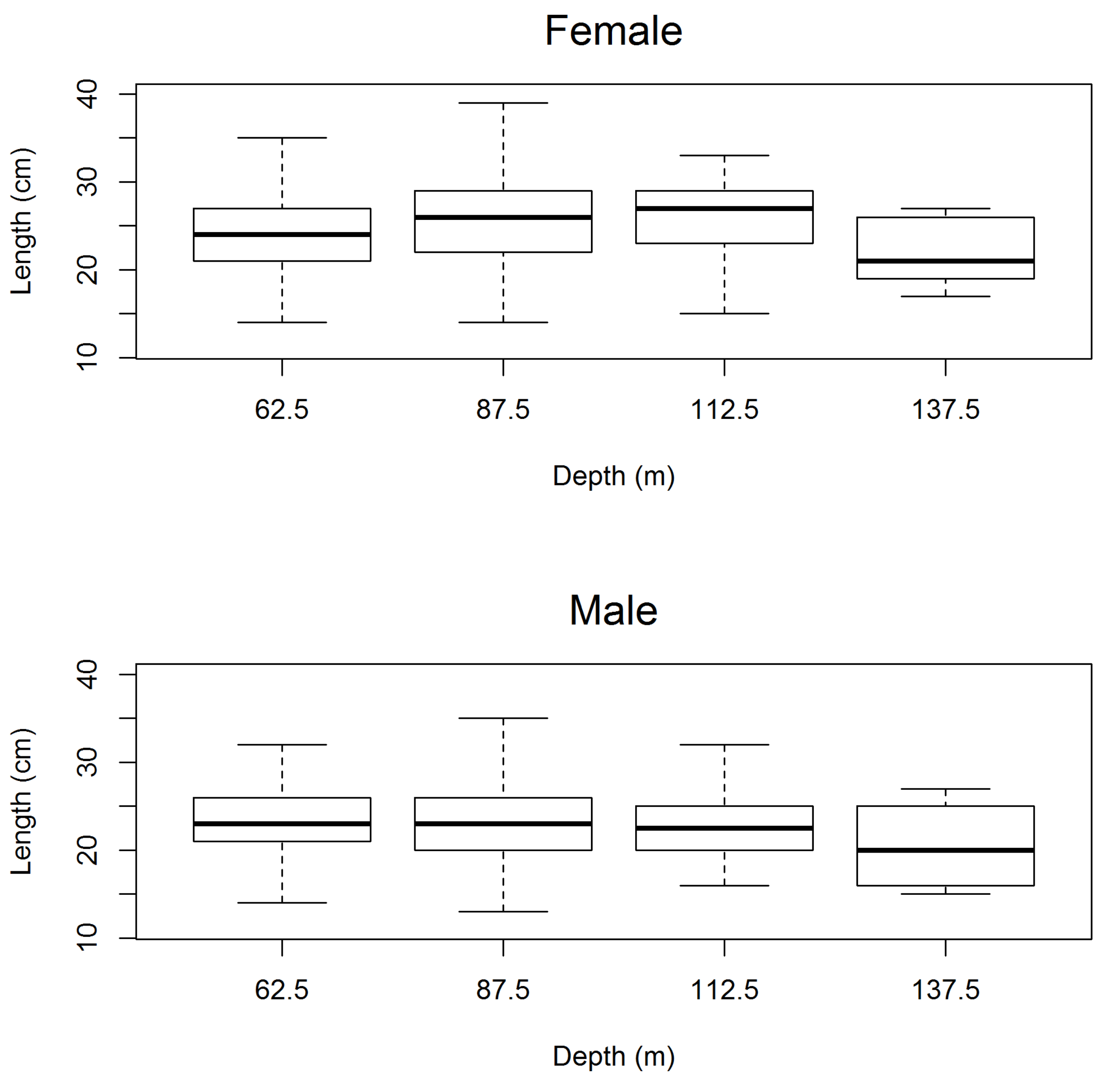

Figure 23: Comparison box plots of raw length data from NWFSC trawl survey by depth zone and sex. fig:Fleet8_NWFSCtrawl_lengthdepth

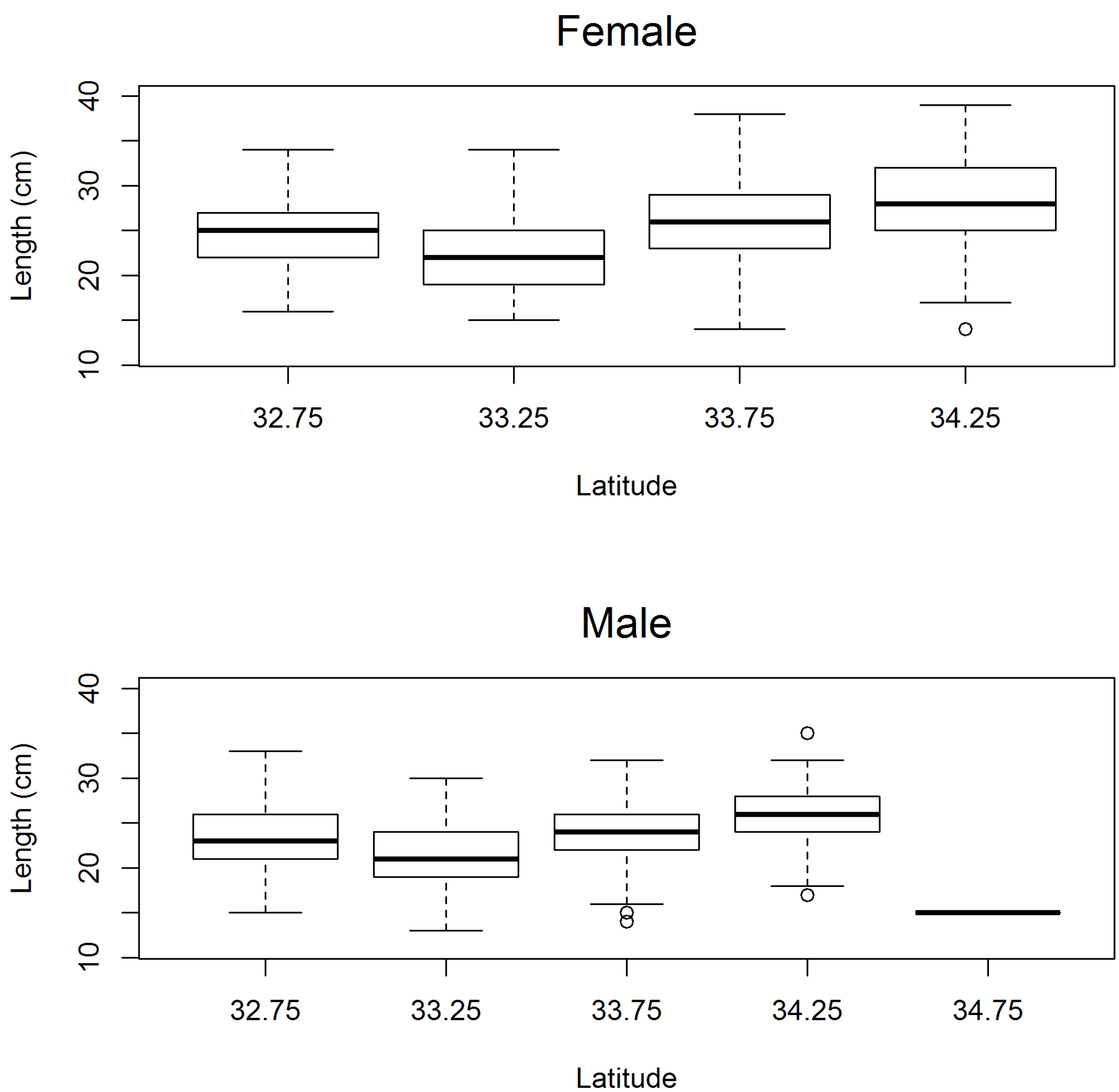

Figure 24: Comparison box plots of raw length data from NWFSC trawl survey by latitude zone and sex. fig:Fleet8_NWFSCtrawl_lengthlat

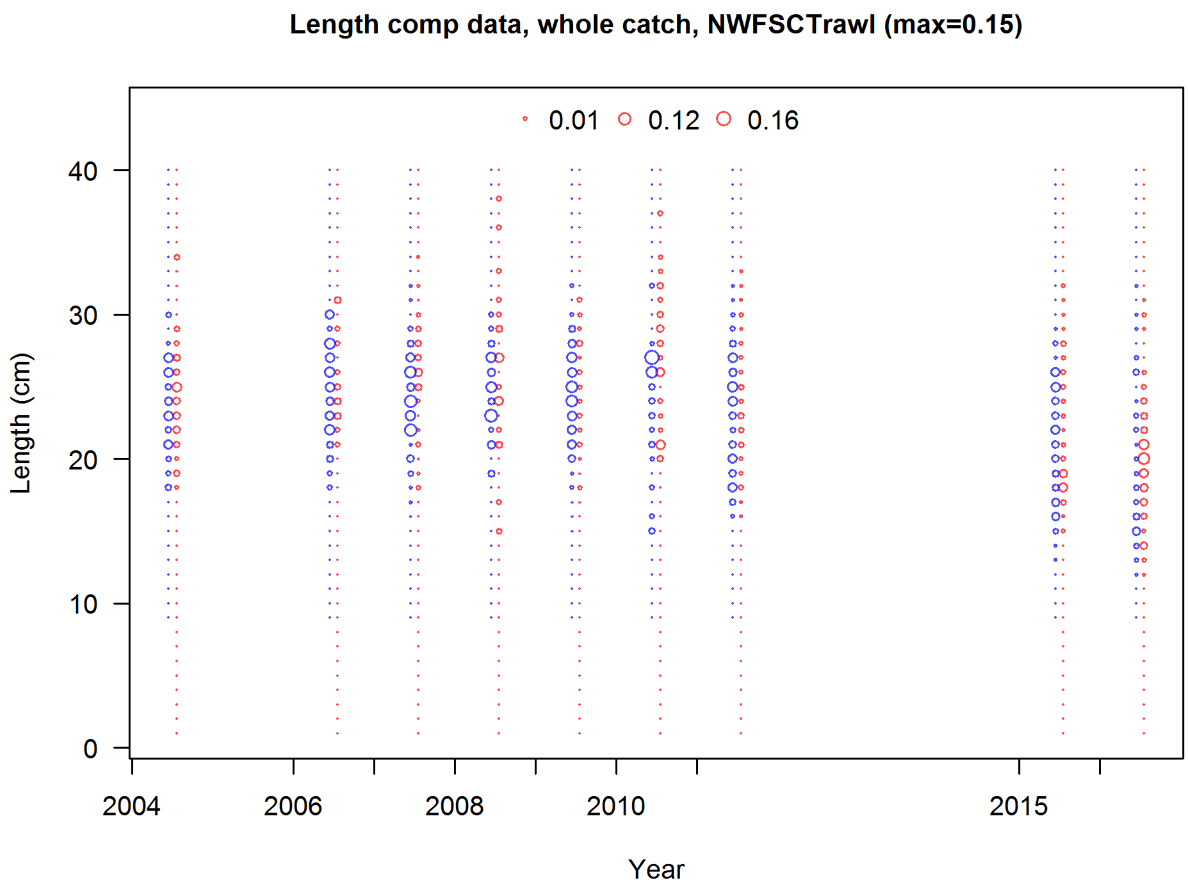

Figure 25: Length frequency distributions of females (red) and male (blue) from the NWFSC trawl survey between 2003 and 2016. fig:Fleet8_comp_lendat_bubflt8mkt0

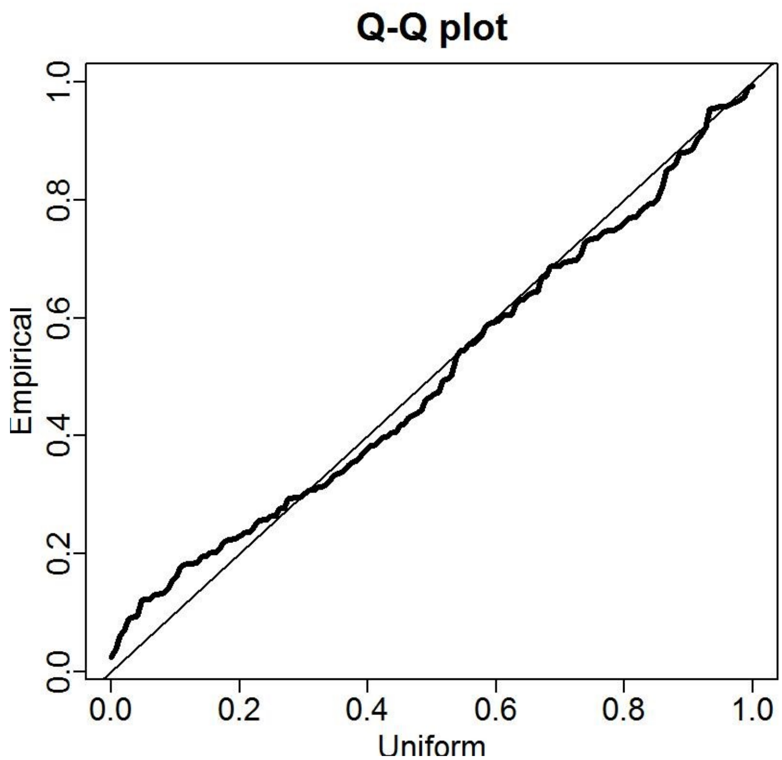

Figure 26: Q-Q plot used to validate the goodness of fit of the VAST analysis for the NWFSC trawl survey between 2003 and 2016. fig:Fleet8_NWFSCtrawl_QQ

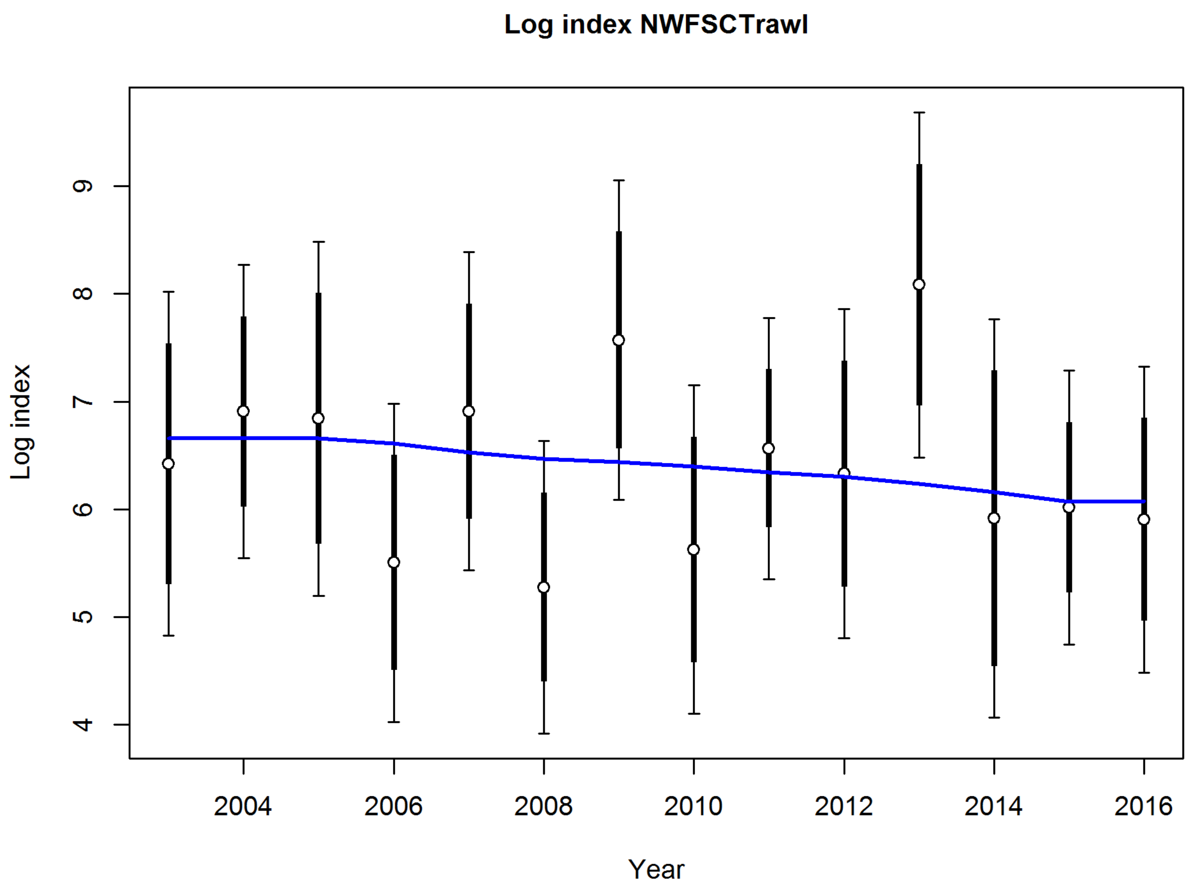

Figure 27: Fit to log index data on log scale for the NWFSC trawl survey from the VAST analysis from 2003-2016. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.
fig:index5_logcpuefit_NWFSCtrawl

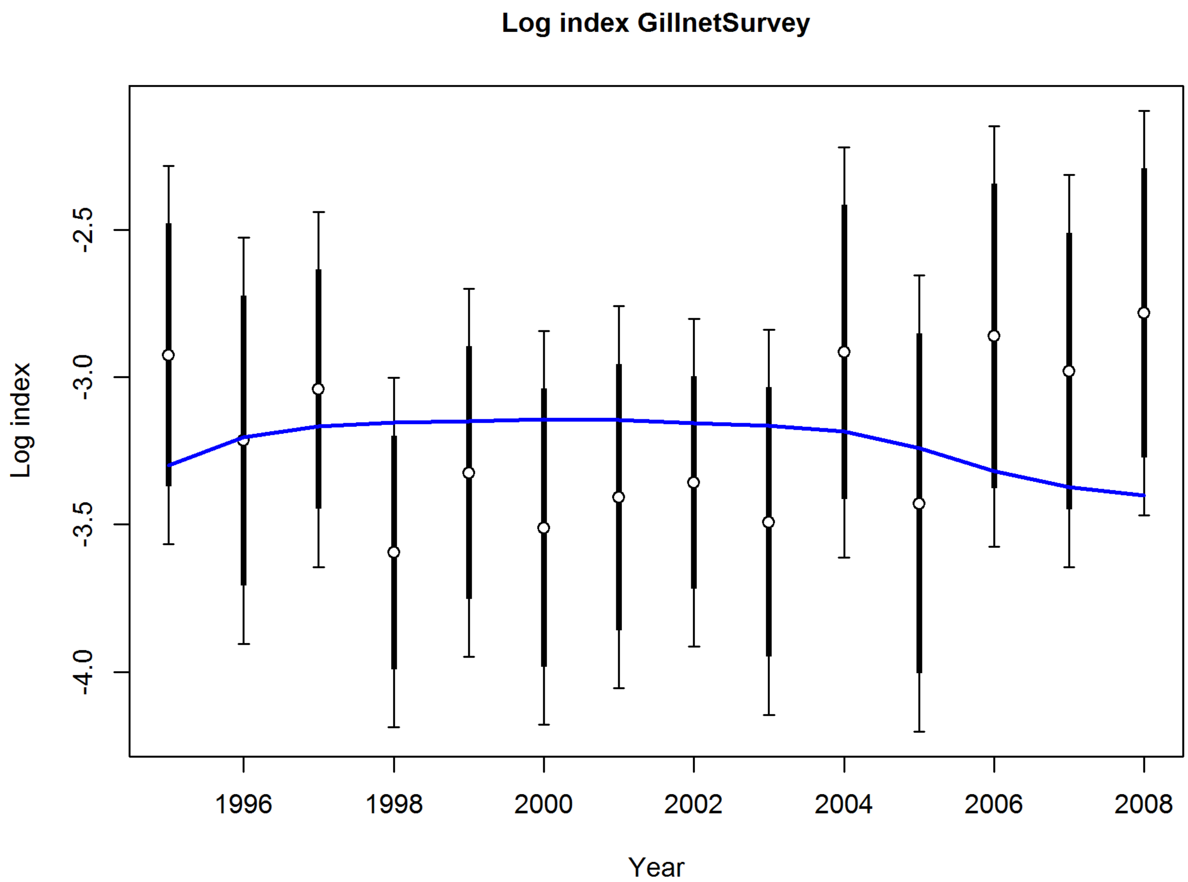

Figure 28: Fit to log index data on log scale for the recreational CSUN/VRG gillnet survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. fig:index5_logcpuefit_Gilln

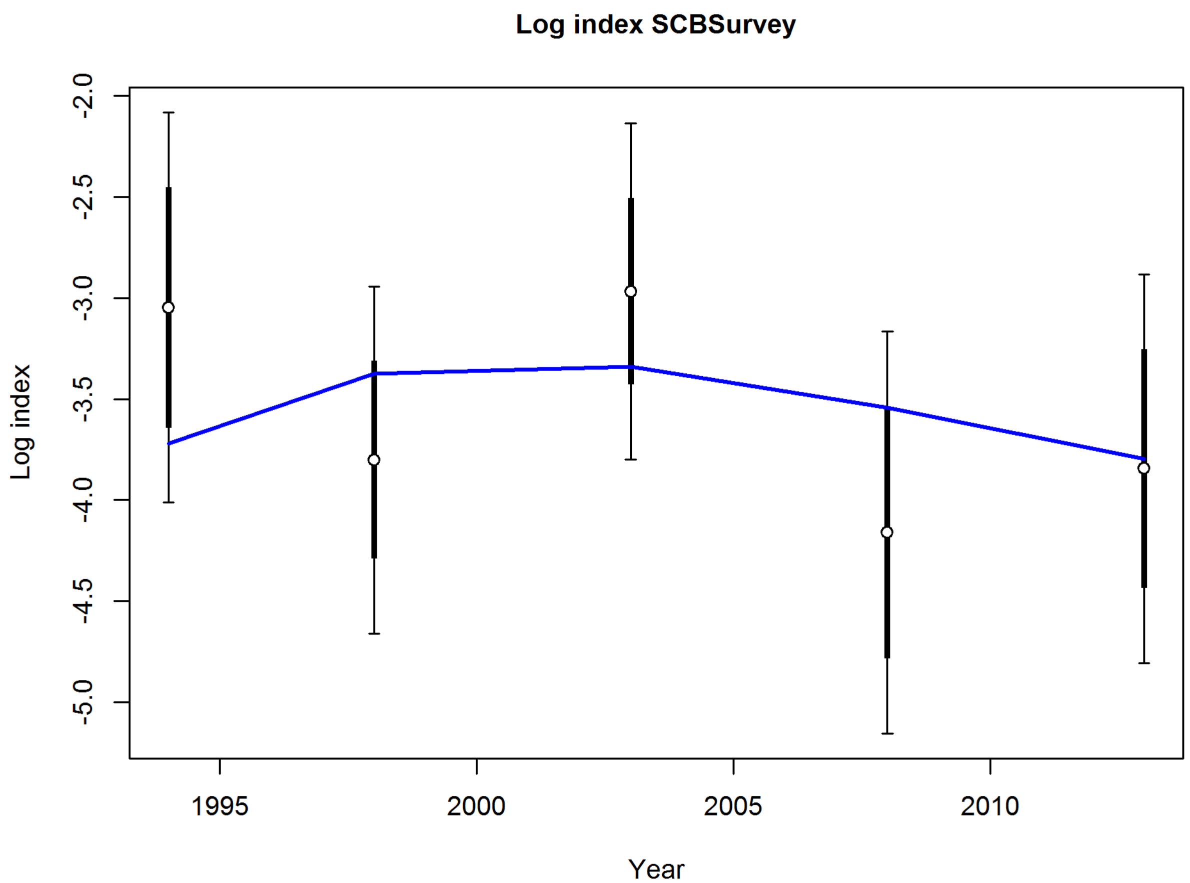

Figure 29: Fit to log index data on log scale for the recreational Southern California Bight trawl survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter. fig:index5_log

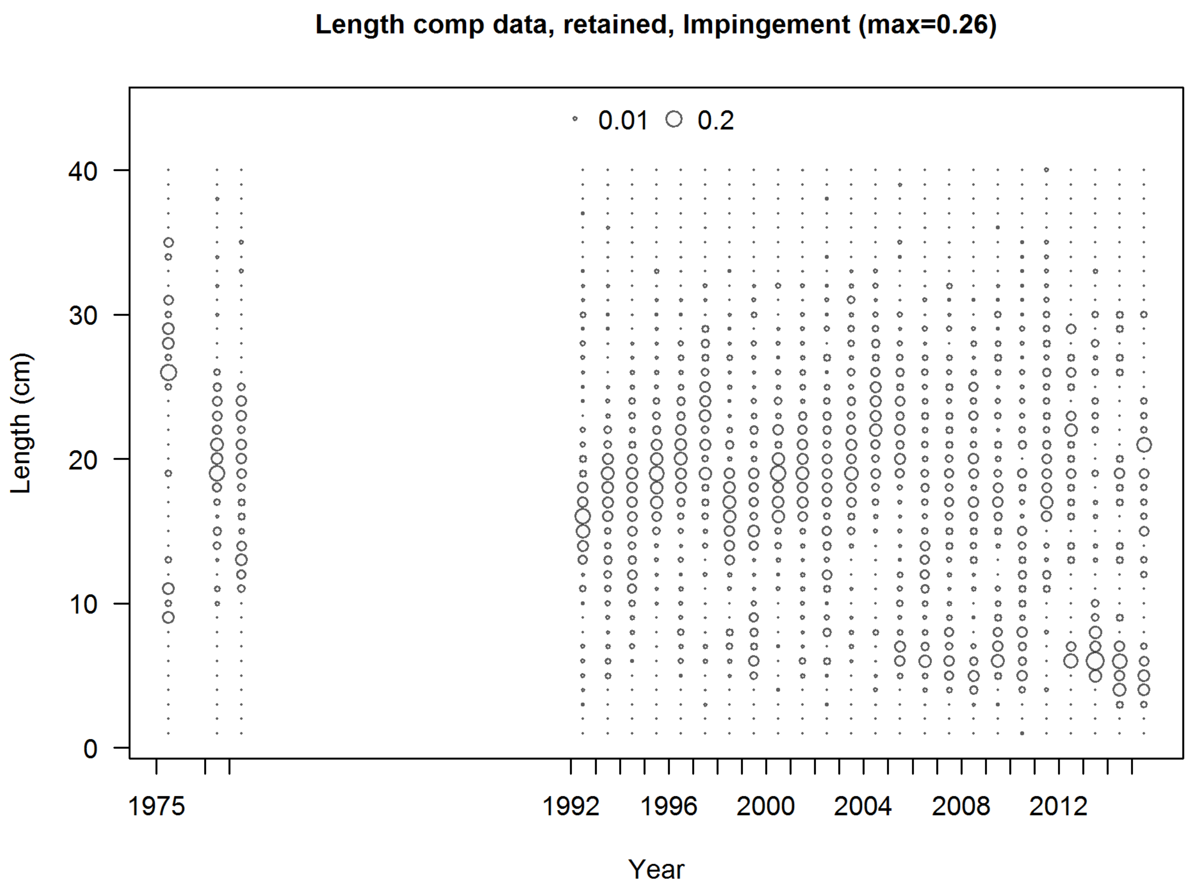

Figure 30: Length frequency distributions from the Impingement surveys. fig:Fleet10_comp_len

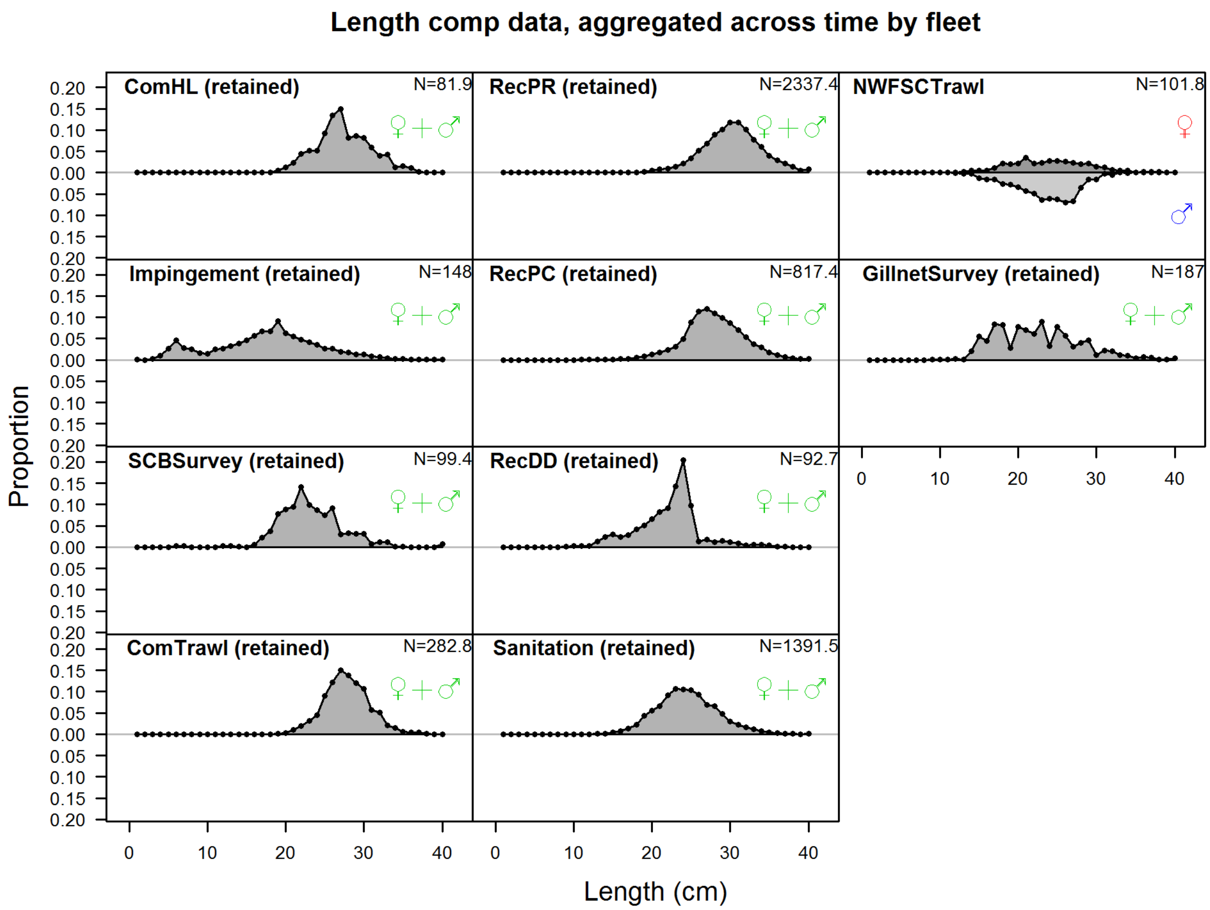

Figure 31: Length comp data, aggregated across time by fleet. Labels 'retained' and 'discard' indicate discarded or retained sampled for each fleet. Panels without this designation represent the whole catch. fig:comp_lendat_aggregated_across_time

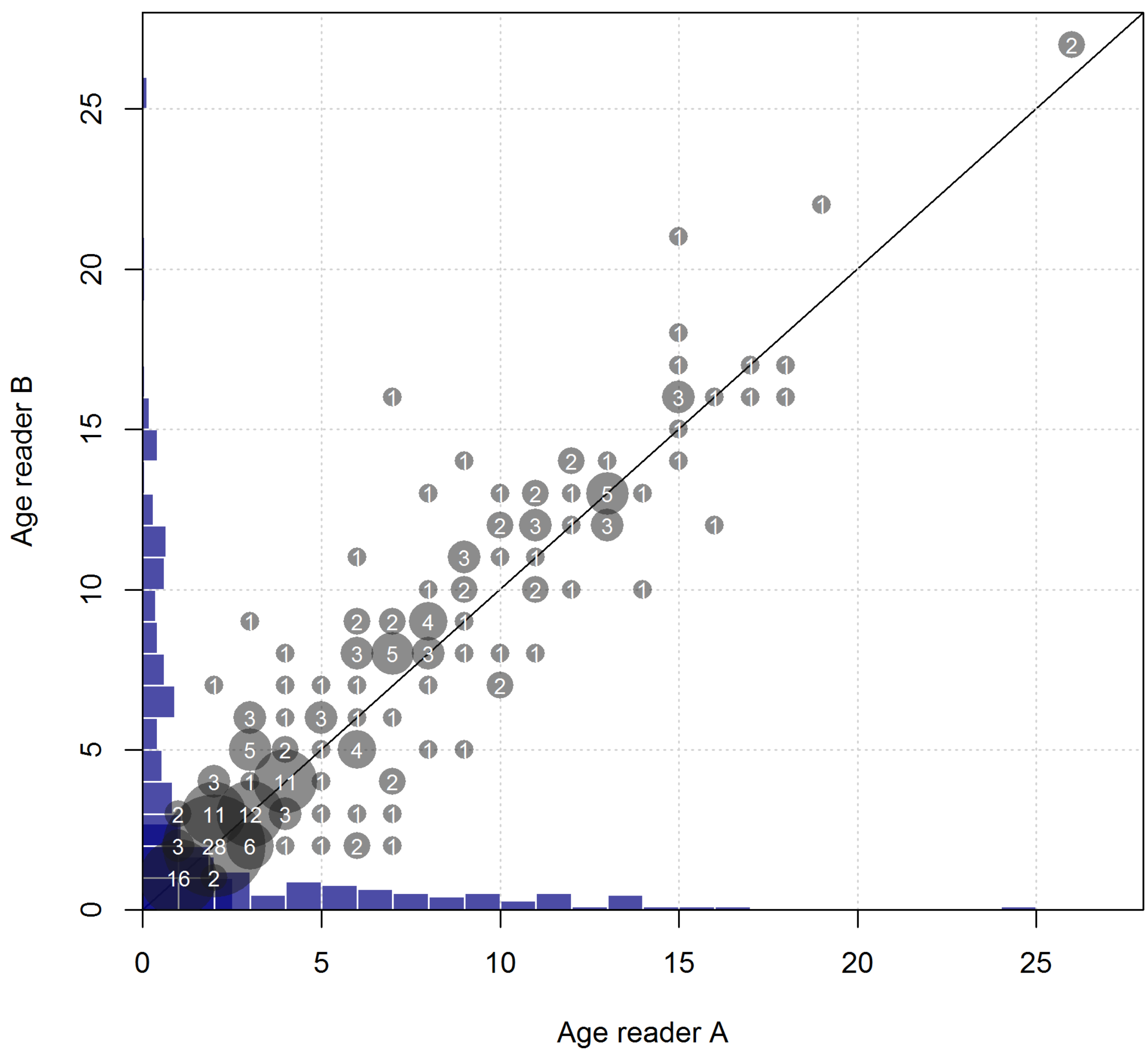

Figure 32: Aging precision between two current age readers at the NWFSC. fig:Fleet8_NWFSCTra

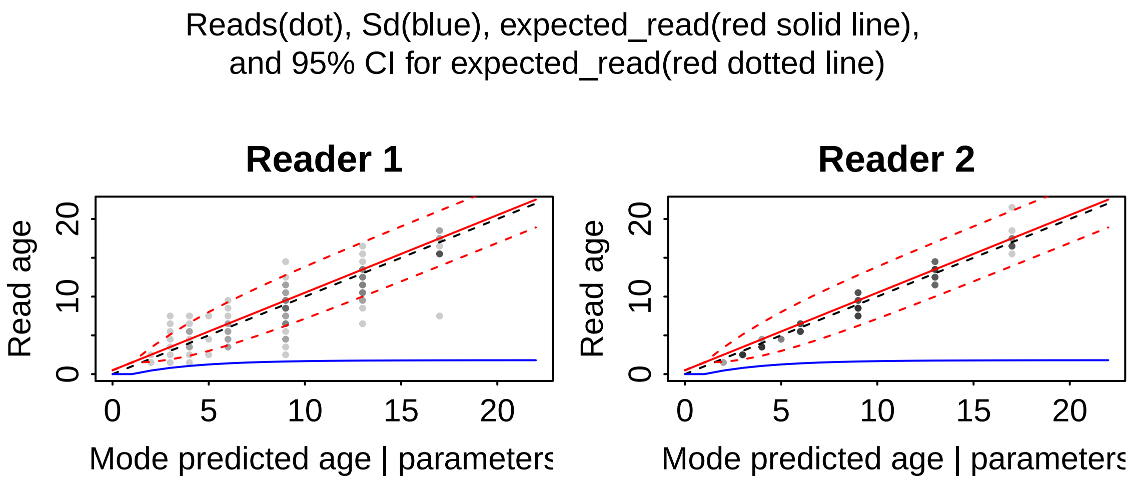

Figure 33: True versus predicted age for two current age readers at the NWFSC from the ageing error software with unbiased reads and curivlinear standard deviation for both readers. fig:Fleet8_NWFSCTrawl_ageerror2

References

references

Alverson, D.L., Pruter, a T., and Ronholt, L.L. 1964. A Study of Demersal Fishes and Fisheries of the Northeastern Pacific Ocean. Institute of Fisheries, University of British Columbia.

Bertalanffy, L. von. 1938. A quantitative theory of organic growth. Human Biology **10**: 181–213.

Daugherty, A. 1949. The commercial fish catch of California for the year 1947 With an historical review 1916–1947. *In* California department of fish and game fishery bulletin no. 74.

Dotson, R., and Charter, R. 2003. Trends in the Southern California sport fishery. CalCOFI Report **44**: 94–106. Available from http://calcofi.org/publications/calcofireports/v44/Vol_44_Dotson_Charter.pdf.

Eschmeyer, W.N., Herald, E., and Hammann, H. 1983. A field guide to Pacific coast fishes of North America. Houghton Mifflin Company, Boston, MA.

Francis, R. 2011. Data weighting in statistical fisheries stock assessment models. Canadian Journal of Fisheries and Aquatic Sciencies **68**: 1124–1138.

Frey, H. 1971. California's living marine resources and their utilization. California Department of Fish; Game, Sacramento, CA.

Hamel, O. 2015. A method for calculating a meta-analytical prior for the natural mortality rate using multiple life history correlates. ICES Journal of Marine Science **72**: 62–69.

Harry, G., and Morgan, A. 1961. History of the trawl fishery, 1884-1961. Oregon Fish Commission Research Briefs **19**: 5–26.

Hill, K.T., and Schneider, N. 1999. Historical logbook databases from California's commercial passenger fishing vessel (partyboat) fishery, 1936-1997. Scripps Institution of Oceanography References Series **99-19**.

Jordan, D. 1887. The fisheries of the Pacific Coast. *In* The fisheries and fishery industris of the unistes states. *Edited by* G. Goode. U.S. Commision of Fish; Fisheries, Section 3. pp. 591–630.

Keller, A.A., Horness, B.H., Fruh, E.L., Simon, V.H., Tuttle, V.J., Bosley, K.L., Buchanan, J.C., Kamikawa, D.J., and Wallace, J.R. 2008. The 2005 U.S. West Coast bottom trawl survey of groundfish resources off Washington, Oregon, and California: Estimates of distribution, abundance, and length composition. NOAA Technical Memorandum NMFS-NWFSC-93. U.S. Department of Commerce.

Lo, N., Jacobson, L.D., and Squire, J.L. 1992. Indices of relative abundance from fish spotter data based on delta-lognornial models. Canadian Journal of Fisheries and Aquatic Sciences **49**: 2515–2526.

Love, M., Yoklavich, M., and Thorsteinson, L. 2002. The rockfishes of the northeast Pacific. University of California Press, Berkeley, CA, USA.

Love, M.S., Axell, B., Morris, P., Collins, R., and Brooks∼-, A. 1987. Life history and fishery of the California scorpionfish, *Scorpaena guttata*, within the Southern California Bight. Fishery Bulletin **85**: 99–116.

Maunder, M.N., Barnes, T., Aseltine-Neilson, D., and MacCall, A.D. 2005. The status of California scorpionfish (*Sorpaena guttata*) off southern California in 2004. Pacific Fishery Management Council, Portland, OR.

McAllister, M.K., and Ianelli, J.N. 1997. Bayesian stock assessment using catch-age data and the sampling - importance resampling algorithm. Canadian Journal of Fisheries and Aquatic Sciences **54**(2): 284–300.

Methot, R.D. 2015. User manual for Stock Synthesis model version 3.24s. NOAA Fisheries, US Department of Commerce.

Miller, E., Williams, J., and Pondella, D. 2009. Life history, ecology, and long-term demographics of queenfish. Coastal Fisheries: Dynamics, Management, and Ecosystem Science

(127): 187–199.

Monk, M., Dick, E., and Pearson, D. 2014. Documentation of a relational database for the California recreational fisheries survey onboard observer sampling program, 1999-2011. NOAA-TM-NMFS-SWFSC-529.

Moser, H. 1996. Scorpaenidae *Scorpaena guttata*. *In* CalCOFI atlas 33: The early stages of the fishes in the califonria current region. pp. 788–789.

Moser, H., Charter, P., Smith, P., Ambrose, D., Charter, S., Meyer, C., Sandknop, E., and Watson, W. 1993. Distributional atlas of fish larvae and eggs in the California current region: taxa with 1000 or more total larvae, 1951 through 1984. Atlas No. 31.

Moser, H.G., R. L. Charter, Smith, P.E., Ambrose, D.A., Watson, W., Charter, S.R., and Sandknop, E.M. 2002. Atlas 35: Distributional atlas of fish larvae and eggs from Manta (surface) samples collected on CalCOFI surveys from 1977 to 2000. California Cooperative Oceanic Fisheries Investigations.

Orton, G. 1955. Early developmental stages of the California scorpionfish, *Scorpaena guttata*. Copeia: 210–214.

Pacific Fishery Management Council. 1993. The Pacific Coast Groundfish Fishery Management Plan: Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery as Amended Through Amendment 7. Pacific Fishery Management Council, Portland, OR.

Pacific Fishery Management Council. 2002. Status of the Pacific Coast Groundfish Fishery Through 2001 and Acceptable Biological Catches for 2002: Stock Assessment and Fishery Evaluation. Pacific Fishery Management Council, Portland, OR.

Pacific Fishery Management Council. 2004. Pacific coast groundfish fishery management plan: fishery management plan for the California, Oregon, and Washington groundfish fishery as amended through Amendment 17. Pacific Fishery Management Council, Portland, OR.

Pacific Fishery Management Council. 2008. Final environmental impact statement for the proposed acceptable biological catch and optimum yield specifications and management measures for the 2009-2010 Pacific Coast groundfish fishery. Pacific Fishery Management Council, Portland, OR.

Quast, J. 1968. Observations on the food of the kelp-bed fishes. California Department of Fish and Game Fish Bulletin (139): 109–142.

Ralston, S., Pearson, D., Field, J., and Key, M. 2010. Documentation of California catch reconstruction project. NOAA-TM-NMFS-SWFSC-461.

Stefnsson, G. 1996. Analysis of groundfish survey abundance data: combining the GLM and delta approaches. ICES Journal of Marine Science **53**: 577–588.

Stephens, A., and MacCall, A. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fisheries Research **70**: 299–310.

Taylor, P. 1963. The venom and ecology of the California scorpionfish, Scorpaena guttata Girard. PhD Thesis, University of California San Diego.

Then, A., Hoenig, J., Hall, N., and Hewitt, D. 2015. Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species. ICES Journal of Marine Science **72**: 82–92.

Thorson, J.T., and Barnett, L.A.K. 2017. Comparing estimates of abundance trends and distribution shifts using single- and multispecies models of fishes and biogenic habitat. ICES Journal of Marine Science **143**(5): 1311–1321. doi: 10.1093/icesjms/fsw193.

Thorson, J.T., Stewart, I.J., and Punt, A.E. 2012. nwfscAgeingError: a user interface in R for the Punt et al. (2008) method for calculating ageing error and imprecision. Available from: http://github.com/nwfsc-assess/nwfscAgeingError/.

Turner, C.H., Ebert, E.E., Given, and R. R. 1969. Man-made reef ecology. California Department of Fish and Game Fish Bulletin **146**: 221.

Wallace, J., and Budrick, J. 2015. Catch-only projections ofr arrowtooth flounder, yelloweye rockfish, blue rockfish, and California scorpionfish models. Pacific Fishery Management Council, Agenda Item I.4, Attachment 3, Novemeber 2015.

Washington, B., Moser, H.G., Laroche, W.A., and W. J. Richards, J. 1984. Scorpaeniformes: development. *In* Ontogeny and systematics of fishes. american society of ichthyologists and herpetologists special publication 1. *Edited by* G.H. Moser, W.J. Richards, D.M. Cohen, M.P. Fahay, W. Kendall, Jr., and S.L. Richardson. pp. 405–428.