

CONTINUING SEA OTTER POPULATION DECLINES
IN THE ALEUTIAN ARCHIPELAGO

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Recently published data demonstrated a sea otter population collapse across the Aleutian archipelago (Doroff *et al.* 2003). This assessment, undertaken in response to earlier reports of precipitous declines at several islands (Estes *et al.* 1998), was based on archipelago-wide aerial surveys conducted in 1965, 1992, and 2000, and skiff surveys of particular islands or small island groups during various years from the early 1990s through 2000. To summarize the main findings: (1) aerial counts declined by about 70% from 1992 to 2000, (2) populations at those islands thought by Kenyon (1969) to be at or near carrying capacity in 1965 had declined 88% by 2000, (3) most of the overall decline occurred after the late 1980s or early 1990s, and (4) sea otters had reached a uniformly low population density (numbers per unit length of shoreline) throughout the Aleutian archipelago by 2000. Doroff *et al.* (2003) interpreted this latter finding to mean that the factors responsible for the decline were density-dependent, thus implying that a steady state may have been attained between killer whale predation, the purported cause of the decline (Estes *et al.* 1998), and the reduced availability of sea otters. If that conjecture is

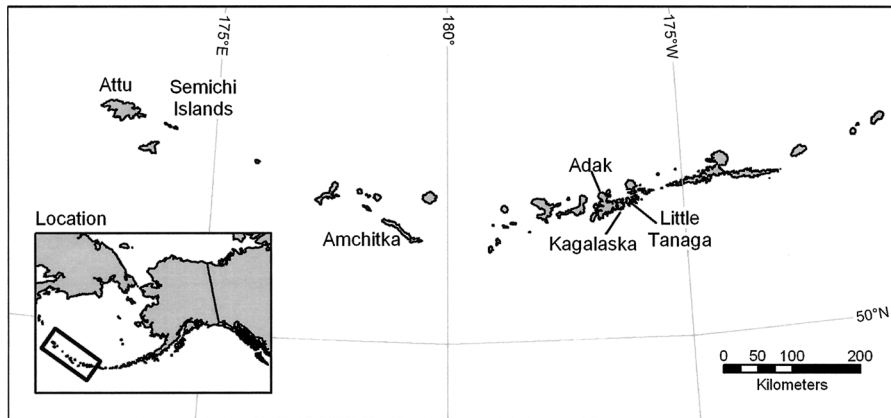


Figure 1. Map of Alaska and the Aleutian archipelago showing locations of the islands surveyed.

correct, then the rate of decline should have lessened or ceased since 2000. Here we evaluate that expectation based on skiff survey results from six islands or island groups that were obtained through summer 2003.

Skiff surveys were conducted according to methods reported by Estes (1990) and Doroff *et al.* (2003). Adak Island (Fig. 1) was surveyed annually. Five other islands or island groups (Amchitka, Attu, Kagalaska, Little Tanaga, and the Semichi islands; Fig. 1) were surveyed in 2000 and 2003 only. Although sea otter densities in 2000 at these six islands (0.62 otters km^{-1} shoreline) exceeded the archipelago-wide average (0.33 otters km^{-1} shoreline), this difference was not statistically significant (separate variance *t*-test, $t_{5,9} = 1.76$, $P = 0.13$). Only part of Amchitka Island (on the Bering Sea side) was surveyed in both 2000 and 2003. All surveys were done during the period from late July through early September.

Sea otter counts have continued to decline since 2000 at all islands surveyed (Table 1). The per-island decrease in number of otters counted over this 3-yr period ranged from 41% to 78%, representing an average drop in numbers of 63% across all six islands. Assuming a simple exponential growth model, this corresponds to an average rate of population decline of $29\% \text{ yr}^{-1}$ (95% CI of $20\% - 38\% \text{ yr}^{-1}$), notably greater than the $17.9\% \text{ yr}^{-1}$ decline rate reported by Doroff *et al.* (2003) for the 1990s. We contrasted the rates of decline for the pre- and post-2000 periods at five of the six Islands (comparable data were not available for Little Tanaga) and found a significant increase in the per-annum rate of decline (2-tailed paired *t*-test, $t_4 = 3.43$, $P = 0.026$).

Sea otter populations at four of the six islands surveyed in 2003 (Adak, Amchitka, Kagalaska, and Little Tanaga) were thought to be at or near carrying capacity in 1965 (Kenyon 1969). Three of these four islands (Amchitka excluded) were surveyed completely in 2003. The magnitude of overall decline at those three islands was determined by adjusting the 1965 aerial counts (data from Kenyon 1969) upward by a factor of 3.58 (in order to account for the estimated differential in number of otters missed between aerial counts and skiff counts; see Doroff *et al.*

Table 1. Sea otter counts from skiff surveys of islands in the western and central Aleutian archipelago during the years 2000 through 2003.

Island name	Year				% Change (2000–2003)
	2000	2001	2002	2003	
Adak	861	632	573	392	–55
Kagalaska	54			15	–72
Little Tanaga	56			19	–66
Attu	606			132	–78
Semichi Islands	76			24	–68
Amchitka ^a	157			93	–41
Total	1,810			675	–63

^a Partial count. Areas surveyed comprised approximately 17% of total available shoreline. The same length of shoreline was counted in 2000 and 2003.

2003 for rationale and details) and then contrasting these adjusted counts with the number of otters counted during the 2003 skiff surveys. This analysis indicates overall population declines ranging from 92% to 99% since 1965.

Declines of sea otter counts at the six islands through 2000 were fairly representative of population change for the entire Aleutian archipelago during this same period (Doroff *et al.* 2003). We bootstrapped the ratio of sea otter counts at these islands in 2000 and 2003 with replacement for 100,000 replicates. The median value of these replicates indicates that the number of otters present in 2003 was only 38% of the 2000 population size (95% bootstrapped CI, 23%–51%). We applied these results to the archipelago-wide 2000 population estimate of 8,742 from Doroff *et al.* (2003) to calculate a comparable estimate for 2003. Assuming no significant difference in the proportion of sea otters missed by observers during the two survey periods and that the areas surveyed were representative of the entire archipelago, this analysis provides a 2003 population estimate of 3,311 sea otters (2,048–4,419 95% CI).¹ This estimate represents an overall population decline of 95.5% and a current sea otter population that is approximately 3% of the estimated carrying capacity for the Aleutian Islands (Burn *et al.* 2003).

Sea otters are now absent or nearly so at some of the smaller islands in the Aleutian archipelago. Many of the remaining populations have become so small that Allee effects (Courchamp *et al.* 1999) may be expected and indeed are a likely explanation for the elevated rates of decline that have occurred since 2000. If the current declining trend continues, sea otters are in danger of disappearing across all or much of the Aleutian archipelago over the next decade. We should point out that sea otter populations in this region previously recovered after having been reduced to extremely low numbers (Kenyon 1969). However, that recovery process took approximately 80 years and occurred in a substantially different environmental setting—one in which human influences were arguably smaller and the co-

¹ These estimates are based on the assumption that no animals are missed in the skiff counts. Some unknown proportion of animals are undoubtedly missed in the skiff counts, and thus the true population sizes are somewhat larger than indicated. However, the bias should have little or no influence on the trend analysis.

occurring marine mammal fauna was more nearly intact. Under present circumstances their recovery is much less certain.

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