NORTHWEST & ALASKA FISHERIES CENTER PROCESSED REPORT

PRELIMINARY EVIDENCE OF A NORTHERN SEA LION *(Eumetopias jubatus)* POPULATION DECLINE IN THE EASTERN ALEUTIAN ISLANDS

by

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U.S. DEPARTMENT OF COMMERCE
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National Marine Fisheries Service
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Preliminary evidence of a northern sea lion (*Eumetopias jubatus*) population decline in the eastern Aleutian Islands

Abstract: From June 1975 to June 1977 six aerial surveys were conducted along Alaska's eastern Aleutian Islands and the north coast of the Alaska Peninsula to determine the distribution and abundance of the northern sea lion, *Eumetopias jubatus*. Systematic counts of sea lions on rookeries and haul-out sites were compared with counts made in 1957, 1960, 1965 and 1968. When rigorously comparing total counts from sites replicated between surveys, we find a significant, chronological population decline of 40-50% over the past 20 years. Factors which may have contributed to the decline are: 1) a westwardly shift in distribution; 2) commercial fisheries interaction; 3) commercial harvest of pups; 4) leptospirosis; and/or 5) an unidentified population controlling factor.

INTRODUCTION

The northern or Steller sea lion, <u>Eumetopias jubatus</u>, is the most abundant sea lion in North America, ranging from California north into the Bering Sea, Alaska (Rice, 1977). The current population level in Alaska is estimated at 200,000 animals (DEIS, 1976) with the greatest numbers occurring from the Gulf of Alaska to the western limits of the Aleutian Islands. However, few systematic studies have been conducted throughout their range especially when they are most likely to be hauled out onto land. As such, reliable estimates of abundance are not available for much of Alaska. Extensive research along the south side of the Alaska Peninsula into the Gulf of Alaska has been conducted by Alaska Department of Fish and Game biologists and others (C.F. Calkins, et al., 1975; Fiscus, et al., 1976), however no surveys since Kenyon and Rice (1961) have been conducted throughout the entire Aleutian Islands.

The Fox Islands in the eastern Aleutians were surveyed by Kenyon and Rice (1961), Mathisen and Lopp (1963), Kenyon and King (1965), Fiscus and Johnson (1968) and Braham et al. (1977). However, coverage was patchy, and time of year varied. From these surveys estimates of sea lion abundance in the eastern Aleutian Islands ranged from about 45,000-50,000 in the late 1950's and early 1960's, or about 20% of the total population (Kenyon and Rice 1961), to 20,000-25,000 in the mid 1970's. Because of proposed oil and gas exploration on the continental shelf north and south of the Fox Islands, a systematic population study was initiated in 1975 to more effectively evaluate the status of the stock (Braham et al., 1977).

This paper reports on the distribution and abundance of northern sea lions within the central range of the species in Alaska. The objectives of the study were to refine the identification of breeding and haul-out sites and to quantify species abundance for comparison with estimates made during previous surveys.

O. Siebert, President of Peninsula Airways, King Salmon, Alaska, flew the survey aircraft and provided guidance and knowledge of the area under study. C. H. Fiscus was instrumental in developing the surveys and provided invaluable field expertise during the 1975-76 surveys. Officers and crew of the NOAA ship Surveyor and the U.S. Coast Guard Station at Cape Sarichef, Alaska, also provided support.

Advice and assistance from D. Calkins, J. Faro, K. Pitcher, K. Schneider and N. Steen, Alaska Department of Fish and Game, were sincerely appreciated. Assisting with the research were co-workers T. Bray, B. Krogman, P. McGuire, R. Mercer, M. Nerini, C. Peterson, N. Severinghaus and D. Withrow of the Marine Mammal Division. Additional staff support was provided by the Northwest and Alaska Fisheries Center, NMFS, Seattle, Washington. We also wish to thank G. Harry, C. Fiscus, R. DeLong, B. Krogman, J. Mitchell and A. Roppel for reviewing the manuscript.

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STUDY AREA

The study area was the central portion of the northern sea lion's range in Alaska, encompassing the north side of the Alaska Peninsula at Amak Island and Sea Lion Rock, including the north and west side of Unimak Island, and west into the eastern Aleutian Islands (Fox Islands group) from Ugamak Island to Samalga Island (Fig. 1).

Sea lions haul out on these islands throughout the year, but occur in greatest numbers on land between May and October during the breeding and molting seasons (Bonnet and Ripley, 1948; Mathisen, 1959; Pike and Maxwell, 1958; Tikhomirov, 1964). Seven breeding rookery sites were identified (not including multiple rookeries -- e.g. Ugamak Island) located at Sea Lion Rock (#45), Ugamak (#40) and Round (#41) Islands, Cape Morgan (#24) on Akutan Island, Bogoslof Island (#10), Ogchul Island (#4) and Adugak Island (#2) (Fig. 1) which is consistent since 1957. Also, 23 significant (> 50 animals at any one time) haul-out areas (non-breeding grounds) were identified and surveyed; 2) are on the Fox Islands.

The islands are of volcanic origin, typically of columnar basalt with a wide range of habitat and substrate types including cobble beaches and rocky outcrops along vertical cliffs. Populated by a mixed tundra-alpine plant community, the islands are residence for the blue Fox (*Alopex lagopus*) and Tundra vole (*Microtus* spp.), plus the brown bear (*Ursus arctos*) on Unimak Island. Other residents in the area include the bald eagle (*Haliaectus leucocephalus*), common raven (*Corvus corax*), horned puffin (*Fratercula corniculata*), tufted puffin (*Lunda cirrhata*), pidgeon guillemot (*Cepphus columba*), killer whale (*Orcinus orca*), minke whale (*Balaenoptera acutorostrata*), Dall porpoise (*Phocoenoides dallii*), harbor porpoise (*Phocoena phocoena*),

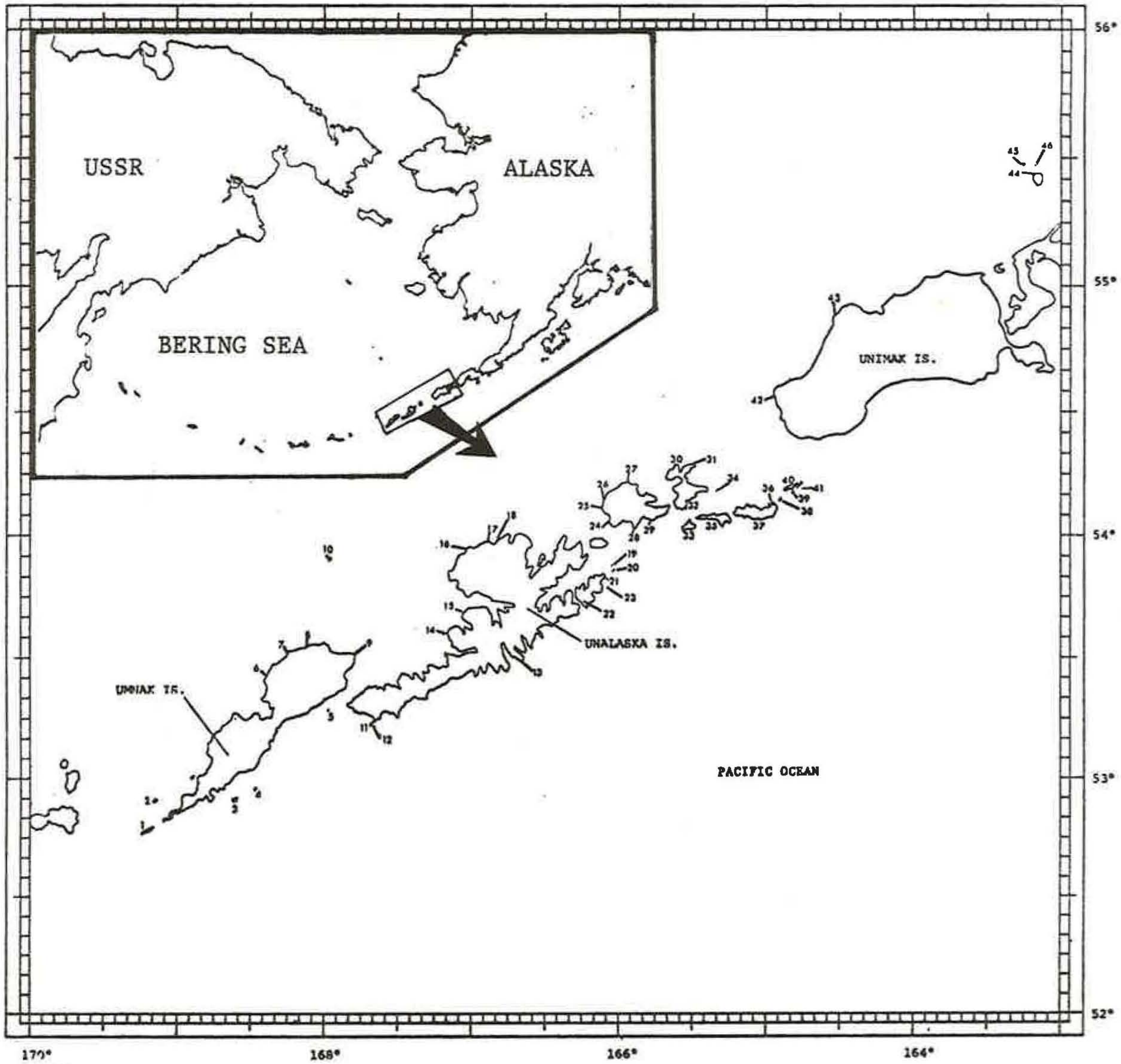

Fig. 1. Northern sea lion, Eumetopias jubatus, population study area in the eastern Aleutian Islands, Alaska. See Table 1 for site identification.

harbor seal (Phoca vitulina richardii) and sea otter (Enhydra lutris). Essentially the entire Alaska population of northern fur seals (Callorhinus ursinus) migrates through the study area twice annually (Fiscus et al, 1964). Waters adjacent to the study area are important Soviet, Japanese and U. S. commercial fishing grounds. Many of the islands are part of the Aleutian Islands Wildlife Refuge System.

METHOD AND MATERIALS

Field Surveys

Systematic aerial surveys were conducted over the study area 17-20 June 1975, 9-13 August 1975, 15-20 June 1976, 19-21 August 1976, 21-25 October 1976 and 28-30 June 1977 - covering from 860 to 1840 nm per survey. Total flight time was 114.5 hours. The height of the breeding period (June-August) was chosen because maximum numbers of animals were expected to be hauled out this time of year (Bonnet and Ripley, 1948; Pike and Maxwell, 1958; Mathisen and Lopp, 1963). Except during 21-25 October 1976, all surveys were conducted in an amphibious twin engine Grumman Widgeon. The October survey was conducted in a Bell 206B helicopter supplied by the NOAA ship Surveyor. Flying was done at 90-240 meter altitudes within 400 meters of the coastline at speeds of 150-190 km hr^{-1} (95-120 mph). These altitudes and speeds were a compromise between optimal visibility and the need to minimize disturbance to hauled-out animals. Higher altitudes were flown near bird nesting areas.

A photographer/observer sat in the right front seat while one or two observers, including the data recorder, sat aft. A battery-operated Miniamp intercom system (Mark 2-D, 9v; Genie Electronics Co., Inc.) with headsets was used for communications among observers and pilot. A cassette tape recorder (Panasonic, DC, 6v) was used (in 1977) during periods of congested observations. Because surveys were primarily coastal, emphasis was placed on the starboard side of the aircraft optimizing the view for the photographer and aft observer(s).

Photographs were taken at all sites with greater than 20 animals, or when direct counts could not be made. In all cases, visual estimates were made, as a backup to the photographs, by one or more observers. Either a 35 mm Nikon-F2 or F2S camera with motor drive unit and 105, 135, or 70-210 mm tele-zoom lenses plus automatic aperture were used. Overlapping photos were taken if more than one photograph was required for complete coverage. High speed Kodak ektachrome film (EH-135-36x) was used at an ASA of 160 or 200. (Reference to brand names does not imply NMFS endorsement). Dark overcast conditions and high travel speeds required shooting at low aperture stops and shutter settings faster than 1/500 sec.

The photographic slides were later projected onto a large roll of white paper for counting. Sea lion images were marked onto the paper during the counting process in order to eliminate duplication. These counts from photographs replaced the corresponding visual estimates made in the field.

Our survey techniques were similar to those conducted from 1957-1968 except that Mathisen and Lopp (1963) used photographic prints rather than transparencies to count sea lions; Kenyon and King (1965) surveyed primarily for sea otters and used only visual estimates for sea lions; Fiscus and Johnson (1968) surveyed from a boat. Kenyon and Rice (1961) used some photographic counts, and comparing them to visual estimates found that: "Counts made from the photographs closely verified the estimates that had been made during the flight" (p. 224).

<u>Data Analysis</u>

In order to effectively evaluate any differences between present and past population estimates, comparisons were made using statistical tests which addressed:

1. Seasonal and yearly differences between rookeries and haul-out sites.
2. Differences in survey thoroughness among years.
3. Differences among surveys with large and small sample range of animal group sizes.
4. Differences among comparable survey sites in the 1975-76-77 sample years.

The following assumptions were made regarding surveys conducted from 1957 to 1977:

1. Precision was similar between surveys.
2. Sea lion haul-out behavior had not changed through time.
3. Survey conditions were similar (e.g. visibility and human biases).

An important factor in the analysis of data among survey years had to do with the time of year the survey was conducted. Not all surveys were flown during the breeding period. Mathisen and Lopp (1963) surveyed in August, late September, and early October, 1957; Kenyon and Rice (1961) surveyed in March, 1960; and Kenyon and King (1965) surveyed in May, 1965. Counts of sea lions during the non-breeding months are less than counts during the breeding season; hence, our statistical comparisons are conservative.

Published figures and counts from our original logs were carefully compared to respective rookery and haul-out sites. In order to minimize biases associated with differences in the counts, the following were done on the survey data: 1) use of maximum counts when two or more visits to a particular site were made on one survey; 2) exclusion of pup counts from surveys made from June through August (pups cannot be easily identified during the breeding season), but inclusion of pups in September and months thereafter was allowed; 3) use of photographic counts rather than visual estimates when available; 4) inclusion of time and date; 5) determination of extent of geographical coverage, and 6) the inclusion of sea lions reported in the water with counts at the closest hauling site.

Nonparametric statistics were generally used in order to avoid assumptions on the data distribution. Theil's distribution free test for the slope of the regression was used, as was Wilcoxon's Signed Rank Test for one sample location of paired replicates (Hollander and Wolfe, 1973). Because of the large sampling effort during some surveys, normal theory (parametric statistics) was also applied where appropriate. The 95 percent confidence level was used as the lowest measure of statistical reliability.

RESULTS AND DISCUSSION

All data collected during the 1975-77 northern sea lion surveys are reported in Table 1. No statistical differences were found among 1975-77 data where the same sites were compared between succeeding survey years (Table 2). Therefore, when appropriate, it was possible to pool the 1975-77 data for comparison with data collected from 1957-1968.

Fewer sea lions were seen during the 1975-1977 surveys than during surveys conducted from 1957-1968 suggesting that a population decline has occurred. Evidence of a decline comes from analysis of the data for differences among survey years, survey sites, and change in group sizes

TABLE 1.--Summary of northern sea lion, Eumetopias jubatus, counts made at rookeries and haul-out sites in the eastern Aleutian Islands, Alaska. Numbers are based on visual estimates or on counts taken from photographs (*). Dashed spaces indicate areas not surveyed; zeros mean no animals were observed.

Map Ref. No.	Location of rookery or haul-out site	1975		1976			1977
		June	Aug.	June	Aug.	Oct.	June
1	Samalga Is.1/	-	90	-	0	153	5
2	Adugak Is.2/	-	1,750*	1,177*	2,000	1,400*	1,842*
	Umnak Is. (so.shore)1/	-	-	-	88	-	139
3	Vsevidof Is.	-	0	-	0	35*	93*
4	Ogchul Is.2/	-	947*	-	1,109*	2,441*	1,130*
5	Polivnoi Rock	-	231*	-	0	-	-
	Umnak Is. (no.shore)1/	-	0	0	8	11	19
6	Cape Aslik	285*	1	221*	5	-	417*
7	Cape Chagak	20	0	0	0	-	62*
8	Reindeer Pt.	0	0	7	0	-	0
9	Cape Idak	0	0	233*	2	-	152*
10	Bogoslof Is.2/	-	1,059*	3,308*	1,591*	490*	2,328*
	Unalaska Is. (so.shore)1/	2	5	-	29	-	13
11	Cape Izigan	-	547*	737*	1,102*	-	1,532*
12	South Rock	-	30*	48*	8	-	1,067*
13	Whalebone Cape	-	1	-	11	-	281*
	Unalaska Is. (no.shore)1/	0	0	0	72	0	2
14	Spray Cape	0	0	0	0	0	2
15	Cape Starichkof	101*	0	78*	0	-	244*
16	Bishop Point	172*	13*	304*	0	136*	501*
17	Pt. Tebenkof	0	0	0	8	0	0
18	Cape Wislow	0	3	0	6	0	0
	Unalaska Is. (e.shore)1/	0	8	0	0	3	4
19	Old Man Rocks	180*	300*	688*	0	-	405*
20	Egg Is.	0	0	32*	0	-	5*
21	Cape Sedanka	0	200	0	0	-	0
22	Sedanka Is.	-	0	364*	0	-	100
23	Outer Signal	-	-	69	6	-	2
	Akutan Is.1/	1	1	0	0	0	6
24	Cape Morgan2/	3,200*	3,585*	3,145*	5,925*	2,345*	2,967*

TABLE 1.--Summary of northern sea lion, *Eumetopias jubatus*, counts made at rookeries and haul-out sites in the eastern Aleutian Islands, Alaska. Numbers are based on visual estimates or on counts taken from photographs (*). Dashed spaces indicate areas not surveyed; zeros mean no animals were observed.--Continued

Map Ref. No.	Location of rookery or haul-out site	1975 June	1975 Aug.	1976 June	1976 Aug.	1976 Oct.	1977 June
25	Reef Bight	365*	188	874*	0	70*	202*
26	Lava Bight	0	178*	0	300	208*	100
27	North Head	0	0	0	-	1	3
28	Battery Pt.	30	1	0	2	0	0
29	Talus Pt.	5	6	0	0	-	0
	Akun Is.1/	0	0	0	0	0	2
30	Akun Head	0	3	0	0	2	0
31	Billings Head Bight	748*	2,641*	1,050*	2,032*	1,133*	1,166*
32	Jackass Pt.	22	0	-	0	2	0
33	Rootok Is.	119*	0	46*	5	66*	0
34	Tanginak Is.	470*	4	358*	20	60*	79*
35	Avatanak Is.1/	1	2	0	0	5	1
36	Tigalda Is. (Rocks N.E.)	80	6	190*	6	75*	84*
37	Tigalda Is.	-	2	314*	19	65	-
38	Kaligagan Is.1/	0	0	0	0	0	1
39	Aiktak Is.	1	0	0	0	0	1
40	Ugamak Is.2/	2,500*	4,569*	4,760*	1,443*	3,765*	5,106*
41	Round Is.2/	-	175*	246*	134*	158*	302*
	Unimak Is. (N & W)1/	63	0	38	39	-	11
42	Cape Sarichef	0	0	0	3	-	4
43	Oksenof Pt.	0	0	2	-	0	0
44	Amak Is.	927*	2,316*	1,777*	1,381*	905*	1,315*
45	Sea Lion Rock2/	2,006*	2,126*	1,944*	2,530*	1,836*	2,130*
46	Unnamed Rock	108*	234*	132*	355*	110*	97*

1/ Includes miscellaneous sightings, usually of animals in the water, or more rarely, hauled out along a broad area but not associated with a specific rookery or haul-out site.

2/ Breeding rookery.

TABLE 2.--Northern sea lion intersurvey data comparison using 1975-77 total counts for the same sites surveyed between succeeding years.

	Sea Lion Counts						
	June 1975	August 1975	June 1976	August 1976	October 1976	June 1977	P 1/
	11,388		15,883				0.127
			21,832			22,224	0.405
		20,663		20,026			0.166
Totals 2/	11,406	21,221	22,142	20,239	15,475	23,922	

1/ Lowest level of statistical significance (Wilcoxon's Signed Rank Test).

2/ Total sea lions seen during that survey; includes sites not visited between survey comparison years.

with time.

Evidence from Unadjusted Survey Totals

Total counts from each survey year conducted between 1957 and 1977 are summarized in Table 3. The 1975-77 estimate of sea lion abundance ($\bar{x}$ = 19,068; n = 6) is 52.1% of the 1957-68 counts ($\bar{x}$ = 36,614; n = 4). The regression was not statistically significant (P = 0.117) because of the large sample variance between sites. Site coverage ranged from 42% in 1957 to 98% in 1977.

More haul-out sites and rookeries were visited in recent years than in the past (n_1 Table 3); however many of these sites had few or no animals on them (e.g., 21 in August 1975). Earlier survey reports often excluded sites where few animals occurred or the counts were pooled with nearby sites; hence the comparisons made for this test are conservative. Because the 1975-77 data include all sites (n 1975-77 > n 1957-68), the actual difference between 1957 and 1975-77 is probably greater than summary figures show.

Evidence from Total Count, Intersurvey Group Sizes

Mean group size was calculated for each survey from 1957 to 1977 (Table 3). Intersurvey group size comparison reduces the bias associated with differences in survey coverage. Group size was determined for sites with greater than 45 animals (45 was the smallest group size reported for this study area by Mathisen and Lopp (1963)). This adjustment to the number of sites visited (n_2 Table 3) during any one survey was made to minimize the effect of data excluded from published sources when very few animals were present or when small groups of sea lions may have been pooled with larger adjacent groups. It may also be noted that 81% of the

TABLE 3.--Summary counts of northern sea lions, *Eumetopias jubatus*, from the eastern Aleutian Islands, Alaska, from 1957-1977. Also recorded are the number of sites visited where sea lions were observed (n_1); number of sites visited with 45 or more animals per site (n_2); and the mean ($\bar{x} \pm$ standard error) number of sea lions per site.

Survey Period Year	Month	Total Survey Counts	n_1	Total Adjusted[1/]	n_2	$\bar{x} \pm \frac{s}{\sqrt{n_2}}$	Reference
1957	Aug.-Oct.	44,637	14	44,637	14	3,188 ± 1,283	1
1960	March	52,540	20	52,520	18	2,918 ± 1,287	2
1965	May	28,220	13	28,185	9	3,132 ± 1,373	3
1968	June	21,057	20	21,050	7	3,007 ± 1,442	4
1975	June[2/]	11,406	29	11,324	12	946 ± 374	5
1975	August	21,221	40	21,136	12	1,764 ± 517	5
1976	June	22,142	35	22,063	18	1,226 ± 380	5
1976	August	20,239	41	20,062	10	2,007 ± 599	5
1976	October	15,475	26	15,416	13	1,184 ± 373	5
1977	June	23,922	40	23,838	20	1,192 ± 337	5

1/ Total count for sites with 45 or more animals.

2/ Poor survey conditions due to weather.

Note: Where sites were subdivided by some researchers and not by others, cumulative figures are used.

References:

1. Mathisen and Lopp (1963)
2. Kenyon and Rice (1961)
3. Kenyon and King (1965)
4. Fiscus and Johnson (1968)
5. Braham et al. (1977)

sites (n = 16) had 100 or more animals per group in 1957, while only 20% of the groups ($\bar{n}$ = 41) had over 100 in 1975-77.

From data used in Table 3, a decline in group size is evident from 1957 to 1977. A test for linearity shows a significant regression (Fig. 2; $r^2 = 0.82$, and slope = -104.5). The mean group size in 1975-77 is 45.3% of the 1957-68 mean.

Evidence from Matching Sites between Survey Years

When comparing the same sites visited between survey years we find a significant decline has occurred since 1957 (Table 4). Analysis of these data was performed by comparing only those survey sites visited among each pair of survey years respectively. That is, Mathisen and Lopp's (1963) 1957 counts were compared to each of the succeeding surveys, and the 1975-77 counts (maximum values) were compared to each of the previous surveys. Each pair of comparisons for among survey differences was analyzed separately in order to better evaluate the decline. Approximately 20,000 more sea lions were present during the 1957 survey than during the 1975-77 surveys ($P = 0.009$). Note that maximum counts were used from 1975-77 data, thus increasing the conservative nature of the comparisons.

Percentile differences for matched sites between survey years also indicates a significant population decline ($P = 0.042$; Fig. 3). The results are the same whether the 1957 data are compared to each succeeding survey year (Fig. 3a), or when the 1975-77 data are compared to preceding survey years (Fig. 3b). Regression analysis indicates that the current population is 44.9% to 54.3% of the 1957 estimate.

This test assumes the continuity of site selection by sea lions. If large aggregations were displaced in 1975-77 to areas with no counts in 1957, a biased decrease may occur in the analysis. This assumption is

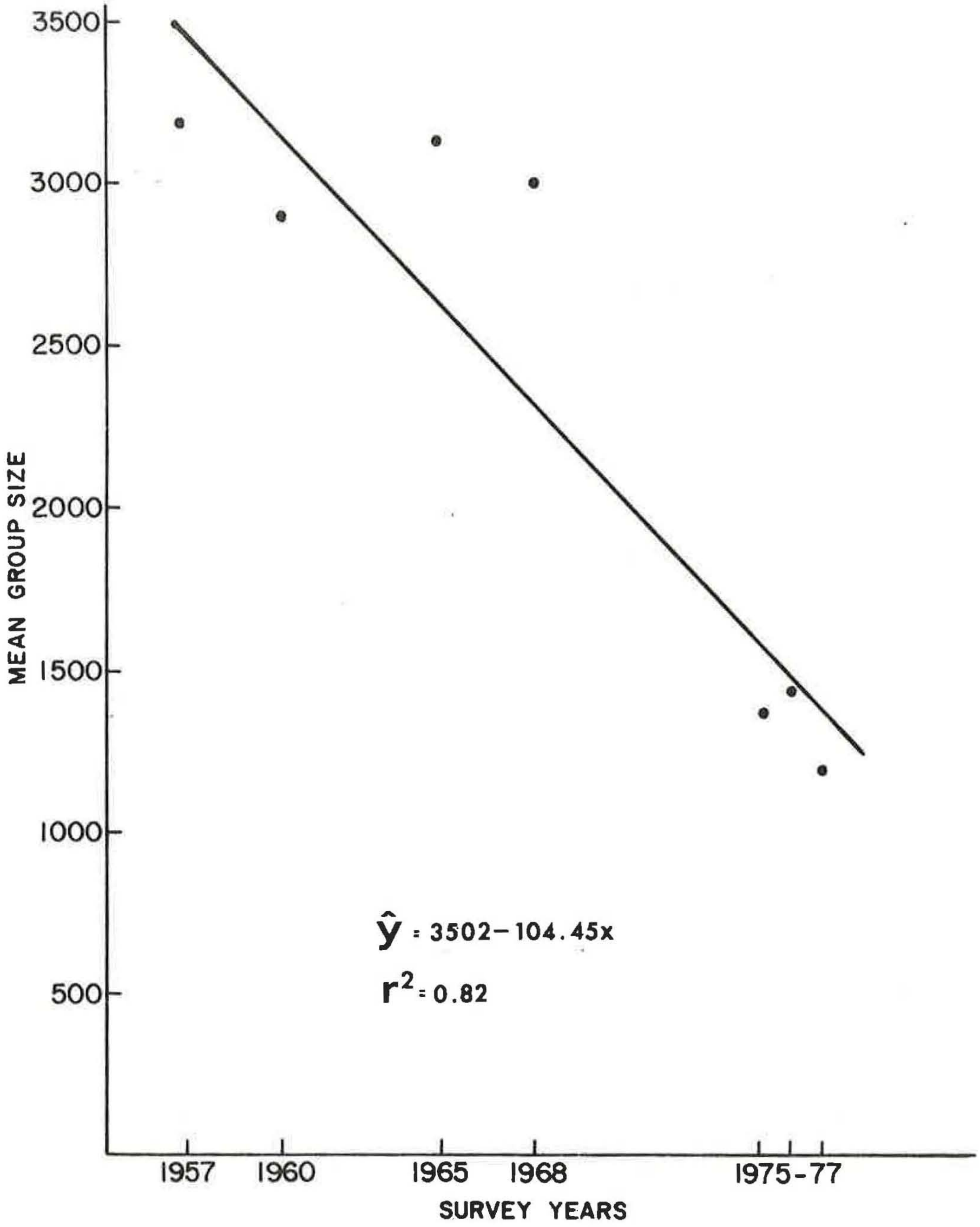

FIGURE 2. Regression analysis of mean sea lion group size among survey years, 1957 to 1977. Only sites with >45 animals were included in the analysis.

TABLE 4.--Actual and percent decrease in the population level of northern sea lions, *Eumetopias jubatus*, in the eastern Aleutian Islands from 1957 to 1977. Comparative values come from the same sites visited between years. The 1975-77 values are maximum counts for those years except when identical months can be compared. Multiple counts by both of a pair of surveys allows increased comparisons.

Comparison of site specific sea lion counts						
1957	1960	1965	1968	1975-77	Percent difference	P 1/
41,685	45,120				108%	0.500
34,702		25,275			73%	0.047
29,635			19,300		65%	0.156
65,498				33,952	52%	0.009
			21,057	14,365	68%	0.165
		28,220		22,110	78%	0.500
	52,540			30,130	57%	0.068

1/ Level of statistical significance (Wilcoxon's Signed Rank Test).

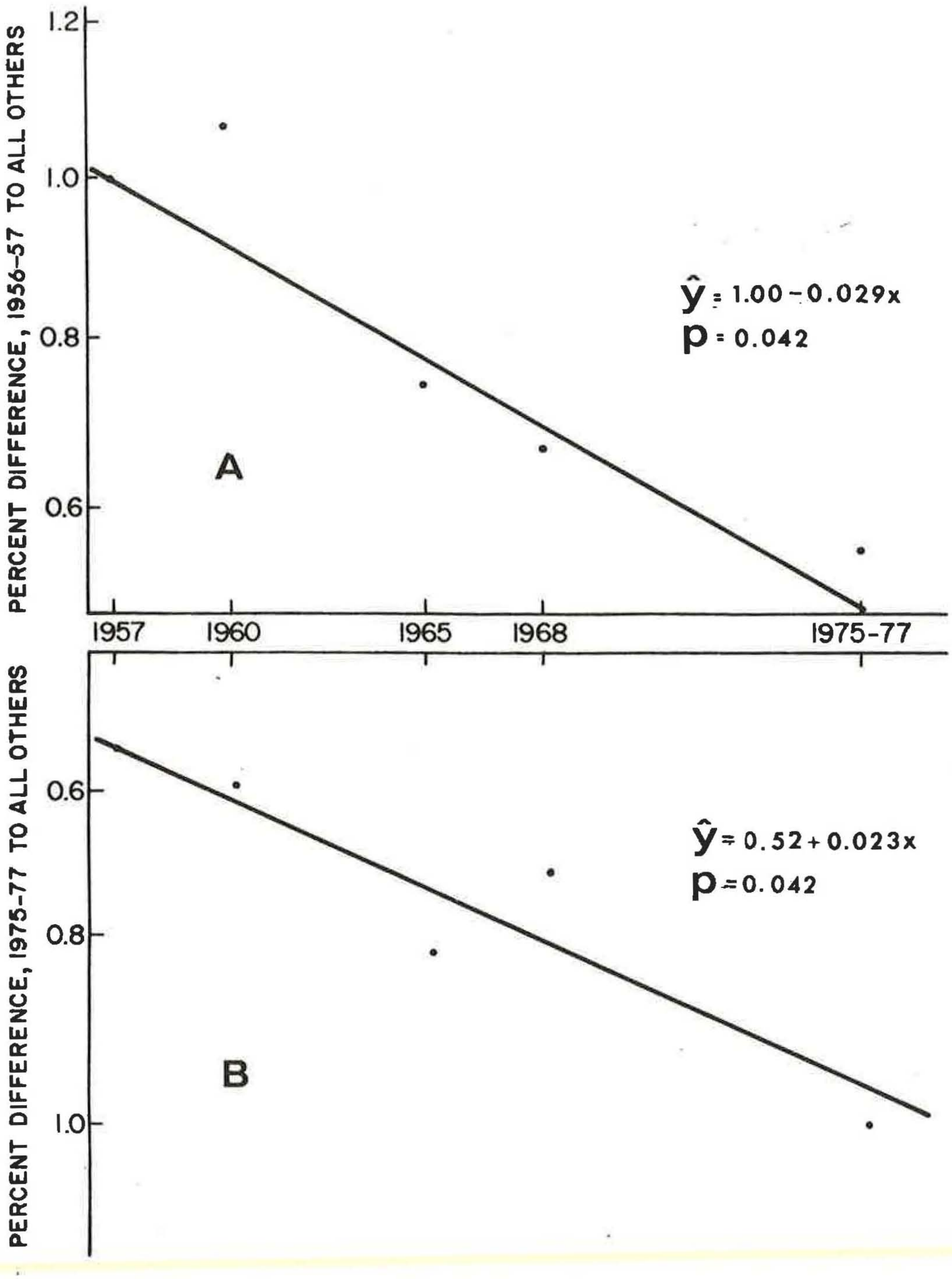

FIGURE 3.--Nonparametric regression analysis (Theil's Test) for percent differences in the number of sea lions at the same haul-out sites (A) comparing 1957 with each succeeding year's survey, and (B) comparing 1975-77 with each preceding year's survey.

justified by (1) noting that the current population is approximately 52% of the 1957 estimate using total counts (Table 3) - considering the increased thoroughness in survey coverage in 1975-77 over earlier years, total counts should have gone up proportionately if the sea lion population was stable or rising; (2) nine sites with major declines (>90% each) had 13,852 fewer sea lions after 1975 while nine sites with major increases had 1,586 more sea lions after 1975 for a net loss of 12,266 animals; (3) sea lions were seen on eight sites prior to 1975 but not after, involving 8,248 animals, but seven sites were used after 1975 and not before, involving only 1,894 animals, (4) rookery sites have been consistently selected by sea lions at least since 1957 and on these sites counts have dropped to less than 40% of the 1957 estimate (see below). The general nature of the population decline is reflected in the disproportionate breaking up of traditional haul-out and rookery sites, with fewer animals hauling out at new sites.

Evidence from Inter-rookery Comparison

The coefficient of variation (100 x standard deviation ÷ mean) for 1975-77 rookery data was found to be significantly lower than for the 1975-77 haul-out site data ($P = 0.0003$). The 1975-77 rookery counts would thus be a more statistically precise representation (smaller variance) of any difference in abundance among years. Counts from all rookeries surveyed between 1957 and 1977 are summarized in Table 5.

Since 1957 and 1960, a significant decline has occurred in the number of animals at the six major breeding locations ($X^2 < 0.01$; test for homogeneity). The mean 1975-77 total is 38.2% of the mean 1957-60 total. The October 1976 total is 34.4% of the October 1957 total. The major

TABLE 5.--Rookery counts between aerial survey years for northern sea lions, *Eumetopias jubatus*, in the eastern Aleutian Islands. The June 1968 data were collected while aboard a boat.

Sea Lion Rookeries	Survey Dates										
	1957 October	1960 March	1965 May	1968 June	1975 June	1975 August	1976 June	1976 August	1976 October	1977 June	P[1/]
Adugak Is.	1,371	1,000	400	-	-	1,750	1,177	2,000	1,400	1,842	0.136
Ogchul Is.	3,391	2,000	-	-	-	947	-	1,109	2,441	1,130	0.117
Bogoslof Is.	3,707	1,100	-	-	-	1,059	3,308	1,591	490	2,328	0.592
Cape Morgan[2/]	7,675	15,720	9,000	6,700	3,565	3,951	4,019	6,225	2,623	3,269	0.028
Ugamak Is.[3/]	16,002	19,400	10,975	10,000+	2,500	4,744	5,006	1,577	3,923	5,408	0.015
Sea Lion Rk.	5,118	2,000	4,100	-	2,006	2,126	1,944	2,530	1,836	2,130	0.068
Totals	37,264	40,220				14,811		15,387	12,823	16,204	

1/ Lowest level of statistical significance using Theil's Test for regression.
2/ Cape Morgan counts include all sightings from Cascade Bight to Lava Bight.
3/ Round Island (#41, Fig. 1) counts were pooled with the Ugamak Island counts.

decrease in animals occurred at Cape Morgan (P = 0.028) and Ugamak Island (P = 0.015). These two locations account for 54% of all animals found on rookeries in the study area (Braham et al., 1977).

Evidence from Maximum and Minimum Data, 1957 Versus 1975-77

From Mathisen and Lopp's (1963) published data it is estimated that 44,637 sea lions were present in the study area in 1957. The estimate of the number of animals seen during the 1975-77 surveys at the same sites varied depending on whether a pooled, direct, or conservative comparison is made (Table 6).

The overall range in percent difference of the sea lion population estimates since 1957 is 29-77%. Column A and Column C in Table 6 are likely to be biased estimates because pooled maximum figures overestimate, and minimum figures underestimate the true counts during 1975-77. Data in Column C (1975-77) reflect poor survey conditions and incomplete area coverage. As such, Column B (54%) more accurately reflects the difference in population size through the past twenty years.

Summary and Conclusions

The population total using current sea lion counts in the study area is approximately 52% of the estimate made in 1957 (a decline of 48%); however, incomplete survey coverage prior to 1975 undoubtedly makes the true difference even higher. By comparing adjusted mean group size by survey since 1957, a statistically significant drop to 45% in the population estimate is evident. When comparing data from matched survey sites between years, the decline is 45 or 54%. Additionally, comparative data among years for the same rookeries show a drop to 34-38%. The tests for differences are summarized in Table 7.

TABLE 6.--Comparison of 1957 and 1975-77 survey data. The 1975-77 estimates are: 1) combined data from all six surveys using maximum count from each site, thus making a model survey of the highest pooled estimate (Column A); 2) an estimate using the largest survey value from any one of the survey years 1975, 1976, or 1977 (Column B); and 3) using the minimum value obtained during any one of the surveys (Column C). (n = number of sites).

Survey Years	Source	Population Estimates Column A (biased maximum)	n	Column B (highest of surveys)	n	Column C (biased minimum)	n
1957	Mathisen & Lopp (1963)	44,637	14	44,637	14	38,764	14
1975-77	Braham et al. (1977); NMFS unpubl. data	34,460	46	23,922[1/]	40	11,406[2/]	29
Percent difference		77.2%		53.6%		28.5%	

1/ June 1977
2/ June 1975

TABLE 7.--Summary of tests used as evidence for a northern sea lion population decline in the eastern Aleutian Islands, Alaska

Evidence from	Actual Decline	P[2/]	Statistical Test	Refer to
Unadjusted survey totals	25,570[1/] (48%)	0.117	Theil's	Table 3
Adjusted mean group sizes	54%	0.005	Method of Least Squares	Table 3 Figure 2
Matched survey site totals	>20,000 46-55%	0.009 0.042	Wilcoxon's Theil's	Table 4 Figure 3
Intersurvey rookery totals	62-66%	0.010	Chi-square	Table 5
Maximum less minimum counts, 1957 versus 1975-77	46%	-	-	Table 6

1/ Comparing the mean ($\bar{x}$ = 19,068) 1975-77 data to the 1957 data.

2/ P ≦ level of statistical significance.

The actual decline in the northern sea lion population in the eastern Aleutian Islands since 1957 may be estimated at 40-50%. This estimate is considered conservative because:

1. The 1975-77 counts were taken almost entirely from photographs which generally provide 10-15% higher counts than do visual estimates (Braham et al., 1977), which suggests those earlier surveys, which relied principally on visual estimates, reflected comparatively lower counts.

2. Maximum counts from each site for 1975-77 data were routinely used during the statistical comparisons resulting in inflated abundance estimates; earlier surveys generally experienced each site only once.

3. The 1975-77 data were collected when sea lions are most likely to haul-out in near maximum numbers (i.e. June-August); whereas pre-1975 surveys were generally made during months when fewer sea lions would be expected to haul-out (e.g. October 1957; March 1960; May 1965).

4. The 1975-77 surveys were specifically designed to count sea lions at all sites in the study area whereas Kenyon and King (1965) were principally looking for sea otters, and Fiscus and Johnson (1968) surveyed only the Krenitzen Islands (i.e. east of Unalaska Is.).

There are many potential causes for the population decline in the study area. A shift in distribution is plausible; however, the number of sea lions east of the study area is apparently not increasing (D. Calkins, Alaska Dept. of Fish and Game, pers. comm.). No current data are available for the Aleutian Islands west of the study area. Emigration to the west cannot, therefore, be ruled out. A slight west to east decrease in total number of sea lions in the study area was evident since

1957 though the data are too incomplete to be statistically reliable. The present number of sea lions in the western Aleutian Islands represents a major data gap.

Recent findings of leptospiroitic antibodies in individual northern sea lions collected on the southern Bering Sea pack ice (F. Fay, pers. comm.) suggests that the Alaska population has been exposed to this disease. The number of California sea lions, Zalophus californianus, along the west coast of North America was apparently reduced by leptospirosis in the early 1970's (Vedros et al., 1971).

Although certainly inconclusive, some correlation may be made between the apparent decline in eastern Aleutian Island sea lion population and the increase in adjacent Bering Sea and North Pacific commercial fisheries since the 1960's. The total catch of ground fish (e.g. turbot, sole, halibut, sablefish, perch, pollock, etc.) near the study area was up 79% from 1960; and the walleye pollock fishery was, in 1974, only 56% of the 1968-69 estimate (Low, 1976). In describing 15 major fish species in the southern Bering Sea, Low (1976) reports that four are becoming fully exploited commercially, five have become fully exploited, and six are overexploited. Although Fiscus and Baines (1966) report that sea lions do not generally prey on commercial fish taken in the United States fisheries, except near fishing boats, increased competition within the ecosystem cannot be overlooked. Also, Soviet and Japanese fisheries include sea lion prey items (e.g. pollock, herring, capelin).

Adult male sea lions were commercially harvested at Ugamak Island in 1959 (Thorsteinson et al., 1961; Thorsteinson and Lensink, 1962). Month old male and female sea lion pups were commercially harvested at Ugamak and Akutan Islands from 1970-72 (Alaska Dept. Fish and Game, unpubl. data). The numbers taken were:

	Ugamak Island	Akutan Island	Totals
1970	525	2,159	2,684
1971	1,064	2,250	3,314
1972	2,184	1,627	3,811

In this paper we have shown that the Ugamak Island and Cape Morgan (Akutan Island) rookeries experienced the greatest population decrease (Table 5). What effect harvesting has on sea lion production is not clear, especially if the population is already depressed. Evidence from studies on Sugarloaf Island, Alaska, indicate that production increases when animals are harvested (D. Calkins, pers. comm.). However, the number of surviving pups produced at Ugamak Island and at Cape Morgan during this three year period (using 1968 estimates and assuming;1) 6,700 breeding females were present [i.e. 50% of animals counted were females]
2) 70% of the females gave birth (Pike and Maxwell, 1958); and
3) 14% natural pup mortality occurred (Sandegren, 1970), for a net production of 4,000 sea lions) nearly equals the total pup harvest between 1970 and 72. The aforementioned assumptions and values are conservative; therefore the loss of three years of a cohort of pups might be significant in the total populations for the respective islands. Female pups harvested in 1970-72 would have been entering the breeding population in 1975-77 (there was no discrimination between male and female pups in the harvest).

Return of management to the State of Alaska of the northern sea lion and eight other species of marine mammals is presently planned (DEIS, 1976). Management decisions and problems associated with sea lion fisheries interaction, harvest limits, and the potential impact of oil and gas exploration near the study area cannot be fully addressed until additional research is conducted on the population dynamics of the northern sea lion throughout the Aleutian Islands.

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