OCEANA Protecting the World's Oceans

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May 21, 2015

Ms. Eileen Sobeck
Assistant Administrator for Fisheries
NOAA Fisheries
1315 East-West Highway
Silver Spring, MD 20910

RE: Pacific sardine

Dear Ms. Sobeck:

Thank you for quickly implementing the Pacific Fishery Management Council's ("Council") action to close the directed Pacific sardine fishery for the remainder of the 2014-15 fishing season. We share your commitment to ending overfishing, recovering depleted fish populations, maintaining long-term sustainable fisheries and healthy ocean ecosystems. We applaud the National Marine Fisheries Service and the Council for taking this action to help the sardine population begin its much needed recovery.

Oceana has been deeply invested in the conservation and management of forage species off the U.S. West Coast for more than ten years, and in particular, we have been closely involved in management issues surrounding Pacific sardine. Forage species, such as sardine, are critical to healthy ocean ecosystems and sustainable fisheries. We read your leadership message describing the sardine collapse;[1] and we are writing to offer you a different perspective on the role of commercial fishing in this collapse and to stress the impacts the lack of prey is having on dependent species. It is important to learn from recent experiences so that the effectiveness of Pacific sardine management can be improved. To that end, in this letter we also describe management changes for the agency to consider so that when the fishery does resume again, it can better account for ecosystem needs, prevent overfishing, and achieve optimum yield.

1. **The role of fishing in the sardine population decline.**

As you are aware, the most recent NOAA Fisheries stock assessment finds that the Pacific sardine population has declined 91 percent since 2007.[2] We agree with you that the sardine population is greatly affected by environmental factors and that Pacific sardine naturally experience wide population fluctuations even in the absence of fishing. Your message, however,

[1] Eileen Sobeck (April 23, 2015). "Researchers, Managers, and Industry Saw This Coming: Boom-Bust Cycle Is Not a New Scenario for Pacific Sardine", accessed at: http://www.nmfs.noaa.gov/aboutus/leadership/apr_2015_leadership_message_sardines.html
[2] Hill, K.T., P.R. Crone, D.A. Demer, J. Zwolinski, E. Dorval, and B.J. Macewicz. 2015. Assessment of the Pacific Sardine Resource in 2015 for U.S.A. Management in 2015-16.

does not acknowledge that commercial fishing also likely played a significant role in the current sardine decline.

Forage fish like sardine are highly vulnerable to overfishing and collapse.[3] As clearly shown in various simulation model runs[4], excessive fishing pressure— particularly during periods of low recruitment and/or abundance— can have the dramatic effect of exacerbating natural sardine population declines. A recent study of forage species around the world, including Pacific sardine, found that fishing forage species during a decline can increase the rate and magnitude of population collapses.[5]

According to the 2015 sardine assessment, the age 1+ biomass of the Northern subpopulation of Pacific sardine will have declined by over 900,000 metric tons (mt) between 2007, when it peaked at 1.037 million mt, and July 2015, when it is estimated to be at 96,688 mt. During this time, the fishery removed 752,403 mt from the subpopulation. It is difficult to understand how the stock would have declined to this extent if those 752,403 mt would have remained in the water.

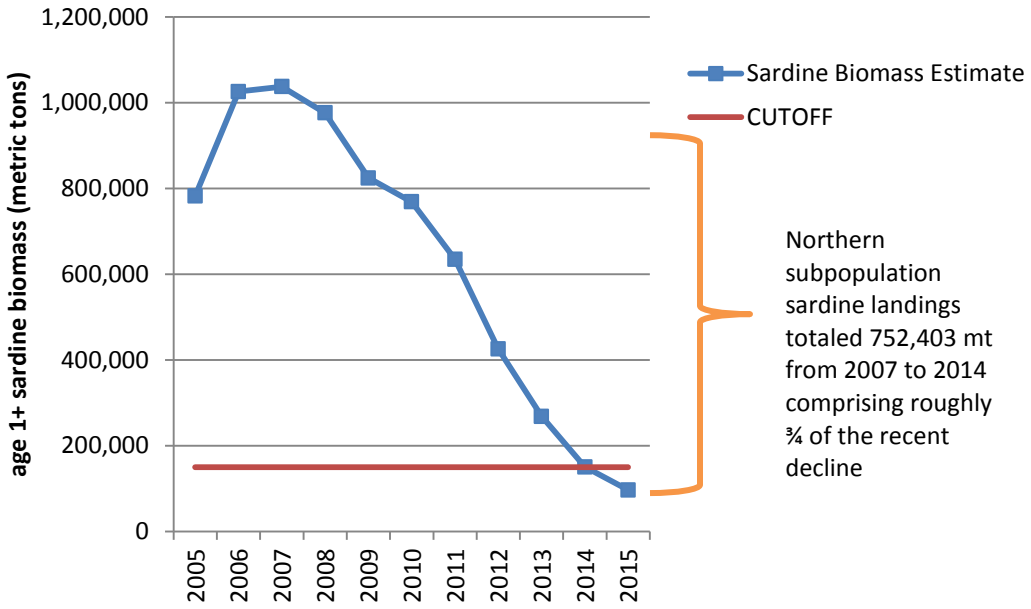

Figure 1. Estimated 1+ sardine biomass (mt) from the 2015 assessment showing CUTOFF and summed sardine northern subpopulation landings from 2007-2014.

[3] See Pinsky et al. 2011. Unexpected patterns of fisheries collapse in the world's ocean. PNAS: 108(20):8317-8322 and Lenfest Forage Fish Task Force Report: Pikitch et al. 2012. Little Fish, Big Impact: Managing a Crucial Link in Ocean Food Webs. Lenfest Ocean Program. Washington, DC. 108 pp.
[4] Hurtado-Ferro & Punt 2014. Revised Analyses Related to Pacific Sardine Harvest Parameters. Agenda Item I.1.b, March 2014 PFMC meeting.
[5] Essington et al. 2015. *Fishing amplifies forge fish population collapses*, PNAS Early Edition, available at http://www.pnas.org/content/early/2015/04/01/1422020112.full.pdf.

At the April 2015 PFMC meeting, assessment author Dr. Kevin Hill presented a Southwest Fisheries Science Center analysis of what the sardine population might look like in the absence of fishing.[6] While it is clear that, with the lack of recruitment, the population would have declined even in the absence of fishing, Dr. Hill's analysis shows the population would be four times higher right now without fishing. His analysis, therefore, shows that fishing made the sardine decline worse Moreover, sardine harvests exceeded Maximum Sustainable Yield levels during the decline.

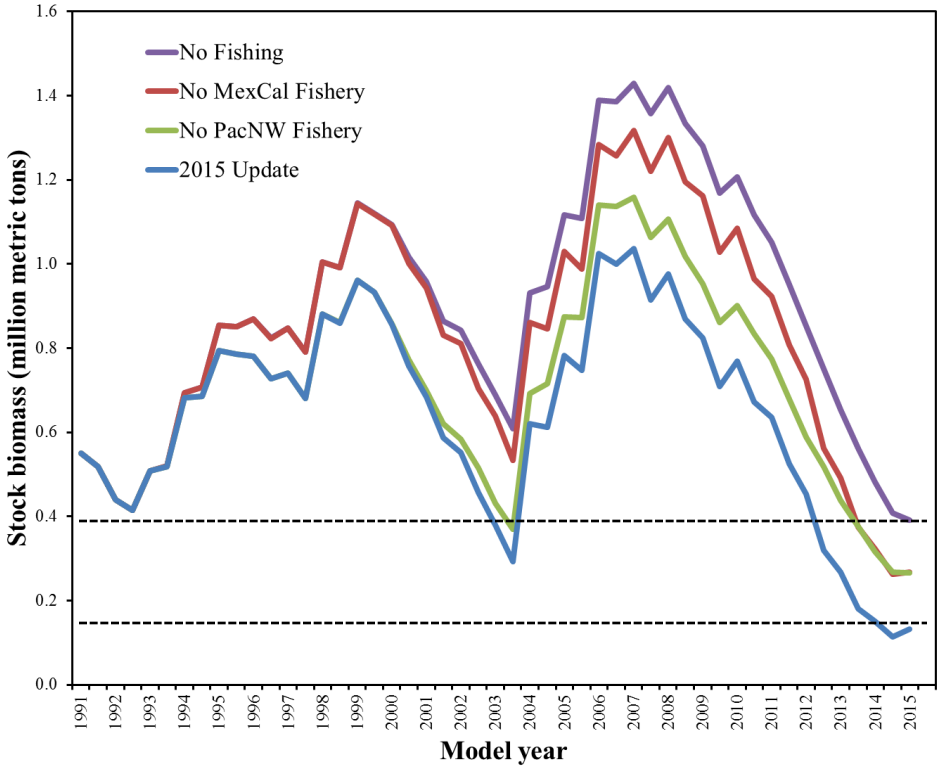

Figure 2. Showing that fishing has made the current sardine population four times smaller than what it would have been without it.[7] The population today without fishing would be approximately 400,000 metric tons (purple line, 'no fishing') versus the current estimated 96,688 metric tons (blue line '2015 update').

2. The best available science shows Pacific sardine overfishing has occurred since 2010.

Under the Magnuson-Stevens Fishery Conservation and Management Act (MSA), "'overfishing and overfished' mean a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis."[8] Maximum sustainable yield (MSY) "is the largest long-term average catch or yield that can be taken from a stock or stock

[6] Hill et al. 2015. Assessment of the Pacific Sardine Resource in 2015 for USA Management in 2015-16. Agenda Item G.1.a Supplemental SWFSC-FRD Power Point. April 2015. Slide #12.
[7] Id.
[8] 16 U.S.C. § 1802(34).

complex under prevailing ecological, environmental conditions and fishery technological characteristics . . . , and the distribution of catch among fleets."[9]

Similarly, the CPS FMP states that, "[b]y definition, overfishing occurs in a fishery whenever fishing occurs over a period of one year or more at a rate that is high enough to jeopardize the capacity of the stock to produce MSY on a continuing basis... ."[10] In March 2014 the Council's Scientific and Statistical Committee (SSC) recommended (and the Council adopted) that, "overfishing limits (OFLs) for the northern subpopulation of Pacific sardine be based on an E_{MSY} proxy derived from the relationship between estimated E_{MSY} and the 3-year moving average of the CalCOFI temperature index, restricted to an E_{MSY} range of 0-25 percent ..."[11] E_{MSY} is the expected constant fishing rate that if applied over the long term would result in MSY. When actual fishing rates are greater than the MSY fishing rates, overfishing occurred.[12]

We compared recent U.S. and coastwide exploitation rates presented in the 2015 sardine assessment to the CalCOFI temperature-based E_{MSY} as adopted in 2014 by the SSC for determining the OFL. That analysis is evidence that overfishing has been occurring in recent years at the both the U.S. and international levels under the SSC endorsed understanding of the MSY rate (Figures 3 and 4).

Though the U.S. fishery did not exceed annual overfishing limits established by the Council that were set at the time, our analysis shows that fishing rates exceeded MSY levels—as they would have been set under current rules—since 2010 by as much as 88% (Table 2 in the supplementary attachment). This "retrospective" analysis is based on current information and data in the sardine assessment that has been adopted by the Council and deemed the best available science.

At the April 2015 Council meeting, the SSC discussed whether or not overfishing is occurring. Based on direction from NMFS staff, the SSC only considered overfishing in the context of whether or not the overfishing level set for the 2014-15 fishing season was exceeded, and they found that the OFL was not exceeded.[13] This is true, but we now know previous OFLs were set far too high. The SSC did find, however, that the 2014-15 exploitation rate (12.6 percent) exceeded the target exploitation rate of 12.2 percent.[14] Further, it was made clear on the Council floor during review of the SSC statement that the fishery is fishing "at a higher exploitation rate than what would be sustainable over time to achieve MSY."[15] This is overfishing.

[9] 50 C.F.R. § 600.310(e)(1)(i).
[10] Pacific Fishery Management Council. 2011. Coastal Pelagic Species Fishery Management Plan as amended through Amendment 13, at page 36. www.pcouncil.org
[11] Pacific Fishery Management Council. I1c Supplemental SSC statement, March 2014. http://www.pcouncil.org/wp-content/uploads/I1c_SUP_SSC_MARCH2014BB.pdf
[12] 50 C.F.R. § 600.310(e)(2)(i)
[13] PFMC Agenda Item J.1.a Supplemental SSC Report. April 2015.
[14] Id.
[15] PFMC, April 13, 2015, Agenda Item J.1.a. Reports and Comments of the SSC. Audio recording.

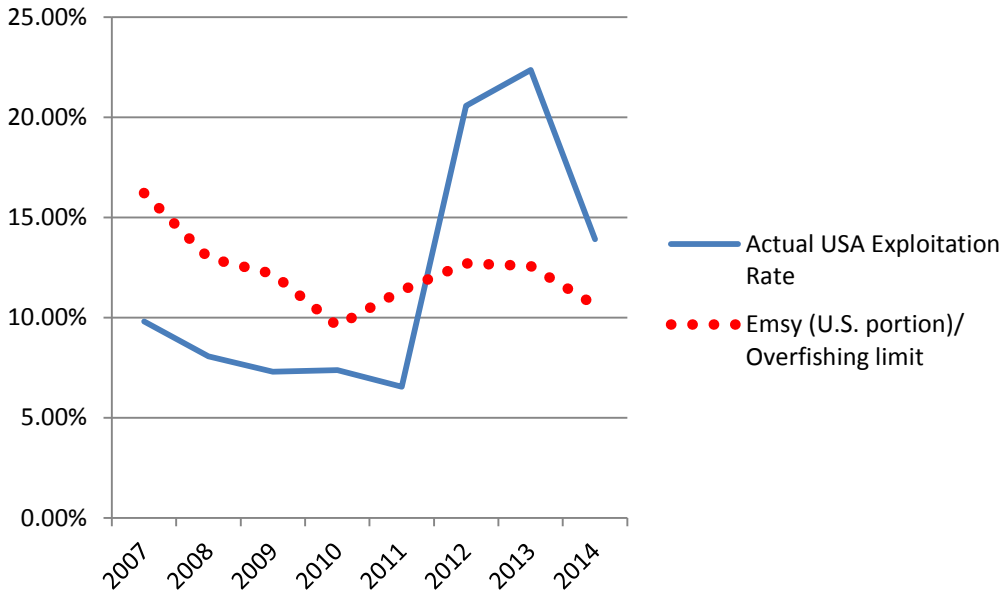

Figure 3. USA exploitation rate compared to the CalCOFI E_{MSY} rates (as recommend by the SSC) for the U.S. distribution of the stock (87%). Exploitation in excess of E_{MSY} are evidence of U.S. overfishing.

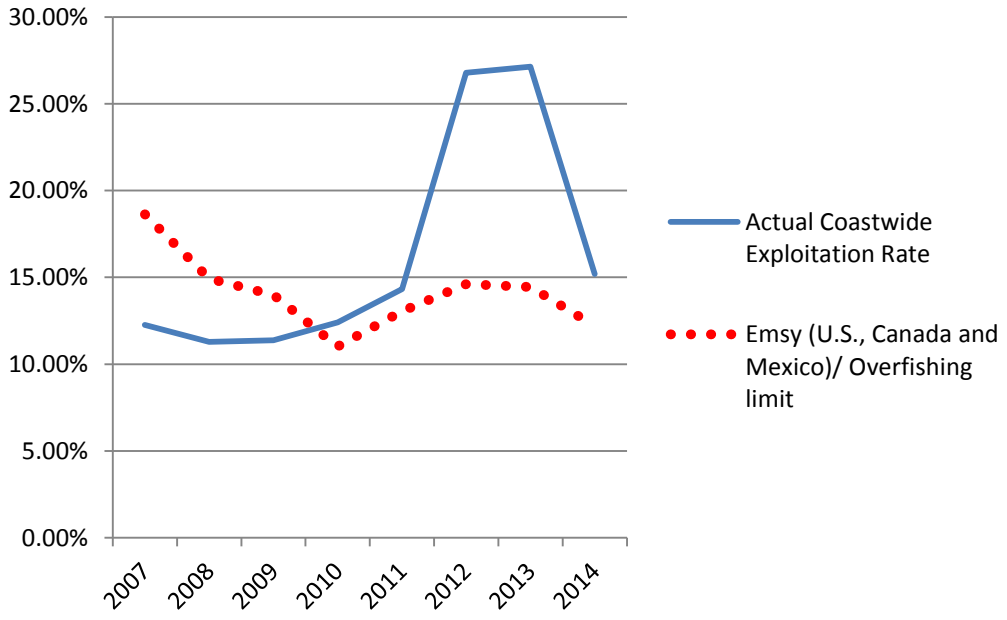

Figure 4. Coastwide (U.S., Mexico and Canada) exploitation rate compared to CalCOFI E_{MSY} rates for the coastwide distribution of the Northern sardine population. Exploitation rates in excess of E_{MSY} are evidence of coastwide overfishing occurring on a continuing basis since 2010.

Several factors may have contributed to the Council and NMFS establishing fishing rates that, in retrospect, were too high. The Council set OFLs based on the scientific advice it received at the time. The Council, however, has been using a flawed harvest control rule (further described below), compounded by stock assessments that overestimated sardine productivity, and a harvest policy that underestimated the risk of overfishing. These issues are not new; Oceana identified these problems and the risk of overfishing in comment letters over the past several years.[16]

One contributing factor to the overestimation of stock size during the recent collapse was that stock assessments used long-term average recruitment estimates to project future recruitment, during a period where recruitment was far below long-term averages. The result was that in each year from 2011 to 2014, the PFMC was given an overly optimistic outlook on the health and biomass of the sardine stock based on static long-term averages that did not reflect the recent poor recruitment (Figure 5.). While scientists and fishery managers have known the stock was declining and recruitment was poor, this was not reflected in the management decisions, contributing to OFLs and Harvest Guidelines that, in retrospect, were set too high.

A very similar situation happened during the 1990s when overfishing occurred on several West Coast rockfish species. In that case, scientists overestimated rockfish productivity and managers set overfishing limits too high based on the scientific advice they received.[17] We urge NMFS to apply this recent experience and add additional safeguards to Pacific sardine management to ensure that sardine are managed in a precautionary manner.

[16] E.g. http://www.pcouncil.org/wp-content/uploads/I2d_SUP_PC_PPT_OCEANA_NOV2010BB.pdf, http://www.pcouncil.org/wp-content/uploads/G3d_SUP_PC2_NOV2012BB.pdf, and http://www.pcouncil.org/wp-content/uploads/C1b_SUP_PC8_SHESTER_MAR2012BB.pdf

[17] Ralston, S. 2002. The Groundfish Crisis: What Went Wrong. Ecosystem Observations. Monterey Bay National Marine Sanctuary.

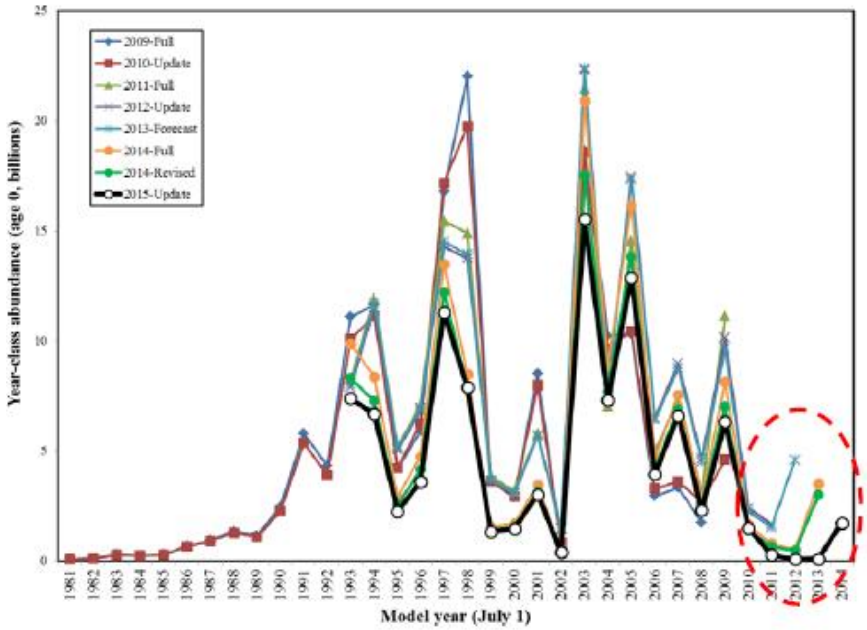

Figure 5: Historical analysis of recruitment, 2015 sardine assessment update vs. previously adopted models presented to the Council.[18]

3. **'CUTOFF' does not prevent the stock from being overfished, and it fails to account for ecosystem needs.**

Another significant aspect leading to the collapse of the sardine population is that the harvest control rule (HCR) is too aggressive because it allows fishing to continue on the sardine population until it is at approximately 9% of its estimated unfished levels.[19] The HCR in the CPS FMP defines how annual catch levels are set.[20] It includes a CUTOFF value of 150,000 mt and directed commercial fishing continues unless the population is below that level, when catch levels are set at zero. At this level, however, CUTOFF does not prevent the population from being overfished during periods of rapid population declines that are not immediately detected; nor does it ensure adequate forage for dependent predators. In fact, the first signs of insufficient prey for key indicator predators were seen several years ago when the stock was well above 150,000 metric tons (e.g., California sea lion unusual mortality event starting in 2013 and brown pelican reproductive failures since 2011).

Oceana recommends that NMFS increase the CUTOFF to 640,000 metric tons,[21] which more closely aligns with recommendations by the Lenfest Forage Fish Task Force and other scientific

[18] Supplemental SWFSC-FRD PowerPoint: Assessment of the Pacific Sardine Resource in 2015 for USA Management in 2015-16; Slide 14. http://www.pcouncil.org/wp-content/uploads/2015/04/G1a_SupSWFSC_PPT_SardineAssessment_APR2015BB.pdf
[19] The CUTOFF of 150,000 tons is approximately 9% of average unfished levels [1.6 million tons] as estimated by the Hurtado-Punt analysis prepared for the SSC and PFMC.
[20] Harvest Guideline = (BIOMASS-CUTOFF) x FRACTION x DISTRIBUTION
[21] See, G. Shester, Oceana. (February 28, 2014) Letter to the Pacific Fishery Management Council, at http://www.pcouncil.org/wp-content/uploads/I1d_SUP_PC3_MAR2014BB.pdf

studies recommending higher cutoff values for forage fishery management.[22] Analysis has demonstrated that such a control rule would maintain long-term total catches, while maintaining higher biomass, providing more forage, and reducing the risk of stock collapse and overfishing. Furthermore, the sardine stock dynamics would be much more similar to an unfished condition than under status quo management.

4. The "DISTRIBUTION" factor in the HCR and supporting analysis is flawed

The DISTRIBUTION factor is the percentage of the population estimated to be in U.S. waters and its purpose is for calculating the U.S. portion of the OFL, allowable biological catch and harvest guideline for this transboundary population. The DISTRIBUTION factor that is used (87%), however, has overestimated the proportion of the population in U.S. waters and failed to keep landings below coastwide target fishing rates or overfishing limits, as documented in the stock assessment and published in a recent study by NOAA and University of California Santa Cruz scientists.[23] The combined catch of the sardine Northern subpopulation (2005-2015) across Mexico and Canada has been twice what is estimated by the DISTRIBUTION parameter. While the U.S. control rule asserts that the U.S. is entitled to 87% of the total target harvest rate and coastwide OFL, and other nations are entitled to the remaining 13%, the actual U.S. catch has been 73% and foreign catch 27% over this time period. The implications of this, as stated in Demer & Zwolinski 2014 are significant:

> *"the current harvest control rule (HCR) for Pacific Sardine has not consistently maintained a total F below the U.S. target value because the "distribution" parameter (used to account for the northern stock's proportion in the U.S. Exclusive Economic Zone [EEZ]), has not adequately accounted for northern stock landings in Mexico and Canada."*

This fact partially explains why coastwide harvest rates have exceeded coastwide MSY rates more severely than when considering U.S. harvest rates in isolation. Correcting the U.S. DISTRIBUTION value so that the annual total tri-national landings more consistently match the target fishing fraction is essential for the long-term conservation of this fish population. NMFS has committed to holding a scientific workshop to examine the DISTRIBUTION parameter in the sardine harvest control rule.

5. The sardine collapse was predicted by some NOAA scientists, but the predictions and cautions were also disputed by the agency and ignored by the Council.

Your leadership message states that the sardine population decline is not a surprise, and that scientists, managers and industry saw this coming. This sardine population collapse was indeed predicted and managers were warned of excessive exploitation rates. In 2012, scientists

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[22] Lenfest Forage Fish Task Force Report: Pikitch et al. 2012. Little Fish, Big Impact: Managing a Crucial Link in Ocean Food Webs. Lenfest Ocean Program. Washington, DC. 108 pp. and
e.g. Essington et al. 2015. *Fishing amplifies forge fish population collapses*, PNAS Early Edition, available at http://www.pnas.org/content/early/2015/04/01/1422020112.full.pdf.

[23] David A. Demer & Juan P. Zwolinski. 2014. Optimizing Fishing Quotas to Meet Target Fishing Fractions of an Internationally Exploited Stock of Pacific Sardine, North American Journal of Fisheries Management, 34:6, 1119-1130, DOI: 10.1080/02755947.2014.951802

Zwolinski and Demer published a study predicting the collapse of the Pacific sardine stock, finding, "All indicators show that the northern sardine stock off the west coast of North America is declining steeply again and that imminent collapse is likely".[24] The authors warned:

> *[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.*[25]

This paper was presented to the Council in March 2012.[26] In May 2012, MacCall et al. (including scientists from NMFS Northwest and Southwest Fisheries Science Centers who were members of the Council's CPS Management Team) published a rebuttal to the Zwolinski and Demer study ("Weak Evidence For Sardine Collapse"), stating that the indicators of stock collapse presented by Zwolinski and Demer "are lacking in explanatory or predictive power."[27] The authors replied to the McCall et al. rebuttal, sticking to their predictions and suggesting that their results could be heeded to refine Pacific sardine management.[28] The warnings and observations were disregarded by NMFS, which urged the Council to ignore the scientific literature predicting sardine collapse. In fact, the Deputy Director of the Southwest Fisheries Science Center presented a letter and testimony to the Council in June 2013 stating:

> *As stated last March 2012, based on current information, expertise, and extensive peer-reviewed research, NOAA's National Marine Fisheries Service believes that the population of Pacific sardines is cyclical and capable of large fluctuations as has taken place in previous decades, with observed increases and decreases in abundance,* ***and is not currently in a state of imminent collapse as referenced in the PNAS article of March 2012****.*[29]

This statement conflicts with the statement that the agency, the Council and industry saw this collapse occurring. Moreover, it calls into question recent management, which allowed an increase in the U.S. exploitation rates during the collapse. The record demonstrates there was a chilling response to the science showing a sardine population collapse. The Council, its CPS management team and industry advisors were reluctant to recognize this science and make improvements to management.

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[24] 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.

[25] *Id. at 1.*

[26] http://www.pcouncil.org/resources/archives/briefing-books/march-2012-briefing-book/#coastal

[27] MacCall, A.D., K.T. Hill, P. Crone, R. Emmett. 2012. Weak evidence for sardine collapse. PNAS Letter. Available at: www.pnas.org/cgi/doi/10.1073/pnas.1203526109.

[28] Demer and Zwolinski. 2012, available at: www.pnas.org/cgi/doi/10.1073/pnas.1203758109

[29] Koch, K. Deputy Director, NOAA SWFSC. June 2013 letter and comments to the PFMC. Agenda Item I.4.c Supplemental SWFSC Report June 2013 (emphasis added).

6. Pacific sardine management is failing to adequately account for the needs of dependent predators.

The low abundance of sardine concurrent with continued low abundance of Northern anchovy is taking a serious toll on dependent species in the California Current Ecosystem. An estimated 70% of the California sea lion pups died in 2013 due to starvation and the current estimates of sea lion pup mortality suggest another 70% or more will die this year.[30] In addition to starving sea lions, California Brown Pelicans breeding in the Channel Islands have undergone a decline in reproductive success since around 2007, culminating in major nesting failures in 2012-2014.

Sardines are an essential prey item for numerous piscivorous seabirds including Brown Pelicans, Elegant Terns, Heermann's Gulls and the threatened Marbled Murrelet. Although sardines comprised 25%-67% of the diets of breeding pelicans in six years of surveys that took place at the Channel Islands between 1991-2005, they have been absent from the diets of breeding pelicans in recent years. The foraging needs of these predators have never been adequately considered and accounted for in the Coastal Pelagic Species Fishery Management Plan despite the FMP's goal to "provide adequate forage for dependent species."[31] As a result, there has been no discussion at the SSC, CPS Management Team, or the Council of the status of these dependent predators in the decision-making process for determining optimum yield for the Pacific sardine fishery (or other CPS fisheries). The needs of dependent species must be assessed in determining optimum yield for the Pacific sardine fishery.

Conclusion

While fishing levels did not exceed overfishing levels set at the time, the best available science shows that those levels were set too high. Consequently, both U.S. and international fishing rates exceeded MSY harvest rates for multiple years during the recent Pacific sardine collapse. The Pacific sardine collapse has been exacerbated by overfishing and application of a harvest control rule that allowed increased fishing rates on a precipitously declining population and during a period of low recruitment.

Overfishing has been compounded by an incorrect DISTRIBUTION assumption and lack of cooperative international management. While we acknowledge there would have been some natural decline in Pacific sardines even without fishing, the excessive fishing rates worsened the natural decline and caused the current sardine population to plummet. The effects of this population collapse are clearly evident above the water with starving sea lions and Brown Pelicans, but this is likely only the tip of the iceberg. The consequences of the overfishing that has already occurred will undoubtedly have long term deleterious impacts on the California Current marine ecosystem.

NMFS must act swiftly to rebuild the sardine population and to fix the fundamental parameters of the harvest control rule, including revising the CUTOFF, Minimum Stock Size Threshold and the U.S. portion of coastwide harvest. Further, the U.S. must press for an international

[30] E.g. http://www.utsandiego.com/news/2015/feb/18/environment-sea-lion-strandings/ and, Melin, S. NOAA Fisheries as in:
http://www.afsc.noaa.gov/News/Sea%20Lion%20Teleconference%202.18.2015.wav
[31] PFMC CPS FMP, at page 12.

management agreement with Mexico and Canada to share scientific information and prevent coastwide overfishing.

We commend NMFS and the Council for acknowledging the severity of the sardine collapse and closing the directed sardine fishery for the remainder of the 2014-15 season and the 2015-16 season. However, in hindsight, the severity of the collapse could have been greatly reduced had there been a more precautionary harvest control rule and had the collapse been acknowledged earlier. The recent closure of the directed sardine fishery now provides an opportunity to learn from this experience and focus agency resources on systemic improvements to the sardine harvest control rule. Please consider this information and direct your agency to consider changes to the Pacific sardine management, public communications, and the treatment of published scientific literature within NMFS to prevent similar situations in the future.

Sincerely,

Susan Murray
Deputy Vice President, Pacific
Oceana

cc. Pacific Fishery Management Council

Attached. Supplementary analysis of sardine overfishing

Supplementary Analysis of Sardine Overfishing

To evaluate whether or not sardine overfishing has been occurring, we compared the actual USA and coastwide (MX, Canada and USA total) exploitation rates (E) as reported on page 10 of the most recent NOAA Pacific sardine stock assessment[32] to the MSY fishing rate (E_{MSY}). There is evidence that overfishing occurs when E is > E_{MSY}, or $E/E_{MSY} > 1$.

Actual exploitation rates are determined as the Northern Subpopulation (NSP) catch divided by the total mid-year biomass (July - 1, ages 0+):

Calendar Year	USA	Total
2000	7.74%	11.31%
2001	8.02%	10.11%
2002	14.78%	17.36%
2003	12.90%	16.77%
2004	11.35%	12.93%
2005	8.52%	10.65%
2006	7.47%	8.68%
2007	9.80%	12.26%
2008	8.07%	11.29%
2009	7.30%	11.37%
2010	7.37%	12.41%
2011	6.54%	14.33%
2012	20.57%	26.79%
2013	22.36%	27.13%
2014	13.91%	15.20%

Table 1. USA and Coastwide Exploitation Rates (2000 to 2014) as in Hill et al. 2015.

MSY levels are determined by the PFMC Scientific and Statistical Committee (SSC) approved formula for setting OFLs. This is how the SSC defines MSY. Under the SSC approved formula, E_{MSY} is calculated as the following function of the CalCOFI 3-year temperature index:

$$E_{MSY} = -18.46452+3.25209*(T)-0.19723*(T^2)+0.0041863*(T^3)$$

Based on these definitions of the actual exploitation rate and MSY exploitation rate, we calculated E/E_{MSY} values for each year from 2000-2014 both on a coastwide basis and also looking at the U.S. harvest rates alone. In assessing U.S. harvest rates, as per the SSC's current method for calculating the U.S. OFL, we multiplied the total E_{MSY} by the current DISTRIBUTION parameter of 0.87 to calculate the U.S. portion of the E_{MSY}.

[32] Hill, K.T., P.R. Crone, D.A. Demer, J. Zwolinski, E. Dorval, and B.J. Macewicz. 2015. Assessment of the Pacific Sardine Resource in 2015 for U.S.A. Management in 2015-16. PFMC Agenda Item G.1a April 2015.

In this analysis we found that evidence of coastwide overfishing for 2002, 2003, and 2010-2014. There is evidence that overfishing occurred in U.S. waters in 2002, 2003, and 2012-2014 (Table 2). In 2012 and 2013, in the middle of the population decline, U.S. harvest exceeded MSY levels by over 60% and coastwide harvest exceeded MSY levels by over 80%. Figure 6 (below) shows that during the decline, exploitation rates increased. While the sardine population would have declined with or without fishing, the effect of fishing on the rate and magnitude of the decline cannot be assumed to be negligible.

Year	3-y CalCOFI SST	CalCOFI Emsy	E (coastwide)	E/Emsy (coastwide)	E (USA)	CalCOFI Emsy (U.S. portion = Emsy*0.87))	E/Emsy (USA)
2000	16.28	26.91%	11.31%	0.42	7.74%	23.41%	0.33
2001	15.95	21.73%	10.11%	0.47	8.02%	18.91%	0.42
2002	15.54	15.38%	17.36%	1.13	14.78%	13.38%	1.10
2003	15.43	13.67%	16.77%	1.23	12.90%	11.90%	1.08
2004	15.51	14.92%	12.93%	0.87	11.35%	12.98%	0.87
2005	15.62	16.62%	10.65%	0.64	8.52%	14.46%	0.59
2006	15.79	19.25%	8.68%	0.45	7.47%	16.75%	0.45
2007	15.75	18.63%	12.26%	0.66	9.80%	16.21%	0.60
2008	15.51	14.92%	11.29%	0.76	8.07%	12.98%	0.62
2009	15.45	13.99%	11.37%	0.81	7.30%	12.17%	0.60
2010	15.26	11.02%	12.41%	1.13	7.37%	9.58%	0.77
2011	15.39	13.05%	14.33%	1.10	6.54%	11.35%	0.58
2012	15.49	14.61%	26.79%	1.83	20.57%	12.71%	1.62
2013	15.48	14.45%	27.13%	1.88	22.36%	12.57%	1.78
2014	15.34	12.19%	15.20%	1.25	13.91%	10.61%	1.31

Table 2. Actual sardine exploitation rates exceeded MSY exploitation rates in 2002, 2003, 2010 (coastwide only), 2011 (coastwide only), 2012, 2013, and 2014.

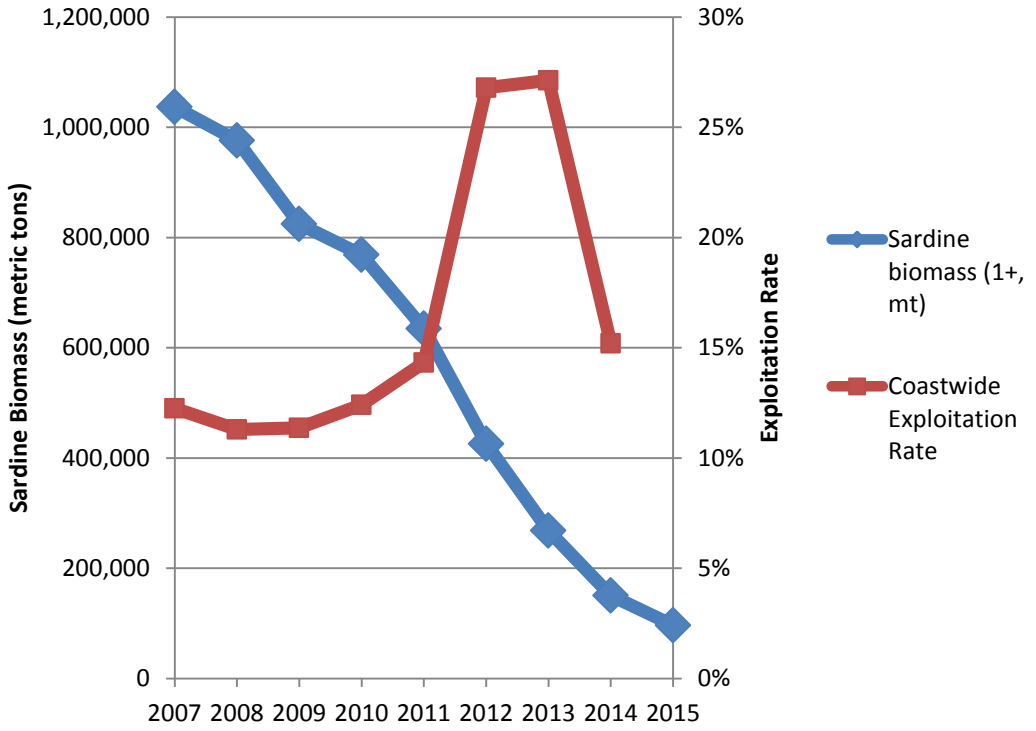

Figure 6. Pacific sardine exploitation rates increased while the Pacific sardine biomass declined.