DECLINE IN ABUNDANCE OF THE NORTHERN SEA LION, *EUMETOPIAS JUBATUS*, IN ALASKA, 1956-86

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ABSTRACT

Aerial, ship, and onshore surveys were conducted to assess the abundance of northern sea lions, *Eumetopias jubatus*, in southwestern Alaska, from the central Gulf of Alaska through the central Aleutian Islands, during June-July of 1984-86. Counts of northern sea lions from these surveys were compared with counts made in 1956-62 and 1975-79. These data indicated that the number of adults and juveniles onshore declined 52% from 140,000 animals in 1956-60 to 68,000 in 1985—an annual rate of decline of at least 2.7%. Numbers have declined throughout the region, with the greatest declines in the eastern Aleutian Islands (79%) and the least in the central Aleutian Islands (8%). This was not due to emigration because significant increases have not been noted elsewhere. Between the 1960s and mid-1970s, there were large decreases in the eastern Aleutian Islands and western Gulf of Alaska, and a major increase in the central Aleutian Islands. Beginning in the late 1970s declines occurred in all areas. The causes of the declines are unknown, but they may be associated with disease, prey availability or quality, or a combined effect of these and other factors. Factors which may contribute to the declines include the pre-1973 commercial harvests, entanglement of juveniles in marine debris, incidental takes in fisheries, and killing by fishermen.

The northern or Steller sea lion, *Eumetopias jubatus*, breeds from the Kuril Islands and Okhotsk Sea through the Aleutian Islands and Gulf of Alaska, and south to California. Loughlin et al. (1984) estimated the maximal population in 1974-80 at 290,000 (including some pups), of which more than 196,000 were in Alaska. The number of northern sea lions counted in Alaska was unchanged since the surveys of Kenyon and Rice (1961) and Mathisen and Lopp (1963) in 1956-60, even though significant declines had occurred in the eastern Aleutian and Pribilof Islands (Kenyon 1962; Braham et al. 1980). These declines were offset by increases in northern sea lion numbers in the central and western Aleutian Islands (Fiscus et al. 1981).

Concern over the decline in northern sea lion numbers in the eastern Aleutian Islands prompted the National Marine Mammal Laboratory (NMML) and the Alaska Department of Fish and Game to conduct surveys in 1984, 1985, and 1986 at sites throughout southwestern Alaska. These included aerial, ship, and onshore surveys of rookeries and major haul-out sites from Kiska Island in the central Aleutian Islands to the Barren Islands in the central Gulf of Alaska, as well as observations during two breeding seasons at Ugamak Island, a major rookery in the eastern Aleutian Islands. Together with earlier data for the Aleutian Islands (Kenyon and Rice 1961; Kenyon 1962[3]; Kenyon and King 1965[4]; Braham et al. 1980; Fiscus et al. 1981) and for the Gulf of Alaska (Mathisen and Lopp 1963; Calkins and Pitcher 1982[5]), these data present a 30-yr record of counting northern sea lions, albeit sporadically, in Alaska waters. The objectives of this paper are 1) to report the results of surveys conducted between 1984 and 1986, thus describing the current distribution and numbers of northern sea lions in much of Alaska, 2) to compare those counts with the historical data, and 3) to discuss the state of knowledge on causes of the decline in sea lion numbers.

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[3]Kenyon, K. W. 1962. Sea otter studies, population and distribution (with notes on Steller sea lion and emperor goose). Unpubl. Rep., U.S. Fish Wildl. Serv., Branch Wildl. Res., Seattle, 47 p. Available from Northwest and Alaska Fish. Cent. Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115.

[4]Kenyon, K. W., and J. G. King, Jr. 1965. Aerial survey of sea otters and other marine mammals, Alaska Peninsula and Aleutian Islands, 19 April to 9 May 1965. Processed Rep., U.S. Fish Wildl. Serv., Bur. Sport Fish. Wildl., Seattle, 52 p. Avaliable from Northwest and Alaska Fish. Cent. Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way, N.E., Seattle, WA 98115.

[5]Calkins, D. G., and K. W. Pitcher. 1982. Population assessment, ecology and trophic relationships of Steller sea lions in the Gulf of Alaska. Alaska Dep. Fish and Game, Final Rep. RU243, 128 p. Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99502.

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STUDY REGION AND METHODS

Study Region

The study included northern sea lion hauling sites in southwestern Alaska from Kiska Island in the Aleutian Island chain eastward to the Barren Islands in the central Gulf of Alaska (Fig. 1). This region was subdivided for analysis into four areas: 1) central Gulf of Alaska, 2) western Gulf of Alaska, 3) eastern Aleutian Islands, and 4) central Aleutian Islands.

Two general types of northern sea lion sites on land were recognized—rookeries and haul-outs (Loughlin et al. 1984). Rookeries were areas where adult males actively defended territories and most females gave birth and mated. Haul-outs were sites where few pups were present and where little breeding took place. Some islands included more than one distinct rookery and haul-out. A total of 114 sites, of which 28 were rookeries (on 27 islands), were surveyed during 1984-86.

Ugamak Island was a site for NMML field studies during the northern sea lion breeding seasons in 1969, 1977, 1978, 1985, and 1986. The island is located in the eastern Aleutian Islands (long. 164°50′W, lat. 54°14′N), about 110 km east of Dutch Harbor, AK. The island contained the largest aggregation of breeding sea lions in the Aleutian Islands as late as 1969.

Survey Methods

Aerial photographic surveys of northern sea lion rookeries and haul-outs in the eastern Aleutian Islands area (Fig. 1) were conducted 7-12 July 1984, using a Bell 205[6] helicopter flown off of the NOAA ship *Surveyor*. A survey of the entire study region

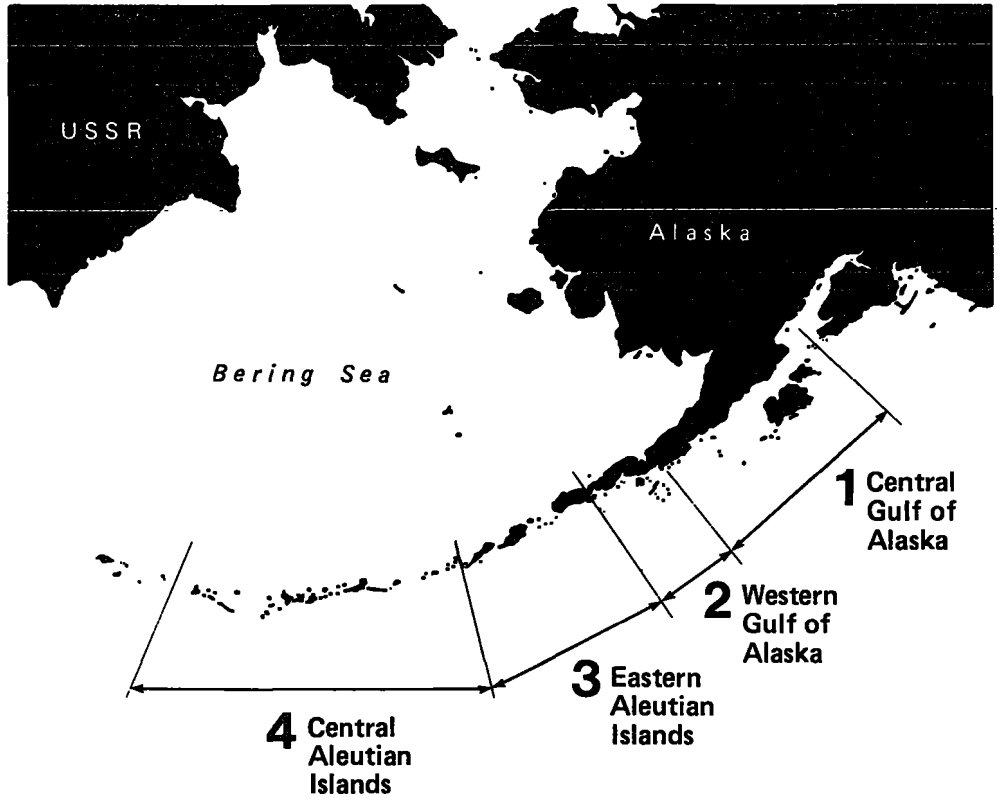


FIGURE 1.—The four Alaskan study areas (left) and 28 northern sea lion rookery sites (right) counted during 1984-86. Rookery island name and number as in Table 2.

was conducted during 9-13 June 1985, using a Grumman Widgeon for the eastern Aleutian Islands and Gulf of Alaska and a Piper Navajo for the central Aleutian Islands. All surveys were conducted between the hours of 1000 and 1800 Alaska Daylight Saving Time (ADT) and from mid-June to mid-July, when the most adult and juvenile sea lions were expected to be onshore (Withrow 1982). Survey methods were those of Braham et al. (1980).

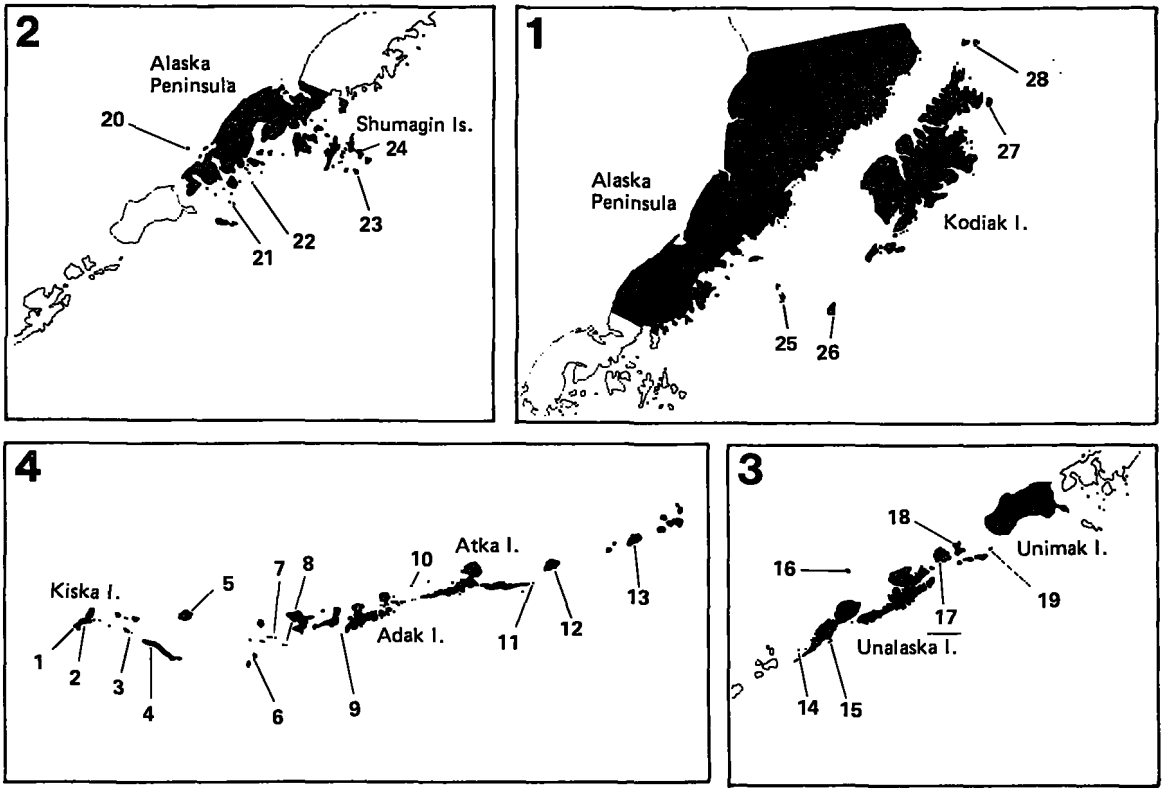
A shipboard survey also was conducted of rookeries and major haul-outs from Ugamak Island to Kiska Island between 25 June and 15 July 1985 (Loughlin et al.[7]). Weather permitting, observers landed at each site and counted the number of northern sea lions present and the number of animals entangled in debris. Pups were counted by first walking through rookeries to drive off the adult and juvenile animals, and then returning to count the pups. This survey was timed to occur after most pups had been born, and before they had begun to enter the water (Withrow 1982).

Pups were counted at northern sea lion rookeries in the central and western Gulf of Alaska between 3 July and 9 July 1984 (Calkins[8]) and between 29 June and 10 July 1986. Access was provided by a skiff launched from a larger vessel or by helicopter.

[6]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

[7]Loughlin, T. R., P. J. Gearin, R. L. DeLong, and R. L. Merrick. 1986. Assessment of net entanglement on northern sea lions in the Aleutian Islands, 25 June-15 July 1985. Processed Rep. 86-02, 50 p. Northwest and Alaska Fish. Cent. Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115.

[8]Calkins, D. G. 1985. Draft final report. Steller sea lion pup counts in and adjacent to Shelikof Strait. Submit. to North Pac. Fish. Manage. Coun., March 8, 1985, 13 p. Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99502.



1, 2 Kiska
3 Ayugadak
4 Amchitka
5 Semisopochnoi
6 Ulak
7 Tag
8 Gramp
9 Adak
10 Kasatochi
11 Agligadak
12 Seguam
13 Yunaska
14 Adugak
15 Ogchul
16 Bogoslof
17 Akutan
18 Akun
19 Ugamak
20 Sea Lion Rock
21 Clubbing Rocks
22 Pinnacle Rock
23 Chernabura
24 Atkins
25 Chowiet
26 Chirikof
27 Marmot
28 Sugarloaf

Pups were counted by driving off the adult animals just ahead of the counting team.

Counts of northern sea lions were made daily by observers on Ugamak Island between 1 June and 3 July 1985 and between 16 June and 26 July 1986. Hourly counts were made between the hours of 0700 and 2400 ADT for 6 days in 1986. Animals were counted from the cliffs above the sites, using 7 × 35 binoculars, a 15-60 power spotting scope, and unassisted vision. Counts were made of animals according to five types: adult territorial male, other adult male, adult female, juvenile, and pup (Merrick 1984). Animals in the water were excluded from counts. Freshly dead pups were recorded when seen, with pup mortality estimated as the total number of dead pups divided by the maximal number of pups counted (living and dead).

Data Analysis

The number of northern sea lions counted in the 1984-86 surveys were compared with counts from surveys in 1956-79 conducted by Kenyon and Rice (1961), Kenyon (fn. 3), Mathisen and Lopp (1963), Braham et al. (1980), Fiscus et al. (1981), and Calkins and Pitcher (fn. 5). Differences in survey areas complicated comparisons for the entire region, so comparisons were generally performed by area.

Comparisons also were complicated by the differences in the counting methods used. Some were counts from land (Fiscus and Johnson 1968[9]; Fiscus et al. 1981; Withrow 1986[10]), while others were estimates from ships (Fiscus and Johnson fn. 9; Calkins and Pitcher fn. 5), and counts from aerial photographs (Mathisen and Lopp 1963; Braham et al. 1980; Calkins and Pitcher fn. 5). The most accurate were visual counts from land and from aerial photos (Withrow 1982); these were the methods used in the 1984-85 aerial surveys.

Several assumptions were made in the analysis of these data. The first was that all sites with more than a few animals were surveyed in 1984-85. Second, the dates and times of peak seasonal and daily abundance were considered to have remained constant throughout the 30-yr period. The 1984-85 surveys and those conducted by Braham et al. (1980) were scheduled to coincide with these peaks; whereas, those of Kenyon and Rice (1961) and Kenyon (fn. 3) were conducted in the spring and without regard to time of day. A smaller proportion of animals were probably onshore in the spring than in the summer (Mathisen and Lopp 1963; Braham et al. 1980). Third, the proportion of the population onshore was assumed to have remained unchanged in the 30 years of counting. Finally, double counting was considered to be negligible in all the surveys because large areas were surveyed in a single day.

Counts presented here are indices of population size because they exclude animals at sea and because it is difficult to count at the exact time peak numbers are ashore. There are few data on the proportion of animals that are at sea at the time the peak number is onshore. Consequently, it was necessary to assume that the proportion had not changed over time. Even during the period when maximal numbers of animals were expected onshore there was variation due to weather and tidal affects (Withrow 1982; Merrick 1984), so that it was unlikely that a survey would occur on the day and time of peak numbers. However, because the sites on Ugamak Island were counted daily, the maximal number counted there was a closer approximation than the aerial survey counts of the actual peak number of animals onshore during the breeding season. Thus the Ugamak Island data were used to determine if seasonal and daily variation in northern sea lion hauling patterns had changed and to assess the potential amount of error (due to counting at the wrong time) in the aerial photo counts.

Rates of decline between two points in time were calculated using the formula

$$N_t = N_0 d^t$$

where N_0 = count in base year
N_t = count in future year t
t = number of years between the base year and year t
d = rate of change, with the percent annual change calculated as $(d - 1) \times 100$.

Area counts were regressed as a linear function of time to determine if trends in population sizes existed. Student's t-test was used to assess the significance of the regressions. Wilcoxon's signed rank test was used for between year comparisons of paired site counts within an area (Hollander and Wolfe 1973).

[9]Fiscus, C. H., and A. M. Johnson. 1968. Site for research on the Steller sea lion, June-July 1968. Processed Rep., U.S. Fish Wildl. Serv., Bur. Commer. Fish., Mar. Mammal Biol. Lab., Seattle, 33 p. Northwest and Alaska Fish. Cent. Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115.

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RESULTS

1984-86 Survey Findings

The 1984 survey of the eastern Aleutian Islands resulted in a count of 9,833 adult and juvenile northern sea lions on 16 sites (Table 1). The six rookery islands surveyed included 7,934 animals (Table 2), 91% of the total count. One rookery, Adugak Island, and several haul-out sites were not surveyed owing to inclement weather.

A total of 10,802 adult and juvenile northern sea lions were seen in the 1985 survey of the eastern Aleutian Islands (Table 1), which was not significantly different from the 9,833 animals counted there in 1984 ($P > 0.05$). A total of 67,617 animals were counted at 105 sites in the entire study region. Most (60%) of the animals were associated with the 27 rookeries surveyed; the largest rookeries were in the central Gulf of Alaska, notably at Marmot Island, and in the Central Aleutian Islands. The rookery on Semisopochnoi Island was not surveyed; eight previously identified haul-out sites were unoccupied.

Observers in the 1985 shipboard survey counted 4,950 pups at six rookeries in the eastern Aleutian Islands and 9,170 pups at nine rookeries in the central Aleutian Islands (Table 3). In the 1984 and 1986 pup surveys of six rookeries in the Gulf of Alaska (Table 3) 16,278 (excluding Clubbing Rocks and Pinnacle) and 12,025 pups were counted, respectively.

TABLE 1.—Counts and percent declines of adult and juvenile northern sea lions at all sites in spring and summer 1956-85 in the Aleutian Islands and Gulf of Alaska.

	Region				
Year	Central Gulf of Alaska	Western Gulf of Alaska	Eastern Aleutian Islands	Central Aleutian Islands	Reference[1]
1956		[2]24,320			1
1957	35,150				1
1959				28,115	2
1960			[2]52,530		2
1962				31,040	3
1975			21,221		4
1976	30,677	9,480	22,142		4,5
1977			23,922		4
1978		14,917			5
1979				[2]41,677	6
1984			9,833		7
1985	24,389	6,667	10,802	25,759	7
Decline[3]					
Overall	−31%	−73%	−79%	−8%	
Annual	−1.3%	−4.4%	−6.1%	−0.3%	

[1]Reference: 1—Mathisen and Lopp (1963); 2—Kenyon and Rice (1961); 3—Kenyon (text fn. 3); 4—Braham et al. (1980); 5—Calkins and Pitcher (text fn. 5); 6—Fiscus et al. (1981); 7—this study.
[2]Significant difference ($P < 0.05$) from 1985 using Wilcoxon signed rank test.
[3]Declines calculated from earliest survey date.

Trends in Regional Numbers

Comparison of the 1984-85 aerial surveys with historical data (Table 1) shows that significant ($P < 0.05$) declines have occurred in northern sea lion numbers in the western Gulf of Alaska (−73%), and eastern Aleutian Islands (−79%). The central Gulf of Alaska (−31%) and central Aleutian Island populations may have also declined since 1957-59, though the decreases (−31% and −8%, respectively) were not statistically significant ($P > 0.05$). Note that the central Aleutian Islands numbers increased 34% between 1959 and 1979. This suggests that either the population increased markedly, was supplemented by immigration from other areas (e.g., the eastern Aleutian Islands), or was an artifact of the 1979 survey methodology (i.e., a shipboard survey). Linear regression models (Fig. 2) fitted to these counts indicate that the trends of all areas, other than the central Aleutian Islands, exhibit significant negative slopes ($P < 0.05$).

The number of adult breeding animals has declined in all areas since 1957 except the central Aleutian Islands (Table 2). Numbers at the central Aleutian Islands rookeries increased by 88% between 1959 and 1985, a significant increase ($P < 0.01$). As the overall population in the central Aleutian Islands decreased between 1959 and 1985, this may indicate that a larger proportion of the population is now breeding than in the past. Rookery populations in the eastern Aleutian Islands have declined 79% since 1957, a significant decline ($P < 0.05$). A loss of 15,000 animals occurred at the Ugamak and Akutan Island rookeries alone between 1968 and 1975. Numbers at rookeries in the western and central Gulf of Alaska decreased 66% and 47%, respectively, between 1956-57 and 1985.

Trends in Regional Pup Production

Pup counts are available for only a few sites prior to 1984. These data (Table 3) show that the number of northern sea lion pups counted in the central Gulf of Alaska decreased between 1979 and 1986 by 44%, from 18,998 to 10,600. The number of pups has also declined at sites in the western Gulf of Alaska and eastern Aleutian Islands. Pupping decreased 52% at Bogoslof Island between 1968 and 1985, 89% at Walrus Island (in the Pribilof Islands) between 1960

TABLE 2.—Counts of adult and juvenile northern sea lions on individual rookeries for selected surveys from spring and summer 1956 to 1985 in the Aleutian Islands and Gulf of Alaska.

	Year					
Island[1]	1956-59[2]	1960-62[3]	1968[4]	1976-79[5]	1984[6]	1985[6]
Central Aleutians:						
Kiska (1, 2)	1,000	600		7,155		3,066
Ayugadak (3)	600	1,005		1,463		702
Amchitka (4)	600	1,515		1,943		728
Semisopochnoi (5)	2,500	3,700		1,223		nc
Ulak (6)	1,500	550		3,068		2,729
Tag (7)	400	200		1,740		944
Gramp (8)	700	0		2,235		1,290
Adak (9)	0	0		972		964
Kasatochi (10)	200	2,000		2,166		1,170
Agligadak (11)	250	3,000		993		514
Seguam (12)	25	1,275		6,493		2,942
Yunaska (13)	800	110		2,249		1,071
Total	[7]8,575	13,955		[7]31,700		16,120
Eastern Aleutians:						
Adugak (14)	1,275	1,000	nc[8]	1,177	nc	955
Ogchul (15)	2,966	2,000	nc	1,109	712	547
Bogoslof (16)	2,136	1,100	3,310	3,308	1,379	1,287
Akutan (17)	9,275	15,720	10,316	4,019	2,533	1,710
Akun (18)	nc	2,000	1,900	1,050	760	435
Ugamak (19)	14,536	13,400	13,553	4,760	1,252	1,429
Sea Lion Rock (20)	2,871	2,000	nc	2,076	1,298	538
Total	33,059	[7]37,220	29,079	[7]17,499	7,934	6,901
Western Gulf:						
Clubbing Rocks (21)	1,556			2,663		1,251
Pinnacle Rock (22)	3,142			3,692		1,588
Chernabura (23)	4,806			2,758		487
Atkins (24)	4,995			3,943		1,562
Total	14,499			13,056		4,888
Central Gulf:						
Chowiet (25)	6,014			4,441		2,059
Chirikof (26)	1,695			5,199		2,346
Marmot (27)	3,866			6,381		4,983
Sugarloaf (28)	11,963			4,374		2,991
Total	23,538			20,395		12,379

[1]Rookery island name and code (within parentheses) as in Figure 1.
[2]Mathisen and Lopp (1963).
[3]Kenyon (text fn. 3), for central Aleutian Islands in 1962; Kenyon and Rice (1961), for eastern Aleutian Islands in 1960.
[4]Fiscus and Johnson (text fn. 9).
[5]Fiscus et al. (1981), for central Aleutian Islands in 1979; Braham et al. (1980), for eastern Aleutian Islands in 1976; Calkins and Pitcher (text fn. 5), for western Gulf of Alaska in 1978 and central Gulf of Alaska in 1979.
[6]This study.
[7]Significant difference from 1985 at $P < 0.05$.
[8]nc = not counted.

and 1984, and 76% at Akutan Island between 1965 and 1985 (NMML[11]).

Ugamak Island Surveys

The estimated number of sea lions on Ugamak Island was 14,536 in 1957 and 13,553 in 1968 (Table 2). Significant changes were not observed until 1975-78 (Braham et al. 1980), by which time numbers had fallen to about 4,760 animals. Aerial surveys in 1984 and 1985 found 1,252 and 1,429 animals, respectively.

Ground counts of sea lions on Ugamak Island at comparable sites and survey dates (Table 4) showed a decline of 84% from 10,295 in 1969 to 1,684 in 1986. The decline was greatest between 1969 and 1977 when the count fell by 65%, from 10,295 to 3,577. Numbers fell 53% from 1977 to 1986, and 17% between 1985 and 1986.

The number of breeding animals at Ugamak

[11]Data available from NMML files. Northwest and Alaska Fish. Cent. Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115.

TABLE 3.—Counts of northern sea lion pups at sites in the Aleutian Islands and Gulf of Alaska, 1978-86.

Island	Year				
	1978[1]	1979[1]	1984[1]	1985[2]	1986[2]
Central Aleutian:					
Kiska				882+	
Ayugadak				329	
Amchitka				nc	
Semisopochnoi				nc	
Ulak				1,236	
Tag				703	
Gramp				909	
Adak				558	
Kasatochi				892	
Agligadak				nc	
Seguam		2,475		2,635	
Yunaska				1,026	
Total		2,475		9,170+	
Eastern Aleutian:					
Adugak				844	
Ogchul				172	
Bogoslof		914		1,109	
Akutan				1,130	
Akun				60	
Ugamak				1,635	1,386
Sea Lion Rock				nc	
Total		914		4,950	1,386
Western Gulf:					
Clubbing Rocks	725	1,419	1,394		
Pinnacle	615	2,013	2,748		
Chernabura	545	646	200		379
Atkins	2,750	4,538	2,093		1,046
Total	4,635	8,616	6,435		1,425
Central Gulf:					
Chowiet	4,670	5,485	3,207		1,731
Chirikof	1,573	1,649	1,913		1,476
Marmot	6,140	6,741	5,751		4,286
Sugarloaf	5,021	5,123	3,114		3,107
Total	17,404	18,998	13,985		10,600

[1]Calkins and Pitcher (text fn. 5), except for Seguam and Bogoslof Islands, which are from Fiscus et al. (1981).
[2]This study and Loughlin et al. (text fn. 7).

TABLE 4.—Counts of adult and juvenile northern sea lions at Ugamak Island, AK, mid-June 1969-86[1].

Rookery or haul	1969[2]		1977[3]		1985[4]		1986[4]	
	Date	Count	Date	Count	Date	Count	Date	Count
South								
Cone	6/20	400+	6/28	337	6/20	68	6/20	59
Eagle	6/18	1,000+	6/28	412	6/20	95	6/20	85
Ugamak Bay								
A1	6/19	639	6/20	148	6/20	139	6/20	133
A2	6/19	1,583	6/20	406	6/20	439	6/20	546
A3	6/19	257	6/20	27	6/20	3	6/20	35
A4	6/19	1,467	6/20	369	6/20	272	6/20	15
A5	6/12	720	6/28	364	6/20	361	6/20	336
Total south		6,066		2,063		1,377		1,209
North								
North Point								
N1	6/19	576	6/19	80	6/20	1	6/20	0
N2	6/19	262	6/19	56	6/20	9	6/20	15
N3	6/19	197	6/19	330	6/20	3	6/20	2
NE Point								
NE1	6/14	975	6/19	429	6/20	328	6/20	156
NE2	6/14	1,400	6/28	500	6/20	315	6/20	302
North haul	6/19	819	6/28	119	6/20	0	6/20	0
Total north		4,229		1,514		656		475
Grand total		10,295		3,577		2,033		1,684

[1]Excludes three sites not counted in all four years. Last day of counting in 1969 was 20 June, so this table is designed to provide comparable data from other years only, and will not match the maximal count for the year. Sites are identified using scheme developed by Fiscus (text fn. 12).
[2]From Fiscus (text fn. 12).
[3]From land counts, except counts from 28 June 1977, which were taken from aerial photographs (Withrow (text fn. 10)).
[4]This study.

Island has not declined equally at all sites (Table 4). Numbers on the south side of the island at Ugamak Bay declined until 1977, and then changed very little through 1985. However, in 1986 one south side site (A4) was abandoned by breeding females, whereas it had been occupied by over 400 in the previous year. Numbers at north side sites have declined through the present, with most sites there now

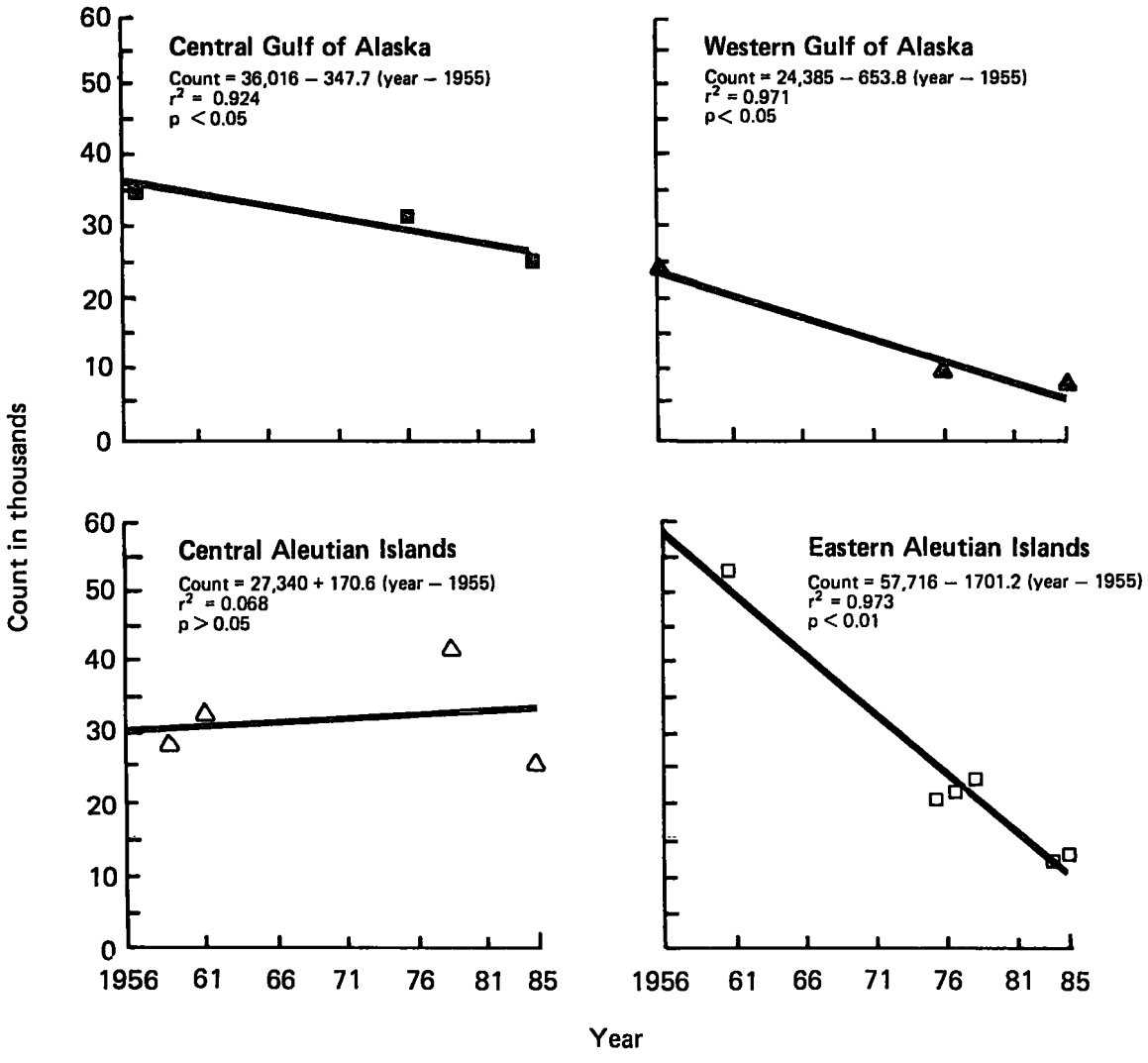

FIGURE 2.—Trends in total adult and juvenile northern sea lion abundance by area in Alaska, for spring and summer surveys conducted from 1956 to 1985.

empty. Although some rookeries have been reduced in size and decreases have been observed in all age and sex groups, the ratio of adult females to territorial males has remained relatively constant between 1977-78 (14.4-17.3) and 1986 (16.4). Between 1985 and 1986, however, the number of adult males remained constant, while the number of females decreased by 26%.

Island totals of juveniles were similar in 1985 (87 animals) and in 1986 (110 animals). However, an analysis of comparable areas of the island (i.e., N1-N3 and A2-A4; Fiscus[12]) indicated that the juvenile portion of the population had decreased significantly (χ^2 = 4.09, $P < 0.05$) from 9.0% in 1977 to 1.4-1.6% in 1985-86. A comparably low rate (2%) has only been observed at Año Nuevo Island (Gentry 1970) and that rate was calculated for a single primary rookery rather than a whole island. Rates such as the 22% observed at Marmot Island in 1983 or the 25% observed for British Columbia in 1956 seem more typical for northern sea lion rookeries (Pike and Maxwell 1958; Merrick 1984).

Counts of pups were available for six rookeries

[12]Fiscus, C. H. 1970. Steller sea lions at Ugamak Island, Aleutian Islands, Alaska, June 1969. Unpubl. Rep., U.S. Fish Wildl. Serv., Bur. Commer. Fish., Mar. Mammal Biol. Lab., Seattle, 78 p. Northwest and Alaska Fish. Cent. Natl. Mar. Mammal Lab., NMFS, NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115.

on the island for 1969, 1977, 1985, and 1986 (Fiscus fn. 12; Withrow fn. 10). The number of pups declined by 72% between 1969 and 1977, with two rookeries abandoned. A decline of 35% occurred between 1977 and 1986, with three more rookeries abandoned. Pupping has probably declined on other parts of the island, because the number of breeding animals decreased at other rookeries (Table 4) where pups were not counted in 1968 and 1977. Between 1985 and 1986, the only years with complete island surveys, there was a decline of 18% in pup numbers. Despite the decline in the number of pups born, the ratio of pups to adult females has increased from 0.75 in 1968 and 0.73-0.81 in 1977-78 to 0.95-1.06 in 1985-86. The Ugamak Island pup mortality during the first 1-2 mo postpartum in 1985-86 was 3.4-4.5%. Median pupping dates were similar in 1977-78 (13 June) and 1985 (12 June).

Finally, the Ugamak Island data allowed an evaluation of the times of peak abundance and variability in the counting methods. Counts peaked in 1985-86 between the third week of June and the first week of July, with 90% of the maximal breeding season population onshore at midday during this period. Hourly counts between 1000 and 2000 ADT during this period were always within 10% of the day's maximum. These occupancy patterns were the same as those observed by Withrow (1982) at Ugamak Island in 1977-78.

The Ugamak Island data also were used to provide an estimate of the accuracy of the 10 June 1985 aerial survey of the island. There was only a 3% difference between the aerial photo count and the simultaneous ground count. Thus, as noted by Withrow (1982), aerial photo counts accurately reflect ground counts. Despite this accuracy, the aerial photo count of 10 June 1985 was 24% lower than the maximal ground count of 25 June 1985. This bias was likely caused by the aerial survey occurring slightly before the period of peak abundance.

DISCUSSION

The number of northern sea lions found at sites within the study region, which included at least 140,000 animals circa 1958, totaled less than 68,000 in 1985—a decline of 52% (−2.7% per year). All indicators (regional numbers, breeding animals on rookeries, pup production, and the Ugamak Island data) confirm this decline. The rates of decline are probably underestimated because declines probably did not begin until after 1958. For example, the Ugamak Island population showed no decline between 1957 and 1969, and then declined at least 10.1% per year between 1969 and 1986. This indicates that the eastern Aleutian Island northern sea lion population may have begun to decline in the early 1970s rather than in 1958, the base year for rate calculations. Data are insufficient to calculate regional or area rates from 1969 to later dates.

Declines may have occurred in two phases. The first phase may have begun in the 1970s and been confined to the eastern Aleutian Islands and western Gulf of Alaska. Numbers for the entire study region fell by 25% (−1.6% per year) between 1958 and 1977. Numbers in the eastern Aleutian Islands appeared to stabilize in the mid-1970s, while those in the central Aleutian Islands and western Gulf of Alaska may have increased. A second phase of the decline may have begun during the late 1970s, with all areas being affected and overall numbers falling 36% (−5.2% per year) between 1977 and 1985. Results of the 1986 pup survey and 1986 Ugamak Island study indicate that the decline is still continuing.

Alternative Explanations for the Declines in Northern Sea Lion Numbers

Consideration has been given as to whether the declines could be explained by counting errors or biases, changes in northern sea lion behavior, or emigration. However, errors in counting or, for that matter, changes in technique do not explain the decline in numbers. Because counts taken in the 1950s and 1960s were conducted in the spring (before abundance had peaked on land) and because sites were missed, we believe that they underestimated sea lion numbers. Braham et al. (1980) estimated that only 42% of the eastern Aleutian Island sites were surveyed in 1957 (Mathisen and Lopp 1963). Animals present were probably accurately counted in the pre-1970 surveys because observers were all experienced. Kenyon and Rice (1961) compared their visual counts to concurrent aerial photos taken and found that their error was between 6 and 10%. Even if they had overestimated numbers the error may have been counterbalanced by any underestimate from counting too early in the year. The counts of the 1970s and 1980s were probably more comparable because they were made during the period of peak numbers onshore. Also there was little variation during this period in methods and personnel were experienced in these survey techniques. Furthermore, the methods used were believed to have been the most accurate. Even if all of the aerial counts were lower than the maximal

count for the season (as observed at Ugamak Island in 1985), the amount of error would be insufficient to explain the low counts. In any event, the declines in northern sea lion numbers observed in aerial surveys since the 1970s have been confirmed by the counts made from land at Ugamak Island and by the pup counts taken in the eastern Aleutian Islands and the Gulf of Alaska.

Pup counts can provide a reliable index of population change since almost all pups born can be counted in surveys scheduled prior to the pups going to sea. However, the index may be biased (Berkson and DeMaster 1985). Briefly stated, if precount pup survival (e.g., live birth rates) is density-dependent the counts would overestimate the rate of decline. If postcount pup survival (e.g., juvenile survival) is density-dependent then the counts would underestimate the rate of decline. Finally, if adult survival is density-dependent there would be little bias. Few data exist on density-dependent population regulation in northern sea lions, so we cannot be sure which, if any, of these mechanisms are operative. However, available data suggest that while precount survival in recent years is either unchanged or has improved, postcount survival has decreased. In both cases, the effect would be for pup counts to understate the rate of decline.

It is unclear whether northern sea lion hauling behavior has changed sufficiently to affect the counts. The 1977-78 and 1985-86 Ugamak Island data show that seasonal and daily hauling patterns and the timing of critical events (e.g., the median pupping date) have not changed. Similar data are not available for the earlier surveys. Animals may have dispersed to other sites, but they still would have been counted in the regional surveys. There is some evidence from Ugamak Island that females may spend less time ashore now than before (e.g., the high ratio of pups to adult females), which would decrease the number of adult animals counted. The low number of juveniles counted at Ugamak Island in 1985-86 may simply reflect increased juvenile dispersal away from the site due to changing prey resources and earlier weaning.

The decline in northern sea lion numbers onshore in the region has not been due to the emigration of animals to other regions because significant increases have not been noted elsewhere. Numerical decreases have been noted at the western extent of the breeding range in the Kuril and Commander Islands (Perlov 1982; Kuzin et al. 1984; Chelnokov 1984). Numbers began to fall in this region circa 1972, and by 1981-82 had fallen by 50% or more. Abundance at sites in the western Aleutian Islands declined 34-61% from 1979 to 1985 (Klett[13]). Adult northern sea lions at the Pribilof Islands have declined in number from approximately 7,000 animals in 1960 to 1,100 in 1981 (Kenyon 1962; Loughlin et al. 1984). Most of these animals were located at Walrus Island which was occupied by 4,000-5,000 northern sea lions in 1960, around 1,500 in 1975, and only 600 in 1982 (Kenyon 1962; NMML fn. 11). In 1960, 2,866 pups were counted at Walrus Island, but this number had fallen to 334 by 1982 (Kenyon 1962; NMML fn. 11). Northern sea lions are regularly seen farther north at St. Matthew and St. Lawrence Islands during the ice-free season, but the total has rarely exceeded 300 animals (Loughlin et al. 1984). Frost et al.[14] estimated 2,000 animals were in northern Bristol Bay during the 1970s, with 1,500 observed in the summers of 1980-82. The only rookery in Bristol Bay, Sea Lion Rock (Table 1), has decreased in size by 81% since the counts of 1957 reported by Mathisen and Lopp (1963). The 1982 count of 7,962 animals in southeast Alaska was not substantially different from the 1973 estimate of 8,430 (Calkins and Pitcher[15]). The number of northern sea lions in British Columbia and in the lower United States (i.e., Washington, Oregon, and California) do not appear to be increasing from 5,700 and 5,410 animals, respectively (Loughlin et al. 1984; Bigg 1985).

Proximate Causes of the Decline

The declines of northern sea lion could either be due to falling reproductive rates or reduced survival of pups, juveniles, and adults (especially females). There does not, however, appear to have been significant declines in reproductive rates or in pup survival 1-2 mo postpartum. The pregnancy rate of females taken in the Gulf of Alaska during April-May 1985 was 62% (n = 62), which was not significantly different from the 67% (n = 102) found there in 1975-78 (χ^2 = 0.002, $P > 0.50$; Pitcher and Calkins 1981; Goodwin and Calkins[16]). In addition,

[13]E. Klett, U.S. Fish and Wildlife Service, Aleutian Island Unit, Alaska Maritime National Wildlife Refuge, Box 5251 Naval Air Station, Adak, AK 98791, pers. comm. March 1986.

[14]Frost, K. J., L. F. Lowry, and J. J. Burns. 1982. Distribution of marine mammals in the coastal zone of the Bering Sea during summer and autumn. Alaska Dep. Fish Game, Final Rep. RU613, 188 p. Alaska Department of Fish and Game, 1400 College Road, Fairbanks, AK 99701.

[15]Calkins, D. G., and K. Pitcher. 1983. 1982 pinniped investigations in southern Alaska. Unpubl. rep., 15 p. Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99502.

[16]Goodwin, E. A., and D. G. Calkins. 1985. Preliminary results of ongoing investigations of San Miguel Sea Lion Virus, Leptospirosis, and Chlamydiosis in Alaska Steller sea lions and their rela-

the ratio of pups to adult females at Ugamak Island has increased since 1968 and 1977-78. The 3.4-4.5% rate of pup mortality at Ugamak Island was low when compared with the 11% found at Marmot Island, 10% at Año Nuevo Island, CA, and the 13-14% at Wooded Island, AK (Gentry 1970; Sandegren 1970; Merrick 1984).

The declines of northern sea lion may be due to reduced survival of pups (after they go to sea), juveniles, and adults. Changes in survival rates are difficult to assess. The precipitous declines in pupping in the Gulf of Alaska (Table 3) may indicate that there have been large declines in the female population there. Numbers of adult females at Ugamak Island also declined between 1985 and 1986. The Ugamak Island data also seem to indicate that juvenile abundance was much lower in 1985-86 than at other sites and in other years, which may indicate unusually high mortality is occurring after pups leave the rookery. Investigation of the declines in juveniles and adult females may hold the greatest promise for further study.

Ultimate Causes of the Decline

The causes of the reduced fecundity or survival of northern sea lions are presently unknown, but there are several possibilities—disease, changes in prey resources, and the combined effects of these and other factors. Disease and prey limitations are particularly plausible causes of the decline because of their potential for widespread impacts (hence declines in other regions) and because they could be implicated in the apparent declines of other Bering Sea and North Pacific Ocean pinniped populations. The number of northern fur seals, *Callorhinus ursinus*, breeding at the Pribilof Islands and on Robben Island in the Sea of Okhotsk have decreased since the mid- to late 1970s (Fowler 1985). Since the 1970s, harbor seal, *Phoca vitulina richardsi*, numbers may have decreased in Bristol Bay (Pitcher[17]) and have declined substantially in the central Gulf of Alaska at Tugidak Island (Calkins and Pitcher[18]).

Diseases resulting in reproductive failures and neonate, juvenile, and adult mortality could be a significant source of mortality. Antibodies to two types of bacteria (*Leptospira* and *Chlamydia*) and one marine calicivirus virus (San Miguel Sea Lion Virus) which could produce such mortality were present in blood taken from northern sea lions in Alaska (Fay et al. 1978[19]; Goodwin and Calkins fn. 16; Barlough et al. in press). Leptospires are spirochete bacteria and are suspected agents of abortion and adult mortality in California sea lions, *Zalophus californianus*, (Smith et al. 1974a) and in northern fur seals (Smith et al. 1974b). San Miguel Sea Lion Virus may also be associated with reproductive failures or neonatal deaths in California sea lions and northern fur seals, although the evidence is limited (Smith et al. 1973). *Chlamydia* has not been studied previously in sea lions. These and other agents are being examined for their possible adverse effects on northern sea lion populations.

The decline in northern sea lion numbers may be related to changes in the quantity and size of their prey. The few studies of the food habits of northern sea lions indicated that their primary prey are walleye pollock, *Theragra chalcogramma*, in the Bering Sea, Gulf of Alaska, and North Pacific Ocean (Klumov 1957; Pitcher 1981; Calkins et al.[20]). This fish is also a major prey item of harbor seals and northern fur seals (Pitcher 1980; Kajimura 1984). Walleye pollock biomass in the eastern Bering Sea rose from less than 5 million metric tons (t) in the 1960s to a peak of over 13 million t in the early 1970s and has since declined to about 8 million t in 1985 (Bakkala et al. in press). While the population biomass remains high, sporadically low abundance of age-1 walleye pollock between 1979 and 1984 could mean that in some years (e.g., 1981, 1982, and 1984) there would be fewer fish in the 10-35 cm range (Bakkala et al. in press). This size range includes the mean sizes consumed by northern sea lions and harbor seals (Pitcher 1981; Frost and Lowry 1986). Declines in abundance and increases in fish length have also been noted since 1981 in the Shelikof Strait region of the Gulf of Alaska (Nelson and Nunnallee 1985). However, there are few data on northern sea lion foraging patterns in the Bering Sea and

tionship to declining pup counts. Presented at the Sixth Biennual Conference on Biology of Marine Mammals, Vancouver, B.C., Nov. 1985. Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99502.

[17]K. Pitcher, Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99502, pers. comm. February 1986.

[18]Calkins, D. G., and K. Pitcher. 1985. Pinniped investigations in southern Alaska: 1983-84. Unpubl. rep., 19 p. Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99502.

[19]Fay, F. H., R. A. Dieterich, L. M. Shults, and B. P. Kelley. 1978. Morbidity and mortality in marine mammals. U.S. Dep. Commer. and U.S. Dep. Inter. (OCSEAP), Environ. Assess. Alaska Cont. Shelf, Ann. Rep., Mar. 1978, 1:39-79.

[20]Calkins, D. G., G. A. Antonelis, Jr., and G. W. Oliver. 1981. Preliminary report of the Steller sea lion/ice seal research cruise of the *ZRS Zvyagino*. Unpubl. rep., 22 p. Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99502.

Gulf of Alaska, so a relationship between the declines in northern sea lion numbers and changes in the abundance of their prey cannot be rejected or confirmed.

The declines of northern sea lion may not have a single cause, but may be due to the effects of a combination of these and other factors. Sources of mortality which alone seem insufficient to account for the declines but which could be important in a combined effect include the pre-1973 commercial sea lion harvests, entanglement in marine debris, incidental taking in fisheries, and the killing of sea lions for bait and predator control.

Northern sea lions were commercially harvested in the eastern Aleutian Islands and Gulf of Alaska from 1959 to 1972. Six hundred and sixteen adult males were taken in an experimental harvest in 1959 (Thorsteinson et al. 1961). A total of 45,178 northern sea lion pups of both sexes were harvested in the eastern Aleutian Islands and Gulf of Alaska between 1963 and 1972 (FEIS[21]). The largest harvests were conducted between 1963 and 1972 at Sugarloaf and Marmot Islands where 16,763 and 14,180 pups, respectively, were killed, and between 1970 and 1972 at Ugamak and Akutan Islands where 3,773 and 6,036 pups, respectively, were killed. The pup harvests, which sometimes reached 50% of the total pup production from a rookery (e.g., at Sugarloaf Island in 1965 and 1968), could have depressed recruitment in the short term. This may partially explain the declines experienced at some sites through the mid-1970s. However, it is unclear why numbers declined in areas where *no* harvest occurred (e.g., the north side of Ugamak Island), while no declines were observed at some harvest sites (e.g., Marmot Island). In any event, those harvests should not currently be affecting the decline, because populations should have stabilized 3-5 years after the cessation of harvesting as unharvested year classes reached breeding age. Furthermore, these harvests probably cannot explain the declines in numbers counted in the western and central Aleutian Island populations.

Little information exists on the effect of entanglement in marine debris on northern sea lions. Despite debris commonly being found in areas northern sea lions frequent (Calkins 1985; Merrell 1985), data from NMML surveys suggest that this is not a problem, at least for adult sea lions. Observed entanglement rates were 0.07% in the 1985 ship survey (Loughlin et al. fn. 7), 0.09-0.17% in the 1985-86 Ugamak Island surveys, and 0.12% at Marmot Island in 1983 (Merrick 1984). Numerous northern sea lion pups were seen in the November 1985 eastern Aleutian Island entanglement survey (Loughlin et al. fn. 7), but none were entangled. Nevertheless, it is possible that entangled northern sea lion pups drown and are not observed.

Numerous northern sea lions have been taken incidental to fisheries in the Bering Sea and Northeast Pacific Ocean since the late 1960s and early 1970s (FEIS fn. 21). In 1978-81 the estimated average annual mortality for all foreign vessels was 724 animals (Loughlin et al. 1983). This does not, however, include animals taken by U.S. fishermen fishing in joint ventures or independently. Loughlin and Nelson (1986) documented the take in the Shelikof Strait joint venture walleye pollock fishery where an estimated 958 to 1,436 northern sea lions were caught by U.S. trawlers in 1982. This take declined to less than 400 animals per season in 1983 and 1984, probably due to changes in fishing technique and the area and times fished. The cumulative impact of foreign independent and joint venture fisheries in the Bering Sea and North Pacific Ocean probably now accounts for less than 500 deaths per year (NMML fn. 11). Domestic fishermen now working independently probably take less since they generally are involved in fisheries that catch few sea lions. However, as foreign fishing is phased out of U.S. waters, the domestic take will probably increase. The foreign and domestic incidental take contributes to but cannot totally account for the decline.

We are uncertain how the killing of northern sea lions by fishermen has affected the population. Fishermen have been observed to kill adult animals at rookeries, haul-outs, and in the water near boats, but the magnitude of this take is generally unknown. Trawl fisheries attract many northern sea lions during haulback operations and shooting at these animals is a common occurrence. One of the few estimates of shooting mortality comes from Matkin and Fay[22] who calculated that 305 northern sea lions were killed directly (shot) while interferring with fishing operations in the spring 1978 Copper River Delta salmon gill net fishery. Northern sea lions at

[21]Final environmental impact statement (FEIS). 1977. Consideration of a waiver of the moratorium and return of management of certain marine mammals to the State of Alaska. Vol. II. U.S. Dep. Commer. and U.S. Dep. Inter., Interagency Task Group, Wash., D.C., 251 p.

[22]Matkin, C. O., and F. H. Fay. 1980. Marine mammal-fishery interactions on the Copper River and in Prince William Sound, Alaska, 1978. Final rep. for contract MMC-78/07 to Mar. Mammal Comm., 71 p. Available from National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161, as PB80-159536.

sites in the eastern Aleutian Islands also would have been prime sources of bait for crab fishermen. Thus it may be more than a coincidence that the onset of the northern sea lion decline in the eastern Aleutian Islands began at the time of peak landings in the Bering Sea king crab (*Paralithodes* spp., *Lithodes aequispina*) and Tanner (snow) crab (*Chionoecetes* spp.) fisheries. Killing "nuisance" northern sea lions continues to this date (R. L. Merrick pers. obs.). This killing may have a significant effect on local populations (e.g., the eastern Aleutian Islands and central Gulf of Alaska) and might have caused animals to disperse away from traditional rookeries and haul-outs. It should have little effect, however, in areas that have not been heavily fished (e.g., the western and central Aleutian Islands).

Sources of mortality that we think are of minor or unknown importance in the decline include changes in oceanographic or climatic conditions, increased predation, harassment, subsistence harvests, and chemical pollutants.

Prospects for the Future

Many pinniped species have experienced population declines within recent history, and in most cases the population has been able to rebuild. Overexploitation has been a cause of long-term but temporary declines in many species, including Southern Hemisphere fur seals (*Arctocephalus* spp.), elephant seals (*Mirounga* spp.), and northern fur seals (Bonner 1982). Other human activities have caused declines, such as that of ringed seals, *Phoca hispida*, in the Baltic Sea, where organochlorines may have caused a high rate of reproductive failures (Helle et al. 1976). Natural mortality and temporary local declines have resulted from influenza outbreaks in northwest Atlantic Ocean harbor seals, *Phoca vitulina concolor*, (Geraci et al. 1983), and Leptospirosis epizootics in California sea lions (Vedros et al. 1971). Decreased prey abundance may have reduced the ringed seal and bearded seal, *Erignathus barbatus*, populations in the eastern Beaufort Sea in 1974-75 (Stirling et al. 1982).

Thus the northern sea lion decline in southwestern Alaska is not unique among pinnipeds, but the causative factor remains difficult to identify. Based on these other examples we can estimate what the ultimate effect of the most plausible hypotheses will be on the population. If one of the causes of the decline is disease, then the population will stabilize and begin to increase once the epizootic has run its course. If a change in prey quantity or quality has reduced the carrying capacity of the Bering Sea, Gulf of Alaska, and North Pacific Ocean for northern sea lions, then the population should stabilize if the critical resource stabilizes. If the decline is caused by a combination of factors, then the outcome cannot be determined. Though serious, the current reduced status of the stock in southwestern Alaska does not yet imperil the population, because a large reservoir of adult breeding animals remains to rebuild the population should the decline abate.

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LITERATURE CITED

BAKKALA, R., V. WESPESTAD, AND L. L. LOW.
In press. Historical trends in abundance and current condition of walleye pollock in the eastern Bering Sea. Fish. Res.

BARLOUGH, J. E., E. S. BERRY, E. A. GOODWIN, R. F. BROWN, R. L. DELONG, AND A. W. SMITH.
In press. Antibodies to marine caliciviruses in the Steller sea lion (*Eumetopias jubatus* Schreber). J. Wildl. Dis.

BERKSON, J. M., AND D. P. DEMASTER.
1985. Use of pup counts in indexing population changes in pinnipeds. Can. J. Fish. Aquat. Sci. 42:873-879.

BIGG, M. A.
1985. Status of the Steller sea lion (*Eumetopias jubatus*) and California sea lion (*Zalophus californianus*) in British Columbia. Can. Spec. Publ. Fish. Aquat. Sci. 77, 20 p.

BONNER, W. N.
1982. Seals and man: A study of interactions. Univ. Wash. Press, Seattle, 170 p.

BRAHAM, H. W., R. D. EVERITT, AND D. J. RUGH.
1980. Northern sea lion population decline in the eastern Aleutian Islands. J. Wildl. Manage. 44:25-33.

CALKINS, D. G.
1985. Steller sea lion entanglement in marine debris. *In* R. S. Shomura and H. O. Yoshida (editors), Proceedings of the Workshop on the Fate and Impact of Marine Debris 27-29 November 1984, Honolulu, Hawaii, p. 308-314. U.S. Dep. Commer., NOAA Tech. Memo. NMFS SWFC-54.

CHELNOKOV, F. G.
1984. Abundance of sea lions and their relationship with fur seals at the southeastern hauling ground of Mednyi Island (Commander Islands). Sov. J. Mar. Biol. 9:191-195. [Engl. transl. Biol. Morya.]

FISCUS, C. H., D. J. RUGH, AND T. R. LOUGHLIN.
1981. Census of northern sea lion (*Eumetopias jubatus*) in central Aleutian Islands, Alaska, 17 June-15 June 1979, with notes on other marine mammals and birds. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS F/NWC-17, 109 p.

FOWLER, C. W.
1985. An evaluation of the role of entanglement in the population dynamics of northern fur seals on the Pribilof Islands. *In* R. S. Shomura and H. O. Yoshida (editors), Proceedings of the Workshop on the Fate and Impact of Marine Debris 27-29 November 1984, Honolulu, Hawaii, p. 291-307. U.S. Dep. Commer., NOAA Tech. Memo. NMFS SWFC-54.

FROST, K. J., AND L. F. LOWRY.
1986. Sizes of walleye pollock, *Theragra chalcogramma*, consumed by marine mammals in the Bering Sea. Fish. Bull., U.S. 84:192-197.

GENTRY, R. L.
1970. Social behavior of the Steller sea lion. Ph.D. Thesis, Univ. California, Santa Cruz, 113 p.

GERACI, J. R., D. J. ST. AUBIN, I. K. BARKER, R. G. WEBSTER, V. S. HINSHAW, W. J. BEAN, H. L. RUNHKE, J. H. PRESCOTT, G. EARLY, A. S. BAKER, S. MADOFF, AND R. T. SCHOOLEY.
1982. Mass mortality of harbor seals: pneumonia associated with influenza A virus. Science (Wash., D.C.) 215:1129-1131.

HELLE, E., M. OLSSON, AND S. JENSEN.
1976. DDT and PCB levels and reproduction in ringed seal from the Bothnian Bay. Ambio 1976, p. 188-189.

HOLLANDER, M., AND D. A. WOLFE.
1973. Nonparametric statistical methods. John Wiley & Sons, N.Y., 503 p.

KAJIMURA, H.
1984. Opportunistic feeding of the northern fur seal, *Callorhinus ursinus*, in the eastern North Pacific Ocean and eastern Bering Sea. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-779, 49 p.

KENYON, K. W.
1962. History of the Steller sea lion at the Pribilof Islands, Alaska. J. Mammal. 43:68-75.

KENYON, K. W., AND D. W. RICE.
1961. Abundance and distribution of the Steller sea lion. J. Mammal. 42:223-234.

KLUMOV, S. K.
1957. Registration of the shore rookeries of sea lions (*Eumetopias jubatus*) in the Kuril Islands and tentative determination of their numerical magnitude. [In Russ.] Dokl. Akad. Nauk. SSSR 117(2):345-348. (Transl. L. V. Sagen, avail. Natl. Mar. Mammal Lab. Library.)

KUZIN, A. E., M. K. MAMINOV, AND A. S. PERLOV.
1984. The number of pinnipeds and sea otters on the Kuril Islands. *In* V. E. Rodin, A. S. Perlov, A. A. Berzin, G. M. Gavrilov, A. I. Shevchenko, N. S. Fadeev, and E. B. Kucheriavenko (editors), Marine mammals of the Far East, p. 54-72. [In Russ.] Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. (TINRO), Vladivostok. (Transl. F. H. Fay., avail. Natl. Mar. Mammal Lab. Library.)

LOUGHLIN, T. R., L. CONSIGLIERI, R. L. DELONG, AND A. T. ACTOR.
1983. Incidental catch of marine mammals by foreign fishing vessels, 1978-81. Mar. Fish. Rev. 45(7-8-9):44-49.

LOUGHLIN, T. R., D. J. RUGH, AND C. H. FISCUS.
1984. Northern sea lion distribution and abundance: 1956-80. J. Wildl. Manage. 48:729-740.

LOUGHLIN, T. R., AND R. NELSON, JR.
1986. Incidental mortality of northern sea lions in Shelikof Strait, Alaska. Mar. Mammal Sci. 2:14-33.

MATHISEN, O. A., AND R. J. LOPP.
1963. Photographic census of the Steller sea lion herds in Alaska, 1956-58. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 424, 20 p.

MERRELL, T. R., JR.
1985. Fish nets and other plastic litter on Alaska beaches. *In* R. S. Shomura and H. O. Yoshida (editors), Proceedings of the Workshop on the Fate and Impact of Marine Debris 27-29 November 1984, Honolulu, Hawaii, p. 160-182. U.S. Dep. Commer., NOAA Tech. Memo., NMFS SWFC-54.

MERRICK, R. L.
1984. Observations on the status of the northern sea lion population in Alaska. M.S. Thesis, Oregon State Univ., Corvallis, 85 p.

NELSON, M. O., AND E. P. NUNNALLEE.
1985. Acoustic-midwater trawl survey of spawning walleye pollock in the Shelikof Strait Region, 1980-81 and 1983-84. *In* R. L. Major (editor), Condition of ground fish resources of the Gulf of Alaska region as assessed in 1984, p. 179-206. U.S. Dep. Commer., NOAA Tech. Memo., NMFS F/NWC-80.

PERLOV, A. S.
1982. Reduction in the number of sea lions. [In Russ.] *In* G. B. Agarkov, V. A. Arsen'ev, V. M. Bel'kovich, V. A. Zemskiyi, L. A. Popov, I. V. Smelova, A. S. Sokolov, A. G. Tomlin, and A. K. Yablokov (editors), The study, preservation, and rational exploitation of marine mammals, p. 284-285. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr., Akad. Nauk. SSSR, Astrakhan. (Transl. by S. Pearson, Natl. Mar. Mammal Lab., NMFS, NWAFC, Seattle.)

PIKE, G. C., AND B. E. MAXWELL.
1958. The abundance and distribution of the northern sea lion (*Eumetopias jubata*) on the coast of British Columbia. J. Fish. Res. Board Can. 15:5-17.

PITCHER, K. W.
1980. Food of the harbor seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. Fish. Bull., U.S. 78:544-549.
1981. Prey of the Steller sea lion, *Eumetopias jubatus*, in the Gulf of Alaska. Fish. Bull., U.S. 79:467-472.

PITCHER, K. W., AND D. G. CALKINS.
1981. Reproductive biology of Steller sea lions in the Gulf of Alaska. J. Mammal. 62:599-605.

SANDEGREN, F. E.
1970. Breeding and maternal behavior of the Steller sea lion (*Eumetopias jubata*) in Alaska. M.S. Thesis, Univ. Alaska, College, AK, 138 p.

SMITH, A. W., S. H. MADIN, AND T. G. AKERS.
1973. Pinnipeds as a possible natural reservoir for a virus

disease of domestic swine. Proceedings of the 10th Annual Conference of the Biological Sonar and Diving Mammals, Stanford Research Inst., Menlo Park, CA.

SMITH, A. W., R. J. BROWN, D. E. SKILLING, AND R. L. DELONG.
1974a. *Leptospira pomona* and reproductive failure in California sea lions. J. Am. Vet. Med. Assoc. 165:996-998.

SMITH, A. W., C. M. PRATO, W. G. GILMARTIN, R. J. BROWN, AND M. C. KEYES.
1974b. A preliminary report on potentially pathogenic microbiological agents recently isolated from pinnipeds. J. Wild. Dis. 10:54-59.

STIRLING, I., M. KINGSLEY, AND W. CALVERT.
1982. The distribution and abundance of seals in the eastern Beaufort Sea, 1974-79. Can. Wildl. Serv., Occas. Pap. 47, 25 p.

THORSTEINSON, F. V., R. W. NELSON, AND D. F. LALL.
1961. Experimental harvest of the Steller sea lion in Alaska waters. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 371, 15 p.

VEDROS, N. A., A. W. SMITH, J. SCHONEWALD, G. MIGAKI, AND R. C. HUBBARD.
1971. Leptospirosis epizootic among California sea lions. Science (Wash., D.C.) 172:1250-1251.

WITHROW, D. E.
1982. Using aerial surveys, ground truth methodology, and haul out behavior to census Steller sea lions, *Eumetopias jubatus*. M.S. Thesis, Univ. Washington, Seattle, 102 p.