

**Proposal for Methodology Review of the Southern California Bight Aerial Survey for Inclusion into the Pacific Sardine Stock Assessment**

1. Title: Southern California Bight Aerial Survey (SCS)
2. Name of Proposers:
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  - b) California Wetfish Producers Association: Diane Pleschner-Steele.
3. How the proposed methodology will improve assessment and management for the stock(s) in question:

The SCS survey will provide information on the southern portion of the U.S. Pacific sardine stock, particularly the nearshore waters (within three miles) of the Southern California Bight (SCB). Since 2009, sardine stock assessments have incorporated aerial survey data, but these surveys have not covered nearshore southern California waters, although the core of the sardine population is thought to reside in the SCB. To date, nearshore abundance has been extrapolated from offshore acoustic surveys.
4. Outline of methods: The current survey design includes aerial transects spanning the Southern California Bight, and along the mainland (Santa Barbara to San Diego) and Channel Islands coastlines (Figure 1). Once sardines are sighted, school biomass is estimated and documented on log sheets. Photos are also taken with an automated camera system attached to a GPS, similar to the system used in the Northwest sardine aerial survey. Identification of species is validated by boat sampling. Aerial survey data will be used to determine a relative index of abundance.

## Aerial Sardine Survey – Southern California Bight

### Introduction

Pacific sardine is a transboundary resource within the California Current Ecosystem whose population center and recruitment are assumed to concentrate near the Southern California Bight (SCB) and Baja CA (Hill et al. 2012). Currently the Pacific sardine resource is assessed annually using a combination of field survey methods. These include daily/total egg production (DEP/TEP) and acoustic surveys conducted seasonally by the Southwest Fisheries Science Center (SWFSC), focused primarily in offshore waters in and around the SCB and along the central coast; and an aerial survey in the Pacific Northwest conducted since 2009 by the northwest sardine fishing industry (NWSS).

The NWSS aerial survey protocol (Jagiello et al. 2012) was adapted from the traditional spotter pilot index (Lo et al. 1992) covering the period 1985-2005; this index was dropped from the sardine stock assessments in 2007 in part because spotters were no longer flying routinely for the fleet in CA (Hill et al. 2007). In 2012, CWPA and CDFW agreed to collaborate on a new survey protocol, modifying the NWSS method by including the nearshore area (i.e., inside 3 miles) where young sardines (and anchovy) congregate in CA. If it is demonstrated that the sampled sardine are predominantly young recruits, the resulting index may serve as an index of recruitment. This new survey will add to the available data used in management of the fishery:

- Most of the CA sardine fishery takes place inside 3 miles from shore, while the NWSS survey expressly excludes the area inside 3 miles to avoid mistaking anchovy for sardine. Sardines behave differently in CA, where fish congregate near shore, versus the northwest, where they form feeding aggregations offshore. By including the nearshore, this survey restores the abundance index originally conducted by spotter pilots that was removed from recent stock assessments.
- This nearshore survey also provides for a better assessment of sardine (and other coastal pelagic species) in nearshore waters than extrapolations from acoustic measurements taken from greater than a few miles offshore.
- Providing an index of relative abundance in CA waters adds important information to complement the estimates of sardine biomass generated from other survey methods.
- An additional index of abundance in future stock assessments will improve biomass estimates and provide more confidence in management, both for sardine and potentially other coastal pelagic species (CPS), such as anchovy.

### Methods

The survey area consists of sixteen open water transects originating from the mainland (Santa Barbara to San Diego) to the extent of the outer Channel Islands, as well as the coastlines of both the mainland and each of the

Channel Islands (Figure 1). Surveys began in summer (July-August) 2012 and have continued with spring (April-May) 2013 and summer (August-September) 2013 surveys. The 2012 design is represented by Group A (green). In 2013, open water transects were randomly chosen from 5 options: the 2012 design + 4 others based on offsetting the 2012 design by 3 nm increments. Group D (black) was selected for the spring 2013 survey, and Group A was again flown for the summer 2013 survey.

The basic method is to fly transects with an experienced spotter pilot observer looking to the right. When sardine (and beginning with summer 2013, other CPS) are identified and confirmed, the plane flies over the fish and photos are taken with the camera system set at 80 percent overlap. The camera system software records time, location, speed, altitude and other information with each image. CDFW staff also record on a log sheet the time and frame number when photos of fish are being taken, the observer-estimated number of schools and tonnage (including percent species composition of mixed schools), along with other relevant comments. Separate flights are paired with boat sampling of observed CPS schools from the air. These boat samples (via diver video, hook-and-line) are used to validate observer identification of species, and provide information on size and age structure of the observed fish.

After the schools are photographed, the log sheets are used to find the corresponding photos with schools. Once identified, these photos are then enhanced with Adobe Lightroom software, and the school areas are measured in Adobe Photoshop. The measured areas give information on relative density; in turn, adjusted for survey area coverage, this density information yields information on abundance. Separately, the observer estimates also provide information on school abundance and are used to derive point estimates of abundance. Over time, a generalized linear model (GLM) will be developed to analyze the data and serve as a predictive tool.

## Results

Observation data from the summer 2012, spring 2013, and summer 2013 field seasons are summarized in Figure 2 and Table 1. The 2012 surveys were conducted from July 30 to August 17, the spring 2013 surveys from April 22 to May 21, and the summer 2013 survey from August 1 to October 4. Boat sampling results demonstrated accurate aerial identification of sardine and CPS.

Sardine school areas in photos from the summer 2012 season have been measured, with 12% of recorded observations corresponding to 76% of estimated tons matched with survey photos. These percentages were 24% and 78%, respectively, for the spring 2013 season. These rates are expected to increase with the summer 2013 data (as yet unanalyzed), when immediate post-survey flight reviews of fish observations with the observer were initiated.

Point estimates of abundance from observer tonnage estimates were 31,649 tons for summer 2012 and 12,280 tons for spring 2013. Summer 2013 data analyses are not complete yet. These estimates are based on observer coverage from the airplane (dependent on altitude and distance to shore) and total survey study area.

## Relevance to management

Pacific sardines and anchovy are important species in the CPS management complex, and are a vital ecological component as forage species. These species are also very important to the CPS 'wetfish' industry and California's fishing economy. The goal of this collaborative research program is to determine an index of relative abundance by modifying existing aerial survey methods, coupled with the traditional spotter pilot index, to produce information of critical importance to improve sardine biomass estimates and trends in abundance. This survey can be useful to assess other CPS as well.

Effective assessment of nearshore sardine abundance, an important potential measure of recruitment, is currently missing from stock assessments. Providing an index of abundance in California, including the nearshore as well as offshore, is needed to forecast trends in population abundance, and can also be used to assess the sardine rate of migration between the population center in Southern CA and the Pacific Northwest.

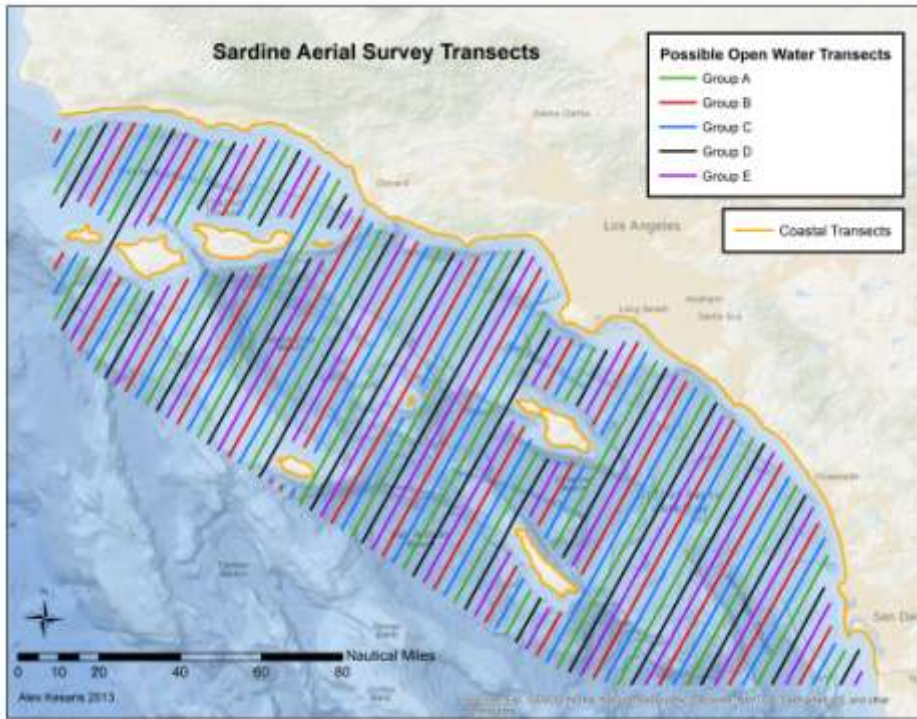
## References

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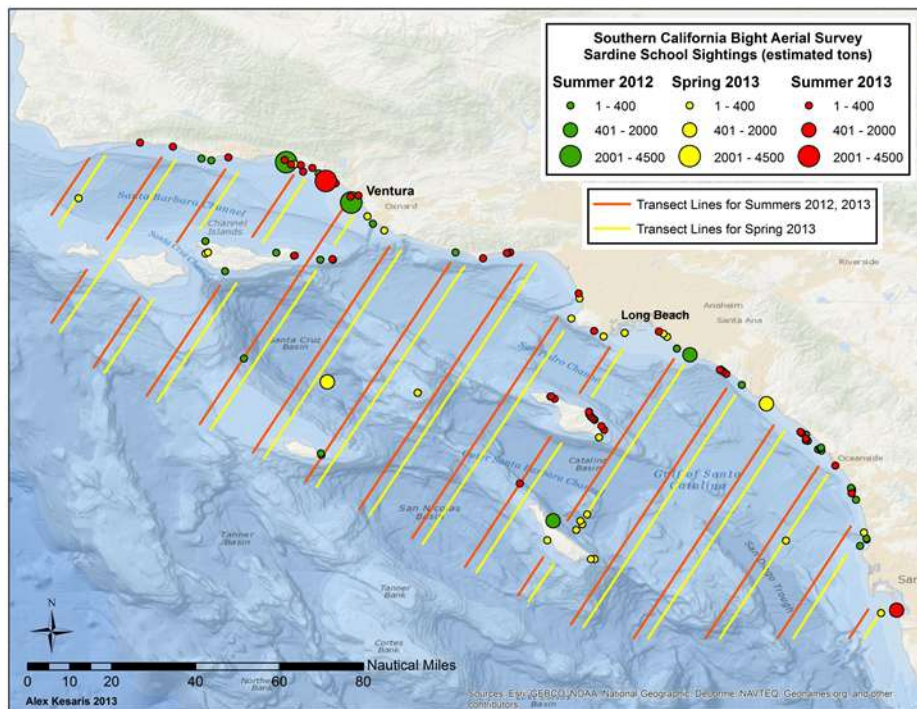
Hill, K. T., P. R. Crone, N. C. H. Lo, D.A. Demer, J.P. Zwolinski, and B. J. Macewicz. 2011. Assessment of the Pacific sardine resource in 2012 for U.S. management in 2013. Pacific Fishery Management Council, Nov 2012 Briefing Book, Agenda Item G.3.b. 193 p.

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**Figure 1.** Survey design consisting of mainland and island coastal transects, and potential open water transects (one transect group randomly chosen each season).



**Figure 2.** Sardine sightings from 2012 and 2013 surveys.

