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REPORT ON THE NMFS CALIFORNIA CURRENT ECOSYSTEM SURVEY (CCES) (APRIL AND JULY-AUGUST 2008)

Edited by
Sam McClatchie

NOAA-TM-NMFS-SWFSC-438

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

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ABSTRACT

Preliminary results from two coast-wide ecosystem surveys of the U.S. West Coast in April and July/August 2008 are presented in this report. The surveys were conducted in an abnormally cold year, strongly influenced by La Niña conditions during the spring spawning season of the Pacific sardine (*Sardinops sagax*). Spawning of sardine was only observed south of San Francisco and was concentrated south of 35°N, with strong indication of spawning extending south of the U.S.–Mexico border in waters that were not surveyed. No Pacific sardine spawning was observed in July/August except at the most southerly station. No evidence was found for spawning of Pacific sardine in northern California, Oregon, or Washington during these surveys.

Acoustic data provided a wealth of information on the distribution of larger plankton and fish that is relevant to assess forage for predators such as seabirds, but were of limited utility for biomass estimation of small pelagic fish. This was due to an unquantifiable contribution to "fish backscatter" from mesopelagic fish and zooplankton. The survey results highlight the need for better acoustic target identification, which is an issue that is currently being addressed with a new towed stereo camera.

Trawling results indicated that cooler surface temperatures might have impacted the movement of Pacific sardine. Compared to a previous coast-wide survey in 2006, sardines were larger in the southern area in 2008, a result that is consistent with delayed or restricted northern movement of sardine. Jack mackerel, Pacific mackerel, and Pacific sardine were absent from research trawl catches in the northern part of the survey in April 2008, but were caught south of 35°N. Pacific sardine were caught at inshore stations in the northern area in July/August. Northern anchovy were caught in both northern and southern areas in both seasons. Unfortunately, trawling was restricted south of San Francisco due to gear problems in July/August, which compromised results.

Seabird counts indicated a seasonal shift in dominant species, which is a result confirming previously published findings. Primarily piscivorous birds constituted 37% of the counts in April compared to 72% in July/August. Planktivorous seabirds such as the northward migrating red phalarope dominated counts in April, followed by the common murre that consume both plankton and small pelagic fish. In contrast, the most abundant species in July/August were summer-resident sooty shearwaters that are more piscivorous, again followed by common murres.

The results summarized in this report do not include ichthyoplankton larval data or hydrographic survey data, which at the time of publication are still being analyzed. Acoustic data are undergoing further analysis, plankton bongo net samples are being sorted for micronekton functional groups, and a detailed study of hydrography, acoustic backscatter and seabird distribution is underway to link predators, forage, and the oceanography.

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INTRODUCTION

The California Current Ecosystem Survey (CCES) was a two ship synoptic survey of the western U.S. coast of North America. The first survey (using the NOAA Ships *David Starr Jordan, DSJ,* and *Miller Freeman, MF*) was conducted in spring (*MF* working north to south from April 1 – May 3 and *DSJ* working south to north from March 24 – May 1, 2008). The second survey using only the *David Starr Jordan* extended the survey into the summer season (*DSJ* working north to south from July 6 – August 20, 2008), repeating most of the transect lines of the April survey, and applying the same methodologies. Although the primary objective was to collect data required for the biomass estimate of Pacific sardine (*Sardinops sagax*), additional data were collected to describe the pelagic ecosystem across a range of trophic levels.

The California Current system (CCS) has overall been in a cool phase since the 1998–2000 ENSO (El Niño – Southern Oscillation) event. A variety of system parameters responded strongly to this forcing. Examples of the parameters that responded strongly to this “regime shift” are sea surface temperature (SST) in many areas of the CCS (e.g., Monterey and the core CalCOFI area in the Southern California Bight), nutricline depth in the core CalCOFI area, concentrations of chlorophyll *a* in Monterey Bay, and zooplankton displacement volume in the CalCOFI area (McClatchie et al. 2008). Year 2008 values of these parameters suggest that this basic state of the system has not changed. The El Niño of 2006 was of moderate strength in the equatorial Pacific but had little effect on the CCS (Goericke et al. 2007). El Niño conditions ended in early 2007 and since the late spring of 2007 various indicators displayed La Niña conditions (e.g., the NINO 3.4 indicator). By early 2008 these indicators had attained values only previously observed during the strongest La Niñas of the last few decades (see review in McClatchie et al. 2008). Higher trophic levels did not respond systematically to the La Niña conditions in the CCS. The biomass of forage and predatory fish off Oregon and small pelagic fish off California is too variable to attribute any specific change to a single cause. Furthermore, if fish were directly affected by SST, as opposed to system state, these would be expected to respond to the unusually warm conditions off Oregon during the summer. Seabird productivity on the Farallon Islands might have been expected to be affected by the La Niña conditions. However, the timing of the upwelling season is another important factor. The response of seabird productivity during 2007 was mixed. Even though upwelling started early off central California and was strong, productivity for seabirds with conservative life histories showed only modest increases, with the exception of the common murre, which showed a dramatic change. Productivity of seabirds with flexible life histories remained very low, comparable to the previous two years.

The state of the California Current in 2008 is discussed in detail in McClatchie et al. 2008. This report presents a preliminary summary of results, prior to a more in depth analysis of the data collected on the two 2008 CCES surveys. At the time of publication of this report, several datasets or sample collections had not yet been completely processed. These include the hydrographic data from CTD casts and the ichthyoplankton data from net tows.

OBJECTIVES

- To conduct continuous underway temperature and salinity sampling of surface waters.
- To record current profiles throughout the duration of the cruise with the Acoustic Doppler Current Profiler.
- To collect information on sardine reproductive parameters, spatial distribution of size,

age and abundance of sardine, and acoustics ground truth information using trawling.

- To collect ichthyoplankton samples with Pairovet, Bongo and Manta nets.
- To estimate spawning biomass of Pacific sardine and other pelagic fish based on fish eggs and larvae, and adult reproductive parameters.
- To monitor environmental conditions within the survey area.
- To make continuous observations of sea birds (and marine mammals when possible).
- To record calibrated multifrequency acoustic backscatter in the upper 200 m on a continuous basis.

METHODS NOT DETAILED ELSEWHERE

CTD/Rosette

A CTD/rosette sampler carrying 3 loaded 2.5-liter hydrographic bottles was lowered to 500 meters (depth permitting) at each station to measure temperature, salinity, oxygen and phytoplankton fluorescence and collect water at discrete depths for analysis of salinity. Casts conducted on line 66.7 were made to a depth of 1000 meters.

Plankton sampling

Net sample processing protocols follow Kramer et al. (1972), Smith and Richardson (1977), and Moser et al. (2002).

CalCOFI Bongo

Standard oblique plankton tows, 300 meters of wire out, depth permitting, were made using paired 505 µm mesh nets with 71 cm diameter openings. The technical requirements for this tow are: descent wire rate of 50 meters per minute and an ascent wire rate of 20 meters per minute. All tows with ascending wire angles lower than 38^o or higher than 51^o in the final 100 meters of wire were repeated. Additionally, a 45^o wire angle was maintained during the ascent and descent of the net frame. All nets (Bongo, Pairovet, and Manta, see below) were rinsed at the conclusion of each tow. The port side sample was preserved in buffered ethanol at every station, while the starboard sample was preserved in buffered formalin.

Manta net (neuston) tow

Neuston samples were collected using a 505 µm mesh net on a frame with a mouth area of 0.1333 m^2. Tows were 15 minutes in duration at a towing speed of approximately 1.5 - 2.0 knots. Wire angles were kept between 15^o and 25^o (or deviations noted).

Pairovet net

Vertical tows were fished from 70 meters to the surface (depth permitting) using paired 25 cm diameter 150 µm mesh nets at all stations. In addition, if sardine eggs were present beyond the westernmost station, Pairovet sampling was continued at 4 mile intervals as long as more than one egg per minute was counted in the CUFES sample. The technical requirements for Pairovet tows are: descent rate of 70 meters per minute, a terminal depth time of 10 seconds and an ascent rate of 70 meters per minute. All tows with wire angles exceeding 15^o during the ascent were repeated where possible.

ADCP (Acoustic Doppler Current Profiler)

The ship's ADCP was run continuously and logged to a data acquisition system. The ADCP was not available on the July/August cruise of the *DSJ* due to equipment failure. Data were stored as 5-minute ensemble averages of currents in 8-meter depth bins.

MULTIFREQUENCY ACOUSTICS SURVEY, by J. Zwolinski, D. A. Demer, G. R. Cutter Jr., T. S. Sessions, J. Renfree, D. Griffith, and S. McClatchie

Introduction

California Current Ecosystem (CCE) surveys were conducted in the spring and summer of 2008 to assess the spatial distributions of pelagic fish, ichthyoplankton, and fish eggs, principally the Pacific sardine (*Sardinops sagax*), from offshore of the northern tip of Vancouver Island, B.C., Canada to San Diego, CA using acoustical and direct-capture methods. The surveys also describe attributes of the pelagic habitat. This section reports on the active-acoustic sampling during the CCE surveys conducted aboard the NOAA Ships *Miller Freeman* and *David Starr Jordan*. Described are the acoustic devices, calibrations, operations, analyses, and preliminary results.

Sardine are important commercially and ecologically. Sardine have supported a major fishery on west coast of the U.S. from the early 1900s, until the stocks declined beginning in the 1940s, and reached a minimum in the 1970s (Hill et al. 2006). Sardine are a key member of the pelagic ecosystem as consumers of phytoplankton, copepods, and euphausiids, for example, and as high energy prey for other fishes (Emmett et al. 2005), sea birds, and marine mammals.

Routine scientific monitoring of sardine populations and ecology has been a major focus of the CalCOFI program since 1949. The surveys described by this report largely followed sampling lines developed for the CalCOFI program in the region south of Cape Mendocino. Further north, the California Current is similarly sampled as far as the Canadian border. These observations provide a continuation of long time-series data for understanding and managing sardine and their environment.

Objectives

The overall objectives of the 2008 CCE surveys were to: 1) describe the spatial distribution of eggs, larvae, and adult *S. sagax* along the entire west coast of the United States of America; 2) gather data for estimating spawning biomass; and 3) collect acoustic data from scientific echosounders, characterize the water-column environment, record current profiles; and collect observations of marine mammals and sea birds.

The objectives of the active-acoustic portion of the survey were to: 1) acoustically map the distributions and estimate the biomasses of coastal pelagic fishes; 2) characterize their biotic and abiotic environment; 3) investigate ecological linkages; and 4) gather information about fish schooling behavior, diel vertical migration, and avoidance reactions to the survey vessel. This report provides details of the echosounder data that were collected and a cursory look at the preliminary results.

Description of operations

The *DSJ* surveyed the west coast of the United States from 24 March – 1 May 2008 (spring) and 30 June–20 August 2008 (summer). The *MF* surveyed the northern west coast of the United States from 26 March–3 May 2008 (spring).The *DSJ* and the *MF* were both equipped with multi-frequency, split-beam echosounders (Simrad EK60) which were used to continuously record acoustic backscatter from marine biota while underway and on station. Four echosounders were operated on *DSJ* at 38, 70, 120, and 200 kHz, and four were operated on *MF* at 18, 38, 120, and 200 kHz. Each echosounder was calibrated prior to the survey using the standard sphere method.

Additional underway measurements on each ship included those from a suite of meteorological sensors, a continuous underway fish egg sampler (CUFES) and an acoustic Doppler current profiler (ADCP). Daytime underway operations also included bird and mammal observations. At prescribed and ad-hoc stations, both vessels collected water samples from a CTD-rosette and ichthyoplankton samples from plankton nets. At some of these and other locations, surface trawls collected fish at night from the *DSJ*.

Summary of results

Numerous species of fish and invertebrates were caught by the surface trawls on the *DSJ* and *MF*. The fish species caught in highest abundances were the northern anchovy (*Engraulis mordax*), Pacific sardine (*Sardinops sagax*) and Pacific mackerel (*Scomber japonicus*). Acoustic scattering from fish alone was identified using differences in volume backscattering strength (S_v) measured at multiple frequencies and by visual inspection of the echograms, allowing fish biomass density to be estimated from the 38 kHz echosounder data. The mean anchovy and sardine biomass estimates from the 38 kHz S_v data collected on the *MF* during the spring CCE survey were 0.000806093 kg m^{-2} (CV = 44.6%) and 0.0001565562 kg m^{-2} (CV = 44.6%), respectively. For the *DSJ* summer CCE survey, the estimates of anchovy and sardine were 0.000282354 kg m^{-2} (CV = 17.9%) and 0.001932028 kg m^{-2} (CV = 17.9%). Estimates from the spring *DSJ* cruise are not available due to corrupted data files. Work continues to remedy these issues.

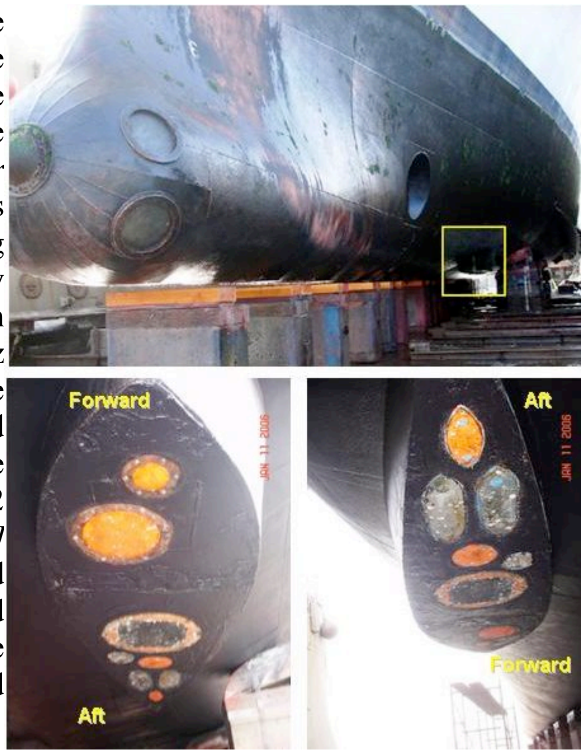

Figure 1. Locations and arrangement of EK60 transducers on *David Starr Jordan*.

Methods
Active-acoustics data collection
David Starr Jordan

Equipment: The EK60 echosounder system operated at 38, 70, 120, and 200 kHz and interfaced to a data acquisition system to estimate small pelagic and krill biomass between ~7 and 250 m. The echosounder transducers on *DSJ* are mounted ~2.75 m below the mean water surface in a blister located on the port side of the ship, toward the bow, and beneath the wheelhouse (Figure 1). The vessel's depth sounders were used minimally at the discretion of the Commanding Officer, but normally remained off while underway.

Calibrations: The echosounders aboard the *DSJ* were calibrated in San Diego Bay on 24 March (pre-cruise) and 24 August 2008 (post-cruise). The vessel was anchored at approximately 18:00 GMT (10:00 PST) at a site near Harbor Island in the San Diego Bay, within the charted special anchorage near 32º 43.2' N, 117º 11.9' W. Pre-cruise, the weather was calm and the current was low; the environmental conditions were: *SST*=14.9 ºC; *SSS*= 33.27 psu; and *c*= 1508.3 m s^{-1}, as measured with a thermosalinograph (Seabird TSG SBE 21). Post-cruise, the environmental conditions were: *SST*=22.6 ºC; *SSS*= 33.97 psu; and *c*= 1527.3 m s^{-1}.

The standard calibration sphere, 38.1 mm diameter and made from tungsten carbide with 6% cobalt binder, was suspended from a monofilament loop affixed into a spark eroded hole with epoxy. The sphere was lowered below the vessel by three lines, each remotely controlled with a motorized downrigger. The downriggers were labeled Aft, Mid, and Fwd. Aft and Fwd were attached to the 02 rail on the port side, aft and forward of the transducer array, respectively; and Mid was attached to the 02 rail on the starboard side, at the location of the array, making a triangular suspension for the sphere. The three stainless steel downrigger lines terminated with swivels and metal clips; each clip was connected to a 2 m length of monofilament line which converged at the sphere. A 2 kg weight was suspended below the sphere by a single 2 m length of monofilament line.

Raw data were recorded with the Simrad ER60 software. Sphere target strength (*TS*) measurements were recorded and processed with the ER60 Calibration program to estimate the system calibration parameters. The range to the sphere was maintained between 9.5 and 10.5 m. In order of increasing frequency, the echosounders were calibrated for the pulse duration and power levels used during the survey (Table 1).

Table 1. Results of the EK60 calibrations aboard the NOAA Ship *David Starr Jordan* on 24 March (pre-cruise) and 24 August 2008 (post-cruise), and comparison data from two previous calibrations (27 March 2007 and 5 April 2006). Bold calibration parameters were used during the CCE08 survey. Note that the system gain (G_{TS}) at 120 kHz (highlighted grey) appears to be unstable vs. time, making that channel inaccurate and increasingly insensitive.

Frequency (kHz)	**38**	**70**	**120**	**200**
Transducers	ES38-B	ES70-7C	ES120-7	ES200-7C
Transducer SN	27281	108	27612	238
Downrigger Aft	59	60	59	60
Downrigger Mid	59	58	58.5	58
Downrigger Fwd	59	57.5	59	58
Angle Sensitivity	**21.90**	**23.00**	**21.00**	**23.00**
Beamwidths (alo/ath)	**6.7°/6.9°**	**7.0°/7.0°**	**7.2°/7.2°**	**7.2°/7.1°**
Angle Offsets (alo/ath)	**0°/0°**	**0°/0°**	**0°/0°**	**0°/0°**
EBA (dB)	**-21.0**	**-21.0**	**-20.5**	**-20.6**
Depth offset (m)	**0**	**0**	**0**	**0**
Transmit power (W)	**2000**	**1000**	**500**	**300**
Pulse duration (μs)	**1024**	**1024**	**1024**	**1024**
Pulse interval (s)	**0.5**	**0.5**	**0.5**	**0.5**
24 August 2008				
Absorption Coeff. (dB/m)	0.00690	0.02030	0.04500	0.07740
Sphere Range (m)	5.5-7.0	5.5-7.0	5.5-7.0	5.5-7.0
TS Theory (dB)	-42.38	-41.65	-39.82	-38.79
G_{TS} (dB)	25.41	26.27	19.93	25.71
Sa_corr (dB)	-0.63	-0.34	-0.66	-0.19
RMS (dB)	0.24	0.26	0.29	0.39
24 March 2008				
Noise Estimate (dB)	[-120, -129]	[-127, -140]	[-135, -149]	[-140, -150]
Absorption Coeff. (dB/m)	0.00841	0.02201	0.04086	0.06066
Bottom range (m)	14.0	13.9	13.8	13.6
Sphere Range (m)	9.5-10.5	9.5-10.5	9.5-10.5	9.5-10.5
TS Theory (dB)	-42.42	-41.55	-39.62	-38.90
G_{TS} (dB)	**25.74**	**26.67**	**20.90**	**25.15**
Sa_corr (dB)	**-0.60**	**-0.28**	**-0.66**	**-0.27**
RMS (dB)	0.13	0.31	0.47	0.36
27 March 2007				
G_{TS} (dB)	25.44	26.09	21.24	25.26
Sa_corr (dB)	-0.61	-0.31	-0.53	-0.28
RMS (dB)	0.5	0.50	0.78	0.59
5 April 2006				
G_{TS} (dB)	25.46	26.11	22.42	25.60
Sa_corr (dB)	-0.62	-0.34	-0.53	-0.29
RMS (dB)	0.30	0.39	0.36	0.78

Miller Freeman

Equipment: The EK60 echosounder system operated at 18, 38, 120, and 200 kHz and interfaced to a data acquisition system to estimate small pelagic and krill biomass between ~12 and 250 m. The echosounder transducers on the *MF* are mounted in a retractable keel which positions them ~9.15 m below the water surface. The vessel's depth sounders were used minimally at the discretion of the Commanding Officer, but normally remained off while underway. The ADCP was set to receive an external trigger from the EK60 to avoid cross talk.

Calibration: Calibration data was supplied by the Resource Assessment and Conservation Engineering (RACE) Division of the Alaska Fishery Science Center (AFSC). The most recent calibration was performed on 14 February 2008 at a transducer temperature of 2.7 °C. To characterize the changes in echosounder-transducer performances vs. water temperature (Demer and Renfree 2008), the historical *TS* gain data were linearly-regressed vs. seawater/transducer temperature (T; °C), resulting in the following equations:

$$TSgain_{18kHz} = -0.0488T + 22.776 \text{ dB};\ R^2 = 0.92 \quad (1)$$
$$TSgain_{38kHz} = -0.0323T + 26.568 \text{ dB};\ R^2 = 0.89 \quad (2)$$
$$TSgain_{120kHz} = -0.00353T + 26.720 \text{ dB};\ R^2 = 0.82 \quad (3)$$
$$TSgain_{200kHz} = -0.0355T + 25.253 \text{ dB};\ R^2 = 0.44 \quad (4)$$

These equations were used to estimate the calibrated system gains (Table 2) appropriate for the environmental conditions off Port Angeles, Washington (SST = 6.5 °C; SSS = 32.4 psu; and c = 1472.5 m s^{-1}). On 30 March 2008, echosounder calibration parameters were entered into the ER60 software controlling the EK60 echosounders aboard the *MF*.

Table 2. Acoustic calibration values used for the April survey aboard the NOAA Ship *Miller Freeman*. System noise values were estimated while the *MF* was docked in Port Angeles, Washington on 30 March 2008. The parameters used during the spring CCE 2008 survey are bold.

Frequency (kHz)	18	38	120	200
Transducers	ES18-11	ES38-B	ES120-7C	ES200-7C
Transducer SN	2074	30595	300	321
Noise Estimate (dB)	[-128, -123]	[-150, -155]	[-142, -146]	[-156, -162]
Angle Sensitivity	**13.90**	**21.90**	**21.00**	**23.00**
Beamwidths (alo/ath)	**10.31° /10.43°**	**6.7° /6.9°**	**7.2° /7.2°**	**7.2° /7.1°**
Angle Offsets (alo/ath)	**0.0° /0.0°**	**0.0° /0.0°**	**0.0° /0.0°**	**0.0° /0.0°**
EBA (dB)	**-17.3**	**-21.0**	**-20.5**	**-20.6**
Transmit power (W)	**2000**	**2000**	**500**	**100**
Pulse duration (µs)	**1024**	**1024**	**1024**	**1024**
Pulse interval (s)	**0.66**	**0.66**	**0.66**	**0.66**
Absorption Coefficient (dB/m)	**0.002749**	**0.009535**	**0.031141**	**0.044335**
G_{TS} (dB)	**22.46**	**26.36**	**26.49**	**25.02**
Sa_corr (dB)	**-0.77**	**-0.58**	**-0.30**	**-0.47**

DSJ and *MF* data collections: EK60 data was collected to 250 m depths by simultaneously transmitting 1024 µs duration pulses at four frequencies every 0.665 seconds. The echoes were sampled every 0.196 m (ER60; .raw data format). Simrad ER60 (Version 2.1.2) software was used to log the .raw files to a networked file server. Data backups were made at regular intervals to USB V2.0 external hard disk.

Active-acoustics data processing

Data were processed following the protocol developed for the 2006 sardine survey (Cutter and Demer 2008), using Myriax Echoview software (V4.60.49). First the .raw EK60 data were checked for errors using Echocheck (V4.50.1.11235). If necessary, files were corrected by a custom routine implemented in Matlab (V7.6.0). Then, Echozip 60 was used to create .ek60 files from the .raw datafiles, retaining only data from the 38 and 200 kHz frequencies. The .ek60 files were loaded into an Echoview fileset to create one .ev file per transect using a custom data processing template.

Echograms of volume backscattering strength (S_v; m^2 m^{-3}) at each of the two frequencies were displayed. An integration start line was created at a fixed depth (*MF*: 3 m below the transducer, roughly 12 m from the sea surface; *DSJ*: 4 m below the transducer, roughly 7 m from the sea surface). An integration stop line was created 2 m above the 38 kHz sounder detected bottom or at 250 m when the bottom was deeper. The S_v echograms were filtered for on-station periods using a slow (i.e. < 5 knots) ship-speed mask as a proxy. The difference between S_v at 200 kHz and S_v at 38 kHz ($S_{v\,200}$- $S_{v\,38}$) was used to retain only the S_v data at 38 kHz from fish with swimbladders (-14 dB < $S_{v\,200}$- $S_{v\,38}$ < 5 dB). The resulting masked 38 kHz-S_v data were thresholded at S_v = –60 dB, integrated over 10 m depth by 1 nmi long cells and output to .csv files. The echograms were visually inspected to filter regions with high S_v from planktonic targets not removed by the aforementioned algorithm that could bias the estimation of abundance of pelagic fish.

The .csv files were imported into R (V2.8.0). Prior to vertical integration, each cell was classified according to the most likely source of scattering. Cells that were within visually defined regions of high planktonic backscatter were classified “no fish.” In the remaining areas, i.e., areas with little or low backscatter from plankton, the integration cells were classified as “fish” if their maximum S_v exceeded -38 dB; otherwise the cell was assigned to “no fish”. The cells classified as fish were integrated vertically from 12-70 m (*MF*) or 7-70 m depth (*DSJ*) to obtain values of nautical area backscattering coefficient s_A (aka *NASC* ; m^2 nmi^{-2}) and to convert them to fish density (kg m^{-2}). The integration files were filtered by the average speed of each 1-nmi-long cell, excluding those cells whose durations were higher than 12 minutes (~5 knots). This step was required as Echoview's integration-by-cell routine only excludes cells in which all pings fall within the speed criteria; cells with partial coverage at the intended speed negatively bias the echo-integral of the cell.

The s_A values were converted to biomass densities using combined target strength-to-length and length-to-biomass relationships developed by Barange and Hampton (1997). The relationships for the Atlantic anchovy species (*E. capensis*) and sardine (*S. sagax*) are based on *in-situ* target strength (*TS*) measurements (Barange et al. 1996):

$$TS\ (\mathrm{dB/kg}) = -12.1*\log L_t-21.1 \text{ for anchovy; and} \qquad (5)$$

$$TS\ (\mathrm{dB/kg}) = -14.9*\log L_t-13.2 \text{ for sardine,} \qquad (6)$$

where L_t (cm) is total fish length determined from the trawls. Calculations were performed using distributions of fish length estimated from the trawl catches. Note that Equations (5) and (6) predict ~5 dB difference in *TS* kg^{-1}, for anchovy and sardine of the same length. Backscatter attributed to fish by the aforementioned algorithm was assumed to arise from either sardine or anchovy. The proportion of the backscatter from each species was obtained by $w_i \times \sigma_{bs_i} / \Sigma(w_i \times \sigma_{bs_i})$, where represents the total weight of sardine or anchovy and σ_{bs_i} is their respective average backscattering cross-sectional area. The σ_{bs} and w values were derived from the length composition and total catches of the pooled set of sampled fish during the survey, respectively. In the case of the spring *MF* survey, the amount of fish captured did not provide reliable length distributions for sardine and anchovy, and therefore, the information used to calculate biomass from s_A was obtained from the trawls performed on the spring *DSJ* survey (Table 3).

Table 3. Proportion of acoustic backscatter allocated to sardine and anchovy based on the length distribution and frequency obtained on the spring and summer *DSJ* surveys.

	Anchovy				Sardine			
Survey	Mean length (cm)	σ_{bs}	Total catch (kg)	% of acoustic backscatter	Mean length (cm)	σ_{bs}	Total catch (kg)	% of acoustic backscatter
Spring	12.57	0.0003611379	531.18	0.786	21.8	0.0005111594	103.23	0.214
Summer	12.76	0.0003611379	378.11	0.087	20.54	0.0005540745	2587.27	0.913

The surveys were conducted along regularly-spaced parallel transects. Each east-west transect was considered a sampling unit. The method of Jolly and Hampton (1990) was used to estimate biomass density and sampling variance from the transect data, assuming that the fish were randomly distributed throughout the survey area. The coefficient of variation (CV) was calculated as the ratio of the standard deviation (s.d.) to the mean of the mean density for each transect. Distributions of epipelagic swim-bladdered fish (e.g. anchovy and sardine) were mapped in space using R (V2.8).

Results

Spring 2008

The CCE survey quasi-synoptically covered the western U.S. coast using two ships. The *DSJ* conducted operations in the Southern California Bight and north to San Francisco. The *MF* conducted similar operations from San Francisco to the Canadian border during the same period.

The .raw files from the spring CCE survey aboard *DSJ* were largely (~66%) corrupted. Efforts are underway to restore the integrity of as many of these files as possible using binary editing. Therefore, this report only includes results from the spring CCE survey aboard *MF* and the summer survey aboard *DSJ*.

The acoustic backscatter attributed to fish by the difference between S_v at 200 kHz and S_v at 38 kHz appears to be contaminated from other gas-bearing sound scatterers, e.g. mesopelagic fish ascending at night, or plankton. After additional post-processing to remove unwanted echoes (Table 4), highest densities of “swim-bladdered fish” were observed in the central, southern and coastal areas (Figure 2). However, the trawl catches in these areas did not include sardine, anchovy, and mackerel (collectively referred to as coastal pelagic species or CPS). Visual inspection of the echograms also indicated only a few candidate schools of CPS in the sampled region between 12-70 m depth (Table 4, Figure 3).

Following the procedures of Jolly and Hampton (1990), and assuming that the fish had a composition and length distribution similar to those obtained further south by the *DSJ*, the mean biomass densities for the west-east transects 1-18 were 0.000806093 kg m^{-2} (CV = 44.6%) and 0.0001565562 kg m^{-2} (CV = 44.6 %) for anchovy and sardine, respectively. A summary of all transects is provided in Tables 5 and 6.

Table 4. Descriptions of acoustic transects from the NOAA Ship *Miller Freeman* during the spring CCE survey.

Transect name	Start Latitude	Start Longitude	Start Time	Start Date	End Latitude	End Longitude	End Time	End Date	Comments/actions taken
Transect 1	48º 23.32' N	124º 34.94 W	0559	04-Apr-08	48º 24.50' N	127º 53.82' W	1701	04-Apr-08	The transect apparently starts within the “Fjord”. One continuous transect without fishing stations. Weak scattering layer (used Sv maximum threshold).
Transect 1 to 2									Offshore section (used Sv maximum threshold).
Transect 2	47º 44.92' N	127º 37.62' W	0104	05-Apr-08	47º 44.49' N	124º 38.52' W	1849	05-Apr-08	Offshore-onshore. 3 segments between 2 trawls. Fish schools at 180 m depth. Weak scattering layer (used Sv maximum threshold).
Transect 2 to 3									Onshore section (used Sv maximum threshold).
Transect 3	46º 40.56' N	124º 14.17' W	0630	06-Apr-08	47º 00.58' N	127º 13.52' W	2310	06-Apr-08	Onshore-offshore. 3 interruptions for CTD+Bongo. 1 Trawl station performed prior to the transect. Two fish schools at the shelf break. Weak scattering layer (used Sv maximum threshold).
Transect 3 to 4									Offshore section (used Sv maximum threshold).
Transect 4	46º 23.22' N	127º 15.45' W	0930	07-Apr-08	46º 20.5' N	124º 12.99" W	0016	08-Apr-08	Offshore-onshore. 3 segments between 2 CTD stations. Trawls performed at the beginning and end of the transect. Fish schools at 250 m next to the shelf break. Few schools on the shelf. Surface noise down to 20 m. Surface noise up to Interval 55 (excluded). Weak scattering layer afterwards (used Sv maximum threshold)
Transect 4 to 5									Onshore segment (used Sv maximum threshold).

Table 4. Continued.

Transect name	Start Latitude	Start Longitude	Start Time	Start Date	End Latitude	End Longitude	End Time	End Date	Comments/actions taken
Transect 5	45º 21.00' N	124º 07.67' W	1547	08-Apr-08	45º 39.2' N	126º 53.41' W	0846	09-Apr-08	Onshore-offshore. 2 interruptions for CTD+Bongo or trawls. 1 Trawl performed at the end of the transect. Few schools on the shelf. Diffuse resonant layer from mid-transect to the end. Weak scattering layer up to Interval 60 (used Sv maximum threshold). Excluded beyond Interval 60.
Transect 5 to 6									Offshore segment (used Sv maximum threshold).
Transect 6	45º 01.43' N	127º 02.80' W	1704	09-Apr-08	45º 01.80' N	124º 11.10' W	0932	10-Apr-08	Offshore-onshore. 2 interruptions for CTD+Bongo or trawls. 1 Trawl performed at the beginning of the transect. Diffuse resonant layer from the start of the transect until mid-transect. Fish schools at mid-transect. Weak scattering layer (used Sv maximum threshold).
Transect 6 to 7									Onshore segment (used Sv maximum threshold).
Transect 7	44º 01.01' N	124º 16.66' W	2127	10-Apr-08	44º 20.96" N	126º 59.28' W	1515	11-Apr-08	Onshore-Offshore. 2 interruptions for CTD+Bongo or trawls. 1 Trawl performed at the beginning of the transect. Fish schools from the ~90 m isobath off to the shelf break. Persistent diffuse resonant layer throughout the transect.
Transect 7 to 8									Offshore segment (used Sv maximum threshold).
Transect 8	43º 42.77' N	126º 59.84' W	2229	11-Apr-08	43º 40.82' N	124º 19.70' W	1506	12-Apr-08	Offshore-onshore. 2 interruptions for CTD+Bongo or trawls. Diffuse resonant layer from the start of the transect until mid-transect. Fish schools at mid-transect (~230 isobath). Weak scattering layer (used Sv maximum threshold).

Table 4. Continued.

Transect name	Start Latitude	Start Longitude	Start Time	Start Date	End Latitude	End Longitude	End Time	End Date	Comments/actions taken
Transect 8 to 9									Onshore segment (used Sv maximum threshold).
Transect 9	43º 22.4' N	124º 29.9' W	1103	13-Apr-08	43º 00.81' N	126º 09.83W	1855	13-Apr-08	Onshore-offshore. 1 interruption for CTD+Bongo or trawls. 1 Trawl performed at the beginning of the transect. Missing part of the last half of the track. Maybe due to the noise reported in the log? Persistent diffuse resonant layer throughout the transect. Few fish schools.
Transect 9 to 10									Does not exist
Transect 10	42º 25.22' N	127º 16.61' W	0612	19-Apr-08	42º 20.49' N	124º 30.44' W	2233	19-Apr-08	Offshore-onshore. 2 interruptions for CTD+Bongo or trawls. 1 Trawl performed at the start of the transect. Diffuse resonant layer from the start of the transect until 4/5 of the transect. Fish schools at 4/5. Strong scattering layer up to interval 129 (excluded). Weak scattering layer from then onwards (used Sv maximum threshold).
Transect 10 to 11									Onshore segment. Fish schools in waters deeper than 70 m (used Sv maximum threshold).
Transect 11	41º 39.44' N	124º 17.93' W	0734	20-Apr-08	41º 40.35' N	127º 47.26' W	0837	21-Apr-08	Onshore-offshore. 3 interruptions for CTD+Bongo or trawls. 1 trawl at the start and 1 at the end. Diffuse resonant layer. Weak scattering layer (used Sv maximum threshold).
Transect 11 to 12									Offshore segment (used Sv maximum threshold).

Table 4. Continued.

Transect name	Start Latitude	Start Longitude	Start Time	Start Date	End Latitude	End Longitude	End Time	End Date	Comments/actions taken
Transect 12	41º 00.34' N	127º 50.80 W	1704	21-Apr-08	41º 03.56' N	124º 12.31' W	0420	23-Apr-08	Offshore-onshore. 3 interruptions for CTD+Bongo or trawls. 1 Trawl performed at the end of the transect. Diffuse resonant layer. Lots of fish schools at the shelf break. Weak scattering layer (used Sv maximum threshold).
Transect 12 to 13									Onshore segment (used Sv maximum threshold).
Transect 13	40º 20.04' N	124º 29.47 W	1437	23-Apr-08	40º 19.67' N	127º 56.89' W	1105	24-Apr-08	Onshore-offshore. 2 interruptions for CTD+Bongo or trawls. 1 Trawl performed at the end of the transect. No fish schools. Diffuse resonant layer. Weak scattering layer (used Sv maximum threshold).
Transect 13 to 14									Offshore segment (used Sv maximum threshold)
Transect 14	39º 41.47' N	127º 31.75' W	2016	24-Apr-08	39º 40.70' N	124º 03.65' W	1955	25-Apr-08	Offshore-onshore. 3 interruptions for CTD+Bongo or trawls. No fish schools. Diffuse resonant layer. Few fish schools in deep water. Weak scattering layer (used Sv maximum threshold).
Transect 14 to 15									Onshore segment (used Sv maximum threshold).
Transect 15	39º 01.05' N	123º 47.40' W	0157	26-Apr-08	39º 00.65' N	127º 11.62' W	2133	26-Apr-08	Onshore-offshore. 3 interruptions for CTD+Bongo or trawls. Diffuse resonant layer. Fish schools near the shelf break in deep waters. Resonant scattering layer.
Transect 15 to 16									Offshore segment (used Sv maximum threshold).

Table 4. Continued.

Transect name	Start Latitude	Start Longitude	Start Time	Start Date	End Latitude	End Longitude	End Time	End Date	Comments/actions taken
Transect 16	37º 12.16' N	126º 15.00' N	1605	27-Apr-08	38º 21.05' N	123º 39.71' W	0940	28-Apr-08	Offshore-onshore. 3 interruptions for CTD+Bongo or trawls. Diffuse resonant layer. No fish schools. Resonant scattering layer. Weak scattering layer (used Sv maximum threshold).
Transect 16 to 17									Onshore segment (used Sv maximum threshold).
Transect 17	37º 51.21' N	123º 01.41' W	1615	28-Apr-08	36º 36.84' N	125º 46. 25' W	1313	29-Apr-08	Onshore-offshore. 4 interruptions for CTD+Bongo or trawls. Diffuse resonant layer. Lots of fish schools.
Transect 17 to 18									Offshore segment (used Sv maximum threshold).
Transect 18	36º 03.76' N	125º 21.54' W	2129	29-Apr-08	37º 45.00' N	122º 39.01 W	1522	30-Apr-08	Offshore-onshore. 1 interruption for CTD+ Bongo or trawls. Few fish schools. Resonant scattering layer. Weak scattering layer (used Sv maximum threshold).

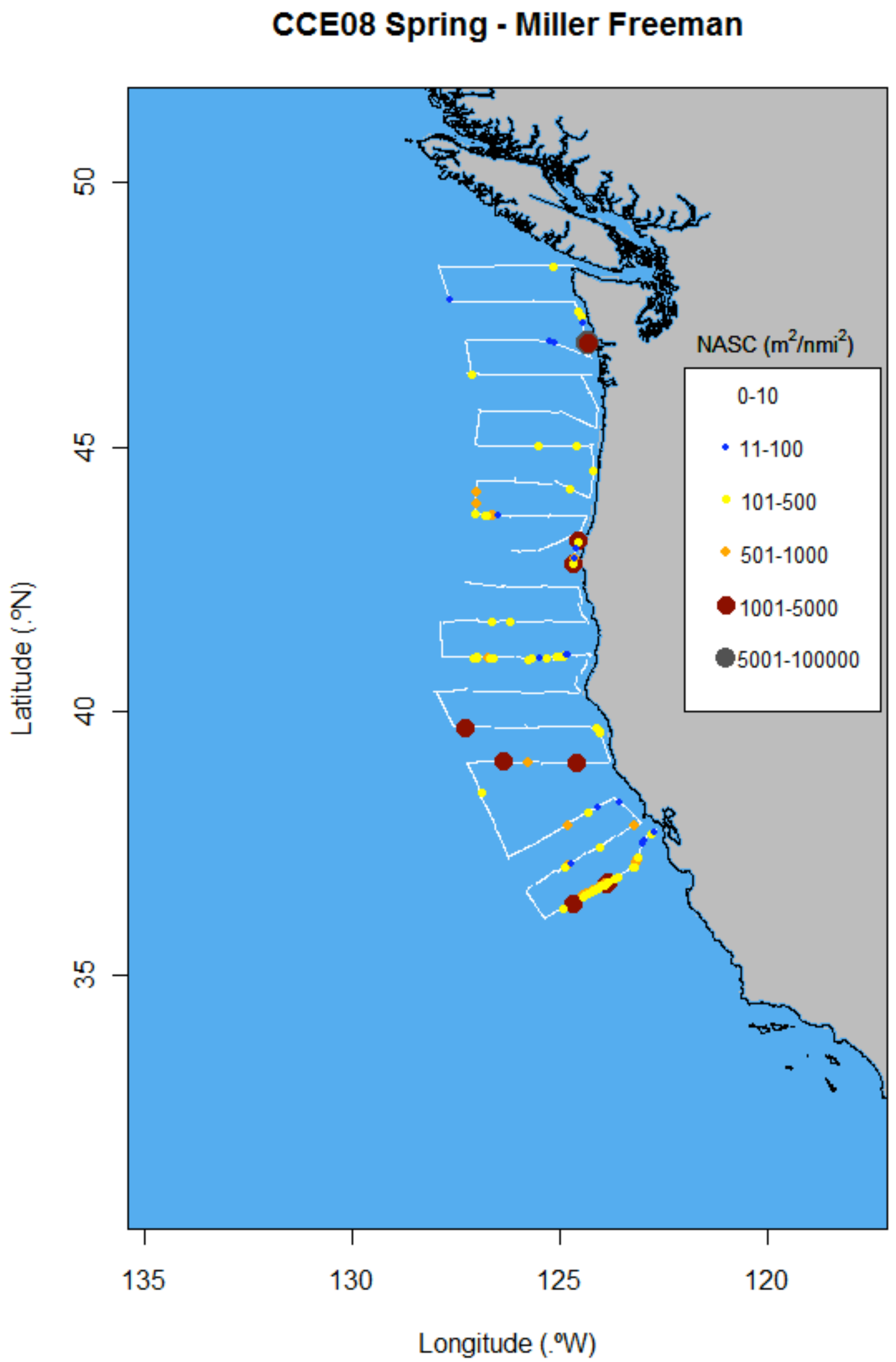

Figure 2. Integrated volume backscattering coefficients at 38 kHz (s_A; m^2 nmi^{-2}) attributed to fish with swim-bladders at 12-70 m depths (colored dots). The largest $s_A \approx 5{,}000$ m^2 nmi^{-2} was mapped off the mouth of the Columbia River in the coastal segment between transects 2 and 3.

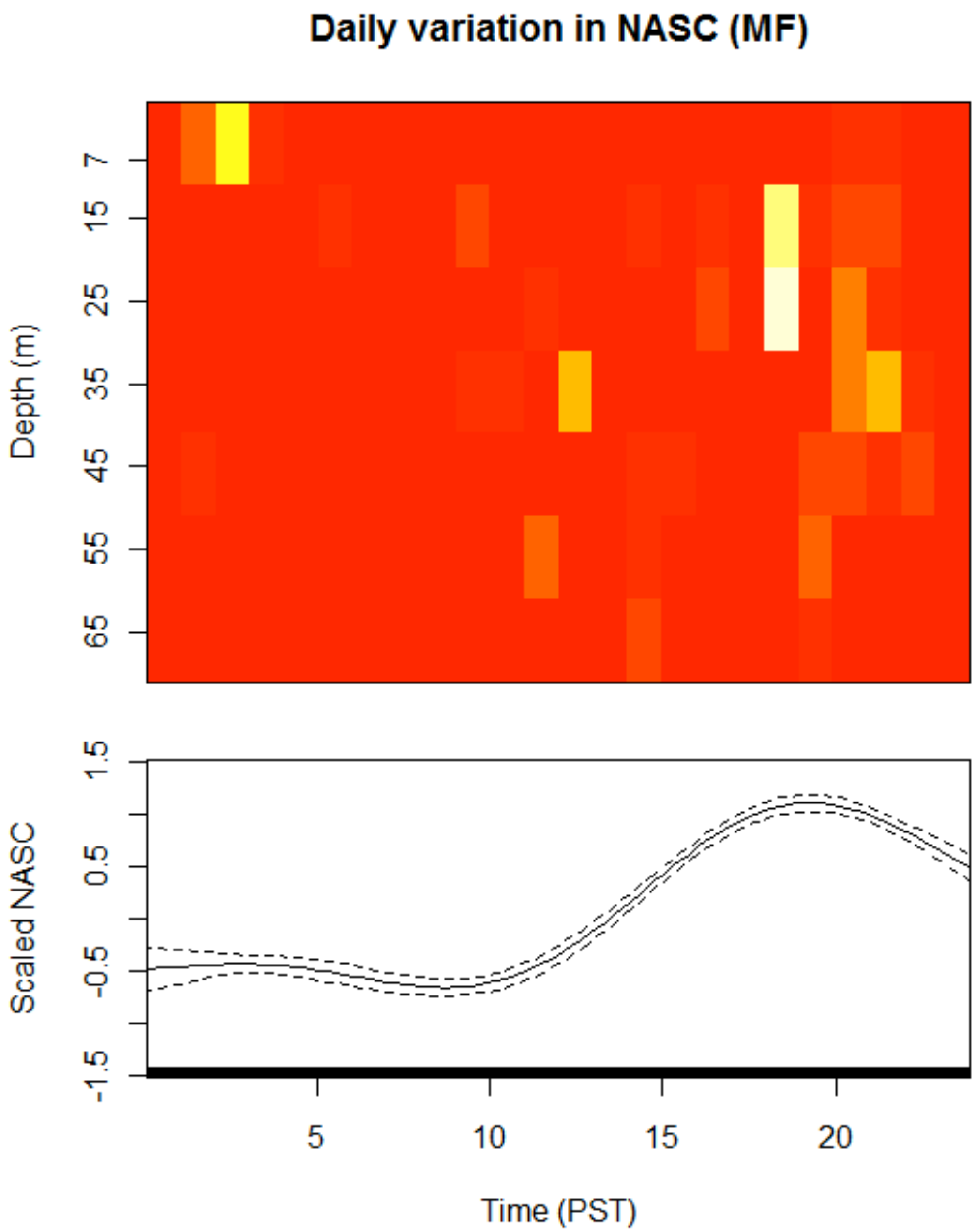

Figure 3. Average s_A (m^2 nmi^{-2}) at 38 kHz after dB-difference and visual filtering vs. depth (10 m bins) and time of day (hour PST). The lower graph shows the daily trend in normalized s_A. The trend is mainly driven by a few number of schools isolated off the mouth of the Columbia River around 7 p.m. PST.

Table 5. Preliminary estimates of biomass density for anchovy, assuming that all of the backscatter is from a mixture of sardine and anchovy. The conversion from s_A to biomass density was done according to Equations (5) and (6) with a species proportion based on the net samples from the spring *DSJ* survey. The mean biomass density = 0.000806093 kg m^{-2}, CV = 44.6%.

Transect	Segment	Length (nmi)	Biomass Density (kg/m^2)	Standard Deviation
1		131	0.00007590456	0.0008687674
	1	43	0.00003.693095	0.0002421724
2		126	0	0
	2	65	0.006.338121	0.0383272797
3		118	0.00007175180	0.0005487810
	3	40	0.0001408176	0.0008906090
4		127	0	0
	4	85	0	0
5		123	0	0
	5	42	0	0
6		129	0.0001139587	0.0009121606
	6	63	0.0001761589	0.0013982179
7		121	0.00005673939	0.0006241333
	7	40	0.002300020	0.0093563750
8		117	0.001027380	0.0056086011
	8	108	0.001856987	0.0105030605
9		74	0	0
	9	na	0	0
10		125	0	0
	10	46	0	0
11		152	0.0002107669	0.0020519412
	11	41	0	0
12		169	0.0009844962	0.0035864807
	12	39	0	0
13		150	0	0
	13	48	0	0
14		157	0.0007199607	0.0085013009
	14	41	0.0004406866	0.0019702010
15		153	0.001359335	0.0103234636
	15	125	0.00006772966	0.0007572406
16		139	0.0003840815	0.0031396944
	16	44	0.00006603899	0.0004380531
17		144	0.0007109758	0.0046017157
	17	39	0	0
18		172	0.006517507	0.0160643979

Table 6. Preliminary estimates of biomass density for sardine, assuming that all of the backscatter is from a mixture of sardine and anchovy. The conversion from s_A to biomass density was done according to Equations (5) and (6) with a species proportion based on the net samples from the spring *DSJ* survey. The mean biomass density = 0.0001565562 kg m^{-2}, CV = 44.6%.

Transect	Segment	Length (nmi)	Biomass Density (kg/m^2)	Standard Deviation
1		131	0.00001474188	0.0001687286
	1	43	0.000007172583	0.00004703377
2		126	0	0
	2	65	0.001230965	0.007443773
3		118	0.00001393535	0.0001065821
	3	40	0.00002734905	0.0001729706
4		127	0	0
	4	85	0	0
5		123	0	0
	5	42	0	0
6		129	0.00002213261	0.0001771562
	6	63	0.00003421288	0.0002715563
7		121	0.00001101970	0.0001212167
	7	40	0.0004467007	0.001817158
8		117	0.0001995338	0.0010892803
	8	108	0.0003606566e	0.002039863
9		74	0	0
	9	na	na	na
10		125	0	0
	10	46	0	0
11		152	0.00004093432	0.0003985199
	11	41	0	0
12		169	0.0001912050	0.0006965521
	12	39	0	0
13		150	0	0
	13	48	0	0
14		157	0.0001398279	0.0016510890
	14	41	0.00008558840	0.00038264460
15		153	0.0002640048	0.0020049823
	15	125	0.00001315419	0.0001470683
16		139	0.00007459479	0.0006097790
	16	44	0.00001282583	000008507694
17		144	0.0001380829	0.0008937270
	17	39	0	0
18		172	1.265804e-03	0.0031199638

Summer 2008

The *DSJ* surveyed the U.S. west coast from Cape Flattery, WA to San Diego, CA using the same methods used in the spring CCE survey. As in the *MF* survey, the daily variation of total s_A retained after filtering by the difference between S_v at 200 kHz and S_v at 38 kHz revealed nearly constant scattering at depths < 40 m. Some of the near-surface scatter may be due to the night-time ascent of mesopelagic fish whereas during daytime, acoustic backscatter in the upper water column is still contaminated from sources other than pelagic fish. More specifically, a diffuse planktonic-looking scattering layer has a frequency response similar to that for CPS. After additional filtering (Table 7), highest densities of swim-bladdered fish were observed in the coastal waters of the central and northern regions of the survey area (Figure 4), closely matching the distribution of trawls with CPS (Figure 8). The daily pattern of backscattering agrees in general to that attributed to CPS. However, minor contamination from mesopelagic fish ascending at night-time is suggested (Figure 5).

Following the procedures of Jolly and Hampton (1990), the mean biomass densities for the west-east transects 1-22 were 0.000282354 kg m^{-2} (CV=17.9%) and 0.001932028 kg m^{-2} (CV=17.9%) for anchovy and sardine, respectively. A summary of all transects is provided in Tables 8 and 9.

Table 7. Descriptions of acoustic transects from the NOAA Ship *David Starr Jordan* during the summer CCE survey.

Transect name	Start Latitude	Start Longitude	Start Time	Start Date	End Latitude	End Longitude	End Time	End Date	Comments/actions taken
Transect 1	48º 24.51' N	124º 55.00' W	0915	06-Jul-08	48º 24.60' N	127º 53.57' W	0318	07-Jul-08	Onshore-offshore. Few fish schools on the shelf. Resonant layer from interval 61 and beyond (used Sv maximum threshold).
Transect 1 to 2									Offshore segment. Resonant layer throughout (used Sv maximum threshold). Fish schools in the intervals 59 and beyond.
Transect 2	47º 43.85' N	127º 37.87' W	1503	07-Jul-08	47º 40.00' N	124º 41.48' W	1057	08-Jul-08	Offshore-onshore. Resonant layer until interval 107 (excluded). Fish schools from then onwards (used maximum Sv threshold).
Transect 2 to 3									Onshore segment. No plankton layer.
Transect 3	46º 35.29' N	124º 28.57 W	1243	09-Jul-08	47º 00.55' N	127º 13.90' W	0936	10-Jul-08	Onshore-offshore. Mixture of plankton layer and schools from interval 31 onwards (used maximum Sv threshold).
Transect 3 to 4									Offshore-segment. Weak resonant layer. A few pseudo-fish schools (used maximum Sv threshold throughout).
Transect 4	46º 21.09' N	127º 08.10' W	1837	10-Jul-08	46º 20.52' N	124º 13,30' W	1531	11-Jul-08	Offshore-onshore. Resonant layer offshore (excluded). Mixture of fish and plankton starting at interval 36 (used Sv maximum threshold). Mixture ends at interval 117. Fish schools from there shorewards.
Transect 4 to 5									Onshore segment. (used maximum Sv threshold).
Transect 5	45º 20.66' N	124º 07.53' W	1447	12-Jul-08	45º 49.89' N	126º 56.31 W	1028	13-Jul-08	Onshore-offshore. Fish schools up to interval 40. Mixture of resonant layer and schools after 40 (used Sv maximum threshold). Resonant layer from interval 48 onwards (excluded)
Transect 5 to 6									Offshore segment. Resonant layer (excluded).

Table 7. Continued.

Transect name	Start Latitude	Start Longitude	Start Time	Start Date	End Latitude	End Longitude	End Time	End Date	Comments/actions taken
Transect 6	45º 01.74' N	127º 02.26' W	2010	13-Jul-08	45º 00.89' N	124º 12.20' W	1813	14-Jul-08	Offshore-onshore. Strong resonant layer at 38 kHz up to interval 122 (excluded). Very few schools afterwards (used Sv maximum threshold).
Transect 6 to 7									Onshore-segment. No resonant layer. Large fish schools (used Sv maximum threshold).
Transect 7	44º 35.60' N	124º 06.89 W	2147	18-Jul-08	44º 21.01' N	126º 55.83' W	2011	19-Jul-08	Onshore-offshore. Fish schools in the 70-80 m range. Weak resonant layer starting at the interval 39 (used Sv maximum threshold). Strong resonant layer beyond interval 65 (excluded).
Transect 7 to 8									Offshore segment. Resonant layer (Excluded).
Transect 8	43º 42.23' N	127º 01.57' W	0522	20-Jul-08	43º 06.00' N	124º 38.46' W	0427	21-Jul-08	Offshore-onshore. Strong resonant layer up to interval 71 (excluded). Mixture up to interval 140 (used Sv maximum threshold). Fish from interval 140 shore-wards.
Transect 8 to 9									Onshore segment. Some fish schools mixed in the resonant layer (used Sv maximum threshold).
Transect 9	42º 38.55' N	124º 40.95' W	1445	21-Jul-08	43º 00.65' N	127º 21.97' W	1347	22-Jul-08	Onshore-offshore. Mixture starting at interval 31 (used Sv maximum threshold). Resonant layer starting at interval 48 (excluded).
Transect 9 to 10									Offshore segment. Resonant layer (excluded).
Transect 10	42º 20.17' N	127º 12.79' W	2157	22-Jul-08	41º 40.70' N	124º 16.18' W	2104	23-Jul-08	Offshore-onshore. Resonant layer up to interval 114 (excluded). Mixture from interval 114 until 150 (used Sv maximum threshold). Fish school afterwards.
Transect 10 to 11									Does not exist.

Table 7. Continued.

Transect name	Start Latitude	Start Longitude	Start Time	Start Date	End Latitude	End Longitude	End Time	End Date	Comments/actions taken
Transect 11	41º 40.25' N	125º 17.84' W	1806	25-Jul-08	41º 40.65' N	127º 50.17' W	1445	26-Jul-08	Onshore-offshore. Weak scattering layer up to the interval 56 (used Sv maximum threshold). Strong scattering layer beyond interval 56 (excluded).
Transect 11 to 12									Offshore segment. Resonant layer (excluded).
Transect 12	40º 59.73' N	127º 50.98' W	2234	26-Jul-08	41º 00.73' N	124º 17.86' W	0138	28-Jul-08	Offshore-onshore. Scattering layer up to interval 89 (excluded). Mixture beyond interval 89 (used Sv maximum threshold).
Transect 12 to 13									Onshore segment. Mixture (used Sv maximum threshold).
Transect 13	40º 19.35' N	124º 30.87' W	1453	28-Jul-08	40º 20.77' N	127º 58.56' W	1733	29-Jul-08	Onshore-offshore. Weak scattering layer up to the interval 27 (used Sv maximum threshold). Strong scattering layer beyond interval 27 (excluded).
Transect 13 to 14									Offshore segment. Weak scattering layer throughout (used Sv maximum threshold).
Transect 14	39º 39.38' N	127º 31.79' W	0216	30-Jul-08	39º 40.86' N	124º 03.62' W	0402	31-Jul-08	Offshore-onshore. Weak scattering throughout (used Sv maximum threshold).
Transect 14 to15									Onshore segment (used Sv maximum threshold).
Transect 15	39º 01.18' N	123º 47.52' W	1336	31-Jul-08	39º 00.76' N	127º 10.82' W	1606	01-Aug-08	Onshore-offshore. Weak scattering layer throughout (used Sv maximum threshold)
Transect 15 to 16									Offshore segment. Weak scattering layer throughout (used Sv maximum threshold).
Transect 16	37º 11.98' N	126º 11.94' W	1534	02-Aug-08	38º 24.49' N	123º 39.50 W	2249	03-Aug-08	Offshore-onshore. Weak scattering layer throughout (used Sv maximum threshold)
Transect 16 to 17									Onshore segment (used Sv maximum threshold). Goes to port and does not connect to transect 17.
Transect 17	37º 37.85' N	123º 11.57 W	2246	06-Aug-08	36º 36.63' N	125º 46.18' W	0058	08-Aug-08	Onshore-offshore. Weak scattering layer throughout (used Sv maximum threshold). Fish schools bellow the 70 m limit.

Table 7. Continued.

Transect name	Start Latitude	Start Longitude	Start Time	Start Date	End Latitude	End Longitude	End Time	End Date	Comments/actions taken
Transect 17 to 18									Offshore segment. Weak scattering layer throughout (used Sv maximum threshold).
Transect 18	36º 03.91' N	125º 20.12' W	1116	08-Aug-08	37º 18.52' N	122º 37.59' W	1817	09-Aug-08	Offshore-onshore. Weak scattering layer throughout (used Sv maximum threshold).
Transect 18 to 19									Does not exist
Transect 19	36º 46.13' N	122º 05.80' W	1033	14-Aug-08	35º 27.28' N	124º 54.11' W	0949	15-Aug-08	Onshore-offshore. Weak scattering layer up to interval 49 (used Sv maximum threshold apply). Strong scattering layer between 49 and 75 (excluded).
Transect 19 to 20									Offshore segment. Weak scattering layer throughout (used Sv maximum threshold).
Transect 20	34º 19.17' N	124º 03.56' W	2034	15-Aug-08	35º 38.63' N	121º 15.42' W	2000	16-Aug-08	Offshore-onshore. Weak scattering layer throughout (used Sv maximum threshold).
Transect 20 to 21									Onshore segment. Weak scattering layer throughout (used Sv maximum threshold).
Transect 21	34º 28.02' N	120º 55.90' W	0459	17-Aug-08	33º 08.74' N	123º 12.59' W	2037	17-Aug-08	Onshore-offshore. Weak scattering layer throughout (used Sv maximum threshold).
Transect 21 to 22									Offshore segment. Weak scattering layer throughout (used Sv maximum threshold).
Transect 22	31º 59.32' N	122º 23.56' W	0448	18-Aug-08	33º 44.41' N	118º 47.92' W	0344	19-Aug-08	Offshore-onshore. Weak scattering layer throughout (used Sv maximum threshold).

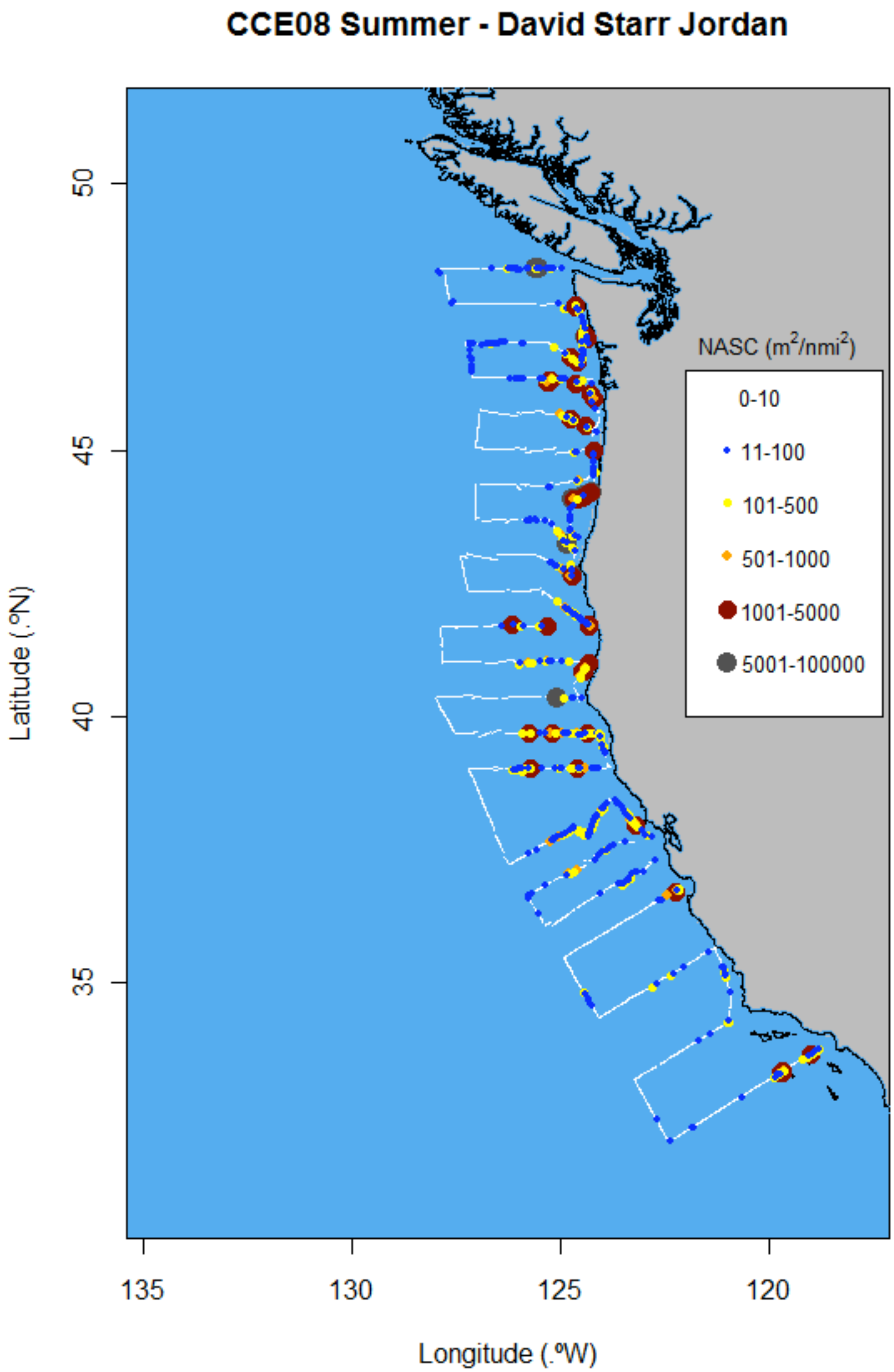

Figure 4. Nautical-area backscattering coefficients at 38 kHz (s_A; m^2 nmi^{-2}) attributed to fish schools at 7-70 m depths (colored dots). The largest $s_A \approx 60,000$ m^2 nmi^{-2} was mapped in the coastal segment between transects 7 and 8.

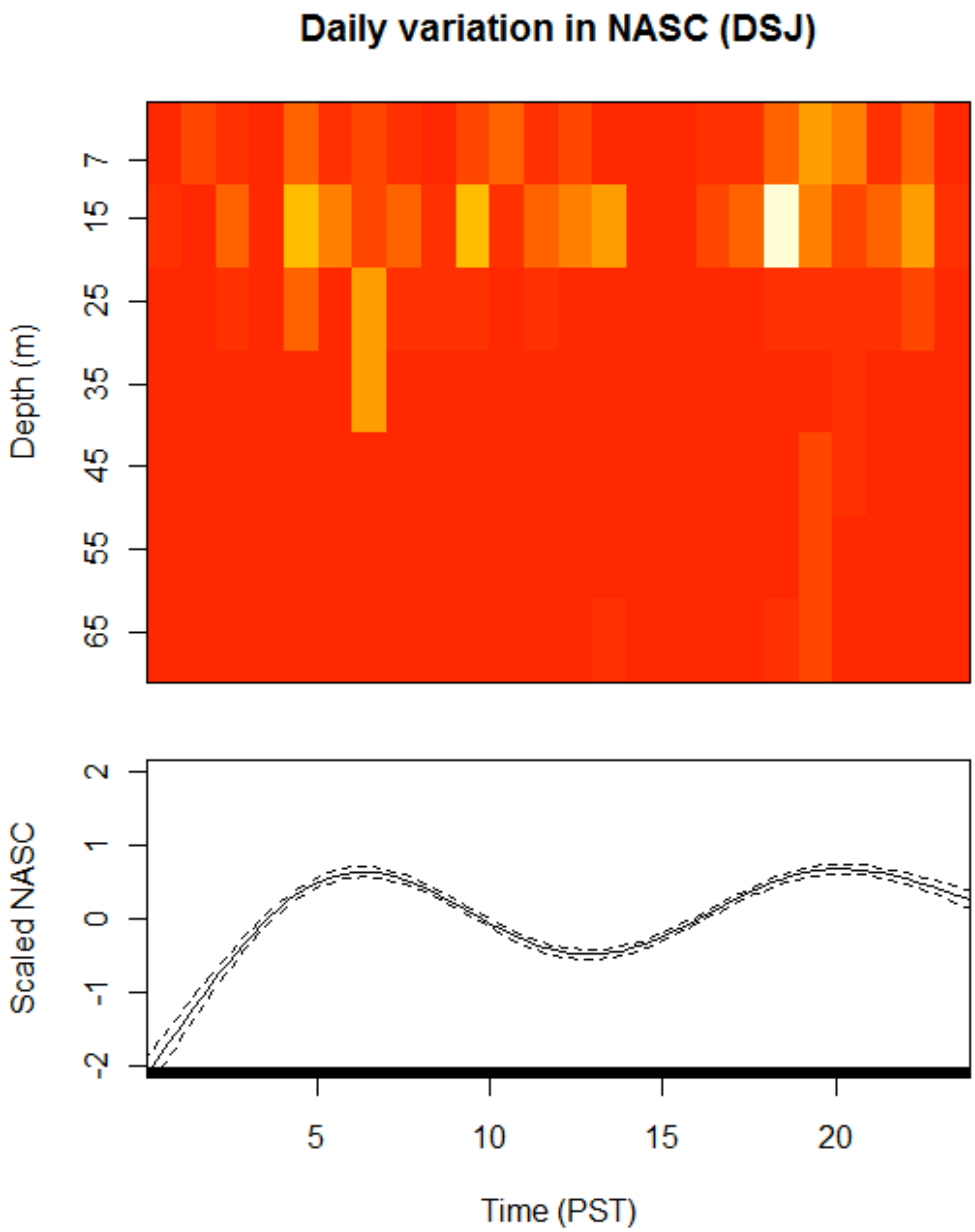

Figure 5. Average s_A (m^2 nmi^{-2}) attributed to epipelagic fish schools vs. depth (10 m bins) and time of day (hour PST). The lower graph shows the daily trend in normalized s_A. The backscatter increase between 0 and 7 a.m. PST and the relative decrease after 9 p.m. PST is indicative of the diel vertical migration of CPS. Contamination from upward migrating mesopelagic fish is suggested by the slight decrease of s_A at night-time.

Table 8. Preliminary estimates of biomass density for anchovy, assuming that all of the backscatter is from a mixture of sardine and anchovy. The conversion from s_A to biomass density was done according to Equations (5) and (6) with a species proportion based on the net samples. The mean biomass density = 0.000282354 kg m^{-2}, CV=17.9%.

Transect	Segment	Length (nmi)	Biomass Density (kg m^{-2})	Standard Deviation
1		109	0.0006827135	0.004421835
	1	39	0.00004313167	0.0001345327
2		112	0.00006167183	0.0003131876
	2	91	0.001581559	0.005546401
3		121	0.0004216353	0.002709410
	3	36	0.00006187186	0.0001134990
4		121	0.0006441413	0.002369862
	4	100	0.0003883112	0.002391141
5		110	0.0004091347	0.0001914667
	5	39	0	0
6		122	0.0004390595	0.0002654718
	6	106	0.008747329	0.03664750
7		122	0.0004737251	0.0003222177
	7	40	0	0
8		116	0.0005091807	0.004422679
	8	19	0.001121575	0.003836154
9		125	0.0007980220	0.008345256
	9	40	0	0
10		140	0.0003883181	0.002285863
	10	na	na	na
11		108	0.0001773982	0.001144766
	11	33	0	0
12		159	0.00008692396	0.0004670699
	12	46	0.001251712	0.002844685
13		148	0.0003605676	0.004127218
	13	45	0	0
14		153	0.0005732514	0.002184159
	14	30	0.0004819798	0.0009361518
15		159	0.0003097275	0.001443137
	15	107	0	0
16		147	0.0002894049	0.0005946522
	16	57	0.0008073950	0.001481308
17		131	0.0001213503	0.00005452254
	17	31	0	0
18		150	0.0007050563	0.0002435032

Table 8. Continued.

Transect	Segment	Length (nmi)	Biomass Density (kg m^{-2})	Standard Deviation
	18	na	na	na
19		152	0.0001445515	0.001013623
	19	81	0.000006553422	0.00004824941
20		158	0.0001570767	0.00009883916
	20	74	0.0001571151	0.0004867248e
21		138	0.00002666586	0.0001928570
	21	88	0.000006034477	0.00005660841
22		209	0.0002384390	0.001040142

Table 9. Preliminary estimates of biomass density for sardine, assuming that all of the backscatter is from a mixture of sardine and anchovy. The conversion from s_A to biomass density was done according to Equations (5) and (6) with a species proportion based on the net samples. The mean biomass density = 0.001932028 kg m^{-2}, CV=17.9%.

Transect	Segment	Length (nmi)	Biomass Density (kg m^{-2})	Standard Deviation
1		109	0.0046715166	0.0302567236
	1	39	0.0002951316	0.0009205494
2		112	0.0004219939	0.0021430090
	2	91	0.01082193	0.0379516459
3		121	0.0028850701	0.0185393350
	3	36	0.0004233627	0.0007766249
4		121	0.0044075835	0.0162159523
	4	100	0.002657047	0.0163615565
5		110	0.0027995336	0.0131012477
	5	39	0	0
6		122	0.0003004296	0.0018165097
	6	106	0.05985423	0.2507631837
7		122	0.0003241498	0.0022047979
	7	40	0	0
8		116	0.0034841054	0.0302624998
	8	19	0.007674461	0.0262491604
9		125	0.0054605232	0.0571030156
	9	40	0	0
10		140	0.0026570950	0.0156411805
	10		na	na
11		108	0.0012138598	0.0078331413
	11	33	0	0
12		159	0.0005947835	0.0031959595
	12	46	0.008564933	0.0194649644
13		148	0.0024672101	0.0282407869
	13	45	0	0
14		153	0.0039225142	0.0149452666
	14	30	0.003297982	0.006405686
15		159	0.0021193329	0.0098747663
	15	107	0	0
16		147	0.0019802741	0.0040689505
	16	57	0.005524659	0.0101359567
17		131	0.0008303483	0.0037307439

Table 9. Continued.

Transect	Segment	Length (nmi)	Biomass Density (kg m^{-2})	Standard Deviation
	17	31	0	0
18		150	0.0004824398	0.0016661882
	18	na	na	na
19		152	0.0009891038	0.0069357855
	19	81	0.00004484227	0.0003301501
20		158	0.0001074809	0.0006763141
	20	74	0.001075072	0.0033304496
21		138	0.0001824631	0.0013196381
	21	88	0.00004129134	0.0003873471
22		209	0.0016315360	0.0071172463

PACIFIC SARDINE and NORTHERN ANCHOVY EGG DISTRIBUTIONS, by R. Charter, W. Watson, S. McClatchie, and N.C.H. Lo

Pacific sardine and Northern anchovy egg distributions along the transects were well resolved by the Continuous Underway Fish Egg Sampler (CUFES). In April 2008 very few Pacific sardine eggs were found north of San Francisco (37.9^{o}N), and no eggs at all were detected north of Point Arena (or north of 39^{o}N) (Figure 7). Sardine eggs were found in offshore waters to the south of San Simeon (36^{o}N) (Figure 7). Highest concentrations were found between 30-35^{o}N, and the distribution pattern indicates that eggs would have been found to the south of the U.S.-Mexican border if we had sampled there. There was some evidence for two sardine egg concentrations: one more offshore at approximately 123^{o}W and a second concentration in the center of the Southern California Bight (SCB) at 119^{o}W (Figure 7). In contrast to April very few sardine eggs were found anywhere along the entire U.S. West Coast during the July/August survey (Figure 8).

Northern anchovy eggs were abundant in the SCB inshore of the sardine eggs in April. No anchovy eggs were found north of the SCB in April (Figure 7). During the July/August survey a few anchovy eggs were found in the SCB, but the highest concentrations were found off Oregon and Washington at 45-46^{o}N (Figure 8).

Pacific sardine eggs were found at sea surface temperatures (SST) greater than 10 ^{o}C and less than 15 ^{o}C in April (Figure 7). In July/August a few sardine eggs were encountered at the most southern location sampled in waters as warm as 19-20 ^{o}C SST (Figure 8). A few sardine eggs were also found offshore of the Columbia River where SST was 15-16 ^{o}C (Figure 8).

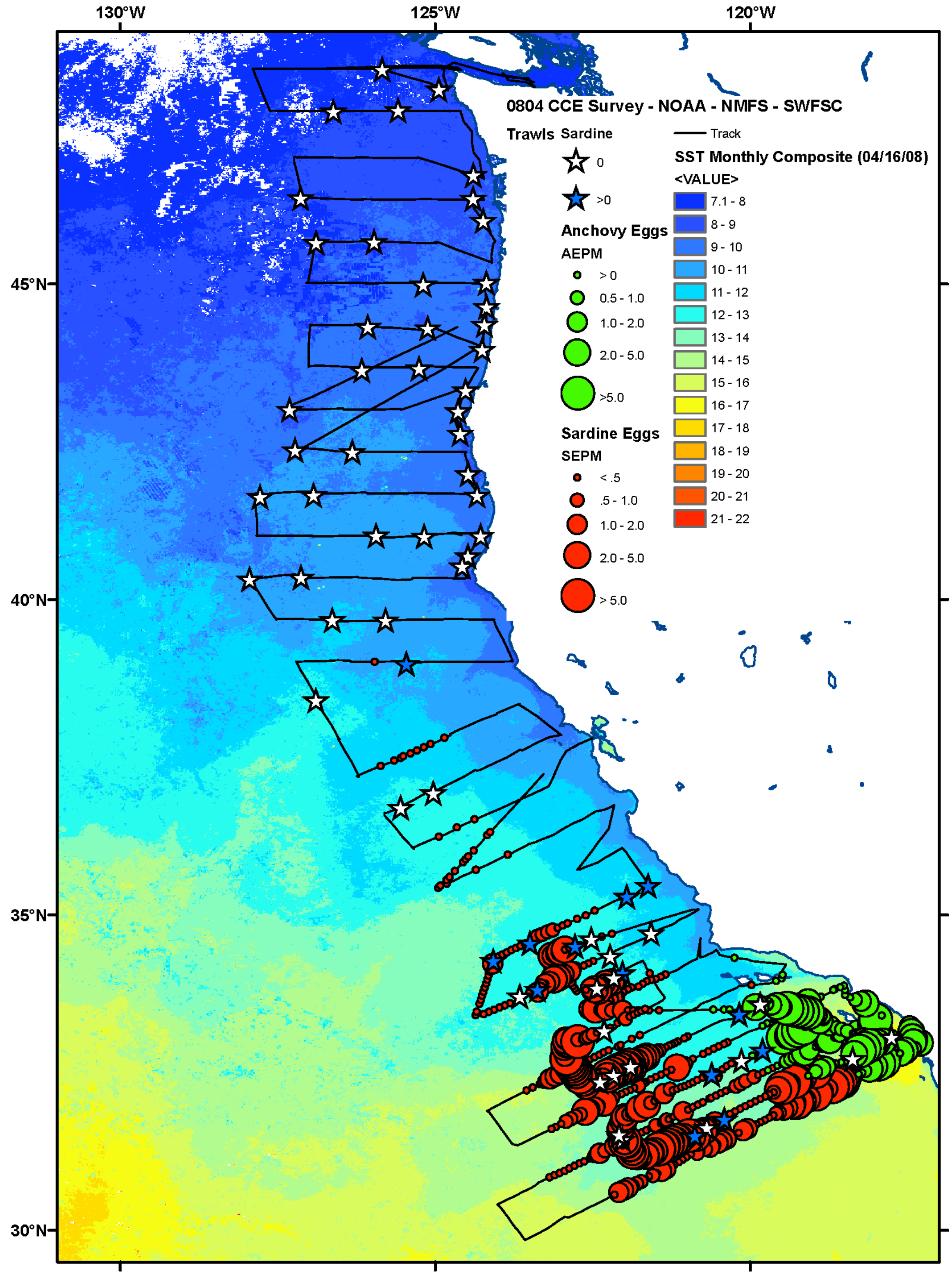

Figure 7. Egg distributions from CUFES and the locations and catches from surface trawls overlaid on a month-long composite of sea surface temperature (satellite SST) for the April 2008 survey.

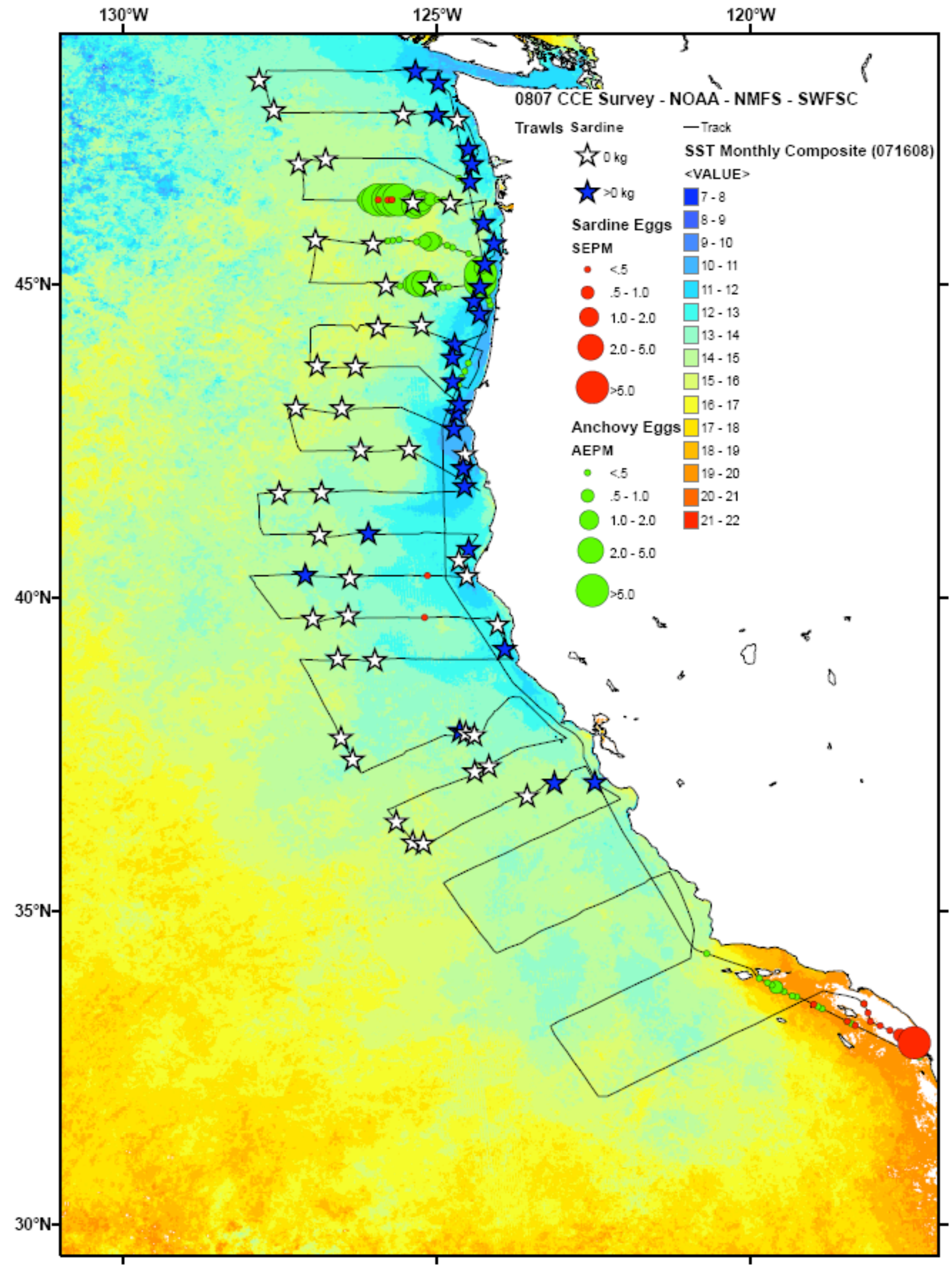

Figure 8. Egg distributions from CUFES and the locations and catches from surface trawls overlaid on a month-long composite of sea surface temperature (satellite SST) for the July/August 2008 survey.

SURFACE TRAWLING, by B. Macewicz, D. Griffith, R. Charter, and N.C.H. Lo

During both the April and July/August surveys a Nordic 264 surface trawl was deployed between dusk and dawn within the Southern California Bight and north up to Cape Flattery at positions indicated in Figures 7 and 8. Each tow was fished for 30 minutes at a towing speed of approximately 3.5 knots. At the start of fishing during trawling operations, sea temperature (3 m depth) was recorded (Tables 10 and 11).

A marine mammal watch was initiated 30 minutes before trawling. Trawling was the first activity on arrival at a trawling station, or was located away from a previously occupied station to avoid any mammals that may have been attracted to the vessel. The trawl was fitted with a 162 dB source level, variable frequency pinger rated to discourage cetaceans. If any mammals were detected, the trawl position was moved to a new area and the mammal watch reinitiated. Any mammal capture triggered immediate cessation of trawling and telephone contact to the Division Director of FRD, SWFSC, who contacted the Director of SWFSC. Trawling was only reinitiated on instructions from NMFS Chief Scientist Dr. Steve Murawski.

Catch Processing

Sorting and weighing of the catch of each tow was performed regardless of catch size or its composition. The catch was defined as anything removed from the cod-end of the net as well as all individual fish or squid falling onto the deck, or pulled from the net during haul back. As the catch was deposited, we immediately recorded the length and weight of any sunfish (*Mola mola*) or sharks (from which we also took a genetic sample) before returning them to the sea alive. Any adult salmon caught in a trawl were immediately returned to the sea and assumed to have survived. Any juvenile salmon caught incidentally were frozen and turned over to Dr. Bob Emmett at NWFSC for further study. The remaining fish were identified and sorted by species (except myctophid species were combined when time was critical). Species were not sorted by size. Unless time was available for individual identification, invertebrates were sorted and weighed by the following categories: 1) market squid (*Loligo opalescens*); 2) other squid; and 3) other invertebrates, noting approximate proportions of the invertebrate catch, i.e. 80% jellyfish, 10% salps, 10% euphausiids.

Presence in the catch of the target specie, Pacific sardine (*Sardinops sagax*), initiated an immediate random subsampling of 50 sardines (or all if less than 50 present) and processing of the fish for biological samples in the wet lab, even before the whole catch was weighed. This immediate processing of the biological sample was necessary to obtain the best preservation of tissues sampled. Each sardine was sexed, measured to the nearest millimeter and weighed to the nearest half-gram. Gonads were visually classified (Table 12), otoliths were collected for aging, tail tissue was preserved in 95% ethanol for genetics, and ovaries were removed and preserved in 10% neutral buffered formalin for assessment of reproductive state. If the 50-fish subsample did not have 25 females visually classed as ovary codes 2-4, more females were sampled to obtain 25 potentially mature females per trawl for estimation of reproductive parameters for spawning biomass estimation (Lo et al. 2007b; Lo et al. 2008). From time to time additional females were also processed for use in estimating batch fecundity. The additional mature female sardines were not included in the original random subsample for length distributions. Any non-subsampled sardines were weighed and total sardine catch weight was calculated.

After sorting, a random subsample of 50 fish per species (or the entire catch if fewer than 50, excluding myctophids) was weighed and lengths recorded to the nearest centimeter. The non-subsampled fish were weighed and total species weight was calculated. Most species were not sexed. Jack mackerel, *Trachurus symmetricus*, and Pacific (chub) mackerel, *Scomber japonicus* were sexed and fork length centimeter measurements recorded by maturity stage as: 1) male; 2) active female (ovaries visually contained yolking or hydrated oocytes); 3) inactive female; or 4) indeterminate. Northern anchovy (*Engraulis mordax*) were biologically sampled: each anchovy in the subsample of 50 random fish (or the entire sample if <50 were present in haul) was sexed, weighed to nearest half-gram, standard length measured to nearest millimeter, maturity recorded (Table 10), and otoliths and tails were removed and saved.

Results

Trawling during the 2008 CCE surveys (April and July/August) covered a large area off the west coast of the U.S. from Cape Flattery, WA to San Diego, CA (Tables 10 and 11). Both surveys caught a wide variety of species (Tables 13 and 14). We examined the catch data of the four target species (Pacific sardine, Northern anchovy, Jack mackerel, and Pacific (chub) mackerel) in three areas off the coast: Washington and Oregon (NW), northern California (N CA), and in the standard DEPM area (std. DEPM). The four target species were present in more areas during July/August than during April and were always found to the south in the std. DEPM area (Tables 15 and 16). The three migratory fish species (Jack mackerel, Pacific (chub) mackerel, and Pacific sardine) were absent off the NW during April while Northern anchovy, fish with a resident subpopulation off the NW, was caught in both April and July/August (Figure 9).

The only previous spring trawling conducted for coastal pelagic species off the whole west coast was during the April-May 2006 Coast-wide Pacific Sardine survey (Lo et al. 2007a). In the three areas off the coast, the range of sea temperatures (3 m depth) was lower in April 2008 than April 2006 (Table 17). We found that during April 2008 sardine eggs and adults were present only in N CA and std. DEPM areas while during the warmer April 2006 they were present in all three areas. In the N CA area, only a single adult male was taken, compared to 101 sardine adults and high eggs densities collected in 2006 (Table 17). Although sardines have been caught during spring in the std. DEPM area since 1994 (Lo et al. 2008), the average size of sardines in 2008 was larger than in 2006 (Figure 10). In summary, compared to the 2006 coast-wide survey, the surface water temperatures measured during trawling were lower in 2008, the sardines caught in the southern area were much larger in 2008 than in 2006, and sardine eggs were not found as far north in 2008 as they were in 2006. It is likely that the colder temperatures encountered in 2008 may have delayed or restricted the northward movement of sardines.

The only previous summer surveys for Pacific sardine have been in the northeastern Pacific off Washington and Oregon, the NW area, and sea temperatures recorded during trawling were much cooler during July 2008 (Table 18). The sardines were smaller than the 2003 and 2007 surveys (2004 size bias because of many 2003 year class fish) but about the same size as those caught in April in the std. DEPM area (Figure 10, Table 17). More spawning (presence of samples with high egg densities) occurred during the warmer summer surveys. If the cooler temperatures delayed migration, it is possible that the sardines lacked the energy to spawn again in the north during July 2008.

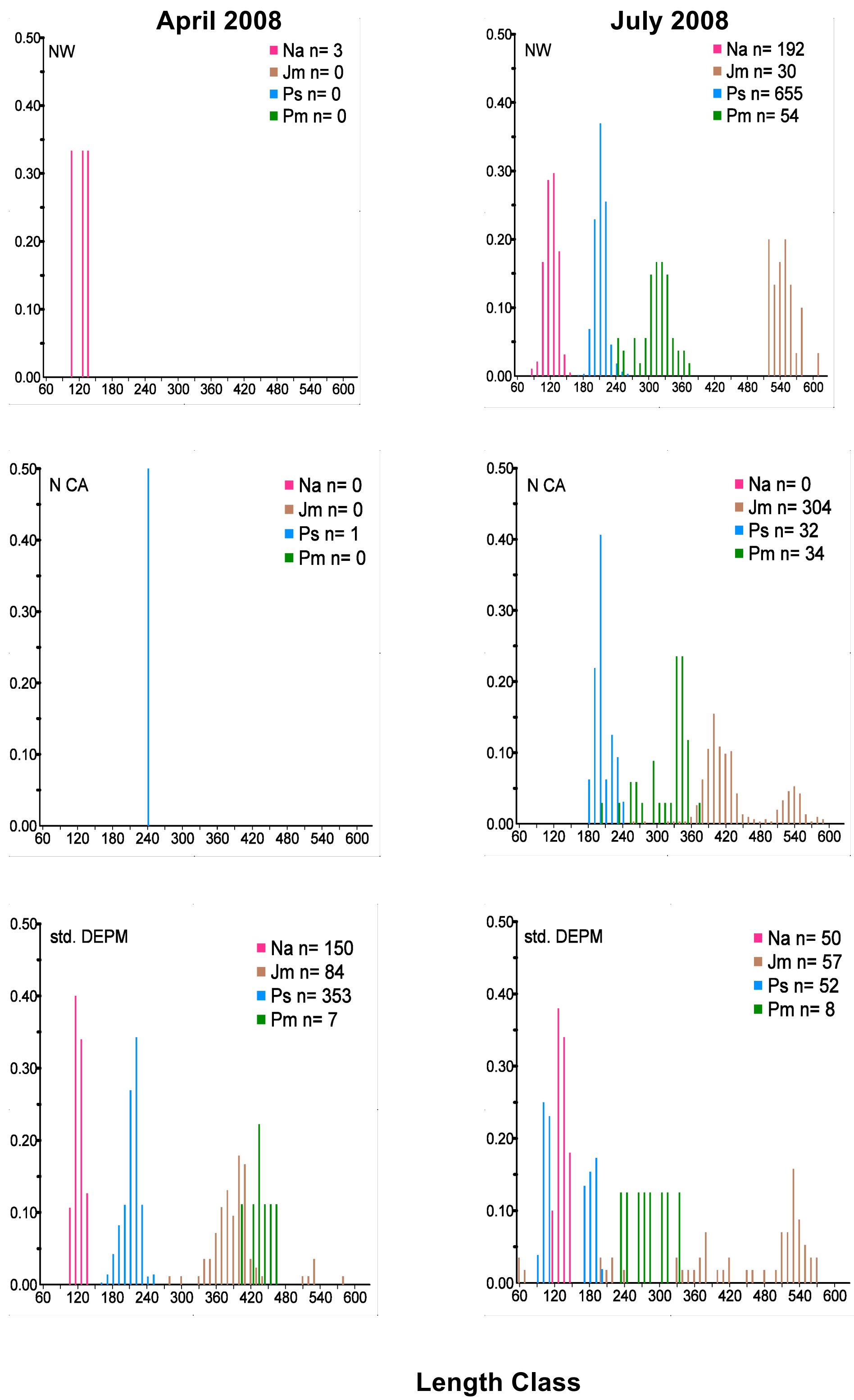

Figure 9. Length distribution (fraction of species caught in each 10 mm length class) of four fish species taken in trawls during the April and July 2008 CCE surveys. The species are Northern anchovy (Na), Jack mackerel (Jm), Pacific sardine (Ps), and Pacific (chub) mackerel (Pm). Sardine and N. anchovy measurements are standard length while the mackerels are fork length. Note: n is the number of fish in the random sample of each species.

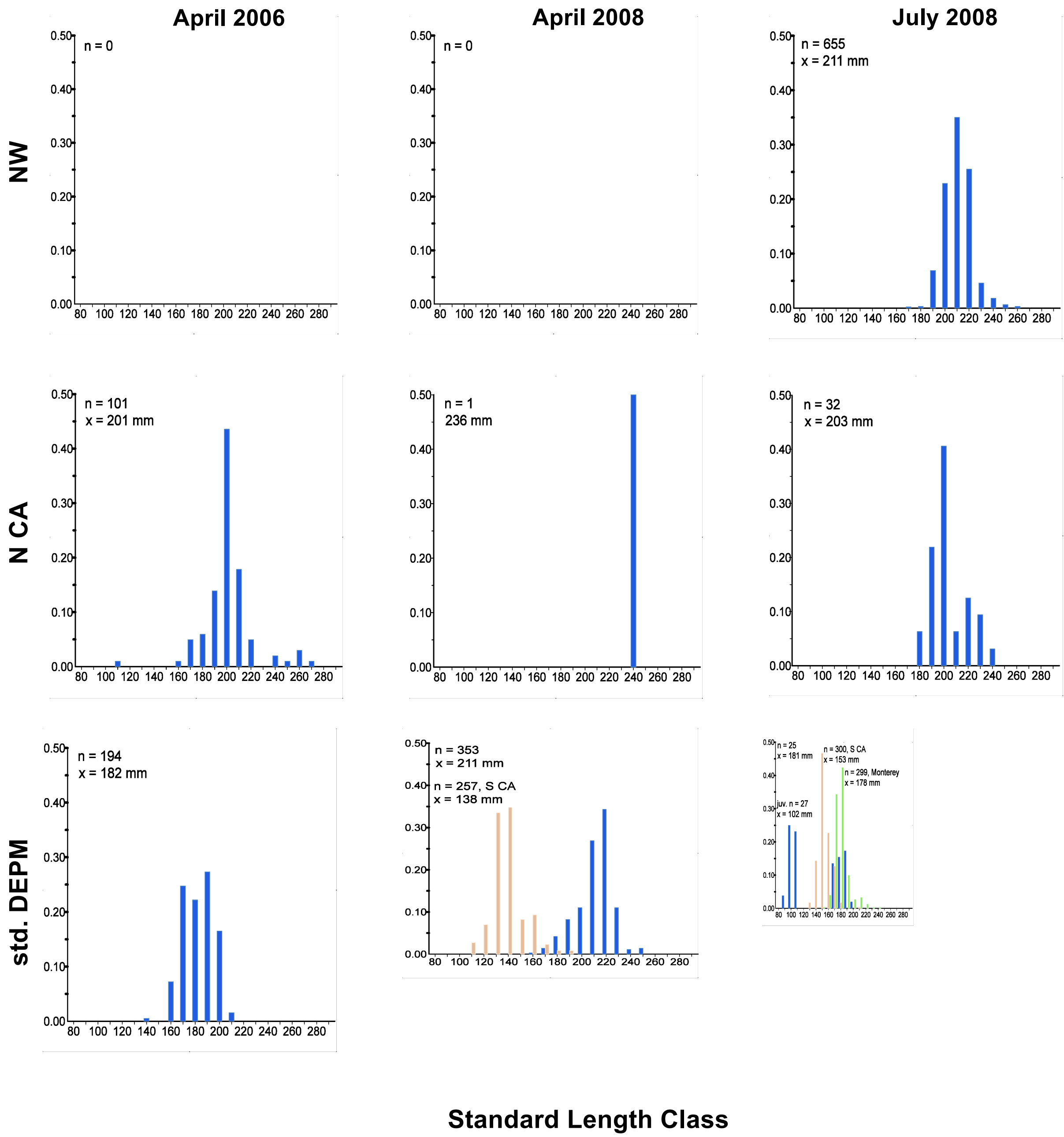

Figure 10. Length distributions and mean standard length (x) of Pacific sardine caught in the 2006 and 2008 surveys by each subarea and the 2008 port samples. Blue bar is survey fish, tan bar is southern CA port fish, and green bar is Monterey port fish.

Table 10. Trawl and catch data from the spring 2008 CCE survey off the U.S. West Coast using the NOAA Ships *Miller Freeman* (trawls 2371-2412) and *David Starr Jordan* (trawls 2300-2328).

	Trawl Information						Target Species and Total Catch Weight (kilograms)					
Area	**ID**	**Date**	**Time**	**Latitude (°N)**	**Longitude (°W)**	**Sea Temp. at 3m (°C)**	**Pacific Sardine**	**Northern Anchovy**	**Jack Mackerel**	**Pacific Mackerel**	**Market Squid**	**Total Catch**
	2371	4/2/2008	22:34	48.091	124.946	8.3	0	0	0	0	0	1.28
	2372	4/3/2008	3:21	48.408	125.844	8.2	0	0	0	0	0	16.26
NW	2373	4/4/2008	23:12	47.741	126.620	7.8	0	0	0	0	0	4.03
	2374	4/5/2008	4:29	47.762	125.591	7.8	0	0	0	0	0	1.83
	2375	4/5/2008	23:42	46.731	124.399	8.1	0	0.06	0	0	0	0.68
	2376	4/6/2008	23:46	46.369	127.137	7.9	0	0	0	0	0	0
	2377	4/7/2008	19:50	46.358	124.400	8.2	0	0	0	0	0	0.18
	2378	4/7/2008	23:05	46.010	124.241	8.6	0	0	0	0	0	0.77
	2379	4/8/2008	20:04	45.674	125.972	8.8	0	0	0	0	0	6.32
	2380	4/9/2008	1:09	45.660	126.894	8.2	0	0	0	0	0	1.85
	2381	4/9/2008	20:35	44.998	125.192	9.1	0	0	0	0	0	6.84
	2382	4/10/2008	1:49	45.028	124.190	9.1	0	0	0	0	0	0.46
	2383	4/10/2008	20:05	44.308	125.121	9.4	0	0	0	0	0	1.79
	2384	4/11/2008	0:55	44.329	126.074	9.1	0	0	0	0	0	4.37
	2385	4/11/2008	20:09	43.641	126.167	9.4	0	0	0	0	0	16.53
	2386	4/12/2008	0:53	43.668	125.259	9.9	0	0	0	0	0	6.16
	2387	4/12/2008	20:01	42.635	124.604	9.6	0	0	0	0	0	0.87
	2388	4/12/2008	23:09	42.990	124.640	9.9	0	0	0	0	0	0.53
	2389	4/13/2008	2:01	43.320	124.521	9.8	0	0	0	0	0	0.06
	2390	4/13/2008	20:22	43.015	127.313	9.7	0	0	0	0	0	4.45
	2391	4/17/2008	20:31	44.643	124.188	8.3	0	0	0	0	0	0.11
	2392	4/18/2008	0:40	44.359	124.222	9.2	0	0	0	0	0	1.67
	2393	4/18/2008	4:13	43.964	124.256	8.8	0	0	0	0	0	0.28
	2394	4/18/2008	21:10	42.372	127.226	10.1	0	0	0	0	0	5.46
	2395	4/19/2008	2:20	42.344	126.318	10.0	0	0	0	0	0	2.84
	2396	4/19/2008	20:23	41.993	124.480	8.2	0	0	0	0	0	0
	2397	4/20/2008	0:06	41.658	124.337	7.8	0	0	0	0	0	0.47
	2398	4/20/2008	20:21	41.662	126.932	10.0	0	0	0	0	0	10.59
N CA	2399	4/21/2008	1:10	41.638	127.788	10.2	0	0	0	0	0	11.56
	2400	4/21/2008	20:14	41.020	125.940	10.3	0	0	0	0	0	4.58
	2401	4/22/2008	0:38	41.008	125.176	10.1	0	0	0	0	0	7.62
	2402	4/22/2008	22:00	41.013	124.280	9.1	0	0	0	0	0	0
	2403	4/23/2008	1:00	40.693	124.481	9.2	0	0	0	0	0	0
	2404	4/23/2008	3:10	40.531	124.574	9.2	0	0	0	0	0	0
	2405	4/23/2008	22:51	40.355	127.131	10.3	0	0	0	0	0	1.94
	2406	4/24/2008	3:30	40.329	127.950	10.8	0	0	0	0	0	1.04

Table 10. Continued.

	Trawl Information						Target Species and Total Catch Weight (kilograms)					
Area	**ID**	**Date**	**Time**	**Latitude (°N)**	**Longitude (°W)**	**Sea Temp. at 3m (°C)**	**Pacific Sardine**	**Northern Anchovy**	**Jack Mackerel**	**Pacific Mackerel**	**Market Squid**	**Total Catch**
N CA	2407	4/24/2008	20:14	39.680	126.635	11.6	0	0	0	0	0	26.37
	2408	4/25/2008	0:33	39.678	125.790	10.8	0	0	0	0	0	19.86
	2409	4/26/2008	2:28	38.985	125.458	11.5	0.15	0	0	0	0	5.97
	2410	4/26/2008	20:36	38.409	126.894	13.2	0	0	0	0	0	14.24
std. DEPM	2411	4/28/2008	21:33	36.936	125.032	11.9	0	0	0	0	0	2.15
	2412	4/29/2008	3:35	36.703	125.550	12.6	0	0	0	0	0	5.87
	2300	4/12/2008	19:34	33.069	117.759	15.5	0	217.92	0	0	0	234.28
	2301	4/13/2008	1:51	32.726	118.377	15.0	0	309.74	0	0	1.28	386.46
	2302	4/13/2008	19:58	31.764	120.414	13.6	6.17	0	0	0	0	21.46
	2303	4/13/2008	23:26	31.634	120.694	14.3	0	0	0	0	0	1.22
	2304	4/14/2008	2:58	31.505	120.882	13.9	8.09	0	16.36	0	0	28.54
	2305	4/14/2008	19:20	31.447	122.030	13.3	0	0	0	0	0	2.25
	2306	4/14/2008	22:57	31.522	122.086	13.4	0	0	0	0	0	0.19
	2307	4/16/2008	18:57	32.478	120.615	12.8	19.46	0	0	0	0	20.98
	2308	4/16/2008	23:29	32.696	120.144	12.5	0	0	0	0	0	3.23
	2309	4/17/2008	3:13	32.861	119.806	11.6	2.04	0	0	0	0	3.29
	2310	4/17/2008	19:53	33.592	119.843	13.0	0	3.86	0	0	0.04	31.23
	2311	4/17/2008	23:46	33.430	120.176	11.4	49.63	0	0	0	0	92.49
	2312	4/18/2008	18:50	32.601	121.903	13.1	0	0	0	0	0	1.68
	2313	4/18/2008	23:56	32.462	122.171	13.9	0	0	0	0	0	0.93
	2314	4/19/2008	4:03	32.361	122.385	13.2	0	0	0	0	0	0.38
	2315	4/20/2008	18:56	33.169	122.320	12.0	0	0	0	0	0	81.8
	2316	4/21/2008	20:01	34.085	122.028	11.8	1.34	0	7.73	0.52	0	22.09
	2317	4/21/2008	23:22	34.009	122.167	12.2	0	0	0	0	0	9.17
	2318	4/22/2008	3:35	33.845	122.435	12.6	0	0	0	0	0	0.15
	2319	4/22/2008	19:10	34.511	122.781	12.4	0.29	0	0	0	0	7.93
	2320	4/22/2008	22:22	34.624	122.523	12.2	0	0	0	0	0	37.53
	2321	4/23/2008	22:37	34.716	121.574	11.2	0	0	0	0	0	2.36
	2322	4/24/2008	4:33	34.350	122.227	11.9	0	0	0.57	0	0	1.98
	2323	4/24/2008	21:24	33.822	123.379	12.8	0.25	0	0	0.36	0	11.56
	2324	4/25/2008	3:09	33.716	123.660	13.1	0	0	0	0.38	0	2.14
	2325	4/25/2008	20:01	34.278	124.081	13.0	10.18	0	1.58	0.91	0	59.56
	2326	4/26/2008	2:22	34.558	123.500	12.8	2.75	0	0	0.45	0	153
	2327	4/26/2008	21:09	35.297	121.963	11.2	2.83	0	34.5	0	0	50.19
	2328	4/27/2008	3:27	35.469	121.624	11.8	0.2	0	0	0	0	38.08

Table 11. Trawl and catch data from the summer 2008 CCE survey off the U.S. West Coast using the NOAA Ship *David Starr Jordan*.

	Trawl Information						Target Species and Total Catch Weight (kilograms)					
Area	ID	Date	Time	Latitude (°N)	Longitude (°W)	Sea Temp. at 3m (°C)	Pacific Sardine	Northern Anchovy	Jack Mackerel	Pacific Mackerel	Market Squid	Total Catch
	2413	7/4/2008	22:32	44.970	124.314	15.5	311.08	35.15	0	2.8	0	353.61
	2414	7/5/2008	21:29	48.230	124.980	12.8	2.87	0	4.2	0	0	92.84
NW	2415	7/6/2008	3:27	48.415	125.343	12.5	4.88	0	0	0	0	1071.01
	2416	7/6/2008	22:51	48.274	127.837	13.1	0	0	0	0	0	4.45
	2417	7/7/2008	3:29	47.793	127.602	13.3	0	0	0	0	0	33.28
	2418	7/7/2008	20:32	47.728	125.543	14.0	0	0	0	0	0	55.31
	2419	7/7/2008	23:56	47.720	125.009	13.3	3.16	0	0	0	0	222.76
	2420	7/8/2008	3:31	47.636	124.679	13.3	0	0	0	0	0.08	12.84
	2421	7/8/2008	21:17	47.175	124.502	13.1	222.33	0	0	0	0.02	712.35
	2422	7/8/2008	23:58	46.934	124.443	13.1	47.71	0	0	0	0.01	374.35
	2423	7/9/2008	3:28	46.651	124.474	14.1	18.07	0	0	0	0.01	208.79
	2424	7/9/2008	21:34	47.010	126.777	14.3	0	0	0	0	0	3.25
	2425	7/10/2008	4:12	46.937	127.209	13.8	0	0	0	0	0	7.84
	2426	7/10/2008	20:54	46.317	125.386	14.5	0	320.93	0	0	0	342.53
	2427	7/11/2008	3:33	46.308	124.789	14.2	0	0	0	0	0	1.85
	2428	7/11/2008	20:43	45.994	124.265	12.5	2.48	0.14	7.3	0	0	80.18
	2429	7/11/2008	23:56	45.664	124.093	8.5	0.21	0	0	0	0	3.45
	2430	7/12/2008	3:22	45.334	124.239	10.8	0.3	0.03	0	0	0	16.22
	2431	7/12/2008	20:52	45.658	126.024	15.1	0	0	0	0	0	2.1
	2432	7/13/2008	2:59	45.719	126.938	15.7	0	0	0	0	0	20.51
	2433	7/13/2008	20:40	44.994	125.814	14.6	0	0	0	0	0	0.54
	2434	7/14/2008	3:55	44.995	125.113	13.8	0	1.95	0	0	0	26.5
	2435	7/14/2008	21:10	44.050	124.717	9.0	933.42	0	0	15.5	0	948.92
	2436	7/14/2008	23:59	43.841	124.752	10.1	15.03	0.88	0	0.95	0	24.86
	2437	7/15/2008	3:28	43.461	124.749	9.2	1.19	0.03	1.85	0	0	14.11
	2438	7/15/2008	22:20	44.744	124.415	9.4	681.99	0	0	0	0	701.69
	2439	7/16/2008	2:55	44.542	124.322	8.6	3.24	0	0	0	0	4.52
	2440	7/18/2008	22:05	44.357	125.245	12.7	0	0	0	0	0	14.64
	2441	7/19/2008	3:30	44.295	125.939	15.5	0	0	0	0	0	17.66
	2442	7/19/2008	22:28	43.695	126.904	15.5	0	0	0	0	0	24.49
	2443	7/20/2008	3:27	43.669	126.304	13.8	0	0	0	0	0	3.62
	2444	7/20/2008	21:00	43.063	124.652	9.6	13.58	0	2	2.4	0	31.07
	2445	7/21/2008	0:48	42.962	124.712	9.2	0.42	0	0	0.3	0	4.77
	2446	7/21/2008	3:30	42.673	124.743	9.1	134.04	0.06	2	0	0	180.12

Table 11. Continued.

	Trawl Information						Target Species and Total Catch Weight (kilograms)					
Area	**ID**	**Date**	**Time**	**Latitude (°N)**	**Longitude (°W)**	**Sea Temp. at 3m (°C)**	**Pacific Sardine**	**Northern Anchovy**	**Jack Mackerel**	**Pacific Mackerel**	**Market Squid**	**Total Catch**
NW	2447	7/21/2008	21:40	43.002	126.511	14.3	0	0	0	0	0	40.29
	2448	7/22/2008	3:30	43.014	127.231	14.7	0	0	0	0	0	1.94
	2449	7/22/2008	21:40	42.353	126.203	13.9	0	0	39.8	0	0	58.47
	2450	7/23/2008	2:50	42.348	125.441	14.3	0	0	0	0	0	8.3
	2451	7/24/2008	22:00	42.273	124.557	8.9	0	0.01	0	0.16	0	9.12
	2452	7/25/2008	0:30	42.048	124.587	9.4	183.42	0	0	0.65	0	184.07
N CA	2453	7/25/2008	3:30	41.760	124.559	9.4	0.39	0	0	0.24	0	1.07
	2454	7/25/2008	20:50	41.687	126.869	15.1	0	0	1.65	2.1	0	5.62
	2455	7/26/2008	3:28	41.673	127.479	16.1	0	0	22.35	0.6	0	25.33
	2456	7/26/2008	22:00	40.996	126.836	15.8	0	0	0	0	0	2.14
	2457	7/27/2008	3:00	41.017	126.067	12.8	0.22	0	17.5	0	0	51.38
	2458	7/27/2008	21:25	40.768	124.506	11.6	2.09	0	89.47	0	0	246.17
	2459	7/28/2008	0:38	40.579	124.650	13.3	0	0	23.64	2.73	0	68.1
	2460	7/28/2008	3:28	40.317	124.523	12.5	0	0	7.73	0	0	15.42
	2461	7/28/2008	21:25	40.323	126.420	15.8	0	0	0	4.09	0	6.03
	2462	7/29/2008	2:03	40.357	127.078	15.8	0.45	0	34.09	5	0	55.75
	2463	7/29/2008	21:25	39.652	126.973	16.2	0	0	0	0	0	2.76
	2464	7/30/2008	3:30	39.709	126.380	15.5	0	0	0	0	0	3.57
	2465	7/30/2008	22:55	39.551	124.019	12.3	0	0	15.45	0	0	67.72
	2466	7/31/2008	2:38	39.155	123.903	10.8	0.18	0	2.27	0	0	11.86
	2467	7/31/2008	21:25	39.001	125.964	15.6	0	0	27.27	0.44	0	154.25
	2468	8/1/2008	3:30	39.020	126.546	16.9	0	0	0	0	0	0.24
	2469	8/1/2008	21:30	37.754	126.529	17.4	0	0	0	0	0	9.63
	2470	8/2/2008	3:25	37.401	126.342	15.4	0	0	5.91	0	0	27.89
	2471	8/2/2008	22:39	37.873	124.633	14.1	0.39	0	16.82	0	0	73.4
	2472	8/3/2008	0:55	37.823	124.521	13.3	0	0	44.09	1.61	0	118.66
	2473	8/3/2008	3:35	37.779	124.384	12.9	0	0	79.55	0.27	0	155.38
std. DEPM	2475	8/6/2008	0:05	37.322	124.175	14.7	0	0	11.1	0	0	48
	2476	8/7/2008	4:53	37.233	124.399	13.7	0	0	0	0	0	86.2
	2477	8/7/2008	20:50	36.435	125.651	16.9	0	0	0.01	0	0	8.06
	2478	8/8/2008	0:21	36.108	125.387	17.5	0	0	0	0	0	4.35
	2479	8/8/2008	4:22	36.087	125.218	16.5	0	0	0	0	0	0.6
	2480	8/8/2008	20:40	36.846	123.563	15.4	0	0	48.4	0	0	229.6
	2481	8/9/2008	3:41	37.055	123.129	13.1	0.17	0	2.2	2	0	31.58
	2482	8/13/2008	21:03	37.067	122.485	13.1	3.97	4.57	0	0	45.5	154.05

Table 12. Gross anatomical classification system for female and male Pacific sardine gonads.

Female:

Code - Ovary description

1 Clearly Immature: oocytes not visible, ovary is very small, translucent/clear, and thin but with rounded edges (torpedo shape).

2 Intermediate: Individual oocytes are not visible to unaided eye (no visible yolk or hydrate oocytes in the ovaries) but ovary is not clearly immature. Includes possible maturing and regressed ovaries.

3 Active: Yolked oocytes visible, any size or amount as long as you can see them by the unaided eye in ovaries. This includes the smaller opaque oocytes (around 0.4-0.5 mm) to the large yellowish oocytes (about 0.6-0.8mm). If hydrated oocytes are also present, then classify ovary as "4".

4 Hydrated oocytes present, yolked oocytes may, or not, also be seen; any amount of hydrated oocytes (large and transparent) qualifies for this class from few to many or even if loose or "oozing/running" from ovary.

Male:

Code - Testis description

1 Clearly Immature: testis is very small, knife-shaped, translucent/clear, thin with a flat ventral edge

2 Intermediate: no milt evident and is not a clear immature; includes maturing or regressed testes

3 Milt is present: either oozing from pore, in the duct, or when testis is cut with a knife

Table 13. Species composition, occurrences (positive trawls), and total weight from combined trawl catches during April 2008 survey.

April 2008 Catch			
Species	Common Name	Occurrences	Total Weight (kg)
FISH:			
Engraulis mordax	Northern anchovy	4	531.58
Sardinops sagax	Pacific sardine (pilchard)	13	103.38
Alopias vulpinus	Thresher shark	1	68.20
Prionace glauca	Blue shark	4	63.48
Trachurus symmetricus	Jack mackerel	5	60.74
Mola mola	Ocean sunfish	3	44.38
Lamna ditropis	Salmon shark	1	34.10
Myctophidae	Lanternfishes	28	33.16
Oncorhynchus kisutch	Coho salmon	1	10.27
Clupea pallasii	Pacific herring	2	6.11
Thalassenchelys coheni	Eel larvae	13	5.80
Symbolophorus californiensis	California lanternfish	16	5.30
Bathylagus spp.		8	2.76
Scomber japonicus	Pacific mackerel (chub mackerel)	5	2.61
Sebastes melanops	Black rockfish	1	1.72
Oncorhynchus tshawytscha	Chinook salmon (king salmon)	3	1.51
	fish larva unident.	3	1.30
	fish unident.	2	1.12
Allosmerus elongatus	Whitebait smelt	3	0.88
Tarletonbeania crenularis	Blue lanternfish	9	0.75
Citharichthys spp.	Sanddabs	4	0.53
Peprilus simillimus	Pacific butterfish or pompano	1	0.46
Merluccius productus	Pacific hake or whiting	1	0.37
Trachipterus altivelis	King-of-the-salmon	2	0.35
Pleuronectiformes larva	flatfish larva unident.	2	0.29
Ophiodon elongatus	Lingcod	2	0.10
Anotopterus pharao	Daggertooth	1	0.07
Icichthys lockingtoni	Medusafish	1	0.02
Microstomus pacificus	Dover sole	1	0.01
Bathylagus wesethi	snubnose blacksmelt	1	0.01
Chauliodontinae	Viperfishes	1	0.01
Stenobrachius leucopsarus	Northern lampfish	1	0.01
Diaphus spp.	Headlightfishes	3	0.01
Paralepididae	Barracudinas	1	0.01
INVERTEBRATES:			
Scyphozoa	Jellyfish unident.	23	75.63
Aurelia spp.	Moon jelly	17	41.62
Onychoteuthis borealijaponicus	Boreal clubhook squid	16	31.29
Dosidicus gigas	Humboldt squid	3	20.13
	Shrimp unident.	5	16.98
Thaliacea unident.	Salp unident.	17	15.01
	Squid unident.	33	9.52
Ctenophora	Comb jelly (*Hormiphora cucumaris*)	9	3.61
Abraliopsis felis	Abraliopsis	13	1.47
Loligo opalescens	market squid	2	1.31
	Invertebrates combined	3	1.03
	Invertebrate unident.	3	0.78
Gonatopsis borealis	Boreopacific armhook squid	6	0.70
Euphausiacea	Euphausid unident.	2	0.65
Octopodidae	Octopus unident.	3	0.37
Cranchia scabra	Sandpaper (tennisball) squid	4	0.13
Pterygioteuthis gemmata	jewel squid	3	0.09
Trichotropidae	Hairysnail unident.	1	0.01

Table 14. Species composition, occurrences (positive trawls), and total weight from combined trawl catches during July/August 2008 survey.

	July/August 2008 Catch		
Species	Common Name	Occurrences	Total Weight (kg)
FISH:			
Sardinops sagax	Pacific sardine (pilchard)	27	2587.27
Squalus acanthias	Spiny dogfish	5	921.60
Trachurus symmetricus	Jack mackerel	26	506.65
Galeorhinus galeus	Soupfin shark	3	445.00
Engraulis mordax	Northern anchovy	10	363.76
Oncorhynchus kisutch	Coho salmon	7	214.53
Merluccius productus	Pacific hake or whiting	9	207.57
Oncorhynchus tshawytscha	Chinook salmon (king salmon)	14	171.90
Mola mola	Ocean sunfish	4	130.00
Clupea pallasii	Pacific herring	5	81.52
Prionace glauca	Blue shark	8	68.25
Myctophidae	Lanternfishes	15	52.48
Lamna ditropis	Salmon shark	3	50.00
Thunnus alalunga	Albacore	3	42.40
Scomber japonicus	Pacific mackerel (chub mackerel)	17	41.83
Brama japonica	Pacific pomfret	7	32.89
Icosteus aenigmaticus	Ragfish	2	24.59
Symbolophorus californiensis	California lanternfish	24	24.38
Paralepididae	Barracudinas	16	22.63
Tetragonurus cuvieri	Smalleye squaretail	12	15.15
Tarletonbeania crenularis	Blue lanternfish	25	12.91
Sebastes spp.	Rockfishes	21	12.91
Anoplopoma fimbria	Sablefish (blackcod)	4	12.81
Ophiodon elongatus	Lingcod	1	9.70
Merluccius productus, juvenile	Pacific hake juvenile	5	5.94
Alosa sapidissima	American shad	5	5.66
Diaphus spp.	Headlightfishes	20	4.01
Thalassenchelys coheni	Eel larvae	13	1.92
Atheresthes stomias	Arrowtooth flounder	1	1.70
Citharichthys sordidus	Pacific sanddab	1	1.10
Oncorhynchus keta	Chum salmon	1	1.00
Bathylagus ochotensis	Popeye blacksmelt	9	0.89
Icichthys lockingtoni	Medusafish	1	0.50
Lyopsetta exilis	Slender sole	2	0.22
Tactostoma macropus	Longfin dragonfish	4	0.20
Anarrhichtys ocellatus	Wolf eel	2	0.17
Stenobrachius leucopsarus	Northern lampfish	1	0.15
Thaleichthys pacificus	Eulachon	2	0.13
Allosmerus elongatus	Whitebait smelt	3	0.11
Lampetra tridentata	Pacific lamprey	3	0.09
Bathylagus spp.		1	0.05
Microgadus proximus	Pacific tomcod	1	0.05
Cololabis saira	Pacific saury	1	0.04
Glyptocephalus zachirus, larva	Rex sole larvae	8	0.04
Hexagrammidae	greenling unident.	4	0.03
	fish unident.	1	0.02
Microstomus pacificus	Dover sole	6	0.02
Oncorhynchus nerka	Sockeye salmon, juvenile	1	0.01
	fish larva unident.	1	0.01
Nemichthys scolopaceus	Slender snipe eel	1	0.01
Pleuronectidae	Righteyed flounders	1	0.01

Table 14. Continued.

July/August 2008 Catch			
Species	Common Name	Occurrences	Total Weight (kg)
INVERTEBRATES:			
Dosidicus gigas	Humboldt squid	13	370.47
	Invertebrates combined	8	309.38
Chrysaora spp.	Chrysaora sp. jellyfish	2	300.21
Aurelia spp.	Moon jelly	4	215.64
Scyphozoa	Jellyfish unident.	19	154.14
Loligo opalescens	market squid	5	45.61
	Squid unident.	25	31.34
Onychoteuthis borealijaponicus	Boreal clubhook squid	22	23.74
Abraliopsis felis	Abraliopsis	22	12.23
Ctenophora	Comb jelly (*Hormiphora cucumaris*)	17	11.11
Gonatopsis borealis	Boreopacific armhook squid	15	7.09
Euphausiacea	Euphausid unident.	7	4.05
Thaliacea unident.	Salp unident.	2	2.50
Phacellophora camtchatica	Eggyolk jelly	5	2.10
Gonatopsis spp.	Armhook squid	2	1.94
	Aequorea jellyfish	3	0.70
Gonatus spp.	gonatus sp.	6	0.27
Chiroteuthis calyx	Chiroteuthis calyx	3	0.23
Cranchia scabra	Sandpaper (tennisball) squid	1	0.11
	Amphipod unident.	1	0.01

Table 15. Summary of length (L) and weight (Wt) for target small pelagic fish species in catches during April 2008 CCE survey.

Survey Areas	Trawl ID	Pacific sardine					Northern anchovy					Jack mackerel			Pacific mackerel		
		N	Mean SL (mm)	Range SL (mm)	Mean Wt (g)	Range Wt (g)	N	Mean SL (mm)	Range SL (mm)	Mean Wt (g)	Range Wt (g)	N	Mean FL (mm)	Range FL (mm)	N	Mean FL (mm)	Range FL (mm)
NW	2375						3	124	110-137	19	12-24						
N CA	2409	1	236		148												
	2300						50	124	108-144	21	14-28						
std.	2301						50	125	112-146	20	15-32						
DE PM	2302	55	210	180-227	112	60-162											
	2304	50	220	206-248	115	92-160						14	460	370-580			
	2307	50	210	185-232	93	70-122											
	2309	30	184	163-215	68	48-90											
	2310						50	125	107-148	21	12-32						
	2311	55	205	172-223	86	46-110											
	2316	11	217	210-225	122	109-139						13	370	330-410	1	347	
	2319	2	234	220-248	143	123-164											
	2322											2	400	380-410			
	2323	2	224	221-227	127	116-138									1	320	
	2324														1	325	
	2325	50	222	207-239	126	106-154						3	359	341-381	3	301	275-319
	2326	26	214	192-253	106	78-170									1	340	
	2327	25	216	195-232	113	79-137						52	390	280-430			
	2328	2	206	202-210	98	97-99											
All		354	211	163-248	105	46-164	153	125	107-148	21	12-32	84	400	280-580	7	319	275-347

SL is standard length and FL is fork length.

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Table 16. Summary of length (L) and weight (Wt) for target small pelagic fish species in catches during July/August 2008 CCE survey.

		Pacific sardine					**Northern anchovy**					**Jack mackerel**			**Pacific mackerel**		
Survey Area	**Trawl ID**	N	Mean SL (mm)	Range SL (mm)	Mean Wt (g)	Range Wt (g)	N	Mean SL (mm)	Range SL (mm)	Mean Wt (g)	Range Wt (g)	N	Mean FL (mm)	Range FL (mm)	N	Mean FL (mm)	Range FL (mm)
	2413	50	209	185-227	108	76-138	50	115	100-146	17	12-36				9	297	250-330
	2414	20	230	210-257	144	104-190						2	580	550-610			
NW	2415	42	212	196-238	116	94-148											
	2419	24	220	205-243	132	102-175											
	2421	50	214	195-227	110	85-130											
	2422	50	214	195-234	117	88-156											
	2423	50	213	195-247	117	82-181											
	2426						50	131	113-161	26	16-48						
	2428	23	211	200-220	108	92-128	1	-		14		4	560	540-580			
	2429	2	206	200-212	106	100-112											
	2430	3	200	195-206	100	86-114	2	111	110-112	14	13-16						
	2434						50	126	111-145	22	15-30						
	2435	50	206	189-225	122	98-153									32	321	240-370
	2436	50	210	186-248	113	76-178	34	128	116-145	26	20-37				3	270	240-290
	2437	11	212	189-239	108	82-135	1	140		32							
	2438	50	211	197-225	120	98-140											
	2439	27	213	189-233	120	82-147											
	2444	50	200	174-239	112	81-161						1	580	0	7	297	250-340
	2445	4	218	190-240	104	89-128									1	300	
	2446	50	207	189-224	125	99-155	4	108	86-145	15	6-35	1	560				
	2449											22	539	520-570			
	2451						1	88		7					1	240	
	2452	50	200	186-222	108	87-164									1	320	

Table 16. Continued.

Survey Area	Trawl ID	Pacific sardine					Northern anchovy					Jack mackerel			Pacific mackerel		
		N	Mean SL (mm)	Range SL (mm)	Mean Wt (g)	Range Wt (g)	N	Mean SL (mm)	Range SL (mm)	Mean Wt (g)	Range Wt (g)	N	Mean FL (mm)	Range FL (mm)	N	Mean FL (mm)	Range FL (mm)
N CA	2453	3	209	197-229	130	111-156									1	260	
	2454											2	410	390-430	4	333	330-340
	2455											23	427	400-470	1	350	
	2457	2	196	190-202	112	104-119						17	435	400-550			
	2458	19	198	179 231	110	88-153						34	543	510-590			
	2459											21	440	400-580	5	326	290-340
	2460											5	486	410-540			
	2461														6	337	310-350
	2462	3	222	209-235	151	129-176						35	425	400-550	8	323	200-370
	2465											9	529	510-560			
	2466	2	193	189-197	88	82-93						1	550				
	2467											23	452	390-580	3	243	230-250
	2470											5	454	400-530			
	2471	3	224	222-227	129	123-133						26	398	260-490			
	2472											52	397	330-540	5	296	260-340
	2473											51	410	340-560	1	270	
std. DEPM	2475											15	389	240-550			
	2477											3	63	60 - 70			
	2480											33	512	380-570			
	2481	2	189	188-190	87	82-92						6	260	200-510	8	278	230-330
	2482	50	138	85-195	43	8-96	50	135	121-150	27	22-36						
All		740	205	85-257	111	8-190	242	126	86-161	23	6-48	391	444	60 -610	96	308	200-370

SL is standard length and FL is fork length.

Table 17. Temperatures (3 m depth) and adult Pacific sardine taken in trawls and presence of sardine eggs collected in CUFES samples (egg min^{-1}) within three survey areas during the spring 2006 Coast-wide Sardine and 2008 CCE surveys off the west coast of the United States. Region 1 is the post-cruise identified area of high (≥ 1 egg min^{-1}) egg density and Region 2 is low (< 1 egg min^{-1}).

Survey Area Information	**April 2006**	**April 2008**	**July 2008**
Washington-Oregon: 48.5° - 42°N			
Sea Temperature Range (°C)	9.1-11.8	8.2-10.1	8.5-15.7
Mean °C of sardine positive trawls	na	na	11.0
Number positive trawls (total)	0 (9)	0 (25)	19 (40)
Number of adult sardine	-	-	655
Mean body weight (g)	-	-	116
Eggs, Region 1	+	-	-
Eggs, Region 2	+	-	+
Northern California: 42°N- CalCOFI line 60			
Sea Temperature Range (°C)	10.8-12.2	7.8-11.6 *	9.4-17.4
Mean °C of sardine positive trawls	11.4	11.5	12.4
Number positive trawls (total)	3 (4)	1 (15)	6 (21)
Number of sardines	101	1	32
Mean body weight (g)	91	148	116
Eggs, Region 1	+	-	-
Eggs, Region 2	+	+	+
standard DEPM: CalCOFI lines 60-93 (San Francisco - San Diego)			
Sea Temperature Range (°C)	13.3-16.6	11.2-13.9	13.1-17.5
Mean °C of sardine positive trawls	14.4	12.4	13.1
Number positive trawls (total)	7 (22)	12 (31)	2 (8)
Number of adults	194	353	25**
Mean body weight (g)	67	105	79
Eggs, Region 1 (area, km^2)	+ (98034)	+ (53514)	+
Eggs, Region 2	+	+	+

* a single negative offshore trawl at 38.4°N recorded 13.2 °C

** 27 juveniles (mean of 13 g) also taken; mean weight of port samples: 79 g (Monterey) and 48 g (San Pedro)

Table 18. Comparison of the results from the July/August 2008 CCE survey to three previous summer surveys in the northeastern Pacific. Presence of sardine eggs in CUFES samples (egg min^{-1}) were separated into high (≥ 1 egg min^{-1}) and low (< 1 egg min^{-1}) egg densities.

Surveys off Washington-Oregon	**July-Aug 2008**	**June 2007**	**July 2004**	**July 2003**
Sea Temperature Range (°C)	8.5-15.7	13.3-16.6	12.4-19.4*	13.3-17.3
Mean °C of sardine positive trawls	11.0	13.6	15.6	15.3
Number positive trawls (total)	19 (40)	6 (14)	27 (58)	36 (48)
Number of sardine adults	655	179	805	1316
Mean body weight (g)	116	142	102	187
Samples with ≥ 1 sardine egg/min	-	+	+	+
Samples with < 1 sardine egg/min	+	+	+	+

* a single negative inshore trawl at Cape Blanco recorded 9.4 °C

MARINE BIRD OBSERVATIONS, by J. Zamon, T. Guy, J. Jahncke, J. Howar, and J. Roth

Methods

Marine birds and mammals were counted using modified line transect methods (Tasker et al. 1984). Observations were recorded during daylight hours when the vessel was moving at speeds in excess of 8 m s^{-1} (4 knots) and when weather conditions permitted observation. Transects occurred on pre-determined lines that extended up to 500 km offshore. Observations began at dawn each morning. One (*David Starr Jordan*, 31 March to 30 April 2008) or two (all other cruise legs) dedicated observers counted and identified all flying or sitting birds within a strip extending 300 m out from the bow to the beam of the ship in a 90° arc. Strip width was determined visually with a calibrated range finder (Heinemann 1981). Observers worked from the flying bridge of the NOAA Ships *Miller Freeman* and *David Starr Jordan*. Data were collected from the side of the vessel with the best viewing conditions and least amount of sun glare. Observers took breaks for meals and when the ship stopped for daytime oceanographic stations or trawl operations.

Sightings of interest beyond 300 m were recorded only when doing so did not compromise complete coverage of the primary survey area. Sightings of interest were also recorded opportunistically while off survey effort during daylight hours. Binoculars of at least 8X magnification were used to aid counting and species identification.

Observers recorded species identification, counts, and behaviors (e.g. sitting, flying, feeding) onto a laptop computer. The computer automatically appended a time stamp to all observations. Latitude and longitude positions were also appended to each observation during April aboard the *Miller Freeman* and during July/August aboard the *David Starr Jordan*. For sightings on the *David Starr Jordan* in April that did not have position stamps, we used the time stamps, ship course, ship speed, and dead-reckoning methods to interpolate sighting positions from latitude and longitude positions recorded manually during each transect.

Results

Dates, locations, and survey effort

Two different pairs of observers actively collected data during each of two cruise legs aboard the *Miller Freeman* between 1 April and 2 May 2008. Coverage began at Cape Flattery, WA and ended in San Francisco, CA. A single observer also collected data during a post-cruise transit from San Francisco, CA to Seattle, WA between 1 and 2 May 2008. On-effort sightings covered a total of 4,015 km linear survey distance (approximately 1,204 km^2 survey area). No data were collected during the in-port period of 15 to 17 April 2008.

A single observer actively collected data from the *David Starr Jordan* between 13 and 29 April 2008. Coverage began at San Diego, CA and ended at San Francisco, CA. On-effort sightings covered 1,149 km linear survey distance (approximately 343 km^2 survey area). No data were collected during 19 to 22 April 2008.

Three different pairs of observers actively collected data during each of three cruise legs aboard the *David Starr Jordan* between 5 July and 18 August 2008. On-effort sightings covered a total of 4,992 km linear survey distance (approximately 1,497 km^2 survey area).

Survey effort by date is shown in (Tables 19 and 20). The locations of all on-effort sightings are mapped over monthly composites of mean sea surface temperature in Figures 11 and 12. In these figures, bird sightings are summed within 3-km bins along each transect. Larger circles represent survey segments with more bird sightings.

Bird species counts by survey day

During the April *Miller Freeman* survey, 45 bird species and 5 mammal species were identified. During the April *David Starr Jordan* survey, 25 bird species and 4 mammal species were identified. During the July/August *David Starr Jordan* survey, 57 bird species and 11 mammal species were identified. The total numbers of each species seen vs. survey day are shown in Tables 21, 22, and 23. Most bird species were marine birds or water birds, but some land birds were sighted offshore (e.g. passerines).

Two endangered immature short-tailed albatross, *Phoebastria albatrus*, were seen during survey efforts. One bird occurred on 06 April 2008 approximately 184 km west of Grays Harbor, WA in about 2500 m of water. A second immature short-tailed albatross was observed greater than 300 meters from the ship on 19 April 2008, approximately 36 km southwest of Gold Beach, OR. Observers were able to photograph both birds.

Twenty-two endangered marbled murrelets (*Brachyramphus mamoratus*) were seen: two on 03 April 2008 and twenty on 10 April 2008. The first pair was seen ~57 km west of the entrance to Juan de Fuca, and all others were seen within 22 km of the mouth of the Siuslaw River near Florence, OR. Some of these individuals were in breeding plumage, and some were still in winter plumage.

Relative bird species composition

Two pie charts (Figures 13 and 14) present the most common types of birds seen during the April and July/August research cruises, respectively. The April chart combines data from both the *Miller Freeman* and the *David Starr Jordan* cruises in April. Bird species that made up at least two percent of total sightings are presented as individual wedges in the charts.

During April, a total of 11,466 birds were detected during the combined surveys. Both migratory and breeding species were encountered (e.g. Briggs et al. 1987). The most common bird was the red phalarope, *Phalaropus fulicarius* (27% of sightings), a planktivorous shorebird undergoing spring migration to Arctic breeding grounds. The next most common bird (14%) was the common murre, *Uria aalge*, a piscivorous (and occasionally planktivorous) diving bird with active breeding colonies located in California, Oregon, and Washington. This bird is capable of capturing fish such as anchovy and sardine as well as krill and large amphipods. Other species seen are capable of capturing anchovy and sardine including sooty shearwater (*Puffinus griseus*, 8%), rhinoceros auklet (*Cerorhinca monocerata*, 6%), gulls of various species (*Larus* species, 8%), and northern fulmar (*Fulmarus glacialis*, 2%).

During July and August, a total of 11,925 birds were detected during the survey. Unlike in April, when spring migrants such as phalaropes accounted for almost one-third of the species seen, the summer resident sooty shearwater (29%) and common murre (20%) dominated the community in July/August. Both of these species consume pelagic schooling fishes such as anchovy and sardine. Other species capable of consuming anchovy or sardine include the gulls (*Larus* species, 9%), pink-footed shearwater (*Puffinus creatopus*, 4%), northern fulmar (*Fulmarus glacialis*, 4%), Brandt's cormorant (*Phalacrocorax pencillatus*, 2%), black-footed albatross (*Phoebastria nigripes*, 2%), and rhinoceros auklet (*Cerorhinca monocerata*, 2%).

Survey data show a significant seasonal (spring vs. summer) shift in the species composition of the marine bird community, similar to previous reports (e.g. Briggs et al. 1987). Relatively more piscivorous individuals were seen in July (72%) compared to April (37%). This increase in piscivorous species coincides with the appearance of sardine in almost all nearshore trawls north of San Francisco.

Spatial pattern in distribution of dominant bird species

The three most commonly seen species in April showed different inshore/offshore and north/south distribution patterns. Red phalaropes were seen primarily offshore, almost exclusively between Point Arena, California in the south to the Oregon/Washington border in the north (Figure 15). The next most abundant species, the common murre, was seen exclusively inshore north of San Francisco, near locations consistent with attendance at coastal breeding colonies in northern California, Oregon, and Washington (Figure 16). Sooty-shearwaters, a non-breeding summer resident which migrates to the California Current during the austral winter, were found throughout the entire survey area, both inshore and offshore (Figure 17). Most large groups of shearwaters were seen north of San Francisco, except for three aggregations associated with anchovy spawning in the Southern California Bight. Red phalaropes and common murres did not overlap with sardine and anchovy spawning areas off the Southern California Bight.

The three most commonly seen species in July/August also showed spatial patterns that differed among species and in some cases differed from April patterns. Sooty shearwaters were found somewhat further inshore in July than in April (Figure 18). Large numbers of shearwaters off northern Oregon appeared to co-occur with cool, upwelled water (7-10 °C), anchovy eggs, and inshore areas where trawls contained sardine. Not all shearwaters were found in this upwelling domain, however. Common murre distributions were similar between April and July, and overlapped sooty shearwater distributions in July (Figure 19). However, almost all murres were seen in nearshore, upwelling habitat. Leach's storm-petrels were found primarily in warmer, offshore waters (>15 °C), away from areas of active upwelling, sardines, and anchovy eggs; their distribution overlapped with offshore groups of sooty shearwaters, but only overlapped with murres off Cape Blanco, OR (Figure 20).

Table 19. Bird survey effort on April 2008 surveys, linear distance.

DATE	TOTAL KM OF BIRD SURVEY EFFORT, *MILLER FREEMAN*	TOTAL KM OF BIRD SURVEY EFFORT, *DAVID STARR JORDAN*
01-Apr-08	15.0	-
02-Apr-08	91.0	-
03-Apr-08	198.1	-
04-Apr-08	166.0	-
05-Apr-08	123.5	-
06-Apr-08	153.6	-
07-Apr-08	113.5	-
08-Apr-08	125.7	-
09-Apr-08	174.6	-
10-Apr-08	131.9	-
11-Apr-08	171.3	-
12-Apr-08	130.1	-
13-Apr-08	160.9	137.3
14-Apr-08	90.1	92.7
17-Apr-08	-	77.4
18-Apr-08	238.3	121.4
19-Apr-08	172.6	-
20-Apr-08	138.9	-
21-Apr-08	180.9	-
22-Apr-08	14.7	-
23-Apr-08	168.6	87.2
24-Apr-08	146.1	81.4
25-Apr-08	175.0	143.5
26-Apr-08	175.2	128.8
27-Apr-08	114.1	128.4
28-Apr-08	96.2	-
29-Apr-08	130.3	94.3
30-Apr-08	25.2	-
01-May-08	212.3	-
02-May-08	182.2	-
GRAND TOTAL KM SURVEY DISTANCE	4015.9	1092.4

Table 20. Bird survey effort on July/August 2008 survey, linear distance.

DATE	TOTAL KM OF BIRD SURVEY EFFORT
05-Jul-08	151.0
06-Jul-08	140.5
07-Jul-08	148.5
08-Jul-08	94.4
09-Jul-08	129.1
10-Jul-08	148.8
11-Jul-08	109.6
12-Jul-08	123.8
13-Jul-08	159.9
14-Jul-08	138.7
15-Jul-08	86.0
16-Jul-08	66.2
17-Jul-08	135.0
18-Jul-08	140.1
19-Jul-08	146.9
20-Jul-08	143.9
21-Jul-08	109.3
22-Jul-08	7.4
23-Jul-08	143.8
24-Jul-08	155.8
25-Jul-08	102.2
26-Jul-08	134.8
27-Jul-08	132.7
28-Jul-08	118.0
29-Jul-08	146.7
30-Jul-08	148.7
31-Jul-08	136.0
01-Aug-08	129.8
06-Aug-08	77.3
07-Aug-08	141.4
08-Aug-08	137.9
09-Aug-08	72.3
13-Aug-08	46.5
14-Aug-08	156.6
15-Aug-08	174.4
16-Aug-08	162.7
17-Aug-08	220.3
18-Aug-08	204.8
GRAND TOTAL KM SURVEY DISTANCE	4922.2

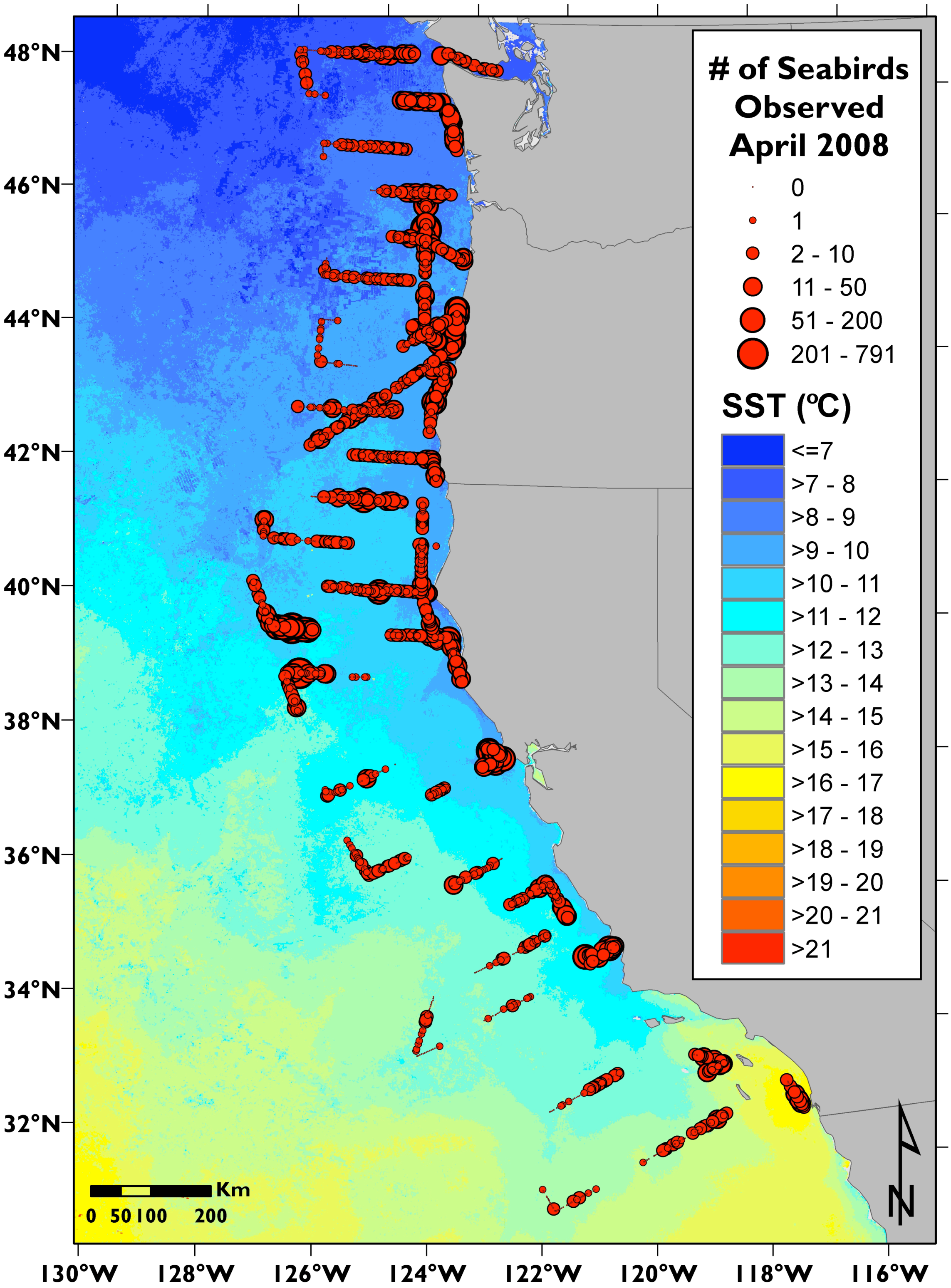

Figure 11. Locations and abundance of all seabirds observed during the April 2008 survey.

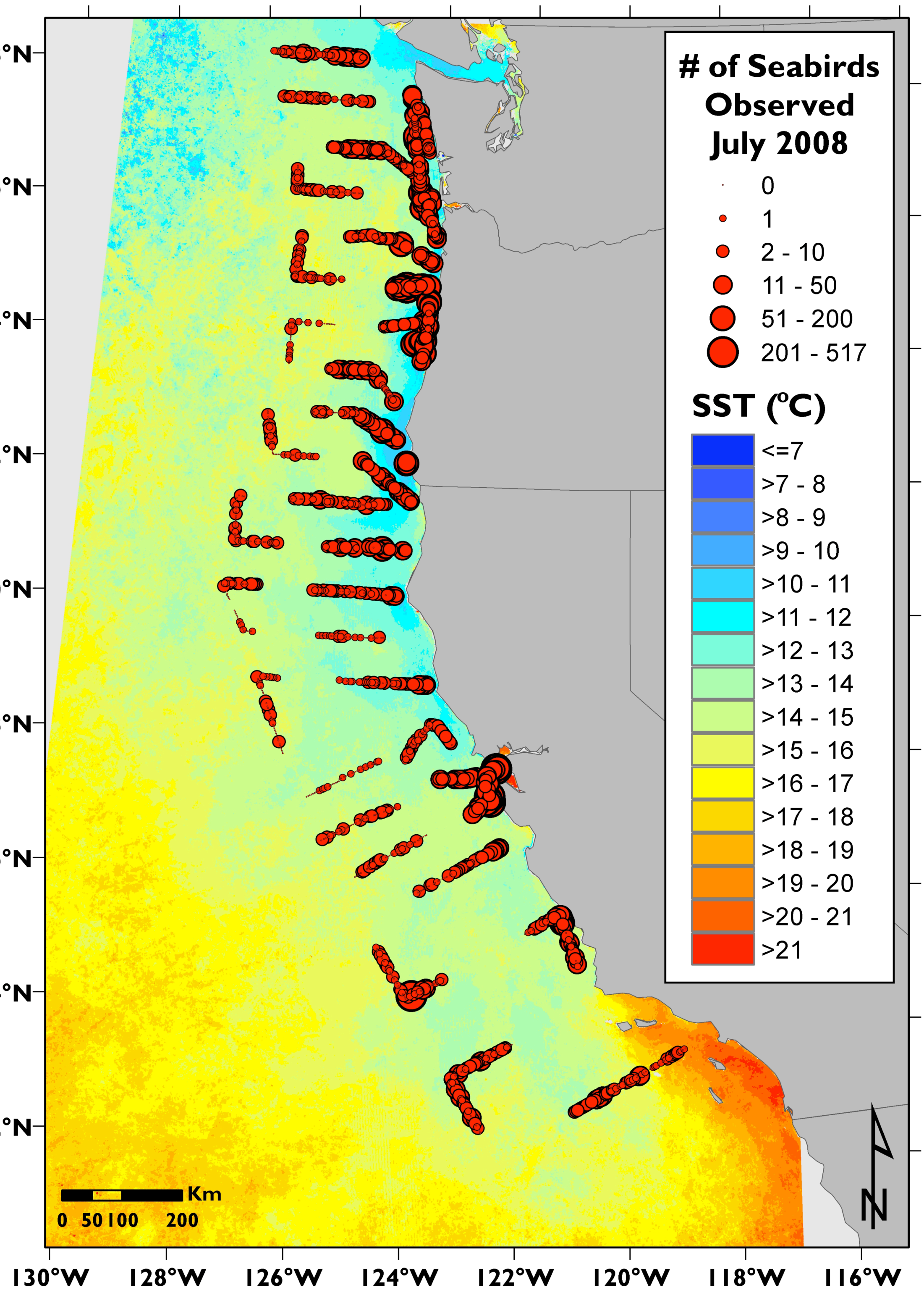

Figure 12. Locations and abundance of all seabirds observed during the July/August 2008 survey.

Table 21. Bird species counted by survey day during the April 2008 *Miller Freeman* cruise, Cape Flattery to San Francisco.

SCIENTIFIC NAME	COMMON NAME	01-Apr-08	02-Apr-08	03-Apr-08	04-Apr-08	05-Apr-08	06-Apr-08	07-Apr-08	08-Apr-08	09-Apr-08	10-Apr-08	11-Apr-08	12-Apr-08	13-Apr-08
Marine birds														
Class Aves	unidentified bird	-	-	-	-	-	-	-	-	-	-	-	-	-
Gavia immer	common loon	-	-	-	-	-	-	-	-	-	3	-	2	-
Gavia stellata	red-throated loon	-	-	-	-	-	-	-	-	-	-	-	1	-
Gavia pacifica	Pacific loon	-	-	-	-	1	-	-	2	-	28	-	86	-
Phoebastria albatrus	short-tailed albatross	-	-	-	-	-	1	-	-	-	-	-	-	-
Phoebastria nigripes	black-footed albatross	-	-	3	-	48	3	11	7	5	2	1	1	-
Diomedea immutabilis	Laysan albatross	-	-	-	-	1	-	-	-	-	-	-	-	-
Fulmarus glacialis	northern fulmar	-	-	11	3	11	19	9	8	5	8	2	-	2
Puffinus creatopus	pink-footed shearwater	-	-	-	-	-	-	-	-	-	-	-	-	-
Puffinus griseus	sooty shearwater	-	-	124	2	224	15	9	28	7	203	2	3	15
Puffinus spp.	dark shearwater	-	-	2	-	-	-	-	-	-	-	-	-	-
Pterodroma inexpectata	mottled petrel	-	-	-	-	-	-	-	-	2	-	1	-	-
Pterodroma cookii	Cook's petrel	-	-	-	-	-	-	-	-	-	-	-	-	-
Pterodroma ultima	Murphy's petrel	-	-	-	-	-	1	-	-	-	-	-	-	3
Oceanodroma spp.	unidentified storm-petrel	-	-	-	-	-	2	-	-	-	-	-	-	-
Oceanodroma furcata	fork-tailed storm-petrel	-	-	-	8	-	2	6	26	17	-	1	-	13
Oceanodroma leucorhoa	Leach's storm-petrel	-	-	-	-	-	11	63	7	17	-	1	-	7
Oceanodroma homochroa	ashy storm-petrel	-	-	-	-	-	1	-	-	-	-	-	-	-
Phalacrocorax penicillatus	Brandt's cormorant	-	1	-	-	10	-	-	2	-	2	-	-	-
Phalacrocorax pelagicus	pelagic cormorant	-	-	-	-	-	-	-	-	-	-	-	-	-
Anas spp.	unidentified duck	-	3	-	-	-	-	-	-	-	-	-	-	-
Melanitta fusca	white-winged scoter	-	-	-	-	3	-	-	-	-	-	-	1	-
Melanitta perspicillata	surf scoter	-	-	-	-	-	-	-	-	-	31	-	63	-

Table 21. Continued.

SCIENTIFIC NAME	COMMON NAME	01-Apr-08	02-Apr-08	03-Apr-08	04-Apr-08	05-Apr-08	06-Apr-08	07-Apr-08	08-Apr-08	09-Apr-08	10-Apr-08	11-Apr-08	12-Apr-08	13-Apr-08
Marine birds (con't)														
Suborder Charadrii	unidentified shorebird	-	-	-	-	1	-	-	-	-	8	-	-	-
Phalaropus spp.	unidentified phalarope	-	-	-	-	-	-	-	-	-	-	-	-	-
Phalaropus fulicarius	red phalarope	-	-	-	-	-	-	-	1	-	-	2	-	34
Phalaropus lobatus	red-necked phalarope	-	-	-	-	-	-	-	12	-	12	-	1	15
Stercorarius pomarinus	pomarine jaeger	-	-	-	-	1	-	1	1	-	-	-	-	-
Stercorarius parasiticus	parasitic jaeger	-	-	-	-	-	-	-	-	-	-	-	-	-
Stercorarius longicaudus	long-tailed jaeger	-	-	-	-	-	-	-	-	-	-	-	-	-
Larus occidentalis x glaucescens	western x glaucous-winged gull	2	7	14	3	63	3	4	37	9	46	2	37	6
Larus spp.	unidentified gull	-	-	-	-	4	-	-	-	-	-	-	-	-
Larus hyperboreus	glaucous gull	-	-	1	-	-	-	-	-	-	-	-	-	-
Larus glaucescens	glaucous-winged gull	-	-	1	-	5	-	-	-	-	-	-	1	-
Larus occidentalis	western gull	-	-	-	-	-	-	-	7	-	7	-	7	-
Larus argentatus	herring gull	-	-	1	2	6	1	1	3	4	3	-	1	11
Larus thayeri	Thayer's gull	-	1	-	1	-	-	-	-	-	-	-	-	-
Larus californicus	California gull	-	-	1	-	-	-	1	1	-	-	-	-	-
Larus canus	mew gull	-	2	1	-	-	-	-	-	-	2	-	3	-
Larus philadelphia	Bonaparte's gull	-	-	-	-	-	-	-	1	-	-	-	-	-
Xema sabini	Sabine's gull	-	-	-	-	-	1	1	-	-	3	-	-	1
Rissa tridactyla	black-legged kittiwake	-	-	15	1	7	20	21	19	2	4	-	-	1
Sterna spp.	unidentified tern	-	-	-	-	-	-	-	-	-	-	-	-	-
Family Alcidae	unidentified alcid	-	-	-	-	-	-	-	1	-	-	-	-	-
Uria aalge	common murre	-	14	8	-	105	-	-	19	-	776	-	265	-
Uria lomvia	thick-billed murre	-	-	1	-	-	-	-	-	-	-	-	-	-
Cepphus columba	pigeon guillemot	-	1	-	-	1	-	-	-	-	3	-	-	-

Table 21. Continued.

SCIENTIFIC NAME	COMMON NAME	01-Apr-08	02-Apr-08	03-Apr-08	04-Apr-08	05-Apr-08	06-Apr-08	07-Apr-08	08-Apr-08	09-Apr-08	10-Apr-08	11-Apr-08	12-Apr-08	13-Apr-08
Marine birds (con't)														
Brachyramphus marmoratus	marbled murrelet	-	-	2	-	-	-	-	-	-	20	-	-	-
Synthliboramphus antiquus	ancient murrelet	-	-	-	-	-	-	-	-	-	3	-	3	-
Ptychoramphus aleuticus	Cassin's auklet	-	-	35	3	13	-	2	10	3	233	-	2	3
Cyclorrhynchus psittacula	parakeet auklet	-	-	-	-	19	1	-	-	-	3	-	-	-
Cerorhinca monocerata	rhinoceros auklet	8	25	107	-	140	2	12	15	7	202	-	23	-
Fratercula corniculata	horned puffin	-	-	-	-	-	-	-	-	-	-	-	-	-
Fratercula cirrhata	tufted puffin	-	-	-	-	-	-	-	1	-	-	-	-	1
Order Passeriformes	passerine	-	2	-	-	-	-	-	-	-	-	-	-	-
Marine mammals														
Lagenorhynchus obliquidens	Pacific white-sided dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-
Phocoenoides dalli	Dall's porpoise	-	-	-	-	-	-	-	-	-	-	-	-	-
Megaptera novaeangliae	hump-backed whale	-	-	-	-	-	-	-	-	-	-	-	-	-
Eumetopias jubatus	Steller sea lion	-	1	-	-	-	-	-	-	-	-	-	-	-
Callorhinus ursinus	northern fur seal	-	-	-	2	-	1	-	-	1	-	2	-	1
TOTAL BY DAY		10	57	327	25	662	84	141	208	78	1602	13	500	112

Table 21. Continued.

SCIENTIFIC NAME	COMMON NAME	14-Apr-08	18-Apr-08	19-Apr-08	20-Apr-08	21-Apr-08	22-Apr-08	23-Apr-08	24-Apr-08	25-Apr-08	26-Apr-08	27-Apr-08	28-Apr-08	29-Apr-08
Marine birds (con't)														
Class Aves	unidentified bird	-	-	-	-	-	-	1	-	-	5	-	-	-
Gavia immer	common loon	-	-	-	-	-	-	-	-	2	-	-	-	-
Gavia stellata	red-throated loon	-	-	-	-	-	-	-	-	-	-	-	-	-
Gavia pacifica	Pacific loon	-	-	4	-	-	-	-	-	51	-	-	12	-
Phoebastria albatrus	short-tailed albatross	-	-	-	-	-	-	-	-	-	-	-	-	-
Phoebastria nigripes	black-footed albatross	8	5	10	2	10	5	9	5	8	-	1	5	5
Diomedea immutabilis	Laysan albatross	-	1	-	-	-	-	-	-	-	-	-	-	-
Fulmarus glacialis	northern fulmar	3	34	3	8	4	-	12	1	11	7	2	9	-
Puffinus creatopus	pink-footed shearwater	-	-	-	-	-	-	-	-	1	-	-	1	-
Puffinus griseus	sooty shearwater	26	9	14	-	-	-	48	1	41	2	-	13	1
Puffinus spp.	dark shearwater	-	-	-	-	-	-	-	-	-	-	-	-	-
Pterodroma inexpectata	mottled petrel	-	3	-	-	-	-	-	-	-	-	-	-	-
Pterodroma cookii	Cook's petrel	-	-	-	-	-	-	-	-	-	-	-	-	29
Pterodroma ultima	Murphy's petrel	-	1	-	-	1	-	1	10	2	2	-	-	6
Oceanodroma spp.	unidentified storm-petrel	-	2	-	1	-	-	-	-	-	-	-	-	-
Oceanodroma furcata	fork-tailed storm-petrel	-	38	7	14	6	-	39	4	-	5	6	-	-
Oceanodroma leucorhoa	Leach's storm-petrel	-	31	13	255	38	-	34	302	-	47	15	-	37
Oceanodroma homochroa	ashy storm-petrel	-	-	-	-	-	-	-	-	-	-	-	4	-
Phalacrocorax penicillatus	Brandt's cormorant	-	-	-	-	-	-	-	-	-	-	-	1	-
Phalacrocorax pelagicus	pelagic cormorant	-	-	-	-	-	-	-	-	-	-	-	-	-
Anas spp.	unidentified duck	-	-	-	-	-	-	-	-	-	-	-	-	-
Melanitta fusca	white-winged scoter	-	-	-	-	-	-	-	-	-	-	-	-	-
Melanitta perspicillata	surf scoter	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 21. Continued.

SCIENTIFIC NAME	COMMON NAME	14-Apr-08	18-Apr-08	19-Apr-08	20-Apr-08	21-Apr-08	22-Apr-08	23-Apr-08	24-Apr-08	25-Apr-08	26-Apr-08	27-Apr-08	28-Apr-08	29-Apr-08
Marine birds (con't)														
Suborder Charadrii	unidentified shorebird	1	-	-	-	-	-	-	-	-	-	-	2	-
Phalaropus spp.	unidentified phalarope	-	2	2	2	-	-	5	-	8	-	-	-	-
Phalaropus fulicarius	red phalarope	2	76	26	1	24	-	85	844	20	336	2	-	2
Phalaropus lobatus	red-necked phalarope	16	3	26	-	-	-	14	-	20	-	-	180	-
Stercorarius pomarinus	pomarine jaeger	-	-	-	-	-	-	-	-	-	1	-	-	-
Stercorarius parasiticus	parasitic jaeger	-	-	-	-	-	-	-	-	-	-	-	-	-
Stercorarius longicaudus	long-tailed jaeger	-	-	-	-	-	-	-	1	1	1	1	1	1
Larus occidentalis x glaucescens	western x glaucous-winged gull	13	10	23	8	-	-	3	-	10	-	-	-	-
Larus spp.	unidentified gull	2	-	1	-	-	-	-	-	5	-	2	1	-
Larus hyperboreus	glaucous gull	-	-	-	-	-	-	-	-	-	-	-	-	-
Larus glaucescens	glaucous-winged gull	-	2	2	-	-	-	2	-	-	-	-	-	-
Larus occidentalis	western gull	-	11	12	7	-	1	6	-	25	-	-	32	-
Larus argentatus	herring gull	5	3	3	2	-	-	3	-	2	-	5	2	-
Larus thayeri	Thayer's gull	-	-	-	-	-	-	-	-	1	-	-	-	-
Larus californicus	California gull	4	29	6	1	1	1	11	-	67	-	-	9	-
Larus canus	mew gull	3	-	-	-	-	-	-	-	-	-	-	-	-
Larus philadelphia	Bonaparte's gull	2	-	16	2	-	-	4	-	1	-	-	-	-
Xema sabini	Sabine's gull	1	9	-	2	-	-	5	-	18	-	-	-	-
Rissa tridactyla	black-legged kittiwake	-	-	-	-	1	-	-	-	-	-	-	-	-
Sterna spp.	unidentified tern	-	-	-	-	-	-	-	-	-	-	-	-	-
Family Alcidae	unidentified alcid	-	1	-	-	-	-	-	2	-	-	-	-	-
Uria aalge	common murre	18	3	45	-	-	-	-	-	54	-	-	180	-
Uria lomvia	thick-billed murre	-	-	-	-	-	-	-	-	-	-	-	-	-
Cepphus columba	pigeon guillemot	-	-	-	-	-	-	-	-	-	-	-	1	-

Table 21. Continued.

SCIENTIFIC NAME	COMMON NAME	14-Apr-08	18-Apr-08	19-Apr-08	20-Apr-08	21-Apr-08	22-Apr-08	23-Apr-08	24-Apr-08	25-Apr-08	26-Apr-08	27-Apr-08	28-Apr-08	29-Apr-08
Marine birds (con't)														
Brachyramphus marmoratus	marbled murrelet	-	-	-	-	-	-	-	-	-	-	-	-	-
Synthliboramphus antiquus	ancient murrelet	-	-	-	-	-	-	-	-	-	-	-	-	-
Ptychoramphus aleuticus	Cassin's auklet	15	11	14	-	7	1	5	-	12	-	-	27	-
Cyclorrhynchus psittacula	parakeet auklet	-	2	-	-	-	-	-	-	-	-	-	-	-
Cerorhinca monocerata	rhinoceros auklet	9	26	50	-	-	2	1	1	19	-	-	6	-
Fratercula corniculata	horned puffin	-	-	-	-	-	-	-	5	-	1	-	-	-
Fratercula cirrhata	tufted puffin	-	-	-	-	-	-	-	-	-	-	-	-	-
Order Passeriformes	passerine	-	-	-	-	-	-	-	-	-	-	-	-	-
Marine mammals														
Lagenorhynchus obliquidens	Pacific white-sided dolphin	-	-	-	-	10	-	-	-	36	-	-	-	-
Phocoenoides dalli	Dall's porpoise	-	-	3	-	-	-	-	-	-	-	13	-	-
Megaptera novaeangliae	hump-backed whale	-	-	-	-	-	-	-	-	-	-	-	-	-
Eumetopias jubatus	Steller sea lion	-	-	1	-	-	-	-	-	-	-	-	-	-
Callorhinus ursinus	northern fur seal	-	1	1	-	1	-	1	5	-	5	-	1	-
TOTAL BY DAY		128	313	282	305	103	10	289	1181	415	412	47	487	81

Table 21. Continued.

SCIENTIFIC NAME	COMMON NAME	30-Apr-08	01-May-08	02-May-08	TOTAL BY SPECIES
Marine birds (con't)					
Class Aves	unidentified bird	-	-	-	6
Gavia immer	common loon	-	-	-	7
Gavia stellata	red-throated loon	1	-	-	2
Gavia pacifica	Pacific loon	-	4	-	188
Phoebastria albatrus	short-tailed albatross	-	-	-	1
Phoebastria nigripes	black-footed albatross	-	41	23	217
Diomedea immutabilis	Laysan albatross	-	-	-	1
Fulmarus glacialis	northern fulmar	-	3	1	176
Puffinus creatopus	pink-footed shearwater	-	3	2	7
Puffinus griseus	sooty shearwater	6	33	7	833
Puffinus spp.	dark shearwater	-	-	-	2
Pterodroma inexpectata	mottled petrel	-	-	-	5
Pterodroma cookii	Cook's petrel	-	-	-	29
Pterodroma ultima	Murphy's petrel	-	3	-	29
Oceanodroma spp.	unidentified storm-petrel	-	-	-	5
Oceanodroma furcata	fork-tailed storm-petrel	-	1	73	266
Oceanodroma leucorhoa	Leach's storm-petrel	-	-	-	878
Oceanodroma homochroa	ashy storm-petrel	-	-	-	5
Phalacrocorax penicillatus	Brandt's cormorant	-	-	-	16
Phalacrocorax pelagicus	pelagic cormorant	1	-	-	1
Anas spp.	unidentified duck	-	-	-	3
Melanitta fusca	white-winged scoter	-	-	-	4
Melanitta perspicillata	surf scoter	2	-	-	96

Table 21. Continued.

SCIENTIFIC NAME	COMMON NAME	30-Apr-08	01-May-08	02-May-08	TOTAL BY SPECIES
Marine birds (con't)					
Suborder Charadrii	unidentified shorebird	-	-	-	12
Phalaropus spp.	unidentified phalarope	-	-	-	19
Phalaropus fulicarius	red phalarope	-	38	1497	2990
Phalaropus lobatus	red-necked phalarope	2	26	366	693
Stercorarius pomarinus	pomarine jaeger	-	-	-	4
Stercorarius parasiticus	parasitic jaeger	-	1	2	3
Stercorarius longicaudus	long-tailed jaeger	-	-	-	6
Larus occidentalis x glaucescens	western x glaucous-winged gull	-	1	14	315
Larus spp.	unidentified gull	-	1	-	16
Larus hyperboreus	glaucous gull	-	-	-	1
Larus glaucescens	glaucous-winged gull	-	-	-	13
Larus occidentalis	western gull	7	10	19	151
Larus argentatus	herring gull	-	19	8	85
Larus thayeri	Thayer's gull	-	-	-	3
Larus californicus	California gull	1	5	23	161
Larus canus	mew gull	-	-	-	11
Larus philadelphia	Bonaparte's gull	-	2	-	28
Xema sabini	Sabine's gull	-	3	16	60
Rissa tridactyla	black-legged kittiwake	-	-	-	91
Sterna spp.	unidentified tern	-	1	-	1
Family Alcidae	unidentified alcid	-	-	-	4
Uria aalge	common murre	139	-	-	1626
Uria lomvia	thick-billed murre	-	-	1	2
Cepphus columba	pigeon guillemot	-	-	-	6

Table 21. Continued.

SCIENTIFIC NAME	COMMON NAME	30-Apr-08	01-May-08	02-May-08	TOTAL BY SPECIES
Marine birds (con't)					
Brachyramphus marmoratus	marbled murrelet	-	-	-	22
Synthliboramphus antiquus	ancient murrelet	-	-	-	6
Ptychoramphus aleuticus	Cassin's auklet	1	-	6	403
Cyclorrhynchus psittacula	parakeet auklet	-	-	-	25
Cerorhinca monocerata	rhinoceros auklet	-	9	58	722
Fratercula corniculata	horned puffin	-	-	-	6
Fratercula cirrhata	tufted puffin	-	-	-	2
Order Passeriformes	passerine	-	-	-	2
Marine mammals					
Lagenorhynchus obliquidens	Pacific white-sided dolphin	-	3	-	49
Phocoenoides dalli	Dall's porpoise	-	-	2	18
Megaptera novaeangliae	hump-backed whale	-	1	-	1
Eumetopias jubatus	Steller sea lion	-	-	-	2
Callorhinus ursinus	northern fur seal	-	-	1	23
TOTAL BY DAY		160	208	2119	10359

Table 22. Bird species counted by survey day during the April 2008 *David Starr Jordan* cruise, San Diego to San Francisco.

SCIENTIFIC NAME	COMMON NAME	13-Apr-08	14-Apr-08	17-Apr-08	18-Apr-08	23-Apr-08	24-Apr-08	25-Apr-08	26-Apr-08	27-Apr-08	29-Apr-08	TOTAL BY SPECIES
Marine birds												
Gavia sp.	unidentified loon	-	-	-	-	175	-	-	-	-	-	175
Gavia pacifica	Pacific loon	-	-	-	-	1	-	-	-	-	-	1
Gavia immer	common loon	-	-	6	-	4	-	-	-	-	-	10
Phoebastria nigripes	black-footed albatross	-	2	-	1	-	-	-	1	-	2	6
Phoebastria immutabilis	Laysan albatross	-	-	-	1	-	-	-	-	-	-	1
Fulmarus glacialis	northern fulmar	1	-	2	10	20	5	4	17	16	8	95
Pterodroma inexpectata	mottled petrel	-	-	-	-	-	-	-	-	-	1	1
Pterodroma cookii	Cook's petrel	-	-	-	-	-	-	1	-	-	16	17
Puffinus bulleri	Buller's shearwater	3	-	-	-	-	-	-	-	-	-	3
Puffinus sp.	unidentified shearwater	1	-	-	-	-	-	-	-	-	-	1
Puffinus griseus	sooty shearwater	23	4	22	2	32	-	-	1	5	-	100
Puffinus creatopus	pink-footed shearwater	4	-	2	1	2	-	-	-	-	1	10
Oceanodroma furcata	fork-tailed storm-petrel	1	-	-	-	1	-	-	-	-	-	2
Pelecanus occidentalis	brown pelican	-	-	56	-	-	-	-	-	-	-	69
Melanitta perspicillata	surf scoter	-	-	-	-	6	-	-	-	-	-	6
Phalaropus sp.	unidentified phalarope	-	5	-	-	-	1	-	1	94	-	101
Phalaropus lobatus	red-necked phalarope	8	3	-	2	93	1	10	1	118	3	239
Phalaropus fulicarius	red phalarope	1	-	-	-	6	-	1	1	-	-	9
Stercorarius sp.	unidentified jaeger	-	-	-	-	-	-	-	-	-	2	2
Stercorarius pomarinus	pomarine jaeger	-	-	-	-	1	-	-	3	1	3	8
Stercorarius parasiticus	parasitic jaeger	-	-	1	-	1	-	-	-	1	-	4
Xema sabini	Sabine's gull	-	-	-	-	33	-	-	-	18	-	51
Larus sp.	unidentified gull	-	-	4	1	-	-	-	-	2	-	11
Larus californicus	California gull	22	1	12	2	11	4	2	3	27	1	101

Table 22. Continued.

SCIENTIFIC NAME	COMMON NAME	13-Apr-08	14-Apr-08	17-Apr-08	18-Apr-08	23-Apr-08	24-Apr-08	25-Apr-08	26-Apr-08	27-Apr-08	29-Apr-08	TOTAL BY SPECIES
Marine birds (con't)												
Larus glaucescens	glaucous-winged gull	-	-	-	1	-	-	-	-	-	-	1
Larus occidentalis	western gull	14	-	33	17	21	-	-	-	1	-	91
Sterna sp.	unidentified tern	-	-	-	-	-	-	-	-	-	2	2
Sterna elegans	elegant tern	-	-	-	-	-	-	-	-	-	-	40
Family Alcidae	unidentified alcid	1	-	-	-	3	-	-	-	-	-	4
Synthliboramphus hypoleucus	Xantus' murrelet	-	-	-	-	1	-	-	-	-	-	1
Ptychoramphus aleuticus	Cassin's auklet	4	-	11	-	7	-	-	-	4	1	27
Cerorhinca monocerata	rhinoceros auklet	4	-	7	-	-	-	-	-	-	-	11
Marine mammals												
Order Cetacea	unidentified whale	5	-	1	-	-	-	1	-	1	-	8
Physeter macrocephalus	sperm whale	7	-	-	-	-	-	-	-	2	-	9
Family Delphinidae	unidentified dolphin	-	-	-	-	-	-	-	-	-	-	10
Phocoenoides dalli	Dall's porpoise	3	-	-	-	-	-	-	-	-	-	3
Pinnipedia	unidentified pinniped	1	-	-	-	-	-	-	-	-	-	1
Callorhinus ursinus	northern fur seal	-	-	-	1	-	-	-	-	-	-	1
Zalophus californianus	California sea lion	4	-	13	-	-	-	-	-	1	-	18
TOTAL BY DAY		107	15	170	39	418	11	19	28	291	40	1250

Table 23. Bird species counted by survey day during the July/August 2008 survey, Cape Flattery to San Diego.

SCIENTIFIC NAME	COMMON NAME	05-Jul-08	06-Jul-08	07-Jul-08	08-Jul-08	09-Jul-08	10-Jul-08	11-Jul-08	12-Jul-08	13-Jul-08	14-Jul-08	15-Jul-08	18-Jul-08
Pelagic fish													
Mola mola	ocean sunfish	1	1	1	-	2	-	-	1	-	-	-	-
Marine birds													
Class Aves	unidentified bird	-	-	-	-	1	-	-	-	-	-	-	-
Gavia immer	common loon	1	-	-	5	-	-	-	-	-	-	-	-
Aechmophorus occidentalis	western grebe	-	-	-	-	-	-	-	-	-	-	-	-
Phoebastria nigripes	black-footed albatross	16	31	2	-	17	3	-	6	3	-	-	5
Diomedea immutabilis	Laysan albatross	-	-	-	-	-	-	-	-	-	-	-	-
Fulmarus glacialis	northern fulmar	6	7	2	1	5	-	-	3	-	20	3	40
Puffinus creatopus	pink-footed shearwater	161	5	-	-	4	-	1	7	-	110	1	17
Puffinus carneipes	flesh-footed shearwater	-	-	-	-	-	-	-	-	-	-	-	-
Puffinus bulleri	Buller's shearwater	-	-	-	-	-	-	-	1	-	-	-	-
Puffinus griseus	sooty shearwater	695	35	-	9	40	-	17	113	1	1014	41	26
Puffinus tenuirostris	short-tailed shearwater	-	-	-	-	-	1	-	-	-	-	-	-
Pterodroma cookii	Cook's petrel	-	-	-	-	-	-	-	-	-	-	-	-
Oceanodroma spp.	unidentified storm-petrel	-	2	-	-	-	-	-	-	-	-	-	-
Oceanodroma furcata	fork-tailed storm-petrel	2	74	10	-	14	-	-	9	-	26	-	2
Oceanodroma leucorhoa	Leach's storm-petrel	-	48	58	-	213	72	-	41	37	-	-	-
Oceanodroma homochroa	ashy storm-petrel	-	2	-	-	-	-	-	-	-	-	-	-
Oceanodroma melania	black storm-petrel	-	-	-	-	-	-	-	-	-	-	-	-
Halocyptena microsoma	least storm-petrel	-	-	-	-	-	-	-	-	-	-	-	-
Oceanites oceanicus	Wilson's storm-petrel	-	-	-	-	-	-	-	-	-	-	-	-
Phaethon aethereus	red-billed tropicbird	-	-	-	-	-	-	-	-	-	-	-	-
Phaethon rubricauda	red-tailed tropicbird	-	-	-	-	-	-	-	-	-	-	-	-
Pelecanus occidentalis	brown pelican	4	-	-	-	-	-	8	-	-	-	-	-

Table 23. Continued.

SCIENTIFIC NAME	COMMON NAME	05-Jul-08	06-Jul-08	07-Jul-08	08-Jul-08	09-Jul-08	10-Jul-08	11-Jul-08	12-Jul-08	13-Jul-08	14-Jul-08	15-Jul-08	18-Jul-08
Marine birds (con't)													
Phalacrocorax auritus	double-crested cormorant	-	-	-	-	-	-	-	-	-	-	-	-
Phalacrocorax penicillatus	Brandt's cormorant	-	-	-	-	-	-	-	-	-	-	1	-
Phalacrocorax pelagicus	pelagic cormorant	-	-	-	-	-	-	-	-	-	-	-	-
Ardea herodias	great blue heron	-	-	-	-	-	-	-	-	-	-	1	-
Suborder Charadrii	unidentified shorebird	-	-	-	-	-	-	-	-	1	-	3	1
Numenius phaeopus	whimbrel	-	-	-	-	-	-	-	-	-	-	-	-
Tringa flavipes	lesser yellowlegs	-	-	-	-	-	-	-	-	-	-	-	-
Tringa incana	wandering tattler	-	-	-	-	-	-	-	-	-	-	-	1
Limnodromus spp.	unidentified dowitcher	-	-	-	-	-	-	-	-	-	-	-	-
Phalaropus fulicarius	red phalarope	-	-	-	-	-	-	-	-	-	-	-	-
Phalaropus lobatus	red-necked phalarope	-	1	-	-	-	-	-	-	-	-	195	-
Stercorarius pomarinus	pomarine jaeger	-	-	-	-	-	-	-	-	-	-	-	-
Stercorarius parasiticus	parasitic jaeger	1	-	-	-	-	-	-	2	6	-	-	1
Stercorarius longicaudus	long-tailed jaeger	-	-	-	-	-	-	-	-	-	-	-	1
Catharacta maccormicki	south polar skua	2	1	-	-	1	1	-	2	-	-	-	-
Larus occidentalis x glaucescens	western x glaucous-winged gull	92	-	-	22	3	-	132	7	-	9	3	-
Larus spp.	unidentified gull	-	-	-	-	-	-	-	-	-	-	-	-
Larus glaucescens	glaucous-winged gull	-	-	-	-	-	-	1	-	-	1	-	-
Larus occidentalis	western gull	21	-	-	1	-	-	56	36	-	43	19	5
Larus argentatus	herring gull	-	-	-	-	-	-	-	1	-	8	6	-
Larus californicus	California gull	1	-	-	3	-	-	7	5	-	20	9	4
Larus heermanni	Heermann's gull	-	-	-	-	-	-	-	-	-	-	-	-
Xema sabini	Sabine's gull	1	-	-	-	-	-	-	-	-	-	-	-
Sterna hirundo	common tern	1	-	-	-	-	-	-	-	-	-	-	-
Sterna paradisaea	Arctic tern	-	-	1	-	-	1	-	-	-	-	-	-

Table 23. Continued.

SCIENTIFIC NAME	COMMON NAME	05-Jul-08	06-Jul-08	07-Jul-08	08-Jul-08	09-Jul-08	10-Jul-08	11-Jul-08	12-Jul-08	13-Jul-08	14-Jul-08	15-Jul-08	18-Jul-08
Marine birds (con't)													
Sterna caspia	Caspian tern	7	-	-	-	-	-	75	-	-	-	-	-
Thalasseus elegans	elegant tern	-	-	-	-	-	-	-	-	-	-	-	-
Family Alcidae	unidentified alcid	-	-	-	1	-	-	-	-	-	-	-	-
Uria aalge	common murre	114	-	-	103	1	-	45	95	-	212	424	36
Cepphus columba	pigeon guillemot	-	-	-	3	-	-	-	-	-	-	-	-
Synthliboramphus antiquus	ancient murrelet	-	-	-	-	-	-	-	-	-	-	-	-
Synthliboramphus hypoleucus	Xantus's murrelet	-	-	-	-	-	-	-	-	-	-	-	-
Ptychoramphus aleuticus	Cassin's auklet	5	59	1	4	3	-	-	3	-	-	25	2
Cerorhinca monocerata	rhinoceros auklet	98	5	-	25	7	-	-	1	-	1	4	-
Fratercula corniculata	horned puffin	-	-	-	-	-	-	-	-	-	-	-	1
Fratercula cirrhata	tufted puffin	4	1	-	1	1	-	1	-	-	-	-	-
Zenaida macroura	mourning dove	-	-	-	-	-	-	-	-	-	-	-	-
Order Passeriformes	passerine	-	-	-	-	-	-	-	-	-	-	-	-
Vermivora celata	orange-crowned warbler	-	-	-	-	-	-	-	-	-	-	-	-
Dendroica petechia	yellow warbler	-	-	-	-	-	-	-	-	-	-	-	-
Molothrus ater	brown-headed cowbird	-	-	-	-	-	-	-	-	-	-	-	-
Marine mammals													
Delphinus spp.	common dolphin	-	-	-	-	-	-	-	-	-	-	-	-
Lagenorhynchus obliquidens	Pacific white-sided dolphin	3	5	-	-	-	5	-	-	-	2	-	-
Lissodelphis borealis	northern right whale dolphin	-	1	-	-	-	-	-	-	-	-	-	-
Grampus griseus	Risso's dolphin	-	-	-	-	-	-	-	-	-	-	-	-
Phocoena phocoena	harbor porpoise	1	-	-	-	-	-	-	-	-	-	1	-
Phocoenoides dalli	Dall's porpoise	-	5	6	-	-	3	-	-	8	-	-	-
Balaenoptera acutorostrata	minke whale	1	-	-	-	-	-	-	-	-	-	-	-

Table 23. Continued.

SCIENTIFIC NAME	COMMON NAME	05-Jul-08	06-Jul-08	07-Jul-08	08-Jul-08	09-Jul-08	10-Jul-08	11-Jul-08	12-Jul-08	13-Jul-08	14-Jul-08	15-Jul-08	18-Jul-08
Marine mammals (con't)													
Megaptera novaeangliae	hump-backed whale	-	-	-	-	-	-	-	-	-	1	-	-
Zalophus californianus	California sea lion	-	-	-	-	-	-	-	-	-	-	-	-
Eumetopias jubatus	Steller sea lion	-	-	-	1	-	-	-	-	-	-	-	-
Callorhinus ursinus	northern fur seal	-	-	-	-	-	3	-	-	-	-	-	-
Phoca vitulina	harbor seal	-	-	-	-	-	-	1	-	-	-	-	-
TOTAL BY DAY		1238	283	81	179	312	89	344	333	56	1467	736	142

Table 23. Continued.

SCIENTIFIC NAME	COMMON NAME	19-Jul-08	20-Jul-08	21-Jul-08	22-Jul-08	23-Jul-08	24-Jul-08	25-Jul-08	26-Jul-08	27-Jul-08	28-Jul-08	29-Jul-08	30-Jul-08	31-Jul-08
Pelagic fish														
Mola mola	ocean sunfish	-	-	-	1	-	-	-	-	1	1	-	-	-
Marine birds														
Class Aves	unidentified bird	-	-	-	-	-	-	-	-	-	-	-	-	-
Gavia immer	common loon	-	-	-	-	-	-	-	-	-	-	-	-	-
Aechmophorus occidentalis	western grebe	-	-	-	-	-	-	-	-	-	-	-	-	-
Phoebastria nigripes	black-footed albatross	2	3	4	2	22	-	1	1	11	1	2	1	31
Diomedea immutabilis	Laysan albatross	-	-	-	-	-	-	-	-	-	-	-	-	-
Fulmarus glacialis	northern fulmar	8	222	29	1	46	-	3	-	16	4	-	-	20
Puffinus creatopus	pink-footed shearwater	-	-	19	-	30	-	-	-	3	16	-	-	13
Puffinus carneipes	flesh-footed shearwater	-	-	-	-	1	-	-	-	-	-	-	-	-
Puffinus bulleri	Buller's shearwater	-	-	-	-	-	-	-	-	-	-	-	1	-
Puffinus griseus	sooty shearwater	-	116	126	-	56	2	16	1	13	10	-	-	44
Puffinus tenuirostris	short-tailed shearwater	-	-	-	-	-	-	-	-	-	-	-	-	-
Pterodroma cookii	Cook's petrel	-	-	-	-	-	-	-	-	-	-	-	-	-
Oceanodroma spp.	unidentified storm-petrel	-	-	-	-	-	-	-	-	-	-	-	-	-
Oceanodroma furcata	fork-tailed storm-petrel	-	19	100	-	5	-	2	-	33	3	-	1	-
Oceanodroma leucorhoa	Leach's storm-petrel	4	-	76	9	90	-	112	23	161	41	23	9	1
Oceanodroma homochroa	ashy storm-petrel	-	-	-	-	-	-	-	-	-	-	-	-	-
Oceanodroma melania	black storm-petrel	-	-	-	-	-	-	-	-	-	-	-	-	-
Halocyptena microsoma	least storm-petrel	-	-	-	-	-	-	-	-	-	-	-	-	-
Oceanites oceanicus	Wilson's storm-petrel	-	-	-	-	-	-	-	-	-	-	-	-	-
Phaethon aethereus	red-billed tropicbird	-	-	-	-	-	-	-	-	-	-	-	-	-
Phaethon rubricauda	red-tailed tropicbird	-	-	-	-	-	-	-	-	-	-	-	-	-
Pelecanus occidentalis	brown pelican	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 23. Continued.

SCIENTIFIC NAME	COMMON NAME	19-Jul-08	20-Jul-08	21-Jul-08	22-Jul-08	23-Jul-08	24-Jul-08	25-Jul-08	26-Jul-08	27-Jul-08	28-Jul-08	29-Jul-08	30-Jul-08	31-Jul-08
Marine birds (con't)														
Phalacrocorax auritus	double-crested cormorant	-	-	-	-	-	-	-	-	-	-	-	-	-
Phalacrocorax penicillatus	Brandt's cormorant	-	-	-	-	-	-	-	-	-	-	-	-	-
Phalacrocorax pelagicus	pelagic cormorant	-	-	-	-	-	-	-	-	-	-	-	-	-
Ardea herodias	great blue heron	-	-	-	-	-	-	-	-	-	-	-	-	-
Suborder Charadrii	unidentified shorebird	-	-	2	-	-	-	-	-	-	-	-	-	-
Numenius phaeopus	whimbrel	-	-	1	-	-	-	-	-	-	-	-	-	-
Tringa flavipes	lesser yellowlegs	-	-	-	-	-	-	-	-	-	-	-	-	-
Tringa incana	wandering tattler	-	-	-	-	-	-	-	-	-	-	-	-	-
Limnodromus spp.	unidentified dowitcher	-	-	30	-	-	-	-	-	-	-	-	-	-
Phalaropus fulicarius	red phalarope	-	-	-	13	-	-	6	20	-	14	7	2	7
Phalaropus lobatus	red-necked phalarope	-	-	-	-	-	-	-	-	-	-	-	-	14
Stercorarius pomarinus	pomarine jaeger	-	-	-	-	-	-	-	-	3	1	-	-	-
Stercorarius parasiticus	parasitic jaeger	-	-	-	2	5	-	-	-	-	1	-	1	-
Stercorarius longicaudus	long-tailed jaeger	-	3	-	1	-	-	3	-	12	5	7	2	3
Catharacta maccormicki	south polar skua	-	1	-	-	-	-	-	-	2	-	-	-	-
Larus occidentalis x glaucescens	western x glaucous-winged gull	-	-	-	-	2	-	-	-	-	-	-	-	1
Larus spp.	unidentified gull	-	-	1	-	-	1	-	-	-	-	-	-	-
Larus glaucescens	glaucous-winged gull	-	-	-	-	-	-	-	-	-	-	-	-	-
Larus occidentalis	western gull	-	-	11	-	14	11	-	-	-	-	-	-	20
Larus argentatus	herring gull	-	-	-	-	-	-	-	-	-	-	-	-	-
Larus californicus	California gull	-	1	1	-	6	1	-	-	-	1	-	-	3
Larus heermanni	Heermann's gull	-	-	-	-	2	10	2	-	-	9	-	-	3
Xema sabini	Sabine's gull	-	-	-	-	-	-	-	-	5	-	-	-	-
Sterna hirundo	common tern	-	-	-	-	-	-	-	-	-	-	-	-	-
Sterna paradisaea	Arctic tern	-	7	1	1	-	-	9	1	10	3	4	-	2

Table 23. Continued.

SCIENTIFIC NAME	COMMON NAME	19-Jul-08	20-Jul-08	21-Jul-08	22-Jul-08	23-Jul-08	24-Jul-08	25-Jul-08	26-Jul-08	27-Jul-08	28-Jul-08	29-Jul-08	30-Jul-08	31-Jul-08
Marine birds (con't)														
Sterna caspia	Caspian tern	-	-	-	-	-	-	-	-	-	-	-	-	-
Thalasseus elegans	elegant tern	-	-	-	-	-	-	-	-	-	-	-	-	-
Family Alcidae	unidentified alcid	-	-	-	-	-	-	-	-	-	-	-	-	2
Uria aalge	common murre	-	10	95	-	43	94	5	-	8	2	-	-	-
Cepphus columba	pigeon guillemot	-	-	-	-	-	-	-	-	-	-	-	-	-
Synthliboramphus antiquus	ancient murrelet	-	1	-	-	-	-	-	-	-	-	-	-	-
Synthliboramphus hypoleucus	Xantus's murrelet	-	-	-	2	-	-	3	-	-	-	-	-	-
Ptychoramphus aleuticus	Cassin's auklet	-	7	20	1	19	3	4	-	7	35	-	-	1
Cerorhinca monocerata	rhinoceros auklet	-	-	-	1	2	-	13	-	7	-	-	-	1
Fratercula corniculata	horned puffin	-	-	-	-	-	-	-	-	-	-	-	-	-
Fratercula cirrhata	tufted puffin	-	-	-	-	-	-	-	-	-	-	-	-	-
Zenaida macroura	mourning dove	-	-	-	-	-	-	-	-	-	-	-	-	-
Order Passeriformes	passerine	-	-	-	-	-	-	-	-	-	-	-	-	-
Vermivora celata	orange-crowned warbler	-	-	-	-	-	-	-	-	-	-	-	-	-
Dendroica petechia	yellow warbler	-	-	-	-	-	-	-	-	-	-	-	-	-
Molothrus ater	brown-headed cowbird	-	-	-	-	-	-	-	-	-	1	-	-	-
Marine mammals														
Delphinus spp.	common dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-
Lagenorhynchus obliquidens	Pacific white-sided dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-
Lissodelphis borealis	northern right whale dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-
Grampus griseus	Risso's dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-
Phocoena phocoena	harbor porpoise	-	-	-	-	-	-	-	-	-	-	-	-	-
Phocoenoides dalli	Dall's porpoise	-	5	1	-	4	-	3	-	-	3	-	3	-
Balaenoptera acutorostrata	minke whale	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 23. Continued.

SCIENTIFIC NAME	COMMON NAME	19-Jul-08	20-Jul-08	21-Jul-08	22-Jul-08	23-Jul-08	24-Jul-08	25-Jul-08	26-Jul-08	27-Jul-08	28-Jul-08	29-Jul-08	30-Jul-08	31-Jul-08
Marine mammals (con't)														
Megaptera novaeangliae	hump-backed whale	-	-	-	-	-	-	-	-	-	-	-	-	-
Zalophus californianus	California sea lion	-	-	-	-	-	-	-	-	-	-	-	-	-
Eumetopias jubatus	Steller sea lion	-	-	-	-	-	-	-	-	-	-	-	-	1
Callorhinus ursinus	northern fur seal	-	1	-	-	-	-	1	-	2	-	-	-	-
Phoca vitulina	harbor seal	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL BY DAY		14	396	517	34	347	122	183	46	294	151	43	20	167

Table 23. Continued.

SCIENTIFIC NAME	COMMON NAME	01-Aug-08	02-Aug-08	03-Aug-08	06-Aug-08	07-Aug-08	08-Aug-08	09-Aug-08	13-Aug-08	14-Aug-08	15-Aug-08	16-Aug-08	17-Aug-08	18-Aug-08
Pelagic fish														
Mola mola	ocean sunfish	-	1	-	-	-	-	-	-	-	-	6	-	1
Marine birds														
Class Aves	unidentified bird	-	-	-	-	-	-	-	-	-	-	7	-	-
Gavia immer	common loon	-	-	-	-	-	-	-	-	-	-	-	-	-
Aechmophorus occidentalis	western grebe	-	-	-	-	-	-	4	-	-	-	-	-	-
Phoebastria nigripes	black-footed albatross	3	4	24	-	-	-	6	-	7	-	-	5	2
Diomedea immutabilis	Laysan albatross	-	-	1	-	-	-	-	-	-	-	-	-	-
Fulmarus glacialis	northern fulmar	-	-	17	-	-	-	2	-	-	-	1	-	-
Puffinus creatopus	pink-footed shearwater	-	-	23	19	-	-	5	6	11	-	74	-	2
Puffinus carneipes	flesh-footed shearwater	-	-	-	-	-	-	-	-	-	-	-	-	-
Puffinus bulleri	Buller's shearwater	-	-	-	2	-	-	2	-	16	3	6	17	4
Puffinus griseus	sooty shearwater	-	1	16	52	-	-	677	36	38	-	201	-	1
Puffinus tenuirostris	short-tailed shearwater	-	-	-	-	-	-	-	-	-	-	-	-	-
Pterodroma cookii	Cook's petrel	-	-	-	-	1	10	-	-	-	12	-	3	1
Oceanodroma spp.	unidentified storm-petrel	-	-	-	-	-	-	-	-	-	-	-	4	-
Oceanodroma furcata	fork-tailed storm-petrel	-	-	-	-	-	-	-	-	-	-	-	-	-
Oceanodroma leucorhoa	Leach's storm-petrel	9	-	1	-	2	4	-	-	-	12	-	147	150
Oceanodroma homochroa	ashy storm-petrel	-	-	1	-	1	-	8	-	2	-	-	1	-
Oceanodroma melania	black storm-petrel	-	-	-	-	-	-	-	-	-	-	-	-	1
Halocyptena microsoma	least storm-petrel	-	-	-	-	-	-	-	-	-	1	-	1	-
Oceanites oceanicus	Wilson's storm-petrel	-	-	-	-	-	-	-	-	-	1	-	-	-
Phaethon aethereus	red-billed tropicbird	-	-	-	-	-	-	-	-	-	-	-	-	2
Phaethon rubricauda	red-tailed tropicbird	-	-	-	-	-	-	-	-	-	-	-	1	-
Pelecanus occidentalis	brown pelican	-	-	-	7	-	-	5	2	1	-	7	-	1

Table 23. Continued.

SCIENTIFIC NAME	COMMON NAME	01-Aug-08	02-Aug-08	03-Aug-08	06-Aug-08	07-Aug-08	08-Aug-08	09-Aug-08	13-Aug-08	14-Aug-08	15-Aug-08	16-Aug-08	17-Aug-08	18-Aug-08
Marine birds (con't)														
Phalacrocorax auritus	double-crested cormorant	-	-	-	1	-	-	-	-	-	-	-	-	-
Phalacrocorax penicillatus	Brandt's cormorant	-	-	-	168	-	-	107	8	-	-	-	-	-
Phalacrocorax pelagicus	pelagic cormorant	-	-	-	3	-	-	-	-	-	-	-	-	-
Ardea herodias	great blue heron	-	-	-	-	-	-	-	-	-	-	-	-	-
Suborder Charadrii	unidentified shorebird	-	-	-	-	-	2	-	-	-	1	4	-	-
Numenius phaeopus	whimbrel	-	-	-	-	-	-	-	-	-	-	-	-	-
Tringa flavipes	lesser yellowlegs	-	-	-	-	1	-	-	-	-	-	-	-	-
Tringa incana	wandering tattler	-	-	-	-	-	-	-	-	-	-	-	-	-
Limnodromus spp.	unidentified dowitcher	-	-	-	-	-	-	-	-	-	-	-	-	-
Phalaropus fulicarius	red phalarope	8	4	1	4	7	12	-	-	-	267	1	102	1
Phalaropus lobatus	red-necked phalarope	-	-	-	16	-	-	4	2	1	-	39	-	-
Stercorarius pomarinus	pomarine jaeger	-	-	-	-	-	-	-	-	-	-	-	-	-
Stercorarius parasiticus	parasitic jaeger	-	-	7	-	4	-	-	-	12	6	1	1	-
Stercorarius longicaudus	long-tailed jaeger	3	1	7	-	13	-	-	-	1	1	-	-	-
Catharacta maccormicki	south polar skua	-	-	2	1	2	-	-	-	-	-	-	-	-
Larus occidentalis x glaucescens	western x glaucous-winged gull	-	-	-	-	-	-	1	-	5	-	-	-	-
Larus spp.	unidentified gull	-	-	-	-	-	-	2	-	-	-	-	-	-
Larus glaucescens	glaucous-winged gull	-	-	-	-	-	-	-	-	-	-	-	-	-
Larus occidentalis	western gull	-	-	8	117	-	-	107	68	8	-	62	-	24
Larus argentatus	herring gull	-	-	-	28	-	-	27	1	8	-	5	-	-
Larus californicus	California gull	-	-	5	10	-	-	79	5	54	-	8	-	1
Larus heermanni	Heermann's gull	-	-	-	-	-	-	-	-	-	-	-	-	-
Xema sabini	Sabine's gull	-	-	-	2	-	-	13	-	-	-	2	-	-
Sterna hirundo	common tern	-	-	-	-	-	-	-	-	4	-	-	-	-
Sterna paradisaea	Arctic tern	1	-	-	-	11	10	-	-	-	10	-	2	1

Table 23. Continued.

SCIENTIFIC NAME	COMMON NAME	01-Aug-08	02-Aug-08	03-Aug-08	06-Aug-08	07-Aug-08	08-Aug-08	09-Aug-08	13-Aug-08	14-Aug-08	15-Aug-08	16-Aug-08	17-Aug-08	18-Aug-08
Marine birds (con't)														
Sterna caspia	Caspian tern	-	-	-	-	-	-	-	-	-	-	-	-	-
Thalasseus elegans	elegant tern	-	-	-	-	-	-	4	-	26	-	16	-	12
Family Alcidae	unidentified alcid	-	1	-	-	-	-	-	-	-	-	-	-	-
Uria aalge	common murre	-	-	2	539	-	-	319	116	-	-	98	-	-
Cepphus columba	pigeon guillemot	-	-	-	-	-	-	-	-	-	-	-	-	-
Synthliboramphus antiquus	ancient murrelet	-	-	-	-	-	-	-	-	-	-	-	-	-
Synthliboramphus hypoleucus	Xantus's murrelet	-	-	-	-	6	2	-	-	-	4	3	2	1
Ptychoramphus aleuticus	Cassin's auklet	-	-	-	1	-	-	2	3	9	2	3	6	-
Cerorhinca monocerata	rhinoceros auklet	-	-	-	8	-	-	2	3	1	-	1	-	-
Fratercula corniculata	horned puffin	-	-	-	-	-	-	-	-	-	-	-	-	-
Fratercula cirrhata	tufted puffin	-	-	-	-	-	-	-	-	-	-	-	-	-
Zenaida macroura	mourning dove	-	-	-	-	-	-	-	-	-	-	1	-	-
Order Passeriformes	passerine	-	-	-	-	-	-	-	-	-	6	-	1	-
Vermivora celata	orange-crowned warbler	-	-	-	-	-	-	-	-	-	-	-	-	1
Dendroica petechia	yellow warbler	-	-	-	-	-	-	-	-	-	-	-	-	1
Molothrus ater	brown-headed cowbird	-	-	-	-	-	-	-	-	-	-	-	-	-
Marine mammals														
Delphinus spp.	common dolphin	-	-	-	-	-	-	-	-	-	15	-	20	56
Lagenorhynchus obliquidens	Pacific white-sided dolphin	-	-	4	-	30	-	-	-	-	-	-	-	-
Lissodelphis borealis	northern right whale dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-
Grampus griseus	Risso's dolphin	-	-	-	6	-	-	-	-	-	-	-	-	-
Phocoena phocoena	harbor porpoise	-	-	-	-	-	-	3	-	-	-	-	-	-
Phocoenoides dalli	Dall's porpoise	-	1	4	2	-	-	3	-	-	-	5	-	-
Balaenoptera acutorostrata	minke whale	-	-	1	-	-	-	-	-	-	-	-	-	-

Table 23. Continued.

SCIENTIFIC NAME	COMMON NAME	01-Aug-08	02-Aug-08	03-Aug-08	06-Aug-08	07-Aug-08	08-Aug-08	09-Aug-08	13-Aug-08	14-Aug-08	15-Aug-08	16-Aug-08	17-Aug-08	18-Aug-08
Marine mammals (con't)														
Megaptera novaeangliae	hump-backed whale	-	-	-	-	-	-	-	-	-	-	-	-	-
Zalophus californianus	California sea lion	-	-	-	10	-	-	60	26	-	-	48	-	4
Eumetopias jubatus	Steller sea lion	-	-	-	1	-	-	4	-	-	-	1	-	-
Callorhinus ursinus	northern fur seal	-	-	-	-	-	-	-	-	-	-	4	-	-
Phoca vitulina	harbor seal	-	-	-	1	-	-	-	-	-	-	-	-	-
TOTAL BY DAY		24	13	124	998	78	40	1446	276	204	341	604	313	267

Table 23. Continued.

SCIENTIFIC NAME	COMMON NAME	TOTAL BY SPECIES
Pelagic fish		
Mola mola	ocean sunfish	17
Marine birds		
Class Aves	unidentified bird	8
Gavia immer	common loon	6
Aechmophorus occidentalis	western grebe	4
Phoebastria nigripes	black-footed albatross	215
Diomedea immutabilis	Laysan albatross	1
Fulmarus glacialis	northern fulmar	456
Puffinus creatopus	pink-footed shearwater	527
Puffinus carneipes	flesh-footed shearwater	1
Puffinus bulleri	Buller's shearwater	52
Puffinus griseus	sooty shearwater	3397
Puffinus tenuirostris	short-tailed shearwater	1
Pterodroma cookii	Cook's petrel	27
Oceanodroma spp.	unidentified storm-petrel	6
Oceanodroma furcata	fork-tailed storm-petrel	300
Oceanodroma leucorhoa	Leach's storm-petrel	1343
Oceanodroma homochroa	ashy storm-petrel	15
Oceanodroma melania	black storm-petrel	1
Halocyptena microsoma	least storm-petrel	2
Oceanites oceanicus	Wilson's storm-petrel	1
Phaethon aethereus	red-billed tropicbird	2
Phaethon rubricauda	red-tailed tropicbird	1
Pelecanus occidentalis	brown pelican	35
Phalacrocorax auritus	double-crested cormorant	1
Phalacrocorax penicillatus	Brandt's cormorant	284
Phalacrocorax pelagicus	pelagic cormorant	3
Ardea herodias	great blue heron	1
Suborder Charadrii	unidentified shorebird	14
Numenius phaeopus	whimbrel	1
Tringa flavipes	lesser yellowlegs	1
Tringa incana	wandering tattler	1
Limnodromus spp.	unidentified dowitcher	30
Phalaropus fulicarius	red phalarope	476
Phalaropus lobatus	red-necked phalarope	272
Stercorarius pomarinus	pomarine jaeger	4

Table 23. Continued.

SCIENTIFIC NAME	COMMON NAME	TOTAL BY SPECIES
Marine birds (con't)		
Stercorarius parasiticus	parasitic jaeger	50
Stercorarius longicaudus	long-tailed jaeger	63
Catharacta maccormicki	south polar skua	15
Larus occidentalis x glaucescens	western x glaucous-winged gull	277
Larus spp.	unidentified gull	4
Larus glaucescens	glaucous-winged gull	2
Larus occidentalis	western gull	631
Larus argentatus	herring gull	84
Larus californicus	California gull	224
Larus heermanni	Heermann's gull	26
Xema sabini	Sabine's gull	23
Sterna hirundo	common tern	5
Sterna paradisaea	Arctic tern	75
Sterna caspia	Caspian tern	82
Thalasseus elegans	elegant tern	58
Family Alcidae	unidentified alcid	4
Uria aalge	common murre	2361
Cepphus columba	pigeon guillemot	3
Synthliboramphus antiquus	ancient murrelet	1
Synthliboramphus hypoleucus	Xantus's murrelet	23
Ptychoramphus aleuticus	Cassin's auklet	225
Cerorhinca monocerata	rhinoceros auklet	180
Fratercula corniculata	horned puffin	1
Fratercula cirrhata	tufted puffin	8
Zenaida macroura	mourning dove	1
Order Passeriformes	passerine	7
Vermivora celata	orange-crowned warbler	1
Dendroica petechia	yellow warbler	1
Molothrus ater	brown-headed cowbird	1
Marine mammals		
Delphinus spp.	common dolphin	91
Lagenorhynchus obliquidens	Pacific white-sided dolphin	49
Lissodelphis borealis	northern right whale dolphin	1
Grampus griseus	Risso's dolphin	6
Phocoena phocoena	harbor porpoise	5
Phocoenoides dalli	Dall's porpoise	56

Table 23. Continued.

SCIENTIFIC NAME	COMMON NAME	TOTAL BY SPECIES
Marine mammals (con't)		
Balaenoptera acutorostrata	minke whale	2
Megaptera novaeangliae	hump-backed whale	1
Zalophus californianus	California sea lion	148
Eumetopias jubatus	Steller sea lion	8
Callorhinus ursinus	northern fur seal	11
Phoca vitulina	harbor seal	2
GRAND TOTAL		12322

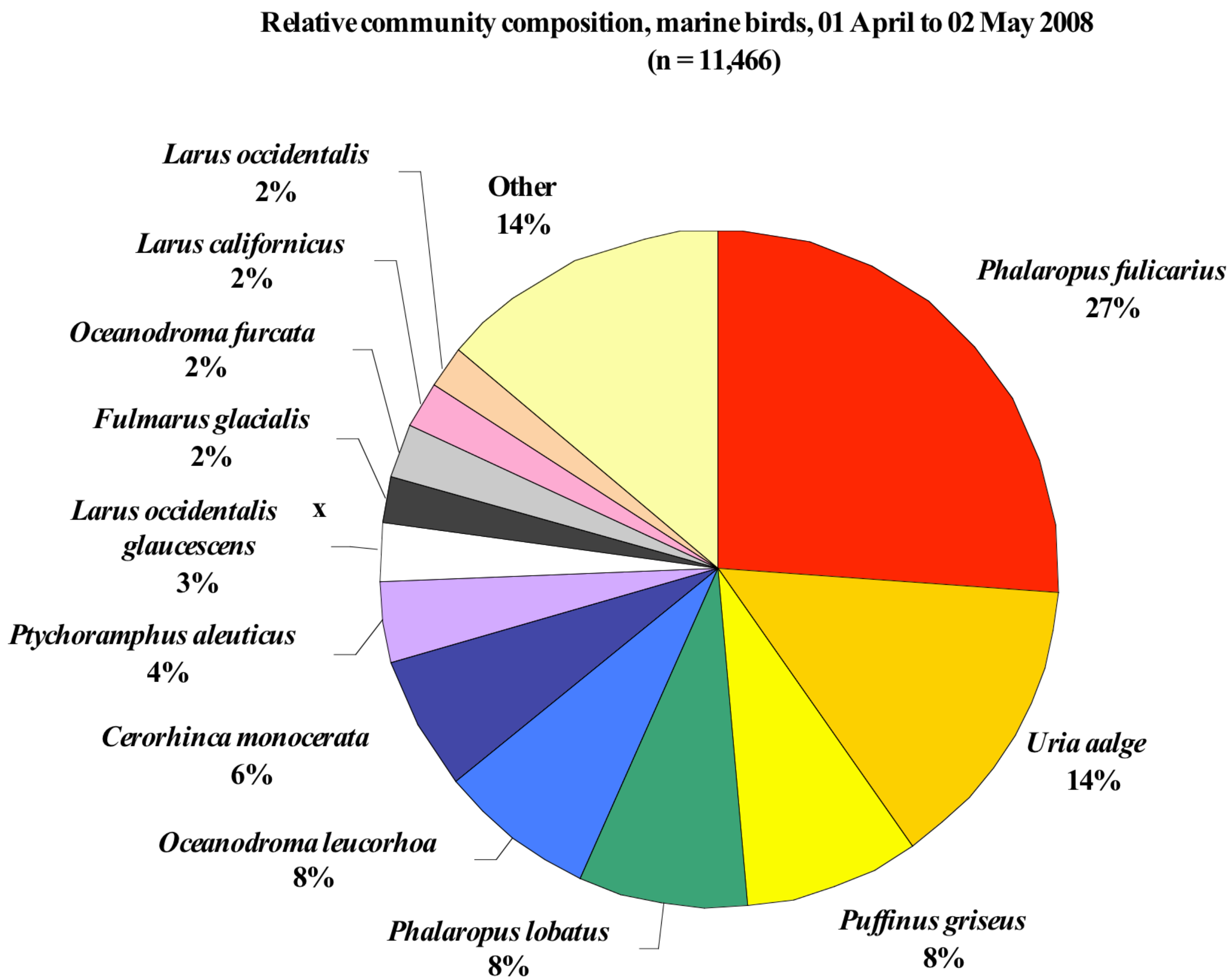

Figure 13. Relative species composition of all marine birds (> 2% of total) during the April 2008 cruises.

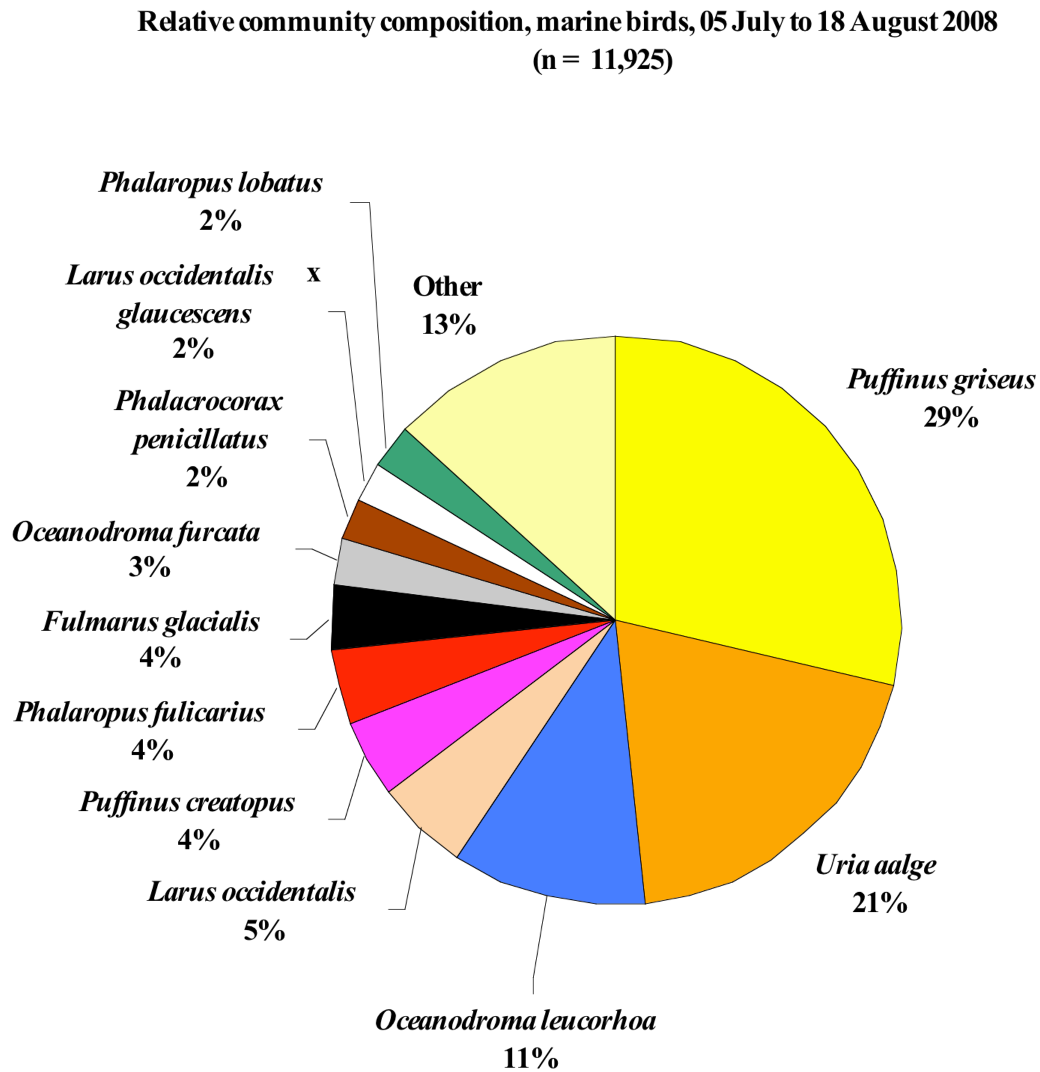

Figure 14. Relative species composition of all marine birds (>2% of total) during the July/August 2008 cruise.

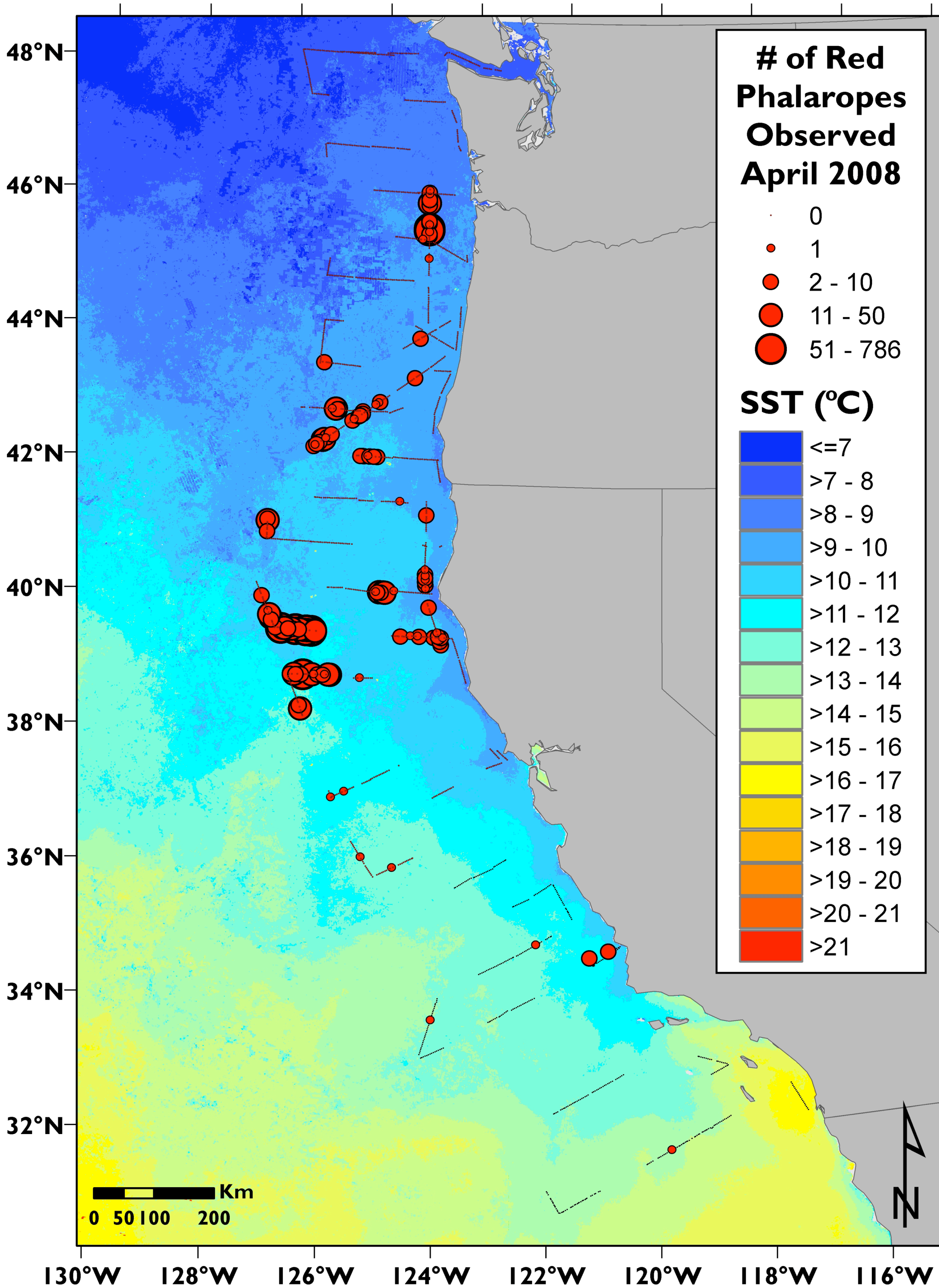

Figure 15. Along transect spatial pattern of red phalaropes during the April 2008 cruises.

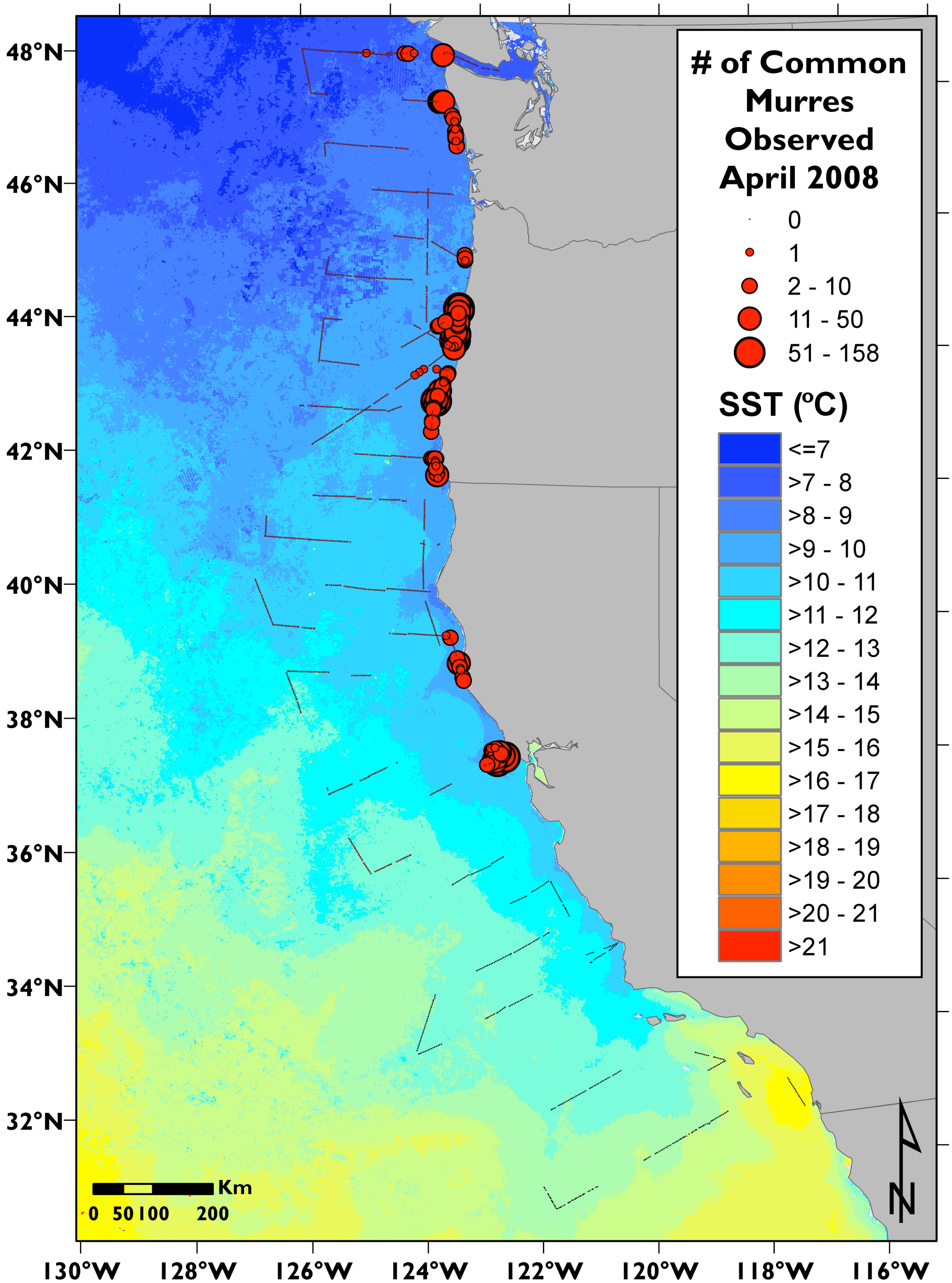

Figure 16. Along transect spatial pattern of common murres during the April 2008 cruises.

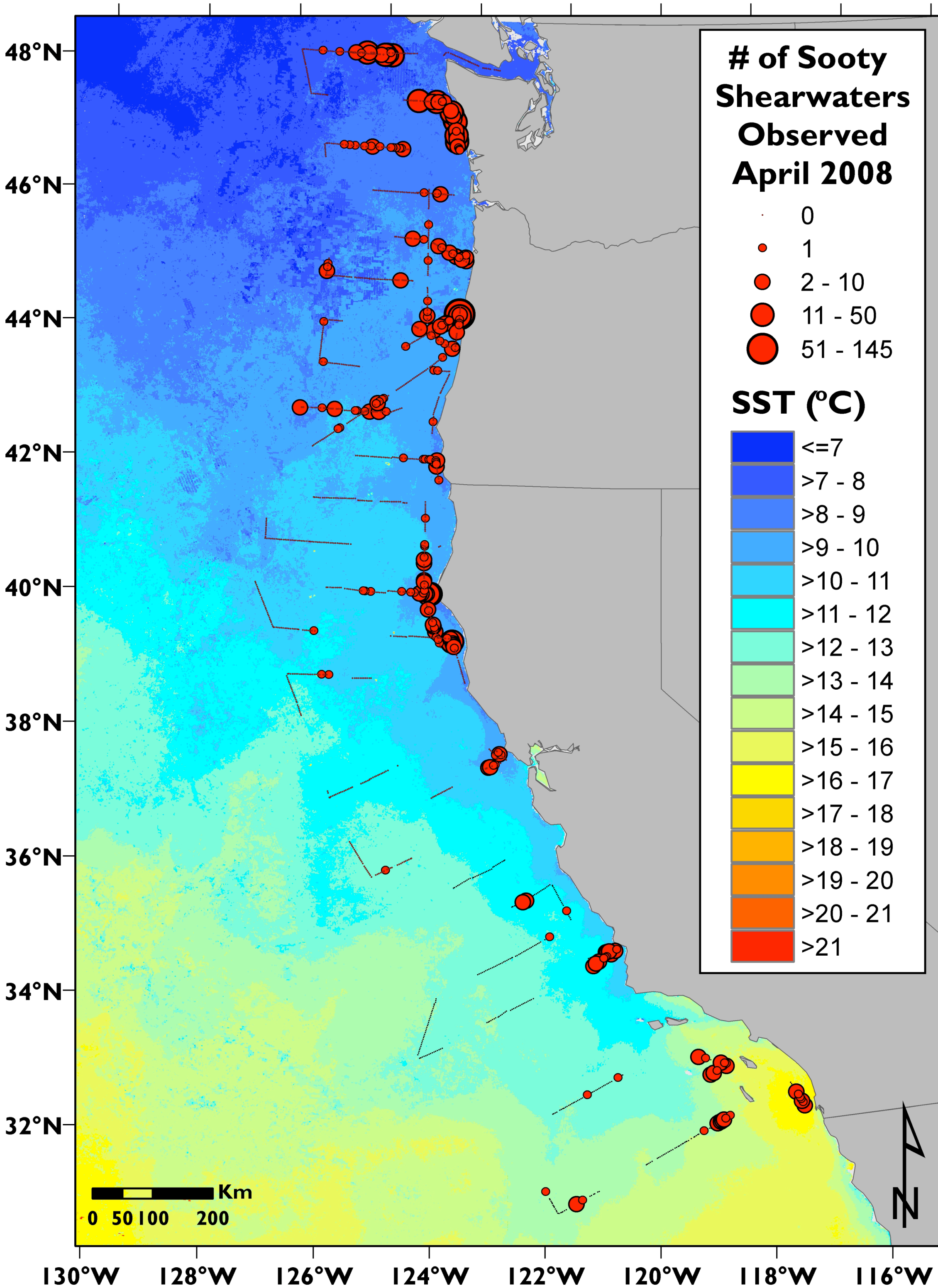

Figure 17. Along transect spatial pattern of sooty shearwaters during the April 2008 cruises.

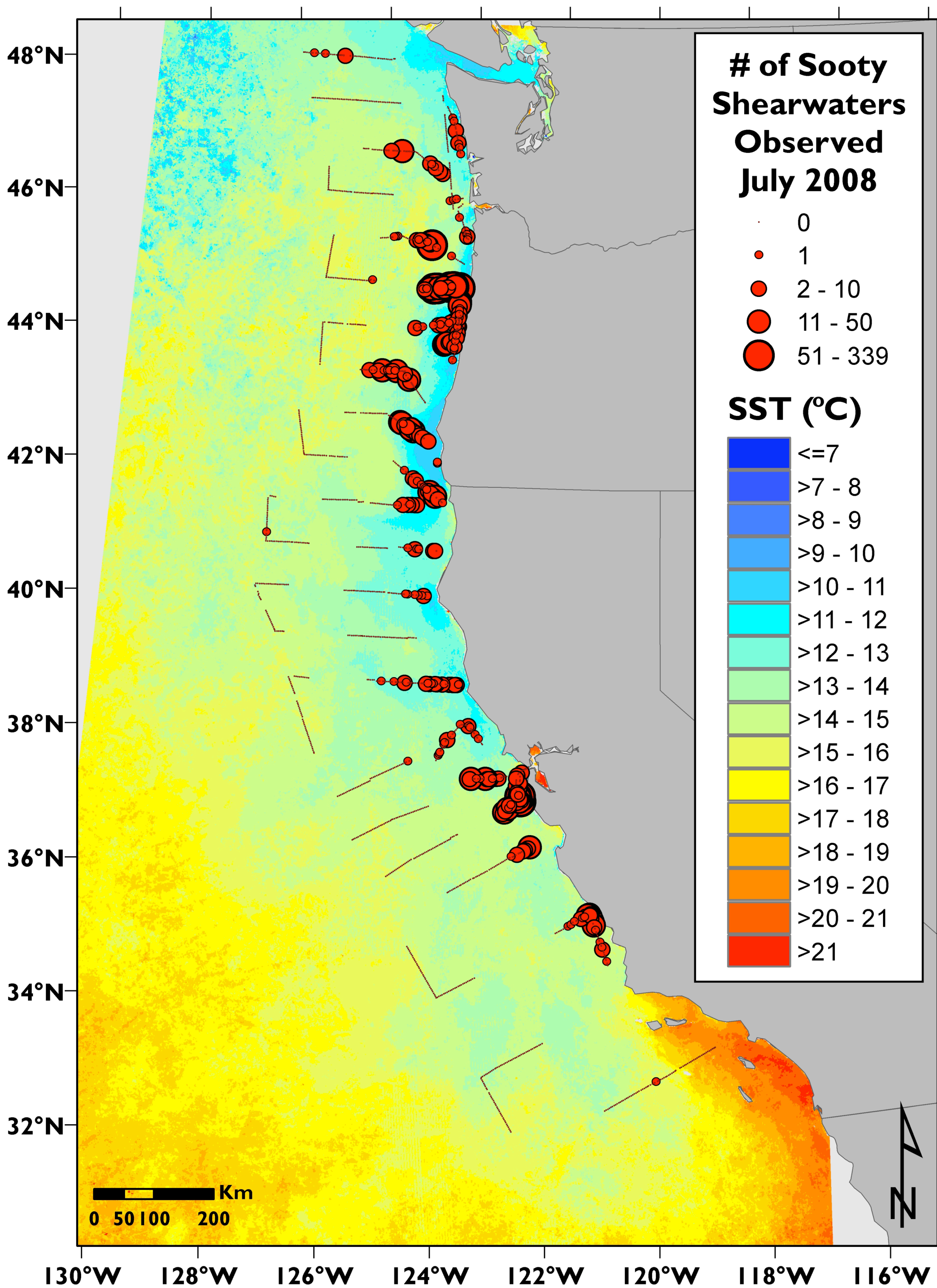

Figure 18. Along transect spatial pattern of sooty shearwaters during the July/August 2008 cruise.

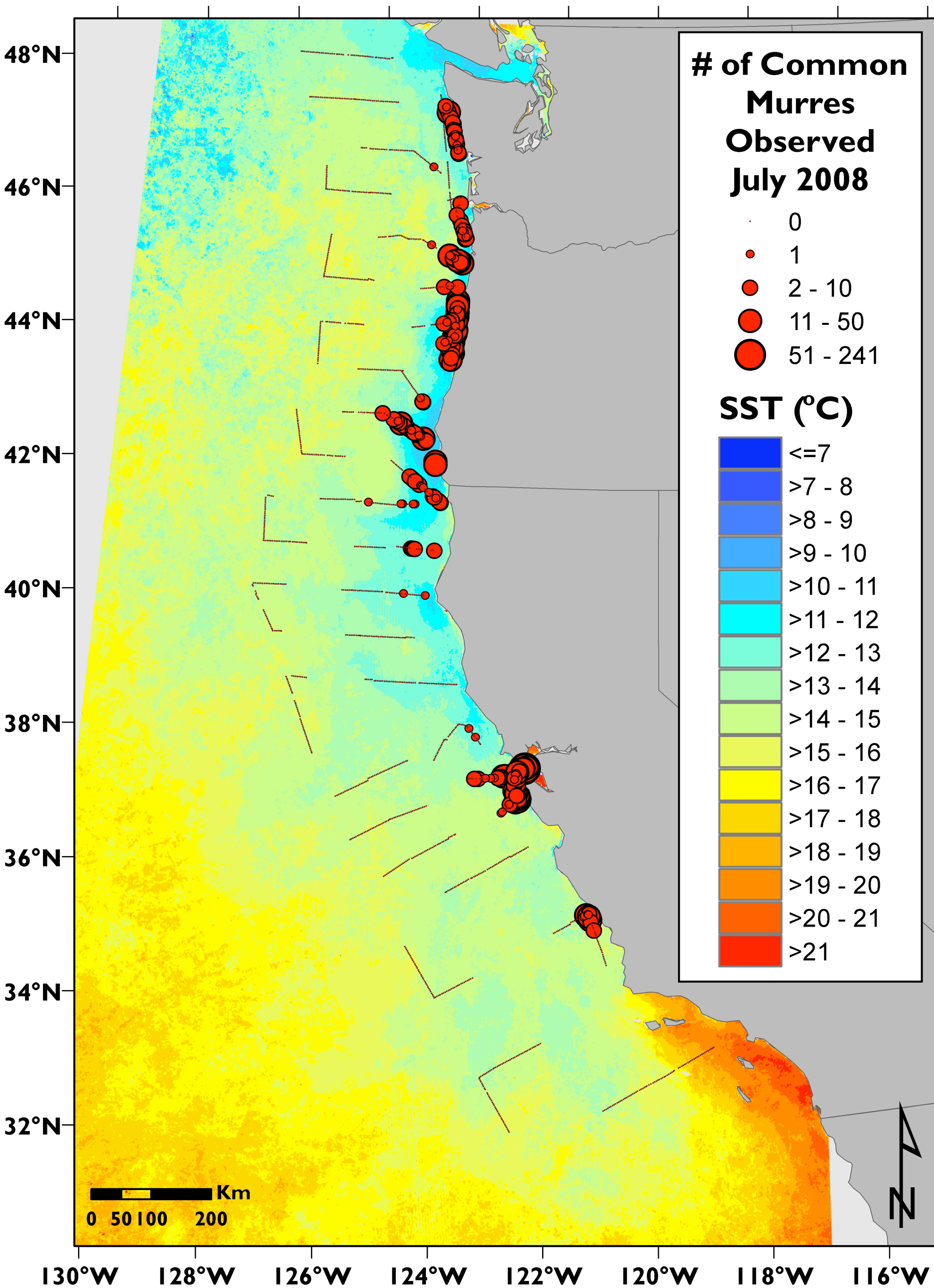

Figure 19. Along transect spatial pattern of common murres during the July/August 2008 cruise.

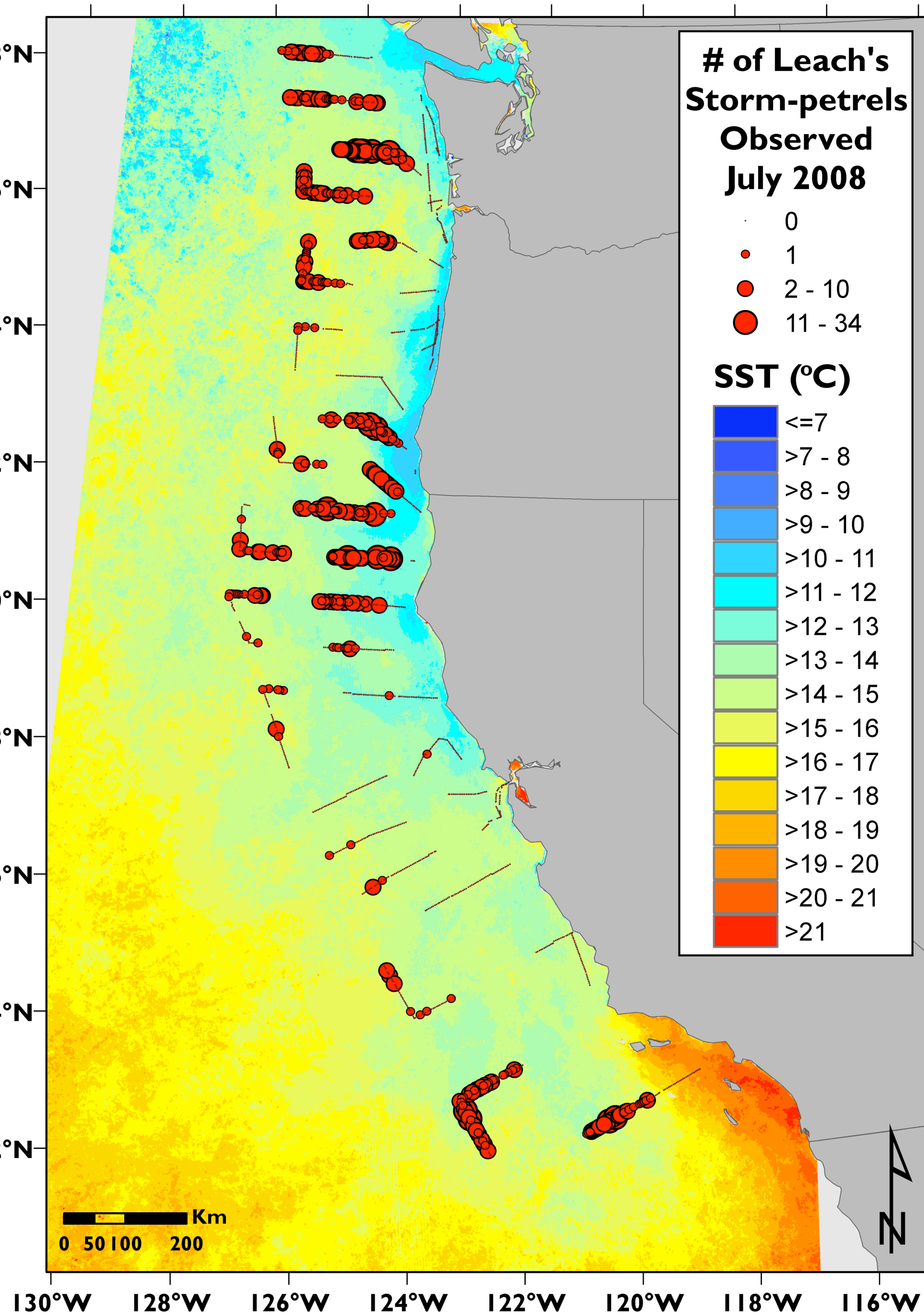

Figure 20. Along transect spatial pattern of Leach's storm-petrel during the July/August 2008 cruise.

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