Proposal for Methodology Review of the Southern California Coastal Pelagic Species Survey for Inclusion in the Pacific Sardine Stock Assessment

1. Title: Southern California Coastal Pelagic Species Survey (SCCPSS)
2. Name of Proposers:
    a) California Department of Fish and Wildlife: Kirk Lynn, Dianna Porzio, Alex Kesaris.
    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 SCCPSS will provide information on the southern portion of the U.S. Pacific sardine (sardine) stock, particularly in 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. The SCCPSS will be able to provide abundance estimates in nearshore waters which can better inform or replace extrapolations from offshore surveys.
4. Outline of methods: The current survey design includes aerial transects covering the Southern California mainland (Point Conception to San Diego) and Channel Islands coastlines (Figure 1). Once sardine are sighted, school biomass is estimated and documented. Photos are also taken with an automated camera system attached to a GPS. Identification of species is validated by boat sampling. Aerial survey data will be used to determine a relative index of abundance for sardine and other coastal pelagic species.

Aerial CPS Survey – Southern California Bight

Introduction

Pacific sardine (*Sagax sardinops*, 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. 2015). Currently the sardine resource is assessed annually using data from a combination of field survey methods. These include daily/total egg production (DEP/TEP) and acoustic/trawl surveys conducted seasonally by the Southwest Fisheries Science Center, which are focused primarily in offshore waters in and around the SCB and along the U.S. Pacific coast. For management years 2010 through 2013 the assessment model also included an aerial survey in the Pacific Northwest conducted by the northwest sardine fishing industry (NWSS).

The NWSS aerial survey protocol (Jagielo 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). Sardines behave differently in CA, where fish congregate near shore, versus the northwest, where they form feeding aggregations offshore. In 2012, the California Department of Fish and Wildlife (CDFW) and the California Wetfish Producers Association (CWPA) began collaboration on a new aerial survey, modifying the NWSS method by including the nearshore area (within 3 nautical miles [nm]) where young sardine (and northern anchovy [*Engraulis mordax,* anchovy]) congregate in CA. Most of the CA sardine fishery takes place in nearshore waters, while the NWSS survey expressly excludes the nearshore area to avoid mistaking anchovy for sardine. By including nearshore waters, this survey restores the relative abundance index originally conducted by spotter pilots that was removed from recent stock assessments. If it is demonstrated that the sampled sardine are predominantly young recruits, the resulting index may also serve as an index of recruitment. This nearshore survey also provides for a better assessment of sardine (and other coastal pelagic species [CPS]) in nearshore waters than extrapolations from offshore acoustic surveys. Providing an index of relative abundance in CA waters adds important information to complement the estimates of sardine biomass generated from other surveys. An additional index of abundance in future stock assessments will improve biomass estimates and provide more confidence in management for sardine and potentially other CPS, such as anchovy.

Methods

The study area was originally surveyed by: 1) 16 open water transects originating from the mainland (Santa Barbara to San Diego) to the extent of the outer Channel Islands, 2) transects along the coastlines of the mainland and each of the Channel Islands (Figure 1). Surveys began in summer (Jul-Aug) 2012 and have continued with spring (Apr-May) 2013, summer (Aug-Sep) 2013, spring (May-Jun) 2014, summer (Aug) 2014, and summer (Aug-Oct) 2015 surveys. The 2012 design for the open water areas is represented by Group A (green). Starting 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. In spring of 2014, the open water transects were omitted; instead, multiple bands were flown for coastal transects off the mainland and around the islands. The summer 2014 protocol reverted to the original design with open water (Group B) and coastal transects. No survey was conducted in spring 2015 due to plane repairs and diversion of resources to a Pacific bluefin tuna survey. In summer 2015, the open water areas were permanently dropped from the survey methodology because the lack of visibility in deeper water made it difficult for the observer to spot fish schools at depth, and to increase the focus of resources on nearshore survey efforts.

The basic method is to fly strip transects with an experienced spotter pilot observer looking to the right. Coastal transects were initially flown at 1,000 feet (ft) altitude to maximize observer identification, and open water transects at 2,000 ft to maximize observer coverage and transect width; this was standardized to 1,500 ft altitude for both transect types in the summer 2014 season. 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, metric tonnage (mt; including percent species composition of mixed schools), and any other relevant comments. After the schools are photographed, the log sheets are used to find the corresponding photos with schools. The observer estimates are used to derive estimates of abundance. For the first three seasons and summer 2014, abundance estimates are for combined coastal and open water areas and are based on observer coverage from the plane and total survey study area. Raw field data from open water transects were expanded to the total area covered by the open water transects to estimate open water abundance. Spring 2014 and summer 2015 seasons surveyed only coastal mainland and island areas, and so estimates of abundance for those seasons represent coastal areas only. In addition, location data from aerial observations are used to analyze fish-habitat associations with regard to sea-surface temperature and chlorophyll concentrations.

Separate flights are paired with boat sampling of observed CPS schools from the air. These boat samples (via diver video, hook-and-line, gillnet) are used to validate observer identification of species, and provide information on size and age structure of the observed fish.

Results

Observation data for sardine and anchovy for all seasons are summarized in Figures 2 and 3, and Tables 1 and 2. Each season's boat sampling results demonstrated accurate aerial identification CPS.

Estimates of sardine abundance from observer tonnage estimates were 34,251 mt for summer 2012, 12,012 mt for spring 2013, 5,915 mt for summer 2013, 4,122 mt for spring 2014, 58 mt for summer 2014, and 222 mt (SE = 117) for summer 2015. Estimates of anchovy abundance were 13,776 mt for summer 2013, 6,891 mt for spring 2014, and 6,406 mt for summer 2014. There were no anchovy observed during summer 2015.

Relevance to management

Pacific sardine 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. Effective assessment of nearshore abundance, an important potential measure of recruitment, is currently missing from sardine 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 examine the sardine rate of migration between the population center in Southern CA and the Pacific Northwest. The goal of this collaborative research program is to fill some of these data gaps by developing indices of relative abundance using aerial survey methods and provide information of critical importance to improve CPS biomass estimates and determine trends in abundance.

The recent focus on northern anchovy abundance highlights the need for additional sources of information. Similar to sardine, this survey provides data on the nearshore abundance and distribution of anchovy in the SCB, and can supplement other data from surveys operating outside of a few nautical miles from shore.

As part of this joint effort, CWPA provides a spotter pilot on contract as the observer, loans the camera system, and plans to continue supporting the survey. The project also uses a CDFW plane, pilot, boat, crew, and biologist staff; these elements are funded and will continue to be for the foreseeable future.

References

Hill, K. T., E. Dorval, N. C. H. Lo, B. J.Macewicz, C. Show, and R. Felix-Uraga. 2007. Assessment of the Pacific sardine resource in 2007 for U.S. management in 2008. NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-413. 178 p.

Hill, K. T., P. R. Crone, N. C. H. Lo, E. Dorval, and B. J. Macewicz. 2015. Assessment of the Pacific sardine resource in 2015 for U.S. management in 2015-16. Pacific Fishery Management Council, April 2015 Briefing Book, Agenda Item G.1.a. 168 p.

Jagielo, T. H., Howe, R., and M. Mikesell. 2012. Northwest Aerial Sardine Survey. Sampling Results in 2012. Prepared for Northwest Sardine Survey, LLC. Pacific Fishery Management Council, Nov 2012 Briefing Book, Agenda Item G.3.a. 82 p.

Lo, N.C.H., Jacobson, L.D and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49: 2515-2526.

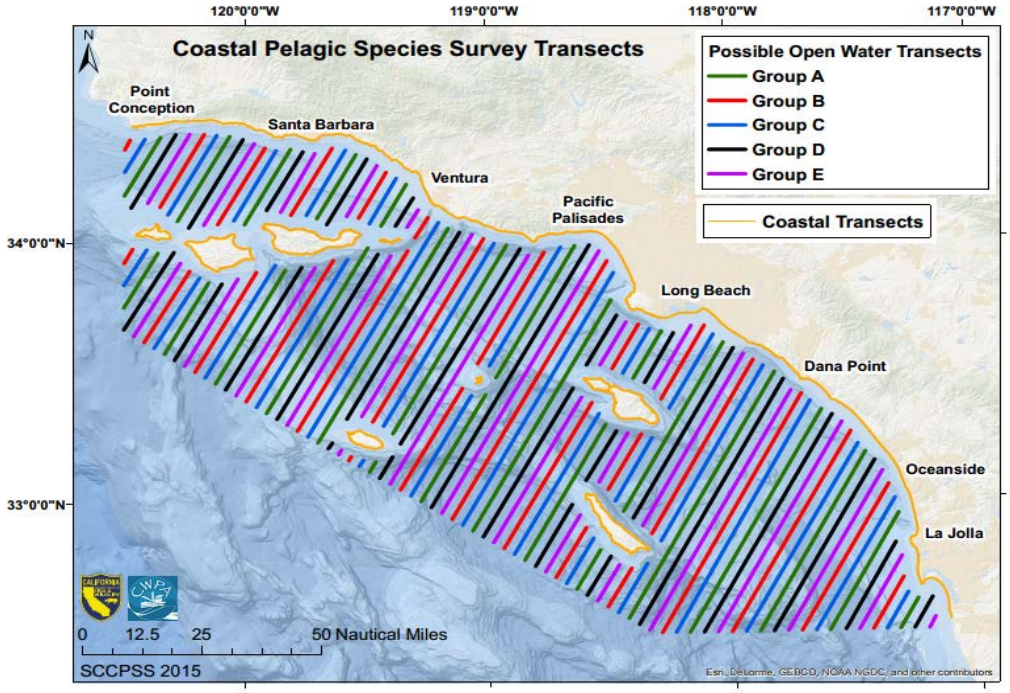

Figure 1. Survey design consisting of mainland and island coastal transects, and potential open water transects (transect group randomly chosen for 2012-2013 and summer 2014 seasons).

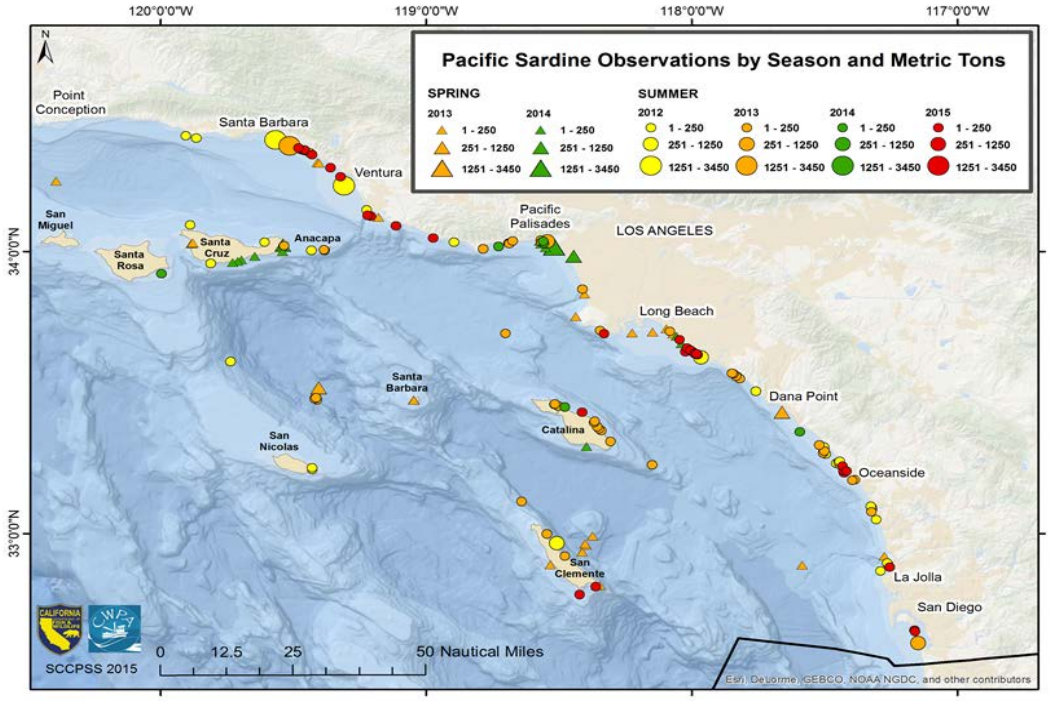

Figure 2. Sardine sightings from 2012-2015 surveys.

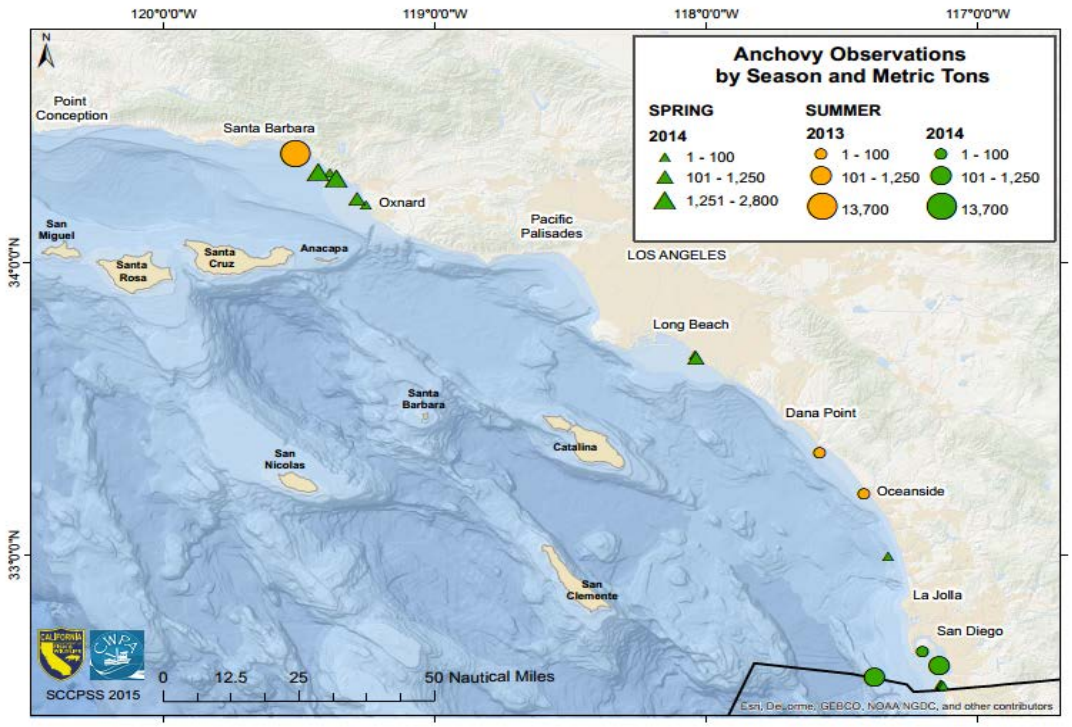

Figure 3. Anchovy sightings from 2013-2015 surveys.

Table 1. Summary of sardine field data from summer 2012, spring 2013, summer 2013, spring 2014, summer 2014, and summer 2015 seasons. See text for final biomass estimates.

Summer 2012

Date	Tons	Schools	Location Type	Transect
7/30/2012	1,200	79	Coastal-Island	San Clemente
8/6/2012	10	2	Coastal-Mainland	North Coast
8/6/2012	10	1	Coastal-Mainland	North Coast
8/6/2012	13	8	Coastal-Mainland	North Coast
8/6/2012	3,000	100	Coastal-Mainland	North Coast
8/6/2012	15	1	Coastal-Mainland	North Coast
8/6/2012	5	1	Coastal-Mainland	North Coast
8/8/2012	5	2	Coastal-Mainland	South Coast
8/8/2012	25	1	Coastal-Mainland	South Coast
8/8/2012	5	1	Coastal-Mainland	South Coast
8/8/2012	5	1	Coastal-Mainland	South Coast
8/8/2012	4	1	Coastal-Mainland	South Coast
8/8/2012	10	1	Coastal-Mainland	South Coast
8/8/2012	15	1	Coastal-Mainland	South Coast
8/8/2012	8	1	Coastal-Mainland	South Coast
8/8/2012	5	1	Coastal-Mainland	South Coast
8/8/2012	18	5	Coastal-Mainland	South Coast
8/8/2012	5	1	Coastal-Mainland	South Coast
8/8/2012	10	2	Coastal-Mainland	South Coast
8/8/2012	55	8	Coastal-Mainland	South Coast
8/8/2012	95	3	Coastal-Mainland	South Coast
8/8/2012	28	3	Coastal-Mainland	South Coast
8/8/2012	250	7	Coastal-Mainland	South Coast
8/8/2012	50	1	Coastal-Mainland	South Coast
8/8/2012	1,250	50	Coastal-Mainland	South Coast
8/8/2012	175	5	Coastal-Mainland	South Coast
8/11/2012	38	3	Coastal-Island	San Nicolas
8/11/2012	130	8	Coastal-Island	San Nicolas
8/11/2012	5	1	Coastal-Island	Santa Cruz
8/11/2012	1	1	Coastal-Island	Santa Cruz
8/11/2012	100	3	Coastal-Island	Santa Cruz
8/11/2012	20	1	Open Water	A5
8/17/2012	1	2	Coastal-Island	Anacapa
8/17/2012	3,000	100	Open Water	A5
Total	9,564	406		

Spring 2013

Date	Tons	Schools	Location Type	Transect
4/22/2013	5	1	Coastal-Mainland	South Coast
4/22/2013	850	15	Coastal-Mainland	South Coast
4/22/2013	5	1	Coastal-Mainland	South Coast
4/22/2013	10	1	Coastal-Mainland	South Coast
4/22/2013	1	1	Coastal-Mainland	South Coast
4/22/2013	50	4	Coastal-Mainland	South Coast
4/22/2013	200	6	Coastal-Mainland	South Coast
4/22/2013	25	3	Coastal-Mainland	South Coast
4/23/2013	4	1	Coastal-Mainland	North Coast
4/23/2013	15	2	Coastal-Mainland	North Coast
4/23/2013	6	1	Coastal-Mainland	North Coast
4/23/2013	5	1	Open Water	D1
4/23/2013	15	1	Coastal-Mainland	North Coast
4/25/2013	1	1	Coastal-Island	Santa Cruz
4/25/2013	25	3	Coastal-Island	Santa Cruz
4/25/2013	8	2	Coastal-Island	Santa Cruz
5/7/2013	3	1	Open Water	D14
5/20/2013	1,000	10	Open Water	D6a
5/20/2013	75	1	Coastal-Island	Santa Barbara
5/20/2013	28	1	Coastal-Island	Santa Barbara
5/21/2013	55	2	Coastal-Island	San Clemente
5/21/2013	8	1	Coastal-Island	San Clemente
5/21/2013	14	1	Coastal-Island	San Clemente
5/21/2013	60	2	Open Water	D11
5/21/2013	25	1	Open Water	D11
5/21/2013	25	1	Open Water	D11
5/21/2013	15	1	Open Water	D11
Total	2,531	66		

Summer 2013

Date	Tons	Schools	Location Type	Transect
8/1/2013	28	2	Coastal-Mainland	South Coast
8/1/2013	5	1	Coastal-Mainland	South Coast
8/1/2013	6	4	Coastal-Mainland	South Coast
8/1/2013	3	1	Coastal-Mainland	South Coast
8/1/2013	1	1	Coastal-Mainland	South Coast
8/1/2013	3	1	Coastal-Mainland	South Coast
8/1/2013	15	3	Coastal-Mainland	South Coast
8/1/2013	27	3	Coastal-Mainland	South Coast
8/1/2013	9	1	Coastal-Mainland	South Coast
8/1/2013	100	20	Coastal-Mainland	South Coast
8/1/2013	10	2	Coastal-Mainland	South Coast
8/1/2013	600	13	Coastal-Mainland	South Coast
8/1/2013	100	25	Coastal-Mainland	South Coast
8/5/2013	3,426	366	Coastal-Mainland	North Coast
8/5/2013	15	1	Coastal-Mainland	North Coast
8/5/2013	25	1	Coastal-Mainland	North Coast
8/5/2013	70	2	Coastal-Mainland	North Coast
8/5/2013	20	1	Coastal-Mainland	North Coast
8/5/2013	545	13	Coastal-Mainland	North Coast
8/5/2013	220	7	Coastal-Mainland	North Coast
8/5/2013	80	4	Coastal-Mainland	North Coast
8/5/2013	50	2	Coastal-Mainland	North Coast
8/15/2013	1	1	Open Water	A10
8/20/2013	80	1	Coastal-Island	Anacapa
8/20/2013	13	4	Coastal-Island	Anacapa
8/20/2013	10	1	Coastal-Island	Santa Cruz
8/20/2013	8	1	Coastal-Island	Santa Cruz
8/28/2013	4	1	Coastal-Island	Catalina
8/28/2013	1	1	Coastal-Island	Catalina
8/28/2013	1	1	Coastal-Island	Catalina
8/28/2013	12	3	Coastal-Island	Catalina
8/28/2013	30	4	Coastal-Island	Catalina
8/28/2013	8	5	Coastal-Island	Catalina
8/28/2013	1	1	Coastal-Island	Catalina
8/28/2013	108	18	Coastal-Island	Catalina
8/28/2013	35	1	Coastal-Island	Catalina
9/23/2013	7	1	Coastal-Island	San Clemente
9/23/2013	15	1	Coastal-Island	San Clemente
9/23/2013	5	1	Open Water	E11
9/23/2013	3	1	Open Water	E8
9/24/2013	5	1	Open Water	E6
9/24/2013	5	1	Open Water	E6
9/24/2013	5	1	Open Water	E6
Total	5,714	524		

Spring 2014

Date	Tons	Schools	Location Type	Transect
5/13/2014	1	1	Coastal-Island	Catalina
5/14/2014	2,750	100	Coastal-Mainland	North Coast
5/14/2014	35	2	Coastal-Mainland	North Coast
5/14/2014	30	1	Coastal-Mainland	North Coast
5/14/2014	25	3	Coastal-Mainland	North Coast
5/14/2014	30	1	Coastal-Mainland	North Coast
5/14/2014	30	2	Coastal-Mainland	North Coast
5/14/2014	500	4	Coastal-Mainland	North Coast
5/16/2014	65	80	Coastal-Mainland	South Coast
5/16/2014	30	2	Coastal-Mainland	South Coast
6/19/2014	325	9	Coastal-Island	Santa Cruz
6/19/2014	170	7	Coastal-Island	Santa Cruz
6/19/2014	10	2	Coastal-Island	Santa Cruz
6/19/2014	17	2	Coastal-Island	Santa Cruz
6/19/2014	6	1	Coastal-Island	Santa Cruz
6/19/2014	8	2	Coastal-Island	Santa Cruz
6/19/2014	90	9	Coastal-Island	Santa Cruz
Total	4,122	228		

Summer 2014

Date	Tons	Schools	Location Type	Transect
08/04/14	28	7	Coastal-Mainland	North Coast
08/04/14	6	2	Coastal-Mainland	North Coast
08/04/14	4	5	Coastal-Mainland	North Coast
08/04/14	18	1	Coastal-Mainland	South Coast
08/08/14	1	2	Coastal-Island	Catalina
08/18/14	1	1	Coastal-Island	Santa Cruz
Total	58	18		

Summer 2015

Date	Tons	Schools	Location Type	Transect
Replicate 1				
8/10/2015	8	1	Coastal-Island	San Clemente
8/10/2015	10	1	Coastal-Island	San Clemente
8/11/2015	1	1	Coastal-Mainland	South Coast
8/11/2015	1	1	Coastal-Mainland	South Coast
8/11/2015	1	1	Coastal-Island	Catalina
8/13/2015	13	3	Coastal-Mainland	South Coast
8/13/2015	3	1	Coastal-Mainland	South Coast
8/26/2015	25	4	Coastal-Mainland	North Coast
8/26/2015	8	1	Coastal-Mainland	North Coast
8/26/2015	1	1	Coastal-Mainland	North Coast
8/26/2015	6	1	Coastal-Mainland	North Coast
8/26/2015	13	1	Coastal-Mainland	North Coast
8/26/2015	3	1	Coastal-Mainland	North Coast
8/26/2015	2	1	Coastal-Mainland	North Coast
8/26/2015	8	4	Coastal-Mainland	North Coast
8/26/2015	4	2	Coastal-Mainland	North Coast
Total	107	25		
Replicate 2				
10/2/2015	6	1	Coastal-Mainland	North Coast
10/2/2015	85	12	Coastal-Mainland	North Coast
10/2/2015	8	1	Coastal-Mainland	North Coast
10/3/2015	29	6	Coastal-Mainland	South Coast
10/3/2015	13	2	Coastal-Mainland	South Coast
10/3/2015	3	1	Coastal-Mainland	South Coast
10/3/2015	2	1	Coastal-Mainland	South Coast
10/3/2015	4	2	Coastal-Mainland	South Coast
10/3/2015	2	1	Coastal-Mainland	South Coast
10/3/2015	2	1	Coastal-Mainland	South Coast
10/3/2015	11	2	Coastal-Mainland	South Coast
10/3/2015	140	20	Coastal-Mainland	South Coast
10/3/2015	24	2	Coastal-Mainland	South Coast
10/3/2015	9	1	Coastal-Mainland	South Coast
10/3/2015	2	1	Coastal-Mainland	South Coast
Total	340	54		

Table 2. Summary of anchovy field data from summer 2013, spring 2014, and summer 2014 seasons. See text for final biomass estimates.

Summer 2013

Date	Tons	Schools	Location Type	Transect
8/1/2013	32	4	Coastal-Mainland	South Coast
8/1/2013	40	20	Coastal-Mainland	South Coast
8/5/2013	13,704	366	Coastal-Mainland	North Coast
Total	13,776	390		

Spring 2014

Date	Tons	Schools	Location Type	Transect
5/16/2014	51	8	Coastal-Mainland	South Coast
5/16/2014	1235	80	Coastal-Mainland	South Coast
5/31/2014	20	8	Coastal-Mainland	North Coast
5/31/2014	75	19	Coastal-Mainland	North Coast
5/31/2014	18	5	Coastal-Mainland	North Coast
5/31/2014	1750	65	Coastal-Mainland	North Coast
5/31/2014	750	50	Coastal-Mainland	North Coast
5/31/2014	2800	100	Coastal-Mainland	North Coast
6/5/2014	4	1	Coastal-Mainland	South Coast
6/5/2014	95	2	Coastal-Mainland	South Coast
6/5/2014	90	2	Coastal-Mainland	South Coast
6/5/2014	3	1	Coastal-Mainland	South Coast
Total	6,891	341		

Summer 2014

Date	Tons	Schools	Location Type	Transect
08/04/14	630	21	OpenWater	B16
08/04/14	350	11	Coastal-Mainland	South Coast
08/04/14	5	5	Coastal-Mainland	South Coast
Total	985	37		