Status of bocaccio, *Sebastes paucispinis*, in the Conception, Monterey and Eureka INPFC areas as evaluated for 2013

John C. Field
Groundfish Analysis Team
Fisheries Ecology Division,
Southwest Fisheries Science Center
110 Shaffer Rd. Santa Cruz CA 95060
John.Field@noaa.gov

EXECUTIVE SUMMARY

Stock

This update of the 2011 stock assessment of the bocaccio rockfish (*Sebastes paucispinis*) reports the best estimate of bocaccio abundance and productivity off of the west coast of the United States, from the U.S.-Mexico border to Cape Blanco, Oregon (representing the Conception, Monterey and Eureka INPFC areas). This update conforms to the strict definition of an update as defined by the PFMC terms of reference, with respect to updating the 2011 model.

Catches

Bocaccio rockfish have long been one of the most important targets of both commercial and recreational fisheries in California waters, accounting for between 25 and 30% of the commercial rockfish (*Sebastes*) historical catch over the past century. However, this percentage has declined in recent years as a result of stock declines, management actions and the development of alternative fisheries. Since 2002 catches have generally been less than 200 tons per year, with the largest fraction of catches coming from the southern California recreational fishery.

Table E1. Recent catches (in metric tons) of bocaccio rockfish south of Cape Blanco

	Trawl south of 38° N	Trawl north of 38° N	Hook and line	Setnet	Rec south of 34.5° N	Rec north of 34.5° N	Total (S. of 43 ° N)
1999	19.00	53.00	26.00	20.70	7.20	71.00	196.90
2000	13.50	60.00	6.60	7.00	0.70	52.00	139.80
2001	9.20	49.00	4.40	7.80	0.90	60.00	131.30
2002	28.04	20.67	0.13	0.01	35.88	4.93	89.66
2003	5.07	0.31	0.00	0.00	5.53	1.87	12.78
2004	13.86	3.52	1.84	0.21	63.43	2.27	85.13
2005	24.64	0.43	1.50	0.17	69.90	10.70	107.34
2006	16.09	0.31	2.25	0.25	29.00	11.80	59.70
2007	4.06	1.58	3.39	0.38	44.20	8.92	62.53
2008	0.42	1.98	2.02	0.08	31.50	3.33	39.33
2009	1.12	4.85	1.50	0.03	40.30	9.70	57.50
2010	2.90	10.97	1.45	0.05	50.07	6.54	71.97
2011	1.30	4.93	2.39	0.01	99.26	4.06	111.95
2012	12.89	48.81	1.10	0.01	119.08	5.65	187.54

Data and Assessment

The last full assessment of bocaccio rockfish was done in 2009 using the SS3 assessment model, with an update (including several substantive model structural changes) in 2011. This update extends the time series included in that model for the CalCOFI larval abundance survey, the NWFSC Southern California Bight hook and line survey, the NWFSC combined trawl survey, the SWFSC juvenile abundance survey, and the power plant impingement index. No new length frequency data are available for commercial fisheries, however new length frequency data are available and included for southern and central/northern California recreational fisheries. An index for the recent (2003-2011) southern California recreational fishery was developed and included in the model documentation, but was not included in the model.

In the 2011 update it was found that the length composition data from the 2010 NWFSC trawl survey was dominated by small (Young-of-the-Year, YOY) individuals, which had an overly strong influence on the model results in the initial (pre-review) models. As a result, a narrow range of analyses were recommended by the SSC to address how best to address the potential magnitude of this year class. Ultimately, the STAT proposed a model in which it is assumed that the bottom trawl survey does not provide an accurate index of age 0 abundance. The index and associated length composition data were revised to remove age 0 fish (fish smaller than 22 cm), and age selectivity was fixed to be non-selective for age 0 fish. Additionally, in order to account for what appeared to be several strong incoming year classes at that time (2009, 2010), the 2011 model included an index of YOY abundance derived from southern California power plant impingement survey data. This index extends nearly 30 years, and was found to have a strong correlation with the model estimated recruitment time series, the index remains in this update.

Stock spawning output

For this update, trends in abundance and historical recruitment are only modestly changed from the 2009 and 2011 model results. The final result is nearly identical through the 2011 period, but is slightly more optimistic with respect to current (2013) depletion due to the increased estimated year class strength of the 2009 and 2010 year classes (31.4%, relative to ~28% in the 2011 update). These year classes were strongly evident in recreational length frequency data, in the NWFSC hook and line survey data (and length comps), in the power plant impingement dataset and in an index (not included) of recreational CPUE. However, the NWFSC combined trawl survey index continued to decline, suggesting that somehow fish were less available to this survey (although the length composition data from this survey also capture strong 2009 and 2010 year classes).

The most recent (2011) point in the CalCOFI index was comparable to a (recent) relative high point (2008), with the overall trend from this survey over the past ~5 years is relatively flat. This is to be expected as this index reflects spawning output, and thus does not yet capture the presumed increase in spawning output that will be associated with the strong 2009 and 2010 year classes. As these year classes mature, the stock spawning output is predicted to increase substantially, with the base model projection (under the assumption of the rebuilding SPR of 0.777) indicating that the stock is likely to be rebuilt by 2015 (expected to be ~43% of unfished spawning output).

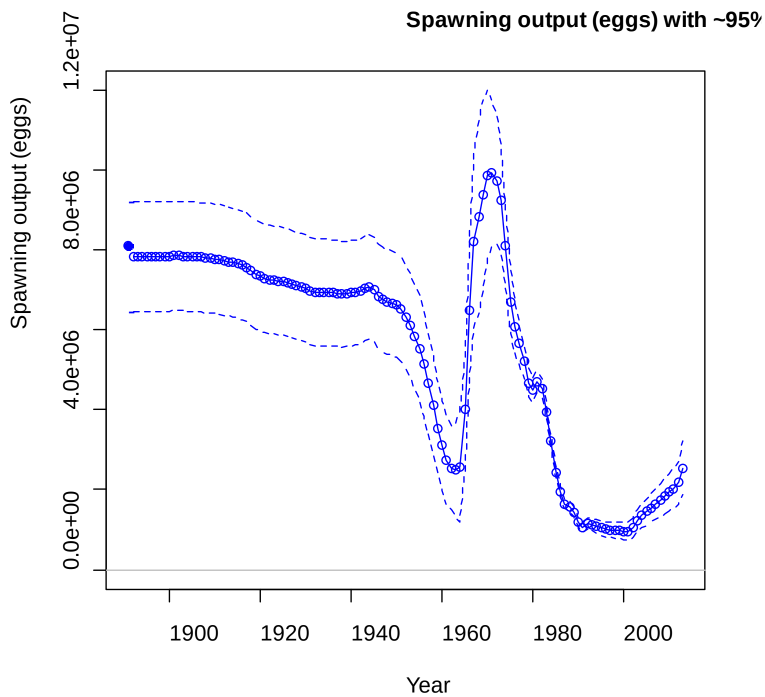


Figure E1. Estimated spawning output time series (1892-2013) for the base case, with approximate 95% confidence interval.

Table E2. Recent trends in estimated spawning output and relative depletion level

Year	Spawning output (10^9 larvae)	CV Spawning output	Depletion	Confidence interval depletion (~95%)
1999	975	0.11	12.01%	(0.093 - 0.146)
2000	961	0.11	11.84%	(0.091 - 0.145)
2001	956	0.12	11.78%	(0.09 - 0.145)
2002	1053	0.12	12.97%	(0.099 - 0.16)
2003	1233	0.12	15.19%	(0.116 - 0.187)
2004	1373	0.12	16.92%	(0.129 - 0.208)
2005	1454	0.12	17.91%	(0.136 - 0.221)
2006	1541	0.12	18.98%	(0.144 - 0.235)
2007	1644	0.12	20.25%	(0.153 - 0.251)
2008	1745	0.12	21.49%	(0.162 - 0.267)
2009	1850	0.12	22.78%	(0.171 - 0.283)
2010	1936	0.12	23.85%	(0.179 - 0.297)
2011	2022	0.13	24.91%	(0.186 - 0.311)
2012	2176	0.13	26.81%	(0.199 - 0.336)
2013	2551	0.13	31.43%	(0.231 - 0.396)

Recruitment

Recruitment for bocaccio is highly variable, with a small number of year classes tending to dominate the catch in any given fishery or region. Recruitment appears to have been at very low levels throughout most of the 1990s, but the 1999 year class was the highest since 1988, and led to a substantive increase in abundance during the early 2000s. Several year classes of moderate strength (2003, 2005) occurred in the mid-2000s, and two recent very strong year classes (2009 and 2010) are now estimated to be comparable to (2009) and roughly double (2010) the size of the 1999 year class. These strong year classes are already estimated to have resulted in an increase in abundance and spawning output, and should propel the stock spawning output to target levels by approximately 2015 as the 2010 year class continues to grow and mature. Preliminary estimates from the juvenile rockfish survey also indicate very strong abundance of young-of-the-year rockfish of many species (including bocaccio) in 2013, suggesting anecdotally that 2013 will also be a strong recruitment year for bocaccio, as well as for other species. However, these data are not yet incorporated into the 2013 update, which only includes data through 2012. Estimated recruitments and model derived confidence intervals for 1999 to 2012 recruitments are shown in Table E3 and Figure E3.

Table E3. Estimated recruitment with 95% confidence interval, 1999-2012

	Recruits (1000s)	CV Recruitment	Confidence interval recruitment (~95%)
1999	6690	0.12	(5024 - 8354)
2000	274	0.36	(74 - 474)
2001	249	0.36	(71 - 425)
2002	942	0.19	(581 - 1302)
2003	3302	0.14	(2408 - 4195)
2004	425	0.29	(177 - 672)
2005	3191	0.14	(2277 - 4103)
2006	927	0.24	(484 - 1369)
2007	1844	0.17	(1203 - 2484)
2008	2071	0.18	(1328 - 2813)
2009	5074	0.16	(3422 - 6725)
2010	14000	0.16	(9469 - 18529)
2011	2252	0.34	(736 - 3767)
2012	1881	0.60	(0 - 4156)

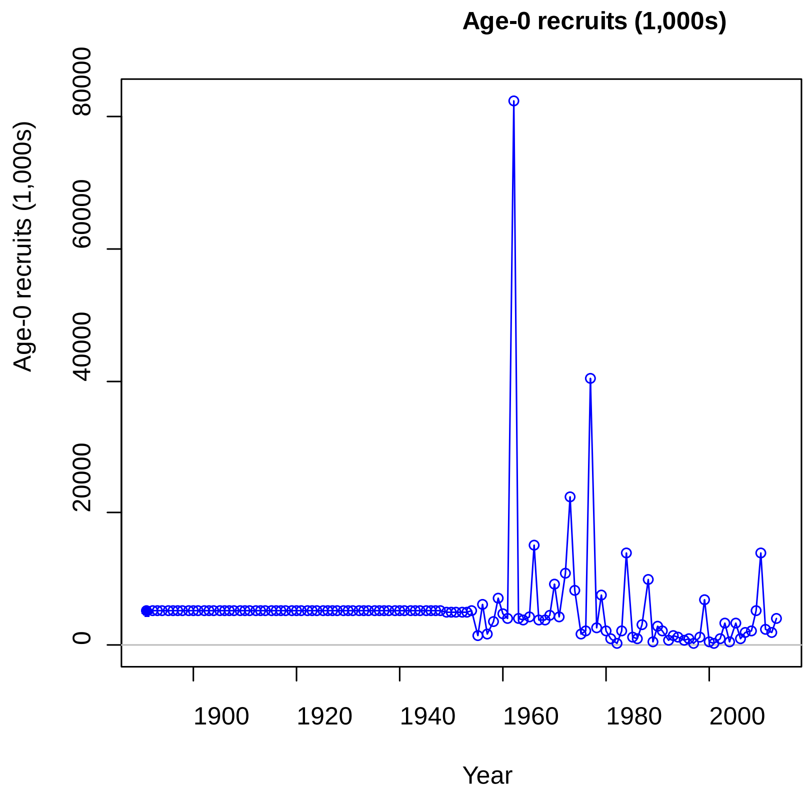


Figure E3. Estimated recruitment of bocaccio rockfish from 1892-2013

Reference Points

Reference points are presented in Table E4, including the unfished summary biomass, unfished spawning output, mean unfished recruitment, the proxy estimates for MSY based on the $SPR_{50\%}$ rate, the fishing mortality rate associated with a spawning stock output of 40% of the unfished level, and MSY estimated based on the spawner/recruit relationship. Reference points did not change substantively from previous estimates, although the slightly higher estimate of h in this update is reflected in slightly higher estimates of MSY and the MSY proxies. As with earlier models, the difference between the estimated MSY (1378) and the proxy MSY reference points (1341-1347) is minimal, despite a substantial decline in the SPR and spawning output associated with the estimated MSY value.

Table E4. Summary of reference points for bocaccio rockfish from the base model

Unfished Stock	Estimate	~ 95% Confidence Limits Lower	Upper
Summary (1+) Biomass (tons)	45476	37435	53517
Spawning Output (* 10^9)	8118	5302	10934
Equilibrium recruitment	5169	3370	6968

	Yield reference Points		
	$SSB_{40\%}$	SPR proxy	MSY est.
SPR	0.494	0.500	0.428
Exploitation rate	0.068	0.067	0.084
Yield (tons)	1347	1341	1378
Spawning output ($x10^9$)	3247	3307	2614
SSB/SSB_0	0.4	0.41	0.32

Exploitation Status

The 2013 spawning output is estimated to be at 31% of the unfished spawning output, and exploitation rates are estimated to have ranged from 0.04 to 0.08% over the past five years, with corresponding SPR ratios of approximately 0.11 to 0.21 of the default SPR of 0.5. (Table E5, Figures E5-E6).

Table E5. Base model estimated exploitation rate and spawning potential ratio (SPR)

Year	Total catch	Exploitation rate	SPR rate (rel. to 0.5)
1999	213	0.219	0.69
2000	160	0.167	0.55
2001	139	0.145	0.39
2002	90	0.085	0.21
2003	13	0.010	0.03
2004	85	0.062	0.19
2005	107	0.074	0.23
2006	60	0.039	0.13
2007	63	0.038	0.13
2008	59	0.034	0.11
2009	58	0.031	0.11
2010	75	0.039	0.14
2011	112	0.055	0.16
2012	188	0.086	0.21

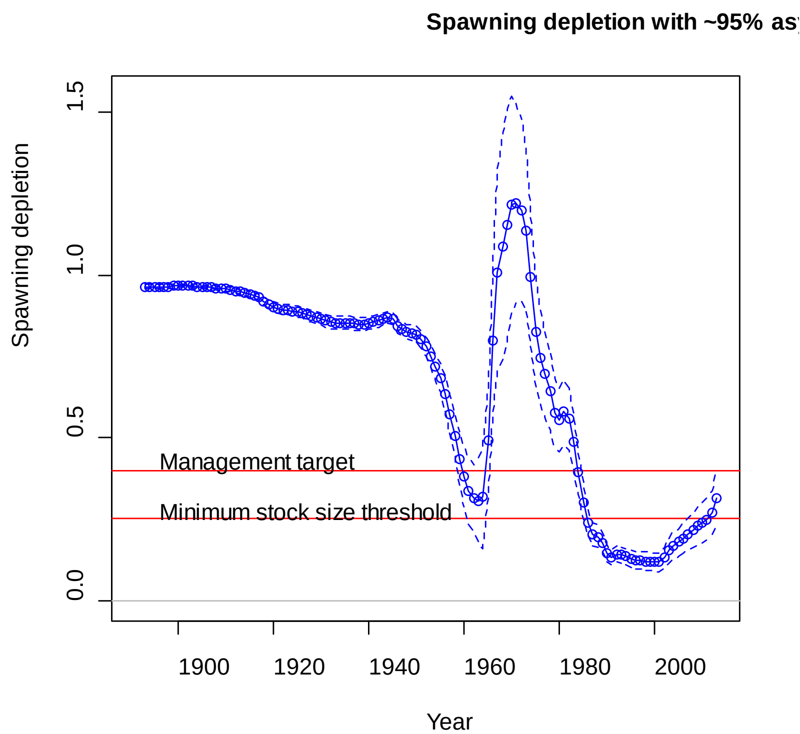


Figure E4. Time series of estimated depletion level of bocaccio from the STAT base model

Management Performance and forecast

Bocaccio rockfish were formally designated as overfished in March of 1999, and the OY/ACL has ranged from 218 to 337 tons since 2003 (Table E6), with actual catches (including discards) estimated to be less than half of that amount in most years. The current forecast is for sustained progress towards rebuilding as a result of the 2009 and 2010 year classes; under the deterministic projection from the base model, the stock is anticipated to rebuild in 2015.

Table E6. Management performance

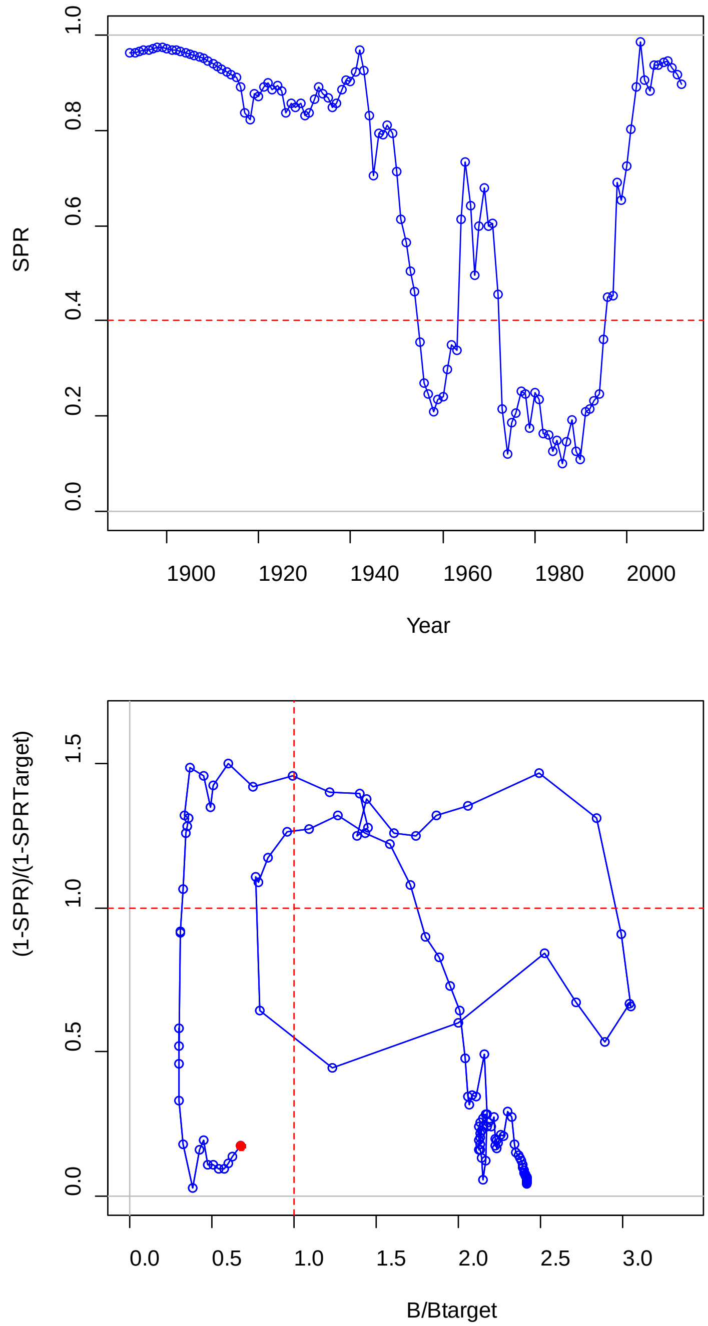
	Catch	ABC	OFL	OY/ACL
2003	12.78	244		20
2004	85.13	400		199
2005	107.34	566		307
2006	59.7	549		306
2007	62.53	602		218
2008	39.33	618		218
2009	57.5	793		288
2010	75.36	793		288
2011	111.95	737		263
2012	187.54	732		274
2013		845	884	320
2014		842	881	337

Table E7. Forecast of bocaccio ACL and OFL, with depletion estimates associated with each catch stream (ACL based on the SPR= 0.777, OFL is based on SPR=0.5, beginning 2015)

	SPR= 0.777 catches	Projected depletion with SPR= 0.777	OFL catches	Projected depletion with SPR= 0.50
2013	320	0.314	321	0.314
2014	337	0.377	338	0.377
2015	547	0.426	1536	0.426
2016	537	0.459	1437	0.441
2017	537	0.486	1379	0.449
2018	543	0.510	1348	0.454
2019	553	0.531	1332	0.457
2020	563	0.550	1321	0.457
2021	573	0.566	1314	0.457
2022	582	0.581	1309	0.456
2023	591	0.595	1305	0.454
2024	599	0.607	1301	0.452

Unresolved problems and major uncertainties

A major uncertainty for the 2011 update was the relative magnitude of the incoming 2010 year class. There is considerably greater certainty, as evidenced from several sources (impingement dataset, recreational length composition, NWFSC hook and line survey, CPFV CPUE indices that are not used in the model) that this year class is indeed very strong and is likely to see the stock to a rebuilt status as it matures. However, the extent to which this year class may be a largely "southern California" event, and the extent to which rebuilding is taking place in central and northern California waters, remains unclear. The ongoing pessimistic result of the NWFSC trawl survey index, which appears to be driven largely by a declining incidents of catches and catch rates in central and northern California waters, is cause for some concern with respect to abundance trends north of Point Conception. Similarly, as discussed in the 2009 assessment and the 2011 update, the CalCOFI data suggest that bocaccio abundance is relatively high levels within the Cowcod Conservation Areas (CCAs), and likely relatively lower levels outside of those areas, leading to concerns regarding the accuracy of indices based solely on effort expended outside of the CCAs. Thus, despite the largely optimistic outlook suggested by recent data and this update assessment result, the extent of spatial heterogeneity in abundance and abundance trends remains one of the most substantive problems in assessing status and trends for this stock.



Figures E5- E6. Spawner potential ratio (SPR) over time (top), with reference proxy for Sebastes (note reference should be 0.5, plotting has bug) and phase plot of SPR rate plotted against SSB, against target levels (bottom).

Decision Table

In the 2011 update, which faced a unique challenge related to uncertainty regarding the relative strength of the 2010 year class, the decision table was not comparable to the decision table from the 2009 assessment. The 2011 update instead bracketed optimistic and pessimistic results with respect to the relative strength of the 2010 year class. However, as the strength of this year class is considerably more resolved in this model, the decision table for this update is structured analogously to that in the 2009 assessment, with optimistic and pessimistic states of nature bracketing the base model derived from the relative weighting of two “optimistic” indices (the Southern California recreational CPUE index and the CalCOFI larval abundance time series) and two “pessimistic” indices (the trawl logbook time series and the triennial trawl survey time series). In the resulting (deterministic) projections, the 2013 and 2014 catches are set to the adopted 2013 and 2014 ACL’s, and the 2015-2024 catches are set based on a projection of the current rebuilding SPR (0.777) for each of those scenarios. Additionally, a run with catches set at the OFL levels beyond 2014 is included for each of the three states of nature. Under the base model, the stock is projected to rebuild by 2015 (depletion of ~43%), while under the “optimistic” scenario the stock is estimated to have rebuilt in 2013. However, under the pessimistic scenario with base model catches, the stock is not anticipated to rebuild until 2022.

Research and Data Needs

Since large scale area closures and other management actions were initiated in 2001, the spatial distribution of fishing mortality has changed over both large and small spatial scales. Not only has this effectively truncated several abundance indices (recreational CPUE), this confounds the interpretation of survey indices for surveys that do not sample in the Cowcod Conservation Areas (CCAs), as insights from larval surveys suggest that the greatest abundance of bocaccio is found in that area. This, in turn, infers that fishing mortality is greater on the fraction of the stock currently outside of the CCAs. The declining trend in the NWFSC trawl survey index, which is inconsistent with trends observed in the CalCOFI index, the NWFSC hook and line survey index, the impingement time series, and a recently developed (but not included in this update) recreational CPUE index are cause for some concern, and may reflect a reduced rate of rebuilding and stock recovery in central and northern California waters. Other research and data needs are unchanged from the 2009 assessment. Recently, some progress has been made in developing age reading criteria for bocaccio, and age data are expected to be available for the next full assessment.

Table E8: Decision Table for the bocaccio update

Pessimistic catches		Pessimistic model	Base model	Optimistic model
2013	*320*	0.20	0.31	**0.42**
2014	*337*	0.24	0.38	**0.50**
2015	324	0.27	**0.43**	**0.56**
2016	329	0.30	**0.46**	**0.61**
2017	341	0.32	**0.49**	**0.64**
2018	357	0.34	**0.52**	**0.67**
2019	374	0.36	**0.55**	**0.70**
2020	391	0.39	**0.57**	**0.72**
2021	407	**0.41**	**0.59**	**0.74**
2022	422	**0.43**	**0.61**	**0.76**
2023	436	**0.45**	**0.63**	**0.77**
2024	449	**0.47**	**0.65**	**0.78**
Base model catches		State 1	Base	State 2
2013	*320*	0.20	0.31	**0.42**
2014	*337*	0.24	0.38	**0.50**
2015	547	0.27	**0.43**	**0.56**
2016	537	0.29	**0.46**	**0.60**
2017	537	0.31	**0.49**	**0.63**
2018	543	0.33	**0.51**	**0.66**
2019	553	0.34	**0.53**	**0.68**
2020	563	0.36	**0.55**	**0.70**
2021	573	0.38	**0.57**	**0.71**
2022	582	**0.40**	**0.58**	**0.73**
2023	591	**0.42**	**0.59**	**0.74**
2024	599	**0.44**	**0.61**	**0.74**
Optimistic catches		State 1	Base	State 2
2013	*320*	0.20	0.31	**0.42**
2014	*337*	0.24	0.38	**0.50**
2015	632	0.27	**0.43**	**0.56**
2016	613	0.29	**0.46**	**0.60**
2017	603	0.30	**0.48**	**0.63**
2018	600	0.32	**0.50**	**0.66**
2019	601	0.34	**0.52**	**0.68**
2020	603	0.35	**0.54**	**0.69**
2021	605	0.37	**0.56**	**0.70**
2022	608	0.39	**0.58**	**0.71**
2023	610	**0.41**	**0.59**	**0.72**
2024	612	**0.42**	**0.61**	**0.73**
OFL catches (>2014)		State 1	Base	State 2
2013	*321*	0.20	0.31	**0.42**
2014	*338*	0.21	0.38	**0.47**
2015	1536	0.22	**0.43**	**0.51**
2016	1437	0.21	**0.44**	**0.53**
2017	1379	0.21	**0.45**	**0.54**
2018	1348	0.21	**0.45**	**0.55**
2019	1332	0.21	**0.46**	**0.55**
2020	1321	0.21	**0.46**	**0.55**
2021	1314	0.21	**0.46**	**0.56**
2022	1309	0.21	**0.46**	**0.56**
2023	1305	0.21	**0.45**	**0.56**
2024	1301	0.21	**0.45**	**0.56**

INTRODUCTION

This update of the 2011 stock assessment meets the terms of reference for an update, as there have been no significant changes to the model structure or data sources, and the results of this update are highly consistent with those in the 2011 and 2009 assessments. However, this update tracks the model structure of the 2011 assessment, which despite being generally an update, included several modest structural changes in order to avoid what the STAT found to be unrealistic results from the traditional update. The “unrealistic” result was an extremely strong 2010 year class inferred from the length frequency data of the NWFSC combined trawl survey. Although there were then (and are now) multiple signs of strong recruitment for bocaccio in 2009 and 2010 the magnitude of the 2010 recruitment estimate in the “strict” (terms of reference) 2011 model was essentially unprecedented and considered to be implausible by the STAT. As a result, in the final 2011 model, which was reviewed during the “mop-up” panel, the STAT excluded age 0 bocaccio from the NWFSC trawl survey index (fixing age selectivity for age 0 fish at 0, and excluding fish smaller than 22 cm from the length composition data). The STAT then added a time series of pre-recruit (age 0) abundance data which had been used in past assessments, the power plant impingement dataset. This update does not include the background information provided in the full 2009 assessment, for which the 2009 assessment should be referred to (Field et al. 2009). Moreover, dataset descriptions, diagnostics and model fits are included only for time series that were extended in this update, as the model results and fits through the year 2009 change only modestly for these datasets.

DATA

Fishery Dependent Data

Commercial and Recreational catches

Commercial bocaccio catch estimates were updated from 2010 through 2012 based on the NWFSC total mortality reports for 2011, and GMT scorecard estimates for 2012, consistent with the means by which catches were estimated in the 2011 update (Tables 1-2, Figure 1). A more rigorous evaluation of bycatch data and rates by gear type and region should be undertaken in the next full assessment.

Commercial Length Frequency Compositions

The number of length observations from commercial fisheries sources are inadequate to include as length composition information in this update. Consequently, no new commercial length frequency data are included in the update (as was the case in the 2011 update). Length frequency information of discards from the observer program was not incorporated in the 2009 assessment, and thus is not included in this update.

Recreational Length Frequency Data

New recreational length frequency data area available from the CRFSS monitoring program (accessed from the RecFIN website) for 2011-2012. The total number of clusters, fish sampled, and initial effective sample sizes are presented as Table 3, and the length compositions for 2011 and 2012 (as well as the average from 2008-2010) are presented as Figure 2. The southern recreational fisheries data are strongly indicative of a moderately strong 2009 year class and a very strong 2010 year class, there are some hints of the same in the central/northern fisheries data, but to a lesser degree (and there are less overall samples available).

Fishery-Dependent Indices

None of the fishery-dependent indices (trawl or recreational CPUE) were updated for this assessment as all of the time series have been effectively truncated by management actions. However, for exploratory purposes a recreational CPUE index was developed by Melissa Monk (FED, CSTAR/UCSC) based on data from the California Department of Fish and Wildlife (CDFW) Onboard Observer Program (1999-2011). The methods used are described in more detail in the data moderate assessment document and supporting documentation, as they are comparable to those used to develop indices of relative abundance for those assessments, but are summarized here for reference. Discussion of this index was included to provide some additional context for interpretation of the inconsistencies between the various indices that are included in the base model.

Data were analyzed at the drift level and catch was taken to be the sum of observed retained and discarded fish. Trips and drifts outside of U.S. waters, or in which 70% or more of the observed catch was not bottomfish, were excluded, as were those deeper than 60 fathoms (due to depth restrictions), those in conservation areas, those in San Diego Harbor, those missing both starting and ending location (latitude/longitude), and those identified as having possible erroneous location or time data. Fishing time and number of observed anglers were limited to include 95% of the data to remove potential outliers. Remaining drifts were between 5 and 119 minutes and observed anglers between 4 and 19 persons.

The following methods were applied to identify regions of suitable habitat, and to determine the number of drifts to include in the analysis. The locations of positive encounters were mapped, using the drift starting locations. Regions of suitable habitat were defined by creating detailed hulls (similar to an alpha hull) with a 0.01 decimal degree buffer around a location or cluster of locations (Data East 2003). Any portion of a region that intersected with land was removed. As an example of the buffers, a region with only one positive encounter has an ellipsoid area of $3.22km^2$. Each drift (both positive and zero-catch) was assigned to the region with which it intersected. Drifts that did not intersect with a region were considered structural zeroes, i.e., outside of the species habitat, and not used in analyses.

To develop an index more directly comparable to the NWFSC hook and line survey, a second filter was applied to identify the common areas between the CDFW Onboard Program and that survey. Areas defined within the CDFW Onboard Program were retained if they intersected with or were within 2km of a fixed NWFSC Hook & Line Survey fixed station. To ensure suitable sample sizes and to test for YEAR:REGION interactions, the buffered areas were then aggregated into 2 regions; 1) Coastal locations north of San Pedro and 2) Coastal locations south of San Pedro. Data from the months of January and February were removed due to low sample sizes, as well as data from the year 1999. Data from 2003 were also removed because the bocaccio fishery was closed. Abundance was measured as catch per angler hour, and the distribution for positives was lognormal (which was strongly favored over gamma by a delta AIC). The binary model used a logit transformation which was which was indistinguishable from the alternatives. The resulting year effects index is shown as Figure 3, and although not used in this assessment, this index should be considered for inclusion in the next full assessment for this stock.

Fishery-Independent Data

CalCOFI larval abundance data

The CalCOFI larval abundance time series was updated with a small number of observations from (late) 2010, and new observations for all of 2011 (n= 243 n positives = 21, Table 4). Data for 2012 are not yet available. The index was developed with the same approach adopted in the past assessment, a delta-GLM model with the main (fixed) effects of interest being year (adjusted to spawning season), month and line-station effects. These estimates and the associated standard errors estimated from a jackknife routine were used in the model as a relative index of population spawning output (Figures 4). The year effects through 2010 were virtually identical from the most recent GLM results, the 2010 data point is little changed from the 2011 update, and the new datapoint for 2011 represents a return to approximately the 2008 high point for the recent period. As the 2009 and 2010 year classes were presumably not mature and spawning by 2011, we did not expect to see a dramatic increase for the 2011 datapoint. However, we would anticipate that 2012 and 2013 larval abundance indices should begin to reflect a substantive increase in spawning biomass as the 2009 and 2010 year classes mature.

Northwest Center Trawl Survey

The Northwest Fishery Science Center has conducted combined shelf and slope trawl surveys since 2003, based on a random-grid design from depths of 55 to 1280 meters. Additional details on this survey and design are available in the abundance and distribution reports by Keller et al. (2008, 2013). Bocaccio CPUE (kg/ha) and negative tows (in depths less than 350 m) for age 1+ catches pooled over all years (2003-2012) are shown as Figure 5a and b; catches of age 1+ fish for 2011 and 2012 are shown in Figures 6-7, and catches of age 0 abundance in 2011 and 2012 (which were excluded from the GLMM index) are shown in Figures 8-9. Additional data on the number of tows, number of positive tows, number of length measurements and mean CPUE rates by depth and INPFC area are provided in Tables 5. As in 2010, the 2012 survey encountered large numbers of young-of-the-year (YOY) rockfish in the northeast part of the Southern California Bight, suggesting both that 2012 may also be a strong year class, and that continuing the approach adopted in the 2011 update (excluding age 0 fishes) is likely to be a reasonable approach for model stability.

The 2009 assessment used a GLMM approach for the development of a relative abundance index (using standard depth strata and area, as well as year, as factors), this index was updated with the latest catch data. However, the GLMM package (based in R) has also been updated by NWFSC staff, and this updated package was used to develop an index for this assessment. This was necessary, as the package used in the 2011 assessment to develop the index could not be loaded into newer versions of R, and attempts to align the most appropriate R versions and packages with this software were not successful. The STAT does not consider this a major concern, as past updates have used new GLMM code (although this practice has also been questioned by the SSC), and as the year effects estimated in the recent package closely align with those from the index developed for the 2011 update. However, there was a difference in the model-estimated error around the index estimates. Specifically, the CV in the most recent GLMM was considerably greater (approximately 2.1, relative to approximately 0.4 in the last GLMM), representing a potentially significant change in the model. To account for this, the variance adjustment was tuned as to give the 2013 index the same model variance as used in the 2011 update for the first iteration of the model that included this dataset, and this was adjusted in the final variance adjustment stage. The model was relatively insensitive to this change, however, as the abundance of other time series, most of which are inconsistent with this time series, has traditionally led to a poor fit to the index trends for this index.

NWFSC Southern California Bight hook-and-line survey

The NWFSC hook and line survey (Harms et al. 2008, 2010) was used to develop an updated CPUE index by NWFSC staff (J. Harms and J. Wallace, pers. com.). The extended index (Figure 11a) and associated length frequency data (Figure 11b) are used in the model. The index suggested a slight decline from 2004-2008 in the last assessment, a steeper decline from 2009-2010, and a sharp increase in 2011-2012, for which both points are above all previously observed values. The length frequency data for 2011 and 2012 are highly consistent with a strong 2009 and very strong 2010 year class. As with the trawl survey index, the hook and line survey index does not include sampling in the Cowcod Conservation Areas where much of the spawning biomass of bocaccio is thought to reside.

Recruitment Indices

Two young-of-the-year (YOY) recruitment indices were used in the 2009 bocaccio assessment: the coastwide midwater trawl survey index (2001-2008) and a recreational pier fishery CPUE index that included historical data from the 1950s and 60s. The coastwide midwater trawl survey index was updated by K. Sakuma and S. Ralston, documentation of the update is included as Appendix A of this assessment. Only one new datapoint is available, as the 2011 survey coverage was limited, precluding the development of a coastwide index. Although the 2010 estimated recruitment was the highest in the coastwide time series, the 2012 data point was among the lowest. However, prelimary data from the 2013 survey suggest a very strong year class (of multiple species), with catch rates in the "core" survey area the second highest on record, and catch rates of bocaccio higher than they have been since the late 1980s (e.g., the 1984 and 1988 year classes). These data are not yet included in the assessment, but are anecdotally encouraging. Although the pier fishery index was updated in the 2011 update, there are insufficient data to update that index for this assessment.

A third juvenile index, based in power plant impingement data, had been used in previous assessments, and as discussed earlier was included in the 2011 model. This index represents data collected from coastal cooling water intakes at Southern California electrical generating stations from 1972 to the present, and have been previously described by Love et al. (1998), Miller et al (2009), and Field et al. (2010) with respect to trends in abundance of *Sebastes* species, queenfish (*Seriphus politus*), and bocaccio respectively. The dataset includes observations on as many as 1.8 million fish (off all species) encountered during heat treatments of water taken in intakes for cooling southern California power plants. Although the frequency of all of these sampling methods is irregular over the 28 year time series, as a result of changes in operating schedules, regulatory requirements and changes in ownership over time, the time series is uninterrupted at the annual scale from 1972-2012. Table 9 shows the sample sizes (number of observations), number of positive observations, and the year effects index with associated CV from a Delta-GLM as described in the 2011 assessment. The index is shown in Figure 11, together with recruitment estimates from the 2009 model (which did not include the index), for which the index compared very well (R^2 of 0.60 based on log scale). In contrast to the juvenile trawl survey index, the power plant index estimates strong recruitment in 2012, which are also suggested in the catches of age 0 bocaccio in the trawl survey (noting that these are not included in the model). Preliminary results for both the trawl survey and the impingement survey suggest very large numbers of young-of-the-year (YOY) bocaccio in 2013 as well.

Model Description

Modeling software

The 2009 assessment used the Stock Synthesis 3 (SS-V3.03A) modeling framework developed by Dr. Richard Methot (Methot 2009a; Methot 2009b). The 2011 assessment used version 3.20b, in order to better take advantage of the R4SS graphing package developed by the NWFSC, this assessment maintained the use of that version.

Base model results

The basic model outputs and likelihood values corresponding to the sequential addition of new data (as well as corresponding to the 2009 and 2011 results) are reported in Table 7. Most of the additional data had only modest impacts on overall model trends and results, with the more optimistic data (e.g., recent high data points in CalCOFI, strong year classes inferred in recruitment indices) having a slightly pessimistic result on relative status, as a consequence of the scaling downward of earlier recruitments. However, all of the new data were consistent with a (very slightly) more optimistic estimation of steepness (from 0.595 to 0.614) relative to the 2011 model (noting that the 2009 model had a point estimate of 0.573). Despite these modest changes, the overall trajectory of spawning output, relative spawning output, total biomass and recruitment are barely distinguishable as changed from the 2011 model (Figures 15-16), with the most important change being the relative strength of the 2010 year class.

A summary of the available data by type and year is included as Figure 17. Selectivity curves for all surveys and fisheries are shown in Figure 18-19. Fits to the updated relative abundance indices (CalCOFI, the NWFSC hook and line index, the NWFSC trawl survey index, the juvenile trawl survey index, the pier fishery CPUE index and the impingement index) are shown in Figures 20-24, in both arithmetic and log space, including plots of the observed vs. predicted values. Fits to the truncated time series (trawl CPUE, triennial survey and the recreational CPUE indices) are not included as they are essentially unchanged from the 2009 assessment. Note that the fits to the NWFSC trawl survey index are very poor. These indices estimate a declining trend in abundance while the model (based on CalCOFI, the hook and line survey, and other indices) estimates an increasing trend. These inconsistencies relate directly to what the STAT considers to be the greatest uncertainties and data needs; a better appreciation for the selectivity and catchability of bocaccio related to the trawl survey, which should not be assumed to fish bocaccio habitat adequately, and reconciliation of trend data from the areas solely outside of closed areas with those for the entire southern California Bight (e.g., CalCOFI).

Fits to the length composition data, along with plots of residual values and input relative to effective sample sizes, for the recreational fisheries and updated surveys are presented as Figures 25-32. The length composition data for the southern recreational fisheries data and the and the NWFSC hook and line survey are both indicative of the strong 2009 and very strong 2010 year classes, which are also evident in the NWFSC trawl survey length composition data and the central/northern California length composition data. Note that fisheries or surveys for which no new data are available were not included, as the historical fits have not changed significantly (as illustrated by the trivial changes in the likelihood values of length composition datasets, prior to tuning, for which no new data were available, Table 7).

The mean input RSME's and variance adjustments are reported in Tables 8 and 9. As discussed earlier, the only substantive change was the unusual use of a negative variance adjustment for the trawl survey data, as the new GLMM code resulted in a very similar trend, but a very different variance for this index (approximately 0.4 in the 2011 update, approximately 2.1 for this update). Although a reduction in variance is an atypical approach, and the previously mentioned poor fit and low influence of the trawl survey index in this model might justify inclusion of the most recent variance estimate, the STAT felt that for the purposes of an "update" a major change in the effective variance for this index would be inappropriate. Moreover, running the base model without the reduction in variance for this index led to no significant difference in the overall model result or in model projections.

Point estimates of parameters (including the recruitment deviation point estimate values) for the base model are reported in Tables 10 and 11, along with the corresponding estimates from the 2011 model. With the exception of the selectivity parameters for the NWFSC combined trawl survey that were made in the 2011 model, and the estimates of recent recruitment strength, the growth, recruitment and selectivity and productivity parameter values have changed very little since the 2009 assessment.

The base model results are shown as Figures 33- 39 (with values reported in Table 12), for summary biomass, spawning output, depletion, age-0 recruits, recruitment deviation estimates, the spawner-recruit curve, the equilibrium yield curve, and the estimated SPR (including phase plot against B target). The resulting estimates of unfished summary (age 1+) biomass, spawning output and mean age 0 recruitment are only modestly changed from the 2009 and 2011 results (see Table 7). The estimated steepness has increased modestly since the 2009 assessment (to 0.61 from 0.57 in 2009 and 0.60 in 2011). Biomass, spawning output and exploitation trends were virtually identical to the 2009 and 2011 models, with the primary differences respective to the 2009 and 2010 year classes and subsequent biomass and spawning output trajectories. The current model projection is considerably more optimistic than earlier models as a consequence of the strength of the 2010 year class, which is currently estimated to be the strongest since 1977 (although the point estimate of the total number of recruits is nearly identical, but slightly less than, the estimated strength of the 1984 year class). The relative spawning output (depletion) for 2013 is estimated to be 31.4% of the mean unfished level, with spawning output expected to increase sharply as the 2010 year class matures, such that under projections based on the currently adopted ACL's for 2013 and 2014, the stock is likely to be rebuilt (depletion of ~43%) in 2015.

Uncertainty and sensitivity analysis

In the 2009 stock assessment, both the STAT and the STAR Panel identified the major sources of uncertainty in the model as relating to the tension between two generally pessimistic indices (the triennial trawl survey and the trawl fishery CPUE index, both derived primarily from north of Point Conception, California) and two optimistic indices (the CalCOFI index and the Southern California recreational fishery CPUE index, both derived primarily from south of Point Conception). Consequently, the two alternative states of nature sequentially increased the emphasis on each of these groups to bracket uncertainty. However, in the 2011 assessment, the challenges associated with estimating the relative strength of the 2010 year class were considered a more substantive uncertainty for that assessment. For this update, given the greater certainty associated with the relative magnitude of the 2010 year class, we returned to the 2009 primary axes of uncertainty, which provide useful contrast between an apparent, but poorly understood, spatial dimension to relative abundance trends. In all of these runs, catches were based on the rebuilding SPR rate of 0.777 for each respective model.

Figures 40 and 41 shows a comparison of the base model estimated spawning biomass, spawning depletion, relative SPR rate and recruitment relative to the "optimistic" and "pessimistic" scenarios 2009 model estimates and ten year projections for spawning biomass, relative depletion, recruitment and recruitment deviation values. The subsequent decision table (Table 13) shows the estimated spawning depletion for each of the three scenarios between 2013 and 2024, based on the catch streams associated with the SPR of 0.777 for each of the three models, as well as the catch stream associated with the OFL SPR of 0.50 subsequent to the 2013-2014 period (for which the ACL's have already been adopted).

In the base model (as previously stated) the stock is projected to rebuild (depletion ~0.43) by 2015, an outcome that does not change with any of the catch streams as the 2013 and 2014 catches are assumed to be fixed at the current ACL's. For the optimistic model, the stock is expected to have achieved a rebuilt status by the current year (2013), however under the pessimistic scenario the current stock status is approximately 20% of the unfished level, and rebuilding is expected in 2022 (with only a year of improvement if the catch stream associated with the pessimistic model is adopted instead of the catch stream associated with the base model). Most of the other results in the decision table are intuitive.

Reference Points

Reference points are presented in Table 14, including the unfished summary biomass, unfished spawning output, mean unfished recruitment, the proxy estimates for MSY based on the SPR50% rate, the fishing mortality rate associated with a spawning stock output of 40% of the unfished level, and MSY estimated based on the spawner/recruit relationship. Reference points did not change substantively from previous estimates, although the slightly higher estimate of h in this update is reflected in slightly higher estimates of MSY and the MSY proxies. As with earlier models, the difference between the estimated MSY (1378) and the proxy MSY reference points (1341-1347) is minimal, despite a substantial decline in the SPR and spawning output associated with the estimated MSY value.

Retrospective Analysis

Retrospective analysis were conducted by removing the influence of the most recent two and four years of data and comparing the subsequent estimates of spawning output, depletion, recruitment and relative harvest levels (Table x, Figures 42-43). These two and four year periods correspond with the data available for 2011 and 2009 (most recent update and last full assessment) time frames. The most notable change in model output is a slight shift in the timing and magnitude of several early recruitments in the 1960s, a shift which has been previously noted to take place with subtle model changes as a consequence of instability in the likelihood surface regarding the timing of the recruitment events associated with the increase in larval abundance inferred by the 1960s CalCOFI data (Field et al. 2009). The other noticeable change is the estimated magnitude of the 2010 year class, which was intuitively not observed when data are limited to the time period through 2008 (4 year retrospective) and which is moderately notable in the 2 year retrospective as driven solely by the impingement time series. In the opinion of the STAT, the retrospective analyses indicate that the new data and current model results are wholly consistent with the 2009 and 2011 models and results.

Future Research Needs

Research needs are discussed comprehensively in the 2009 assessment and have changed little since that time. Since large scale area closures and other management actions were initiated in 2001, the spatial distribution of fishing mortality has changed over both large and small spatial scales. Not only has this effectively truncated several abundance indices (recreational CPUE), this confounds the interpretation of survey indices for surveys that do not sample in the Cowcod Conservation Areas (CCAs), as insights from larval surveys suggest that the greatest abundance of bocaccio is found in that area. This, in turn, infers that fishing mortality is greater on the fraction of the stock currently outside of the CCAs. The declining trend in the NWFSC trawl survey index, which is inconsistent with other data sources and the base model results, may reflect a reduced rate of rebuilding and stock recovery in central and northern California waters. Other research and data needs are unchanged from the 2009 assessment. Recently, some progress has been made in developing age reading criteria for bocaccio, and age data are expected to be available for the next full assessment.

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Table 1. Total catches (metric tons) and PFMC adopted ABC/OY values for bocaccio rockfish.

	Catch	ABC	OY
1999	196.90	230	230
2000	139.80	164	100
2001	131.30	122	100
2002	89.66	122	100
2003	12.78	244	20
2004	85.13	400	199
2005	107.34	566	307
2006	59.70	549	306
2007	62.53	602	218
2008	39.33	618	218
2009	57.50	793	288
2010	75.36	793	288
2011		737	263
2012		732	274

Table 2. Estimated domestic commercial landings and discards of bocaccio rockfish south of Cape Blanco, by region and gear type, 1999-2012 (metric tons).

	trawl south of 38° N	trawl north of 38° N	hook and line	setnet	rec south of 34.5° N	rec north of 34.5° N	total (S. of 43 ° N)
1999	19.00	53.00	26.00	20.70	7.20	71.00	196.90
2000	13.50	60.00	6.60	7.00	0.70	52.00	139.80
2001	9.20	49.00	4.40	7.80	0.90	60.00	131.30
2002	28.04	20.67	0.13	0.01	35.88	4.93	89.66
2003	5.07	0.31	0.00	0.00	5.53	1.87	12.78
2004	13.86	3.52	1.84	0.21	63.43	2.27	85.13
2005	24.64	0.43	1.50	0.17	69.90	10.70	107.34
2006	16.09	0.31	2.25	0.25	29.00	11.80	59.70
2007	4.06	1.58	3.39	0.38	44.20	8.92	62.53
2008	0.42	1.98	2.02	0.08	31.50	3.33	39.33
2009	1.12	4.85	1.50	0.03	40.30	9.70	57.50
2010	2.90	10.97	1.45	0.05	50.07	6.54	71.97
2011	1.30	4.93	2.39	0.01	99.26	4.06	111.95
2012	12.89	48.81	1.10	0.01	119.08	5.65	187.54

Table 3. Total number of length frequency observations, subsamples, and input effective sample size for recreational fisheries, 2008-2012 (see 2009 assessment for complete table).

	Southern California			Central/Northern California		
	obs	samples	Neff	obs	samples	Neff
2008	1811	484	400	163	88	110
2009	2085	444	400	216	90	120
2010	1869	368	400	185	88	114
2011	3240	543	400	188	98	124
2012	3950	595	400	237	111	144

Table 4. Total number of plankton tows, positive tows, and the mean cpue of positives for 2000-2011 (see 2009 assessment for complete table).

	Northern area (lines<77)			Southern area (lines>=77)		
	total tows	positive	ave cpue	total tows	positives	ave cpue
2000				96	8	0.77
2001				93	6	0.46
2002				118	10	1.04
2003	46	4	0.59	143	14	0.98
2004	46	3	1.28	99	11	4.85
2005				146	16	1.64
2006	28	4	1.60	149	13	0.72
2007	10	4	5.65	108	11	1.20
2008	20	1	0.27	176	13	1.83
2009	24	1	0.22	170	10	0.65
2010	***40***	***5***	***1.13***	***188***	***8***	***0.41***
2011	***61***	***3***	***0.74***	***182***	***18***	***1.12***

Table 5. Summary of all bocaccio catch information for NWFSC combined shelf-slope bottom trawl survey, by latitude and inside of 350 meters depth, 2003-2012

Total number of hauls, 50 to 350 m

lat	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
32	37	39	48	49	57	50	64	60	56	62
34.5	20	18	17	16	23	24	29	24	17	24
36	23	24	32	31	29	41	42	38	41	42
38	34	39	50	45	33	42	33	45	48	42
40.5	56	28	50	34	41	36	44	49	43	44
43	129	136	167	172	196	164	171	180	180	161

Number of positive tows

lat	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
32	9	9	13	11	12	2	8	16	11	25
34.5	7	4	2	2	6	3	6	10	5	7
36	6	7	12	9	6	8	4	6	2	5
38	8	10	8	12	1	8	5	3	2	6
40.5	4	0	3	1	2	1	1	0	0	0
43	5	0	2	3	3	4	0	1	2	5

Percent positive

lat	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
32	0.24	0.23	0.27	0.22	0.21	0.04	0.13	0.27	0.20	0.40
34.5	0.35	0.22	0.12	0.13	0.26	0.13	0.21	0.42	0.29	0.29
36	0.26	0.29	0.38	0.29	0.21	0.20	0.10	0.16	0.05	0.12
38	0.24	0.26	0.16	0.27	0.03	0.19	0.15	0.07	0.04	0.14
40.5	0.07	0.00	0.06	0.03	0.05	0.03	0.02	0.00	0.00	0.00
43	0.04	0.00	0.01	0.02	0.02	0.02	0.00	0.01	0.01	0.03

Mean CPUE (kg/ha) of positives

lat	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
32	2.0	3.0	1.7	1.8	6.1	2.3	0.8	1.1	1.5	7.3
34.5	1.0	5.8	1.7	29.0	3.7	1.7	4.7	2.2	2.7	80.3
36	2.1	66.0	14.3	2.1	4.7	11.4	3.2	1.2	0.7	3.5
38	3.5	4.0	3.2	3.4	1.9	4.8	2.5	1.8	2.3	3.2
40.5	2.7	0.0	2.7	0.3	2.7	0.0	4.5	0.0	0.0	0.0
43	5.0	0.0	1.4	27.1	6.8	5.1	0.0	0.7	5.8	2.3

Number of length measurements

lat	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
32	37	54	111	92	98	7	26	207	79	401
34.5	15	29	4	81	25	10	44	48	10	72
36	11	378	165	16	21	63	19	8	7	19
38	25	32	22	22	1	21	8	3	3	14
40.5	9	0	15	1	4	1	3	0	0	0
43	16	0	2	50	8	9	0	1	6	10

Table 6: Sample sizes, number of positives, % positive, CPUE index and CV for the Power Plant Impingement Index

	Sample size	Number positives	% positive	Index	CV
1972	38	23	0.61	805.6	0.47
1973	34	17	0.50	240.1	0.54
1974	42	18	0.43	169.1	0.40
1975	42	27	0.64	209.9	0.37
1976	59	12	0.20	20.8	0.40
1977	48	17	0.35	559.2	0.53
1978	38	18	0.47	82.5	0.41
1979	54	18	0.33	67.1	0.37
1980	47	12	0.26	23.1	0.49
1981	47	5	0.11	9.2	0.70
1982	43	3	0.07	1.9	0.74
1983	44	0	0.00	n/a	n/a
1984	39	4	0.10	10.6	0.88
1985	52	7	0.13	19.7	0.52
1986	54	5	0.09	6.4	0.53
1987	47	0	0.00	n/a	n/a
1988	45	16	0.36	215.5	0.48
1989	41	7	0.17	15.1	0.57
1990	47	3	0.06	7.0	0.69
1991	44	13	0.30	46.2	0.47
1992	60	6	0.10	36.5	0.62
1993	47	1	0.02	n/a	n/a
1994	52	0	0.00	n/a	n/a
1995	39	4	0.10	19.1	0.74
1996	54	4	0.07	5.6	1.15
1997	46	2	0.04	4.9	0.93
1998	44	0	0.00	n/a	n/a
1999	31	10	0.32	61.1	0.52
2000	44	7	0.16	8.6	0.57
2001	52	2	0.04	1.0	0.80
2002	45	8	0.18	16.3	0.41
2003	37	12	0.32	52.9	0.57
2004	34	4	0.12	2.6	0.81
2005	35	13	0.37	67.1	0.47
2006	26	0	0.00	n/a	n/a
2007	35	5	0.14	8.5	0.66
2008	33	5	0.15	6.4	0.56
2009	27	8	0.30	21.0	0.47
2010	27	9	0.33	52.5	0.51
2011	32	3	0.09	5.5	0.94
2012	7	2	0.29	74.5	0.76

Table 7: Key model outputs and likelihood values with sequential addition of new data sources.

	2009 base model	2011 update base model	Update catches, extend model to 2012	Update CalCOFI larval abundance time series	Update SCB hook and line index, LFs	Update NWFSC bottom trawl survey index and LFs	Update rec fishery LFs	Update juvenile indices (trawl survey and power plant)	Final base model (Post tuning, single iteration)
R0	5060	5106	5215	5400	5342	5265	5371	5196	5169
SSB0 (x10^9 larvae)	7861	7812	7979	8274	8199	8063	8203	7923	8118
Unfished biomass	44070	44116	45122	46771	46336	45610	46446	44888	45546
S2009/SSB0	0.281	0.247	0.247	0.236	0.239	0.237	0.236	0.230	0.228
S2011/SSB0		0.260	0.259	0.248	0.256	0.253	0.255	0.247	0.249
S2013/SSB0			0.286	0.271	0.319	0.315	0.322	0.308	0.314
H. est	0.573	0.595	0.577	0.596	0.597	0.599	0.608	0.614	0.614
Likelihoods	3102.1	3303.8	3303.9	3320.9	3340.6	3382.7	3461.5	3459.6	3825.2
Survey	85.4	143.1	143.7	161.8	138.6	149.7	152.5	147.2	129.9
Length_comp	2986.7	3126.2	3125.6	3126.0	3166.6	3196.7	3273.9	3275.2	3658.7
Recruitment	32.9	32.7	32.0	31.4	33.8	34.7	33.5	34.7	35.2
Parm_priors	1.4	1.5	2.6	1.6	1.6	1.6	1.5	2.5	1.5
Survey									
Trawl_south	7.6	7.2	7.4	7.1	6.9	6.8	6.9	6.6	8.1
RecSouth	7.7	8.0	8.0	8.0	8.0	8.1	8.1	8.2	8.0
RecCentral	10.1	10.8	10.6	10.8	11.0	11.1	11.0	11.4	10.1
CalCOFI	21.3	21.7	22.4	40.1	40.3	39.6	40.5	39.5	38.4
Triennial	4.1	3.8	3.9	3.8	3.7	3.7	3.7	3.5	4.1
CPFV_index	6.0	5.6	5.7	5.6	5.5	5.5	5.5	5.4	6.6
SCB_hook	2.4	32.3	32.1	32.5	8.4	8.3	8.5	8.3	4.6
Combo	2.9	3.8	3.8	3.8	4.1	16.3	16.6	16.3	5.5
Juv_trawl	3.9	5.7	5.7	5.7	7.2	7.2	7.3	7.3	5.9
Pier_index	19.4	20.5	20.5	20.7	20.9	20.8	21.4	21.1	20.1
Impingement	0.0	23.6	23.7	23.6	22.6	22.5	23.0	19.6	18.5
Length									
Trawl_south	468.1	466.5	466.7	467.0	466.6	466.5	465.4	465.0	496.3
hook-line	363.0	363.3	363.4	363.2	363.4	363.4	363.1	363.1	366.0
setnet	356.2	354.3	354.3	354.5	355.1	354.9	354.1	353.9	296.3
RecSouth	375.4	422.8	422.9	423.5	427.5	427.6	454.8	455.3	567.3
RecCentral	365.2	396.7	396.8	396.3	397.2	397.4	439.9	440.5	435.5
Trawl_north	365.4	369.2	369.0	368.6	368.6	369.4	370.2	371.2	681.1
CalCOFI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Triennial	151.0	148.4	148.4	148.7	149.3	149.1	148.9	148.7	270.4
CPFV_index	213.1	215.3	215.2	214.9	214.1	214.4	214.0	214.4	135.5
SCB_hook	60.9	81.0	81.1	80.9	117.1	116.8	119.7	119.8	93.7
Combo	137.3	177.7	177.0	177.6	177.4	207.0	210.1	209.3	142.8
RecSouthObs	131.0	131.0	131.0	131.0	130.2	130.3	133.6	134.1	173.8

Table 8: Mean input RSME's and variance adjustments for 2013 update

Fleet	years	mean input rsme	2011 variance adjustment	input+ adjustment	2013 model rsme	new variance adjustment
trawlsouth	15	0.32	0.06	0.38	0.36	0.04
recSO	20	0.17	0.59	0.76	0.78	0.60
recCEN	20	0.15	0.60	0.75	0.79	0.64
CalCOFI	54	0.22	0.29	0.51	0.60	0.37
Triennial trawl survey	9	0.20	0.50	0.70	0.66	0.45
CPFV CPUE	12	0.15	0.22	0.37	0.35	0.20
NWFSC hook&line	9	0.12	0.15	0.27	0.39	0.27
NWFSC trawl survey	10	2.10	0.25	0.57	-0.99	-1.05
juvenile trawl survey	11	0.02	0.96	0.98	1.13	1.11
pier_juv	33	0.79	0.00	0.79	0.85	0.06
power.plant.index	35	0.60	0.37	0.97	1.04	0.43

Table 9: Mean input effective sample sizes and variance adjustments for LF data

Fleet	years	mean start effN	mean model effN	model effN/ input*var.adj
trawlsouth	26	156	154	0.98
hook and line	23	52	52	0.89
setnet	17	120	122	1.00
recSO	30	126	121	1.00
recCEN	29	89	91	1.00
trawlnorth	25	58	59	1.00
Triennial trawl survey	9	32	31	0.98
South CPFV observer	12	290	235	0.84
Central CPFV observer	9	148	292	0.71
NWFSC hook&line	10	58	103	0.94
NWFSC trawl survey	7	18	67	1.00

Table 10. Fixed and estimated parameter values with standard deviations for the base model.

Parameter	est.	11.value	13.value	st. dev
Natural mortality, both sexes	no			
Length@Amin, both sexes	no			
Length@Amax, females	yes	67.29	68.11	0.35
VonBert K females	yes	0.22	0.22	0.004
Length@Amax, males	yes	58.49	59.31	0.29
VonBert K males	yes	0.27	0.26	0.01
CV of size at Amin, both sexes	no			
CV of size at Amax, both sexes	no			
log R0	yes	8.54	8.55	0.09
Steepness (h)	yes	0.60	0.62	0.07
Sigma-R	no			
Initial F, hook and line fleet	yes	0.0100	0.0059	0.0006
length@peak_trawlsou	yes	43.25	43.46	0.17
Width of top_trawlsou	no	-4.82		
Ascending width_trawlsou	no	4.3		
Decending width_trawlsou	no	4.76		
Initial sel_trawlsou	no	-10.5		
final sel_trawlsou	no	-0.77		
length@peak_hook and line	yes	50.06	50.15	0.75
Width of top_hook and line	yes	-4.12	-4.28	2.62
Ascending width_hook and line	yes	4.32	4.32	0.12
Decending width_hook and line	yes	3.99	3.99	0.50
Initial sel_hook and line	yes	-9.38	-9.37	4.08
final sel_hook and line	yes	-0.66	-0.68	0.31
length@peak_setnet	yes	48.47	48.48	0.39
Width of top_setnet	yes	-7.48	-7.38	5.39
Ascending width_setnet	yes	3.44	3.43	0.11
Decending width_setnet	yes	4.14	4.12	0.20
Initial sel_setnet	yes	-6.03	-6.07	0.35
final sel_setnet	yes	-1.58	-1.54	0.23
length@peak_southern rec	yes	38.27	38.41	0.41
Width of top_southern rec	yes	-7.84	-7.79	5.07
Ascending width_southern rec	yes	4.58	4.52	0.08
Decending width_southern rec	yes	5.32	5.35	0.08
Initial sel_southern rec	yes	-4.65	-4.87	0.24
final sel_southern rec	yes	-3.05	-3.21	0.34
logistic, size infl_central rec	yes	33.70	33.64	0.42
logistic, width 95%_central rec	yes	11.03	10.67	0.52
logistic, size infl_northern trawl	yes	40.13	40.41	0.29
logistic, width 95%_northern trawl	yes	6.21	6.34	0.37
length@peak_triennial	no	24		
Width of top_triennial	no	-9.79		
Ascending width_triennial	no	6.11		
Decending width_triennial	no	5.56		
Initial sel_triennial	no	-2.86		
final sel_triennial	no	-1.25		
length@peak_SCB hook line	yes	47.81	45.50	2.30
Width of top_SCB hook line	yes	-1.46	-1.10	0.32
Ascending width_SCB hook line	yes	5.28	5.03	0.29
Decending width_SCB hook line	yes	2.61	2.36	1.61
Initial sel_SCB hook line	yes	-5.75	-6.59	1.59
final sel_SCB hook line	yes	-1.13	-1.15	0.48
logistic, size inflection_NWFSC combo	yes	9.91	15.65	6.52
logistic, width 95% inflect_NWFSC combo	yes	15.86	16.17	8.58

Table 11. Fixed and estimated parameter values for recruitment deviations for the base model.

Parameter	est.	11.value	13.value	st. dev
RecrDev_1954	yes	0.08	0.06	0.64
RecrDev_1955	yes	-1.29	-1.22	0.70
RecrDev_1956	yes	0.18	0.24	0.69
RecrDev_1957	yes	-1.23	-1.15	0.72
RecrDev_1958	yes	-0.36	-0.28	0.98
RecrDev_1959	yes	1.35	0.47	1.28
RecrDev_1960	yes	0.17	0.11	1.12
RecrDev_1961	yes	0.07	0.01	1.08
RecrDev_1962	yes	0.04	3.06	0.28
RecrDev_1963	yes	3.06	0.00	1.07
RecrDev_1964	yes	-0.03	-0.02	1.05
RecrDev_1965	yes	-0.08	-0.08	1.02
RecrDev_1966	yes	1.34	1.16	0.59
RecrDev_1967	yes	-0.19	-0.22	0.94
RecrDev_1968	yes	-0.17	-0.18	0.96
RecrDev_1969	yes	-0.01	0.03	1.06
RecrDev_1970	yes	0.39	0.78	0.79
RecrDev_1971	yes	0.09	0.05	0.98
RecrDev_1972	yes	1.16	1.07	0.24
RecrDev_1973	yes	1.90	1.85	0.11
RecrDev_1974	yes	0.92	0.92	0.14
RecrDev_1975	yes	-0.51	-0.69	0.25
RecrDev_1976	yes	-0.28	-0.37	0.22
RecrDev_1977	yes	2.54	2.62	0.07
RecrDev_1978	yes	-0.03	-0.11	0.32
RecrDev_1979	yes	0.95	0.98	0.09
RecrDev_1980	yes	-0.36	-0.36	0.17
RecrDev_1981	yes	-1.02	-1.19	0.20
RecrDev_1982	yes	-2.69	-2.85	0.34
RecrDev_1983	yes	-0.28	-0.24	0.10
RecrDev_1984	yes	1.72	1.69	0.05
RecrDev_1985	yes	-0.59	-0.68	0.16
RecrDev_1986	yes	-0.71	-0.81	0.16
RecrDev_1987	yes	0.50	0.47	0.11
RecrDev_1988	yes	1.61	1.64	0.10
RecrDev_1989	yes	-1.27	-1.29	0.30
RecrDev_1990	yes	0.43	0.48	0.15
RecrDev_1991	yes	0.39	0.30	0.17
RecrDev_1992	yes	-0.86	-0.89	0.30
RecrDev_1993	yes	-0.08	-0.25	0.18
RecrDev_1994	yes	-0.38	-0.41	0.18
RecrDev_1995	yes	-0.95	-1.06	0.24
RecrDev_1996	yes	-0.45	-0.58	0.18
RecrDev_1997	yes	-1.87	-2.10	0.33
RecrDev_1998	yes	-0.29	-0.36	0.20
RecrDev_1999	yes	1.57	1.52	0.15
RecrDev_2000	yes	-1.57	-1.66	0.36
RecrDev_2001	yes	-1.71	-1.76	0.35
RecrDev_2002	yes	-0.43	-0.49	0.20
RecrDev_2003	yes	0.62	0.68	0.13
RecrDev_2004	yes	-1.50	-1.43	0.28
RecrDev_2005	yes	0.51	0.56	0.13
RecrDev_2006	yes	-0.99	-0.71	0.22
RecrDev_2007	yes	-0.24	-0.05	0.15
RecrDev_2008	yes	-0.31	0.04	0.15
RecrDev_2009	yes	0.61	0.91	0.13
RecrDev_2010	yes	0.51	1.90	0.12
RecrDev_2011			0.05	0.32
RecrDev_2012			-0.16	0.59

Table 12. Time series of key model outputs for 2011 base model.

Year	Total biomass	Summary biomass	Spawning output	CV spawning	Depletion	Recruits (x 103)	CV recruits	Total catch	Exploit. rate	SPR ratio (rel. 0.50)
Unfished	45543	45476	8117510	0.087	1.000	5169	0.087	0	0.000	0.00
Initial	44114	44046	7834240	0.090	0.965	5169	0.087	153	0.003	0.08
1892	44114	44046	7834240	0.090	0.965	5140	0.086	167	0.004	0.08
1893	44097	44030	7831880	0.090	0.965	5139	0.086	157	0.004	0.07
1894	44087	44019	7831080	0.090	0.965	5139	0.086	148	0.003	0.07
1895	44081	44014	7831400	0.090	0.965	5139	0.086	139	0.003	0.06
1896	44082	44015	7832400	0.090	0.965	5140	0.086	131	0.003	0.06
1897	44087	44020	7833920	0.090	0.965	5140	0.086	123	0.003	0.06
1898	44097	44030	7836140	0.090	0.965	5140	0.086	115	0.003	0.05
1899	44113	44046	7839170	0.090	0.966	5140	0.086	108	0.002	0.05
1900	44134	44067	7843100	0.089	0.966	5141	0.086	119	0.003	0.05
1901	44142	44074	7844730	0.089	0.966	5141	0.086	131	0.003	0.06
1902	44136	44069	7844110	0.089	0.966	5141	0.086	142	0.003	0.06
1903	44119	44052	7841340	0.089	0.966	5140	0.086	154	0.003	0.07
1904	44091	44023	7836560	0.089	0.965	5140	0.086	165	0.004	0.07
1905	44052	43985	7829900	0.089	0.965	5139	0.086	176	0.004	0.08
1906	44005	43938	7821530	0.089	0.964	5138	0.086	188	0.004	0.08
1907	43951	43884	7811590	0.089	0.962	5137	0.086	199	0.005	0.09
1908	43888	43821	7800230	0.089	0.961	5136	0.086	210	0.005	0.09
1909	43820	43753	7787560	0.089	0.959	5135	0.086	237	0.005	0.11
1910	43730	43663	7771180	0.090	0.957	5133	0.086	263	0.006	0.12
1911	43621	43554	7751230	0.090	0.955	5131	0.086	289	0.007	0.13
1912	43494	43427	7727890	0.090	0.952	5128	0.086	316	0.007	0.14
1913	43350	43283	7701370	0.090	0.949	5125	0.086	342	0.008	0.15
1914	43191	43124	7671920	0.091	0.945	5122	0.086	368	0.009	0.16
1915	43019	42952	7639740	0.091	0.941	5119	0.086	395	0.009	0.18
1916	42834	42767	7605060	0.091	0.937	5115	0.086	474	0.011	0.21
1917	42582	42516	7559450	0.092	0.931	5110	0.086	747	0.018	0.32
1918	42073	42007	7470060	0.093	0.920	5100	0.085	799	0.019	0.35
1919	41545	41478	7374800	0.094	0.909	5089	0.085	529	0.013	0.24
1920	41325	41259	7328850	0.095	0.903	5083	0.085	550	0.013	0.25
1921	41109	41042	7284270	0.095	0.897	5078	0.085	463	0.011	0.22
1922	41003	40936	7258650	0.095	0.894	5075	0.085	417	0.010	0.20
1923	40958	40892	7244470	0.095	0.892	5073	0.085	489	0.012	0.23
1924	40849	40783	7221120	0.096	0.890	5070	0.085	442	0.011	0.21
1925	40798	40732	7207830	0.096	0.888	5069	0.085	505	0.012	0.23
1926	40691	40625	7185980	0.096	0.885	5066	0.085	711	0.018	0.32
1927	40384	40318	7131560	0.096	0.879	5059	0.085	610	0.015	0.28
1928	40197	40131	7095810	0.097	0.874	5055	0.084	639	0.016	0.30
1929	39992	39926	7057470	0.097	0.869	5050	0.084	597	0.015	0.28
1930	39845	39779	7027410	0.097	0.866	5046	0.084	715	0.018	0.33
1931	39591	39525	6980300	0.098	0.860	5040	0.084	689	0.017	0.32
1932	39385	39319	6938700	0.098	0.855	5035	0.084	556	0.014	0.27
1933	39329	39264	6923090	0.098	0.853	5033	0.084	429	0.011	0.21
1934	39411	39345	6931300	0.098	0.854	5034	0.084	494	0.013	0.24

Table 12 (continued)

Year	Total biomass	Summar y biomass	Spawning output	CV spawning	Depletion	Recruits (x 103)	CV recruits	Total catch	Exploit. rate	SPR ratio (rel. 0.50)
1935	39425	39360	6931050	0.098	0.854	5034	0.084	534	0.014	0.26
1936	39399.3	39333.6	6924670	0.098	0.853	5033	0.084	632	0.016	0.30
1937	39274	39208	6902810	0.098	0.850	5030	0.084	589	0.015	0.28
1938	39198	39132	6888190	0.098	0.849	5029	0.084	461	0.012	0.23
1939	39255	39189	6895330	0.098	0.849	5030	0.084	373	0.010	0.19
1940	39403	39337	6917230	0.097	0.852	5032	0.084	382	0.010	0.19
1941	39535	39470	6938450	0.097	0.855	5035	0.084	308	0.008	0.15
1942	39735	39669	6972000	0.096	0.859	5039	0.084	124	0.003	0.06
1943	40107	40041	7036160	0.095	0.867	5048	0.084	292	0.007	0.15
1944	40297	40231	7067660	0.095	0.871	5052	0.084	737	0.018	0.34
1945	40047	39981	7015010	0.095	0.864	5045	0.084	1413	0.035	0.58
1946	39155	39090	6839970	0.098	0.843	5022	0.084	880	0.023	0.41
1947	38823	38758	6771860	0.098	0.834	5013	0.083	890	0.023	0.41
1948	38507	38441	6706470	0.099	0.826	5004	0.083	766	0.020	0.38
1949	38320	38255	6672950	0.100	0.822	5000	0.083	828	0.022	0.41
1950	38074	38008	6631090	0.100	0.817	4994	0.083	1216	0.032	0.56
1951	37435	37370	6526020	0.102	0.804	4979	0.083	1759	0.047	0.76
1952	36271	36206	6327620	0.105	0.780	4950	0.083	1966	0.054	0.86
1953	34915	34851	6102670	0.109	0.752	4915	0.082	2271	0.065	0.98
1954	33298	33230	5827180	0.114	0.718	5195	0.616	2402	0.072	1.07
1955	31564	31546	5538350	0.120	0.682	1423	0.700	3053	0.097	1.28
1956	29058	28979	5149610	0.128	0.634	6046	0.667	3650	0.126	1.45
1957	25766	25747	4657940	0.138	0.574	1465	0.721	3566	0.139	1.49
1958	22599	22555	4107720	0.151	0.506	3377	0.983	3580	0.159	1.56
1959	19418	19328	3535940	0.166	0.436	6911	1.274	2847	0.147	1.51
1960	17307	17248	3101810	0.184	0.382	4585	1.136	2436	0.141	1.50
1961	16120	16068	2729090	0.206	0.336	3991	1.096	1924	0.120	1.39
1962	16794	15719	2542980	0.211	0.313	82414	0.212	1731	0.110	1.29
1963	22139	22090	2494890	0.239	0.307	3820	1.094	2008	0.091	1.31
1964	33345	33295	2569970	0.274	0.317	3774	1.077	1523	0.046	0.76
1965	45073	45019	4004610	0.177	0.493	4103	1.023	1746	0.039	0.52
1966	54436	54238	6492330	0.131	0.800	15150	0.577	3418	0.063	0.71
1967	59349	59299	8188450	0.133	1.009	3765	0.943	5331	0.090	1.00
1968	59879	59830	8829560	0.140	1.088	3776	0.957	3405	0.057	0.79
1969	60004	59946	9378930	0.130	1.155	4457	1.064	2347	0.039	0.63
1970	59442	59324	9866130	0.109	1.215	9057	0.779	2846	0.048	0.79
1971	57250	57196	9912790	0.095	1.221	4143	0.989	2497	0.044	0.78
1972	54998	54856	9723740	0.084	1.198	10881	0.223	3653	0.067	1.07
1973	51627	51335	9227200	0.072	1.137	22368	0.076	7201	0.140	1.55
1974	45901	45793	8086430	0.063	0.996	8226	0.114	9001	0.197	1.74
1975	39872	39852	6684710	0.060	0.823	1525	0.243	6404	0.161	1.61
1976	36542	36515	6061560	0.054	0.747	2050	0.210	6177	0.169	1.57
1977	32878	32351	5643970	0.047	0.695	40317	0.029	4861	0.150	1.48
1978	31518	31484	5206830	0.042	0.641	2586	0.319	4367	0.139	1.49
1979	32981	32882	4678600	0.041	0.576	7527	0.075	6116	0.186	1.63
1980	32476	32451	4485640	0.036	0.553	1946	0.164	5384	0.166	1.48

Table 12 (continued)

Year	Total biomass	Summary biomass	Spawning output	CV spawning	Depletion	Recruits (x 103)	CV recruits	Total catch	Exploit. rate	SPR ratio (rel. 0.50)
1981	31545	31533	4703570	0.029	0.579	853	0.188	5752	0.182	1.51
1982	28548	28546	4530030	0.025	0.558	161	0.338	6599	0.231	1.65
1983	23095.2	23067.6	3949030	0.024	0.486	2113.23	0.093	5598	0.243	1.66
1984	17896	17717	3205210	0.026	0.395	13759	0.026	4676	0.264	1.72
1985	13976	13961	2428170	0.030	0.299	1165	0.151	2864	0.205	1.68
1986	12810	12797	1937840	0.035	0.239	927	0.139	3121	0.244	1.78
1987	11459	11418	1645670	0.038	0.203	3105	0.075	2649	0.232	1.69
1988	10536	10409	1580560	0.038	0.195	9781	0.044	2304	0.221	1.60
1989	10068	10061	1447660	0.040	0.178	500	0.293	2756	0.274	1.73
1990	9422	9387	1184860	0.048	0.146	2649	0.105	2624	0.280	1.76
1991	8715	8688	1066010	0.056	0.131	2081	0.128	1714	0.197	1.56
1992	8663	8654	1152630	0.058	0.142	665	0.288	1832	0.212	1.55
1993	8104	8087	1132060	0.066	0.139	1249	0.151	1593	0.197	1.52
1994	7383	7370	1087470	0.076	0.134	1033	0.155	1294	0.176	1.49
1995	6682	6675	1038240	0.086	0.128	528	0.222	818	0.123	1.26
1996	6282	6271	1006170	0.095	0.124	836	0.159	547	0.087	1.09
1997	6008	6006	997959	0.102	0.123	181	0.327	498	0.083	1.08
1998	5680	5666	972721	0.109	0.120	1014	0.187	211	0.037	0.61
1999	5640	5553	975318	0.112	0.120	6690	0.124	213	0.038	0.69
2000	5911	5907	961259	0.115	0.118	274	0.364	160	0.027	0.55
2001	6667	6663	956309	0.117	0.118	249	0.356	139	0.021	0.39
2002	7392	7380	1053080	0.117	0.130	942	0.192	90	0.012	0.21
2003	8014	7970	1233330	0.117	0.152	3302	0.135	13	0.002	0.03
2004	8646	8640	1373430	0.117	0.169	425	0.291	85	0.010	0.19
2005	9216	9174	1454170	0.118	0.179	3191	0.143	107	0.012	0.23
2006	9718	9705	1540910	0.120	0.190	927	0.239	60	0.006	0.13
2007	10301	10277	1644130	0.121	0.203	1844	0.174	63	0.006	0.13
2008	10807	10780	1744770	0.122	0.215	2071	0.179	59	0.006	0.11
2009	11334	11267	1849530	0.123	0.228	5074	0.163	58	0.005	0.11
2010	12184	12001	1935940	0.124	0.238	14000	0.162	75	0.006	0.14
2011	13920	13891	2022350	0.126	0.249	2252	0.336	112	0.008	0.16
2012	16561	16537	2176180	0.127	0.268	1881	0.605	188	0.011	0.21
2013	*19077*	*19027*	*2551060*	*0.131*	*0.314*	*3855*				

Table 13: Decision table for base model

Pessimistic catches		Pessimistic	Base	Optimistic
2013	*320*	0.20	0.31	**0.42**
2014	*337*	0.24	0.38	**0.50**
2015	324	0.27	**0.43**	**0.56**
2016	329	0.30	**0.46**	**0.61**
2017	341	0.32	**0.49**	**0.64**
2018	357	0.34	**0.52**	**0.67**
2019	374	0.36	**0.55**	**0.70**
2020	391	0.39	**0.57**	**0.72**
2021	407	**0.41**	**0.59**	**0.74**
2022	422	**0.43**	**0.61**	**0.76**
2023	436	**0.45**	**0.63**	**0.77**
2024	449	**0.47**	**0.65**	**0.78**
Base model catches		State 1	Base	State 2
2013	*320*	0.20	0.31	**0.42**
2014	*337*	0.24	0.38	**0.50**
2015	547	0.27	**0.43**	**0.56**
2016	537	0.29	**0.46**	**0.60**
2017	537	0.31	**0.49**	**0.63**
2018	543	0.33	**0.51**	**0.66**
2019	553	0.34	**0.53**	**0.68**
2020	563	0.36	**0.55**	**0.70**
2021	573	0.38	**0.57**	**0.71**
2022	582	**0.40**	**0.58**	**0.73**
2023	591	**0.42**	**0.59**	**0.74**
2024	599	**0.44**	**0.61**	**0.74**
Optimistic catches		State 1	Base	State 2
2013	*320*	0.20	0.31	**0.42**
2014	*337*	0.24	0.38	**0.50**
2015	632	0.27	**0.43**	**0.56**
2016	613	0.29	**0.46**	**0.60**
2017	603	0.30	**0.48**	**0.63**
2018	600	0.32	**0.50**	**0.66**
2019	601	0.34	**0.52**	**0.68**
2020	603	0.35	**0.54**	**0.69**
2021	605	0.37	**0.56**	**0.70**
2022	608	0.39	**0.58**	**0.71**
2023	610	**0.41**	**0.59**	**0.72**
2024	612	**0.42**	**0.61**	**0.73**
OFL catches (>2014)		State 1	Base	State 2
2013	*321*	0.20	0.31	**0.42**
2014	*338*	0.21	0.38	**0.47**
2015	1536	0.22	**0.43**	**0.51**
2016	1437	0.21	**0.44**	**0.53**
2017	1379	0.21	**0.45**	**0.54**
2018	1348	0.21	**0.45**	**0.55**
2019	1332	0.21	**0.46**	**0.55**
2020	1321	0.21	**0.46**	**0.55**
2021	1314	0.21	**0.46**	**0.56**
2022	1309	0.21	**0.46**	**0.56**
2023	1305	0.21	**0.45**	**0.56**
2024	1301	0.21	**0.45**	**0.56**

Table 14: Base model reference points

Unfished Stock	Estimate	95% Confidence Limits Lower	Upper
Summary (1+) Biomass	45476	37435	53517
Spawning Output (* 109)	8118	5302	10934
Equilibrium recruitment	5169	3370	6968

	Yield reference Points $SSB_{40\%}$	SPR proxy	MSY est.
SPR	0.494	0.500	0.428
Exploitation rate	0.068	0.067	0.084
Yield (tons)	1347	1341	1378
Spawning output (x109)	3247	3307	2614
SSB/SSB_0	0.40	0.41	0.32

Table 15: Results of 2009 base model, 2011 update base model, this base model, and the two retrospective (2 and 4 year) runs conducted for sensitivity analysis.

	2009 base model	2011 update	2013 base model	retrospective (two year)	retrospective (four year)
R0	5060	5106	5169	5045	5066
SSB0 (x10^9 larvae)	7861	7812	8118	7982	8125
Unfished biomass	44070	44116	45546	44606	45072
S2009/SSB0	0.281	0.247	0.228	0.233	0.257
S2011/SSB0		0.260	0.249	0.252	0.265
S2013/SSB0			0.268	0.274	0.263
H. est	0.573	0.595	0.614	0.597	0.565
Likelihoods	3102.1	3303.8	3825.2	3673.4	3522.2
Survey	85.4	143.1	129.9	118.0	108.1
Length_comp	2986.7	3126.2	3658.7	3520.0	3379.0
Recruitment	32.9	32.7	35.2	33.9	33.6
Parm_priors	1.4	1.5	1.5	1.4	1.6
Survey					
Trawl_south	7.6	7.2	8.1	8.0	8.6
RecSouth	7.7	8.0	8.0	8.0	7.7
RecCentral	10.1	10.8	10.1	10.0	9.4
CalCOFI	21.3	21.7	38.4	36.5	34.8
Triennial	4.1	3.8	4.1	4.1	4.4
CPFV_index	6.0	5.6	6.6	6.6	7.0
SCB_hook	2.4	32.3	4.6	4.4	0.4
Combo	2.9	3.8	5.5	0.9	0.3
Juv_trawl	3.9	5.7	5.9	4.5	3.5
Pier_index	19.4	20.5	20.1	19.5	18.5
Impingement	0.0	23.6	18.5	15.4	13.6
Length					
Trawl_south	468.1	466.5	496.3	497.9	499.3
hook-line	363.0	363.3	366.0	366.3	366.4
setnet	356.2	354.3	296.3	297.0	298.6
RecSouth	375.4	422.8	567.3	523.1	469.4
RecCentral	365.2	396.7	435.5	394.3	361.1
Trawl_north	365.4	369.2	681.1	678.4	674.3
CalCOFI	0.0	0.0	0.0	0.0	0.0
Triennial	151.0	148.4	270.4	271.8	274.3
CPFV_index	213.1	215.3	135.5	136.3	134.8
SCB_hook	60.9	81.0	93.7	62.0	47.1
Combo	137.3	177.7	142.8	121.6	87.0
RecSouthObs	131.0	131.0	173.8	171.3	166.6

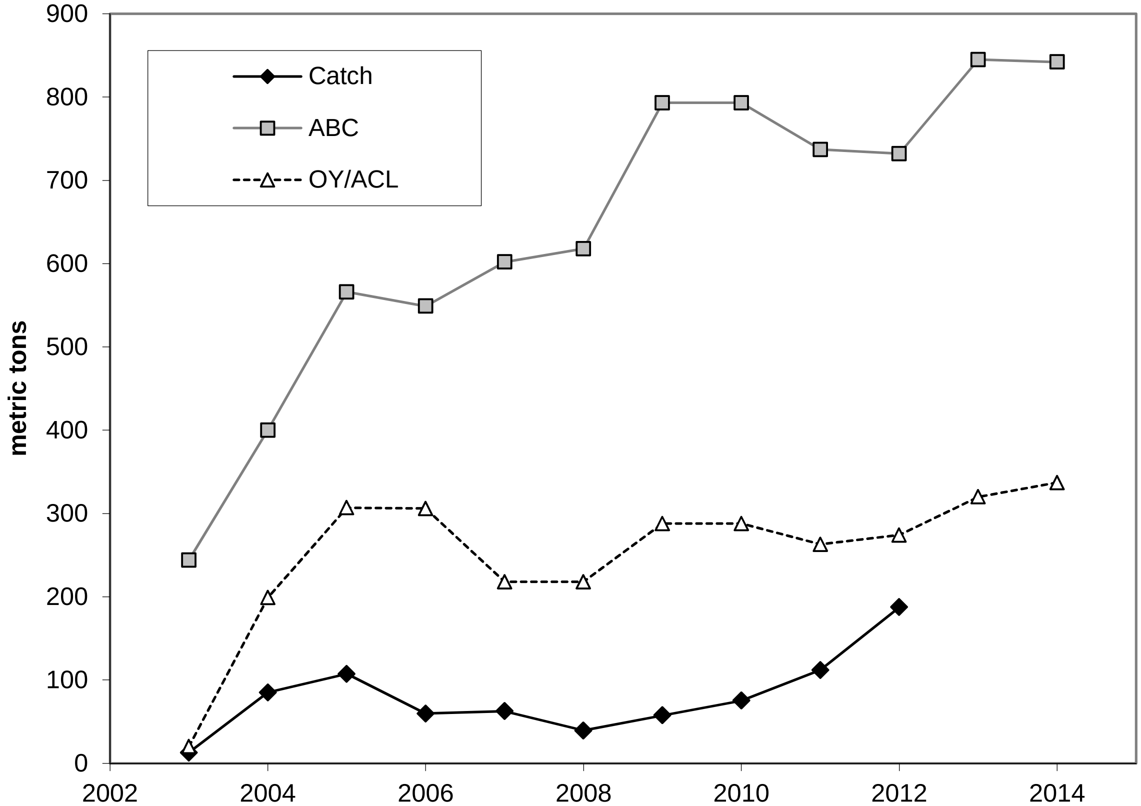


Figure 1: Management performance with PFMC adopted ABC and OY values relative to estimated catches from 2000-2014

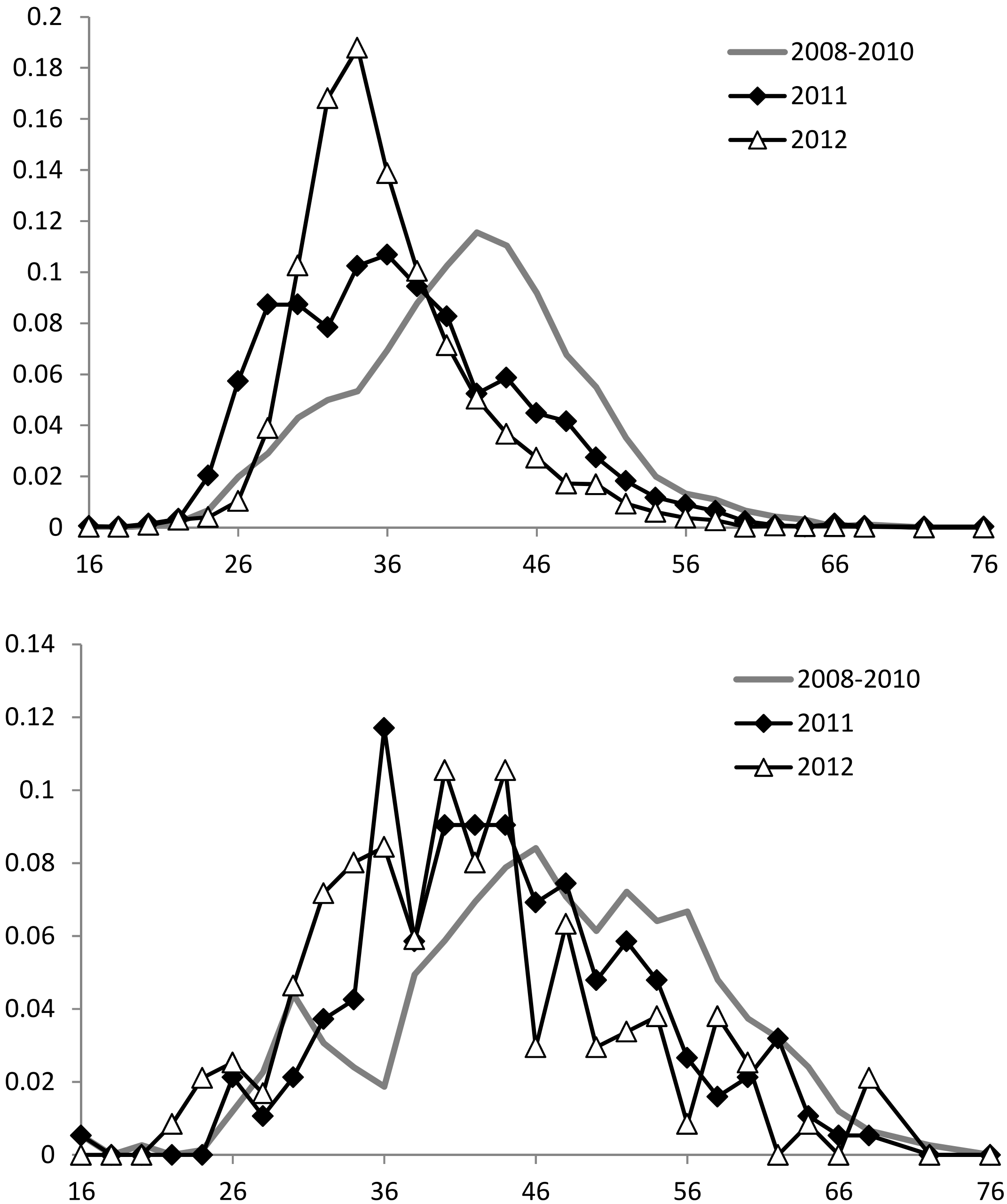


Figure 2: Length composition data for southern (top) and central/northern (bottom) California recreational fisheries.

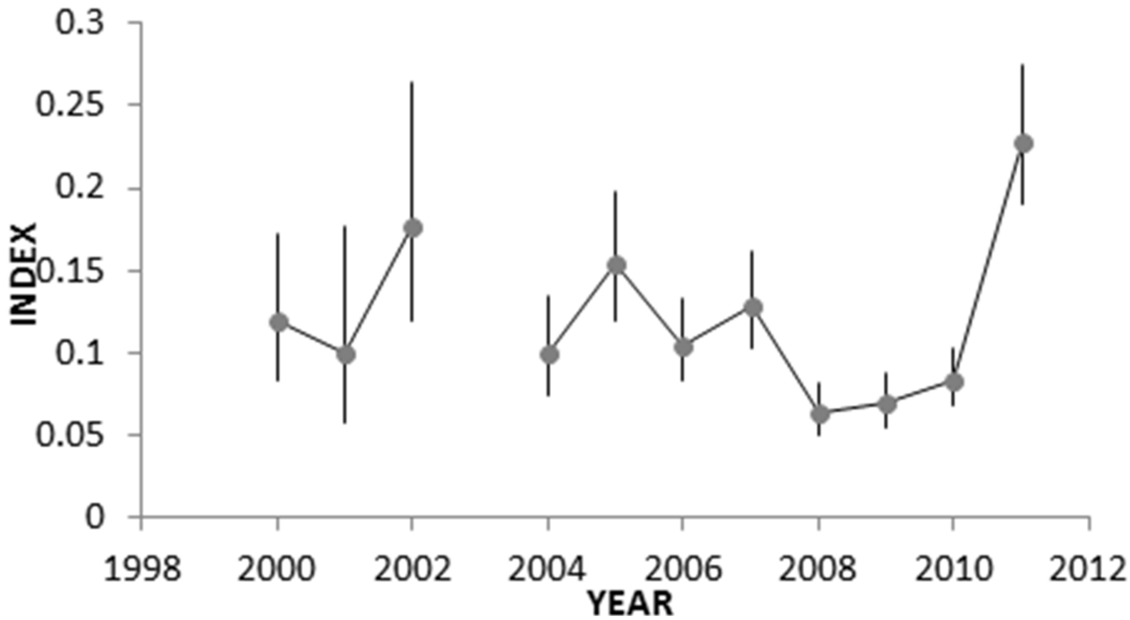


Figure 3: Southern California Recreational CPUE Index (for descriptive purposes only, not included in model).

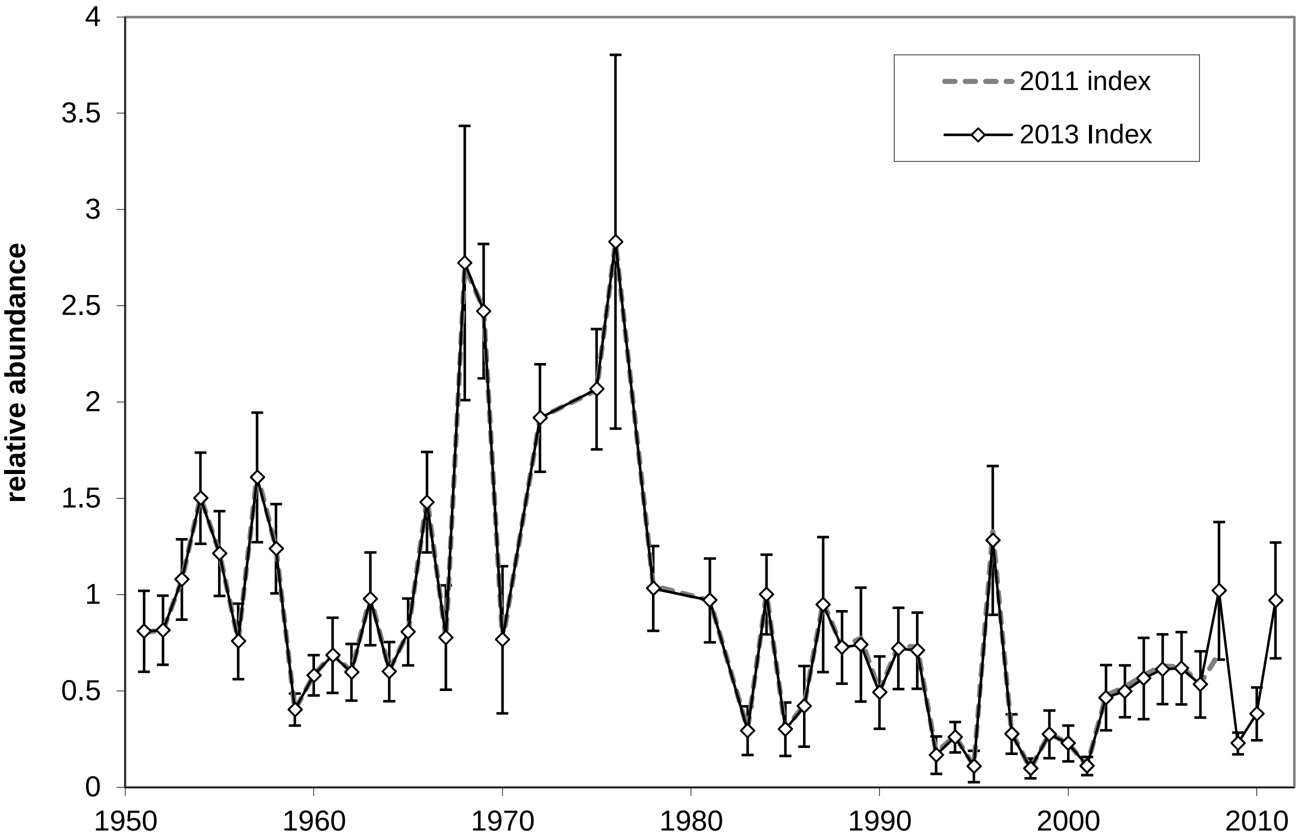


Figure 4: CalCOFI larval abundance indices for the coastwide bocaccio model updated through 2011 as compared to the 2011 model index (which included data through 2010).

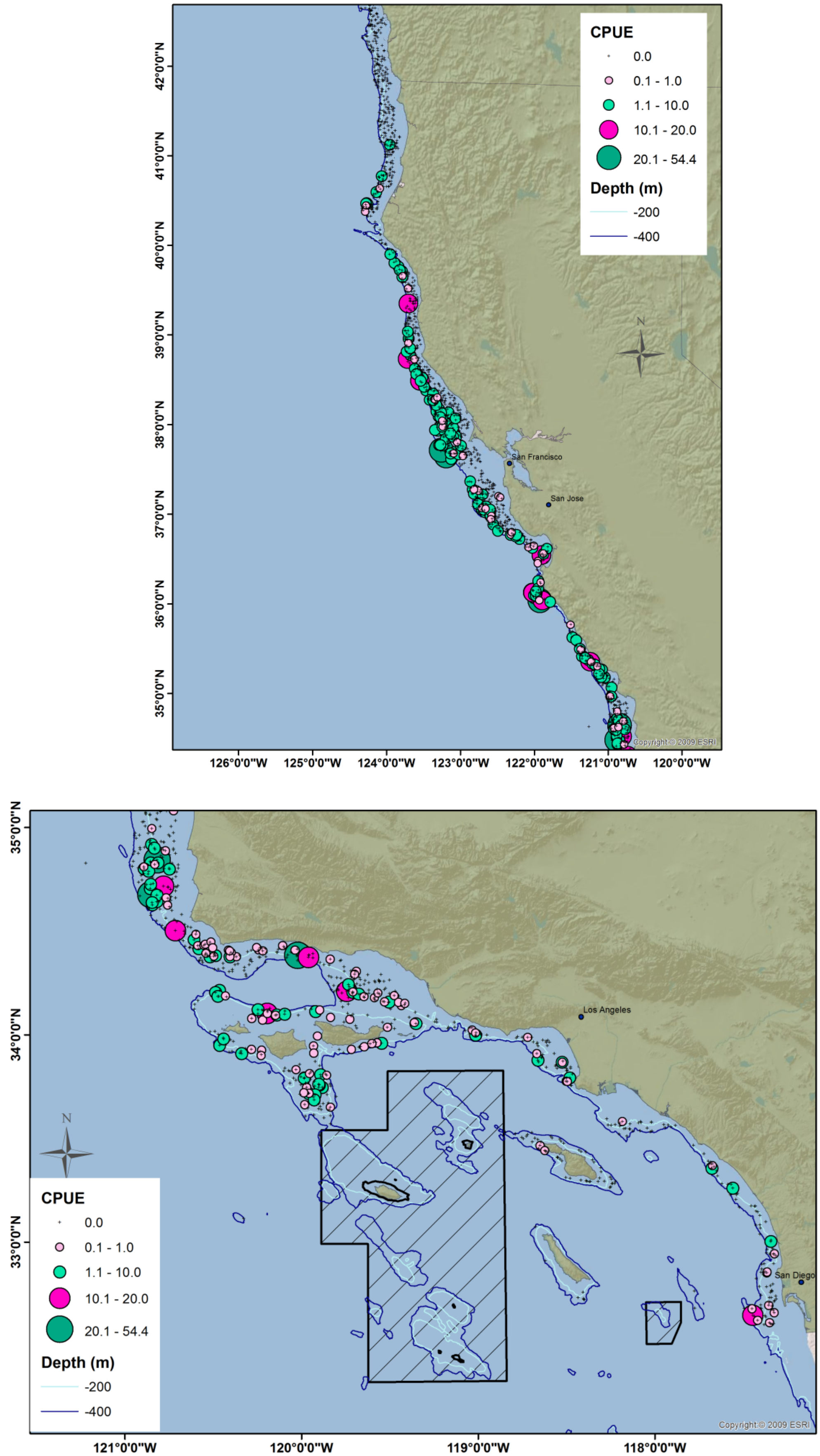
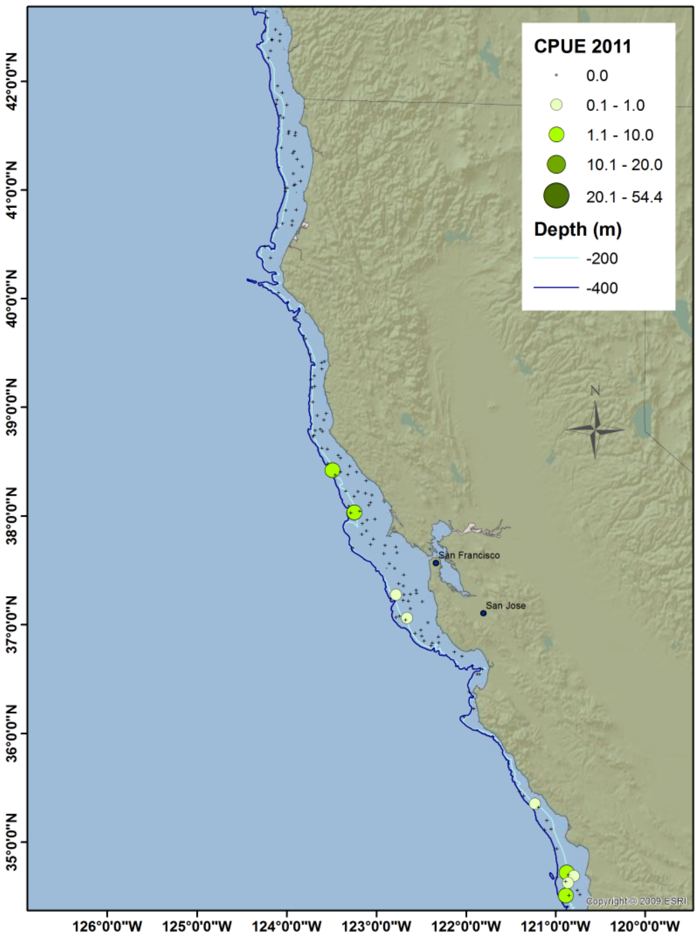
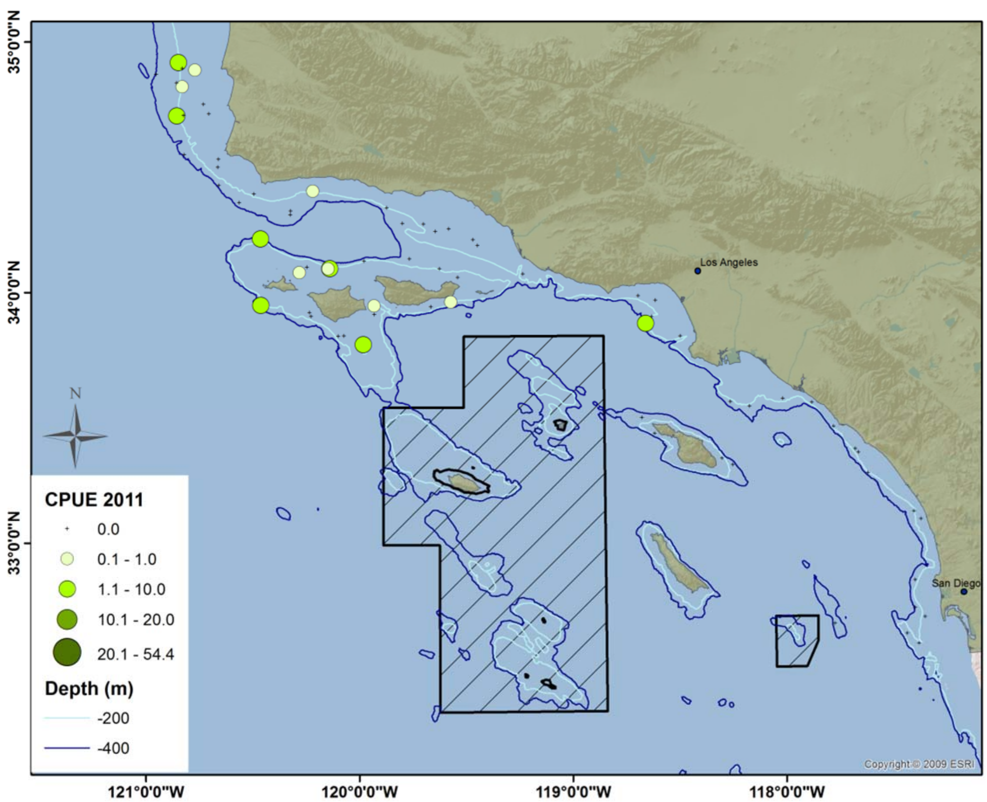
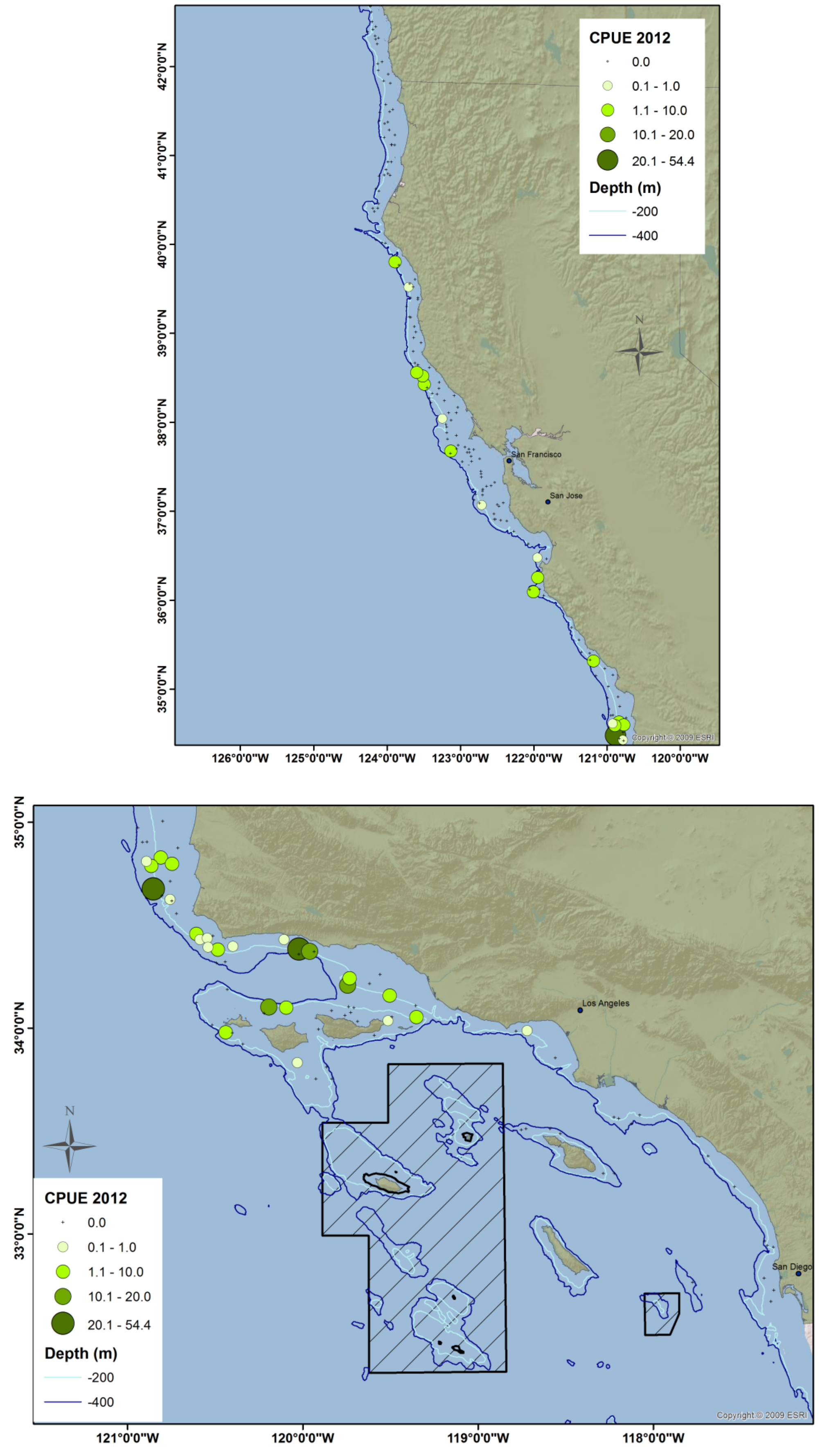


Figure 5a-b: NWFSC Combined shelf-slope survey CPUE for bocaccio rockfish (age 1+), all years (2003-2012) combined.

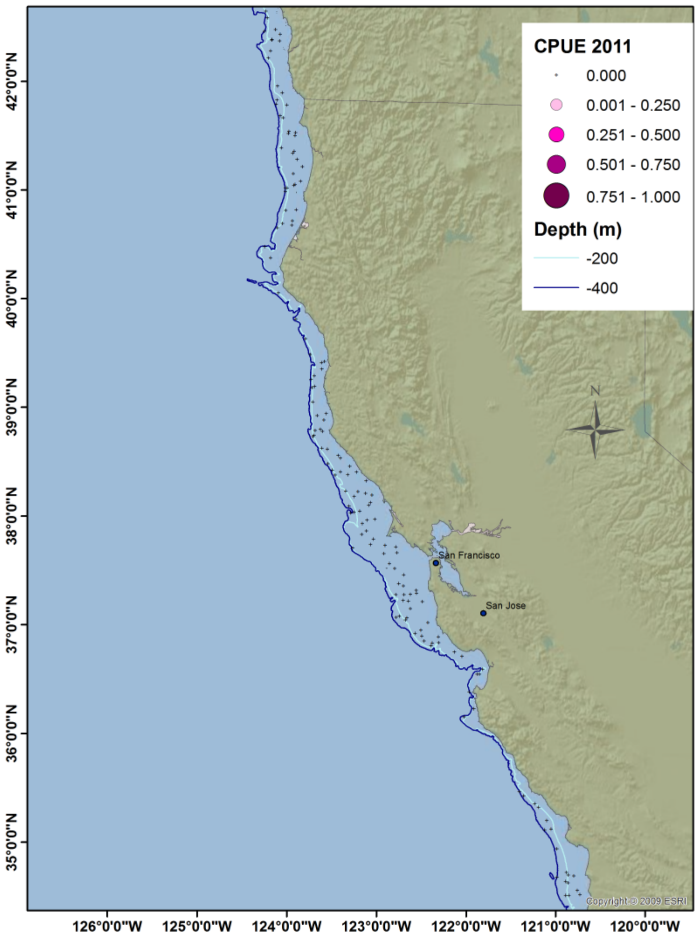


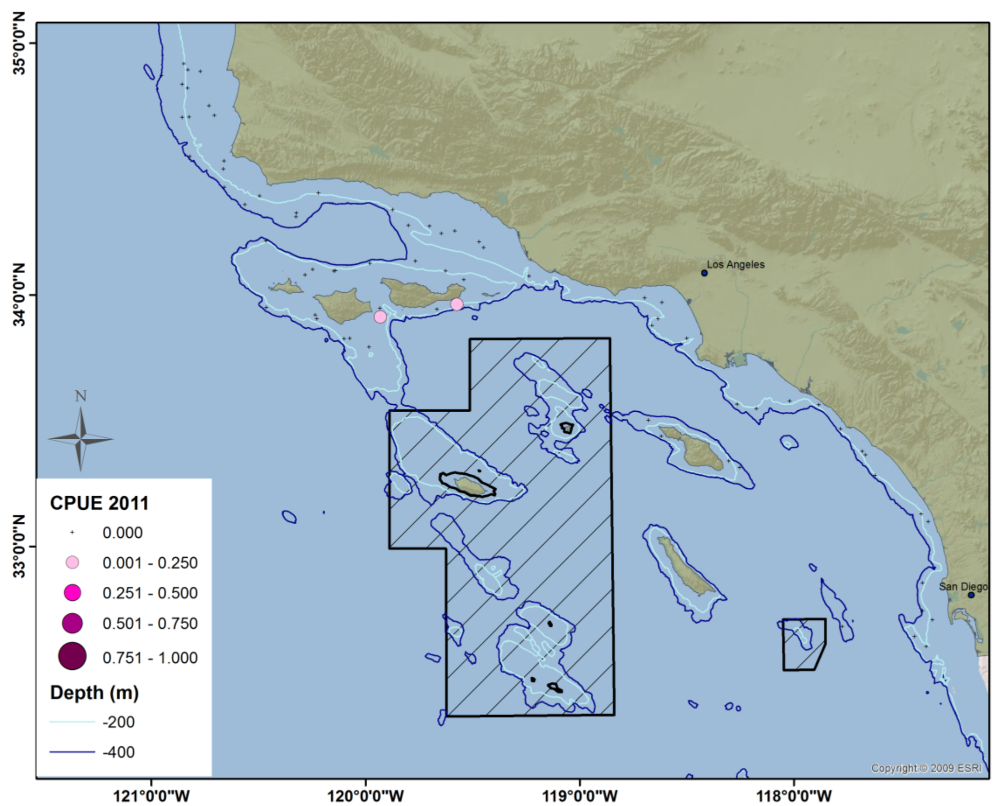


Figures 6a-b. Northwest Fisheries Science Center combined trawl survey catches of age 1+ (>20 cm) bocaccio during 2011.

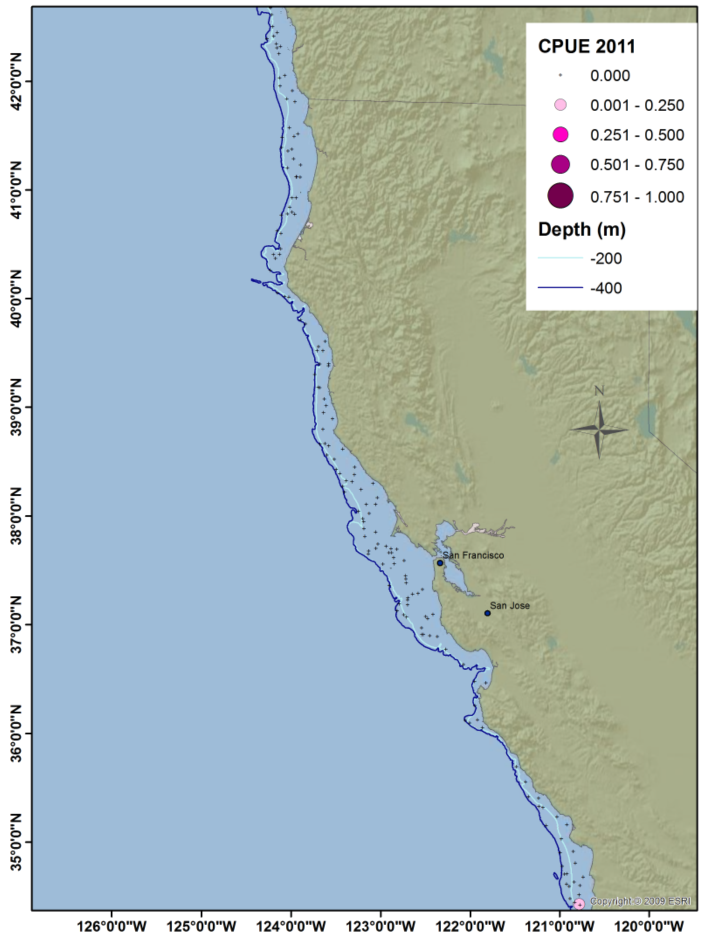


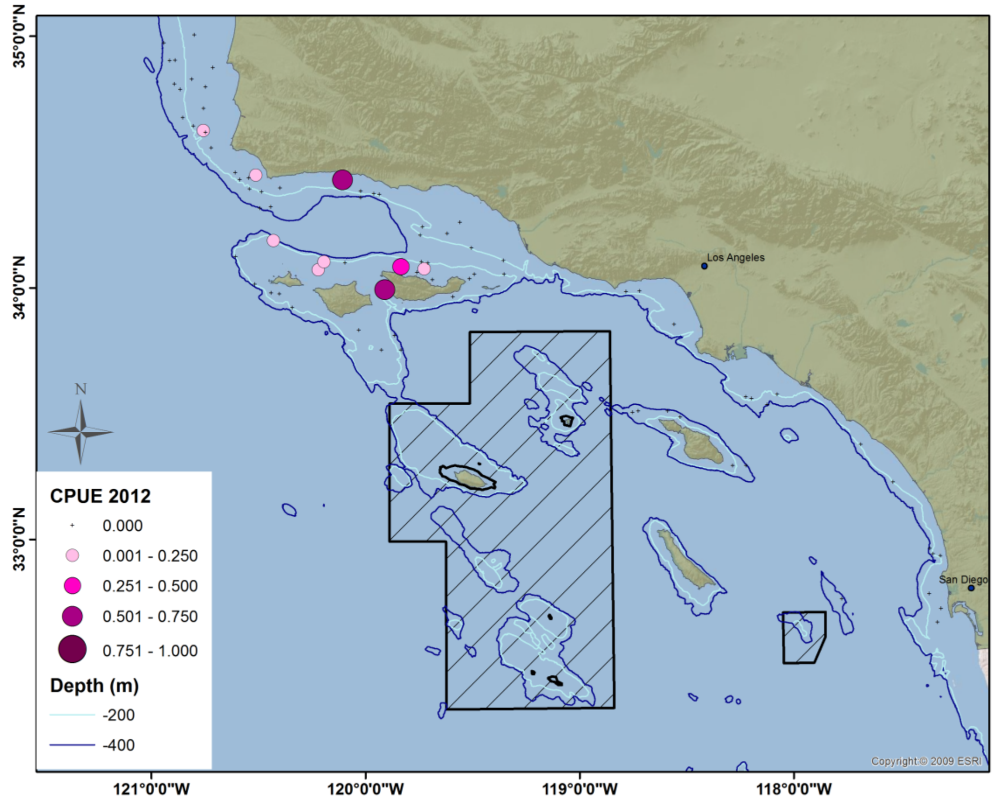
Figures 7a-b. Northwest Fisheries Science Center combined trawl survey catches of age 1+ (>20 cm) bocaccio during 2012.



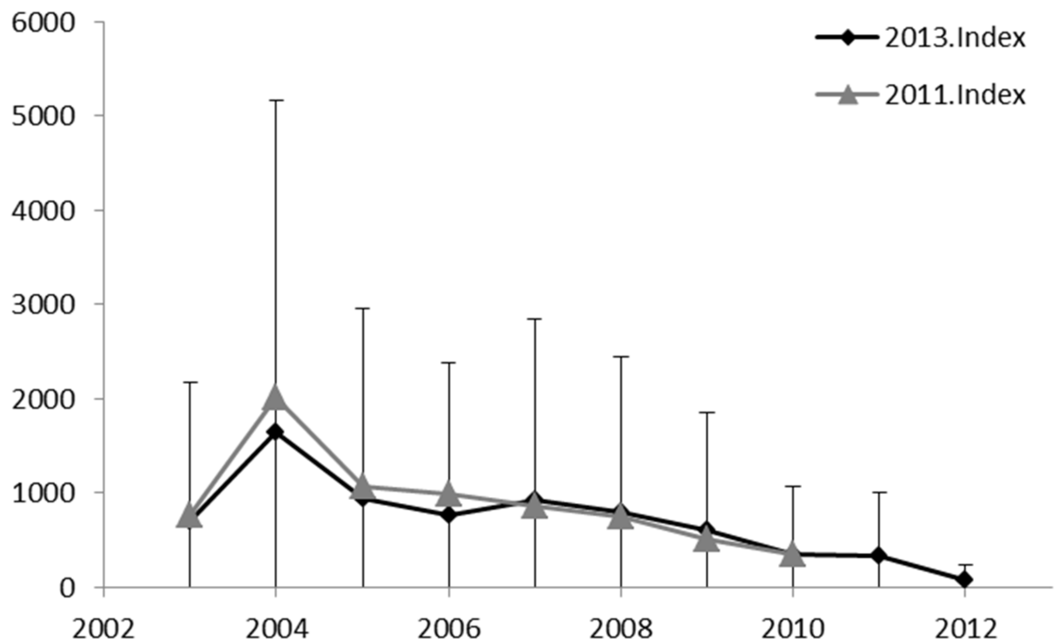


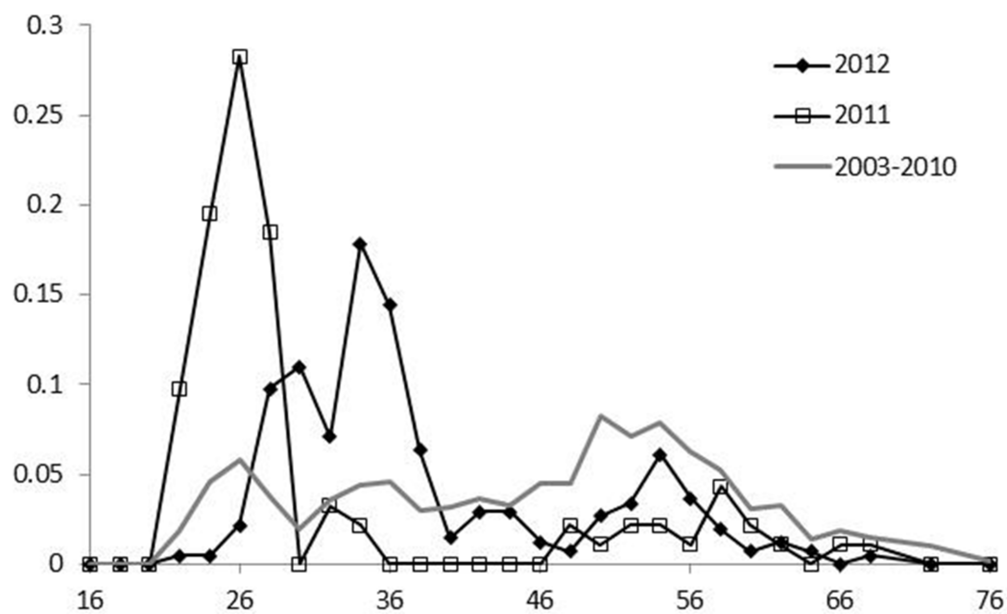
Figures 8a-b. Northwest Fisheries Science Center combined trawl survey catches of likely age-0 (<22 cm) bocaccio 2011.





Figures 9a-b. Northwest Fisheries Science Center combined trawl survey catches of likely age-0 (<22 cm) bocaccio in 2012.





Figures 10a-b. 5a (top), Comparison of the 2011 and updated 2013 GLMM indices from the NWFSC trawl survey. 10b (bottom), length composition data over 2003-2010 period compared to 2011 and 2012. Both figures represent indices and compositional data after removal of age 0 (<22 cm) fish.

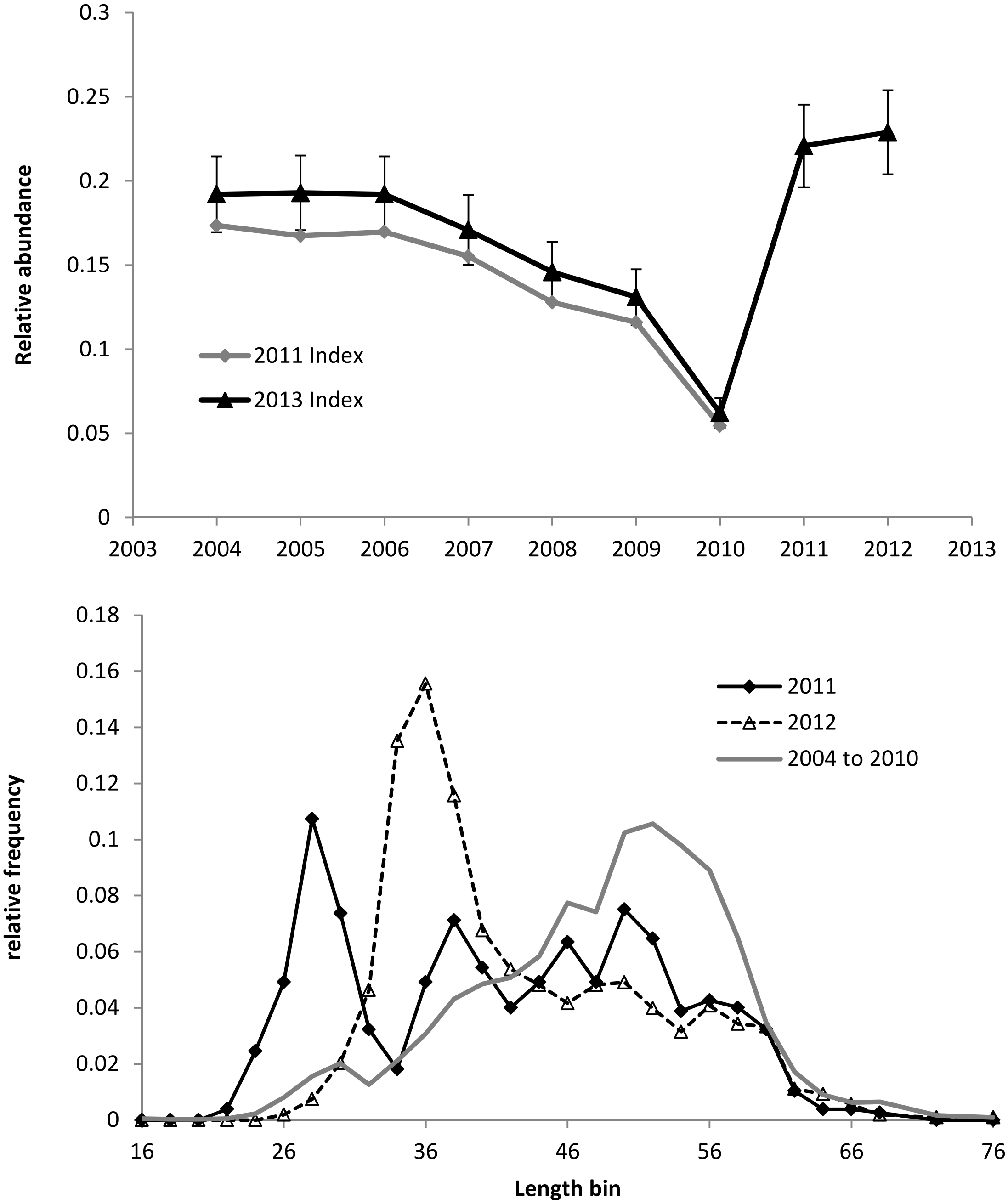


Figure 11a-b: Figure 11a (top) Comparison of the 20011 NWFSC hook and line survey CPUE index with the index developed for 2013 , and 11b (bottom) length composition data associated with the 2011 and 2012 (relative to all previous years) from the hook and lin esurvey.

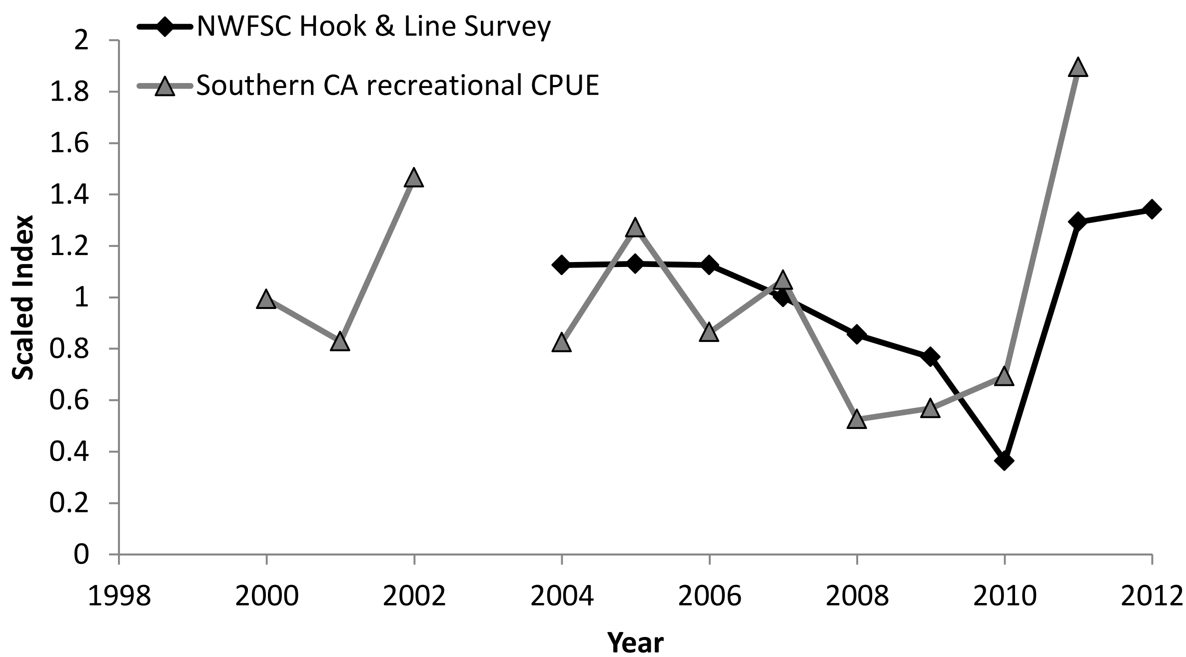


Figure 12: Comparison of the NWFSC hook and line survey index with an index developed from observer data onboard recreational CPFV vessels.

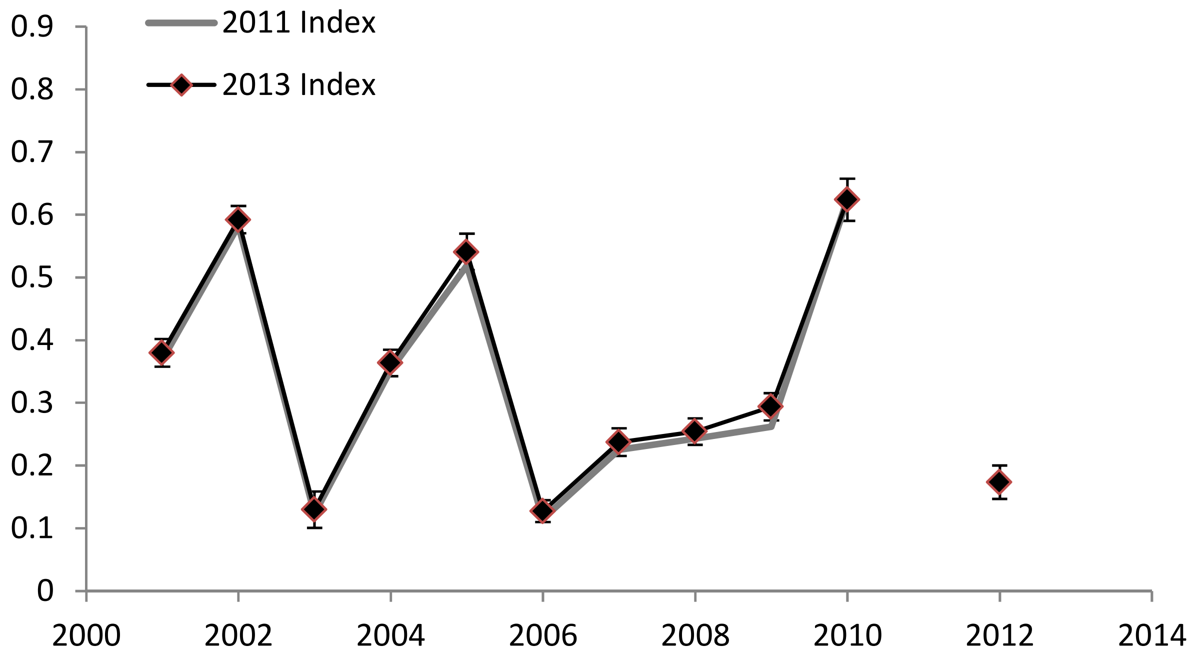


Figure 13: Juvenile rockfish survey estimates of young-of-the-year (YOY) abundance, compared to the index used in the 2011 update. Lack of data in the southern area precluded the ability to generate an index point for 2011.

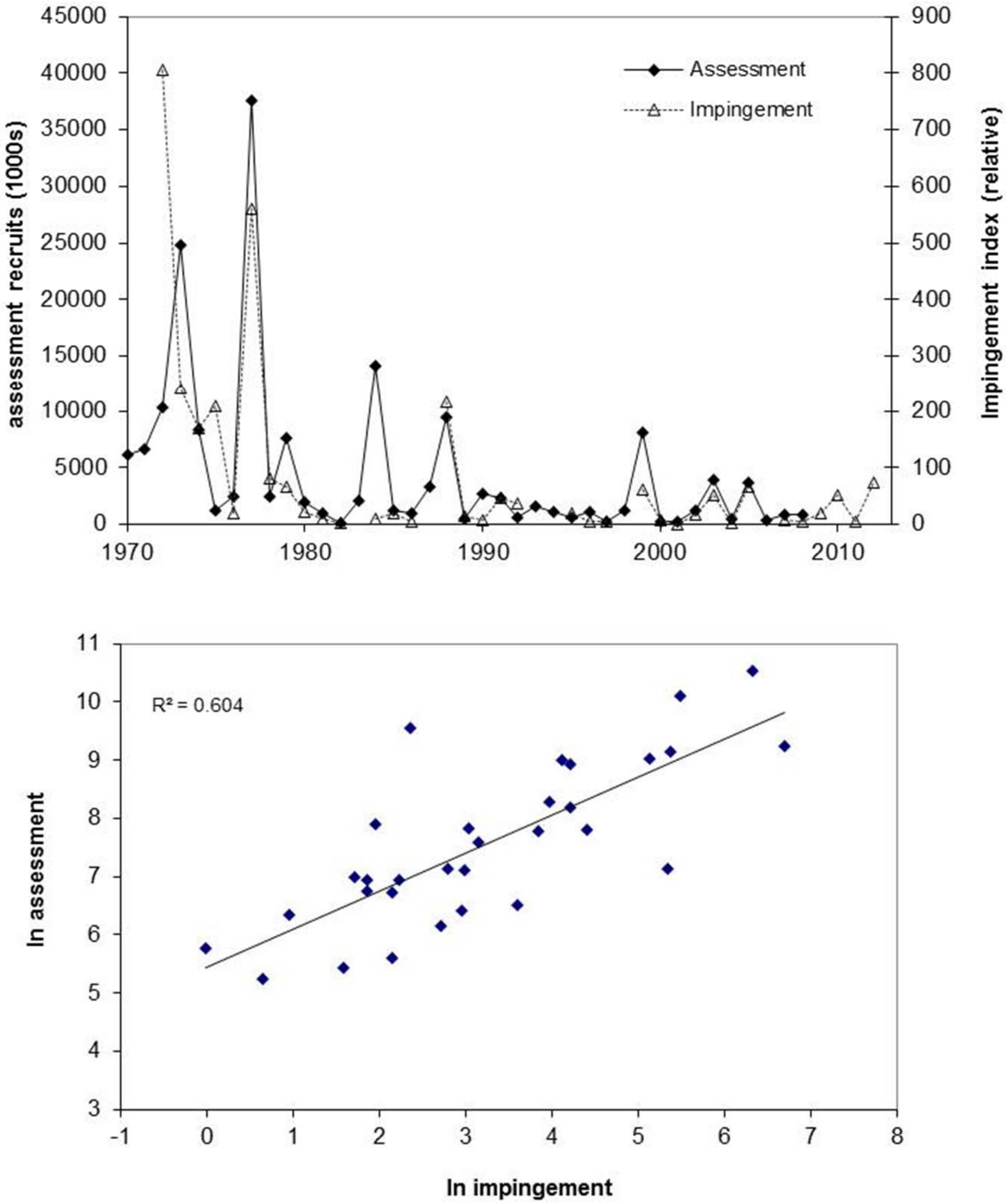


Figure 14: Comparison of the power plant impingement dataset for age 0 abundance with the 2009 base model estimates of recruitment (which did not include this dataset).

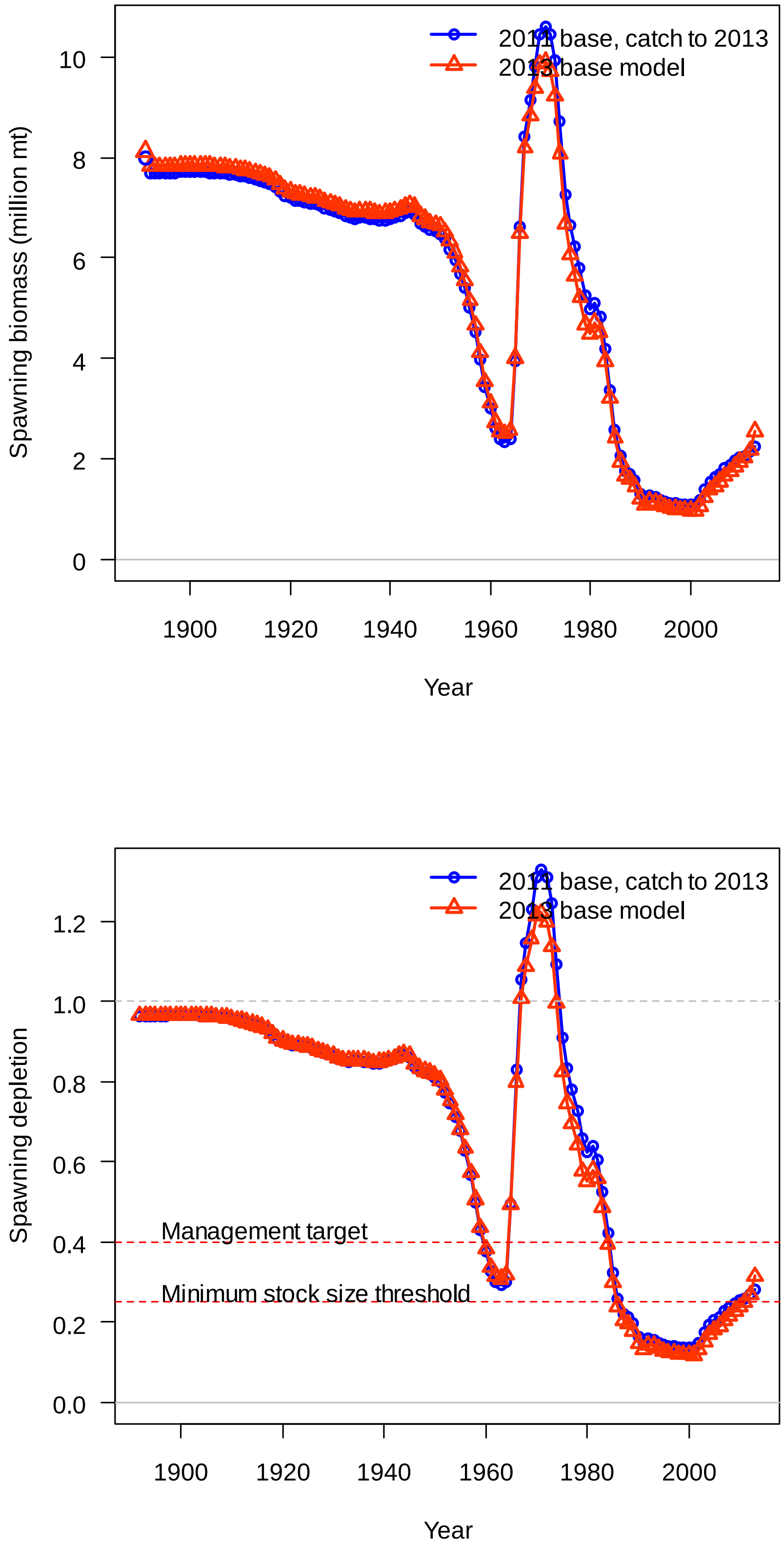
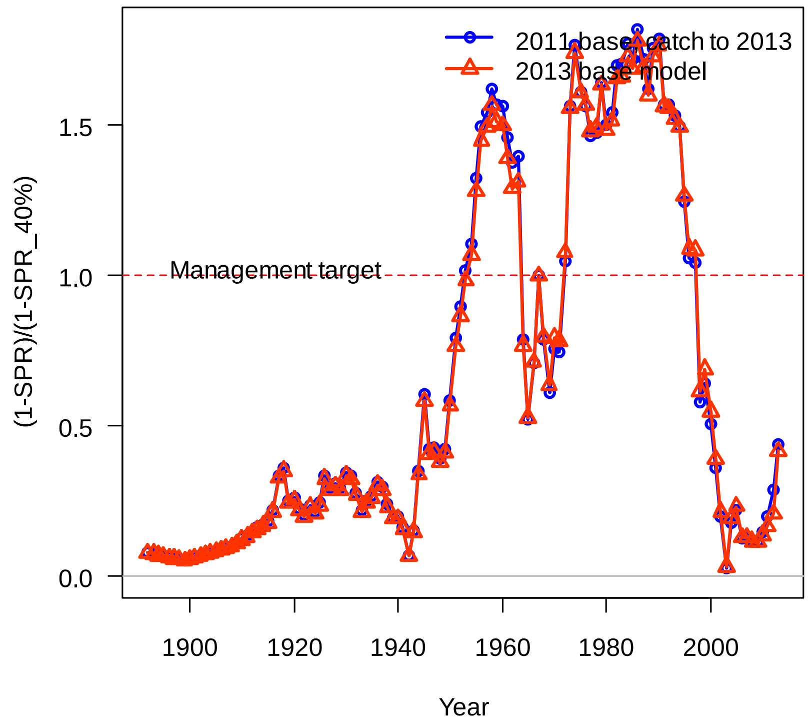


Figure 15: Comparison of spawning output and depletion estimates between the 2011 update (projected forward to 2013 with catches only) and the 2013 base model



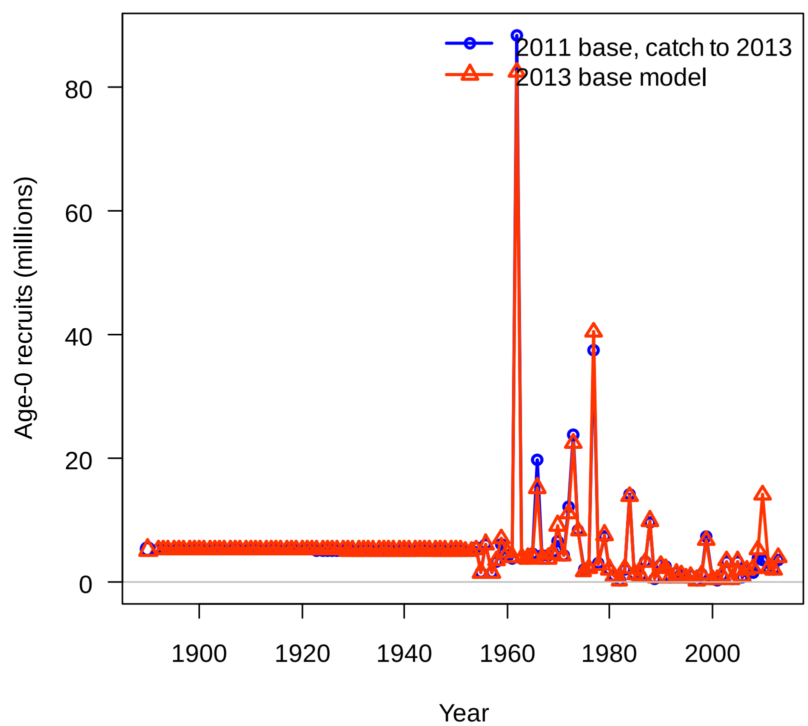


Figure 16: Comparison of recruitment and recruitment deviation estimates between the 2011 update (projected forward to 2013 with catches only) and the 2013 base model.

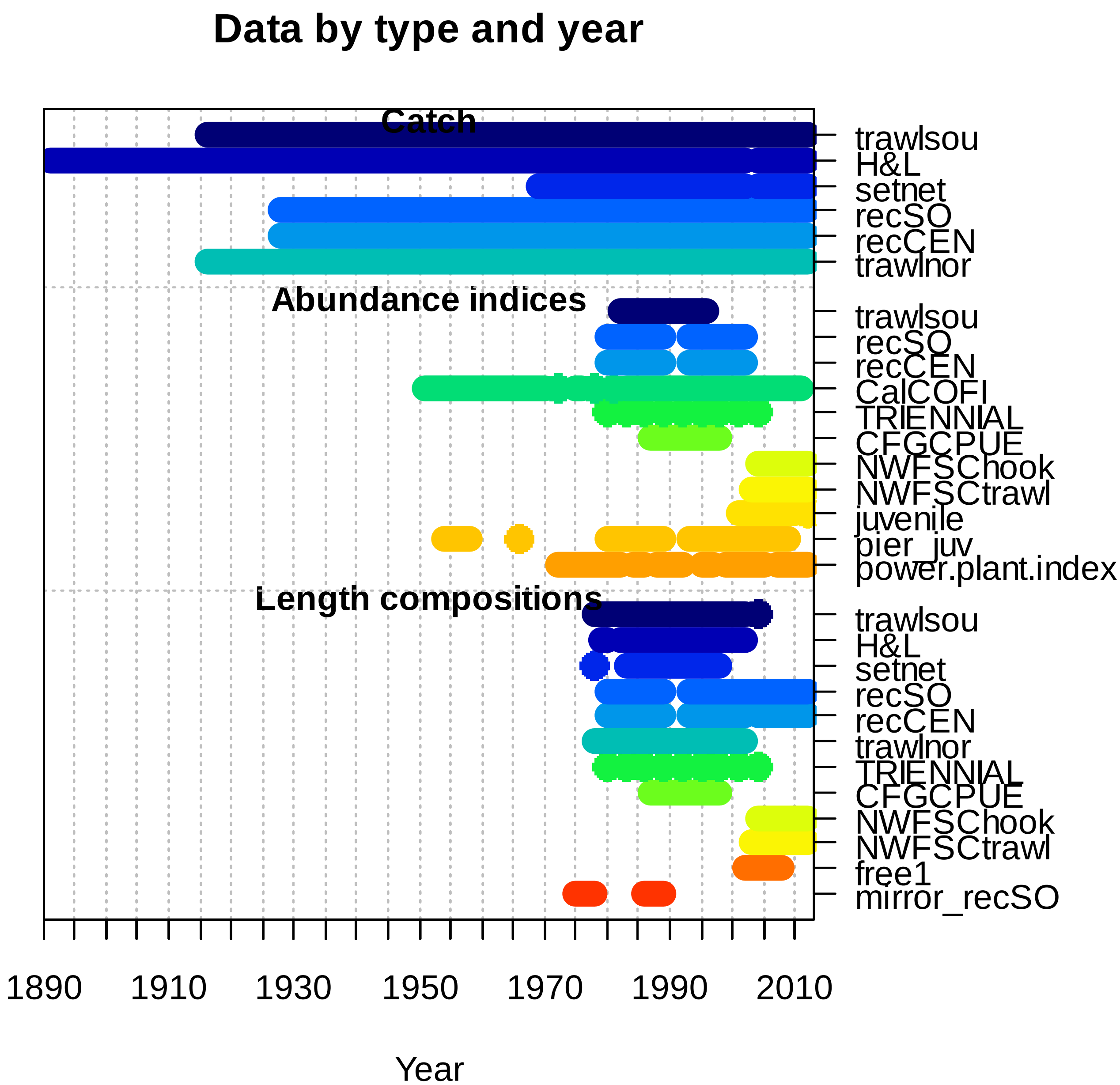
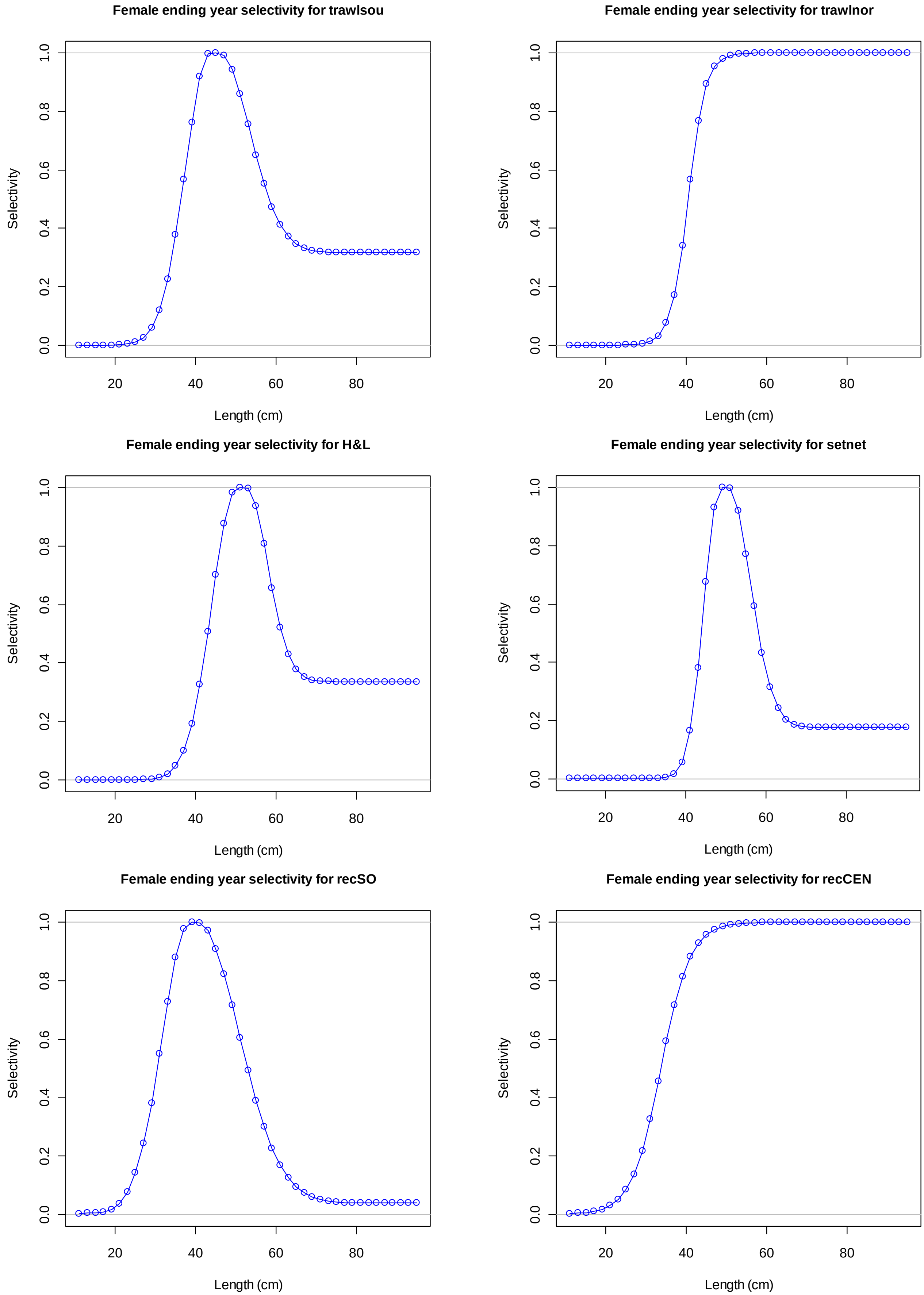
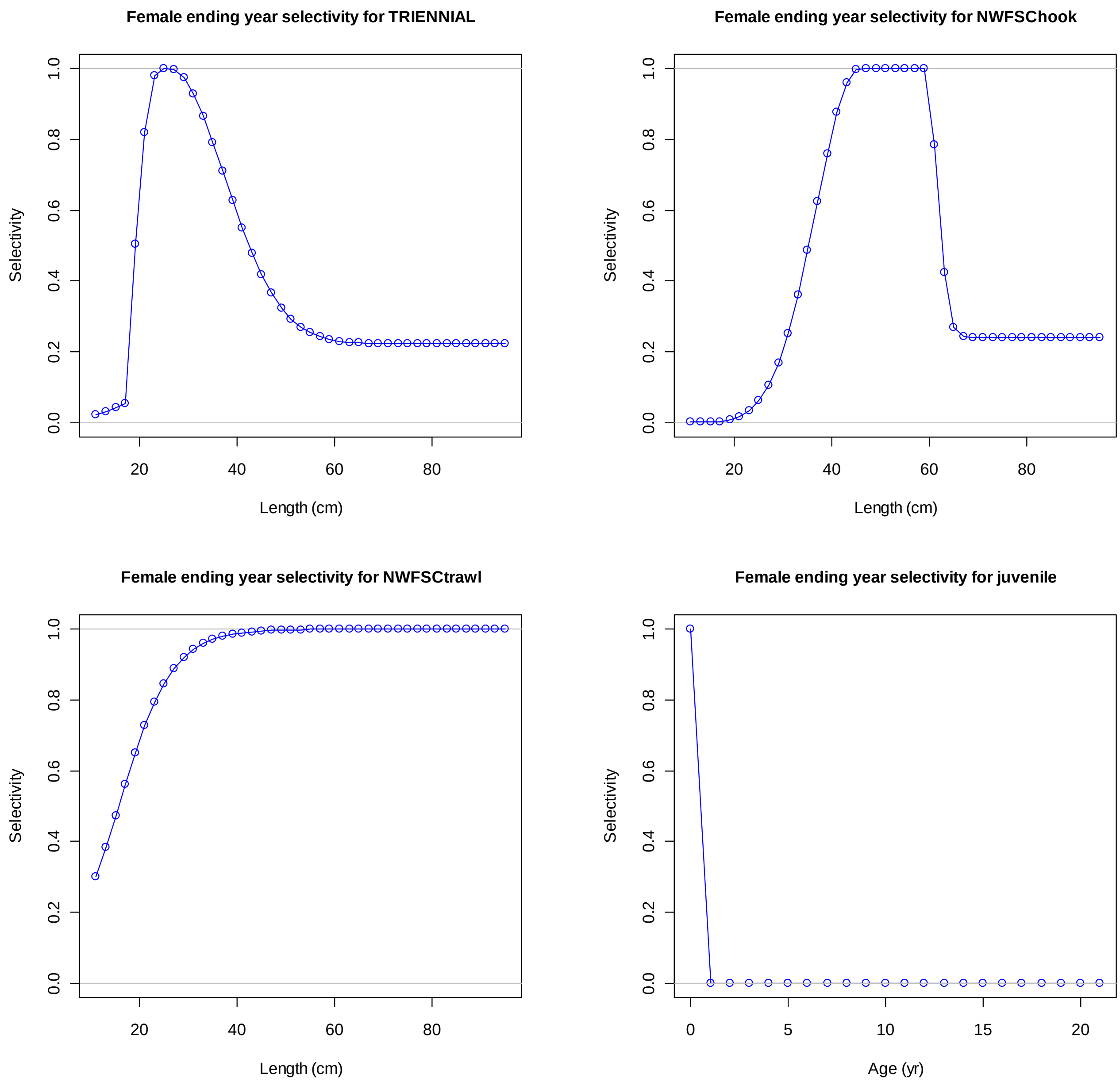


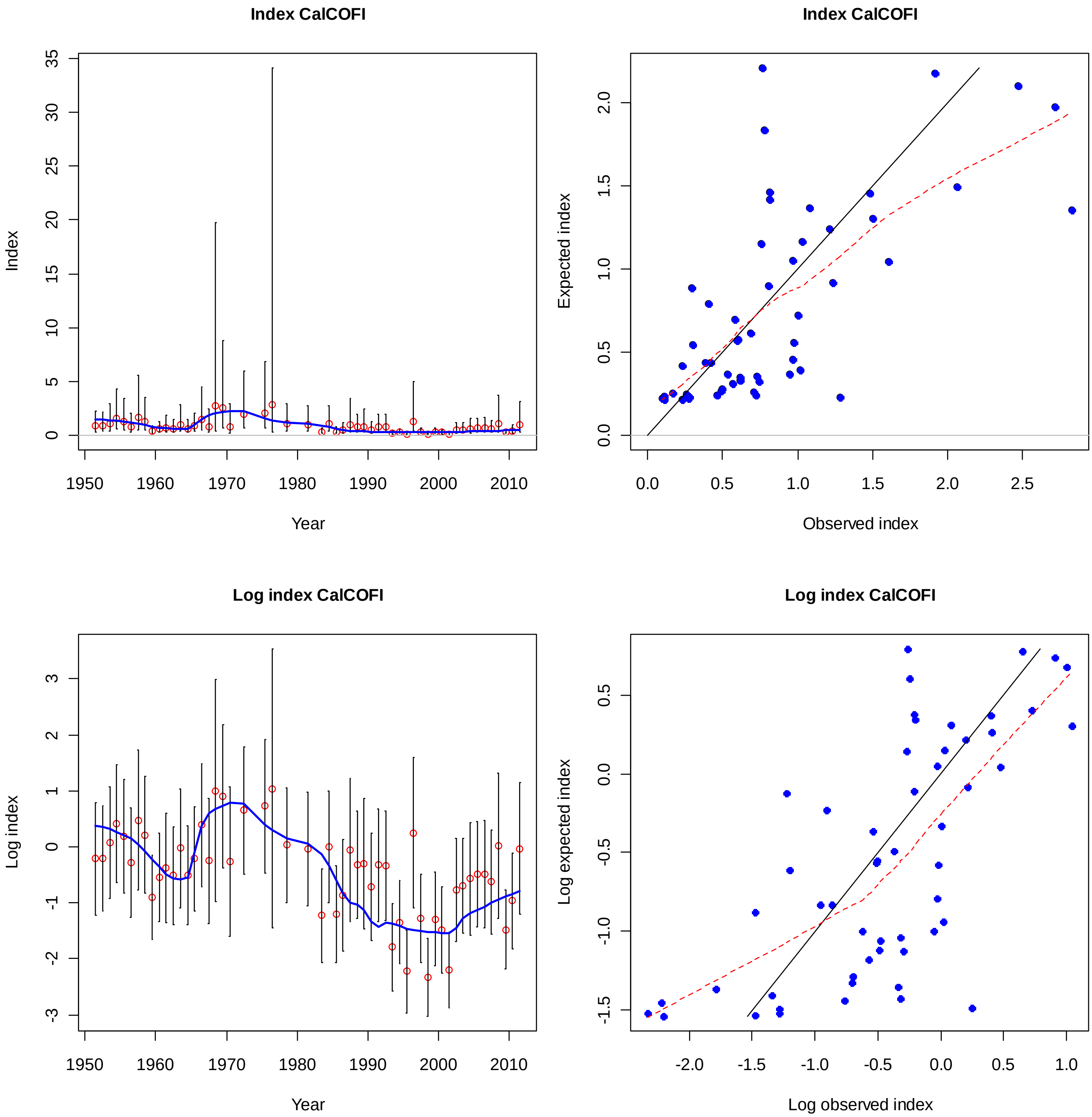
Figure 17: Summary of major sources of data used in the 2013 bocaccio model.



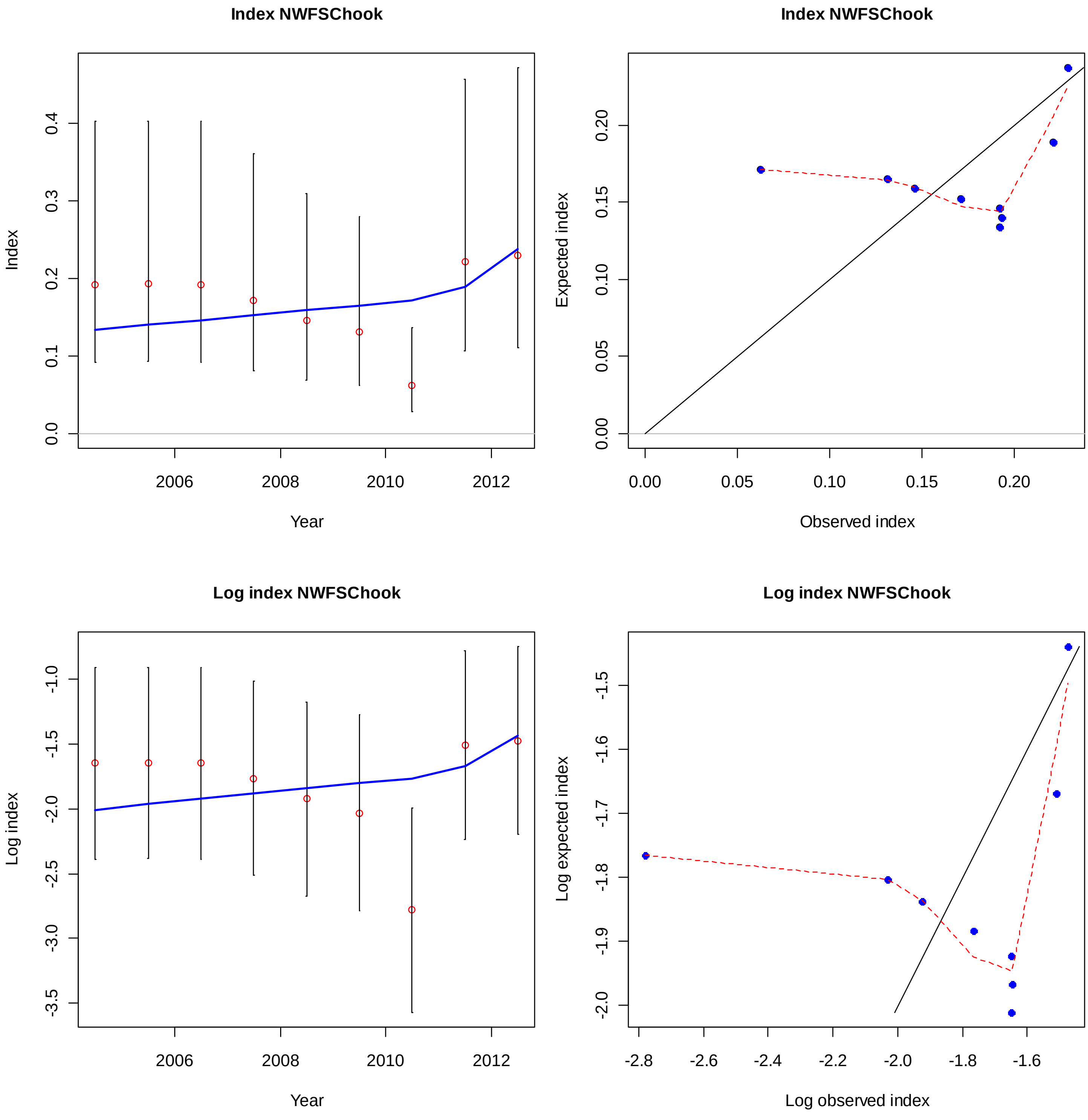
Figures 18 a-f. Selectivity curves for bocaccio in commercial and recreational fisheries as estimated in the 2013 base model.



Figures 19 a-d. Selectivity curves as estimated for fishery independent surveys from the 2013 base model.



Figures 20a-d. Arithmetic and log fits, with corresponding observed and predicted values, to the CalCOFI larval abundance time series of bocaccio abundance.



Figures 21a-d. Arithmetic and log fits, with corresponding observed and predicted values, to the NWFSC hook and line survey GLMM index of bocaccio abundance.

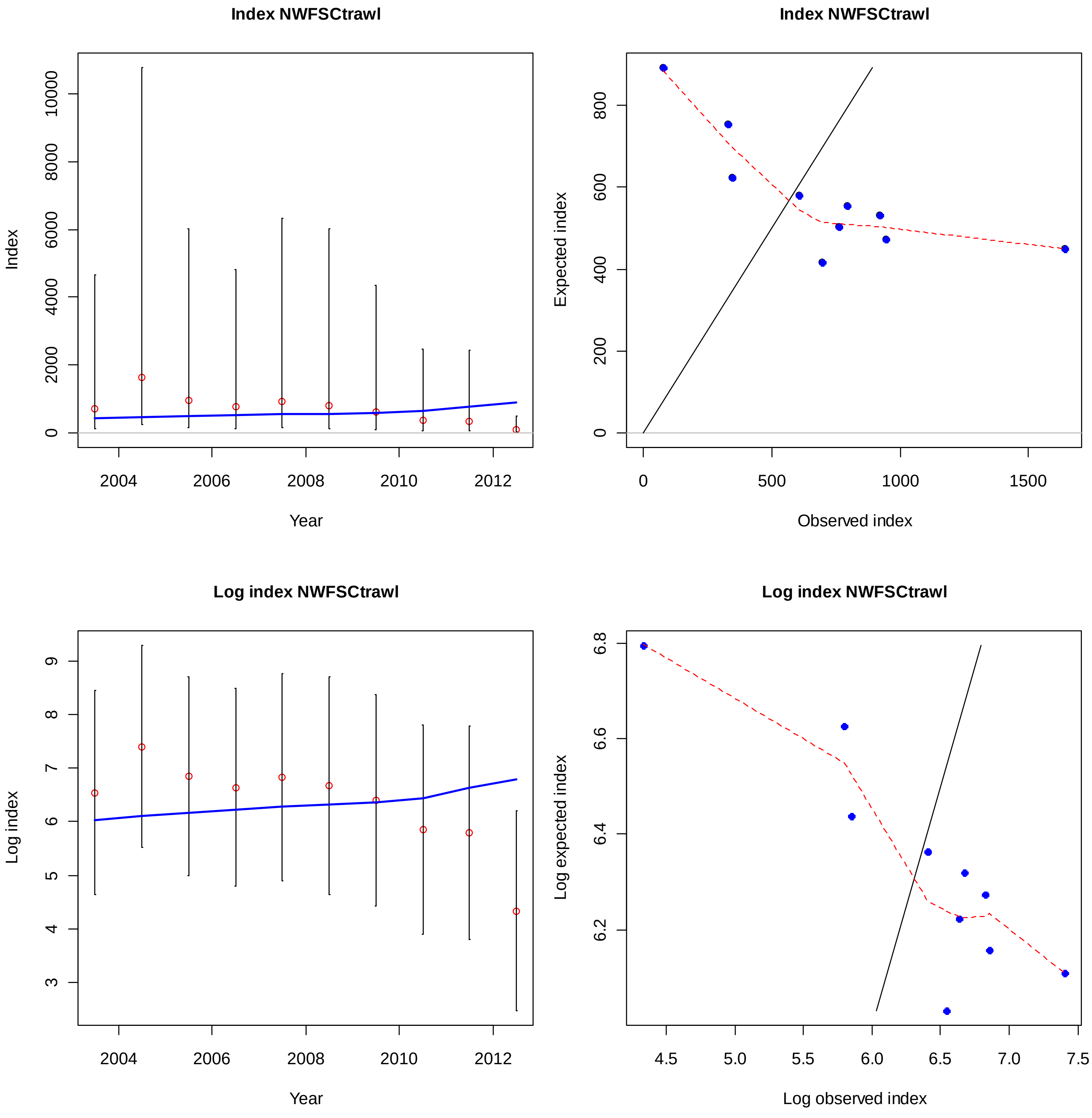


Figure 15a-d: Arithmetic and log fits, with corresponding observed and predicted values, to the NWFSC combined trawl survey index (revised to exclude age 0 fish, for STAT base model).

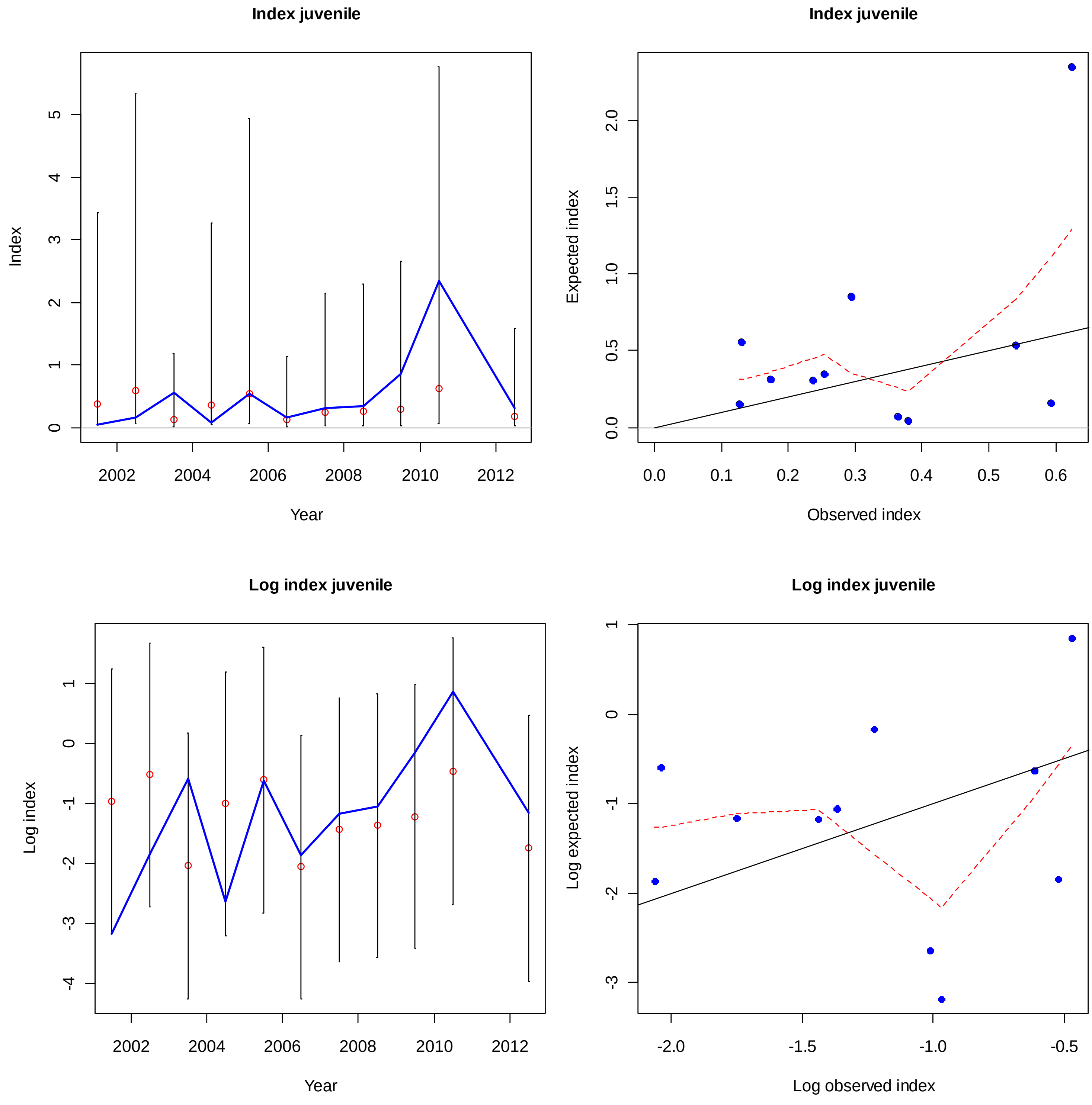


Figure 23a-d: Arithmetic and log fits, with corresponding observed and predicted values, to the SWFSC juvenile trawl survey index.

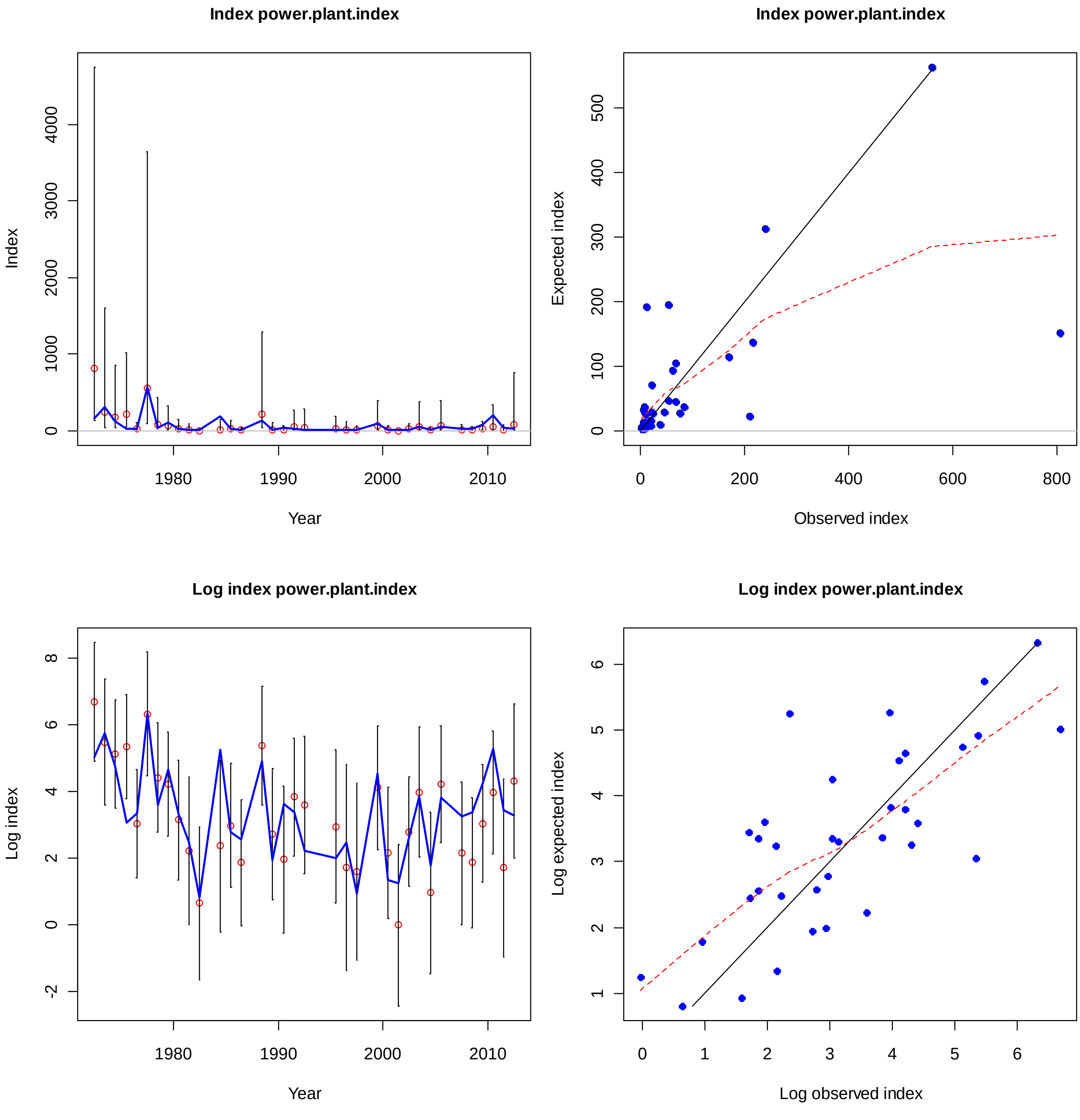


Figure 24: Arithmetic and log fits, with corresponding observed and predicted values, to the power plant impingement index.

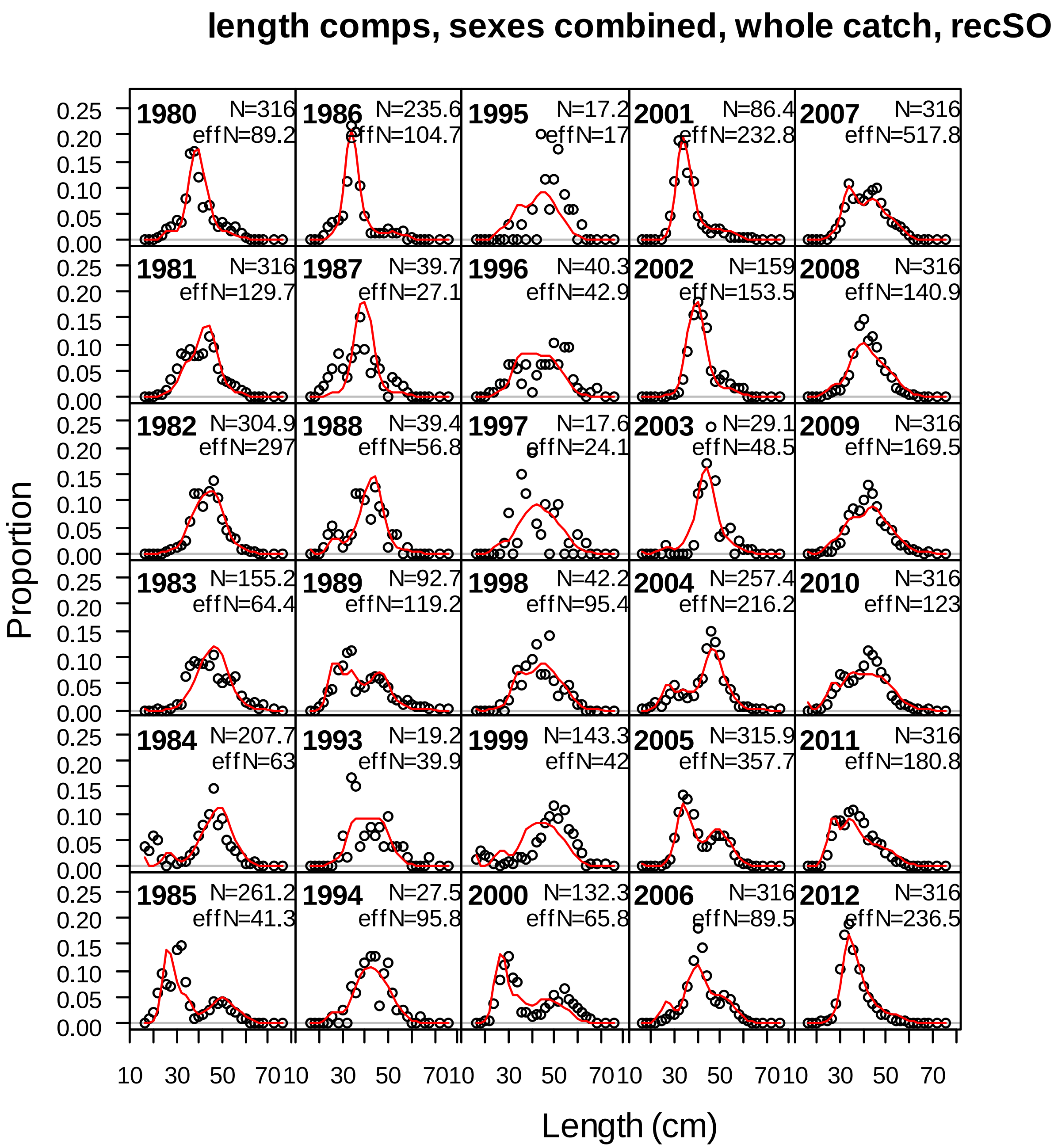
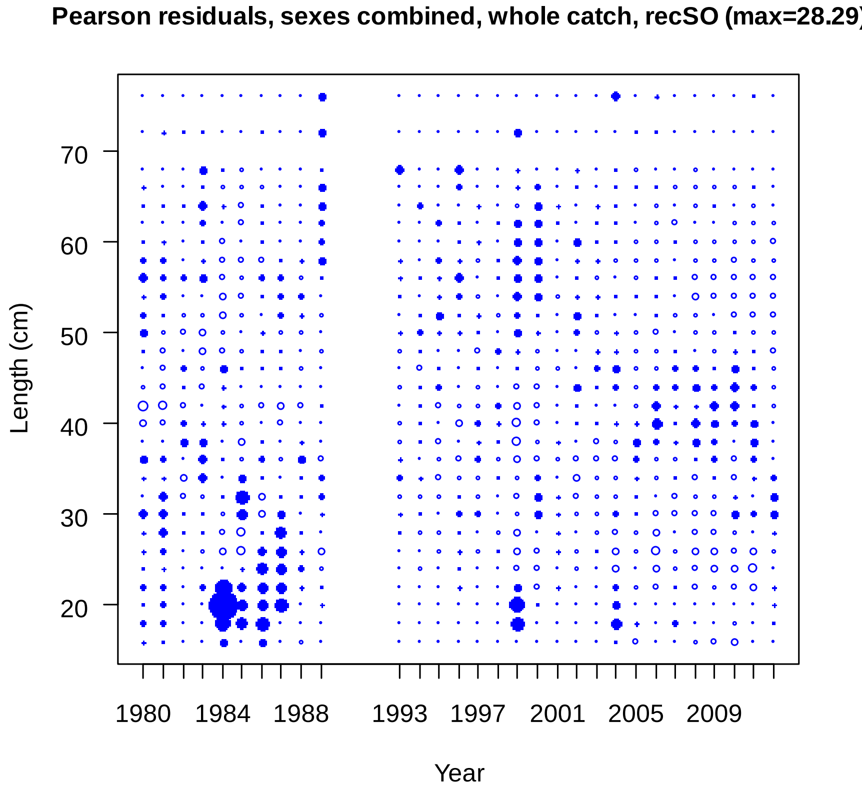


Figure 25: Fits to length frequency data (sexes combined) for the southern recreational fishery (2011 and 2012 data are new to update).



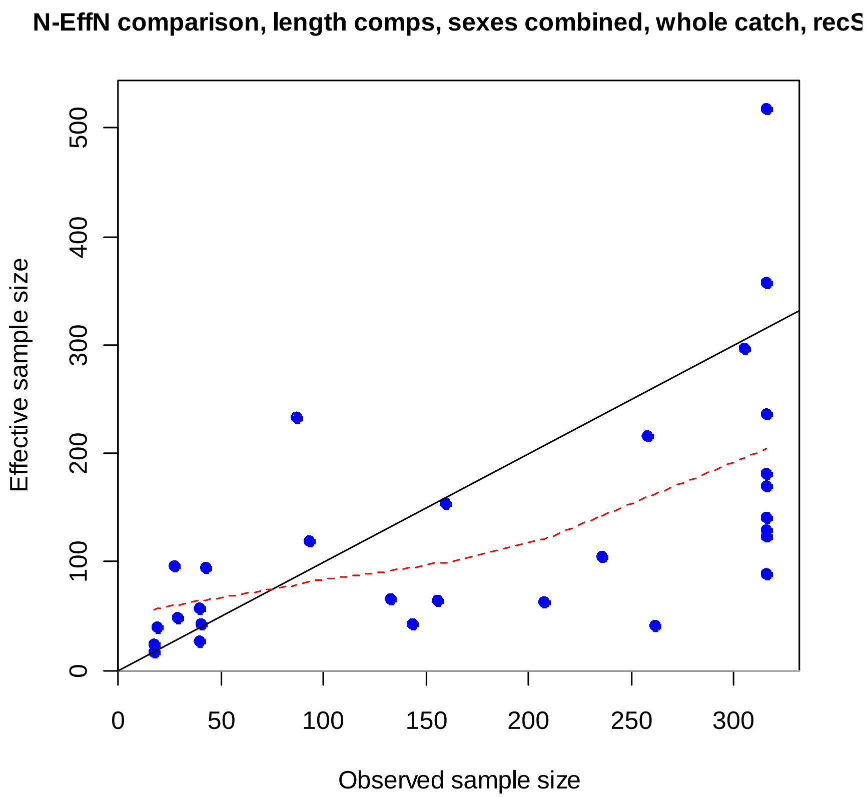


Figure 26: Residuals to length frequency fits and observed vs. effective sample sizes for the southern recreational fishery.

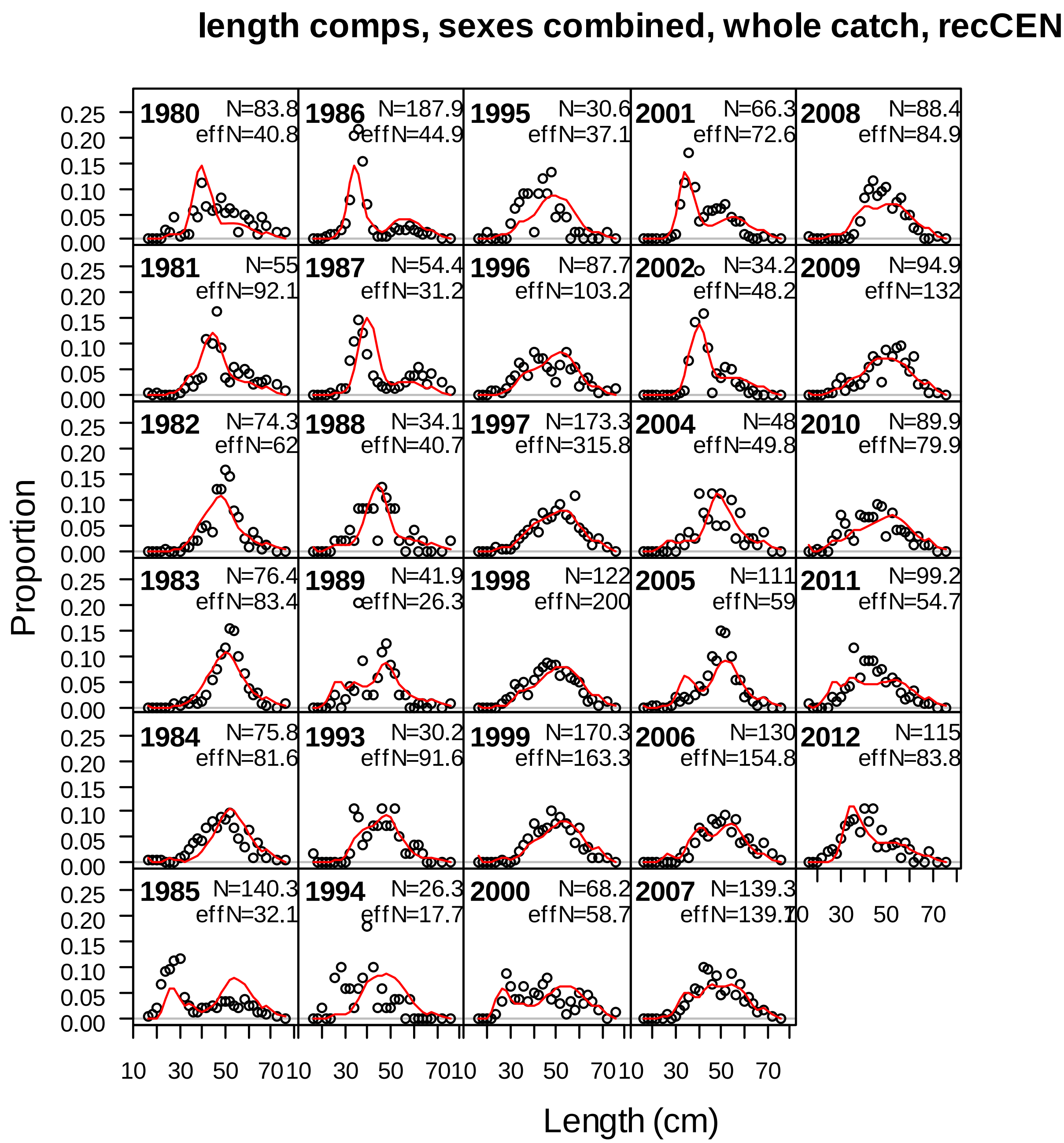
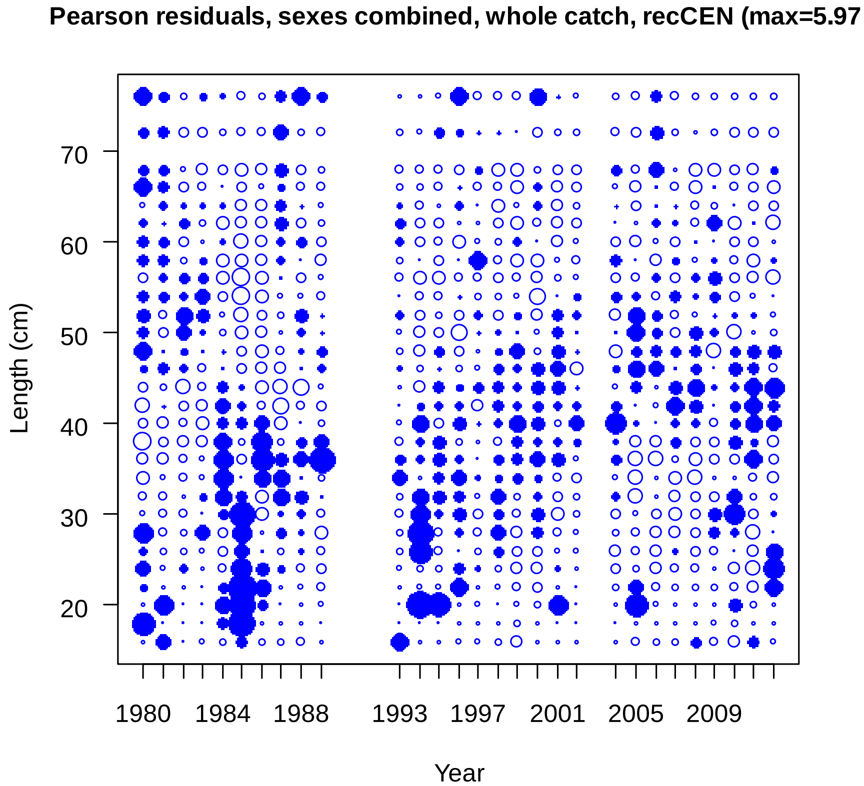


Figure 27: Fits to length frequency data (sexes combined) for the central California recreational fishery (2011 and 2012 data are new to update).



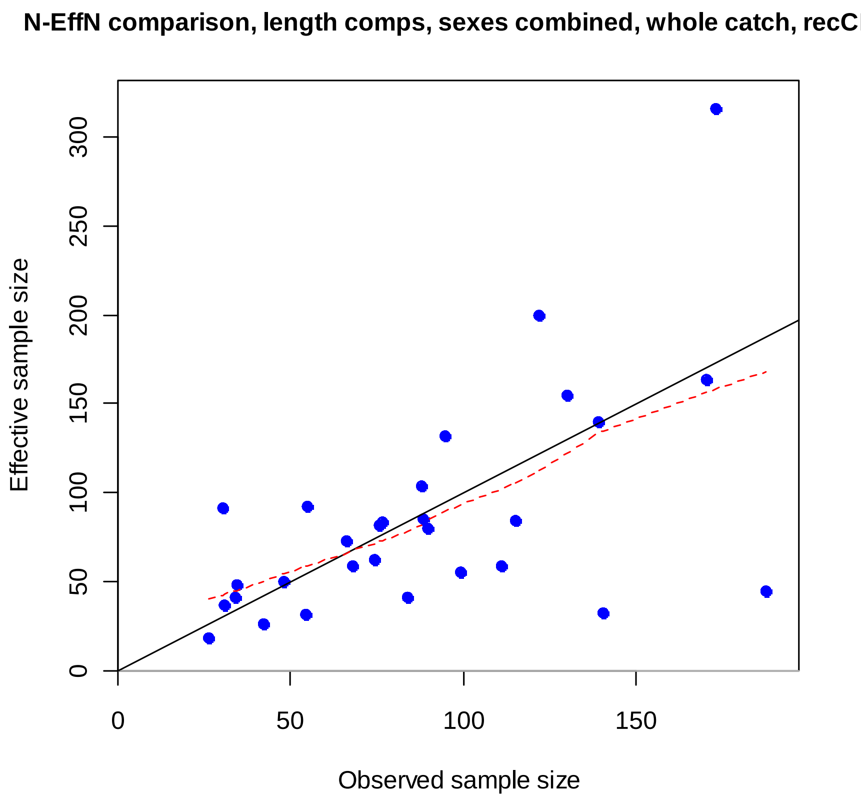


Figure 28: Residuals to length frequency fits and observed vs. effective sample sizes for the southern recreational fishery.

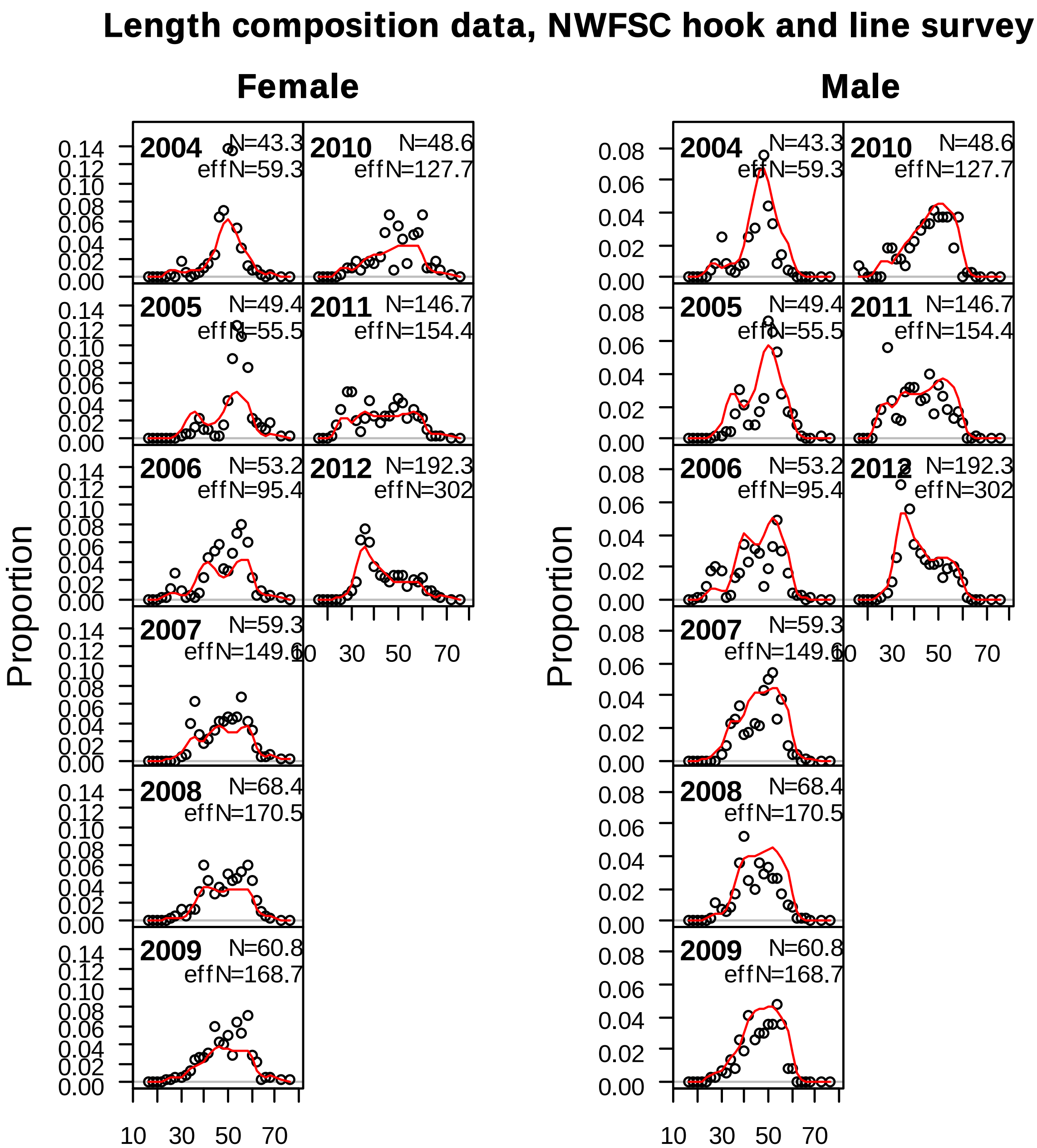


Figure 29: Fits to the NWFSC hook and line survey length frequency data.

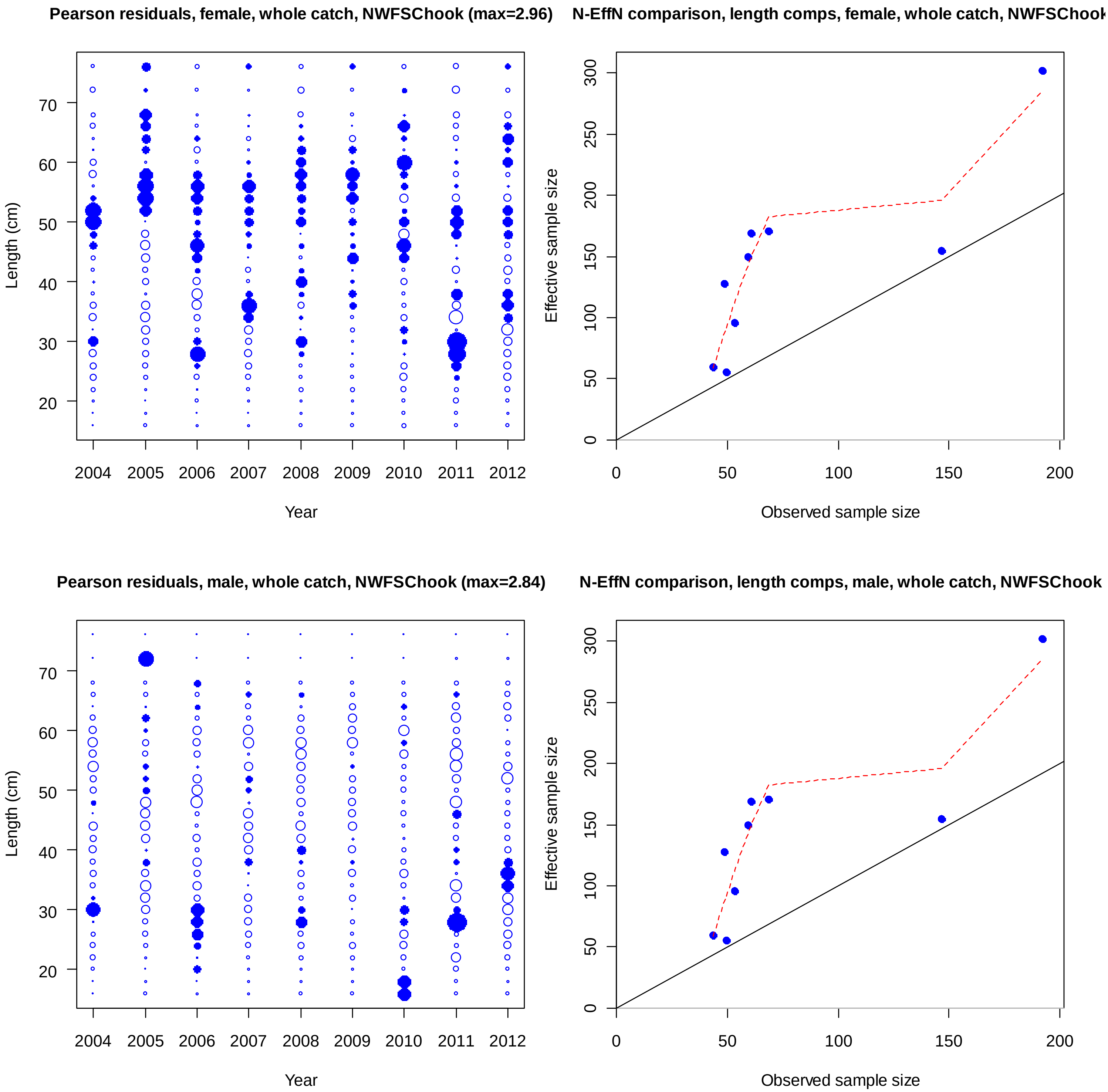


Figure 30: Residuals to length frequency fits and observed vs. predicted sample sizes for NWFSC hook and line survey data.

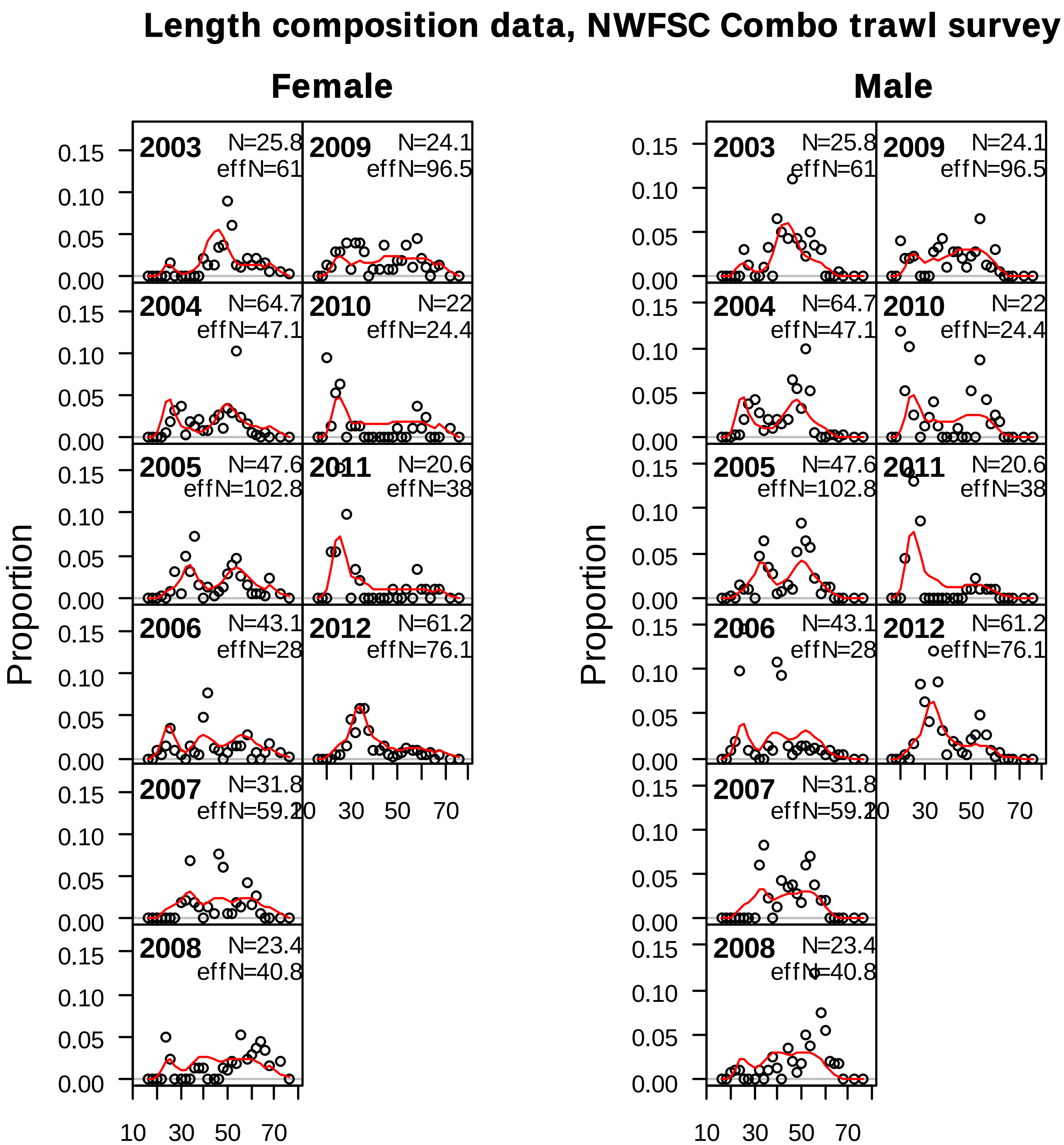


Figure 31: Fits to the NWFSC combined shelf-slope trawl survey length frequency data (for STAT model, sizes <20 cm removed, selectivity unselected for age-0 fish).

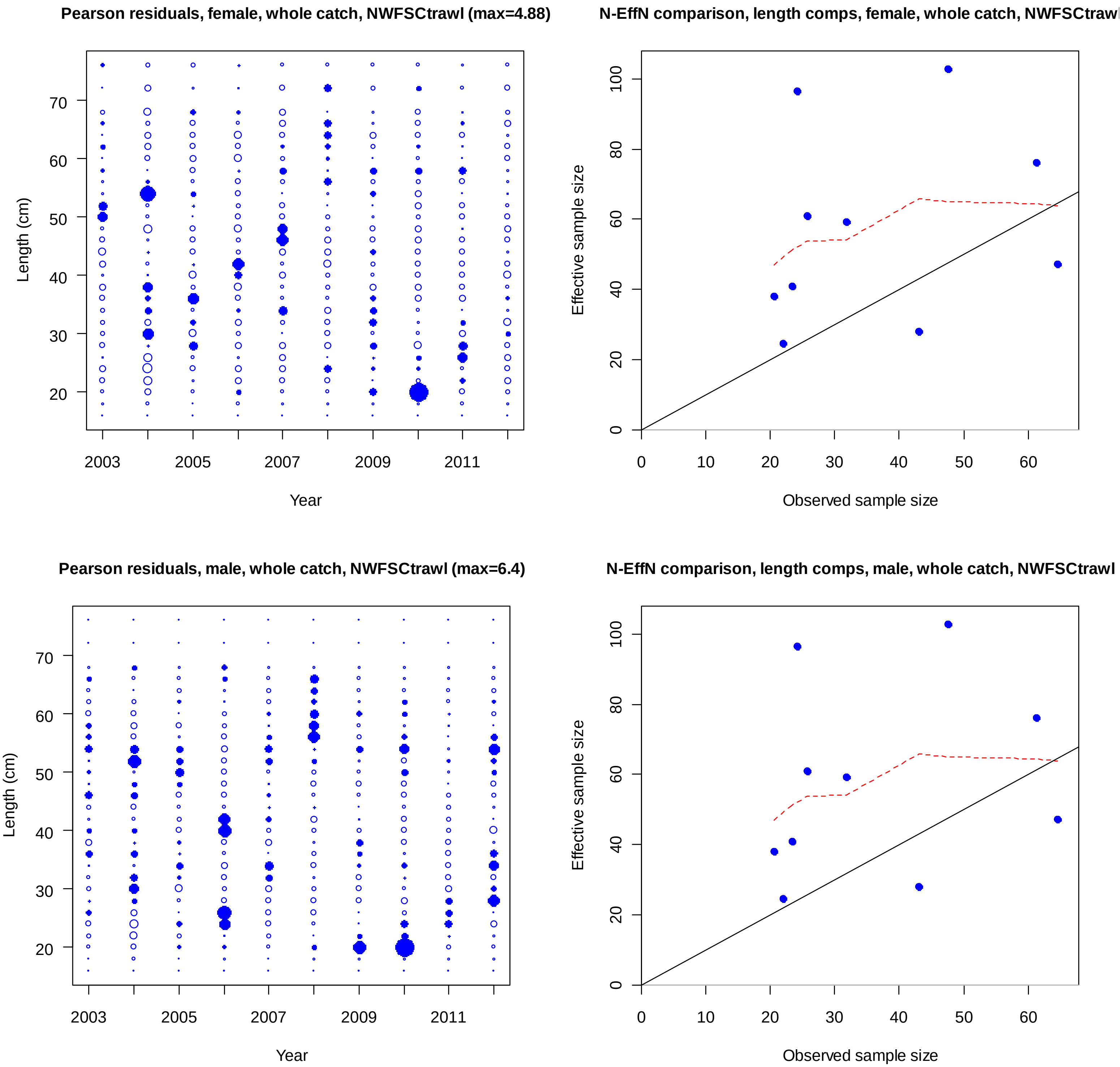


Figure 32: Residuals to length frequency fits and observed vs. predicted sample sizes for NWFSC shelf-slope bottom trawl survey data

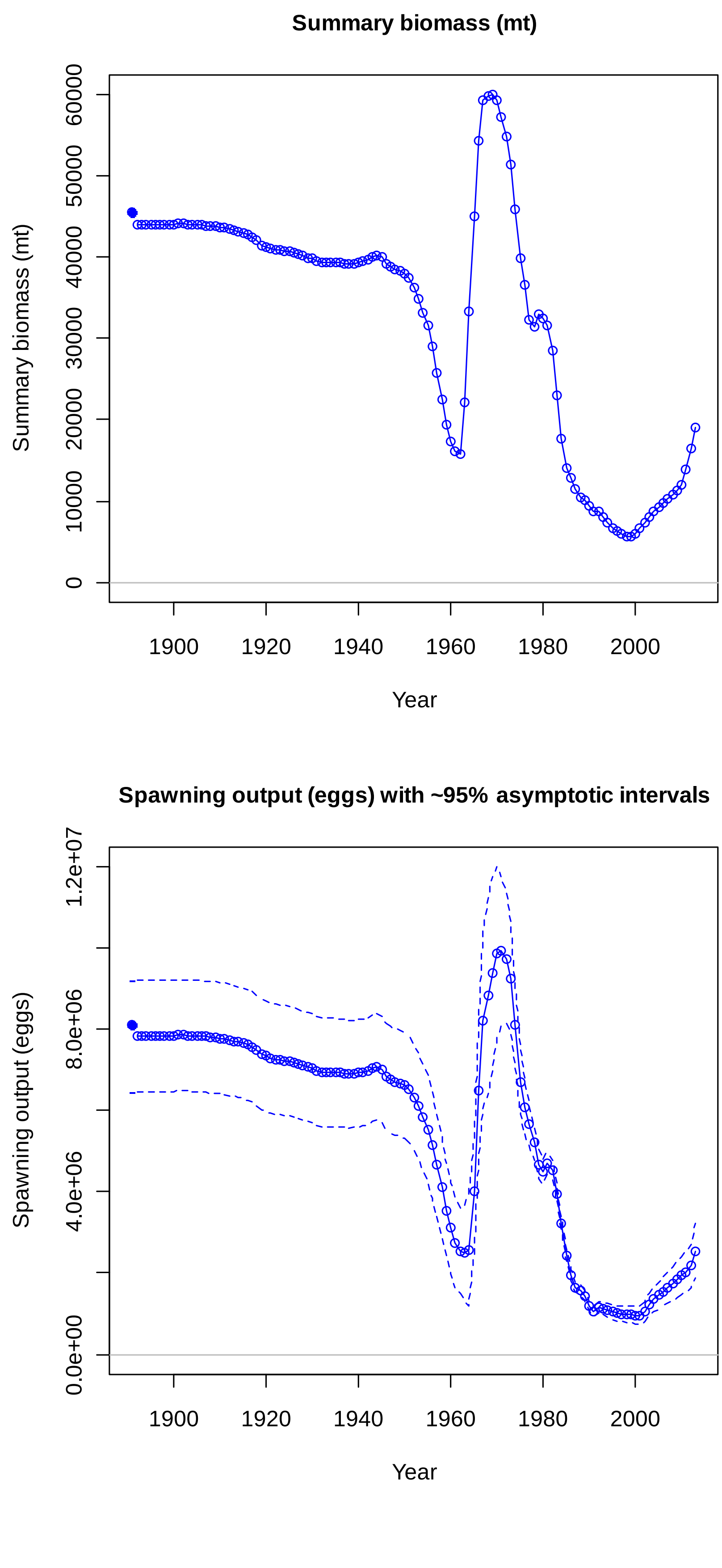


Figure 33: Summary biomass and spawning output for STAT base model.

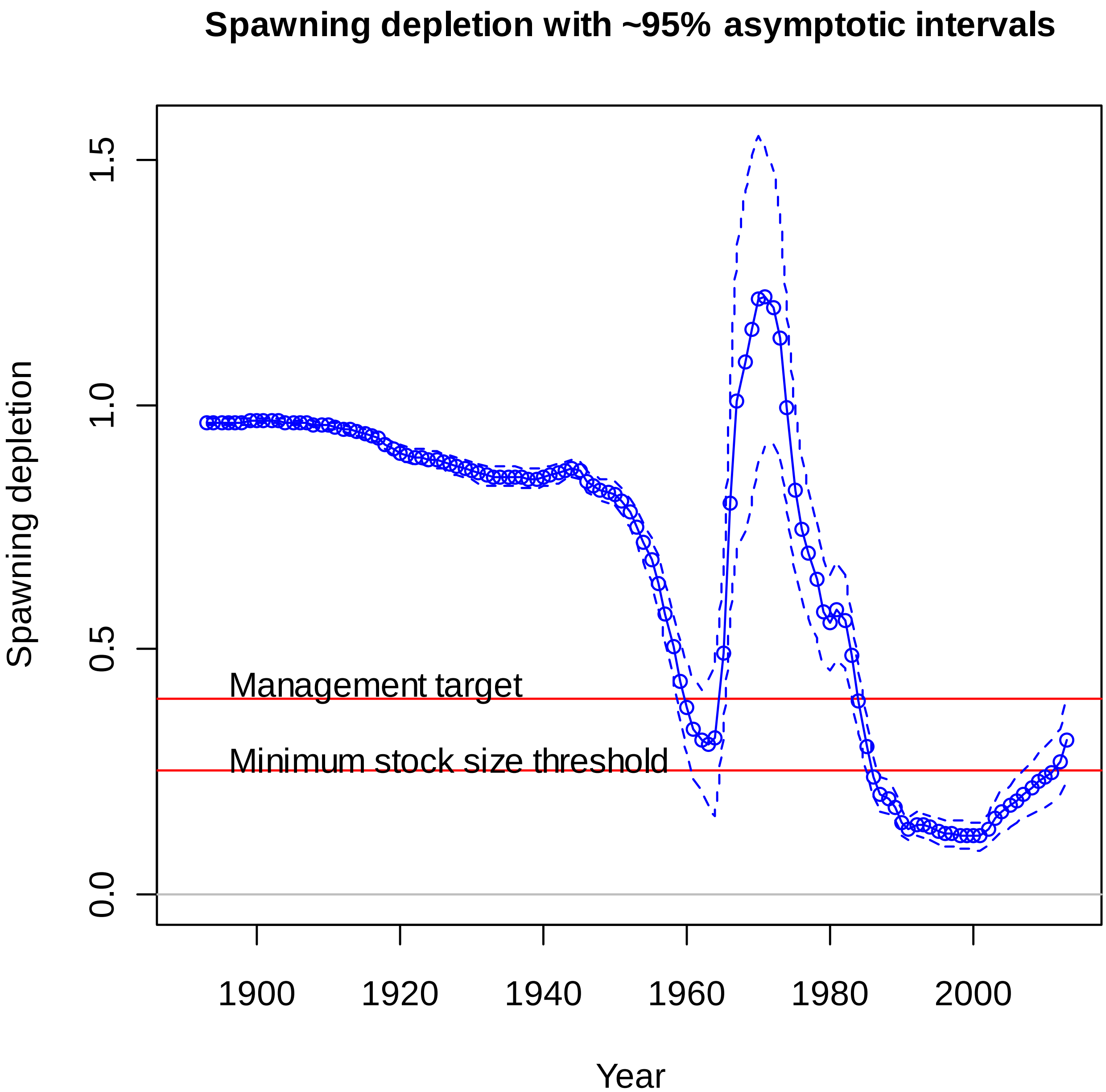
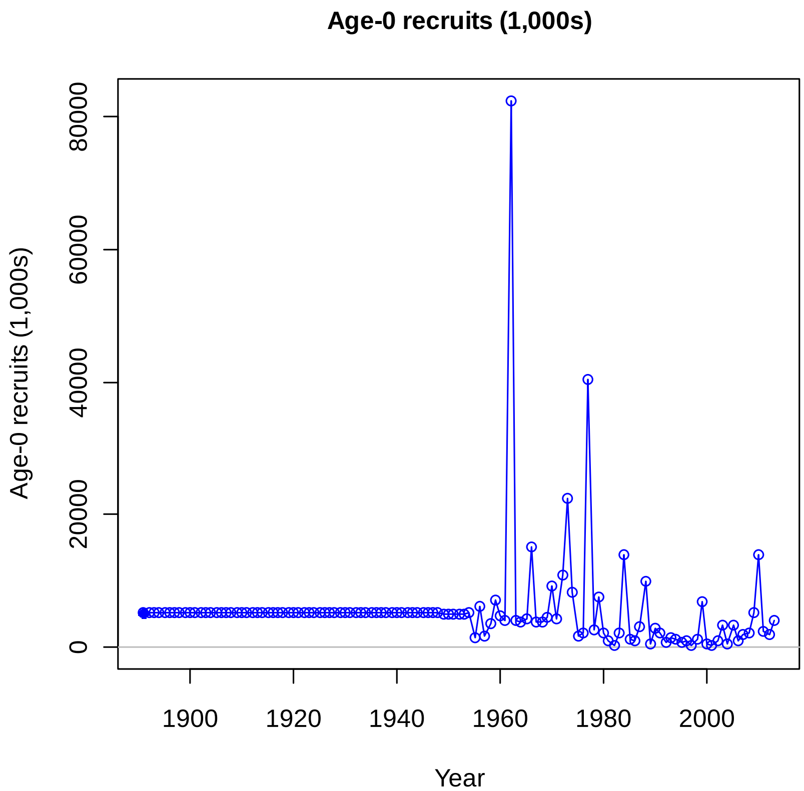


Figure 34: Relative depletion (top) with ~ 95% confidence limits (bottom) for base model.



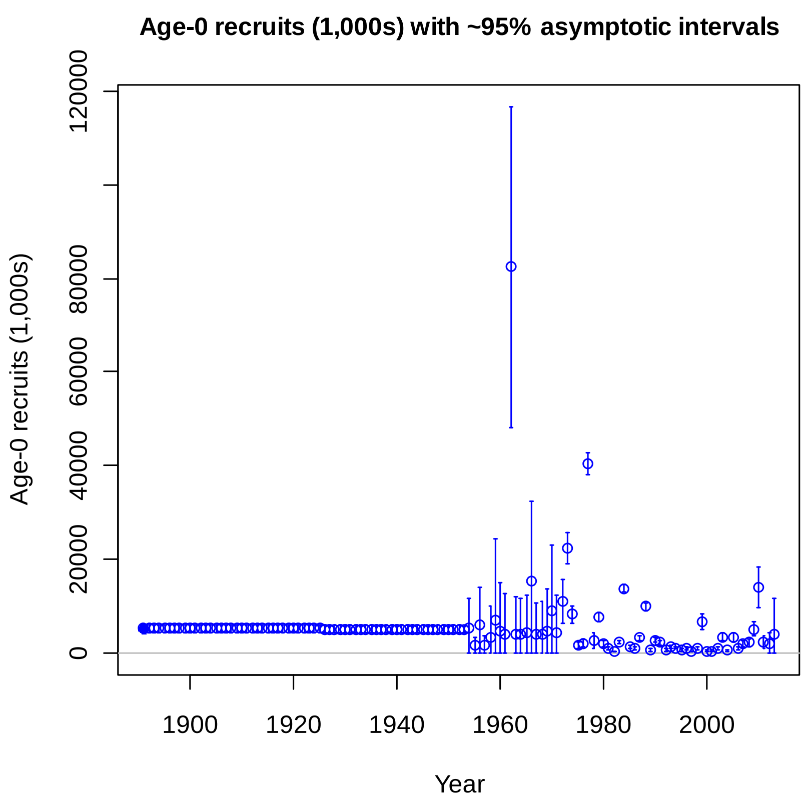
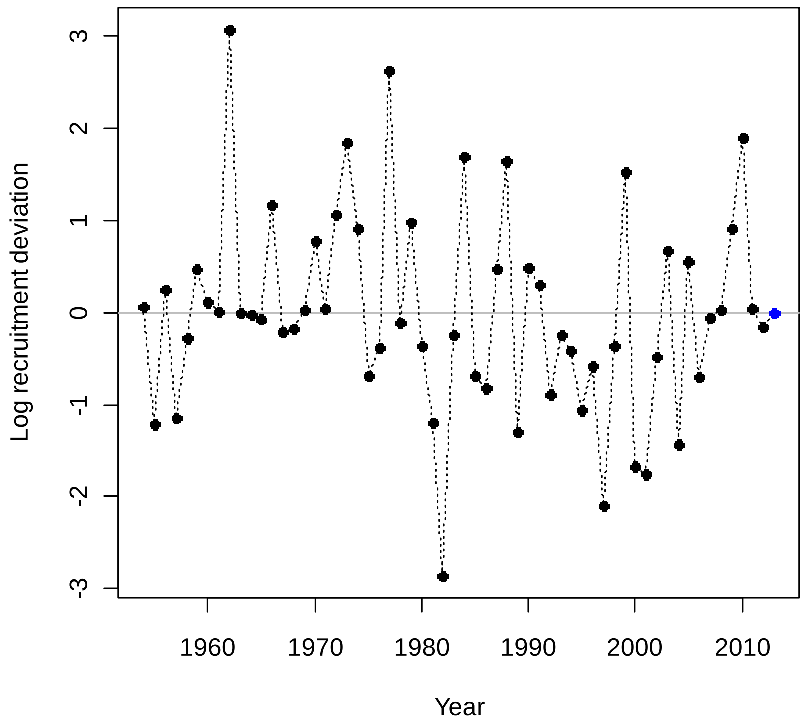


Figure 35: Recruitment estimates (top) with ~ 95% confidence limits (bottom) for base model.



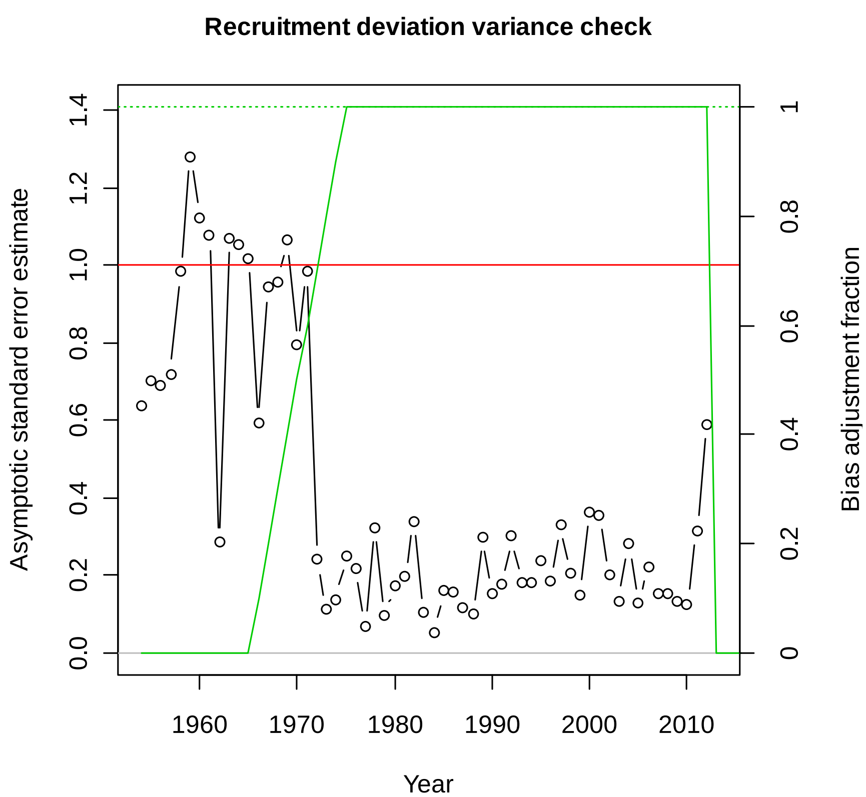


Figure 36: Estimated recruitment deviation parameter values (top) with approximate standard error estimates (bottom).

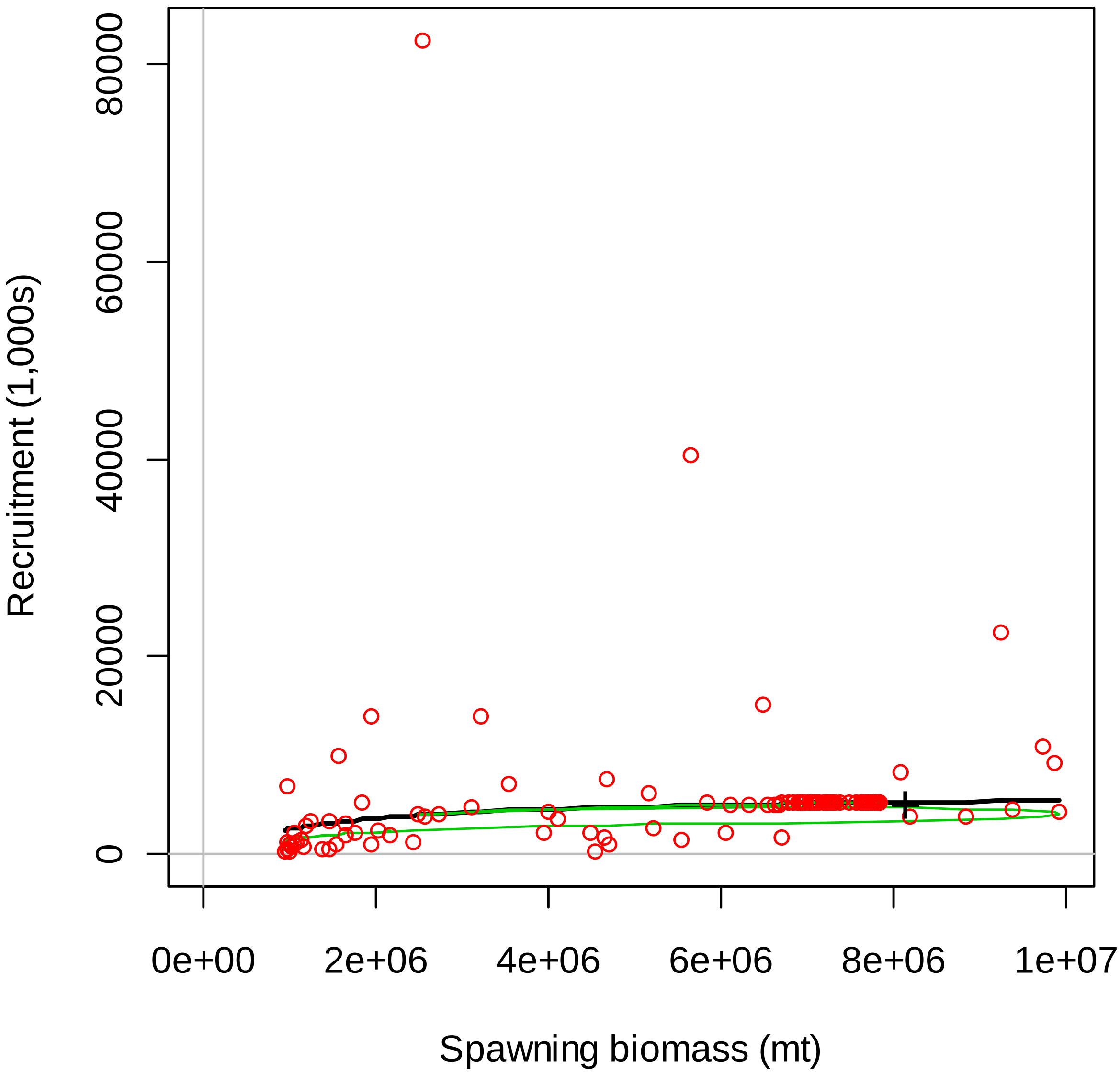
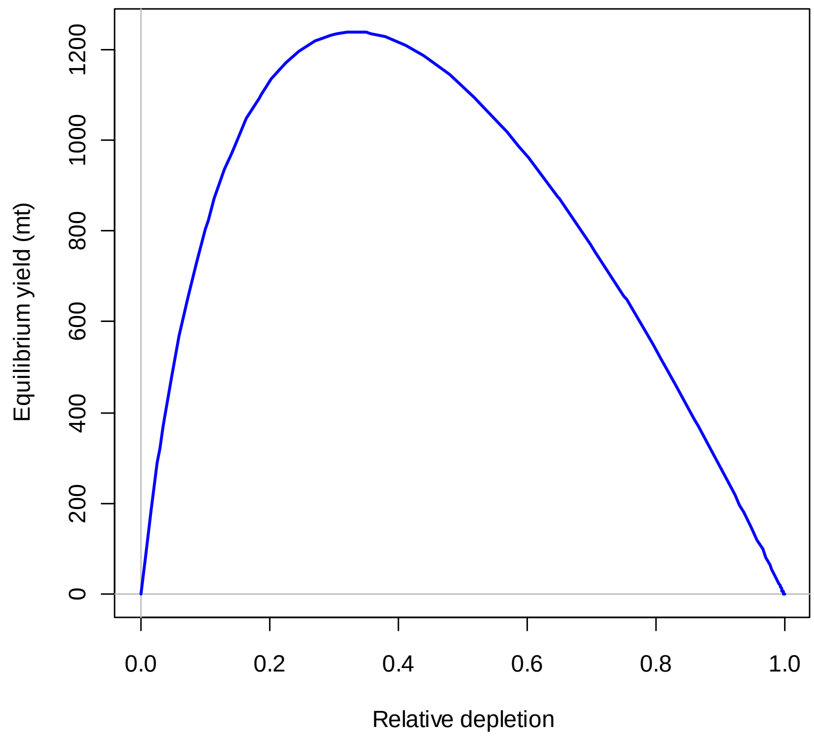


Figure 37: Estimated spawner-recruit relationship, with observed recruitments, for the base model



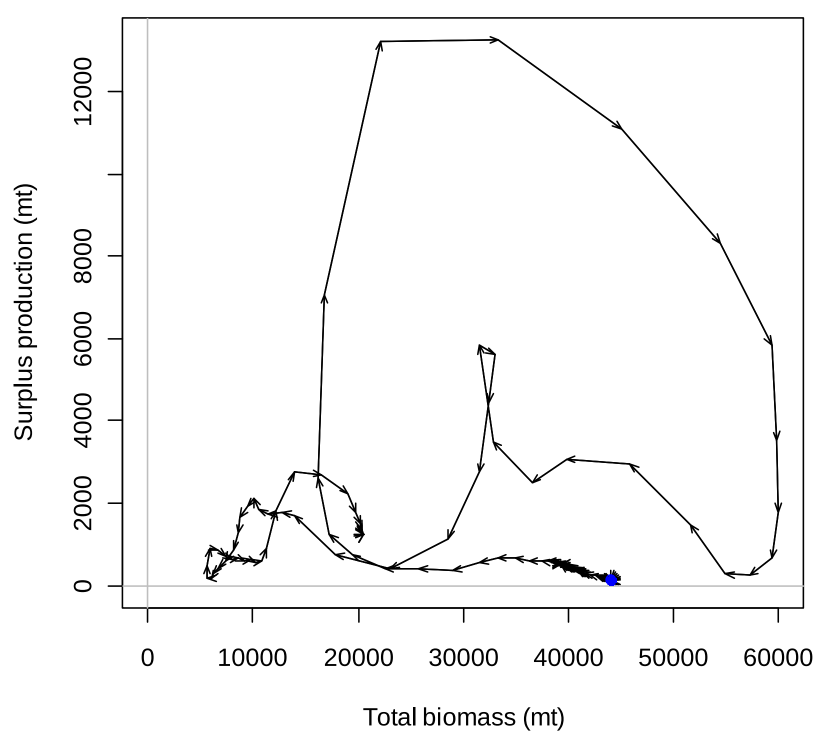
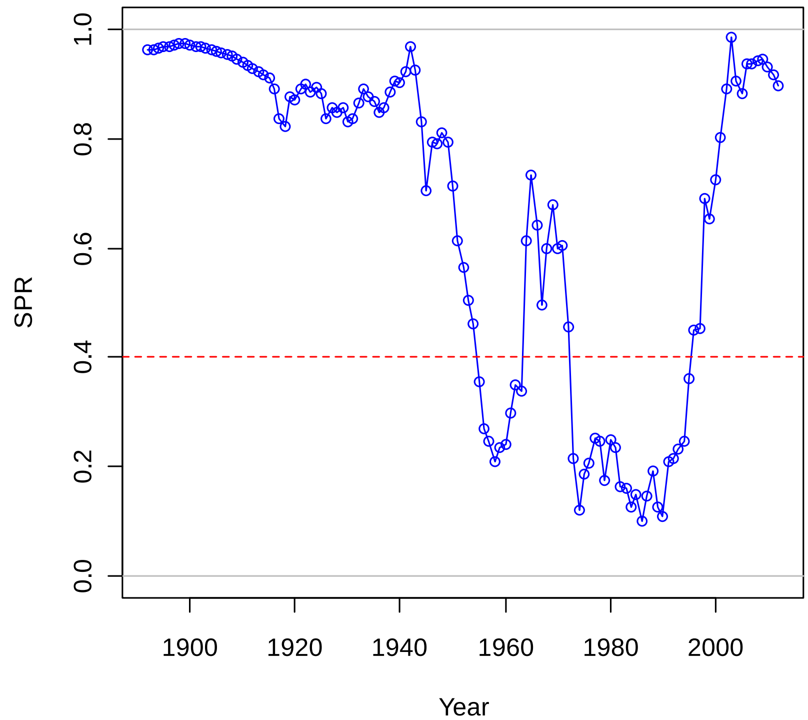


Figure 38: Estimated equilibrium yield curve (top) and phase plot of total biomass against surplus production (bottom) for base model



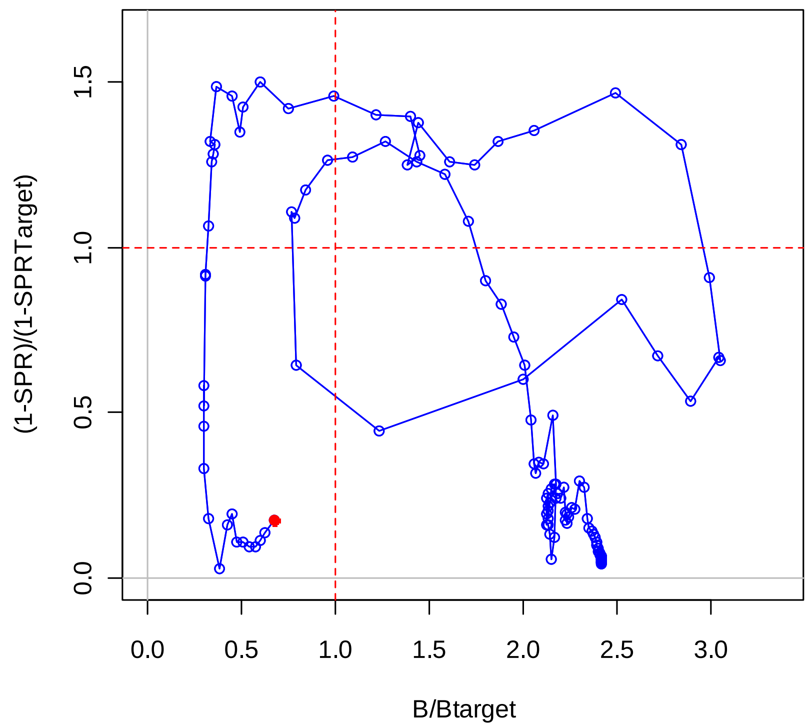


Figure 39: Base model estimates of SPR and relative SPR against biomass (relative to target)- NOTE SPR target incorrectly listed here as 0.4, should be 0.5.

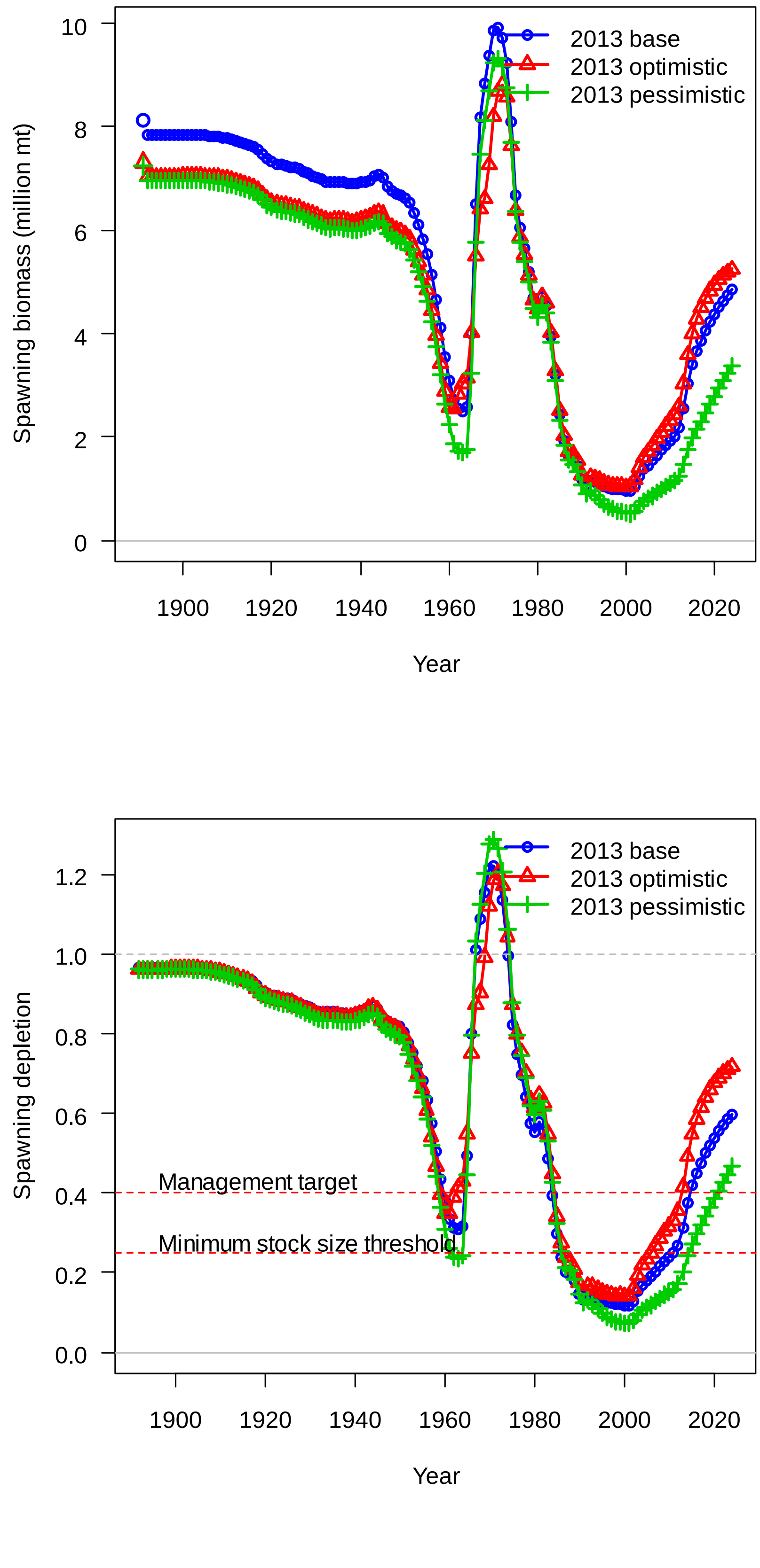
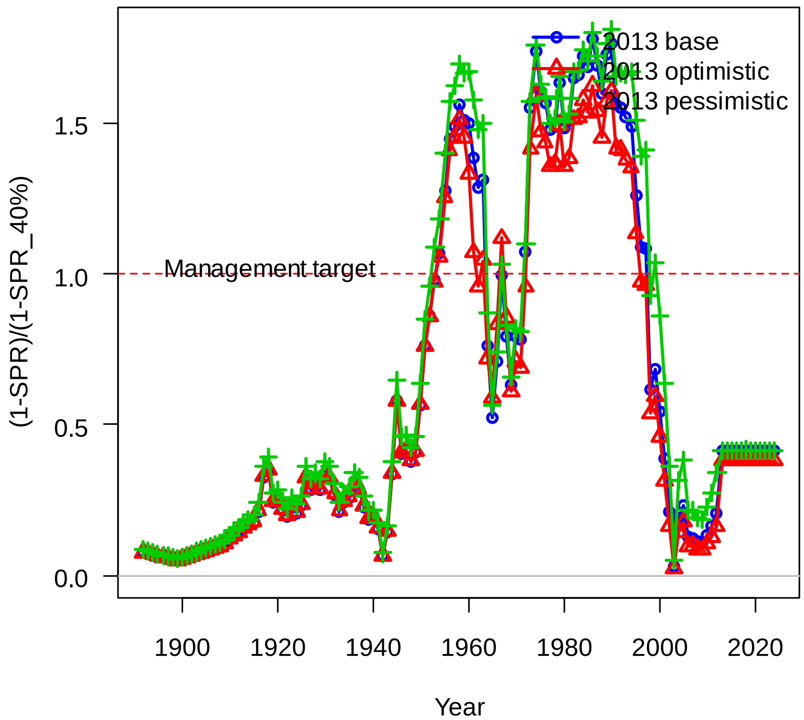


Figure 40: Comparison of base model spawning output and relative depletion results with alternative states of nature and 12 year forecast.



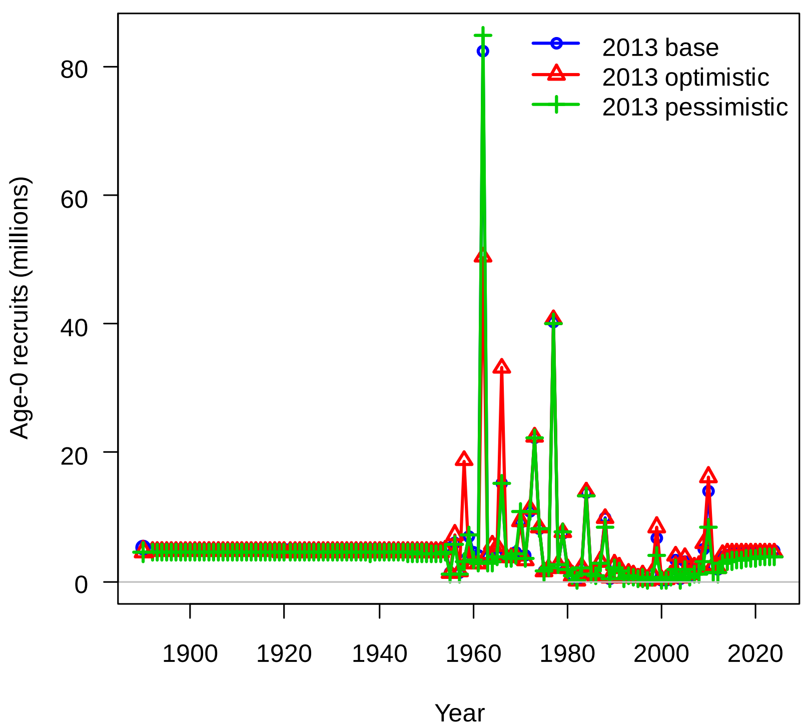
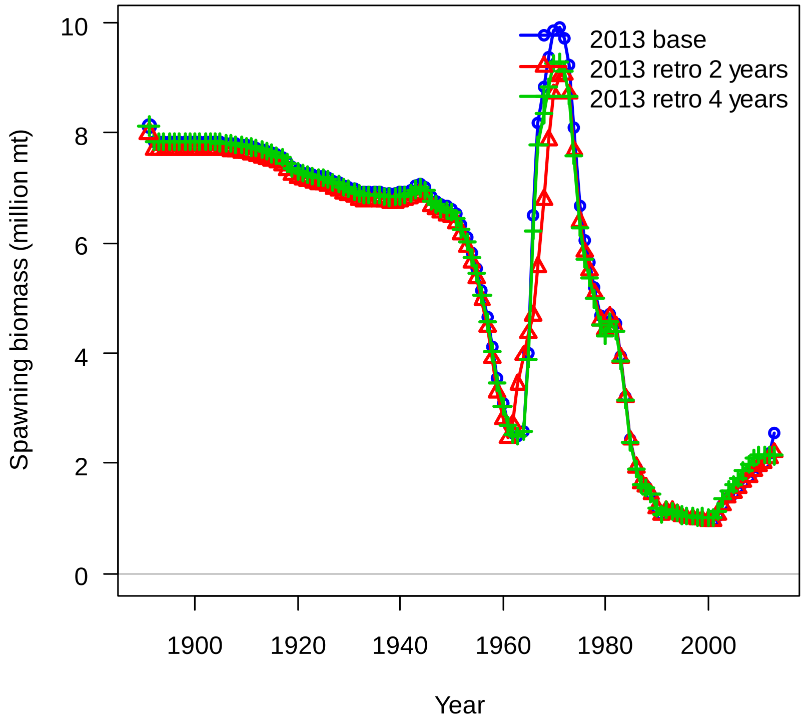


Figure 41: Comparison of base model relative harvest rate and recruitment estimates with alternative states of nature.



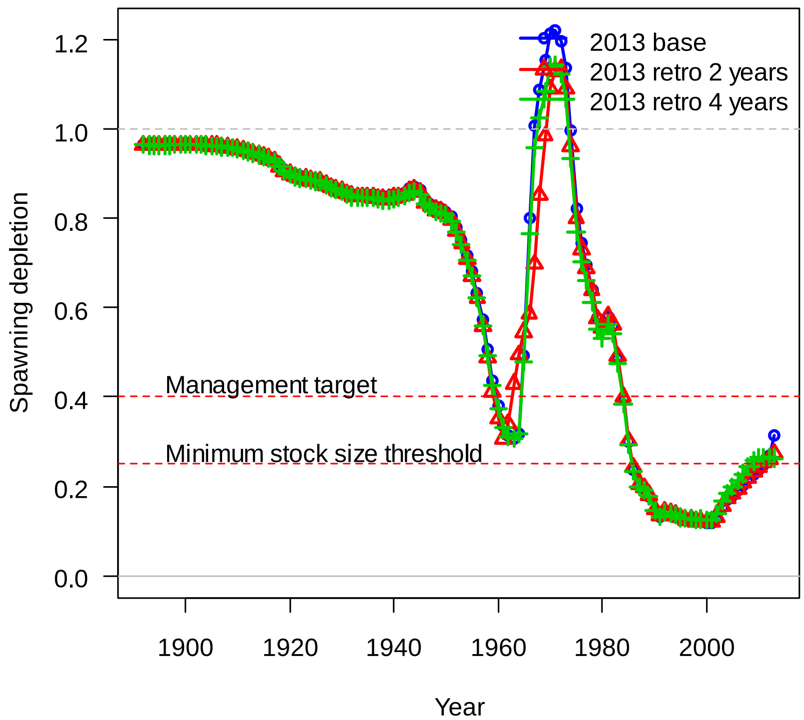


Figure 42: Comparison of base model spawning output and relative depletion with retrospective (2 and 4 year) analysis.

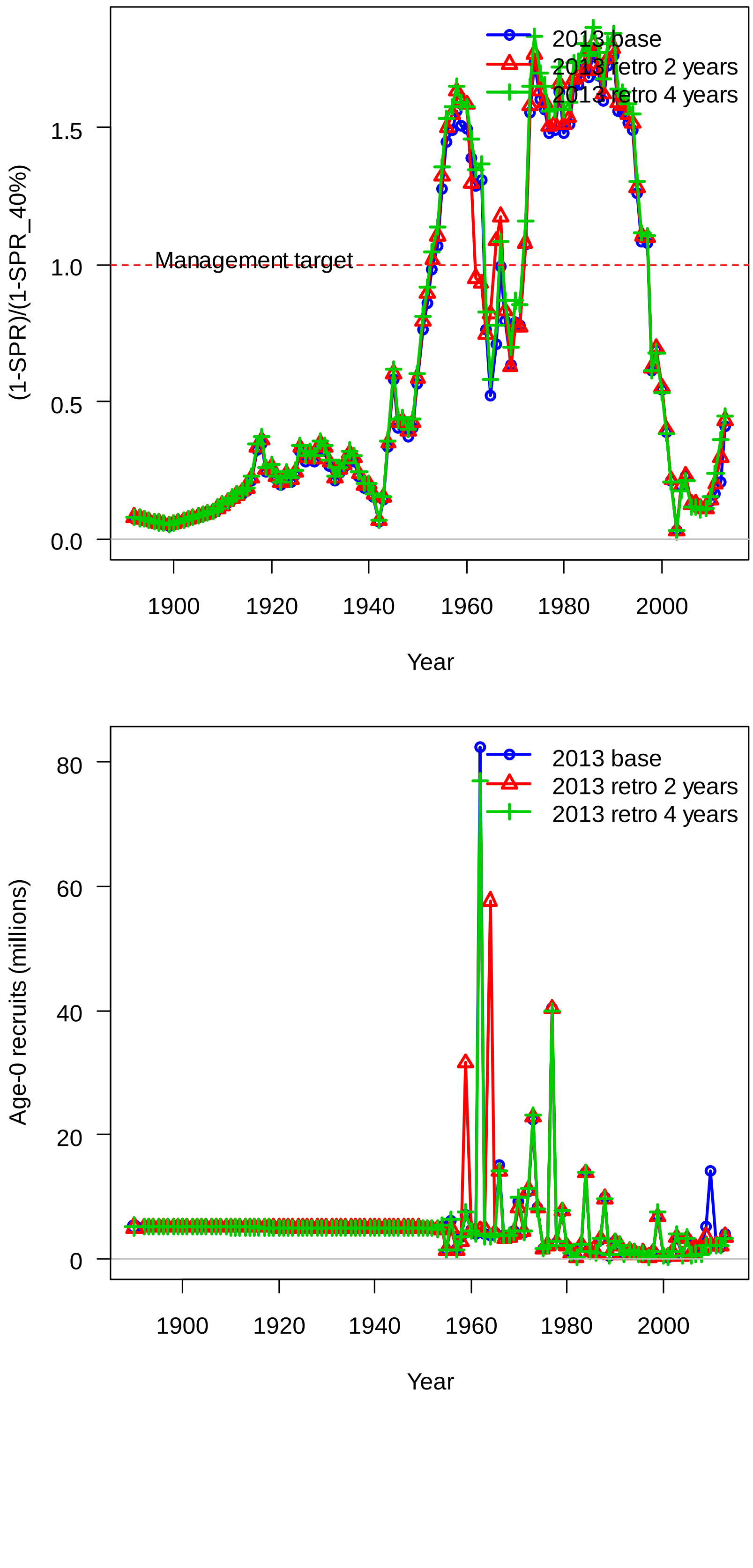


Figure 43: Comparison of base model harvest rate and recruitment estimates with retrospective (2 and 4 years) analysis.