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

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**DRAFT**
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Cowcod line drawing from CDF&G Fish Bulletin No. 157 (1972)
Executive Summary

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

Catch: Retention of cowcod is currently prohibited. Recreational landings in this assessment are identical to those in the previous assessment, but estimates of commercial landings have been updated to reflect three additional data sources: 1) recovered port samples from Southern California (1983-1985), 2) regional summaries of total rockfish landings (1928-1968) provided by the NMFS SWFSC Environmental Research Division, and 3) California rockfish landings by region (1916-1927), published in CDF&G Fish Bulletin No. 105 (1958). From 2001 to the present, we assume a discard rate of 0.5 metric tons per year for the commercial and recreational fisheries combined (Table ES1).

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Commercial</th>
<th>Recreational</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>7.30</td>
<td>1.85</td>
<td>9.15</td>
</tr>
<tr>
<td>1998</td>
<td>1.21</td>
<td>2.81</td>
<td>4.03</td>
</tr>
<tr>
<td>1999</td>
<td>3.47</td>
<td>3.77</td>
<td>7.24</td>
</tr>
<tr>
<td>2000</td>
<td>0.45</td>
<td>4.49</td>
<td>4.94</td>
</tr>
<tr>
<td>2001</td>
<td>--</td>
<td>--</td>
<td>0.5</td>
</tr>
<tr>
<td>2002</td>
<td>--</td>
<td>--</td>
<td>0.5</td>
</tr>
<tr>
<td>2003</td>
<td>--</td>
<td>--</td>
<td>0.5</td>
</tr>
<tr>
<td>2004</td>
<td>--</td>
<td>--</td>
<td>0.5</td>
</tr>
<tr>
<td>2005</td>
<td>--</td>
<td>--</td>
<td>0.5</td>
</tr>
<tr>
<td>2006</td>
<td>--</td>
<td>--</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Figure ES1: Estimated cowcod landings, 1900-2006
**Data and assessment:** The model structure and data inputs are very similar to the 2005 assessment. It is an age-structured production model, with three estimated parameters: virgin recruitment ($R_0$), catchability for the CPFV logbook index, and catchability for the visual survey biomass estimate. In the 2005 assessment, the selectivity curves for the fishery and CPFV index were inadvertently set equal to female fecundity. In this update, length-based selectivities for the fishery and logbook index are set equal to the female maturity schedule, as was the intention of Piner et al. (2005). Changes to the historical catch data are summarized above, and described in detail in the “Updated data sources” section. The length-at-age relationship was slightly adjusted based on evidence that lengths recorded during the ageing process were total length rather than fork length. The logbook index from the Commercial Passenger Fishing Vessel (CPFV) fishery and the estimate of cowcod biomass in 2002 from the submersible line-transect survey are identical to the previous assessment (no new data). Steepness of the Beverton-Holt stock-recruitment curve was fixed, but model outputs are reported for three values (0.4, 0.5, 0.6). In the base model steepness is fixed at 0.5 and natural mortality is fixed at 0.055. The period modeled in the 2005 assessment (1916-2007) was extended by a linear ramp in catch from 1900-1916. The software used to fit the base model was Stock Synthesis 2 (SS2), version 2.00c.

**Unresolved problems and major uncertainties:** Uncertainty analyses show that estimates of steepness (h) and the natural mortality rate (M) are highly uncertain, and both parameters are treated as fixed and known. The CPFV time series of relative abundance ends in 2000, and no abundance indices are currently available to inform recent trends. Together, these characteristics imply that conclusions regarding rebuilding success are highly uncertain.

**Reference points:** For *Sebastes*, the PFMC currently uses $F_{50\%}$ as a proxy for the fishing mortality rate that achieves maximum sustainable yield ($F_{MSY}$). Estimates from the current model indicate that cowcod is currently overfished, with spawning biomass (SB) in 2007 between 6.4% and 8.0% of the unfished level. Retention of cowcod is prohibited and bycatch is thought to be minimal, so it is unlikely that overfishing is currently an issue.

**Table ES2: Reference points**

<table>
<thead>
<tr>
<th>Reference Point</th>
<th>Assumed value of steepness</th>
<th>units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$h = 0.4$</td>
<td>$h = 0.5$</td>
</tr>
<tr>
<td>Unfished summary (age-1+) biomass</td>
<td>5836</td>
<td>5466</td>
</tr>
<tr>
<td>Unfished spawning biomass ($SB_0$)</td>
<td>5489</td>
<td>5141</td>
</tr>
<tr>
<td>Unfished recruitment ($R_0$)</td>
<td>121</td>
<td>114</td>
</tr>
<tr>
<td>40% of $SB_0$ (proxy for $SB_{MSY}$)</td>
<td>2196</td>
<td>2056</td>
</tr>
<tr>
<td>Exploitation rate at $F_{50%}$ (proxy for $F_{MSY}$)</td>
<td>2.9%</td>
<td>2.9%</td>
</tr>
<tr>
<td>Spawning biomass in 2007 ($SB_{2007}$)</td>
<td>353</td>
<td>367</td>
</tr>
<tr>
<td>$SB_{2007}$ / $SB_0$</td>
<td>6.4%</td>
<td>7.1%</td>
</tr>
</tbody>
</table>
Stock biomass: Estimates of 2007 spawning stock biomass, based on the three assumed values of steepness, have declined to 353-392 mt in 2007 from an unfished biomass of 4895-5489 mt.

Figure ES2: Time series of spawning biomass

Table ES3: Recent trends in cowcod biomass and depletion

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>282</td>
<td>241</td>
<td>4.4%</td>
<td>274</td>
<td>226</td>
<td>4.4%</td>
<td>273</td>
<td>218</td>
<td>4.5%</td>
</tr>
<tr>
<td>1999</td>
<td>294</td>
<td>256</td>
<td>4.7%</td>
<td>289</td>
<td>243</td>
<td>4.7%</td>
<td>292</td>
<td>237</td>
<td>4.8%</td>
</tr>
<tr>
<td>2000</td>
<td>303</td>
<td>266</td>
<td>4.8%</td>
<td>301</td>
<td>256</td>
<td>5.0%</td>
<td>307</td>
<td>253</td>
<td>5.2%</td>
</tr>
<tr>
<td>2001</td>
<td>313</td>
<td>277</td>
<td>5.0%</td>
<td>315</td>
<td>270</td>
<td>5.2%</td>
<td>325</td>
<td>270</td>
<td>5.5%</td>
</tr>
<tr>
<td>2002</td>
<td>328</td>
<td>291</td>
<td>5.3%</td>
<td>332</td>
<td>287</td>
<td>5.6%</td>
<td>347</td>
<td>290</td>
<td>5.9%</td>
</tr>
<tr>
<td>2003</td>
<td>341</td>
<td>305</td>
<td>5.5%</td>
<td>350</td>
<td>303</td>
<td>5.9%</td>
<td>370</td>
<td>310</td>
<td>6.3%</td>
</tr>
<tr>
<td>2004</td>
<td>355</td>
<td>317</td>
<td>5.8%</td>
<td>368</td>
<td>320</td>
<td>6.2%</td>
<td>392</td>
<td>330</td>
<td>6.7%</td>
</tr>
<tr>
<td>2005</td>
<td>368</td>
<td>330</td>
<td>6.0%</td>
<td>385</td>
<td>336</td>
<td>6.5%</td>
<td>415</td>
<td>351</td>
<td>7.2%</td>
</tr>
<tr>
<td>2006</td>
<td>381</td>
<td>342</td>
<td>6.2%</td>
<td>403</td>
<td>351</td>
<td>6.8%</td>
<td>439</td>
<td>371</td>
<td>7.6%</td>
</tr>
<tr>
<td>2007</td>
<td>393</td>
<td>353</td>
<td>6.4%</td>
<td>421</td>
<td>367</td>
<td>7.1%</td>
<td>464</td>
<td>392</td>
<td>8.0%</td>
</tr>
</tbody>
</table>

Recruitment: Predicted recruitments were taken directly from the assumed stock-recruitment relationship, estimating only virgin recruitment. The updated models suggest that recruitment declined rapidly from about 1965-1990, followed by an increasing trend (Fig. ES3).
Exploitation status: The 2005 assessment with the corrected selectivity curve (no other changes) generates harvest rates over 13 times the rate at MSY (Fig. ES4). The revised landings and growth estimates in the 2007 update assessment amplify this effect.
The history of exploitation according to the update model (steepness fixed at 0.5) is summarized here with two phase diagrams. Figure ES5(a) shows annual harvest rates relative to the target harvest rate ($F_{50\%}$), plotted against spawning biomass relative to 40% of unfished spawning biomass (SB$_{40\%}$). Figure ES5(b) replaces harvest rates with spawning potential ratios (SPR), the ratio of equilibrium spawning output per recruit under fished conditions to spawning output per recruit in the virgin population.

**Figure ES5(a): Phase diagram of cowcod exploitation history (relative harvest rates)**

![Phase diagram of cowcod exploitation history (relative harvest rates)](image)

**Figure ES5(b): Phase diagram of cowcod exploitation history (SPR)**

![Phase diagram of cowcod exploitation history (SPR)](image)
**Management performance:** Retention of cowcod is currently prohibited. Piner et al. (2005) and Butler et al. (1999) describe the recent history of management measures.

**Table ES4: Recent management performance**

<table>
<thead>
<tr>
<th>Years</th>
<th>ABC [mt]</th>
<th>OY [mt]</th>
<th>Catch [mt]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-2004</td>
<td>5</td>
<td>2.4</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>2005-2006</td>
<td>5</td>
<td>2.1</td>
<td>&lt; 1</td>
</tr>
</tbody>
</table>

**Forecasts:** We used SS2 to generate 60-year forecasts for three fixed values of steepness (0.4, 0.5, 0.6), assuming no retention and a total discard rate of 0.5 metric tons per year.

**Table ES5: 60-yr forecasts of age 1+ biomass and depletion (SB/SB₀)**

<table>
<thead>
<tr>
<th>Year</th>
<th>h = 0.4 age 1+ biomass</th>
<th>h = 0.5 age 1+ biomass</th>
<th>h = 0.6 age 1+ biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>406 6.6%</td>
<td>439 7.4%</td>
<td>463 8.4%</td>
</tr>
<tr>
<td>2009</td>
<td>418 6.8%</td>
<td>457 7.8%</td>
<td>484 8.8%</td>
</tr>
<tr>
<td>2010</td>
<td>430 7.0%</td>
<td>476 8.1%</td>
<td>502 9.0%</td>
</tr>
<tr>
<td>2011</td>
<td>443 7.2%</td>
<td>495 8.4%</td>
<td>519 9.3%</td>
</tr>
<tr>
<td>2012</td>
<td>455 7.4%</td>
<td>513 8.7%</td>
<td>536 9.7%</td>
</tr>
<tr>
<td>2013</td>
<td>468 7.6%</td>
<td>532 9.0%</td>
<td>558 9.9%</td>
</tr>
<tr>
<td>2014</td>
<td>480 7.8%</td>
<td>549 9.4%</td>
<td>576 10.3%</td>
</tr>
<tr>
<td>2015</td>
<td>493 8.0%</td>
<td>567 9.7%</td>
<td>596 10.5%</td>
</tr>
<tr>
<td>2016</td>
<td>506 8.2%</td>
<td>586 10.1%</td>
<td>615 11.2%</td>
</tr>
<tr>
<td>2017</td>
<td>519 8.4%</td>
<td>606 10.5%</td>
<td>635 11.5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>age 1+ biomass</th>
<th>depletion</th>
<th>h = 0.4 age 1+ biomass</th>
<th>depletion</th>
<th>h = 0.5 age 1+ biomass</th>
<th>depletion</th>
<th>h = 0.6 age 1+ biomass</th>
<th>depletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>406 6.6%</td>
<td></td>
<td>439 7.4%</td>
<td></td>
<td>463 8.4%</td>
<td></td>
<td>519 8.4%</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>418 6.8%</td>
<td></td>
<td>457 7.8%</td>
<td></td>
<td>484 8.8%</td>
<td></td>
<td>541 9.4%</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>430 7.0%</td>
<td></td>
<td>476 8.1%</td>
<td></td>
<td>514 8.7%</td>
<td></td>
<td>568 9.8%</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>443 7.2%</td>
<td></td>
<td>495 8.4%</td>
<td></td>
<td>576 9.3%</td>
<td></td>
<td>597 10.3%</td>
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</tr>
<tr>
<td>2012</td>
<td>455 7.4%</td>
<td></td>
<td>513 8.7%</td>
<td></td>
<td>599 9.7%</td>
<td></td>
<td>626 10.5%</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>468 7.6%</td>
<td></td>
<td>532 9.0%</td>
<td></td>
<td>605 9.9%</td>
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<td>656 11.4%</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>480 7.8%</td>
<td></td>
<td>549 9.4%</td>
<td></td>
<td>634 10.2%</td>
<td></td>
<td>696 11.2%</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>493 8.0%</td>
<td></td>
<td>567 9.7%</td>
<td></td>
<td>719 10.5%</td>
<td></td>
<td>753 11.3%</td>
<td></td>
</tr>
</tbody>
</table>

2008 406 6.6% h = 0.4 h = 0.5 h = 0.6
**Decision table:** [tbd]

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

**Rebuilding projections:** [tbd]

**Regional management:** The current model assumes that cowcod in the Southern California Bight are isolated from cowcod north of Point Conception and south of the U.S.-Mexico border. This assumption remains untested. Cowcod landings in California (1969-2005) primarily occur within the current stock boundaries (Fig. ES6).

**Figure ES6: Cowcod Landings by California Port Complex, 1969-2005**