STATUS AND TRENDS OF THE CALIFORNIA SEA OTTER POPULATION

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The purpose of this report is to summarize and discuss information on the size, distribution, and productivity of the California sea otter population. This information is broadly relevant to two federally mandated goals: 1) removing the population's listing as "Threatened" under the Endangered Species Act, and 2) obtaining an "Optimal Sustainable Population" under the Marine Mammal Protection Act.

Except for the population in central California, by 1911 sea otters (Enhydra lutris) had been hunted to near extinction between Prince William Sound and Baja California (Kenyon 1969). Wilson et al. (1991), based on variations in cranial morphology, recently assigned subspecific status (Enhydra lutris nereis) to the California sea otter. Furthermore, mitochondrial DNA analysis has revealed genetic differences among populations in California, Alaska, and Asia (National Biological Survey, unpublished data).

In 1977, the California sea otter was listed as threatened under the Endangered Species Act, largely because of its small population size and perceived risks from such factors as human disturbance, competition with fisheries, and pollution. Because of unique threats and growth characteristics, the California population is treated separately from sea otter populations elsewhere in the North Pacific (see accompanying status and trends report).

Survey design

Data on size and distribution of the California sea otter have been gathered for more than 50 years. Surveys conducted prior to 1981 employed differing methods, thus confounding the interpretation of trends. Although most of these early data were obtained from aerial surveys, a variety of flight patterns, counting techniques, and estimation procedures were utilized. In 1982 a survey technique was developed in which most of the California sea otter's range was counted from shore by groups of two observers. Counters scan the ocean's surface through binoculars and spotting scopes, marking on standardized maps the location of each otter observed. Supplemental data for each sighting include group size, activity, number and size of pups, and habitat (i.e., species of associated surface-canopy kelp, or open water). The observer teams sequentially survey contiguous areas within assigned survey zones. Zone boundaries have been determined by natural landmarks, across which the short-term movement of sea otters is thought to be minimal. Areas that cannot be counted from shore are surveyed from a low-flying aircraft. Rangewide surveys are done in late spring and mid-autumn.

Dependent pups are classified as large or small, based on whether or not they have molted their natal pelage. Molting of the natal pelage occurs about 8-12 weeks after birth (Payne and Jameson 1984). We use the sum of the total spring pup count and the subsequent autumn count of small (natal-coated) pups as a minimal estimate of the annual number of births. Rate of annual pup production is defined as the ratio of annual births to independent otters counted during the spring survey.

In 1985 a study was conducted (Estes and Jameson 1988) to estimate the probability of sighting sea otters by shore-based survey teams, and to determine if the value obtained is affected by activity, group size, observer variation, coastal area, date, and/or distance from shore. This was done by having two observer teams simultaneously count the same areas, using methods similar to those employed in rangewide surveys. The teams' maps were compared and each sighting was scored as having been made by both teams or one team only. Using these data, an estimator for the probability of sighting was developed. The overall probability of sighting was 0.95. The estimate was affected by activity and group size, but not by any of the other variables examined.

Sea Otter Population Trends 1914-1993

The California sea otter population has increased steadily through most of the 1900s (Fig. 1). Rate of increase was about 5% per year until the mid-1970s. Only one survey was completed between 1976 and 1982, although the collective data suggest that population growth had ceased by the mid-1970s, and that the population may have declined by as much as 30% between the mid-1970s and early 1980s. Uncorrected counts made since 1983 have increased at about 5-6% per year. In spring 1993, 2,239 California sea otters were counted.

The lineal range (distance along the 5-fm isobath between the northernmost and southernmost sightings) has also increased, although more slowly and erratically than the population size (data summarized by Riedman and Estes 1990). A large interannual variation in range mainly results from the highly variable locations of extralimital individuals, which is to say that the ends of the range have not been defined in a way that is consistently meaningful.

The direction of range expansion was predominately southward prior to 1981, but northward thereafter (Riedman and Estes 1990). An analysis of changes in distribution and population density is possible only for data obtained after 1981. Comparison between spring surveys conducted in 1983 and 1993 (Fig. 2) is sufficient to draw several conclusions. First, the population's range limits changed little during this 10-year period, even though large numbers of individuals accumulated near the range peripheries. Second, population density increased throughout this time, although rates of increase were lowest near the center of the range. Finally, the relative abundance of individuals has remained largely unchanged (compare Fig. 2a (1983) with Fig. 2b (1993) noting the similarity in forms of distributions for kilometer segments 10-21.

Although the number of dependent pups counted in spring surveys almost doubled between 1983 and 1993, the geographic range within which these pups were born has changed very little (Fig. 2). Rate of annual pup production ranged from 0.14 to 0.28, but in most years it varied between 0.18 and 0.21. There are no obvious trends in rate of annual pup production between 1983 and 1993. Although the incremental change in the population from one year to the next appeared to be positively related to the annual number of births (Fig. 3), this relationship cannot be shown to be statistically significant (F test, $P > 0.09$).

Implications of Sea Otter Population Trends

The California sea otter population has been increasing at about 5% per year throughout most of the twentieth century. The only obvious deviation from this pattern occurred from the mid-1970s to the early 1980s, during which period the population ceased growing and probably declined. Entanglement mortality in a coastal set-net fishery was the likely cause of this decline. The decline's beginning coincided with expansion of a set-net fishery in central California in which sea otter losses were estimated at about 100 individuals per year (Wendell et al. 1985). Restrictions were imposed on the fishery in 1982, and the population apparently responded by resuming its prior rate of increase.

The maximum rate of increase (r_{max}) for sea otter populations is about 20% per year. Except for the California otters, all increasing populations for which data are available have grown at about this rate (Estes 1990). Several populations (e.g., Attu Island and southeast Alaska) have sustained these maximum rates of increase and currently have numbers exceeding that of the California population. These patterns, coupled with the absence of any size- or density-related reduction in growth rates, make the relatively slow rate of increase in the California population a perplexing feature.

Although the ultimate reason for these disparate growth rates among sea otter populations is presently unknown, we believe that causes relate more to increased mortality than diminished reproduction. It is difficult to compare population-level reproductive rates between sea otters in Alaska and California because of differing study techniques and varying seasonal patterns of reproduction among these populations. Nonetheless, when comparing California and Alaska populations, longitudinal studies of marked individuals indicate that both age of first reproduction and annual birth rate of adult females are similar between the two groups. Furthermore, the close similarity between r_{max} and observed rates of population increase for sea otters in Washington, Canada, and portions of Alaska suggests that mortality from birth to senescence in these populations is quite low. In contrast, rates of mortality in the California sea otter are comparatively high. An estimated 40-50% of newborns are lost prior to weaning (Siniff and Ralls 1991; Jameson and Johnson 1993; Riedman et al. 1994), and this alone would significantly depress a population's potential rate of increase. Furthermore, the age composition of beach-cast carcasses in California indicates that most postweaning deaths occur well in advance of physiological senescence (Pietz et al. 1988, Bodkin and Jameson 1991). These patterns likely explain the depressed rate of increase in the California sea otter population.

Although the demographic patterns of mortality in California sea otters are becoming clear, the causes of deaths remain uncertain. There is growing evidence for the importance of predation by great white sharks (Carcharodon carcharias) on sea otters in California. The overall age structure of beach-cast carcasses indicates that the probability of mortality of sea otters in California is independent of age. In contrast, natural mortality in Alaskan populations occurs mainly in very young and very old animals. Contaminants may be having a detrimental effect on California sea otters, although as yet there is no direct evidence for this. However, PCB and DDT levels, known to be high in the California Current, are also high in the liver and muscle tissues of California sea otters (C. Bacon, unpublished data). Of particular concern are that: 1) average PCB levels in California sea otters approach PCB levels that cause reproductive failure in mink, which are in the same family as otters, and 2) preweaning pup losses are especially high in primiparous females. This latter point may be significant because environmental contaminants that accumulate in fat can be transferred via milk in at extraordinarily high concentrations, especially to the first-born young in species such as the sea otter with prolonged sexual immaturity. Alternatively, young, inexperienced females simply may be poor mothers, although observed population growth rates near r_{max} for populations elsewhere would seem to exclude this possibility.

Indexing terms: marine mammals, mustelids, population growth, threatened populations, Pacific Ocean, California

Captions for Figures

Fig. 1 Trends in abundance of the California sea otter population from 1914 through 1993.

Fig. 2 Distribution and abundance of California sea otters in 1983 and 1993. Data are from the spring surveys.

Fig. 3 The number of pups born to the California sea otter population in year X versus the incremental change in the number of independent otters counted one year later.

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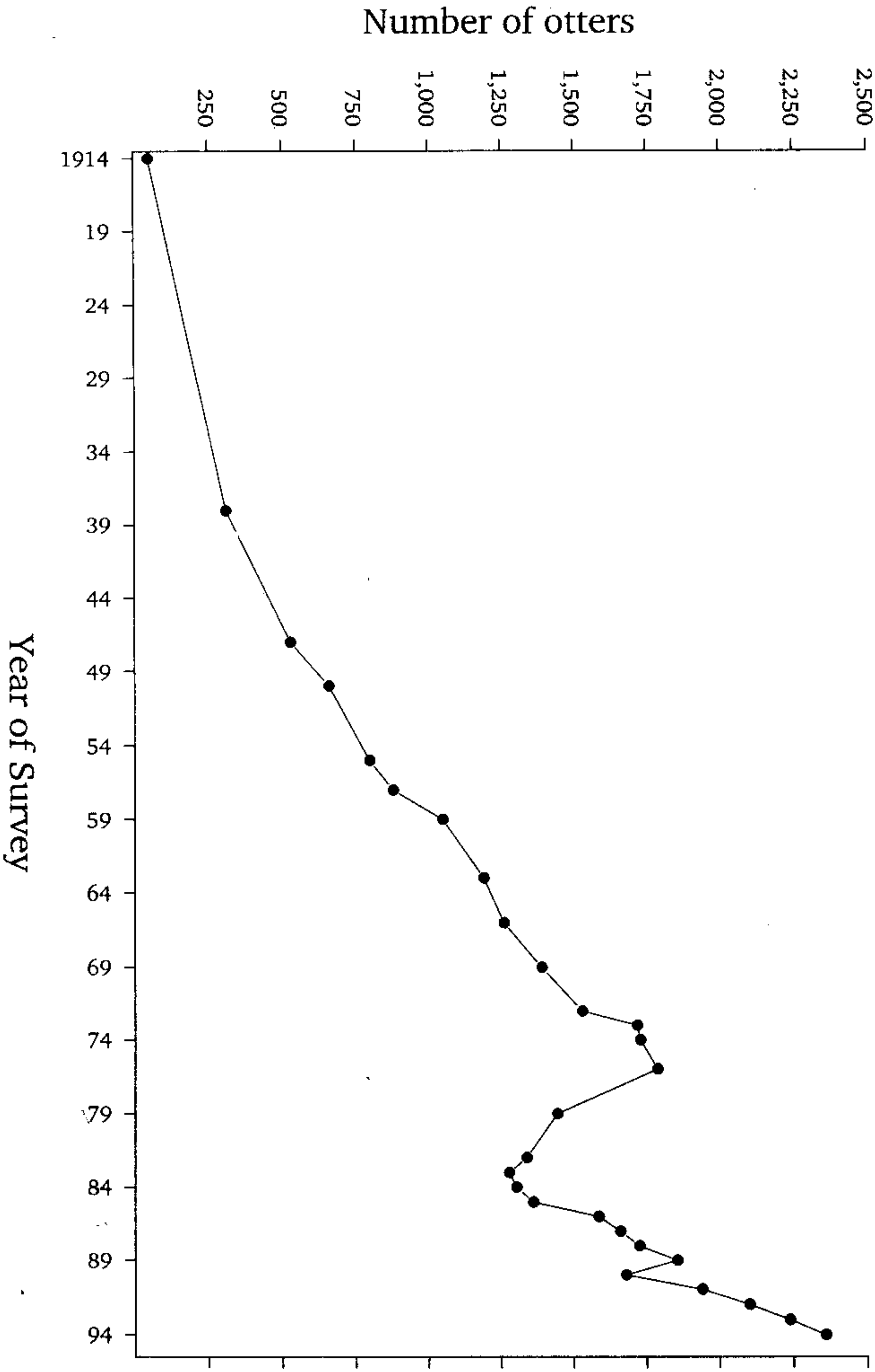
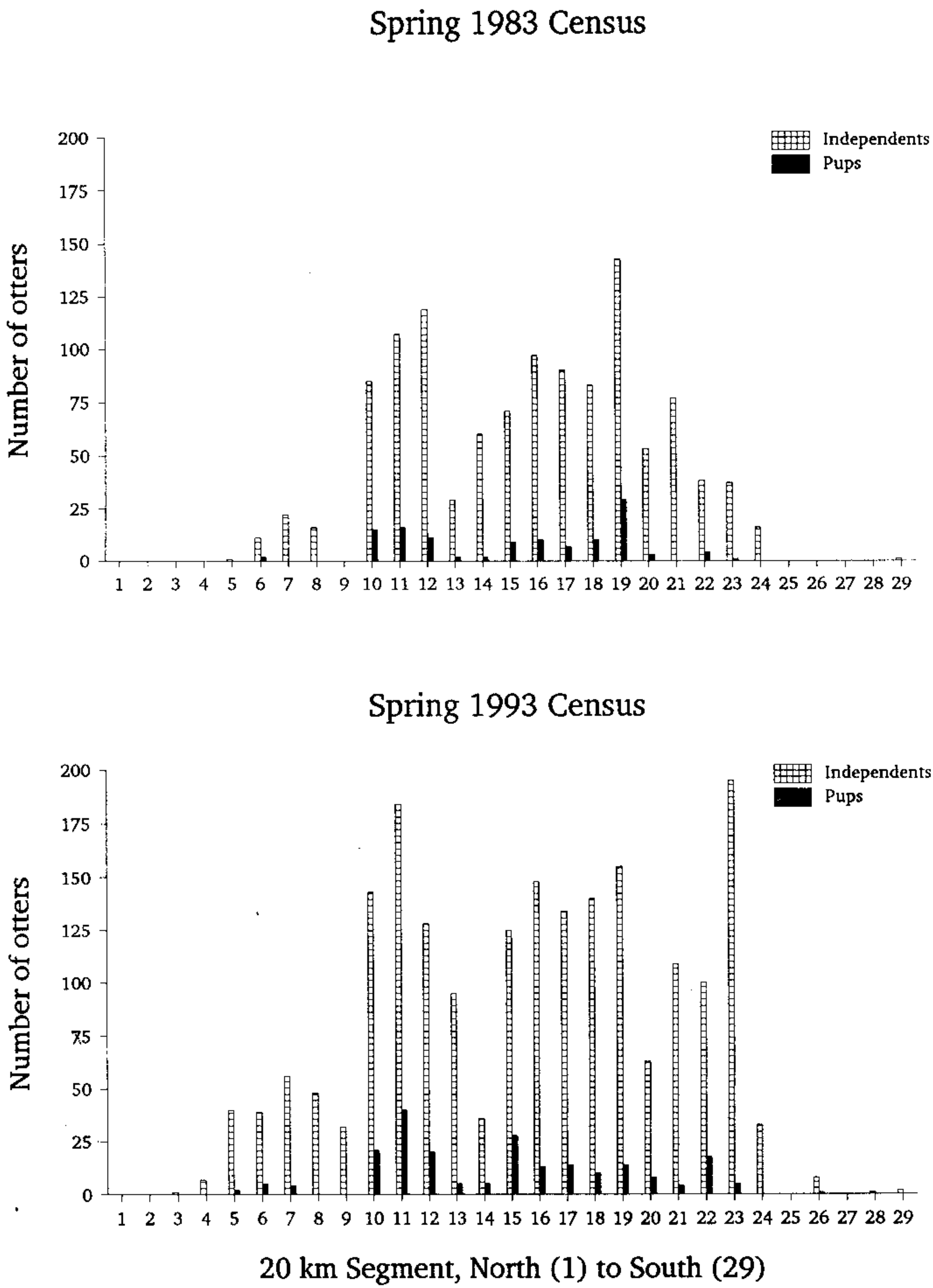
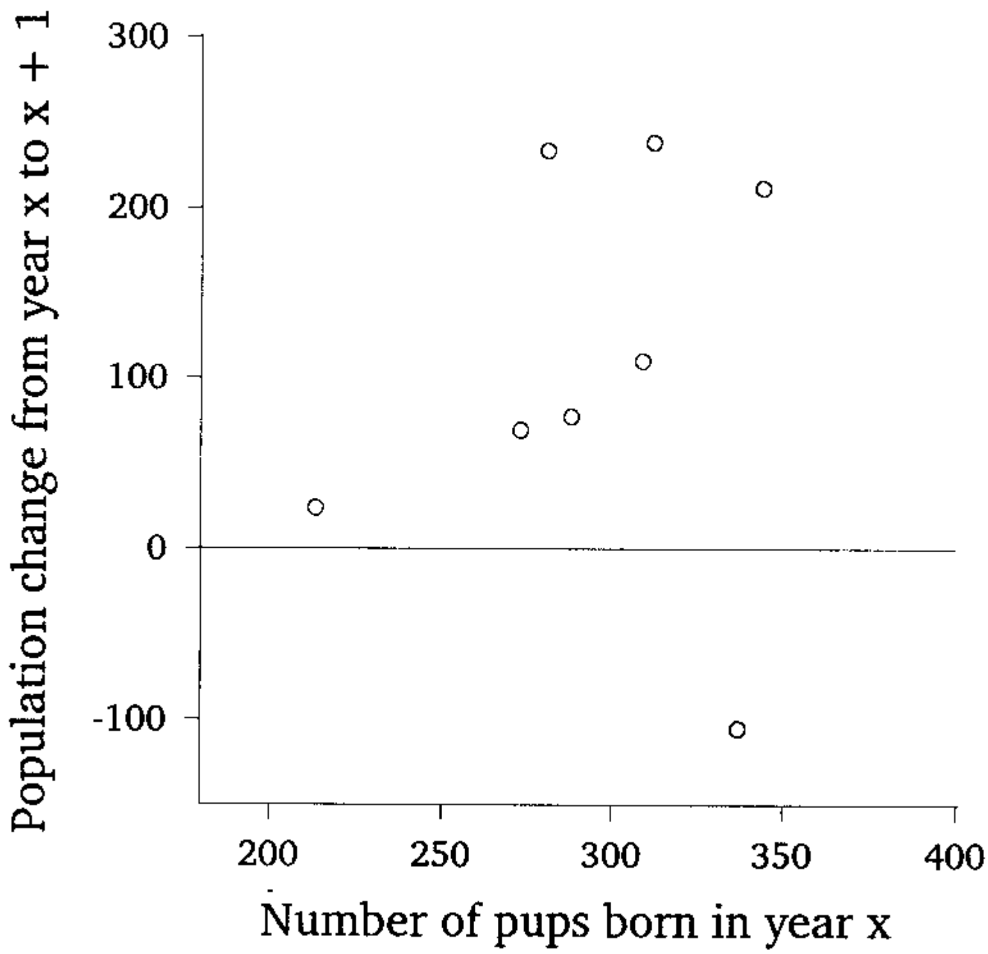
Fig. 1


Number of otters
250
500
750
1,000
1,250
1,500
1,750
2,000
2,250
2,500
Year of Survey
1914
19
24
29
34
39
44
49
54
59
64
69
74
79
84
89
94


Spring 1983 Census
Independents
Pups
Number of otters
200
175
150
125
100
75
50
25
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
Spring 1993 Census
Independents
Pups
Number of otters
200
175
150
125
100
75
50
25
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
20 km Segment, North (1) to South (29)


Population change from year x to x + 1
300
200
100
0
-100
200
250
300
350
400
Number of pups born in year x