

(*Pelecanus occidentalis*) fueron más abundantes en mayo; la Pardela Gris, la Pardela Cola-corta, Gaviotas Occidentales, Pelícanos Pardo, y Gaviotas Ploma (*Larus heermanni*) fueron más abundantes en septiembre. Comparada a las densidades históricas de aves marítimas colectadas hace dos décadas (1975–1978 y 1980–1983), la abundancia fue más baja en un 14% en enero, 57% en mayo, y 42% en septiembre. El Arao Común (*Uria aalge*,  $\geq 75\%$  en cada estación), Pardelas Gris (55% en mayo, 27% en septiembre), y La Gaviota de Bonaparte (*L. philadelphia*,  $\geq 95\%$  en cada estación) tuvieron densidades más bajas. En cambio, los Pelícanos Pardo (167% total), el Mergulo de Xantos (*Synthliboramphus hypoleucus*; 125% total), la Arcuela Oscura (100% total), el Paiño Cenizo (*Oceanodroma homochroa*, 450% total) y las Gaviotas Occidentales (55% en mayo), y el Cormorán de Brandt (*Phalacrocorax penicillatus*, 450% en septiembre) tuvieron densidades mayores. Nuestros resultados indican que la abundancia de aves marinas ha declinado fuera de la costa de California Sur en las últimas dos décadas, y dichas declinaciones quizás sean signos de alerta de degradación ambiental en la región o efectos de fuerzas mayores, tales como el cambio climático.

Ocean waters off southern California, and the Southern California Bight (SCB) in particular, comprise important habitat for numerous seabird species (Hunt et al. 1980, Briggs et al. 1987; Veit et al. 1996, 1997; Pierson et al. 2000; K. Briggs, unpubl. data; H. Carter, unpubl. data). More than 20 species of seabirds breed in southern California, almost entirely on the California Channel Islands (hereafter Channel Islands), including four threatened or endangered seabird species (USDI Fish and Wildlife Service 2002). The SCB is the only region in the U.S. supporting breeding Brown Pelicans (*Pelecanus occidentalis*), Black Storm-Petrels (*Oceanodroma melania*), Elegant Terns (*Thalasseus elegans*), and Xantus's Murrelets (*Synthliboramphus hypoleucus*; H. Carter, unpubl. data; Burness et al. 1999). The region also contains about half of the world population of Xantus's Murrelets and Ashy Storm-Petrels (*Oceanodroma homochroa*; Carter et al., in press; Karnovsky et al., in press; H. Carter, unpubl. data; E. Burkett, unpubl. data). In addition, numerous seabirds migrate through or winter in southern California (Briggs et al. 1987, Mason, unpubl. data).

The SCB is bordered by major metropolitan areas (Los Angeles, Santa Barbara, and San Diego). Approximately \$9,000,000,000 are contributed annually to local economies via offshore oil production, oil transportation by tankers, commercial shipping, commercial fishing, military activities (weapons testing and exercises), and public recreation (Anderson et al. 1993, Carter et al. 2000, Carter et al. 2003, McCrary et al. 2003, USDI Fish and Wildlife Service 2005). From 1970–2000, human populations increased by 64% with concomitant increases in coastal development, sewage discharge, recreational use, and commercial activities (U.S. Census Bureau 2003). More than 16,000,000 people currently live in counties rimming the SCB (U.S. Census Bureau 2003). As a consequence, great concern exists regarding potential effects of human activities on seabird and marine mammal populations, and federal

and state agencies have established the Channel Islands National Park, Channel Islands National Marine Sanctuary, and several smaller marine reserves to protect wildlife in this region.

In the past 20 yr, southern California also has undergone changes in physical and biological oceanography. An increase in sea-surface temperature (SST) coincident with the Pacific Decadal Oscillation (PDO) began in 1977 and extended to 1999. This period was characterized by reduced phytoplankton and zooplankton abundances and altered prey-fish distributions (Mantua et al. 1997, Minobe 1997, Peterson and Schwing 2003). The period from 1999–2002 was characterized by La Niña conditions very different from the preceding years with record-high upwelling values (1999), high primary productivity, and high seabird productivity (Peterson and Schwing 2003). Several studies in the 1980s and 1990s reported declines in abundance or changes in community composition of plankton and seabirds in the California Current System (CCS; Veit et al. 1996, 1997; McGowan et al. 1998, Oedekoven et al. 2001, Hyrenbach and Veit 2003). The CCS extends 1,000 km from southern British Columbia, Canada, to northwestern Baja California, Mexico, and consists of a southward surface current, a poleward undercurrent, and several surface countercurrents. A temperature increase of 0.8 C in the upper 500 m of the CCS occurred between 1950 and 1992, with most of the increase occurring since 1975 (Roemmich 1992). Reproductive success of seabirds generally declined as ocean temperatures increased off central California (Ainley and Boekelheide 1990; Ainley et al. 1994, 1996; Sydeman 2001).

In contrast, the effects of DDE (dichlorodiphenyldichloroethylene) contamination have abated in the SCB, leading to increased reproductive success of several seabird species including Brown Pelicans and cormorants (*Phalacrocorax* spp.; F. Gress, unpubl. data), although other species (e.g., storm-petrels) may still be affected (Carter et al., in press). Based on seabird surveys conducted in 1991, H. Carter

(unpubl. data) reported increased populations of several species, including Brown Pelicans, cormorants, and Western Gulls (*Larus occidentalis*), but decreased populations of Cassin's Auklets (*Ptychoramphus aleuticus*) and Xantus's Murrelets compared with surveys conducted in the 1970s.

Collectively, these changes in oceanography and human activities prompted a need for updated information regarding at-sea populations of seabirds in southern California using techniques that would allow comparison with previous seabird surveys conducted by Briggs et al. (1987). In 1975–1978 and 1980–1983 (hereafter 1975–1983), Briggs et al. (1987) conducted the first replicated, quantitative assessment of the distribution, abundance, and diversity of seabirds off California using aerial-survey techniques. Surveys in the SCB were conducted from 1975–1978 and off central and northern California from 1980–1983. More than two decades later (1999–2002), we used similar aerial-survey techniques to provide updated information and examine trends in the at-sea

distribution and abundance of seabirds in southern California.

#### STUDY AREA

The study area encompassed continental-shelf and slope waters from 35° 35' N (off the city of Cambria, San Luis Obispo County, California) south to 32° 32' N (the Mexican border), and from the mainland shoreline west to 122° W at the northern boundary, and to 119° 30' W at the southern boundary (Fig. 1). In this area, most of the coastline and seafloor are oriented north to south. Like most parts of the California coast, the continental shelf gradually slopes westward before dropping precipitously to depths >3,000 m. At Point Conception, the coastline and bottom topography abruptly turn eastward to southeastward and transition to a southward orientation between Los Angeles and San Diego.

For this study, we considered that the SCB extended from Point Conception to just south of the Mexican border. Off Point Conception and



FIGURE 1. Map of central and southern California showing locations of county boundaries, major cities, coastal points, and islands.