SEASONALITY AND ABUNDANCE OF BLUE WHALES OFF SOUTHERN CALIFORNIA

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ABSTRACT

We counted blue whales (*Balaenoptera musculus*) on transect surveys on 33 CalCOFI cruises between May 1987 and October 1995. Abundance of blue whales over this nine-year period was strongly seasonal: the numbers peaked in August–October, and no blue whales were recorded on winter cruises. We detected no increasing trend of abundance over the nine years. This finding contrasts with recent reports of pronounced increases in the size of blue whale aggregations feeding near the Channel Islands and elsewhere off southern California.

INTRODUCTION

Blue whales have a worldwide distribution that is usually divided into three different stocks: one each in the North Pacific and North Atlantic, and a third in the Southern Hemisphere (Leatherwood and Reeves 1983). North Pacific blue whales summer between the Gulf of Alaska and California, and winter in the temperate Pacific, south at least to 20°N. The Alaska and California whales may represent two separate stocks (J. Barlow, pers. comm.). North Atlantic blue whales summer from the Gulf of St. Lawrence to Iceland, and winter mainly in temperate latitudes, perhaps as far south as the tropics. Antarctic blue whales remain south of 40°S during the summer, and move north in winter to Brazil, Ecuador, and South Africa. There is perhaps a fourth population of "pygmy" blue whales, which is thought to be nonmigratory. It inhabits the Subantarctic Zone in the vicinity of Kerguelen, Crozet, and Heard Islands (Ichihara 1961; Ellis 1985). Accurate estimates of these populations have been notoriously difficult to make, but recent estimates of the eastern North Pacific population range as high as 6,000 (Rice 1974).

Blue whales feed on large zooplankton, especially euphausiids and small schooling fishes (Leatherwood and Reeves 1983). Off southern California they probably feed upon swarms of *Euphausia pacifica* or *Thysanoessa spinifera*, and anchovies or sardines.

Barlow (1994) compared whale surveys made off the west coast of the United States in 1979–80 and in 1991, and estimated 704 whales and 1,872 whales, respectively. Calambokidis et al. (1990), using mark-recapture estimates based on photographs, obtained estimates ranging from 1,989 to 2,315 blue whales for the period 1991–93. Barlow (1995) later increased his 1994 estimate for the 1991 cruise to 2,250 blue whales. Thus the blue whale population off the west coast of the United States appears to have increased from fewer than 1,000 in 1980 to over 2,000 in the early 1990s.

Estimates of blue whale populations off California have not included repeated systematic surveys with internally consistent methodology. The CalCOFI cruises provide an ideal opportunity for such a protocol. Veit and colleagues (Ainley et al. 1995; Veit et al. 1996, 1997) have been surveying seabird abundance on CalCOFI cruises since May 1987. All whales sighted during these seabird surveys have been recorded. Although counts of whales on CalCOFI cruises lack the precision required for estimating absolute abundance or population size, the methods were consistent over all 33 cruises, so we felt it would be worthwhile to analyze the counts of blue whales, and to use the counts as an index of relative abundance. As far as we are aware, this paper represents the first attempt to estimate seasonal and interannual variability in whale abundance on the basis of transects conducted from ships.

DATA COLLECTION

Whales were counted during a program designed to measure abundance and distribution of marine birds on CalCOFI cruises (Veit et al. 1996). Bird density is ordinarily low enough in the region sampled by CalCOFI to allow ample time for the person collecting data to scan for whales. Blue whales are especially easy to spot and identify because of their tall spouts, their distinctively tiny dorsal fins, and their habit of resting at the surface in groups. We acknowledge, however, the possibility that some other rorquals may have been misidentified as blue whales.

Because we did not record distance or bearing to each whale sighted, we were unable to convert our counts to estimates of density or population size (Barlow 1994). Nevertheless, our methods were consistent across all 33 cruises, and we feel that our counts faithfully reflect real changes in whale abundance over the nine-year period.

Our basic measurement of abundance was the number of blue whales recorded per nautical mile (nmi) of

[Manuscript received March 16, 1998.]

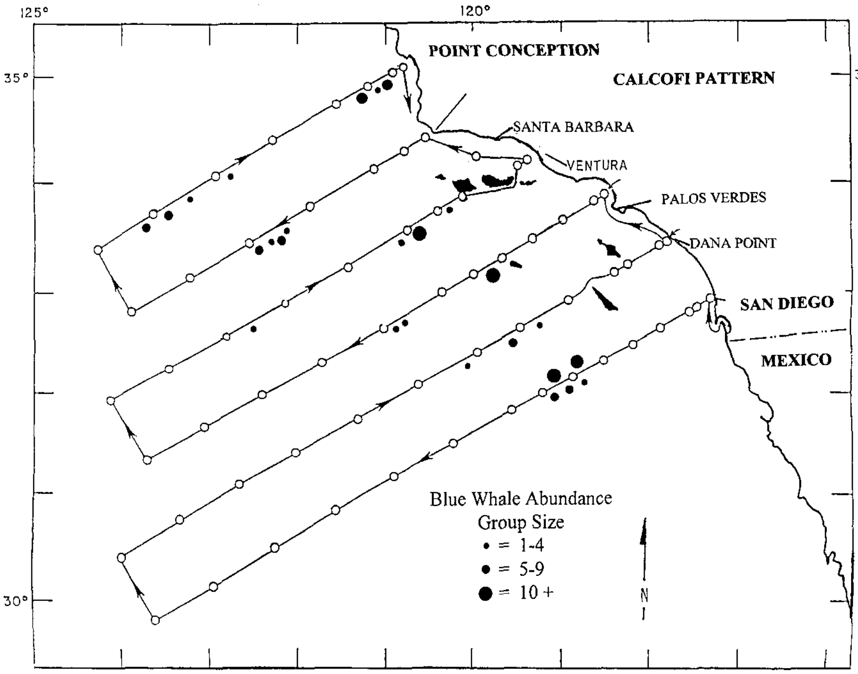

Figure 1. Spatial distribution of blue whales identified on CalCOFI cruises, 1987–95.

transect. An average of 864 nmi (1,600 km) of transect was surveyed during each cruise.

To take into consideration some misidentification of whales, we constructed two different time series. The first series consisted of whales identified as blue whales only, and the second series consisted of all large rorquals—blue, fin, sei, or unidentified whales.

RESULTS

The distribution of the 140 blue whales sighted on 33 CalCOFI cruises between May 1987 and October 1995 is shown in figure 1, and the time series of blue whale abundances and blue whale plus unidentified rorqual abundances are shown in figure 2. Blue whales were distinctly seasonal in their appearance in the region sampled by CalCOFI (fig. 3a). Blue whales were more abundant in the summer and fall over the nine-year period between 1987 and 1995 (one-way ANOVA, $F = 12.5$, df $= 3$, $P < 0.001$). Essentially the same held true for the abundance of large rorquals (fig. 3b).

We used linear regression to search for trends in blue whale abundance over the period 1987–96, and found no significant trend. We calculated the statistical power of this regression model as 0.88, using methods described by Zar (1996; pp. 343, 379; see also Gerodette 1987).

DISCUSSION

Blue whale abundance off the California coast was strongly seasonal between 1987 and 1996, and peaked in July–September. The three largest aggregations that

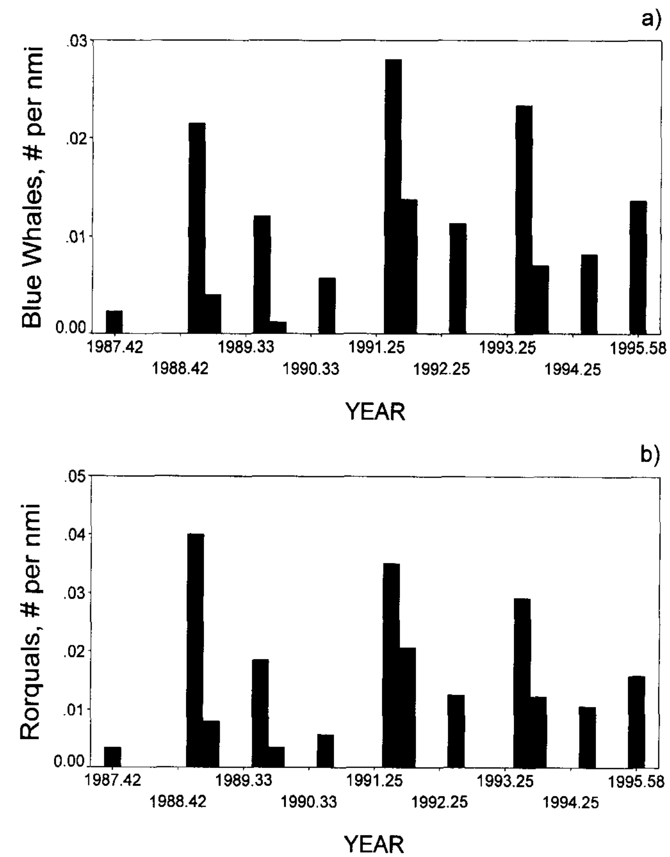

Figure 2. Whales (individuals per nmi) counted on 33 CalCOFI cruises, May 1987–July 1995: *a*, blue whales; *b*, blue whales plus unidentified rorquals. The x-axis is numbered in decimal years.

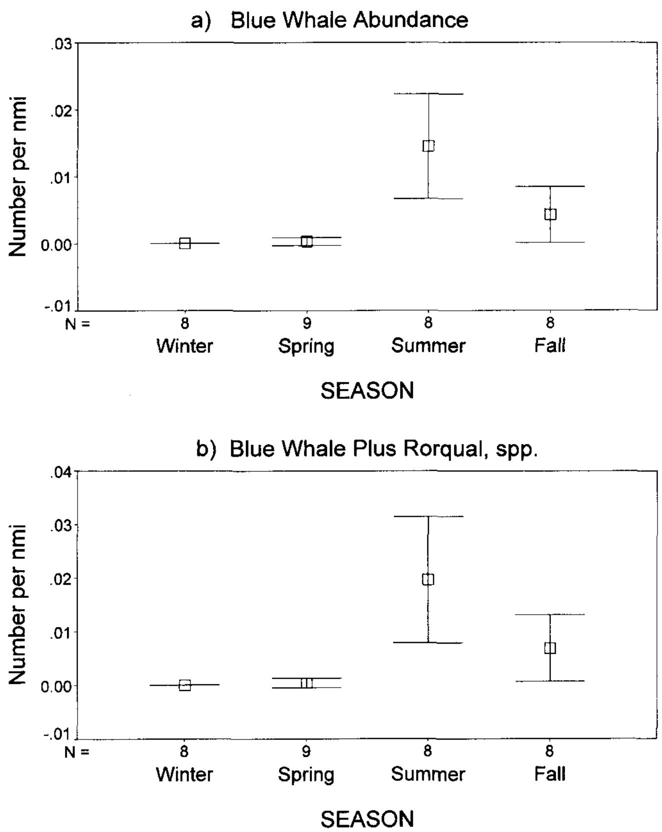

Figure 3. Seasonal distribution of whales sighted on CalCOFI cruises, 1987–95. Winter = December to February; spring = March to June; summer = July to September; fall = September to November. (One-way ANOVA $F = 12.5$, df = 3, $P < 0.001$). *a*, Blue whales; *b*, blue whales plus unidentified rorquals.

we saw were (1) off Avila Beach, 40 nmi north of Point Conception, (2) off San Miguel Island, and (3) in 1995, about 40 nmi southwest of the south end of San Clemente Island.

We did not detect any increasing trend in abundance of blue whales. This finding was surprising, and inconsistent with the findings of Barlow (1994) and Calambokidis et al. (1990) and with numerous recent sightings of especially large aggregations of blue whales feeding near the northern Channel Islands (P. E. Smith, pers. comm.). Our analysis is unique in that we have repeated very nearly the same survey pattern four times a year for nine years. For that reason alone, one would anticipate that we would have noticed an increase in abundance if such an increase had occurred. We freely admit that our techniques lack the precision of Barlow (1994, 1995) or Calambokidis et al. (1990). Nevertheless, our methods were consistent across all 33 cruises.

The CalCOFI pattern may not be ideally suited to surveying blue whales. For example, some of the largest aggregations that we have seen have been close to San Miguel Island, an area barely grazed by the regular transect line. Still, the disparity in results between our CalCOFI counts and the censuses reported by Barlow (1994) and Calambokidis et al. (1990) suggests that we need to determine the appropriate spatial scale for cetacean surveys.

The abundance of marine birds has declined dramatically from 1987 to 1995 (Veit et al. 1996, 1997). Because the most numerous marine birds of the Southern California Bight feed on the same zooplankton and small fish that are probable prey to blue whales, it seems paradoxical that especially large aggregations of blue whales should be more evident now.

There are at least two possible explanations for the disparity among recent estimates of blue whale numbers. First, it is possible that blue whales increased substantially up until about 1990, after which the growth slowed. Such a pattern would account for both Barlow's estimated increase and the apparent lack of increase in the CalCOFI data. Second, it is possible that food has become extremely aggregated in the vicinity of the Channel Islands, thus accounting for the especially large numbers of blue whales recorded there recently.

Detectability of whales varied with weather conditions, especially wind speed. Because the winter and spring CalCOFI cruises tended to be windier than the summer and fall cruises, part of the seasonal pattern we have described may be an artifact of the variability of detection. But the data suggest otherwise. In January 1995, for example, the weather was nearly flat calm for the entire cruise, and no blue whales were seen. Furthermore, we have often spotted blue whales in wind speeds over 30 knots; the whales' tall spouts and habit of resting near the surface make them conspicuous even in rough weather. Therefore, we believe that the patterns we describe are real.

Aircraft surveys conducted concurrently with CalCOFI surveys could help clarify the issue of scale of aggregation of blue whales, as well as how well suited the CalCOFI surveys are to monitoring their abundance.

ACKNOWLEDGMENTS

J. Barlow and an anonymous reviewer provided numerous helpful comments. We gratefully acknowledge C. Alexander, J. Dunn, C. Elphick, the late R. Forster, B. Leventhal, M. Lippsmeyer, K. Molina, R. Morgan, P. Pyle, A. Reitsch, E. Root, R. Russell, D. Sibley, K. Stowe, and O. Williams for their help with collecting data. The officers and crews of the R/V *David Starr Jordan* and the R/V *New Horizon* provided invaluable assistance. G. Hemingway, T. Hayward, and S. Cummings arranged for our participation on CalCOFI cruises.

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