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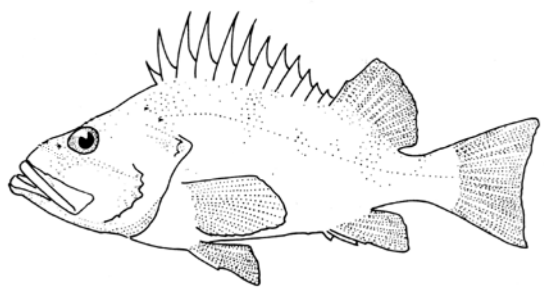
Status of cowcod, *Sebastes levis*, in the Southern California Bight



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Cowcod drawing adapted from Fish Bulletin No. 157 (CDF&G, 1972)

Executive Summary

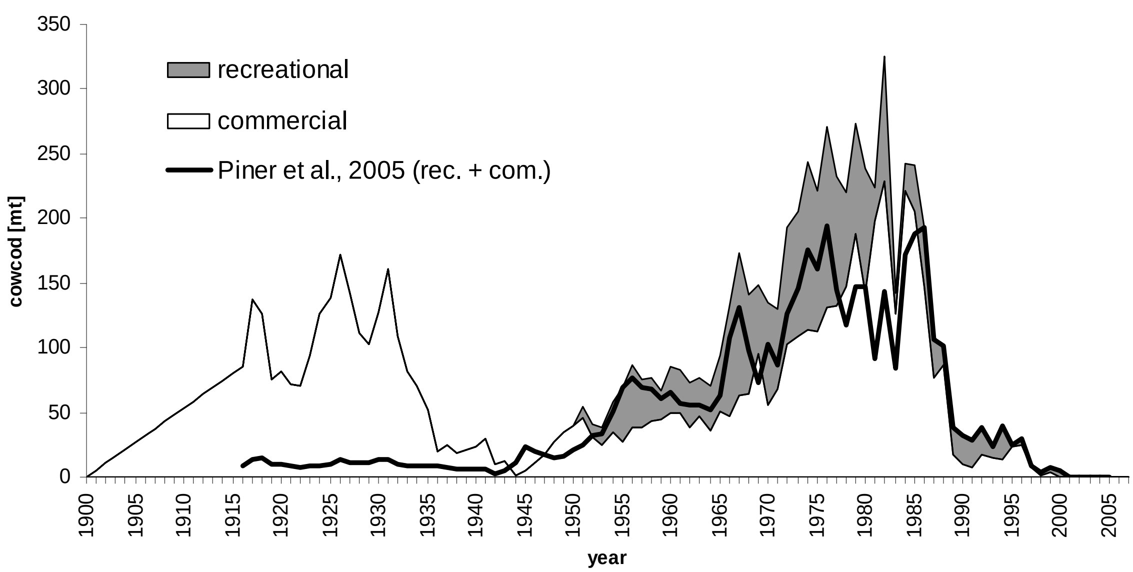
Stock: This is an assessment of *Sebastes levis* in the Southern California Bight (SCB), defined as U.S. waters off California and south of Point Conception (34°27'). Waters north and south of the SCB are not considered in this assessment due to sparse data and possible differences in abundance trends (Piner et al., 2005). The assumption of an isolated stock remains untested, and no information is available regarding dispersal across the northern or southern stock boundaries.

Catch: Retention of cowcod has been prohibited since January 2001. Recreational catches in this assessment are identical to those in the previous assessment, but estimates of commercial catches have been updated to reflect three additional data sources: 1) recovered port samples from Southern California (1983-1985), 2) regional summaries of total rockfish landings (1928-1968) provided by the NMFS SWFSC Environmental Research Division, and 3) California rockfish landings by region (1916-1927), published in CDF&G Fish Bulletin No. 105 (1958). From 2001 to the present, we assume a discard rate of 0.25 metric tons per year, per fishery (Table ES1).

Table ES1: Recent catch [metric tons] of cowcod in the Southern California Bight

Year	Commercial	Recreational	Total
1997	7.30	1.85	9.15
1998	1.21	2.81	4.03
1999	3.47	3.77	7.24
2000	0.45	4.49	4.94
2001	0.25	0.25	0.5
2002	0.25	0.25	0.5
2003	0.25	0.25	0.5
2004	0.25	0.25	0.5
2005	0.25	0.25	0.5
2006	0.25	0.25	0.5

Figure ES1: Estimated cowcod catch, 1900-2006



Data and assessment: The model is an age-structured production model, with three estimated parameters: virgin recruitment (R_0), catchability for the CPFV logbook index, and catchability for the visual survey biomass estimate. In the previous assessment (Piner et al., 2005), the selectivity curves for the combined recreational/commercial fishery and CPFV logbook index were inadvertently set equal to female fecundity. Changing the selectivity curve to mirror the female maturity schedule as originally intended causes the 2005 estimate of depletion to drop from 17.8% to 9.4%.

In this assessment, the commercial fishery (all gears combined) is modeled separately from the recreational fishery. Gear selectivity for the commercial fleet is set equal to the female maturity schedule, as was the intention of Piner et al. (2005). Cowcod length data from a CDF&G observer study are used to estimate a selectivity curve for the recreational fishery and CPFV logbook index. Changes to the historical catch data (Fig. ES1) are described in detail in the main document. The period modeled in the 2005 assessment (1916-2007) was extended (1900-2007) by assuming a linear ramp in catch from 0.1 metric tons in 1900 to the revised catch estimate for 1916.

An index derived from Commercial Passenger Fishing Vessel (CPFV) logbook data was reconstructed using a revised spatial stratification, but logbook data from 2001 to the present are excluded due to the effects of management. A revised estimate of cowcod biomass in 2002 (524 mt; Yoklavich et al., 2007) from the submersible line-transect survey is modeled as a relative abundance index with a prior probability distribution on catchability. The revised estimate and its effect on the assessment were reviewed and approved by the Science and Statistical Committee (SSC) during their November 2007 meeting. This document has been updated to reflect the change with the exception of some preliminary analyses as indicated in the main text.

The length-at-age relationship was slightly adjusted based on evidence that lengths recorded during the ageing process were total length rather than fork length. The steepness parameter (*h*) in the Beverton-Holt stock-recruitment curve was fixed at 0.6 based on a recent meta-analysis of several rockfish stocks, as opposed to 0.5 in the previous assessment. Natural mortality (M) was fixed at 0.055.

The base model was bracketed by evaluating alternative values of steepness (0.4 and 0.8), and by examining the effect of removing the CPFV logbook index. Removing the CPFV index reduces the model to a deterministic trajectory that is forced through the 2002 biomass estimate. Stock Synthesis 2 (SS2), version 2.00c was used to fit the model.

Unresolved problems and major uncertainties

The most important unresolved problem for this assessment is the lack of data to inform us about productivity of the stock and recent biomass trends. The base model fixes steepness at 0.6 based on the expectation of a prior distribution from a meta-analysis of rockfish steepness parameters. The CPFV logbook index of relative abundance ends in 2000, and no informative abundance indices are currently available to monitor recent trends. Together, these characteristics imply that conclusions regarding rebuilding success are highly uncertain. Indications of recent stock increases are inferred from the model but have not been confirmed by observations.

It is likely that the base model underestimates our uncertainty about this stock's status. Simple models such as this require stronger assumptions (e.g. fixed steepness and natural mortality, recruitments drawn from the stock-recruitment curve, catches are known without error), and estimates from the base model are unrealistically precise. To better capture our uncertainty about the stock's status, the Stock Assessment Team (STAT) identified the steepness parameter and the inclusion of the CPFV logbook index as the two dominant sources of uncertainty in the model. Other sources of uncertainty such as natural mortality, historical catch, gear selectivity, and recruitment variability are also important to consider, but are difficult to estimate with the available data. Our analyses show that estimates of both steepness (h) and the natural mortality rate (M) are highly uncertain, and both parameters are treated as fixed and known. Models without the visual survey were not considered due to unreasonably high estimates of annual exploitation rate (total catch divided by summary biomass). The exploitation rates in the base model are also quite high considering what we know about the life history characteristics of cowcod, and the STAT considers this issue an important topic for future research.

Historical commercial landings are based on a ratio estimator that tracks rockfish landings in the Southern California Bight, rather than statewide rockfish landings. The amount of cowcod in these landings is estimated using data from relevant ports and gear types, using the earliest data for which we have actual samples. However, our uncertainty in the percentage of cowcod in total rockfish landings is not well understood, and this percentage is assumed to be constant over the historical period. Sensitivity analyses for different levels of historical landings are explored.

The CPFV logbook index is a long-term time series (1963-2000) of relative abundance which shows declining catch rates over time in the SCB. It is estimated from logbook records of catch and effort that are aggregated by year, month, and CDFG block. This level of aggregation makes it difficult to determine the amount of effective effort for cowcod. Given the model assumptions, the biomass trajectory is unable to match the rate of decline exhibited by this index, i.e. a 'hyperdepletion' pattern exists.

The biomass estimate from the 2002 visual survey is expanded to represent the biomass in the entire SCB via an estimated catchability coefficient with an informative prior distribution. This data point and the CPFV survey provide conflicting information about the status of the stock in 2002. The influence of the visual survey on model results is largely determined by the assumed precision of the prior on the catchability coefficient. The STAT believes that a reasonable lower bound for the CV of the prior (20%) was derived in Appendix 4 of the previous assessment. The base model uses a CV of 50%, based on the previous assessment. Future surveys should aim for adequate spatial coverage within the SCB to avoid this issue.

Reference points: For *Sebastes*, the PFMC currently uses $F_{50\%}$ as a proxy for the fishing mortality rate that achieves maximum sustainable yield (F_{MSY}). Spawning biomass (SB) in 2007 is estimated to be between 3.4% and 16.3% of the unfished level (Table ES2). The poor precision of this estimate is due to 1) a lack of data to inform our estimates of stock productivity, and 2) conflicting information from fishery-dependent and fishery–independent data. Even the most optimistic model presented here, which assumes a high-productivity stock and ignores declines in CPFV catch rates, suggests that spawning biomass has been below 25% since 1980

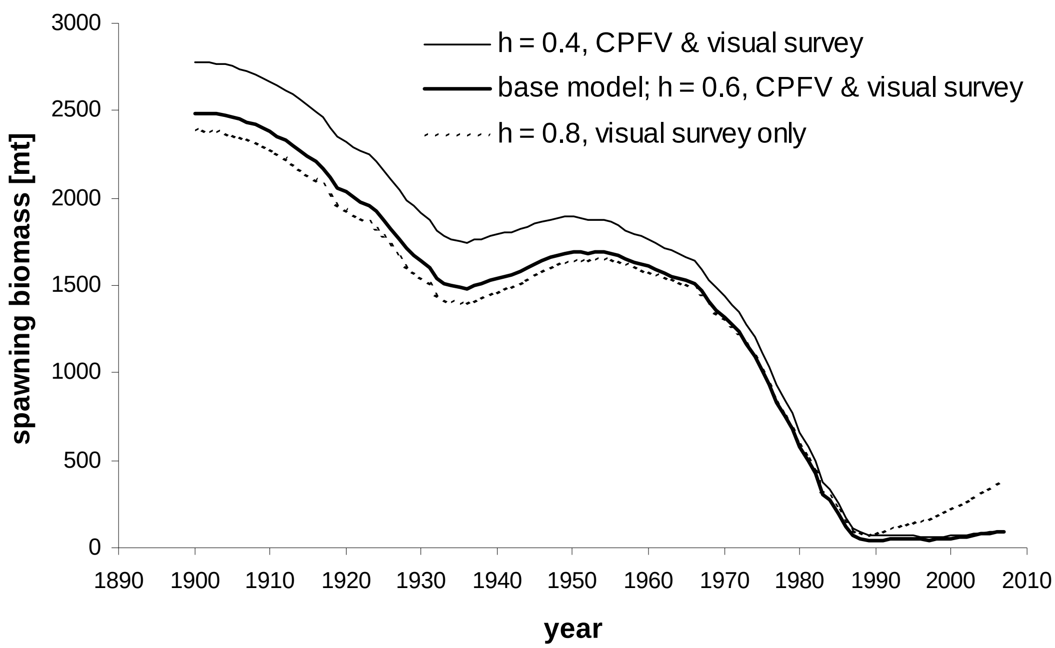
(Fig. ES2). Retention of cowcod is prohibited and bycatch is thought to be minimal, so it is unlikely that overfishing is currently an issue. In the previous assessment and a previous draft of this report, spawning biomass was reported as mature biomass of males and females. In this document spawning biomass refers to the biomass of mature females only.

Table ES2: Reference points from the base model (h = 0.6) and alternative low- and high-productivity models.

	Model Description			
	h = 0.4	h = 0.6	h = 0.8	
Reference Point	**CPFV Logbook + Visual Survey**	**CPFV Logbook + Visual Survey**	**Visual Survey**	**units**
Unfished summary (age-1+) biomass	5905	5291	5080	metric tons
Unfished female spawning biomass (SB_0)	2777	2488	2389	metric tons
Unfished recruitment (R_0)	123	110	106	1000s of fish
40% of SB_0 (proxy for SB_{MSY})	1111	995	956	metric tons
Exploitation rate at $F_{50\%}$ (proxy for F_{MSY})	2.7%	2.7%	2.7%	percent
Spawning biomass in 2007 (SB_{2007})	94	94	389	metric tons
SB_{2007} / SB_0	3.4%	3.8%	16.3%	percent

Spawning stock biomass: Estimates of female spawning stock biomass in 2007 are highly uncertain. The current models suggest that spawning biomass has declined from an unfished biomass of 2389-2777 mt to 94-389 mt in 2007 (Fig. ES2, Table ES2).

Figure ES2: Time series of spawning biomass



Relative depletion: Estimates of relative depletion in 2007 range from 3.4% to 16.3% (Fig. ES3). Indications of recent stock increases (Table ES3) are inferred from the model but have not been confirmed by observations.

Figure ES3: Time series of depletion (biomass as a percentage of unfished biomass).

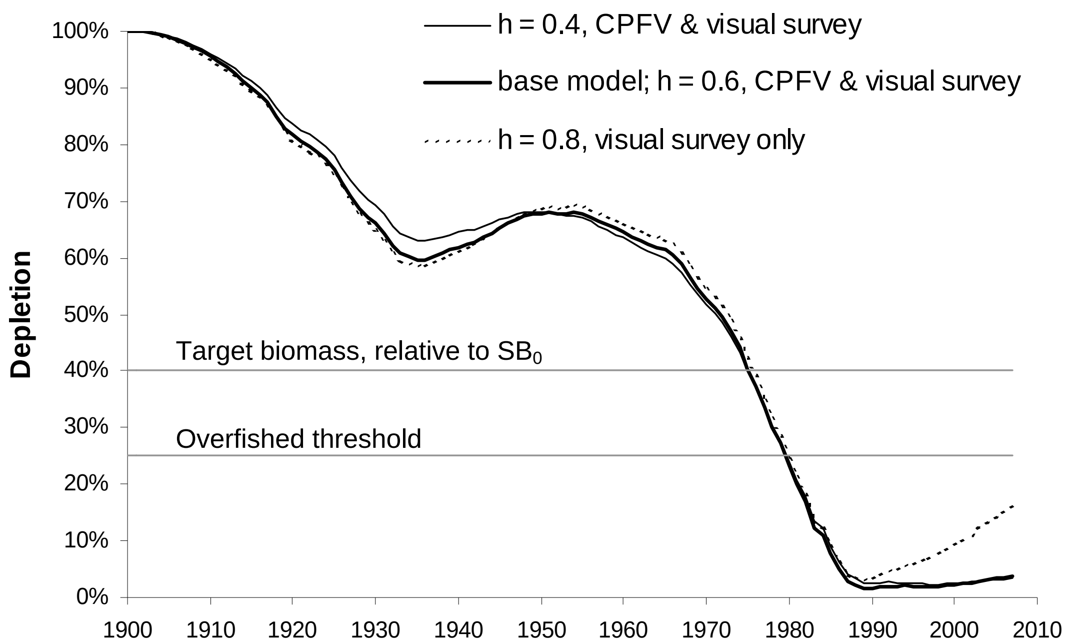


Table ES3: Recent trends in cowcod biomass and depletion

	h = 0.4, CPFV index & visual survey			h = 0.6, CPFV index & visual survey			h = 0.8, visual survey only		
year	Age 1+ biomass [mt]	SB [mt]	SB/SB_0	Age 1+ biomass [mt]	SB [mt]	SB/SB_0	Age 1+ biomass [mt]	SB [mt]	SB/SB_0
1998	150	62	2.2%	129	48	1.9%	490	184	7.7%
1999	156	66	2.4%	137	53	2.1%	533	204	8.5%
2000	159	68	2.4%	143	56	2.2%	575	223	9.3%
2001	164	71	2.5%	150	59	2.4%	620	243	10.2%
2002	172	75	2.7%	162	65	2.6%	671	265	11.1%
2003	180	79	2.8%	174	71	2.8%	724	288	12.1%
2004	188	83	3.0%	186	76	3.1%	779	312	13.1%
2005	196	87	3.1%	198	82	3.3%	835	337	14.1%
2006	203	91	3.3%	211	88	3.5%	894	363	15.2%
2007	211	94	3.4%	224	94	3.8%	954	389	16.3%

Recruitment: Predicted recruitments were taken directly from the assumed stock-recruitment relationship, estimating only virgin recruitment. The base model suggests that recruitment declined rapidly from about 1970-1990, followed by an increasing trend (Fig. ES4, Table ES4).

Figure ES4: Time series of estimated recruitment

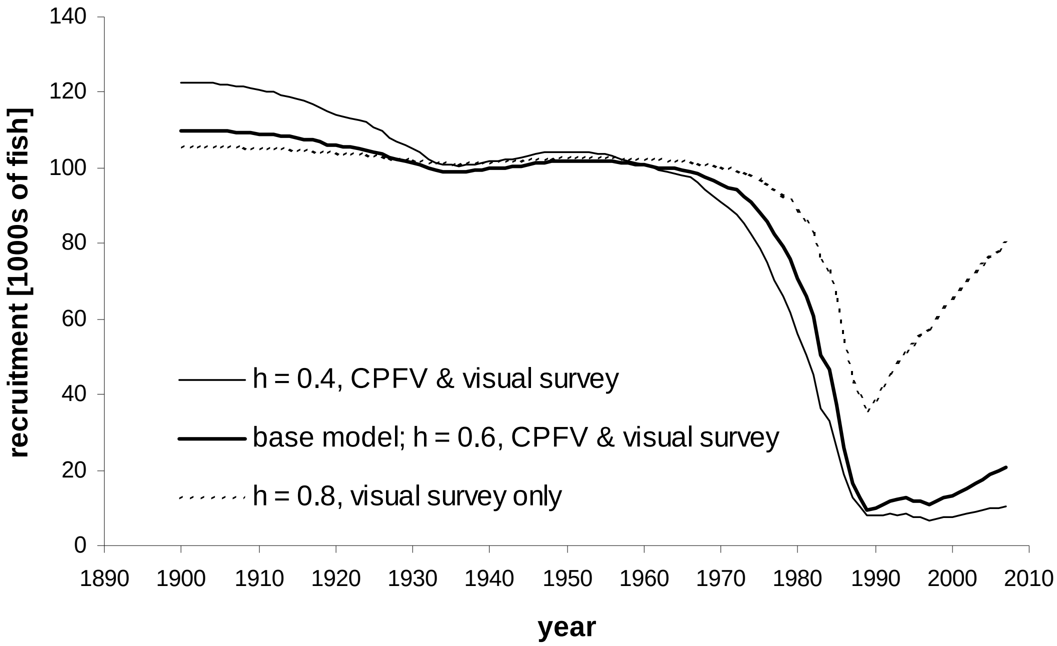


Table ES4: Estimated recruitments from the base model's stock-recruitment curve.

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Rec.	11.6	12.6	13.3	14.1	15.2	16.4	17.5	18.7	19.8	20.9

Exploitation status: The 2005 assessment combined landings from the recreational and commercial fisheries into a single fishery. The correction to the selectivity curve increased the estimates of annual exploitation rate (total catch / age 1+ biomass) after the mid-1980s (Fig. ES5). However, this comparison does not reflect changes among models in the exploitation rate at the target fishing mortality ($F_{50\%}$). A comparison of relative exploitation rates (each model's annual exploitation rates divided by its exploitation rate at target F) is a more informative comparison of exploitation histories (Fig. ES6). The higher relative exploitation rates from the 2007 base model are mainly the result of increased estimates of historical catches and catches from the mid-1980s. The current model separates the catch into a commercial fishery (all gears combined) and a recreational fishery (Fig. ES7).

Figure ES5: Estimated annual exploitation rates (total catch / age 1+ biomass) from the previous assessment, showing the effect of changing the selectivity curve to mirror the female maturity schedule rather than female fecundity.

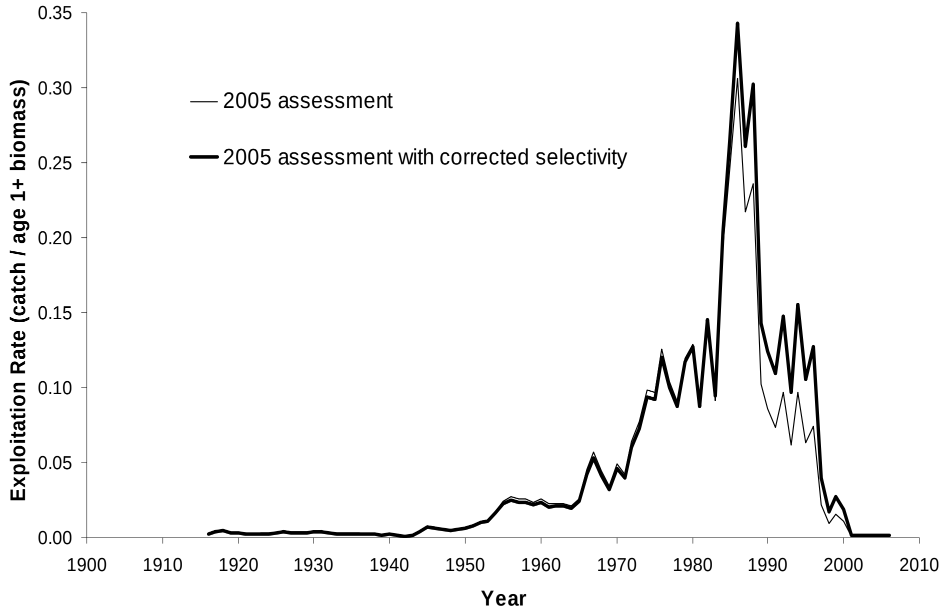


Figure ES6: Comparison of annual exploitation rates (total catch / age 1+ biomass) from the current assessment and previous models, relative to their respective exploitation rates at the target fishing mortality rate ($F_{50\%}$). A value of 1 is the relative exploitation rate at the target mortality rate ($F_{50\%}$).

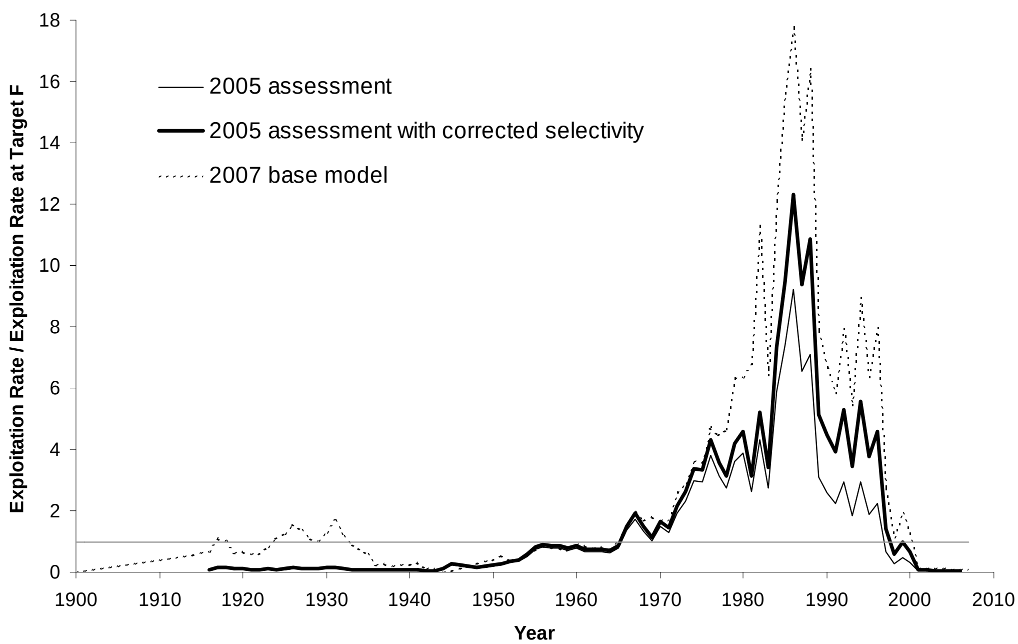


Figure ES7: Exploitation rates (catch / age 1+ biomass) by fishery for the 2007 base model.

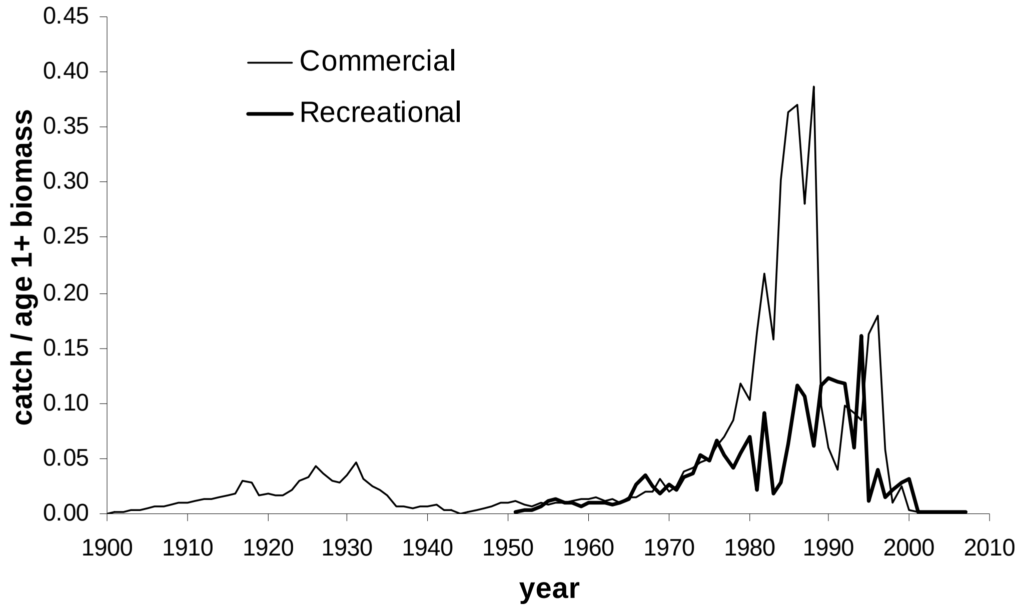


Table ES5: Recent exploitation rates (catch / age 1+ biomass) from the 2007 base model. Rates since 2001 are based on assumed catch (discard) of 0.5 mt per year.

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Expl.	0.0312	0.0527	0.0346	0.0033	0.0031	0.0029	0.0027	0.0025	0.0024	0.0022

The history of exploitation according to the base model is summarized here with two phase diagrams. Figure ES8(a) shows annual exploitation rate (catch / age 1+ biomass) relative to the exploitation rate at $F_{50\%}$, plotted against spawning biomass relative to target spawning biomass ($SB_{40\%}$). Figure ES8(b) replaces exploitation rates with spawning potential ratios (SPR), the ratio of equilibrium spawning output per recruit under fished conditions to spawning output per recruit in the virgin population.

Figure ES8(a): Phase diagram of cowcod exploitation history (relative exploitation rate)

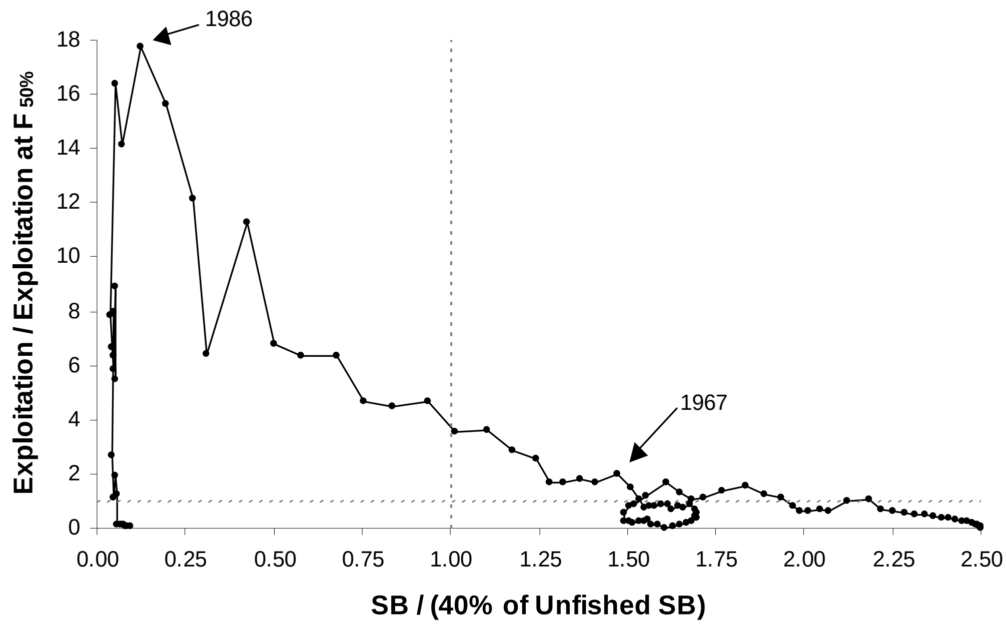
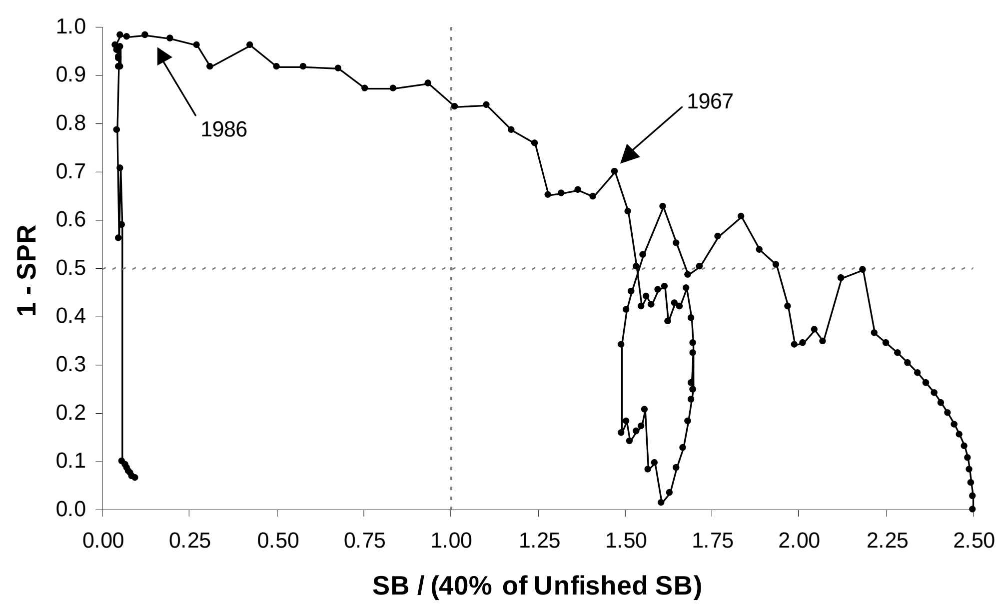


Figure ES8(b): Phase diagram of cowcod exploitation history (SPR)



Management performance: Retention of cowcod is currently prohibited. Catch statistics suggest that landings in the SCB have not exceeded the OY limits in recent years. Piner et al. (2005) and Butler et al. (1999) describe the history of management measures.

Table ES6: Recent management performance

Years	ABC [mt]	OY [mt]	Catch [mt]
2001-2004	5	2.4	< 1
2005-2006	5	2.1	< 1

Forecasts / Rebuilding Projections: These are presented as part of a separate rebuilding analysis.

Decision table: Three alternative states of nature were defined during the Stock Assessment Review (STAR) panel, bracketing values of the Beverton-Holt steepness parameter and considering models with and without the CPFV logbook index (Table ES7). Projected catches are divided equally between the commercial and recreational fisheries, based on relative catches in each fishery during the period 1990-1999.

Table ES7: Spawning biomass and depletion (% Virgin) trajectories for alternative management actions and states of nature.

		Landings [mt]		Low Productivity Stock Steepness (h) = 0.4 Visual survey and CPFV logbook index		Base Model Steepness (h) = 0.6 Visual survey and CPFV logbook index		High Productivity Stock Steepness (h) = 0.8 Visual Survey only	
Management Action	**Year**	**Comm.**	**Rec.**	**Sp. Bio. [mt]**	**% Virgin**	**Sp. Bio. [mt]**	**% Virgin**	**Sp. Bio. [mt]**	**% Virgin**
	2008	0.25	0.25	98	3.5%	99	4.0%	417	17.4%
	2009	0.25	0.25	101	3.6%	105	4.2%	445	18.6%
	2010	0.25	0.25	104	3.7%	111	4.5%	474	19.9%
	2011	0.25	0.25	107	3.9%	118	4.7%	505	21.1%
Status quo catch (zero retention, 0.5 mt assumed discard)	2012	0.25	0.25	110	4.0%	124	5.0%	536	22.4%
	2013	0.25	0.25	113	4.1%	131	5.3%	567	23.8%
	2014	0.25	0.25	116	4.2%	138	5.5%	600	25.1%
	2015	0.25	0.25	119	4.3%	145	5.8%	633	26.5%
	2016	0.25	0.25	123	4.4%	153	6.1%	667	27.9%
	2017	0.25	0.25	126	4.5%	161	6.5%	702	29.4%
Management Action	**Year**	**Comm.**	**Rec.**	**Sp. Bio. [mt]**	**% Virgin**	**Sp. Bio. [mt]**	**% Virgin**	**Sp. Bio. [mt]**	**% Virgin**
	2008	0.41	0.41	98	3.5%	99	4.0%	417	17.4%
	2009	0.43	0.43	101	3.6%	105	4.2%	445	18.6%
	2010	0.46	0.45	104	3.7%	111	4.5%	474	19.8%
	2011	0.48	0.48	107	3.8%	117	4.7%	504	21.1%
Landings from F90% Harvest Control Rule applied to base model	2012	0.51	0.50	109	3.9%	123	5.0%	535	22.4%
	2013	0.53	0.53	112	4.0%	130	5.2%	567	23.7%
	2014	0.56	0.56	115	4.1%	137	5.5%	599	25.1%
	2015	0.59	0.59	118	4.2%	144	5.8%	632	26.4%
	2016	0.62	0.62	121	4.3%	151	6.1%	665	27.9%
	2017	0.65	0.65	124	4.4%	159	6.4%	700	29.3%

Research and data needs

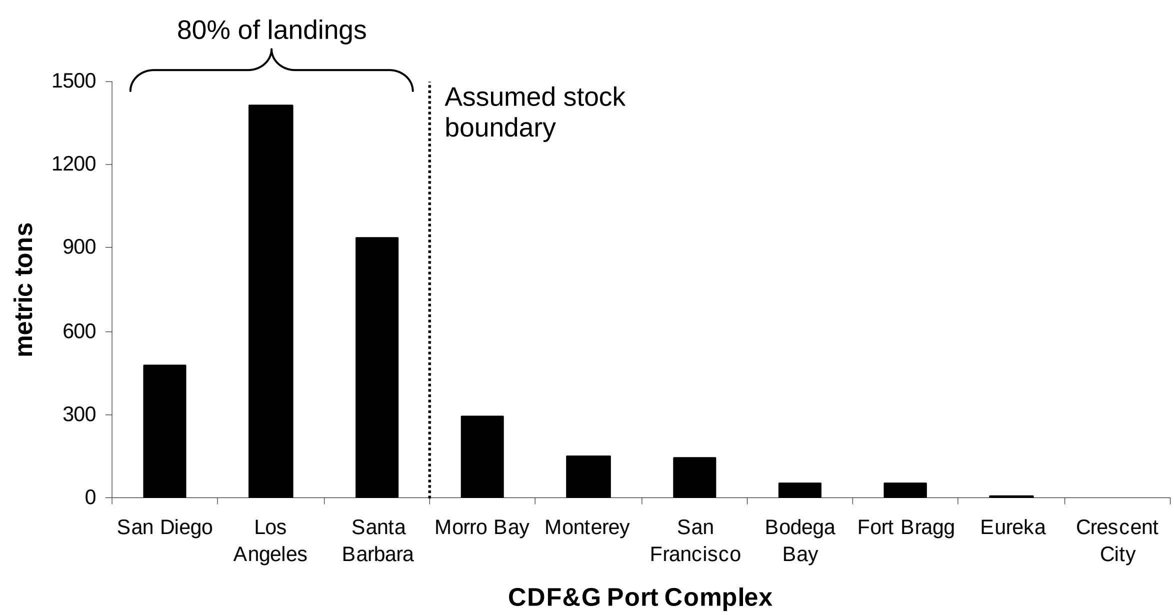
There is an urgent need for an informative abundance index that can monitor the recovery of this stock. The submersible line-transect survey (Yoklavich et al., in review) used in this assessment is a direct measure of cowcod abundance and was formally reviewed in 2004. A pilot study for an acoustical-optical survey (D. Demer, pers. comm.) has estimated cowcod abundance by first estimating rockfish biomass using echosounders, and then apportioning that biomass to species based on video and still camera images. These types of non-lethal surveys could potentially monitor the recovery of cowcod, and given the projected length of time to recovery it may be sufficient to conduct the surveys on a less-than-annual basis.

Our understanding of uncertainty in historical landings estimates could improve from additional analysis. Sampling coverage in Southern California has been sparse relative to the number of sampling strata. This becomes particularly problematic for rare species such as cowcod. The assumption that recreational catch was zero prior to 1951 should be reevaluated.

The accelerated schedule for this assessment did not allow for a complete review of all available data sets (e.g. CalCOFI, West Coast Slope/Shelf Combination Groundfish Survey, etc.). Future assessments should revisit all available data sources.

Regional management: The current model assumes that cowcod in the Southern California Bight are isolated from cowcod north of Point Conception and south of the U.S.-Mexico border. This assumption remains untested. Cowcod landings in California (1969-2005) primarily occur within the current stock boundaries (Fig. ES9). The magnitude of Mexican catches is unknown.

Figure ES9: Cowcod Landings by California Port Complex, 1969-2005



Introduction

This assessment revises the last full assessment of cowcod, *Sebastes levis*, in the Southern California Bight (Piner et al., 2005). The stock boundary (Fig. 1) is defined as U.S. waters off California and south of Point Conception (34°27'). Waters north and south of the SCB are not considered in this assessment due to sparse data and possible differences in abundance trends (Piner et al., 2005). The assumption of an isolated stock remains untested, and no information is available regarding dispersal across the northern or southern stock boundaries.

The current assessment was originally prepared as an “update” stock assessment. While preparing the update, an error was discovered in the previous assessment’s specification of the selectivity curve. The Stock Assessment Team (STAT) also proposed several revisions including new estimates of historical landings, a corrected growth curve, and a two-fishery model. The Scientific and Statistical Committee (SSC) concluded that the assessment did not meet the terms of reference for an update assessment due to the resulting changes in depletion, historical exploitation rates, and consistency with the visual survey. The SSC agreed that further analysis of the proposed revisions would be fruitful, and the Council requested that a full review of the assessment be conducted during the darkblotched rockfish Stock Assessment Review (STAR) panel.

Due to the accelerated schedule, this report focuses on six topics: (1) correcting the selectivity error from the previous assessment, (2) correcting length data that were used in estimating the growth curve, (3) a revision of the historical catch series based on recovery of a substantial number of “early” southern California port samples from CDFG and an improved stratification scheme, (4) analysis of the recreational CPUE time series to better account for the last two years in the time series and to obtain a more parsimonious statistical model, (5) consideration of developing a two-fishery model (commercial and recreational), and (6) evaluating the effect of using a Bayesian prior distribution of spawner-recruit steepness obtained from a recently conducted hierarchical meta-analysis.

The STAT refers the reader to the previous two cowcod assessments (Butler et al., 1999; Piner et al., 2005) for general information regarding the fisheries and biology of cowcod. Due to time constraints some items from the Stock Assessment Terms of Reference have been omitted.

Data

Life History Parameters

Weight-at-length and maturity-at-length relationships for cowcod were published by Love et al. (1990), and their estimates are used in this assessment. Natural mortality (M) was estimated using the method of Beverton (1992), and estimates of total mortality (Z) were calculated from Hoenig’s (1983) method and a catch curve regression (Table 1). Age data used for the catch curve were prepared for the 1999 cowcod assessment and are further described by Butler et al. (1999, 2003). The slope of the catch curve based on ages 12-44 (Fig. 2) was –0.055, with a 95% confidence interval of (-0.072, -0.038). We assume that natural mortality is constant with respect to age, and M is fixed at 0.055 in the base model. Profiles over a range of natural mortality rates are presented in the Uncertainty Analysis section.

A previous study examined length-at-age for 131 cowcod from the commercial fishery,129 cowcod from the recreational fishery, and 4 juveniles caught as bycatch in the spot prawn fishery (Butler et al., 2003). Cowcod otoliths in the study were primarily collected prior to 1993, and evidence suggests that the recorded lengths were total length, rather than fork length as reported in the study. Prior to 1993, the standard measure of fish length used by California's port samplers was total length (D. Pearson, pers. comm.). In 1993 a decision was made to adopt fork length as the standard measure of length, and all lengths in the CALCOM database were converted to fork length. We confirmed that lengths from the commercial samples used in the age study were total length by examining a subset of the original port samplers' data sheets and also by comparing aged fish to matching records in CALCOM. Since the lengths of the aged fish appear to be total length, the conversion from fork length to total length in the 2005 assessment was unnecessary. We fit the von Bertalanffy growth function (VBGF) to length-at-age data, external to the model, treating lengths as total length. We compared predicted length at age from the 2005 assessment with results from the base model (Table 2, Fig. 3).

To specify the error structure for the length-at-age model, we plotted the CV of observed lengths at age versus mean length at age, using only ages with greater than four observed lengths (Fig. 4). To approximate the observed level of variability in length at age, we extrapolated the linear fit shown in Figure 4 to a CV of 26.5% at a length of 16.2 cm (predicted mean length at age 2). We visually evaluated the error structure by plotting the 95% confidence intervals of the fitted VBGF against the observed data (Fig. 5). The revised growth curve has a small, but noticeable effect on the spawning biomass trajectory (Fig. 6, dotted line) but only changes depletion by about 0.5% (Table 3).

Landings

Historical commercial landings, 1916-1968

Butler et al. (1999) developed a time series of historical landings of cowcod by the commercial fisheries (1916-1981) using a ratio estimator applied to published landings of total rockfish in California (CDF&G Fish Bulletin No. 149, 1970). Since their assessment, other sources of information have become available that provided us an opportunity to revise the historical landings. As described below, we used this information to develop a ratio estimator stratified by port complex and gear group, based on the earliest available data from the SCB.

In his "Rockfish Review" (CDF&G Fish Bulletin No. 105, 1958), J.B. Phillips provided a record of total rockfish landings by region (Southern, Central, and Northern California) for the period 1916-1956 (Table 4). These data combine the genus *Sebastolobus* (thornyheads) with *Sebastes*, and include rockfish caught in foreign waters but landed at U.S. ports. The regional data show that the relative proportion of California's commercial rockfish landed in each area has changed dramatically over time (Fig. 7). This result prompted us to develop a ratio estimator that tracks rockfish landings in the SCB rather than statewide rockfish landings.

The NMFS SWFSC Environmental Research Division (ERD) currently hosts a live-access server (http://las.pfeg.noaa.gov/LAS/CA_market_catch.html) with commercial landings originally published in the CDF&G Fish Bulletin series. Similar to the data from Fish Bulletin No. 105, rockfish landings in this dataset include thornyheads (up to 1977), however, the ERD data exclude fish caught in foreign waters. We queried this database to obtain total rockfish landings by region for the period 1928-1968 (Table 4). The 6 geographic regions in the ERD database are San Diego (San Diego County), Los Angeles (Los Angeles and Orange Counties), Santa Barbara (San Luis Obispo Santa Barbara, and Ventura Counties), Monterey (Santa Cruz and Monterey Counties), San Francisco (Sonoma, Marin, San Mateo and San Francisco Counties, plus San Francisco Bay), and Eureka (Del Norte, Humboldt and Mendocino Counties). The "Southern" area described by Phillips (CDF&G Fish Bulletin No. 105, 1958) is spatially equivalent to the San Diego, Los Angeles, and Santa Barbara regions in the ERD database. The "Central" area is spatially equivalent to the ERD's Monterey and San Francisco areas, and the "Northern" area is equivalent to the ERD's Eureka region. When the ERD data from Southern California are spatially aggregated to mimic the Southern rockfish landings in Fish Bulletin No. 105, the ERD landings are consistently smaller than the Fish Bulletin landings. This is expected, because the ERD data only include fish caught in U.S. waters. To account for this difference, we calculated annual estimates of "foreign-caught rockfish" (Table 5) as the difference between the sum of the ERD landings in the San Diego, Los Angeles, and Santa Barbara regions and the "Southern" landings in Fish Bulletin No. 105. To estimate the amount of foreign-caught rockfish prior to 1928, we used a ratio estimator based on the years 1928-1933. This estimate (0.74%) was applied as a correction factor to the Fish Bulletin Southern-area data for years 1916-1927.

The "Santa Barbara" region as defined in the Fish Bulletin series (and hence the ERD database) includes San Luis Obispo (SLO) County, which is north of Point Conception and is therefore outside the stock boundary as defined in this assessment. Therefore, it was necessary to adjust the rockfish landings in this region to exclude catches north of Point Conception. Beginning in 1949, CDF&G's Fish Bulletin series reported port-specific rockfish landings for the Santa Barbara region. We entered these data and observed that in the mid-1950s rockfish landings in the Santa Barbara region increased dramatically due to landings at Morro Bay and Avila (Fig. 8, Table 5). We subtracted the rockfish landed at these two ports to create an "adjusted Santa Barbara" region that reflects rockfish catch within the assumed stock boundary (Table 5). In doing so, we assume that annual rockfish landings are zero at other ports north of Point Conception but within the Santa Barbara region (e.g. San Simeon). This is unlikely to have a major effect on our results due to the relative size of landings at Morro Bay and Avila compared to other ports in the region. For the years 1928-1949, we extrapolated Morro Bay and Avila landings using a ratio estimator based on the fraction of rockfish in the Santa Barbara region landed at each port during the years 1949-1951 (Table 5). The rockfish catch in Avila was not reported in 1952-53 or 1958-61, so we calculated ratio estimates for these years using catches in proximal years (Table 5).

To extend our time series of rockfish landings in the Los Angeles, San Diego, and adjusted Santa Barbara regions back to 1916, we subtracted our estimates of foreign-caught rockfish from the total rockfish landings in the Southern area. We then used a ratio estimator based on landings from 1928-1933 to estimate the fraction of rockfish caught in each region during the period 1916-1927. For example, we divided the sum of rockfish landings in the Los Angeles region from 1928-1933 by the sum of rockfish landings in the San Diego, Los Angeles, and adjusted Santa Barbara regions during the same years. We assume that this percentage (64.6%) of rockfish caught in the Southern area and landed in the Los Angeles region is constant from 1916-1927. By the same method, ratio estimates for the San Diego and adjusted Santa Barbara regions were 33.4% and 0.97%, respectively. The final time series of historical rockfish landings by region, 1916-1968, is illustrated in Fig. 9.

The final step in deriving the historical commercial landings was to determine the fraction (by weight) of the rockfish landings that was cowcod. We based our estimates on 5-year averages from the earliest years for which we have actual samples (1984-1988) in all port complexes (Table 6). Gear types were chosen to be consistent with the historical fisheries. Hook

& line was the dominant gear group for rockfish prior to 1944 (CDF&G Fish Bulletin No. 126, 1964), and prior to 1968 it was illegal to process a trawl net south of Ventura County (Frey, 1971). Therefore, we estimated the percentage of rockfish that was cowcod in the Los Angeles and San Diego regions from their respective hook and line fisheries. In Santa Barbara the trawl fishery developed in the mid-1940s, so we based our estimates on the combination of line and trawl gears beginning in 1944, and on the hook and line fishery for years prior to 1944. The annual fraction of cowcod in rockfish landings was variable, but without trend, in the San Diego hook and line fishery, whereas the fraction in the Los Angeles and Santa Barbara fisheries showed steep declines during the 1980s (Fig. 10).

The 1984-88 ratio estimate of the fraction of cowcod in the Los Angeles hook & line fishery is large relative to other fisheries and relative to subsequent years in the same fishery. Most of the strata were well sampled during this period (Table 7), but it is unknown whether estimates based on these five years are representative of previous years. The results of additional analyses are presented under "Responses to STAR panel requests." As a sensitivity analysis, we compared the base model to a model with one half of the estimated historical commercial catch (Table 8). The effect on depletion in 2007 was less than 1%.

Revised CALCOM landings, 1969-1985

Landings from 1969 through 1985 were re-estimated for this assessment because a total of 611 new market samples were recovered following the 2005 assessment. The new samples all came from southern California port complexes (Santa Barbara, Los Angeles, and San Diego), and were collected in 1983, 1984, and 1985. In Piner et al. (2005), no samples were available for the SCB prior to 1986. Thus, landings prior to 1986 for the SCB relied on samples collected in 1986. These samples were used to estimate the landings back to 1969 using the standard expansion protocols developed by CALCOM (California Cooperative Survey: CDFG, Belmont, CA; PSMFC, Belmont, CA; NMFS, Santa Cruz, CA).

Appendix A describes changes to CALCOM since the last assessment that affect cowcod landings between 1969 and 1985. Don Pearson (NMFS, SWFSC, FED) is preparing an extensive publication that describes the relative reliability of California commercial landings by species.

Landings since 1986 have not changed since the last assessment, with the obvious exception of an additional two years of data (we assume 0.25 mt discard per year, per fishery). Retention of cowcod has been prohibited since January 2001. Figure 11 illustrates the differences between the revised CALCOM landings (1969 – present) and those used in the 2005 assessment. The recovered market samples from 1984 and 1985 resulted in a 34% and 46% increase in cowcod landings, respectively. The revised estimation method increased estimates of cowcod landings from 1969-1983, largely due to the recovered market samples from 1984 and 1985. Figure 12 shows the contribution of each gear group to commercial landings.

The final time series of estimated cowcod landings is provided as Table 9. Although very little catch information is available prior to 1916, rockfish are known to have been commercially important since at least 1875 (CDF&G Fish Bulletin No. 105, 1958). In this assessment, cowcod landings were assumed to increase linearly from 0.01 mt in 1900 to the estimated catch in 1916 of 85.36 mt.

Recreational landings, 1951-2000

Landings from the recreational fishery (1980 – 2000) were queried from the online RecFIN database using the following criteria: Southern California, ocean only, party boat and private rentals, catch type A + B1. Recreational catch from 1951 through 1979 is assumed to be the same as reported in the previous assessment (Table 9).

Length data

CDF&G conducted creel onboard observer surveys from 1975-78 and 1986-89 for the CPFV fishery in Southern California. The survey data were never published, but a brief description is provided in Piner et al. (2005). These data were evaluated for the purpose of estimating a selectivity curve for the recreational fishery and CPFV logbook index.

The length compositions from the 1970s were assigned to 'shift years' (Nov-Apr) to mimic the approach used for the CPFV logbook index (Fig. 13). In summer months the effective effort for cowcod decreases due to targeting of pelagic species (Butler et al., 1999). The data from shift-year 1974 were removed due to small sample sizes. Larger fish were caught in 1977, a year in which a larger proportion of observed offshore locations were visited (Fig. 14). In 1978, the vast majority of cowcod caught on observed trips were from a single block, so data from this year were not included in our analysis. An examination of cowcod length versus depth fished did not show a conclusive pattern (Fig. 15). Since these patterns are only representative of the observed trips, not the fishery, we examined annual changes in effort data from CPFV logbooks (months of November through April and blocks where at least one cowcod was caught in that year). These data suggest that the spatial distribution of the observer data for these three years is not a reflection of the distribution of effort in the fishery (Fig 16).

A major change since the previous assessment was our choice to model separate commercial and recreational fisheries, using the length comps from 1975-77 to estimate a simple logistic selectivity curve for the recreational fishery and CPFV index (Fig. 17). At first, we attempted to develop a model with freely estimated selectivity parameters for the recreational fishery. However, even after tuning effective sample sizes, the length data tended to overwhelm the likelihood components for the CPFV index and visual. This effect seemed unreasonable given that length data are only being used to estimate a selectivity curve, and not changes in recruitment. Therefore in the base model recreational selectivity is fixed at the model-estimated values, and length data were removed.

Length data from the commercial fisheries were obtained from CALCOM, and we plotted length compositions by major gear group (Fig. 18). The net fisheries had the largest sample size, but length compositions varied considerably among years and showed no clear modal progression (Fig. 19). For lack of better information, we set the commercial selectivity curve (for all gears combined) equal to the female maturity curve, as was the intention of Piner et al. (2005). The final selectivity curves used in the base model are illustrated in Figure 20.

CPFV Logbook CPUE

K. Hill (SWFSC) provided logbook data from commercial passenger fishing vessels (CPFV) for the period 1964-2000. The data are aggregated by year, month, and CDFG block and include the catch (in numbers) of cowcod and total rockfish. Prior to 1964, cowcod were combined with total rockfish, and data after 2000 were excluded due to the effects of management. Additional information about the CPFV logbook data is available in Hill and Schneider (1999), Butler et al. (1999), and Piner et al. (2005). Although the raw data for the index have not changed, we chose to revisit the model structure due to the importance of the index in this assessment.

Butler et al. (1999) used a generalized additive model to estimate separate trends in CPUE (catch per unit effort) for each pseudo-block. Pseudo-blocks were defined as single blocks if a continuous time series was available. Blocks with missing data in some years were aggregated into pseudo-blocks according to quartiles of mean CPUE to complete the time series for that pseudo-block. Complete time series in each pseudo-block allowed Butler et al. to estimate a year-area interaction term in the standardization model. Blocks in the 1st quartile of mean CPUE were excluded from the analysis, as they were unlikely to be informative about trends in cowcod abundance. The spatial stratification and year-area interaction term were attempts to capture onshore/offshore movement of the fishery over time. The final index was an area-weighted sum of 30 time series of relative abundance (Fig. 44 in Butler et al., 1999). A problem with this approach, however, is that blocks are aggregated based on quartiles of mean catch rate, and not by spatial relationships.

We began our analysis by visually inspecting the stratification scheme used in the 1999 assessment (Fig. 21). Blocks with complete time series ("independent" blocks, shown in grey) were primarily around the islands and nearshore areas, while the offshore fishing areas (e.g. Tanner, Cortes, San Nicolas Island, 43-Fathom) were estimated as part of the aggregated pseudo-blocks, each of which covers a large portion of the SCB. This might limit the model's ability to track movement of the fishery over time. Also, areas of contiguous habitat were often modeled as several independent time series. For example, the 1999 stratification fits six CPUE trends around Catalina Island, and six trends around Santa Barbara Island/hidden reef (Fig. 21). Given the inherent variability of logbook data, we were concerned about over-fitting the data. A year-area interaction term adds considerable complexity to a GLM model, requiring (30-1 blocks)×(37-1 years) = 1044 parameters, although a GAM may have a smaller effective number of parameters. Since the final index was an area-weighted sum of the individual time series, we calculated the amount of cowcod habitat (defined as area between 50-300m) in each pseudo-block (Table 10). Pseudo-blocks 2, 3, and 4 account for 15%, 23%, and 21% of the total area, respectively. Each of the remaining 27 blocks had areas (weights) of between 4.2% and 0.2%of the total habitat. The final index, therefore, was largely driven by the area-weighted sum of pseudo-blocks 2, 3, and 4, and integrated trends over large areas.

The 2005 assessment used a simplified spatial stratification (Fig. 22), defining 3 pseudo-blocks, weighted by the number blocks in each pseudo-block. This reduces the number of parameters in the year-area interaction term, but retains the assumption that abundance trends are identical among blocks with similar mean CPUE.

To address these issues, we developed a new spatial stratification that is based largely on the assumption that adjacent (or nearby) blocks are likely to have similar trends in CPUE (Fig. 23). Similar to the previous two assessments, we excluded blocks below the first quartile of mean CPUE, as well as any data from the months of May-October due to seasonal changes in target species. We also excluded data from blocks that represent data of uncertain location, and catch reported in blocks that don't exist. Blocks with very sparse time series (<3 years with positive catch of cowcod) were dropped from the analysis. Finally, we defined a fishing "season" to include the month of November through April the following year.

We plotted changes in mean CPUE by region and decade, and noted a consistent pattern of declining CPUE across regions (Fig. 24). Data from three regions (North Islands, San Nicolas, and San Pedro Channel) showed an initial increase in CPUE, followed by steep declines. The reason for this initial increase is unknown at this time, although more detailed knowledge of these fishing grounds may have improved targeting during the initial phase of fishery development.

An additional source of information in the CPFV data is the catch (in numbers) of total rockfish. Minami et al. (2007) used the abundance of co-occurring species (tuna) as a covariate in their model for shark bycatch. Although the CPFV data are heavily aggregated, we feel it is reasonable to assume that blocks with high rockfish catch (excluding cowcod) in a given year and month are likely to have more cowcod than blocks that have reported little or no rockfish catch. We acknowledge that some cowcod were probably reported as part of the rockfish total (and perhaps vice-versa), but for this analysis we assume the reported values are correct. In our revised CPFV index we include the natural log of total rockfish catch as a covariate, after subtracting the mean of the log-transformed data to remove correlation between the intercept and slope parameters.

Our revised index is a delta-GLM model (Lo et al., 1992, Stefansson, 1996), composed of a binomial GLM with logit link and a normal linear model for the natural log of cowcod CPUE, defined as cowcod per angler hour. In both models, the initial set of covariates was year, month, region, and log(rockfish). Given the inherent variability of the logbook data and the large amount of data (7,782 observations), we used the Bayesian Information Criterion (BIC) in stepwise model selection routines (Table 11). The stepwise procedure was initiated with models that included all 2-way interactions and associated main effects. According to this criterion, month effects were not supported by the data (results omitted to simplify presentation). The BIC 'best' models for the components of the delta-GLM were

Binomial GLM: $cpue^{*} = year + region + logRF$, ($cpue^{*}=1$ if $cpue>0$, else $cpue^{*}=0$)

Gaussian GLM: $\log(cpue) = year + region + logRF + region{:}logRF$

The binomial GLM did not converge when the year:region interaction term was included (68 cells had either all zeros or ones), but the data did not support any of the other 2-way interactions. As an approximate test for the year:region interaction, we compared a main-effects negative binomial model ($\Delta BIC=0$) to a model with main-effects and a year:region interaction term ($\Delta BIC>1600$). This suggests that the data do not support the inclusion of the year:region interaction term, given the observed level of variability. The negative binomial model was not considered for the final index due to potential bias in parameter estimates (Minami et al., 2006). We attempted to fit zero-inflated negative binomial (ZINB) models, but had problems with model convergence. We then compared the fit of our revised model structure to the spatial stratification used in the 1999 assessment, with and without the year:block interaction term (Table 11). In both cases, the revised model structure was the BIC-preferred model.

To compare the revised index (Table 12) to previous results (Table 7 in Butler et al., 1999, and Table 3 in Piner et al., 2005) we scaled the trends to a unit mean and plotted them on a log scale (Fig. 25). We also compared CVs from each version of the index, prior to any iterative reweighting procedure (Fig. 25). In the 2005 assessment, the population trajectory was unable to fit the CPFV index in 1999 and 2000 without a substantial inflation of the original CVs. The revised index produces estimates for these last two years that are more consistent with the predicted trend in abundance. CVs for the revised index are consistently larger than the 2005 index for years after 1982. We compared the fit of the base model using the 2005 CPFV index, to the base model with the revised index, without iteratively reweighting the CVs. There is a 206 point reduction in the total negative log likelihood when the model is fit to the revised index. Tuning the model with the 2005 index results in CVs 4.5 times larger than the original values, while the tuned CVs of the revised index are 2.4 times the original values. The model fit to the revised CPFV logbook index with iteratively reweighted CVs is shown in Figure 26. Clearly, the model still has trouble fitting the revised index, but we feel that the improvement in fit is substantial, especially given the parsimonious model structure.

Visual line-transect survey

One of the data sets included in the 2007 assessment was an estimate of cowcod biomass in 2002 based on a visual transect survey conducted from an occupied submersible (Yoklavich et al., 2007). A formal review of this survey was conducted in 2004 with the assistance of the Center for Independent Experts (http://www.rsmas.miami.edu/groups/cie/) and the biomass estimate was included in the last assessment as a relative index of abundance with an informative prior on the catchability parameter (Piner et al., 2005). In this way, estimated biomass from the survey area was adjusted to reflect the expected biomass in the entire Southern California Bight.

An error was recently discovered in the visual survey methodology, related to the calculation of mean weight (M. Yoklavich, pers. comm.). During the survey, cowcod at greater distances were easier to detect if they were large. Although the originally reported numbers and densities of cowcod remain unchanged, the total biomass estimate (940 metric tons) was based on estimates of mean weight that did not account for this effect. The survey investigators therefore adjusted their estimates of mean weight to include only cowcod sighted within 2.7 meters of the transect line. Within this distance they found no relationship between fish size and distance. Their revised estimate of cowcod biomass in the survey area is 524 metric tons, 56% of the previous estimate.

The survey is briefly described as item 8 under “Responses to STAR panel requests” and is fully documented in Yoklavich et al. (2007). The cowcod biomass estimate was included in the 2005 assessment as a relative index with a prior distribution on catchability, with mean 0.75 and standard error of 0.5 (Piner et al., 2005, Appendix IV).

Whereas the visual survey had a very minor effect on the 2005 assessment, models with the corrected selectivity curve (including this assessment) are highly sensitive to the visual survey and removing the survey causes a substantial change in estimated levels of depletion (Table 13). We ran sensitivities of the base model to the assumed value of the prior’s CV. Appendix IV of the 2005 assessment estimated catchability of the visual survey as 0.751 with a standard error of 0.147. We profiled over CVs of 1%, 20%, 50%, and 100% (Table 14).

Other data sources

The STAR panel requested a list of data sets that were not included in this assessment. For each data set we have included references to the literature, previous assessments, or preliminary analyses included in this report.

1. California Cooperative Fisheries Investigations (CalCOFI) (www.calcofi.org; Butler et al., 2003; Piner et al., 2005)
2. Los Angeles County and Orange County sanitation departments outfall trawl indices (Butler et al., 2003; Piner et al., 2005)
3. Acoustic in combination with Remotely Operated Vehicle Survey (Piner et al., 2005; D. Demer, pers. comm.)
4. Cowcod intensive sampling (Piner et al., 2005)
5. NWFSC Hook and Line survey (Piner et al., 2005)
6. RecFIN recreational fishery CPUE (Piner et al., 2005; see item 9 under "Responses to STAR panel requests")
7. NMFS NWFSC West Coast Slope/Shelf Combination Groundfish survey (see item 14 under "Responses to STAR panel requests")

Assessment model

The model is an age-structured production model, with three estimated parameters: virgin recruitment (R_0), catchability for the CPFV logbook index, and catchability for the visual survey biomass estimate. The likelihood is composed of three components: the CPFV logbook index, the 2002 visual survey, and the prior distribution for catchability of the visual survey. Natural mortality (M) is fixed at 0.055. Recruitments are drawn from a Beverton-Holt stock recruitment curve, with steepness (h) fixed at 0.6. Catches are assumed known without error, and are divided into a commercial and recreational fishery. Gear selectivity for the commercial fishery mirrors the female maturity schedule, and selectivity for the recreational fishery was internally estimated from length data, but later fixed in the model. Length at age was estimated externally and fixed in the model.

Major changes in the base model since the last assessment include 1) correction of the gear selectivity curve for the commercial fishery, 2) revised historical landings estimates, 3) modeling separate commercial and recreation fisheries rather than a single combined fishery, 4) a revised selectivity curve for the recreational fishery and the CPFV logbook index, 5) a revised model structure for the CPFV logbook CPUE index, and 6) a correction to the data used in the length-at-age analysis.

Incremental changes due to the two corrections (selectivity and growth) are presented in Table 3, with comparisons to the base model and alternative states of nature. The assessment model was fit using Stock Synthesis 2, version 2.00c. Data, control, and forecast files are attached as Appendix B.

Uncertainty analysis

We profiled each component of the base model's negative log likelihood (NLL) over a grid of values for natural mortality (0.04 – 0.07) and the Beverton-Holt steepness parameter (0.3 – 0.9). This analysis was conducted prior to the revision of the 2002 biomass estimate from the visual survey, but the results show that the data do not support models with combinations of high steepness and high natural mortality (Table 15). A bivariate 95% confidence region is bounded by a difference of 3 likelihood points from the minimum (min(NLL) + $\chi_2^2(0.95)/2$, where $\chi_2^2(0.95) \cong 6$). For most assumed values of steepness, the goodness-of-fit is similar across the three different assumptions about natural mortality. The CPFV logbook index dominates the total NLL, with an improved fit for lower values of steepness.

The two major axes of uncertainty defined for this assessment are steepness and inclusion of the CPFV logbook index. Other sources of uncertainty such as natural mortality, historical catch, gear selectivity, and recruitment variability are also important to consider, but are difficult to estimate with the available data. Our analyses show that estimates of both steepness and the natural mortality rate are highly uncertain, and both parameters are treated as fixed and known. Models without the visual survey were not considered due to unreasonably high estimates of annual exploitation rate (total catch divided by summary biomass). The exploitation rates in the base model are also quite high considering what we know about the life history characteristics of cowcod, and the STAT considers this issue an important topic for future research.

Markov Chain Monte Carlo simulations were generated for the base (3-parameter) model, and we also attempted to estimate steepness and natural mortality with informative priors, as per the request of the STAR panel. Results are presented as Appendix C.

Informative prior on steepness

The steepness parameter (*h*) of the Beverton-Holt stock-recruitment relationship is a major axis of uncertainty in this assessment, and was fixed (assumed known) in all models discussed up to this point. We estimated steepness using an informative beta prior distribution based on a meta-analysis of steepness for west-coast rockfish (M. Dorn, pers. comm.), and compared results to the base model (Table 16). The steepness and virgin recruitment parameters are highly correlated (-0.999) and the reduced value of steepness (0.32) is associated with an increase in estimated virgin biomass. The overall fit is similar to the base model, indicating that the data do not effectively discriminate between very different interpretations of the stock.

Responses to STAR panel requests

These responses and the associated tables and figures refer to results from the base model at the time of the STAR panel. Due to subsequent changes (e.g. the revised 2002 visual survey estimate), values may differ from the results presented in the Executive Summary and/or previous sections of the main document.

1. Determine how harvest rate was calculated in Figure ES4 (and in SS2).

   The STAR panel noted that in the draft assessment, the comparison of harvest rates in the 2005 assessment to harvest rates in the 'corrected' 2005 assessment was incorrect, since harvest rates (catch divided by vulnerable biomass) depend on selectivity. The STAT clarified the definitions of "harvest rate" and "exploitation rate" as used in SS2, and identified two measures of fishing intensity:
   a) Total catch divided by age "x+" biomass (aka "exploitation rate")
   b) SPR (equilibrium spawning output per recruit under fished conditions, divided by spawning output per recruit under no fishing)

2. Compare biomass estimates from the three assessments on the same basis, i.e., female spawning stock biomass and base model plus plots of exploitation rate from each model on a comparable basis.

    Spawning biomass trends from the 2005 assessment, the 2005 assessment with corrected selectivity curve, and 2007 base model are shown in Fig. 6. Revised estimates of historical landings in the 2007 assessment produce an increased estimate of virgin biomass, relative to the 2005 assessment.

    Exploitation rates for the 2005 assessment were compared using age 11+ biomass (Fig. 27). Predicted mean length at age 11 is approximately 43 cm, the assumed length of 50% maturity, and 50% selectivity in the commercial fishery. Using this metric, exploitation rates for the 2007 model are very high, even exceeding 1 in one year (Fig. 28). The STAR panel suggested bracketing our uncertainty in these rates (see response to request #7) by calculating 'lower-bound' exploitation rates based on length at 50% selectivity in the recreational fishery (Fig. 28). The assumed length at 50% selectivity is 34 cm for the recreational fishery, and predicted length at age 8 is approximately 35 cm. Fishing intensity, defined as 1 – SPR, was also compared among the three models (Fig. 29).

3. Obtain CalCOFI data with the intent of looking at the time series again to see if it can provide information for the recent years for monitoring recovery of the stock.

    There was insufficient time under the accelerated assessment schedule to complete an adequate analysis of the most recent CalCOFI data. These data were not previously examined because the assessment was classified as an update, and the time series was not included in the 2005 assessment. The STAT agrees that future assessments should investigate recent results from this survey, as it might provide information about trends in spawning stock biomass.

4. Obtain more details on the recovered CALCOM data with respect to whether or not the data were representative of landings in general or were more restricted with respect to species, etc.

    Don Pearson (pers. comm.) provided an Excel chart showing the distribution of landings between market categories, with information on how sample coverage was used to estimate the landings (Fig. 30). The distribution of actual samples suggests that the recovered samples were not directed toward a particular market category.

5. Further investigation of the GLM analysis of CPFV [*sic*] requires more models to be run. In particular, need models for no log(rockfish catch), log(rockfish catch) for binomial model only. Compare annual trends for predicted CPFV [*sic*] from all three models.

    The STAT presented time series of CPUE based on delta-GLM models with the log(rockfish catch) covariate in both GLMs, in the binomial GLM only, and in neither GLM (Fig. 31). The STAT and STAR panel disagreed about the appropriateness of including this covariate in the standardization model, but agreed that the differences had little effect on the assessment as a whole. The trend in the CPUE index is primarily driven by the binomial GLM (Fig. 32).

In the CPFV fishery, the probability of catching a cowcod increases with (log) total rockfish catch (Tables 11 and 17). Species associations have previously been used to determine effective effort and/or as a proxy for habitat (Stephens and MacCall, 2004; Minami et al., 2007). In some years and regions, there is a negative correlation between the log(CPUE) and log(rockfish catch) (Figs. 33 and 34, Table 18). One possible explanation for this is the rockfish bag-limit (15 fish). An angler that catches a large number of rockfish could be limited in the number of cowcod he or she could retain. This effect would be lessened if catch were shared among anglers on a given trip. Standardized residual plots from the GLM for positive observations are presented in Figure 35.

6. Plot CPUE data from CPFV series over time by region.

As described in the Data section, the STAT developed a revised CPUE index from the CPFV logbook data. Model selection for this index was based on the BIC criterion, evaluated for a set of candidate models that included all main effects and 2-way interactions whenever possible. The best from the set of candidate models did not have an interaction between years and spatial strata. The STAR panel expressed some concern about this result, indicating that the set of candidate models was perhaps too limited to detect a year-area interaction. Specifically, the panel recommended evaluating a set of models with an intermediate number of effective parameters (e.g. GAMs), that would allow for year-area interactions without imposing such a severe penalty for increased model complexity.

The STAT presented several time series of average CPUE by region (e.g. Fig. 36). These plots suggest that a year-area interaction may exist, and the STAT agrees that this is an important topic for future research. However, a comparison of indices used in the past three assessments (including the 1999 GAM-based index) suggests that the index may be relatively robust to these alternative model specifications (Fig. 25).

7. Plot selectivity curve against the commercial length frequencies.

The 2007 base model assumes that gear selectivity for the commercial fishery mirrors the female maturity schedule, with 50% selectivity at a length of 43 cm. The STAT presented length frequency data from the net and hook-and-line fisheries, aggregated across years (Fig. 37). Logistic selectivity curves were fitted to the data, external to the model, and compared to the assumed selectivity curve in the base model.

For the net fishery, the ascending limb of the selectivity curve might be better approximated by a curve shifted to the left of the maturity ogive. If fish are selected at lengths smaller than the current model assumption, this would inflate exploitation rates (catch / summary biomass) that are based on the current selectivity curve. The length-frequency data from the hook-and-line fishery are more consistent with the assumed length at 50% selectivity, but the slope of the curve at the inflection point may be reduced relative to current assumption. The STAT and STAR panel agreed that selectivity curves for the commercial fisheries should be re-examined in future assessments.

8. Present background information on visual survey including copy of paper to appear in the Canadian Journal of Fisheries and Aquatic Science.

The STAT distributed a draft of Yoklavich et al. (in press) to the panel, and a brief summary of the visual survey:

- Manned submersible visual survey in 2002
- Sampled eight rocky banks within the Cowcod Conservation Area
- Banks were chosen from prior information that they were likely cowcod habitat
- Transects within 1.5km^2 blocks randomly chosen from grid placed over banks
- Survey biomass estimate of cowcod in the study area: 940 mt (CV = 25%)

The STAT summarized the survey's treatment in the 2005 assessment:

- Survey treated as relative index of abundance with prior on (log) catchability
- Analysis of CPUE and estimated habitat area suggests q = 0.75 with standard error 0.147 (Appendix IV, Piner et al., 2005). This is likely to be a minimum estimate of the actual error in this estimate.
- CV of the prior for (log) catchability was fixed at 0.5.

The STAT also provided a sensitivity analysis comparing models based on different values of the CV for the prior probability distribution for the catchability parameter (Table 14). As illustrated in Tables 13 and 14, the assessment is very sensitive to the visual survey data and the assumed precision of its catchability coefficient (in effect, the 'weight' given to the survey). This emphasizes the need for future surveys to provide adequate coverage of areas inside and outside the CCAs.

9. Contact observer program re: CPFV observer data from charter boat on species composition.

During the panel, it was suggested that recent data from CPFV observer programs in Southern California might inform recent trends. The STAT obtained location-specific data from 1999-2006 (Wade Van Buskirk, pers. comm.), during which time a total of 35 cowcod were recorded as kept or returned, based on a query of the recommended NODC8, ALPHA5, and RecFIN species codes. The database contained records from over 16,000 site visits. Although efforts could be made to better determine effective effort for cowcod, it appears that this species is not observed often enough in these surveys to provide meaningful trend information.

10. Follow up with knowledgeable Southwest Fisheries Science Center staff concerning the LA outfall bottom trawl survey and CalCOFI data. STAT should present these data in supporting documentation as being used historically.

The STAR panel requested that the CalCOFI data and outfall bottom trawl survey data be presented in the current assessment. The STAT agrees that these and other potentially informative data sources should be catalogued and examined during the course of a full stock assessment. During the 2005 assessment both data sets were evaluated, but ultimately omitted. The STAT was unable to complete additional analyses of these two data sets, given the accelerated schedule.

11. Need to know how many samples were taken in recent years versus what we see now with the recovered market samples. Construct a table of distribution of found samples by port, market category and year by gear. Do something simple to see how sensitive model results are to our concerns about the landings once a base model has been developed

    An unresolved issue in this assessment is the accuracy of the estimated proportion of cowcod in the historical rockfish catch. Some members of the STAR panel expressed concern that the samples used to determine these proportions could be less representative of the fishery than samples taken in later years.

    The STAT compared the number of samples taken from 1984-1988 (the five years used to determine the percentage of cowcod in total rockfish catch) with adjacent years for which we have samples (Table 19). The STAR panel concluded that there was little evidence that samples taken during this time period were less representative than adjacent years.

12. Would like to see a plot of the prior on the catchability for the visual survey and final estimate.

    The STAT plotted the prior distribution for log catchability along with the point estimate (posterior mode) from the fitted model (Fig. 38). This illustrates how the CPFV logbook index and visual transect survey provide conflicting information about stock status in 2002. Since this plot does not take into account posterior uncertainty, we compare MCMC draws from the posterior with the prior distribution in Appendix C.

13. Call from Observer Program. There may be observer data. Follow up.

    See response to item 9.

14. NWFSC staff working on NWFSC survey and sending all tows in SCB. Follow up.

    Jim Hastie and Beth Horness provided data from the West Coast Slope/Shelf Combination Groundfish survey, including the number, combined weight, and individual lengths of cowcod caught during all tows in the SCB from 2003-2006. Trawl surveys are limited as indices of abundance for cowcod, in that they cannot access rocky, high-relief habitat. The survey caught a total of 45 cowcod over the 4-year period, between the depths of 127 and 288 meters. There were 141 tows between 50-300m. For each of these tows, the STAT calculated the number of cowcod per hectare of area swept by the trawl (Table 20). The proportion of tows that caught at least one cowcod ranged from 7% - 17%. The number of tows within the 50-300m depth range ranged from 30 – 41 per year. Given the short time series, the limitations regarding trawlable habitat, and the large number of zero observations the STAT feels that this index is not suitable for the current assessment, but suggests that it be re-evaluated in future assessments.

15. Calculate harvest rate as total catch over summary biomass defined by 50% selectivity for the recreational fishery.

    See response to item 2 and Fig. 28.

16. Sensitivity runs for the abundance indices:

a) Drop visual, keep CPFV
b) Keep visual, drop CPFV
c) Keep visual and CPFV add power term for CPFV

Removing the visual survey has a dramatic effect on the 2005 assessment with corrected selectivity curve (Table 13) and the 2007 assessment. Depletion in 2007 is estimated at 2.1% when the visual survey is removed (Table 21). The STAT did not use models without the visual survey to bracket uncertainty because the associated exploitation rates (total catch over age 11+ summary biomass) became impossibly high, exceeding 1.5 in some years.

The "Visual Survey only" run in Table 21 only differs from the "high-productivity" model (Table ES2, third column) in that steepness is fixed at 0.6 versus 0.8. Both models are simply calculating the level of virgin recruitment required to match the 2002 visual survey biomass estimate, given the model assumptions.

The STAR panel requested a run in which the CPFV logbook index is fit with a power term (Table 21). This relaxes the proportionality assumption and improves the fit to the CPFV index and visual survey. Adding the additional parameter adds complexity that is not, in the STATs opinion, well understood or justified. Instead, the STAT recommends additional research regarding the nature of the observed hyperdepletion pattern.

17. Investigate the impact of different scenarios for the level of landings during the historical period in this fishery. Try runs of the model with one half and double (or some other factor at the STAT discretion) the landings from 1900 to 1968 using the case with both visual and CPFV in the model.

The STAT completed model runs with +/- 50% of the historical commercial catch from 1900-1968 (Table 22). Estimates of spawning biomass in 2007 are relatively insensitive to this change, but estimates of unfished spawning biomass range from 4646 mt to 6063 mt. Absolute depletion changes by less than 1% in either direction, but the relative change is about +/-12%.

18. The Panel requested an MCMC run on the full model with the following characteristics.

Results from preliminary Bayesian models are presented as Appendix C.

19. STAT to provide summary of runs to date to establish the range of uncertainties to be captured with the base run.

The STAR panel requested a set of runs profiling values of natural mortality and steepness, for models with both the CPFV logbook index and the visual survey as well as models with either the CPFV index or visual survey. The STAT produced estimates of unfished spawning biomass, 2007 spawning biomass and 2007 depletion for 27 model runs

(Table 23). Natural mortality was fixed at either 0.04, 0.055, or 0.07., and steepness was fixed at 0.4, 0.6, or 0.8.

Models that included both the CPFV index and visual survey produced estimates of depletion ranging from 3.8% to 8.9% and estimates of SB_0 between 2008 mt and 3153 mt. Removing the CPFV logbook index (using only the visual survey) produced estimates of depletion between 18.8% and 30.5%, with SB_0 between 2143 and 3465 mt.

We bracket uncertainty in this assessment using three values of steepness (0.4, 0.6, and 0.8) and by excluding the CPFV logbook index from the model with steepness fixed at 0.8. The estimated biomass trajectory from the model that assumes a relatively high level of productivity and ignores the declining catch rates in the CPFV index still falls below the overfished threshold from 1981 until 2005 (Fig. ES3).

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Tables

Table 1. Mortality estimates; natural (M) or total (Z)

Method	M	Z	range (if available)
Hoenig (1983); GM regression for all groups		0.072	n/a
Catch curve; age at full recruitment = 12		0.055	(0.038, 0.072)
Beverton (1992); Tmax = 55	0.045		(0.027, 0.064)

Table 2. Parameters for the revised growth curve, compared to values in the 2005 assessment.

parameter [units]	2005 assessment (converted from SS2 .tpl file)	2007 assessment
L_∞ [mm, total length]	914	870
k [$years^{-1}$]	0.056	0.052
t_0 [years]	-0.46	-1.94

Table 3. Incremental changes associated with corrections to selectivity and growth in the 2005 assessment, with comparisons to the 2007 base model and possible alternative (low- and high-productivity) states of nature. Natural mortality is fixed at 0.055 in all models. Increased estimates of virgin biomass are largely due to revised estimates of historical landings. The high-productivity (h=0.8) model calculates the level of virgin recruitment required to match the 2002 biomass estimate, given the model assumptions. Therefore, likelihood components are not informative and are not reported for this model.

	2005 (SS2 v1.23d, h = 0.5, M = 0.055)			**2007 assessment (SS2 v2.00c)**		
	(unchanged)	selex = maturity	selex = maturity & revised growth	h = 0.4 CPFV index & visual survey	h = 0.6 CPFV index & visual survey	h = 0.8 Visual survey only
Reference Points						
Unfished female spawning biomass (SB_0)	1522	1660	1568	2777	2488	2389
Unfished summary (age-1+) biomass	3191	3481	3333	5905	5291	5080
40% of SB_0 (proxy for SB_{MSY})	609	664	627	1111	995	956
Exploitation rate at $F_{50\%}$ (proxy for F_{MSY})	3.3%	2.8%	2.9%	2.7%	2.7%	2.7%
Female spawning biomass in final year	271	157	155	94	94	389
SB in final year / unfished SB	17.8%	9.4%	9.9%	3.4%	3.8%	16.3%
Parameter Estimates						
Unfished recruitment (R_0)	59.6	65.0	69.2	122.7	109.9	105.6
Catchability for CPFV logbook index	1.46E-05	5.95E-05	5.72E-05	2.05E-04	2.16E-04	n/a
Catchability for visual survey	1.49	2.34	2.36	2.22	2.30	0.75
Initial fishing mortality	9.25E-05	6.13E-04	6.48E-04	n/a	n/a	n/a
Likelihood components						
Total negative log likelihood	13.43	14.98	14.36	15.90	16.54	n/a
CPFV logbook index	12.23	11.83	11.16	12.92	13.34	n/a
Visual survey	0.23	0.63	0.64	0.64	0.68	n/a
Prior on visual survey	0.91	2.52	2.56	2.35	2.51	n/a
penalties	0.06	0.00	0.00	0.00	0.00	n/a

Table 4. Regional rockfish landings (metric tons) from CDF&G Fish Bulletin No. 105 (1958) and the NMFS SWFSC ERD Live-Access Server (http://las.pfeg.noaa.gov/LAS/CA_market_catch.html).

	CDF&G Fish Bulletin No. 105			NMFS ERD Live Access Server					
year	Southern	Central	Northern	San Diego	Los Angeles	Santa Barbara	Monterey	San Francisco	Eureka
1916	966.62	1258.10	6.48						
1917	1559.70	1953.81	12.74						
1918	1422.29	2286.85	29.72						
1919	850.46	1591.24	6.84						
1920	923.72	1622.13	9.28						
1921	806.94	1339.01	13.91						
1922	794.00	1151.53	10.37						
1923	1063.85	1244.55	3.39						
1924	1426.24	715.81	9.29						
1925	1564.44	895.04	30.12						
1926	1941.86	1448.95	29.71						
1927	1611.49	1230.84	56.40						
1928	1373.50	1489.87	48.65	554.76	769.85	46.65	1037.07	452.80	48.65
1929	1389.53	1231.60	116.94	641.80	687.26	44.60	744.37	487.23	116.94
1930	1415.63	1747.90	113.84	477.91	906.13	21.15	1281.84	466.06	113.84
1931	1617.81	1635.24	48.06	400.30	1182.35	30.91	1162.02	473.23	48.06
1932	1135.48	1380.64	40.48	298.47	797.37	34.76	929.54	451.10	40.48
1933	907.47	1250.11	14.12	252.63	588.30	46.54	734.27	515.84	14.12
1934	857.00	1178.65	52.70	129.53	510.38	127.60	762.08	413.50	57.76
1935	741.23	1377.44	72.72	77.85	373.92	177.65	975.39	402.05	72.72
1936	424.05	1579.23	85.01	69.72	122.80	181.88	1188.37	390.87	85.01
1937	460.65	1425.30	60.52	65.18	156.84	166.26	954.94	470.30	60.52
1938	309.18	1092.21	248.39	33.82	126.04	72.76	838.72	253.49	248.15
1939	389.66	779.56	342.66	92.01	140.83	91.19	602.61	176.25	341.65
1940	396.32	958.58	264.72	66.63	153.11	136.40	752.37	206.21	264.06
1941	470.11	867.78	206.88	42.15	202.95	131.57	662.24	205.29	206.26
1942	192.96	329.34	123.36	10.13	74.46	38.27	297.51	31.76	123.36
1943	226.43	402.58	623.90	5.17	89.07	38.61	310.60	91.98	623.75
1944	43.38	363.18	2506.52	4.63	10.34	22.14	331.89	31.28	2505.76
1945	92.92	617.92	5315.58	4.56	26.97	44.95	533.96	84.16	5313.17
1946	161.19	608.31	4293.16	8.71	79.60	48.78	508.01	100.30	4005.49
1947	185.46	785.98	2883.46	8.79	131.60	26.85	690.04	95.94	2496.14
1948	287.68	886.56	1792.71	24.12	200.08	36.11	748.25	122.98	1594.18
1949	412.09	847.60	1492.66	36.64	258.88	61.88	611.25	236.35	1274.85
1950	427.87	1555.09	1698.35	33.67	294.00	85.96	1106.22	448.88	1555.57
1951	470.81	2440.55	2074.55	14.55	328.93	121.63	1440.72	999.83	2051.35
1952	366.25	3301.04	1195.31	9.47	218.59	108.15	1676.93	1624.11	1089.52
1953	298.74	3845.54	1402.36	14.71	179.44	88.66	1953.92	1891.82	1335.43
1954	583.02	3702.04	1448.42	14.10	247.22	263.09	2348.59	1353.71	1262.75
1955	1810.39	2595.75	1346.19	48.45	199.07	1532.34	1886.96	708.79	1224.17
1956	1481.43	3882.16	1414.68	35.07	257.45	1168.67	2547.45	1334.71	1304.76
1957				32.08	227.86	1522.51	2481.72	1278.15	1675.42
1958				141.03	228.89	1425.89	2656.71	1902.85	1609.67
1959				94.83	264.46	671.00	2130.96	2232.76	1365.33
1960				89.91	238.78	1280.67	1616.42	1492.34	1299.30
1961				98.52	174.94	1052.77	1464.21	1007.77	884.82
1962				70.09	172.42	916.79	1294.95	902.29	808.21
1963				112.15	220.54	1180.38	1118.88	1069.85	1331.18
1964				87.01	207.47	718.63	986.50	793.93	767.33
1965				132.79	248.71	786.04	1187.70	714.95	1081.89
1966				136.44	226.38	1026.92	1535.84	731.57	821.78
1967				167.07	250.56	1313.09	1155.41	388.93	1074.81
1968				126.06	242.67	1187.51	1086.20	264.96	1271.15

Table 5. Data and derived quantities used to develop ratio estimates of total rockfish landings in the SCB. Gray shading indicates ratio estimate (see text for details). "Ratio years" are the range of years over which ratio estimates were calculated. Sources include the NMFS SWFSC ERD Live Access Server and several volumes of the CDF&G Fish Bulletin (FB) series.

	FB 105	NMFS ERD live-access server			foreign catch	Major SLO Ports		Source of	adjusted	ratio
year	Southern	San Diego	Los Angeles	Santa Barbara	landed in U.S.	Morro Bay	Avila	SLO catch	Santa Barbara	years
1916	966.62	330.18	620.06		7.11			ratio	9.27	1928-33
1917	1559.70	532.76	1000.51		11.47			ratio	14.96	1928-33
1918	1422.29	485.83	912.36		10.46			ratio	13.64	1928-33
1919	850.46	290.50	545.55		6.26			ratio	8.16	1928-33
1920	923.72	315.52	592.54		6.80			ratio	8.86	1928-33
1921	806.94	275.63	517.63		5.94			ratio	7.74	1928-33
1922	794.00	271.21	509.33		5.84			ratio	7.61	1928-33
1923	1063.85	363.39	682.43		7.83			ratio	10.20	1928-33
1924	1426.24	487.18	914.90		10.49			ratio	13.68	1928-33
1925	1564.44	534.38	1003.54		11.51			ratio	15.00	1928-33
1926	1941.86	663.30	1245.65		14.29			ratio	18.62	1928-33
1927	1611.49	550.45	1033.73		11.86			ratio	15.45	1928-33
1928	1373.50	554.76	769.85	46.65	2.24	17.44	13.90	ratio	15.31	1949-51
1929	1389.53	641.80	687.26	44.60	15.86	16.68	13.28	ratio	14.64	1949-51
1930	1415.63	477.91	906.13	21.15	10.44	7.91	6.30	ratio	6.94	1949-51
1931	1617.81	400.30	1182.35	30.91	4.25	11.56	9.21	ratio	10.14	1949-51
1932	1135.48	298.47	797.37	34.76	4.88	13.00	10.35	ratio	11.41	1949-51
1933	907.47	252.63	588.30	46.54	19.99	17.40	13.86	ratio	15.27	1949-51
1934	857.00	129.53	510.38	127.60	89.49	47.72	38.01	ratio	41.88	1949-51
1935	741.23	77.85	373.92	177.65	111.81	66.43	52.92	ratio	58.30	1949-51
1936	424.05	69.72	122.80	181.88	49.65	68.02	54.18	ratio	59.69	1949-51
1937	460.65	65.18	156.84	166.26	72.37	62.17	49.52	ratio	54.56	1949-51
1938	309.18	33.82	126.04	72.76	76.56	27.21	21.67	ratio	23.88	1949-51
1939	389.66	92.01	140.83	91.19	65.63	34.10	27.16	ratio	29.93	1949-51
1940	396.32	66.63	153.11	136.40	40.18	51.01	40.63	ratio	44.76	1949-51
1941	470.11	42.15	202.95	131.57	93.44	49.20	39.19	ratio	43.18	1949-51
1942	192.96	10.13	74.46	38.27	70.11	14.31	11.40	ratio	12.56	1949-51
1943	226.43	5.17	89.07	38.61	93.57	14.44	11.50	ratio	12.67	1949-51
1944	43.38	4.63	10.34	22.14	6.27	8.28	6.60	ratio	7.27	1949-51
1945	92.92	4.56	26.97	44.95	16.45	16.81	13.39	ratio	14.75	1949-51
1946	161.19	8.71	79.60	48.78	24.10	18.24	14.53	ratio	16.01	1949-51
1947	185.46	8.79	131.60	26.85	18.22	10.04	8.00	ratio	8.81	1949-51
1948	287.68	24.12	200.08	36.11	27.37	13.50	10.76	ratio	11.85	1949-51
1949	412.09	36.64	258.88	61.88	54.69	20.62	22.95	FB 80	18.30	
1950	427.87	33.67	294.00	85.96	14.24	41.23	28.68	FB 86	16.05	
1951	470.81	14.55	328.93	121.63	5.71	38.91	28.63	FB 89	54.08	
1952	366.25	9.47	218.59	108.15	30.04	32.53	25.91	FB 95, ratio	49.72	1949-51
1953	298.74	14.71	179.44	88.66	15.94	56.38	5.04	FB 102, ratio	27.23	1954-56
1954	583.02	14.10	247.22	263.09	58.61	183.91	43.30	FB 102	35.88	
1955	1810.39	48.45	199.07	1532.34	30.52	1393.82	119.73	FB 105	18.79	
1956	1481.43	35.07	257.45	1168.67	20.23	1026.90	69.94	FB 105	71.83	
1957		32.08	227.86	1522.51		1298.20	71.55	FB 108	152.76	
1958		141.03	228.89	1425.89		1136.08	88.64	FB 108, ratio	201.17	1954-57
1959		94.83	264.46	671.00		470.07	36.68	FB 111, ratio	164.25	1954-57
1960		89.91	238.78	1280.67		910.70	71.06	FB 117, ratio	298.92	1954-57
1961		98.52	174.94	1052.77		550.97	42.99	FB 121, ratio	458.81	1954-57
1962		70.09	172.42	916.79		602.72	56.92	FB 125	257.15	
1963		112.15	220.54	1180.38		652.24	230.78	FB 129	297.36	
1964		87.01	207.47	718.63		467.92	114.14	FB 132	136.56	
1965		132.79	248.71	786.04		453.99	40.04	FB 135	292.00	
1966		136.44	226.38	1026.92		666.11	82.68	FB 138	278.13	
1967		167.07	250.56	1313.09		721.16	96.73	FB 144	495.20	
1968		126.06	242.67	1187.51		612.31	34.81	FB 149	540.39	

Table 6. Estimated percentages (by weight) of cowcod in rockfish landings based on 5-year averages (1984-1988). Estimates for the Los Angeles, San Diego, and Santa Barbara (1916-1943) strata are from their respective hook-and-line fisheries. The estimate for the Santa Barbara (1944-1968) stratum is based on the combined trawl and hook-and-line fisheries.

Region (time period)	% cowcod, 1984-88
Santa Barbara (1916-1943)	4.95%
Santa Barbara (1944-1968)	5.56%
Los Angeles (1916-1968)	12.85%
San Diego (1916-1968)	2.10%

Table 7. Number of port samples and number of sampled rockfish (RF) by stratum (year, gear, port complex) for the five earliest-sampled years in the SCB (1984-1988).

Year	SB Hook & Line		SB Trawl		LA Hook & Line		SD Hook & Line	
	# samp.	# RF	# samp.	# RF	# samp.	# RF	# samp.	# RF
1984	11	297	11	366	15	485	19	492
1985	19	514	6	196	38	1098	19	739
1986	43	1335	5	215	38	1262	64	2388
1987	3	99	7	315	37	1422	55	2007
1988	15	537	0	0	9	316	25	848

Table 8. Effect of a 50% decrease in the estimated historical commercial catch (1900-1968).

Reference Point	Base model	Historical commercial catch (1900-68) reduced by 50%	units
Unfished summary (age-1+) biomass	5291	4632	metric tons
Unfished spawning biomass (SB_0)	2488	2179	metric tons
Unfished recruitment (R_0)	110	96.3	1000s of fish
40% of SB_0 (proxy for SB_{MSY})	995	871	metric tons
Exploitation rate at $F_{50\%}$ (proxy for F_{MSY})	2.7%	2.7%	percent
Spawning biomass in 2007 (SB_{2007})	94	92	metric tons
SB_{2007} / SB_0	3.8%	4.2%	percent

Table 9. Estimated recreational and commercial landings of cowcod [mt] in the Southern California Bight, 1900-2007.

year	recreational	commercial	total	year	recreational	commercial	total
1900		0.01	0.01	1954	24	34.05	58.05
1901		5.34	5.34	1955	42	27.62	69.62
1902		10.68	10.68	1956	49	37.80	86.80
1903		16.01	16.01	1957	37	38.43	75.43
1904		21.35	21.35	1958	33	43.54	76.54
1905		26.68	26.68	1959	22	45.09	67.09
1906		32.02	32.02	1960	36	49.18	85.18
1907		37.35	37.35	1961	33	50.05	83.05
1908		42.68	42.68	1962	35	37.92	72.92
1909		48.02	48.02	1963	30	47.21	77.21
1910		53.35	53.35	1964	34	36.07	70.07
1911		58.69	58.69	1965	43	50.97	93.97
1912		64.02	64.02	1966	85	47.41	132.41
1913		69.35	69.35	1967	110	63.22	173.22
1914		74.69	74.69	1968	77	63.87	140.87
1915		80.02	80.02	1969	53	94.98	147.98
1916		85.36	85.36	1970	79	55.92	134.92
1917		137.73	137.73	1971	62	68.06	130.06
1918		125.59	125.59	1972	90	102.51	192.51
1919		75.10	75.10	1973	97	108.79	205.79
1920		81.57	81.57	1974	129	114.26	243.26
1921		71.26	71.26	1975	109	112.47	221.47
1922		70.11	70.11	1976	140	131.35	271.35
1923		93.94	93.94	1977	100	132.44	232.44
1924		125.94	125.94	1978	73	147.75	220.75
1925		138.15	138.15	1979	86	187.52	273.52
1926		171.48	171.48	1980	96.43	142.62	239.05
1927		142.30	142.30	1981	26.55	197.59	224.14
1928		111.30	111.30	1982	96.99	228.55	325.54
1929		102.48	102.48	1983	15.13	126.55	141.68
1930		126.78	126.78	1984	21.22	221.14	242.35
1931		160.80	160.80	1985	35.99	204.75	240.73
1932		109.27	109.27	1986	45.99	146.99	192.98
1933		81.64	81.64	1987	29.14	76.62	105.76
1934		70.36	70.36	1988	13.91	86.60	100.52
1935		52.56	52.56	1989	20.60	17.38	37.98
1936		20.19	20.19	1990	21.60	10.41	32.01
1937		24.22	24.22	1991	20.90	7.10	28.00
1938		18.08	18.08	1992	20.70	17.21	37.91
1939		21.50	21.50	1993	9.68	14.85	24.53
1940		23.28	23.28	1994	26.01	13.63	39.65
1941		29.10	29.10	1995	1.75	23.30	25.04
1942		10.40	10.40	1996	5.36	24.57	29.93
1943		12.18	12.18	1997	1.85	7.30	9.15
1944		1.83	1.83	1998	2.81	1.21	4.03
1945		4.38	4.38	1999	3.77	3.47	7.24
1946		11.30	11.30	2000	4.49	0.45	4.94
1947		17.58	17.58	2001	0.25	0.25	0.50
1948		26.87	26.87	2002	0.25	0.25	0.50
1949		35.05	35.05	2003	0.25	0.25	0.50
1950		39.37	39.37	2004	0.25	0.25	0.50
1951	9	45.57	54.57	2005	0.25	0.25	0.50
1952	10	31.05	41.05	2006	0.25	0.25	0.50
1953	13	24.88	37.88	2007	0.25	0.25	0.50

Table 10: Area (km^2) between 50-300m in pseudo-blocks as defined by Butler et al. (1999).

pseudo-block	area [km^2]	% of total habitat
3	1417	23.2%
4	1289	21.1%
2	910	14.9%
684	254	4.2%
685	203	3.3%
667	195	3.2%
690	164	2.7%
710	163	2.7%
878	137	2.2%
683	125	2.0%
762	108	1.8%
867	108	1.8%
765	106	1.7%
740	82	1.3%
739	82	1.3%
861	81	1.3%
850	79	1.3%
806	73	1.2%
682	69	1.1%
725	64	1.0%
738	59	1.0%
761	54	0.9%
829	52	0.9%
709	46	0.7%
708	45	0.7%
707	43	0.7%
724	39	0.6%
807	38	0.6%
737	16	0.3%
719	9	0.2%

Table 11: Model selection for the delta-GLM CPFV logbook index. BIC selects the revised spatial stratification over the 1999 model structure, with and without the year-area interaction term. * Due to minor differences between the data used in the 1999 index and the revised index, it was impossible to exactly replicate the spatial stratification from the 1999 assessment.

Spatial stratification	model	distribution	# of parameters	BIC	delta-BIC
1999*	log(cpue) = year + month + pseudo.block	normal	70	9089.8	182.8
1999	log(cpue) = year + month + pseudo.block + year:pseudo.block	normal	1032	12095.9	3188.9
revised	log(cpue) = year + region	normal	48	9079.4	172.4
revised	log(cpue) = year + region + log.RF	normal	49	8914.5	7.6
revised	log(cpue) = year + region + log.RF + region:log.RF	normal	58	8907.0	0.0
revised	log(cpue) = year + region + log.RF + year:region	normal	382	10360.8	1453.8
1999	cpue = year + month + pseudo.block	binomial	69	8617.4	913.9
1999	cpue = year + month + pseudo.block + year:pseudo.block	binomial	1031	failed to converge	
revised	cpue = year + region	binomial	47	8901.0	1197.5
revised	cpue = year + region + log.RF	binomial	48	7703.5	0.0
revised	cpue = year + region + log.RF + year:region	binomial	381	failed to converge	

Table 12: Revised CPFV logbook index with jackknife CVs

year	index	CV
1963	0.51167	0.330
1964	0.39318	0.253
1965	0.27507	0.225
1966	0.23974	0.231
1967	0.14688	0.246
1968	0.17299	0.178
1969	0.18585	0.237
1970	0.20804	0.273
1971	0.25156	0.195
1972	0.13262	0.211
1973	0.22675	0.141
1974	0.21390	0.157
1975	0.26081	0.149
1976	0.15214	0.152
1977	0.13932	0.198
1978	0.10625	0.218
1979	0.08861	0.187
1980	0.06066	0.167
1981	0.08139	0.168
1982	0.04213	0.190
1983	0.06033	0.154
1984	0.05002	0.178
1985	0.03699	0.205
1986	0.04158	0.196
1987	0.02307	0.225
1988	0.03375	0.241
1989	0.02558	0.234
1990	0.03275	0.212
1991	0.04156	0.182
1992	0.03030	0.244
1993	0.03317	0.349
1994	0.02111	0.290
1995	0.01769	0.337
1996	0.01610	0.299
1997	0.00879	0.458
1998	0.01075	0.274
1999	0.00309	0.444
2000	0.00291	0.672

Table 13. Effect of removing visual survey from the 2005 assessment (with corrected selectivity). Steepness was fixed at h = 0.5.

	2005 assessment (selex = maturity)		
Reference Point	**with visual survey**	**without visual survey**	**units**
Unfished summary (age-1+) biomass	3481	3389	metric tons
Unfished spawning biomass (SB_0)	3320	3232	metric tons
Unfished recruitment (R_0)	65.0	63.3	1000s of fish
40% of SB_0 (proxy for SB_{MSY})	1328	1293	metric tons
Exploitation rate at $F_{50\%}$ (proxy for F_{MSY})	2.8%	2.8%	percent
Spawning biomass in end year (SB_{end})	313	61	metric tons
SB_{end} / SB_0	9.4%	1.9%	percent
Catchability coefficient for visual survey	2.3	n/a	n/a

Table 14. Profile over the CV of the prior distribution for catchability of the visual survey. These model runs were conducted as part of our preliminary analyses and therefore do not represent final model runs. The qualitative behavior from altering the CV of the prior distribution for catchability remains unchanged.

	CV of prior on (log) catchability for visual survey			
Reference Points	**1%**	**20%**	**50%**	**100%**
Unfished spawning biomass (SB0)	2542	2521	2495	2484
Unfished summary (age-1+) biomass	5405	5361	5306	5282
40% of SB0 (proxy for SBMSY)	1017	1008	998	994
Spawning biomass in final year	266	204	118	78
SB in final year / unfished SB	10.5%	8.1%	4.7%	3.1%
Parameter Estimates				
Unfished recruitment (R0)	112.3	111.4	110.3	109.8
Catchability for CPFV logbook index	1.71E-04	1.84E-04	2.07E-04	2.23E-04
Catchability for visual survey	0.75	1.20	2.98	5.75
Likelihood components				
Total negative log likelihood	28.6	25.1	18.4	13.9
CPFV logbook index	21.6	17.9	12.9	11.1
Visual survey	6.99	4.41	1.20	0.21
Prior on visual survey	0.01	2.77	4.27	2.66

Table 15. Bivariate likelihood profiles for the Beverton-Holt steepness parameter (h) and natural mortality (M), with associated estimates of unfished female spawning biomass, depletion, catchability for the visual survey, and MSY. These model runs were conducted as part of our preliminary analyses and therefore do not represent final model runs. The qualitative behavior of altering steepness and natural mortality remains unchanged.

Total Negative Log Likelihood (NLL)

		Natural Mortality		
		0.040	**0.055**	**0.070**
Steepness	**0.30**	16.5	16.6	16.6
	0.45	17.5	17.4	17.3
	0.60	18.1	17.9	17.7
	0.75	18.6	18.3	18.1
	0.90	19.4	21.6	26.0

Visual Survey NLL

		Natural Mortality		
		0.040	**0.055**	**0.070**
Steepness	**0.30**	0.91	0.92	0.93
	0.45	1.02	1.01	1.00
	0.60	1.08	1.05	1.01
	0.75	1.11	1.04	0.86
	0.90	1.06	0.42	0.17

CPFV Index NLL

		Natural Mortality		
		0.040	**0.055**	**0.070**
Steepness	**0.30**	11.99	11.98	11.94
	0.45	12.38	12.39	12.35
	0.60	12.65	12.67	12.66
	0.75	12.99	13.10	13.78
	0.90	14.06	19.44	25.02

Visual Survey Prior (NLL)

		Natural Mortality		
		0.040	**0.055**	**0.070**
Steepness	**0.30**	3.63	3.70	3.72
	0.45	4.06	4.04	3.98
	0.60	4.34	4.19	4.03
	0.75	4.46	4.14	3.43
	0.90	4.23	1.68	0.68

Unfished Spawning Biomass (SB_0)

		Natural Mortality		
		0.040	**0.055**	**0.070**
Steepness	**0.30**	3387	3052	2754
	0.45	3068	2692	2373
	0.60	2886	2494	2170
	0.75	2762	2361	2037
	0.90	2663	2271	1958

Catchability for 2002 visual survey

		Natural Mortality		
		0.040	**0.055**	**0.070**
Steepness	**0.30**	2.89	2.92	2.94
	0.45	3.12	3.11	3.08
	0.60	3.27	3.19	3.10
	0.75	3.34	3.17	2.78
	0.90	3.22	1.88	1.35

Depletion (SB_{2007} / SB_0)

		Natural Mortality		
		0.040	**0.055**	**0.070**
Steepness	**0.30**	3.7%	3.9%	4.1%
	0.45	3.8%	4.2%	4.6%
	0.60	4.0%	4.6%	5.2%
	0.75	4.2%	5.0%	6.4%
	0.90	4.7%	10.2%	16.8%

MSY

		Natural Mortality		
		0.040	**0.055**	**0.070**
Steepness	**0.30**	0.00	0.00	0.00
	0.45	39.57	46.20	51.54
	0.60	53.19	61.19	67.39
	0.75	57.87	65.89	71.99
	0.90	59.71	67.79	73.94

Table 16. Comparison of base model results (fixed h = 0.6) to a model that estimates steepness with a prior probability distribution from a meta-analysis of rockfish stocks.

Reference Points	base model	estimate steepness with prior
Unfished spawning biomass (SB0)	2488	2988
Unfished summary (age-1+) biomass	5291	6353
40% of SB0 (proxy for SBMSY)	995	1195
Spawning biomass in final year	94	97
SB in final year / unfished SB	3.8%	3.2%
Parameter Estimates		
Unfished recruitment (R0)	109.9	132.0
Catchability for CPFV logbook index	2.16E-04	2.00E-04
Catchability for visual survey	2.30	2.14
Steepness	**0.6 (fixed)**	**0.32**
Likelihood components		
Total negative log likelihood	16.5	16.1
CPFV logbook index	13.3	12.7
Visual survey	0.68	0.59
Prior on visual survey	2.51	2.79

Table 17. Summary statistics from the binomial GLM in the CPFV logbook delta-GLM model.

```
Call: glm(formula = cpue ~ season + region + logRF, family = binomial, data = bindat)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.4471  -0.7508  -0.3831   0.7736   2.8519

Coefficients:
                        Estimate Std. Error z value Pr(>|z|)
(Intercept)              0.94993    0.31499   3.016 0.002563 **
season1964              -0.09233    0.31936  -0.289 0.772505
season1965               0.25317    0.31383   0.807 0.419826
season1966               0.15198    0.30862   0.492 0.622389
season1967              -0.27623    0.31847  -0.867 0.385747
season1968               0.15311    0.31134   0.492 0.622864
season1969              -0.53414    0.31098  -1.718 0.085864 .
season1970              -0.37944    0.31557  -1.202 0.229219
season1971              -0.24020    0.31200  -0.770 0.441376
season1972              -0.14216    0.30483  -0.466 0.640962
season1973               1.02891    0.30179   3.409 0.000651 ***
season1974               0.68591    0.30422   2.255 0.024158 *
season1975               1.38708    0.30923   4.486 7.27e-06 ***
season1976               0.77587    0.30034   2.583 0.009786 **
season1977               0.22333    0.29943   0.746 0.455744
season1978               0.68891    0.37217   1.851 0.064157 .
season1979               0.13610    0.31073   0.438 0.661377
season1980               0.47993    0.29158   1.646 0.099772 .
season1981               0.47224    0.29235   1.615 0.106246
season1982              -0.01647    0.29626  -0.056 0.955675
season1983               0.71169    0.29634   2.402 0.016324 *
season1984               0.18727    0.29598   0.633 0.526914
season1985              -0.41398    0.31015  -1.335 0.181947
season1986              -0.15969    0.31048  -0.514 0.607013
season1987              -0.73989    0.31100  -2.379 0.017355 *
season1988              -0.72032    0.30421  -2.368 0.017893 *
season1989              -0.60857    0.30795  -1.976 0.048135 *
season1990              -0.45486    0.30450  -1.494 0.135235
season1991              -0.07619    0.29725  -0.256 0.797718
season1992              -0.37193    0.31357  -1.186 0.235574
season1993              -1.27221    0.34226  -3.717 0.000201 ***
season1994              -1.11143    0.33248  -3.343 0.000829 ***
season1995              -1.05965    0.32653  -3.245 0.001174 **
season1996              -0.86865    0.31566  -2.752 0.005925 **
season1997              -1.72993    0.38497  -4.494 7.00e-06 ***
season1998              -0.94803    0.32510  -2.916 0.003545 **
season1999              -2.04664    0.44463  -4.603 4.16e-06 ***
season2000              -2.10206    0.59788  -3.516 0.000438 ***
regionBackside_Catalina -1.05866    0.20891  -5.068 4.03e-07 ***
regionNorth_islands     -2.65911    0.19323 -13.762  < 2e-16 ***
regionOceanside         -1.67080    0.24216  -6.900 5.21e-12 ***
regionOffshore_banks    -0.65207    0.20922  -3.117 0.001830 **
regionSan_Clemente      -2.10109    0.21342  -9.845  < 2e-16 ***
regionSan_Nicolas       -1.77770    0.20612  -8.625  < 2e-16 ***
regionSan_Pedro_Channel -1.31484    0.19457  -6.758 1.40e-11 ***
regionSB_Hidden_Reef    -1.59668    0.20143  -7.927 2.25e-15 ***
regionSouth_coastal     -2.68037    0.21435 -12.504  < 2e-16 ***
logRF                    0.76015    0.02590  29.347  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

    Null deviance: 9789.1  on 7781  degrees of freedom
Residual deviance: 7273.4  on 7734  degrees of freedom
```

Table 18. Summary statistics from the Gaussian GLM in the CPFV logbook delta-GLM model.

```
glm(formula = log(cpue) ~ season + region + logRF + region:logRF, family = gaussian)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-4.4785  -0.8141   0.0913   0.9178   5.7089

Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                  -1.209800   0.283006  -4.275 1.99e-05 ***
season1964                   -0.236781   0.312932  -0.757 0.449331
season1965                   -0.685057   0.300901  -2.277 0.022891 *
season1966                   -0.798242   0.296449  -2.693 0.007136 **
season1967                   -1.163025   0.307126  -3.787 0.000156 ***
season1968                   -1.124844   0.299193  -3.760 0.000174 ***
season1969                   -0.833012   0.304861  -2.732 0.006332 **
season1970                   -0.778900   0.308135  -2.528 0.011541 *
season1971                   -0.637021   0.304601  -2.091 0.036601 *
season1972                   -1.308468   0.298521  -4.383 1.22e-05 ***
season1973                   -1.011320   0.278340  -3.633 0.000285 ***
season1974                   -1.021159   0.283891  -3.597 0.000328 ***
season1975                   -0.908640   0.276620  -3.285 0.001035 **
season1976                   -1.376032   0.281108  -4.895 1.05e-06 ***
season1977                   -1.358337   0.287368  -4.727 2.41e-06 ***
season1978                   -1.721394   0.330868  -5.203 2.13e-07 ***
season1979                   -1.789598   0.296210  -6.042 1.76e-09 ***
season1980                   -2.244806   0.278192  -8.069 1.10e-15 ***
season1981                   -1.949369   0.278580  -6.998 3.35e-12 ***
season1982                   -2.492199   0.287642  -8.664  < 2e-16 ***
season1983                   -2.291038   0.282161  -8.120 7.32e-16 ***
season1984                   -2.373959   0.290507  -8.172 4.81e-16 ***
season1985                   -2.493257   0.312544  -7.977 2.27e-15 ***
season1986                   -2.462944   0.310977  -7.920 3.57e-15 ***
season1987                   -2.832696   0.315551  -8.977  < 2e-16 ***
season1988                   -2.460784   0.307497  -8.003 1.86e-15 ***
season1989                   -2.785799   0.312227  -8.922  < 2e-16 ***
season1990                   -2.599893   0.305297  -8.516  < 2e-16 ***
season1991                   -2.488713   0.292618  -8.505  < 2e-16 ***
season1992                   -2.708233   0.316565  -8.555  < 2e-16 ***
season1993                   -2.195748   0.366933  -5.984 2.49e-09 ***
season1994                   -2.737882   0.350334  -7.815 8.08e-15 ***
season1995                   -2.942286   0.342562  -8.589  < 2e-16 ***
season1996                   -3.132509   0.326410  -9.597  < 2e-16 ***
season1997                   -3.233369   0.435156  -7.430 1.49e-13 ***
season1998                   -3.497139   0.340066 -10.284  < 2e-16 ***
season1999                   -4.050691   0.509022  -7.958 2.65e-15 ***
season2000                   -4.068197   0.707020  -5.754 9.80e-09 ***
regionBackside_Catalina      -1.270068   0.160118  -7.932 3.24e-15 ***
regionNorth_islands          -1.279452   0.150594  -8.496  < 2e-16 ***
regionOceanside              -2.154937   0.222795  -9.672  < 2e-16 ***
regionOffshore_banks          0.524952   0.156033   3.364 0.000779 ***
regionSan_Clemente           -1.124961   0.181650  -6.193 6.90e-10 ***
regionSan_Nicolas            -0.310789   0.169905  -1.829 0.067493 .
regionSan_Pedro_Channel      -1.738109   0.148275 -11.722  < 2e-16 ***
regionSB_Hidden_Reef         -0.506515   0.161100  -3.144 0.001686 **
regionSouth_coastal          -1.758563   0.197066  -8.924  < 2e-16 ***
logRF                        -0.005808   0.100492  -0.058 0.953919
regionBackside_Catalina:logRF -0.129265   0.131973  -0.979 0.327441
regionNorth_islands:logRF    -0.277307   0.111539  -2.486 0.012978 *
regionOceanside:logRF        -0.627487   0.189999  -3.303 0.000972 ***
regionOffshore_banks:logRF   -0.307573   0.149875  -2.052 0.040257 *
regionSan_Clemente:logRF     -0.042219   0.153253  -0.275 0.782967
```

```
regionSan_Nicolas:logRF        -0.359699   0.127861  -2.813 0.004944 **
regionSan_Pedro_Channel:logRF -0.233015   0.109458  -2.129 0.033369 *
regionSB_Hidden_Reef:logRF    -0.451922   0.121956  -3.706 0.000216 ***
regionSouth_coastal:logRF     -0.890979   0.132332  -6.733 2.06e-11 ***
---
(Dispersion parameter for gaussian family taken to be 1.733394)

    Null deviance: 7477.7  on 2511  degrees of freedom
Residual deviance: 4255.5  on 2455  degrees of freedom
```

Table 19. Number of port samples taken by gear, port complex, market category, and year in the SCB, 1983-1990. Species compositions from 1984-1988 (grey) were used to estimate the fraction of total rockfish that was cowcod in the historical fisheries. HKL = hook and line, TWL = trawl, OLA = Los Angeles, OSB = Santa Barbara, OSD = San Diego. Source: CALCOM, 2007.

Sum of sample_ct			year								
gear_grp	port_complex	mark_cat	1983	1984	1985	1986	1987	1988	1989	1990	Grand Total
HKL	OLA	250		3	9	1	3				16
		667		2	12	13	14	2	3		46
		956		6	3	8	7	3	10		37
		959		4	14	16	13	4	17		68
	OLA Total			15	38	38	37	9	30		167
	OSB	245							1		1
		250		3	8	17	2	2	1		33
		667			1	2	1	6	12	3	25
		956	1	3	6	16		2	7	1	36
		959	1	5	3	8		5	13	2	37
		960			1						1
	OSB Total		2	11	19	43	3	15	34	6	133
	OSD	250	10	17	8	52	35	15	5	3	145
		252		1							1
		269				1					1
		657								1	1
		667		1	8	3	3	4		1	20
		956						1	1		2
		959			3	8	17	5	10	4	47
	OSD Total		10	19	19	64	55	25	16	9	217
HKL Total			12	45	76	145	95	49	80	15	517
TWL	OSB	245		1							1
		250	5	2	1		5				13
		253	2	6							8
		956		1	3	4	1				9
		959		1	2						3
	OSB Total		7	11	6	4	6				34
TWL Total			7	11	6	4	6				34
Grand Total			19	56	82	149	101	49	80	15	551

Table 20. Summary of West Coast Slope/Shelf Combination Groundfish survey data within the Southern California Bight. Analysis restricted to tows between 50-300m. cc = cowcod.

Survey Year	# tows	sum area (sq m)	# cowcod	prop. pos.	avg. cc per hectare (avg. of ratios)	sum(cc) / sum(hectares)
2003	30	527239	4	0.067	0.072	0.076
2004	34	606968	11	0.118	0.185	0.181
2005	36	616654	11	0.167	0.179	0.178
2006	41	634469	19	0.146	0.275	0.299

Table 21. Comparison of requested model runs to base model (see item 16 under Responses to STAR panel requests).

	Model Description				
	base model, h = 0.6	h = 0.6	h = 0.6	h = 0.6	
Reference Point	CPFV Logbook & Visual Survey	CPFV Logbook only	Visual Survey only	CPFV Logbook with power term & Visual Survey	units
Unfished summary (age-1+) biomass	5303	5267	5764	5403	metric tons
Unfished female spawning biomass (SB_0)	2494	2477	2711	2541	metric tons
Unfished recruitment (R_0)	110	109	120	112	1000s of fish
40% of SB_0 (proxy for SB_{MSY})	997	991	1084	1016	metric tons
Exploitation rate at $F_{50\%}$ (proxy for F_{MSY})	2.7%	2.7%	2.7%	2.7%	percent
Spawning biomass in 2007 (SB_{2007})	113	52	658	264	metric tons
SB_{2007} / SB_0	4.6%	2.1%	24.3%	10.4%	percent
CPFV catchability exponent	1 (fixed)	1 (fixed)	n/a	1.56	n/a
Visual survey log catchability	1.16	n/a	-0.286	0.468	metric tons

Table 22. Sensitivity to estimates of historical commercial catch (+/- 50% relative to the base model).

Reference Point	Base model	Historical commercial catch (1900-68) reduced by 50%	Historical commercial catch (1900-68) increased by 50%	units
Unfished summary (age-1+) biomass	5303	4646	6063	metric tons
Unfished spawning biomass (SB_0)	2494	2185	2851	metric tons
Unfished recruitment (R_0)	110	96.5	126.0	1000s of fish
40% of SB_0 (proxy for SB_{MSY})	997	874	1141	metric tons
Exploitation rate at $F_{50\%}$ (proxy for F_{MSY})	2.7%	2.7%	2.7%	percent
Spawning biomass in 2007 (SB_{2007})	113	112	115	metric tons
SB_{2007} / SB_0	4.6%	5.1%	4.0%	percent

Table 23. Summary of runs requested to help bracket uncertainty in the base model. The three final models (shown in grey) used steepness values of 0.4, 0.6, and 0.8, and included either the visual survey and CPFV logbook index or only the visual survey. Models with only the CPFV index were not considered due to extreme estimates of exploitation rates.

		M = 0.04 Steepness			M = 0.055 Steepness			M = 0.07 Steepness		
Data	**Quantity**	**0.4**	**0.6**	**0.8**	**0.4**	**0.6**	**0.8**	**0.4**	**0.6**	**0.8**
Visual Survey & CPFV index	**SB_0**	3153	2886	2727	2785	2494	2324	2471	2170	2008
	SB_{2007}	119	115	117	115	113	121	111	112	179
	depletion	3.8%	4.0%	4.3%	**4.1%**	**4.6%**	5.2%	4.5%	5.2%	8.9%
Visual Survey only	**SB_0**	3465	3145	2943	3062	2711	2496	2721	2359	2143
	SB_{2007}	652	677	701	635	658	681	613	634	653
	depletion	18.8%	21.5%	23.8%	20.7%	24.3%	**27.3%**	22.5%	26.9%	30.5%
CPFV index only	**SB_0**	3123	2866	2713	2761	2477	2314	2449	2155	2005
	SB_{2007}	51	47	50	53	52	79	54	56	171
	depletion	1.6%	1.6%	1.9%	1.9%	2.1%	3.4%	2.2%	2.6%	8.5%

Table 24a. Population numbers (in thousands) at age by year (ages 0 – 39).

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
1900	109.94	104.06	98.49	93.22	88.23	83.51	79.04	74.81	70.81	67.02	63.43	60.04	56.82	53.78	50.90	48.18	45.60	43.16	40.85	38.67	36.60	34.64	32.78	31.03	29.37	27.80	26.31	24.90	23.57	22.31	21.11	19.98	18.92	17.90	16.94	16.04	15.18	14.37	13.60	12.87
1901	109.94	104.06	98.49	93.22	88.23	83.51	79.04	74.81	70.81	67.02	63.43	60.04	56.82	53.78	50.90	48.18	45.60	43.16	40.85	38.67	36.60	34.64	32.78	31.03	29.37	27.80	26.31	24.90	23.57	22.31	21.11	19.98	18.91	17.90	16.94	16.04	15.18	14.37	13.60	12.87
1902	109.92	104.06	98.49	93.22	88.23	83.51	79.04	74.81	70.80	67.00	63.41	60.01	56.79	53.75	50.86	48.14	45.56	43.12	40.81	38.63	36.56	34.60	32.75	31.00	29.34	27.77	26.28	24.88	23.54	22.28	21.09	19.96	18.89	17.88	16.93	16.02	15.16	14.35	13.58	12.86
1903	109.89	104.04	98.49	93.22	88.23	83.51	79.04	74.80	70.79	66.98	63.38	59.96	56.73	53.68	50.79	48.06	45.48	43.04	40.73	38.55	36.48	34.53	32.68	30.93	29.28	27.71	26.23	24.82	23.49	22.24	21.05	19.92	18.85	17.85	16.89	15.99	15.13	14.32	13.55	12.83
1904	109.83	104.01	98.47	93.22	88.23	83.51	79.03	74.79	70.77	66.95	63.33	59.90	56.65	53.58	50.68	47.94	45.36	42.91	40.61	38.43	36.37	34.42	32.58	30.83	29.18	27.62	26.14	24.74	23.42	22.16	20.98	19.86	18.79	17.79	16.84	15.93	15.08	14.27	13.51	12.79
1905	109.76	103.95	98.44	93.20	88.23	83.51	79.03	74.79	70.76	66.93	63.29	59.83	56.56	53.47	50.55	47.80	45.21	42.76	40.45	38.27	36.22	34.27	32.44	30.70	29.06	27.50	26.03	24.64	23.32	22.07	20.89	19.77	18.71	17.71	16.76	15.87	15.02	14.21	13.45	12.73
1906	109.66	103.88	98.39	93.17	88.22	83.51	79.03	74.78	70.74	66.90	63.24	59.76	56.46	53.35	50.41	47.64	45.03	42.57	40.26	38.09	36.03	34.09	32.26	30.53	28.90	27.35	25.89	24.50	23.19	21.95	20.77	19.66	18.61	17.61	16.67	15.78	14.94	14.14	13.38	12.66
1907	109.55	103.79	98.32	93.12	88.19	83.49	79.03	74.78	70.73	66.87	63.19	59.69	56.36	53.22	50.25	47.45	44.83	42.36	40.05	37.87	35.82	33.88	32.06	30.34	28.71	27.17	25.72	24.34	23.04	21.81	20.64	19.53	18.49	17.50	16.56	15.68	14.84	14.04	13.29	12.58
1908	109.42	103.69	98.24	93.06	88.14	83.46	79.01	74.77	70.71	66.84	63.14	59.61	56.26	53.08	50.08	47.26	44.61	42.13	39.80	37.62	35.57	33.64	31.83	30.11	28.50	26.97	25.52	24.16	22.86	21.64	20.48	19.38	18.35	17.37	16.44	15.56	14.72	13.94	13.19	12.48
1909	109.27	103.57	98.14	92.98	88.08	83.42	78.98	74.75	70.70	66.81	63.09	59.54	56.15	52.94	49.91	47.06	44.39	41.88	39.54	37.35	35.30	33.37	31.56	29.86	28.25	26.73	25.30	23.94	22.66	21.45	20.30	19.21	18.19	17.21	16.29	15.42	14.59	13.81	13.07	12.37
1910	109.10	103.42	98.02	92.89	88.01	83.36	78.94	74.72	70.67	66.78	63.04	59.46	56.04	52.80	49.74	46.85	44.15	41.62	39.27	37.06	35.00	33.08	31.27	29.57	27.98	26.47	25.05	23.71	22.44	21.23	20.10	19.02	18.00	17.04	16.13	15.27	14.45	13.68	12.94	12.25
1911	108.91	103.26	97.89	92.78	87.92	83.29	78.89	74.67	70.63	66.73	62.98	59.38	55.93	52.66	49.56	46.64	43.91	41.36	38.98	36.76	34.69	32.76	30.96	29.27	27.68	26.18	24.77	23.44	22.19	21.00	19.87	18.81	17.80	16.85	15.95	15.09	14.29	13.52	12.80	12.11
1912	108.71	103.09	97.74	92.65	87.81	83.21	78.82	74.61	70.58	66.68	62.92	59.30	55.82	52.51	49.38	46.43	43.67	41.09	38.68	36.45	34.37	32.43	30.63	28.94	27.36	25.87	24.47	23.16	21.91	20.74	19.63	18.57	17.58	16.64	15.75	14.91	14.11	13.35	12.64	11.96
1913	108.48	102.89	97.57	92.51	87.69	83.11	78.73	74.54	70.51	66.61	62.84	59.20	55.71	52.36	49.20	46.21	43.42	40.81	38.38	36.12	34.03	32.08	30.28	28.59	27.01	25.54	24.15	22.85	21.62	20.45	19.36	18.32	17.34	16.41	15.53	14.70	13.91	13.17	12.47	11.80
1914	108.23	102.67	97.38	92.35	87.56	82.99	78.64	74.46	70.43	66.53	62.75	59.10	55.58	52.21	49.01	45.99	43.16	40.52	38.07	35.79	33.68	31.73	29.91	28.22	26.65	25.18	23.81	22.51	21.30	20.15	19.07	18.05	17.08	16.16	15.30	14.48	13.71	12.97	12.28	11.62
1915	107.96	102.44	97.18	92.17	87.40	82.86	78.53	74.36	70.34	66.44	62.65	58.98	55.44	52.04	48.81	45.76	42.90	40.24	37.76	35.46	33.33	31.36	29.54	27.85	26.28	24.81	23.44	22.16	20.96	19.83	18.76	17.75	16.80	15.90	15.05	14.24	13.48	12.76	12.08	11.43
1916	107.66	102.18	96.95	91.98	87.24	82.72	78.40	74.26	70.24	66.34	62.54	58.85	55.28	51.86	48.61	45.53	42.64	39.94	37.44	35.12	32.97	30.99	29.16	27.46	25.89	24.43	23.07	21.79	20.60	19.48	18.43	17.44	16.50	15.62	14.78	13.99	13.24	12.53	11.86	11.23
1917	107.34	101.90	96.71	91.77	87.05	82.56	78.27	74.13	70.13	66.22	62.41	58.71	55.12	51.67	48.39	45.28	42.36	39.64	37.11	34.77	32.61	30.61	28.77	27.07	25.49	24.03	22.67	21.41	20.23	19.12	18.09	17.11	16.19	15.32	14.50	13.72	12.98	12.29	11.63	11.01
1918	106.79	101.60	96.45	91.54	86.85	82.38	78.10	73.95	69.91	65.95	62.06	58.28	54.61	51.10	47.76	44.61	41.67	38.93	36.39	34.04	31.88	29.89	28.06	26.37	24.81	23.36	22.02	20.78	19.62	18.54	17.53	16.58	15.68	14.84	14.04	13.29	12.57	11.90	11.26	10.66
1919	106.27	101.07	96.16	91.29	86.64	82.19	77.93	73.80	69.76	65.77	61.85	58.00	54.27	50.69	47.30	44.11	41.13	38.36	35.81	33.45	31.28	29.29	27.46	25.77	24.22	22.78	21.46	20.23	19.09	18.02	17.03	16.10	15.22	14.40	13.63	12.89	12.20	11.55	10.93	10.34
1920	106.00	100.59	95.66	91.02	86.40	81.99	77.77	73.69	69.71	65.78	61.90	58.08	54.36	50.76	47.33	44.10	41.08	38.28	35.68	33.29	31.09	29.08	27.22	25.52	23.95	22.51	21.17	19.94	18.80	17.74	16.75	15.82	14.96	14.15	13.38	12.66	11.98	11.34	10.73	10.16
1921	105.70	100.33	95.20	90.54	86.14	81.77	77.58	73.53	69.59	65.71	61.88	58.09	54.38	50.78	47.33	44.07	41.01	38.17	35.54	33.12	30.89	28.85	26.97	25.25	23.67	22.22	20.88	19.64	18.49	17.44	16.45	15.53	14.68	13.88	13.12	12.41	11.74	11.11	10.52	9.96
1922	105.45	100.04	94.96	90.11	85.70	81.53	77.37	73.36	69.45	65.63	61.85	58.12	54.45	50.88	47.43	44.15	41.06	38.18	35.52	33.06	30.80	28.72	26.82	25.08	23.48	22.01	20.65	19.41	18.26	17.19	16.21	15.29	14.44	13.65	12.90	12.20	11.54	10.92	10.33	9.78
1923	105.21	99.80	94.69	89.88	85.29	81.11	77.14	73.16	69.29	65.50	61.78	58.10	54.49	50.95	47.52	44.24	41.14	38.23	35.53	33.04	30.75	28.64	26.71	24.94	23.32	21.83	20.46	19.20	18.05	16.98	15.99	15.07	14.22	13.43	12.69	11.99	11.34	10.73	10.15	9.61
1924	104.85	99.58	94.46	89.62	85.07	80.71	76.73	72.92	69.05	65.26	61.54	57.87	54.28	50.77	47.37	44.10	41.00	38.08	35.37	32.85	30.54	28.41	26.46	24.68	23.04	21.54	20.17	18.90	17.74	16.67	15.68	14.77	13.92	13.14	12.41	11.72	11.08	10.48	9.91	9.38
1925	104.31	99.24	94.25	89.41	84.82	80.50	76.35	72.50	68.76	64.93	61.15	57.44	53.81	50.29	46.89	43.64	40.55	37.64	34.93	32.41	30.10	27.97	26.02	24.23	22.60	21.10	19.72	18.47	17.31	16.25	15.27	14.36	13.52	12.75	12.03	11.36	10.73	10.15	9.60	9.08
1926	103.69	98.73	93.92	89.20	84.62	80.27	76.14	72.12	68.33	64.60	60.76	56.97	53.28	49.72	46.31	43.05	39.98	37.09	34.39	31.88	29.58	27.45	25.51	23.73	22.10	20.60	19.24	17.99	16.84	15.78	14.81	13.92	13.09	12.33	11.63	10.97	10.36	9.79	9.25	8.75
1927	102.86	98.14	93.44	88.90	84.43	80.08	75.91	71.89	67.90	64.06	60.26	56.36	52.56	48.90	45.43	42.15	39.08	36.21	33.54	31.07	28.79	26.70	24.77	23.02	21.41	19.94	18.59	17.36	16.23	15.19	14.24	13.37	12.56	11.81	11.13	10.49	9.90	9.35	8.83	8.35
1928	102.18	97.35	92.89	88.44	84.14	79.90	75.73	71.69	67.73	63.74	59.88	56.05	52.18	48.45	44.91	41.58	38.49	35.62	32.96	30.51	28.24	26.16	24.26	22.51	20.91	19.45	18.11	16.89	15.77	14.74	13.80	12.94	12.14	11.41	10.73	10.11	9.53	8.99	8.49	8.02
1929	101.69	96.71	92.14	87.92	83.71	79.63	75.58	71.56	67.60	63.68	59.72	55.89	52.12	48.35	44.75	41.38	38.24	35.35	32.68	30.22	27.95	25.87	23.97	22.22	20.61	19.15	17.81	16.59	15.47	14.44	13.50	12.64	11.85	11.12	10.45	9.83	9.26	8.73	8.23	7.77
1930	101.25	96.24	91.53	87.21	83.21	79.22	75.32	71.42	67.49	63.59	59.71	55.79	52.03	48.36	44.73	41.30	38.12	35.18	32.49	30.01	27.74	25.66	23.75	21.99	20.39	18.92	17.57	16.34	15.22	14.19	13.25	12.39	11.60	10.87	10.20	9.59	9.02	8.49	8.01	7.56
1931	100.65	95.83	91.09	86.64	82.54	78.75	74.93	71.15	67.30	63.38	59.47	55.59	51.71	48.02	44.47	41.01	37.78	34.80	32.08	29.60	27.33	25.26	23.36	21.62	20.02	18.56	17.22	15.99	14.88	13.85	12.92	12.06	11.28	10.56	9.89	9.29	8.73	8.21	7.73	7.29
1932	99.78	95.26	90.70	86.22	82.00	78.11	74.46	70.73	66.95	63.05	59.07	55.09	51.19	47.36	43.77	40.37	37.11	34.11	31.38	28.89	26.64	24.59	22.72	21.01	19.44	18.00	16.69	15.48	14.38	13.38	12.46	11.62	10.85	10.14	9.49	8.90	8.35	7.85	7.38	6.95
1933	99.29	94.44	90.16	85.85	81.60	77.60	73.88	70.35	66.67	62.92	59.03	55.07	51.15	47.35	43.66	40.23	37.03	33.99	31.21	28.69	26.40	24.34	22.46	20.75	19.19	17.75	16.44	15.24	14.14	13.13	12.22	11.38	10.61	9.90	9.26	8.67	8.13	7.63	7.17	6.74
1934	99.01	93.98	89.39	85.34	81.25	77.23	73.41	69.83	66.38	62.76	59.06	55.23	51.36	47.57	43.92	40.42	37.19	34.19	31.36	28.77	26.44	24.33	22.42	20.69	19.11	17.67	16.35	15.14	14.04	13.02	12.10	11.25	10.48	9.77	9.12	8.53	7.98	7.48	7.02	6.60
1935	98.83	93.71	88.95	84.61	80.77	76.90	73.06	69.39	65.92	62.53	58.98	55.34	51.61	47.88	44.25	40.78	37.47	34.44	31.64	29.00	26.61	24.44	22.49	20.73	19.13	17.67	16.34	15.12	14.00	12.98	12.04	11.18	10.40	9.69	9.03	8.43	7.88	7.38	6.92	6.49
1936	98.80	93.54	88.70	84.19	80.08	76.44	72.76	69.09	65.55	62.17	58.86	55.40	51.88	48.30	44.73	41.28	38.00	34.89	32.05	29.44	26.98	24.75	22.73	20.91	19.27	17.79	16.43	15.19	14.06	13.02	12.07	11.20	10.40	9.67	9.01	8.40	7.84	7.33	6.86	6.43
1937	99.03	93.51	88.53	83.95	79.68	75.79	72.34	68.84	65.34	61.96	58.72	55.55	52.25	48.89	45.48	42.10	38.84	35.75	32.81	30.14	27.68	25.36	23.26	21.37	19.66	18.12	16.72	15.45	14.28	13.21	12.24	11.34	10.52	9.78	9.09	8.47	7.90	7.37	6.89	6.45
1938	99.23	93.73	88.51	83.80	79.46	75.41	71.72	68.44	65.10	61.74	58.49	55.38	52.35	49.19	46.00	42.77	39.57	36.49	33.58	30.82	28.30	25.99	23.82	21.84	20.06	18.46	17.01	15.70	14.50	13.41	12.41	11.49	10.65	9.88	9.18	8.54	7.95	7.41	6.92	6.47
1939	99.48	93.92	88.71	83.77	79.31	75.20	71.37	67.86	64.74	61.54	58.33	55.22	52.25	49.36	46.35	43.33	40.27	37.25	34.34	31.60	29.00	26.63	24.45	22.41	20.55	18.88	17.37	16.01	14.77	13.65	12.62	11.67	10.81	10.02	9.30	8.64	8.03	7.48	6.98	6.51
1940	99.70	94.16	88.89	83.96	79.29	75.07	71.17	67.53	64.18	61.18	58.12	55.05	52.07	49.23	46.47	43.62	40.76	37.87	35.02	32.28	29.70	27.25	25.03	22.98	21.06	19.32	17.74	16.32	15.04	13.88	12.82	11.86	10.97	10.16	9.42	8.74	8.12	7.55	7.03	6.56
1941	99.91	94.37	89.12	84.14	79.47	75.04	71.04	67.33	63.86	60.65	57.78	54.83	51.89	49.04	46.34	43.72	41.02	38.31	35.59	32.90	30.33	27.90	25.60	23.51	21.59	19.78	18.14	16.67	15.33	14.13	13.04	12.05	11.14	10.31	9.54	8.85	8.21	7.63	7.09	6.60
1942	100.07	94.56	89.32	84.35	79.63	75.22	71.01	67.20	63.66	60.33	57.24	54.47	51.64	48.82	46.10	43.52	41.04	38.49	35.94	33.38	30.86	28.44	26.16	24.01	22.05	20.24	18.55	17.01	15.63	14.38	13.25	12.23	11.30	10.44	9.66	8.95	8.30	7.70	7.15	6.65
1943	100.36	94.71	89.50	84.54	79.83	75.37	71.19	67.20	63.58	60.22	57.04	54.10	51.46	48.77	46.09	43.51	41.08	38.73	36.32	33.91	31.49	29.11	26.83	24.68	22.65	20.80	19.10	17.50	16.05	14.74	13.56	12.50	11.54	10.66	9.85	9.12	8.44	7.83	7.26	6.74
1944	100.63	94.99	89.64	84.71	80.01	75.56	71.33	67.36	63.58	60.13	56.93	53.90	51.10	48.59	46.03	43.49	41.05	38.74	36.52	34.25	31.97	29.69	27.45	25.30	23.27	21.35	19.61	18.01	16.50	15.13	13.90	12.79	11.79	10.88	10.05	9.29	8.60	7.96	7.38	6.85
1945	100.96	95.24	89.90	84.85	80.18	75.73	71.52	67.51	63.75	60.17	56.91	53.87	51.00	48.35	45.97	43.55	41.14	38.83	36.65	34.55	32.39	30.24	28.09	25.96	23.93	22.01	20.20	18.55	17.03	15.61	14.32	13.15	12.10	11.15	10.29	9.50	8.79	8.13	7.53	6.98
1946	101.26	95.55	90.14	85.09	80.31	75.89	71.68	67.68	63.89	60.33	56.92	53.83	50.95	48.23	45.72	43.46	41.17	38.89	36.71	34.64	32.66	30.62	28.59	26.55	24.54	22.62	20.81	19.09	17.53	16.10	14.75	13.53	12.43	11.44	10.54	9.73	8.98	8.31	7.69	7.12
1947	101.51	95.84	90.44	85.32	80.54	76.01	71.82	67.83	64.04	60.43	57.04	53.80	50.85	48.11	45.53	43.15	41.01	38.84	36.69	34.63	32.68	30.80	28.88	26.96	25.04	23.15	21.34	19.63	18.01	16.54	15.19	13.92	12.76	11.72	10.79	9.94	9.17	8.47	7.83	7.25
1948	101.70	96.07	90.71	85.60	80.75	76.23	71.93	67.96	64.16	60.55	57.10	53.86	50.78	47.97	45.36	42.91	40.65	38.63	36.58	34.55	32.60	30.77	29.00	27.19	25.39	23.58	21.79	20.09	18.48	16.96	15.57	14.30	13.10	12.02	11.04	10.16	9.36	8.64	7.98	7.38
1949	101.83	96.26	90.93	85.86	81.02	76.43	72.14	68.05	64.26	60.63	57.16	53.86	50.76	47.81	45.13	42.65	40.33	38.19	36.28	34.35	32.44	30.62	28.89	27.23	25.53	23.84	22.14	20.46	18.86	17.35	15.92	14.62	13.42	12.30	11.28	10.36	9.54	8.79	8.11	7.49
1950	101.90	96.38	91.11	86.07	81.26	76.68	72.33	68.24	64.34	60.70	57.20	53.87	50.69	47.72	44.90	42.36	40.01	37.81	35.79	34.00	32.18	30.39	28.68	27.06	25.51	23.92	22.33	20.74	19.17	17.67	16.25	14.91	13.70	12.57	11.52	10.57	9.71	8.93	8.23	7.60
1951	101.93	96.44	91.22	86.23	81.46	76.91	72.56	68.41	64.50	60.75	57.24	53.87	50.66	47.62	44.78	42.10	39.68	37.46	35.39	33.50	31.81	30.11	28.43	26.83	25.32	23.86	22.38	20.89	19.40	17.93	16.53	15.20	13.95	12.81	11.76	10.78	9.89	9.08	8.36	7.70
1952	101.87	96.48	91.28	86.34	81.61	77.07	72.74	68.57	64.57	60.79	57.16	53.76	50.51	47.42	44.52	41.82	39.28	37.00	34.92	32.98	31.21	29.63	28.05	26.48	24.99	23.58	22.23	20.84	19.46	18.07	16.70	15.40	14.16	12.99	11.93	10.96	10.04	9.21	8.46	7.78
1953	101.89	96.42	91.31	86.39	81.71	77.21	72.89	68.74	64.74	60.90	57.25	53.76	50.50	47.40	44.46	41.70	39.15	36.76	34.62	32.66	30.84	29.19	27.71	26.23	24.77	23.37	22.05	20.79	19.49	18.19	16.90	15.62	14.40	13.24	12.15	11.16	10.25	9.39	8.61	7.91
1954	101.92	96.43	91.26	86.42	81.76	77.30	73.02	68.88	64.89	61.05	57.35	53.86	50.52	47.41	44.46	41.68	39.08	36.67	34.42	32.42	30.58	28.87	27.32	25.94	24.56	23.19	21.88	20.64	19.46	18.24	17.03	15.82	14.62	13.48	12.40	11.38	10.45	9.59	8.79	8.06
1955	101.83	96.47	91.27	86.37	81.78	77.33	73.05	68.91	64.90	61.04	57.32	53.76	50.40	47.21	44.26	41.46	38.84	36.40	34.15	32.05	30.17	28.46	26.87	25.43	24.14	22.85	21.58	20.36	19.21	18.11	16.98	15.85	14.72	13.61	12.54	11.54	10.59	9.72	8.93	8.18
1956	101.65	96.38	91.31	86.38	81.71	77.30	72.99	68.82	64.78	60.88	57.13	53.54	50.13	46.93	43.91	41.13	38.51	36.06	33.78	31.68	29.73	27.99	26.40	24.93	23.59	22.39	21.20	20.01	18.89	17.82	16.80	15.75	14.70	13.65	12.62	11.63	10.70	9.82	9.02	8.28
1957	101.36	96.21	91.22	86.41	81.71	77.22	72.93	68.71	64.61	60.65	56.84	53.21	49.75	46.49	43.46	40.62	38.01	35.57	33.29	31.18	29.24	27.44	25.83	24.36	23.00	21.76	20.66	19.56	18.47	17.43	16.44	15.50	14.53	13.57	12.60	11.65	10.73	9.87	9.06	8.32
1958	101.14	95.94	91.06	86.33	81.75	77.25	72.90	68.73	64.61	60.61	56.76	53.07	49.57	46.28	43.18	40.32	37.65	35.21	32.94	30.82	28.86	27.06	25.39	23.90	22.54	21.29	20.14	19.12	18.10	17.09	16.13	15.22	14.34	13.45	12.56	11.66	10.78	9.93	9.14	8.39
1959	100.91	95.73	90.80	86.18	81.68	77.29	72.95	68.72	64.65	60.63	56.73	53.00	49.45	46.11	42.97	40.05	37.36	34.87	32.59	30.48	28.51	26.70	25.03	23.49	22.11	20.85	19.69	18.63	17.69	16.74	15.81	14.92	14.07	13.27	12.44	11.61	10.78	9.97	9.19	8.45
1960	100.74	95.51	90.60	85.94	81.55	77.25	73.04	68.84	64.74	60.78	56.87	53.10	49.50	46.10	42.92	39.96	37.21	34.69	32.35	30.24	28.27	26.45	24.76	23.21	21.78	20.50	19.34	18.26	17.28	16.40	15.52	14.66	13.83	13.05	12.30	11.53	10.77	10.00	9.24	8.52
1961	100.44	95.35	90.39	85.75	81.31	77.10	72.93	68.82	64.70	60.68	56.81	53.01	49.38	45.94	42.71	39.70	36.92	34.35	32.01	29.85	27.89	26.07	24.39	22.83	21.41	20.08	18.90	17.83	16.83	15.93	15.12	14.31	13.52	12.75	12.03	11.34	10.64	9.93	9.22	8.52
1962	100.16	95.07	90.24	85.55	81.13	76.87	72.80	68.73	64.71	60.68	56.75	52.98	49.32	45.84	42.57	39.52	36.70	34.10	31.71	29.54	27.54	25.73	24.05	22.49	21.06	19.74	18.52	17.44	16.44	15.53	14.69	13.95	13.20	12.47	11.76	11.10	10.46	9.81	9.16	8.50
1963	99.95	94.80	89.98	85.40	80.94	76.70	72.58	68.60	64.63	60.70	56.78	52.98	49.36	45.86	42.56	39.48	36.62	33.99	31.57	29.35	27.34	25.48	23.80	22.26	20.81	19.48	18.27	17.14	16.13	15.21	14.37	13.59	12.91	12.21	11.53	10.88	10.27	9.68	9.08	8.47
1964	99.70	94.60	89.72	85.15	80.81	76.53	72.43	68.42	64.53	60.64	56.80	52.99	49.33	45.87	42.55	39.43	36.54	33.87	31.42	29.17	27.11	25.25	23.53	21.98	20.55	19.22	17.99	16.87	15.83	14.90	14.05	13.27	12.55	11.92	11.28	10.65	10.05	9.48	8.94	8.38
1965	99.52	94.37	89.53	84.91	80.57	76.39	72.26	68.26	64.34	60.54	56.76	53.04	49.38	45.89	42.61	39.48	36.56	33.86	31.37	29.09	27.01	25.10	23.37	21.78	20.35	19.02	17.79	16.65	15.62	14.65	13.79	13.01	12.28	11.62	11.03	10.44	9.86	9.30	8.78	8.27
1966	99.15	94.19	89.32	84.73	80.33	76.14	72.08	68.01	64.07	60.19	56.45	52.76	49.17	45.67	42.35	39.26	36.34	33.62	31.12	28.82	26.72	24.80	23.05	21.46	20.00	18.69	17.46	16.34	15.29	14.34	13.45	12.66	11.94	11.28	10.67	10.13	9.59	9.05	8.54	8.06
1967	98.47	93.84	89.15	84.52	80.12	75.81	71.64	67.53	63.42	59.45	55.60	51.92	48.35	44.92	41.63	38.54	35.68	32.99	30.51	28.22	26.13	24.23	22.49	20.90	19.46	18.13	16.94	15.83	14.81	13.86	13.00	12.19	11.48	10.83	10.22	9.67	9.18	8.69	8.21	7.74
1968	97.43	93.20	88.82	84.35	79.89	75.54	71.18	66.89	62.66	58.45	54.45	50.63	47.05	43.64	40.41	37.36	34.52	31.92	29.49	27.25	25.21	23.33	21.63	20.07	18.66	17.37	16.19	15.12	14.13	13.22	12.38	11.60	10.89	10.25	9.66	9.13	8.63	8.20	7.76	7.33
1969	96.61	92.21	88.21	84.04	79.76	75.40	71.07	66.69	62.35	58.09	53.90	49.96	46.25	42.82	39.60	36.59	33.76	31.16	28.79	26.58	24.56	22.71	21.02	19.48	18.08	16.80	15.65	14.58	13.62	12.73	11.91	11.15	10.45	9.81	9.23	8.71	8.22	7.78	7.38	6.99
1970	95.69	91.44	87.28	83.48	79.49	75.33	71.04	66.72	62.30	57.93	53.66	49.51	45.65	42.06	38.79	35.75	32.96	30.36	27.99	25.84	23.84	22.02	20.36	18.85	17.47	16.21	15.06	14.03	13.07	12.21	11.41	10.67	9.99	9.37	8.79	8.27	7.80	7.37	6.97	6.62
1971	94.86	90.57	86.54	82.58	78.93	75.01	70.84	66.50	62.13	57.69	53.35	49.17	45.17	41.49	38.12	35.07	32.28	29.72	27.35	25.20	23.26	21.46	19.82	18.32	16.96	15.72	14.59	13.56	12.62	11.76	10.99	10.27	9.61	8.99	8.43	7.91	7.45	7.02	6.63	6.27
1972	94.06	89.78	85.72	81.89	78.10	74.52	70.61	66.43	62.05	57.66	53.25	48.99	44.94	41.12	37.65	34.50	31.68	29.11	26.78	24.64	22.69	20.94	19.32	17.84	16.49	15.26	14.14	13.13	12.20	11.36	10.58	9.89	9.24	8.64	8.09	7.59	7.12	6.70	6.32	5.97
1973	92.55	89.02	84.98	81.10	77.41	73.64	69.96	65.90	61.53	57.01	52.53	48.13	43.96	40.07	36.48	33.26	30.38	27.84	25.55	23.48	21.58	19.87	18.33	16.91	15.62	14.44	13.36	12.38	11.49	10.68	9.94	9.27	8.66	8.09	7.57	7.08	6.64	6.23	5.87	5.53
1974	90.78	87.60	84.25	80.40	76.65	72.95	69.06	65.16	60.86	56.31	51.68	47.19	42.88	38.88	35.24	31.93	29.01	26.44	24.19	22.17	20.36	18.71	17.22	15.88	14.65	13.53	12.51	11.58	10.73	9.96	9.25	8.61	8.03	7.50	7.01	6.56	6.14	5.75	5.40	5.08
1975	88.37	85.93	82.91	79.71	75.94	72.12	68.18	63.95	59.67	55.07	50.34	45.68	41.29	37.19	33.49	30.19	27.24	24.68	22.44	20.51	18.78	17.24	15.84	14.58	13.44	12.40	11.45	10.58	9.80	9.08	8.42	7.83	7.29	6.79	6.35	5.93	5.55	5.19	4.87	4.57
1976	86.01	83.64	81.32	78.43	75.30	71.48	67.46	63.22	58.67	54.11	49.35	44.60	40.06	35.89	32.10	28.74	25.79	23.20	20.98	19.05	17.39	15.92	14.61	13.42	12.35	11.39	10.51	9.70	8.97	8.30	7.69	7.14	6.63	6.18	5.76	5.38	5.03	4.70	4.40	4.13
1977	82.56	81.40	79.16	76.92	74.04	70.73	66.57	62.08	57.34	52.38	47.55	42.71	38.07	33.79	29.99	26.62	23.70	21.18	19.00	17.15	15.56	14.19	12.99	11.91	10.94	10.07	9.29	8.57	7.91	7.31	6.77	6.27	5.82	5.41	5.04	4.69	4.38	4.10	3.83	3.59
1978	79.35	78.14	77.04	74.89	72.65	69.65	66.06	61.54	56.65	51.58	46.40	41.50	36.76	32.38	28.46	25.05	22.10	19.59	17.46	15.63	14.09	12.78	11.65	10.66	9.78	8.98	8.26	7.62	7.03	6.49	6.00	5.55	5.15	4.78	4.44	4.13	3.85	3.60	3.36	3.14
1979	75.98	75.10	73.95	72.89	70.76	68.42	65.19	61.25	56.35	51.12	45.79	40.54	35.70	31.20	27.17	23.65	20.68	18.15	16.03	14.25	12.74	11.47	10.40	9.48	8.67	7.95	7.30	6.72	6.20	5.72	5.28	4.88	4.52	4.18	3.88	3.61	3.36	3.13	2.93	2.73
1980	70.89	71.92	71.07	69.96	68.84	66.53	63.80	60.03	55.45	49.99	44.34	38.82	33.63	29.03	24.95	21.43	18.46	16.01	13.98	12.30	10.91	9.74	8.77	7.94	7.24	6.62	6.07	5.58	5.13	4.73	4.37	4.03	3.73	3.45	3.20	2.97	2.76	2.57	2.39	2.23
1981	65.94	67.10	68.06	67.23	66.03	64.61	61.83	58.45	53.98	48.81	43.01	37.29	31.97	27.17	23.09	19.59	16.67	14.26	12.31	10.71	9.41	8.33	7.44	6.69	6.06	5.52	5.05	4.63	4.25	3.91	3.61	3.33	3.07	2.84	2.63	2.44	2.26	2.10	1.96	1.82
1982	60.66	62.41	63.51	64.40	63.57	62.29	60.63	57.45	53.46	48.35	42.65	36.58	30.88	25.81	21.46	17.91	14.97	12.60	10.70	9.19	7.97	6.99	6.18	5.51	4.96	4.49	4.09	3.74	3.43	3.15	2.90	2.67	2.47	2.28	2.11	1.95	1.81	1.68	1.56	1.45
1983	50.37	57.41	59.06	60.05	60.72	59.48	57.44	54.63	50.14	44.86	38.81	32.66	26.75	21.63	17.42	14.04	11.43	9.39	7.80	6.57	5.61	4.85	4.24	3.75	3.34	3.01	2.72	2.48	2.27	2.08	1.91	1.76	1.62	1.50	1.38	1.28	1.18	1.10	1.02	0.94
1984	46.59	47.68	54.34	55.89	56.79	57.30	55.84	53.41	50.02	44.96	39.24	33.03	27.05	21.59	17.07	13.49	10.72	8.63	7.03	5.81	4.88	4.16	3.59	3.14	2.78	2.48	2.23	2.01	1.84	1.68	1.54	1.41	1.30	1.20	1.11	1.02	0.94	0.87	0.81	0.75
1985	37.14	44.10	45.12	51.41	52.82	53.48	53.48	51.19	47.52	42.70	36.46	30.03	23.81	18.40	13.93	10.53	8.02	6.20	4.89	3.94	3.23	2.69	2.29	1.97	1.73	1.52	1.36	1.22	1.11	1.01	0.92	0.84	0.78	0.71	0.66	0.61	0.56	0.52	0.48	0.44
1986	25.94	35.15	41.73	42.68	48.52	49.62	49.40	48.05	44.03	38.51	32.15	25.26	19.05	13.84	9.86	6.95	4.95	3.60	2.69	2.08	1.65	1.34	1.11	0.94	0.81	0.71	0.63	0.56	0.50	0.45	0.41	0.38	0.35	0.32	0.29	0.27	0.25	0.23	0.21	0.20
1987	16.49	24.56	33.26	39.45	40.18	45.18	45.08	43.24	39.67	33.61	26.70	19.98	13.96	9.35	6.06	3.90	2.52	1.68	1.16	0.84	0.63	0.50	0.40	0.33	0.28	0.24	0.21	0.19	0.17	0.15	0.13	0.12	0.11	0.10	0.09	0.09	0.08	0.07	0.07	0.06
1988	12.84	15.60	23.24	31.45	37.16	37.45	41.24	39.71	36.16	30.98	24.17	17.52	11.90	7.56	4.63	2.78	1.68	1.03	0.66	0.45	0.32	0.24	0.19	0.15	0.12	0.10	0.09	0.08	0.07	0.06	0.06	0.05	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.03
1989	9.43	12.15	14.77	21.98	29.67	34.79	34.43	36.56	33.18	27.76	21.32	14.61	9.15	5.33	2.90	1.53	0.81	0.44	0.25	0.15	0.10	0.07	0.05	0.04	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1990	10.07	8.92	11.50	13.96	20.69	27.64	31.82	30.66	31.46	27.45	22.02	16.21	10.67	6.45	3.64	1.93	1.00	0.52	0.28	0.16	0.10	0.06	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
1991	10.99	9.54	8.44	10.87	13.14	19.28	25.31	28.43	26.61	26.48	22.39	17.44	12.50	8.05	4.77	2.66	1.40	0.72	0.37	0.20	0.11	0.07	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	11.99	10.40	9.02	7.98	10.24	12.26	17.70	22.74	24.92	22.74	22.07	18.25	13.94	9.84	6.25	3.67	2.03	1.06	0.54	0.28	0.15	0.08	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	12.08	11.36	9.84	8.53	7.52	9.55	11.25	15.85	19.77	20.96	18.47	17.32	13.87	10.30	7.10	4.43	2.56	1.40	0.73	0.37	0.19	0.10	0.06	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	12.76	11.43	10.74	9.31	8.05	7.06	8.89	10.33	14.31	17.48	18.11	15.59	14.30	11.23	8.20	5.57	3.44	1.98	1.08	0.56	0.28	0.15	0.08	0.04	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	11.93	12.08	10.82	10.15	8.75	7.48	6.43	7.87	8.83	11.80	13.90	13.92	11.62	10.39	7.99	5.74	3.85	2.36	1.35	0.73	0.38	0.19	0.10	0.05	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	11.82	11.29	11.43	10.23	9.60	8.27	7.03	5.99	7.21	7.93	10.32	11.81	11.48	9.33	8.14	6.13	4.33	2.88	1.74	0.99	0.54	0.28	0.14	0.07	0.04	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	10.96	11.18	10.69	10.82	9.67	9.04	7.72	6.48	5.40	6.33	6.74	8.47	9.36	8.82	6.96	5.93	4.38	3.06	2.01	1.21	0.69	0.37	0.19	0.10	0.05	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	11.60	10.37	10.59	10.11	10.23	9.14	8.52	7.24	6.03	4.98	5.78	6.09	7.58	8.30	7.75	6.08	5.15	3.80	2.64	1.73	1.04	0.59	0.32	0.16	0.08	0.04	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	12.61	10.98	9.82	10.02	9.56	9.66	8.60	7.99	6.76	5.61	4.62	5.34	5.61	6.96	7.61	7.10	5.56	4.71	3.47	2.41	1.58	0.95	0.54	0.29	0.15	0.08	0.04	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	13.26	11.93	10.39	9.29	9.47	9.02	9.08	8.05	7.43	6.25	5.15	4.21	4.84	5.06	6.26	6.82	6.35	4.96	4.20	3.09	2.15	1.41	0.85	0.48	0.26	0.13	0.07	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	14.07	12.55	11.29	9.84	8.78	8.93	8.48	8.49	7.49	6.88	5.76	4.74	3.86	4.43	4.63	5.71	6.22	5.79	4.53	3.83	2.82	1.96	1.28	0.77	0.44	0.24	0.12	0.06	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	15.24	13.31	11.88	10.69	9.31	8.31	8.45	8.02	8.03	7.08	6.50	5.44	4.47	3.64	4.18	4.36	5.39	5.87	5.46	4.27	3.61	2.66	1.85	1.21	0.73	0.41	0.22	0.11	0.06	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	16.40	14.42	12.60	11.24	10.12	8.81	7.86	7.99	7.58	7.59	6.69	6.14	5.14	4.22	3.44	3.95	4.12	5.08	5.53	5.15	4.03	3.40	2.50	1.74	1.14	0.69	0.39	0.21	0.11	0.05	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2004	17.54	15.52	13.65	11.93	10.64	9.57	8.33	7.44	7.56	7.17	7.17	6.32	5.80	4.85	3.98	3.25	3.72	3.88	4.80	5.22	4.86	3.80	3.21	2.36	1.64	1.08	0.65	0.37	0.20	0.10	0.05	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2005	18.67	16.60	14.69	12.92	11.29	10.07	9.06	7.88	7.03	7.15	6.77	6.78	5.97	5.47	4.58	3.76	3.06	3.52	3.67	4.53	4.93	4.58	3.58	3.03	2.23	1.55	1.02	0.61	0.35	0.19	0.10	0.05	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2006	19.78	17.67	15.71	13.90	12.23	10.68	9.53	8.57	7.46	6.65	6.75	6.40	6.40	5.63	5.17	4.32	3.55	2.89	3.32	3.46	4.27	4.65	4.33	3.38	2.86	2.10	1.46	0.96	0.58	0.33	0.18	0.09	0.05	0.02	0.01	0.01	0.00	0.00	0.00	0.00
2007	20.87	18.72	16.72	14.87	13.16	11.57	10.11	9.01	8.10	7.05	6.28	6.38	6.05	6.05	5.32	4.88	4.08	3.35	2.73	3.13	3.27	4.03	4.39	4.08	3.19	2.70	1.99	1.38	0.91	0.54	0.31	0.17	0.09	0.04	0.02	0.01	0.01	0.00	0.00	0.00

Table 24b. Population numbers (in thousands) at age by year (ages 40-80+).

	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1900	12.18	11.53	10.91	10.33	9.78	9.25	8.76	8.29	7.85	7.43	7.03	6.65	6.30	5.96	5.64	5.34	5.05	4.78	4.53	4.28	4.06	3.84	3.63	3.44	3.25	3.08	2.92	2.76	2.61	2.47	2.34	2.21	2.10	1.98	1.88	1.78	1.68	1.59	1.51	1.43	25.22
1901	12.18	11.53	10.91	10.33	9.78	9.25	8.76	8.29	7.85	7.43	7.03	6.65	6.30	5.96	5.64	5.34	5.05	4.78	4.53	4.28	4.06	3.84	3.63	3.44	3.25	3.08	2.92	2.76	2.61	2.47	2.34	2.21	2.10	1.98	1.88	1.78	1.68	1.59	1.51	1.43	25.22
1902	12.17	11.52	10.90	10.32	9.77	9.24	8.75	8.28	7.84	7.42	7.02	6.65	6.29	5.95	5.63	5.33	5.05	4.78	4.52	4.28	4.05	3.83	3.63	3.43	3.25	3.08	2.91	2.76	2.61	2.47	2.34	2.21	2.09	1.98	1.88	1.78	1.68	1.59	1.51	1.42	25.19
1903	12.14	11.49	10.88	10.30	9.74	9.22	8.73	8.26	7.82	7.40	7.01	6.63	6.28	5.94	5.62	5.32	5.04	4.77	4.51	4.27	4.04	3.83	3.62	3.43	3.24	3.07	2.91	2.75	2.60	2.46	2.33	2.21	2.09	1.98	1.87	1.77	1.68	1.59	1.50	1.42	25.14
1904	12.10	11.46	10.84	10.26	9.71	9.19	8.70	8.24	7.80	7.38	6.98	6.61	6.26	5.92	5.60	5.30	5.02	4.75	4.50	4.26	4.03	3.81	3.61	3.42	3.23	3.06	2.90	2.74	2.59	2.46	2.32	2.20	2.08	1.97	1.87	1.77	1.67	1.58	1.50	1.42	25.06
1905	12.05	11.41	10.80	10.22	9.67	9.15	8.66	8.20	7.76	7.35	6.95	6.58	6.23	5.90	5.58	5.28	5.00	4.73	4.48	4.24	4.01	3.80	3.59	3.40	3.22	3.05	2.88	2.73	2.58	2.45	2.31	2.19	2.07	1.96	1.86	1.76	1.66	1.57	1.49	1.41	24.95
1906	11.99	11.34	10.74	10.16	9.62	9.10	8.62	8.16	7.72	7.31	6.92	6.55	6.19	5.86	5.55	5.25	4.97	4.71	4.45	4.22	3.99	3.78	3.57	3.38	3.20	3.03	2.87	2.71	2.57	2.43	2.30	2.18	2.06	1.95	1.85	1.75	1.65	1.57	1.48	1.40	24.81
1907	11.91	11.27	10.67	10.10	9.56	9.04	8.56	8.10	7.67	7.26	6.87	6.50	6.15	5.83	5.51	5.22	4.94	4.67	4.42	4.19	3.96	3.75	3.55	3.36	3.18	3.01	2.85	2.70	2.56	2.42	2.29	2.16	2.05	1.94	1.84	1.74	1.64	1.56	1.47	1.39	24.65
1908	11.82	11.18	10.59	10.02	9.48	8.98	8.50	8.04	7.61	7.20	6.82	6.45	6.11	5.78	5.47	5.18	4.90	4.64	4.39	4.16	3.93	3.72	3.52	3.34	3.16	2.99	2.83	2.68	2.53	2.40	2.27	2.15	2.03	1.92	1.82	1.72	1.63	1.54	1.46	1.38	24.46
1909	11.71	11.09	10.49	9.93	9.40	8.90	8.42	7.97	7.54	7.14	6.76	6.40	6.05	5.73	5.42	5.13	4.86	4.60	4.35	4.12	3.90	3.69	3.49	3.31	3.13	2.96	2.80	2.65	2.51	2.38	2.25	2.13	2.02	1.91	1.81	1.71	1.62	1.53	1.45	1.37	24.25
1910	11.60	10.97	10.39	9.83	9.31	8.81	8.34	7.89	7.47	7.07	6.69	6.33	5.99	5.67	5.37	5.08	4.81	4.55	4.31	4.08	3.86	3.65	3.46	3.27	3.10	2.93	2.77	2.63	2.49	2.35	2.23	2.11	1.99	1.89	1.79	1.69	1.60	1.52	1.43	1.36	24.01
1911	11.47	10.85	10.27	9.72	9.20	8.71	8.24	7.80	7.38	6.99	6.61	6.26	5.93	5.61	5.31	5.02	4.76	4.50	4.26	4.03	3.82	3.61	3.42	3.24	3.06	2.90	2.74	2.60	2.46	2.33	2.20	2.08	1.97	1.87	1.77	1.67	1.58	1.50	1.42	1.34	23.74
1912	11.32	10.72	10.14	9.60	9.09	8.60	8.14	7.70	7.29	6.90	6.53	6.18	5.85	5.54	5.24	4.96	4.70	4.44	4.21	3.98	3.77	3.57	3.38	3.20	3.02	2.86	2.71	2.56	2.43	2.30	2.17	2.06	1.95	1.84	1.75	1.65	1.56	1.48	1.40	1.33	23.44
1913	11.17	10.57	10.00	9.47	8.96	8.48	8.03	7.60	7.19	6.81	6.44	6.10	5.77	5.46	5.17	4.89	4.63	4.38	4.15	3.93	3.72	3.52	3.33	3.15	2.98	2.82	2.67	2.53	2.39	2.27	2.14	2.03	1.92	1.82	1.72	1.63	1.54	1.46	1.38	1.31	23.12
1914	11.00	10.41	9.85	9.33	8.83	8.36	7.91	7.48	7.08	6.70	6.35	6.01	5.68	5.38	5.09	4.82	4.56	4.32	4.09	3.87	3.66	3.47	3.28	3.10	2.94	2.78	2.63	2.49	2.36	2.23	2.11	2.00	1.89	1.79	1.70	1.60	1.52	1.44	1.36	1.29	22.77
1915	10.82	10.24	9.69	9.17	8.68	8.22	7.78	7.36	6.97	6.59	6.24	5.91	5.59	5.29	5.01	4.74	4.49	4.25	4.02	3.80	3.60	3.41	3.23	3.05	2.89	2.74	2.59	2.45	2.32	2.20	2.08	1.97	1.86	1.76	1.67	1.58	1.49	1.41	1.34	1.27	22.40
1916	10.63	10.06	9.52	9.01	8.53	8.07	7.64	7.23	6.84	6.48	6.13	5.80	5.49	5.20	4.92	4.66	4.41	4.17	3.95	3.74	3.54	3.35	3.17	3.00	2.84	2.69	2.54	2.41	2.28	2.16	2.04	1.93	1.83	1.73	1.64	1.55	1.47	1.39	1.31	1.24	22.00
1917	10.42	9.86	9.33	8.84	8.36	7.91	7.49	7.09	6.71	6.35	6.01	5.69	5.39	5.10	4.82	4.57	4.32	4.09	3.87	3.66	3.47	3.28	3.11	2.94	2.78	2.63	2.49	2.36	2.23	2.11	2.00	1.89	1.79	1.70	1.61	1.52	1.44	1.36	1.29	1.22	21.57
1918	10.09	9.55	9.04	8.56	8.10	7.66	7.25	6.87	6.50	6.15	5.82	5.51	5.22	4.94	4.67	4.42	4.19	3.96	3.75	3.55	3.36	3.18	3.01	2.85	2.70	2.55	2.41	2.29	2.16	2.05	1.94	1.83	1.74	1.64	1.56	1.47	1.39	1.32	1.25	1.18	20.89
1919	9.79	9.27	8.77	8.30	7.86	7.44	7.04	6.66	6.31	5.97	5.65	5.35	5.06	4.79	4.53	4.29	4.06	3.84	3.64	3.44	3.26	3.08	2.92	2.76	2.62	2.48	2.34	2.22	2.10	1.99	1.88	1.78	1.68	1.59	1.51	1.43	1.35	1.28	1.21	1.15	20.27
1920	9.61	9.10	8.61	8.15	7.71	7.30	6.91	6.54	6.19	5.86	5.55	5.25	4.97	4.70	4.45	4.21	3.99	3.77	3.57	3.38	3.20	3.03	2.87	2.71	2.57	2.43	2.30	2.18	2.06	1.95	1.85	1.75	1.65	1.57	1.48	1.40	1.33	1.26	1.19	1.13	19.90
1921	9.42	8.92	8.44	7.99	7.56	7.16	6.77	6.41	6.07	5.74	5.44	5.14	4.87	4.61	4.36	4.13	3.91	3.70	3.50	3.31	3.14	2.97	2.81	2.66	2.52	2.38	2.25	2.13	2.02	1.91	1.81	1.71	1.62	1.53	1.45	1.37	1.30	1.23	1.17	1.10	19.50
1922	9.25	8.76	8.29	7.85	7.43	7.03	6.65	6.30	5.96	5.64	5.34	5.05	4.78	4.53	4.28	4.06	3.84	3.63	3.44	3.25	3.08	2.92	2.76	2.61	2.47	2.34	2.21	2.10	1.98	1.88	1.78	1.68	1.59	1.51	1.43	1.35	1.28	1.21	1.14	1.08	19.16
1923	9.09	8.60	8.14	7.71	7.30	6.90	6.54	6.19	5.85	5.54	5.24	4.96	4.70	4.45	4.21	3.98	3.77	3.57	3.38	3.20	3.03	2.86	2.71	2.57	2.43	2.30	2.18	2.06	1.95	1.84	1.75	1.65	1.56	1.48	1.40	1.33	1.26	1.19	1.12	1.06	18.82
1924	8.88	8.40	7.95	7.52	7.12	6.74	6.38	6.04	5.71	5.41	5.12	4.85	4.59	4.34	4.11	3.89	3.68	3.48	3.30	3.12	2.95	2.80	2.65	2.50	2.37	2.24	2.12	2.01	1.90	1.80	1.70	1.61	1.53	1.44	1.37	1.29	1.23	1.16	1.10	1.04	18.37
1925	8.59	8.13	7.69	7.28	6.89	6.52	6.17	5.84	5.53	5.23	4.95	4.69	4.44	4.20	3.97	3.76	3.56	3.37	3.19	3.02	2.86	2.70	2.56	2.42	2.29	2.17	2.05	1.94	1.84	1.74	1.65	1.56	1.48	1.40	1.32	1.25	1.19	1.12	1.06	1.00	17.77
1926	8.28	7.83	7.41	7.01	6.64	6.28	5.95	5.63	5.33	5.04	4.77	4.52	4.27	4.05	3.83	3.62	3.43	3.25	3.07	2.91	2.75	2.61	2.47	2.33	2.21	2.09	1.98	1.87	1.77	1.68	1.59	1.50	1.42	1.35	1.27	1.21	1.14	1.08	1.02	0.97	17.12
1927	7.89	7.47	7.07	6.69	6.33	5.99	5.67	5.36	5.08	4.81	4.55	4.30	4.07	3.86	3.65	3.45	3.27	3.09	2.93	2.77	2.62	2.48	2.35	2.22	2.11	1.99	1.89	1.79	1.69	1.60	1.51	1.43	1.36	1.28	1.21	1.15	1.09	1.03	0.98	0.92	16.32
1928	7.58	7.17	6.78	6.42	6.07	5.75	5.44	5.15	4.87	4.61	4.37	4.13	3.91	3.70	3.50	3.32	3.14	2.97	2.81	2.66	2.52	2.38	2.26	2.14	2.02	1.91	1.81	1.71	1.62	1.54	1.45	1.38	1.30	1.23	1.17	1.10	1.04	0.99	0.94	0.89	15.67
1929	7.35	6.94	6.57	6.21	5.88	5.56	5.26	4.98	4.72	4.46	4.22	4.00	3.78	3.58	3.39	3.21	3.04	2.87	2.72	2.57	2.44	2.31	2.18	2.07	1.96	1.85	1.75	1.66	1.57	1.49	1.41	1.33	1.26	1.19	1.13	1.07	1.01	0.96	0.91	0.86	15.16
1930	7.13	6.74	6.37	6.03	5.70	5.39	5.10	4.83	4.57	4.33	4.10	3.88	3.67	3.47	3.29	3.11	2.94	2.79	2.64	2.50	2.36	2.24	2.12	2.00	1.90	1.79	1.70	1.61	1.52	1.44	1.36	1.29	1.22	1.16	1.09	1.04	0.98	0.93	0.88	0.83	14.70
1931	6.88	6.49	6.14	5.80	5.49	5.19	4.91	4.65	4.40	4.16	3.94	3.73	3.53	3.34	3.16	2.99	2.83	2.68	2.54	2.40	2.27	2.15	2.04	1.93	1.82	1.73	1.63	1.55	1.46	1.38	1.31	1.24	1.17	1.11	1.05	1.00	0.94	0.89	0.84	0.80	14.13
1932	6.55	6.18	5.84	5.52	5.22	4.93	4.67	4.41	4.18	3.95	3.74	3.54	3.35	3.17	3.00	2.84	2.69	2.55	2.41	2.28	2.16	2.04	1.93	1.83	1.73	1.64	1.55	1.47	1.39	1.32	1.25	1.18	1.12	1.06	1.00	0.95	0.90	0.85	0.80	0.76	13.43
1933	6.35	5.99	5.65	5.33	5.04	4.76	4.50	4.26	4.03	3.82	3.61	3.42	3.23	3.06	2.90	2.74	2.60	2.46	2.32	2.20	2.08	1.97	1.87	1.77	1.67	1.58	1.50	1.42	1.34	1.27	1.20	1.14	1.08	1.02	0.96	0.91	0.86	0.82	0.77	0.73	12.95
1934	6.21	5.85	5.51	5.20	4.91	4.64	4.39	4.15	3.92	3.71	3.51	3.33	3.15	2.98	2.82	2.67	2.53	2.39	2.26	2.14	2.03	1.92	1.82	1.72	1.63	1.54	1.46	1.38	1.31	1.24	1.17	1.11	1.05	0.99	0.94	0.89	0.84	0.80	0.75	0.71	12.61
1935	6.10	5.74	5.41	5.10	4.81	4.54	4.29	4.06	3.84	3.63	3.43	3.25	3.07	2.91	2.75	2.61	2.47	2.33	2.21	2.09	1.98	1.87	1.77	1.68	1.59	1.50	1.42	1.35	1.27	1.21	1.14	1.08	1.02	0.97	0.92	0.87	0.82	0.78	0.74	0.70	12.31
1936	6.04	5.67	5.34	5.03	4.74	4.47	4.22	3.99	3.77	3.57	3.37	3.19	3.02	2.86	2.71	2.56	2.42	2.29	2.17	2.05	1.94	1.84	1.74	1.65	1.56	1.48	1.40	1.32	1.25	1.19	1.12	1.06	1.01	0.95	0.90	0.85	0.81	0.76	0.72	0.68	12.10
1937	6.05	5.68	5.33	5.02	4.73	4.45	4.20	3.97	3.75	3.55	3.35	3.17	3.00	2.84	2.69	2.54	2.41	2.28	2.16	2.04	1.93	1.83	1.73	1.64	1.55	1.47	1.39	1.31	1.24	1.18	1.11	1.05	1.00	0.95	0.89	0.85	0.80	0.76	0.72	0.68	12.02
1938	6.06	5.68	5.33	5.01	4.71	4.44	4.18	3.95	3.73	3.52	3.33	3.15	2.98	2.82	2.67	2.52	2.39	2.26	2.14	2.02	1.92	1.81	1.72	1.62	1.54	1.46	1.38	1.30	1.23	1.17	1.11	1.05	0.99	0.94	0.89	0.84	0.79	0.75	0.71	0.67	11.92
1939	6.09	5.70	5.34	5.01	4.71	4.43	4.17	3.94	3.71	3.51	3.31	3.13	2.96	2.80	2.65	2.51	2.37	2.25	2.13	2.01	1.90	1.80	1.71	1.62	1.53	1.45	1.37	1.30	1.23	1.16	1.10	1.04	0.98	0.93	0.88	0.83	0.79	0.75	0.71	0.67	11.85
1940	6.12	5.72	5.36	5.02	4.71	4.43	4.17	3.92	3.70	3.49	3.30	3.11	2.94	2.78	2.63	2.49	2.36	2.23	2.11	2.00	1.89	1.79	1.69	1.60	1.52	1.44	1.36	1.29	1.22	1.15	1.09	1.03	0.98	0.93	0.88	0.83	0.78	0.74	0.70	0.67	11.77
1941	6.16	5.75	5.38	5.03	4.72	4.43	4.16	3.91	3.69	3.47	3.28	3.10	2.92	2.77	2.61	2.47	2.34	2.21	2.10	1.98	1.88	1.78	1.68	1.59	1.51	1.43	1.35	1.28	1.21	1.14	1.08	1.03	0.97	0.92	0.87	0.82	0.78	0.74	0.70	0.66	11.68
1942	6.19	5.77	5.39	5.04	4.72	4.42	4.15	3.90	3.67	3.46	3.26	3.07	2.90	2.74	2.59	2.45	2.32	2.19	2.08	1.97	1.86	1.76	1.67	1.58	1.49	1.41	1.34	1.27	1.20	1.13	1.07	1.02	0.96	0.91	0.86	0.82	0.77	0.73	0.69	0.65	11.57
1943	6.27	5.84	5.45	5.09	4.76	4.45	4.17	3.92	3.68	3.46	3.26	3.07	2.90	2.74	2.59	2.45	2.31	2.19	2.07	1.96	1.85	1.75	1.66	1.57	1.49	1.41	1.33	1.26	1.19	1.13	1.07	1.01	0.96	0.91	0.86	0.81	0.77	0.73	0.69	0.65	11.53
1944	6.36	5.91	5.51	5.14	4.80	4.48	4.20	3.93	3.69	3.47	3.26	3.07	2.90	2.73	2.58	2.44	2.31	2.18	2.06	1.95	1.85	1.75	1.65	1.57	1.48	1.40	1.33	1.26	1.19	1.13	1.07	1.01	0.95	0.90	0.86	0.81	0.77	0.72	0.69	0.65	11.49
1945	6.48	6.02	5.60	5.21	4.86	4.54	4.24	3.97	3.72	3.49	3.28	3.09	2.91	2.74	2.59	2.44	2.31	2.18	2.06	1.95	1.85	1.75	1.65	1.57	1.48	1.40	1.33	1.26	1.19	1.13	1.06	1.01	0.95	0.90	0.85	0.81	0.77	0.72	0.69	0.65	11.48
1946	6.60	6.12	5.69	5.29	4.93	4.59	4.29	4.01	3.75	3.52	3.30	3.10	2.92	2.75	2.59	2.44	2.31	2.18	2.06	1.95	1.84	1.75	1.65	1.56	1.48	1.40	1.33	1.25	1.19	1.12	1.06	1.01	0.95	0.90	0.85	0.81	0.76	0.72	0.68	0.65	11.46
1947	6.71	6.22	5.77	5.36	4.99	4.65	4.33	4.04	3.78	3.54	3.32	3.11	2.93	2.75	2.59	2.44	2.31	2.18	2.06	1.95	1.84	1.74	1.65	1.56	1.47	1.40	1.32	1.25	1.18	1.12	1.06	1.00	0.95	0.90	0.85	0.80	0.76	0.72	0.68	0.65	11.43
1948	6.83	6.32	5.86	5.44	5.05	4.70	4.37	4.08	3.81	3.56	3.33	3.12	2.93	2.76	2.59	2.44	2.30	2.17	2.05	1.94	1.83	1.73	1.64	1.55	1.47	1.39	1.31	1.24	1.18	1.11	1.05	1.00	0.94	0.89	0.85	0.80	0.76	0.72	0.68	0.64	11.37
1949	6.93	6.41	5.93	5.50	5.10	4.74	4.41	4.11	3.83	3.58	3.34	3.13	2.93	2.75	2.59	2.43	2.29	2.16	2.04	1.92	1.82	1.72	1.63	1.54	1.46	1.38	1.30	1.23	1.17	1.10	1.05	0.99	0.94	0.89	0.84	0.79	0.75	0.71	0.67	0.64	11.28
1950	7.02	6.49	6.00	5.56	5.15	4.78	4.44	4.13	3.85	3.59	3.35	3.13	2.93	2.75	2.58	2.42	2.28	2.15	2.02	1.91	1.80	1.70	1.61	1.52	1.44	1.36	1.29	1.22	1.16	1.09	1.04	0.98	0.93	0.88	0.83	0.79	0.74	0.70	0.67	0.63	11.16
1951	7.11	6.56	6.07	5.62	5.20	4.82	4.47	4.15	3.86	3.60	3.36	3.13	2.93	2.74	2.57	2.41	2.27	2.13	2.01	1.89	1.79	1.69	1.59	1.51	1.42	1.35	1.28	1.21	1.14	1.08	1.02	0.97	0.92	0.87	0.82	0.78	0.74	0.70	0.66	0.62	11.03
1952	7.17	6.62	6.11	5.65	5.23	4.84	4.49	4.17	3.87	3.60	3.35	3.13	2.92	2.73	2.55	2.39	2.25	2.11	1.99	1.87	1.76	1.66	1.57	1.48	1.40	1.33	1.26	1.19	1.12	1.06	1.01	0.95	0.90	0.85	0.81	0.76	0.72	0.69	0.65	0.61	10.85
1953	7.28	6.71	6.19	5.72	5.29	4.89	4.53	4.20	3.90	3.62	3.37	3.13	2.92	2.73	2.55	2.39	2.24	2.10	1.97	1.86	1.75	1.65	1.56	1.47	1.39	1.31	1.24	1.17	1.11	1.05	0.99	0.94	0.89	0.84	0.80	0.76	0.72	0.68	0.64	0.61	10.72
1954	7.40	6.81	6.28	5.79	5.35	4.95	4.58	4.24	3.93	3.65	3.39	3.15	2.93	2.74	2.55	2.39	2.24	2.10	1.97	1.85	1.74	1.64	1.54	1.46	1.38	1.30	1.23	1.16	1.10	1.04	0.98	0.93	0.88	0.83	0.79	0.75	0.71	0.67	0.63	0.60	10.61
1955	7.50	6.89	6.34	5.84	5.39	4.98	4.61	4.26	3.95	3.66	3.39	3.15	2.93	2.73	2.55	2.38	2.22	2.08	1.95	1.83	1.72	1.62	1.52	1.44	1.36	1.28	1.21	1.14	1.08	1.02	0.97	0.92	0.87	0.82	0.78	0.73	0.70	0.66	0.62	0.59	10.43
1956	7.59	6.96	6.39	5.88	5.42	5.00	4.62	4.27	3.95	3.66	3.39	3.15	2.92	2.72	2.53	2.36	2.21	2.06	1.93	1.81	1.70	1.60	1.50	1.41	1.33	1.26	1.19	1.12	1.06	1.00	0.95	0.90	0.85	0.80	0.76	0.72	0.68	0.65	0.61	0.58	10.22
1957	7.64	7.00	6.42	5.90	5.43	5.00	4.62	4.26	3.94	3.65	3.38	3.13	2.90	2.70	2.51	2.34	2.18	2.03	1.90	1.78	1.67	1.57	1.47	1.39	1.30	1.23	1.16	1.10	1.04	0.98	0.93	0.88	0.83	0.78	0.74	0.70	0.66	0.63	0.60	0.56	9.96
1958	7.70	7.07	6.48	5.94	5.46	5.02	4.63	4.27	3.95	3.65	3.38	3.13	2.90	2.69	2.50	2.32	2.16	2.02	1.88	1.76	1.65	1.54	1.45	1.36	1.28	1.21	1.14	1.07	1.01	0.96	0.91	0.86	0.81	0.77	0.73	0.69	0.65	0.61	0.58	0.55	9.74
1959	7.76	7.12	6.54	5.99	5.50	5.05	4.65	4.28	3.95	3.65	3.37	3.12	2.89	2.68	2.49	2.31	2.15	2.00	1.87	1.74	1.63	1.52	1.43	1.34	1.26	1.19	1.12	1.05	0.99	0.94	0.89	0.84	0.79	0.75	0.71	0.67	0.63	0.60	0.57	0.54	9.52
1960	7.84	7.19	6.60	6.06	5.56	5.10	4.68	4.31	3.97	3.66	3.38	3.13	2.90	2.68	2.48	2.31	2.14	1.99	1.86	1.73	1.62	1.51	1.41	1.33	1.24	1.17	1.10	1.04	0.98	0.92	0.87	0.82	0.78	0.73	0.69	0.66	0.62	0.59	0.56	0.53	9.33
1961	7.86	7.23	6.63	6.09	5.59	5.12	4.70	4.32	3.97	3.66	3.38	3.12	2.88	2.67	2.47	2.29	2.13	1.97	1.84	1.71	1.60	1.49	1.39	1.30	1.22	1.15	1.08	1.01	0.95	0.90	0.85	0.80	0.76	0.72	0.68	0.64	0.61	0.57	0.54	0.51	9.09
1962	7.86	7.25	6.67	6.12	5.62	5.16	4.73	4.33	3.98	3.66	3.38	3.12	2.88	2.66	2.46	2.28	2.11	1.96	1.82	1.69	1.58	1.47	1.37	1.28	1.20	1.13	1.06	0.99	0.93	0.88	0.83	0.78	0.74	0.70	0.66	0.62	0.59	0.56	0.53	0.50	8.85
1963	7.87	7.27	6.70	6.17	5.66	5.20	4.77	4.37	4.01	3.68	3.39	3.12	2.88	2.66	2.46	2.28	2.11	1.96	1.81	1.69	1.57	1.46	1.36	1.27	1.19	1.11	1.04	0.98	0.92	0.86	0.81	0.77	0.72	0.68	0.65	0.61	0.58	0.55	0.52	0.49	8.66
1964	7.83	7.27	6.72	6.19	5.70	5.23	4.80	4.41	4.04	3.70	3.40	3.13	2.88	2.66	2.46	2.27	2.10	1.95	1.81	1.68	1.56	1.45	1.35	1.26	1.17	1.10	1.03	0.96	0.90	0.85	0.80	0.75	0.71	0.67	0.63	0.60	0.56	0.53	0.50	0.48	8.45
1965	7.76	7.24	6.73	6.22	5.73	5.27	4.84	4.44	4.08	3.74	3.43	3.15	2.90	2.67	2.46	2.28	2.10	1.95	1.80	1.67	1.55	1.44	1.34	1.25	1.16	1.09	1.02	0.95	0.89	0.84	0.79	0.74	0.70	0.66	0.62	0.58	0.55	0.52	0.49	0.47	8.26
1966	7.60	7.12	6.65	6.18	5.71	5.26	4.84	4.44	4.08	3.75	3.43	3.15	2.89	2.66	2.45	2.26	2.09	1.93	1.79	1.66	1.53	1.42	1.32	1.23	1.15	1.07	1.00	0.93	0.87	0.82	0.77	0.72	0.68	0.64	0.60	0.57	0.54	0.51	0.48	0.45	8.01
1967	7.31	6.89	6.46	6.03	5.60	5.18	4.77	4.39	4.03	3.70	3.40	3.11	2.85	2.62	2.41	2.22	2.05	1.89	1.75	1.62	1.50	1.39	1.29	1.20	1.12	1.04	0.97	0.90	0.85	0.79	0.74	0.70	0.65	0.62	0.58	0.55	0.52	0.49	0.46	0.43	7.68
1968	6.91	6.52	6.15	5.77	5.38	5.00	4.62	4.26	3.92	3.59	3.30	3.03	2.78	2.55	2.34	2.15	1.98	1.83	1.69	1.56	1.45	1.34	1.24	1.15	1.07	1.00	0.93	0.86	0.81	0.75	0.71	0.66	0.62	0.58	0.55	0.52	0.49	0.46	0.43	0.41	7.24
1969	6.60	6.23	5.88	5.54	5.19	4.85	4.50	4.16	3.84	3.53	3.24	2.97	2.73	2.50	2.29	2.11	1.94	1.79	1.65	1.52	1.41	1.30	1.21	1.12	1.04	0.96	0.90	0.84	0.78	0.73	0.68	0.64	0.60	0.56	0.53	0.49	0.47	0.44	0.41	0.39	6.89
1970	6.27	5.92	5.58	5.27	4.97	4.66	4.35	4.04	3.73	3.44	3.16	2.90	2.67	2.45	2.24	2.06	1.89	1.74	1.60	1.48	1.37	1.26	1.17	1.08	1.00	0.93	0.86	0.80	0.75	0.70	0.65	0.61	0.57	0.53	0.50	0.47	0.44	0.42	0.39	0.37	6.53
1971	5.96	5.64	5.32	5.02	4.74	4.47	4.19	3.91	3.63	3.36	3.09	2.85	2.61	2.40	2.20	2.02	1.85	1.70	1.56	1.44	1.33	1.23	1.14	1.05	0.97	0.90	0.84	0.78	0.72	0.67	0.63	0.59	0.55	0.51	0.48	0.45	0.42	0.40	0.38	0.35	6.21
1972	5.65	5.36	5.07	4.79	4.52	4.27	4.02	3.77	3.52	3.27	3.02	2.78	2.56	2.35	2.16	1.98	1.82	1.67	1.53	1.41	1.30	1.20	1.11	1.02	0.95	0.88	0.81	0.75	0.70	0.65	0.61	0.57	0.53	0.49	0.46	0.43	0.41	0.38	0.36	0.34	5.91
1973	5.22	4.94	4.69	4.44	4.19	3.96	3.73	3.52	3.30	3.08	2.86	2.64	2.44	2.24	2.06	1.89	1.74	1.59	1.46	1.34	1.23	1.14	1.05	0.97	0.90	0.83	0.77	0.71	0.66	0.61	0.57	0.53	0.49	0.46	0.43	0.40	0.38	0.36	0.33	0.31	5.47
1974	4.79	4.53	4.28	4.07	3.85	3.63	3.43	3.24	3.05	2.86	2.67	2.48	2.29	2.11	1.94	1.78	1.64	1.50	1.38	1.26	1.16	1.07	0.98	0.91	0.84	0.78	0.72	0.66	0.62	0.57	0.53	0.49	0.46	0.43	0.40	0.37	0.35	0.33	0.31	0.29	5.01
1975	4.30	4.06	3.83	3.62	3.44	3.26	3.07	2.90	2.74	2.58	2.42	2.26	2.10	1.94	1.79	1.64	1.51	1.39	1.27	1.17	1.07	0.98	0.90	0.83	0.77	0.71	0.66	0.61	0.56	0.52	0.48	0.45	0.42	0.39	0.36	0.34	0.32	0.30	0.28	0.26	4.48
1976	3.87	3.64	3.44	3.24	3.07	2.91	2.76	2.61	2.46	2.32	2.19	2.05	1.91	1.78	1.64	1.51	1.39	1.28	1.17	1.08	0.99	0.91	0.83	0.77	0.71	0.65	0.60	0.56	0.51	0.48	0.44	0.41	0.38	0.35	0.33	0.31	0.29	0.27	0.25	0.24	4.02
1977	3.36	3.16	2.97	2.80	2.65	2.50	2.38	2.25	2.12	2.00	1.89	1.78	1.67	1.56	1.45	1.34	1.23	1.14	1.04	0.96	0.88	0.81	0.74	0.68	0.62	0.58	0.53	0.49	0.45	0.42	0.39	0.36	0.33	0.31	0.29	0.27	0.25	0.23	0.22	0.20	3.47
1978	2.94	2.76	2.59	2.44	2.30	2.17	2.05	1.95	1.85	1.74	1.64	1.55	1.46	1.37	1.28	1.19	1.10	1.01	0.93	0.86	0.79	0.72	0.66	0.61	0.56	0.51	0.47	0.44	0.40	0.37	0.34	0.32	0.30	0.27	0.25	0.24	0.22	0.21	0.19	0.18	3.02
1979	2.56	2.39	2.24	2.11	1.98	1.87	1.77	1.67	1.59	1.50	1.42	1.34	1.26	1.19	1.12	1.04	0.97	0.89	0.82	0.76	0.70	0.64	0.59	0.54	0.49	0.45	0.42	0.38	0.35	0.33	0.30	0.28	0.26	0.24	0.22	0.21	0.19	0.18	0.17	0.16	2.60
1980	2.09	1.95	1.83	1.71	1.61	1.51	1.43	1.35	1.28	1.21	1.15	1.08	1.02	0.96	0.91	0.85	0.80	0.74	0.68	0.63	0.58	0.53	0.49	0.45	0.41	0.38	0.35	0.32	0.29	0.27	0.25	0.23	0.21	0.20	0.18	0.17	0.16	0.15	0.14	0.13	2.10
1981	1.70	1.59	1.49	1.39	1.31	1.23	1.15	1.09	1.03	0.97	0.92	0.87	0.83	0.78	0.73	0.69	0.65	0.61	0.56	0.52	0.48	0.44	0.40	0.37	0.34	0.31	0.29	0.26	0.24	0.22	0.21	0.19	0.18	0.16	0.15	0.14	0.13	0.12	0.11	0.10	1.70
1982	1.35	1.26	1.18	1.10	1.03	0.97	0.91	0.86	0.81	0.76	0.72	0.68	0.65	0.61	0.58	0.54	0.51	0.48	0.45	0.42	0.39	0.36	0.33	0.30	0.28	0.25	0.23	0.21	0.20	0.18	0.17	0.15	0.14	0.13	0.12	0.11	0.10	0.10	0.09	0.08	1.34
1983	0.88	0.82	0.77	0.72	0.67	0.63	0.59	0.55	0.52	0.49	0.46	0.44	0.41	0.39	0.37	0.35	0.33	0.31	0.29	0.27	0.25	0.23	0.22	0.20	0.18	0.17	0.15	0.14	0.13	0.12	0.11	0.10	0.09	0.09	0.08	0.07	0.07	0.06	0.06	0.05	0.86
1984	0.70	0.65	0.61	0.57	0.53	0.50	0.46	0.43	0.41	0.38	0.36	0.34	0.32	0.31	0.29	0.27	0.26	0.24	0.23	0.22	0.20	0.19	0.17	0.16	0.15	0.13	0.12	0.11	0.10	0.10	0.09	0.08	0.07	0.07	0.06	0.06	0.05	0.05	0.05	0.04	0.68
1985	0.41	0.38	0.36	0.33	0.31	0.29	0.27	0.25	0.24	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.13	0.12	0.11	0.10	0.09	0.09	0.08	0.07	0.07	0.06	0.06	0.05	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.40
1986	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.17
1987	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.05
1988	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
1989	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 25. Time series of total biomass (mt), age 1+ biomass (mt), and female spawning biomass (mt), depletion (spawning biomass relative to unfished spawning biomass), recruitment (1000s of age-0 fish), and total exploitation rate (catch divided by summary biomass).

Year	Tot_Bio	Smry_Bio	Sp_Bio	Depletion	Recruits	Exploitation	Year	Tot_Bio	Smry_Bio	Sp_Bio	Depletion	Recruits	Exploitation
1900	5293.1	5290.8	2488.1	1.000	109.9	0.000	**1954**	3668.2	3666.1	1690.3	0.679	101.9	0.016
1901	5293.1	5290.8	2488.1	1.000	109.9	0.001	**1955**	3654.0	3651.9	1683.3	0.677	101.8	0.019
1902	5287.9	5285.6	2485.6	0.999	109.9	0.002	**1956**	3628.1	3626.0	1670.8	0.672	101.7	0.024
1903	5277.6	5275.3	2480.5	0.997	109.9	0.003	**1957**	3585.4	3583.3	1650.0	0.663	101.4	0.021
1904	5262.3	5260.1	2472.9	0.994	109.8	0.004	**1958**	3553.9	3551.8	1634.5	0.657	101.1	0.022
1905	5242.1	5239.8	2463.0	0.990	109.8	0.005	**1959**	3521.5	3519.5	1618.5	0.650	100.9	0.019
1906	5217.1	5214.8	2450.6	0.985	109.7	0.006	**1960**	3498.7	3496.7	1607.0	0.646	100.7	0.024
1907	5187.4	5185.1	2435.9	0.979	109.6	0.007	**1961**	3458.5	3456.4	1587.2	0.638	100.4	0.024
1908	5153.1	5150.8	2418.9	0.972	109.4	0.008	**1962**	3420.8	3418.7	1568.6	0.630	100.2	0.021
1909	5114.3	5112.0	2399.7	0.964	109.3	0.009	**1963**	3393.3	3391.3	1555.0	0.625	99.9	0.023
1910	5071.1	5068.8	2378.3	0.956	109.1	0.011	**1964**	3362.2	3360.1	1539.6	0.619	99.7	0.021
1911	5023.6	5021.4	2354.8	0.946	108.9	0.012	**1965**	3338.3	3336.3	1527.9	0.614	99.5	0.028
1912	4972.0	4969.8	2329.2	0.936	108.7	0.013	**1966**	3291.6	3289.6	1505.2	0.605	99.2	0.040
1913	4916.4	4914.2	2301.7	0.925	108.5	0.014	**1967**	3207.6	3205.6	1464.6	0.589	98.5	0.054
1914	4856.8	4854.6	2272.2	0.913	108.2	0.015	**1968**	3084.4	3082.4	1405.1	0.565	97.4	0.046
1915	4793.4	4791.2	2240.8	0.901	108.0	0.017	**1969**	2993.9	2991.9	1361.0	0.547	96.6	0.049
1916	4726.3	4724.1	2207.6	0.887	107.7	0.018	**1970**	2897.9	2895.9	1313.8	0.528	95.7	0.047
1917	4655.5	4653.3	2172.6	0.873	107.3	0.030	**1971**	2815.4	2813.4	1273.4	0.512	94.9	0.046
1918	4535.6	4533.4	2113.5	0.849	106.8	0.028	**1972**	2738.8	2736.9	1235.8	0.497	94.1	0.070
1919	4429.9	4427.7	2061.2	0.828	106.3	0.017	**1973**	2602.7	2600.8	1169.7	0.470	92.6	0.079
1920	4375.4	4373.2	2034.1	0.818	106.0	0.019	**1974**	2455.0	2453.1	1098.0	0.441	90.8	0.099
1921	4316.3	4314.1	2004.8	0.806	105.7	0.017	**1975**	2272.1	2270.2	1009.6	0.406	88.4	0.097
1922	4268.8	4266.6	1981.3	0.796	105.4	0.016	**1976**	2111.9	2110.1	932.0	0.375	86.0	0.128
1923	4223.9	4221.7	1959.1	0.787	105.2	0.022	**1977**	1904.6	1902.9	832.1	0.334	82.6	0.122
1924	4157.2	4155.1	1926.3	0.774	104.8	0.030	**1978**	1736.8	1735.2	750.9	0.302	79.3	0.127
1925	4061.2	4059.1	1879.2	0.755	104.3	0.034	**1979**	1582.2	1580.7	675.8	0.272	76.0	0.173
1926	3955.5	3953.3	1827.3	0.734	103.7	0.043	**1980**	1378.6	1377.1	578.0	0.232	70.9	0.173
1927	3819.6	3817.5	1760.6	0.708	102.9	0.037	**1981**	1208.8	1207.4	497.2	0.200	65.9	0.185
1928	3714.7	3712.6	1708.9	0.687	102.2	0.030	**1982**	1055.6	1054.4	423.5	0.170	60.7	0.308
1929	3642.1	3640.0	1673.0	0.672	101.7	0.028	**1983**	806.4	805.4	307.3	0.124	50.4	0.176
1930	3579.8	3577.7	1642.3	0.660	101.3	0.035	**1984**	731.4	730.4	271.7	0.109	46.6	0.331
1931	3495.8	3493.7	1601.0	0.643	100.6	0.046	**1985**	563.9	563.1	195.0	0.078	37.1	0.427
1932	3380.8	3378.7	1544.7	0.621	99.8	0.032	**1986**	397.9	397.4	121.8	0.049	25.9	0.485
1933	3317.8	3315.7	1513.7	0.608	99.3	0.025	**1987**	274.0	273.7	71.1	0.029	16.5	0.386
1934	3283.1	3281.0	1496.7	0.602	99.0	0.021	**1988**	224.2	224.0	53.7	0.022	12.8	0.448
1935	3260.6	3258.6	1485.7	0.597	98.8	0.016	**1989**	177.4	177.2	38.3	0.015	9.4	0.214
1936	3256.3	3254.3	1483.8	0.596	98.8	0.006	**1990**	175.4	175.2	41.1	0.017	10.1	0.182
1937	3284.1	3282.1	1497.7	0.602	99.0	0.007	**1991**	175.0	174.8	45.2	0.018	11.0	0.160
1938	3308.4	3306.4	1510.0	0.607	99.2	0.005	**1992**	175.0	174.8	49.8	0.020	12.0	0.217
1939	3338.9	3336.8	1525.5	0.613	99.5	0.006	**1993**	164.2	164.0	50.1	0.020	12.1	0.149
1940	3366.1	3364.0	1539.4	0.619	99.7	0.007	**1994**	162.5	162.3	53.3	0.021	12.8	0.244
1941	3391.5	3389.5	1552.5	0.624	99.9	0.009	**1995**	144.0	143.8	49.5	0.020	11.9	0.174
1942	3411.2	3409.2	1562.8	0.628	100.1	0.003	**1996**	137.5	137.2	49.0	0.020	11.8	0.218
1943	3448.9	3446.8	1581.7	0.636	100.4	0.004	**1997**	124.6	124.4	45.1	0.018	11.0	0.073
1944	3484.5	3482.4	1599.5	0.643	100.6	0.001	**1998**	128.9	128.7	48.0	0.019	11.6	0.031
1945	3529.6	3527.6	1621.9	0.652	101.0	0.001	**1999**	137.5	137.3	52.6	0.021	12.6	0.053
1946	3571.8	3569.7	1642.9	0.660	101.3	0.003	**2000**	143.0	142.8	55.6	0.022	13.3	0.035
1947	3606.6	3604.5	1660.1	0.667	101.5	0.005	**2001**	150.5	150.2	59.4	0.024	14.1	0.003
1948	3634.8	3632.7	1674.1	0.673	101.7	0.007	**2002**	162.2	161.9	65.0	0.026	15.2	0.003
1949	3653.3	3651.2	1683.3	0.677	101.8	0.010	**2003**	174.2	173.9	70.6	0.028	16.4	0.003
1950	3663.5	3661.4	1688.3	0.679	101.9	0.011	**2004**	186.4	186.0	76.3	0.031	17.5	0.003
1951	3669.0	3666.8	1690.9	0.680	101.9	0.015	**2005**	198.8	198.4	82.0	0.033	18.7	0.003
1952	3659.2	3657.1	1686.1	0.678	101.9	0.011	**2006**	211.6	211.2	87.7	0.035	19.8	0.002
1953	3662.3	3660.2	1687.5	0.678	101.9	0.010	**2007**	224.7	224.3	93.5	0.038	20.9	0.002

Figures

Figure 1. Map of stock boundary from Piner et al. (2005), showing INPFC areas.

Figure 2. Catch curve estimation of total mortality (Z). The assumed age at full recruitment is 12 years old, and ages greater than 44 years were excluded due to consistently small sample sizes.

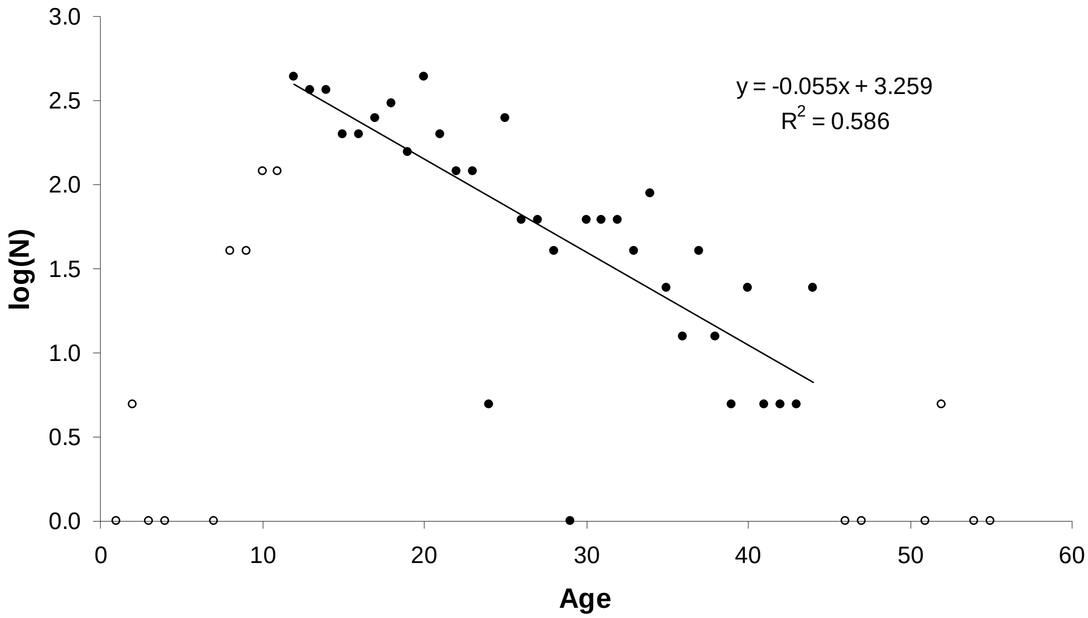


Figure 3. von Bertalanffy growth curve fit to length-at-age data (sexes combined).

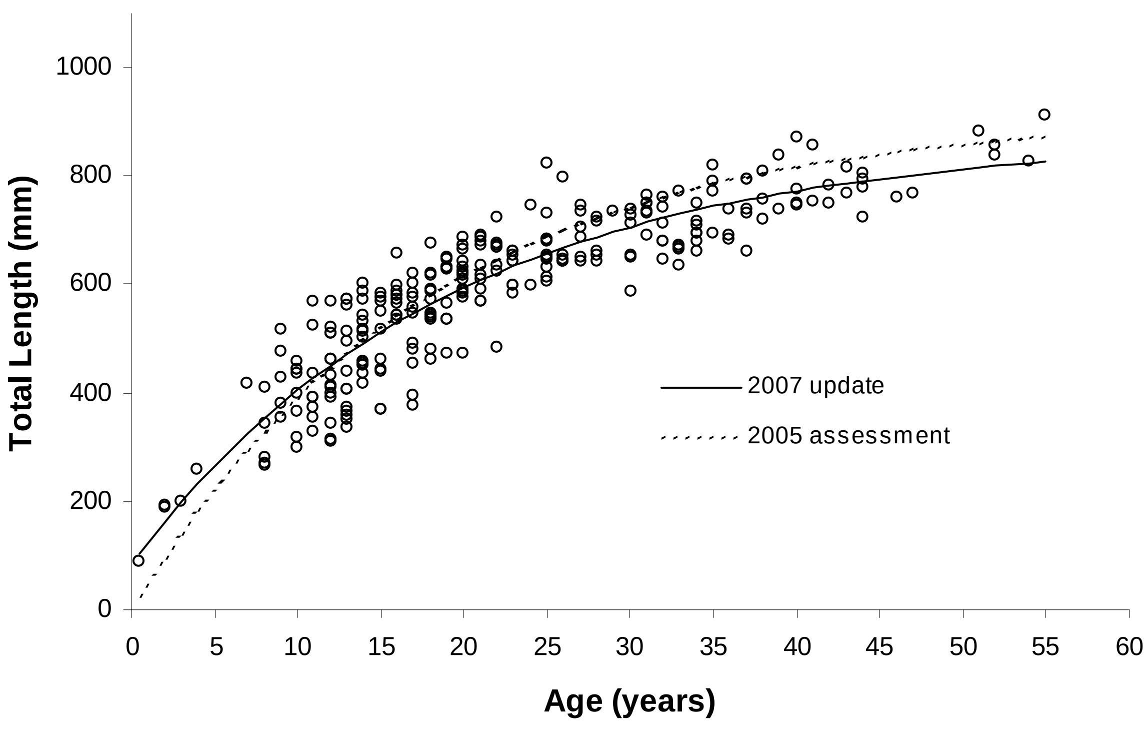


Figure 4. CVs of length at age versus mean length for cowcod. The linear trend was extrapolated to better approximate the observed variability in length at age (see Figure 5).

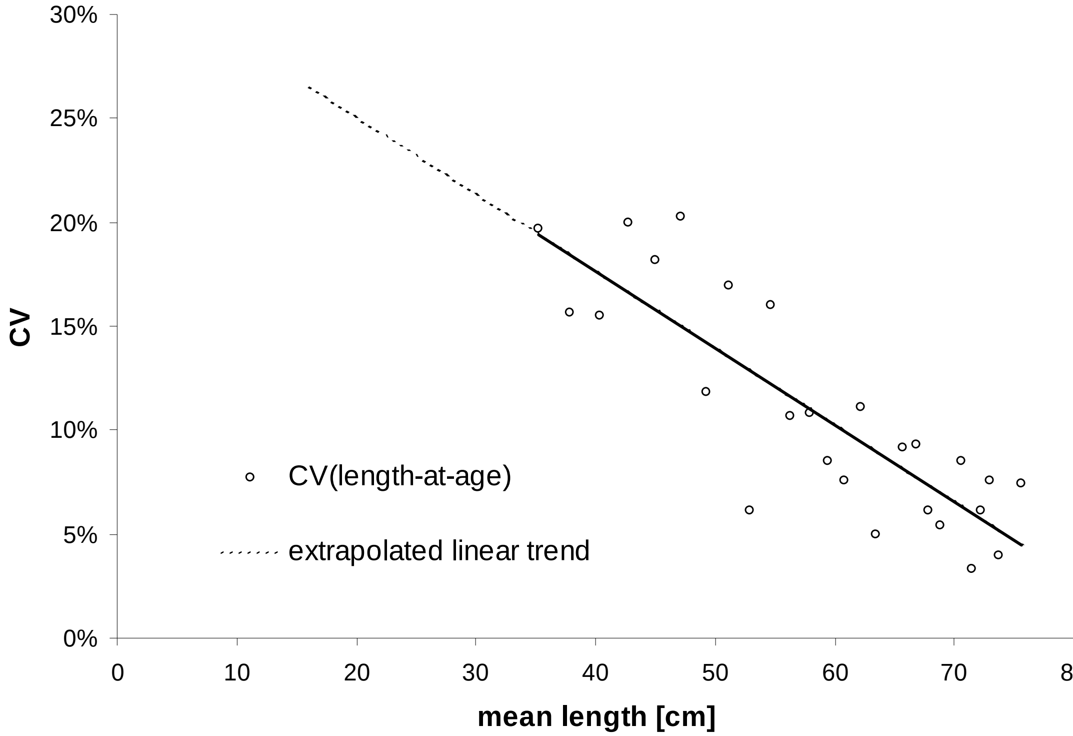


Figure 5. Updated von Bertalanffy growth curve, assumed CVs as a function of age, and 95% confidence intervals used in the base model.

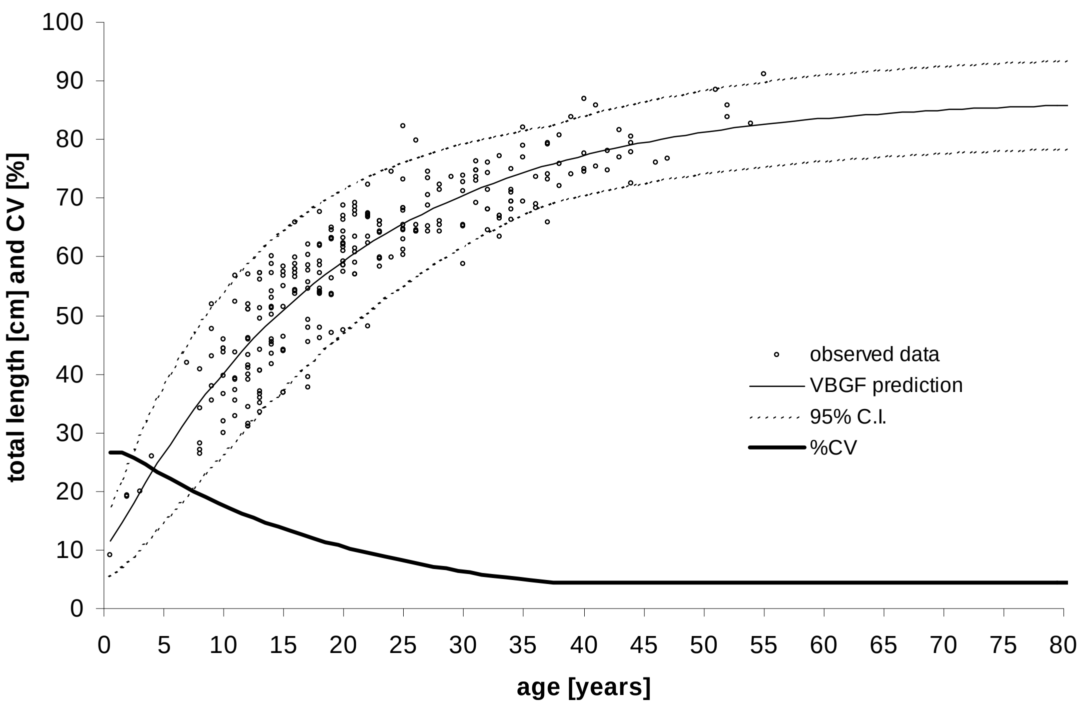


Figure 6. Incremental effects of the corrected selectivity curve and growth function on the spawning biomass trajectory for cowcod, with comparison to the base model.

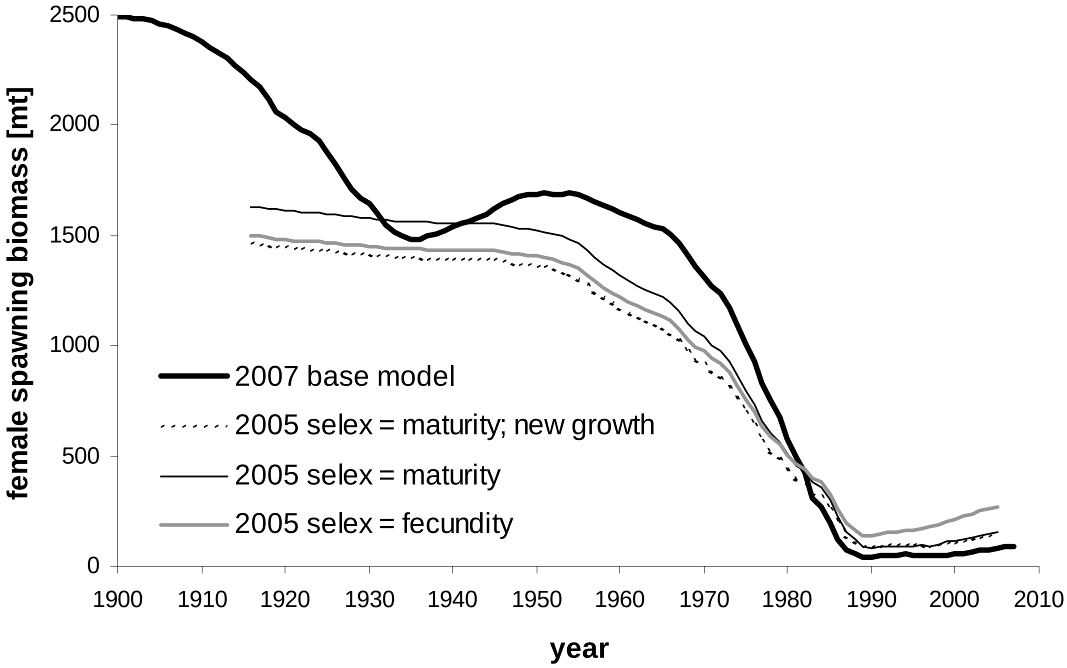


Figure 7. Total rockfish landings by area in California, 1916-1968. See text for definition of regions. Data from 1916-1927 are from CDF&G Fish Bulletin No. 105 (1958), and data after 1927 are from the NMFS SWFSC ERD Live-Access Server.

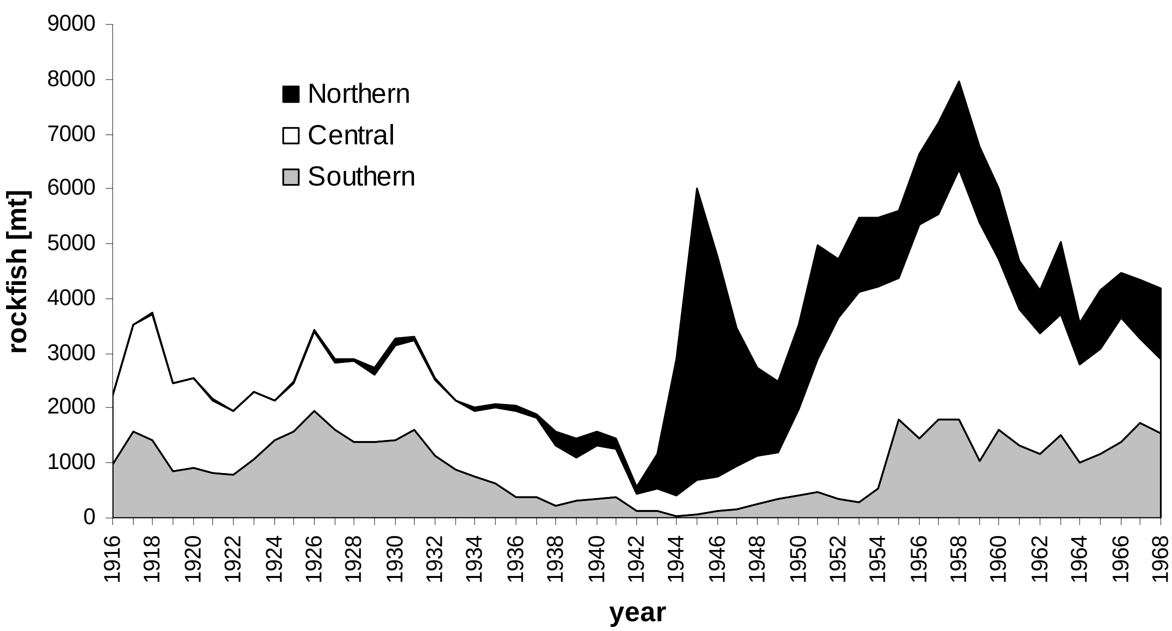


Figure 8. Total rockfish landings in Southern California, 1928-1968, from the ERD database. Landings include thornyheads (genus *Sebastolobus*) and exclude foreign catch. Increased catch in the Santa Barbara region (1954+) is largely due to landings at Morro Bay and Avila.

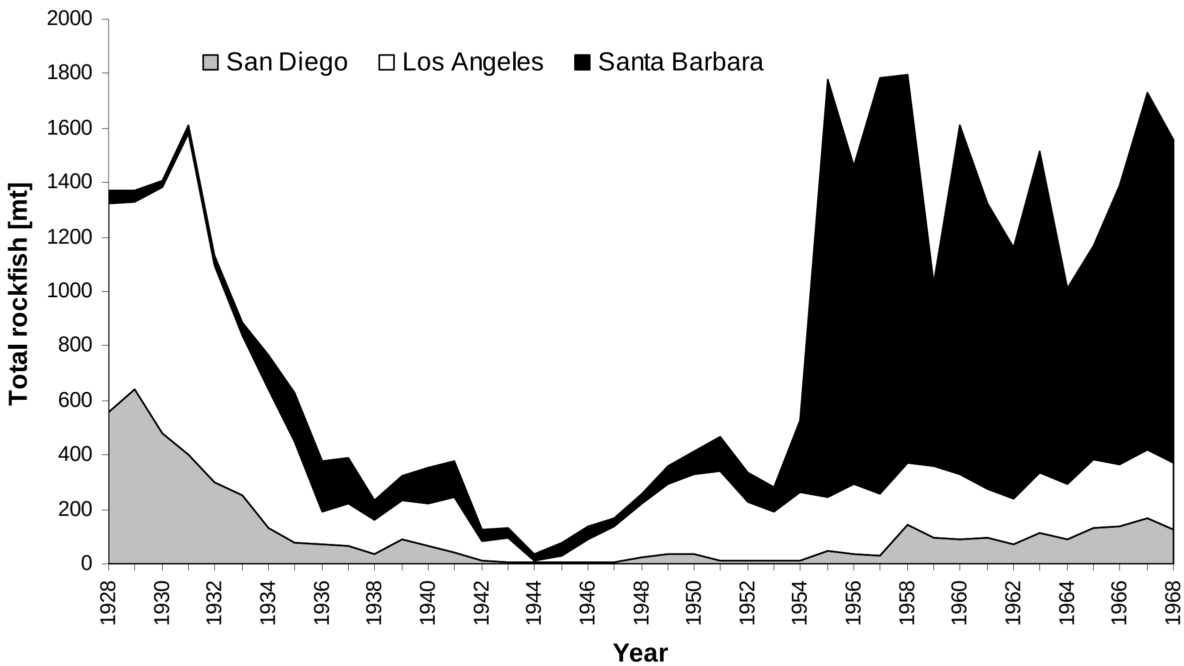


Figure 9. Total rockfish landings in Southern California by region, 1916-1968. Catch in the Santa Barbara region has been adjusted to exclude landings at Morro Bay and Avila (Table 2).

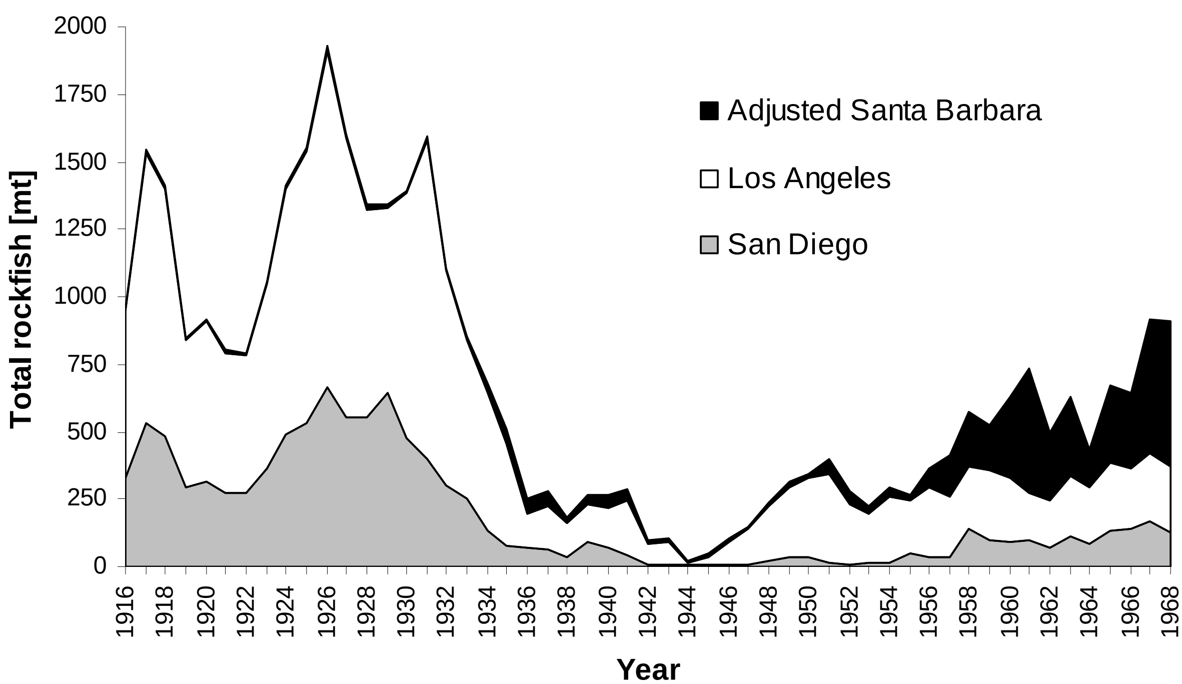
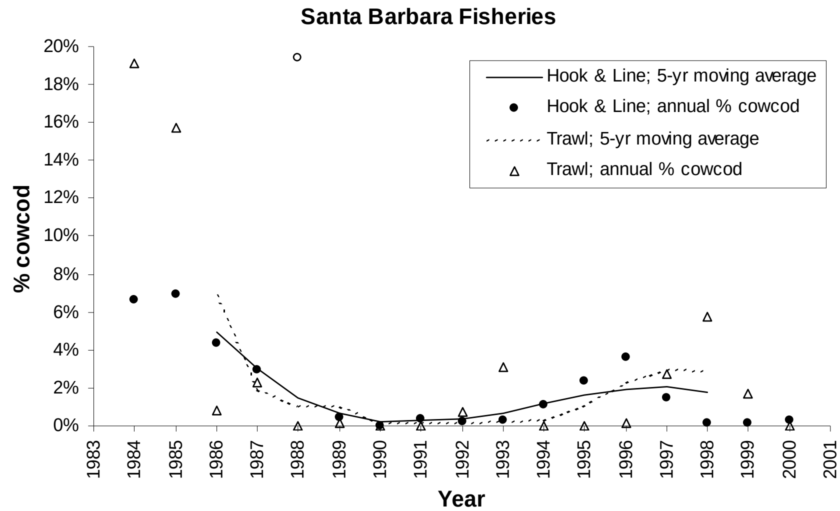
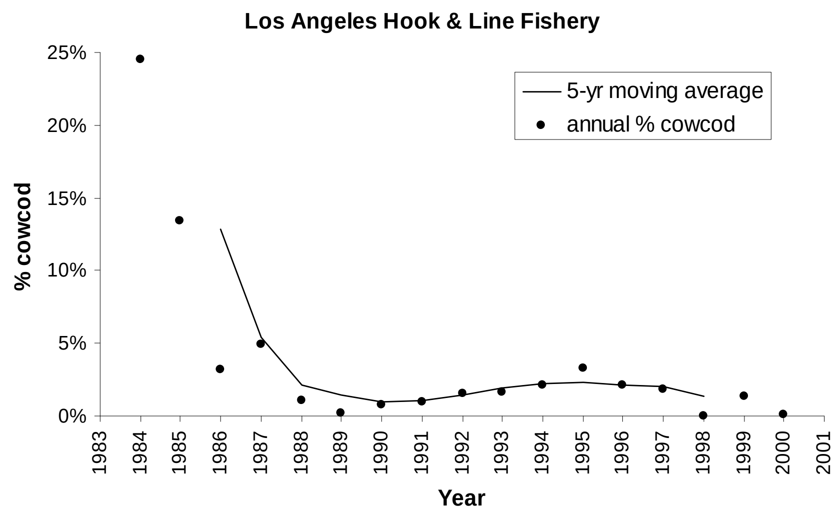


Figure 10. Percent cowcod in rockfish landings, 1984-2000, by year, port, and gear. Moving averages for the Santa Barbara hook & line fishery do not include data from 1988 (open circle).





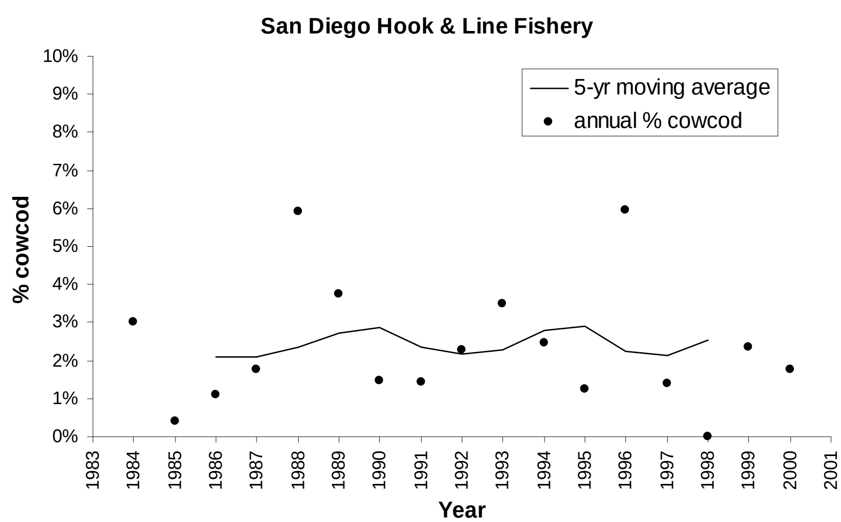


Figure 11. Southern California cowcod landings, 1969-2000, from CALCOM. The 2007 estimates reflect recovered port samples from the region (1983-1985) and the revised expansion procedure.

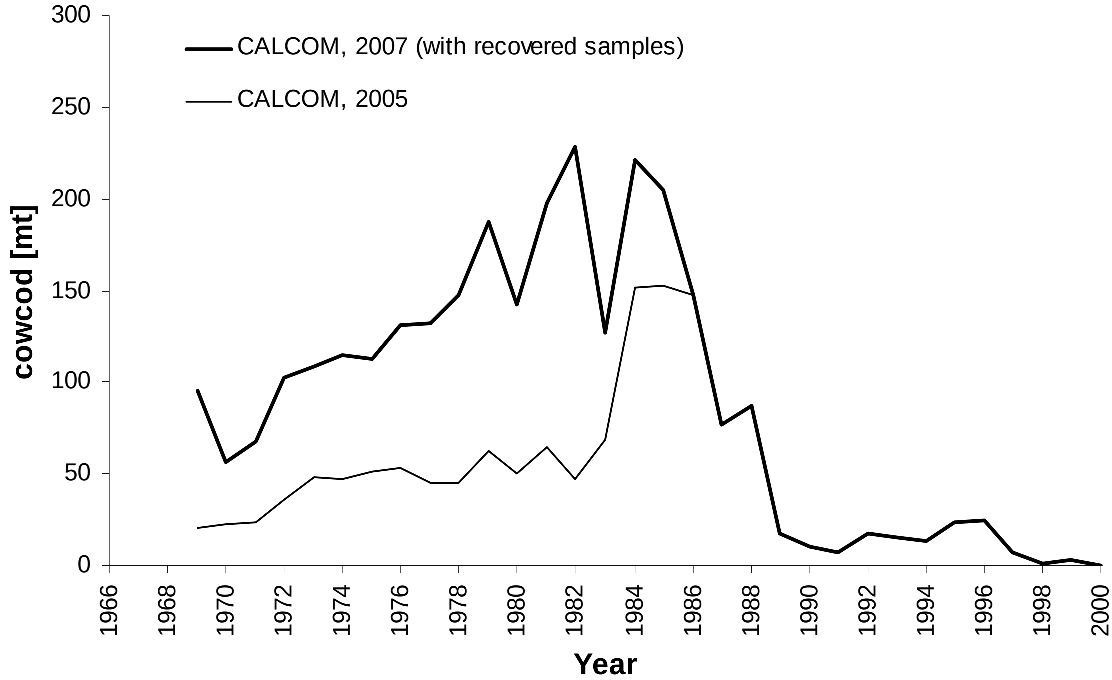


Figure 12. Commercial catches of cowcod by gear type (CALCOM, 2007). Gear groups are hook & line (HKL), trawl (TWL), net (NET), and other (OTH).

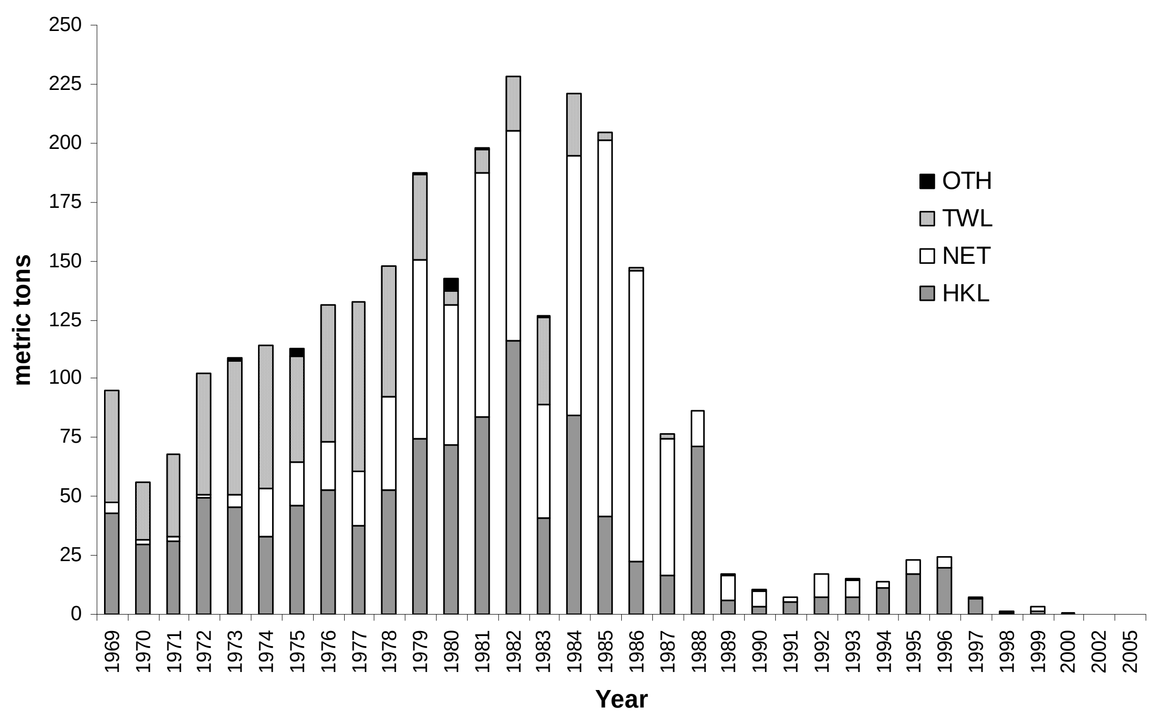


Figure 13. Length compositions by shift-year from CDFG onboard observer creel surveys

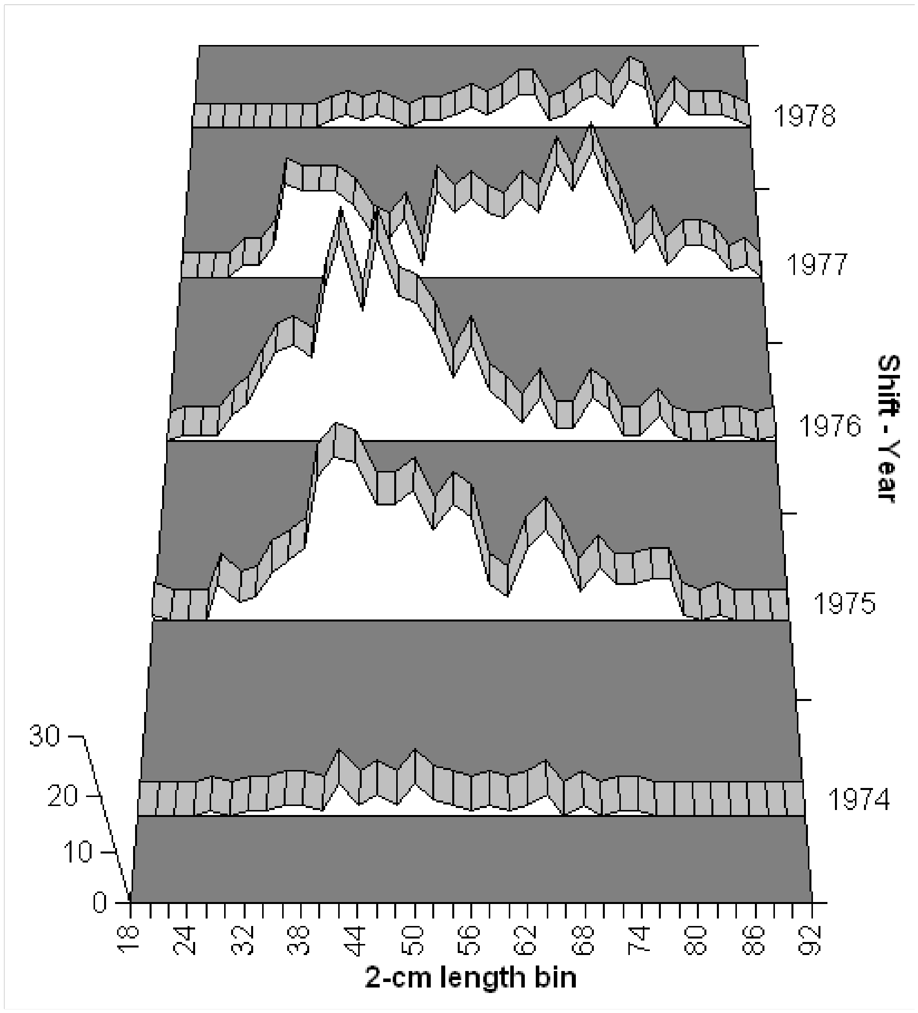


Figure 14. Locations of cowcod caught during 1970s CPFV observer study. Light grey = 1-9 cowcod, dark grey = 10 – 49 cowcod, black = 50+ cowcod.

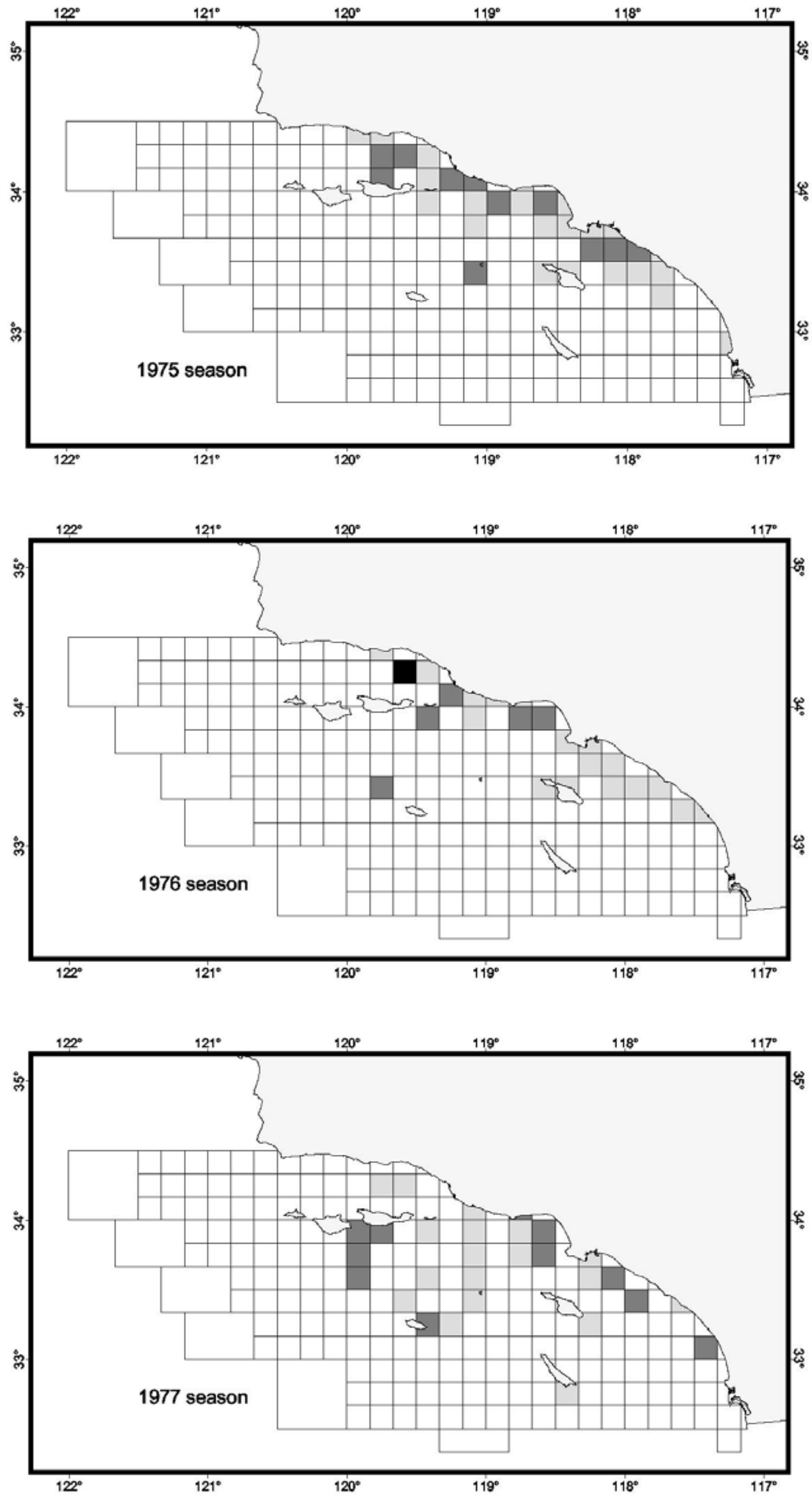


Figure 15. Length of cowcod versus depth fished from CPFV observer data from the SCB. Years are “shift-years” as described in text. The group of larger fish in 1977 was all caught in a single month and block.

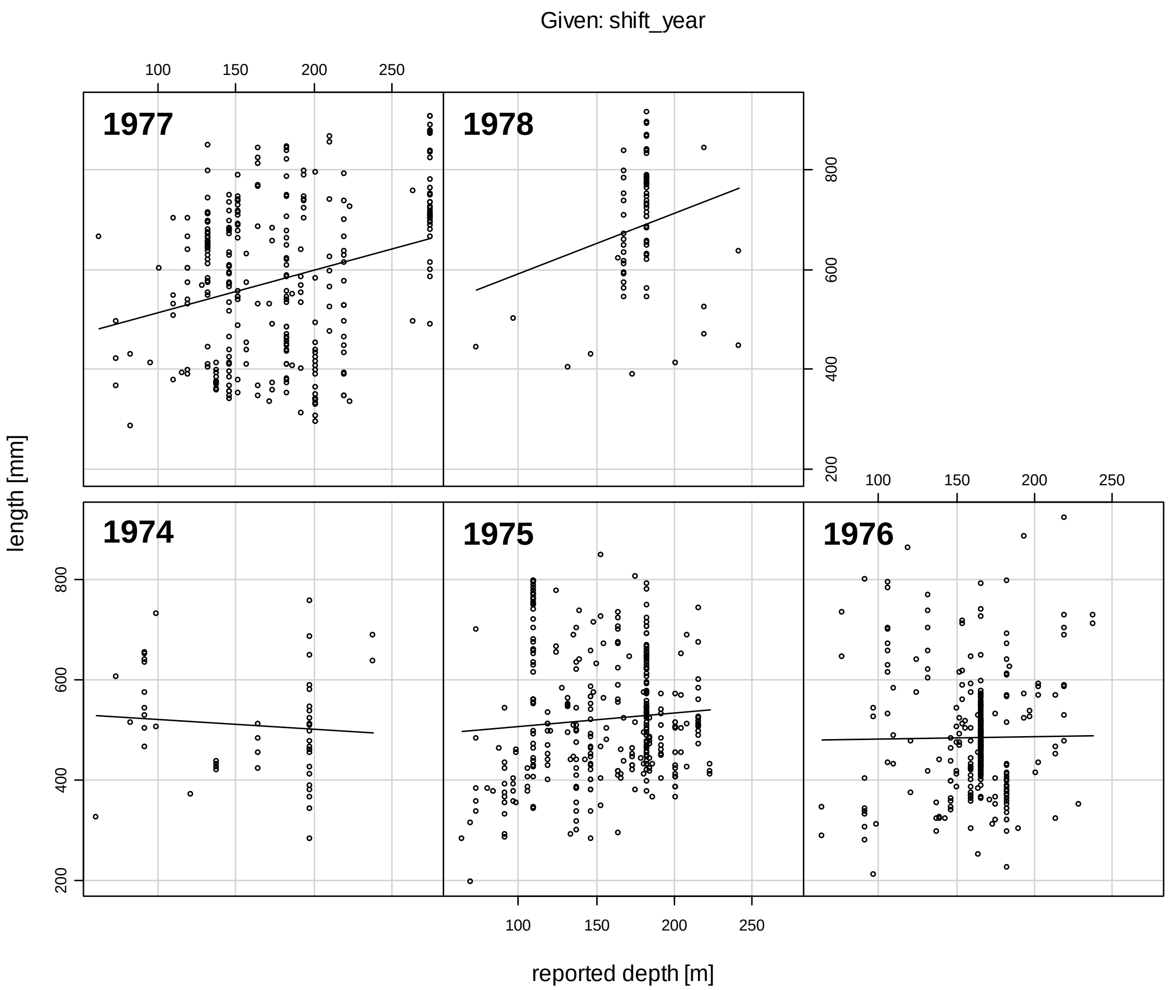


Figure 16: Distribution of effort recorded in CPFV logbook database. Effort is defined as the sum of angler hours between the months of Nov - Apr. for blocks in which 1+ cowcod were caught.

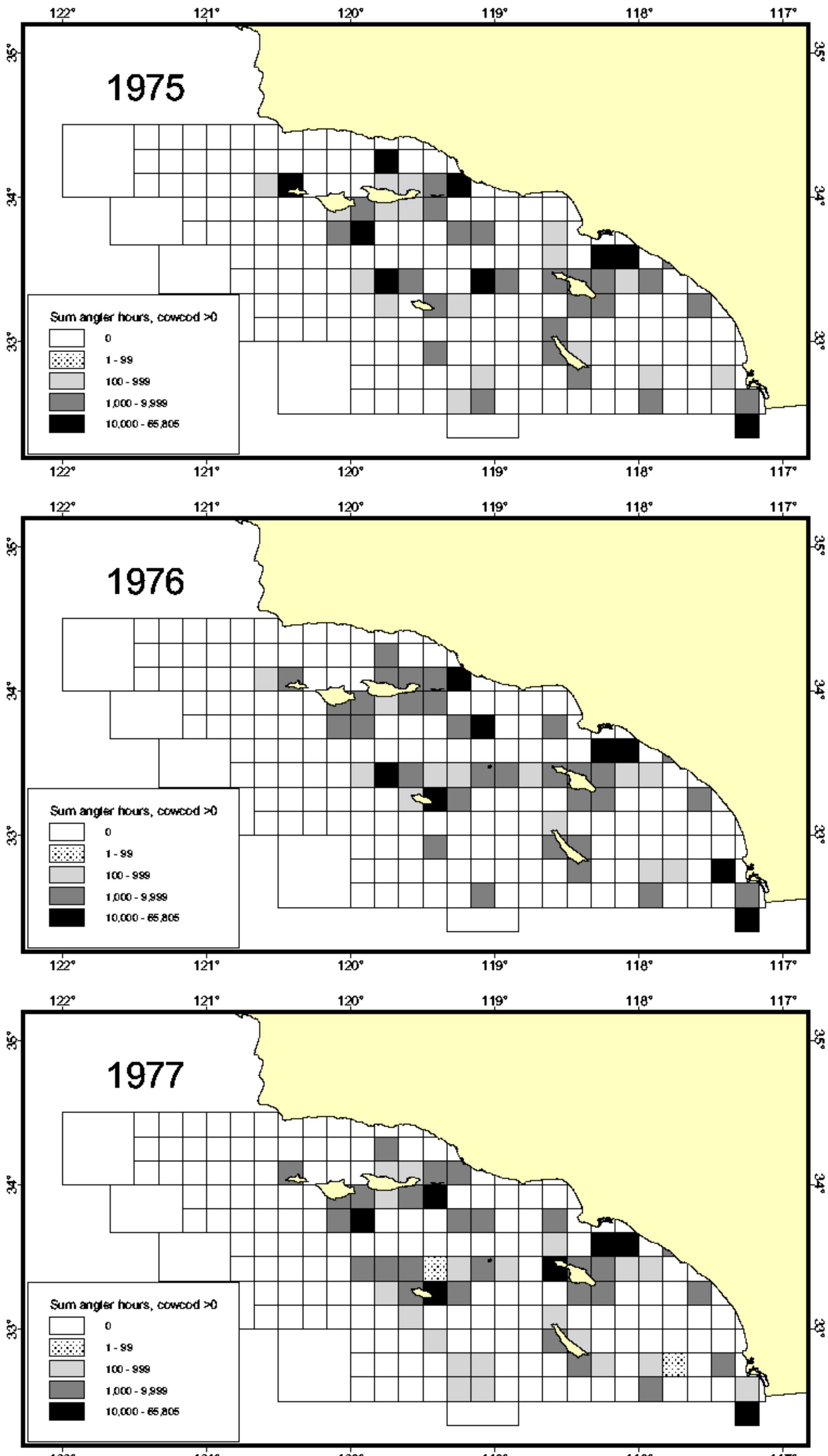


Figure 17: Comparison of selectivity curves; solid black line is curve fitted to 1970s CPFV observer data, broken line mirrors the female maturity schedule.

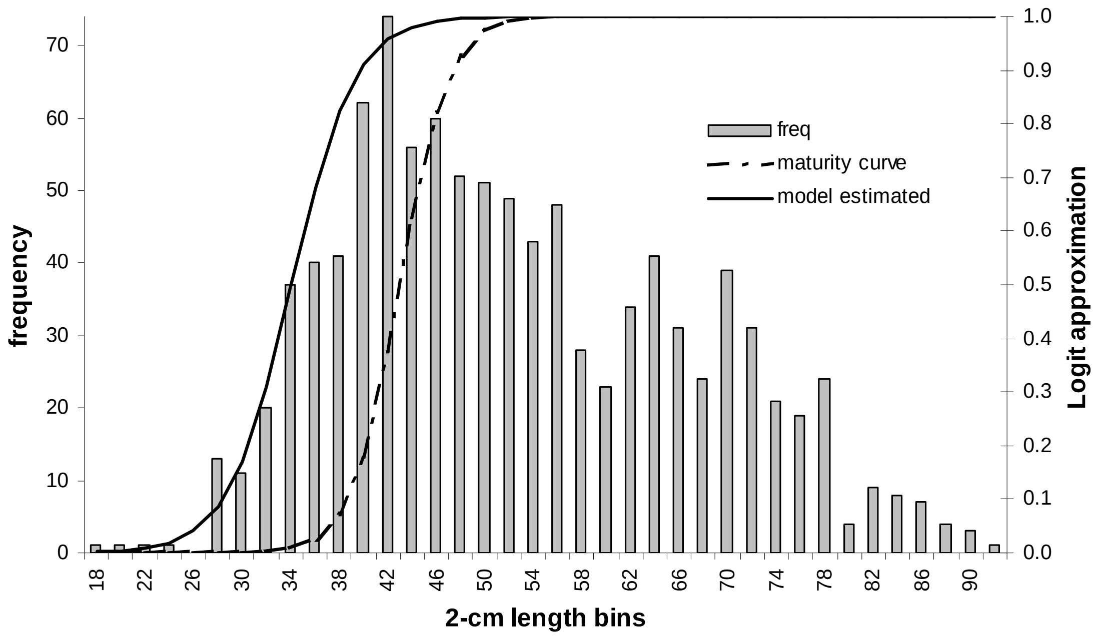


Figure 18: Cowcod length compositions from commercial fisheries, by gear group, in the SCB. TWL = trawl, HKL = hook and line.

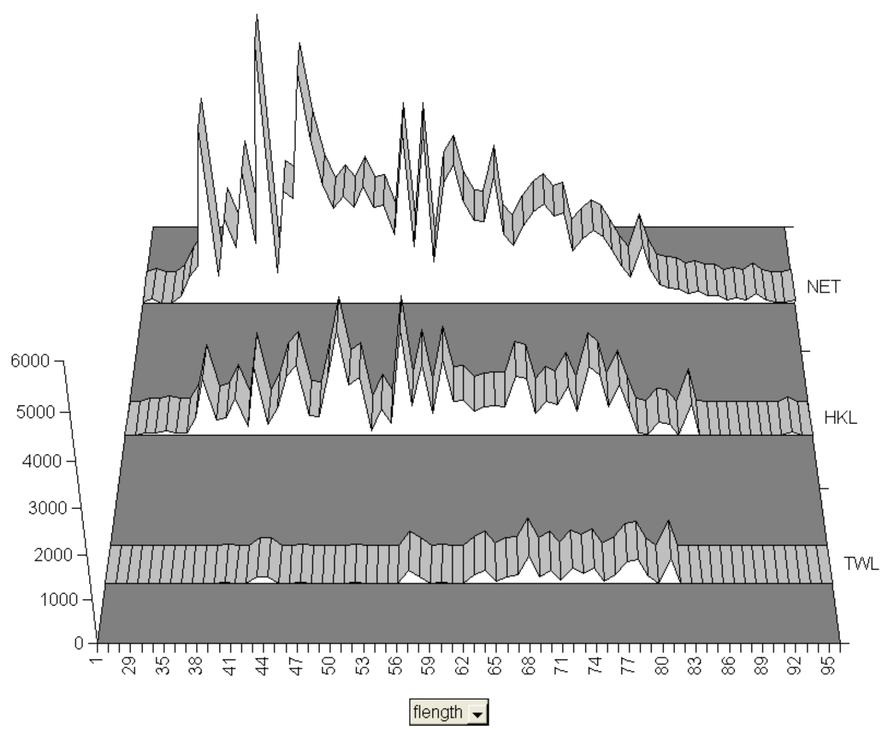


Figure 19: Cowcod length compositions from the commercial net fishery in the SCB.

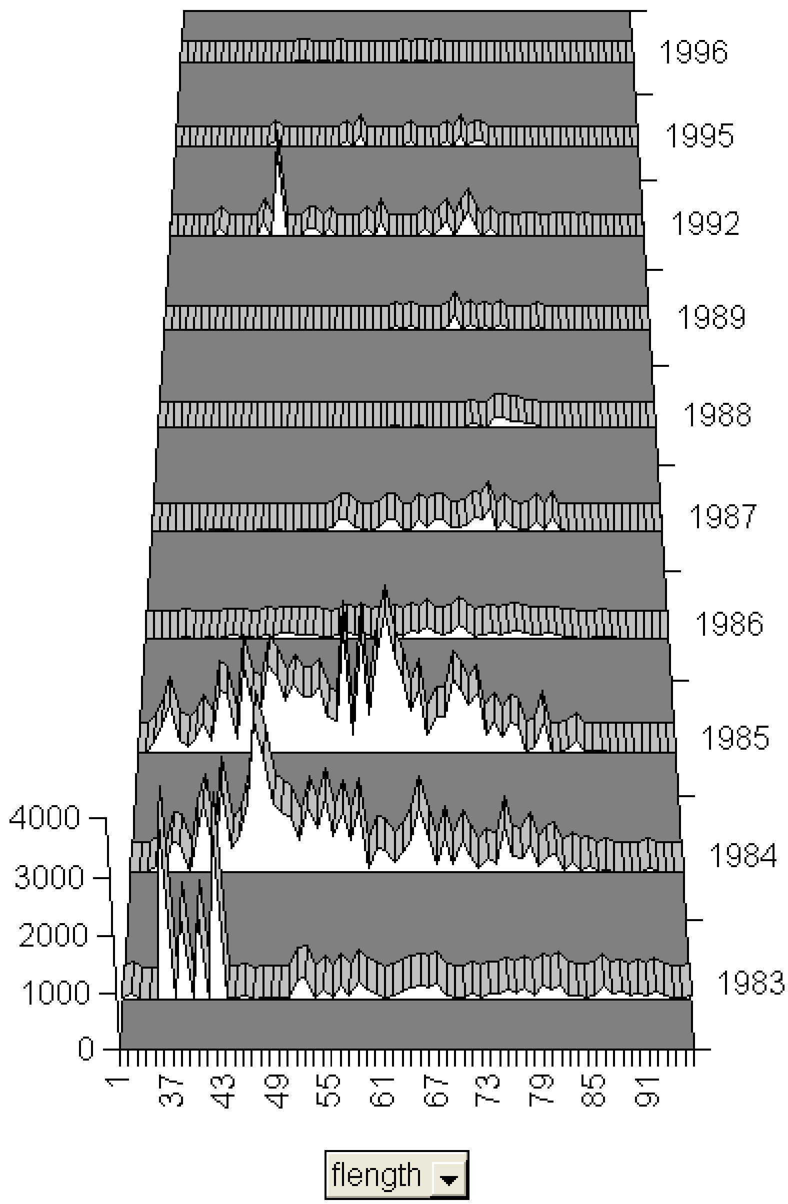


Figure 20. Final selectivity curves for the base model.

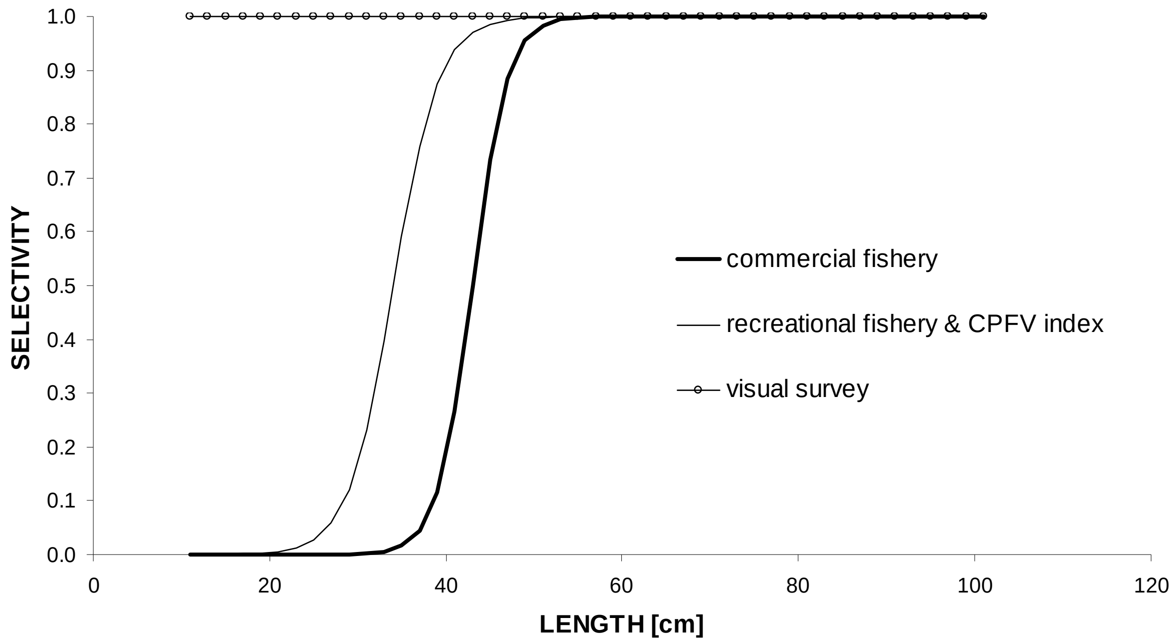


Figure 21: Spatial stratification of the 1999 CPFV logbook index (Butler et al., 1999).

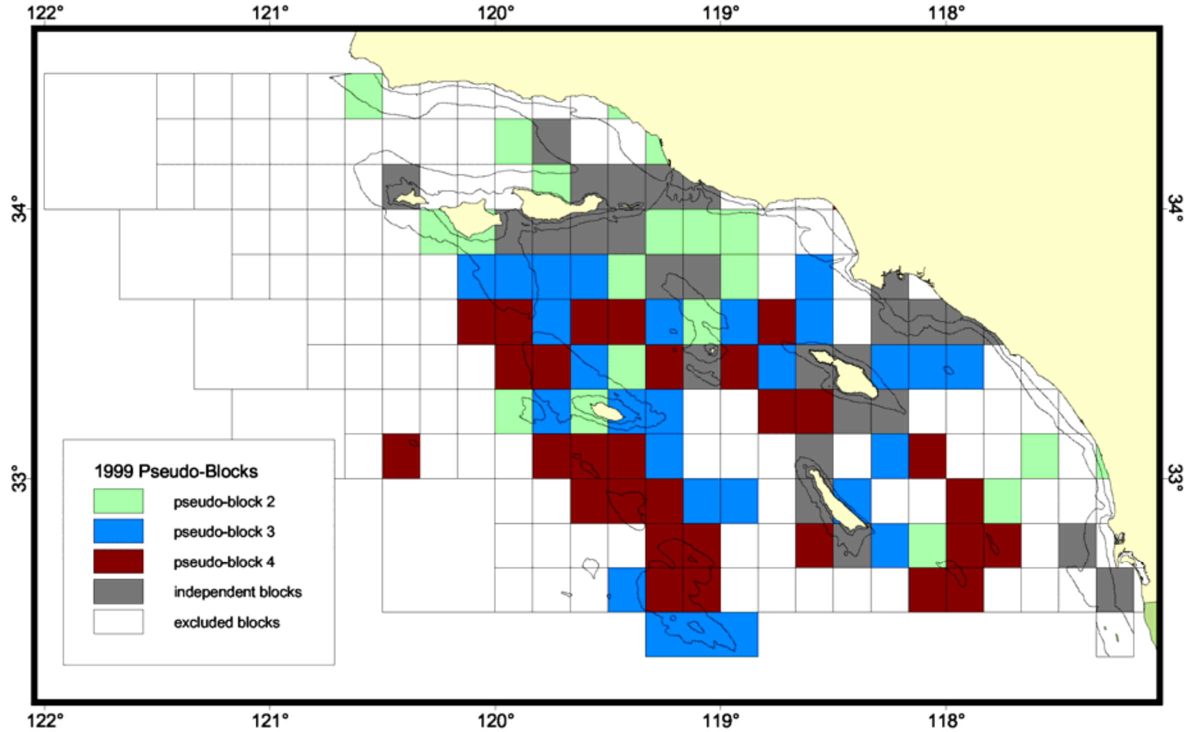


Figure 22: Spatial stratification of the 2005 CPFV logbook index (Piner et al., 2005).

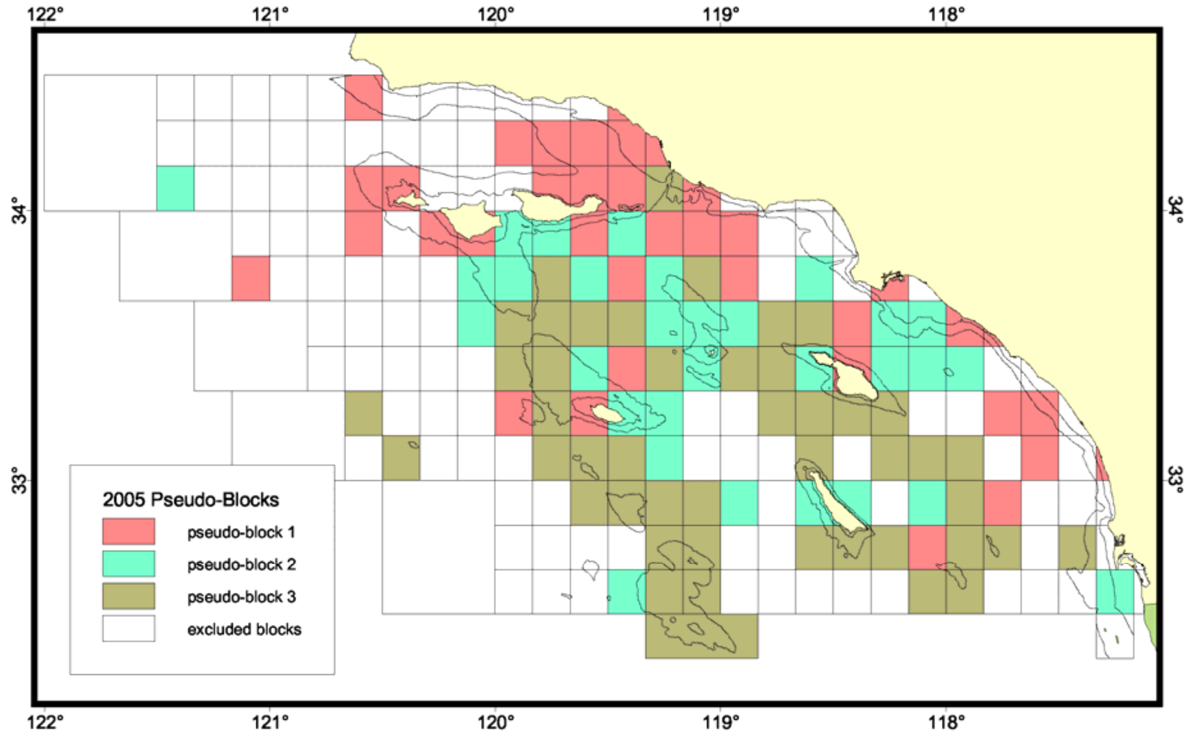


Figure 23: Spatial stratification of the CPFV logbook index in the 2007 assessment.

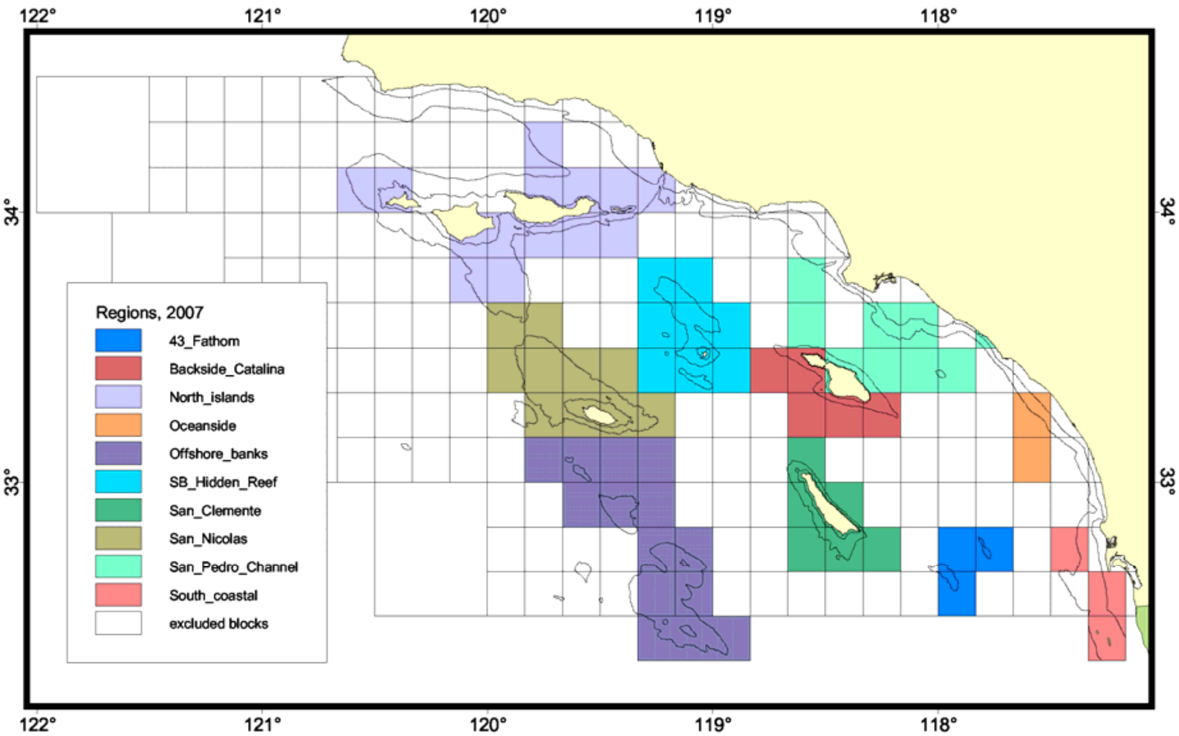


Figure 24: Changes in average cowcod CPUE by decade and region.

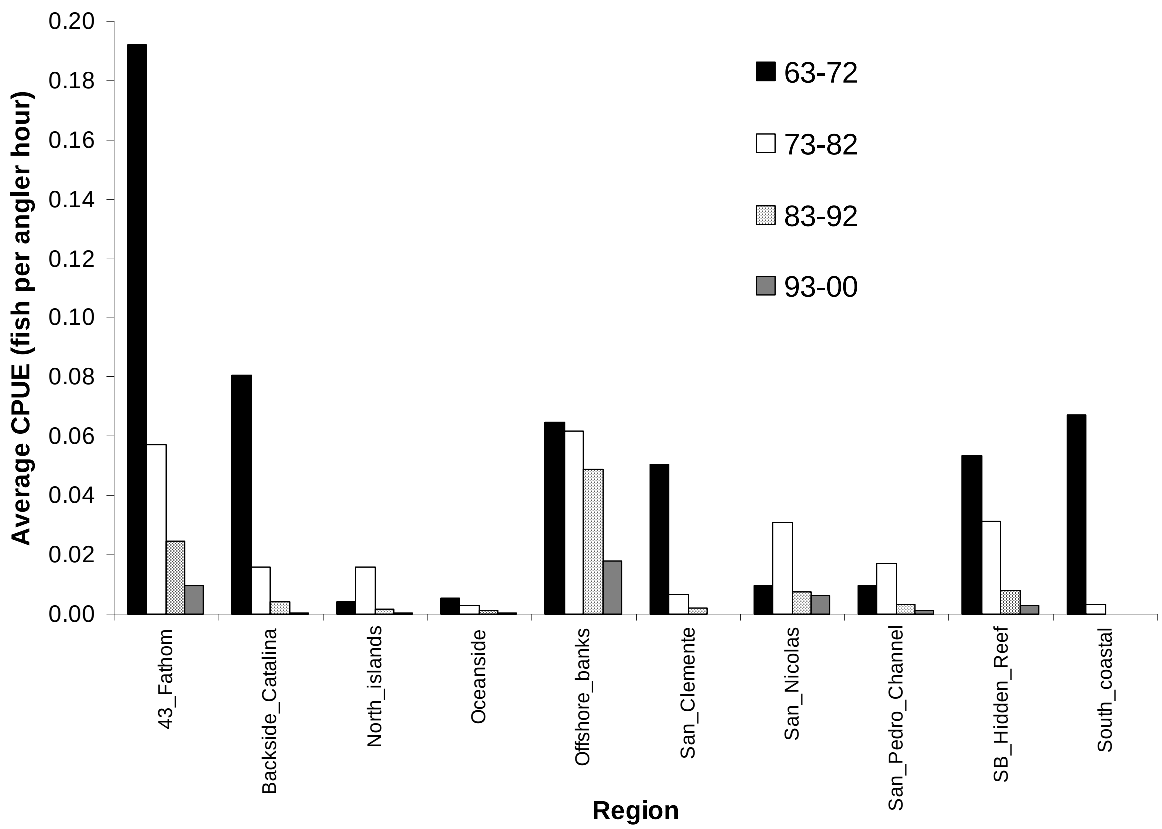


Figure 25: Comparison of CPFV logbook indices and unweighted CVs from the 2007 assessment to results from previous assessments. Note the log scale for indices. The axis for the CVs has been vertically extended to visually separate the two sets of data.

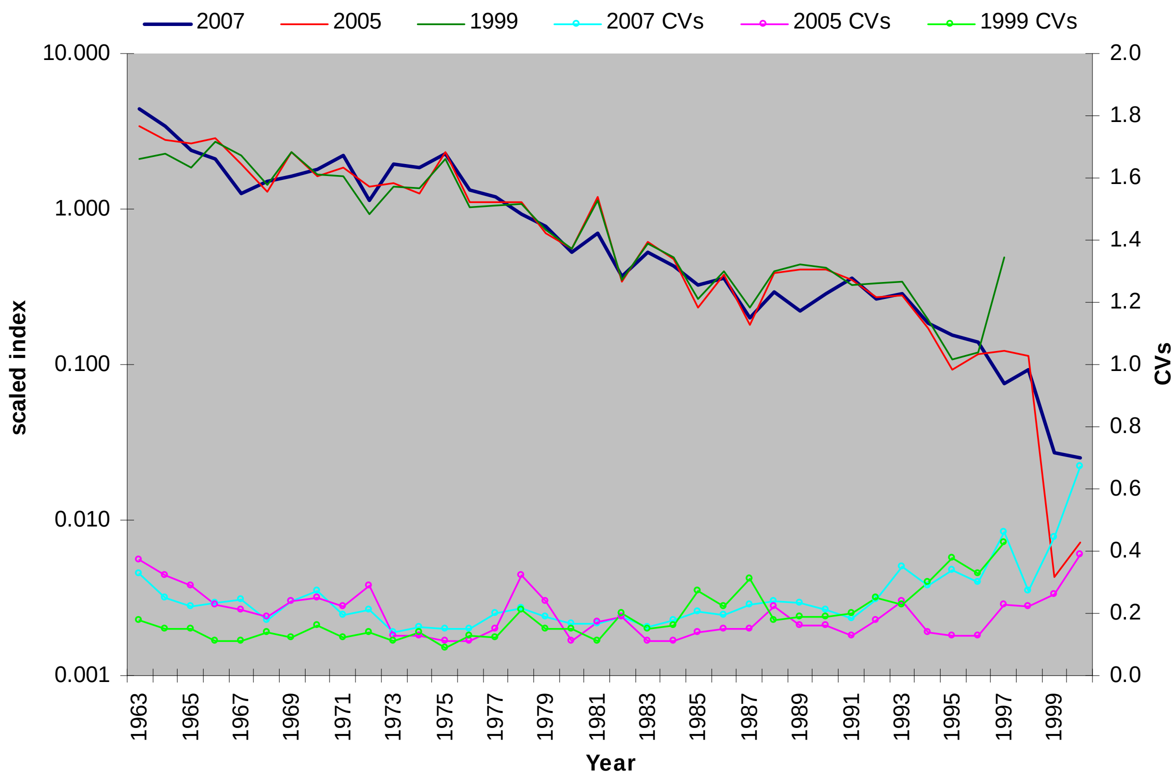


Figure 26: Base model fit to the revised CPFV logbook index, with tuned CVs.

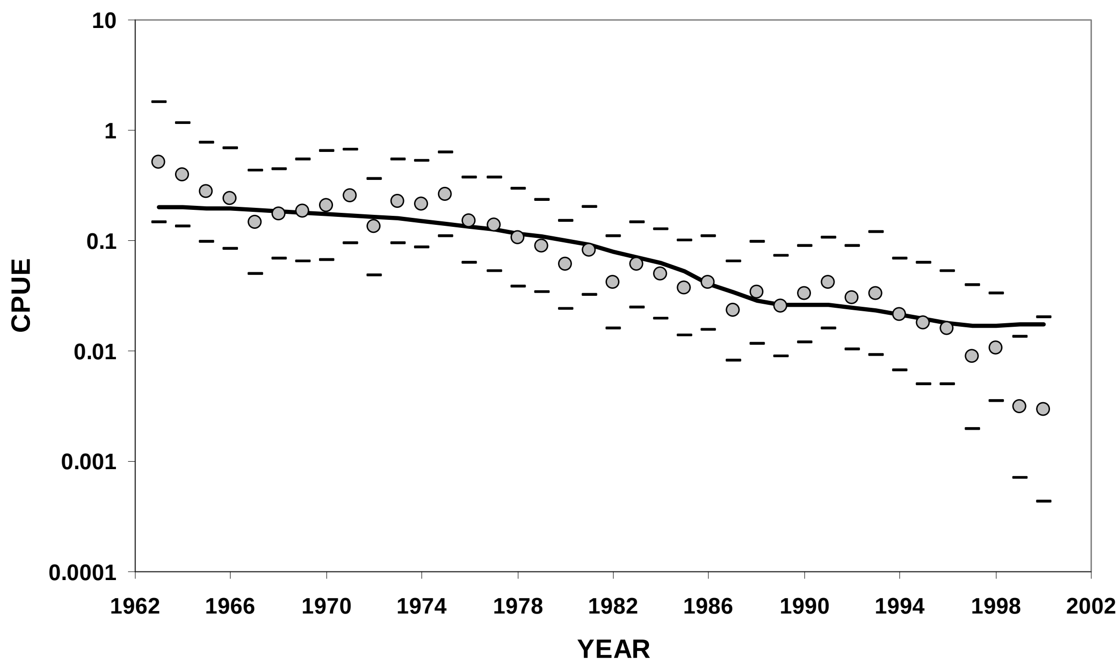


Figure 27: Effect of the corrected selectivity curve in the 2005 assessment on exploitation rates (catch divided by age 11+ biomass).

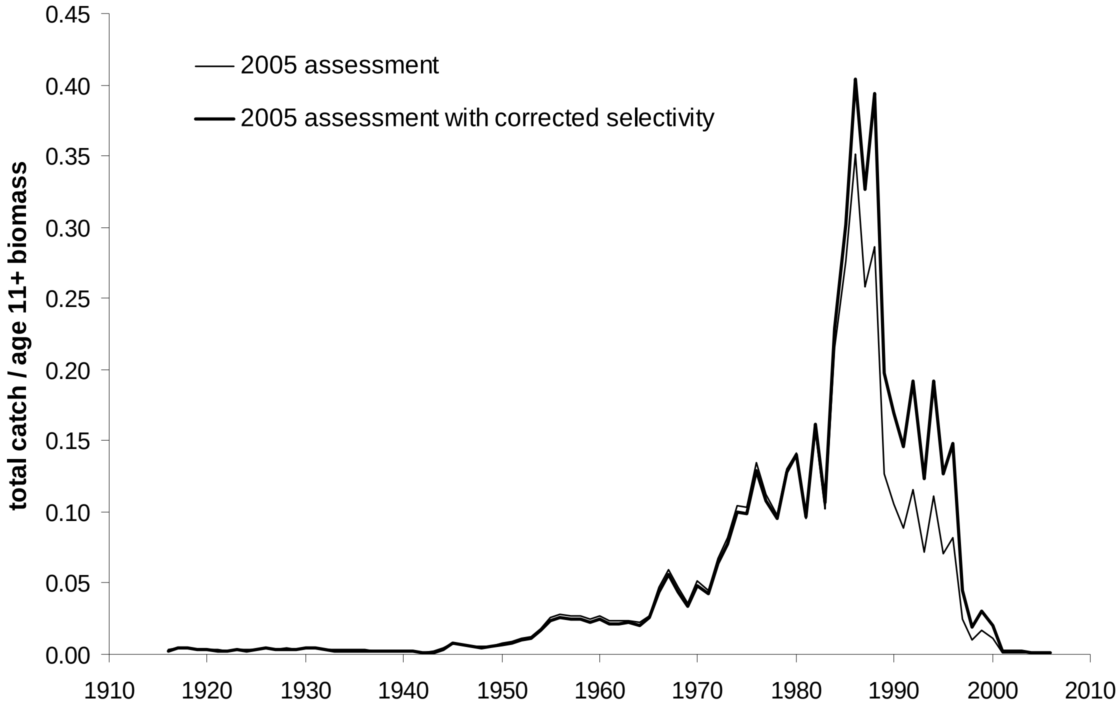


Figure 28: Exploitation rates based on alternative summary ages for the 2007 base model.

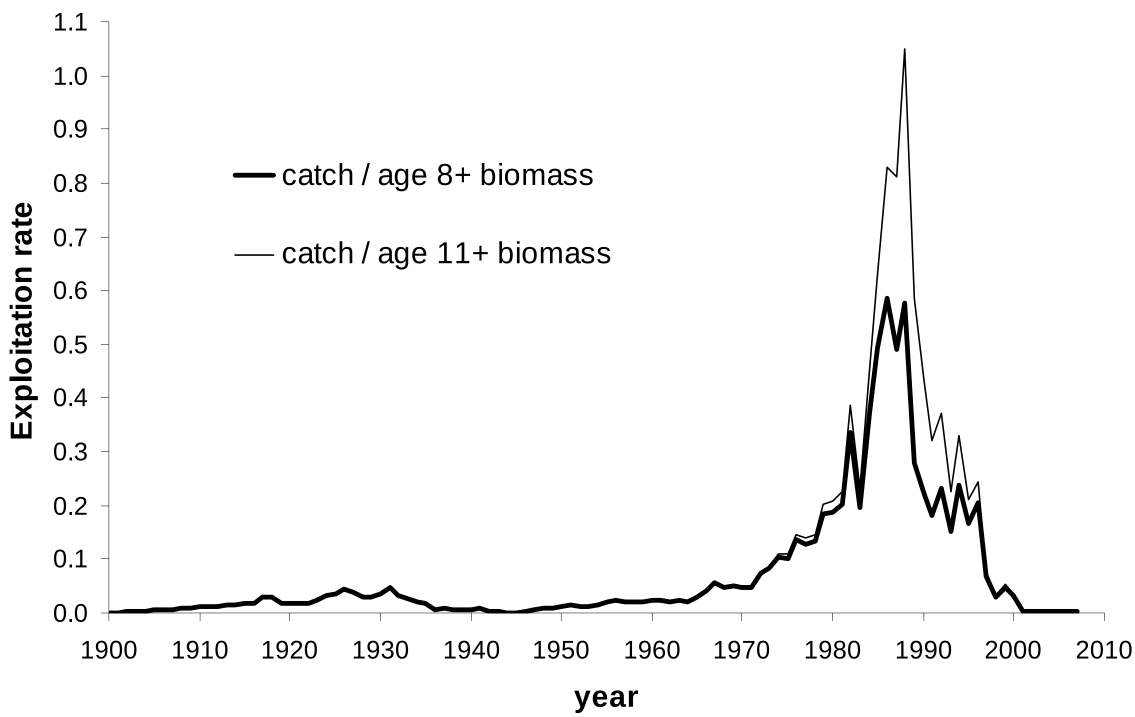


Figure 29: Time series of fishing intensity defined as 1 – SPR.

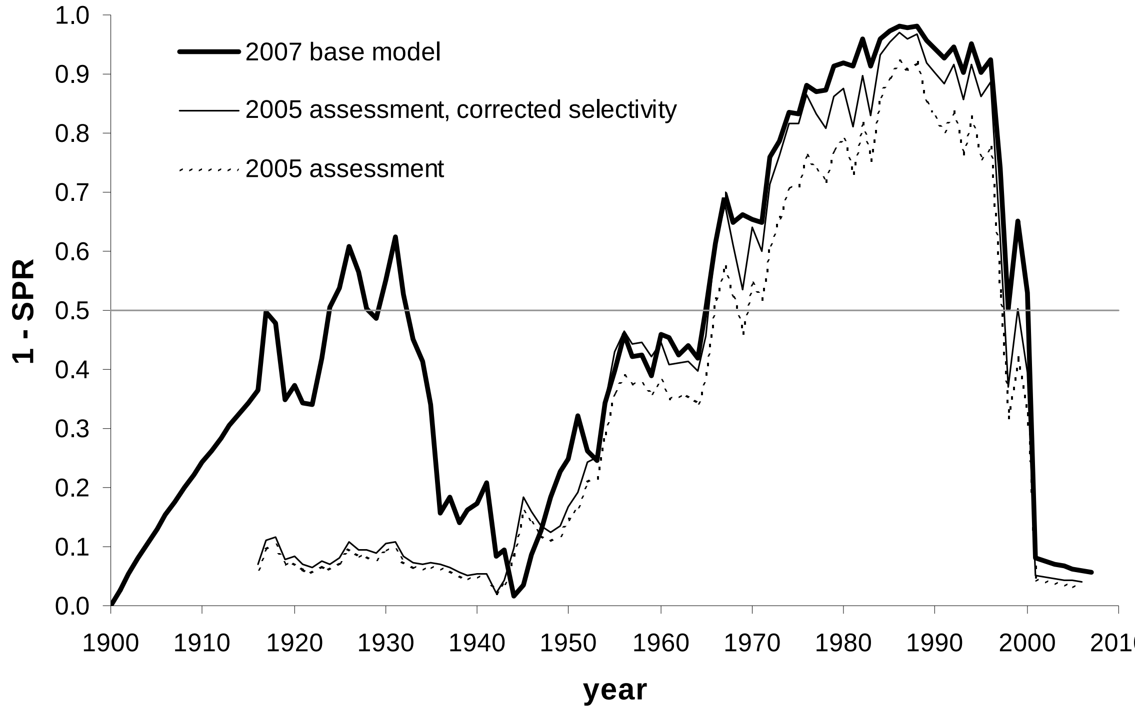


Figure 30: Rockfish landings in the southern California bight (1983 – 1985) by market category and method with which sample coverage was used to estimate the landings (CALCOM, 2007).

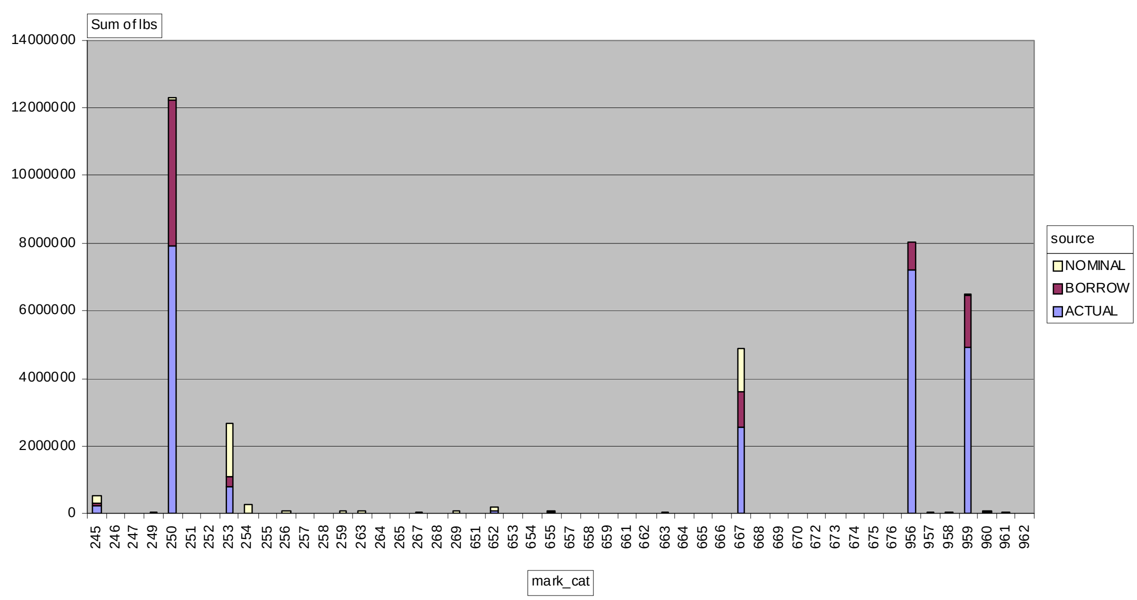


Figure 31: CPFV logbook indices, with and without log(rockfish catch) as a covariate.

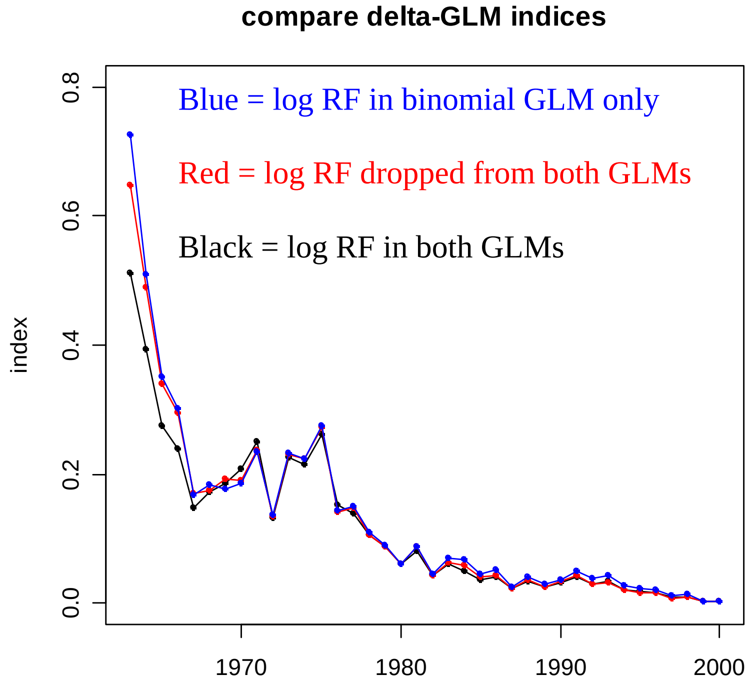


Figure 32: Components of the delta-GLM model from the revised CPFV logbook index.

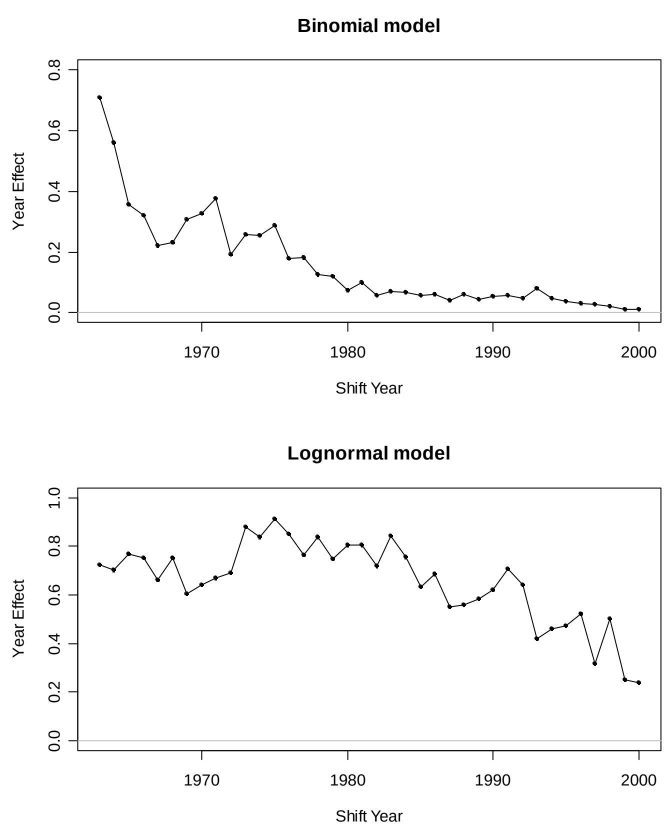


Figure 33: Natural log of CPUE (number of cowcod per angler hour) as a function of log(rockfish catch) with mean subtracted, by shift-year (aka “season”) defined as the months of November – April. All regions are combined. Data for the 1963 season are in the lower left corner, and years increase from left to right, then upward by row.

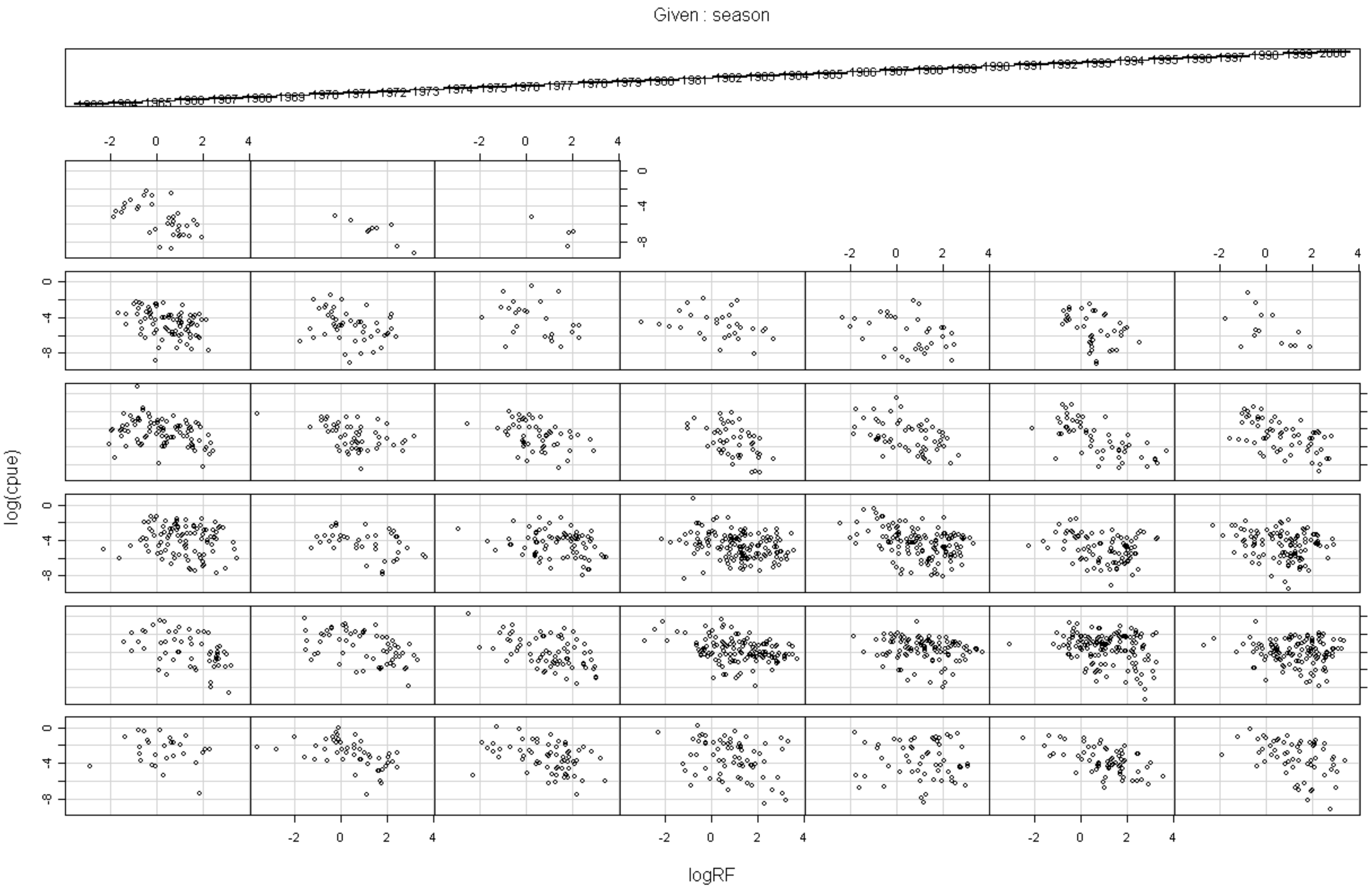


Figure 34: Natural log of CPUE (number of cowcod per angler hour) as a function of log(rockfish catch) with mean subtracted, shown by region (see Fig. 23) for all years. Data from 43-fathom bank are in the lower left corner, and regions progress as per the legend from left to right, and upward by row.

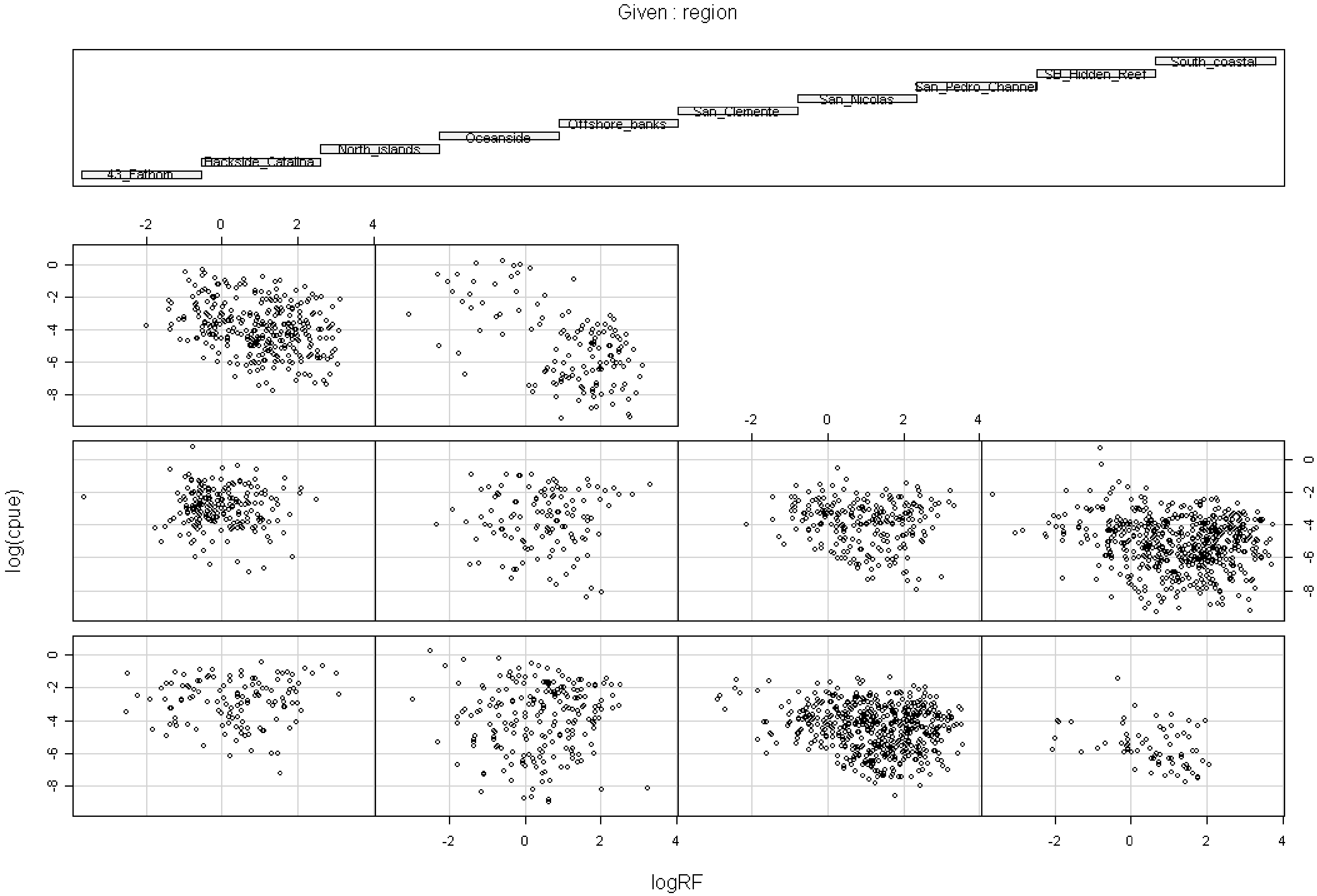


Figure 35: Standardized residual plots from the “BIC-best” Gaussian GLM for log(CPUE).

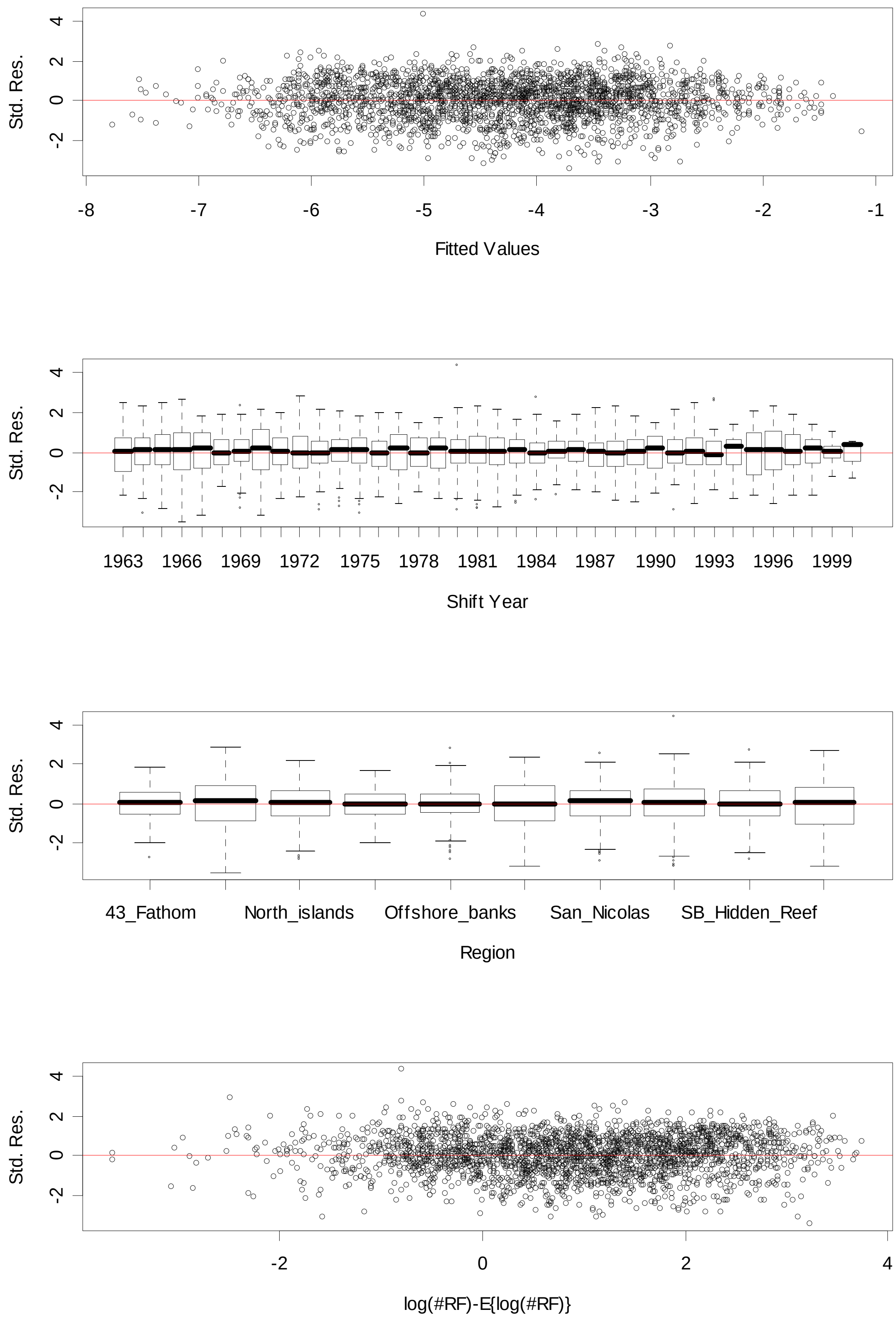


Figure 36: Time series of mean CPUE, by region, for the CPFV logbook data.

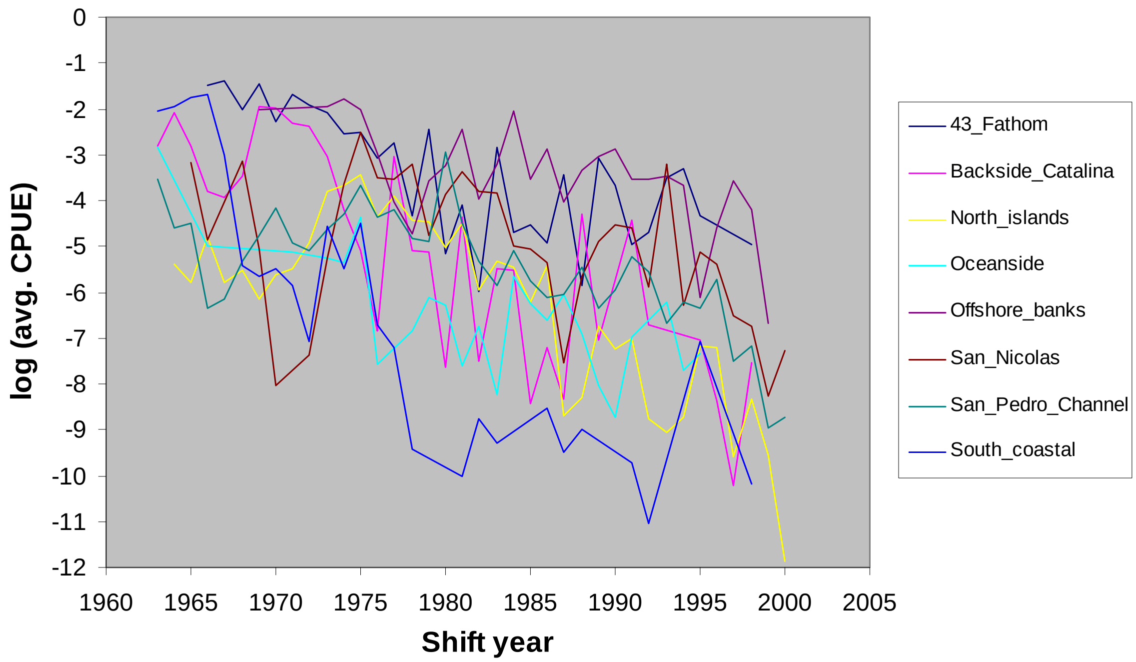
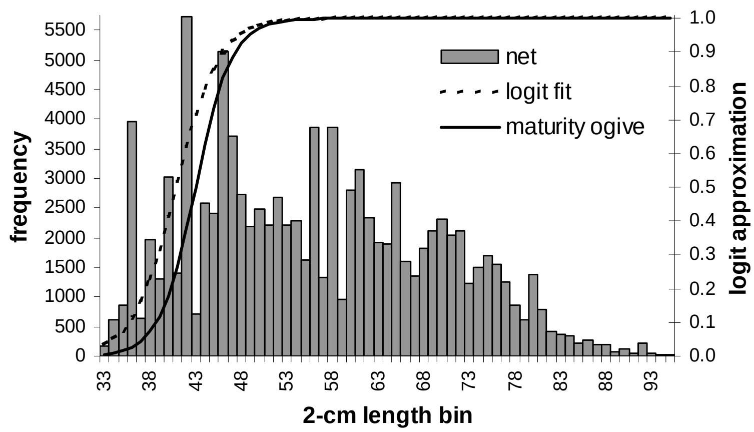


Figure 37: Length frequencies from the a) commercial net and b) hook-and-line fisheries.

a)



b)

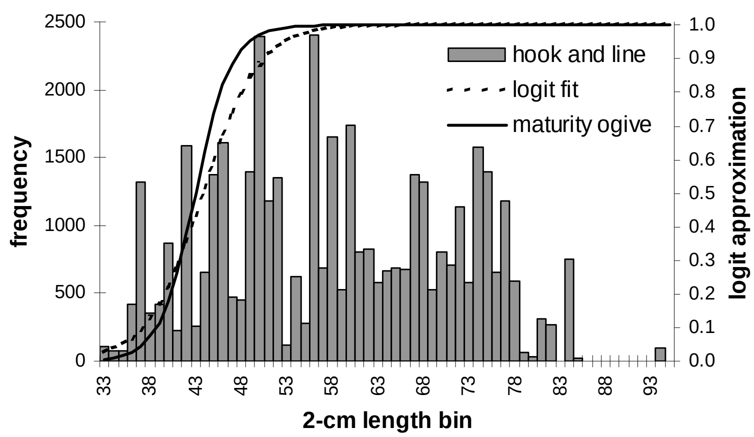
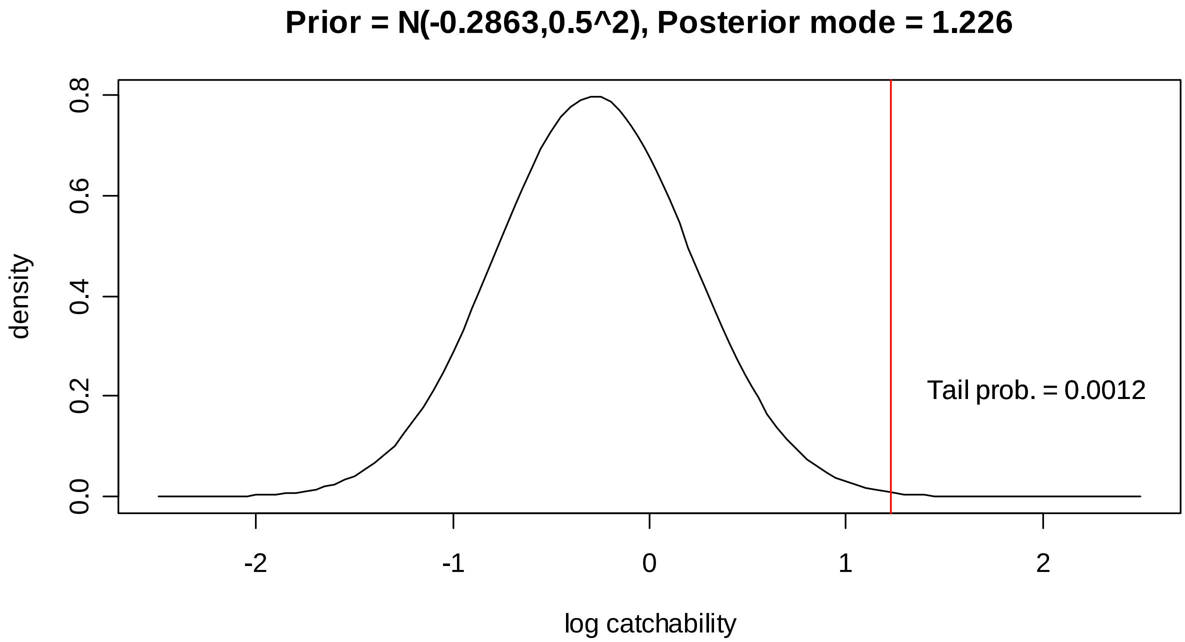


Figure 38: Comparison of the prior probability distribution for the logarithm of the visual survey catchability parameter to the posterior mode. See Appendix C for a comparison of the prior and MCMC draws from the marginal posterior distribution.



Appendix A

California Commercial Rockfish Landing Estimation Methods for 1969-1983

In September 2005, the California Cooperative Groundfish Survey (CCGS) incorporated newly acquired commercial landings statistics from 1969-77 into the CALCOM database. Species-specific rockfish landings were estimated using stratified species compositions gathered during the earliest years when port sampling was conducted. Stratification of CCGS port samples typically includes year, port, gear, quarter, and market category as classification variables. However, analysis of the data indicated that during the earlier period, when no port samples were available (1969-77), at least one market category had been redefined, resulting in serious errors in the landing estimates. In October 2006, the 1969-77 landings were re-estimated using a ratio estimator approach that dropped market category as a classification variable. In addition, since port samples for Los Angeles, Santa Barbara, and San Diego were not available until 1984, the landings for these three ports were re-estimated for 1978 through 1983 using the same approach. The ratio estimator was based on pooling the three earliest years in which port sampling was conducted, with stratification by port, gear, and quarter (i.e., market category was dropped). Species compositions that could be applied to the combined "rockfish" landings during the earlier time period were estimated as the sum of the landings for a species divided by the sum of the total rockfish landings by port, gear, and quarter. A brief explanation of the reasons for the re-estimation of early landings statistics is provided here.

When the yelloweye rockfish (*Sebastes ruberrimus*) stock assessment was being conducted in 2005 (Wallace et al. 2006), it was noticed that yelloweye landings between 1969 through 1977 were estimated to be unrealistically high. This initiated a careful examination of expansion procedures to determine the cause. The current approach to estimating rockfish landings in California relies on stratifying by year, port, gear, condition (live or dead), market category, and quarter. Market category usage has been highly dynamic over time (Figure A1). Note, for example, that there are currently over 50 defined market categories, whereas during the 1970s there were less than 20 categories in use. This highlights why market category is an essential stratum for catch expansions. However, its use depends on the assumption that market category definitions are stable, especially when they are applied over an extended time period. While new market categories can be added, it is important that the definition of existing market categories must not change within an expansion time interval; if they do, landing estimates can be strongly affected. This is what occurred in the early 1980's with market category 265 (currently defined as nominal "yelloweye rockfish").

In the 1970's, a large fraction of the rockfish was landed in market category 265 (up to 18% of the landings) (see Figure A2). Because not all strata (=years) had been sampled, species compositions gathered later in the time series were applied to these earlier landings: this was a mistake. As can be seen in Figure A2, the fraction of rockfish landed in market category 265 declines to nearly zero in 1982 and remains very small thereafter.

In Figure A3, the species compositions using samples from market category 265 before 1982 (n=26) are compared to compositions taken from 1991-1993 (n=31). Less than 2% of market category 265 was actually *Sebastes ruberrimus* prior to 1982, while more than 98% was later on. Furthermore, market category 265 nearly disappears after 1982 and market category 959 (defined as "group red"), starts to show up in 1983 (Figure A2). Examination of the species composition of market category 959 after 1982 indicates that many of the species previously landed in market category 265 were landed in market category 959. Taken altogether we feel that this indicates that market category 265 was redefined in 1982.

The next question that needs to be asked is what market category was used to land yelloweye rockfish if market category 265 was not being used. In Figure A4, it can be seen that the majority of *S. ruberrimus* have been landed in the well-sampled market category 250 ("unspecified rockfish"). Large landings are also made in market category 959 after 1982. Figure A4 is based on actual samples and does not represent all estimated landings, but it is clear that market category 265 does not account for the preponderance of landings.

Given that yelloweye rockfish sorting practices in commercial markets have changed markedly, it is not surprising that landings estimates of other species have been altered as well. This is because the total catch of all *Sebastes* spp. must still sum to the reported "rockfish" catch. Since estimates of yelloweye rockfish catch in the 1970s were reduced, catch estimates for other taxa were increased.

Currently the CCGS is preparing a written report on the reliability of landing estimates for all groundfish in the database, with a final version due by the end of 2007. Nonetheless, current landing estimates in CALCOM are now deemed to be the best available data by the State of California. The report that is in preparation will provide guidance to authors on how reliable the estimates are for any given species.

Wallace, F., T. Tsou, T. Jagielo, and Y. W. Cheng. 2006. Status of yelloweye rockfish off the U.S. west coast in 2006. In: Stock Assessment and Fishery Evaluation. Pacific Fishery Management Council, 2130 SW Fifth Ave., Suite 224, Portland, OR, 97210.

Fig A1: Rockfish Landings and Number of Market Categories

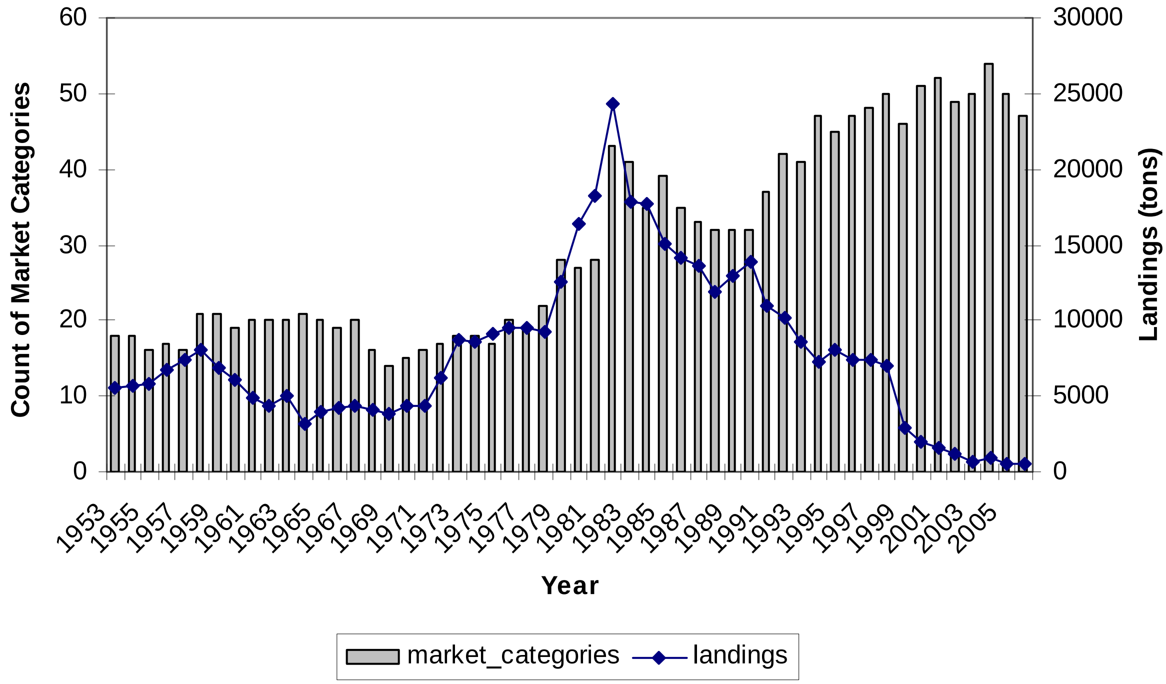


Fig. A2: Percent of Rockfish Landings By Selected Market Cateories

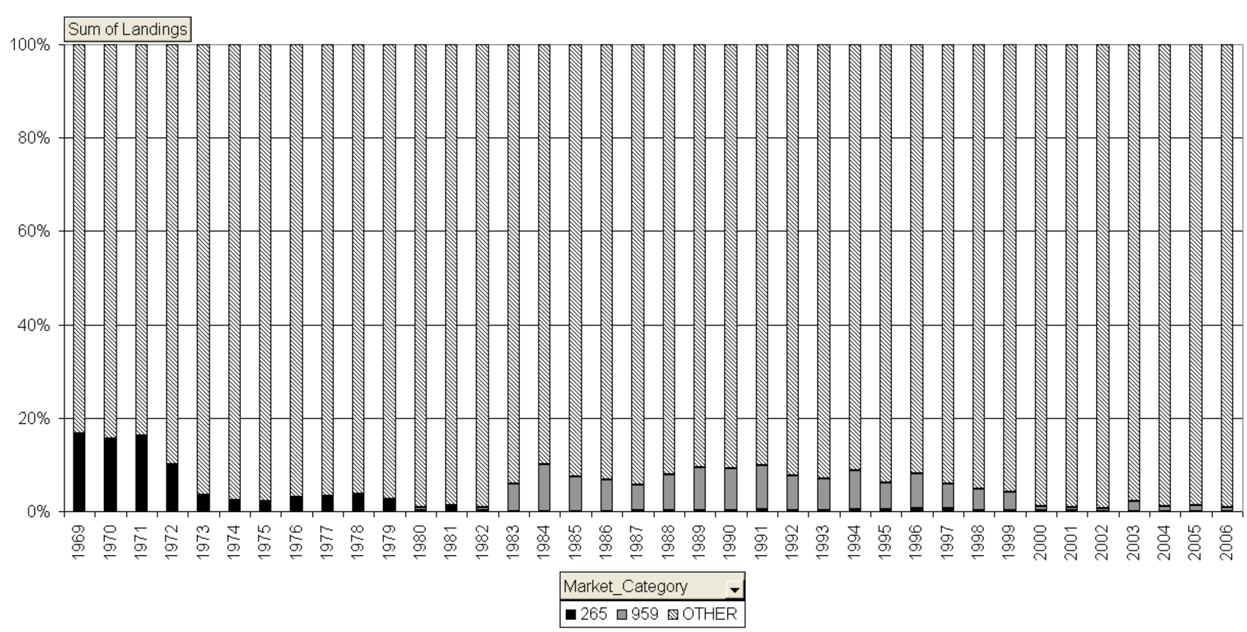


Fig. A3: Market Category 265 Species Composition

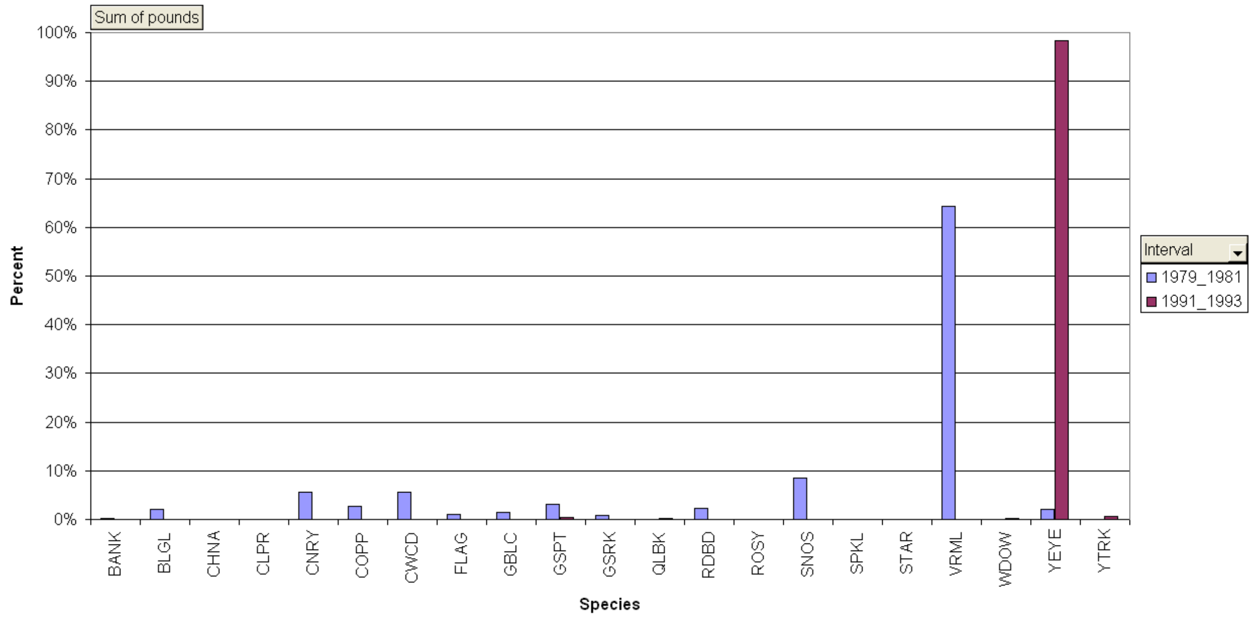
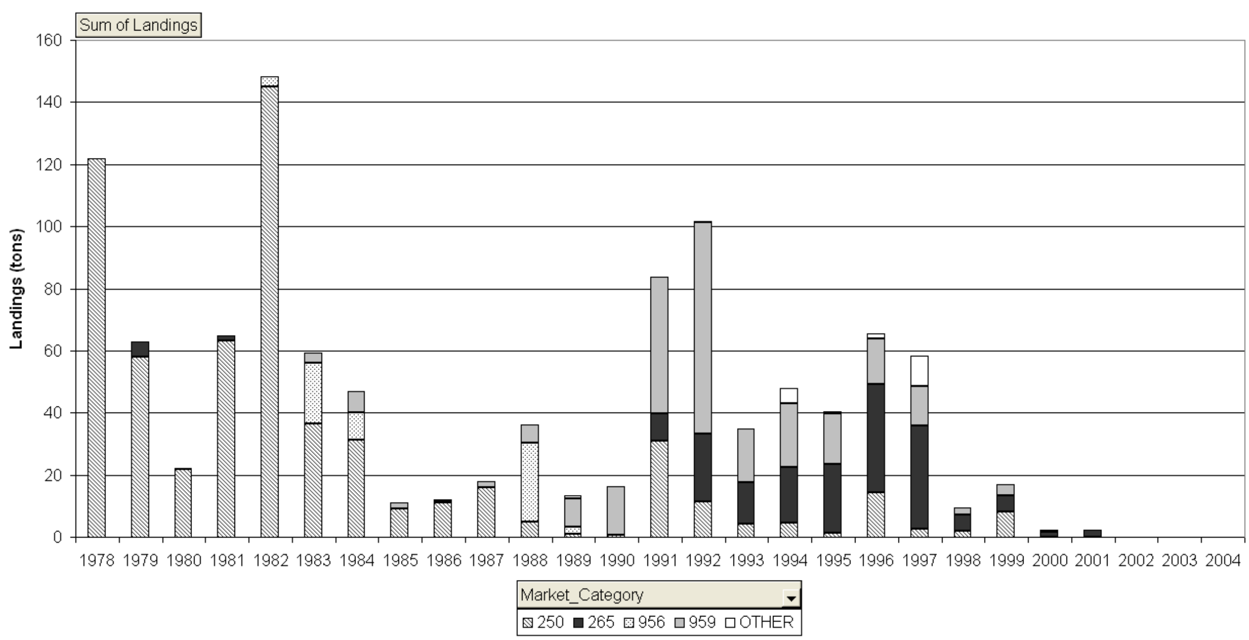


Fig. A4: Actual Yelloweye Landings By Market Category



Appendix B: Stock Synthesis 2 files for base model

```
##
##  SS2 Version 2.00
##
##  Data & Control Files
moo3_base.dat
moo3_base.ctl
##
0       # Read PAR File (0 = No, 1 = Yes)
1       # Verbosity Flag
1       # Write Report File
0       # Number of Bootstrap Files
4       # Last Phase
Code_version_:_        # Code Version Label
1       # Burn In MCMC
1       # Thinning MCMC
0.0     # Jitter Value
0.01    # Push Value
-1      # Min Year SP_BIO
-1      # Max Year SP_BIO
1.0e-6  # Convergence Criteria
0       # Retrospective Year
1       # Keep Catches; set to 0 when calc'ing dynamic B0
0.2     # Ball Park F
-1      # Ball Park Year (negative value omits from optimization, ignores ball park F)
1       # Pope's Approximation (1=Pope's, 0=estimate F's)
1       # Summary Age
1       # Forecast Option # 0 = no forecast; 1 = use target F
1       # MSY Option; 1 = set F(msy) = F(spr); 2=calc F(MSY); 3=set F(MSY) equal to F(Btarget)
0       # West Coast Groundfish Rebuilder Program Option
2000    # Start Year Rebuilder
2007    # End Year Rebuilder


# control file for 2007 cowcod assessment
# Stock Synthesis 2, version 2.00c
# E.J. Dick, NMFS SWFSC Santa Cruz Lab
# December 2007

1       #_N_Growth_Patterns
1       #_N_submorphs
1       #_N_areas
1 1 1 1 #_area_assignments_for_each_fishery_and_survey

1       #_recruit_design_(G_Pattern_x_birthseas_x_area)_X_(0/1_flag)
0       #_recr_distr_interaction
0       #_Do_migration
0 0 0   #_movement_pattern_(for_each_season_x_source_x_destination)_input_(0/1_flag)_minage_maxage
```

```
0       #_Nblock_Designs
0.5     #_fracfemale
1000    #_submorph_between/within
1       #vector_submorphdist_(-1_first_val_for_normal_approx)
1       #_natM_amin
2       #_natM_amax

2       #_Growth_Age-at-L1 (Amin)
37      #_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(LAA))

1       #_maturity_option; 1 = length logistic
1       #_First_Mature_Age that can spawn, as per specified maturity ogive
3       #_parameter_offset_approach; 3 = offsets same as SS2 v1.xx
1       #_env/block/dev_adjust_method(1/2)
-1      #_MGparm_Dev_Phase

# mortality & growth_parms
# LO    HI      INIT    PRIOR   PR_type SD              PHASE
0.01    0.1     0.055   0.055   0       0.007653        -1      0 0 0 0 0.5 0 0         # natural mortality young
0       0       0       0       0       0.007653        -1      0 0 0 0 0.5 0 0         # natural mortality old (offset)
10      20      16.2    16.2    0       10              -1      0 0 0 0 0.5 0 0         # length at Amin
70      80      75.6    75.6    0       0.8             -1      0 0 0 0 0.5 0 0         # length at Amax
0.01    0.25    0.052   0.052   0       0.8             -1      0 0 0 0 0.5 0 0         # k, von Bertalanffy growth coef.
0.01    0.5     0.265   0.265   0       99              -1      0 0 0 0 0.5 0 0         # CV young
0       1       -1.781  -1.781  0       0.8             -1      0 0 0 0 0.5 0 0         # CV old (exp. offset)

#_wt-len, maturity, and [eggs/kg]=a+b*weight
-3      3       1.01e-5 1.01e-5 0       0.8     -1      0 0 0 0 0.5 0 0
-3      3       3.093   3.093   0       0.8     -1      0 0 0 0 0.5 0 0
-3      3       43      43      0       0.8     -1      0 0 0 0 0.5 0 0
-3      3       -0.5106 -0.5106 0       0.8     -1      0 0 0 0 0.5 0 0
0       1       1       1       0       0.8     -1      0 0 0 0 0.5 0 0
0       1       0       0       0       0.8     -1      0 0 0 0 0.5 0 0

# recruitment apportionment
-4      4       0       0       -1      99      -3      0 0 0 0 0.5 0 0         #_recrdistribution_by_growth_pattern
-4      4       0       0       -1      99      -3      0 0 0 0 0.5 0 0         #_recrdistribution_by_area 1
-4      4       4       0       -1      99      -3      0 0 0 0 0.5 0 0         #_recrdistribution_by_season 1
1       1       1       1       -1      99      -3      0 0 0 0 0.5 0 0         #_cohort_growth_deviation

0 #_custom_MG-env_setup

0 #_custom_MG-block_setup

#_Spawner-Recruitment
1 #_SR_function
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE
2       8       7       4.5     -1      100     1       # virgin recruitment
0.2     1       0.6     0.597   2       0.183   -2      # steepness
```

```
0       2       0.01    0.4     0       1000    -3      # sigma-r
-5      5       0       0       0       1       -3      # env-link
-5      5       0       0       0       1       -3      # offset for initial equilibrium
0       0.5     0       0       -1      99      -2      # [reserve for future autocorrelation]

0       #_SR_env_link
1       #_SR_env_target_1=devs;_2=R0;_3=steepness
0       #do_recr_dev:  0=none; 1=devvector; 2=simple deviations

#first_yr       last_yr min_log_res     max_log_res     phase
2006    2005    -15     15      -3      #_recr_devs
1492    #_first_yr_fullbias_adj_in_MPD

#_initial_F_parms
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE
0       0.2     0       0       0       1000    -1
0       0.2     0       0       0       1000    -1

#_Q_setup
# A=do power, B=env-var, C=extra SD, D=devtype(<0=mirror, 0/1=none, 2=cons, 3=rand, 4=randwalk),
# E=0=num/1=bio, F=err_type
#_A  B  C  D  E  F
0 0 0 0 1 0
0 0 0 0 1 0
0 0 0 2 0 0
0 0 0 2 1 0

#_Q_parms(if_any)
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE
-14     -1      -9.5    -9      -1      1000    1       # catchability for CPFV index
-2.3    2.3     0.5     -0.2863 0       0.5     1       # catchability for visual survey

#_size_selex_types
#_Pattern Discard Male Special
1 0 0 0 # 1
1 0 0 0 # 2
5 0 0 2 # 3
0 0 0 0 # 4

#_age_selex_types
#_Pattern Discard Male Special
10 0 0 0 # 1
10 0 0 0 # 2
10 0 0 0 # 3
11 0 0 0 # 4

#_selex_parms
# LO    HI      INIT    PRIOR   PR_type SD      PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn
#_size_sel: 1 -- commercial fishery; mirrors maturity ogive
40      46      43      43      0       1000    -1      0 0 0 0 0.5 0 0
5       6       5.767   5.767   0       1000    -1      0 0 0 0 0.5 0 0
```

```
#_size_sel: 2 -- recreational fishery
10      50      34.06   35      0       1000    -1      0 0 0 0 0.5 0 0
5       15      7.52    7       0       1000    -1      0 0 0 0 0.5 0 0
#_size_sel: 3 -- CPFV index; mirrors recreational fishery
10      50      -1      35      0       1000    -1      0 0 0 0 0.5 0 0
5       15      -1      7       0       1000    -1      0 0 0 0 0.5 0 0
#_size_sel: 4
#_age_sel: 1
#_age_sel: 2
#_age_sel: 3
#_age_sel: 4 -- visual survey
0       1       0       0       0       1000    -1      0 0 0 0 0.5 0 0
79      80      80      80      0       1000    -1      0 0 0 0 0.5 0 0

1       #_env/block/dev_adjust_method(1/2)
0       #_custom_sel-env_setup
0       #_custom_sel-block_setup
-1      #_selparmdev-phase

#_Variance_adjustments_to_input_values
#_1 2 3 4
0 0 0.255 0    #_add_to_survey_CV
0 0 0 0 #_add_to_discard_CV
0 0 0 0 #_add_to_bodywt_CV
1 0 1 1 #_mult_by_lencomp_N
1 1 1 1 #_mult_by_agecomp_N
1 1 1 1 #_mult_by_size-at-age_N

30      #_DF_for_discard_like
30      #_DF_for_meanbodywt_like

1       #_maxlambdaphase
0       #_sd_offset

#_lambdas_(columns_for_phases)
0       # commercial fishery
0       # recreational fishery
1       # CPFV logbook index
1       # visual survey
0       #_discard:_1
0       #_discard:_2
0       #_discard:_3
0       #_discard:_4
0       #_meanbodyweight
0       #_lencomp:_1
0       #_lencomp:_2
0       #_lencomp:_3
0       #_lencomp:_4
0       #_agecomp:_1
0       #_agecomp:_2
0       #_agecomp:_3
```

```
0      #_agecomp:_4
0      #_size-age:_1
0      #_size-age:_2
0      #_size-age:_3
0      #_size-age:_4
0      #_init_equ_catch
0      #_recruitments
1      #_parameter-priors
0      #_parameter-dev-vectors
100    #_crashPenLambda
0.9    #_maximum allowed harvest rate

999


# data file for 2007 cowcod assessment
# REVISED 2002 BIOMASS ESTIMATE FROM VISUAL SURVEY
# Stock Synthesis 2, version 2.00c
# Revised December 2007
#
# MODEL DIMENSIONS
# ----------------
1900   # start year
2007   # 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
2      # number of fishing fleets
2      # number of surveys
#
# string containing names for all fisheries and surveys, delimited by the "%" character
commercial%recreational%CPFV%visual
# fraction of season elapsed before CPUE measured or survey conducted
0.5 0.5 0.5 0.5
#
1      # number of genders; females are gender 1
80     # accumulator age
#
# CATCH DATA
# ----------
0 0    # initial equilibrium catch for each fishery
# catch biomass (mtons); catch is retained catch, not total catch
# comm  rec     year
0.01   0      # 1900
5.34   0
10.68  0
16.01  0
21.35  0
26.68  0
32.02  0
37.35  0
```

```
42.68  0
48.02  0
53.35  0       # 1910
58.69  0
64.02  0
69.35  0
74.69  0
80.02  0
85.36  0
137.73 0
125.59 0
75.1   0
81.57  0       # 1920
71.26  0
70.11  0
93.94  0
125.94 0
138.15 0
171.48 0
142.3  0
111.3  0
102.48 0
126.78 0       # 1930
160.8  0
109.27 0
81.64  0
70.36  0
52.56  0
20.19  0
24.22  0
18.08  0
21.5   0
23.28  0       # 1940
29.1   0
10.4   0
12.18  0
1.83   0
4.38   0
11.3   0
17.58  0
26.87  0
35.05  0
39.37  0       # 1950
45.57  9
31.05  10
24.88  13
34.05  24
27.62  42
37.80  49
38.43  37
43.54  33
```

```
45.09   22
49.18   36      # 1960
50.05   33
37.92   35
47.21   30
36.07   34
50.97   43
47.41   85
63.22   110
63.87   77
94.98   53
55.92   79      # 1970
68.06   62
102.51  90
108.79  97
114.26  129
112.47  109
131.35  140
132.44  100
147.75  73
187.52  86
142.62  96.43   # 1980
197.59  26.55
228.55  96.99
126.55  15.13
221.14  21.22
204.75  35.99
146.99  45.99
76.62   29.14
86.60   13.91
17.38   20.60
10.41   21.60   # 1990
7.10    20.90
17.21   20.70
14.85   9.68
13.63   26.01
23.30   1.75
24.57   5.36
7.30    1.85
1.21    2.81
3.47    3.77
0.45    4.49    # 2000
0.25    0.25
0.25    0.25
0.25    0.25
0.25    0.25
0.25    0.25
0.25    0.25
0.25    0.25    # 2007
#
# ABUNDANCE INDICES
```

```
# -----------------
#
39      # number of observations
#
#year   season  type    value           CV
1963    1       3       0.511667932     0.3302199
1964    1       3       0.39318353      0.2527121
1965    1       3       0.275071085     0.2246714
1966    1       3       0.239739296     0.2308946
1967    1       3       0.146883176     0.2463383
1968    1       3       0.172989635     0.1777022
1969    1       3       0.185848155     0.2369852
1970    1       3       0.208035274     0.2734493
1971    1       3       0.251555595     0.1952652
1972    1       3       0.132619837     0.211407
1973    1       3       0.22675229      0.1413628
1974    1       3       0.213903213     0.1574918
1975    1       3       0.260807514     0.1488574
1976    1       3       0.152136187     0.1515156
1977    1       3       0.139320919     0.1980102
1978    1       3       0.106248194     0.2184173
1979    1       3       0.088607116     0.1867767
1980    1       3       0.060658815     0.1674501
1981    1       3       0.081386727     0.1680148
1982    1       3       0.042134063     0.190058
1983    1       3       0.060328342     0.1540601
1984    1       3       0.050024814     0.1784306
1985    1       3       0.036993343     0.2046437
1986    1       3       0.041577946     0.1963785
1987    1       3       0.023065175     0.2253322
1988    1       3       0.033749003     0.24057
1989    1       3       0.025582052     0.2341604
1990    1       3       0.032747243     0.2118718
1991    1       3       0.041559421     0.182387
1992    1       3       0.030297922     0.2437875
1993    1       3       0.033171318     0.3494245
1994    1       3       0.021107241     0.2903738
1995    1       3       0.017687439     0.3372674
1996    1       3       0.016099821     0.2987764
1997    1       3       0.008792843     0.4584879
1998    1       3       0.010754417     0.2743454
1999    1       3       0.003092846     0.443594
2000    1       3       0.002914665     0.6721232
# revised biomass estimate as of Oct. 2007
2002    1       4       524.3   0.26
#
# DISCARD BIOMASS
# ---------------
#
1       # 1=biomass(mt) discarded; 2=fraction of total catch discarded
0       # number of observations
```

```
#
# MEAN BODY WEIGHT
# ----------------
0       # number of observations
#
# COMPOSITION CONDITIONERS
# -----------------------
-1      # negative value causes no compression
0.0001  # constant added to proportions at length & age (renormalized to sum to 1 after constant is added)
#
# LENGTH COMPOSITION
# ------------------
#
46      # number of length bins
# vector containing lower edge of length bins
10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94 96 98
100
#
0       # number of lines of length comp observations
#
# AGE COMPOSITIONS
# ----------------
0       # number of age bins
#
0       # number of unique ageing error matrices
0       # number of age observations
#
# 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
#
999     # end of data file


# forecast file for cowcod assessment, 2007
#
0.5     # target SPR
1       # number of forecast years
1       # number of forecast years with stddev
0       # emphasis for the forecast recrutment devs that occur prior to endyyr+1
0       # fraction of bias adjustment to use with forecast_recruitment_devs before endyr+1
0       # fraction of bias adjustment to use with forecast_recruitment_devs after endyr
0.40    # topend of 40:10 option; set to 0.0 for no 40:10
0.10    # bottomend of 40:10 option
1.0     # OY scalar relative to ABC
1990    # first yr for average fish selex to use in MSY and forecast
```

```
2000    # last yr for average fish selex to use in MSY and forecast
1       # for forecast:  1=set relative F from endyr; 2=use relative F read below
1 1     # relative F for forecast when using F;  seasons; fleets within season
999     # verification read for end of the correct number of relative F reads
0.25    # year 1, comm. fleet
0.25    # year 1, rec. fleet
```

Appendix C: Results of a Preliminary Bayesian Analysis

This appendix refers to results from the base model at the time of the STAR panel. Due to subsequent changes (e.g. the revised 2002 visual survey estimate), values may differ from the results presented in the Executive Summary and/or previous sections of the main document.

The STAR panel requested a MCMC run for a model with the following specifications:

1. Use Dorn's prior for h.
2. M: Normal with 95% within 0.04 and 0.07.
3. q: for Visual as before.
4. Recruitment fixed, no recruit deviations (recdevs)
5. R0: uniform prior on log R0
6. Log(q): uniform for CPFV (bounds at author's discretion).
7. Thinning, burn-in and total number of runs will be determined based on how much time this takes---author's discretion.

We presented preliminary results for this request, which appeared promising at first. Subsequent, longer runs failed to converge, as was clearly apparent from visual inspection of trace plots and running means (e.g. Fig. C1). Simulations with alternative starting values were explored, with similar results. Two runs with fixed natural mortality were simulated for 10 million iterations, thinned to every 10,000th iteration, and appeared to be making progress towards convergence but took four days to complete. Results of this analysis were not complete as of this report.

The base model has fixed steepness and natural mortality, estimating only virgin recruitment and catchability coefficients for the CPFV index and visual survey. MCMC is easy for this model, so we ran two simulations. Each chain consisted of 450,000 iterations, thinned every 30th iteration, for a total of 15,000 samples per chain. Visual inspection of the trace plots (Fig. C2) suggest that a burn-in of 5000 samples was more than sufficient. The first chain was initialized with the MLEs, and appeared to converge immediately. MCMC diagnostics were generated with the "boa" package in R (Table C1, http://www.public-health.uiowa.edu/boa). A thinning interval of 30 appeared to be sufficient, the convergence criteria were met, and parameter correlations were sufficiently small (Table C1, Fig. C3). We plotted posterior densities for each chain and model parameter (Fig. C4).

Although this is one of the simplest models for generating MCMC simulations, it does provide some useful information. The point estimate of depletion from the current base model is based on the posterior mode. The posterior distribution for depletion is necessarily skewed as it approaches zero (depletion cannot be negative). As illustrated by the MCMC results we see that the mode < median < mean (Table C2, Fig. C5). From the MCMC results, the posterior mean for depletion is 5.1%, with a 95% posterior interval of (2.8%, 8.3%), compared to the base model's point estimate (posterior mode) of 4.55% with a 95% asymptotic interval of (2.1%, 7.0%). This suggests that for severely depleted stocks, the posterior mode might present an overly pessimistic point estimate of depletion. Of course, as stocks rebuild this effect will usually diminish.

Not surprisingly, the precision of the parameter estimates and derived quantities from this model are unrealistically high (Table C2, Figs. C4 and C5). Simple models with limited data necessarily make strong assumptions, such as fixing steepness and natural mortality and not estimating recruitment deviations. The 3-parameter model suggests that we know unfished recruitment to within 2000 fish and MSY to within one metric ton. In short, the MCMC results from this simple model do not solve the problems associated with quantifying our uncertainty about stock status.

We conclude this preliminary analysis with a comparison of the prior and posterior distributions for log catchability of the visual survey (Fig. C6). The results are qualitatively similar to the comparison of the point estimate and prior in Fig. 38, but the MCMC results provide more information about our uncertainty regarding this parameter. All 20,000 samples (chains combined) were larger than the prior mean, illustrating the strong tension between the CPFV index and visual survey in the base model.

Table C1: Output from Bayesian Output Analysis Program (BOA) for MCMC, version 1.1.6-1 (http://www.public-health.uiowa.edu/boa)

```
LAGS AND AUTOCORRELATIONS:
==========================

Chain: parm.c1
--------------
             Lag 1        Lag 5       Lag 10       Lag 50
Qparm1  0.05059082 -0.003040157 -0.001018786  0.001758045
Qparm2  0.07085449 -0.008748758  0.003910217  0.001163979
SRparm1 0.15567511 -0.011644322  0.014002676 -0.005173011

Chain: parm.c2
--------------
             Lag 1        Lag 5       Lag 10       Lag 50
Qparm1  0.08559620  0.012673099  0.001173011 -0.001624859
Qparm2  0.06745626 -0.001882962 -0.013923475 -0.009092964
SRparm1 0.16756270 -0.019647828 -0.007815128 -0.010236029

CROSS-CORRELATION MATRIX:
=========================

Chain: parm.c1
--------------
        Qparm1     Qparm2     SRparm1
Qparm1  1
Qparm2  0.3833836  1
SRparm1 -0.5392519 -0.6908106 1

Chain: parm.c2
--------------
        Qparm1     Qparm2     SRparm1
Qparm1  1
Qparm2  0.3771232  1
SRparm1 -0.5330452 -0.6946958 1


HIGHEST PROBABILITY DENSITY INTERVALS:
======================================

Alpha level = 0.05

Chain: parm.c1
--------------
        Lower Bound Upper Bound
Qparm1    -8.693740    -8.30580
Qparm2     0.483681     1.70890
SRparm1    4.696540     4.71214

Chain: parm.c2
--------------
        Lower Bound Upper Bound
Qparm1    -8.686700    -8.29990
Qparm2     0.461683     1.70944
SRparm1    4.696580     4.71241

SUMMARY STATISTICS:
===================

Bin size for calculating Batch SE and (Lag 1) ACF = 50
```

```
Chain: parm.c1
--------------
              Mean          SD     Naive SE     MC Error     Batch SE   Batch ACF
Qparm1  -8.492155 0.099174685 9.917468e-04 1.203833e-03 1.123891e-03  0.06224635
Qparm2   1.096091 0.313570001 3.135700e-03 3.276657e-03 3.381300e-03 -0.03303373
SRparm1  4.703869 0.004201987 4.201987e-05 4.529227e-05 5.000215e-05 -0.08289252

             0.025       0.5     0.975 MinIter MaxIter Sample
Qparm1  -8.6869597 -8.491095 -8.298476    5001   15000  10000
Qparm2   0.4823342  1.097150  1.708005    5001   15000  10000
SRparm1  4.6974300  4.703250  4.713710    5001   15000  10000

Chain: parm.c2
--------------
              Mean          SD     Naive SE    MC Error     Batch SE   Batch ACF
Qparm1  -8.494836 0.099321550 9.932155e-04 0.001303578 1.164007e-03  0.11249145
Qparm2   1.091375 0.317588837 3.175888e-03 0.003198754 3.452430e-03 -0.07255780
SRparm1  4.703946 0.004233298 4.233298e-05 0.000052233 5.121901e-05  0.02502094

             0.025       0.5     0.975 MinIter MaxIter Sample
Qparm1  -8.6896645 -8.494055 -8.302354    5001   15000  10000
Qparm2   0.4684662  1.092055  1.717138    5001   15000  10000
SRparm1  4.6974000  4.703395  4.713730    5001   15000  10000


BROOKS, GELMAN, AND RUBIN CONVERGENCE DIAGNOSTICS:
==================================================

Iterations used = 10001:15000

Potential Scale Reduction Factors
---------------------------------
  Qparm1   Qparm2  SRparm1
1.000212 1.000119 1.000269

Multivariate Potential Scale Reduction Factor = 1.000300

Corrected Scale Reduction Factors
---------------------------------
        Estimate    0.975
Qparm1  1.000213 1.001469
Qparm2  1.000183 1.001064
SRparm1 1.000582 1.002069


GEWEKE CONVERGENCE DIAGNOSTIC:
==============================

Fraction in first window = 0.1
Fraction in last window = 0.5

Chain: parm.c1
--------------
           Qparm1    Qparm2    SRparm1
Z-Score 0.1815178 1.3707555 -0.4795196
p-value 0.8559612 0.1704512  0.6315690

Chain: parm.c2
--------------
           Qparm1    Qparm2    SRparm1
Z-Score 0.1994390 0.9027804 -1.0762908
p-value 0.8419194 0.3666425  0.2817972
```

```
HEIDLEBERGER AND WELCH STATIONARITY AND INTERVAL HALFWIDTH TESTS:
=================================================================

Halfwidth test accuracy = 0.1

Chain: parm.c1
--------------
        Stationarity Test  Keep Discard   C-von-M Halfwidth Test      Mean    Halfwidth
Qparm1             passed 10000       0 0.1265813         passed -8.492155 2.359470e-03
Qparm2             passed 10000       0 0.2134562         passed  1.096091 6.422131e-03
SRparm1            passed 10000       0 0.1401630         passed  4.703869 8.877121e-05

Chain: parm.c2
--------------
        Stationarity Test  Keep Discard   C-von-M Halfwidth Test      Mean    Halfwidth
Qparm1             passed 10000       0 0.2181740         passed -8.494836 0.0025549662
Qparm2             passed 10000       0 0.2935478         passed  1.091375 0.0062694434
SRparm1            passed 10000       0 0.3730528         passed  4.703946 0.0001023748


RAFTERY AND LEWIS CONVERGENCE DIAGNOSTIC:
=========================================

Quantile = 0.025
Accuracy = +/- 0.005
Probability = 0.95

Chain: parm.c1
--------------
         Thin Burn-in Total Lower Bound Dependence Factor
Qparm1     1       2  3802        3746          1.014949
Qparm2     1       2  3897        3746          1.040310
SRparm1    1       2  3942        3746          1.052322

Chain: parm.c2
--------------
         Thin Burn-in Total Lower Bound Dependence Factor
Qparm1     1       2  3929        3746          1.048852
Qparm2     1       3  4061        3746          1.084090
SRparm1    1       2  3797        3746          1.013615
```

Table C2: Posterior summaries of derived quantities, based on combined samples from chains 1 and 2 (20,000 samples total).

	0.025	**median**	**mean**	**0.975**
SPB_Vir	2482	2497	2498	2523
Recr_Vir	109663	110314	110379	111467
SPB_2007	70	123	128	209
Depl.endyr	2.8%	4.9%	5.1%	8.3%
Bmsy	1985	1997	1998	2018
MSY	60.9	61.3	61.3	61.9

Figure C1: Example of trace plots from one MCMC run as per STAR panel request. 500,000 iterations. M = Mgparm1, R0 = SRparm1, h = SRparm2, CPFV catchability = Qparm1, visual survey catchability = Qparm2.

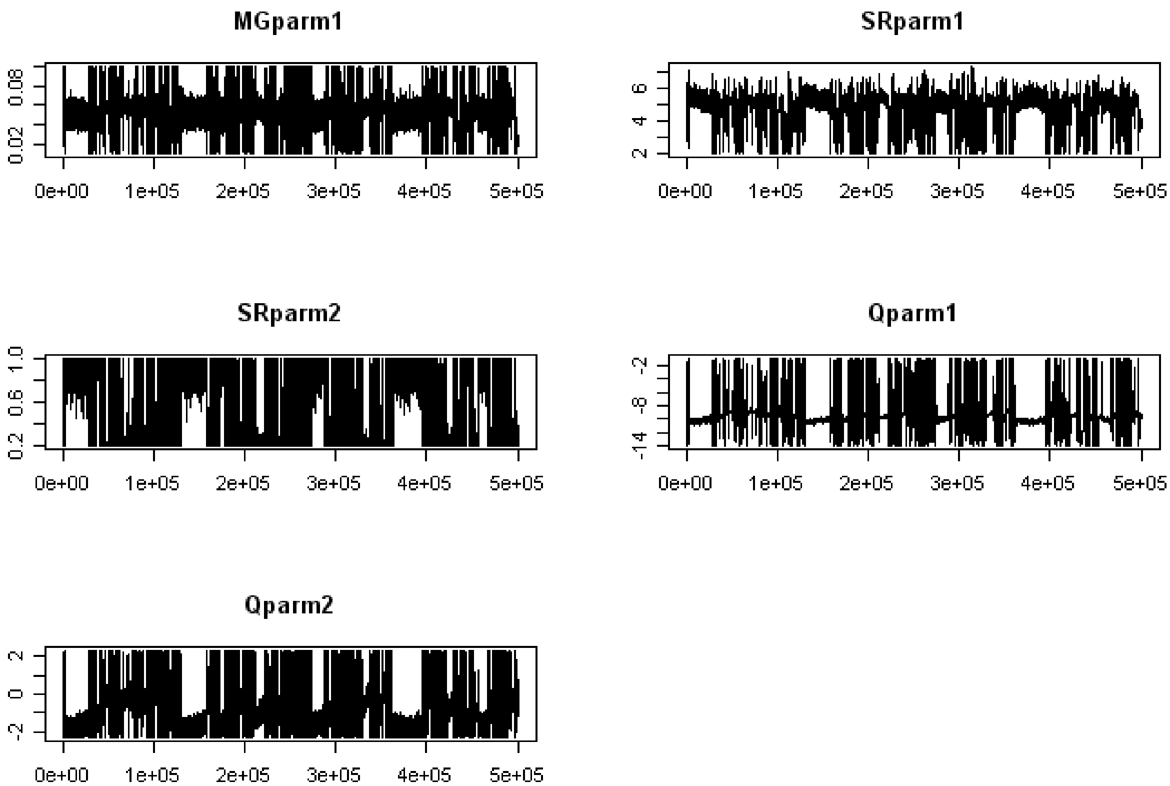


Figure C2: Trace plots from 2 MCMC simulations for the 3-parameter base model. Chain 1 was initialized with values from the optimization stage (posterior modes) and chain 2 was initialized with alternative values. The first 5000 iterations were removed from both chains prior to analysis.

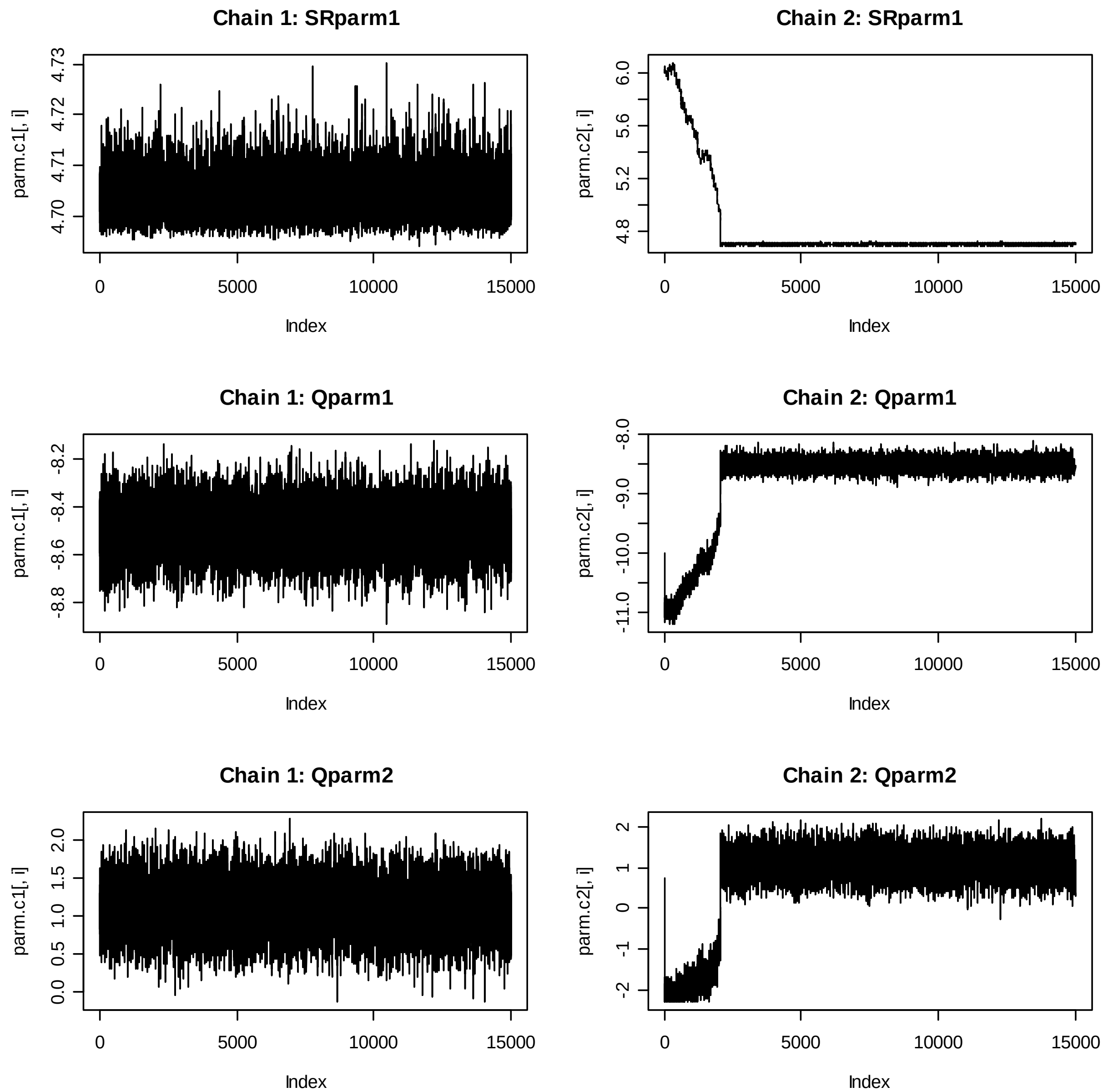


Figure C3: Scatterplot of posterior simulations from the 3-parameter base model.

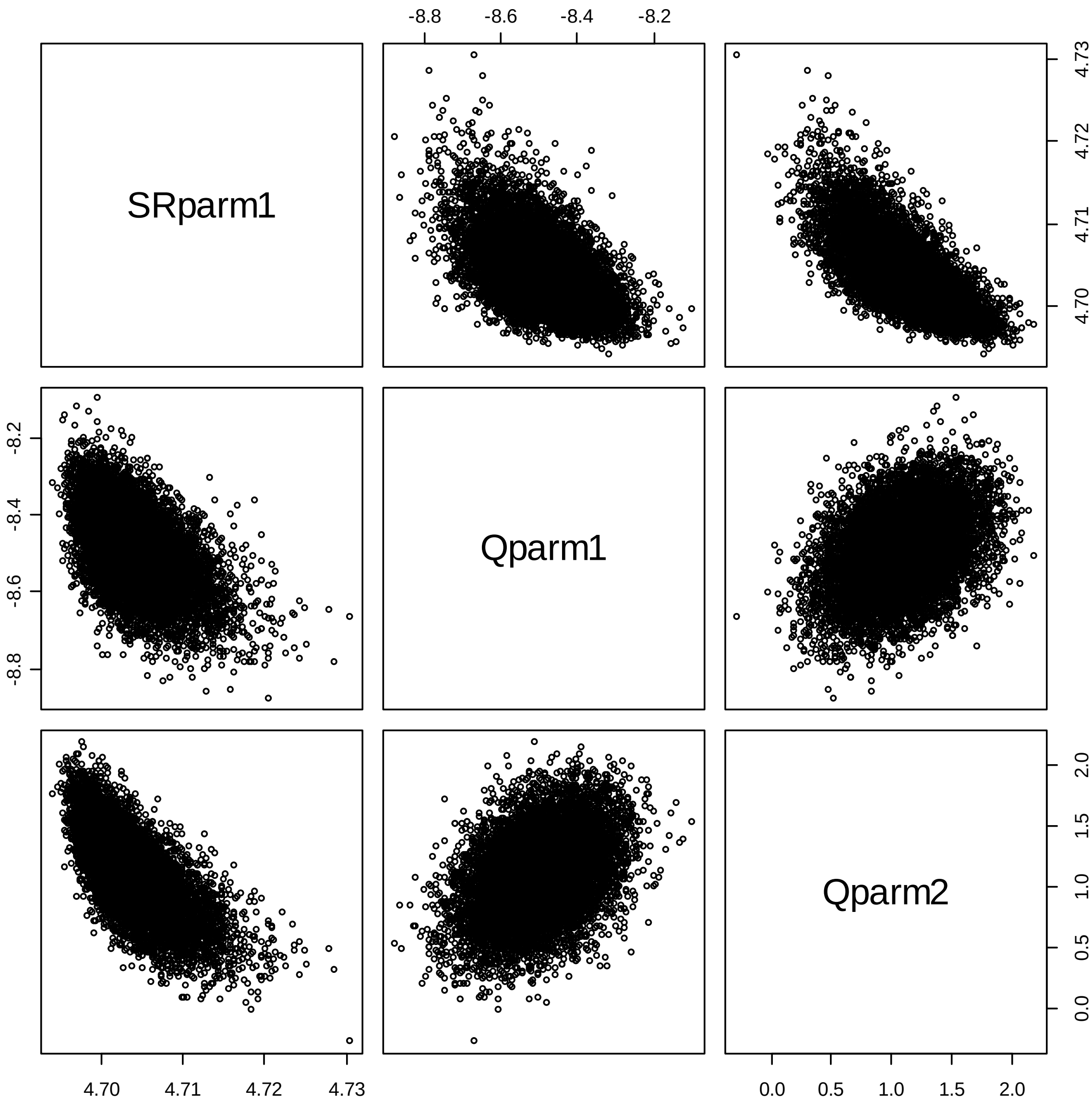


Figure C4: Posterior densities of parameters in the 3-parameter base model. Qparm1 = log catchability for the CPFV index, Qparm2 = log catchability for the visual survey, and Srparm1 = log unfished recruitment. Results are shown for two chains (solid and dotted lines) of 300,000 iterations each, thinned every 30 iterations, for a total of 10,000 samples per chain.

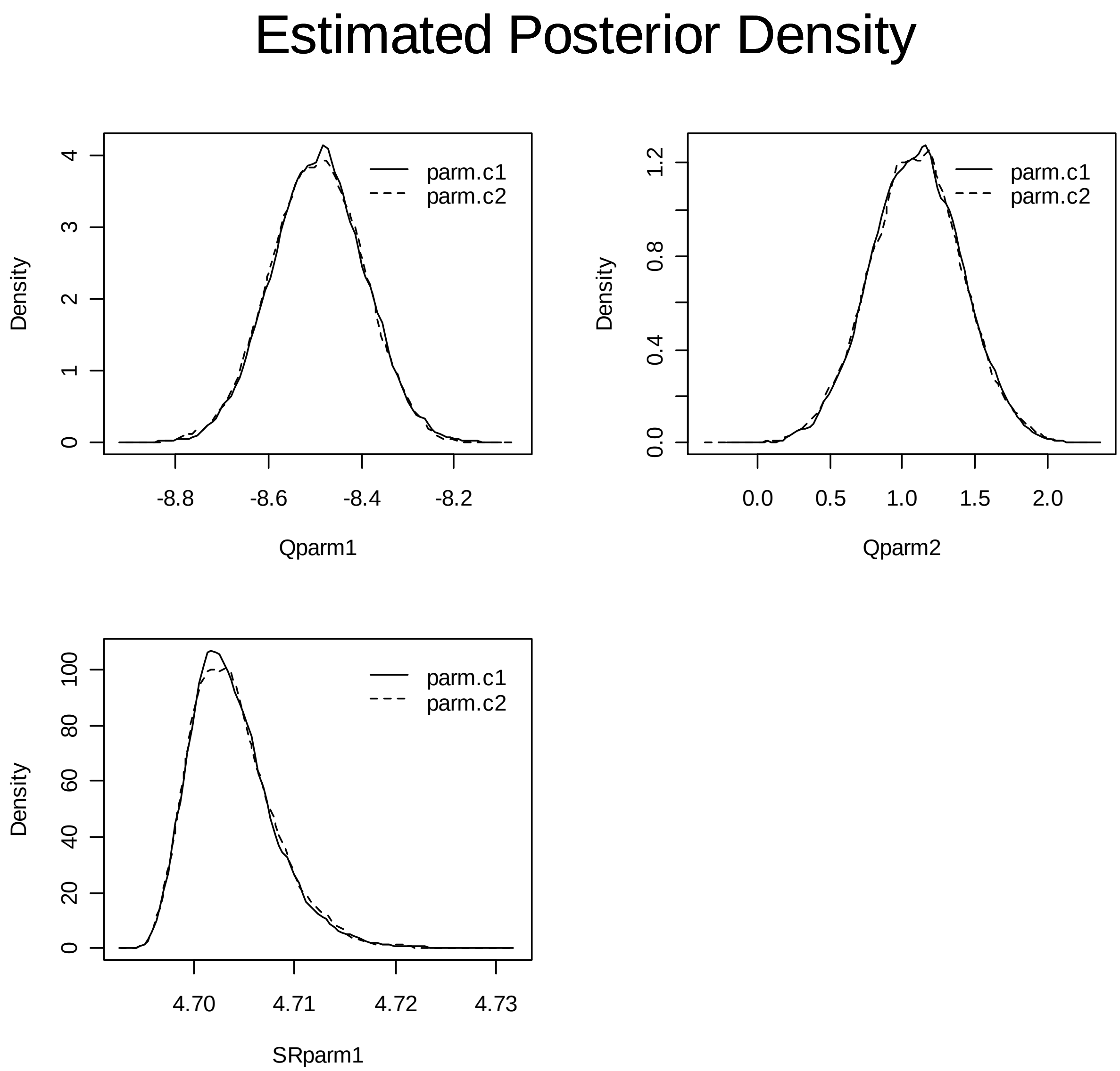


Figure C5: Posterior densities of derived quantities from the 3-parameter base model. Results are shown for two chains (solid and dotted lines) of 300,000 iterations each, thinned every 30 iterations, for a total of 10,000 samples per chain.

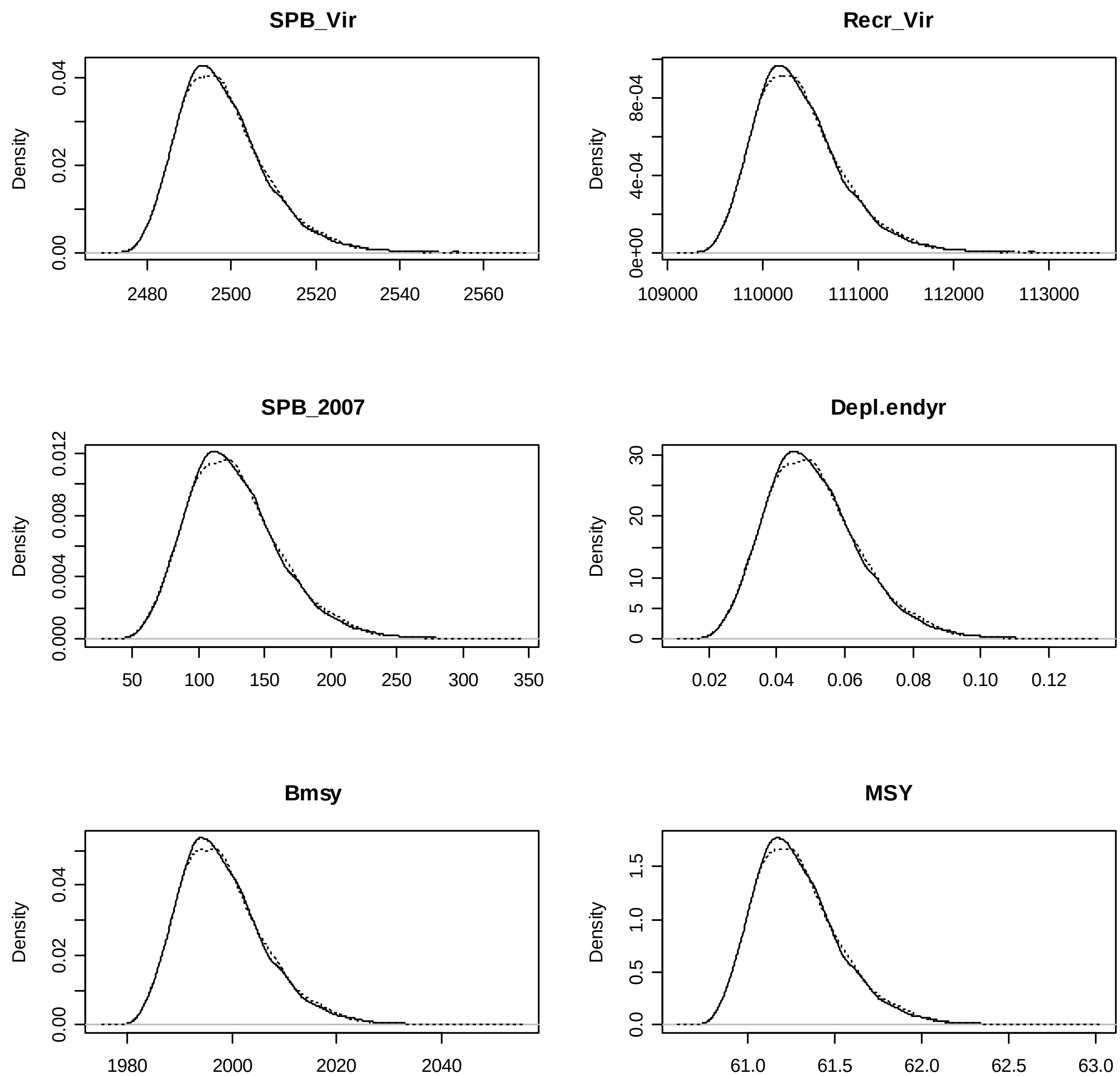


Figure C6: Comparison of the prior distribution for log catchability and 20,000 draws from the posterior distribution. The prior is normal with mean –0.2863 and standard deviation 0.5. The posterior mean is 1.09, with a 99% posterior interval of (0.29, 1.89).