

PACIFIC SARDINE BIOMASS PROJECTION IN 2013 FOR U.S. MANAGEMENT DURING THE FIRST HALF OF 2014 (EXECUTIVE SUMMARY)

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INTRODUCTION

The Pacific sardine resource is assessed annually in support of the Pacific Fishery Management Council's (PFMC) process of specifying acceptable catch levels for the U.S. fishery. In June 2013, the PFMC adopted a change to the fishery start date from January 1 to July 1, effective 2014. The following catch-only projection was conducted to provide a biomass estimate for interim harvest specifications during the first six months of 2014. The projection model included updated catches from 2012 and 2013, but does not include other fishery or survey data collected over the past year. New data will, however, be incorporated in the next full assessment tentatively scheduled for early March 2014. The 2014 full assessment will serve as the basis for the new fishery management cycle beginning July 1, 2014.

METHODS

The following catch-only projection for 2014 management is based on data and methods described by Hill et al. (2011, 2012), as reviewed by a Stock Assessment Review (STAR) Panel in September 2011 and the Scientific and Statistical Committee's (SSC) coastal pelagic species (CPS) Subcommittee during October 2012. The assessment projection was conducted using Stock Synthesis (SS v. 3.21d). The 2012 update model files (Hill et al. 2012) served as the basis for this projection.

The assessment includes sardine landings (metric tons) from six major fishing regions: Ensenada (ENS), southern California (SCA), central California (CCA), Oregon (OR),

Washington (WA), and British Columbia (BC). Catch data for the fisheries off ENS, SCA, and CCA were pooled into a single ‘MexCal’ fleet, in which selectivity was modeled separately for each season (S1 and S2). Catch data from OR, WA, and BC were combined and treated as a single ‘PacNW’ fleet in the model. The sardine model is based on a July-June model year, with two semester-based seasons per year (S1=Jul-Dec and S2=Jan-Jun).

Details regarding the projection estimate are as follows:

- Landings for model steps 2011-2 through 2012-2 (i.e., calendar year 2012 through the first half of 2013) were revised with updated landings data for all fishing regions (ENS to BC). See Table below.
- The projection was parameterized as one year of forecasted catch (fixed, dead) for the three fleets included in the model.
- Landings for model step 2013-1 (i.e., Jul-Dec 2013) were based on final data for BC, WA, and OR, and projected through the end of 2013 for CCA and SCA (see Table below). The ENS landings were not available after June 2013, so the 2013-1 model step was substituted with 2012-1 landings. Landings for the 2013-1 and 2013-2 model steps were included as fixed catch in the forecast file.
- The bias adjustment ramp (Methot & Taylor 2011) for recent years of the main data period (‘first recent year for no bias adjustment in MPD’) was advanced from 2011 to 2012 in the CTL file. The estimated alternative bias adjustment relationship matched well to the model, and there was negligible impact on model results.
- No other data or parameterization changes were made to the assessment model.

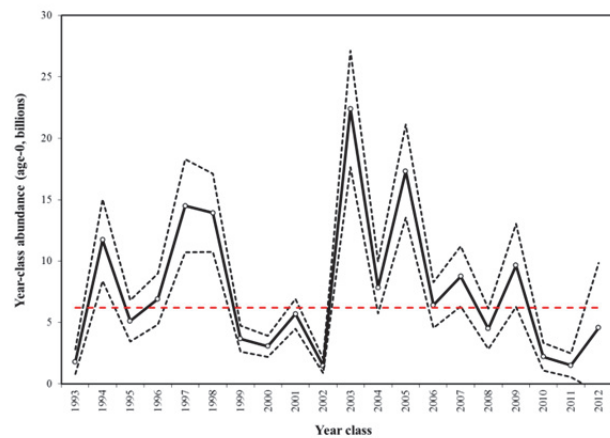
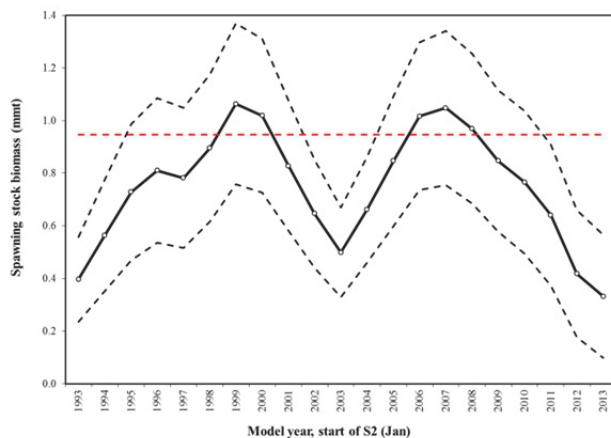
Calendar year-semester	Model year-semester	ENS	SCA	CCA	OR	WA	BC	Total
2004-1	2003-2	11,213	15,232	2,146	2,204	235	180	31,209
2004-2	2004-1	30,684	17,161	13,163	33,908	8,564	4,258	107,739
2005-1	2004-2	17,323	15,419	115	692	324	0	33,874
2005-2	2005-1	38,000	14,834	7,825	44,316	6,605	3,231	114,811
2006-1	2005-2	17,601	17,158	2,033	102	0	0	36,893
2006-2	2006-1	39,636	16,128	15,711	35,547	4,099	1,575	112,696
2007-1	2006-2	13,981	26,344	6,013	0	0	0	46,338
2007-2	2007-1	22,865	19,855	28,769	42,052	4,663	1,522	119,726
2008-1	2007-2	23,488	24,127	2,515	0	0	0	50,130
2008-2	2008-1	43,378	6,962	24,196	22,940	6,435	10,425	114,336
2009-1	2008-2	25,783	9,251	11,080	0	0	0	46,114
2009-2	2009-1	30,128	3,310	13,935	21,482	8,025	15,334	92,215
2010-1	2009-2	12,989	19,428	2,909	437	511	422	36,695
2010-2	2010-1	43,832	9,925	1,397	20,415	11,870	21,801	109,240
2011-1	2010-2	18,514	12,526	2,713	0	0	0	33,754
2011-2	2011-1	51,823	5,115	7,358	11,023	8,008	20,719	104,047
2012-1	2011-2	10,235	11,906	3,673	2,874	2,932	0	31,620
2012-2	2012-1	39,575	6,896	569	39,744	32,510	19,172	138,465
2013-1	2012-2	9,780	2,680	84	149	1,421	0	14,115
2013-2	2013-1	39,575	3,858	864	26,599	27,285	0	98,181

RESULTS

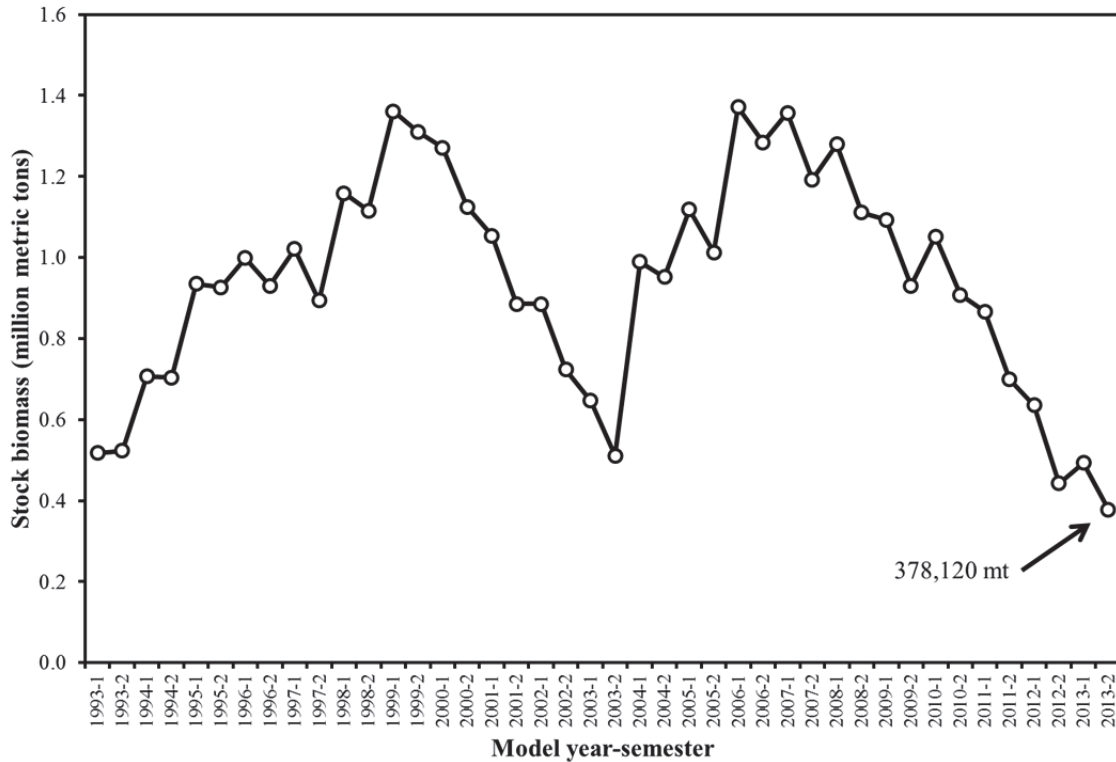
Spawning Biomass, Recruitment, and Stock Biomass

Per the 2012 assessment update, recruitment was modeled using the Ricker stock-recruitment relationship ($\sigma_R=0.727$), with steepness being estimated at $h=2.8$. Virgin recruitment (R_0) was estimated to be 6.22 billion age-0 fish (red dashed line), and virgin spawning stock biomass (SSB) was estimated to be 0.946 mmt (red dashed line). The SSB increased throughout the 1990s, peaking at 1.063 million metric tons (mmt) in 1999 and 1.048 mmt in 2007. The SSB is projected to be 0.332 mmt (CV=0.35) as of January 2014. Recruitment (year-class abundance) peaked at 14.5 billion fish in 1997, 22.4 billion in 2003, 17.3 billion in 2005, and 9.65 billion in 2009. The 2010 and 2011 year classes were the weakest in recent history. Recent survey and fishery data provide no indication of a sizable year class since 2009.

Calendar year-semester	Model year-semester	Stock biomass (mt)	SSB (mt)	SSB Std. Dev	Recruit abundance (billions)	Recruit Std Dev
2003-1	2002-2	723,342	646,484	102,588		
2003-2	2003-1	646,971			22.387	2.367
2004-1	2003-2	511,357	499,399	85,307		
2004-2	2004-1	989,222			7.851	1.053
2005-1	2004-2	951,788	662,323	100,683		
2005-2	2005-1	1,118,270			17.316	1.891
2006-1	2005-2	1,012,870	847,236	123,603		
2006-2	2006-1	1,371,320			6.410	0.927
2007-1	2006-2	1,284,380	1,016,840	140,557		
2007-2	2007-1	1,356,870			8.754	1.227
2008-1	2007-2	1,192,610	1,047,870	146,546		
2008-2	2008-1	1,279,250			4.491	0.824
2009-1	2008-2	1,110,770	968,909	142,208		
2009-2	2009-1	1,093,190			9.648	1.690
2010-1	2009-2	930,069	846,669	134,507		
2010-2	2010-1	1,051,900			2.220	0.555
2011-1	2010-2	907,777	765,872	135,396		
2011-2	2011-1	866,584			1.521	0.481
2012-1	2011-2	699,258	640,511	133,969		
2012-2	2012-1	635,551			4.575	2.632
2013-1	2012-2	442,396	418,225	120,590		
2013-2	2013-1	493,479			---	---
2014-1	2013-2	378,120	331,964	116,721		

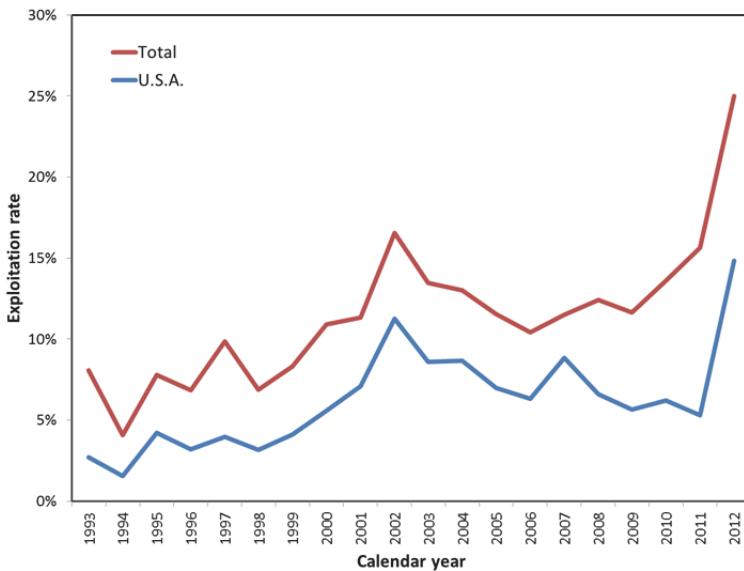


Stock biomass, used for calculating harvest specifications, is defined as the sum of the biomasses for sardine ages one and older (age 1+). Stock biomass increased rapidly throughout the 1990s, peaking at 1.36 mmt in 1999 and 1.37 mmt in 2006. Stock biomass is projected to be 378,120 mt as of January 2014:



Exploitation Status

Exploitation rate is defined as the calendar year catch divided by the total mid-year biomass (July-1, ages 0+). Based on the latest model and historic catches, the U.S. exploitation rate approached 15% and total exploitation (including Mexico and Canada landings) was about 25% during 2012. U.S. and total exploitation rates follow:



Calendar year	U.S.A.	Total
2000	5.57%	10.91%
2001	7.07%	11.34%
2002	11.26%	16.55%
2003	8.59%	13.46%
2004	8.68%	13.02%
2005	6.99%	11.53%
2006	6.33%	10.43%
2007	8.85%	11.50%
2008	6.59%	12.43%
2009	5.64%	11.64%
2010	6.23%	13.59%
2011	5.30%	15.63%
2012	14.85%	24.98%

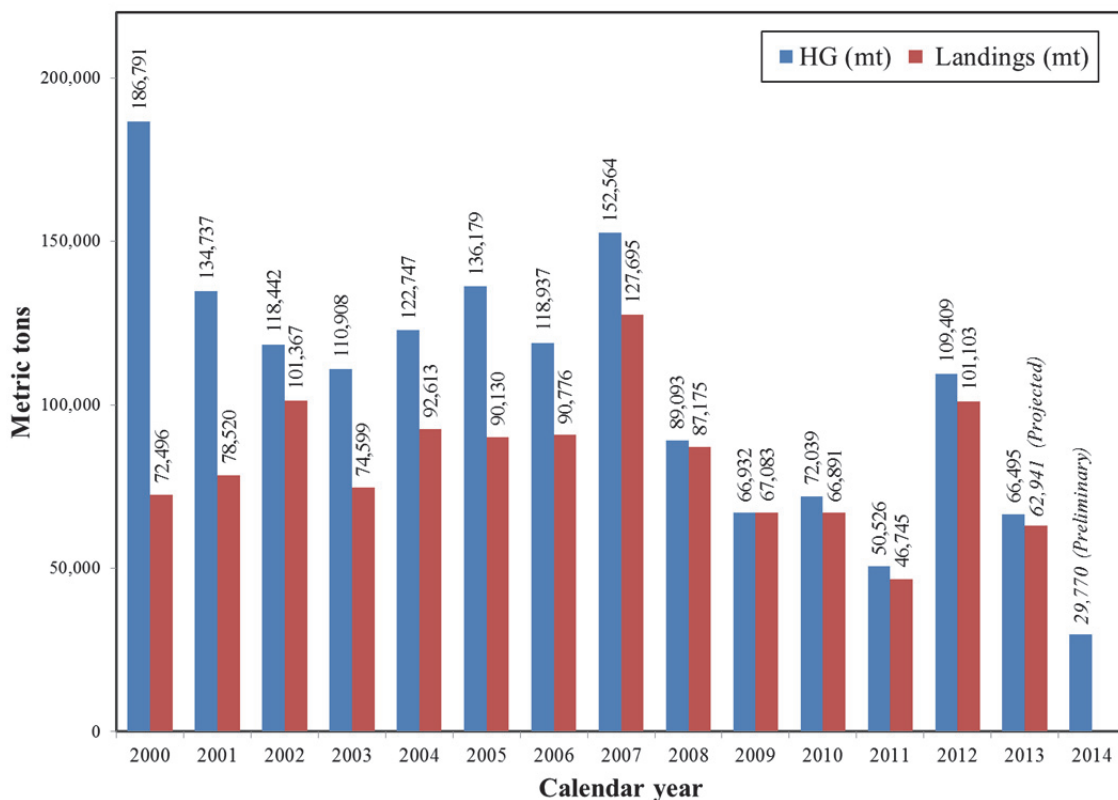
Harvest Control Rules

Harvest guideline

Based on results from the projection model, the preliminary harvest guideline (HG) for the U.S. fishery in calendar year 2014 will be 29,770 mt. The HG was calculated as follows:

$$HG_{2014} = (\text{BIOMASS} - \text{CUTOFF}) \cdot \text{FRACTION} \cdot \text{DISTRIBUTION},$$

where HG_{2014} is the total U.S. quota for 2014, BIOMASS (378,120 mt) is the stock biomass (ages 1+) at the start of the 2014 fishing year (PFMC 2012, 2013), CUTOFF (150,000 mt) is the lowest level of biomass for which harvest is allowed, FRACTION (15%) is the percentage of biomass above the CUTOFF that can be harvested, and DISTRIBUTION (87%) is the average portion of BIOMASS assumed in U.S. waters. The HG values and catches since 2000 are displayed below. The preliminary 2014 HG is 55% lower than the HG established for 2013. The 29,770 mt HG will be divided into seasonal (i.e. Season 1) and other allocations during the November 2013 Council meeting.



OFL and ABCs

The Magnuson-Stevens Reauthorization Act requires fishery managers to define an overfishing limit (OFL), allowable biological catch (ABC), and annual catch limit (ACL) for species managed under a federal management plan (FMP). By definition, ABC must always be lower than the OFL based on uncertainty in the assessment approach. The SSC has recommended the P-star buffer calculation to mitigate scientific uncertainty when defining ABC, which was adopted under Amendment 13 to the CPS FMP.

The estimated biomass of 378,120 mt (ages 1+), an F_{MSY} proxy of 0.18, and a distribution proportion of 87% of the stock in U.S. waters results in a U.S. OFL of 59,214 mt for 2014. The CV of the terminal year SSB was equal to 0.352 ($\sigma = 0.341$) and thus, is still within the sigma

level (0.36) specified for Tier 1 assessments. The ABC buffer will depend on the probability of the overfishing level (P-star) policy chosen by the PFMC. Uncertainty buffers and ABC values associated with a range of discrete P-star values are provided as follows:

Harvest Control Rule Formulas										
	OFL = BIOMASS * F_{MSY} * DISTRIBUTION									
	ABC _{P-star} = BIOMASS * BUFFER _{P-star} * F_{MSY} * DISTRIBUTION									
	HG = (BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION									
Harvest Formula Parameters										
BIOMASS (ages 1+, mt)	378,120									
P-star	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05	
ABC Buffer _{Tier 1}	0.95577	0.91283	0.87048	0.82797	0.78442	0.73861	0.68859	0.63043	0.55314	
ABC Buffer _{Tier 2}	0.91350	0.83326	0.75773	0.68553	0.61531	0.54555	0.47415	0.39744	0.30596	
F_{MSY}	0.18									
FRACTION	0.15									
CUTOFF (mt)	150,000									
DISTRIBUTION (U.S.)	0.87									
Harvest Control Rule Values (MD)										
OFL =	59,214									
ABC _{Tier 1} =	56,595	54,052	51,544	49,027	46,448	43,736	40,774	37,330	32,753	
ABC _{Tier 2} =	54,091	49,340	44,868	40,592	36,435	32,304	28,076	23,534	18,117	
HG =	29,770									

DISCUSSION

The Pacific sardine population is projected to continue a downward trend attributed largely to low recent recruitments. While no new biological-composition data for fisheries or surveys were included in the forecast model, the downward population trajectory and assumption of poor recent recruitment is consistent with preliminary observations from various sources along the Pacific coast of North America:

- The British Columbia fleet captured no sardine during the Summer 2013 (Jordan Mah, CDFO, pers. comm.);
- The Canada DFO trawl survey found no sardine off the coast of Vancouver Island during the Summer 2013 (Linnea Flostrand, CDFO, pers. comm.);
- The SWFSC's Spring 2013 survey found few young sardine (no age-0, few age-1) in trawl collections off California (Jenny McDaniel, SWFSC, pers. comm.);
- The Summer 2013 SaKe survey observed small volumes of sardine off California (relative to WA and OR) and no sardine off Canada;
- Preliminary acoustic-trawl survey (ATM) estimates from Spring and Summer 2013 indicate lower biomass than estimated from the two surveys conducted in 2012 (David Demer, SWFSC, pers. comm.);
- INAPESCA conducted an ATM survey along the outer Baja California peninsula during the Summer 2012. No sardine were observed in northern Baja California (Manuel O. Nevarez, INAPESCA, pers. comm.);
- Poor recent recruitment is indicated in recent assessments;

- Commercial catches are lower than normal in California;
- California's live-bait fishery off San Diego has communicated some difficulty locating sardine in 2013, instead targeting anchovy.

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