ABOUT THESE MAPS

Figures 4.7a, b and c show the density (animals/ km^2) of California sea lions (*Zalophus californianus*) in three ocean seasons – Upwelling, Oceanic, and Davidson Current, displayed in cells of 10' latitude by 10' longitude. Figure 4.7d shows the corrected overall density combining all three seasons. Densities are based on the combined data sets of several studies conducted from 1980-2003; see "Data and Analyses" section of this chapter for more information. The color and mapping intervals were selected to show the most structure and highlight significant areas, while allowing comparisons among species. Cells that were surveyed but in which no California sea lions were observed have a density of zero. Areas not surveyed appear white; no information is available for these areas. Dark blue lines indicate the boundaries of the National Marine Sanctuaries in the study area: Cordell Bank, Gulf of the Farallones and Monterey Bay. Bathymetric contours for the 200 meter and 2,000 meter isobaths are shown in blue.

See also the additional map and description for haulouts and rookeries of the California sea lion.

DATA SOURCES AND METHODS

Densities for marine mammals at sea in this assessment are based on the CDAS central California data set, (1980-2003), developed using software called Marine Mammal and Seabird Computer Data Analysis System (CDAS), by the R.G. Ford Consulting Co. This data set contains data from eight survey programs (five aerial surveys, three ship surveys) conducted between 1980 and 2003; the data extends from Pt. Arena to Pt. Sal in the study area. See the Data and Analyses section of this chapter for information on the at-sea survey data sets and methods used to estimate density.

RESULTS AND DISCUSSION

The California sea lion (*Zalophus californianus californianus*) is subdivided into three subspecies: *Z. c. californianus* (occurs from southwestern Canada to southern Mexico); *Z. c. wollebaeki* (occurs on the Galapagos Islands); and *Z. c. japonicus* (found in Japan but now thought to be extinct) (Carretta *et al.,* 2004; Carretta *et al.,* 2006). The breeding areas of the California subspecies are primarily in three locations: on islands along the coasts of southern California, western Baja California, and the Gulf of California. These geographic regions are used to separate *Z. c. californianus* into three stocks: 1) the United States stock (from Canada south to the U.S./ Mexico border); 2) the Western Baja California stock (from the southern tip of the Baja California peninsula northward to the U.S./Mexico border; and 3) the Gulf of California stock (includes the Gulf of California from the southern tip of the Baja California peninsula and across to the mainland, extending to southern Mexico (Carretta *et al.,* 2006).

The breeding time period and rookery occupancy is mid-May to late July (Reidman, 1990); most births occur from mid-May to mid-June, with peaks in mid-June (Reidman, 1990). Lactation can last from six months to a year. In central California, a small number of pups are born on Año Nuevo Island, Southeast Farallon Island and occasionally at a few other locations (see additional haulout/rookery map for California sea lion); otherwise the central California population is composed of non-breeders. Adult females and immatures remain near the rookeries year-round, whereas adult males (along with most immatures) migrate northward to feeding areas ranging from central California to British Columbia.

Because all age and sex classes are never ashore at the same time, censuses are conducted by counting pups after all pups are born (July). In 2001, the minimum population size of the U.S. stock was estimated to be 138,881 (Carretta *et al.,* 2006).

Periods of unusually warm ocean waters associated with El Niño oceanographic conditions affect the number of California sea lions and pup production; off central and northern California the warm-water events have been associated with increases in the numbers of individuals at sea, as well as pup production. Conversely, during non-El Niño periods (e.g., La Niña), the number of individuals at sea and pups born have decreased in the study area (Lowry and Forney, 2005). Impacts of El Niño can also affect

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numbers of adult females available in the population to produce pups; this can subsequently affect future recruitment in the adult population. The frequency, length, timing and severity of future El Niño events will have significant effects on the sea lion population growth rate (Carretta *et al.,* 2006)

These at-sea data were not analyzed for effects of cold/warm water events on differences in abundance, therefore, no interpretation can be made relative to these events. However, although not apparent in the maps, distinct differences in at-sea abundance and distribution of California sea lions does occur off central/northern California during warm (El Niño) and cold water (La Niña) periods (Lowry and Forney, 2005). El Niño events have been known to alter at-sea distribution patterns and may result in greater numbers of sea lions off central California (Bonnell and Ford, 1987; Trillmich and Ono, 1991; Allen, 1994; Keiper, 2001; Keiper *et al.,* 2005; Lowry and Forney, 2005). During highly anomalous warm-water conditions in early 2005, male California sea lions altered their foraging effort by spending more time at sea and ventured up to 450 km off shore (Weise *et al.,* 2006).

In the study area, the California sea lion was the most abundant of the pinnipeds observed in the CDAS central California data set: 1,906 sightings and 5,509 individuals, with maximum group size sighted of 250. The species was widely distributed throughout the shelf and upper slope regions of the three national marine sanctuaries, and in the study area species forage mostly within 20 nmi of shore (Lowry and Forney, 2005). In general, the seasonal abundance of California sea lions off central California is linked to spring and fall pre- and post-breeding migrations, with greater numbers of sea lions present during the Oceanic season, just after breeding (August - November). The at-sea distribution map during the Oceanic season (post-breeding migration) reflects this pattern: greatest densities (0.58 animals/km^2) occurred in the Oceanic Season, whereas densities were somewhat less in the Upwelling Season (0.20 animals/km^2) and Davidson Current Season (0.26 animals/km^2). The temporal pattern observed in the mapping results may be due to migrating subadult and adult male sea lions on their way to (fall) and from (spring) British Columbia, Washington, and Oregon (Mate, 1975; Bigg, 1988 in: Lowry and Forney, 2005). Overall (all seasons and years combined), the density of California sea lions was relatively greater south of Monterey Bay, off Carmel. During the Oceanic Season, relatively greater densities occurred within the northeastern region of Monterey Bay and off Carmel, and during the Davidson Current Season, greatest densities occurred south of Pt. Año Nuevo, off Santa Cruz. The within-season spatial patterns observed in the maps likely reflect prey availability.

Since 1998, harmful algal blooms (HABs) have impacted the health of California sea lions. HABs associated with the diatom *Pseudonitzschia australis* (having domoic acid, a naturally-occurring neurotoxin) has been responsible for the deaths of sea lions in southern California (Scholin, 2000; Silvagni *et al.,* 2005; Gulland *et al.,* 2002) and reproductive failure (Brodie *et al.,* 2006). In 2006 there was a collaborative project to study the long-term effects of domoic acid exposure in California sea lions being conducted by, among others, The Marine Mammal Center (TMMC), California Department of Health Services, University of California, Santa Cruz. At TMMC, research is being conducted to study the sublethal and long term effects of domoic acid toxicity on health, survival, and reproduction in California sea lions. Results of this study suggest previous sub-lethal exposure to domoic acid can cause epilepsy and reproductive failure in California sea lions. Domoic acid can cross the placenta, and may expose the fetus to sublethal doses while the female is alive (Goldstein, pers. comm., June 2007).

Live strandings of California sea lions have been monitored and studied for over a decade (Greig *et al.,* 2005) and have provided a unique method of detecting diseases that may reflect environmental changes such as ocean pollution, prey shifts, and changes in ocean climate. Greig *et al.,* (2005) found malnutrition to be the most common reason for stranding (32%), followed by leptospirosis (27%), trauma (18%), domoic acid intoxication (9%) and cancer (3%).

Human-related sources of mortality include entanglement in set and drift gillnet fisheries, with an average annual mortality estimate of 1,476 California sea lions (Carretta *et al.,* 2006). Mortality also occurs in salmon troll fisheries, non-salmon troll fisheries, California herring purse seine fishery, California anchovy, mackerel, and tuna purse seine fishery, salmon net pen fishery, groundfish trawl fishery, and commercial passenger fishing vessel fishery (Carretta *et al.,* 2006; Perez, pers. comm.; Olesiuk, pers. comm.). Other sources of human-related mortality include illegal shooting, entanglements in gillnet fishing gear observed at rookeries and haulouts, hook and line entanglements, boat collisions, and entrainment in power plants. The serious injury and total fishery mortality rate for the California sea lion stock is more than 10% of the calculated potential for biological removal (PBR) and cannot be considered to be insignificant (Carretta *et al.,* 2006). The PBR is the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. However, the population, as of 15 December 2003, is increasing at a rate of 5.4% to 6.1% per year (Carretta *et al.,* 2006).

California sea lions feed on a diversity of seasonally abundant fish (e.g., Pacific hake, northern anchovy, Pacific sardine, Pacific whiting, Pacific mackerel, herring, rockfish, salmon and steelhead) and invertebrates (e.g., market squid and octopus) (Weise, 2000; Reidman, 1990; Lowry and Forney, 2005).