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May 29, 2013

Mr. William Stelle, Regional Administrator
NOAA Fisheries, West Coast Region
7600 Sand Point Way, NE, Bldg 1
Seattle, WA 98115

Mr. Dan Wolford, Chair
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, OR 97220

RE: Agenda Item I.4. Pacific Sardine Management: Revised Harvest Parameters, Request for Immediate In-season Action, and Proposed Harvest Control Rule Alternative

Dear Mr. Stelle, Mr. Wolford, and Members of the Council:

The Pacific sardine population is in a state of collapse and current management measures are not using the best available science. Unfortunately, the Pacific sardine fishery has **not** been managed for long-term sustainability in a manner that prevents overfishing, achieves optimum yield, and protects the health of our ocean ecosystem. We are now seeing direct impacts of this sardine collapse on the water, including the recent Unusual Mortality Event of yearling California sea lions, which are starving due to a lack of prey, and are also seeing remarkably low landings in the California sardine fishery so far this year. Furthermore, new analysis of temperature data indicates that recent environmental conditions are unfavorable for sardine productivity and that recent exploitation rates have resulted in overfishing. In order to prevent overfishing from occurring again in 2013 and to correct current fundamental flaws in the Pacific sardine control rule, we request the National Marine Fisheries Service (NMFS) and Pacific Fishery Management Council (PFMC):

1. Take immediate action to either close the Pacific sardine fishery due to recently identified overfishing, the current sardine decline and low abundance, or at minimum, correct the 2013 overfishing limit (OFL), allowable biological catch (ABC) and harvest guideline based on biomass estimates at the start of the fishing/calendar year, and using the new CalCofi temperature index;
2. Request the SSC reevaluate the "sigma" value used to assess scientific uncertainty associated with the OFL and in setting the ABC; and
3. Consider, evaluate and adopt Oceana's proposed Pacific sardine harvest control rule, included in this letter, for 2014 management and beyond.

It has recently become much clearer that the harvest control rule used for setting sardine annual catch specifications is fundamentally flawed and current catch levels (both U.S. and coastwide) have been set significantly higher than intended by the current legal and management

framework. The result is that NMFS and the PFMC have not been following the current control rule in the Coastal Pelagic Species Fishery Management Plan (CPS FMP), and, in retrospect, significant overfishing has occurred on a declining sardine population.

1) The Pacific Sardine Population is in Collapse

According to the 2012 stock assessment[1], the Pacific sardine population has declined 52% over the past six years. Recruitment is the lowest it has been in decades, coastwide exploitation rates have increased substantially in recent years, and the stock biomass is far below the "critical biomass" threshold (SSB < 740,000 mt) identified by NMFS sardine stock assessment scientists. NMFS scientists Zwolinski and Demer (2012) published a study last year in the Proceedings of the National Academy of Sciences forecasting this collapse, and the failure of management to respond.[2] The authors concluded in the abstract:

> ***[a]larming is the repetition of the fishery's response to a declining sardine stock - progressively higher exploitation rates targeting the oldest, largest, and most fecund fish.***

The utter dearth of sardines is now having ramifications in the ecosystem as indicated by an unprecedented number of yearling California sea lions starving on the beach.[3] It is also the reason why the fishery has made unprecedentedly low landings at this time, five months into the year. As of May 29 only 715.9 mt of sardine – 3.6% of the seasonal (January 1 to June 30) allocation of 20,123 mt - have been landed.[4] Forage fish like sardine are highly susceptible to overfishing due to their schooling nature and rapid response to environmental conditions, and if the fishery does find them soon, increased catch levels could quickly lead to overfishing.

2) Action Must be Taken to Change the Proposed 2013 Catch Levels

a. The Proposed 2013 Catch Levels Are Based on an Incorrect Biomass Estimate

The proposed 2013 catch levels are based on a biomass estimate of age 1+ sardine from July 2012. Between July 2012 and January 2013 when the fishery commenced, however, the fishery model shows that the population would continue to decline. This means that that the formula used to calculate the 2013 specifications does not represent the most current or accurate biomass estimate, resulting in a substantially inflated OFL and harvest guideline (HG). Table 12 (p. 50)

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[1] Hill et al. 2012. Assessment of the Pacific sardine resource in 2012 for U.S. Management in 2013. PFMC November 2012. Agenda Item G.3.b Supplemental Assessment Report 2.

[2] Zwolinski, J. and D.A. Demer. 2012. A cold oceanographic regime with high exploitation rates in the Northeast Pacific forecasts a collapse of the sardine stock. Proceedings of the National Academy of Sciences (PNAS) 109 (11). 4175-4180. Available at: http://www.pnas.org/content/early/2012/02/24/1113806109.full.pdf and PFMC, Agenda Item C.1b8, supplemental public comment. March 2012. http://www.pcouncil.org/wp-content/uploads/C1b_SUP_PC8_SHESTER_MAR2012BB.pdf.

[3] NOAA. California Sea Lion Unusual Mortality Event in California. http://www.nmfs.noaa.gov/pr/health/mmume/californiasealions2013.htm

[4] PacFIN. May 24, 2013. All W-O-C Commercial Landed Catch Species Report #307

of the 2012 Pacific sardine stock assessment indicates the estimate of the 2012 age 1+ mid-year biomass to be 659,539 mt, while the 2012 age 1+ end of year biomass is estimated at 454,683 mt.

The SSC recently recommended that, "the biomass at the start of the fishing season be used for harvest specification."[5] Although concerns were raised by the SSC and during PFMC discussion, and the PFMC gave direction to change the biomass used in the 2014 specifications, these concerns have not been addressed for 2013 management.

	Age 1+ Biomass	2013 OFL	2013 HG
Mid-year biomass (2012)	659,539 mt	103,284 mt	66,495 mt
End-year biomass (2012)	454,683 mt	71,203 mt	39,761 mt

Table 1. Difference in OFL and HG when using different biomass estimates. 2013 catch levels are based on the 2012 mid-year biomass estimate rather than the biomass estimate from the end of 2012.

Table 1 shows the 2013 U.S. OFLs and U.S. HGs using the current formulas specified in the CPS FMP, using the two different biomass estimates. As this table indicates, the choice of mid-year or end-year biomass is extremely consequential. In particular, the use of the end-year biomass (keeping all other parameters the same) would result in a 31% lower 2013 OFL and a 40% lower 2013 HG than the mid-year biomass as proposed by the PFMC and NMFS in the 2013 specifications.

b. The Proposed 2013 Catch Levels Are Based on a Harvest Control Rule that does not utilize the correct temperature index, and this is resulting in overfishing

In 2010, McClatchie et al. provided strong evidence that temperatures measured at Scripps Pier are an inappropriate indicator of sardine productivity and should thus be "removed from sardine management."[6] In February 2013 the PFMC hosted a workshop to reevaluate the harvest control rule and one of the major conclusions is that while there is a relationship between Sea Surface Temperature (SST) and sardine productivity, the best measure of SST for relating to sardine productivity is the CalCOFI SST index. This has major ramifications for modeling the dynamics of this sardine population and for setting annual catch levels.

Hurtado-Ferro and Punt[7] found that changing the environmental variable from SIO to CalCofi would have resulted in reduced harvest guidelines in nine of the last thirteen years since this population has been under federal management. Oceana updated the table provided on May 27, 2013 with the U.S. and coastwide OFL and actual U.S. and coastwide landings (Table 2). We found that actual landings exceeded the U.S. OFL in four recent years (2008-2010, 2012) and

[5] "[T]the SSC recommends that the biomass at the start of the fishing season be used for harvest specification." PFMC. Agenda Item I.1.b Supplemental SSC Report. April 2013. And see PFMC. Agenda Item G.3.c Supplemental SSC Report November 2012.

[6] McClatchie, S. R. Goericke, G. Auad, and K. Hill. 2010. Re-assessment of the stock-recruit and temperature-recruit relationships for Pacific sardine (*Sardinops sagax*). *Can. J. Fish. Aq. Sci.* 67: 1782-1790.

[7] Hurtado-Ferror, F. and A. Punt. 2013. Revised Analysis Related to Evaluating Parameter Value Choices for Pacific Sardine. Presented to CPSMT/ SSC, March 2013. Updated Table provided on May 27, 2013.

that coastwide landings exceeded the coastwide OFL every year for the last five years. This means managers have inadvertently and substantially overestimated sardine productivity, as well as the U.S. HG, and the OFL, and we now know the population has been overfished the past several years while it has been in decline.

		CalCOFI 3-year average				CalCOFI OFL and Actual Landings				
Mgmt year	**Biomass (July)**	**3-y SST**	**HG Fraction**	**HG**	**Difference From Actual SIO HG**	**OFL Fraction**	**U.S. OFL**	**U.S. Landings**	**Coastwide OFL**	**Coastwide Landings**
2000	1,581,346	16.18	0.15	186,791	0	0.24	331,561	72,496	381,104	142,063
2001	1,182,465	15.82	0.15	134,737	0	0.20	202,183	78,520	232,394	125,857
2002	1,057,599	15.47	0.14	106,625	-11,817	0.14	124,247	101,367	142,812	148,952
2003	999,871	15.38	0.12	88,639	-22,270	0.12	104,283	74,599	119,866	116,919
2004	1,090,587	15.46	0.13	109,008	-13,738	0.13	126,392	92,613	145,278	138,948
2005	1,193,515	15.56	0.15	135,381	-797	0.15	154,842	90,130	177,979	148,684
2006	1,061,391	15.71	0.15	118,937	0	0.18	162,261	90,776	186,506	149,588
2007	1,319,072	15.62	0.15	152,564	0	0.16	184,025	127,695	211,523	166,065
2008	832,706	15.38	0.12	71,394	-17,699	0.12	**87,081**	**87,175**	**100,093**	**164,466**
2009	662,886	15.30	0.11	48,181	-18,750	0.11	**62,272**	**67,083**	**71,578**	**138,328**
2010	702,024	15.11	0.08	38,243	-33,796	0.08	**48,634**	**66,891**	**55,901**	**145,935**
2011	537,173	15.26	0.10	33,950	-16,576	0.10	47,103	46,745	**54,142**	**137,801**
2012	988,385	15.15	0.09	62,453	-46,956	0.09	**73,627**	**101,547**	**84,628**	-
2013	659,539	-	-	-	-	-	-	-	-	-

Table 2. Recalculated Harvest Guidelines (HG) and Overfishing Levels (OFL) (as defined in Amendment 13) using the CalCofi 3-year average index compared with the actual HG based on temperatures from Scripps Pier (SIO) and actual U.S. and Coastwide Landings. Bolded numbers indicate overfishing: where U.S and coastwide landings were greater than the U.S. and coastwide OFL. 2012 U.S. landings from PacFIN and all other landings from Hill et al. 2012 (*supra note* 1).

We are greatly concerned that catch levels this year could once again result in overfishing if the PFMC and NMFS continue to manage the population using the SIO Pier index and mid-year biomass estimate. Oceana requests immediate action to either close the Pacific sardine fishery, or at minimum correct the 2013 catch specifications so that they are based on the best available science regarding the current biomass estimate for the start of the fishing year and so that the harvest guideline and OFL parameters are based on the CalCofi SST index.

Based on the Biomass (1+) at the start of 2013 (454,683 mt), the corrected HG FRACTION of 0.09 based on recent CalCOFI data, and the current HG formula in the CPS FMP (CUTOFF= 150,000; DISTRIBUTION = 87%), we calculate a total corrected U.S. H.G. of 23,857 mt, which we recommend be implemented instead of the current 66,495 mt.[8]

3) We request the PFMC direct its SSC to reevaluate the "sigma" value in its Allowable Biological Catch calculation to address scientific uncertainty associated

[8] U.S. HG = (Biomass – Cutoff)*Fraction*Distribution = (454,683-150,000)*0.09*0.87 = 23,856 mt

with the sardine harvest parameters beyond solely the uncertainty associated with current year biomass.

The conclusions from the Pacific sardine workshop highlight the significant uncertainty associated with the various parameters of the sardine harvest control rule. The SSC's current approach to quantify scientific uncertainty through the selection of a sigma value (estimates of variation within and among stock assessments) that is then applied to the calculation of the ABC, does not represent a complete–or sufficient–treatment of uncertainty in the OFL. The sigma of 0.39 for sardine is the result of the SSC's quantification of only one source of uncertainty, *i.e.*, process error (as measured by between stock assessment variability), which is unlikely to be the sole source of significant uncertainty. Sources of error that are not included in the SSC's quantification exercise include forecast error (including the lag between surveys and projected biomass for use in the specifications), uncertainty associated with optimal exploitation rate (Fmsy or Emsy), uncertainty with respect to oceanographic conditions and their effects on stock productivity, and the temperature-recruit relationship. The SSC did not include time lags in updating assessments, the degree of retrospective revision of assessment results, or projections in their estimates of sigma[9], as set forth by National Standard 1.[10]

Indeed, the SSC acknowledged that these sigma values (0.36 for category I stocks and 0.39 for sardine) are "only a first step, in part because it just considers uncertainty in biomass. Going forward, it will be important to consider other sources of uncertainty, such as F_{MSY}. Because of that it was also recognized that *the present analysis underestimates total variance*."[11] Since only one source of uncertainty is contained in the sigma values for sardine, the PFMC and NMFS have implicitly set all other sources of uncertainty equal to zero. This is a highly risky assumption, and because of these recent findings, we request a reevaluation of the current sigma value to address these other important sources of error and uncertainty that can lead to catch levels being set too high.

4) Proposed Alternative Harvest Control Rule

We appreciate and commend the recent updates to the sardine simulation model resulting from the PFMC Harvest Parameters Workshop. In our October 23, 2012 letter to the Council, we raised issues with the updated Pacific sardine simulation model being used at the time to determine a fixed Fmsy value, particularly the lack of oscillations in sardine productivity. It appears that issue has been resolved and we commend the SSC for making improvements to the simulation model based on more recent data and making the new operating model publicly available. Since the new operating model has been posted, we have conducted our own initial

[9] PFMC. March 2010 Agenda. An Approach to Quantifying Scientific Uncertainty in West Coast Stock Assessments. Agenda Item E4b_SUP_SSC1..
[10] 50 C.F.R. § 600.310(f)(4). "The ABC control rule must articulate how ABC will be set compared to the OFL based on the scientific knowledge about the stock or stock complex and the scientific uncertainty in the estimate of OFL and any other scientific uncertainty. The ABC should consider uncertainty in factors such as stock assessment results, time lags in updating assessments, …."
[11] PFMC March 2010 Agenda, Item E.4.b, Supplemental SSC Report 2 (emphasis added).

analysis and we have developed an alternative harvest control rule which we propose for implementation beginning in the 2014 season.

We respectfully propose the following changes to the parameters of the existing Pacific sardine harvest control rule:

	Current (Am 13)	Proposed
U.S. OFL	BIOMASS * Fmsy * DISTRIBUTION	BIOMASS * Fmsy – Lcanada – Lmexico
U.S. ABC	BIOMASS* BUFFER*Fmsy * DISTRIBUTION	(BIOMASS*Fmsy – Lcanada – Lmexico)* BUFFER
U.S. ACL	Less than or equal to ABC	Less than or equal to ABC
U.S. HG	(BIOMASS – CUTOFF) * FRACTION * DISTRIBUTION	(BIOMASS – CUTOFF) * FRACTION – Lcanada – Lmexico
U.S. ACT	Equal to HG or ACL, whichever is less	Equal to HG or ACL, whichever is less

Where Lcanada and Lmexico refer to Canadian and Mexican landings in the previous year.

- Increase CUTOFF from 150,000 mt to 640,000 mt, which is based on 40% of the estimated unfished biomass (1+).
- Set MSST equal to CUTOFF (640,000 mt).
- Keep FRACTION with the range of 5-15% based on the CalCOFI Index.
- Increase MAXCAT to 300,000 mt.
- Set OFL = E_{MSY}, based on the relationship with the CalCOFI index.
- Replace DISTRIBUTION with a catch-based method determined by the formula:
    - $HG_{US} = HG_{TOTAL} – L_{MEXICO} - L_{CANADA}$
    - $OFL_{US} = OFL_{TOTAL} – L_{MEXICO} - L_{CANADA}$

Parameters	**Current HG**	**Oceana Proposed**
CUTOFF (1+, mt)	150,000	640,000
CUTOFF (%B0)	9.4%	40.0%
FRACTION	5-15% (based on SIO index)	5-15% (based on CalCOFI index)
MAXCAT (mt)	200,000	300,000
DISTRIBUTION (U.S.)	87% of TOTAL HG	TOTAL HG - Lmexico - Lcanada
MSST (1+, mt)	50,000	640,000
MSST (%B0)	3.1%	40.0%
OFL (TOTAL)	18% of Biomass (1+)	Emsy based on CalCOFI
OFL (US)	87% of TOTAL OFL	TOTAL OFL - Lmexico - Lcanada

Table 3: Summary of Current HG in the CPS FMP and Oceana's proposed Harvest Control Rule.

Rationale and Basis for Proposed Changes:

CUTOFF: Recent scientific analyses of forage fish dynamics indicate that fishing has the greatest impacts and poses the greatest risks to forage fish stocks during periods of low abundance. Based on this information, we analyzed a range of CUTOFF values and consequently we are proposing the CUTOFF be set at 40% of the mean unfished biomass, which aligns with the Lenfest Forage Fish Task Force recommended CUTOFF for Tier 2 stocks (intermediate information level). The increase in CUTOFF results in lower fishing pressure during periods of low relative abundance to minimize risk and increase overall mean biomass.

FRACTION: Our proposed HCR would maintain the current range of FRACTION between 5-15%. We recommend, however, the new CalCOFI SST index be adopted as is being proposed by the SSC to replace the use of SIO pier SST index.

MAXCAT: Increase the maximum catch parameter to 300,000 mt to maintain average catch at similar levels to "Option J" and allow higher catch levels when the stock is at high biomass under favorable productivity. This essentially balances the potential impact of lower catches in times of low abundance, by allowing increased catch at times of high abundance, hence maintaining overall average catch levels in concert with the increase in CUTOFF.

DISTRIBUTION: The Pacific sardine stock is not managed tri-nationally, and the current U.S. HG does not account for landings in Canada, or control the Mexican and Canadian landings. In particular, Mexico does not use quotas and Canada estimates the sardine distribution in Canadian waters based on a three year average that has recently been as high as 27%. Furthermore, the distribution of the stock across its potential habitat in the three nations is likely not constant, not homogenous, and not predictable. Also, the proportions of sardine habitat associated with each country are not equivalent to their fractions of the total landings from the stock. The 87% DISTRIBUTION was set based on aerial spotter data from 1963-1992, and is therefore not reflective of the current distribution of the stock. As a result, the static U.S. DISTRIBUTION value of 87% in the current HG results in the actual total coastwide harvest consistently exceeding the "target" coastwide harvest as intended by the HG. In other words, actual coastwide catch is greatly exceeding the catch specified by the HG in Amendment 8's "Option J".

Correcting the U.S. DISTRIBUTION value so that the annual total tri-national landings more consistently match the target fishing fraction is essential for managing this stock. Therefore, we propose the PFMC adopt the landings-based formula for calculating U.S. distribution as proposed in Demer & Zwolinski 2013a (attached). While some scientists (including Demer & Zwolinski) believe the stock is differentiated into a "northern" and "southern" stock, the stock assessments to date and existing management structure treat the stock as a single undifferentiated stock. As the current system is based on a single undifferentiated stock, the landing-based formula is the best way to address tri-national landings.

L_{MEXICO} and L_{CANADA} are set based on the prior year's landings, as the U.S. has no control over Mexican or Canadian landings in the absence of an international agreement. If harvest

guidelines are known for Mexico and Canada prior to setting the U.S. HG and U.S. OFL, then they could be substituted for L_{MEXICO} and L_{CANADA}, respectively. Otherwise, the values reported for L_{MEXICO} and L_{CANADA} in one year are good estimators for their values during the subsequent year, based on serial correlation in landings data.[12,13]

Demer and Zwolinski (2013a) state the benefits of such an approach based on a retrospective application of it to landings from 1995-2011:

> *"[We] demonstrate that application of the method would reduce the discrepancy between the target fishing fraction and the total tri-national fraction, optimally increase U.S. landings when the stock is primarily off U.S. waters, and inherently reduce U.S. exploitation when large proportions of the landings are at Mexico, Canada, or both."*[14]

Until such time as the U.S. enters into a tri-national agreement, we believe this is the best approach for ensuring the long-term sustainability of the sardine population.

MSST: The minimum stock size threshold (MSST) is intended to indicate when a stock is considered "overfished", prompting rebuilding. While we recognize the difficulty in using this term for a stock that may vary widely even in the absence of fishing, the practical application is generally that fishing effort be reduced or ceased when the stock is below MSST. Therefore, we would set MSST equal to the proposed CUTOFF and fishing for sardine would close whenever the biomass drops below this threshold value.

Initial Analysis:

For the following analysis, we used the code publicly posted at: https://code.google.com/p/sardine-harvest-guideline-parameters/downloads/detail?name=Sardine%20OM.exe&can=2&q=, downloaded on May 15, 2013. For each HCR variant, we conducted 20 simulations, each running for 10,000 years in duration—which was a similar duration to the analyses conducted in Amendment 8. Based on the simulation results, we evaluated each HCR variant according to the performance metrics in Hurtado-Ferro and Punt (2013).[15] For HCR variants with a temperature-dependent Emsy, we used the option to have the HG and OFL temperature-dependent; otherwise the Emsy (for use in OFL) and FRACTION were fixed. Following previous HCR analyses in Amendment 8, Amendment 13, and the Sardine Harvest Parameters Workshop, the performance metrics reflect coastwide catch (not solely the U.S. portion).

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[12] Demer, D.A. and Zwolinski, J.P. 2013a. Optimizing U.S.-harvest quotas to meet the target total exploitation of an internationally exploited stock of Pacific sardine (*Sardinops sagax*). Manuscript (Jan. 28, 2013) presented at 2013 Pacific Sardine Harvest Parameters Workshop. Pacific Fishery Management Council. 20 pp.

[13] Hill, K., Crone, P. R., Lo, N. C. H., Macewicz, B. J., Dorval, E., McDaniel, J. D., and Gu, Y. 2011. Assessment of the Pacific sardine resource in 2011 for U.S. management in 2012. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-SWFSC-487, 16 pp.

[14] Demer and Zwolinski. 2013a, *supra note* 12.

[15] Hurtado-Ferro, F. and Punt, A. 2013. Initial Analyses Related to Evaluating Parameter Value Choices for Pacific Sardine. Agenda Item I.1.b, Attachment 2, April 2013. Pacific Fishery Management Council.

Given that actual coastwide catch has deviated from Option J, we included an additional scenario to generally approximate the actual implementation, called: "Actual Current HCR". This scenario uses a CUTOFF of 150,000 mt, a constant FRACTION of 25%, and a MAXCAT of 300,000 mt. We believe this is a conservative and reasonable approximate of how the current harvest control rule has been implemented since 2000 in the U.S. (using a constant Fraction of 15% and DISTRIBUTION of 87%) given that the actual U.S. portion of coastwide landings has been estimated to be 52% based on data from 1993 to 2011 without stock differentiation, and it has generally been lower in recent years.[16] We have included the DISTRIBUTION analysis by Demer and Zwolinski as Attachment 2 to this letter. The formula for our calculation is:

> FRACTION (ACTUAL) = FRACTION (in U.S. HG) x U.S. DISTRIBUTION (in U.S. HG) / U.S. DISTRIBUTION (ACTUAL) = 15% x 87% / 52% = 25%

We note that while there may be some debate about whether there are two differentiated stocks of Pacific sardine, the current 2012 stock assessment assesses Pacific sardine as one undifferentiated stock. Therefore, until the stock is assessed differently, we use the undifferentiated stock. We also set the MAXCAT at 300,000 mt for this option to reflect that Mexico and Canada are not constrained by a 200,000 mt cap. Coastwide landings could easily reach this level in a time when U.S. landings hit the cap. In the current simulation model, all temperature-based options are based on the CalCOFI index. Therefore, while "Option J" in Amendment 8 was based on the SIO temperature index, the analysis in this document for Scenario "HG-J" assumes the use of the CalCOFI index.

The "Without Fishing" option is intended to serve as a reference for the "unfished" condition for comparison purposes, and is not intended to be a proposed harvest control rule. The "HG-V4", "OFL", and "L (Emsy)" scenarios are meant to be consistent with the scenarios used in the Hurtado-Ferro and Punt 2013 analysis. The "F = 15%" scenario is a constant F scenario shown for illustrative purposes, and does not have a CUTOFF or MAXCAT. The "Lenfest" scenario is based on our interpretation and application of the Lenfest Forage Fish Task Force recommendations for a forage fish stock with an intermediate level of information level (i.e., Tier 2), including a CUTOFF of 40% mean Bzero, a FRACTION of ½ Emsy that includes a temperature relationship, and no MAXCAT.[17]

We added an additional performance metric of the percentage of years the Spawning Stock Biomass (SSB) is greater than 740,000 mt, based on the "critical biomass" threshold identified by Zwolinski & Demer 2012[18], under which sardines progressively disappeared and collapsed in the 1940s and 1950s. The rationale for this threshold is that the combination of unfavorable environmental conditions, continued fishing pressure, and the stock declining below this

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[16] Demer, D. and Zwolinski, J. 2013b. An estimate of the average portion of the northern stock of Pacific sardine (*Sardinops sagax*) residing in the U.S. exclusive economic zone. Manuscript presented at 2013 Pacific Sardine Harvest Parameters Workshop. Pacific Fishery Management Council. 7 pp.

[17] Lenfest Forage Fish Task Force 2012. Pikitch, E., Boersma, P.D., Boyd, I.L., Conover, D.O., Cury, P., Essington, T., Heppell, S.S., Houde, E.D., Mangel, M., Pauly, D., Plagányi, É., Sainsbury, K., and Steneck, R.S.. Little Fish, Big Impact: Managing a Crucial Link in Ocean Food Webs. Lenfest Ocean Program. Washington, DC. 108 pp.

[18] Zwolinski and Demer. 2012, *supra note* 3

threshold together precipitated the historic collapse by preventing the remaining sardine from reproducing successfully. Therefore, this metric provides a key alternative measure of the proportion of the time when the stock is at risk of collapse.

Furthermore, a new performance metric includes the percentage of simulations where the stock becomes completely extirpated (in a mathematical sense, the biomass becomes zero). This is a different definition of "collapse" than is generally used in management, as it refers to actual extirpation rather than the more frequently used definition as commercial extirpation.[19]

Lastly, due to changes to the operating model since the analysis was presented in the April 2013 briefing book, as well as differences in the number of years and simulations, there are some minor discrepancies between the performance metrics presented the Hurtado-Ferrero and Punt April 2013 analysis and our analysis shown here. The relative rankings of the scenarios, however, appear consistent.

Initial Results:

The main results are presented in Table 4 below, comparing the alternative HCR scenarios in terms of the full suite of performance metrics, as well as Figures 1-5 included at the end of this letter. Figures 1 and 2 illustrate the operational differences between the shapes of the HCRs, comparing Oceana's proposed HCR with Option J. Note that the slopes of the lines are parallel in Figure 1 as the FRACTION varies with temperature in the same manner (5-15%), however, the differences result from the different CUTOFF and MAXCAT thresholds. Figure 3 shows an example of a simulated 100-year catch trajectory under Option J and the Oceana proposed scenario, providing a visual depiction of the fundamental strategic difference in which the Oceana proposed scenario results in higher catches during high abundance years and lower catches during low abundance years. In other words, Option J appears to favor stability in the catch with higher catches at times of low sardine abundance when the stock is at most risk.

Figure 4 shows an example of a simulated 100-year biomass (1+) trajectory under 4 scenarios. While Option J and the actual current HCR deviate from the unfished trajectory particularly during years of low relative abundance, the Oceana proposed HCR aligns much closer to the unfished trajectory, during both the peaks and valleys of abundance.

In comparing Oceana's proposed HCR to both the theoretical Option J and the actual current harvest, the Oceana HCR substantially outperforms along the metrics that indicate a high mean biomass and contribution to forage (Fig. 5a), the health of the sardine population (Fig. 5b), and the risk to the stock (Figs. 5c and 5d). In terms of mean sardine catch, the Oceana HCR is roughly equivalent (slightly outperforms) to the Option J HCR, however the actual current HCR results in higher catch than Option J or the Oceana HCR (Fig. 5e). The number of years with low relative catch is higher under the Oceana HCR (Fig. 5f), however this is somewhat offset by higher catch in years with greater sardine abundance (Fig. 4). It is worth noting that the CPS

[19] E.g. Pinski, M.L., O.P. Jensen, D. Ricard, and S. Palumbi. 2011. Unexpected patterns of fisheries collapse in the world's oceans. Proceedings of the National Academy of Science (PNAS). www.pnas.org/cgi/doi/10.1073/pnas.1015313108

fishery targets other species besides sardine (notably market squid in recent years); therefore, it would be incorrect to infer that the capital, employment, and infrastructure associated with CPS fisheries is not being utilized in years of low or zero sardine catch. We hope that the PFMC's analysis can closely examine these tradeoffs, particularly given the multi-species context of the CPS FMP.

Of note is that only two HCRs resulted in complete collapse (extirpation) in these simulations. These two are those that did not include a CUTOFF. In particular, the Emsy (constant exploitation rate of 18%) resulted in extirpation within the 10,000 year window for 13 of the 20 simulation runs. This is significant, as it calls into question whether an OFL set as a fixed percentage of the stock biomass is appropriate or sufficiently conservative to avoid overfishing.

5) Conclusion

In conclusion, Pacific sardine management is currently in a crisis situation, and fishery managers appear to be making the same mistakes that were made with Pacific sardine management over 60 years ago when the fishery collapsed. Today's crisis presents a unique opportunity to make the necessary corrections to end overfishing of this critically important forage species, and provide for long-term sustainable fisheries and a healthy ocean ecosystem.

Rather than simply criticizing existing management, we have gone to great lengths to develop and propose a set of solutions, and we hope NMFS and the PFMC consider and analyze our proposals carefully. Both NMFS and the PFMC currently have the authority and the mandate to make serious changes to correct the current 2013 quota and the system through which quotas are set in 2014 and beyond. For the sake of our public resources, our ocean wildlife, our fishing industries and our coastal communities, we ask you implement these requested near-term and long-term changes to Pacific sardine management.

Sincerely,

Geoffrey Shester, Ph.D.
California Program Director

Ben Enticknap
Pacific Campaign Manager & Senior Scientist

Attachments:

1. Demer & Zwolinski 2013a. Optimizing U.S.-harvest quotas to meet the target total exploitation of an internationally exploited stock of Pacific sardine (*Sardinops sagax*).
2. Demer & Zwolinski 2013b. An estimate of the average portion of the northern stock of Pacific sardine (*Sardinops sagax*) residing in the U.S. exclusive economic zone.

Additional Tables and Figures from Oceana's HCR Analysis:

HCR Variant	Without Fishing	HG-J	HG-V4	OFL	L (Emsy)	F=15%	Oceana	Current HCR*	Lenfest **
Harvest Parameters									
Fmin	0	0.05	0.05	0.45	0.18	0.15	0.05	0.25	0.02
Fmax	0	0.15	0.18	0.45	0.18	0.15	0.15	0.25	0.09
Temp-based OFL, HG	NA	Yes	Yes	No	No	No	Yes	No	Yes
Cutoff (tmt)	NA	150	.33 B0	.33 B0	0	0	.4B0	150	.4 B0
Maxcat (tmt)	NA	200	None	None	None	None	300	300	None
Performance Metrics									
Mean_catch (tmt)	0.0	110.1	141.8	231.0	149.2	144.1	114.2	151.4	88.2
SD_catch (tmt)	NA	70.5	158.0	182.0	151.6	135.5	95.7	101.9	91.6
Median_catch (tmt)	NA	102.9	89.4	204.8	102.4	104.9	84.9	135.5	61.7
Mean_B1+ (tmt)	1,598.5	1,258.8	1,287.8	1,031.5	578.3	937.2	1,375.5	952.8	1,429.3
SD_B1+ (tmt)	895.9	879.8	767.9	747.2	768.8	835.5	836.8	866.2	828.4
Median_B1+ (tmt)	1,430.2	1,036.9	1,113.6	836.0	309.2	737.1	1,186.3	696.7	1,254.1
Mean_SSB (tmt)	1,326.3	978.1	993.0	748.8	413.3	688.5	1,085.7	699.1	1,142.8
SD_SSB (tmt)	797.3	752.6	612.5	571.5	582.5	659.2	705.4	716.2	696.8
Median_SSB (tmt)	1,163.8	778.4	852.3	600.8	213.3	525.5	921.1	480.9	987.8
% Years with B1+ > 400 tmt	99.1	94.7	98.1	90.0	44.8	71.6	98.5	73.0	98.6
% Years with no catch	100.0	2.7	16.0	28.6	30.9	3.1	21.3	5.2	20.1
% Years with Catch < 50 tmt	100.0	30.4	44.4	38.2	49.9	26.3	48.6	25.4	54.1
Mean age (yrs)	3.23	2.81	2.82	2.55	1.67	2.45	2.93	2.51	3.00
Mean_Catch_Age (yrs)	2.14	1.83	1.84	1.65	1.08	1.58	1.92	1.62	1.97
Mean Consec. Years No Catch	NA	1.7	1.8	2.2	390.2	170.8	2.1	1.5	2.1
%HCR_min	100.0	11.9	11.9	100.0	100.0	100.0	11.9	100.0	4.5
%HCR_max	100.0	52.2	42.1	100.0	100.0	100.0	52.2	100.0	74.3
Mean_Yrs_HCRmin	NA	2.6	2.6	NA	NA	NA	2.6	NA	2.0
Mean_Yrs_HCRmax	NA	7.4	6.0	NA	NA	NA	7.4	NA	11.3
% Runs with Full Collapse	0.0	0.0	0.0	0.0	65.0	10.0	0.0	0.0	0.0
Mean Yrs with SSB < 740 tmt	21.0	46.8	38.4	63.8	80.4	64.9	32.8	68.4	28.9

Table 4. Performance of alternative HCR scenarios based on May 2013 sardine simulation model results.

* Based on an approximation incorporating discrepancies in DISTRIBUTION and FRACTION.
** Oceana's interpretation and application of Lenfest Forage Fish Task Force recommendations for Tier 2.

Figure 1. Depiction of two coastwide harvest guidelines as a function of biomass (1+). The actual harvest guideline is determined by the FRACTION, which in both HCRs have a temperature-dependent fraction ranging from 5-15%.

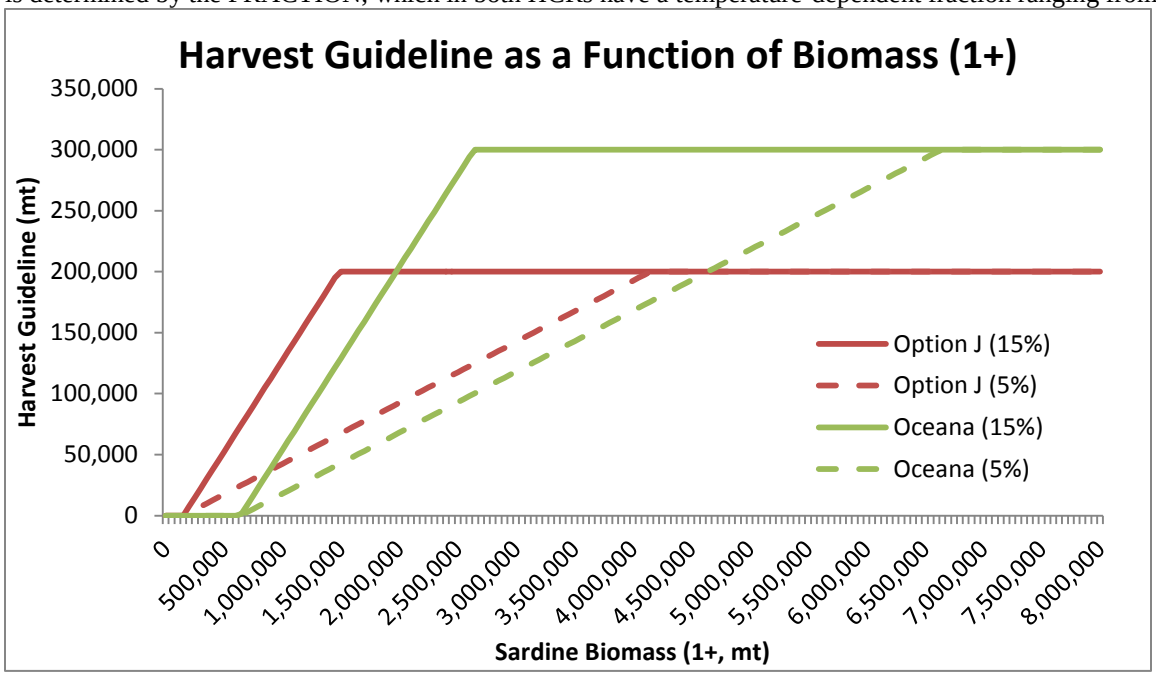

Figure 2. Depiction of two harvest guidelines in terms of the exploitation rate (% of the total biomass (1+) that is harvested) as biomass varies.

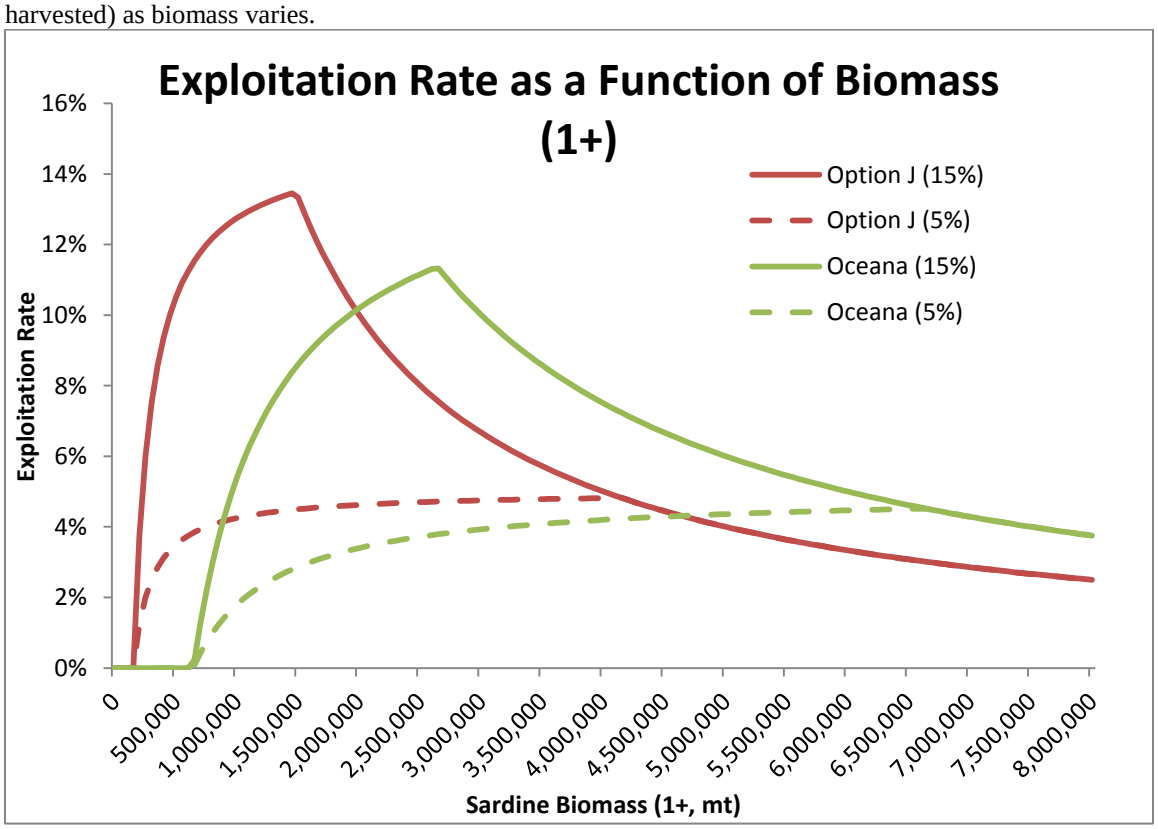

Figure 3. Example 100 years of simulated harvest guidelines under two alternative HCR scenarios.

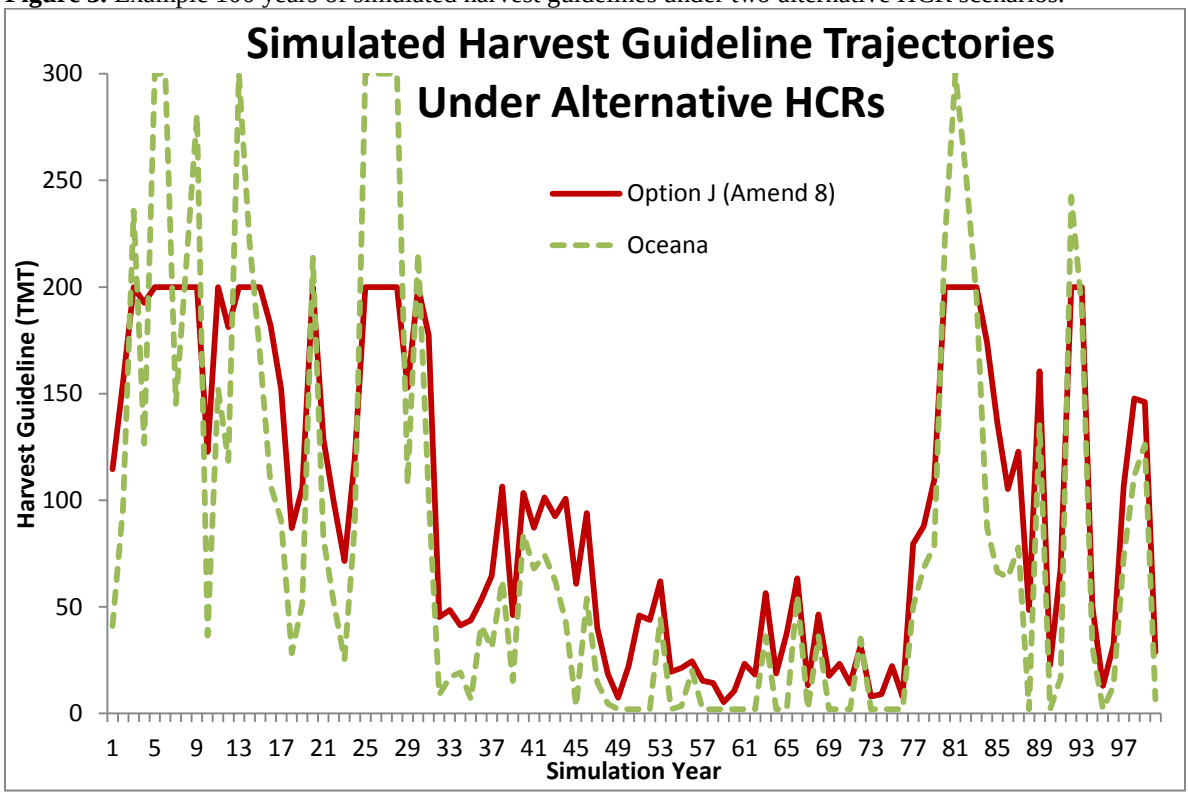

Figure 4. Example 100 years of simulated sardine biomass under four alternative HCR scenarios.

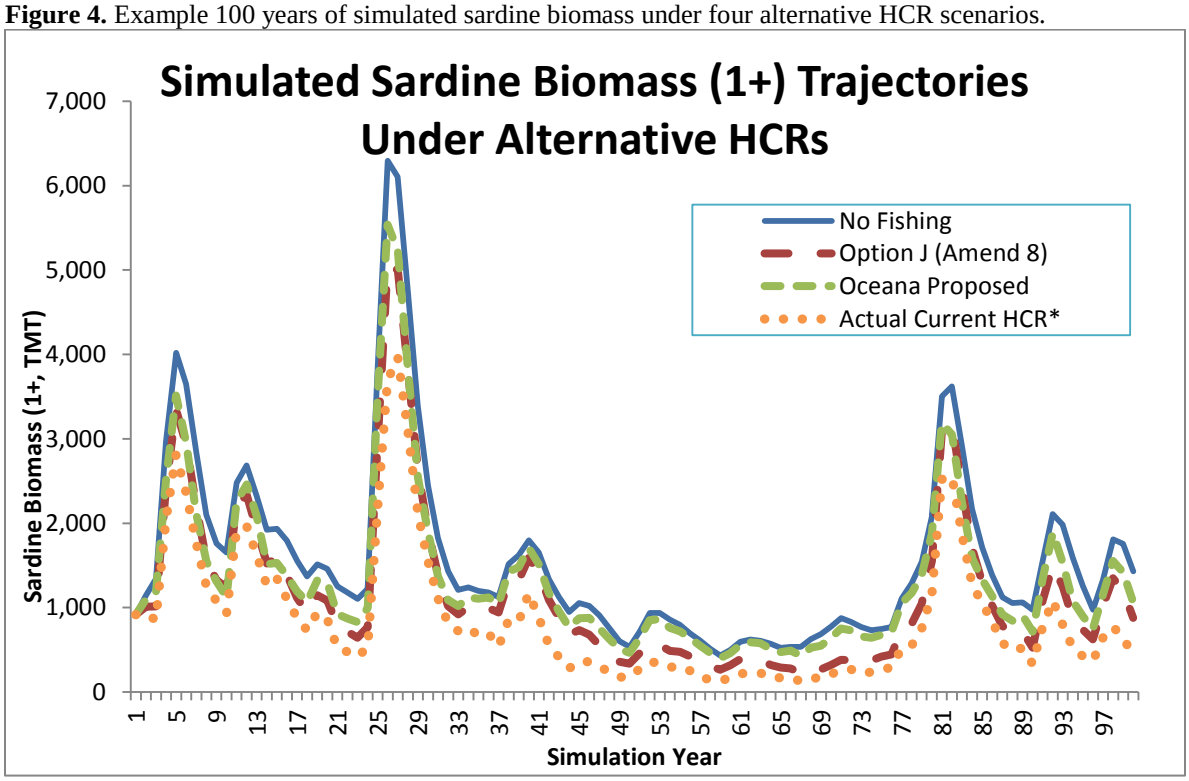

Figure 5. Comparing the unfished scenario with three HCR variants across performance metrics. Data labels in (a) refer to % of mean unfished biomass (Bzero). Error bars in (e) display +/- 1 Standard Deviation.