OCS Study
BOEM 2016-009

Characterizing and Quantifying California Sea Lion (*Zalophus californianus*) Use of Offshore Oil and Gas Platforms in California

US Department of the Interior
Bureau of Ocean Energy Management
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Authors

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Disclaimer

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Report & Data Availability

To download a PDF of this report, go to the US Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program Information System (ESPIS) website at http://marinecadastre.gov/espis/#/ and search on OCS Study BOEM 2016-009. The report may also be downloaded from BOEM's Recently Completed Environmental Studies – Pacific webpage at http://www.boem.gov/Pacific-Completed-Studies/.

Metadata for this study is provided in InPort NMFS Enterprise Data Management Program (https://inport.nmfs.noaa.gov); Dataset ID 26353. Data for this study are archived at NOAA National Centers for Environmental Information (https://nodc.noaa.gov); Package Reference ID R1B85T.

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List of Acronyms

BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
MML	Marine Mammal Laboratory
MMPA	Marine Mammal Protection Act
NOAA	National Oceanic and Atmospheric Administration
OCS	Outer Continental Shelf
PXP	Plains Exploration and Production Company

ABSTRACT

There are 23 oil and gas production platforms in federal waters offshore southern California. These platforms provide haulout space near foraging areas for California sea lions (*Zalophus californianus*), a species protected under the Marine Mammal Protection Act. Information on abundance, and age-, sex-, and seasonal-use patterns of California sea lions on oil and gas platforms is useful for the environmental review of ongoing activities and the eventual removal of platforms when oil and gas production ceases (i.e. decommissioning). Quantitative estimates of potential harassment, injury, or mortality for future activities may be derived from data collected during this study.

For this study, 5 of the 23 federal platforms were selected as focal sites based on their geographical location and relative accessibility by sea lions. Time-lapse camera systems were deployed on the platforms from January 2013 to January 2015. Photos were taken every 30 minutes during day and night. A subsample of images was randomly selected from six-hour blocks of time throughout the day, and during randomly selected days throughout each month. Individuals were counted and identified to a particular age/sex-class, when possible. Counts of animals by month and hour were conducted to examine intra-platform (temporal) and inter-platform (spatial) comparisons. A subsample of images (n_{total} = 12,489; Platform Elly = 1,981, Platform Gina = 1,960, Platform Habitat = 4,742, Platform Heritage = 2,551, Platform Harvest = 1,255) was used in data analyses. There were no consistent spatial trends (i.e. south-to-north) in numbers of sea lions using the platforms. Platform Habitat (central) had the highest counts of sea lions (Median: 2013_{range} = 32 – 134; 2014_{range} = 40 – 110), whereas Platform Gina (south) had the lowest (Median: 2013_{range} = 1 – 21; 2014_{range} = 3 – 22) throughout the study. Also, there were no consistent seasonal trends in numbers across all platforms. At some platforms (i.e. Platforms Gina and Habitat), the animals primarily hauled out at night and were away during the middle of the day, whereas at others (i.e. Platforms Heritage and Harvest) the opposite trend was apparent. At Platform Elly, the sea lions used the platform relatively consistent throughout the day.

Additional observations made during this study included: (1) pinniped-use on all platforms was dominated by California sea lions, however Steller sea lions (*Eumetopias jubatus*) were occasionally present at Platforms Elly and Habitat; (2) California sea lion adult females were observed nursing at platforms; and (3) adult and subadult California sea lion males were seen at the platforms year-round. These observations have enhanced our understanding about the distribution and behavior of California sea lions and their use of offshore platforms.

Keywords: California sea lion, oil and gas platform, Pacific Outer Continental Shelf, pinniped, time-lapse camera system, *Zalophus californianus*.

INTRODUCTION

As of 2016, there are 27 oil and gas production platforms offshore southern California. Twenty-three of the platforms are in federal waters offshore San Pedro Bay (n = 4), the Santa Barbara Channel (n = 15), and in the Santa Maria Basin (n = 4). These platforms are under leases issued by the Bureau of Ocean Energy Management (BOEM) and administered by the Bureau of Safety and Environmental Enforcement (BSEE). The other four platforms are in state waters (less than 5 km from shore) and operate under leases issued by the California State Lands Commission.

The federal platforms were erected between 1967 and 1989. Currently, they produce approximately 63,000 barrels of oil and 130 million cubic feet (Mmcf) of natural gas per day (BOEM Studies Plan). At this rate, production could be sustained into the next decade. However, eventually all of these facilities will be decommissioned at the end of their productive life times.

Many of the oil and gas platforms provide haulout space near foraging areas for pinniped species like the California sea lion (*Zalophus californianus*), the Steller sea lion (*Eumetopias jubatus*), and the Pacific harbor seal (*Phoca vitulina*). Analyses of on-going activities and decommissioning of platforms will benefit from the information collected during this study.

Decommissioning of platforms falls under the jurisdiction of BSEE, and BOEM conducts environmental studies and environmental review support for BSEE actions. During 2012, BOEM entered an inter-agency agreement with the National Oceanic and Atmospheric Administration's (NOAA) Marine Mammal Laboratory (MML; Seattle, Washington) to collect information in support of analyses pursuant to the National Environmental Policy Act (NEPA) and Marine Mammal Protections Act (MMPA) permitting requirements. Specifically, the objectives of this study were to: (1) characterize and quantify California sea lion use of oil and gas platforms offshore southern California area of the Pacific OCS Region; and (2) assess the abundance, seasonal use patterns, and age/sex class structure of animals using the offshore facilities.

METHODS

Platforms & camera systems

All 23 federal platforms were visited between 30 October and 7 November 2012 (Fig. 1). During these visits, the number and age/sex class of each individual pinniped hauled out on the platforms were recorded. Additionally, each platform was evaluated for the installation of digital automated time-lapse camera systems including; number and size of landing decks, height of railing above pinniped-occupied decks, and diameter of rails.

Figure 1. Several of the 23 oil and gas production platforms in federal waters offshore southern California that were visited during October and November 2012 to evaluate for the installation of time-lapse camera systems to document the use of the platforms by pinnipeds.

Camera systems could not be placed on all the platforms due to time and monetary constraints. After the initial assessments were completed, 5 of the 23 platforms were selected as focal study sites. Selection criteria included: (1) high usage by pinnipeds, (2) camera placement constraints, and (3) a "good" representative within a particular geographical area. The five platforms selected were (from south to north): Platform Elly (Beta Offshore; San Pedro Bay), Platform Gina (DCOR; Point Hueneme Unit), Platform Habitat (DCOR; Pitas Point Unit), Platform Heritage (Exxon Mobil; Santa Ynez Unit), and Platform Harvest (originally Plains Exploration and Production Company (PXP) but ownership transferred to Freeport McMoran during the study; Point Arguello Unit; Fig. 2).

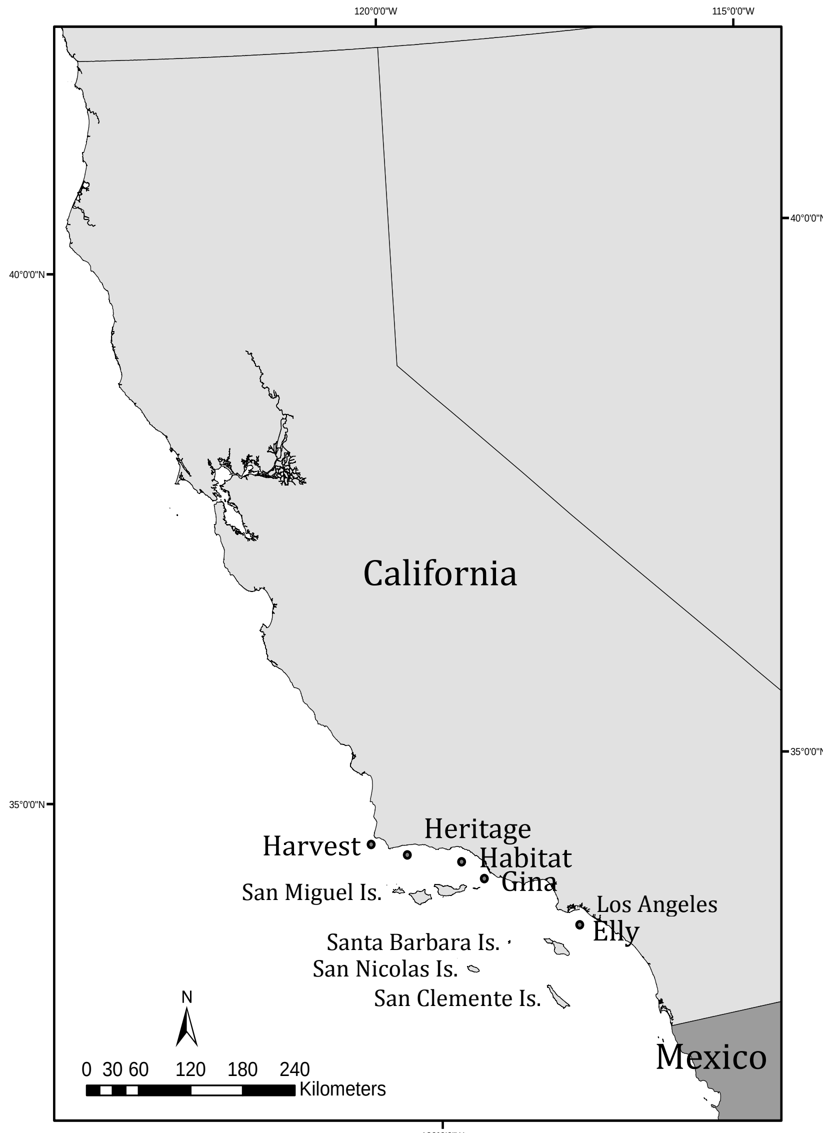

Figure 2. Locations of gas and oil platforms located in the Pacific Outer Continental Shelf Region offshore southern California where time-lapse camera systems were installed to document the use of the platforms by pinnipeds between January 2013 and January 2015. The offshore platforms included (from south to north): Platform Elly (Beta Offshore; San Pedro Bay), Platform Gina (DCOR; Point Hueneme Unit), Platform Habitat (DCOR; Pitas Point Unit), Platform Heritage (Exxon Mobil; Santa Ynez Unit), and Platform Harvest (Plains Exploration and Production Company (PXP)/Freeport McMoran; Point Arguello Unit).

The camera systems (Trail Watcher Game Cameras; Monticello, Georgia; Fig. 3) were composed of a timing circuit, a small point-and-shoot camera (Sony Cyber-shot DSC-WX50, 16.2 megapixels), and battery bank (Energizer Ultimate Lithium AA and Duracell Procell C), which were all mounted within a small Pelican® waterproof case (Fig. 3). Cameras systems were attached to custom fabricated aluminum backing plates with a hood. The backing plates containing the camera systems were attached to railings on the platform using clamps and stainless steel fastings (Fig. 3). Initially, the time-lapse camera systems were programmed to take a photo every 15 minutes between the hours of 0300h and 1900h. 16GB memory cards were installed in each camera. Cameras were deployed on Platforms Elly, Gina, Habitat and Heritage in January 2013 and Platform Harvest in February 2013. The number of cameras required, location, and viewing angle to maximize coverage of pinniped-use areas were all considered in determining the placement of the camera systems. The number of camera systems installed on each platform were as follows: Platform Elly = 3, Platform Gina = 3, Platform Habitat = 4, Platform Heritage = 4, and Platform Harvest = 3.

Figure 3. Digital automated time-lapse camera systems (developed by Trail Watcher Game Cameras; Monticello, Georgia) that were installed on five gas and oil platforms offshore southern California and programmed to take images between January 2013 and January 2015. The systems consisted of a timing circuit, a camera, and battery bank. They were placed in locations where most areas where pinnipeds could be viewed were covered.

In February 2013, the four platforms that had camera systems were revisited so that the conditions of the camera systems could be inspected and maintenance performed (e.g. batteries replaced, battery voltage measured) and memory cards containing digital images were collected and replaced with new/empty cards. It was determined that 16GB memory cards did not have sufficient space to store two-months' worth of images at a rate of 1 image/15 min. The sampling protocol was changed to 1 image/30 min throughout the entire day and 16GB cards were replaced by 32GB cards. We also encountered problems of failing battery voltage on a few of the camera systems [i.e. Platform Elly (n = 2) and Platform Gina (n = 1)], which resulted in the cameras operating for less than a month. During this month, three camera systems were deployed on Platform Harvest.

In April 2013, all five of the platforms were revisited so that batteries and memory cards could be exchanged and other maintenance (e.g. cleaning viewing window) could be performed following a two-month deployment. A couple of the camera systems [i.e. Platform Elly (n = 1) and Platform Habitat (n = 1)] were determined not be working properly, resulting in failures to take photos at programmed times since the last visit. The failing units were replaced with functional ones and subsequently repaired or replaced.

After April 2013, we visited the platforms every two to three months for data retrieval and maintenance of the camera systems, which included replacing the batteries, measuring battery voltage, and checking the functionality of the cameras (Table 1). All camera systems were removed from the platforms in January 2015.

Data collection

Images were uploaded from memory cards to a laptop computer. Some of the digital images were examined to determine if there were any issues with camera performance or the camera system housing (e.g. unclear viewing window, faulty programming, alteration of housing unit). Organizational and nomenclature changes of images were made using the freeware Total Commander [C. Ghisler, Ver. 8.51a, 32 bit (2014)]. Image file names were changed to a Year Month Day, Hour Minute Second, original file name, and Camera Number format: "YYYYMMDD_HHMMSS_original file name_CAM #".

A Microsoft Access database was created to archive and analyze the time-lapse images. The database contained fields to input metadata for each image (e.g. visibility quality, environmental conditions, distance of camera from haulout sites, species of pinniped seen), as well as to identify and count animals. To identify and count individuals, an analyst would view the image files for a given platform corresponding to a specific date and time. Landmarks on images that had overlapping areas taken from two or more cameras were marked. For each image file, the analyst used their computer mouse to place a marker on each animal they saw hauled out on the platform. The analyst chose one of seven different age/sex class (individuals that generally share the same morphological characteristics) or unclassified markers and a blank category indicating no animals were seen (the first four categories are descriptors for California sea lions only): (1) "mature males" – included subadult and adult males; approximately 6 or more years old, 1.5 to 2 m long, brown to black in coloration, sagittal crest partially or fully developed, thick neck; (2) "adult females" – 5 or more years old, 1.5 to 2 m long, light brown or cream colored, no sagittal crest present; (3) "juveniles" – of both sexes, approximately 1 to 4 years old, from <1 to 1.5 m long, light to dark brown coloration; (4) "pups" – of both sexes, <1 year old, ≤ 1

Table 1. Tasks and dates of visitation to oil and gas platforms in federal waters off the southern California Bight. Camera systems were deployed on the platforms to document their usage by pinnipeds between January 2013 and January 2015.

Trip #	Purpose	Dates	Platforms	Notes
1	Reconnaissance	30 October - 7 November 2012	All 23	
2	Camera system installation	7-10 January 2013	Elly, Gina, Habitat, Heritage, Harvest	
3	Data retrieval, maintenance	7-12 February 2013	Elly, Gina, Habitat, Heritage, Harvest	
4	Data retrieval, maintenance	9-14 April 2013	Elly, Gina, Habitat, Heritage, Harvest	Camera 1 removed from Harvest
5	Data retrieval, maintenance	4 - 7 and 25 June 2013	Elly, Gina, Habitat, Heritage, Harvest	
6	Data retrieval, maintenance	20 - 24 August 2013	Elly, Gina, Habitat, Heritage, Harvest	
7	Data retrieval, maintenance	12 - 22 November 2013	Elly, Gina, Habitat, Heritage, Harvest	
8	Data retrieval, maintenance	24 February - 2 and 23 March 2014	Elly, Gina, Habitat, Heritage, Harvest	
10	Data retrieval, maintenance	20 - 24 May 2014	Elly, Gina, Habitat, Heritage, Harvest	
11	Data retrieval, maintenance	18 - 31 August 2014	Elly, Gina, Habitat, Heritage, Harvest	
12	Data retrieval, maintenance	1 - 6 December 2014	Elly, Gina, Habitat, Heritage, Harvest	
13	Data retrieval, camera system removal	12 - 17 January 2015	Elly, Gina, Habitat, Heritage, Harvest	

m long, dark brown coloration. It was often difficult to discern yearlings (categorized as juveniles) from older pups, therefore 1 July was set as the demarcation date in which individuals that looked like pups were categorized as juveniles; (5) "unknown" – individuals that could not be identified to a specific age/sex class or could only see a body part (e.g. flipper, rump); (6) "cannot count" – for various reasons (e.g. blurred images, too dark); and (7) "blank". Tallies of identifications were automatically computed using coding embedded in the database. Analysts also noted if an image contained marked (e.g. branded, tagged, instrumented) individuals, animals with shark bites or lesions, evidence of fishery-interactions (e.g. individual entangled with monofilament line, bands, fish hooks), human disturbance (e.g. humans working on the platform, crew boat exchange), or any other unusual occurrence (e.g. birthing, nursing). Analysts were conservative with their identifications. If there were any uncertainties in assigning an age/sex class to an animal, then the analyst would consult with other analysts or label animal as "unknown". Additionally, individuals that were difficult to differentiate between being a pup or juvenile were marked as "juvenile". Individuals that were questionable to identify as juvenile, adult female, or subadult male were labeled as "unknown".

Quality control

To ensure that identifications and counts were done correctly, the analyst would open the image a second time and view the assigned markers. Images were viewed at least twice to make sure all animals were accounted for. A subset of images was viewed by at least two analysts to determine if the counts and identifications were consistent across analysts. Additionally, a subset of images was re-analyzed after all images for a platform were processed in order to determine if analysts were consistent with their counts and identifications from the beginning through the end of their image counting processing.

Data analyses

Due to time constraints, it was not possible to analyze all the images obtained during the study, so a subsampling protocol was developed. The dates when all the cameras on a given platform were operational was split into two-week blocks. From each block, two days were selected at random. Within each day, two images were analyzed from the following blocks of time: 0001h/earliest hour – 0659h, 0700h – 1259h, 1300h – 1859h, 1900 – 0000h/latest hour. Months when a particular camera-system was not operational were not included in the subsampling protocol (Table 2). If an image from one or more camera-systems on a platform was not able to be analyzed (e.g. too dark, out of focus) then discernable photos from the nearest in time (prior in time was given preference) to the time period selected in the subsampling protocol were used.

Total counts were calculated by summing the number of individuals (identified to a specific age/sex class, if possible) counted from images taken from all cameras for the same time and date. Only individuals on the platform, including supporting beams, landing decks, and stairs were counted. Individuals in the water beneath the platform or around landing decks were not. Counts were used to generate hourly, daily, and monthly median numbers of animals using the platforms. Inter-platform comparisons were made to examine spatial trends in animal usage. Intra-platform comparisons were examined to determine if there were any temporal (i.e. monthly/seasonal) changes.

Statistical differences in counts of California sea lions were assessed using generalized linear models (GLMs) with the *glm* function (quasipoisson family) in R (R Core Team 2015). GLMs included response variables platform, year, month, hour, and interaction terms. GLMs were used because response variables had non-normal distributions. Significance level was set at α = 0.05. No statistical comparisons were made among age/sex classifications because most identifications were "unknown" and individuals were not assigned to an age/sex class on Platform Habitat.

Table 2. Months during which at least one camera system located at a focal gas and oil platform was not operational, or not set up (e.g. January 2013 for Platform Harvest). Data were not analyzed during those months.

Platform	**2013**	**2014**	**2015**
Elly	January, March, April, May	February, March, April	
Gina	January	October, November, December	January
Habitat	January	February	January
Heritage		September, October	
Harvest	January	September, October, November	

RESULTS

Of the 464,174 images obtained from all the platforms during this study, 12,489 (Platform Elly = 1,981, Platform Gina = 1,960, Platform Habitat = 4,742, Platform Heritage = 2,551, Platform Harvest = 1,255) were used in data analyses. There were periods of time when one or more of the camera-systems were not functioning properly. Images were not analyzed during those months (Table 2).

Steller sea lions were observed in photographs on only two of the platforms: Platform Elly on 22 February 2013 and 3 January 2014, and Platform Habitat on 22 January 2014 (Fig. 4a). Harbor seals were occasionally seen in waters adjacent to the platforms during our visits, but none were actually seen hauled out on the platforms (Fig. 4b).

(a)

(b)

Figure 4. Pinniped species observed at or near the gas and oil platforms besides the California sea lion (*Zalophus californianus*) included: **(a)** Steller sea lion (*Eumetopias jubatus*), and **(b)** Pacific harbor seal (*Phoca vitulina richardii*).

Intra-platform (temporal) comparisons

Platform Elly

Counts could not be conducted during several months on Platform Elly because of camera-system malfunctions (Table 2). Therefore it was not possible to examine complete inter- and intra-annual comparisons of California sea lion use on this platform. However, using data that were collected and analyzed indicated that significantly more sea lions used the platform during 2013 compared to 2014 (GLM, $p < 0.05$; Fig. 5).

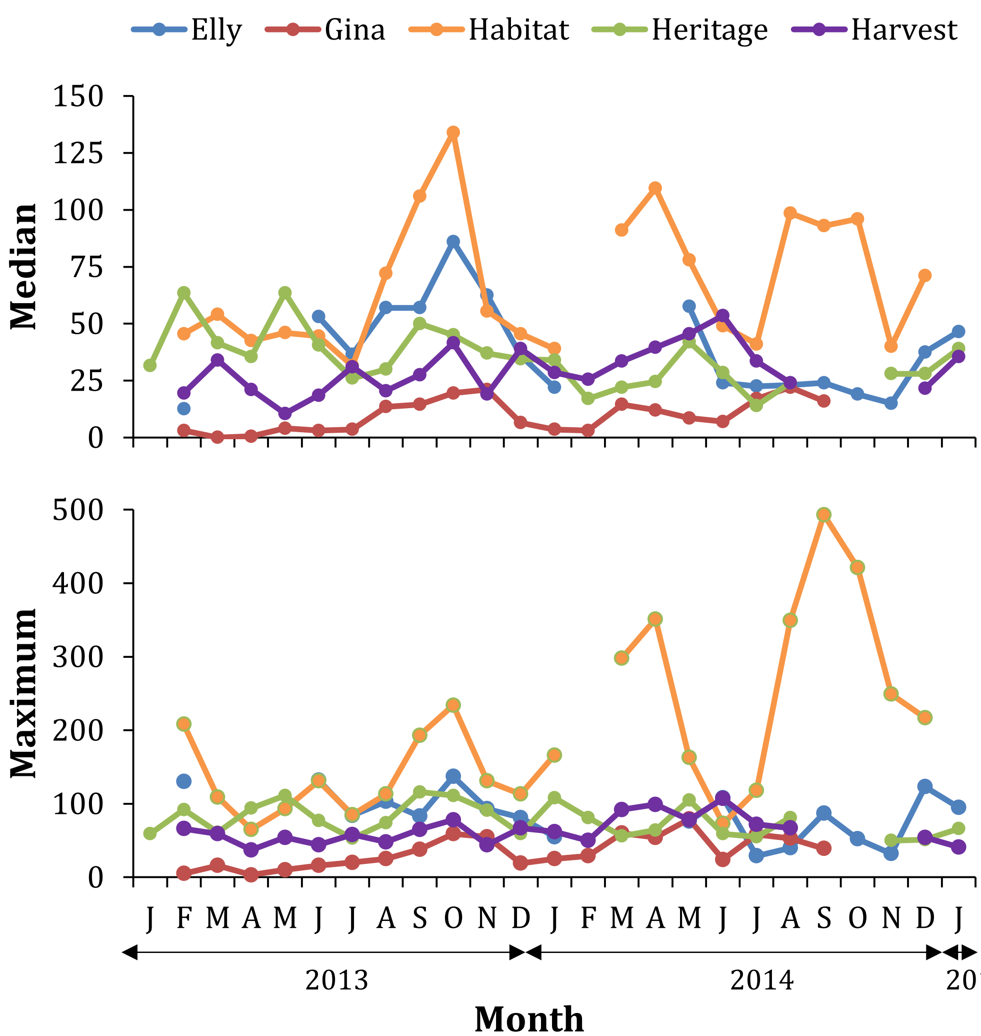

Figure 5. Monthly median **(top)** and maximum **(bottom)** counts of California sea lions (*Zalophus californianus*) on gas and oil platforms located in the Pacific Outer Continental Shelf Region offshore southern California from January 2013 to January 2015. Platforms are listed in order from south to north.

Monthly comparisons: Monthly median counts fluctuated throughout the study and differed significantly (GLM, $p < 0.05$). During 2013, monthly median counts ranged from 13 (February) to 86 (October). The range of monthly maximum counts was 81 (December) to 137 (October; Fig. 5). During 2014, monthly median counts were more consistent and ranged from 15 (November) to 58 (May). The range of monthly maximum estimates was 32 (November) to 123 (December; Fig. 5). Intra-monthly counts/trends were not consistent and differed significantly between years (GLM, $p < 0.05$). For example, the highest number of animals were observed during October 2013, whereas October 2014 had some of the lowest counts (Fig. 5).

Hourly comparisons: Overall, hourly median counts differed significantly (GLM, $p < 0.05$). During 2013, hourly median numbers ranged from 33 (0300h) to 83 (1500h; Fig. 6). Hourly maximum counts ranged from 64 (0100h) and 137 (1800h). During 2014, hourly median counts ranged from 13 (1800h) to 54 (0200h). Hourly maximum estimates ranged from 25 (1200h) to 123 (2200h; Fig. 6). Intra-hourly comparisons of median counts indicated that in 2013 there was a gradual increase in numbers of sea lions hauled out from early morning to the afternoon (0300h – 1500h) then a decrease in numbers during the remainder of the day, whereas median counts were relatively consistent throughout the day during 2014 (Fig. 6).

Age/sex class comparisons: The monthly mean percentage (± standard error) of individuals identified to an age/sex class was 47.3% (SE = 4.0) during 2013 and 49.8% (SE = 3.4) during 2014.

Juvenile California sea lions comprised the highest proportion of identified animals on Platform Elly during every month of the study (Fig. 7). They represented a higher proportion of animals using the platform during 2013 [range: 0.75 (September) – 0.92 (July)] compared to 2014 [0.73 (November, December) – 0.86 (May)].

In general, adult females had the second highest proportions of identified individuals, depending on month (Fig. 7). Their monthly proportions were higher in 2014 [range: 0.09 (May) – 0.18 (December)] compared to 2013 [range: 0.04 (July, November) – 0.14 (February)].

Mature males had higher proportions than adult females during five months of the sampling period (i.e. August, September, and December 2013; January and July 2014); however, overall they represented the third most assigned age/sex class. During 2013, the proportion of mature males ranged from 0.06 (February, November) to 0.14 (September; Fig. 7). During 2014, they constituted 4.4% (May) to 12.8% (January) of the classified population (Fig. 7). The mean annual proportion of mature males was the same during both years (mean = 0.08, standard deviation = 0.03).

Pups were only seen on Platform Elly during February 2013 (0.5%, n = 4; Fig. 7). There did not appear to be a consistent seasonal trend in the proportion of individuals within any age/sex class during any year of the study (Fig. 7).

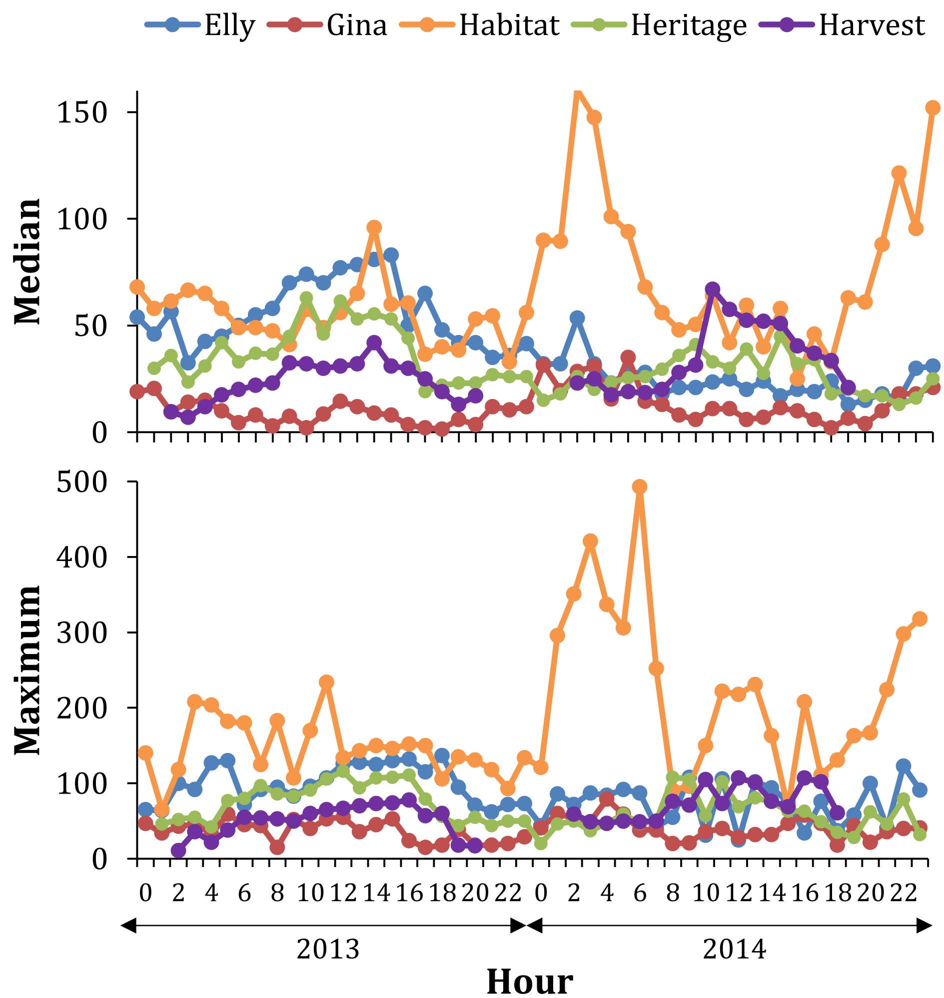

Figure 6. Hourly median **(top)** and maximum **(bottom)** counts of California sea lions (*Zalophus californianus*) on gas and oil platforms located in the Pacific Outer Continental Shelf Region offshore southern California during 2013 and 2014. Platforms are listed in order from south to north.

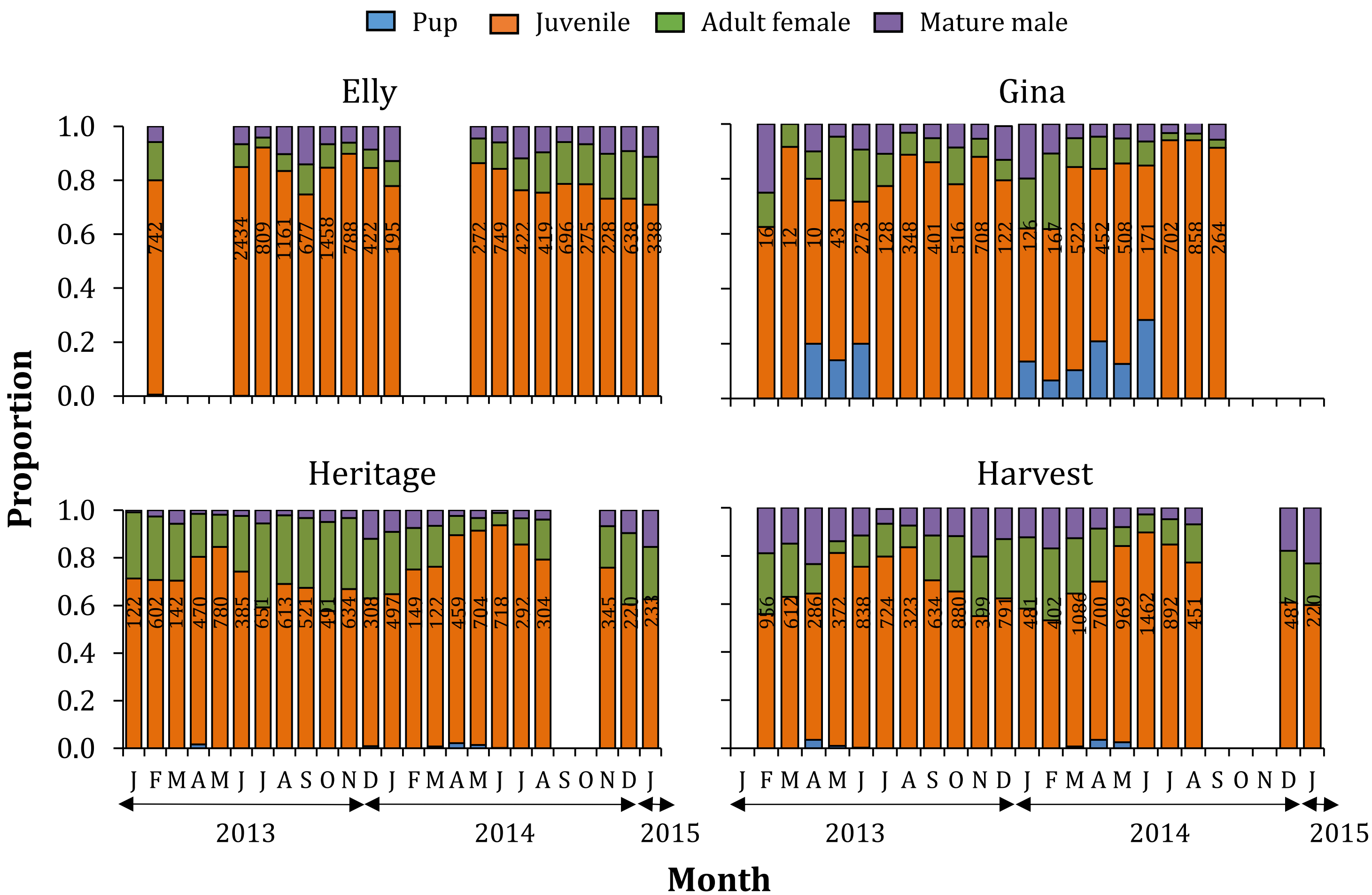

Figure 7. Proportion of California sea lions (*Zalophus californianus*) using gas and oil platforms that were identified to a specific age/sex class [(from south (top, left) to north (bottom, right)] by month from January 2013 through January 2015. Numbers within bars indicate total number of animals identified during that month.

Platform Gina

Data were not obtained during January 2013 nor any month after September 2014 from Platform Gina because of camera-system failures. Therefore, complete inter- and intra-annual comparisons could not be made. However, general patterns in the number of sea lions using Platform Gina could be ascertained from the months that were sampled.

Monthly comparisons: During 2013, monthly median numbers ranged from 1 (April) to 21 (November); and maximum monthly counts ranged from 3 (April) to 59 (October; Fig. 5). During 2014, monthly median counts ranged from 3 (February) to 22 (August). The range for monthly maximum estimates was 24 (June) to 79 (May; Fig. 5). There was a general upward trend in the number of California sea lions using Platform Gina from February to November 2013 (Fig. 5). During 2014, the trajectory was similar to 2013 until June, after which counts fluctuated (Fig. 5).

Hourly comparisons: General trends of hourly median data indicated that California sea lions hauled out less during "daytime" hours (~0600h-2000h) compared to "nighttime" hours in both 2013 and 2014 (Fig. 6). During 2013, hourly median counts ranged from 2 (1000h, 1700h, and 1800h) to 21 (0100h; Fig. 6). Hourly maximum counts ranged from 15 (0800h and 1700h) to 59 (0500h). During 2014, hourly median numbers ranged from 2 (1700h) to 35 (0500h). The range of hourly maximum counts was 18 (1800h) to 79 (0400h; Fig. 6). General patterns of intra-hourly and inter-annual counts were similar (Fig. 6).

Age/sex class comparisons: The monthly mean percentage of individuals identified to an age/sex class was 59.2% (SE = 5.2) during 2013 and 73.0% (SE = 4.7) during 2014.

Juveniles were the most numerous age/sex class during every month for which data were available (Fig. 7). Overall, juveniles had approximately the same proportions during 2013 [range: 0.52 (June) to 0.92 (March)] and 2014 [range: 0.48 (January) to 0.94 (July, August)]; however, their proportions were not consistent by month (Fig. 7).

Adult females were the second most common age/sex class counted. Their proportions were similar between years [range 2013: 0.07 (November, December) to 0.23 (May); range 2014: 0.02 (August) to 0.28 (February)] although intra-monthly comparisons were not (Fig. 7).

Pups were only seen during May to June 2013. Their proportions ranged from 0.14 (May) to 0.20 (April, June; Fig. 7). During 2014, pups were sighted as early as January. Their monthly proportions ranged from 0.07 (February) to 0.29 (June; Fig. 7).

Mature males monthly proportions ranged from 0 (March) to 0.25 (February) during 2013, and 0.03 (July) to 0.20 (January) during 2014 (Fig. 7).

There did not appear to be a consistent seasonal trend in the proportion of individuals within any age/sex class during either year of the study (Fig. 7).

Platform Habitat

Data were obtained during all months on Platform Habitat except January 2013, February 2014, and January 2015. Using data that were collected and analyzed indicated that California sea lions used Platform Habitat significantly more during 2014 compared to 2013 (GLM, $p < 0.05$; Fig. 5).

Monthly comparisons: During 2013, monthly median counts ranged from 32 (July) to 134 (October). Maximum monthly counts ranged from 65 (April) to 234 (October; Fig. 5). During 2014, monthly median numbers ranged from 40 (November) to 110 (April); and maximum monthly counts ranged from 73 (June) to 493 (September; Fig. 5). Intra-monthly median counts were different between years (GLM, $p < 0.05$), however some trends were apparent. For example, prior to July, there was a general downward trend in median counts, followed by an upward trend in counts until November during both years (Fig. 5).

Hourly comparisons: There were significant differences in hourly median counts in both years (GLM, $p < 0.05$). During 2013, hourly median counts ranged from 33 (2200h) to 96 (1400h); and hourly maximum counts ranged from 65 (0100h) to 234 (1100h; Fig. 6). During 2014, hourly median numbers ranged from 25 (1500h) to 161 (0200h); and hourly maximum counts ranged from 67 (1500h) to 493 (0600h; Fig. 6). Intra-hourly trends were similar during some periods of the day. For example, there was a decreasing trend in the number of sea lions using the platform from 0300h to approximately 1000h, although the decrease in numbers was more pronounced during 2014 (Fig. 6). Intra-hourly trends were inconsistent during other periods of the day (Fig. 6).

Age/sex class comparisons: Individuals were not identified to a particular age/sex class on Platform Habitat during the study, primarily because animals were at a distance from the camera systems or tightly aggregated that made classifying difficult.

Platform Heritage

Although images were obtained during every month on Platform Heritage except September and October 2014, it was not possible to examine complete inter- and intra-annual comparisons of California sea lion usage of the platform. From data that were available, it was apparent that California sea lions used the platform significantly more during 2013 compared to 2014 (GLM, $p < 0.05$; Fig. 5).

Monthly comparisons: During 2013, monthly median counts ranged from 26 (July) to 64 (February and May). Monthly maximum estimates ranged from 53 (July) to 116 (September; Fig. 5). During 2014, monthly median counts ranged from 14 (July) to 42 (May). Monthly maximum counts ranged from 50 (November) to 108 (January; Fig. 5). Although the median number of animals were different between years, the inter-annual pattern of median numbers between April through August were similar (Fig. 5).

Hourly comparisons: During 2013, hourly median counts ranged from 19 (1700h) to 63 (1000h). Hourly maximum counts ranged from 42 (0400h) to 116 (1200h; Fig. 6). During 2014, hourly median counts ranged from 13 (2100h) to 45 (1400h); and maximum hourly counts ranged from 20 (0000h) to 108 (0800h; Fig. 6). Intra-hourly trends were similar during both years (Fig. 6). Hourly median data indicated that California sea lions were hauled out on Platform Heritage more during late morning through afternoon (~0900h – 1500h) compared to other periods of the day (Fig. 6).

Age/sex class comparisons: The monthly mean percentage of individuals identified to an age/sex class was 50.9% (SE = 3.0) during 2013 and 42.8% (SE = 3.9) during 2014.

Juveniles represented more than 50% of classified animals during every month. They represented a greater proportion of individuals during 2014 [range: 0.60 (December) to 0.94 (June); Fig. 7] compared to 2013. During 2013, proportion of juveniles ranged from 0.58 (October) to 0.85 (May; Fig. 7).

Adult females were the second-most classified sea lions. They had higher monthly proportions during 2013 compared to 2014 (GLM, $p < 0.05$). During 2013, adult females represented between 13.5% (May) to 37.5% (October) of animals identified during each month (Fig. 7). During 2014, the monthly proportion of adult females ranged from 0.05 (May, June) to 0.30 (December; Fig. 7).

Proportions of mature males were similar in 2013 and 2014 (Fig. 7). During 2013, their monthly proportions ranged from 0.01 (January) to 0.12 (December; Fig. 7). Mature males comprised between 1.1% (June) to 9.5% (December) of the classified population during 2014 (Fig. 7).

Pups represented the age/sex class least identified on Platform Heritage. They were seen during two months during 2013 and their monthly proportions ranged from 0.01 – 0.02 in December and April, respectively (Fig. 7). Pups were seen during spring 2014. Their monthly proportions ranged from 0.01 (March, May) to 0.02 (April; Fig. 7).

There did not appear to be any other consistent monthly or annual trends in the proportion of individuals within any age/sex class (Fig. 7).

Platform Harvest

Data were not obtained in January 2013, and September – November 2014 on Platform Harvest due to camera-system operational issues; therefore, complete inter- and intra-annual monthly and hourly comparisons of California sea lion numbers on this platform were not possible. However, using data that were collected and analyzed indicated that there were slightly more California sea lions using Platform Harvest during 2014 compared to 2013 (Fig. 5).

Monthly comparisons: During 2013, monthly median counts ranged from 19 (June and November) to 42 (October). Monthly maximum counts ranged from 37 (April) to 78 (October; Fig. 5). During 2014, monthly median numbers ranged from 22 (December) to 54 (June); and monthly maximum counts ranged from 50 (February) to 107 (June; Fig. 5). Intra-monthly median count trends were not consistent between years (Fig. 5). Monthly median counts fluctuated during 2013, whereas in 2014 they steadily increased during January through June followed by a steady decrease until August (Fig. 5).

Hourly comparisons: During 2013, hourly median counts ranged from 7 (0300h) to 42 (1400h); and hourly maximum estimates ranged from 11 (0200h) to 78 (1600h; Fig. 6). During 2014, hourly median numbers ranged from 18 (0400h) to 67 (1000h). Hourly maximum counts ranged from 47 (0400h) to 107 (1200h and 1600h; Fig. 6). Intra-hourly comparisons from both years indicated that sea lions were most often present on Platform Harvest during late morning through the afternoon (~1000h – 1400h) compared to other hours of the day (Fig. 6). Hourly platform-use patterns were similar during both years (Fig. 6).

Age/sex class comparisons: The monthly mean percentage of individuals identified to an age/sex class was 73.3% (SE = 1.1) during 2013 and 82.8% (SE = 2.3) during 2014.

Similar to other platforms, juveniles comprised the majority of individuals classified during each month on Platform Harvest (Fig. 7). Their monthly proportions ranged from 0.55 (November) to 0.80 (May, July) during 2013 (Fig. 7). During 2014, their monthly proportions ranged from 0.53 (February) to 0.90 (June; Fig. 7).

Adult females had the second highest proportions of classified animals, however they were outnumbered by mature males during a few months of the study period (i.e. April 2013, May 2014, and January 2015; Fig. 7). During 2013, adult female monthly proportions ranged from 0.05 (May) to 0.25 (February, November, and December; Fig. 7). Their monthly proportions ranged from 0.08 (May, June) to 0.30 (January, February) during 2014 (Fig. 7).

Mature males had higher monthly proportions during 2013 [range: 0.06 (July) to 0.23 (April); Fig. 7] compared to 2014 [range: 0.03 (June) to 0.18 (December); Fig. 7].

Fewer pups were seen on Platform Harvest compared to other age/sex classes. Additionally, they were only seen during three months in both 2013 and 2014 (Fig. 7). When present, their monthly proportions ranged from 0.01 (May) to 0.03 (April) during 2013; and 0.01 (March) to 0.04 (April) during 2014 (Fig. 7).

Using data that were available indicated that there were inter-annual and intra-monthly trends of proportions of juveniles and mature males. The proportion of juveniles increased during summer and decreased during winter. The opposite trend was apparent for mature males (Fig. 7).

Inter-platform (spatial) comparisons

Monthly comparisons

There were monthly data that were not analyzed because of issues with the camera systems. The months of camera system inoperability were not identical for all platforms. Comparisons here were made using data that were available.

There were no consistent spatial (south-to-north) trends in the number of California sea lions using the offshore platforms by month (Fig. 5). However, the number of sea lions increased during October 2013, which was consistent across platforms. During the first five months of 2013, Platforms Habitat and Heritage had the highest median number of animals. Median numbers decreased for Platform Heritage after May, increased until September and subsequently decreased the remainder of 2013, whereas numbers of animals increased at Platform Habitat until August, after which they declined (Fig. 5). Median counts on Platform Elly (southernmost platform) increased during the summer 2013 and remained one of the most used platforms the rest of the year. Median counts at

Platform Gina were the lowest throughout 2013 with the exception of November (Fig. 5). Platform Harvest was the second least used platform during 2013 (Fig. 5).

In 2014, more animals were counted at Platform Habitat during each month except March when no counts were available and June (Fig. 5). Platform Gina remained the least used platform with the exception of July and August during which time counts were similar to those at other platforms. Median numbers of sea lions at Platform Harvest were slightly higher than at Platform Heritage, with the exception of January, December, and January 2015 (Fig. 5). Patterns of median numbers at Platform Elly were similar to those at Platform Harvest (Fig. 5). After pooling all monthly data, the order of mean medians (from lowest to highest) was Platform Gina, Platform Harvest, Platform Heritage, Platform Elly, and Platform Habitat.

Contrary to monthly data analyzed separately for each year, averaged monthly data from all years (e.g. mean $January_{2013\text{-}2015}$, $February_{2013\text{-}2014}$, etc.) indicated that there was a general increase in California sea lion numbers at Platforms Elly, Gina, and Habitat from January to at least May, and a corresponding decrease in numbers at Platforms Heritage and Habitat. There was another increase in numbers of individuals at Platforms Gina, Habitat, and Heritage in August and September, corresponding with no change at the other platforms. However, from examining the count data by individual dates, it did not appear that individuals from one of the selected platforms moved to another of the selected ones because of a disturbance (including change in accessibility). However, animals could have moved to any one of the adjacent facilities during such events.

Hourly comparisons

As with monthly comparisons, there were no distinct, consistent spatial (south-to-north) patterns of time of day when California sea lions hauled out on the platforms (Fig. 6). During 2013, the general trend for Platforms Elly, Heritage, and Harvest was a gradual increase in numbers from morning to midday, followed by a gradual decrease from midday to night (Fig. 6). The exact opposite trend was exhibited at Platform Habitat. Median numbers at Platform Gina gradually decreased until midday, but then remained relatively the same during the remaining hours of the day (Fig. 6). Median count trends were more variable during 2014 across platforms. Numbers increased after 2200h, which also happened during 2013, with the exception of Platform Elly (Fig. 6).

Age/sex class comparisons

In general, Platforms Elly and Gina had a higher proportion of juveniles than Platforms Heritage and Harvest. Platform Heritage had a higher proportion of adult females compared to the other platforms, and Platform Harvest had a higher proportion of adult males (Fig. 7). Proportion of juveniles tended to increase during late spring/early summer on Platforms Heritage and Harvest (Fig. 7). Only four pups were counted during just one month (February 2013) on Platform Elly, whereas more pups were counted on the other platforms (esp. Platform Gina) during multiple months (Fig. 7).

Using all age/sex class data pooled together, there were some noticeable spatial south-to-north patterns with age/sex classes. There tended to be a decrease in the number of immature animals (pups and juveniles) starting from the southern-most platform (Platform Elly) northward to Platform Harvest. Contrarily, the northern platforms

(Platforms Heritage and Harvest) had more adult females than those more southerly (i.e. Platforms Gina and Elly).

DISCUSSION

Platforms & camera systems

The five platforms selected for this study met the selection criteria of being used by pinnipeds (California sea lions, in particular) and were located in areas that encompassed the distribution range of the 23 oil and gas platforms administered by BOEM in the Southern California Planning Area. Some of the other offshore facilities had physical barriers up that limited access to pinnipeds. Although other platforms were viable options to conduct this study at, we were limited in the number of camera systems that could be installed. We decided to allocate enough camera-systems on each selected platform as to best cover areas where animals potentially could be located rather than just cover some areas on more platforms. Additionally, rather than change platforms during the different years of the study (environmental conditions were not the same during both years, which is addressed later under the "*Intra-platform (temporal) comparison*" section), we decided to retain the same sites so that temporal comparisons in pinniped-use of the platforms could be examined in addition to the spatial comparisons. Although the chosen platforms were selected as focal sites to represent other adjacent platforms, it might not be possible to extrapolate our findings to those other sites because of differences in structure, exposure, or activities on each facility.

Prior to the onset of this project, there were concerns that the time-lapse camera systems might not be useful because they might have been affected by the salt spray common on the lower levels of the platforms where the animals hauled out. Failure to obtain satisfactory images could have occurred due to salt spray covering the lens or penetrating the electrical control panel of the camera system. Although there is experience with remote digital camera systems in marine mammal research, what has been done was based on terrestrial applications at sites near the sea (e.g. Burkanov and Altukhov 2014, 2015) but not on artificial platforms poised just above the sea surface. Despite the conditions that the camera systems experienced, for the most part the salt spray did not adversely affect the cameras' ability to obtain quality images. This is not to say that some of the images were not compromised, but the vast majority were usable.

There were other issues with the camera systems on the platforms at different times throughout the study period. On several occasions, we noticed that batteries apparently shifted from their proper positions within the battery bank. The probable cause of battery displacement was from vibrations on the rails on which the camera systems were mounted that were caused by platform activities. Batteries were strapped and taped into their proper position, but upon examination during the subsequent maintenance trip, a battery occasionally was not in proper alignment. It is not clear if this was a cause of camera-system failure. A couple of the camera systems were malfunctioning and were subsequently replaced and sent back to the manufacturer. Regardless of the reason why a camera system was not operating properly, we could not detect the problem until the following maintenance trip. This resulted in an inability to capture photos for a period of time. We chose to only include times when all camera systems were functional to assure that data were comparable throughout the study.

Despite our best efforts, not all areas where animals potentially could haul out on the platforms were covered by the camera systems. Additionally, some of the camera systems were partially obstructed, placed in locations where it was difficult to ascertain the age/sex class of the animals, or were altered by activities conducted on the platforms.

Data Analysis Issues

Except for the first two months, the time-lapse camera systems were programmed to take a photo every 30 minutes and over 400,000 photos were produced. Three people analyzed the photos. Without additional help it would have taken a couple of years to analyze all of the images. Because of time constraints and lack of additional analyzers, it was not possible to examine every image to count and identify the animals. The subsampling protocol encompassed all time periods of the day and month so that a reasonable amount of information could be examined to address the objectives of this study. All of the images are retained in a database and in a public repository [NOAA National Centers for Environmental Information (https://nodc.noaa.gov); Package Reference ID R1B85T] so that data are available for additional analysis, as needed.

Because of issues with the time-lapse camera systems, and understanding that only animals actually on the platforms were counted, it is important to recognize that the counts represent a minimum estimate of animals using these offshore facilities. There may have been animals that were present but not seen in areas not covered by the camera systems. Individuals jugging (i.e. resting) or swimming underneath or around the platform may have used the platform prior to or after the photo was acquired. However, this was not known with certainty and we defined "use" as physically being on the platform. There were other factors that impeded pinnipeds from hauling out on the platforms at different times of the study, including: tidal height, physical barriers, and platform activities. Additionally, animals were disturbed at times and actively encouraged into the water during the arrival/departure of the crew boats (Table 3). The end result was that there were fewer animals on the platforms during those periods. However, some of the animals may have been in nearby waters waiting to get back onto the platforms when it was possible to do so. It should be noted that hourly and monthly numbers of animals do not necessarily reflect different individuals. Many of the same individuals could have been photographed in multiple images.

Identifying individuals to a particular age/sex class was often challenging. Difficulties included (but not limited to): only seeing part of an animal, inadequate light during the night to see clearly, blurry image, animal(s) at a distance, animals congregated too tightly to discern each individual, and morphology of animal not distinct enough to assign classification. Because of distinct morphological characteristics, the easiest animals to be assigned a particular age/sex class were pups and adult males. However, it should be noted that because of the smaller size of some yearlings (here, categorized with older juveniles) during the past few years, it was challenging to differentiate some juveniles from pups. Often it was difficult to distinguish large juveniles, adult females, and subadult males, so they were labeled "unknown". Analyzers did their best to identify individuals and be consistent with their identifications; however, the age/sex class information provided here is incomplete and undoubtedly is not consistent with the actual use by individuals within specific age/sex categories. It should not be assumed that the proportions of classified individuals are reflective of those unidentified.

Table 3. Crew boat departure to (Platforms Elly, Gina, and Habitat) or arrival at (Platform Heritage) platform times. Actual arrival times to platforms were dependent on weather and sea-state conditions, and activities of the crew but usually within 1.5 hours. Crew exchanges on Platform Harvest were primarily done by helicopter.

Platform	Mon	Tue	Wed	Thr	Fri	Sat	Sun
Elly	0500h	0500h	0500h	0500h	0500h	0500h	0500h
(Depart to)	0700h	0700h	0700h	0700h	0700h	0700h	0700h
	1000h	1000h	1000h	1000h	1000h	1000h	1000h
	1600h	1600h	1600h	1600h	1600h	1600h	1600h
Gina	0645h	0645h	0645h	0530h	0645h	1400h	1400h
(Depart to)	1400h	1000h	1400h	1400h	1000h		
		1400h	1730h	1730h	1400h		
Habitat	0630h	0630h	0630h	0630h	0630h	0630h	0630h
(Depart to)	0830h	0830h	0830h	0830h	0830h	0830h	0830h
	1430h	1430h	1430h	1430h	1430h	1430h	1430h
	1830h	1830h	1830h	1830h	1830h	1830h	1830h
Heritage	0900h	0900h	0900h	0715h	0900h	0900h	0900h
(Arrive)	1830h	1200h	1200h	0900h	1830h	1830h	1830h
		1830h	1830h	1200h			
		2300h		1830h			
Harvest	Helicopter						

Pinniped presence

California sea lions were the dominant pinniped species on the platforms. This was expected because the California sea lion is the most abundant pinniped within the California Current ecosystem and their use of manmade structures is well documented. California sea lions primarily breed in the United States at several of the California Channel Islands, including Santa Barbara (33.48°N, 119.04°W), San Clemente (32.90°N, 118.50°W), San Miguel (34.03°N, 120.38°W), and San Nicolas (33.25°N, 119.50°W) Islands, which are all relatively near the oil and gas platforms.

Steller sea lions were seen at two of the platforms (i.e. Platforms Elly and Habitat) during winter months. This species also is present in the California Current ecosystem, although not as abundant as California sea lions. In U.S. waters, they are distributed from Alaska to central California. They used to breed as far south as the California Channel Islands, however no pups have been seen there in decades (although mature males have been sighted at San Miguel Island). There are a few Steller sea lion rookeries in California including Año Nuevo Island (37.11°N, 122.34°W), the Farallon Islands (37.72°N, 123.03°W), and St. George Reef (Southwest Seal Rock; 41.80°N, 124.35°W); however, all are located well north of the study area.

Pacific harbor seals in the eastern Pacific also occur in the California Current ecosystem. They haulout and breed on rocky islets, mud flats, reefs and mainland beaches along the North American coast from San Quintin Bay, Baja California, Mexico to Nome, Alaska (including the Channel Islands; Reeves et al. 1992). They exhibit strong site fidelity, however they are capable of making long-distance movements (Reeves et al. 1992). Harbor seals were seen at the Carpinteria Harbor Seal Preserve and Rookery, Carpinteria, California, which is near several platforms, including Platform Habitat. Although harbor seals were seen in waters near platforms, they were never seen actually on the platforms, which may be due to an inability to get onto the platforms, a propensity to return to a preferred haulout, or other reasons.

Intra-platform (temporal) comparisons

Because California sea lions were the dominant pinniped species using the platforms, we will restrict our discussion to this species. The largest differences in counts among months were observed at Platforms Gina and Habitat. These platforms also exhibited the greatest disparity in counts either among hours throughout the day or between years. Platforms Heritage and Harvest exhibited similar use patterns by hour during both years of the study with animals hauling out more frequently during the day and leaving at night; whereas, Platform Gina exhibited the opposite pattern.

Seasonal variability in numbers of animals using the platforms can be expected due to reproductive, foraging, and physiological characteristics of California sea lions, as well as changes in regional prey availability, oceanic conditions, and sea state. Their breeding season starts in May, when adult males arrive at rookeries to establish and defend territories. Adult females return to rookeries during May and June, and give birth four to five days after coming ashore. Postpartum females remain on land nursing their pups for approximately seven to ten days, and then alternate between foraging trips of one to three days and nursing periods of one to two days (Heath 1989, Antonelis et al. 1990, Ono 1991, Melin 2000). They continue this pattern of feeding and nursing until their pup is weaned (~11 months). Lactating females are central place foragers and are constrained in duration by their pups' fasting limitations to forage near rookeries during the reproductive season (Melin et al. 2000). Although lactating females can go on longer foraging trips because their pups start supplementing their diet by feeding at sea as early as 6 months-of-age (Orr et al. 2012), they, along with other adult females, generally remain near rookeries year-round (Odell 1975, Antonelis et al. 1990, Melin 2000, Kuhn 2006, Kuhn and Costa 2014). Adult females may have been using the offshore platforms as resting sites while traveling to and from foraging areas, some of which were near the platforms. Although the distribution and at-sea behavior of adult females from different rookeries (e.g. San Miguel and San Nicolas Islands) may differ by geographically – individuals from San Nicolas Island forage predominately in the Los Angeles Bight (offshore Los Angeles county; Kuhn, 2006, Kuhn and Costa 2014), and those from San Miguel Island feed in the Santa Barbara Channel, northward in the Santa Maria Basin, and farther north to Monterey Bay (Antonelis et al. 1990, Melin and DeLong 2000; Melin et al. 2008) – these locations are near all of the platform sites. Adult females may not have been as abundant on the platforms as juveniles because of their need to return and nurse their young or because of our inability to classify many of them as "adult females".

Adult and subadult male California sea lions usually depart from the Channel Island rookeries during late July and August and migrate north to northern California, Oregon, Washington, and British Columbia, Canada (Peterson and Bartholomew 1967, Weise 2006, Wright et al. 2010, Gearin unpubl. data). This species reduces intraspecific competition by habitat partitioning and niche divergence. Therefore, mature males would normally only be present in the southern California OCS from April/May (when they are migrating to rookeries) through August (when they are making their return migrations). However, they were seen on the platforms during every month of the study, though in relatively low numbers during the breeding season. This finding was not expected because there are relatively few mature males at the rookery islands during the non-breeding season. Their presence during the breeding season might be attributable to non-territorial bulls using the platforms as resting sites while foraging (either at or away from the platform). Mature males present at the offshore facilities during the non-breeding season may be individuals from the Channel Islands, or they might have been animals migrating from rookeries off west side of Baja California, Mexico. They were not as abundant on the platforms as adult females or juveniles because of their inconsistent attendance in the southern California Bight, or that many of them were at the islands defending territories.

Juvenile California sea lions were the most abundant age/sex class on the platforms. Unlike adult females, they are not necessarily central place foragers. Once weaned, juveniles are not obligated to return to the rookery until they are sexually mature. They only require energy for self-maintenance and growth. Although they need to alter their behaviors in response to prey movements, theoretically they can afford to be more selective in prey choice or follow migrating prey for greater distances than adult females, if needed. However, physiological factors that limit dive duration and traveling distance are positively correlated with body size and age (Feldkamp et al. 1989, Horning and Trillmich 1997, Burns 1999, Baker and Donohue 2000, Fowler et al. 2007a,b). Therefore, the morphological, physiological, and energetic requirement changes that these immature individuals undergo may influence their distribution, at-sea behaviors, and use of the platforms throughout the year. Orr et al. (2012) reported that yearlings and juveniles instrumented with satellite tags at San Miguel Island were primarily distributed in areas around the northern California Channel Islands, and on the continental shelf just north and south of Point Conception, California, which are locations in close proximity to the oil and gas platforms in the Santa Barbara Channel. Seasonal changes in prey availability [e.g. spawning of market squid (*Doryteuthis opalescens*)] also may strongly influence where juveniles fed and rested.

California sea lion pups were seen the least of the age/sex classes. During their first 6-months of life, they are dependent exclusively on their mothers for nutrition (Orr et al. 2012). As pups grow and develop, they begin to attain the necessary morphological and physiological characteristics, as well as the motor skills to swim and transition from dependence to foraging in the marine environment. After approximately 6-months of age, they begin to supplement their milk diet with prey acquired at sea (Orr et al. 2012). This was reflected by the presence of pups at Platform Gina as early as January. Their numbers increased during the spring until June when they were weaned and considered juveniles after their first birthday.

Apart from the natural history aspects of California sea lions, and aforementioned factors (e.g. tidal heights, sea state, disturbance from the arrival/departure of crew boats or crew activities), their numbers may have fluctuated temporally because of environmental conditions. Environmental conditions strongly affect the annual and seasonal variability in prey distribution, availability, and abundance. These attributes of prey may also be influenced by potentially longer- or larger-scale periodic anomalies or perturbations (e.g. “The Blob”, El Niño). “The Blob” was a warm-water mass that started during fall 2013 when the usual winter storms in the Gulf of Alaska did not occur to cool down the North Pacific Ocean. That resulted in an expanse of warmer than usual water that by summer 2014 spanned 3,200 km from Alaska to Baja, Mexico, and stretched 800 km wide (Almasy et al. 2015, Bond et al. 2015, Kintisch 2015). It was observed that many individuals of some species died and others behaved abnormally (Almasy et al. 2015). Even prior to “The Blob” and the current El Niño (2015-2016), the National Marine Fisheries Service declared an Unusual Mortality Event in March 2013, in response to high numbers of stranded California sea lion pups on southern California Beaches (Melin and DeLong 2014). Pups at San Miguel and San Nicolas Islands (the two largest rookeries of California sea lions) exhibited low growth with pups averaging at least 10 kg lower than normal at 7 months of age (Melin and DeLong 2014). One hypothesis for the poor condition of pups was that prey distribution and abundance changed such that it was difficult for their mothers to find enough food for self-maintenance and nutrition for their pups. The stranding of pups on mainland California beaches indicated that the pups weaned early and sought to forage at sea because their mothers were not able to support them nutritionally (Melin and DeLong 2014). Warmer, less productive waters have persisted in the eastern Pacific Ocean during the past few years and the compromised condition of pups (indicated by their lower weights) has reflected that. Therefore, the presence of pups observed on the platforms as early as January might reflect that many these individuals weaned early and foraged at sea because they had to for survival.

Inter-platform (spatial) comparisons

There did not appear to be a spatial (south-to-north) pattern in the use of the platforms by California sea lions. Rather, size or space on the platform (i.e. the amount of structure that was available and accessible to use), location, and human activities (e.g. maintenance) appeared to be more important factors. Fencing and platform activities severely limited haulout space on all platforms except Platform Habitat at various times during the study, which had a direct effect on the numbers of California sea lions counted. Some of the fencing was a permanent barrier; however, some of it was set up temporarily. Platform Habitat was not necessarily one of the larger facilities, but it had many large pipes and supporting structures that provided areas where sea lions could rest. Sea lions were observed occupying most of the lower-level deck. Platform Gina, on the contrary, was one of the smaller platforms where camera-systems were deployed. Although there were areas where sea lions potentially could have used, they predominantly used the landing decks, stairs, and periphery of the lower-level deck. Overall, the animals used Platform Heritage just slightly more than Platform Harvest. Whereas both platforms are north and relatively close to San Miguel Island, Platform Heritage is south of Point Conception within the southern California Bight, which provides a lee from the prevailing north-west winds. Wind and sea-state conditions are calmer at Platform Heritage compared to Platform Harvest. California sea lions were abundant on Platform Elly as well. It is east of Santa Barbara, San Clemente, and San Nicolas Islands. Individuals from these islands may have been using Platform Elly as a resting or foraging site.

Notables

During travels to/from the platforms, while installing and servicing the camera systems, and from examining the images obtained during the study, we observed California sea lions with characteristics or were engaged in activities that enhanced our understanding about the ecology of these animals or found qualities about the offshore platforms that were deemed noteworthy.

Above the water surface, the offshore platforms provided structure and space for animals like pinnipeds, gulls (*Larus* spp.), brown pelicans (*Pelecanus occidentalis*), and cormorants (*Phalacrocorax* spp.) to rest, and peregrine falcons (*Falco peregrinus*) to nest and hunt. Below the water surface, the gas and oil platforms provided structure and habitat for various invertebrate and fish communities. Consequently, areas beneath and around the platforms were habitats that California sea lions (among other species) could exploit for foraging. Love et al. (2006) noted that the offshore platforms harbor three fish assemblages: (1) ones that inhabit the shell mound area surrounding the base of the platform; (2) those that utilize the areas adjacent to the platform bottom; and (3) ones that occupy the midwater. Rockfishes (*Sebastes* spp.) predominate these assemblages (Love et al. 2006). Rockfishes are known prey of California sea lions (Antonelis et al. 1984, Lowry et al. 1991, Melin et al. 2008, Orr et al. 2011) and were seen being consumed by sea lions during our visits to the platforms (Fig. 8). Spiny dogfish (*Squalus acanthias*) were also seen being eaten by the sea lions during the study (Fig. 8). We observed schools of fish within a kilometer of the platforms being attacked by several predators, including: California sea lions, common dolphins (*Delphinus delphis* or *D. capensis*), minke whales (*Balaenoptera acutorostrata*), gulls, brown pelicans, cormorants, among others (Fig. 8).

Figure 8. California sea lions (*Zalophus californianus*) feeding in waters adjacent to gas and oil platforms; sometimes feeding with other animals including cetaceans and sea birds.

Adult female California sea lions were observed nursing their young (including pups, yearlings, and juveniles; Fig. 9) on the offshore platforms. This is notable because Melin et al. (2000) examined the at-sea distribution and diving behaviors of adult female California sea lions and observed that adult female-pup pair attendance patterns indicated that the pups did not accompany their mothers to sea on foraging trips. Our observations indicated that some pups and older conspecifics follow their mothers from rookeries (e.g. Santa Barbara, San Clemente, San Miguel, and San Nicolas Islands) to foraging areas. Dispersal of mother-pup Steller sea lion pairs from natal rookeries has been documented as well (Calkins and Pitcher 1982, Merrick et al. 1988, Raum-Suryan et al. 2002, 2004). Dead premature pups were also seen on the offshore platforms during the study period. Premature birthing can occur at any place including the water, so we did not believe that the adult females were selecting the platforms to give birth. Rather they delivered the fetus prior to arriving at their rookery.

Figure 9. Adult female California sea lions (*Zalophus californianus*) nursing pup **(left)** and juvenile **(right)** while hauled out on gas and oil platforms during the study period.

California sea lions that were marked (branded and/or flipper-tagged) for demographic studies on San Miguel Island or in the Pacific Northwest conducted by the MML were spotted using the gas and oil platforms or adjacent waters (Fig. 10). Individuals that were rehabilitated, flipper-tagged, and released by one of the rehabilitation centers in central or southern California also were seen using the platforms (Fig. 10). Additionally, pups that were instrumented with satellite instruments by researchers at Hubbs-Sea World Research Institute (San Diego, California) during the 2013 Unusual Mortality Event were observed on the offshore facilities. Further examination of additional images obtained during this study may provide insight about the dispersal and movements of marked California sea lions for these various studies.

(a)

(b)

(c)

Figure 10. Marked (i.e. **(a)** tagged, **(b)** branded, or **(c)** instrumented) California sea lions (*Zalophus californianus*) were seen on and around the gas and oil platforms during the study area. Marked individuals included those that were: (a) were rehabilitated and tagged at The Marine Mammal Center, Sausalito, CA; and (b) tagged and/or branded by the Marine Mammal Laboratory, Seattle, WA for demographic studies on San Miguel Island, WA or in the Pacific Northwest.

California sea lions (and harbor seals) depredate fish caught by anglers using line or gillnets. The animals may follow fishing vessels and subsequently take the fish that has been caught and being reeled in. While trying to capture the fish, these predators may get hooked with the fishing gear. Gillnets may be difficult for these animals to detect; subsequently, they might swim into or through the nets. Those that are not caught in the nets might still be entangled with pieces of the net around their neck or body (Fig. 11a). As the animal grows, the net can cut into their body and eventually kill the animal. Many sea lions on the platforms had fishing line or remnants of gill nets wrapped around them. Further examination of additional images collected during this study may provide information about the type of gillnets being used and which animals primarily are being entangled.

The main predators of California sea lions include killer whales and sharks. The prevalence of shark predation or attacks by great white (*Carcharodon carcharias*) and mako sharks (*Isurus oxyrinchus*) on California sea lions have appeared to increase during the past several years, perhaps partly due to the recovery of these shark species. We observed several sea lions on the platforms that exhibited evidence of interactions with sharks (i.e. bite or teeth-rake lesions; Fig. 11b). With further examination of the images collected during this study, one may gain insight about which species of shark are attacking sea lions, what part of the body they are striking, and the age/sex class of sea lions they are targeting.

California sea lions generally are skittish around humans. On the spectrum of fight-or-flight responses, they will usually flee from humans until they are far enough away that they feel comfortable, or if they are in the water. This behavior was not observed on the platforms. The sea lions often had to be coaxed to move. Therefore, it should be noted that crew activities may not have necessarily adversely affected the sea lions.

(a

(b

Figure 11. California sea lions (*Zalophus californianus*) hauled out on gas and oil platforms exhibiting signs of encounters with **(a)** fisheries (e.g. monofilament fishing line) and **(b)** sharks (e.g. lesions).

Conclusions

The platforms provide benefits to pinnipeds (esp. California sea lions). Whereas some human activities may be disruptive to resting pinnipeds, the overall benefit of having a structure to rest in areas where pinnipeds feed or along foraging routes likely outweighed any negative impacts of human disturbance. The temporal and spatial variability in number of California sea lions using the platforms was pronounced for some platforms and minimal at others. They were observed on the platforms year-round and during all hours of the day. Most of the identified animals were juveniles; however, proportionally relatively few of the animals were identified to a particular age/sex class in comparison to all counted individuals. Therefore, caution should be taken when using or interpreting findings.

We only analyzed images during periods when all camera systems were operational on a given platform for consistency in interpreting results. Many images remain to be examined and analyzed, which may result in a better resolution of our understanding of usage of the offshore oil and gas platforms by pinnipeds. Analyses of additional images may also be useful for other projects. For example, we now have empirical evidence that some California sea lion pups and juveniles travel with their mothers to areas a good distance away from their rookeries. Marked individuals were found using the platforms. It may be possible to examine their residency times and general movement patterns if they are seen at different platforms or other haulouts where either camera systems or observers are located. From examining images of individuals entangled in fishing gear, it may be possible to get an idea of the quantity of entanglement and information about the fishing gear/fishery for management purposes. Useful information may also be obtained from images with individuals with shark bite lesions, such as age/sex class of sea lion, species of predator, and geographical location information if there is a pattern. During this study, we have obtained information about the use of oil and gas platforms by pinnipeds in support of analyses pursuant to the NEPA and MMPA permitting requirements by owners of the offshore facilities when they are decommissioned. However, we also gained a greater understanding of the ecology of these animals in pursuant to scientific knowledge.

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LITERATURE CITED

Almasy, S., D. Hennen, and J. Gray. 2015. Blob of warm Pacific water threatens ecosystem, may intensify drought. http://www.cnn.com/2015/04/22/us/pacific-ocean-blob/. Accessed 5 April 2016.

Antonelis, G. A., C. H. Fiscus, and R. L. DeLong. 1984. Spring and summer prey of California sea lions, *Zalophus californianus*, at San Miguel Island, California, 1978-79. Fishery Bulletin (Washington D.C.). 82:67-76.

Antonelis, G. A., B. S. Stewart, and W. F. Perryman. 1990. Foraging characteristics of female northern fur seals (*Callorhinus ursinus*) and California sea lions (*Zalophus californianus*). Canadian Journal of Zoology 68:150-158.

Baker, J. D., and M. J. Donohue. 2000. Ontogeny of swimming and diving in northern fur seal (*Callorhinus ursinus*) pups. Canadian Journal of Zoology 78:100-109.

Bond, N. A., M. C. Cronin, H. Freeland, and N. Mantua. 2015. Causes and impacts of the 2014 warm anomaly in the NE Pacific. Geophysical Research Letters 42:3414-3420. http://dx.doi.org/10.1002/2015GL063306.

Burkanov, V., A. Altukhov, and T. S. Gelatt. 2014. Long-term surveillance of SSL rookeries with time-lapse cameras in Russia and Alaska. Presented as poster presentation at Alaska Marine Science Symposium. Anchorage, Alaska. 20-24 January 2014. 251 p.

Burkanov, V., A. Altukhov, and T. S. Gelatt. 2015. Using high-resolution time-laps photo cameras for long-term surveillance of the Steller sea lion rookeries and haulouts. Vth International Wildlife Management Congress. Sapporo, Hokkaido, Japan. 26-30 July 2015. 97 p.

Burns, J. M. 1999. The development of diving behavior in juvenile Weddell seals: pushing physiological limits in order to survive. Canadian Journal of Zoology 77:737-747.

Calkins, D. G., and K. W. Pitcher. 1982. Population assessment, ecology and trophic relationships of Steller sea lions in the Gulf of Alaska. Pages 447-546 *in* Environmental assessment of the Alaska continental shelf. U.S. Department of Commerce and U.S. Department of Interior. Final Reports of Principal Investigators. Volume 19.

Feldkamp, S. D., R. L. DeLong, and G. A. Antonelis. 1989. Diving patterns of California sea lions, *Zalophus californianus*. Canadian Journal of Zoology 67:872-883.

Fowler, S. L., D. P. Costa, J. P. Y. Arnould, N. J. Gales, and J. M. Burns. 2007*a*. Ontogeny of oxygen stores and physiological diving capacity in Australian sea lion. Functional Ecology 21:922-935.

Fowler, S. L., D. P. Costa, and J. P. Y. Arnould. 2007*b*. Ontogeny of movements and foraging ranges in the Australian sea lion. Marine Mammal Science 23:598-614.

Heath, C. B. 1989. The behavioral ecology of the California sea lion, *Zalophus californianus*. Ph.D. dissertation, University of California, Santa Cruz, Santa Cruz, California.

Horning, M., and F. Trillmich. 1997*b*. Development of hemoglobin, hematocrit, and erthyrocyte values in Galapagos fur seals. Marine Mammal Science 13:100-113.

Kintisch, E. 2015. "The Blob" invades Pacific, flummoxing climate experts. Science 348:17-18. http://dx.doi.org/10.1126/science.348.6230.17.

Kuhn, C. E. 2006. Measuring at sea feeding to understand the foraging behavior of pinnipeds. Ph.D. Thesis, University of California, Santa Cruz, Santa Cruz, California, 129 p.

Kuhn, C. E., and D. P. Costa. 2014. Interannual variation in the at-sea behavior of California sea lions (*Zalophus californianus*). Marine Mammal Science. 30:1297-1319. Doi: 10.1111/mms.12110.

Lowry, M. S., B. S. Stewart, C. B. Heath, P. K. Yochem, and J. M. Francis. 1991. Seasonal and annual variability in the diet of California sea lions *Zalophus californianus* at San Nicolas Island, California, 1981-86. Fishery Bulletin (Washington D.C.). 89:331-336.

Love, M. S., D. M. Schroeder, W. Lenarz, A. MacCall, A. S. Bull, and L. Thorsteinson. 2006. Potential use of offshore marine structures in rebuilding an overfished rockfish species, bocaccio (*Sebastes paucispinis*). Fishery Bulletin 104:383-390.

Melin, S. R., and R. L. DeLong. 2000. At-Sea Distribution and diving behaviour of California sea lion females from San Miguel Island, California. pp. 407-412. In: Proceedings of the Fifth California Islands Symposium. Mineral Management Service, OCS Study MS 99-0038 (published on Compact Disc, February 2000) and Brown, D. R., K.L. Mitchel, H. W. Chaney (Eds) Santa Barbara Museum of Natural History, 2002.

Melin, S. R., R. L. DeLong, and D. B. Siniff. 2008. The effects of El Niῆo on the foraging behaviour of lactating California sea lions (*Zalophus californianus californianus*) during the nonbreeding season. Canadian Journal of Zoology. 86:192-206.

Melin, S. R., and R. L. DeLong. 2014. Spring and summer foraging behavior of lactating California sea lions at San Miguel Island, California during the 2013 Unusual Mortality Event. Final Report for the Waitt Foundation. 30 pp.

Merrick, R. L., P. J. Gearin, S. Osmek, and D. E. Withrow. 1988. Field studies of northern sea lions at Ugamak Island, Alaska during the 1985 and 1986 breeding seasons. U.S. Department of Commerce, NOAA Technical Memorandum NMFS F/NWC-143. U.S.

Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center. 60 pp.

Odell, D. K. 1975. Abundance of California sea lions on San Nicolas Island, California. Wildlife Management 39:729-736.

Ono, K. 1991. Introductory remarks and the natural history of the California sea lion. pp. 109-112. *In* Pinnipeds and El Niño: responses to environmental stress. Trillmich, F., and K. Ono (Eds.). Springer-Verlag, New York.

Orr, A. J., G. R. VanBlaricom, R. L. DeLong, V. H. Cruz-Escalona, and S. D. Newsome. 2011. Intraspecific comparison of diet of California sea lions (*Zalophus californianus*) assessed using fecal and stable isotope analyses. Canadian Journal of Zoology. 89:109-122.

Orr, A. J. S. D. Newsome, J. L. Laake, G. R. VanBlaricom, and R. L. DeLong. 2012. Ontogenetic dietary information of the California sea lion (*Zalophus californianus*) assessed using stable isotope analysis. Marine Mammal Science. 28:714-732.

Peterson, R. S., and G. A. Bartholomew. 1967. The natural history and behavior of the California sea lion. American Society of Mammalogists, Stillwater, Oklahoma.

R Core Team. 2015. R: A language and environment for statistical computing. https://www.R-project.org.

Raum-Suryan, K. L., K. P. Pitcher, D. G. Calkins, J. L. Sease, and T. R. Loughlin. 2002. Dispersal, rookery fidelity, and metapopulation structure of Steller sea lions (*Eumetopias jubatus*) in an increasing and a decreasing population in Alaska. Marine Mammal Science. 18:746-764.

Raum-Suryan, K. L., M. J. Rehberg, G. W. Pendleton, K. W. Pitcher, and T. S. Gelatt. 2004. Development of dispersal, movement patterns, and haul-out use by pup and juvenile Steller sea lions (*Eumetopias jubatus*) in Alaska. Marine Mammal Science. 20:823-850.

Reeves, R. R., B. S. Stewart, and S. Leatherwood. 1992. The Sierra Club handbook of seals and sirenians. Sierra Club Books, San Francisco. 359 p.

Weise, M. J., D. P. Costa, and R. M. Kudela. 2006. Movement and diving behavior of male California sea lion (*Zalophus californianus*) during anomalous oceanographic conditions of 2005 compared to those of 2004. Geophysical Research Letters 33, L22S10, DOI: 10.1029/2006GL027113.

Wright, B. E., M. J. Tennis, and R. F. Brown. 2010. Movements of male California sea lions captured in the Columbia River. Northwest Science. 84:60-72. http://dx.doi.org/10.3955/046.084.0107.

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