Status of the U.S. Pacific Sanddab Resource in 2013

by

Xi He[1], Donald E. Pearson[1], John C. Field[1], Lyndsey Lefebvre[1] and Meisha Key[2]

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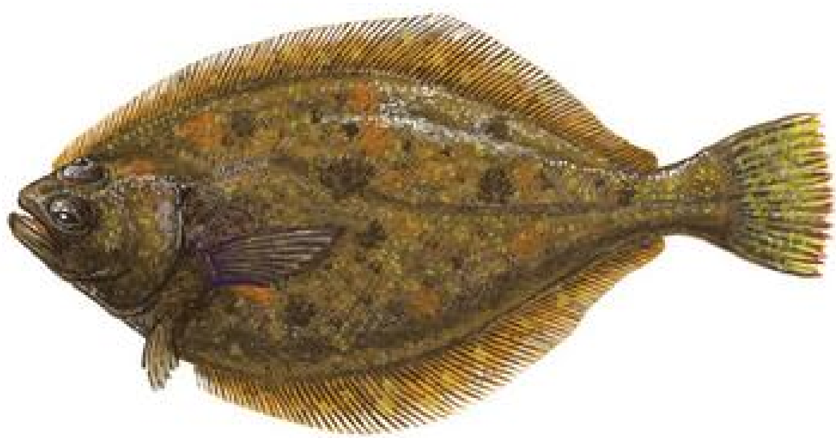
[1]Fisheries Ecology Division
Southwest Fisheries Science Center
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
110 Shaffer Road
Santa Cruz, CA 95060

xi.he@noaa.gov

[2]Meisha Key
California Department of Fish and Wildlife
c/o[1]



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Executive Summary

Stock

Pacific sanddab (*Citharichthys sordidus*) is a left-eyed flounder of the family Paralichthyidae and is widely distributed along the Pacific west coast from the Bering Sea to Cabo San Lucas, at the tip of Baja California. This assessment reports the stock status off the coast of California, Oregon, and Washington, and it is the first time that the stock is being assessed. The stock is considered a single stock as there are no genetic studies or other evidences of stock structure along the U.S. coast.

Catches

Although Pacific sanddab has not historically been a primary target in commercial fisheries, it has been commonly caught, mostly by bottom trawl gears. The earliest reported catch was recorded in 1892. Total landings were close to 1,200mt in the late 1910s (Figure a). Landings were at relative low levels (~400mt) between the late 1930s and the early 1970s, with an increasing trend from the early 1970s to the late 1990s. Since then, landings have been declining and total landings in recent years were around 200 mt (Table a). Discards of Pacific sanddab were generally high, primarily due to its small size, but larger sanddabs are highly prized by the commercial and recreational fisheries for their excellent edibility.

Recreational landings, mostly taken by hook and line, were at the highest levels in the early 1980s (just over 20 0mt), ranging between 20 mt and 80 mt in recent years. Recreational landings averaged about 7% of total landings between 1981 and 2012, but increased to 30% in recent years (2010 to 2012 average).

Table a. Annual total landed catches (mt) of Pacific sanddab from 2003 to 2012.

Year	Total landings (mt)
2003	650.6
2004	523.2
2005	398.3
2006	440.6
2007	315.3
2008	229.1
2009	326.7
2010	198.0
2011	235.7
2012	221.8

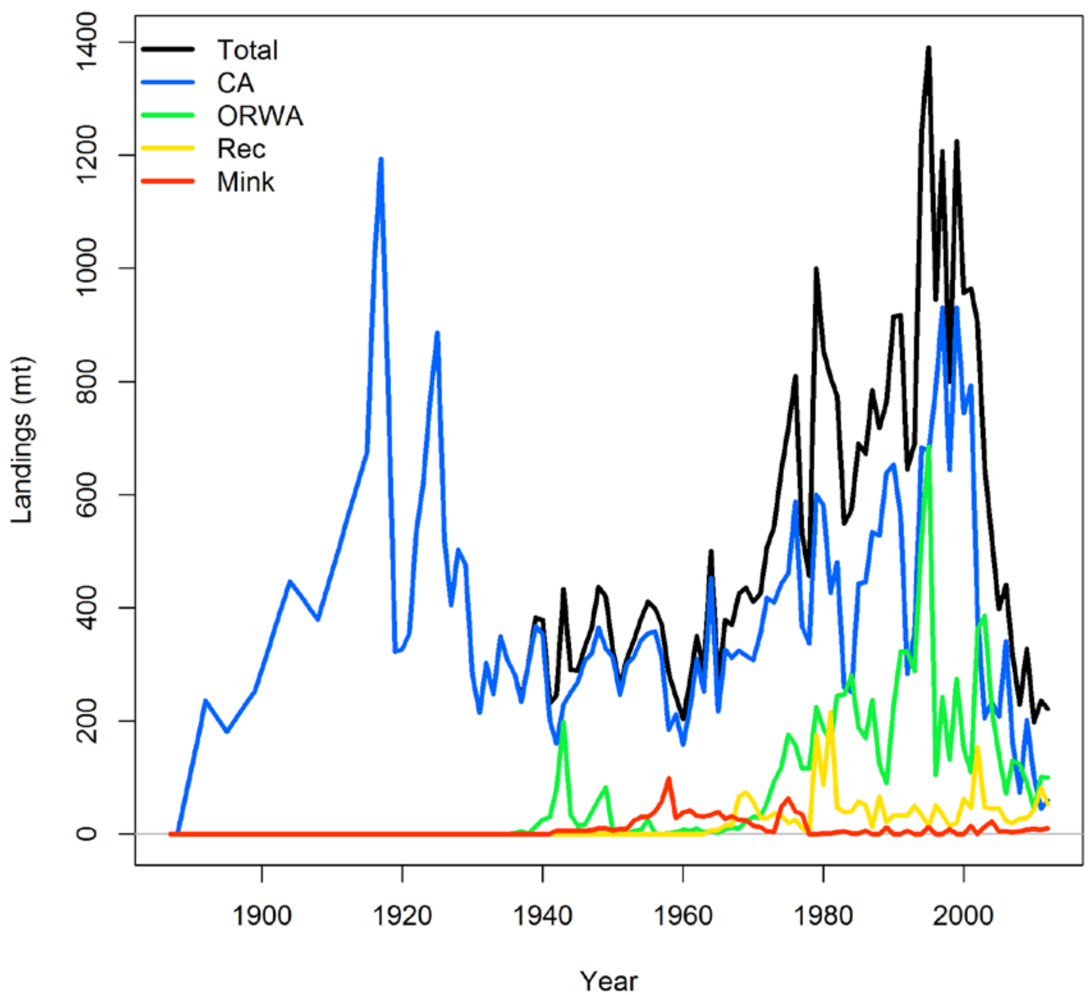

Figure a: Time series of total landings and landings by four fleets catching Pacific sanddab from 1888 to 2012.

Data and assessment

This is the first time that the Pacific sanddab stock has been being assessed on the U.S. West Coast. To our knowledge, no assessments have even been conducted in Alaska, Canada and Mexico. Catch data for Pacific sanddab by various fleets were assembled from a variety of sources, including published historical catch reports, the Pacific Fisheries Information Network (PacFIN), the Recreational Fisheries Information Network (RecFIN), and most recently, from the West Coast Groundfish Observer Program (WCGOP) total mortality estimates. Survey and index data included the NWFS triennial bottom trawl survey, the NWFSC bottom trawl survey, and the California Commercial Passenger Fishing Vessels (CA CPFV) fishery CPUE index. Over 12,590 otoliths from variety of sources were aged, most of which were from the NWFSC survey, which was the most comprehensive data source for estimates of growth and relative stock abundances in recent years. Length composition data were available from all surveys and from a range of years for the two commercial trawl fisheries and the recreational fishery. Estimates of fishery discards were provided by the Pikitch study in the late 1980s, and by the WCGOP observer program in recent years.

The base case assessment model assumed the stock was in an unfished condition in 1888, and subject to exploitation by the four fisheries modeled in this assessment: two commercial trawl fisheries, one recreational fishery, and one trawl fishery for mink food. Two sexes were used in the model given evidence of sexually dimorphic growth. Key parameters, including stock-recruit steepness, virgin recruitment, growth, and natural mortality, were internally estimated. Selectivity functions for all surveys and fisheries were assumed to be asymptotic and sex-specific where size composition data were available by sex.

The assessment was conducted using the most recent version of Stock Synthesis (SS, version 3.24O, April 2013). The survey indices were derived from using R programs developed by scientists from the NWFSC and SWFSC. Graphic outputs were produced using the r4ss R programs developed by the NWFSC.

Stock biomass

The time series of estimated spawning biomass from the base case assessment model is plotted in Figure b, along with approximate asymptotic 95% intervals. The recent trend in spawning biomass and stock depletion is presented in Table b. The stock was relatively stable until the mid-1990s, and then declined continuously through the mid-2000s, primarily due to low recruitments during the period (Figure c). The stock has been continuously increasing in recent years.

Table b: Recent trend in beginning of the year biomass and depletion (%).

Year	Spawning biomass (mt)	~95% confidence interval	Estimated Depletion (%)	~95% confidence interval
2004	3719	541-6897	41.5	24.7-58.4
2005	3319	357-6281	37.1	37.1-53.5
2006	3210	181-6239	35.9	18.2-53.5
2007	3281	0-6657	36.6	15.5-57.7
2008	3832	0-8048	42.8	15.1-70.5
2009	4654	0-9834	52.0	17.7-86.3
2010	5362	0-11286	59.9	20.8-99.0
2011	6277	0-12933	70.1	27.3-112.9
2012	7568	0-15412	84.5	34.7-134.4
2013	8554	128-16980	95.5	43.7-147.3

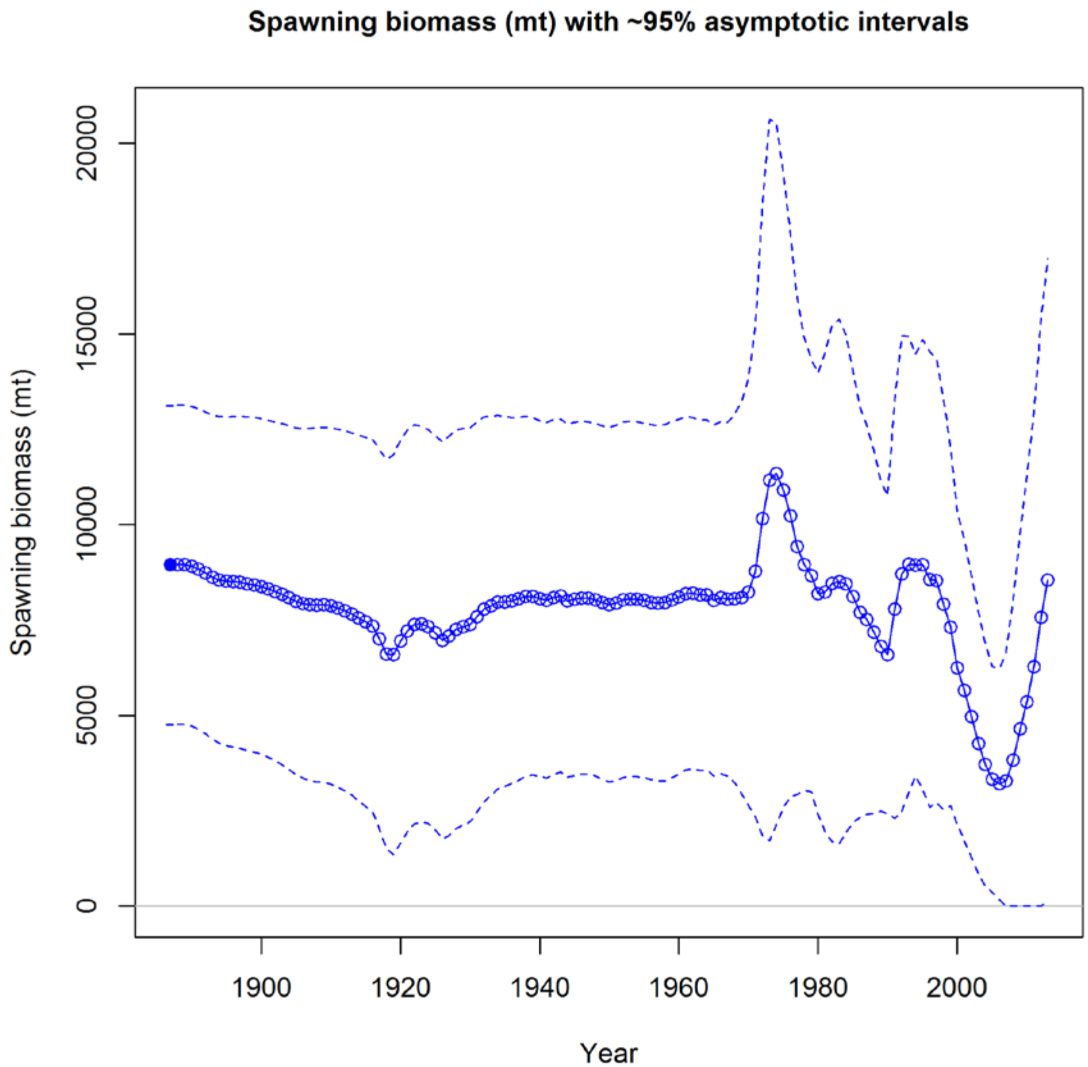

Figure b: Estimated time series of annual spawning biomass from the base model (open circle and solid line) with approximate asymptotic 95% confidence intervals (dashed lines).

Recruitment

The Beverton-Holt stock recruitment function was assumed in this assessment. Both stock-recruit parameters, virgin recruitment (R_0) and steepness (h) were estimated in the model. While there was no informative prior for R_0, a prior for h that were commonly used for flatfish species (mean = 0.80, *SD*=0.09), was used in the assessment. Annual recruitment deviations were estimated between 1966 and 2011.

Annual recruitment deviations were treated in a log-normal distribution with σ_R fixed at 0.45. Estimated recruitments for the last 11 years (2004 to 2013), along with approximate asymptotic 95% intervals, are listed in Table c, and the annual recruitments for all years are plotted in Figure

c. Low recruitments occurred from the early 2000s to the mid-2000s. Recruitments in recent years have been at or above the long term average, with a strong recruitment in 2010.

Table c. Recent trend in recruitment.

Year	Estimated recruitment (1,000s)	~95% confidence interval
2004	130606	24513-695886
2005	137966	25586-743954
2006	236307	43538-1282584
2007	233162	43338-1254442
2008	217592	41261-1147488
2009	269346	51577-1406577
2010	421590	80414-2210282
2011	263968	49184-1416690
2012	200639	37343-1078010
2013	231713	43286-1240367

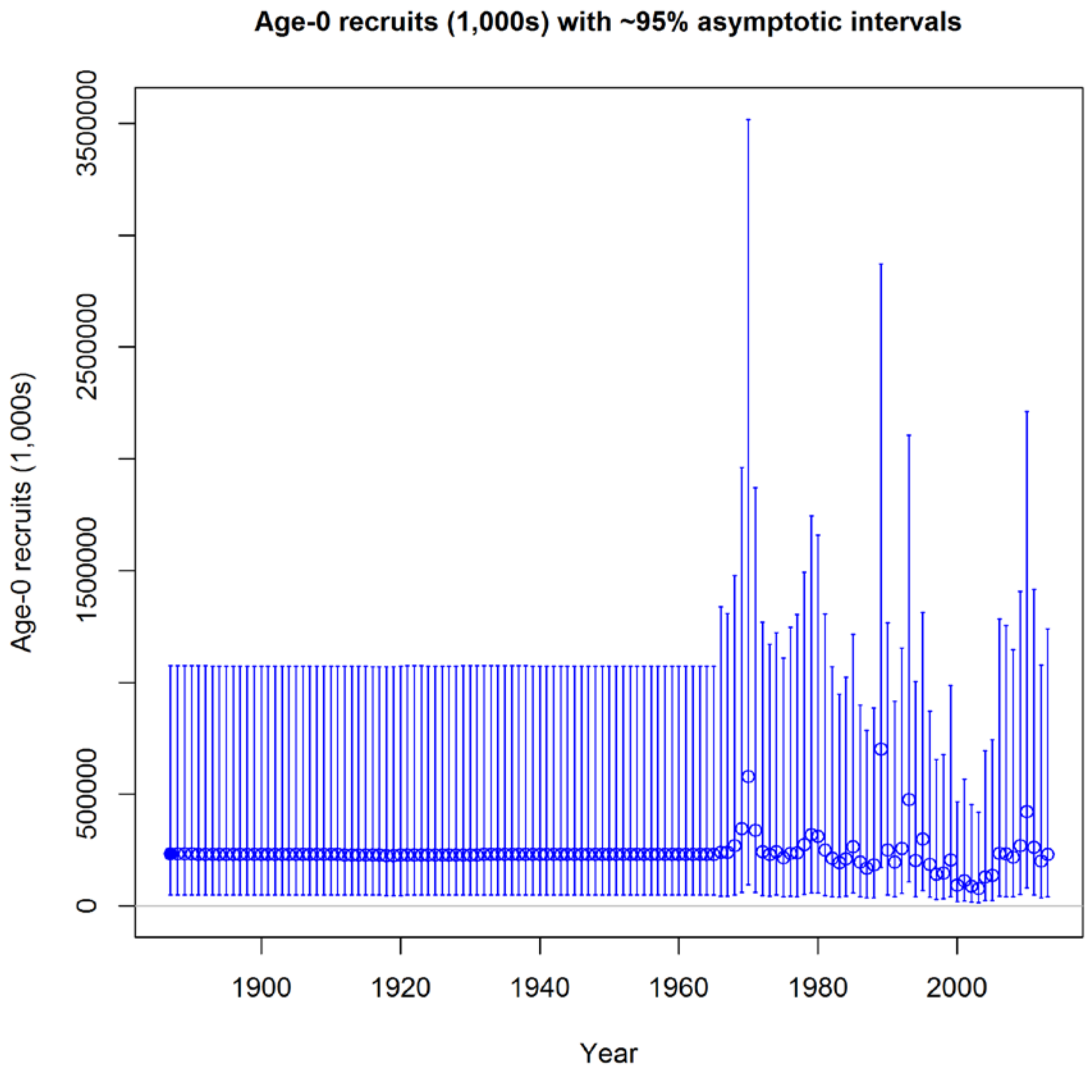

Figure c: Estimated annual recruitment and approximate asymptotic 95% intervals from the base case assessment model, 1888-2013.

Exploitation status

The stock is estimated to be at 95.5% of its unfished level at the beginning of 2013 (Table b), well above the management target for flat fish of $B_{25\%}$ (Figure d). The estimated spawning potential ratio (1-SPR) was 10.4% at the beginning of 2012, and was well below the (1-SPR) target F_{MSY} targe of 70% (Table d and Figure e). Proportional harvest rates were generally low (Table d).

The STAR Panel did not recommend the results from this assessment to be used for management as there exist large uncertainties in the scales of biomass estimates as compared to estimates from fishery-independent surveys (see the STAR Panel report for details). As such, no reference points will be reported in this assessment.

Table d. Recent trend in spawning potential ratio (entered as 1-SPR) and summary exploitation rate (catch divided by biomass of age-0 and older fish)

Year	Estimated 1-SPR (%)	~95% confidence interval	Harvest rate (proportion)	~95% confidence interval
2004	26.1	0-54.2	0.141	0.008-0.274
2005	23.2	0-50.1	0.111	0-0.222
2006	24.9	0-53.6	0.115	0-0.236
2007	22.1	0-49.2	0.080	0-0.175
2008	18.7	0-43.2	0.052	0-0.116
2009	21.6	0-48.6	0.064	0-0.141
2010	13.8	0-33.7	0.032	0-0.069
2011	12.5	0-30.2	0.028	0-0.061
2012	10.4	0-25.2	0.024	0-0.050

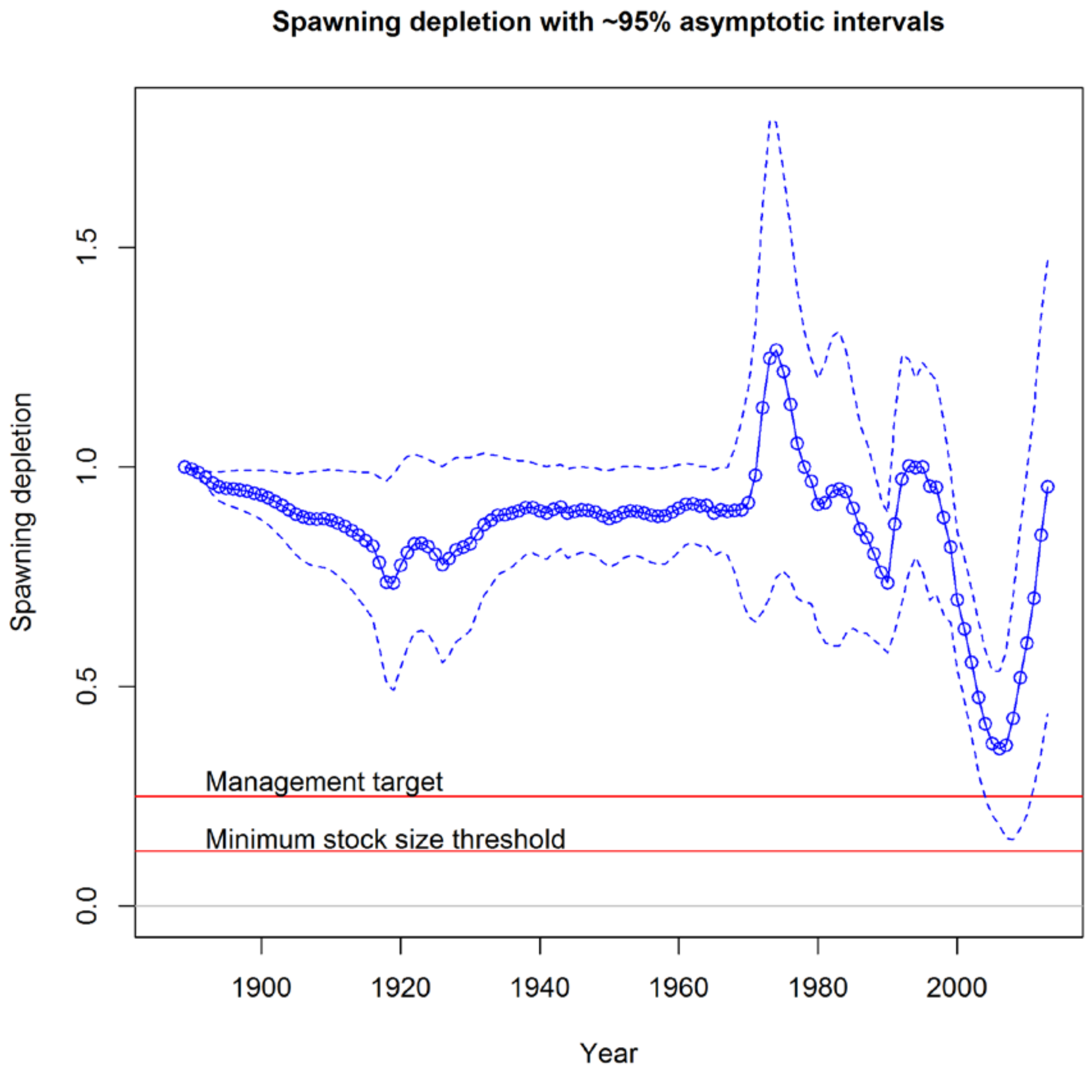

Figure d. Estimated relative depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model.

Ecosystem considerations

Pacific sanddabs play an important role in trophic interactions in the continental ecosystems along the Pacific coast, primarily because it is relatively abundant, and more importantly, it serves as trophic links among low levels of invertebrate preys and high level trophic predators. Pacific sanddabs feed on variety of benthic and pelagic invertebrates, and coastal pelagic species (e.g., northern anchovies). Many piscivorous fishes, some of which are important commercial species, feed on Pacific sanddabs. Other predators include marine mammals and sea birds. The results of this assessment will provide some baseline information for future studies on trophic interactions in ecosystem research.

Management performance

Pacific sanddabs on the west coast are managed as part of the Other Flatfish stock complex. Harvest specifications (overfishing limits (OFLs), acceptable biological catches (ABCs), and annual catch limits (ACLs)) are managed at the complex level and calculated as the sum of estimated harvest specification contributions from the component stocks, which include Pacific sanddab, rex sole, sand sole, starry flounder and four other species. Prior to 2011, the overfishing level, now called the OFL, was called the ABC and the ACL was called the optimum yield (OY). The OFLs (ABCs prior to 2011) for Pacific sanddab have been estimated using on catch-based methods. Since 2011, the method used to estimate the OFL was depletion-based stock reduction analysis (DBSRA). The ACL since 2011 was set equal to the ABC; the ABC was based on a 30.6% reduction from the OFL based on scientific uncertainty (category 3 stock with a sigma of 1.44) and the Council's tolerance of risk (overfishing probability (P*) of 0.40). From 2005-2010, the overfishing limit (then called the ABC) was based on the highest recent year (1981-2003) landed catch (1,364 mt in 1995) with an assumed discard rate of 57% based on the Oregon trawl Enhanced Data Collection Program (EDCP) study results during 1995-1997 to determine an overfishing limit of 3,172 mt (PFMC 2004). The overfishing limit contribution of Pacific sanddabs to the Other Flatfish complex was reduced by 25% to determine an annual total catch limit (then called OY) of 2,379 mt during 2005-2010 (Table f). Prior to 2005 the Other Flatfish ABC and OY (analogous to the current OFL and ACL, respectively) was 7,700 mt. The basis for these harvest specifications was not documented but is believed to have been based on average catches of the aggregate species comprising the complex in the 1970s. A contribution Pacific sanddab-based harvest specification was not calculated.

The management performance in recent years for Pacific sanddab has been good; the average 2005-2012 total annual catch has been about 23% of the ACL/OY contribution (Table f).

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

Year	OFL (mt)	ACL (mt)	Commercial Landings (mt)	Estimated Total Catch (mt)
2004	NA	NA	456.6	860
2005	3172	3172	347.3	629
2006	3172	3172	412.5	666
2007	3172	3172	292.2	512
2008	3172	3172	196.5	389
2009	3172	3172	290.7	562
2010	3172	3172	146.3	322
2011	4943	3432	1462.	339
2012	4943	3432	159.2	326
2013	4801	3332	NA	NA

Unresolved problems and major uncertainties

Uncertainties in the model structure and parameter estimations were explored through sensitivity and profile analyses. Asymptotic confidence intervals were estimated and reported for all key parameters and management quantities. Data uncertainties included historical catches and estimates of historical discard rates of Pacific sanddab from the commercial trawl fisheries, as well as lack of length and age composition data in the early years of the fisheries.

Both the NWFSC and triennial surveys provided estimates of biomass of Pacific sanddabs. These estimates were much higher than those estimated in the assessment model. Although the catchability coefficient (*Q*) was treated as a nuisance (scalar) parameter, which is typical of most assessments, the nominal estimate for these values from the trawl surveys was very high. For example, the estimated catchability coefficient was 19.4 for the NWFSC combined shelf-slope trawl survey. Given that these surveys did not cover the entirety of suitable Pacific sanddab habitat (the survey were not conducted depths shallower than 50 m), it was expected that these catchability coefficients should be less than (or close to) one. However, it was also noted that previous nominal catchability coefficients for flatfish have varied by approximately an order of magnitude (from 0.31 for Arrowtooth flounder to 3.36 for Petrale sole, with the other three species ranging from 0.7 to 1.79, arithmetic scale). This demonstrates that uncertainties in the scales of biomass estimates relative to estimates from fishery-independent surveys are frequently high, although both the STAT and the STAR Panel agreed that the scale of the discrepancies for this species exceeded the level at which confidence in the model could be achieved. A range of factors could contribute to these uncertainties, including the assumption that all areas are suitable habitat for Pacific sanddab (untrawlable areas are likely to be less suitable) and herding effects of the trawl gear (Bryan *et al*. in review). A suite of model sensitivities suggests that tensions existed in the model between conditional age-at-length data and other composition and index data that may have constrained the total biomass by influencing model estimates of natural mortality, selectivity or other factors. However, both the STAT and the STAR Panel agreed that if the biomass levels estimated by the NWFSC trawl survey are a reasonable representation of the actual biomass of Pacific sanddabs in the ecosystem, then the impacts of both historical and contemporary catches on the stock are likely to be very minimal.

Larger Pacific sanddabs have been a desirable component of the nearshore flatfish fishery for over 100 years (CDFG 1949), and the high catches of California Pacific sanddabs in the 1910s and 1920s were consistent with high effort by trawl fisheries on other components of the nearshore assemblage (such as California halibut, starry flounder and English sole). However, the species has not always been a primary target for commercial trawl fisheries, and their relatively small sizes have long been associated with high, yet highly uncertain, discard rates. Thus, as with other stocks, there are uncertainties regarding historical catches, and particularly historical discard rates. Sensitivity analyses were conducted to assess these uncertainties.

Reliable length and age composition data for Pacific sanddab were only available in recent years, most of which came from the NWFSC survey. As these data provided critical information in the assessment model for estimating growth, natural mortality, and the stock-recruitment relationship, it is uncertain whether estimates based on recent year data represent stock dynamics in the early years. A comparison of maturity estimates from recent data with one study conducted in the 1950s suggests that the size at 50% maturity has shifted substantially (approximately 6 cm) to the left, such that a majority of 1 year old fish are reproductively active. A similar shift was documented in an assessment of English sole (Stewart 2007). Despite considerable efforts to develop comprehensive age and life history information, natural mortality remains highly uncertain, particularly as ecological theory would suggest that a small, fast growing species with a relatively high natural mortality rate is unlikely to have constant mortality across all ages. However, sensitivity to a Lorenzen natural mortality function did not improve model behavior or fits to the data.

All key parameters, including growth, mortality, and the stock recruitment relationship, were estimated in this assessment. There were uncertainties associated with this approach because of strong correlations among these parameters. This was demonstrated by large effects of priors (e.g., steepness prior) on the model outputs. A sensitivity analysis where the steepness prior was not used showed that estimated steepness was lower and that the current stock depletion would be slightly lower without the use of the steepness prior (e.g. freely estimated).

Research and data needs

1) The proportion of the total catch of Pacific sanddab were discarded is uncertain. Discard rates varied among fisheries and states. The WCGOP has provided important information on discard rates, as well as length composition of discards in recent years. It will be important to continue to collect these data in future years. In addition, it will be helpful to record the catch of Pacific sanddab separately from other sanddab species. This is particularly informative when length composition data for both retained and discarded catches are available for the species.
2) Continue estimating catch and collecting length compositions of Pacific sanddabs in the recreational fishery. An increased sample size of length data from both retained and discarded catches from the fishery will provide more accurate information on estimates of fishery selectivity.
3) A coastwide juvenile groundfish survey data is available for most years since 2001, and has been used in assessments of other groundfish. However, sanddabs were not identified to the species level in the northern survey areas, and thus truly coast-wide data is not available for this species. Data from a more limited geographic range does not indicate a strong correlation between juvenile abundance and subsequent recruitment to the adult population, however species level data in recent years may provide useful information on the annual recruit strength and may help in estimating the stock recruitment relationship.
4) Continuations of collecting data on reproductive biology of Pacific sanddabs will provide more comprehensive data for future assessments. This is particularly important that data are to be collected from the northern area (i.e. Oregon and Washington) and from the southern California. More data from other seasons (i.e. winter months) will also provide

more complete information on spawning frequencies and spawning seasons. Consideration of the potential causes, and consequent influence on model results and dynamics, of the apparent shift in the maturity curve from maturity estimates in the 1950s would also be beneficial.

5) Stock and catch data from both Mexico and Canada have not been used in this assessment. Although there are some data and samples from the Canadian catches on Pacific sanddab, there is no information from Mexican fisheries on the species. Data gathering on the Pacific sanddab catches from Mexican waters will be useful to estimate potential impacts on the U.S. stock.
6) Pacific sanddab along the U.S. coast have been treated as a single stock in this assessment, as there is no genetic study on the stock structure of this species. Although this assumption is likely reasonable given the extended larval duration (200 to 250 days) of pelagic young-of-the-year sanddabs, genetic studies on the stock structure of Pacific sanddab could help to determine potential stock structure in future assessments.
7) The discrepancy between the survey biomass estimates and the model estimates of total biomass suggest either that the survey is dramatically overestimating total biomass for some unknown reason, or that the model us unreasonably constrained to estimating a lower biomass. Alternative sources of information, or alternative types of analyses, may shed light on both the factors that appear to drive variability in catchability for small flatfish in bottom trawl surveys would be beneficial. Alternative means of analyzing trawl survey data, or of conducting more focused surveys that could shed light on catchability issues and relative abundance and density of this species in the ecosystem, may also be beneficial.
8) Pacific sanddabs play an important role in the ecosystem, and likely experience high natural mortality rates, rates which are likely to vary both with size and age, and over space and time. A greater understanding of the appropriate mortality functions and the extent to which ecosystem changes may have altered natural mortality rates in either space or time would benefit future assessments.

Table g. Summary table of the results from the base model.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Commercial landings (mt)	456.6	347.3	412.5	292.2	196.5	290.7	146.3	146.2	159.2	NA
Estimated total catch (mt)	860	629	666	512	389	562	322	339	326	NA
OFL (mt)	NA	3172	3172	3172	3172	3172	3172	4943	4943	4801
ACL (mt)	NA	3172	3172	3172	3172	3172	3172	3432	3432	3332
1-SPR (%)	26.1	23.2	24.9	22.1	18.7	21.6	13.8	12.5	10.4	NA
Exploitation rate (catch/ age 0+ biomass)	0.141	0.111	0.115	0.080	0.052	0.064	0.032	0.028	0.024	NA
Age 0+ biomass (mt)	11567	11933	11713	12059	12488	12130	13069	13244	13479	NA
Spawning Biomass	3719	3319	3210	3281	3832	4654	5362	6277	7568	8554
~95% Confidence Interval	541-6897	357-6281	181-6239	0-6657	0-8048	0-9834	0-11286	0-12933	0-15412	128-16980
Recruitment	130606	137966	236307	233162	217592	269346	421590	263968	200639	231713
~95% Confidence Interval	24513-695866	25586-743954	43538-1282584	43338-1254442	41261-1147488	51577-1406577	80414-2210282	49184-1416690	37343-1078010	43286-1240367
Depletion (%)	41.5	37.1	35.9	36.6	42.8	52.0	59.9	70.1	84.5	95.5
~95% Confidence Interval	24.7-58.4	20.7-53.5	18.2-53.5	15.5-57.7	15.1-70.5	17.7-86.3	20.8-99.0	27.3-100.13	34.7-134.4	43.7-147.3

1 Introduction

1.1 Basic Information

Pacific sanddab (*Citharichthys sordidus*) is a left-eyed flounder of the family Paralichthyidae and is widely distributed along the Pacific west coast from the Bering Sea to Cabo San Lucas, at the tip of Baja California (Arora 1951, Miller and Lea 1972, Hart 1973, Rackowski and Pikitch. 1989, Kramer *et al*. 1995, Love *et al*. 2005). Early studies reported that the species is the most abundant in the north-central portion of California from Eureka to San Francisco, but were also fairly common in southern California (Rackowski and Pikitch 1989). Early studies also reported that the species is usually found at depths between 18m and 275m and most commonly found at depths between 35m and 95m (Arora 1951, Roedel 1953, Demory 1971, Miller and Lea 1972, Hart 1973). On Oregon's continental shelf, Pacific sanddab is the most abundant small flatfish on sandy-bottom in the depths between 74 and 102m (Pearcy 1978). Young Pacific sanddab (ages 0 and 1) are also found to be concentrated in the same depth range (Donohoe 2000). Pacific sanddab was also found to be relatively more abundant in shallow waters at higher latitudes (Chamberlain 1979).

Pacific sanddab are generally not considered a primary target for commercial fisheries along the U.S. west coast, but they are nevertheless highly prized by the commercial and recreational fisheries for their excellent edibility (CDFG 2001), and have long been an important component of the nearshore flatfish fishery, commanding a high price in fresh fish markets (CDFG 1949, Arora 1951). Commercial catches of Pacific sanddab were mostly from bottom trawl fisheries, and there is a long history of catches (Table 1and Figure 1). Recreational catches of Pacific sanddab are from the hook and line fishery and most of this catch is from southern California waters. Some recreational anglers target Pacific sanddab in southern California, mostly from small boats and CPFVs (CDFG 2001).

Pacific sanddabs can growth to 35cm in length. They are sexually dimorphic, with females attaining larger sizes than males. Analysis of growth rates for both sexes between the southern and northern areas (divided at the California-Oregon border at 42^{o} N lat.) showed no significant difference in growth rates for both sexes between the two areas (Figure 7 and also see biology section below). In this assessment, Pacific sanddabs occurring in all waters off the U.S. west coast was treated as a single stock.

There are no genetic or tagging studies informing stock structure of Pacific sanddab along the U.S. Pacific coast. Bottom trawl surveys in recent years (both NWFSC and triennial surveys) showed that Pacific sanddab are commonly caught along the coastal areas of all U.S. waters (Figure 2 to Figure 5). Recent fishery observer data also showed a similar pattern (Figure 6).

Pacific sanddabs play an important role in the coastal ecosystems in the U.S. waters, particularly because they are a relatively abundant species and are important prey items to a wide range of marine predators, including piscivorous fishes, sea mammals, and sea birds (Field *et al*. 2006, Levin *et al*. 2006).

1.2 Map

This assessment is for Pacific sanddab occurring in U.S. waters off California, Oregon, and Washington. Maps depicting the distribution of two scientific surveys (the NWFSC survey and the triennial survey) are shown in Figure 2 to Figure 5. Two commercial fisheries (the California fishery and Oregon/Washington fishery) were modeled separately south and north of the California-Oregon border at 42^{o} N lat., which allowed easy fishery data summaries for the assessment and for accessing state fishery regulations on the fisheries. Spatial distributions of commercial fishery catches of Pacific sanddab in recent years are based on WCGOP observations. A map depicting relative commercial trawl catch rates of Pacific sanddab by latitude and depth is provided by the NWFSC (Figure 6, provided by Ian Taylor, NWFSC).

1.3 Life History

Pacific sanddabs can attain lengths of 35 cm and weights of 0.9 kg (Arora 1951), though most are less than 25 cm and 0.2 kg (CDFG 2001). They are sexually dimorphic, with females attaining larger sizes than males (Arora 1951; Appendix B). Females are reported to live up to 12 to 13 years with very few individuals being older than 11 years old (Arora 1951, recent aging data). Maximum age of males is one or two years less than females. An early study showed that about 50% of female Pacific sanddabs mature at a length of about 19cm (about 3 years old) in California (Arora 1951). However, recent studies indicate that fish mature at smaller sizes (details in Biology section).

While Pacific sanddabs have been reported to depths of 275 m, they are most frequently found in sandy-bottomed continental shelf waters shallower than 100 m (Arora 1951, Pearcy and Hancock 1978). Pacific sanddabs are benthic dwellers but are also found pelagically; adults are frequently collected in mid-water trawl surveys (Pearcy and Hancock 1978; Sakuma, pers. comm.). Pacific sanddabs primarily feed pelagically on crustaceans (euphausiids, copepods, cumaceans), cephalopods, and small fishes (larval and adult northern anchovy and other small fishes [Pearcy and Hancock 1978, Rackowski 1989]). In turn pelagic larval sanddabs are consumed by commercially important fish species such as tuna and salmon (Horn 1980, Rackowski 1989). Pacific sanddabs are likely an important forage species of fishes and sea birds as juveniles and adults due to their size, prevalence, and propensity to occupy pelagic waters.

Early reproductive studies showed that Pacific sanddab caught off central California spawn between June and September, with peak activity in August, and suggested individual females spawn multiple times a year (Arora 1951, Chamberlain 1979). A recent field study conducted in the same region showed that spawning extends into the fall and early winter and confirmed that individuals spawn multiple times a year (Appendix B). The spawning season appears to occur later with increasing latitude. Barss (1976) noted that Pacific sanddab spawn in summer off Oregon, while Ureña (1989) suggested spawning in the same region extended from late summer to early spring. In Puget Sound spawning was reported to occur from February through May (Barss 1976).

A study on the reproductive biology of Pacific sanddabs based on samples collected from the Monterey Bay area was conducted by the Fisheries Ecology Division of the SWFSC in 2012 and 2013 (Appendix B). The study showed that Pacific sanddabs are capable of spawning multiple times in a spawning season, and the spawning season may last from July through January. On average, captive female Pacific sanddabs had a spawning frequency of 1.6 days and were capable of spawning on successive days. Initial batch fecundity estimates from wild-caught female sanddabs ranged from 810 to 17,400 (mean = 6,350) eggs released per spawn. Batch fecundity increased linearly with length; however, relative batch fecundity showed no significant relationship with length. The study also showed that Pacific sanddab mature at smaller sizes (50% maturity at a length of 13cm) than those estimated by Arora (1951) from the same area.

Pacific sanddabs are oviparous broadcast spawners. Fertilized eggs are transparent and small (0.78-0.84 mm), and newly hatched larvae are transparent or nearly so (Moser and Sumida 1996). Eggs and larvae drift with currents. Larvae may be found many miles from shore (Barss 1976) but are most abundant in nearshore bongo (Moser *et al*. 2001, Brodeur *et al*. 2008) and midwater trawl (Ureña 1989) collections. Eye migration initiates at 16-25 mm standard length (SL), and the entire metamorphosis process takes up to 5 months (Donohoe 2000). The larval and metamorphic-stage duration is long (up to 271 days), and Pacific sanddabs settle at sizes as large as 39 mm SL (Sakuma and Larson 1995; Donohoe 2000). Abundance patterns of Pacific sanddabs at various stages of eye migration and metamorphosis suggest the process of settlement is gradual. Individuals collected over the mid-continental shelf at depths of 50-99 m were older relative to fish collected on the upper continental and outer shelf (Donohoe 2000). Sakuma and Larson (1995) found that, while there was generally an even distribution of the various metamorphic stages, the number of small fish decreased with depth.

1.4 Ecosystem Considerations

Pacific sanddabs are a relatively abundant species in the coastal environment, particularly in shelf waters between approximately 30 and 150 m depth. As such, they represent a substantial fraction of the standing biomass, particularly that of smaller individuals, and play an important role in food web interactions, particularly as a prey item to a wide range of higher trophic level predators, including piscivorous fishes, sea birds, and sea mammals. As a smaller, rapidly growing and early maturing species, Pacific sanddabs can best be characterized as having a relatively low vulnerability to overfishing (Cope et al. 2011), and trends of increased abundance in recent decades would be consistent with the characterization of ecosystem trends in the California Current as favoring smaller, more high turnover species, particularly flatfish, (Levin et al. 2006). For example, the latter manuscript described a decline in the average weight of flatfish over time, such that the average flatfish caught in 2001 had only 57% of the weight of the average flatfish caught in 1980. Moreover, Levin *et al*. (2006) also characterized an inverse relationship of trends in population density and length at maturity, such that species with smaller lengths at maturity tended to exhibit population increases while larger species exhibited declines.

Ecosystem models also suggest that as larger, piscivorous fishes decline in response to fishing, smaller species that tend to be prey items for larger species are likely to either increase or remain at relatively high abundance levels even in the face of substantial fishing mortality. In a model of the Northern California Current ecosystem, Field *et al*. (2006) found that stronger food web interactions could be observed in commercially important species such as shrimp and small flatfish (including sanddabs, English sole, and rex sole), where increases in abundance appeared to be associated with declines in predation mortality as many of their key predators experienced population declines in response to fishing. Kaplan et al. (2012) found similar results, in exploring alternative fishing scenarios they found that those scenarios with strong increases in fishing mortality on all exploited groups led to increased abundance of many of the smaller bodied prey groups, such as small flatfish. Although both models included “small flatfish” as an aggregate of multiple species, the general result is robust and illustrates that the a priori assumption for this species is that declines in predators in response to fishing should have decreased natural mortality rates to some extent and could have led to increased population productivity even in the face of higher fishing mortality. To consider these potential factors more closely, a comprehensive literature search of the role of this species in the food web was undertaken, with particular emphasis on known or likely predators and the likely relative predation pressure that might be associated with each.

With respect to their foraging behavior and prey selectivity, Pacific sanddabs in general are known to forage largely (but not exclusively) on pelagic prey items. Kravitz et al. (1977) evaluated the feeding habits of five species of flatfish on the Oregon shelf, and found that Pacific sanddabs fed heavily on northern anchovies, euphausiids, shrimps, amphipods and crab larvae. Pearcy and Handcock (1978) assessed the food habits of slender sole and Pacific sanddab, both of which they characterized as chiefly pelagic feeders. Pacific sanddabs specifically fed on about

75% euphausiids and calanoid copepods, 7% polychaetes, and trace amounts of mollusks, echinoderms and other (principally benthic) taxa. Wakefield (1984) also reports on diet data for Pacific and speckled sanddabs, although limited to a small number of samples (33), a more diverse prey base was described, principally mysids, euphpausiids, and other crustaceans, but including modest amounts of cephalopods, gelatinous zooplankton, sculpins and poachers, tomcod, butter sole and other pleuronectids (presumably juvenile stages of most of these).

The known and suspected predators of Pacific sanddabs (and sanddabs more generally, where not identifiable to the species level) are many, and varied. Large flatfish, skates, other piscivorous fishes and marine mammals (particularly nearshore pinnipeds) are likely among the greatest sources of mortality, particularly for larger individuals, while pelagic young-of-the-year and recently settled individuals are also important prey for pelagic predators such as salmon, Pacific hake, rockfish and seabirds.

With respect to salmon as predators, Merkel (1957) found that Chinook off of central California fed primarily on anchovy and other forage fish, juvenile rockfish, and euphausiids, with sanddabs (not identified to species) present in very modest amounts (10, out of over 2500 fishes identified to species or genus). The size range in this study was 2.5 to 5 cm, suggesting that most were pelagic young-of-year. Other salmon food habits studies have similarly found trace amounts of either sanddabs or small flatfish (Silliman 1941, Brodeur et al 1987, Brodeur and Pearcy 1990), however we suspect that these pelagic predators are typically feeding on pelagic young-of-the-year. Pacific hake is another pelagic predator that feeds primarily on krill and small forage fishes, but occasionally on small flatfishes and other prey. Approximately 2% of the diet by weight is estimated to be small flatfish in the AFSC food habits database (which contains data on over 10,000 hake stomachs); most could not be identified to the species level, although Pacific sanddab accounted for over half of those that could. Gotschall (1969) also found Pacific sanddab to be among the most frequently occurring fishes in over 500 hake stomachs (from northern California shrimping grounds). Size data aggregated into all flatfish show that Pacific hake largely prey on flatfish smaller than 14 cm in length, and very infrequently on flatfish from 14 to 27 cm; consequently most predation is again likely to be on age 0 or age 1 Pacific sanddabs, although they clearly feed on Pacific sanddabs larger than pelagic young-of-the-year. Given the large biomass of Pacific hake, this could translate into non-trivial amounts of predation, although predation on fish greater than two years of age is likely to be minimal. Finally, Humboldt squid (*Dosidicus gigas*), a typically subtropical predator that was highly abundant in California Current waters from 2003 through 2009, were observed to have fed on Pacific sanddab, which were present in nearly 2% of Humboldt squid stomachs examined during 2005 and 2006, ranging in size from 13 to 23 cm fork length (Field *et al*. 2007).

Most large flatfish have been documented predators of Pacific sanddab (or sanddab species more generally). Orcutt (1950) describes the food habits of starry flounder (*Platichthysstellatus*) as primarily benthic invertebrates such as amphipods (and other crustaceans), mollusks (primarily bivalves) and echinoderms, but noted that larger (>300 mm) starry flounder would also prey on fishes, including Pacific sanddabs. As starry flounder tend to have a relatively shallow distribution (typically found within 80 m depth) and can achieve large sizes (up to 900 mm), they likely represent a potentially respectable source of predation for Pacific sanddabs as well. California halibut (*Paralichthy scalifornicus*) are among the most abundant, commercially important large flatfish in nearshore California waters, where they are the target of significant trawl, hook and line and (historically) gillnet fisheries. Adults feed primarily on fishes, with most studies showing northern anchovy to be the most important prey species, but including numerous species of croakers, turbots, Pacific hake, rockfish, perches, and sanddabs. In none of the studies reviewed by Allen (1990) were sanddabs a major component, but they were a non-trivial component in many of the studies cited. Arrowtooth flounder are a large, piscivorous northern flatfish that are likely one of the most significant predators in northern waters. Gotschall (1969) examined over 400 Arrowtooth flounder stomachs in the mid-1960s , collected from northern California shrimping grounds, and found that while crustaceans (primarily ocean shrimp and krill) were among the most important prey, fishes were also important prey and Pacific sanddabs were the most numerous of the ten species of fish encountered (followed by slender sole and rex sole). Wakefield (1990) also found that rock sole fed on a substantial proportion of sanddabs (nearly 25%) as well as other pleuronectids.

Other more benthic oriented predators include Pacific sablefish (*Anoplopoma fimbria*), another abundant groundfish species that may prey fairly frequently on Pacific sanddab, particularly younger, smaller individuals in the shallower depth strata (in deeper depth strata, overlap is minimal). Buckley *et al*. (1999) found that Pacific sanddab occurred with modest frequency in the stomachs of sablefish caught in shallower depths, but were among one of the most important prey by weight, while Laidig *et al*. (1997) found no evidence of predation on Pacific sanddabs in a comparably sized study (albeit one that focused on animals captured from greater depths, where spatial overlap was minimal). Lingcod (*Ophiodon elongatus*) are another abundant, piscivorous predator whose range overlaps considerably more with Pacific sanddabs. Steiner (1979) evaluated food habits from 148 lingcod (over four seasons) caught at neritic reefs (typically 20 to 50 m depth) off of the central Oregon coast, and found a wide range of prey items, which included approximately 2.2% unidentified pleuronectids and 1.2% sanddabs (along with respectable numbers of other flatfishes identified to species). Wakefield (1984) described the diets of four lingcod caught off of Newport, Oregon as consisting entirely of pleuronectids (21% sanddabs, 4% unidentified pleuronectids) and unidentified fishes (75%).

Finally, skates also represent a substantial source of predation mortality for Pacific sanddabs. Wakefield (1984) reported on the stomach contents of several *Raja* species caught in nearshore waters off of central Oregon in 1979 (n=51, most *R. Binoculata*). Benthic shrimp (mostly crangonid species) were the most important prey, however Pacific and speckled sanddabs (*Citharichthys* spp.) were amongst the most important fish prey, making up an average of more than 10% of all prey over all species. Other small flatfish (including rex, butter and English sole) were also important prey. Robinson (2007) examined longnose skate food habits off of central California (over 600 stomachs) and found that Pacific sanddabs were the third most frequently encountered fish (after shortbelly rockfish and unidentified rockfish), with fishes in turn representing the majority of prey items by percent weight and percent frequency of occurrence. Given that those samples were collected at depths ranging from 15 to >500 m, such that perhaps half of the total samples were collected outside of the range of sanddabs, it seems clear that longnose (and other) skate species are likely among the more important sanddab predators.

Many breeding seabirds in the California Current specialize on juvenile (young-of-year) groundfish during the breeding season, and although juvenile rockfish are typically among the more important prey items (Ainley and Boekelheide 1990), pigeon guillemots appear to be a sanddab specialist, with as much as 50 to 60% of observed prey items described as either Pacific or speckled sanddabs in some studies (Robinette *et al*. 2007), and Brandts cormorants are frequent predators of Pacific sanddabs as well (Ainley and Boekelheide 1990). Sea lions in central California also preyed on Pacific sanddabs. Although coastal pelagic species (Pacific sardine, northern anchovy and market squid) and other groundfish (particularly rockfish and Pacific hake) were of considerably greater importance, Weise and Harvey (2008) estimated that California sea lions consumed on the order of 150 to 175 tons of Pacific sanddab in 1998 and 1999, comparable to commercial fisheries landings during this same time period and region.

Although there appear to be relatively few "specialists" on Pacific sanddab (with the likely exception of Pigeon Guillemots), the relative importance of this species as prey for such a wide range of both commercially and ecologically important species suggests that they represent an important source of energy transfer from lower to higher tropic levels. As such, their role in the ecosystem may be worth greater consideration with respect to management practices and target biomass levels, as the current "target" biomass of 25% of the unfished level could represent a non-trivial impact on the availability of Pacific sanddabs for predators. Recent empirical and simulation studies (Cury et al., Smith et al. Kaplan et al. 2013) have indicated that the impacts of fisheries removals on predators and other components of the ecosystem are likely to be relatively modest when populations are reduced to roughly half of their unfished or unexploited level, but become increasingly severe as populations are reduced to below 20 to 30% of the unfished level, levels that correspond with the current proxy targets for flatfish biomass. The recent flatfish proxy harvest levels were not developed in recognition of such considerations, however such considerations could be germane to management, particularly for flatfish species that have been shown to have numerous food web interactions. Although there are no signs that Pacific sanddabs have historically experienced such high exploitation rates, and no expectation of such impacts in the immediate future based on the constraints and effort levels of current fisheries, such factors might be relevant to future management decisions and analyses.

1.5 Fishery Information

There is a long history of commercial catches on Pacific sanddab (CDFG 1949, Barss 1976). Sette and Fiedler (1928) reported that landings of flatfish in California waters were first reported in 1892. The first available landing of Pacific sanddab in Oregon waters was in 1942 (Gertseva *et al*. 2010, Karnowski *et al*. 2012). There were also commercial catches for mink foods in both California and Oregon waters in the 1950s and 1960s (Best 1959 and 1961, Nitsos and Reed 1965). Reported total catches of Pacific sanddab were high in the late 1920s. And there was an increasing trend from the 1960s and reached the highest catch level in the late 1990s (Figure 1). Discards of Pacific sanddab in commercial trawl fisheries were high, primarily due to its small size (Sampson 2002, John Wallace, NWFSC, personal communication). Catches of the species in recent years were in the range of 200 mt and 400 mt. In this assessment, four fishing fleets were defined and modeled: (1) the California trawl fishery; (2) the combined Oregon and Washington trawl fishery; (3) the mink food fishery, and (4) the recreational fishery. Detailed definitions and descriptions for each fishery are described in the fishery-dependent data section.

1.6 Management History and Performance

Pacific sanddabs have been under federal management since the implementation of the groundfish FMP in 1982 and managed within the Other Flatfish complex of unassessed flatfish species. Harvest specifications (overfishing limits (OFLs), acceptable biological catches (ABCs), and annual catch limits (ACLs)) are managed at the complex level and calculated as the sum of estimated harvest specification contributions from component stocks such as Pacific sanddab. Prior to 2011, the overfishing level, now called the OFL, was called the ABC and the ACL was called the optimum yield (OY). The OFLs (ABCs prior to 2011) for Pacific sanddab have been estimated using on catch-based methods. Since 2011, the method used to estimate the OFL was depletion-based stock reduction analysis (DBSRA). The ACL since 2011 was set equal to the ABC; the ABC was based on a 30.6% reduction from the OFL based on scientific uncertainty (category 3 stock with a sigma of 1.44) and the Council's tolerance of risk (overfishing probability (P*) of 0.40). From 2005-2010, the overfishing limit (then called the ABC) was based on the highest recent year (1981-2003) landed catch (1,364 mt in 1995) with an assumed discard rate of 57% based on the Oregon trawl Enhanced Data Collection Program (EDCP) study results during 1995-1997 to determine an overfishing limit of 3,172 mt (PFMC 2004). The overfishing limit contribution of Pacific sanddabs to the Other Flatfish complex was reduced by 25% to determine an annual total catch limit (then called OY) of 2,379 mt during 2005-2010 (Table 1). Prior to 2005 the other flatfish ABC and OY (analogous to the current OFL and ACL, respectively) was 7,700 mt. The basis for these harvest specifications was not documented but is believed to have been based on average catches of the aggregate species comprising the complex in the 1970s. A contribution Pacific sanddab-based harvest specification was not calculated until 2005.

The management performance in recent years for Pacific sanddab has been good; the average 2005-2012 total annual catch has been about 23% of the ACL/OY contribution (Table 2).

Appendix A details the history of management measures pertinent to Pacific sanddabs.

1.7 Fisheries off Canada, Alaska, and Mexico

Although Pacific sanddab are widely distributed from the Bering Sea to Baja California, there have been no records that Pacific sanddab have been assessed in waters off Alaska, Canada and Mexico. Data reports of the AFSC on bottom trawl surveys in the Gulf of Alaska indicate encounters of Pacific sanddab, but no abundance or biomass estimates were reported, indicating only a few individual fish being caught by the surveys (von Szalay *et al*. 2010, Tom Wilderbuer, AFSC, personal communication).

In Canada, annual total catches ranged between 4.3mt to 101.1mt between 1996 and 2012 (Table 2, Kate Rutherford, Fisheries and Oceans Canada, personal communication). However, most catches were discarded. Discard rates were very high, with nearly all catches being discarded before 2001, and close to 70% of the total catch being discarded in recent years.

There is no published information on Pacific sanddab fishery in Mexico. A Google search shows that there are some recreational fishery catches in the Mexican waters.

2 Assessment

2.1 Data

Summary of data sources and time periods of each data set are presented in Figure 8. Brief descriptions of each data set follow:

1) Fishery independent survey data from both the NMFS triennial bottom trawl survey (1980 to 2004) and recent years of the NWFSC bottom trawl survey (2003 to 2012). The triennial survey data provided indices of abundance, length composition data by sex, and spatial distributions of survey catches. The NWFSC survey provided indices of abundance, length composition data, age-at-length composition data, estimates of growth, and spatial distribution of survey catches.
2) Biological data, including estimates of maturity and fecundity, were taken from recent field samplings in the Monterey Bay area (full report in Appendix B).
3) Aging data were obtained from examining otoliths from the NWFSC survey and commercial trawl fisheries. A total of 12,590 otoliths were aged between 1995 and 2012.
4) Historical commercial landings from both Oregon and California waters were provided by the Oregon and California data projects. Some records for early years were directly taken from published literature.
5) Recent commercial landings from all states were downloaded from the PacFIN database and from the WCGOP.

6) Estimates of discard rates in Oregon Fisheries are obtained from the Pikitch study for the years 1985 to 1987. Estimates of discard rates of commercial fisheries from recent years are used from the WCGOP. Limited length composition data were also provided by both data sets.
7) Recent recreational catches from California and Oregon were downloaded from the RecFIN database. Recent recreational catch estimates were provided by the Washington Department of Fish and Wildlife. Discard rates and discard length composition data from the California recreational fisheries were estimated from the California CPFV (Commercial Passenger Fishing Vessels) survey. Historical recreational landings were obtained from the estimates of the CPFV data base.

2.1.1 Fishery Independent Survey

2.1.1.1 NWFSC Survey

The NWFSC survey is an ongoing bottom trawl survey, and has been conducted by the Northwest Fisheries Science Center since 2003. This survey provided the most comprehensive data for this assessment, including estimated annual biomass, age and length frequency data, and spatial distribution of the species. Age and length data were used to construct annual age-at-length matrixes in the assessment, which enabled the assessment model to internally estimate growth for both sexes of Pacific sanddab.

The survey is based on a random-grid design and it covers the coastal waters from California to Washington (Keller *et al*. 2007); survey trawls were deployed in the depth ranges between 55 m and 1,271 m (Figure 2 and Figure 3). Initial analysis of the survey data indicated that Pacific sanddab were rarely caught at depths greater than 250m (Table 4). Therefore, all data from depths greater than 250m were excluded from the catch rate analysis.

Figure 9 and Figure 10 show the proportions of positive hauls and the catch rates of positive hauls of the survey by latitude and by depth, respectively. Proportions of positive tows by latitude showed a slightly decreasing trend from south to north, ranging from close to 90% in the southern area to about 40% in the northern area (top panel, Figure 9). However, there was no trend in catch rates of positive tows between the northern and southern areas (bottom panel, Figure 9). Proportions of positive tows by depth showed a decreasing trend (top panel, Figure 10). There were no large differences of catch rates of positive tows by depth (bottom panel, Figure 10).

Boxplots of length and age data from the NWFSC survey were used to depict mean lengths and ages by sex and their variance along gradients of latitude and depth (Figure 11 to Figure 14). In general, plots showed that mean lengths (Figure 11) and mean ages (Figure 13) of both sexes tend to be slightly higher in the northern area (41^{o} N lat.) than those in the southern area. There were no such trends in mean lengths (Figure 12) and mean ages (Figure 14) along the depth gradient.

Length composition data by sex from the NWFSC survey from 2003 to 2012 are shown in Figure 15, and conditional age-at-length for both sexes from 2003 to 2012 are depicted in Figure 16 and Figure 17, respectively. Annual numbers of length measurements and fish aged by sex, and percentages of length measurements and fish aged are listed in Table 5 and Table 6, respectively. Annual numbers of trawl hauls were used as initial sample sizes for both length and age composition data.

Estimates of Pacific sanddab biomass from the NWFSC survey were developed using a GLMM model developed by NWFSC scientists (Thorson *et al*. 2011, Thorson *et al*. 2012, Thorson and Ward, in press). The model has being commonly used in many stock assessment models, including those used in the current stock assessment cycle. In the analysis, numbers of iterations of MCMC simulation were compared, and it was found that one million MCMC iteration (with six parallel chains) was generally sufficient as its outputs were comparable to those from a larger number of MCMC iterations (e.g., 2 million and 5 million). The thinning factor in MCMC simulations was set to be between 500 and 1000 with the half of iterations treated as burn-in runs. Estimated biomass using these survey data for years between 2002 and 2012 are listed in Table 7, and plotted in Figure 18 along with their standard deviations.

2.1.1.2 Triennial Survey

The triennial survey, which also used bottom trawl gears, was conducted by the Alaska Fisheries Science Center (AFSC) between 1977 and 2001, and by the Northwest Fisheries Science Center (NWFSC) in 2004. Detailed survey methods and sampling designs were described in Dark and Wilkins (1994) and Weinberg *et al*. (2002). All of the trawls were conducted between early summer through early fall, but actual survey timing changed slightly over time. The 1977 data were not used in this assessment mainly because the minimum trawl depth of 91 m differed from all other survey years, which had minimum depths of 55 m. Water hauls identified from the survey (Zimmermann *et al*., 2001, Zimmermann *et al*. 2003) and those hauls conducted in Canadian waters were excluded from the analysis Exclusion of the 1977 data from the analysis, as well as data from water hauls and from Canadian waters, has been common practice in stock assessments that used the triennial survey data (He *et al*. 2011, Hicks and Wetzel 2011, Haltuch *et al*. 2013).

Figure 4 and Figure 5 show spatial distributions of catch rates of Pacific sanddab in Washington, Oregon, and California waters from this survey. These data indicate Pacific sanddab are widely distributed along the U.S. west coast. Proportions of positive hauls and the catch rates of positive hauls were not significantly different along the U.S. west coast (Figure 19). Summary statistics of haul catch data by three depth zones (<=150 m, 150-250 m, and >250 m) showed that proportions of positive hauls and catch rates of positive hauls decreased dramatically as depths increased (Figure 20), and that Pacific sanddab were rarely caught in depths greater than 250m (Table 8 and Figure 20). Like the NWFSC survey, all hauls from depths greater than 250m from the survey were excluded from catch rate analysis.

Box plots of length data from the triennial survey were used to depict mean lengths by sex and their variance along gradients of latitude and depth (Figure 21 and Figure 22). The plots showed that mean lengths of both sexes tend to be slightly higher in high latitudes than those in low latitudes. There were no such trends in mean lengths along the depth gradient. Both trends were similar to those from the NWFSC survey.

The survey data from the entire time period (1980-2004) was stratified into two time periods (1980 to 1992, and 1994 to 2004) in many recent stock assessments (Stewart 2007). Splitting the triennial survey time series into two-time periods has been commonly used for flatfish assessments, such as in the petrale sole (*Eopsetta jordani*) stock assessment (Haltuch *et al*. 2013), and the Dover sole (*Microstomus pacificus*) stock assessment (Hicks and Wetzel 2011). This stratification was done because the survey timing changed seasonally mid-July to late September between 1980 and 1992, to the May to July period between 1994 and 2004 (Figure 23). This change of survey time may affect the availability of species being assessed. Initial analysis to assess the effects of survey time period on survey indices and assessment results was conducted and it showed that the survey time period had minimal effects on the survey indices on estimated Pacific sanddab abundance (Figure 24), with very similar time series of abundance indices from using one-time period or using two-time periods. However, the estimated index CVs were different, with larger CVs from using two-time periods than those using one-time period. This was expected as splitting the survey creates two short time series and abundance trends are informed by less data. Further analysis regarding the use of one or two time series during model development indicated there were large effects on stability of the stock assessment models. In particular, estimated catchability coefficients (*Q*) and added survey CVs were very different between time periods. Treating the survey as two separated time series resulted in much a more stable model, with slightly better fits of survey data to assessment models. Therefore, the survey was modeled as two independent time series, with the early year period (1980 to 1992), labeled as "TriEarlyYr" and late year time period (1995 to 2004), labeled as "TriLateYr". A sensitivity analysis using one-time period of the triennial survey was also conducted to compare the assessment results between these two approaches.

Length frequency distributions of the triennial survey data by year and by sex are plotted in Figure 25. The plots showed that there were generally smaller fish for both sexes in the later years than in the early years. However, no statistical tests were conducted to show that these patterns were significantly different, or that these patterns resulted from different recruitments during these two time periods. Summaries of numbers of hauls and length measurements by year and by sex for the triennial survey are presented in Table 9. As for the NWFSC survey, annual numbers of trawl hauls were used as initial sample sizes for the length composition data.

Estimates of Pacific sanddab biomass from the triennial survey were done using a GLMM method similar to that used in analyzing the NWFSC survey data. As in the analysis of the NWFSC survey data, different iterations of MCMC simulations were also conducted and it was found that one million MCMC iterations (with six parallel chains) was generally sufficient as those outputs were very similar to those from larger numbers of MCMC iterations (e.g., 5 million). The thinning factor for MCMC simulations was set to be between 500 and 1000 with half of the iterations treated as burn-in runs. Biomass estimates for both survey time periods are provided in Table 11, and plotted in Figure 27and Figure 28 with their standard deviations.

A GIS analysis was conducted to calculate total areas by three depth zones (0-49 m, 50-150 m, and 151-250 m) of the coastal waters off all three states (Table 10, Rebecca Miller, SWFSC, personal communication). This analysis indicates that 23.2% of the EEZ depths out to 250 m are shallow depths <50 m. This analysis indicates that the Pacific sanddab biomass estimates generated from the NWFSC and triennial surveys may have under-estimated total biomass of because both surveys did not sample these shallow areas.

2.1.1.3 SWFSC FED Ecology Survey

A regional fisheries ecology survey, using both trawl and longline gear, was conducted by the Fisheries Ecology Division of the Southwest Fisheries Science Center (SWFSC FED) between 2001 and 2005. The trawl survey was conducted by chartering a commercial trawl vessel in the Monterey Bay area between depths of 16m and 275m. The survey used a cod-end liner with ¾ inch mesh. Only trawls conducted in <=250 m were used in the analysis, resulting in a total of 71 hauls used in the analysis. The survey was conducted in all months except May. Data collected from this survey included catch numbers and weights by species, trawl depth, trawl duration, and other gear-related information. Although the fixed gear effort did occasionally encounter sanddabs, those data are not used here.

The main purpose of this survey was to collect ecology data on the groundfish species in the Monterey Bay area. Data from this survey was only used to examine relative depth distributions of Pacific sanddab in the area. Raw catch rates (number of fish caught per trawl hour) by three depth zones are presented in Figure 33. It showed that catch rate was low in the depth zones of <50 m and >150 m. Mean lengths and their standard deviations by sex and by three depth zones are presented in Figure 34. These data indicate that Pacific sanddab caught in the shallow depth zone (<=50 m) were slightly smaller than those caught in deeper zones. In this survey, it was observed that catches of speckle sanddabs were rare, and that the only times they were caught were from trawls in less than 30m bottom depths. Most of speckle sanddabs catches were less than 20cm in length.

2.1.1.4 Pelagic Juvenile Survey

Pelagic young-of-the-year (YOY) sanddabs have been monitored in the central California region since 1987, and from the region between Cape Medocino, CA and the U.S./Mexico border since 2004, in an annual May/June survey of pelagic juvenile groundfish (Juvenile rockfish ecosystem assessment survey) conducted by the Fisheries Ecology Division of the Southwest Fisheries Science Center (Sakuma *et al*. 2006, Ralston *et al*. 2013). Although the survey began in 1983, sanddabs were not identified to the species level until 1987, and unfortunately in a companion survey conducted by the Pacific Whiting Conservation Cooperative and the Northwest Fisheries Science Center from 2001 through 2010 (see Sakuma et al. 2006), sanddabs were also not identified to the species level. In the FED survey, pelagic YOY groundfish and other micronekton are sampled during hours of darkness (as some pelagic YOY can avoid the net during daylight hours) at a range of fixed stations, with trawls typically conducted at 30 meters headrope depth (shallow stations are sampled at 10 meters) using a modified Cobb midwater trawl with a 26 meter footrope depth and a 9.5 mm codend liner. Additional details are provided in the references listed above.

This survey was developed to provide abundance indices for age 0 (YOY) rockfish for use in stock assessments and to support fisheries oceanography studies, but has also resulted in time series of abundance for other YOY groundfish and a wide range of other micronektonic forage species (e.g., market squid, coastal pelagic species, mesopelagic species, krill) as well as time series of physical data, seabird and mammal observations, in order to better evaluate other ecosystem interactions (e.g., Field *et al*. 2010, Santora *et al*. 2011, Santora *et al*. 2012, Wells *et al*. 2012). These assemblages also appear to covary in time, with sanddab species tending to be more abundant during periods of high abundance of other YOY groundfish, market squid, and krill, and less abundant during periods when mesopelagic species and coastal pelagic species (Pacific sardine and northern anchovy) are in relatively greater abundance (Bjorkstedt *et al*. 2011, Ralston, Sakuma and Field, unpublished data).

Initial investigations into the early life history of Pacific sanddabs in particular were initiated by Sakuma and Larson (1995) who characterized the distribution and early life history of pelagic YOY Pacific and speckled sanddabs. They characterized the metamorphic development of pelagic juveniles in considerably greater detail than will be presented here, and summarized available information on the ages of pelagic YOY Pacific sanddabs, which were found to spend up to (and perhaps more than) 271 days in the pelagic YOY state prior to settling to benthic habitat (speckled sanddabs were found to have pelagic stages up to 324 days; Sakuma and Larson 1995 and references therein). It was found that earlier life history stages often occurred shallower in the water column, while later stages tended to have a slightly deeper distribution, potentially related to decreased buoyancy as a result of increased otolith size and bone development. All stages tended to be widely distributed, with some suggestion that earlier life history stages were more abundant offshore and later stages were more abundant nearshore (presumably as they approached the age and/or size associated with settlement). This widespread distribution was also noted by Santora *et al*. (2012). Metamorphisis (to the benthic life history stage) in both species was found to occur in a wide range of sizes, suggesting little change in body size during this period. Due to this observation, as well as the fact that size and age data are only available for a small number of years, the abundance indices developed for this species did not adjust for the relative age and size of individuals, as has been done for juvenile rockfish in order to account for size-dependent mortality prior to settlement (Ralston and Howard 1995, Ralston *et al*. 2013). Abundance indices were developed for both the core survey area (1987 through 2012) and the expanded survey area (2004-2012), using a delta-glm approach comparable to the approach taken with juvenile abundances in other studies (e.g., Ralston *et al*. 2013). The models included year, station and temporal (binned Julian day) effects, although there is some indication that due to the widespread distribution of YOY sanddabs, station clusters or groups would likely be a more appropriate means of evaluating this species, and alternative model structures are still under consideration. Interestingly, there was very strong coherence between the coastwide and core area indices for the time period in which they overlapped (Figure 35), which has not been reported with most other rockfish species (e.g., Ralston 2010). Although this initially provided some hope that the core area index could correlate well with recruitments inferred from age, size and abundance data in the stock assessment, preliminary analysis of both indices suggested no indication of any relationship between either index and the recruitment time series produced by the base model. Due to this mismatch between potential pre-recruit indices and the recruitment indices from the model, it was determined that inclusion of a pre-recruit index into the assessment model at this stage was premature, until the potential mechanisms for the mismatch could be further explored.

2.1.2 Biology

2.1.2.1 Length-Weight Relationship

A length-weight relationship was derived from using the standard power function of $W = aL^b$ where L is total length in centimeters, W is weight in grams, and a and b are coefficients. Both coefficients are sex-specific and were estimated using 2003-2012 NWFSC survey data. The estimated coefficients are: $W = 0.00005117L^{3.214}$ for females, and $W = 0.00007419L^{3.081}$ for males (Figure 36).

2.1.2.2 Growth

The von Bertalanffy growth model was used in the assessment. Analyses on the length at age data indicate sexually dimorphic growth of Pacific sanddab, with females being smaller at younger ages and larger at older ages than males. A re-parameterized growth model available in SS was used in this assessment. The three growth parameters were *L1*, *L2* and *K*, where *L1* is length at age 0, *L2* is length at age 11, and *K* is the von Bertalanffy growth coefficient. All these parameters were estimated internally in the assessment model.

2.1.2.3 Natural Mortality

It is expected that the natural mortality rate (*M*) for Pacific sanddabs is high, relative to other large flatfishes (e.g., Petrale and Dover soles), because of their short life span and high predation rate on the species. Male natural mortality rate was expected to be higher than those of females as males have a shorter life span than females. Priors for both sexes were calculated using Hoenig's maximum ages, von Bertalanffy's growth coefficients (*K*), asymptotic lengths, and mean temperature (Owen Hamel, NWFSC, personal communication). Estimated natural mortalities were 0.3212 (SD=0.3600 in log space) for females and 0.3735 (SD=0.3598 in log space) for males. These priors were used in the assessment model, and natural mortality rates for both sexes were internally estimated.

2.1.2.4 Maturity and Fecundity

The only available maturity data on Pacific sanddab prior to a recent study initiated by the SWFSC (described in Appendix B) was from a study of female fish collected from the San Francisco region fish markets in the 1930s and 1940s (Arora 1951). Maturity was determined by measuring oocytes from the ovary using a dissecting microscope and eye-piece micrometer. Data from 227 females collected in the month of August (determined to be the peak month of spawning) were used to construct the maturity curve. While Arora collected females with total lengths (TL) as small as 95 mm in other months, in the month of August the smallest were 150 mm. Of the 13 females 150-169 mm examined in August, none were mature. Based on Arora's data, female Pacific sanddab first matured at 170 mm TL, reached 50% maturity at approximately 190 mm TL, and nearly all fish were mature by 220 mm TL.

A recent field study examining the reproductive biology and ecology of Pacific sanddab in the Monterey Bay area found that females mature at significantly smaller sizes (approximately 12 to 13 cm) than those reported by Arora (1951). A similar shift to smaller size (and younger age) at maturity was found in English sole (Stewart 2007). Details of this study, including data collection and laboratory examinations on maturity and fecundity, are presented in Appendix B.

In this study maturity was determined macroscopically, with a subset of tissues examined histologically to confirm staging. During the peak spawning period, August to November, most mature ovaries had hydrated oocytes (HO), that were in the final stages of maturation, with ovulation and spawning of those oocytes imminent. Hydrated oocytes are readily distinguished from other maturing oocytes due to their large size and translucent appearance. Macroscopic staging outside of the peak spawning period did not allow for accurate assignment of maturity stage; therefore, the maturity curve was constructed from data collected from 154 females during the peak spawning period. There is a sharp increase in the slope of the maturation curve, going from 0 fish mature in the 110-119 mm TL size block to 50% of the fish being mature in the 120-129 mm block to all fish being mature by 140 mm (Figure 37).

Maturity of male Pacific sanddab was examined only macroscopically in the recent study (Appendix B). All males collected appeared to be mature; all testes were opaque and tan in color. Testes appeared similar throughout the year with no detectable changes in appearance during the reproductive season.

Female fecundity in Pacific sanddab has not been thoroughly examined. Fecundity has been examined as part of the recent reproductive ecology study (Appendix B), but fecundity values should be considered preliminary as samples from only 50 females have been analyzed and not all ovarian tissue samples from those individuals have been examined histologically. Batch fecundity (the number of eggs released per spawning event) values ranged from 810 to 17,400 (mean=6,350 ± 610). Relative batch fecundity (the number of eggs per gram ovary-free body weight released per spawning event) values ranged from 15 to 115 (mean=61 ± 4). Initial analysis show that while batch increases with length, there appears to be no significant relationship between relative batch fecundity and length. Fecundity by length and weight are plotted in Figure 38 and Figure 39, respectively. In this assessment, spawning biomass was used to represent stock status, and stock depletion was computed as ratios of annual spawning biomass relative to the virgin spawning biomass.

2.1.2.5 Sex Ratio

The sex ratio at birth was assumed to be 1:1. However, both survey and fishery catches showed that higher proportions of female were caught than those of males (Table 5, Table 6, Table 9, Table 13, and Table 14). This could result from dimorphic growth between two sexes. Females could inhabit differently from males, but there were no data in supporting this hypothesis.

2.1.2.6 Aging and Aging Precision and Bias

Considerable effort was put into aging Pacific sanddab since this was the first time this species as assessed. All aging was done at the Fishery Ecology Division of the SWFSC, with otolith samples collected from the NWFSC survey as well as from the California and Oregon trawl fisheries. Aging effort was concentrated on the samples from the NWFSC survey because the survey had the most otolith samples and these samples were from the most recent years. The NWFSC aging data were also used in constructing conditional age-at-length data matrices that enabled the assessment model to estimate growth rates internally. These data are also useful in estimation of recent recruitment.

Prior to February 2012, no one at the Santa Cruz Laboratory had experience with aging of Pacific sandddabs, and only a few sanddabs had been aged from the collections of available otoliths (ODFW commercial). After an extensive literature search, we could not find any source of information on how to do production aging of this species so we began an effort to develop an aging criteria for the species. To develop the criteria, we used several approaches, including margin examination to determine edge type; growth ring analysis to examine the pattern of annulus formation; daily aging of young fish to confirm the location of the first annulus; and image processing to attempt to distinguish between checks and true annuli.

Firstly, we determined the best way to view the presumed annuli. We examined otoliths following conventional aging techniques such as the break-and-burn, break-and-bake, and thin sectioning methods as well as burning, kiln-baking, and surface viewing of whole otoliths. After using each of these methods on many fish of different sizes, we found that any method of heating the otoliths destroyed all visible marks. Apparently this is also true of petrale sole otoliths (Patrick MacDonald, NWFSC, Personal Communication, November 2012). Thin sectioning did not provide any assistance in viewing the marks. Image processing to enhance marks in photomicrographs of otoliths provided mixed results and was abandoned. Whole, unburned otoliths provided the clearest viewing, and were determined to be the preferred method for aging this species. The next step was to determine when the winter growth zone formed on the edge of the otolith. To do this, we used several hundred otoliths from fish collected in various months and from fish of both sexes of various sizes. It became clear that “winter” growth zones could be readily detected on the edge of otoliths at any time of the year; this was true for fish of all sizes and both sexes. Subsequent data on the life history of this species indicated that this species is a broadcaster spawner with an extended reproductive season lasting from late spring through early winter which may produce a spawning check. Other species have been shown to produce a spawning check in the otolith.

The next step was to measure the first three apparent annuli. We measured the diameter of each presumed annuli along the dorso-ventral axis from several hundred fish. We found that there were two modes for the size of the first annuli with some fish having a very small first annulus. Since this seemed to be an anomaly, we reexamined otoliths lacking the small first annulus to determine if one was present but just too faint to be readily identified. Even with image enhancement, we concluded that not all fish had that small inside annulus. Since this seemed unusual, we attempted to do daily increment counts on younger fish within the small inside annulus.

Daily increment counts were very difficult to perform; however, on several fish, we were able to determine that the small inside annulus represented less than 200 days of life. Donohoe (2000) previously performed daily increment aging on this species and found a similar pattern. He concluded the small inside check was formed after the completion of eye migration during metamorphosis and did not represent a full year of growth.

The final step in developing the aging criteria was to look at a large number of otoliths and attempt to understand the growth pattern. Two agers working side by side viewed the otoliths and reached an agreed upon age. We assumed that in most cases, fish would slow down their growth with age. We also found that while some otoliths had many checks, there was still an overriding pattern of growth which could be detected. We also noted that if an otolith appeared to have many false marks in the first years of life, it would indicate the possible presence of checks in later years. Using the above information, we settled on the following aging criteria: both otoliths were needed to determine an age, surface aging was required for all otoliths, if a faint inside mark was present it was not counted, and if winter growth was present on the outer edge during the summer, it was not counted as an actual annulus. Given the difficulty of aging this species, we agreed to have a high level of cross-reads between agers and second reads by the same ager to prevent age reading drift which resulted in approximately 20% of otoliths being read at least two times.

Table 17 show the numbers of otolith samples aged from the California and Oregon fisheries and from the NWFSC survey that were used in the assessment. No otolith samples were available from other sources. Note that there were generally many more otolith samples of females than those of males. Even for the survey samples, there were about twice as many as otolith samples from females than those from males. In the Oregon fishery, there were about eight times more otolith samples from females than those from males (Table 17). The same case was also found in the length composition data, where there were many more length samples from females than from males.

A total of 12,590 otoliths were ultimately aged for this assessment, including 1,550 otoliths aged by both readers in order to estimate aging biases and aging errors. Selections of otolith samples were stratified-random as attention was paid to select a range of ages from different sampling sources ((1,116 from the NWFSC survey, 208 from the California fishery, and 226 from the Oregon fishery)). Aging error data were analyzed using an ADMB program written by Andrè Punt (University of Washington) with front end programs and output analysis written by James Thorson (NWFSC). Plots of aging bias and errors are presented in Figure 40. Comparisons of aging bias and aging errors with true age and no errors are presented in Figure 41 and Figure 42. Estimated aging bias and aging errors from the analysis were used in the assessment.

2.1.3 Fishery Dependent Data

2.1.3.1 Definition of Fishing Fleets and Fishery Landings

Four fishing fleets were defined and used in this assessment. Modeled fleets included three commercial fishing fleets and one recreational fleet. Two commercial bottom trawl fisheries were defined as the California bottom trawl fishery (thereafter referred to as the CA fishery) and combined Oregon and Washington bottom trawl fishery (thereafter referred to as the OR/WA fishery). Both fisheries included minor catches from other bottom trawl gears (i.e., shrimp trawls) and other fishing gears. These catches might also include small portions of other small sanddab species, such as speckled sanddabs (*Citharichthys stigmaeus*), which share similar habitats and have similar spatial distributions as Pacific sanddab (Rackowski and Piktich 1989). However, any such catches are likely to be minimal, as an analysis of California species composition data for the 2003-2011 period (in which the sanddab market category was sampled) indicated that over 98% of landed fish were Pacific sanddabs. All catch records (i.e., PacFIN estimates and/or observed total mortality estimates) from south of the California-Oregon border at 42^{o} N. lat. were combined into the CA fishery, and all catch records from north of 42^{o} N. lat. were combined into the OR/WA fishery. Although these two fisheries shared some similar characteristics, they were treated as separated fisheries because (1) the OR/WA fishery tend to discard more Pacific sanddabs than the CA fishery; and (2) data sources, including catch and composition data collections, were different between the two fisheries.

The third commercial fishery was defined as the mink, or animal food fishery, which covered most areas off northern California and Oregon. The fishery was active from the early 1950s to the late 1970s, with some small catches in the 1980s and early 1990s, and the main gear for this fishery was bottom trawl. The primary goal of this fishery was to catch fish as food to support mink and other animal farms, and as such virtually all of the catch was landed, such that no discards are assumed to take place. The lack of discards was the primary rationale for treating these landings as a separate fishery. The fourth fishery was defined as the recreational fishery, and was set to cover all catches from all waters off the three states by anglers mainly using hook and line gears. The majority of recreational catches were from the California waters. The time series of estimated annual landings by all four fisheries are listed in Table 1 and plotted in Figure 1.

Commercial landings of Pacific sanddabs for both the CA and OR/WA fisheries in recent years were obtained from the PacFIN database (1981 to 2001, and 2012) and from the total mortality estimates provided by the WCGOP (2002 to 2011). These data indicated about two third of commercial landings of Pacific sanddabs were from California.

Efforts on constructing historical commercial landings from California waters have been ongoing in recent years, based on recovered block summary and fish ticket data (Pearson *et al*. 2008, Ralston *et al*. 2010). Commercial landings for Pacific sanddab by month, gear, and port were constructed between 1969 and 1980, and the landings by month and block were constructed between 1931 and 1968. These data were then summarized to obtain annual total landings of Pacific sanddab for the CA fishery. Note that the high catches of sanddabs in the historical period (between 1916 and the 1940s, but declining through the 1930s and 1940s) is consistent with other ongoing efforts to understand the spatial patterns of development of California groundfish fisheries. Specifically, in the earliest years of the fishery, catches tended to take place in shallower waters, closer to primary ports, as demonstrated by the observation that landings of Pacific sanddab, Starry flounder, California halibut and English sole were at relative high levels during the 1910s and 1920s (CDFW 1949). The block summary data (which begin ~ 1930) indicate that over the seventy years since that period, catches have taken place in areas of increasingly deeper habitat, with an increasing distance between catch locations and ports, and in increasingly inclement weather conditions (Miller et al. in review).

Commercial landings between 1916 and 1930 were obtained from a published report (Staff of the Bureau of Marine Fisheries 1949). In the report, annual landings of sanddabs were recorded (Table 44 in the report) between 1916 and 1947. The reported catches consisted of two small flatfishes (Pacific and speckled sanddabs). However, catches of speckled sanddab were very small, and were not separated from the total sanddab catches in the report. In this assessment, it is assumed that all reported catches were Pacific sanddab. The report also stated that nearly all catches were from trawls. Prior to 1938, most landings were from the San Francisco region. After 1938, 47% of landings were from the San Francisco region while 40% of landings were from the Eureka area. There was a small amount of sanddab catch from southern California from hook-and-line gear, but these catches were not separated in the report.

Commercial landings prior to 1916 were difficult to obtain. The only source of data was from the summarized landings of aggregated species market categories along the U.S. west coast between 1892 and 1926 (Sette and Fiedler 1928). In the report, landings of flatfish were first recorded in 1892, and yearly landings were recorded in 3 to 7 year intervals between 1892 and 1915. The reported total flatfish landings of 13 million pounds in 1915 were comparable to that in the California report (Staff of the Bureau of Marine Fisheries 1949). To get estimates of Pacific sanddab landings between 1888 and 1915, the following two-step procedure was taken. First, total flatfish landings for those years that had missing landing data between 1888 and 1915 were linearly interpolated with those years that had landing estimates. The landing for 1888 was set to zero. Second, the annual landings for Pacific sanddab were then estimated by assuming that 11.66% of flatfish landings in those years were Pacific sanddab. This was the average percentage of Pacific sanddab catches of the total flatfish catches between 1916 and 1920.

Historical landings of Pacific sanddab in the Oregon waters were obtained through the Historical Reconstruction Project (Karnowski et al. 2012, V. Gertseva, NWFSC, personal communication). The reconstructed data were provided by Gertseva of the NWFSC and included commercial landings of Pacific sanddab between 1896 and 1986, and catches of Pacific sanddab for animal foods between 1942 and 1979. In the Reconstruction Project report, it estimated that most Pacific sanddab catches were from trawl gears.

There were very few historical records of Pacific sanddab catches in Washington waters. The Washington Department of Fish and Wildlife (WDFW) provided some limited estimates of Pacific sanddab landings between 1970 and 1980 (Theresa Tsou, personal communication). To get estimates of historical landings of Pacific sanddab in Washington waters before 1980, a constant ratio of catches between the Oregon and Washington fisheries was obtained by using an average catch ratio of the species between these two states between 1981 and 2011; this ratio was then applied to the Oregon catch between 1896 and 1980 to obtain historical landings of Pacific sanddab in Washington waters.

The commercial trawl fishery targeting fish for animal food, mainly for mink farms, started in 1953 in California (Best 1959 and 1961, Nitsos and Read 1965). In Oregon, a portion of the landings of flatfish and rockfish were used as mink foods from 1942 through the 1970s (Harry 1956, Karnowski *et al*. 2012). Catches from mink food fisheries from both states were treated as a separate fishery from other commercial trawl fisheries because it is assumed almost all catches were retained and discards were minimal. Because there were no composition data from the fishery, fishery selectivity could not be estimated independently. It was assumed that selectivity for this fishery was the same as the CA fishery in the assessment model.

Total catches of all fish species for animal foods in California ranged from 436 mt in 1953 to 1,817 mt in 1960. Catches of sanddab were low, generally consisting of less than 2% of total fish catches during the period. Most catches of sanddab were from northern California (Eureka and San Francisco areas). The California Department of Fish and Game started collecting data on animal food in 1953. Total annual catches of animal foods between 1953 and 1962 were reported in the published literature (Best 1959 and 1961, Nitsos and Reed 1965). Annual catches of Pacific sanddab were available only for years between 1958 and 1962 and might not be complete for some ports of landing. An average catch ratio of sanddab over all animal food landings between 1958 and 1963 was calculated to estimate 1.230% of all landings for animal foods for the whole time period were of sanddab. This ratio was then applied to total animal food landings between 1953 and 1957 to obtain estimates of sanddab landings for those years.

There were no published records of animal food landings in California after 1962. The only data source available after 1962 were reported total animal food landings in the CALCOM database (market category 992). The recorded landings showed that large animal food landings occurred in the mid-1960s (around 1,300 mt) and almost no landings in the late 1970s. There were some reported landings in the same market category in 1980s, but it was unclear if these landings were for mink foods, so these landings were not included in estimating catches for Pacific sanddab. To get estimates of animal food landings of Pacific sanddab between 1963 and 1979, the same sanddab catch ratio (1.230%) was applied to total landings of animal foods for the same time period.

There were no records of landings of Pacific sanddab for animal food in California before 1953. However, it was expected there were some landings in those early years as there were some estimated landings in Oregon. To resolve this issue, an estimated landing of 5.5 mt in 1953 was used to assume the amount of sanddab landed annually in the animal food fishery between 1942 (the first year of reported animal food landings in Oregon) and 1952.

The Oregon historical catch reconstruction project provided estimated catches of Pacific sanddab for mink foods (Gertseva *et al*.2010, Karnowski *et al*. 2012). Annual estimates of the Oregon animal food landings were provided by Gertseva (NWFSC, personal communication). Most mink food catches were between 1953 and 1977, and the catches ranged between 2.5 mt to 80.5 mt. This is the same time period when there were mink food catches in California.

There were no records of mink food catches in Washington. One possible way to get estimates of mink food catches in Washington was to use the commercial catch ratio between these two states. Overall, it was assumed that mink food catches in Washington were very small; therefore, no animal food catches from Washington waters were included in this assessment.

Estimated recreational catches of Pacific sanddab between 1980 and 2012 were obtained from the RecFIN database. Estimated catches were the sums of weight of type A catches (examined by samplers) and type B1 catches (reported by anglers as dead fish). Separate estimates were obtained for all California waters and for the Oregon and Washington waters combined. Since there were no estimates in the RecFIN database between 1990 and 1992, these missing values were linearly interpolated with three-year averages before 1989 and after 1993. In general, recreational catches were much higher in California waters than those in Oregon/Washington waters. In California, recreational catches ranged from 12 mt in 1987 to 216 mt in 1981, and the average catch during 2002-2011 was 51 mt. In Oregon/Washington waters, estimated catches ranged from <1 mt in recent years to the highest catch of 102 mt in 1997; average catches in recent years (2006-2011) have been very low (<0.2 mt). A small amount of estimated recreational catch (<0.3 mt) from the Washington recreational fishery (Tsou, WDFW, personal communication) in recent years was also added to total coastwide recreational catches.

Recreational catches from California in 1979 were obtained from a published record (Holliday et al. 1984). There were no records of sanddab catches from Oregon and Washington waters that year. Estimated total catch (Type A) from California waters was 78 mt between July and December of 1979. By comparing type B1 catch from the same time period and extending the estimate to the whole year, it was estimated that the total recreational catch in California waters was 174.8 mt in 1979.

Historical recreational catches from both Oregon and Washington are relatively low based on recent RecFIN data. There were no records of historical recreational catches from California before 1979. Estimates of the California recreational catches from 1971 to 1978 were constructed using a regression estimator of the CPFV logbook and the RecFIN database during periods when data were available. These estimates may not be accurate because Pacific sanddabs were not explicitly identified in CPFV logbooks. The catches included other sanddab species (i.e., speckle sanddab). However, catches of other sanddab species were relatively small compared to catches of Pacific sanddab.

2.1.3.2 Fishery discards

One of the main characteristics of the Pacific sanddab fisheries was that discard rates were high in commercial trawl catches, mainly because the species was often not a primary targeted by commercial trawl fleets, and the species are generally too small to have high values in fish markets. Estimates of historical discard rates in commercial fisheries were difficult as there were no reliable studies on the species. The first discard study available was from Pikitch *et al*. (1988) on the Oregon trawl fishery. Estimated discard rates of Pacific sanddab were between 48% and 58% of total catches from 1986 to 1988 (Wallace *et al*. 1996, John Wallace, NWFSC, personal communication). A similar discard rate (50.5%) was also observed in the Oregon trawl fisheries in the mid-1990s (Sampson 2002). There were no estimates of discards in the California trawl fishery during the same time period. Estimated discard rates by commercial trawl fisheries in recent years (2002 to 2011) were however available from the WCGOP observer program.

There were some historical studies on discards of commercial trawl fisheries. Harry (1956) took 12 sampling trips on the Oregon otter trawl fishery in 1950. With exception of two sampling trips that were to catch fish for mink foods, he estimated that nearly all of Pacific sanddab caught were discarded, primarily due to fish being caught were too small and would be unmarketable. In the same report, discard rates for other major flatfishes were also high. The discard rates was 27.4% for English sole (*Parophrys vetulus*), 17.0% for Dover sole (*Microstomus pacificus*), and 32.5% for petrale sole (*Eopstetta jordani*).

In summarizing the San Francisco trawl fishery in 1934, Clark (1935) reported that sanddab (scientific name used in the report is *Orthopsetta sordida*) consisted of 7% of total catches in weight, while high catches were pointed-nosed sole (*Parophrys vetulus*) (46%) and round-nosed sole (*Eopsetta jordani*) (20%). In describing the California trawl fishery in 1935, Clark (1936) reported that sanddab was one of five major species in fishery production. He also reported that trawls operated mostly in the depths between 25 to 100 fathoms between San Francisco and the Oregon border. Although many flatfishes were discarded because fish were too small for markets, some small sanddab (6 inches) were kept. Majority of sanddab caught, however, were around 8 inches (around 20cm).

A series of on-board trawl samples were conducted in the Morro Bay area from 1957 to 1958 (Heimann and Miller 1960). Since majority of trawls were sampled in the rockfish trawl area, the flatfish, including Pacific sanddab, only made up 4.5% of the total catches. Out of 257 pounds of sanddab caught, all were discarded.

In the Monterey Bay area, analysis of catch compositions from 1960 showed high percentages of sanddab catches were discarded (Heimann 1963). Of ten shallow water trawls (30-60 fathoms) sampled between Pigeon Point and Point Sur, a total of 1,010 pounds of sanddab were caught and 40.1% of fish were discarded. Of nineteen intermediate-depth trawls (60-130 fathoms) sampled between Pigeon Point and Point Sur, a total of 43 pounds of sanddab were caught and 37% of fish were discarded. Of four deep water trawls (130-200 fathoms), no sanddab was caught.

Herrmann and Harry reported sampling results on Oregon trawl vessels between 1950 and 1961 (Herrmann and Harry 1963). The results were summarized from a total of 41 sampling trips and 383 trawling tows (Table 1, Herrmann and Harry 1963). Of the total 11,983 pounds of Pacific sanddab caught, all were discarded. Total recorded catches varied greatly between years and within years. For example, there were 6,694 pounds of sanddab caught in 1950 but no sanddab caught in 1950. In 1951, one trip caught 3,581 pounds of sanddab while another trip caught none (Table 3, Herrmann and Harry 1963).

In 1974, TenEyck and Demory examined utilization of flatfish caught by Oregon fisheries and also found high discard rates of Pacific sanddab (TenEyck and Demory 1975). On a total of eight trawl trips they sampled, a total of 903 fish were caught and 641 of them were discarded. Discard rate differed between sexes, with discard rates being 71.9% for females and 93.8% for males.

In light of inconsistence of historical estimates of discard rates on Pacific sanddab, none of these estimates were used in the assessment. Historical discard rates for the OR/WA fishery was set to be the mean discard rate from the 1988 Pikitch study (average of 1985 to 1987, John Wallace, NWFSC, personal communication). Discard rates between 2002 and 2010 for each fishery were obtained from the recent WCGOP observer program (Table 16). In general, discard rates in recent years were higher in the OR/WA fishery (average = 0.6184) than those in the CA fishery (average = 0.3254). Since there were no discard estimates in the CA fishery prior to 2002, an average discard rate (=0.3256) between 2002 and 2009 from the WCGOP observer program was used as historical discard rate for the CA fishery (Table 16).

2.1.3.3 California CPFV Recreational Fishery Survey

Recent year (1999-2011) CPFV data

The California Department of Fish and Wildlife (CDFW) conducted CPFV (Commercial Passenger Fishing Vessels) recreational survey in the California waters from Monterey Bay through southern California (mostly in southern California) between 1999 and 2011 (Reilly *et al*. 1998). Melissa Monk of the SWFSC retrieved and analyzed the data, and provided a time series of the survey indices during these years. Length composition data of retained and discarded fish were also retrieved from the survey.

For the survey index analysis, data were analyzed at the drift level. Drifts meeting the following criteria were excluded from analyses:

1. trips outside U.S. waters;
2. drifts deeper than 60 fm (data availability);
3. drifts in conservation areas (e.g., Cowcod Conservation Areas and MPAs) established prior to 2012 which prohibit the take of finfish;
4. drifts in large bays or harbors (e.g., San Francisco Bay,and San Diego Harbor);
5. drifts missing both starting and ending location;
6. drifts identified as having possible erroneous location or time data;
7. drifts missing the number of observed anglers.

Fishing time and number of observed anglers were limited to 95% of the data to remove potential outliers. Remaining drifts were between 5 and 120 minutes in duration and 14-18 anglers observed.

The following methods were applied to identify regions of suitable habitat, and to determine the number of drifts to include in the analysis. The locations of positive encounters were mapped, using the drift starting locations. Regions of suitable habitat were defined by creating detailed hulls (similar to an alpha hull) with a 0.01 decimal degree buffer around a location or cluster of locations (Data East 2003). Any portion of a region that intersected with land was removed. As an example of the buffers, a region with only one positive encounter has an ellipsoid area of $3.22km^2$. Each drift (both positive and zero-catch) was assigned to the region with which it intersected. Drifts that did not intersect with a region were considered structural zeroes, i.e., outside of the species habitat, and not used in the analysis. Data were filtered for each species to exclude regions that did not consistently produce catch of the species of interest (i.e. having fewer than 5 years with positive observations).

A total of 173 buffered areas were identified from the CDFW data (N = 15830, positive N = 2154). Of these, 24 areas (53% of the total km^2 defined as suitable habitat) had at least 5 years of positive observations. Sampling coverage was insufficient to test for difference in CPUE trends among regions (i.e. an interaction between YEAR and REGION variables) and one index was created for California.

The selected data (N = 10197; positive N = 1693) contained categorical variables for YEAR (11 levels) and two possible additional effects, MONTH (12 levels), and 15-fm depth bins ("DEP15", 4 levels). The data were analyzed using a delta GLMM method developed by the SWFSC FED. The distribution for positives was lognormal (which was strongly favored over gamma by a delta AIC of 327). The binary model used a logit transformation which was indistinguishable from the alternatives. In both submodels, stepwise BIC removed all interaction terms. The final positive and binomial models without interactions retained YEAR, DEP15, and REGION, and MONTH (Table 18). The annual abundance indices (YEAR effects) are shown in Figure 31.

CPFV early year length composition data (1975-1998)
Recreational length composition data in early years came from three sampling sources in California. The CDFW have historically collected catch and length information for groundfish through their CPFV observer program. There were two surveys in southern California, one in the 1970s and the other in the 1980s. The survey from 1975-1978 measured a total of 876 Pacific sanddabs in 180 trips. There were only 16 Pacific sanddabs (caught in 8 trips) sampled in 1975, so this year was excluded from further analysis. The survey from 1986-1989 measured a total of 2,188 Pacific sanddabs in 271 trips. All measurements were retained from this survey. There was also another survey in northern and central California from 1987-1998, where a total of 2,274 Pacific sanddabs were sampled in 484 trips. The first year of this survey focused only in Monterey Bay and sample sizes were small (3 Pacific sanddabs in 2 trips); therefore 1987 was excluded from further analysis. Sex was not identified for these fish.

Annual trips that caught Pacific sanddabs and the number of lengths sampled from these surveys can be found in Table 12. The number of Pacific sanddabs measured per trip was low, ranging from 2.1 to 9.5 fish, compared to those from other surveys and/or fisheries. Length samples were aggregated to port-complex-month to be comparable to other length sample sizes used in this assessment.

There was an overlap between two surveys in the years 1988 and 1989. Since this assessment is a coastwide assessment, the length compositions from the two surveys in these two years were combined. Figure 32 showed that there were small differences between length frequency distributions in the two areas.

2.1.3.4 Fishery Length and Age Composition Data
There were no composition data available from the mink food fishery. Available composition data from fisheries included the following:

1) length composition data by sex and by retained/discarded fish for the Oregon trawl fishery from the mesh study in 1990 (John Wallace, NWFSC, personal communication);
2) combined sex length composition data for discarded catches for both CA and OR/WA fisheries from 2006 to 2011 from the WCGOP;
3) length composition data by sex for retained fish from the CA trawl fishery from 2003 to 2012 downloaded from the PacFIN database;

4) length composition data by sex for retained fish from the OR/WA trawl fishery from 1994 to 2012 downloaded from the PacFIN database;
5) length composition data by retained/discarded fish for recreational catches were obtained from the CA recreational survey. The data were from two sources: (1) the CPFV data of retained catches between 1976 and 1998, and (2) the recent survey data between 1999 and 2001 (Melissa Monk, SWFSC, personal communication);
6) age composition data by sex for retained fish from the CA trawl fishery for years of 2003, 2007, and 2008. Otolith samples for these fish were provided by the ODFW; and
7) age composition data by sex for retained fish from the OR/WA trawl fishery from 1995 to 2012 (no data for some years). Otoliths for these fish were provided by the CDFW.

Numbers of sampled trips and length measurements for all fisheries are listed in Table 13 to Table 15. Numbers of sampled trips and fish aged for all fisheries are listed in Table 17. For both CA and OR/WA fisheries, sampled trips are defined as sample numbers in port sampling records. Numbers of fish per sample ranged between 31 and 52 for both fisheries.

2.2 History of Modeling Approaches Used for This Stock

This is the first time that Pacific sanddab has been assessed. No stock assessment has been done for Pacific sanddab in Alaska, Canada, and Mexico.

2.3 Model Description

2.3.1 Basic Model Structures

This assessment was based on an age-structured population model, commonly used in U.S. west coast groundfish assessment modeling. One stock of Pacific sanddabs was assumed since there is no strong evidence that shows differences by area in growth, fecundity, and other biological characteristics. There have been some catches reported in Canadian and Mexican waters, but no data were used for this assessment. It is assumed that catches in those waters have minimum impact on the Pacific sanddab population in the waters off the U.S. west coast and there are no significant migrations of Pacific sanddabs between these areas.

The population model was structured as a two-sex model given evidence of sexually dimorphic growth and sex-specific natural mortality rates.

2.3.2 Fishing Fleets and Surveys

Four fishing fleets and three fishery-independent surveys were defined and used in this assessment. Details on these fishing fleets and survey are described in above.

2.3.3 Modeling software

The modeling software used in this assessment is Stock Synthesis 3 (SS3, version 4.23O, April 2013), developed by Richard Methot (Methot and Wetzel 2013). R programs developed at the NWFSC, including R software packages for GLMM and aging error analysis and r4ss software, were used in analyzing data and producing graphics for this assessment (r4ss, Taylor *et al*. 2012).

2.3.4 General Model Specifications

This assessment assumed that a single stock of Pacific sanddabs occurs along the U.S. west coast, and that the stock was subject to fishing by four fisheries (see details in the previous sections). Most commercial catches were from bottom trawl gears. All selectivity functions are length-based, asymptotic, and sex-specific where data are available. A Beverton-Holt stock-recruitment relationship is modeled in this assessment.

This assessment assumes sexually dimorphic growth, and sex-specific natural mortality and length-weight relationship. Natural mortality was assumed to be constant for all ages in each sex.

The likelihood components included in the assessment model are: catches, discards, indices, length and age compositions, recruitment deviations, parameters priors, and parameter soft bounds. All input files for the SS program are attached in Appendix D (page 284).

2.3.5 Estimated and Fixed Parameters

2.3.5.1 Parameter Priors

Priors for two sets of parameters, stock recruitment steepness (*h*) and natural mortality rate (*M*) by sex, were modeled in this assessment. The steepness prior derived for flatfish species from the Myers meta-analysis (Myers et al. 1999) was used (mean = 0.80, and SD = 0.09) (Figure 55). Sex-specific priors for natural mortality were based on a metal-analysis provided by Owen Hamel (NWFSC, personal communication). Input parameters to Hamel's analysis included mean temperature, asymptotic lengths, and growth rates (*K*) from preliminary analysis of available data. Estimated median values of *M* from Hamel's analysis for female and male were 0.321 and 0.374, respectively (Figure 56).

2.3.5.2 Life History Parameters

Details on specifications of life history parameters were described in the Biology Section. Growth and natural mortalities for both sexes were estimated internally, while other life history parameters, including the length-weight relationships and maturity, were estimated outside the assessment and fixed in the assessment model.

2.3.5.3 Stock-Recruitment Parameters

A density-dependent Beverton-Holt stock-recruitment relationship is assumed for this assessment. The log of virgin recruitment ($ln(R_0)$) and steepness (*h*) are estimated in the model. Recruitment deviations are estimated from 1966 to 2011, and stratified in three time periods, early-year period (1966-1976), main period (1977-2011), and late-year period (2012-2013). Recruitment variability parameter (σ_R) was set to 0.45, which was evaluated during model development and found to be stable and slightly larger than that of the estimated root mean square error (RMSE) in the base model.

2.3.5.4 Survey and Fishery Selectivity Parameters

Selectivity functions for all surveys and fisheries were assumed to be length-based and to be asymptotic. Sex-specific selectivity was used where sex-specific composition data were available. Because there are no composition data available from the mink food fishery, its selectivity was assumed to be the same as the CA fishery. Age selectivity was set to 1.0 for all ages because there were age-0 fish catches in the NWFSC trawl survey.

2.3.6 Data Weighting

The data weighting process involved changing input sample sizes for the composition data and adding extra variance to abundance indices. For composition data, if both length and age data were taken from the same individual fish, these data would need to be down-weighted to avoid double-use of the data. The main purpose of the process is to reduce disproportional effects of particular data on overall model fits (Stewart and Hamel, in review).

There are two steps in the data weighting process. First, initial sample sizes for composition data and initial standard deviations (SD) or coefficient of variances (CVs) for index data are inputted into the assessment model. The model is run once and the SS program produces estimates of effective sample sizes for each set of composition data and an extra SD for each set of indices. Second, estimates of effective sample sizes and extra SDs are then inputted to the model to replace the initial sample sizes and SDs, and then the model is re-run. Additional steps can be taken following the same procedure in the second step, but it has been common practice in groundfish assessments to use this two-step weighting process, as additional steps often produce comparable model outputs. The SS program is capable of estimating extra SD internally. In this case, only effective sample sizes for composition data are needed in the second step. This is the approach that was used in this assessment.

In this assessment, there were only length composition data available from the triennial survey double-use of the composition data was not an issue. Numbers of trawl tows were used as initial sample sizes for the survey. For the NWFSC survey, both length and age composition data were used in the model. Because the age composition data were used as conditional age-at-length compositions, numbers of trawl tows were still used as initial sample sizes for the length composition inputs while numbers of fish aged were used initial sample sizes for the conditional age-at-length composition. The estimated effective sample sizes for the NWFSC survey were slightly larger (about 112%) than those of the initial sample sizes for the length composition data, but were about 18% of the initial sample sizes for the conditional age-at-length composition data. For both commercial trawl fisheries, because both length and age composition data were used in the model, overall weighting (lambda values in the SS program) were set to be 0.5 to account for double-usages of both composition data.

One additional issue of data weighting is how to determine standard deviation of recruitment deviations (σ_R). In this assessment, an initial value of σ_R was set to be slightly larger than the estimated RMSE of the recruitment deviations. The model was then rerun to ensure that σ_R was consistently slightly larger than RMSE. This iterative process could be done in the early model development but the process may need to be repeated if there are major changes in model structures and data inputs.

2.4 Model Selection and Evaluation

2.4.1 Key Assumptions and Structural Choices

Selection of the base model was based on balances of data availability, model realism, and parsimony. As this is the first time the Pacific sanddab stock is being assessed, much efforts was made to evaluate fishing fleet structures, selectivity patterns, sex-specific biological and fishing parameters, and other productivity parameters (e.g., stock-recruitment, natural mortality). The selection process started with fixing some key parameters, such as natural mortality rates and steepness, at their prior values, and then gradually set these parameters to be estimated. During the process, many exploratory model runs were also conducted to evaluate sex-offset selectivity and time-varying selectivity functions.

Key assumptions in the base model included the following: (1) the Beverton-Holt stock-recruit function; (2) asymptotic selectivity functions for all fleets and both sexes; and (3) time-invariant catchability coefficients (Qs) for all surveys. It was also assumed that reported catches, by all commercial and recreational fleets, were accurate, especially in recent years, and that historical catches of Pacific sanddabs might not be well recorded.

Discard rates were relatively high for Pacific sanddabs. It was assumed in this assessment that all discarded fish were dead in trawl fisheries. Since there were no data available to estimate discard mortality in the recreational fishery, a 50% of discard mortality rate was assumed for the recreational fishery. This assumption has minimum effects on model outputs since discard rates in the recreational fishery are low (about 6% of total catch).

A series of sensitivity analysis were conducted to evaluate these key assumptions (see the Uncertainty and sensitivity analysis section).

2.4.2 Alternative models considered

Alternative models that were explored during the model selection process included: (1) treating the triennial survey as one continuous survey series; and (2) using time block on commercial trawl fishery selectivity in 2003. These alternative models were not used in the base model for a variety of reasons. For the triennial survey, it has been suggested that differences in survey timing between the early and late survey periods may affect CPUE of flatfish. Splitting the survey into two indices has been done in other west coast flatfish assessment. Using time block on commercial trawl fisheries (e.g., time block in 2003 when RCAs were implemented coastwide) has also been done in many groundfish assessments. A time block in 2003 was not used in the base model because there were no length or age composition data before 2003 from the CA trawl fishery.

There were few alternative models considered and explored during the STAR Panel review (see details in the STAR Panel Recommendations section). The base model adopted during the STAR Panel review includes the following changes to the pre-STAR base model: (1) add time-varying retention for two commercial trawl fisheries in 2001 to reflect changes of fishery management (IFQ); (2) modify discard rates for two commercial trawl fisheries to better fits to the discard mortalities reported by the WCGOP observer program; (3) remove the discard estimate for the 2003 OR/WA to better fit observed and estimate discard mortalities for the OR/WA trawl fishery in recent years; (4) remove length frequency data of the 1990 mesh size study from the assessment model as there was no evidence that the study used the similar trawl gears as used in the fisheries during that time; and (5) use the revised recreational CPUE data.

2.4.3 Model Convergence, Jitter and Phase Analysis and Repeated Model Runs

To ensure that the assessment model produced stable outputs and was not affected by ranges of initial conditions and phase setting, a series of tests on model stability were conducted. This included jitter analysis, in which initial parameter vales were jittered by randomly alternating initial parameter values by 5% and rerunning the model. The phase analyses were conducted by alternating phases for most estimated parameters. Repeated model runs were done by running the same model multiple times. Outputs from all these test runs showed that the proposed model was stable. That is, all test runs converged well with convergence criteria close to or less than convergence criteria (0.01), and all test runs produced the same outputs.

2.5 Response to STAR Panel Recommendations

1) Compare growth differences between Arora (1951) and Lefebvre (2012) or simply compare mean length-at-age.
    - Response: In the Arora study, fish were aged primarily by scale annuli and scale widths, although otoliths were somehow included in the criteria (actual aging method not entirely clear). Thus, the mean size at age data may not be directly comparable. However, there is no evidence of a dramatic difference between mean size at age from Arora (n=87) and that from the aged fish from the trawl survey (n=~7000). Consequently, it appears that the substantial shift in size at maturity indicated by a comparison of the two studies does reflect a shift in maturity, but not necessarily growth, at age.

2) Use the new recreational CPUE index, the revised mink food fishery catches, put a retention time block at 2011, and use empirical discard estimates, and remove the 2003 OR/WA discard rate estimate in the new base model. All additional analyses should use this new base model.
   - Response: A new model was constructed according to the recommendations. Estimated discarded catches were more comparable to those estimated by the WCGOP in recent years. The new model indicated lower virgin recruitment and the stock was less depleted, as the stock depletion changed from 60.6% in the pre-STAR model to 74.3%.
3) Sensitivity run for the pre-1930s CA catch history by doubling and halving the CA trawl catches prior to 1930.
   - Response: Doubling the pre-1930s CA catches resulted in higher virgin spawning biomass and much less stock depletion than those runs without doubling or halving. Halving the pre-1930s CA catches resulted in no changes of stock dynamics in recent years. Additional information with regard to the scale of the small flatfish fishery during this time period was presented, demonstrating that California fisheries for other nearshore flatfish (including California halibut, starry flounder and English sole) were substantial during this time period (Pacific sanddab represented on the order of 10-15% of the total California small flatfish catch during this period), and that larger Pacific sanddabs were considered a desirable and marketable species during this time period.
4) Clarify Wallace (1996) mesh size study data were filtered adequately to inform fishery discard rates and catch composition.
   - Response: Further examinations of the Wallace 1990 mesh size study (published in 1996) indicated no sufficient evidence to support the same mesh size being used between the study and fisheries. Length frequency data from the study were then removed from the assessment.
5) Justify why only triennial survey index data were removed in the sensitivity run. Explore removing the length comp. data as well. Additionally, provide a sensitivity run removing the early triennial survey index and comp. data.
   - Response: Two model runs were conducted. In the first run, all data from the early time period of the triennial survey, including length composition and survey indices, were removed. In the second run, all data from the survey were removed. The results showed that removing data from the early time period had large effects than removing all triennial data. It suggested that there might be some conflicting signals between data in these two time periods. The Panel and STAT team discussed the utilities of the survey data, and it was agreed that the survey data can be included in the assessment model.
6) Test the influence of the fishery age comps. and survey conditional age-at-length data by 1) removing age comps., 2) fixing growth parameters from the base model and removing conditional age-at-length data, and 3) fixing growth parameters from the base model and removing all these data to explore reasons for the variable scale of the SSB.
   - Response: Three assessment model runs, corresponding to each of three requests listed above, were conducted. The results showed that removing only fishery age composition data had relatively small effects on the model outputs, but that removing conditional age-at-length data (with fixed growth rates before data removal) had very large effects on the model outputs. Removing the conditional age-at-length data resulted in estimates of higher virgin recruitment, and larger natural mortality, along with larger uncertainties in these estimates. The results were more consistent with the survey estimates of Pacific sanddab total biomass.
7) Profile on ln(R0) with each likelihood component (by fleet, survey, and data component).

- Response: Because it is a relatively new r4ss function, STAT team was not be able to complete the profile runs and plots. The STAR Panel indicated that the request was intended to be a diagnostic tool.

8) There was no formal Request #8 from the STAR Panel. The STAT team made an effort to test a simple production model to test scales on the estimated virgin recruitments. This run was conducted by (1) fixing all parameter values at the proposed base model, except virgin recruitment; and (2) setting all recruit deviations to zeros. The results showed similar time series trends in spawning biomass and about 25% higher in virgin recruitment. Stock depletion level was about 11% higher from using the simple production model. The model was consistent with declining stock trends during increased exploitation rates during the 1990s and increasing stock trends as catches declined during the 2000s.
9) Using the new base model (provisions from requests 2 and 4, use the 2011 trawl discard rates for 2012 for both CA and OR/WA fleets), provide a run exploring a Lorenzen *M* or some other modeling structure to allow higher *Ms* for younger fish. Show the total likelihood, including the number of estimated parameters.
    - Response: Five runs from using Lorenzen M with reference ages fixed at ages 1 to 5 were completed and the model outputs were compared among these runs and the proposed base model. Estimated Lorenzen *Ms* were higher in high reference ages than those in low reference ages. Similar trends were also estimated in virgin recruitments and stock depletions. The STAR and STAT Teams agreed that there were ecological reasons to consider the Lorenzen curve as a more appropriate mortality function for rapidly growing, high turnover species such as Pacific sanddab, but that there was relatively little direct support for this alternative in the data.
10) Provide a sensitivity analysis that allow dome-shaped selectivity for all surveys except for one fishery (which selects for the largest fish), which should remain asymptotic. M should be fixed according to the new base model. Provide fits to the comps. aggregated across all years. Show the total likelihood, including the number of estimated parameters.
    - Response: Three model runs were conducted in responds to this request: (1) all selectivity functions were set to be dome-shaped except the CA fishery; (2) selectivity functions for all fisheries were set to be dome-shaped and selectivity functions for all surveys were set to be asymptotic; and (3) all selectivity function were set to be dome-shaped. Key model outputs and aggregated model fits to the composition data from these Runs were presented. Overall, model outputs from the Runs (1) and (2) were not dramatically different from the proposed base model. But the outputs from Run (2) indicated higher virgin recruitment (about twice as much) than the proposed model, along with much large uncertainties in spawning biomass estimates.
11) If requests 9 and/or10 do not result in significant changes to model results, provide these runs with removal of conditional age-at-length (fix growth parameters according to the new base model).
    - Response: Additional runs were conducted by removing the conditional age-at-length data on the model runs from the Requests 9 and 10. In general, model outputs from these runs were similar to previous runs without the conditional age-at-length data. Without the conditional age-at-length data, estimated virgin recruitments were higher and the stock was less depleted, along with larger confident intervals on estimated biomass and depletion levels.
12) The STAT team also conducted test model runs with *Q* prior derived from other flatfish assessments (Table 19). In the first test run, extra standard deviations for the survey indices were estimated and the model outputs were very similar to those from the base model. In the second test run, standard deviations were not estimated and standard deviation for the *Q* prior was set to be very small to force the model to fit estimated biomass from the surveys. The

results show improved fits between model and survey estimates, but estimates of other model parameters seemed to be beyond reasonable ranges.

2.6 Base-Model Results

Estimated parameter values and their standard deviations are listed in Table 20. Parameter estimates were in reasonable ranges. Estimated growth curves by sex are plotted in Figure 57. While males were at slightly larger size at age 0 than females, females grew faster than males and attained a large size. Estimated natural mortality for females is lower than that for males (Table 20), similar to the patterns found for many other west coast groundfish species. Because of differences in natural mortality and growth rates, it is expected that there are more females at older ages than males. This is supported by the observations that more females were sampled than males.

Comparisons of selectivity functions for all surveys and fishing fleets are plotted in Figure 58. Individual selectivity curves by sex and for each survey and fishery are plotted from Figure 59 to Figure 71. Fishery retentions curves and discard mortality rates by length are also presented in these plots where discards occurred. In general, fisheries tended to select larger fish than surveys. Sex-specific selectivity was evident in all surveys and fisheries, with males selected at smaller size than females (Figure 58 to Figure 71).

Fits of the base model to composition data from all surveys and fishing fleets were presented in Figure 72 to Figure 105. Detailed fits to each composition data set are presented in Appendix C. These figures provided general diagnostics of the model fits to the composition data. Specifically, they help to visually identify outliers and serial patterns of the model fits to the composition data. Included in these figures were:

1. aggregated length and age composition fits across time by fleet for each data set;
2. Pearson residuals of each composition datum point;
3. comparisons of observed and effective sample sizes by year for each data set; and
4. conditional age-at-length fits and standard deviations by year.

In general, the base model was able to fit composition data well. There was a notable lack of fit to the OR/WA female age frequencies between 1995 and 2005 and for males between 1995 and 2001 (Figure 78, Figure 84, and Figure 85). A similar but less severe pattern was also observed for the fit to the CA female age frequencies in 2007 and 2008 (Figure 78 and Figure 84). This lack of fit to the data might result from interactions between sex-specific growth and selectivity as the model fitted well to all other composition data from the same fisheries during the same periods.

Effective sample sizes for length and age composition data were generally larger than input samples sizes (Figure 86 to Figure 94). In the base model tuning process, these input sample sizes were adjusted upward from 1.16 to 3.86 times. One exception was for the conditional age-at-length data from the NWFSC survey, in which the observed sample size was adjusted downward to 0.18 of the input sample sizes. This was likely because numbers of fish aged were used as the input sample sizes. There were no apparent lacks of fits in conditional age-at-length data (Figure 105). Standard deviations of the fits were larger in young and old fish than those in the middle age range. This was expected as there were few age samples in the young and older age groups.

The base model fit well to patterns of the estimated biomass from the NWFSC survey (Figure 106). During the periods between 2003 and 2012, in which the estimates were available, the estimated biomass was lowest in 2007 with an increasing trend since then. There were generally lacks of fit to the other three indices (both periods of the triennial survey and the recreational survey) (Figure 107 to Figure 109). This suggested that these three indices were less informative of stock biomass. Sensitivity runs were conducted to evaluate effects of the lack of fit to these surveys, and it was found that these lacks of fit minimally affected model outputs (see the Sensitivity analysis section).

It was expected that catchability coefficients (*Q*) from all trawl surveys should be less than zero (in log scale), because these surveys were only conducted in depths greater than 55 m, and Pacific sanddabs are found shallower than 55 m. However, the internally calculated catchability coefficients are much greater than one (Table 20). Estimated catchability coefficients (*Q*) were 19.39, 4.78, and 13.5 for the NWFSC survey and two triennial surveys, respectively. This could be due to overestimation of biomass from all surveys (NWFSC and both triennial surveys), since surveys were conducted on the trawlable grounds and expansions of swept-are biomass estimates assume that all areas are trawlable and that all areas are suitable habitats for Pacific sanddabs. Average estimated total biomass from the NWFSC survey between 2003 and 2012 was about 50,000 mt, which was much larger than the estimate of virgin biomass (Table 21). In addition, high biomass estimates from surveys may result from herding effects of trawl gears that could also lead to inaccurate calculations of density in trawlabe areas (Haltuch *et al*. 2013). However, these reasons alone may not fully explain such large discrepancies between estimates of the assessment model and the surveys. The STAR Panel identified that there exist large uncertainties in the scale of biomass estimates between the model and survey estimates of biomass.

Fits of the base model to the discard rate data for three fleets (excluding the mink food fishery) are presented in Figure 110 to Figure 112. Although fits to the data are within reasonable ranges, they showed some lack of fits to two commercial trawl fisheries. Sensitivity analyses were conducted to assess the effects of fishery discard rates on model outputs (see the Sensitivity analysis section).

The estimated stock-recruitment function, along with its bias-adjusted curve and estimated annual recruitments, is presented in Figure 113. Time series of recruitment deviations, spawning biomass, and stock depletion are presented in Figure 114 to Figure 116. Figure 114 shows that recruitments were at or near the lowest level between 2000 and 2005 in the last 50 years during which the recruitment estimates were made, but increased to an above average level in recent years (2007 to 2011), with a very strong 2010 year class.

Spawning biomass and stock depletion, along with their approximate asymptotic 95% confidence intervals, are estimated to be above the target levels for all years (Figure 115 and Figure 116). Table 21 lists the annual time series of the population and fishery summary statistics, including biomass, catch, stock depletion, SPR and relative exploitation rate. The estimated stock depletion in 2013 was 0.955 (95.5%).

2.7 Uncertainty and Sensitivity Analyses

A series of uncertainty and sensitivity analysis were conducted on the base model. Sensitivity analyses were conducted on fishery discard rates, historical catch estimates, fish maturity function, and inclusion of triennial survey and recreational indices. Sensitivity analyses were also conducted on the inputted model parameters, such as the prior on stock-recruitment steepness (*h*). Likelihood profile runs on stock-recruit steepness (*h*), natural mortality (M), and virgin recruitment (R_0) were also conducted, along with a retrospective analysis that sequentially excludes the last three years of input data. Other sensitivities runs conducted during the STAR Panel review include using the Lorenzen function of natural mortality, using dome-shaped selectivity functions on surveys, and excluding the conditional age-at-length data to evaluate their effects on the model outputs.

2.7.1 Sensitivity Analysis of Discard Rates

Fishery discard rates were considered to be one of the most uncertain inputs to the model because discard rates on fishery catches were high and there is very limited information on fishery discards. In the analysis, discard rates for all fishing fleets were increased and decreased by 20%, and sensitivity runs with theses discard rates were compared with the base model outputs. Model outputs on the estimated time series of spawning biomass and stock depletion from these two sensitivity runs were compared with those from the base model (Figure 117 and Figure 118). Model performance and summary outputs are listed in Table 22. The analysis showed that although discard rates had a moderate effect on model results, especially spawning biomass at early years, they had a minimum effect on stock depletion.

2.7.2 Sensitivity Analysis of Historical Catch Data

The historical catch data for Pacific sanddab are also uncertain because discard rates were high and also because catches may include other small sanddab species, such as speckled sanddab. A sensitivity analysis was conducted by reducing and increasing 20% of catches by all fleets before 1980. Time series of spawning biomass and stock depletion from this sensitivity analysis were compared with the base model outputs in Figure 119 and Figure 120. Model performance and summary outputs from this analysis are listed in Table 22. The analysis showed that reduction of historical catches lead to increases in spawning biomass and that the stock was less depleted in 2013. Increases of the historical catches by 20% resulted in a change of estimated stock depletion from 60.6% to 55.8% in 2013.

2.7.3 Sensitivity Analysis of Steepness Prior

A sensitivity analysis was also conducted to evaluate using a steepness prior in the assessment. In the non-h prior run, a non-informative prior was used (by setting “Prior type = (-1)” and standard deviation to 99). Comparisons of model outputs are plotted in Figure 121 and Figure 122. Model performance and summary outputs from the analysis are listed in Table 23. The comparisons showed that whether to include an *h*-prior in the assessment had large effects on the model outputs. Without using an *h*-prior, *h* was estimated to be 0.431, which was lower than the estimated *h* of 0.753 when the *h*-prior was used. As expected, virgin recruitment (R_0) was estimated to be higher without the *h*-prior in the base model, and the stock depletion changed from 95.5% in the base model to 68.9% when a non-informative prior was used.

2.7.4 Sensitivity Analysis of Maturity Schedules

A sensitivity analysis was conducted to evaluate two different maturity functions: (1) a maturity function based on recently collected maturity data between August and November, which was used in the base model; and (2) maturity function derived using data collected by Arora in 1951. Comparison plots of spawning biomass and stock depletion from these two sensitivity runs are presented in Figure 123 and Figure 124. Model performance and summary outputs from using these two maturity functions are listed in Table 23. They showed that spawning biomass was lower using Arora’s maturity function than estimated spawning biomass those using the recent data to inform the maturity function. The stock depletion changed from 95.5% in the base model to 80.7% when the Arora’s maturity function was used.

2.7.5 Sensitivity Analysis on excluding Triennial and Recreational Survey Indices

The base model runs showed poor fits to both the triennial and recreational survey indices of abundance. Sensitivity analyses were conducted to evaluate the effects of these indices on estimated stock status. In the analyses, indices of both surveys were excluded while composition data from these surveys were retained in the model. Comparisons of spawning biomass and stock depletions from these sensitivity runs are presented in Figure 125 to Figure 128. Model performance and summary outputs from exclusion of these two survey indices are listed in Table 24. The results suggest that both indices had minimal effects on estimated stock status.

2.7.6 Sensitivity Analysis on Lorenzen natural mortality estimation

It is expected that natural mortality of Pacific sanddab would decrease as fish grow larger, probably due to decreases in predations. Sensitivity analyses were conducted to evaluate the effects of changes of natural mortality by age on estimated stock status. In the analyses, six reference ages (1 to 6) were used. Estimated natural mortalities by ages are presented in Figure 129. Comparisons of spawning biomass and stock depletions from these sensitivity runs are presented in Figure 130 and Figure 131. Model performance and summary outputs from exclusion of these two survey indices are listed in Table 25. The results showed comparable outputs between the base model and the model using the Lorenzen function with reference age at 5 years old.

2.7.7 Sensitivity Analysis on applying dome-shaped selectivity to surveys

A sensitivity analysis was conducted by applying dome-shaped selectivity to all surveys while selectivities for all fisheries were kept asymptotic. With six more parameters, the model outputs are similar to the base model (Table 26, Figure 132 and Figure 133).

2.7.8 Sensitivity Analysis on excluding conditional age-at-length data

To evaluate effects of the NWFSC conditional age-at-length data on the model outputs and estimated catchability coefficients, a sensitivity analysis was conducted by removing all data after growth parameters were fixed at the values estimated in the base model. Model performance and summary outputs from the analysis are presented in Table 26, and Figure 134 and Figure 135. Without the conditional age-at-length data, estimated virgin recruitment (ln(R_0)) is much higher than that estimated in the base model. Estimated natural mortalities were also higher, being 0.612 and 0.72 for females and males. Stock depletion changes from 95.5% in the base model to 120.2%. Estimated catchability coefficients reduce from 19.39. 4.78, and 13.54 in the base model to 6.04, 2.88, and 5.41 for the NWFSC and both triennial surveys, respectively. This suggests large effects of this data set on estimation of stock productivity and catchability coefficients of the surveys.

2.7.9 Likelihood Profiles

Sensitivity analyses using likelihood profiles were conducted on three important model parameters: (1) stock-recruitment steepness (*h*), (2) virgin recruitment (R_0), and natural mortality (*M*) for both sexes. These parameters are estimated in the model.

Steepness (*h*) Profile

Steepness profile runs were conducted across a range of *h* values (0.3 and 1.0 at an interval of 0.05). A likelihood profile and comparisons of spawning biomass and stock depletion vs. steepness are presented in Figure 136 to Figure 138. The analysis showed that the steepness prior had a large effect on estimates of steepness parameter (Figure 136), and therefore had large effect on estimates of spawning biomass and stock depletion (Figure 137and Figure 138). These results confirmed results of the sensitivity analysis using a non-information prior on steepness (see section 2.7.3).

Virgin Recruitment (R_0) Profile

Spawning biomass and stock depletion from the profile run on the virgin recruit parameter are presented in Figure 139 to Figure 141. The results showed that changes in negative log likelihood values were relatively small, compared to the profiles of steepness and natural mortality. This suggests that the data were not very informative in estimating virgin recruitment.

Natural Mortality (*M*) Profile
Spawning biomass and stock depletion from the profile run on natural mortality are presented in Figure 142 to Figure 144. As expected, estimated spawning biomass and stock depletion are sensitive to natural mortality. The higher values of natural mortality, the more productive the stock, which lead to higher spawning biomass and a less depleted stock.

2.7.10 Retrospective Analysis

The retrospective analysis was conducted by excluding the last two years of data. A similar run by excluding the last three years of data could not be done because time-varying selectivity was applied in the last two years. Comparisons of spawning biomass and stock depletion of these runs with the base model are presented in Figure 145 and Figure 146, and model performance and summary outputs are listed in Table 27. Spawning biomass and stock depletion from not using last year's data were very similar to the base model estimates, but estimation without using the last three-year's data indicated a much higher spawning biomass and a less depleted stock. However, there were greater uncertainties, as shown with larger asymptotic confidence intervals, in estimates of spawning biomass and stock depletion as these data were removed.

3 Regional management considerations

Pacific sanddabs are managed within the Other Flatfish complex without any regional stratification of harvest specifications or allocations on the U.S. west coast. Given that there is no evidence of stock structure on the U.S. west coast (e.g., differential growth rates by area), regional estimates of biomass were not made. The catch and survey data can be used to post stratify relative biomass if regional management allocations are considered.

4 Research Needs

1) Both the NWFSC and triennial surveys provided estimates of biomass of Pacific sanddabs. These estimates were much higher than those estimated in the assessment model. Although the catchability coefficient (Q) was treated as a nuisance (scalar) parameter, which is typical of most assessments, the nominal estimate for these values from the trawl surveys was very high. For example, the estimated catchability coefficient was 19.4 for the NWFSC combined shelf-slope trawl survey. Given that these surveys did not cover the entirety of suitable Pacific sanddab habitat (the survey were not conducted depths shallower than 50 m), it was expected that these catchability coefficients should be less than (or close to) one. Further studies on the model structure, as well as on estimated survey biomass, are needed to provide general guidelines for future assessments of this species.
2) One of major uncertainties in the Pacific sanddab catch history has been the proportions of catches discarded. Discard rates varied among fisheries and states. The WCGOP has provided important information on the discard rates and length composition of discarded catches in recent years. It will be important that these data continue to be collected in the future. In addition, future assessments will benefit if Pacific sanddabs are identified separately from other sanddab species in landings and discards. This is particularly informative when length composition data for both retained and discarded catches are available for the species.

3) Continued collection of recreational catch data for Pacific sanddabs is recommended. Increases in sample sizes of length composition data from both retained and discarded catch will provide more accurate information on estimates of fishery selectivity.
4) A coastwide juvenile groundfish survey data is available for most years since 2001, and has been used in assessments of other groundfish. However, sanddabs were not identified to the species level in the northern survey areas, and thus truly coastwide data is not currently available for this species. Data from a more limited geographic range does not indicate a strong correlation between juvenile abundance and subsequent recruitment to the adult population, despite the fact that correlations (albeit not extremely strong) are typically observed for rockfish recruitment indices and subsequent realized recruitment based on assessment results. The reasons for this disparity are of interest with respect to early life history dynamics and recruitment processes.
5) Stock and catch data from both Mexico and Canada have not been used in this assessment. Although there are some data of Pacific sanddab and samples from Canadian fisheries, there is no information from Mexican fisheries on the species. Data on Pacific sanddab catches in Mexican waters will be useful to estimate potential impacts on the U.S. west coast stock.
6) The Pacific sanddabs stock on the U.S. coast has been treated as a single stock in this assessment since there is no genetic study on the stock structure of this species. A genetic study on the stock structure of Pacific sanddabs will help to determine the stock structure in future assessments.
7) The implications of fully achieving potential yield with the current harvest policy on predators and the ecosystem should be more fully explored.

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7 Tables

Table 1. Annual landings (mt) and catches (mt) of Pacific sanddab by four fishing fleets from 1888 to 2012. Catches include landings and estimated discards. See text for detail description of each fishery.

Year	CA trawl fishery	Oregon & Washington trawl fishery	Recreational fishery	Mink food fishery	Landings	Catches
1888	0.0	0.0	0.0	0.0	0.0	0.0
1889	59.0	0.0	0.0	0.0	59.0	76.7
1890	118.1	0.0	0.0	0.0	118.1	153.9
1891	177.1	0.0	0.0	0.0	177.1	231.7
1892	236.1	0.0	0.0	0.0	236.1	310.7
1893	217.6	0.0	0.0	0.0	217.6	287.9
1894	199.1	0.0	0.0	0.0	199.1	264.5
1895	180.6	0.0	0.0	0.0	180.6	240.5
1896	198.7	0.0	0.0	0.0	198.7	265.0
1897	216.7	0.0	0.0	0.0	216.7	289.5
1898	234.7	0.0	0.0	0.0	234.7	314.1
1899	252.8	0.0	0.0	0.0	252.8	339.0
1900	291.5	0.0	0.0	0.0	291.5	392.0
1901	330.3	0.0	0.0	0.0	330.3	446.0
1902	369.0	0.0	0.0	0.0	369.0	500.6
1903	407.8	0.0	0.0	0.0	407.8	556.5
1904	446.5	0.0	0.0	0.0	446.5	613.3
1905	429.8	0.0	0.0	0.0	429.8	593.9
1906	413.1	0.0	0.0	0.0	413.1	573.2
1907	396.4	0.0	0.0	0.0	396.4	551.3
1908	379.6	0.0	0.0	0.0	379.6	528.3
1909	422.1	0.0	0.0	0.0	422.1	587.9
1910	464.5	0.0	0.0	0.0	464.5	648.5
1911	506.9	0.0	0.0	0.0	506.9	710.6
1912	549.3	0.0	0.0	0.0	549.3	774.5
1913	591.7	0.0	0.0	0.0	591.7	840.3
1914	634.1	0.0	0.0	0.0	634.1	908.2
1915	676.6	0.0	0.0	0.0	676.6	978.3
1916	1010.9	0.0	0.0	0.0	1010.9	1488.7
1917	1193.8	0.0	0.0	0.0	1193.8	1818.4
1918	794.5	0.0	0.0	0.0	794.5	1242.5
1919	321.9	0.0	0.0	0.0	321.9	499.6
1920	327.4	0.0	0.0	0.0	327.4	495.2
1921	355.6	0.0	0.0	0.0	355.6	525.8
1922	531.1	0.0	0.0	0.0	531.1	774.2
1923	618.7	0.0	0.0	0.0	618.7	898.7

Table 1 (continued). Annual landings (mt) and catches (mt) of Pacific sanddab by four fishing fleets from 1988 to 2012. Catches include landings and estimated discards. See text for detail description of each fishery.

Year	CA trawl fishery	Oregon & Washington trawl fishery	Recreational fishery	Mink food fishery	Landings	Catches
1924	771.0	0.0	0.0	0.0	771.0	1126.7
1925	885.8	0.0	0.0	0.0	885.8	1314.8
1926	518.9	0.0	0.0	0.0	518.9	777.0
1927	404.9	0.0	0.0	0.0	404.9	601.5
1928	502.9	0.0	0.0	0.0	502.9	739.8
1929	477.1	0.0	0.0	0.0	477.1	696.8
1930	279.6	0.0	0.0	0.0	279.6	403.7
1931	214.5	0.0	0.0	0.0	214.5	304.9
1932	301.5	0.5	0.0	0.0	302.0	424.1
1933	247.7	0.2	0.0	0.0	247.9	344.9
1934	347.9	0.1	0.0	0.0	348.0	481.4
1935	306.4	0.2	0.0	0.0	306.7	423.1
1936	282.0	0.9	0.0	0.0	282.9	389.5
1937	234.1	4.6	0.0	0.0	238.7	328.5
1938	301.2	0.1	0.0	0.0	301.2	412.3
1939	368.2	14.2	0.0	0.0	382.4	527.3
1940	353.4	25.5	0.0	0.0	378.9	527.0
1941	200.5	30.5	0.0	0.0	230.9	325.1
1942	160.4	78.5	0.0	5.6	244.4	352.7
1943	229.2	197.9	0.0	5.9	433.1	643.2
1944	250.1	34.3	0.0	6.3	290.6	407.3
1945	268.6	15.1	0.0	5.6	289.2	399.8
1946	308.0	17.1	0.0	5.8	331.0	456.8
1947	318.2	38.1	0.0	6.5	362.8	506.1
1948	365.0	61.6	0.0	10.0	436.6	614.3
1949	327.6	83.0	0.0	9.9	420.5	600.8
1950	312.9	3.9	0.0	7.3	324.1	448.3
1951	246.8	5.3	0.0	8.8	260.9	359.1
1952	299.5	0.1	0.0	9.2	308.8	422.3
1953	313.2	5.5	0.0	23.1	341.8	463.1
1954	341.8	7.3	0.0	30.1	379.3	512.5
1955	354.5	25.4	0.0	30.7	410.6	561.3
1956	358.0	1.3	0.0	39.8	399.1	537.1
1957	313.9	0.1	0.0	57.1	371.1	491.9
1958	184.4	0.8	0.0	98.5	283.6	354.6

Table 1 (continued). Annual landings (mt) and catches (mt) of Pacific sanddab by four fishing fleets from 1988 to 2012. Catches include landings and estimated discards. See text for detail description of each fishery.

Year	CA trawl fishery	Oregon & Washington trawl fishery	Recreational fishery	Mink food fishery	Landings	Catches
1959	211.7	3.2	0.0	28.0	242.9	324.4
1960	158.0	8.1	0.0	37.7	203.8	267.0
1961	225.2	5.6	0.0	41.4	272.2	357.2
1962	308.4	9.5	0.0	31.7	349.5	467.0
1963	252.0	3.3	0.0	30.8	286.1	379.5
1964	452.7	6.1	7.1	34.1	500.0	670.5
1965	217.3	2.4	7.4	38.8	266.0	348.6
1966	326.6	9.1	15.5	27.1	378.4	506.2
1967	311.6	11.2	15.7	31.1	369.6	494.2
1968	324.1	9.4	65.9	25.8	425.3	555.9
1969	315.7	22.1	73.7	24.5	436.1	574.1
1970	307.8	30.3	57.7	14.3	410.1	553.3
1971	353.9	28.9	29.1	13.0	424.9	592.0
1972	417.7	55.0	28.5	5.2	506.3	739.0
1973	410.0	93.1	36.2	4.3	543.7	831.6
1974	442.4	117.8	33.4	47.5	641.0	978.0
1975	460.6	175.3	19.9	63.1	719.0	1090.3
1976	586.9	157.0	25.5	40.0	809.4	1179.7
1977	367.2	116.9	11.0	35.1	530.2	748.2
1978	337.1	116.8	2.5	0.4	456.8	646.4
1979	600.0	224.1	174.9	0.1	999.1	1350.8
1980	580.8	186.1	87.6	0.8	855.4	1205.4
1981	427.4	162.9	216.0	0.8	807.0	1116.5
1982	480.1	244.7	46.3	2.8	773.9	1215.1
1983	259.1	246.8	38.5	4.9	549.4	907.0
1984	251.1	280.6	40.0	0.7	572.4	951.3
1985	442.4	188.8	57.6	1.1	689.8	1061.4
1986	445.6	170.2	51.4	5.6	672.8	1002.8
1987	533.5	237.2	12.6	0.4	783.6	1189.0
1988	528.0	122.9	66.6	0.5	717.9	1047.4
1989	638.7	90.8	21.1	12.1	762.7	1132.1
1990	653.1	227.6	33.5	0.4	914.6	1424.6
1991	561.3	322.7	33.3	0.1	917.4	1546.2
1992	283.3	322.4	33.3	6.3	645.2	1220.1
1993	352.9	288.2	49.3	0.0	690.4	1318.7

Table 1 (continued). Annual landings (mt) and catches (mt) of Pacific sanddab by four fishing fleets from 1988 to 2012. Catches include landings and estimated discards. See text for detail description of each fishery.

Year	CA trawl fishery	Oregon & Washington trawl fishery	Recreational fishery	Mink food fishery	Landings	Catches
1994	683.3	524.4	34.5	0.0	1242.1	2321.0
1995	677.5	685.5	14.3	13.2	1390.5	2539.5
1996	789.3	105.3	50.2	0.0	944.8	1537.3
1997	930.2	241.5	35.5	0.0	1207.3	2043.5
1998	644.3	132.5	13.3	9.0	799.0	1326.1
1999	930.1	273.6	20.9	0.0	1224.6	1999.7
2000	744.6	150.1	62.4	0.0	957.2	1464.0
2001	793.1	109.9	46.9	15.0	964.9	1436.7
2002	387.7	362.5	153.9	0.0	904.2	1417.4
2003	204.6	386.0	47.3	12.7	650.6	1123.6
2004	235.4	221.2	44.6	22.1	523.2	860.3
2005	207.5	139.8	45.7	5.3	398.3	628.6
2006	340.7	71.8	23.1	4.9	440.6	666.4
2007	161.8	130.4	19.7	3.3	315.3	512.0
2008	73.5	123.0	27.3	5.4	229.1	389.1
2009	200.6	90.1	28.4	7.7	326.7	561.7
2010	101.5	44.8	42.7	8.9	198.0	322.3
2011	45.1	101.1	81.2	8.4	235.7	338.6
2012	59.5	99.7	53.2	9.4	221.8	325.5

Table 2 Recent trend in commercial landings and estimated total catch relative to the management guidelines. Estimated total catch reflect the commercial landings plus the model estimated discarded biomass.

Year	OFL (mt)	ACL (mt)	Commercial landings (mt)	Estimated total catch (mt)
2004	NA	NA	456.6	860.3
2005	3172	2379	347.3	628.6
2006	3172	2379	412.5	666.4
2007	3172	2379	292.2	512.0
2008	3172	2379	196.5	389.1
2009	3172	2379	290.7	561.7
2010	3172	2379	146.3	322.3
2011	4943	3432	146.2	338.6
2012	4943	3432	159.2	325.5
2013	4801	3332	NA	NA

Table 3 Annual summaries of coastal wide landings and discards of Pacific sanddabs in Canada. Summary data were provided by Kate Rutherford of the Fisheries and Oceans Canada.

Year	Landings (mt)	Discards (mt)	Total catch (mt)	Discard rate (%)
1996	0.0	4.3	4.3	100.0
1997	0.0	14.7	14.7	100.0
1998	0.0	12.5	12.5	100.0
1999	0.0	21.5	21.5	100.0
2000	0.0	62.5	62.5	100.0
2001	0.1	52.2	52.2	99.9
2002	0.4	72.7	73.1	99.5
2003	0.8	95.6	96.4	99.1
2004	1.2	99.9	101.1	98.8
2005	1.7	35.2	36.9	95.5
2006	0.5	19.9	20.5	97.4
2007	1.1	25.0	26.1	95.8
2008	2.3	8.7	11.0	79.4
2009	4.0	8.9	12.9	69.1
2010	2.8	27.4	30.2	90.8
2011	10.0	39.4	49.3	79.8
2012	7.1	19.5	26.6	73.3

Table 4 Summary of positive catch hauls and catch weight by three depth strata from the NWFSC survey. Percentages of total catch weight were calculated among three depth strata. No trawl hauls in the deep stratum were used in the catch rate analysis.

Depth stratum	Depth range (m)	No haul	Positive catch haul	% of Positive haul	% of total catch weight
Shallow	55-150	2183	1754	80.3	94.3
Middle	151-250	935	207	22.1	5.7
Deep	>250	3334	0	0.0	0.0

Table 5 Summary of annual number of hauls, total length measurements, and length measurement by sex from the NWFSC survey from 2003 to 2012.

Year	No haul	No. length	No. length per haul	No. female	No. male	% of female
2003	132	8852	67.1	5251	3601	59.3
2004	165	10933	66.3	7093	3840	64.9
2005	218	10111	46.4	6223	3888	61.5
2006	178	5940	33.4	3727	2213	62.7
2007	190	4326	22.8	2815	1511	65.1
2008	203	4536	22.3	2791	1745	61.5
2009	214	2823	13.2	1743	1080	61.7
2010	239	1486	6.2	942	544	63.4
2011	242	4521	18.7	2897	1624	64.1
2012	244	4593	18.8	2929	1664	63.8

Table 6 Summary of annual number of hauls, total fish aged, and number of fish aged by sex from the NWFSC survey from 2003 to 2012. Note that there were no fish aged in 2009.

Year	No hauls	No. fish	No female	No. male	% of female
2003	58	779	501	278	64.3
2004	156	1429	966	463	67.6
2005	211	988	626	362	63.4
2006	176	708	465	243	65.7
2007	185	729	526	203	72.2
2008	202	768	520	248	67.7
2010	234	1009	640	369	63.4
2011	216	742	482	260	65.0
2012	241	819	545	274	66.5

Table 7: Estimated biomass of Pacific sanddab and standard errors (natural log of estimates) using GLMM analysis from the NWFSC survey.

Year	Biomass (mt)	Standard error (ln)
2003	58,254	0.2102
2004	49,940	0.2205
2005	37,508	0.1845
2006	37,337	0.1964
2007	25,816	0.1954
2008	39,337	0.1911
2009	56,781	0.1892
2010	65,278	0.1837
2011	56,331	0.1813
2012	73,364	0.2042

Table 8 Summary of positive catch hauls and catch weight by three depth strata from the triennial survey. Percentages of total catch weight were calculated among three depth strata. No trawl hauls in the deep stratum were used in the catch rate analysis.

Depth stratum	Depth range (m)	No haul	Positive catch haul	% of Positive haul	% of total catch weight
Shallow	50-150	2394	1940	81.0	96.7
Middle	151-250	663	113	17.0	3.3
Deep	>250	894	15	1.6	<0.001

Table 9 Summary of annual number of hauls, total length measurements, and length measurement by sex from two time periods of the triennial trawl survey from 1980 to 2004. Note that there were no fish aged for the triennial survey.

Year	No. hauls	No. length	No length per haul	No. female length	No. male length	% of female length
Early year						
1980	5	574	114.8	447	127	77.9
1983	16	2632	164.5	1445	1187	54.9
1986	11	1021	92.8	636	385	62.3
1989	90	8638	96.0	4846	3792	56.1
1992	147	12778	86.9	7595	5183	59.4
Late year						
1995	149	16438	110.3	9132	7306	55.6
1998	223	20516	92.0	12465	8051	60.8
2001	231	19262	83.4	10830	8432	56.2
2004	166	16548	99.7	8962	7586	54.2

Table 10: Summary statistics from a GIS analysis on areas by three depth zones of the coastal waters off all three states (CA, OR, and WA).

Depth zone (m)	Area (km^2)	% of area
0-49	14,161	23.2
50-150	36,145	57.3
151-250	12,357	19.6

Table 11: Estimated biomass of Pacific sanddab and standard errors (natural log of estimates) using GLMM analysis from the triennial survey for two time periods. Two time periods were defined as early year time period (1980 to 1992) and late year time period (1995 to 2004).

Year	Estimated biomass (mt)	Standard error (ln)
Early year		
1980	3,372	0.4217
1983	9,224	0.3438
1986	10,263	0.3322
1989	29,374	0.3511
1992	18,623	0.3163
Late year		
1995	45,513	0.4727
1998	31,152	0.6505
2001	46,639	0.4462
2004	65,976	0.3929

Table 12 Summary of annual numbers of sampling trips, port complex-month counts, fish measured for length compositions, and fish measured for length per sample trip and per port complex-month counts from the CA CPFV sampling. Sex was not identified in the sampling.

Year	No. trips	No. port complex-month	No. fish	No. fish per trip	No fish per port complex-month
1976	71	38	308	4.3	8.1
1977	44	27	239	5.4	8.9
1978	57	36	311	5.5	8.6
1986	62	39	480	7.7	12.3
1987	69	42	323	4.7	7.8
1988	82	46	380	4.6	8.3
1989	151	74	1432	9.5	19.4
1990	23	13	67	2.9	5.2
1991	20	11	104	5.2	9.5
1992	46	23	185	4.0	8.0
1993	37	21	198	5.4	9.4
1994	49	25	249	5.1	10.0
1995	75	28	329	4.4	11.8
1996	67	25	388	5.8	15.5
1997	58	25	294	5.1	11.8
1998	14	10	30	2.1	3.0

Table 13 Summary of annual sampling trips, fish measured for length compositions, and fish aged for age compositions from the CA fishery. Length data included samples from both retained and discard catches while all age data were from retained catches. Sex was not identified in the discard length data.

Year	No. trips	No. fish	No. fish per trip	No. female	% of female
Length data retained					
2003	23	1212	52.7	901	74.3
2004	14	755	53.9	579	76.7
2005	13	967	74.4	719	74.4
2006	28	1971	70.4	1649	83.7
2007	27	1451	53.7	1257	86.6
2008	22	1212	55.1	1045	86.2
2009	16	752	47.0	638	84.8
2010	17	684	40.2	618	90.4
2011	4	246	61.5	217	88.2
2012	8	1212	151.5	304	85.6
Length data discarded					
2006	98	625	6.4	NA	NA
2007	49	328	6.7	NA	NA
2008	61	386	6.3	NA	NA
2009	28	212	7.6	NA	NA
2010	37	337	9.1	NA	NA
2011	82	660	8.0	NA	NA
Age data retained					
2003	8	349	43.6	217	62.1
2007	13	440	33.8	374	85.0
2008	8	316	39.5	263	83.2

Table 14 Summary of annual sampling trips, fish measured for length compositions, and fish aged for age compositions from the OR/WA fishery. Length data included samples from both retained and discard catches while all age data were from retained catches. Sex was not identified in the discard length data.

Year	No. trips	No. fish	No. fish per trip	No. female	% of female
Length data retained					
1994	3	147	49.0	75	51.0
1995	4	215	53.8	127	59.1
1996	2	160	80.0	96	60.0
1997	11	584	53.1	515	88.2
1998	9	588	65.3	502	85.4
1999	5	251	50.2	229	91.2
2000	8	413	51.6	363	87.9
2001	9	398	44.2	352	88.4
2002	11	538	48.9	468	87.0
2003	8	340	42.5	329	96.8
2004	11	478	43.5	438	91.6
2005	11	566	51.5	502	88.7
2006	17	804	47.3	746	92.8
2007	21	630	30.0	577	91.6
2008	15	465	31.0	440	94.6
2009	25	925	37.0	818	88.4
2010	25	834	33.4	784	94.0
2011	23	829	36.0	725	87.5
2012	19	709	37.3	638	90.0
Length data discarded					
2006	80	879	11.0	NA	NA
2007	48	484	10.1	NA	NA
2008	39	362	9.3	NA	NA
2009	79	1037	13.1	NA	NA
2010	32	407	12.7	NA	NA
2011	127	1678	13.2	NA	NA
Age data retained					
1995	2	92	46.0	53	57.6
1997	10	480	48.0	427	89.0
1999	5	236	47.2	215	91.1
2001	9	382	42.4	335	87.7
2003	5	207	41.4	204	98.6
2005	10	521	52.1	460	88.3
2006	2	60	30.0	54	90.0
2007	14	492	35.1	426	86.6
2009	16	494	30.9	427	86.4
2011	16	551	34.4	500	90.7
2012	2	92	46.0	53	57.6

Table 15 Summary of annual sampling trips, fish measured for length compositions for both retained and discarded catches for the 2005 recreational fishery. Discard data were only available were from 2005 sampling.

Year	No. trips	No. fish
Length data retained		
2005	28	102
Length data discarded		
2005	71	112

Table 16: Estimated discard rates for the CA and OR/WA fisheries and their standard deviations (StdDev). Discard rate and its standard deviation for the CA fishery in 1986 were averages of estimates between 2002 and 2010.

Year	CA discard rate	CA stdDev	OR/WA discard rate	OR/WA discard StdDev
1986	***0.3256***	***0.051***	0.5124	0.4064
2002	0.2064	0.0379	0.7068	0.1071
2003	0.3288	0.0257	0.8785	0.1290
2004	0.2450	0.0877	0.6261	0.1517
2005	0.3579	0.0585	0.5874	0.1197
2006	0.3260	0.0001	0.4662	0.1081
2007	0.2810	0.0709		
2008	0.3205	0.0993	0.4854	0.0948
2009	0.4417	0.0745	0.5784	0.0708
2010	0.4210	0.0033		
Average of 2002-2010	**0.3254**		**0.6184**	

Table 17: Numbers of otolith aged from California and Oregon fisheries and from the NWFSC survey. No otolith samples were taken from the triennial survey and recreational fishery. Numbers of sampling trips were used as initial sample sizes for both fisheries. Numbers of fish aged were used as initial sample sizes in the conditional age-at-length matrix for NWFSC survey.

Source and year	Female	Male	Total	No of sample	No. fish per sample
California fishery total	866	238	1105	29	34.3
2003	168	106	274	8	38.6
2007	426	76	502	13	41.0
2008	272	56	328	8	46.0
Oregon fishery total	3102	413	3515	89	48.0
1995	53	39	92	2	47.2
1997	427	53	480	10	42.4
1999	215	21	236	5	41.4
2001	336	46	382	9	52.1
2003	204	3	207	5	30.0
2005	460	61	521	10	35.1
2007	54	6	60	2	30.9
2009	426	66	492	14	34.4
2011	427	67	494	16	48.0
2012	500	51	551	16	47.2
NWFSC survey total	5271	2700	7971		
2003	501	278	779		
2004	966	463	1429		
2005	626	362	988		
2006	465	243	708		
2007	526	203	729		
2009	520	248	768		
2010	640	369	1009		
2011	482	260	742		
2012	545	274	819		
Grand total	9239	3351	12590		

Table 18: Estimated CPUE indices and CVs from the GLMM analysis for the California recreational fishery survey (CPFV survey) between 1999 and 2011. The indices were provided by Melissa Monk of the SWFSC.

Year	Index	CV
1999	0.1658	0.194
2000	0.1504	0.299
2001	0.2214	0.444
2002	0.1992	0.289
2003	0.4135	0.265
2004	0.3477	0.230
2005	0.0801	0.202
2006	0.2417	0.150
2007	0.1421	0.162
2008	0.1473	0.133
2009	0.1636	0.120
2010	0.2693	0.121
2011	0.2937	0.106

Table 19: Catchability coefficient values for the NWFSC survey estimated in recent flatfish assessments. Average and standard deviation are used as prior for test runs during the STAR Panel review.

Species	Arithmetic Q	Ln Q	Source
English sole	1.22	0.198	Cope *et al*. in review
Rex sole	1.79	0.582	Cope *et al*. in review
Dover sole	0.70	-0.362	Hicks 2011
Petrale sole	3.36	1.211	Haltuch *et al*. 2013
Arrowtooth flounder	0.31	-1.171	Kaplan *et al*. 2011
Average	**1.475**	**0.388**	
Standard deviation	**1.191**	**0.174**	

Table 20: Key model parameters in the base case assessment model. Symbol (*) indicates if prior was available to the parameter. Prior type for natural mortality (*M*) was lognormal, with mean = (-1.136) and *SD*=0.3600 for female and with mean = (-0.9848) and *SD* = 0.3598 for male. Prior type for steepness (*h*) was normal, with mean = 0.8 and *SD* = 0.09. A total of 102 parameters were estimated in the base model.

Parameter	Parameter bounds	No. of parameter	Estimated?	Value
Natural mortality (*M*)				
*Female	0.01-2.0	1	Yes	0.459
*Male	0.01-2.0	1	Yes	0.566
			Yes	
Stock recruitment				
Ln(R_0) virgin recruitment	0.1-30.0	1	Yes	12.36
*Steepness (*h*)	0.2-1.0	1	Yes	0.768
Recruitment variability (σ_R)	0.0-1.5	1	No	0.450
Ln(Early recruitment devs): 1966-1975	-3.0-3.0	10	Yes	Vary
Ln(Early recruitment devs): 1976-2011	-5.0-5.0	36	Yes	Vary
Ln(Early recruitment devs): 2012-2013	-3.0-3.0	2	Yes	Vary
Female growth				
L1 (length at age 0)	2-20	1	Yes	4.23
L2 (length at age 11)	10-40	1	Yes	30.33
Von Bertalanffy *K*	0.01-0.50	1	Yes	0.169
Growth CV young	0.02-0.35	1	Yes	0.299
Growth CV old	0.02-0.35	1	Yes	0.042
Male growth				
L1 (length at age 0)	2-20	1	Yes	4.66
L2 (length at age 11)	10-40	1	Yes	26.47
Von Bertalanffy *K*	0.01-0.50	1	Yes	0.212
Growth CV young	0.02-0.35	1	Yes	0.250
Growth CV old	0.02-0.35	1	Yes	0.056
Catchability (*Q*) and extra SD for *Q*				
Recreational survey *Q*		1	No	0.00012
NWFSC survey *Q*		1	No	19.39
Triennial early survey *Q*		1	No	4.776
Triennial late survey *Q*		1	No	13.54
Extra SD Recreational survey *Q* (ln)	0.001-2.0	1	Yes	0.242
Extra SD NWFSC survey	0.001-2.0	1	No	0.001
Extra SD for triennial early survey	0.001-2.0	1	Yes	0.433
Extra SD for triennial late survey	0.001-2.0	1	Yes	0.094

Table continued from previous page.

Parameter	Parameter bounds	No. of parameter	Estimated?	Value
<u>Fishery selectivity</u>				
CA fishery				
Peak (female)	10-34.5	1	Yes	34.26
Ascending width (female)	-4-12	1	Yes	3.983
Retention inflection	3-34.5	1	Yes	24.43
Retention slope	0.1-10.0	1	Yes	1.291
Retention asymptotic	0.001-1.0	1	Yes	0.986
Peak (male offset)	-15.0-15.0	1	Yes	-2.478
Ascending width (male offset)	-15.0-15.0	1	Yes	0.056
Time-varying retention inflection	-5.0-5.0	1	Yes	0.0261
Time-varying retention slope	-5.0-5.0	1	Yes	0.3924
Time-varying retention asymptotic	-5.0-5.0	1	Yes	2.0263
OR/WA fishery				
Peak (female)	10-34.5	1	Yes	34.50
Ascending width (female)	-8-12	1	Yes	3.675
Retention inflection	3-34.5	1	Yes	26.09
Retention slope	0.1-10.0	1	Yes	1.206
Retention asymptotic	0.001-1.0	1	Yes	0.886
Peak (male offset)	-15.0-15.0	1	Yes	-0.011
Ascending width (male offset)	-15.0-15.0	1	Yes	0.053
Time-varying retention inflection	-5.0-5.0	1	Yes	-0.106
Time-varying retention slope	-5.0-5.0	1	Yes	0.122
Time-varying retention asymptotic	-5.0-5.0	1	Yes	0.198
Recreational fishery				
Peak (female)	10-34.5	1	Yes	29.74
Ascending width (female)	-4-12	1	Yes	3.686
Retention inflection	3-34.5	1	Yes	14.01
Retention slope	0.1-10.0	1	Yes	3.289
Retention asymptotic	0.001-1.0	1	Yes	0.990
<u>Survey selectivity</u>				
NWFSC survey				
Peak (female)	10-34	1	Yes	28.44
Ascending width (female)	-4-12	1	Yes	3.785
Peak (male offset)	-15.0-15.0	1	Yes	-3.764
Ascending width (male offset)	-15.0-15.0	1	Yes	-0.481
Triennial early years				
Peak (female)	10-34	1	Yes	34.00
Ascending width (female)	-4-12	1	Yes	4.311
Peak (male offset)	-15.0-15.0	1	Yes	-4.805
Ascending width (male offset)	-15.0-15.0	1	Yes	-0.411
Triennial late years				
Peak (female)	10-34	1	Yes	30.82
Ascending width (female)	-4-12	1	Yes	4.398
Peak (male offset)	-15.0-15.0	1	Yes	-6.258
Ascending width (male offset)	-15.0-15.0	1	Yes	-0.811

Table 21: Time series of population status, outputs, and exploitation from the base assessment model.

Year	Total biomass (mt)	Spawning biomass (mt)	Recruit (*1000)	Total catch (mt)	Depletion	SPR	Relative exploitation rate
1888	14622	8954	232532	0	1.000	1.000	0.0000
1889	14452	8954	232532	77	1.000	0.985	0.0052
1890	14288	8910	232446	154	0.995	0.970	0.0106
1891	14127	8835	232295	232	0.987	0.956	0.0160
1892	13964	8737	232096	311	0.976	0.941	0.0217
1893	13992	8623	231858	288	0.963	0.944	0.0203
1894	14028	8554	231713	265	0.955	0.947	0.0187
1895	14072	8519	231637	241	0.951	0.951	0.0171
1896	14020	8507	231611	265	0.950	0.946	0.0189
1897	13968	8485	231564	289	0.948	0.942	0.0206
1898	13915	8455	231499	314	0.944	0.937	0.0225
1899	13861	8420	231422	339	0.940	0.932	0.0243
1900	13752	8381	231335	392	0.936	0.923	0.0282
1901	13641	8323	231207	446	0.930	0.913	0.0323
1902	13527	8252	231046	501	0.922	0.903	0.0365
1903	13409	8171	230860	556	0.913	0.893	0.0409
1904	13288	8083	230652	613	0.903	0.883	0.0454
1905	13295	7989	230427	594	0.892	0.883	0.0444
1906	13315	7932	230287	573	0.886	0.885	0.0431
1907	13346	7901	230213	551	0.882	0.888	0.0416
1908	13385	7891	230187	528	0.881	0.891	0.0399
1909	13278	7895	230198	588	0.882	0.882	0.0444
1910	13164	7866	230126	649	0.879	0.872	0.0491
1911	13043	7813	229991	711	0.873	0.862	0.0541
1912	12916	7741	229808	775	0.865	0.851	0.0594
1913	12781	7655	229586	840	0.855	0.840	0.0650
1914	12639	7559	229331	908	0.844	0.828	0.0710
1915	12492	7455	229047	978	0.833	0.816	0.0773
1916	11767	7343	228736	1489	0.820	0.757	0.1191
1917	11226	7006	227741	1818	0.782	0.714	0.1511
1918	11709	6606	226445	1243	0.738	0.752	0.1082
1919	13024	6596	226410	500	0.737	0.860	0.0436
1920	13153	6948	227564	495	0.776	0.871	0.0414
1921	13178	7211	228358	526	0.805	0.873	0.0427
1922	12782	7389	228866	774	0.825	0.840	0.0617

Table (continued): Time series of population status, outputs, and exploitation from the base assessment model.

Year	Total biomass (mt)	Spawning biomass (mt)	Recruit (*1000)	Total catch (mt)	Depletion	SPR	Relative exploitation rate
1923	12590	7392	228873	899	0.826	0.824	0.0715
1924	12232	7330	228699	1127	0.819	0.795	0.0903
1925	11907	7170	228237	1315	0.801	0.768	0.1072
1926	12621	6963	227609	777	0.778	0.827	0.0649
1927	12989	7083	227976	601	0.791	0.857	0.0495
1928	12792	7260	228500	740	0.811	0.841	0.0597
1929	12894	7319	228668	697	0.817	0.849	0.0559
1930	13504	7383	228849	404	0.825	0.901	0.0322
1931	13776	7582	229394	305	0.847	0.925	0.0238
1932	13559	7783	229915	424	0.869	0.906	0.0324
1933	13747	7867	230127	345	0.879	0.922	0.0261
1934	13495	7971	230384	481	0.890	0.901	0.0361
1935	13611	7975	230392	423	0.891	0.911	0.0317
1936	13685	8009	230476	389	0.894	0.917	0.0291
1937	13819	8053	230581	329	0.899	0.929	0.0244
1938	13661	8118	230736	412	0.907	0.915	0.0304
1939	13450	8121	230742	527	0.907	0.897	0.0389
1940	13438	8060	230598	527	0.900	0.895	0.0391
1941	13823	8017	230494	325	0.895	0.929	0.0242
1942	13784	8095	230681	353	0.904	0.925	0.0261
1943	13284	8136	230778	643	0.909	0.881	0.0474
1944	13652	8007	230471	407	0.894	0.914	0.0304
1945	13671	8047	230566	400	0.899	0.916	0.0297
1946	13568	8079	230643	457	0.902	0.907	0.0339
1947	13478	8071	230623	506	0.901	0.899	0.0375
1948	13283	8037	230542	614	0.898	0.882	0.0457
1949	13287	7954	230341	601	0.888	0.882	0.0451
1950	13542	7901	230211	448	0.882	0.905	0.0338
1951	13732	7947	230324	359	0.888	0.921	0.0270
1952	13620	8028	230520	422	0.897	0.911	0.0315
1953	13548	8051	230577	463	0.899	0.905	0.0344
1954	13456	8046	230564	513	0.899	0.897	0.0381
1955	13364	8015	230489	561	0.895	0.889	0.0419
1956	13391	7966	230371	537	0.890	0.892	0.0403
1957	13469	7944	230318	492	0.887	0.898	0.0369

Table (continued). Time series of population status, outputs, and exploitation from the base assessment model.

Year	Total biomass (mt)	Spawning biomass (mt)	Recruit (*1000)	Total catch (mt)	Depletion	SPR	Relative exploitation rate
1958	13744	7953	230340	355	0.888	0.922	0.0266
1959	13822	8033	230534	324	0.897	0.929	0.0242
1960	13959	8108	230711	267	0.906	0.941	0.0197
1961	13784	8193	230910	357	0.915	0.926	0.0262
1962	13578	8206	230940	467	0.916	0.908	0.0342
1963	13735	8155	230821	380	0.911	0.921	0.0279
1964	13215	8166	230847	670	0.912	0.876	0.0493
1965	13770	8016	230491	349	0.895	0.924	0.0260
1966	13474	8081	241912	506	0.903	0.898	0.0375
1967	13488	8048	240358	494	0.899	0.900	0.0366
1968	13363	8066	269628	556	0.901	0.888	0.0409
1969	13322	8084	345390	574	0.903	0.884	0.0415
1970	13358	8228	579491	553	0.919	0.887	0.0377
1971	13306	8783	338486	592	0.981	0.884	0.0359
1972	13111	10156	243987	739	1.134	0.867	0.0406
1973	13051	11168	231374	832	1.247	0.862	0.0440
1974	12957	11339	244282	978	1.266	0.854	0.0525
1975	12898	10904	217228	1090	1.218	0.849	0.0616
1976	12810	10225	235867	1180	1.142	0.841	0.0715
1977	13291	9428	237623	748	1.053	0.882	0.0489
1978	13411	8957	275233	646	1.000	0.893	0.0440
1979	12453	8659	320495	1351	0.967	0.809	0.0931
1980	12434	8189	311834	1205	0.915	0.809	0.0847
1981	12402	8227	250919	1117	0.919	0.804	0.0772
1982	12255	8464	213629	1215	0.945	0.795	0.0831
1983	12659	8510	193996	907	0.950	0.828	0.0632
1984	12661	8444	211274	951	0.943	0.828	0.0681
1985	12532	8112	266280	1061	0.906	0.817	0.0790
1986	12585	7693	196094	1003	0.859	0.822	0.0773
1987	12297	7507	168783	1189	0.838	0.799	0.0945
1988	12345	7180	184382	1047	0.802	0.802	0.0880
1989	12146	6808	702990	1132	0.760	0.787	0.0961
1990	11685	6588	249855	1425	0.736	0.749	0.1080
1991	11425	7785	195742	1546	0.869	0.729	0.1059
1992	11848	8710	257299	1220	0.973	0.762	0.0806

Table (continued). Time series of population status, outputs, and exploitation from the base assessment model.

Year	Total biomass (mt)	Spawning biomass (mt)	Recruit (*1000)	Total catch (mt)	Depletion	SPR	Relative exploitation rate
1993	11936	8971	476777	1319	1.002	0.769	0.0854
1994	11191	8936	204425	2321	0.998	0.711	0.1459
1995	10993	8947	300395	2540	0.999	0.696	0.1640
1996	11685	8562	186339	1537	0.956	0.749	0.1045
1997	11246	8539	142740	2044	0.954	0.715	0.1435
1998	11929	7921	147896	1326	0.885	0.769	0.1031
1999	11252	7318	205671	2000	0.817	0.716	0.1698
2000	11574	6241	94208	1464	0.697	0.740	0.1423
2001	11395	5657	112345	1437	0.632	0.726	0.1563
2002	11191	4971	88235	1417	0.555	0.708	0.1761
2003	11346	4256	79726	1124	0.475	0.722	0.1624
2004	11567	3719	130606	860	0.415	0.739	0.1414
2005	11933	3319	137966	629	0.371	0.768	0.1108
2006	11713	3210	236307	666	0.359	0.751	0.1153
2007	12059	3281	233162	512	0.366	0.779	0.0801
2008	12488	3832	217592	389	0.428	0.813	0.0518
2009	12130	4654	269346	562	0.520	0.784	0.0637
2010	13069	5362	421590	322	0.599	0.862	0.0317
2011	13244	6277	263968	339	0.701	0.875	0.0280
2012	13479	7568	200639	326	0.845	0.896	0.0237
2013		8554	231713		0.955		

Table 22: Model performances and output summaries of the sensitivity analysis on discard rates, and historical catch data.

Performance and output	Base	Discard rates -20%	Discard rates +20%	Historical catches -20%	Historical catches +20%
Management quantities					
2013 depletion	0.955	1.104	0.778	0.977	96.6
2012 SPR	0.896	0.934	0.837	0.905	89.8
Negative log-likelihood					
Total	774.138	764.454	784.757	773.274	775.261
Indices	-15.117	-16.135	-13.906	-15.171	-15.201
Length comp.	482.288	477.518	487.612	481.596	482.654
Age comp.	364.370	364.002	365.194	364.576	364.495
Discard	-59.494	-62.045	-56.678	-59.366	-59.524
Key model parameters					
Ln(R_0)	12.36	12.82	11.89	12.47	12.37
Steepness (h)	0.768	0.781	0.759	0.771	0.766
Female M	0.459	0.524	0.385	0.474	0.459
Male M	0.566	0.642	0.424	0.582	0.567
Female L at A_1	4.23	4.14	4.24	4.21	4.24
Female L at A_2	30.33	30.38	30.17	30.31	30.35
Female K	0.169	0.165	0.178	0.169	0.168
Male L at A_1	4.66	4.62	4.76	4.67	4.65
Male L at A_2	26.47	26.52	26.45	26.48	26.47
Male K	0.212	0.206	0.216	0.210	0.212

Table 23: Model performances and output summaries of the sensitivity analysis on use of non-informative steepness (*h*) prior and maturity functions.

Performance and output	Base	Non-informative *h* prior	Maturity (Arora 1951)
Management quant			
2013 depletion	0.955	0.689	0.807
2013 SPR	0.896	0.884	0.862
Negative log-likelihood			
Total	774.138	772.520	774.314
Indices	-15.117	-14.748	-15.136
Length comp.	482.288	482.48	482.24
Age comp.	364.370	363.608	364.416
Discard	-59.494	-59.480	-59.459
Key model parameters			
Ln(R_0)	12.36	12.51	12.35
Steepness (*h*)	0.768	0.376	0.776
Female *M*	0.459	0.456	0.456
Male *M*	0.566	0.562	0.564
Female *L* at A_1	4.23	4.30	4.22
Female *L* at A_2	30.33	30.26	30.32
Female *K*	0.169	0.171	0.170
Male *L* at A_1	4.66	4.71	4.65
Male *L* at A_2	26.47	26.49	26.47
Male *K*	0.212	0.211	0.212

Table 24: Model performances and output summaries of the sensitivity analysis on exclusions of the triennial and recreational survey indices. Note that likelihood values of these runs are not directly comparable.

Performance and output	Base	No triennial survey indices	No recreational survey indices
Management quantities			
2013 depletion	0.955	0.865	0.759
2013 SPR	0.896	0.865	0.830
Negative log-likelihood			
Total	774.138	*772.863*	*777.407*
Indices	-15.117	*-15.953*	*-11.344*
Length comp.	482.288	*482.726*	*484.217*
Age comp.	364.370	*363.647*	*362.738*
Discard	-59.494	*-59.815*	*-60.303*
Key model parameters			
Ln(R_0)	12.36	12.03	11.77
Steepness (h)	0.768	0.760	0.754
Female M	0.459	0.418	0.386
Male M	0.566	0.522	0.487
Female L at A_1	4.23	4.18	4.26
Female L at A_2	30.33	30.27	30.23
Female K	0.169	0.174	0.176
Male L at A_1	4.66	4.63	4.64
Male L at A_2	26.47	26.45	26.43
Male K	0.212	0.216	0.220

Table 25: Model performances and output summaries of the sensitivity analysis on using the Lorenzen function on estimates of natural mortality. Six runs were conducted using the reference ages between age 1 to age 6. The Listed natural mortality rates are those rates at reference ages.

Performance and output	Base	Reference age at 1	Reference age at 2	Reference age at 3	Reference age at 4	Reference age at 5	Reference age at 6
Management quantities							
2013 depletion	0.955	0.601	0.696	0.767	0.848	0.916	0.963
2013 SPR	0.896	0.727	0.779	0.814	0.848	0.874	0.891
Negative log-likelihood							
Total	774.138	779.39	777.163	775.873	775.020	774.379	773.895
Indices	-15.117	-13.64	-13.960	-14.188	-14.435	-14.643	-14.801
Length comp.	482.288	486.437	485.141	484.338	483.499	482.779	482.292
Age comp.	364.370	362.226	362.355	362.507	362.767	363.081	363.345
Discard	-59.494	-60.329	-60.305	-60.248	-60.148	-60.071	-59.998
Key model parameters							
Ln(R_0)	12.36	12.48	13.02	13.449	13.948	14.396	14.740
Steepness (h)	0.768	0.763	0.759	0.758	0.759	0.760	0.762
Female M	0.459	0.625	0.561	0.523	0.512	0.505	0.495
Male M	0.566	0.719	0.659	0.622	0.615	0.613	0.608
Female L at A_1	4.23	3.40	3.40	3.41	3.42	3.43	3.43
Female L at A_2	30.33	29.92	30.09	30.21	30.34	30.45	30.53
Female K	0.169	0.196	0.187	0.180	0.173	0.166	0.161
Male L at A_1	4.66	4.08	4.05	4.03	4.03	4.03	4.03
Male L at A_2	26.47	26.20	26.29	26.37	26.44	26.49	26.54
Male K	0.212	0.237	0.229	0.223	0.216	0.210	0.205
Q NWFSC survey	19.39	27.67	26.36	25.46	24.57	23.84	23.31
Q early triennial survey	4.78	4.71	5.31	5.46	5.60	5.70	5.79
Q late triennial survey	13.54	15.46	15.29	15.17	15.08	14.96	14.86

Table 26: Model performances and output summaries of the sensitivity analysis on using dome-shaped selectivity functions for surveys and exclusions of the conditional age-at-length data (CAAL) from the base model. Note that likelihood values from both runs are not comparable to the base model run.

Performance and output	Base	Dome-shaped selectivity for surveys	No CAAL data
Management quantities			
2013 depletion	0.955	0.971	1.202
2013 SPR	0.896	0.900	0.981
Negative log-likelihood			
Total	774.138	*772.669*	*417.611*
Indices	-15.117	*-15.373*	*-17.081*
Length comp.	482.288	*480.799*	*460.605*
Age comp.	364.370	*364.882*	*31.653*
Discard	-59.494	*-59.245*	*-59.753*
Key model parameters			
Ln(R_0)	12.36	12.37	13.94
Steepness (h)	0.768	0.773	0.801
Female M	0.459	0.458	0.612
Male M	0.566	0.566	0.720
Female L at A_1	4.23	4.22	4.23
Female L at A_2	30.33	30.37	30.33
Female K	0.169	0.169	0.169
Male L at A_1	4.66	4.64	4.66
Male L at A_2	26.47	26.47	26.47
Male K	0.212	0.213	0.212
NWFSC survey Q	19.39	18.62	6.04
Triennial early survey Q	4.776	4.79	2.88
Triennial late survey Q	13.54	13.15	5.41

Table 27: Model performances and output summaries of the retrospective analysis to prior three years. Negative log-likelihood values were not listed as they were incomparable among the models.

Model	Base	-1 year	-2 years	-3 years
Management quantities				
2013 depletion	0.955	1.130	1.275	
2012 SPR	0.896	0.939	0.950	
Key parameters				
Ln(R_0)	12.36	13.16	13.55	
Steepness (h)	0.768	0.778	0.791	
Female M	0.459	0.570	0.600	
Male M	0.566	0.679	0.699	
Female L at A_1	4.23	5.23	4.32	
Female L at A_2	30.33	30.89	31.13	
Female K	0.169	0.123	0.127	
Male L at A_1	4.66	5.35	4.45	
Male L at A_2	26.47	26.74	26.61	
Male K	0.212	0.247	0.188	

Table 28: Summary table of input data and model results between 2004 and 2013.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Commercial landings (mt)	456.6	347.3	412.5	292.2	196.5	290.7	146.3	146.2	159.2	NA
Estimated total catch (mt)	860	629	666	512	389	562	322	339	326	NA
OFL (mt)	NA	3172	3172	3172	3172	3172	3172	4943	4943	4801
ACL (mt)	NA	3172	3172	3172	3172	3172	3172	3432	3432	3332
1-SPR (%)	26.1	23.2	24.9	22.1	18.7	21.6	13.8	12.5	10.4	NA
Exploitation rate (catch/ age 0+ biomass)	0.141	0.111	0.115	0.080	0.052	0.064	0.032	0.028	0.024	NA
Age 0+ biomass (mt)	11567	11933	11713	12059	12488	12130	13069	13244	13479	NA
Spawning Biomass	3719	3319	3210	3281	3832	4654	5362	6277	7568	8554
~95% Confidence Interval	541-6897	357-6281	181-6239	0-6657	0-8048	0-9834	0-11286	0-12933	0-15412	128-16980
Recruitment	130606	137966	236307	233162	217592	269346	421590	263968	200639	231713
~95% Confidence Interval	24513-695866	25586-743954	43538-1282584	43338-1254442	41261-1147488	51577-1406577	80414-2210282	49184-1416690	37343-1078010	43286-1240367
Depletion (%)	41.5	37.1	35.9	36.6	42.8	52.0	59.9	70.1	84.5	95.5
~95% Confidence Interval	24.7-58.4	20.7-53.5	18.2-53.5	15.5-57.7	15.1-70.5	17.7-86.3	20.8-99.0	27.3-100.13	34.7-134.4	43.7-147.3

8 Figures

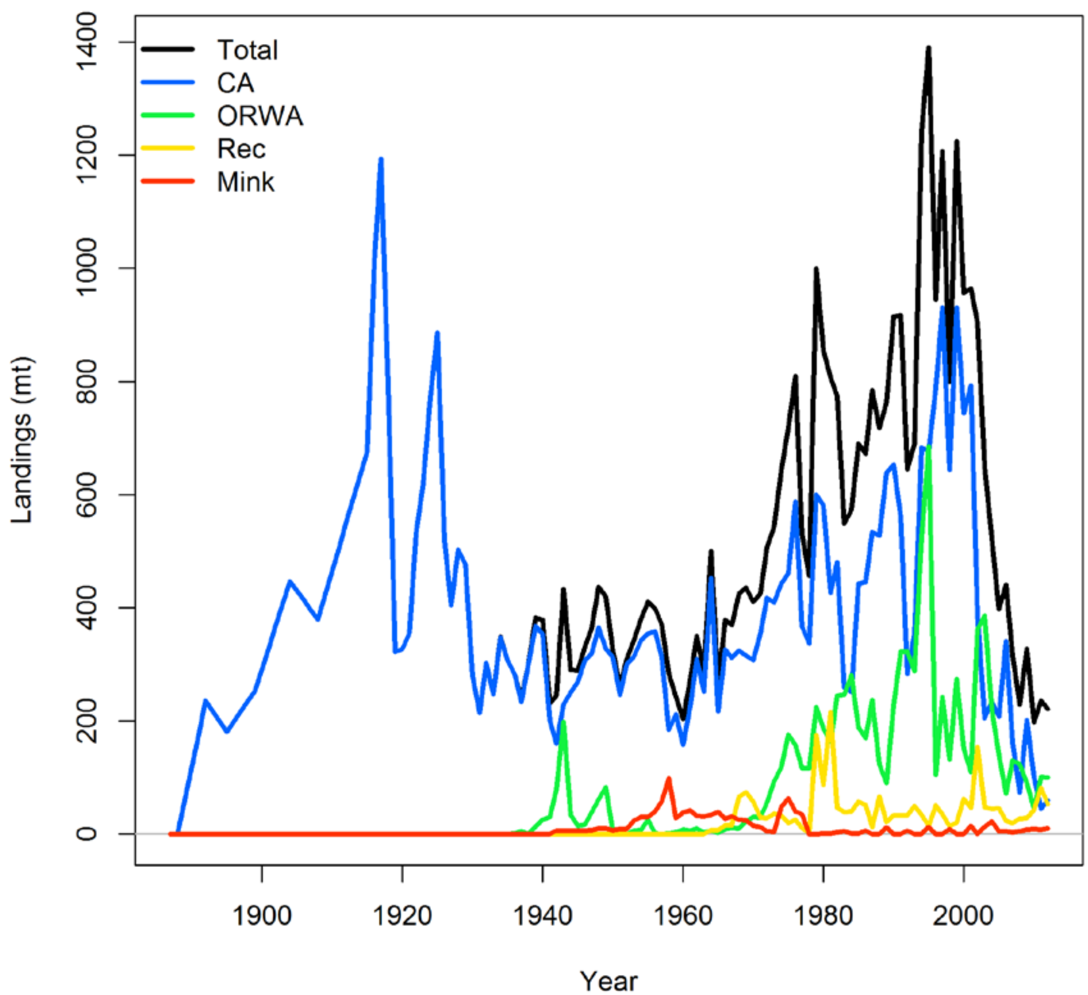


Figure 1. Time series of total landings and landings by four fisheries of Pacific sanddab from 1888 to 2012. Small amount of survey catches between 1980 and 2012 were added to the Mink fishery.

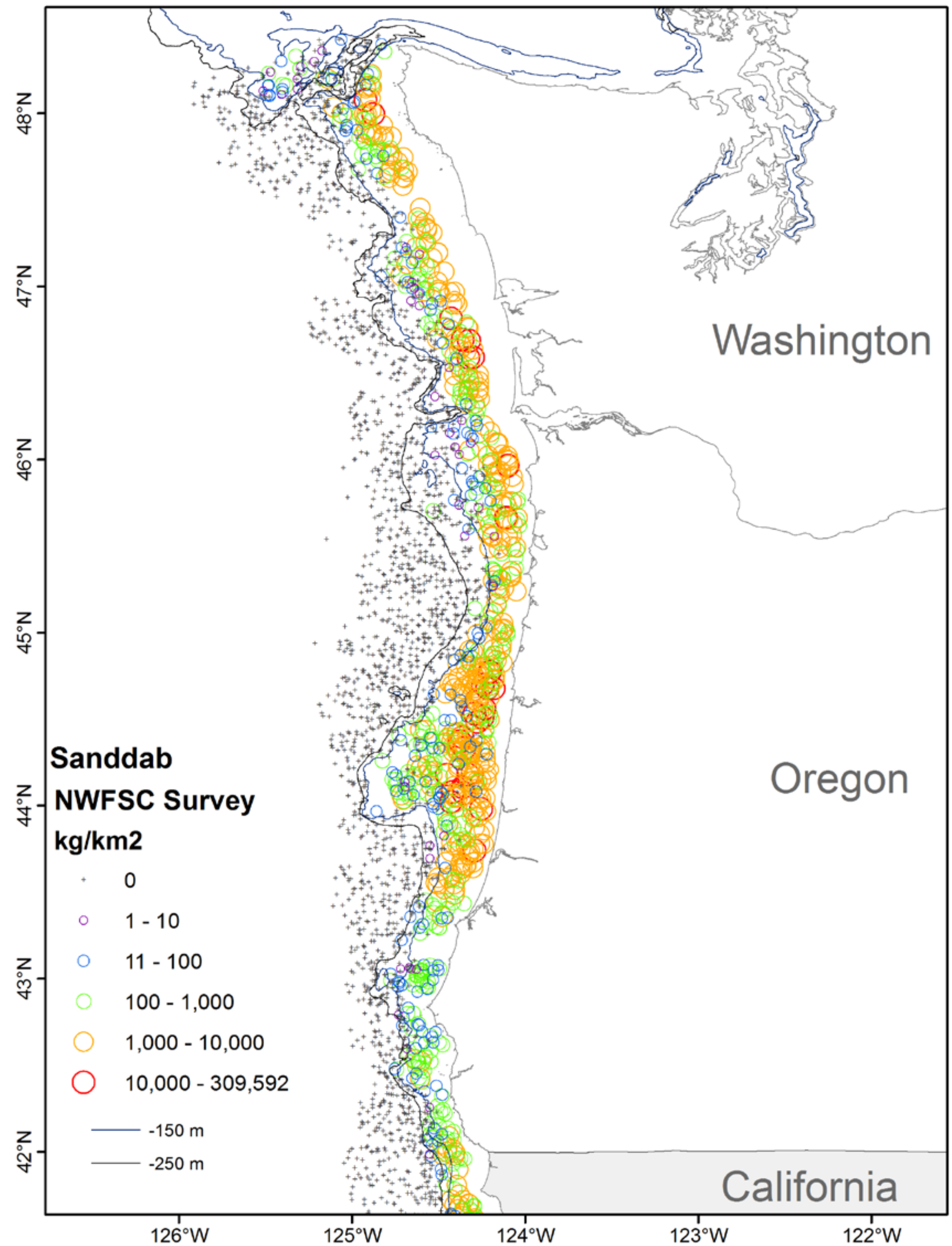


Figure 2. Spatial distribution of raw catch rates of Pacific sanddab from NWFSC trawl survey hauls in Oregon and Washington waters for time periods of 2003 and 2012. Contour lines of 150m and 250m are shown. Note that sizes and color of circles represent catch rate in log scale. (Credit Rebecca Miller, SWFSC)

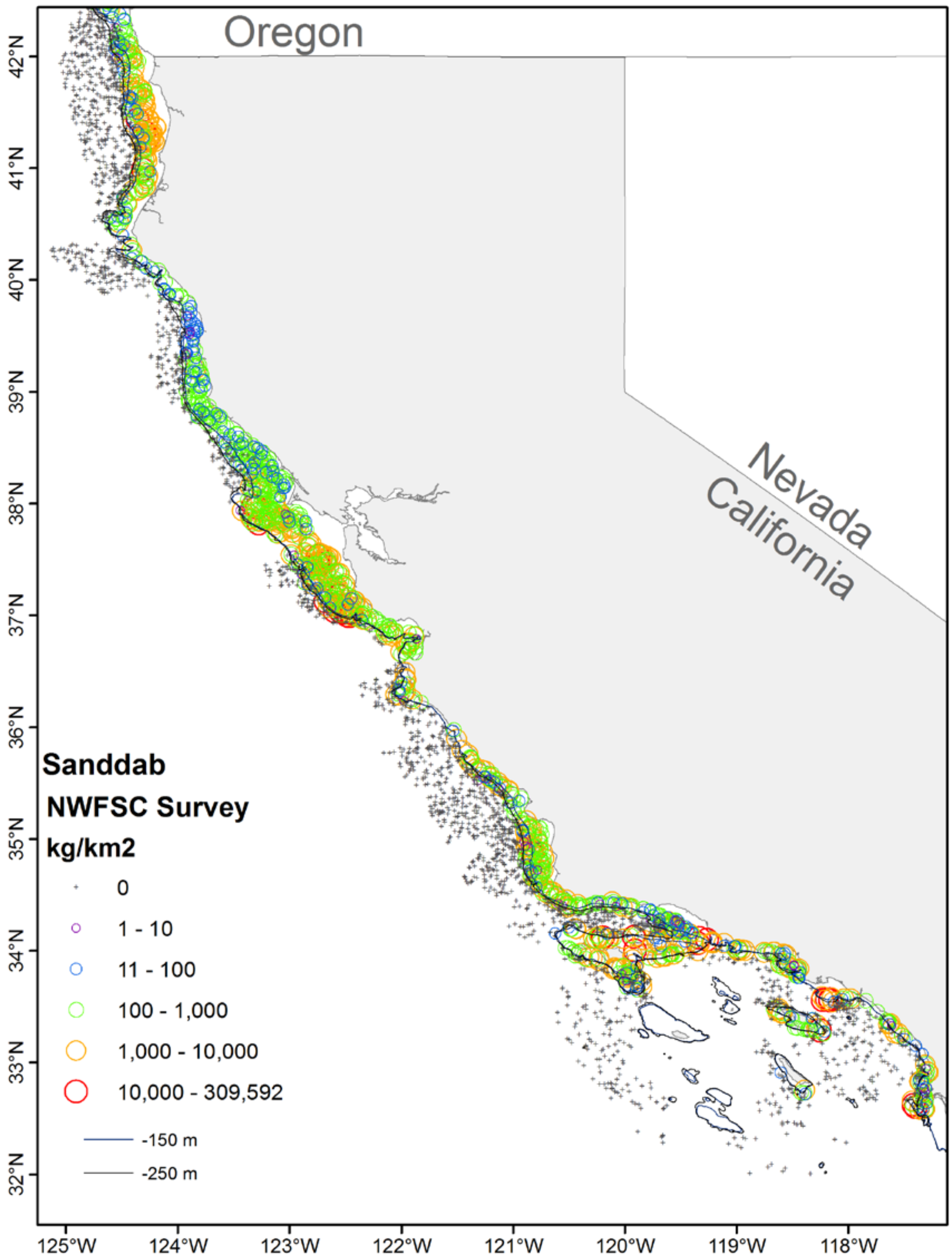


Figure 3. Spatial distribution of raw catch rates of Pacific sanddab from NWFSC trawl survey hauls in California waters for time periods of 2003 and 2012. Contour lines of 150m and 250m are shown. Note that sizes and color of circles represent catch rate in log scale. (Credit Rebecca Miller, SWFSC)

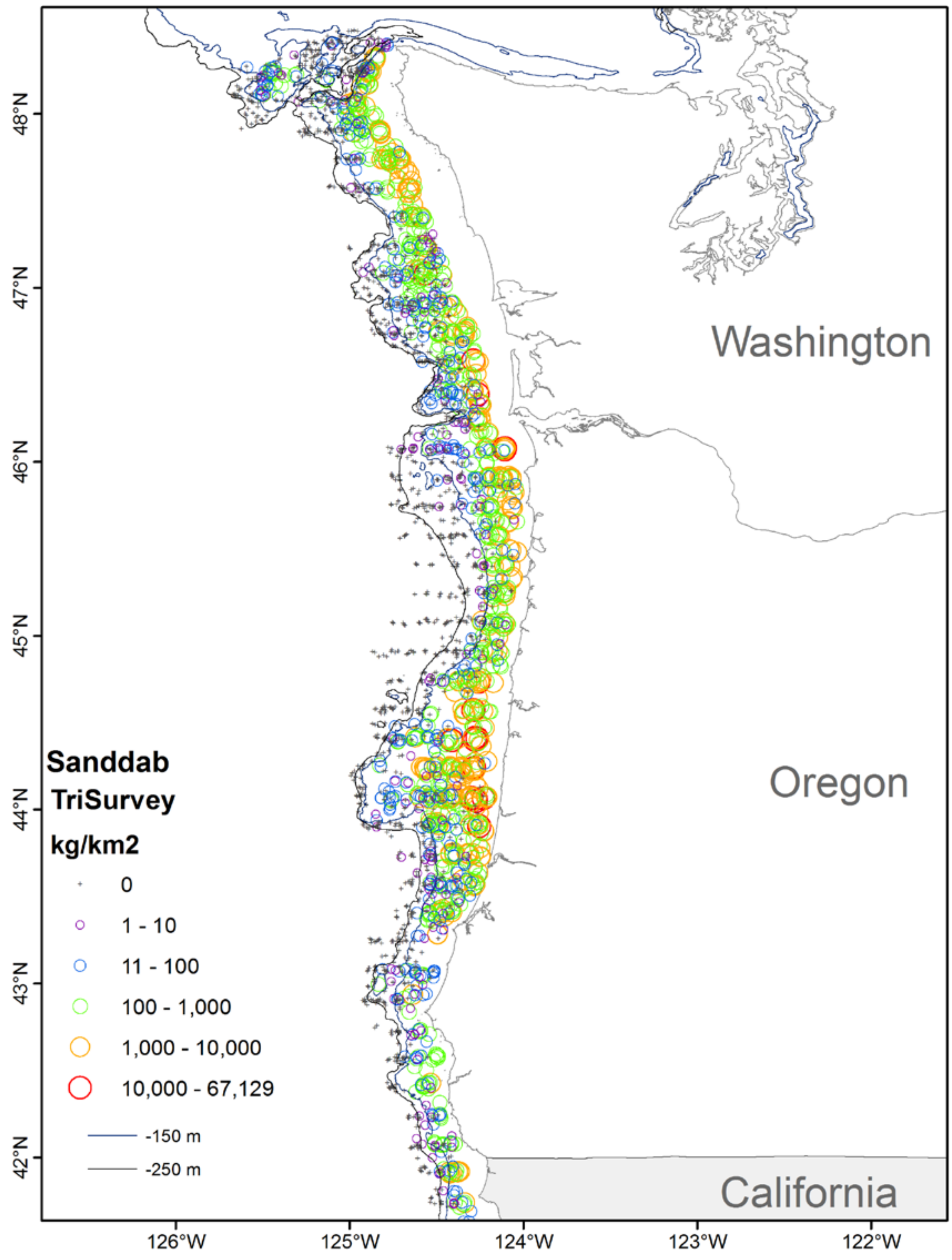


Figure 4. Spatial distribution of catch rates of Pacific sanddab from triennial trawl survey hauls in Oregon and Washington waters for time periods of 1980 and 2004. Contour lines of 150m and 250m are shown. Note that sizes and color of circles represent catch rate in log scale. (Credit Rebecca Miller, SWFSC)

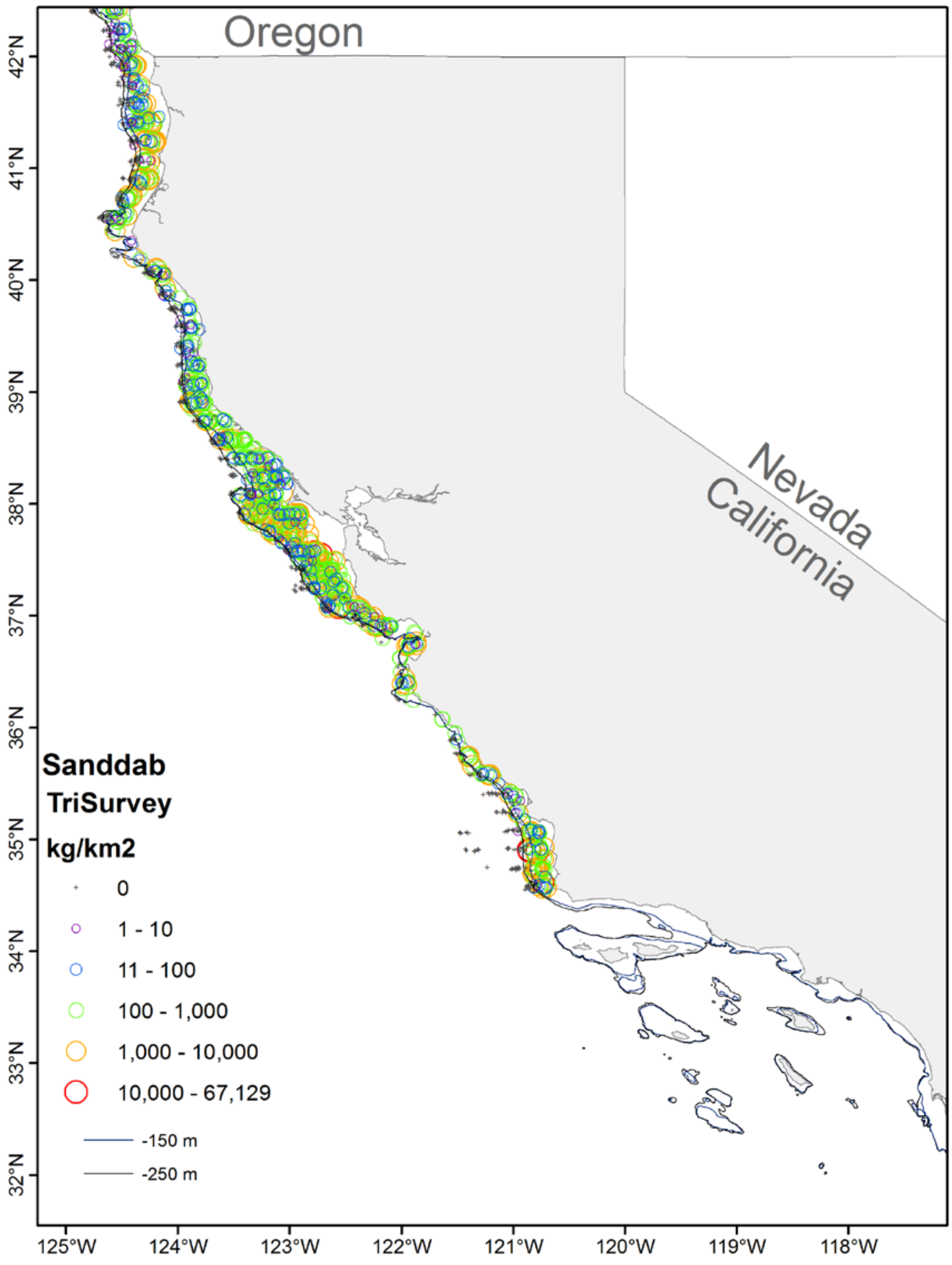


Figure 5. Spatial distribution of catch rates of Pacific sanddab from triennial trawl survey hauls in California waters for time periods of 1980 and 2004. Contour lines of 150m and 250m are shown. Note that sizes and color of circles represent catch rate in log scale. (Credit Rebecca Miller, SWFSC)

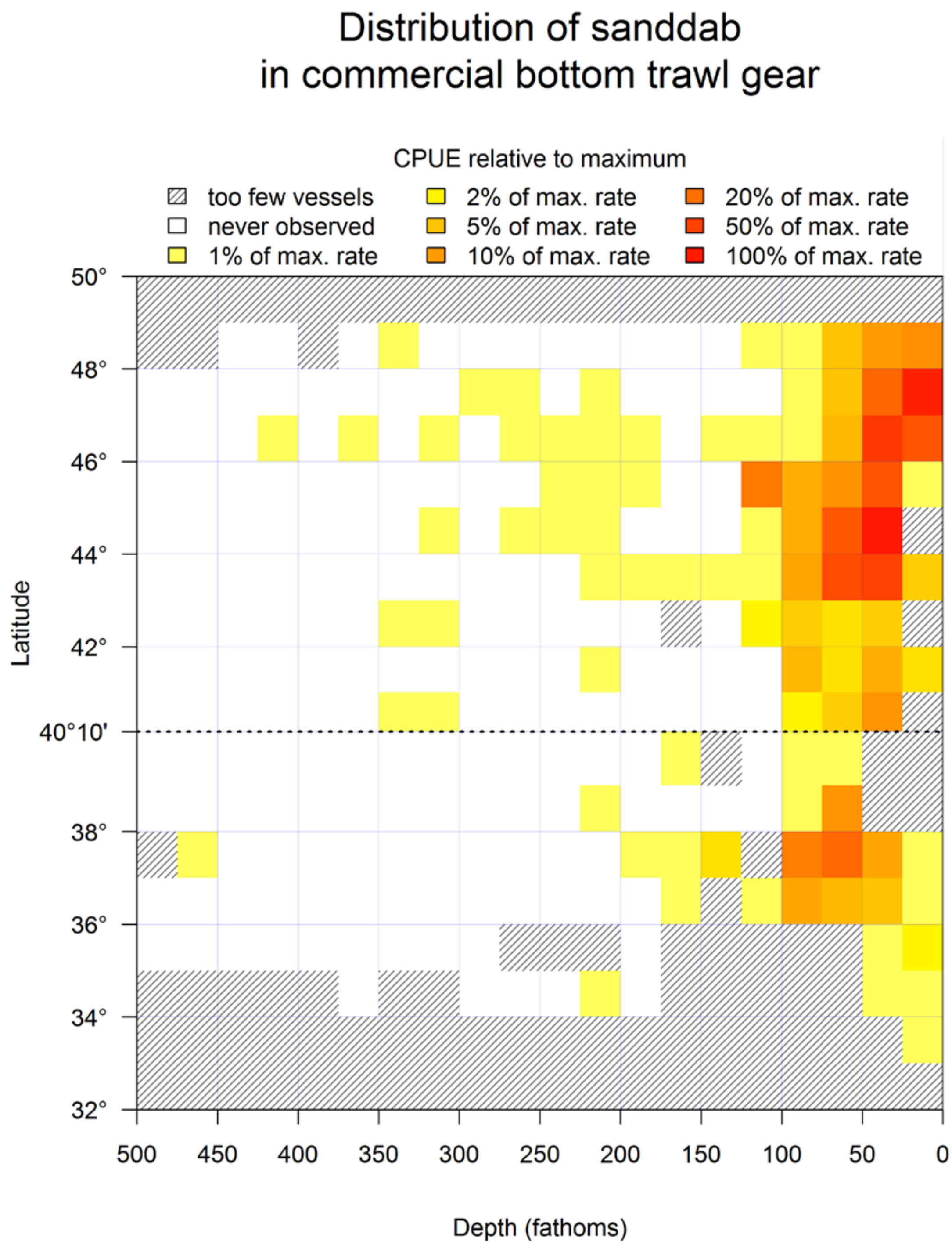


Figure 6. Plots of relative commercial trawl catch per unit effort (CPUE) from the WCGOP observer data between 2002 and 2011 by latitude and depth along the U.S. Pacific coast (credit of Ian Taylor of NWFSC). The map only shows data from more than three vessels in each grid.

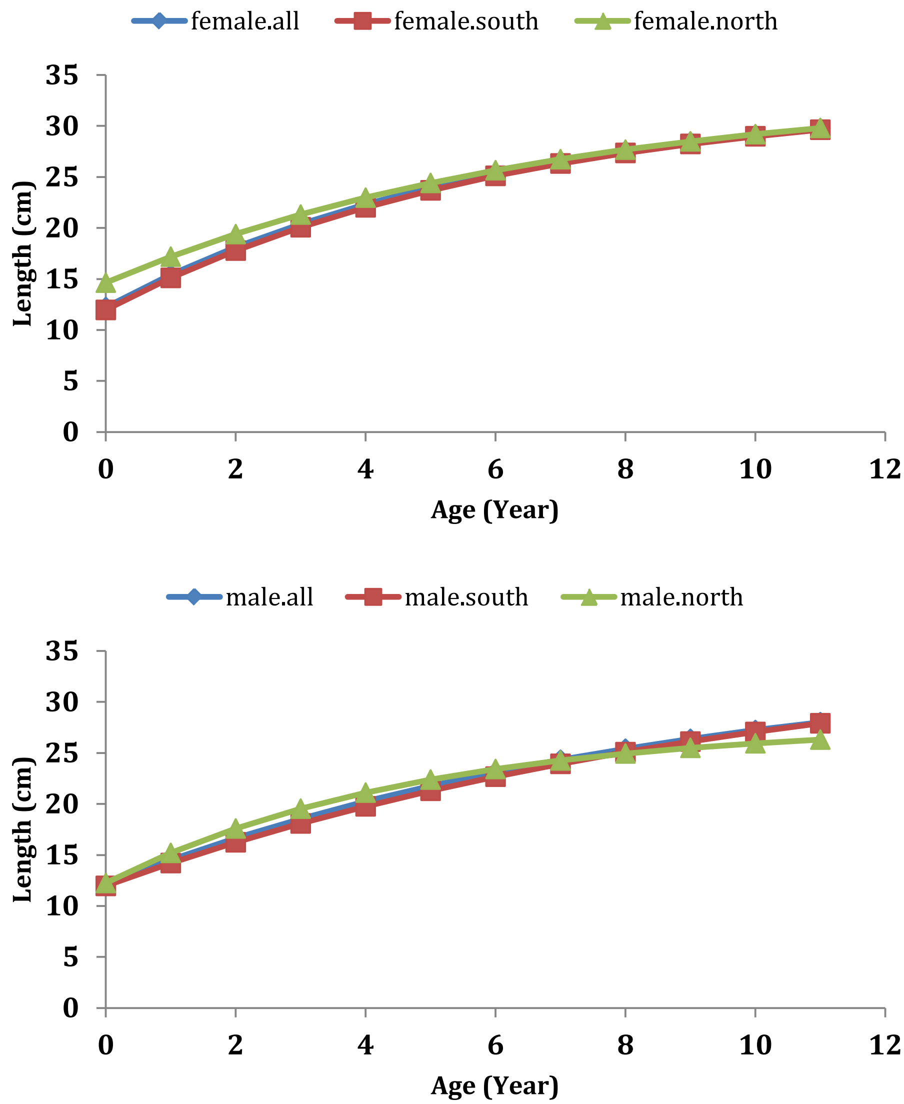


Figure 7. Comparison plots of growth by sex and by area using the NWFSC survey data from 2003 to 2012. Two areas are defined as northern and southern areas (divided by latitude of 42^{o} at the boarder of California and Oregon).

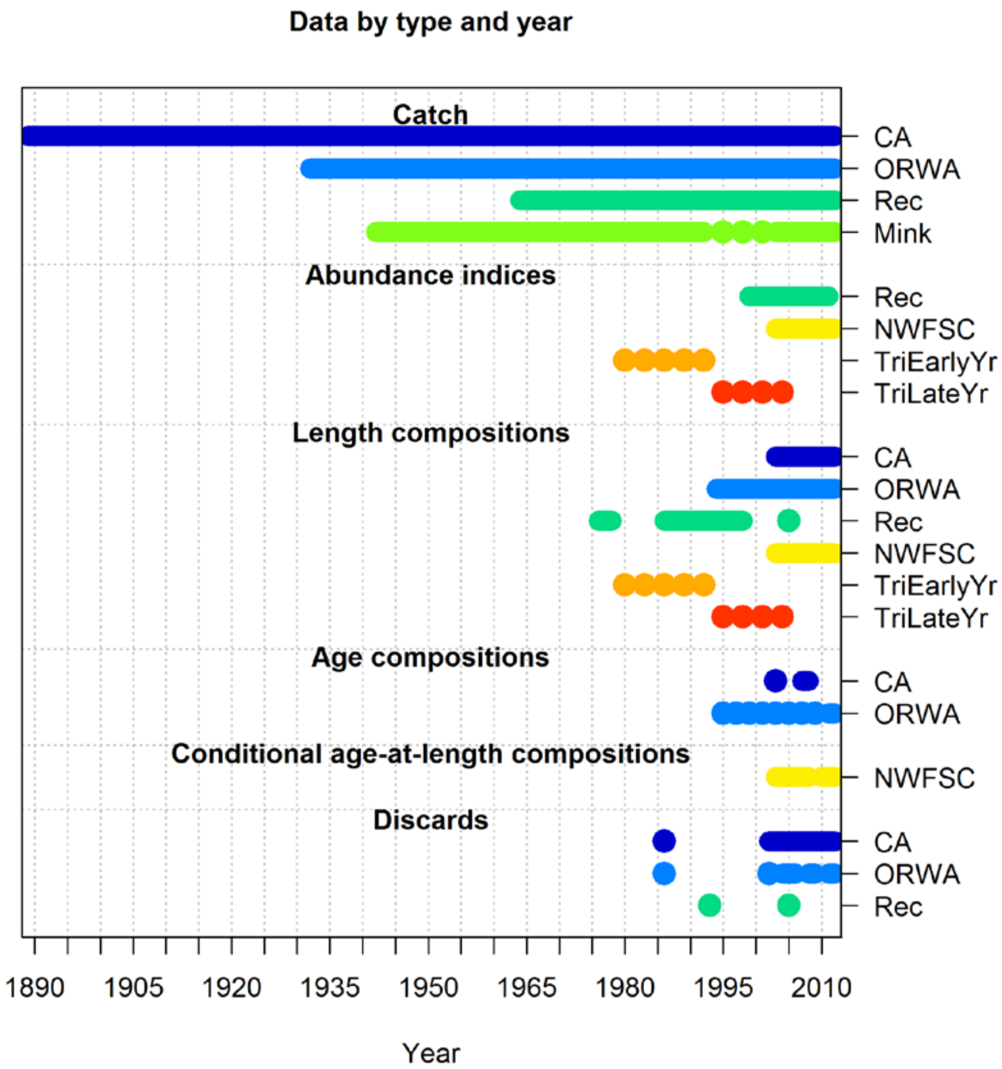


Figure 8. Summary of data sources and time periods of availability of each data set that were used in this assessment.

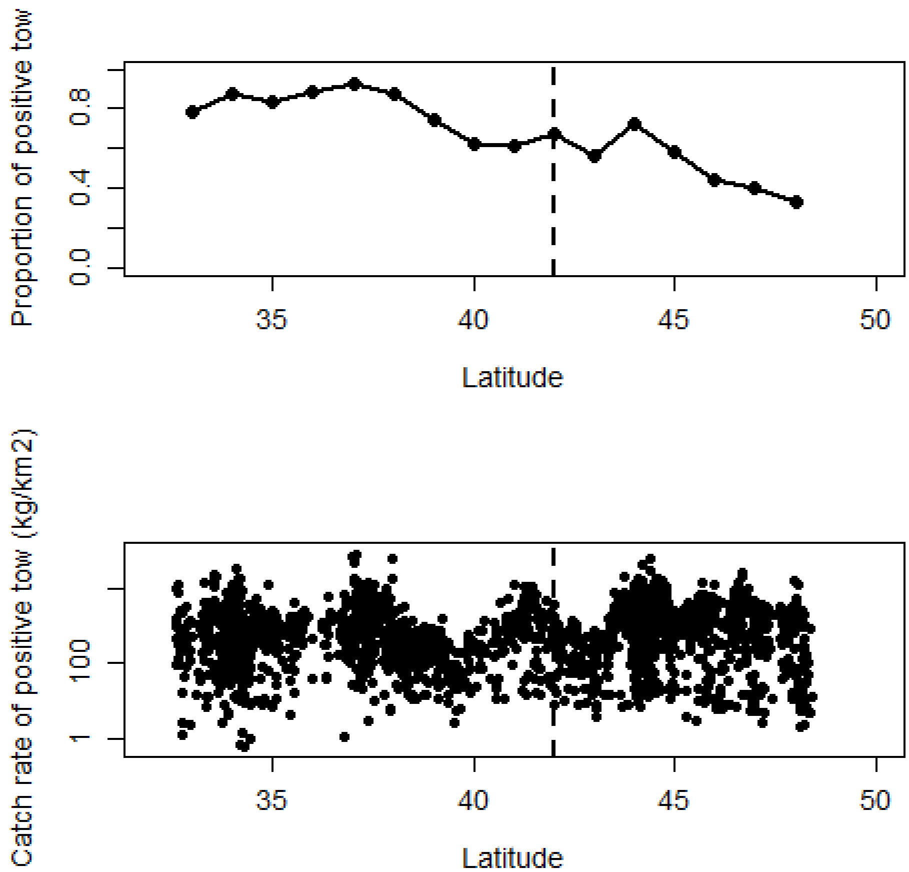


Figure 9. Plots of the proportion of positive tows (top panel) and the catch rates of positive tows (bottom panel) by latitude for NWFSC survey data. Vertical dash lines show latitude line 42 degree (boarder of Oregon and California). Note that y-axis on the bottom panel is in log-scale.

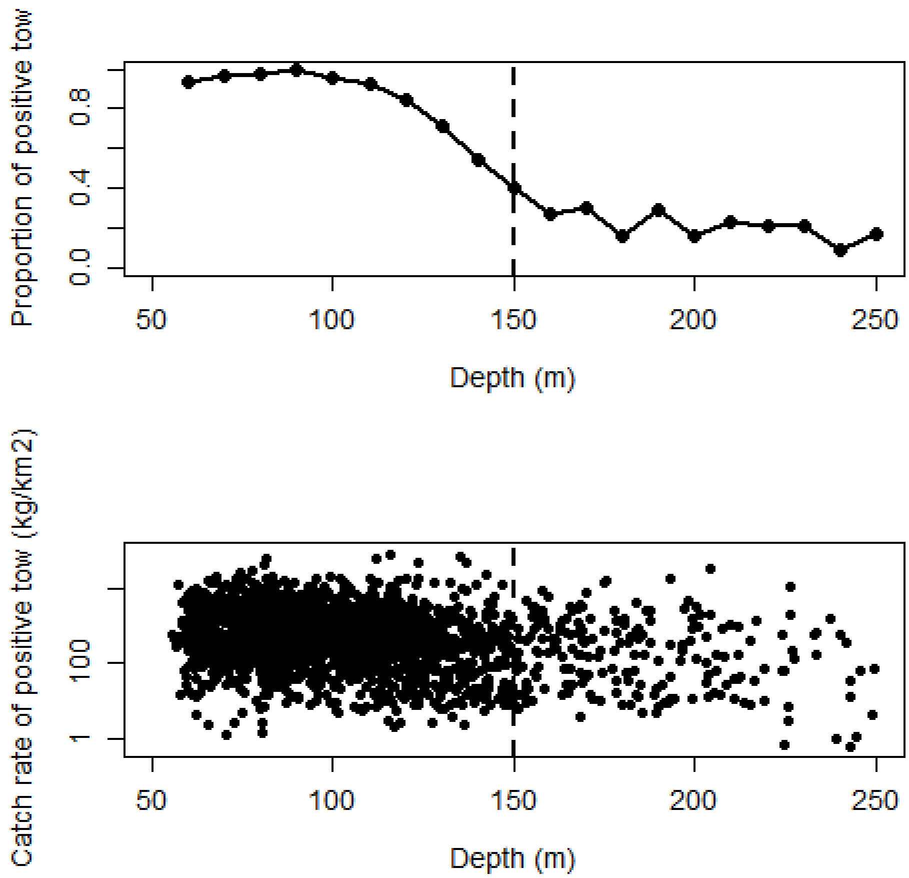


Figure 10. Plots of the proportion of positive hauls (top panel) and the catch rates of positive tows (bottom panel) by depth zones for NWFSC survey data. Vertical dash lines show depths of 150m and 250m. Note that y-axis on the bottom panel is in log-scale.

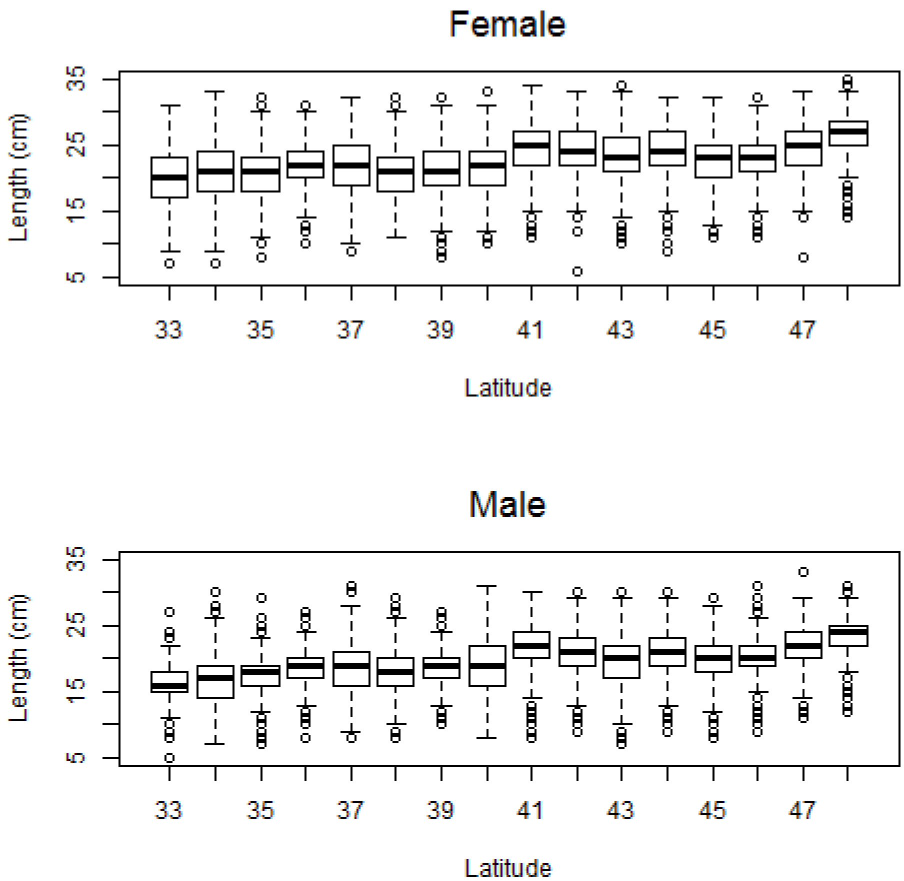


Figure 11. Comparison box plots of raw length data from the NWFSC survey by sex and by latitude.

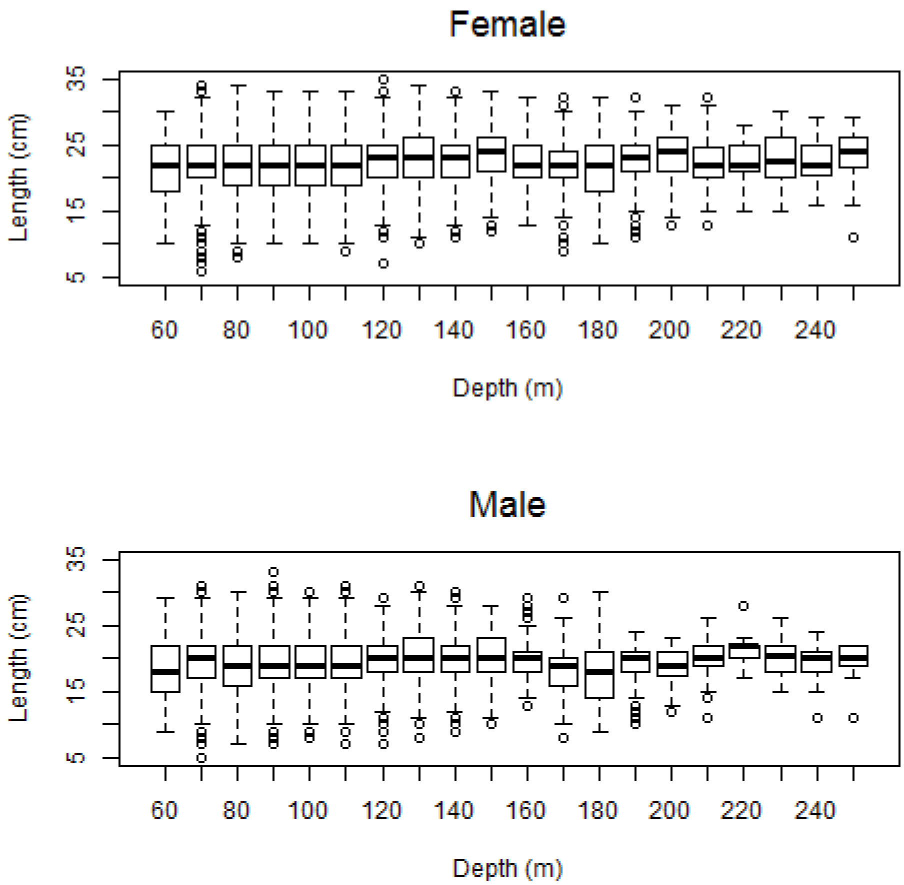


Figure 12. Comparison box plots of raw length data from the NWFSC survey by sex and by depth.

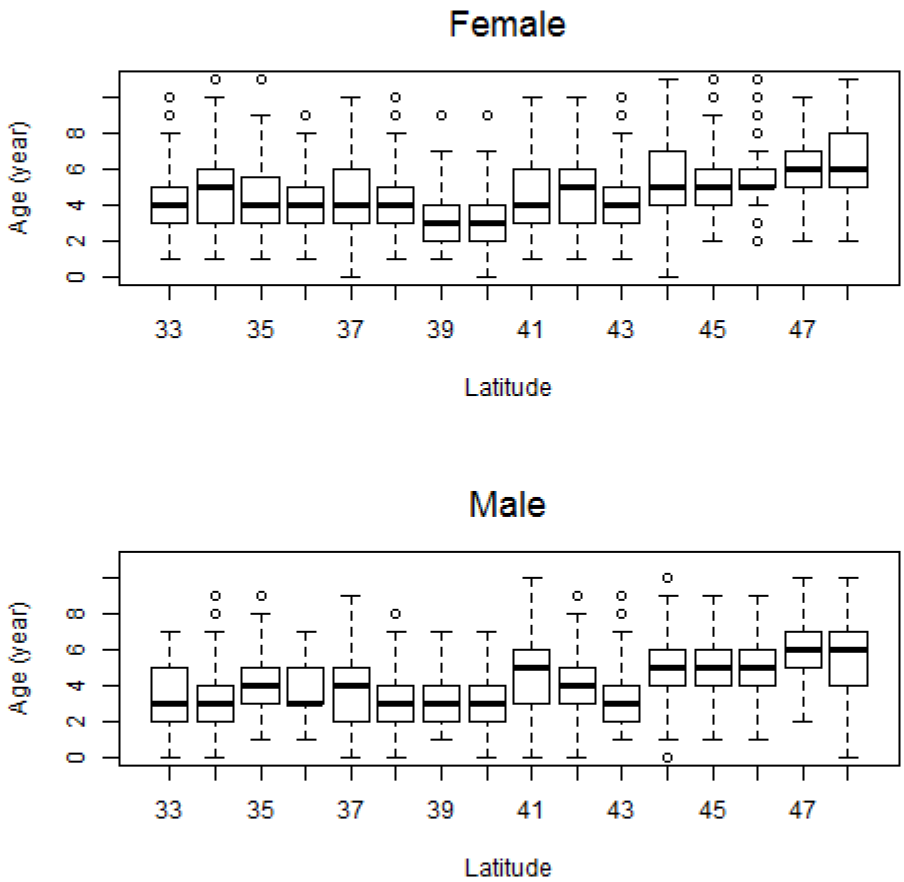


Figure 13. Comparison box plots of raw age data from the NWFSC survey by sex and by latitude.

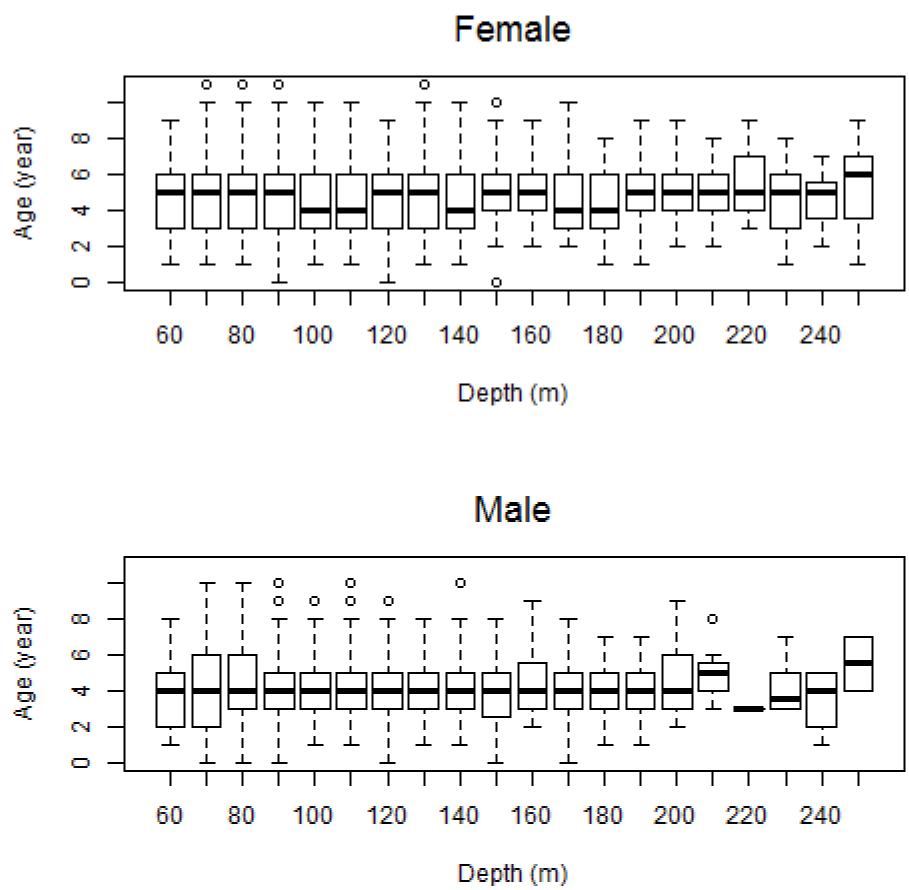
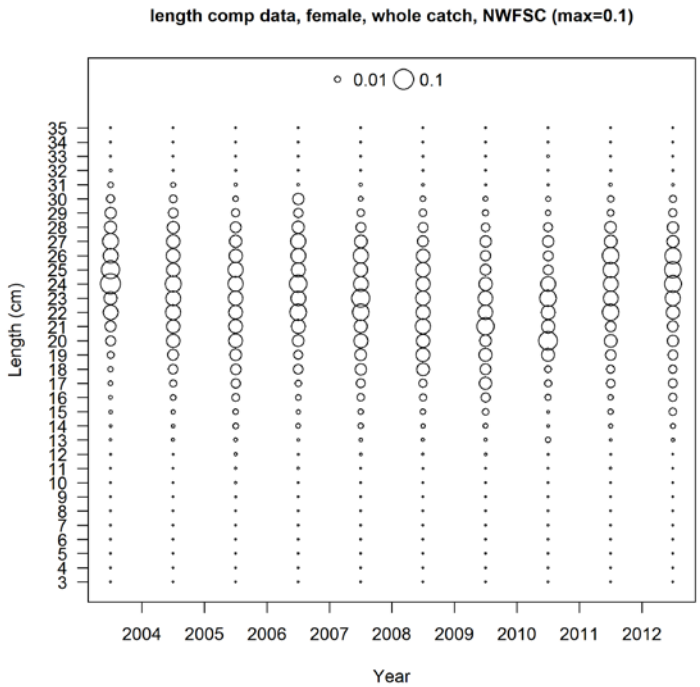


Figure 14. Comparison box plots of raw age data from the NWFSC survey by sex and by depth.



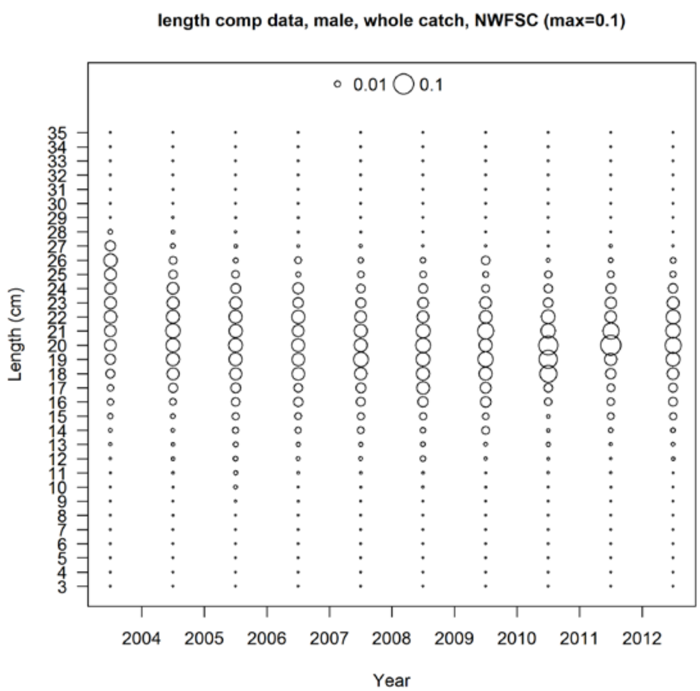


Figure 15. Length composition data by sex used in the assessment model from the NWFSC survey from 2003 to 2012.

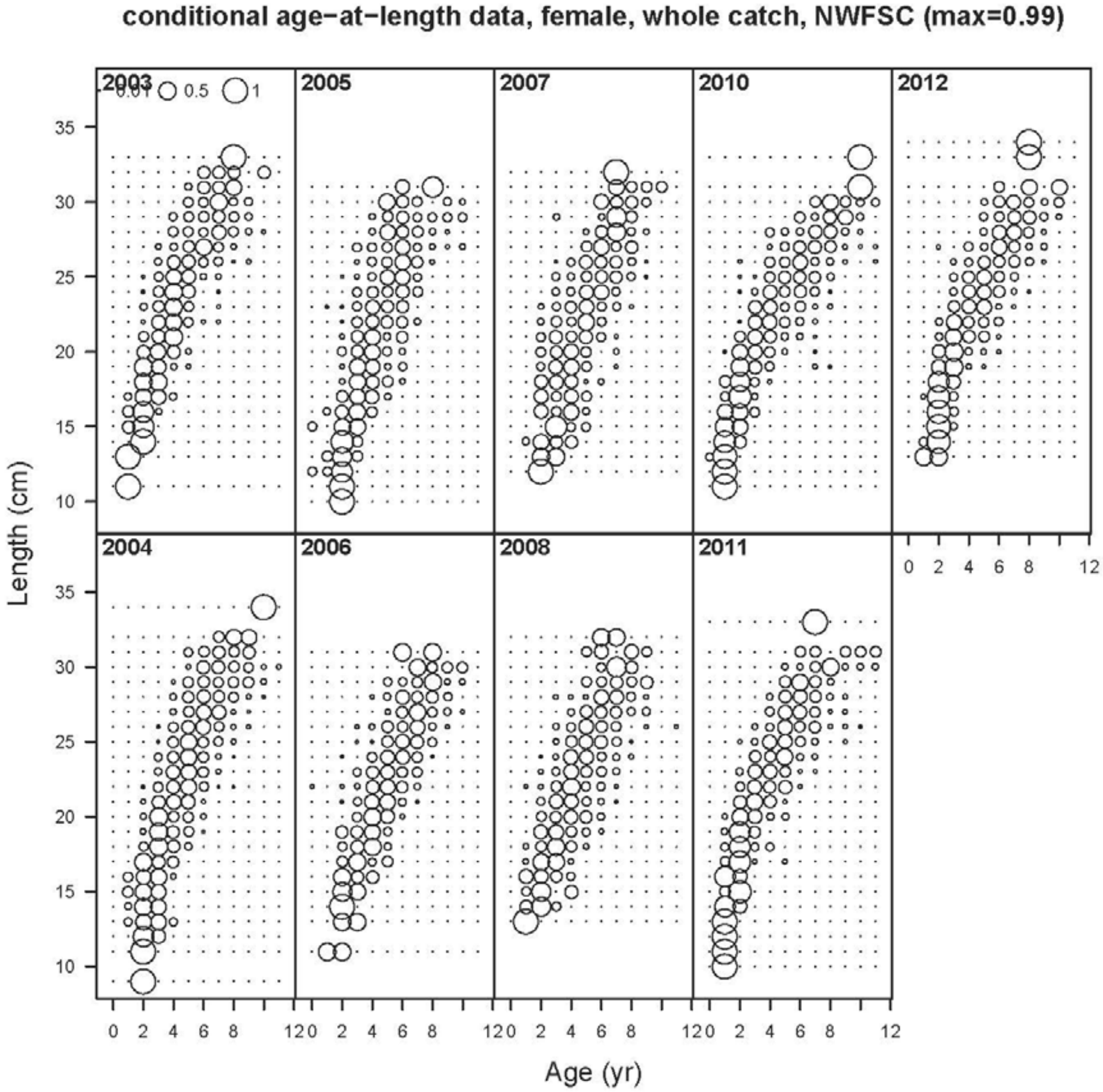


Figure 16. Plots of conditional age-at-length frequencies for females from the NWFSC survey from 2003 to 2012.

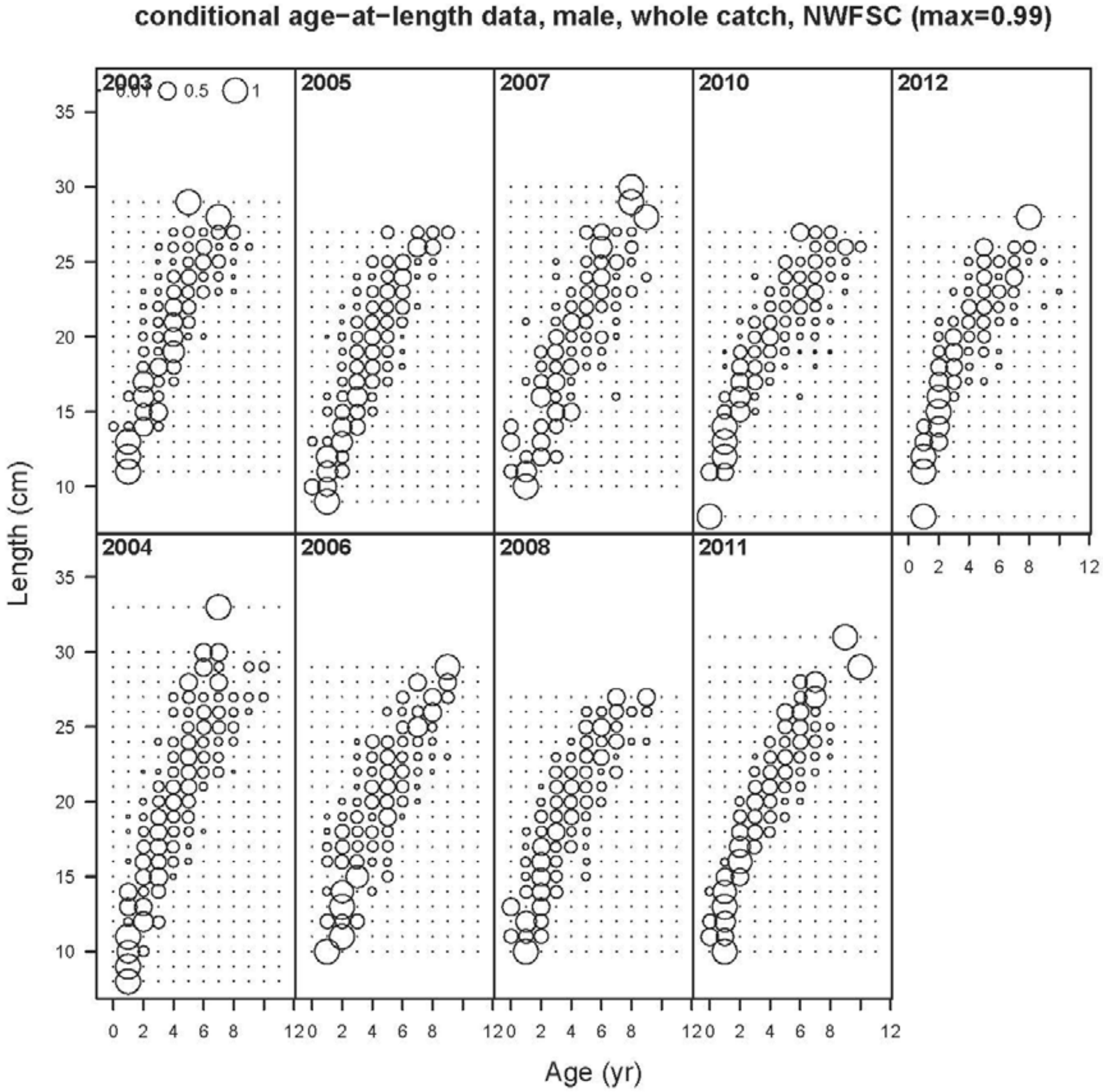


Figure 17. Plots of conditional age-at-length frequencies for males from the NWFSC survey from 2003 to 2012.

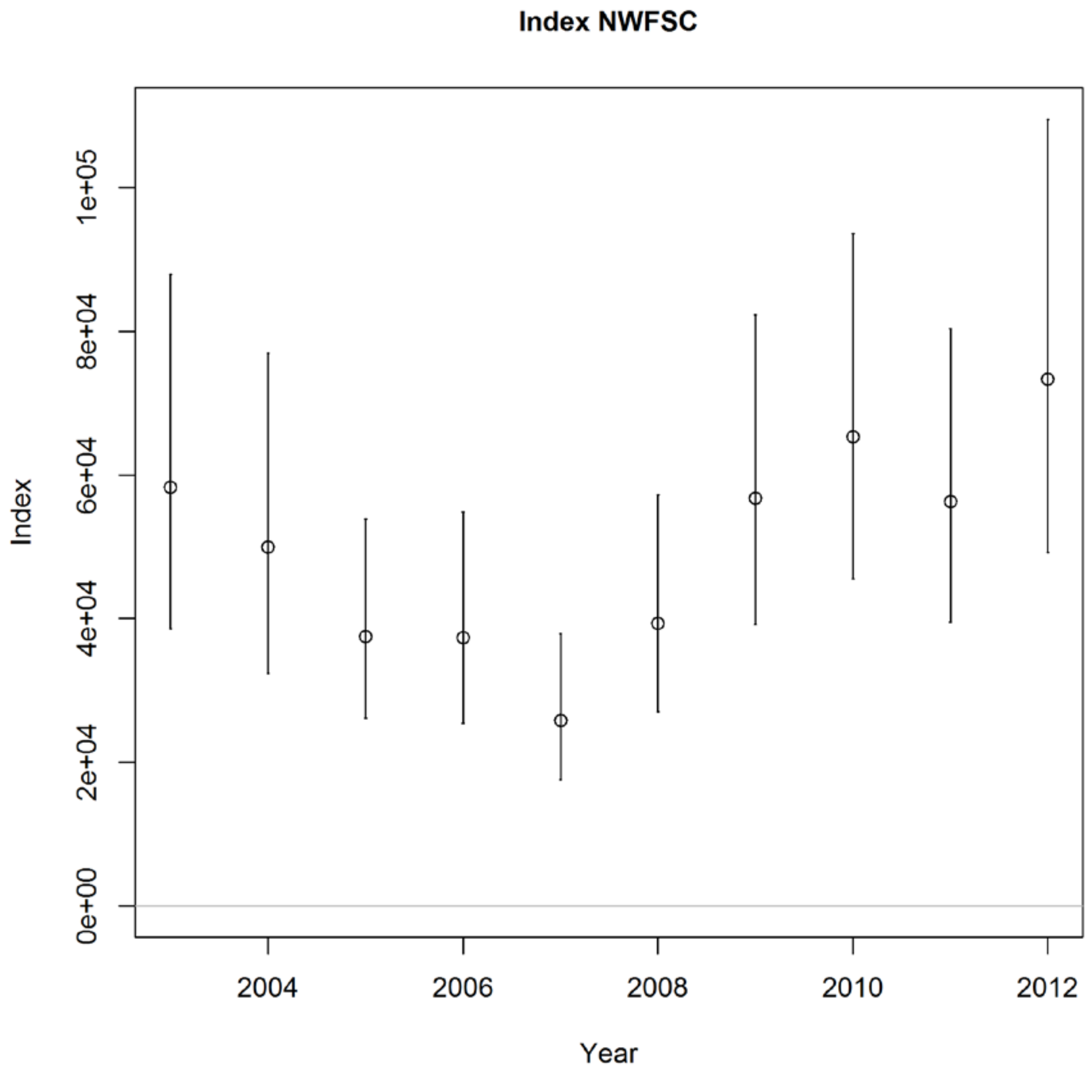


Figure 18. Estimated biomass and their standard deviations from the GLMM analysis for the NWFSC survey.

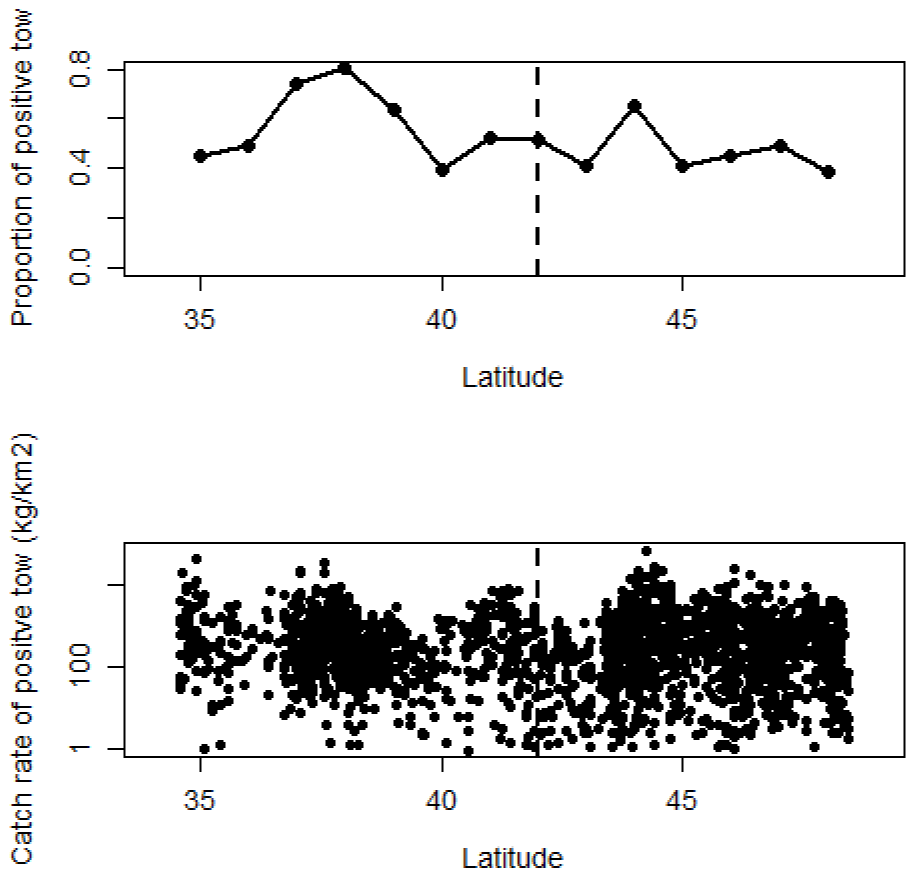


Figure 19. Plots of the proportion of positive tows (top panel) and the catch rates of positive tows (bottom panel) by latitude for triennial survey data. Vertical dash lines show latitude line 42 degree (boarder of Oregon and California). Note that y-axis on the bottom panel is in log-scale.

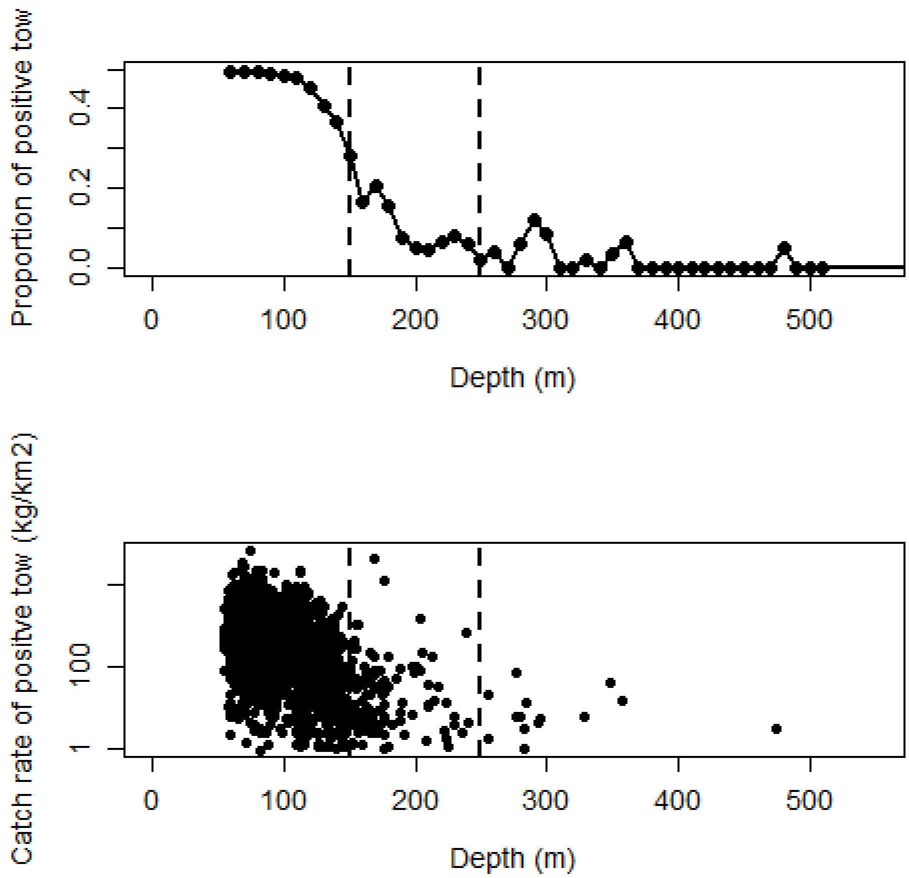


Figure 20. Plots of the proportion of positive hauls (top panel) and the catch rates of positive tows (bottom panel) by depth zones for triennial survey data. Vertical dash lines show depths of 150m and 250m. Note that y-axis on the bottom panel is in log-scale.

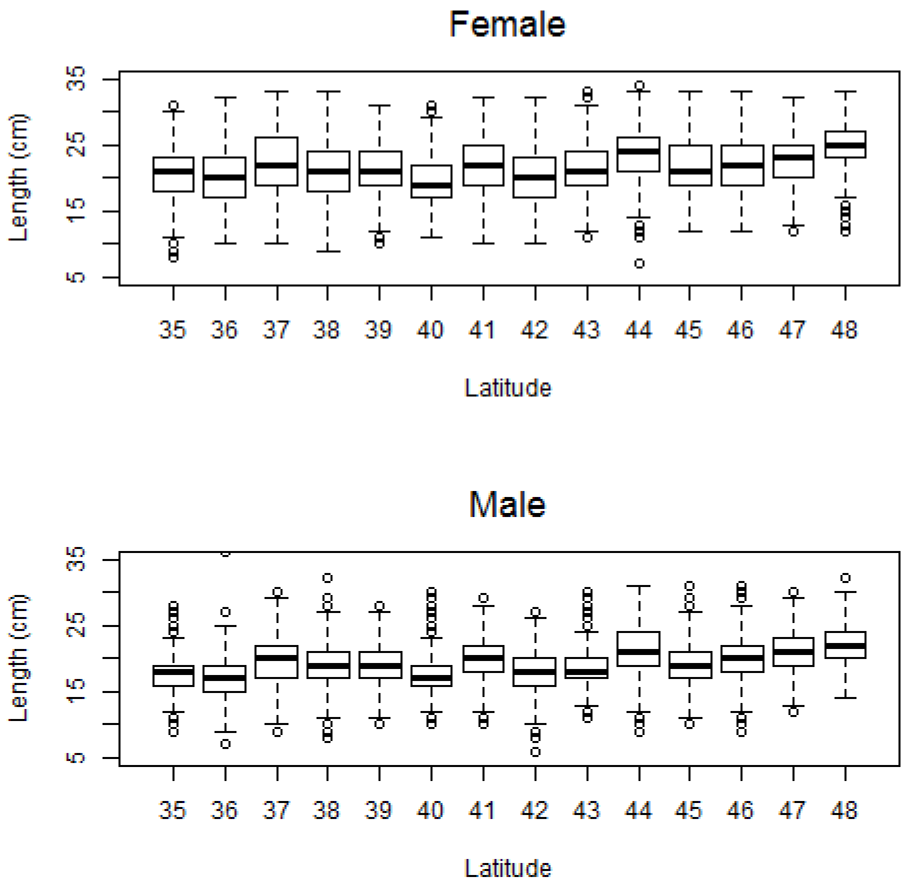


Figure 21. Comparison box plots of raw length data from the triennial survey by sex by latitude.

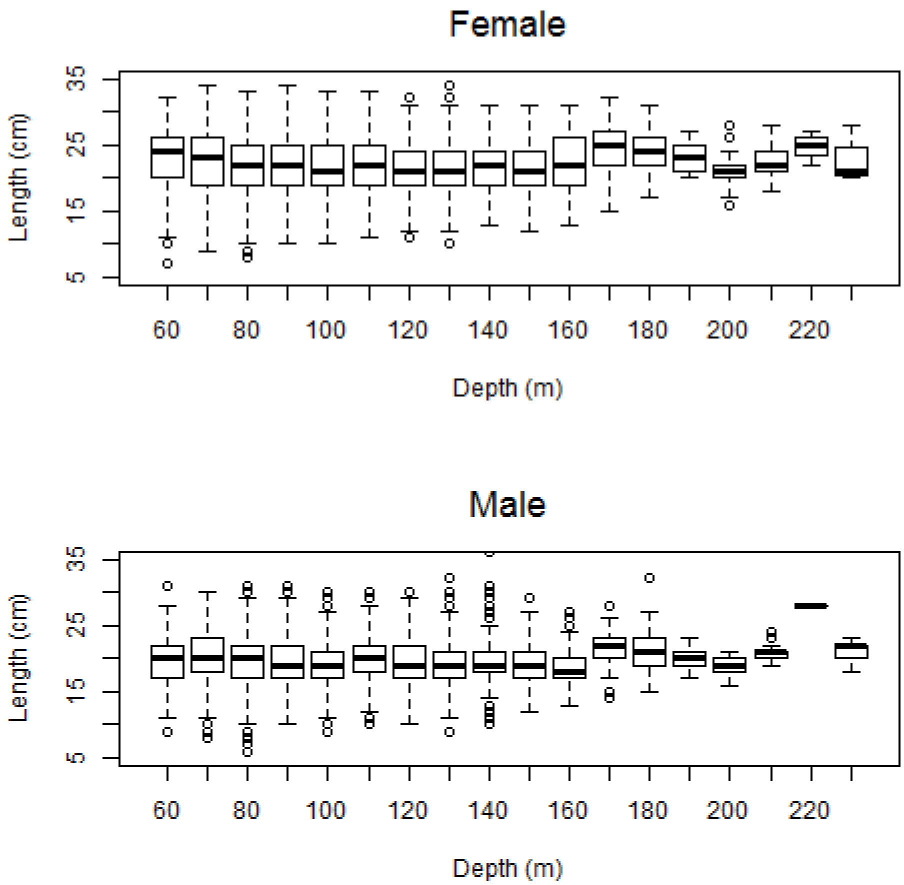


Figure 22. Comparison box plots of raw length data from the triennial survey data by sex and by depth.

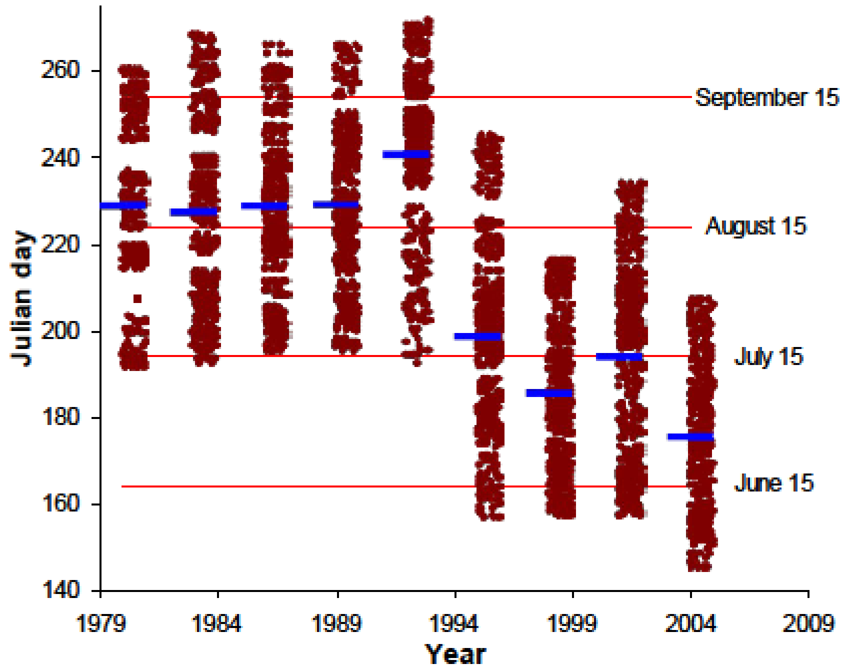


Figure 23. Distribution of date of operation for the triennial survey (1980-2004). Solid bars show the mean date for each survey year, points represent individual haul dates, but are jittered to allow better delineation of the distribution of individual points. (Figure and caption copied from Hicks and Wetzel (2011), and original figure from Stewart (2007)).

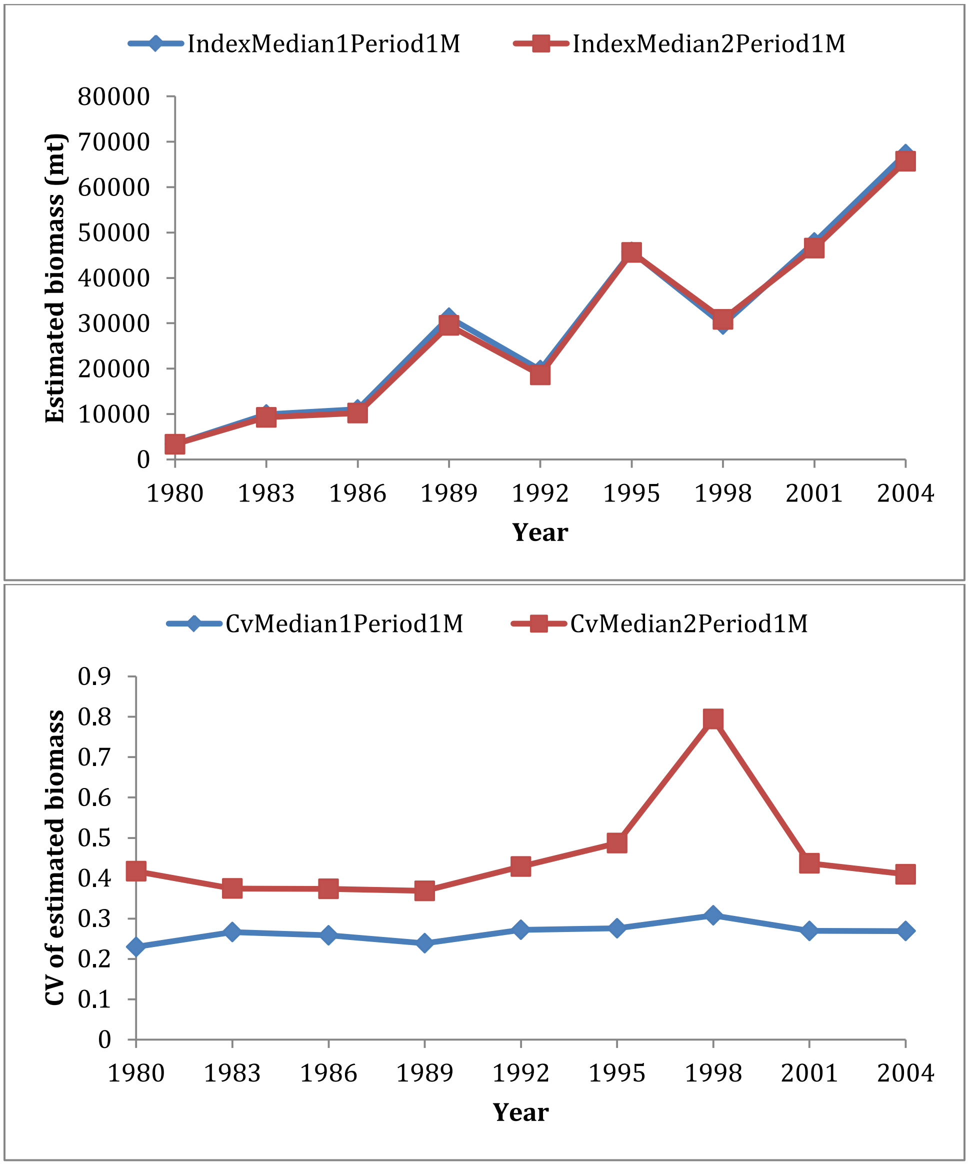
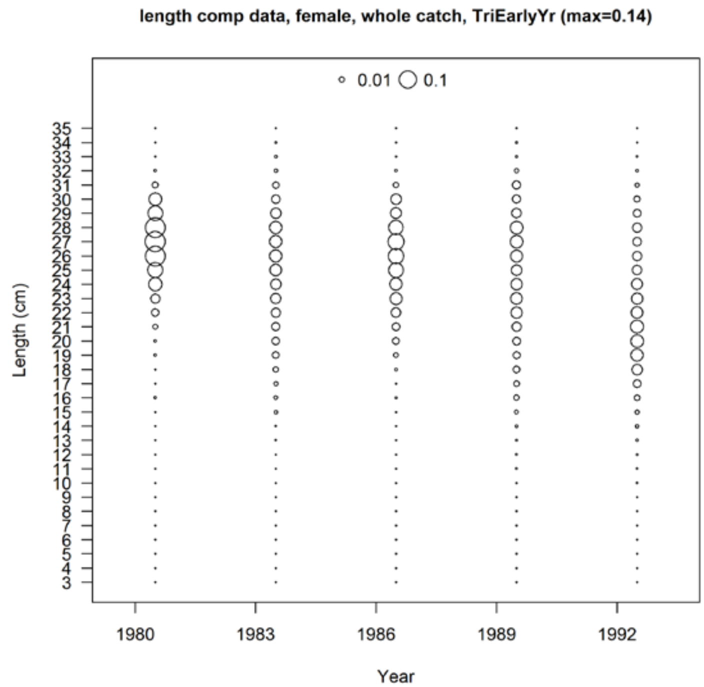


Figure 24. Comparisons of estimated abundance indices for Pacific sanddab from the triennial trawl survey between 1980 and 2004 using one time period and two time periods (top panel), and their associated CVs (bottom panel). Blue lines are statistics from using one time period approach while red lines are those from using two-time period approach.



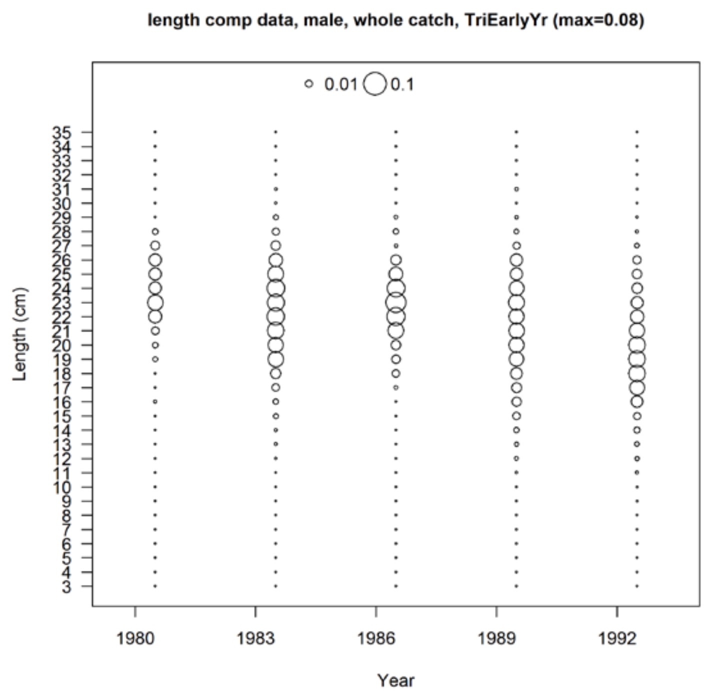


Figure 25. Plots of length frequency distributions of females (top panel) and males (bottom panel) from the early year triennial survey used in the assessment model between 1980 and 1992.

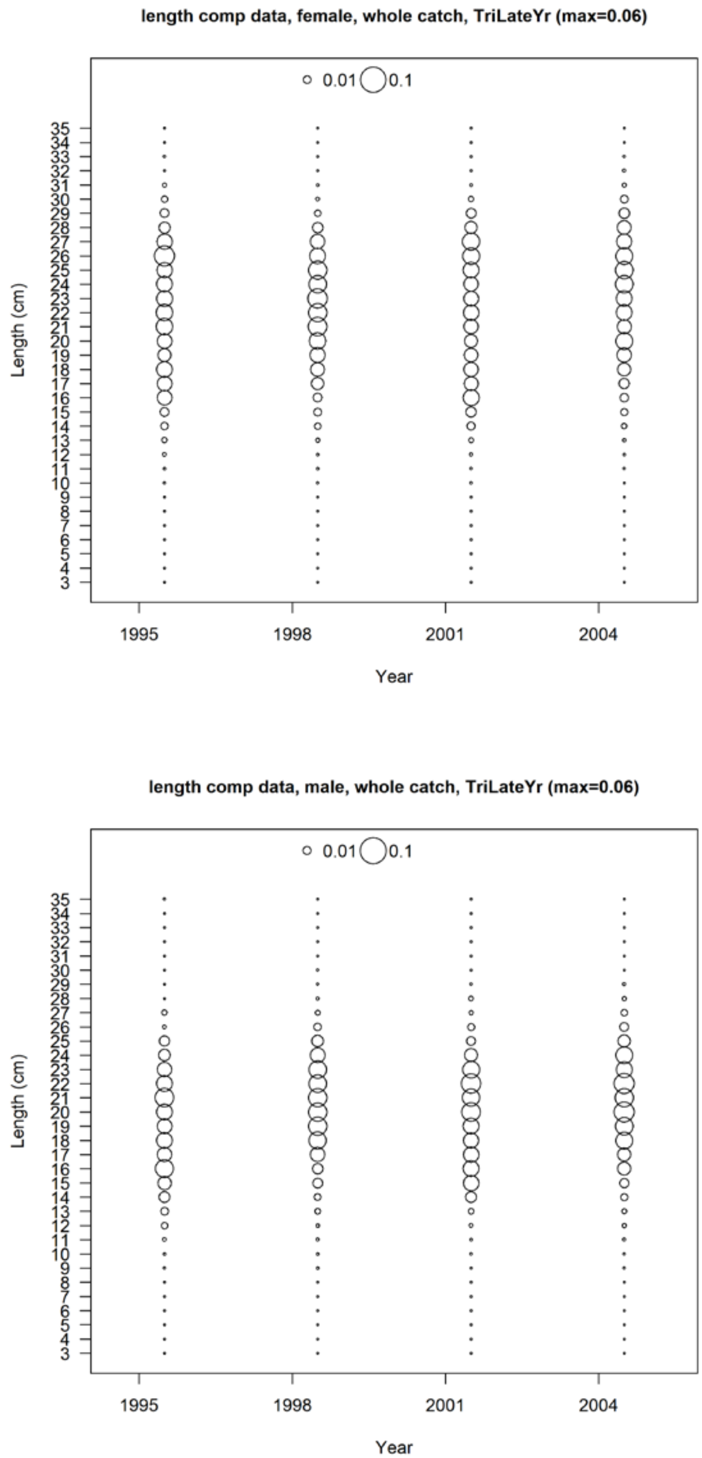


Figure 26. Plots of length frequency distributions of females (top panel) and males (bottom panel) from the early year triennial survey used in the assessment model between 1980 and 1992.

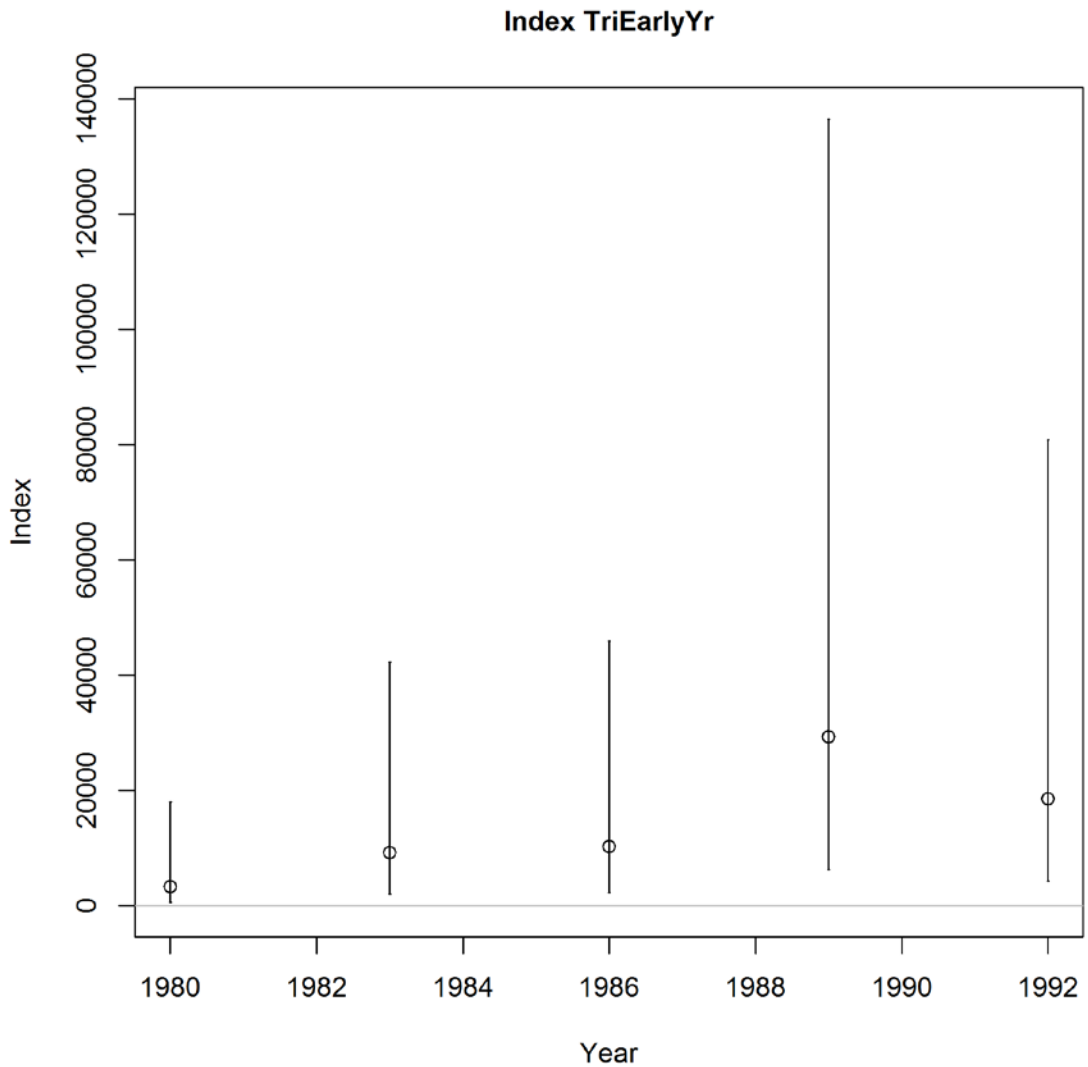


Figure 27. Estimated biomass from the GLMM analysis for early years (1980-1992) of the triennial survey.

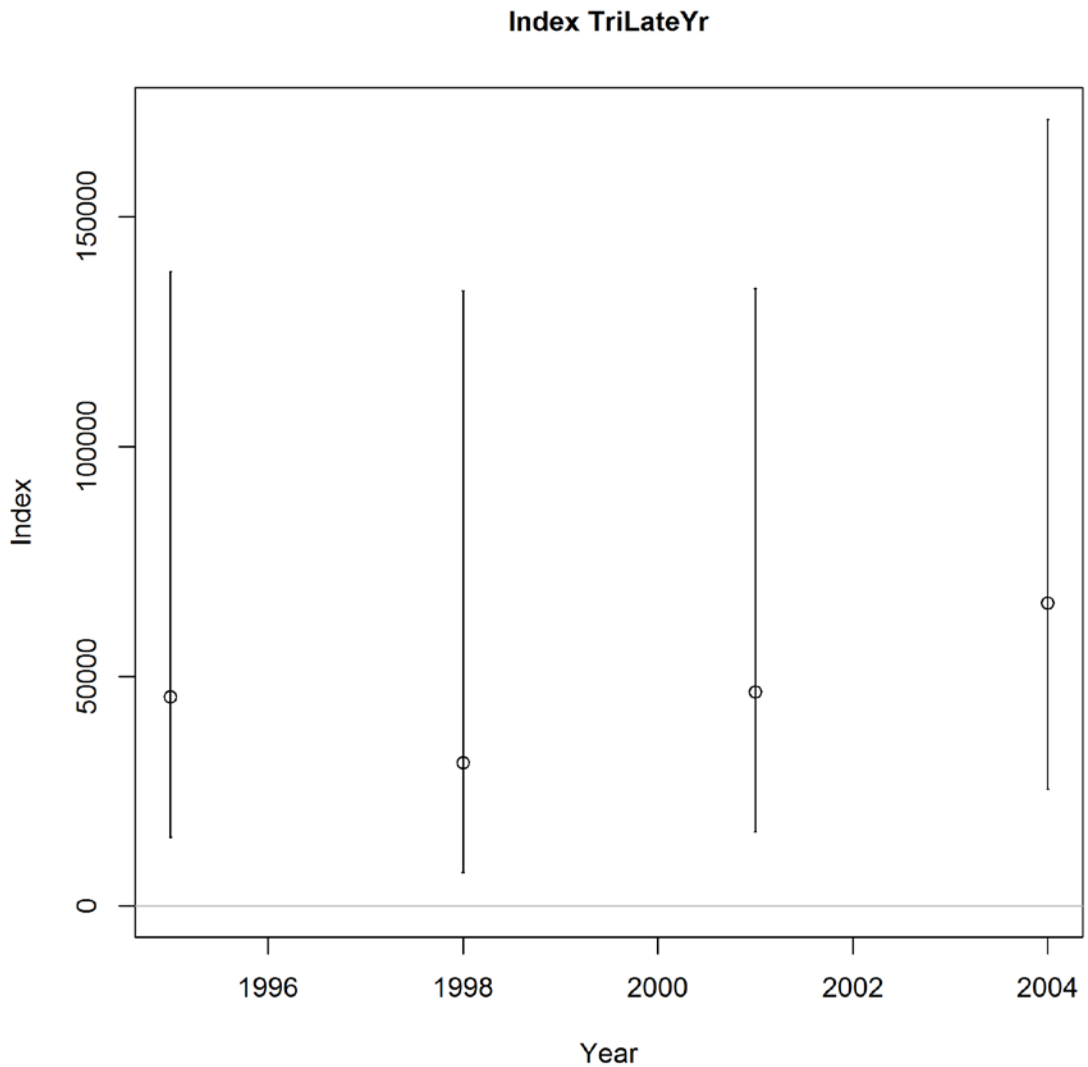


Figure 28. Estimated biomass from the GLMM analysis for late years (1994-2001) of the triennial survey.

Figure 29. Length frequency distributions of retained catches from the recreational fishery (sexes combined) from 1976 to 2005. Data were from the CDFW Commercial Passenger Fishing Vessels (CPFV) sampling program.

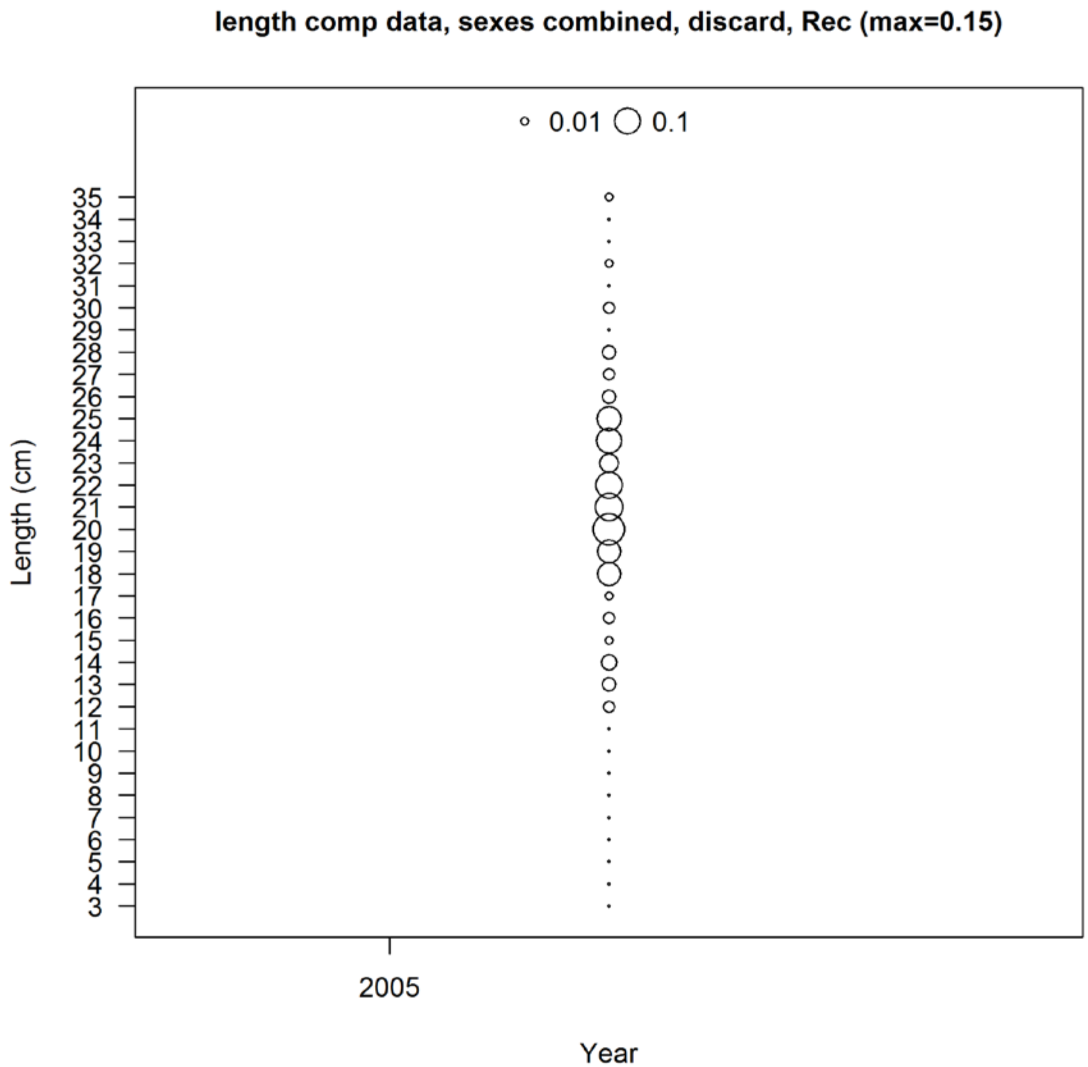


Figure 30. Length frequency distributions of discarded catches from the recreational fishery (sexes combined) in 2005. Data were from the CDFW Commercial Passenger Fishing Vessels (CPFV) sampling program.

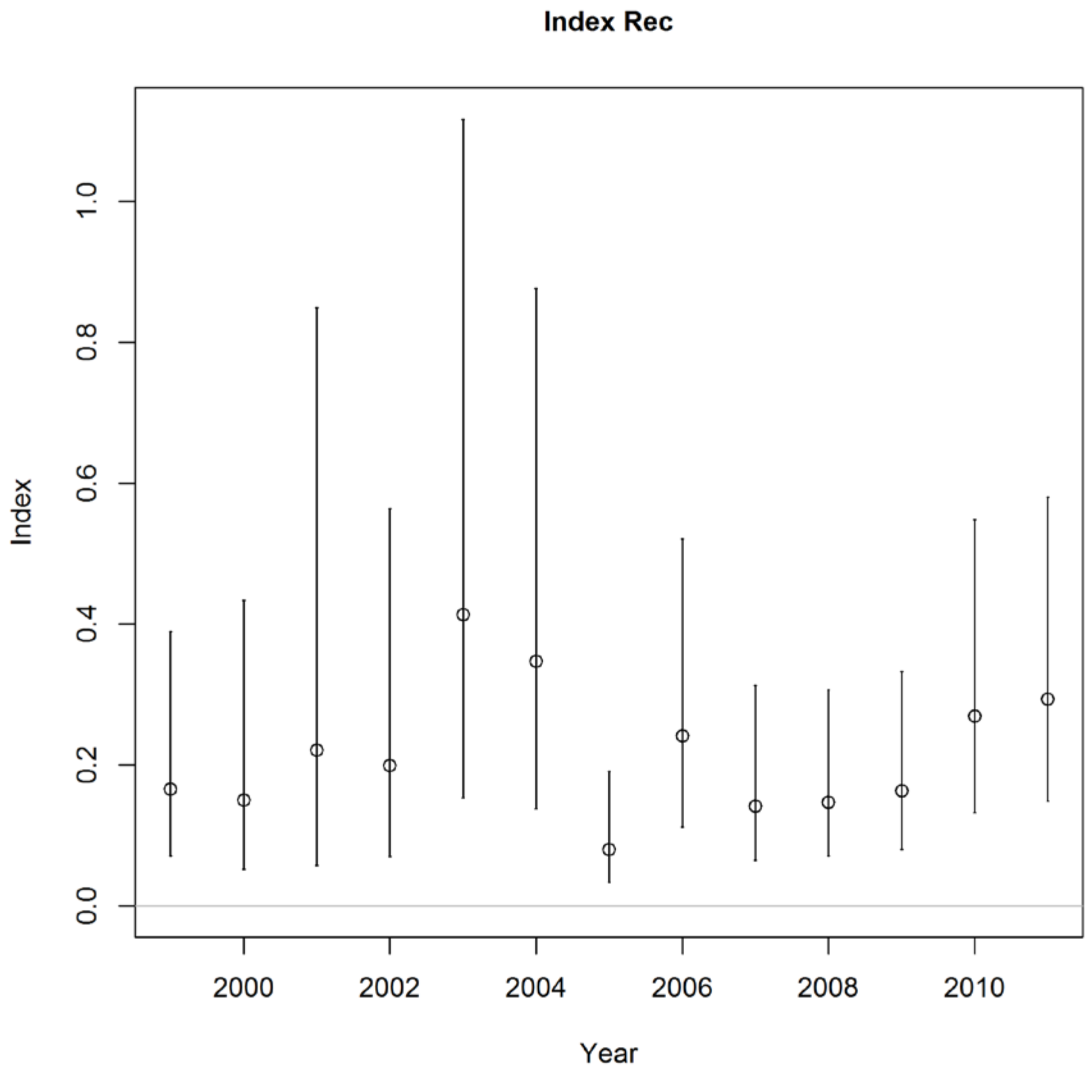


Figure 31. Estimated CPUE indices and CVs from the GLM analysis for the California recreational fishery survey (CPFV survey) between 1999 and 2011. The indices were provided by Melissa Monk of the SWFSC).

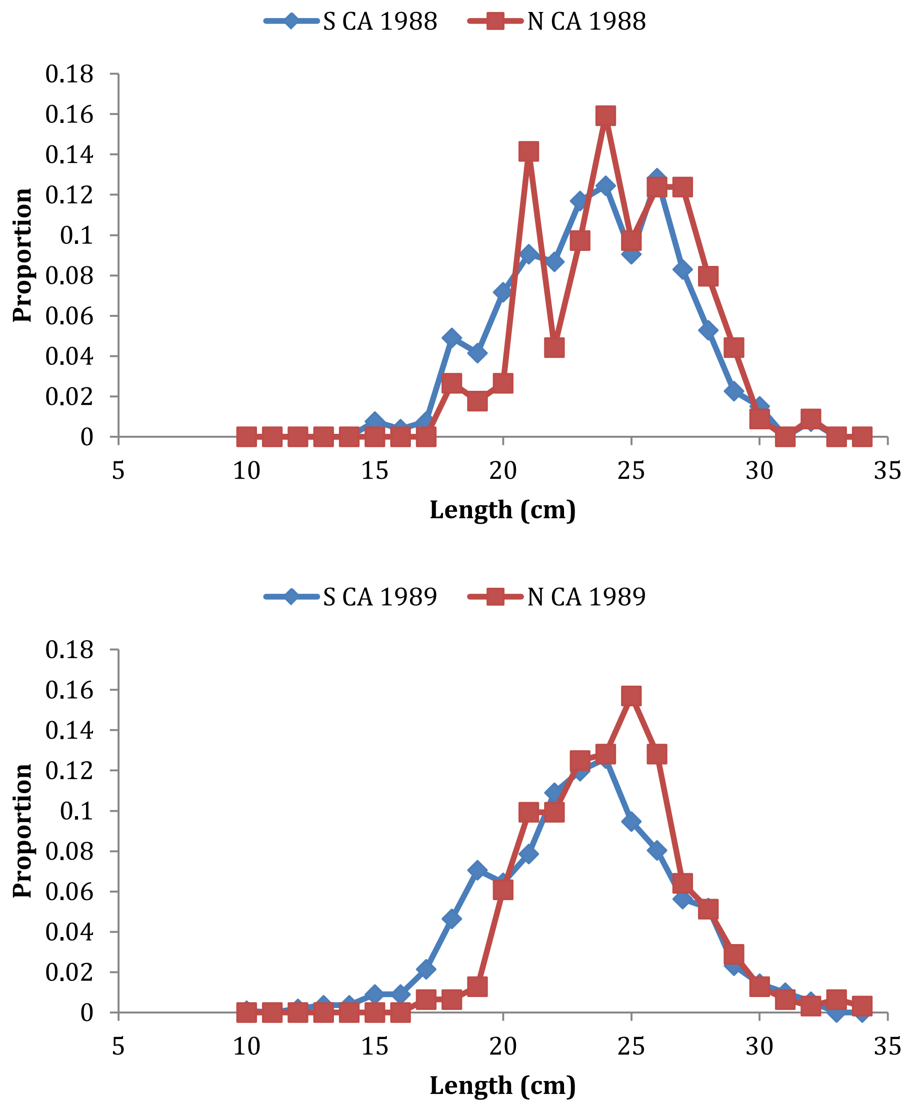


Figure 32. Comparison plots of length frequency distributions of CPFV samples from southern and northern California in 1988 and 1989.

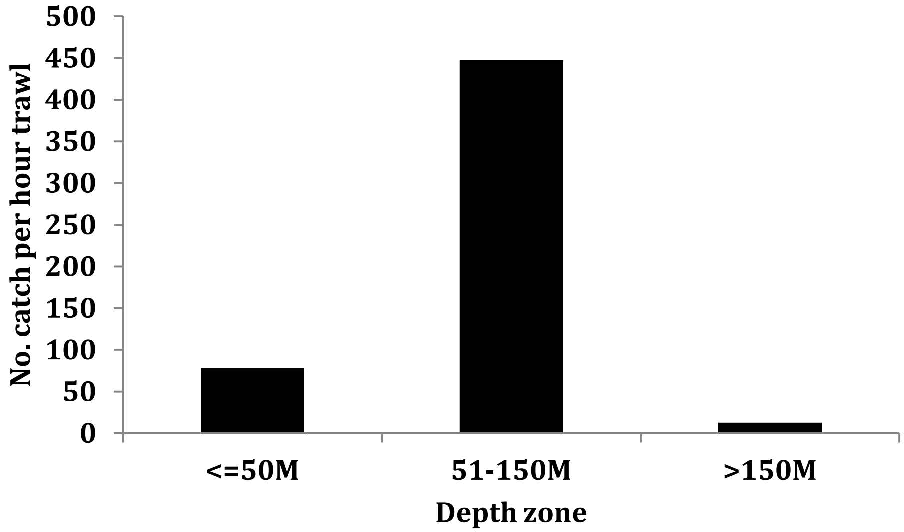


Figure 33. Raw catch rate in three depth zones from the SWFSC FED ecology survey in the Monterey Bay area between 2002 and 2004. Numbers of tows for three depth zones were 28, 28, and 15, respectively.

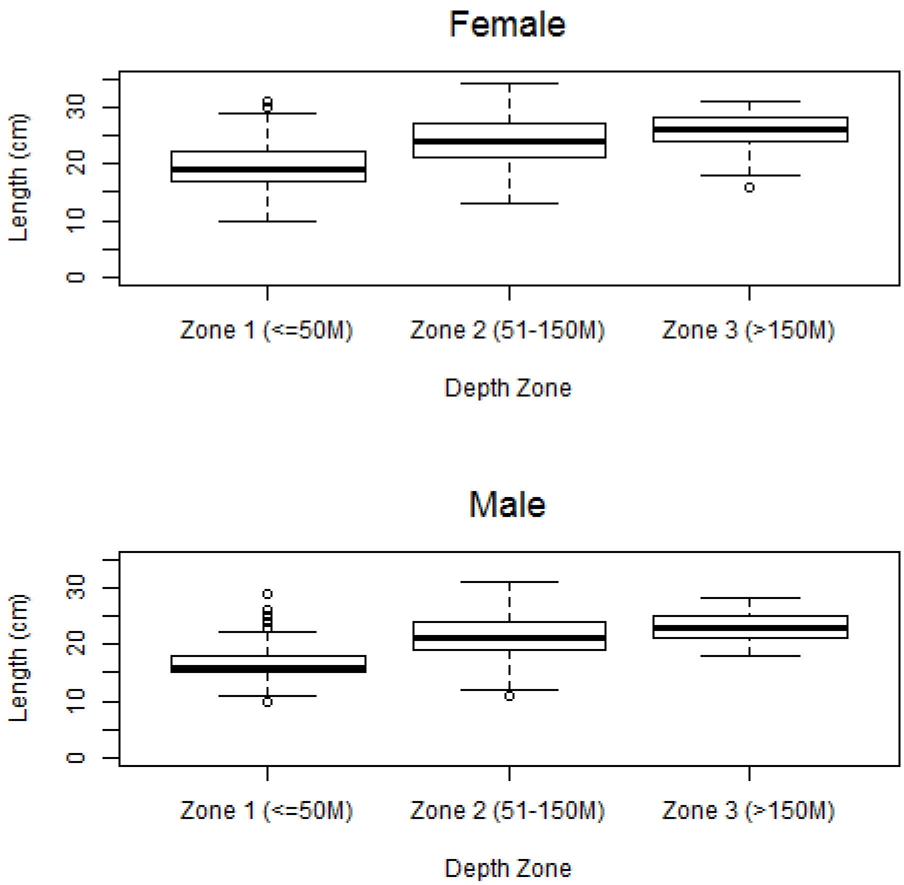


Figure 34. Mean lengths and their standard deviations by sex for Pacific sanddab catches from the SWFSC FED ecology survey between 2001 and 2005 in the Monterey Bay area.

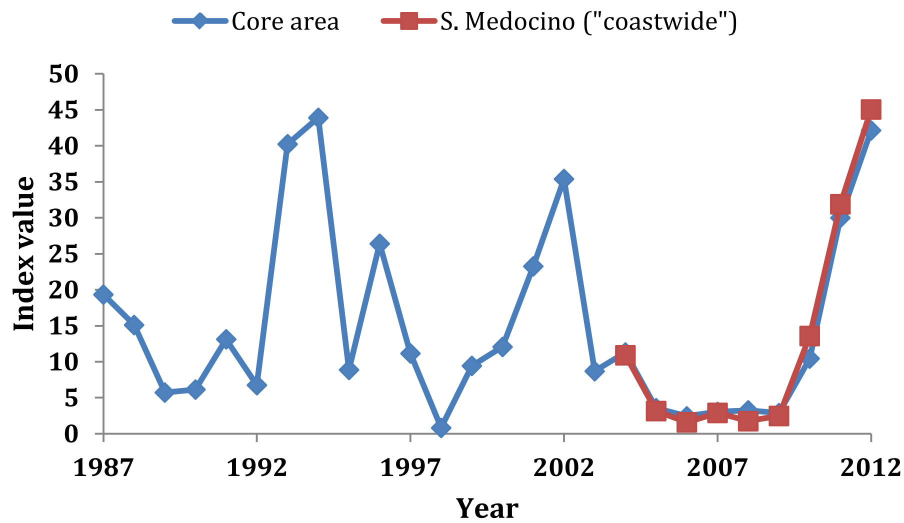


Figure 35. Comparisons of juvenile survey indices between the SWFSC FED (core area) and PWCC/NWFSC (coastwide) surveys from 1987 to 2012.

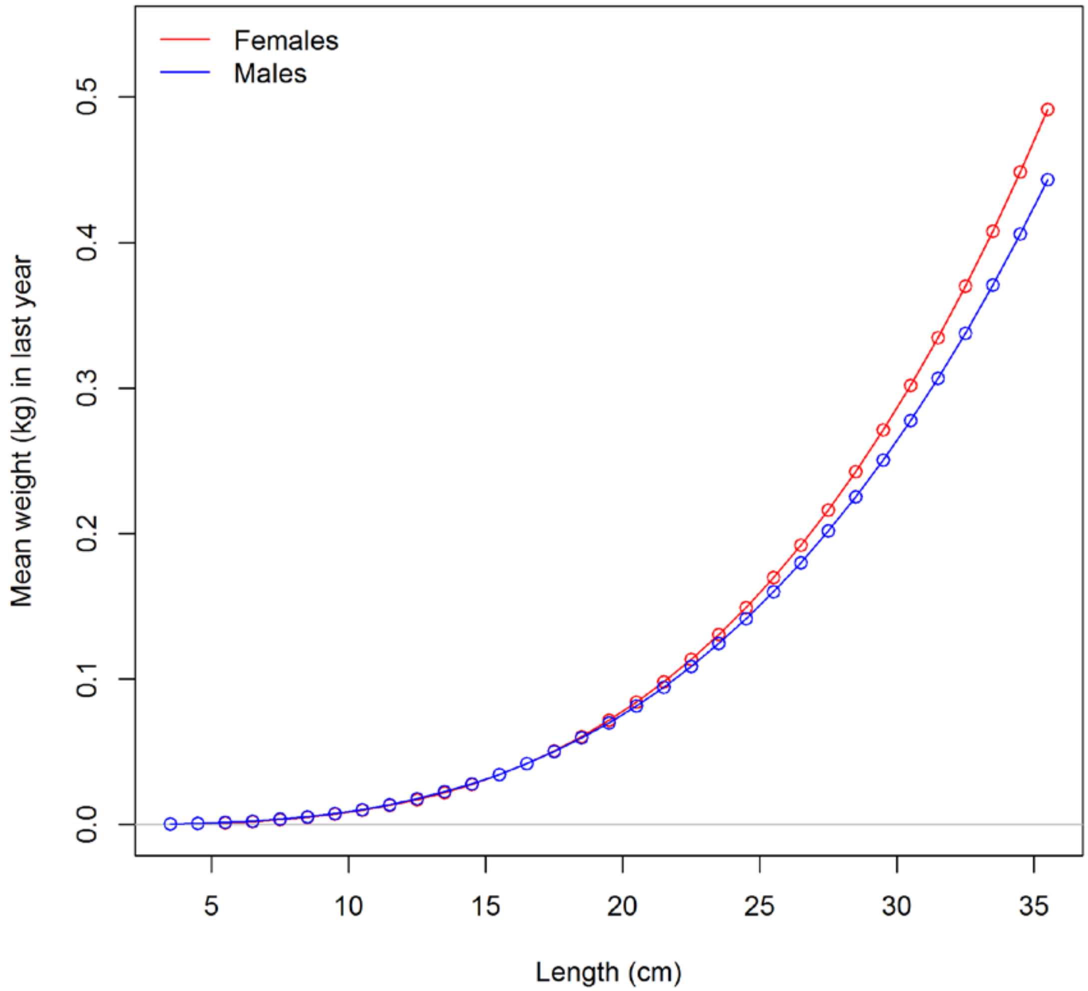


Figure 36. Length-weight relationships by sex of Pacific sanddab used in this assessment.

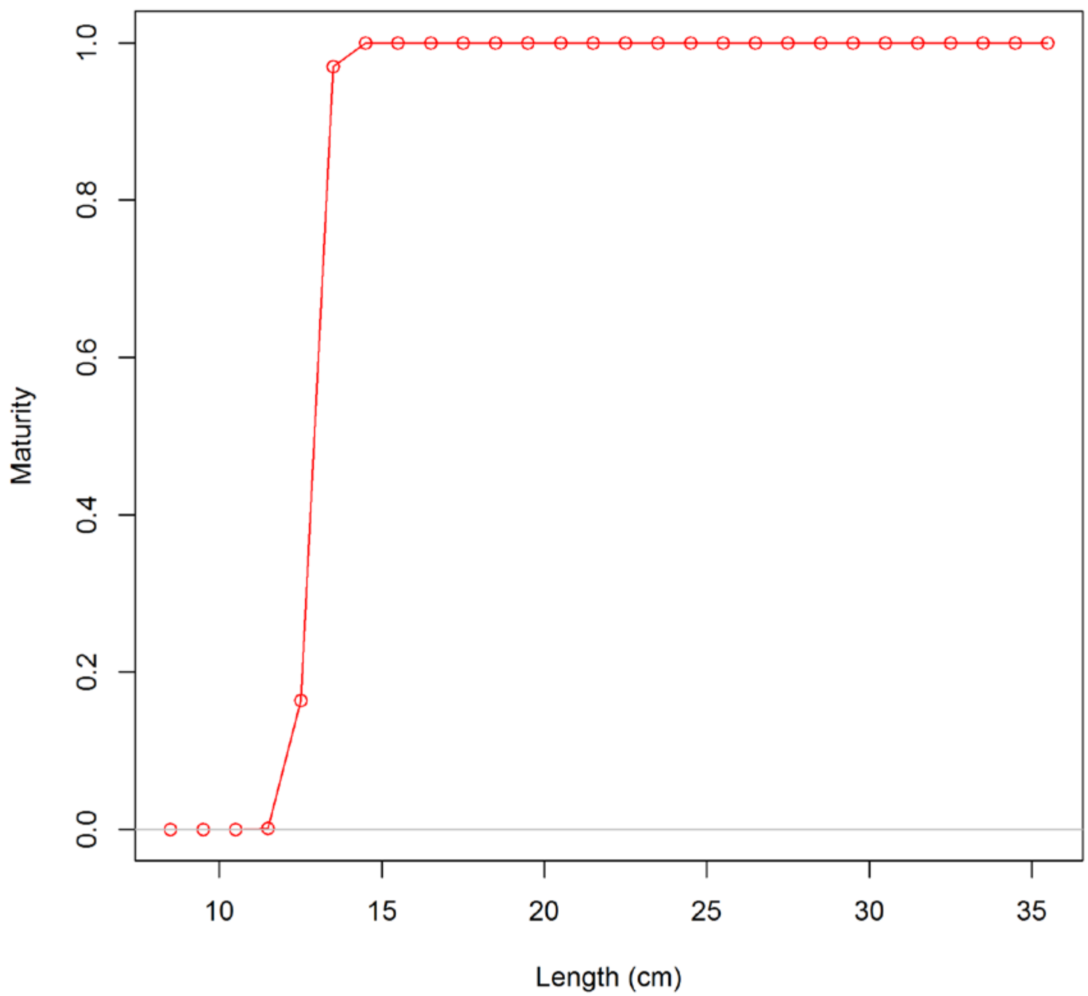


Figure 37. Maturity ogive of females of Pacific sanddab used in this assessment.

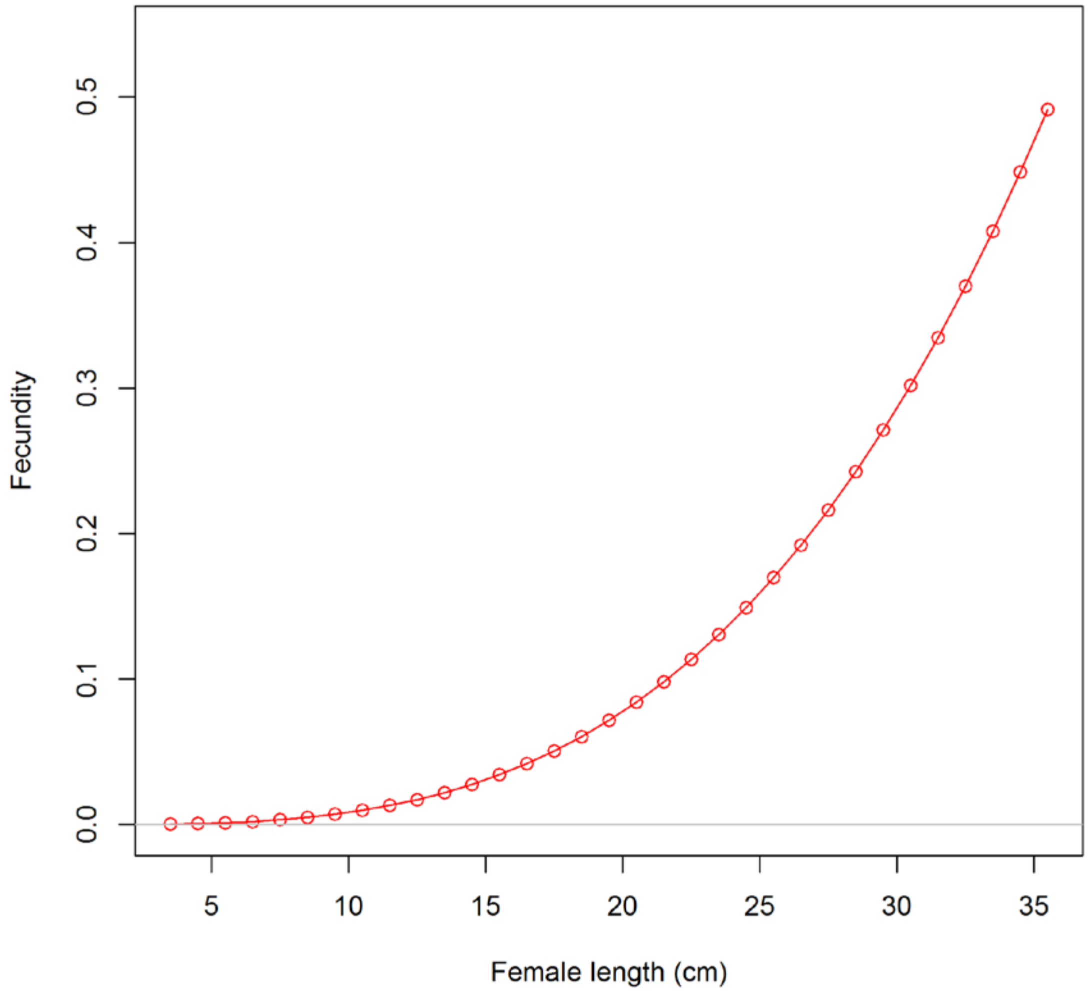


Figure 38. Fecundity by length of Pacific sanddab used in this assessment.

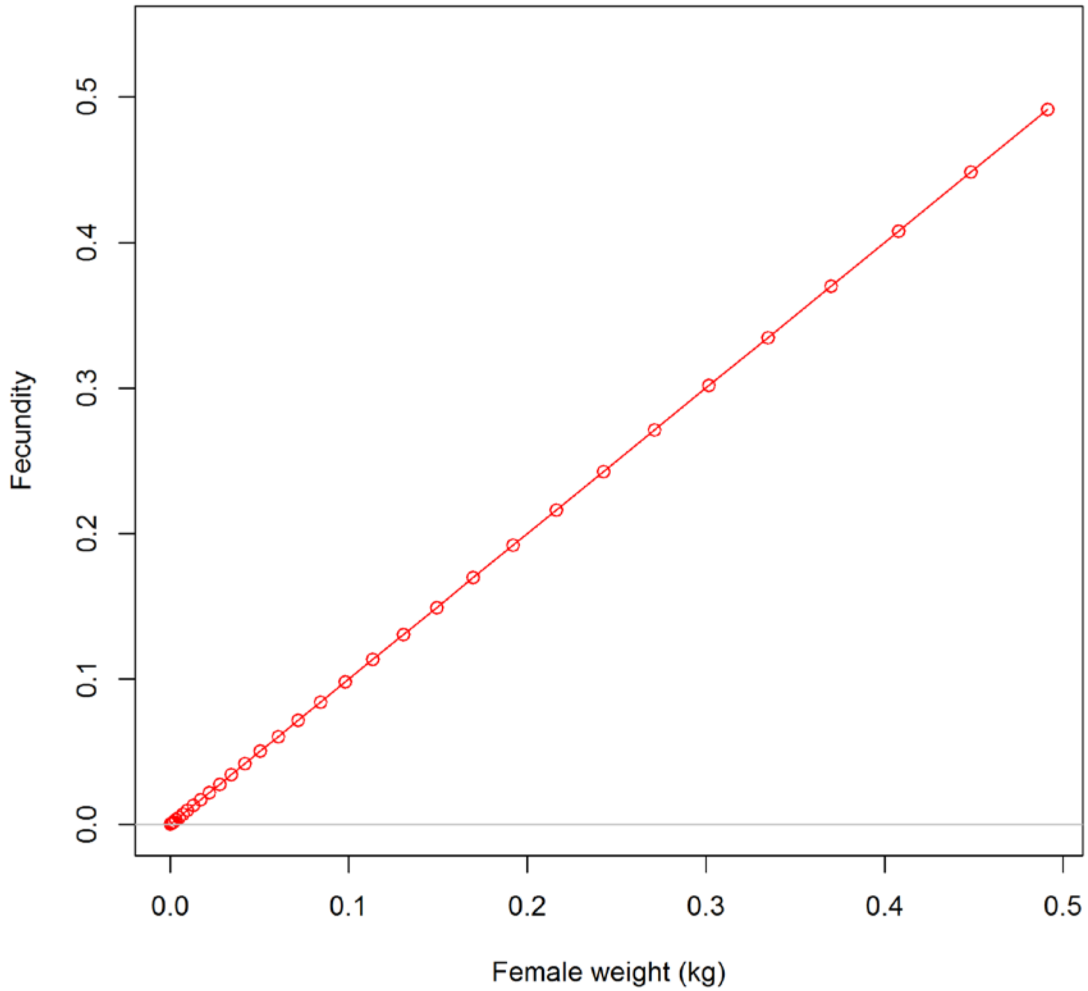


Figure 39. Fecundity by weight of Pacific sanddab used in this assessment.

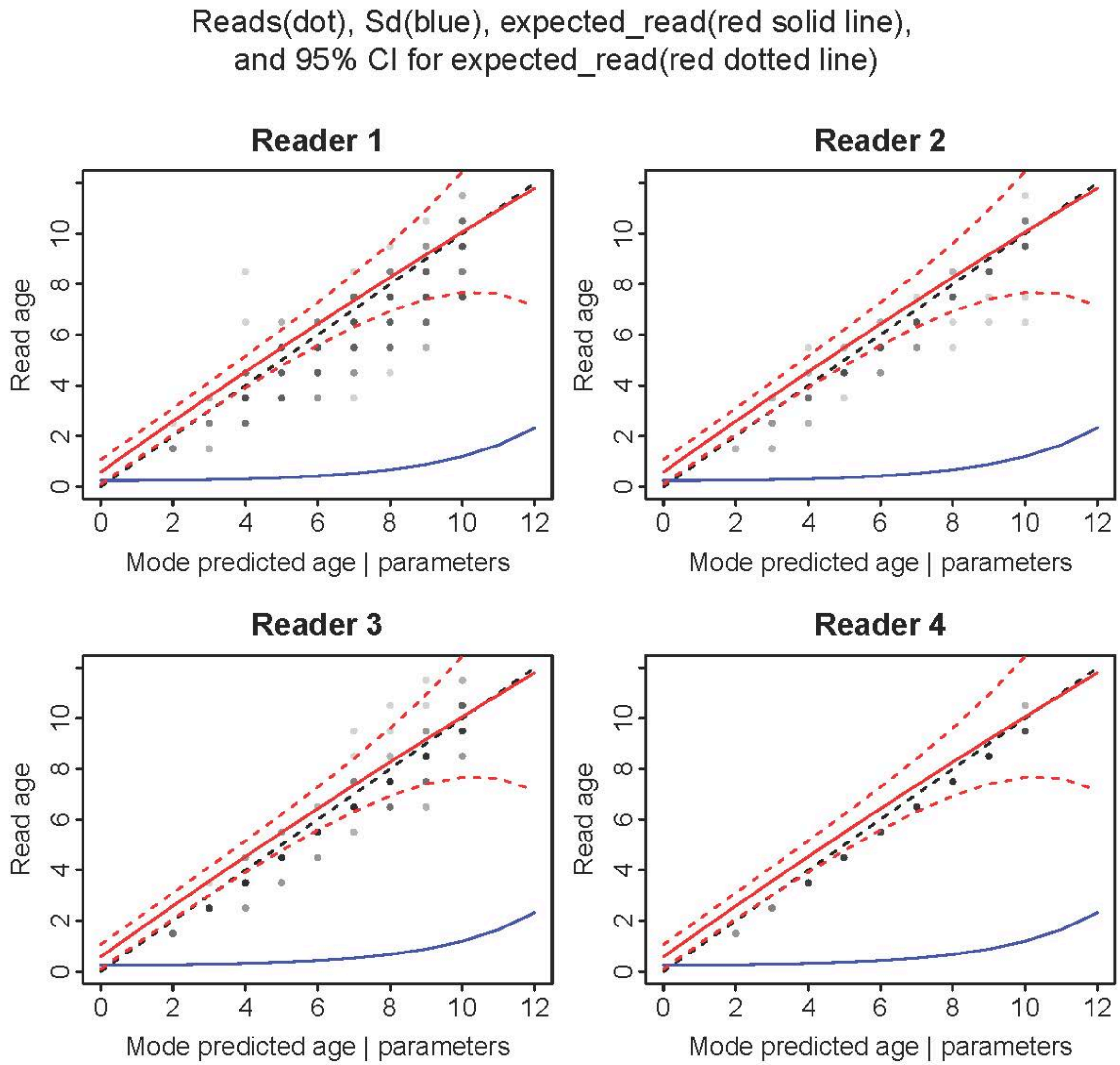


Figure 40. Plots of aging bias and errors at different age classes by four readers. Line and dot symbols are specified at top of the figure. The graph was produced from a R program written by J. Thorson. Readers 1 and 2 are double reads from same ager and Readers 3 and 4 are double reads from the second reader.

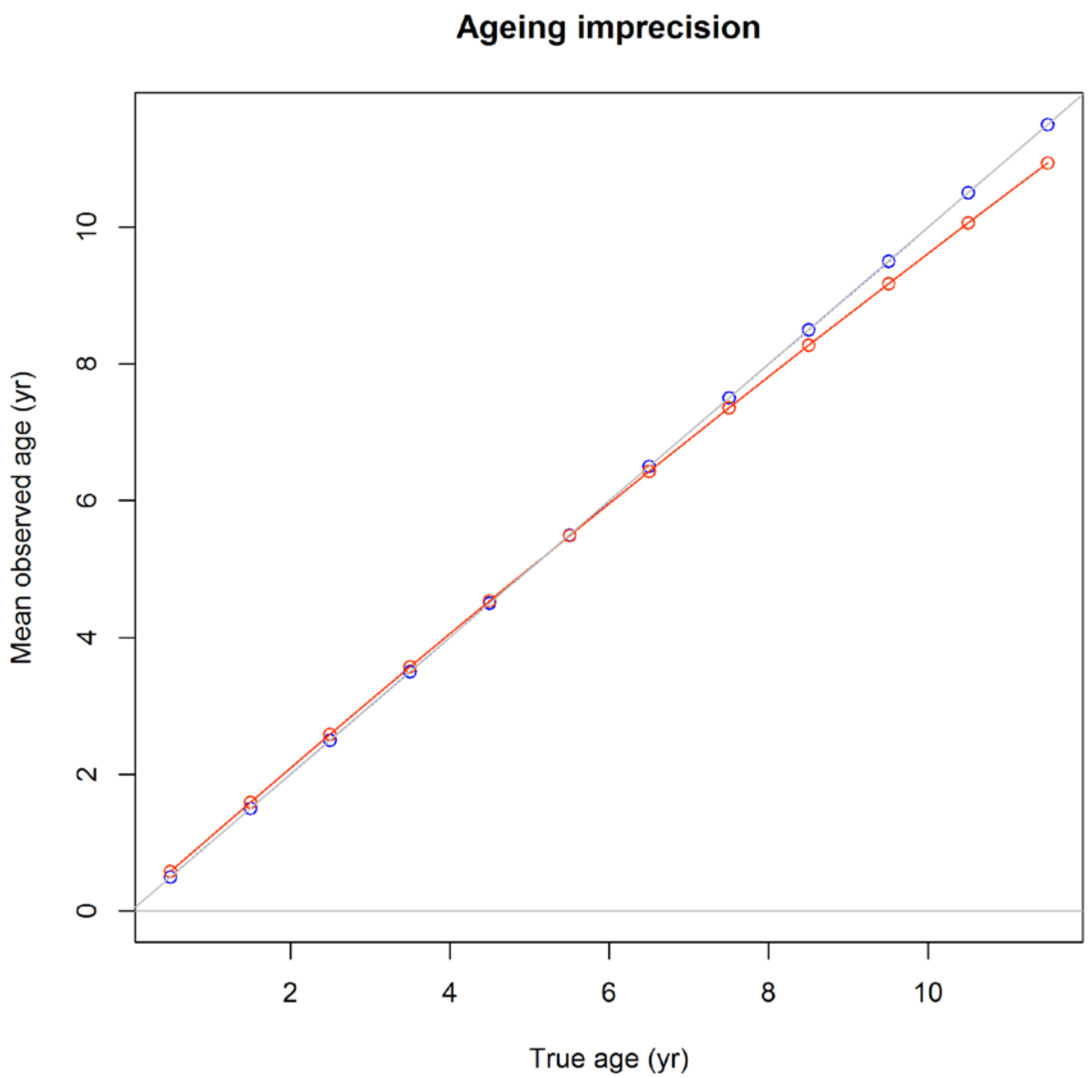


Figure 41. Plots of aging bias at different age classes (red line), which was used in the assessment. The blue is a reference line that assumes no aging bias.

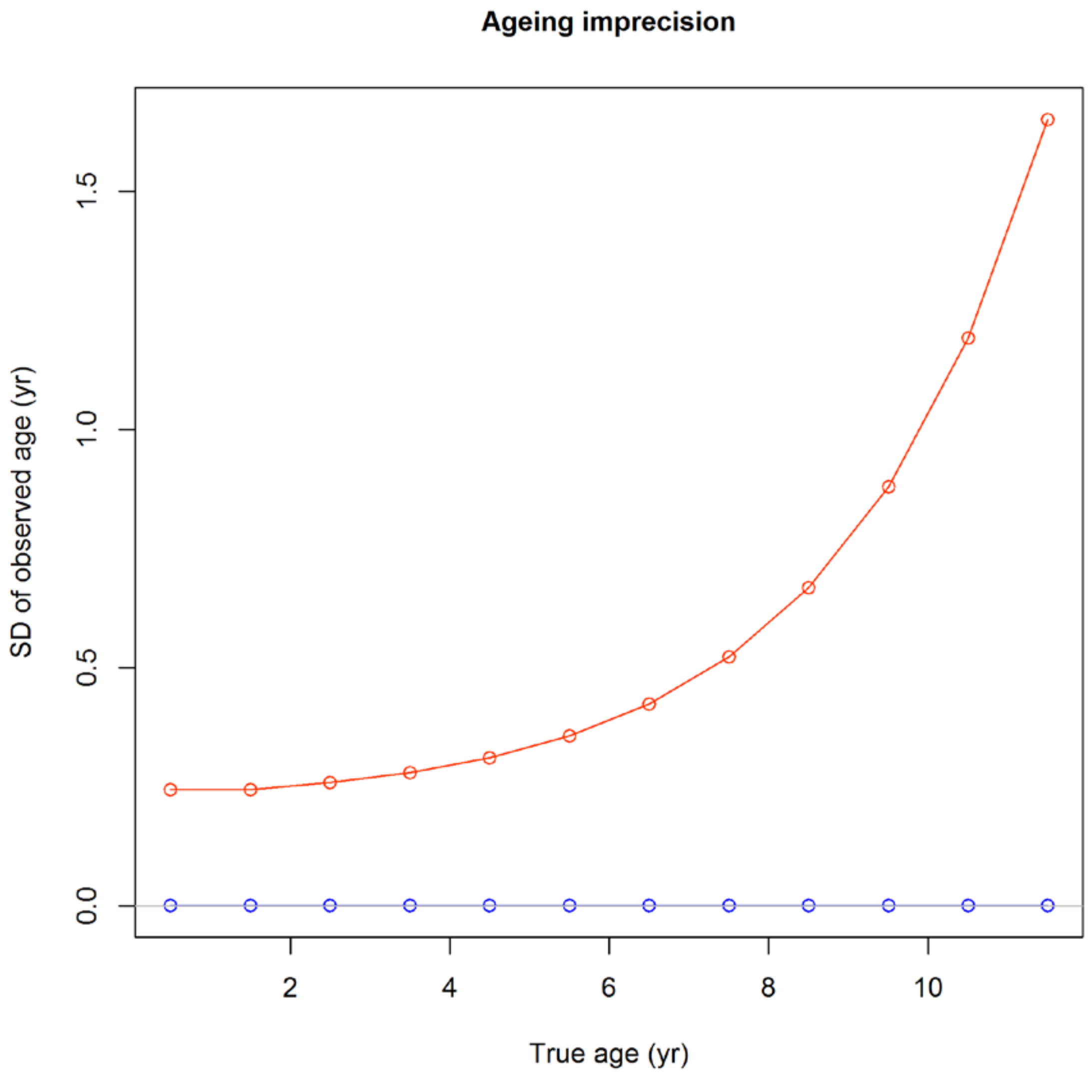


Figure 42. Plots of aging error in terms of standard deviations (SD) at different age classes (red line), which was used in the assessment. The blue line is a reference that assumes no aging errors.

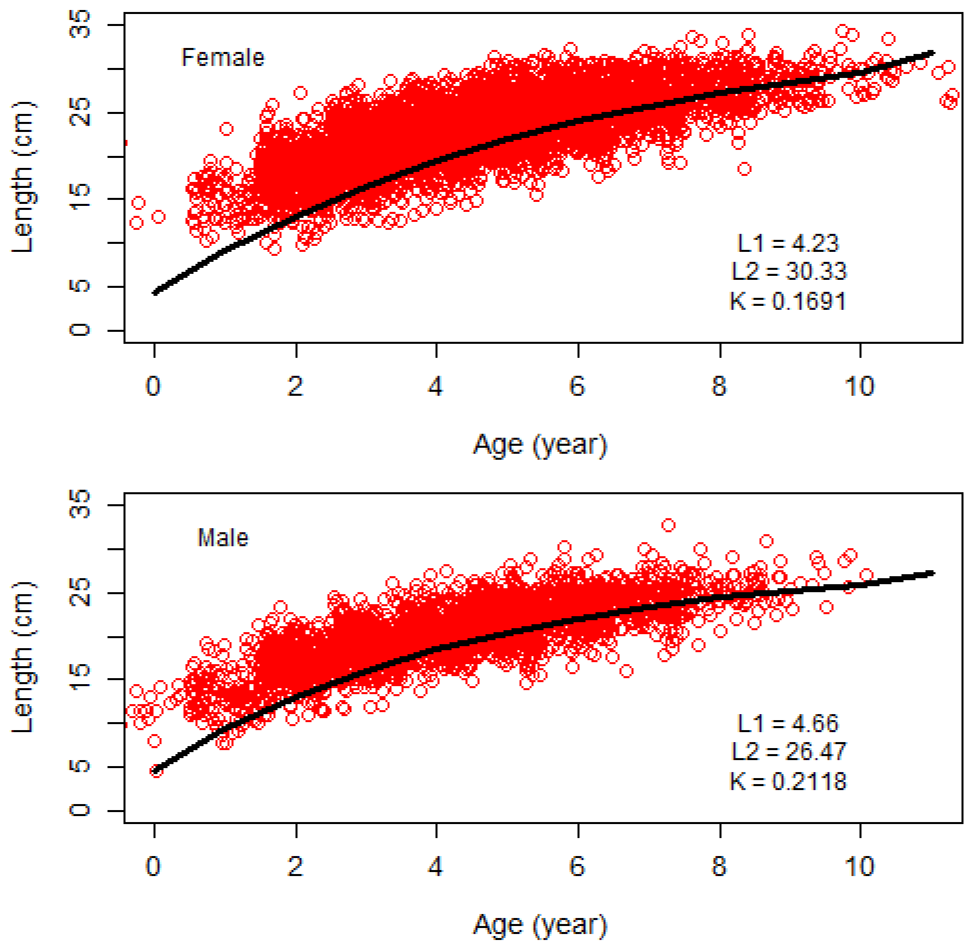


Figure 43. Age-at-length data plot from the NWFSC survey data (red circles) for females (top panel) and males (bottom panel), and fitted growth curve from the base model (black lines). Datum points (red circles) were randomly jittered by plus and minus of 0.5 along both axis to show densities of data. L1 and L2 are estimated lengths at ages 0 and 11, respectively, for both sexes.

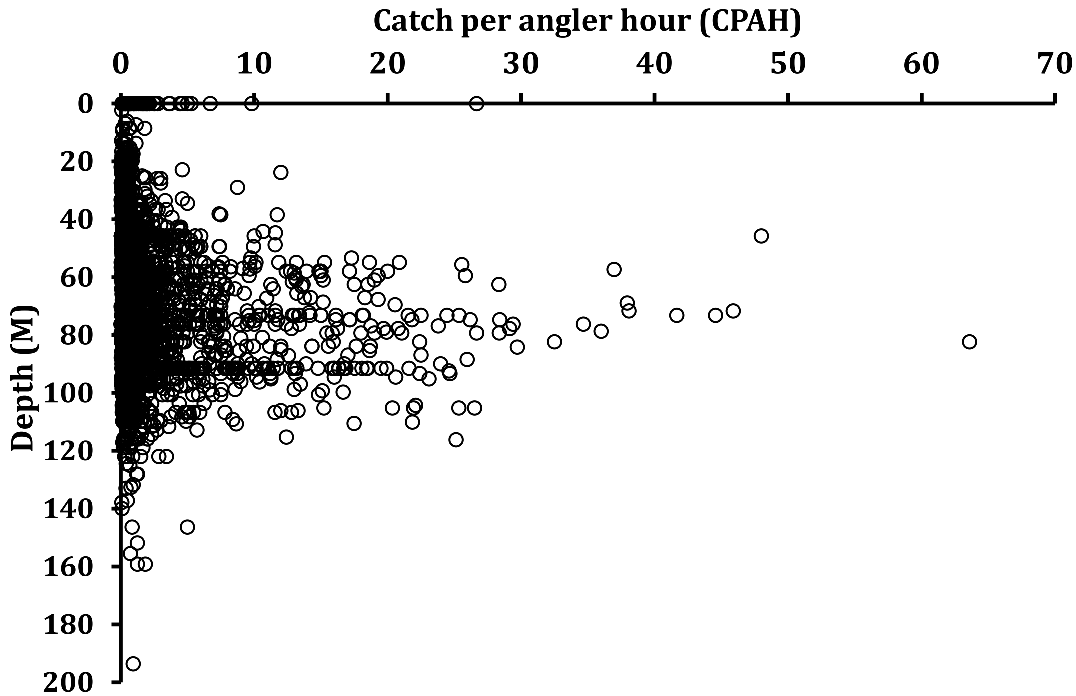


Figure 44. Plot of raw recreational catch rates (catch per angler hour) by depth in California waters. Most samples were from south of Santa Barbara. Data with greater than 500 fish encountered were not included in the plot (8 out of 2,873). Data were downloaded from RecFIN (Melissa Monk, SWFSC).

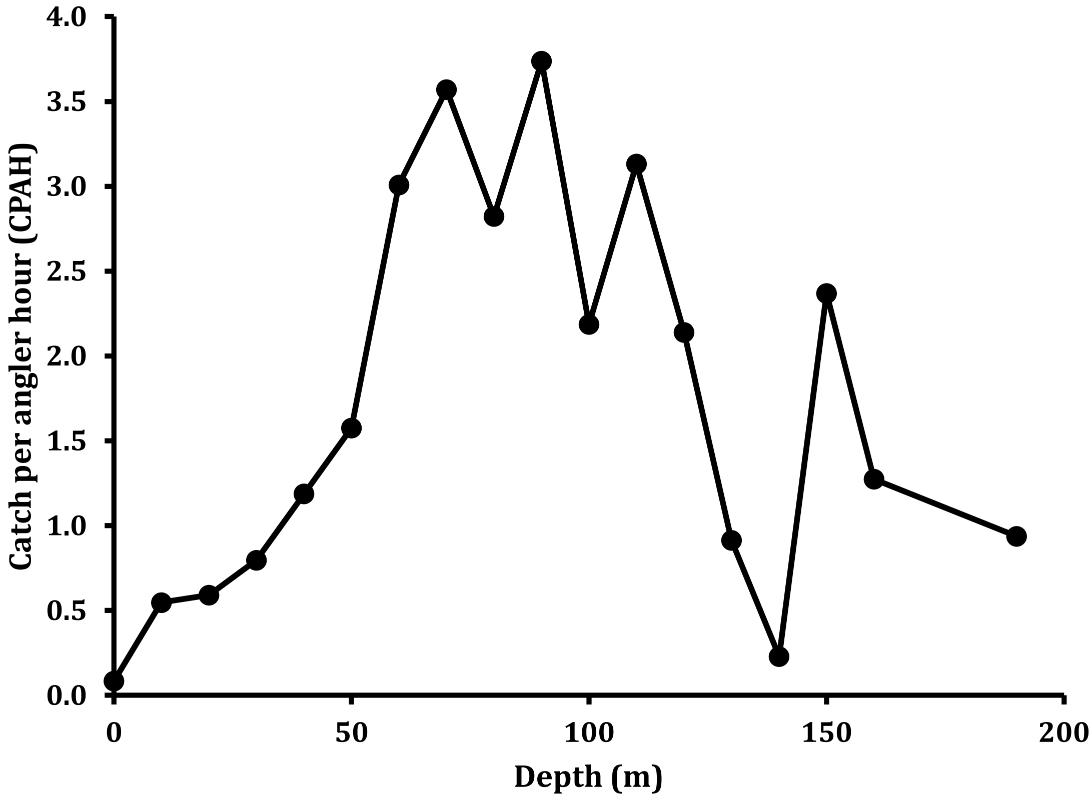


Figure 45. Plot of average raw recreational catch rates (catch per angler hour) by depth in California waters. Most samples were from south of Santa Barbara. Data with greater than 500 fish encountered were not included in the plot (8 out of 2,873). There were no data from depths greater than 190m. Data were downloaded from RecFIN (Melissa Monk, SWFSC).

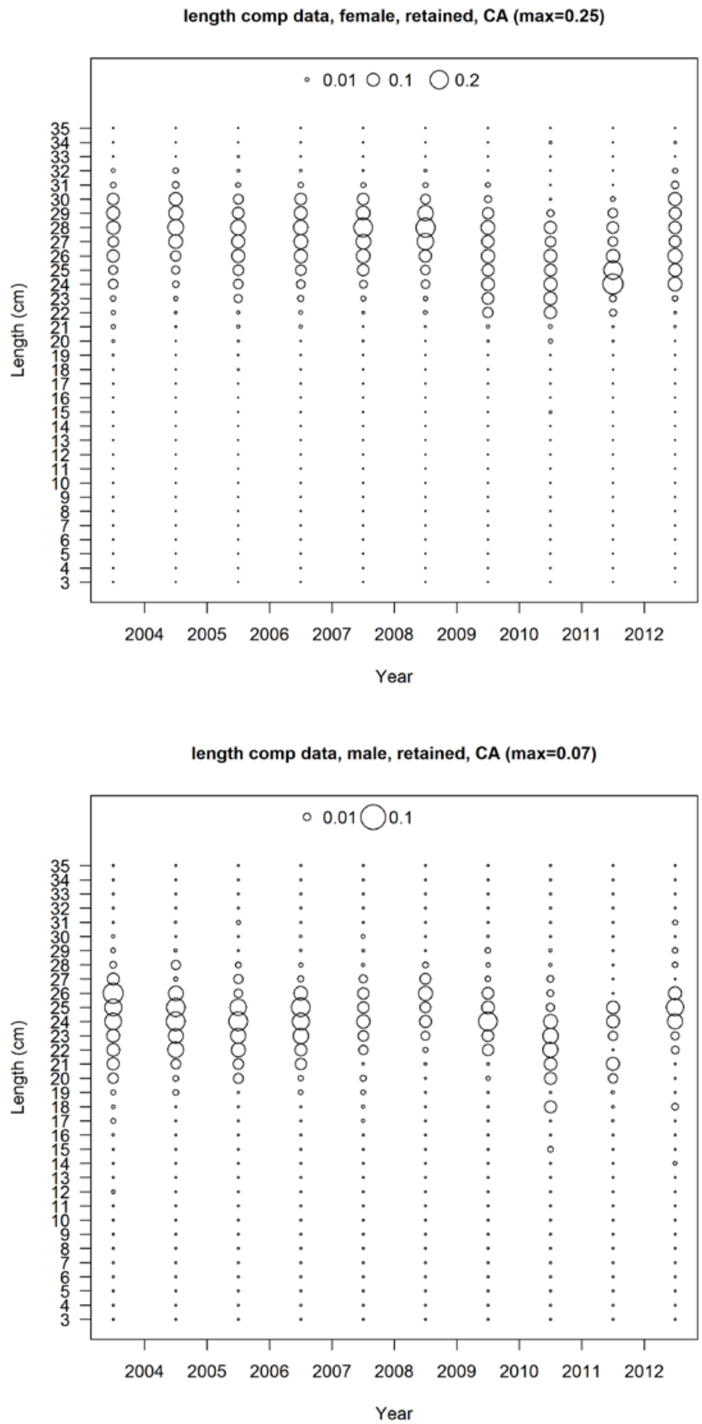


Figure 46. Length composition data by sex used in the assessment model from retained catches of the California trawl fisheries from 2003 to 2012.

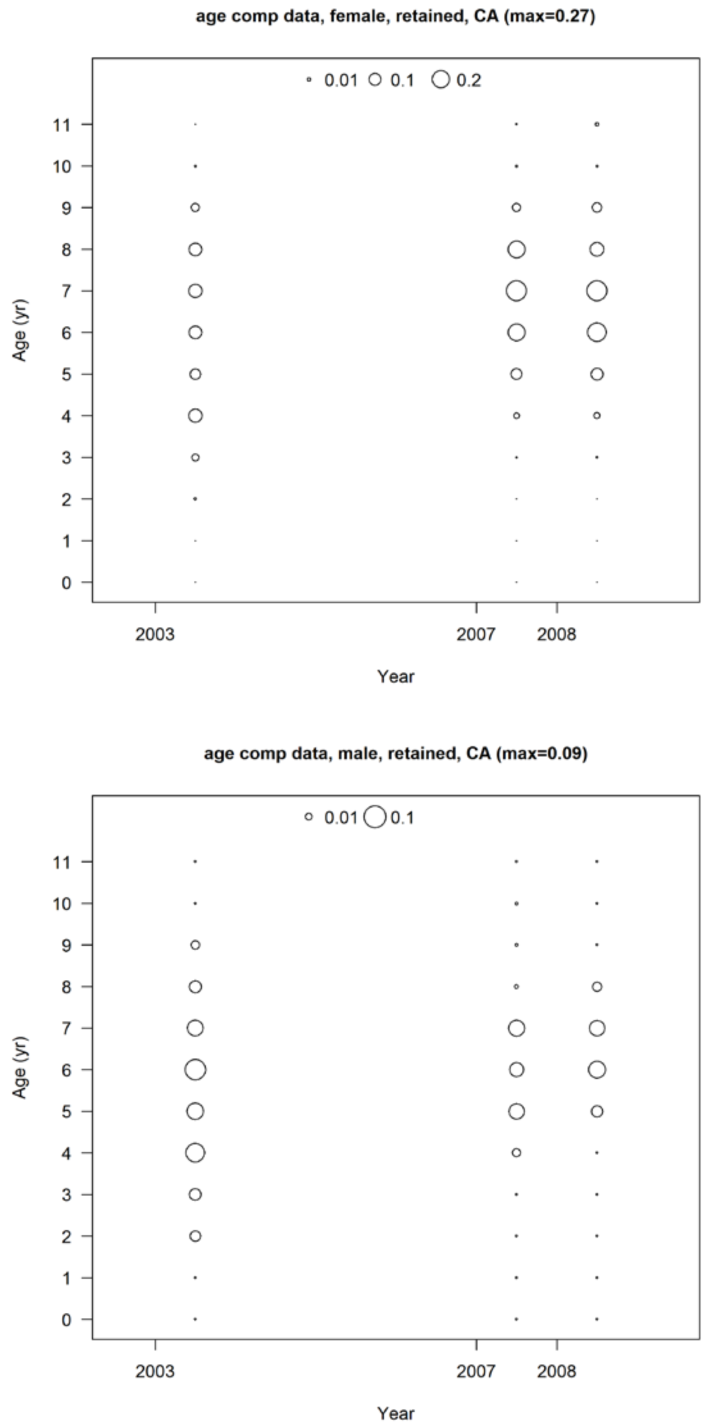


Figure 47. Age composition data by sex used in the assessment model from retained catches of the California trawl fisheries for years of 2003, 2007, and 2008.

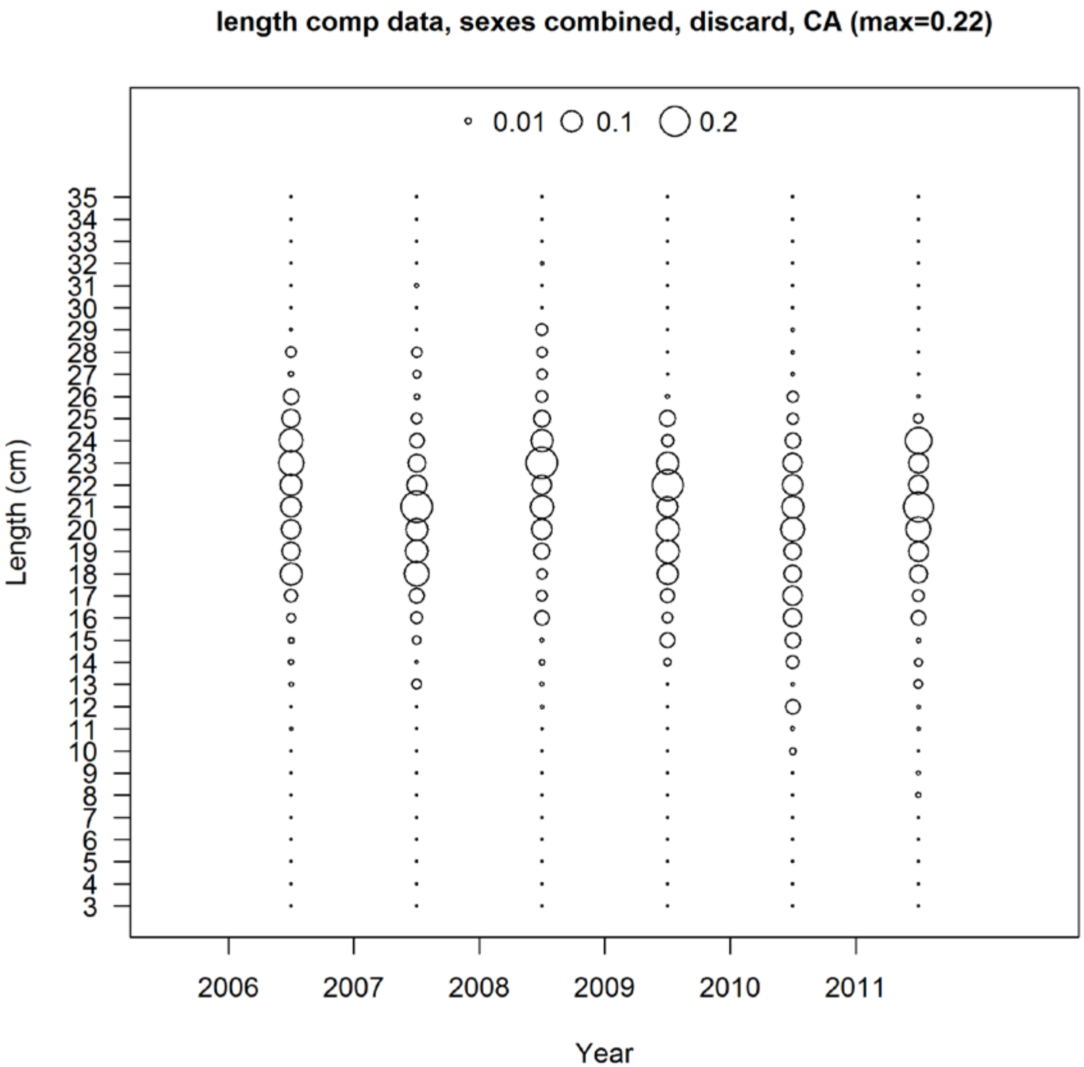


Figure 48. Length composition plots of discarded catches of combined sexes from the WCGOP program on the CA fishery from 2006 to 2011.

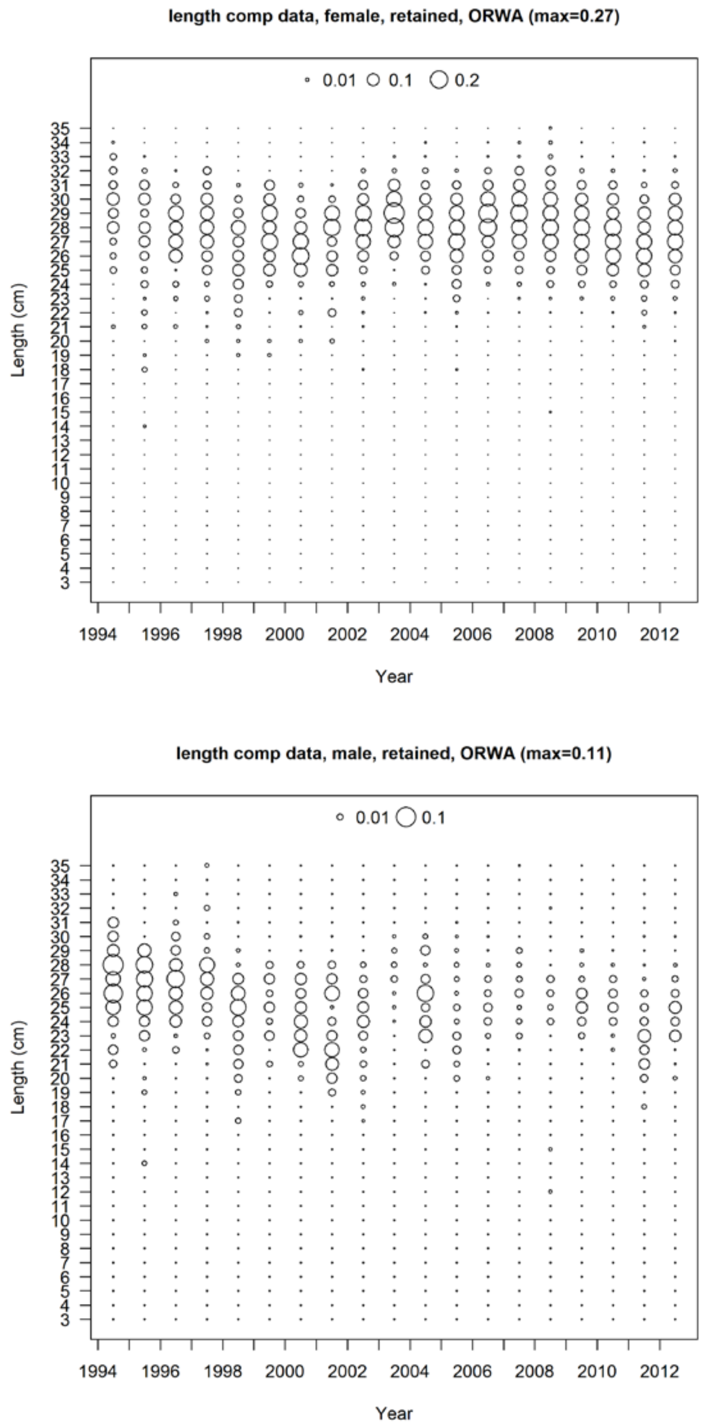
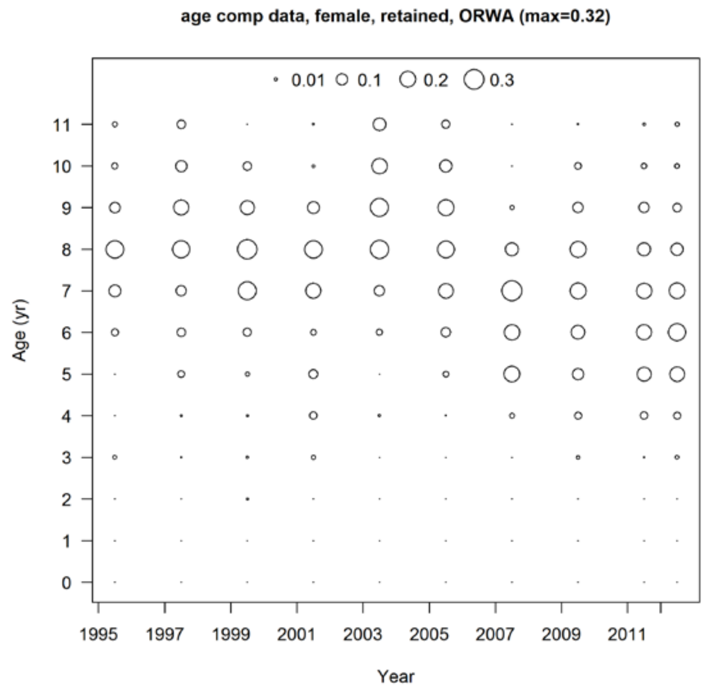


Figure 49. Length composition data by sex used in the assessment model from retained catches of the Oregon trawl fisheries between 1990 and 2012 (no data in some year).



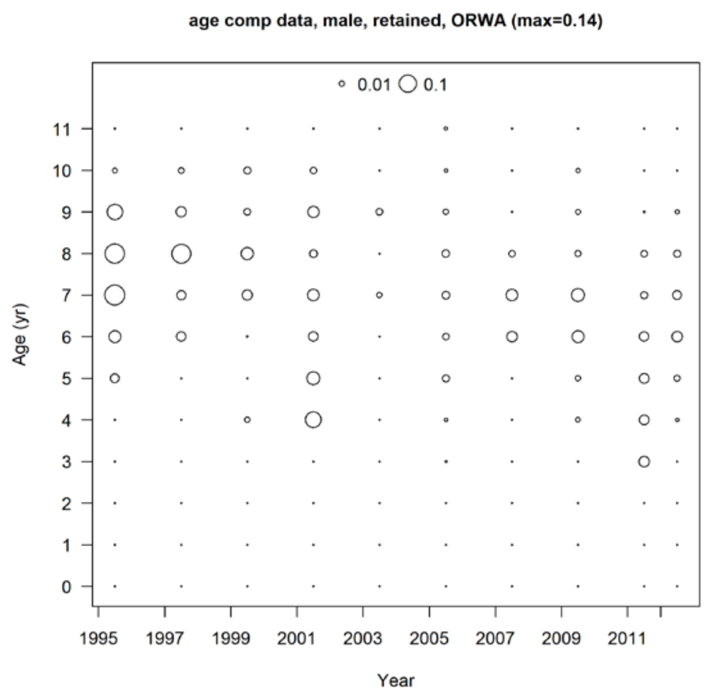
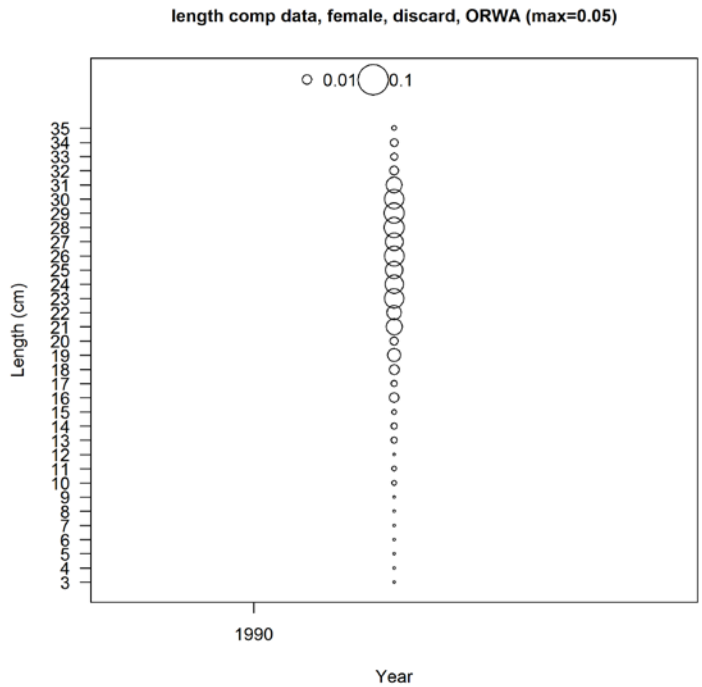


Figure 50. Age composition data by sex used in the assessment model from retained catches of the Oregon trawl fisheries between 1995 and 2012 (no data in some year).



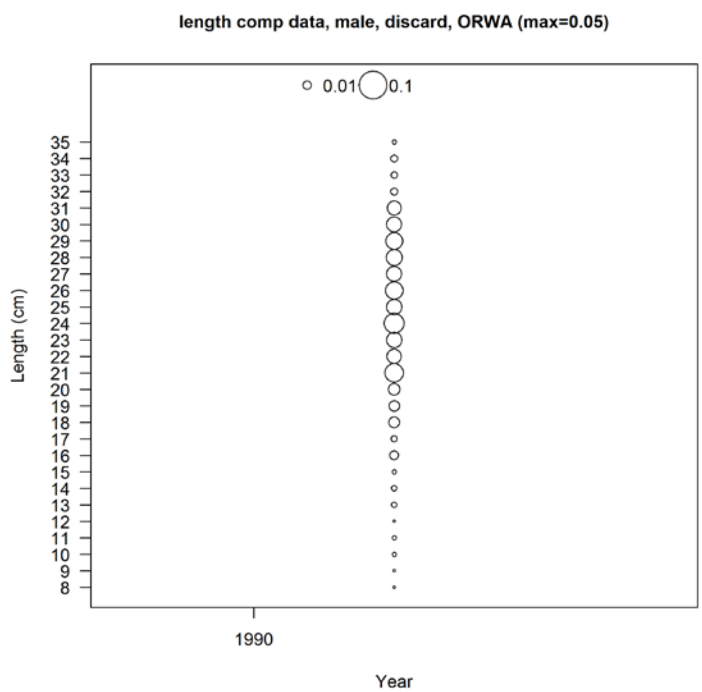


Figure 51. Length composition plots of discarded catches from the 1990 mesh study for females (top) and males (bottom). The data were used in estimating discarded catches of the Oregon trawl fishery in 1990.

Figure 52. Length composition plots of discarded catches of combined sexes from the WCGOP program on the OR/WA fishery from 2006 to 2011.

Figure 53. Length composition plots of recreational fishery catches (sex combined) from the CA CPFC survey.

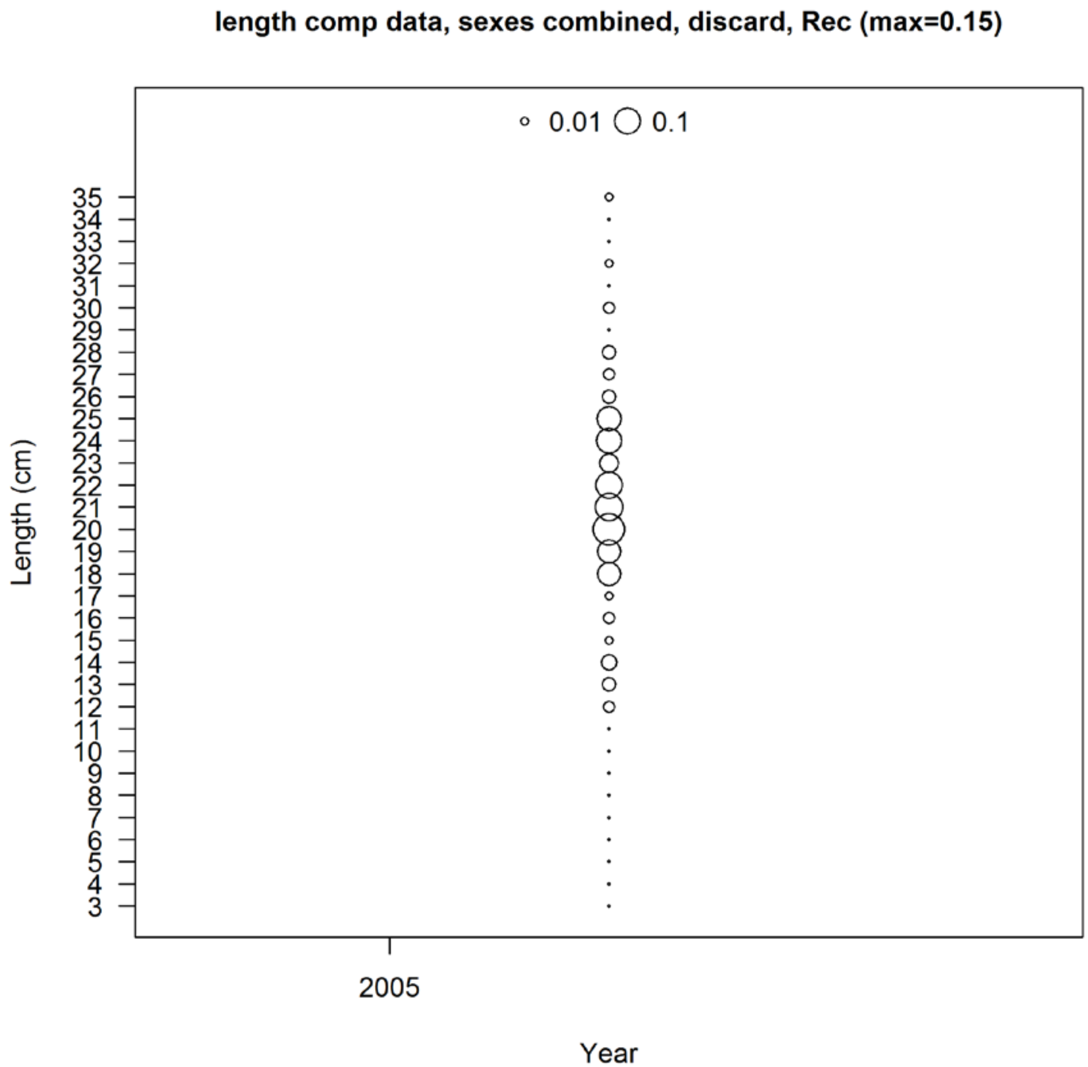


Figure 54. Length composition plots of discarded catch from the 2005 recreational fishery (sex combined).

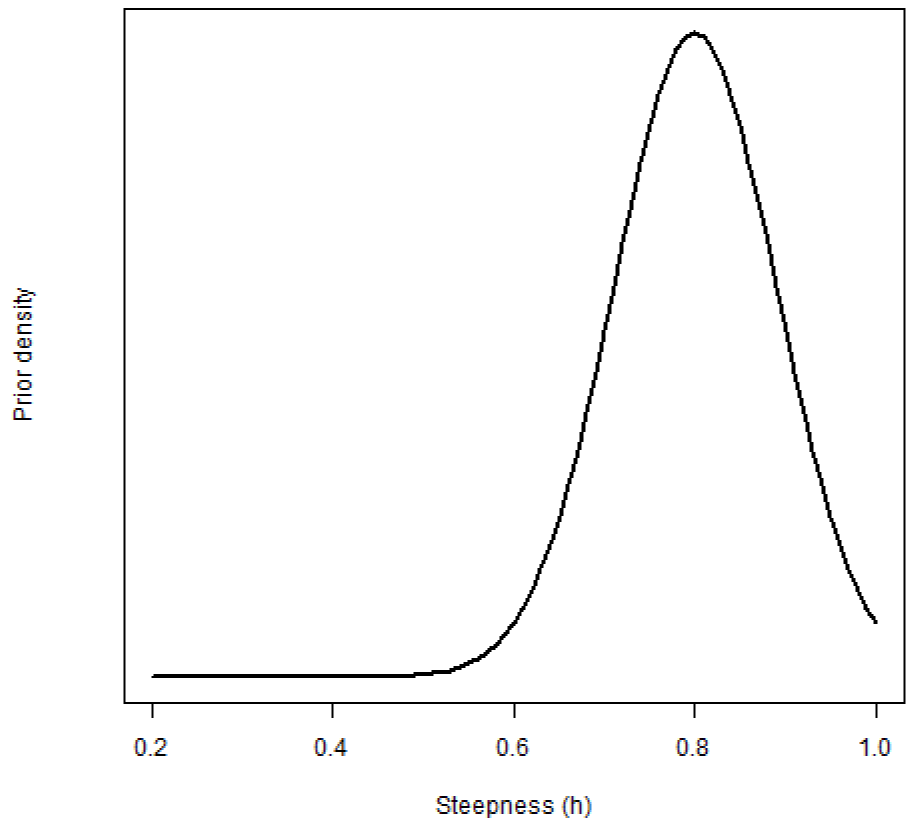


Figure 55. Priors of stock-recruitment steepness parameter (h) used in this assessment.

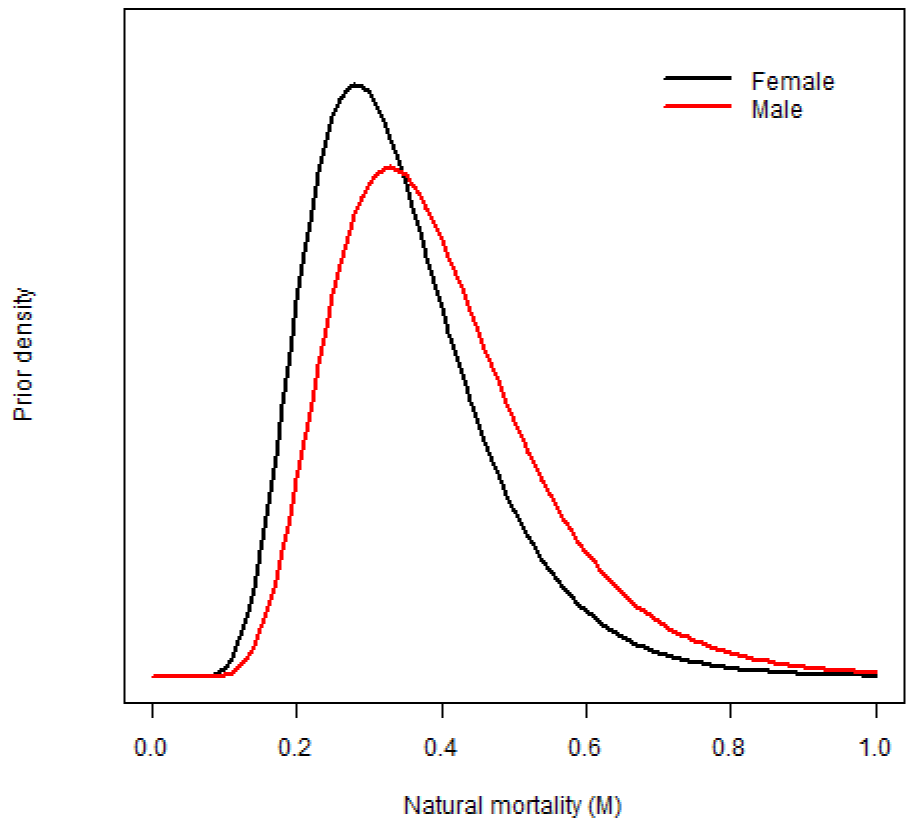


Figure 56. Priors of natural mortalities for female (black line) and for males (red line) that were used in this assessment.

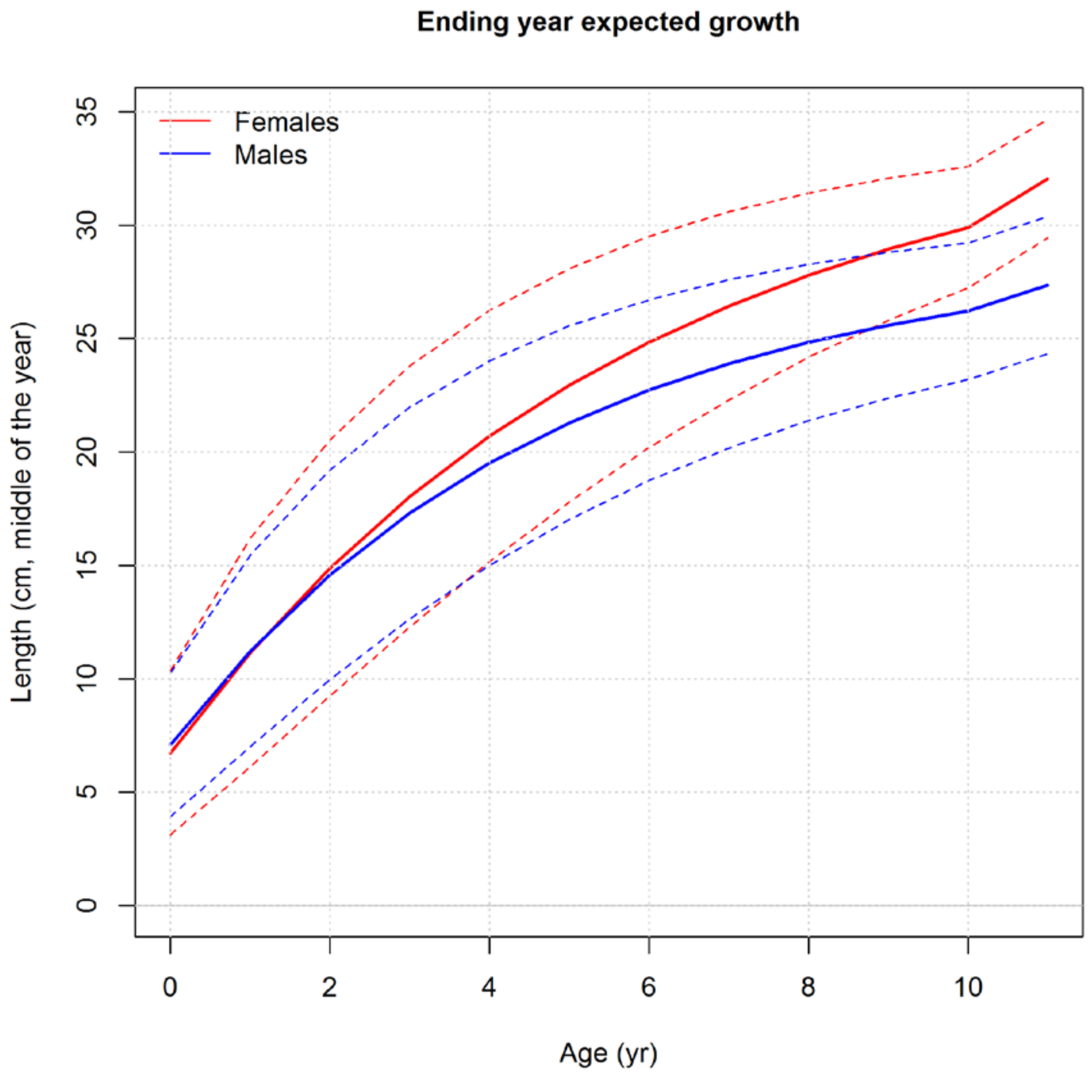


Figure 57. Estimated growth curves for females (red solid line) and males (blue solid line) with 95% intervals (dashed lines with the same colors).

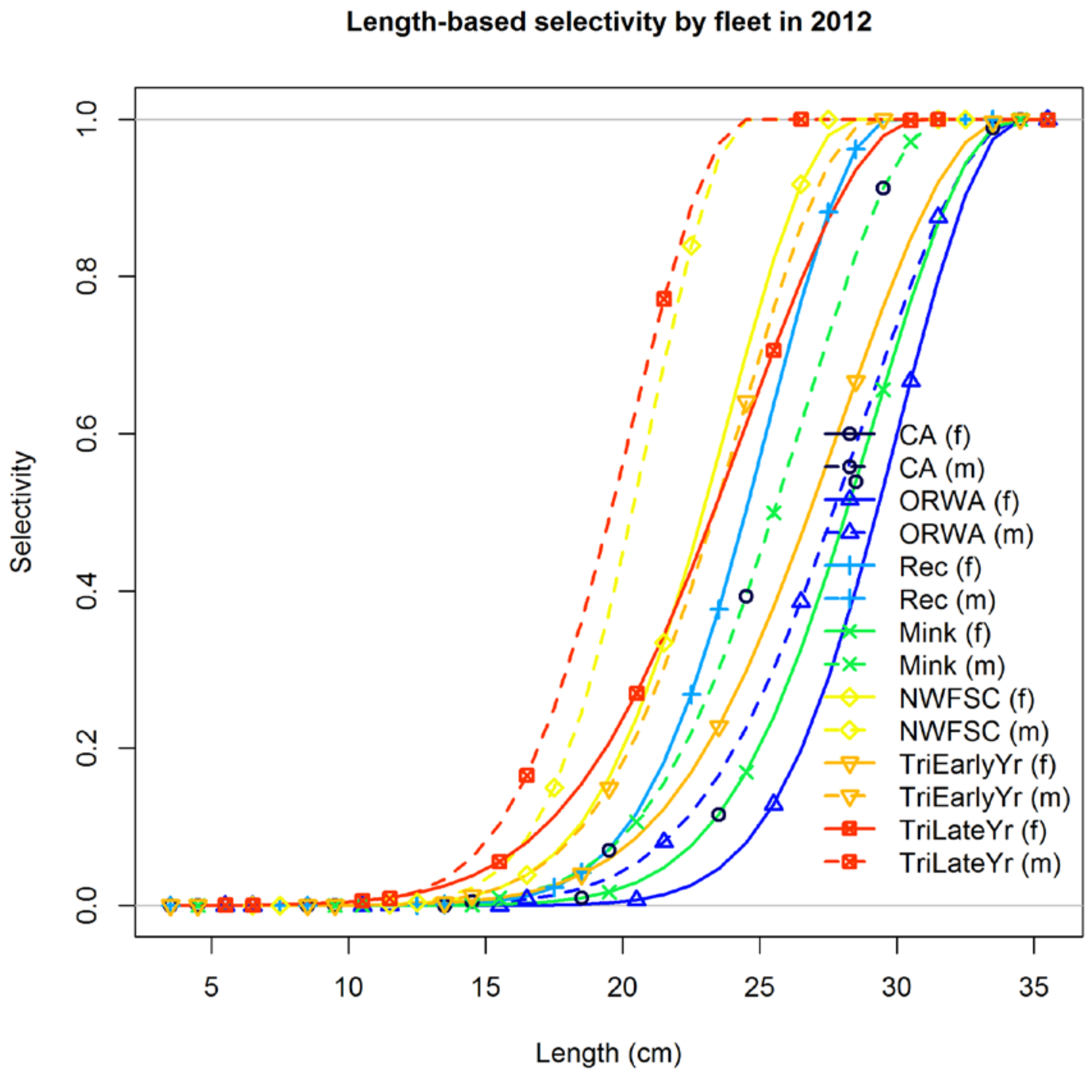


Figure 58. Estimated length-based selectivity curves by sex for all fleets and surveys. (Selectivity for each fleet and survey, including discards etc, to be included in separated figures)

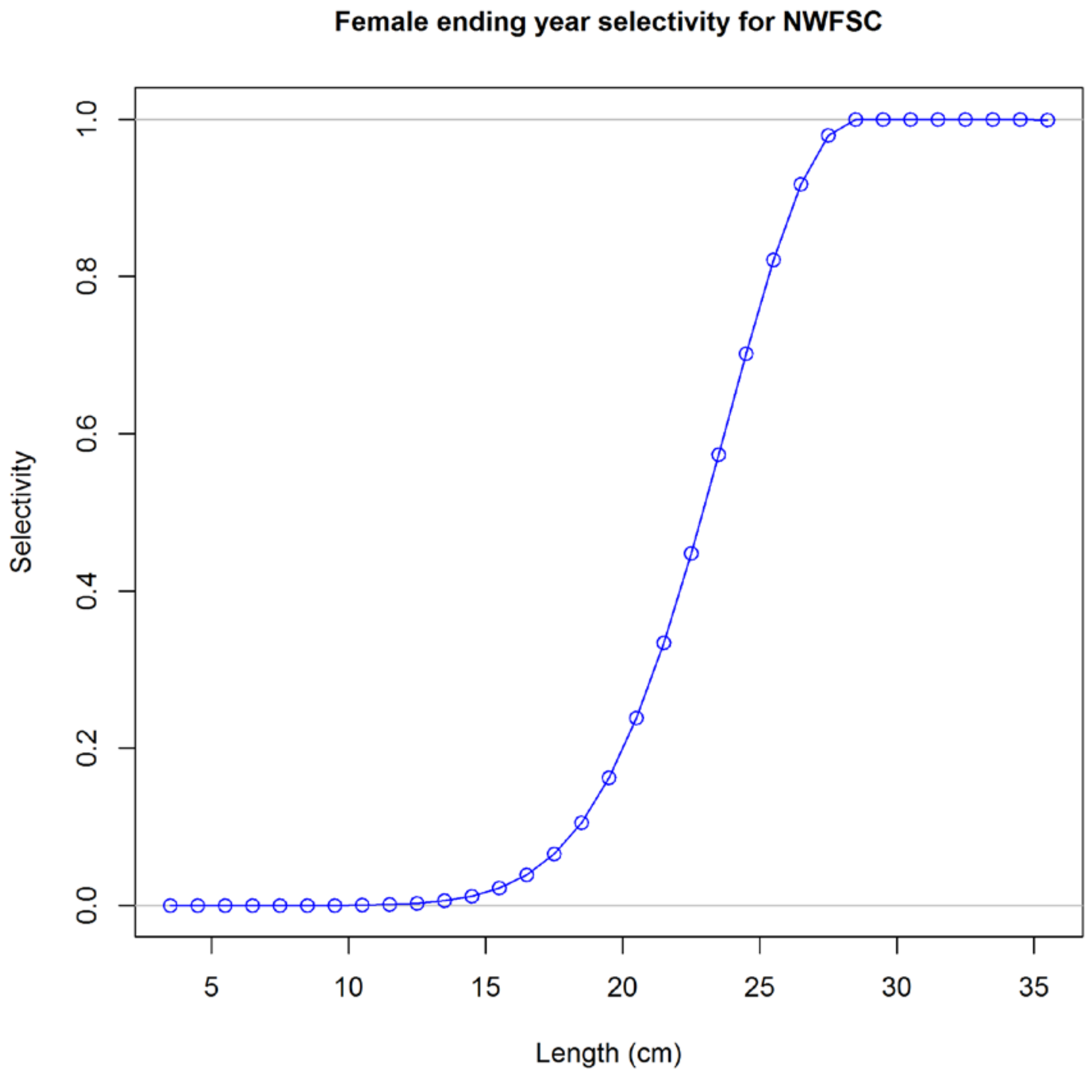


Figure 59. Estimated length-based selectivity for females for the NWFSC survey.

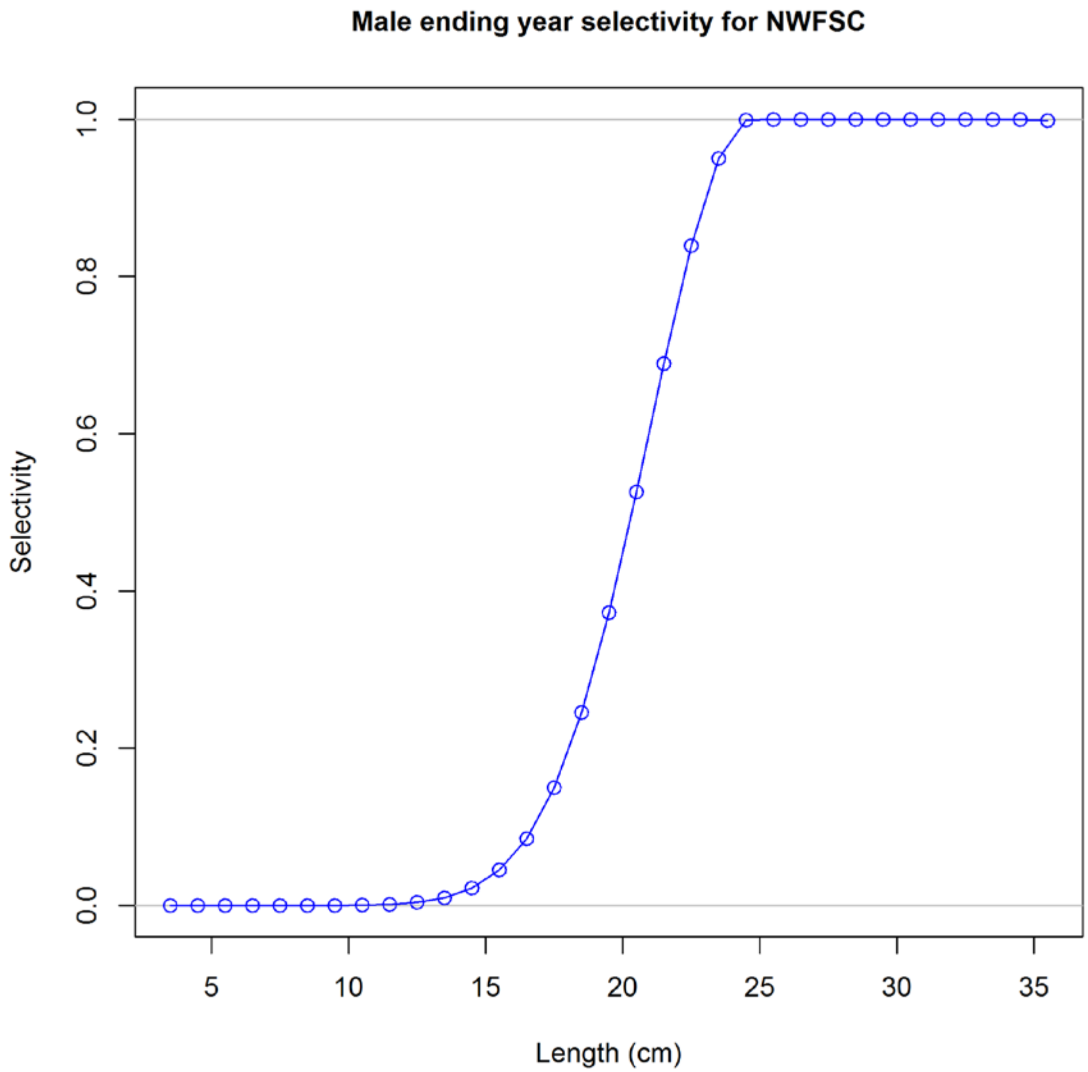


Figure 60. Estimated length-based selectivity for males for the NWFSC survey.

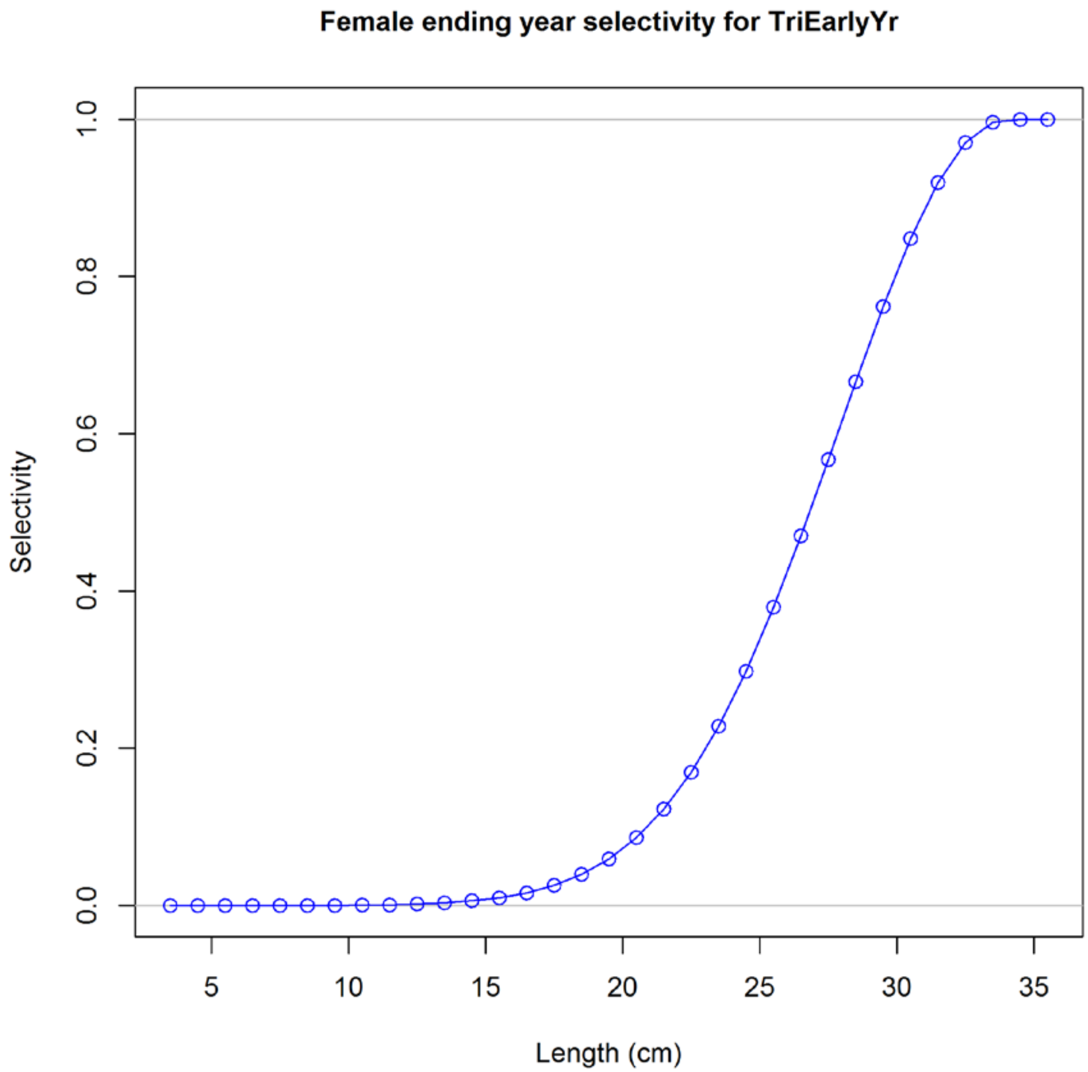


Figure 61. Estimated length-based selectivity for females for the early year triennial survey.

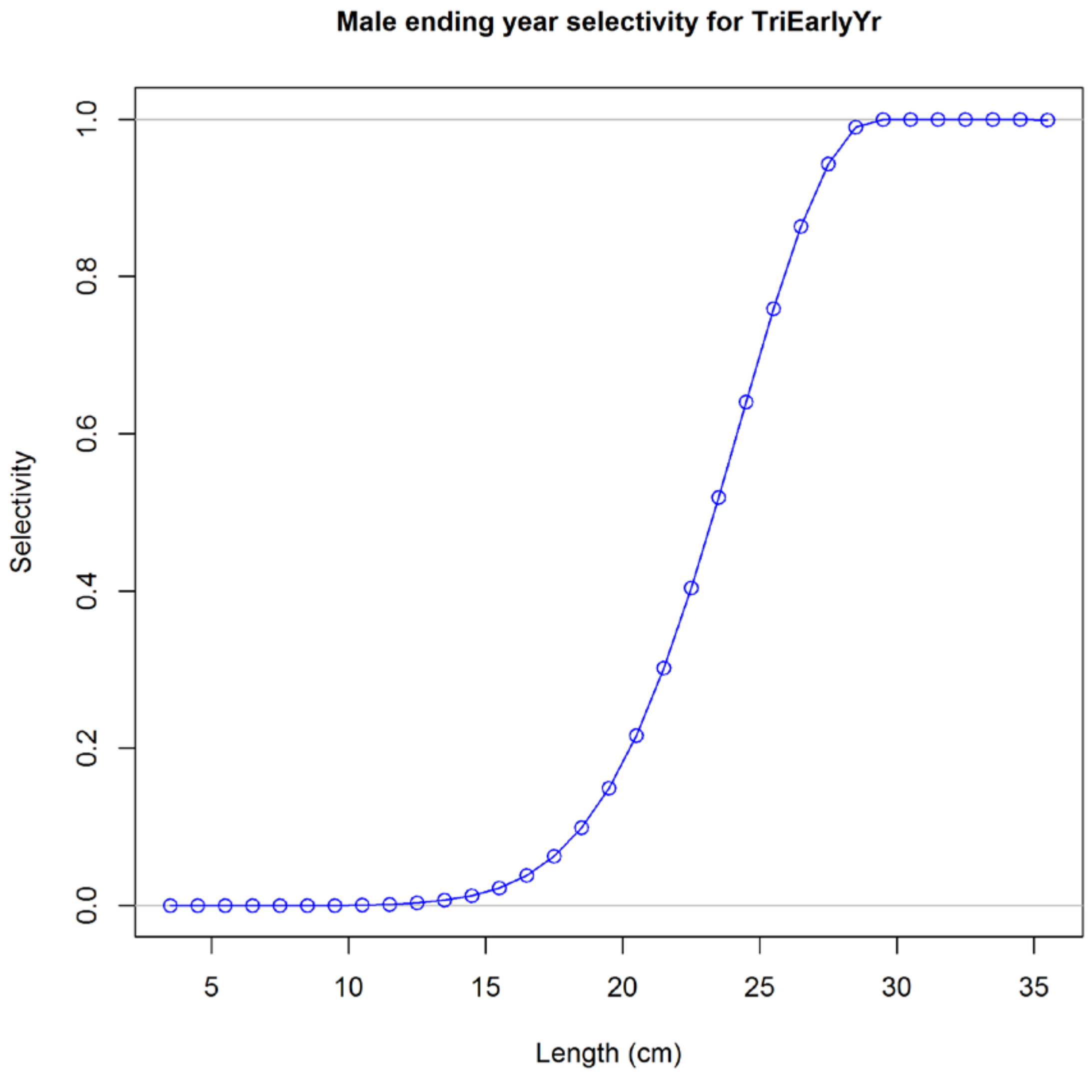


Figure 62. Estimated length-based selectivity for males for the early year triennial survey.

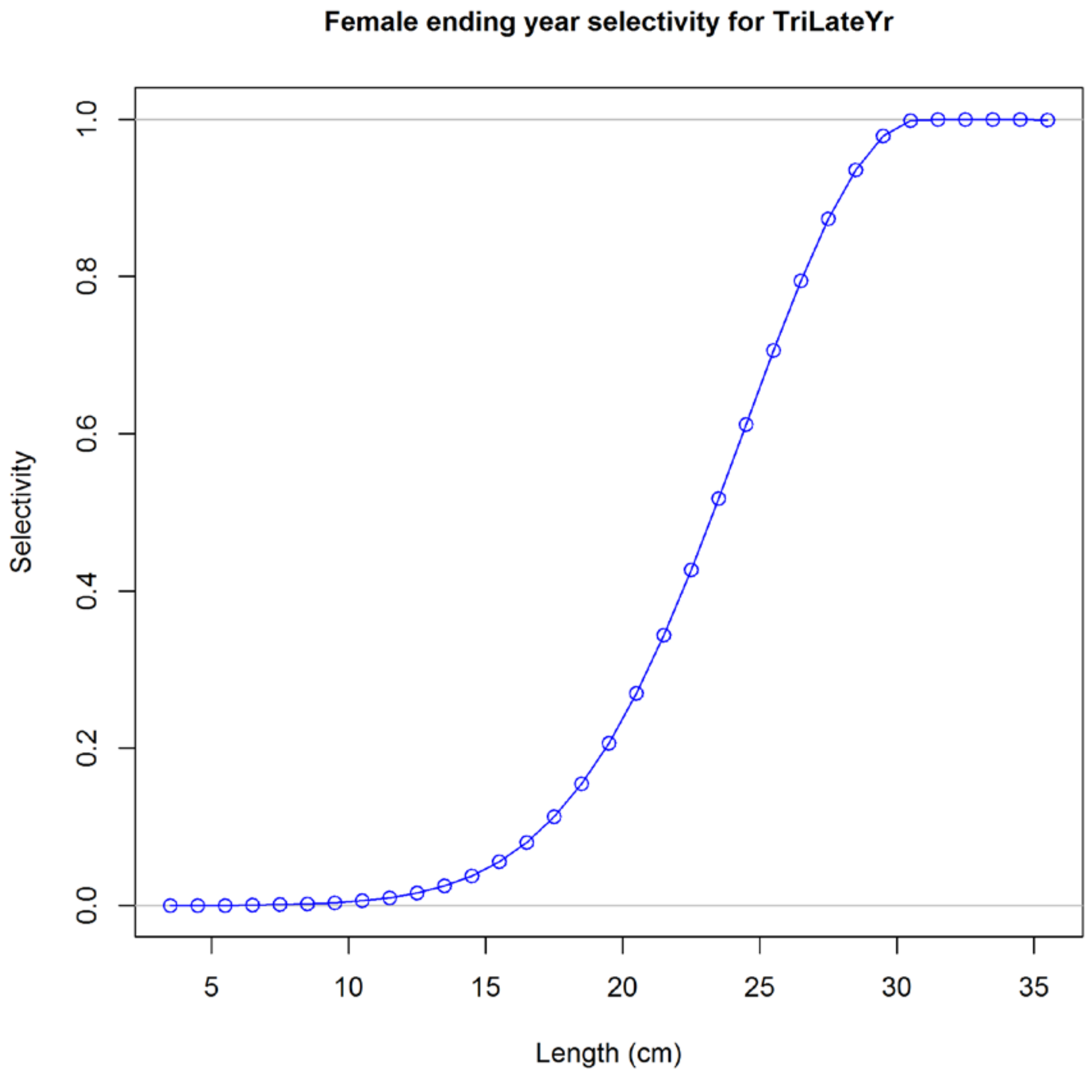


Figure 63. Estimated length-based selectivity for females for the late year triennial survey.

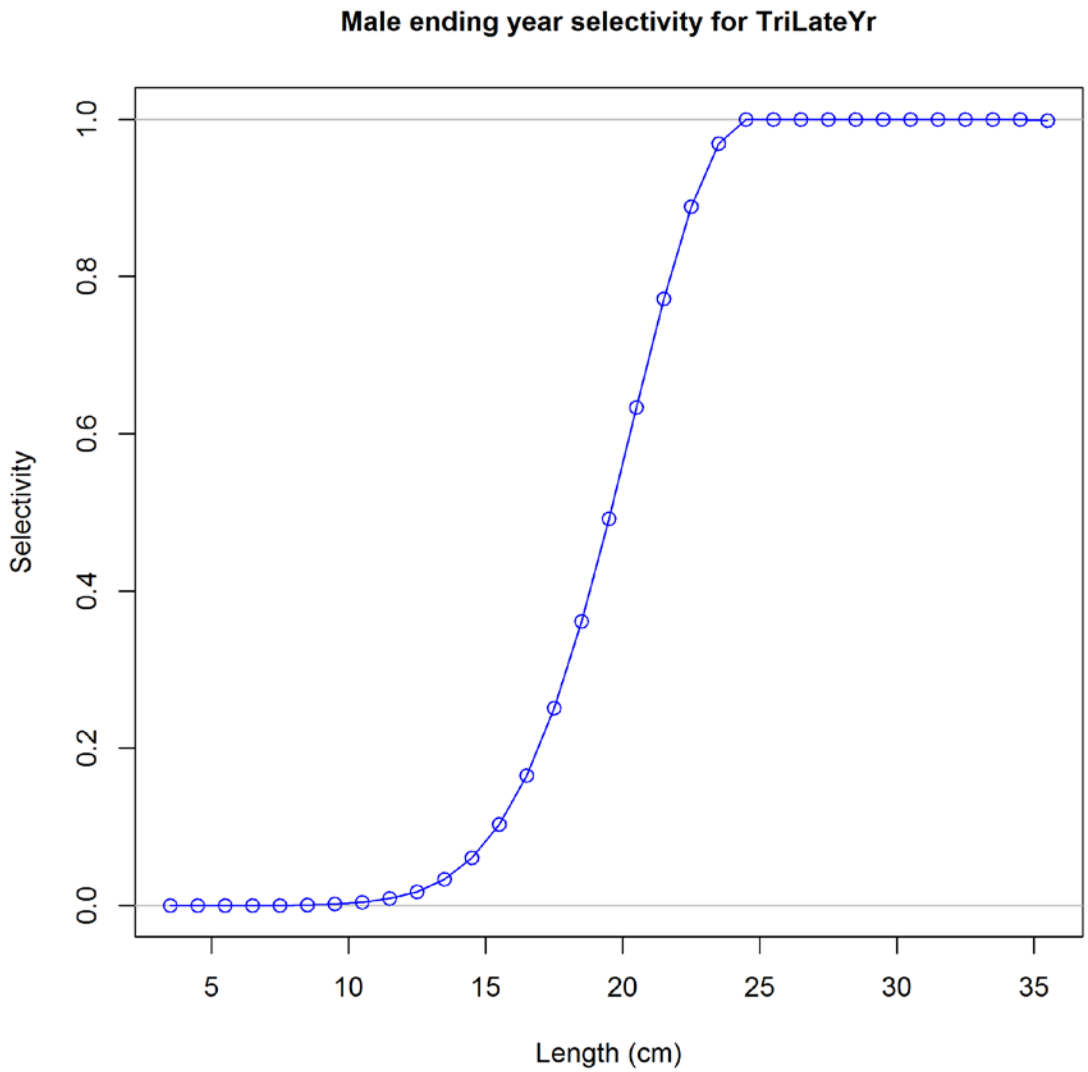


Figure 64. Estimated length-based selectivity for males for the early year triennial survey.

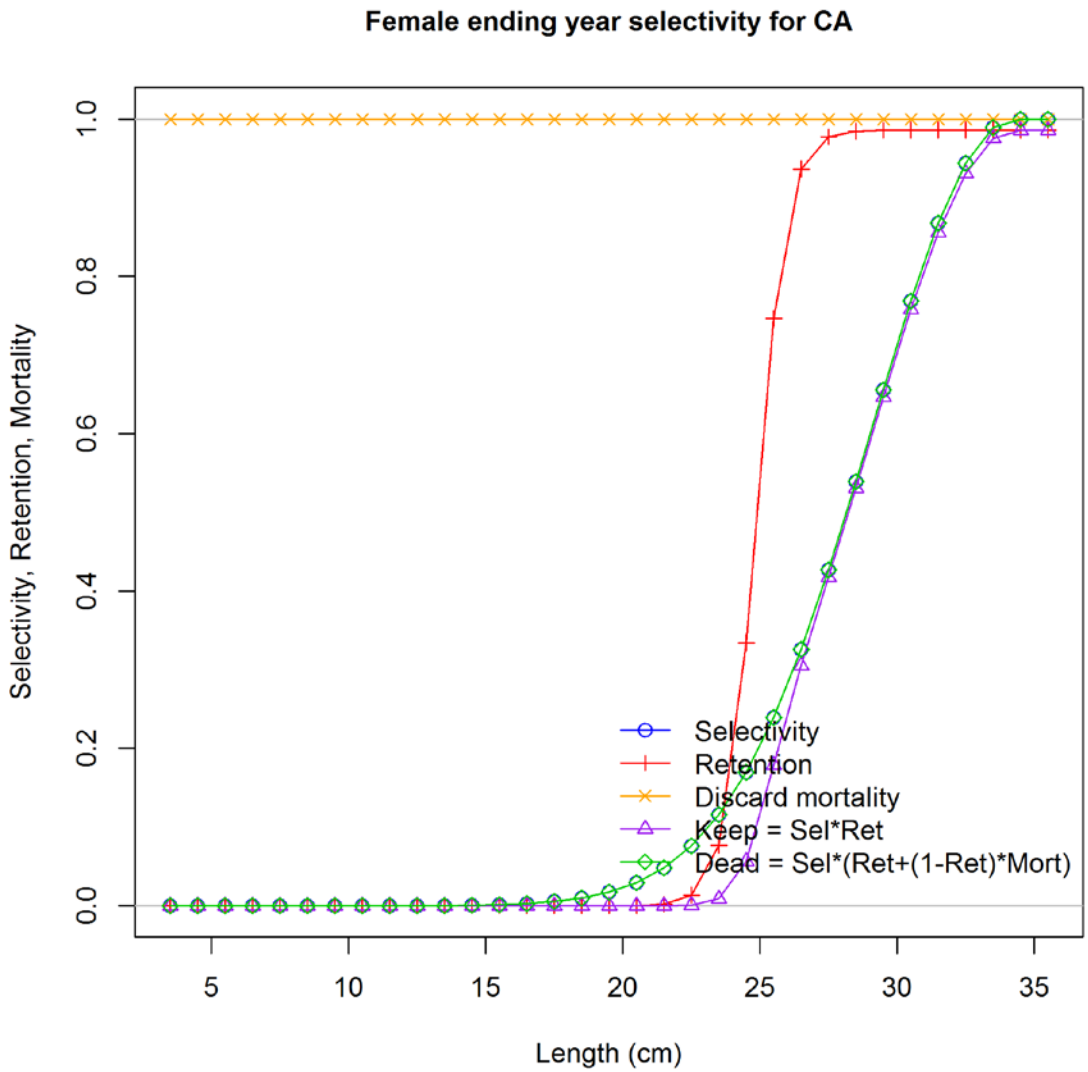


Figure 65. Estimated length-based selectivity for females for the California fishery.

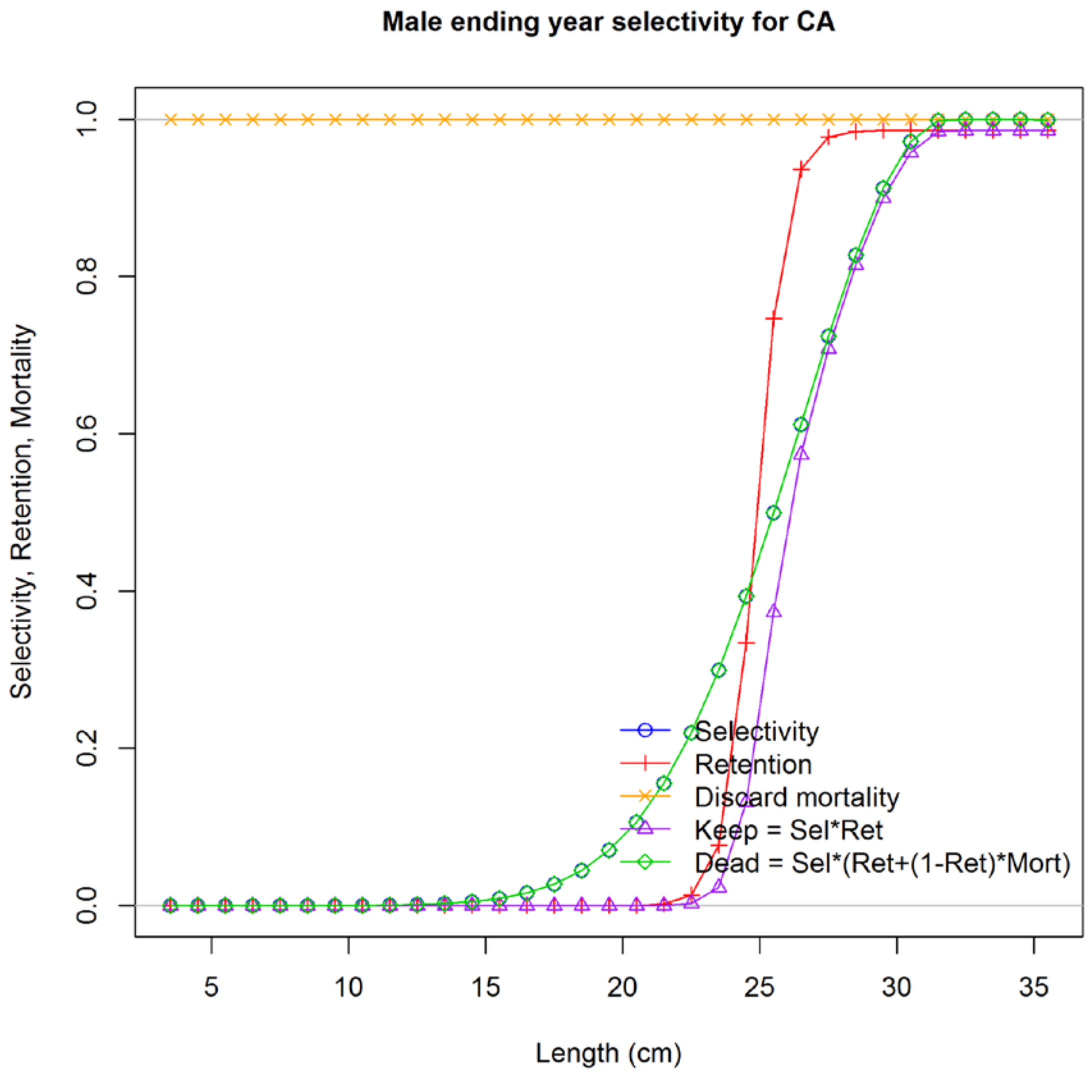


Figure 66. Estimated length-based selectivity for males for the California fishery.

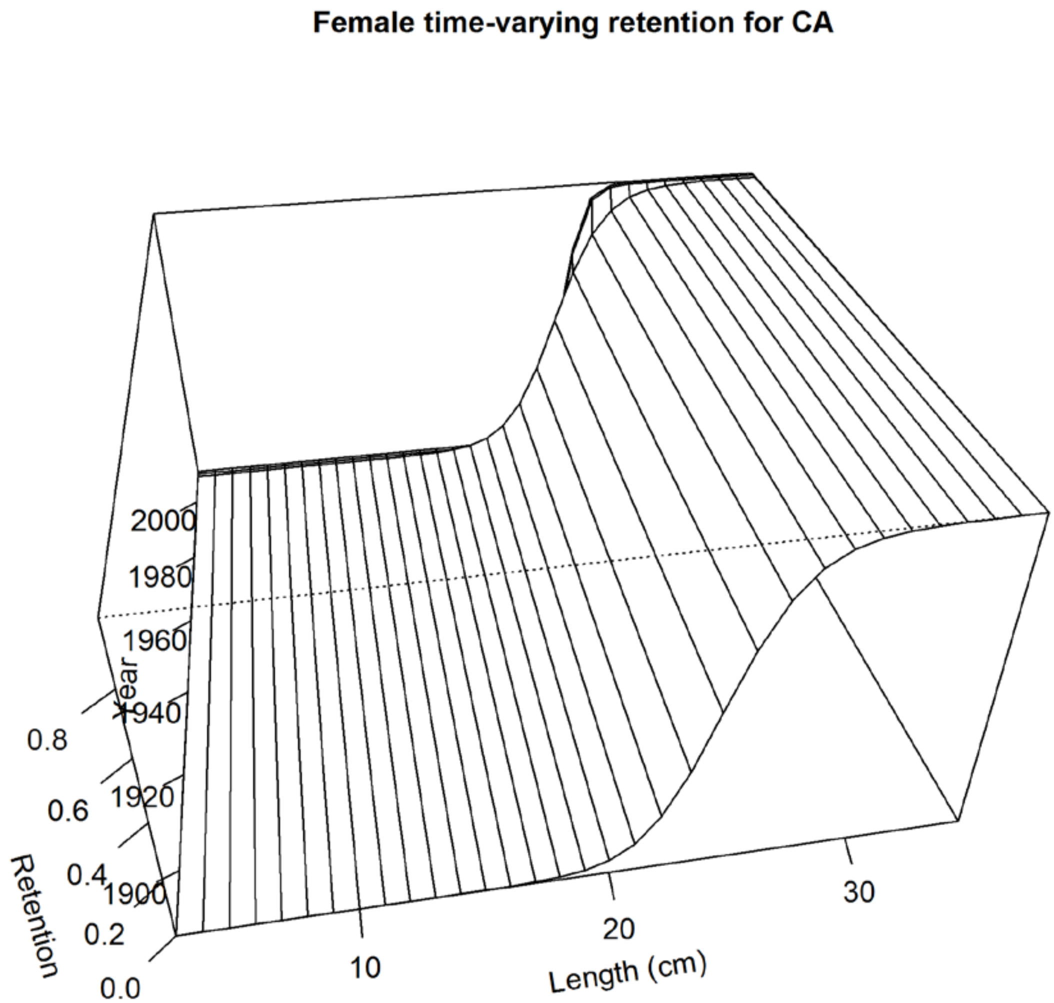


Figure 67. Estimated time-varying retention selectivity for both sexes for the California fishery (labeled as female time-varying retention).

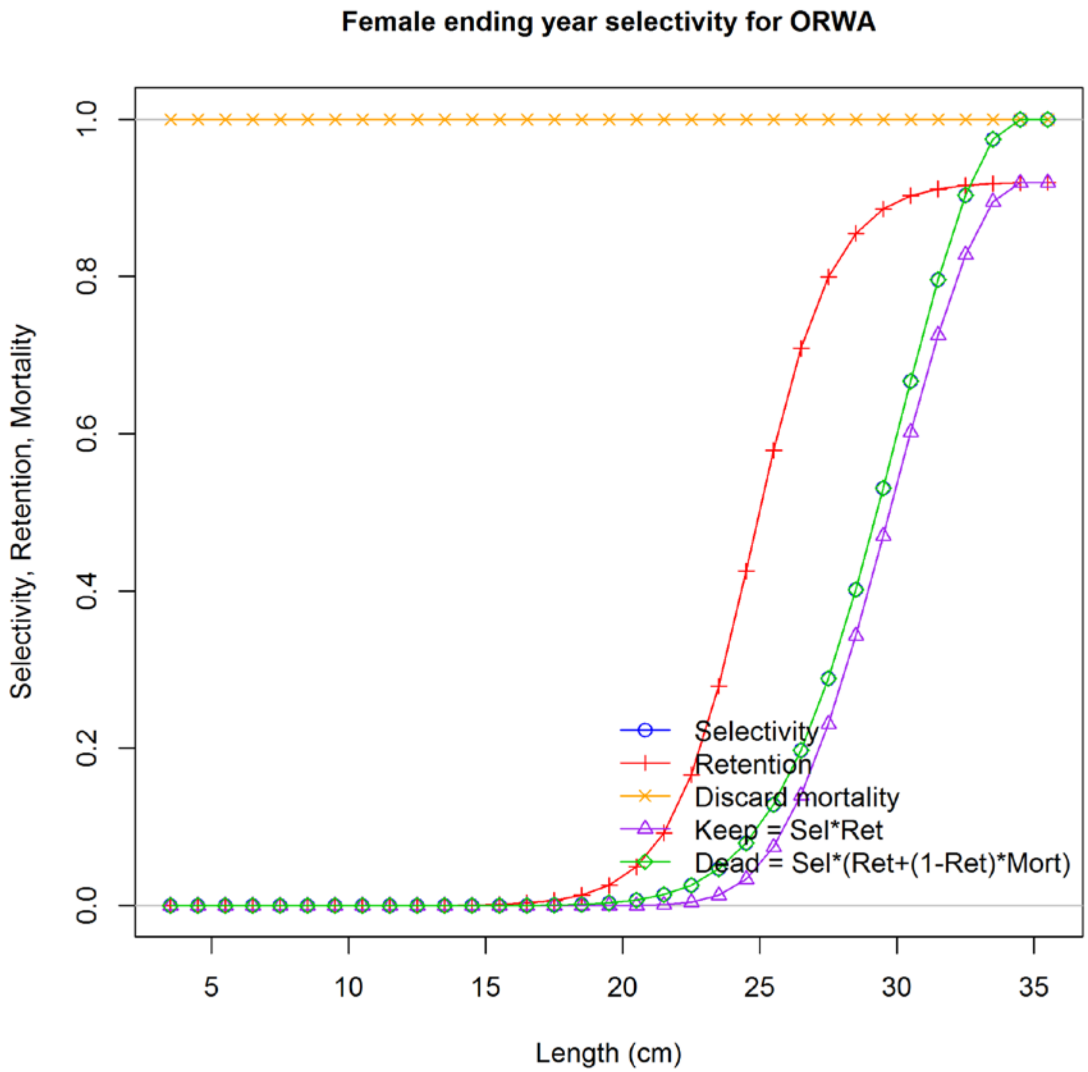


Figure 68. Estimated length-based selectivity for females for the Oregon/Washington fishery.

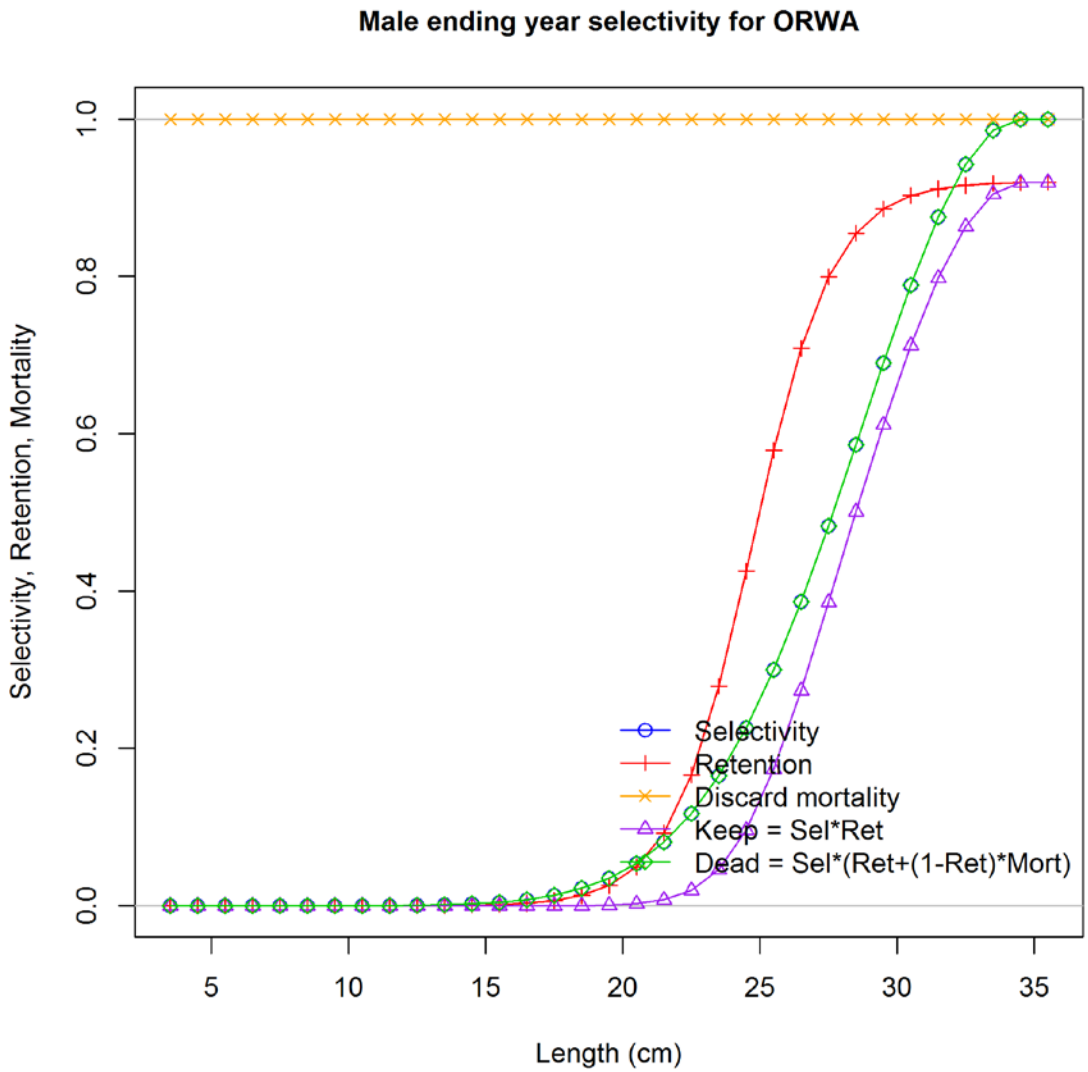


Figure 69. Estimated length-based selectivity for males for the Oregon/Washington fishery.

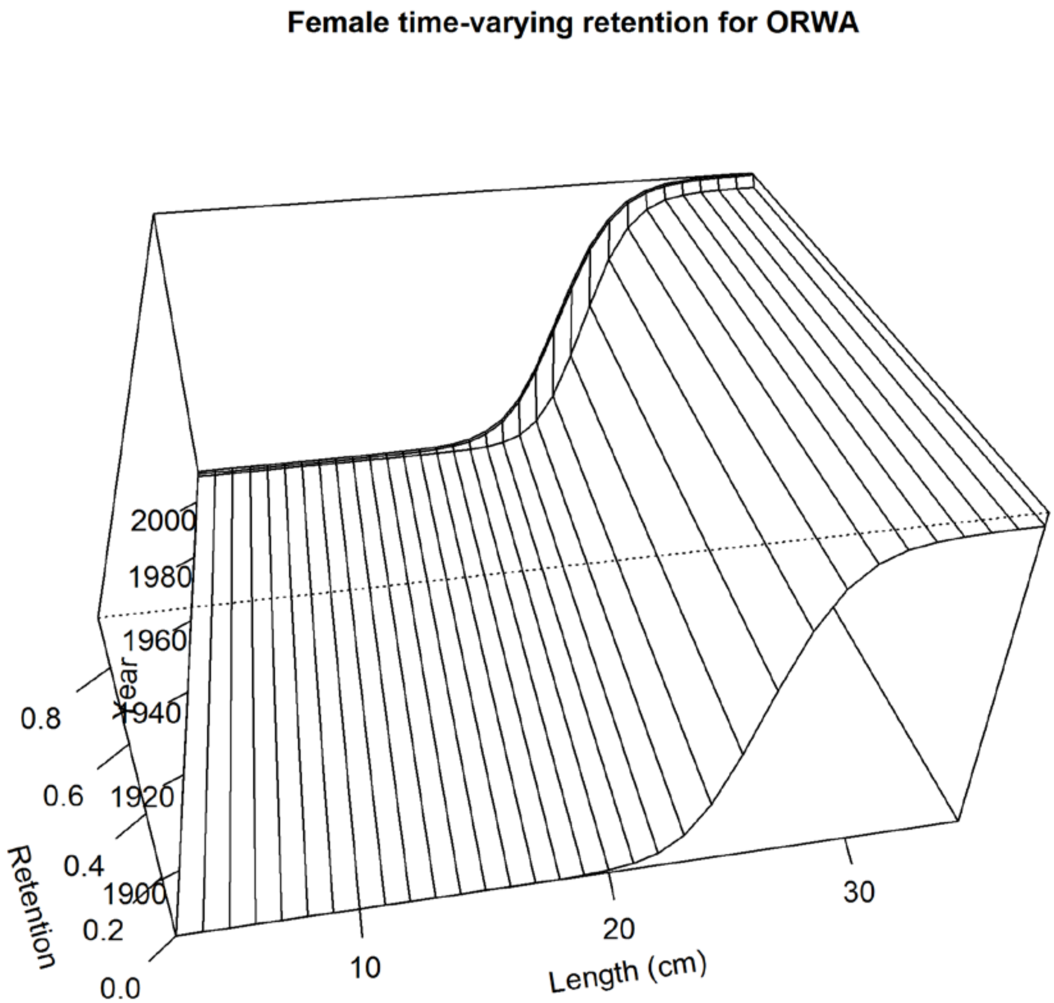


Figure 70. Estimated time-varying retention selectivity for both sexes for the Oregon/Washington fishery (labeled as female time-varying retention).

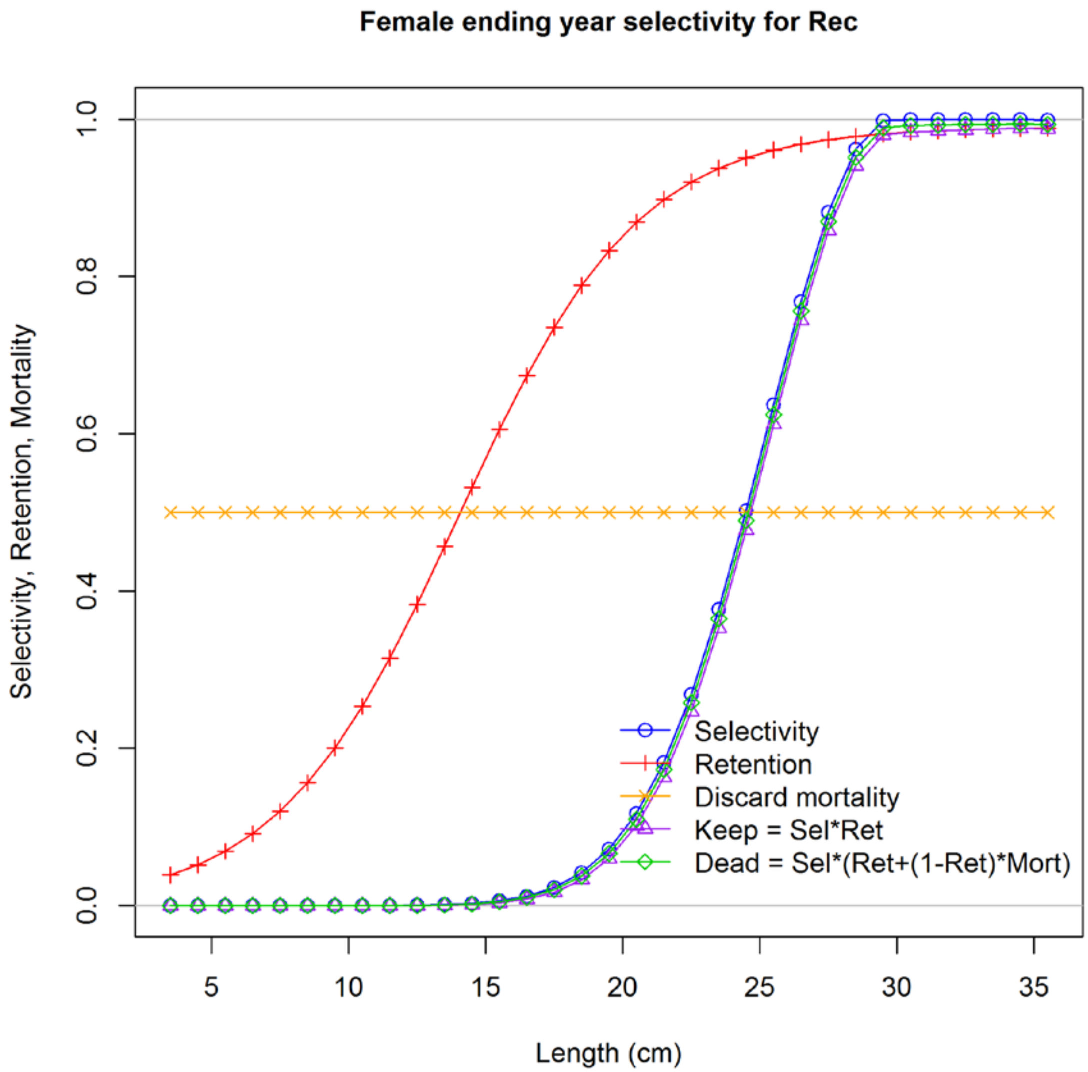


Figure 71. Estimated length-based selectivity for females for the recreational fishery.

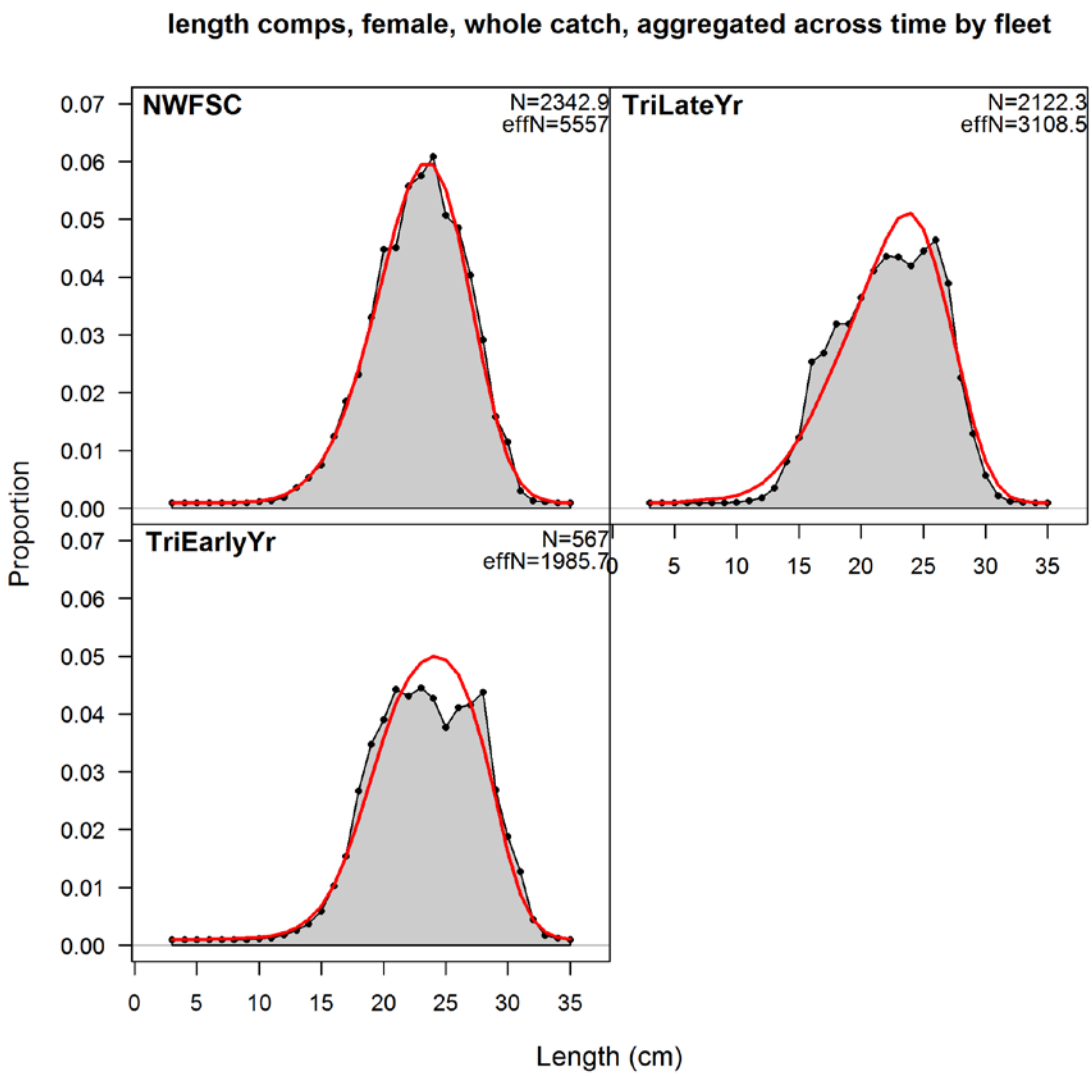


Figure 72. Fits of base model outputs to the time-aggregated length compositions of females for three fishery-independent surveys.

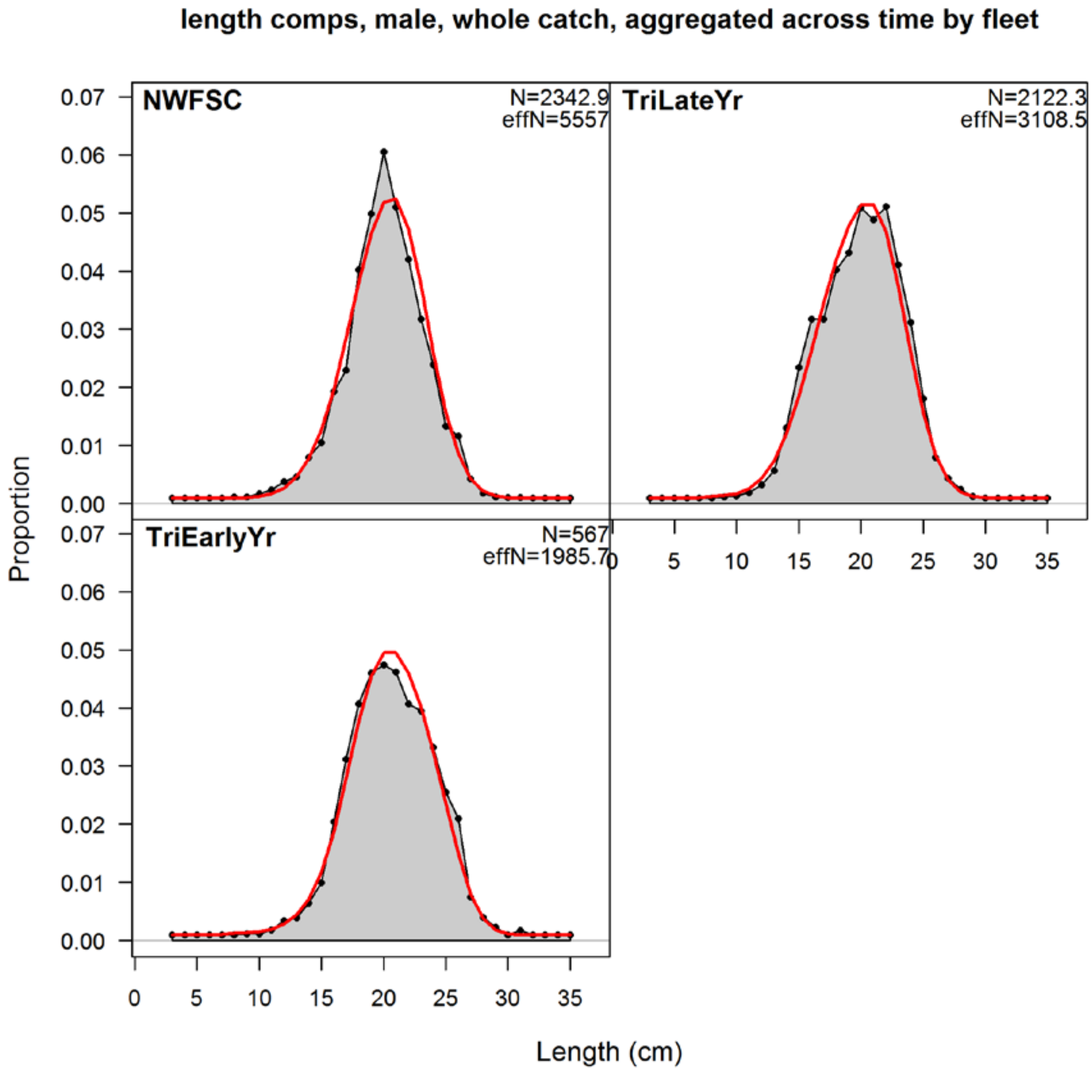


Figure 73. Fits of base model outputs to the time-aggregated length compositions of males for three fishery-independent surveys.

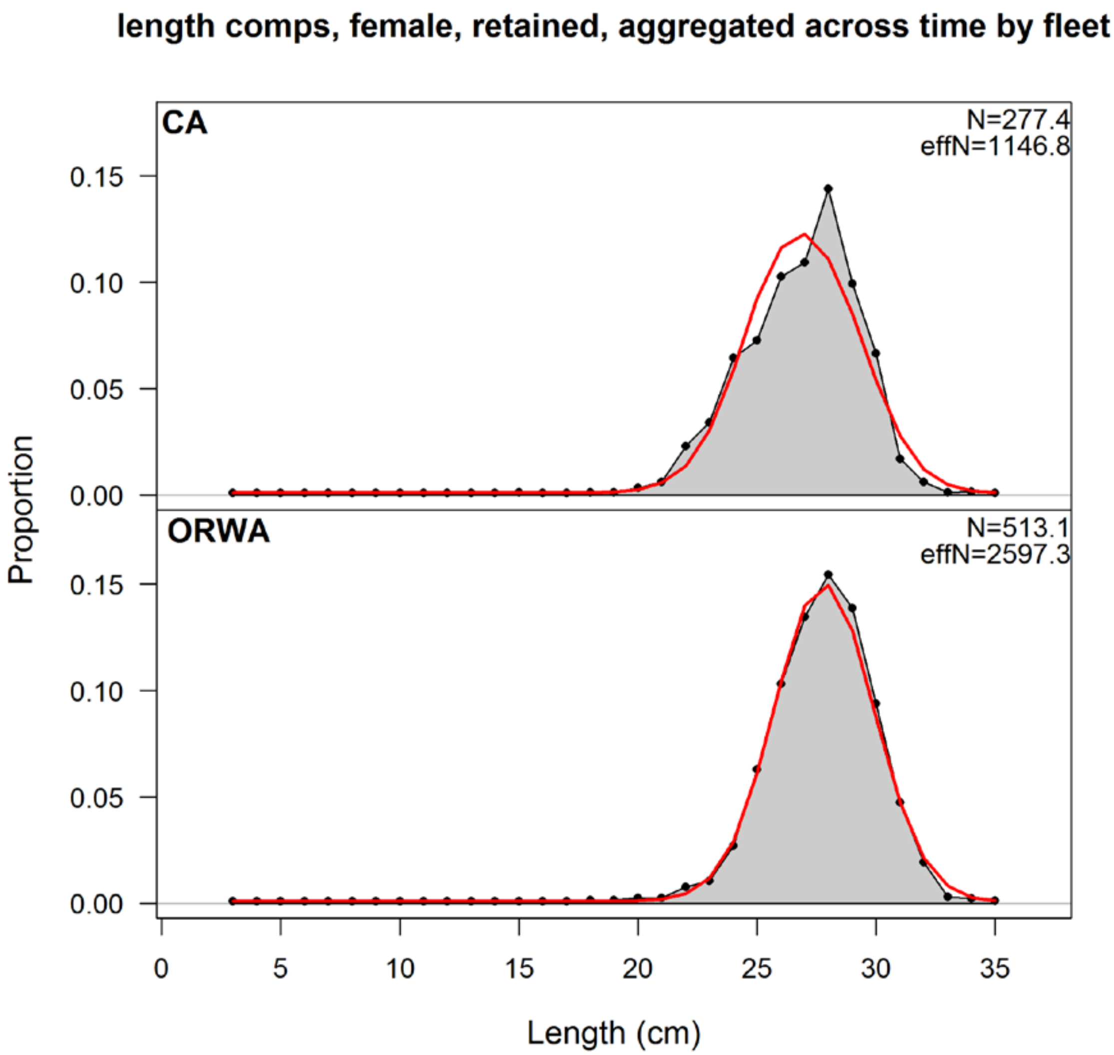


Figure 74. Fits of base model outputs to the time-aggregated length compositions of females for the CA and OR/WA fisheries.

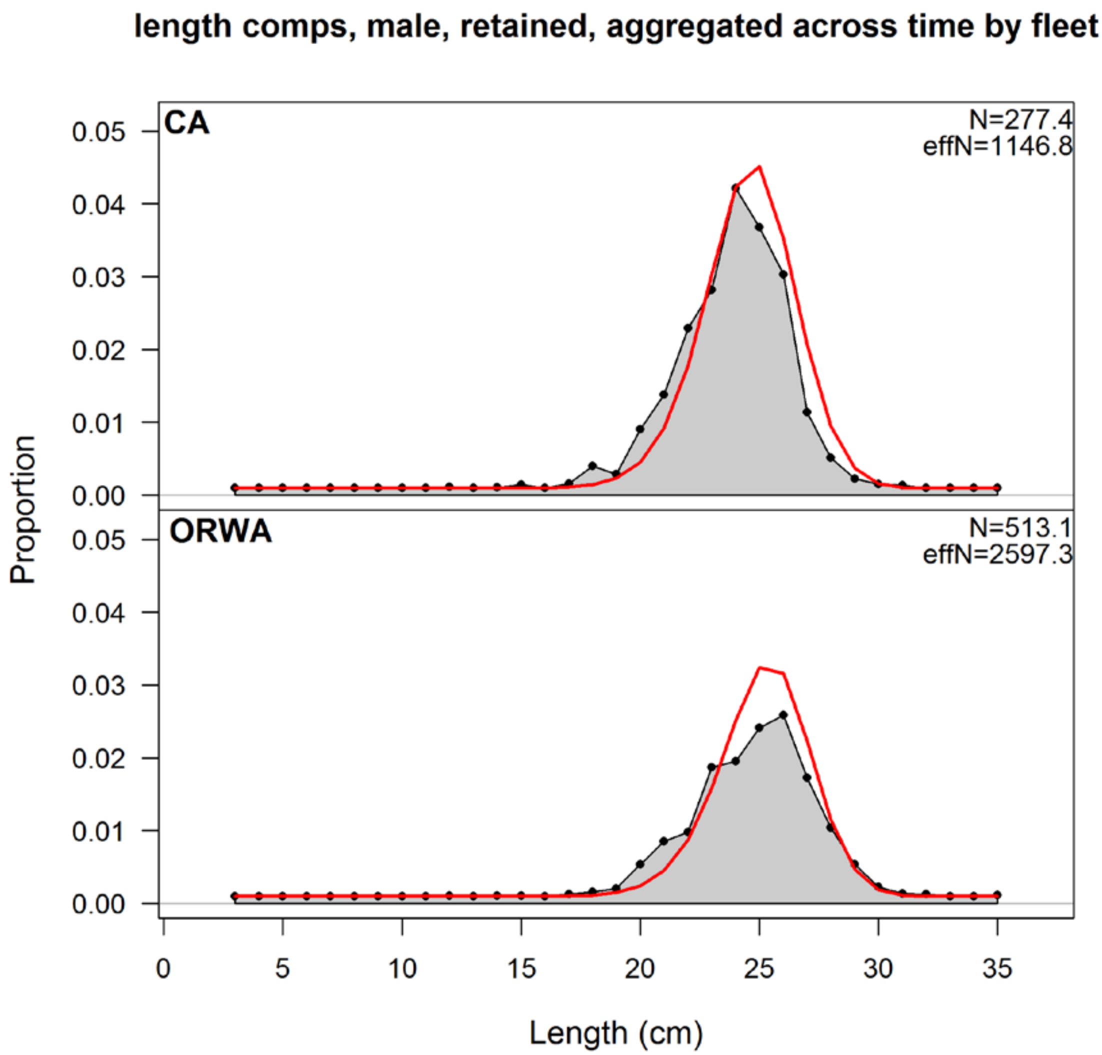


Figure 75. Fits of base model outputs to the time-aggregated length compositions of males for CA and OR/WA fisheries.

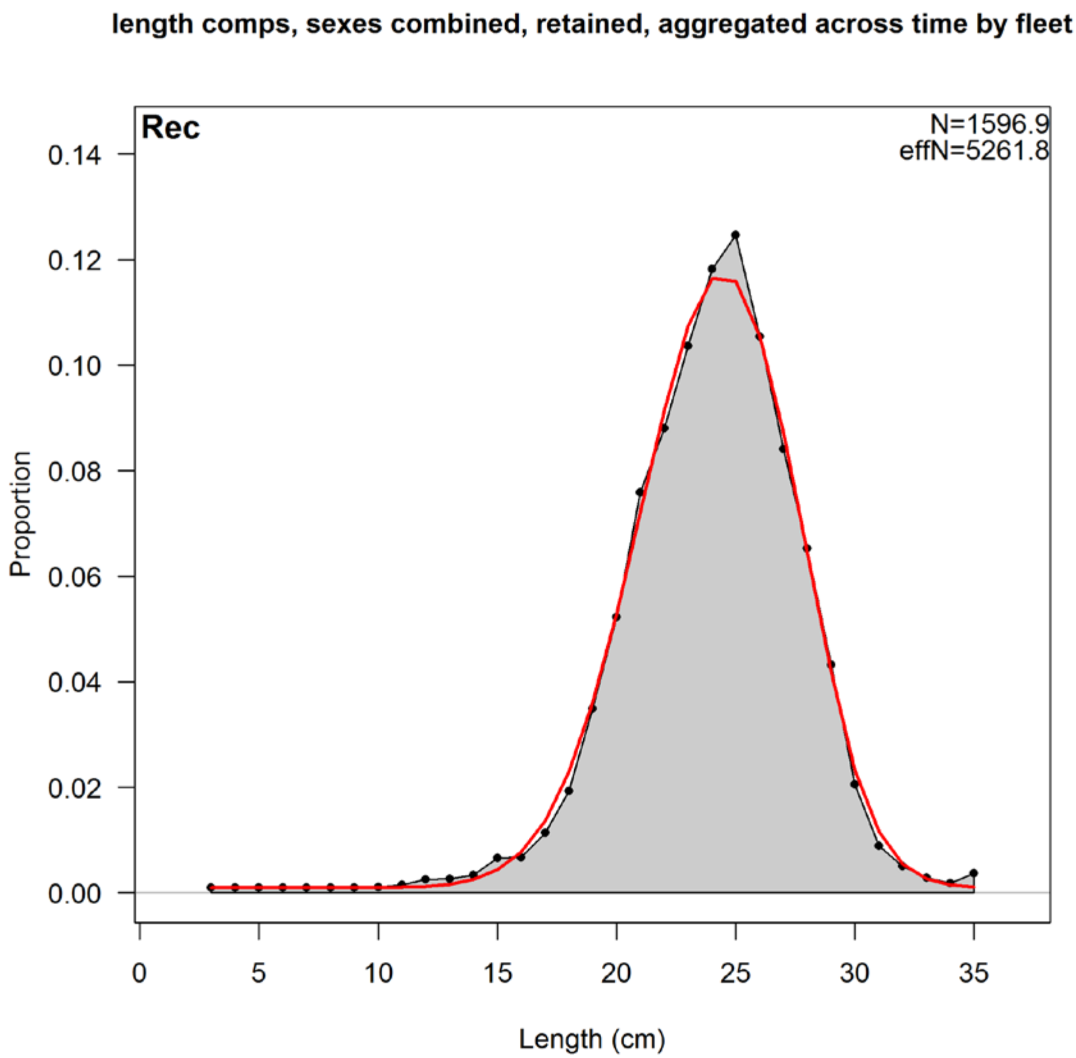


Figure 76. Fits of base model outputs to the time-aggregated and sex combined length compositions of males for the recreational fishery.

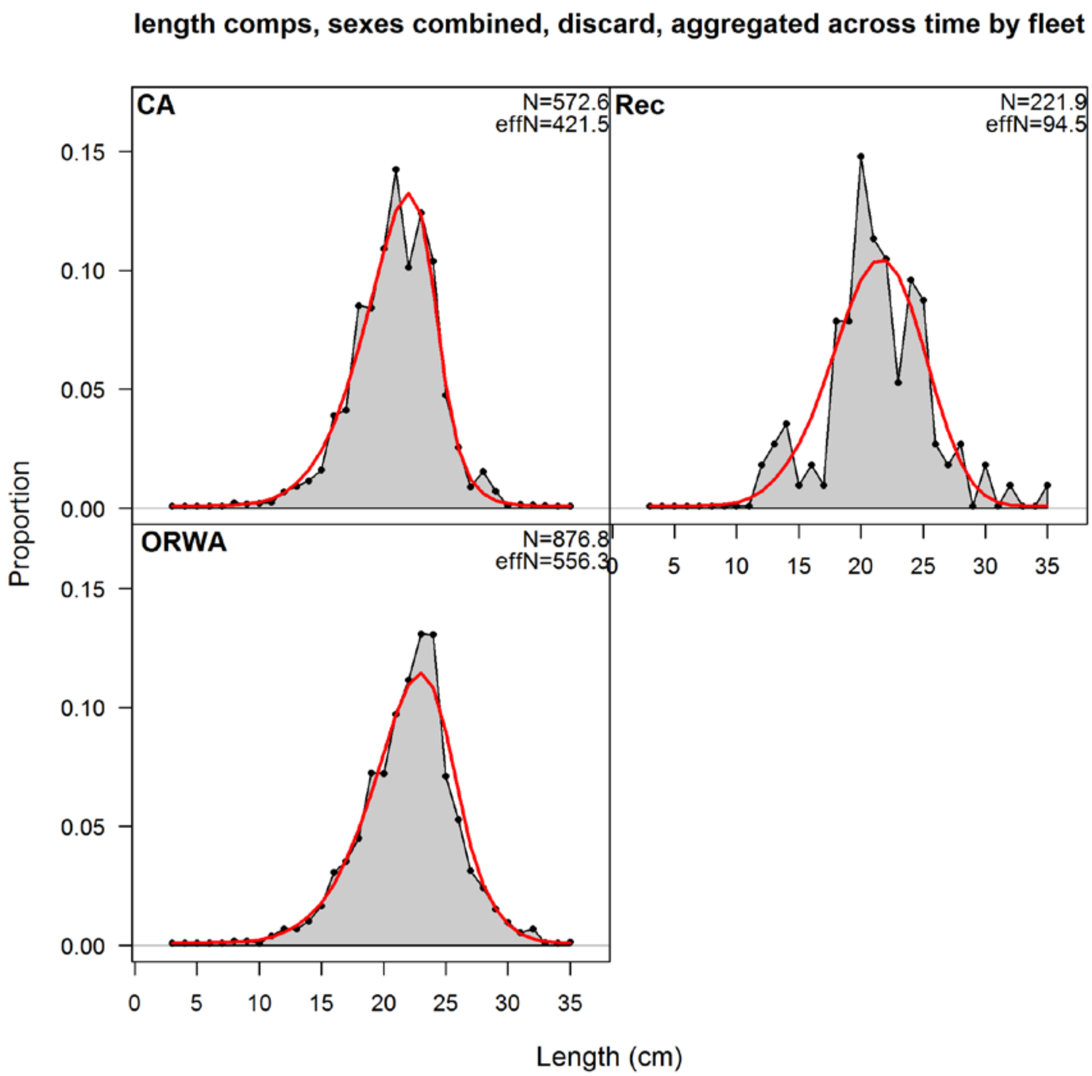


Figure 77. Fits of base model outputs to the time-aggregated length compositions of combined sexes for three fishing fleets.

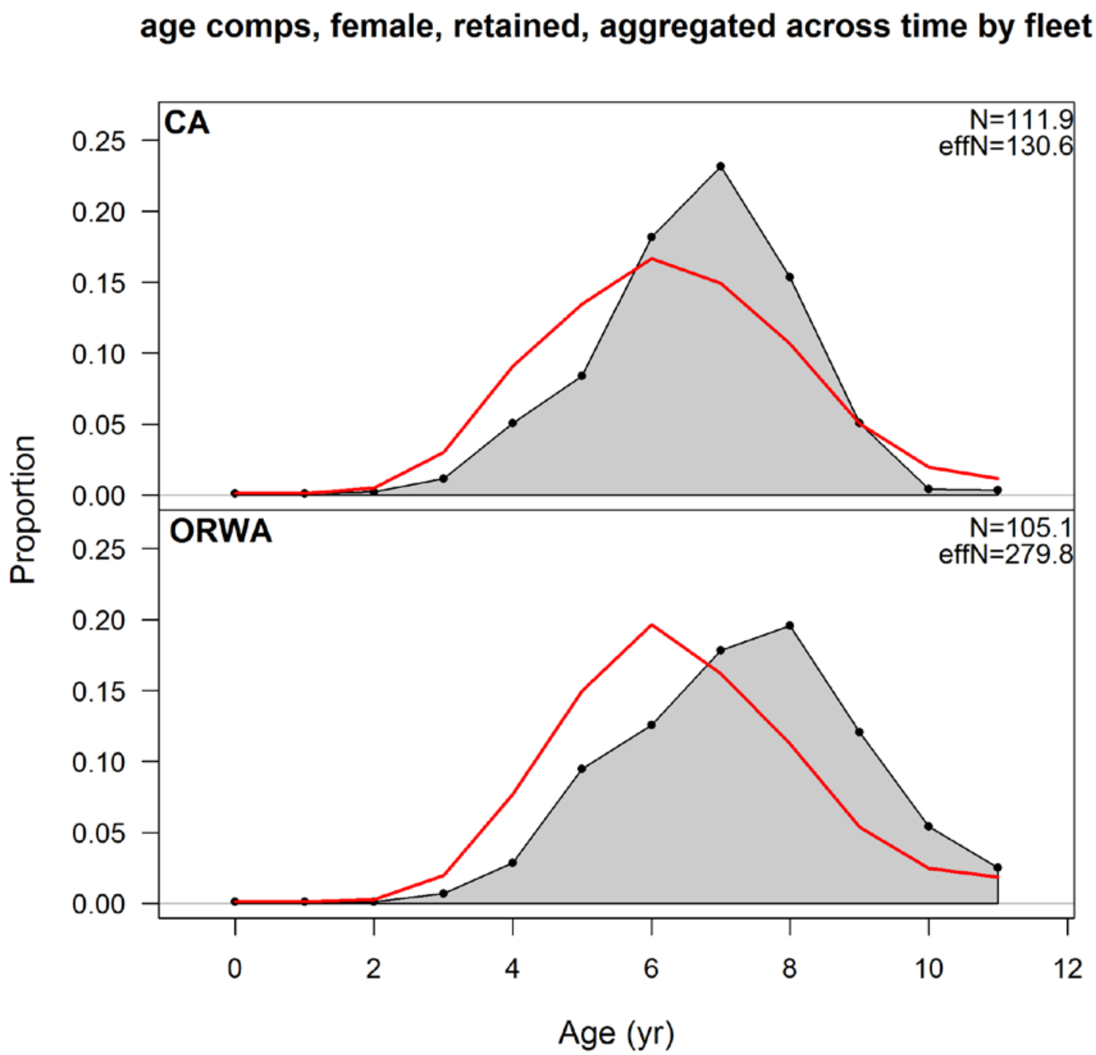


Figure 78. Fits of base model outputs to the time-aggregated age compositions for females by two fishing fleets.

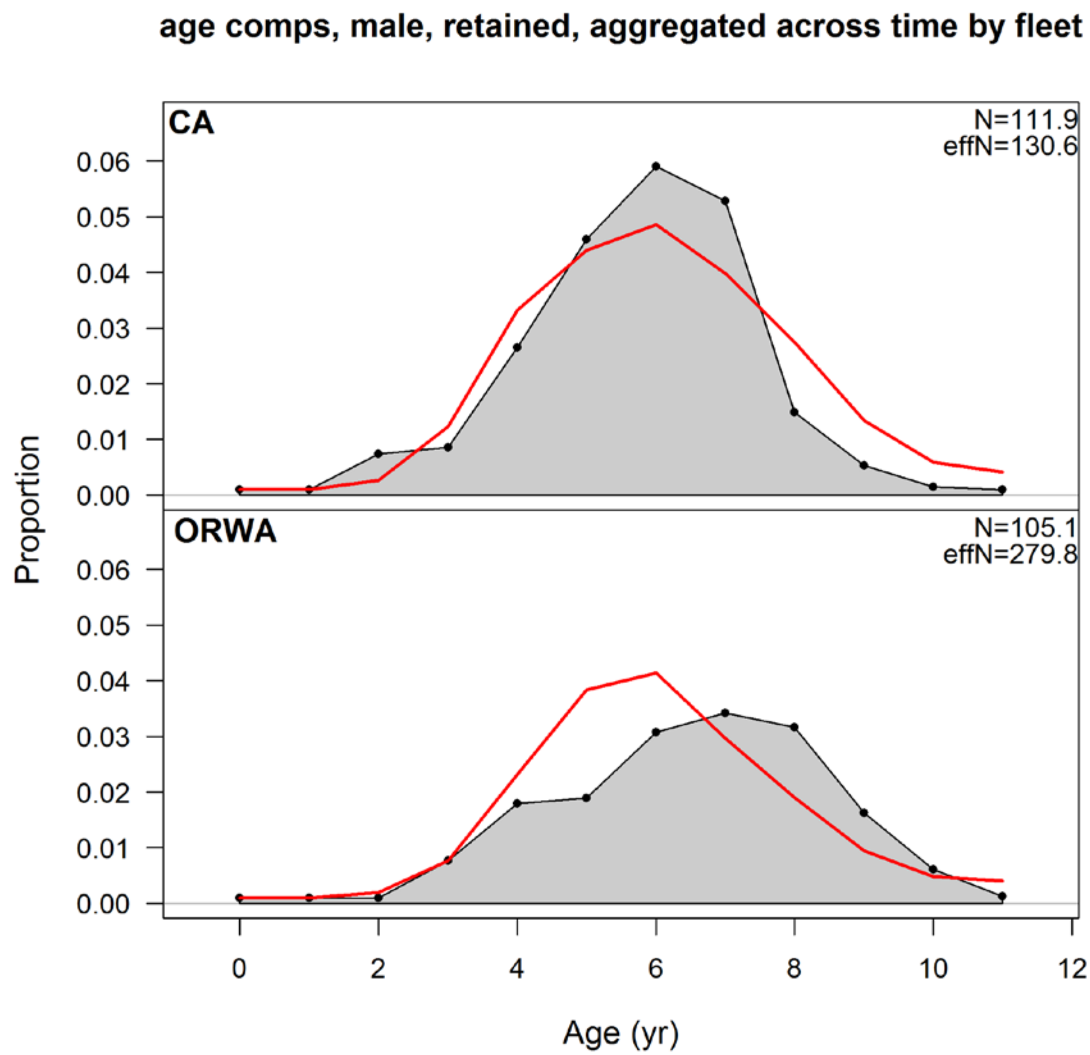


Figure 79. Fits of base model outputs to the time-aggregated age compositions for males by two fishing fleets.

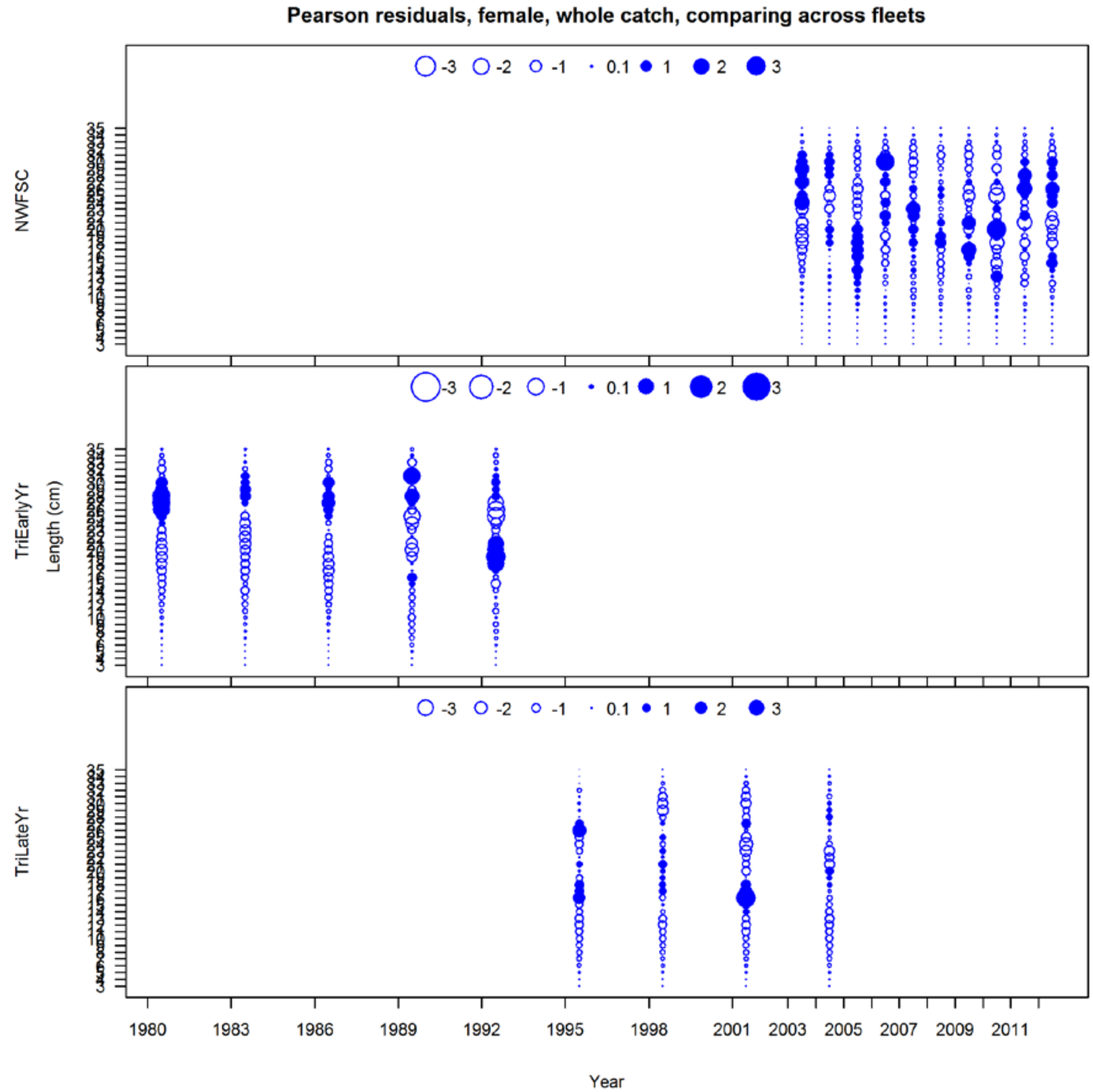


Figure 80. Pearson residuals for the fits to length frequency data of females from the three fishery-independent surveys.

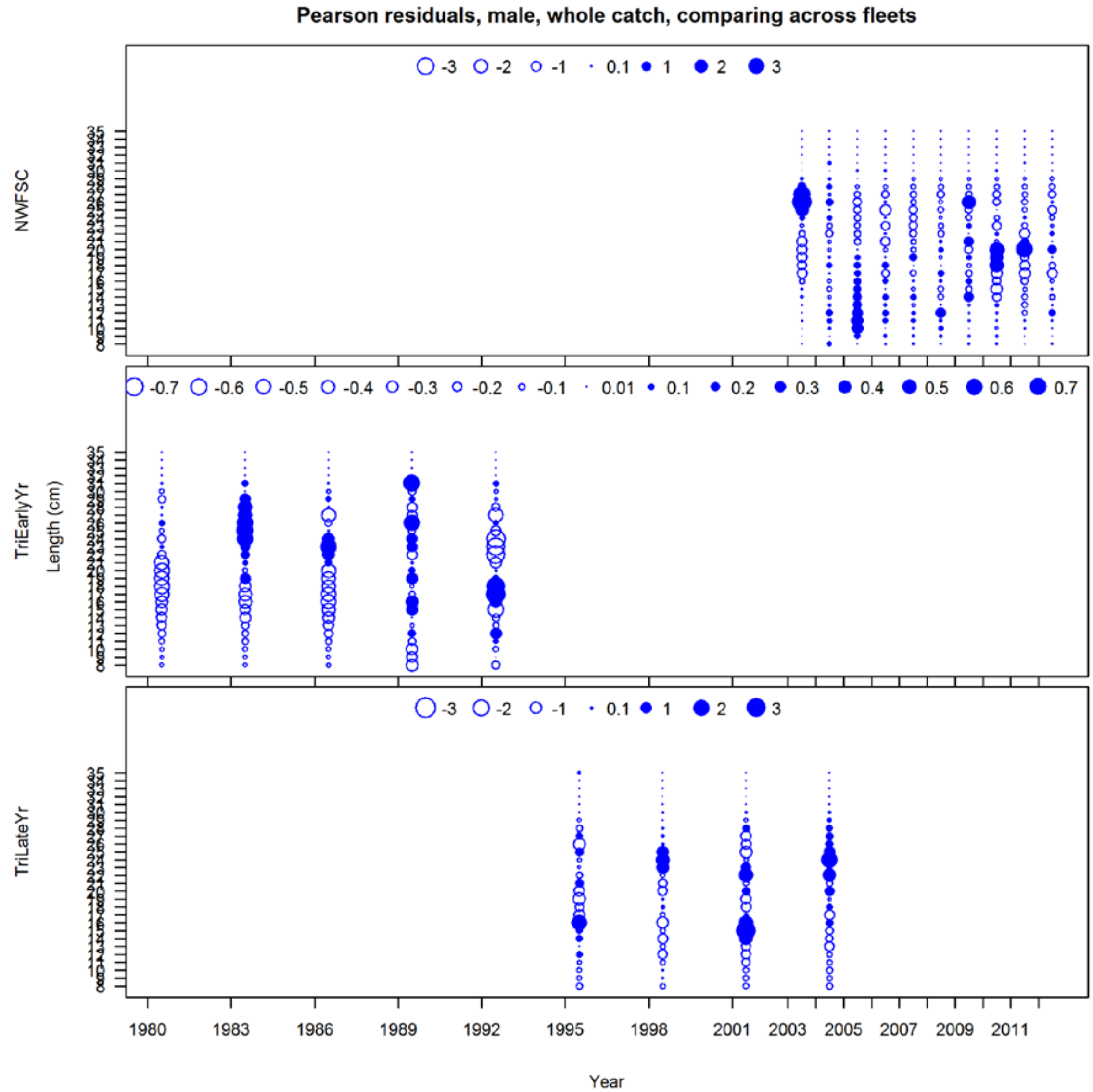


Figure 81. Pearson residuals for the fits to length frequency data of males from the three fishery-independent surveys.

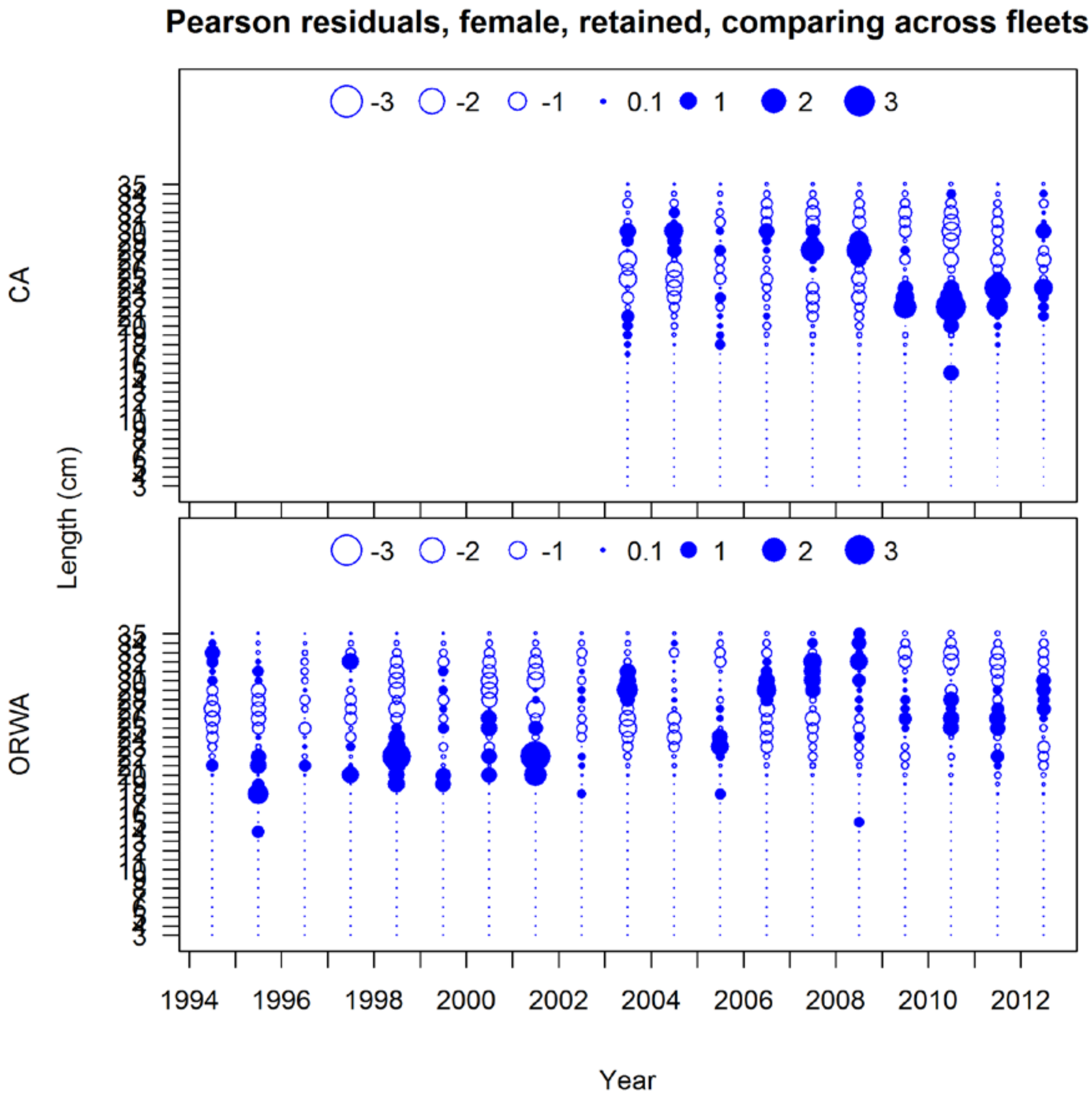


Figure 82. Pearson residuals for the fits to length frequency data of females from the California and Oregon/Washington trawl fisheries.

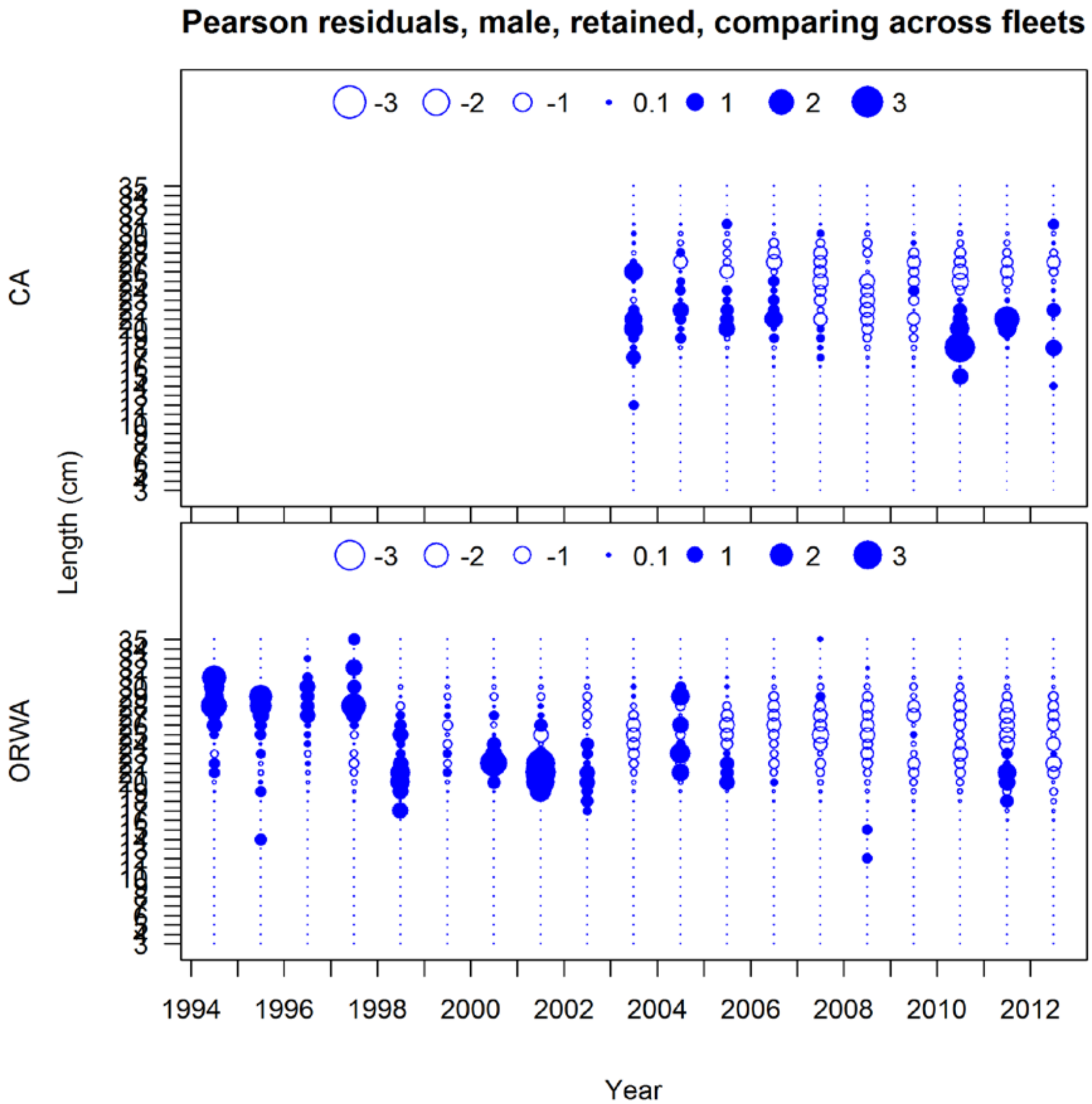


Figure 83. Pearson residuals for the fits to length frequency data of males from the California and Oregon/Washington trawl fisheries.

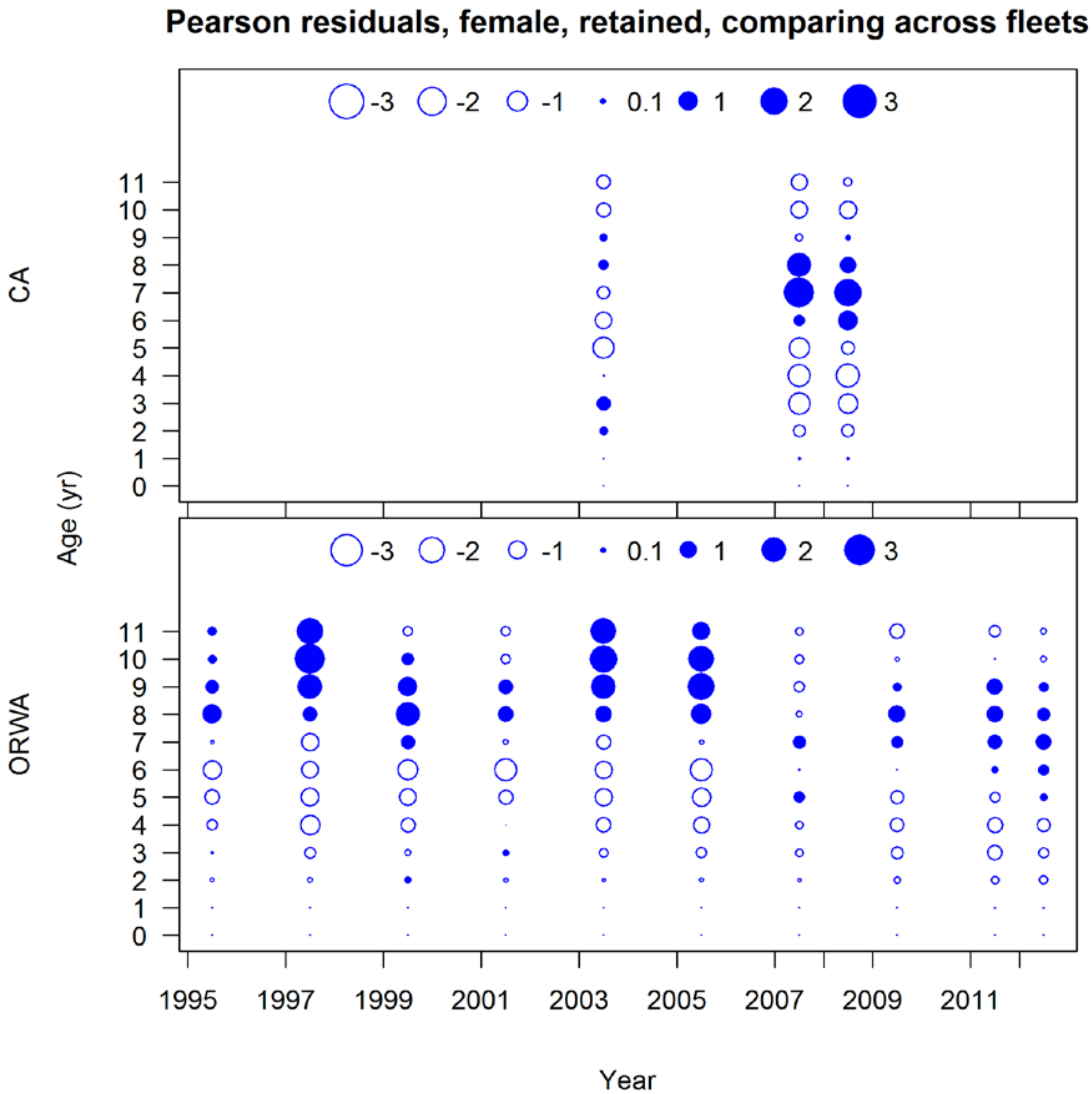


Figure 84. Pearson residuals for the fits to age frequency data of females from the California and Oregon/Washington trawl fisheries.

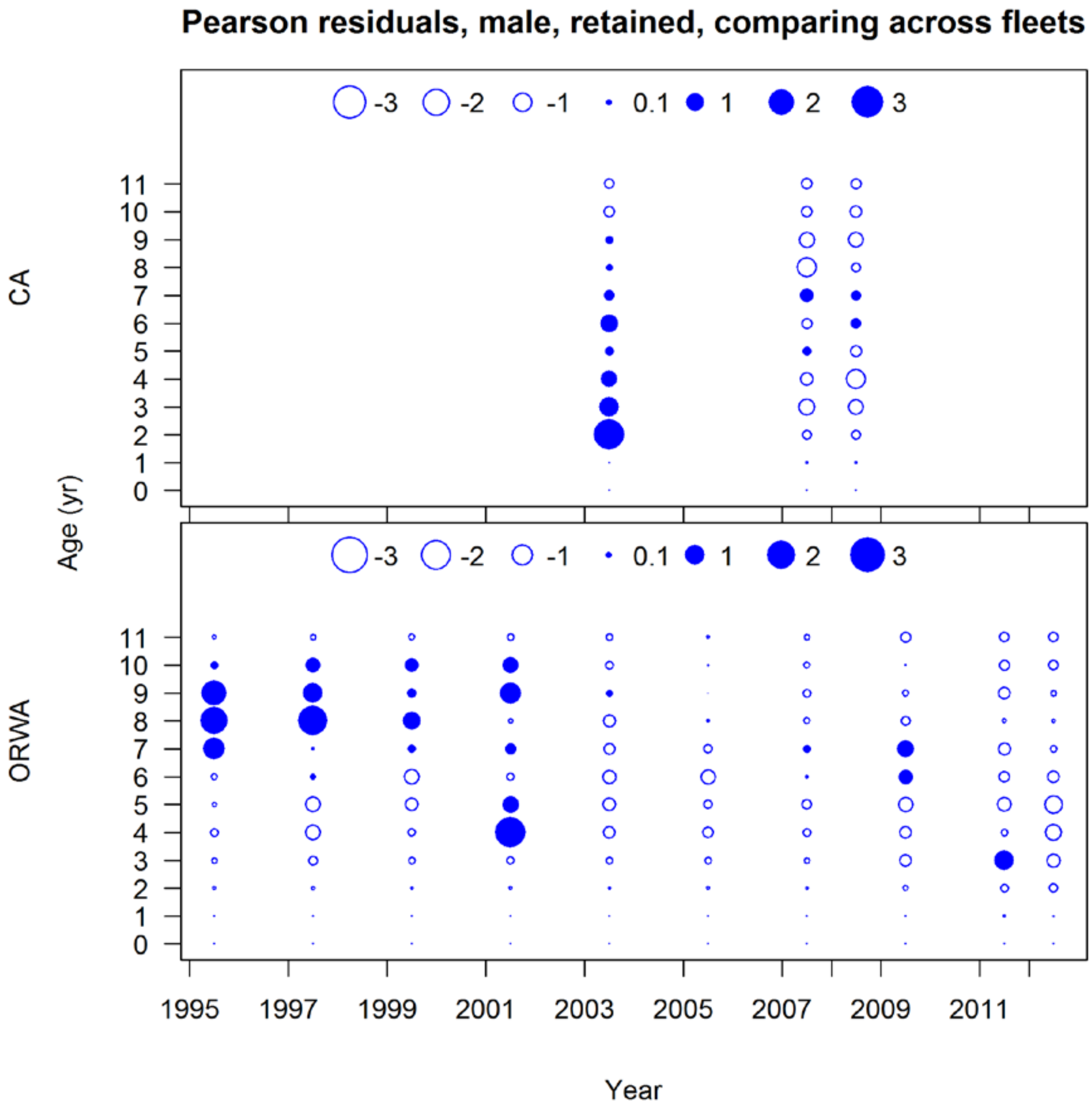


Figure 85. Pearson residuals for the fits to age frequency data of males from the California and Oregon/Washington trawl fisheries.

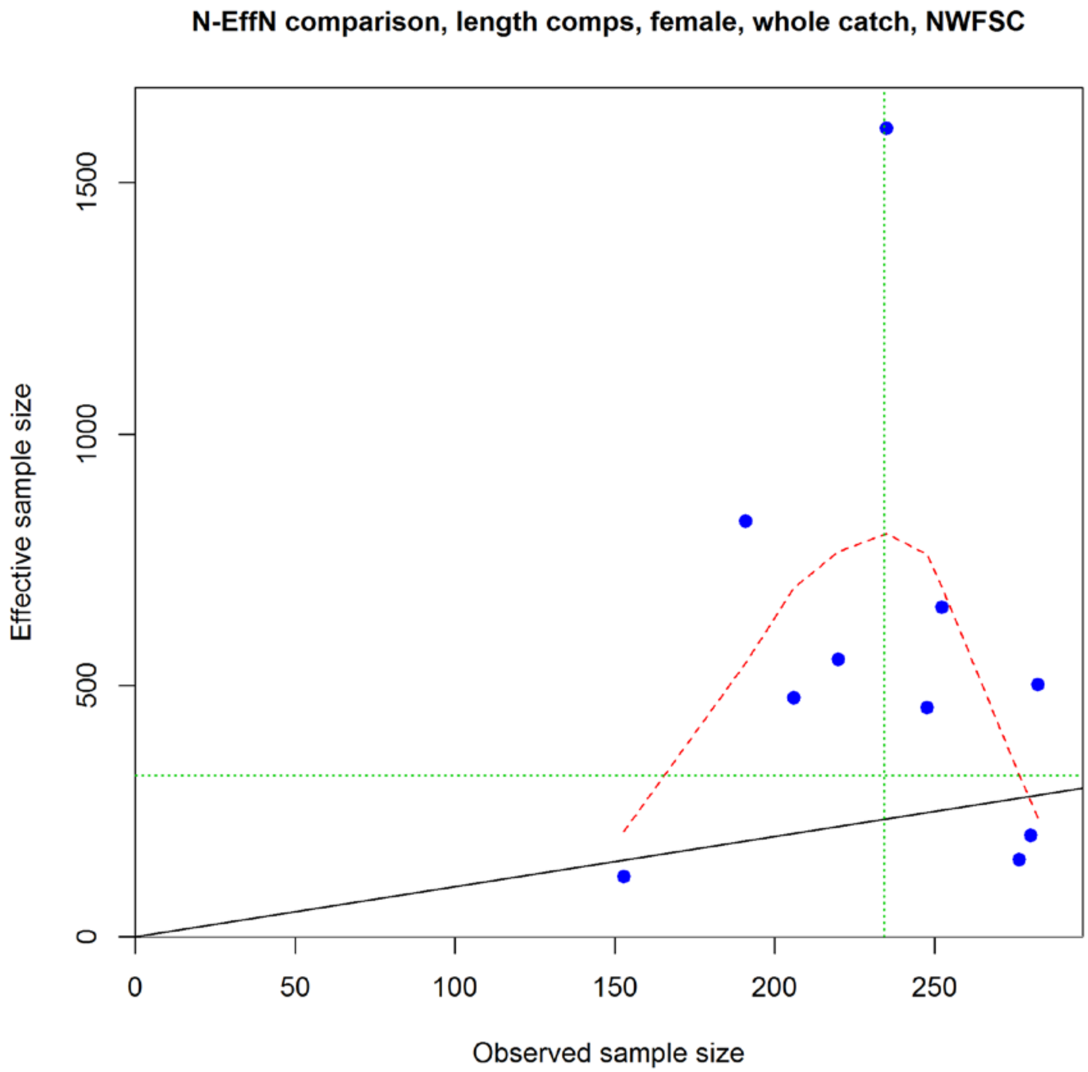


Figure 86. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the NWFSC survey length frequency data.

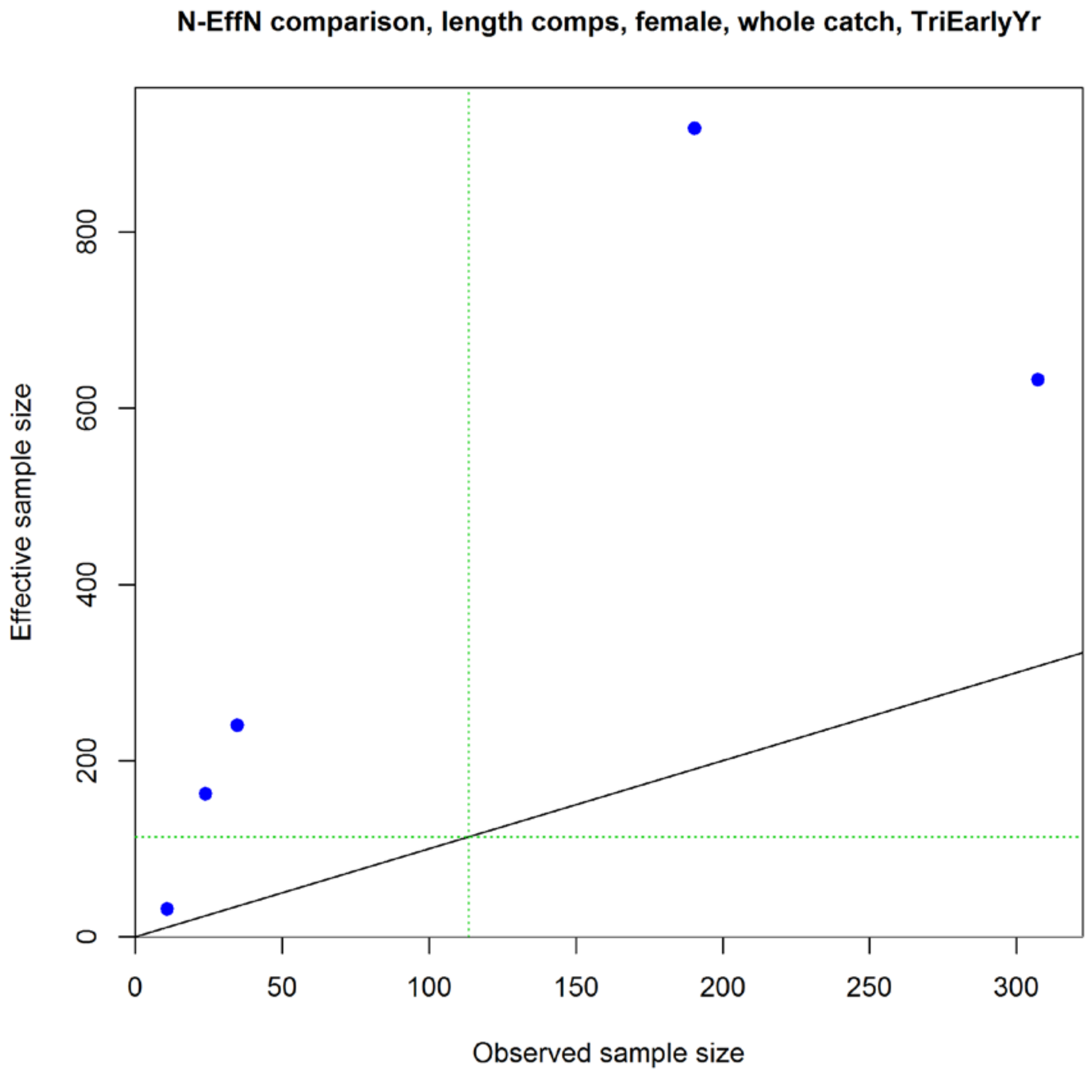


Figure 87. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the early time period triennial survey length frequency data.

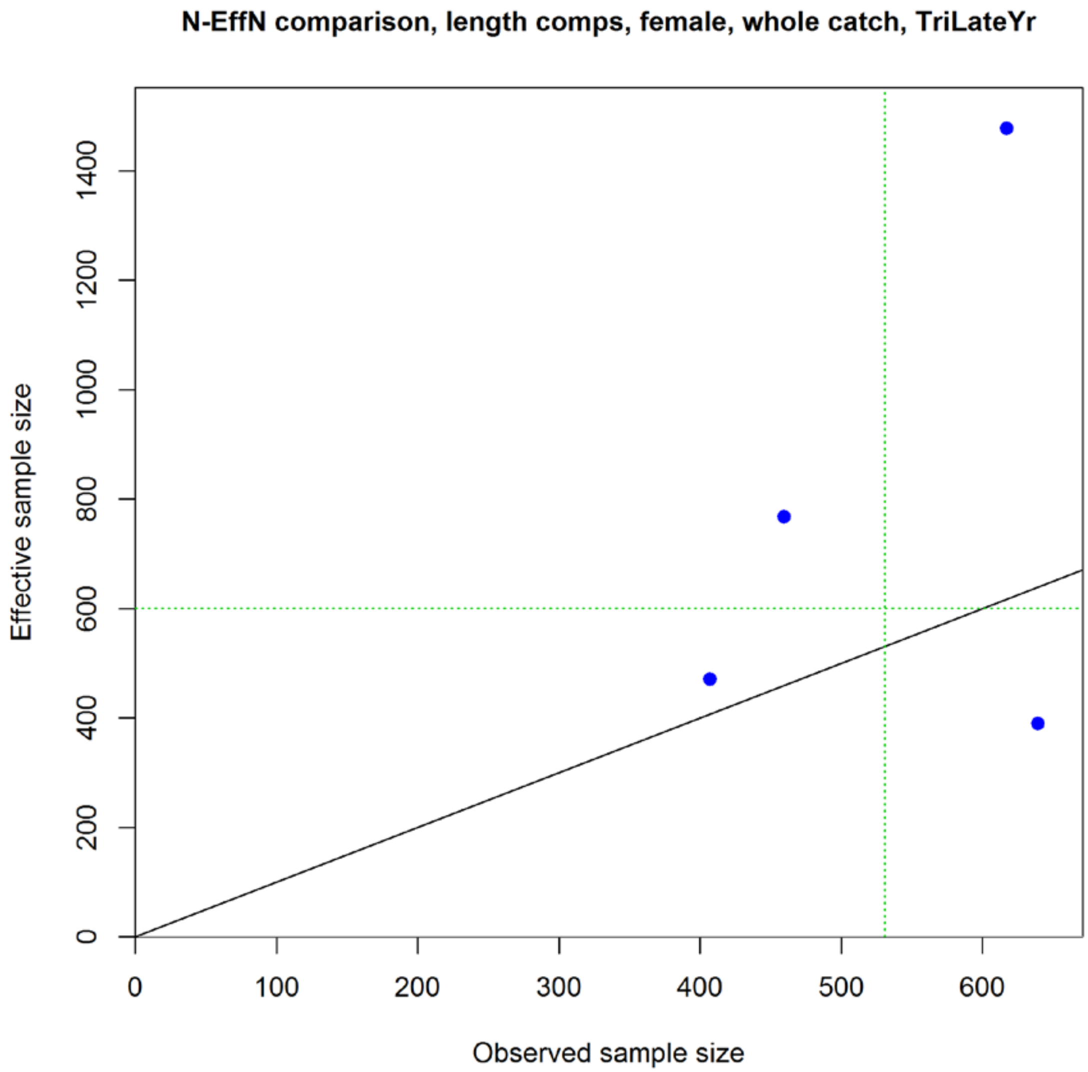


Figure 88. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the late time period triennial survey length frequency data.

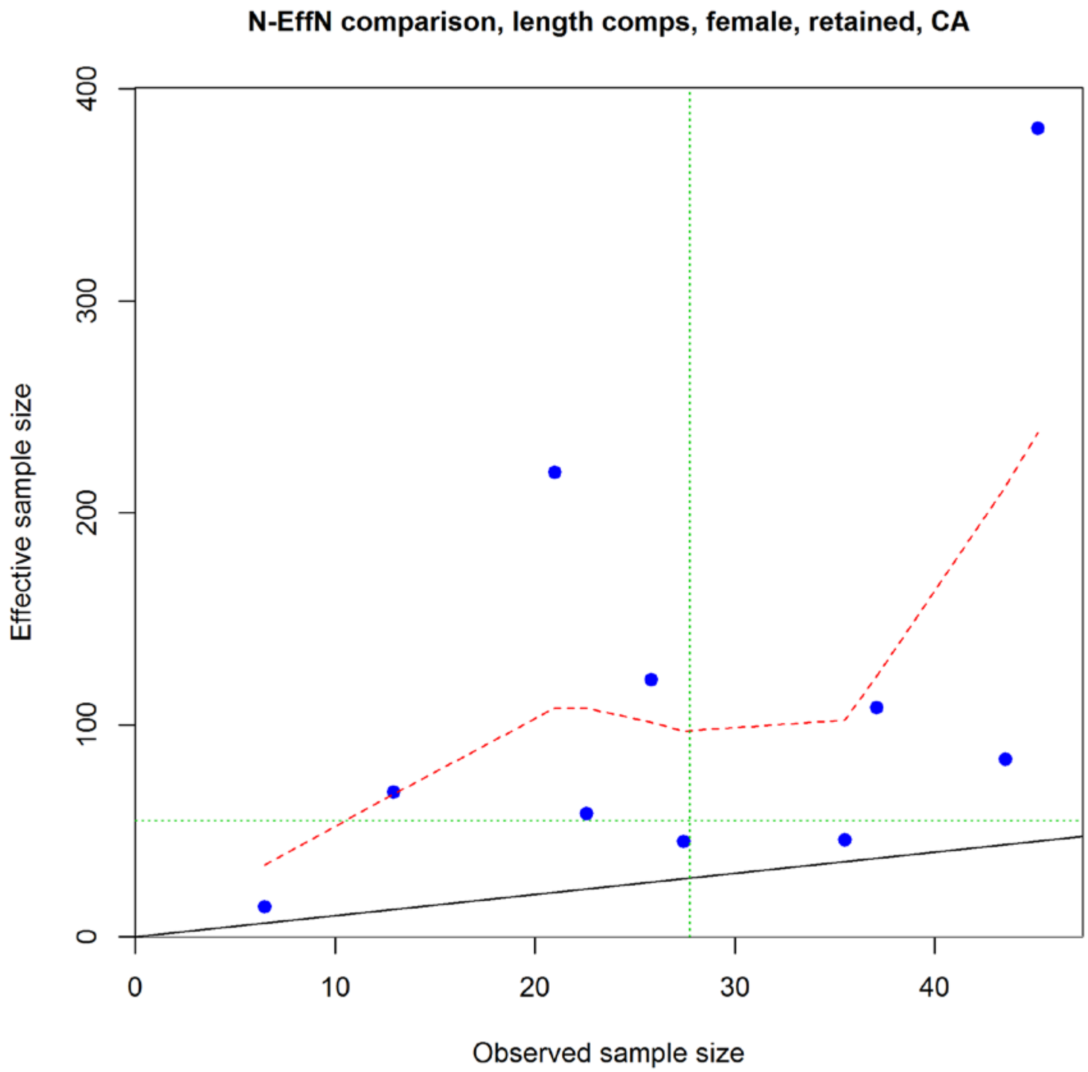


Figure 89. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the length frequency data of the CA retained catches.

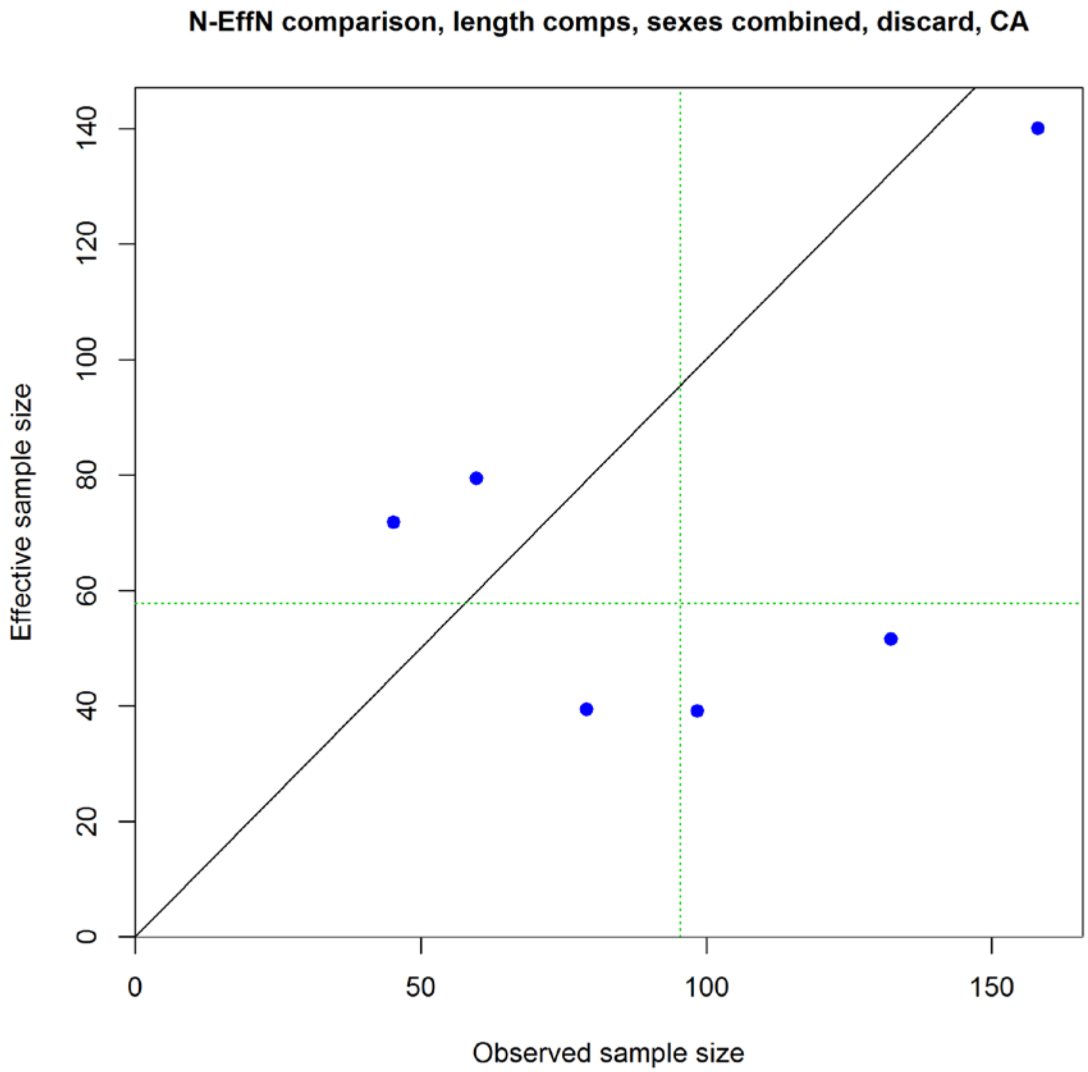


Figure 90. Observed and effective sample sizes for both sexes for the length frequency data of the CA discarded catches.

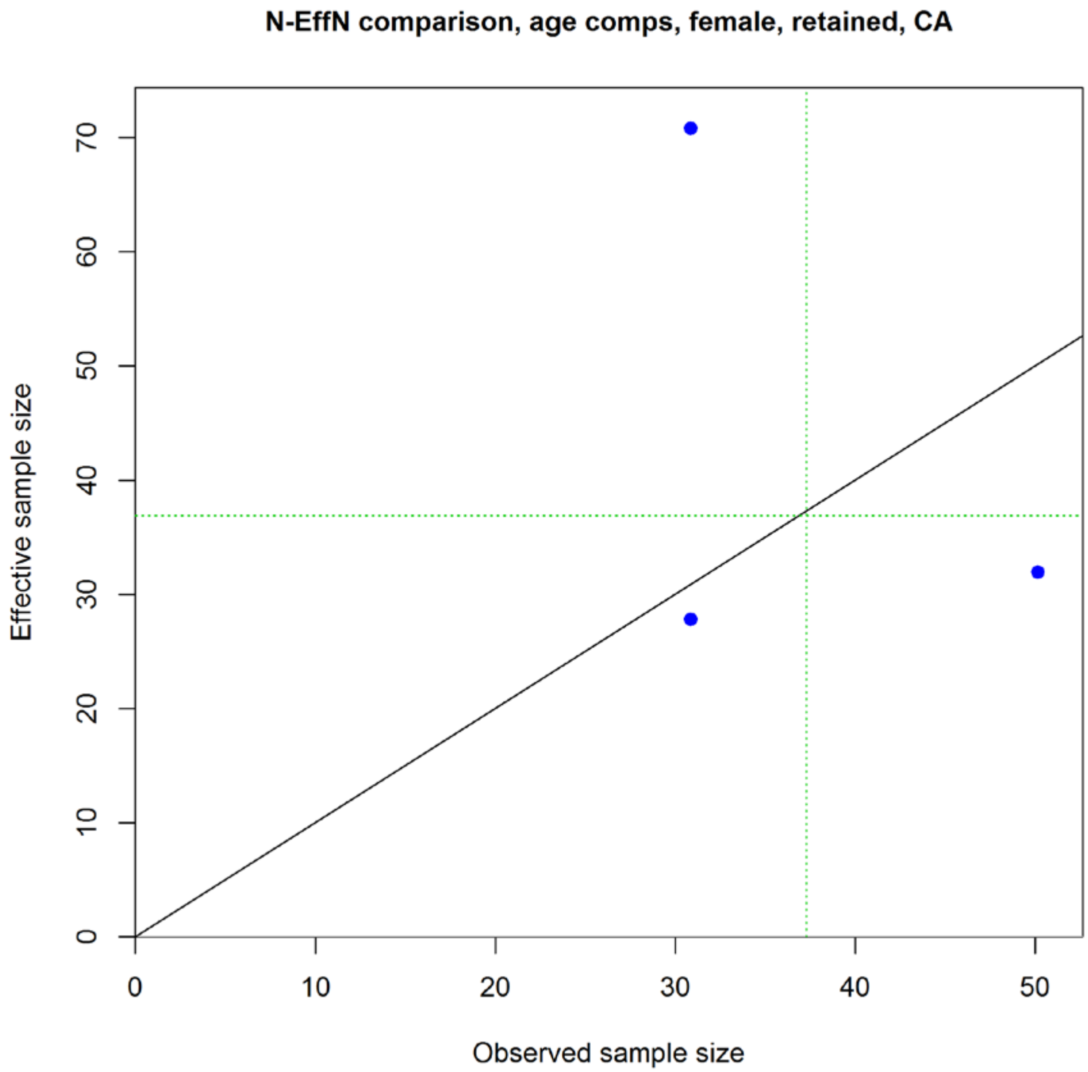


Figure 91. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the age frequency data of the CA retained catches.

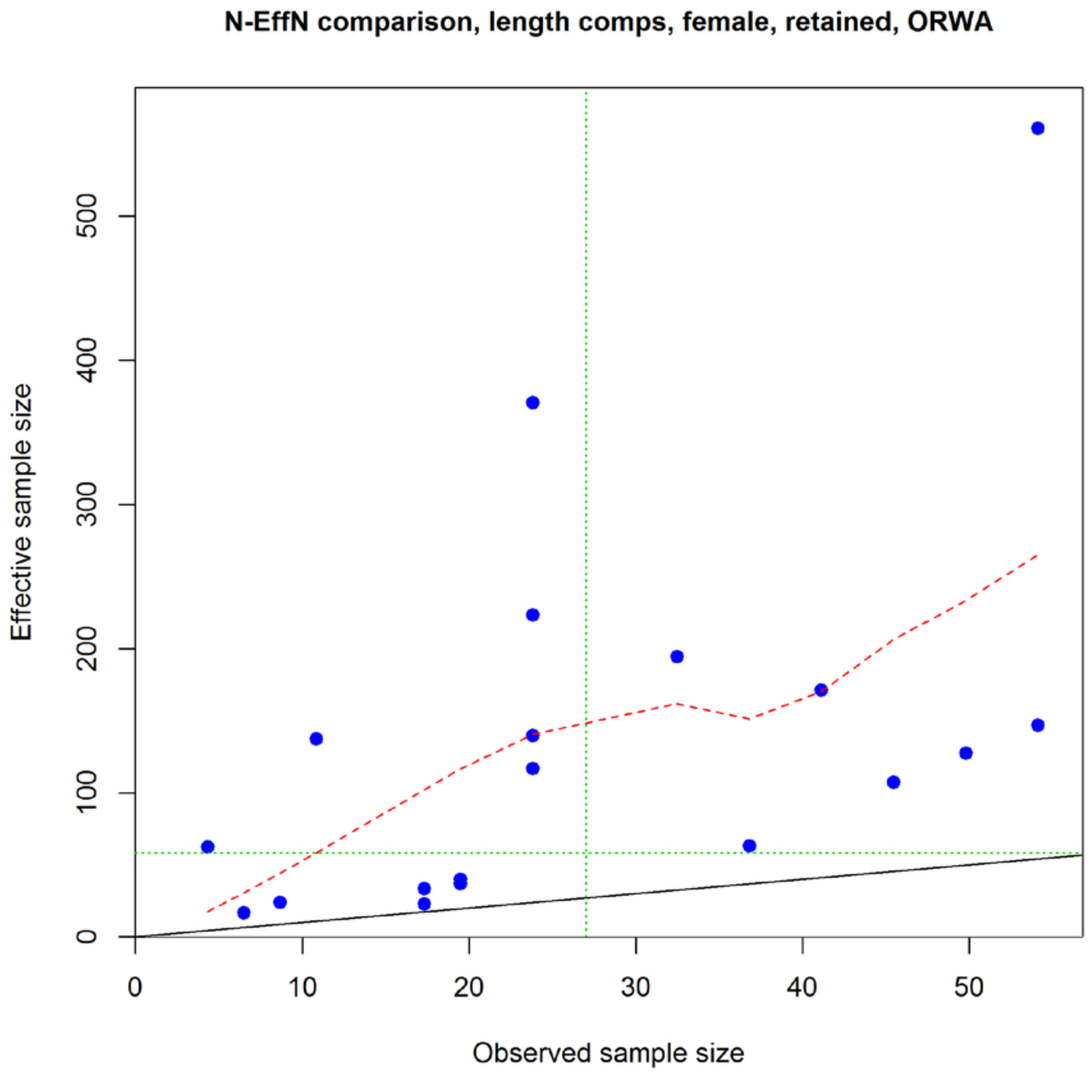


Figure 92. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the length frequency data of the OR/WA retained catches.

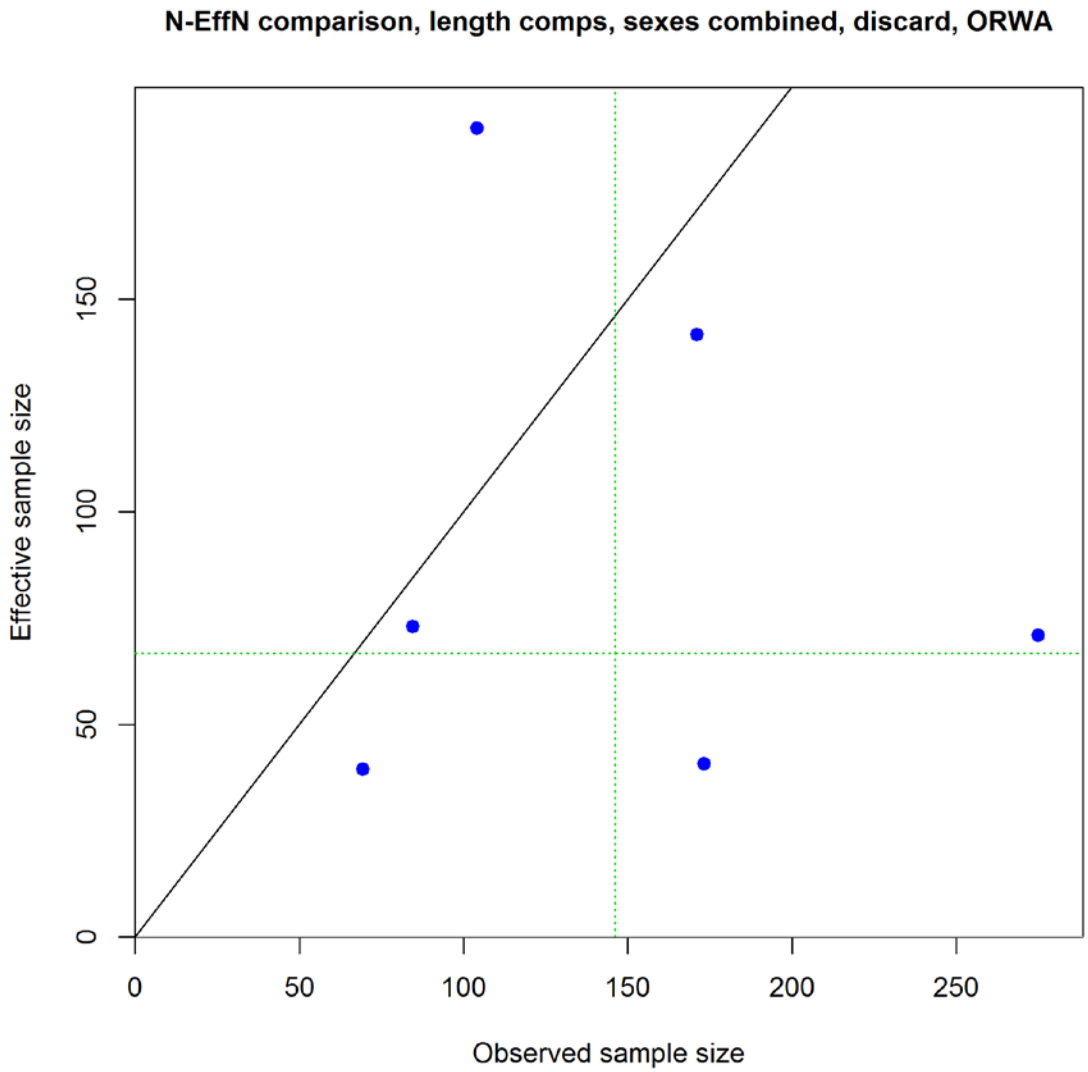


Figure 93. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the length frequency data of the OR/WA discarded catches.

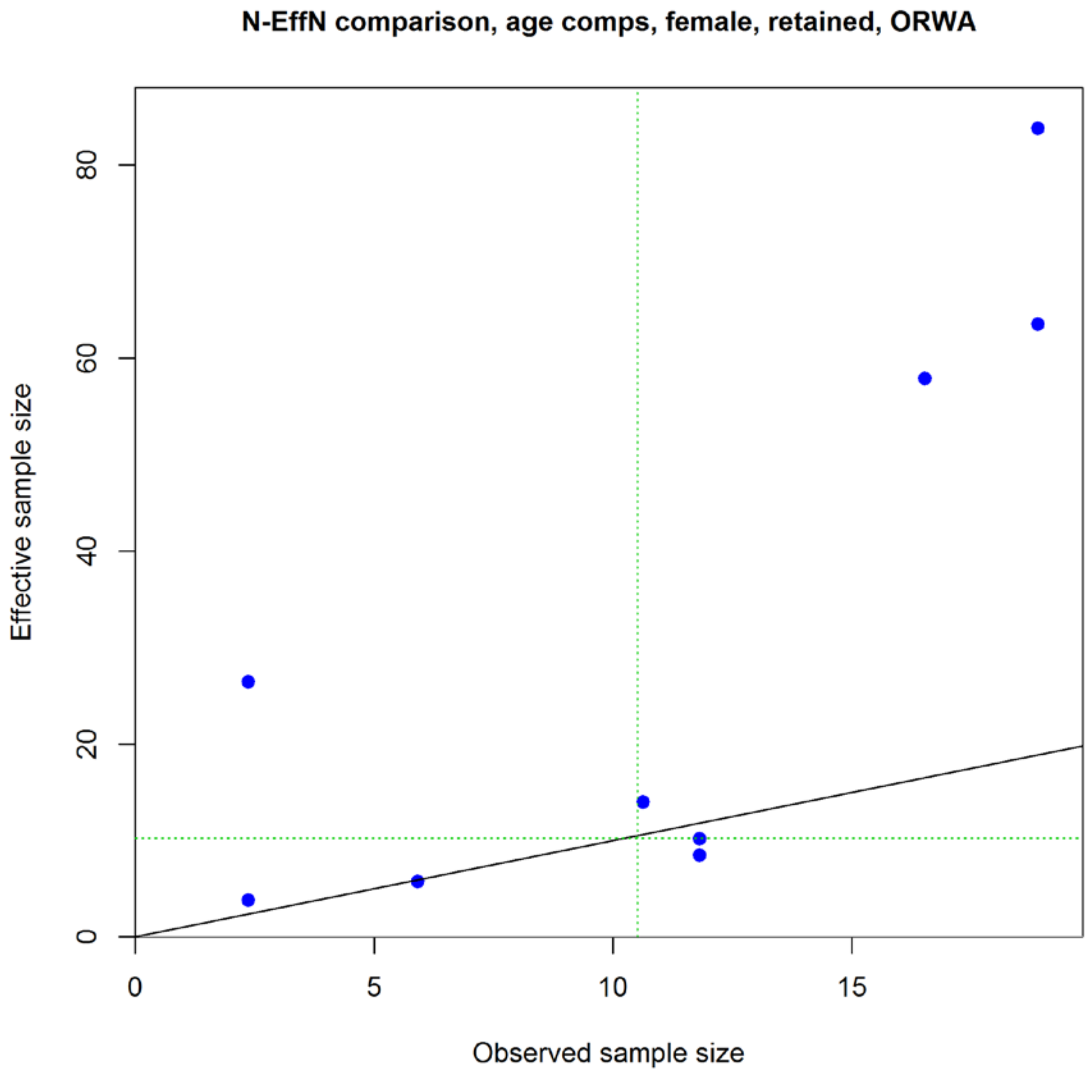


Figure 94. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the age frequency data of the OR/WA retained catches.

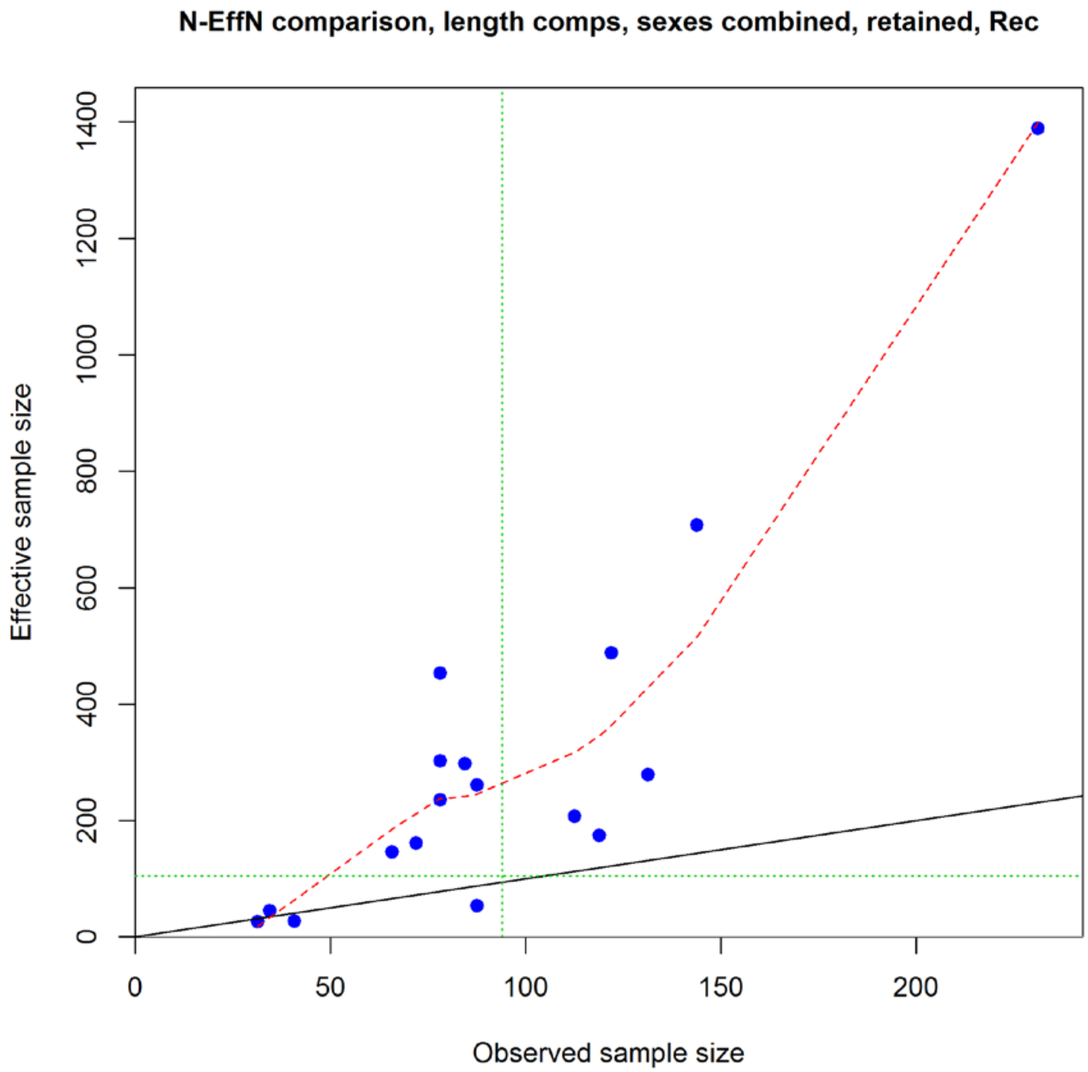


Figure 95. Observed and effective sample sizes for both sexes for the length frequency data from retained recreational catches.

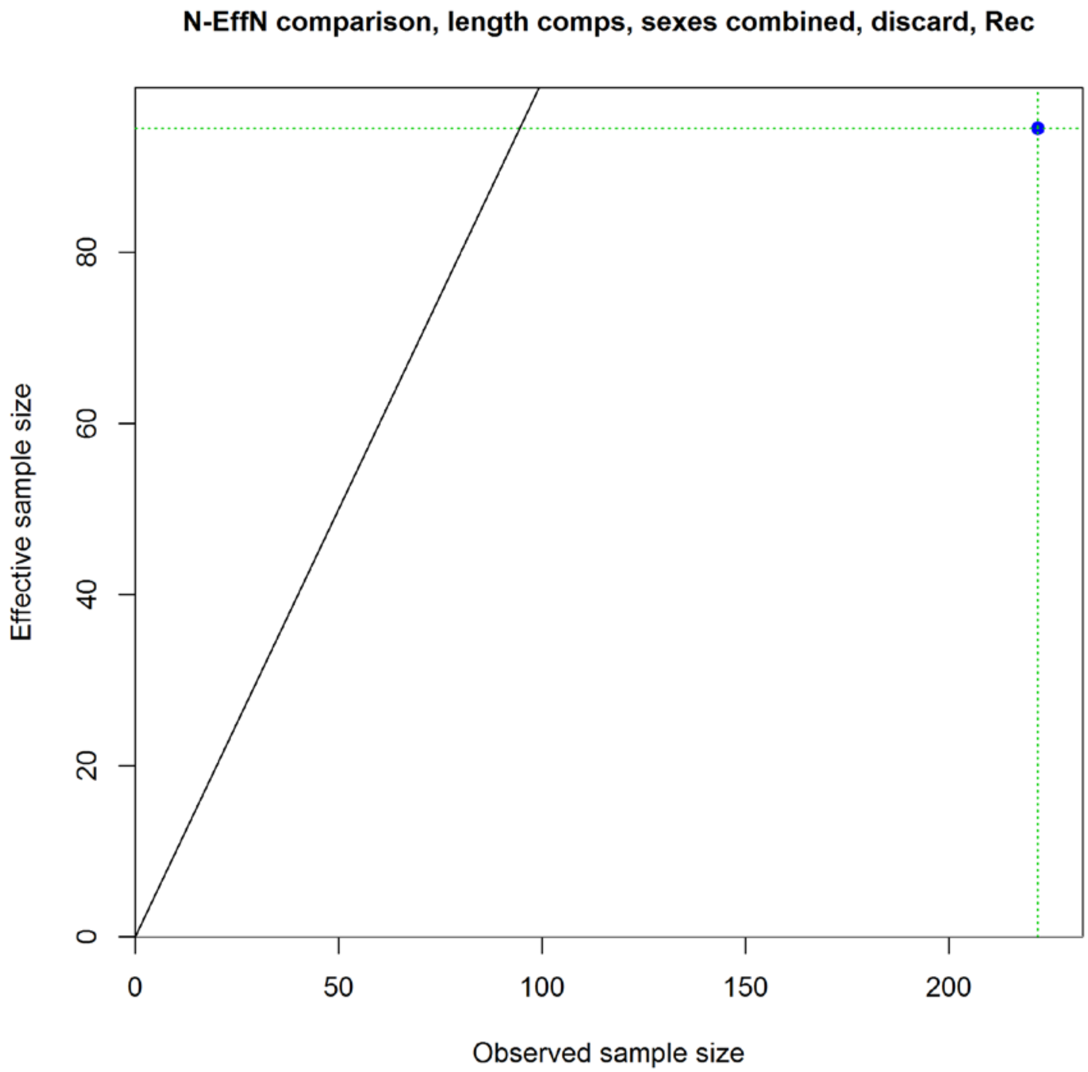


Figure 96. Observed and effective sample sizes for both sexes for the length frequency data from discarded recreational catches.

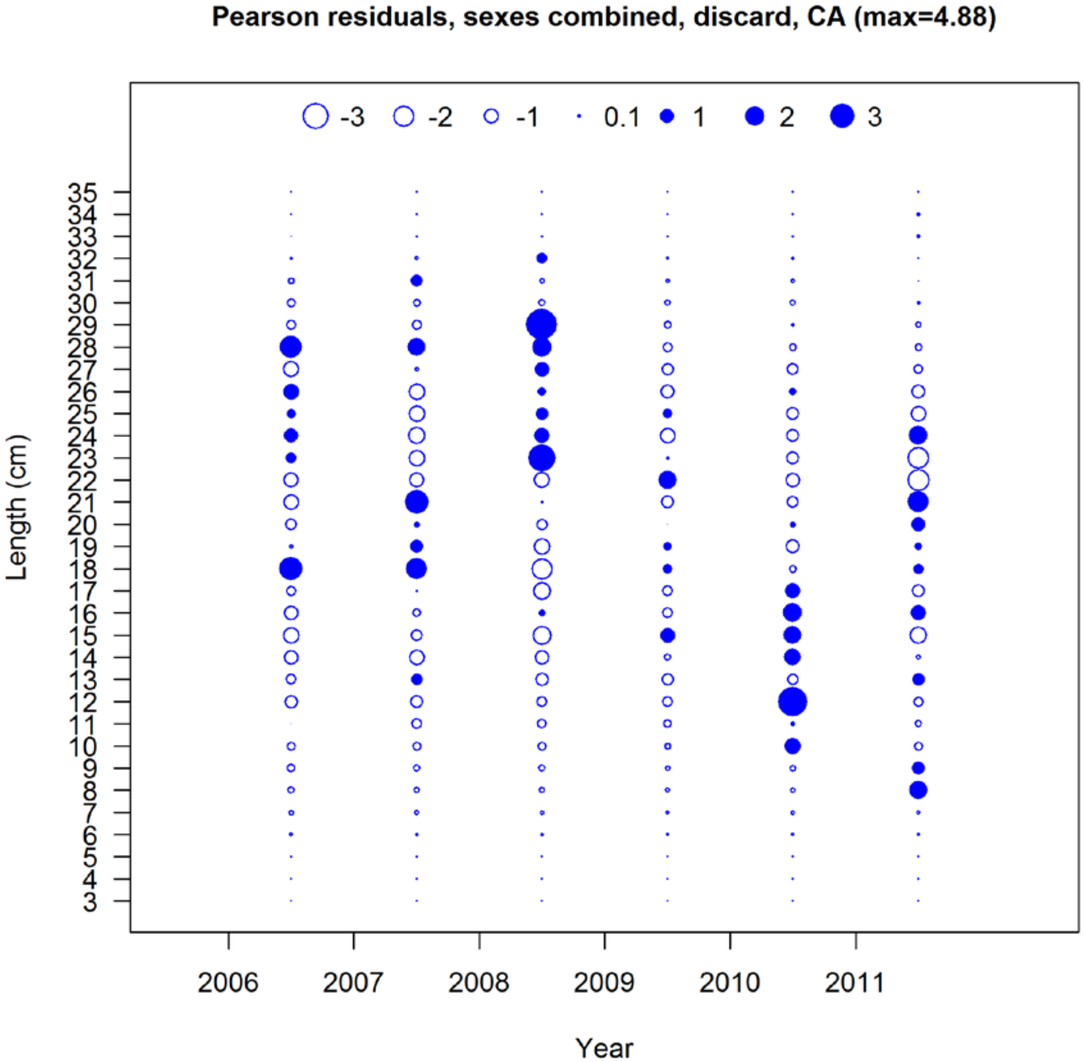


Figure 97. Pearson residuals of the base model fits to length frequency data from the WCGOP observer data from the California fishery between 2006 and 2011 (sex combined).

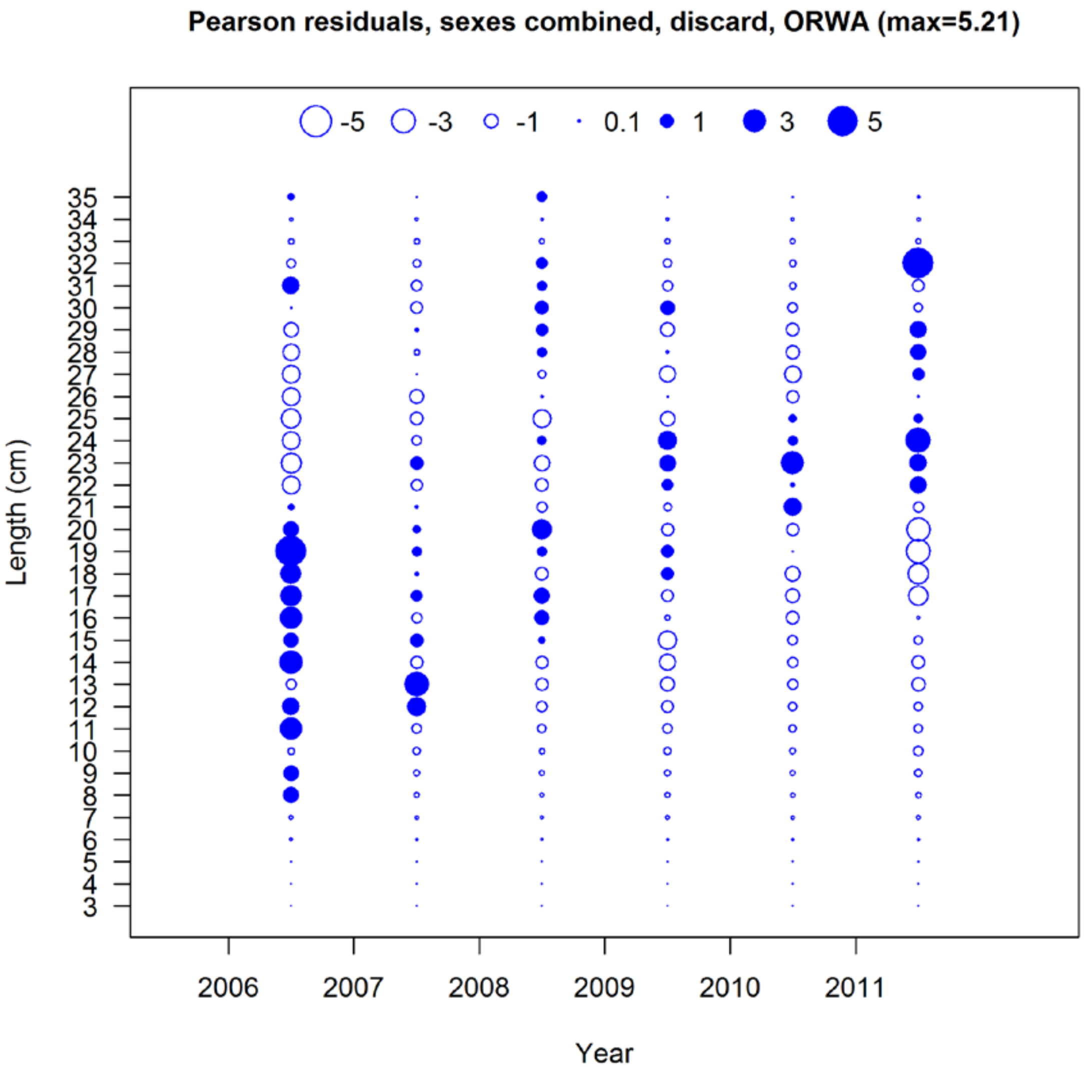


Figure 98. Pearson residuals of the base model fits to length frequency data from the WCGOP observer data from the OR/WA fishery between 2006 and 2011 (sex combined).

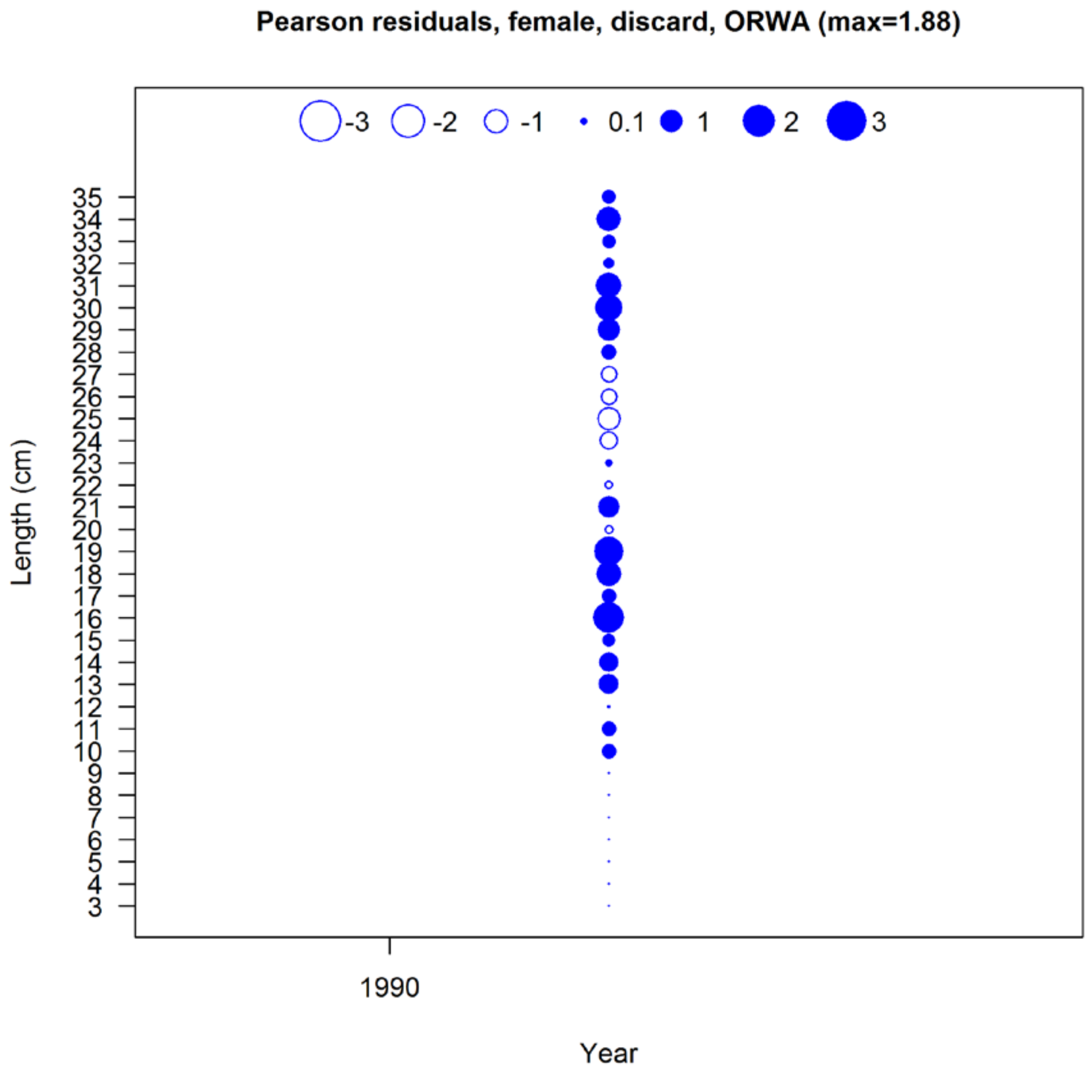


Figure 99. Pearson residuals of the base model fits to female discard length frequency data from the 1990 Pikitch study of the Oregon fishery.

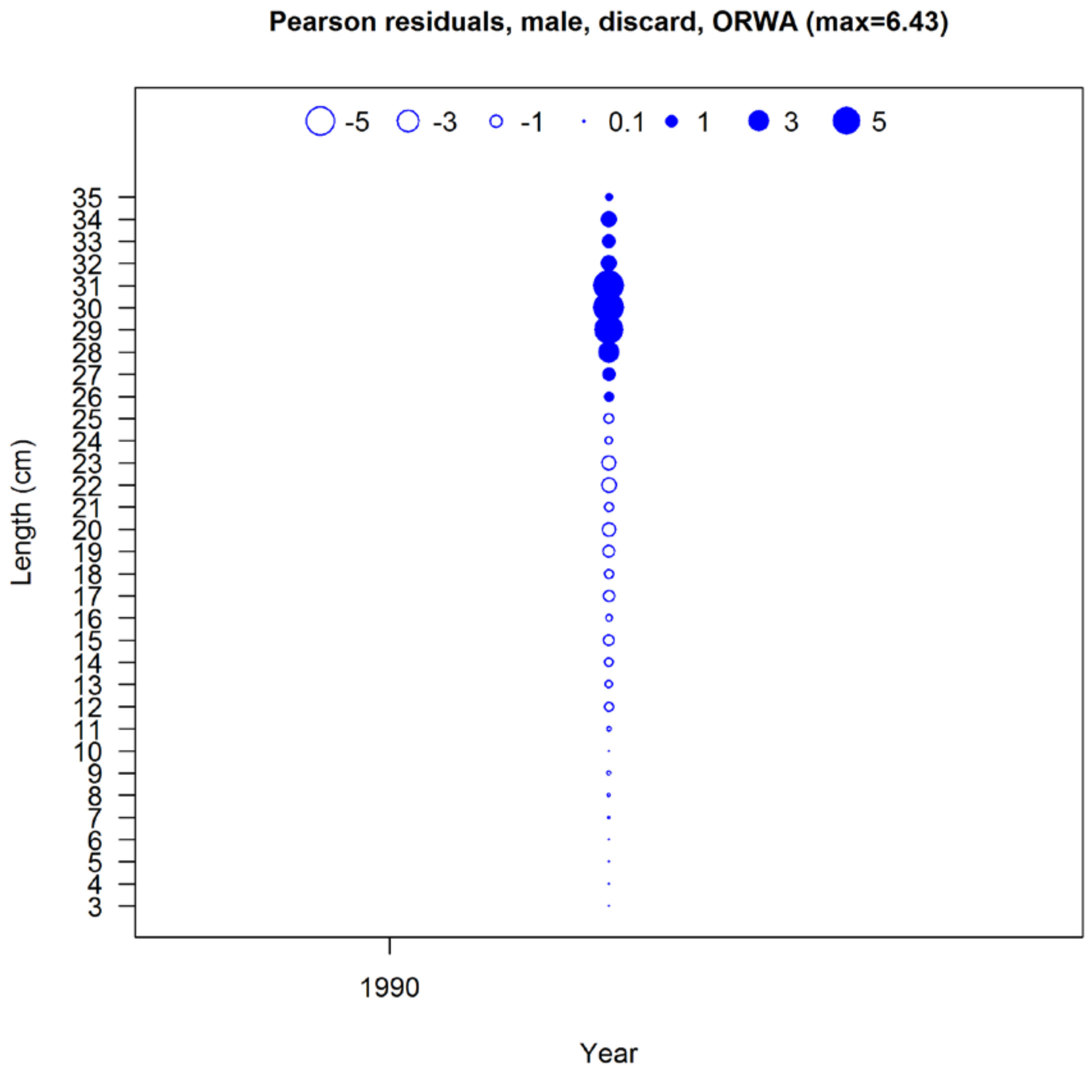


Figure 100. Pearson residuals of the base model fits to male discard length frequency data from the 1990 Pikitch study of the Oregon fishery.

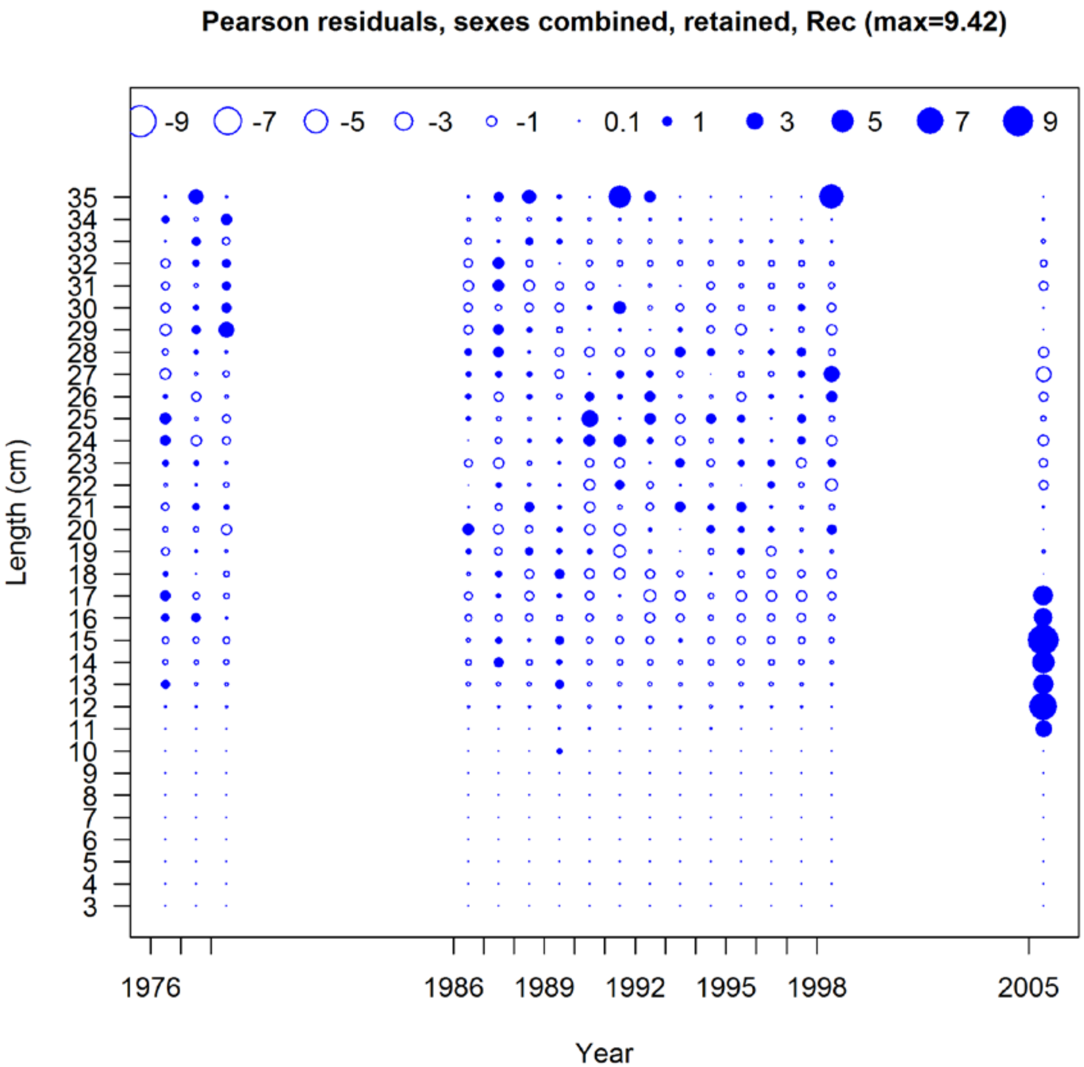


Figure 101. Pearson residuals of the base model fits to length frequency data from the recreational fishery (sex combined).

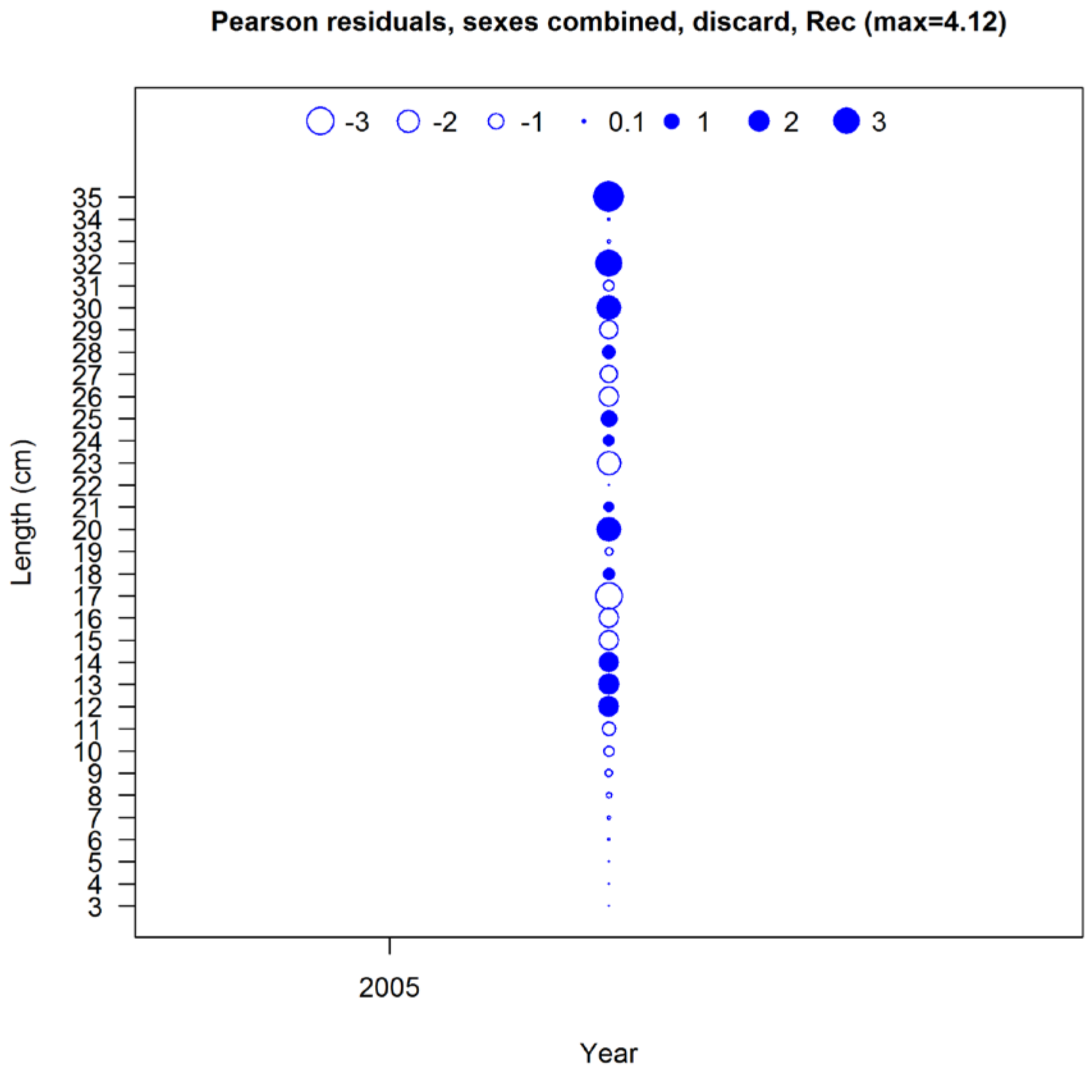


Figure 102. Pearson residuals of the base model fits to length frequency data from the 2005 recreational fishery (sex combined).

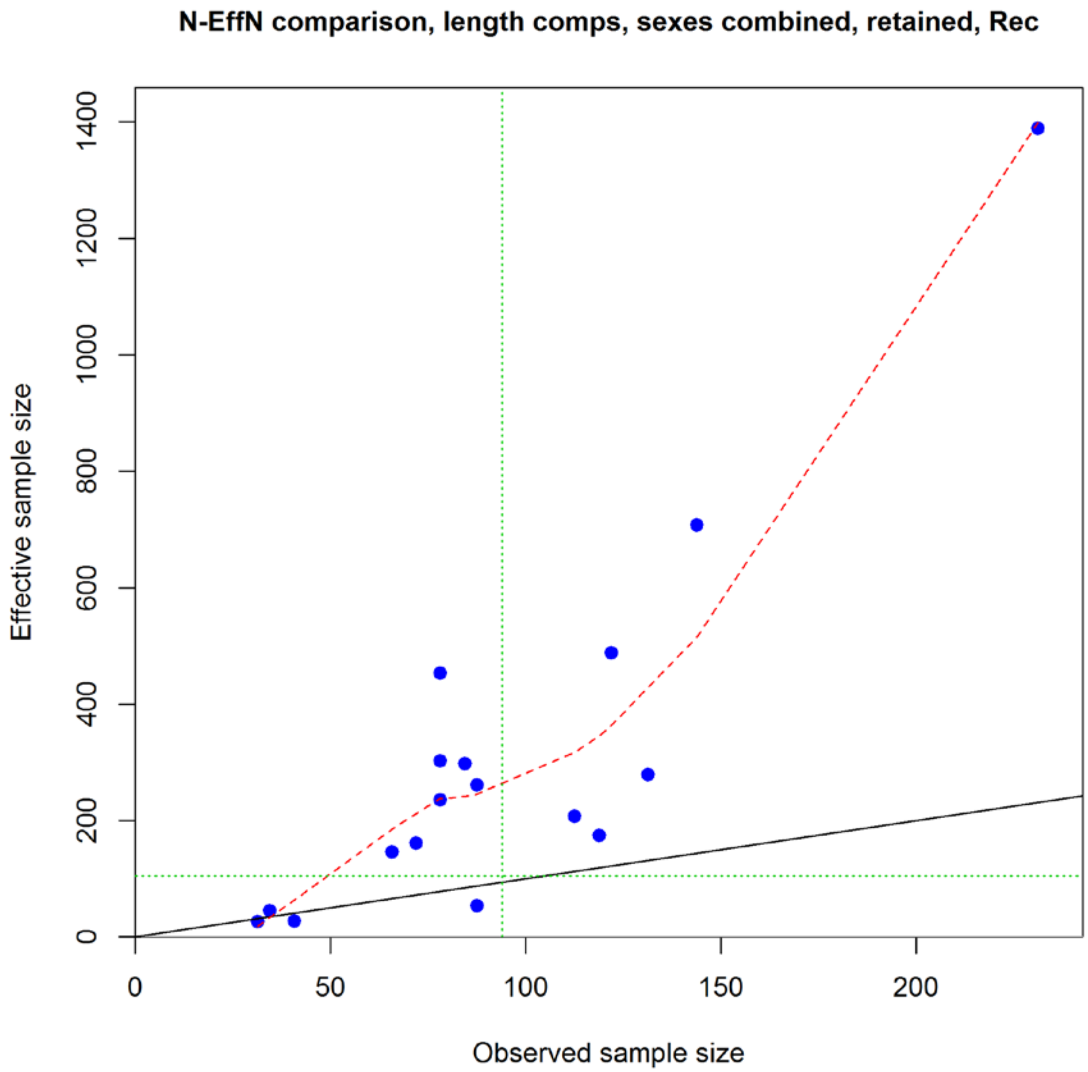


Figure 103. Observed and effective sample sizes for the length frequency distributions for the recreational fishery (retained catches and sexes combined).

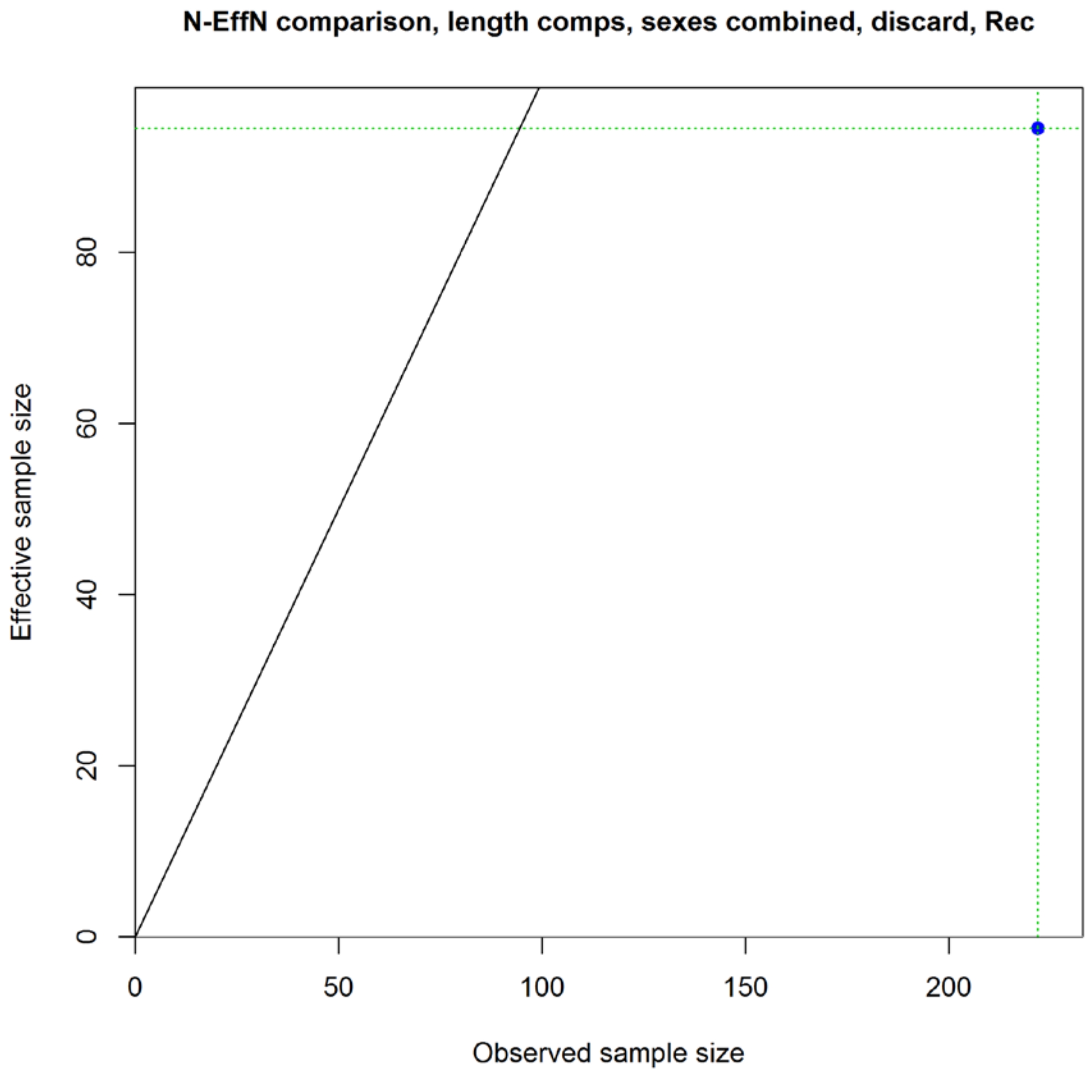


Figure 104. Observed and effective sample sizes for the length frequency distributions for the recreational fishery (discarded catch and sexes combined). Only one year data in 2005 were available.

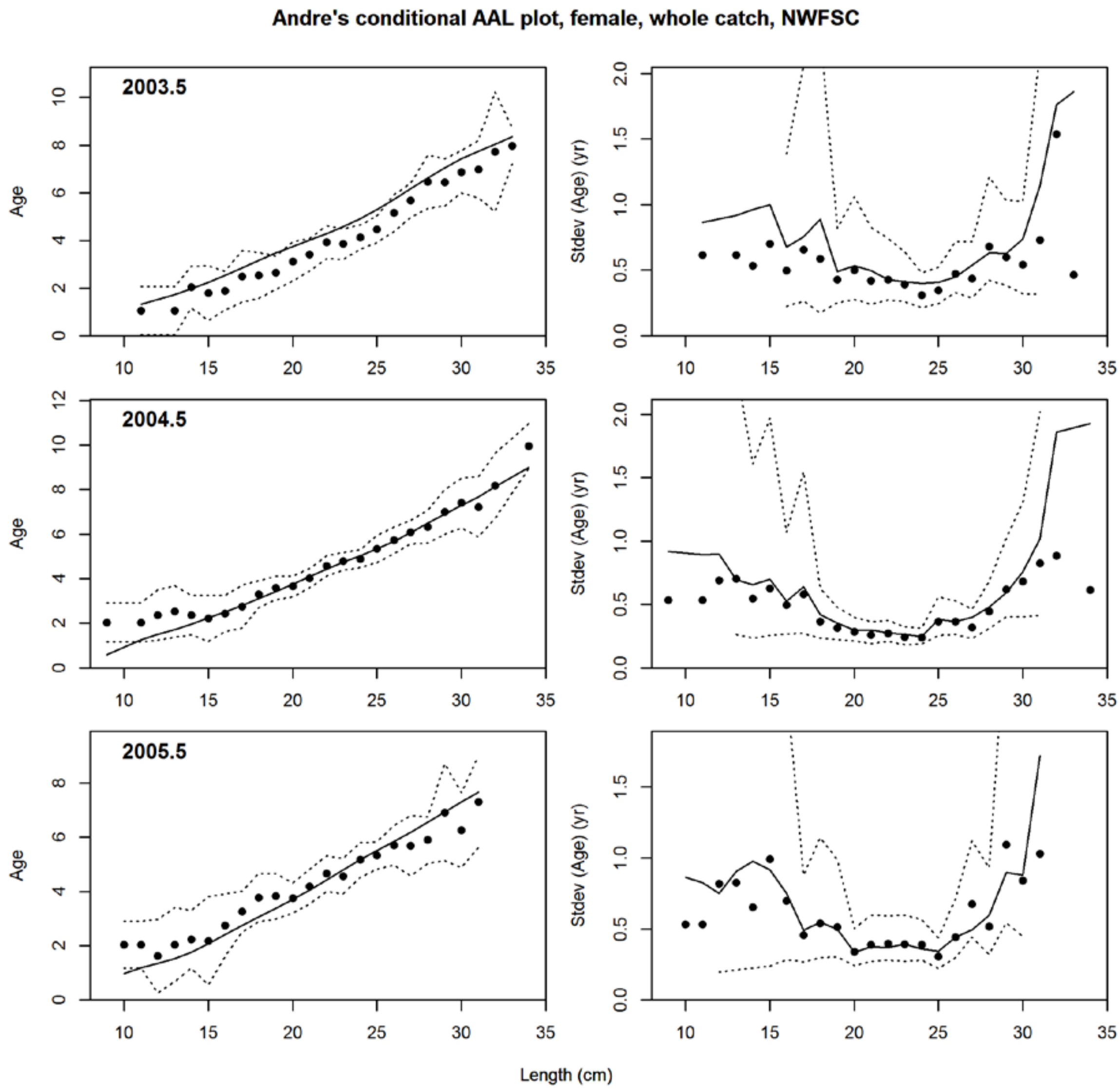


Figure 105. Conditional age-at-length and their standard deviations by year and by sex for the NWFSC survey data (page 1 of 6).

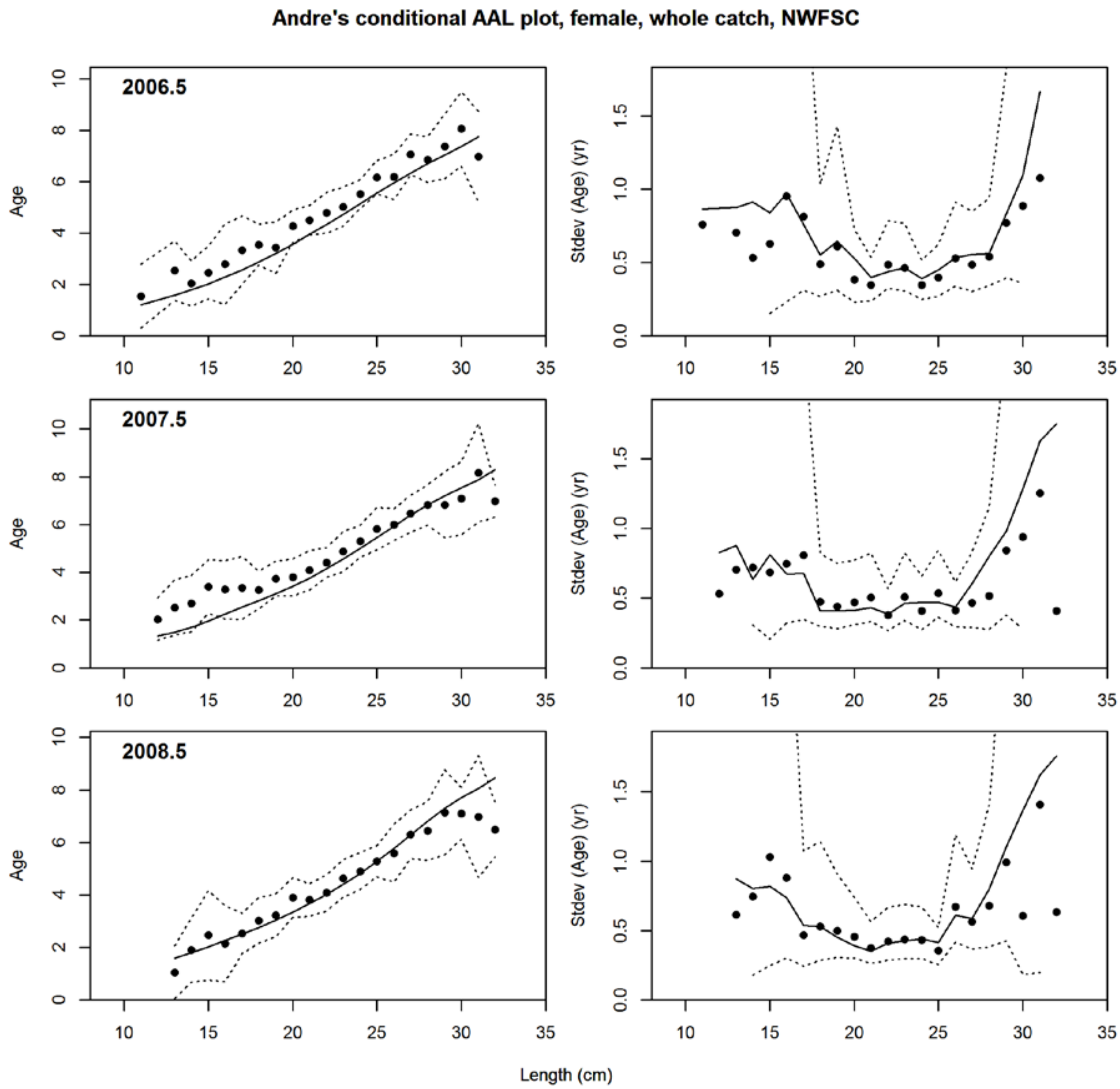


Figure (continued). Conditional age-at-length and their standard deviations by year and by sex for the NWFSC survey data (page 2 of 6).

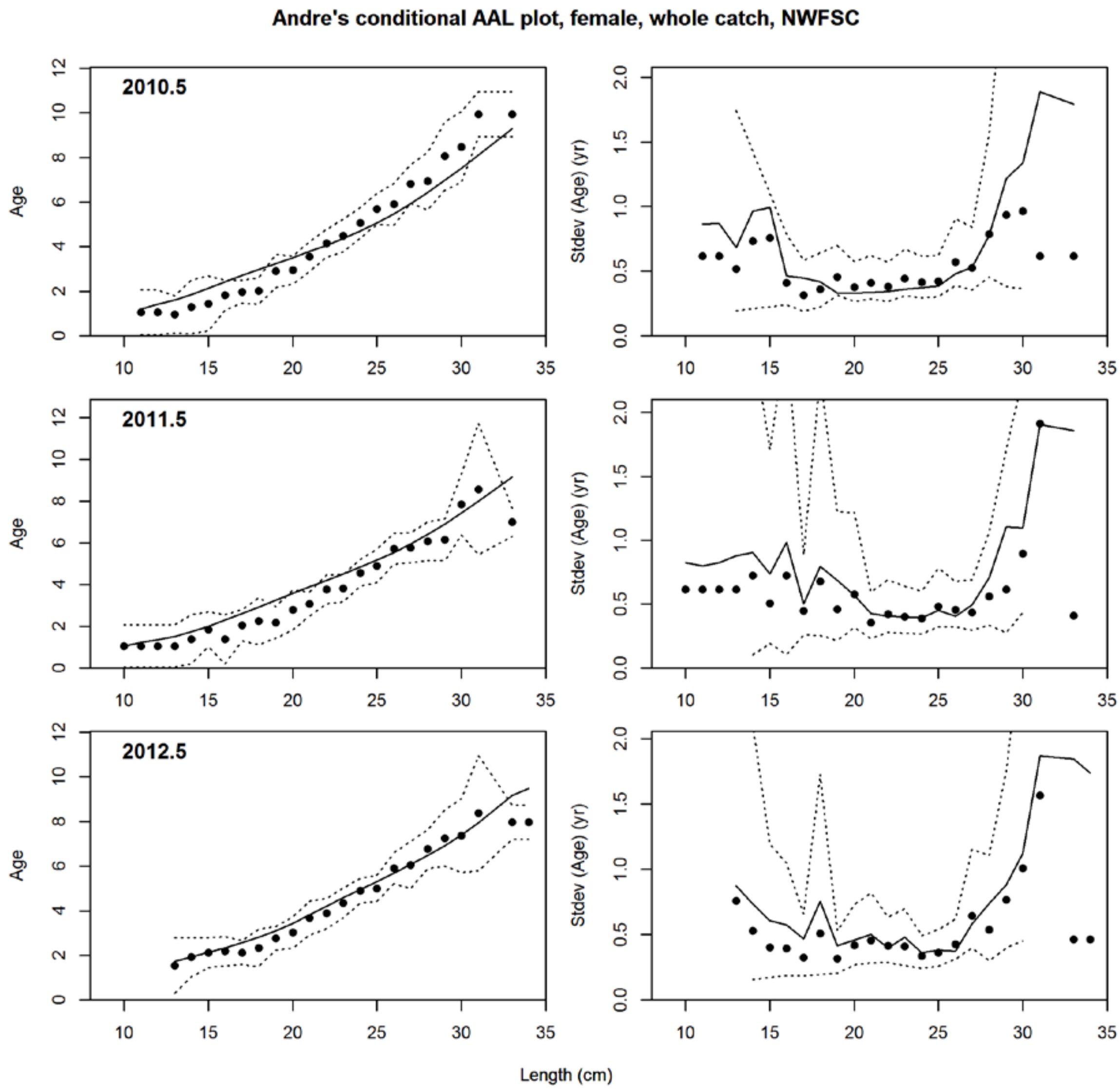


Figure (continued). Conditional age-at-length and their standard deviations by year and by sex for the NWFSC survey data (page 3 of 6).

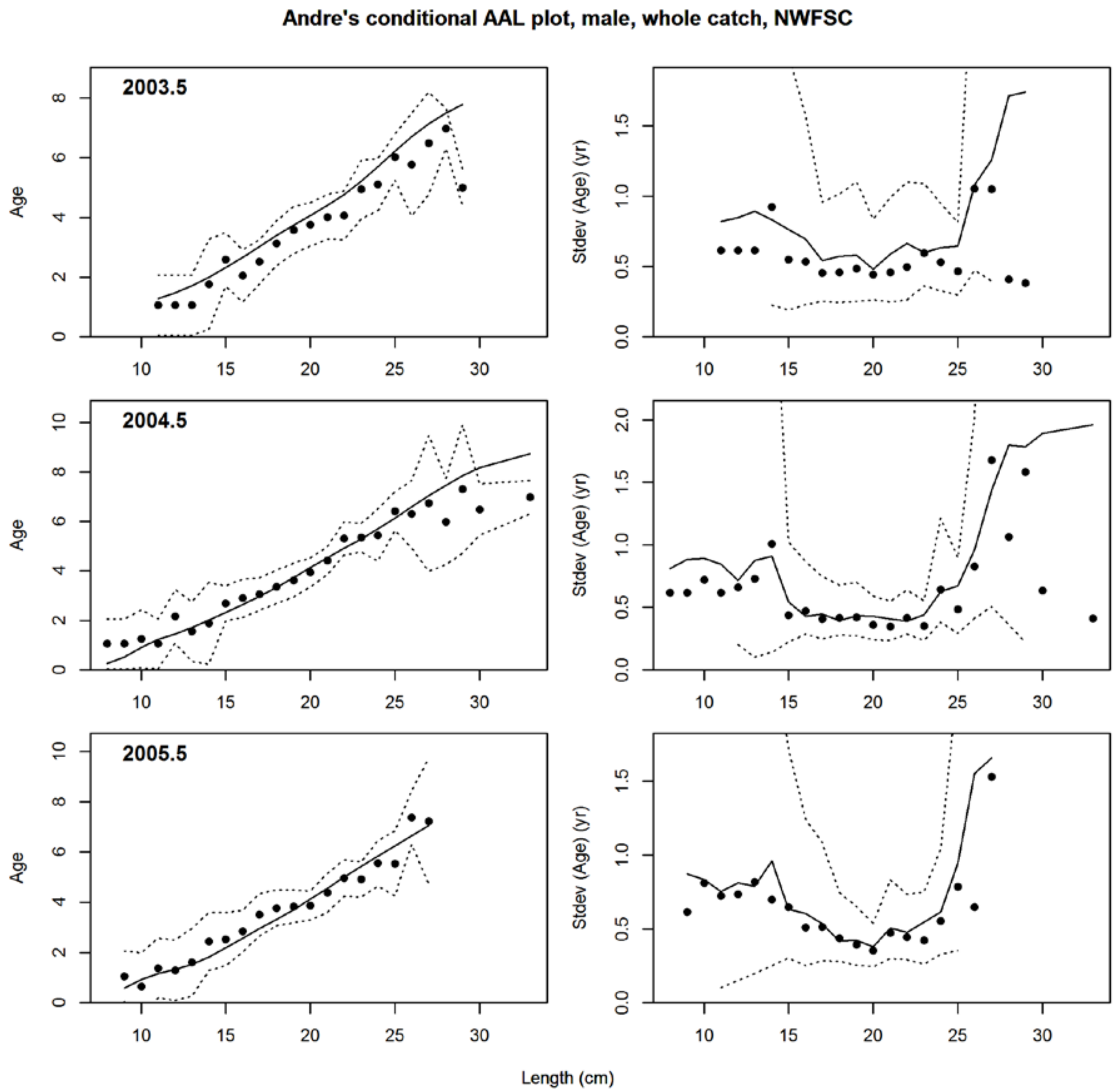


Figure (continued). Conditional age-at-length and their standard deviations by year and by sex for the NWFSC survey data (page 4 of 6).

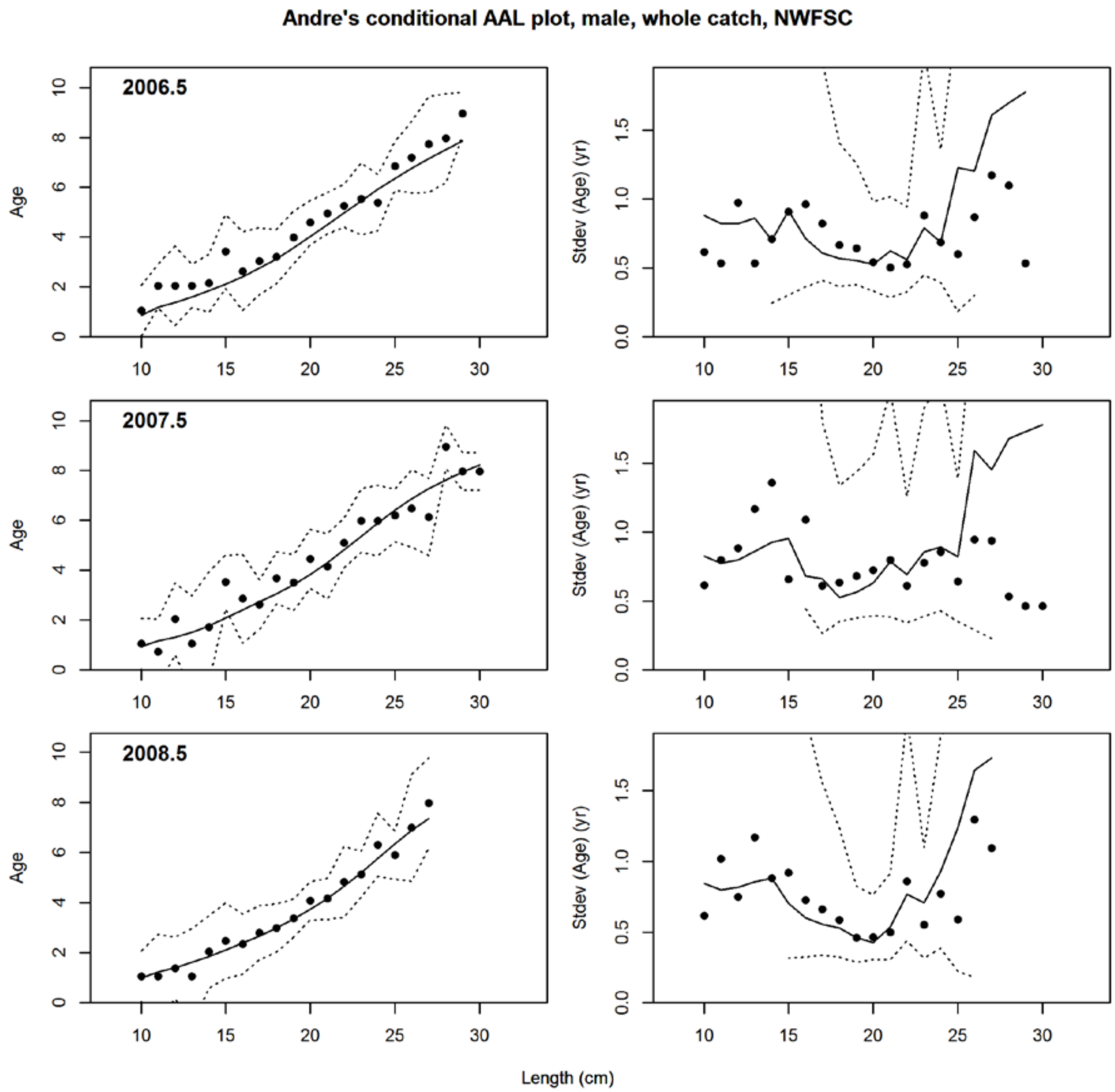


Figure (continued). Conditional age-at-length and their standard deviations by year and by sex for the NWFSC survey data (page 5 of 6).

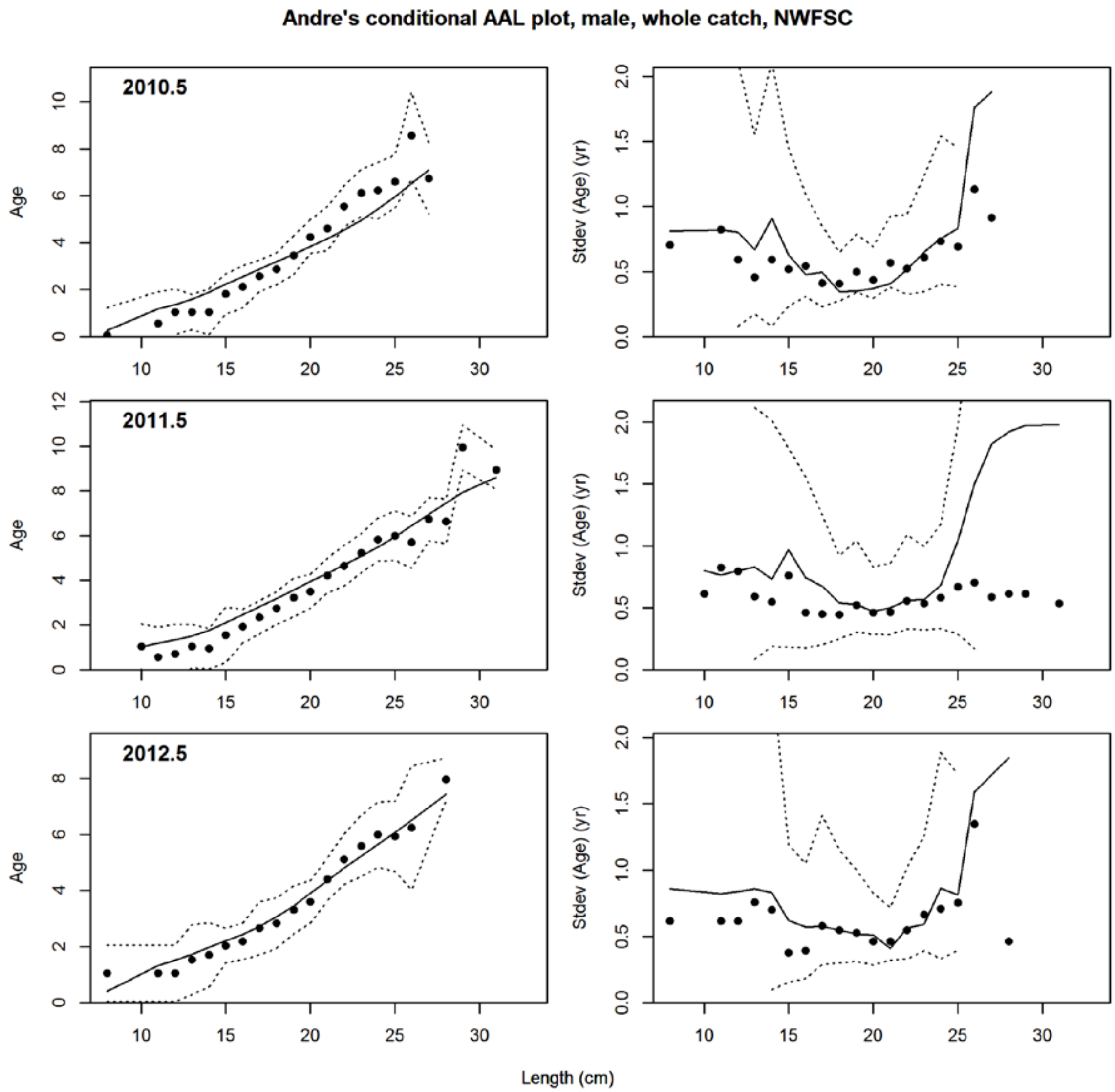


Figure (continued). Conditional age-at-length and their standard deviations by year and by sex for the NWFSC survey data (page 6 of 6).

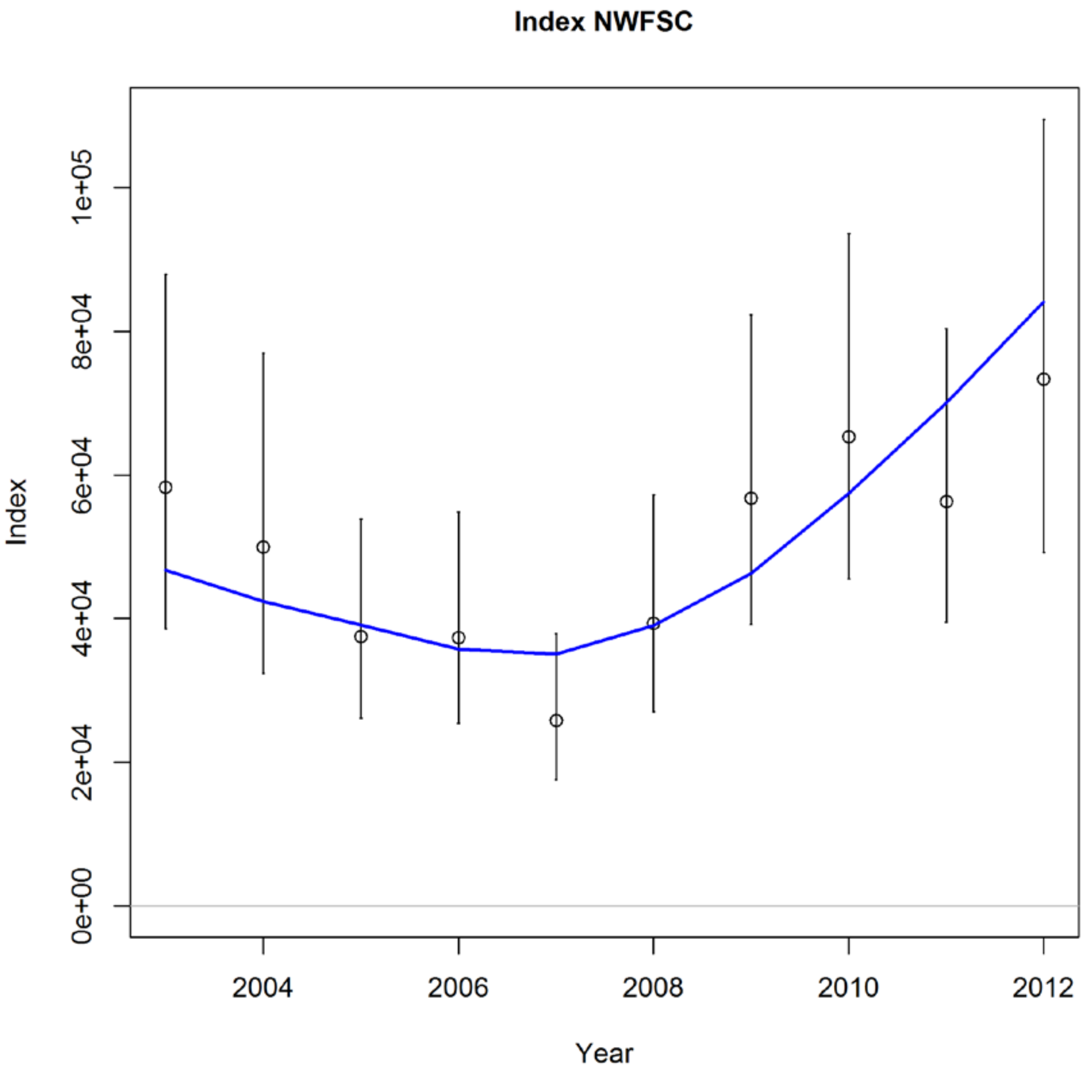


Figure 106. Fits of base model outputs to the NWFSC survey.

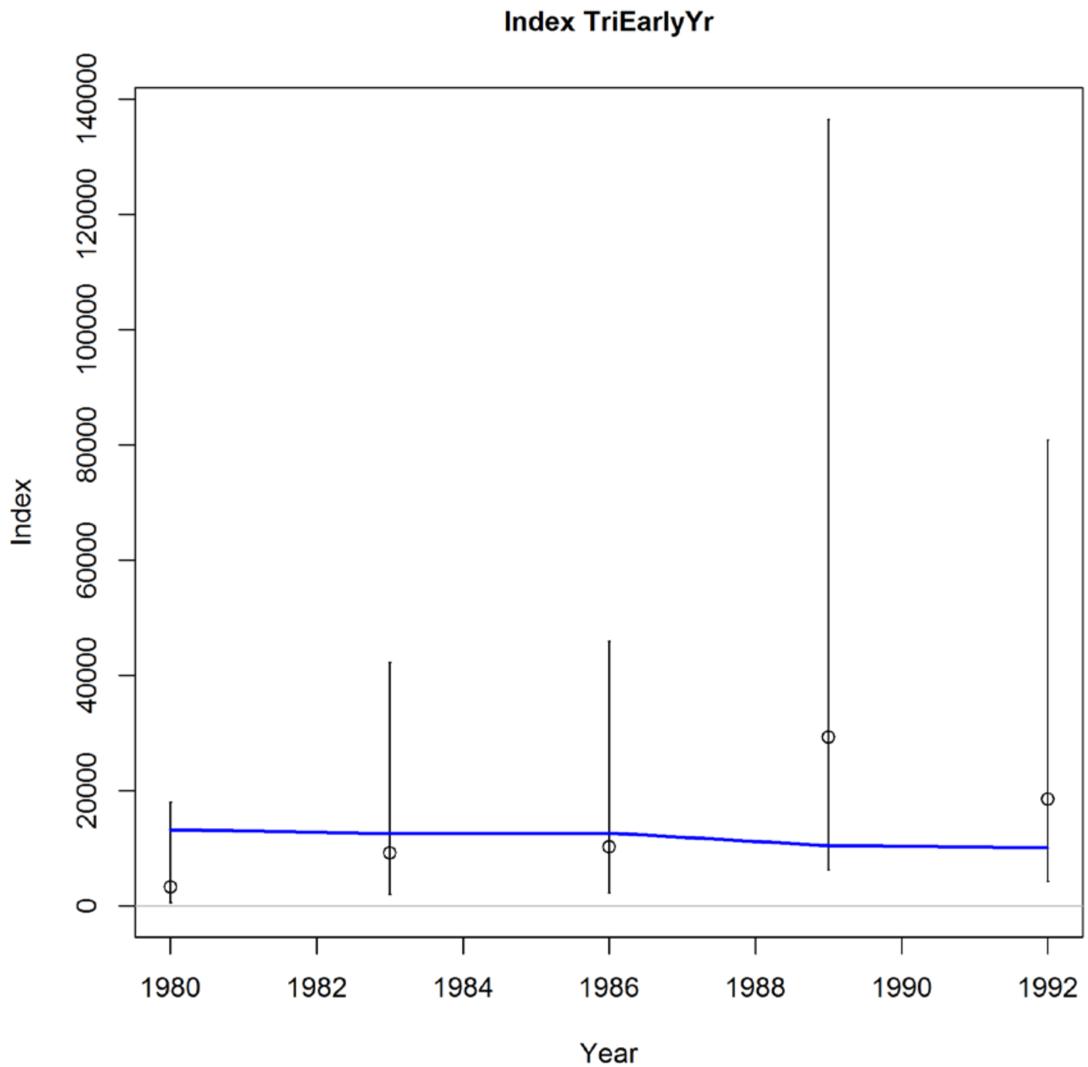


Figure 107. Fits of base model outputs to the early period of the triennial trawl survey.

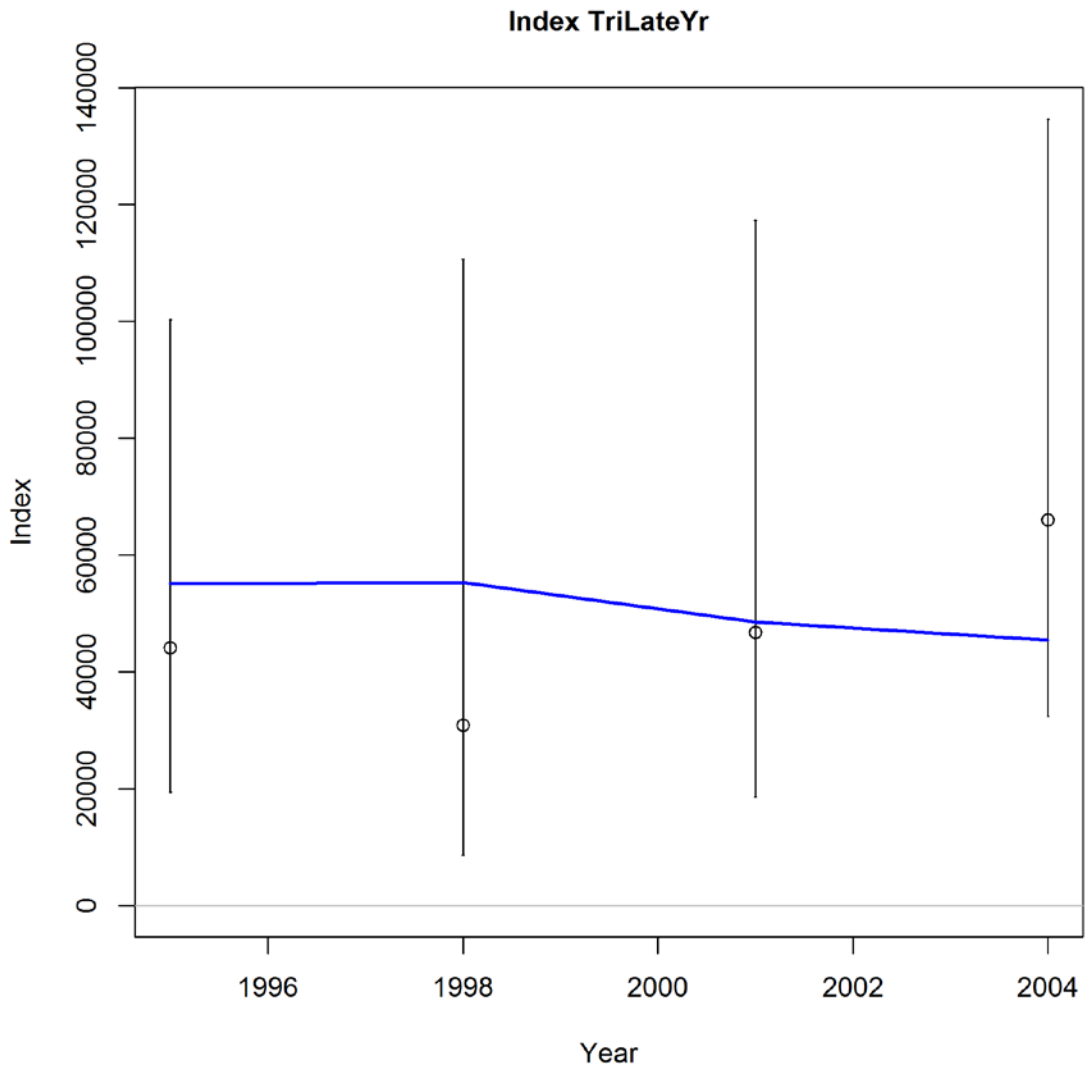


Figure 108. Fits of base model outputs to the late period of the triennial trawl survey.

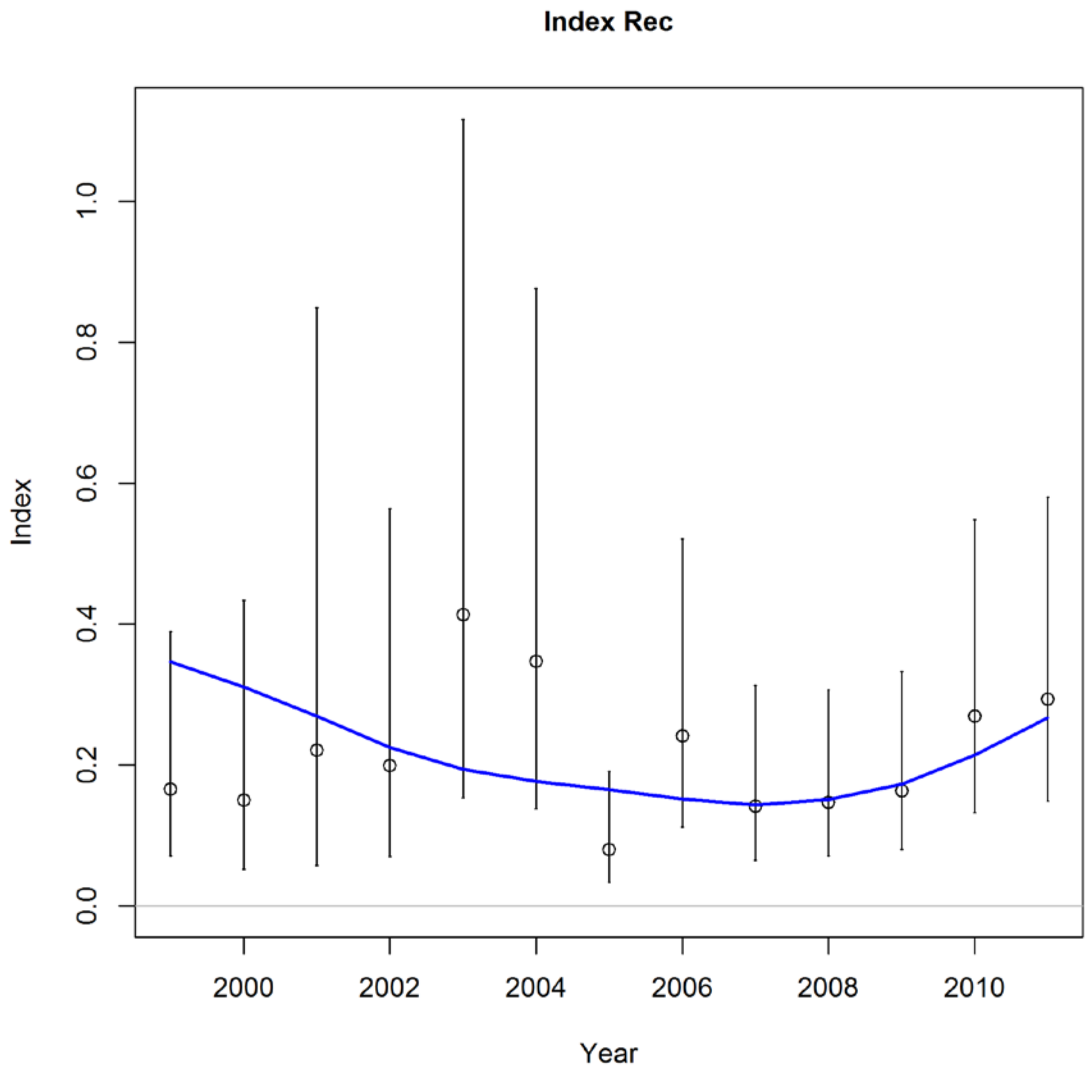


Figure 109. Fits of base model outputs to the recreational survey.

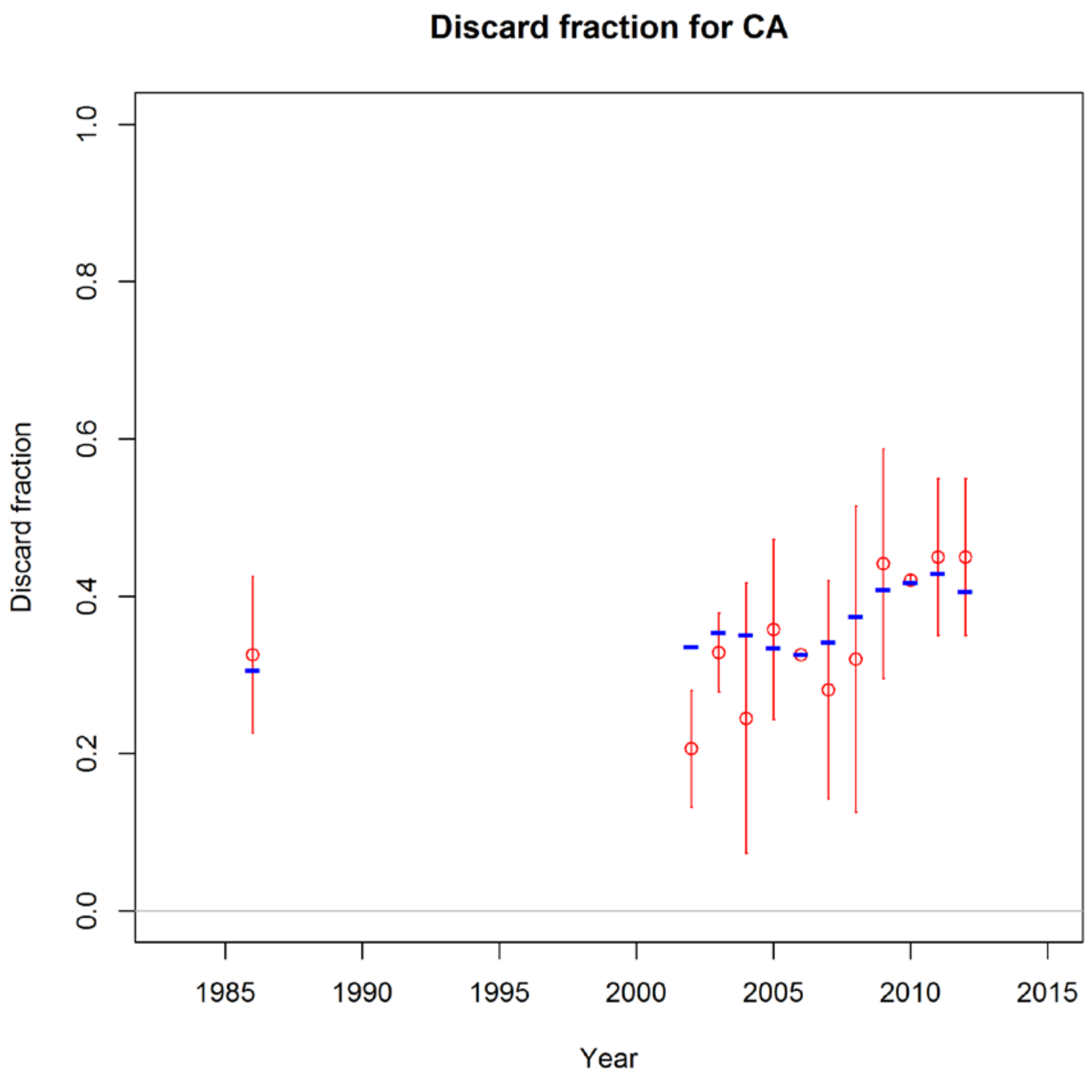


Figure 110. Fits of base model estimates of discard ratios (blue) to inputted values and standard deviations (red circle and line) for the CA fishery.

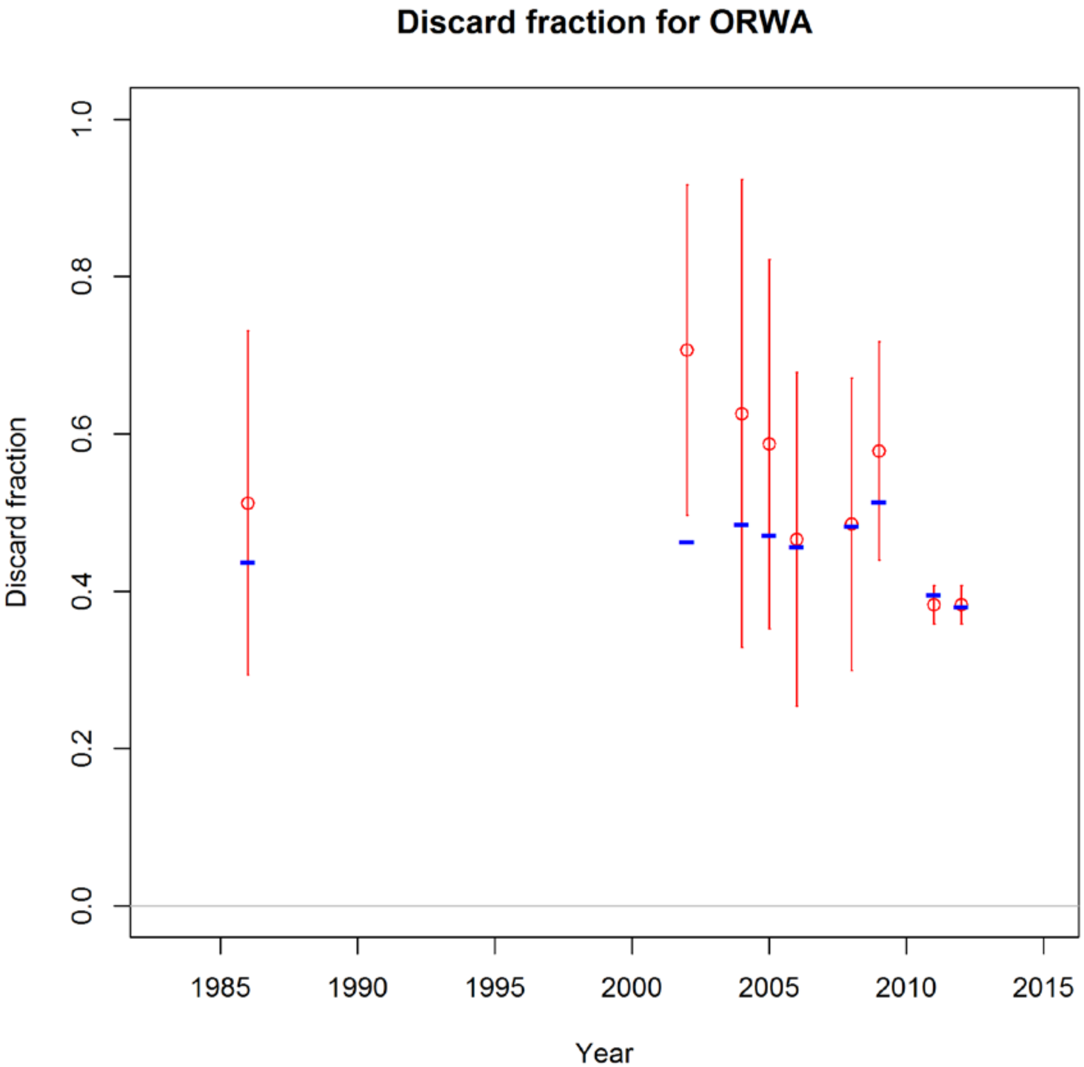


Figure 111. Fits of base model estimates of discard ratios (blue) to inputted values and standard deviations (red circle and line) for the OR/WA fishery.

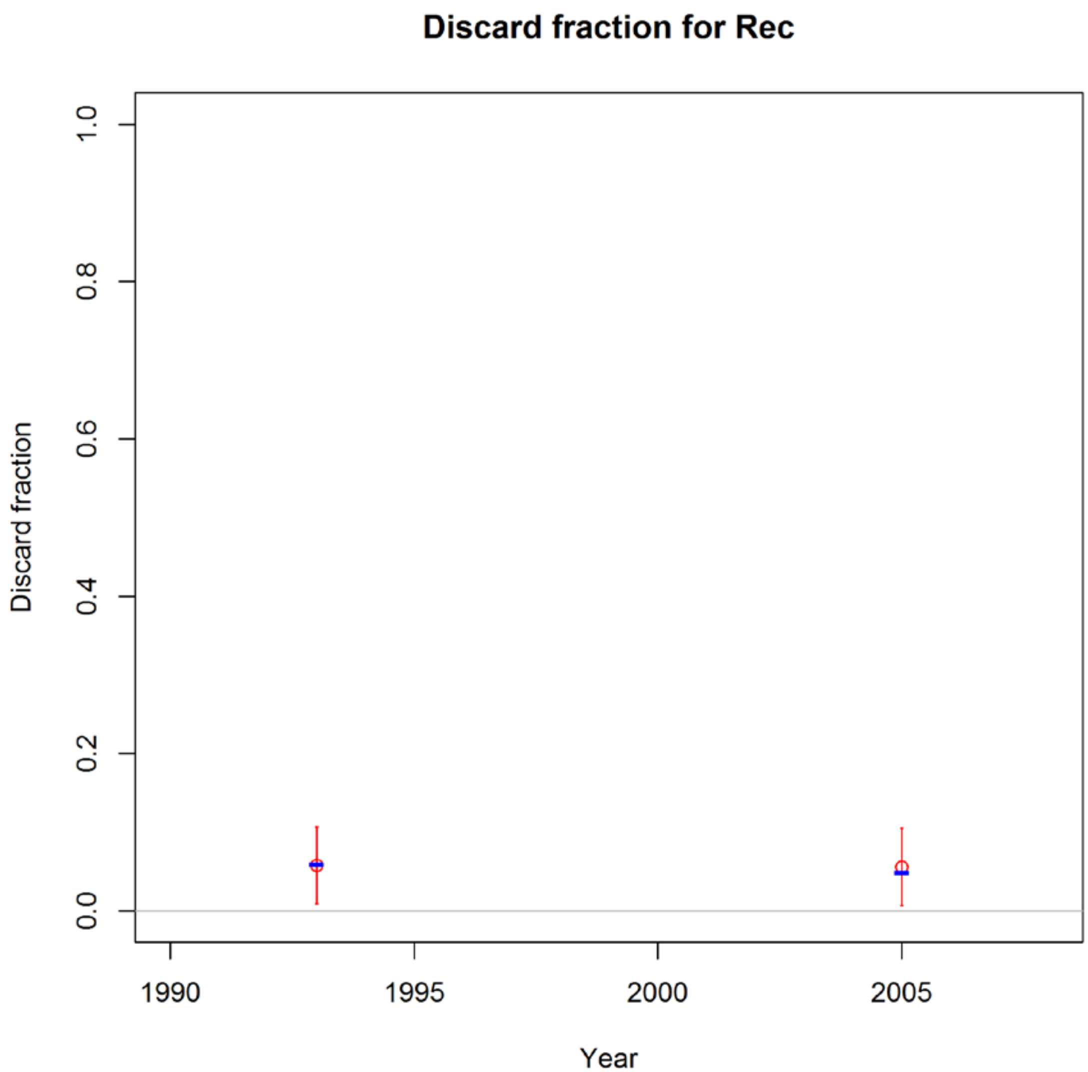


Figure 112. Fits of base model estimates of discard ratios (blue) to inputted values and standard deviations (red circle and line) for the recreational fishery.

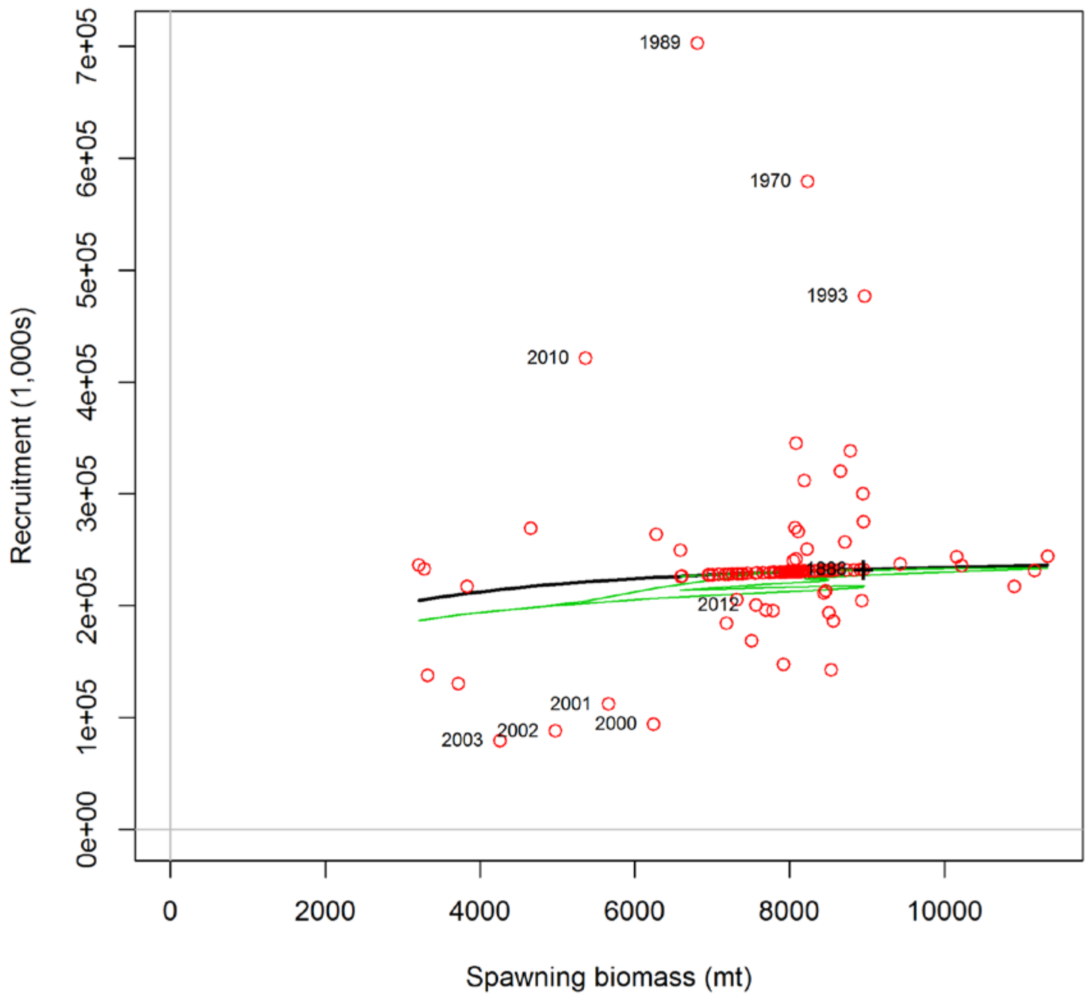


Figure 113. Estimated stock-recruit function (black line) with predicted annual recruitments (red circle), and bias-corrected recruitment expectations (green line).

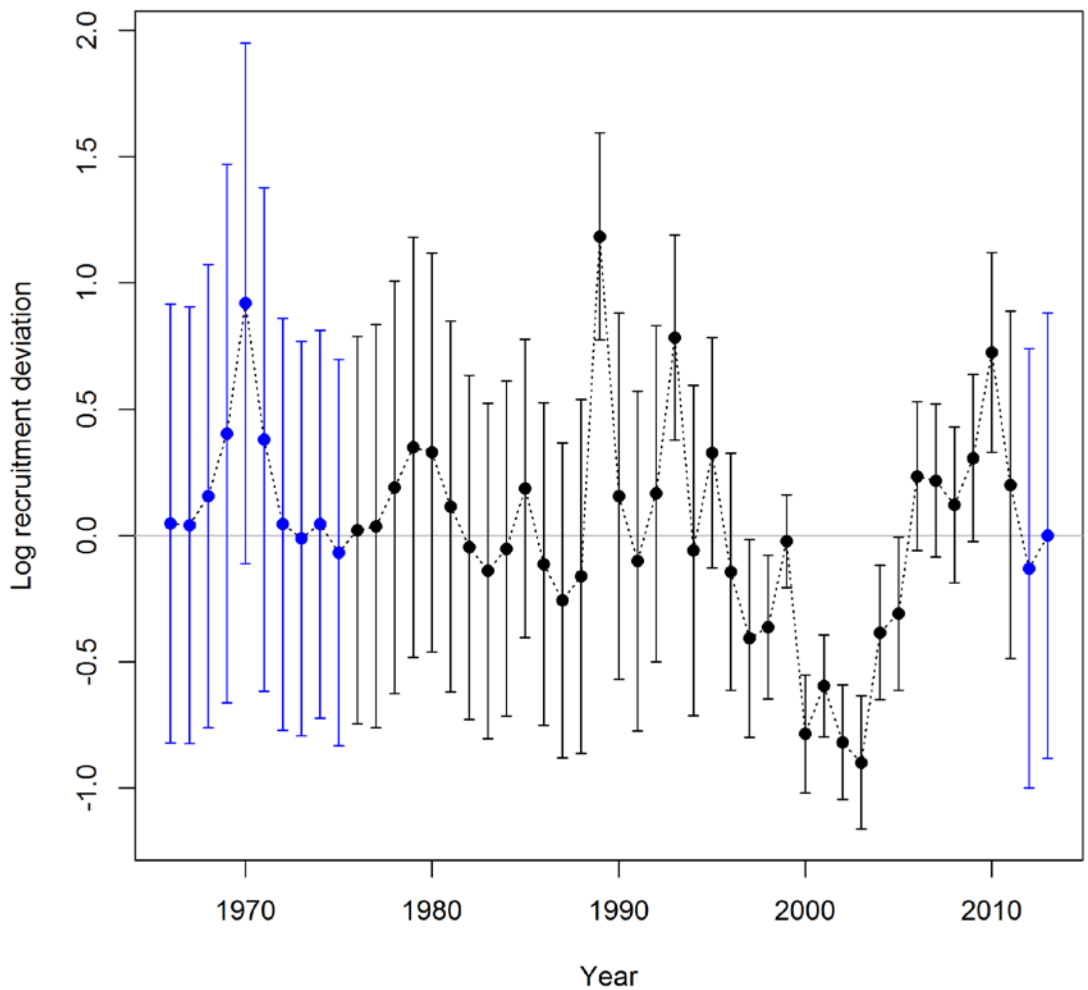


Figure 114. Estimated annual recruitment deviations and their standard deviations from the base model. Black dots and bars were for the main recruitment period (1980 to 2011), and blue dots and lines were for the early and late periods, respectively.

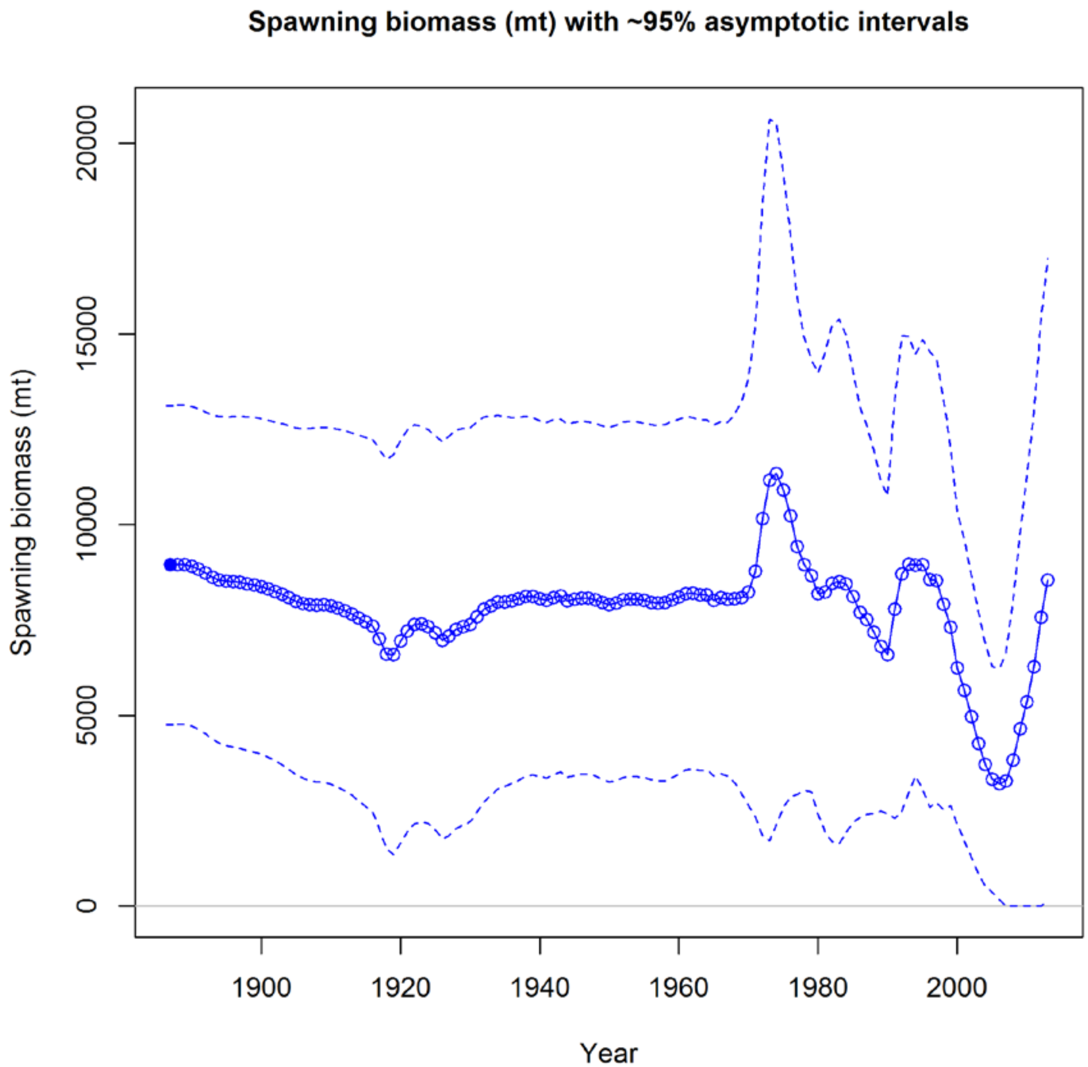


Figure 115. Estimated time series of annual spawning biomass from the base model (open circle and solid line) with approximate asymptotic 95% confidence intervals (dashed lines).

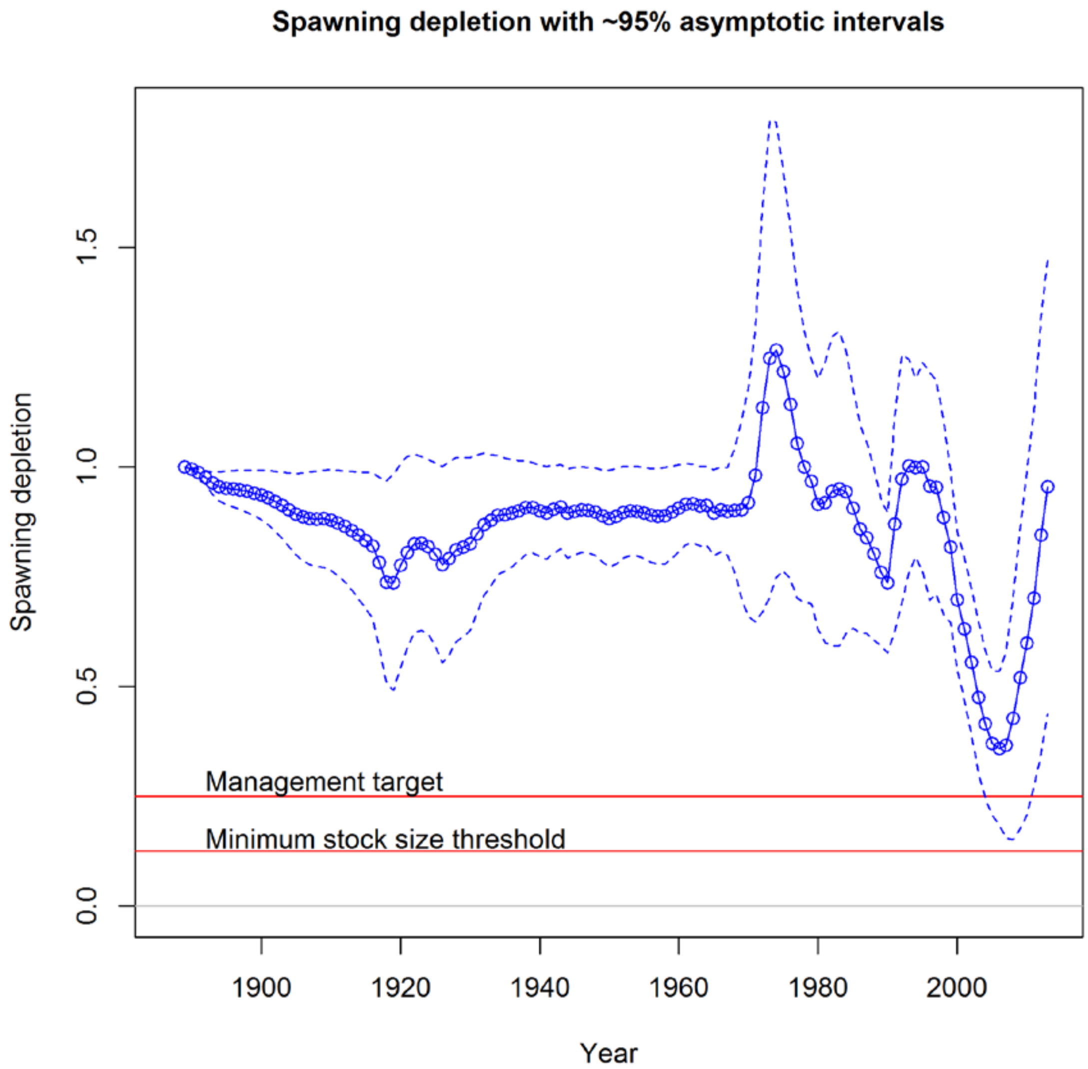


Figure 116. Estimated time series of annual stock depletion (open circle and solid line) from the base model with approximate asymptotic 95% confidence intervals (dashed line). Levels of management target (0.25) and minimum stock threshold (0.125) are also shown (solid red lines).

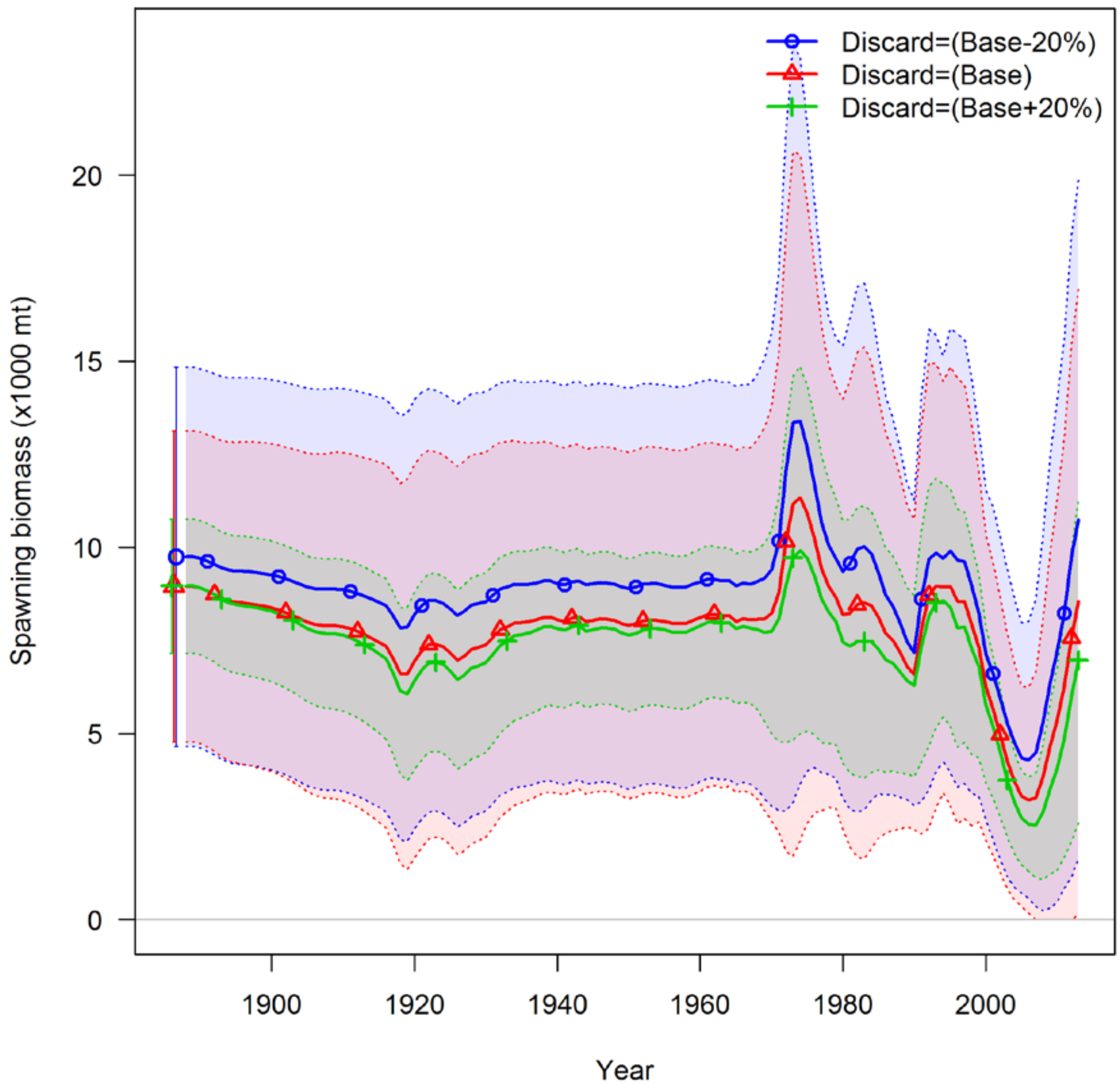


Figure 117. Estimated time series of spawning biomass with approximate asymptotic 95% confidence intervals from sensitivity runs on inputted fishery discard rates. Outputs from three model runs were compared: (1) Discard rates reduced by 20% (blue circle and line); (2) Discard rates used in the base model (red circle and line); and (3) Discard rates increased by 20% (green circle and line).

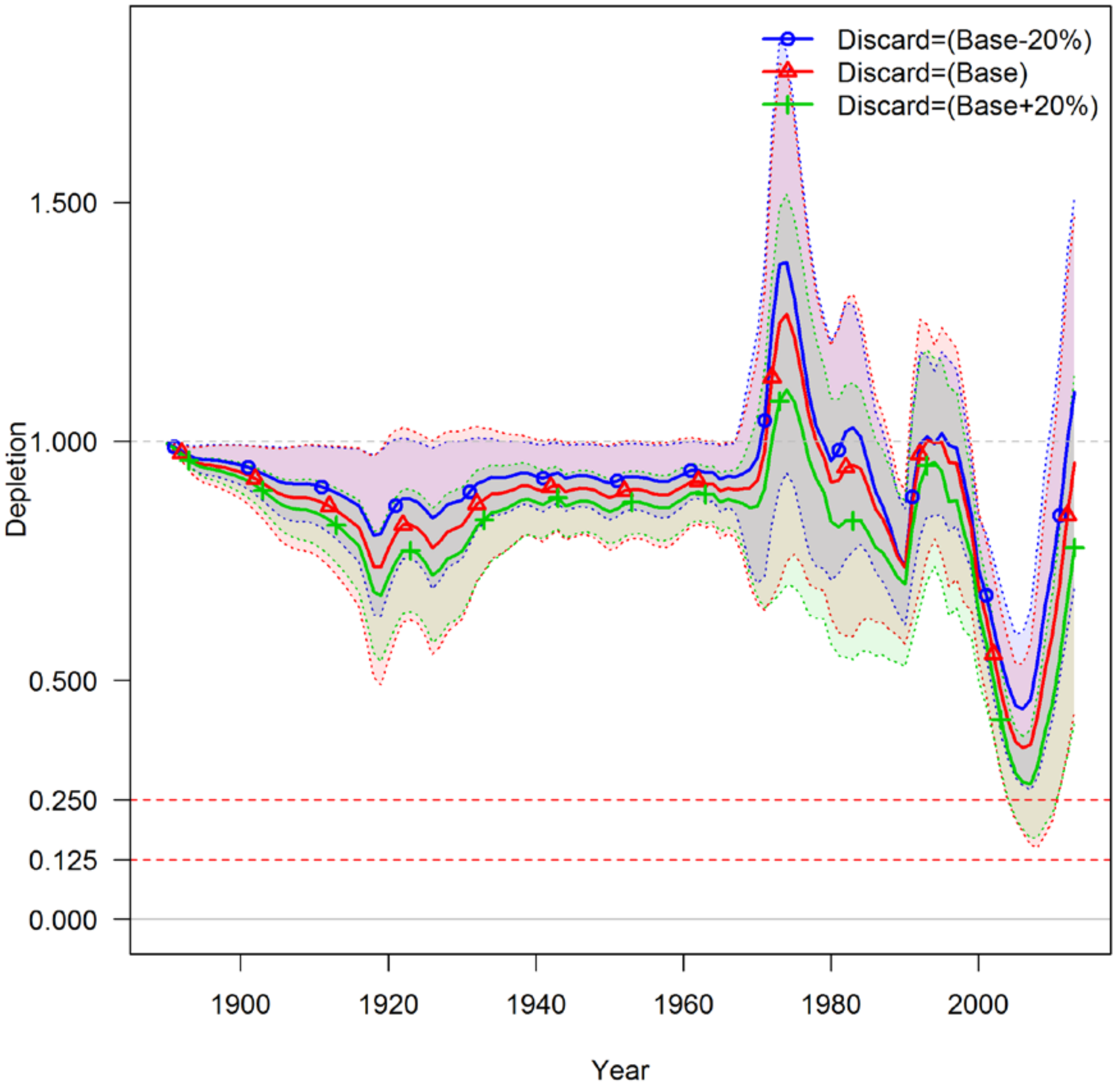


Figure 118. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on inputted fishery discard rates. Outputs from three model runs were compared: (1) Discard rates reduced by 20% (blue circle and line); (2) Discard rates used in the base model (red circle and line); and (3) Discard rates increased by 20% (green circle and line).

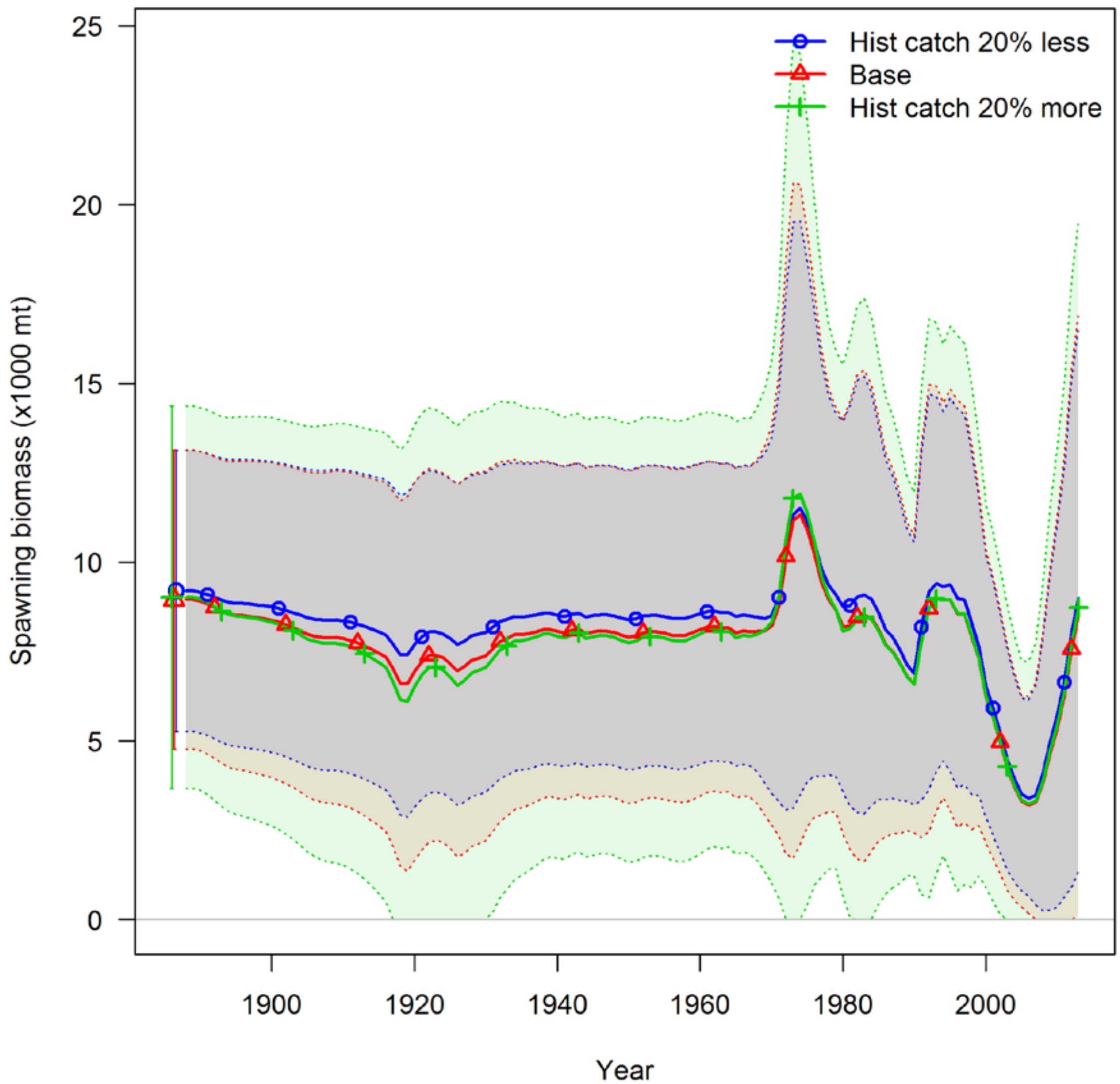


Figure 119. Estimated time series of spawning biomass with approximate asymptotic 95% confidence intervals from sensitivity runs on three levels of historical catch data. Historical catch data were referred to all catch data before 1980.

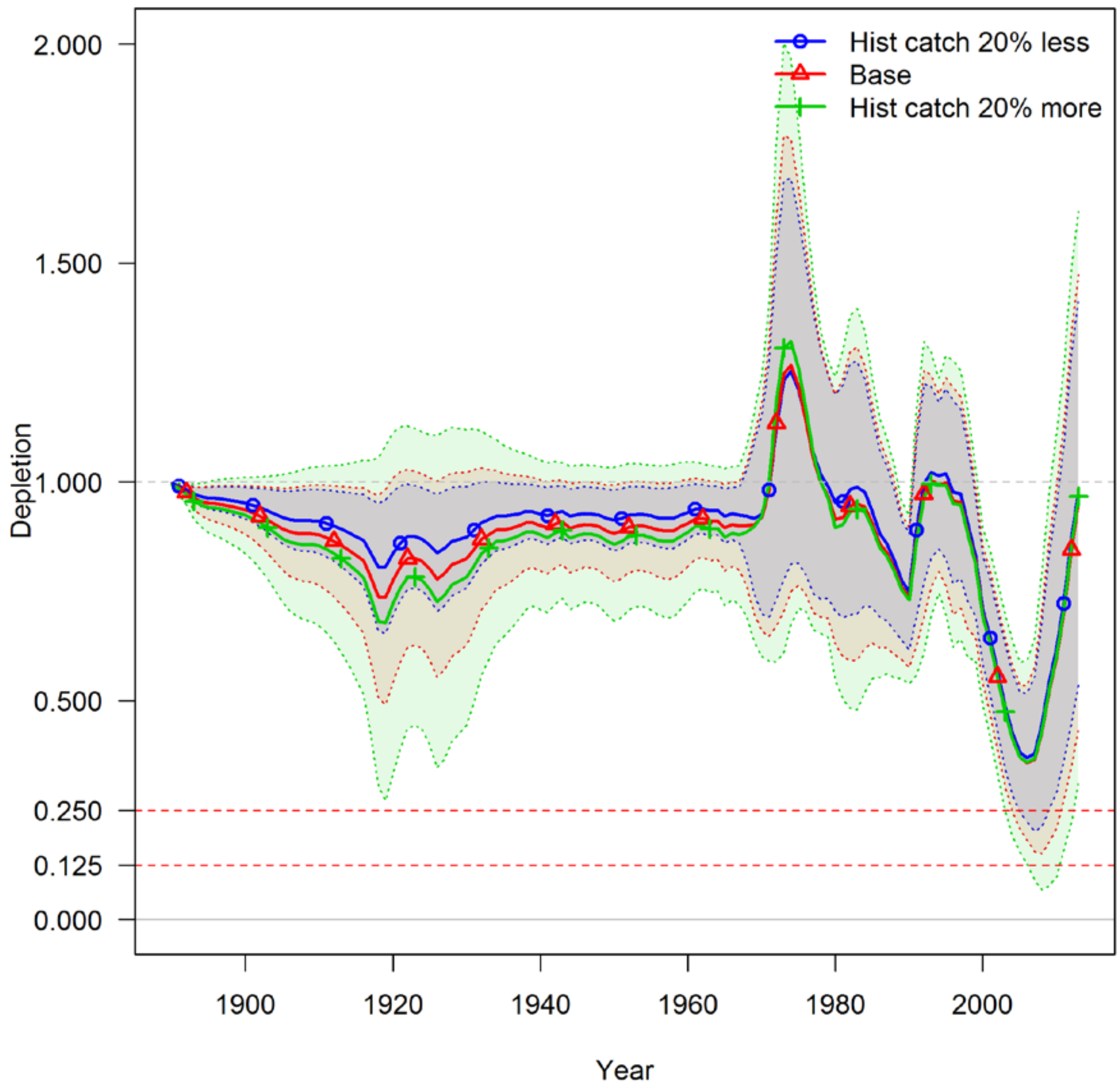


Figure 120. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on three levels of historical catch data. Historical catch data were referred to all catch data before 1980.

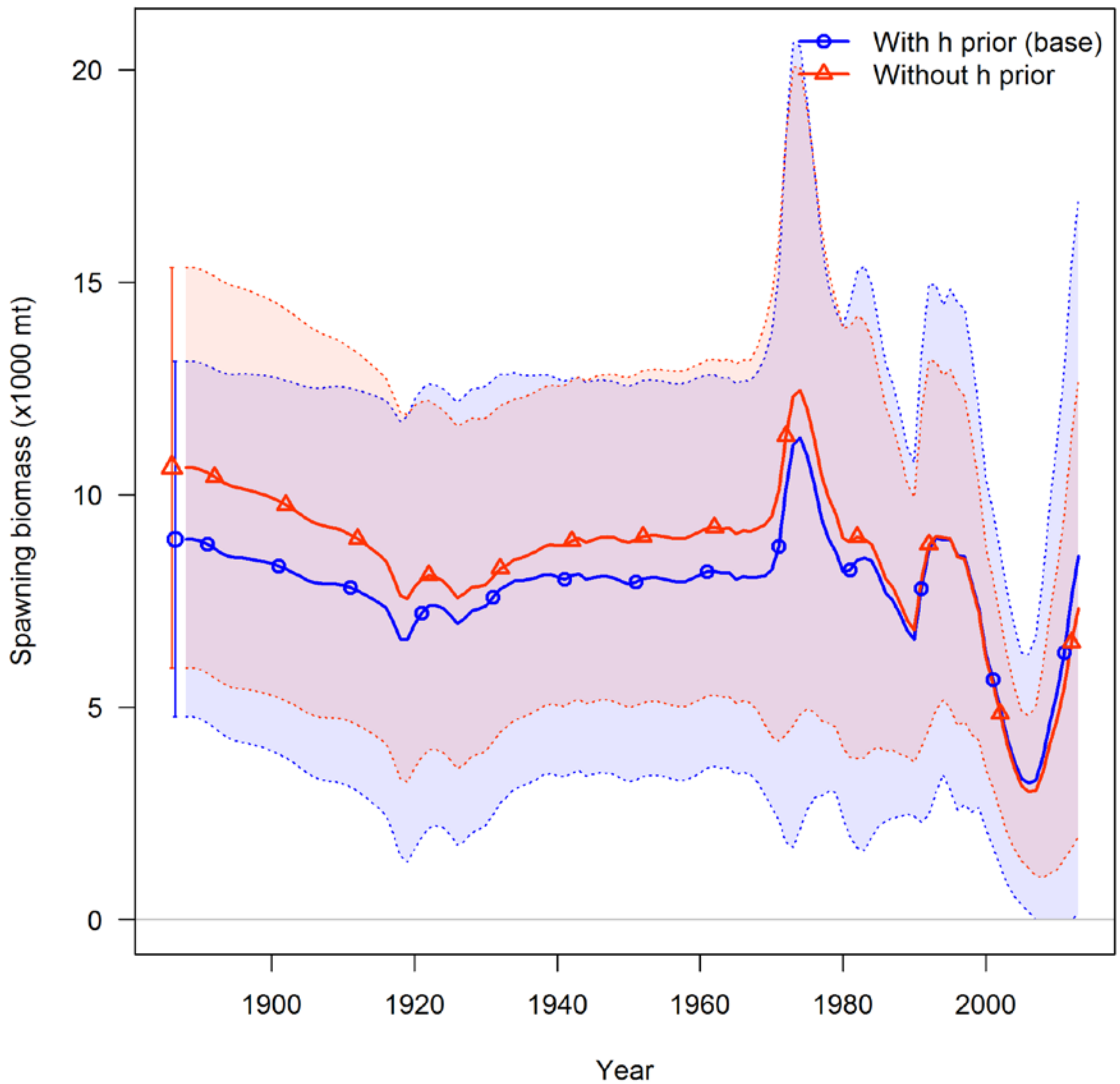


Figure 121. Estimated time series of spawning biomass with approximate asymptotic 95% confidence intervals from sensitivity runs on with and without steepness (*h*) prior.

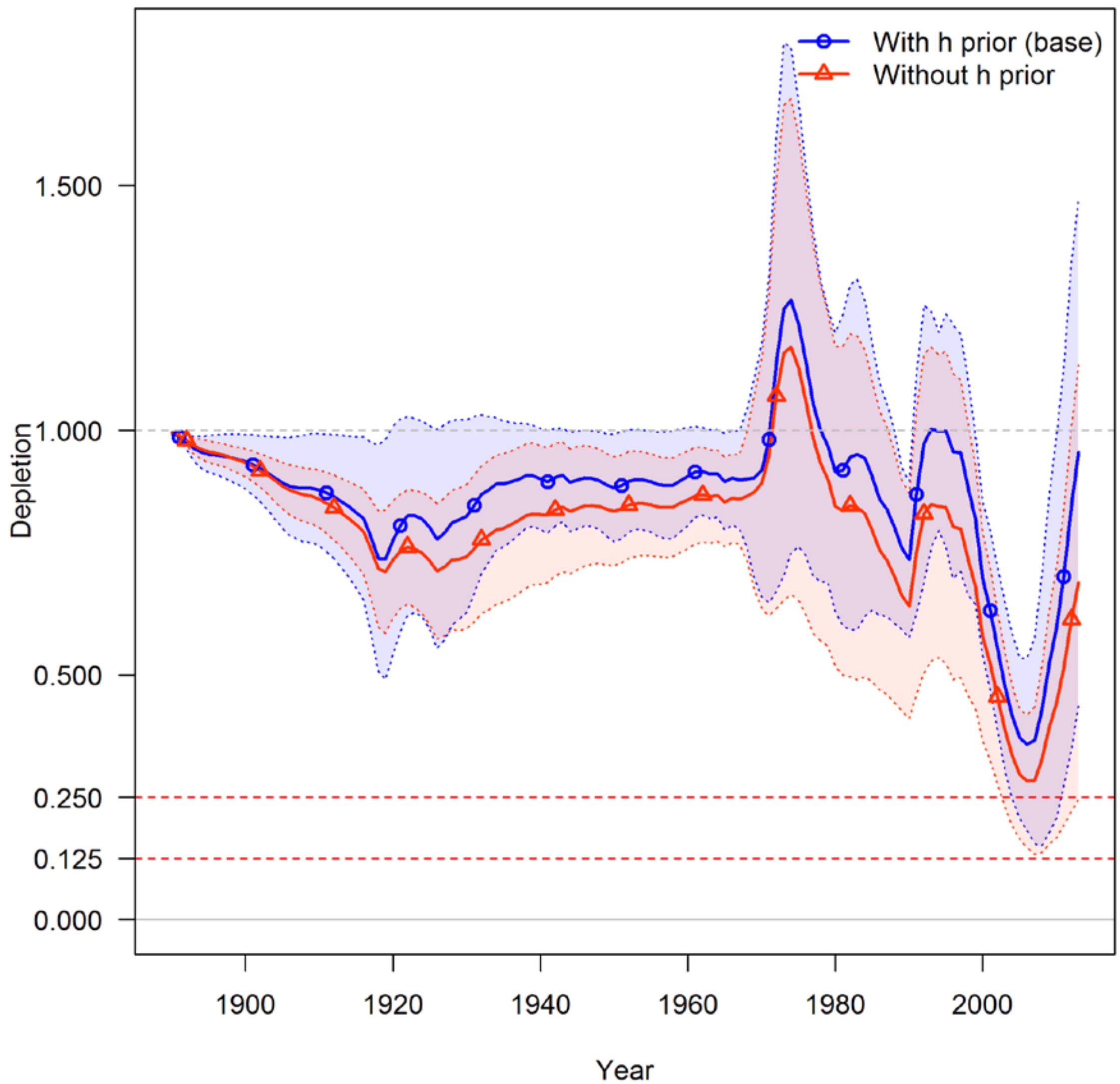


Figure 122. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on with and without steepness (*h*) prior.

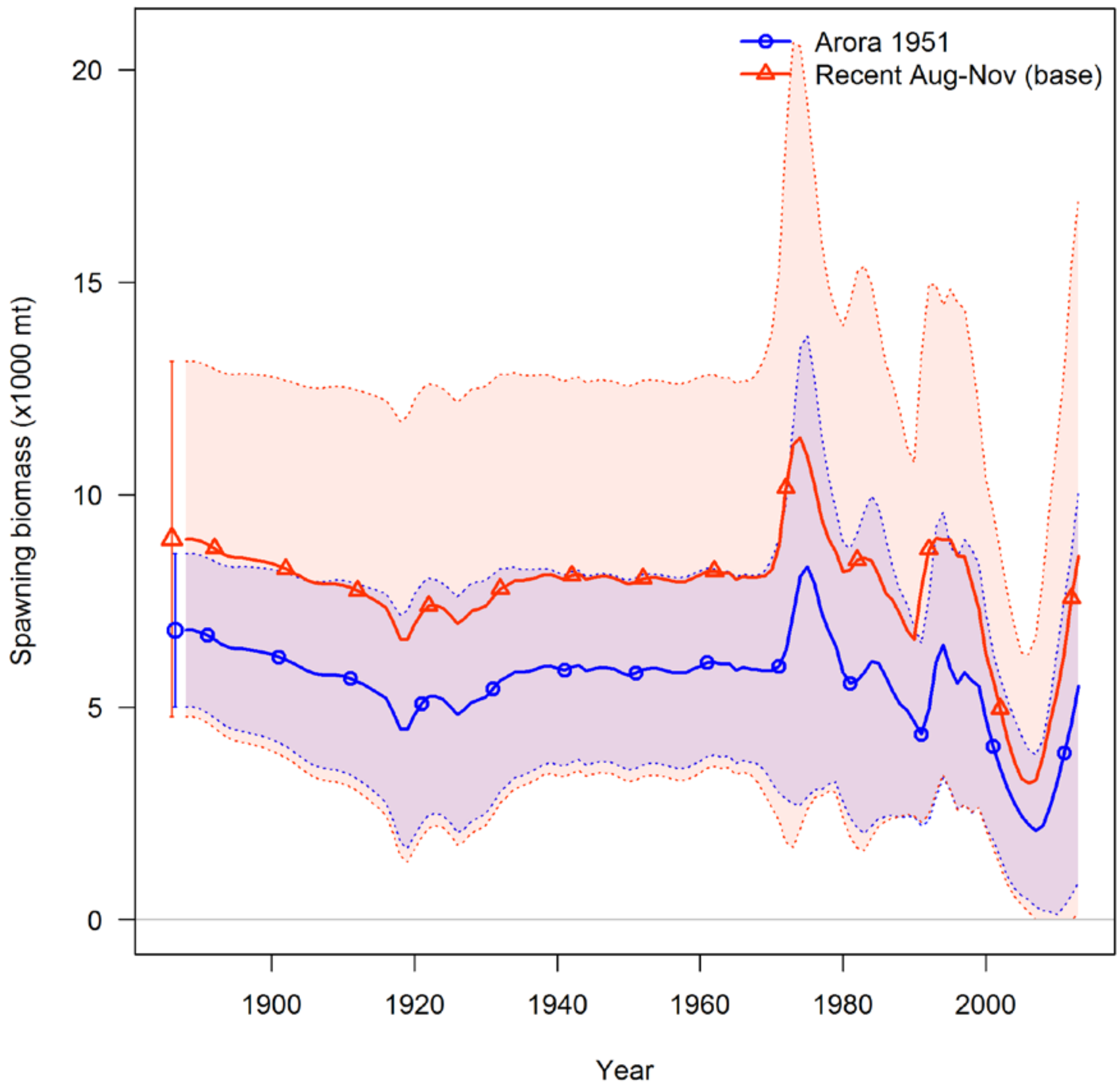


Figure 123. Estimated time series of spawning biomass with approximate asymptotic 95% confidence intervals from sensitivity runs on three maturity schedules.

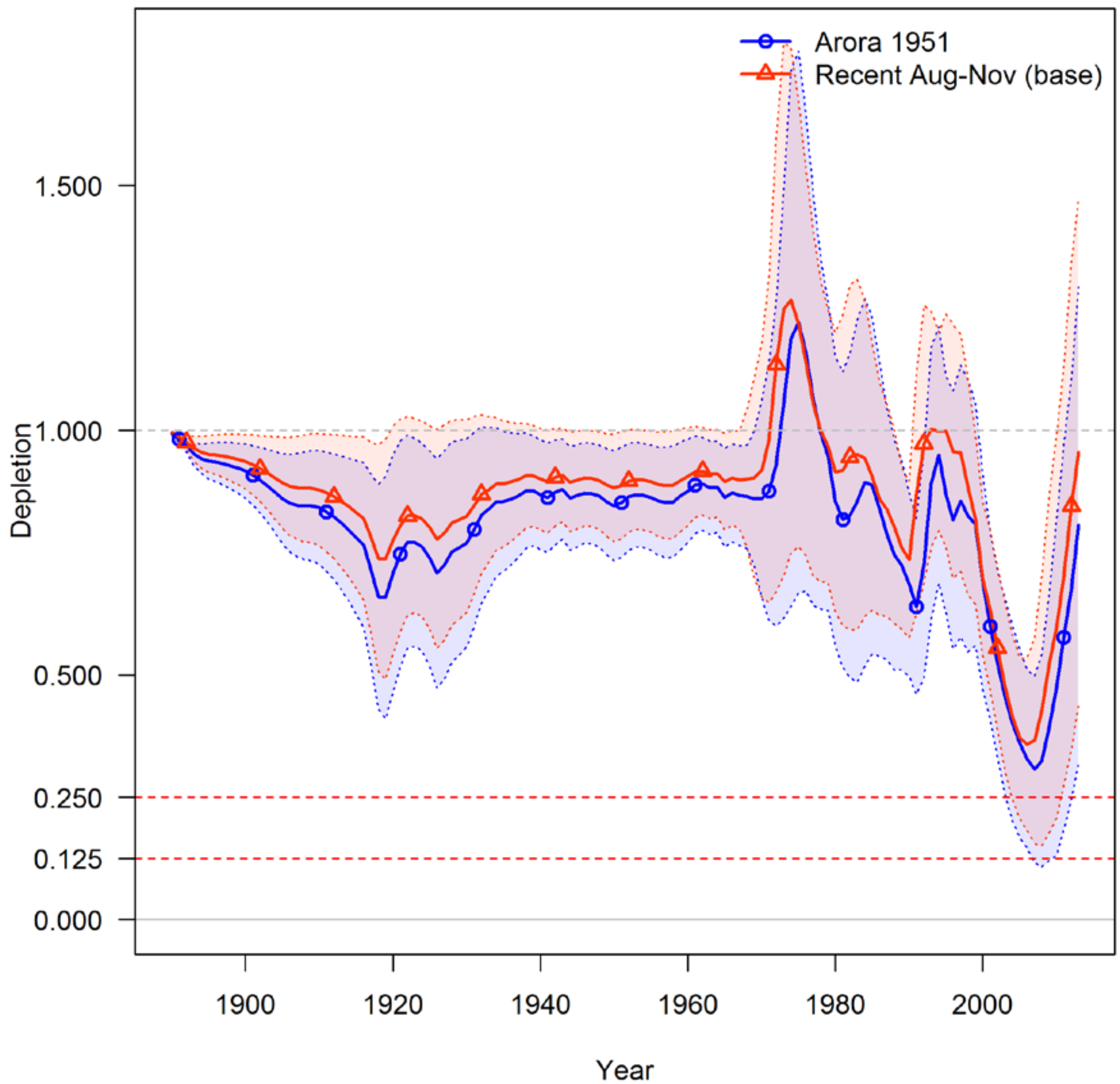


Figure 124. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on three maturity schedules.

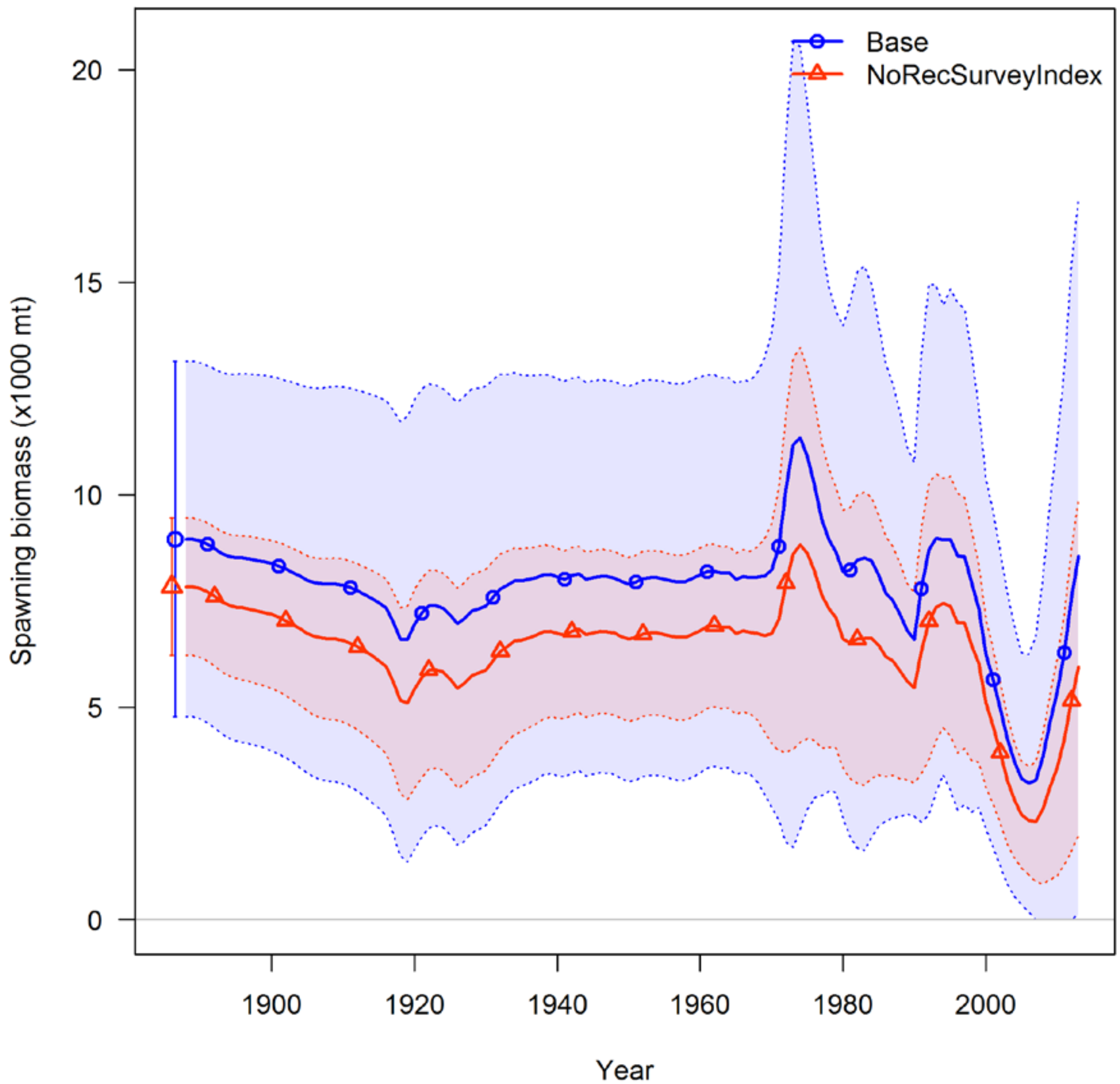


Figure 125. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on two maturity schedules.

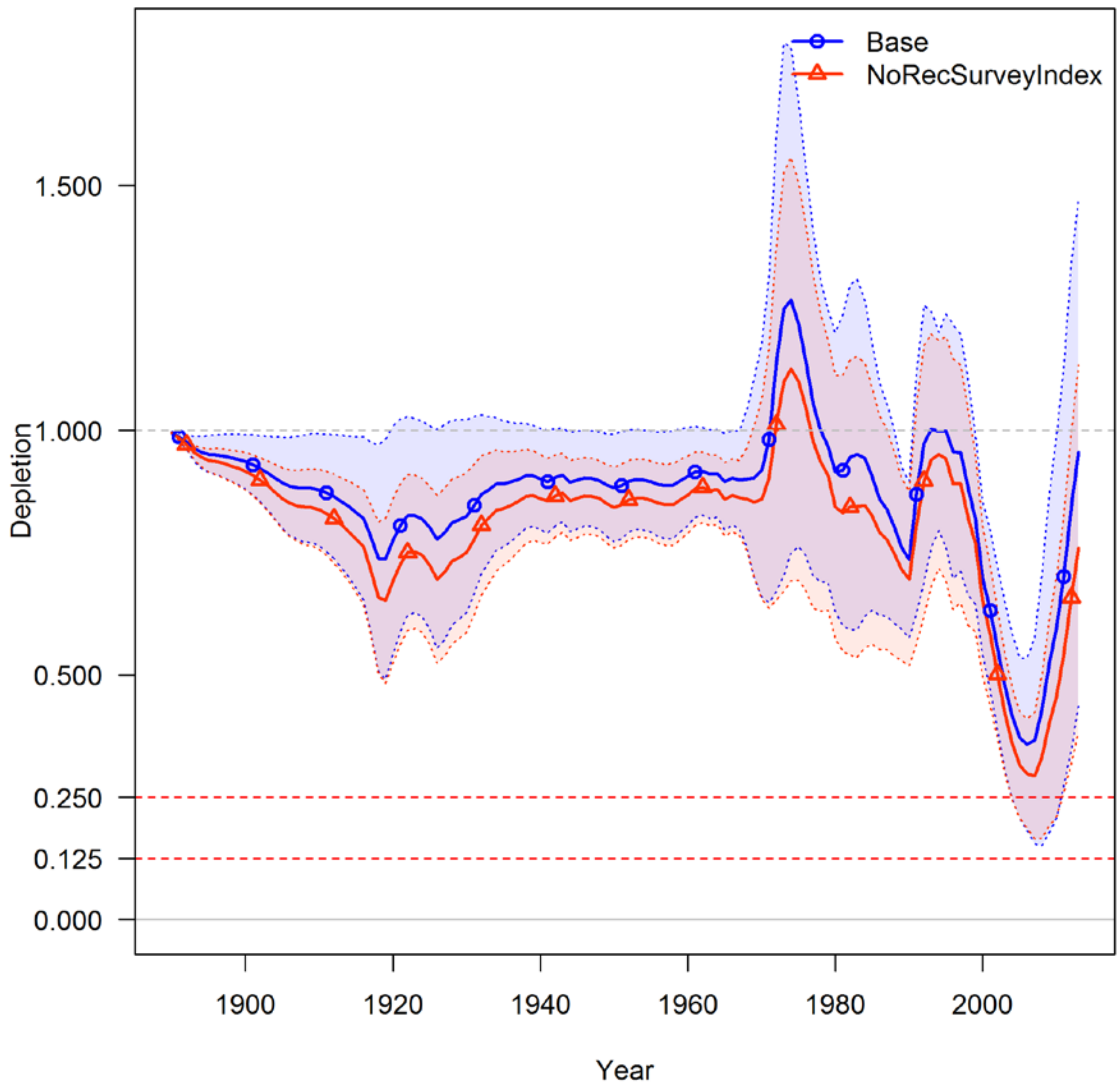


Figure 126. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on two maturity schedules.

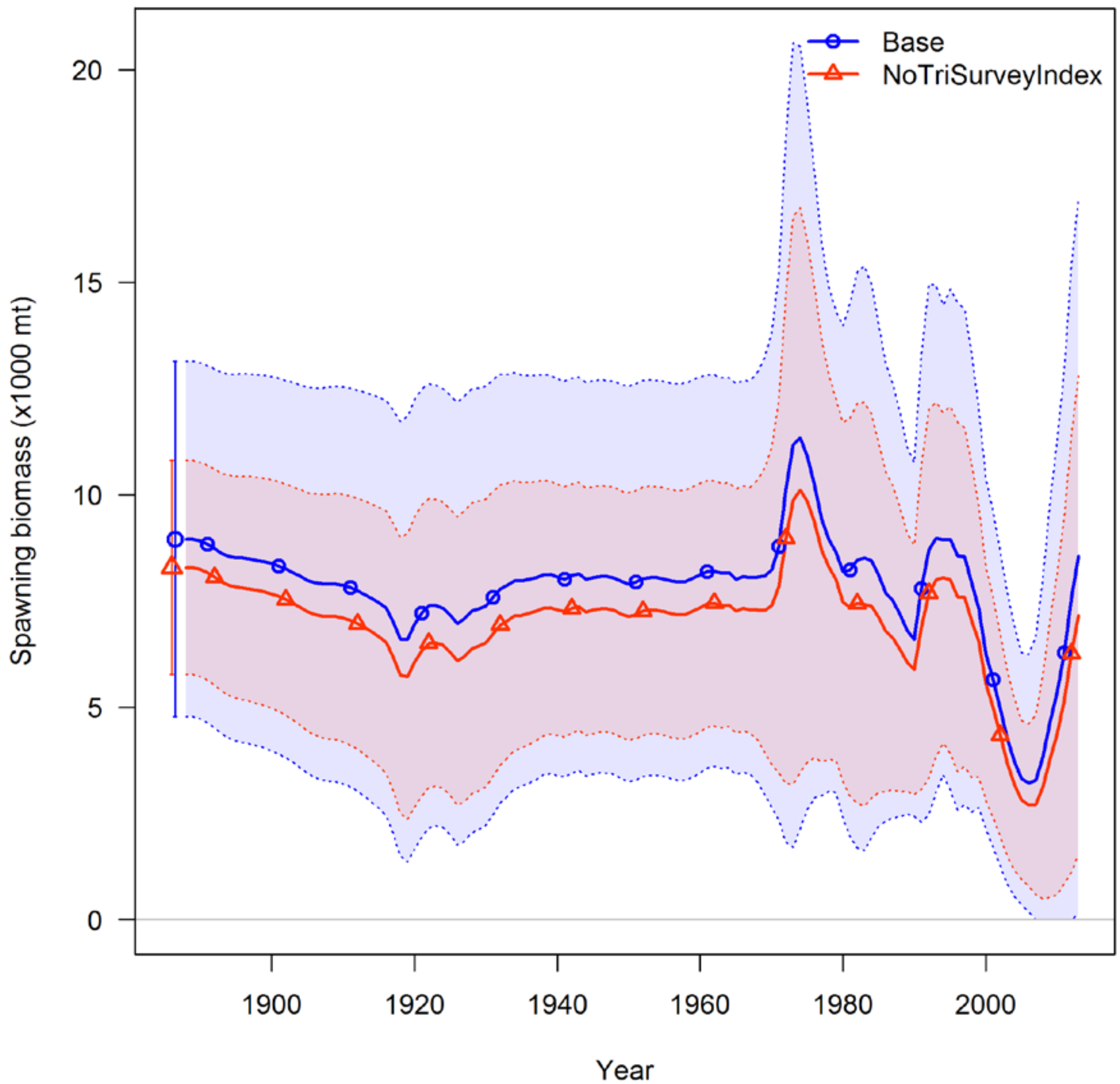


Figure 127. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on three maturity schedules.

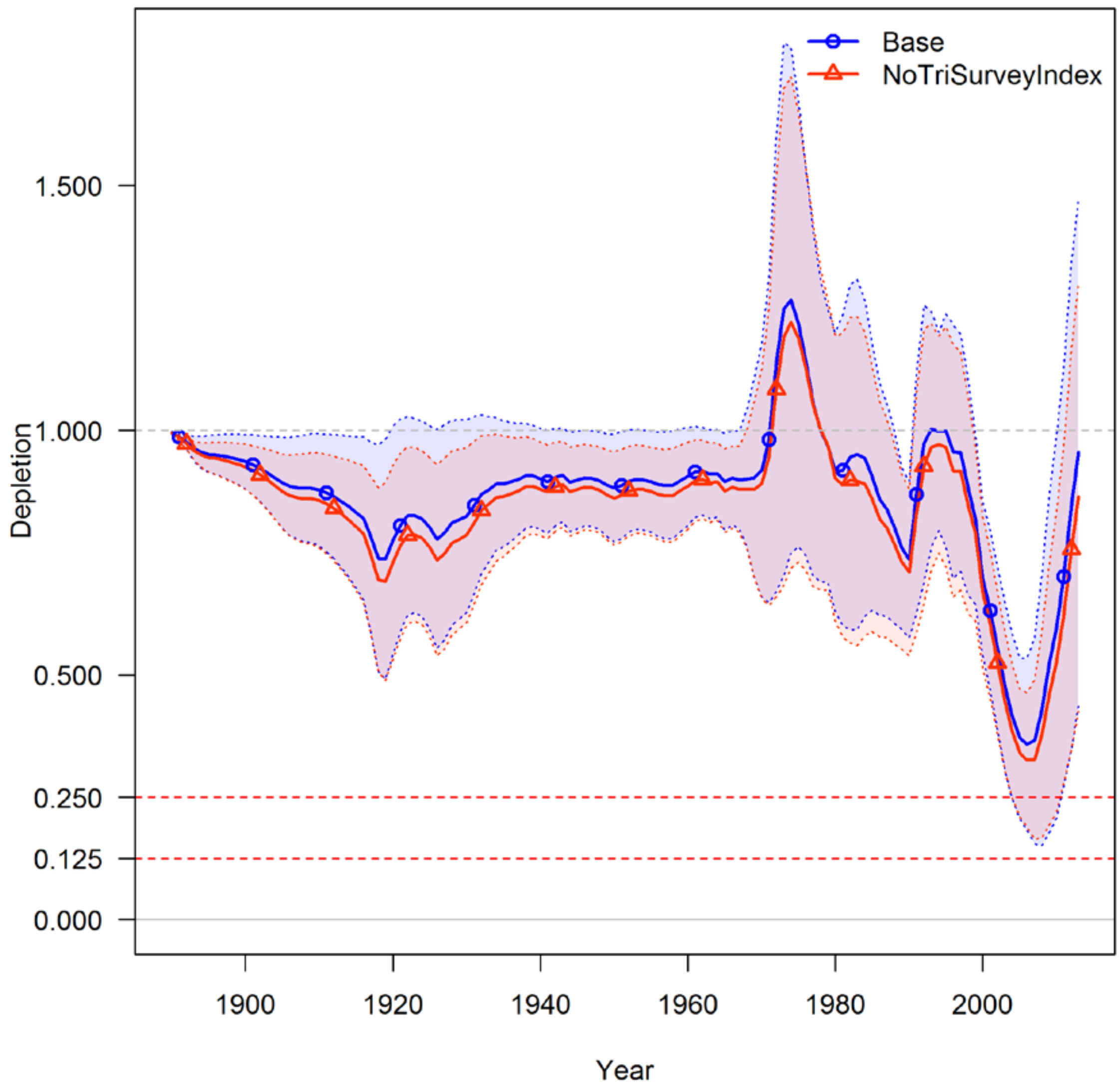


Figure 128. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on three maturity schedules.

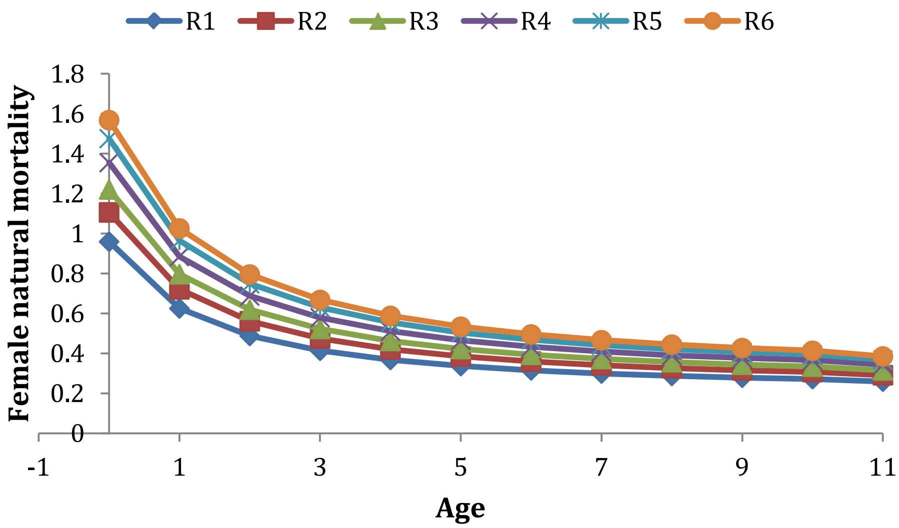


Figure 129. Estimated female natural mortality by age using the Lorenzen function for natural mortality for six reference ages (R1 = age 1, R2 = age 2, R3 = age 3, R4 = age 4, R5 = age 5, and R6 = age 6).

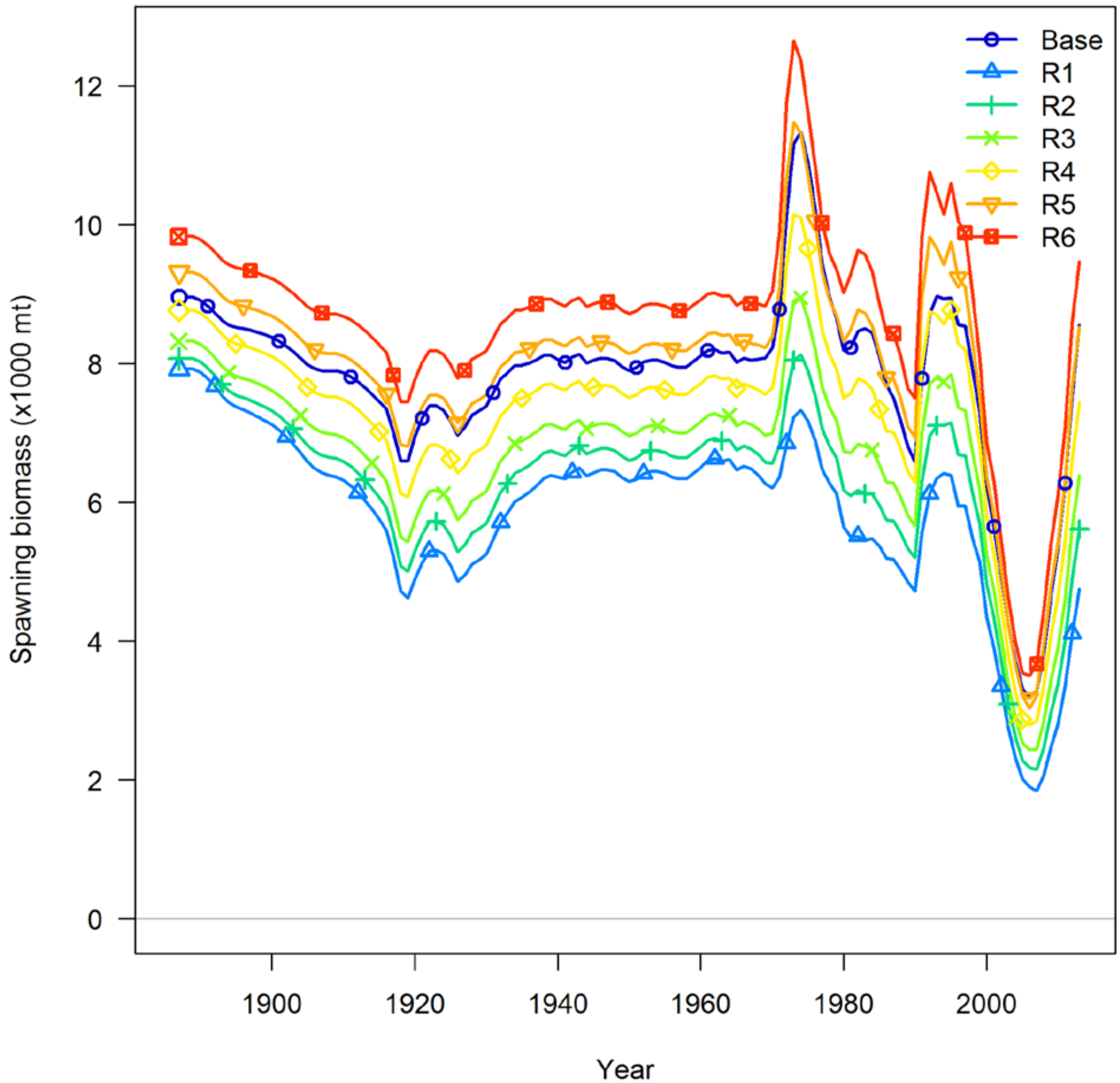


Figure 130. Estimated time series of spawning biomass from sensitivity runs on using the Lorenzen function for natural mortality at six reference ages (R1 = age 1, R2 = age 2, R3 = age 3, R4 = age 4, R5 = age 5, and R6 = age 6). Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.

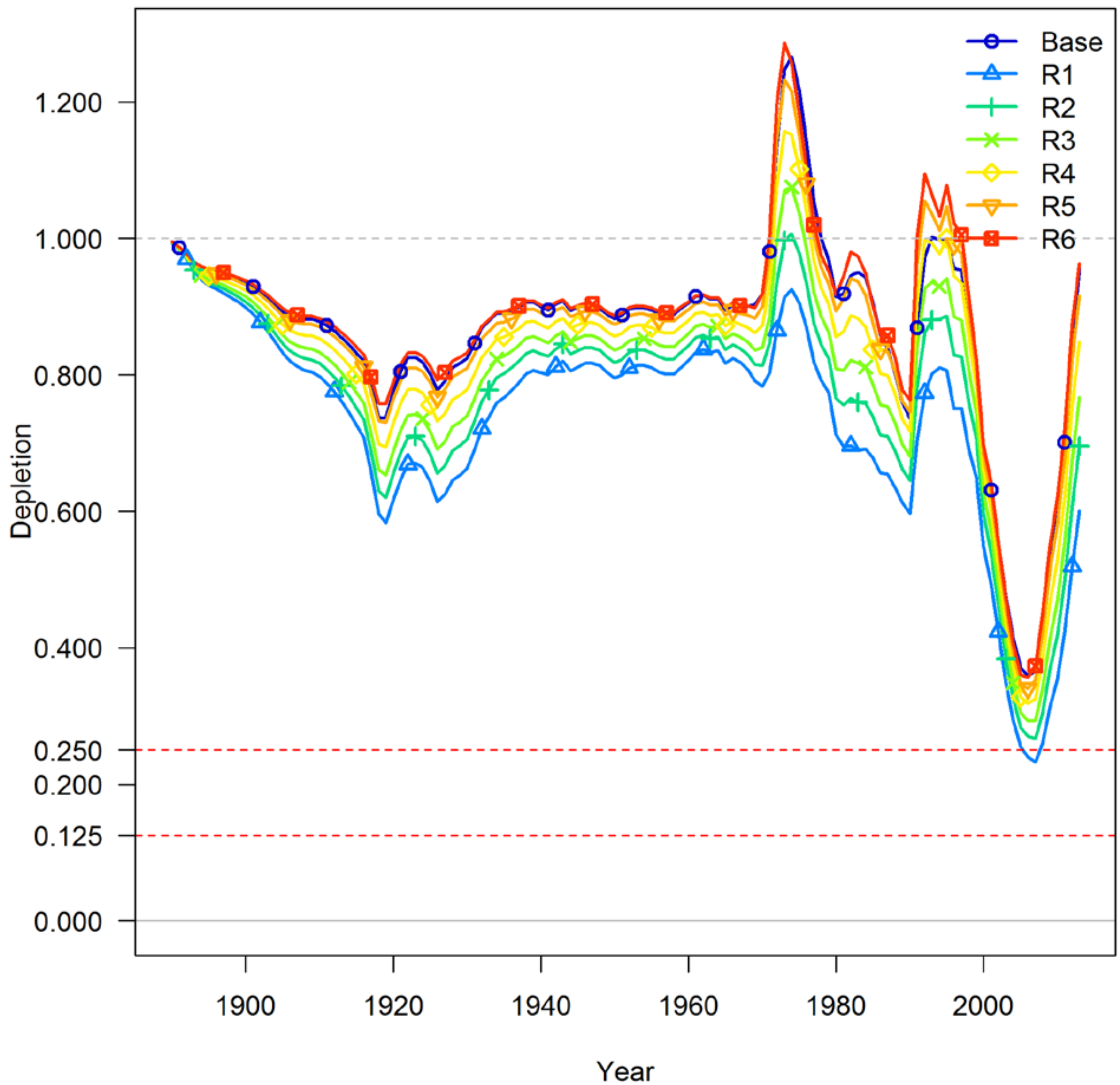


Figure 131. Estimated time series of stock depletion from sensitivity runs on using the Lorenzen function for natural mortality at six reference ages (R1 = age 1, R2 = age 2, R3 = age 3, R4 = age 4, R5 = age 5, and R6 = age 6). Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.

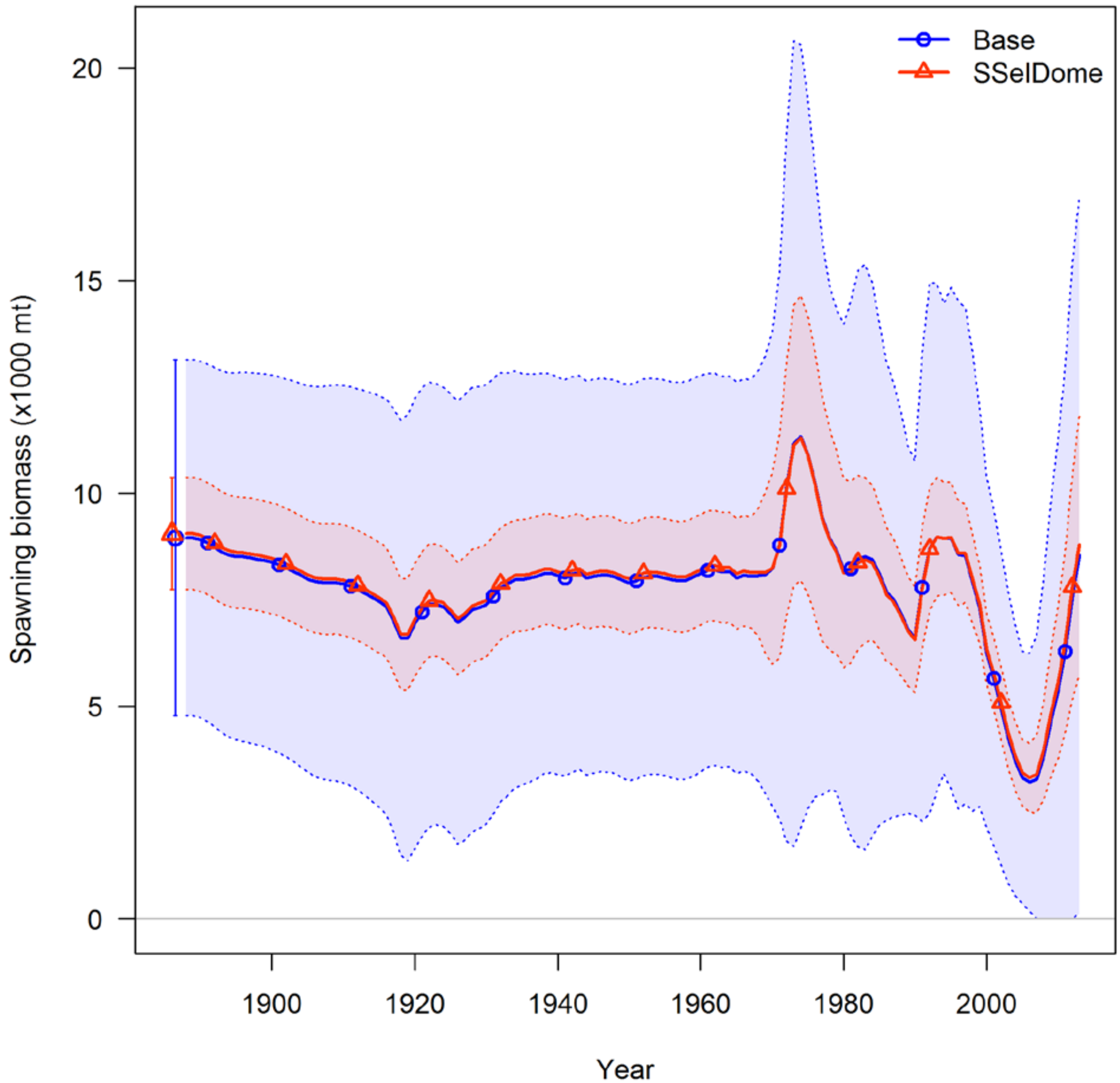


Figure 132. Estimated time series of spawning biomass with approximate asymptotic 95% confidence intervals from sensitivity runs on applying dome-shaped selectivity function on all surveys. Selectivity functions for all fisheries are still asymptotic.

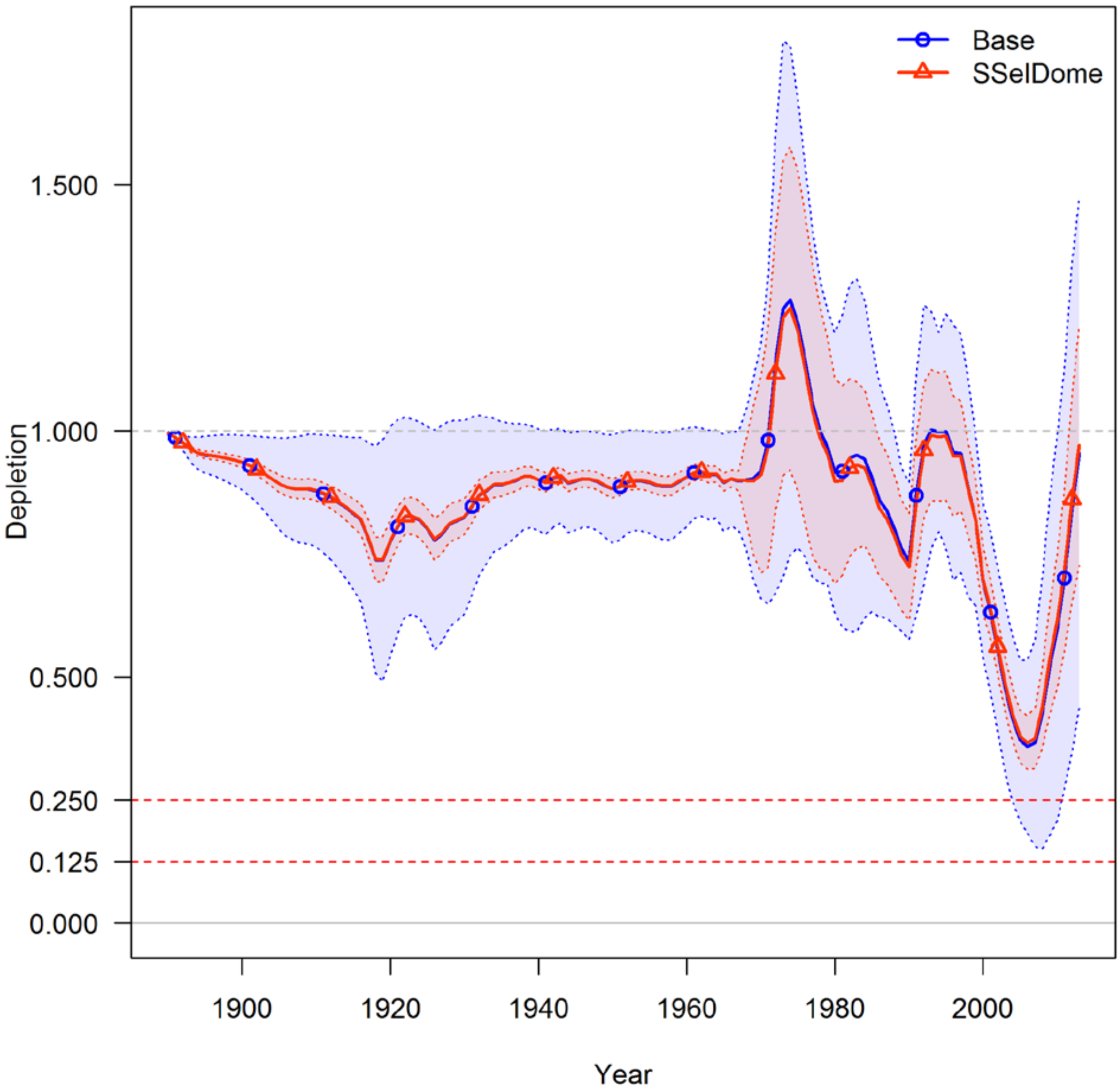


Figure 133. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on applying dome-shaped selectivity function on all surveys. Selectivity functions for all fisheries are still asymptotic.

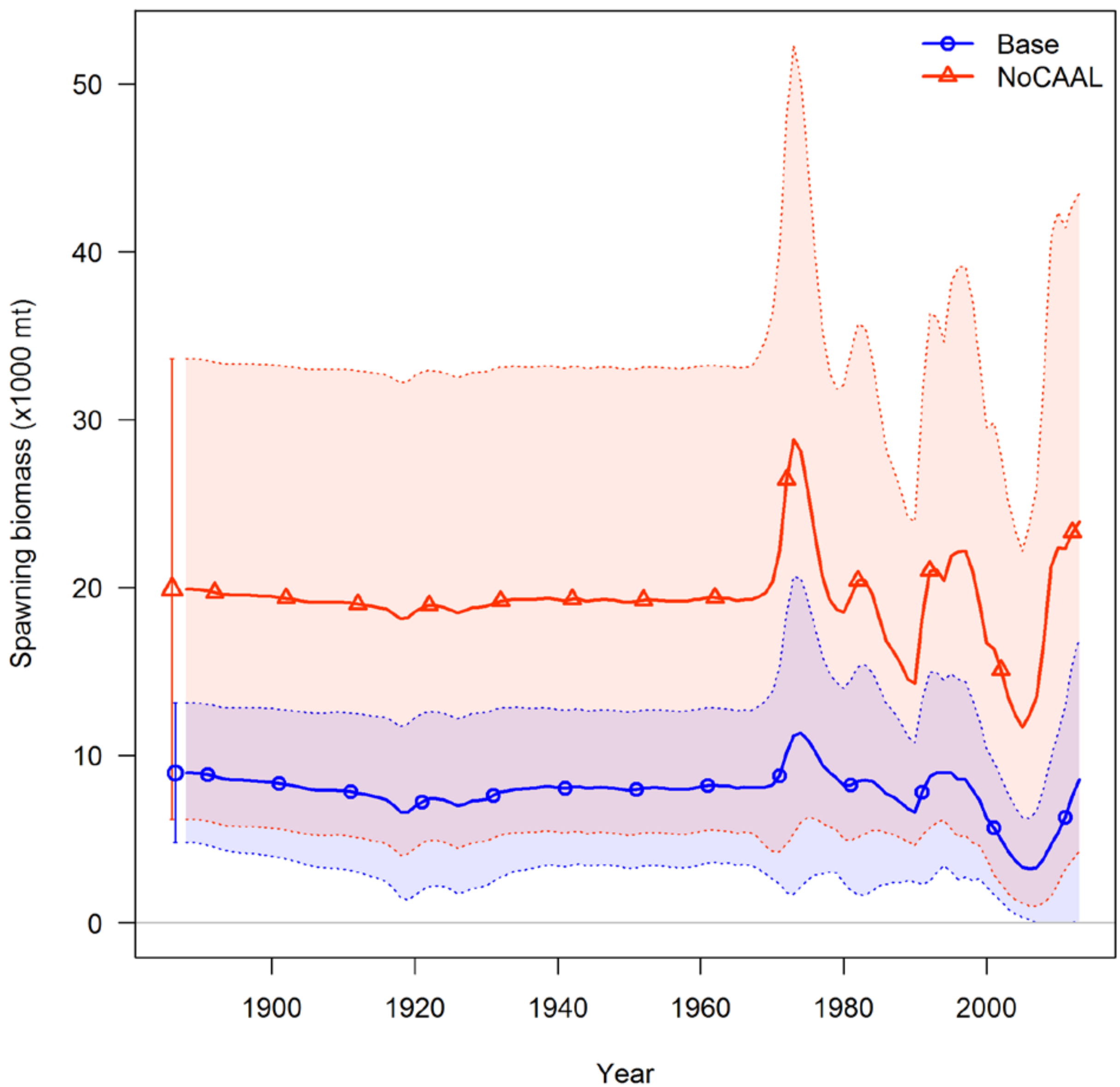


Figure 134. Estimated time series of spawning biomass with approximate asymptotic 95% confidence intervals from sensitivity runs on not using the conditional age-at-length (CAAL) data. Growth parameters were fixed before the CAAL data were removed.

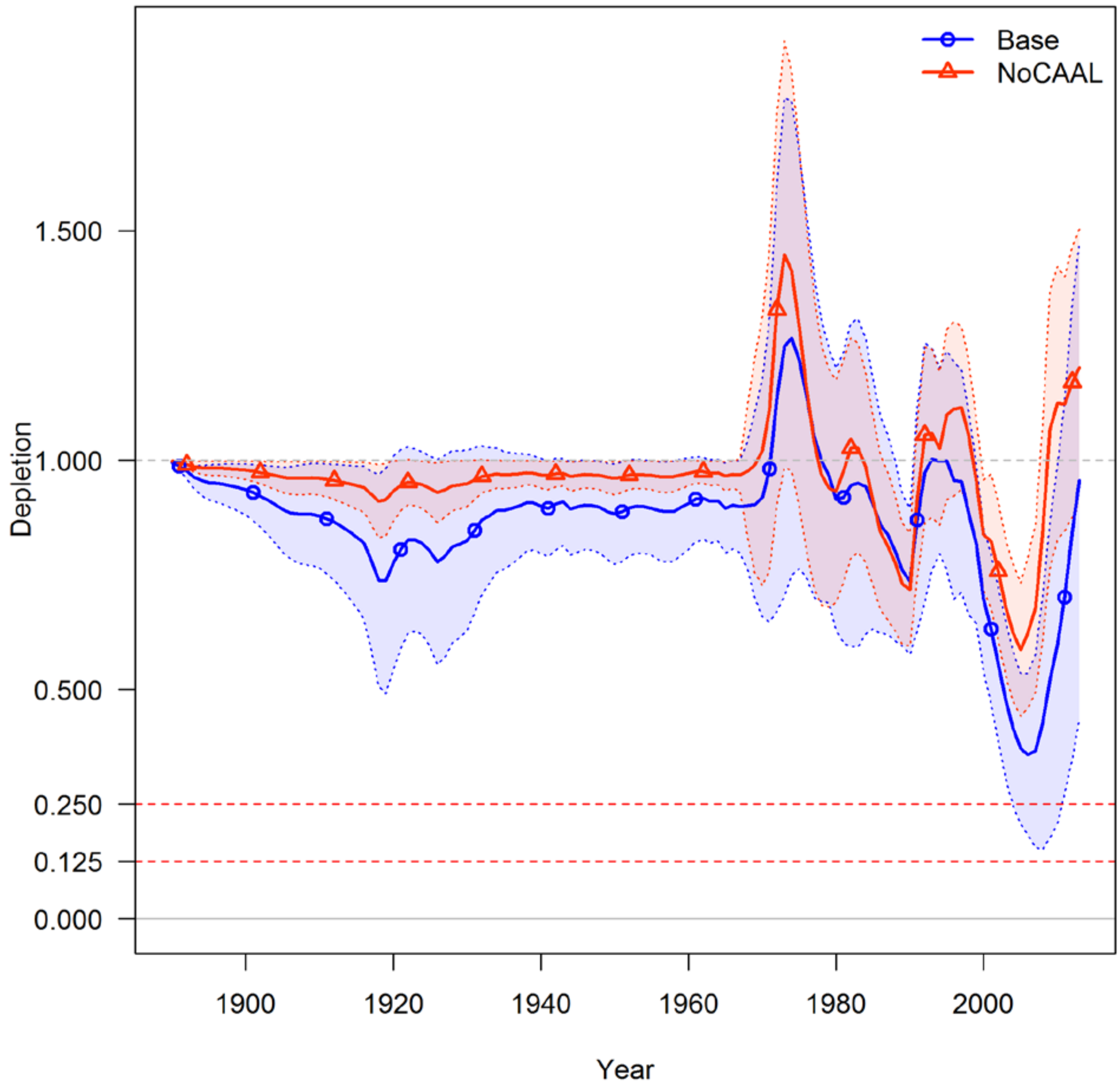


Figure 135. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on not using the conditional age-at-length (CAAL) data. Growth parameters were fixed before the CAAL data were removed.

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Figure 136. Likelihood profile for stock-recruit steepness (*h*), ranged from 0.3 to 1.0 at interval of 0.025.

Figure 137. Estimated time series of spawning biomass from a profile run on steepness (*h*=0.3 to *h*=1.0 at interval of 0.025). Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.

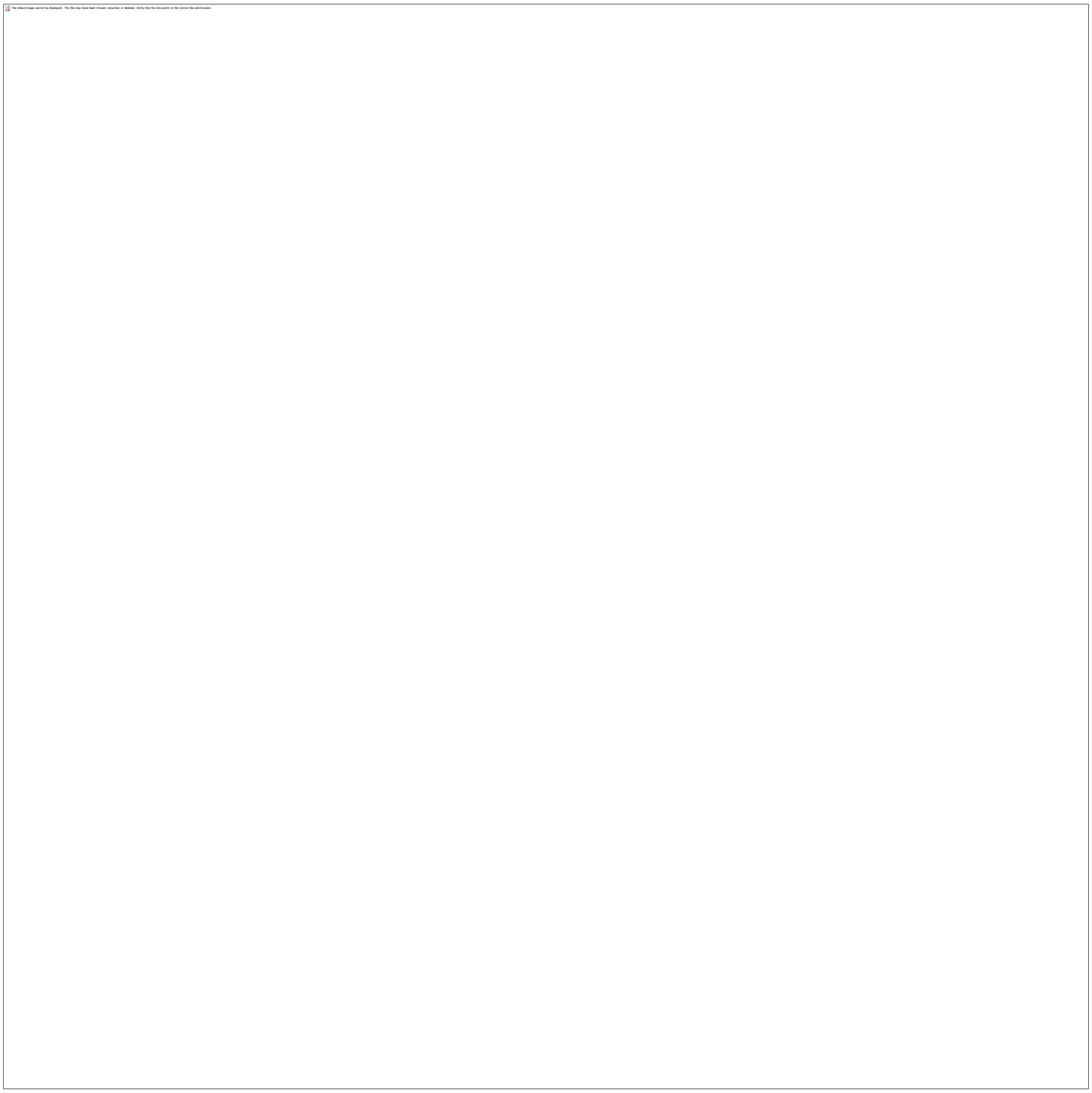

Figure 138. Estimated time series of stock depletion from a profile run on steepness (*h*=0.3 to *h*=1.0 at interval of 0.025). Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.

Figure 139. Likelihood profile for virgin recruitment (*$LN(R_0)$*).

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Figure 140. Estimated time series of spawning biomass from a profile run on virgin recruitment (*$LN(R_0)$*). Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.

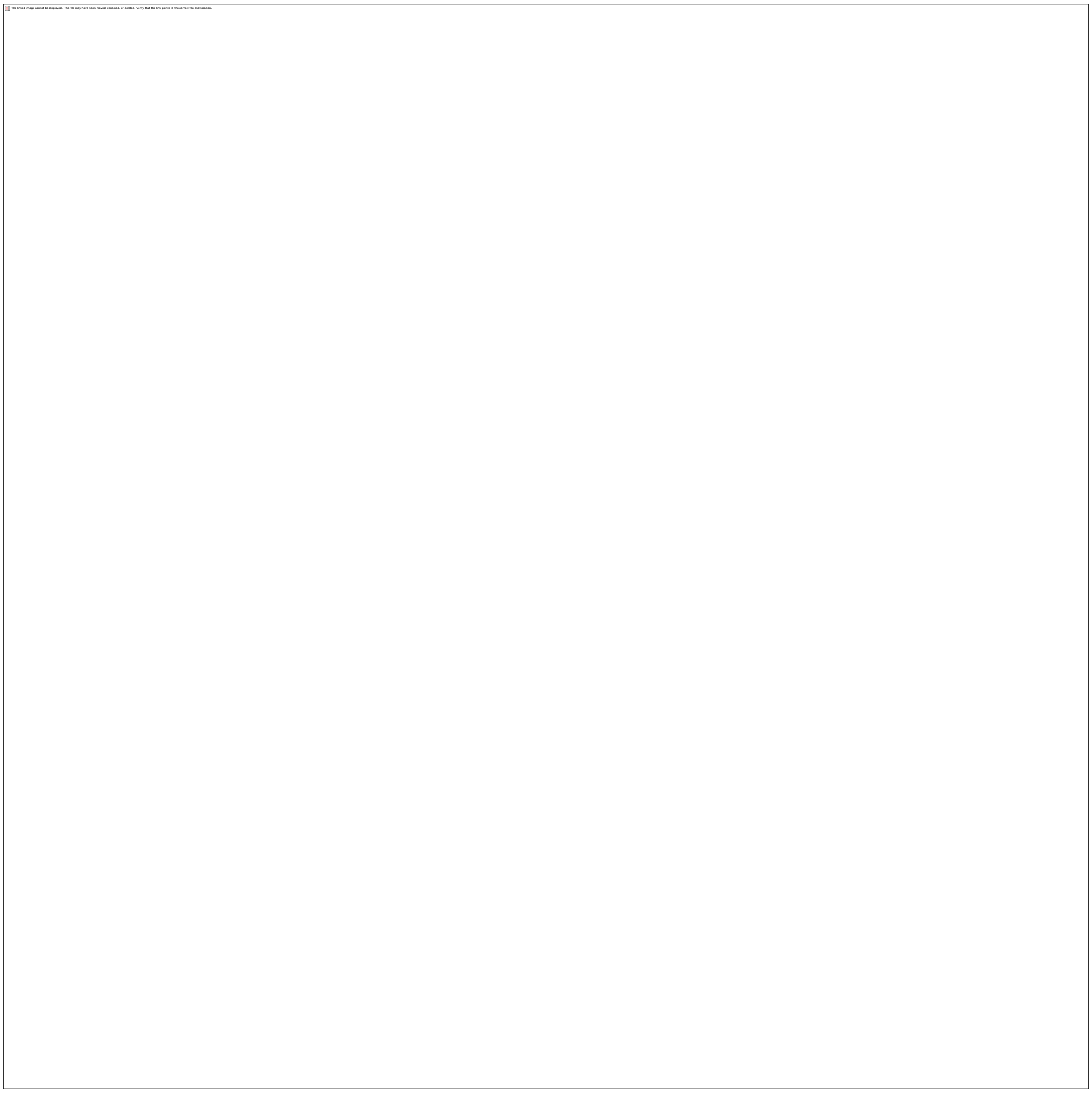

Figure 141. Estimated time series of stock depletion from a profile run on virgin recruitment (*$LN(R_0)$*). Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.

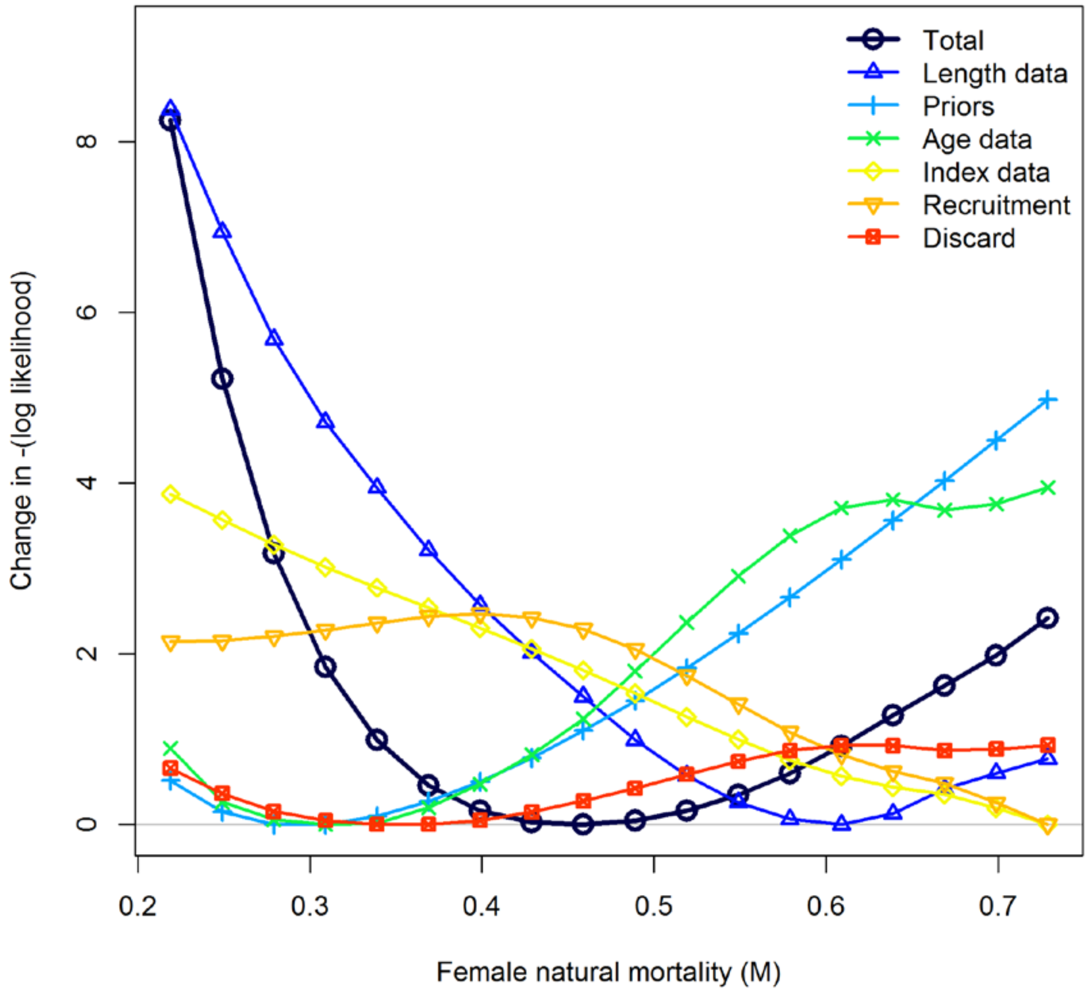

Figure 142. Likelihood profile for female natural mortality (M), ranged from 0.20 to 0.44. Male natural mortalities were changed in the same increment.

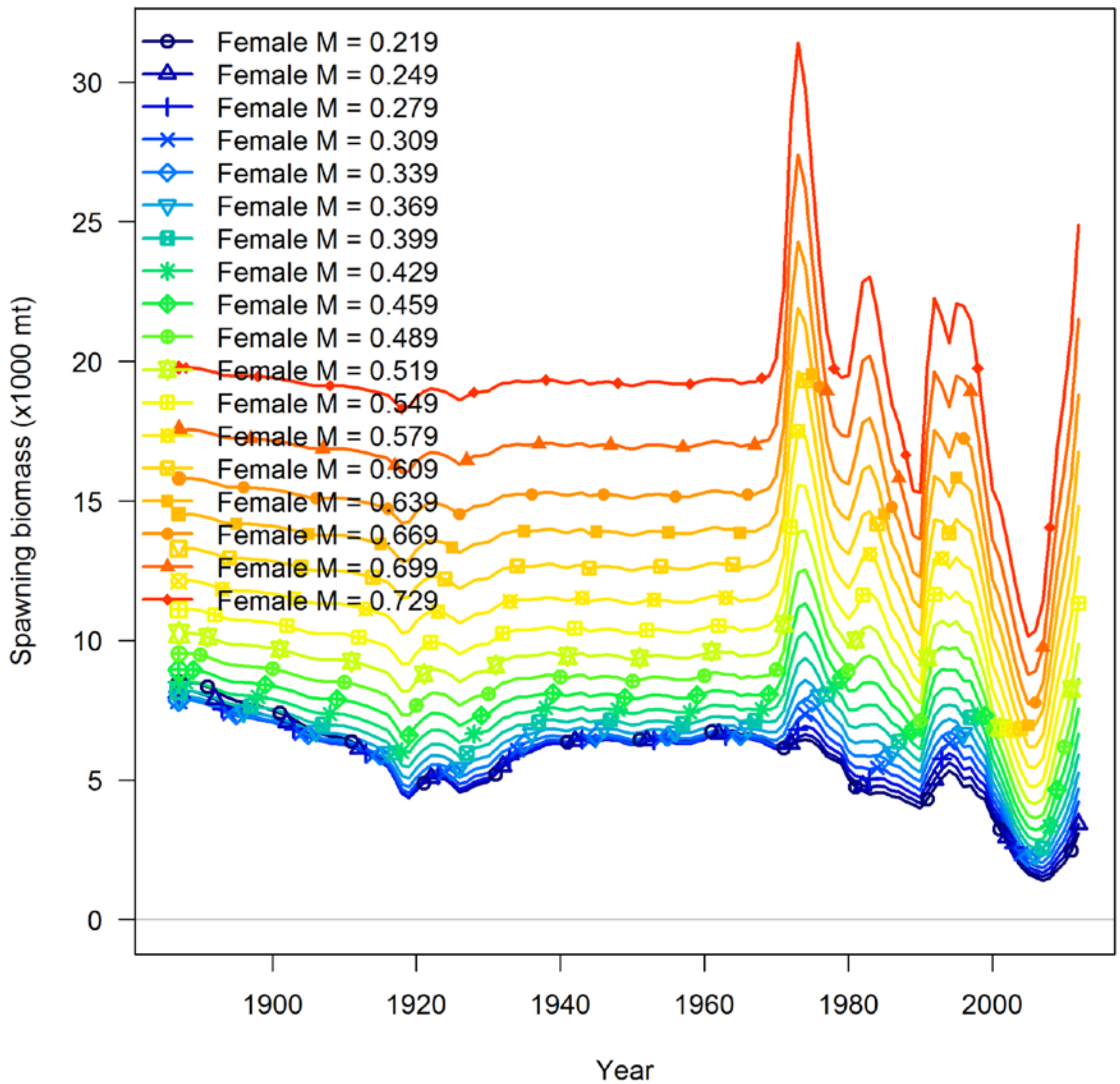

Figure 143. Estimated time series of spawning biomass from a profile run on female natural mortality (*M*=0.20 to *M*=0.44 at interval of 0.02). Male natural mortalities were changed in the same increment. Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.

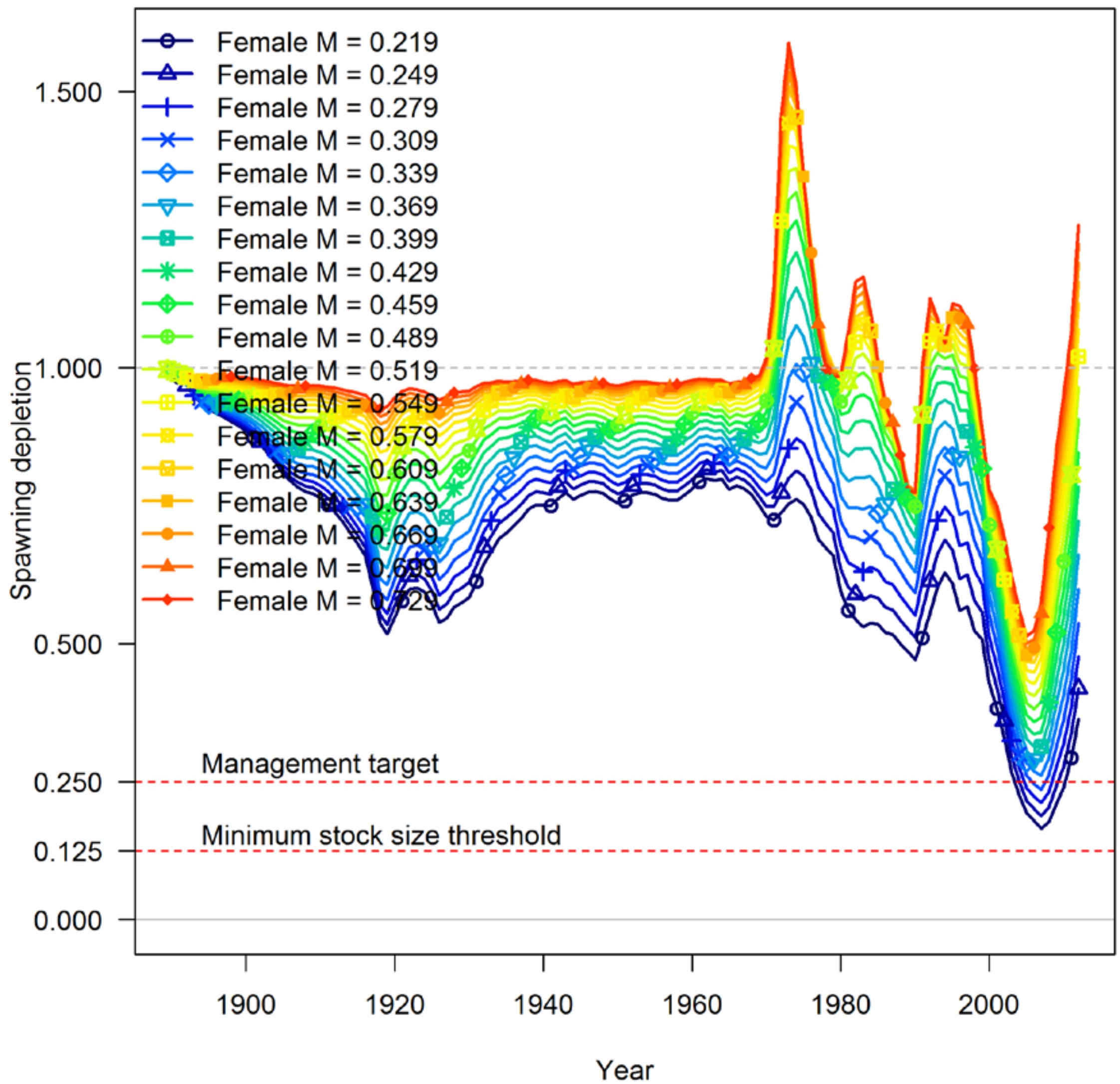

Figure 144. Estimated time series of stock depletion from a profile run on female natural mortality (*M*=0.20 to *M*=0.44 at interval of 0.02). Male natural mortalities were changed in the same increment. Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.

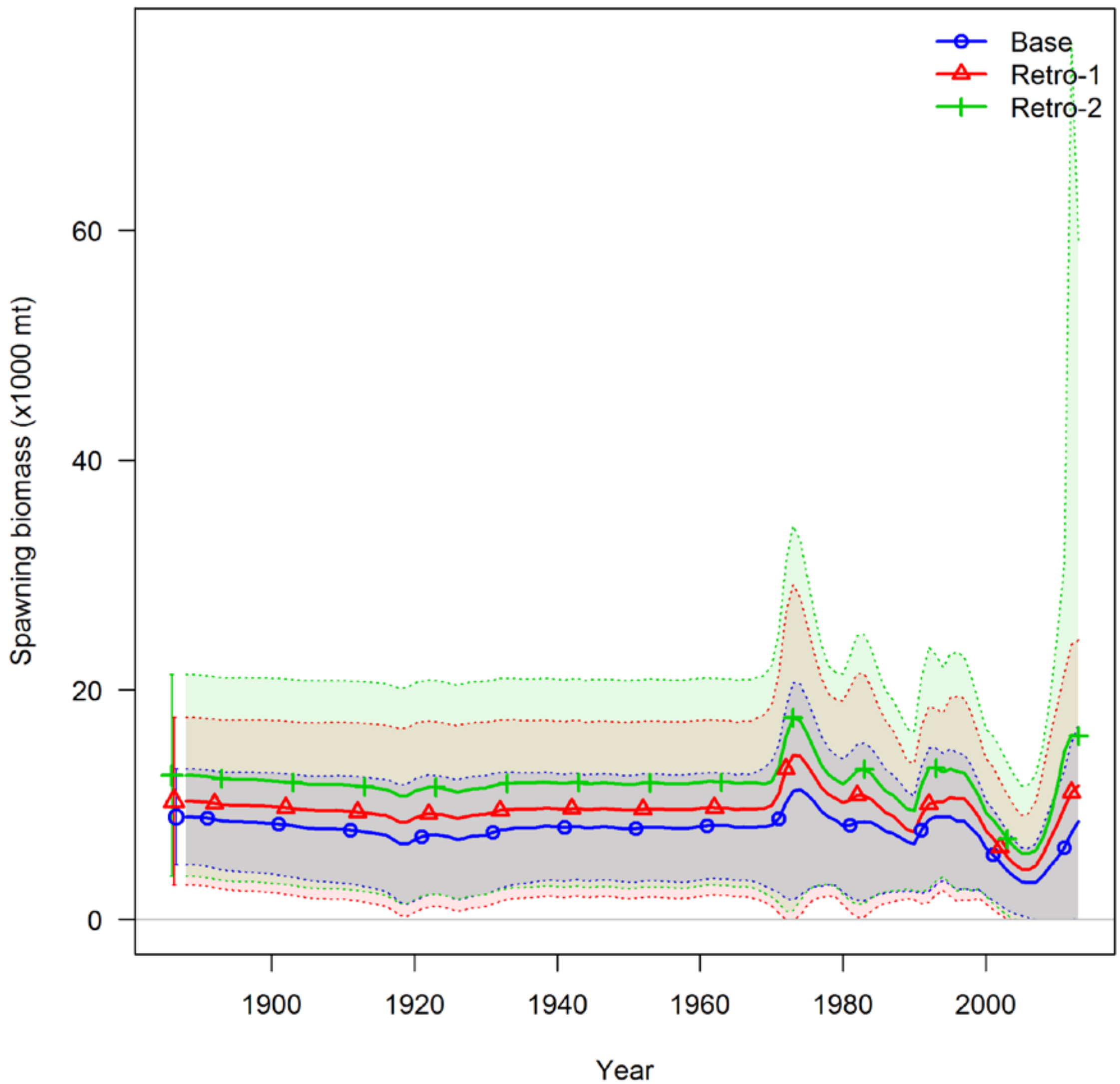

Figure 145. Estimated time series of spawning biomass with approximate asymptotic 95% confidence intervals from retrospective analysis of 0 to 3 years.

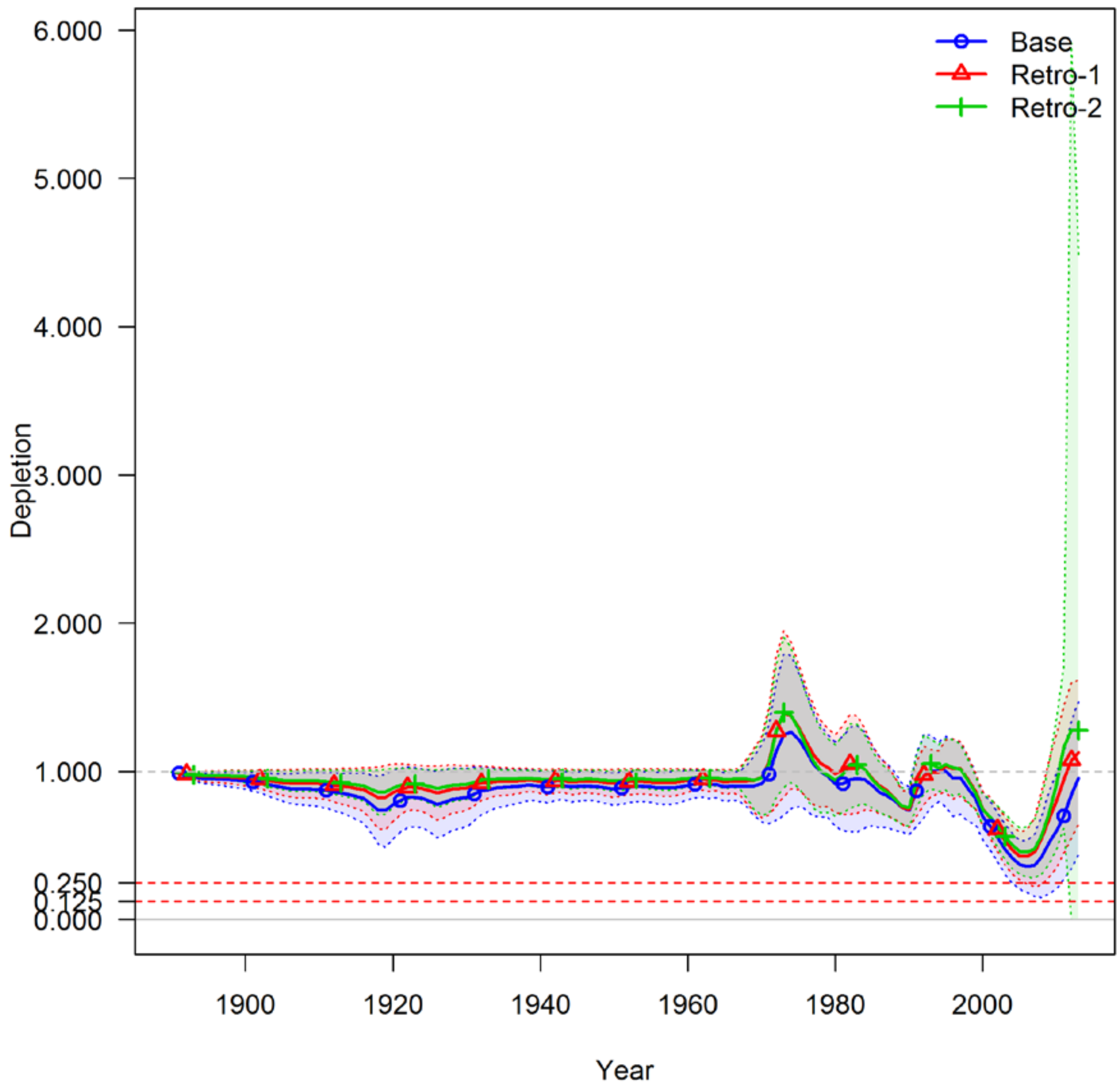

Figure 146. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from retrospective analysis of 0 to 3 years.

Appendix A. History of Management Measures Affecting the Pacific Sanddab Fishery

Pacific sanddabs have been managed in the Other Flatfish complex of species since implementation of the Groundfish FMP in 1982.

Pacific sanddabs have historically been taken by bottom trawls, commercial and recreational hook-and-line gear, and gillnets before that gear was prohibited. The vast majority of the take of Pacific sanddab has been with bottom trawls. Trawl discards of Pacific sanddabs have been relatively high although some targeting of the stock has occurred. For example, Scottish seine gear, which is legal trawl gear, has been deployed to selectively harvest Pacific sanddabs off central California (Steve Fitz, personal communication). Trawl fleet distribution and fishing behavior changed dramatically in 2011 with implementation of the trawl rationalization program where the shoreside trawl sector (i.e., those vessels delivering to shore-based processors) is managed under a system of individual fishing quotas (IFQs). Prior to 2011, trawl landings of species managed in the Other Flatfish complex were managed with cumulative landing limits (Table A1). With the advent of the trawl IFQ program, a trawl sector allocation of Other Flatfish was apportioned to trawl-endorsed permits based on permit catch history. These permit quotas or IFQs can be fished at any time during the season and traded to other IFQ participants. Since all catch, both landed and discarded (there is 100% observer requirement to track discards under the IFQ program), are counted against quota, any marketable catch is landed if there is room onboard the vessel to retain the catch. This has changed discard rates for many species caught in bottom trawls under the IFQ program. While it is assumed that most of the historical discarding prior to the IFQ program was market-based, there may have been some regulatory-induced discarding due to landing limits (Table A1).

To facilitate implementation of the trawl rationalization program, a formal allocation of stocks important to the trawl fishery was decided under Amendment 21, which decided trawl:non-trawl sector allocations. The trawl sector allocation of the non-tribal fishery harvest guideline (fishery HG or the available harvest guideline for non-tribal sectors) for the Other Flatfish species is 90% of the fishery HG (species in the Other Flatfish complex are trawl-dominant or primarily caught by trawl gears).

In 1992, the minimum mesh size of commercial trawls was increased from 3 in. to 4.5 in. This may have changed the selectivity of Pacific sanddabs to commercial trawls.

The trawl Rockfish Conservation Area (RCA) was implemented by emergency regulation in September 2002 south of 40º10’ N lat. and coastwide in annual regulations implemented since 2003. While the bounds of the RCA have changed seasonally to achieve management objectives (i.e., allow attainment of healthy target species’ catch limits while minimizing the mortality of overfished species), the core closed area has limited access to Pacific sanddabs. Despite that, there are continued trawl catches of Pacific sanddabs, mostly shoreward of the RCA. Washington does not allow commercial fishing in their state waters (0-3 nm) and California does not allow trawling in their state waters (with few designated zones south of Pt. Conception that are open).

Prior to 2000, there was no trawl limit on Other Flatfish species (Table A1). Also in 2000, trawls with small footropes (≤8 in. diameter) were required to land Other Flatfish species. Starting in 2001, there were differential limits specified for large and small footrope trawls with larger limits for the latter gear type. Beginning in 2005, selective flatfish trawl that were less efficient at catching rockfish and more efficient at catching flatfish, were required when fishing shoreward of the RCA north of 40º10’ N lat. (small footrope trawl are required when fishing shoreward of the RCA south of 40º10’ N lat.).

While Pacific sanddabs are trawl-dominant, there is non-trawl catch and some targeting of Pacific sanddabs by line gears. This catch is controlled by cumulative landing limits and area restrictions in the commercial non-trawl fisheries (Table A2) and daily bag limits, area restrictions, depth restrictions, and gear restrictions in recreational fisheries. Commercial access using non-trawl sectors to Other Flatfish species was not limited by regulations prior to 1999 for the open access sector and prior to 2002 for the limited entry fixed gear sector (Table A2). The non-trawl RCA was implemented by emergency regulation in September 2002 south of 40º10' N lat. and coastwide in annual regulations implemented since 2003. However, hook-and-line gear restrictions were implemented beginning in 2003 for efforts targeting Pacific sanddab south of 40º10' N lat. and for all waters off California beginning in 2005 (i.e., the Pacific sanddab hook-and-line fishery was not subject to RCA restrictions provided the gear specified in Table A2 was used).

Recreational catches of Pacific sanddabs are controlled by state-specific management measures such as bag limits, season restrictions, gear restrictions, depth restrictions, and other area restrictions (see Table A3 for 2013 recreational management measures affecting Pacific sanddabs). The California recreational fishery, where most of the recreational catch of Pacific sanddabs occurs, uses a similar gear restriction as the hook-and-line commercial sector to gain access Pacific sanddabs in areas otherwise closed to groundfish fishing (Table A3).

Table A1. Limited entry trawl cumulative landing limits for species in the Other Flatfish complex, including Pacific sanddabs, 1982-2010.

Year	Area	Gear	Period	Cumulative Landing Limits
2010	N of 40º10’	Large FR and small FR	1&6	110,000 lbs/2 mo.
			2-5	110,000 lbs/2 mo., no more than 9,500 lb/2 mo. of which may be petrale sole
		Sel. FF & multiple bottom trawl gears a/	1	90,000 lbs/2 mo., no more than 9,500 lb/2 mo. of which may be petrale sole
			2-6	60,000 lbs/2 mo., no more than 9,500 lb/2 mo. of which may be petrale sole
	S of 40º10’	All trawl gears	1&6	110,000 lbs/2 mo.
			2-5	110,000 lbs/2 mo., no more than 9,500 lb/2 mo. of which may be petrale sole
2009	N of 40º10’	Large FR and small FR	1&6	110,000 lbs/2 mo.
			2	110,000 lbs/2 mo., no more than 25,000 lb/2 mo. of which may be petrale sole
			3-5	110,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole
		Sel. FF & multiple bottom trawl gears a/	1&6	90,000 lbs/2 mo., no more than 16,000 lb/2 mo. of which may be petrale sole
			2-5	90,000 lbs/2 mo., no more than 18,000 lb/2 mo. of which may be petrale sole
	S of 40º10’	All trawl gears	1&6	110,000 lbs/2 mo.
			2-5	110,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole
2008	N of 40º10’	Large FR and small FR	1&6	110,000 lbs/2 mo.
			2	110,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole
			3-5	110,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole
		Sel. FF & multiple bottom trawl gears a/	1	70,000 lbs/2 mo., no more than 10,000 lb/2 mo. of which may be petrale sole
			2	70,000 lbs/2 mo., no more than 18,000 lb/2 mo. of which may be petrale sole
			3	50,000 lbs/2 mo., no more than 18,000 lb/2 mo. of which may be petrale sole
			4	80,000 lbs/2 mo., no more than 18,000 lb/2 mo. of which may be petrale sole
			5	80,000 lbs/2 mo., no more than 16,000 lb/2 mo. of which may be petrale sole
			6	80,000 lbs/2 mo., no more than 10,000 lb/2 mo. of which may be petrale sole
	S of 40º10’	All trawl gears	1&6	110,000 lbs/2 mo.
			2-5	110,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole

Year	Area	Gear	Period	Cumulative Landing Limits
2007	N of 40º10’	Large FR and small FR	1	110,000 lbs/2 mo.
			2	110,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole
			3-4	110,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole
			5	150,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole
			6	150,000 lbs/2 mo., including arrowtooth flounder
		Sel. FF & multiple bottom trawl gears a/	1	90,000 lbs/2 mo., no more than 16,000 lb/2 mo. of which may be petrale sole
			2	90,000 lbs/2 mo., no more than 25,000 lb/2 mo. of which may be petrale sole
			3-4	70,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole
			5	70,000 lbs/2 mo., no more than 15,000 lb/2 mo. of which may be petrale sole
			6	30,000 lbs/2 mo. (including arrowtooth flounder), no more than 8,000 lb/2 mo. of which may be petrale sole
	S of 40º10’	All trawl gears	1	110,000 lbs/2 mo.
			2	110,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole
			3-4	110,000 lbs/2 mo., no more than 25,000 lb/2 mo. of which may be petrale sole
			5	150,000 lbs/2 mo., no more than 25,000 lb/2 mo. of which may be petrale sole
			6	150,000 lbs/2 mo., including arrowtooth flounder
2006	N of 40º10’	Large FR and small FR	1	55,000 lbs/2 mo.
			2-5	90,000 lbs/2 mo., no more than 28,000 lbs/2 mo. of which may be petrale sole
			6	110,000 lbs/2 mo.
		Sel. FF & multiple bottom trawl gears a/	1	45,000 lbs/2 mo.
			2	90,000 lbs/2 mo., no more than 25,000 lbs/2 mo. of which may be petrale sole
			3-5	90,000 lbs/2 mo., no more than 28,000 lbs/2 mo. of which may be petrale sole
			6	90,000 lbs/2 mo.
	S of 40º10’	All trawl gears	1	55,000 lbs/2 mo.
			2-5	110,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole
			6	110,000 lbs/2 mo.

Year	Area	Gear	Period	Cumulative Landing Limits
2005	N of 40º10’	Large FR and small FR	1	110,000 lbs/2 mo.
			2	110,000 lbs/2 mo., no more than 42,000 lb/2 mo. of which may be petrale sole
			3-5	110,000 lbs/2 mo., no more than 40,000 lb/2 mo. of which may be petrale sole
			6	80,000 lbs/2 mo., no more than 60,000 lb/2 mo. of which may be petrale sole
		Sel. FF & multiple bottom trawl gears a/	1	100,000 lbs/2 mo., no more than 25,000 lbs/2 mo. of which may be petrale sole
			2	100,000 lbs/2 mo., no more than 35,000 lbs/2 mo. of which may be petrale sole
			3-5	90,000 lbs/2 mo., no more than 35,000 lbs/2 mo. of which may be petrale sole
			6	75,000 lbs/2 mo., no more than 15,000 lbs/2 mo. of which may be petrale sole
	S of 40º10’	All trawl gears	1&6	110,000 lbs/2 mo.
			2-5	110,000 lbs/2 mo., no more than 42,000 lb/2 mo. of which may be petrale sole
2004	N of 40º10’	Large FR	1-3&6	100,000 lbs/2 mo.
			4-5	100,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole
		Small FR	1-2	30,000 lbs/2 mo., no more than 10,000 lb/2 mo. of which may be petrale sole
			3	80,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole
			4-5	80,000 lbs/2 mo., no more than 26,000 lb/2 mo. of which may be petrale sole
			6	100,000 lbs/2 mo.
	S of 40º10’	All trawl gears	1	100,000 lbs/2 mo.
			2	100,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole
			3-5	120,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole
			6	120,000 lbs/2 mo., no more than 100,000 lb/2 mo. of which may be petrale sole
2003	N of 40º10’	Large FR	1&6	100,000 lbs/2 mo.
			2-5	100,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole
		Small FR	1&6	100,000 lbs/2 mo.
			2-5	20,000 lbs/2 mo., no more than 10,000 lb/2 mo. of which may be petrale sole
	S of 40º10’	All trawl gears	1&6	70,000 lbs/2 mo.
			2-5	70,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole

Year	Area	Gear	Period	Cumulative Landing Limits
2002	N of 40º10’	Small FR	1	15,000 lbs/2 mo.
			2	35,000 lbs/2 mo.
			3	30,000 lbs/2 mo., no more than 10,000 lb/2 mo. of which may be petrale sole
			4	40,000 lbs/2 mo., no more than 15,000 lb/2 mo. of which may be petrale sole
			5	50,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole
			6	50,000 lbs/2 mo.
	S of 40º10’	Small FR	1-2&6	70,000 lbs/2 mo., no more than 40,000 lb/2 mo. of which may be Pacific sanddabs
			3-5	70,000 lbs/2 mo., no more than 40,000 lb/2 mo. of which may be Pacific sanddabs, no more than 15,000 lb/2 mo. of which may be petrale sole
2001	N of 40º10’	Large FR	1-6	1,000 lbs/trip
		Small FR	1,2&6	No limit
			3-5	30,000 lb/mo. for all flatfish except Dover sole
	S of 40º10’	Large FR	1-6	1,000 lbs/trip
		Small FR	1-6	No limit
2000	Coastwide	Small FR	1-6	No limit - only small footrope gear can be used to take and retain flatfish other than Dover sole, petrale sole, rex sole, or arrowtooth flounder during various periods
1982-1999	Coastwide	All trawl gears	Year-round	No limit - for flatfish other than Dover sole, petrale sole, rex sole, or arrowtooth flounder during various periods

a/ If a vessel has both selective flatfish gear and large or small footrope gear on board during a cumulative limit period (either simultaneously or successively), the most restrictive cumulative limit for any gear on board during the cumulative limit period applies for the entire cumulative limit period.

Table A2. Limited entry fixed gear and open access cumulative landing limits for species in the Other Flatfish stock complex, including Pacific sanddabs, 1982-2012.

Year	Area	Sector	Period	Cumulative Landing Limits	Other Regulations
2005-2012	Coastwide	LEFG	Year-round	5,000 lbs/mo.	South of 42º N lat. (i.e., waters off CA), when fishing for Other Flatfish, vessels using hook-and-line gear with no more than 12 hooks per line, using hooks no larger than "Number 2" hooks, which measure 11 mm (0.44 inches) point to shank, and up to two 1 lb (0.45 kg) weights per line are not subject to the RCAs
		OA	Year-round	3,000 lb/mo., no more than 300 lb of which may be species other than Pacific sanddabs	
2004	N of 40º10’	LEFG	Year-round	5,000 lbs/mo.	RCAs
		OA	Year-round	3,000 lb/mo., no more than 300 lb of which may be species other than Pacific sanddabs	
	S of 40º10’	LEFG	Year-round	5,000 lbs/mo.	When fishing for Other Flatfish, vessels using hook-and-line gear with no more than 12 hooks per line, using hooks no larger than "Number 2" hooks, which measure 11 mm (0.44 inches) point to shank, and up to two 1 lb (0.45 kg) weights per line are not subject to the RCAs
		OA	Year-round	3,000 lb/mo., no more than 300 lb of which may be species other than Pacific sanddabs	
2003	N of 40º10’	LEFG	Year-round	5,000 lbs/mo.	RCAs
		OA	Year-round	3,000 lb/mo., no more than 300 lb of which may be species other than Pacific sanddabs	
	S of 40º10’	LEFG	Year-round	5,000 lbs/mo.	When fishing for Pacific sanddabs, vessels using hook-and-line gear with no more than 12 hooks per line, using hooks no larger than "Number 2" hooks, which measure 11 mm (0.44 inches) point to shank, and up to two 1 lb (0.45 kg) weights per line are not subject to the RCAs
		OA	Year-round	3,000 lb/mo., no more than 300 lb of which may be species other than Pacific sanddabs	
2002	N of 40º10’	LEFG	Year-round	5,000 lbs/mo.	None
		OA	Year-round	3,000 lb/mo., no more than 300 lb of which may be species other than Pacific sanddabs	
	S of 40º10’	LEFG	Year-round	5,000 lbs/mo.	Closed deeper than 20 fm in periods 4-6

Year	Area	Sector	Period	Cumulative Landing Limits	Other Regulations
		OA	Year-round	3,000 lb/mo., no more than 300 lb of which may be species other than Pacific sanddabs	
1999-2001	Coastwide	LEFG	Year-round	No limit	None
		OA	Year-round	300 lb/mo.	
1982-1998	Coastwide	All a/	Year-round	No limit	None

a/ Non-trawl sector designations were implemented in 1994 with the designation of limited entry and open access sectors. Limited entry participants, based on the fishing history of qualifying vessels, were further divided with permits endorsed for one or more of three gear types (trawl, longline, and pot/trap).

Table A3. 2013 recreational management measures affecting Pacific sanddabs by state.

State	Daily Bag Limit	Depth Restrictions	Other Area Restrictions	Special Gear Restrictions for Flatfish
CA	None	None	No fishing in federal and state MPAs	When fishing for Other Flatfish, vessels using hook-and-line gear with hooks no larger than "Number 2" hooks, which measure 11 mm (0.44 inches) point to shank, and up to two 1 lb (0.45 kg) weights per line are not subject to depth or season restrictions
OR	25 fish limit per day for all flatfish, excluding Pacific halibut, but including all soles, flounders and Pacific sanddabs,	Closed >40 fm seasonally	No fishing in federal MPAs and YRCAs	None
WA	12 bottomfish, including sanddabs, per day	Closed >20 fm seasonally in Marine areas 3 and 4 and closed >30 fm seasonally in Marine area 2	No fishing in federal YRCAs and state MPAs; seasonal restrictions	None

Appendix B. Summaries of Field and Laboratory Studies on Reproductive Biology of Pacific Sanddab

Lyndsey Lefebvre
Fisheries Ecology Division
SWFSC, Santa Cruz, CA
June 2013

Introduction

Data on the reproductive ecology of Pacific sanddab, *Citharichthys sordidus*, are limited. Arora (1951) described the ovarian cycle based on measurements of eggs from the ovaries of females collected by otter trawl from Pt. Reyes to San Francisco, CA. The spawning season was stated to last from July through early-September, as egg diameters reached maximum values and no females with spent ovaries were collected during this time period. Arora suggested sanddabs were capable of spawning multiple times a season, due to the occurrence of multiple modes of maturing eggs in the ovaries, but was unable to test this hypothesis. It was estimated that 50% of females were mature at 190 mm total length (TL) with nearly all mature by 220 mm TL, corresponding to an age of 3 years.

To estimate the spawning season, Chamberlain (1979) used descriptions of gross morphological changes to the ovary as well as finer scale histological descriptions of oocyte development from Pacific sanddab collected between December 1969 and June 1972 between Santa Barbara and San Diego, CA. Chamberlain suggested initial oocyte development (vitellogenesis) started in February and that females were in spawning condition by June. The spawning season continued through September as the first fish with spent ovaries were collected in October. A maturity curve was not provided; however, the smallest mature female reported was 160 mm TL. Chamberlain made no mention of the possibility of sanddab being batch spawners.

Both Arora (1951) and Chamberlain (1979) provide insight into Pacific sanddab reproductive biology but fail to provide data important in assessing population status, such as spawning frequency and fecundity. Additionally, Pacific sanddab larvae and metamorphic-stage fish were collected year-round off the coast of central and southern California by the California Cooperative Oceanic Fisheries Investigations (CalCOFI) from 1954-1960 and 1984 (Moser et al. 2001). While sanddab have a long larval and metamorphic-stage duration (up to 9 months [Sakuma and Larson 1995; Donohoe 2000]) and size and the stage of fish were not provided by the CalCOFI data, the year-round collection suggest spawning may be occurring outside of the time period proposed by Arora and Chamberlain.

In order to determine spawning season; describe the female reproductive cycle; and estimate size and length at maturity, fecundity, and spawning frequency of females, Pacific sanddab were collected via hook-and-line from the Monterey Bay during 13 sampling trips between March 2012 and April 2013. Additional Pacific sanddab were collected opportunistically from mid-water trawl and live trap surveys conducted in the same region. Ovarian tissue from a subset of females collected was examined histologically to microscopically describe the reproductive cycle and estimate spawning frequency of wild Pacific sanddab. Additional studies of captive fish provided information on biological capabilities for reproduction in sanddab.

Materials and Methods

Collections and General Reproductive Biology

Collections of Pacific sanddab have been ongoing since March 2012. The majority of fish were collected by hook-and-line; 13 individuals from May and early June 2012 were collected in a mid-water trawl and 17 individuals from early August were caught in a live trap, all in the same area as hook-and-line fishing occurred in the southern Monterey Bay. In March and July fishing occurred in the northern Monterey Bay off of Santa Cruz in the 70-90 m depth range. In May and June 2012 and from August onward, all fish were collected from the southern portion of Monterey Bay, off of the Monterey Peninsula and Point Piños, in the 50-70 m depth range. Female sanddab were targeted but a random sampling of males was made during each collection.

Total length, total body weight, liver weight, and sex were recorded and saggital otoliths were removed for aging when possible. For all females gonads were excised, weighed, and macroscopically staged for maturity (Table B1) and a latitudinal cross-section collected from the middle portion of one ovarian lobe was fixed in 10% neutral buffered formalin for histological analysis. When weights were available, the gonadosomatic index (*GSI*) was calculated as:

$$GSI = \left(\frac{ow}{ofbw}\right) * 100$$

where ow=ovary weight (g) and $ofbw$=ovary-free body weight (g). T-tests were performed to compare monthly GSI values with significance levels of p=0.05. When ovaries with hydrated oocytes (HO) were encountered, two weighed subsamples of ovarian tissue were preserved in 10% neutral buffered formalin for fecundity analysis. for comparison to histological phases described in the next section, females with mature ovaries were further classified as “inactive”, “developing”, or “active” (Table B1) based on their macroscopic stage. Inactive females were those incapable of spawning in the near future; developing females were those capable of spawning in the near future; and active females were those capable of spawning in the immediate future or that had spawned recently. Male gonads were examined for maturity did not remain intact upon removal.

Histology

A subset of ovarian tissues from each sampling day was selected for histological processing by standard techniques (Humason 1972). Briefly, after at least 24 hours of fixation, tissues were rinsed in freshwater and stored in 70% ethanol. Tissues were taken through a graded series of ethanol before being infiltrated and embedded in paraffin; sectioned to a thickness of 4-6 µm using a rotary microtome; mounted on glass slides; and stained and counterstained using Hematoxylin and Eosin-y. Histology sections were examined at 100x and 250x magnification using a compound microscope, and each was assigned an ovarian maturity phase (Table B2). Ovarian phases were based on descriptions of teleost oocyte development by Wallace and Selman (1981) and modified from Lefebvre and Denson (2012) and Brown-Peterson et al. (2011). Mature females were further classified as “inactive”, “developing”, or “active” (Table B2) based on the ovarian phase assigned, level of atresia, and presence or absence of postovulatory follicles (POFs). Inactive females were those incapable of spawning in the near future or lacking evidence of recent spawning activity. Developing females had ovaries that were capable of proceeding to the spawning capable phase in the near future. Active females were capable of spawning in the immediate future, were actively spawning, or showed evidence of a recent spawn. POFs were assigned an approximate age according to descriptions of POF degradation in Hunter and Macewicz (1985a) and Ganias et al. (2007) and based on observations from a laboratory study described in the “spawning frequency” section.

Fecundity

Fecundity was estimated using the hydrated oocyte method (Hunter et al. 1985); each weighed subsample of ovarian tissue from female sanddabs with ovaries macroscopically staged as ripe (HO present in ovary but not in oviduct) were placed onto gridded Petri dishes, viewed under a dissection microscope, and HO enumerated. Absolute batch fecundity (ABF; the number of oocytes released per spawning event) for each subsample was calculated as:

$$ABF = \left(\frac{c_x}{ss_x}\right) * ow$$

where c_x=count of HO in subsample x, ss=weight (g) of subsample x, and ow=ovary weight (g). The ABF for each female was calculated as the mean of the ABF of the two subsamples. To remove the effect of fish size on fecundity, relative batch fecundity (RBF) was calculated as:

$$RBF = \frac{ABF_x}{ofbw}$$

where ABF_x=absolute batch fecundity of subsample x and $ofbw$=ovary-free body weight (g). The RBF for each female was calculated as the mean of the RBF of the two subsamples. Linear regressions were performed to examine length-specific changes in ABF and RBF.

Spawning Frequency

To examine spawning frequency, male and female Pacific sanddab were collected from the Monterey Bay in July, August, and September and brought into aquariums maintained at the Fisheries Ecology Division, SWFSC/NMFS. Fish were initially kept in one large (diameter=183 cm, height=127 cm) circular tank with approximately 3-4 cm of 16 grit sand on the bottom. As experiments progressed fish were separated into 10 smaller tanks (diameter=85 cm, height=127 cm), each filled with 3-4 cm of 16 grit sand. Ambient temperature seawater pumped directly from the ocean was filtered through 2 sand filters (10-100 µm) and passed through a UV sterilizer before mixing with chilled seawater. Tank temperatures fluctuated between 8 and 13˚C (primarily between 9.5-12.5˚C). Each tank had separate inflowing and outflowing standpipes. Water was constantly flowed into the tanks at a rate of 100 mL/s, and the net motion of the surface water was circular. Outflowing water was filtered through an egg collector lined with 333 µm mesh netting. All tanks were covered by black tarps; however, some light made it into the tanks at the inflow standpipes. Fish were exposed to ambient light regimes until October 31, 2012 when a 16 hour light, 8 hour dark regime was established for a separate experiment. Fish were fed to satiation a diet of mixed fish and market squid three days per week. An aliquot (0.2-0.9 ml settled volume) of eggs collected from the large tank on 5 different days was placed in a petri dish, and all the eggs were counted twice to get the average number of eggs per ml.

In late August five male-female pairs were segregated into individual tanks. The volume of eggs collected was measured and the stages of egg development were recorded daily (Mon-Fri) when eggs were present. If volumes of eggs collected on Monday were at least double the volume from individual spawns the week before, the fish was estimated to have spawned twice. The number of spawns recorded was a minimum value since spawning activity was not monitored over weekends and holidays; therefore, there may have been additional unrecorded spawns. When egg collectors overflowed, a spawn was recorded if eggs were present and the stage of development could be determined, though no volumes were available. The spawning frequency for each female was calculated as the quotient of the total number of days in isolation and the minimum number of spawns. The average batch fecundity for each female was calculated by summing the recorded volumes of spawns from the date of isolation to November 30, 2012, multiplying by the average number of eggs per ml, and dividing the total number of eggs by the minimum number of spawns.

To establish guidelines for aging POFs in histological sections of ovaries from wild-caught fish, male-female pairs were placed into the remaining five individual tanks, and females were sacrificed at post-spawning intervals (4 hour intervals to 24 hours post-spawning and 8 hour intervals thereafter to 48 hours). A cross section from the middle portion of one ovarian lobe of each female was collected and processed histologically as described in the histology section. Slides were examined and POFs were described for each 24-hour time.

Results and Discussion

Collections and General Reproductive Biology

Three hundred seventy-two (312 females; 60 males) Pacific sanddab were collected over twenty-two sampling days between March 2012 and April 2013. Sanddab were sexually dimorphic, with females reaching larger total length (TL) than males (Fig. B1). Females ranged in size from 110 to 290 mm TL (90% were 130-240 mm); males ranged in size from 120 to 230 mm TL (90% were 140-200 mm). Ages of females ranged from 0 to 8 years while males collected ranged from 1 to 6 years of age.

Macroscopic examination of testes from male Pacific sanddab suggested that all males collected were mature. Testes from all males were opaque and tan in color. Testes appeared similar throughout the year with no detectable changes in appearance during the reproductive season

Macroscopic staging of ovaries (Fig. B2a) showed an increasing proportion of females with developing ovaries through the late winter and early summer. By June ovaries were near spawning condition. In August all of the females collected were actively spawning, and the majority of females remained in the actively spawning stages through at least November (no collection was made in December). Immature females were easily distinguished from mature females between August and November due in large part to most mature individuals having hydrated oocytes (HO) visible during this time. HO, which are evidence of an imminent spawn, were readily distinguished from maturing oocytes based on their large size and translucent appearance. In individuals from October and November that had finished spawning for the season, oocytes were still visible in mature individuals whereas immature ovaries were translucent.

GSI values were available for 257 female Pacific sanddab from all sampling months except May and June and mirrored trends in macroscopic staging (Fig. B2a). Mean GSI values were significantly lower (1.74-2.41) through the winter and early summer (February through July) than the rest of the year. GSI peaked in August (mean=6.70) and decreased slightly in September (mean=4.80), remaining at a level that was not significantly different through November. The mean GSI value decreased significantly again in January (mean=3.13). The gross staging of ovaries and GSI values suggest that Pacific sanddab have a protracted spawning season extending from August through at least November. This season is similar to that reported by both Arora (1951) and Chamberlain (1979); however the season lasts longer than either previous study reported.

Histology

A subsample of 97 ovarian tissues from females collected in all months sampled, except for February and April, have been processed and staged (as of May 2013). The fish were chosen to represent the size range and macroscopic maturity stages of fish collected at each time period. An additional 60 samples are being processed to obtain representative histology samples from February, March, and April 2013 and to fill in underrepresented sampling months. General histological trends mirror macroscopic trends (Fig. B2b), and all histological phases were encountered (Figs. B3 and B4). The majority of female sanddab collected between January and May had inactive ovaries, indicating that they were between spawning seasons. By July most fish were in or nearing spawning condition. The majority of females remained active through November, though some spawning activity persisted until January.

Histological examination of tissues allows for viewing of cellular structures (e.g., POFs and oocytes in initial stages of oocyte maturation [OM]) not visible to the naked eye, thereby allowing for refinement of the reproductive cycle. The finer scale histological phases show a more nuanced trend in the annual reproductive cycle of sanddab (Fig. B3) and that the reproductive season extended from July through January, with a peak of activity from August through November. Oocyte development is rapid with the first vitellogenic oocytes found in May and the first actively spawning ovaries found in July. In August all females collected had previously spawned and were nearing another spawning event. The first spent ovaries were found in September (as found by Arora [1951]), but the majority of females remained in the spawning capable phase through November. During the peak of spawning activity, all stages of oocytes were found in ovaries from actively spawning females, indicating oocyte development is asynchronous, oocyte recruitment is continuous, and fecundity is indeterminate in Pacific sanddab (Murua and Saborido-Rey 2003; Korta et al. 2010). By January the majority of females had ovaries in the regressing phase and had ceased spawning activity; only one female in the regressing phase had POFs, suggesting spawning activity had ended at least several days prior to collection. Chamberlain (1979) had suggested that vitellogenesis began as early as February but his lack of samples between November and February, when fish may still have been spawning, may have led him erroneously to this conclusion. More likely the early vitellogenic oocytes he found were from the previous spawning season and had not yet undergone atresia.

Oocytes in the initial stages of OM, the hormonally controlled “point-of-no-return” which ultimately results in ovulation and spawning of mature eggs, were found in sanddab ovaries that also had HO. Laboratory held sanddabs mostly spawned in the early morning hours (0200-0800 hrs), before the typical sampling time of wild fish; however, HO were found in wild-caught females collected 0800-1200 and as well as 1600-1800 hrs. The histological and field evidence suggests OM is not a rapid event in Pacific sanddab. OM, like other physiological processes, is influenced by temperature; the duration of hydration (the final stage of OM) took 20 hours at 9˚C but less than 5 hours at 20˚C in Japanese flounder, *Paralichthys olivaceus* (Kurita et al. 2011). Even longer durations of hydration, from 35 to 54 hours, have been found in deep-dwelling Atlantic halibut, *Hippoglossus hippoglossus* (Finn et al. 2002). Water temperatures at the time of collection were not available but Pacific sanddab are reported to be tolerant of waters between 5-13˚C (Love 2011), and it is presumed temperatures were within this range. It is plausible that hydration could last 20-24 hours in Pacific sanddab, with the next batch of oocytes destined to be spawned initiating OM 24 hours prior to the onset of hydration.

The lack of immature females in histological samples from March, May, and June and the comparatively high proportion from macroscopic staging during the same time period (Fig. B2) illustrates how misclassification of immature, mature, and resting ovaries outside of the reproductive season is an issue for indices of maturity relying on macroscopic data (West 1990). Macroscopically, the immature ovary, which only contains early growth oocytes (late primary growth and early cortical alveolar) and has no atretic oocytes, appears similar to the regenerating ovary, which has similar stages of oocytes but pronounced atresia as well. Similarly, while nearly half the females collected in January were macroscopically staged as having developing ovaries, histological examination of five of these revealed that the oocytes visible to the naked eye were atretic, being resorbed as part of the end of the season “cleanup” that occurs in regressing and regenerating ovaries. Because of these issues, the growth curve for female sanddab (Fig. B5) was constructed utilizing macroscopic stages of ovaries from fish collected only during the peak reproductive period, August through November (n=154). Compared to Arora (1951), who used maturity data collected from 227 female Pacific sanddab collected in August, females in the current study reached maturity at a much smaller size. In the current study, no fish were mature below 120 mm TL, 50% maturity occurred before 130 mm, and 100% maturity occurred at 150 mm TL. In contrast, Arora (1951) showed first maturity around 170 mm, 50% around 185 mm, and 95% around 200 mm TL. Though no females smaller than 150 mm were available in his August collections, Arora did collect females as small as 95 mm as part of his other life history work. The differences in the two growth curves may be attributable in part to regional differences or interannual variability; however, fishing-induced evolution can result in fish maturity at smaller sizes (Rijnsdorp et al. 2010; van Walraven et al. 2010).

Fecundity

Fecundity subsamples were collected from 100 females during the spawning season. Data collection is ongoing; however, as of May 2013, fecundity estimates have been made from 50 females. Average batch fecundity (ABF) values ranged from 810 to 17,400 (mean=6,350 ± 610) eggs spawned per batch and increased linearly with TL (Fig. B6a; R^2=0.55). Relative batch fecundity (RBF) values ranged from 15 to 115 (mean=61 ± 4) eggs per gram ovary-free body weight and showed no significant relationship with length (Fig. B6b; R^2=0.06). Not all ovarian samples from females for which fecundity was estimated were examined histologically, and it is therefore possible that the reported values may be biased low: without histological examination to look for new POFs, it is impossible to say whether or not a particular female had ovulated and spawned a portion of the batch of eggs. Despite the potential for fecundity values to be underestimates, these data provide novel information on the minimum reproductive output of Pacific sanddab.

Fecundity data are limited on flatfish species, especially other Paralichthyids, and, more generally, fish with indeterminate spawning strategies due to the difficulty in obtaining sufficient data (Murua et al. 2003; Fitzhugh et al. 2012). Two other Paralichthyid species, Patagonian flounder (*Paralichthys patagonicus*) and yellowfin sole (*Limanda aspera*) have much larger batch fecundities, 80,380 on average for the former (Militelli 2011) and between 2,400 and 408,000 for the latter (Nichol and Acuna 2001). Relative batch fecundity was similar, however, in the Patagonian flounder (means of 71-93 HO per gram OFBW; Militelli 2011). Batch fecundity in captive yellowtail flounder (*Limanda ferruginea*), a Pleuronectid, was also higher, falling between 10,000 and 20,000 eggs spawned (Manning and Crimm 1998). Relative batch fecundity in captive Dover sole, *Microstomus pacificus* (Pleuronectidae), was even lower than that estimated for Pacific sanddab, decreasing from 10 oocytes per gram OFBW early to 5 oocytes per gram late in the spawning season (Hunter et al. 1992). However, comparisons between Pacific sanddab and the other species mentioned should be made cautiously as yellowfin sole, Dover sole, and yellowtail flounder have determinate fecundity and fecundity type in Patagonian flounder was not explicitly stated.

Spawning Frequency

Pacific sanddab collected from Monterey Bay and brought into the laboratory acclimatized well: spawning often occurred the night fish were collected and brought into the lab. On average there were 2,012 eggs per ml of eggs collected from the large group tank. The 5 male-female pairs began spawning within one or two days of being isolated (Table B3), and females often spawned on successive days throughout the time period. The ABF for these 5 captive female sanddab ranged from 3,026 to 5,961 eggs. The ABF in captive females is within the range of ABF estimated from wild females but may be less than the average for several reasons. Firstly, all but one of the captive females were smaller than 200 mm TL; ABF from wild-caught females above 200 mm TL were generally greater than 6,000 eggs/batch and contributed to the high average. Secondly, it is possible that not all the eggs spawned made it into the egg collectors: sanddab eggs are positively buoyant but unfertilized or non-viable eggs sink (Smith et al. 1999). Lastly, a female may not ovulate and release all HO at once (Burt et al. 1988). Additionally, the actual batch fecundity of captive females may be even lower than initial estimates due to unrecorded spawns. Captive female sanddab spawned every 1.6 days on average (i.e., an individual would be expected to spawn twice every three days), though this is likely an underestimate due to lack of monitoring of spawning activity over weekends and holidays.

Four of the original five pairs of sanddab are still isolated: one pair was euthanized in March 2013 due to injuries. Spawning continued regularly in all tanks until a rapid drop in temperature from 10.5 to 8.5 ˚C in December, at which time spawning volumes dropped in four tanks and ceased all together in one. Spawning resumed in four tanks once temperatures were adjusted upwards. In February an additional two females ceased spawning activity. Spawning activity in the two remaining tanks remained fairly regular, with spawning frequency decreasing to around once every three days, from December through March. In April the females began to spawn daily the majority of the time. Sporadic spawning in the two tanks with females that had stopped in February began again in early May as temperatures rose from 9.5-10.0ºC to 11.5-12.5ºC. Other examples of species in which individual females are capable of spawning daily include New Zealand snapper, *Pagrus auratus* (Scott et al. 1993); yellowfin tuna, *Thunnus albacores* (Schaeffer 1998); and Japanese flounder (Kurita et al. 2011). However, in Japanese flounder, while the population-level spawning period lasts 5 months, an individual female only spawns 2-3 months (Kurita et al. 2011). While the tank conditions are completely artificial compared to environmental conditions wild fish encounter, female Pacific sanddab are biologically capable of prolonged reproductive activity.

Histology samples from 36 females sacrificed at known intervals post-spawning were examined. Because most spawning occurred between midnight and 0800 hrs in the lab and the majority of wild fish were collected between 0800-1200 hrs, day 1, day 2 and day 3+ POFs were considered those 0-12, >12 to 36, and >36 hours old, respectively (Fig. B7). POFs were distinguishable from other atretic material (atretic oocytes and late-stage atresia of oocytes and POFs) for at least 2 days (48 hrs); POF persistence beyond that time is unknown since no females were held in experimental tanks past 48 hours post-spawning. Based on the morphology of the 48-hour old POFs and presence of multiple "modes" of POFs present in ovaries examined, they likely remain distinguishable beyond that time. POFs persisted as long as 58 hours in Mediterranean sardine, *Sardina pilchardus sardine* (Ganias et al. 2003) and up to 3-4 days in northern anchovy, *Engraulis mordax* (Hunter and Macewicz 1985b). Kurita et al. (2011), however, found that POFs in Japanese flounder were no longer evident 16 hours after spawning at 9˚C.

Spawning in the laboratory occurred most frequently between 0200 and 0800 hrs and most sampling of wild Pacific sanddab occurred from 0800 to 1200 hrs; therefore, Day 0, day 1, and day 2+ POFs were considered to be 0-12, >12-36, and >36 hours old, respectively. In Day 0 POFs, the cells of the granulosa layer were cuboidal in shape with prominent nuclei and formed a convoluted shape in the lumen of the empty follicle. Day 1 POFs were further condensed often with less space in the lumen and the granulosa layer began to form a single layer within the lumen by the end of the stage. Day 2+ POFs were smaller and triangular in shape with a very small, single layer of granulosa cells and a thickened layer of thecal cells. In the oldest discernible POFs, the granulosa layer was nearly absent and the thecal layer was thicker.

Due to a restricted space to set up more spawning tanks and a lack of diel synchronicity in spawning of captive sanddab, it was impossible to get a sufficient number of samples from all post-spawning time periods in order to fully examine the degradation of POFs over time. Temperature significantly effects the rate of degradation of POFs in other species (Kurita et al. 2011), and the fluctuating temperatures in experimental tanks over the course of spawning further precluded solidification of precise criteria to establish age of POFs. Additionally, as spawning activity of females prior to their isolation was unknown, most of the histological sections had POFs from multiple spawns complicating interpretation. The experiment did help establish a general idea of new, recent, and older POFs which, while not applicable for accurately establishing spawning frequency in wild sanddab, assisted with histological staging.

Conclusions

Pacific sanddab in the Monterey Bay are indeterminate spawners with asynchronous oocyte development and are capable of spawning many times throughout a protracted reproductive season extending from July through January. While histological evidence was unable to allow for population level spawning frequency estimates of wild fish, it does suggest that females are capable of spawning on successive days. Biologically, female sanddab are capable of spawning daily for at least several days in a row, as evidenced by the spawning activity of captive fish. If a wild female is assumed to exhibit a similar spawning frequency to laboratory held fish during the peak spawning months of August through November and an average batch fecundity of 6,350 eggs, that female could potentially spawn 76 times during the peak, producing up to 4.8 million eggs. Sanddab appear to be maturing at significantly smaller sizes and younger ages from fish collected off the California coast in the 1930s and 1940s (Arora 1951). Whether the change in size and age at maturation was induced by fishing related evolution or was due to spatial and/or temporal variability is unknown but the change is compelling and has significant repercussions on estimates of spawning stock biomass.

Fecundity and spawning frequency results presented here are introductory, and further sample processing and research would allow us to examine other aspects of the reproductive ecology of Pacific sanddab. For example, in other indeterminate spawning teleosts, batch fecundity has been shown to vary between the beginning and end of the spawning season (Ruchon et al. 1993; Militelli and Macchi 2004).

More importantly, while relative fecundity appears to be unrelated to female size in our initial analysis, maternal age and/or size may still be relevant to other aspects of the spawning ecology of Pacific sanddab. Maternal age or size has been shown to influence the quality of eggs and larvae in several species (Berkeley 2004; Sogard 2008). The duration of spawning season and frequency often differs between fish of different age and size categories (Lowerre-Barbierri et al. 2011), most often with older, larger females spawning for longer and more frequently than younger, smaller females (Fitzhugh et al. 2012). When this is failed to be accounted for in stock assessment models, the result is an overestimate of biological reference points that are used in setting harvest rates (Fitzhugh et al. 2012). Collection of additional fecundity samples and closer examination of spawning frequency of wild-caught fish may allow us to determine if there are age and size differences in the reproductive ecology of these fish and what effects the reduced size at maturity may have on the population of Pacific sanddab along the Central California coast.

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Table B1. Macroscopic stages of maturity for Pacific sanddabs.

Stage	**Visual description**	**Gross Maturity Category**
Immature	Ovaries thin; no oocytes visible; translucent. As approaching maturity, lamellae are faintly visible.	Immature
Developing	Oocytes visible, giving ovary a granular appearance; ovary vascularized; ovary opaque peach in color	Mature--Developing
Ripe	Hydrated oocytes (clear) visible in ovary, but not in oviduct or lumen; the rest of the ovary looks like the "Developing" ovary	Mature--Active
Running	Hydrated oocytes loose in lumen and/or oviduct; additional hydrated oocytes may be visible in ovarian tissue; rest of the ovary looks like the "Developing" ovary	Mature--Active
Regressing	Ovary bright red/pink (well vascularized) & flaccid; oocytes visible but not throughout ovary and not patterned; ovary has a loose and gelatinous texture	Mature--Active
Regenerating or Early Developing	Ovaries small and mostly translucent; lamellae/early oocytes visible creating track- or maze-like pattern in ovary	Mature--Inactive

Table B2. Histological phase criteria and descriptions for Pacific sanddab. Phases were based on descriptions of teleost development in Wallace and Selman (1981) and modified from Lefebvre and Denson (2012) and Brown-Peterson et al. (2011). PG=primary growth; CA=cortical alveolar; Vtg=vitellogenic; POF=postovulatory follicle; HO=hydrated

Phase	**Subphase**	**Description**	**Gross Maturity Category**
Immature		Only oogonia and PG oocytes present, though early CA oocytes may be present towards the end of the phase; no atresia; no prominent blood vessels or muscle bundles; tissue organized	Immature
Developing	Early Developing	Oogonia, PG, and CA oocytes present; tissue organized; little to no atresia present	Mature--Inactive
	Maturing (mid-maturation)	Vitellogenic (VTG) 1 and Vtg2 are the most advanced oocytes; minor atresia may be present	Mature--Developing
Spawning Capable	Late Developing	Vtg3 oocytes are the most advanced oocyte present; minor atresia may be present; evidence of recent spawning (POFs)	Mature--Active
	Gravid	HO are the most advanced oocytes; no evidence of recent spawning (POFs)	Mature--Active
	Recent spawn	Day 0 and Day 1 POFs present; older POFs may also be present; rest of ovary resembles the "Maturing", "Late Developing", or "Gravid" ovary; moderate delta and gamma atresia may be present	Mature--Active
	Past spawn	Day 2+ POFs present and readily distinguishable from older atresia; rest of ovary resembles the "Maturing", "Late Developing", or "Gravid" ovary; moderate delta and gamma atresia may be present	Mature--Active
Regressing		Majority of Vtg and/or HO oocytes are undergoing alpha and/or beta atresia; lamellae appear loose and disorganized; some non-atretic Vtg and CA may be present; POFs may or may not be distinguishable from other atretic material	POFs visible: Mature--Active POFs not visible: Mature--Inactive
Regenerating		Oogonia and PG oocytes dominate, though CA oocytes may be present; lamellae appear more organized compared to "Regressing" ovary; some beta atresia may be present but delta and gamma atresia dominate; muscle bundles, blood vessels, and connective tissue often prominent	Mature--Inactive

Table B3. Average batch fecundity and spawning frequency of laboratory held Pacific sanddab. For each female, the number of days used to estimate spawning frequency was the total days from the date isolated until November 30, 3012. The average batch fecundity was estimated by first multiplying the total volume of eggs spawned from date of isolation until November 30, 2012 by 2,012 (the number of eggs per ml), then dividing by the minimum number of spawns.

Tank #	Date Isolated	Date of First Spawn	Minimum # of spawns	Average batch fecundity	Spawning frequency
1	8/21/2012	8/23/2012	62	4,851	1.6
2	8/29/2012	8/30/2012	62	3,329	1.5
3	8/27/2012	8/28/2012	75	3,085	1.3
4	8/29/2012	8/31/2012	54	5,961	1.7
5	8/22/2012	8/23/2012	59	3,026	1.7

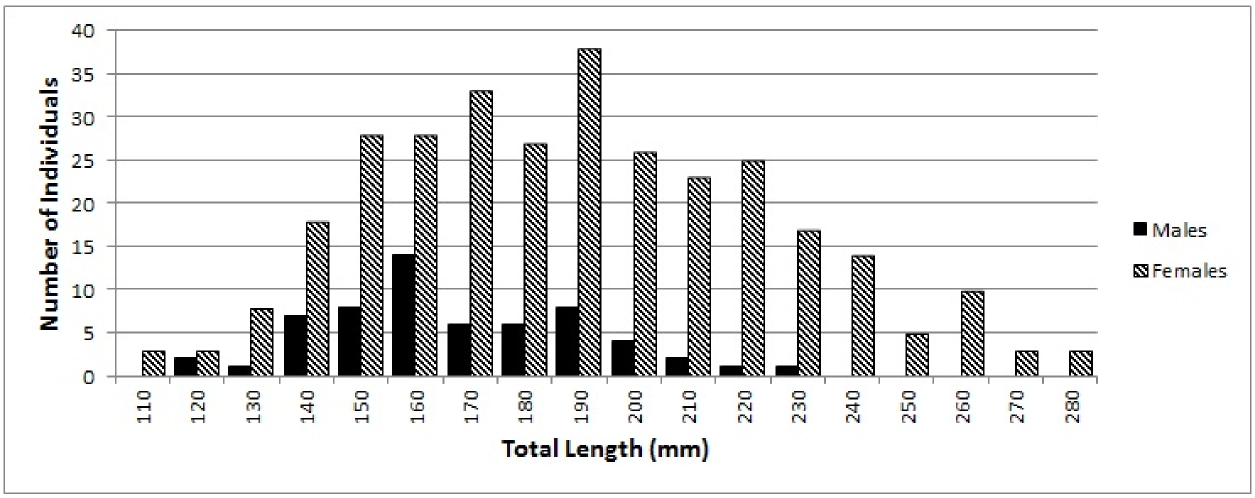
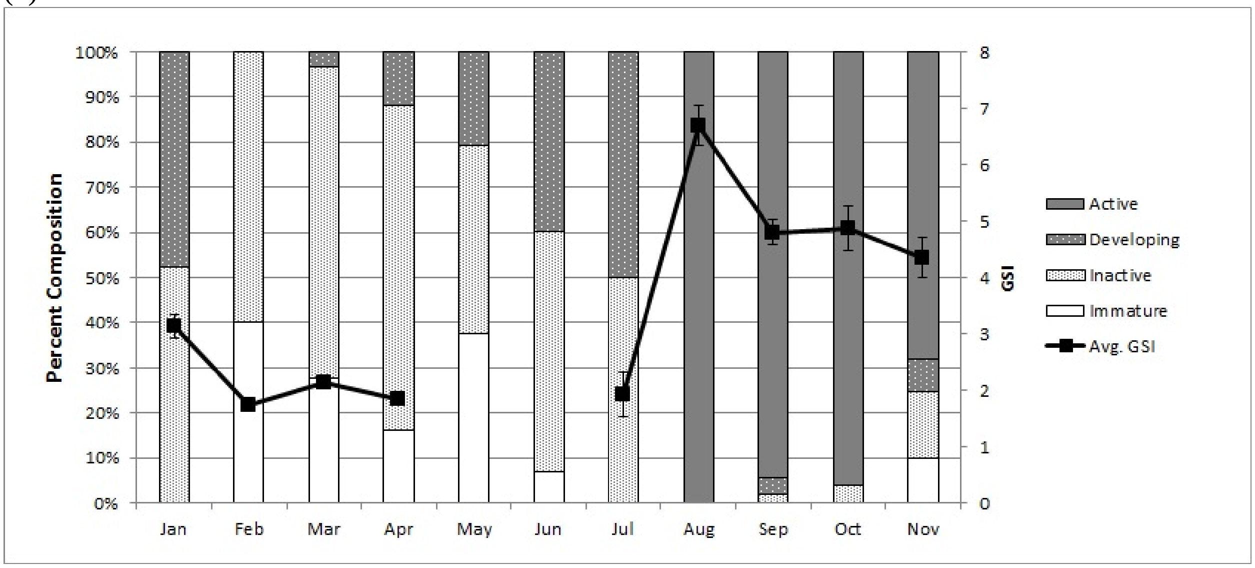


Figure B1. Size distribution of Pacific sanddab (*Citharichthys sordidus*) collected from the Monterey Bay, California, between March 2012 and April 2013.

(**a**)



(**b**)

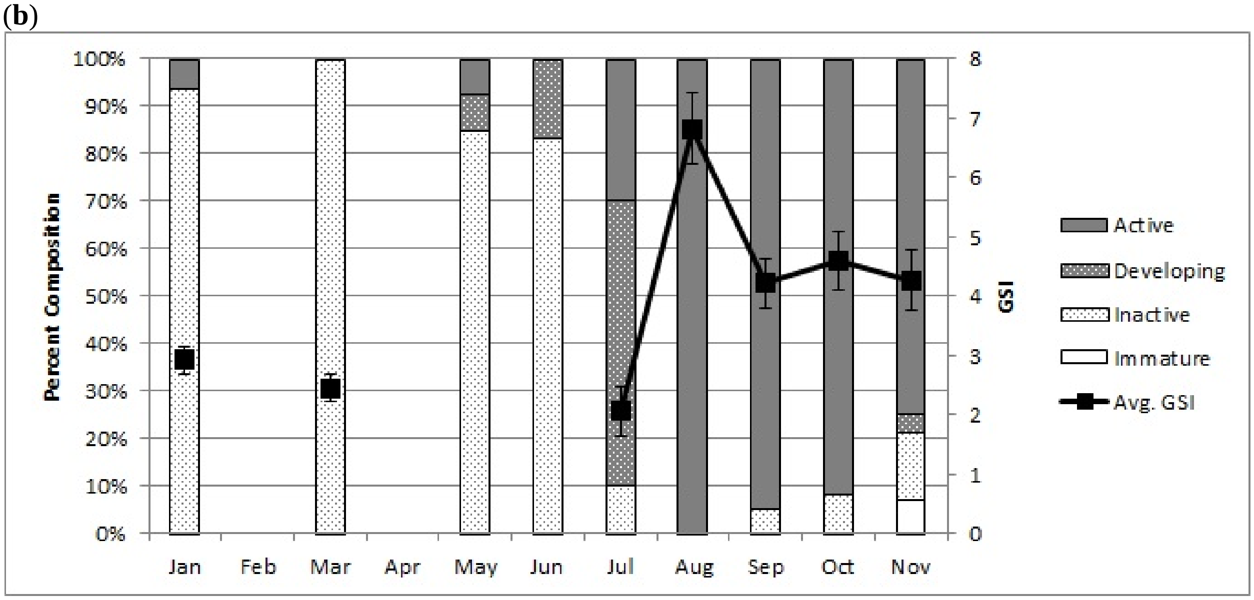


Figure B2. Percent composition of females in gross maturity categories and average GSI values for Pacific sanddab (*Citharichthys sordidus*) collected March 2012-April 2013 for **(a)** all females collected (n=312), with gross maturity based on macroscopic staging and **(b)** females examined histologically (n=97).

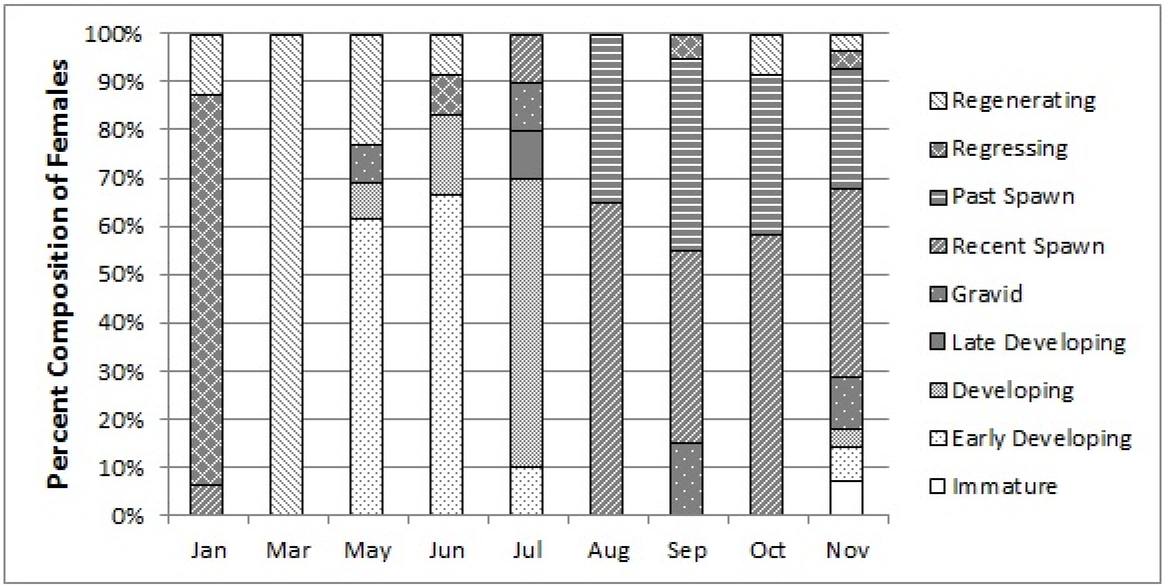
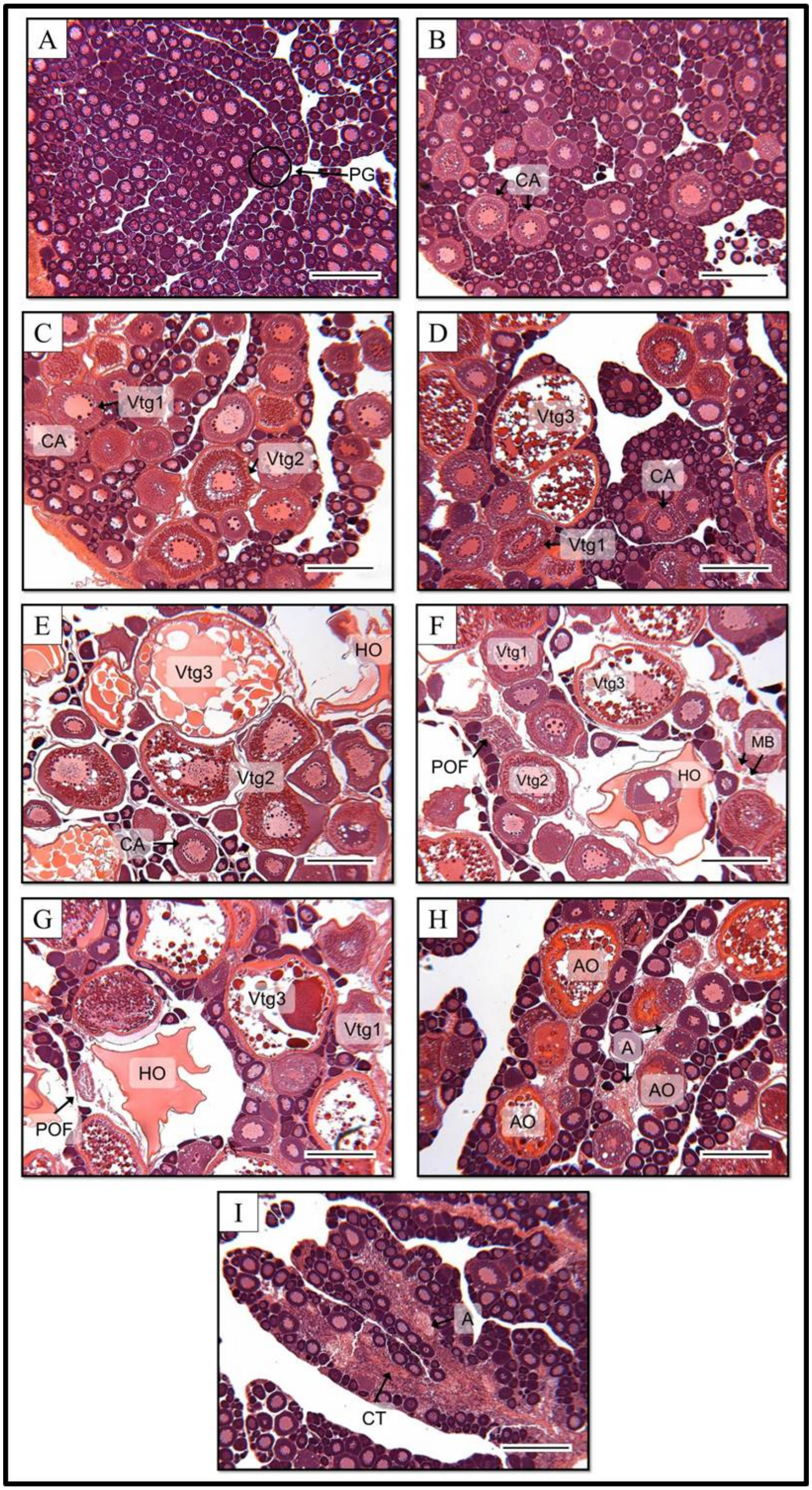


Figure B3. Percent composition of female Pacific sanddab (*Citharichthys sordidus*) in each of the histological phases in each of the months for which histological samples were available.



A
PG
B
CA
C
Vtg1
CA
Vtg2
D
Vtg3
CA
Vtg1
E
HO
Vtg3
Vtg2
CA
F
Vtg1
Vtg3
MB
POF
Vtg2
HO
G
Vtg3
Vtg1
HO
POF
H
AO
A
AO
AO
I
A
CT

Figure B4. Histological micrographs of the phases of ovarian development in Pacific sanddab (*Citharichthys sordidus*) collected in the Monterey Bay between March 2012 and April 2013. Scale bars=250 µm. Phases were based on descriptions of teleost development in Wallace and Selman (1981) and modified from Lefebvre and Denson (2012) and Brown-Peterson et al. (2011). **(A)** Immature: oogonia and primary growth (PG) are the only oocytes present; no atresia, connective tissue, muscle bundles, or blood vessels present; tissue is highly organized. **(B)** Developing, early developing subphase: early- and mid- cortical alveolar (CA) oocytes present with oogonia and PG; no atresia; tissue is highly organized. **(C)** Developing, mid-maturation subphase: vitellogenic (Vtg) stage 1 and 2 oocytes present with earlier oocyte stages. **(D)** Spawning capable, late developing subphase: early Vtg3 oocytes (nuclear migration and initial yolk coalescence) present with earlier oocyte stages; no evidence of recent spawning activity (postovulatory follicles [POF]). **(E)** Spawning capable, gravid subphase: hydrated oocytes (HO) present with late Vtg3 and earlier oocyte stages; no evidence of recent spawning activity (POF). **(F)** Spawning capable, recent spawn subphase: day0 and day1 postovulatory follicles (<36 hours old are present); muscle bundles (MB), blood vessels, and connective tissue may be present in fish that have spawned previously; the rest of the section resembles the "gravid" subphase. **(G)** Spawning capable, past spawn subphase: day2+ POF present; the rest of the ovary resembles the "gravid" subphase. **(H)** Regressing: Vtg oocytes undergoing alpha atresia (AO); delta and gamma atresia (A) present as well; most advanced "healthy" oocytes are CA stage. **(I)** Regenerating: only oogonia and PG oocytes present; connective tissue (T) and late stage gamma A common in interior of lamellae.

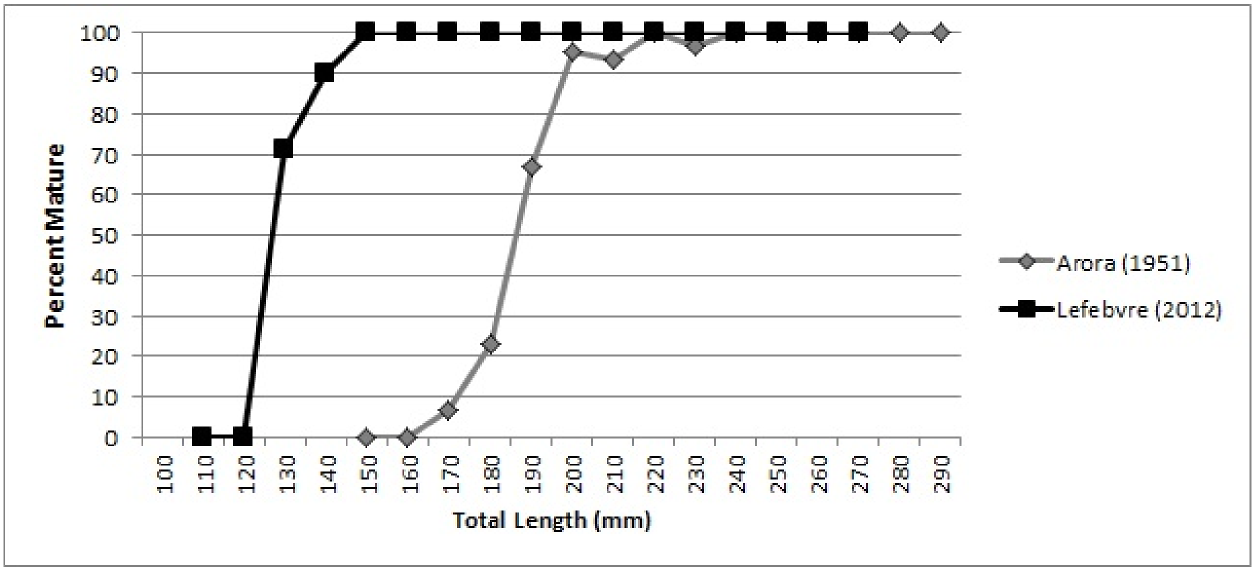
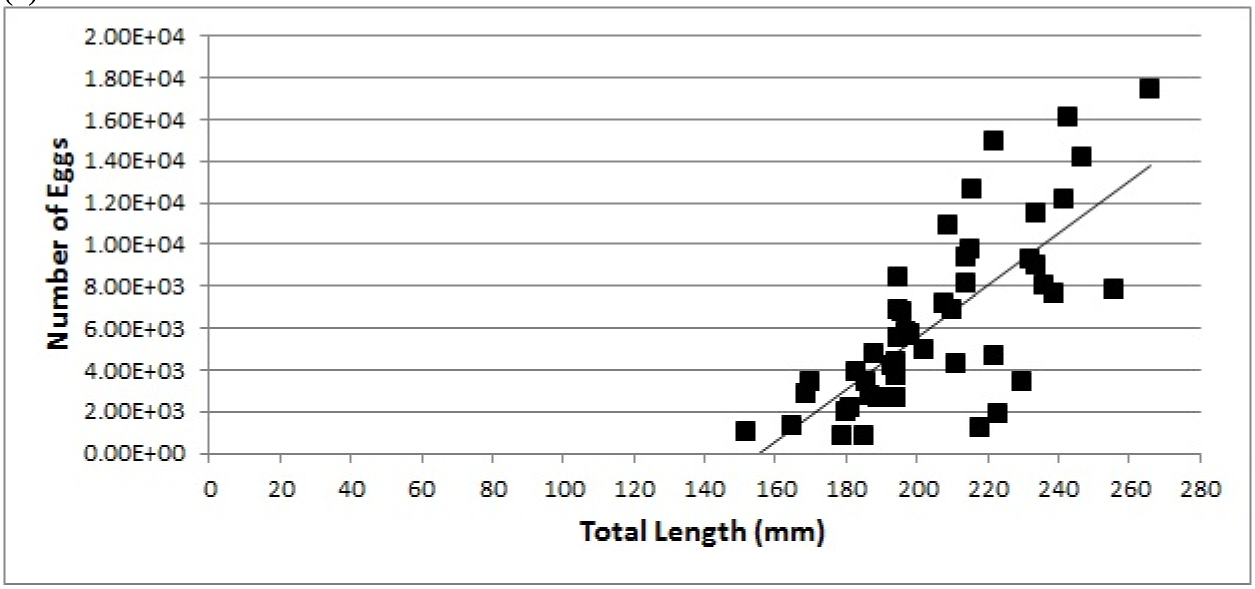


Figure B5. The percentage of Pacific sanddab (*Citharichthys sordidus*) females mature at given total lengths. The blue triangles and lines are data from Arora (1951) from fish collected from Pt. Reyes to San Francisco, California in August during the 1930s and 1940s (n=227). The red squares and line are from fish collected in the Monterey Bay between August and November 2012 (n=154).

(**a**)



(**b**)

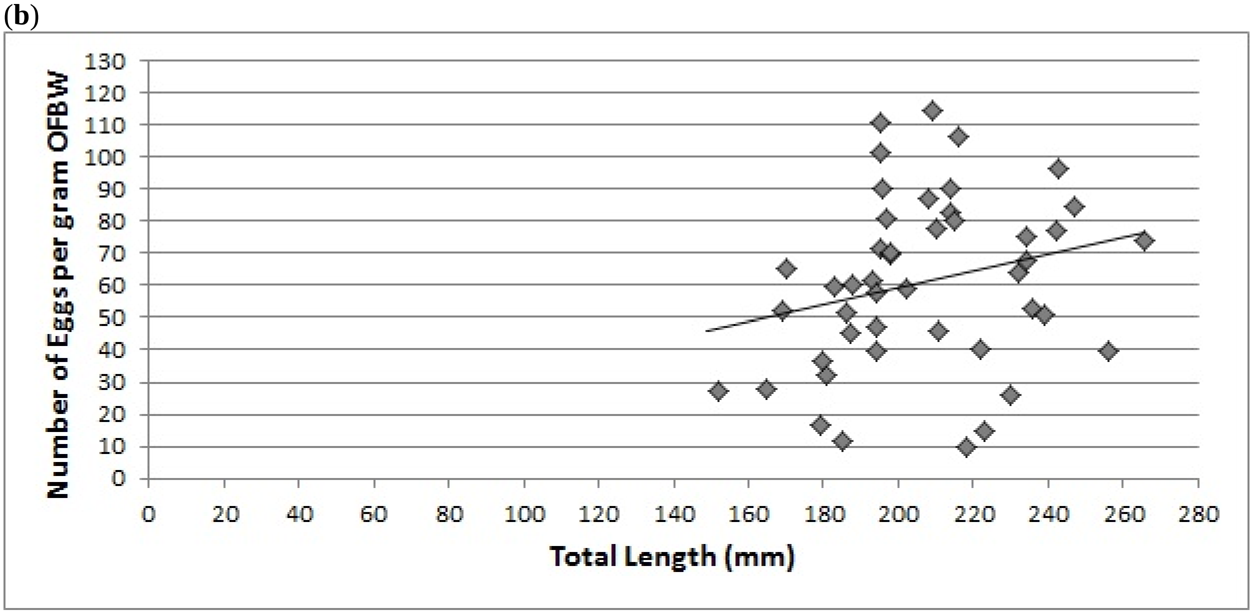


Figure B6. Batch fecundities estimated from 50 female Pacific sanddabs (*Citharichthys sordidus*) collected in the Monterey Bay in August and September 2012. **(a)** Absolute batch fecundity increased linearly with fish length (R^2=0.55); however, **(b)** Relative batch fecundity showed no significant relationship with length (R^2=0.06). OFBW=ovary-free body weight (g).

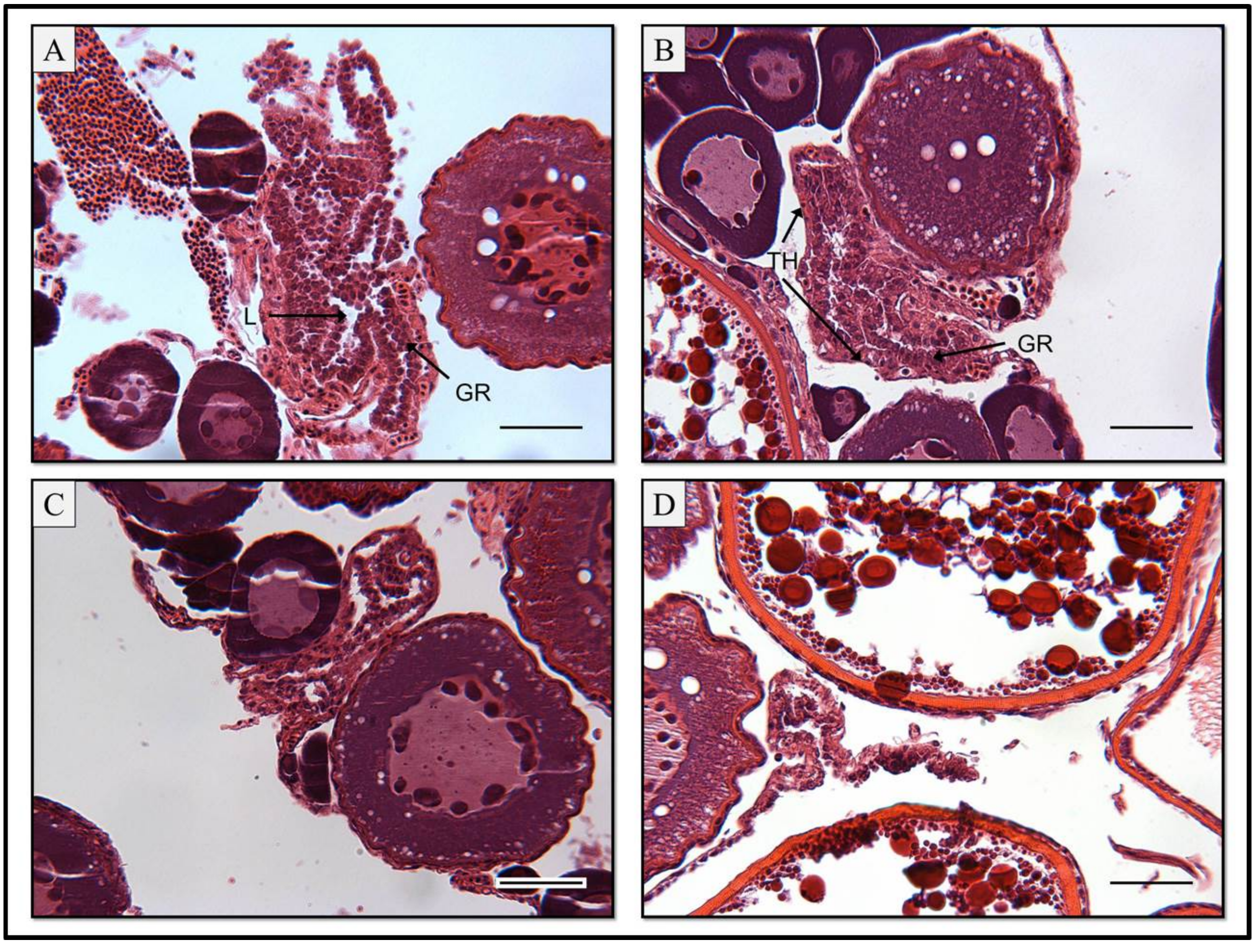


Figure B7. Photomicrographs of postovulatory follicles (POFs) from the ovaries of captive Pacific sanddab (*Citharichthys sordidus*) held at 10.6-11.9˚C and sampled successive time intervals post-spawning. TH=thecal cell layer. Scale bars=50 µm. **(A)** Day 0 POF, 0-4 hrs old. Granulosa cells (GR) are cuboidal in shape with prominent nuclei and form a convoluted shape in the lumen (L) of the follicle. **(B)** Day 1 POF, 20-24 hrs old. The POF condenses as the GR layer becomes less convoluted. **(C)** Day 2 POF, 40-48 hrs old. POF is further reduced in size as GR forms a single layer. **(D)** Day 2+ POF, unknown age. Oldest POFs are generally triangular in shape and are recognizable from atretic oocytes when along margin of lamellae.

Appendix C. Base Model Fits to Length and Age Frequency Data by Year, Fleet and Sex for All Surveys and Fisheries

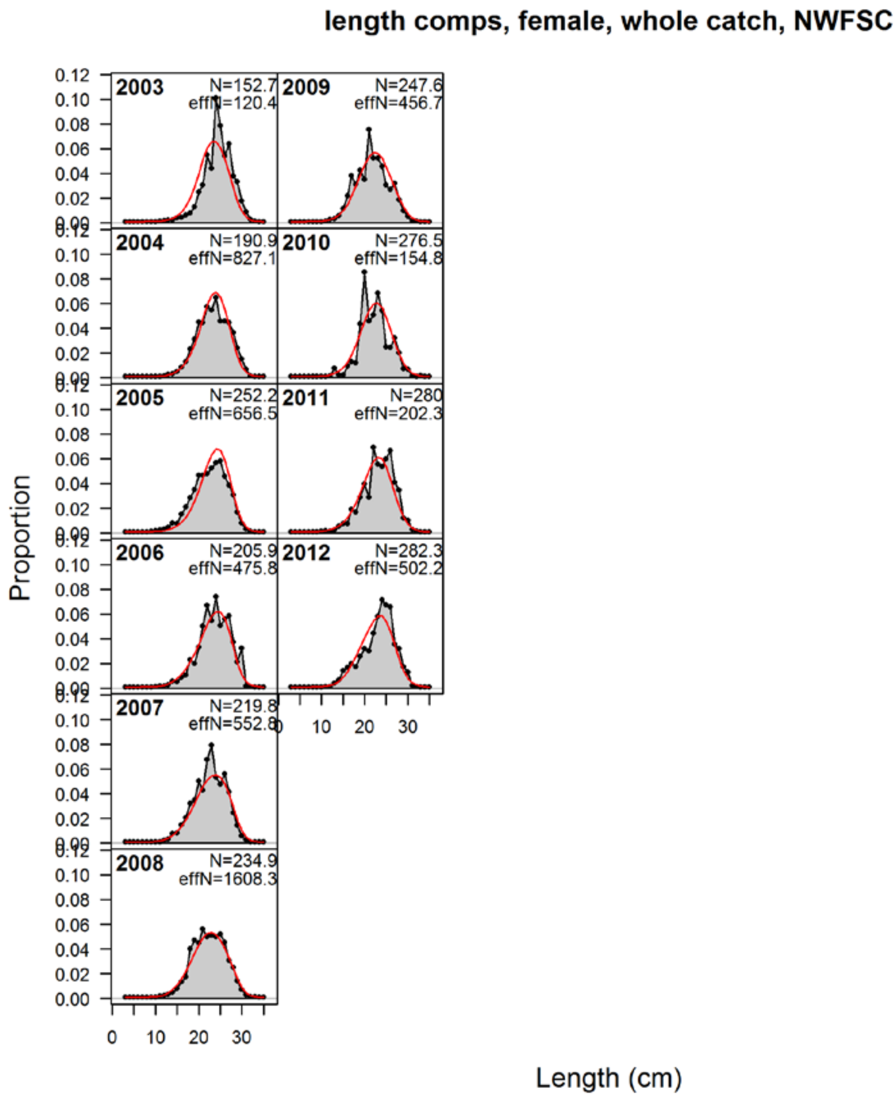


Figure C.1: Base model fits to length frequency distributions of females from the NWFSC survey from 2003 to 2012.

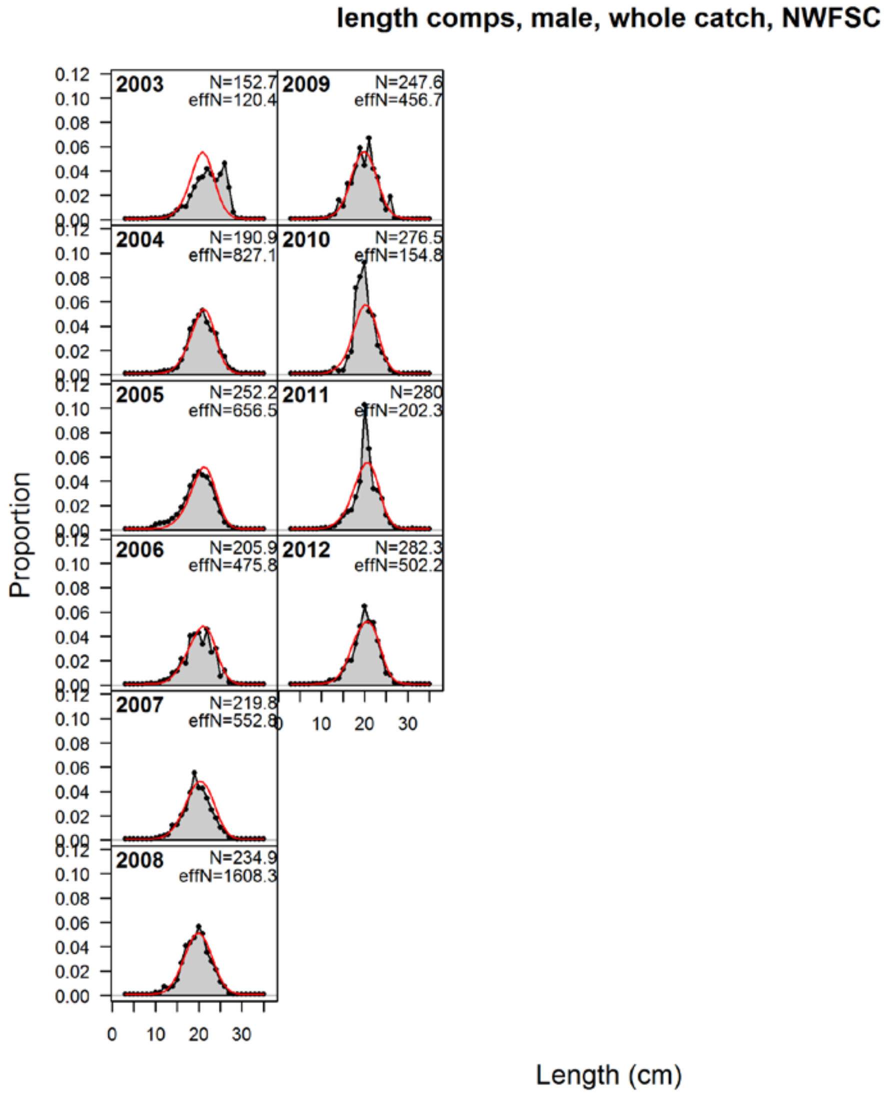


Figure C.2: Base model fits to length frequency distributions of males from the NWFSC survey from 2003 to 2012.

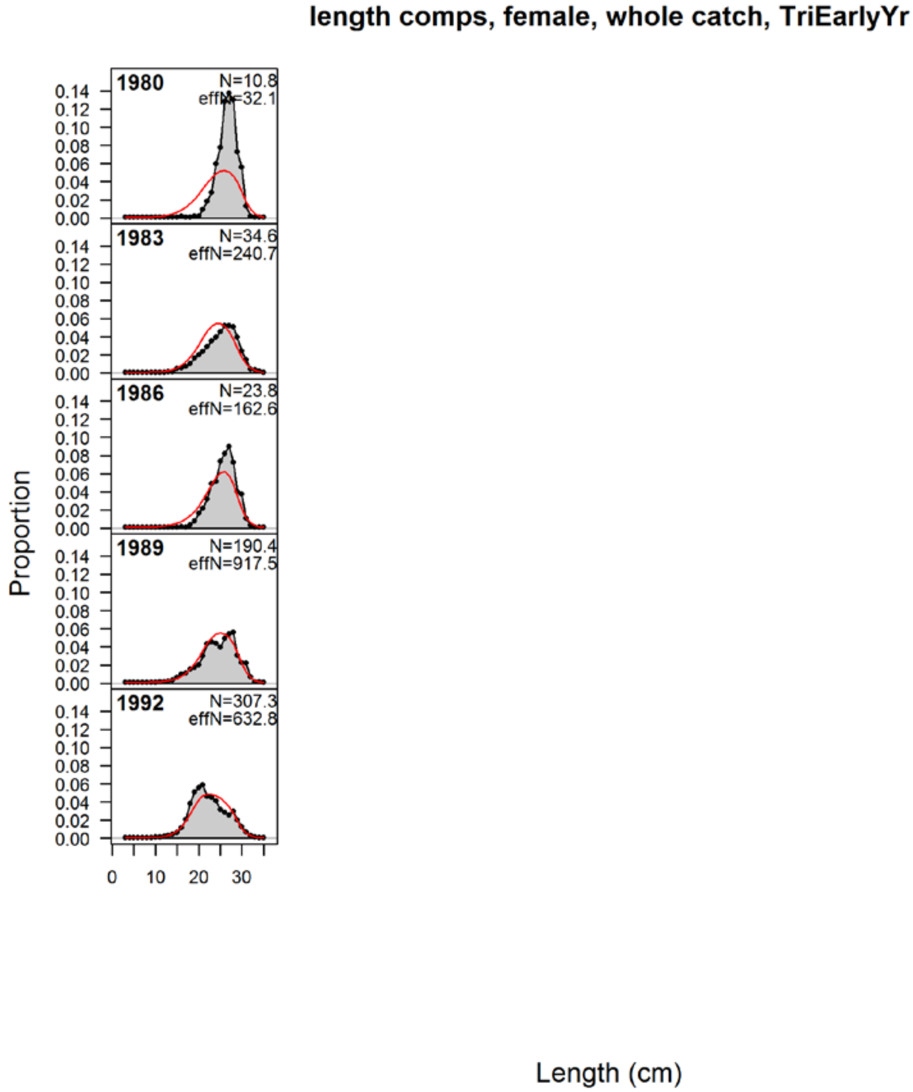


Figure C.3: Base model fits to length frequency distributions of females from the early year triennial survey from 1980 to 1992.

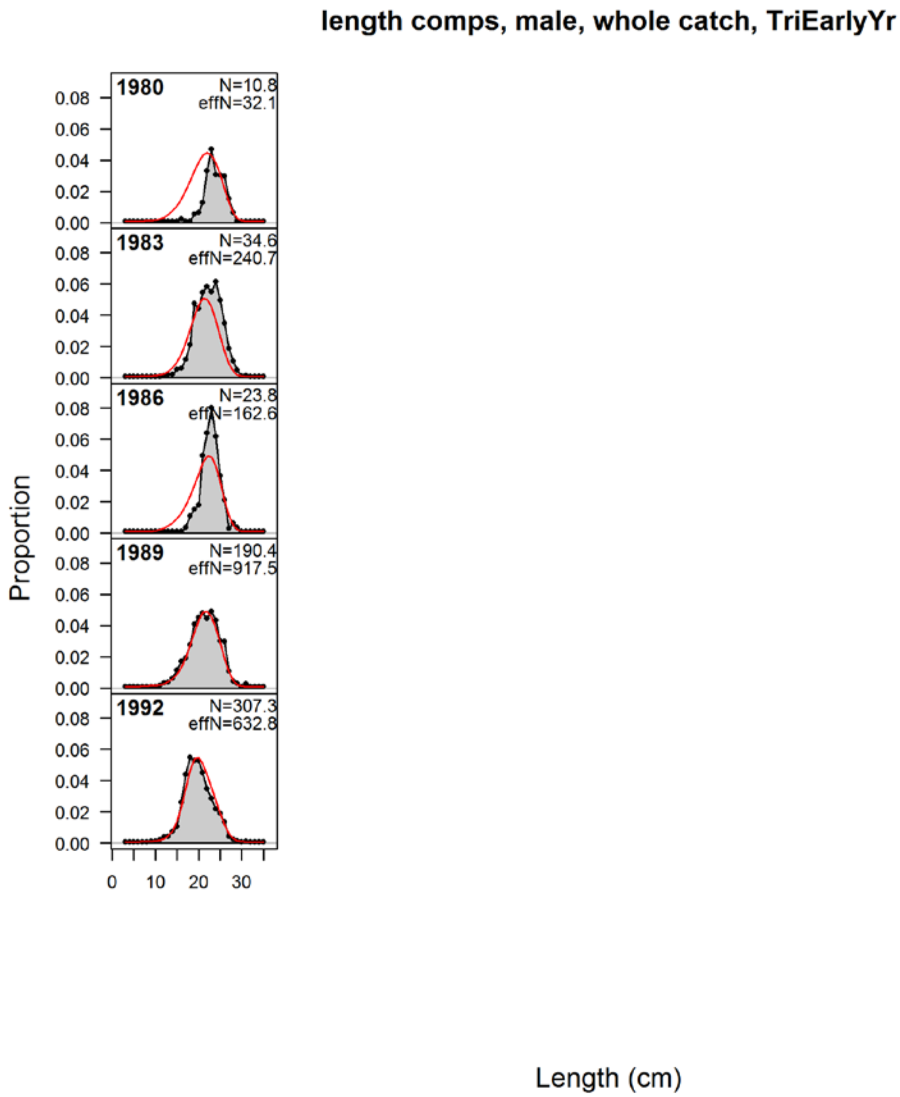


Figure C.4: Base model fits to length frequency distributions of males from the early year triennial survey from 1980 to 1992.

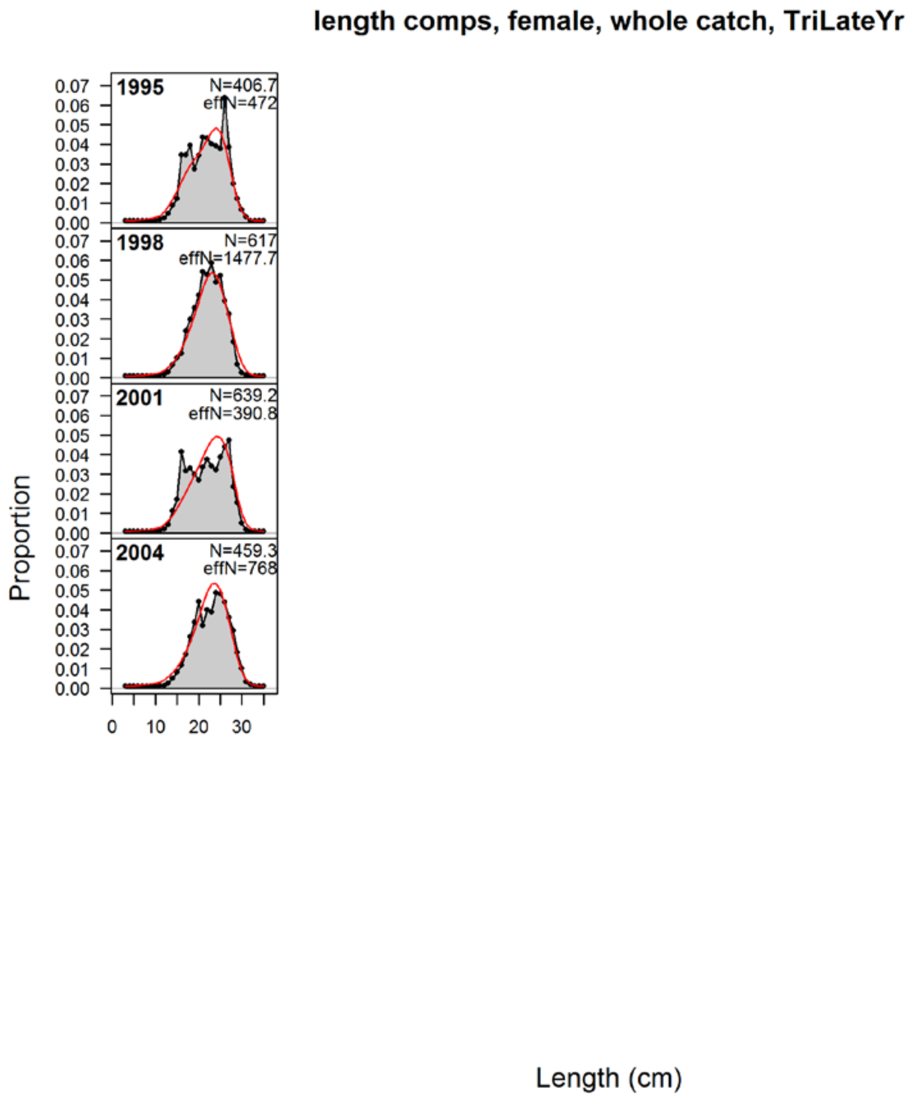


Figure C.5: Base model fits to length frequency distributions of females from the late year triennial survey from 1980 to 1992.

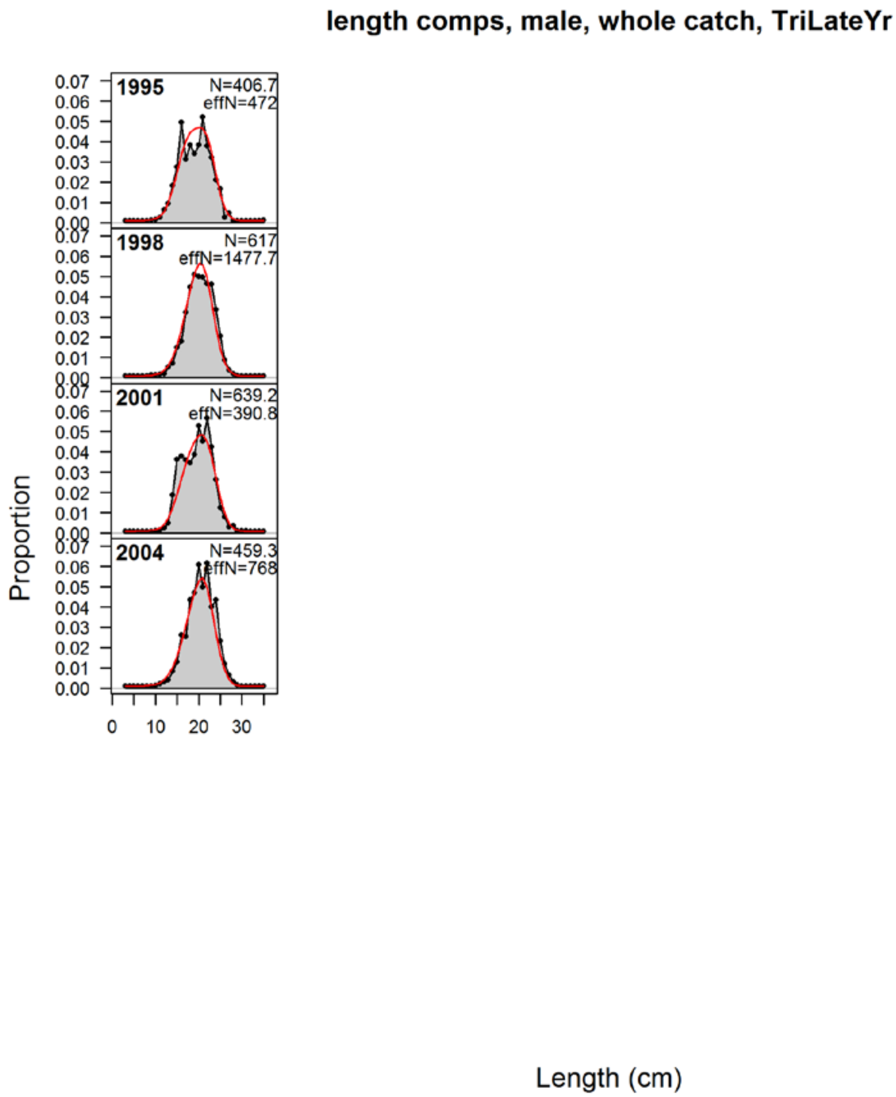


Figure C.6: Base model fits to length frequency distributions of males from the late year triennial survey from 1980 to 1992.

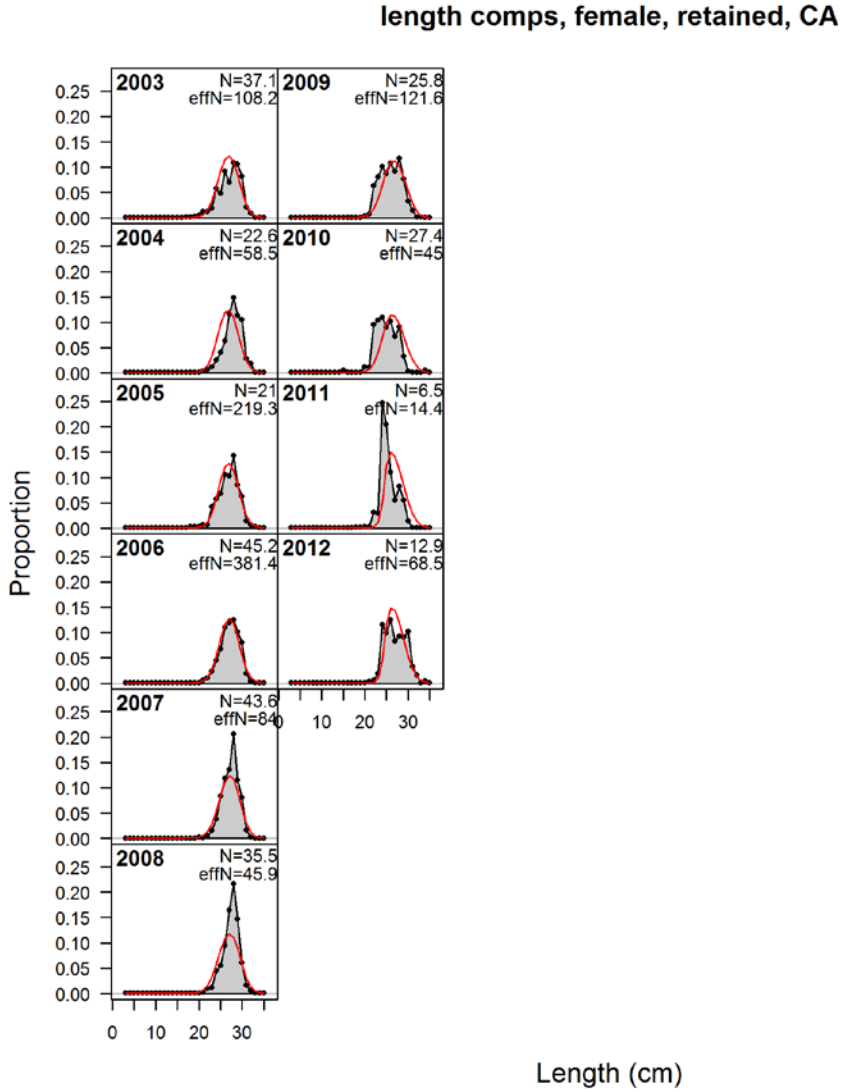


Figure C.7: Base model fits to length frequency distributions of females for retained catches from the CA fishery from 2003 to 2012.

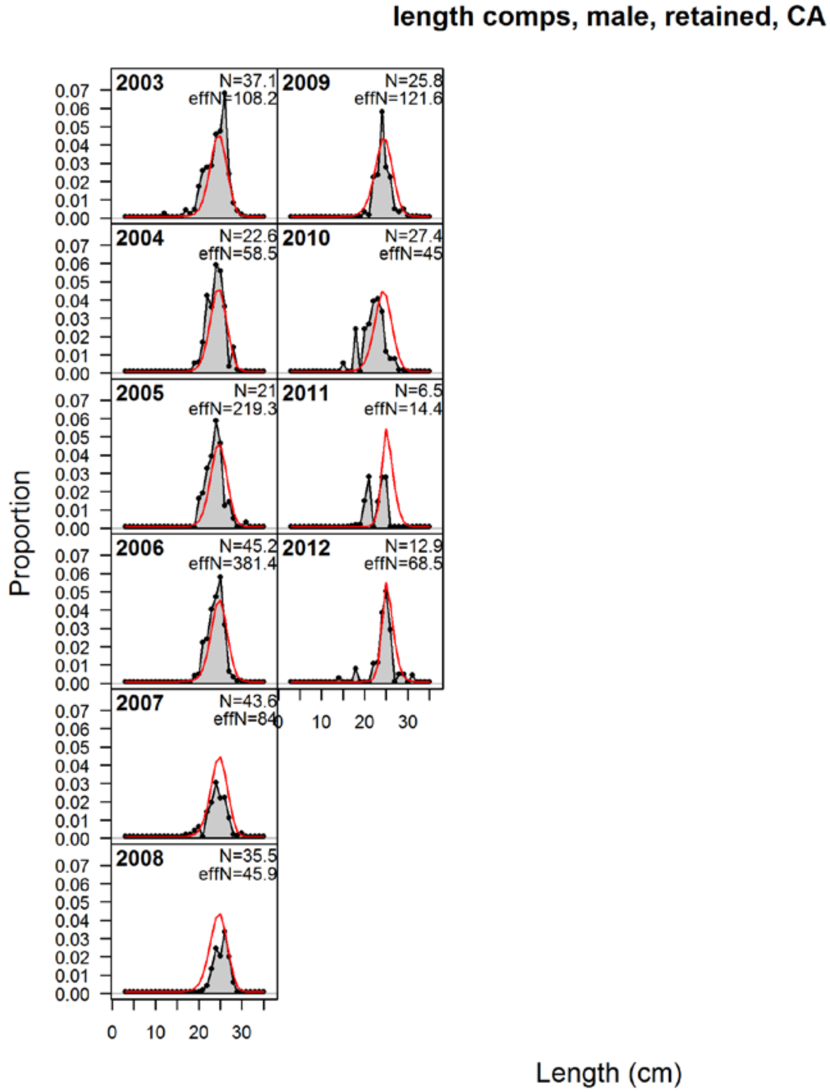


Figure C.8: Base model fits to length frequency distributions of males for retained catches from the CA fishery from 2003 to 2012.

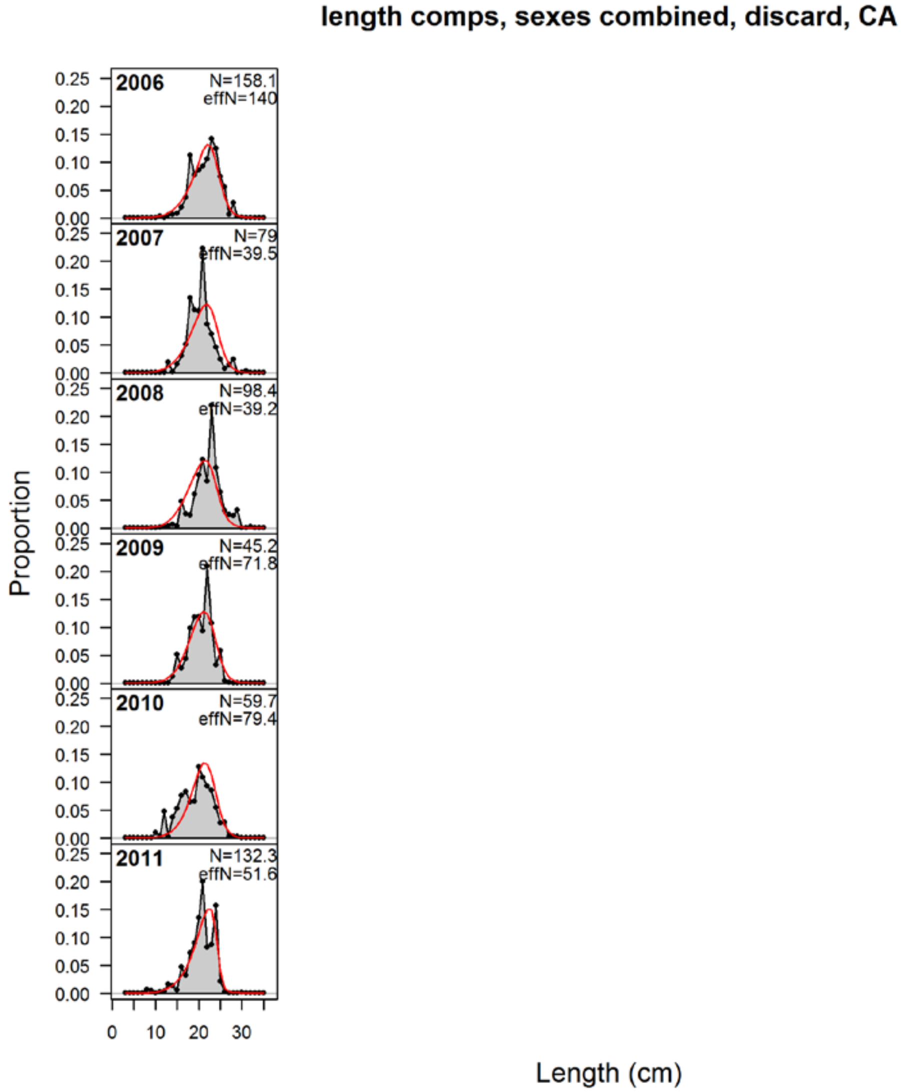
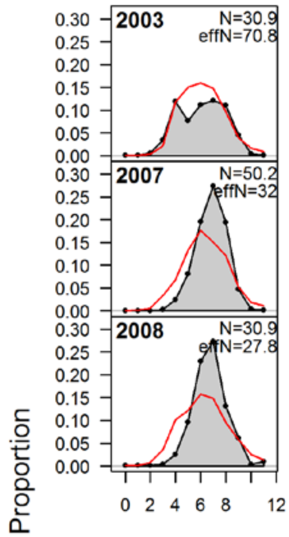


Figure C.9: Base model fits to length frequency distributions of combined sexes for discarded catches from the CA fishery from 2006 to 2011.

age comps, female, retained, CA



Age (yr)

Figure C.10: Base model fits to age frequency distributions of females for retained catches from the CA fishery from 2003, 2007 and 2008.

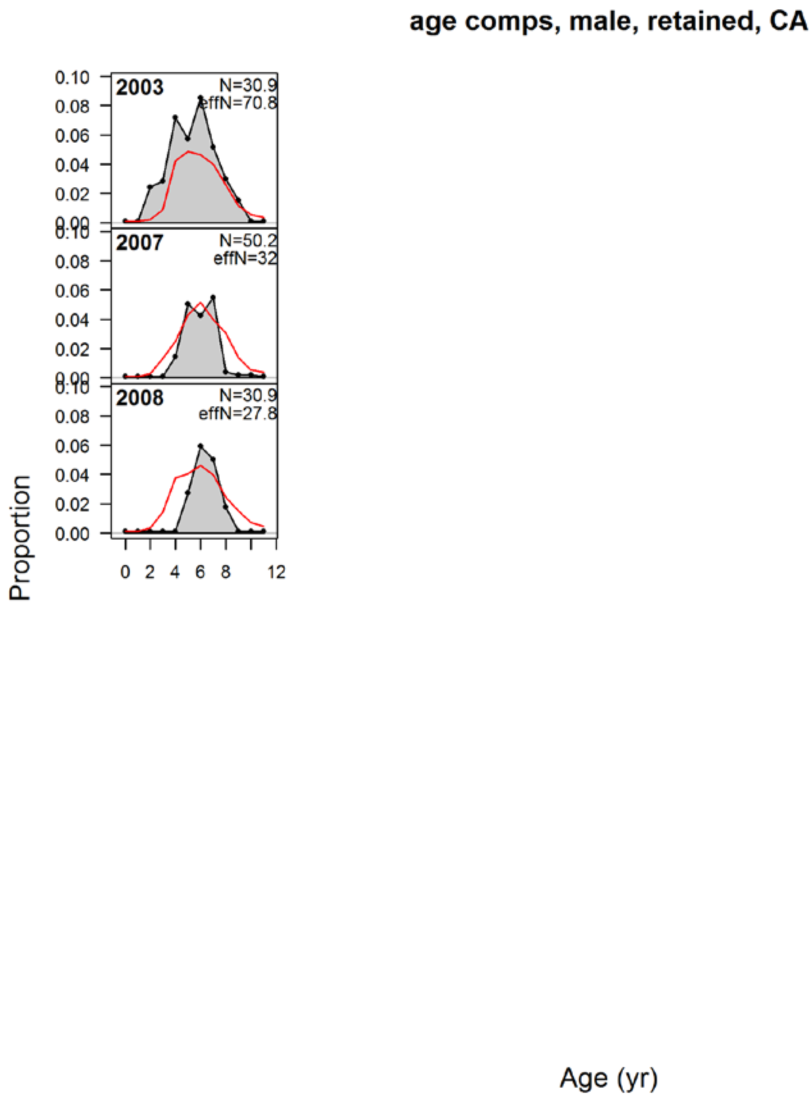


Figure C.11: Base model fits to age frequency distributions of males for retained catches from the CA fishery from 2003, 2007 and 2008.

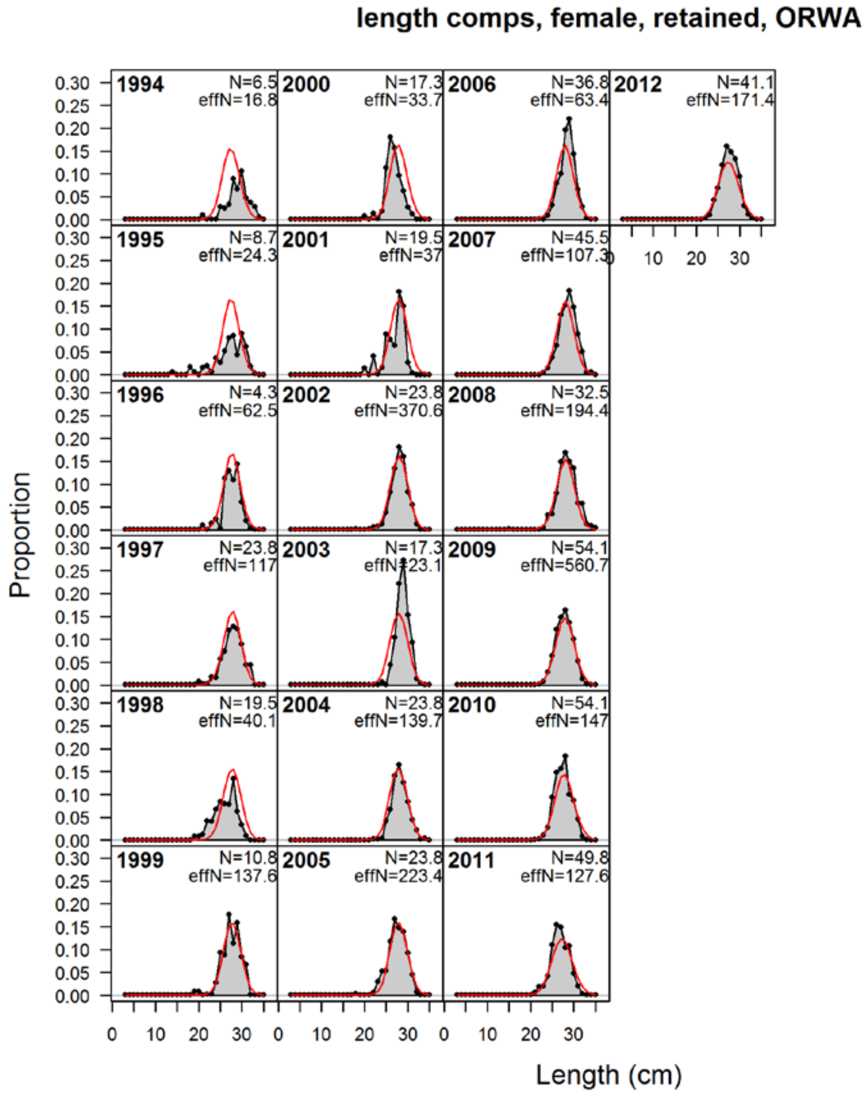


Figure C.12: Base model fits to length frequency distributions of females for retained catches from the OR/WA fishery from 1990 to 2012.

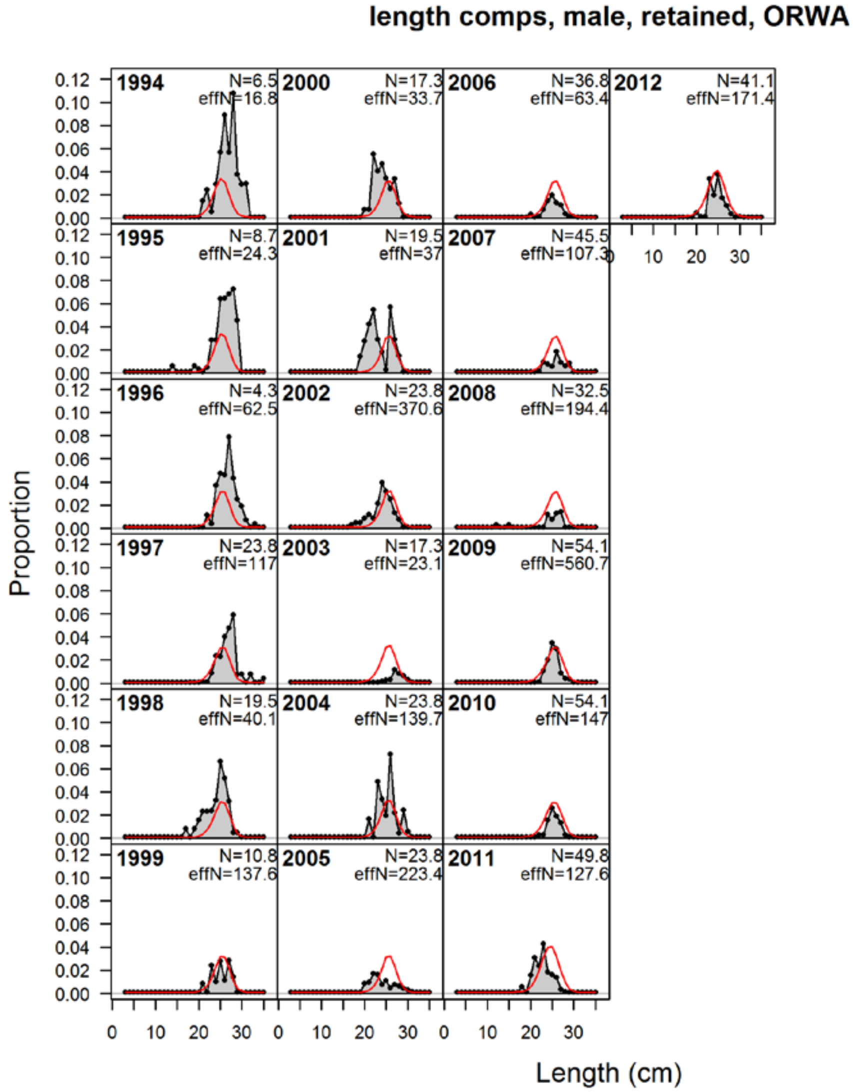


Figure C.13: Base model fits to length frequency distributions of males for retained catches from the OR/WA fishery from 1990 to 2012.

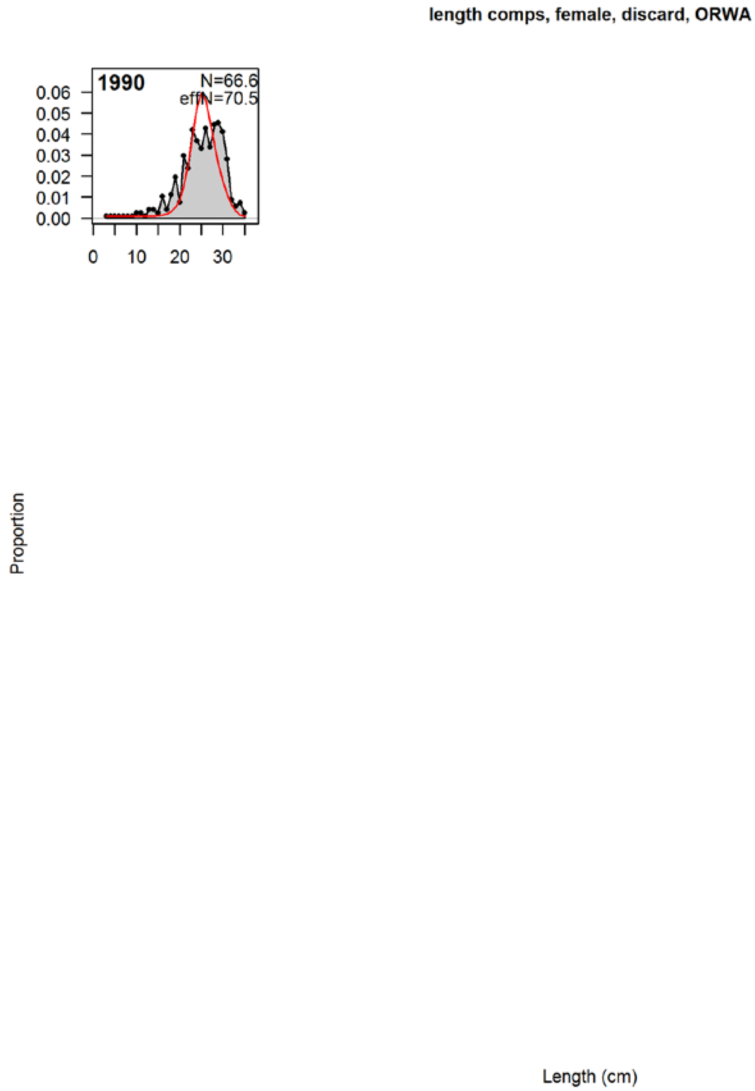


Figure C.14: Base model fits to length frequency distributions of females for discarded catches from the OR/WA fishery in 1990.

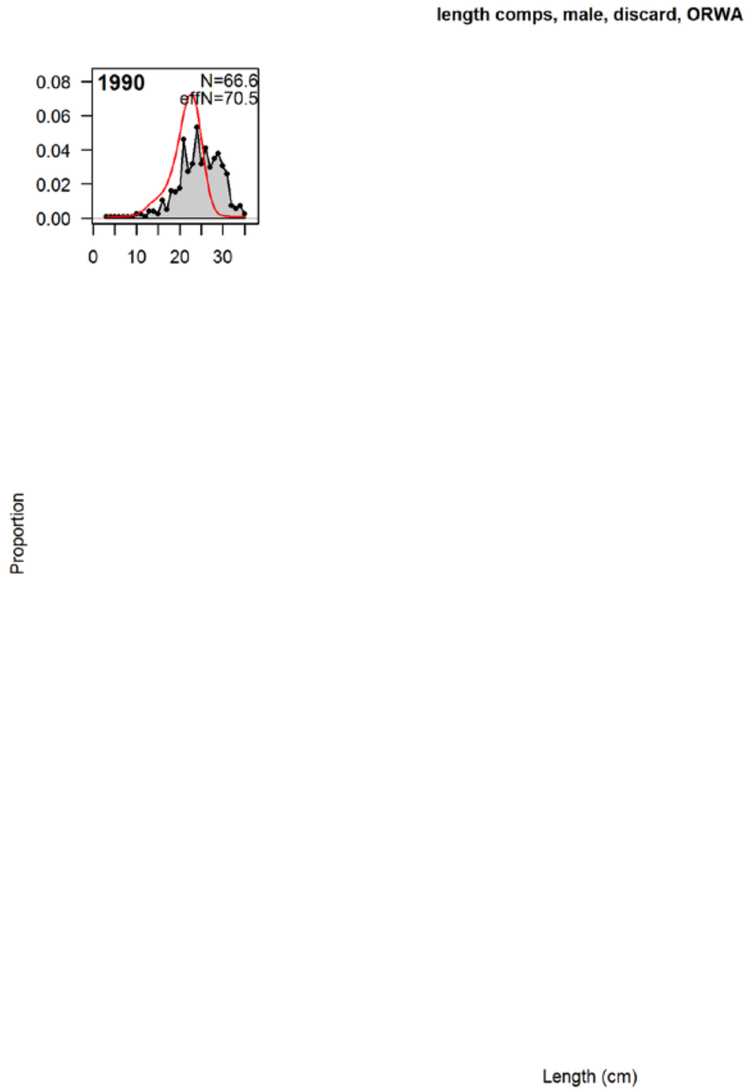


Figure C.15: Base model fits to length frequency distributions of males for discarded catches from the OR/WA fishery in 1990.

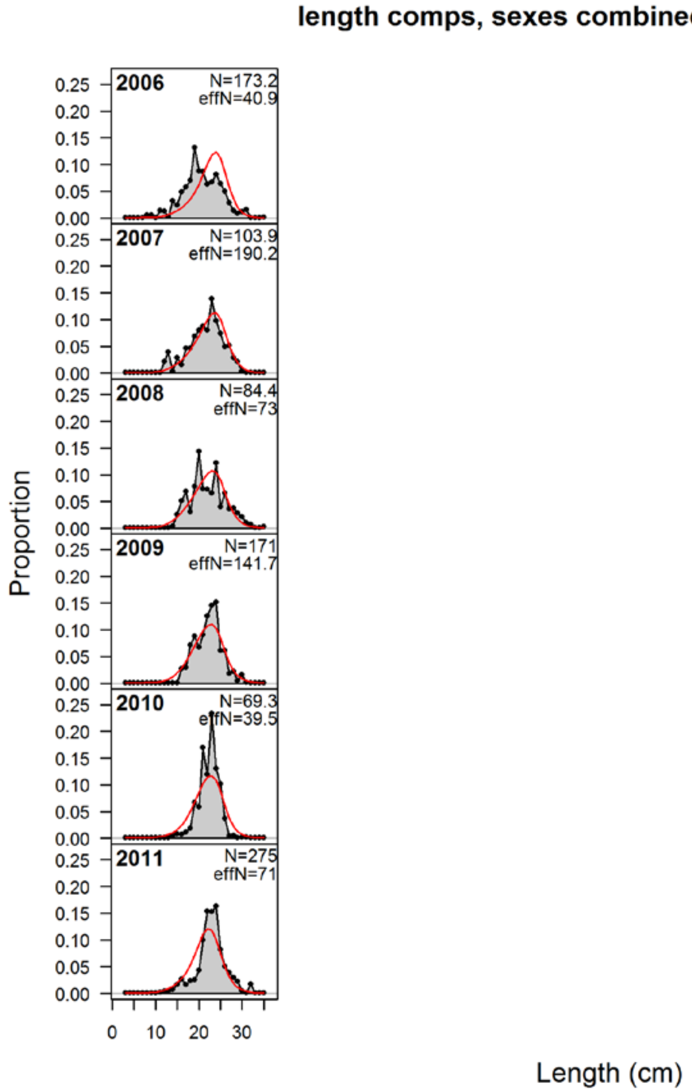


Figure C.16: Base model fits to length frequency distributions of combined sexes for discarded catches from the OR/WA fishery from 2006 to 2011.

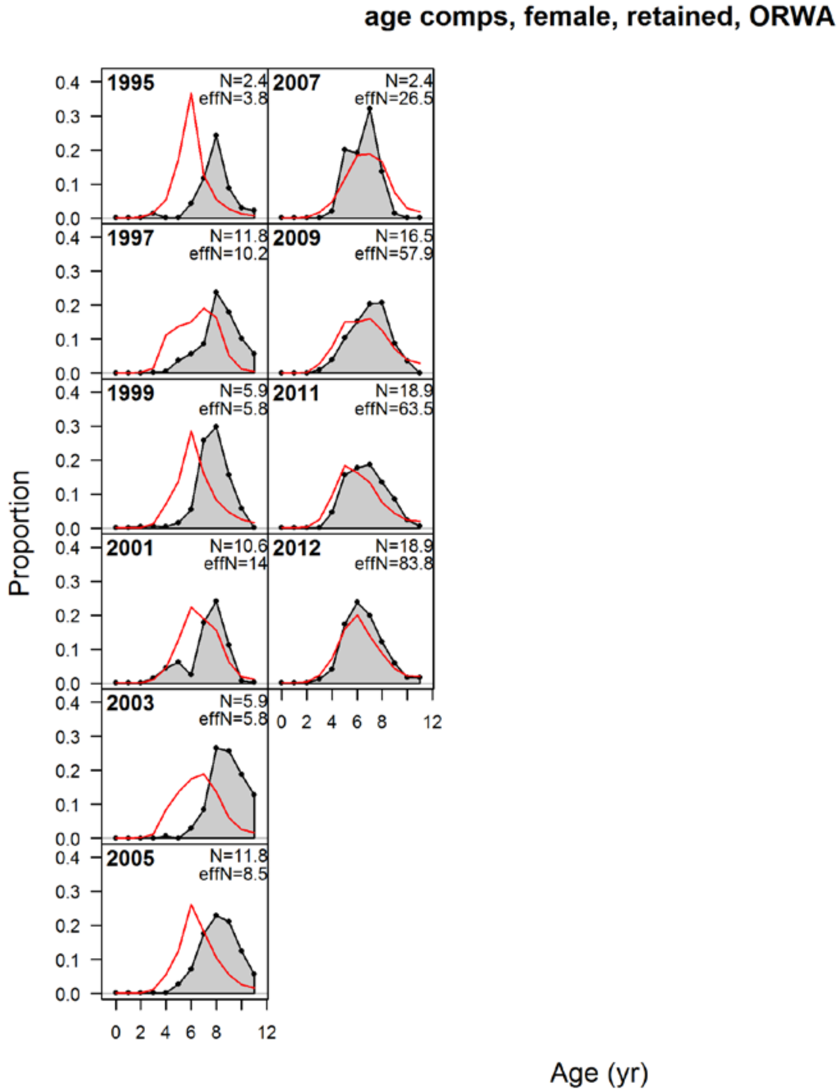


Figure C.17: Base model fits to age frequency distributions of females for retained catches from the OR/WA fishery from 1995 to 2012.

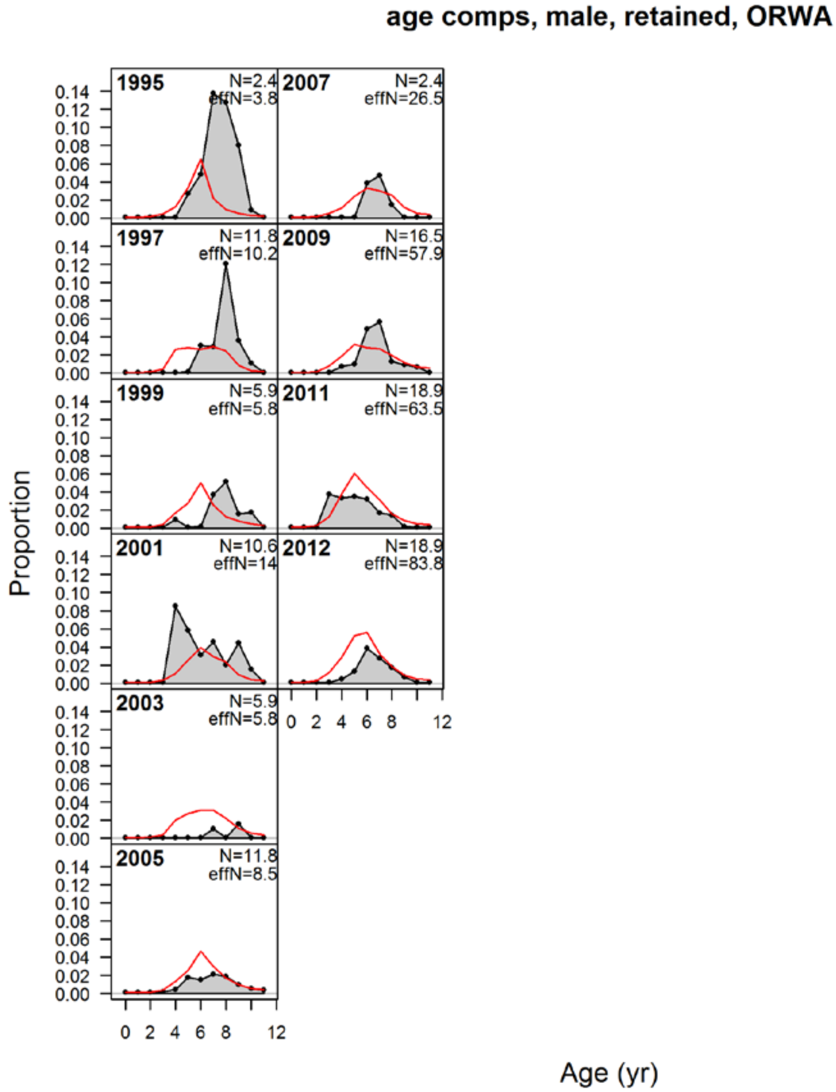


Figure C.18: Base model fits to age frequency distributions of males for retained catches from the OR/WA fishery from 1995 to 2012.

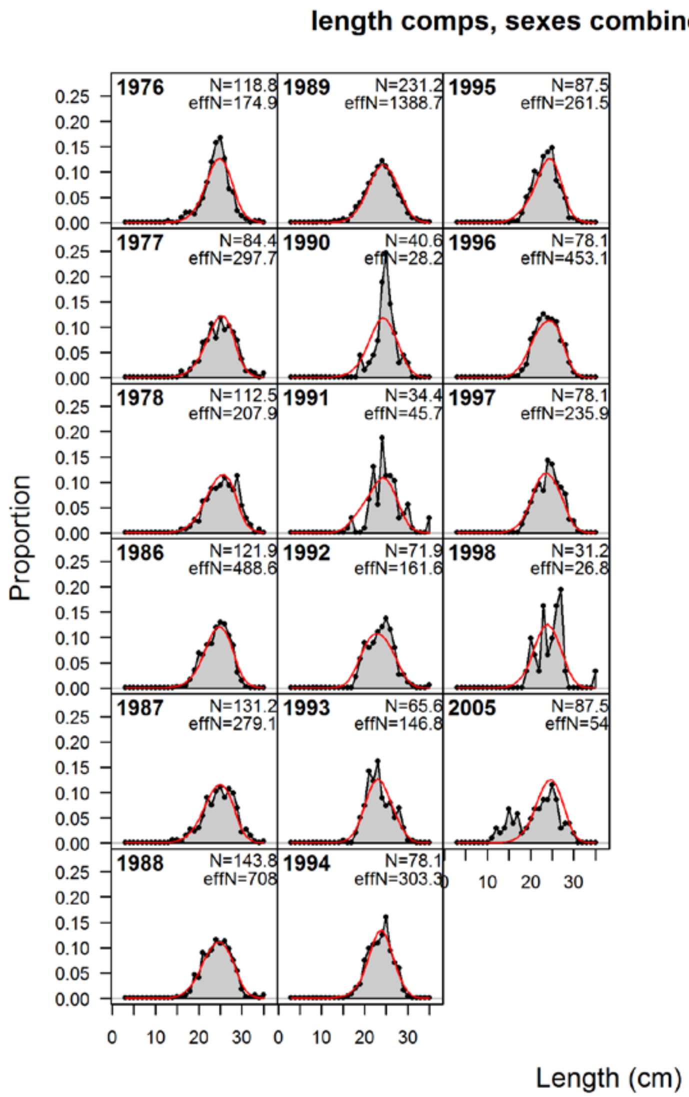


Figure C.19: Base model fits to length frequency distributions of combined sexes for retained catches from the recreational fishery from 1976 to 2005.

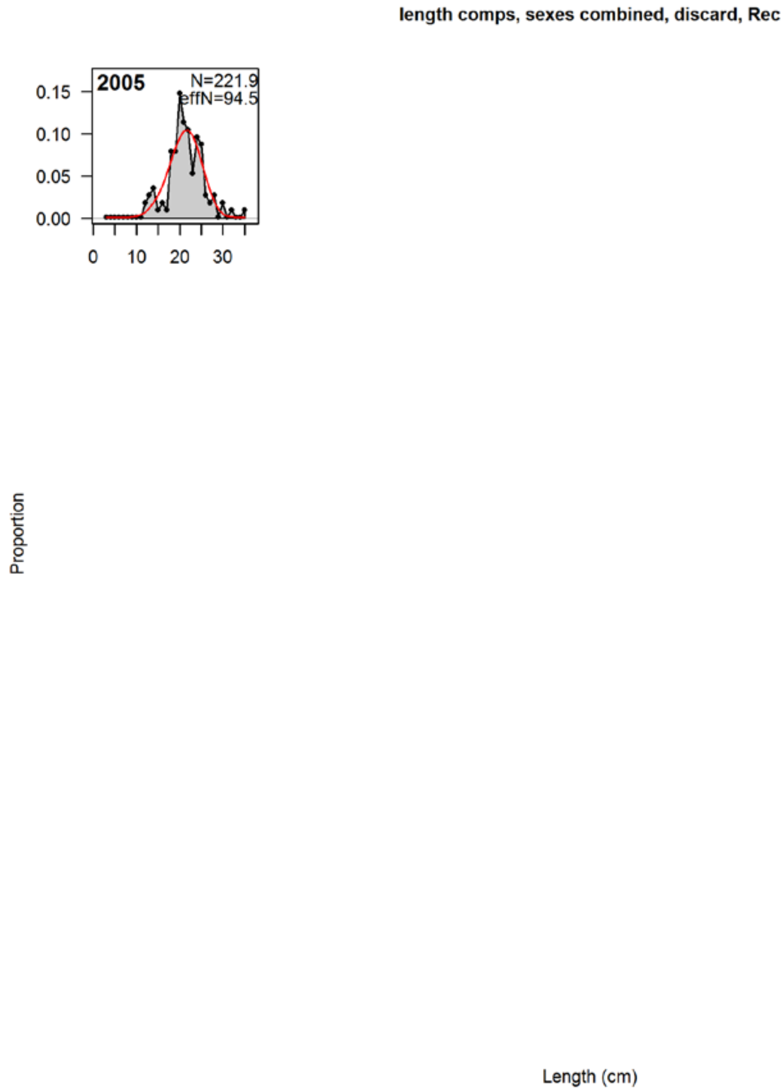


Figure C.20: Base model fits to length frequency distributions of combined sexes for discarded catches from the recreational fishery in 2005.

Appendix D. Input Files of the Base Model to the SS3 Program

Appendix D.1. Data File (SDB1.dat)

#C 2013_Pacific_Sanddab_Stock_Assessment_Xi_He__NMFS_SWFSC__Santa_Cruz_CA
#SS-V3.24O-opt-
win64;_04/10/2013;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_11.1

```
#
# MODEL DIMENSIONS
# ----------------
1888    #_start year
2012    #_end year
1               #_number of seasons per year
12              # vector with N months in each season
1               #_spawning occurs at the beginning of this season
4               #_number of fishing fleets
3               #_number of surveys
1               #_N_areas

# string containing names for all fisheries and
# surveys, delimited by the % character
CA%ORWA%Rec%Mink%NWFSC%TriEarlyYr%TriLateYr
# fraction of season elapsed before CPUE measured or survey conducted
0.50    0.50    0.50    0.50    0.62    0.62    0.50    #_Catch or survey timing_in_season
1   1   1       1   1       1           1
        #_area_assignments_for_each_fishery_and_survey

# Fishery information
1               1   1   1           #_units of catch:  1=bio; 2=num
0.01    0.01    0.01  0.01          #_se of log(catch) only used for init_eq_catch and for
Fmethod 2 and 3; use -1 for discard only fleets

2 #_number of genders; females are gender 1
11 #_accumulator age

#_initial equilibrium catch for each fishery
0.00   0.00   0.00      0.00    #_initial equilibrium catch for each fishery

# Catch outputs from "C:\XiHe1\SDB2013\Landing\SDBLandingNew2.xlsx" (save as .prn to
retain formats)
125             #_N_lines_of_catch_to_read

#CA    ORWA   Rec    Mink   Year   Index
   0.0    0.0    0.0    0.0   1888     1
  59.0    0.0    0.0    0.0   1889     1
 118.1    0.0    0.0    0.0   1890     1
 177.1    0.0    0.0    0.0   1891     1
 236.1    0.0    0.0    0.0   1892     1
```

217.6	0.0	0.0	0.0	1893	1
199.1	0.0	0.0	0.0	1894	1
180.6	0.0	0.0	0.0	1895	1
198.7	0.0	0.0	0.0	1896	1
216.7	0.0	0.0	0.0	1897	1
234.7	0.0	0.0	0.0	1898	1
252.8	0.0	0.0	0.0	1899	1
291.5	0.0	0.0	0.0	1900	1
330.3	0.0	0.0	0.0	1901	1
369.0	0.0	0.0	0.0	1902	1
407.8	0.0	0.0	0.0	1903	1
446.5	0.0	0.0	0.0	1904	1
429.8	0.0	0.0	0.0	1905	1
413.1	0.0	0.0	0.0	1906	1
396.4	0.0	0.0	0.0	1907	1
379.6	0.0	0.0	0.0	1908	1
422.1	0.0	0.0	0.0	1909	1
464.5	0.0	0.0	0.0	1910	1
506.9	0.0	0.0	0.0	1911	1
549.3	0.0	0.0	0.0	1912	1
591.7	0.0	0.0	0.0	1913	1
634.1	0.0	0.0	0.0	1914	1
676.6	0.0	0.0	0.0	1915	1
1010.9	0.0	0.0	0.0	1916	1
1193.8	0.0	0.0	0.0	1917	1
794.5	0.0	0.0	0.0	1918	1
321.9	0.0	0.0	0.0	1919	1
327.4	0.0	0.0	0.0	1920	1
355.6	0.0	0.0	0.0	1921	1
531.1	0.0	0.0	0.0	1922	1
618.7	0.0	0.0	0.0	1923	1
771.0	0.0	0.0	0.0	1924	1
885.8	0.0	0.0	0.0	1925	1
518.9	0.0	0.0	0.0	1926	1
404.9	0.0	0.0	0.0	1927	1
502.9	0.0	0.0	0.0	1928	1
477.1	0.0	0.0	0.0	1929	1
279.6	0.0	0.0	0.0	1930	1
214.5	0.0	0.0	0.0	1931	1
301.5	0.5	0.0	0.0	1932	1
247.7	0.2	0.0	0.0	1933	1
347.9	0.1	0.0	0.0	1934	1
306.4	0.2	0.0	0.0	1935	1
282.0	0.9	0.0	0.0	1936	1
234.1	4.6	0.0	0.0	1937	1
301.2	0.1	0.0	0.0	1938	1
368.2	14.2	0.0	0.0	1939	1
353.4	25.5	0.0	0.0	1940	1
200.5	30.5	0.0	0.0	1941	1
160.4	78.5	0.0	5.6	1942	1
229.2	197.9	0.0	5.9	1943	1

250.1	34.3	0.0	6.3	1944	1
268.6	15.1	0.0	5.6	1945	1
308.0	17.1	0.0	5.8	1946	1
318.2	38.1	0.0	6.5	1947	1
365.0	61.6	0.0	10.0	1948	1
327.6	83.0	0.0	9.9	1949	1
312.9	3.9	0.0	7.3	1950	1
246.8	5.3	0.0	8.8	1951	1
299.5	0.1	0.0	9.2	1952	1
313.2	5.5	0.0	23.1	1953	1
341.8	7.3	0.0	30.1	1954	1
354.5	25.4	0.0	30.7	1955	1
358.0	1.3	0.0	39.8	1956	1
313.9	0.1	0.0	57.1	1957	1
184.4	0.8	0.0	98.5	1958	1
211.7	3.2	0.0	28.0	1959	1
158.0	8.1	0.0	37.7	1960	1
225.2	5.6	0.0	41.4	1961	1
308.4	9.5	0.0	31.7	1962	1
252.0	3.3	0.0	30.8	1963	1
452.7	6.1	7.1	34.1	1964	1
217.3	2.4	7.4	38.8	1965	1
326.6	9.1	15.5	27.1	1966	1
311.6	11.2	15.7	31.1	1967	1
324.1	9.4	65.9	25.8	1968	1
315.7	22.1	73.7	24.5	1969	1
307.8	30.3	57.7	14.3	1970	1
353.9	28.9	29.1	13.0	1971	1
417.7	55.0	28.5	5.2	1972	1
410.0	93.1	36.2	4.3	1973	1
442.4	117.8	33.4	47.5	1974	1
460.6	175.3	19.9	63.1	1975	1
586.9	157.0	25.5	40.0	1976	1
367.2	116.9	11.0	35.1	1977	1
337.1	116.8	2.5	0.4	1978	1
600.0	224.1	174.9	0.1	1979	1
580.8	186.1	87.6	0.8	1980	1
427.4	162.9	216.0	0.8	1981	1
480.1	244.7	46.3	2.8	1982	1
259.1	246.8	38.5	4.9	1983	1
251.1	280.6	40.0	0.7	1984	1
442.4	188.8	57.6	1.1	1985	1
445.6	170.2	51.4	5.6	1986	1
533.5	237.2	12.6	0.4	1987	1
528.0	122.9	66.6	0.5	1988	1
638.7	90.8	21.1	12.1	1989	1
653.1	227.6	33.5	0.4	1990	1
561.3	322.7	33.3	0.1	1991	1
283.3	322.4	33.3	6.3	1992	1
352.9	288.2	49.3	0.0	1993	1
683.3	524.4	34.5	0.0	1994	1

677.5	685.5	14.3	13.2	1995	1
789.3	105.3	50.2	0.0	1996	1
930.2	241.5	35.5	0.0	1997	1
644.3	132.5	13.3	9.0	1998	1
930.1	273.6	20.9	0.0	1999	1
744.6	150.1	62.4	0.0	2000	1
793.1	109.9	46.9	15.0	2001	1
387.7	362.5	153.9	0.0	2002	1
204.6	386.0	47.3	12.7	2003	1
235.4	221.2	44.6	22.1	2004	1
207.5	139.8	45.7	5.3	2005	1
340.7	71.8	23.1	4.9	2006	1
161.8	130.4	19.7	3.3	2007	1
73.5	123.0	27.3	5.4	2008	1
200.6	90.1	28.4	7.7	2009	1
101.5	44.8	42.7	8.9	2010	1
45.1	101.1	81.2	8.4	2011	1
59.5	99.7	53.2	9.4	2012	1

#_ABUNDANCE INDICES
32 #_number of CPUE observations

#_Units: 0=numbers; 1=biomass; 2=F
#_Errtype: -1=normal; 0=lognormal; >0=T
#_Fleet Units Errtype
1 1 0
2 1 0
3 1 0
4 1 0
5 1 0
6 1 0
7 1 0

RecFIN CPUE copied from
"C:\XiHe1\SDB2013\Landing\RecCatch\MelissaMonkData\EmailData_8_5_2013\Pacific_sanddabFor Model.xlsx"

#Year	Sea	Flt	Index	CV
1999	1	3	0.1658	0.194
2000	1	3	0.1504	0.299
2001	1	3	0.2214	0.444
2002	1	3	0.1992	0.289
2003	1	3	0.4135	0.265
2004	1	3	0.3477	0.230
2005	1	3	0.0801	0.202
2006	1	3	0.2417	0.150
2007	1	3	0.1421	0.162
2008	1	3	0.1473	0.133
2009	1	3	0.1636	0.120
2010	1	3	0.2693	0.121
2011	1	3	0.2937	0.106

NWFSC survey indices
3M MCMC outputs
Copied from
"C:\XiHe1\SDB2013\SurveyData\NWFSC\GLMM3\NWFSCIndies3M_MCMC.csv"

2003	1	5	58253.95	0.21019
2004	1	5	49939.52	0.22051
2005	1	5	37508.32	0.18454
2006	1	5	37337.45	0.19642
2007	1	5	25816.00	0.19540
2008	1	5	39337.43	0.19108
2009	1	5	56780.54	0.18919
2010	1	5	65277.99	0.18370
2011	1	5	56330.88	0.18127
2012	1	5	73364.17	0.20418

new data after removal of water hauls: 3M MCMC outputs
Outputs copied from
"C:\XiHe1\SDB2013\SurveyData\Triennial\TriSurveyCPUEComparisonOneAndTwoTimePeriodsNew1.xlsx"

# Year	Sea	Flt	Index	CV
1980	1	6	3372.1	0.42168
1983	1	6	9224.2	0.34384
1986	1	6	10262.6	0.33218
1989	1	6	29373.5	0.35109
1992	1	6	18622.5	0.31633
1995	1	7	45513.1	0.47265
1998	1	7	31151.5	0.65045
2001	1	7	46638.5	0.44623
2004	1	7	65976.1	0.39292

#
IF DISCARD
3 #_N_fleets_with_discard
#_discard_units (1=same_as_catchunits(bio/num); 2=fraction; 3=numbers)
#_discard_errtype: >0 for DF of T-dist(read CV below); 0 for normal with CV; -1 for normal with se; -2 for lognormal

#Flt	Disc_units	err_type
1	2	-1
2	2	-1
3	2	-1

23 #_number of discard observations
discard rates using total catch as weight

No discard information before 2002 observer data
Using average discard rates from 2002 to 2010
copied from:
"C:\XiHe1\SDB2013\Discard\WCGOP\DataFromJasonJannot_6_5_2013\Analysis1\WCGOP discard summary for model 1.xlsx"

1986	1		1		0.3256	0.0509	# using average estimate from 2002 to 2010

Estimates from Jaaon Jannot's data with pooled Pacific sanddab and Unid sanddab
copied from:
"C:\XiHe1\SDB2013\Discard\WCGOP\DataFromJasonJannot_6_5_2013\Analysis1\WCGOP discard summary for model 1.xlsx"
#Year	Sea	Flt	Obs	StDev
2002	1	1	0.206370.03792
2003	1	1	0.328820.02572
2004	1	1	0.245010.08774
2005	1	1	0.357920.05846
2006	1	1	0.326010.00008
2007	1	1	0.280980.07085
2008	1	1	0.320470.09925
2009	1	1	0.441660.07453
2010	1	1	0.420950.00325
2011	1	1	0.45000 0.05090
2012	1	1	0.45000 0.05090

Oregon
From John Wallace's estimates of Pikitch 1985 to 1987 study
File in
"C:\XiHe1\SDB2013\Discard\PikitchData\JohnWallacePikitchEstimatesNew1\Analysis\dis6methodsNew1-Averaged for model.csv"
1986	1		2		0.5124	0.1116		#Pikitch - John Wallace data

Estimates from Jaaon Jannot's data with pooled Pacific sanddab and Unid sanddab
copied from:
"C:\XiHe1\SDB2013\Discard\WCGOP\DataFromJasonJannot_6_5_2013\Analysis1\WCGOP discard summary for model 1.xlsx"
#Year	Sea	Flt	Obs	StDev
2002	1	2	0.706790.10712
#2003	1	2	0.878450.06000
2004	1	2	0.626120.15174
2005	1	2	0.587370.11974
2006	1	2	0.466160.10809
2008	1	2	0.485370.09479
2009	1	2	0.578350.07083
2011	1	2	0.383160.0125
2012	1	2	0.383160.0125

Estiamtes from Meisha Key's data for recreational fisheries
from
C:\XiHe1\SDB2013\Landing\CACPFVRecData\CPFVDataMeishaKey_7_3_2013\Data\90s_AllDabsDiscardRateEstimate.xlsc
Pooled all year and use 1993 year
1993	1		3		0.05802		0.025

Estiamtes from Melissa's data for recreational fisheries

from
C:\XiHe1\SDB2013\Landing\RecCatch\MelissaMonkData\Analysis1\Sanddab_DataRecMelissaMonk_QuickSummary.xlsx
Pooled all year and use 2005 year
2005 1 3 0.056216 0.025

If no discard, use the following two lines
#0 #_N_fleets_with_discard
#0 #_number of discard observations

#
#_MEAN BODY WEIGHT
#_----------------
0 #_number of observations
30 #_DF_for_meanbodywt_T-distribution_like
1 # length bin method: 1=use databins; 2=generate from width, min,max below; 3=read nbins, then vector
#
COMPOSITION CONDITIONERS

-1 # negative value causes no compression
0.001 #_constant added to proportions at length & age (renormalized to sum to 1 after constant is added)
0 #_combine males into females at or below this bin number
#
#_LENGTH COMPOSITION
#_------------------
#_vector containing lower edge of length bins
33 #_number of length bins
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 30 31 32 33 34 35

78 #_number of lines of length comp observations

Gender setting: 0=combined femal and male; 1=female only; 2=male only; 3=both genders are used
if Gender=0, male portions also needed; as for Gender = 1 and 2
Partition setting: 0=combined; 1=discard; 2=retained

WCGOP observer discard length comps from Andi
Sex combined data, Gender = 0
Outputs from
"C:\XiHe1\SDB2013\Landing\WCGOP\DataFromAndi_4_10_2013\PDAB.Observer.CompsAnalysis1.xlsx"
#Yr SE Flt GD Pt Ns 8 9 10
11 12 13 14 15 16
17 18 19 20 21 22
23 24 25 26 27 28
29 30 31 32 33 34
35 8 9 10 11 12
13 14 15 16 17 18
19 20 21 22 23 24

25 26 27 28 29 30
31 32 33 34 35
2006 1 1 0 1 98 0 0 0 0 0 0.00000.0000 0.0001 0.0027 0.0001
0.0048 0.0054 0.0075 0.0190 0.0373 0.1148 0.0782 0.0875 0.0949 0.1083 0.1453
0.1273 0.0755 0.0562 0.0061 0.0272 0.0013 0.0002 0.0000 0.0001 0.0001 0.0000
0.0000 0 0 0 0 0 0.00000.0000 0.0001 0.0027 0.0001 0.0048 0.0054 0.0075 0.0190
0.0373 0.1148 0.0782 0.0875 0.0949 0.1083 0.1453 0.1273 0.0755 0.0562 0.0061
0.0272 0.0013 0.0002 0.0000 0.0001 0.0001 0.0000 0.0000
2007 1 1 0 1 49 0 0 0 0 0 0.00000.0000 0.0000 0.0002 0.0000
0.0200 0.0012 0.0152 0.0310 0.0520 0.1385 0.1163 0.1138 0.2295 0.0891 0.0715
0.0473 0.0250 0.0070 0.0143 0.0243 0.0002 0.0001 0.0036 0.0000 0.0000 0.0000
0.0000 0 0 0 0 0 0.00000.0000 0.0000 0.0002 0.0000 0.0200 0.0012 0.0152 0.0310
0.0520 0.1385 0.1163 0.1138 0.2295 0.0891 0.0715 0.0473 0.0250 0.0070 0.0143
0.0243 0.0002 0.0001 0.0036 0.0000 0.0000 0.0000 0.0000
2008 1 1 0 1 61 0 0 0 0 0 0.00000.0000 0.0001 0.0009 0.0024
0.0030 0.0065 0.0032 0.0491 0.0257 0.0232 0.0614 0.0970 0.1252 0.0864 0.2262
0.1109 0.0657 0.0316 0.0242 0.0223 0.0327 0.0002 0.0000 0.0021 0.0000 0.0000
0.0000 0 0 0 0 0 0.00000.0000 0.0001 0.0009 0.0024 0.0030 0.0065 0.0032 0.0491
0.0257 0.0232 0.0614 0.0970 0.1252 0.0864 0.2262 0.1109 0.0657 0.0316 0.0242
0.0223 0.0327 0.0002 0.0000 0.0021 0.0000 0.0000 0.0000
2009 1 1 0 1 28 0 0 0 0 0 0.00000.0000 0.0000 0.0000 0.0000
0.0000 0.0122 0.0528 0.0269 0.0441 0.1015 0.1215 0.1222 0.0962 0.2156 0.1104
0.0333 0.0595 0.0036 0.0004 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0 0 0 0 0 0.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0122 0.0528 0.0269
0.0441 0.1015 0.1215 0.1222 0.0962 0.2156 0.1104 0.0333 0.0595 0.0036 0.0004
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2010 1 1 0 1 37 0 0 0 0 0 0.00000.0000 0.0100 0.0035 0.0494
0.0020 0.0379 0.0540 0.0787 0.0857 0.0660 0.0669 0.1309 0.1121 0.0959 0.0874
0.0559 0.0282 0.0287 0.0023 0.0021 0.0024 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0 0 0 0 0 0.00000.0000 0.0100 0.0035 0.0494 0.0020 0.0379 0.0540 0.0787
0.0857 0.0660 0.0669 0.1309 0.1121 0.0959 0.0874 0.0559 0.0282 0.0287 0.0023
0.0021 0.0024 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2011 1 1 0 1 82 0 0 0 0 0 0.00590.0037 0.0001 0.0019 0.0027
0.0158 0.0134 0.0046 0.0476 0.0317 0.0736 0.0912 0.1372 0.2031 0.0837 0.0881
0.1590 0.0213 0.0017 0.0005 0.0003 0.0003 0.0007 0.0003 0.0001 0.0003 0.0003
0.0000 0 0 0 0 0 0.00590.0037 0.0001 0.0019 0.0027 0.0158 0.0134 0.0046 0.0476
0.0317 0.0736 0.0912 0.1372 0.2031 0.0837 0.0881 0.1590 0.0213 0.0017 0.0005
0.0003 0.0003 0.0007 0.0003 0.0001 0.0003 0.0003 0.0000
2006 1 2 0 1 80 0 0 0 0 0 0.00470.0047 0.0001 0.0137 0.0124
0.0022 0.0326 0.0237 0.0490 0.0586 0.0721 0.1357 0.0901 0.0892 0.0648 0.0688
0.0836 0.0654 0.0507 0.0280 0.0139 0.0081 0.0111 0.0155 0.0002 0.0001 0.0000
0.0008 0 0 0 0 0 0.00470.0047 0.0001 0.0137 0.0124 0.0022 0.0326 0.0237 0.0490
0.0586 0.0721 0.1357 0.0901 0.0892 0.0648 0.0688 0.0836 0.0654 0.0507 0.0280
0.0139 0.0081 0.0111 0.0155 0.0002 0.0001 0.0000 0.0008
2007 1 2 0 1 48 0 0 0 0 0 0.00000.0000 0.0000 0.0000 0.0211
0.0397 0.0028 0.0290 0.0156 0.0466 0.0470 0.0706 0.0816 0.0891 0.0821 0.1429
0.0999 0.0754 0.0507 0.0521 0.0295 0.0213 0.0025 0.0004 0.0001 0.0000 0.0000
0.0000 0 0 0 0 0 0.00000.0000 0.0000 0.0000 0.0211 0.0397 0.0028 0.0290 0.0156
0.0466 0.0470 0.0706 0.0816 0.0891 0.0821 0.1429 0.0999 0.0754 0.0507 0.0521
0.0295 0.0213 0.0025 0.0004 0.0001 0.0000 0.0000 0.0000

2008 1 2 0 1 39 0 0 0 0 0 0.00000.0000 0.0004 0.0000 0.0000
0.0000 0.0031 0.0253 0.0516 0.0705 0.0304 0.0801 0.1473 0.0755 0.0747 0.0665
0.1251 0.0404 0.0670 0.0366 0.0380 0.0287 0.0210 0.0094 0.0064 0.0000 0.0000
0.0021 0 0 0 0 0 0.00000.0000 0.0004 0.0000 0.0000 0.0000 0.0031 0.0253 0.0516
0.0705 0.0304 0.0801 0.1473 0.0755 0.0747 0.0665 0.1251 0.0404 0.0670 0.0366
0.0380 0.0287 0.0210 0.0094 0.0064 0.0000 0.0000 0.0021
2009 1 2 0 1 79 0 0 0 0 0 0.00000.0000 0.0000 0.0000 0.0000
0.0000 0.0002 0.0001 0.0268 0.0297 0.0725 0.0898 0.0690 0.0932 0.1285 0.1488
0.1554 0.0625 0.0623 0.0175 0.0222 0.0043 0.0160 0.0009 0.0002 0.0001 0.0000
0.0000 0 0 0 0 0 0.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0002 0.0001 0.0268
0.0297 0.0725 0.0898 0.0690 0.0932 0.1285 0.1488 0.1554 0.0625 0.0623 0.0175
0.0222 0.0043 0.0160 0.0009 0.0002 0.0001 0.0000 0.0000
2010 1 2 0 1 32 0 0 0 0 0 0.00000.0000 0.0000 0.0000 0.0004
0.0004 0.0032 0.0079 0.0066 0.0113 0.0187 0.0687 0.0594 0.1738 0.1228 0.2402
0.1336 0.1041 0.0379 0.0039 0.0045 0.0000 0.0013 0.0014 0.0000 0.0000 0.0000
0.0000 0 0 0 0 0 0.00000.0000 0.0000 0.0000 0.0004 0.0004 0.0032 0.0079 0.0066
0.0113 0.0187 0.0687 0.0594 0.1738 0.1228 0.2402 0.1336 0.1041 0.0379 0.0039
0.0045 0.0000 0.0013 0.0014 0.0000 0.0000 0.0000 0.0000
2011 1 2 0 1 127 0 0 0 0 0 0.00000.0000 0.0000 0.0015 0.0037
0.0031 0.0068 0.0156 0.0267 0.0158 0.0231 0.0257 0.0441 0.1022 0.1581 0.1570
0.1680 0.0837 0.0509 0.0396 0.0301 0.0222 0.0041 0.0003 0.0171 0.0002 0.0000
0.0002 0 0 0 0 0 0.00000.0000 0.0000 0.0015 0.0037 0.0031 0.0068 0.0156 0.0267
0.0158 0.0231 0.0257 0.0441 0.1022 0.1581 0.1570 0.1680 0.0837 0.0509 0.0396
0.0301 0.0222 0.0041 0.0003 0.0171 0.0002 0.0000 0.0002

CA and OR trawl length data
Outputs from directory
"C:\XiHe1\SDB2013\Landing\PacFIN\PacFINCompDataFromDon\PacFINCompDataFromDon_3_29_2013Set3\Analysis1"
Length data from "PacFINLengthComp2.csv"
Sam (NSample) from "PacFINLengthcomp_effN.csv"
Final outputs to SS3 from "PacFINLengthCompForModelNew1.csv"
#Yr Sea Flt Gen Pt Sam N8.x N9.x
N10.x N11.x N12.x N13.x N14.x N15.x
N16.x N17.x N18.x N19.x N20.x N21.x
N22.x N23.x N24.x N25.x N26.x N27.x
N28.x N29.x N30.x N31.x N32.x N33.x
N34.x N35.x N8.y N9.y N10.y N11.y
N12.y N13.y N14.y N15.y N16.y N17.y
N18.y N19.y N20.y N21.y N22.y N23.y
N24.y N25.y N26.y N27.y N28.y N29.y
N30.y N31.y N32.y N33.y N34.y N35.y
2003 1 1 3 2 23 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000701 0.001089 0.002236
0.004790 0.012639 0.012378 0.019722 0.061125
0.050002 0.096999 0.073807 0.114579 0.111776
0.086783 0.021653 0.009224 0.000000 0.000000
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.001649 0.000000 0.000000 0.000000 0.000318
0.003814 0.001528 0.004082 0.017577 0.026626

```
     0.028527 0.029650 0.047690 0.049902 0.071787
     0.024918 0.007707 0.003427 0.001292 0.000000
     0.000000 0.000000 0.000000 0.000000
2004 1 1 3 2 14 0 0 0 0 0 0.000000 0.000000
     0.000000 0.000000 0.000000 0.000000 0.000000
     0.000000 0.000000 0.000000 0.000000 0.000000
     0.000000 0.002751 0.005809 0.011556 0.025642
     0.041643 0.066077 0.122727 0.157848 0.120403
     0.111610 0.028954 0.018538 0.000128 0.000000
     0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
     0.000000 0.000000 0.000000 0.000000 0.000000
     0.000000 0.000000 0.005010 0.005482 0.017021
     0.044243 0.037604 0.062013 0.058582 0.037872
     0.002813 0.014021 0.001259 0.000000 0.000387
     0.000000 0.000010 0.000000 0.000000
2005 1 1 3 2 13 0 0 0 0 0 0.000000 0.000000
     0.000000 0.000000 0.000000 0.000000 0.000000
     0.000000 0.000000 0.000000 0.002582 0.002044
     0.002650 0.006404 0.006353 0.044233 0.060599
     0.072193 0.111641 0.108467 0.150728 0.089827
     0.065636 0.013587 0.005781 0.002582 0.000000
     0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
     0.000000 0.000000 0.000000 0.000000 0.000000
     0.000000 0.000000 0.000000 0.016307 0.019533
     0.033960 0.040794 0.061656 0.048425 0.012192
     0.014361 0.004823 0.000000 0.000000 0.002582
     0.000000 0.000060 0.000000 0.000000
2006 1 1 3 2 28 0 0 0 0 0 0.000000 0.000000
     0.000000 0.000000 0.000000 0.000000 0.000000
     0.000000 0.000000 0.000035 0.000000 0.000000
     0.000000 0.006098 0.009749 0.023559 0.047114
     0.071302 0.116433 0.127055 0.132729 0.106952
     0.085291 0.019739 0.003744 0.000040 0.000000
     0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
     0.000000 0.000000 0.000000 0.000000 0.000000
     0.000000 0.000000 0.003388 0.004242 0.022814
     0.024946 0.041986 0.049357 0.061011 0.033047
     0.005873 0.002680 0.000363 0.000452 0.000000
     0.000000 0.000000 0.000000 0.000000
2007 1 1 3 2 27 0 0 0 0 0 0.000000 0.000000
     0.000000 0.000000 0.000000 0.000000 0.000000
     0.000000 0.000000 0.000000 0.000000 0.000000
     0.001389 0.000533 0.004811 0.015570 0.039631
     0.088485 0.124710 0.143780 0.218938 0.121512
     0.085282 0.016356 0.001397 0.000000 0.000000
     0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
     0.000000 0.000000 0.000000 0.000000 0.000000
     0.001276 0.001276 0.003471 0.005684 0.000226
     0.014393 0.019858 0.031299 0.022543 0.022754
     0.011114 0.001219 0.000599 0.001893 0.000000
     0.000000 0.000000 0.000000 0.000000
```

2008	1 1	3 2	22	0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000421	0.001952	0.010027	0.012231	0.046273
	0.058262	0.101000	0.174269	0.229607	0.156023
	0.063684	0.015921	0.005194	0.000395	0.000000
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000852
	0.003571	0.013564	0.025187	0.020809	0.034826
	0.020457	0.005475	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	
2009	1 1	3 2	16	0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.002855	0.006906	0.066569	0.085085	0.106696
	0.091669	0.114127	0.096748	0.123929	0.081018
	0.033933	0.014727	0.000417	0.000374	0.000000
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.002816	0.000675
	0.022821	0.024046	0.060994	0.028522	0.022935
	0.004416	0.002693	0.004408	0.000355	0.000177
	0.000089	0.000000	0.000000	0.000000	
2010	1 1	3 2	17	0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.004943	0.000050	0.000050	0.000117	0.000017
	0.011840	0.010764	0.100954	0.110004	0.116212
	0.095405	0.107920	0.074993	0.095719	0.034387
	0.002928	0.000021	0.000036	0.000000	0.004954
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.004943	0.000008
	0.000000	0.024721	0.000043	0.024810	0.027431
	0.040892	0.042219	0.034895	0.011707	0.007365
	0.007389	0.001130	0.001130	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	
2011	1 1	3 2	4	0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000247	0.001219	0.001150
	0.002515	0.002590	0.032133	0.029954	0.261509
	0.217211	0.116302	0.058103	0.086831	0.057469
	0.014367	0.000000	0.000000	0.000000	0.000000
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000247	0.000884	0.001206	0.015011	0.029214
	0.000000	0.014367	0.028734	0.028734	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	
2012	1 1	3 2	8	0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000

	0.000000	0.003634	0.005906	0.019443	0.121746
	0.105325	0.132436	0.087565	0.097590	0.095541
	0.107957	0.034946	0.016375	0.000000	0.004915
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.002005	0.000000	0.000000
	0.000000	0.007449	0.000000	0.000000	0.000000
	0.010553	0.010901	0.040136	0.052767	0.030379
	0.000000	0.004218	0.004399	0.000000	0.003815
	0.000000	0.000000	0.000000	0.000000	
1994	1 2	3 2	3	0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.010175	0.000000	0.000000	0.000000
	0.029666	0.025272	0.034587	0.095043	0.069701
	0.111813	0.049350	0.038981	0.029069	0.004921
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.015096
	0.025008	0.004921	0.030193	0.059262	0.093779
	0.059262	0.113936	0.039244	0.030193	0.030526
	0.000000	0.000000	0.000000	0.000000	
1995	1 2	3 2	4	0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.005794
	0.000000	0.000000	0.000000	0.017381	0.005794
	0.000000	0.015611	0.019859	0.005794	0.037241
	0.027199	0.054492	0.085491	0.090671	0.045064
	0.095178	0.065018	0.019021	0.002478	0.000000
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.005794	0.000000	0.000000
	0.000000	0.000000	0.005794	0.002478	0.000000
	0.004024	0.029677	0.029453	0.067402	0.067626
	0.071649	0.076381	0.047636	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	
1996	1 2	3 2	2	0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.011137	0.000000	0.014376	0.024092
	0.003239	0.119667	0.137678	0.115007	0.153079
	0.063981	0.020853	0.003239	0.000000	0.000000
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.011137	0.003239	0.038468	0.049605	0.048184
	0.083017	0.044945	0.025909	0.019432	0.006477
	0.000000	0.003239	0.000000	0.000000	
1997	1 2	3 2	11	0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.007945	0.001829	0.002837	0.017276	0.015953
	0.060577	0.078276	0.126587	0.135213	0.130432

0.094992 0.045622 0.045557 0.000000 0.000000
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000457
0.000457 0.008368 0.024316 0.023533 0.042004
0.049990 0.062017 0.007179 0.007488 0.000000
0.007488 0.000000 0.000000 0.003607
1998 1 2 3 2 9 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.007895
0.007981 0.012406 0.044872 0.042423 0.070830
0.089050 0.084126 0.082699 0.142508 0.066089
0.035896 0.009665 0.000000 0.000000 0.000000
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.007861 0.000000 0.007861 0.016020 0.024121
0.023756 0.024567 0.034216 0.069958 0.054032
0.032946 0.004080 0.004080 0.000000 0.000064
0.000000 0.000000 0.000000 0.000000
1999 1 2 3 2 5 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.008235
0.008235 0.000000 0.001323 0.001323 0.028014
0.098307 0.093469 0.186975 0.120742 0.168058
0.088973 0.070074 0.000000 0.000000 0.000000
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.008235
0.000000 0.024706 0.009559 0.028993 0.011211
0.029414 0.014153 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000
2000 1 2 3 2 8 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.006899 0.000087 0.013886 0.000578 0.018977
0.120048 0.191432 0.166525 0.101583 0.066502
0.027764 0.012839 0.000000 0.000000 0.000000
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.006986 0.006986
0.057845 0.042185 0.048997 0.035674 0.026351
0.035444 0.012269 0.000000 0.000142 0.000000
0.000000 0.000000 0.000000 0.000000
2001 1 2 3 2 9 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.014320 0.000000 0.042961 0.000930 0.016215
0.093582 0.081147 0.067482 0.192848 0.158904
0.028108 0.003814 0.000000 0.000000 0.000000
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000

	0.000000	0.000000	0.014320	0.028641	0.044046
	0.057282	0.029955	0.018541	0.002170	0.059719
	0.029844	0.015057	0.000057	0.000057	0.000000
	0.000000	0.000000	0.000000	0.000000	
2002	1 2	3 2	11	0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.002018	0.000000
	0.000000	0.002018	0.004879	0.008073	0.013332
	0.039538	0.087883	0.141649	0.191913	0.170744
	0.087452	0.057917	0.013302	0.000000	0.000000
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.002018	0.004037	0.004037	0.008073	0.011648
	0.008073	0.021737	0.040728	0.032615	0.025912
	0.013236	0.007168	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	
2003	1 2	3 2	8	0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.006712
	0.000514	0.046527	0.109528	0.234868	0.290010
	0.162633	0.098346	0.013810	0.003281	0.000000
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000932	0.002045	0.002622
	0.011418	0.007998	0.006135	0.002622	0.000000
	0.000000	0.000000	0.000000	0.000000	
2004	1 2	3 2	11	0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.001872	0.001428	0.003321
	0.044667	0.071558	0.149682	0.174035	0.133843
	0.088683	0.047261	0.021946	0.001590	0.003560
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.016976
	0.000000	0.051394	0.035145	0.020015	0.076432
	0.022655	0.003800	0.024810	0.005326	0.000000
	0.000000	0.000000	0.000000	0.000000	
2005	1 2	3 2	11	0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.002703	0.000000
	0.000000	0.000189	0.005466	0.031505	0.055565
	0.056348	0.124088	0.176963	0.156953	0.147040
	0.097248	0.047059	0.007056	0.000000	0.000000
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.008169	0.009211
	0.017289	0.016398	0.006934	0.010706	0.004168

0.007006 0.005625 0.003695 0.001924 0.000693
0.000000 0.000000 0.000000 0.000000
2006 1 2 3 2 17 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000799 0.000000 0.008466
0.032875 0.083945 0.105344 0.208185 0.233762
0.152586 0.069303 0.029807 0.002575 0.000377
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.002300 0.000000
0.000189 0.007025 0.014969 0.019796 0.013074
0.010907 0.002772 0.000377 0.000566 0.000000
0.000000 0.000000 0.000000 0.000000
2007 1 2 3 2 21 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000060 0.004669 0.014474
0.038479 0.066825 0.139182 0.162253 0.195441
0.156673 0.094168 0.053348 0.004881 0.005275
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000728 0.009122 0.007086 0.005011 0.018969
0.008609 0.005577 0.008502 0.000000 0.000000
0.000000 0.000000 0.000000 0.000668
2008 1 2 3 2 15 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.002197 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000327 0.004593 0.033919
0.035657 0.084958 0.157589 0.179143 0.158224
0.143427 0.062126 0.060719 0.012575 0.009792
0.003965 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.002197 0.000000 0.000000 0.002197 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.011651 0.007277 0.012549
0.014377 0.000000 0.000000 0.000000 0.000000
0.000539 0.000000 0.000000 0.000000
2009 1 2 3 2 25 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000864 0.008205 0.028877
0.068272 0.129624 0.157356 0.173353 0.144434
0.105484 0.054797 0.014297 0.001003 0.000283
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000368 0.010298 0.020586 0.036159 0.030532
0.008497 0.003625 0.003085 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000

```
2010	1	2	3	2	25		0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.001402	0.002321	0.011623	0.029166
	0.099786	0.157107	0.165592	0.195601	0.105865
	0.091851	0.048002	0.008698	0.000234	0.000000
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.002209	0.002179	0.016108	0.026836	0.019306
	0.013543	0.002388	0.000183	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000
2011	1	2	3	2	23		0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.005279	0.019014	0.020531	0.044187
	0.117081	0.163652	0.157829	0.109809	0.114325
	0.050743	0.020796	0.002399	0.000000	0.000527
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.005121	0.000000	0.015667	0.031692
	0.024381	0.044584	0.018900	0.016309	0.013916
	0.002331	0.000801	0.000000	0.000126	0.000000
	0.000000	0.000000	0.000000	0.000000
2012	1	2	3	2	19		0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000312	0.000000	0.002888	0.010365	0.044695
	0.072121	0.126908	0.170412	0.156584	0.139962
	0.099788	0.031715	0.011175	0.002468	0.000000
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.003953	0.000447
	0.000124	0.035362	0.020008	0.039309	0.017532
	0.010449	0.002888	0.000000	0.000536	0.000000
	0.000000	0.000000	0.000000	0.000000

# CPFV data from Meisha Key 6_24_2013
# copied from
"C:\XiHe1\SDB2013\Landing\CACPFVRecData\CPFVLengthDataMeishaKey_7_2_2013\Analysis1\DataAllYear1WithOutputs.xlsx"
#Yr	Sea	Flt	Ge	Pt	Nsm	8	9	10	11	12	13
	14	15	16	17	18	19	20	21	22	23	24
	25	26	27	28	29	30	31	32	33	34	35
	8	9	10	11	12	13	14	15	16	17	18
	19	20	21	22	23	24	25	26	27	28	29
	30	31	32	33	34	35
1976	1	3	0	2	38	0 0 0 0 0 0	0	0	0	0
	1	0	0	3	6	6	5	11	15	25	38
	50	53	40	21	19	7	4	2	0	1	1
	0	0 0 0 0 0 0	0	0	0	0	1	0	0	3
```

	6	6	5	11	15	25	38	50	53	40	21
	19	7	4	2	0	1	1	0			
1977	1	3	0	2	27	0 0 0 0 0 0		0	0	0	0
	0	0	0	3	1	4	7	8	17	18	26
	19	29	23	25	22	18	9	3	3	2	0
	2	0 0 0 0 0 0		0	0	0	0	0	0	0	3
	1	4	7	8	17	18	26	19	29	23	25
	22	18	9	3	3	2	0	2			
1978	1	3	0	2	36	0 0 0 0 0 0		0	0	0	0
	0	0	0	2	2	4	8	7	20	21	28
	28	30	35	30	27	36	17	9	5	0	2
	0	0 0 0 0 0 0		0	0	0	0	0	0	0	2
	2	4	8	7	20	21	28	28	30	35	30
	27	36	17	9	5	0	2	0			
1986	1	3	0	2	39	0 0 0 0 0 0		0	0	0	0
	0	0	1	1	2	8	17	34	32	42	43
	59	64	62	51	41	15	7	1	0	0	0
	0	0 0 0 0 0 0		0	0	0	0	0	0	1	1
	2	8	17	34	32	42	43	59	64	62	51
	41	15	7	1	0	0	0	0			
1987	1	3	0	2	42	0 0 0 0 0 0		0	0	0	0
	0	2	2	1	5	9	8	10	18	30	25
	34	37	30	36	33	23	7	9	5	1	0
	1	0 0 0 0 0 0		0	0	0	0	0	2	2	1
	5	9	8	10	18	30	25	34	37	30	36
	33	23	7	9	5	1	0	1			
1988	1	3	0	2	46	0 0 0 0 0 0		0	0	0	0
	0	0	1	1	2	5	18	16	35	33	37
	45	42	44	38	29	21	7	1	1	2	0
	2	0 0 0 0 0 0		0	0	0	0	0	0	1	1
	2	5	18	16	35	33	37	45	42	44	38
	29	21	7	1	1	2	0	2			
1989	1	3	0	2	74	0 0 0 0 0 0		0	1	0	0
	4	4	9	6	20	45	58	85	113	139	162
	179	163	142	107	80	59	27	12	9	5	2
	1	0 0 0 0 0 0		0	1	0	0	4	4	9	6
	20	45	58	85	113	139	162	179	163	142	107
	80	59	27	12	9	5	2	1			
1990	1	3	0	2	13	0 0 0 0 0 0		0	0	0	0
	0	0	0	0	0	0	3	1	2	3	5
	13	17	10	6	2	3	2	0	0	0	0
	0	0 0 0 0 0 0		0	0	0	0	0	0	0	0
	0	0	3	1	2	3	5	13	17	10	6
	2	3	2	0	0	0	0	0			
1991	1	3	0	2	11	0 0 0 0 0 0		0	0	0	0
	0	0	0	1	3	0	0	1	7	14	6
	20	12	12	11	3	4	6	1	0	0	0
	3	0 0 0 0 0 0		0	0	0	0	0	0	0	1
	3	0	0	1	7	14	6	20	12	12	11
	3	4	6	1	0	0	0	3			

1992	1	3	0	2	23	0 0 0 0 0 0	0	0	0	0	
	0	0	0	0	0	4	11	17	15	17	21
	23	26	22	15	5	5	2	1	0	0	0
	1	0 0 0 0 0 0	0	0	0	0	0	0	0	0	
	0	4	11	17	15	17	21	23	26	22	15
	5	5	2	1	0	0	0	1			
1993	1	3	0	2	21	0 0 0 0 0 0	0	0	0	0	
	0	0	1	0	0	4	10	15	29	25	33
	18	15	16	10	14	6	1	1	0	0	0
	0	0 0 0 0 0 0	0	0	0	0	0	0	1	0	
	0	4	10	15	29	25	33	18	15	16	10
	14	6	1	1	0	0	0	0			
1994	1	3	0	2	25	0 0 0 0 0 0	0	0	0	0	
	0	0	0	1	2	5	7	19	25	27	28
	32	41	24	18	15	4	1	0	0	0	0
	0	0 0 0 0 0 0	0	0	0	0	0	0	0	1	
	2	5	7	19	25	27	28	32	41	24	18
	15	4	1	0	0	0	0	0			
1995	1	3	0	2	28	0 0 0 0 0 0	0	0	0	0	
	0	0	0	1	1	6	17	22	34	32	44
	47	50	28	24	16	3	3	1	0	0	0
	0	0 0 0 0 0 0	0	0	0	0	0	0	0	1	
	1	6	17	22	34	32	44	47	50	28	24
	16	3	3	1	0	0	0	0			
1996	1	3	0	2	25	0 0 0 0 0 0	0	0	0	0	
	0	0	0	1	1	6	10	30	35	46	50
	47	46	44	29	26	12	4	1	0	0	0
	0	0 0 0 0 0 0	0	0	0	0	0	0	0	1	
	1	6	10	30	35	46	50	47	46	44	29
	26	12	4	1	0	0	0	0			
1997	1	3	0	2	25	0 0 0 0 0 0	0	0	0	0	
	0	0	0	0	0	5	12	18	25	29	25
	43	41	30	27	23	8	7	1	0	0	0
	0	0 0 0 0 0 0	0	0	0	0	0	0	0	0	
	0	5	12	18	25	29	25	43	41	30	27
	23	8	7	1	0	0	0	0			
1998	1	3	0	2	10	0 0 0 0 0 0	0	0	0	0	
	0	0	0	0	0	0	1	3	2	1	5
	2	3	5	6	1	0	0	0	0	0	0
	1	0 0 0 0 0 0	0	0	0	0	0	0	0	0	
	0	0	1	3	2	1	5	2	3	5	6
	1	0	0	0	0	0	0	1			

RecFIN data: only one year from Melissa Monk's data
Data from directory "C:\XiHe1\SDB2013\Landing\RecCatch\MelissaMonkData\Analysis1"
Length data from file "RecMelissaDataDiscardLength.xlsx"
Sample size from data sheet "SampleSize" of file "RecMelissaDataDiscardLength.xlsx"

#Yr		Sea	Flt	Gen	Pt	Sam	8	9	10	11	12
	13	14	15	16	17	18	19	20	21	22	23
	24	25	26	27	28	29	30	31	32	33	34
	35	8	9	10	11	12	13	14	15	16	17

```
        18      19      20      21      22      23      24      25      26      27      28
        29      30      31      32      33      34      35
2005    1       3       0       2       28      0 0 0 0 0 0     0       0       1       3
        2       3       7       4       6       2       3       5       7       7       9
        9       12      9       3       4       4       2       0       0       0       0
        0       0       0       0 0 0 0 0 0     1       3       2       3       7       4
        6       2       3       5       7       7       9       9       12      9       3
        4       4       2       0       0       0       0       0
2005    1       3       0       1       71      0 0 0 0 0 0     0       0       0       2
        3       4       1       2       1       9       9       17      13      12      6
        11      10      3       2       3       0       2       0       1       0       0
        1       0       0       0 0 0 0 0 0     0       2       3       4       1       2
        1       9       9       17      13      12      6       11      10      3       2
        3       0       2       0       1       0       0       1


# NWFSC survey length comps
# use Allan Hicks' expantion program
# program and output dir: "C:\XiHe1\SDB2013\SurveyData\NWFSC\LengthFreqNew2"
# data copied from "NWFSCLengthCompsForModel.xlsx"
#yr            SE      Flt     GD      Pt      Ns      F8              F9              F10
        F11             F12             F13             F14             F15             F16
        F17             F18             F19             F20             F21             F22
        F23             F24             F25             F26             F27             F28
        F29             F30             F31             F32             F33             F34
        F35             M8              M9              M10             M11             M12
        M13             M14             M15             M16             M17             M18
        M19             M20             M21             M22             M23             M24
        M25             M26             M27             M28             M29             M30
        M31             M32             M33             M34             M35
2003    1       5       3       0       132     0 0 0 0 0 0.00000       0.000000.001840.01222
        0.053090.105540.144130.298810.375200.536040.728181.253912.544213.156075.76804
        4.5557010.67838.273735.645896.698913.927873.421391.780530.823120.161830.00422
        0.000000.000000 0 0 0 0 0.00000         0.005780.018550.050530.102220.192430.36289
        0.766811.071071.015271.997792.758193.505753.615014.366083.855443.353563.87896
        4.816362.731270.564210.008760.012600.001700.000000.000000.000000.00000
2004    1       5       3       0       165     0 0 0 0 0 0.00305       0.002940.016600.02600
        0.066520.216000.254480.457280.796821.289462.384203.225174.700824.647636.00390
        5.757826.851224.786174.817114.650673.797592.459831.531160.606840.071890.02698
        0.006370.002280 0 0 0 0 0.07936         0.014780.050970.135930.257060.259460.33642
        0.558101.196512.194703.894774.568135.113825.553184.465183.829683.515761.94149
        1.526190.551250.313870.092780.015610.057570.000000.011160.000000.00000
2005    1       5       3       0       218     0 0 0 0 0 0.00000       0.054650.081350.12514
        0.237790.371370.770460.696411.515622.117712.920443.620614.866074.878115.01043
        5.486335.964436.125664.762104.011263.164921.691580.742150.233280.062760.00617
        0.000000.000000 0 0 0 0 0.01523         0.097470.363020.472480.516330.608440.92735
        1.265971.878512.623883.762694.603174.997834.703484.533363.900662.663561.47995
        0.573590.301600.112210.056640.000000.000000.000000.000000.000000.00000
2006    1       5       3       0       178     0 0 0 0 0 0.00000       0.000000.027300.07732
        0.073650.183990.511080.440250.831491.009272.329742.036253.455245.242557.05928
        5.687707.785195.295825.853266.132933.878302.145463.323990.083700.032330.00000
```

0.000000.000000 0 0 0 0 0.02784 0.058760.035040.184240.325330.414730.95703
1.154942.215261.825094.220404.309344.502203.500454.777852.791903.098800.63440
1.173060.166740.078360.041840.000000.000000.000000.000000.000000.00000
2007 1 5 3 0 190 0 0 0 0 0 0.00000 0.000000.000000.02032
0.158060.272580.732550.749351.473982.110423.316133.608065.287724.463017.10252
8.342265.604134.980945.880354.313642.523051.413400.535180.196400.005910.00000
0.000000.000000 0 0 0 0 0.00000 0.007720.072080.186910.323780.400861.20907
1.253762.105122.590294.045035.808844.501654.433293.588422.581611.845741.00841
0.688710.194690.049340.008340.006360.000000.000000.000000.000000.00000
2008 1 5 3 0 203 0 0 0 0 0 0.00000 0.000000.000000.06915
0.125790.241900.443800.740171.307861.730354.147254.919814.705635.876655.22531
5.331195.213325.442254.711053.148142.534321.415170.681200.174250.040310.04614
0.000000.000000 0 0 0 0 0.02286 0.000000.128820.150270.677210.492720.68692
1.255762.757834.220404.530844.961415.917905.299723.658992.890942.150751.08439
0.693720.115020.012380.000000.018220.000000.000000.000000.000000.00000
2009 1 5 3 0 214 0 0 0 0 0 0.00000 0.000000.001070.01390
0.166930.194650.518441.094412.203013.960503.196414.436553.647047.928585.48366
5.477464.778013.148972.777573.304011.860280.910660.475900.071530.007800.00000
0.000000.000000 0 0 0 0 0.00305 0.000000.039160.050300.213580.382101.60123
1.101393.045853.086844.593456.186674.632937.038344.345283.572451.645900.80449
1.891230.092890.015520.000000.000000.000000.000000.000000.000000.00000
2010 1 5 3 0 239 0 0 0 0 0 0.00000 0.000000.000000.00302
0.075150.709570.152500.174570.918251.304991.176614.564968.989534.800835.30686
7.217895.705772.551662.542433.329692.025820.684210.634020.061490.000000.09014
0.000000.000000 0 0 0 0 0.00423 0.000000.011300.100110.149600.478050.27460
0.305991.447181.915507.531408.466339.753655.472105.085822.470181.837481.25542
0.362170.058910.000000.000000.000000.000000.000000.000000.000000.00000
2011 1 5 3 0 242 0 0 0 0 0 0.00000 0.000000.032530.09194
0.051150.142140.456440.701820.728411.920571.692743.003084.137172.968317.28456
5.831435.645816.317447.006814.261083.616831.191630.989400.191460.059800.00935
0.000000.000000 0 0 0 0 0.01453 0.012040.044300.110550.113980.234920.55850
1.144371.506861.623272.778004.1252710.84817.037453.523183.341632.648831.21180
0.523370.194960.027360.009760.010630.024370.000000.000000.000000.00000
2012 1 5 3 0 244 0 0 0 0 0 0.00105 0.002110.000000.01601
0.017630.300560.585501.400821.707712.021661.713232.619463.284953.083814.60352
6.095267.514087.084696.891733.665493.306121.720871.251230.136210.040980.00324
0.002620.000000 0 0 0 0 0.02317 0.008400.027760.076070.306280.364720.52400
1.292612.035532.063723.524845.025576.817785.465805.346303.760642.368110.92618
0.821300.129640.008140.000000.006650.000000.000000.000000.000000.00000

triennial survey length comps
use Allan Hicks' expantion program (with "FREQUENCY" variable applied)
program and output dir: "C:\XiHe1\SDB2013\SurveyData\Triennial\LengthFreqNew1"
Note: raw data have frequency variable to expand total length measurements
Outputs are same for analyzing two periods together or separately

#yr SE Flt GD Pt Ns F8 F9 F10
F11 F12 F13 F14 F15 F16
F17 F18 F19 F20 F21 F22
F23 F24 F25 F26 F27 F28
F29 F30 F31 F32 F33 F34

	F35		F8.1	F9.1	F10.1	F11.1	F12.1	F13.1	F14.1	F15.1	F16.1
	F17.1	F18.1	F19.1	F20.1	F21.1	F22.1	F23.1	F24.1	F25.1	F26.1	F27.1
	F28.1	F29.1	F30.1	F31.1	F32.1	F33.1	F34.1	F35.1			
1980	1	6	3	0	5	0 0 0 0 0 0.00000.0000			0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.1540	0.0000	0.0000	0.1472	0.1472	0.9242	1.8796	2.9175
	6.2674	8.2141	13.617614.550713.79837.6865				5.8748	1.3032	0.1540	0.0000	0.0000
	0.0000	0 0 0 0 0 0.00000.0000			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1472
	0.0000	0.0000	0.4793	0.5889	1.2530	3.4558	4.8893	3.1978	3.1476	3.0604	1.5322
	0.6121	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
1983	1	6	3	0	16	0 0 0 0 0 0.00000.0000			0.0000	0.0000	0.0000
	0.0649	0.0543	0.4256	0.4832	0.6724	1.0479	1.6616	2.0633	2.4613	3.0367	3.6682
	4.0883	4.7217	5.4304	5.4454	5.3036	4.1017	2.4719	1.4890	0.3879	0.2826	0.0906
	0.0000	0 0 0 0 0 0.00000.0000			0.0000	0.0000	0.0649	0.1408	0.1324	0.4644	0.5347
	1.1542	2.1481	4.9622	4.6160	5.7011	6.1142	5.7638	6.4407	5.2046	3.6145	1.8985
	1.0376	0.4297	0.0435	0.0812	0.0000	0.0000	0.0000	0.0000			
1986	1	6	3	0	11	0 0 0 0 0 0.00000.0000			0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0911	0.0000	0.2605	0.7310	1.6607	2.2447	3.3250	5.1180
	5.3529	7.7411	8.6398	9.5046	7.6200	4.2199	3.9024	1.0567	0.1918	0.0000	0.0000
	0.0000	0 0 0 0 0 0.00000.0000			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.2605	1.0640	1.5010	1.8179	5.1802	6.6931	8.4135	6.4660	3.7817	2.1499	0.1918
	0.5607	0.2594	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
1989	1	6	3	0	88	0 0 0 0 0 0.00000.0068			0.0000	0.0438	0.0771
	0.1242	0.2442	0.5650	0.9596	1.0786	1.5286	1.7322	2.0817	3.0796	4.5252	4.7717
	4.5687	4.1164	5.1725	5.6985	5.8960	3.1704	2.3035	2.2949	0.6462	0.0975	0.0884
	0.0000	0 0 0 0 0 0.00000.0020			0.0000	0.0790	0.2625	0.3051	0.5495	1.1286	1.7401
	1.9520	2.8484	4.2549	4.7112	5.0065	4.6437	5.1160	4.5290	3.0940	3.0725	1.0454
	0.3845	0.2094	0.0023	0.1922	0.0000	0.0000	0.0000	0.0000			
1992	1	6	3	0	142	0 0 0 0 0 0.00000.0025			0.0492	0.0358	0.1166
	0.2338	0.3832	0.5727	1.1631	2.0924	3.9804	5.3219	5.8381	6.1370	4.8276	4.6979
	4.3003	3.2531	2.9340	2.6019	3.0980	2.0809	1.3034	0.6031	0.2389	0.0546	0.0000
	0.0000	0 0 0 0 0 0.00220.0339			0.0337	0.1278	0.3133	0.3744	0.7153	1.0244	2.6929
	4.5877	5.7323	5.5282	5.5337	4.7185	3.6225	2.9408	2.2184	1.9174	1.3478	0.3591
	0.1683	0.0586	0.0046	0.0239	0.0000	0.0000	0.0000	0.0000			
1995	1	7	3	0	147	0 0 0 0 0 0.00000.0000			0.0191	0.0700	0.1652
	0.3879	0.8600	1.2088	3.5988	3.5867	4.0912	2.8104	3.5766	4.5370	4.5036	4.1999
	4.0835	3.9361	6.7012	4.0069	2.0106	1.2195	0.6217	0.2259	0.0087	0.0187	0.0073
	0.0038	0 0 0 0 0 0.00000.0206			0.0618	0.1665	0.5882	0.9103	1.8622	2.8458	5.1871
	3.2488	3.9841	3.5193	3.9977	5.4580	3.9407	3.3303	2.1344	1.6796	0.1700	0.4000
	0.0076	0.0000	0.0034	0.0000	0.0000	0.0000	0.0000	0.0243			
1998	1	7	3	0	223	0 0 0 0 0 0.00000.0000			0.0127	0.0549	0.0761
	0.2181	0.6035	0.9799	1.2206	2.4389	3.0883	3.7164	4.3845	5.6669	5.5413	6.1513
	5.1088	5.4641	4.0906	3.3753	1.8423	0.6301	0.1879	0.0471	0.0039	0.0000	0.0000
	0.0000	0 0 0 0 0 0.00130.0515			0.0654	0.0933	0.1233	0.4711	0.6665	1.4970	1.8030
	3.3354	4.6779	5.3307	5.2269	5.2053	4.8357	4.8221	3.5022	2.1070	0.8231	0.3165
	0.0986	0.0250	0.0110	0.0000	0.0011	0.0000	0.0000	0.0000			
2001	1	7	3	0	231	0 0 0 0 0 0.00000.0000			0.0274	0.0131	0.1022
	0.3455	1.0886	1.7243	4.3380	3.2827	3.4400	3.1032	2.7705	3.4884	3.9049	3.5465
	3.3260	4.0328	4.5876	4.9510	2.4186	1.5555	0.4354	0.0759	0.0045	0.0022	0.0000
	0.0000	0 0 0 0 0 0.00000.0000			0.0288	0.0459	0.1542	0.4279	1.9027	3.7758	3.9321

```
        3.7315  3.5985  4.0247  5.5240  4.7120  5.9467  4.4309  2.7036  1.2394  0.7336  0.2308
        0.2635  0.0197  0.0021  0.0062  0.0005  0.0000  0.0000  0.0000
2004    1       7       3       0       166     0 0 0 0 0 0.00280.0000  0.0000  0.0371  0.0539
        0.1489  0.4361  0.7697  1.1586  1.7452  2.7105  3.4624  4.6078  3.2904  4.1510  4.0376
        5.0830  5.0439  4.5749  3.7485  3.0317  1.8287  0.9540  0.2483  0.1067  0.0133  0.0007
        0.0020  0 0 0 0 0 0.00300.0110  0.0289  0.1098  0.2401  0.3151  0.7732  1.2809  2.6913
        2.6024  4.5516  4.9160  6.3883  5.2082  6.4703  4.1727  4.5444  2.3726  1.1719  0.5722
        0.2455  0.0777  0.0023  0.0000  0.0000  0.0000  0.0000  0.0000

#_Age composition data
12      # number of age bins
0 1 2 3 4 5 6 7 8 9 10 11

2       #_number of unique ageing error matrices to generate
# Vector 1: Set SD to small values to assume no ageing errors
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5
0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001

# Vector 2: new ageing error estimates from all ageing error readings (3/21/2013)
0.5775  1.5888  2.5856  3.5679  4.5361  5.4904  6.4308  7.3577  8.2713  9.1716  10.059010.9335
0.2444  0.2444  0.2589  0.2802  0.3114  0.3572  0.4244  0.5231  0.6680  0.8807  1.1928  1.6511

386     #_number of age observations
3       #_Lbin_method: 1=poplenbins; 2=datalenbins; 3=lengths
0       #_combine males into females at or below this bin number

# CA trawl fisheries
# Program and output directory: "C:\XiHe1\SDB2013\AgeData\CAFishery\Analysis1"
# Output copied from file "PacFINCAAgeCompForModel.xlsx"
#Yr             Se      Flt     Ge      Pt      AE      LO      HI      Sam     N.0.x
        N.1.x           N.2.x           N.3.x           N.4.x           N.5.x           N.6.x
        N.7.x           N.8.x           N.9.x           N.10.x          N.11.x          N.0.y
        N.1.y           N.2.y           N.3.y           N.4.y           N.5.y           N.6.y
        N.7.y           N.8.y           N.9.y           N.10.y          N.11.y
2003    1       1       3       2       2       -1      -1      8       0.000000
        0.000000        0.004335        0.034406        0.119666        0.076870
        0.112857        0.121735        0.111311        0.045654        0.003356
        0.000000        0.000000        0.000000        0.023702        0.027822
        0.072082        0.057270        0.085785        0.051517        0.029474
        0.014554        0.000000        0.000000
2007    1       1       3       2       2       -1      -1      13      0.000000
        0.000000        0.000000        0.001333        0.023647        0.081477
        0.198816        0.279622        0.197356        0.047363        0.003301
        0.000160        0.000000        0.000000        0.000000        0.000000
        0.013576        0.050458        0.042661        0.055230        0.002949
        0.000941        0.001108        0.000000
2008    1       1       3       2       2       -1      -1      8       0.000000
        0.000000        0.000000        0.002198        0.025421        0.097423
        0.234064        0.279122        0.133398        0.061388        0.003312
        0.009065        0.000000        0.000000        0.000000        0.000000
```

```
	0.000000	0.027107	0.059780	0.050639	0.017082
	0.000000	0.000000	0.000000

# OR trawl fisheries
# Program and output directory: "C:\XiHe1\SDB2013\AgeData\ORFishery\Analysis1"
# Output copied from file "PacFINORAgeCompForModel.xlsx"
#Year	Se	Flt	Ge	Pt	AE	LO	HI	Sam	N.0.x	N.1.x
	N.2.x	N.3.x	N.4.x	N.5.x	N.6.x	N.7.x
	N.8.x	N.9.x	N.10.x	N.11.x	N.0.y	N.1.y
	N.2.y	N.3.y	N.4.y	N.5.y	N.6.y	N.7.y
	N.8.y	N.9.y	N.10.y	N.11.y
1995	1	2	3	2	2	-1	-1	2	0.000000
	0.000000	0.000000	0.013385	0.000000	0.000000
	0.043255	0.119480	0.248185	0.089610	0.029870
	0.021627	0.000000	0.000000	0.000000	0.000000
	0.000000	0.026770	0.048397	0.140048	0.129764
	0.081367	0.008243	0.000000
1997	1	2	3	2	2	-1	-1	10	0.000000
	0.000000	0.000000	0.000721	0.004319	0.037217
	0.057620	0.086251	0.241778	0.183529	0.103445
	0.057260	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000213	0.030417	0.028669	0.122784
	0.035505	0.010272	0.000000
1999	1	2	3	2	2	-1	-1	5	0.000000
	0.000000	0.003616	0.005786	0.004339	0.016344
	0.054391	0.262555	0.304870	0.159526	0.058128
	0.000111	0.000000	0.000000	0.000000	0.000000
	0.009001	0.000000	0.000723	0.036950	0.051511
	0.015359	0.016791	0.000000
2001	1	2	3	2	2	-1	-1	9	0.000000
	0.000000	0.000000	0.014865	0.044764	0.062900
	0.025440	0.182349	0.245252	0.114328	0.006565
	0.002049	0.000000	0.000000	0.000000	0.000000
	0.086438	0.058717	0.030876	0.046023	0.020007
	0.044770	0.014658	0.000000
2003	1	2	3	2	2	-1	-1	5	0.000000
	0.000000	0.000000	0.000000	0.005943	0.000000
	0.029586	0.085341	0.270428	0.262572	0.191405
	0.129478	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.009651	0.000000
	0.015594	0.000000	0.000000
2005	1	2	3	2	2	-1	-1	10	0.000000
	0.000000	0.000000	0.000000	0.000192	0.026419
	0.071883	0.178231	0.233017	0.215400	0.126840
	0.056678	0.000000	0.000000	0.000000	0.000835
	0.003613	0.016844	0.014592	0.020853	0.018452
	0.009018	0.004355	0.002778
2007	1	2	3	2	2	-1	-1	2	0.000000
	0.000000	0.000000	0.000000	0.019247	0.205160
	0.194840	0.328174	0.138493	0.014087	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
```

```
        0.000000    0.000000    0.038493    0.047420    0.014087
        0.000000    0.000000    0.000000
2009    1   2       3   2       2   -1      -1  14      0.000000
        0.000000    0.000000    0.009765    0.039743    0.105040
        0.154193    0.207033    0.210983    0.088209    0.036001
        0.000342    0.000000    0.000000    0.000000    0.000000
        0.006771    0.009350    0.049034    0.057061    0.011973
        0.008319    0.006184    0.000000
2011    1   2       3   2       2   -1      -1  16      0.000000
        0.000000    0.000000    0.000270    0.046681    0.159013
        0.181223    0.191283    0.136993    0.085737    0.024051
        0.006091    0.000000    0.000000    0.000000    0.037389
        0.033250    0.034790    0.031904    0.016656    0.013900
        0.000770    0.000000    0.000000
2012    1   2       3   2       2   -1      -1  16      0.000000
        0.000000    0.000000    0.012297    0.041732    0.177307
        0.242207    0.203722    0.124450    0.059427    0.017458
        0.016395    0.000000    0.000000    0.000000    0.000199
        0.003888    0.012212    0.038310    0.027616    0.016720
        0.006060    0.000000    0.000000

# NWFSC survey conditiona age-at-length
# Program and output directory: "C:\XiHe1\SDB2013\SurveyData\NWFSC\AgeAtLength1"
# Outputs copied from file: "AgeAtLenForSS3Model.xlsx"
# NOTE: one record with LbinLo = 5 needs to be deleted

#year   Se      Flt     gd      prn     aE      Lo      Hi      nS      F0      F1      F2
        F3      F4      F5      F6      F7      F8      F9      F10     F11     M0      M1
        M2      M3      M4      M5      M6      M7      M8      M9      M10     M11
2003    1       5       1       0       2       11      11      1       0.0000  100.0000
        0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
        100.0000        0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
        0.0000
2003    1       5       1       0       2       13      13      1       0.0000  100.0000
        0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
        100.0000        0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
        0.0000
2003    1       5       1       0       2       14      14      3       0.0000  0.0000
        100.0000        0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
        0.0000  0.0000  100.0000        0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
        0.0000  0.0000
2003    1       5       1       0       2       15      15      4       0.0000  25.000075.0000
        0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  25.0000
        75.00000.0000   0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
2003    1       5       1       0       2       16      16      13      0.0000  23.076969.2308
        7.6923  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  23.0769
        69.23087.6923  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
2003    1       5       1       0       2       17      17      11      0.0000  9.0909  45.4545
        36.36369.0909  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  9.0909
        45.454536.36369.0909  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
```

2003	1	5	1	0	2	18	18	8	0.0000	0.0000	50.0000
	50.00000.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	50.000050.00000.0000			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
2003	1	5	1	0	2	19	19	26	0.0000	0.0000	53.8462
	34.61547.6923		3.8462	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	53.846234.61547.6923			3.8462	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
2003	1	5	1	0	2	20	20	21	0.0000	0.0000	28.5714
	38.095228.57144.7619			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	28.571438.095228.57144.7619				0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
2003	1	5	1	0	2	21	21	24	0.0000	0.0000	16.6667
	29.166754.16670.0000			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	16.666729.166754.16670.0000				0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
2003	1	5	1	0	2	22	22	34	0.0000	0.0000	2.9412
	32.352944.117614.70592.9412				2.9412	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	2.9412	32.352944.117614.70592.9412				2.9412	0.0000	0.0000	0.0000	0.0000	
2003	1	5	1	0	2	23	23	41	0.0000	0.0000	9.7561
	21.951248.780517.07320.0000				2.4390	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	9.7561	21.951248.780517.07320.0000				2.4390	0.0000	0.0000	0.0000	0.0000	
2003	1	5	1	0	2	24	24	51	0.0000	0.0000	1.9608
	19.607847.058829.41180.0000				1.9608	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	1.9608	19.607847.058829.41180.0000				1.9608	0.0000	0.0000	0.0000	0.0000	
2003	1	5	1	0	2	25	25	57	0.0000	0.0000	1.7544
	14.035138.596533.33337.0175				5.2632	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	1.7544	14.035138.596533.33337.0175				5.2632	0.0000	0.0000	0.0000	0.0000	
2003	1	5	1	0	2	26	26	54	0.0000	0.0000	0.0000
	9.2593	27.777829.629614.814812.96301.8519					3.7037	0.0000	0.0000	0.0000	0.0000
	0.0000	9.2593	27.777829.629614.814812.96301.8519					3.7037	0.0000	0.0000	
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	4.8780	9.7561	21.951243.902414.63414.8780				0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	4.8780	9.7561	21.951243.902414.63414.8780				0.0000	0.0000	0.0000	
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	0.0000	15.625015.625012.500031.250015.62506.2500					3.1250	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	15.625015.625012.500031.250015.62506.2500					3.1250	0.0000		
2003	1	5	1	0	2	29	29	35	0.0000	0.0000	0.0000
	0.0000	11.428617.142920.000025.714317.14298.5714					0.0000	0.0000	0.0000	0.0000	
	0.0000	0.0000	11.428617.142920.000025.714317.14298.5714					0.0000	0.0000		
2003	1	5	1	0	2	30	30	27	0.0000	0.0000	0.0000
	0.0000	0.0000	14.814814.814848.148111.111111.11110.0000					0.0000	0.0000	0.0000	
	0.0000	0.0000	0.0000	14.814814.814848.148111.111111.11110.0000					0.0000		
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	0.0000	0.0000	0.0000	8.3333	25.000025.000041.66670.0000				0.0000	0.0000	
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	0.0000	0.0000	0.0000	25.000025.000025.00000.0000				25.00000.0000		0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	25.000025.000025.00000.0000				25.00000.0000		
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	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	100.0000		0.0000	0.0000
	0.0000										
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	100.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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0.0000 0.0000
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2006 1 5 1 0 2 31 31 2 0.0000 0.0000 0.0000
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2007 1 5 1 0 2 14 14 12 0.0000 8.3333 41.6667
25.000025.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 8.3333
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2007 1 5 1 0 2 15 15 8 0.0000 0.0000 0.0000
75.000012.500012.50000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2007 1 5 1 0 2 16 16 12 0.0000 0.0000 33.3333
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2007 1 5 1 0 2 17 17 12 0.0000 0.0000 33.3333
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2007 1 5 1 0 2 20 20 40 0.0000 0.0000 15.0000
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2007 1 5 1 0 2 22 22 57 0.0000 0.0000 7.0175
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2007 1 5 1 0 2 24 24 44 0.0000 0.0000 0.0000
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2007 1 5 1 0 2 25 25 47 0.0000 0.0000 0.0000
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2007 1 5 1 0 2 31 31 5 0.0000 0.0000 0.0000
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2008 1 5 1 0 2 14 14 7 0.0000 28.571457.1429
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2008 1 5 1 0 2 16 16 9 0.0000 33.333333.3333
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2008 1 5 1 0 2 17 17 18 0.0000 5.5556 44.4444
44.44445.5556 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 5.5556
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2008 1 5 1 0 2 18 18 20 0.0000 5.0000 20.0000
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2008 1 5 1 0 2 19 19 30 0.0000 0.0000 30.0000
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2008 1 5 1 0 2 24 24 50 0.0000 0.0000 2.0000
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2008 1 5 1 0 2 25 25 63 0.0000 0.0000 0.0000
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2008 1 5 1 0 2 26 26 32 0.0000 0.0000 0.0000
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2008 1 5 1 0 2 27 27 38 0.0000 0.0000 0.0000
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2008 1 5 1 0 2 28 28 22 0.0000 0.0000 0.0000
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2008 1 5 1 0 2 31 31 6 0.0000 0.0000 0.0000
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2010 1 5 1 0 2 14 14 4 0.0000 75.000025.0000
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2010 1 5 1 0 2 15 15 5 0.0000 60.000040.0000
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2010 1 5 1 0 2 16 16 26 0.0000 38.461546.1538
15.38460.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 38.4615
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2010 1 5 1 0 2 17 17 28 0.0000 14.285778.5714
7.1429 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 14.2857
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2010 1 5 1 0 2 18 18 32 0.0000 21.875062.5000
12.50003.1250 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 21.8750
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2010 1 5 1 0 2 19 19 52 0.0000 0.0000 51.9231
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2010 1 5 1 0 2 20 20 54 0.0000 1.8519 40.7407
31.481518.51855.5556 0.0000 1.8519 0.0000 0.0000 0.0000 0.0000 0.0000 1.8519
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2010 1 5 1 0 2 21 21 55 0.0000 0.0000 20.0000
36.363625.45459.0909 7.2727 1.8182 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2010 1 5 1 0 2 22 22 56 0.0000 0.0000 1.7857
32.142933.928617.857110.71433.5714 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2010 1 5 1 0 2 23 23 56 0.0000 0.0000 0.0000
28.571432.142912.500019.64293.5714 3.5714 0.0000 0.0000 0.0000 0.0000 0.0000
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2010 1 5 1 0 2 24 24 59 0.0000 0.0000 1.6949
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2010 1 5 1 0 2 25 25 62 0.0000 0.0000 1.6129
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2010 1 5 1 0 2 26 26 46 0.0000 0.0000 2.1739
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2010 1 5 1 0 2 27 27 45 0.0000 0.0000 0.0000
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2010 1 5 1 0 2 30 30 10 0.0000 0.0000 0.0000
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2010 1 5 1 0 2 31 31 1 0.0000 0.0000 0.0000
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2010 1 5 1 0 2 33 33 1 0.0000 0.0000 0.0000
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2011 1 5 1 0 2 14 14 6 0.0000 66.666733.3333
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2011 1 5 1 0 2 15 15 10 0.0000 20.000080.0000
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2011 1 5 1 0 2 18 18 10 0.0000 10.000070.0000
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2011 1 5 1 0 2 19 19 14 0.0000 7.1429 71.4286
21.42860.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 7.1429
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2011 1 5 1 0 2 20 20 21 0.0000 4.7619 42.8571
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2011 1 5 1 0 2 21 21 38 0.0000 0.0000 28.9474
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2011 1 5 1 0 2 22 22 42 0.0000 0.0000 14.2857
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33.333333.333320.00002.2222 2.2222 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2011 1 5 1 0 2 27 27 46 0.0000 0.0000 0.0000
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2012 1 5 1 0 2 14 14 8 0.0000 12.500087.5000
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2012 1 5 1 0 2 15 15 12 0.0000 0.0000 91.6667
8.3333 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
91.66678.3333 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 1 0 2 16 16 14 0.0000 0.0000 85.7143
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85.714314.28570.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 1 0 2 17 17 23 0.0000 4.3478 82.6087
13.04350.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 4.3478
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2012 1 5 1 0 2 18 18 10 0.0000 0.0000 70.0000
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2012 1 5 1 0 2 19 19 38 0.0000 0.0000 36.8421
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2012 1 5 1 0 2 20 20 34 0.0000 0.0000 29.4118
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38.461521.153817.307713.46150.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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22.222233.333336.11115.5556 2.7778 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2003 1 5 2 0 2 15 15 9 0.0000 0.0000 44.4444
55.55560.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2003 1 5 2 0 2 16 16 12 0.0000 16.666766.6667
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2003 1 5 2 0 2 17 17 21 0.0000 0.0000 66.6667
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2003 1 5 2 0 2 18 18 19 0.0000 0.0000 21.0526
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15.000055.000025.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2003 1 5 2 0 2 22 22 19 0.0000 0.0000 5.2632
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2003 1 5 2 0 2 25 25 34 0.0000 0.0000 0.0000
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2003 1 5 2 0 2 26 26 13 0.0000 0.0000 0.0000
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2003 1 5 2 0 2 28 28 1 0.0000 0.0000 0.0000
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2004 1 5 2 0 2 12 12 8 0.0000 12.500062.5000
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2004 1 5 2 0 2 13 13 6 0.0000 50.000050.0000
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2004 1 5 2 0 2 14 14 6 0.0000 50.000016.6667
33.33330.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 50.0000
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2004 1 5 2 0 2 15 15 17 0.0000 0.0000 41.1765
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2004 1 5 2 0 2 16 16 29 0.0000 3.4483 37.9310
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2004 1 5 2 0 2 17 17 29 0.0000 0.0000 27.5862
44.827624.13793.4483 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2004 1 5 2 0 2 18 18 42 0.0000 2.3810 16.6667
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2004 1 5 2 0 2 19 19 38 0.0000 2.6316 7.8947
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2004 1 5 2 0 2 20 20 41 0.0000 0.0000 7.3171
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2004 1 5 2 0 2 21 21 46 0.0000 0.0000 0.0000
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2004 1 5 2 0 2 22 22 52 0.0000 0.0000 1.9231
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2004 1 5 2 0 2 23 23 46 0.0000 0.0000 0.0000
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2004 1 5 2 0 2 24 24 27 0.0000 0.0000 0.0000
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2005 1 5 2 0 2 10 10 5 40.000060.00000.0000
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2005 1 5 2 0 2 11 11 6 0.0000 66.666733.3333
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2005 1 5 2 0 2 12 12 4 0.0000 75.000025.0000
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2005 1 5 2 0 2 13 13 7 14.285714.285771.4286
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2005 1 5 2 0 2 15 15 14 0.0000 14.285735.7143
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2005 1 5 2 0 2 16 16 16 0.0000 6.2500 18.7500
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2005 1 5 2 0 2 19 19 39 0.0000 0.0000 7.6923
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2006 1 5 2 0 2 16 16 10 0.0000 20.000030.0000
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2006 1 5 2 0 2 17 17 16 0.0000 12.500031.2500
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31.250018.750018.750018.75000.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2006 1 5 2 0 2 18 18 21 0.0000 4.7619 33.3333
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2006 1 5 2 0 2 19 19 25 0.0000 4.0000 12.0000
24.00008.0000 48.00004.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 4.0000
12.000024.00008.0000 48.00004.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2006 1 5 2 0 2 20 20 30 0.0000 0.0000 6.6667
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2007 1 5 2 0 2 16 16 11 0.0000 0.0000 63.6364
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2007 1 5 2 0 2 18 18 21 0.0000 0.0000 19.0476
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38.095214.285714.28579.5238 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2007 1 5 2 0 2 20 20 20 0.0000 0.0000 0.0000
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2008 1 5 2 0 2 12 12 3 0.0000 66.666733.3333
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2008 1 5 2 0 2 15 15 9 0.0000 11.111155.5556
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2008 1 5 2 0 2 16 16 13 0.0000 15.384653.8462
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2008 1 5 2 0 2 17 17 17 0.0000 5.8824 47.0588
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2008 1 5 2 0 2 19 19 31 0.0000 0.0000 25.8065
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2008 1 5 2 0 2 20 20 40 0.0000 0.0000 10.0000
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2008 1 5 2 0 2 26 26 6 0.0000 0.0000 0.0000
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2010 1 5 2 0 2 15 15 13 0.0000 30.769261.5385
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2010 1 5 2 0 2 16 16 23 0.0000 17.391369.5652
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2010 1 5 2 0 2 18 18 46 0.0000 2.1739 43.4783
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2010 1 5 2 0 2 19 19 47 0.0000 2.1277 27.6596
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2010 1 5 2 0 2 20 20 46 0.0000 0.0000 2.1739
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2011 1 5 2 0 2 18 18 22 0.0000 0.0000 45.4545
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0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 100.0000
0.0000
2011 1 5 2 0 2 31 31 1 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 100.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 100.0000 0.0000
0.0000
2012 1 5 2 0 2 11 11 1 0.0000 100.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
100.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000
2012 1 5 2 0 2 12 12 1 0.0000 100.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000

100.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000
2012 1 5 2 0 2 13 13 2 0.0000 50.000050.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 50.0000
50.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 14 14 6 0.0000 33.333366.6667
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 33.3333
66.66670.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 15 15 11 0.0000 0.0000
100.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 100.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000
2012 1 5 2 0 2 16 16 14 0.0000 0.0000 85.7143
14.28570.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
85.714314.28570.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 17 17 16 0.0000 0.0000 56.2500
31.25006.2500 6.2500 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
56.250031.25006.2500 6.2500 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 18 18 21 0.0000 0.0000 42.8571
42.85719.5238 0.0000 4.7619 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
42.857142.85719.5238 0.0000 4.7619 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 19 19 27 0.0000 0.0000 22.2222
48.148111.111114.81483.7037 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
22.222248.148111.111114.81483.7037 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 20 20 31 0.0000 0.0000 12.9032
41.935519.354825.80650.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
12.903241.935519.354825.80650.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 21 21 51 0.0000 0.0000 9.8039
15.686327.451027.451011.76477.8431 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
9.8039 15.686327.451027.451011.76477.8431 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 22 22 28 0.0000 0.0000 0.0000
0.0000 35.714335.714317.85717.1429 0.0000 3.5714 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 35.714335.714317.85717.1429 0.0000 3.5714 0.0000 0.0000
2012 1 5 2 0 2 23 23 27 0.0000 0.0000 0.0000
7.4074 11.111129.629629.629618.51850.0000 0.0000 3.7037 0.0000 0.0000 0.0000
0.0000 7.4074 11.111129.629629.629618.51850.0000 0.0000 3.7037 0.0000
2012 1 5 2 0 2 24 24 14 0.0000 0.0000 0.0000
0.0000 7.1429 35.71437.1429 50.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 7.1429 35.71437.1429 50.00000.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 25 25 18 0.0000 0.0000 0.0000
0.0000 11.111133.333322.222222.22225.5556 5.5556 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 11.111133.333322.222222.22225.5556 5.5556 0.0000 0.0000
2012 1 5 2 0 2 26 26 4 0.0000 0.0000 0.0000
0.0000 0.0000 50.00000.0000 25.000025.00000.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 50.00000.0000 25.000025.00000.0000 0.0000 0.0000
2012 1 5 2 0 2 28 28 1 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 100.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 100.0000 0.0000 0.0000
0.0000
2012 1 5 2 0 2 8 8 1 0.0000 100.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000

100.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000

#
MEAN SIZE-AT-AGE

-1 #_number of size-at-age observations; negative value excludes from likelihood
ENVIRONMENTAL DATA
----
0 #_number of environmental variables
0 #_number of environmental observations
0 # no wtfreq data
0 # no tag data
0 # no morphcomp data

#
999 #_end of data file

Appendix D.2. Control File (SDB1.ctl)

#C 2013_Pacific_Sanddab_Stock_Assessment_Xi_He__NMFS_SWFSC__Santa_Cruz_CA
#SS-V3.24O-opt-win64;_04/10/2013;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_11.1
1 #_N_Growth_Patterns
1 #_N_submorphs
1 #_Nblock_Designs
1 #_blocks_per_pattern
2011 2012 # begin and end years of first blocks

0.5 #_fracfemale
0 #_natM_type:_0=1Parm; 1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=agespec_withseasinterpolate

1 # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=not implemented; 4=not implemented
0 #_Growth_Age-at-L1 (Amin)
11 #_Growth_Age-at-L2 (Amax)
0 #_SD_add_to_LAA (set equal to 0.1 to mimic SS2 v1.xx)
0 #_CV_Growth_Pattern (0: CV=f(LAA) 1: CV=f(A) 2: SD=f(LAA) 3: SD=f(A))

1 #_maturity_option: 1=length logistic; 2=age logistic; 3=read age-maturity matrix by growth_pattern; 4=read age-fecundity; 5=read fec and wt from wtatage.ss
1 #_First_Mature_Age
1 #_fecundity option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b
0 #_hermaphroditism option: 0=none; 1=age-specific fxn
1 #_parameter_offset_approach (1=none, 2= M, G, CV_G as offset from female-GP1, 3=like SS2 V1.x)
1 #_env/block/dev_adjust_method (1=standard; 2=logistic transform keeps in base parm bounds; 3=standard w/ no bound check)

mortality & growth_parms - pop=1 sex=1
LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn

0.01 2 0.458827 -1.136 3 0.36 1 0 0 0 0 0.5 0 0 # NatM_p_1_Fem_GP_1
2 20 4.23068 4 -1 99 2 0 0 0 0 0.5 0 0 # L_at_Amin_Fem_GP_1
10 40 30.3297 29.13 -1 99 2 0 0 0 0 0.5 0 0 # L_at_Amax_Fem_GP_1
0.01 0.5 0.169119 0.1645 -1 99 2 0 0 0 0 0.5 0 0 # VonBert_K_Fem_GP_1
0.02 0.35 0.299078 0.21 -1 99 3 0 0 0 0 0.5 0 0 # CV_young_Fem_GP_1
0.02 0.35 0.0415139 0.04 -1 99 3 0 0 0 0 0.5 0 0 # CV_old_Fem_GP_1

0.01 2 0.566423 -0.9848 3 0.3598 1 0 0 0 0 0.5 0 0 # NatM_p_1_Mal_GP_1
2 20 4.65669 4 -1 99 2 0 0 0 0 0.5 0 0 # L_at_Amin_Mal_GP_1
10 40 26.4735 27.24 -1 99 2 0 0 0 0 0.5 0 0 # L_at_Amax_Mal_GP_1
0.01 0.5 0.211796 0.1126 -1 99 2 0 0 0 0 0.5 0 0 # VonBert_K_Mal_GP_1
0.02 0.35 0.249627 0.17 -1 99 3 0 0 0 0 0.5 0 0 # CV_young_Mal_GP_1
0.02 0.35 0.0563119 0.05 -1 99 3 0 0 0 0 0.5 0 0 # CV_old_Mal_GP_1

#_wt-len, maturity, and [eggs/kg]=a+b*weight
Note: in SS3: length in cm and weight in Kg
LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn
-3.00 3.00 0.000005117 0.000005117 -1 99 -1 0 0 0 0 0.5 0 0 #_wt-len-intercept female
0.00 5.00 3.21400000 3.21400000 -1 99 -1 0 0 0 0 0.5 0 0 #_wt-len-exponent female
5.00 35.00 12.81910000 12.81910000 -1 99 -1 0 0 0 0 0.5 0 0 #_Maturity: Length-inflection (use new data from Lyndsey 5/17/2013 Aug-Nov only)
-9.00 1.00 -5.10500000 -5.10500000 -1 99 -1 0 0 0 0 0.5 0 0 #_Maturity: Slope; negative value required (use new data from Lyndsey 5/17/2013 Aug-Nov only)
5.00 35.00 13.58040000 13.58040000 -1 99 -1 0 0 0 0 0.5 0 0 #_Maturity: Length-inflection (All data from Lyndsey all months most in Aug-Nov)
-3.00 3.00 -0.83020000 -0.83020000 -1 99 -1 0 0 0 0 0.5 0 0 #_Maturity: Slope; negative value required (All data from Lyndsey all months most in Aug-Nov)
10.00 35.00 19.06242000 7.00000000 -1 99 -1 0 0 0 0 0.5 0 0 #_Maturity: Length-inflection (use Arora 1951 data from Aug only)
-3.00 3.00 -1.89509000 -1.89509000 -1 99 -1 0 0 0 0 0.5 0 0 #_Maturity: Slope; negative value required (use Arora 1951 data from Aug only)
-3.00 3.00 1.00000000 1.00000000 -1 99 -1 0 0 0 0 0.5 0 0 #_Fecundity: eggs/gm intercept
-3.00 3.00 0.00000000 0.00000000 -1 99 -1 0 0 0 0 0.5 0 0 #_Fecundity: eggs/gm slope
-3.00 3.00 0.000007419 0.000007419 -1 99 -1 0 0 0 0 0.5 0 0 #_wt-len-intercept male
0.00 5.00 3.08100000 3.08100000 -1 99 -1 0 0 0 0 0.5 0 0 #_wt-len-exponent male

recruitment apportionment
#
-2 2 1 1 -1 99 -3 0 0 0 0 0.5 0 0 #_recrdistribution_by_growth_pattern
-2 2 1 1 -1 99 -3 0 0 0 0 0.5 0 0 #_recrdistribution_by_area 1
-2 2 1 1 -1 99 -3 0 0 0 0 0.5 0 0 #_recrdistribution_by_season 1
-2 2 1 1 -1 99 -3 0 0 0 0 0.5 0 0 #_cohort_growth_deviation

#
#_Cond 0 #custom_MG-env_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no MG-environ parameters
#
#_Cond 0 #custom_MG-block_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no MG-block parameters
#_Cond No MG parm trends
#

#_seasonal_effects_on_biology_parms
0 0 0 0 0 0 0 0 0 0 #_femwtlen1,femwtlen2,mat1,mat2,fec1,fec2,Malewtlen1,malewtlen2,L1,K

#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no seasonal MG parameters
#
#_Cond -4 #_MGparm_Dev_Phase

#_Spawner-Recruitment
3 #_SR_function: 2=Ricker; 3=std_B-H; 4=SCAA; 5=Hockey; 6=B-H_flattop; 7=survival_3Parm
#_LO HI INIT PRIOR PR_type SD PHASE
0.1 20 11.24 11.24 -1 99 1 # SR_LN(R0)
0.2 1 0.75 0.8 0 0.09 2 # SR_BH_steep
0 1.5 0.450.45 -1 99 -1 # SR_sigmaR
-5 5 0 0 -1 99 -3 # SR_envlink
-5 5 0 0 -1 99 -4 # SR_R1_offset
0 0.5 0 0 -1 99 -2 # SR_autocorr
0 #_SR_env_link
0 #_SR_env_target_0=none;1=devs;_2=R0;_3=steepness

1 #do_recdev: 0=none; 1=devvector; 2=simple deviations
1976 # first year of main recr_devs; early devs can preceed this era
2011 # last year of main recr_devs; forecast devs start in following year
3 #_recdev phase

1 # (0/1) to read 13 advanced options
-10 #_recdev_early_start (0=none; neg value makes relative to recdev_start)
4 #_recdev_early_phase
0 #_forecast_recruitment phase (incl. late recr) (0 value resets to maxphase+1)
1 #_lambda for Fcast_recr_like occurring before endyr+1
#1970.1 #_last_early_yr_nobias_adj_in_MPD
1970.1 #_last_early_yr_nobias_adj_in_MPD
2002.0 #_first_yr_fullbias_adj_in_MPD
2009.7 #_last_yr_fullbias_adj_in_MPD
2012.1 #_first_recent_yr_nobias_adj_in_MPD
0.9080 #_max_bias_adj_in_MPD (-1 to override ramp and set biasadj=1.0 for all estimated recdevs)
0 #_period of cycles in recruitment (N parms read below)
-3 #min rec_dev
3 #max rec_dev
0 #_read_recdevs
#_end of advanced SR options
#

#Fishing Mortality info

0.05 # F ballpark for tuning early phases
1982 # F ballpark year
3 # F_Method: 1=Pope; 2=instan. F; 3=hybrid (hybrid is recommended)
2.9 # max F or harvest rate, depends on F_Method
no additional F input needed for Fmethod 1
read overall start F value; overall phase; N detailed inputs to read for Fmethod 2
read N iterations for tuning for Fmethod 3 (recommend 3 to 7)
if FMethod=2 (instan.), active next line
0.1 4 0 # overall start F value; overall phase; N detailed inputs to read

Number of tuning iterations in hybrid F: 4 or 5 may be good - check how catches data match estimated catches
if FMethod=3 (hybrid), active next line: phase for FMothod=3
4 #_Phase for FMethod=3

#_initial_F_parms
#LO HI INIT PRIOR PR_type SD PHASE
 0 0.5 0 0 -1 99 -2 # InitF_1CA
 0 0.5 0 0 -1 99 -2 # InitF_2ORWA
 0 0.5 0 0 -1 99 -2 # InitF_3Rec
 0 0.5 0 0 -1 99 -2 # InitF_4Mink

Q_setup details: for columns A, B, C, D
A = do power: 0=skip, index is proportional to abundance, 1= add an extra parameter for non-linearity
B = envir links: 0=skip, 1= add parameter for envior effect on Q
C = extra SD: 0=skip, 1= add additional parameter for additive constant to input SE (in ln space)
D = Q type: <0=mirror lower abs(#) fleet, 0=no par Q is median unbiased, 1=no par Q is mean unbiased, 2=estimate par for ln(Q)
3 = ln(Q) + set of devs about ln(Q) for all years. 4=ln(Q) + set of devs about Q for indexyr-1

D definition in SS3 (devtype): <0=mirror, 0=float_nobiasadj, 1=float_biasadj, 2=parm_nobiasadj, 3=parm_w_random_dev, 4=parm_w_randwalk, 5=mean_unbiased_float_assign_to_parm
#_for_env-var:_enter_index_of_the_env-var_to_be_linked

Q settings
#A B C D -> No Q and with extra SD
 0 0 0 0 # 1 CA
 0 0 0 0 # 2 ORWA
 0 0 1 0 # 3 Rec
 0 0 0 0 # 4 Mink
 0 0 0 0 # 5 NWFSC
 0 0 1 0 # 6 TriEarlyYr
 0 0 1 0 # 7 TriLateYr

#1 #_Cond 0 #_If q has random component, then 0=read one parm for each fleet with random q; 1=read a parm for each year of index

Parameter settings for extra SD for fishery and/or surveys (if any)
activate next lines if extra SDs are to be estimated
#LO HI INIT PRIOR PR_Type SD PHASE
0.001 2 0.241555 0.421 -1 99 1 #
Q_extraSD_3_Rec
0.001 2 0.432606 0.432 -1 99 2 #
Q_extraSD_6_TriEarlyYr
0.001 2 0.0935646 0.093 -1 99 2 #
Q_extraSD_7_TriLateYr

#_size_selex_types
Patter 24 (double normal): 6 parameters:
P1= PEAK: begging size for the plateau (in cm)
P2= TOP: width of platuean, as logistice between PEAK and MAXLEN
P3= ASC_WIDTH: parameter value is ln(width)
P4= DESC_WDITH: parameter value is in(width)
P5= INIT: selectivity at first bin, as logistic between 0 and 1
P6= FINAL: select as last bin, as logistic between 0 and 1
if P5=-999: ignore the initial selectivity algorithm and simple decay the small fish selectivity according to P3
if P6=-999: ignore the final selectivity algorithm and simply decay the large fish selectivity according to P4

Discard_options:_0=none;_1=define_retention;_2=retention&mortality;_3=all_discarded_dead

Male offset: New gender offset selectivity with 5 parameters:
Male offset P1: added to the first selectivity parm (peak)
Male offset P2: added to the third seleectivity parm (width of ascending side); then exp(this sum) per previous transform
Male offset P3: added to the fourth selectivity parm (width of descending side); then exp(sum) per previous transform
Male offset P4: added to the sixth selectivity parm (selectivity at final size bin); then 1/(1+exp(-sum)) per previous transform
Male offset P5: is the apical selectivity for males
Note: Only P1 and P2 are estimated in most cases

#_Pattern Discard Male Special
24 1 3 0 # 1 CA
24 1 3 0 # 2 ORWA
24 2 0 0 # 3 Rec
5 0 0 1 # 4 Mink
24 0 3 0 # 5 NWFSC
24 0 3 0 # 6 TriEarlyYr
24 0 3 0 # 7 TriLateYr

#_age_selex_types
Age selectivity = Type 10 (selectivity=0 for age 0 and =1 for all other ages): no parameter needed
Age selectivity = Type 11 (selectivity=1 for all ages): Additional parameter settings needed (see end of sel para settings)

#_Pattern ___ Male Special

Type 11
11 0 0 0 # 1 CA
11 0 0 0 # 2 ORWA
11 0 0 0 # 3 Rec
11 0 0 0 # 4 Mink
11 0 0 0 # 5 NWFSC
11 0 0 0 # 6 TriEarlyYr
11 0 0 0 # 7 TriLateYr

#_length_sel
#LO HI INIT PRIOR PR_type SD PHASE enVar
use_dev dvMiYr dvMxYr dvStd Block Block_Fxn

10 34.5 34.2554 30 -1 3 5 0 0 0 0 0.5 0 0 # SizeSel_1P_1_CA
-5 3 3 0.7 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_1P_2_CA
-4 12 3.98291 3.42 -1 3 5 0 0 0 0 0.5 0 0 # SizeSel_1P_3_CA
-2 6 6 6 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_1P_4_CA
-15 8 -999 -7 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_1P_5_CA
-5 5 -999 0.15 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_1P_6_CA

3 34.5 24.4278 15 -1 9 5 0 0 0 0 0.5 1 1 # Retain_1P_1_CA
0.1 10 1.29104 3 -1 9 5 0 0 0 0 0.5 1 1 # Retain_1P_2_CA
0.001 1 0.985702 1 -1 9 5 0 0 0 0 0.5 1 1 # Retain_1P_3_CA
-10 10 0 0 -1 9 -2 0 0 0 0 0.5 0 0 # Retain_1P_4_CA

-15 15 -2.47815 0 -1 5 5 0 0 0 0 0.5 0 0 # SzSel_1Male_Peak_CA
-15 15 0.0560898 0 -1 5 5 0 0 0 0 0.5 0 0 # SzSel_1Male_Ascend_CA
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_1Male_Descend_CA
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_1Male_Final_CA
-15 15 1 1 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_1Male_Scale_CA

10 34.5 34.4975 20 -1 5 5 0 0 0 0 0.5 0 0 # SizeSel_2P_1_ORWA
-5 3 3 0.7 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_2P_2_ORWA
-8 12 3.67526 3.42 -1 5 5 0 0 0 0 0.5 0 0 # SizeSel_2P_3_ORWA
-2 6 6 6 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_2P_4_ORWA
-15 8 -999 -7 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_2P_5_ORWA
-5 5 -999 0.15 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_2P_6_ORWA

3 34.5 26.0907 15 -1 9 5 0 0 0 0 0.5 1 1 # Retain_2P_1_ORWA
0.1 10 1.20642 3 -1 9 5 0 0 0 0 0.5 1 1 # Retain_2P_2_ORWA
0.001 1 0.886272 1 -1 9 5 0 0 0 0 0.5 1 1 # Retain_2P_3_ORWA
-10 10 0 0 -1 9 -2 0 0 0 0 0.5 0 0 # Retain_2P_4_ORWA

-15 15 -0.0106927 0 -1 5 5 0 0 0 0 0.5 0 0 # SzSel_2Male_Peak_ORWA
-15 15 0.530417 0 -1 5 5 0 0 0 0 0.5 0 0 # SzSel_2Male_Ascend_ORWA
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_2Male_Descend_ORWA
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_2Male_Final_ORWA
-15 15 1 1 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_2Male_Scale_ORWA

10 34 29.7404 20 -1 3 5 0 0 0 0 0.5 0 0 # SizeSel_3P_1_Rec
-5 3 3 0.7 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_3P_2_Rec
-4 12 3.68577 3.42 -1 3 5 0 0 0 0 0.5 0 0 # SizeSel_3P_3_Rec
-2 6 6 6 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_3P_4_Rec
-15 8 -999 -7 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_3P_5_Rec
-5 5 -999 0.15 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_3P_6_Rec

3 34 14.0095 15 -1 9 5 0 0 0 0 0.5 0 0 # Retain_3P_1_Rec
0.1 10 3.289 3 -1 9 5 0 0 0 0 0.5 0 0 # Retain_3P_2_Rec
0.001 1 0.990329 1 -1 9 5 0 0 0 0 0.5 0 0 # Retain_3P_3_Rec
-10 10 0 0 -1 9 -2 0 0 0 0 0.5 0 0 # Retain_3P_4_Rec

3 34 3 3 -1 9 -5 0 0 0 0 0.5 0 0 # DiscMort_3P_1_Rec
1e-005 10 0.001 0.001 -1 9 -5 0 0 0 0 0.5 0 0 # DiscMort_3P_2_Rec
0.001 1 0.5 0.5 -1 9 -5 0 0 0 0 0.5 0 0 # DiscMort_3P_3_Rec
-10 10 0 0 -1 9 -2 0 0 0 0 0.5 0 0 # DiscMort_3P_4_Rec

-5 34 -1 -1 -1 99 -2 0 0 0 0 0.5 0 0 # SizeSel_4P_1_Mink
-5 34 -1 -1 -1 99 -2 0 0 0 0 0.5 0 0 # SizeSel_4P_2_Mink

10 34 28.4449 20 -1 5 6 0 0 0 0 0.5 0 0 # SizeSel_5P_1_NWFSC
-5 3 3 0.7 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_5P_2_NWFSC
-4 12 3.78482 3.42 -1 5 6 0 0 0 0 0.5 0 0 # SizeSel_5P_3_NWFSC
-2 6 6 6 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_5P_4_NWFSC
-15 8 -999 -999 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_5P_5_NWFSC
-5 5 -999 0.15 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_5P_6_NWFSC
-15 15 -3.76426 0 -1 5 6 0 0 0 0 0.5 0 0 # SzSel_5Male_Peak_NWFSC
-15 15 -0.481021 0 -1 5 6 0 0 0 0 0.5 0 0 # SzSel_5Male_Ascend_NWFSC
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_5Male_Descend_NWFSC
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_5Male_Final_NWFSC
-15 15 1 1 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_5Male_Scale_NWFSC

10 34 33.9983 20 -1 5 6 0 0 0 0 0.5 0 0 # SizeSel_6P_1_TriEarlyYr
-5 3 3 0.7 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_6P_2_TriEarlyYr
-4 12 4.31144 3.42 -1 5 6 0 0 0 0 0.5 0 0 # SizeSel_6P_3_TriEarlyYr
-2 6 6 6 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_6P_4_TriEarlyYr
-15 8 -999 -999 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_6P_5_TriEarlyYr
-5 5 -999 0.15 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_6P_6_TriEarlyYr
-15 15 -4.80543 0 -1 5 6 0 0 0 0 0.5 0 0 # SzSel_6Male_Peak_TriEarlyYr
-15 15 -0.411124 0 -1 5 6 0 0 0 0 0.5 0 0 # SzSel_6Male_Ascend_TriEarlyYr
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_6Male_Descend_TriEarlyYr
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_6Male_Final_TriEarlyYr
-15 15 1 1 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_6Male_Scale_TriEarlyYr

10 34 30.8193 20 -1 5 6 0 0 0 0 0.5 0 0 # SizeSel_7P_1_TriLateYr
-5 3 3 0.7 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_7P_2_TriLateYr
-4 12 4.39848 3.42 -1 5 6 0 0 0 0 0.5 0 0 # SizeSel_7P_3_TriLateYr
-2 6 6 6 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_7P_4_TriLateYr
-15 8 -999 -999 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_7P_5_TriLateYr
-5 5 -999 0.15 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_7P_6_TriLateYr
-15 15 -6.25803 0 -1 5 6 0 0 0 0 0.5 0 0 # SzSel_7Male_Peak_TriLateYr

-15 15 -0.811322 0 -1 5 6 0 0 0 0 0.5 0 0 # SzSel_7Male_Ascend_TriLateYr
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_7Male_Descend_TriLateYr
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_7Male_Final_TriLateYr
-15 15 1 1 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_7Male_Scale_TriLateYr

Age selectivity = Type 10 (selectivity=0 for age 0 and =1 for all other ages): no parameter needed
Age selectivity = Type 11 (selectivity=1 for all ages): following lines need to be activated

0 11 0.1 0.1 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_1P_1_CA
0 11 11 11 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_1P_2_CA
0 11 0.1 0.1 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_2P_1_ORWA
0 11 11 11 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_2P_2_ORWA
0 11 0.1 0.1 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_3P_1_Rec
0 11 11 11 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_3P_2_Rec
0 11 0.1 0.1 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_4P_1_Mink
0 11 11 11 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_4P_2_Mink
0 11 0.1 0.1 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_5P_1_NWFSC
0 11 11 11 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_5P_2_NWFSC
0 11 0.1 0.1 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_6P_1_TriEarlyYr
0 11 11 11 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_6P_2_TriEarlyYr
0 11 0.1 0.1 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_7P_1_TriLateYr
0 11 11 11 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_7P_2_TriLateYr

#_Cond 0 #_custom_sel-env_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no enviro fxns
#_Cond 0 #_custom_sel-blk_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no block usage
#_Cond No selex parm trends
#_Cond -4 # placeholder for selparm_Dev_Phase
#_Cond 0 #_env/block/dev_adjust_method (1=standard; 2=logistic trans to keep in base parm bounds; 3=standard w/ no bound check)

Comment out next three lines if no time block
1 #_custom_sel-blk_setup (0/1)

-5 5 0 0 -1 99 5 #_placeholder when no block usage
-5 5 0 0 -1 99 5 #_placeholder when no block usage
-5 5 0 0 -1 99 5 #_placeholder when no block usage
-5 5 0 0 -1 99 5 #_placeholder when no block usage
-5 5 0 0 -1 99 5 #_placeholder when no block usage
-5 5 0 0 -1 99 5 #_placeholder when no block usage

2 #_env/block/dev_adjust_method (1=standard; 2=logistic trans to keep in base parm bounds; 3=standard w/ no bound check)

Tag loss and Tag reporting parameters go next
0 # TG_custom: 0=no read; 1=read if tags exist
-6 6 1 1 2 0.01 -4 0 0 0 0 0 0 0 #_placeholder if no parameters

1 #_Variance_adjustments_to_input_values
#_This part is for iterative reweighting of the input variance factors
#_There are six rows and a value for each fleet_survey on each row
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 #_add_to_survey CV, 0 for no efffect
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 #_add_to_discard stddev
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 #_add_to_mean boday wt stddev
1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 #_Multipier for lencomp effective N (set to 1.0 for no effect)
1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 #_Multipier for agecomp effective N (set to 1.0 for no effect)
1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 #_Multipier for size-at-age effective N (set to 1.0 for no effect)

re-weight
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 #_add_to_survey CV, 0 for no efffect
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 #_add_to_discard stddev
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 #_add_to_mean boday wt stddev
1.613000 2.165000 3.125000 0.000000 1.157000 2.164000 2.767000 #_Multipier for lencomp effective N (set to 1.0 for no effect)
3.859000 1.181000 1.000000 1.000000 0.180000 1.000000 1.000000 #_Multipier for agecomp effective N (set to 1.0 for no effect)
1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 #_Multipier for size-at-age effective N (set to 1.0 for no effect)

6 #_maxlambdaphase
1 #_sd_offset

8 # number of changes to make to default Lambdas (default value is 1.0)
lambdas
Like_comp codes: 1=surv; 2=disc; 3=mnwt; 4=length; 5=age; 6=SizeFreq; 7=sizeage; 8=catch; 9=init_equ_catch;
10=recrdev; 11=parm_prior; 12=parm_dev; 13=CrashPen; 14=Morphcomp; 15=Tag-comp; 16=Tag-negbin; 17=F_ballpark

Lambdas from comp data from two fisheries (CA and OR/WA) need to be cut (double uses of samples)
Component 17 was new in new SS3 (used to be turned off automatically, now need to turn off manually) (Hicks' May 25 email)

#like_comp fleet/survey phase value sizefreq_method
4 1 1 0.500 1
4 2 1 0.500 1
5 1 1 0.500 1
5 2 1 0.500 1
17 1 1 0.000 1

17 2 1 0.000 1
17 3 1 0.000 1
17 4 1 0.000 1

0 # (0/1) read specs for more stddev reporting

999

Appendix D.3. Starter File (starter.ss)

#C 2013_Pacific_Sanddab_Stock_Assessment_Xi_He__NMFS_SWFSC__Santa_Cruz_CA
#SS-V3.24O-opt-
win64;_04/10/2013;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_11.1

SDB1.dat
SDB1.ctl

```
0	# 0=use init values in control file; 1=use ss2.par
0	# run display detail (0,1,2)
2	# detailed age-structured reports in SS2.rep (0,1,2)
0	# write detailed checkup.sso file (0,1)
1	# write parm values to ParmTrace.sso (0=no,1=good,active; 2=good,all;
3=every_iter,all_parms)
0	# write to cumreport.sso (0=no,1=like&timeseries; 2=add survey fits)
1	# Include prior_like for non-estimated parameters (0,1)
1	# Use Soft Boundaries to aid convergence (0,1) (recommended)
1	# Number of bootstrap datafiles to produce
10	# Turn off estimation for parameters entering after this phase
0	# MCMC burn interval
1	# MCMC thin interval
0.00001# jitter initial parm value by this fraction
-1	# begin annual SD report in start year
-2	# end annual SD report in end year (-2=end of annual SD report in last forecast year
0	# N individual STD years (0=none)

#vector of year values

0.001	# final convergence criteria (e.g. 1.0e-04)
0	# retrospective year relative to end year (e.g. -4)
0	# min age for calc of summary biomass
1	# Depletion basis:  denom is: 0=skip; 1=rel X*B0; 2=rel X*Bmsy; 3=rel X*B_styr
1	# Fraction (X) for Depletion denominator (e.g. 0.4)
4	# (1-SPR)_reporting:  0=skip; 1=rel(1-SPR); 2=rel(1-SPR_MSY); 3=rel(1-SPR_Btarget);
4=no denominator (report actural 1-SPR values)
1	# F_std reporting: 0=skip; 1=exploit(Bio); 2=exploit(Num); 3=sum(frates)
0	# F_report_basis: 0=raw; 1=rel Fspr; 2=rel Fmsy ; 3=rel Fbtgt

999	# check value for end of file
```

Appendix D.4. Forecast File (forecast.ss)

#C 2013_Pacific_Sanddab_Stock_Assessment_Xi_He__NMFS_SWFSC__Santa_Cruz_CA
#SS-V3.24O-opt-win64;_04/10/2013;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_11.1

Note on Btarget
Btarget should be 0.25 for flatfish, but setting it to 0.25 causes poor convergence in Fmsy (fish mature at very young)
Have to fish very hard on the selected fish to get biomass to the target - low targes are not feasible
Fmsy search fails (QNAN) - getting invalidated variance estimates for other outputs (i.e. most derivated outputs)
To get around this: set Biomass target to 0.4 or higher, then to manually set ss_output readin values: myreplist$btarg <- 0.25 myreplist$minbthresh <- 0.125

for all year entries except rebuilder; enter either: actual year, -999 for styr, 0 for endyr, neg number for rel. endyr
1 # Benchmarks: 0=skip; 1=F(SPR); 2=F(MSY);3=F(Btarget); 4=F(endyr); 5=Ave recent F (not implemented); 6= read Fmult (not implemented)
4 # MSY: 1= set to F(SPR); 2=calc F(MSY); 3=set to F(Btgt); 4=set to F(endyr)
0.3 # SPR target (e.g. 0.40), 0.5 for west coast groundfish
0.25 # Biomass target (e.g. 0.40)

#_Bmark_years: beg_bio, end_bio, beg_selex, end_selex, beg_relF, end_relF (enter actual year, or values of 0 or -integer to be rel. endyr)
0 0 0 0 0 0
2 #Bmark_relF_Basis: 1 = use year range; 2 = set relF same as forecast below

1 # Forecast: 0=none; 1=F(SPR); 2=F(MSY) 3=F(Btgt); 4=F(endyr); 5=Ave F (enter yrs); 6=read Fmult
1 # N foreast year
1 # F scaler (only used for Do_Forecast==5)
#_Fcast_years: beg_selex, end_selex, beg_relF, end_relF (enter actual year, or values of 0 or -integer to be rel. endyr)
0 0 -10 0
1 # Control rule method (1=catch=f(SSB) west coast; 2=F=f(SSB))
0.25 # Control rule Biomass level for constant F (as frac of Bzero, e.g. 0.40)
0.05 # Control rule Biomass level for no F (as frac of Bzero, e.g. 0.10)
0.75 # Control rule target as fraction of Flimit (e.g. 0.75)
3 #_N forecast loops (1-3) (fixed at 3 for now)
3 #_First forecast loop with stochastic recruitment
0 #_Forecast loop control #3 (reserved for future bells&whistles)
0 #_Forecast loop control #4 (reserved for future bells&whistles)
0 #_Forecast loop control #5 (reserved for future bells&whistles)

2013 #FirstYear for caps and allocations (should be after years with fixed inputs)
0.0 # stddev of log(realized catch/target catch) in forecast (set value>0.0 to cause active impl_error) (if=0, there will be N_forecase_years less parameters estimated)
0 # Do West Coast gfish rebuilder output (0/1)

-1 # Rebuilder: first year catch could have been set to zero (Ydecl)(-1 to set to 1999)
-1 # Rebuilder: year for current age structure (Yinit) (-1 to set to endyear+1)
1 # fleet relative F: 1=use first-last alloc year; 2=read seas(row) x fleet(col) below
Note that fleet allocation is used directly as average F if Do_Forecast=4
2 # basis for fcast catch tuning and for fcast catch caps and allocation (2=deadbio; 3=retainbio; 5=deadnum; 6=retainnum)
Conditional input if relative F choice = 2
Fleet relative F: rows are seasons, columns are fleets
max totalcatch by fleet (-1 to have no max) must enter value for each fleet
-1 -1 -1 -1
max totalcatch by area (-1 to have no max); must enter value for each fleet
-1
fleet assignment to allocation group (enter group ID# for each fleet, 0 for not included in an alloc group)
0 0 0 0
#_Conditional on >1 allocation group
allocation fraction for each of: 0 allocation groups
no allocation groups
0 # Number of forecast catch levels to input (else calc catch from forecast F)
3 # basis for input Fcast catch: 2=dead catch; 3=retained catch; 99=input Hrate(F) (units are from fleetunits; note new codes in SSV3.20)
Input fixed catch values
#Year Seas Fleet Catch(or_F)

999 # verify end of input