Stock assessment update of blackgill rockfish, *Sebastes melanostomus*, in the Conception and Monterey INPFC areas for 2017

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Auxiliary Stock Synthesis Files, including starter, forecast, data and control, are available at https://www.pcouncil.org/groundfish/stock-assessments/by-species/blackgill-rockfish/

B. Executive Summary

B.1 Stock

This update assessment reports the status of blackgill rockfish (*Sebastes melanostomus*) for the Conception and Monterey INPFC areas, using data from 1950 through 2016. The resource is modeled as a single stock. Although the distribution of blackgill rockfish extends north to at least Canadian waters and south into Mexican waters, the species becomes rare north of Cape Mendocino, CA, and data from Mexican waters are unavailable.

B.2 Catches

Historical catches of blackgill rockfish were largely made in southern California (south of Point Conception), where the species is the target of both directed and incidental catches from fixed gear (hook and line, and historically, gillnet). In recent years, a greater fraction of the total catch has come from central California waters, in fixed gear (hook and line, pot and trap, historically setnet) and trawl fisheries. Catch estimates from 2010 through 2015 were based on NWFSC total mortality reports and area/gear landings from the California Cooperative Groundfish Survey (CalCOM) database. Catches for 2016 were based on CalCOM catch estimates and averaged discard rates for the 2010-2015 period by fishery. Fleets in this model are identical to the 2011 model, including southern California fixed gear, central California fixed gear, and central California trawl.

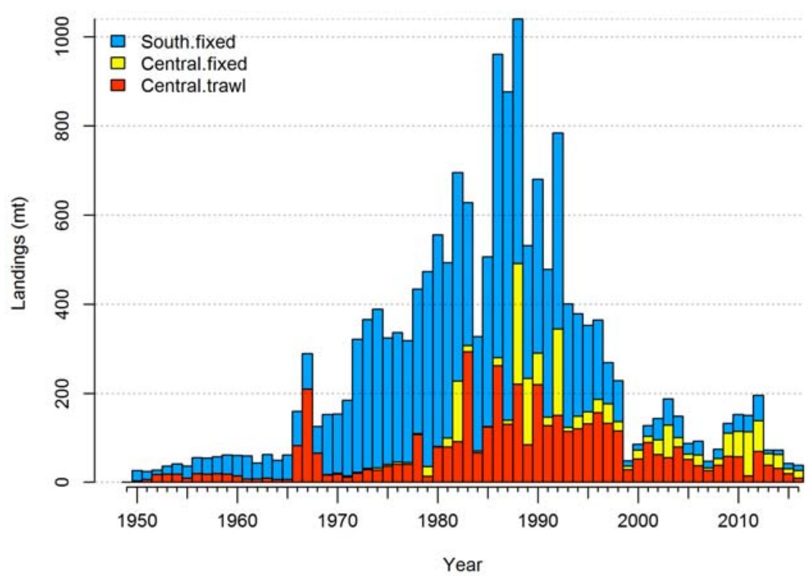

Figure B.1: Estimated catches by fleet from 1950-2016

Table B1: Recent commercial catches (mt, including discards) by fleet

	south fixed	central fixed	central trawl	total
2007	14.6	6.2	34.3	55.1
2008	20.2	17.3	41.7	79.2
2009	22.9	53	60.9	136.8
2010	37.5	57.3	57.5	152.3
2011	37.0	99.1	14.1	150.2
2012	56.6	69.4	69.4	195.4
2013	7.5	26.4	38.1	72
2014	9.9	31.1	31.8	72.8
2015	12.9	10.9	19.0	42.8
2016	12.4	17.5	8.8	38.7

B.3 Data and Assessment

This update assessment uses the Stock Synthesis 3 (SS3, version 3.24u) integrated length and age structured model, and includes both length frequency and conditional length-at-age data from all three commercial fisheries. The basic structure (fleets, estimated parameters) is unchanged from the 2011 model; the only new parameter is from a selectivity time block added to the trawl fishery to account for full retention of blackgill rockfish in that fishery following implementation of the trawl fishery rationalization program. The updated model does incorporate new life history data (maturity and fecundity) developed and published since the 2011 assessment, and nearly 2000 new age observations from the NWFSC bottom trawl survey to inform growth (estimated internally). The model also includes new length composition data from 2010-2016 for all three fisheries (southern fixed gear, central CA fixed gear and central CA trawl), as well extends the NWFSC shelf and slope survey index from 2010 through 2016, including associated length and age data. The base model uses the updated rockfish steepness prior (Thorson 2016) for rockfish of 0.718 (versus 0.76 in the 2011). The estimated natural mortality rates of 0.063 (females) and 0.065 (males) are unchanged from the 2011 assessment, and model results are highly sensitive to the assumed values for M. As in the 2011 model, recruitment is assumed to be deterministic.

B.4 Stock biomass

The assessment uses a size-dependent fecundity relationship, and the model suggests that the spawning output of blackgill rockfish was at high levels in the mid-1970s; began to decline steeply in the late 1970s through the 1980s (consistent with the rapid development and growth of the targeted fishery); and reached a low point of approximately 20% of the unfished level in the mid-1990s. Since that time, catches have declined sharply and spawning output has increased, such that the current estimated larval production is nearly to the target level of 40% of the unfished larval output.

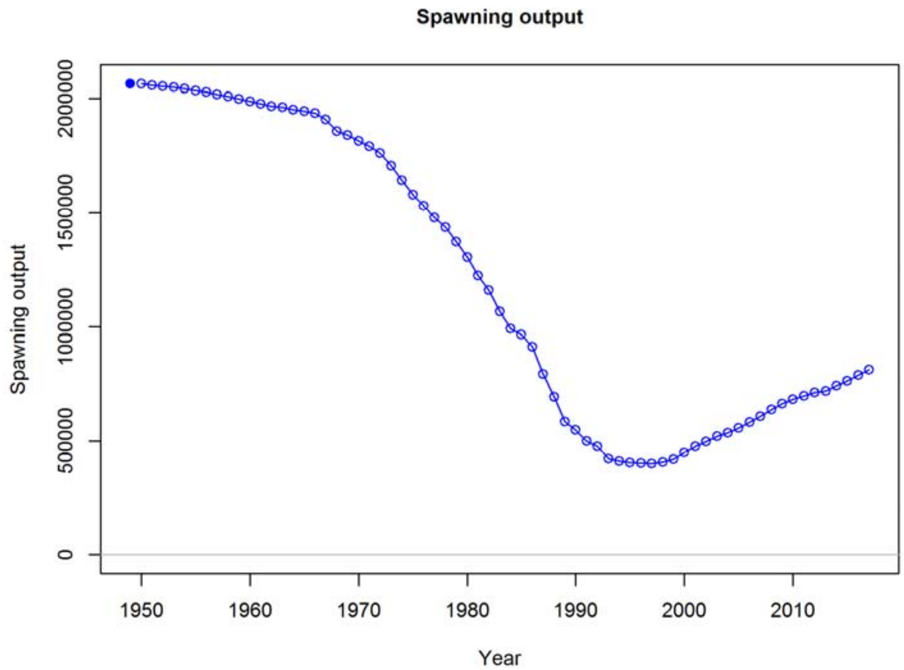

Figure B.2: Estimated spawning output (millions of larvae) from the base model

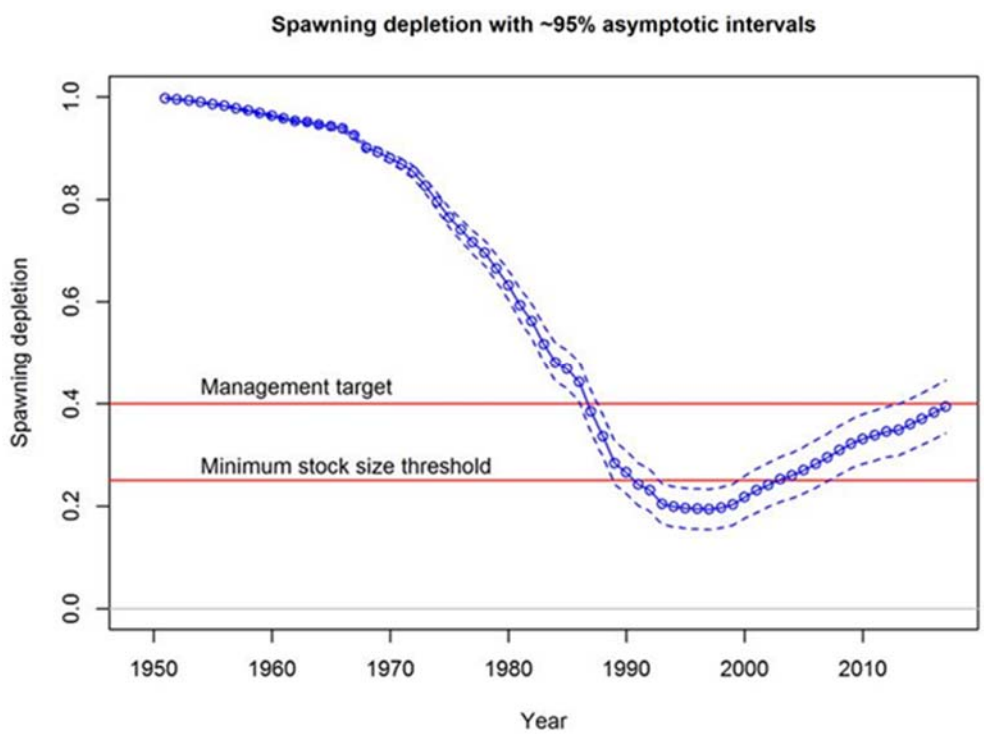

Figure B.3: Estimated relative depletion from the base model

Table B.2: Recent trends in blackgill rockfish spawning output, recruitment and depletion

	Summary Biomass	Larval prod ($x10^9$)	Depletion	Recruit ($x 10^3$)
2008	7409	637	0.309	2124
2009	7461	663	0.321	2138
2010	7492	682	0.330	2150
2011	7521	697	0.338	2161
2012	7505	711	0.345	2167
2013	7596	720	0.349	2182
2014	7684	742	0.360	2197
2015	7796	763	0.370	2212
2016	7910	788	0.382	2227
2017	7917	812	0.394	2232

B.5 Recruitment

In the assessment, the Beverton-Holt model was used to describe the stock-recruitment relationship. The log of the unexploited recruitment level was treated as an estimated parameter; recruits were taken deterministically from the stock-recruit curve. Recruitment deviations were not estimated, as the lack of obvious cohorts in either age or length data and the high degree of ageing uncertainty make plausible estimates unlikely. The estimated recruitment is projected to be at relatively high levels due to the fixed value of steepness.

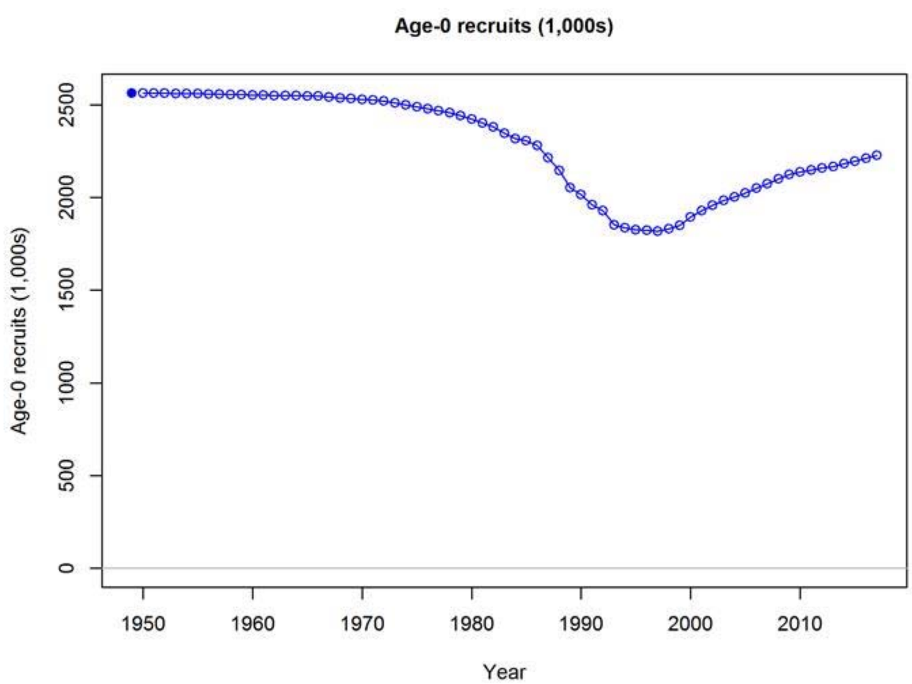

Figure B.4: Estimates of recruitment based on deterministic S/R relationship

B.6 Exploitation Status

The base model estimates that the spawning potential ratio (SPR) was below the current target (of 50% of the unfished level) from the late 1970s through the 1990s, and in several years of the 2000s. However, average SPR rates have been near or above target levels since the very late 1990s, corresponding to an apparent increase in stock abundance. Over the past four years, SPR rates have ranged between 0.70 and 0.82, corresponding to roughly half of the overfishing limit SPR (0.50). The exploitation rates reported here reflect catch divided by the summary (age 1+) biomass.

Table B.3: Recent catches, estimated SPR and relative exploitation rates

	Catches	*Summary Biomass*	*SPR*	*Exploitation rate*
2008	74	7409	0.677	0.010
2009	133	7461	0.531	0.018
2010	152	7492	0.498	0.020
2011	150	7521	0.503	0.020
2012	195	7505	0.432	0.026
2013	72	7596	0.701	0.009
2014	73	7684	0.702	0.009
2015	43	7796	0.810	0.005
2016	39	7910	0.827	0.005
2017	n/a	7917	n/a	n/a

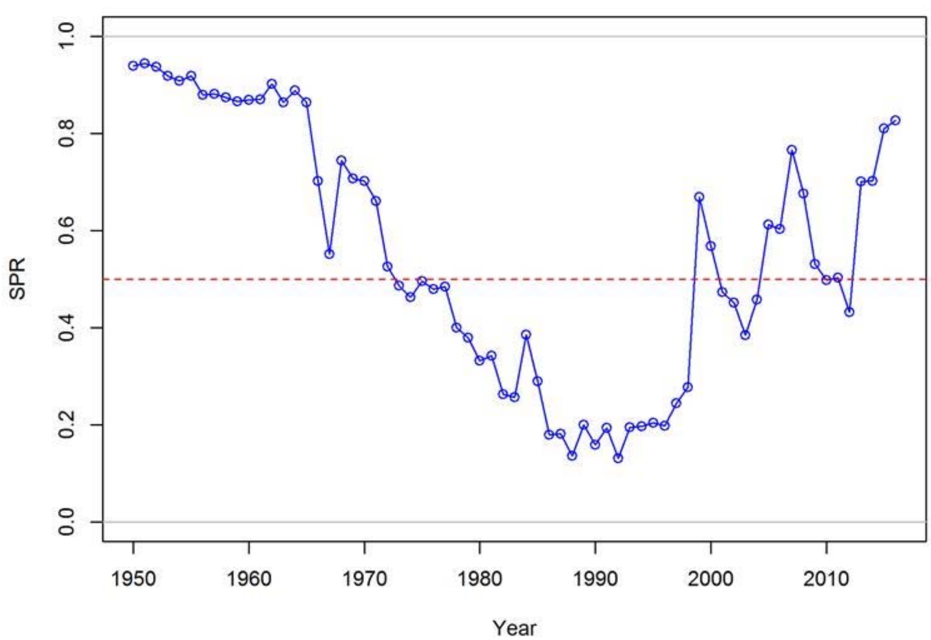

Figure B.5: Time series of estimated SPR rate for the base case model.

B.7 Ecosystem Considerations

Blackgill rockfish are among the most deeply distributed of all of the California Current *Sebastes*, living at the edge of the low oxygen (hypoxic) conditions that characterize the slope waters of the California Current. As a shoaling (expansion into shallower waters) of this low oxygen habitat has already been observed in the California Current, and is predicted to be a likely or plausible response to future climate change, this species could be vulnerable to climate induced changes in distribution and productivity in the future. Key predators for this stock include sablefish and shortspine thornyheads, which have themselves undergone shifts in abundance in response to fishing, potentially altering predation mortality. However, neither of these ecosystem considerations are explicitly accounted for in this stock assessment.

B.8 Reference Points

The unfished larval production was estimated to be 2.064 trillion larvae, corresponding to a total (summary, age 1+) biomass of 14,187 tons (within a model estimated range of 13,313 to 15,061 tons). The overfishing limit is 25% of the unfished spawning output, and the estimated spawning output is well above that level at the current time. The target stock size of 40% of the unfished level is associated with a summary biomass of 8037 tons and a yield of 188 tons (relative to 192 in the 2011 assessment, and considerably greater than recent catches). It should be emphasized that this biomass estimate is inclusive of immature fish and mature fish too small to be vulnerable to current fisheries. Estimated maximum yields vary relatively modestly (across a range of 31 tons) over the $SSB_{40\%}$, $SPR_{50\%}$ and MSY estimates.

Table B4: Key reference points for blackgill rockfish

Unfished Stock	Estimate	95% Confidence Limits Lower	95% Confidence Limits Upper
Summary (1+) Biomass (tons)	14187	13313	15061
Spawning Output (billions larvae)	2064	1812	2316
Equilibrium recruitment (1000s)	2564	2394	2733

	Yield reference Points		
	$SSB_{40\%}$	$SPR_{50\%}$	MSY est.
SPR	0.459	0.500	0.314
Exploitation rate	0.025	0.022	0.044
Yield	188	178	209
Spawning output	826	919	493
Summary biomass	8037	8590	5815
SSB/SSB_0	0.400	0.446	0.239

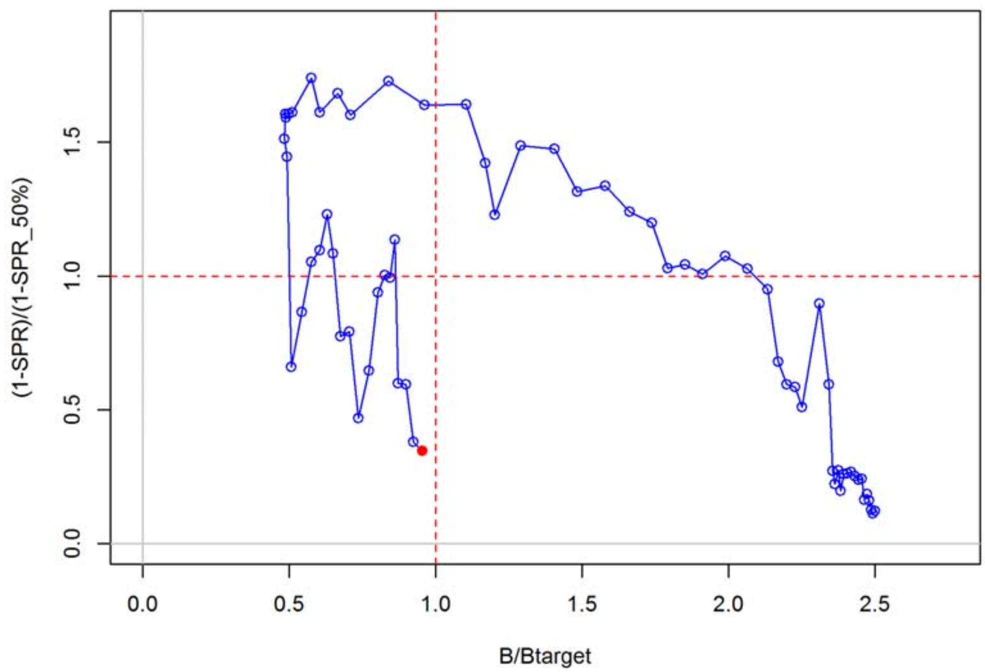

Figure B.6: Phase plot of relative depletion against estimated SPR rate (red point represents the end year of 2016).

B.8 Management performance

Estimated total catches (landings plus discards estimated by the West Coast Groundfish Observer Program) have been well below ACL and OFL levels for the past decade, typically less than 50% of the adopted levels.

Table B.5: Recent catches relative to OFL (ABC) and ACL (OY) targets for recent years.

	Catch	ACL	ABC	OFL	% of ABC	% of OFL
2008	74	292	292	292	0.25	0.25
2009	132.7	282	282	282	0.47	0.47
2010	152.3	282	282	282	0.54	0.54
2011	150.3	279	282	282	0.53	0.53
2012	195.4	275	282	282	0.69	0.69
2013	72	113.8	118.7	130	0.6	0.55
2014	72.8	117.2	122.3	134	0.59	0.54
2015	42.8	120.2	125.1	137	0.34	0.31
2016	38.7	123	127.8	140	0.3	0.27
2017			130.6	143		
2018			133	146		

B.9 Unresolved problems and major uncertainties

This assessment is not as data rich as an age structured model would ideally be. Catch data are generally reliable for most of the time period, although there is significant uncertainty in catch data prior to the late 1970s and early 1980s as species composition data are unavailable and the fishery was undergoing a spatial expansion into deeper and more offshore waters. Ageing is very difficult for this species, which appears to have highly variable size at age, as well as apparent regional differences in growth rates and potentially other life history traits. There is some suggestion in the diagnostics of differences in age estimates between fish aged for the 2011 assessment and those aged for this update. The growing time series for the NWFSC bottom trawl survey is increasingly important to assess population trends, however the lack of survey effort in the Cowcod Conservation Areas (CCAs) presents current and future challenges to interpretation of both fishery and survey data. Recruitment is not estimated in the current model, although survey data for recent years suggest possible recent pulses in recruitment.

B.10 Forecast of model results and decision table

The base model was projected forward 12 years, with catches in the first two years (2017-2018) based on the currently adopted ACLs and subsequent harvests based on either status quo harvests, the base model ABC removal projections, or the OFL harvest rates. No 40:10 adjustment is applied given that the stock is projected to be above 40% of the unfished larval production by 2019. As in the 2011 assessment, the natural mortality rate is considered to be the greatest source of uncertainty for this stock, and scenarios designed to bracket uncertainty (alternative states of nature) were based on the standard deviations from a prior on natural mortality (M) used in the 2011 assessment. The base model values for the natural mortality rate are 0.063 and 0.065 for females and males, respectively. The low M values used in the decision table are 0.046 and 0.048 for females and males, respectively, while the high M values are 0.086 and 0.089.

Table B.6: Base model projected ABC and OFL values, assuming ABC attainment

	ABC	OFL
2017	131	
2018	133	
2019	159	174
2020	159	174
2021	159	174
2022	159	174
2023	159	174
2024	159	173
2025	158	173
2026	158	173
2027	158	173
2028	158	173

Table B.7: Decision Table, based on status quo (2014-2016) catches and alternative assumptions on natural mortality rates.

		Low M model		Base model		High M model	
status quo catches		Sp.out	depletion	Sp.out	depletion	Sp.out	depletion
2017	*131*	613	0.28	812	0.39	1060	0.55
2018	*133*	622	0.28	824	0.40	1072	0.56
2019	51	630	0.28	835	0.40	1083	0.56
2020	51	648	0.29	855	0.41	1103	0.58
2021	51	665	0.30	875	0.42	1122	0.59
2022	51	683	0.31	895	0.43	1141	0.59
2023	51	700	0.31	914	0.44	1159	0.60
2024	51	716	0.32	933	0.45	1176	0.61
2025	51	733	0.33	951	0.46	1193	0.62
2026	51	749	0.34	969	0.47	1209	0.63
2027	51	764	0.34	986	0.48	1225	0.64
2028	51	780	0.35	1003	0.49	1240	0.65

		Low M model		Base model		High M model	
ABC catches		Sp.out	depletion	Sp.out	depletion	Sp.out	depletion
2017	*131*	613	0.28	812	0.39	1060	0.55
2018	*133*	622	0.28	824	0.40	1072	0.56
2019	159	630	0.28	835	0.40	1083	0.56
2020	159	633	0.28	841	0.41	1089	0.57
2021	159	635	0.29	846	0.41	1094	0.57
2022	159	637	0.29	850	0.41	1099	0.57
2023	159	638	0.29	854	0.41	1103	0.58
2024	159	638	0.29	857	0.42	1107	0.58
2025	158	638	0.29	860	0.42	1110	0.58
2026	158	637	0.29	862	0.42	1113	0.58
2027	158	636	0.29	864	0.42	1116	0.58
2028	158	635	0.28	866	0.42	1118	0.58

		Low M model		Base model		High M model	
OFL catches		Sp.out	depletion	Sp.out	depletion	Sp.out	depletion
2017	*131*	613	0.28	813	0.39	1060	0.55
2018	*133*	622	0.28	824	0.40	1072	0.56
2019	174	630	0.28	835	0.40	1083	0.56
2020	174	631	0.28	839	0.41	1087	0.57
2021	173	631	0.28	842	0.41	1090	0.57
2022	173	631	0.28	844	0.41	1093	0.57
2023	172	629	0.28	846	0.41	1096	0.57
2024	172	628	0.28	847	0.41	1098	0.57
2025	171	625	0.28	848	0.41	1099	0.57
2026	171	623	0.28	848	0.41	1101	0.57
2027	170	620	0.28	848	0.41	1102	0.57
2028	170	617	0.28	848	0.41	1103	0.58

B.11 Research and Data needs

Age estimates are highly uncertain, and this species has proven very difficult to age. There is some indication of aging bias between ages developed for the 2011 assessment and for this update, despite the fact that they were aged by the same reader, using the same criteria. Conducting cross reads with other laboratories, as well as additional age validation, are important factors for future efforts.

Histology studies have shown that this species is slow to mature and often undergoes abortive maturation, particularly at younger ages (smaller sizes), complicating maturity estimates. There also appear to be latitudinal clines in growth, maturity and potentially other life history parameters that are not accounted for in the model.

Despite considerable investment in catch reconstruction efforts, historical catches remain uncertain for this stock due to the lack of historical species composition data and spatial patterns of fishery development in California waters. Efforts to analyze spatially explicit historical catch data have indicated that fisheries for this and other rockfish species tended to fish deeper waters, further offshore, in more inclement weather over time, suggesting that historical catches of this deeply distributed species that are derived from species compositions from later in the time series may be overestimated.

A large fraction of blackgill rockfish habitat is currently closed to both fishing and survey effort in the Cowcod Conservation Areas (CCAs), complicating efforts to interpret both catch and survey data. Alternative means of exploring relative or absolute abundance in this region is a key research priority.

Greater investigation into the likely or plausible consequences of a shoaling of the oxygen minimum zone (OMZ) on blackgill rockfish habitat will aid in evaluating threats to this species that may be posed by global climate change.

C. Introduction

C.1 Range, distribution and stock structure

This assessment reports the status of blackgill rockfish (*Sebastes melanostomus*) for the Conception and Monterey INPFC areas (Figure 1), using data from 1950 through 2016. The resource is modeled as a single stock. Readers are referred to the 2011 stock assessment for more complete reviews of these factors, which are discussed briefly here.

Blackgill rockfish (*Sebastes melanostomus*), also known at times as blackmouth rockfish or deepsea rockfish, range from at least central Vancouver Island to central Baja California (Love et al. 2002). However, the species is relatively uncommon north of Cape Mendocino and occurs in the greatest densities in the Southern California Bight (SCB). The name very accurately describes the most identifying characteristic of adult blackgill rockfish, in that they have black pigmentation on the rear edge of their gill cover, as well as in the fold above the upper jaw and inside of the mouth. It is a medium-sized (to about 62 cm maximum length) and deep bodied species. Additional descriptions and meristics can be found in Love et al. (2002) for adults and Moser (1996) for larvae and juveniles.

The CalCOFI Ichthyoplankton survey has been used recently to explore indices of relative abundance for several rockfish species for which larvae cannot be morphologically identified to species by using genetic methods (Thompson et al. 2016), however in their initial efforts, catches of blackgill rockfish have been too sparse to be informative. There is at least some potential to consider relative abundance indices of age-0 juveniles from the Southwest Fishery Science Center's Rockfish Recruitment and Ecosystem Assessment Survey in the future, as blackgill rockfish young-of-the-year are frequently encountered in the southern range of the now coastwide survey, although given the very slow growth and difficulty in ageing of blackgill rockfish it is unlikely improved understandings of high frequency variation in year class strength will be of substantial near term benefit to the model.

C.2 Fisheries off Mexico, Canada or Alaska

Abundance south of the U.S./Mexico border is uncertain, but there appear to be substantial numbers and catches of blackgill rockfish in many areas, and pelagic juveniles have been found as far south as Punta Abreojos, in southern Baja California (Moser and Ahlstrom 1978). However, there have not been assessments or targeted research on this stock in Mexican waters. Landings outside of the assessment area in Oregon and Washington waters are very low, and although the species ranges up to Vancouver Island, it is very rare and has not been subject to assessments or focused research. The stock does not extend in range to Alaskan waters.

C.3 Life history and ecosystem interactions

Blackgill rockfish are a slope species, and are generally rare in waters less than 100 meters and most abundant in waters between 300 and 500 meters depth. Adults are usually associated with high relief rocky outcrops, canyons or deep rock pinnacles, although fishermen often report taking them in midwater (Kronman 1999, Love et al. 2002, J. Butler and K. Stierhoff, SWFSC, unpublished data). This species has among the deepest distribution of all of the California Current *Sebastes*, living at the edge of the low oxygen (hypoxic) conditions that characterize the slope waters of the California Current. As a shoaling of this low oxygen habitat has already been observed in the California Current (Bograd et al. 2008, Gilly et al. 2013), and is predicted to be a likely or plausible response to future climate change, this species could be vulnerable to climate induced changes in distribution and productivity in the future.

C.4 History of the fishery and summary of management actions

Blackgill rockfish have historically represented a minor part of California rockfish landings north of Point Conception, but a substantial fraction of landings occur south of Conception. Based on consultations with fishery participants, Butler et al. (1998) and Kronman (1999) defined the southern California targeted fishery for blackgill rockfish as being a relatively recent phenomenon. Although longline fishing had long been the primary means of catching rockfish in southern California waters, increased participation and declines in the catches of many highly desired shelf species (such as vermillion and cowcod) contributed to a gradual shift in effort towards deeper and more offshore waters. Additionally, set nets (gillnets) also began to be deployed at a larger scale in southern California in the 1970s and 1980s, often targeting deep reefs for larger rockfish species, including blackgill rockfish. As suggested in Kronman (1999) and demonstrated in Miller et al. (2014), California groundfish fisheries did demonstrate a movement to deeper waters, further from ports and in more inclement weather over time, which could bias historical length composition data if they represent sequential depletion of key fishing grounds.

In 2001 the Cowcod Conservation Areas (CCAs) were established in the southern California Bight, in the region in which a substantial fraction of catches had been achieved for blackgill rockfish (see survey data maps, Figure 5). This management measure has had a tremendous impact on the southern fixed gear fleet that targets blackgill rockfish, as the deep offshore banks and features that characterize the CCAs in deep water are optimal habitat for this species. By contrast, the shelf closures (rockfish conservation areas) implemented to protect rebuilding shelf species (such as bocaccio, canary and widow rockfish) have presumably had a negligible direct effect, as the depths closed in the RCAs do not encompass the depths at which most blackgill rockfish are encountered.

The implementation of the trawl rationalization program in 2011, which resulted in 100% observer coverage and presumably increased retention rates in the fishery, is associated with a decline in trawl fishery discard rates and a shift to the left of size composition data in the trawl fishery.

Historically, blackgill rockfish south of 40°10’ N have been managed in the Southern Slope Rockfish complex (or in other aggregations prior to the establishement of that complex). However, as of the 2018 management cycle, blackgill rockfish are managed as their own stock with their own ACL, ABC and OFL. The ACL for 2018 was based on the ABC, a P* = 0.45, and the 40-10 adjustment. Additional details can be found in the biennial management specifications documents produced by the PFMC (http://www.pcouncil.org/groundfish/current-season-management/).

D. Assessment

D.1 Life history and data sources

D.1.a Maturity

The 2011 assessment included a rigorous effort to compile and develop additional maturity information, and included updated maturity curves. Those studies continued past the 2011 assessment, and resulted in a publication (Lefebvre and Field 2015) that documented the best available information for estimating maturity for this stock. Specifically, the revised maturity curve accounts for the mass atresia (re-absorption) of developing oocytes during periods of "prolonged adolescence" discussed in the 2011 assessment, and documented for many other West Coast slope rockfish species (Nichol and Pikitch 1994, Hannah and Parker 2007).

However, prior to revising the maturity curve, it was noted that the 2011 assessment included an error associated with mis-transcribed units, which was corrected and reported as a sensitivity in the current update assessment. The parameters developed for the 2011 included a size of 50% maturity of 33.0 cm with a corresponding slope parameter of -0.31 (incorrectly entered as -0.031). The revised estimates are for a size of 50% maturity of 33.4 cm with a slope parameter of -0.35. As described in greater detail in Lefebvre and Field (2015), the analysis also demonstrated a fairly clear trend of increasing size at maturity with more northerly latitudes, which in turn indicates that the paucity of maturity data in the Southern California Bight, where most of the historical fishery has taken place, is a non-trivial uncertainty for this model.

D.1.b Fecundity

The development and analysis of new fecundity information was prioritized for the 2011 stock assessment, for which new estimates were documented and used in the model. Additional collections and analysis continued past 2011, and were ultimately published in 2015 (Beyer et al. 2015). Those parameters (based on the weight-specific fecundity relationship) were used in this model. Note that Dick et al. (2017) in their fecundity meta-analysis did not explicitly model blackgill rockfish to the species level, as the species was not a component of the seven sub-genera that provide the basis for the hierarchical analysis. Thus, the Beyer et al. (2015) fecundity estimates provide the best available fecundity data for this stock.

D.1.c Age estimation

Blackgill rockfish were first aged by the SWFSC for the 1998 stock assessment (Butler et al. 1999) using thin section analysis. Stevens et al. (2004) also conducted an age study, finding that agreement among the three readers was low, with 24% of the age estimates within one year, 61% within 5 years and 87% within 10 years.[1] Most importantly, Stevens et al. confirmed their age estimates using radiometric analysis, although their results were based on pooled, rather than individual samples due to poor radium recovery. This led to a relatively small sample size (n=14) that was based on average ages and radium levels within a sample. For the 2011 assessment, aging criteria were developed by an experienced ager, and those criteria are described in detail in the 2011 assessment; essentially each otolith was hand cut with a diamond saw and placed in an oven at 500 °F for 30 minutes. As in earlier studies, there is high uncertainty in age estimates, with inconsistent banding patterns among specimens, high compression of increments for older individuals, and frequent and difficult to interpret false growth zones (checks) on many otoliths. New age data for this assessment include nearly 2000 age estimates from recent years (2011-2012, 2014-2015) of the NWFSC combined bottom trawl survey.

D.1.d Growth

Blackgill rockfish have long been known to be amongst the most slowly growing of the *Sebastes* species, with past von-Bertalanffy growth coefficient (K) values ranging from 0.04 to 0.05 for females and 0.06 to 0.08 for males (Butler et al. 1999, Stevens et al. 2004, Helser 2006). For the 2011 model, and in this update, growth parameters were estimated internally, based on the Schnute formulation for von-Bertalanffy growth, with A_{min} and A_{max} (corresponding to the estimated parameters L_{min} and L_{max}) set to 6 and 60. The results are discussed more comprehensively in the results section of the assessment.

D.1.e Natural Mortality

The 2011 model used point estimates for females and males with a maximum age of 64 of 0.063 and 0.065 respectively, based on priors developed by O. Hamel for the 2011 assessment cycle and described in detail in the 2011 assessment. The natural mortality values used in this update were not updated from those used in the 2011 assessment.

D.2 Commercial Landings Data

Historical catches of blackgill rockfish were largely made in southern California (south of Point Conception), where the species is the target of both directed and incidental catches from fixed gear (hook and line, and historically, gillnet). Historical landings are unchanged from the 2011 assessment update. In recent years, a greater fraction of the total catch has come from central California waters, in both fixed gear (both hook and line as well as pot) and trawl fisheries. Catch estimates from 2010 through 2015 were based on NWFSC total mortality reports and area/gear landings from the California Cooperative Groundfish Survey (CalCOM) database. Specifically, CalCOM estimates were used to provide estimated landings by gear group and region for the fleets defined in this model,

1 Note that the 2005 assessment incorrectly suggests that the Steven's et al. (2004) study found 87% among reader agreement, while the study actually reports 87% agreement within ten years.

those were multiplied by the discard rates provided by the West Coast Groundfish observer program, and those values in turn were scaled across all fisheries to provide a matching catch to the WCGOP total mortality reports for blackgill rockfish south of 40° 10'. Thus, the total mortality reports are assumed to be the best available information for total catches, with landings and gear data from CalCOM used to scale those catches to the appropriate regions and fisheries. Neither the 2011 assessment nor this update have attempted to model the discard and retention processes for blackgill rockfish. Figure 2 shows estimated total catches by fleet for the entire assessment period.

D.2.a Commercial Length and Age Composition Data

Length and species composition data first began being collected by port-samplers in the early 1980s; prior to this period there are very few species or length composition data available (although there are some data for 1978 and 1979). Since that time, approximately 40,000 length observations have been collected from the three fisheries described for this model. However, sampling density has been variable over both space and time, and the amount of data collected from monitoring efforts can be variable by region. Only about half of these historical observations have gender associated with the observation, and in particular, for southern California Bight fisheries, gender information (as well as maturity and age structures) was only collected from 1985 through 1990. Since that time, most southern California processors have not allowed port samplers to cut fish in order to determine gender or to remove age structures, as based on California law such sampling is voluntary, rather than mandatory (as it is in Oregon and Washington). Since the period of the last assessment, the frequency of sex observations associated with length frequency observations has also declined in both the central California trawl and fixed gear fisheries as well, with only 10-20% of observations in any given fishery and year having an associated gender observation. Consequently, all new length frequency observations were modeled as mixed gender.

As in the 2011 assessment, the initial effective sample sizes (input N, or N_{eff}) for commercial, recreational and fishery independent length frequency data were calculated using the approach developed by Stewart (2008) in which:

$N_{eff} = N_{hauls} + 0.138*N_{fish}$ if $N_{fish}/N_{hauls} < 44$
$N_{eff} = 7.06*N_{hauls}$ if $N_{fish}/N_{hauls} \geq 44$

Where fishing trips for recreational data, and hauls for the trawl survey, are considered to be unique sampling events, and the maximum input N_{eff} is capped at 400. As described in the 2011 assessment, commercial fishery length composition data were based on raw, rather than expanded, length observations due to an apparent coarsening of the length frequency data when sample sizes were small. The number of port sample clusters and individual length observations, with the associated initial sample size, for commercial fisheries since 2010 are shown in table 5. Age composition data for commercial fisheries were included in the 2011 assessment and have not changed. No new commercial age data have been developed.

D.3 Fishery Independent Data

An abundance index and length composition data from the West Coast triennial trawl survey (limited to the years 1995-2004) were developed for the 2011 assessment and are unchanged in this update. Similarly, the NWFSC slope survey index (1999 through 2002) is unchanged from the 2011 assessment. As in the 2011 assessment, all survey indices were treated as relative abundance indices.

The 2011 assessment used the Combined West Coast Bottom Trawl survey data from 2003-2010, for which the survey sampled the entire Conception and Monterey areas and depth strata. New data from this survey were available from 2011-2016, and those data were used to develop a revised abundance index using the VAST software package developed by Thorson et al. (2015). In comparing the VAST output to the delta-GLMM output (as well as to the design-based estimates) there were modest differences (Figure 3), although the model is generally insensitive to these differences. The Q/Q plot for the VAST model is also shown (Figure 4); other standard diagnostics are available on request.

Length composition data were updated, and ages from the fish sampled in the 2011-2012 and 2014-2015 surveys were estimated using the “break and bake” approach described earlier (and in greater detail in the 2011 assessment). Age data were included as conditional age-at-length (CAAL), as they were in the 2011 assessment. Initial effective sample sizes were the number of age observations in a given length bin.

Figures 5 and 6 show the pooled (all years) CPUE observations for the trawl survey for central and southern California, respectively, with 200 meter isobaths and a background that is based on kriging features in ArcGIS (spatial variogram estimates) of catch rates over space. Year-specific figures for survey catches are available upon request. The kriging is based only on catch data, and thus does not include depth, rugosity or other habitat covariates (data shallower than 200 meters and deeper than 600 meters are masked due to the rarity of positive observations in those depth ranges). The results do indicate a relative rarity of blackgill rockfish in slope habitats close to port, and high abundance of blackgill rockfish at the Santa Lucia bank off of Morro Bay, along the southwest side of the continental slope in the Northwest Channel Islands, and at other seamounts in the western side of the Southern California Bight (particularly as abutting the western Cowcod Conservation Area).

E. Model

The first assessment for blackgill rockfish was done in 1998 (Butler et al. 1998) and was based on stock reduction analysis (assuming constant recruitment) for the Conception INPFC area only. Data were used from 1980 through 1997, the model assumed that vulnerable biomass was equal to mature biomass based on comparisons between maturity curves and length frequency data, and assumed a natural mortality rate of 0.047. The results indicated that the then status quo fishing mortality rates (associated with catches in the range of 150 to 250 tons) were approximately equal to $F_{50\%}$-$F_{55\%}$, and thus likely to be “reasonable upper bounds on management targets.”

Blackgill rockfish were again assessed in 2005 (Helser 2006) using stock synthesis 2 and with an expanded geographic range which included both Conception and Monterey INPFC areas. Catch data were interpolated back to 1950 based on a linear increase in the fraction of total California rockfish catches to reflect the movement by the fishery to deeper and more offshore waters. The 2005 assessment included more comprehensive exploration of plausible proxies and estimates of natural mortality rates, developed several time series of abundance based on the triennial and both AFSC and NWFSC slope surveys. Growth parameters were estimated internally using the relatively limited conditional age-at-length data published by Stevens et al. (2004). The base model results from 2005 suggested that the spawning biomass of blackgill rockfish had declined from 9503 metric tons in 1950 (the unfished level) to 4797 in 1999 and increased from then to 4977 tons (52% of the unfished level) in 2004. The 2005 model estimated MSY was 223 tons.

The 2011 model structure was moderately changed from the 2005 model, with three fisheries and three surveys (and four "ghost" fisheries were added to track various composites of size and age information without affecting the likelihood estimation). There are two sexes modeled, and the length and age data are organized into 30 length bins, from 6 to 64 cm, and 29 age bins, from ages 4 through 60. The modeled time period was from 1950 through 2010. Natural mortality is based on the point estimates for the Hamel prior that were available for the 2011 stock assessment (Field and Pearson 2011) and are unchanged for this assessment update. These values are 0.063 and 0.065 for females and males, respectively. Steepness in the base model was fixed at the point estimate of the Dorn prior (as updated in 2011), 0.76. A total of 23 parameters were estimated in the base model, reflecting primarily growth (8 parameters estimated), selectivity (14 parameters estimated), and unfished recruitment (R0, a single parameter). Growth was estimated internally, however as the model behaved poorly when trying to estimate L_{min} (the length of fish at the smallest age class defined in the Schnute model), this value was fixed at 12 cm (for age 6 fish), based on the distribution of ages for 12 cm fish observed in the NWFSC Shelf/Slope Bottom Trawl Survey data. Selectivity was modeled with double logistic curves for the fisheries and asymptotic logistic curves for the surveys.

The 2011 base model results estimated that unfished larval production was on the order of 1.19 trillion larvae, corresponding to a total (summary) biomass of 12,927 tons (within a model estimated range of 11,836-14,019 tons). The target stock size of 40% of the unfished level was associated with a summary biomass of 7,576 tons and a yield of 192 tons; comparable but somewhat less than the equilibrium yield estimated in the Helser model. The abundance of blackgill rockfish was estimated to have declined below target levels by the late 1980s and below the current minimum stock size threshold (MSST) of 25% of the unfished level in 1990. The model estimated that the stock increased back above the overfished threshold in 2006, and continued to be headed in an upward trajectory in 2011. The base model estimated that SPR rates for the years immediately preceding that assessment were fairly close to the target levels (e.g. 0.62 in 2008, approximately 0.46 in 2009 and 2010).

F. Base model selection and evaluation

As this is an update, very few changes were made since the last full assessment. The first change made was that SS3 v. 3.20 files from the 2011 assessment were updated to the SS3 v 3.24u format without altering data or model structure, and we confirmed that both models provided essentially identical results and likelihood values. The few changes, and sequential additions of new data are described below, with corresponding key model results and likelihood values for each change or addition reported in Table 7.

The first substantive change to be made was to correct the mis-specified maturity function slope parameter (as described in section D.1.a). As the incorrect maturity ogive greatly overestimated the fraction of immature, larger fish, the result of this correction was to substantially increase the overall estimated larval production in the model, from approximately 1.2 to 1.8 trillion larvae (Table 7, Figure 7a-b). Changes in relative spawning biomass (depletion) were considerably more modest, although the correction did result in a slightly more pessimistic stock trajectory in the recent period, with the estimated 2011 depletion declining from ~30 to ~27% of the unfished level. By contrast, the application of the more recently published maturity relationship, which accounted for abortive maturation (Lefebvre and Field 2015) was fairly minor, with spawning output and depletion very nearly (but not exactly) identical to that with the corrected 2011 maturity estimate. Updating the model with the latest fecundity relationship, which had a slightly lower slope than that used in 2011, scaled larval output upwards notably, and interestingly also had the result of nearly cancelling out the somewhat more pessimistic perception of stock status that resulted from the mis-specified maturity relationship.

Next, the model was extended to 2017 (with the addition of updated 2010 through 2016 catches), and fisheries dependent and independent datasets were updated. Notably, the addition of revised 2010 through 2016 length composition data from commercial fisheries had a fairly substantial impact on the overall spawning output and relative depletion, scaling the former upwards and resulting in a considerably more optimistic estimate of relative stock status in the latter (Figure 8a-b). This was largely a consequence of unexpectedly large numbers of smaller fish in the commercial trawl fishery, which were poorly fit in the length composition data. This was quickly presumed to be a consequence of the greater retention in that fishery following the shift to 100% observer coverage and increased retention as part of the trawl rationalization process. A time-block for trawl fishery selectivity was consequently added after the addition of all new data.

Addition of the NWFSC length and age composition data also scaled the spawning output and depletion levels up slightly, as did the addition of the NWFSC Shelf/Slope Bottom Trawl Survey index, which was noisy but did have an upward trend. The addition of the length and age data also had the effect of estimating a lower female growth (K) parameter (from approximately 0.028 to 0.022; Table 7). Analysis of the fits to the CAAL data indicate that the recent data suggest slower growth and smaller size-at-age than the age data developed for the 2011 assessment. The data were read by the same age reader using the same age determination criteria, which suggests the apparent change in growth was not due to age-reading error. Both the 2011 assessment and this update subsequently highlight the need to conduct both additional age validation studies and establish a greater number of cross-read age estimates for this stock in future assessments.

The addition of a time block for the trawl fishery selectivity brought the spawning output and relative abundance back downwards slightly, but the net effect of the additional data prior to tuning was largely optimistic with respect to stock status (Figure 8a-b). With the exception of an additional time selectivity block on the trawl fishery, to account for the shift to full retention in that fishery beginning in 2011, and an update to the steepness prior (from 0.76 to 0.718), no substantive changes were made to model structure given that this was an updated stock assessment.

To tune the model, we first removed all previous adjustments to indices and compositional data and re-ran the model inclusive of all data through 2016. We then adjusted the standard deviation added to the survey CVs based on model estimates and applied harmonic tuning and Francis A tuning to the length and age compositional data. Results changed very little with harmonic tuning after a single iteration, changes were somewhat more substantive after the first iteration of Francis A tuning, but were very minor after a second iteration (Table 8, Table 9). Francis A tuning was adopted for the base model consistent with the best practices guidance for groundfish assessments in the 2017 assessment cycle (Figure 9a-b).

G. Response to previous STAR panel recommendations

The 2011 STAR Panel recommendations, and responses, follow. In general, few of the recommendations have been fully addressed in this update assessment.

To address uncertainty regarding the portion of blackgill rockfish population residing in Mexico, the Panel follows the suggestions of the 2005 STAR Panel to attempt to document catches in Mexican waters by both U.S. and Mexican fishers and consider the implications of blackgill rockfish being a shared stock. The Panel also suggests exploring alternative sources of information (i.e. to investigate whether there are relevant studies conducted at Universities in Mexico), that could yield information on biology, life history and exploitation of the blackgill rockfish that could be used in the next assessment.

Response: This remains a key research and management priority for virtually all West Coast groundfish populations, but was beyond the scope of this assessment update.

The Panel recommends devoting additional efforts to reconstructing historical landings. This recommendation applies to most groundfish species on the U.S. West Coast (and not only blackgill rockfish). In addition to providing the best reconstructed catch histories by species, this effort should develop alternative catch streams that would reflect differences in data quantity and quality available for different time periods. Such (more realistic) alternative catch streams would be very useful while exploring model sensitivity to uncertainty in catch history (rather than applying a simple multiplier to entire catch time-series, which is currently the case for most groundfish assessments). Also, taking into account a spatial shift in fishing efforts to deeper waters would be a significant improvement to catch reconstruction of blackgill rockfish and other species landed in mixed-species categories.

Response: The analysis by Miller et al. (2014) was developed to better inform future catch reconstruction efforts with respect to the movement of rockfish fisheries over time. Some additional analyses were presented at the 2016 catch reconstruction workshop (PFMC 2016), however these have not yet progressed to the point at which new historical catch estimates are available for inclusion in this model.

Both the STAR Panel and the STAT agreed that alternative means of exploring relative or absolute abundance in the CCA is a key research priority. Submersible or other visual survey methods could potentially provide additional information on habitat and abundance for this species. Also, it is important to develop alternative methods to monitor length and age compositions of fish inside the CCA.

Response: This remains a high research priority, but was beyond the scope of this assessment update.

The STAT emphasized that blackgill rockfish has proven to be very difficult to age, and age estimates are highly uncertain. Improving age data quality (through validation studies, otolith exchange between labs) and greater exploration of possible differences in age and growth throughout the range of this stock using the data from otoliths that have not yet been processed is desirable. The STAR Panel agreed, but noted that careful consideration should be devoted to producing exactly the age data which would be of most direct benefit to the assessment, based on representative sampling, since expertise, time and funds are all Limited.

Response: Age validation work remains a key priority, as does greater exploration of life history parameters over space, but addressing these concerns was beyond the scope of this assessment.

H. Base-case model results

H.1 Model diagnostics and convergence

The base model was run ten times with jittered (jitter was set to 0.01 of initial values) starting values to ensure convergence. The first three of these runs (following the initial tuning) provided convergence gradients of 0.000480836, 0.000783907, 0.000332567 with no discernable (to 0.01 units) changes in likelihood in these (or later, e.g., forecast simulation) model runs. Thus, the STAT concluded that the model demonstrated good convergence.

H.2 Evaluation of model parameters and base model results

A full list of all estimated parameters in both the 2011 model and this update (including the assumed values for key fixed parameters) is provided in Table 9, and a composite of the available catch, survey, length and age frequency data, by fleet and year, used in the base model is shown in Figure 10. The mean input sample sizes, effective sample sizes, and variance adjustments for survey indices, length composition data and age composition data are provided in Table 10. Growth, maturity and fecundity relationships are shown as Figures 11-12. The estimated selectivity curves (including the offset for the southern fixed gear fishery) are shown as Figures 13-14. The most substantive observed changes were in the growth parameters, with the von Bertalanffy growth coefficient (K) declining from approximately 0.028 to 0.023 for females, and from 0.047 to 0.040 for males. Length at A_{max} also increased slightly for both sexes, and the CVs of size at age increasing for both female and male fish. This is attributed to the previously mentioned indication of bias between age estimates for the 2011 base model and age estimates for this update, despite the fact that all ages were estimated by the same age reader, using the same age determination criteria.

Fits to the NWFSC Shelf/Slope Bottom Trawl Survey index (in both arithmetic and log scale) are presented as Figures 15-16 (fits to the unaltered triennial and NWFSC slope survey are not shown, as indices were unchanged from the 2011 model, but are available in the R4SS plots). As discussed earlier, the fits to the survey indices are poor due to the variable nature of the year-by-year estimates. However, all three indices are suggestive of an increasing trend in relative abundance, a trend that is also suggested by the model fit.

Fits to commercial length data, including residuals and fits to mean length, are presented in Figures 17-23. Most fits appear reasonable, albeit often noisy at times. The strong shift in length compositions (and mean length) in the central trawl fishery beginning in 2011 stands out as a prominent feature in commercial composition data. Fits to commercial CAAL data are not shown as those data have not changed since the 2011 assessment, but are available in the r4ss output package.

Fits to the NWFSC Shelf/Slope Bottom Trawl Survey length composition data (Figures 24-25) are somewhat noisier than fits to commercial length data, as this survey encounters considerable numbers of smaller fish. There are some indications of temporal trends in many of the residuals that may well indicate pulses or periods of good (bad) recruitment. It may be that as the time series of length and age data increase from this survey, some trends in recruitment can be estimated in future assessments. Figure 26 shows composite fits to all length frequency data from the fisheries and surveys (the “ghost” fisheries represent composites that simply pool all sexed and unsexed fish into a single gender for purposes of evaluating the fits).

Fits to the conditional age-at-length (CAAL) data are shown for all fisheries (Figures 27-33), given that the addition of new age data appears to have influenced growth estimates. Fits for most fisheries and surveys are reasonable (albeit noisy), although the fits to the newly aged specimens for the combined bottom trawl survey (years 2011-12, 2014-2015; Figure 31) do suggest a potential bias in overestimates of age relative to the model estimates for those years, as also suggested in the fits to the mean age for that survey (Figure 33).

The base model results for spawning output, summary (age 1+) biomass, recruitment, SPR, and exploitation rate are reported in Table 11. The base model estimated total unfished larval production to be 2.064 trillion larvae, corresponding to a total (summary, age 1+) biomass of 14,187 tons (within a model estimated range of 13,313 to 15,061 tons). The biomass and spawning output trajectories (Figure 34 a-b), and relative depletion (Figure 35) suggests that the spawning output was at high levels in the mid-1970s, began to decline steeply in the late 1970s through the 1980s, consistent with the rapid development and growth of the targeted fishery, and reached a low of approximately 20% of the unfished level in the mid- 1990s. The model suggests that spawning biomass has been slowly increasing since that time. As steepness is fixed at a relatively high level in the spawner-recruit relationship (Figure 36a), the model suggests that recruitment has been maintained at a fairly high level throughout this period, dipping to no less than approximately 70% of the long-term mean at the low point in spawning abundance (Figure 36b).

The base model estimates that the spawning potential ratio (SPR) was below the current target (of 50% of the unfished level) from the mid- 1970s through most of the 1990s (Figure 37), and irregularly in the 2000s. SPR rates have been near or above target levels for most years since the very late 1990s, corresponding to an apparent increase in stock abundance (Figure 38). Over the past four years, SPR rates have ranged between 0.70 and 0.82, corresponding to exploitation rates roughly half of the overfishing limit (0.50).

I. Uncertainty and Sensitivity Analysis

A comparison of likelihood profiles and model results across alternative values of steepness (h) are shown as Figures 39-40 and Table 12. The likelihood profiles suggests better fits for lower values of steepness, although the overall improvement in likelihood was less than two likelihood units over the rage of ~0.3 to 0.8. There were strong conflicts between survey and length composition data (which fit better with high steepness) and age composition data (which fit better with low steepness). Assumptions regarding steepness had relatively less influence on the model outcome and total likelihood than natural mortality (Figures 41-42, Tables 12 and 13), for which model results are predictably more pessimistic with lower natural mortality rates and more optimistic with higher natural values. As in the 2011 assessment, the age composition data fit better with higher natural mortality rates and the length composition fit better with lower natural mortality rates. Consistent with what intuition might suggest, the low M scenarios are considerably more pessimistic (2017 depletion of approximately 30% with M=0.05), while the high M scenarios are more optimistic (2017 depletion of approximately 50% with =0.08). For the purposes of constructing this profile for natural mortality, the female and male mortality rates were set equal and profiled across 0.01 intervals.

Retrospective analyses were done by removing the last two, and the last five, years of data from the model (Figure 43). Unlike the 2011 model, this model was relatively insensitive to the retrospective analysis; the 5 year retrospective was somewhat more pessimistic, but not tremendously so when compared to the five year retrospective in 2011 when the five year retrospective estimated depletion to be approximately 17% of the unfished level. At that time this was thought to be a consequence of having very few fish at small sizes to estimate growth (as most of the NWFSC Shelf/Slope Bottom Trawl Survey data were excluded). The five year retrospective in this update essentially approximates the 2011 model.

J. Reference Points

Key biomass reference points (unfished summary biomass, spawning output and equilibrium recruitment) along with approximate 95% confidence limits are reported in Table 14. The unfished larval production was estimated to be 2.064 trillion larvae, corresponding to a total (summary, age 1+) biomass of 14,187 tons (within a model estimated range of 13,313 to 15,061 tons). The target stock size of 40% of the unfished level is associated with a summary biomass of 8037 tons and a yield of 188 tons (relative to 192 in the 2011 assessment, and considerably greater than recent catches). It should be emphasized that this biomass estimate is inclusive of immature fish and mature fish too small to be vulnerable to current fisheries. Estimated maximum yields vary relatively modestly (across a range of 31 tons) over the $SSB_{40\%}$ (188 mt), $SPR_{50\%}$ (178 mt) and MSY (209 mt) estimates. The potential yield curve is shown as Figure 44.

K. Harvest Projections and Decision Tables

The projected ABC and OFL values for the base model, assuming attainment of the 2017 and 2018 ABCs, are included as Table 15. As the biomass is approaching the target level of 40% of the unfished spawning output, and recruitment is assumed to be deterministic, both sets of values are extremely stable with respect to projections over the next ten years.

The decision table axis of uncertainty was unchanged from the 2011 assessment, as uncertainty in the natural mortality rate is by far the greatest source of uncertainty in this stock with respect to abundance, productivity and relative stock status. As in 2011, we used the standard deviation for the Hamel prior as the basis for the uncertainty in M in the decision table (Table B7 in executive summary). This led to a high (0.086 females, 0.089 males) and low (0.046 for females, 0.048 for males) natural mortality rate alternative states of nature (base case point estimates for M were 0.063 for females, 0.065 for males). Catch streams for this update were not developed from the same criteria as in the 2011 model, but rather reflect status quo catches (average over the past three years), the base model estimated ABC catches, and the corresponding base model estimated OFL catches (Figure 45).

In all catch scenarios, the base model reaches 40% of the unfished larval output in 2018. In the status quo catch scenario the stock continues to slowly build to nearly 50% of the unfished level by 2028, and as expected, in both the ABC and OFL catch scenarios, the stock is maintained at just at or above 40% of the unfished larval output. The biomass trajectories under the alternative states of nature are of course considerably different, under the low natural mortality rate scenario the stock in 2017 is at 28% of the unfished level, and increases substantively only with the status quo (low catch) stream, although even under ABC or OFL catches the stock is not projected to decline from this level. Under the high natural mortality rate scenario, the stock is at 55% of the unfished larval output in 2017, and increases under all catch scenarios.

L. Regional management considerations

The vast majority (approximately 65%) of historical landings have taken place south of Point Conception by fixed gear (hook and line, and historically, setnet) fisheries. In this region, blackgill rockfish were, and remain, a targeted fishery although they are encountered incidentally in other fisheries as well. Blackgill rockfish catches appear to be somewhat incidental to fisheries targeting sablefish and other species north of Point Conception, with some exceptions in targeted fisheries out of Morro Bay and possibly Monterey regions. The historical magnitude of catches by region should probably be a consideration in developing management recommendations throughout the area south of 40º10'. North of 40º10' blackgill rockfish are uncommon and may well have different life history characteristics, although there is no evidence that these animals represent a distinct stock. As noted in the 2011 assessment, the Cowcod Conservation Areas (CCAs) have had notable effects on the size composition of catches in the southern area, consistent with the expectation that the habitat in the CCAs is optimal for this species. Continued closure of this area to fishing will have the effect of concentrating effort on that fraction of the stock that remains in habitat open to fishing, presumably leading to greater disparity in abundance and size structure between these large fished and unfished regions.

M Research Recommendations

Age estimates are highly uncertain and this species has proven very difficult to age, which is not uncommon for deepwater species that inhabit environments where seasonal variability is muted. There is some indication of aging bias between ages developed for the 2011 assessment and for this update, despite the fact that they were aged by the same reader, using the same age determination criteria. Conducting cross reads with other laboratories, as well as consideration of alternative age validation and bias evaluation methods, are important factors for future efforts.

Both the previous assessment and a subsequent publication indicate differences in size-at-maturity over space, with fish maturing at larger sizes (older ages) further north. Although recent histological studies have shown that this species is slow to mature and often undergoes abortive maturation (particularly at younger ages), additional investigations into spatial and potentially temporal variability in reproductive parameters are needed. There also appear to be latitudinal clines in growth and potentially other life history parameters that are not accounted for in the model; greater exploration of possible differences in age structure and growth, as well as maturity, throughout the range of this stock are desirable. As this species occupies a wide range of depths, some investigation of the potential effects of depth on growth variability may also be desirable.

Recent efforts to analyze spatially explicit historical catch data have indicated that fisheries for this and other rockfish species tended to fish deeper waters, further offshore, in more inclement weather over time, suggesting that historical catches of this deeply distributed species may be overestimated. In general, historical catches remain very uncertain for this (and other) rockfish stocks. The potential for the fishery to sequentially deplete regions of abundance for this species could also bias estimates of stock status and productivity if length composition data do not reflect a constant mortality rate exhibited on the whole of the stock biomass.

A large fraction of blackgill rockfish habitat is currently closed to both fishing and survey effort in the Cowcod Conservation Areas (CCAs), complicating efforts to interpret both catch and survey data. Alternative means of exploring relative or absolute abundance in this region is a key research priority. Submersible or other survey methods could potentially provide additional habitat and abundance information for this species as they have for others.

Greater investigation into the likely or plausible consequences of a shoaling of the oxygen minimum zone (OMZ) on blackgill rockfish habitat will aid in evaluating threats to this species that may be posed by global climate change.

As the slope environment is dominated by a relatively small number of species, for which respectable abundance and food habits information exists on key predators (such as sablefish and shortspine thornyheads), this environment could be an ideal one for exploring the consequences of fishing on trophic interactions and altered predator abundance levels.

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O. Sources

Beyer, S.G., S. M. Sogard, C.J. Harvey and J.C. Field. 2015. Variability in rockfish (*Sebastes spp*.) fecundity: species contrasts, maternal size effects, and spatial differences. Environmental Biology of Fishes 98: 81–100.

Bograd, S.J., C.G. Castro, E. Di Lorenzo, D.M. Palacios, H. Bailey, W. Gilly and F.P. Chavez. 2008. Oxygen declines and the shoaling of the hypoxic boundary in the California Current. Geophysical Research Letters 35: L12607.

Butler, J.L., L.D. Jacobson and J.T. Barnes. 1999. Stock assessment for blackgill rockfish. In Appendix to the status of the Pacific coast groundfish fishery through 1998 and recommended acceptable biological catches for 1999: stock assessment and fishery evaluation, 92 p. Pacific Fishery Management Council, 2130 SW Fifth Avenue, Suite 224, Portland, Oregon.

Dick, E.J., S.G. Beyer, M. Mangel and S. Ralston. 2017. A meta-analysis of fecundity in rockfishes (genus *Sebastes*). Fisheries Research 187: 73-85.

Field, J.C. and D. Pearson. 2011. Status of the blackgill rockfish, *Sebastes melanostomus*, in the Conception and Monterey INPFC areas for 2011. In Status of the Pacific Coast Groundfish Fishery through 2011, Stock Assessment and Fishery Evaluation. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, Or.

Gertseva, V.V., Cope, J.M. and S.E. Matson. 2010. Growth variability in the splitnose rockfish *Sebastes diploproa* of the northeast Pacific Ocean: pattern revisited. Marine Ecology Progress Series 413: 125-136.

Haldorson, L. and M. Love. 1991. Maturity and fecundity in the rockfishes, *Sebastes* spp., a review. Marine Fisheries Review 53: 25-31.

Hannah, R.W. and S.J. Parker. 2007. Age modulated variation in reproductive development of female Pacific Ocean perch (*Sebastes alutus*) in waters off Oregon. pp 1-19 in J. Heifetz, J. Dicosimo, A.J. Gharrett, M.S. Love, V. M. O'connell and R.D. Stanley (editors) Proceedings of the Lowell-Wakefield Symposium on the Biology, Assessment and Management of North Pacific Rockfish. University of Alaska Sea Grant: Anchorage, Alaska.

Helser, T. 2006. Stock Assessment of the blackgill rockfish (*Sebastes melanostomus*) population off the west coast of the United States in 2005. In Volume 5: Status of the Pacific Coast Groundfish Fishery Through 2005, Stock Assessment and Fishery Evaluation Portland, OR: Pacific Fishery Management Council.

Kronman, M. 1999. Santa Barbara's hook-and-line fisheries. Santa Barbara Maritime History Museum.

Lefebvre, L. and J.C. Field. 2015. Reproductive complexity in a long-lived deepwater fish, Blackgill rockfish *Sebastes melanostomus*. Transactions of the American Fisheries Society 144: 383–399.

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

Methot, R.D. 2009. User manual for Stock Synthesis Model Version 3.03a. May 11, 2009.

Miller, R.R., Field, J.C., Santora, J.A., Schroeder, I.D., Huff, D.D., Key, M., Pearson, D.E. and A.D. MacCall. 2014. A spatially distinct history of the development of California groundfish fisheries. Public Library of Science One 9(6): p.e99758.

Nichol, D.G. and E.K. Pikitch. 1994. Reproduction of darkblotched rockfish off the Oregon coast. Transactions of the American Fisheries Society 123: 469-481.

Stevens, M.M., A.H. Andrews, G.M. Cailliet, K.H. Coale and C.C. Lundstrom. 2004. Radiometric validation of age, growth, and longevity for the blackgill rockfish (*Sebastes melanostomus*). Fishery Bulletin 102: 711-722.

Stewart, I.J. 2008. Status of the U.S. canary rockfish resource in 2007. In: Status of the Pacific Coast Groundfish Fishery Through 2007, Stock Assessment and Fishery Evaluation: Stock Assessments and Rebuilding Analyses Portland, OR: Pacific Fishery Management Council.

Thompson, A.R., J.R. Hyde, W. Watson, D.C. Chen and L.W. Guo. 2016. Rockfish assemblage structure and spawning locations in southern California identified through larval sampling. Marine Ecology Progress Series 547: 177-192.

Thorson, J.T., A.O. Shelton, E.J. Ward and H.J. Skaug. 2015. Geostatistical delta-generalized linear mixed models improve precision for estimated abundance indices for West Coast groundfishes. ICES Journal of Marine Science 72: 1297-1310. doi:10.1093/icesjms/fsu243.

Table 1: Recent catches, ACL, ABC and OFL values for blackgill rockfsih

	Catch	ACL	ABC	OFL	% of ABC	% of OFL
2008	74	292	292	292	0.25	0.25
2009	132.7	282	282	282	0.47	0.47
2010	152.3	282	282	282	0.54	0.54
2011	150.3	279	282	282	0.53	0.53
2012	195.4	275	282	282	0.69	0.69
2013	72	113.8	118.7	130	0.6	0.55
2014	72.8	117.2	122.3	134	0.59	0.54
2015	42.8	120.2	125.1	137	0.34	0.31
2016	38.7	123	127.8	140	0.3	0.27
2017			130.6	143		
2018			133	146		

Table 2: WCGOP Total Mortality estimates for blackgill rockfish south of 40 10 by gear group (research is included with trawl)

	fixed	trawl	total
2010	90.45	61.87	152.33
2011	133.99	16.28	150.27
2012	122.03	73.41	195.44
2013	33.22	38.80	72.02
2014	37.49	35.30	72.79
2015	23.95	18.87	42.81

Table 3: CalCOM reported landings by model fleet and region

	south fixed	central fixed	central trawl	total
2010	40.30	49.78	61.54	151.62
2011	41.82	89.32	14.22	145.36
2012	58.28	54.09	73.49	185.86
2013	7.40	25.93	39.67	73.00
2014	11.01	22.32	25.30	58.63
2015	12.34	8.85	17.20	38.39
2016	12.15	13.63	8.67	34.45

Table 4: Model input catches by year and fleet

	south fixed	central fixed	central trawl	total
2010	37.50	57.33	57.50	152.33
2011	37.00	99.15	14.12	150.27
2012	56.63	69.40	69.40	195.43
2013	7.52	26.44	38.06	72.02
2014	9.94	31.09	31.77	72.80
2015	12.89	10.95	18.98	42.82
2016	12.40	17.47	8.83	38.70

Table 5: Number of length observations, subsamples, and effective initial sample size for the three fishing fleets, 2010-2016

	Subsample Count			Fish Count			initial Neff		
	south fixed	central fixed	central trawl	south fixed	central fixed	central trawl	south fixed	central fixed	central trawl
2010	23	37	29	278	447	447	61.36	98.68	90.68
2011	13	45	28	185	598	340	38.53	127.52	74.92
2012	11	13	40	276	259	632	49.08	48.74	127.21
2013	8	3	24	122	49	428	24.83	9.76	83.06
2014	4	16	10	101	270	123	17.93	53.26	26.97
2015	20	10	23	436	161	455	80.16	32.21	85.79
2016	22	15	28	473	260	606	87.27	50.88	111.62

Table 6: Number of hauls, positive hauls, length observations, and effective sample sizes for NWFSC combined shelf-slope (2003-2016) bottom trawl survey within the assessment area (Conception and Monterey INPFC areas).

	positive hauls	total hauls	length observations	Initial Neff
2003	19	199	117	38.146
2004	14	218	410	76.58
2005	24	282	388	81.544
2006	31	302	749	138.362
2007	27	298	288	69.744
2008	35	330	320	88.16
2009	35	325	541	114.658
2010	42	340	518	116.484
2011	36	322	357	93.266
2012	38	319	504	112.552
2013	28	188	395	85.51
2014	38	315	854	155.852
2015	39	331	718	139.084
2016	31	313	371	85.198

Table 7a: Tracking key model outputs and likelihood values with sequential updates and revisions to the 2011 base model.

	2011 base model	2011 base, SS3 v3.24u	2017 fix maturity	2017 new maturity	2017 new fecundity	2011 data, catches to 2016	2017 add com LFs	2017 add NWC survey LFs
Unfished larvae	1188	1187	1733	1732	1866	1866	2153	2222
Unfished recruits	2275	2275	2276	2276	2275	2275	2534	2555
2011 Depletion	0.302	0.302	0.282	0.280	0.310	0.310	0.380	0.386
2017 Depletion						0.365	0.450	0.446
2011 SPR ratio	0.454	1.378	1.441	1.445	1.389	1.102	0.898	0.882
Female Lmax	52.253	52.254	52.403	52.414	52.413	52.295	52.693	53.118
Female K	0.028	0.028	0.028	0.028	0.028	0.028	0.030	0.030
Total likelihood	3275.3	3275.6	3274.5	3274.4	3275.0	3275.0	3608.6	3853.9
Survey	-7.9	-7.9	-7.9	-7.9	-7.9	-7.9	-7.9	-7.9
Length_comp	1158.4	1158.4	1160.8	1161.0	1159.3	1159.3	1460.6	1705.3
Age_comp	2124.8	2124.8	2121.3	2121.0	2123.4	2123.4	2154.8	2155.3
Surveys								
Triennial	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4
NWFSC slope	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4
NWFSC combo	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2
Length data								
South fixed	376.6	376.6	376.9	376.9	376.6	376.7	428.8	435.3
Central fixed	182.2	182.2	182.9	182.9	182.5	182.5	222.7	217.6
Central trawl	392.7	392.7	394.3	394.4	393.2	393.2	609.5	609.8
Triennial	63.1	63.1	63.3	63.3	63.2	63.2	62.0	61.8
LF.5								
NWFSC Combo	143.7	143.7	143.4	143.4	143.7	143.7	137.5	380.7
Age data	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South fixed	239.9	239.9	239.6	239.5	239.8	239.8	244.3	243.3
Central fixed	121.2	121.2	121.1	121.1	121.1	121.1	120.0	120.1
Central trawl	820.1	820.1	819.0	818.9	819.7	819.7	828.8	828.2
NWFSC combo	943.7	943.7	941.6	941.5	942.7	942.7	961.7	963.6

Table 7b: Continued tracking key model outputs and likelihood values with sequential updates and revisions to the 2011 base model.

	2017 add survey LFs	2017 add survey LFs, CAALs	add survey index	add trawl time block	Update steep-ness	2017 all data, untuned
Unfished larvae	2222	2205	2206	2100	2110	2057
Unfished recruits	2555	3130	3130	2991	2994	2962
2011 Depletion	0.386	0.395	0.395	0.367	0.365	0.363
2017 Depletion	0.446	0.457	0.457	0.430	0.425	0.423
2011 SPR ratio	0.882	0.870	0.870	0.934	0.936	0.944
Female Lmax	53.118	52.148	52.148	52.082	52.124	51.837
Female K	0.030	0.022	0.022	0.021	0.021	0.022
Total likelihood	3853.9	5627.0	5621.7	5474.4	5475.1	5703.4
Survey	-7.9	-7.9	-7.9	-7.9	-7.9	-7.9
Length_comp	1705.3	1726.2	1726.1	1589.1	1590.7	1753.9
Age_comp	2155.3	3907.5	3907.6	3897.6	3896.7	3964.6
Surveys						
Triennial	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4
NWFSC slope	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4
NWFSC combo	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2
Length data						
South fixed	435.3	447.7	447.7	441.2	441.0	584.6
Central fixed	217.6	216.1	216.1	230.7	231.2	235.6
Central trawl	609.8	616.7	616.7	469.2	471.5	468.0
Triennial	61.8	62.0	62.0	62.0	62.2	78.8
LF.5						
NWFSC Combo	380.7	383.7	383.7	385.9	384.9	386.9
Age data	0.0	0.0	0.0	0.0	0.0	0.0
South fixed	243.3	322.9	322.9	320.8	320.1	375.9
Central fixed	120.1	114.9	114.9	113.4	113.5	113.7
Central trawl	828.2	920.2	920.2	916.3	915.2	909.2
NWFSC combo	963.6	2549.5	2549.5	2547.0	2547.9	2565.8

Table 8: Key model outputs and likelihood values with alternative model tuning approaches (and with retrospective analyses) for the 2017 base model. Note that alternative tuning methods change the scale of the log-likelihoods so they are not always comparable among columns.

	2017 all data, untuned	Simple tuning (Eff/input N)	Harmonic tuning	Francis A tuning	Francis A, second round	Francis A, final (base model)	retro- two years	retro- five years
Unfished larvae	2057	2061	2059	2116	2063	2063	2078	1188
Unfished recruits	2962	2963	2918	2502	2563	2563	2505	2275
2011 Depletion	0.363	0.363	0.370	0.325	0.338	0.338	0.334	0.302
2017 Depletion	0.423	0.423	0.428	0.380	0.394	0.394	0.389	0.364
2011 SPR ratio	0.944	0.944	0.928	1.018	0.993	0.993	1.004	0.454
Female Lmax	51.837	51.855	51.773	54.062	53.261	53.261	53.261	52.253
Female K	0.022	0.022	0.022	0.022	0.023	0.023	0.023	0.028
Total likelihood	5703.4	5687.4	2800.0	1308.8	1198.8	1198.8	1198.8	3275.3
Survey	-7.9	-7.9	-7.9	-7.9	-7.9	-7.9	-7.9	-7.9
Length_comp	1753.9	1737.9	1032.5	233.6	233.9	233.9	233.9	1158.4
Age_comp	3964.6	3964.7	1782.6	1090.3	980.0	980.0	980.0	2124.8
Surveys								
Triennial	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4
NWFSC slope	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4
NWFSC combo	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2
Length data								
South fixed	584.6	584.5	219.6	39.7	39.7	39.7	39.7	376.6
Central fixed	235.6	235.4	147.4	22.8	21.2	21.2	21.2	182.2
Central trawl	468.0	468.0	309.7	94.7	97.9	97.9	97.9	392.7
Triennial	78.8	63.0	56.6	27.7	27.4	27.4	27.4	63.1
LF.5								
NWFSC Combo	386.9	386.9	299.3	48.6	47.8	47.8	47.8	143.7
Age data	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South fixed	375.9	375.9	126.8	56.5	56.5	56.5	56.5	239.9
Central fixed	113.7	113.7	91.7	51.8	52.2	52.2	52.2	121.2
Central trawl	909.2	909.4	497.0	448.2	340.9	340.9	340.9	820.1
NWFSC combo	2565.8	2565.7	1067.1	533.7	530.4	530.4	530.4	943.7

Table 9: Key fixed and all estimated parameters for the 2011 base blackgill rockfish model and this (2017) assessment update.

Parameter	2011 Point estimate	2017 Point estimate	Param StDev
Natural Mortality (females)	0.063	0.063	fixed
Natural Mortality (males)	0.065	0.065	fixed
Steepness (h)	0.76	0.718	fixed
Sigma R	0	0	fixed
L_at_Amin (male and female)	12	12	fixed
L_at_Amax (female)	52.3	53.26	1.2521
VonBert_K (female)	0.028	0.023	0.0028
CV length at age, young (female)	0.17	0.21	0.025
CV length at age, old (female)	0.13	0.10	0.0189
L_at_Amax (male)	45.60	46.12	0.8603
VonBert_K (male)	0.047	0.04	0.0033
CV length at age, young (female)	0.21	0.25	0.017
CV length at age, old (female)	0.06	0.07	0.0103
Unfished recruitment (log)	7.73	7.85	0.033
Selectivity, southern fixed, peak	46.69	46.13	1.0825
Selectivity, southern fixed, asc. width	3.73	3.72	0.2052
Selectivity, southern fixed, init	-11.10	-11.14	6.3065
Selectivity, southern fixed, block offset	-0.33	-0.31	0.0391
Selectivity, central fixed, peak	51.39	43.67	2.4557
Selectivity, central fixed, asc. width	4.67	4.06	0.3736
Selectivity, central fixed, init	-17.75	-15.41	65.9106
Selectivity, central trawl, peak	43.88	41.11	0.8346
Selectivity, central trawl, asc. width	4.25	3.91	0.1362
Selectivity, central trawl, init	-17.62	-15.98	56.983
Selectivity, central trawl, block offset	n/a	-0.13	0.0215
Selectivity, triennial, inflection	45.26	43.02	2.276
Selectivity, triennial, slope	11.43	11.38	1.2975
Selectivity, NWFSC combo, inflection	26.58	26.73	3.6867
Selectivity, NWFSC combo, slope	13.19	15.14	3.5957

Table 10 a, b, c: Mean input sample sizes, effective sample sizes, and variance adjustments for survey indices, length composition data and age composition data.

Survey data

Fleet	r.m.s.e.	Input	var. adj
Triennial	0.27	0.28	0.06
NWFSC.slope	0.27	0.34	0.00
NWFSC.combo	0.53	0.53	0.25

Length composition data

Fleet	N	model Neff	input Neff	Harm. Mean Neff	Francis A Mean Neff
South.fixed	33	33	78.36	78.36	5.1
Central.fixed	23	23	55.16	55.16	5.27
Central.trawl	41	41	110.46	110.46	21.65
Triennial	4	4	55.19	55.19	19.8
NWFSC.combo	14	14	101.57	101.57	12.97

Age composition data

Fleet	N	model Neff	input Neff	Harm. Mean Neff	Francis A Mean Neff
South.fixed	35	5.94323	8.37143	2.6551	0.03704
Central.fixed	30	2.67385	2.46667	1.87633	0.09473
Central.trawl	170	4.12963	4.08824	1.91186	0.44249
NWFSC.combo	392	5.40678	7.40816	2.65136	0.03162

Table 11: Base model results for total biomass, larval production, depletion.

	Summary Biomass	Larval prod ($x10^9$)	CV. Larval prod	Depletion	Recruit ($x 10^3$)	Catch (mt)	SPR	Expl. Rate
INIT	14187	2064	0.061	1.00	2564	0	1.000	0.000
1950	14164	2064	0.061	1.00	2563	27	0.939	0.002
1951	14143	2058	0.061	1.00	2563	24	0.944	0.002
1952	14121	2053	0.061	0.99	2562	28	0.937	0.002
1953	14091	2048	0.061	0.99	2561	36	0.919	0.003
1954	14058	2042	0.061	0.99	2560	41	0.908	0.003
1955	14031	2034	0.061	0.99	2559	36	0.918	0.003
1956	13988	2027	0.061	0.98	2558	55	0.879	0.004
1957	13947	2017	0.061	0.98	2557	54	0.881	0.004
1958	13906	2007	0.061	0.97	2555	58	0.874	0.004
1959	13862	1997	0.061	0.97	2554	62	0.866	0.004
1960	13822	1987	0.061	0.96	2553	60	0.869	0.004
1961	13784	1977	0.061	0.96	2551	59	0.870	0.004
1962	13762	1967	0.061	0.95	2551	43	0.902	0.003
1963	13724	1961	0.061	0.95	2549	62	0.863	0.005
1964	13700	1951	0.061	0.95	2548	49	0.889	0.004
1965	13666	1944	0.061	0.94	2547	61	0.864	0.004
1966	13545	1935	0.061	0.94	2543	160	0.702	0.012
1967	13312	1908	0.061	0.92	2536	290	0.551	0.022
1968	13234	1858	0.061	0.90	2533	125	0.745	0.009
1969	13138	1840	0.061	0.89	2530	152	0.707	0.012
1970	13044	1815	0.061	0.88	2526	154	0.702	0.012
1971	12927	1791	0.061	0.87	2521	185	0.660	0.014
1972	12697	1761	0.061	0.85	2512	322	0.525	0.025
1973	12438	1705	0.061	0.83	2501	366	0.486	0.029
1974	12170	1643	0.062	0.80	2489	390	0.463	0.032
1975	11968	1578	0.062	0.76	2479	325	0.496	0.027
1976	11763	1529	0.062	0.74	2468	338	0.479	0.029
1977	11584	1479	0.062	0.72	2458	319	0.485	0.028
1978	11311	1435	0.062	0.70	2443	435	0.400	0.038
1979	11019	1373	0.063	0.67	2425	474	0.380	0.043
1980	10668	1304	0.063	0.63	2402	556	0.331	0.052
1981	10384	1224	0.064	0.59	2382	493	0.342	0.047
1982	9940	1160	0.065	0.56	2348	696	0.263	0.070
1983	9565	1066	0.067	0.52	2318	627	0.256	0.066
1984	9461	992	0.069	0.48	2306	328	0.386	0.035
1985	9212	965	0.070	0.47	2281	507	0.289	0.055
1986	8598	912	0.071	0.44	2216	961	0.179	0.112
1987	8085	794	0.077	0.38	2147	877	0.181	0.108
1988	7456	693	0.082	0.34	2054	1040	0.136	0.139
1989	7258	585	0.091	0.28	2018	532	0.200	0.073

Table 11 (continued): Base model results for total biomass, larval production, depletion.

	Summary Biomass	Larval prod $(x10^9)$	CV. Larval prod	Depletion	Recruit $(x\ 10^3)$	Catch (mt)	SPR	Expl. Rate
1990	6951	549	0.094	0.27	1961	680	0.159	0.098
1991	6814	499	0.099	0.24	1930	479	0.194	0.070
1992	6446	475	0.101	0.23	1853	784	0.130	0.122
1993	6383	421	0.108	0.20	1837	401	0.194	0.063
1994	6336	410	0.109	0.20	1827	380	0.197	0.060
1995	6306	404	0.109	0.20	1824	353	0.204	0.056
1996	6264	402	0.109	0.19	1820	366	0.197	0.058
1997	6288	399	0.110	0.19	1832	270	0.244	0.043
1998	6340	407	0.108	0.20	1850	229	0.278	0.036
1999	6525	419	0.107	0.20	1894	48	0.670	0.007
2000	6672	448	0.103	0.22	1930	85	0.568	0.013
2001	6775	475	0.100	0.23	1959	128	0.473	0.019
2002	6857	498	0.097	0.24	1985	144	0.452	0.021
2003	6896	520	0.095	0.25	2004	188	0.385	0.027
2004	6960	537	0.094	0.26	2025	149	0.458	0.021
2005	7071	557	0.092	0.27	2052	87	0.612	0.012
2006	7171	583	0.090	0.28	2075	93	0.603	0.013
2007	7304	608	0.088	0.29	2102	47	0.766	0.006
2008	7409	637	0.086	0.31	2124	74	0.677	0.010
2009	7461	663	0.084	0.32	2138	133	0.531	0.018
2010	7492	682	0.084	0.33	2150	152	0.498	0.020
2011	7521	697	0.083	0.34	2161	150	0.503	0.020
2012	7505	711	0.083	0.34	2167	195	0.432	0.026
2013	7596	720	0.083	0.35	2182	72	0.701	0.009
2014	7684	742	0.082	0.36	2197	73	0.702	0.009
2015	7796	763	0.081	0.37	2212	43	0.810	0.005
2016	7910	788	0.080	0.38	2227	39	0.827	0.005
2017	7917	812	0.078	0.39	2232	*n/a*	*n/a*	*n/a*

Table 12: Key model outputs and likelihood values with alternative fixed values for steepness (h).

	h=0.21	h=0.3	h=0.4	h=0.5	h=0.6	h=0.7	h=0.8	h=0.9	h=0.99
Unfished larvae	2049	2079	2098	2102	2081	2065	2054	2044	2034
Unfished recruits	2526	2527	2530	2539	2554	2562	2569	2578	2586
2011 Depletion	0.235	0.267	0.291	0.309	0.325	0.336	0.346	0.355	0.362
2011 SPR ratio	1.213	1.135	1.083	1.045	1.016	0.996	0.980	0.966	0.953
Female Lmax	52.651	53.130	53.439	53.539	53.380	53.276	53.194	53.099	52.994
Female K	0.028	0.026	0.025	0.024	0.023	0.023	0.023	0.023	0.023
Total likelihood	1205.6	1199.1	1197.9	1198.2	1198.6	1198.7	1199.0	1199.7	1201.5
Survey	-7.9	-7.9	-7.9	-7.9	-7.9	-7.9	-7.9	-7.9	-7.9
Length_comp	238.9	236.8	236.0	235.8	235.1	234.1	233.1	232.2	231.5
Age_comp	971.6	973.0	974.7	976.4	978.1	979.7	981.2	982.7	983.9
Surveys									
Triennial	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4
NWFSC slope	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4
NWFSC combo	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2
Length data									
South fixed	38.7	38.9	39.2	39.4	39.6	39.7	39.7	39.8	39.9
Central fixed	23.5	22.9	22.4	21.9	21.5	21.2	20.9	20.7	20.5
Central trawl	110.3	106.7	103.8	101.6	99.7	98.2	97.0	96.0	95.3
Triennial	28.6	28.3	28.1	27.8	27.6	27.4	27.2	27.1	27.0
LF.5									
NWFSC Combo	37.8	39.9	42.6	45.0	46.8	47.7	48.2	48.6	48.9
Age data	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South fixed	54.9	55.2	55.5	55.8	56.2	56.5	56.7	56.9	57.1
Central fixed	51.9	51.9	52.0	52.1	52.2	52.2	52.3	52.3	52.4
Central trawl	338.0	338.0	338.4	339.0	340.0	340.8	341.5	342.1	342.7
NWFSC combo	526.9	527.9	528.8	529.5	529.8	530.3	530.8	531.3	531.8

Table 13: Key model outputs and likelihood values with alternative fixed values for natural morality (M)

	M=0.03	M=0.04	M=0.05	M=0.06	M=0.07	M=0.08	M=0.09	M=0.1
Unfished larvae	2265	2196	2128	2029	1956	1893	1845	1818
Unfished recruits	531	879	1395	2171	3345	5138	7899	12185
2011 Depletion	0.132	0.194	0.256	0.318	0.382	0.449	0.517	0.584
2011 SPR ratio	1.654	1.427	1.219	1.045	0.893	0.759	0.642	0.538
Female Lmax	49.025	50.612	52.035	53.042	53.942	54.578	54.966	55.160
Female K	0.037	0.032	0.028	0.024	0.021	0.019	0.017	0.016
Total likelihood	1235.9	1214.3	1204.5	1199.7	1198.1	1199.3	1202.8	1208.1
Survey	-7.10	-7.12	-7.14	-7.16	-7.18	-7.20	-7.22	-7.23
Length_comp	220.6	225.4	230.4	233.3	234.7	235.7	236.6	237.4
Age_comp	1024.0	1001.5	988.7	981.6	977.9	976.1	975.4	975.3
Surveys								
Triennial	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4
NWFSC slope	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4
NWFSC combo	-1.3	-1.5	-1.7	-1.9	-1.11	-1.13	-1.15	-1.16
Length data								
South fixed	42.1	41.6	41.0	40.2	39.5	39.1	39.0	39.2
Central fixed	19.2	20.4	21.0	21.3	21.2	20.9	20.5	19.9
Central trawl	88.3	92.0	95.2	97.5	99.5	101.2	102.5	103.6
Triennial	27.2	27.1	26.9	26.7	26.6	26.4	26.3	26.3
LF.5								
NWFSC Combo	43.8	44.3	46.2	47.6	47.9	48.1	48.3	48.4
Age data	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South fixed	70.7	64.3	60.0	57.3	55.4	54.0	53.1	52.4
Central fixed	53.8	53.0	52.6	52.3	52.2	52.2	52.1	52.0
Central trawl	370.2	355.6	347.0	342.3	339.3	337.5	336.5	335.9
NWFSC combo	529.4	528.6	529.1	529.7	531.0	532.4	533.7	534.9

Table 14: Reference points for the 2017 blackgill rockfish model

		95% Confidence Limits	
Unfished Stock	Estimate	Lower	Upper
Summary (1+) Biomass (tons)	14187	13313	15061
Spawning Output (billions larvae)	2064	1812	2316
Equilibrium recruitment (1000s)	2564	2394	2733

	Yield reference Points		
	$SSB_{40\%}$	SPR proxy	MSY est.
SPR	0.459	0.500	0.314
Exploitation rate	0.025	0.022	0.044
Yield	188	178	209
Spawning output	826	919	493
Summary biomass	8037	8590	5815
SSB/SSB_0	0.400	0.446	0.239

Table 15: Base model projected ABC and OFL values, assuming ABC attainment

	ABC	OFL
2017	131	
2018	133	
2019	159	174
2020	159	174
2021	159	174
2022	159	174
2023	159	174
2024	159	173
2025	158	173
2026	158	173
2027	158	173
2028	158	173

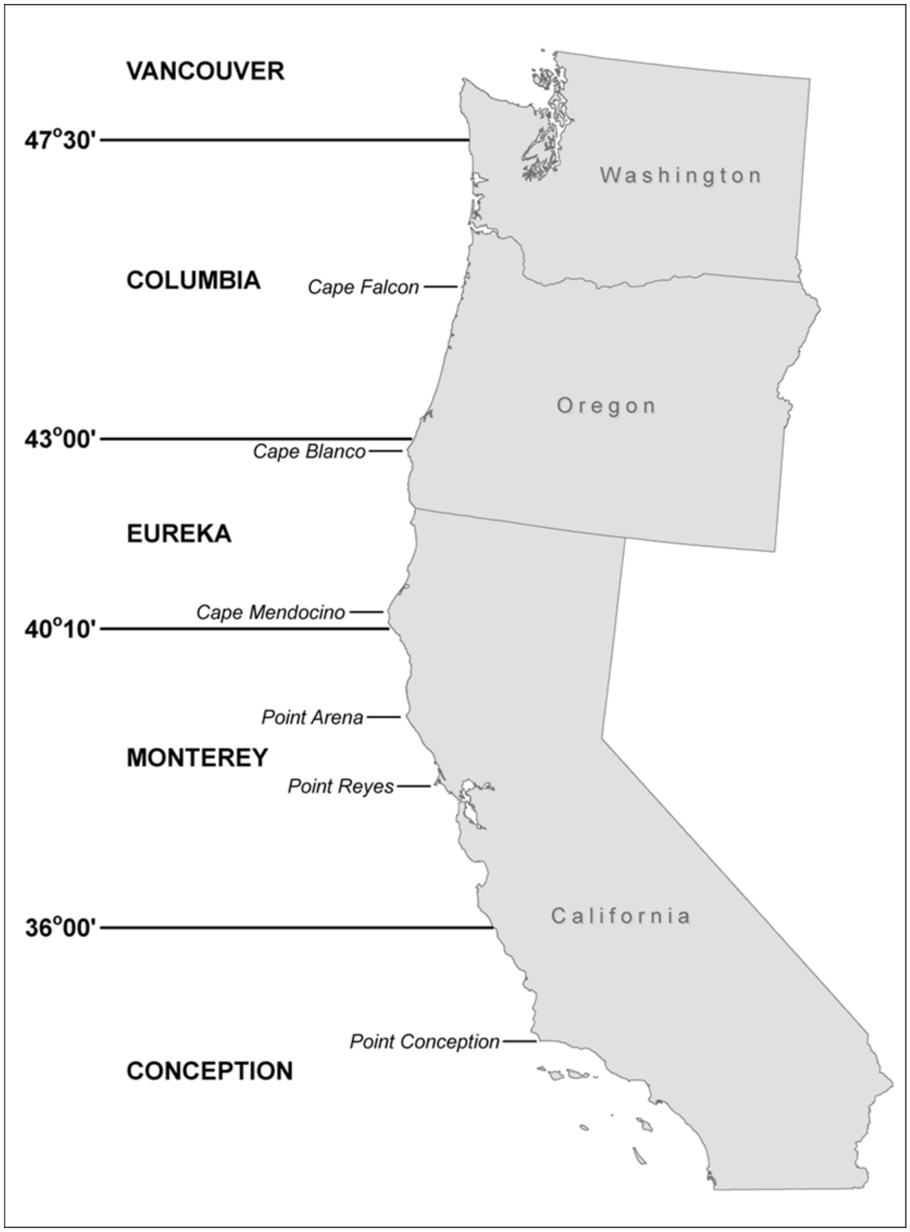


Figure 1: U.S. West coast with International North Pacific Fishery Commission (INPFC) areas and key management lines. This assessment includes only catches and survey data from the Monterey and Conception INPFC areas.

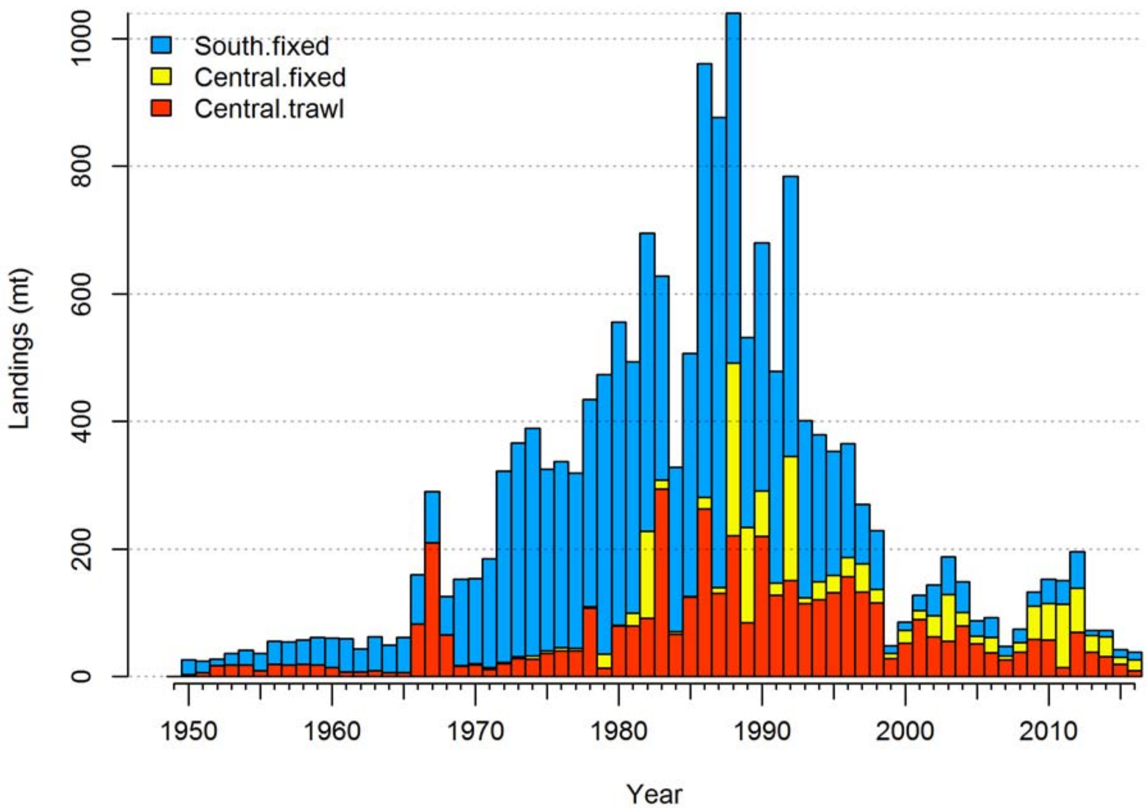


Figure 2: Catch history for the 2017 base model

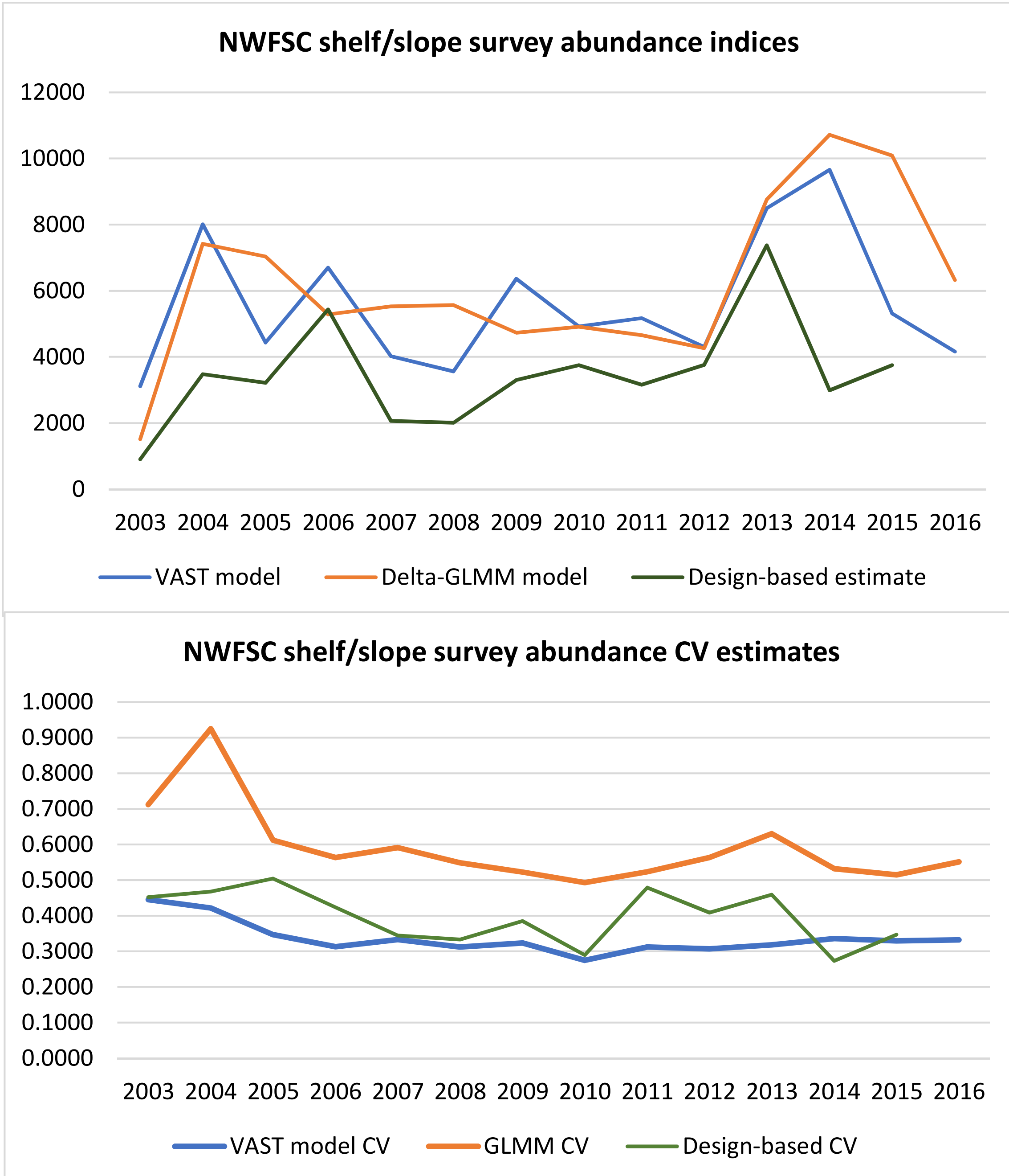


Figure 3: Comparison of VAST, Delta-GLMM and Design-based abundance estimates and associated CVs from the NWFSC shelf/slope bottom trawl survey.

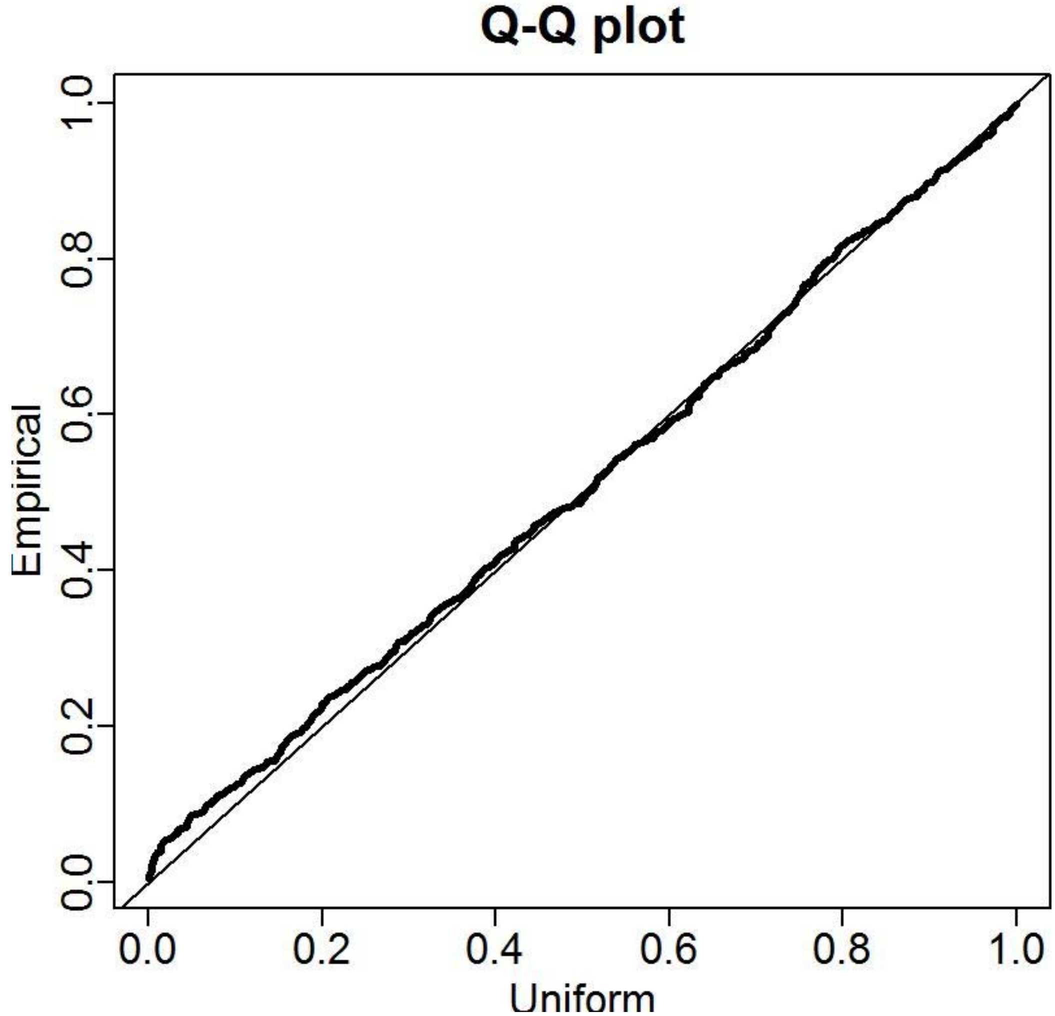


Figure 4: Q/Q plot of base VAST model run for blackgill abundance index.

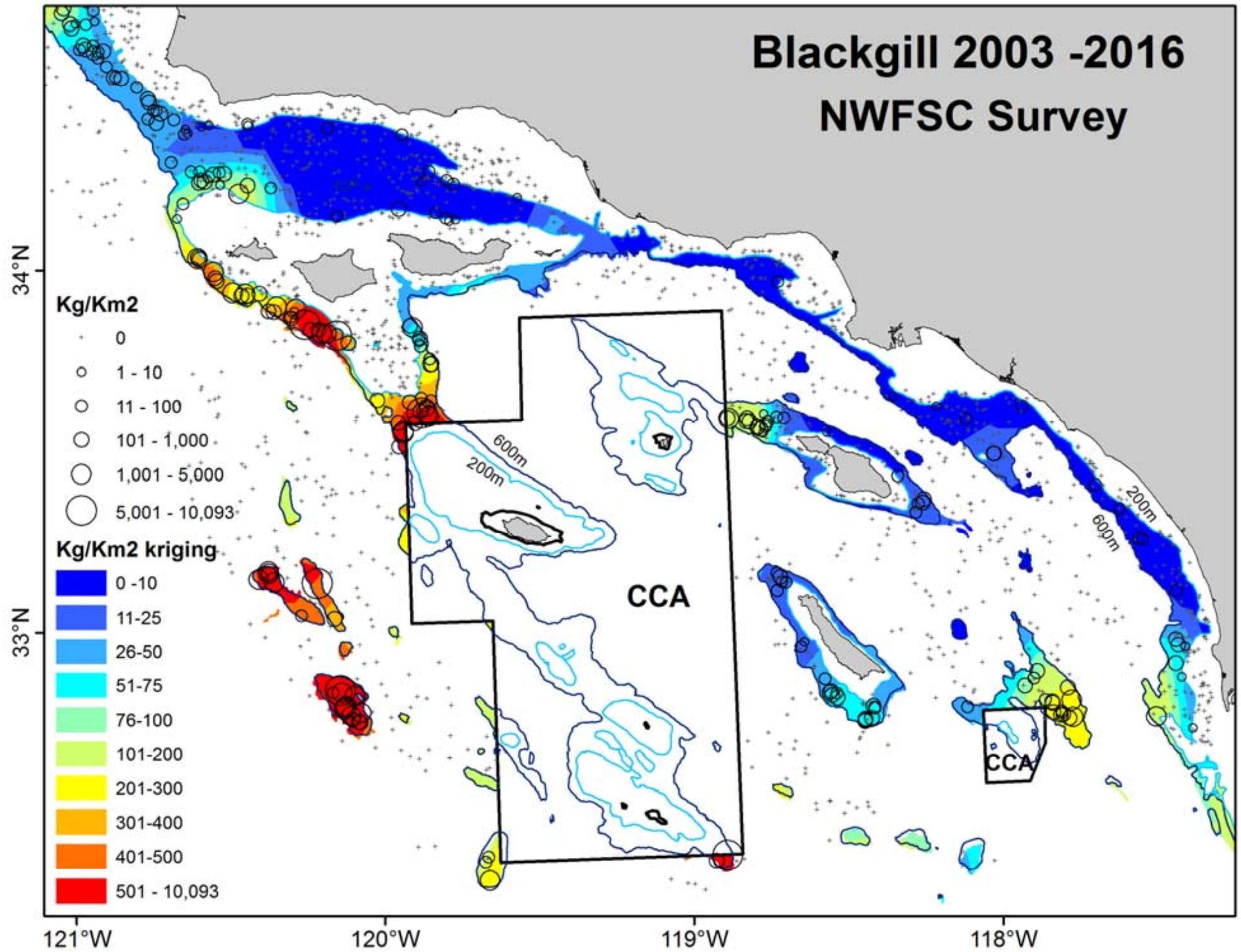


Figure 5: Location and relative CPUE of all NWFSC combined trawl survey hauls in the southern California region (2003-2016), overlaid on a kriged distribution of abundance.

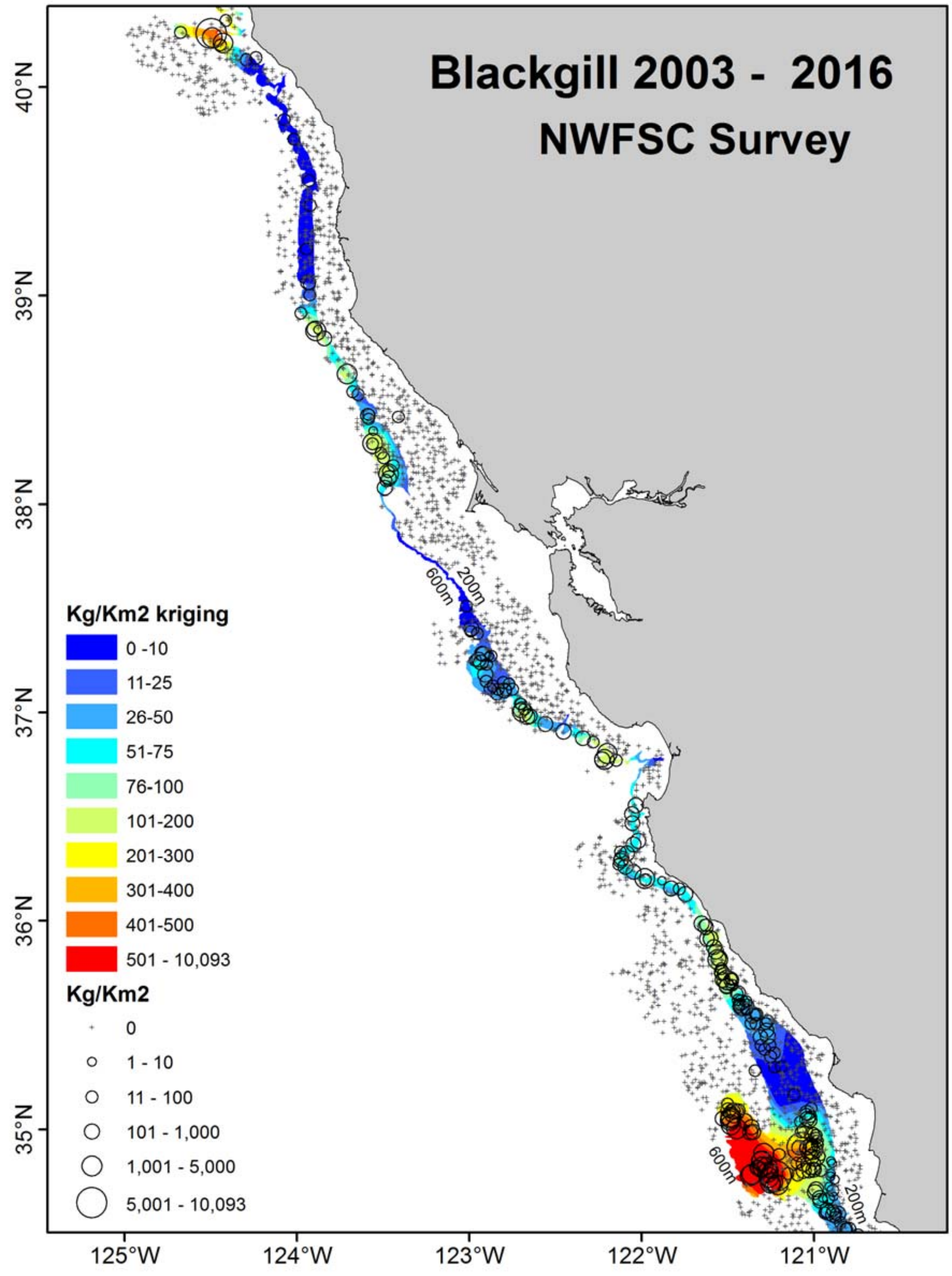


Figure 6: Location and relative CPUE of all NWFSC combined trawl survey hauls in the central California region 2003-2016), overlaid on a kriged abundance estimate .

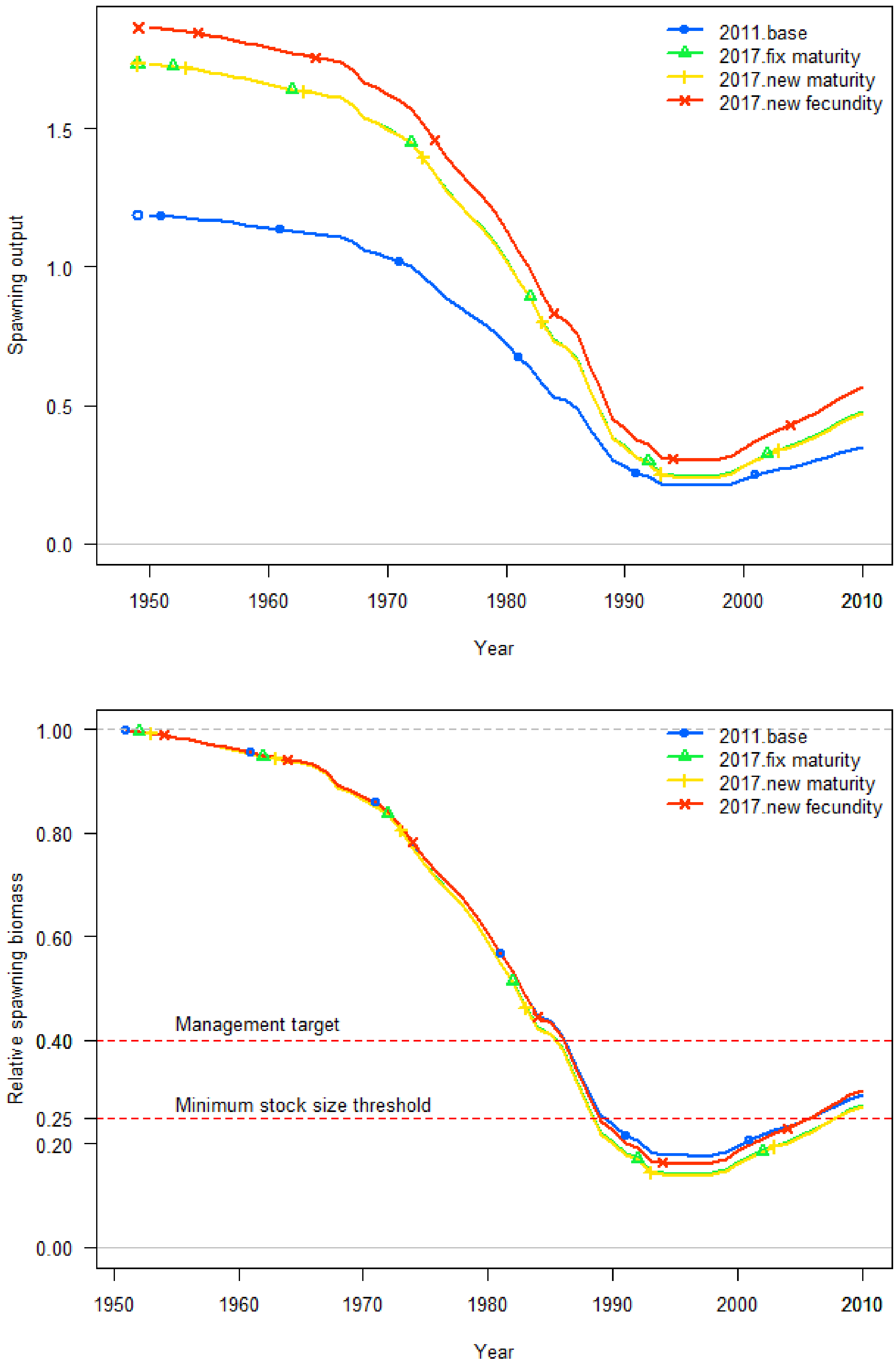
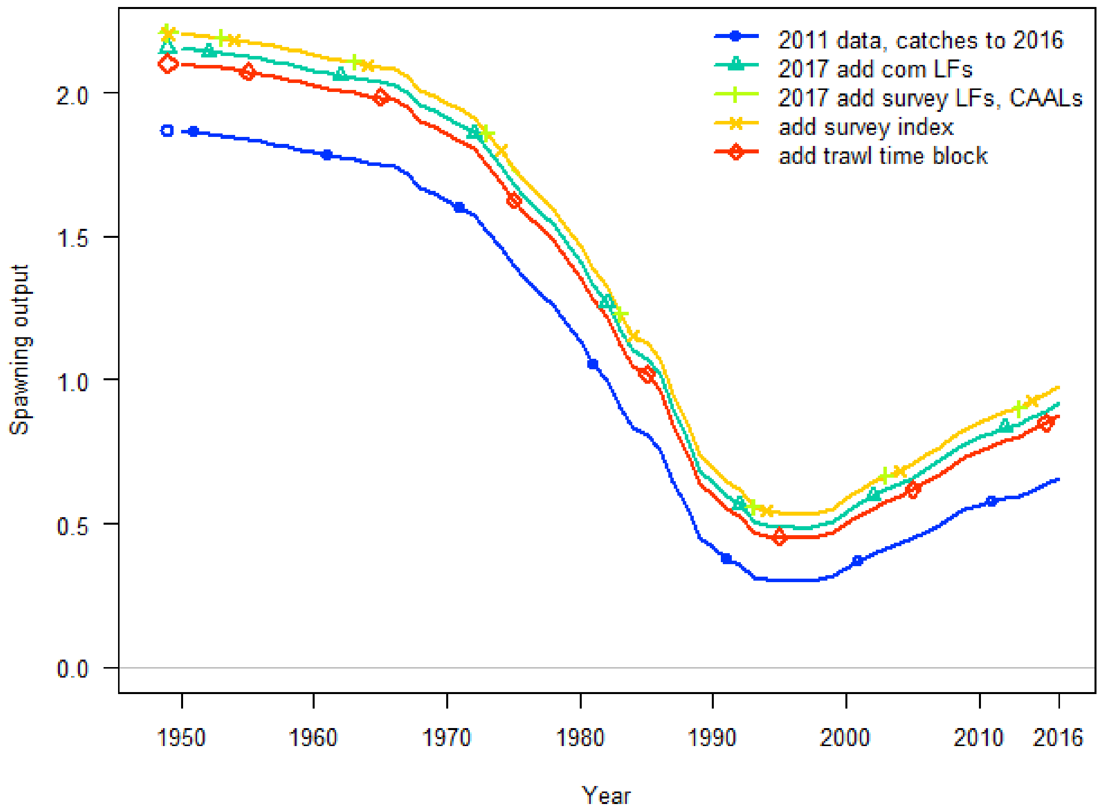


Figure 7a-b: Tracking of model sensitivity to updated life history data from the 2011 base model



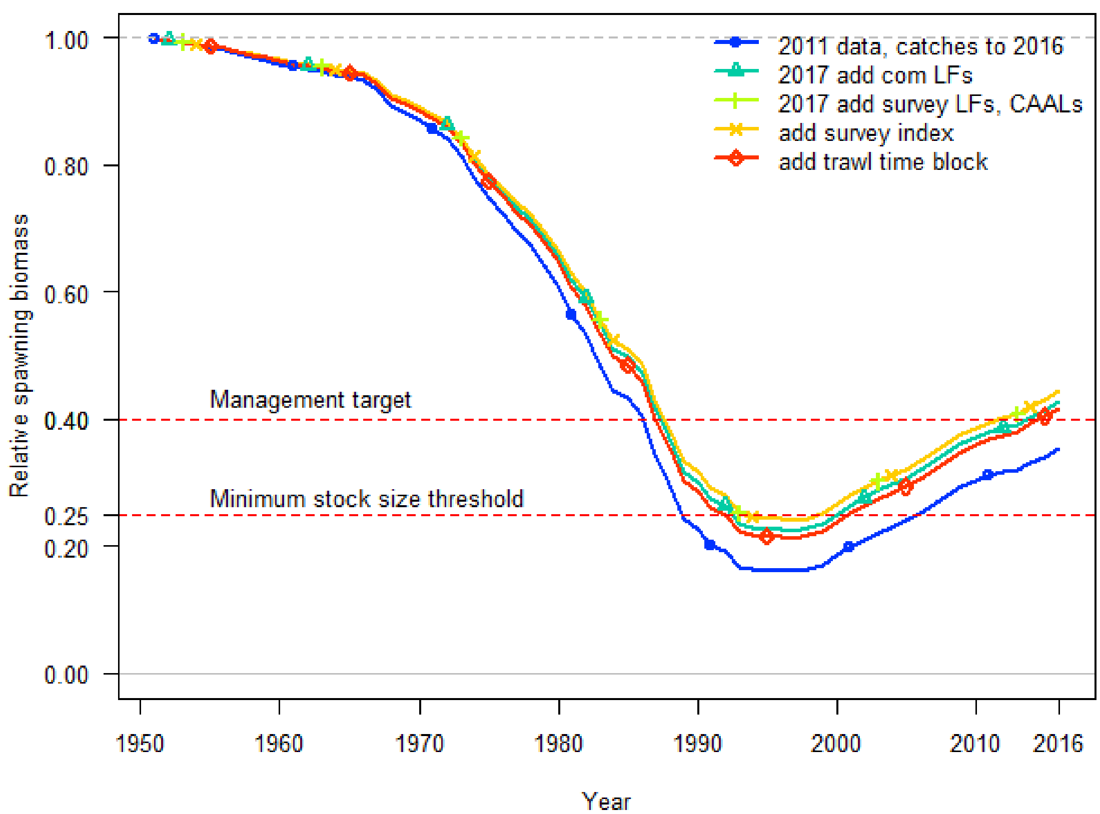
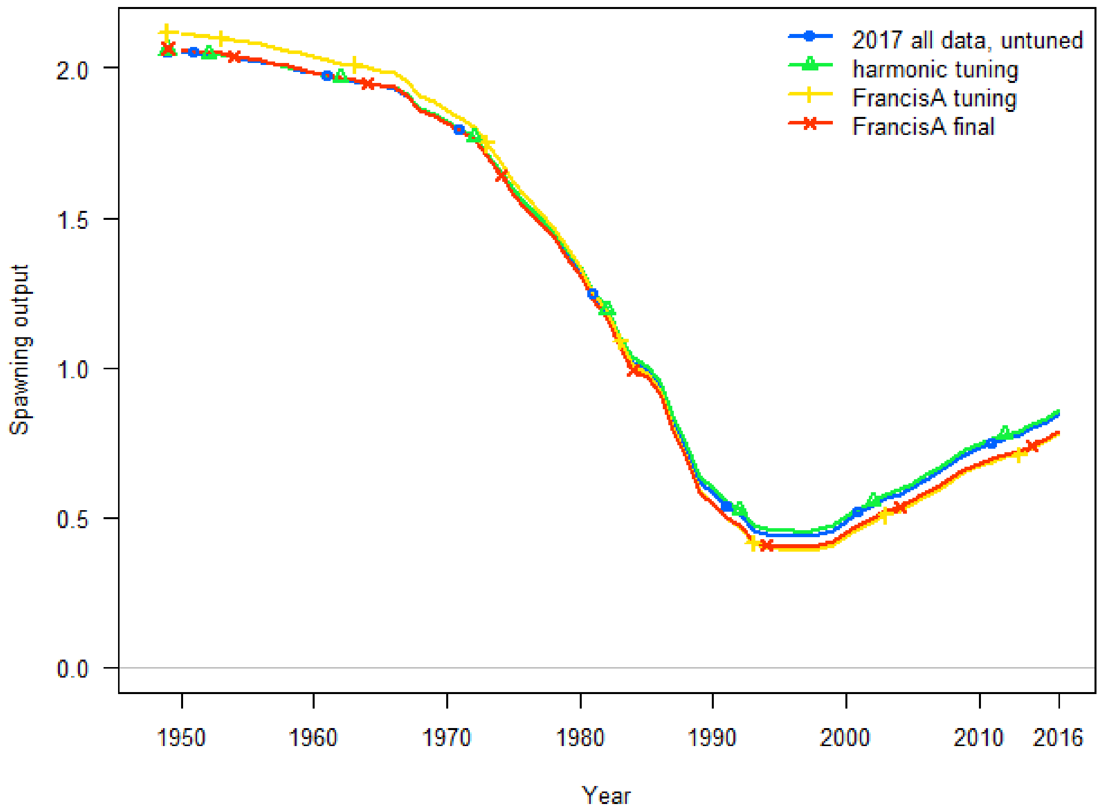


Figure 8a-b: Tracking of model changes to updated data for the 2017 base model



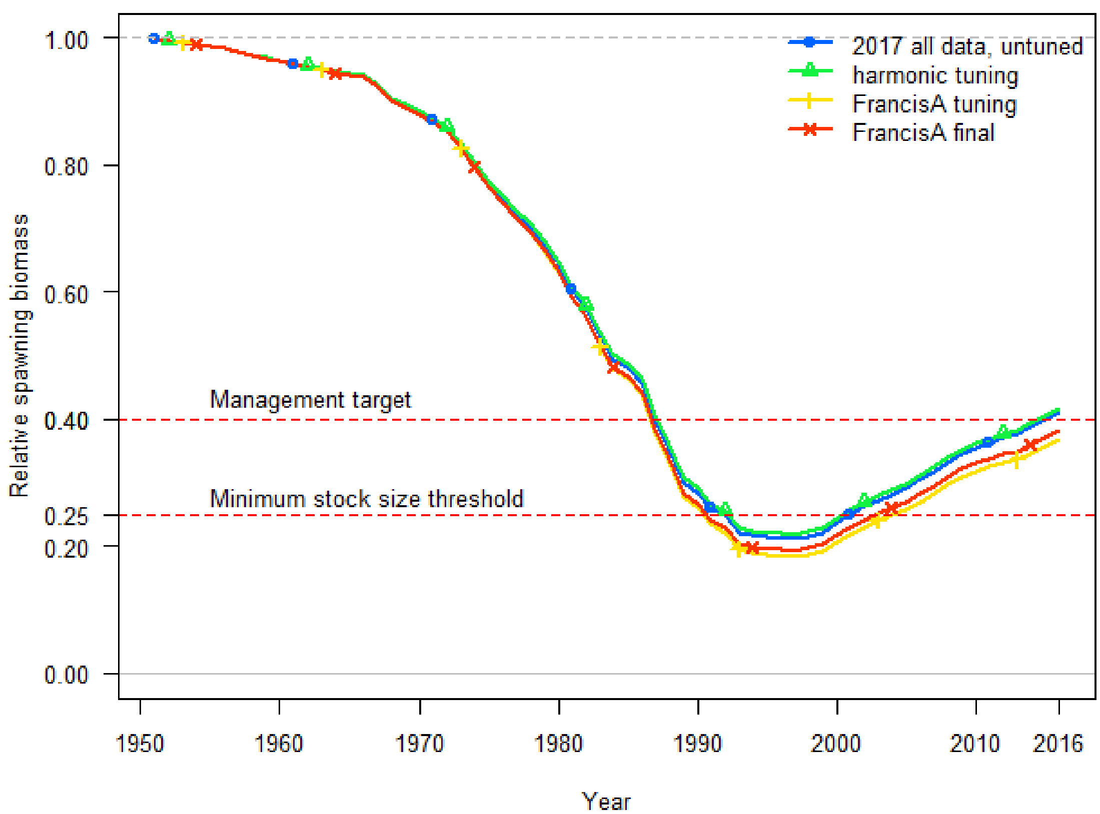


Figure 9a-b: Sensitivity of the model to alternative survey, length composition and conditional age-at-length tuning methods

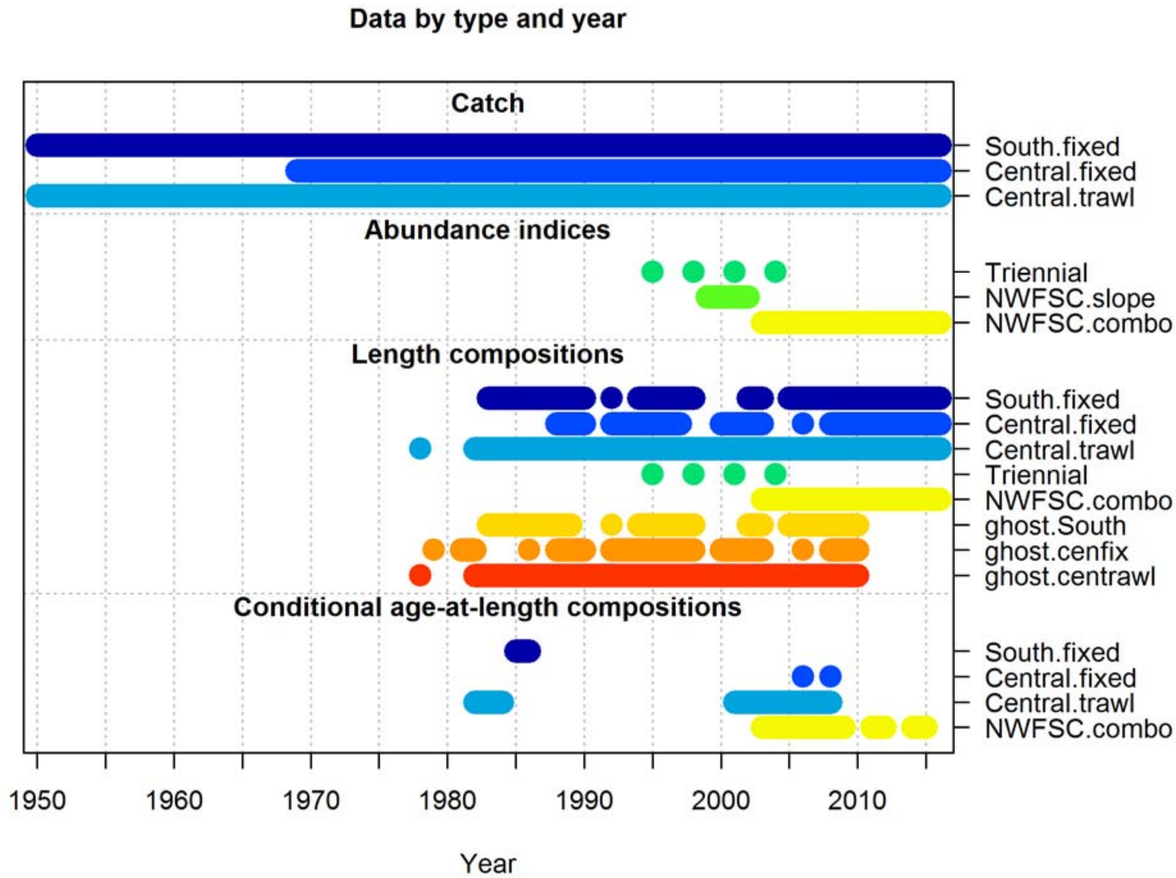
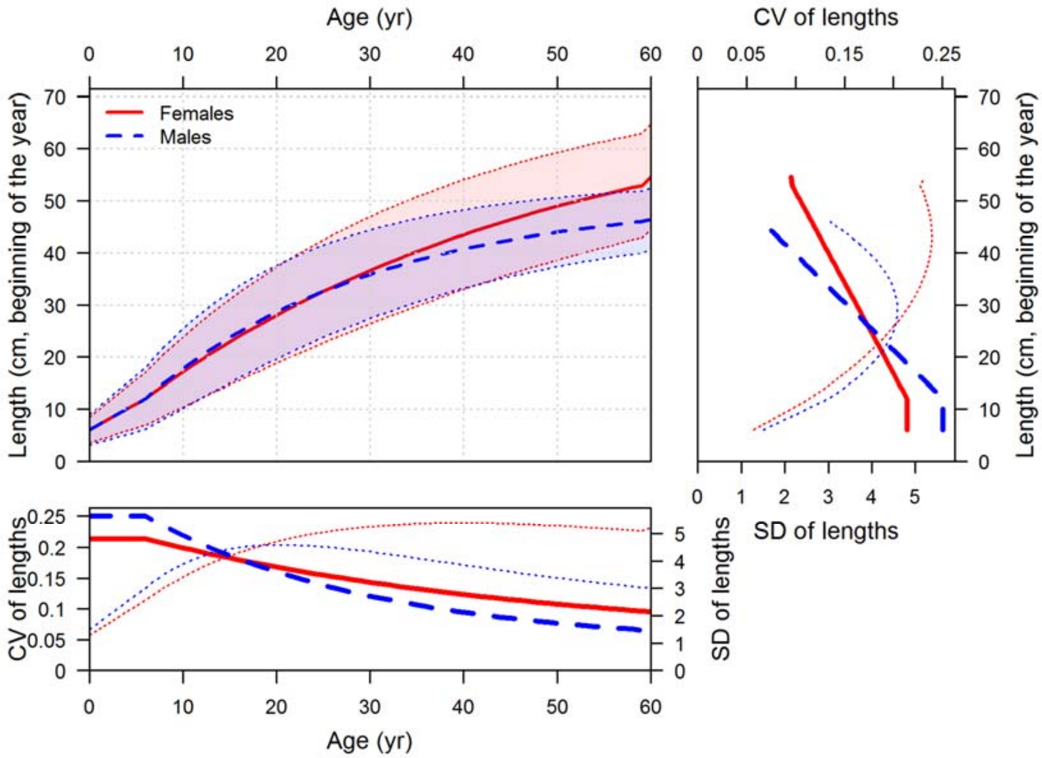


Figure 10: Overview of data sources used in this assessment



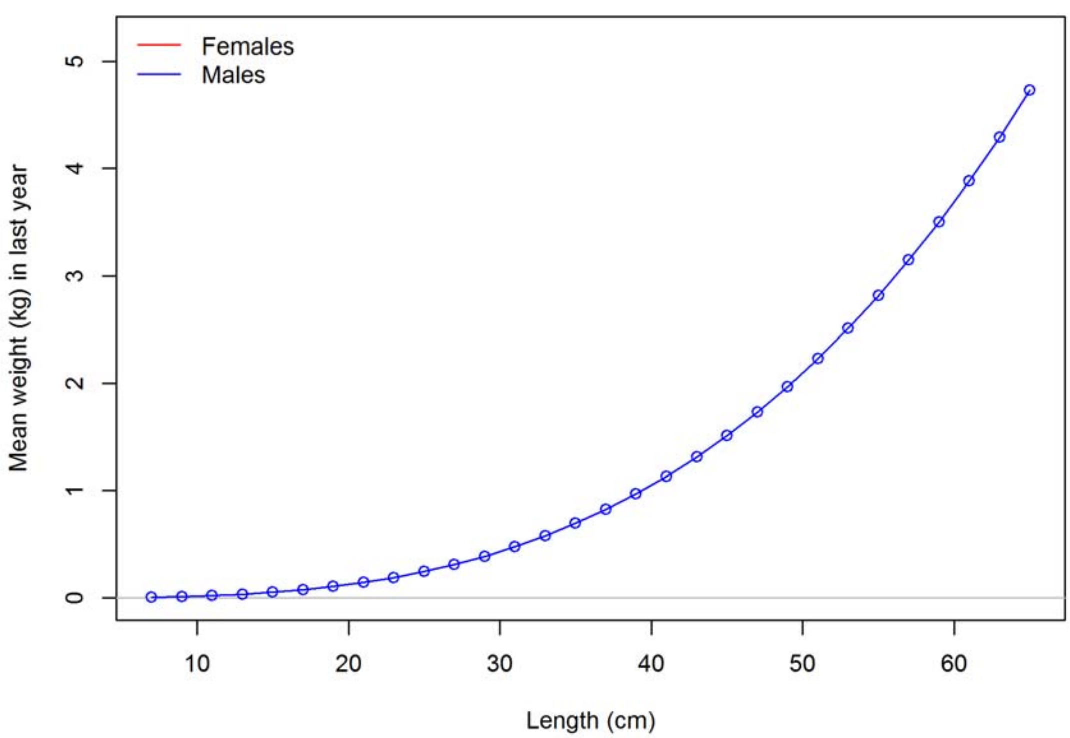


Figure 11a-b Base model life history functions

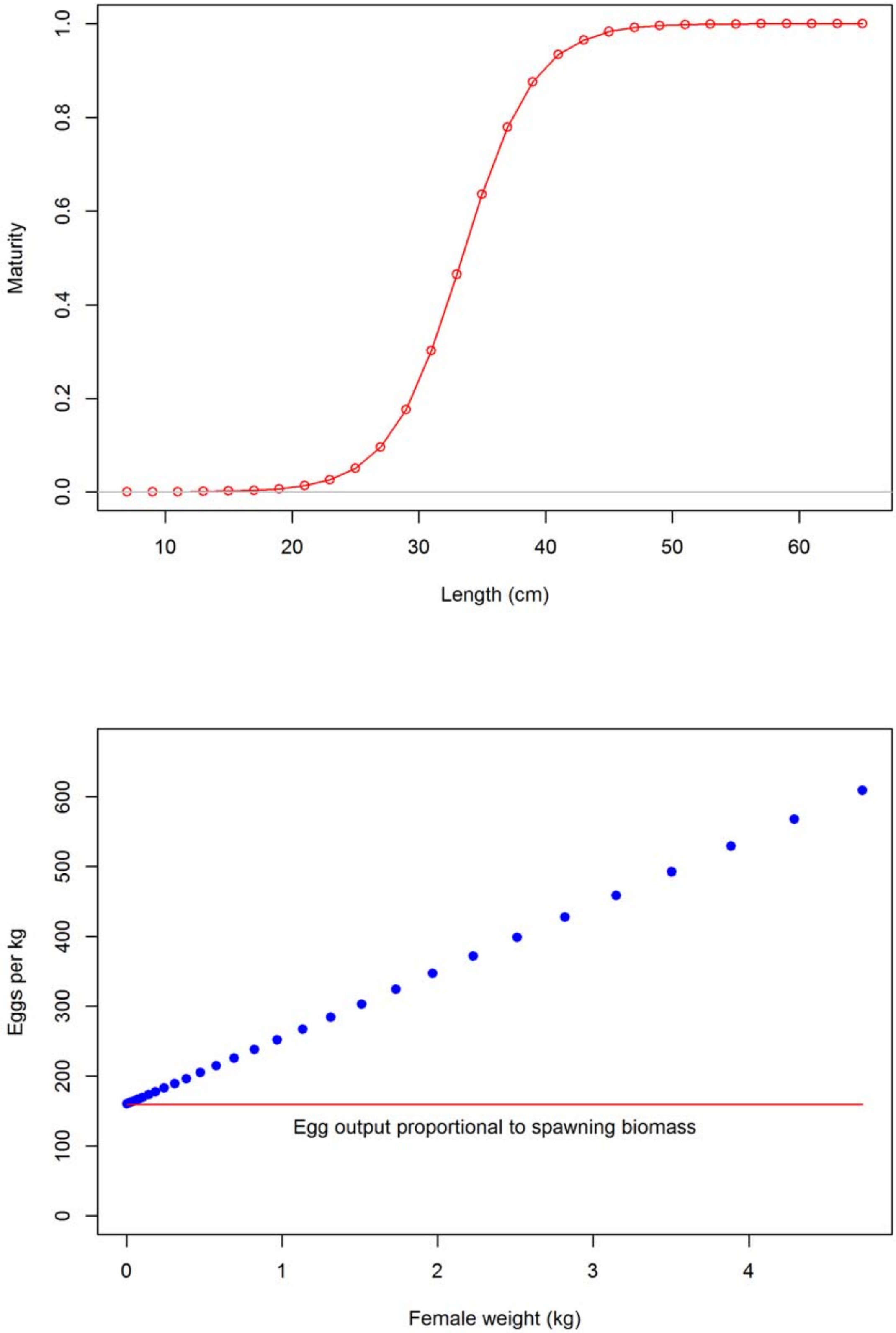
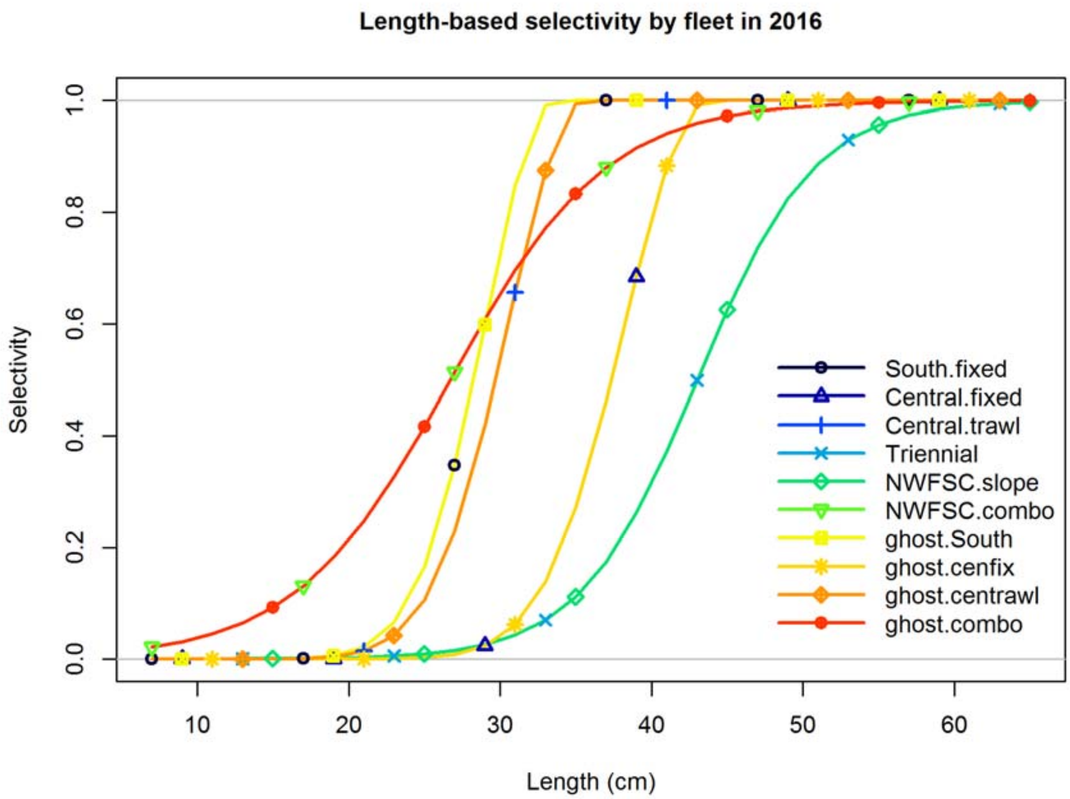


Figure 12 a-b: 2017 base model maturity and relative fecundity functions



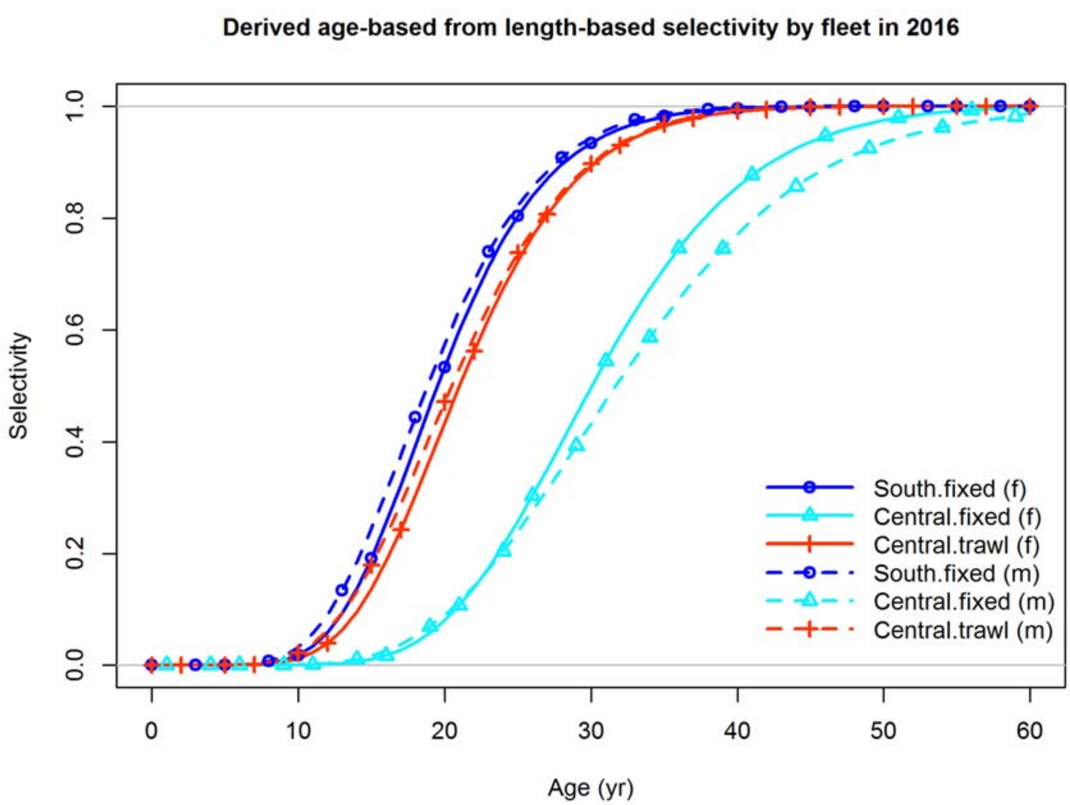
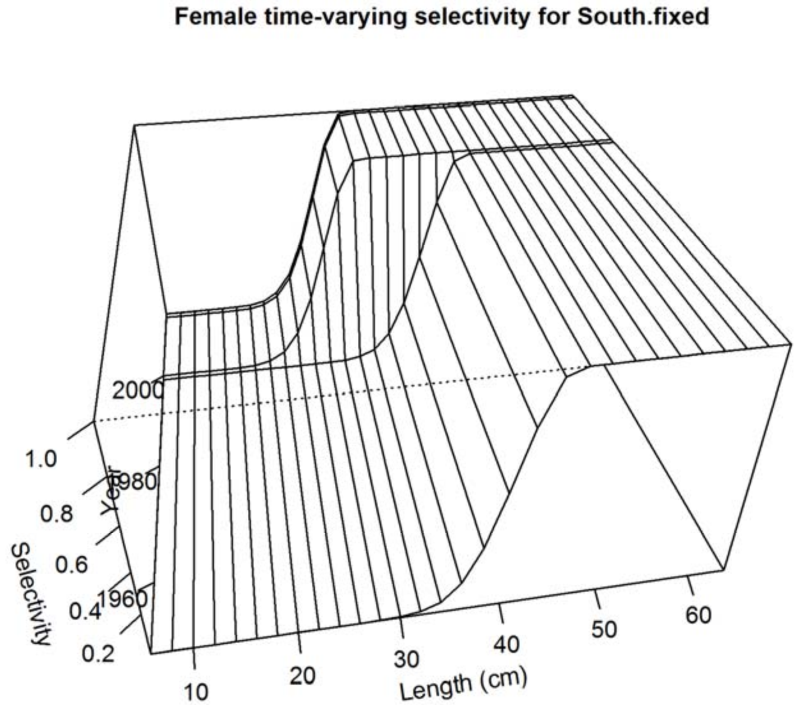


Figure 13 a-b: Estimated selectivity curves for base model surveys and fisheries (top) with derived age-based selectivity (bottom).



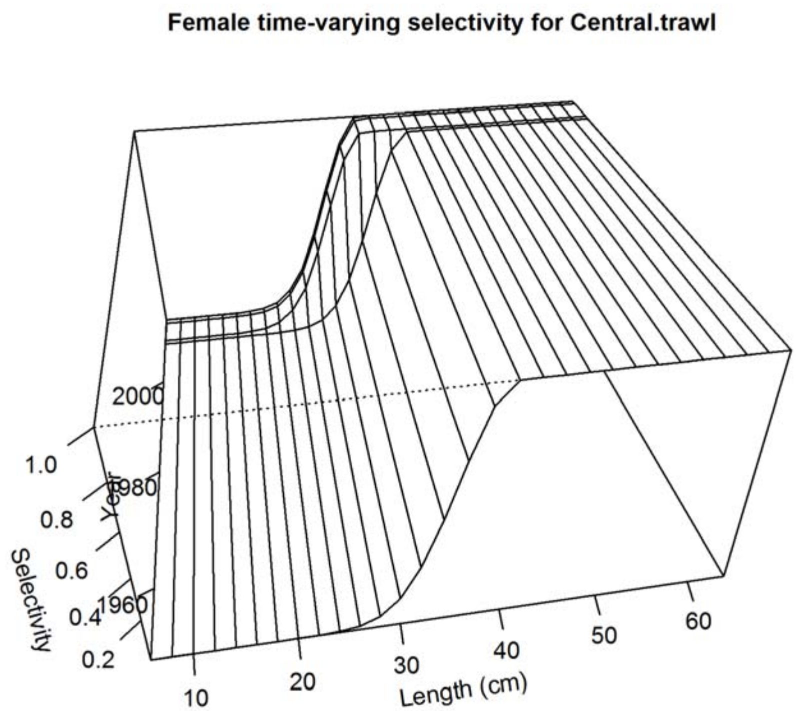


Figure 14 a-b: Estimated selectivity curves for the southern fixed gear fishery (top) and central California trawl (bottom), with associated time blocks

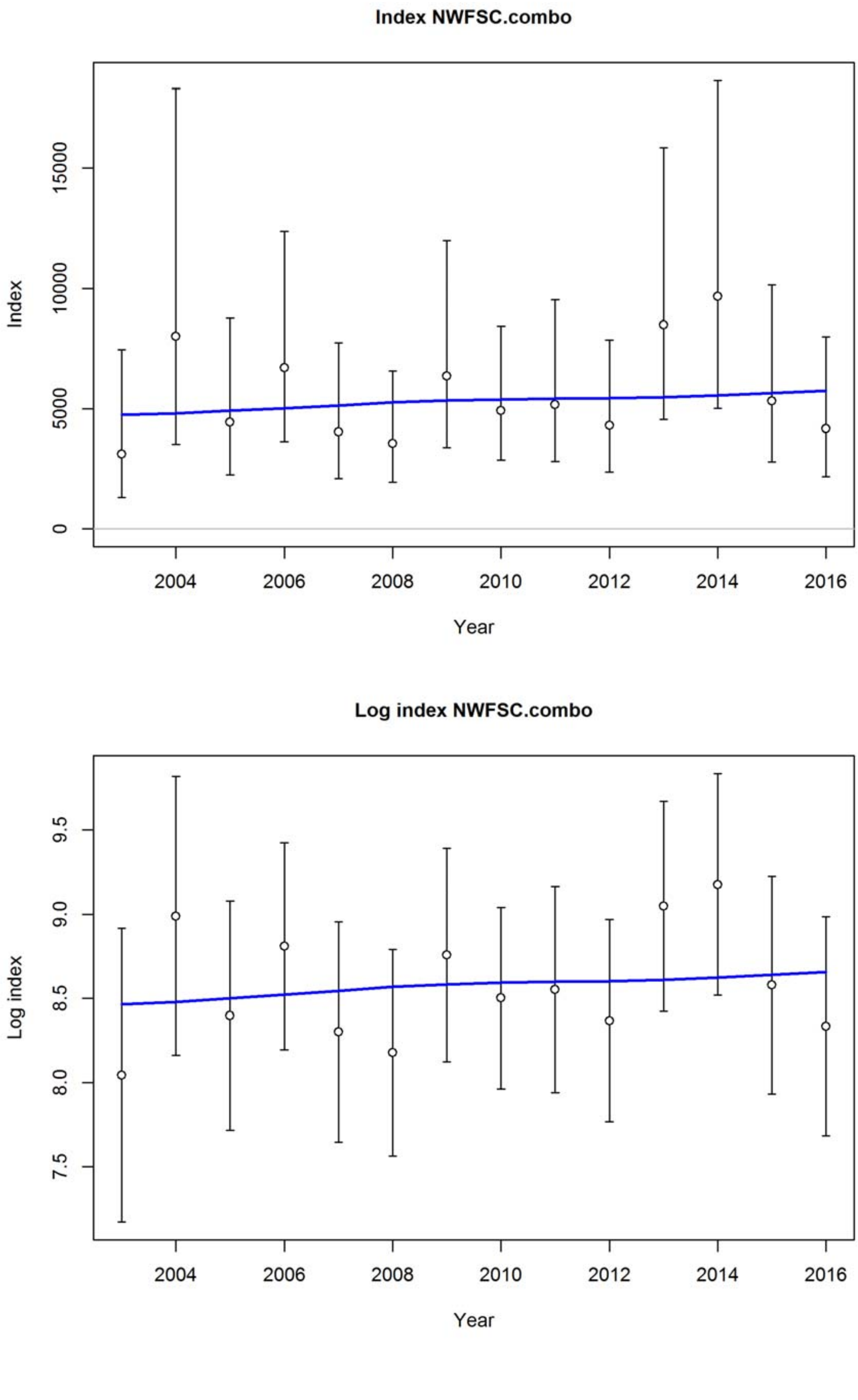
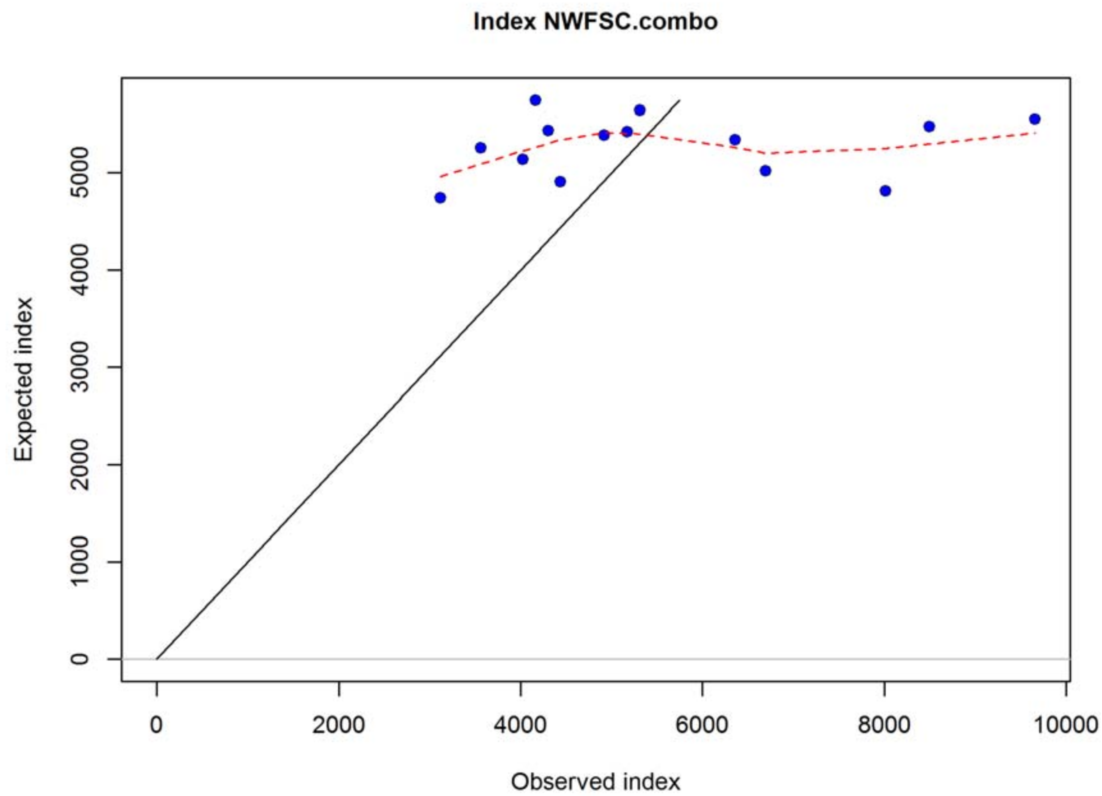


Figure 15 a-b: Fits to the NWFSC combined shelf and slope bottom trawl survey index (2003-2016) in arithmetic (top) and log (bottom) scale.



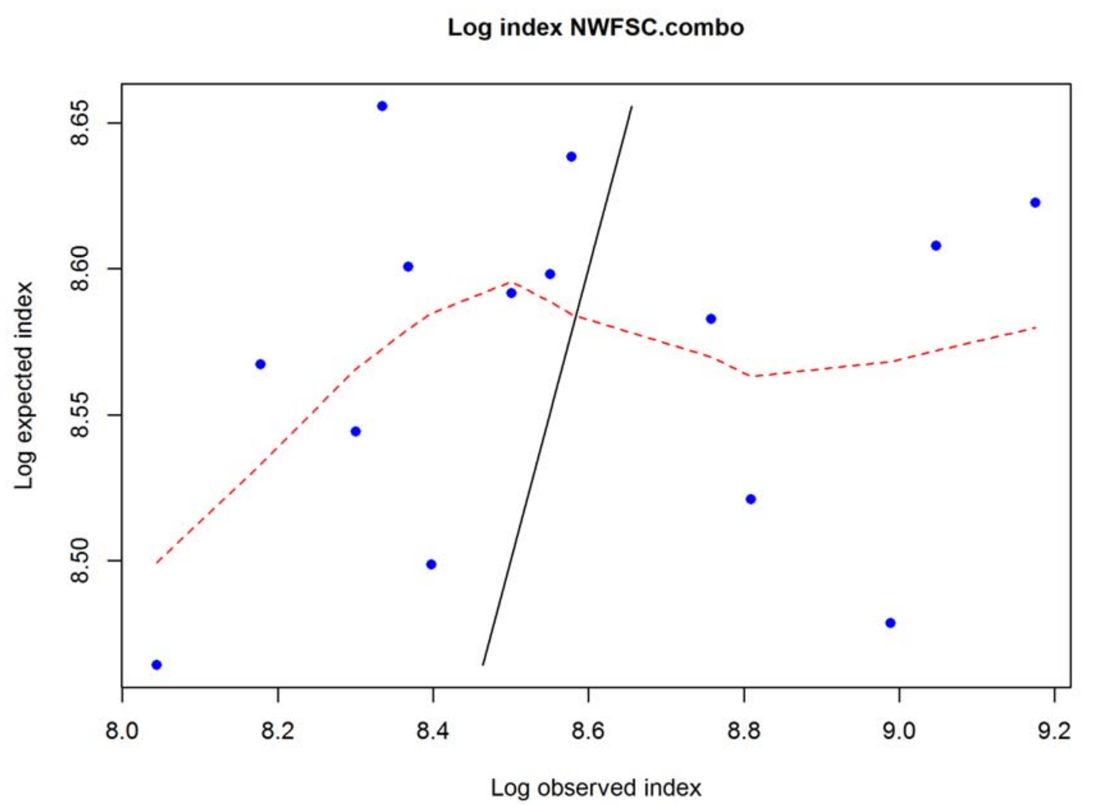
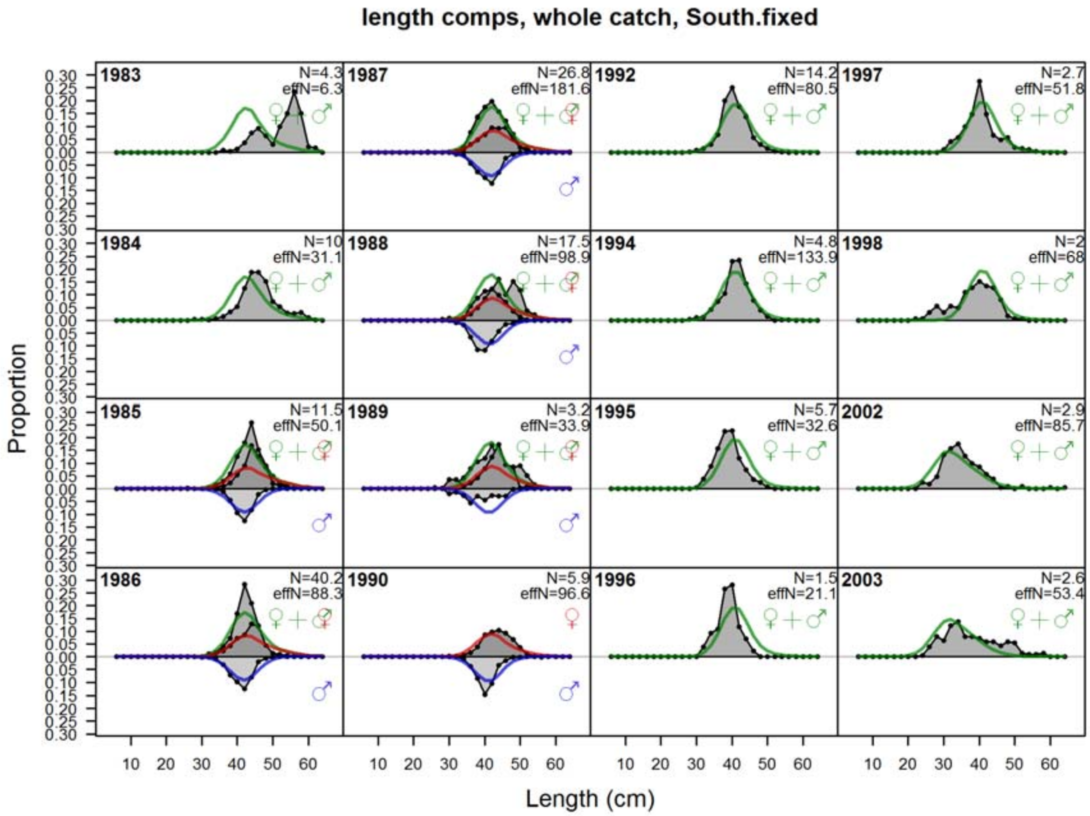


Figure 16 a-b: Observed and predicted values of fits to the NWFSC combined shelf and slope bottom trawl survey index (2003-2016) .



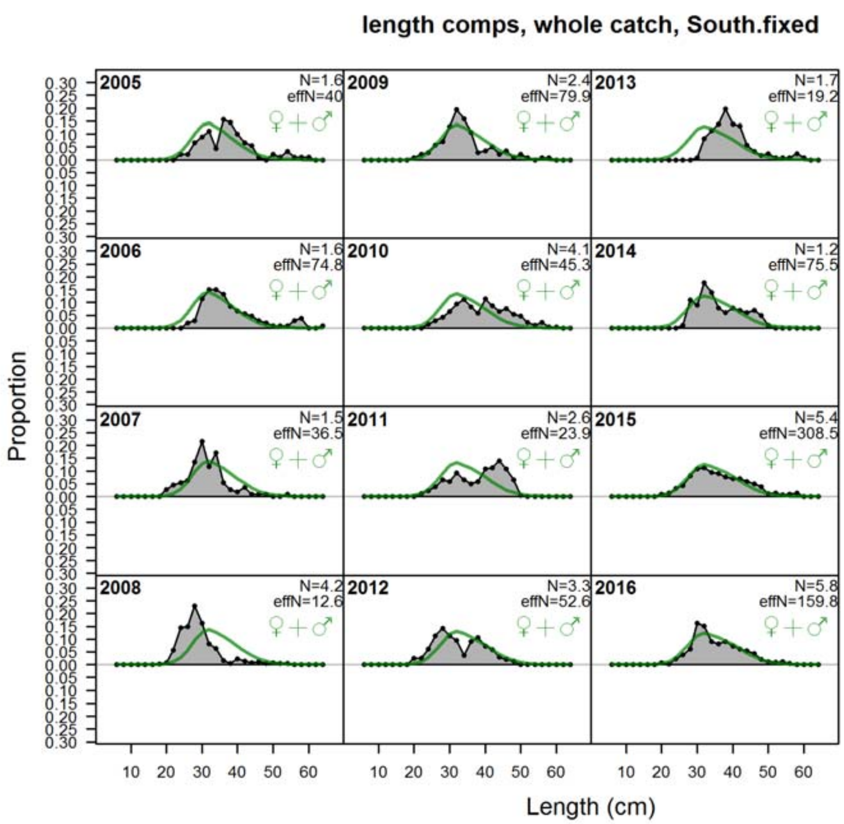


Figure 17 a-b: Observed and predicted length composition data (sexes combined) for the southern California fixed gear fishery (1983-2016)

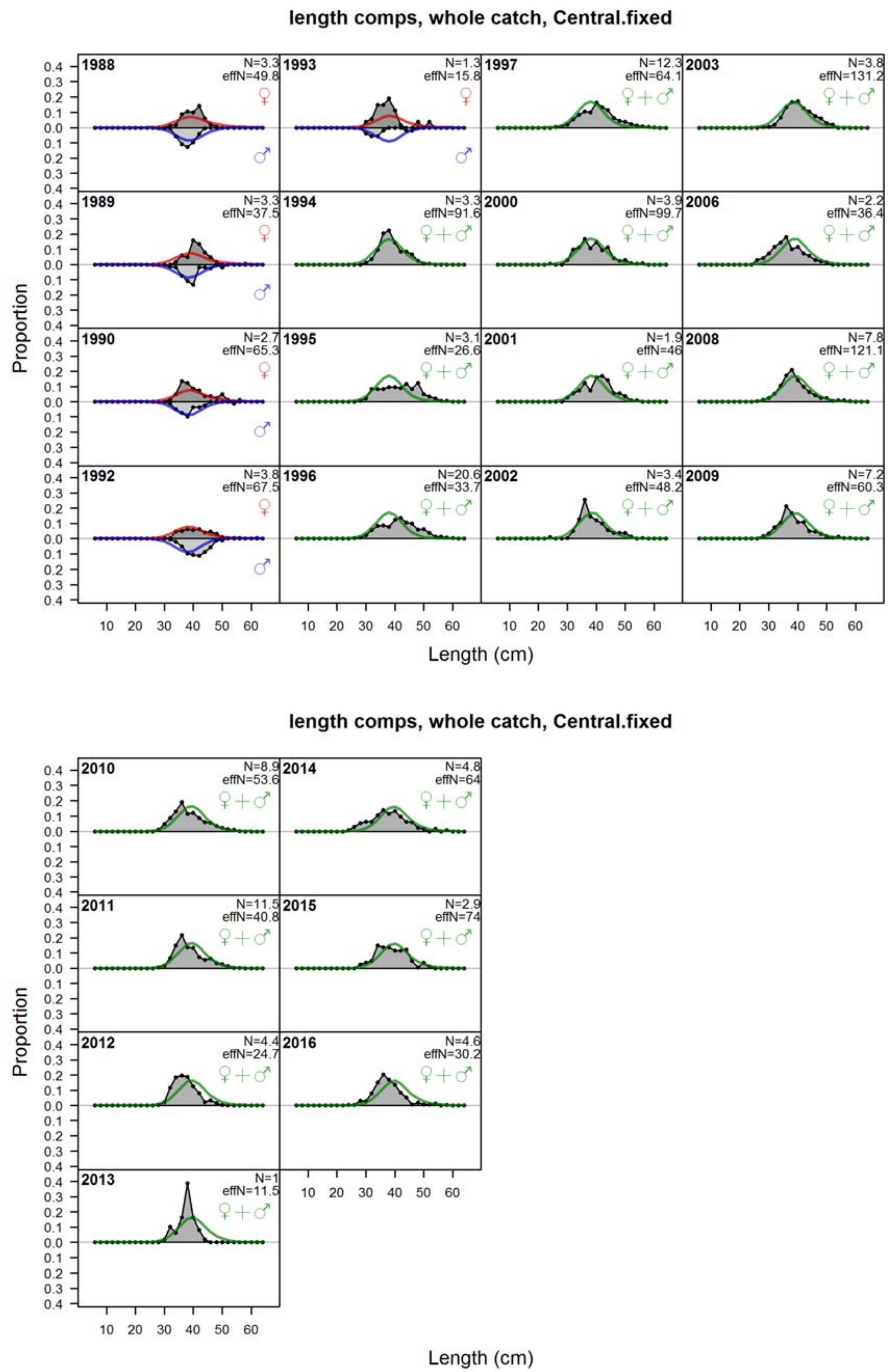
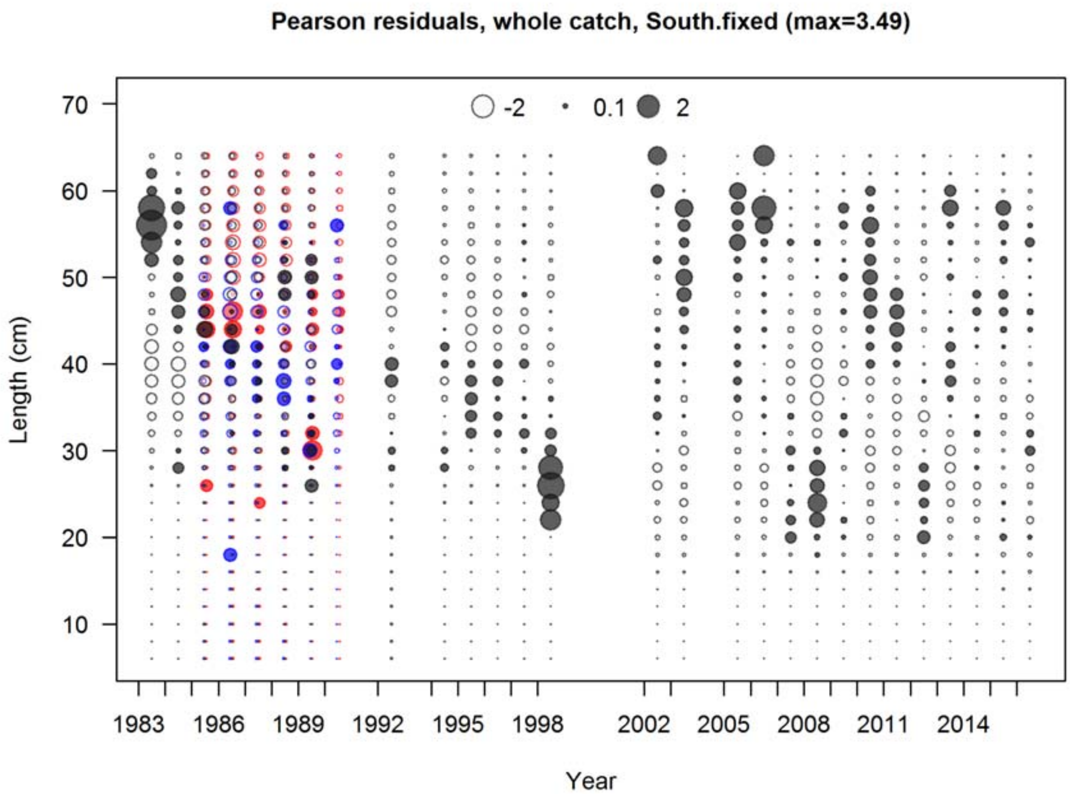


Figure 18 a-b: Observed and predicted length composition data (sexes combined) for the central California fixed gear fishery (1983-2016)



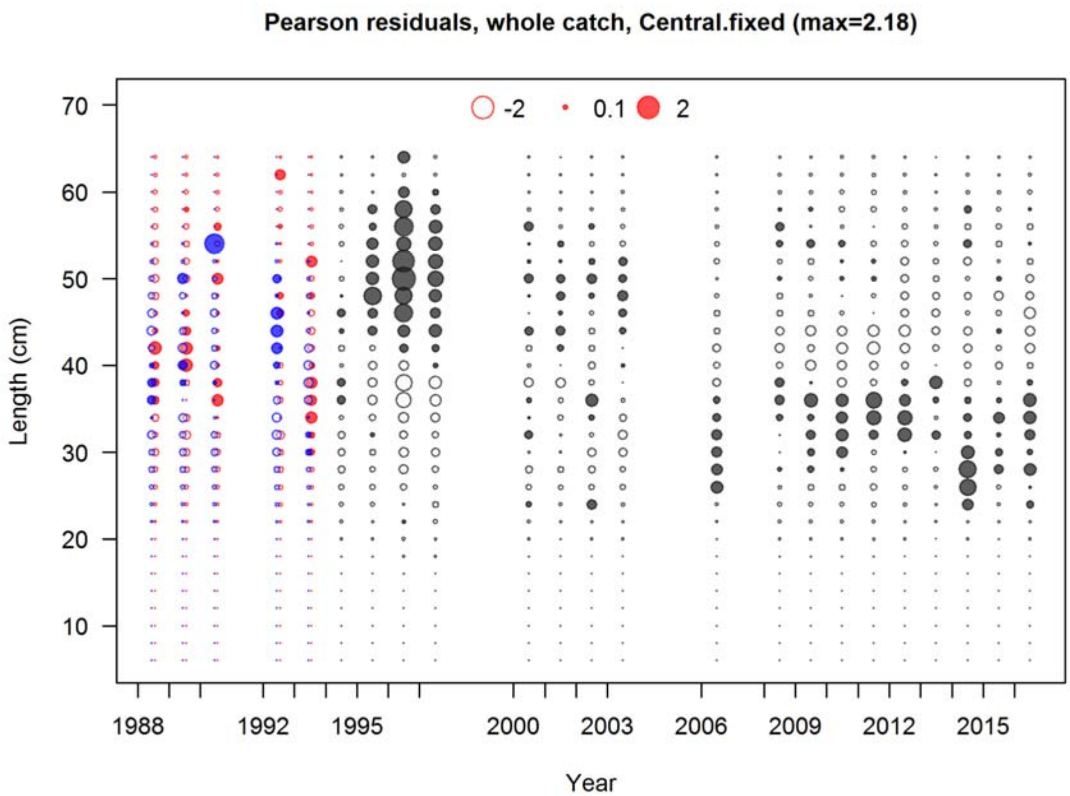


Figure 19 a-b: Residuals for fits to length composition data for the southern fixed gear fishery

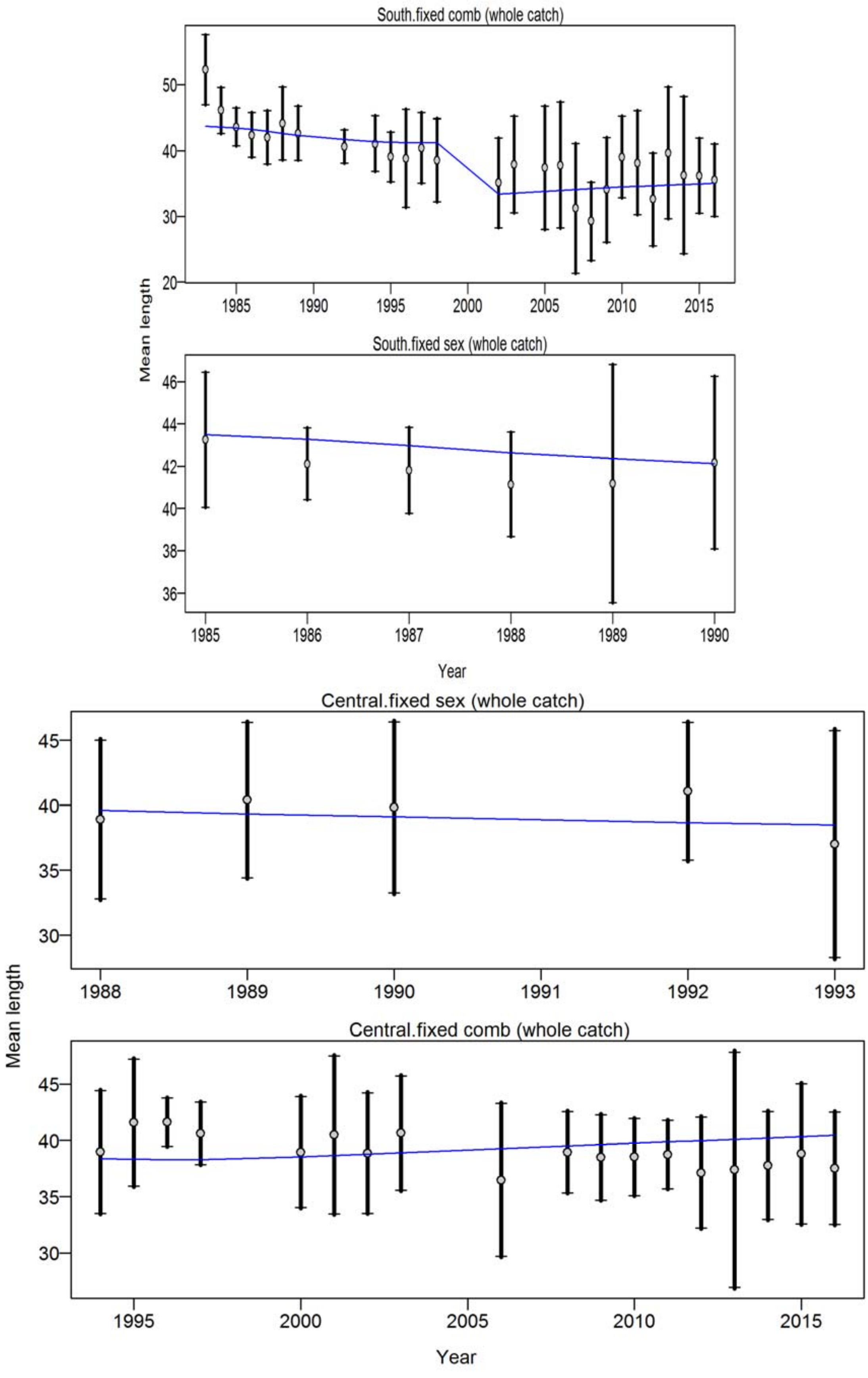
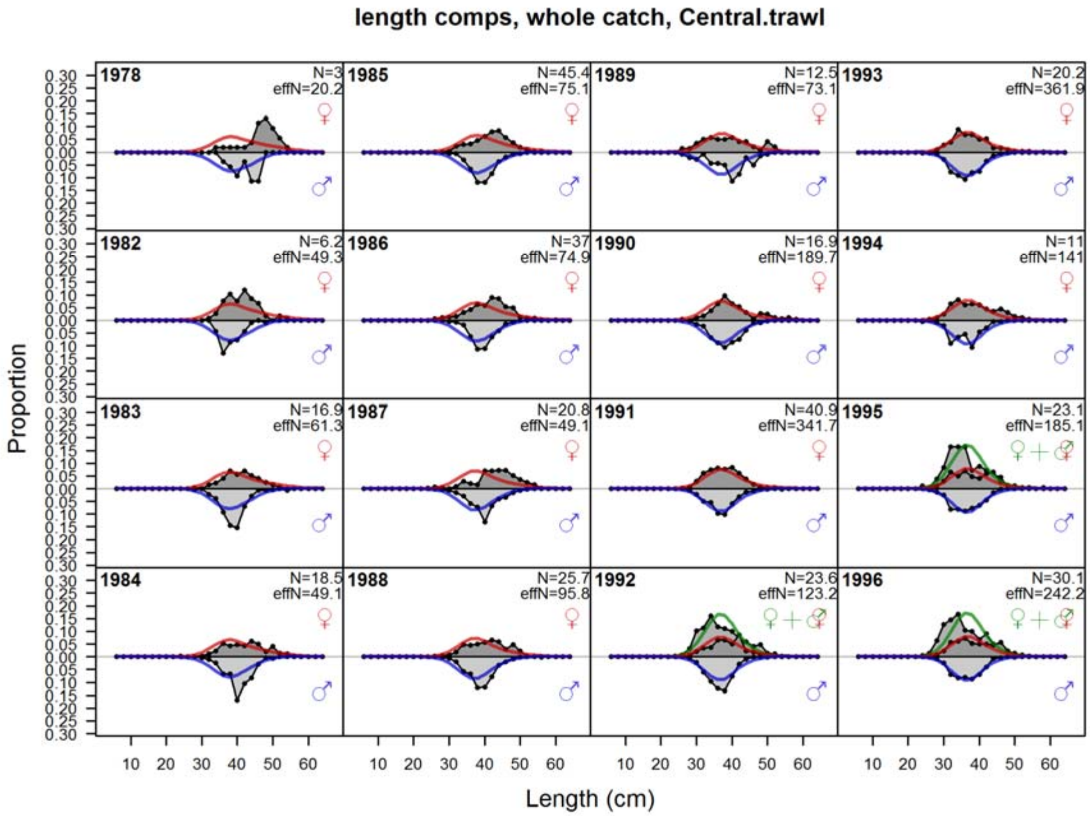


Figure 20 a-b: Fits to mean lengths for the southern and central fixed gear fisheries



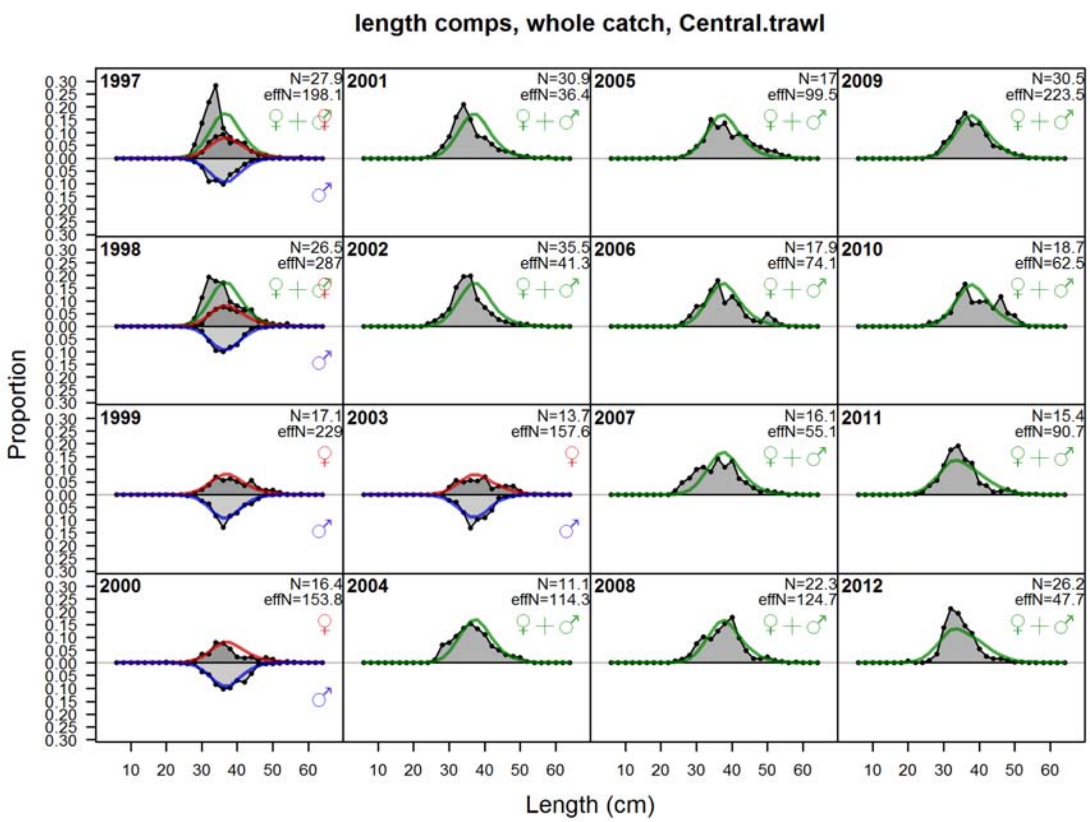


Figure 21 a-b: Observed and predicted length composition data (sexes combined) for the central California fixed gear fishery (1983-2016)

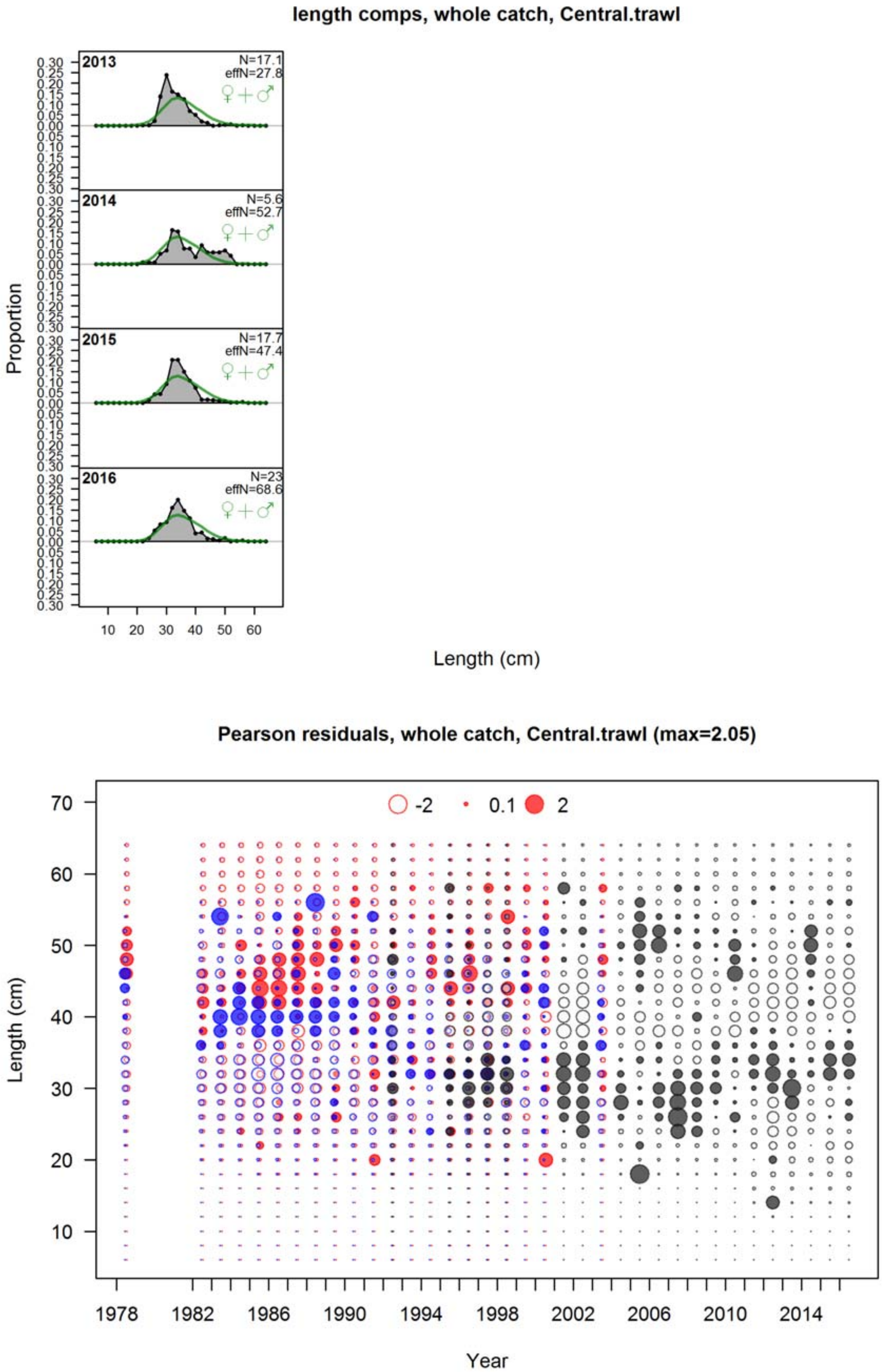


Figure 22 a-b: Residuals (top) and effective sample sizes by year (bottom) for combined sex length frequency data from the central California fixed gear fishery (1994-2010)

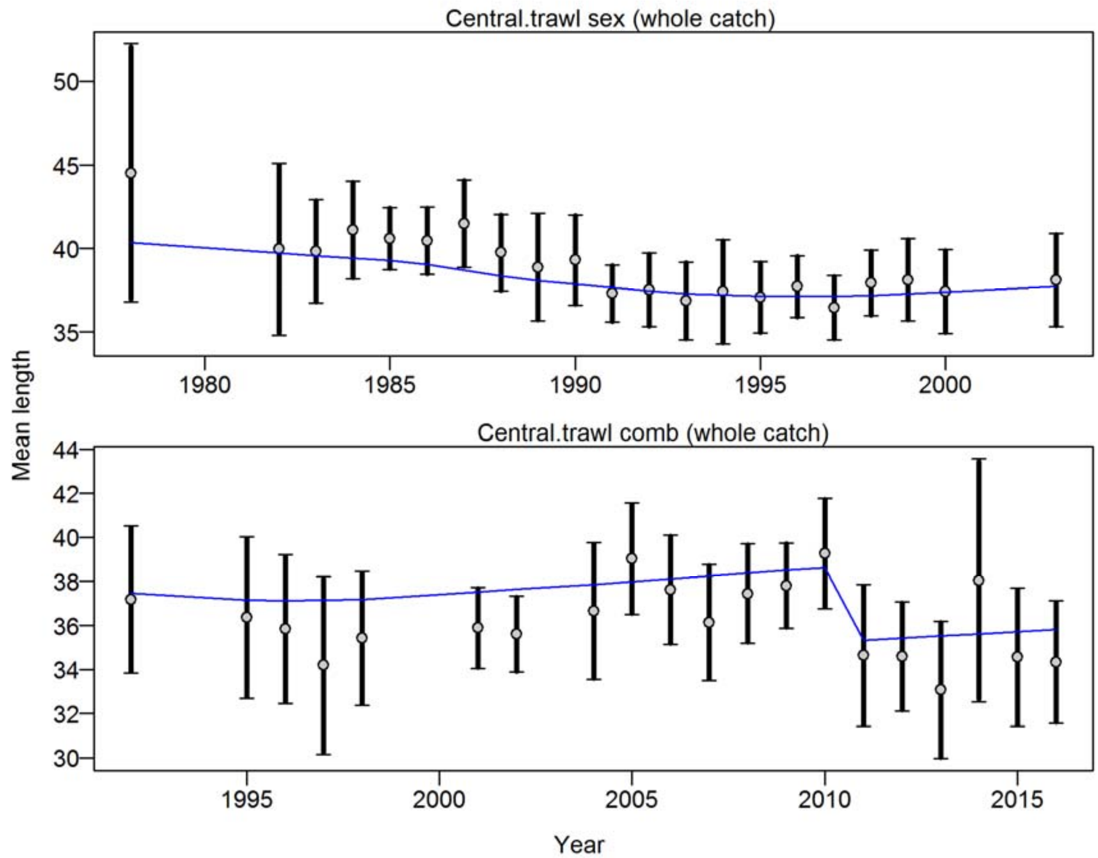
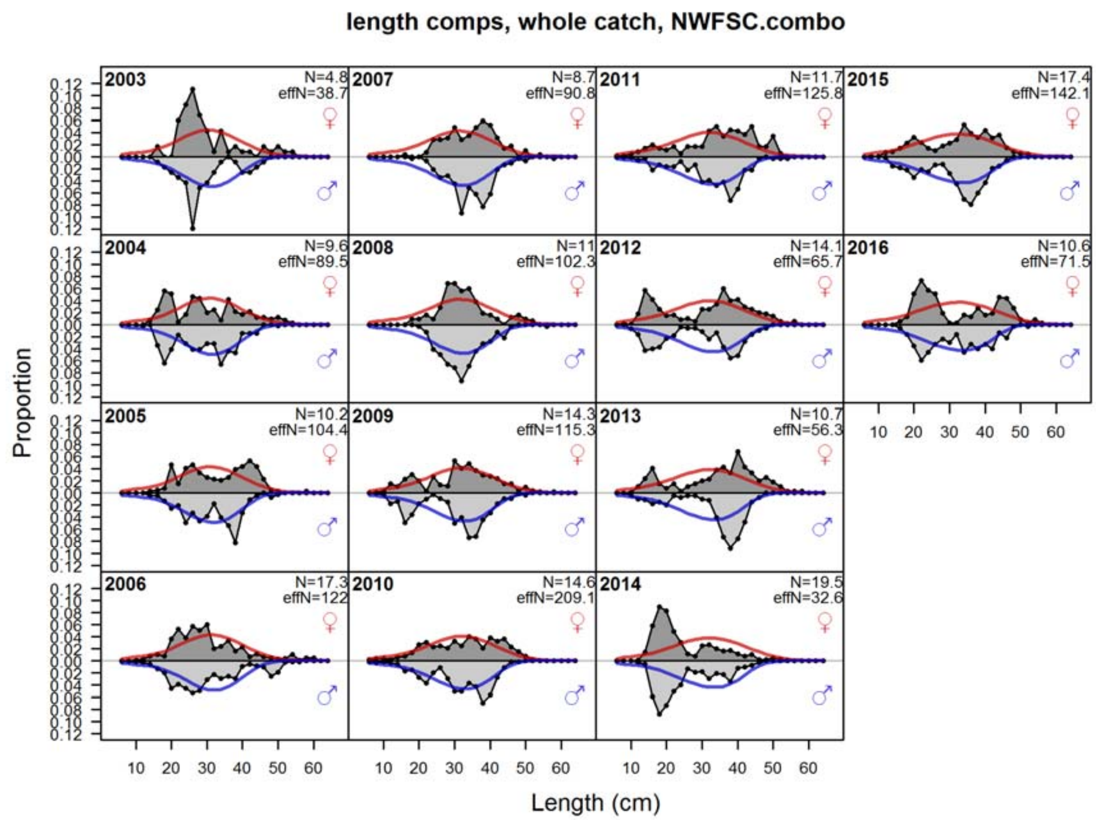


Figure 23 a-b: Fits to mean length data for the central trawl fishery.



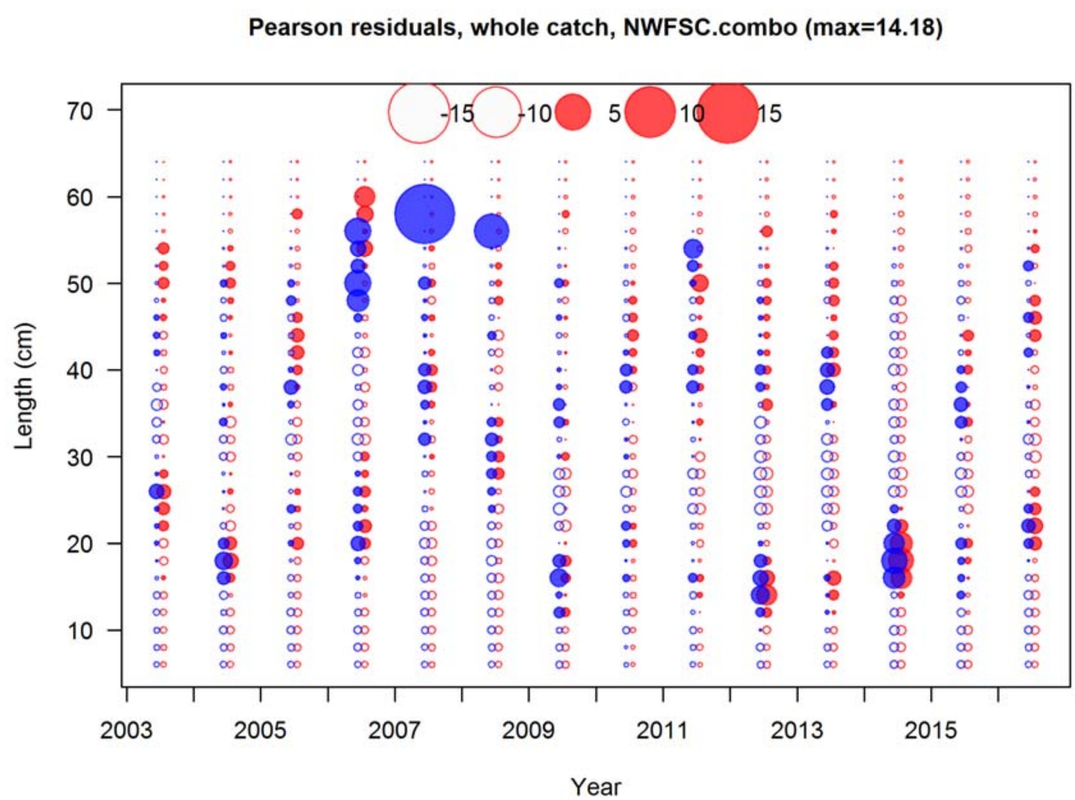


Figure 24 a-b: Observed and predicted length composition data (by sexes for the NWFSC combined bottom trawl survey (2003-2016)

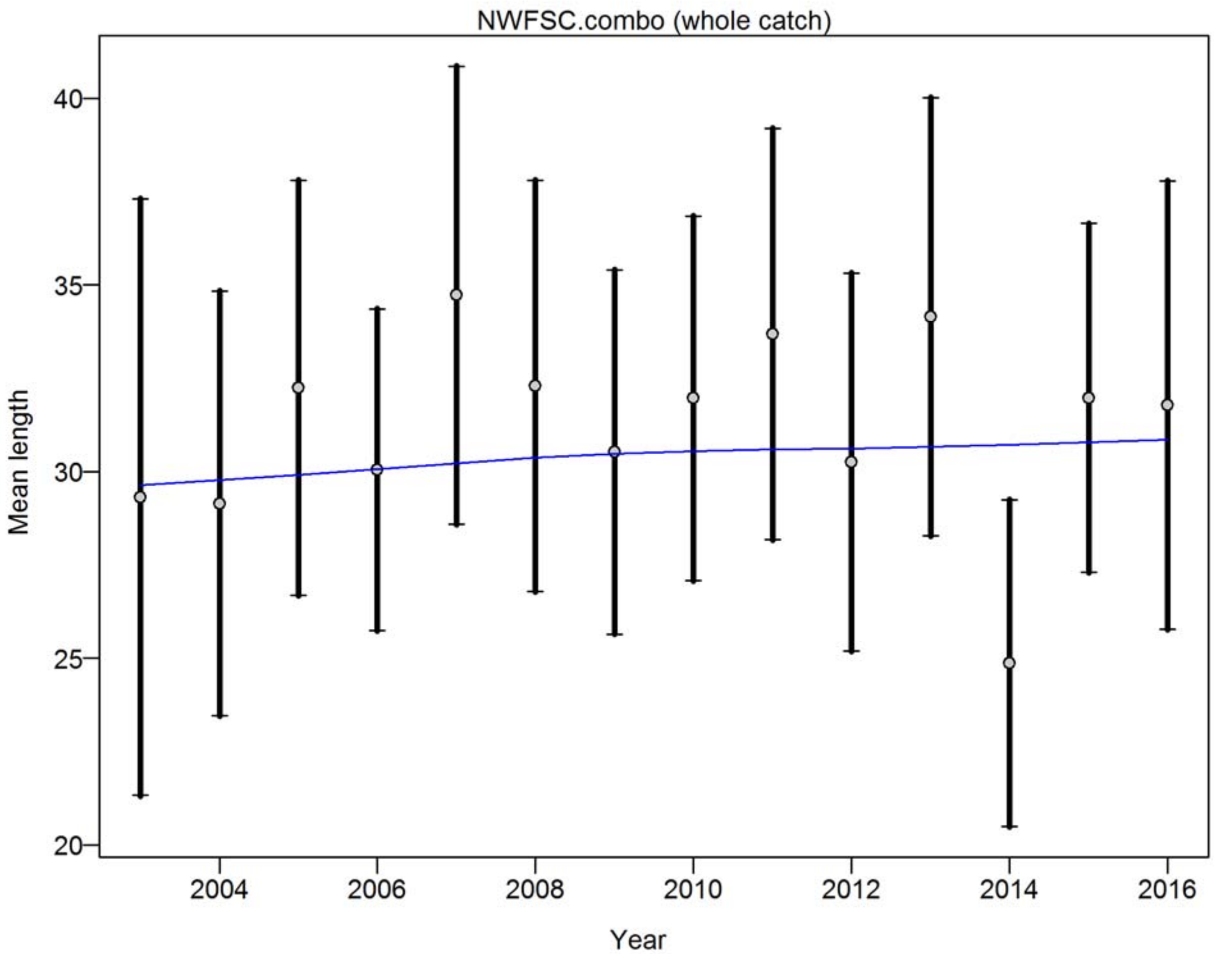


Figure 25: Fits to mean length data for the NWFSC combined bottom trawl survey

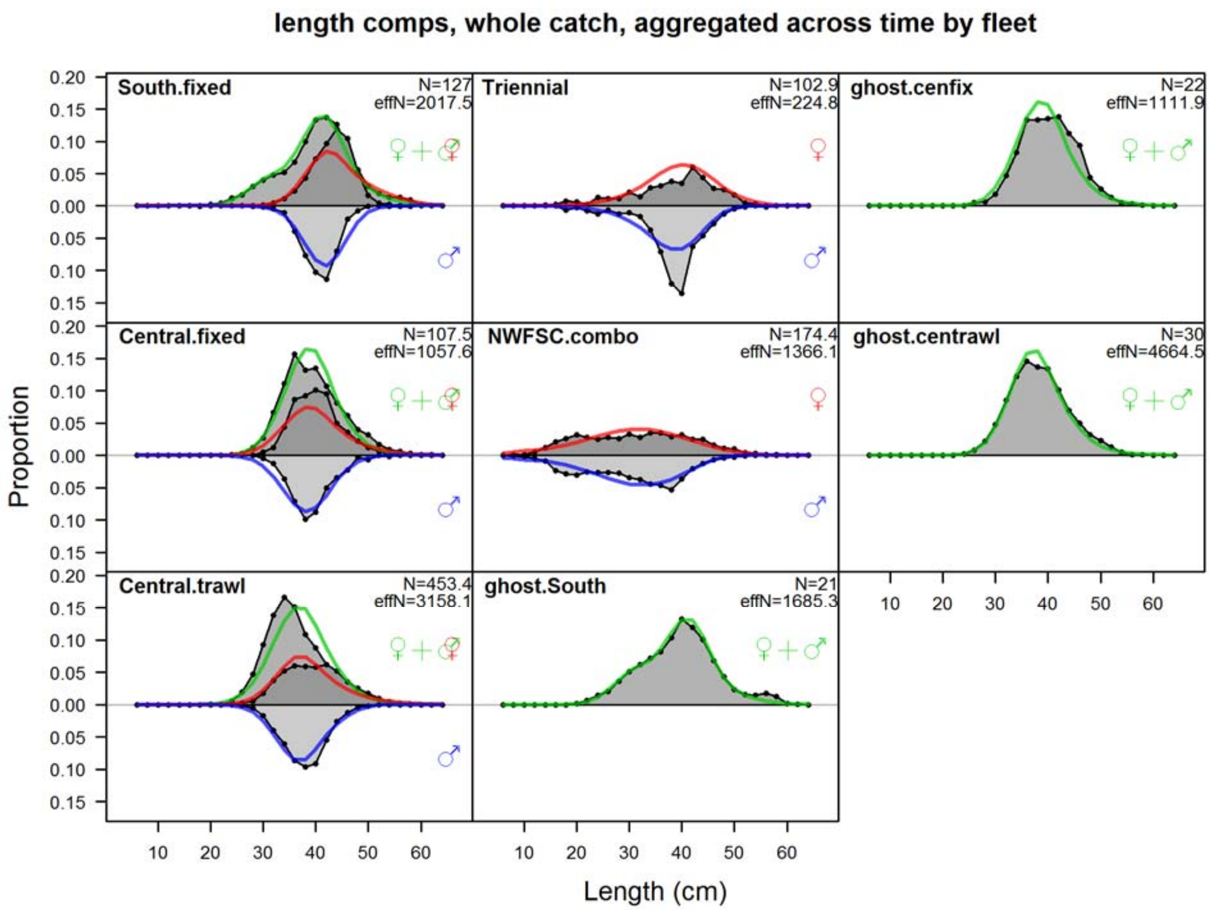


Figure 26: Observed and predicted length composition data aggregated across all years for the three commercial fisheries ("ghost" fisheries reflect data to 2010 only).

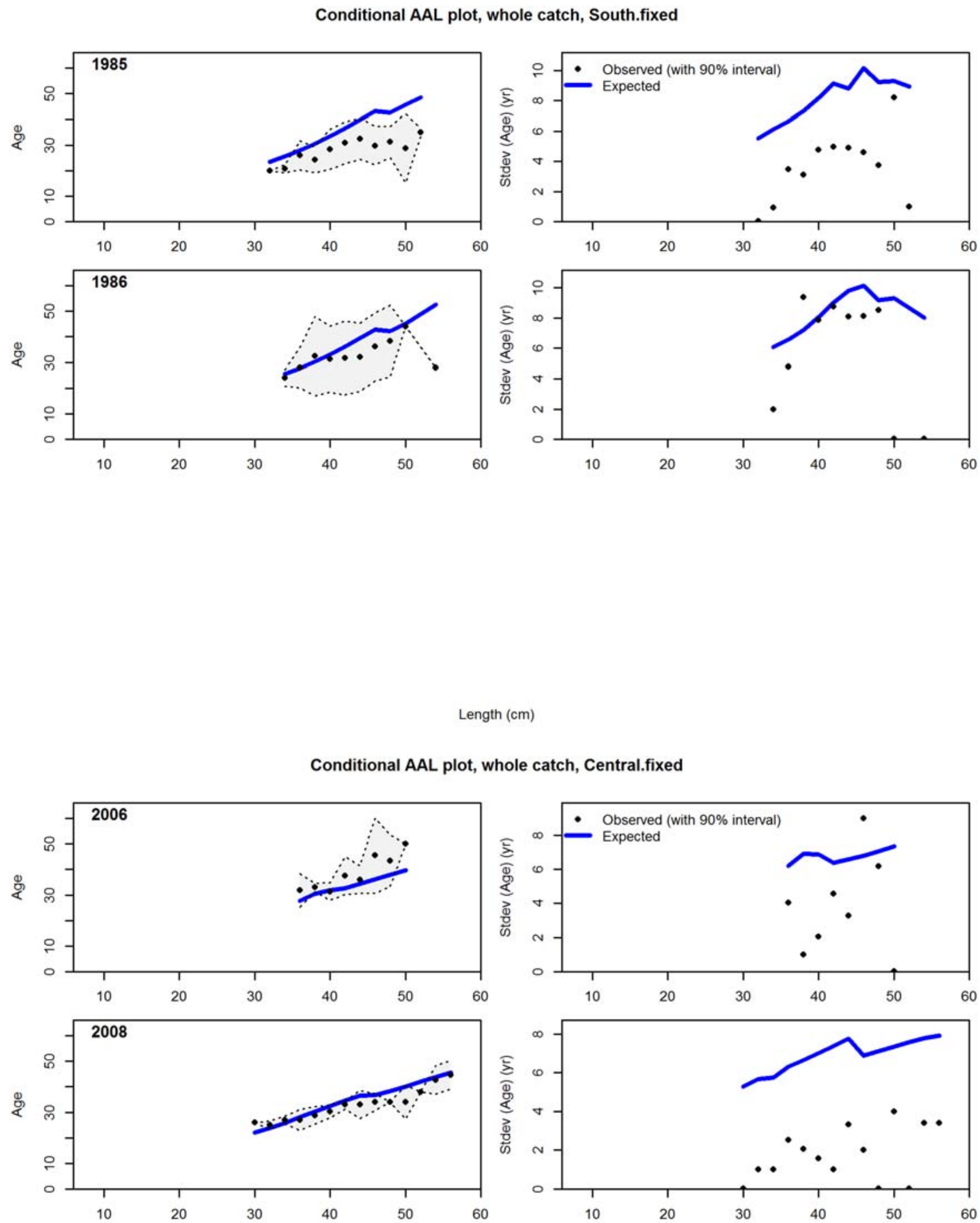


Figure 27 a-b: Fits to conditional age-at-length data for the southern and central fixed gear fisheries

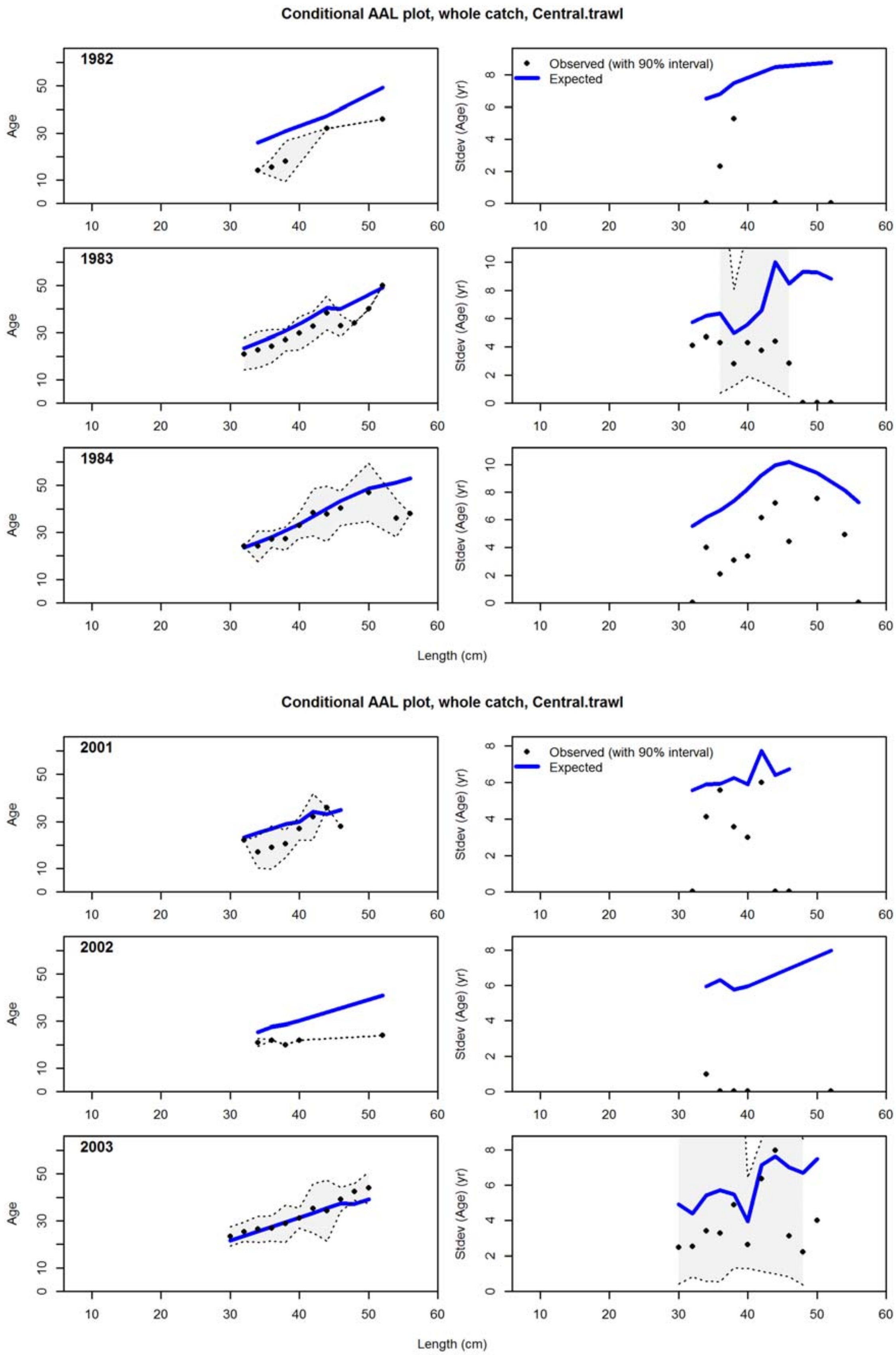
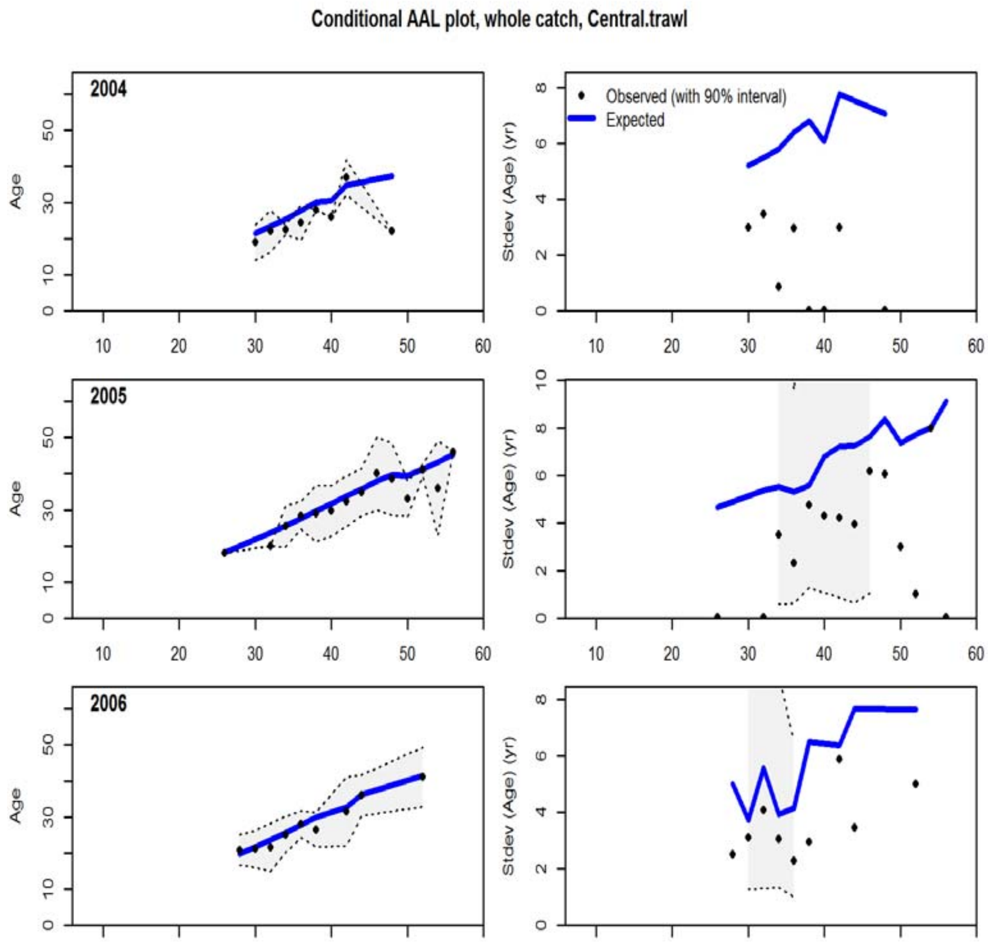


Figure 28 a-b: Fits to conditional age-at-length data for central trawl fishery



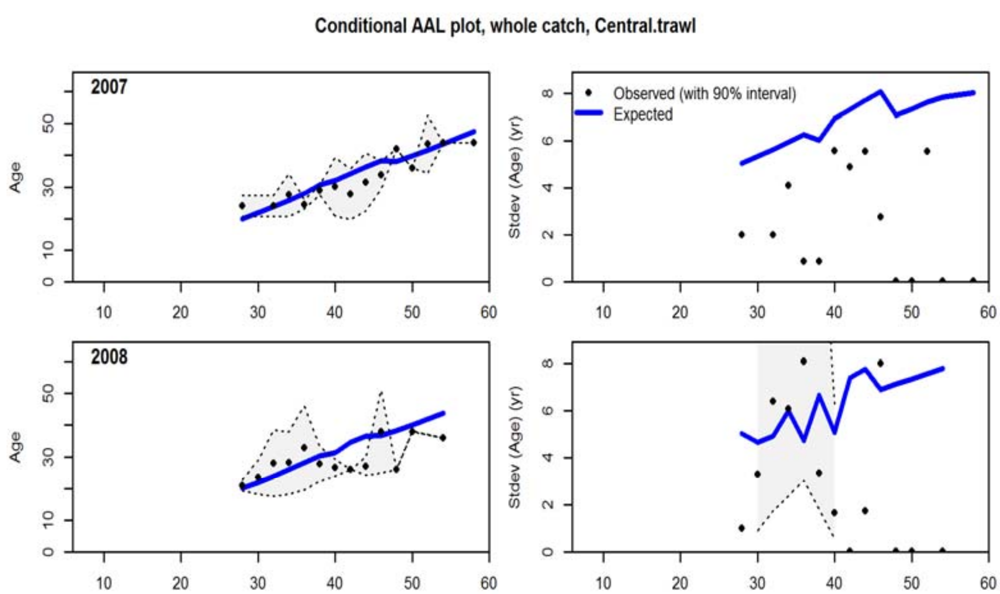
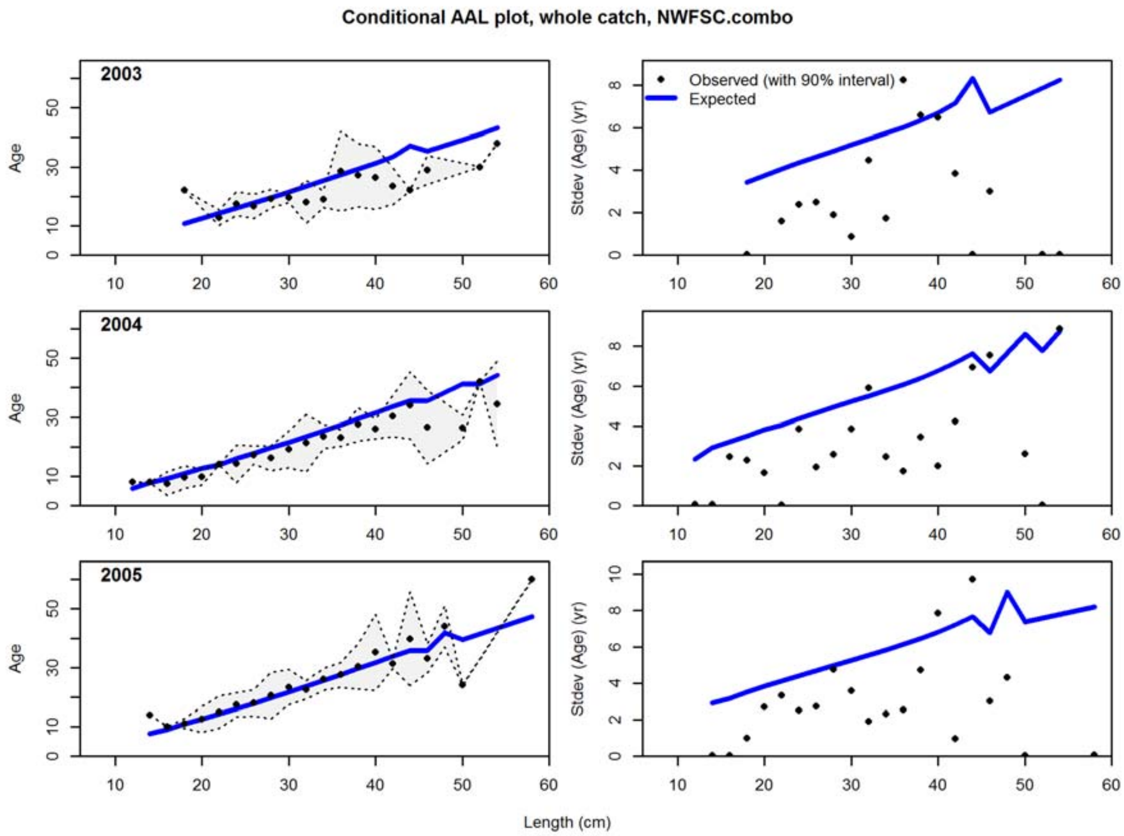


Figure 29 a-b: Fits to conditional age-at-length data for central trawl fishery



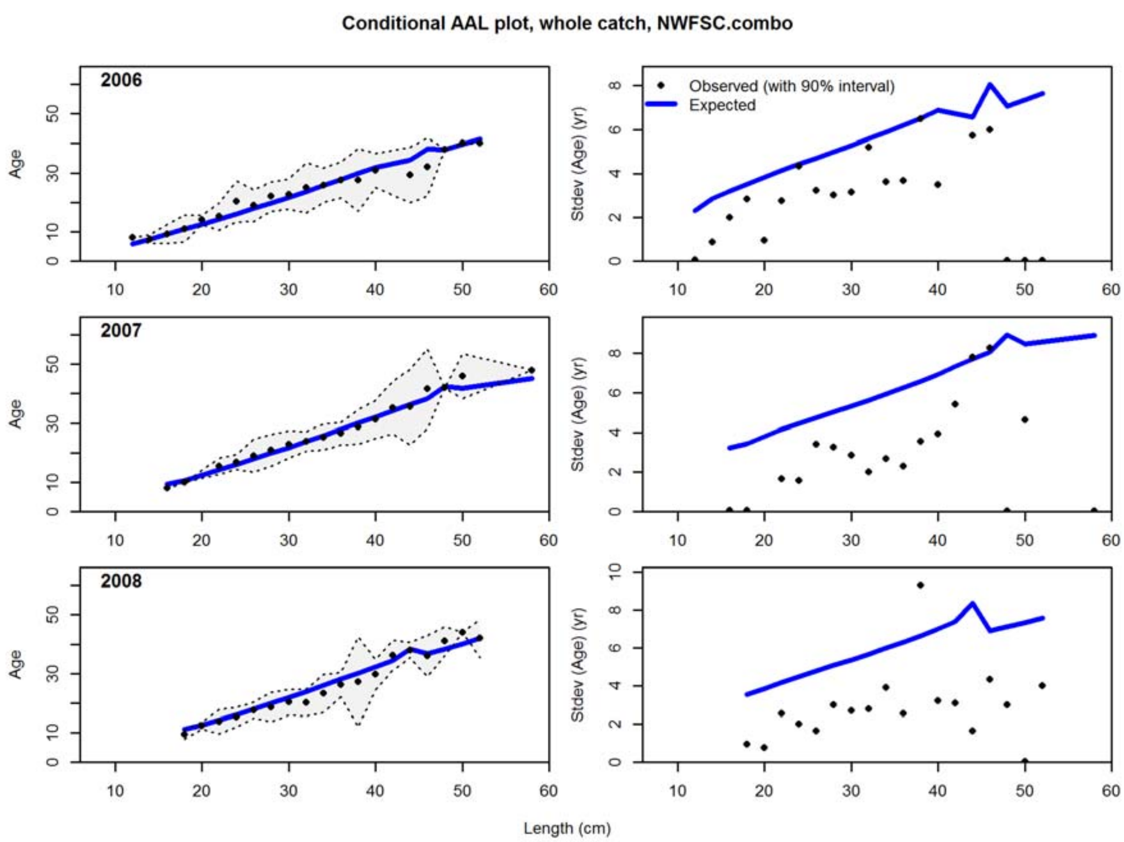
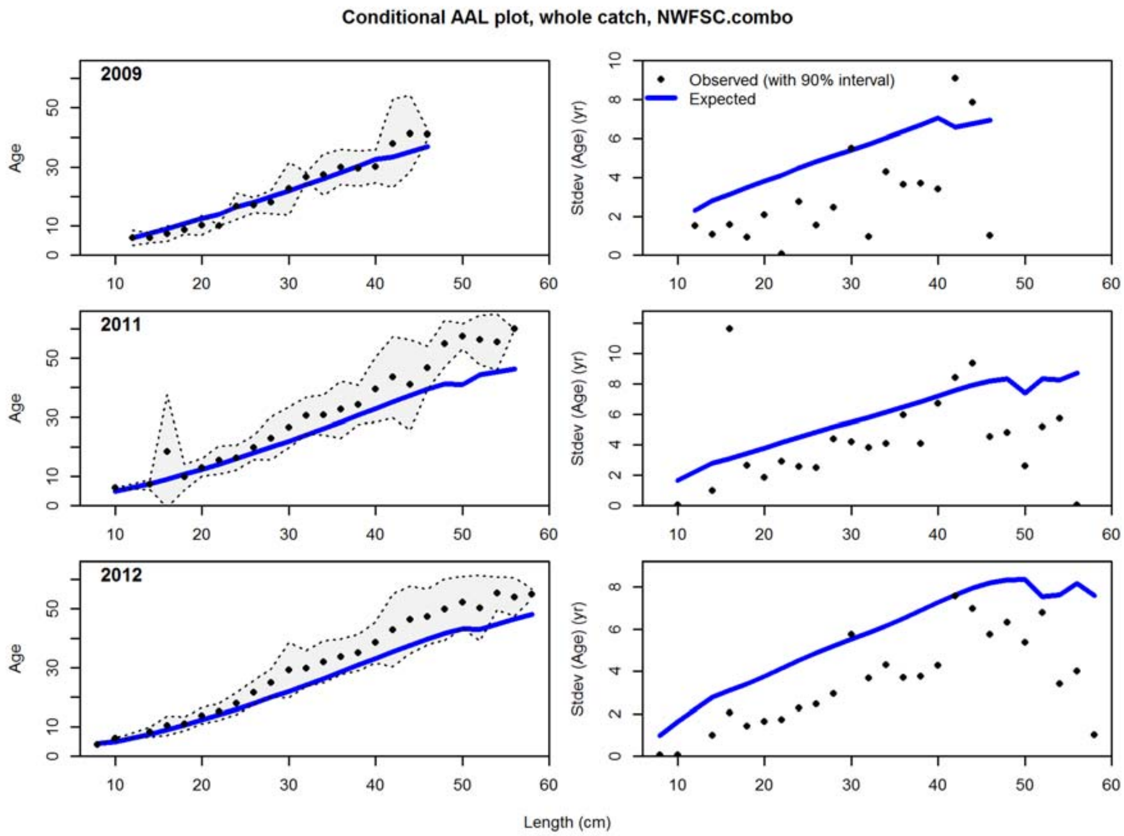


Figure 30 a-b: Fits to conditional age-at-length data for the NWFSC combined trawl survey



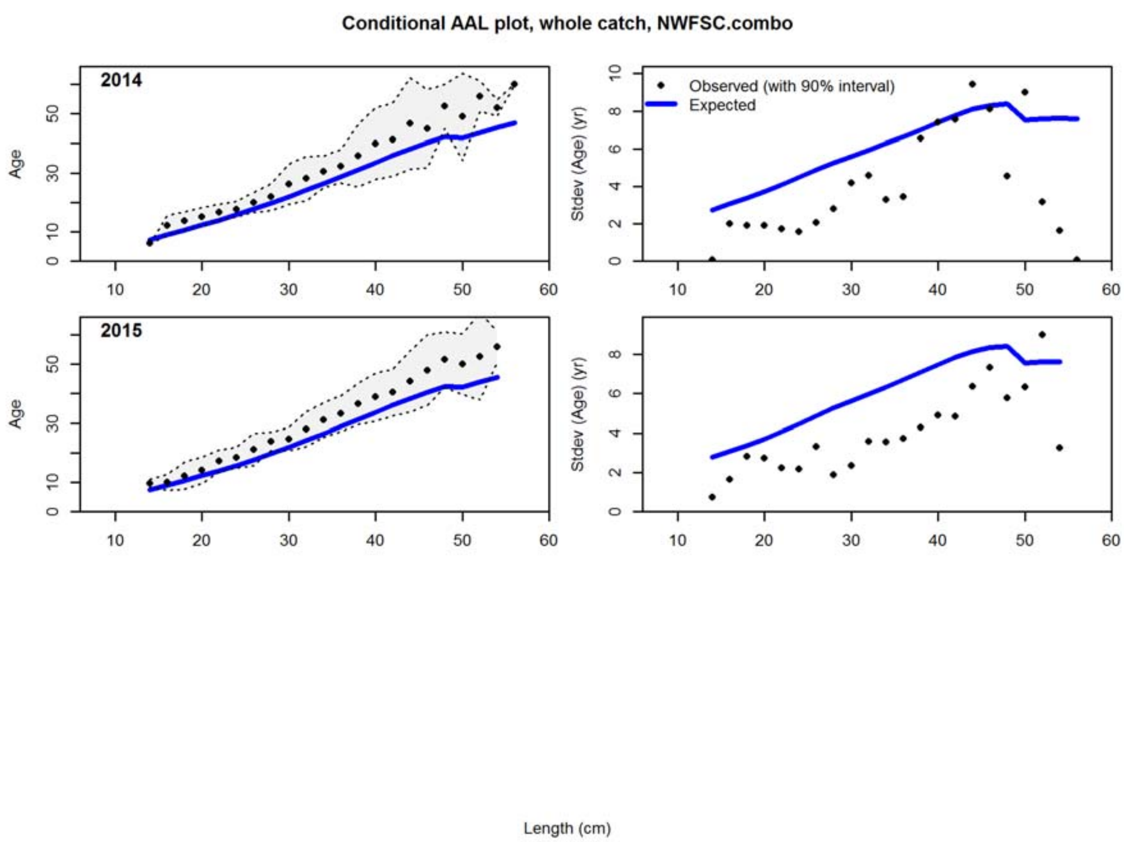


Figure 31 a-b: Fits to conditional age-at-length data for NWFSC combined trawl survey

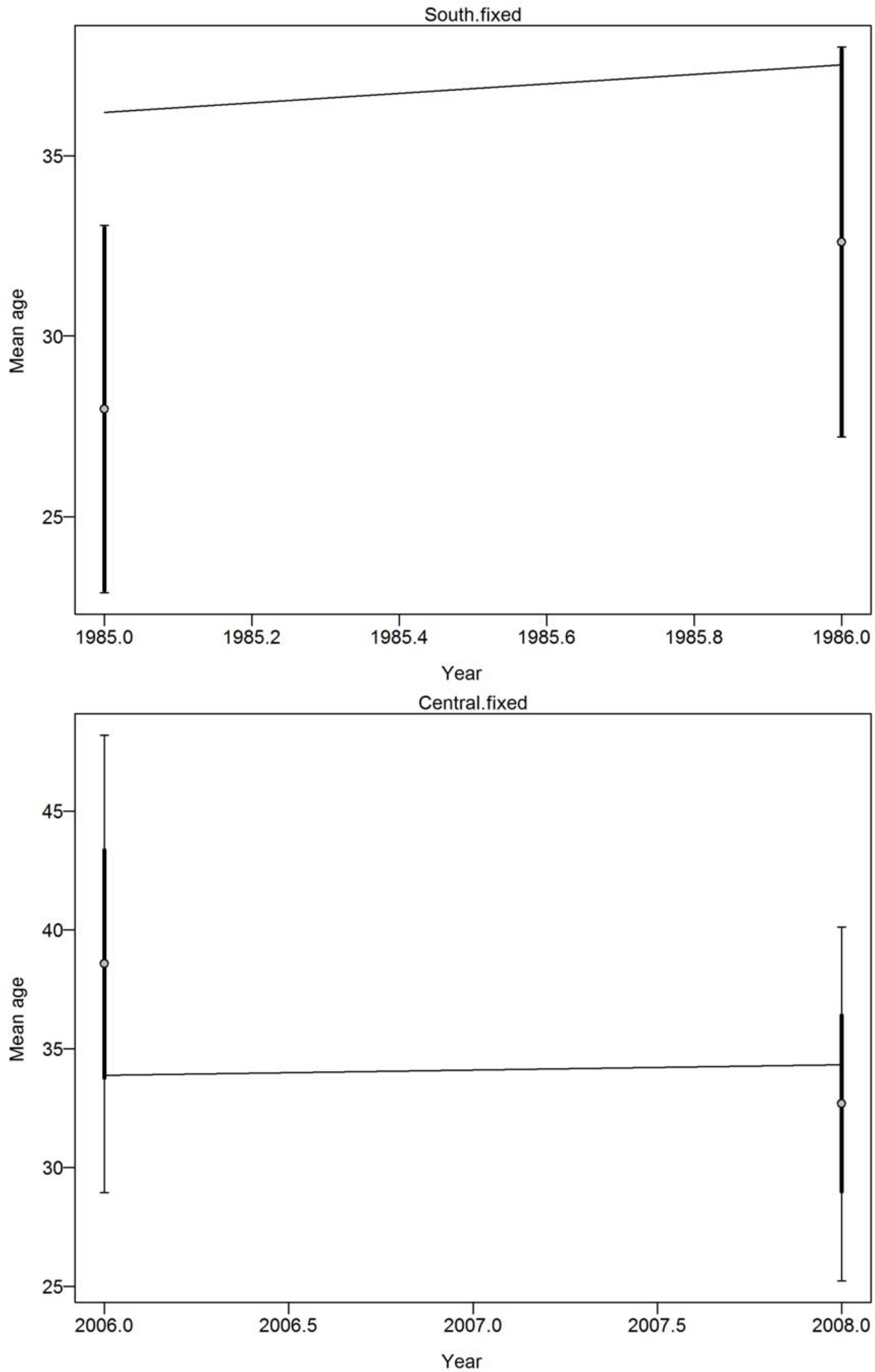


Figure 32 a-b: Fits to mean age for conditional age-at-length for southern fixed gear (top) and central fixed gear (bottom)

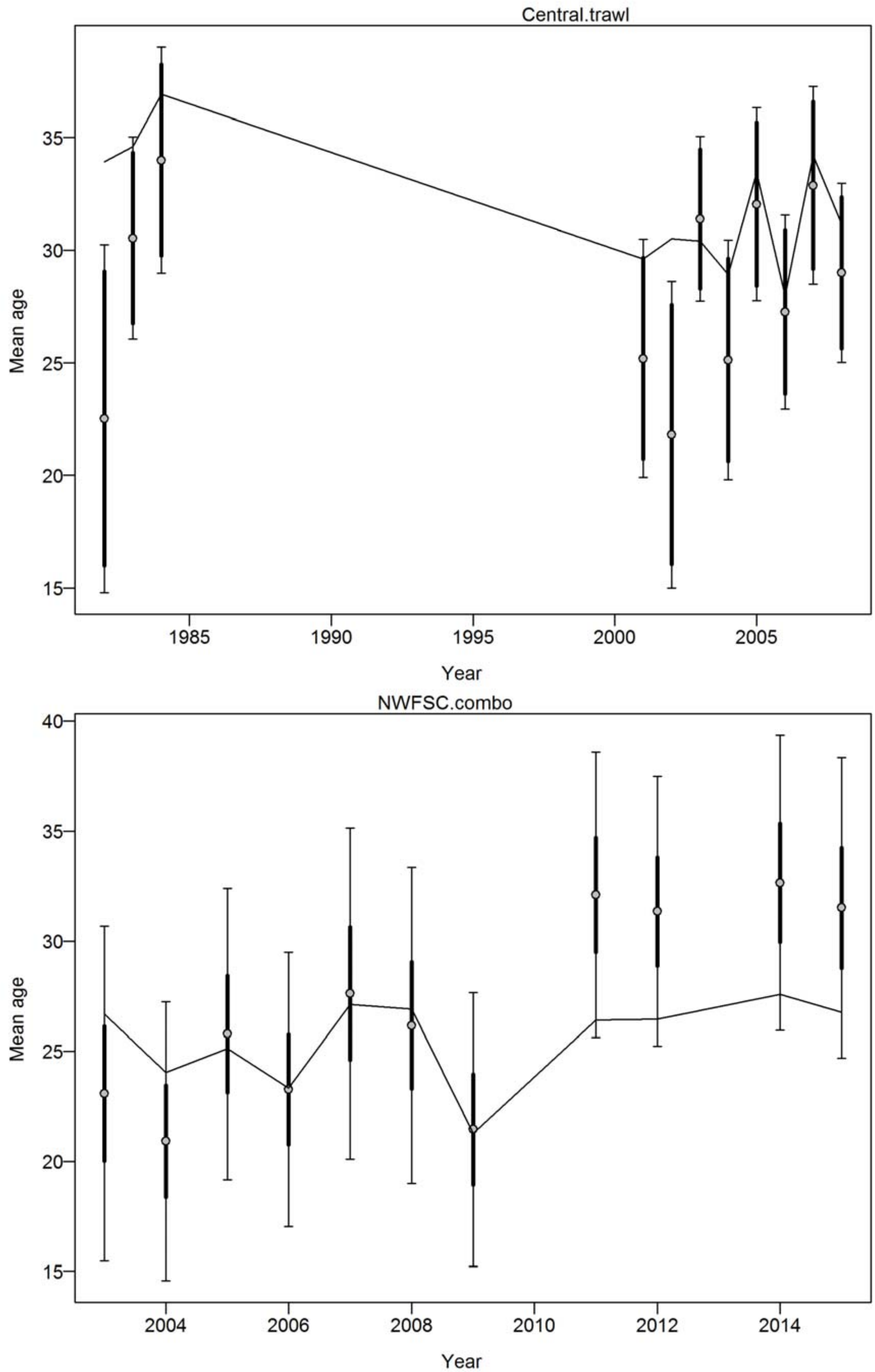
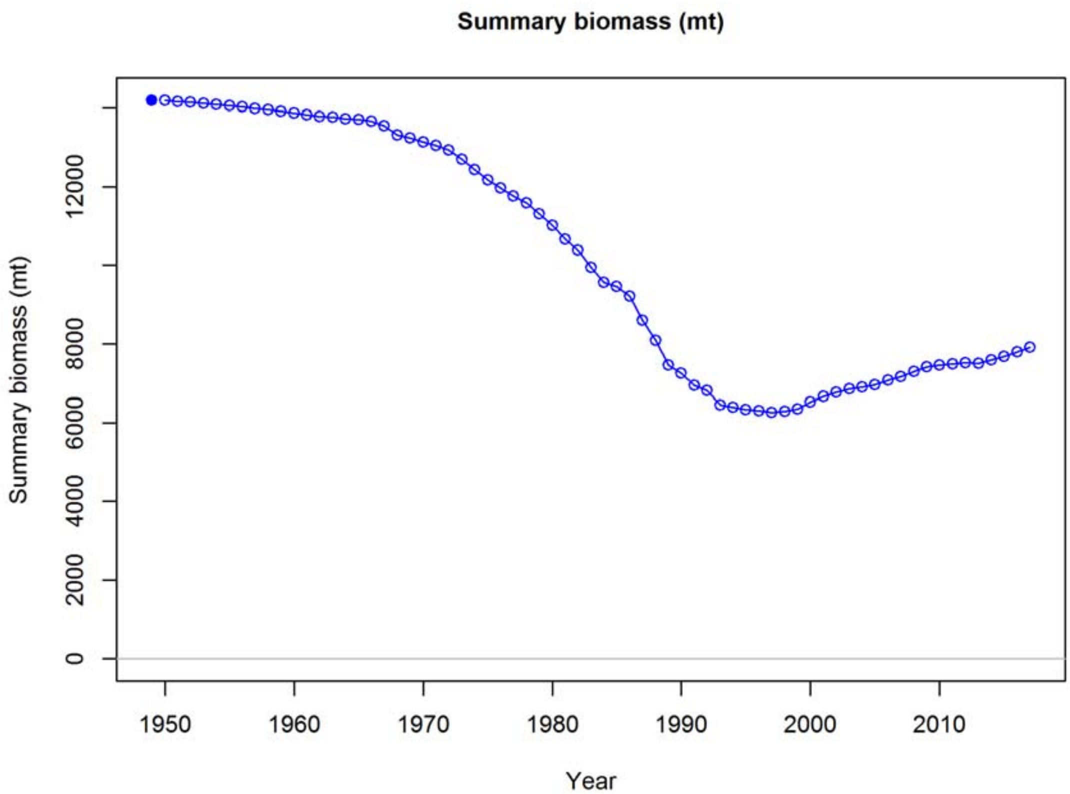


Figure 33 a-b: Fits to mean age for conditional age-at-length for central trawl (top) and NWFSC combined shelf-slope bottom trawl survey (bottom)



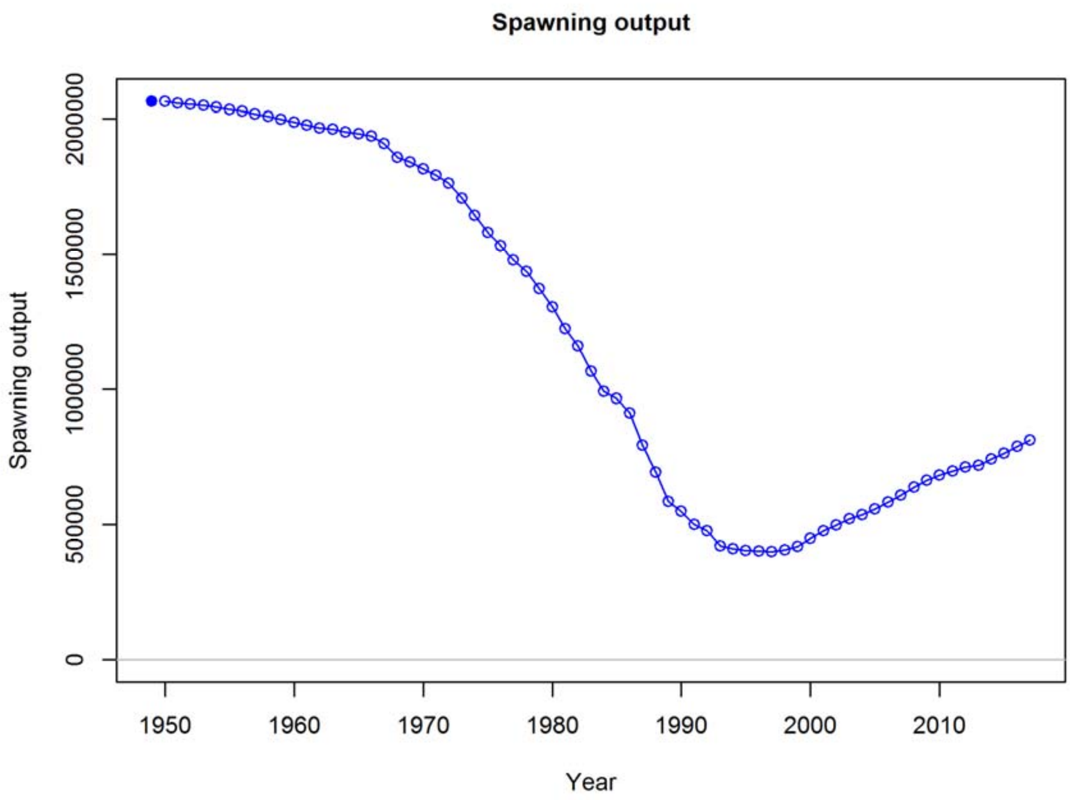


Figure 34 a-b: Base model estimates of total biomass and spawning output (x 10^6).

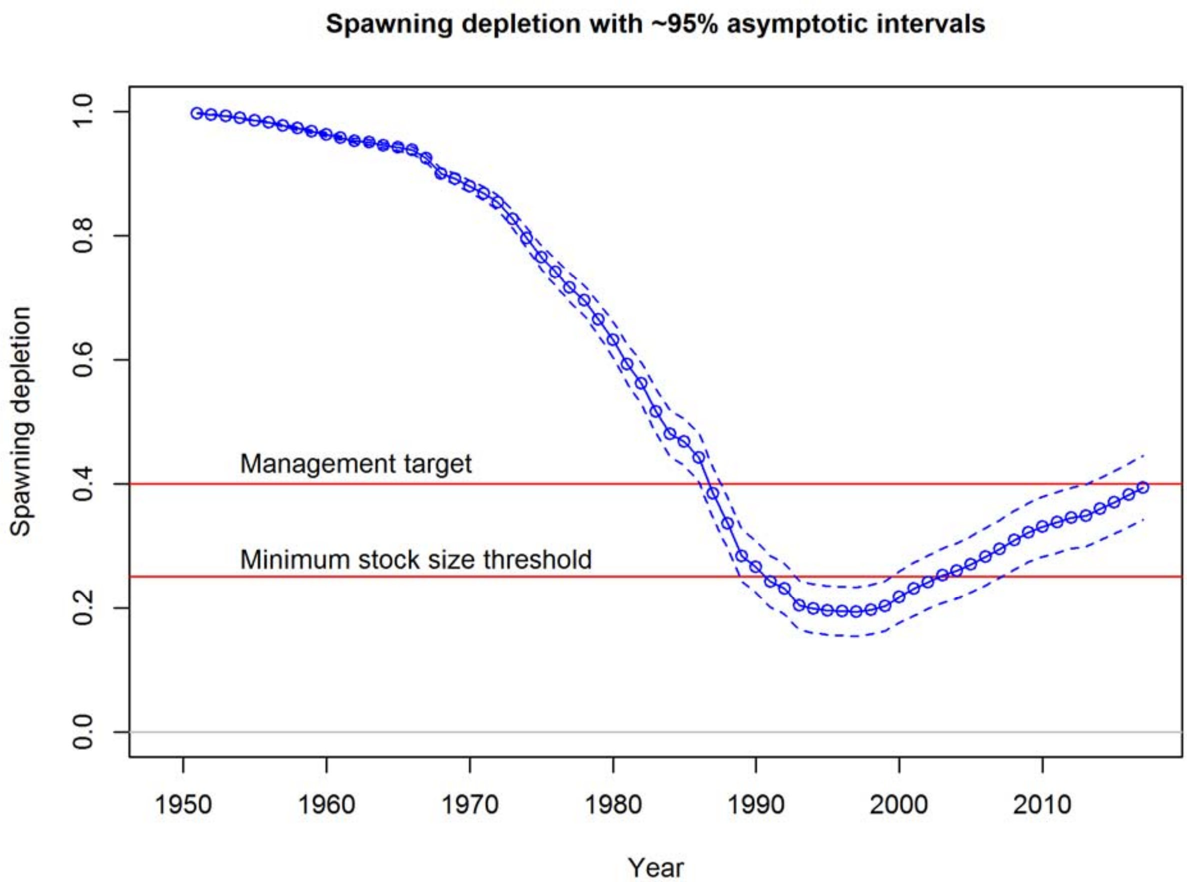


Figure 35: Base model estimates of spawning depletion (with approximate 95% confidence intervals).

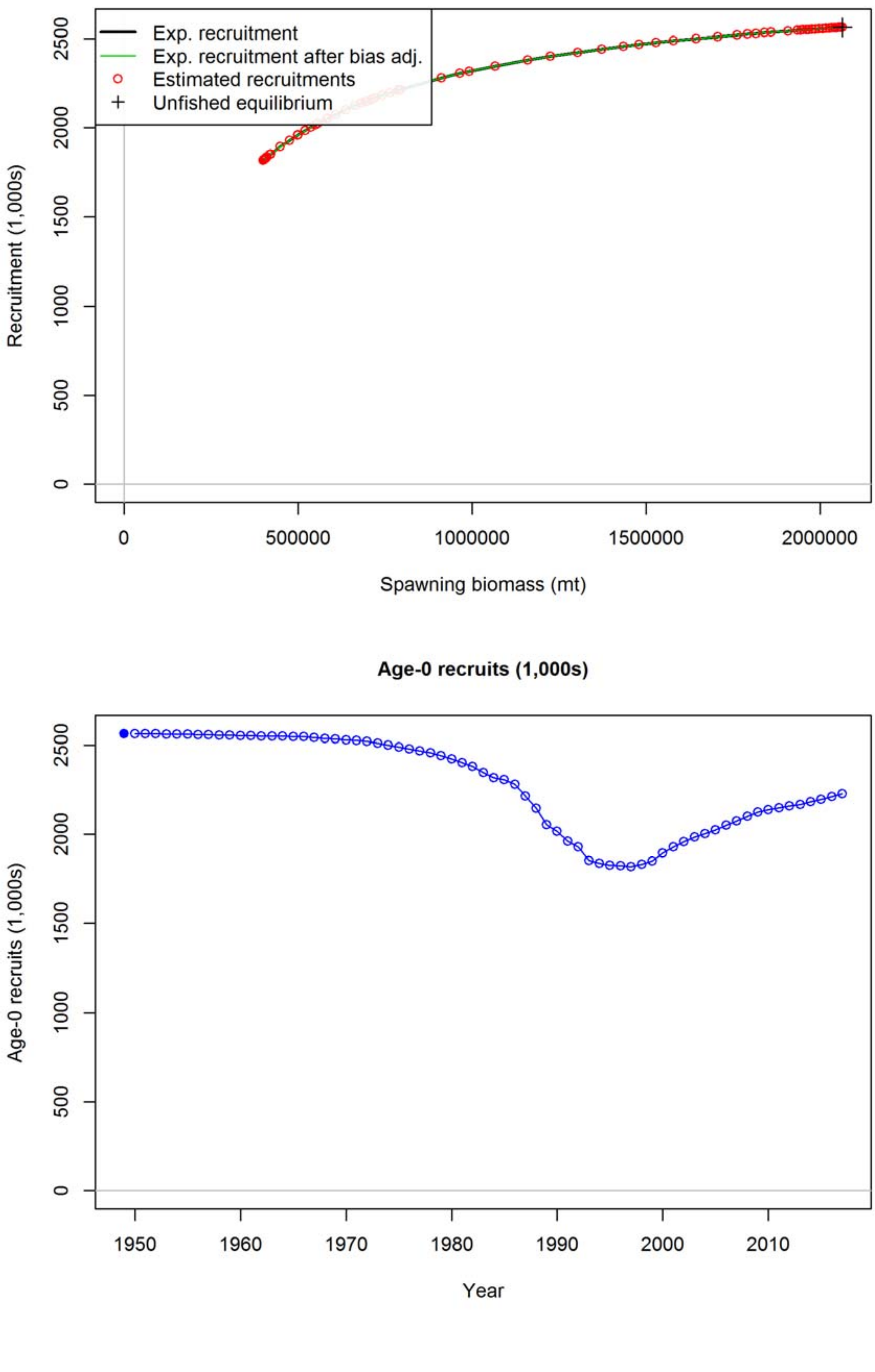
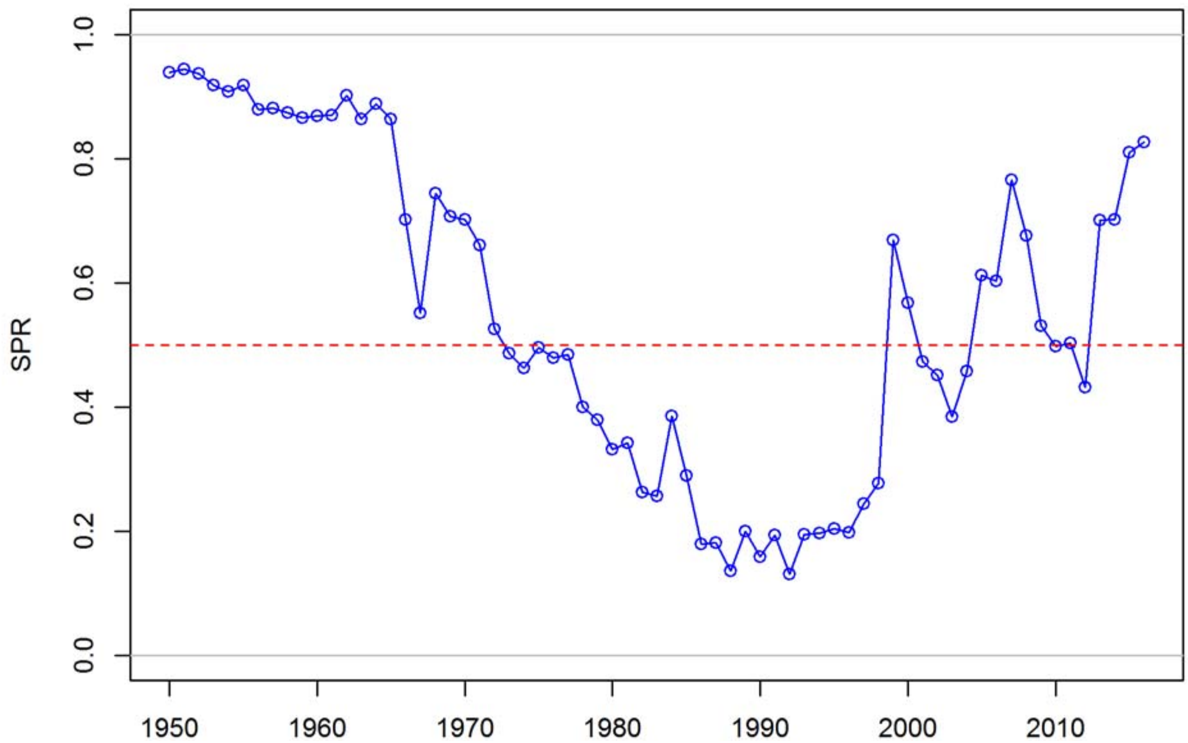


Figure 36 a-b: Spawner-recruit curve (based on fixed value for steepness) and time series of estimated age 0 recruits for the base model.



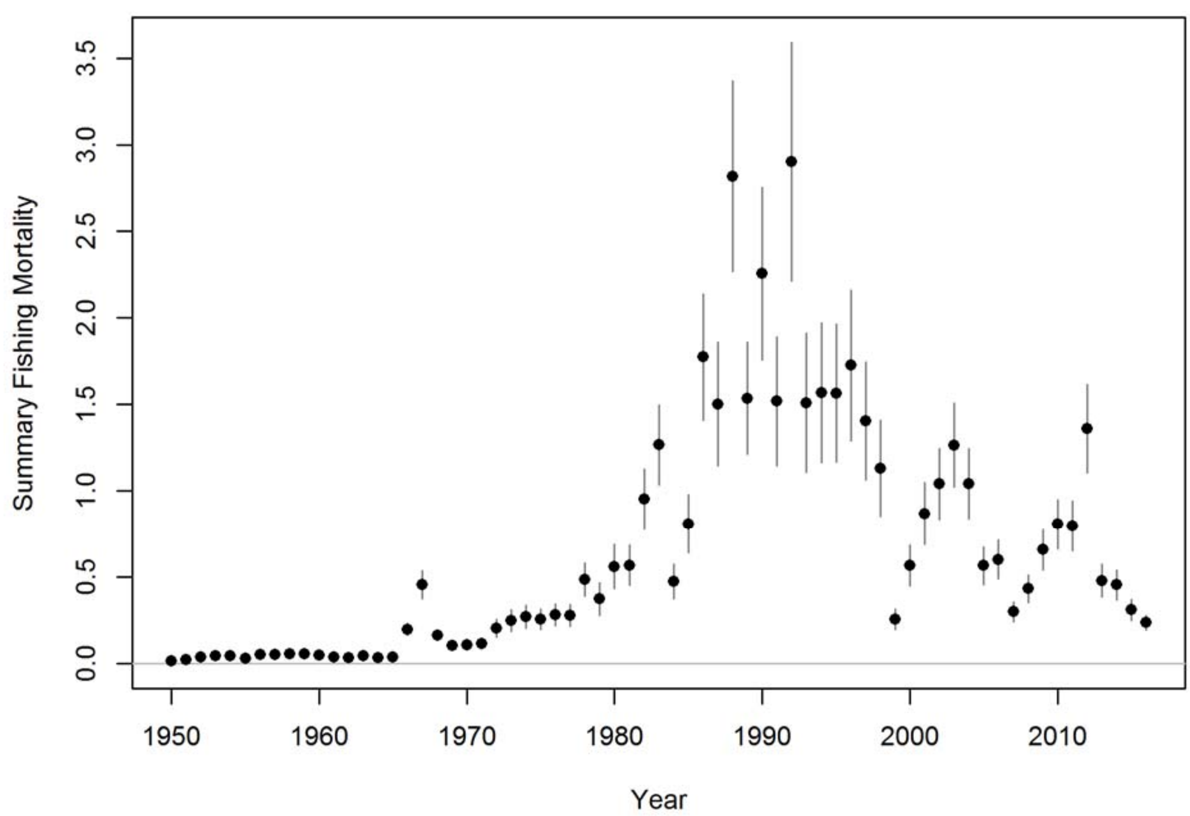


Figure 37 a-b: Estimated spawner potential ratio (top) and summary fishing mortality (bottom) for base model.

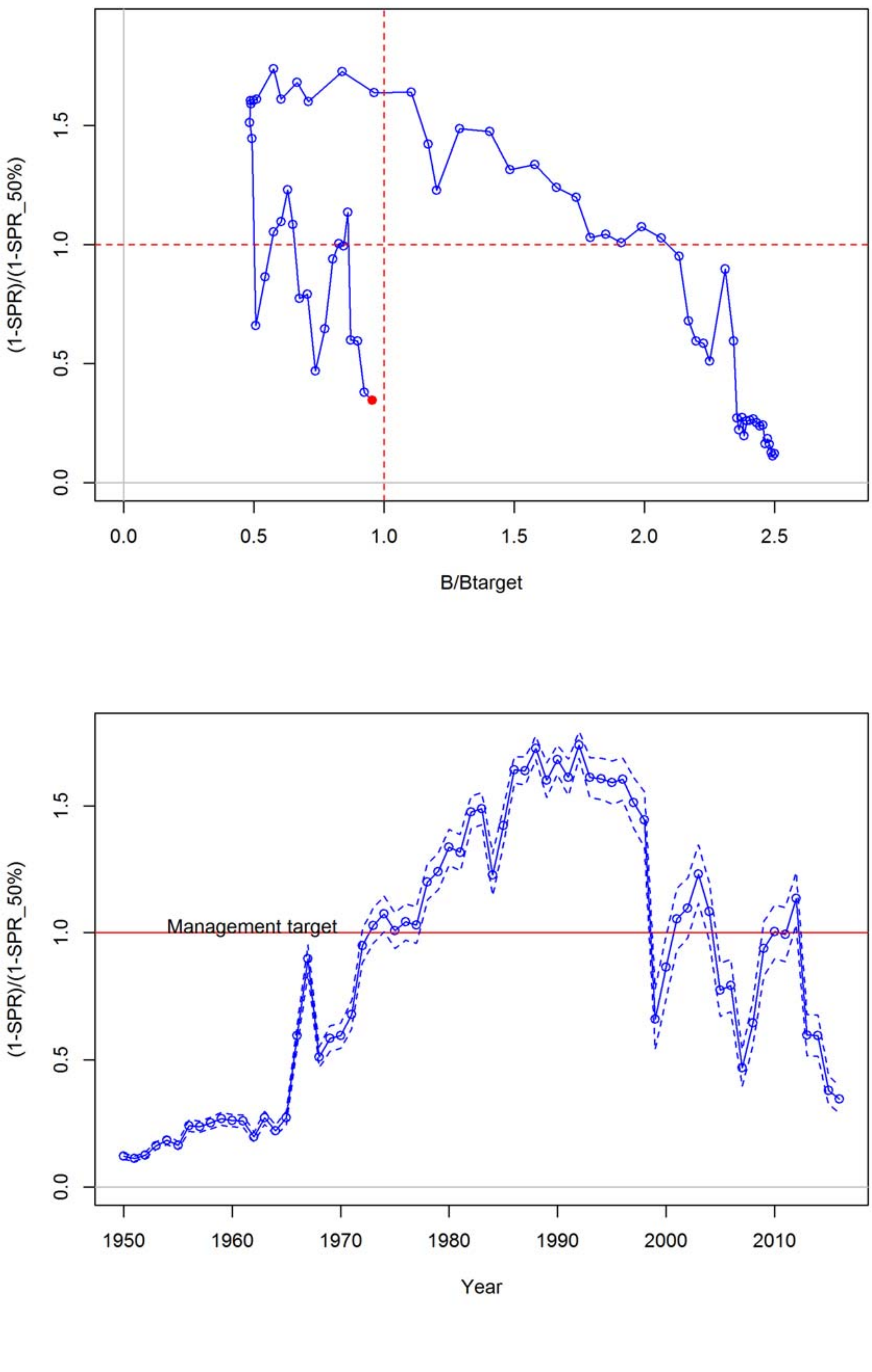


Figure 38 a-b: SPR/depletion phase plot and management target plot for base modell.

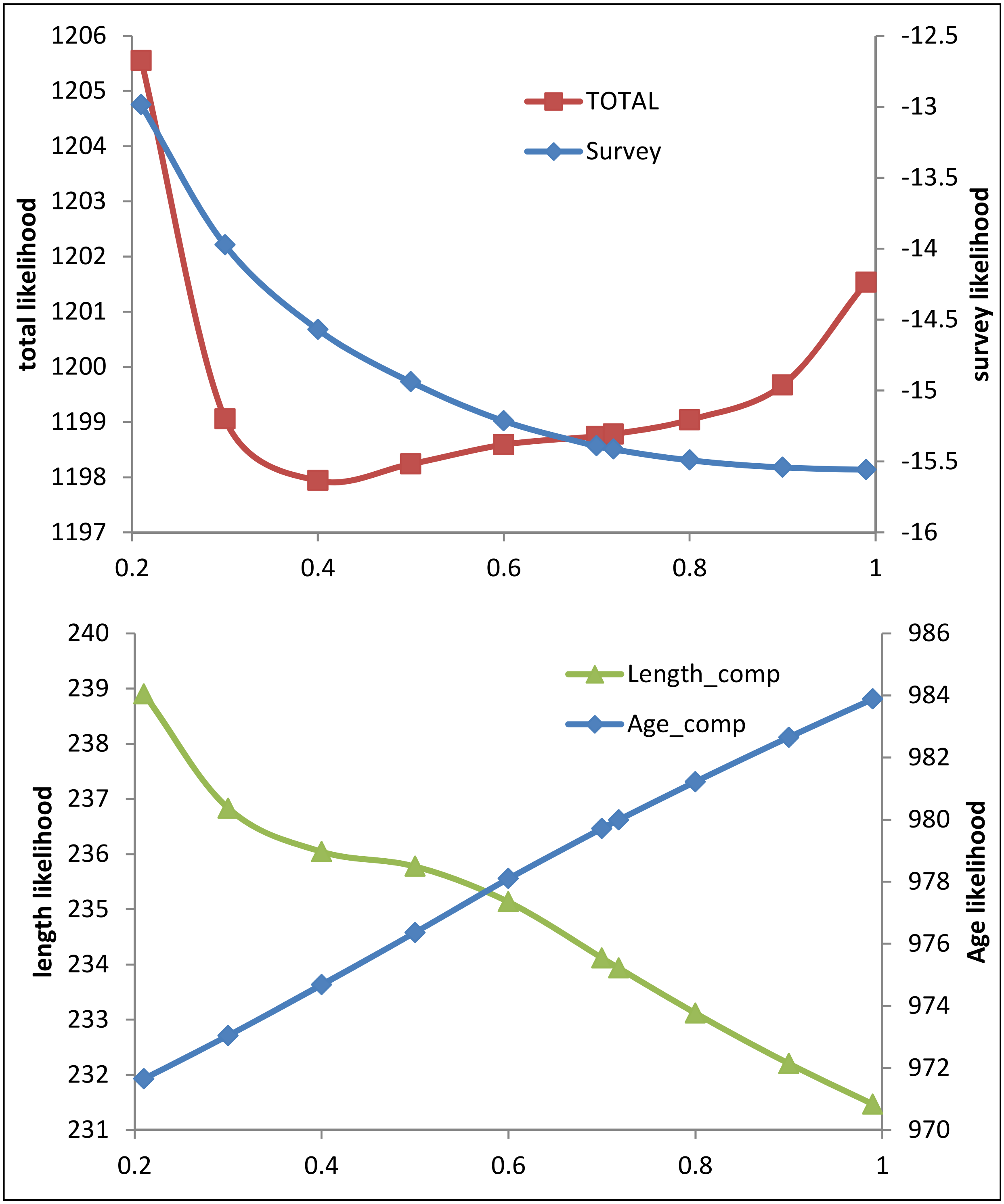


Figure 39: Profiles of total negative log likelihood values by model component under alternative assumptions (fixed values) for steepness (h)

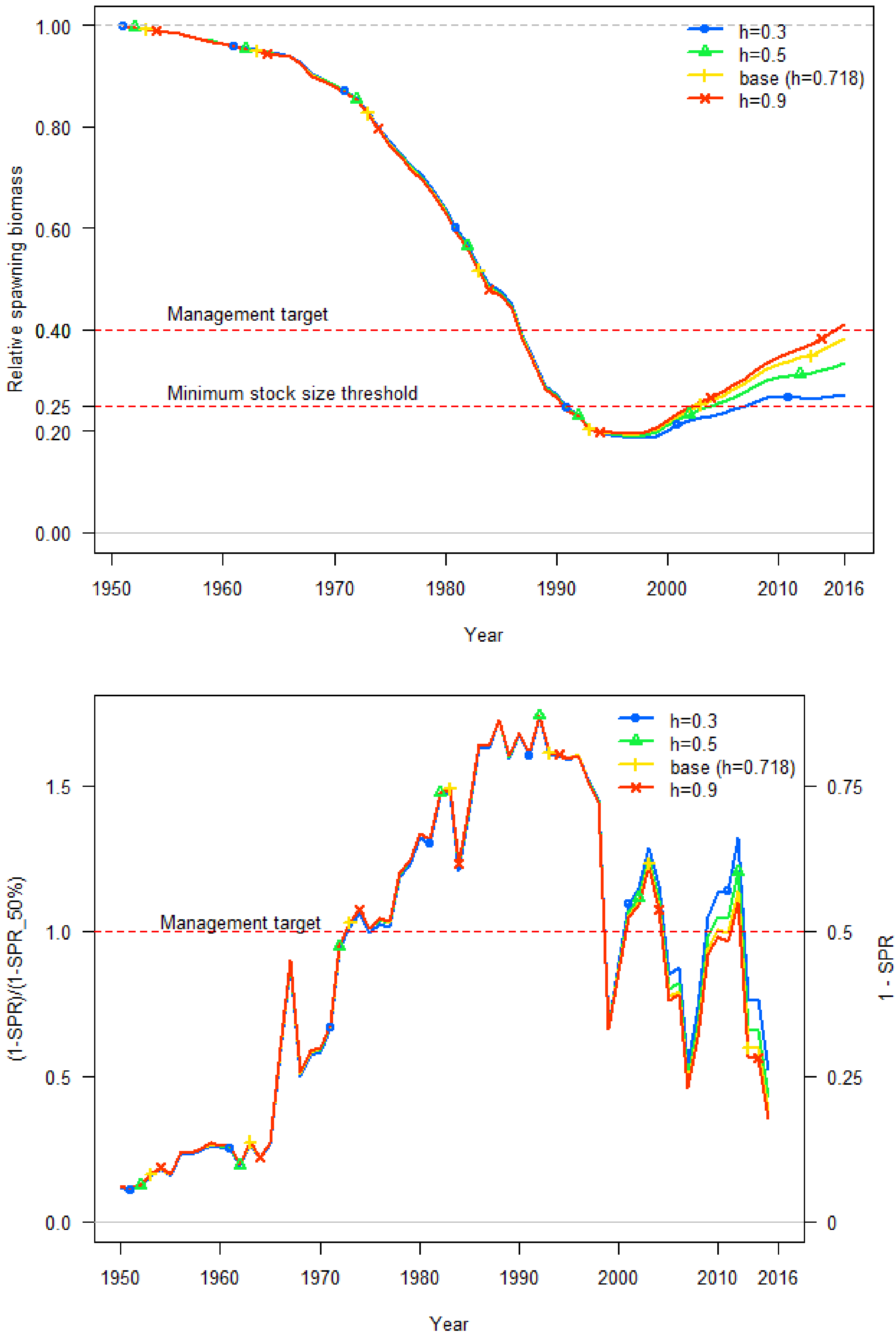


Figure 40: Profiles of estimated quantities of depletion and relative SPR under alternative assumptions (fixed values) for steepness

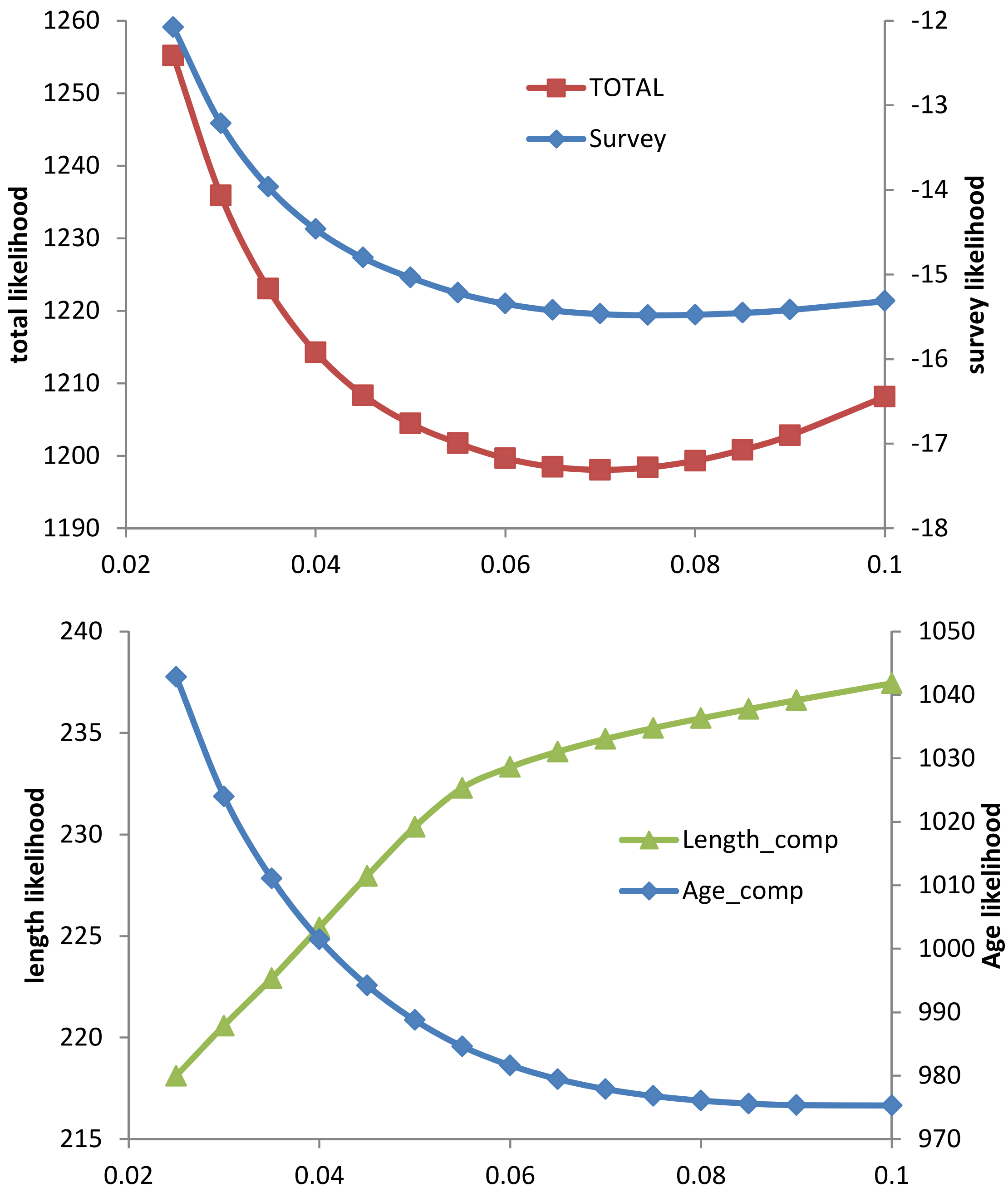


Figure 41: Profiles of total negative log likelihood values by fleet for age composition data (conditional AAL) under alternative assumptions (fixed values) for natural mortality (M).

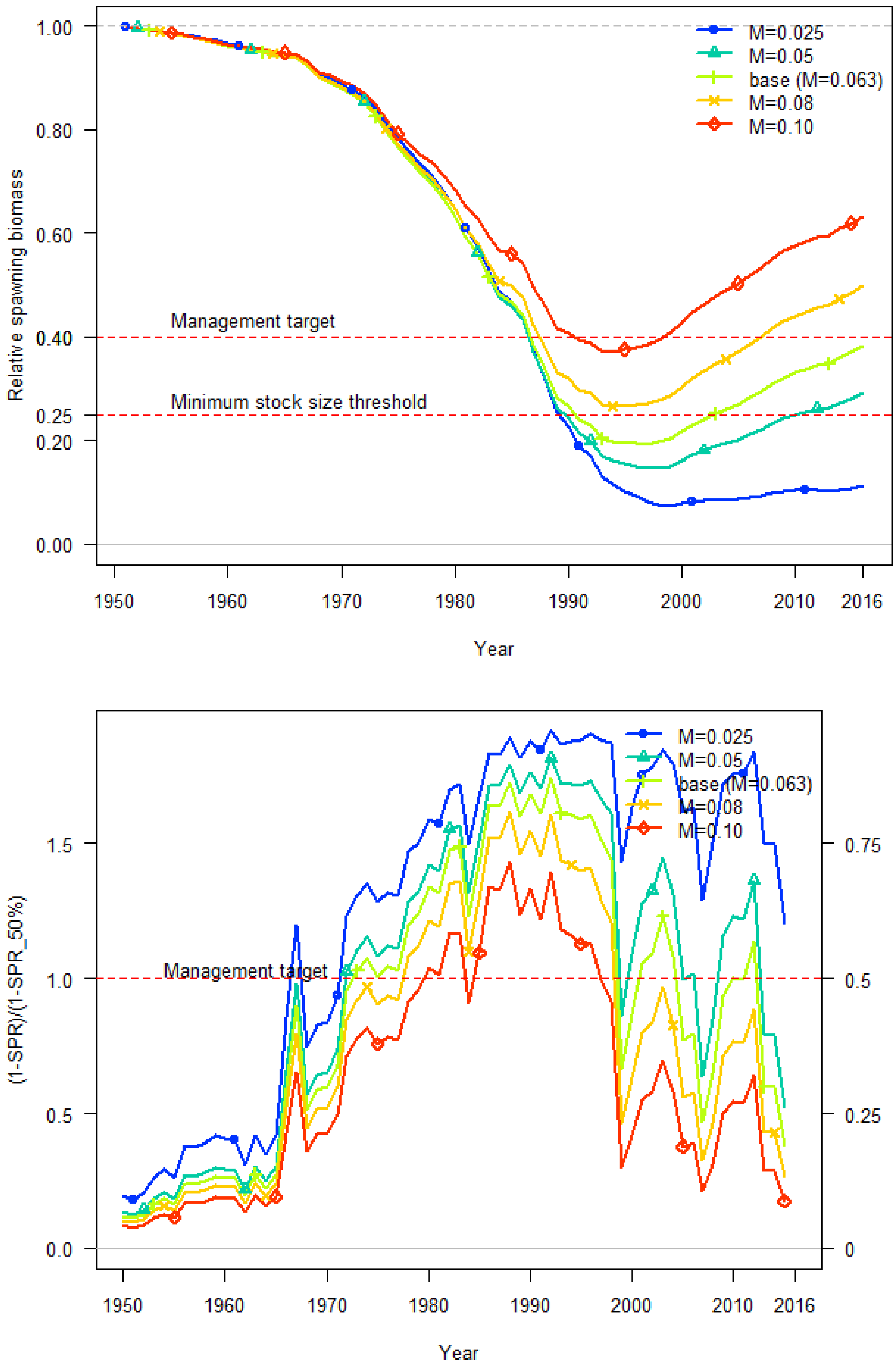


Figure 42: Profiles of estimated quantities of depletion and relative SPR under alternative assumptions for natural mortality (M).

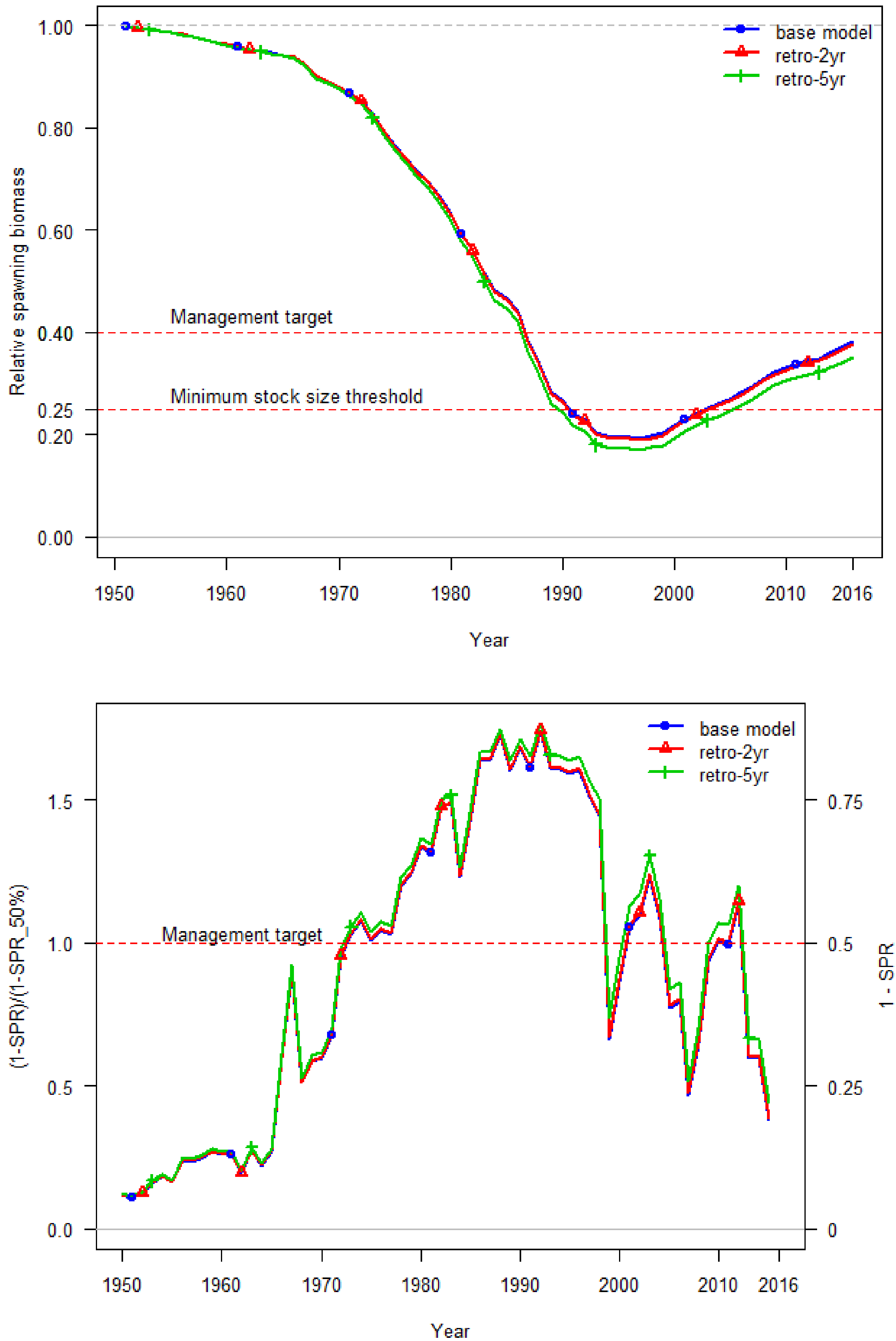


Figure 43: Retrospective analysis of base model

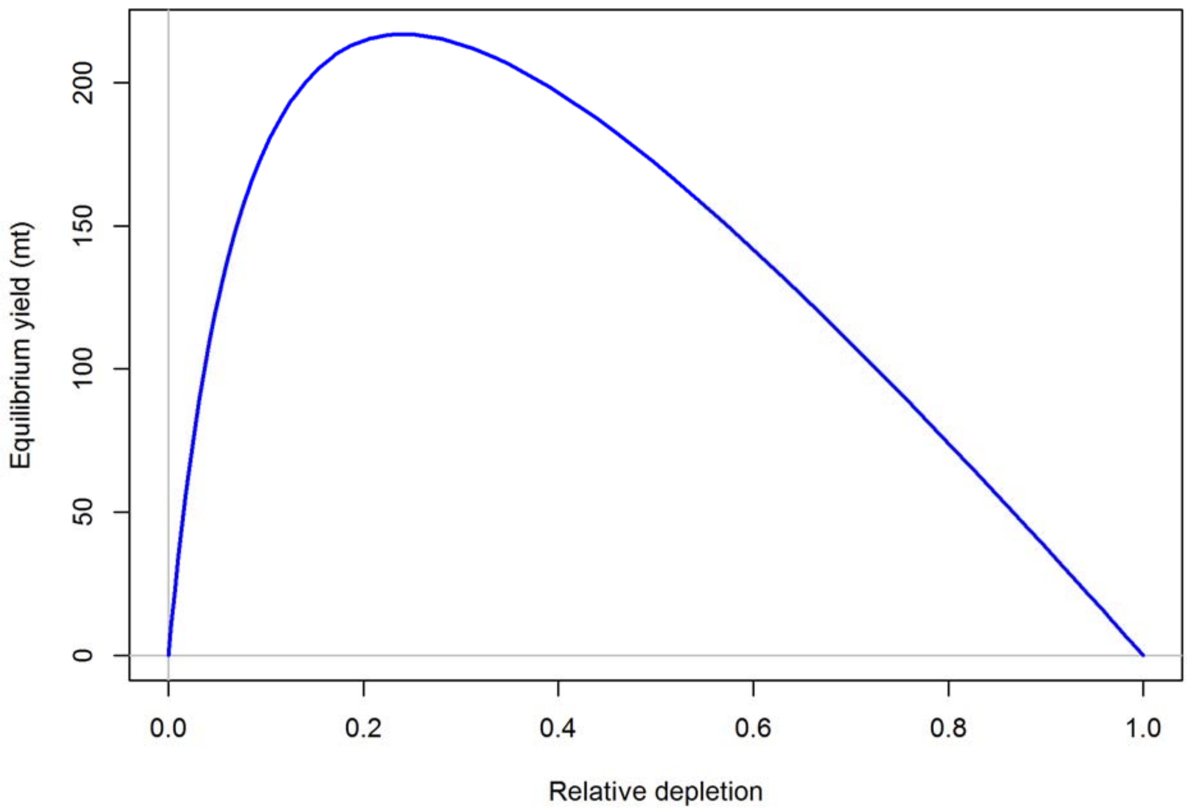


Figure 44: Potential yield curve from base model

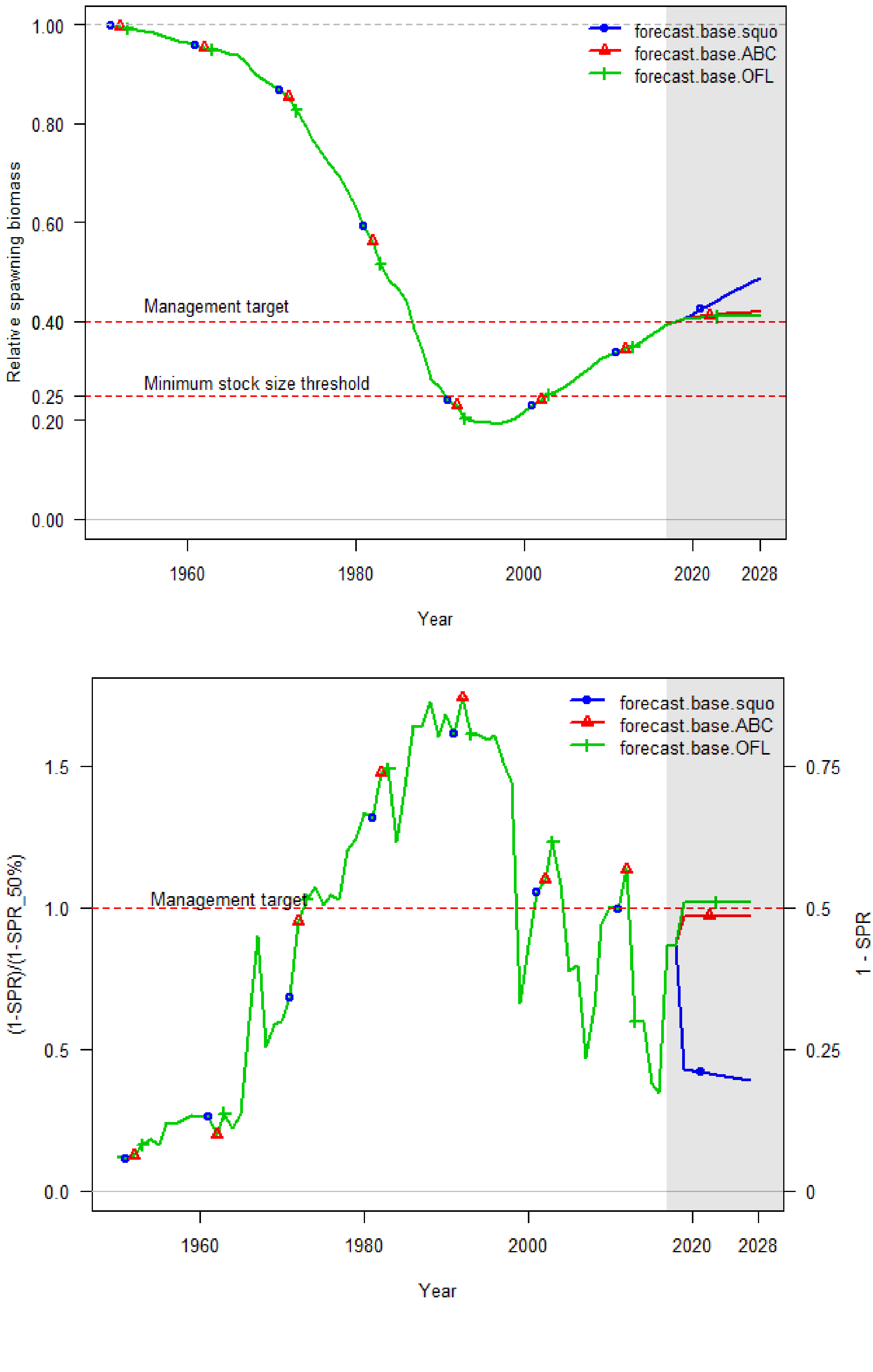


Figure 45: Base model forecast depletion and relative SPR trajectories under alternative future harvest strategies.

Appenix A: Blackgill rockfish 2017 Assessment update base model estimated numbers at age (1000s)

Female numbers at age: 0-29

Yr	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Init	1282	1204	1130	1061	996	936	878	825	774	727	683	641	602	565	531	498	468	439	412	387	364	341	321	301	283	265	249	234	220	206
1950	1282	1204	1130	1061	996	936	878	825	774	727	683	641	602	565	531	498	468	439	412	387	364	341	321	301	283	265	249	234	220	206
1951	1282	1204	1130	1061	996	936	878	825	774	727	683	641	602	565	531	498	468	439	412	387	364	341	321	301	283	265	249	234	220	206
1952	1281	1203	1130	1061	996	936	878	825	774	727	683	641	602	565	531	498	468	439	412	387	364	341	320	301	282	265	249	234	219	206
1953	1281	1203	1130	1061	996	936	878	825	774	727	683	641	602	565	531	498	468	439	412	387	364	341	320	301	282	265	249	234	219	206
1954	1281	1203	1130	1061	996	936	878	825	774	727	683	641	602	565	531	498	468	439	412	387	363	341	320	301	282	265	249	233	219	205
1955	1280	1202	1129	1061	996	936	878	825	774	727	683	641	602	565	531	498	468	439	412	387	363	341	320	301	282	265	248	233	219	205
1956	1280	1202	1129	1060	996	935	878	825	774	727	683	641	602	565	531	498	468	439	412	387	363	341	320	301	282	265	248	233	219	205
1957	1279	1202	1129	1060	996	935	878	825	774	727	683	641	602	565	531	498	468	439	412	387	363	341	320	300	282	265	248	233	218	205
1958	1278	1201	1128	1060	995	935	878	825	774	727	683	641	602	565	531	498	468	439	412	387	363	341	320	300	282	264	248	233	218	205
1959	1278	1200	1128	1059	995	935	878	824	774	727	683	641	602	565	531	498	468	439	412	387	363	341	320	300	282	264	248	233	218	204
1960	1277	1200	1127	1059	995	934	877	824	774	727	683	641	602	565	531	498	468	439	412	387	363	341	320	300	282	264	248	232	218	204
1961	1276	1199	1126	1058	994	934	877	824	774	727	683	641	602	565	531	498	468	439	412	387	363	341	320	300	282	264	248	232	218	204
1962	1276	1198	1126	1058	994	933	877	824	774	727	682	641	602	565	531	498	468	439	412	387	363	341	320	300	282	264	248	232	218	204
1963	1275	1198	1125	1057	993	933	876	823	773	726	682	641	602	565	531	498	468	439	412	387	363	341	320	300	282	264	248	233	218	204
1964	1275	1197	1125	1057	993	932	876	823	773	726	682	641	602	565	531	498	468	439	412	387	363	341	320	300	282	264	248	233	218	204
1965	1274	1197	1124	1056	992	932	876	823	773	726	682	640	601	565	531	498	468	439	412	387	363	341	320	301	282	265	248	233	218	204
1966	1274	1196	1124	1056	992	931	875	822	772	725	682	640	601	565	530	498	468	439	412	387	363	341	320	301	282	265	248	233	218	204
1967	1272	1196	1123	1055	991	931	875	822	772	725	681	640	601	565	530	498	468	439	412	387	363	341	320	300	281	264	247	232	217	203
1968	1268	1194	1123	1055	991	931	874	821	771	725	681	640	601	564	530	498	467	439	412	386	362	340	319	299	280	262	245	229	215	201
1969	1267	1191	1121	1054	990	930	874	821	771	724	681	639	601	564	530	498	467	439	412	386	362	340	319	298	280	262	245	229	214	200
1970	1265	1189	1118	1053	990	930	873	821	771	724	680	639	600	564	530	497	467	439	412	386	363	340	319	299	280	262	245	229	214	200
1971	1263	1188	1117	1050	988	929	873	820	770	724	680	639	600	564	529	497	467	439	412	387	363	340	319	299	280	262	245	229	214	200
1972	1261	1186	1115	1049	986	928	873	820	770	723	679	638	600	563	529	497	467	438	412	387	363	340	319	299	280	262	245	229	214	200
1973	1256	1184	1113	1047	985	925	871	819	770	723	679	638	599	563	529	497	467	438	412	386	363	340	319	299	280	262	245	228	213	199
1974	1250	1179	1111	1045	983	924	869	818	769	723	679	638	599	563	529	497	466	438	411	386	362	340	319	299	279	261	244	228	212	197
1975	1244	1174	1107	1044	982	923	868	816	768	722	679	637	599	562	528	496	466	438	411	386	362	340	318	298	279	261	243	227	211	196
1976	1239	1168	1102	1040	980	922	867	815	766	721	678	637	598	562	528	496	466	438	411	386	362	340	318	298	279	260	243	226	211	196
1977	1234	1164	1097	1035	976	920	865	814	765	719	677	637	598	562	528	496	466	437	411	386	362	339	318	298	278	260	243	226	210	195
1978	1229	1159	1093	1030	972	917	864	813	764	719	675	636	598	562	528	496	465	437	410	385	362	339	318	297	278	260	242	226	210	194
1979	1222	1154	1088	1026	967	913	861	811	763	717	675	634	597	561	527	495	465	437	410	385	361	338	317	297	277	259	241	224	208	193
1980	1212	1147	1084	1021	963	908	857	808	762	716	674	633	595	561	527	495	465	437	410	385	361	338	317	296	277	258	240	223	207	191
1981	1201	1138	1077	1017	959	904	853	805	759	715	673	633	595	559	526	495	465	436	410	384	360	337	316	295	275	256	238	221	204	189
1982	1191	1128	1069	1011	955	901	849	801	755	712	671	632	594	558	525	494	464	436	409	384	360	337	315	294	274	255	237	219	203	187
1983	1174	1118	1059	1004	949	897	846	797	752	709	669	630	593	558	524	493	464	436	409	383	359	336	313	292	272	252	234	216	199	182
1984	1159	1102	1050	994	942	891	842	794	749	706	666	628	592	557	523	492	462	434	408	382	357	334	311	290	269	249	230	212	194	178
1985	1153	1088	1035	986	933	885	837	791	745	703	663	625	590	556	523	491	462	434	408	382	358	334	312	290	270	250	231	213	195	178
1986	1141	1083	1022	972	926	876	831	786	742	700	660	622	587	554	522	491	461	433	406	382	358	334	312	290	269	249	230	211	193	177
1987	1108	1071	1017	959	913	869	823	780	738	697	657	620	584	551	520	489	460	432	405	379	355	332	308	286	264	243	223	204	185	168
1988	1074	1040	1005	954	901	857	816	773	732	693	655	617	582	548	517	488	459	431	404	379	354	330	307	284	262	240	219	199	180	161
1989	1027	1008	977	944	896	846	804	766	726	688	651	615	579	546	515	485	457	429	402	376	351	326	302	278	255	232	210	189	169	150
1990	1009	965	946	917	886	841	794	755	719	681	646	611	577	544	513	483	455	428	402	376	350	326	301	278	254	231	209	188	167	148
1991	980	947	906	889	861	832	790	746	709	675	640	606	573	542	510	481	453	426	400	374	349	324	299	275	251	228	205	183	162	143
1992	965	920	889	850	834	808	781	742	700	666	634	601	569	538	508	479	451	424	399	374	349	324	300	275	252	228	206	183	162	142
1993	927	906	864	835	798	783	759	734	697	657	625	595	564	534	505	477	449	422	396	371	346	321	296	271	246	222	199	176	154	134
1994	919	870	851	811	784	750	736	713	689	654	617	587	559	529	502	474	447	420	395	370	345	321	297	273	248	224	200	178	156	135
1995	914	863	817	799	762	736	704	691	669	647	614	579	551	525	497	471	445	419	393	369	344	321	297	273	249	225	202	179	158	137

1996	912	858	810	767	750	715	691	661	649	628	607	577	544	517	493	466	441	416	392	367	343	320	297	274	250	227	204	181	159	139
1997	910	856	806	760	720	704	672	649	621	609	590	570	541	511	486	462	437	413	389	366	342	319	295	273	250	227	204	182	160	139
1998	916	854	804	756	714	676	661	631	609	583	572	554	535	508	479	456	433	409	387	364	341	318	295	272	250	228	206	184	163	143
1999	925	860	802	755	710	670	635	621	592	572	547	537	520	503	477	450	427	406	383	362	339	317	295	273	251	230	209	187	167	147
2000	947	868	807	753	709	667	629	596	583	556	537	514	504	488	472	448	422	401	381	360	339	318	297	276	255	235	215	194	175	155
2001	965	889	815	758	707	665	626	591	560	547	522	504	482	473	458	443	420	396	376	357	336	317	297	277	257	237	218	199	180	161
2002	980	906	835	766	712	664	625	588	555	526	514	490	474	453	444	430	415	393	371	351	333	314	295	276	257	238	219	201	183	165
2003	993	920	851	784	719	668	623	587	552	521	493	483	460	444	425	416	403	388	368	346	328	310	291	273	255	237	219	202	184	168
2004	1002	932	864	799	736	675	628	585	551	518	489	463	453	432	417	398	390	377	363	343	322	304	287	269	252	235	218	201	184	168
2005	1013	941	875	811	750	691	634	589	550	517	487	459	435	425	405	391	373	365	352	339	320	300	283	267	249	233	217	200	184	169
2006	1026	951	883	822	762	704	649	595	553	516	486	457	431	408	399	380	366	349	342	330	317	299	280	264	248	232	217	201	186	171
2007	1038	963	893	829	771	715	661	609	559	519	484	456	429	405	383	374	356	343	327	320	308	296	279	261	245	231	216	201	186	172
2008	1051	974	904	838	779	724	671	621	572	525	488	455	428	403	380	359	351	334	322	307	300	289	277	261	244	229	216	201	187	174
2009	1062	987	915	849	787	731	680	630	583	537	493	458	427	402	378	356	337	329	313	302	287	280	270	259	243	227	214	201	187	174
2010	1069	997	927	859	797	739	687	639	592	547	504	462	430	401	377	354	334	316	308	293	282	268	261	251	241	226	211	198	186	173
2011	1075	1004	936	870	807	749	694	645	600	556	514	473	434	403	376	354	332	313	296	288	274	263	250	243	233	223	209	195	182	171
2012	1080	1009	943	879	817	757	703	652	605	563	522	483	444	407	379	353	331	311	293	277	269	255	245	232	226	216	206	193	180	168
2013	1083	1014	948	885	825	767	711	660	612	568	529	490	453	417	382	354	330	310	290	273	257	250	236	226	214	208	199	189	177	164
2014	1091	1017	952	890	831	775	720	668	620	574	534	496	460	425	391	358	332	309	290	272	255	240	233	221	211	200	194	185	176	164
2015	1098	1024	955	894	836	780	728	676	627	582	539	501	466	432	399	367	336	312	290	272	254	239	225	218	206	197	186	180	172	164
2016	1106	1031	962	897	840	784	733	683	635	589	546	506	470	437	405	374	344	315	292	272	254	238	223	210	204	192	184	174	168	161

Female numbers at age: 30-60+

Yr	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Init	194	182	171	160	151	141	133	125	117	110	103	97	91	85	80	75	71	66	62	59	55	52	48	45	43	40	38	35	33	31	479
1950	194	182	171	160	151	141	133	125	117	110	103	97	91	85	80	75	71	66	62	59	55	52	48	45	43	40	38	35	33	31	479
1951	193	182	171	160	150	141	132	124	117	110	103	97	91	85	80	75	70	66	62	58	55	51	48	45	43	40	38	35	33	31	477
1952	193	181	170	160	150	141	132	124	117	109	103	96	90	85	80	75	70	66	62	58	55	51	48	45	42	40	37	35	33	31	476
1953	193	181	170	160	150	141	132	124	116	109	102	96	90	85	80	75	70	66	62	58	54	51	48	45	42	40	37	35	33	31	474
1954	193	181	170	159	150	140	132	124	116	109	102	96	90	84	79	74	70	66	62	58	54	51	48	45	42	40	37	35	33	31	472
1955	193	181	170	159	149	140	131	123	116	108	102	95	90	84	79	74	70	65	61	57	54	51	48	45	42	39	37	35	33	31	470
1956	192	181	169	159	149	140	131	123	115	108	101	95	89	84	79	74	69	65	61	57	54	50	47	44	42	39	37	35	32	30	468
1957	192	180	169	158	149	139	131	123	115	108	101	95	89	83	78	73	69	65	61	57	53	50	47	44	41	39	37	34	32	30	465
1958	192	180	169	158	148	139	130	122	114	107	101	94	88	83	78	73	68	64	60	57	53	50	47	44	41	39	36	34	32	30	461
1959	192	180	168	158	148	139	130	122	114	107	100	94	88	83	77	73	68	64	60	56	53	49	46	44	41	38	36	34	32	30	458
1960	192	179	168	158	148	138	130	121	114	107	100	94	88	82	77	72	68	63	60	56	52	49	46	43	41	38	36	34	31	30	454
1961	191	179	168	157	147	138	129	121	113	106	99	93	87	82	77	72	67	63	59	55	52	49	46	43	40	38	35	33	31	29	451
1962	191	179	168	157	147	138	129	121	113	106	99	93	87	81	76	71	67	63	59	55	52	48	45	43	40	38	35	33	31	29	447
1963	191	179	168	157	147	138	129	121	113	106	99	93	87	81	76	71	67	63	59	55	51	48	45	42	40	37	35	33	31	29	444
1964	191	179	168	157	147	138	129	120	113	105	99	92	86	81	76	71	66	62	58	55	51	48	45	42	40	37	35	33	31	29	441
1965	191	179	168	157	147	138	129	120	113	105	99	92	86	81	76	71	66	62	58	54	51	48	45	42	39	37	35	32	30	29	438
1966	191	179	168	157	147	137	129	120	112	105	98	92	86	80	75	70	66	62	58	54	51	47	44	42	39	37	34	32	30	28	434
1967	190	178	167	156	146	136	127	119	111	104	97	91	85	79	74	69	65	61	57	53	50	47	44	41	38	36	34	32	30	28	425
1968	188	175	164	153	143	134	125	116	109	102	95	89	83	77	72	67	63	59	55	52	48	45	42	40	37	35	33	31	29	27	411
1969	187	175	163	153	142	133	124	116	108	101	94	88	82	77	71	67	62	58	54	51	48	45	42	39	37	34	32	30	28	26	404
1970	187	175	163	152	142	132	123	115	107	100	93	87	81	76	71	66	61	57	54	50	47	44	41	38	36	34	31	29	28	26	395
1971	187	174	163	152	141	132	123	114	106	99	92	86	80	75	70	65	61	57	53	49	46	43	40	38	35	33	31	29	27	25	386
1972	186	174	162	151	141	131	122	113	105	98	91	85	79	74	69	64	59	55	52	48	45	42	39	37	34	32	30	28	26	25	375
1973	185	172	160	149	139	129	120	111	103	96	89	83	77	71	66	62	57	53	50	46	43	40	38	35	33	31	29	27	25	24	357
1974	184	171	158	147	136	126	117	108	100	93	86	80	74	69	64	59	55	51	47	44	41	38	36	33	31	29	27	25	24	22	336
1975	182	169	157	145	134	124	114	106	98	90	83	77	71	66	61	57	52	49	45	42	39	36	34	31	29	27	26	24	22	21	314
1976	181	168	155	144	133	122	113	104	96	88	81	75	69	64	59	55	51	47	43	40	37	35	32	30	28	26	24	23	21	20	297
1977	181	167	154	142	131	121	111	102	94	86	80	73	67	62	57	53	49	45	42	39	36	33	31	29	27	25	23	21	20	19	280
1978	180	166	153	141	130	120	110	101	92	85	78	71	66	60	55	51	47	43	40	37	34	32	29	27	25	24	22	20	19	18	264
1979	178	164	151	139	128	117	107	98	90	82	75	69	63	58	53	49	45	41	38	35	32	30	28	26	24	22	20	19	18	16	244
1980	176	162	149	137	125	114	104	95	87	79	72	66	60	55	50	46	42	38	35	32	30	28	25	24	22	20	19	17	16	15	222
1981	174	159	146	133	122	111	101	91	83	75	68	62	56	51	47	43	39	35	32	30	27	25	23	21	20	18	17	16	15	13	197
1982	171	157	144	131	119	108	98	89	80	72	65	59	54	48	44	40	36	33	30	28	25	23	21	20	18	17	15	14	13	12	177
1983	167	152	138	125	113	102	92	83	75	67	60	54	49	44	40	36	33	29	27	24	22	20	19	17	16	14	13	12	11	11	151
1984	162	147	134	121	109	98	88	79	71	63	57	51	45	41	37	33	30	27	24	22	20	18	17	15	14	13	12	11	10	9	131
1985	163	148	134	121	109	98	87	78	70	62	56	50	44	40	35	32	29	26	23	21	19	17	16	14	13	12	11	10	9	9	121
1986	161	145	131	118	106	95	85	75	67	60	53	47	42	37	33	30	26	24	21	19	17	16	14	13	12	11	10	9	8	8	106
1987	151	136	122	108	96	85	75	67	59	52	45	40	35	31	27	24	21	19	17	15	14	12	11	10	9	8	8	7	6	6	79
1988	144	128	113	100	88	77	67	59	51	44	39	34	29	26	22	20	17	15	13	12	11	9	8	8	7	6	6	5	5	4	58
1989	132	116	101	88	76	66	57	49	42	36	31	27	23	20	17	15	13	11	10	9	8	7	6	5	5	4	4	4	3	3	39
1990	130	114	99	85	73	63	54	46	39	33	28	24	21	18	15	13	11	10	8	7	7	6	5	5	4	4	3	3	3	2	31
1991	125	108	93	80	68	58	49	41	35	29	25	21	18	15	13	11	9	8	7	6	5	4	4	3	3	3	2	2	2	2	23
1992	124	107	92	78	66	56	47	39	33	27	23	19	16	13	11	9	8	7	6	5	4	4	3	3	3	2	2	2	2	1	18
1993	115	98	83	70	58	48	40	33	27	22	18	15	12	10	9	7	6	5	4	4	3	3	2	2	2	2	1	1	1	1	11
1994	116	99	83	70	58	48	39	32	26	21	17	14	12	9	8	6	5	4	4	3	3	2	2	2	1	1	1	1	1	1	9
1995	118	100	84	70	58	48	39	32	26	21	17	14	11	9	7	6	5	4	3	3	2	2	2	1	1	1	1	1	1	1	7

1996	119	101	85	71	59	48	39	32	26	21	17	13	11	9	7	6	5	4	3	3	2	2	1	1	1	1	1	1	1	1	6
1997	120	103	86	72	59	49	39	32	26	20	16	13	10	8	7	5	4	3	3	2	2	2	1	1	1	1	1	1	1	0	5
1998	123	106	90	75	62	51	41	33	27	21	17	14	11	9	7	5	4	4	3	2	2	2	1	1	1	1	1	1	0	0	4
1999	128	110	94	79	66	54	44	36	29	23	18	14	11	9	7	6	5	4	3	2	2	2	1	1	1	1	1	1	0	0	4
2000	136	119	102	87	73	61	50	41	33	26	21	17	13	11	8	7	5	4	3	3	2	2	1	1	1	1	1	1	1	0	4
2001	143	126	109	94	80	67	56	46	37	30	24	19	15	12	10	8	6	5	4	3	2	2	2	1	1	1	1	1	1	0	4
2002	148	131	115	100	85	72	61	50	41	34	27	22	17	14	11	9	7	5	4	3	3	2	2	1	1	1	1	1	1	0	4
###	151	135	119	104	90	77	66	55	46	37	31	25	20	16	13	10	8	6	5	4	3	2	2	2	1	1	1	1	1	1	4
###	152	137	122	108	94	81	70	59	49	41	33	27	22	18	14	11	9	7	6	4	3	3	2	2	1	1	1	1	1	1	4
###	154	139	125	111	98	85	74	63	53	45	37	30	25	20	16	13	10	8	6	5	4	3	2	2	2	1	1	1	1	1	4
###	156	142	128	115	103	90	79	68	58	49	41	34	28	23	18	15	12	9	7	6	5	4	3	2	2	1	1	1	1	1	4
###	158	144	131	118	106	94	83	72	62	53	45	38	31	26	21	17	13	11	8	7	5	4	3	3	2	2	1	1	1	1	5
###	160	147	134	122	110	99	88	77	67	58	49	42	35	29	24	19	16	12	10	8	6	5	4	3	2	2	2	1	1	1	5
###	161	149	136	125	113	102	91	81	71	62	54	46	39	32	27	22	18	14	11	9	7	6	5	4	3	2	2	1	1	1	5
2010	160	148	137	125	114	103	93	83	74	65	57	49	42	35	29	24	20	16	13	10	8	7	5	4	3	3	2	2	1	1	6
2011	159	147	136	125	114	104	94	85	76	67	59	51	44	38	32	27	22	18	15	12	9	7	6	5	4	3	2	2	1	1	6
2012	157	146	135	124	114	104	95	86	77	69	61	54	47	40	34	29	24	20	16	13	11	9	7	5	4	3	3	2	2	1	7
2013	153	143	133	123	113	104	95	86	78	70	62	55	48	42	36	31	26	22	18	15	12	10	8	6	5	4	3	2	2	2	7
2014	153	142	133	123	114	105	96	88	80	72	65	58	51	45	39	33	29	24	20	17	14	11	9	7	6	4	4	3	2	2	8
2015	153	142	132	123	114	105	97	89	81	74	67	60	53	47	41	36	31	26	22	19	15	13	10	8	7	5	4	3	3	2	9
2016	153	143	132	123	115	106	98	90	83	76	69	62	56	50	44	39	34	29	25	21	17	14	12	9	8	6	5	4	3	2	10

Male numbers at age 0- 29

Yr	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Init	1282	1201	1126	1055	988	926	868	813	762	714	669	627	588	551	516	484	453	425	398	373	349	327	307	287	269	252	237	222	208	195
1950	1282	1201	1126	1055	988	926	868	813	762	714	669	627	588	551	516	484	453	425	398	373	349	327	307	287	269	252	237	222	208	195
1951	1282	1201	1126	1055	988	926	868	813	762	714	669	627	588	551	516	484	453	425	398	373	349	327	307	287	269	252	236	222	208	195
1952	1281	1201	1126	1055	988	926	868	813	762	714	669	627	588	551	516	484	453	425	398	373	349	327	307	287	269	252	236	221	207	194
1953	1281	1201	1125	1055	988	926	868	813	762	714	669	627	588	551	516	483	453	425	398	373	349	327	307	287	269	252	236	221	207	194
1954	1281	1200	1125	1055	988	926	868	813	762	714	669	627	588	551	516	483	453	425	398	373	349	327	306	287	269	252	236	221	207	194
1955	1280	1200	1125	1054	988	926	868	813	762	714	669	627	588	551	516	483	453	424	398	373	349	327	306	287	269	252	236	221	207	194
1956	1280	1200	1124	1054	988	926	868	813	762	714	669	627	588	551	516	483	453	424	398	373	349	327	306	287	269	252	236	221	207	194
1957	1279	1199	1124	1054	988	926	868	813	762	714	669	627	588	551	516	483	453	424	398	373	349	327	306	287	269	252	236	221	207	193
1958	1278	1199	1124	1053	987	926	867	813	762	714	669	627	588	551	516	483	453	424	398	373	349	327	306	287	269	252	236	221	206	193
1959	1278	1198	1123	1053	987	925	867	813	762	714	669	627	588	551	516	483	453	424	398	373	349	327	306	287	269	251	235	220	206	193
1960	1277	1197	1123	1052	987	925	867	813	762	714	669	627	588	551	516	483	453	424	398	373	349	327	306	287	269	251	235	220	206	193
1961	1276	1197	1122	1052	986	925	867	812	762	714	669	627	588	551	516	483	453	424	398	373	349	327	306	287	269	251	235	220	206	193
1962	1276	1196	1121	1051	986	924	866	812	761	714	669	627	588	551	516	483	453	424	398	373	349	327	306	287	269	251	235	220	206	193
1963	1275	1195	1121	1051	985	924	866	812	761	713	669	627	587	551	516	483	453	424	398	373	349	327	306	287	269	251	235	220	206	193
1964	1275	1195	1120	1050	985	923	866	811	761	713	668	627	587	550	516	483	453	425	398	373	349	327	306	287	269	252	235	220	206	193
1965	1274	1194	1120	1050	984	923	865	811	760	713	668	626	587	550	516	483	453	425	398	373	349	327	306	287	269	252	235	220	206	193
1966	1274	1194	1119	1049	984	922	865	811	760	713	668	626	587	550	516	483	453	425	398	373	349	327	306	287	269	252	236	220	206	193
1967	1272	1193	1119	1049	983	922	864	810	760	712	668	626	587	550	516	483	453	424	398	372	349	327	306	286	268	251	235	220	205	192
1968	1268	1192	1118	1048	983	921	864	810	759	712	667	626	587	550	515	483	452	424	397	372	348	326	305	285	266	249	233	218	203	190
1969	1267	1188	1117	1048	982	921	863	809	759	711	667	625	586	550	515	483	452	424	397	372	348	326	305	285	266	249	233	217	203	190
1970	1265	1187	1114	1046	982	921	863	809	758	711	667	625	586	549	515	483	452	424	397	372	348	326	305	285	266	249	233	217	203	189
1971	1263	1185	1112	1043	981	920	863	809	758	711	666	625	586	549	515	483	452	424	397	372	348	326	305	285	267	249	233	217	203	189
1972	1261	1184	1111	1042	978	919	862	808	758	710	666	624	585	549	515	482	452	424	397	372	348	326	305	285	267	249	233	217	203	189
1973	1256	1181	1109	1041	977	916	861	808	758	710	666	624	585	549	514	482	452	424	397	372	348	326	305	285	266	249	232	217	202	188
1974	1250	1177	1107	1039	975	915	859	807	757	710	665	624	585	548	514	482	452	423	397	372	348	326	305	285	266	248	232	216	201	187
1975	1244	1172	1103	1037	974	914	858	805	756	710	665	624	585	548	514	482	451	423	396	371	348	325	304	284	266	248	231	215	201	187
1976	1239	1166	1098	1033	972	913	856	804	754	708	665	623	584	548	513	481	451	423	396	371	347	325	304	284	265	248	231	215	200	186
1977	1234	1161	1093	1029	968	911	855	802	753	706	664	623	584	547	513	481	451	423	396	371	347	325	304	284	265	247	231	215	200	185
1978	1229	1156	1088	1024	964	907	854	801	752	706	662	622	584	547	513	481	451	422	396	371	347	325	304	284	265	247	230	214	199	185
1979	1222	1152	1084	1020	959	903	850	800	751	705	661	620	583	547	513	481	450	422	395	370	346	324	303	283	264	246	229	213	198	183
1980	1212	1145	1079	1015	956	899	847	797	749	704	660	620	581	546	513	480	450	422	395	370	346	324	302	282	263	245	228	212	197	182
1981	1201	1136	1073	1011	951	895	842	793	747	702	659	619	581	545	512	480	450	421	395	369	345	323	302	281	262	244	227	210	195	180
1982	1191	1125	1065	1005	948	892	839	789	743	700	658	618	580	544	510	479	450	421	394	369	345	322	301	281	261	243	226	209	193	179
1983	1174	1116	1055	998	942	888	835	786	740	697	656	617	579	543	510	478	449	421	394	368	344	321	299	279	259	240	223	206	190	175
1984	1159	1100	1046	988	935	883	832	783	737	693	653	614	578	542	509	477	447	419	392	367	342	319	297	276	256	237	219	202	186	171
1985	1153	1086	1031	980	926	876	827	780	734	690	650	612	576	541	508	476	447	418	392	367	343	319	297	276	257	238	220	203	186	171
1986	1141	1080	1018	966	918	868	821	775	731	687	647	609	573	539	507	476	446	418	391	366	342	319	297	276	256	237	218	201	185	169
1987	1108	1069	1012	954	905	860	813	769	726	685	644	606	570	537	505	474	445	416	390	364	340	316	294	272	251	232	213	195	178	162
1988	1074	1038	1001	949	894	848	806	762	721	681	642	604	568	534	503	473	444	416	389	363	338	315	292	270	249	228	209	191	173	157
1989	1027	1006	973	938	889	837	795	756	714	675	638	601	565	532	500	470	441	414	386	360	334	310	287	264	242	221	201	182	164	147
1990	1009	963	943	912	879	833	785	745	708	669	633	597	563	530	498	468	440	412	386	359	334	310	286	263	241	220	200	180	162	145
1991	980	945	902	883	854	824	781	735	698	663	627	593	560	527	496	466	437	410	384	358	332	307	283	260	238	217	196	176	158	140
1992	965	919	886	845	828	800	772	732	689	654	622	587	556	524	494	464	436	408	382	357	332	308	284	260	238	217	196	176	157	140
1993	927	904	861	830	792	776	750	724	685	646	613	582	550	520	491	462	433	406	379	354	329	304	280	256	233	211	190	170	150	133
1994	919	868	847	807	778	742	727	703	678	642	605	574	546	515	487	459	432	405	379	353	329	305	281	257	234	212	191	170	151	133
1995	914	861	814	794	756	729	695	681	659	635	602	567	538	511	483	456	429	403	377	352	328	304	281	258	235	213	192	171	152	134
1996	912	856	807	763	744	708	683	652	638	617	595	564	531	504	479	452	426	401	376	351	327	303	281	258	236	214	193	172	153	135
1997	910	854	802	756	715	697	664	640	611	598	578	558	528	497	472	448	422	398	374	350	326	302	279	257	235	214	193	173	153	135
1998	916	853	801	752	708	670	653	622	600	572	560	542	523	495	466	442	419	394	371	348	325	302	279	257	236	215	194	174	155	137

1999	925	858	799	750	704	664	627	612	583	562	536	525	508	490	463	436	413	391	368	346	324	302	279	258	237	216	196	177	158	140
2000	947	867	804	749	703	660	622	588	574	546	527	502	492	476	459	434	408	387	366	345	324	303	282	261	241	221	202	183	165	147
2001	965	887	812	754	701	659	619	583	551	538	512	493	471	461	445	429	406	382	362	342	322	302	282	262	242	223	205	187	169	152
2002	980	904	831	761	706	657	617	580	546	516	504	479	462	441	431	417	401	380	356	337	319	299	280	261	243	224	206	188	172	155
2003	993	918	847	779	713	662	616	579	543	512	484	472	449	433	412	403	389	375	354	332	313	296	277	259	241	224	206	189	173	157
2004	1002	930	860	794	730	668	620	577	542	509	479	453	442	420	405	385	377	363	349	329	308	290	273	255	238	222	205	188	173	157
2005	1013	939	872	806	744	684	626	581	541	508	477	449	424	414	393	378	360	351	338	325	306	286	269	253	236	220	204	188	173	158
2006	1026	949	880	817	755	697	641	587	544	507	476	447	421	397	387	368	354	337	328	316	303	285	266	250	235	219	204	189	174	160
2007	1038	961	889	824	765	708	653	601	550	510	475	446	418	394	372	362	344	331	314	306	295	282	265	247	232	218	203	189	175	161
2008	1051	972	901	833	772	717	663	612	563	515	478	445	418	392	369	348	339	322	310	294	286	275	264	248	231	217	203	189	176	163
2009	1062	985	911	844	781	724	672	622	574	527	483	448	417	391	367	345	326	317	301	289	275	267	257	246	231	215	202	189	176	163
2010	1069	995	923	854	791	732	678	630	582	538	494	452	420	390	366	344	323	305	297	281	270	256	249	239	228	214	199	186	174	162
2011	1075	1002	932	865	800	741	686	636	590	546	504	463	424	393	365	343	321	302	284	276	262	251	238	231	221	211	197	183	172	160
2012	1080	1007	939	874	810	750	695	642	596	553	511	472	434	397	368	342	320	300	282	265	257	244	233	221	214	205	195	182	169	158
2013	1083	1012	944	880	819	759	703	651	602	558	518	479	442	406	371	343	319	298	279	261	246	238	225	215	203	196	188	178	167	154
2014	1091	1015	949	885	824	767	712	658	610	564	523	485	449	414	380	347	321	298	279	261	244	229	222	209	200	189	183	174	166	155
2015	1098	1022	951	889	829	772	719	667	617	571	529	490	455	420	387	356	325	300	279	260	243	228	214	207	195	186	176	170	162	154
2016	1106	1029	958	891	833	777	724	674	625	578	535	495	459	426	393	363	333	304	281	260	243	227	213	199	193	182	174	164	158	151

Male numbers at age: 30-60+

Yr	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Init	182	171	160	150	141	132	123	116	108	102	95	89	84	78	73	69	64	60	57	53	50	47	44	41	38	36	34	32	30	28	412
1950	182	171	160	150	141	132	123	116	108	102	95	89	84	78	73	69	64	60	57	53	50	47	44	41	38	36	34	32	30	28	412
1951	182	171	160	150	140	132	123	116	108	101	95	89	83	78	73	69	64	60	56	53	50	46	44	41	38	36	34	31	29	28	411
1952	182	171	160	150	140	131	123	115	108	101	95	89	83	78	73	68	64	60	56	53	49	46	43	41	38	36	33	31	29	28	410
1953	182	170	160	150	140	131	123	115	108	101	95	89	83	78	73	68	64	60	56	53	49	46	43	41	38	36	33	31	29	27	408
1954	182	170	159	149	140	131	123	115	108	101	94	88	83	78	73	68	64	60	56	52	49	46	43	40	38	35	33	31	29	27	407
1955	181	170	159	149	140	131	122	115	107	101	94	88	83	77	72	68	64	60	56	52	49	46	43	40	38	35	33	31	29	27	405
1956	181	170	159	149	139	131	122	114	107	100	94	88	82	77	72	68	63	59	56	52	49	46	43	40	38	35	33	31	29	27	403
1957	181	170	159	149	139	130	122	114	107	100	94	88	82	77	72	67	63	59	55	52	48	45	43	40	37	35	33	31	29	27	400
1958	181	169	159	148	139	130	122	114	107	100	93	87	82	77	72	67	63	59	55	52	48	45	42	40	37	35	33	30	29	27	398
1959	181	169	158	148	139	130	121	114	106	99	93	87	81	76	71	67	62	58	55	51	48	45	42	39	37	35	32	30	28	27	395
1960	181	169	158	148	138	129	121	113	106	99	93	87	81	76	71	66	62	58	54	51	48	45	42	39	37	34	32	30	28	26	392
1961	180	169	158	148	138	129	121	113	106	99	92	86	81	76	71	66	62	58	54	51	47	44	42	39	36	34	32	30	28	26	389
1962	180	169	158	148	138	129	121	113	106	99	92	86	81	75	70	66	62	58	54	50	47	44	41	39	36	34	32	30	28	26	386
1963	180	169	158	148	138	129	121	113	105	99	92	86	81	75	70	66	62	58	54	50	47	44	41	39	36	34	32	30	28	26	384
1964	180	169	158	148	138	129	121	113	105	98	92	86	80	75	70	66	61	57	54	50	47	44	41	38	36	34	31	29	27	26	381
1965	181	169	158	148	138	129	120	113	105	98	92	86	80	75	70	65	61	57	53	50	47	44	41	38	36	33	31	29	27	26	379
1966	180	169	158	148	138	129	120	112	105	98	92	86	80	75	70	65	61	57	53	50	46	43	41	38	35	33	31	29	27	25	376
1967	180	168	157	147	137	128	119	112	104	97	91	85	79	74	69	64	60	56	52	49	46	43	40	37	35	33	31	29	27	25	369
1968	177	166	155	144	135	126	117	109	102	95	89	83	77	72	67	63	59	55	51	48	44	42	39	36	34	32	30	28	26	24	356
1969	177	165	154	144	134	125	117	109	101	95	88	82	77	71	67	62	58	54	50	47	44	41	38	36	33	31	29	27	26	24	351
1970	177	165	154	143	134	125	116	108	101	94	88	82	76	71	66	61	57	53	50	46	43	40	38	35	33	31	29	27	25	23	344
1971	177	165	154	143	133	124	116	108	100	93	87	81	75	70	65	61	57	53	49	46	43	40	37	35	32	30	28	26	25	23	336
1972	176	164	153	143	133	124	115	107	100	93	86	80	75	69	65	60	56	52	48	45	42	39	36	34	32	30	28	26	24	22	328
1973	176	163	152	141	132	122	114	106	98	91	85	79	73	68	63	58	54	50	47	44	41	38	35	33	30	28	26	25	23	21	313
1974	174	162	151	140	130	121	112	104	96	89	83	77	71	66	61	57	52	49	45	42	39	36	34	31	29	27	25	24	22	20	296
1975	173	161	149	139	128	119	110	102	94	87	81	75	69	64	59	55	51	47	43	40	37	35	32	30	28	26	24	22	21	19	278
1976	173	160	149	138	127	118	109	101	93	86	79	73	68	62	58	53	49	46	42	39	36	33	31	29	27	25	23	21	20	18	264
1977	172	159	148	137	126	117	108	99	92	84	78	72	66	61	56	52	48	44	41	38	35	32	30	28	26	24	22	20	19	18	250
1978	171	159	147	136	125	116	107	98	91	83	77	71	65	60	55	51	47	43	40	36	34	31	29	26	25	23	21	19	18	17	237
1979	170	157	145	134	123	114	105	96	88	81	75	68	63	58	53	49	45	41	38	35	32	29	27	25	23	21	20	18	17	16	220
1980	169	156	144	132	122	112	103	94	86	79	72	66	61	55	51	46	43	39	36	33	30	28	25	23	22	20	18	17	16	15	202
1981	166	153	141	130	119	109	100	91	83	76	69	63	58	53	48	44	40	37	33	31	28	26	23	22	20	18	17	15	14	13	181
1982	165	152	139	128	117	107	97	89	81	74	67	61	55	50	46	42	38	35	31	29	26	24	22	20	18	17	15	14	13	12	164
1983	161	147	135	123	112	102	93	85	77	69	63	57	52	47	42	38	35	31	29	26	24	21	20	18	16	15	14	13	11	11	141
1984	157	143	131	119	108	98	89	81	73	66	59	54	48	44	39	35	32	29	26	24	21	19	18	16	15	13	12	11	10	9	124
1985	157	143	131	119	108	98	89	80	72	65	59	53	47	43	38	35	31	28	25	23	21	19	17	15	14	13	12	11	10	9	115
1986	155	141	129	117	106	96	86	78	70	63	56	51	45	41	36	33	29	26	24	21	19	17	16	14	13	12	10	10	9	8	101
1987	148	134	121	109	98	88	79	70	63	56	50	44	39	35	31	28	25	22	20	18	16	14	13	11	10	9	8	8	7	6	78
1988	142	128	115	103	91	81	72	64	57	50	44	39	34	30	27	23	21	18	16	14	13	11	10	9	8	7	6	6	5	5	58
1989	132	117	104	92	81	72	63	55	48	42	37	32	28	24	21	18	16	14	12	11	10	8	7	7	6	5	5	4	4	3	40
1990	129	115	102	90	79	69	60	52	45	39	34	30	26	22	19	17	14	13	11	10	8	7	6	6	5	4	4	4	3	3	32
1991	124	110	96	84	74	64	55	48	41	35	30	26	22	19	17	14	12	11	9	8	7	6	5	5	4	4	3	3	2	2	24
1992	123	108	95	83	72	62	53	46	39	33	29	24	21	18	15	13	11	9	8	7	6	5	4	4	3	3	3	2	2	2	19
1993	116	101	88	75	65	55	47	40	34	28	24	20	17	14	12	10	9	7	6	5	4	4	3	3	2	2	2	2	1	1	13
1994	116	101	87	75	64	55	46	39	33	27	23	19	16	13	11	9	8	7	6	5	4	3	3	2	2	2	2	1	1	1	10
1995	117	102	88	75	64	54	46	38	32	27	22	19	15	13	11	9	7	6	5	4	4	3	3	2	2	2	1	1	1	1	8
1996	118	102	88	76	64	54	46	38	32	26	22	18	15	12	10	8	7	6	5	4	3	3	2	2	2	1	1	1	1	1	7
1997	118	103	89	76	64	54	46	38	32	26	22	18	15	12	10	8	7	5	5	4	3	3	2	2	2	1	1	1	1	1	6
1998	120	105	91	78	66	56	47	39	33	27	22	18	15	12	10	8	7	6	5	4	3	3	2	2	1	1	1	1	1	1	5

1999	123	108	94	80	69	58	49	41	34	28	23	19	16	13	10	9	7	6	5	4	3	3	2	2	1	1	1	1	1	1	5
###	130	115	100	87	74	63	54	45	38	31	26	21	18	14	12	10	8	6	5	4	4	3	2	2	2	1	1	1	1	1	5
2001	136	120	105	92	80	68	58	49	41	35	29	24	20	16	13	11	9	7	6	5	4	3	3	2	2	1	1	1	1	1	5
###	139	124	110	96	84	72	62	53	45	37	31	26	21	18	14	12	10	8	6	5	4	4	3	2	2	2	1	1	1	1	5
###	142	127	113	100	87	76	66	56	48	40	34	28	23	19	16	13	11	9	7	6	5	4	3	3	2	2	1	1	1	1	6
###	143	129	115	102	90	79	68	59	50	43	36	30	25	21	17	14	12	9	8	6	5	4	3	3	2	2	2	1	1	1	6
###	144	130	117	105	93	82	71	62	53	46	39	33	27	23	19	16	13	10	9	7	6	5	4	3	3	2	2	1	1	1	6
###	146	133	120	108	97	85	75	66	57	49	42	35	30	25	21	17	14	12	10	8	6	5	4	3	3	2	2	2	1	1	6
###	148	135	122	111	100	89	79	69	60	52	45	38	33	27	23	19	16	13	11	9	7	6	5	4	3	3	2	2	1	1	7
###	150	137	125	114	103	92	82	73	64	56	48	42	36	30	25	21	18	15	12	10	8	7	5	4	4	3	2	2	2	1	7
###	151	139	127	116	105	95	85	76	67	59	52	45	38	33	28	23	20	16	13	11	9	7	6	5	4	3	3	2	2	1	8
2010	150	139	128	117	106	96	87	78	69	61	54	47	41	35	30	25	21	18	15	12	10	8	7	6	5	4	3	2	2	2	8
2011	149	138	127	117	107	97	88	79	71	63	56	49	43	37	32	27	23	19	16	13	11	9	7	6	5	4	3	3	2	2	9
2012	147	137	126	116	107	97	88	80	72	65	57	51	44	39	33	29	24	21	17	15	12	10	8	7	6	5	4	3	2	2	10
2013	144	134	124	115	106	97	88	80	72	65	58	52	46	40	35	30	26	22	19	16	13	11	9	7	6	5	4	3	3	2	11
2014	143	133	124	115	106	98	90	82	74	67	60	54	48	42	37	32	28	24	20	17	14	12	10	8	7	6	5	4	3	2	12
2015	143	133	124	115	107	98	90	83	75	68	62	56	50	44	39	34	30	26	22	19	16	13	11	9	8	6	5	4	3	3	13
2016	143	134	124	115	107	99	92	84	77	70	64	58	52	46	41	36	32	28	24	20	17	15	12	10	9	7	6	5	4	3	15