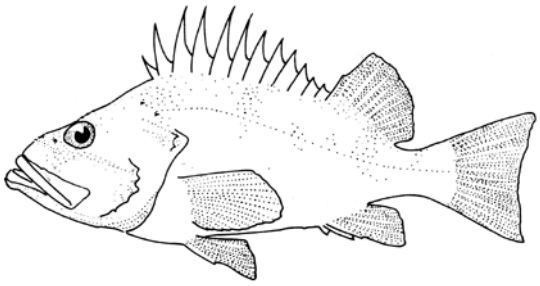
Updated status of cowcod, *Sebastes levis*, in the Southern California Bight



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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.

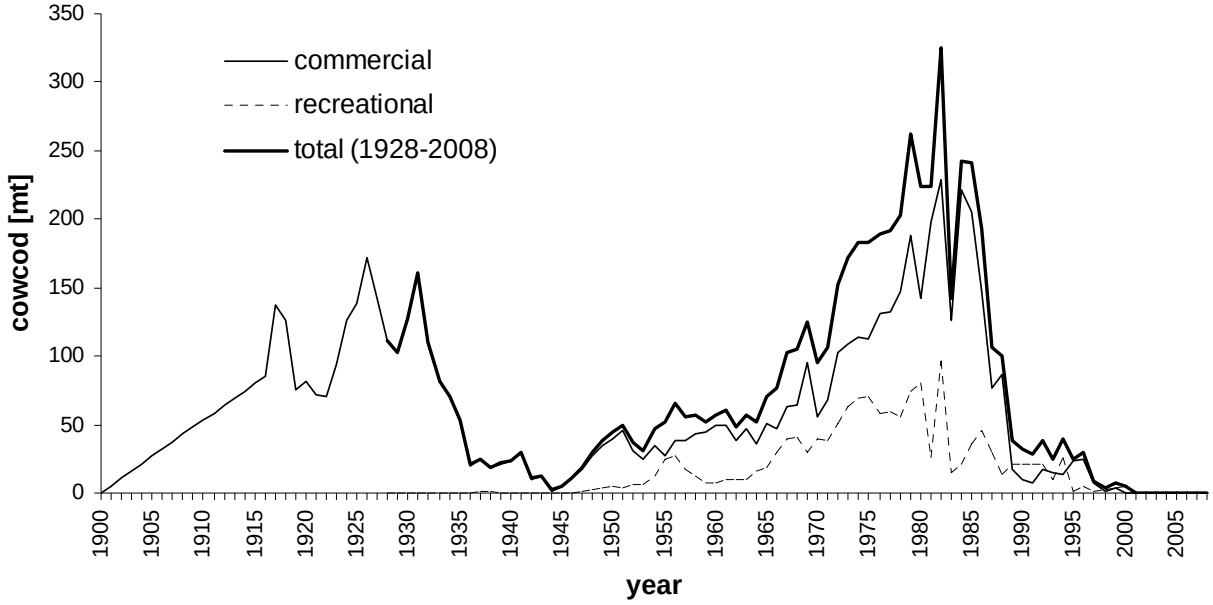
Catch: Commercial landings of cowcod from 1969-2008 were obtained from the CALCOM database (CALCOM, 2009). Recreational landings were obtained from the RecFIN database (www.recfin.org) for the period 1981-2008. Retention of cowcod has been prohibited since January 2001. Due to uncertainty in total mortality 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.

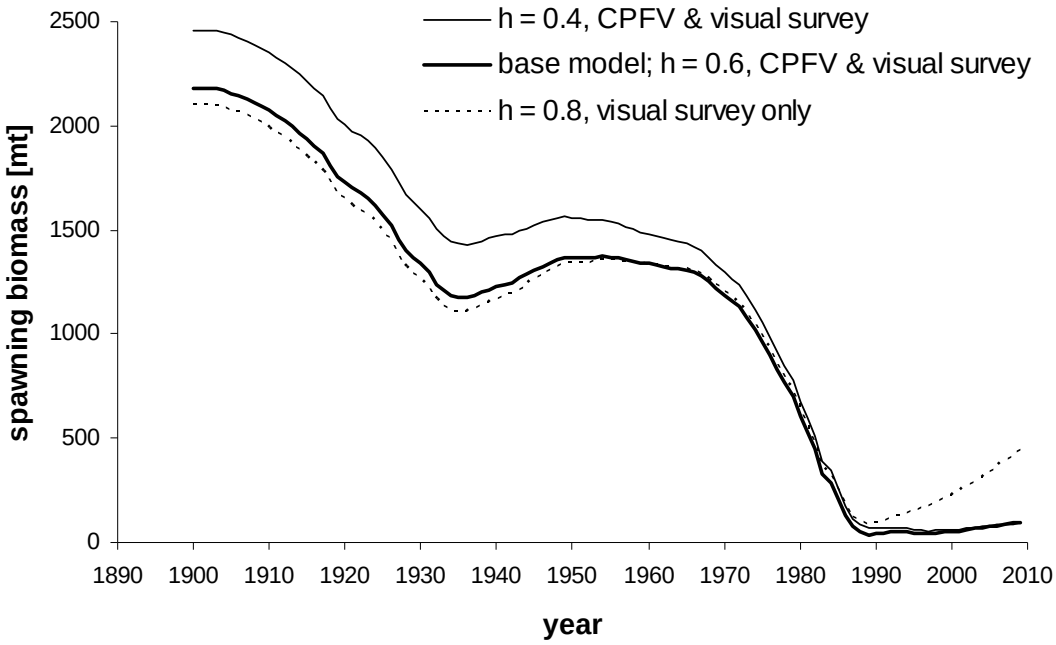
Reference points: For *Sebastes*, the PFMC currently uses $F_{50\%}$ as a proxy for the fishing mortality rate that achieves maximum sustainable yield (F_{MSY}). Estimated spawning biomass (SB) in 2009 is between 3.8% and 21.0% of the unfished level (Table ES2). The poor precision of this estimate is 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).

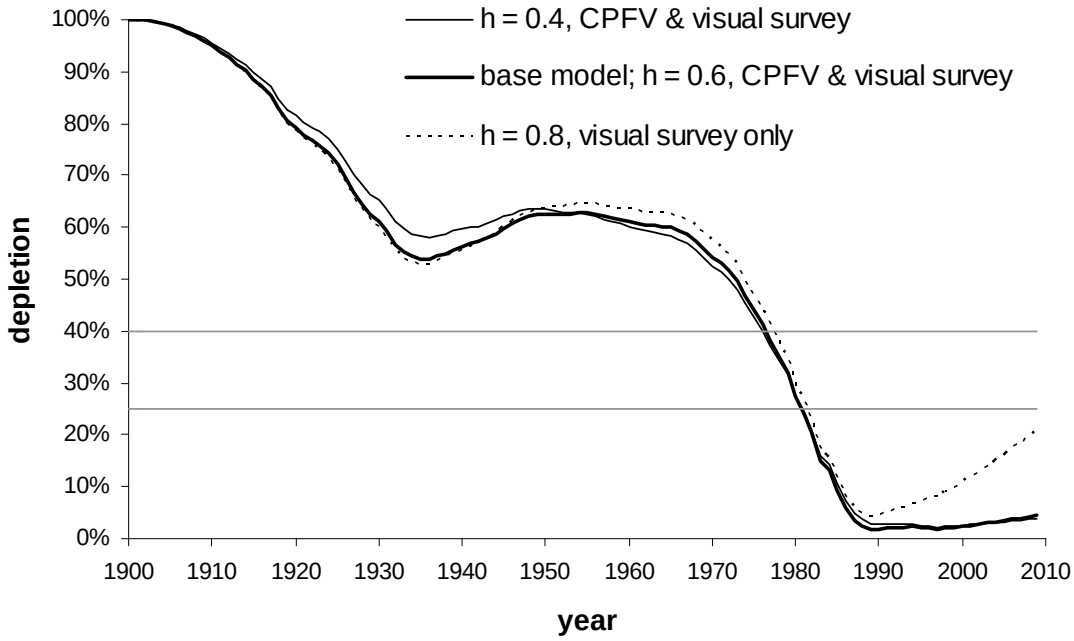


Table ES3: Recent trends in cowcod biomass and depletion

	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

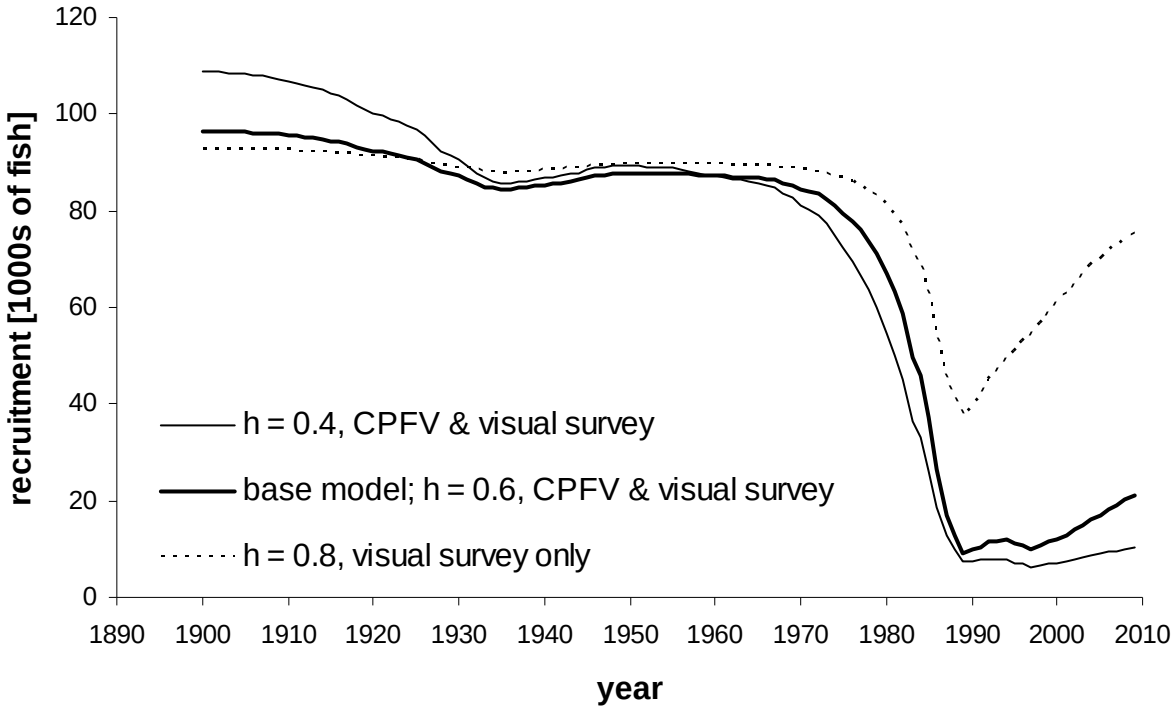


Table ES4: Estimated recruitments from the base model stock-recruitment curve.

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)

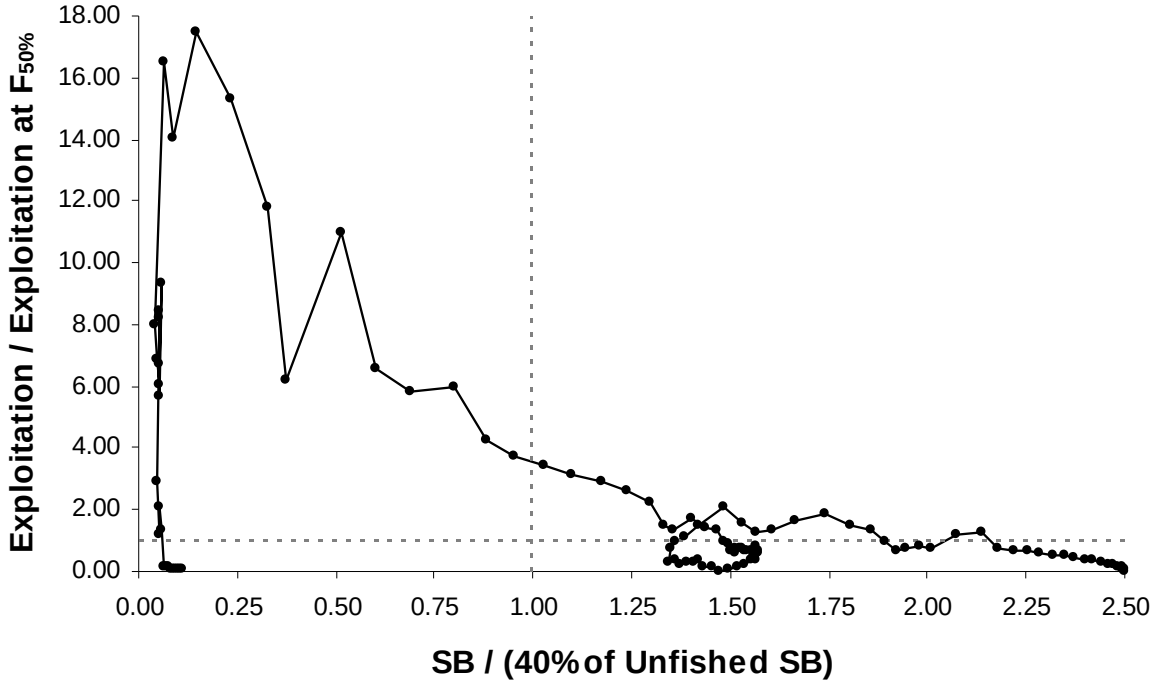
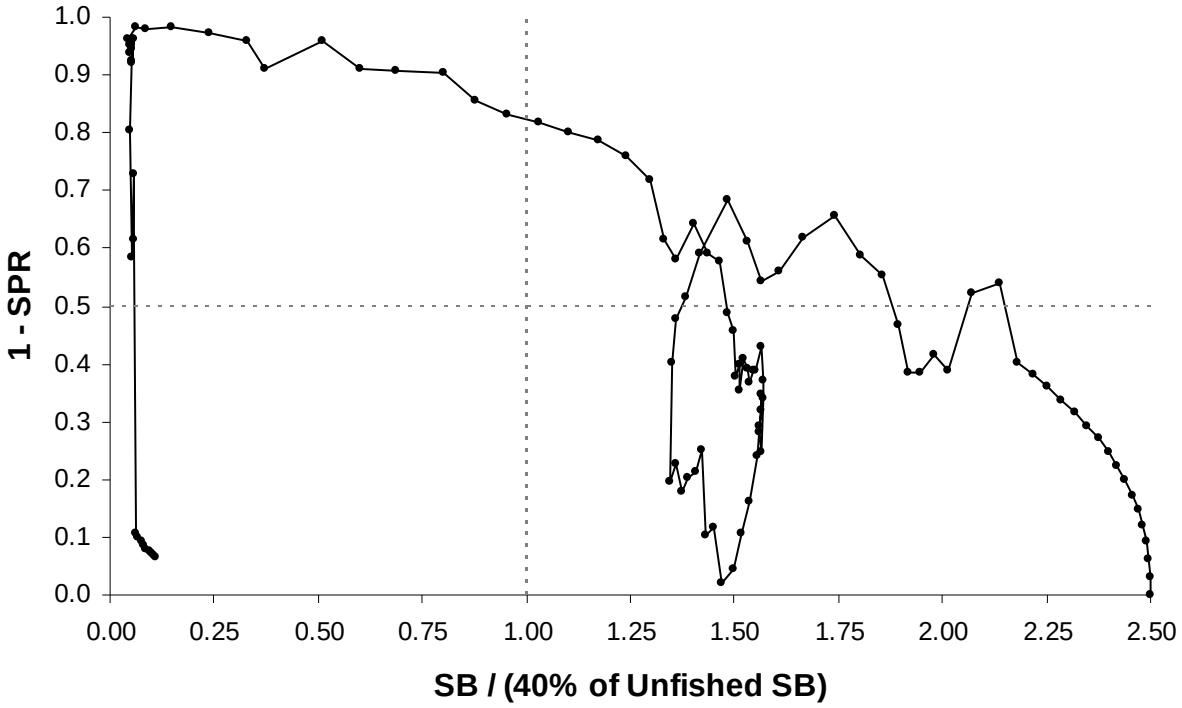


Figure ES6: Phase diagram of cowcod exploitation history (1-SPR)



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		ABC[a]	OY[a]
				Commercial	Recreational		
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