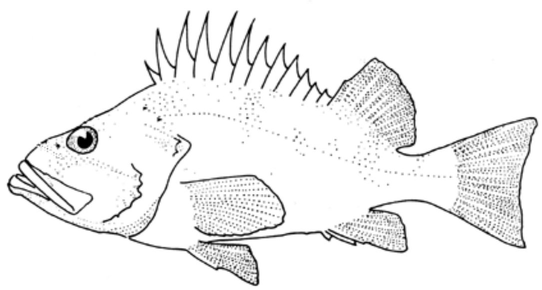
Updated status of cowcod, *Sebastes levis*, in the Southern California Bight



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Cowcod drawing adapted from Fish Bulletin No. 157 (California Department of Fish and Game, 1972)

Executive Summary

Stock: This assessment describes the status of cowcod (*Sebastes levis*) in the Southern California Bight (SCB), defined as U.S. waters off California and south of Point Conception (34°27' north latitude). The assumption of an isolated stock is untested, and no information is available regarding stock structure or dispersal across the assumed stock boundaries.

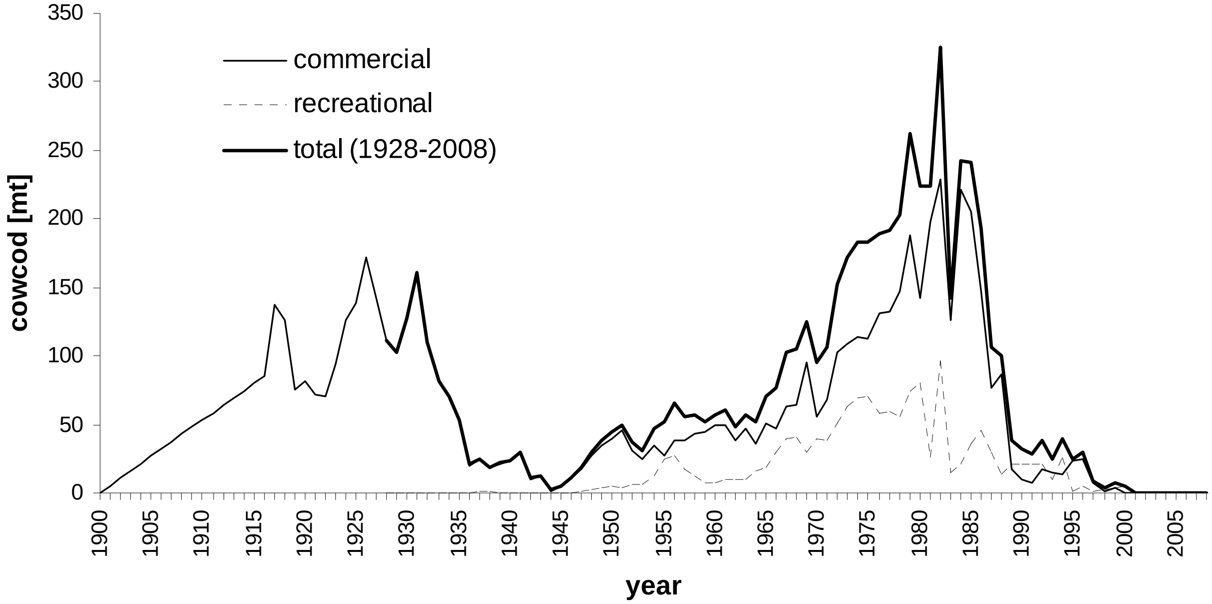
Catch: Commercial landings of cowcod from 1969-2008 were obtained from the CALCOM database (CALCOM, 2009). Recreational landings were obtained from the RecFIN database (www.recfin.org) for the period 1981-2008. Retention of cowcod has been prohibited since January 2001. Due to uncertainty in total mortality since no-retention regulations took effect, recreational and commercial mortalities have been fixed at 0.25 metric tons per year, per fishery (Table ES1).

Dick et al. (2007) estimated historical commercial landings of cowcod in Southern California (1900-1968). Estimated catches from a recent commercial catch reconstruction effort (Ralston et al., in review) are slightly larger than those reported by Dick et al., but represent landings in the Conception INPFC area rather than south of Point Conception. For this reason, we retain the commercial landings reconstruction from the previous assessment. Historical recreational landings were estimated by Butler et al. (1999) for the period 1951-1979. An alternative reconstruction of recreational landings (Ralston et al., in review) for the years 1928-1980 produced slightly lower estimates, but included 1970s species composition data from a CDF&G recreational observer program. We present model results based on both recreational time series (see main text), and incorporate the reconstructed recreational landings from Ralston et al. in the base model.

Table ES1: Recent estimated catches of cowcod (mt) in the Southern California Bight.

Year	Commercial	Recreational	Total
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*
2007	*0.25*	*0.25*	*0.5*
2008	*0.25*	*0.25*	*0.5*

Figure ES1: Estimated cowcod catch, 1900-2008



Data and assessment: The last assessment of cowcod was completed in 2007 (Dick et al., 2007). The current assessment is based on an identical age-structured model with three estimated parameters: virgin recruitment (R_0), catchability for a logbook index from the Commercial Passenger Fishing Vessel (CPFV) fleet, and catchability for a biomass estimate from a submersible line-transect survey (Yoklavich et al., 2007). Recruitment is assumed to follow a Beverton-Holt type relationship with steepness (h) fixed at 0.6. Natural mortality (M) is fixed at 0.055 yr^{-1}. The model was created using Stock Synthesis 2 (version 2.00c, 3/26/07).

All commercial gear types are modeled as a single fishery, with selectivity for the combined commercial fleet set equal to the female maturity schedule. Recreational landings are also modeled as a single fishery. Length data from a CDF&G observer study were used to estimate a selectivity curve that is shared by the combined recreational fishery and Commercial Passenger Fishing Vessel (CPFV) logbook index.

Abundance indices include a time series of relative abundance derived from CPFV logbook data (details in Dick et al., 2007). The CPFV logbook index ends in 2000 due to the adoption of no-retention regulations in 2001. An estimate of cowcod biomass in 2002 from a submersible line-transect survey inside the Cowcod Conservation Areas (Yoklavich et al., 2007) is modeled as a relative abundance index with a Gaussian prior probability distribution on the logarithm of catchability (details in Piner et al., 2005).

Uncertainty in the base model was characterized by evaluating alternative values of steepness (0.4 and 0.8) and examining the effect of removing the CPFV logbook index. Removing the CPFV index reduces the model to a deterministic trajectory, solving for the value of unfished recruitment that allows the model to exactly match the adjusted 2002 biomass estimate.

Unresolved problems and major uncertainties

The CPFV index ends in 2000, and no data in the model inform trends in biomass since the 2002 submersible survey. Indications of stock increases since 2002 are inferred from the model but have not been confirmed by observations. Replication of the non-lethal submersible survey, inside and outside the Cowcod Conservation Areas (CCA), could provide information on rebuilding progress without impacting affected fisheries.

The CPFV logbook index is a long-term (1963-2000) time series 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. The biomass trajectory from the population model is unable to match the rate of decline exhibited by this index, i.e. a 'hyperdepletion' pattern exists. The STAT recommends further analysis of this data set in future full assessments of cowcod.

The base model fixes steepness at 0.6 based on the expectation of a prior distribution from a meta-analysis of rockfish steepness parameters. Attempts to quantify uncertainty in this parameter, given the current model structure, suggest that the current value may overestimate productivity of the stock (see Uncertainty Analysis in main text). Recruitments are estimated directly from the stock-recruitment relationship, although considerable interannual variation in recruitment is a common characteristic of rockfish species.

The base model underestimates our uncertainty about the status of the stock. Several model assumptions (e.g. fixed steepness and natural mortality, recruitments drawn from the stock-recruitment curve, catches known without error) generate results that are unrealistically precise. The last full assessment identified the steepness parameter and the CPFV logbook index as two dominant sources of uncertainty in the model. Other sources of uncertainty such as natural mortality, historical catch, gear selectivity, and recruitment variability are almost certainly important as well, but difficult to estimate with the available data.

Historical commercial landings are based on species composition data from relevant ports and gear types, using the earliest data for which we have actual samples (1980s). However, the percentage of cowcod in total rockfish landings in years prior to the 1980s is not well understood, and this percentage is assumed to be constant over the historical period.

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. To avoid this issue, future visual surveys should be expanded to include areas outside the Cowcod Conservation Areas.

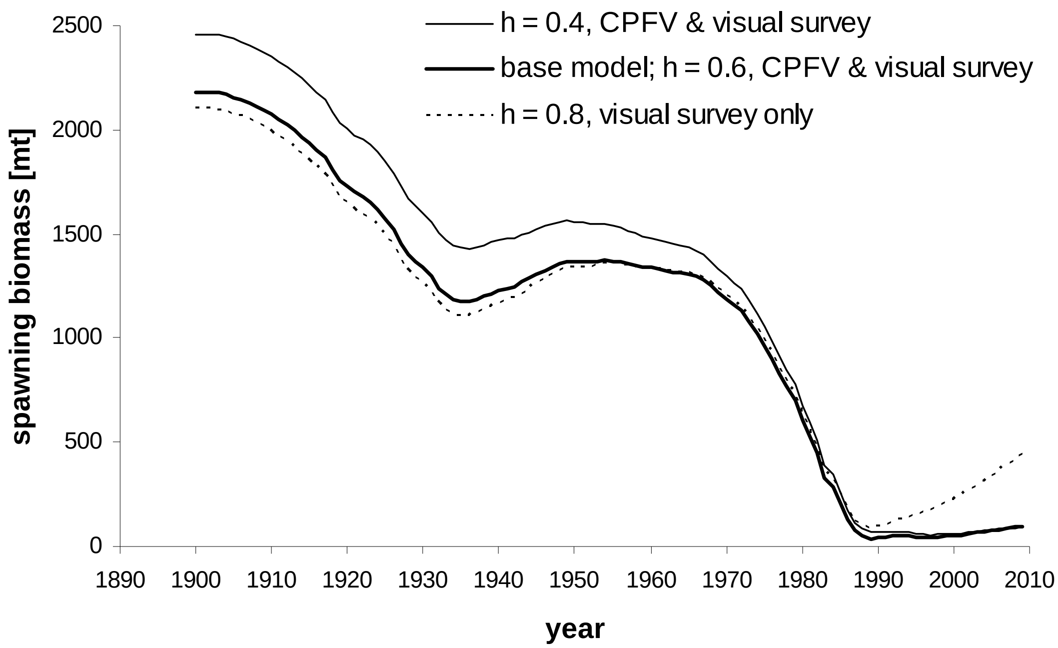
Reference points: For *Sebastes*, the PFMC currently uses $F_{50\%}$ as a proxy for the fishing mortality rate that achieves maximum sustainable yield (F_{MSY}). Estimated spawning biomass (SB) in 2009 is between 3.8% and 21.0% of the unfished level (Table ES2). The poor precision of this estimate is due to 1) a lack of data to inform estimates of stock productivity, and 2) conflicting information from fishery-dependent and fishery–independent data. The most optimistic model presented here, which assumes a high-productivity stock (h = 0.8) and ignores declines suggested by CPFV catch rates, suggests that female 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.

Table ES2: Base model (h = 0.6) reference points 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	5233	4643	4469	metric tons
Unfished female spawning biomass (SB_0)	2461	2183	2101	metric tons
Unfished recruitment (R_0)	109	96	93	1000s of fish
40% of SB_0 (proxy for SB_{MSY})	984	873	841	metric tons
Exploitation rate at $F_{50\%}$ (proxy for F_{MSY})	2.7%	2.7%	2.7%	percent
Spawning biomass in 2009 (SB_{2009})	93	98	441	metric tons
SB_{2009} / SB_0	3.8%	4.5%	21.0%	percent

Spawning stock biomass: Estimates of female spawning stock biomass in 2009 are highly uncertain. The current models suggest that spawning biomass has declined from an unfished biomass of 2101-2461mt to 93-441 mt in 2009 (Fig. ES2, Table ES2).

Figure ES2: Time series of female spawning biomass for cowcod



Relative depletion: Estimates of relative depletion in 2009 range from 3.8% to 21% (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 relative depletion for cowcod (female spawning biomass in 2009 as a percentage of unfished female spawning biomass).

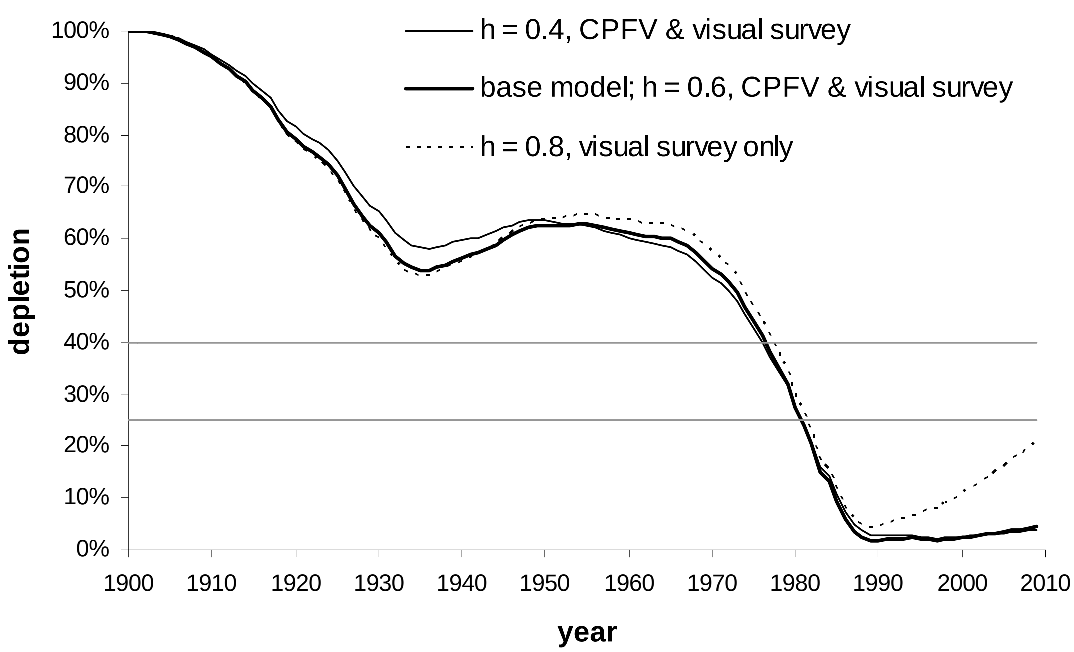


Table ES3: Recent trends in cowcod biomass and depletion

	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
2000	146	62	2.5%	132	51	2.3%	579	226	10.8%
2001	150	65	2.6%	139	55	2.5%	623	246	11.7%
2002	158	69	2.8%	150	60	2.7%	672	268	12.8%
2003	166	73	3.0%	161	65	3.0%	723	291	13.8%
2004	173	77	3.1%	172	71	3.2%	775	314	14.9%
2005	180	80	3.3%	184	76	3.5%	829	338	16.1%
2006	187	84	3.4%	195	81	3.7%	884	363	17.3%
2007	194	87	3.5%	208	87	4.0%	941	388	18.5%
2008	201	90	3.7%	220	92	4.2%	999	414	19.7%
2009	208	93	3.8%	233	98	4.5%	1058	441	21.0%

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 for cowcod

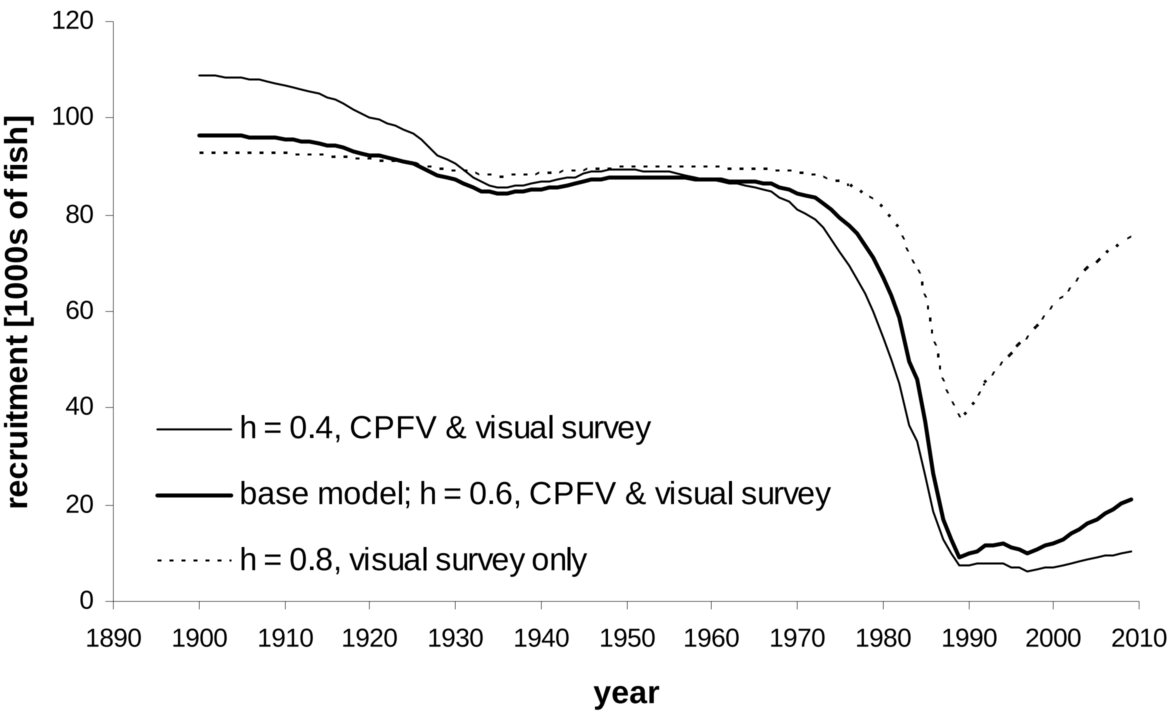


Table ES4: Estimated recruitments from the base model stock-recruitment curve.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Recruitment (1000s)	12.1	12.9	14.0	15.0	16.1	17.1	18.2	19.2	20.2	21.1

Exploitation status: We summarize the history of exploitation according to the base model with two phase diagrams. Figure ES5 shows total 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 ES6 replaces exploitation rate with the complement of the spawning potential ratio (1-SPR). SPR is the ratio of equilibrium spawning output per recruit under fished conditions to spawning output per recruit in the virgin population.

Figure ES5: Phase diagram of cowcod exploitation history (relative exploitation rate)

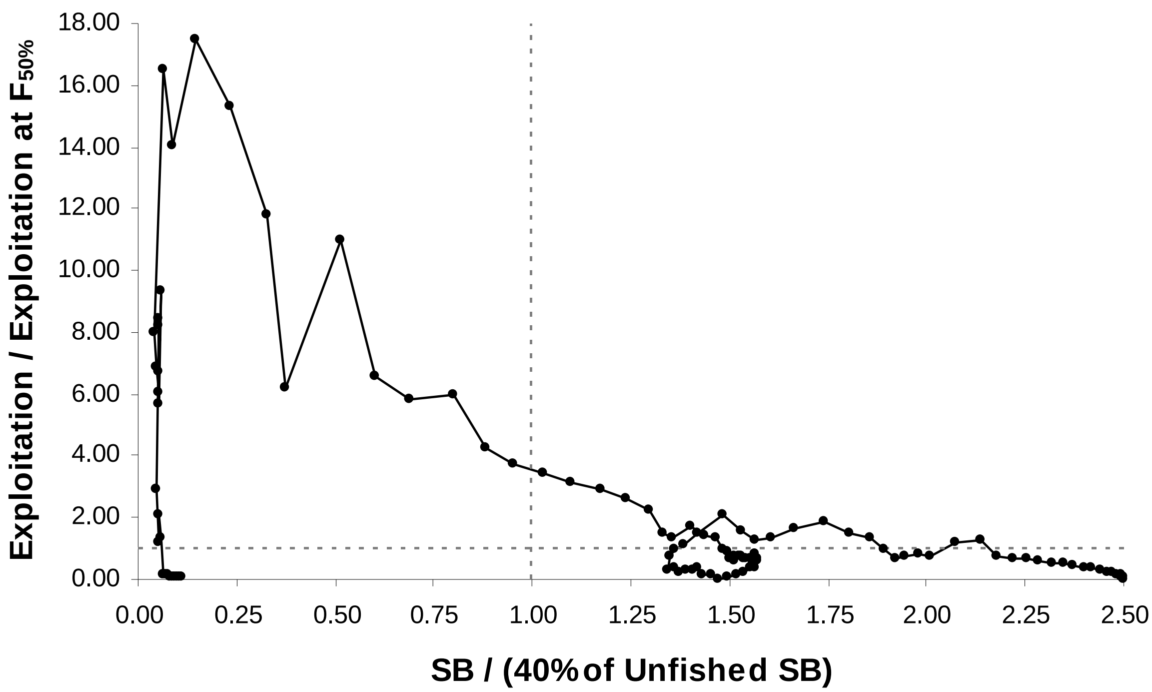
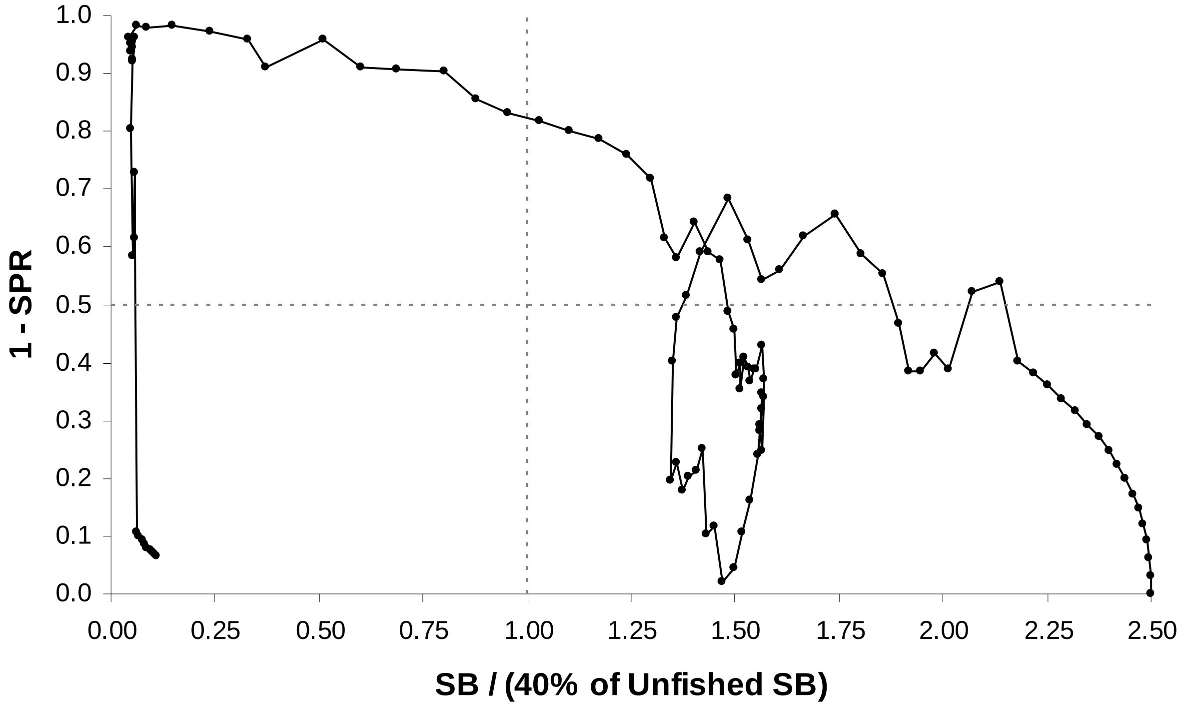


Figure ES6: Phase diagram of cowcod exploitation history (1-SPR)



Management performance: The CCAs are effective at minimizing fishing mortality over offshore rocky habitat in the SCB. However, evaluation management performance for cowcod is difficult for several reasons. Retention of cowcod is prohibited; requiring estimation of bycatch to assess total mortality. Few cowcod have been observed in the SCB by the West Coast Groundfish Observation Program (WCGOP), and estimates of commercial discard are highly uncertain. Recreational discard rates have not been thoroughly assessed. Recreational observer data are available for the CPFV fleets, but little is known about discard from private boats.

A portion of the recreational rockfish catch has not been identified to species (the “rockfish genus” category in RecFIN), and is not included in current estimates of total mortality for rockfish species. Cowcod are a small component of rockfish catch in recent years but given the low OYs even a small fraction of cowcod in the total unidentified catch may influence management decisions. The PFMC has tasked the RecFIN committees, state, NMFS, and Council staff to evaluate this issue and report to the Council at the September 2009 meeting (PFMC, 2009).

Although current total mortality estimates are highly uncertain, the available catch estimates and mortality reports suggest that landings in the SCB have not exceeded the OY limits in recent years (Table ES5). Piner et al. (2005) and Butler et al. (1999) describe the history of management measures related to cowcod in greater detail.

Table ES5: Recent management performance

Year	Commercial (CalCOM)	Recreational (RecFIN)	Total Mortality Report	Assumed Total Mortality: Commercial	Assumed Total Mortality: Recreational	ABC[a]	OY[a]
1999	3.47	3.77	--	3.47	3.77	[b]	[b]
2000	0.45	4.49	--	0.45	4.49	5	<5
2001	--	--	--	0.25	0.25	5	2.4
2002	0.03	0.49	0.02	0.25	0.25	5	2.4
2003	--	--	0.00	0.25	0.25	5	2.4
2004	--	0.45	0.54	0.25	0.25	5	2.4
2005	0.04	0.15	0.25	0.25	0.25	5	2.1
2006	--	0.07	0.10	0.25	0.25	5	2.1
2007	0.06	0.11	0.21	0.25	0.25	17	4
2008	--	0.19	--	0.25	0.25	17	4

[a] ABCs and OYs are for the Conception area only

[b] cowcod managed under "other rockfish"

Forecasts and Decision Tables

Principal results from the cowcod rebuilding analysis will be included in the SAFE version of this assessment.

Table ES6: Summary of recent trends in cowcod exploitation and stock levels from the base case model.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Assumed total mortality (mt)	4.94	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	NA
ABC[a] (mt)	5	5	5	5	5	5	5	17	17	13
OY[a] (mt)	<5	2.4	2.4	2.4	2.4	2.1	2.1	4	4	4
SPR	38.6%	89.3%	90.1%	90.8%	91.4%	91.9%	92.4%	92.8%	93.2%	NA
Exploitation rate (catch / 1+ biomass)*100%	3.73%	0.36%	0.33%	0.31%	0.29%	0.27%	0.26%	0.24%	0.23%	NA
Age 1+ biomass	132.0	138.7	149.7	160.8	172.1	183.7	195.5	207.6	220.0	232.9
Spawning biomass (mt)	51.1	54.6	59.9	65.2	70.5	75.9	81.3	86.7	92.1	97.6
Recruitment (1000s)	12.1	12.9	14.0	15.0	16.1	17.1	18.2	19.2	20.2	21.1
Depletion	2.3%	2.5%	2.7%	3.0%	3.2%	3.5%	3.7%	4.0%	4.2%	4.5%

[a] ABC and OY for 2009 is for Conception and Monterey areas; other ABCs and OYs are for the Conception area only

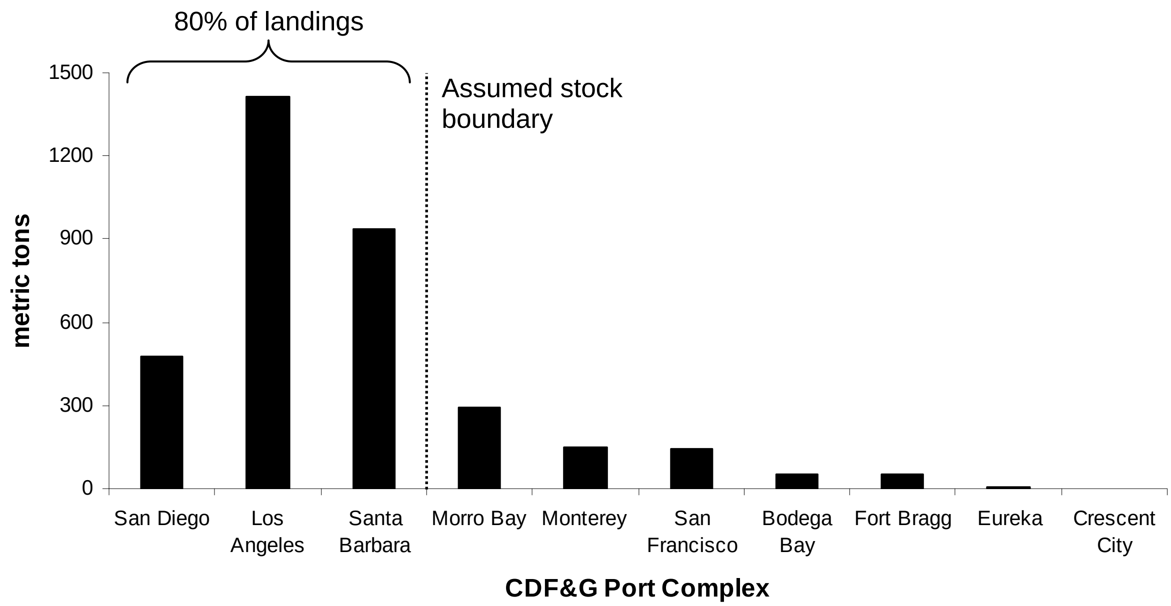
Research and data needs

The cowcod assessment is a data-poor assessment. Current progress toward rebuilding is not based on data, but rather model assumptions. Promising topics for future research include, but are not limited to:

- Development of an informative index to inform progress toward recovery
- Biological sampling to improve our understanding of life-history characteristics (length at age, maturity, fecundity, etc.)
- Improved monitoring of commercial and recreational catch and discard.
- Further refinement of methods used to estimate CPFV logbook index; future STAT teams should explore trip-specific catch composition data (1980-present) to refine estimates of effective effort for cowcod (e.g. Stephens and MacCall, 2004), and explore spatial differences in CPUE trends
- Exploration of alternative model structures and methods to quantify uncertainty
- Replication of non-lethal surveys to monitor rebuilding progress, with extended sampling inside and outside the CCAs
- Evaluation of the assumed selectivity curve for commercial gears; commercial selectivity currently matches the female maturity curve
- Examination of alternative indices, including those previously dropped from the assessment (CalCOFI, sanitation surveys, etc.), to identify potential signs of stock recovery or pulses in recruitment.

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 (Figure ES7). The magnitude of Mexican catches is unknown.

Figure ES7: Cowcod Landings by California Port Complex, 1969-2005



Introduction

This assessment updates the last assessment of cowcod, *Sebastes levis*, in the Southern California Bight (Dick et al., 2007). The stock boundary (Figure 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. We refer the reader to previous cowcod assessments (Butler et al., 1999; Piner et al., 2005, Dick et al., 2007) for general information regarding the fisheries and biology of cowcod.

The current assessment is presented as an "update" stock assessment. No significant changes have been made with respect to data, analytical methods, software, model structure, statistical framework, weighting of data components, or treatment of model outputs. Landings data have been updated as per the 2009-2010 terms of reference for groundfish stock assessments (PFMC, 2008). No abundance indices have been updated since the last stock assessment.

Updated data sources

Dick et al. (2007) estimated historical commercial landings of cowcod in Southern California (1900-1968). Estimated catches from a recent commercial catch reconstruction effort (Ralston et al., in review) are slightly larger than those reported by Dick et al., but represent landings in the Conception INPFC area rather than south of Point Conception (Figure 2). For this assessment, we retain the commercial landings reconstruction from the previous assessment (Dick et al., 2007).

Historical recreational landings were estimated by Butler et al. (1999) for the period 1951-1979. An alternative reconstruction of recreational landings (Ralston et al., in review) for the years 1928-1980 produced slightly lower estimates (Figure 3). Historical recreational landings used in the previous assessments were an average of expansions of CPFV logbook and LA Times reports to RecFIN cowcod catch during 1980-1997 (Butler et al., 1999). Ralston et al. (in review) used CDF&G recreational observer data from 1975-1978 (species compositions and average weights) to estimate cowcod catch based on CPFV logbook data for total rockfish catch, adjusted for compliance. Model results based on this alternative catch reconstruction do not differ significantly (Table 1). Estimated unfished biomass is slightly lower and depletion is slightly higher in the model based on reconstructed landings by Ralston et al.

The base model uses the reconstructed recreational landings from Ralston et al. (in review). Compliance rates for CPFV logbook data are not well known, and may vary over time. This is an issue for both reconstruction alternatives. The ratio of RecFIN catch to CPFV logbook or LA Times reports over the period 1980-1997 may not reflect ratios in earlier years of the fishery. Similarly, the approach taken by Ralston et al. makes the assumption that species compositions are constant prior to 1975. We chose to base the recreational catch history on the results of Ralston et al. because it uses reliable species composition data (observer data) from a time period preceding the years in which RecFIN data are available.

Model structure

The model structure is identical to the previous assessment (Dick et al., 2007): age-structured 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. Gear selectivity for the commercial fishery mirrors the female maturity ogive that was derived from Love et al. (1990). Selectivity for the recreational fishery is also a logistic function, internally estimated from CPFV length data but later fixed in the model. Length-at-age parameters for the von Bertalanffy growth equation were estimated externally and fixed in the model. The assessment model was fit using Stock Synthesis 2 (SS2), version 2.00c. Input files for SS2 are attached as Appendix B.

Base run results

See the Executive summary for figures depicting time series of spawning biomass, depletion, and recruitment. Additional base model results (parameter estimates and likelihood components) are provided as Table 2. Tabular summaries of total and spawning stock biomass, recruitment, and other relevant quantities are included as Table 3.

Uncertainty analysis

Uncertainty in the 2007 assessment was characterized by alternative hypotheses of stock productivity (steepness) and by removing the CPFV logbook index. This approach was adopted because uncertainty estimates generated by the base model are unrealistically precise (see Dick et al., 2007 for details). We characterize uncertainty in the updated assessment following the approach used in 2007 (Table ES2).

Previous attempts to integrate uncertainty in steepness and natural mortality into model results using Markov Chain Monte Carlo (MCMC) techniques were unsuccessful (Dick et al., 2007). The 2007 STAR panel suggested that an alternative model (CASAL) may be capable of generating improved MCMC output. We fit the cowcod assessment using CASAL, evaluated uncertainty using MCMC, and provide a brief summary of our results as Appendix A.

10-year harvest projections based on 2007 harvest policy

The Council's final preferred alternative harvest rate for cowcod in 2009-2010 increased from *F90%* (the 2007-2008 rate) to *F82.1%*. The increased harvest rate was adopted to match the 2007-2008 OY of 4 mt. 10-year harvest projections under the 2009 harvest policy (*F82.1%*) will be included in the SAFE version of this assessment.

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Tables

Table 1. Comparison of model results using alternative recreational catch reconstructions.

	Historical Recreational Landings Source		
Reference Point	**Butler et al. (1999)**	**Ralston et al. (in review)**	**units**
Unfished summary (age-1+) biomass	5291	4643	metric tons
Unfished female spawning biomass (SB_0)	2488	2183	metric tons
Unfished recruitment (R_0)	110	96	1000s of fish
40% of SB_0 (proxy for SB_{MSY})	995	873	metric tons
Exploitation rate at $F_{50\%}$ (proxy for F_{MSY})	2.7%	2.7%	percent
Spawning biomass in 2009 (SB_{2009})	105	98	metric tons
SB_{2009} / SB_0	4.2%	4.5%	percent

Table 2. Model results, parameter estimates, and likelihood components for the 2009 cowcod update assessment. Steepness (*h*) is fixed at 0.6 in the base model.

Reference Points	h = 0.4 CPFV index & visual survey	h = 0.6 CPFV index & visual survey	h = 0.8 Visual survey only
Unfished female spawning biomass (SB_0)	2461	2183	2101
Unfished summary (age-1+) biomass	5233	4643	4469
40% of SB_0 (proxy for SB_{MSY})	984	873	841
Exploitation rate at $F_{50\%}$ (proxy for F_{MSY})	2.7%	2.7%	2.7%
Female spawning biomass in 2009	93	98	441
SB in 2009 / unfished SB	3.8%	4.5%	21.0%
Parameter Estimates			
Unfished recruitment (R_0)	108.7	96.5	92.9
Catchability for CPFV logbook index	2.17E-04	2.29E-04	n/a
Catchability for visual survey	2.37	2.45	0.75
Likelihood components			
Total negative log likelihood	17.36	17.98	n/a
CPFV logbook index	14.00	14.43	n/a
Visual survey	0.71	0.76	n/a
Prior on visual survey	2.64	2.80	n/a

Table 3. Time series of total biomass (mt), age 1+ biomass (mt), and female spawning biomass (mt), depletion (spawning biomass as a fraction of unfished spawning biomass), recruitment (1000s of age-0 fish), and total exploitation rate (catch divided by summary biomass × 100%).

Year	Tot_Bio	Smry_Bio	Sp_Bio	Depletion	Recruits	Exploitation	Year	Tot_Bio	Smry_Bio	Sp_Bio	Depletion	Recruits	Exploitation
1900	4644.7	4642.7	2183.3	1.000	96.5	0.00%	**1955**	2988.4	2986.6	1370.7	0.628	87.8	1.74%
1901	4644.7	4642.7	2183.3	1.000	96.5	0.11%	**1956**	2979.1	2977.3	1366.2	0.626	87.7	2.19%
1902	4639.5	4637.5	2180.8	0.999	96.5	0.23%	**1957**	2956.9	2955.0	1355.3	0.621	87.6	1.88%
1903	4629.2	4627.2	2175.7	0.997	96.4	0.35%	**1958**	2943.9	2942.1	1348.8	0.618	87.5	1.91%
1904	4613.9	4611.9	2168.2	0.993	96.4	0.46%	**1959**	2930.3	2928.5	1342.0	0.615	87.3	1.78%
1905	4593.7	4591.7	2158.2	0.988	96.3	0.58%	**1960**	2920.8	2919.0	1337.1	0.612	87.3	1.95%
1906	4568.7	4566.7	2145.8	0.983	96.2	0.70%	**1961**	2906.8	2905.0	1330.0	0.609	87.2	2.07%
1907	4539.0	4537.0	2131.1	0.976	96.1	0.82%	**1962**	2890.1	2888.3	1321.7	0.605	87.0	1.66%
1908	4504.7	4502.7	2114.1	0.968	96.0	0.95%	**1963**	2885.2	2883.4	1319.2	0.604	87.0	1.99%
1909	4465.9	4463.9	2094.9	0.959	95.8	1.08%	**1964**	2871.4	2869.6	1312.4	0.601	86.9	1.81%
1910	4422.7	4420.7	2073.5	0.950	95.6	1.21%	**1965**	2863.1	2861.3	1308.3	0.599	86.8	2.45%
1911	4375.2	4373.3	2050.0	0.939	95.4	1.34%	**1966**	2837.1	2835.4	1295.7	0.593	86.6	2.70%
1912	4323.7	4321.7	2024.4	0.927	95.2	1.48%	**1967**	2805.0	2803.2	1280.1	0.586	86.3	3.65%
1913	4268.0	4266.0	1996.9	0.915	95.0	1.62%	**1968**	2748.0	2746.3	1252.5	0.574	85.8	3.82%
1914	4208.4	4206.5	1967.4	0.901	94.7	1.77%	**1969**	2688.9	2687.1	1223.8	0.561	85.3	4.65%
1915	4145.0	4143.1	1936.0	0.887	94.5	1.93%	**1970**	2611.0	2609.3	1185.7	0.543	84.6	3.67%
1916	4077.9	4075.9	1902.8	0.872	94.2	2.09%	**1971**	2562.1	2560.4	1161.7	0.532	84.1	4.14%
1917	4007.1	4005.1	1867.8	0.855	93.8	3.44%	**1972**	2503.9	2502.2	1133.2	0.519	83.6	6.09%
1918	3887.1	3885.2	1808.7	0.828	93.3	3.23%	**1973**	2401.3	2399.6	1083.2	0.496	82.5	7.15%
1919	3781.4	3779.4	1756.5	0.804	92.7	1.99%	**1974**	2280.9	2279.3	1024.7	0.469	81.2	8.05%
1920	3726.8	3724.9	1729.3	0.792	92.4	2.19%	**1975**	2150.1	2148.4	961.1	0.440	79.6	8.49%
1921	3667.6	3665.7	1700.0	0.779	92.1	1.94%	**1976**	2021.5	2019.9	898.6	0.412	77.9	9.37%
1922	3620.0	3618.1	1676.4	0.768	91.8	1.94%	**1977**	1887.7	1886.1	833.4	0.382	76.0	10.13%
1923	3574.9	3573.0	1654.2	0.758	91.6	2.63%	**1978**	1753.5	1752.0	768.2	0.352	73.8	11.59%
1924	3508.2	3506.3	1621.4	0.743	91.2	3.59%	**1979**	1609.2	1607.7	698.2	0.320	71.2	16.29%
1925	3412.0	3410.1	1574.2	0.721	90.6	4.05%	**1980**	1409.4	1408.0	602.0	0.276	67.1	15.87%
1926	3306.1	3304.2	1522.2	0.697	90.0	5.19%	**1981**	1247.5	1246.2	524.5	0.240	63.2	17.97%
1927	3170.0	3168.1	1455.5	0.667	89.1	4.49%	**1982**	1087.2	1086.0	447.2	0.205	58.6	29.94%
1928	3064.7	3062.9	1403.7	0.643	88.3	3.63%	**1983**	830.6	829.6	326.4	0.149	49.5	17.06%
1929	2991.6	2989.7	1367.6	0.626	87.8	3.43%	**1984**	749.5	748.6	287.3	0.132	45.9	32.34%
1930	2928.7	2926.9	1336.6	0.612	87.3	4.33%	**1985**	575.5	574.8	206.3	0.094	37.1	41.83%
1931	2844.0	2842.2	1295.0	0.593	86.6	5.66%	**1986**	403.6	403.1	128.8	0.059	26.4	47.81%
1932	2728.1	2726.3	1238.4	0.567	85.6	4.02%	**1987**	275.1	274.8	74.4	0.034	16.9	38.44%
1933	2664.1	2662.3	1206.9	0.553	85.0	3.08%	**1988**	222.5	222.3	54.8	0.025	12.9	45.17%
1934	2628.1	2626.4	1189.3	0.545	84.7	2.69%	**1989**	173.6	173.5	37.9	0.017	9.2	21.87%
1935	2604.3	2602.5	1177.8	0.539	84.5	2.04%	**1990**	170.8	170.6	40.1	0.018	9.7	18.74%
1936	2598.5	2596.7	1175.2	0.538	84.4	0.79%	**1991**	169.7	169.5	43.6	0.020	10.5	16.50%
1937	2624.7	2622.9	1188.3	0.544	84.7	0.95%	**1992**	169.0	168.8	47.7	0.022	11.4	22.43%
1938	2647.1	2645.4	1199.8	0.550	84.9	0.71%	**1993**	157.7	157.4	47.6	0.022	11.4	15.56%
1939	2675.8	2674.0	1214.4	0.556	85.2	0.82%	**1994**	155.4	155.1	50.4	0.023	12.0	25.51%
1940	2701.3	2699.5	1227.6	0.562	85.4	0.88%	**1995**	136.4	136.2	46.3	0.021	11.1	18.36%
1941	2725.2	2723.5	1240.0	0.568	85.6	1.08%	**1996**	129.3	129.1	45.5	0.021	10.9	23.15%
1942	2743.4	2741.7	1249.5	0.572	85.8	0.39%	**1997**	115.9	115.7	41.4	0.019	10.0	7.90%
1943	2779.7	2778.0	1267.7	0.581	86.1	0.45%	**1998**	119.6	119.4	44.0	0.020	10.6	3.36%
1944	2814.0	2812.2	1284.9	0.589	86.4	0.07%	**1999**	127.5	127.2	48.3	0.022	11.5	5.68%
1945	2858.0	2856.2	1306.8	0.599	86.8	0.16%	**2000**	132.3	132.0	51.1	0.023	12.1	3.73%
1946	2898.9	2897.1	1327.1	0.608	87.1	0.40%	**2001**	139.0	138.7	54.6	0.025	12.9	0.36%
1947	2932.4	2930.6	1343.7	0.615	87.4	0.64%	**2002**	150.0	149.7	59.9	0.027	14.0	0.33%
1948	2958.5	2956.7	1356.6	0.621	87.6	1.01%	**2003**	161.1	160.8	65.2	0.030	15.0	0.31%
1949	2973.2	2971.4	1363.9	0.625	87.7	1.30%	**2004**	172.5	172.1	70.5	0.032	16.1	0.29%
1950	2978.9	2977.1	1366.8	0.626	87.7	1.48%	**2005**	184.0	183.7	75.9	0.035	17.1	0.27%
1951	2979.1	2977.3	1366.8	0.626	87.7	1.65%	**2006**	195.8	195.5	81.3	0.037	18.2	0.26%
1952	2973.9	2972.1	1364.1	0.625	87.7	1.23%	**2007**	208.0	207.6	86.7	0.040	19.2	0.24%
1953	2980.6	2978.7	1367.2	0.626	87.7	1.05%	**2008**	220.4	220.0	92.1	0.042	20.2	0.23%
1954	2992.2	2990.4	1372.7	0.629	87.8	1.56%	**2009**	233.3	232.9	97.6	0.045	21.1	0.21%

Figures

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

Figure 2. Comparison of historical commercial catch reconstructions for cowcod. Estimates by Ralston et al. (in review) represent catch in the Conception INPFC area. Dick et al. (2007) estimated cowcod catches for U.S. waters south of Point Conception.

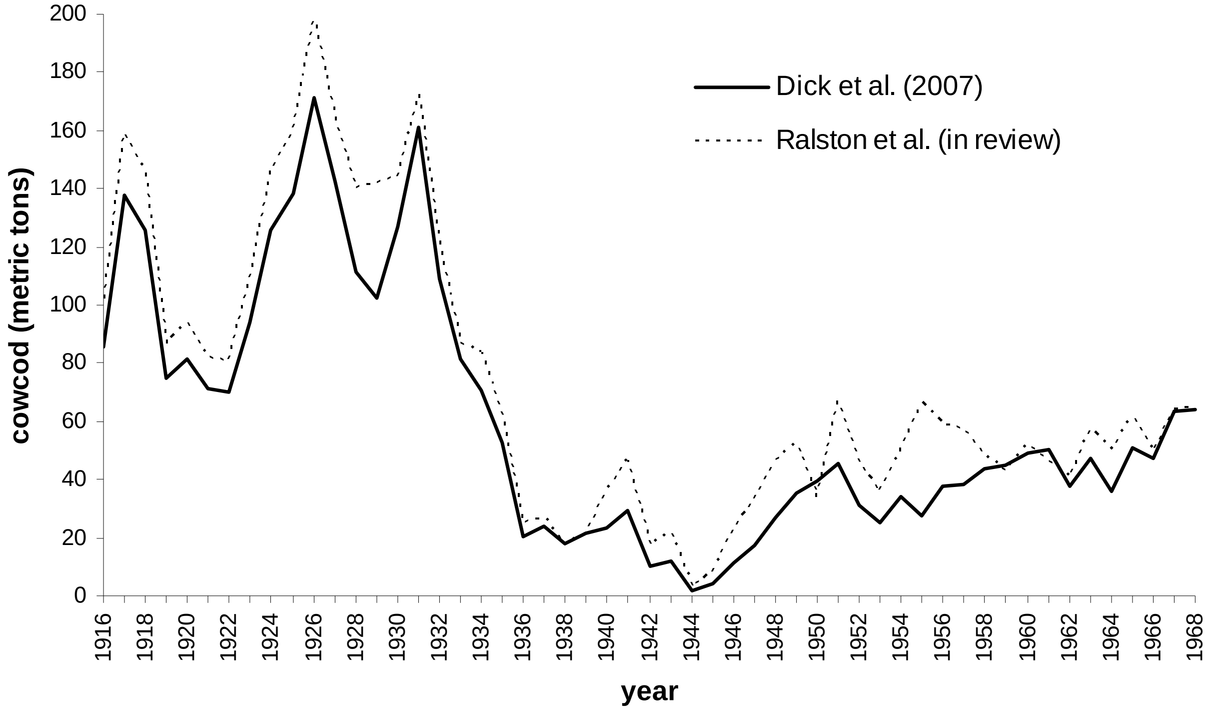
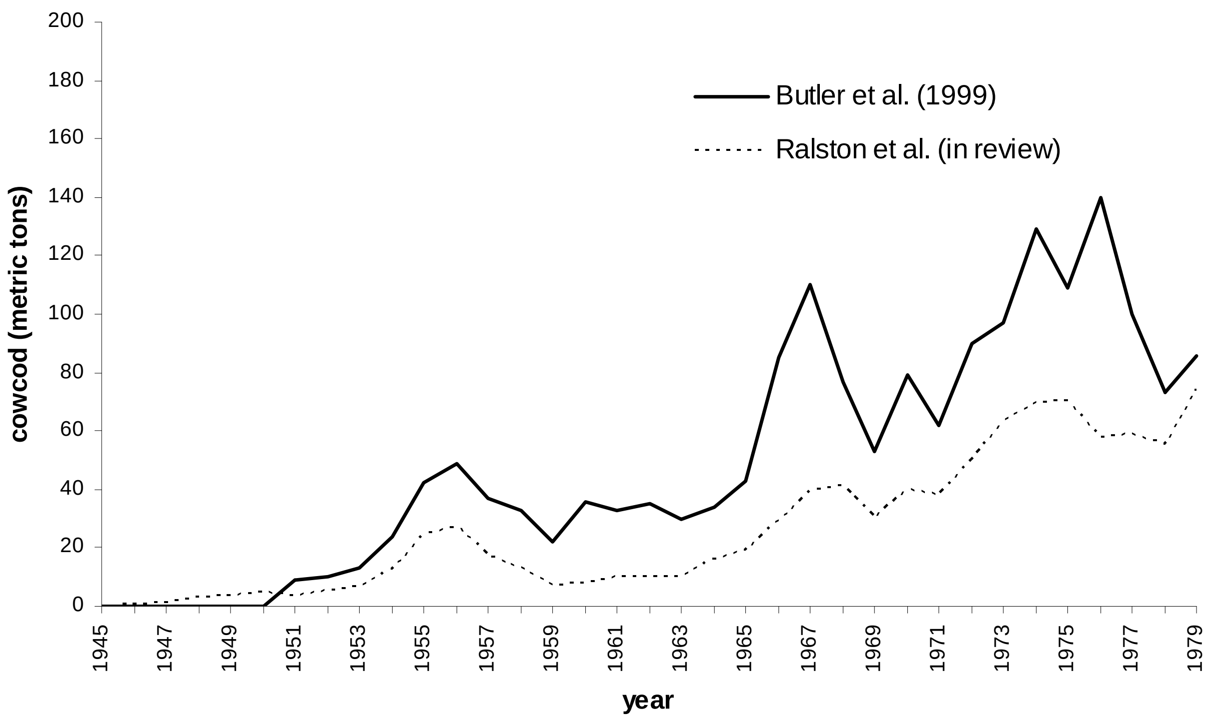


Figure 3. Comparison of historical recreational catch reconstructions for cowcod. Estimated catches prior to 1947 are less than 1 mt per year, and not shown (Ralston et al., in review).



Appendix A: Bayesian Analysis using CASAL

In the previous assessment of cowcod, Dick et al. (2007, Appendix C) attempted a Bayesian approach. While the model with only 3 parameters (virgin spawning biomass, B_0, and the catchabilites, *q*, for the CPFV and visual surveys) mixed well, when the model was expanded to estimate *M* and steepness, the model performed poorly (Fig. A1 here, or Fig. C1 in Dick et al. 2007). It was suggested by one of the STAR panel members that running the Bayesian model in another program, CASAL (C++ Algorithmic Stock Assessment Laboratory), might result in better mixing. This appendix describes the model run and results of the Bayesian assessment using CASAL.

CASAL is a flexible age- or size- structured model developed and distributed freely by NIWA (http://www.niwascience.co.nz/ncfa/tools/casal/), and the technical details of the model can be found in Bull et al. (2008). Every attempt was made to make the model in CASAL as close to the model of Dick et al. (2007) run in SS2. While CASAL and SS2 are similar, they are not identical, so results from the two models may not be identical.

The Model

Three different Bayesian models were run in CASAL. The first run estimated 3 parameters, B_0, and the *q*'s for the CPFV and visual survey CPUE estimates, while *M* and steepness were fixed at 0.055 and 0.6, respectively. Uniform priors were used for B_0 and the CPFV *q*, while a lognormal prior was used for the visual survey *q* (following Dick et al. 2007). This model run is herein referred to as the 3-parameter model. The second and third model runs estimated 5 parameters: B_0, the CPFV and visual survey *q*'s, *M*, and steepness. The same priors were used for B_0, and the two *q*'s, and the prior for *M* was a normal centered at 0.055 and with 95% probability between 0.04 and 0.07 (as specified by the cowcod STAR panel; PMFC, 2007). The difference between these 5-parameter models is in the prior for steepness. We explored a "narrow" and "broad" prior for steepness, as shown in Fig. A2. The broad prior is the CASAL interpretation of the Dorn prior (a Beta with a mean of 0.597 and a standard deviation of 0.183). The narrow prior is a Beta with same mean, but with a standard deviation of 0.0915 (half the spread of the Dorn prior).

The model was run from 1900 to 2007 using the same catch and CPUE series (and corresponding selectivities) as Dick et al. (2007), as well as the same age-length / age-maturity/ length-weight relationships.

Results

In general, the 3-parameter Bayesian model performed well with good mixing of the posterior samples (Fig. A3) and low correlation between parameter draws (Fig. A4). The median posterior estimate of virgin spawning biomass (B_0) from the 3-parameter model was 5,128 mt, (95% credibility interval between 5,115 and 5,148 mt). These values are slightly higher than the estimates produced with SS2 by Dick et al. (2008; Table A1; Fig. A5). Median estimates of depletion in 2007 were nearly identical between models (approximately 4.9%), but CASAL produced a more narrow 95% CI (Table A1). Posterior estimates for the survey *q*'s can be found in Table A2. MCMC diagnostics for the 3 parameter model are shown in Tables A3 and A4.

For the 5-parameter models, posterior estimates are found in Table A2, and MCMC results and diagnostics are shown in Figs. A6-A11 and Tables A5-A8. In general, both models mixed well, although the model with the "broad" prior on steepness mixed less well than the "narrow" prior model (Figs. A6 and A9). In fact, the model with the broad prior failed the stationarity diagnostic, indicating that the model had not converged after 20 million samples of the posterior. Certain trends appear from the results of both models. Estimates of both the CPFV *q* and the visual survey *q* are very similar to the 3-parameter model estimates (Table A2). Posterior estimates of *M* for both models were very similar to the prior density (with medians near 0.055 and 95% CI roughly between 0.04 and 0.07). However, as the uncertainty in steepness increases (i.e. going from the narrow to the broad prior) the posterior for B_0 increases, and the posterior for steepness decreases. As a result, estimates of depletion are greater for the model with the broad steepness prior (Table A2). Thus, the prior for steepness has a large effect on the posterior estimates of B_0 and steepness, and the derived estimate of depletion.

Conducting the Bayesian model in CASAL was an attempt to determine if another model platform could produce different results for the 5-parameter model of Dick et al. (2007). The conclusion from this exercise is that the 5-parameter models in CASAL (both with narrow and broad steepness priors) resulted in better mixing (Figs. A6 and A9 compared to A1). Quantitative results from CASAL runs presented here are merely preliminary. More work is needed to identify the underlying mechanisms causing the differences between the two models.

Appendix A References

Bull, B.; Francis, R.I.C.C.; Dunn, A.; McKenzie, A.; Gilbert, D.J.; Smith, M.H.; Bian, R. (2008). CASAL (C++ algorithmic stock assessment laboratory): CASAL User Manual v2.20-2008/02/14. *NIWA Technical Report 130*. 275 p.

Dick, E., S. Ralston, and D. Pearson. 2007. Status of cowcod, *Sebastes levis*, in the Southern California Bight. Pacific Fishery Management Council, Portland, Oregon. December 2007. 101 p.

PFMC. 2007. Cowcod STAR Panel Meeting Report. Agenda Item G.4.a, Attachment 10, September 2007. Pacific Fishery Management Council, Portland, Oregon.

Table A1. Comparison of the posterior estimates of B_0 (in mt) and depletion in 2007 from the 3 parameter model in SS2 (Dick et al. 2008) and CASAL. The lower and upper values represent the bounds of the 95% credibility intervals.

	Model	lower	median	mean	upper
	SS2	4964	4994	4996	5046
Virgin Biomass (B_0)	CASAL	5115	5128	5129	5148
	SS2	2.80%	4.90%	5.10%	8.30%
Depletion in 2007	CASAL	3.63%	4.88%	4.94%	6.53%

Table A2. Posterior estimates for the 3 parameter model and the 5 parameter model with a "narrow" and "broad" prior on steepness. (the standard deviation of the broad prior is double that of the narrow prior) The lower and upper values represent the bounds of the 95% credibility intervals.

		3 parameter			5 parameter (narrow)			5 parameter (broad)	
	lower	median	upper	lower	median	upper	lower	median	upper
Virgin Biomass (B0) (mt)	5114.7	5128.3	5147.7	4978.2	5618.5	6311.04	5625.9	6501.2	7268.8
CPFV q	0.000308	0.000334	0.000363	0.00292	0.000322	0.000356	0.000264	0.000295	0.00033
Visual Survey q	1.4	2.26	3.71	1.48	2.39	3.74	1.55	2.41	3.76
steepness	-	-	-	0.349	0.444	0.556	0.206	0.259	0.338
Natural mortality (M)	-	-	-	0.039	0.0525	0.067	0.0398	0.056	0.0716
Depletion (B2007/B0)	0.0363	0.0488	0.0651	0.0286	0.04	0.0551	0.0247	0.0331	0.0442

Table A3. Geweke diagnostic for the 3 parameter model.

```
GEWEKE CONVERGENCE DIAGNOSTIC (Z-score)
=======================================

Iterations used = 1:2000
Thinning interval = 1
Sample size per chain = 2000

$chain1

Fraction in 1st window = 0.1
Fraction in 2nd window = 0.5

       B0     CPFVq      Visq Depletion
  0.09086  -0.33109   0.01603   0.08452
```

Table A4. Heidelberger and Welch diagnostic for the 3 parameter model

```
HEIDELBERGER AND WELCH STATIONARITY AND INTERVAL HALFWIDTH TESTS
=================================================================

Iterations used = 1:2000
Thinning interval = 1
Sample size per chain = 2000

Precision of halfwidth test = 0.1

$chain1

          Stationarity start     p-value
          test         iteration
B0        passed       1         0.882
CPFVq     passed       1         0.815
Visq      passed       1         0.657
Depletion passed       1         0.881

          Halfwidth Mean     Halfwidth
          test
B0        passed    5.13e+03 1.02e+00
CPFVq     passed    3.35e-04 9.45e-07
Visq      passed    2.33e+00 6.04e-02
Depletion passed    4.94e-02 8.75e-04
```

Table A5. Geweke diagnostic for the 5 parameter model with the narrow steepness prior.

```
GEWEKE CONVERGENCE DIAGNOSTIC (Z-score)
=======================================

Iterations used = 1:2000
Thinning interval = 1
Sample size per chain = 2000

$chain1

Fraction in 1st window = 0.1
Fraction in 2nd window = 0.5

      B0      CPFVq       Visq  steepness          M  Depletion
  0.9676    -0.7582     0.4243    -0.5140    -0.5641     0.2072
```

Table A6. Heidelberger and Welch diagnostic for the 5 parameter model with the narrow steepness prior

```
HEIDELBERGER AND WELCH STATIONARITY AND INTERVAL HALFWIDTH TESTS
=================================================================

Iterations used = 1:2000
Thinning interval = 1
Sample size per chain = 2000

Precision of halfwidth test = 0.1

$chain1

          Stationarity start     p-value
          test         iteration
B0        passed       1         0.957
CPFVq     passed       1         0.214
Visq      passed       1         0.659
steepness passed       1         0.190
M         passed       1         0.889
Depletion passed       1         0.528

          Halfwidth Mean     Halfwidth
          test
B0        passed    5.64e+03 3.36e+01
CPFVq     passed    3.23e-04 1.52e-06
Visq      passed    2.44e+00 5.35e-02
steepness passed    4.47e-01 7.33e-03
M         passed    5.25e-02 8.37e-04
Depletion passed    4.05e-02 5.31e-04
```

Table A7. Geweke diagnostic for the 5 parameter model with the broad steepness prior.

```
GEWEKE CONVERGENCE DIAGNOSTIC (Z-score)
=======================================

Iterations used = 1:2000
Thinning interval = 1
Sample size per chain = 2000

$chain1

Fraction in 1st window = 0.1
Fraction in 2nd window = 0.5

       B0 steepness         M     CPFVq      Visq Depletion
  -0.4145   -0.6292    1.4975   -0.8018    1.5432   -0.8455
```

Table A8. Heidelberger and Welch diagnostic for the 5 parameter model with the broad steepness prior.

```
HEIDELBERGER AND WELCH STATIONARITY AND INTERVAL HALFWIDTH TESTS
=================================================================

Iterations used = 1:2000
Thinning interval = 1
Sample size per chain = 2000

Precision of halfwidth test = 0.1

$chain1

          Stationarity start     p-value
          test         iteration
B0        failed        NA       5.89e-07
steepness failed        NA       1.53e-06
M         passed         1       2.08e-01
CPFVq     passed         1       2.30e-01
Visq      passed       201       5.35e-02
Depletion passed         1       7.96e-02

          Halfwidth Mean     Halfwidth
          test
B0        <NA>            NA        NA
steepness <NA>            NA        NA
M         passed    0.055828 6.97e-04
CPFVq     passed    0.000296 1.71e-06
Visq      passed    2.464086 4.18e-02
Depletion passed    0.033525 4.48e-04
```

Figure A1. Trace plots from the 5-parameter Bayesian model run in the 2007 cowcod assessment (this is Figure C1 in Dick et al. (2007)). Mgparm1 = *M*, SRparm1 = virgin recruitment (R_0), SRparm2 = steepness, CPFV catchability = Qparm1, visual
survey catchability = Qparm2.

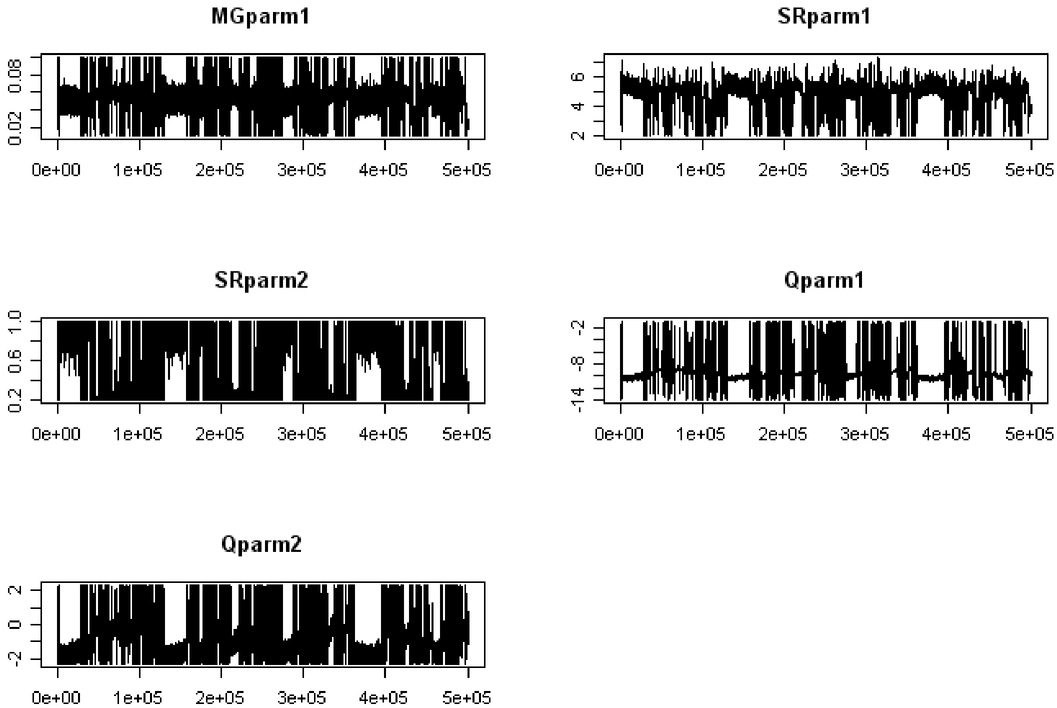


Figure A2. Prior densities for steepness explored in the 5-parameter model. The “broad” prior is the CASAL interpretation of the Dorn prior (a Beta with a mean of 0.597 and a standard deviation of 0.183). The “narrow” prior is a Beta with same mean, but with a standard deviation of 0.0915).

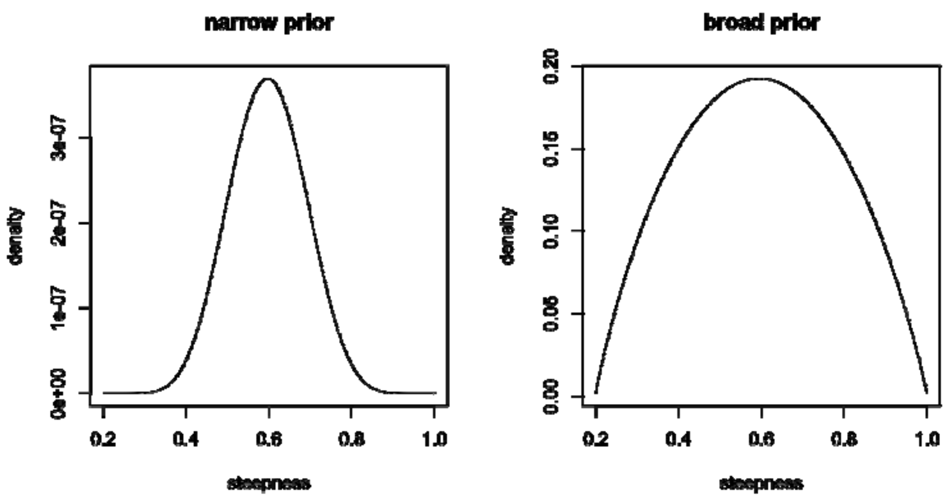


Figure A3. MCMC trace plots and densities of the posterior samples from the 3 parameter model. The 3 parameters are B_0, and the catchability coefficients (q) for the CPFV and visual surveys. The estimates of depletion (B_{2007} / B_0) are derived for each posterior draw. A total of 2 millions iterations were run, keeping every 1000^{th} draw.

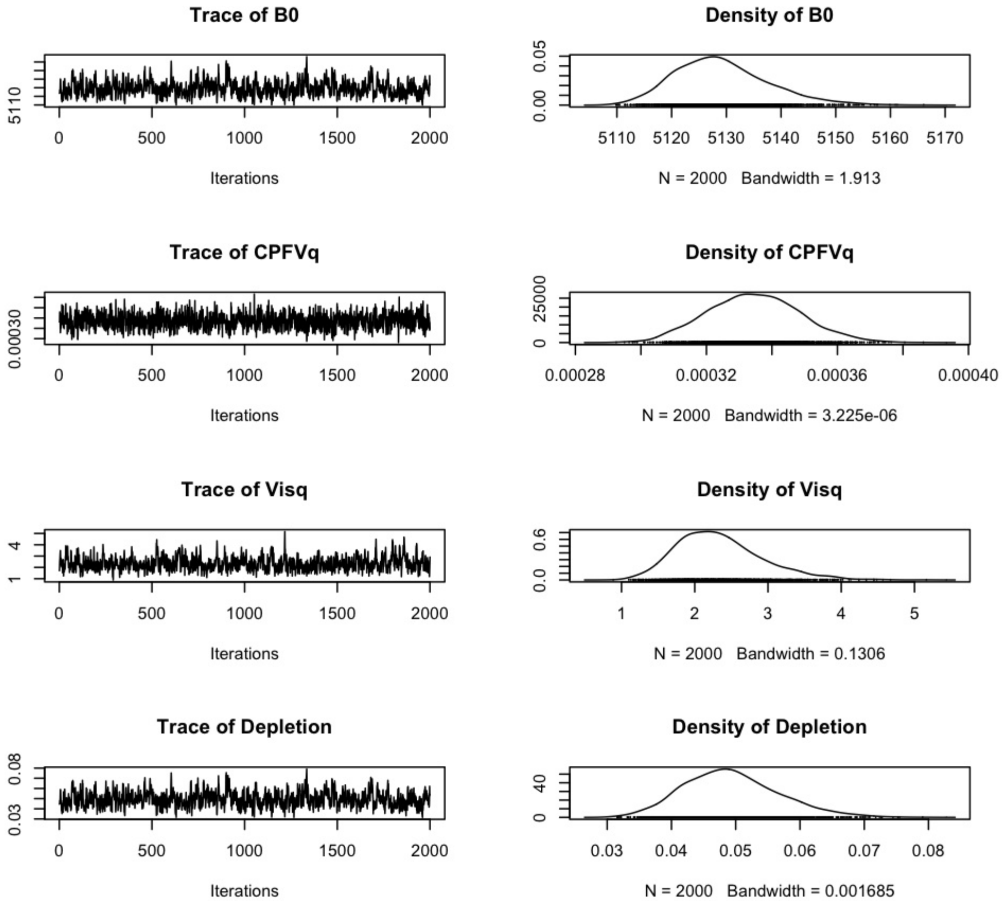


Figure A4. Autocorrelation function (ACF) plots for the 3 parameters and the derived estimate of depletion.

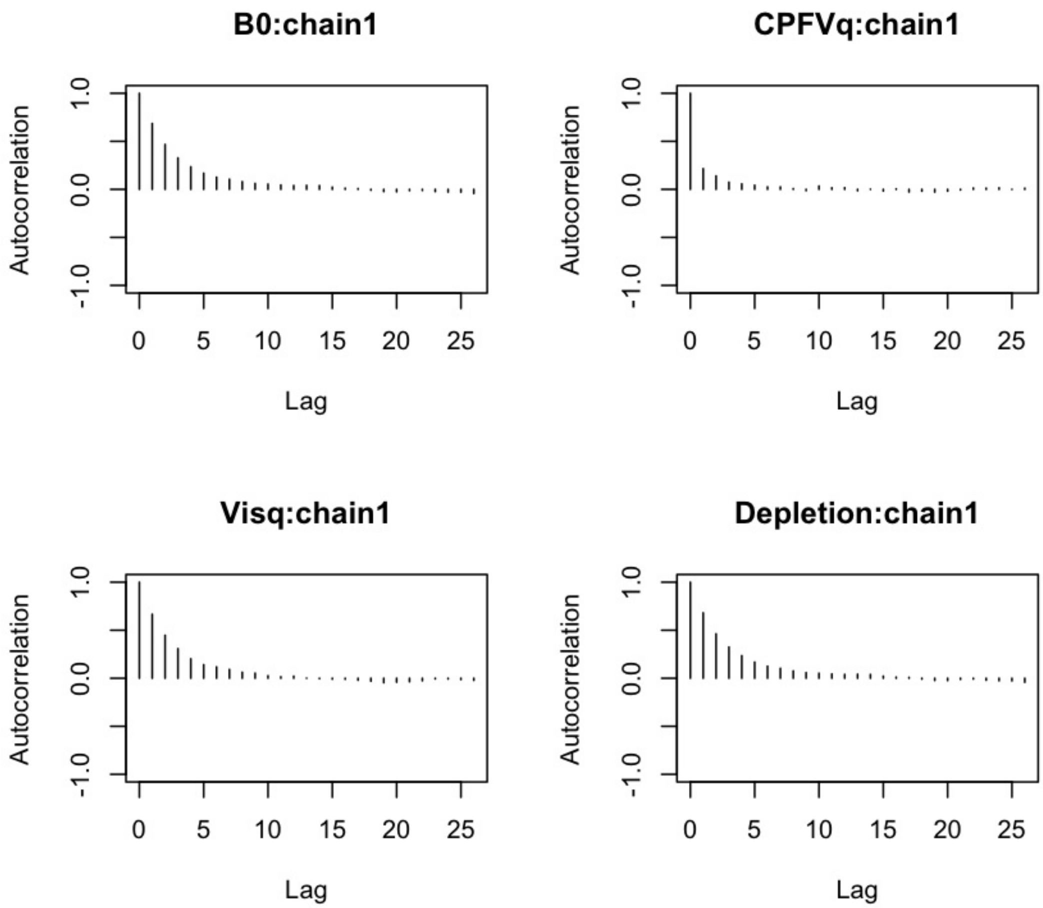


Figure A5. Scatterplot of posterior samples for the various combinations of parameters and the derived quantity Depletion.

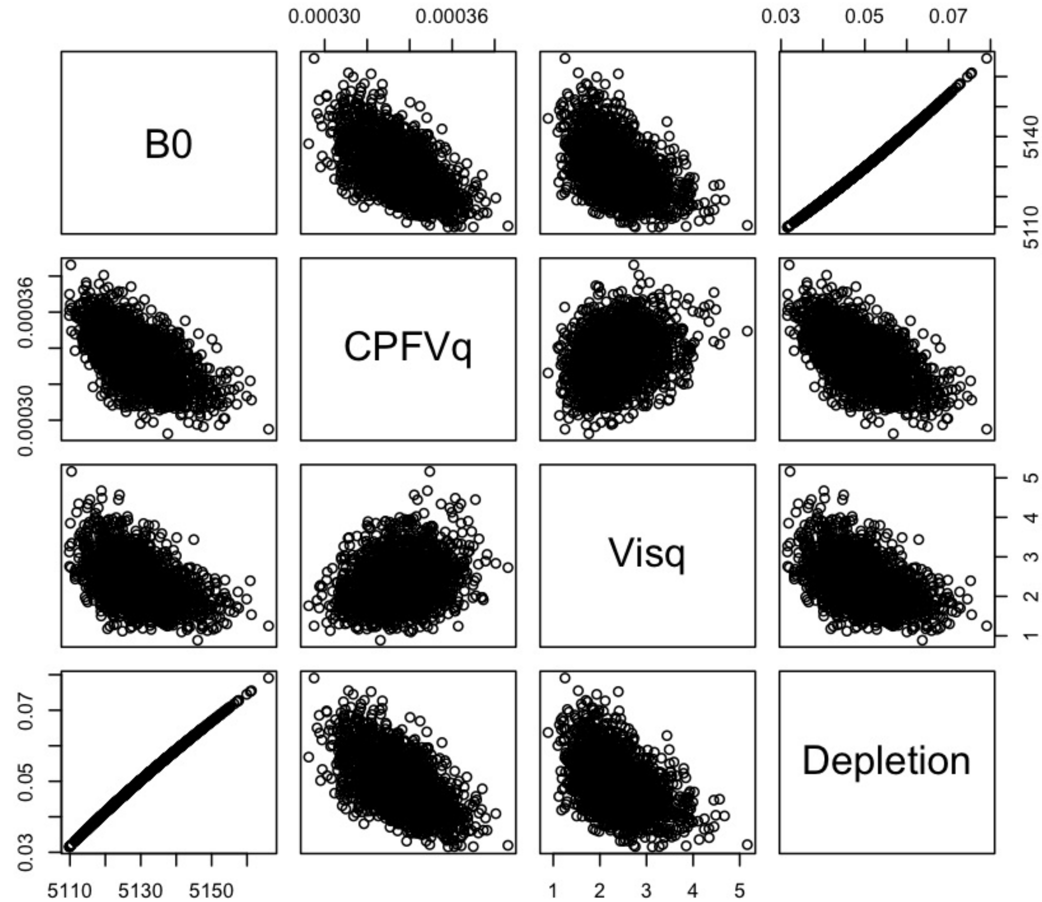


Figure A6a. MCMC trace plot and densities of the samples of the posterior for the 5-parameter model with the "narrow" prior on steepness. The 5 parameters are B_0, and the catchability coefficients (*q*) for the CPFV and visual surveys, M, and steepness. The estimates of depletion (B_{2007} / B_0) are derived for each posterior draw. A total of 2 millions iterations were run, keeping every 1000[th] draw. The first three parameters are shown on this page, with the remaining three on the following page.

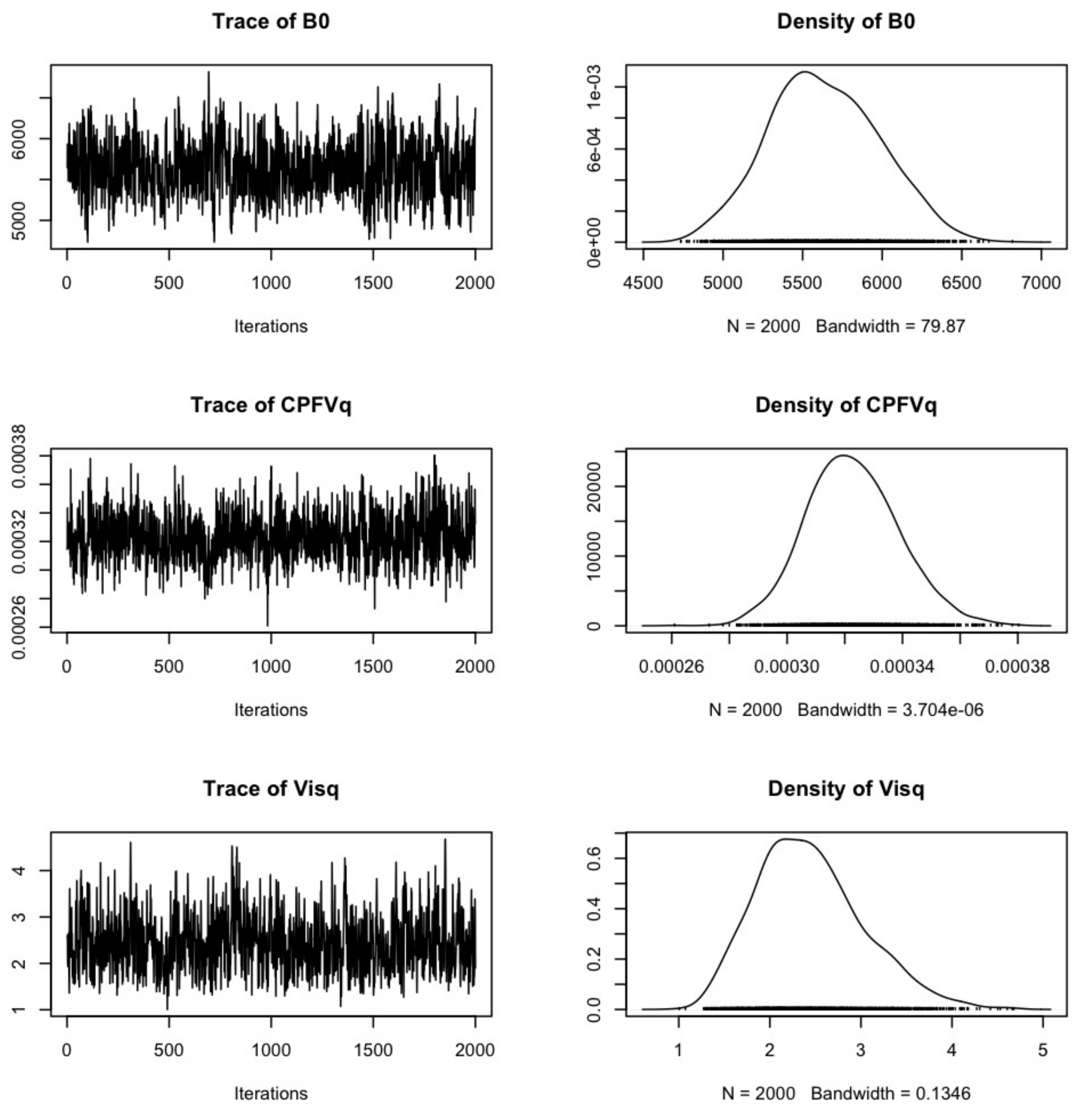


Figure A6b.

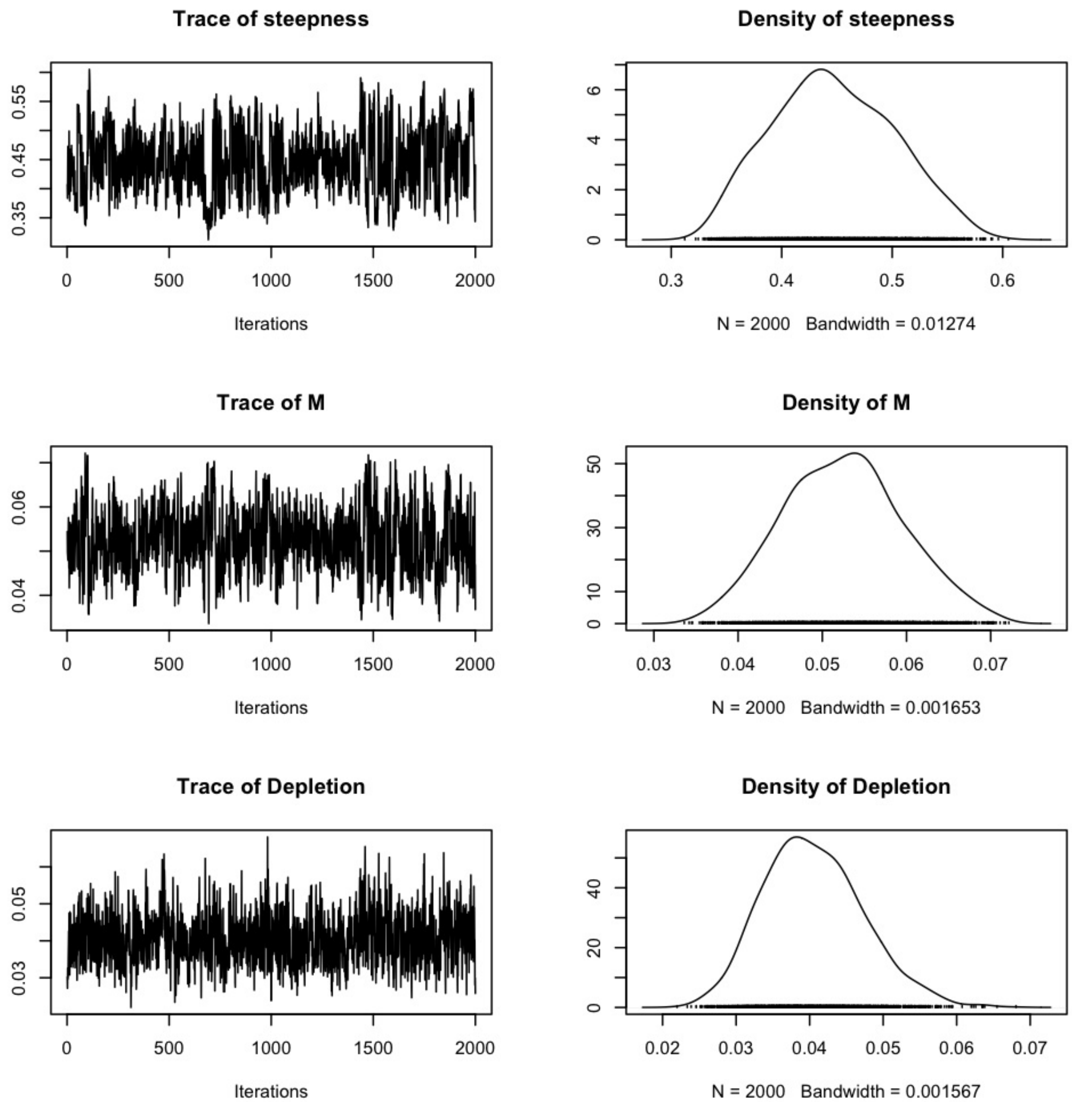

Trace of steepness
0.35
0.45
0.55
0
500
1000
1500
2000
Iterations
Density of steepness
0
2
4
6
0.3
0.4
0.5
0.6
N = 2000 Bandwidth = 0.01274
Trace of M
0.04
0.06
0
500
1000
1500
2000
Iterations
Density of M
0
10
30
50
0.03
0.04
0.05
0.06
0.07
N = 2000 Bandwidth = 0.001653
Trace of Depletion
0.03
0.05
0
500
1000
1500
2000
Iterations
Density of Depletion
0
20
40
0.02
0.03
0.04
0.05
0.06
0.07
N = 2000 Bandwidth = 0.001567

Figure A7. Autocorrelation function (ACF) plots for the 5-parameters and the derived estimate of depletion for the model with the “narrow” prior on steepness.

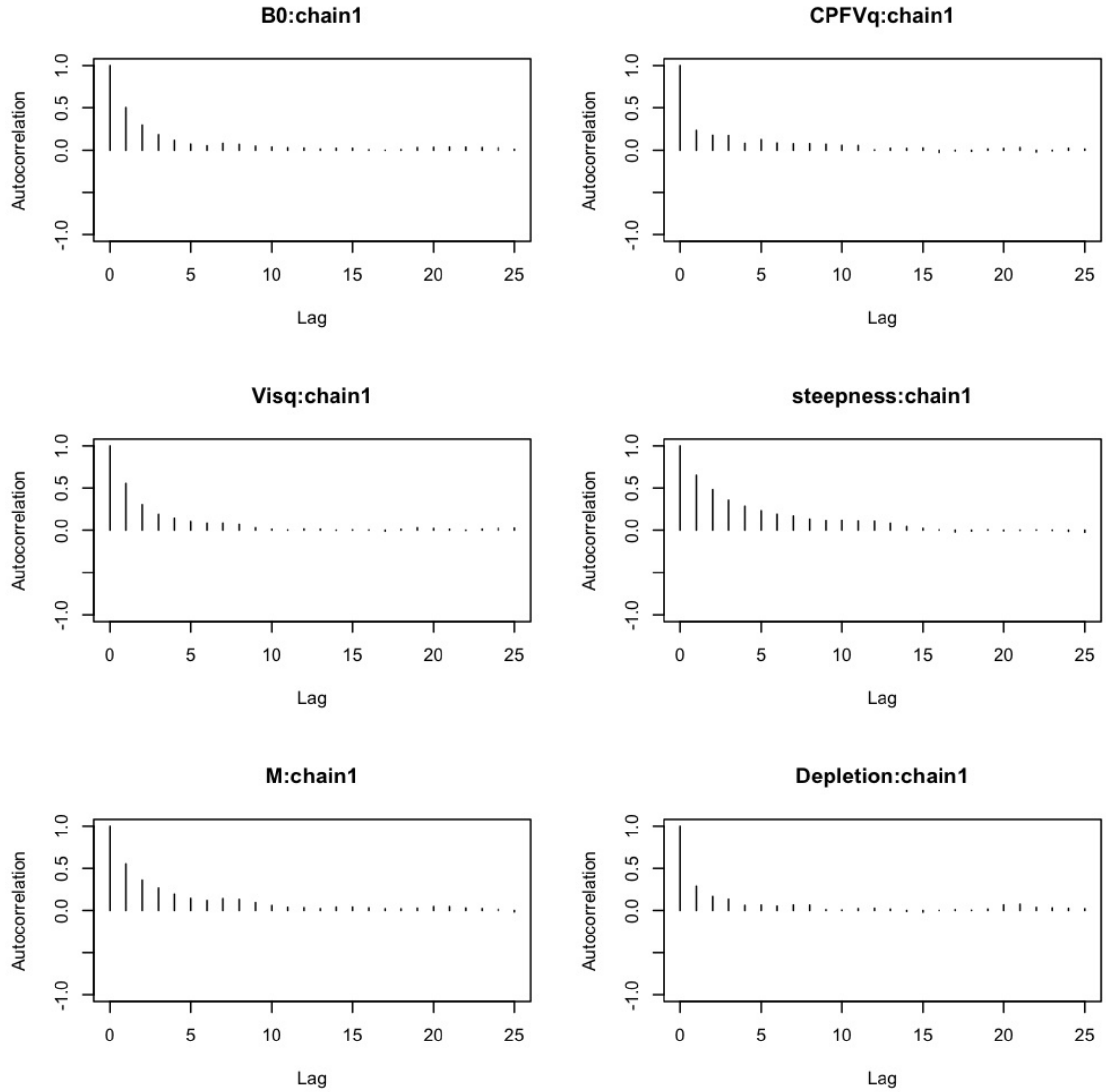


Figure A8. Scatterplot of posterior samples for the various combinations of parameters and the derived quantity depletion for the 5-parameter model with the “narrow” prior on steepness.

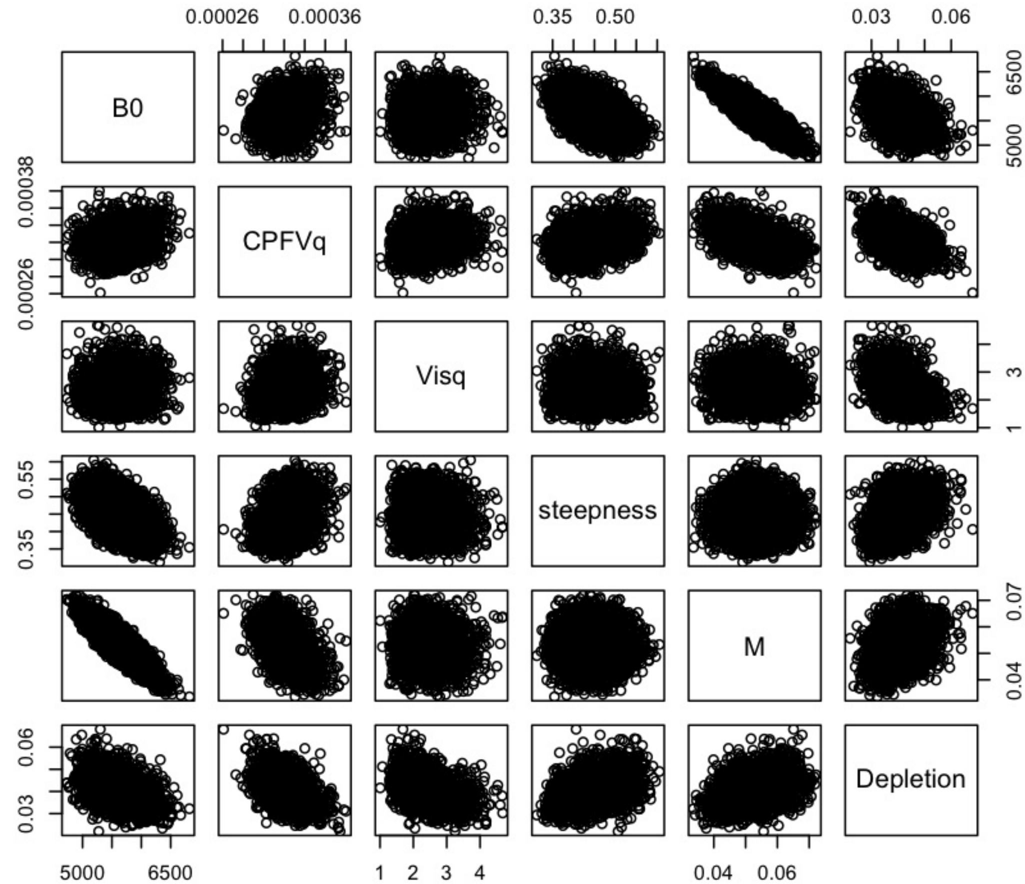


Figure A9a. MCMC trace plot of the samples of the posterior for the 5-parameter model with the “broad” prior on steepness. The 5 parameters are B_0, and the catchability coefficients (*q*) for the CPFV and visual surveys, M, and steepness. The estimates of depletion (B_{2007} / B_0) are derived for each posterior draw. A total of 20 millions iterations were run, keeping every 10,000th draw. The first three parameters are shown on this page, with the remaining three shown on the following page.

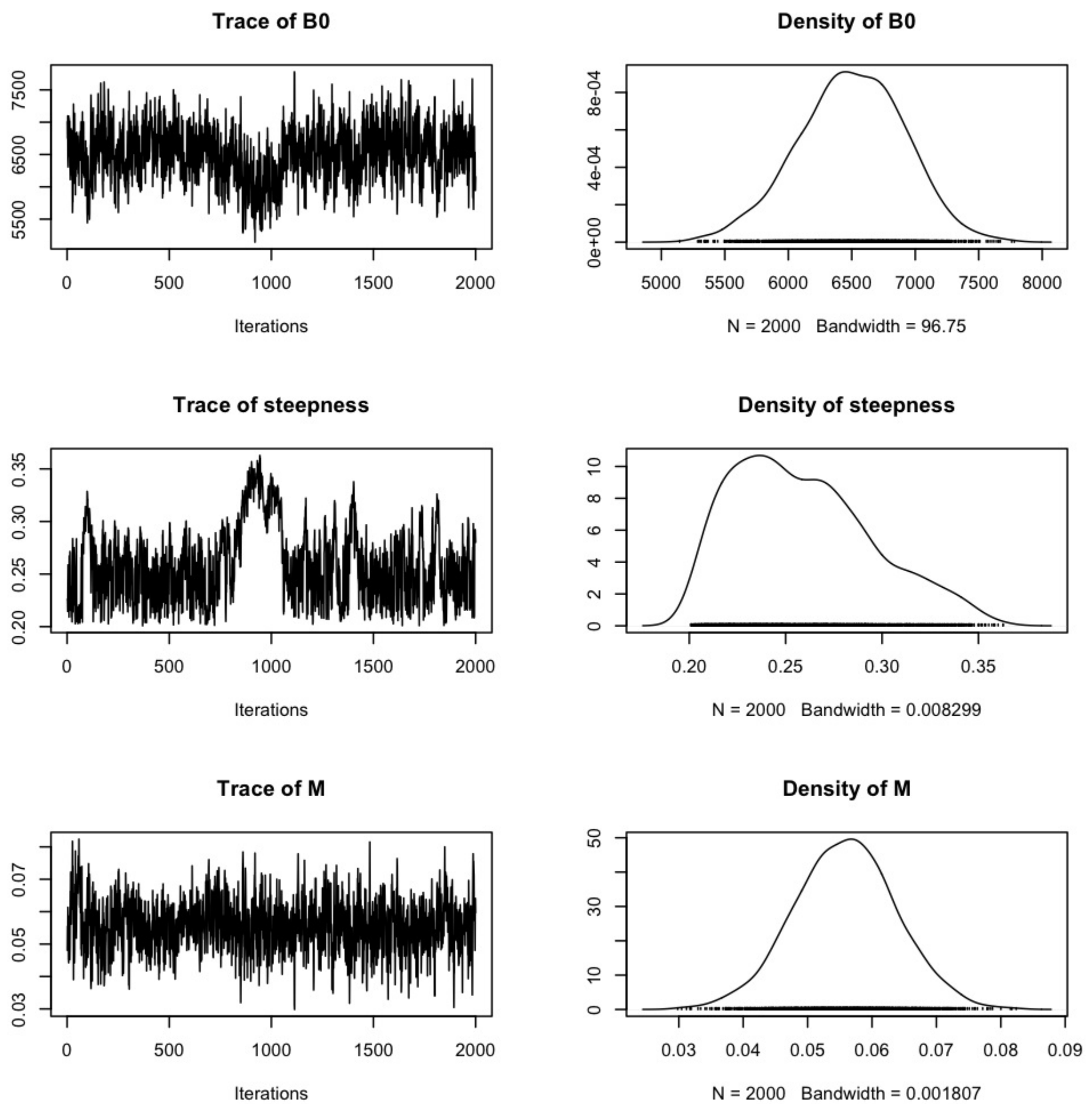


Figure A9b.

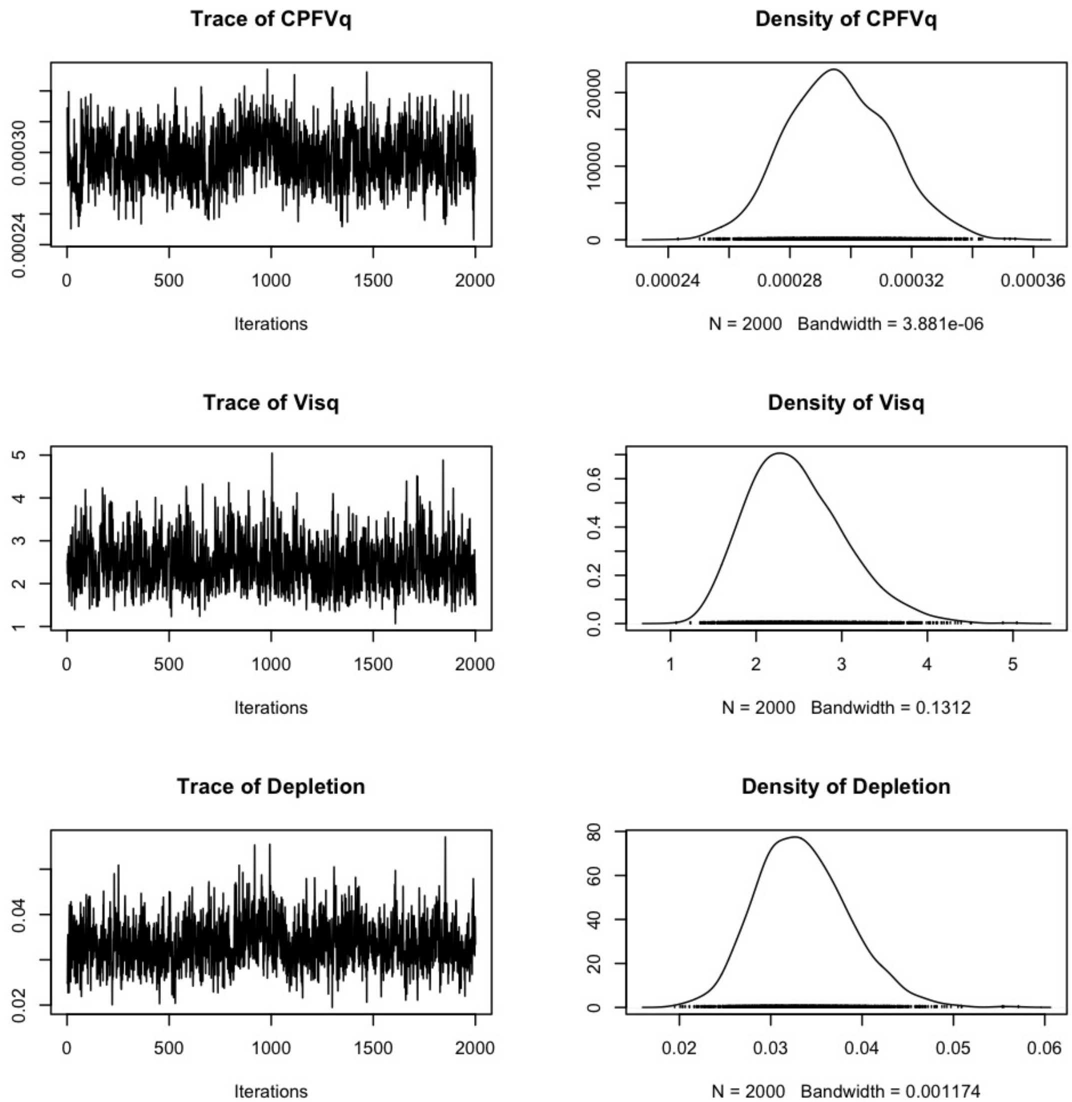

Trace of CPFVq
0.00024
0.00030
0 500 1000 1500 2000
Iterations
Density of CPFVq
0
10000
20000
0.00024 0.00028 0.00032 0.00036
N = 2000 Bandwidth = 3.881e-06
Trace of Visq
1 2 3 4 5
0 500 1000 1500 2000
Iterations
Density of Visq
0.0 0.2 0.4 0.6
1 2 3 4 5
N = 2000 Bandwidth = 0.1312
Trace of Depletion
0.02
0.04
0 500 1000 1500 2000
Iterations
Density of Depletion
0 20 40 60 80
0.02 0.03 0.04 0.05 0.06
N = 2000 Bandwidth = 0.001174

Figure A10. Autocorrelation function (ACF) plots for the 5-parameters and the derived estimate of depletion for the model with the “broad” prior on steepness.

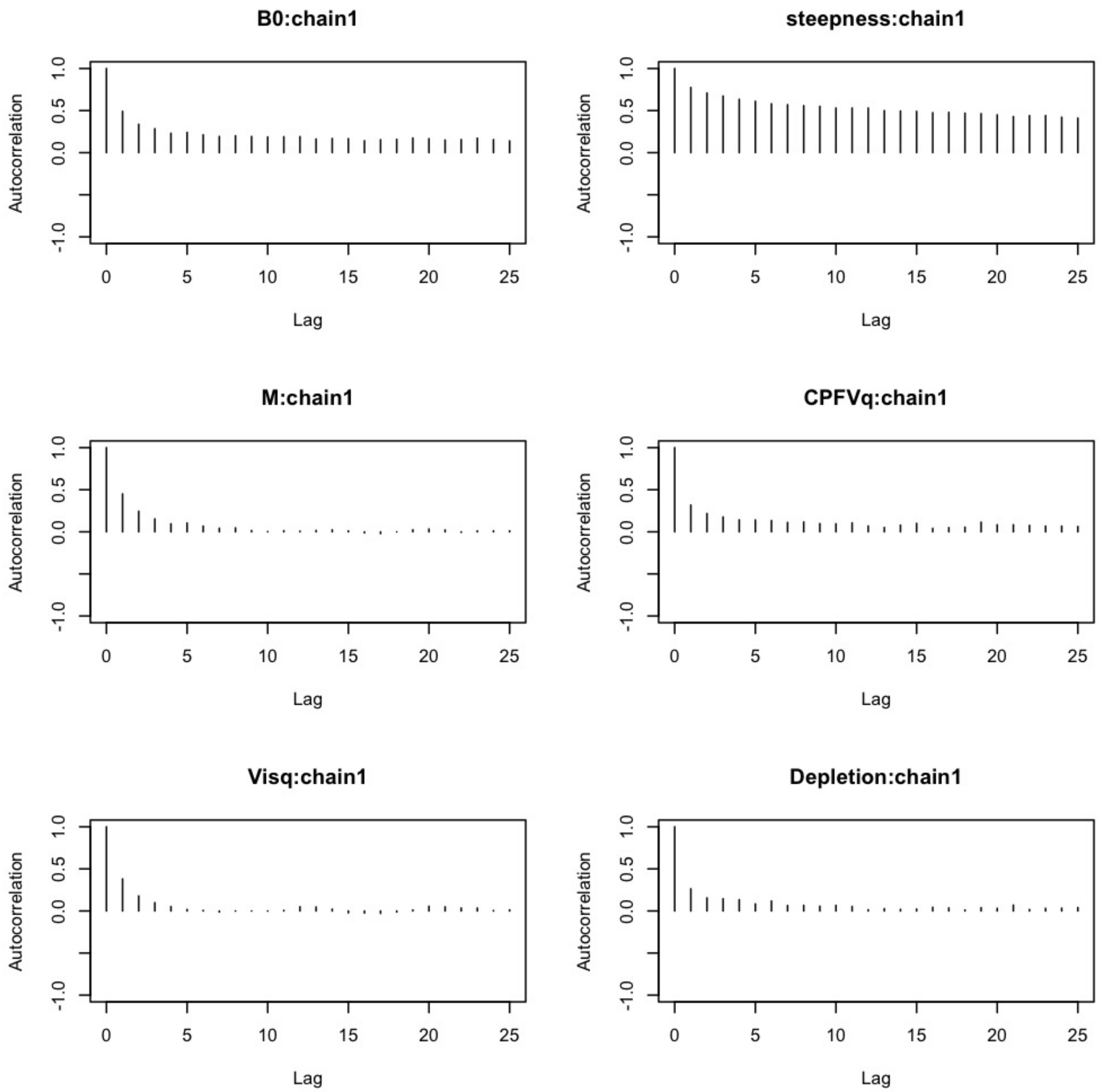
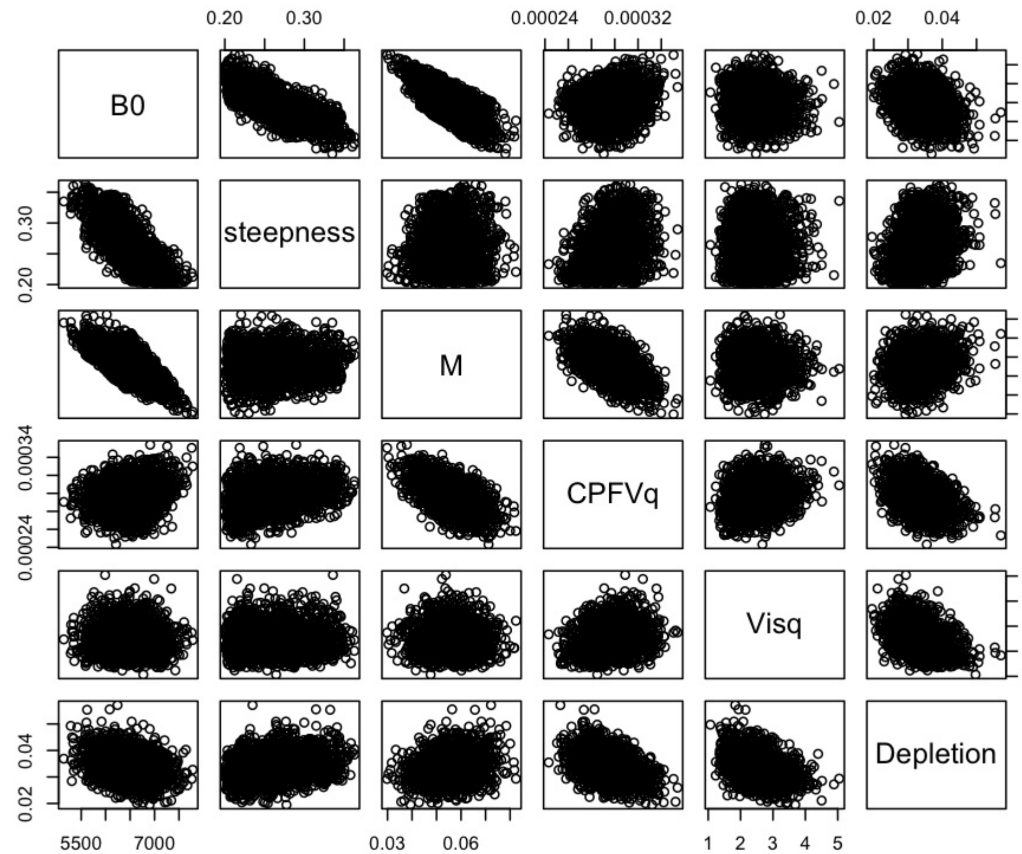


Figure A11. Scatterplot of posterior samples for the various combinations of parameters and the derived quantity depletion for the 5-parameter model with the “broad” prior on steepness.



CASAL Code

CASAL requires at least 3 input files to run, the population file, the estimation file, and the output file. The code from the 3 files used in the cowcod assessment are below. Any text following a # or contained within { } is “texted out.”

The following goes in the Population.csl file

```
#---------------- INITALISATION --------------------------------------------------------
@initialization
B0 4500          # the starting value for B0  used in the optimizer
#----------------- PARTITION -----------------------------------------------------------
@size_based false   # Define the model as age-based
@min_age 0
@max_age 80        # The partition keeps account of fish aged 0-80
@plus_group true    # the final age group is a plus group (80+)
@sex_partition false # The model is not sex-based
@mature_partition false # Maturity is excluded from the partition
@n_areas 1         # Only a single fishing area is defined
@n_stocks 1        # This is a single stock model
# ---------------- TIME SEQUENCE --------------------------------------------------------
@initial 1900      # The model is defined to run from 1900
@current 2007      # to the current year, 2007
@final 2007
@annual_cycle
time_steps 5
recruitment_time 2
spawning_time 1 1
spawning_part_mort 0.0  # SSBs are calculated after spawning fish have undergone 0 mortality in the time step
spawning_ps 1.0     # proportion of mature fish that spawn
aging_time 1       # Age incrementation occurs in this time step
growth_props  0.0 0.2 0.4 0.6 0.8  # proportion  of growth that occurs BY each time step
M_props  0.2 0.2 0.2 0.2 0.2  # proportion of M IN each time step
baranov false      # Is the baranov catch equation used?
midmortality_partition weighted_sum
fishery_names commercial recreational # There is a commercial and recreational fishery
fishery_times 3 3   # Both occur in the 3rd time step
n_migrations 0      # No migrations are defined
#----------------- RECRUITMENT ---------------------------------------------------------------------
@y_enter 0         # Recruits enter this many years after birth
@standardise_YCS false  # Use the "Haist" parameterisation of YCS?
@recruitment       # the two following lines define the starting values for recruitment deviations
YCS_years 1900 1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920
1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943
1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966
1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
YCS      1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
1.00 1.00 1.00 1.00 1.00 1.00
p_male 0.5         # 50% of ‘recruits’ are males
sigma_r 0.0        # Standard deviation of YCS for projections
SR BH              # Use the Beverton-Holt stock-recruit relationship
steepness 0.6      #the fixed value of steepness
{when steepness is an estimated parameter, this value is just used as the starting point in the estimation process}
# ---------------- RECRUITMENT VARIABILITY ---------------------------------------------------------
@randomisation_method lognormal # Use the lognormal distribution when assigning YCS to unknown years during projections
@first_random_year 2008 # Defines the first unknown YCS as 1999
```

```
# ----------------  NATURAL MORTALITY -------------------------------------------------------------------
@natural_mortality
all 0.055  # natural mortality is fixed at 0.055
{when M is an estimated parameter, this value is just used as the starting point in the estimation process}
#------------------ COMMERCIAL FISHING -----------------------------------------------------------------
@fishery commercial    # Define the catch from the commercial fishery for years 1900-2007
years   1900 1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920
1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943
1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966
1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
catches 0.01 5.34 10.68 16.01 21.35 26.68 32.02 37.35 42.68 48.02 53.35 58.69 64.02 69.35 74.69 80.02 85.36 137.73 125.59
75.1 81.57 71.26 70.11 93.94 125.94 138.15 171.48 142.3 111.3 102.48 126.78 160.8 109.27 81.64 70.36 52.56 20.19 24.22
18.08 21.5 23.28 29.1 10.4 12.18 1.83 4.38 11.3 17.58 26.87 35.05 39.37 45.57 31.05 24.88 34.05 27.62 37.8 38.43 43.54 45.09
49.18 50.05 37.92 47.21 36.07 50.97 47.41 63.22 63.87 94.98 55.92 68.06 102.51 108.79 114.26 112.47 131.35 132.44 147.75
187.52 142.62 197.59 228.55 126.55 221.14 204.75 146.99 76.62 86.60 17.38 10.41 7.1 17.21 14.85 13.63 23.3 24.57 7.3 1.21
3.47 0.45 0.25 0.25 0.25 0.25 0.25 0.25 0.25
selectivity CommSel   #  with the selectivity named “CommSel” which is defined below
U_max 0.9             # the maximum possible exploitation rate
F_max 1.0              # This needs to be specified when using the baranov catch equation
# --------------- RECREATIONAL FISHING -----------------------------------------------------------------
@fishery recreational    # Define the catch from the recreational fishery for years 1900-2007
years   1900 1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920
1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943
1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966
1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
catches 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 9 10 13 24 42 49 37 33 22
36 33 35 30 34 43 85 110 77 53 79 62 90 97 129 109 140 100 73 86 96.43 26.55 96.99 15.13 21.22 35.99 45.99 29.14 13.91
20.60 21.60 20.90 20.70 9.68 26.01 1.75 5.36 1.85 2.81 3.77 4.49 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
selectivity RecSel # with the selectivity named “RecSel” which is defined below
U_max 0.9            # with a maximum possible exploitation rate of 0.9
F_max 1.0
# --------------------  SELECTIVITIES ---------------------------------------------------------------------
@selectivity_names CommSel RecSel # Define the two selectivities used
@selectivity CommSel                  # Fishing selectivity for commercial fishery
all size_based logistic 43 5.767      # Size where 50% are harvested is 43 cm, and at 95% is 48.767
@selectivity RecSel                  # Fishing selectivity for rec. fishery
all size_based logistic 34.06 7.52   #
# ------------------  MATURATION ---------------------------------------------------------------------
{Note:  CASAL does allow a size based maturity ogive in an age-based model, so the corresponding ages at 43 cm and 48.767
cm were used}
@maturity_props  # Define the maturity ogive for males and females
all logistic 11.32901 2.73682 # This is the age in years, not size!
#--------------------  LENGTH AT AGE  ------------------------------------------------------------------
@size_at_age_type Schnute   # Defines that the age-length relationship is Schnute
@size_at_age_dist normal
@size_at_age
y1 16.2  # reference size at tau1 (age 2)
y2 75.6  # reference size at tau2 (age 37)
tau1 2   # age 2
tau2 37  # age 37
a 0.052  # analogous to k
b 1      # when b=1 this becomes von bert
cv1 0.265   # cv at tau1
cv2 0.0446  #cv at tau2
# --------------------- LENGTH-WEIGHT ---------------------------------------------------------------------
@size_weight    # Defines the length-weight relationship
a 1.01e-5
b 3.093
{Note: CASAL wants the weight of a fish to be in the same units that the catch is in (mt in this case).  For cowcod, this would
mean that the parameter a = 1.01 e-8.  However, CASAL also keeps track of total #’s of fish, whereas SS2 uses fish in the 1000s
```

(i.e. 100,000 fish in CASAL = 100 fish in SS2). I therefore set a = 1.01 e-5 to make a fish weigh 1000x more than it really does so that there are 1000 x fewer fish in the model. Doing so made estimates of q for the CPFV logbook CPUE on the same scale as in the 2007 update assessment..}

The following goes into the estimation.csl file

```
#-------------- ESTIMATION-------------------------------------------------
@estimator Bayes   # Either use 'likelihood' or 'Bayes'
@max_iters 3000   # With maximum number of iterations for the point estimates
@max_evals 3000  # and this number of function evaluations
@grad_tol 0.002    # Set the tolerance for the convergence test at 0.002
@MCMC
start 5      # A value greater than 0 here starts the MCMC at a random value –
length 2000000       # length of MCMC chain
keep 1000              # keeping every __th sample
stepsize 0.006         # This value * the covariance matrix is used to generate the proposed value
adaptive_stepsize true            # allows the proposoal stepsize to adapt
adapt_at  25 50 75 100 150 200 250 # when in the chain to adapt the stepsize?
burn_in 0              # The total burn-in is this value * keep
covariance_adjustment covariance  #use either the covariance matrix or the correlation matrix
#max_cor 0.8                        # Max correlation in the covariance proposal matrix (default = 0.8)
#min_diff 0.001
#---------------CPFV LOGBOOK---------------------------------------------------
@relative_abundance CPFVCPUE # Define a relative abundance series "CPFVCPUE"
biomass false   # This time series is an abundance index
q CPFVq         # and has a catchability coefficient called "CPFVq"
years 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000
step 3         # Occurs in time step 3
proportion_mortality 0.5# after 0.5 of mortality has been recorded in that time step
ogive RecSel   # with the Recreational selectivity
#year       CPUE
1963        0.511667932
1964        0.39318353
1965        0.275071085
1966        0.239739296
1967        0.146883176
1968        0.172989635
1969        0.185848155
1970        0.208035274
1971        0.251555595
1972        0.132619837
1973        0.22675229
1974        0.213903213
1975        0.260807514
1976        0.152136187
1977        0.139320919
1978        0.106248194
1979        0.088607116
1980        0.060658815
1981        0.081386727
1982        0.042134063
1983        0.060328342
1984        0.050024814
1985        0.036993343
1986        0.041577946
1987        0.023065175
1988        0.033749003
1989        0.025582052
1990        0.032747243
1991        0.041559421
1992        0.030297922
1993        0.033171318
1994        0.021107241
1995        0.017687439
1996        0.016099821
```

```
1997	0.008792843
1998	0.010754417
1999	0.003092846
2000	0.002914665

# year  CV
cv_1963 0.3302199
cv_1964 0.2527121
cv_1965 0.2246714
cv_1966 0.2308946
cv_1967 0.2463383
cv_1968 0.1777022
cv_1969 0.2369852
cv_1970 0.2734493
cv_1971 0.1952652
cv_1972 0.211407
cv_1973 0.1413628
cv_1974 0.1574918
cv_1975 0.1488574
cv_1976 0.1515156
cv_1977 0.1980102
cv_1978 0.2184173
cv_1979 0.1867767
cv_1980 0.1674501
cv_1981 0.1680148
cv_1982 0.190058
cv_1983 0.1540601
cv_1984 0.1784306
cv_1985 0.2046437
cv_1986 0.1963785
cv_1987 0.2253322
cv_1988 0.24057
cv_1989 0.2341604
cv_1990 0.2118718
cv_1991 0.182387
cv_1992 0.2437875
cv_1993 0.3494245
cv_1994 0.2903738
cv_1995 0.3372674
cv_1996 0.2987764
cv_1997 0.4584879
cv_1998 0.2743454
cv_1999 0.443594
cv_2000 0.6721232

dist lognormal	# where the c.v.s have lognormal distribution
cv_process_error 0.0 # and there is no process error applied
# ------------------ VISUAL SURVEY -----------------------------------------
@relative_abundance VisualSurvey # Defines an abundance series "VisualSurvey"
biomass true	# This time series is an abundance index
q VisSurvq  # and has a catchability coefficient called "VisSurvq"
years 2002 # index years
step 3		# Occurs in time step 3
proportion_mortality 0.5 # after all mortality has been recorded in that time step
2002 524.3	# the biomass estimate from the visual survey (in mt)
cv_2002 0.26 # the cv from the visual survey
dist lognormal	# where the c.v.s have lognormal distribution
cv_process_error 0.0 # and there is no process error applied
#----------------- CATCHABILITY COEFFICIENTS---------------------------------
@q_method free	#treat q's as free parameters to estimate
@q CPFVq
q 2.00e-5		#specify a starting value for 'CPFVq'
```

```
@q VisSurvq
q 4.2                                   #specify a starting value for 'VisSurvq'
#------------------ PARAMETERS TO ESTIMATE ---------------------------------
@estimate
parameter initialization.B0 # Estimate B0
phase 1
lower_bound 1000           # Define the lower bound
upper_bound 10000                              # Define the upper bound
prior uniform
MCMC_fixed false

@estimate
parameter q[CPFVq].q            # Estimate the parameter q[CPFV_q].q when fitting the model
phase 1
lower_bound 1.0e-9         # with a lower bound
upper_bound 5.0e-2        # and upper bound
prior uniform
MCMC_fixed false

@estimate
parameter q[VisSurvq].q   # Estimate the parameter q[VisSurvq].q when fitting the model
phase 1
lower_bound 0.1
upper_bound 10
#prior uniform
prior lognormal
mu 2.27
cv 0.3886
MCMC_fixed false

@estimate
parameter recruitment.steepness
phase 1
lower_bound 0.2
upper_bound 1.0
prior beta
mu 0.597
stdev 0.183 # the Dorn prior
#stdev 0.0915  # half the s.d. of the Dorn prior
A 0.199
B 1.0012

@estimate
parameter natural_mortality.all
phase 1
lower_bound 0.001
upper_bound 0.2
prior normal
mu 0.055
cv 0.139
#--------------------- PENALTIES-------------------------------------------
@catch_limit_penalty  # This specifies that the model must attempt to have a biomass large enough so that the catch is takable
from the population
label CatchMustBeTaken
fishery commercial
log_scale false
multiplier 1000       # The penalty has a high "multiplier"

@catch_limit_penalty  # This specifies that the model must attempt to have a biomass large enough so that the catch is takable
from the population
label CatchMustBeTaken
fishery recreational
```

```
log_scale false
multiplier 1000       # The penalty has a high "multiplier"
```

The following goes in the output.csl file

```
@print # Specifies the outputs that CASAL should generate
# ----------- ESTIMATION SECTION-----------------------
parameters false
fits_every_eval false
objective_every_eval false
parameters_every_eval false
parameter_vector_every_eval false
fits true
resids false
pearson_resids false
normalised_resids false
estimation_section false
covariance true
requests false
initial_state false
state_annually false
state_every_step false
final_state true
results true
#----------OUTPUT SECTION----------------------------------
yields true
unused_parameters true

@quantities
all_free_parameters true
fishing_pressures true
true_YCS false
B0 true
R0 true
SSBs true
YCS false
actual_catches false

#@MCY_CAY
#do_MCY false
#MCY_guess 10000
#n_discard 100
#n_keep 100
#n_simulations 100
#do_CAY true
#F_CAY_guess 0.2
#interactive false
```

Appendix B. SS2 input files for 2009 cowcod update assessment (base model)

```
##  SS2 Version 2.00
##
##  Data & Control Files
moo4_base.dat
moo4_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

# forecast file for cowcod assessment, 2009
#
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
```

```
# control file for 2009 cowcod assessment update
# Stock Synthesis 2, version 2.00c
# E.J. Dick, NMFS SWFSC Santa Cruz Lab
# June 2009

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)_mi
nage_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     10     1      # virgin recruitment
0.2    1      0.6    0.597  2      0.183  -2     # steepness
0      2      0.01   0.4    0      10     -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      100    -1
0      0.2    0      0      0      100    -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     100    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      100    -1     0 0 0 0 0.5 0 0
5      6      5.767  5.767  0      100    -1     0 0 0 0 0.5 0 0
#_size_sel: 2 -- recreational fishery
10     50     34.06  35     0      100    -1     0 0 0 0 0.5 0 0
5      15     7.52   7      0      100    -1     0 0 0 0 0.5 0 0
#_size_sel: 3 -- CPFV index; mirrors recreational fishery
10     50     -1     35     0      100    -1     0 0 0 0 0.5 0 0
5      15     -1     7      0      100    -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      100    -1     0 0 0 0 0.5 0 0
79     80     80     80     0      100    -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 2009 cowcod assessment update
# Stock Synthesis 2, version 2.00c
# June 2009
#
# MODEL DIMENSIONS
# ----------------
1900   # start year
2009   # 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
75.10  0
```

```
81.57  0      # 1920
71.26  0
70.11  0
93.94  0
125.94 0
138.15 0
171.48 0
142.30 0
111.30 0.05
102.48 0.11
126.78 0.16   # 1930
160.80 0.22
109.27 0.27
81.64  0.33
70.36  0.38
52.56  0.44
20.19  0.44
24.22  0.66
18.08  0.63
21.50  0.51
23.28  0.41   # 1940
29.10  0.38
10.40  0.20
12.18  0.19
1.83   0.16
4.38   0.21
11.30  0.36
17.58  1.18
26.87  3.05
35.05  3.63
39.37  4.63   # 1950
45.57  3.62
31.05  5.62
24.88  6.33
34.05  12.76
27.62  24.43
37.80  27.37
38.43  17.25
43.54  12.82
45.09  7.21
49.18  7.87   # 1960
50.05  9.99
37.92  10.11
47.21  10.13
36.07  15.82
50.97  19.11
47.41  29.22
63.22  39.15
63.87  41.15
94.98  30.13
55.92  39.92  # 1970
68.06  38.03
102.51 50.10
108.79 62.98
114.26 69.38
112.47 70.06
131.35 57.97
132.44 58.77
147.75 55.41
187.52 74.60
142.62 80.98  # 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  20.6
10.41  21.6   # 1990
7.10   20.9
17.21  20.7
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   # 2005
0.25   0.25
0.25   0.25
0.25   0.25
0.25   0.25   # 2009
#
# 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 from Yoklavich et al. (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
```