VARIATIONS IN MARINE BIRD COMMUNITIES OF THE CALIFORNIA CURRENT, 1986–1994

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ABSTRACT

Concurrent sampling (1986–94) off central and southern California revealed strongly concordant fluctuations in abundance of several of the California Current's most numerous seabirds. Pronounced anomalies of abundance occurred in 1986, 1988–89, and 1992–93. In 1986 and 1992–93, sea-surface temperatures were high; cold-water species were scarce; and warm-water species were abundant. In 1988–89 the reverse patterns held. These patterns exemplify bird populations' short-term response to large-scale change in oceanic conditions, particularly sea-surface temperature. In addition to these short-term responses, our surveys revealed long-term (7–8 year) declines of cold-water species and similarly long-term increases of warm-water species. The temporal contrast of these changes underlines the ecological importance of continuous, long-term records of animal abundance.

INTRODUCTION

Long-term data sets of variability in physical factors and of biological responses at the base of the food web are relatively common in marine systems (e.g., Peterson 1989). But long time series from upper trophic levels are rare. This is because of (1) the difficulty and expense in accumulating records, and (2) the effect of market conditions on the apparent prevalence of exploited resources. California Cooperative Oceanic Fisheries Investigations (CalCOFI) has done a remarkable job in maintaining a unique record of lower-ecosystem responses to marine climate variability (e.g., Brinton 1981; Chelton et al. 1982); recently, studies of upper trophic level organisms have been added to the program.

We report on variation in the abundance of upper trophic level predators (birds) as determined on CalCOFI cruises from 1987 to 1994, and compare that variation to patterns observed farther north, from 1986 to 1994. These are the longest such quantitative data sets on annual variation in at-sea marine bird abundance anywhere in the world. This long effort is born of necessity: given the extreme annual variation in marine climate found in eastern boundary currents, sampling for 5–10 years is the minimum required to characterize the variability inherent in the system and its avifauna. Previously, seasonal occurrence patterns of marine birds off California were reported by Ainley (1976) and Briggs et al. (1987). The former report also presented an analysis of interannual variability (1955–73) exceptional for its broad spatial and temporal coverage, and based on data collected in a semiquantitative fashion.

METHODS

We compared data sets gathered independently in the southern and central portions of the California Current (figure 1). Those from the southern area were collected in April and July 1987–94; those from the central area were collected in June 1986–94. The same vessel usually surveyed in both areas, and many of the same people conducted the work. Cruises covered waters from the coast to well beyond the continental shelf in the

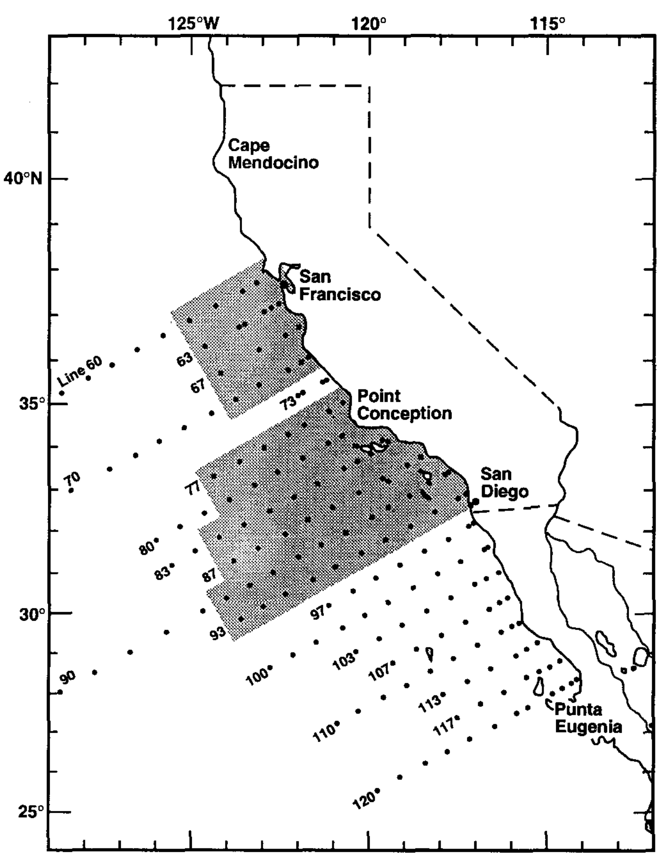

Figure 1. The CalCOFI study area, shaded to indicate the regions in which seabird studies were conducted.

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southern region, and to the deeper portion of the continental slope (e.g., 2000 m) in the central region.

One observer in the southern region and two in the central region counted birds continuously as they passed within a 300 m wide strip on one forequarter of the ship. Censuses continued whenever the ship was under way during daylight. In the south, birds that were attracted to the ship were counted when first detected but subsequently ignored. In the north, such birds were counted as 0.3 individuals if they approached the ship from the direction toward which censuses were being conducted; thereafter they were ignored like the rest of the ship followers. Censuses in the central region were corrected to account for bird flux, a function of the relative speed and direction of the ship and the birds (Spear et al. 1992). Thus, counts between the two regions are comparable on a relative but not absolute basis. In the central region, we did not include data gathered in waters <200 m deep between Point Reyes and Point San Pedro in an attempt to delete complications to overall patterns due to local birds associated with the huge breeding colonies at the Farallon Islands, midway between these two points.

Observations were converted to densities—i.e., number of birds per km^2 of ocean surveyed (a function of the distance the ship traveled during unit time multiplied by 300 m strip width). We report seasonal variation from the average density calculated for all spring or summer cruises. Differences were compared from year to year relative to average sea-surface temperature. The latter was assessed from data gathered from the ships' thermosalinographs, with a temperature reading made for each 1–3 km census segment along cruise tracks.

RESULTS

We include analyses for the numerically dominant species, and for less numerous species that showed clear-cut differences in annual abundance related to El Niño or to cooler periods. During the period of study, sea-surface temperatures were highest during 1992–93 (Sydeman and Ainley 1994; figure 2). Both that period and 1986 were considered El Niño periods (see other contributions in this volume for details).

In the central region, we separated species depending on whether they did or did not breed locally (figures 3 and 4). The dominant species was the sooty shearwater (see appendix for scientific names), a species that breeds on islands in the South Pacific. Like the black-footed albatross, it was more abundant early in the study period, especially 1988–89, than later (Veit et al., unpubl. data). Among the species that could be categorized as having affinity for cool water (Ainley 1976; Briggs et al. 1987), densities of sooty and pink-footed shearwaters and black-footed albatross were low during 1992–93;

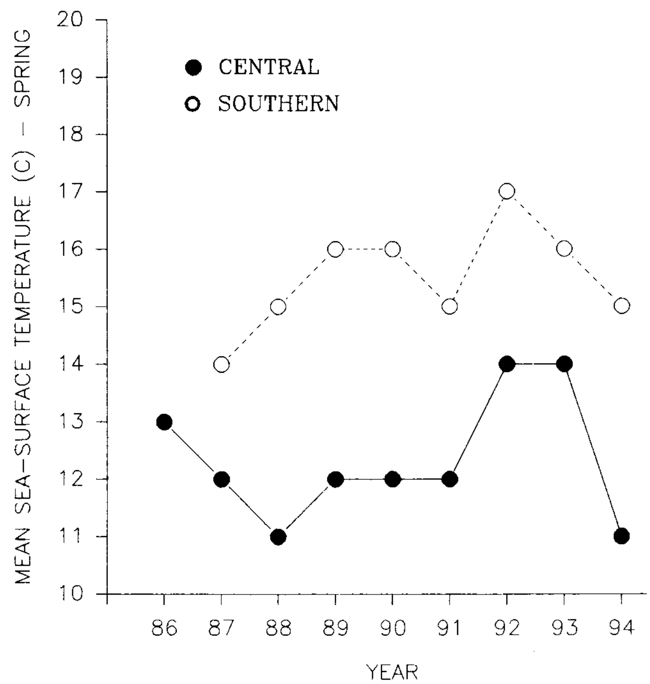

Figure 2. Average sea-surface temperatures (°C) based on measurements made during cruises from 1986 through 1994.

density of shearwaters was also low in 1986. The remaining species not breeding locally in central California (black-vented shearwater, black storm-petrel, brown pelican, Heermann's gull, and Xantus' murrelet) were all more abundant during 1992; black-vented shearwater was also more abundant in 1986 and 1993; and Heermann's gull was also more abundant in 1986. These species breed in areas of warmer water—on islands off Mexico. The occurrence pattern of the brown pelican was least consistent with the other members of this group.

Among six prevalent species that breed and remain in central California for all or most of the year, Leach's storm-petrel, Brandt's cormorant, and common murre were more abundant during 1992–93 (figure 4). Cassin's auklet showed a large increase in 1986 and 1994; the western gull appears to have decreased in the second half of the study period; and the rhinoceros auklet demonstrated no clear pattern (rhinoceros auklets did change spatially, however; Allen 1994).

In the southern region, all species except sooty shearwater and least storm-petrel bred locally (figure 5). The gradually decreasing abundance of sooty shearwater and the gradually increasing abundance of Leach's storm-petrel were consistent with patterns in the central region. Also consistent with the central region were increases in density of black-vented shearwater and black storm-petrel in 1992. The least storm-petrel, a species that rarely occurs as far north as the central California Current region, also demonstrated this pattern. The remaining species showed no pattern that was consistent with the others.

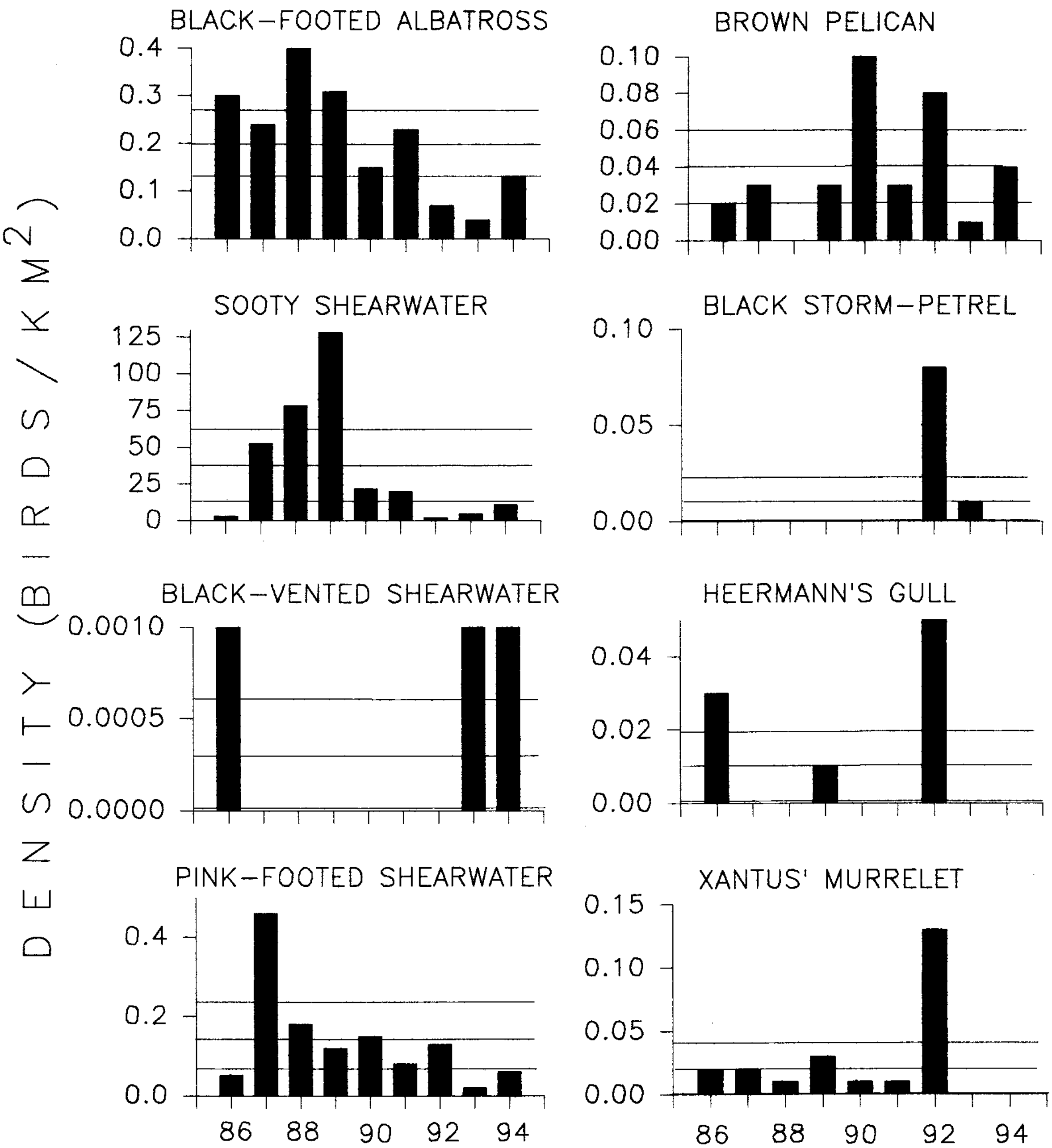

Figure 3. Mean densities (birds/km^2) of nonbreeding seabird species off central California, June 1986–94. *Horizontal lines* indicate the overall mean and plus or minus 95% confidence intervals.

DISCUSSION

When a large number of individuals of a single seabird species appear in a region such as central California, or if a species becomes uncommon for a time, one might consider that (1) reproduction or survivorship was especially good or poor, or (2) ocean conditions had changed to attract one species over another. The latter may be especially important in climatically variable eastern boundary currents such as the California Current (e.g., Glantz and Thompson 1981). Ainley (1976) showed convincingly that annual fluctuation in the prevalence of many seabird species in the nearshore California Current region reflected variation in marine climate, especially sea-surface temperature. Longer-term trends in abundance could be due to changed climate and to a change in food-web structure (e.g., Roemmich and McGowan 1995).

Accordingly, we observed increased numbers of most warm-water species in the southern and central portions of the California Current in 1986 and especially in

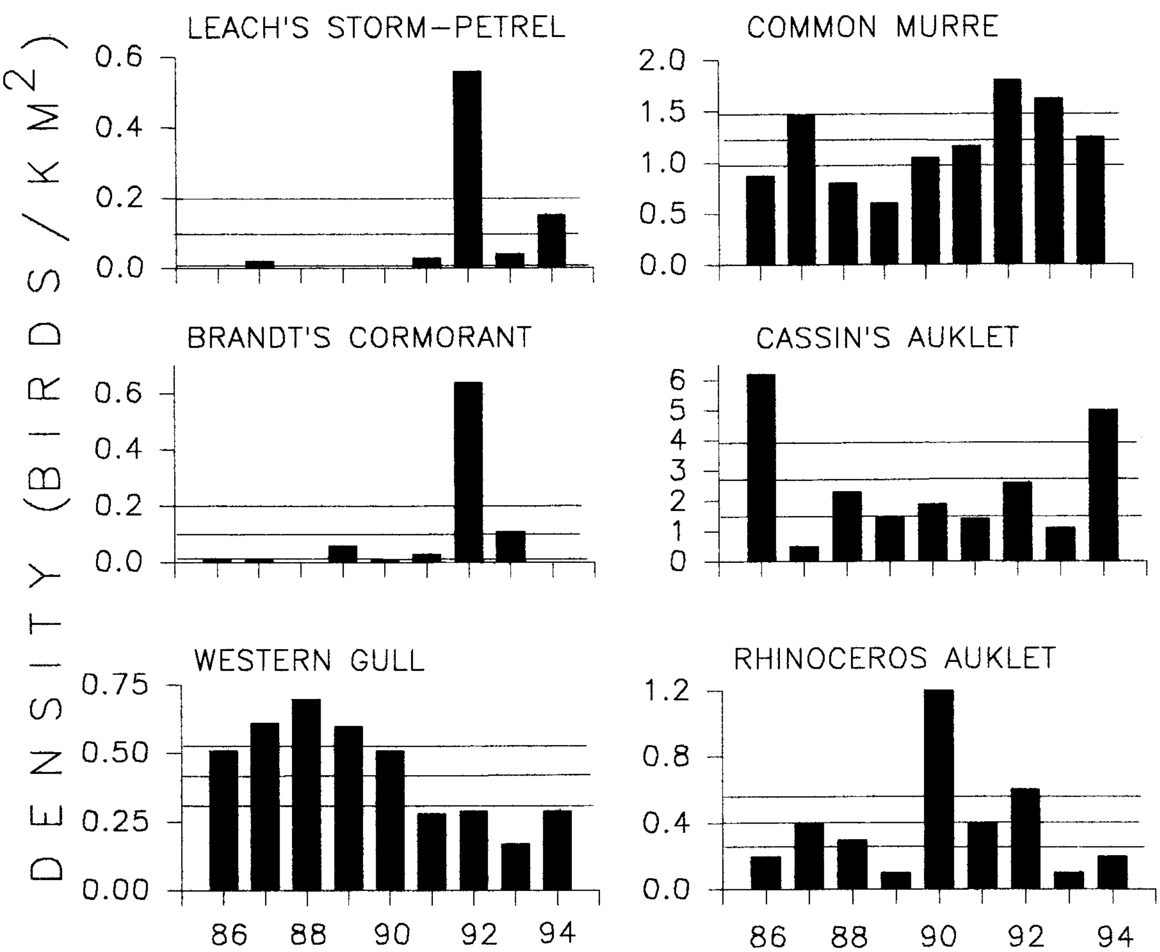

Figure 4. Mean densities (birds/km²) of locally breeding species of seabirds off central California, June 1986–94. *Horizontal lines* indicate the overall mean and plus or minus 95% confidence intervals.

1992–93 (El Niño periods). Abundance of cool-water species decreased during these periods. Although some of the cool-water species were more abundant during the cooler period around 1988, regional and species concordance was less consistent. This may indicate that during this study cool-water periods in the California Current were well within the limits preferred by the region's avifauna. When water temperatures increased, however, the region was invaded by species from the south. In fact, considering also Ainley's 1976 data, the species that best indicated warm-water anomalies were black-vented shearwater, black storm-petrel, and least storm-petrel in a positive fashion (i.e., becoming more prevalent) and sooty shearwater in a negative way (becoming uncommon). Among the three warm-water species, increased abundance of the black-vented shearwater in central California ranks with invasions of the pelagic red crab (*Pleuroncodes planipes*) as a biological indicator of an especially strong California Countercurrent (Davidson Current); countercurrent strength is intensified during El Niño (McLain and Thomas 1983). Under normal conditions, only a few black-vented shearwaters reach central California during the Davidson Current season.

The brown pelican's inconsistent response to El Niño (increase in central California during 1992 but not 1986) was somewhat surprising, because a species often commensal with the brown pelican—Heermann's gull—showed a consistent response. The two species are among those that have large breeding populations in Mexico and that move in large numbers to the California Current during the nonbreeding season. Greatest numbers of pelicans occurred in 1990, not an El Niño year, but one in which their reproductive success was especially good (D. W. Anderson, pers. comm.). Thus the greater abundance that year could have resulted from large numbers of first-year birds that dispersed widely. During warm-water events, pelicans from the southern regions, and sometimes the Southern California Bight, appear in central and northern California much earlier in the year than otherwise (because they usually forego or lessen breeding in those years; D. W. Anderson, pers. comm.).

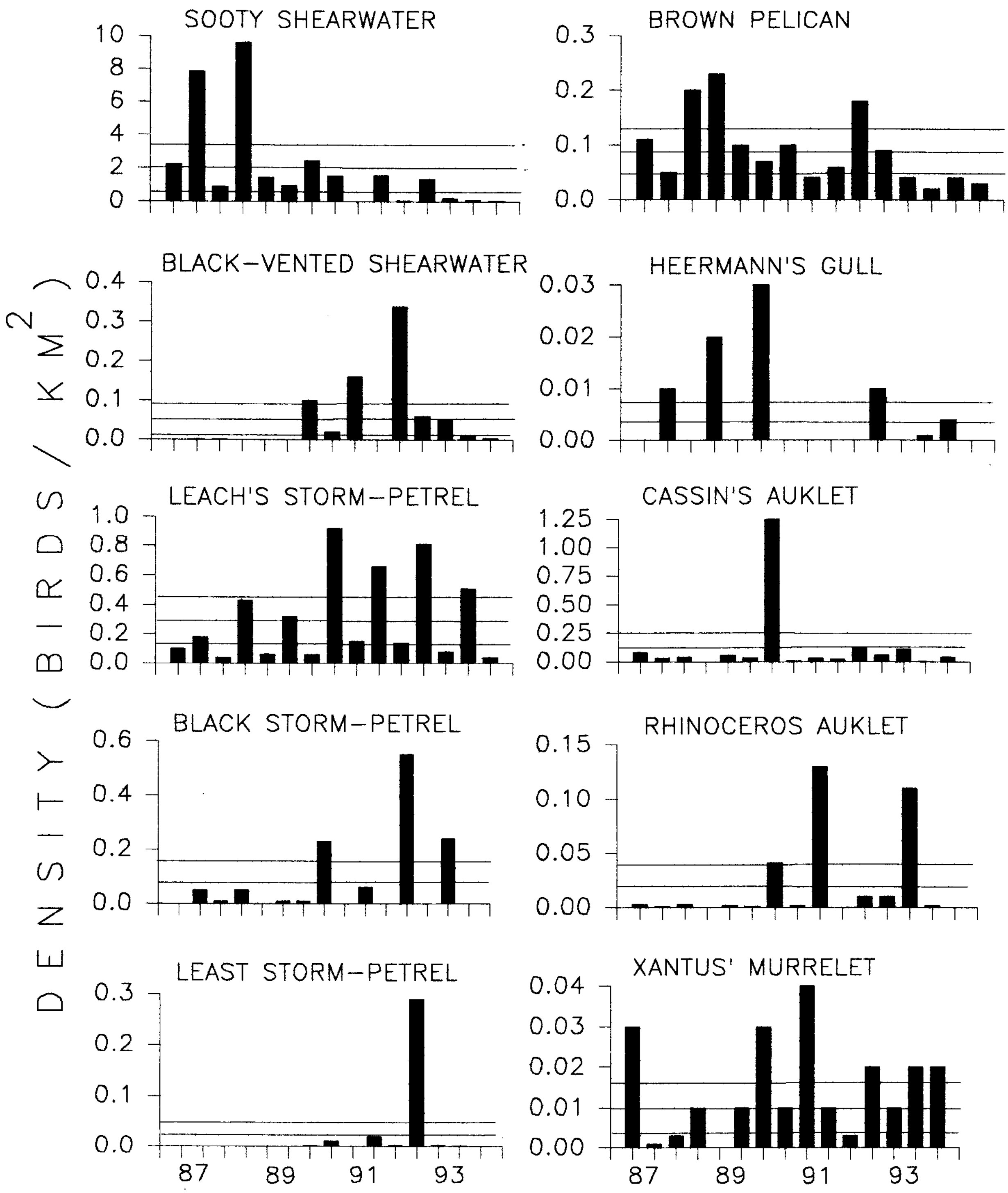

Figure 5. Mean densities (birds/km²) of breeding and nonbreeding species of seabirds off southern California, April and June 1987–94. *Horizontal lines* indicate the overall mean and plus or minus 95% confidence intervals.

Such a within-year response is not evident in our analysis of the data, probably because of our inability to separate individuals from the local and the more distant breeding populations. In addition, Jacques (1995) has shown that pelicans move farther north than usual (to Oregon and Washington) during warm-water years, although not necessarily in larger numbers. Finally, the pelican and Heermann's gull are not as behaviorally linked in California as they are farther south, especially during spring (D. W. Anderson, pers. comm.), which also helps to explain these two southern species' inconsistent response to ocean conditions.

Species that breed locally (e.g., Brandt's cormorant, common murre, and Cassin's auklet) also responded to changed ocean conditions. Unlike the species that are good indicators of warm water, the locally breeding species did not seem to undertake long-distance movements. Rather, the apparent increases in density during El Niño were caused by their dispersing more widely within the region (see Allen 1994), as well as by greater numbers remaining at sea instead of spending considerable time at breeding sites. Indeed, it has become well established that El Niño and other warm-water events discourage breeding among seabirds in the California Current region (Ainley and Boekelheide 1990; Ainley et al. 1995). Conversely, these local species seemed less abundant during cool-water periods because they concentrated close to breeding colonies.

We are aware of no reports of a mass exodus of seabirds from the California Current or mass mortality during El Niño, as has often been observed in the Peru Current (cf. Murphy 1981; Ainley et al. 1986). California species show only slightly elevated mortality (Stenzel et al. 1988). The reason for the difference in the two current systems may stem from the birds' reliance on just one prey species in the Peru Current—the anchoveta (*Engraulis ringens*)—but reliance on a more diverse prey choice in California—e.g., anchovy (*E. mordax*), Pacific mackerel (*Scomber japonicus*), rockfish (*Sebastes* spp.), squid (*Loligo opalescens*), and euphausiids (Ainley and Boekelheide 1990).

ACKNOWLEDGMENTS

We thank the officers and crew of NOAA ship *David Starr Jordan* and the Scripps R/V *New Horizon* for logistical support. CalCOFI and the National Marine Fisheries Service, Tiburon Laboratory, made our participation possible. Our effort in the southern region was supported financially by NSF-OCE; work in the central region was supported by the Environmental Protection Agency, U.S. Fish and Wildlife Service, and the Gulf of the Farallones National Marine Sanctuary. Data analysis was funded, in part, by the state of California, Office of Oil Spill Prevention and Response. We also thank C. Alexander, J. Tweedy, R. Ferris, M. LaBarr, I. Gaffney, and D. Hardesty for help on cruises and G. Ballard for aid in data reduction. D. W. Anderson and A. D. MacCall made many helpful suggestions for improving the manuscript.

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APPENDIX

Common and scientific names of bird species discussed in the text.

Black-footed albatross *Diomedea nigripes*
Sooty shearwater *Puffinus griseus*
Pink-footed shearwater *Puffinus creatopus*
Black-vented shearwater *Puffinus opithomelas*
Black storm-petrel *Oceanodroma melania*
Leach's storm-petrel *Oceanodroma leucorhoa*
Least storm-petrel *Oceanodroma microsoma*
Brown pelican *Pelecanus occidentalis*
Brandt's cormorant *Phalcrocorax penicillatus*
Western gull *Larus occidentalis*
Heerman's gull *Larus heermanni*
Common murre *Uria aalge*
Xantus' murrelet *Synthliboramphus hypoleuca*
Rhinoceros auklet *Cerorhinca monocerata*
Cassin's auklet *Ptychoramphus aleuticus*