

<sup>1</sup> Status of California Scorpionfish (*Scorpaena*  
<sup>2</sup> *guttata*) Off Southern California in 2017



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<sup>82</sup> **Executive Summary**

<sup>83</sup> **Stock**

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

<sup>90</sup> **Catches**

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

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

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

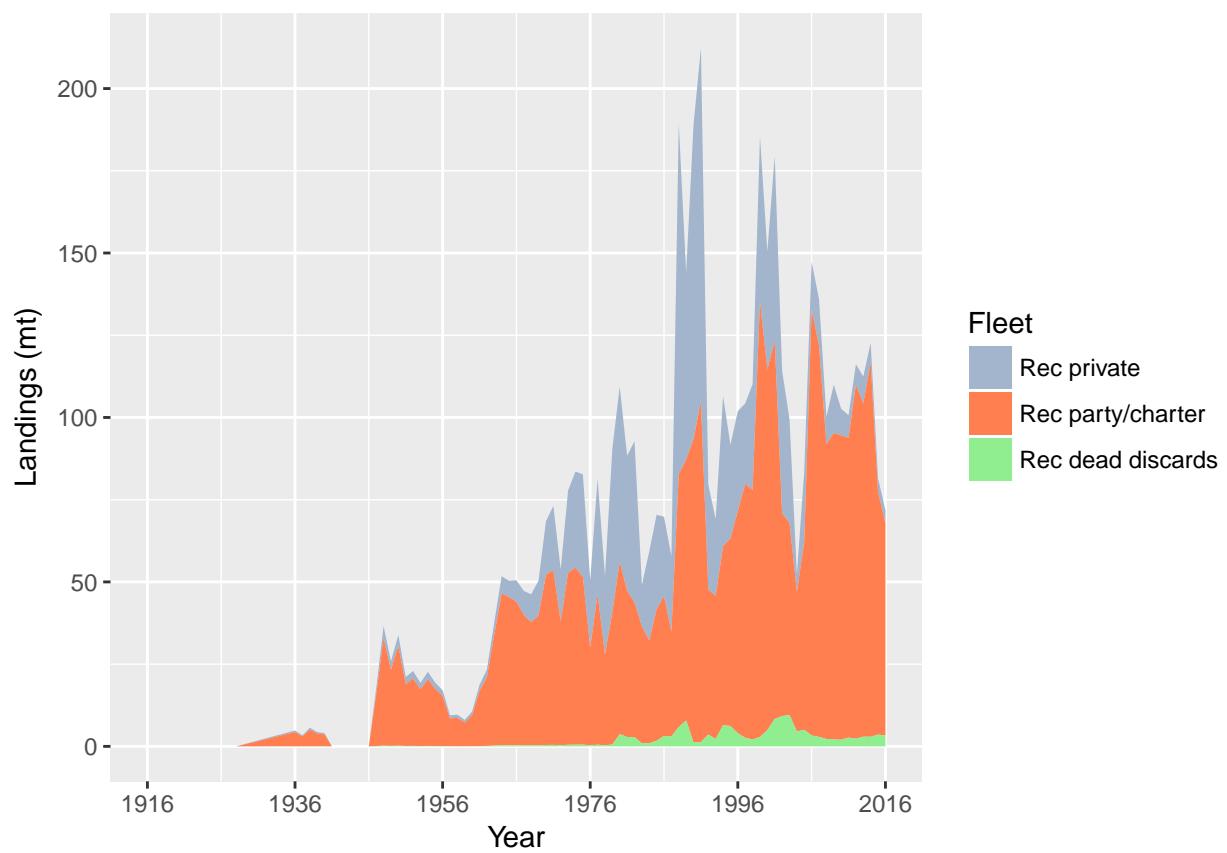


Figure a: California scorpionfish catch history for the recreational fleets.

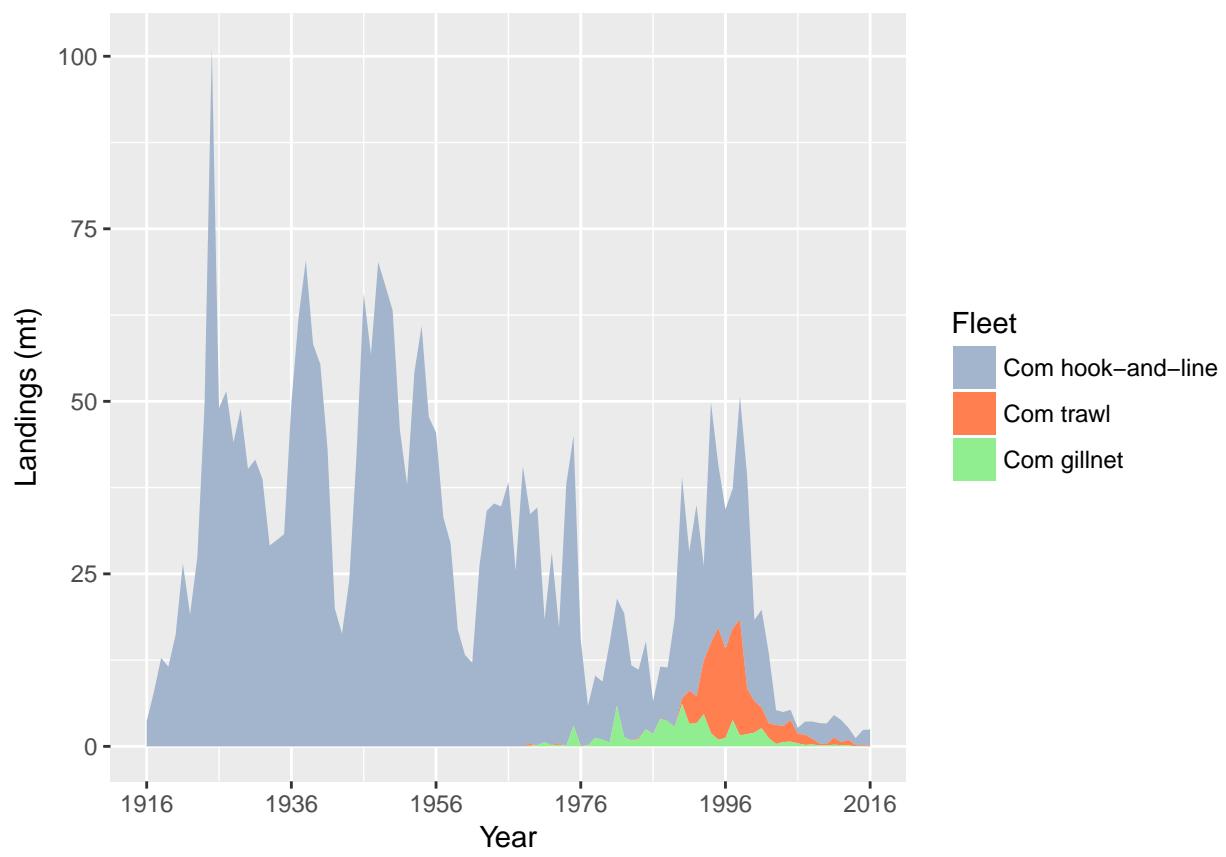


Figure b: Stacked line plot of California scorpionfish catch history for the commercial fleets.

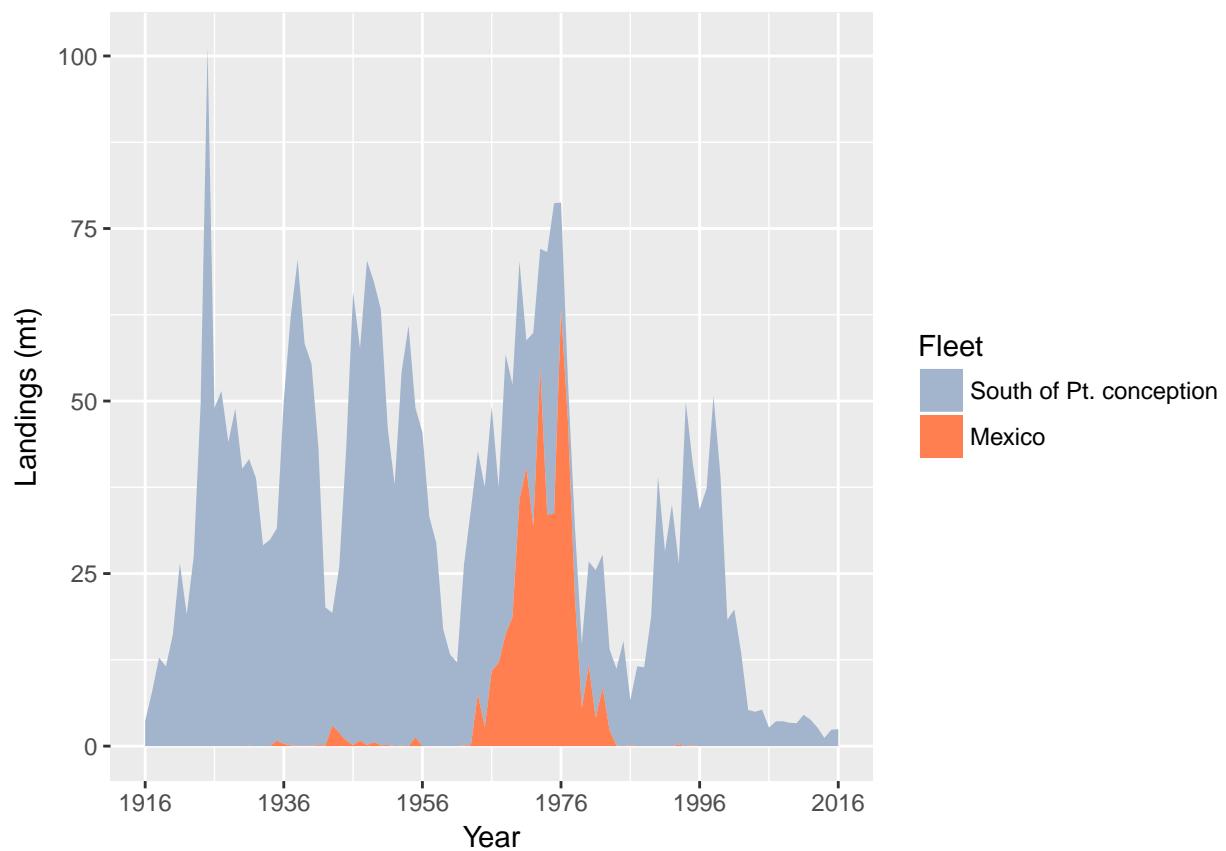


Figure c: Stacked line plot of California scorpionfish catch history from Pt. Conception to the U.S.-Mexico border and catches from Mexican waters.

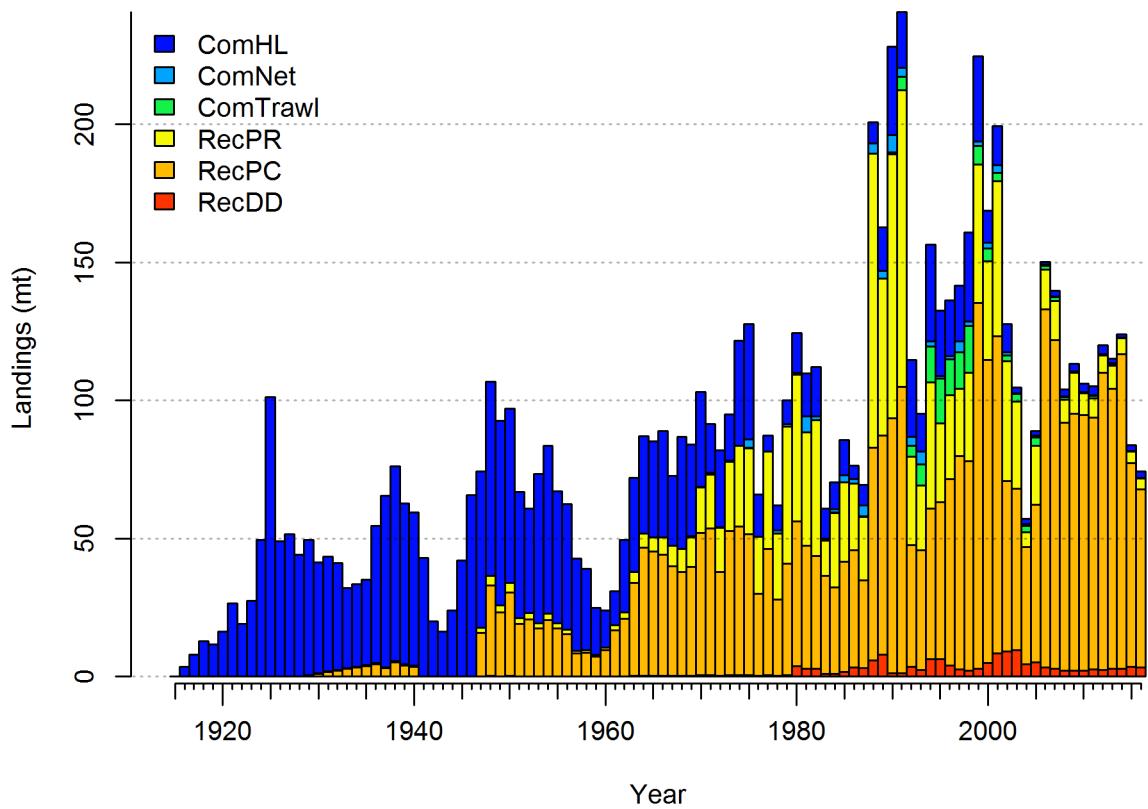


Figure d: Catch history of California scorpionfish in the base model.

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

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

## 105 Data and Assessment

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

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

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

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

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

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

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

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

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

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

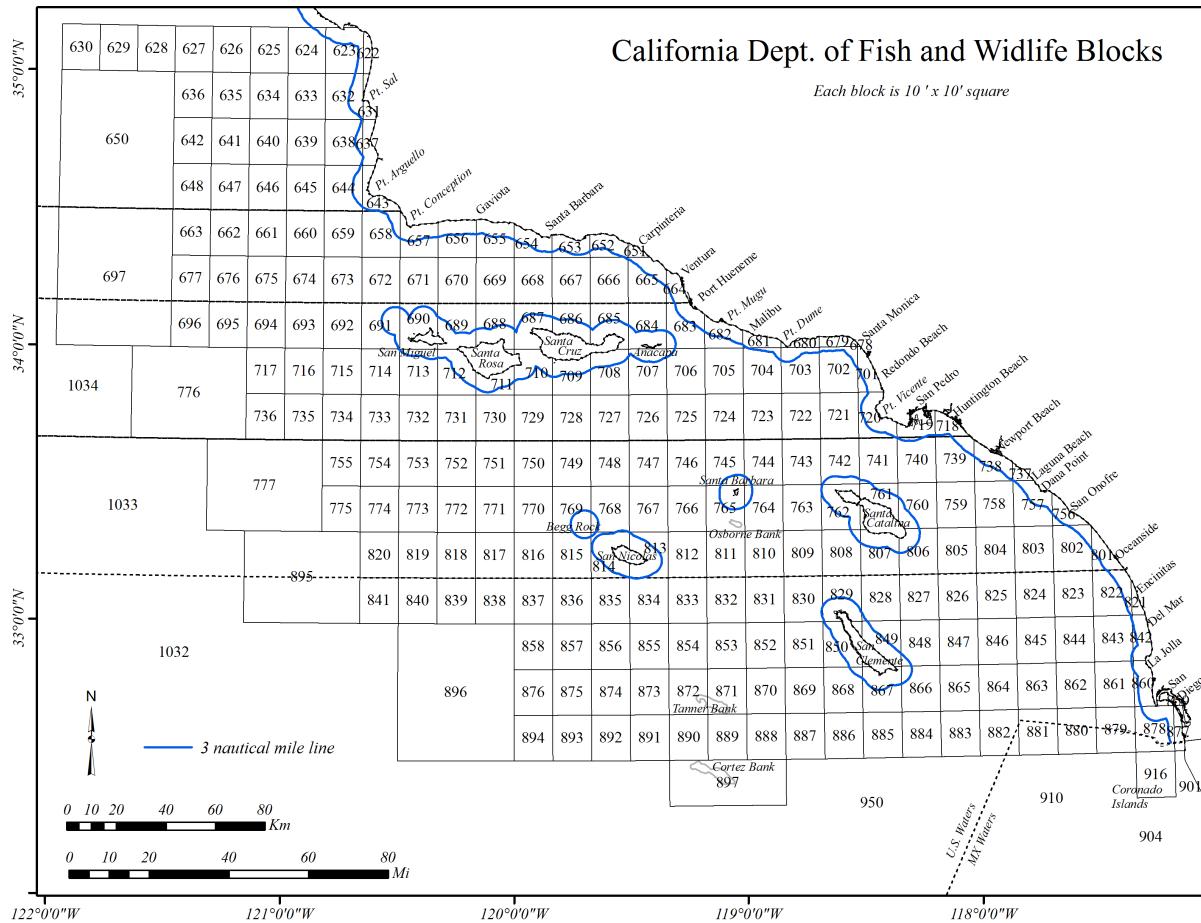


Figure e: Map depicting the boundaries for the base-case model.

<sup>154</sup> **Stock Biomass**

<sup>155</sup> The predicted spawning output from the base model generally showed a slight decline prior  
<sup>156</sup> to 1965, when information on recruitment variability was available (Figure [f](#) and Table [b](#)).  
<sup>157</sup> A short, but sharp decline occurred between 1965 and 1985, followed by a period cyclical  
<sup>158</sup> spawning output and a decline from 2000 to 2015. The stock showed increases in stock size  
<sup>159</sup> in 2015 due to a combination of strong recruitment and smaller catches in 2015 and 2016.  
<sup>160</sup> The 2016 estimated spawning output relative to unfished equilibrium spawning output is  
<sup>161</sup> above the target of 40% of unfished spawning output at 57.4% (~95% asymptotic interval:  $\pm$   
<sup>162</sup> 45.5%-69.4%) (Figure [g](#)). Approximate confidence intervals based on the asymptotic variance  
<sup>163</sup> estimates show that the uncertainty in the estimated spawning output is high.

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

Year	Spawning Output (mt)	~ 95% confidence interval	Estimated depletion	~ 95% confidence interval
2008	963.566	(555.81-1371.32)	0.704	(0.572-0.837)
2009	927.070	(539.76-1314.38)	0.678	(0.554-0.802)
2010	878.164	(513.26-1243.07)	0.642	(0.526-0.758)
2011	841.147	(494.98-1187.31)	0.615	(0.508-0.722)
2012	814.873	(483.41-1146.34)	0.596	(0.495-0.696)
2013	765.845	(451.39-1080.3)	0.560	(0.465-0.655)
2014	693.818	(401.18-986.46)	0.507	(0.417-0.598)
2015	644.488	(362.67-926.31)	0.471	(0.382-0.561)
2016	681.671	(382.78-980.56)	0.498	(0.399-0.597)
2017	785.329	(439.85-1130.8)	0.574	(0.455-0.694)

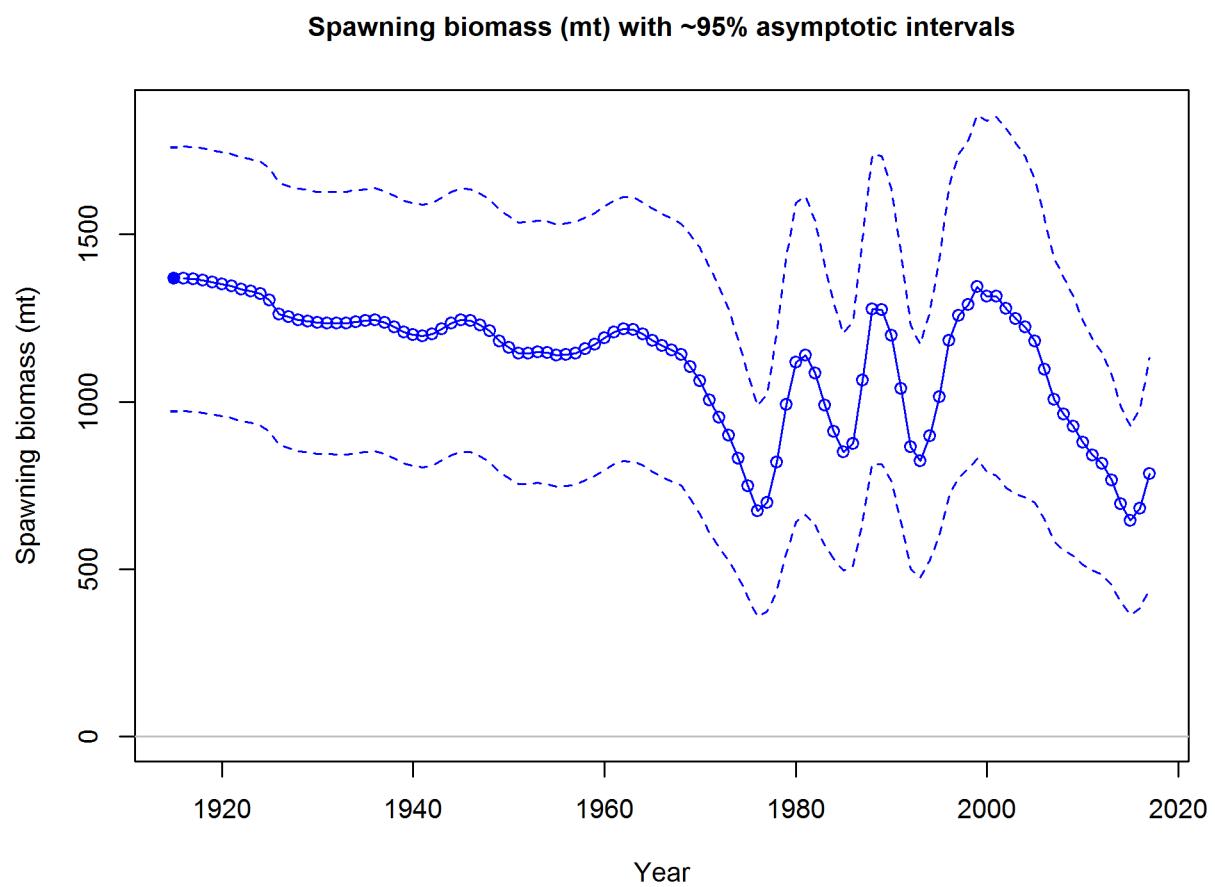


Figure f: Time series of spawning output trajectory (circles and line: median; light broken lines: 95% credibility intervals) for the base case assessment model.

**Spawning depletion with ~95% asymptotic intervals**

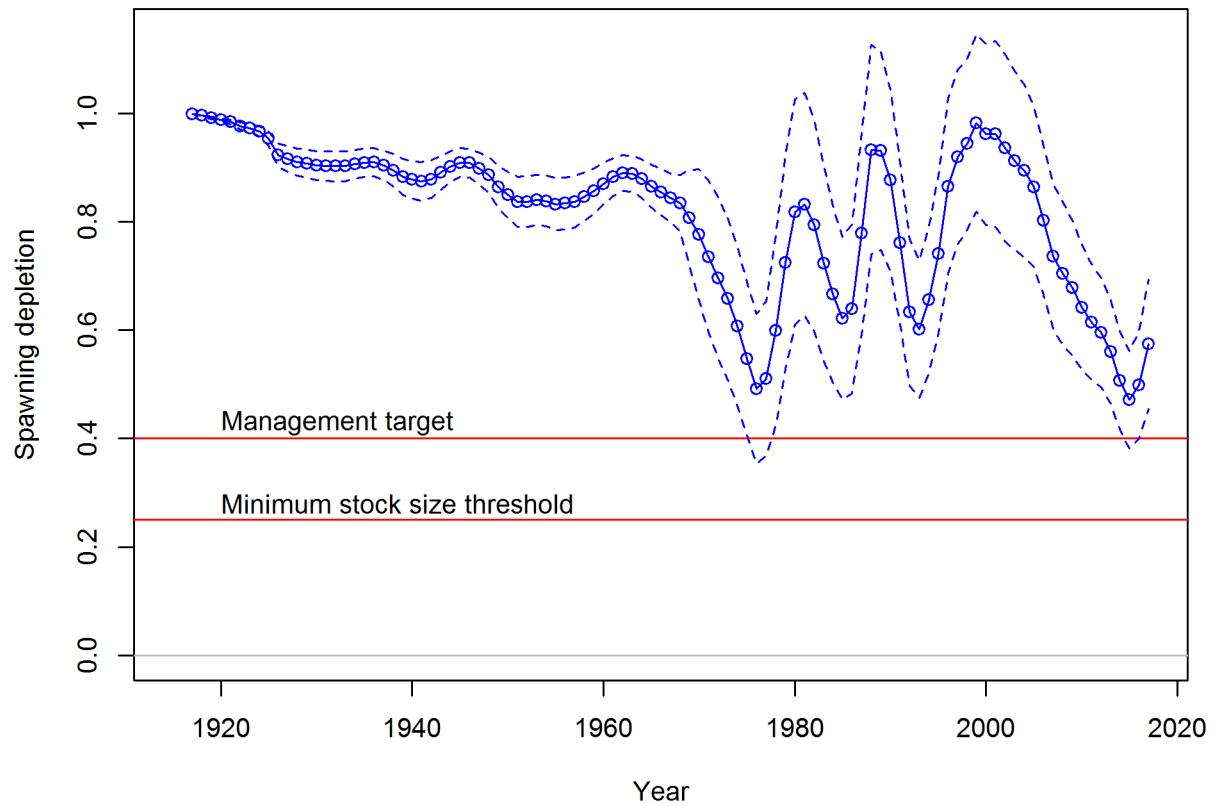


Figure g: Estimated relative depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model.

<sup>164</sup> **Recruitment**

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

Table c: Recent recruitment for the base model.

Year	Estimated Recruitment (1,000s)	~ 95% confidence interval
2008	2260.15	(1164.5 - 4386.66)
2009	2784.55	(1503.55 - 5156.93)
2010	2304.22	(1195.21 - 4442.24)
2011	1163.87	(527.22 - 2569.29)
2012	1107.90	(496.15 - 2473.94)
2013	4073.40	(2239.71 - 7408.36)
2014	3459.51	(1590.35 - 7525.52)
2015	7382.85	(3333.93 - 16349.03)
2016	3183.32	(1035.73 - 9783.91)
2017	3260.47	(1061.6 - 10013.79)

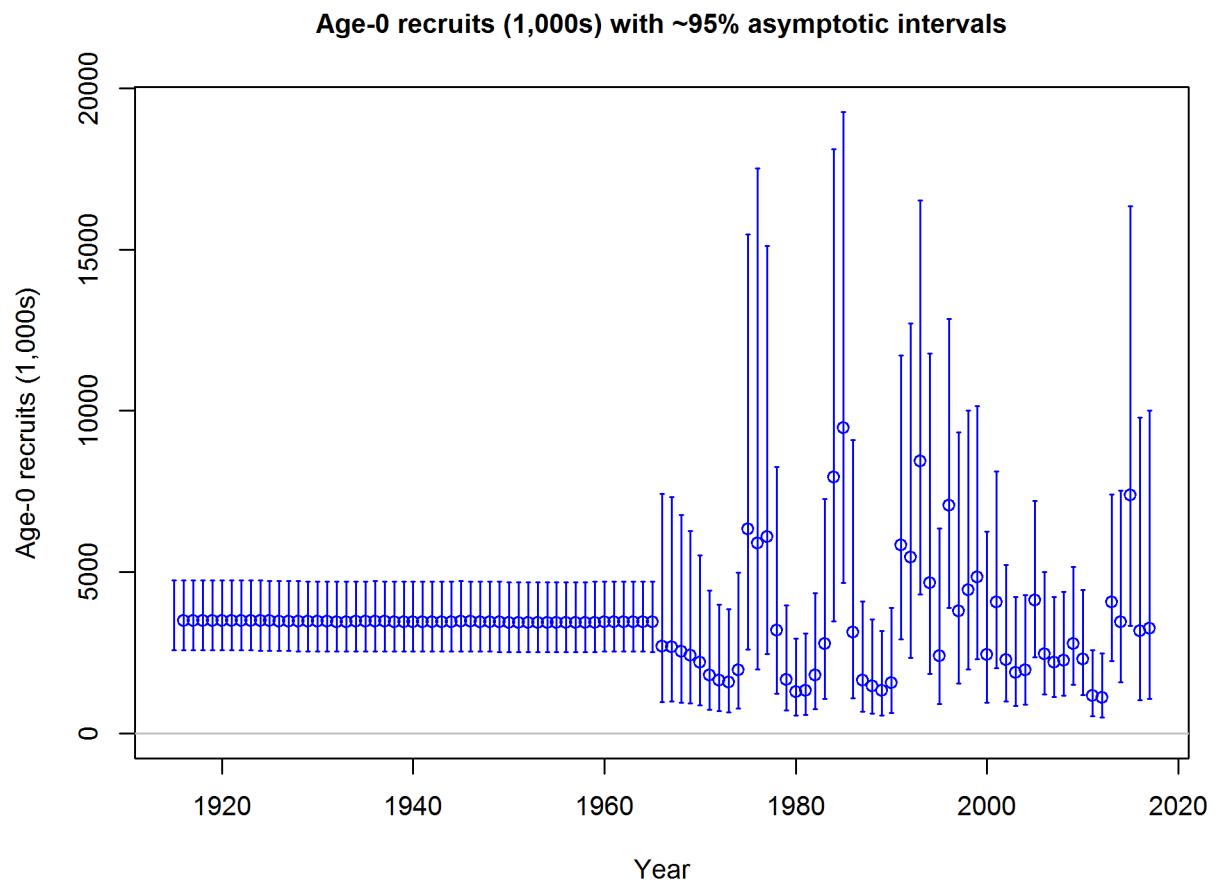


Figure h: Time series of estimated California scorpionfish recruitments for the base-case model with 95% confidence or credibility intervals.

<sup>169</sup> **Exploitation status**

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

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

Year	Fishing intensity	~ 95% confidence interval	Exploitation rate	~ 95% confidence interval
2007	0.51	(0.35-0.66)	0.06	(0.04-0.09)
2008	0.43	(0.29-0.57)	0.05	(0.03-0.07)
2009	0.47	(0.32-0.62)	0.06	(0.04-0.08)
2010	0.47	(0.32-0.61)	0.05	(0.03-0.08)
2011	0.48	(0.33-0.63)	0.06	(0.04-0.08)
2012	0.55	(0.39-0.71)	0.07	(0.04-0.09)
2013	0.55	(0.39-0.72)	0.07	(0.04-0.1)
2014	0.61	(0.43-0.78)	0.08	(0.05-0.11)
2015	0.49	(0.33-0.65)	0.05	(0.03-0.08)
2016	0.46	(0.31-0.62)	0.04	(0.03-0.06)

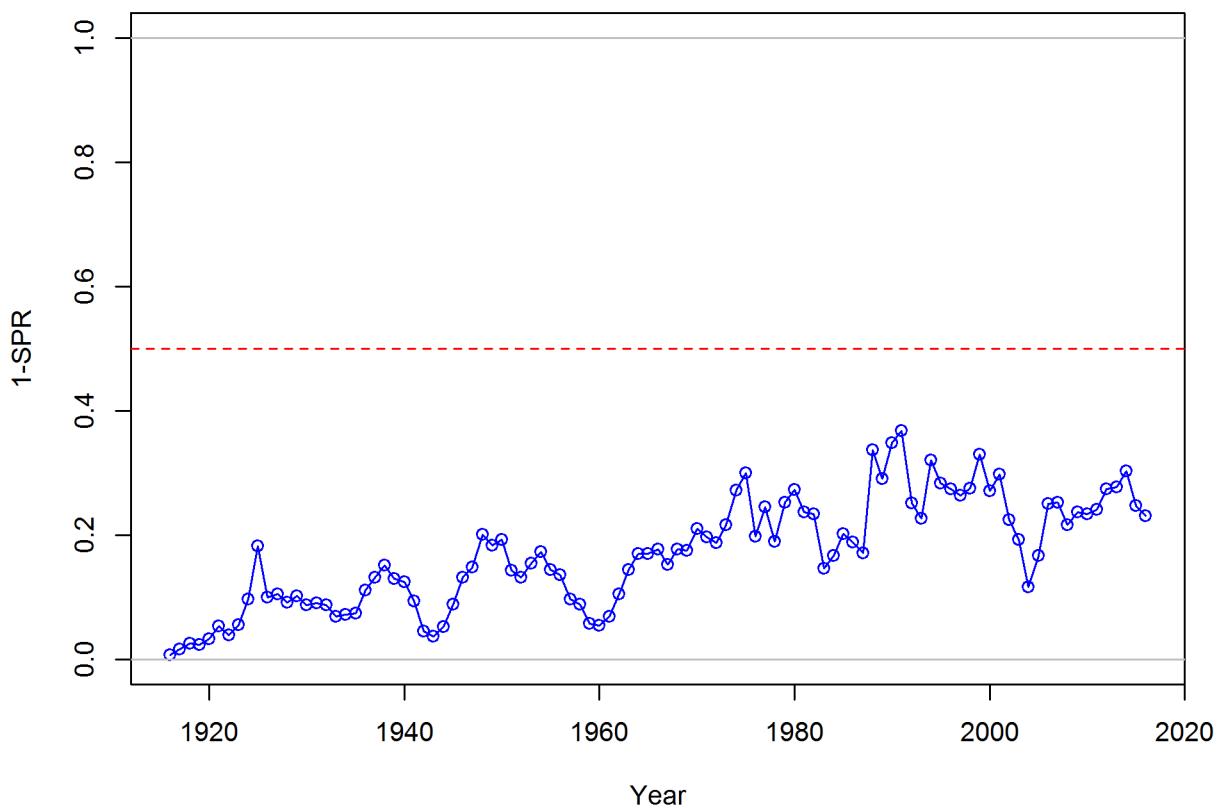


Figure i: Estimated spawning potential ratio (SPR) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing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

<sup>175</sup> **Ecosystem Considerations**

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

<sup>179</sup> **Reference Points**

<sup>180</sup> This stock assessment estimates that California scorpionfish in the base model is above the  
<sup>181</sup> biomass target, and well above the minimum stock size threshold. The estimated relative  
<sup>182</sup> depletion level for the base model in 2016 is 57.4% ( $\sim 95\%$  asymptotic interval:  $\pm 45.5\%-69.4\%$ ,  
<sup>183</sup> corresponding to an unfished spawning output of 785.329 mt ( $\sim 95\%$  asymptotic interval:  
<sup>184</sup> 439.85-1130.8 mt) of spawning output in the base model (Table [e](#)). Unfished age 1+ biomass  
<sup>185</sup> was estimated to be 2796.9 mt in the base case model. The target spawning output based  
<sup>186</sup> on the biomass target ( $SB_{40\%}$ ) is 547.2 mt, which corresponds with an equilibrium yield of  
<sup>187</sup> 235.1 mt. Equilibrium yield at the proxy  $F_{MSY}$  harvest rate corresponding to  $SPR_{50\%}$  is  
<sup>188</sup> 221.2 mt (Figure [j](#)).

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

Quantity	Estimate	95% Confidence Interval
Unfished spawning output (mt)	1367.9	(973.1-1762.7)
Unfished age 1+ biomass (mt)	2796.9	(2030.7-3563)
Unfished recruitment (R0, thousands)	3497.9	(2424.5-4571.3)
Spawning output(2016 mt)	681.7	(382.8-980.6)
Depletion (2016)	0.4983	(0.3994-0.5973)
<b>Reference points based on SB<sub>40%</sub></b>		
Proxy spawning output ( $B_{40\%}$ )	547.2	(389.2-705.1)
SPR resulting in $B_{40\%}$ ( $SPR_{B40\%}$ )	0.4589	(0.4589-0.4589)
Exploitation rate resulting in $B_{40\%}$	0.1745	(0.1613-0.1877)
Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt)	235.1	(166.7-303.5)
<b>Reference points based on SPR proxy for MSY</b>		
Spawning output	609.5	(433.6-785.4)
$SPR_{proxy}$	0.5	
Exploitation rate corresponding to $SPR_{proxy}$	0.1506	(0.1394-0.1617)
Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt)	221.2	(156.9-285.5)
<b>Reference points based on estimated MSY values</b>		
Spawning output at MSY ( $SB_{MSY}$ )	301.8	(213-390.6)
$SPR_{MSY}$	0.2971	(0.2861-0.3082)
Exploitation rate at MSY	0.3268	(0.2944-0.3592)
MSY (mt)	267.5	(189.6-345.4)

## <sup>189</sup> Management Performance

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

## <sup>194</sup> Unresolved Problems And Major Uncertainties

<sup>195</sup> TBD after STAR panel

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

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

## <sup>196</sup> Decision Table

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

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

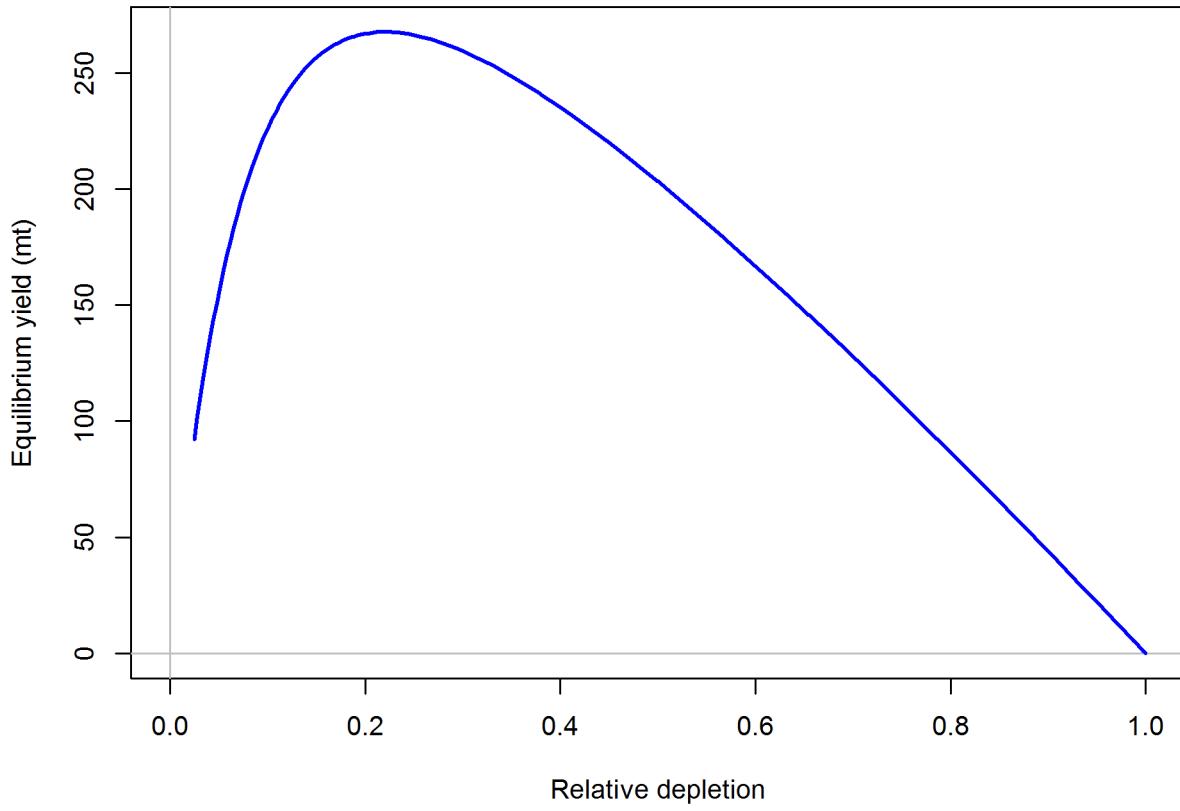


Figure j: Equilibrium yield curve for the base case model. Values are based on the 2016 fishery selectivity and with steepness fixed at 0.718.

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

Year	OFL
2017	282.78
2018	300.05
2019	334.00
2020	326.57
2021	309.69
2022	292.99
2023	279.64
2024	269.39
2025	261.42
2026	255.14
2027	250.17
2028	246.26

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

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

Table i: Base case results summary.

	Quantity	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Laudlings (mt)											
Total Est. Catch (mt)											
OFL (mt)											
ACL (mt)											
$(1-SPR)(1-SPB_{90\%})$	0.43	0.47	0.47	0.48	0.48	0.55	0.55	0.61	0.49	0.46	0.46
Exploitation rate	0.05	0.06	0.05	0.06	0.07	0.07	0.07	0.08	0.05	0.04	0.04
Age 1+ biomass (mt)	2240.78	2110.60	2015.33	1933.13	1858.78	1753.79	1616.09	1566.71	1552.41	1737.27	
Spawning Output	963.6	927.1	878.2	841.1	814.9	765.8	693.8	644.5	681.7	785.3	
95% CI	(555.81-1371.32)	(539.76-1314.38)	(513.26-1243.07)	(494.98-1187.31)	(483.41-1146.34)	(451.39-1080.3)	(401.18-986.46)	(362.67-926.31)	(382.78-980.56)	(439.85-1130.8)	
Depletion	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.6	0.6
95% CI	(0.572-0.837)	(0.554-0.802)	(0.526-0.758)	(0.508-0.722)	(0.495-0.696)	(0.465-0.655)	(0.417-0.598)	(0.382-0.561)	(0.399-0.597)	(0.455-0.694)	
Recruits	2260.15	2784.55	2304.22	1163.87	1107.90	4073.40	3459.51	7382.85	3183.32	3260.47	
95% CI	(1164.5 - 4386.66)	(1503.55 - 5156.93)	(1195.21 - 4442.24)	(527.22 - 2569.29)	(496.15 - 2473.94)	(2239.71 - 7408.36)	(1590.35 - 7325.52)	(3333.93 - 16349.03)	(1035.73 - 9783.91)	(1061.6 - 10013.79)	

<sup>200</sup> **Research And Data Needs**

<sup>201</sup> We recommend the following research be conducted before the next assessment:

<sup>202</sup> 1. List item No. 1 in the list

<sup>203</sup> 2. List item No. 2 in the list, etc.

204 **1 Introduction**

205 **1.1 Basic Information and Life History**

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

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

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

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

234 **1.2 Early Life History**

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

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

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

### <sup>251</sup> 1.3 Map

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

### <sup>254</sup> 1.4 Ecosystem Considerations

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

### <sup>258</sup> 1.5 Fishery Information

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

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

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

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

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

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

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

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

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

## <sup>314</sup> 1.6 Summary of Management History

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

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

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

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

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

<sup>363</sup> Cowcod Conservation Areas (CCAs) also were established in 2001 to reduce fishing effort  
<sup>364</sup> in areas with high encounter rates of cowcod rockfish (PFMC ([2002](#)), Table 29). These  
<sup>365</sup> areas were closed to all recreational and commercial fishing for groundfish except for minor  
<sup>366</sup> nearshore rockfish<sup>1</sup> (including California scorpionfish) within waters less than 20 fathoms.  
<sup>367</sup> The California Rockfish Conservation Area (CRCA) was defined as those ocean waters south  
<sup>368</sup> 40°10' N. latitude to the U.S.-Mexico border with different depth zones specified for the areas  
<sup>369</sup> north and south of Pt. Reyes (37°59.73' N. latitude).

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

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

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

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

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

## <sup>402</sup> 1.7 Management Performance

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

## <sup>406</sup> 1.8 Fisheries off Mexico

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

# <sup>410</sup> 2 Assessment

## <sup>411</sup> 2.1 Data

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

### <sup>414</sup> 2.1.1 Commercial Fishery Landings

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

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

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

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

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

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

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

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

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

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

454 **2.1.2 Commercial Discards**

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

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

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

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

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

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

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

486 **2.2.1 Sport Fishery Removals and Discards**

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

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

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

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

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

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

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

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

## 546 2.2.2 Fishery-dependent Data Sources

### 547 CRFS Private Boat Dockside Intercept Survey

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

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

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

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

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

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

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

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

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

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

## 616 CRFS CPFV Logbook Index

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

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

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

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

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

## 655 MRFSS Party/Charter Boat Dockside Index

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

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

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

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

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

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

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

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

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

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

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

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

774 *Party/Charter Dockside Length Measurements*

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

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

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

797 **Onboard Observer Party/Charter Boat**

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

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

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

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

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

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

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

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

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

853 *Onboard Obsever Discarded Catch Index*

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

862 *Discarded Catch Length Composition*

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

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

875 *Onboard Obsever Retained Catch Index*

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

886 **2.2.3 Fishery-Independent Data Sources**

887 **Sanitation Districts Trawl Survey**

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

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

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

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

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

921 Tow times were recorded starting in 1999, and assumed to be 10 minutes prior to 1999. Haul  
922 depth was missing for approximately half of the hauls, and was imputed as the mean depth

923 of other hauls at that station. All California scorpionfish encountered were measured to the  
924 nearest cm (standard length).

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

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

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

#### 942 *Sanitation Districts Index Standardization*

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

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

964 *Sanitation Districts Length Composition*

965 Each district measures every fish encountered in their survey. Orange County Sanitation  
966 District was the only program sampling in 1970 and 1971 and encountered a small number of  
967 California scorpionfish in those years (Figure 20). Los Angeles County has has encountered  
968 pulses of large numbers of California scorpionfish in 2002, 2004 and 2005. Figure 21 shows  
969 the distribution of lengths for California scorpionfish by 25 m depth bins and Sanitation  
970 District. The median length

971 of fish from the CLAEMD trawls is smaller than the other two districts. However, there are  
972 only 120 in that depth bin, compared to 1,372 fish in the 50-74 m depth bin for the CLAEMD  
973 (Table 25).

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

979 **NWFSC Trawl Survey Index**

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

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

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

996 Summaries of age data by year and sex are presented in Table 30. There were more males ( $n$   
997 = 529) being aged than females ( $n = 340$ ), presumably indicating that there are more males  
998 than females in the populations. The table also shows that mean ages and mean lengths  
999 for both sexes decreased in recent years. Table 31 show five percentiles of fish aged by sex,  
1000 indicating more older males in the population. All aged data from the survey were used as  
1001 conditional age-at-length matrix in the assessment model. The mean age-at-length indicates  
1002 males and females to have similar growth patterns until around age three, at which time,  
1003 females are larger than males (Table 32).

1004 Total biomass estimates from the survey were analyzed using the VAST program (Thorson  
1005 and Barnett 2017). The Q-Q goodness of fit plot and time series of total biomass estimates  
1006 are shown in Figures 29 and 30, respectively. The Q-Q plots shows generally good fits  
1007 and the time series of biomass estimates indicates no significant trend with relatively large  
1008 uncertainties from the survey. The final survey index and log standard error used in the  
1009 assessment model are in Table 33.

1010 **CSUN/VRG Gillnet Survey Index**

1011 California State University Northridge with Vantuna Research Group (CSUN/VRG) con-  
1012 ducted a gillnet survey from 1995-2008 (Daniel Pondela, VRG). Sites along the coast from  
1013 Santa Barbara to Newport were consistently sampled for the time series, as well as Catalina  
1014 Island. Gillnet sets from within Marina Del Rey and Catalina Harbor were removed from the  
1015 analysis.

1016 All gillnets were the same length with six-25' panels (150' in length).  
1017 The standard sampling gillnet had 1“, 1.5“, 2 square mesh, with each mesh on two panels.  
1018 Samples were excluded if they were collected using a net other than the standard sampling  
1019 gear. Other data filters included remove months that were not consistently sampled (Table  
1020 34).

1021 Five covariates were considered in the model standardization, *year* (14 levels), *month* (8  
1022 levels), *site* (8 levels indicating the sampling site location), *float* (2 levels indicate if floats  
1023 were used on the gillnet), and *perp/para* (2 levels indicate if the net was set perpendicular or  
1024 parallel to shore). A lognormal was select over a gamma model for the positive encounters by  
1025 a delta AIC of 108.29. Covariates selected via AIC for both the lognormal binomial models  
1026 included *year*, *site*, and *perp/para* (Table 35, Figure 31). The standardized index decreases  
1027 from 1995-1998 and remains flat until through the early 2000's with three high years at the  
1028 end of the time series (Figure 32).

1029 The survey measured (standard length) every California scorpionfish encountered, totalling  
1030 1,130 fish. The majority of fish encountered were between 14 and 33 cm total length, with no  
1031 strong trends or patterns in age classes during the time period (Figure 33)

1032 **Southern California Bight Regional Monitoring Project Trawl Survey**

1033 The southern California Coast Water Research Project SCCWRP consists of over 60 agencies  
1034 in southern California that conduct monitoring of aquatic environments. One of the monitoring  
1035 programs in the Southern California Bight (SCB) is a trawl survey conducted every five years.  
1036 The pilot year of the survey was 1994. Data from each of the survey years (1994, 1998, 2003,  
1037 2008, and 2013) were provided by the SCCWRP (Shelly Moore).

1038 In each of the five years of the study, sampling stations were chosen via a stratified random  
1039 sampling design (Bight '98 Steering Committee 1998). All participating agencies follow the  
1040 same protocols (net is towed 10 minutes at a speed of 1.0 m/sec) and use the same net

1041 (semiballoon otter trawl). All fish and invertebrates are identified, counted, batch-weighed,  
1042 and measured (standard length to the nearest cm).

1043 A series of data filters were applied to the dataset (Table 37). Only two scorpionfish were  
1044 encountered in hauls deeper than 450 m. Ninety-five percent of the data were retained for  
1045 hauls in shallower than 97 m, which was set as a filter. Stations in harbors (2/114 positive  
1046 hauls), north of Ventura (6/190 positive hauls) and the islands (16/117 positive hauls) were  
1047 excluded due to low encounters of California scorpionfish. The final dataset included 398  
1048 hauls, 129 of which encountered California scorpionfish. The unit of effort for this survey is  
1049 in kg per tow time (minutes).

1050 Covariates considered for the delta-GLM model were *year* (5 levels), *area* (4 regions), and  
1051 *month* (3 levels; July-September). Sampling stations were assigned to one of four regions, 1)  
1052 Ventura to Long Beach, 2) Long Beach to Dana Point, 3) Dana Point to San Diego, and 4)  
1053 San Diego to the U.S./Mexico Border. A lognormal model was selected over a gamma model  
1054 for the positives by a delta AIC of 30. Depth (20-m depth bins) were considered, but none  
1055 of the levels were significant in a full lognorml or binomial model and was not considered  
1056 further. AIC selection for both the lognormal and binomial models selected all covariates  
1057 for the final model (Table 38). The Q-Q plot used to evaluate the goodness-of-fit of the  
1058 lognormal portion of the model is in Figures 34.

1059 The standardized index of abundance indicates higher relative CPUE in 1994 and 2003, with  
1060 the other three years lower (Figure 35). The fact that the survey is conducted every five years  
1061 (4 years between the pilot and the 1998 survey), may preclude drawing any firm conclusions  
1062 on trends in abundance from this data.

1063 The survey measured a total of 427 fish, with the last two years of the survey (2008 and  
1064 2013) only encountering 25 and 53 California scorpionfish, respectively.  
1065 However, the smallest fish observed in this survey were in 2013 (Figure 36).

#### 1066 Generating Station Impingement Surveys

1067 Data from the southern California generating station surveys were provided by Eric Miller  
1068 (MBC Applied Environmental Sciences). The generating stations all draw in seawater  
1069 through an intake system for once-through cooling water. There are five generating stations  
1070 that conduct normal operation and heat treatment surveys with observations of California  
1071 scorpionfish: Scattergood Generating Station (SGS), El Segundo Generating Station (ESGS),  
1072 Redondo Beach Generating Station (RBGS), Huntington Beach Generating Station (HBGS),  
1073 and San Onofre Generation Station (SONGS). Each generating station draws in water from  
1074 different depths and distances from shore: SGS draws from 500 m offshore at 6 m depth,  
1075 ESGS draws from 700 m offshore at 9.8 m depth, RBGS draws from 289 m offshore at 13.7 m  
1076 depth, HBGS draws from 500 m offshore at 5 m depth, and SONGS has two intake systems  
1077 960 m and 900 m offshore and at 9 m and 8 m depth, respectively (Miller et al. 2009).

1078 The two surveys conducted are normal operations surveys and heat treatment surveys. For  
1079 normal operations surveys, the intake screens are rotated and cleaned to start the survey. All

1080 of the impinged fish are washed off the screen at this time and discarded. When the intake  
1081 screens stop running, the survey begins. The generating station then operates as normal for  
1082 24 hours, which includes operating and washing the screens as usual (typically every eight  
1083 hours). The screens are then operated and washed again after a second 24 hours has elapsed.  
1084 Any specimens washed off the screens during the 48 hour study period are retained. The total  
1085 sample is processed to identify, count, weigh, measure the fish and macroinvertebrates. There  
1086 is often no information on the water flow collected during the 48 hour period of the normal  
1087 operations survey. Most fish enter the the generating station and swim in the sedimentation  
1088 basin until either getting exhausted or impinged. The SONGS generating station also has a  
1089 fish elevator that releases a fraction of the fish back to the ocean.

1090 At each generating station, cooling water, i.e., seawater, is pumped into the generating station  
1091 where it reaches a sedimentation basin. Water flow is uni-directional, and fish can reside  
1092 in this area, but not escape. During a heat treatment, water in the sedimentation basin is  
1093 heated to over 38 degrees Celsius, killing all fish and invertebrates, and impinging them on  
1094 the travelling screens.

1095 The screens are operated and washed off per normal operating procedures right up until the  
1096 heat treatment takes place. Therefore, only the fish remaining in the sedimentation basin  
1097 and those impinged since the last screen rotation are counted in the heat treatment survey.  
1098 The total flow between heat treatments has previously been used to standardize indices in  
1099 previous reports. However, this is not representative of the flow relating to fish impinged  
1100 during the heat treatment. The water flows vary widely among heat treatments, time of  
1101 year (higher in summer when energy demands increase), and generating stations. Therefore,  
1102 the generating station impingement surveys were not used to develop indices of abundance.  
1103 However, length composition data from the impingement surveys were used.

1104 The length composition data from the impingement show a higher proportion of smaller (<10  
1105 cm) fish since 2012 (Figure 37)

1106 *California Cooperative Oceanic Fisheries Investigations (CalCOFI) Survey* UCSD Scripps  
1107 Institution of Oceanography, CDFG, and the National Marine Fisheries Service have carried  
1108 out a plankton survey on a regular basis since 1951 (Moser et al. n.d.). Prior to 1965,  
1109 *Scorpaena* samples were not speciated.

1110 California scorpionfish larvae encounters from CalCOFI surveys were provided by Noelle  
1111 Bowlin (NMFS SWFSC). Only 16 positive bongo tows in the core area (lines 77-93) encoun-  
1112 tered California scorpionfish. The majority of the 335 positive bongo tows occurred in Mexico,  
1113 south of Punta Eugenia Baja California and are likely a combination of California scorpionfish  
1114 and other *Scorpaena* species. The California scorpionfish egg masses are encountered in  
1115 the CalCOFI surveys, but because California scorpionfish is not a target species they are  
1116 entered in the database as “unidentified eggs” (William Watson, NMFS SWFSC). An index  
1117 of abundance was not developed for the CalCOFI data due to the small sample sizes.

1118 **2.2.4 Biological Parameters and Data**

1119 California scorpionfish do not have a forked tail, therefore total length and fork length are  
1120 equal. Love et al. (1987) provide conversion factors between standard length (SL) and total  
1121 length (TL):  $TL = 1.21SL + 1.02$  and  $SL = 0.82TL - 0.69$ .

1122 Standard and total lengths of 163 California scorpionfish were available from a halibut trawl  
1123 survey in southern California (Steve Wertz, CDFW). The conversion from SL to TL from  
1124 these data was estimated at  $TL = 1.2225SL + 0.7773$ .

1125 The conversion originating from the halibut trawl data was used in this assessment due to the  
1126 fact that the original data from Love et al. (1987) are not available. The majority of available  
1127 length composition data were measured to total length, except for three of the sanitation  
1128 district trawl surveys, the Southern California Bight Regional Monitoring Program trawl  
1129 survey, and the CSUN/VRG gillnet survey (gillnet survey). Maunder et al. (2005) converted  
1130 all data to standard length due to clumping of data when length data are only available to  
1131 the nearest centimeter. However, the same is true for the conversion from TL to SL when  
1132 data are available to the nearest centimeter. All length data for this assessment are in TL.  
1133 The Sanitation District of Orange county and the VRG gillnet study measured SL to the  
1134 nearest mm.

1135 To avoid missing length bins (specifically 18, 23, 29 cm) in the conversion from SL to TL,  
1136 0.5 was first subtracted from each SL and a random uniform number ( $U[0, 1]$ ) was added to  
1137 the SL measurement. All TL measurements were rounded to the nearest length centimeter  
1138 length bin. A comparison of the length distributions

1139 **Length And Age Compositions**

1140 Include: Sample size information for length and age composition data by area, year, gear,  
1141 market category, etc., including both the number of trips and fish sampled.

1142 Length compositions were provided from the following sources:

- 1143 • CDFW market category study (*commercial dead fish*, 1996-2003)
- 1144 • CALCOM (*commercial dead fish*, 2013-2016)
- 1145 • CDFW onboard observer (*recreational charter discards*, 2003-2016)
- 1146 • Ally onboard observer study (*recreational charter discards*, 1984-1989)
- 1147 • California recreational sources combined (*recreational charter retained catch*)
  - 1148 – CDFW and Ally onboard observer surveys (1984-1989)
  - 1149 – Collins and Crooke onboard observer surveys (1975-1978)
  - 1150 – MRFSS (1980-2003)
  - 1151 – CRFS (2004-2014)
- 1152 • California recreational sources combined (*private mode retained catch*)
  - 1153 – MRFSS (1980-2003)
  - 1154 – CRFS (2004-2016)
- 1155 • Sanitation district trawl surveys (*research*, 1970-2016)

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

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

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

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

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

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

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

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

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

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 44). Two fish with estimated age greater than 21 (plus group age) were excluded 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

1191 The weight-length relationship is based on the standard power function:  $W = \alpha(L^\beta)$  where  
1192  $W$  is individual weight (kg),  $L$  is length (cm), and  $\alpha$  and  $\beta$  are coefficients used as constants.

1193 Sex-specific weight-length relationships were estimated from the NWFSC trawl survey data.  
1194 Length and weight data were available for 340 females and 530 males. The estimated  
1195 parameters for females are  $\alpha = 1.553983e^{-05}$  and  $\beta = 3.057654$ , and for males  $\alpha = 1.9104e^{-05}$   
1196 and  $\beta = 2.980548$ . Love et al. (1987) found males to be heavier at a given length than  
1197 females, whereas the NWFSC data suggestes the opposite (Figure 45).

1198 The original data from Love et al. (1987) are no longer available (Milton Love, personal  
1199 communication, UC Santa Barbara) to re-examine the trends. The weight-length relationships  
1200 estimated from the NWFSC survey are consistent with the sex-specific growth rates and are  
1201 used in the assessment model.

## 1202 Sex Ratio, Maturity, and Fecundity

1203 The NWFSC trawl survey is the only study available with raw data on sex ratios by age.  
1204 Across all ages, the sex ratio from the aged California scorpionfish from the NWFSC trawl  
1205 survey was 60% males and 40% females (Figure 46). At age-1, 39% of the aged fish were  
1206 female (29 of 85), but the sex of 10 fish was unknown. For ages two to five, the percent of  
1207 female fish ranged from 45-54%, with aged fish older than five dominated by males. The  
1208 assessment assumed a sex ratio at birth was 1:1. The NWFSC trawl survey samples a  
1209 minimum depth of 55 m and no information on sex ratios was available from other surveys.

1210 Love et al. (1987) conducted the only published life history study of California scorpionfish,  
1211 but did not report information on sex ratios. Differing numbers of sample sizes (males and  
1212 females) were used for each part of the study (ex. maturity and length-at-age). The raw data  
1213 from this study are no longer available, and we were not able to determine raw samples sizes  
1214 by sex.

1215 No new data on maturity or fecundity for California scorpionfish are available since the  
1216 publication of the 2005 stock assessment. Love et al. (1987) found few California scorpionfish  
1217 to be mature at age-1, 50% of males were mature at 17 cm TL and over 50% of females were  
1218 mature by 18 cm TL, or two years of age. All fish were mature by 22 cm TL. This assessment  
1219 used size at 50% maturity for females of 18 cm TL, with maurity asmyptotign to 1.0 for  
1220 larger fish.

1221 The 2005 assessment model combined information from estimated linear gonadal somatic  
1222 index and maturity based on standard length (Maunder et al. 2005). However, the study used  
1223 to estimate the GSI, was a halibut targeted trawl study using a mesh size of 10.2 cm (Steven  
1224 Wertz, personal communication, CDFW). This assessment assumed linear relationship for  
1225 eggs per kilogram.

1226 **Natural Mortality** Hamel (2015) developed a method for combining meta-analytic ap-

1227 proaches to relating the natural mortality rate  $M$  to other life-history parameters such as  
 1228 longevity, size, growth rate and reproductive effort, to provide a prior on  $M$ . In that same  
 1229 issue of ICESJMS, Then et al. (2015), provided an updated data set of estimates of  $M$  and  
 1230 related life history parameters across a large number of fish species, from which to develop  
 1231 an  $M$  estimator for fish species in general. They concluded by recommending  $M$  estimates  
 1232 be based on maximum age alone, based on an updated Hoenig non-linear least squares  
 1233 (nls) estimator  $M = 4.899 * A_{max}^{-0.916}$ . The approach of basing  $M$  priors on maximum age  
 1234 alone was one that was already being used for west coast rockfish assessments. However,  
 1235 in fitting the alternative model forms relating  $-0.916M$  to  $A_{max}$ , Then et al. (2015) did  
 1236 not consistently apply their transformation. In particular, in real space, one would expect  
 1237 substantial heteroscedasticity in both the observation and process error associated with the  
 1238 observed relationship of  $M$  to  $A_{max}$ . Therefore, it would be reasonable to fit all models under  
 1239 a log transformation. This was not done. Reevaluating the data used in Then et al. (2015) by  
 1240 fitting the one-parameter  $A_{max}$  model under a log-log transformation (such that the slope is  
 1241 forced to be -1 in the transformed space (as in Hamel (2015)), the point estimate for  $M$  is:

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

1242 The above is also the median of the prior. The prior is defined as a lognormal with mean  
 1243  $\ln \frac{5.4}{A_{max}}$  and SE = 0.4384343. Using a maximum age of 21 the point estimate and median of  
 1244 the prior is 0.2545, which is used as a prior for females in the assessment model.

## 1245 2.2.5 Environmental Or Ecosystem Data Included In The Assessment

1246 In this assessment, neither environmental nor ecosystem considerations were explicitly included  
 1247 in the analysis. This is primarily due to a lack of relevant data and results of analyses  
 1248 (conducted elsewhere) that could contribute ecosystem-related quantitative information for  
 1249 the assessment.

## 1250 2.3 History Of Modeling Approaches Used For This Stock

### 1251 2.3.1 Previous Assessments

1252 California scorpionfish was first assessed in 2005 (Maunder et al. 2005) using SS2 (version  
 1253 1.18). The 2005 model was a one-area model for the population south of Pt. Conception  
 1254 to the U.S.-Mexico border. The assessment was sensitive to the inclusion of the sanitation  
 1255 district index of abundance and the STAT team provided reference points for a model that  
 1256 included the sanitation index and one excluding it. The stock was found to be at 80% of

1257 unfished levels for the model with the sanitation index and 58% for the model without the  
1258 sanitation index. The 2015 catch-only projections used the same version of SS2 as the 2005  
1259 assessment model.

1260 The 2005 model assumed removals equivalent to the ACL in all years from 2004-2016. The  
1261 2015 model included catch estimates from 2004-2014, and the ACLs for 2015 and 2016 were  
1262 assumed to be attained. Maunder et al. (2005) assumed no discard mortality, while the 2015  
1263 update applied a 7% discard mortality rate derived by the Groundfish Management Team  
1264 (GMT) (2009-2010 SPEX EIS, Chapter 4, pg. 290) was applied to the estimate of discards to  
1265 provide an estimate of discard mortality for the recreational fleet.

### 1266 2.3.2 2005 Assessment Recommendations

1267 Include: Response to STAR panel recommendations from the most recent previous assessment.

1268 **Recommendation 1:** The sanitation surveys conducted to track the impact  
1269 of sewage outfall provided a fishery independent index of abundance for  
1270 scorpionfish. This data source should be more fully explored for other  
1271 near-shore species of recreational or commercial interest. Methods should  
1272 be developed to produce a more statistically rigorous index from the  
1273 separate surveys.

1274  
1275 STAT response: Data from all sanitation districts in southern California were obtained  
1276 for this assessment. All of the data were pooled across surveys to develop one index of  
1277 abundance using the delta-GLM method

1278 **Recommendation 2:** An age, growth and maturity study for scorpionfish is  
1279 needed. Although there has been previous research on scorpionfish age and  
1280 growth, the available information is not appropriate for stock assessment  
1281 modeling.

1282  
1283 STAT response: Age data are available from the NWFSC trawl survey from 2005-2016.  
1284 There have been no additional studies on growth or maturity for California scorpionfish  
1285 since the 2005 assessment.

1286 **Recommendation 3:** Location information for the historic groundfish data of all  
1287 species is currently available, in hard copy form only, from the California  
1288 Department of Fish and Game. Putting this information into electronic  
1289 format would greatly improve the ability to assign catches of all species to  
1290 specific stocks on a trip-by-trip basis.

1291  
1292 STAT response: The location-specific catches referred to above have been key-punched  
1293 and are available in electronic form from the SWFSC, Santa Cruz.

1294 **Recommendation 4:** The SS2 model should be modified to allow for projections  
1295 of user-specified recruitment at user defined values. It would be most  
1296 helpful if the default harvest policies were then recalculated automatically  
1297 for these user-specified recruitments.

1298

1299 STAT response: The status of this within Stock Synthesis is unknown.

1300 **2.4 Model Description**

1301 **2.4.1 Transition To The Current Stock Assessment**

1302 The first formal stock assessment for California scorpionfish was conducted in 2005 (Maunder  
1303 et al. 2005). The 2005 model conducted in SS2 version 1.18 was first transitioned to SS3.24z  
1304 as a bridge model, before moving forward to SS3.30. During the model transition to SS3.24z  
1305 and error was found in the 2005 model. The harvest rate was estimated at the upper limit of  
1306 0.9 and could not remove all of the input catch (Figure 47).

1307 The older SS2 output did not include separate columns for the observed (input) catch and  
1308 dead removals by the model (output), which would have prevented the 2005 STAT team from  
1309 discovering that the two time series differed (Figure 48). The recreational fishery selects the  
1310 largest fish and removes the highest biomass of California scorpionfish. When the harvest rate  
1311 hit the upper bounds as in the 1970s, there were not enough fish estimated in the population  
1312 to support the large removals, i.e., stock estimated at 500 mt and the recreational catch was  
1313 100 mt. The stock was not productive enough to sustain the observed catch. A comparison  
1314 of time series from the 2005 model, the SS3.24z transition model, and the base model from  
1315 this assessment are in Figure 49.

1316 Below, we describe the most important changes made since the last full assessment in 2005  
1317 and explain rationale for each change. Some of these items are changes due to structure  
1318 changes with Stock Synthesis, and some denote parameters chosen for options that were not  
1319 available in SS2 (version 1.18).

1320 Changes in the bridge model from from SS2 version 1.8 to SS3.24z and SS3.30

1321 The way growth is modeled for age-0 fish changed. More recent versions of Stock Synthesis  
1322 model length-at-age for fish below the first reference age ( $A_{min}$ ) as linearly increasing from  
1323 the initial length bin to the length given by the  $L_{at\_Amin}$  parameter. Since small California  
1324 scorpionfish are selected in the sanitation district survey data, the change in modeled growth  
1325 has the potential to affect estimates of recruitment. We took the following approach in order  
1326 to mimic the methods of SS2 version 1.8:

- 1327 1. Change  $A_{min}$  from 1 to 0.

1328        2. Replace initial value of length at minimum age for females with 7.26567 (the Length  
1329           begin value for age 0 from the SS2.rep file).

1330        3. Replace initial value of length at minimum age for males with 0.35366 (=  
1331           LN(10.3483/7.26567), the log of the ratio of Male to Female length at age 0 from the  
1332           SS2.rep file)

1333        This assessment aggregated the catches from the commercial fish pot fleet with the hook-  
1334           and-line fleet. There were no measured California scorpionfish from the fish pot fleet and  
1335           overall catches were minimal. The commercial trawl and gill net fleets were disaggregated as  
1336           in the 2005 model. The current model also assumes no discards in the commercial fishery.  
1337        The previous assessment combined the recreational party/charter and private modes into a  
1338           single fishery. This assessment disaggregates the two sectors of the recreational fishery and  
1339           adds a fleet to represent the discards (party/charter and private modes combined) from the  
1340           recreational fleet

1341        The 2005 model was a length-based model. This assessment uses conditional age-at-length  
1342           from fish aged from the NWFSC trawl survey.

1343        The historical commercial catches were the same as those used in the previous assessment  
1344           and were updated using CFIS data from 2005-2016. The CFIS database was used instead of  
1345           CALCOM because landings in CALCOM included catches from Mexican waters.

1346        The recreational catches differed from the catch history used in the previous assessment. In  
1347           2010 a catch reconstruction was completed for California (Ralston et al. 2010). Methods  
1348           provided were applied in reconstructing the catch of California scorpionfish for this assessment.  
1349        Both assessments utilized similar data sources including CPFV logbooks and MRFSS data  
1350           providing catch estimates, with the addition of data from the CRFS program for 2004-2016.  
1351        The main difference resides with accounting for discard mortality as well as landed catch  
1352           allowing discards to be modeled as a separate fleet making use of length distribution data for  
1353           discards for 2003-2016. In addition, the recreational catch time series terminated in 1928 for  
1354           the current assessment, as specified for rockfish catch reconstructions in the historical catch  
1355           reconstruction document, rather than in 1916. The ratio of catches for the party-charter boat  
1356           mode to the private and rental boat mode from the MRFSS period were used in combination  
1357           with catch estimates from the CPFV logbook estimates back to 1932 in both assessments to  
1358           approximate mortality the private rental boat mode prior to 1980. A ramp accounting for  
1359           the increase relative contribution of the private boat mode relative to the party charter mode  
1360           from the mid 1965 to 1980, as conducted for rockfish in the historical catch reconstruction  
1361           document. A constant ratio of catch compared to the party charter boat mode was applied  
1362           for man-made and beach and bank modes to provide an estimate of catch back to 1936 as was  
1363           done for the private and rental boat mode in the previous assessment. The CPFV logbook  
1364           data terminated in 1935 and a linear ramp was used to approximate catch from 1936 back to  
1365           zero in 1928 for each mode as compared to 1916 in the 2005 assessment.

1366 The bias adjustment for recruitment deviations did not exist in SS2 (version 1.198). We set  
1367 1965-2015 as the range of years with full bias adjustment in SS3.24z to span the time series  
1368 that was modeled.

1369 Length composition data was updated and sources added for this assessment. The 2005  
1370 assessment used the same source for length compositions for the commercial fisheries, the  
1371 CDFW market category study. The length compositions from CALCOM were all from single  
1372 trips within a year and are not used in the assessment. The measured fish from RecFIN  
1373 (dockside intercept surveys) were disaggregated to the party/charter and private modes.  
1374 Preliminary analyses indicated the recreational private and rental boat mode selects larger  
1375 fish than the party and charter boat mode (add plot).

1376 The 2005 assessment converted all length parameters to SL, which prevented comparisons  
1377 with some of the growth parameters. The values in the SS files from the previous assessment  
1378 also did not match those in the written document. The current model uses TL for all length  
1379 compositions and growth parameters.

1380 The previous assessment modeled selectivity using the double logistic, with defined peak, and  
1381 smooth joiners for all fleets with estimated selectivity. Two parameters were estimated for  
1382 each selectivity curve, the size at which selectivity is halfway between the selectivity at length  
1383 bin = 1 and one, and the slope of the left side of the selectivity curve. This selectivity pattern  
1384 has since been discontinued in SS. All of the double logistic selectivity patterns in the 2005  
1385 assessment were asymptotic and are the same in this assessment. Selectivity in this model is  
1386 assumed to be length-based and is modeled as double-normal for all fleets that were also in  
1387 the previous assessment. This assessment mirrors the selectivity for the trawl and gill net  
1388 commercial fisheries to the commercial hook-and-line fishery. The 2005 assessment included  
1389 two surveys, the CPFV logbook and sanitation district surveys. The length composition  
1390 measurement for the CPFV logbook survey are from the dockside intercept surveys in RecFIN  
1391 and were updated to double normal selectivity in this model.

1392 The time blocks for the commercial fishery is the same as in the previous assessment (1916-  
1393 1998 and 1999-2017). There have been no additional major changes to the commercial  
1394 regulations since the 10-inch minimum size limit and the catches from the commercial fleets in  
1395 the last 10 years have been minimal compared to historical catches. The time blocks for the  
1396 recreational fleets were updated to include a third time block from 2000-2005, when closures  
1397 of the recreational fishery fluctuated annually. Since 2006, the recreational regulations have  
1398 remained fairly consistent.

1399 The 2005 assessment considered six candidate indices of abundance (fishery-dependent: CPFV  
1400 logbook, CDFW monthly block summaries, RecFIN dockside intercept survey, trawl logbook;  
1401 fishery-independent: sanitation survey, CalCOFI, but only included two in the final model  
1402 (CPFV logbook and sanitation district surveys). The sanitation district survey ended up  
1403 being the basis for the decision table in the 2005 assessment, with more weight given to  
1404 the model without the sanitation district survey. All indices were re-evaluated and updated  
1405 through 2016 for this assessment. As in the 2005 assessment, we did not consider the CaCOFI

1406 index, CDFW monthly block summaries, or the trawl survey for the current model. The  
1407 current model includes four fishery-dependent indices and four fishery-independent indices.  
1408 The RecFIN party/charter mode dockside intercept survey was not available at the trip-level  
1409 in 2005 and it is unclear how the 2005 assessment treated data record entries from RecFIN;  
1410 however, the RecFIN index was sensitive to the. The RecFIN private mode index is currently  
1411 only available at the trip-level for the CRFS sampling period, 2004-2016. The onboard  
1412 observer database was also not available for the 2005 assessment and is used here as both  
1413 retained-only and discard-only indices. The CPFV logbook data was updated and reevaluated  
1414 from the 2005 assessment.

1415 The fishery-independent indices are all new for this assessment, except for the sanitation  
1416 districts trawl surveys.

1417 Maturity was changed for this assessment. The Love et al. (1987) study is the only study  
1418 that estimated the maturity ogive. The CDFW cross-shelf halibut survey used in the 2005  
1419 assessment to estimate the GSI were not used in this study as GSI is an indicator of fecundity.  
1420 No information on fecundity is available for California scorpionfish. This assessment uses the  
1421 assumption that eggs are equivalent to spawning biomass.

1422 In this assessment, steepness was set at 0.718, the mean of the beta prior developed from  
1423 a meta-analysis of West Coast groundfish and updated in 2017 (James Thorson, personal  
1424 communication, NWFSC, NOAA).

1425 The prior for female natural mortality was updated to the median of the prior from a meta-  
1426 analysis conducted by Owen Hamel (personal communication, NWFSC, NOAA).

1427 Assuming a maximum age of 21 years, the median of the prior is 0.2547, close to the fixed  
1428 value for younger fish in the 2005 assessment of 0.25.

1429 Due to the fact that the 2005 model was erroneous, a bridge from the 2014 catch update,  
1430 which used SS2 version 1.8 and the 2005 model, was not developed.

1431 Changes in the bridge model from from the SS3.24z model closely matched with the SS2  
1432 version 1.8 model to SS3.30.

#### 1433 2.4.2 Summary of Data for Fleets and Areas

1434 There are twelve fleets in the base model. They include:

1435 *Commercial*: The commercial fleets include three separate fleets, one each for the hook-and-  
1436 line, gillnet, and trawl fisheries. The catch from all other commercial gears is included in the  
1437 hook-and-line catch.

1438 *Recreational*: The recreational fleets include three separate fleets, one each for retained catch  
1439 from the recreational party/charter boat and private boat modes, and one for the dead  
1440 discards from the recreational party/charter boat and private boat modes combined.

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

<sup>1445</sup> **2.4.3 Other specifications**

<sup>1446</sup> Stock synthesis has a broad suite of structural options available. Where possible, the ‘default’  
<sup>1447</sup> or most commonly used approaches are applied to this stock assessment.

<sup>1448</sup> The assessment is sex-specific, including the estimation of separate growth curves, and natural  
<sup>1449</sup> mortality. Sex-specific length-weight parameters were input as fixed values. The assessment  
<sup>1450</sup> only tracks female spawning biomass for use in calculating stock status.

<sup>1451</sup> The selectivity for the generation station impingement surveys was set to 1.0 for all sizes  
<sup>1452</sup> (SS pattern 0). As an example, the cooling intake pipes at SONGS are 18-foot in diameter  
<sup>1453</sup> and draw in seawater at a rate of hundreds of thousands of gallons per minute. The water  
<sup>1454</sup> flow once in the generating station is one directional and organisms cannot escape, unless  
<sup>1455</sup> removed via a fish return system. Flow rates for the cooling water intake range from 0.27-1.2  
<sup>1456</sup> m/s (MBC 2005, 2007, Electric Power Research Institute 2008) and would not allow a fish of  
<sup>1457</sup> any size evade intake cooling pipes.

<sup>1458</sup> The length composition data for some years and fleets was small, and may not have been  
<sup>1459</sup> representative of the total catch. Length composition data were removed from the model if  
<sup>1460</sup> less than one trip sampled and fewer than 20 fish were measured in a given year and fleet.  
<sup>1461</sup> From 1985-1989, two surveys measured fish from the recreational party/charter fleet, the  
<sup>1462</sup> Ally et al. (Ally et al. 1991) onboard observer survey and the dockside intercept survey. The  
<sup>1463</sup> number of trips and fish sampled by the onboard observer survey was far greater than the  
<sup>1464</sup> RecFIN survey and were used in the model.

<sup>1465</sup> The time-series of landings begins in 1916 for the commercial fleet and in 1929 for the  
<sup>1466</sup> recreational fleet. This captures the inception of the fishery, so the stock is assumed to be in  
<sup>1467</sup> equilibrium at the beginning of the modeled period.

<sup>1468</sup> The internal population dynamics model tracks ages 0-21, where age 21 is the ‘plus-group.’  
<sup>1469</sup> There are relatively few observations in the age compositions that are greater than age 21.

<sup>1470</sup> The following likelihood components are included in this model: catch, indices, discards,  
<sup>1471</sup> length compositions, age compositions, recruitments, parameter priors, and parameter soft  
<sup>1472</sup> bounds. See the SS technical documentation for details (Methot 2015).

<sup>1473</sup> Electronic SS model files including the data, control, starter, and forecast files can be found  
<sup>1474</sup> on the [PFMC ftp site](#).

1475 **2.4.4 Modeling Software**

1476 The STAT team used Stock Synthesis 3 version 3.30.0.4 by Dr. Richard Methot at the NWFSC.  
1477 This most recent version was used, since it included improvements and corrections to older  
1478 versions. The r4SS package (GitHub release number v1.27.0) was used to post-processing  
1479 output data from Stock Synthesis.

1480 **2.4.5 Data Weighting**

1481 Length composition and conditional-age-at-length (CAAL) compositions sample sizes for the  
1482 base model were tuned by the “Francis method,” based on equation TA1.8 in Francis  
1483 (2011), and implemented in the r4ss package. This approach involves comparing the residuals  
1484 in the model’s expected mean length with respect to the observed mean length and associated  
1485 uncertainty derived from the composition vectors and their associated input sample sizes.  
1486 The sample sizes are then tuned so that the observed and expected variability are consistent.  
1487 After adjustment to the sample sizes, models were not re-tuned if the bootstrap uncertainty  
1488 value around the tuning factor overlapped 1.0.

1489 As outlined in the Best Practices, a sensitivity run was conducted with length and conditional-  
1490 age-at-length (CAAL) compositions were re-weighted using the Ianelli-McAllister harmonic  
1491 mean method (McAllister and Ianelli 1997).

1492 Extra variability parameters were estimated and added to the input variance for all surveys  
1493 and CPUE indices.

1494 **2.4.6 Priors**

1495 The log-normal prior for female natural mortality were based on a meta-analysis completed  
1496 by Hamel (2015), as described under “Natural Mortality.” Female natural mortality was  
1497 fixed at the median of the prior, 0.257 for an assumed maximum age of 21. An uninformative  
1498 prior was used for the male offset natural mortality, which was estimated.

1499 The prior for steepness ( $h$ ) assumes a beta distribution with parameters based on an update  
1500 for the Thorson-Dorn rockfish prior (Dorn, M. and Thorson, J., pers. comm.), which was  
1501 endorsed by the Science and Statistical Committee in 2017. The prior is a beta distribution  
1502 with  $mu=0.718$  and  $sigma=0.158$ . Steepness is fixed in the base model at the mean of the  
1503 prior. The priors were applied in sensitivity analyses where these parameters were estimated.

1504 **2.4.7 Estimated And Fixed Parameters**

1505 A full list of all estimated and fixed parameters is provided in Tables 41. Time-invariant,  
1506 sex-specific growth is estimated in this assessment, with all SS growth parameters being  
1507 estimated. The log of the unexploited recruitment level for the Beverton-Holt stock-recruit  
1508 function is treated as an estimated parameter. Annual recruitment deviations are estimated  
1509 beginning in 1985, just after the first sets of length composition data enter the model. The  
1510 survey catchability parameters are calculated analytically (set as scaling factors) such that the  
1511 estimate is median unbiased, which is comparable to the way  $q$  is treated in most groundfish  
1512 assessments.

1513 The base model has a total of 102 estimated parameters in the following categories:

- 1514     • Equilibrium recruitment ( $R_0$ ) and 54 recruitment deviations,
- 1515     • Nine growth parameters
- 1516     • Eight index extra standard deviation parameter, and
- 1517     • 31 selectivity parameters

1518 The estimated parameters are described in greater detail below and a full list of all estimated  
1519 and parameters is provided in Table 41.

1520 *Growth.* Five growth parameters were estimated for females: 3 von Bertalanffy parameters  
1521 and 2 parameters for CV as a function of length at age related to variability in length at age  
1522 for small and large fish.

1523 Four parameters are estimated for male growth as offset from female growth. The length at  
1524 Amin was set equal to the female estimate.

1525 *Natural Mortality.* Natural mortality is fixed for females at the value provided by the Hamel  
1526 (Hamel 2015) analysis described above. Natural mortality for males is estimated as an offset  
1527 from the fixed female natural mortality.

1528 *Selectivity.* Selectivity for all fleets (except the impingement survey) was estimated as  
1529 double-normal. The recreational dead discard fleet has a dome-shaped selectivity and all 6  
1530 parameters were estimable.

1531 For all fleets where the estimated parameters were asymptotic, parameters related to the  
1532 dome were fixed, leaving only the position of the peak, the ascending slope, and selectivity at  
1533 the first length bin as estimated parameters. Ten selectivity parameters related to the time  
1534 blocks were also estimated.

1535 *Other Estimated Parameters.* Recruitment deviations for the base model are estimated from  
1536 1984 to 2015. The base model also included estimated recruitment deviations for the forecast  
1537 years, although these have no impact on the model estimates for the current year.

1538 A number of alternate model were explored before the final base model was reached.  
1539 Many variations of the base case model were explored during this analysis. Sensitivities  
1540 to asymptotic vs. domed selectivity were explored for the appropriate fisheries, e.g. trawl  
1541 and gill net fisheries, as well as estimating selectivity and mirroring fleet selectivities. Time  
1542 blocked selectivity without the time block from 2005-2015 for the recreational fisheries was  
1543 investigated. We also considered a model with an additional time block for the commercial  
1544 fishery, but the length composition data were sparse.

1545 This assessment includes discards for the recreational fleet, so time was spent investigating  
1546 changes in selectivity and the most prudent way to incorporate discards.  
1547 Length composition of discards from two recreational party/charter onboard observer programs  
1548 and

1549 Sensitivities to estimates of female natural mortality were explored by fixing other key  
1550 parameters, i.e., steepness. Male natural mortality is still reasonably well estimated, but  
1551 the estimates of  $\ln R_0$  and female  $M$  are not well estimated. The previous assessment fixed  
1552 female and male  $M$ , where male  $M$  was an offset. The previous model had two breakpoints  
1553 for natural mortality, but the natural mortality for older fish was set to the same as for  
1554 younger fish. This model uses one parameter for natural mortality for each sex.

1555 Much time was also spent tuning the advanced recruitment bias adjustment options, which  
1556 are new to SS 3.30. Sensitivities were performed to each of the thirteen advanced options for  
1557 recruitment, e.g., early recruitment deviation start year, early recruitment deviation phase,  
1558 years with bias adjustments, and maximum bias adjustment. The final base model sets the  
1559 first year of recruitment deviations just prior to when length composition are available.

1560 Several models were also investigated where steepness was either estimated, fixed at the prior,  
1561 or an alternate value.

1562 Sensitivities of the model to the spawning and settlement months were also explored.  
1563 The base model originally set spawning month to June and settlement month to July.  
1564 California scorpionfish are summer spawners and settle at a small size. However, a potential  
1565 bug in how recruits move into the numbers-at-age matrix was discovered (Richard Methot,  
1566 personal communication, NWFSC). The final base model sets both the spawning month  
1567 and settlement month to January, which is the equivalent to the settings available in  
1568 SS3.24z. Parameters for extra standard deviation were added to all survey indices in the model  
1569 because they were not exceptionally well fit by the models considered.

1570 *Other Fixed Parameters.* The stock-recruitment steepness is fixed at the SSC approved  
1571 steepness prior for rockfish of 0.718. The initial recommendation for steepness was to explore  
1572 the available estimates of steepness from Myers et al. (1999). Myers (Myers, R.A., Bowen,

1573 K.G., and Barrowman 1999) provides estimates of steepness for three species in the family  
1574 Scorpaenidae, of which California scorpionfish is a member: chilipepper (*Sebastes goodei*),  
1575 0.35; Pacific ocean perch (*Sebastes alutus*) 0.43; and deepwater redfish (*Sebastes mentella*),  
1576 0.47. The estimate of steepness for the family was 0.48. Information for steepness is not  
1577 available for California scorpionfish and there is little information from related species that  
1578 could be considered as a good proxy. A value of 0.718 (the updated 2017 prior) was assumed  
1579 for the assessment.

## 1580 2.5 Model Selection and Evaluation

### 1581 2.5.1 Key Assumptions and Structural Choices

1582 Key assumptions in the model were that the population is a single-stock in the southern  
1583 California Bight. No information is available on the portion of the population in Mexican  
1584 waters. The San Diego recreational party/charter fleet is known to fish for California  
1585 scorpionfish at the Coronado Island in Mexican waters. All catches from Mexican waters and  
1586 landed in the U.S. were removed from the base model data streams.

1587 Female natural mortality and steepness are both fixed in the base model, and sensitivities  
1588 were conducted estimating these parameters. Structurally, the model assumed that the  
1589 landings from each fleet were representative of the population in southern California and  
1590 fishing mortality prior to 1916 was negligible. It is also assumed that commercial discards  
1591 have been negligible and are not included in the base model.

### 1592 2.5.2 Alternate Models Considered

1593 Due to the error in the 2005 model, the population from the base case of this assessment is  
1594 larger in scale. The majority of the alternate models considered were to estimate parameters,  
1595 such as natural mortality and steepness.

1596 The base model is age structured, but 60% of those ages are from males, and a number of  
1597 ages were from younger fish. Models that attempted to estimate female natural mortality  
1598 were considered. However, female natural mortality was estimated at 0.38, much too high to be  
1599 considered a reasonable value. The age data needed to estimate natural mortality (especially  
1600 for older fish) is not yet available. Male natural mortality was estimatable as an offset from  
1601 female natural mortality.

1602 Runs of the base case model estimating steepness were also considered, when female natural  
1603 mortality was fixed. Steepness was estiamted at approximately 0.8. No data exist to inform  
1604 this parameter for California scorpionsh, and the decision was made to fix steepness at the  
1605 mean of the prior developed from a meta-anaylsis of West Coast groundfish.

1606 Additional models considered and run for sensitivity analyses can be found in the Sensitivity  
1607 Analysis Section of this document.

1608 **2.5.3 Convergence**

1609 Model convergence was determined by starting the minimization process from dispersed values  
1610 of the maximum likelihood estimates to determine if the model found a better minimum.  
1611 Jitter is a SS option that generates random starting values from a normal distribution  
1612 logistically transformed into each parameter's range (Methot 2015). This was repeated 100  
1613 times and the minimum was reached in 45% of the runs (Table 40).  
1614 The model did not experience convergence issues, e.g., final gradient was below 0.0001, when  
1615 reasonable starting values were used and there were no difficulties in inverting the Hessian  
1616 to obtain estimates of variability. We did sensitivity runs for convergence by changing the  
1617 phases for key estimated parameters and the total log-likelihood did not change nor the  
1618 parameter estimates.

1619 **2.6 Response To The Current STAR Panel Requests**

1620 **Request No. 1: Add after STAR panel.**

1621

1622 **Rationale:** Add after STAR panel.

1623 **STAT Response:** Add after STAR panel.

1624 **Request No. 2: Add after STAR panel.**

1625

1626 **Rationale:** Add after STAR panel.

1627 **STAT Response:** Add after STAR panel.

1628 **Request No. 3: Add after STAR panel.**

1629

1630 **Rationale:** Add after STAR panel.

1631 **STAT Response:** Add after STAR panel.

1632 **2.7 Base Case Model Results**

1633 The base model parameter estimates and their approximate asymptotic standard errors are  
1634 shown in Table 41 and the likelihood components are in Table 42. Estimates of derived

1635 reference points and approximate 95% asymptotic confidence intervals are shown in Table [e](#).  
1636 Time-series of estimated stock size over time are shown in Table [43](#).

1637 The base model is sex-specific for all biological parameters. Key productivity parameters  
1638 are fixed at measures of central tendency from prior distributions endorsed by the PFMC's  
1639 SSC due to the models' inabilities to estimate reasonable parameter values. Specifically,  
1640 steepness of the assumed Beverton-Holt stock-recruitment relationship was fixed at 0.718. In  
1641 the final base models the instantaneous rate of annual natural mortality was fixed at 0.2547  
1642 for females, and estimated as 0.2078 for males.

### 1643 2.7.1 Parameter Estimates

1644 The base model produces reasonable estimates of growth parameters, for both males and  
1645 females (Figure [42](#)). The von Bertalanffy growth coefficient  $k$  for females was estimated  
1646 close to the external estimate, 0.2496 externally and 0.2494 within SS. For males, the von  
1647 Bertalanffy  $k$  parameter was estimated at 0.2325 externally and 0.2234 within SS. The female  
1648 estimated  $L_{\infty}$  was 33.46 and 27.538 for males.

1649 Females grow faster than male and reach a maximum size greater than the males.

1650 Selectivity curves were estimated for the fishery and survey fleets. The estimated selectivities  
1651 for all fleets within the model are shown in Figure [50](#). The commercial fishery selectivities  
1652 are all asymptotic with the trawl and gillnet fisheries mirroring the hook-and-line fishery.  
1653 Maximum selectivity for the commercial fleet is reached at about 26 cm from 1916-1998 and  
1654 28 cm from 1999-2016 (Figure [51](#)). The shift in selectivity is due to the implementation  
1655 of the 10-inch size limit for the commercial fishery in 1999. The recreational private mode  
1656 sector selects the largest fish, with full selectivity at 41 cm. The time blocked selectivity does  
1657 not show a major shift in selectivity when the fishery was closed for portions of 2001-2005  
1658 (Figure [52](#). This can be explained by the fact the length composition data from the dockside  
1659 intercept survey contains a large number of observed fish when the fishery was closed. The  
1660 recreational private mode also selects the largest fish, and there is no available information  
1661 on discards from this fleet. There is a distinct shift in the selectivity for the retained-catch  
1662 recreational party/charter fleet, with the onboard observer retained-catch fleet mirrored to  
1663 the other recreational party/charter fleet. Prior to the implementation of a 10-in minimum  
1664 size limit the size at maximum selectivity was 36 cm, from 2001-2005 it was 31 cm and since  
1665 2006 the size at maximum selectivity is at 26 cm (Figure [53](#)). The recreational party/charter  
1666 mode discard-catch dome-shaped selectivity reflects the discarding of small fish due to the  
1667 size limit and also the discarding of smaller fish prior to the 10-in minimum size limit due to  
1668 angler preference for larger fish. The selectivity of the discard fleet does not go to 0, because  
1669 some larger fish are still discarded, either due to angler preference, bag limits, and/or fishery  
1670 closure. The onboard observer data also indicates that there are higher discards when an  
1671 aggregation of California scorpionfish was found, i.e., hundreds of fish may be caught at a  
1672 single fishing stop and some are discarded.

1673 All of the survey selectivity curves were asymptotic and none had time blocks. The southern  
1674 California Bight regional monitoring trawl survey uses the same gear as the sanitation district  
1675 trawls survey. All of the three trawl surveys reach full selectivity around 24 cm. The selectivity  
1676 for the gill net survey is mirrored to the trawl survey because small 1"-2" mesh sizes were  
1677 used.

1678 The additional survey variability (process error added directly to each year's input variability)  
1679 for all surveys was estimated within the model. The model estimated a small added variances  
1680 for the recreational private mode of 0.013 and the recreational party/charter discard fleet of  
1681 0.078. The estimated added variance was highest for the recreational party/charter retained-  
1682 catch fleet (0.267), the sanitation district survey (0.225), and the NWFSC trawl survey  
1683 (0.25).

1684 Recruitment deviations were estimated from 1965 to 2015 (Figure 54). Estimates of re-  
1685 cruitment suggest that the California scorpionfish population is characterized by variable  
1686 recruitment with occasional strong recruitments and periods of low recruitment (Figures 55  
1687 and 54). The four lowest recruitments (in ascending order) occurred in 2012, 2011, 1981, and  
1688 1973. There are large estimates of recruitment in 1985, 1993, and 2015. The 2015 recruitment  
1689 event can be observed in the length and conditional length at age compositions from the  
1690 survey data.

1691 The stock-recruit curve resulting from a fixed value of steepness is shown in Figure 56  
1692 with estimated recruitments also shown. The stock is predicted to have never fallen to low  
1693 enough levels that the steepness is obvious. Steepness was not estimated in this model, but  
1694 sensitivities to an alternative value of steepness is discussed below.

## 1695 2.7.2 Fits to the Data

1696 Model fits to the indices of abundance, fishery length composition, survey length composition,  
1697 and conditional age-at-length observations from the NWFSC trawl survey are all discussed  
1698 below.

1699 The fits to the four fishery CPUE and four survey indices are shown in Figures 57 - 64. Extra  
1700 standard error was estimated for all eight of the indices. The indices for the recreational  
1701 private mode and dead-discard fleets were fit relatively well by the model. The recreational  
1702 party/charter retained-catch index was fit moderately well in parts of the time series, but  
1703 did not capture the increases observed in the late 1990s. The extra variability added to this  
1704 index was also large. The onboard observer retained-only catch index was fit well by the  
1705 model except for the two lowest years, 2003 and 2015.

1706 The sanitation district index was fit well by the model, except for the highest four years from  
1707 1979-1982, where the fit is estimated lower than the the added uncertainty.

1708 The NWFSC trawl survey index is flat and fit well by the model, except for in 2013, the

<sup>1709</sup> highest year in the index, with also high uncertainty. The gill net survey was not well fit by  
<sup>1710</sup> the model and did not capture the trend observed in the standardized index. The Southern  
<sup>1711</sup> California Bight trawl survey, conducted every 5 years, was also not well fit by the model.  
<sup>1712</sup> The standardized index from the Bight trawl survey showed peaks in 1994 and 2004, which  
<sup>1713</sup> were not fit by the model.

<sup>1714</sup> Fits to the length data are shown based on the proportions of lengths observed by year and  
<sup>1715</sup> the Pearson residuals-at-length for all fleets. Detailed fits to the length data by year and  
<sup>1716</sup> fleet are provided in Appendix 8. Aggregate fits by fleet are shown in Figure 65. Overall,  
<sup>1717</sup> the length composition data for the commercial hook-and-line, commercial trawl, sanitation  
<sup>1718</sup> survey, recreational private, and party/charter fleets all fit well. The fits to the recreational  
<sup>1719</sup> discard fleet by year were variable, and were worse in years with small sample sizes; however,  
<sup>1720</sup> the aggregate fit is reasonable. The sample sizes by year for each of the gill net, impingement,  
<sup>1721</sup> and Bight trawl surveys were small compared to the fisheries. The fit to the data varies by  
<sup>1722</sup> year and does not capture the high proportion of small fish observed in the impingement  
<sup>1723</sup> survey, especially in 2013.

<sup>1724</sup> Fits to the aggregated and yearly length composition data from the gillnet fishery are not  
<sup>1725</sup> well fit. The selectivity for this fishery is mirrored to the commercial hook-and-line fishery  
<sup>1726</sup> and the sample sizes of the number of measured fish and trips is small compared to other  
<sup>1727</sup> fleets. California scorpionfish are also not a target species for the gill net fishery, but are  
<sup>1728</sup> retained most commonly by the sea bass and halibut fisheries as bycatch. The minimum  
<sup>1729</sup> mesh size for the gill net fishery ranges from 3.5 - 6 inches depending on the year and season.

<sup>1730</sup> The NWFSC trawl survey lengths were well estimated for males and females in aggregate by  
<sup>1731</sup> the model. California scorpionfish are not one of the more common species observed in this  
<sup>1732</sup> survey, with sample size all under 10 hauls per year.

<sup>1733</sup> The observed and expected conditional age-at-length fits are shown in Figure 66 for the  
<sup>1734</sup> NWFSC trawl survey observations. The fits generally match the observations for fish smaller  
<sup>1735</sup> than 30 cm. Some outliers are apparent with large residuals.

<sup>1736</sup> The age data were also weighted according to Francis weighting which adjust the weight  
<sup>1737</sup> given to a data set based on the fit to the mean age by year. The mean ages from the fishery  
<sup>1738</sup> appear to have declined in recent years which could be due to incoming cohorts (Figure 67).  
<sup>1739</sup> Smaller fish were also observed in the sanitation and impingement surveys in the (Figures  
<sup>1740</sup> 68 and 69). The mean length in the recreational private and party/charter fleets increased  
<sup>1741</sup> over time (Figures 70 and 71). The length composition of the recreational fleet discards was  
<sup>1742</sup> smaller in the 1980's and hovers around the 10-in minimum size limit in the 2000's (Figure  
<sup>1743</sup> 72).

### <sup>1744</sup> 2.7.3 Uncertainty and Sensitivity Analyses

<sup>1745</sup> A number of sensitivity analyses were conducted, including:

- 1746 1. Data weighting according to the harmonic mean.
- 1747 2. Removal of the sanitation district index (axis of uncertainty from the 2005 assessment)
- 1748 3. Dome-shaped selectivity for the NWFSC trawl survey and gill net survey - TBD
- 1749 4. Estimating natural female mortality
- 1750 5. Estimating steepness - TBD
- 1751 6. Assume the same fixed natural mortality for males and females
- 1752 7. Remove each index, one at a time - TBD

1753 A number of changes were made since the 2005 assessment, and sensitivities to the current  
1754 base model included changing or fixing a number of parameters to the same as the 2005  
1755 assessment, as well as a number of sensitivities to modelling choices made in developing the  
1756 current base model (Table 44).

1757 Data weighting is an area of uncertainty for stock assessment and research is ongoing to  
1758 determine the effects of data weighting and the most appropriate initial sample sizes for  
1759 length and age composition data. A model run with default weighting increased the total  
1760 likelihood by 2,692 and resulted in a final depletion of 0.771. The base model used the Stewart  
1761 sample sizes for the fishery data and number of trips for all survey sample sizes. Weighting  
1762 the data by the harmonic mean resulted in a model with a total likelihood between the base  
1763 model, which uses the Francis method for weighting, and the model with default weights.  
1764 The Francis weights in the base model were stable, and did not tend to serially decrease  
1765 (downweight) any of the datasets, which has been seen in other assessments.

1766 The sanitation district index was the axis of uncertainty in the 2005 assessment. The  
1767 current assessment has a number of new data sources, including new indices, length data,  
1768 and conditional age-at-length data available. Removing the sanitation index and length  
1769 composition data from the current base model did not have a large effect on the model.  
1770 Depletion dropped from 0.574 to 0.53, but this is a fairly small change compared to the effect  
1771 on the 2005 model.

1772 The 2005 assessment fixed natural mortality at 0.25 for males and females, and steepness at  
1773 0.7. A sensitivity of fixing male and female natural mortality to 0.257, increased depletion  
1774 from 0.574 to 0.594, but did not have a large overall effect on the model.

#### 1775 2.7.4 Retrospective Analysis

1776 A 4-year retrospective analysis was conducted by running the model using data only through  
1777 2012, 2013, 2014, and 2015, progressively (Table 46). The initial population size and estimation

1778 of trends in spawning biomass in the retrospective runs were slightly lower than the base  
1779 model (Figure 73). The initial scale of the spawning population was basically unchanged for  
1780 all of these retrospectives.

1781 The recruitment deviations in the more recent years shrink towards zero the more years are  
1782 removed from the model (Figure 74).

### 1783 2.7.5 Likelihood Profiles

1784 Likelihood profiles were conducted for  $R_0$ , steepness, and over natural mortality values  
1785 separately. These likelihood profiles were conducted by fixing the parameter at specific values  
1786 and estimated the remaining parameters based on the fixed parameter value.

1787 In regards to values of  $R_0$ , the negative log-likelihood was minimized at approximately  $\log(R_0)$   
1788 of 8.0 (Table 48). The recreational private mode fishery minimized at a smaller value of  $R_0$   
1789 whereas the gillnet survey, recreational discard and commercial gillnet fisheries indicated a  
1790 higher value of  $R_0$  (Figure 75). The age and recruitment data indicated a higher value of  $R_0$   
1791 and were minimized at the highest value in the profile (Figure 76). Over the range of values  
1792 of  $R_0$ , depletion ranged from 0.53-0.70 (Figure 77).

1793 For steepness, the negative log-likelihood was essentially flat between values of 0.57-0.87  
1794 (Figure 78 and Table 48).

1795 Likelihood components by data source show that the fishery age data support a low steepness  
1796 value, but the other data sources higher value for steepness (Figure 79). The impingement,  
1797 sanitation, and recreational private mode fleets support higher values of steepness while the  
1798 other surveys are relatively uninformative. The relative depletion for California scorpionfish  
1799 changes very little (0.51-0.60) across different assumed values of steepness (Figure 80).

1800 The negative log-likelihood was minimized at a natural mortality value of 0.38, the profile  
1801 is relatively flat for the priors, index data, and recruitment (Figure 81). The age data  
1802 likelihood contribution was minimized at natural mortality values ranging from 0.035-0.40,  
1803 and the length data contribution was minimized as the largest value of  $M$  run, 0.40 (Table  
1804 48). The impingement survey was the only fleet for which the likelihood profile over  $M$  was  
1805 not relatively flat (Figure 82) The relative depletion for California scorpionfish ranged from  
1806 0.48-0.80 across alternative values of natural mortality (Figure 83).

### 1807 2.7.6 Reference Points

1808 Reference points were calculated using the estimated selectivities and catch distribution  
1809 among fleets in the most recent year of the model, (2015). Sustainable total yield (landings  
1810 plus discards) were 221.2 mt when using an  $SPR_{50\%}$  reference harvest rate and with a 95%  
1811 confidence interval of (156.9-285.5) mt based on estimates of uncertainty. The spawning

1812 output equivalent to 40% of the unfished spawning output ( $SB_{40\%}$ ) was 547.2 millions of  
1813 eggs.

1814 The predicted spawning output from the base model shows an initial decline starting in  
1815 1970, with two year of low spawning biomass in 1976 and 1977. From the late 1970s to the  
1816 mid-2000's the population follows a cyclical pattern (driven by recruitment pulses) and then  
1817 declines until 2015. The last two years of the model indicate an increase in spawning output.  
1818 (Figure 84). Since 2015, the spawning output has been increased due to lower catches and a  
1819 high recruitment pulse in 2015. The 2016 spawning output relative to unfished equilibrium  
1820 spawning output is above the target of 40% of unfished spawning output (Figure 85). The  
1821 fishing intensity,  $(1 - SPR)/(1 - SPR_{50\%})$ , has been well below the management target for  
1822 the entire time series of the model.

1823 Table e shows the full suite of estimated reference points for the base model and Figure 86  
1824 shows the equilibrium curve based on a steepness value fixed at .

### 1825 **3 Harvest Projections and Decision Tables**

1826 The forecasts of stock abundance and yield were developed using the final base model. The  
1827 total catches in 2017 and 2018 are set to the PFMC adopted California scorpionfish ACLs  
1828 (Table \ref{tab:tab:mnmgt\_perform}). CDFW allocated 75% of the ACL to the recreational  
1829 fisheries and 25% to the commercial fisheries. The catches were divided among the fleets  
1830 within each the commercial and recreational fisheries by taking the ratio of the average  
1831 catches from 2012-2016. The average of 2012-2016 catch by fleet was used to distribute  
1832 catches in forecasted years. The research catch harvest guideline for 2017-2018 was set at  
1833 0.2 mt. The average research catch from the NWFSC trawl survey averaged 0.077 mt from  
1834 2012-2016, which was used in the forecast.

#### 1835 **Projections and Decision Table**

1836 Forecasts (Table 49) and decision tables (Table h) to be completed during and/or after the  
1837 STAR panel

### 1838 **4 Regional Management Considerations**

1839 While the proportion of the stock residing within U.S. waters is unknown, the assessment  
1840 provides an adequate geographic representation of portion assessed for management purposes.  
1841 Collaboration with Mexico in conducting future assessments may be mutually beneficial. No  
1842 genetic information is available to inform whether separate stocks or population structure  
1843 pertinent to management exists. Given the relatively small area in the waters off of California

1844 where this species occurs south of Point Conception, there is relatively little concern regarding  
1845 exploitation in proportion to the regional distribution of abundance in the area assessed in  
1846 this study.

1847 While the species does aggregate during the spawning season making harvest of the stock  
1848 more efficient during this period, removals have been well within the harvest limits and the  
1849 stock has not been overfished or subject to overfishing as a whole.

1850 Routine sampling of commercial and recreational fisheries provides mortality estimates to  
1851 monitor catch during the course of season to prevent overfishing should effort increase in  
1852 the future. Analysis of CPUE of areas known to be spawning aggregations over time using  
1853 data from sampling on board CPFVs and comparison to the trajectory of the population as  
1854 a whole could provide information in determining whether localized depletion is occurring.  
1855 Eggs and larvae are expected to travel substantial distance before settling, thus such areas  
1856 should be repopulated from adjacent areas. Time/area closures could be considered where  
1857 deemed beneficial in maintaining a minimum CPUE the remainder of the year, but are not  
1858 necessary to keep aggregate harvest within the current harvest limits.

## 1859 5 Research Needs

1860 There are a number of areas of research that could improve the understand and the stock  
1861 assessment for California scorpionfish. Below are issues identified by the STAT team:

1862 1. **Natural mortality:** Both female natural mortality and steepness were fixed in the  
1863 base model. The collection of age data for older females may improve the ability to  
1864 estimate female natural mortality in the model. The NWFSC trawl survey was the  
1865 only available source of age data for this assessment, of which there were a number of  
1866 age-1 fish and the data were dominated by males.

1867 2. **Steepness:** California scorpionfish has not been fished to a level where information on  
1868 steepness is available. A meta-analysis for species with similar breeding strategies to  
1869 California scorpionfish could be conducted if data are available.

1870 3. **Stock in Mexico:** No available information on the status of California scorpionfish in  
1871 Mexico could be found. A number of emails were sent to researchers in Mexico and  
1872 none were returned. It is known that a portion of the stock resides in Mexico and that  
1873 boat leaving from San Diego target California scorpionfish off the Coronado Islands.

1874 4. **Sex ratio:** The sex ratio in both Love et al. [@Love1987] and samples from the NWFSC  
1875 trawl survey were skewed towards males. Data on sex ratios from the recreational or  
1876 commercial fisheries would help in determining the sex ratio of the population.

1877 5. **Aggregating behavior:** Little is known about the aggregating behavior of California  
1878 scorpionfish. California scorpionfish are known to aggregate in both the spawning

1879 and non-spawning seasons. The location and timing of the aggregations would aid in  
1880 modelling the high catch events.

1881 **6. Fecundity/Maturity:** There are currently no estimates of fecundity for California  
1882 scorpionfish. Love et al. [@Love1987] has published the only estiamtes of maturity for  
1883 California scorpionfish, but the original copies of the data are no long available. Some  
1884 data on the spatial distribution of the eggs are available from CalCOFI, but were not  
1885 keypunched to the species level. California scorpionfish mature at a young age, and  
1886 additional data can help inform the maturity ogive.

## 1887 **6 Acknowledgments**

1888 To be added.

## 7 Tables

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Model	Binomial	Lognormal
Year	6182.366	8103.204
Year + County	5862.9	8003.9
Year + Wave	6091	8092.2
Year + County + Wave	<b>5792.29</b>	<b>8000.45</b>

Table 8: The recreational private mode dockside sample index.

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

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

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

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

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

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

Model	Negative Binomial
Year	1918470
Year+ Month	1901592
Year + Block	1872224
Year+ Month + Block	<b>1854652</b>

Table 12: The recreational CPFV logbook sample index.

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

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

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

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

Model	Binomial	Lognormal
Year	3516.2	2479.6
Year + Month	3123.2	2488.7
Year + County	3293.3	<b>2436.3</b>
Year + Month + County	<b>3091.8</b>	2444.6

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Model	Binomial	Lognormal
Year	7330.73	6748.7
Year + Quarter	7179.5	6642.7
Year + Station	6321.6	6372.8
Year + Station + Quarter	<b>6130.94</b>	<b>6252.71</b>

Table 24: The sanitation districts trawl sample index.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Table 33: The NWFSC trawl survey index.

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

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

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

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

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

Table 36: The recreational private mode dockside sample index.

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

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

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

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

Model	Binomial	Lognormal
Year	494.73	339.56
Year + Region	490.24	343.16
Year + Month	493.02	336.68
Year + Month + Region	<b>486.55</b>	<b>337.87</b>

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

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

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

Description	Value
Minimum likelihood	1097.30
Maximum likelihood	1111.98
Likelihood difference	14.68
Minimum MGC	0.00
Maximum MGC	0.00
Depletion at minimum likelihood percent	57.41
Depletion at maximum likelihood percent	82.99
Difference in depletion percent	25.58
Number of jitters	50.00
Prop of runs at minimum likelihood	0.56
Proportion of runs at maximum likelihood	0.02

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

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
1	NatM_p_1_Fem_GP_1	0.257	-3	(0.01, 1) (2, 30)	OK	0.626	Log_Norm (-1.3581, 0.438438)
2	Lat_Amin_Fem_GP_1	12.434	2	(30, 50)	OK	0.720	None
3	Lat_Amax_Fem_GP_1	33.312	2	(0.05, 0.5)	OK	0.024	None
4	VonBert_K_Fem_GP_1	0.250	2	(0.02, 0.5)	OK	0.019	None
5	CV_young_Fem_GP_1	0.089	3	(0.02, 0.75)	OK	0.008	None
6	CV_old_Fem_GP_1	0.112	3	(-3, 3)	None	None	None
7	Wtlen_1_Fem	0.000	-3	(2, 4)	None	None	None
8	Wtlen_2_Fem	3.058	-3	(10, 30)	None	None	None
9	Mat50%_Fem	18.000	-3	(-3, 3)	None	None	None
10	Mat_slope_Fem	-1.200	-3	(-3, 3)	None	None	None
11	Eggs/kg_inter_Fem	1.000	-3	(-3, 3)	None	None	None
12	Eggs/kg_slope_wt_Fem	0.000	-3	(-3, 3)	None	None	None
13	NatM_p_1_Mal_GP_1	-0.213	2	(-1, 1)	OK	0.049	Normal (0, 99)
14	Lat_Amin_Mal_GP_1	0.000	-2	(-3, 3)	None	None	None
15	Lat_Amax_Mal_GP_1	-0.159	2	(-3, 3)	OK	0.026	None
16	VonBert_K_Mal_GP_1	-0.295	2	(-3, 3)	OK	0.183	None
17	CV_young_Mal_GP_1	1.300	3	(-3, 3)	OK	0.218	None
18	CV_old_Mal_GP_1	-0.452	3	(-3, 3)	OK	0.158	None
19	Wtlen_1_Mal	0.000	-5	(0, 1)	None	None	None
20	Wtlen_2_Mal	2.981	-5	(2, 4)	None	None	None
24	CohortGrowDev	1.000	-1	(1, 1)	None	None	None
25	FracFemale_GP_1	0.500	-4	(0.000001, 0.999999)	OK	0.157	Full_Beta (0.718, 0.158)
26	SR_LN(R0)	8.160	1	(0, 31)	None	None	None
27	SR_BH_stEEP	0.718	-2	(0.21, 0.99)	None	None	None
28	SR_sigmar	0.600	-2	(0, 2)	None	None	None
29	SR_regime	0.000	-4	(-5, 5)	None	None	None

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

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
30	SR.autocorr	0.000	-3	(0, 0.5)			None
106	LnQ_base_RecPR(4)	-6.775	-1	(-15, 15)	OK	0.020	None
107	Q_extraSD_RecPR(4)	0.013	4	(0.0001, 1)			None
108	LnQ_base_RecPC(5)	-11.223	-1	(-15, 15)			None
109	Q_extraSD_RecPC(5)	0.267	4	(0.0001, 1)	OK	0.047	None
110	LnQ_base_RecDD(6)	-10.894	-1	(-15, 15)			None
111	Q_extraSD_RecDD(6)	0.078	4	(0.0001, 1)	OK	0.044	None
112	LnQ_base_Sanitation(7)	-10.544	-1	(-15, 15)			None
113	Q_extraSD_Sanitation(7)	0.225	4	(0.0001, 1)	OK	0.047	None
114	LnQ_base_NWFSC_Trawl(8)	-1.023	-1	(-15, 15)			None
115	Q_extraSD_NWFSC_Trawl(8)	0.250	4	(0.0001, 1)	OK	0.145	None
116	LnQ_base_GillnetSurvey(9)	-12.050	-1	(-15, 15)			None
117	Q_extraSD_GillnetSurvey(9)	0.122	4	(0.0001, 1)	OK	0.070	None
118	LnQ_base_SCBSSurvey(11)	-11.052	-1	(-15, 15)			None
119	Q_extraSD_SCBSSurvey(11)	0.166	4	(0.0001, 1)	OK	0.142	None
120	LnQ_base_RecPCOBR(12)	-10.171	-1	(-15, 15)			None
121	Q_extraSD_RecPCOBR(12)	0.140	4	(0.0001, 1)	OK	0.046	None
122	SizeSel_P1_CoMHL(1)	25.963	5	(13, 44)	OK	2.868	None
123	SizeSel_P2_CoMHL(1)	15.000	-3	(-10, 16)			None
124	SizeSel_P3_CoMHL(1)	2.761	5	(-1, 10)	OK	0.954	None
125	SizeSel_P4_CoMHL(1)	15.000	-3	(-1, 16)			None
126	SizeSel_P5_CoMHL(1)	-15.902	5	(-25, -1)	OK	121.578	None
127	SizeSel_P6_CoMHL(1)	10.000	-3	(-5, 11)			None
128	SizeSel_P1_CoMNet(2)	1.000	-2	(1, 45)			None
129	SizeSel_P2_CoMNet(2)	45.000	-3	(1, 45)			None
130	SizeSel_P1_CoM_Trawl(3)	1.000	-2	(1, 45)			None
131	SizeSel_P2_CoM_Trawl(3)	45.000	-3	(1, 45)			None

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

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
132	SizeSel_P1.RecPR(4)	41.212	5	(13, 44)	OK	2.054	None
133	SizeSel_P2.RecPR(4)	15.000	-3	(-10, 16)	OK	0.163	None
134	SizeSel_P3.RecPR(4)	4.493	5	(-1, 10)	OK	0.163	None
135	SizeSel_P4.RecPR(4)	15.000	-3	(-1, 16)	OK	0.784	None
136	SizeSel_P5.RecPR(4)	-8.340	5	(-25, -1)	OK	0.784	None
137	SizeSel_P6.RecPR(4)	10.000	-3	(-5, 11)	OK	1.358	None
138	SizeSel_P1.RecPC(5)	36.624	5	(13, 44)	OK	1.358	None
139	SizeSel_P2.RecPC(5)	15.000	-3	(-10, 16)	OK	None	None
140	SizeSel_P3.RecPC(5)	4.473	5	(-1, 10)	OK	0.158	None
141	SizeSel_P4.RecPC(5)	15.000	-3	(-1, 16)	OK	None	None
142	SizeSel_P5.RecPC(5)	-8.344	5	(-25, -1)	OK	1.872	None
143	SizeSel_P6.RecPC(5)	10.000	-3	(-5, 11)	OK	0.074	None
144	SizeSel_P1.RecDD(6)	24.530	5	(13, 44)	OK	57.708	None
145	SizeSel_P2.RecDD(6)	-11.238	4	(-15, 16)	OK	0.518	None
146	SizeSel_P3.RecDD(6)	2.727	4	(-1, 10)	OK	65.524	None
147	SizeSel_P4.RecDD(6)	-9.302	4	(-20, 5)	OK	0.472	None
148	SizeSel_P5.RecDD(6)	-2.156	5	(-25, 3)	OK	0.457	None
149	SizeSel_P6.RecDD(6)	-1.709	4	(-5, 11)	OK	0.580	None
150	SizeSel_P1.Sanitation(7)	24.627	4	(13, 44)	OK	None	None
151	SizeSel_P2.Sanitation(7)	15.000	-3	(-10, 16)	OK	0.140	None
152	SizeSel_P3.Sanitation(7)	3.388	4	(-1, 10)	OK	0.633	None
153	SizeSel_P4.Sanitation(7)	15.000	-3	(-1, 16)	OK	2.258	None
154	SizeSel_P5.Sanitation(7)	-4.618	4	(-25, 5)	OK	None	None
155	SizeSel_P6.Sanitation(7)	10.000	-3	(-5, 11)	OK	None	None
156	SizeSel_P1.NWFSCTrawl(8)	24.306	4	(13, 44)	OK	None	None
157	SizeSel_P2.NWFSCTrawl(8)	15.000	-3	(-10, 16)	OK	0.558	None
158	SizeSel_P3.NWFSCTrawl(8)	3.652	4	(-1, 10)	OK	0.558	None

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

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
159	SizeSel_P4_NWFSTrawl(8)	15.000	-3	(-1, 16)			None
160	SizeSel_P5_NWFSTrawl(8)	-12.844	4	(-25, 5)	OK	166.385	None
161	SizeSel_P6_NWFSTrawl(8)	10.000	-3	(-5, 11)			None
162	SizeSel_P1_GilnetSurvey(9)	1.000	-2	(1, 45)			None
163	SizeSel_P2_GilnetSurvey(9)	45.000	-3	(1, 45)			None
164	SizeSel_P1_SCBSurvey(11)	1.000	-2	(1, 45)			None
165	SizeSel_P2_SCBSurvey(11)	45.000	-3	(1, 45)			None
166	SizeSel_P1_RecPCOBR(12)	1.000	-2	(1, 45)			None
167	SizeSel_P2_RecPCOBR(12)	45.000	-3	(1, 45)			None
168	SizeSel_P1_CoMHL(1)_BLK1rep1_1999	28.442	6	(13, 44)	OK	0.489	None
169	SizeSel_P3_CoMHL(1)_BLK1rep1_1999	2.007	6	(-1, 10)	OK	0.251	None
170	SizeSel_P1_RecPR(4)_BLK2rep1_2000	36.584	6	(13, 44)	OK	1.031	None
171	SizeSel_P1_RecPR(4)_BLK2rep1_2006	35.815	6	(13, 44)	OK	0.652	None
172	SizeSel_P3_RecPR(4)_BLK2rep1_2000	3.602	6	(-1, 10)	OK	0.165	None
173	SizeSel_P3_RecPR(4)_BLK2rep1_2006	3.463	6	(-1, 10)	OK	0.110	None
174	SizeSel_P1_RecPC(5)_BLK2rep1_2000	31.799	6	(13, 44)	OK	1.370	None
175	SizeSel_P1_RecPC(5)_BLK2rep1_2006	26.886	6	(13, 44)	OK	0.464	None
176	SizeSel_P3_RecPC(5)_BLK2rep1_2000	3.041	6	(-1, 10)	OK	0.417	None
177	SizeSel_P3_RecPC(5)_BLK2rep1_2006	1.066	6	(-1, 10)	OK	0.412	None

Table 42: Likelihood components from the base model.

Likelihood component	Value
TOTAL	1097.30
Catch	0.00
Survey	-98.12
Length composition	763.02
Age composition	421.52
Recruitment	10.88
Forecast recruitment	0.00
Parameter priors	0.00
Parameter soft bounds	0.01

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

Yr	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative ex- ploitation rate	SPR
1916	2797	1368	0.000	3498	4	0.00	0.99
1917	2794	1366	0.999	3497	8	0.00	0.98
1918	2787	1362	0.996	3496	13	0.00	0.97
1919	2778	1356	0.992	3495	12	0.00	0.98
1920	2771	1352	0.989	3494	16	0.01	0.97
1921	2760	1346	0.984	3492	26	0.01	0.95
1922	2743	1336	0.977	3490	19	0.01	0.96
1923	2734	1331	0.973	3488	27	0.01	0.94
1924	2720	1323	0.967	3486	49	0.02	0.90
1925	2689	1304	0.953	3481	101	0.04	0.82
1926	2618	1262	0.923	3469	49	0.02	0.90
1927	2602	1253	0.916	3467	51	0.02	0.90
1928	2586	1245	0.910	3464	44	0.02	0.91
1929	2579	1241	0.907	3463	50	0.02	0.90
1930	2569	1236	0.904	3462	41	0.02	0.91
1931	2567	1236	0.903	3462	43	0.02	0.91
1932	2564	1235	0.902	3461	41	0.02	0.91
1933	2564	1235	0.903	3461	32	0.01	0.93
1934	2571	1239	0.906	3463	34	0.01	0.93
1935	2577	1243	0.909	3464	35	0.01	0.93
1936	2580	1245	0.910	3464	55	0.02	0.89
1937	2566	1237	0.904	3462	66	0.03	0.87
1938	2545	1224	0.895	3458	76	0.03	0.85
1939	2518	1208	0.883	3453	63	0.02	0.87
1940	2506	1201	0.878	3451	59	0.02	0.88
1941	2498	1197	0.875	3449	43	0.02	0.91
1942	2505	1202	0.879	3451	20	0.01	0.95
1943	2531	1218	0.890	3456	16	0.01	0.96
1944	2557	1234	0.902	3461	24	0.01	0.95
1945	2573	1244	0.909	3464	42	0.02	0.91
1946	2571	1242	0.908	3464	66	0.03	0.87
1947	2549	1229	0.898	3460	74	0.03	0.85
1948	2524	1212	0.886	3454	107	0.04	0.80
1949	2476	1181	0.863	3444	93	0.04	0.82
1950	2446	1162	0.850	3438	97	0.04	0.81
1951	2417	1145	0.837	3432	67	0.03	0.86
1952	2417	1145	0.837	3432	61	0.03	0.87
1953	2423	1149	0.840	3434	73	0.03	0.85
1954	2417	1146	0.838	3433	84	0.03	0.83
1955	2404	1139	0.832	3430	67	0.03	0.86

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

Yr	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative ex- ploitation rate	SPR
1956	2406	1140	0.834	3431	63	0.03	0.86
1957	2411	1144	0.837	3432	43	0.02	0.90
1958	2432	1158	0.847	3437	39	0.02	0.91
1959	2454	1172	0.857	3441	25	0.01	0.94
1960	2484	1191	0.870	3448	24	0.01	0.95
1961	2512	1207	0.882	3453	31	0.01	0.93
1962	2530	1217	0.890	3456	50	0.02	0.90
1963	2530	1216	0.889	3456	72	0.03	0.86
1964	2512	1203	0.879	3451	87	0.03	0.83
1965	2484	1184	0.865	3445	85	0.03	0.83
1966	2462	1169	0.854	2688	89	0.04	0.82
1967	2416	1154	0.844	2686	73	0.03	0.85
1968	2369	1142	0.835	2539	87	0.04	0.82
1969	2296	1105	0.808	2410	84	0.04	0.82
1970	2214	1062	0.777	2194	103	0.05	0.79
1971	2107	1006	0.735	1810	91	0.04	0.80
1972	1996	953	0.696	1652	82	0.04	0.81
1973	1883	900	0.658	1590	95	0.05	0.78
1974	1753	831	0.607	1963	122	0.07	0.73
1975	1617	748	0.547	6328	128	0.08	0.70
1976	1636	673	0.492	5892	66	0.04	0.80
1977	1808	698	0.510	6099	87	0.05	0.75
1978	2042	820	0.599	3189	62	0.03	0.81
1979	2245	991	0.725	1671	100	0.04	0.75
1980	2316	1118	0.817	1278	124	0.05	0.73
1981	2267	1138	0.832	1331	110	0.05	0.76
1982	2155	1086	0.794	1811	112	0.05	0.77
1983	2010	989	0.723	2786	61	0.03	0.85
1984	1928	912	0.667	7937	70	0.04	0.83
1985	2028	850	0.621	9469	86	0.04	0.80
1986	2305	874	0.639	3143	76	0.03	0.81
1987	2523	1065	0.778	1649	69	0.03	0.83
1988	2641	1276	0.933	1473	201	0.08	0.66
1989	2545	1274	0.932	1333	163	0.06	0.71
1990	2390	1199	0.876	1556	228	0.10	0.65
1991	2139	1040	0.760	5837	241	0.11	0.63
1992	2006	866	0.633	5455	115	0.06	0.75
1993	2060	823	0.602	8431	95	0.05	0.77
1994	2297	897	0.656	4667	156	0.07	0.68
1995	2470	1014	0.741	2404	133	0.05	0.72

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

Yr	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative ex- ploitation rate	SPR
1996	2577	1183	0.865	7073	136	0.05	0.73
1997	2745	1258	0.919	3787	142	0.05	0.74
1998	2831	1291	0.944	4445	161	0.06	0.73
1999	2876	1344	0.982	4832	225	0.08	0.67
2000	2864	1315	0.962	2435	169	0.06	0.73
2001	2821	1316	0.962	4058	199	0.07	0.70
2002	2754	1280	0.935	2274	128	0.05	0.78
2003	2680	1248	0.913	1889	105	0.04	0.81
2004	2572	1223	0.894	1953	57	0.02	0.88
2005	2466	1182	0.864	4123	89	0.04	0.83
2006	2384	1098	0.802	2454	150	0.06	0.75
2007	2241	1007	0.736	2191	140	0.06	0.75
2008	2111	964	0.704	2260	104	0.05	0.78
2009	2016	927	0.678	2785	113	0.06	0.76
2010	1933	878	0.642	2304	106	0.05	0.77
2011	1859	841	0.615	1164	105	0.06	0.76
2012	1754	815	0.596	1108	120	0.07	0.73
2013	1616	766	0.560	4073	115	0.07	0.72
2014	1567	694	0.507	3460	124	0.08	0.70
2015	1553	644	0.471	7383	84	0.05	0.75
2016	1737	682	0.498	3183	74	0.04	0.77
2017	1902	785	0.574	3260			

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

Label	Base (Francis weights)	Default weights	Harmonic mean weights	Drop sanita- tion data	Assume equal M	Placeholder <sup>1</sup> Placeholder <sup>2</sup> Placeholder <sup>3</sup>
Female natural mortality	0.26	0.26	0.26	0.26	0.26	-
Male natural mortality	0.21	0.21	0.19	0.21	0.72	-
Steepness	0.72	0.72	0.72	0.72	8.43	-
lnR0	8.16	8.26	8.03	8.09	3110.57	-
Total Biomass (mt)	2796.86	2856.03	2429.68	2518.67	59.12	-
Depletion	0.57	0.76	0.65	0.50	0.64	-
SPR ratio	0.72	0.62	0.79	0.83	11.98	-
Female Lmin	12.43	12.32	12.32	13.01	32.47	-
Female Lmax	33.31	33.77	34.55	34.42	0.26	-
Female K	0.25	0.22	0.22	0.21	0.00	-
Male Lmin (offset)	0.00	0.00	0.00	0.00	-0.14	-
Male Lmax (offset)	-0.16	-0.17	-0.17	-0.15	-0.16	-
Male K (offset)	-0.29	-0.37	-0.83	-0.77	-	-
Negative log-likelihood					1108.05	-
No. parameters	1097.30	3788.31	2302.18	109.00	0.00	-
TOTAL	0.00	0.00	0.00	899.14	0.00	-
Catch	0.00	0.00	0.00	0.00	-98.42	-
Equilibrium catch	-98.12	-87.71	-87.94	0.00	765.37	-
Survey	763.02	2523.37	1684.19	-93.00	430.55	-
Length composition	421.52	1320.36	682.93	550.37	10.54	-
Age composition	10.88	32.28	23.00	432.29	0.00	-
Recruitment	0.00	0.00	0.00	9.48	0.00	-
Forecast Recruitment	0.00	0.00	0.00	0.00	0.00	-
Parameter priors	0.01	0.01	0.00	0.00	0.00	-
Parameter softbounds	0.00	0.00	0.00	0.00	0.00	-
Parameter devs	0.00	0.00	0.00	0.00	0.00	-
Crash Pen	0.00	0.00	0.00	0.00	0.00	-

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

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

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

Label	Base	Retro1	Retro2	Retro3	Retro4
Female natural mortality	0.26	0.26	0.26	0.26	0.26
Male natural mortality	0.72	0.72	0.72	0.72	0.72
Steepness	8.16	8.09	8.07	8.04	8.08
InR0	2796.86	2593.78	2568.77	2498.07	2650.36
Total Biomass (mt)	57.41	53.57	50.74	50.72	54.78
Depletion	0.72	0.76	0.79	0.80	0.74
SPR ratio	12.43	12.45	12.90	12.63	13.03
Female Lmin	33.31	33.50	33.39	33.37	33.46
Female Lmax	0.25	0.24	0.24	0.25	0.23
Female K	0.00	0.00	0.00	0.00	0.00
Male Lmin (offset)	-0.16	-0.16	-0.15	-0.16	-0.15
Male Lmax (offset)	-0.29	-0.30	-0.43	-0.41	-0.56
Male K (offset)					
Negative log-likelihood	1097.30	1047.56	1009.37	961.81	897.04
No. parameters	0.00	0.00	0.00	0.00	0.00
TOTAL	0.00	0.00	0.00	0.00	0.00
Catch	-98.12	-92.00	-89.12	-81.75	-80.59
Equilibrium catch	763.02	739.90	720.39	700.10	670.66
Survey	421.52	390.56	369.97	336.26	299.84
Length composition	10.88	9.09	8.12	7.20	7.12
Age composition	0.00	0.00	0.00	0.00	0.00
Recruitment	0.00	0.00	0.00	0.00	0.00
Forecast Recruitment	0.01	0.01	0.01	0.01	0.01
Parameter priors	0.00	0.00	0.00	0.00	0.00
Parameter softbounds	0.00	0.00	0.00	0.00	0.00
Parameter devs					
Crash Pen					

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

Label	R07400	R07800	R08200	R08600	R09000	h0410	h0570	h0710	h0870	h0990
Female M	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Steepness	0.72	0.72	0.72	0.72	0.72	0.41	0.57	0.71	0.87	0.99
$\ln R_0$	7.40	7.80	8.20	8.60	9.00	8.34	8.21	8.16	8.13	8.11
Total biomass (m)	1623.19	2113.03	2894.72	4173.95	6142.97	3313.42	2943.85	2802.69	2712.12	2667.97
Depletion (%)	46.83	49.83	58.31	66.23	71.80	51.20	55.27	57.32	58.81	59.60
SPR ratio	1.05	0.91	0.70	0.49	0.34	0.68	0.71	0.72	0.72	0.73
Female Lmin	12.16	12.41	12.43	12.39	12.36	12.43	12.44	12.43	12.43	12.43
Female Lmax	34.29	33.83	33.26	32.76	32.42	33.19	33.28	33.31	33.33	33.34
Female K	0.24	0.25	0.25	0.26	0.26	0.25	0.25	0.25	0.25	0.25
Male Lmin (offset)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Male Lmax (offset)	-0.18	-0.17	-0.16	-0.15	-0.15	-0.16	-0.16	-0.16	-0.16	-0.16
Male K (offset)	-0.22	-0.31	-0.29	-0.24	-0.21	-0.27	-0.29	-0.29	-0.30	-0.30
Negative log-likelihood										
TOTAL	1117.15	1101.02	1097.33	1099.69	1102.95	1101.35	1098.58	1097.35	1096.72	1100.21
Catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Equil_catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Survey	-100.10	-99.20	-97.99	-97.00	-96.37	-98.27	-98.18	-98.12	-98.06	-98.03
Length_comp	761.18	760.12	763.44	767.61	770.76	765.11	763.69	763.05	762.58	762.33
Age_comp	437.32	427.37	421.09	418.57	417.98	420.58	421.24	421.51	421.68	421.77
Recruitment	18.74	12.72	10.80	10.50	10.58	12.55	11.40	10.90	10.56	10.38
Forecast_Recruitment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parm_priors	0.00	0.00	0.00	0.00	0.00	1.38	0.42	0.01	-0.04	3.76
Parm_softbounds	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Parm_devs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crash_Pen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 48: Summaries of key assessment outputs and likelihood values from selected likelihood profile runs on female natural mortality. Note that male growth parameters are exponential offsets from female parameters, and depletion and SPR ratio are for the year of 2017.

Label	M0220	M0260	M0300	M0350	M0400
Female M	0.22	0.26	0.30	0.35	0.40
Steepness	0.72	0.72	0.72	0.72	0.72
lnR0	7.67	8.20	8.95	12.21	31.00
Total biomass (m)	2259.39	2861.79	4632.81	89473.50	975357000000.00
Depletion (%)	47.72	58.15	68.08	79.27	79.74
SPR ratio	0.97	0.70	0.41	0.02	0.00
Female Lmin	12.39	12.44	12.43	12.39	12.24
Female Lmax	33.23	33.31	33.31	33.25	33.73
Female K	0.25	0.25	0.25	0.25	0.24
Male Lmin (offset)	0.00	0.00	0.00	0.00	0.00
Male Lmax (offset)	-0.16	-0.16	-0.15	-0.15	-0.15
Male K (offset)	-0.27	-0.30	-0.31	-0.32	-0.36
Negative log-likelihood					
TOTAL	1102.66	1096.96	1092.96	1089.92	1091.52
Catch	0.00	0.00	0.00	0.00	0.00
Equil_catch	0.00	0.00	0.00	0.00	0.00
Survey	-97.79	-98.14	-98.33	-98.33	-98.95
Length_comp	765.50	762.85	760.88	759.19	755.26
Age_comp	422.97	421.41	420.05	418.75	425.16
Recruitment	11.91	10.82	10.30	10.05	9.54
Forecast_Recruitment	0.00	0.00	0.00	0.00	0.00
Parm_priors	0.06	0.00	0.06	0.25	0.51
Parm_softbounds	0.01	0.01	0.01	0.00	0.00
Parm_devs	0.00	0.00	0.00	0.00	0.00
Crash_Pen	0.00	0.00	0.00	0.00	0.00

Table 49: Projection of potential OFL, spawning biomass, and depletion for the base case model.

Yr	OFL contribution (mt)	ACL landings (mt)	Age 5+ biomass (mt)	Spawning Biomass (mt)	Depletion
2017	282.78	150.00	1902.00	785.33	0.57
2018	300.05	150.00	1990.34	900.79	0.66
2019	334.00	307.63	2054.40	952.72	0.70
2020	326.57	300.84	1970.57	891.41	0.65
2021	309.69	285.30	1882.73	825.95	0.60
2022	292.99	269.90	1805.68	772.90	0.57
2023	279.64	257.57	1743.36	734.78	0.54
2024	269.39	248.12	1694.17	708.35	0.52
2025	261.42	240.77	1655.48	689.85	0.50
2026	255.14	234.97	1625.11	676.55	0.49
2027	250.17	230.39	1601.36	666.77	0.49
2028	246.26	226.79	1582.91	659.48	0.48

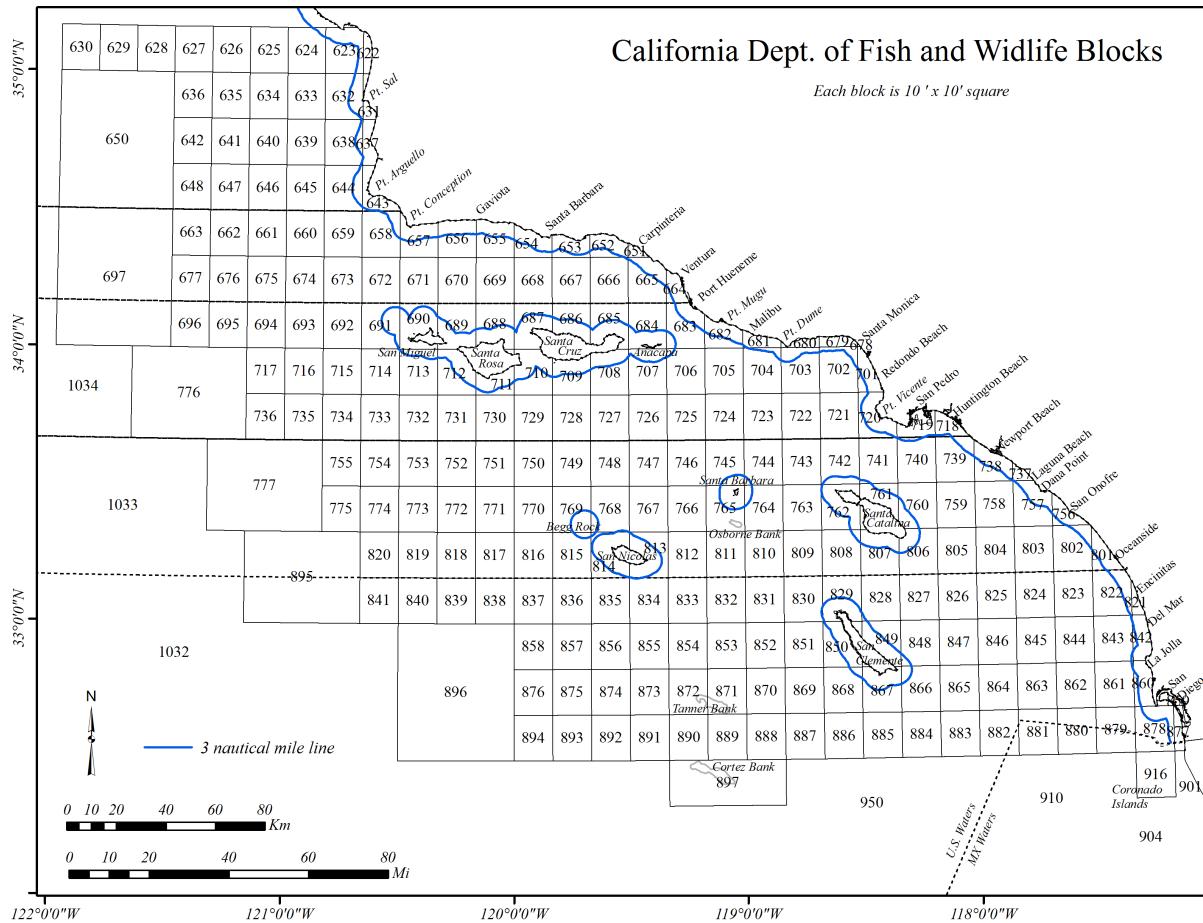


Figure 1: Map showing the state boundary lines for management of the recreational fishing fleets

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

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

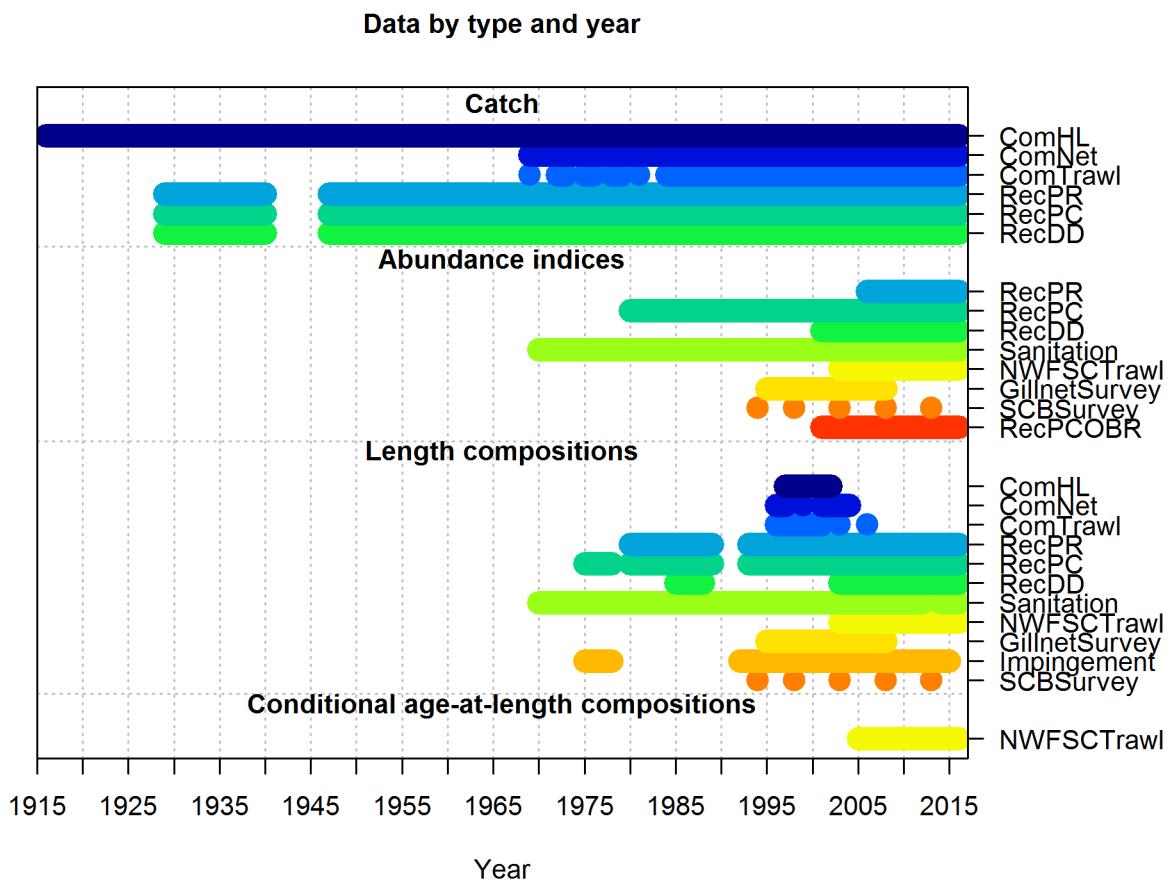


Figure 3: Summary of data sources used in the base model.

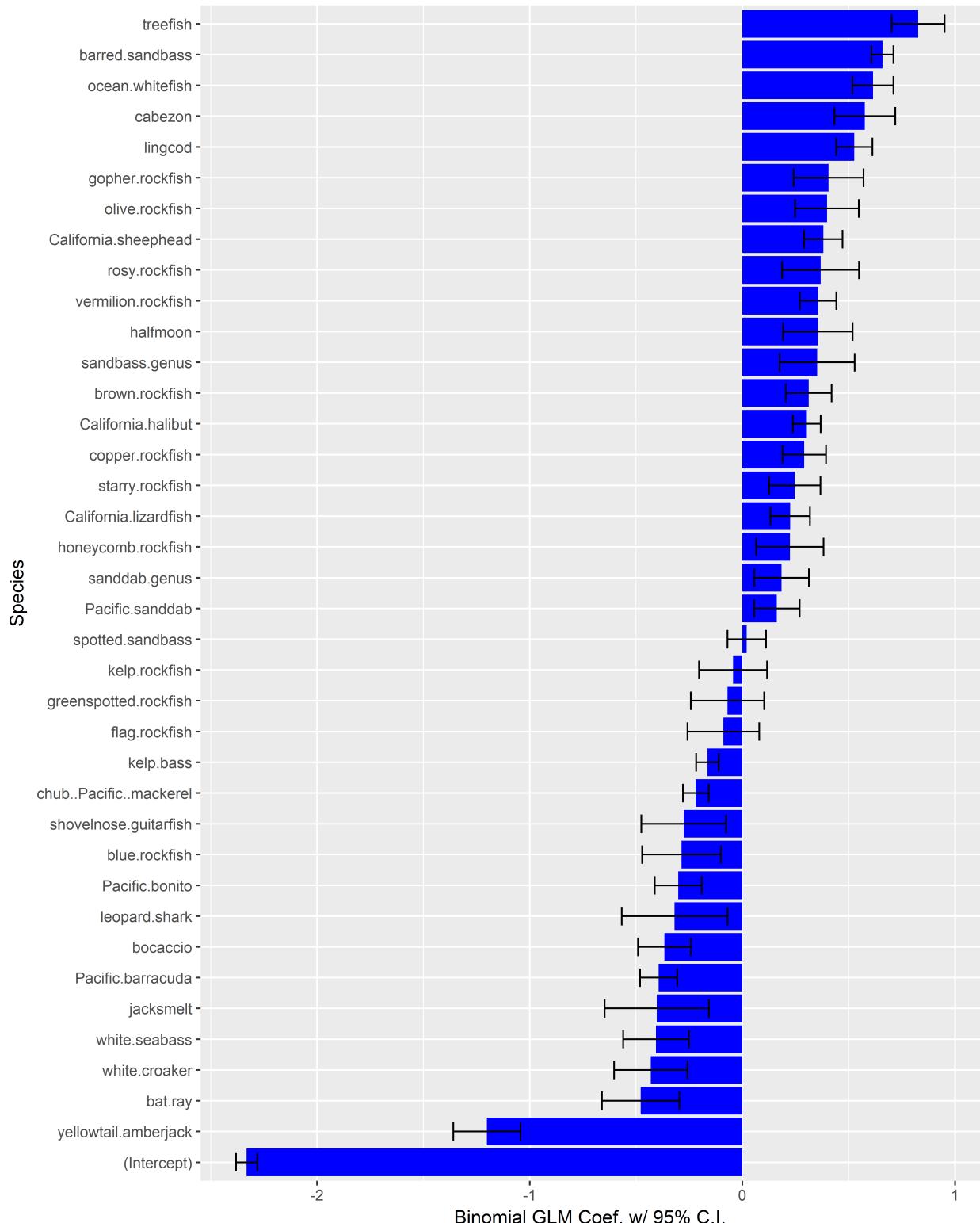


Figure 4: Species coefficients from the binomial GLM for presence/absence of California scorpionfish in the Marine Recreational Fisheries Statistics Survey (MRFSS) private mode dockside survey data set. Horizontal bars are 95% confidence intervals.

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

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

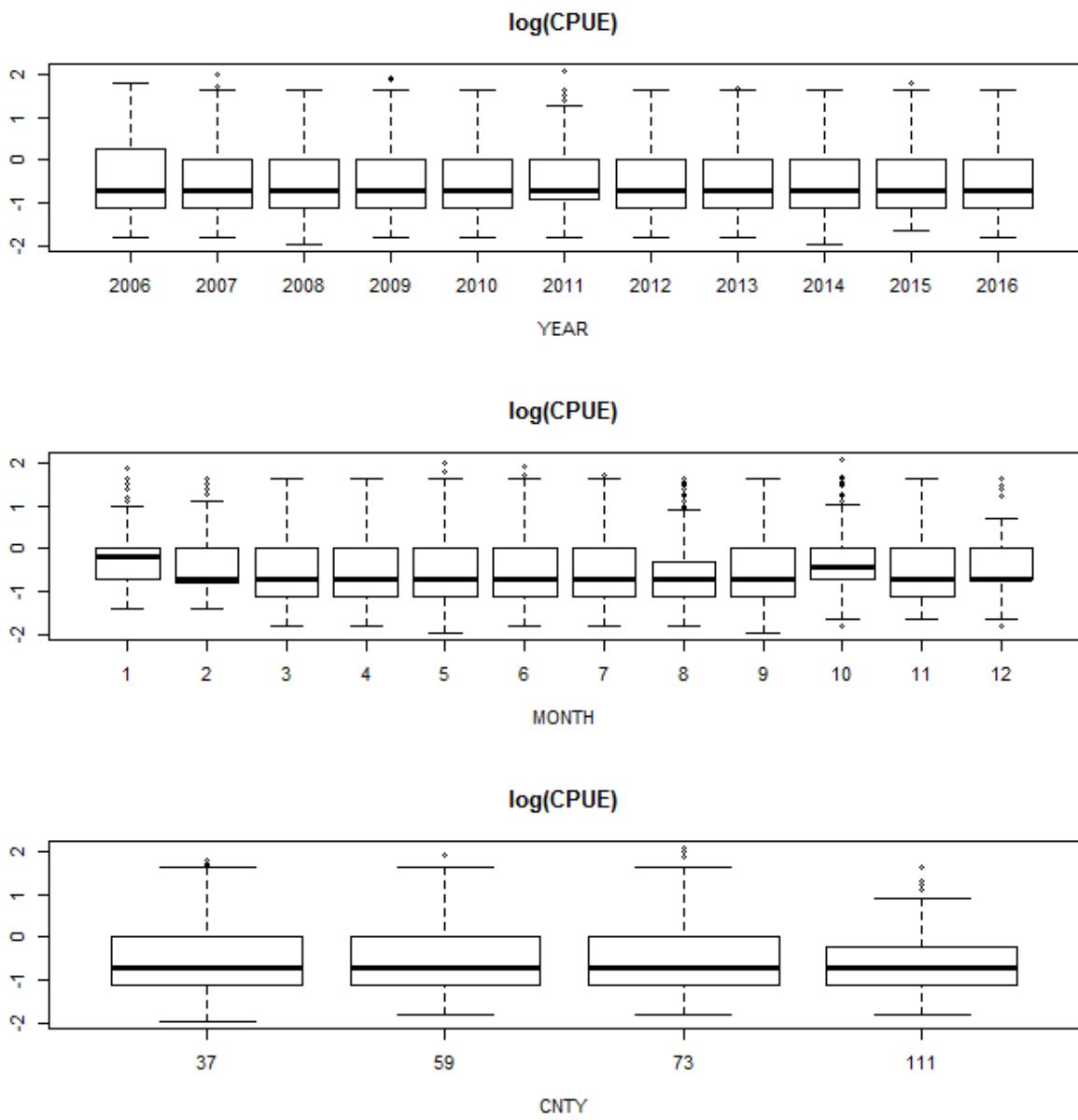


Figure 6: Boxplots of the raw log CPUE by year for each of the three factors considered in the deltaGLM model, county, month and year.

### Normal Q-Q Plot

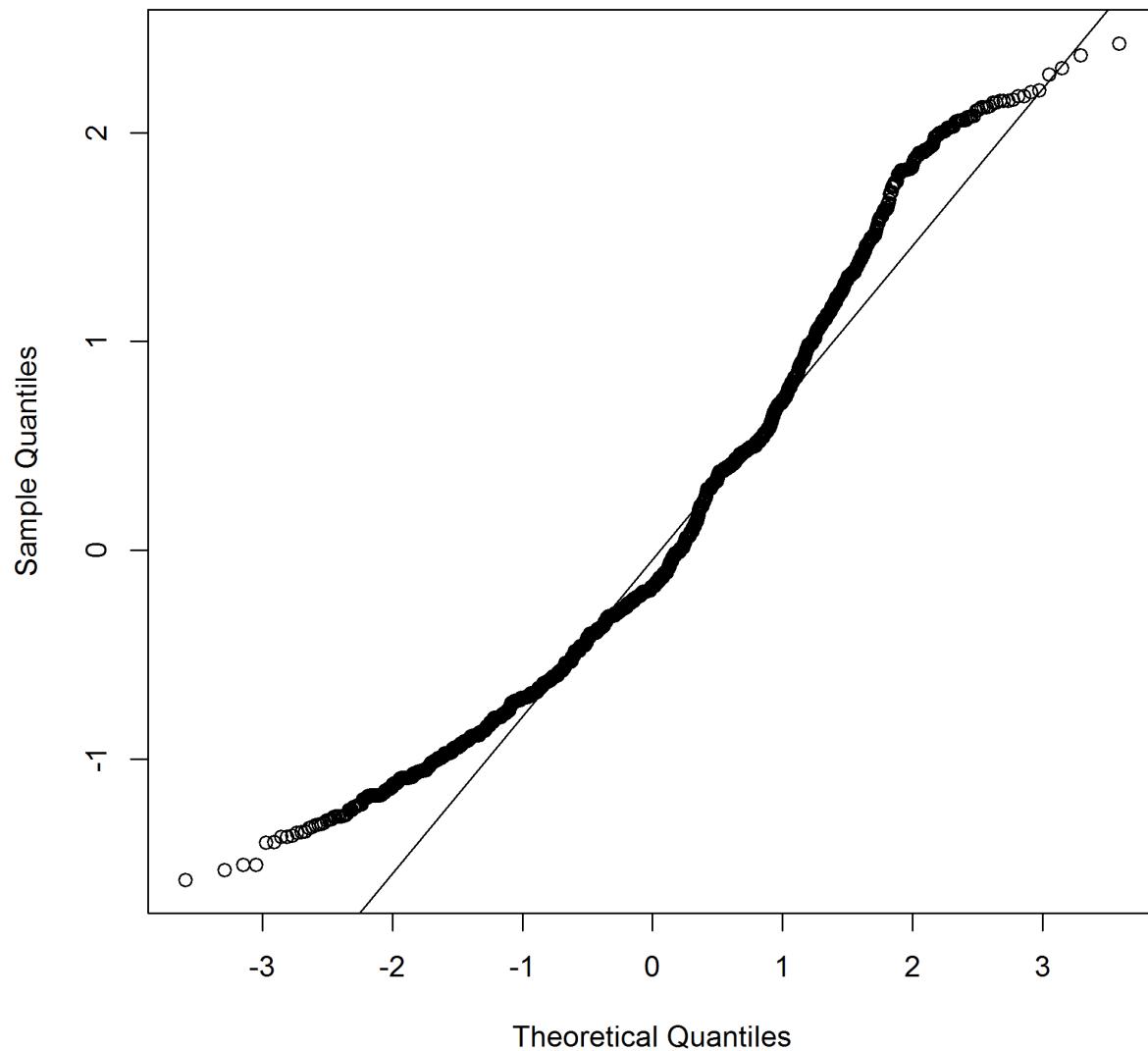


Figure 7: Q-Q plot used to evaluate the fit of the lognormal (positive encounters) of California scorpionfish from the Marine Recreational Fisheries Statistics Survey (MRFSS) private mode dockside survey data set.

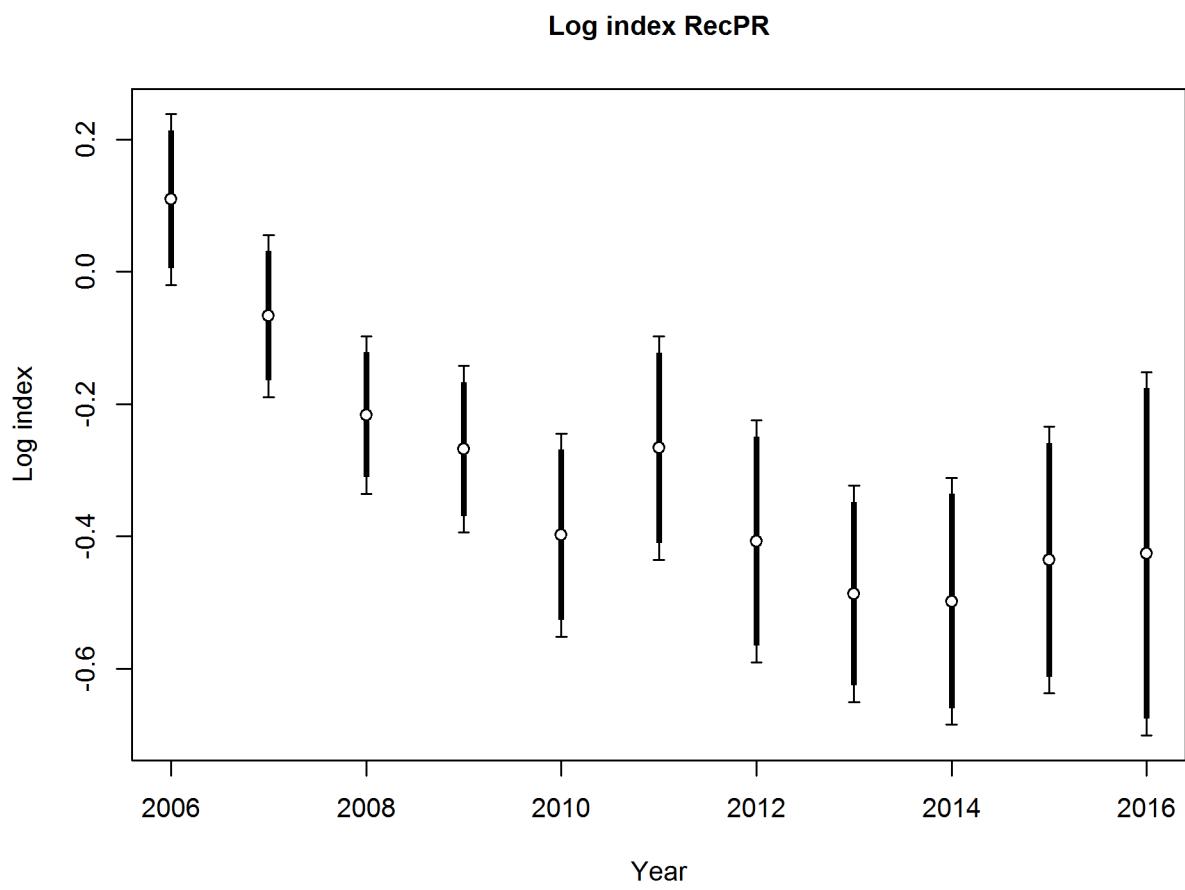


Figure 8: Standardized index on log scale for the recreational CPFV logbook retained catches. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

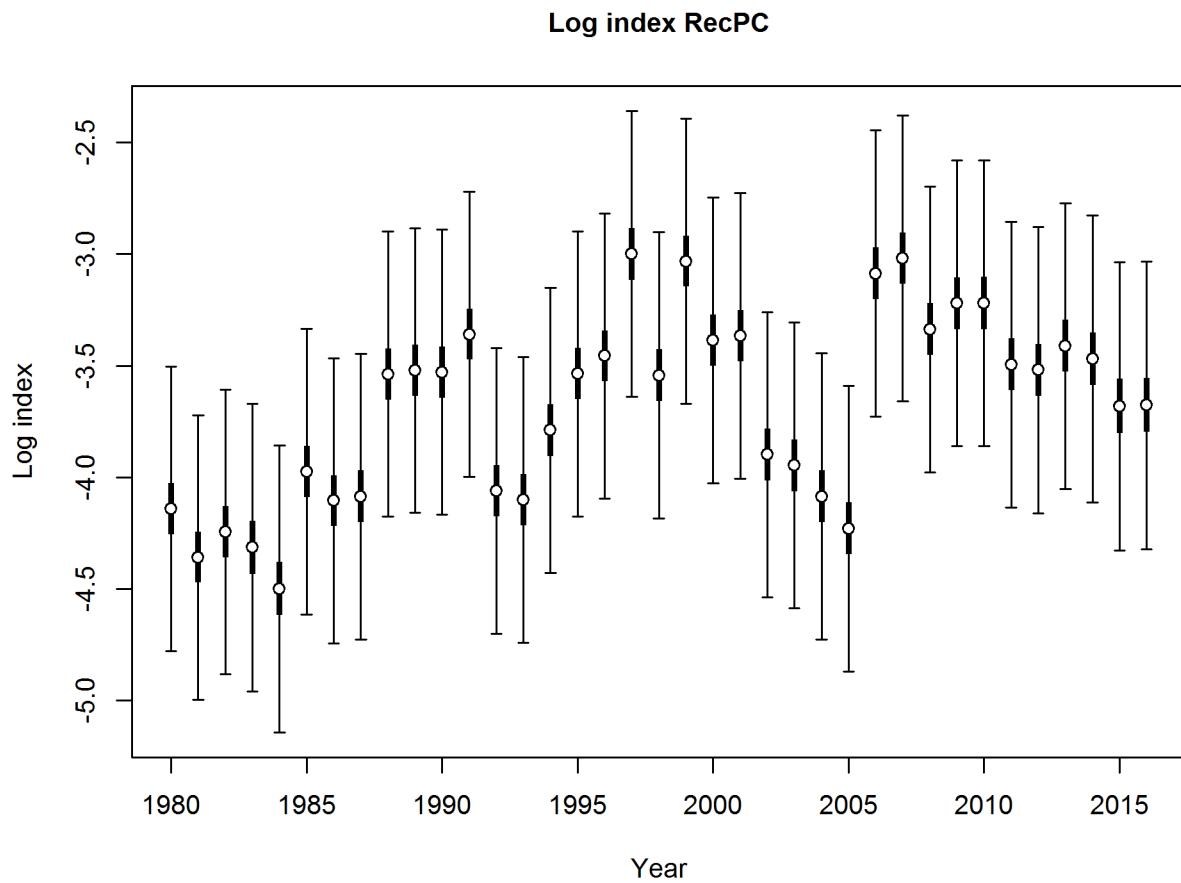


Figure 9: Standardized index on the log scale for the recreational CPFV logbook retained catches. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

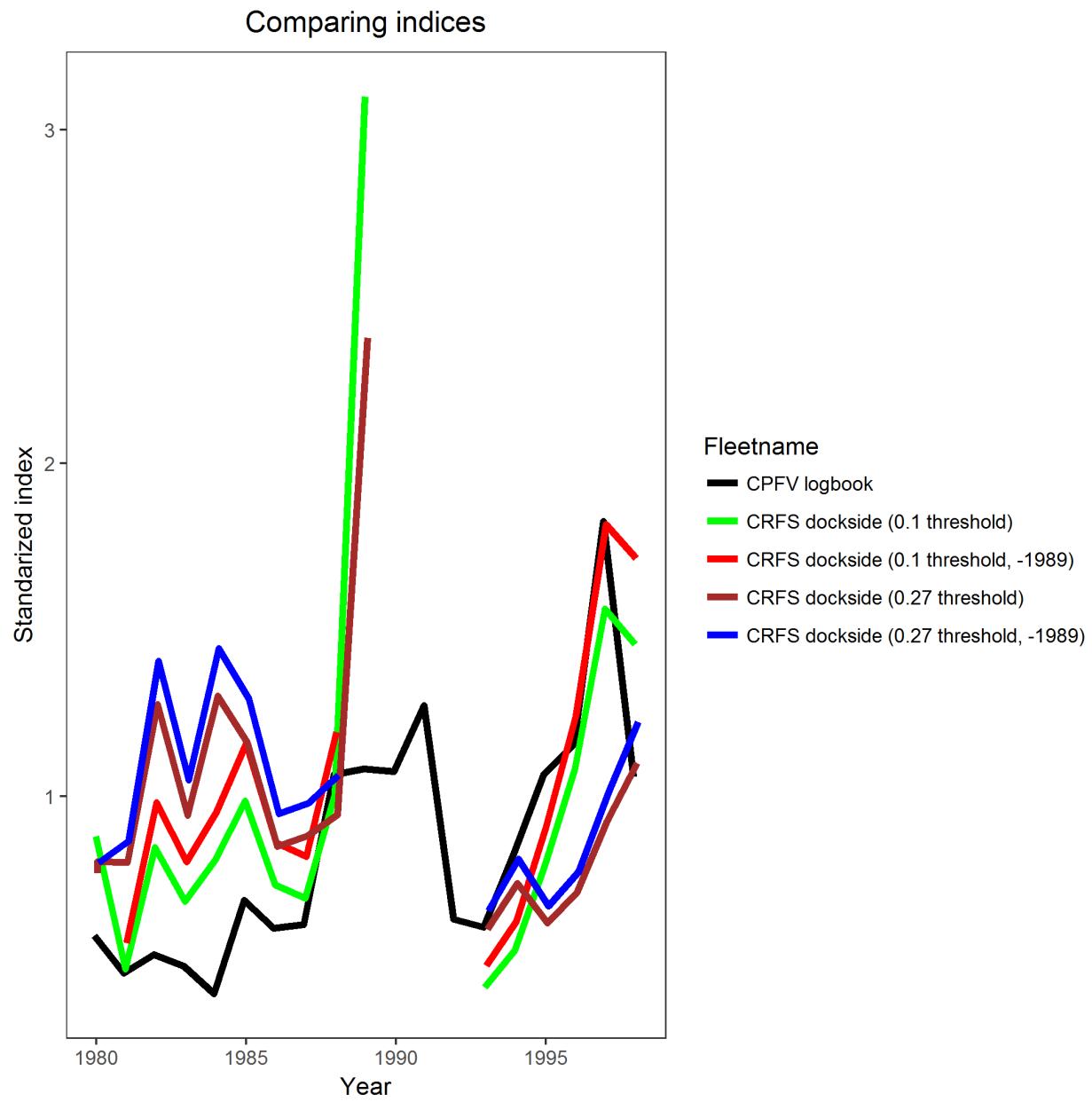


Figure 10: Comparison of standardized indices using two different threshold levels (0.27 and 0.1) from the Stephens-MacCall filtering, and including or excluding the year 1989.

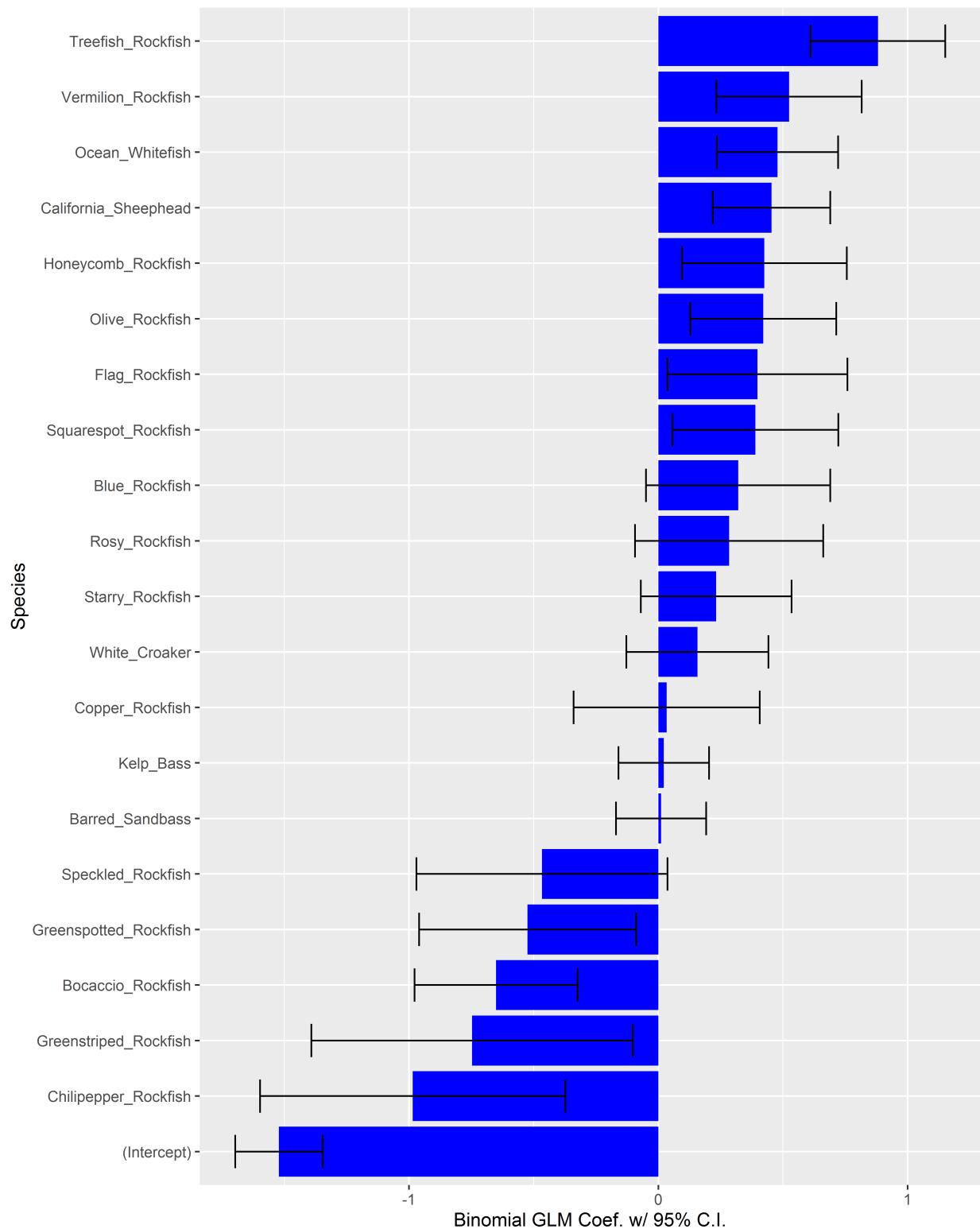


Figure 11: Species coefficients from the binomial GLM for presence/absence of California scorpionfish in the Marine Recreational Fisheries Statistics Survey (MRFSS) party/charter mode dockside survey data set. Horizontal bars are 95% confidence intervals.

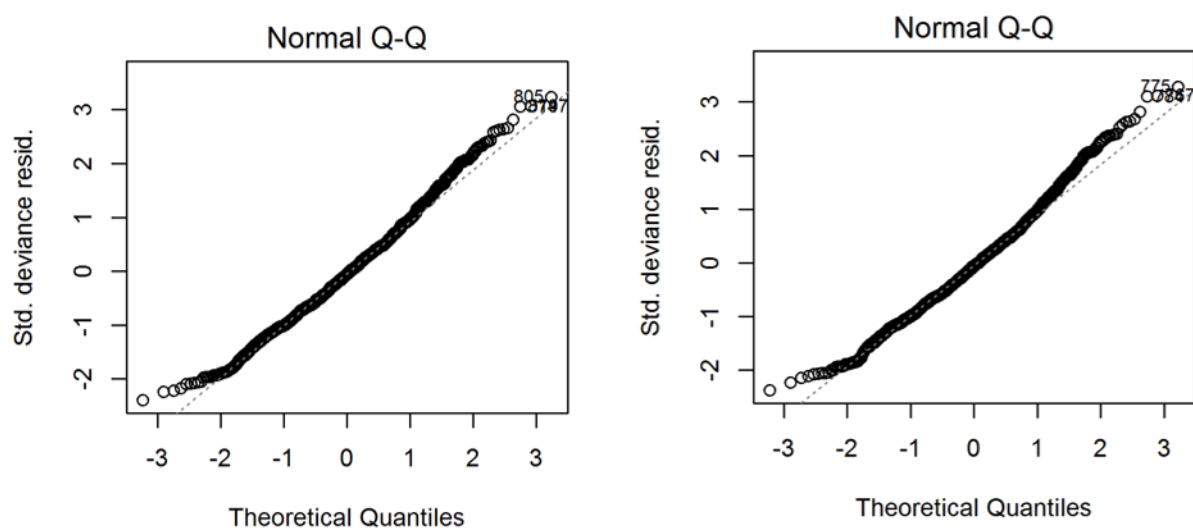


Figure 12: Q-Q plot used to validate the goodness of fit of the lognormal portion (positive catch) of the Marine Recreational Fisheries Statistics Survey (MRFSS) party/charter dockside survey, for thresholds of 0.27 (left) and 0.10 (right) from the Stephens-MacCall filter.

### Normal Q-Q Plot

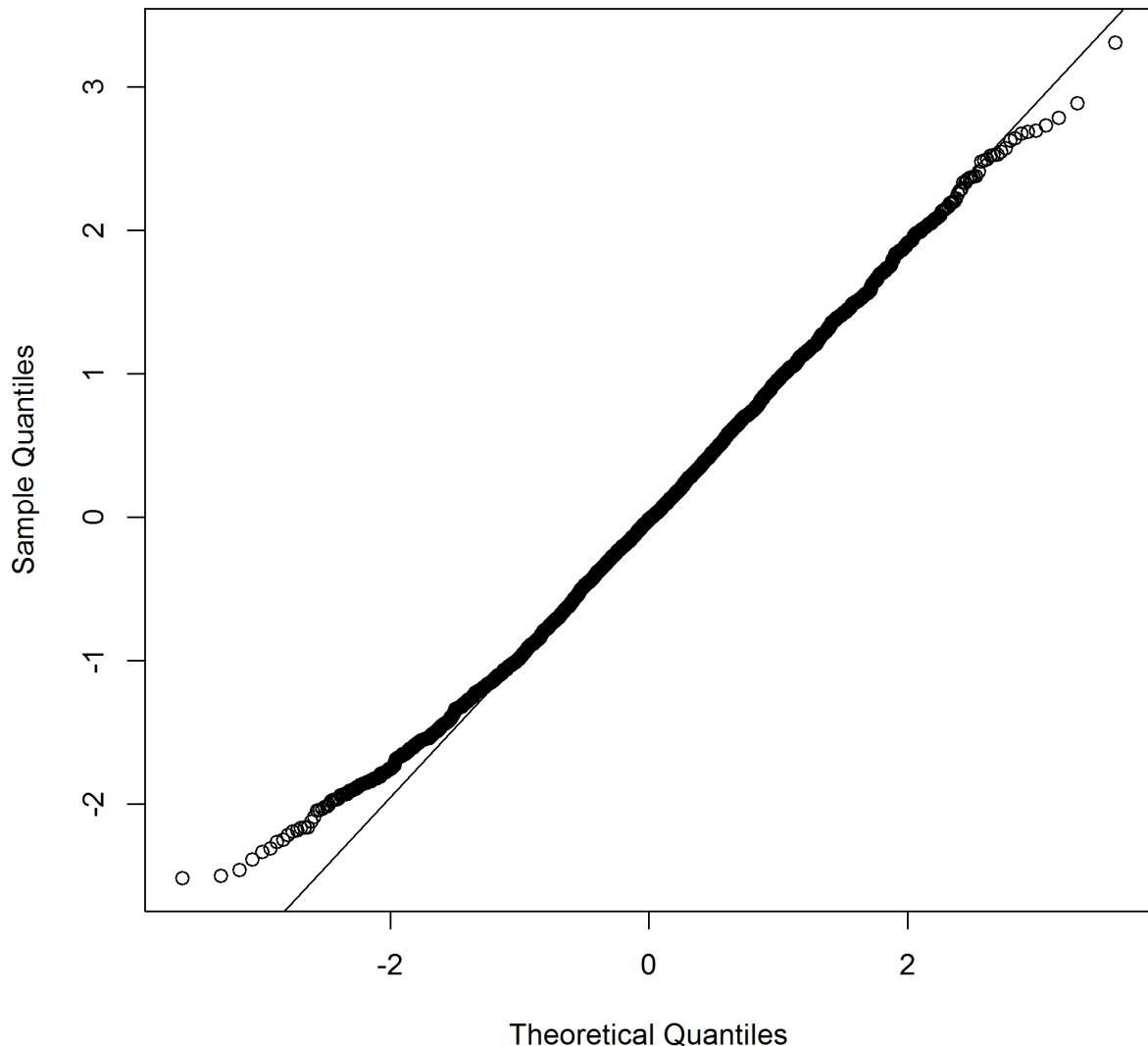


Figure 13: Q-Q plot used to validate the goodness of fit of the lognormal model for the CPFV onboard observer discarded only catch.

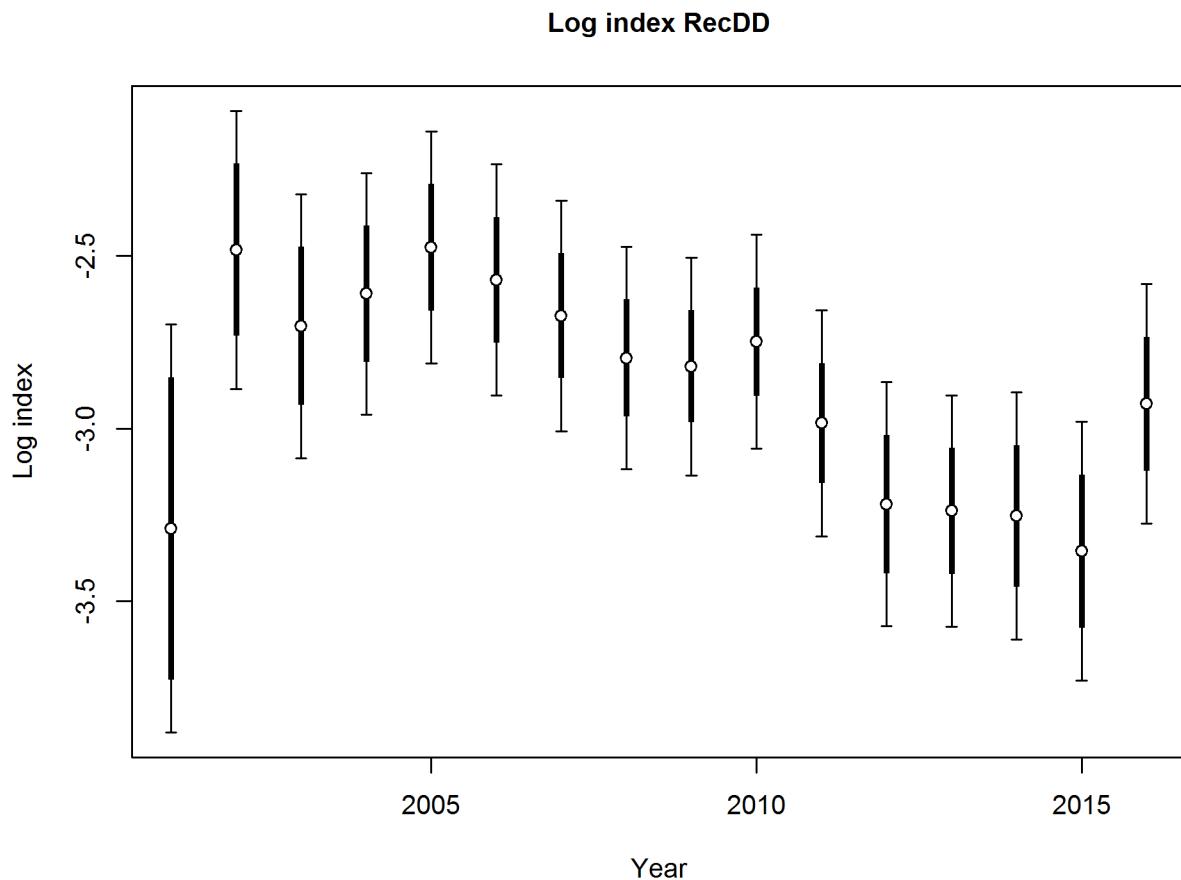


Figure 14: Standardized index on the log scale for the recreational CPFV onboard observer discarded catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

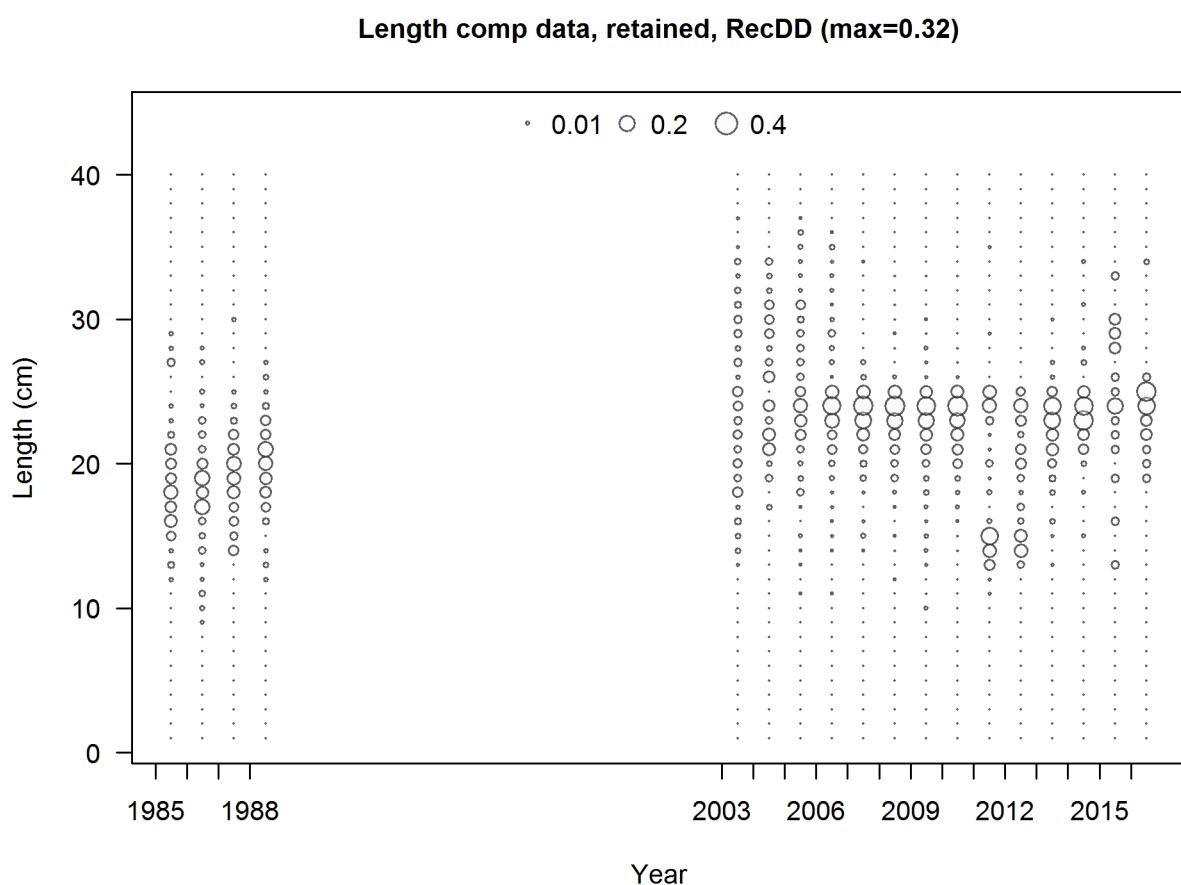


Figure 15: Length frequency distributions from the onboard observer discard-only catch.

### Normal Q-Q Plot

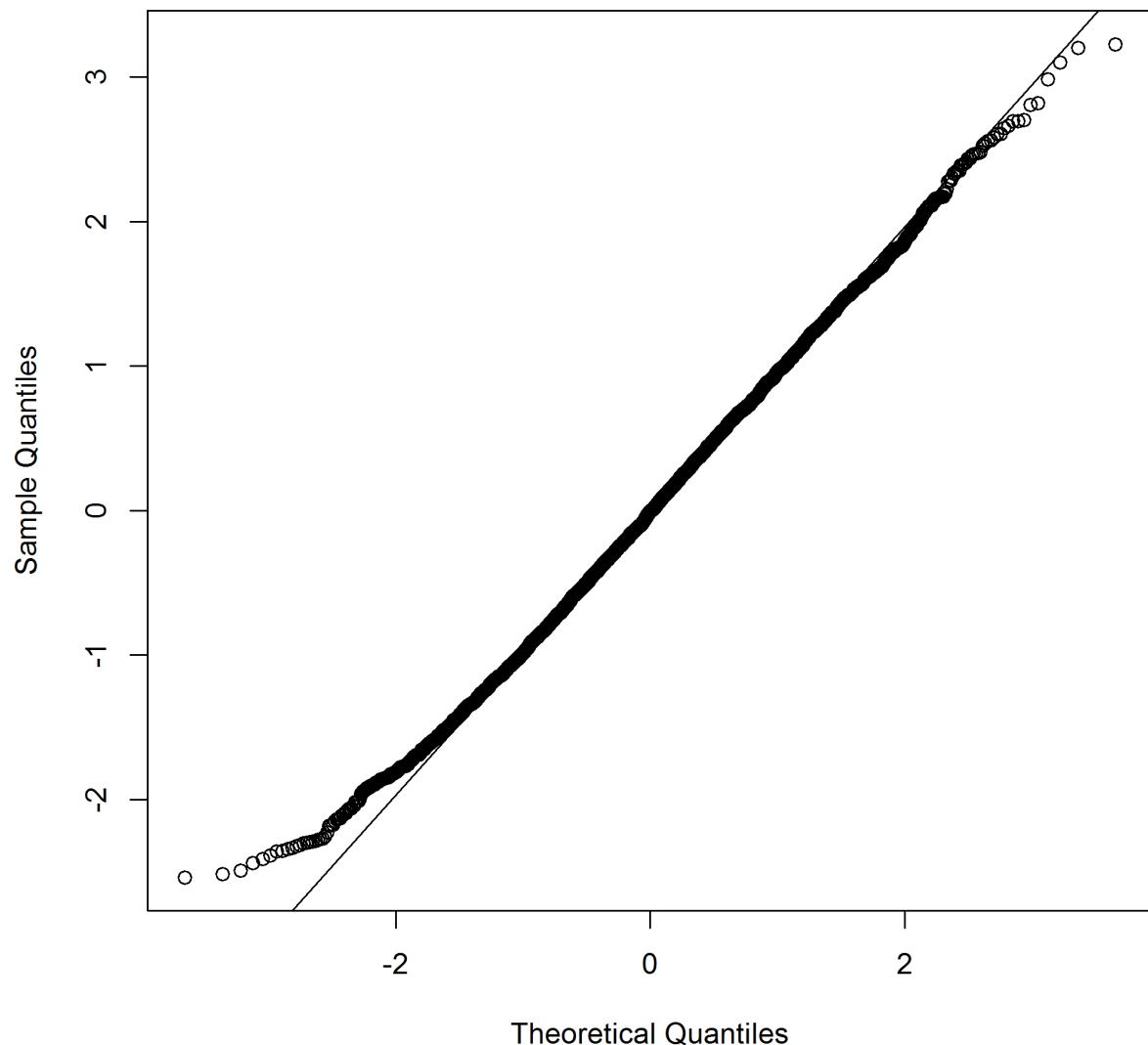


Figure 16: Q-Q plot used to validate the goodness of fit of the lognormal model for the CPFV onboard observer retained only catch.

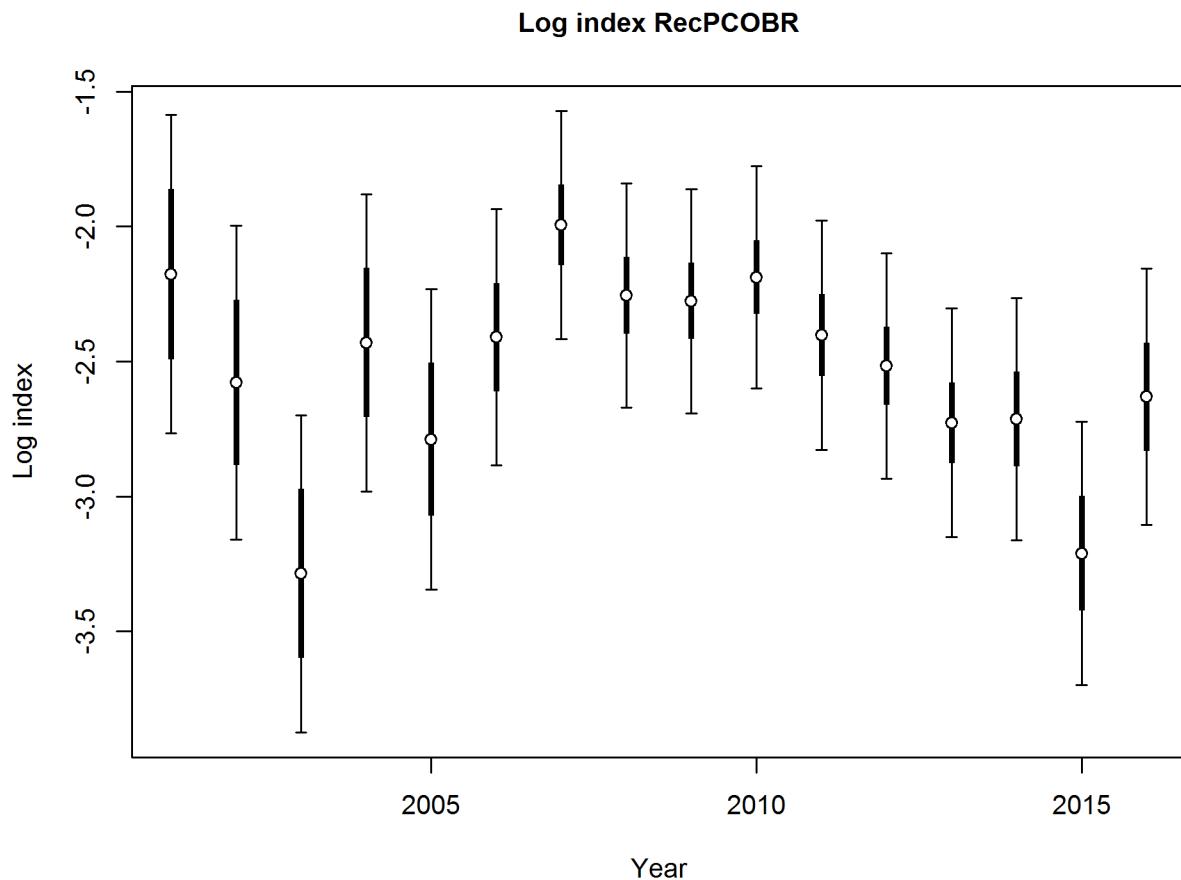


Figure 17: Standardized index on the log scale for the recreational CPFV onboard observer retained catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

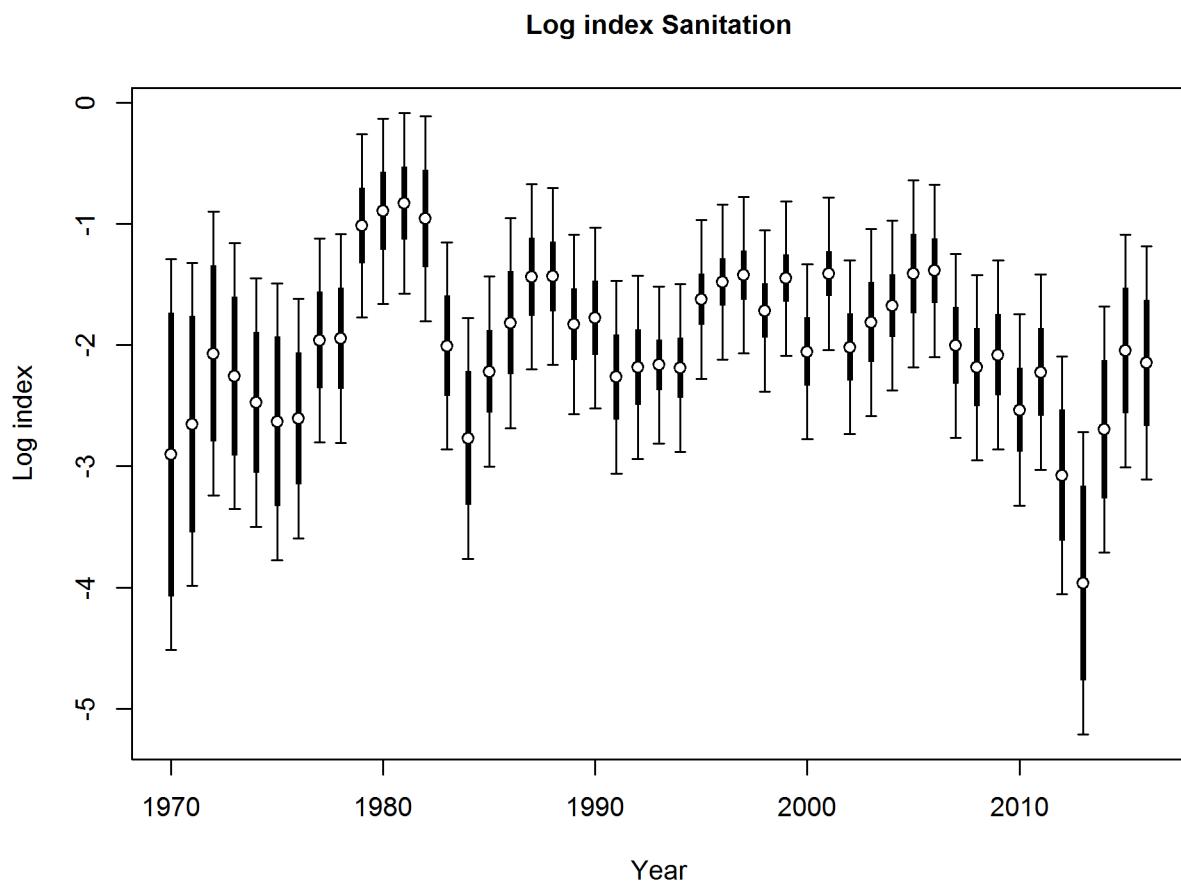


Figure 18: Standardized index on log scale for the sanitation district trawl index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

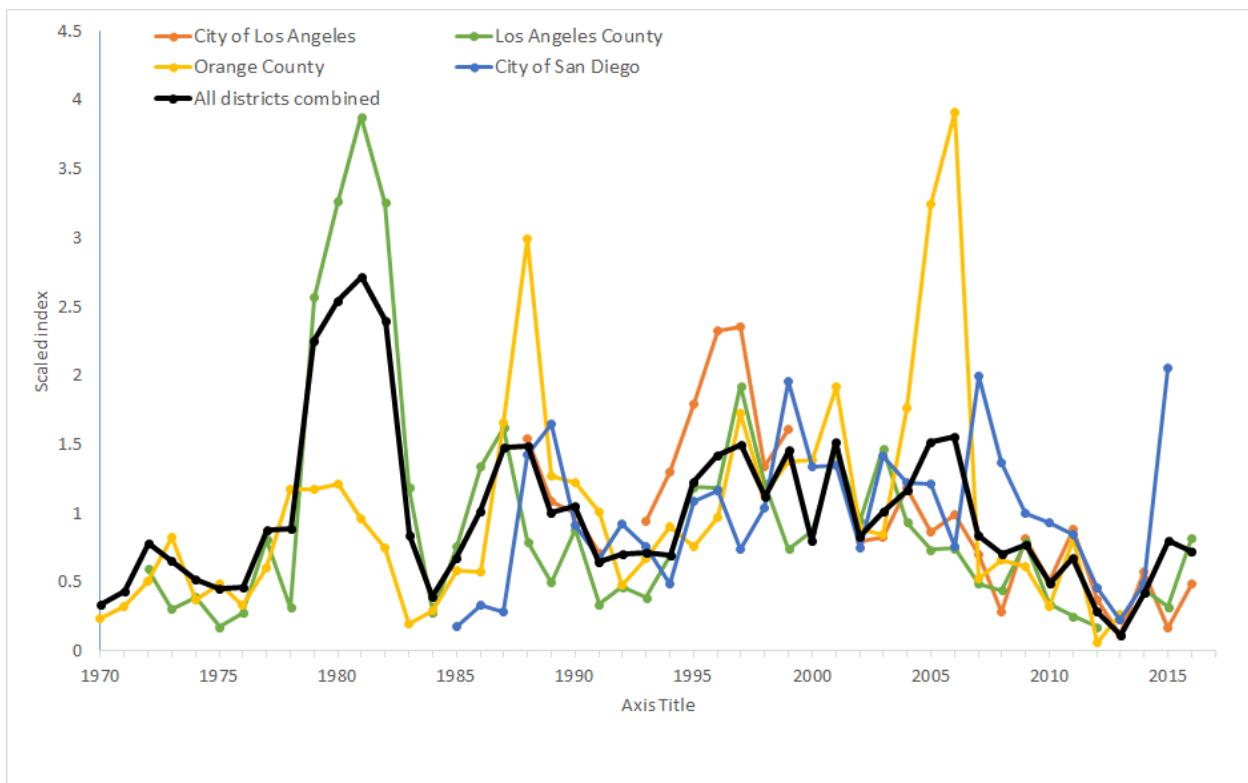


Figure 19: Comparison of standardized indices for each sanitation district independently and with data from all sanitation districts combined.

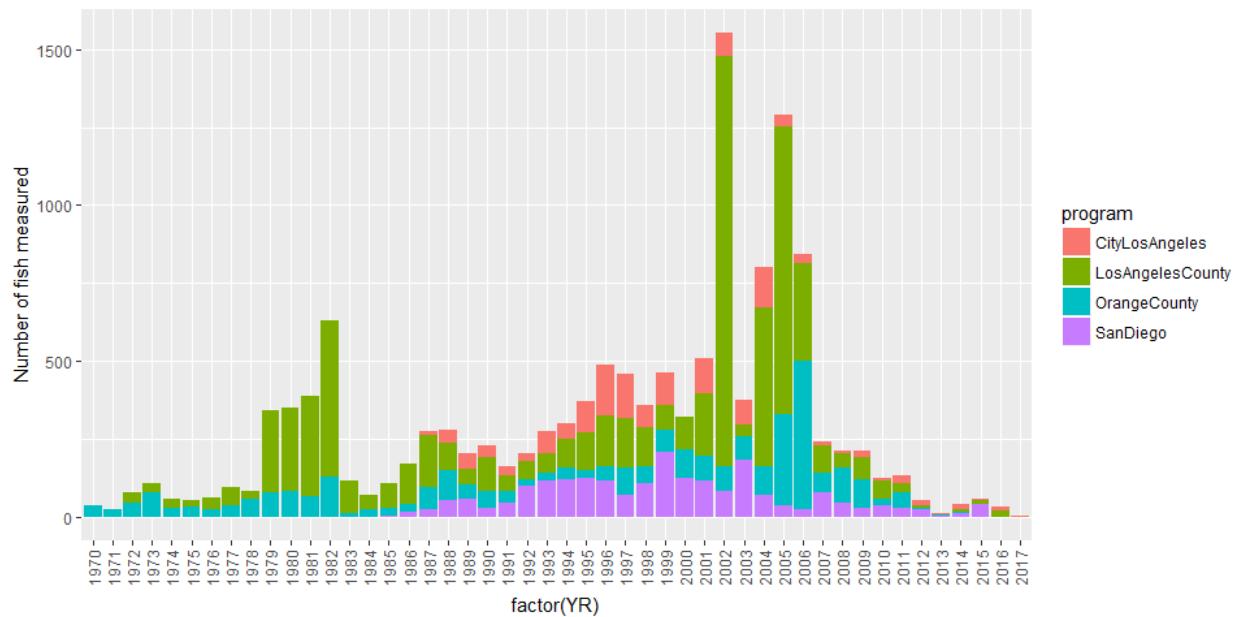


Figure 20: Sample sizes of measured California scorpionfish by sanitation district and year.

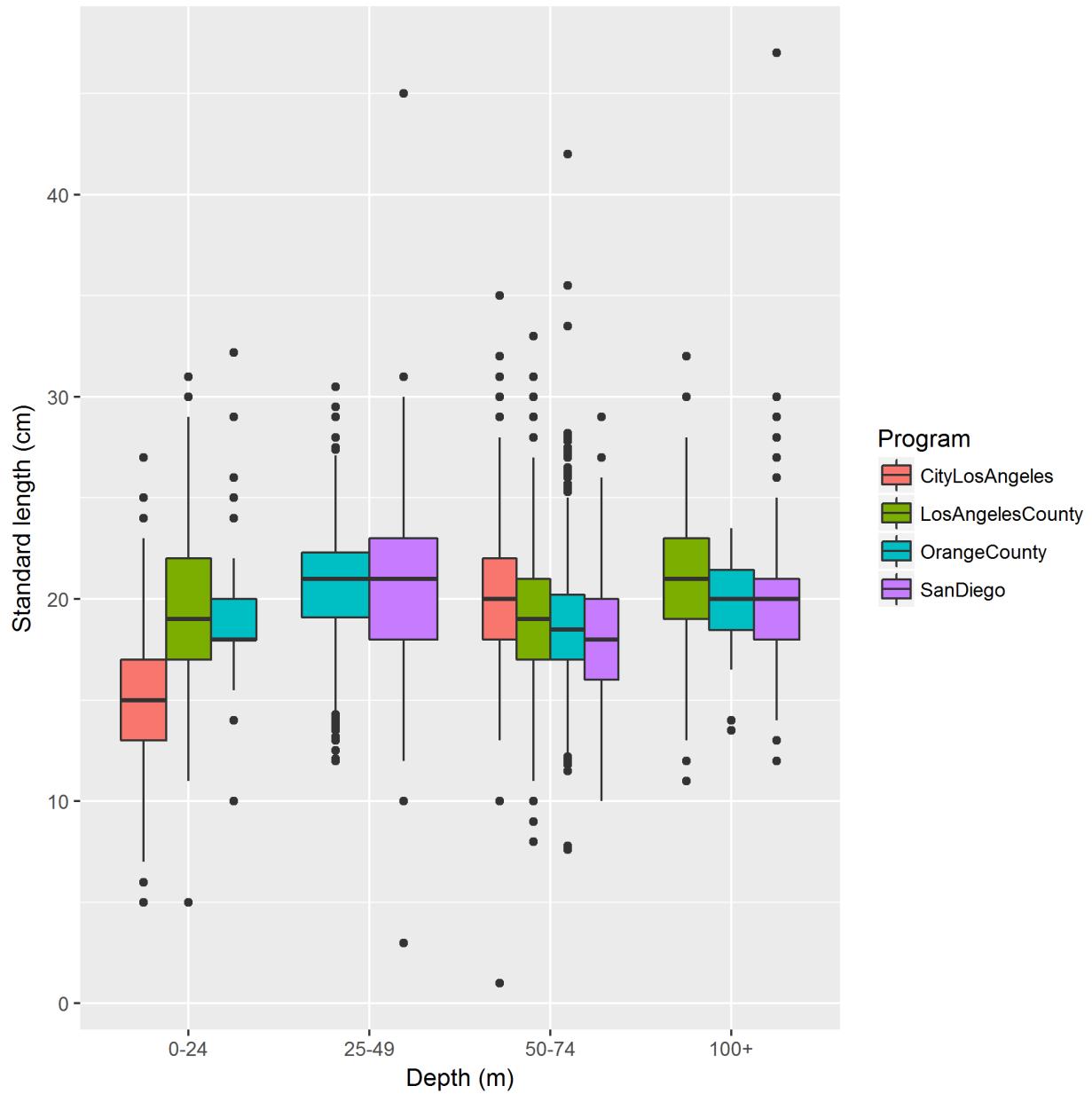


Figure 21: Boxplots of measured California scorpionfish from the sanitation district surveys by program and 25 m depth bins.

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

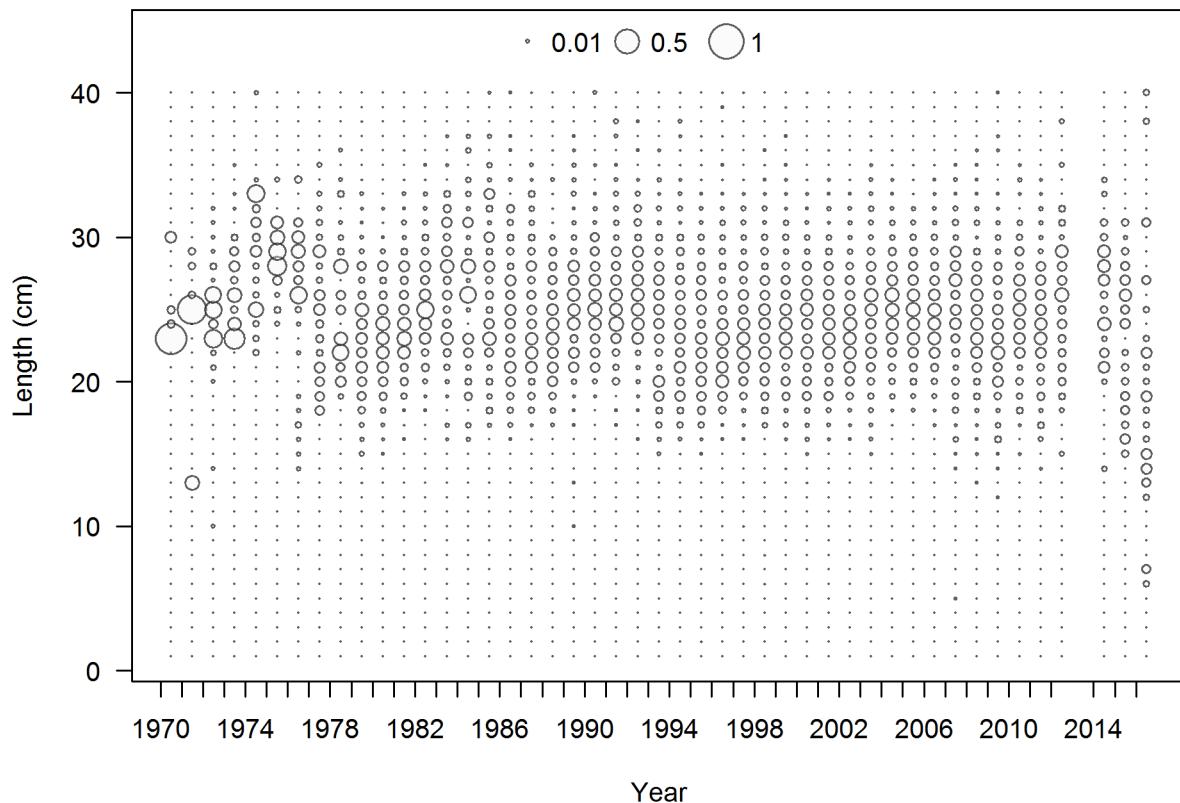


Figure 22: Length frequency distributions from the sanitation districts trawl surveys.

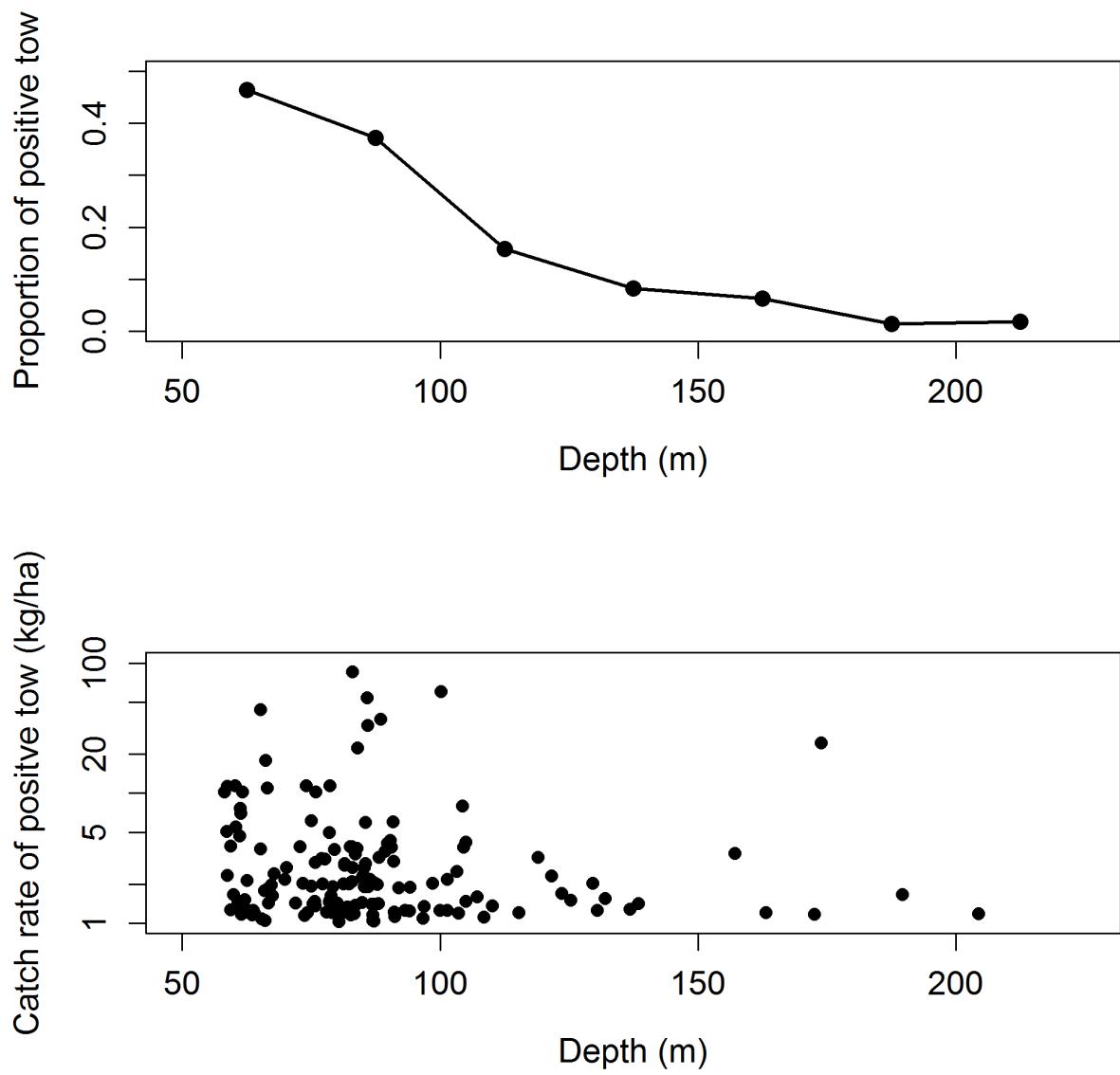


Figure 23: Plots of the proportion of positive tows (top panel) and the raw catch rates of positive tows (bottom panel) by depth zones (25 m interval) for NWFSC trawl survey.

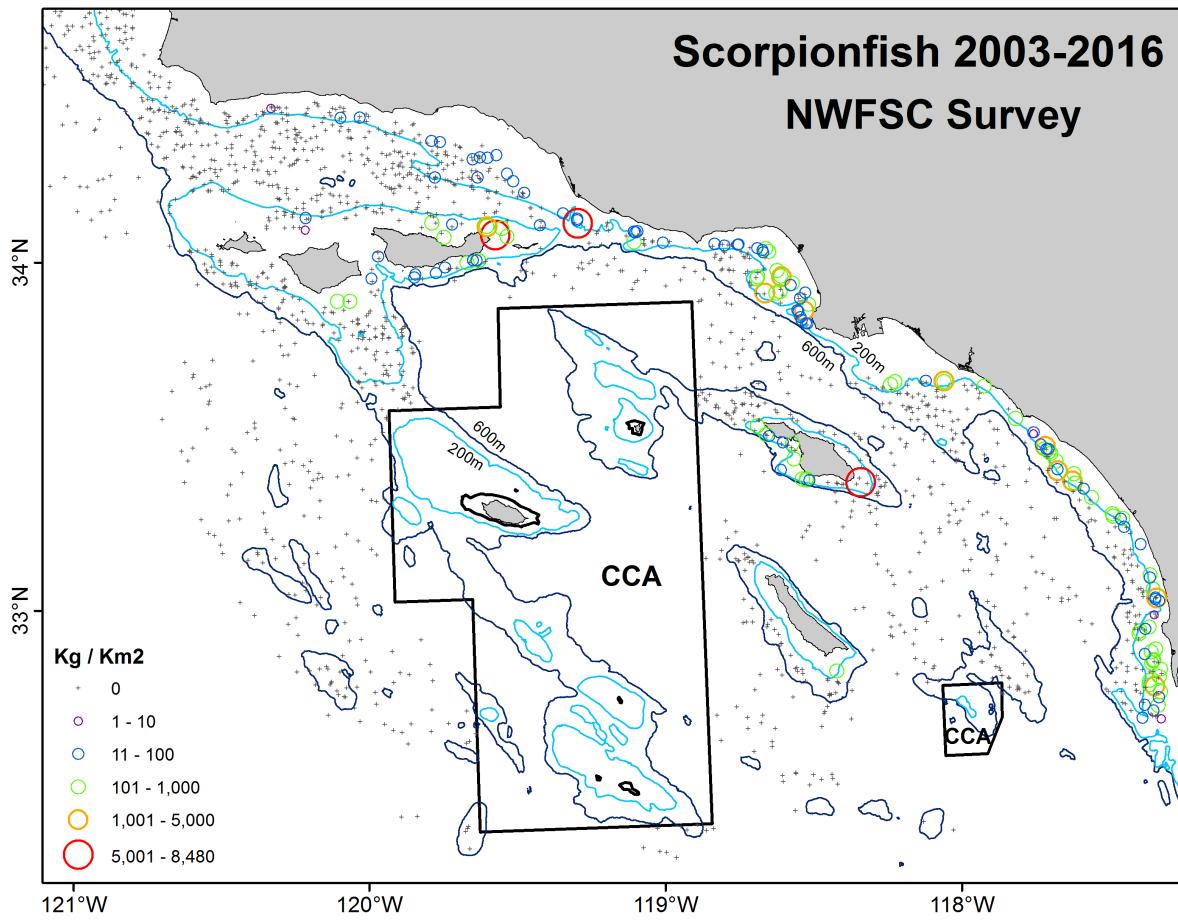


Figure 24: Spatial distribution of raw catch rates of Scorpionfish from NWFSC trawl survey between 2003 and 2016. Depth contour lines of 200m and 600m and the CCA areas are shown. Note that sizes and colors of circles represent catch rate in log scales (Credit of Rebecca Miller, SWFSC).

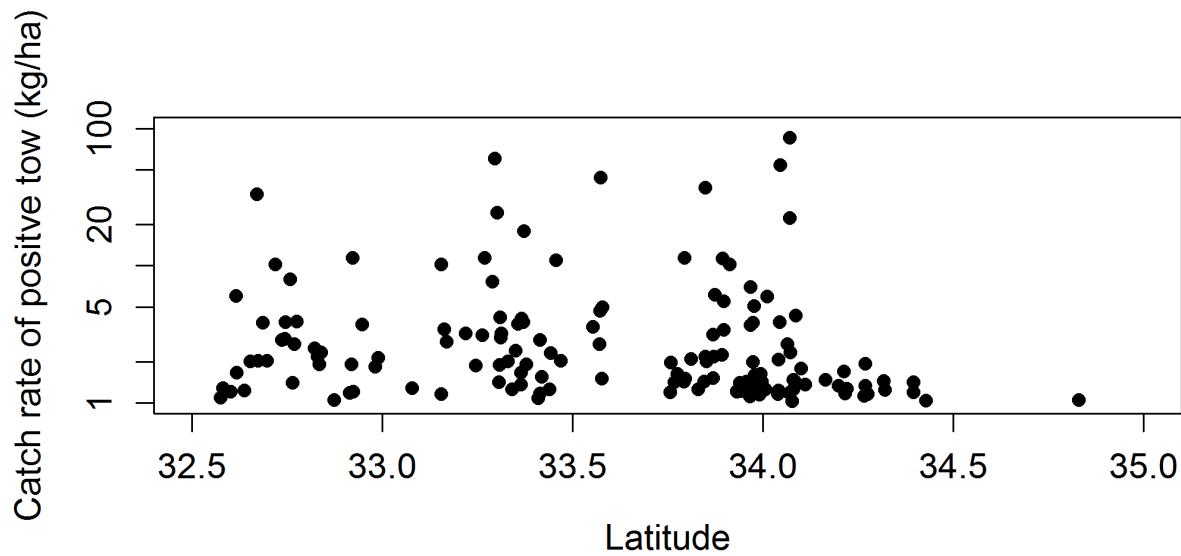
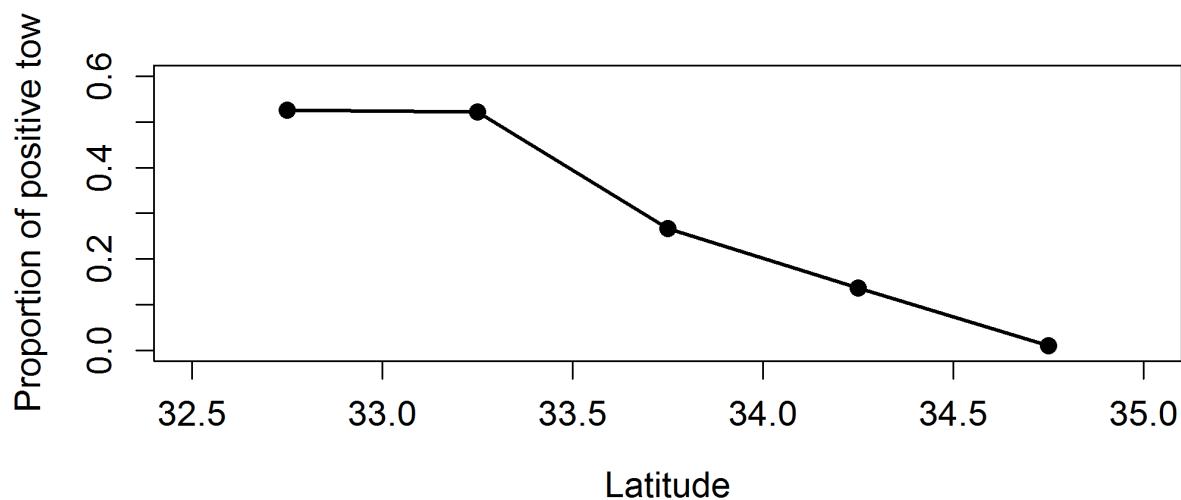


Figure 25: Plots of the proportion of positive tows (top panel) and the raw catch rates of positive tows (bottom panel) by latitude zones (0.5 degree interval) for NWFSC trawl survey.

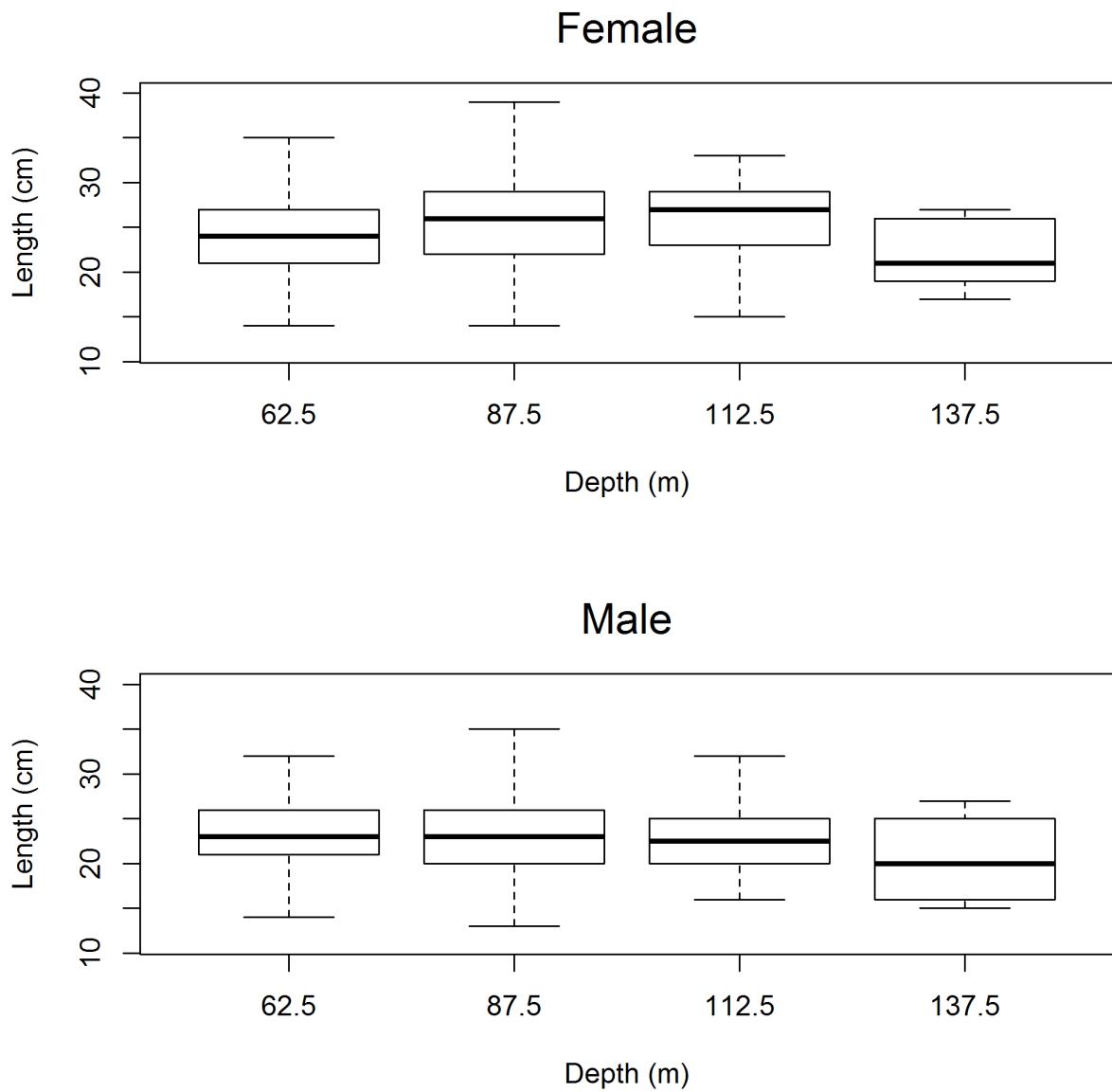


Figure 26: Comparison box plots of raw length data from NWFSC trawl survey by depth zone and sex.

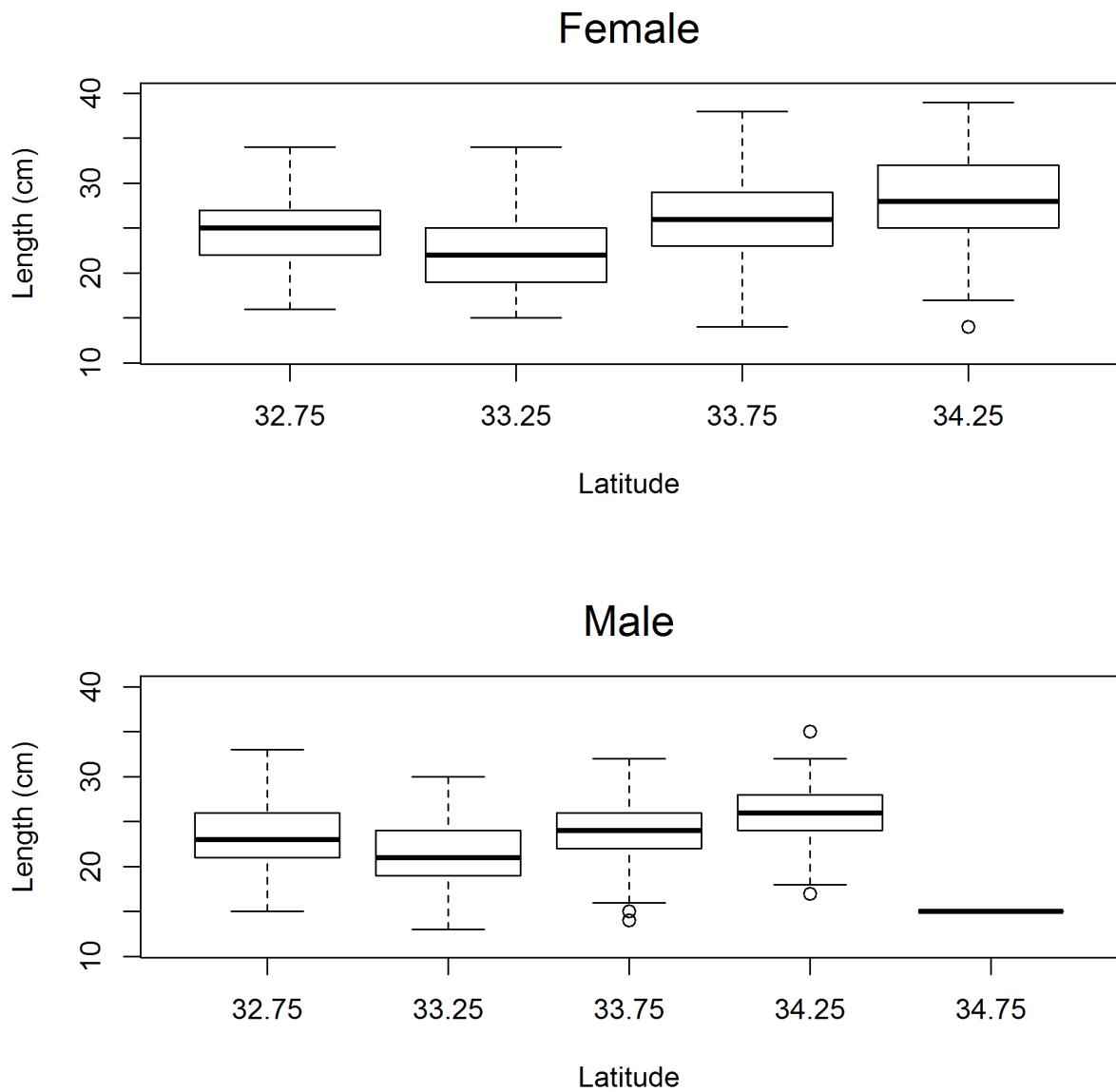


Figure 27: Comparison box plots of raw length data from NWFSC trawl survey by latitude zone and sex.

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

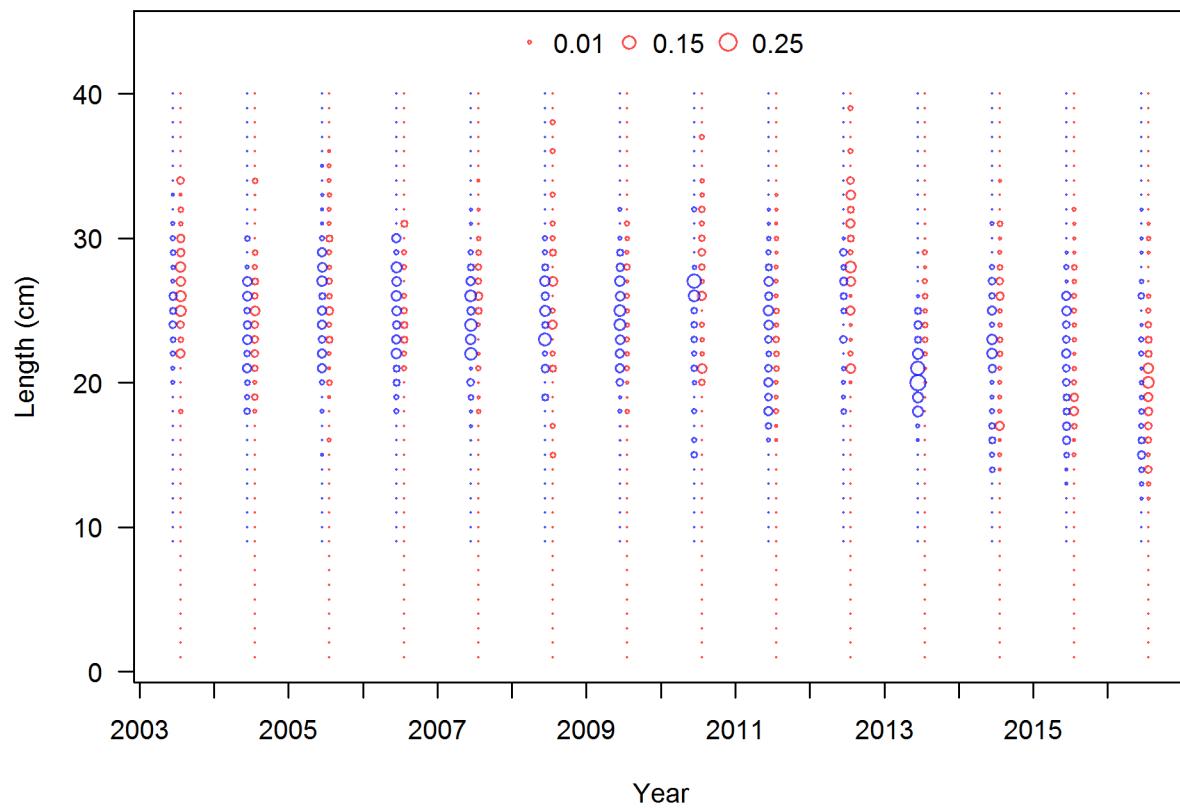


Figure 28: Length frequency distributions of females (red) and male (blue) from the NWFSC trawl survey between 2003 and 2016.

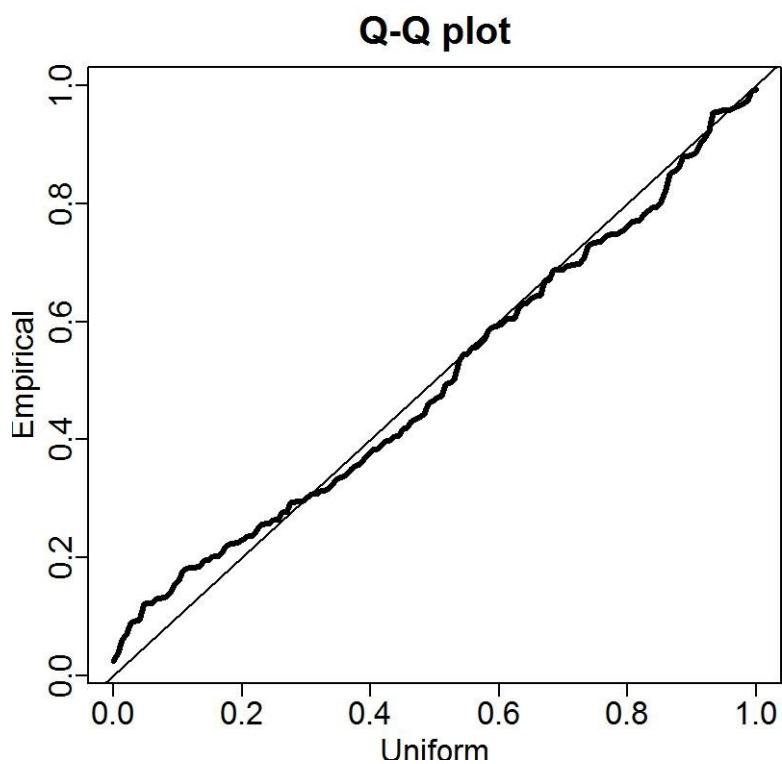


Figure 29: Q-Q plot used to validate the goodness of fit of the VAST analysis for the NWFSC trawl survey between 2003 and 2016.

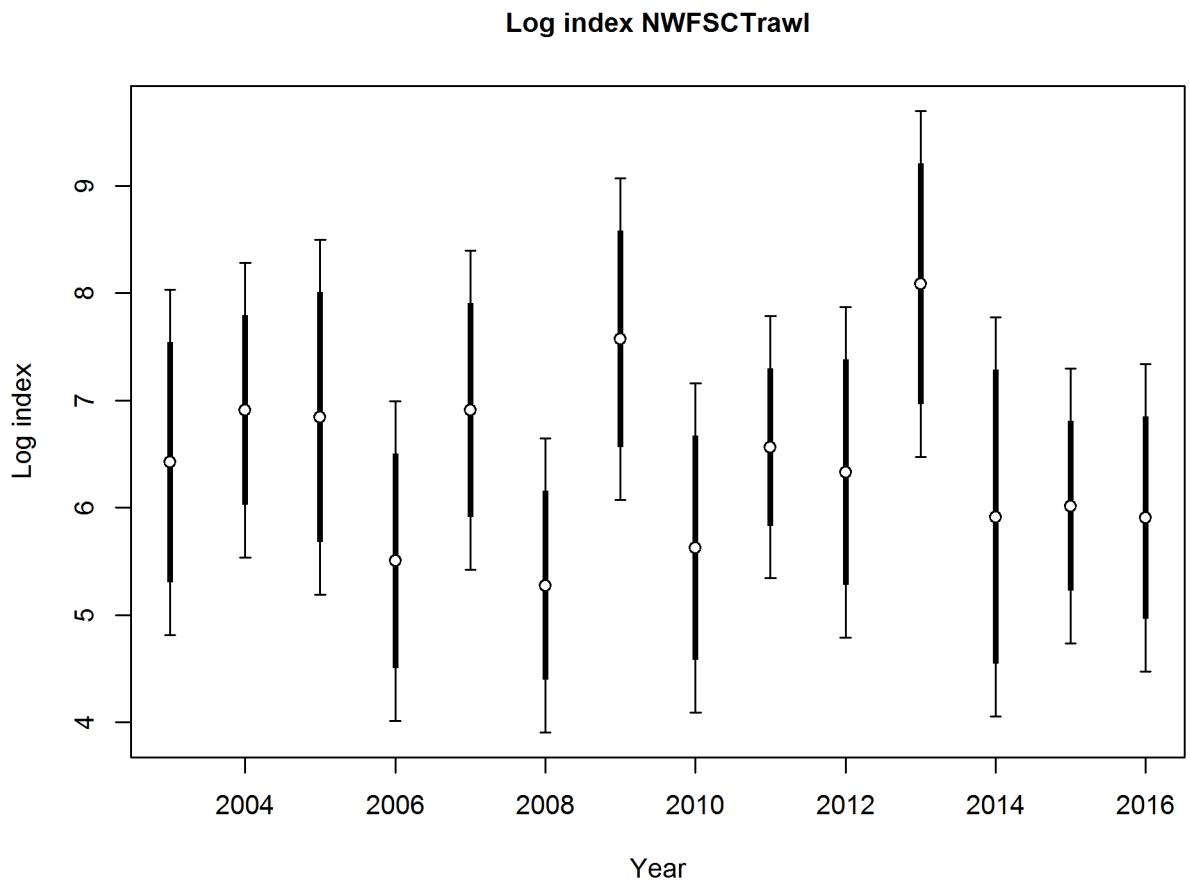


Figure 30: Standardized index on the log scale for the NWFSC trawl survey from the VAST analysis from 2003-2016. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

### Normal Q-Q Plot

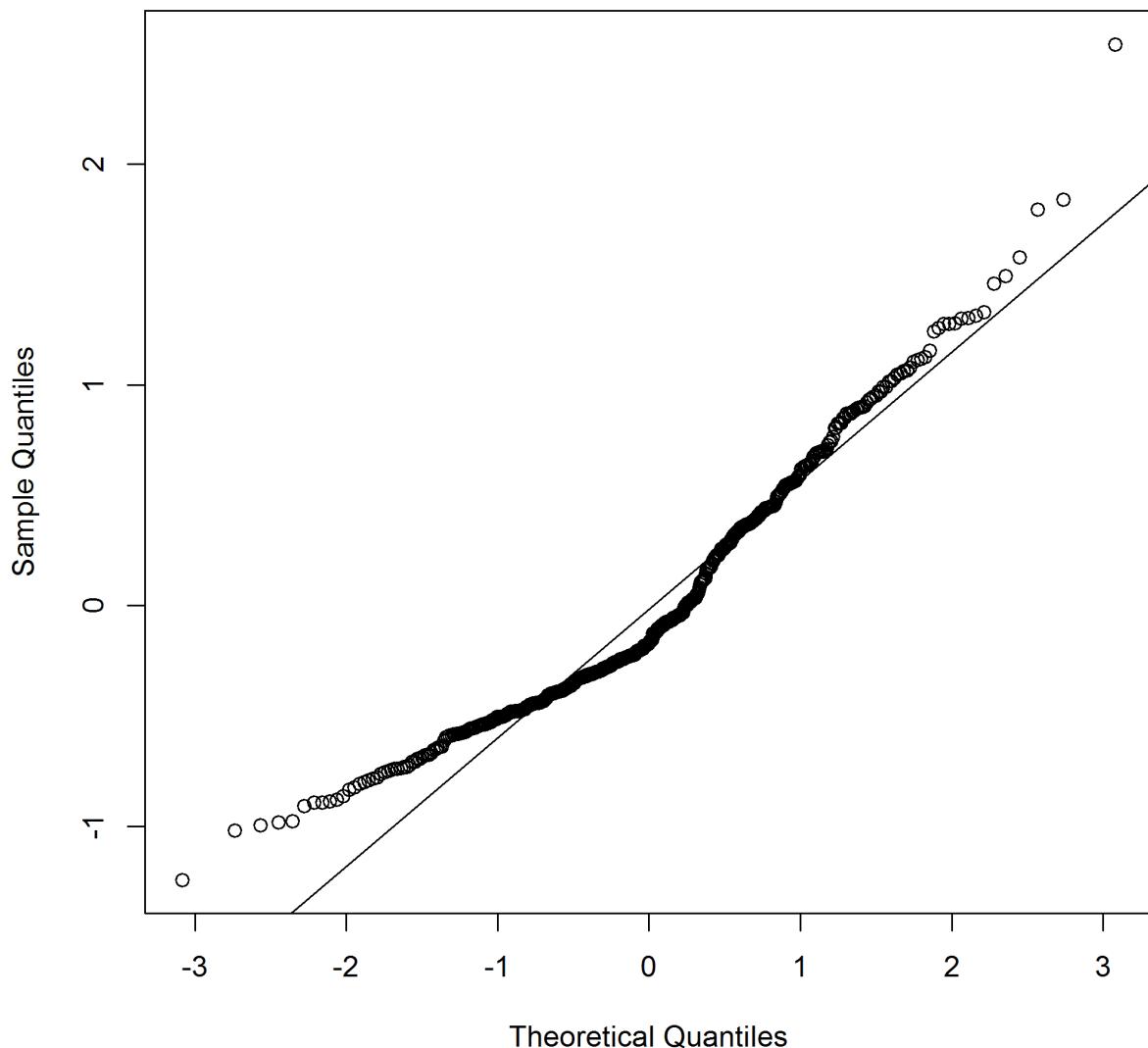


Figure 31: Q-Q plot used to validate the goodness of fit of the lognormal model for the CSUN/VRG gillnet survey from 1995-2008.

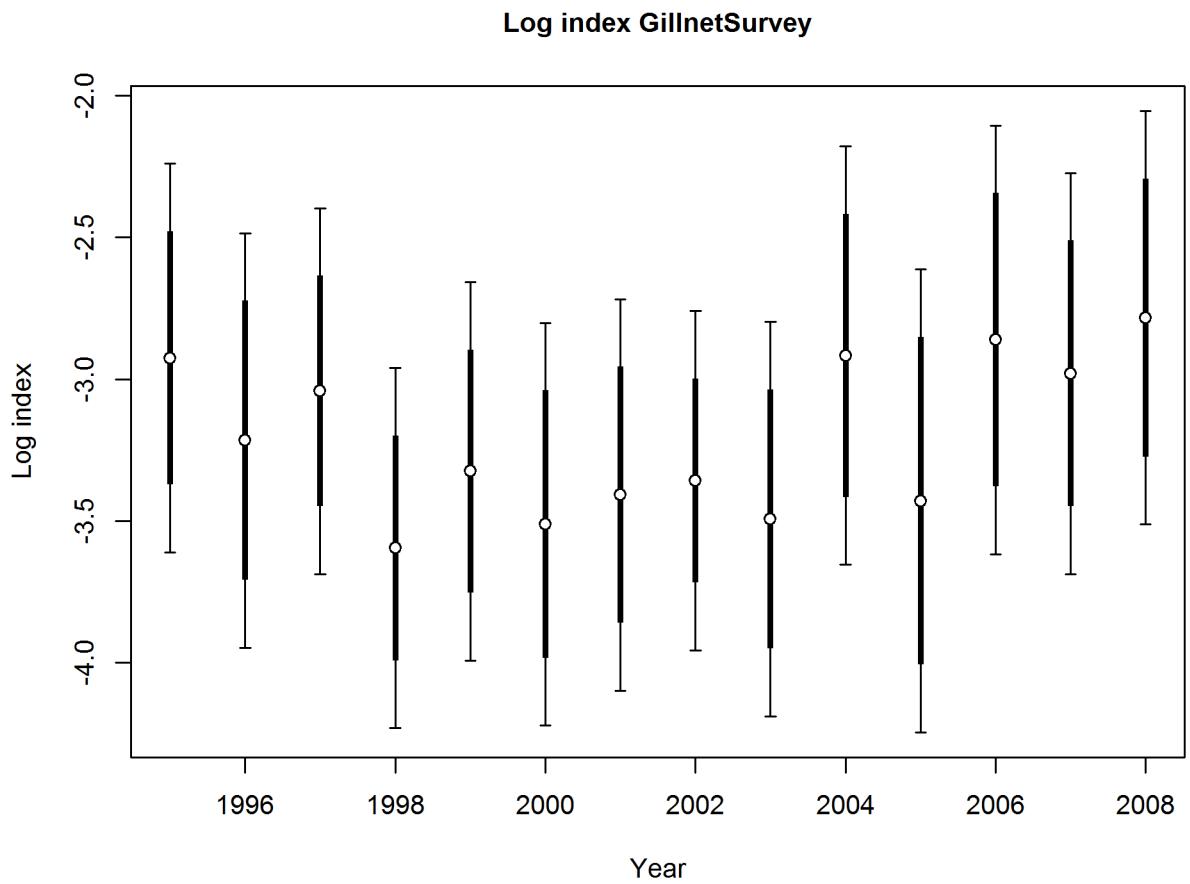


Figure 32: Standardized index on the log scale for the recreational CSUN/VRG gillnet survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

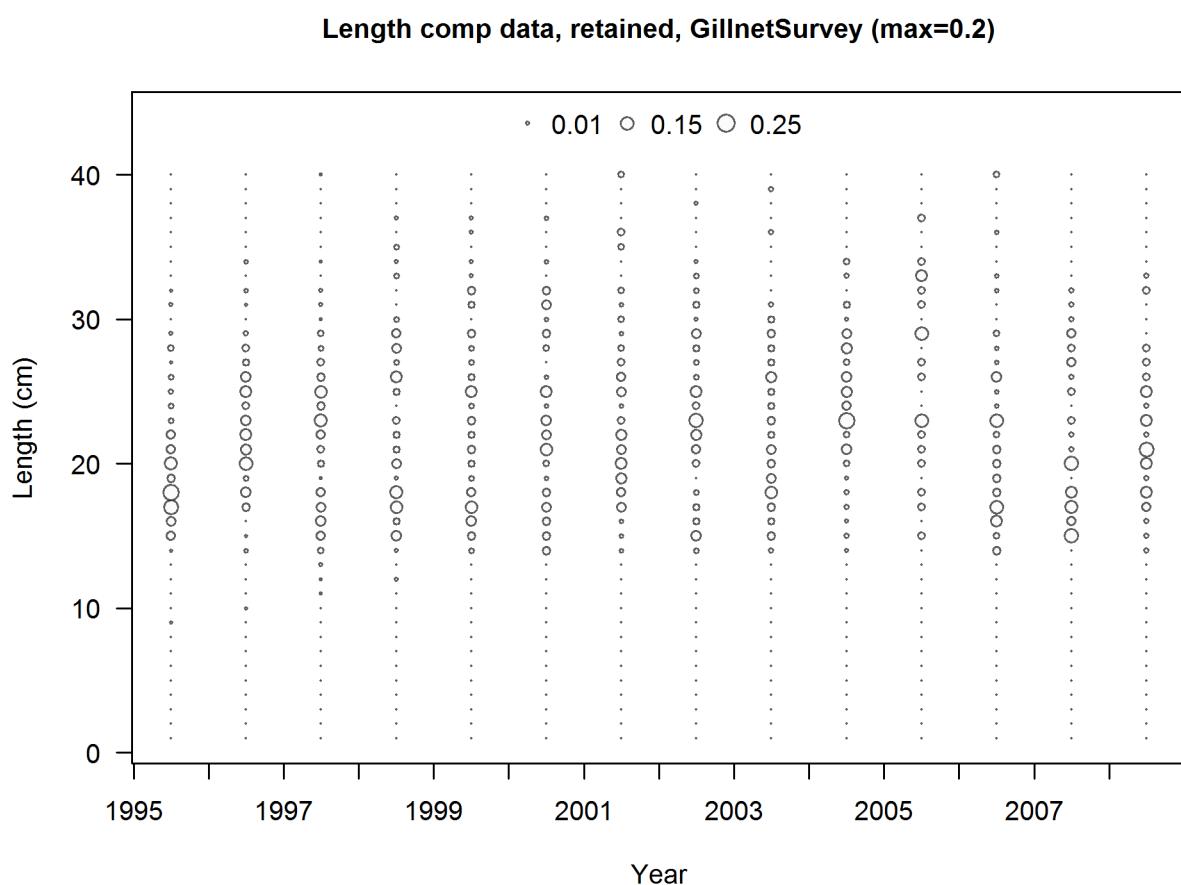


Figure 33: Length frequency distributions from the gill net surveys.

### Normal Q-Q Plot

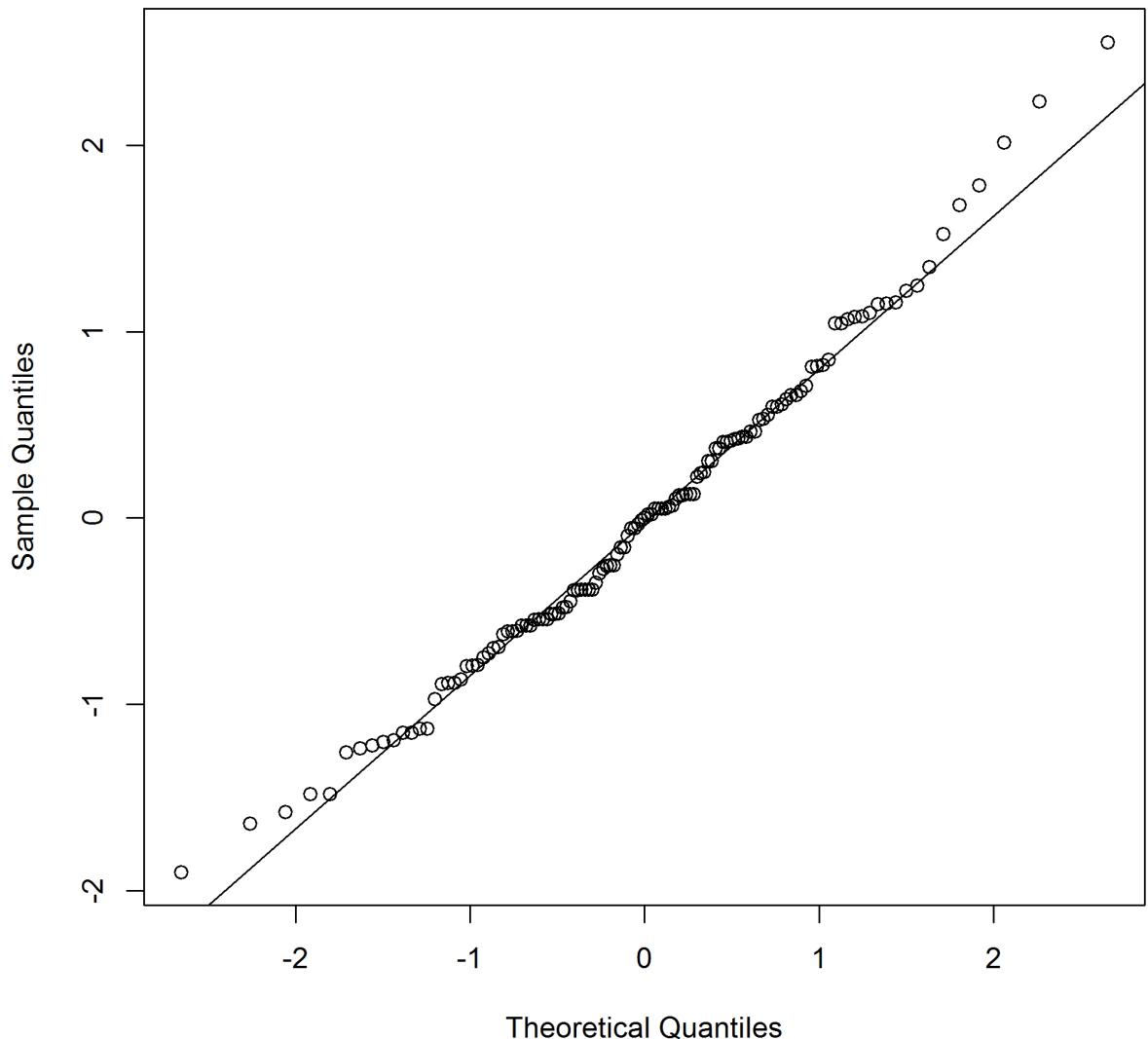


Figure 34: Q-Q plot used to validate the goodness of fit of the lognormal model for the Southern California Bight monitoring program trawl survey.

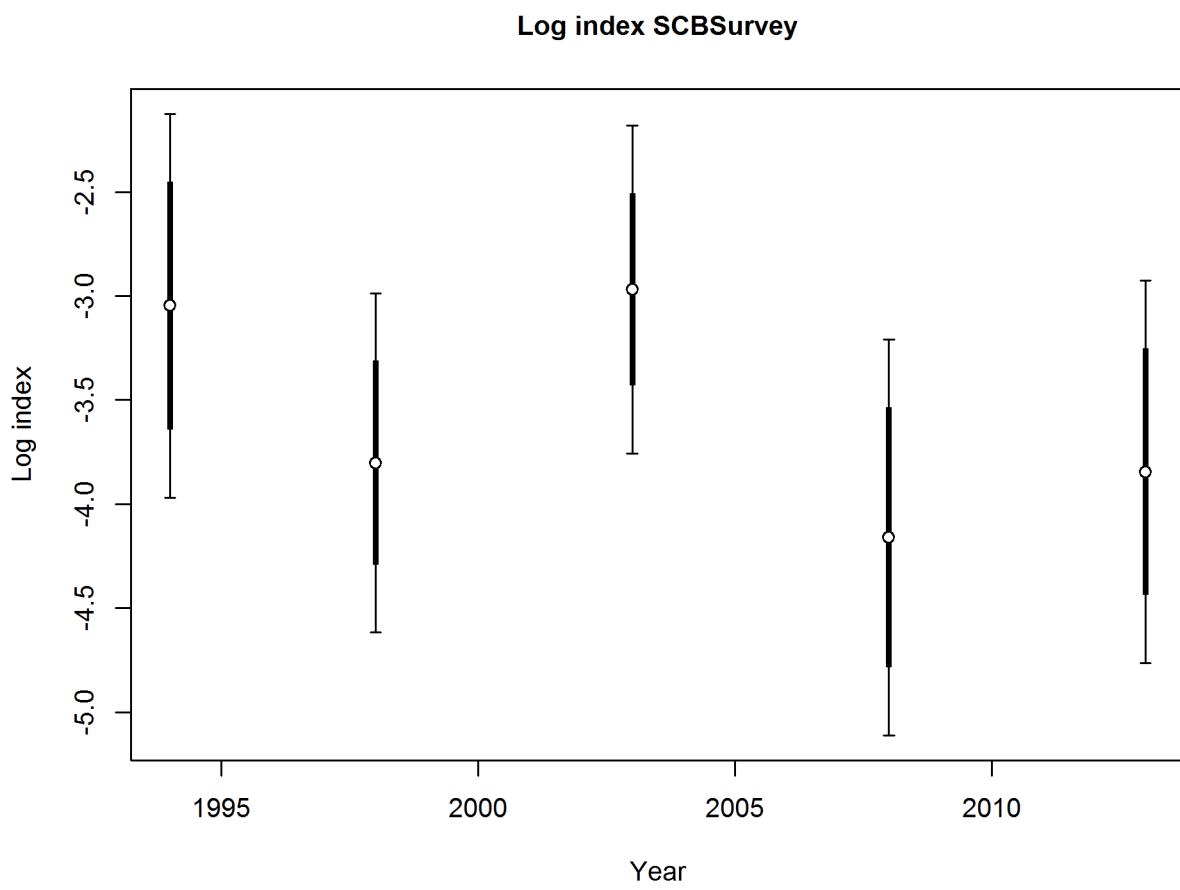


Figure 35: Standardized index on the log scale for the recreational Southern California Bight trawl survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

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

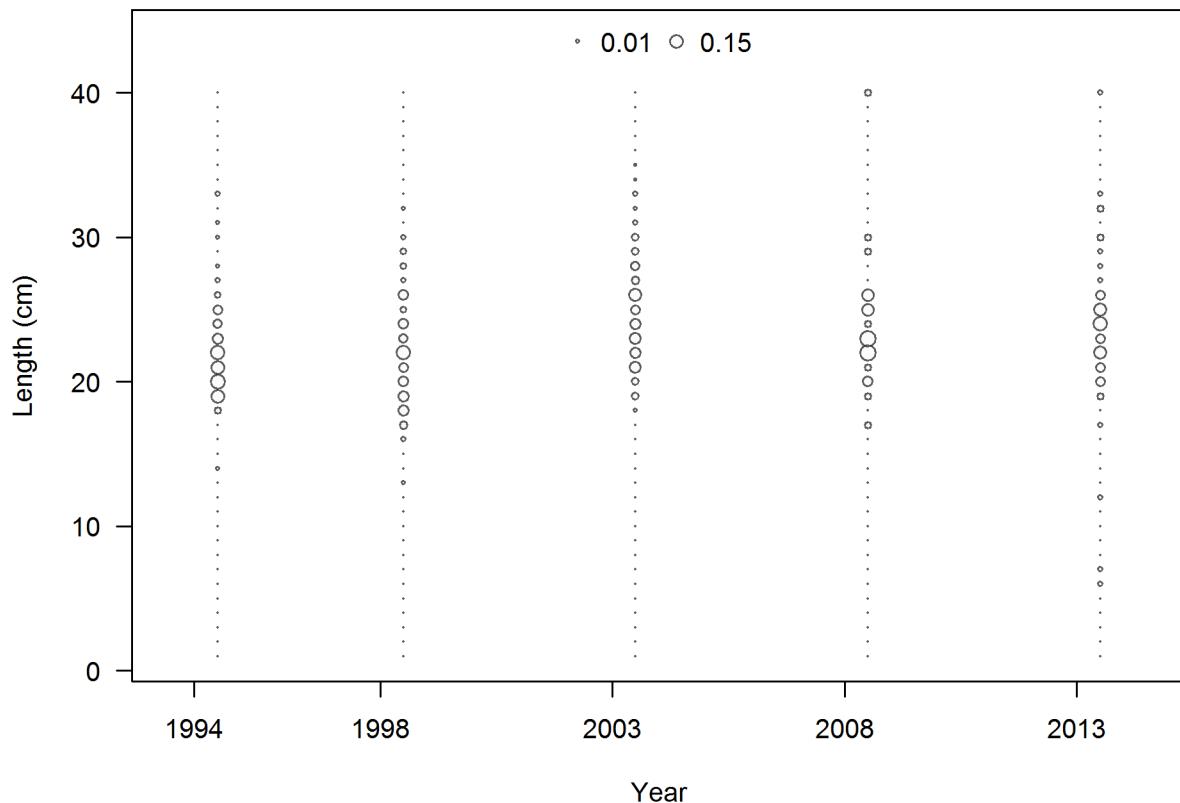


Figure 36: Length frequency distributions from the Southern California Bight regional monitoring program trawl surveys.

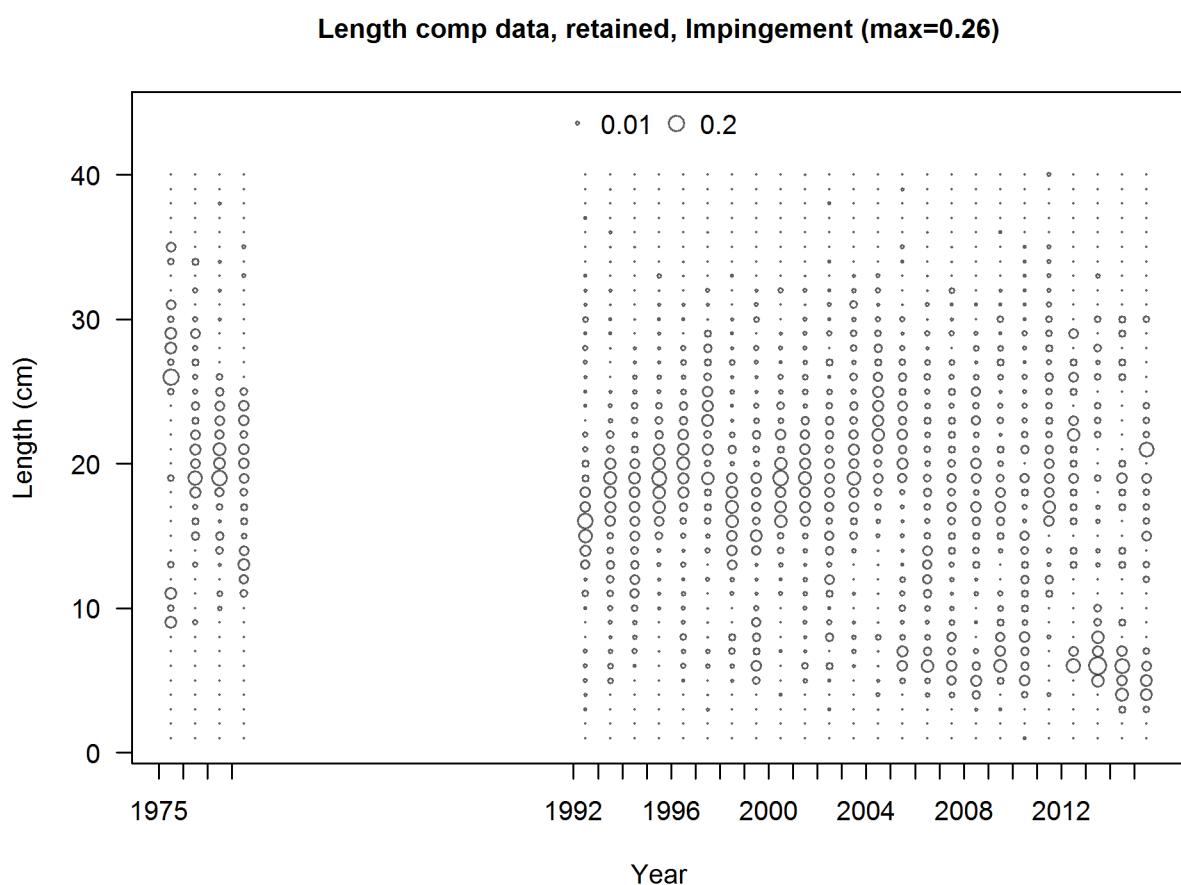


Figure 37: Length frequency distributions from the Impingement surveys.

### Length comp data, aggregated across time by fleet

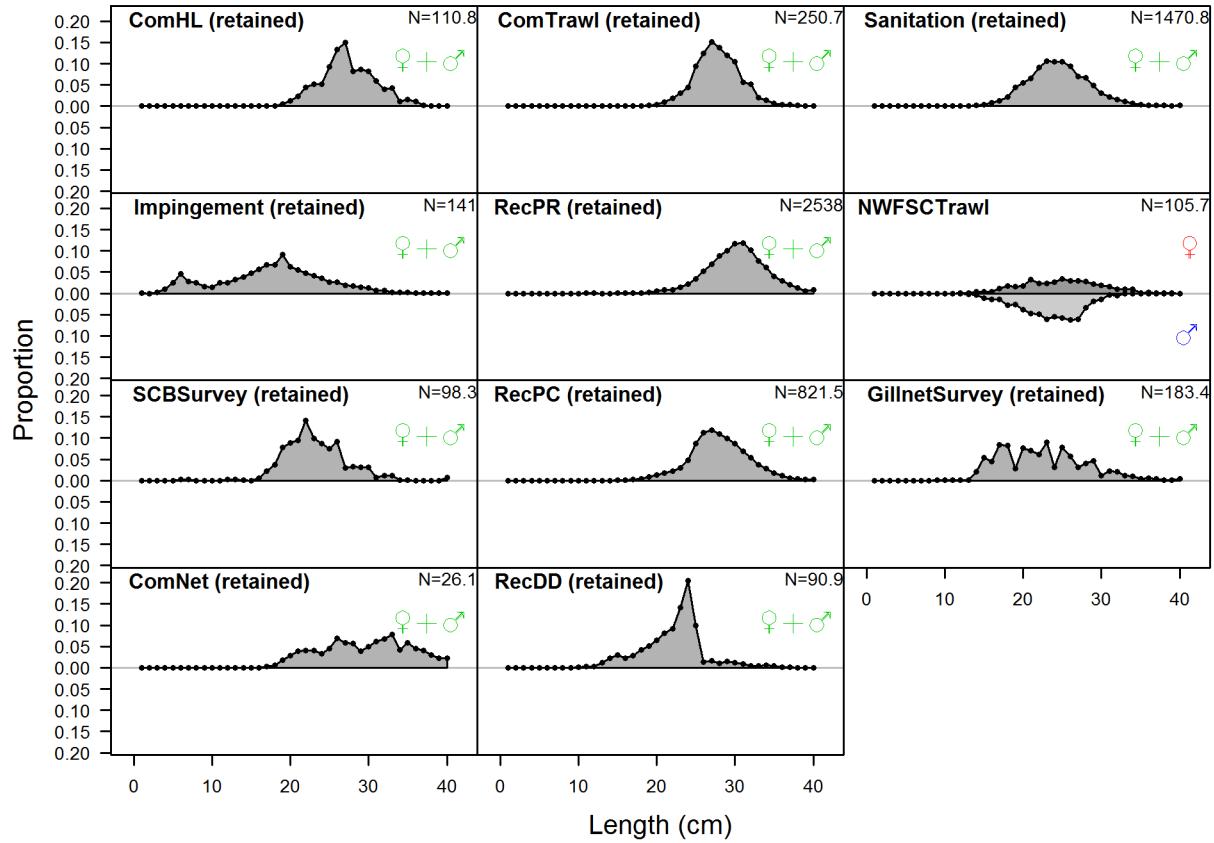


Figure 38: Length comp data, aggregated across time by fleet. Labels ‘retained’ and ‘discard’ indicate discarded or retained sampled for each fleet. Panels without this designation represent the whole catch.

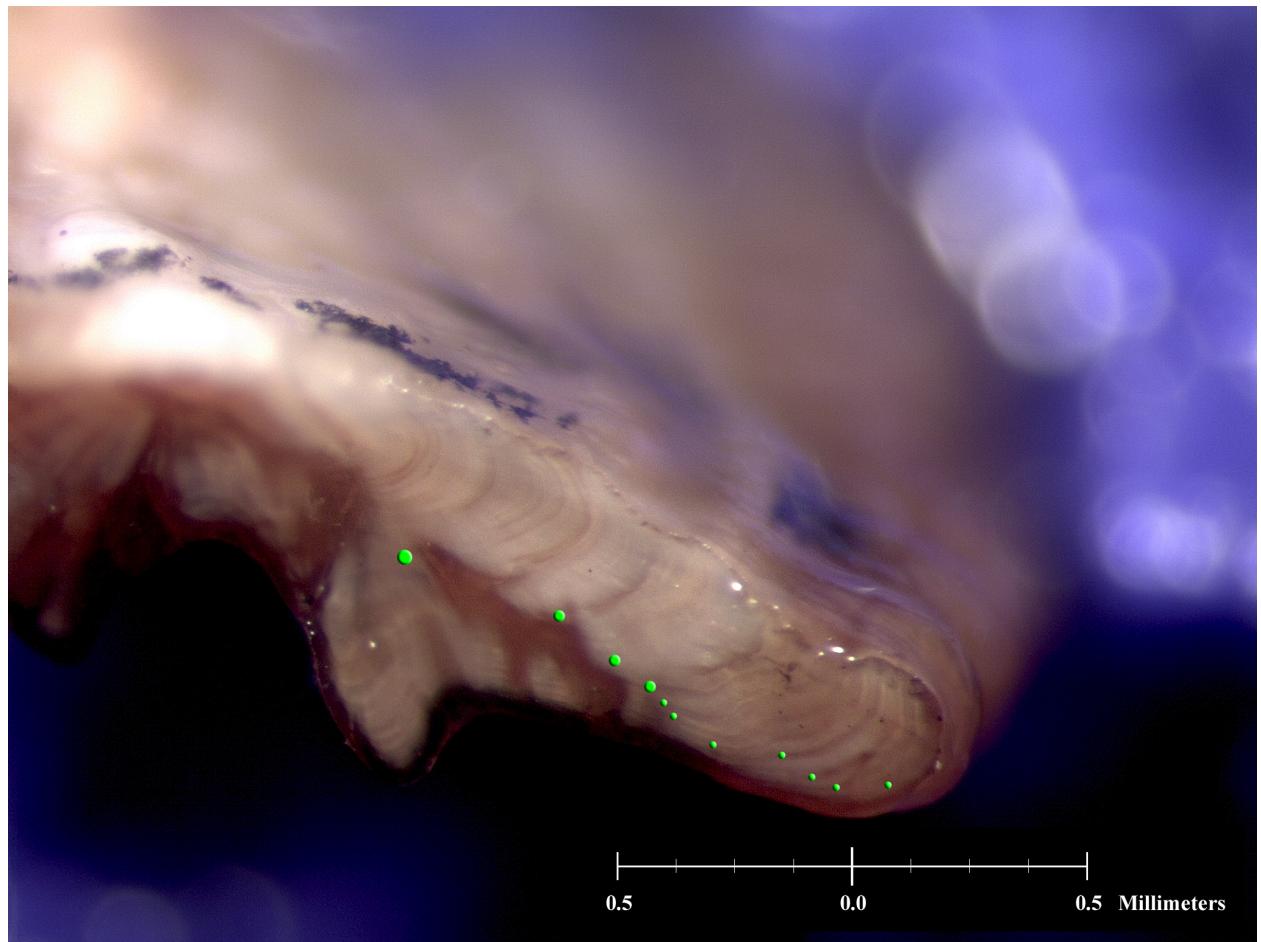


Figure 39: Cross-section of broken and burned California scorpionfish otolith showing. The green dots indicate the number of increments (photo courtesy Lance Sullivan, NWFSC).

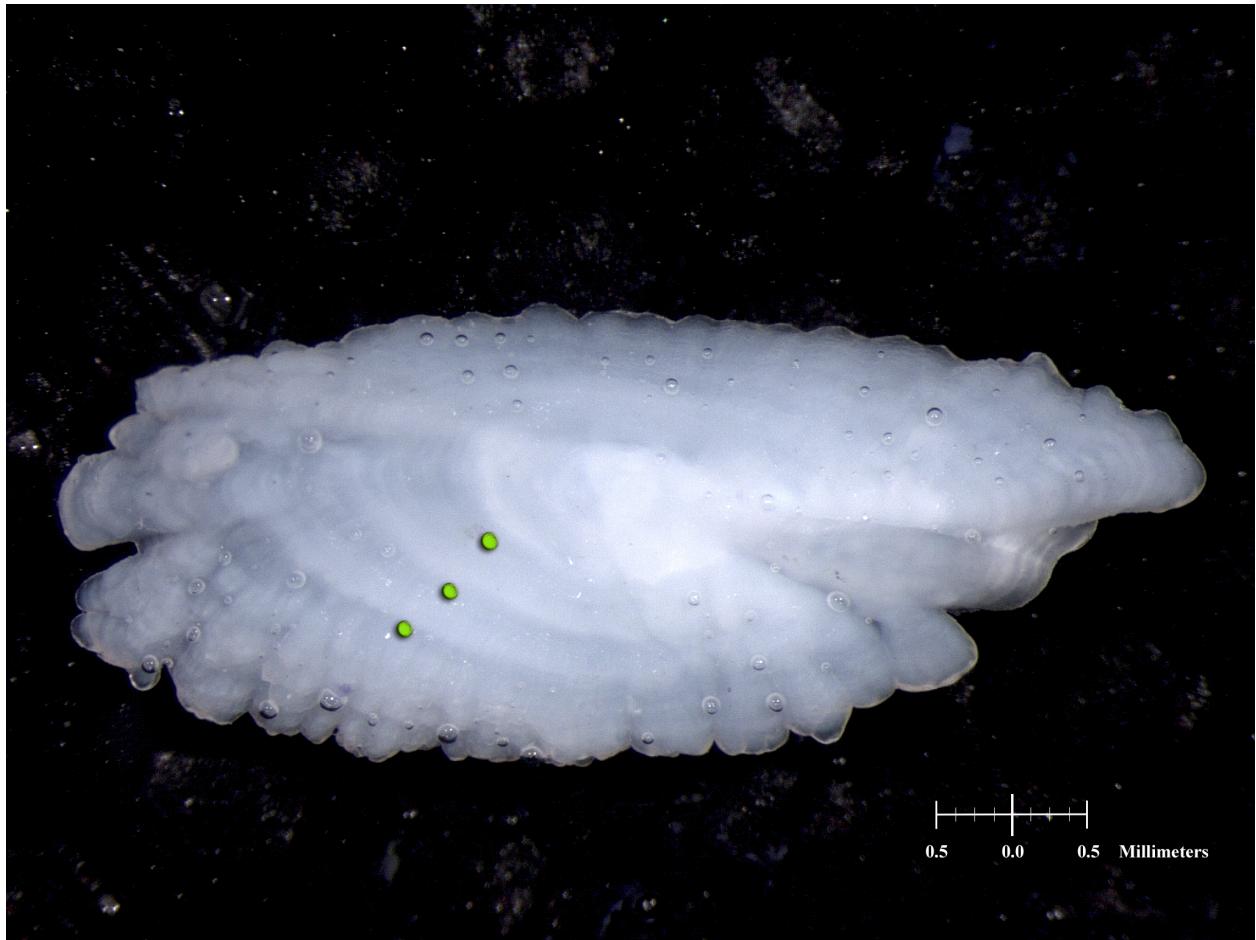
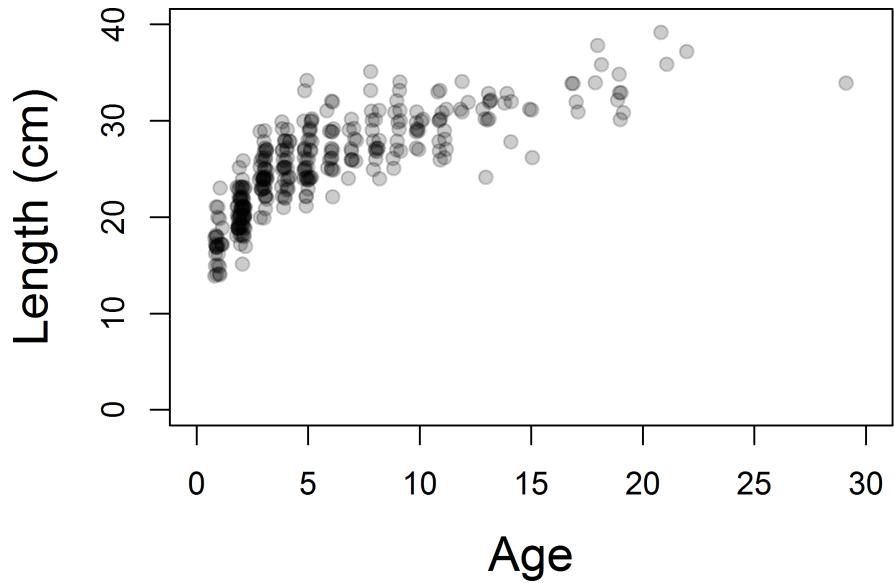


Figure 40: California scorpionfish otolith (photo courtesy Lance Sullivan, NWFSC).

**Female**



**Male**

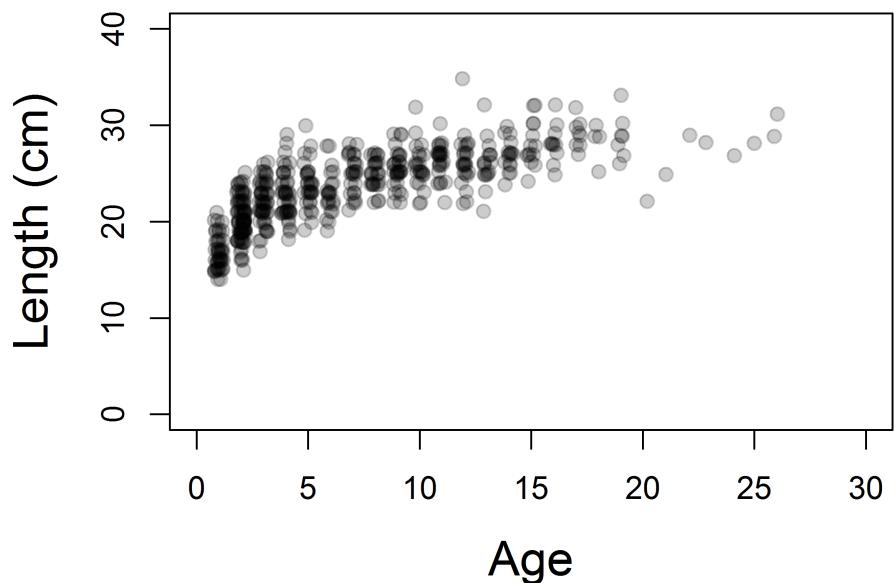
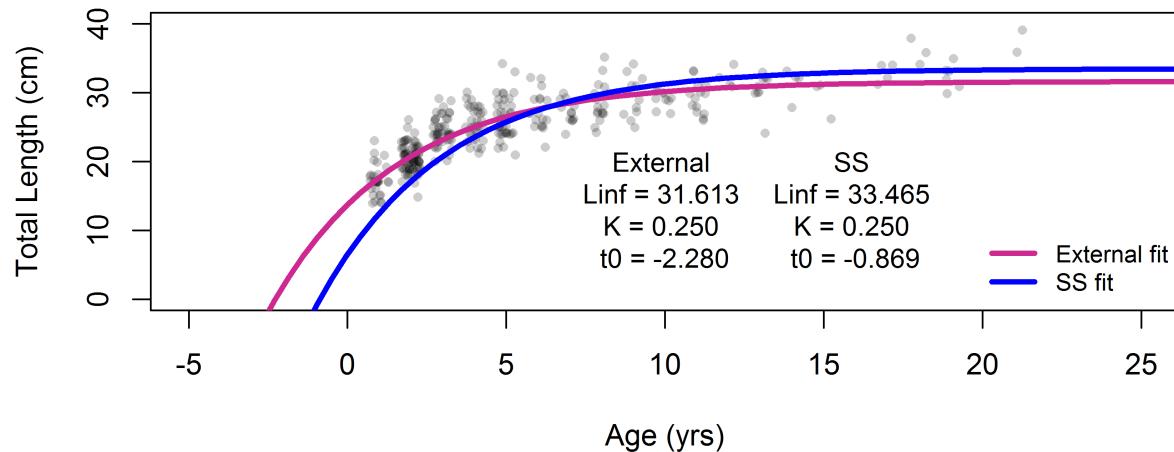


Figure 41: Length at age by sex for California scorpionfish collected from the NWFSC trawl survey.

### **Female**



### **Male**

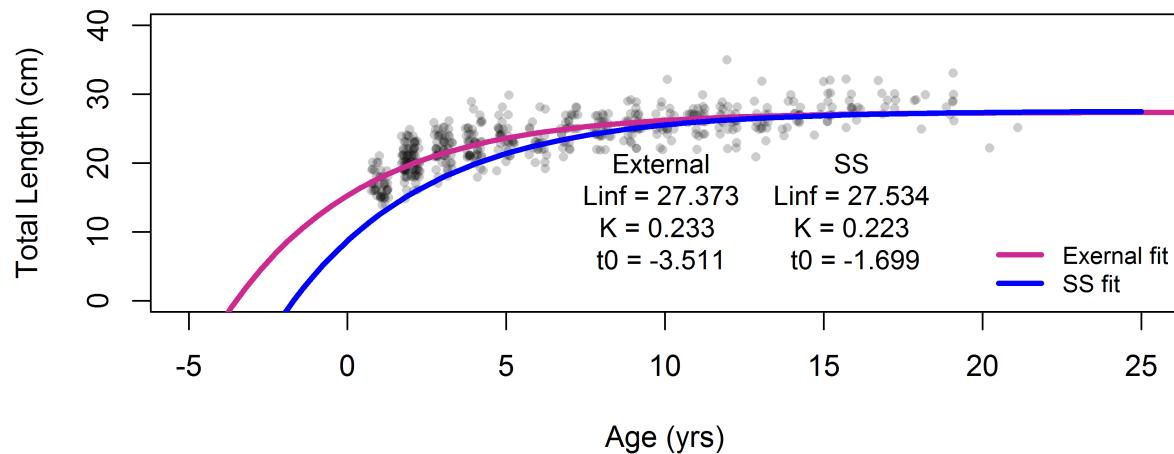
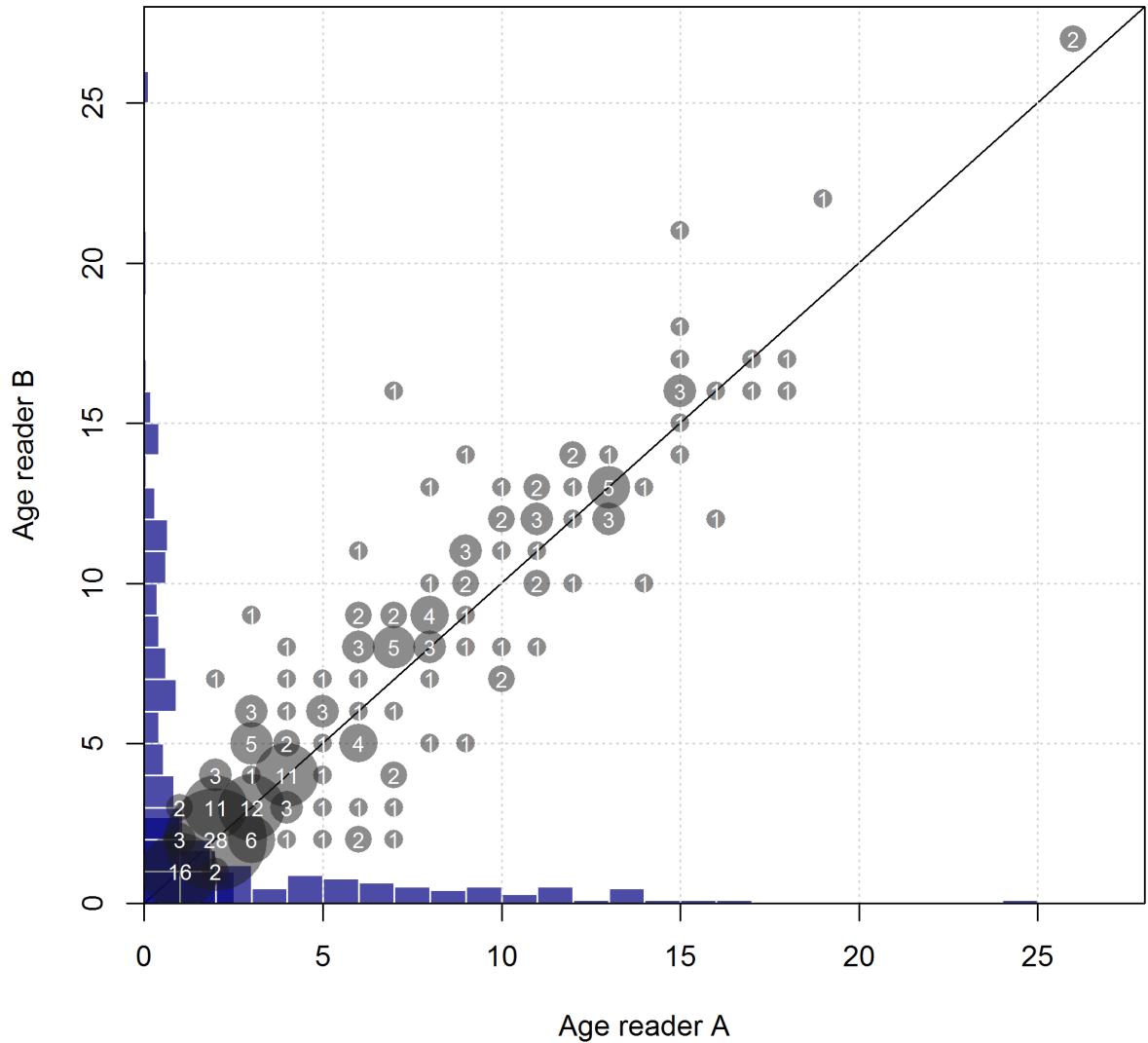


Figure 42: Fitted (external to SS) von Bertalanffy growth by sex for California scorpionfish collected from the NWFSC trawl survey.



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

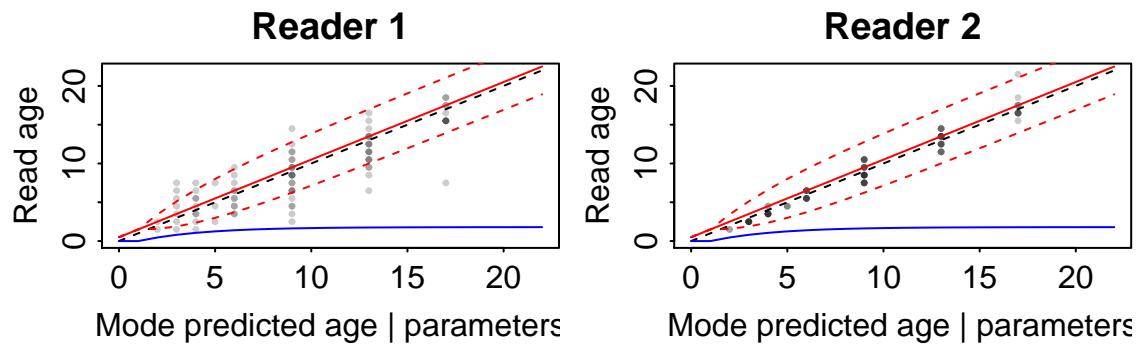


Figure 44: True versus predicted age for two current age readers at the NWFSC from the ageing error software with unbiased reads and curvilinear standard deviation for both readers.

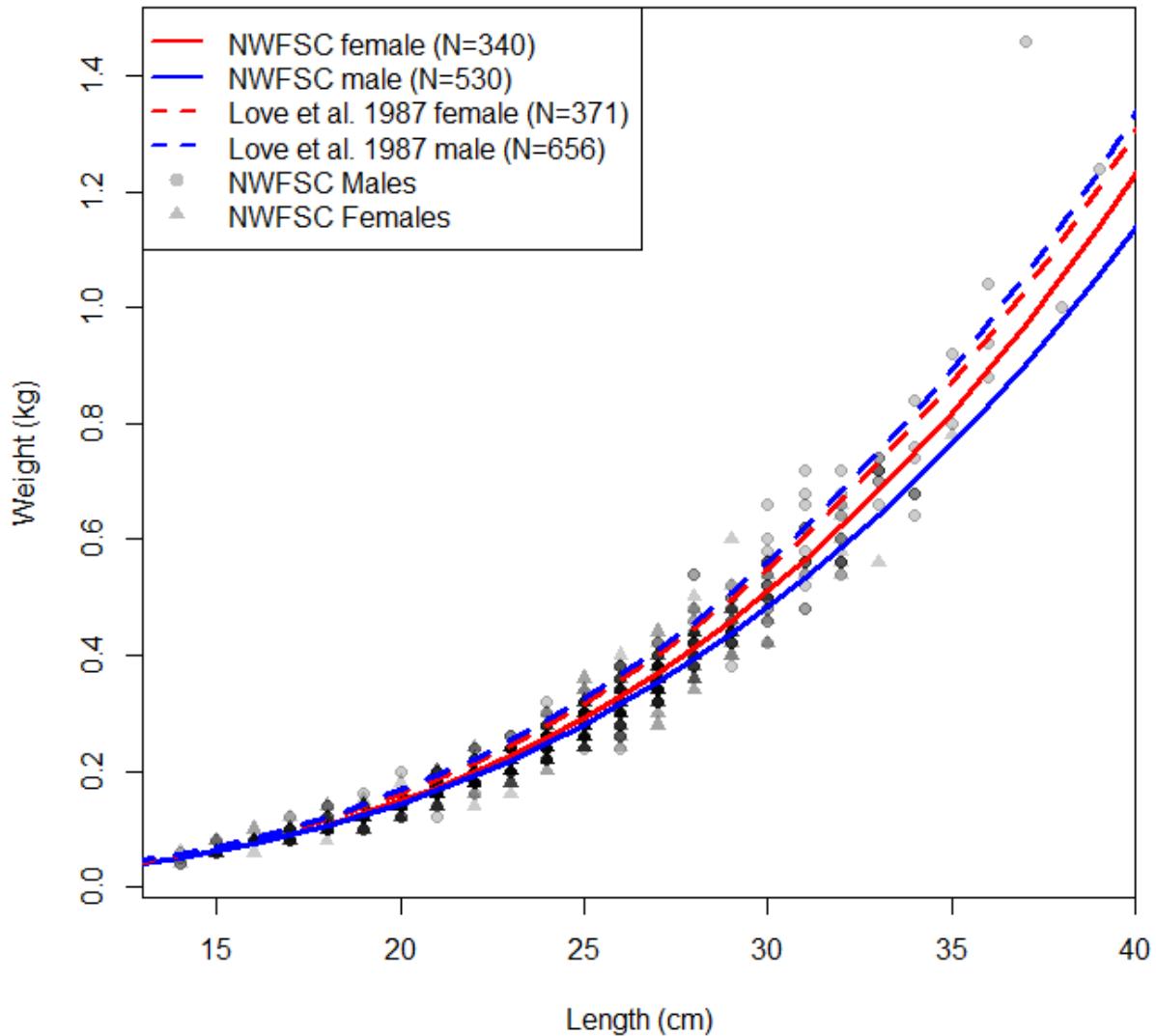


Figure 45: Comparison of the California scorpionfish weight-length curves from Love et al. (1987) and those estimated from the NWFSC trawl survey. The latter is used in this assessment.

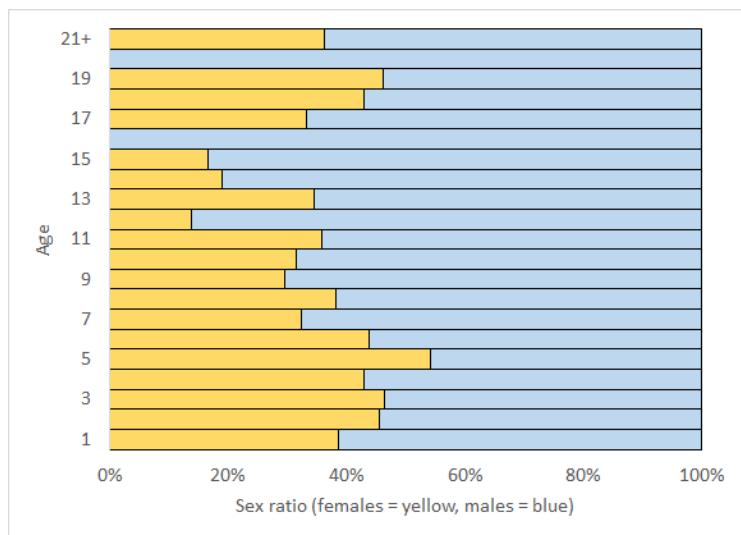


Figure 46: Percent of males and females by age of the fish aged from the NWFSC trawl survey, yellow=females and blue = males.

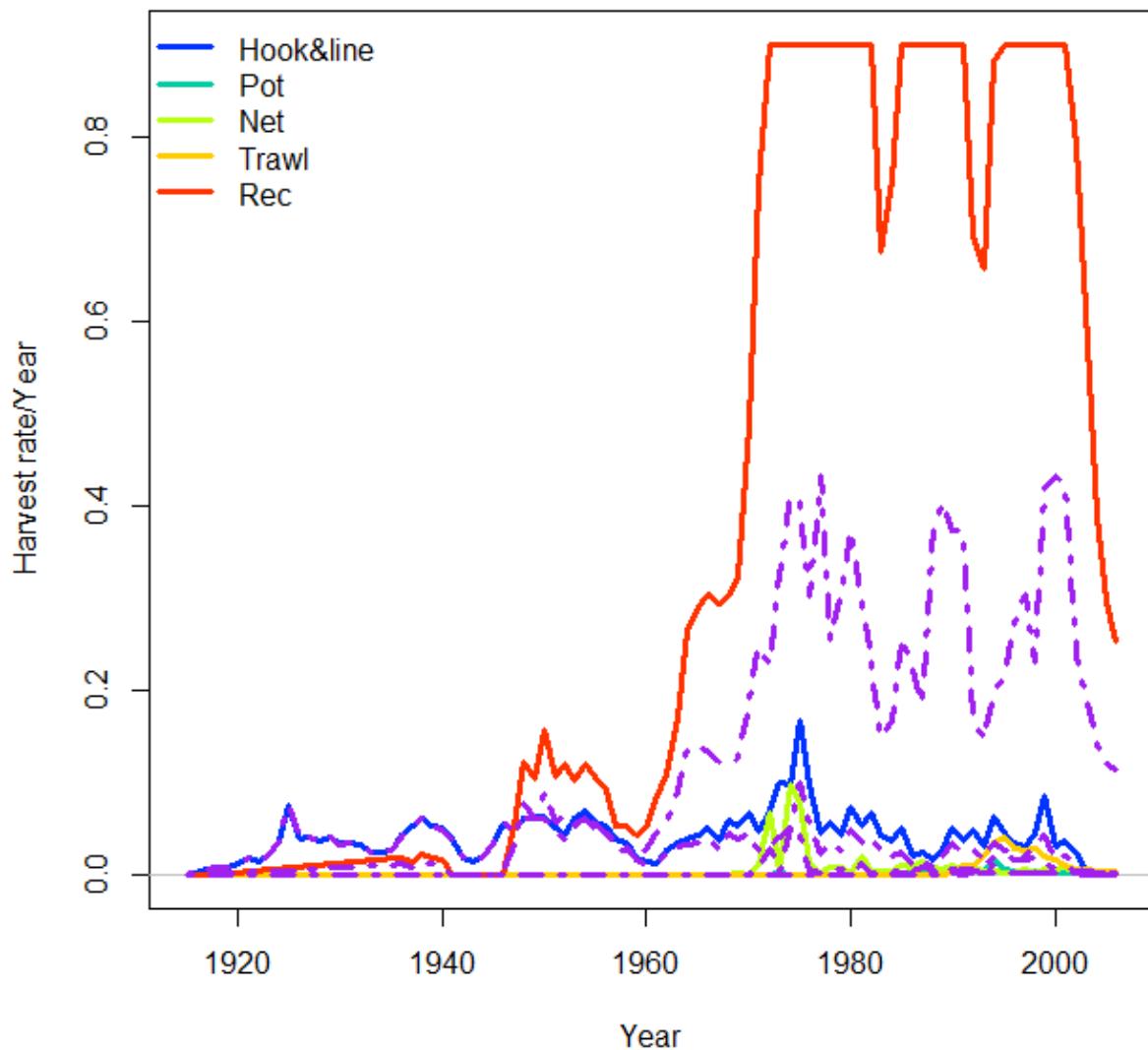


Figure 47: Time series of harvest rates by fleet from the 2005 model where the harvest rate for the recreational fleet hit the boundary of 0.9.

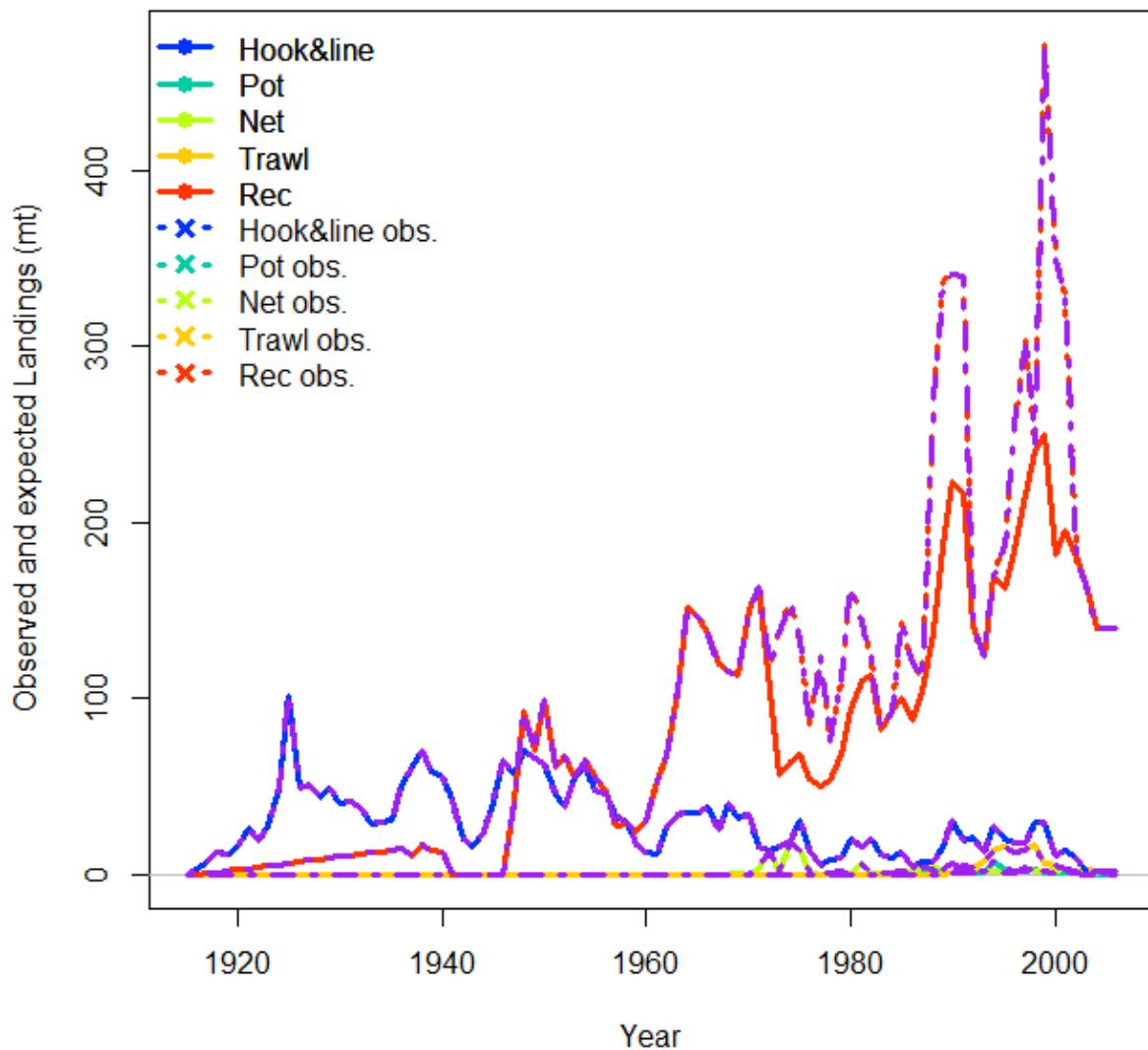


Figure 48: Time series of observed and expected landings by fleet from the 2005 model. The model was not able to remove all of the recreational catches starting around 1970.

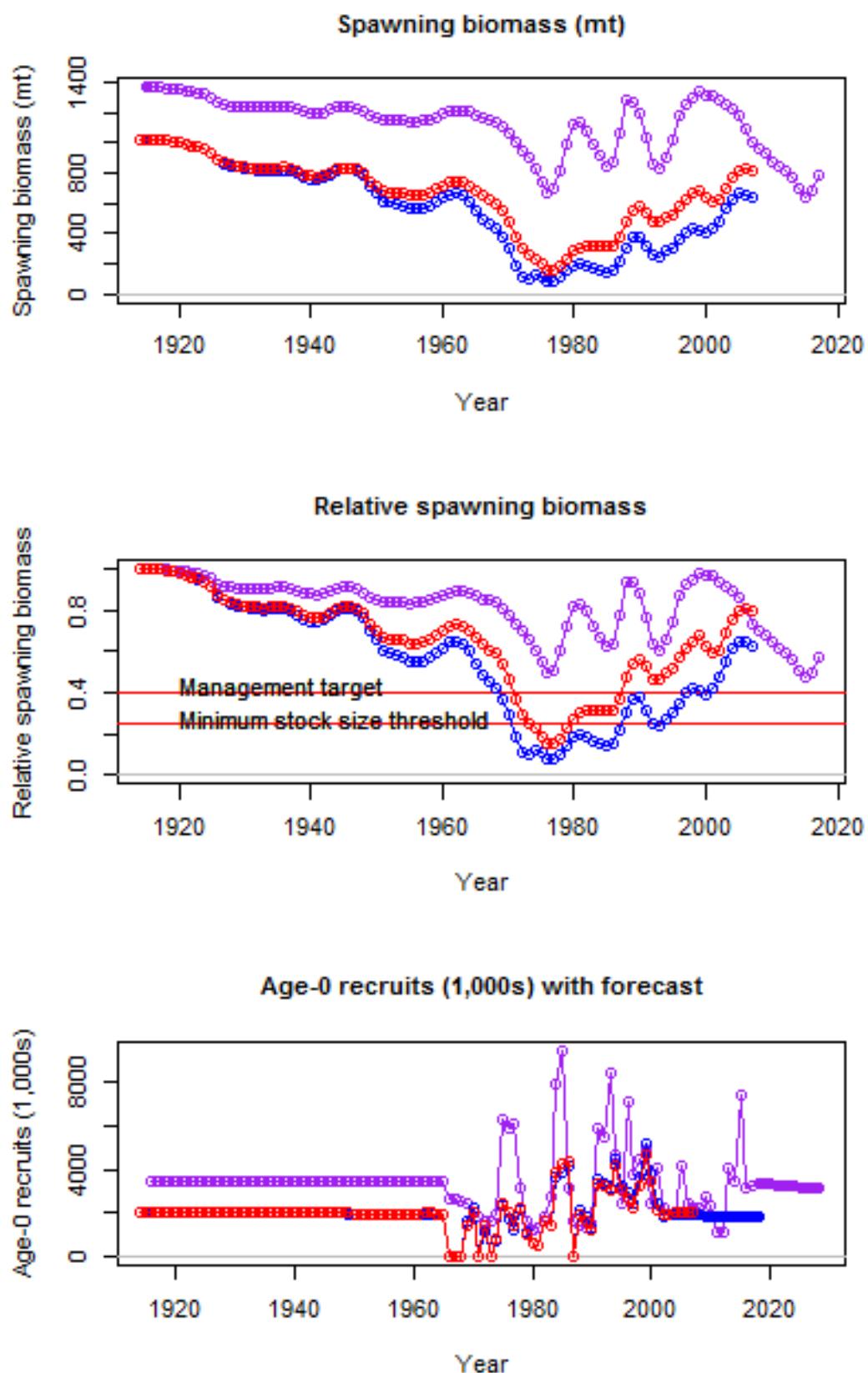


Figure 49: Comparison of spawning output, total biomass, and recruits from the 2005 model (solid red lines) using SS2, the 2005 model converted to SS3.24z (blue lines), and the base model from this assessment (purple lines). Note: The 2005 assessment was found to have an error, and therefore the time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

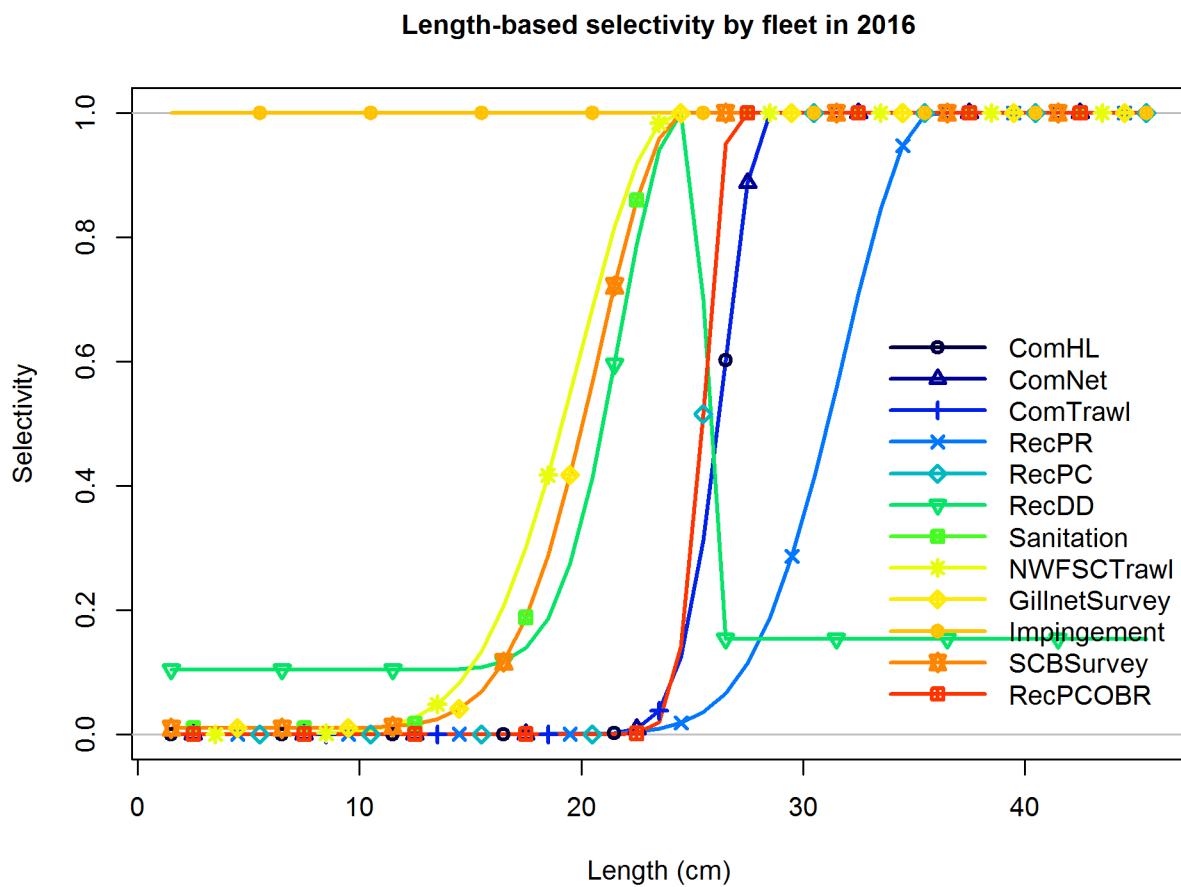


Figure 50: Selectivity at length for all of the fleets in the base model.

### **Female time-varying selectivity for ComHL**

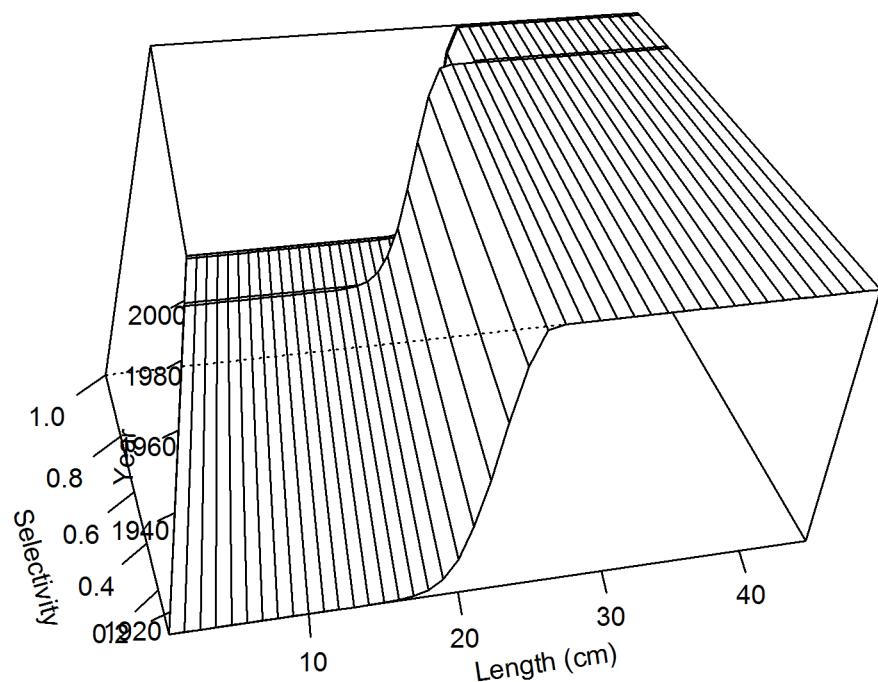


Figure 51: Surface plot of Female time-varying selectivity for the commercial hook-and-line fleet, with time blocks from 1916-1998 and 1999-2016.

### **Female time-varying selectivity for RecPR**

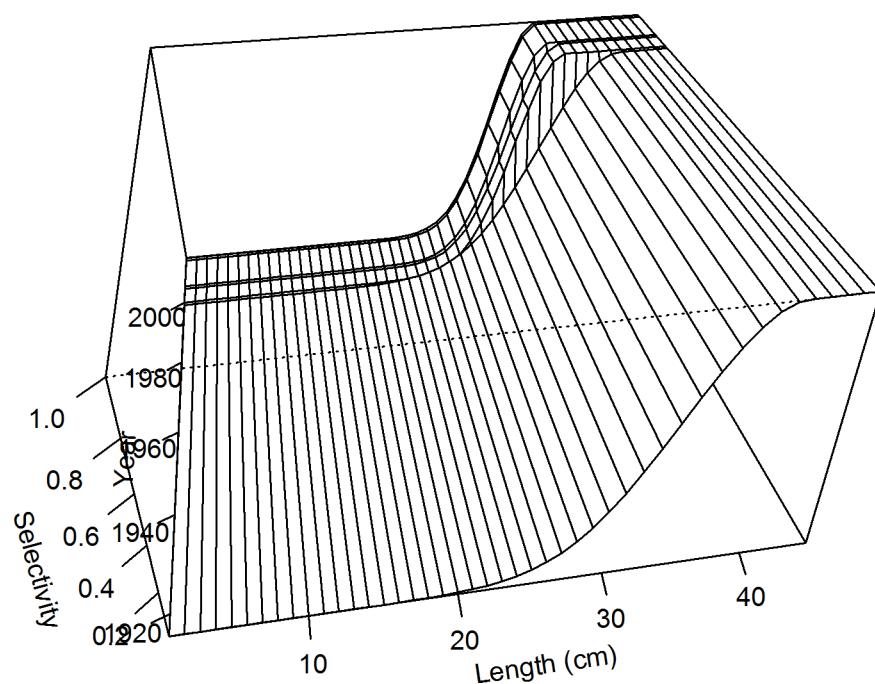


Figure 52: Surface plot of Female time-varying selectivity for the recreational private boat fleet, with time blocks from 1916-2000, 2001-2005, and 2006-2016.

### **Female time-varying selectivity for RecPC**

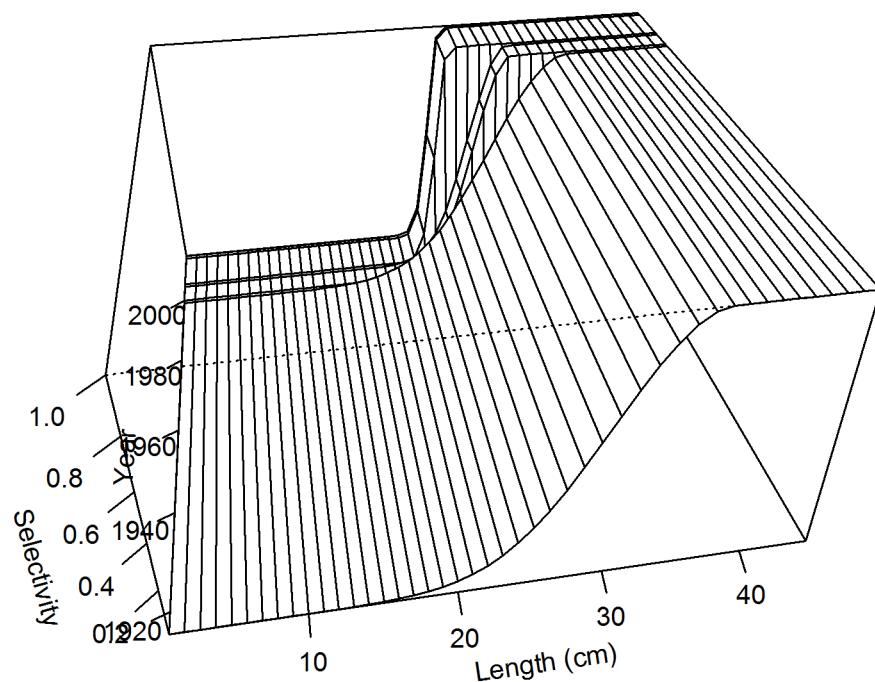


Figure 53: Surface plot of Female time-varying selectivity for the recreational party/charter retained-only catch fleet, with time blocks from 1916-2000, 2001-2005, and 2006-2016.

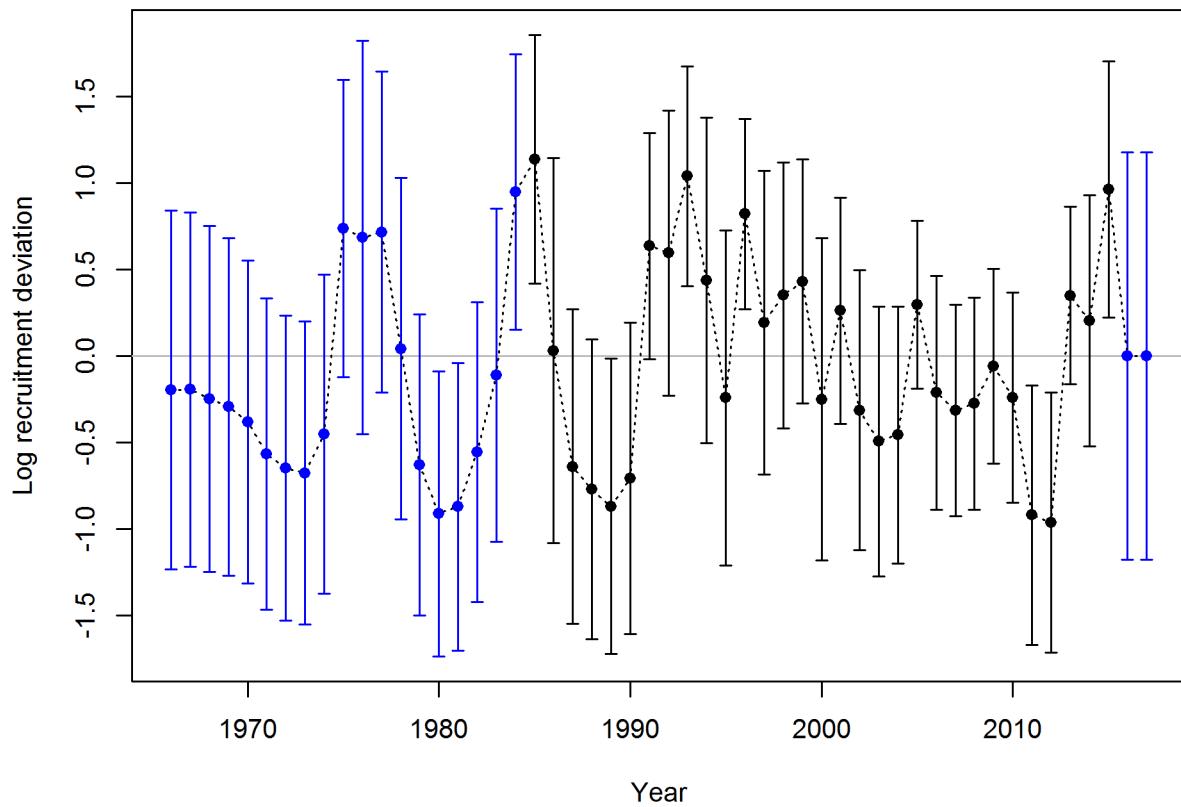


Figure 54: Estimated time-series of recruitment deviations for California scorpionfish with 95% intervals.

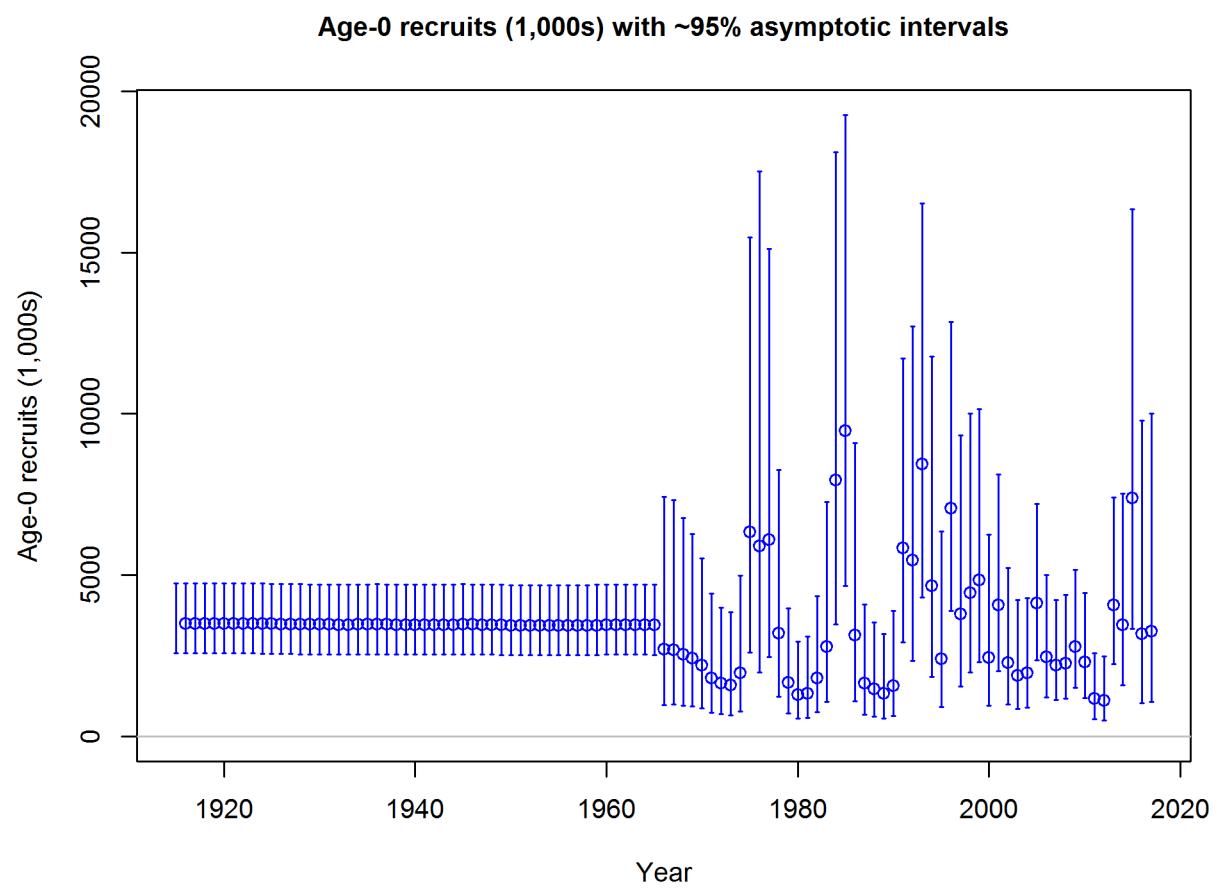


Figure 55: Estimated time-series of recruitment for California scorpionfish.

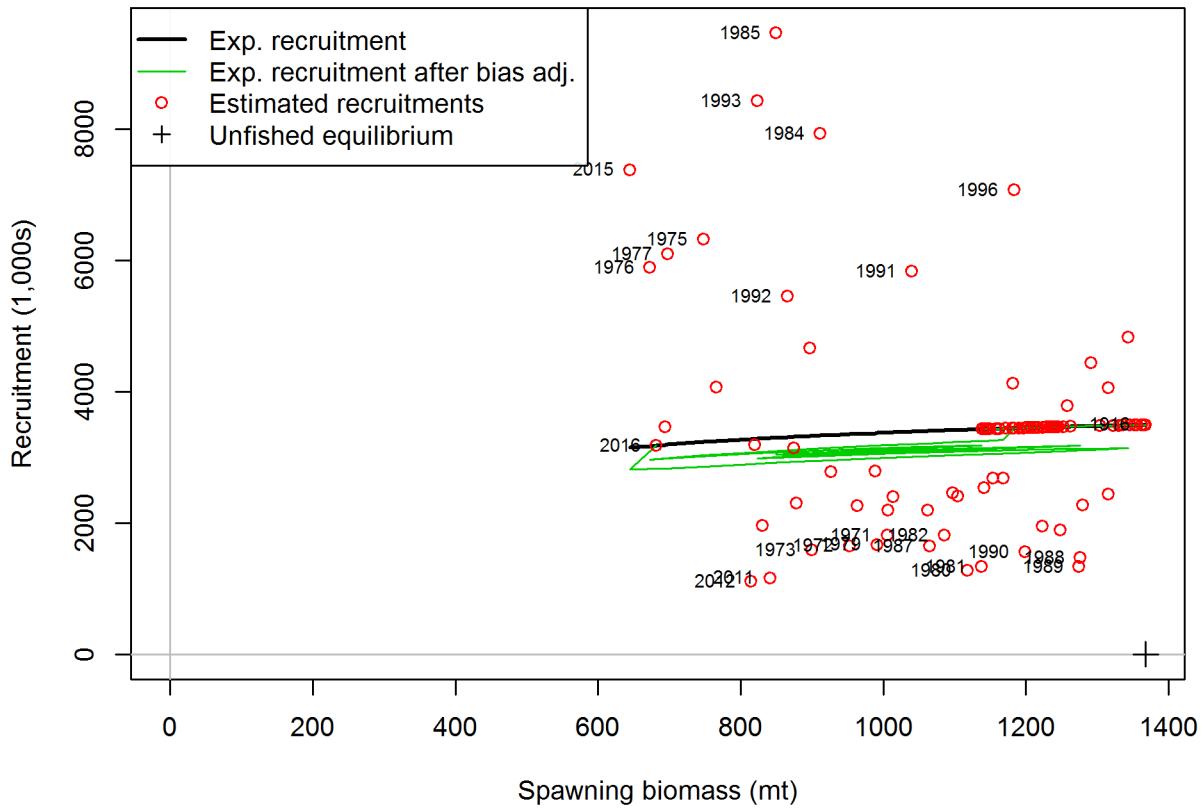


Figure 56: Estimated recruitment (red circles) and the assumed stock-recruit relationship (black line) for California scorpionfish. The green line shows the effect of the bias correction for the lognormal distribution.

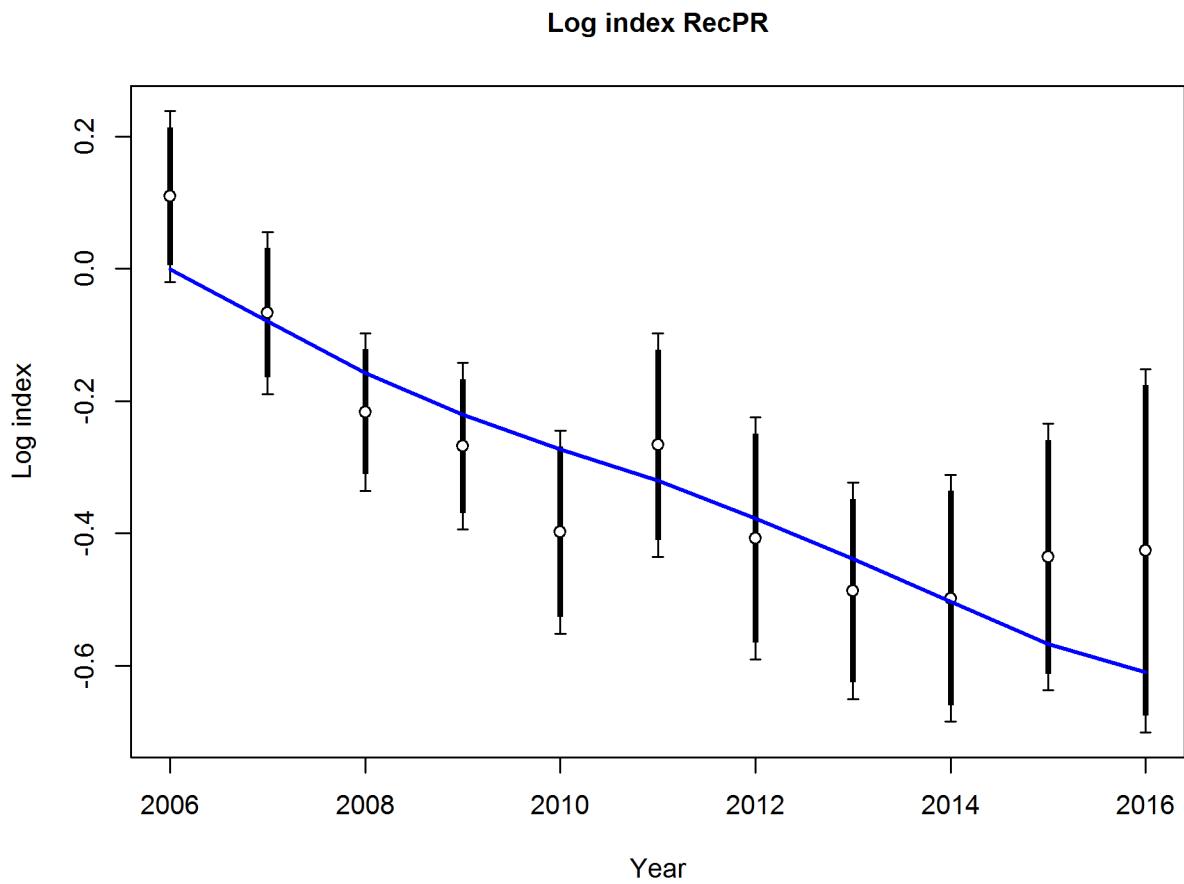


Figure 57: Fit to log index data on log scale for the recreational CPFV logbook retained catches. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

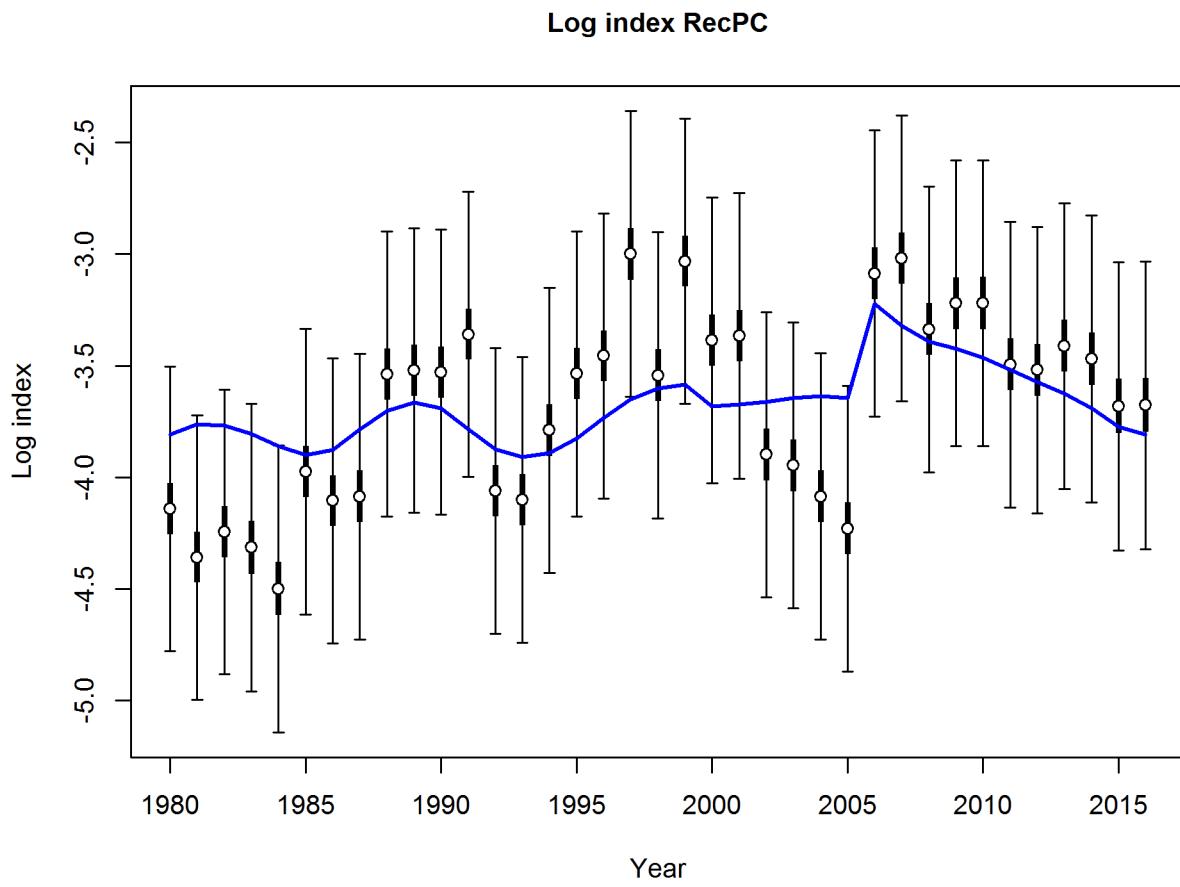


Figure 58: Fit to log index data on log scale for the recreational CPFV logbook retained catches. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

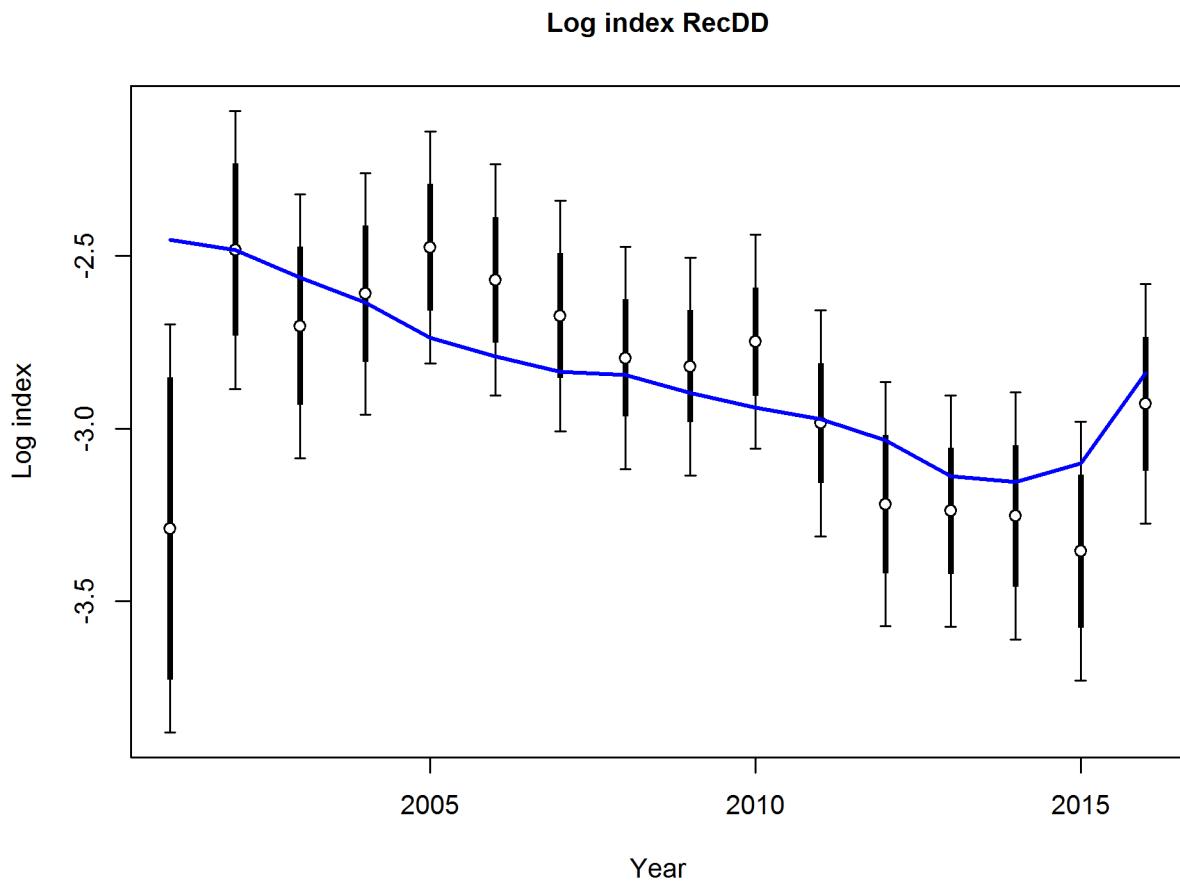


Figure 59: Fit to log index data on log scale for the recreational CPFV onboard observer discard catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

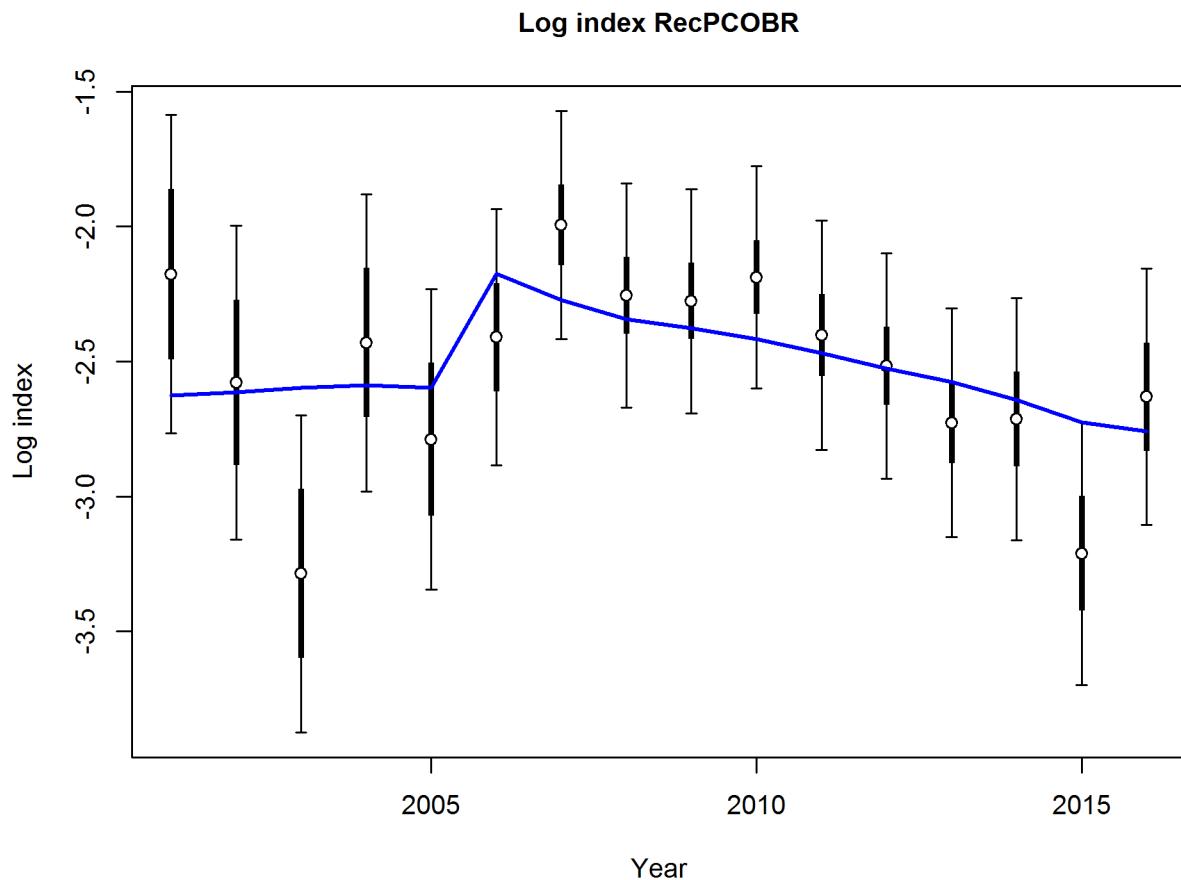


Figure 60: Fit to log index data on log scale for the recreational CPFV onboard observer retained catch index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

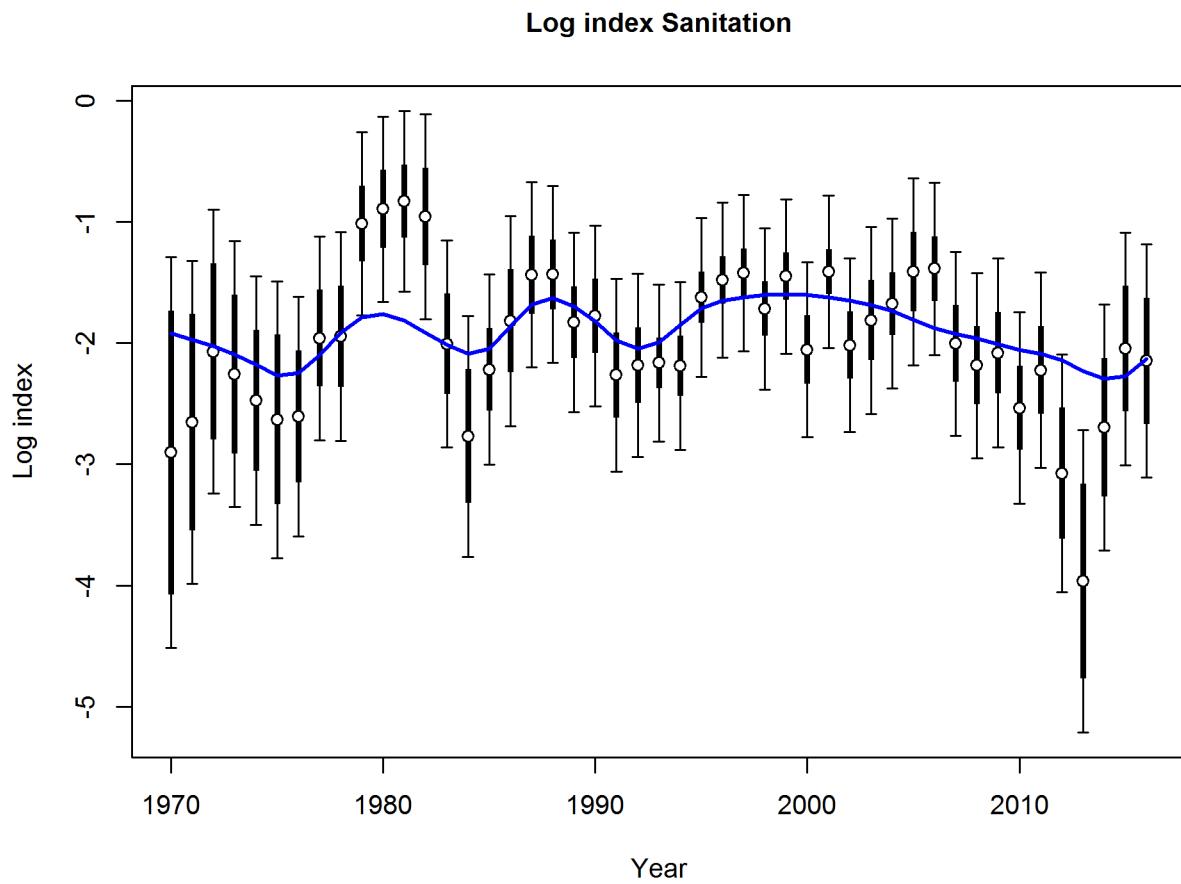


Figure 61: Fit to log index data on log scale for the sanitation district trawl index. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

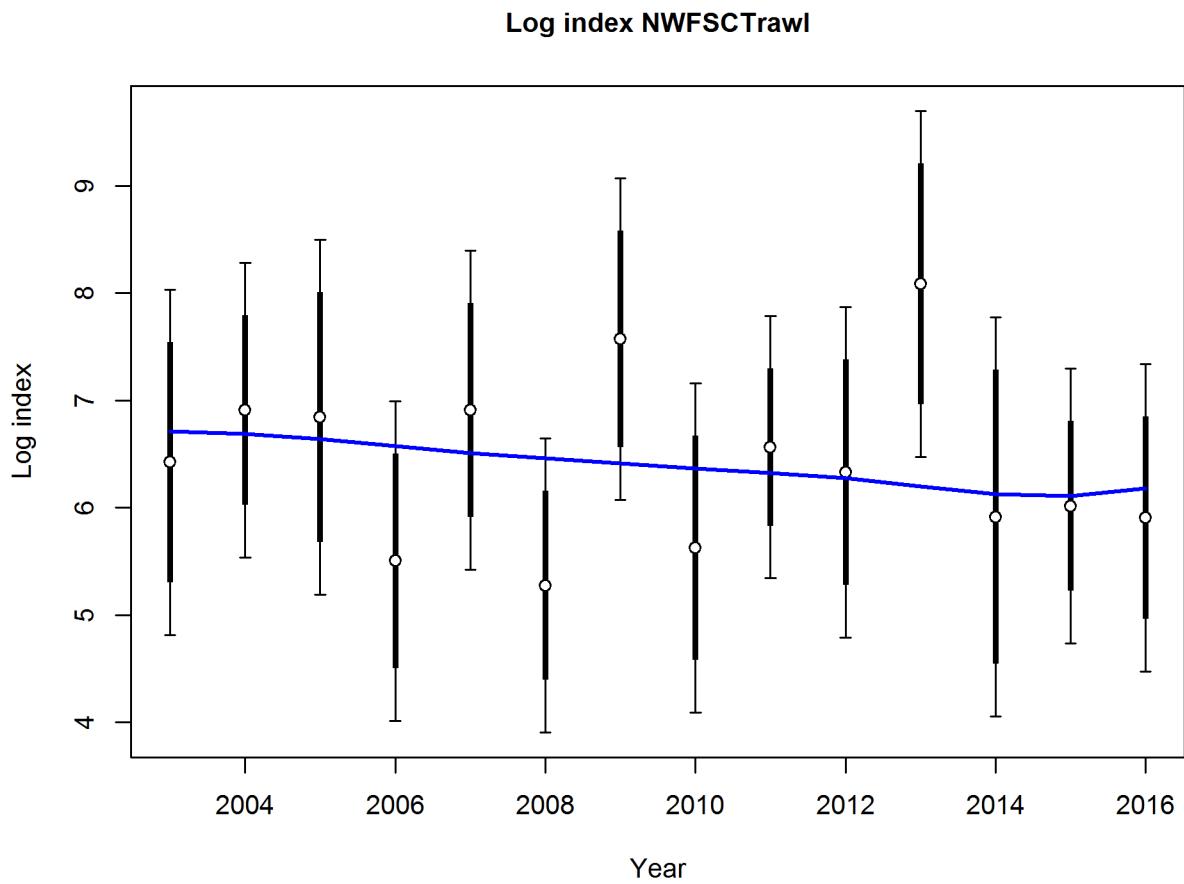


Figure 62: Fit to log index data on log scale for the NWFSC trawl survey from the VAST analysis from 2003-2016. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

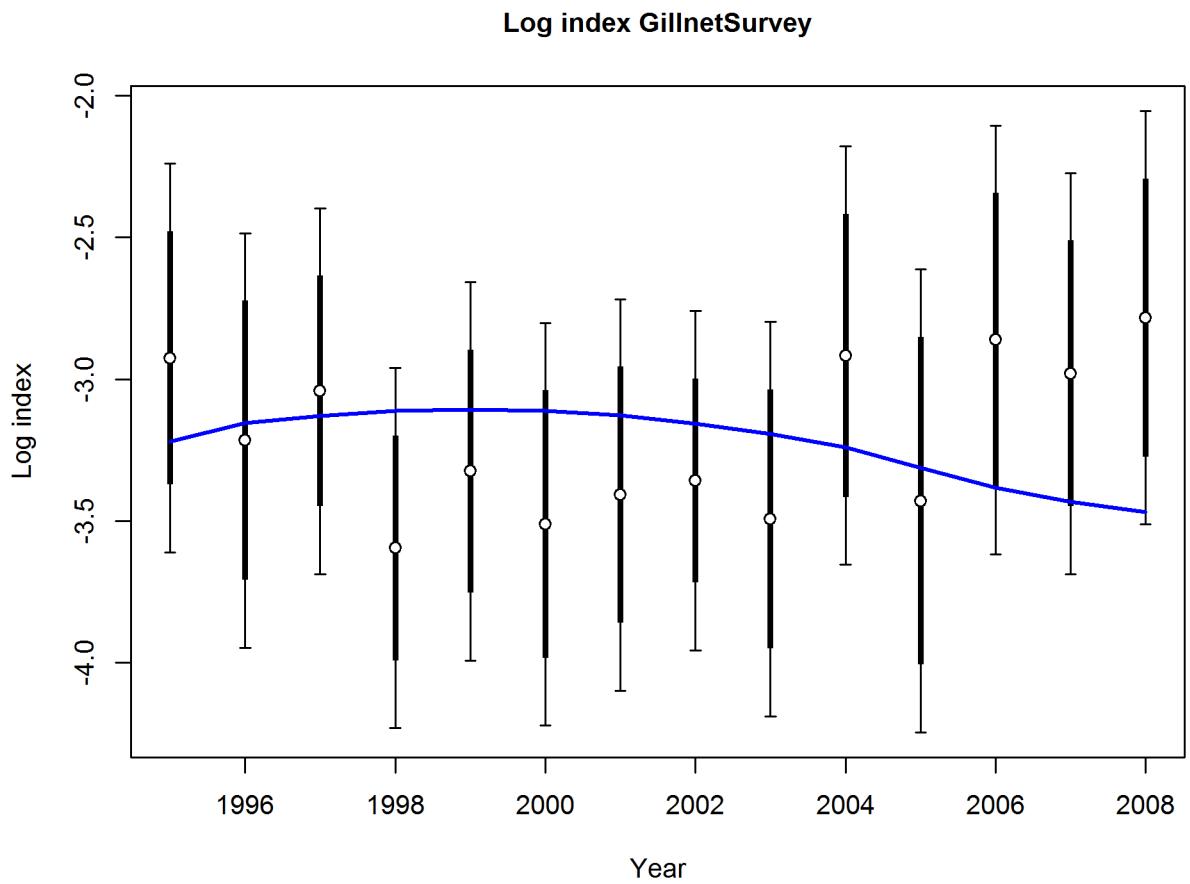


Figure 63: Fit to log index data on log scale for the recreational CSUN/VRG gillnet survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

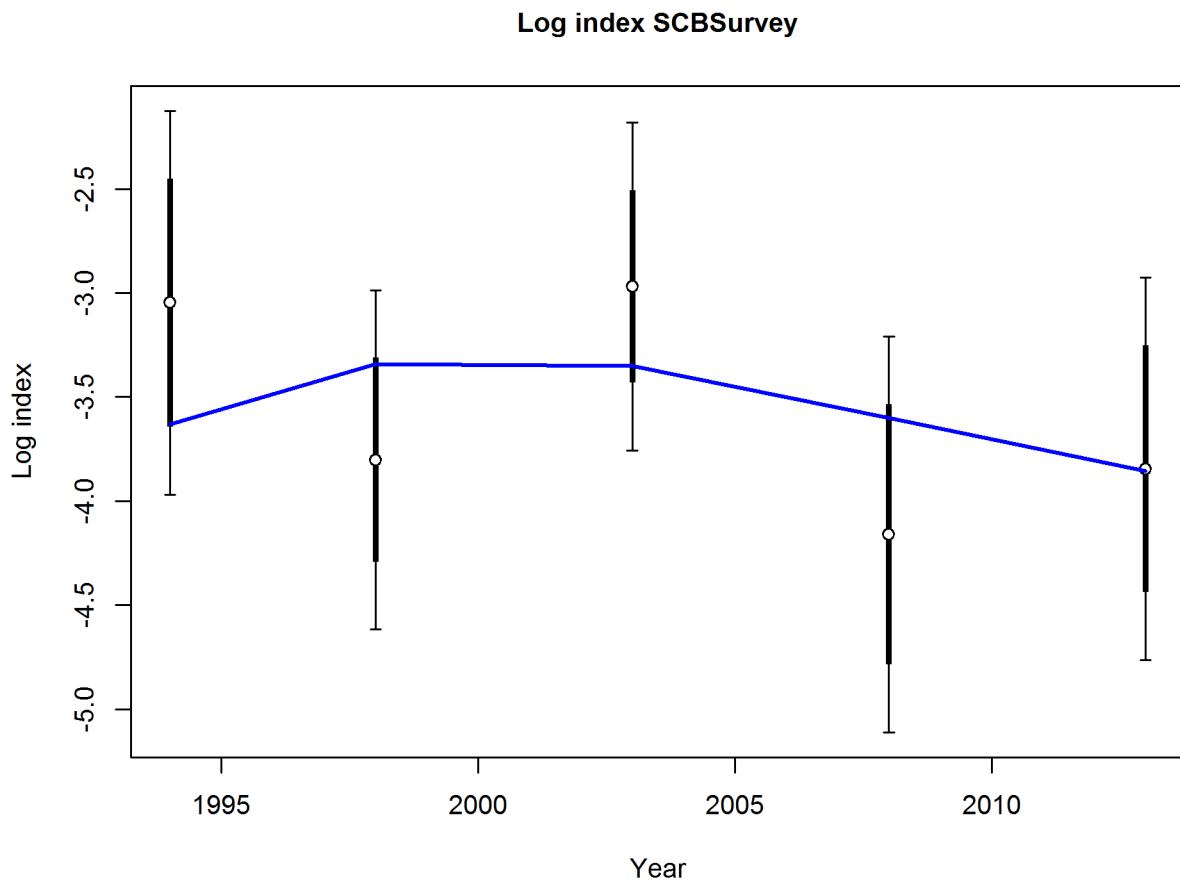


Figure 64: Fit to log index data on log scale for the recreational Southern California Bight trawl survey. Lines indicate 95% uncertainty interval around index values. Thicker lines indicate input uncertainty before addition of estimated additional uncertainty parameter.

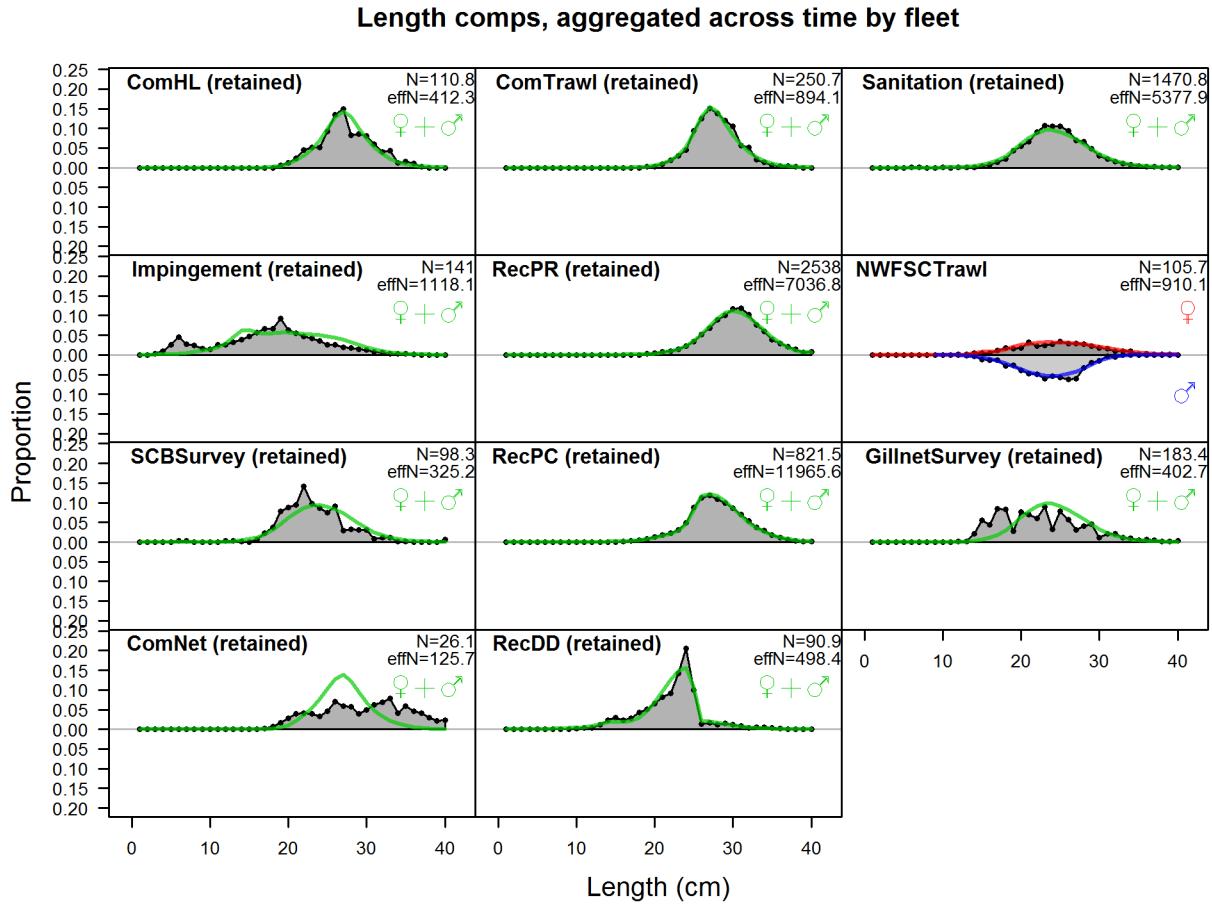


Figure 65: Length compositions aggregated across time by fleet. Labels ‘retained’ and ‘discard’ indicate retained or discarded samples for each fleet. Panels without this designation represent the whole catch.

### Conditional AAL plot, whole catch, NWFSC Trawl

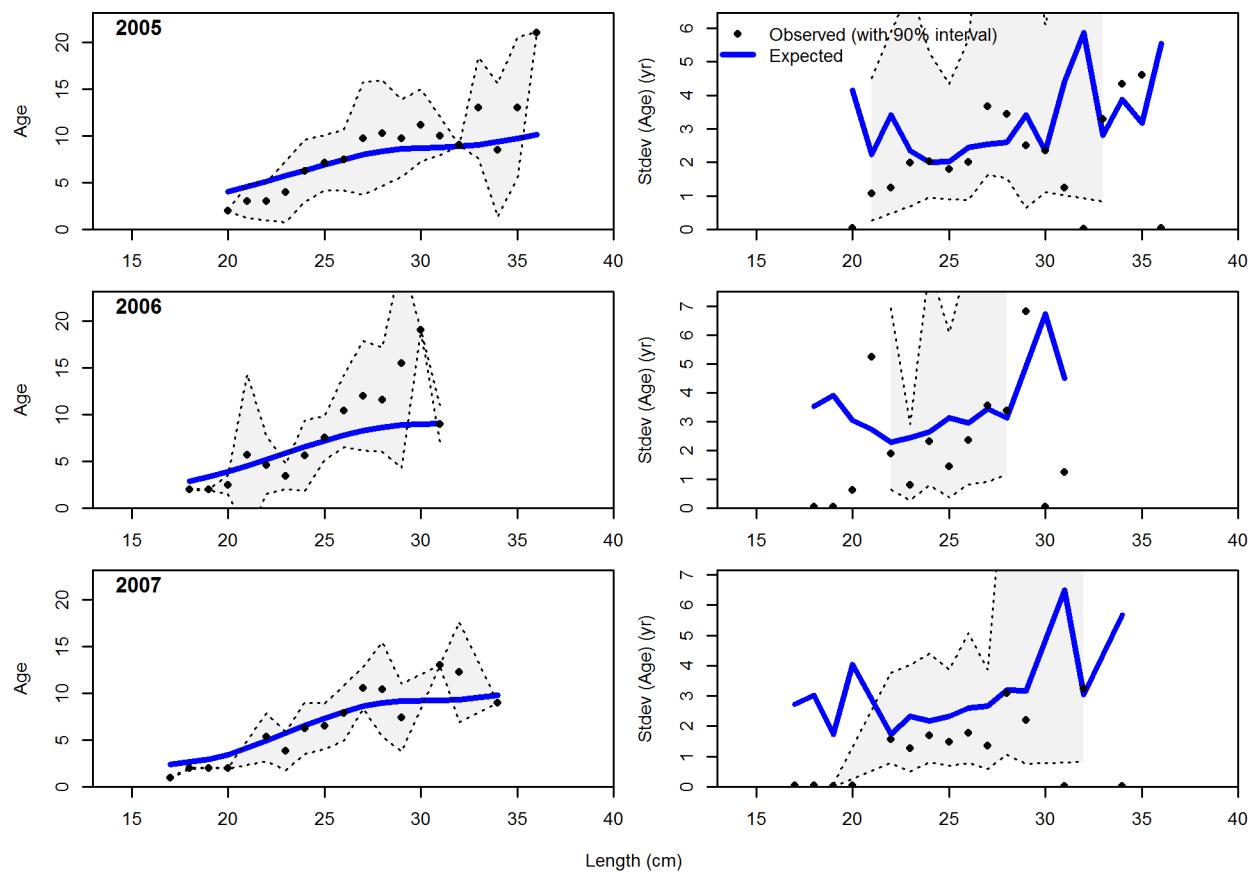
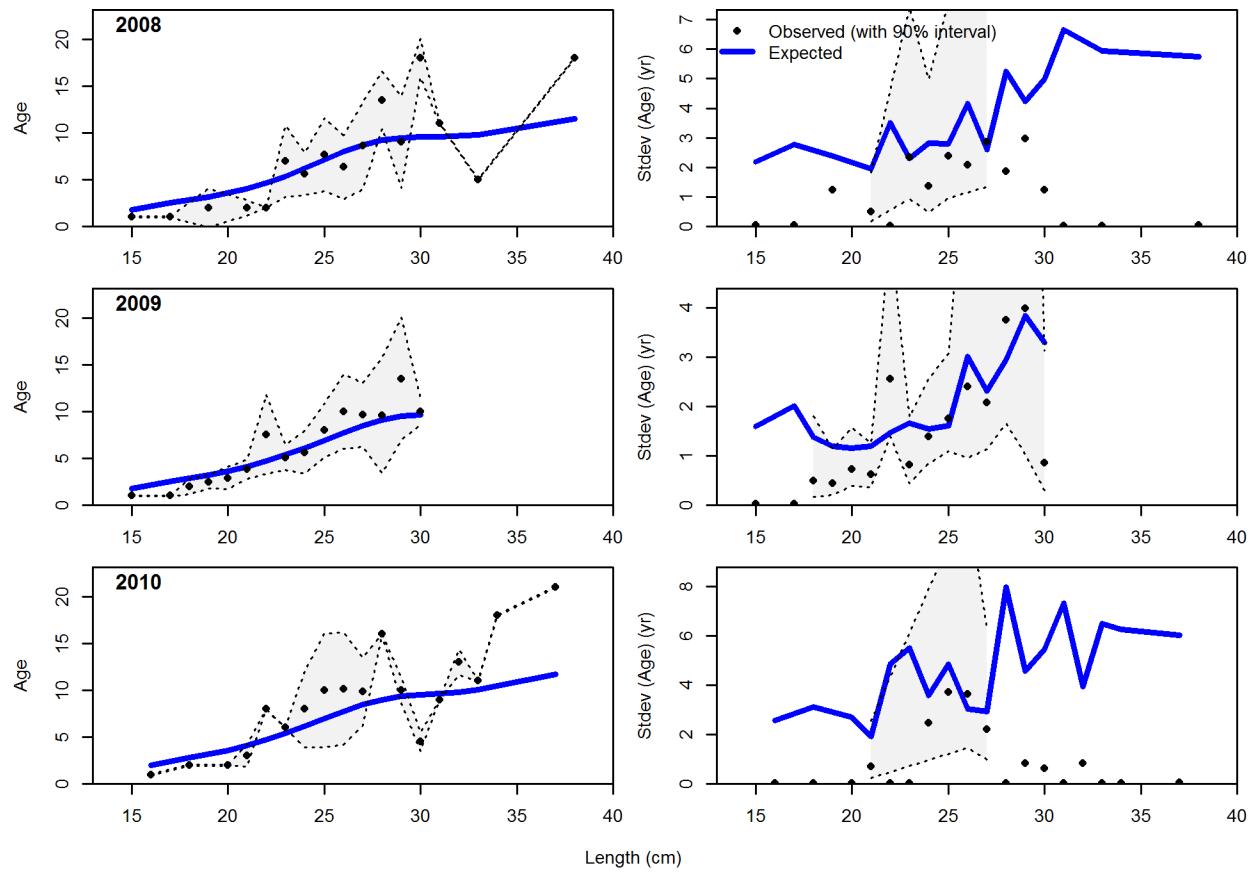


Figure 66: Conditional AAL plot, whole catch, NWFSC Trawl (plot 1 of 4) These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size\_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.)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

Conditional AAL plot, whole catch, NWFSC Trawl

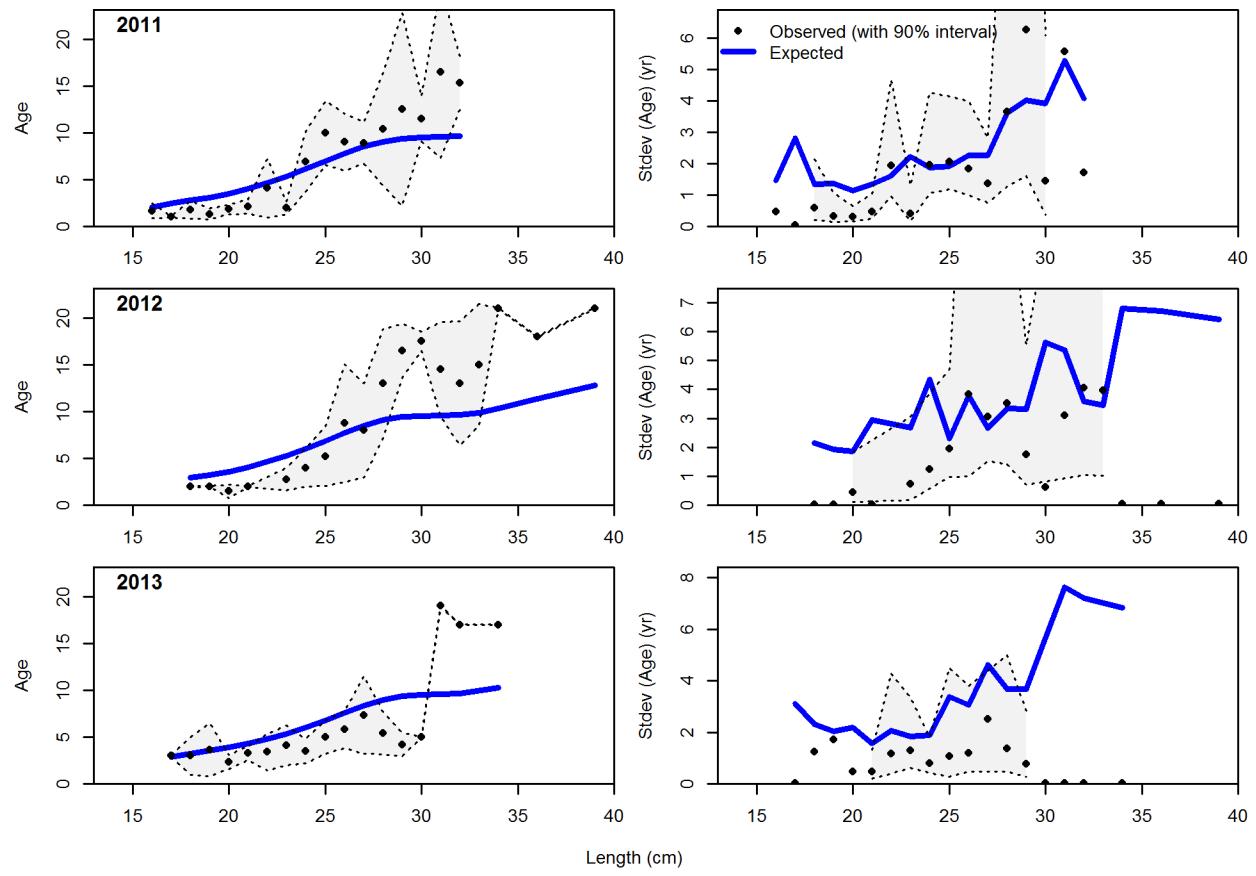


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Conditional AAL plot, whole catch, NWFSC Trawl

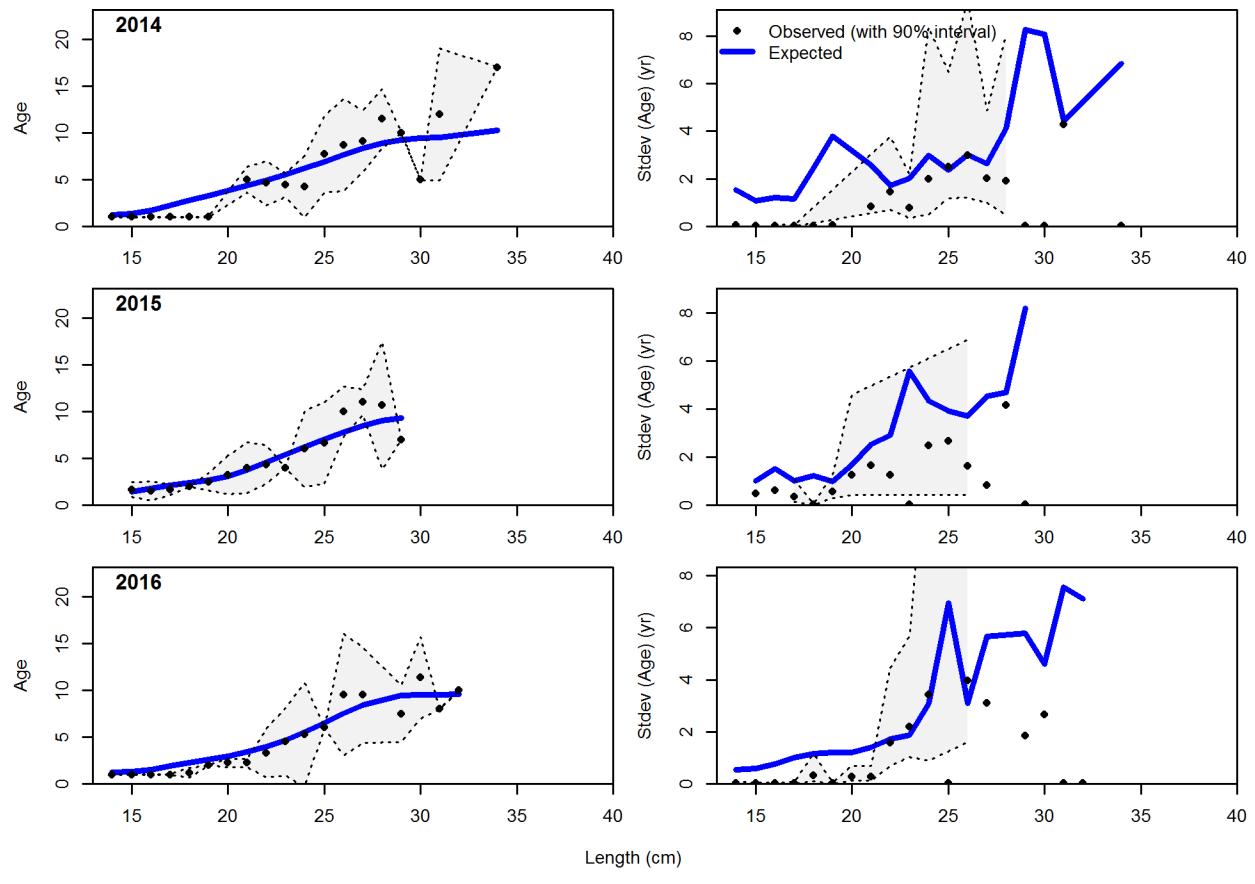


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Conditional AAL plot, whole catch, NWFSC Trawl



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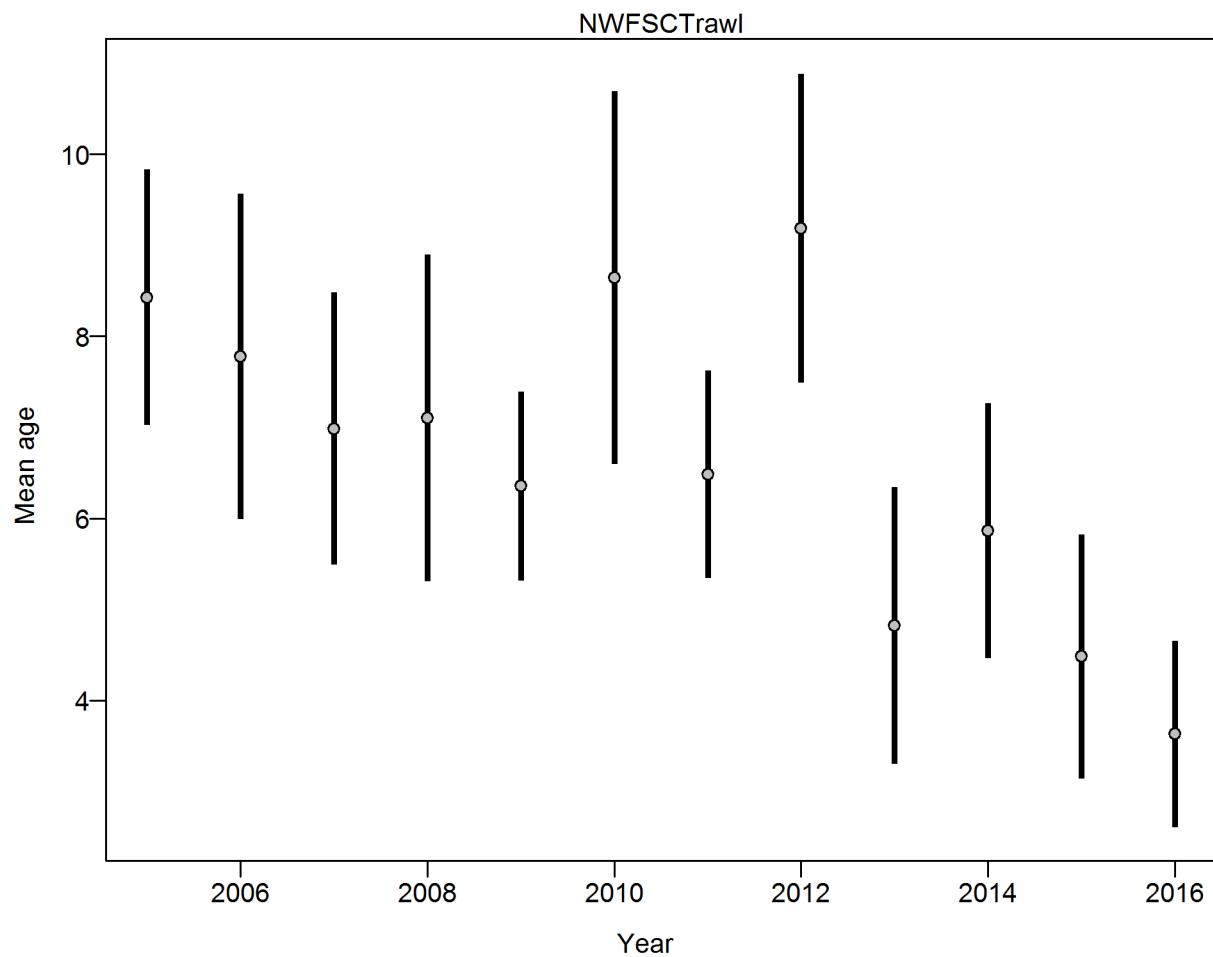


Figure 67: Francis data weighting method TA1.8 for conditional age data from the NWFSC trawl survey. Suggested sample size adjustment (with 95% interval) for conditional age-at-length data from NWFSC trawl is 0.9373 (0.4951-3.7346). For more info, see Francis et al. (2011).

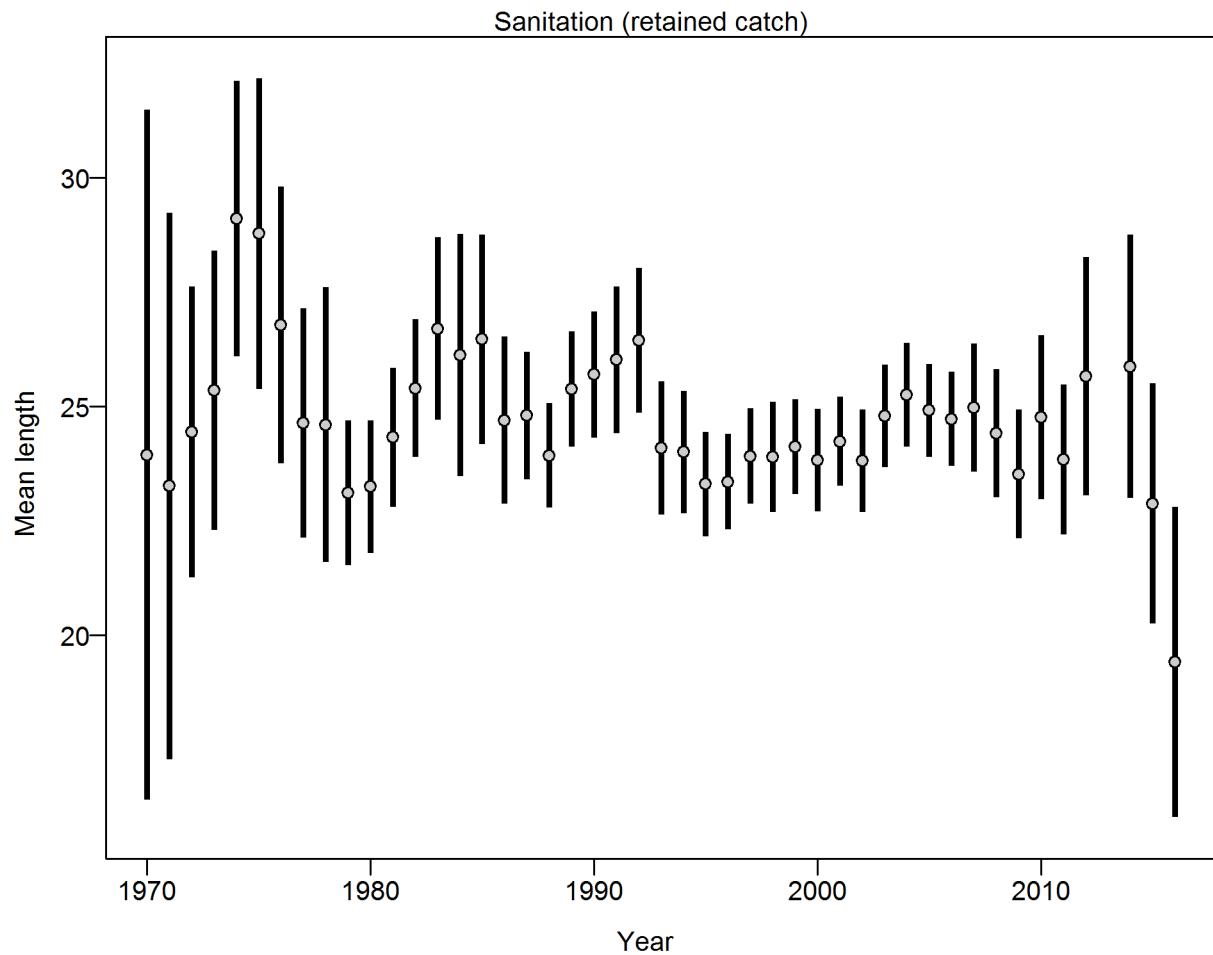


Figure 68: Francis data weighting method TA1.8 for length composition data from the Sanitation district surveys. Suggested sample size adjustment (with 95% interval) for length data from Sanitation surveys is 0.8665 (0.6162-1.3836). For more info, see Francis et al. (2011).

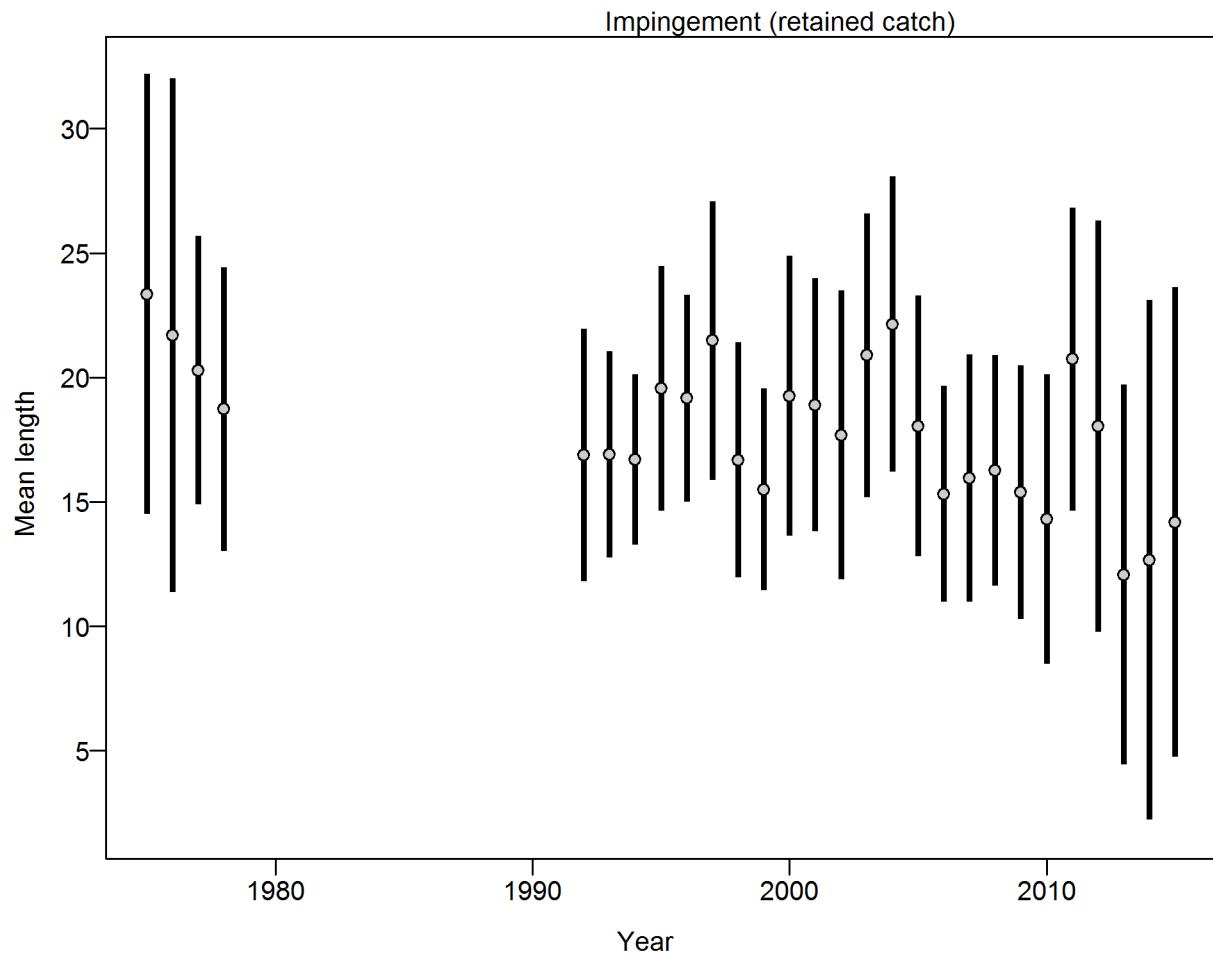


Figure 69: Francis data weighting method TA1.8 for length composition data from the Impingement surveys. Suggested sample size adjustment (with 95% interval) for the length data from the Impingement surveys is 0.9356 (0.7114-1.5026). For more info, see Francis et al. (2011).

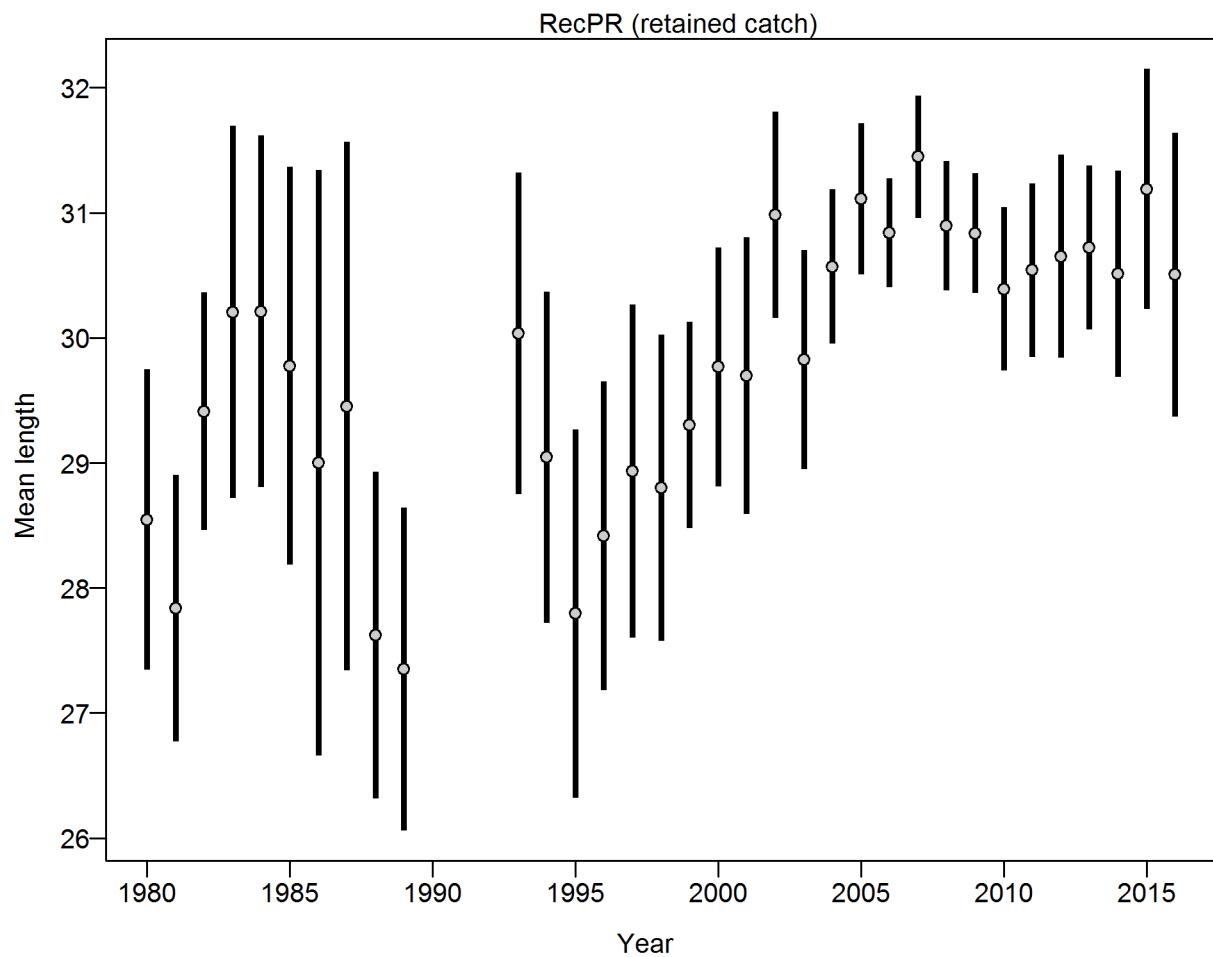


Figure 70: Francis data weighting method TA1.8 for length composition data from the recreational private boat fleet. Suggested sample size adjustment (with 95% interval) for the length data from the recreational private boat fleet is 1.0655 (0.7368-1.7486). For more info, see Francis et al. (2011).

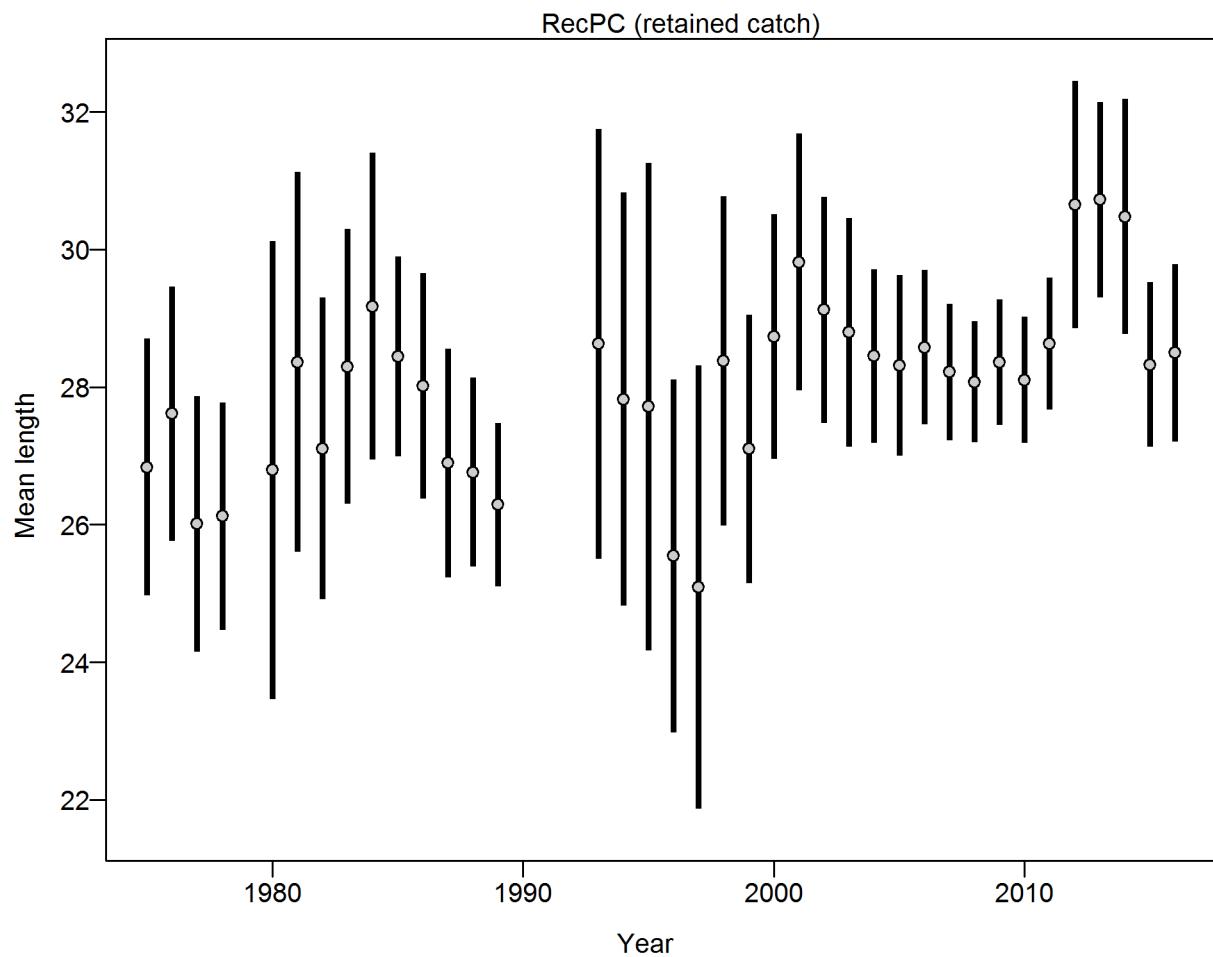


Figure 71: Francis data weighting method TA1.8 for conditional age data from the recreational party/charter retained-catch fleet. Suggested sample size adjustment (with 95% interval) for the length data from the recreational party/charter retained-catch fleet is 0.832 (0.5086-1.8822). For more info,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

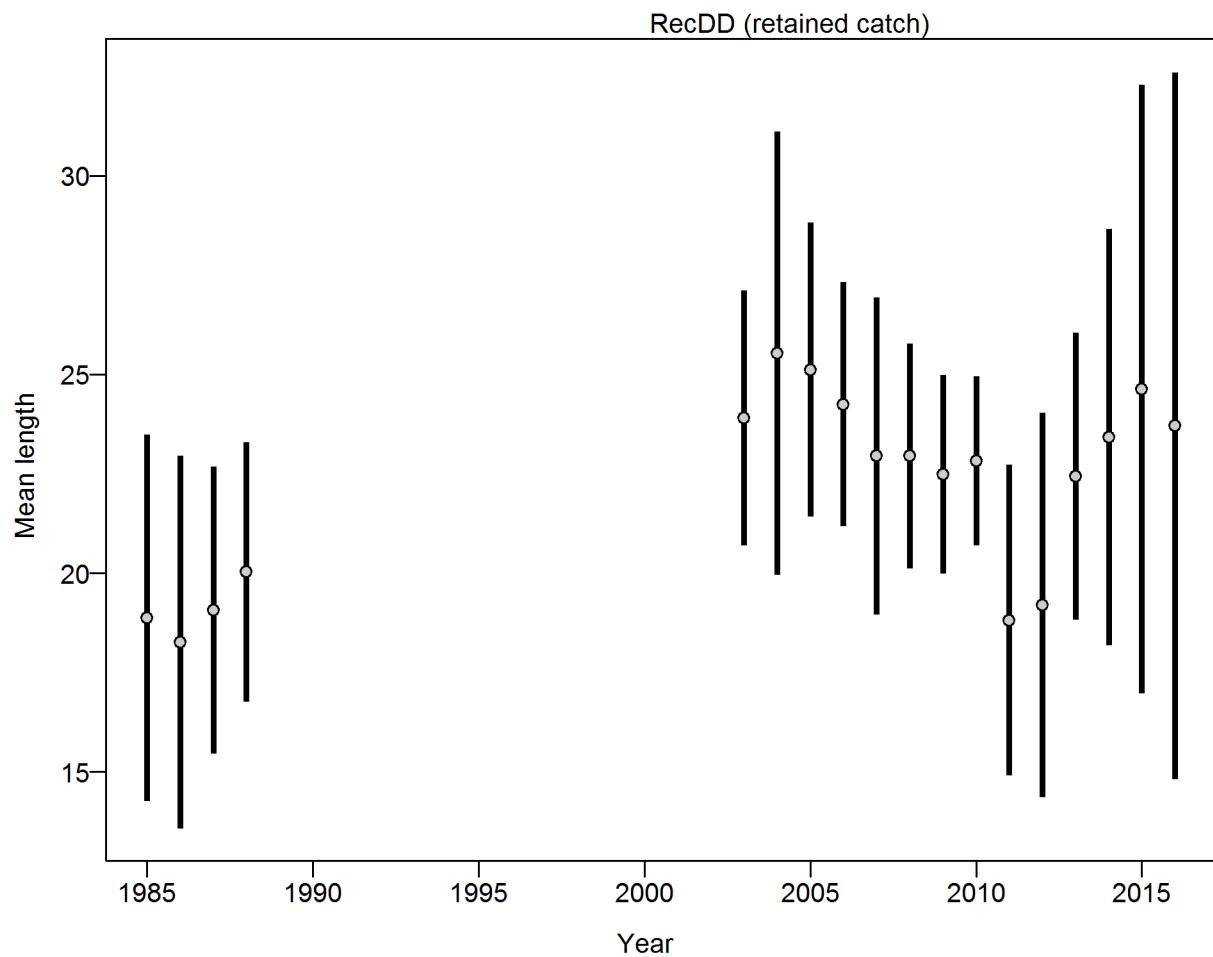


Figure 72: Francis data weighting method TA1.8 for conditional age data from the recreational discard-catch fleet. Suggested sample size adjustment (with 95% interval) for the length data from the recreational discard-catch fleet is 0.9793 (0.7467-1.8748). For more info, see Francis et al. (2011).

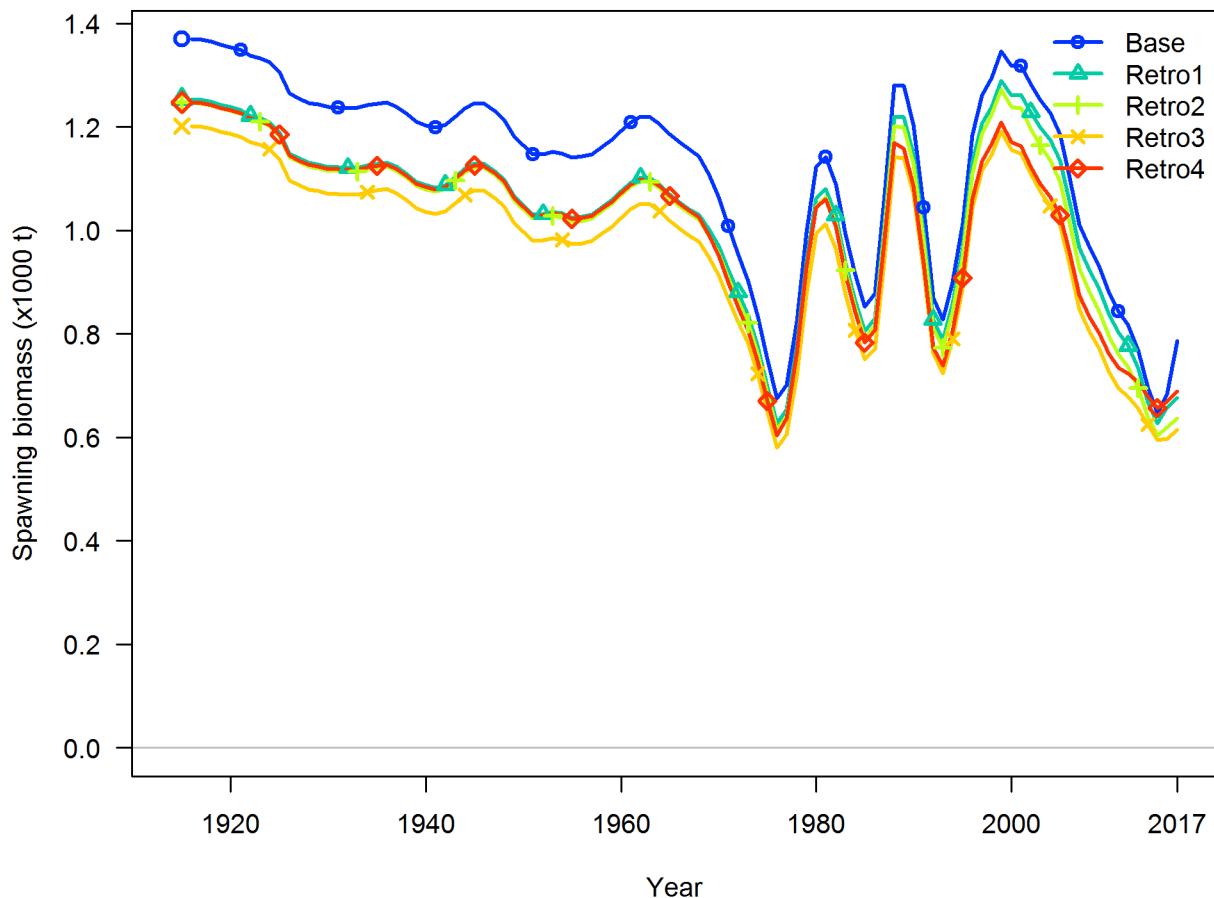


Figure 73: Retrospective pattern for spawning output.

<sup>1897</sup> fig:retro\_recdev

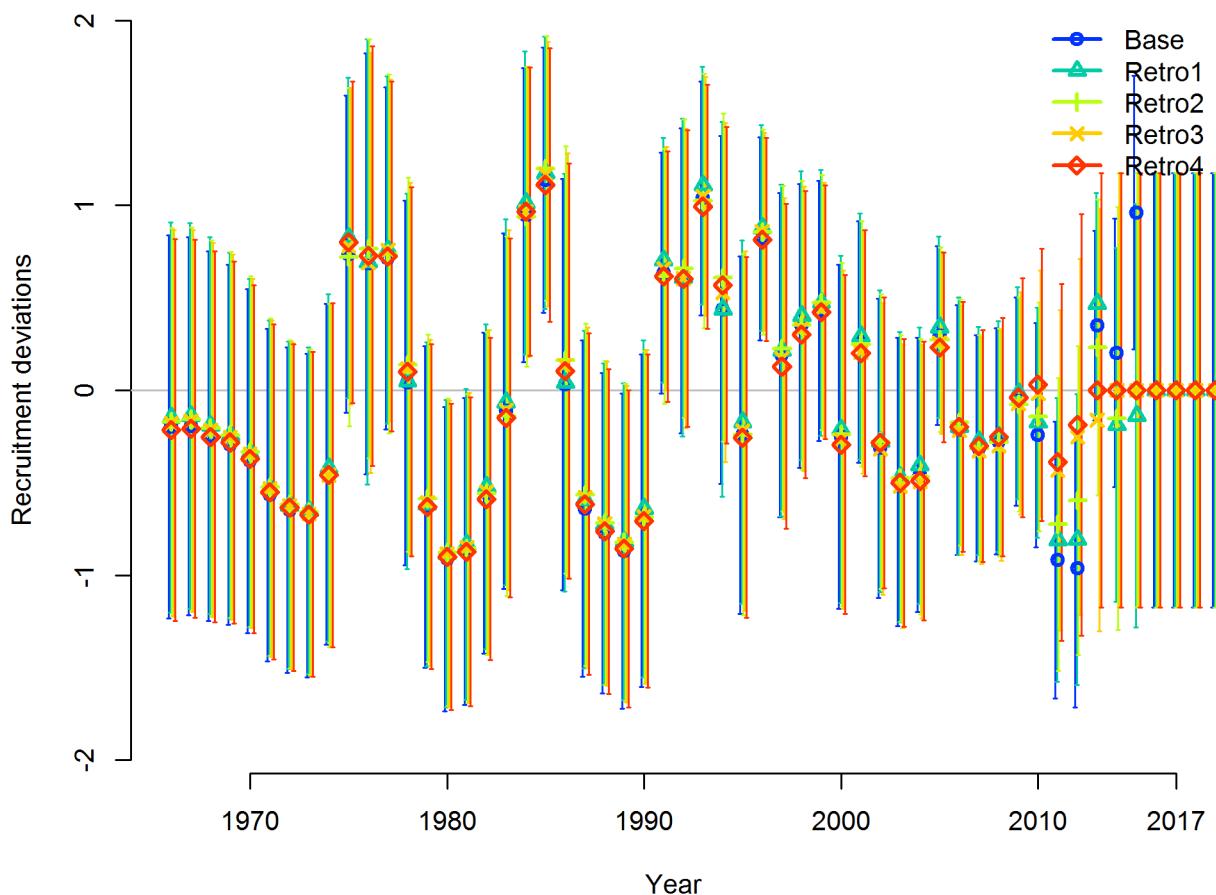


Figure 74: Retrospective pattern for estimated recruitment deviations.

### Changes in length-composition likelihoods by fleet

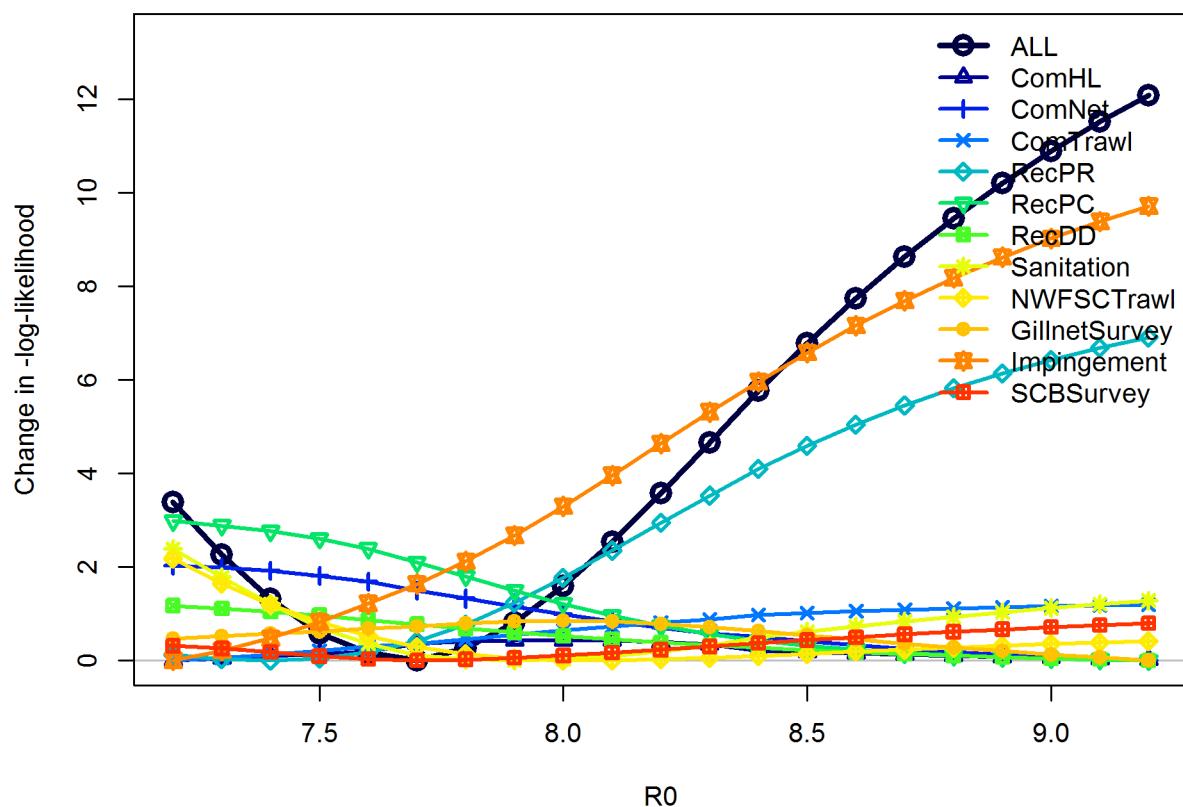


Figure 75: Likelihood profile across  $R_0$  values by fleet.

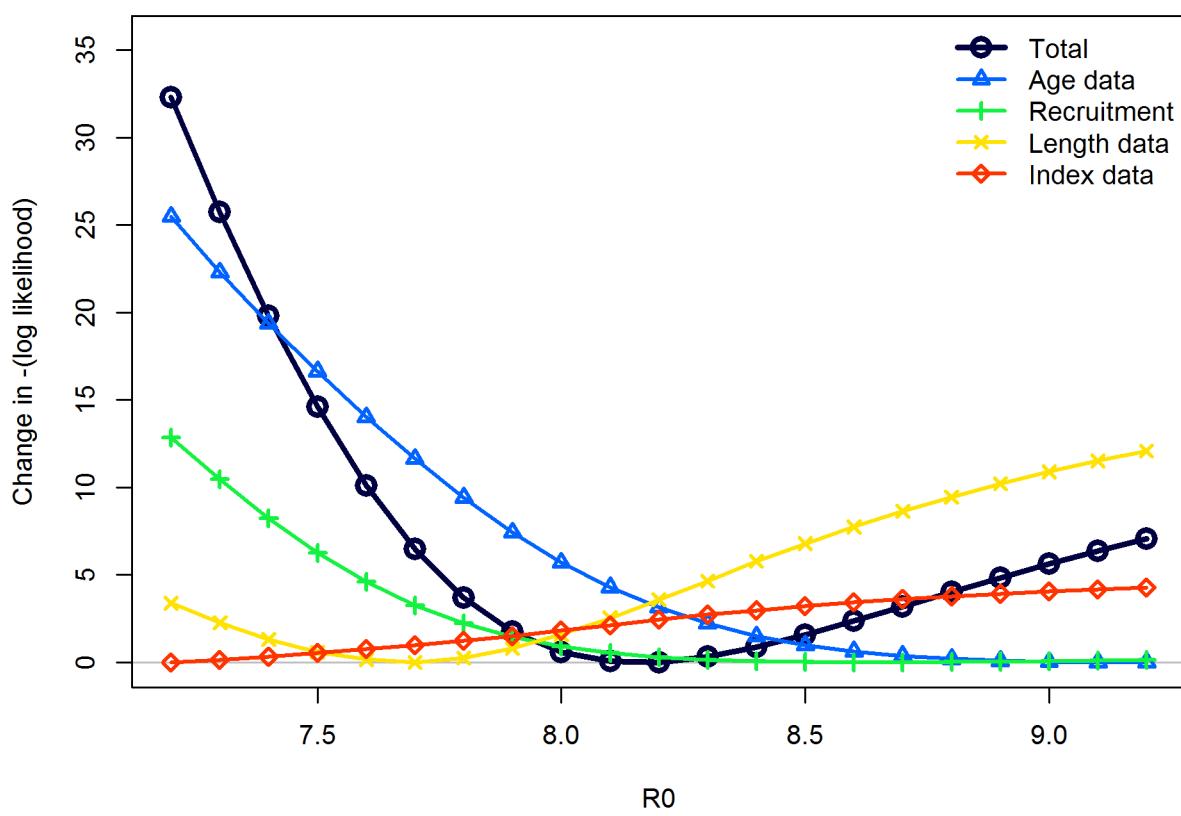


Figure 76: Likelihood profile across  $R_0$  values for each data type.

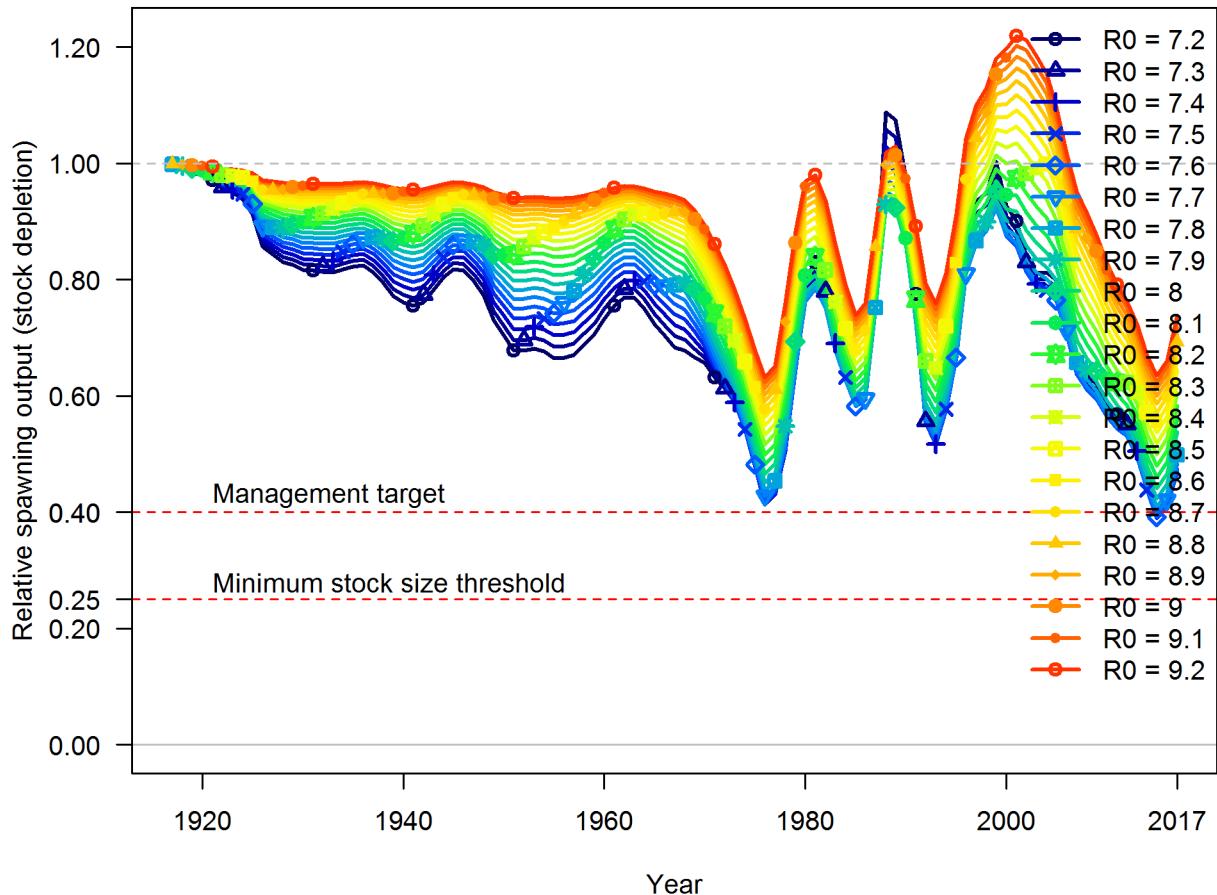


Figure 77: Trajectories of depletion across values of  $R_0$ .

### Changes in length-composition likelihoods by fleet

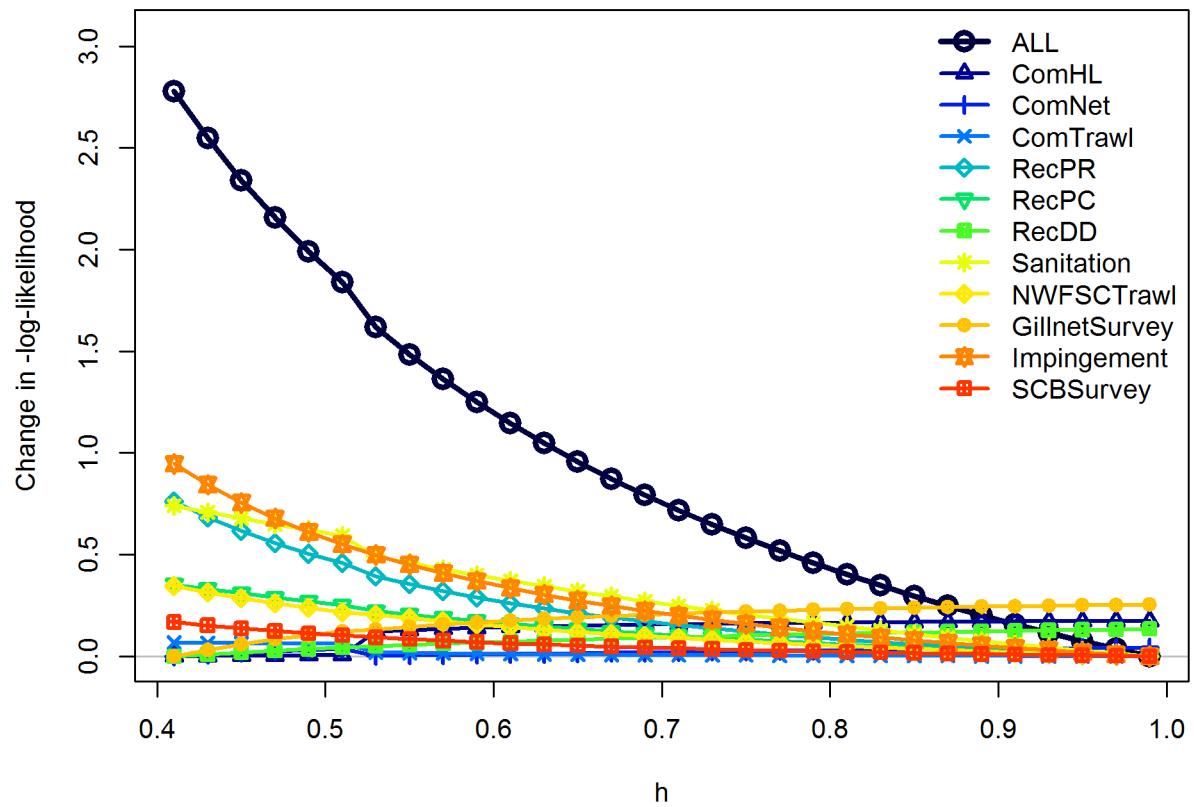


Figure 78: Likelihood profile across steepness values by fleet.

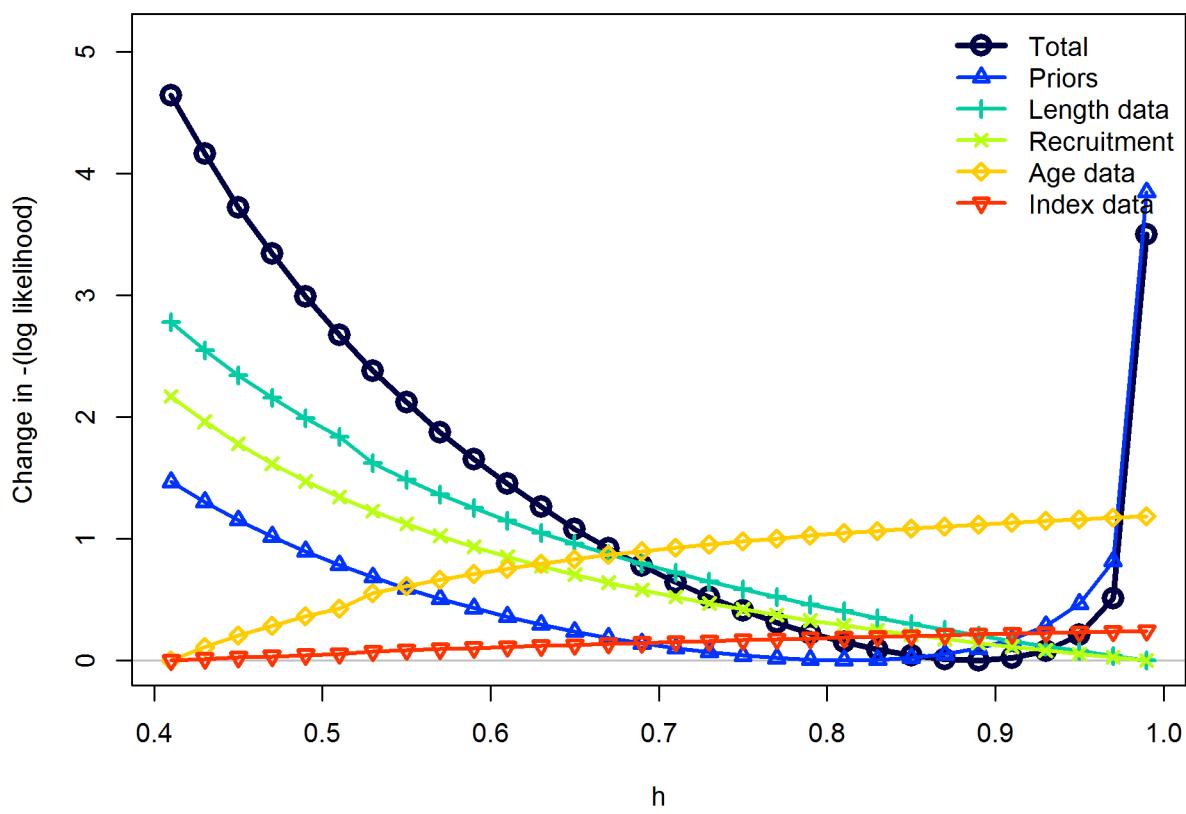


Figure 79: Likelihood profile across steepness values for each data type.

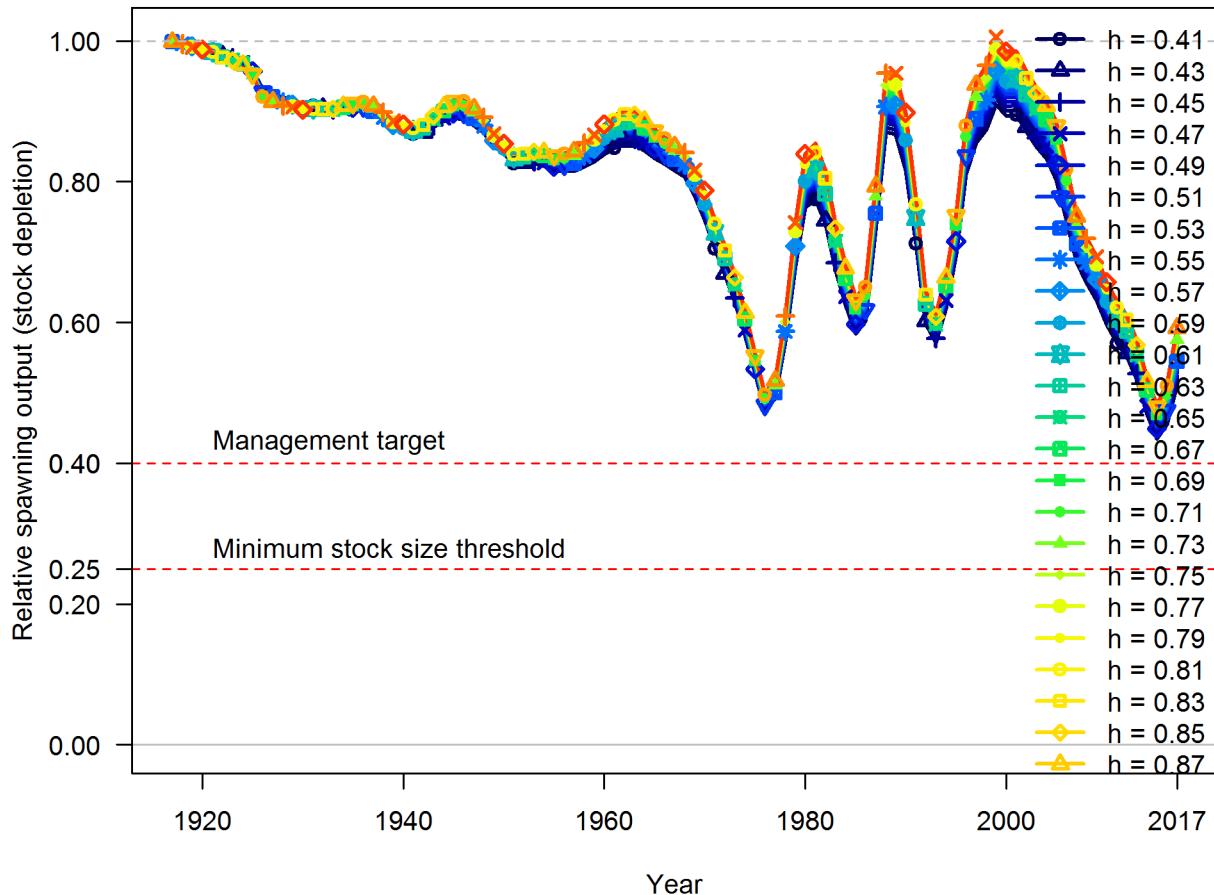


Figure 80: Trajectories of depletion across values of steepness.

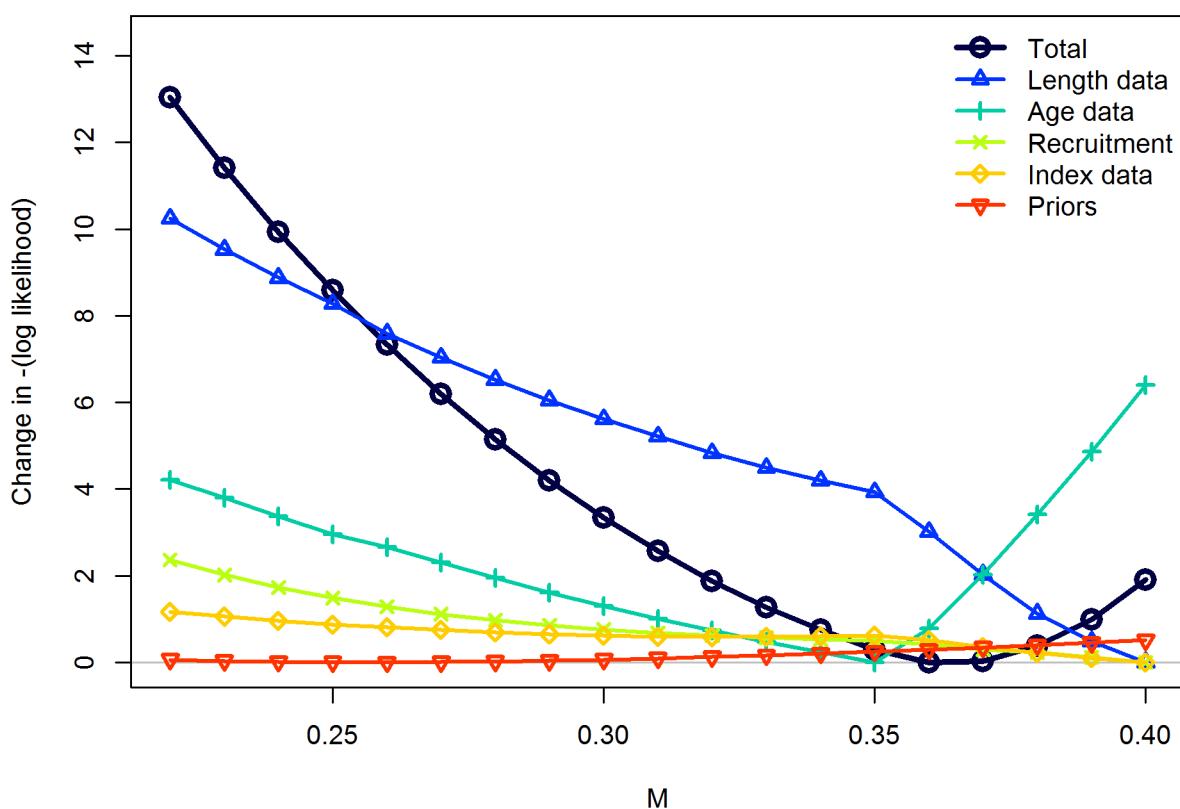


Figure 81: Likelihood profile across female natural mortality values for each data type.

### Changes in length-composition likelihoods by fleet

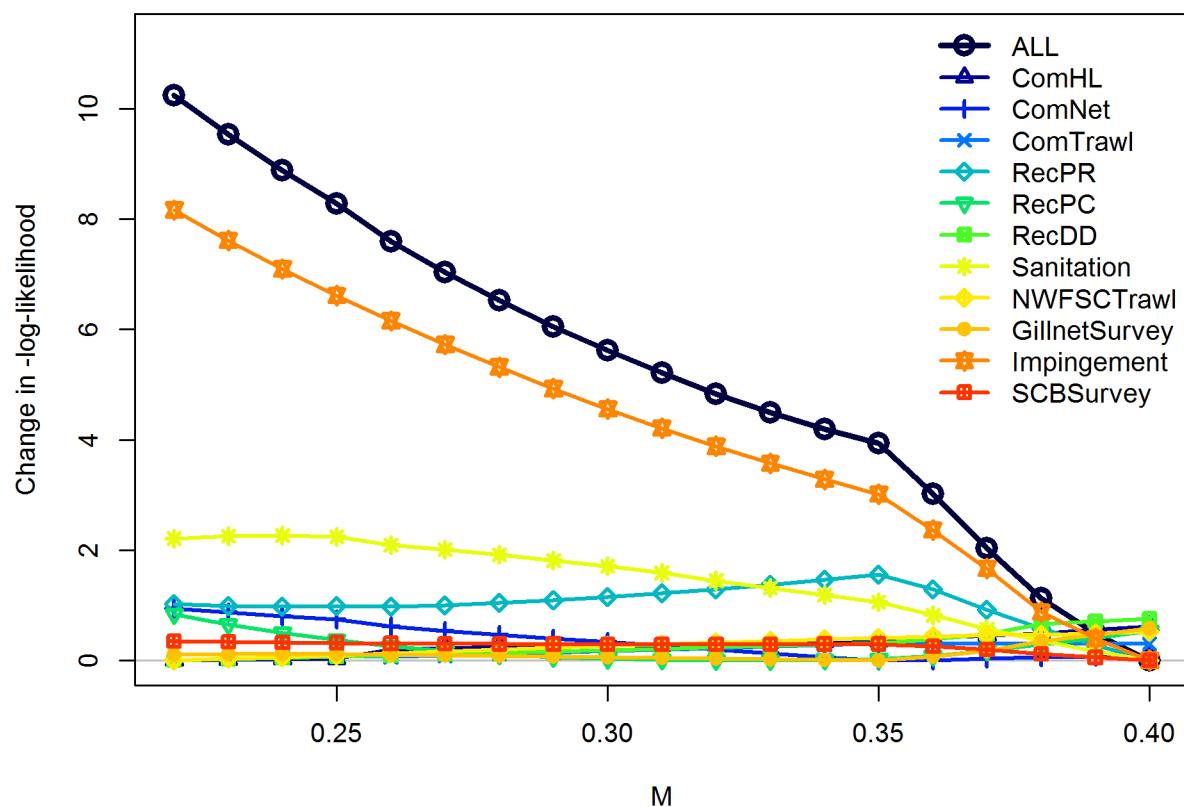


Figure 82: Likelihood profile across female natural mortality values by fleet.

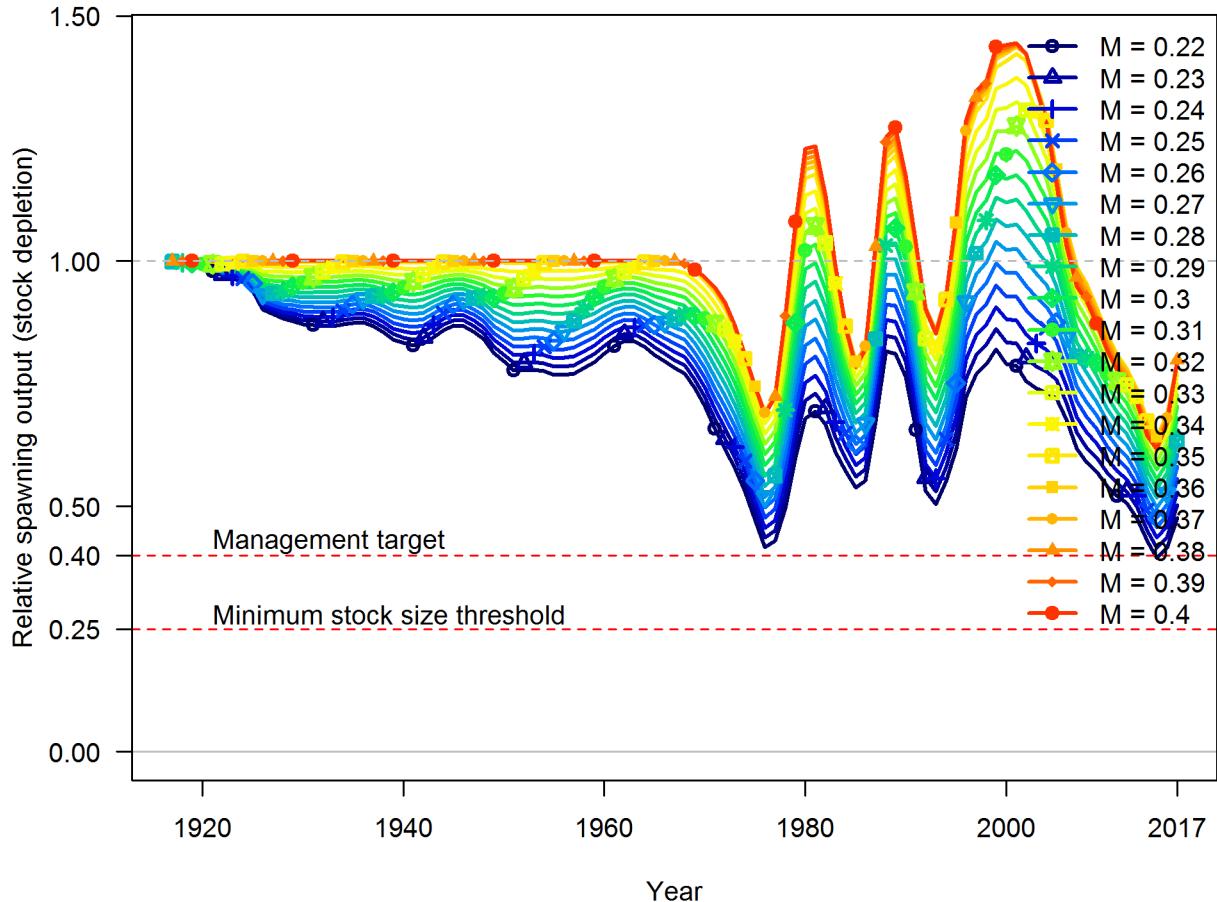


Figure 83: Trajectories of depletion across values of female natural mortality.

### Spawning biomass (mt) with ~95% asymptotic intervals

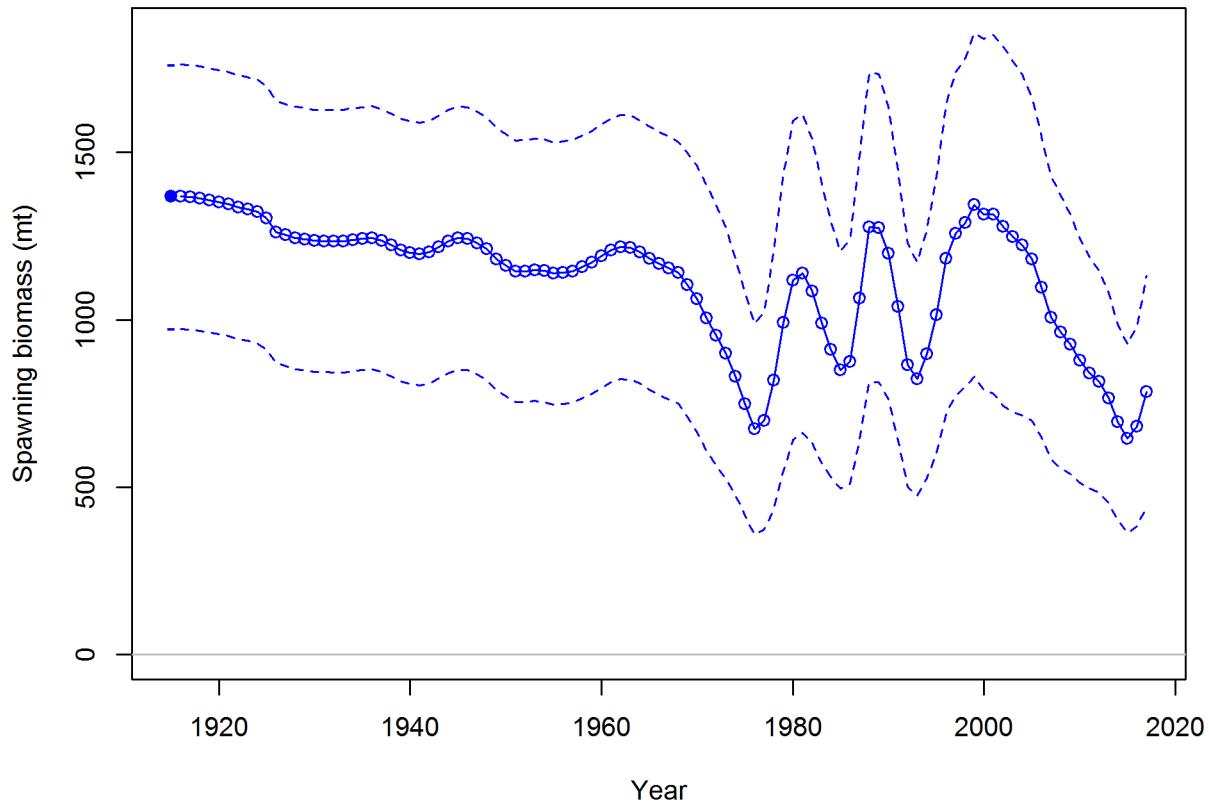


Figure 84: Estimated spawning biomass (mt) with approximate 95% asymptotic intervals.

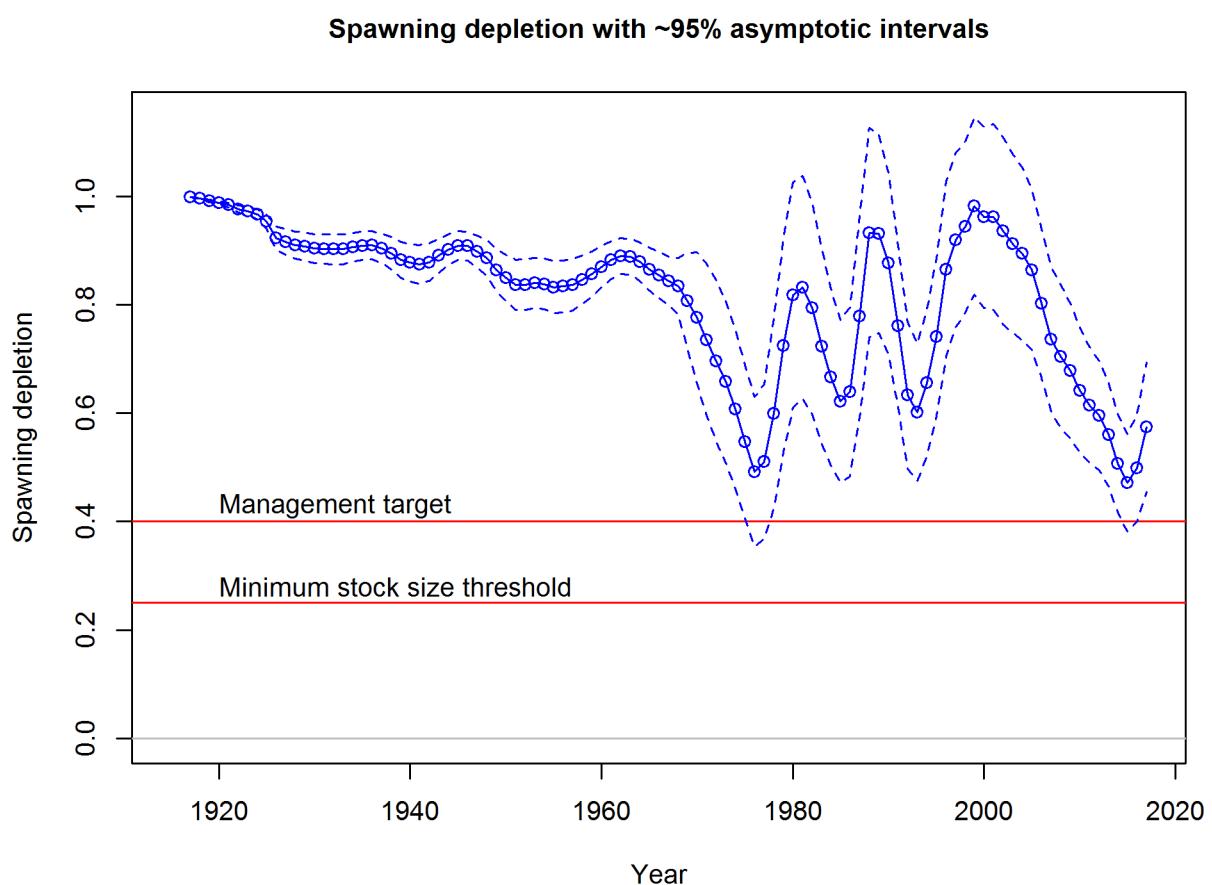


Figure 85: Estimated spawning depletion with approximate 95% asymptotic intervals.

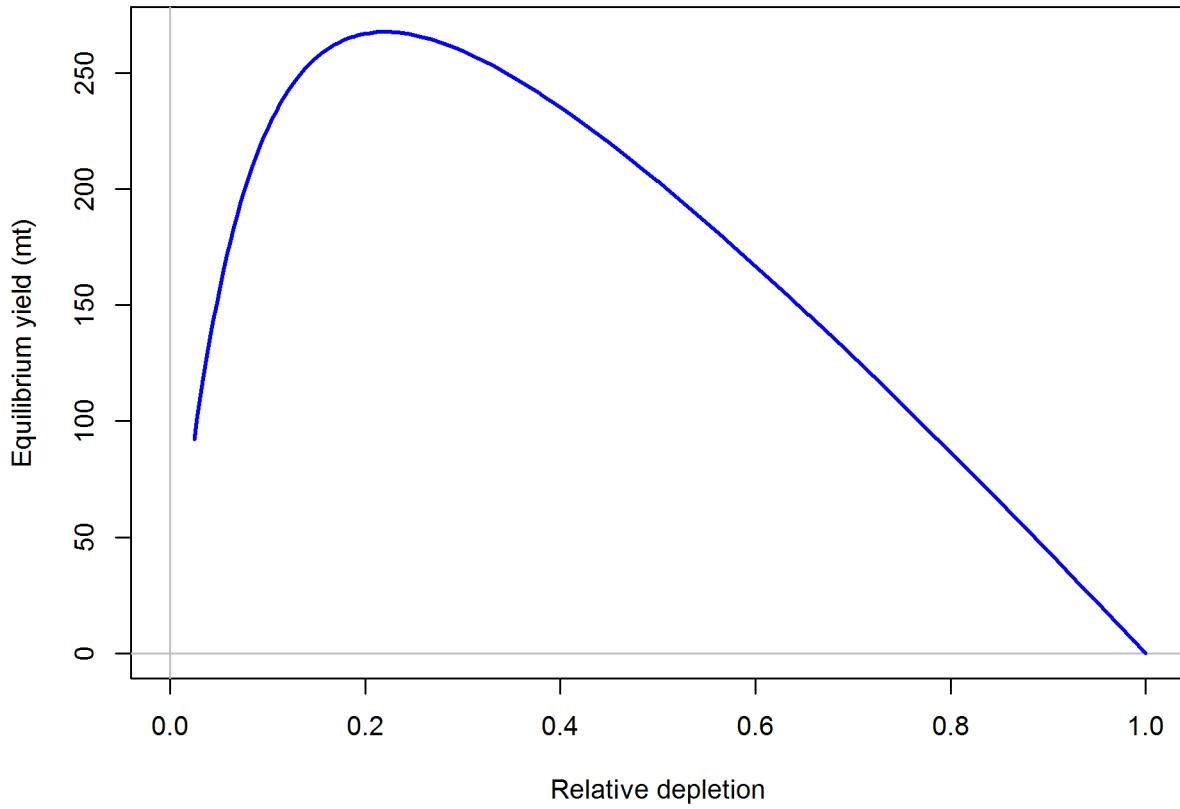


Figure 86: Equilibrium yield curve for the base case model. Values are based on the 2016 fishery selectivity and with steepness fixed at .

1898 Appendix A. Detailed fits to length composition data

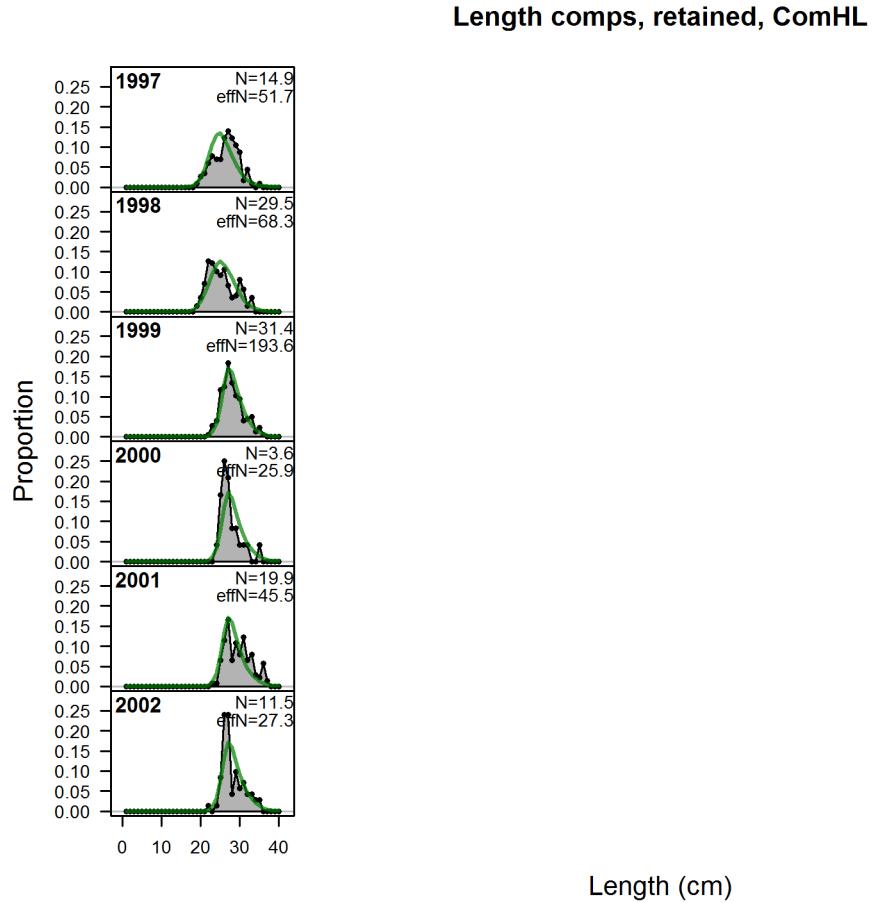


Figure A87: Length comps, retained, ComHL

### Length comps, retained, ComNet

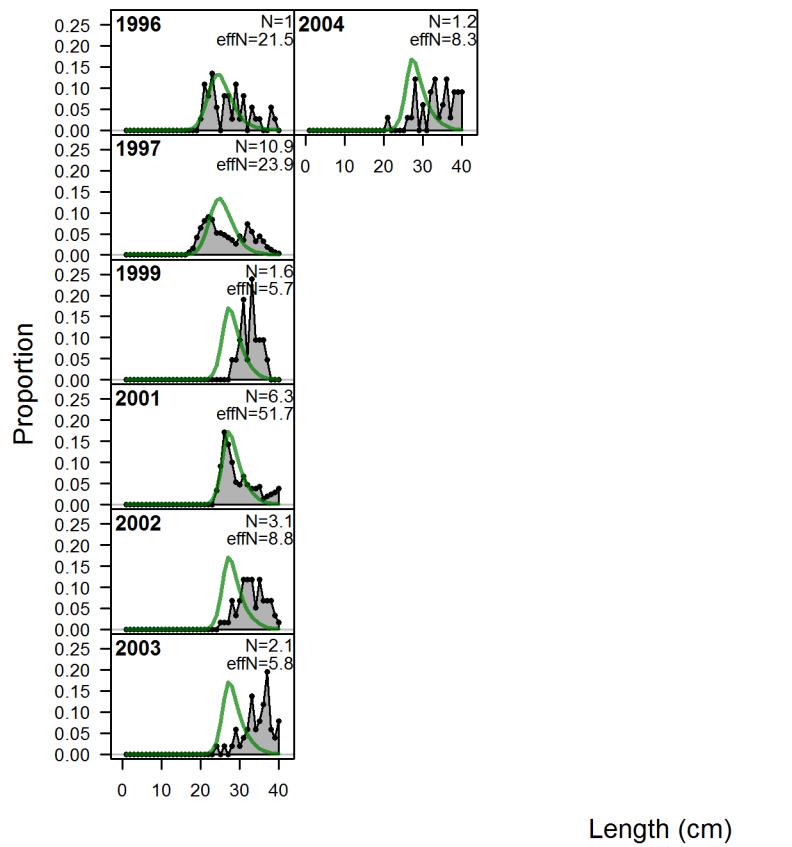


Figure A88: Length comps, retained, ComNet

### Length comps, retained, ComTrawl

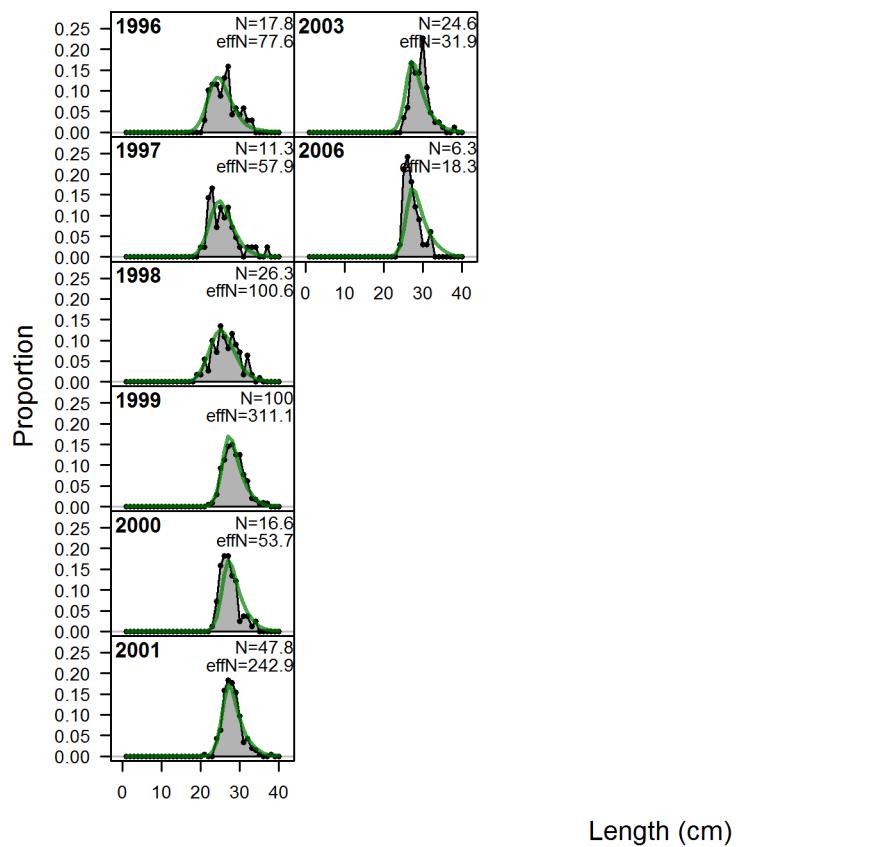


Figure A89: Length comps, retained, ComTrawl

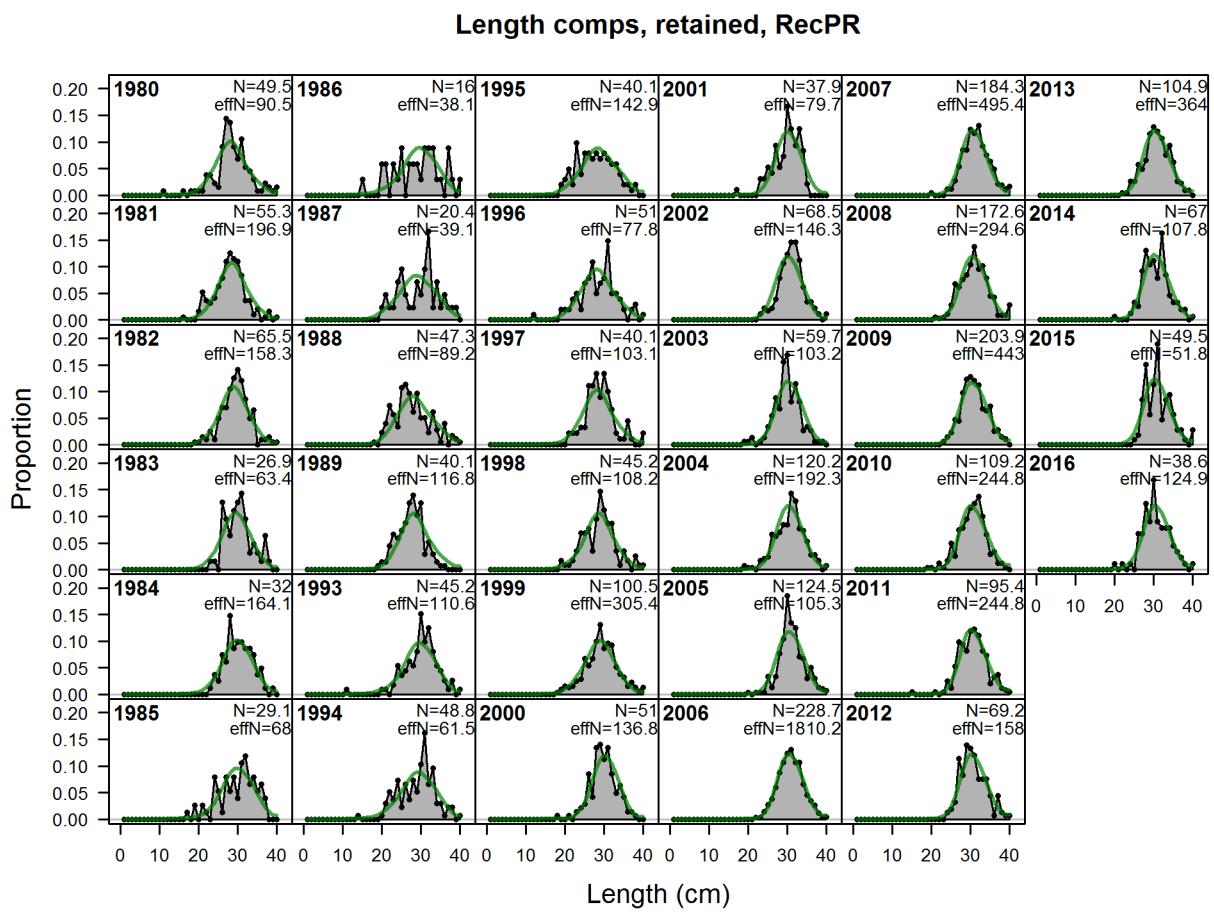


Figure A90: Length comps, retained, RecPR

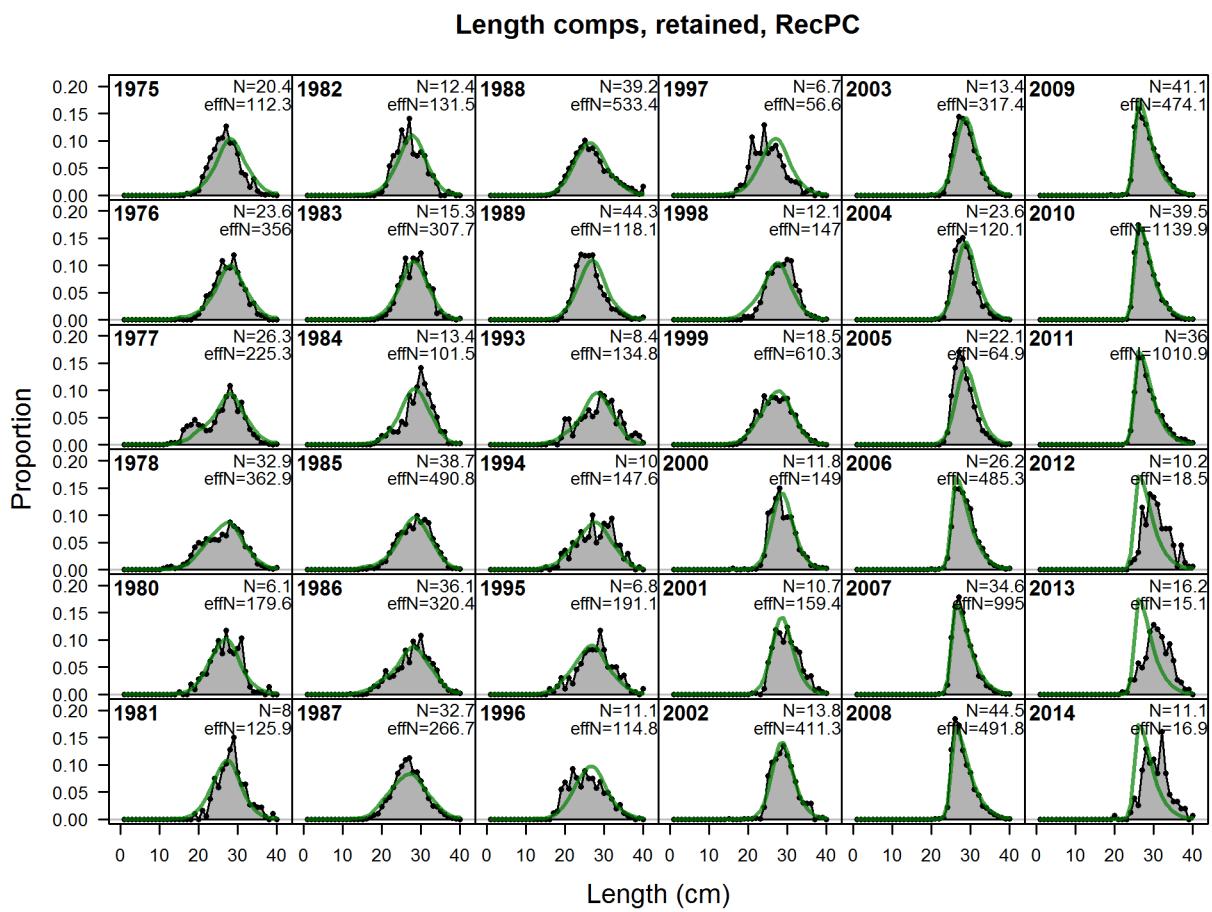
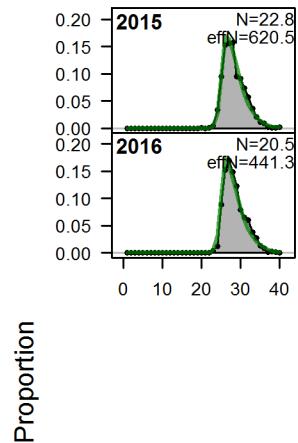


Figure A91: Length comps, retained, RecPC (plot 1 of 2)

**Length comps, retained, RecPC**



1899

Length (cm)

1900

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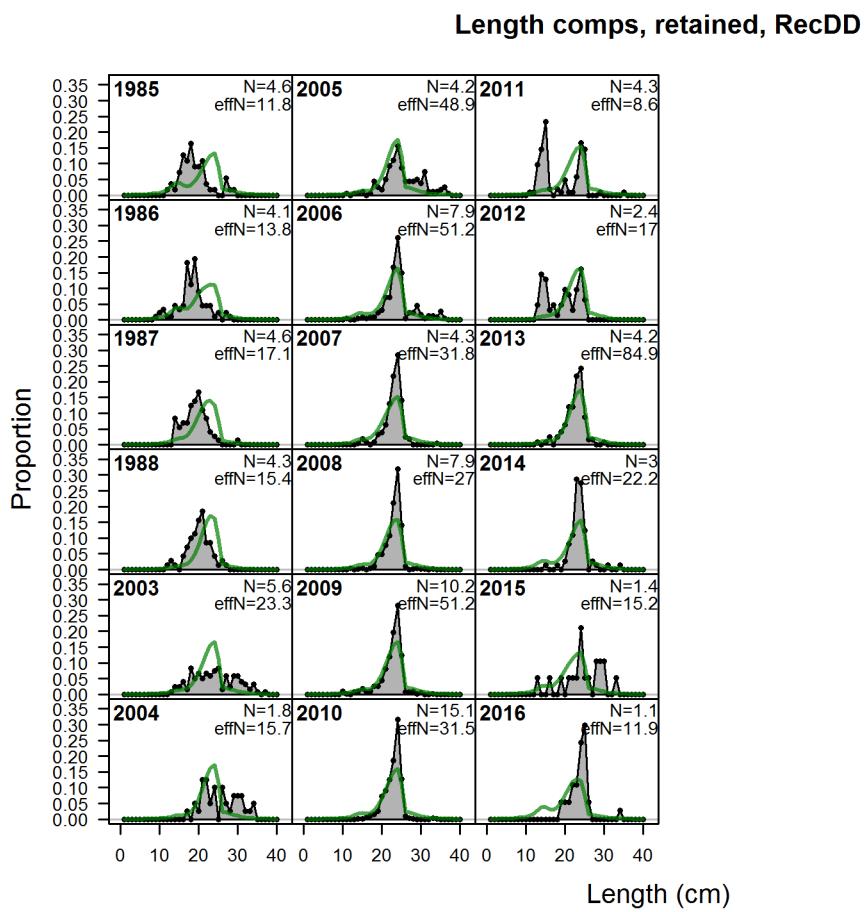


Figure A92: Length comps, retained, RecDD

### Length comps, retained, Sanitation

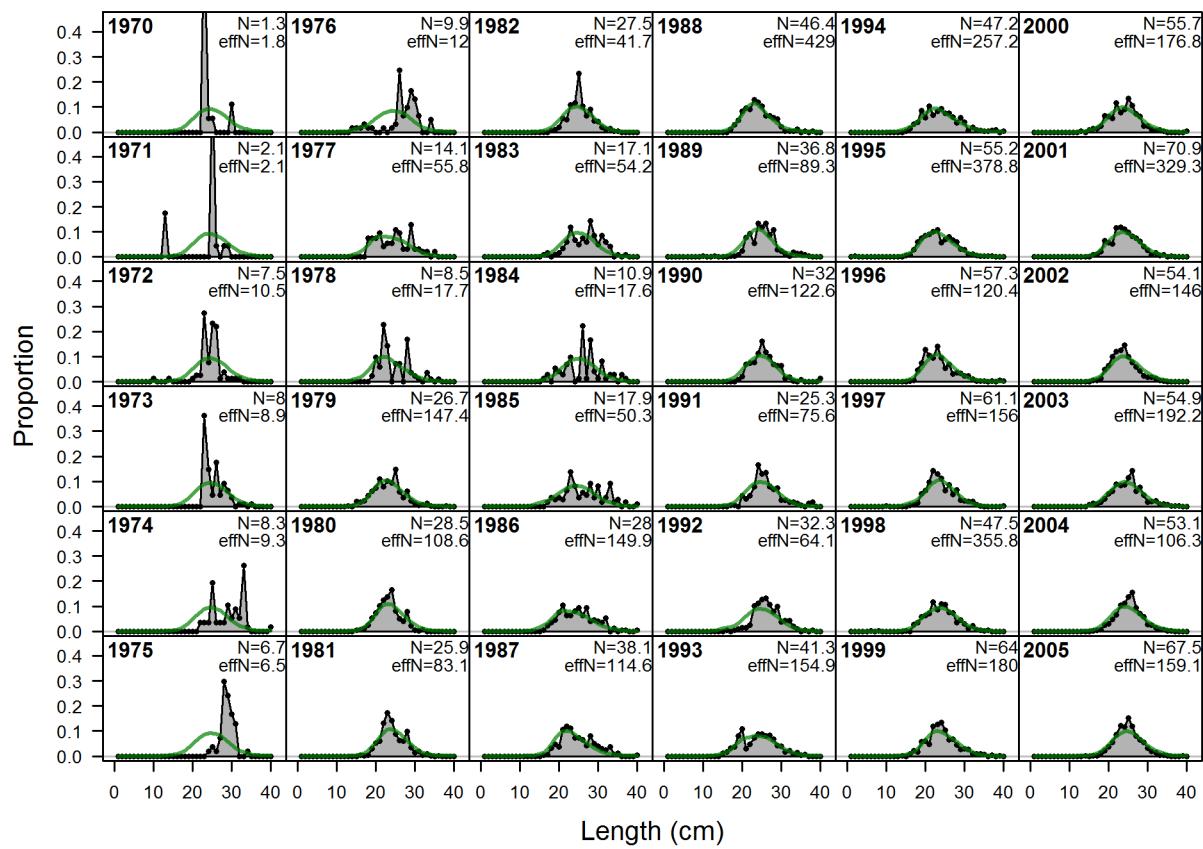
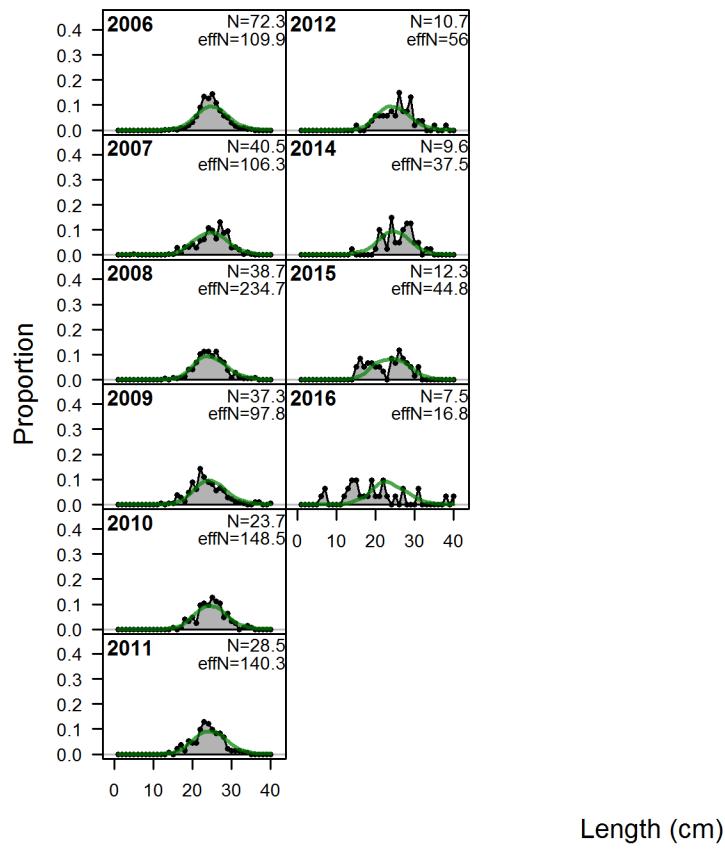


Figure A93: Length comps, retained, Sanitation (plot 1 of 2)

### Length comps, retained, Sanitation



1901

1902

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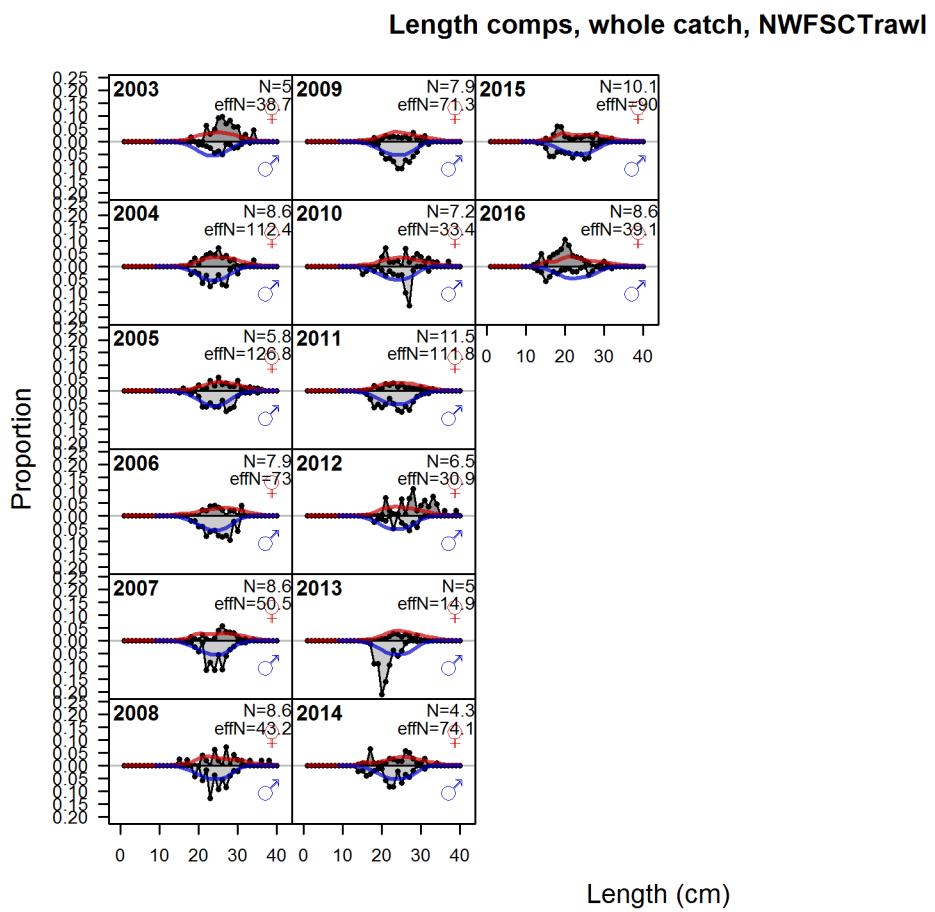


Figure A94: Length comps, whole catch, NWFSC Trawl

### Length comps, retained, GillnetSurvey

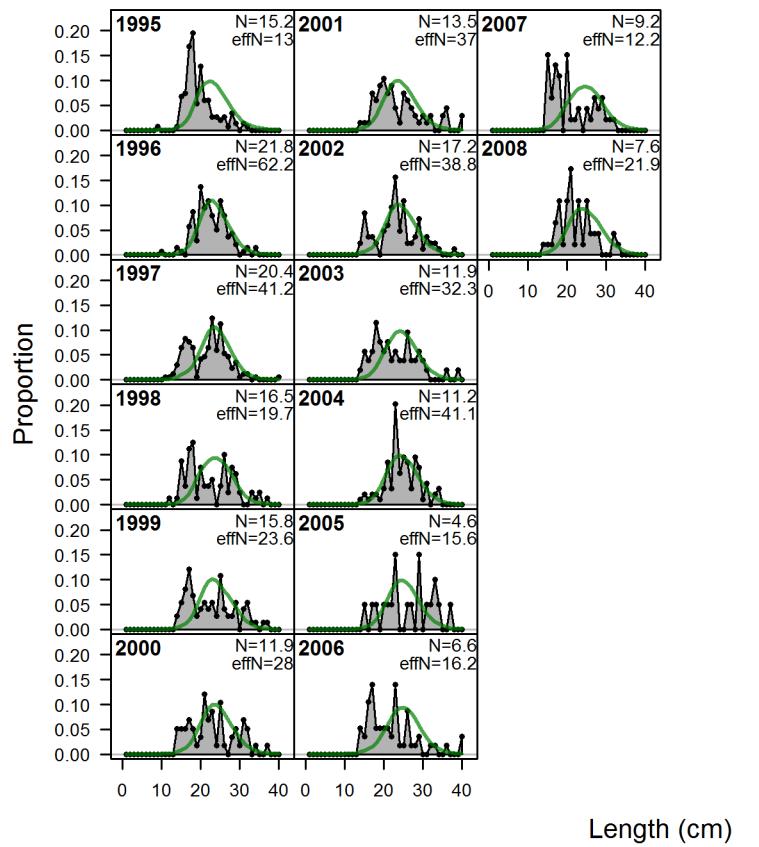


Figure A95: Length comps, retained, GillnetSurvey

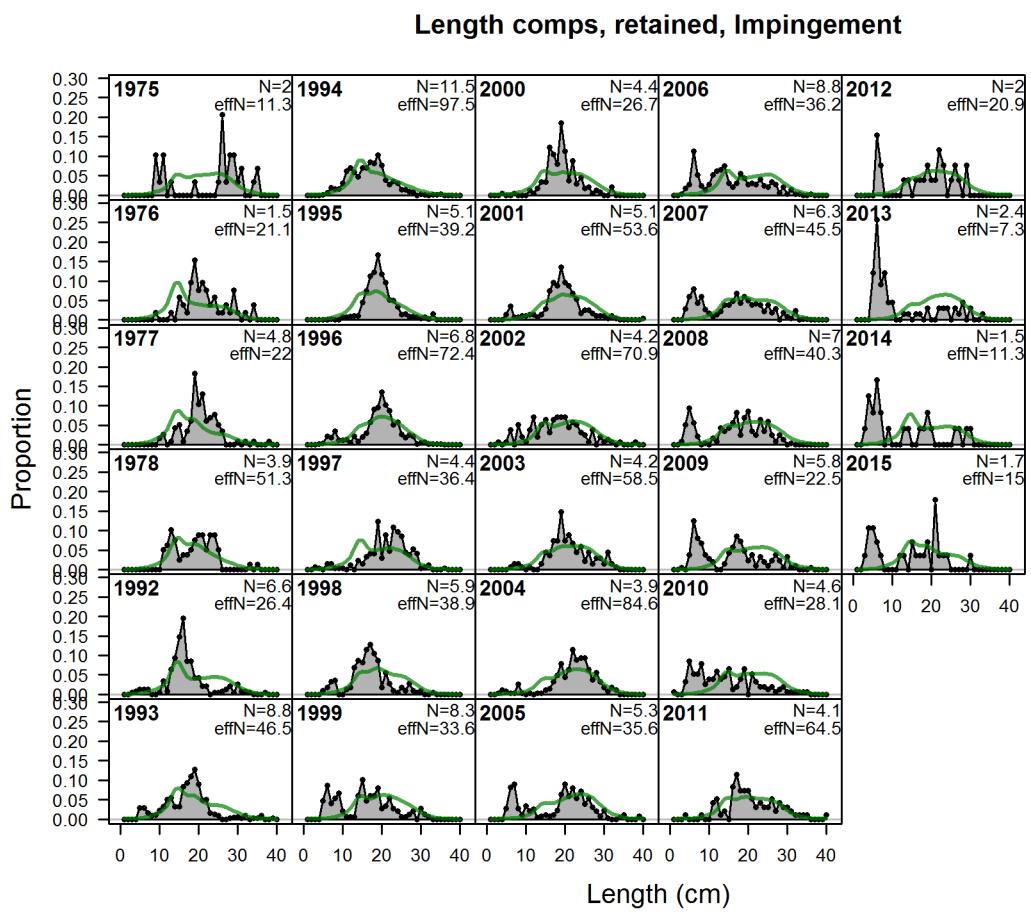


Figure A96: Length comps, retained, Impingement

### Length comps, retained, SCBSurvey

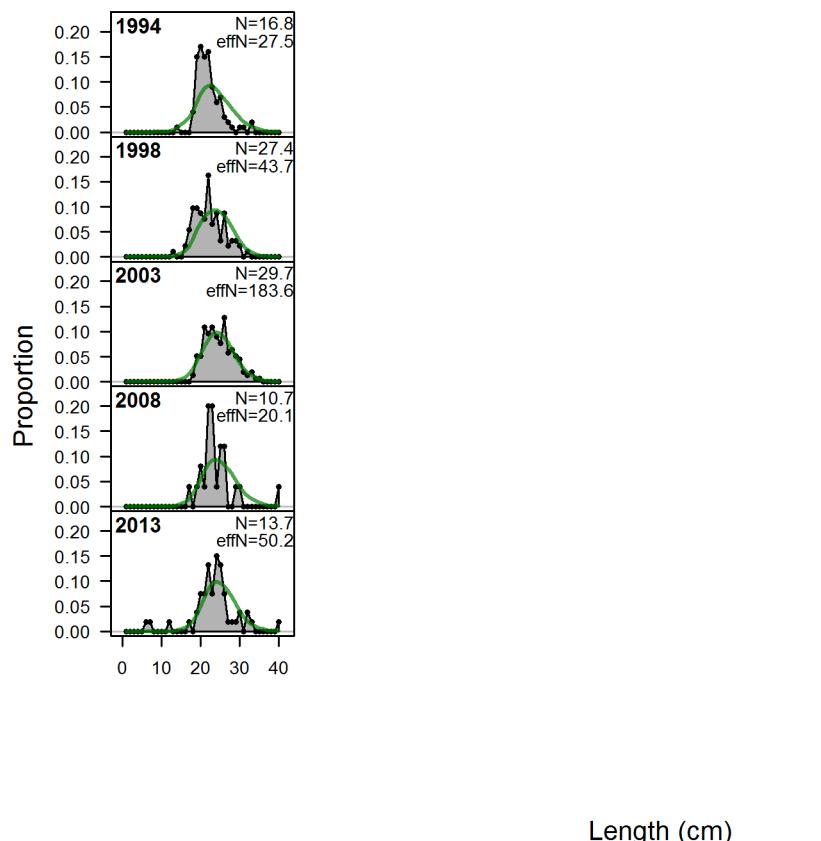


Figure A97: Length comps, retained, SCBSurvey

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