

AT-SEA DISTRIBUTION AND ABUNDANCE OF SEABIRDS OFF SOUTHERN CALIFORNIA: A 20-YEAR COMPARISON

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Abstract. We conducted aerial at-sea and coastal surveys to examine the distribution and abundance of seabirds off southern California, from Cambria, California, to the Mexican border. From May 1999–January 2002, we flew 102 d, covered >54,640 km of transect lines, and conducted nine complete surveys of southern California in January, May, and September. We identified 54 species comprising 12 families and counted >135,000 individuals. Seabird densities were greater along island and mainland coastlines than at sea and were usually greatest in January surveys. Densities were greatest at sea near the northern Channel Islands in January and north of Point Conception in May, and lowest in the southwestern portion of the Southern California Bight in all survey months. On coastal transects, seabird densities were greatest along central and southern portions of the mainland coastline from Point Arguello to Mexico. We estimated that $981,000 \pm 144,000$ ($\bar{x} \pm SE$) seabirds occurred in the study area in January, $862,000 \pm 95,000$ in May, and $762,000 \pm 72,000$ in September. California Gulls (*Larus californicus*), Western Grebes (*Aechmophorus occidentalis*), and Cassin's Auklets (*Ptychoramphus aleuticus*) were most abundant in January surveys at sea, whereas Sooty and Short-tailed shearwaters (*Puffinus griseus* and *P. tenuirostris*), phalaropes (*Phalaropus* spp.), and Western Gulls (*Larus occidentalis*) were most abundant in May and September surveys. On coastal transects, California Gulls, Western Grebes, Western Gulls, and Surf Scoters (*Melanitta perspicillata*) were most abundant in January; Western Grebes, Western Gulls, Surf Scoters, and Brown Pelicans (*Pelecanus occidentalis*) were most abundant in May; and Sooty Shearwaters, Short-tailed Shearwaters, Western Gulls, Western Grebes, Brown Pelicans, and Heermann's Gulls (*Larus heermanni*) were most abundant in September. Compared to historical seabird densities collected in the same area two decades ago (1975–1978 and 1980–1983), abundance was lower by 14% in January, 57% in May, and 42% in September. Common Murres (*Uria aalge*, $\geq 75\%$ in each season), Sooty Shearwaters (55% in May, 27% in September), and Bonaparte's Gulls (*L. philadelphia*, $\geq 95\%$ in each season) had lower densities. Conversely, Brown Pelicans (167% overall), Xantus's Murrelets (*Synthliboramphus hypoleucus*; 125% overall), Cassin's Auklets (100% overall), Ashy Storm-Petrels (*Oceanodroma homochroa*, 450% overall) and Western Gulls (55% in May), and Brandt's Cormorants (*Phalacrocorax penicillatus*, 450% in September) had greater densities. Our results indicate that seabird abundance has declined off the southern California coast in the past two decades, and these declines may be warning signs of environmental degradation in the region or effects of larger forces such as climate change.

Key Words: abundance, aerial surveys, density, distribution, seabirds, Southern California Bight.

DISTRIBUCIÓN Y ABUNDANCIA DE AVES MARINAS FUERA DEL MAR DE CALIFORNIA SUR: UNA COMPARACIÓN DE 20 AÑOS

Resumen. Condujimos muestreos aéreos en el mar y en la costa, con el fin de examinar la distribución y abundancia de aves marinas fuera del mar del sur de California, desde Cambria, California, hasta la frontera Mexicana. De mayo de 1999 a enero del 2002, volamos 102 d, cubriendo >54,640 km de líneas de transecto, y condujimos nueve muestreos completos del sur de California en enero, mayo, y septiembre. Identificamos 54 especies que comprenden 12 familias y contamos >135,000 individuos. Las densidades de aves marinas fueron mayores a lo largo de las líneas costeras de islas y del continente a aquellas del mar, y generalmente fueron mayores en los muestreos de enero. Las densidades fueron más grandes en el mar cerca del norte de las Islas Canal en enero y en el norte de Punto de Concepción en mayo, y las más bajas en la porción suroeste de Ensenada California Sur en todos los meses del muestreo. En los transectos de costa, las densidades de aves marinas fueron las más grandes a lo largo de las porciones central y sureña de la costa continental desde Punto Arguello hasta México. Estimamos que $981,000 \pm 144,000$ ($\bar{x} \pm SE$) aves marinas aparecieron en el área de estudio en enero, $862,000 \pm 95,000$ en mayo, y $762,000 \pm 172,000$ en septiembre. Las Gaviotas de California (*Larus californicus*), el Achichincle Pico-amarillo (*Aechmophorus occidentalis*), y la Alcueta Oscura (*Ptychoramphus aleuticus*) fueron más abundantes en los muestreos de enero en el mar, mientras que la Pardela Gris y la Pardela Colacorta (*Puffinus griseus* and *P. tenuirostris*), el falaropus (*Phalaropus* spp.), y la Gaviota Occidental (*Larus occidentalis*) fueron más abundantes en los muestreos de mayo y septiembre. En los transectos de costa, las Gaviotas de California, Achichincles Pico-amarillo, Gaviotas Occidentales, y la Negreta Nuca-blanca (*Melanitta perspicillata*) fueron más abundantes en enero; Achichincles Pico-amarillo, Gaviotas Occidentales, Negretas Cola-blanca, y Pelícanos Pardo

(*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