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Distribution and Abundance of Sea Otters in Southwestern Bristol Bay

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I. Summary

A systematic aerial strip transect census of sea otters was conducted north of Unimak Island and the Alaska Peninsula. The main range of the population extended from Cape Mordvinof to Cape Lieskof including Bechevin Bay, Izembek Lagoon and Moffet Lagoon. Portions of the population range over 40 km from shore. Small numbers are believed to be scattered to the west and northeast particularly near Port Moller. This range was greatly reduced from that observed in 1970 as a result of mortality caused by extreme sea ice conditions in 1971, 1972 and 1974. No range expansion has been observed since 1972; however, repopulation of former habitat between Cape Lieskof and Port Heiden should occur in the absence of severe sea ice conditions.

Survey results were expanded to indicate a total population of over 17,000 sea otters. The present population appears below the 1970 level and within the carrying capacity of the present range. Distribution within the range was influenced by water depth and perhaps weather. Observed densities averaged 3.1 sea otters/km^2 in waters 0 to 20 m deep, 5.8/km^2 in water 20-40 m deep, 0.5/km^2 in water 40-60 m deep and 0.03/km^2 in water over 60 m deep. Previous surveys indicate that at times higher densities occupy waters between 40 and 80 m deep. Few animals stray beyond the 80 m depth contour. The area between Cape Mordvinof and Cape Lieskof from shore to the 60 m contour including Bechevin Bay should be considered critical to the survival of this population.

II. Introduction

A large, and in many respects unique, population of sea otters occupies the shallow waters of southwestern Bristol Bay north of the Alaska Peninsula and Unimak Island. Most sea otter populations reside close to shore, concentrating in areas with offshore rocks and kelp beds. In contrast, otters in this population range widely in offshore waters. While at times they concentrate within a few kilometers of the adjacent sandy beaches, they frequently scatter to the vicinity of the 80 m depth contour, 50 km or more from shore.

Sea otters are probably the most vulnerable of all marine mammals to the direct effects of oil. Unlike most marine mammals they have no thick blubber layer. They rely on air trapped in their dense fur for conservation of body heat and buoyancy. When clean, this mat of fur is waterproof and the skin over most of the body remains dry. If the fur is soiled it loses its water repellency and its insulative quality. If this is not corrected quickly the animal will die of hypothermia. While little information is available on the quantities and types of petroleum products necessary to kill a sea otter it appears that relatively small amounts of both refined fuels and crude oil will cause death (Kenyon no date, Schneider unpublished data). Kenyon (1969) cited cases where massive kills may have occurred near shipwrecks.

Long-term secondary effects of chronic pollution on all high trophic level species are possible if one or more of the links in the food chain are affected. Sea otters require large quantities of food (20 to 25 percent of their own body weight per day) to support a high metabolic rate. The main factor limiting most sea otter populations appears to be food availability. Sea otters in most areas appear to feed on relatively sessile organisms. Therefore, they may be exceptionally sensitive to changes in the food chain and any effects would tend to be site specific.

The southwestern Bristol Bay sea otter population appears to be vulnerable to oil spills. It is bounded by the proposed Bristol Bay OCS lease area and by Unimak Pass, a potential hazard area for tankers. The population periodically concentrates, making it possible for a small spill to directly kill large numbers of otters. This population appears to be a likely source of otters that will repopulate the Fox and Krenitzin Islands. These island groups contain some of the largest areas of unpopulated sea otter habitat remaining in Alaska and, at present, support only a few tenuously established groups of sea otters. A severe reduction of the Unimak-Alaska Peninsula population could delay repopulation of these islands for many years.

The range and distribution of the Bristol Bay population have fluctuated in recent years, partly as a result of periodic formation of sea ice (Schneider and Faro 1975). There appear to have been some fluctuations in numbers but no reliable estimates have been made.

The objectives of this project were to:

1. Determine the current range of the population.

2. Determine the distribution of sea otters within that range.

3. Identify areas of potentially critical habitat.

4. Estimate the size of the population.

Of particular interest were the offshore limits of distribution, distribution in relationship to water depth, characteristics of the northeastern fringe of the range of the main population, which can be expected to change in the future, and the precise locations of high densities of sea otters that might indicate areas of abundant food organisms.

III. Current State of Knowledge

A number of fixed-wing aerial surveys of the study area have been flown since 1957 by U. S. Fish and Wildlife Service and Alaska Department of Fish and Game personnel. The most significant counts are summarized in Table 1. None of these surveys systematically covered the entire area and the numbers of sea otters counted varied greatly. A general pattern of changes in distribution is evident however.

A remnant population probably survived the period of commercial exploitation prior to 1911. This population was concentrated north of Unimak Island

Table 1. Significant sightings of sea otters along the north side of the Alaska Peninsula and Unimak Island.

	1957	1958	1962	1965	1969	1970	March 1971	Oct. 1971	March 1972	May 1972	Oct. 1972 to June 1973	June 1975	Aug. 1975
Cape Chichagof to Cape Greig										0	4	0	0
Cape Greig to Reindeer Creek				0				4		0		0	0
Reindeer Creek to Cape Kutuzof				0			5	40		0	3	0	0
Cape Kutuzof to Cape Lieskof				39			74	60	18	1		2	0
Cape Lieskof to Moffet Point				20			38	24	1	2		24	0
Moffet Point to Otter Point	786		811	2765	330	2157	20	273	400-600	79		198	2585
Otter Point to Cape Mordvinof				58	152							1	19
Cape Mordvinof to Cape Sarichef				10	0							0	1
Cape Sarichef to Scotch Cap		75										0	0
Total	786	75	811	2892	482	2157	137	401	-	82	7	223	2605

1957-1965 from USFWS reports by Kenyon and Lensink.
1975 Surveys conducted under RU 67 Outer Continental Shelf Environmental Assessment Program.
None of these surveys covered the entire area. The primary purpose of this table is to demonstrate changes in distribution and relative abundance in some areas.

and Izembek Lagoon. During the early 1960's it expanded its range to the vicinity of Port Moller although the largest numbers remained north of Izembek Lagoon (Kenyon 1969). By 1970 sea otters were common as far northeastward as Port Heiden and occasional individuals were seen near Ugashik and Egegik Bays. In 1971, 1972 and 1974 sea ice, which normally forms only to the vicinity of Port Heiden, advanced to Unimak Island. Many sea otters were killed and others were forced southwestward (Schneider and Faro 1975). The cumulative effects of the 3 years of ice formation appeared to severely restrict the range of this population to the area west of Cape Lieskof. Occasional sea otters have been sighted to the northeast of that point particularly near Port Moller; however, no established groups have been located and no evidence of expansion of the main population into formerly occupied habitat northeast of Cape Lieskof has been found since 1972 (Fig. 1).

The effects of the sea ice on numbers of sea otters were less evident. Mortality of several hundred sea otters was observed in 1971 and 1972 and the possibility that several thousand died existed. The lack of range expansion suggests that densities of sea otters west of Cape Lieskof are lower than those in the 1960's when considerable range expansion occurred. This suggests that a significant reduction in numbers did occur.

Because potential range of the population covers over 10,000 km^2 of open water, traditional survey methods have not been adequate to estimate the size of the population. Kenyon (1969) estimated that the population was over 3,800 in 1965 but more recent information indicates that his

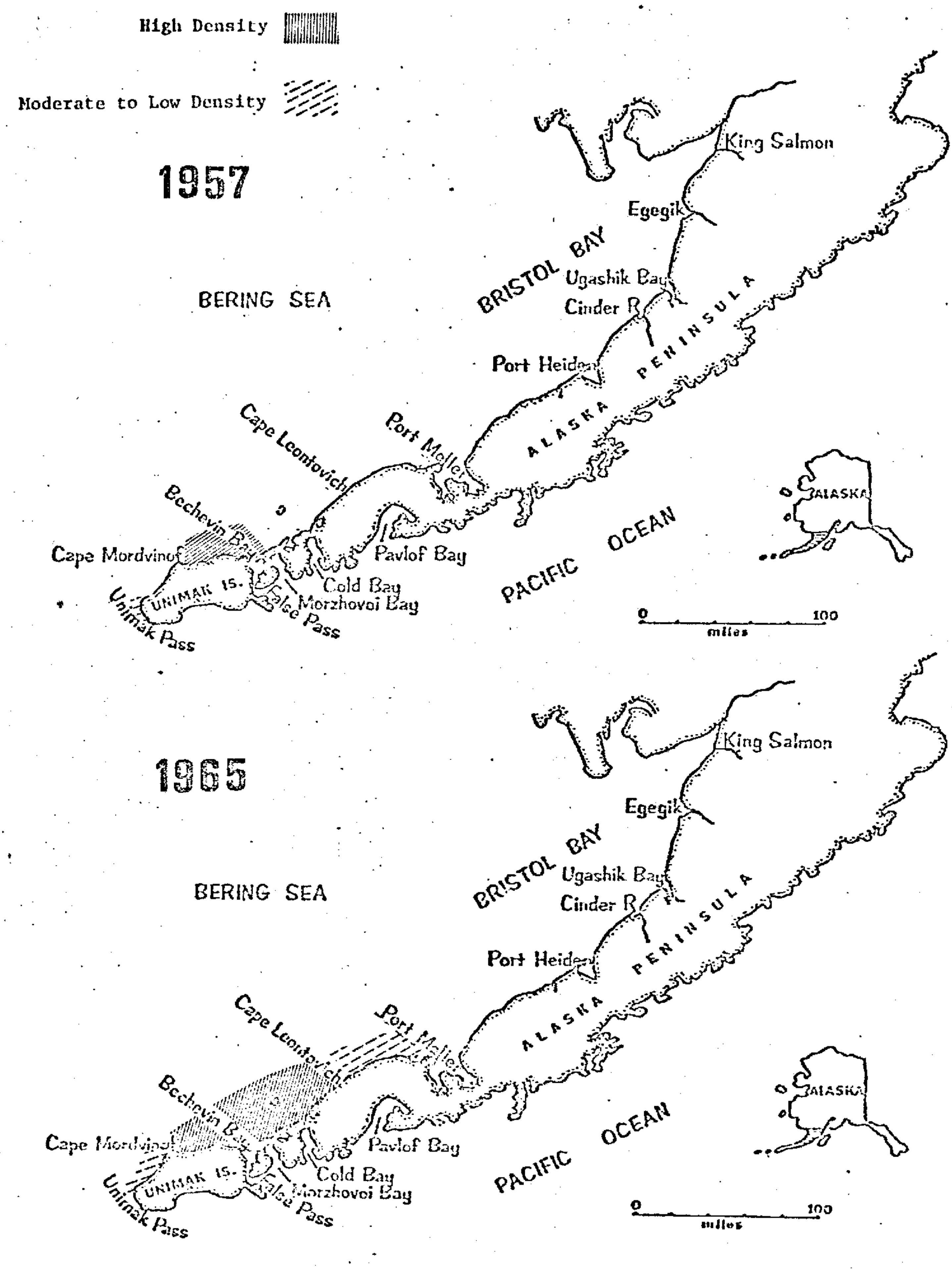


Figure 1. Changes in distribution of sea otters north of the Alaska Peninsula and Unimak Island 1957-1965.

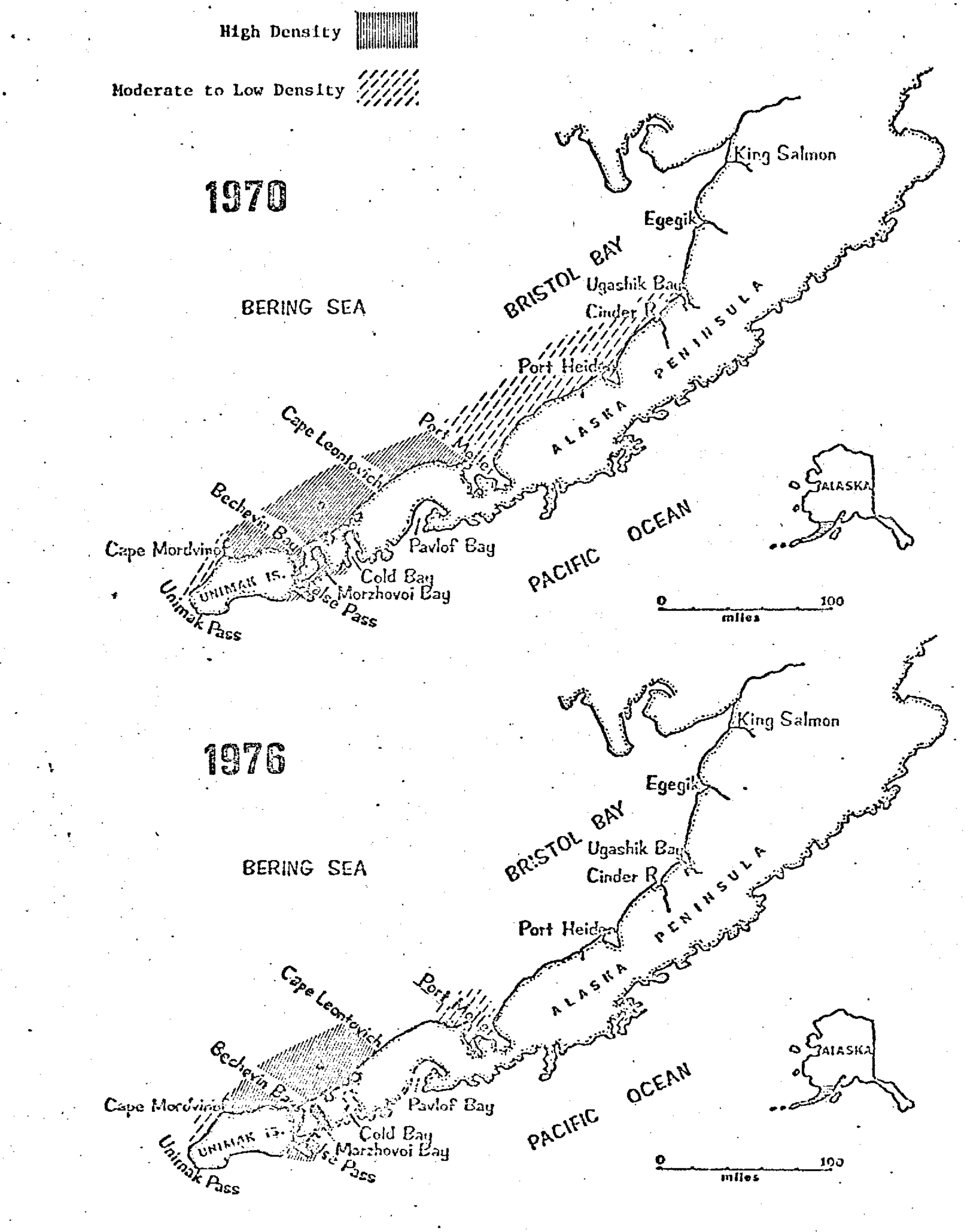


Figure 1.(cont'd.) Changes in distribution of sea otters north of the Alaska Peninsula and Unimak Island 1970-1976.

survey did not cover the entire range of the population and that considerable population growth occurred after that time. In 1970 a total of 2,157 sea otters was counted in photographs of several pods clustered southeast of Amak Island. One of these pods was the largest ever recorded, containing over 1,000 sea otters. No pups were visible in the photographs, indicating that all segments of the population were not represented. Crude estimates made from aerial surveys conducted prior to 1970 indicated that this population contained on the order of 8,000 to 10,000 sea otters (Alaska Department of Fish and Game 1973). These estimates would not stand up to statistical scrutiny however.

IV. Study Area

At one time or another parts of this population have been observed in the waters north of Unimak Island and the Alaska Peninsula from Scotch Cap to Egegik Bay (Fig. 1). They have occupied Bechevin Bay, Izembek Lagoon and Port Moller frequently and probably at least small numbers have used all of the bays and lagoons in the area. Surveys indicate that large numbers may occasionally move offshore to the vicinity of the 80 m depth contour north of Unimak Island and Izembek Lagoon. Some otters have been sighted 50 km from shore and one moribund animal was found over 100 km from shore (T. Newby, pers. comm.). The potential study area delineated by these observations is over 10,000 km^2.

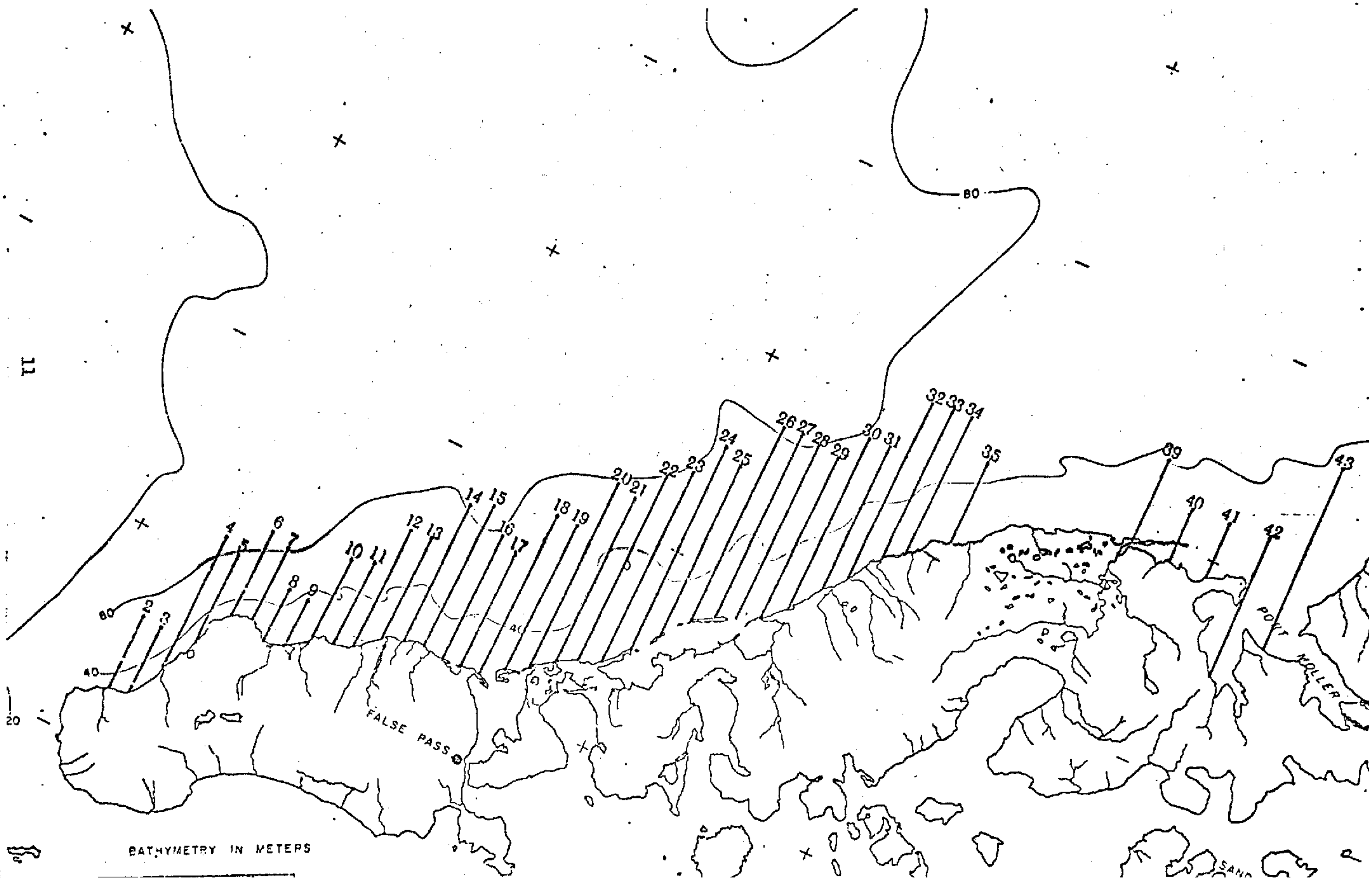
Although information was gathered throughout the entire area during the contract period, most of the effort was directed at the area from Cape Sarichef to Port Möller.

V. Methods

Information on the distribution of the population was gathered on aerial surveys conducted under RU 67 in June and August 1975 and RU 243 in June 1976. These surveys were made from a Grumman Super Widgeon flown in an irregular pattern over concentrations of marine mammals. All sea otters sighted were counted visually or photographed with motor-driven 35 mm cameras.

On 30 and 31 July 1976 a systematic aerial survey of the main population's range was made. The survey platform was the U. S. Department of Interior, Office of Aircraft Services turbo Goose N780. The aircraft was flown along predetermined tracklines which generally extended along north-south lines extending from shore to the vicinity of the 80 m depth contour. Navigation was aided by the Global Navigation System (GNS 500). Corrected flightlines are shown in Fig. 2. The aircraft was maintained at a constant altitude of 200 feet (61 m) and a constant airspeed of 120 knots (222 km/hr). Two observers counted all sea otters seen within 0.1 nautical mile (185 m) strips on either side of the aircraft. Strip width was determined with the aid of an inclinometer specifically designed for the survey. Allowance was made for a strip directly under the aircraft that was not visible to the observers. All observations were transmitted over a portable intercom system to a third individual who recorded them on standardized data sheets. For each group of sea otters the time of the observation, group size, side of the aircraft and whether they were resting or active were recorded.

Figure 2. Strip Transects flown on 30-31 July 1976 sea otter survey.



Two other observers sat in the rear of the aircraft and recorded all sea otters seen regardless of distance from the aircraft. Particular attention was paid to the occurrence of large pods outside of the limited strip transects. While these observers counted "unlimited" width strips, their range was limited by a variety of conditions and no duplication occurred on consective transects. One of the observers recorded observations for both rear observers.

Both recorders synchronized stop watches at the start of each transect and recorded the times of observations to the nearest second. The recorder for the limited strip survey also periodically recorded latitude and longitude indicated by the GNS 500. This procedure permitted fairly precise determination of the location of each observation and facilitated comparison of observations between the limited and unlimited strip surveys.

An irregular flight pattern was used in Bechevin Bay as past surveys indicated that sea otters tended to concentrate in specific parts of the bay making a strip census inappropriate. A direct count was made of this area.

Visibility conditions were classified for each transect according to the following system:

Code

1 Excellent - surface of water calm, usually a high overcast sky with no sun glare. Sea otters appear dark against a uniformly light gray background of the water's surface. Individuals easily distinguished at a distance.

2 Very good - May be light ripple on water's surface or slightly uneven lighting but still relatively easy to distinguish individuals at a distance.

3 Good - may be light chop, some sun glare or shadows. Individuals at a distance may be difficult to distinguish but individuals nearby and small groups at a distance are readily identified.

4 Fair - usually choppy waves and strong sun glare or dark shadows in part of the survey track. Individuals in kelp beds, in the lee of rocks, or near the observer and most pods readily identified but most individuals and some pods in areas of poor lighting or at a distance difficult to distinguish.

5 Poor - individuals difficult to distinguish unless very close and some pods at a distance may be missed, however, conditions still good enough to give a very rough impression of the distribution of animals.

6 <u>Unacceptable</u> - heavy chop with many whitecaps, lighting poor or large waves breaking on rocks. No surveys should be conducted under these conditions but occasionally a sighting of significance may be made in the course of other activities.

This system differs somewhat from that used by Estes and Smith (1973), but is similar to that used by Kenyon (1969).

Personnel participating in the 30-31 July survey were Herman Reuss - pilot, John Sasso - co-pilot, Karl Schneider and Kenneth Pitcher - limited strip observers, Roger Aulabaugh - recorder, Donald Calkins and James Faro - unlimited strip observers. Paul Arneson conducted a survey of birds under RU 3/4 from the rear of the aircraft. Distances were expressed in nautical miles because this unit's relationship to latitude and the speed of the aircraft facilitated the plotting of observations.

VI. Results

Results of the survey are presented in Tables 2 and 3. Each transect was broken into 2 nautical mile (3.7 km) long segments. Segment A extended from shore to 2 nm (3.7 km) from shore, segment B from 2 nm (3.7 km) to 4 nm (7.4 km) from shore, etc. Each segment in the limited width strip survey would represent two parallel rectangles 2 nm (3.7 km) long and 0.1 nm (0.185 km) wide separated by approximately 50 m. The total area surveyed in each limited width segment was 0.4 nm^2 (1.37 km^2). Each segment also represents approximately 1.0 minute of survey time. The data have been grouped into these segments for convenience.

Table 2. Results of sea otter transect survey north of the Alaska Peninsula and Unimak Island - 30 and 31 July 1976.

Transect Number	Trackline Deg. Min. Longitude	Start Date/Time ADT Day	Hour Min.	Visibility Code	Sea Otters Counted: Left Track (0.1nm) Resting	Left Track (0.1nm) Active	Right Track (0.1nm) Resting	Right Track (0.1nm) Active	Total 0.2nm Track	Total Unlim. Track	Density 0.2nm Track (Otters/nm²)	Ratio Unlimited/ 0.2nm Track *
2 A	164° 50'	31	1221	6	0	0	0	0	0	0	0	
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	0	0	
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	0	0	
3 A	164° 45'	31	1214	2	0	0	0	0	0	0	0	
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	0	0	
4 A	164° 40'	.31	1202	2	0	0	0	0	0	0	0	
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	0	0	
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	0	0	
G					0	0	0	0	0	0	0	
H					0	0	0	0	0	0	0	
I					0	0	0	0	0	0	0	
J					0	0	0	0	0	0	0	
5 A	164° 35'	31	1153	2	0	0	0	0	0	0	0	
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	1	0	+
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	0	0	
G					0	0	0	0	0	0	0	
6 A	164° 30'	31	1143	2	0	0	0	0	0	0	0	
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	0	0	
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	0	0	
7 A	164° 25'	31	1136	3	0	0	0	0	0	0	0	
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	0	0	
E					0	0	0	0	0	0	0	

Table 2. (cont'd)

Transect Number	Trackline Deg. Min. Longitude	Start Date/Time ADT Day	Start Date/Time ADT Hour Min.	Visibility Code	Sea Otters Counted: Left Track (0.1nm) Resting	Left Track (0.1nm) Active	Right Track (0.1nm) Resting	Right Track (0.1nm) Active	Total 0.2nm Track	Total Unlim. Track	Density 0.2nm Track (Otters/nm^2)	Ratio * Unlimited/ 0.2nm Track
8 A	164° 20'	31	1128	6	0	0	0	0	0	0	0	
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	0	0	
E					0	0	0	0	0	0	0	
9 A	164° 15'	31	1122	6	0	0	0	0	0	0	0	
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	0	0	
10 A	164° 10'	31	1112	1	2	0	0	2	4	11	10.0	2.8
B					13	0	2	6	21	27	52.5	1.3
C					0	0	6	0	6	26	15.0	4.3
D					0	1	0	0	1	13	7.5	13.0
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	3	0	+
G					0	0	0	0	0	0	0	
11 A	164° 05'	31	1103	1	0	0	0	0	0	0	0	
B					7	0	0	0	7	46	17.5	6.6
C					0	0	15	2	17	50	42.5	2.9
D					0	0	0	0	0	0	0	
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	0	0	
12 A	164° 00'	31	1053.	2	1	0	0	0	1	4	2.5	4
B					21	0	0	7	28	44	70.0	1.6
C					1	1	0	1	3	3	7.5	1.0
D					0	0	0	0	0	0	0	
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	2	0	+
G					0	0	0	0	0	0	0	
H					0	0	0	0	0	0	0	
13 A	163° 55'	31	1044	1	2	2	11	0	15	19	37.5	1.3
B					0	0	0	5	5	4	12.5	0.8
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	1	0	+
E					0	0	0	0	0	1	0	+
F					0	0	0	0	0	0	0	
G					0	0	0	0	0	0	0	

Table 2. (cont'd)

Transect Number	Trackline Deg. Min. Longitude	Start Date/Time ADT Day	Hour Min.	Visibility Code	Sea Otters Counted: Left Track (0.1nm) Resting	Left Track (0.1nm) Active	Right Track (0.1nm) Resting	Right Track (0.1nm) Active	Total 0.2nm Track	Total Unlim. Track	Density 0.2nm Track (Otters/nm^2)	Ratio * Unlimited/ 0.2nm Track
14 A	163° 50'	31	1032	1	4	0	0	0	4	8	10.0	2.0
B					9	0	0	26	35	171	87.5	4.9
C					0	0	0	0	0	3	0	+
D					0	0	0	1	1	0	2.5	0
E					0	0	0	0	0	0	0	
F					0	0	0	1	1	0	2.5	0
G					0	0	0	0	0	0	0	
H					0	0	0	0	0	0	0	
I					0	0	0	0	0	0	0	
J					0	0	0	0	0	0	0	
15 A	163° 45'	31	1020	1	1	1	0	2	4	8	10.0	2.0
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	4	0	+
D					0	0	0	0	0	0	0	
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	0	0	
G					0	0	0	1	1	1	2.5	1.0
H					0	0	0	0	0	0	0	
I					0	0	0	0	0	0	0	
J					0	0	0	0	0	1	0	+
16 A	163° 40'	30	1720	1	3	0	0	0	3	29	7.5	9.6
B					97	0	5	42	144	246	360.0	1.7
C					0	0	4	0	4	17	10.0	4.25
D					3	0	1	0	4	5	10.0	1.25
E					0	0	1	0	1	2	2.5	2.0
F					0	0	0	0	0	2	0	+
G					0	0	0	0	0	0	0	
H					0	0	0	0	0	0	0	
I					0	0	0	0	0	0	0	
17 A	163° 35'	30	1711	2	2	1	0	0	3	6	7.5	2.0
B					0	0	0	1	1	1	2.5	1.0
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	2	0	+
E					0	0	0	0	0	1	0	+
F					0	0	0	0	0	0	0	
G					0	0	0	0	0	0	0	
18 A	163° 30'	30	1658	2	0	0	2	1	3	2	7.5	0.7
B					0	0	2	0	2	1	5.0	0.5
C					0	0	0	0	0	2	0	+

Table 2. (cont'd)

Transect Number	Trackline Deg. Min. Longitude	Start Date/Time ADT Day	Hour Min.	Visibility Code	Sea Otters Counted: Left Track (0.1nm) Resting	Left Track (0.1nm) Active	Right Track (0.1nm) Resting	Right Track (0.1nm) Active	Total 0.2nm Track	Total Unlim. Track	Density 0.2nm Track (Otters/nm^2)	Ratio * Unlimited/ 0.2nm Track
18 D					0	0	0	0	0	0	0	
E					1	2	1	2	6	2	15	0.3
F					0	0	0	0	0	0	0	
G					0	0	0	0	0	0	0	
H					0	0	0	2	2	2	5.0	1.0
I					0	0	0	0	0	0	0	
J					0	0	0	0	0	0	0	
K					1	0	0	0	1	1	2.5	1.0
L					0	0	0	0	0	0	0	
19 A	163° 25'	30	1644	2	0	0	0	0	0	0	0	
B					0	0	0	0	0	44	0	+
C					0	0	0	7	7	2	17.5	0.3
D					0	0	1	1	2	3	5.0	1.5
E					0	2	0	0	2	1	5.0	0.5
F					0	0	0	0	0	0	0	
G					0	1	1	0	2	0	5.0	0
H					0	0	0	0	0	0	0	
I					2	0	0	0	2	1	5.0	0.5
J					0	0	0	0	0	0	0	
K					0	0	0	0	0	0	0	
20 A	163° 20'	30	1320	1	13	2	0	0	15	25	37.5	1.7
B					0	0	0	0	0	2	0	+
C					0	0	0	0	0	0	0	
D					0	0	1	0	1	3	2.5	3.0
E					0	0	0	0	0	0	0	
F					0	0	0	1	1	1	2.5	1.0
G					0	1	0	0	1	0	2.5	0
H					0	0	1	1	2	4	5.0	2.0
I					0	0	0	0	0	0	0	
J					0	0	0	0	0	1	0	+
K					1	0	0	0	1	0	2.5	0
L					0	0	0	0	0	0	0	
M					0	0	0	0	0	0	0	
21 A	163° 15'	30	1307	1	0	0	1	1	2	1	5.0	0.5
B					0	0	0	0	0	1	0	+
C					0	0	0	0	0	3	0	+
D					0	0	0	0	0	0	0	
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	0	0	

Table 2. (cont'd)

Transect Number	Trackline Deg. Min. Longitude	Start Date/Time ADT Day	Hour Min.	Visibility Code	Sea Otters Counted: Left Track (0.1nm) Resting	Left Track (0.1nm) Active	Right Track (0.1nm) Resting	Right Track (0.1nm) Active	Total 0.2nm Track	Total Unlim. Track	Density 0.2nm Track (Otters/nm²)	Ratio * Unlimited/ 0.2nm Track
21 G					0	0	0	0	0	1	0	+
H					0	0	0	0	0	0	0	
I					0	0	0	0	0	2	0	+
J					0	0	0	0	0	0	0	
K					0	0	0	0	0	0	0	
22 A	163° 10'	30	1250	1	0	1	0	1	2	0	5.0	0
B					100	0	0	0	100	50	250.0	0.5
C					0	0	1	0	1	5	2.5	5.0
D					1	0	0	0	1	2	2.5	2.0
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	0	0	
G					0	0	0	0	0	0	0	
H					0	0	0	0	0	0	0	
I					0	0	0	0	0	0	0	
J					0	0	0	0	0	0	0	
K					1	0	0	0	1	1	2.5	1.0
L					0	0	0	0	0	0	0	
M					0	0	0	0	0	0	0	
N					0	0	0	0	0	0	0	
23 A	163° 05'	30	1235	2	0	0	9	0	9	129	22.5	14.3
B					1	1	0	0	2	33	5.0	16.5
C					0	0	1	0	1	20	2.5	20.0
D					2	0	0	0	2	122	5.0	61.0
E					0	0	0	1	1	0	2.5	0
F					0	0	0	1	1	0	2.5	0
G					2	0	0	0	2	1	5.0	0.5
H					0	0	0	0	0	0	0	
I					0	0	0	0	0	0	0	
J					0	0	0	0	0	0	0	
K					0	0	1	0	1	0	2.5	0
L					0	0	0	0	0	0	0	
M					0	0	0	0	0	2	0	
N					0	0	0	0	0	0	0	
O					0	0	0	0	0	2	0	+
24 A	163° 00'	30	1218	2	0	0	0	0	0	0	0	
B					1	3	1	0	5	3	12.5	0.6
C					0	0	0	0	0	1	0	+
D					0	0	0	0	0	0	0	

Table 2. (cont'd)

Transect Number	Trackline Deg. Min. Longitude	Start Date/Time ADT Day Hour Min.	Visibility Code	Sea Otters Counted: Left Track (0.1nm) Resting	Left Track (0.1nm) Active	Right Track (0.1nm) Resting	Right Track (0.1nm) Active	Total 0.2nm Track	Total Unlim. Track	Density 0.2nm Track (Otters/nm²)	Ratio * Unlimited/ 0.2nm Track
24 E				0	0	0	0	0	2	0	+
F				0	0	0	0	0	0	0	
G				0	0	0	0	0	0	0	
H				0	0	0	0	0	0	0	
I				0	0	1	0	1	0	2.5	0
J				0	0	0	0	0	0	0	
K				1	0	0	0	1	1	2.5	1.0
L				0	0	0	0	0	0	0	
M				0	0	0	0	0	0	0	
N				0	0	0	0	0	0	0	
O				0	0	0	0	0	0	0	
P				0	0	0	0	0	2	0	+
25 A	162° 55'	30 1203	1	0	0	0	0	0	0	0	
B				0	0	0	0	0	1	0	+
C				0	0	1	0	1	0	2.5	0
D				2	0	0	0	2	0	5.0	0
E				0	0	0	0	0	3	0	+
F				0	0	0	0	0	0	0	
G				0	0	0	0	0	0	0	
H				0	0	0	0	0	0	0	
I				0	0	0	0	0	0	0	
J				0	0	0	0	0	0	0	
K				0	0	0	0	0	0	0	
L				0	0	0	0	0	0	0	
26 A	162° 50'	30 1146	1	0	0	0	0	0	0	0	
B				0	2	0	0	2	0	5.0	0
C				0	0	0	1	1	2	2.5	2.0
D				2	0	0	0	2	3	5.0	1.5
E				0	0	0	0	0	0	0	
F				0	0	1	0	1	0	2.5	0
G				0	0	0	0	0	1	0	+
H				0	0	0	0	0	0	0	
I				0	0	0	0	0	0	0	
J				0	0	0	0	0	0	0	
K				0	0	0	0	0	0	0	
L				0	0	0	0	0	0	0	
M				0	0	0	0	0	0	0	
N				0	0	0	0	0	0	0	
O				0	0	0	0	0	0	0	

Table 2. (cont'd)

Transect Number	Trackline Deg. Min. Longitude	Start Date/Time ADT Day	Hour Min.	Visibility Code	Sea Otters Counted: Left Track (0.1nm) Resting	Left Track (0.1nm) Active	Right Track (0.1nm) Resting	Right Track (0.1nm) Active	Total 0.2nm Track	Total Unlim. Track	Density 0.2nm Track (Otters/nm^2)	Ratio * Unlimited/ 0.2nm Track
27 A	162° 45'	30	1130	1	1	0	0	0	1	1	2.5	1.0
B					0	2	0	2	4	39	10.0	9.8
C					10	4	22	0	36	52	90.0	1.4
D					0	0	0	0	0	0	0	
E					1	0	0	0	1	2	2.5	2.0
F					0	0	0	1	1	1	7.5	1.0
G					0	0	0	0	0	0	0	
H					0	0	1	0	1	2	2.5	2.0
I					0	0	0	0	0	0	0	
J					0	0	0	0	0	0	0	
K					0	0	0	0	0	0	0	
L					0	0	0	0	0	0	0	
M					0	0	0	0	0	0	0	
28 A	162° 40'	30	1115	1	0	0	0	0	0	1	0	+
B					0	0	0	1	1	38	2.5	38
C					2	1	3	15	21	29	52.5	1.4
D					8	3	2	4	17	19	42.5	1.1
E					3	2	1	8	14	40	35.0	2.9
F					0	0	0	0	0	0	0	
G					0	0	0	0	0	0	0	
H					1	1	0	0	2	0	5.0	0
I					0	0	0	0	0	0	0	
J					0	0	0	0	0	0	0	
K					0	0	0	0	0	0	0	
L					0	0	0	0	0	4	0	+
M					0	0	0	0	0	0	0	
29 A	162° 35'	30	1100	1	0	0	0	0	0	0	0	
B					0	0	2	1	3	0	7.5	0
C					0	0	25	0	25	23	62.5	0.9
D					1	3	1	0	5	87	12.5	17.4
E					4	4	0	0	8	3	20.0	0.4
F					6	3	1	1	11	7	27.5	0.6
G					1	0	0	0	1	68	2.5	68.0
H					0	0	4	0	4	29	10.0	7.3
I					0	0	0	0	0	4	0	+
J					0	0	0	0	0	0	0	
K					0	0	0	0	0	0	0	

Table 2. (cont'd)

Transect Number	Trackline Deg. Min. Longitude	Start Date/Time ADT Day Hour Min.	Visibility Code	Sea Otters Counted: Left Track (0.1nm) Resting	Left Track (0.1nm) Active	Right Track (0.1nm) Resting	Right Track (0.1nm) Active	Total 0.2nm Track	Total Unlim. Track	Density 0.2nm Track (Otters/nm^2)	Ratio * Unlimited/ 0.2nm Track
30 A	162° 30'	30 1454	1	1	0	0	0	1	0	2.5	0
B				2	0	0	0	2	9	5.0	4.5
C				2	0	0	0	2	3	5.0	1.5
D				0	0	0	0	0	0	0	
E				0	0	50	0	50	60	125	1.2
F				0	6	0	0	6	42	15	7.0
G				0	0	0	0	0	2	0	+
H				0	0	0	2	2	3	5.0	1.5
I				0	0	0	3	3	8	7.5	2.7
J				0	0	0	0	0	0	0	
K				0	0	0	0	0	3	0	+
L				0	0	0	0	0	0	0	
M				0	0	0	0	0	0	0	
31 A	162° 25'	30 1509	1	1	0	0	14	15	2	37.5	0.13
B				0	2	3	0	5	3	12.5	0.6
C				35	1	0	0	36	29	90.0	0.8
D				0	0	0	0	0	15	0	+
E				0	0	0	1	1	1	2.5	1.0
F				3	0	0	0	3	1	7.5	0.3
G				0	0	0	0	0	0	0	
H				0	0	0	0	0	0	0	
I				0	0	0	0	0	0	0	
J				0	0	0	0	0	0	0	
K				0	0	0	0	0	0	0	
32 A	162° 20'	30 1518	1	0	0	2	0	2	2	5.0	1.0
B				0	1	0	0	1	0	2.5	0
C				0	0	0	0	0	0	0	
D				0	0	0	1	1	0	2.5	0
E				0	0	0	0	0	0	0	
F				0	0	0	0	0	0	0	
G				0	0	0	0	0	1	0	+
H				0	0	0	0	0	0	0	
I				0	0	0	0	0	0	0	
J				0	0	0	0	0	0	0	
K				0	0	0	0	0	0	0	
L				0	0	0	0	0	0	0	
M				0	0	0	0	0	0	0	
33 A	162° 15'	30 1537	1	0	1	0	0	1	1	2.5	1.0
B				0	0	0	2	2	10	5.0	5.0

Table 2. (cont'd)

Transect Number	Trackline Deg. Min. Longitude	Start Date/Time ADT Day	Hour Min.	Visibility Code	Sea Otters Counted: Left Track (0.1nm) Resting	Left Track (0.1nm) Active	Right Track (0.1nm) Resting	Right Track (0.1nm) Active	Total 0.2nm Track	Total Unlim. Track	Density 0.2nm Track (Otters/nm^2)	Ratio* Unlimited/ 0.2nm Track
33 C					4	2	2	0	8	4	20.0	0.5
D					6	2	0	0	8	0	20.0	0
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	0	0	
G					0	0	0	0	0	0	0	
H					0	0	0	0	0	0	0	
I					0	0	0	0	0	0	0	
J					0	0	0	0	0	0	0	
K					0	0	0	0	0	0	0	
L					0	0	0	0	0	0	0	
34 A	162° 10'	30	1555	1	0	0	0	0	0	0	0	
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	0	0	
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	0	0	
G					0	0	0	0	0	0	0	
H					0	0	0	0	0	0	0	
I					0	0	0	0	0	0	0	
J					0	0	0	0	0	0	0	
K					0	0	0	0	0	0	0	
35 A	162° 00'	30	1612	3	0	0	0	0	0	0	0	
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	0	0	
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	0	0	
39 A	161° 20'	31	1421	2	0	0	0	0	0	0	0	
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	0	0	
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	0	0	
40 A	161° 10'	31	1430	1	0	0	0	0	0	0	0	
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	0	0	

Table 2. (cont'd)

Transect Number	Trackline Deg. Min. Longitude	Start Date/Time ADT Day	Hour Min.	Visibility Code	Sea Otters Counted: Left Track (0.1nm) Resting	Left Track (0.1nm) Active	Right Track (0.1nm) Resting	Right Track (0.1nm) Active	Total 0.2nm Track	Total Unlim. Track	Density 0.2nm Track (Otters/nm²)	Ratio * Unlimited/ 0.2nm Track
41 A	161° 00'	31	1438	1	0	0	0	0	0	0	0	
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	0	0	
42 A	160° 50'	31	1445	1	0	0	0	0	0	0	0	
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	0	0	
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	0	0	
G					0	0	0	0	0	0	0	
H					0	0	0	0	0	0	0	
I					0	0	0	0	0	0	0	
J					0	0	0	0	0	0	0	
43 A	160° 40'	31	1502	1	0	0	0	0	0	0	0	
B					0	0	0	0	0	0	0	
C					0	0	0	0	0	0	0	
D					0	0	0	0	0	0	0	
E					0	0	0	0	0	0	0	
F					0	0	0	0	0	0	0	
G					0	0	0	0	0	0	0	
H					0	0	0	0	0	0	0	
I					0	0	0	0	0	0	0	
J					0	0	0	0	0	0	0	
K					0	0	0	0	0	0	0	
L					0	0	0	0	0	0	0	
M					0	0	0	0	0	0	0	
Bechevin Bay		30	1732	5						186		

* + = Infinity

Table 3. Sizes of sea otter groups sighted on 30-31 July 1976 transect survey.

Transect	Track width	Frequency of Occurance of Group Size 1	2	3	4	5	Sizes of Larger Pods
5 D	0.2 nm						
	Unlimited	1					
10 A	0.2 nm	2	1				
	Unlimited	3	2		1		
B	0.2 nm	2		3			10
	Unlimited	3	2	1			7, 10
C	0.2 nm	1	1	1			
	Unlimited		3			1	6, 9
D	0.2 nm	1					
	Unlimited	2					11
F	0.2 nm						
	Unlimited			1			
11 B	0.2 nm	2	1	1			
	Unlimited	2			1		20, 20
C	0.2 nm	2					15
	Unlimited		2		1		14, 20, 8
12 A	0.2 nm	1					
	Unlimited	1		1			
B	0.2 nm	2	1				6, 7, 11
	Unlimited			2		1	6, 27
C	0.2 nm	3					
	Unlimited	3					
F	0.2 nm						
	Unlimited		1				
13 A	0.2 nm	5	5				
	Unlimited	4	2	2		1	
B	0.2 nm	3	1				
	Unlimited	1		1			
D	0.2 nm						
	Unlimited	1					
E	0.2 nm						
	Unlimited	1					
14 A	0.2 nm	2	1				
	Unlimited	3					
B	0.2 nm	2	1			1	7, 11, 13
	Unlimited				1		80, 20, 30, 20, 17
C	0.2 nm						
	Unlimited	1	1				
D	0.2 nm	1					
	Unlimited						
F	0.2 nm	1					
	Unlimited						

Table 3. (cont.) Sizes of sea otter groups sighted on 30-31 July 1976 transect survey.

Transect	Track width	Frequency of Occurance of Group Size 1	2	3	4	5	Sizes of Larger Pods
15 A	0.2 nm	2	1				
	Unlimited	2	3				
C	0.2 nm						
	Unlimited	2	1				
G	0.2 nm	1					
	Unlimited	1					
J	0.2 nm						
	Unlimited	1					
16 A	0.2 nm	1	1				
	Unlimited	1	1	1			23
B	0.2 nm	7	6				35, 60, 30
	Unlimited		5				100, 40, 8, 9, 50, 17, 12
C	0.2 nm	1		1			
	Unlimited				1		6, 7
D	0.2 nm	4					
	Unlimited	1	2				
E	0.2 nm	1					
	Unlimited	2					
F	0.2 nm						
	Unlimited	2					
17 A	0.2 nm	1	1				
	Unlimited	4	1				
B	0.2 nm	1					
	Unlimited	1					
D	0.2 nm						
	Unlimited	2					
E	0.2 nm						
	Unlimited	1					
18 A	0.2 nm	1	1				
	Unlimited		1				
B	0.2 nm		1				
	Unlimited	1					
C	0.2 nm						
	Unlimited		1				
E	0.2 nm	4	1				
	Unlimited	2					
H	0.2 nm		1				
	Unlimited		1				
K	0.2 nm	1					
	Unlimited	1					

Table 3. (cont.) Sizes of sea otter groups sighted on 30-31 July 1976 transect survey.

Transect	Track width	Frequency of Occurance of Group Size 1	2	3	4	5	Sizes of Larger Pods
19 B	0.2 nm						
	Unlimited						9, 35
C	0.2 nm		1				5
	Unlimited	2					
D	0.2 nm	2					
	Unlimited	1	1				
E	0.2 nm	2					
	Unlimited	1					
G	0.2 nm	2					
	Unlimited						
I	0.2 nm		1				
	Unlimited	1					
20 A	0.2 nm	2			1		9
	Unlimited	1		1			6, 7, 8
B	0.2 nm						
	Unlimited	2					
D	0.2 nm	1					
	Unlimited			1			
F	0.2 nm	1					
	Unlimited	1					
G	0.2 nm	1					
	Unlimited						
H	0.2 nm	2					
	Unlimited	2	1				
J	0.2 nm						
	Unlimited	1					
K	0.2 nm	1					
	Unlimited						
21 A	0.2 nm	2					
	Unlimited	1					
B	0.2 nm						
	Unlimited	1					
C	0.2 nm						
	Unlimited	1	1				
G	0.2 nm						
	Unlimited	1					
I	0.2 nm						
	Unlimited		1				
22 A	0.2 nm	2					
	Unlimited						
B	0.2 nm						100
	Unlimited						50
C	0.2 nm	1					
	Unlimited					1	
D	0.2 nm	1					
	Unlimited	2					
K	0.2 nm	1					
	Unlimited	1					

Table 3. (cont.) Sizes of sea otter groups sighted on 30-31 July 1976 transect survey.

Transect	Track width	Frequency of Occurance of Group Size 1	2	3	4	5	Sizes of Larger Pods
23 A	0.2 nm	1					8
	Unlimited						50, 50, 15, 14
B	0.2 nm	2					
	Unlimited	1	1				30
C	0.2 nm	1					
	Unlimited	1					9, 10
D	0.2 nm		1				
	Unlimited	2					20, 100
E	0.2 nm	1					
	Unlimited						
F	0.2 nm	1					
	Unlimited						
G	0.2 nm		1				
	Unlimited	1					
K	0.2 nm	1					
	Unlimited						
M	0.2 nm						
	Unlimited		1				
O	0.2 nm						
	Unlimited		1				
24 B	0.2 nm	2		1			
	Unlimited	1	1				
C	0.2 nm						
	Unlimited	1					
E	0.2 nm						
	Unlimited	2					
I	0.2 nm	1					
	Unlimited						
K	0.2 nm	1					
	Unlimited	1					
P	0.2 nm						
	Unlimited		1				
25 B	0.2 nm						
	Unlimited	1					
C	0.2 nm	1					
	Unlimited						
D	0.2 nm		1				
	Unlimited						
E	0.2 nm						
	Unlimited	1	1				
26 B	0.2 nm	2					
	Unlimited						
C	0.2 nm	1					
	Unlimited	2					
D	0.2 nm		1				
	Unlimited	1	1				
F	0.2 nm	1					
	Unlimited						
G	0.2 nm						
	Unlimited	1					

Table 3. (cont.) Sizes of sea otter groups sighted on 30-31 July 1976 transect survey.

Transect	Track width	Frequency of Occurance of Group Size 1	2	3	4	5	Sizes of Larger Pods
27 A	0.2 nm	1					
	Unlimited	1					
B	0.2 nm	2	1				
	Unlimited	3					16, 20
C	0.2 nm	6	1	1			8, 17
	Unlimited	2		2	1		7, 7, 10, 16
E	0.2 nm	1					
	Unlimited	2					
F	0.2 nm	1					
	Unlimited	1					
H	0.2 nm	1					
	Unlimited		1				
28 A	0.2 nm						
	Unlimited	1					
B	0.2 nm	1					
	Unlimited						30, 8
C	0.2 nm	4	1				15
	Unlimited	1		1			9, 16
D	0.2 nm	5	2	1		1	
	Unlimited	6	1	1	2		
E	0.2 nm	3	1	1			6
	Unlimited	2	1		2		16, 12
H	0.2 nm	2					
	Unlimited						
L	0.2 nm						
	Unlimited		2				
29 B	0.2 nm	1	1				
	Unlimited						
C	0.2 nm						25
	Unlimited	2	1				19
D	0.2 nm	5					
	Unlimited	1					25, 50, 11
E	0.2 nm				2		
	Unlimited	3					
F	0.2 nm	4	1			1	
	Unlimited	1					6
G	0.2 nm	1					
	Unlimited	1		2		1	6, 50
H	0.2 nm	1		1			
	Unlimited		1	1			10, 14
I	0.2 nm						
	Unlimited	1		1			

Table 3. (cont.) Sizes of sea otter groups sighted on 30-31 July 1976 transect survey.

Transect	Track width	Frequency of Occurance of Group Size 1	2	3	4	5	Sizes of Larger Pods
30 A	0.2 nm	1					
	Unlimited						
B	0.2 nm		1				
	Unlimited	3	1		1		
C	0.2 nm		1				
	Unlimited	1	1				
E	0.2 nm						50
	Unlimited				2		12, 40
F	0.2 nm						6
	Unlimited						11, 10, 21
G	0.2 nm						
	Unlimited		1				
H	0.2 nm		1				
	Unlimited			1			
I	0.2 nm	3					
	Unlimited	2	1		1		
K	0.2 nm						
	Unlimited			1			
31 A	0.2 nm	1	1				12
	Unlimited		1				
B	0.2 nm	3	1				
	Unlimited	1	1				
C	0.2 nm	3				1	28
	Unlimited	1			1		24
D	0.2 nm						
	Unlimited						15
E	0.2 nm	1					
	Unlimited	1					
F	0.2 nm			1			
	Unlimited	1					
32 A	0.2 nm	2					
	Unlimited		1				
B	0.2 nm	1					
	Unlimited						
D	0.2 nm	1					
	Unlimited						
G	0.2 nm						
	Unlimited	1					
33 A	0.2 nm	1					
	Unlimited	1					
B	0.2 nm		1				
	Unlimited	1	1	1	1		
C	0.2 nm	1	2	1			
	Unlimited				1		
D	0.2 nm		1				6

In some cases a partial segment beyond those indicated was surveyed. No sea otters were seen in these partial segments and they have been ommitted from the tables to prevent confusion. Flightlines and distribution of sea otters counted in Bechevin Bay are shown in Fig. 3.

VII. Discussion

Although the 30-31 July survey was considered highly successful there are a number of limitations that should be considered before interpreting the data. The time available for preparation of this report did not allow detailed analysis of all aspects of the survey. Therefore, this discussion will cover factors influencing the survey and the most important conclusions drawn from it. A more detailed analysis might be necessary for comparison with any subsequent surveys.

Strip transects were chosen over line transects because measurement of radial angles, radial distances or right angle distances for each sighting would have been impossible given the speed of the aircraft, number of observations and short distances of observation.

A systematic arrangement of transects was chosen over a random distribution because major objectives of the survey involved determining the distribution of sea otters throughout the entire area. Use of a systematic survey greatly complicates estimation of variance in the population estimate as neither the transects or the sea otters were randomly distributed. This problem could have been overcome by repetetive surveys but, given

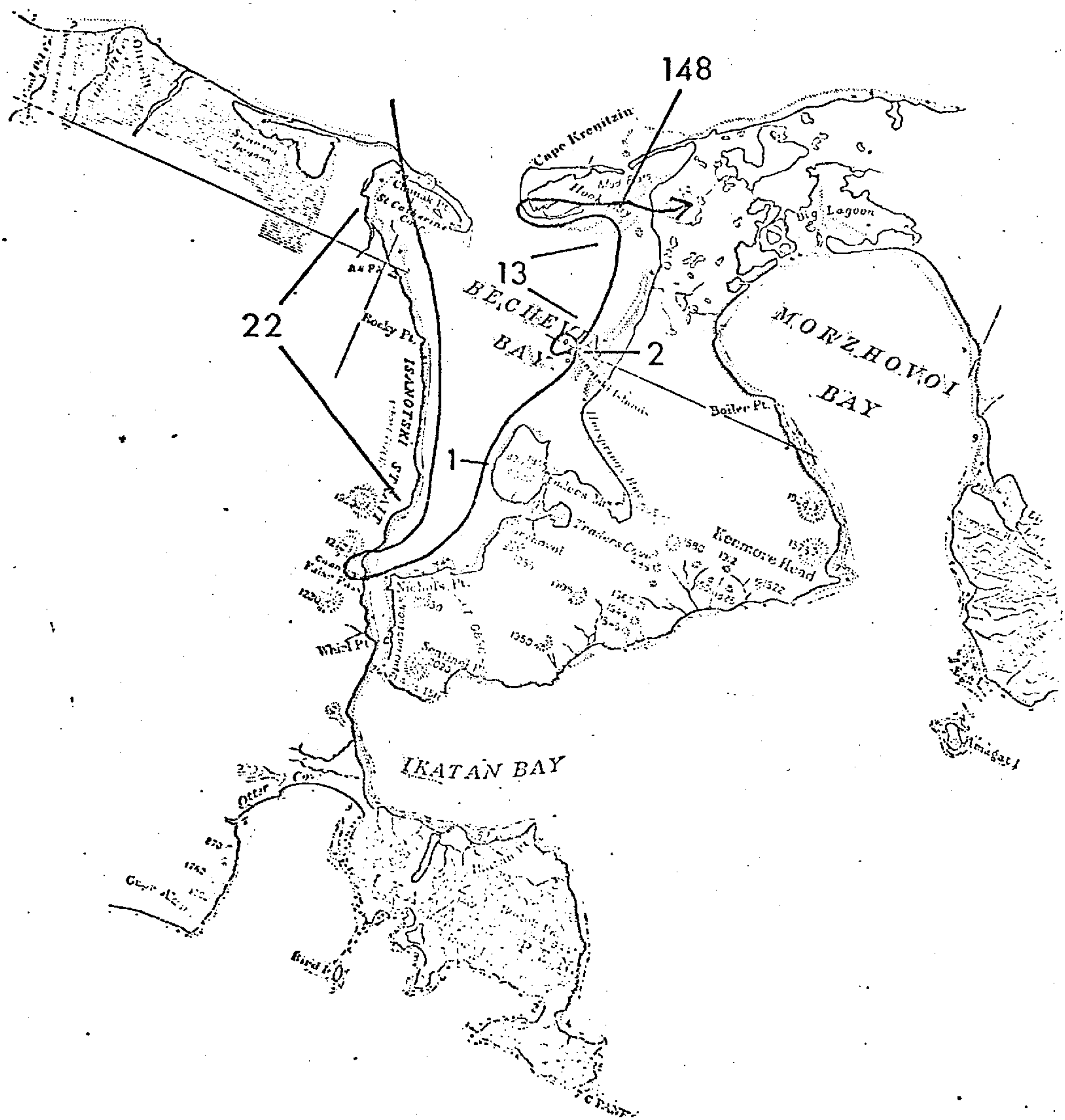


Figure 3. Survey Trackline and locations of sea otters counted in Bechevin Bay on 30 July 1976.

limited funding, several less intensive and perhaps less accurate surveys might have introduced more variability while providing the means to estimate that variability. Systematic sampling can produce estimates that compare favorably with stratified random samples provided no periodicity occurs in the population (Cochran 1963). No known periodicity that would cause bias in the present survey exists.

Effect of Pods

A major problem anticipated in this survey was the distribution of the sea otters in relation to each other. During past surveys distribution has varied from most individuals being widely scattered to the occurrence of large pods of up to 1,000 with a few scattered individuals nearby. The occurrence of large pods could strongly influence estimates of densities depending on whether a pod fell within a count area or not. This was a major reason for conducting an unlimited width strip survey at the same time as the limited width strip survey. It provided information useful in evaluating the influence of large pods. It also increased the possibility of detecting low densities of sea otters.

The occurrence of pods does not appear to have been a serious problem in this survey. No pods of over 100 individuals were seen. Most pods were of moderate size and a number of pods usually occurred within an area so some fell within the limited width strips (Table 3).

A total of 1,901 sea otters was counted in the unlimited transects while 811 were counted in the 0.2 nm transects for a ratio of 2.3. The ratio of the number of pods containing over 10 individuals was 50:15 or 3.2. This might indicate that too few pods were seen in the 0.2 nm transect; however, the effective width of the unlimited width counts would be greater for pods than for individuals since sightability increases with group size. This is evident when the numbers of single animals sighted are compared. Fewer single animals were seen in the unlimited width transects than in the 0.2 nm transects (126:149, ratio 0.85) and a higher percentage of all animals seen were in pods over 10 (71 percent vs. 53 percent). Therefore the effective width of the unlimited width transects was greater for pods than for individuals and the higher ratio of pods sighted between the two surveys would be expected.

The ratio of the number of sea otters in pods was similar to the ratio of the number of pods (3.1 vs 3.2) indicating that pod size had little influence for pods over 10.

This does not rule out the possibility that the occurrence of pods biased the counts. Some bias probably did occur, at least within small areas. Large pods may have occurred between transects out of view of all of the observers. The unlimited width transect observers probably sampled less than half the area even for large pods. Therefore, while no bias resulting from the occurrence of pods could be readily identified, some could have occurred.

Effect of Diving Animals

A major assumption made with most strip transect surveys is that all animals in the strip are counted. This assumption is seldom justified and it certainly isn't in the case of diving mammals. There have been several attempts to estimate the percentage of time a sea otter spends under water. Estes and Smith (1973) estimated that at Amchitka Island 30 percent of the population is under water at any given instant even during periods of minimum feeding activity. The proportion decreases with time, however. If we assume that the observers on the present survey could view a 0.2 nm long strip at any instant, any given point would remain in his field of view for only 6 seconds. The decrease in number of sea otters on the surface would be insignificant during that time. In reality the time the observer could devote to effectively watching one spot is considerably less than 6 seconds.

Estimates by Estes and Smith (1973) were based on observations made in quite different habitat and generally shallower depths (less than 30 m). No suitable data are available for the area north of Unimak Island and the Alaska Peninsula. Water depths are generally greater requiring considerably more time to dive to the bottom. At extreme depths the sea otter would be forced to rest longer between dives however. Food items might be more abundant in that area requiring less time to locate them.

Many sea otters reacted to the aircraft by diving. Observers frequently saw sea otters dive just as they came into view and occasionally saw splashes that could not be positively identified. Observers counting in unlimited width strips sat in the rear of the aircraft and had poorer forward vision than those counting in the limited strips. Many sea otters were under water by the time their location came into view.

While no reliable adjustment can be made for the effect of diving animals on the present survey, Estes and Smith (1973) estimated that 30 percent under water could probably be used as a conservative figure.

Sightability of Animals on the Surface

Experience has shown that not all sea otters on the surface of the water are seen during aerial surveys. Many factors influence the sightability of an individual sea otter. These include:

1. Visibility conditions - Many factors influence the visibility of sea otters in the water. These factors often influence each other providing a wide array of conditions. Often conditions change rapidly. Among the more common factors are sea state and lighting conditions. Any type of wave will reduce visibility. Sharp, choppy waves are worse than large swells so wind velocity and direction at the time of the survey are major factors. Lighting conditions often magnify the effect of sea state. Sun glare on the water's surface, reflection on the windshield of an aircraft, low light intensity because of clouds or time of day and the wave lengths of light reflected from the water's surface strongly influence visibility. Since the angle of incidence of light is important,

visibility on one side of the observer may be significantly different from that on the other side.

The visibility code assigned to each transect was an attempt to classify all of these factors (Table 2). Conditions encountered on this survey were the best ever encountered in this area during a survey. This greatly reduced the effects of visibility conditions on the counts. Only on transects 8 and 9 and in Bechevin Bay did visibility conditions seriously interfere with the survey. A 13 August 1975 survey indicated that substantial numbers of sea otters existed in the area of both transects 8 and 9 although few were found west of there. Some correction should be made for these two transects. Allowing half the number seen on transect 10 for transect 9 (16) and half of that (8) for transect 8 would seem to be a conservative approach.

Visibility conditions probably also reduced the Bechevin Bay count significantly. On 13 August 1975 a total of 444 sea otters was counted in the bay under slightly better conditions. Since sea otters may move in and out of the bay no reliable correction factor can be suggested.

2. Presence of confusing objects - The presence of other species of marine mammals, birds, certain types of kelp, drift or any object that appears similar to the target species will distract the observer and reduce his ability to identify the target species.

There was little kelp or drift in the area. Visibility conditions made identification of other marine mammals and birds relatively easy. The only serious interference was from several million shearwaters in dense flocks. Flocks on the water resembled pods of sea otters at a distance. This tended to distract the unlimited width strip observers and reduced their ability to identify pods at a distance. As the aircraft approached flocks of shearwaters they would take off and fly back and forth over the count area. This created a "screen" effect making it extremely difficult to identify sea otters under them. Fortunately the area of highest shearwater concentrations appeared to lie offshore from the area of highest sea otter density. Some sea otters were probably missed as a result of the presence of birds, however.

3. Behavior - The way animals react to the survey platform, their activity and posture in the water, and their distribution in relation to each other and in relation to geographical features have a strong influence on sightability. Distribution of individuals has an effect that often overrides the effects of all other factors. When most animals are resting on the surface of the water in large groups, counts are almost always high. When they are widely scattered, counts will be low unless other conditions are ideal.

Generally, sea otters are most visible when they are resting on their backs and in groups and least visible when alone and upright in the water. Some movements will enhance sightability, particularly swimming on their backs. Many factors influence behavior including time of day, presence of the aircraft, present weather conditions and even weather conditions of the past few days.

Group size and whether the animals were resting or active were recorded for each sighting in the hope that some comparison of these factors between areas could be made. It would appear that the two limited width strip observers used slightly different definitions of resting and active. The left observer classed as active only those animals that were moving in such a way as to hinder identification. Only 13 percent fell into this catagory. The right observer used a somewhat broader definition and classified 48 percent as active. The difference probably represents animals beginning to react to the aircraft but not diving or upright in the water.

Even when all of the above factors are ideal some animals will be missed. The human eye can not sweep an area giving equal attention to all areas. It tends to focus on points and rapidly move from point to point. The less time available to search a given area and the more distant the area the less efficient the observer. The aircraft used on this survey was relatively fast, giving the observer only a few seconds to locate, identify and count sea otters. There was no way to increase the time of observation without changing the survey platform. This would have been at the expense of coverage or safety.

A relatively narrow strip width was selected to at least partially overcome the problems of aircraft speed and other factors that reduce sightability. It is certain that some sea otters were missed throughout the survey. The bird observer in the rear of the aircraft counted birds in a 100 m strip and noticed some sea otters missed by the left observer. These were not included in the counts.

Observer ability can strongly influence counts. All observers were experienced and all except one of the unlimited width strip observers had participated in intensive sea otter counts in the past year. The left observer counted 55 percent of the sea otters recorded in the 0.2 nm wide strips; however, he saw only 51 percent of the singles and pairs. This suggests that both observers had similar ability and the difference was due to the size of a few larger groups.

All of the factors discussed above tend to reduce the percentage of sea otters on the surface that are seen. Unfortunately without some form of ground truth it is impossible to quantify these factors. It was not logistically or economically feasible to attempt to gather ground truth information on this survey.

Comparisons of aerial counts with shore counts or boat counts have been attempted in other areas. All indicate that a significant percentage of sea otters are missed in aerial counts. However, these comparisons have never included strip counts over open water. Therefore, there is no reliable way to estimate the percentage of sea otters on the surface that are missed. One must simply recognize that the counts and any estimates derived from the counts are low.

Sea Otters Outside of the Survey Area

The available information indicates that most of the population was in the area surveyed but that small numbers may have been outside the area. Only one sighting of sea otters south of Cape Sarichef has been recorded (Table 1). Seventy-five sea otters sighted there in 1958 may have been a transient group as none have been reported from there since and none were seen on two surveys in 1975. The 1975 surveys indicated that few sea otters were west of Cape Mordvinof, perhaps even fewer than in 1965 when Kenyon (1969) counted 10. Results of the present survey seemed to confirm this (Table 2).

We encountered fog and were unable to complete transects 36-38. No sea otters were sighted on transects 34 or 35 and none were seen in the Port Moller area. A total of six survey tracklines paralleling the shore at various distances from shore have been flown in this area since June 1975. The last of these was made under excellent conditions the morning of the first day of this survey. On all of these surveys only two sightings of sea otters, both near the western side of the entrance to Port Moller and Herendeen Bay, have been made. Reports from biologists in the area indicate that very few sea otters remain northeast of Cape Lieskof. Therefore, it appears that scattered individuals and perhaps a few very small groups were northeast of Cape Lieskof. We were not able to survey intensively enough to estimate their numbers. They probably compose only a fraction of a percent of the population.

Sea otters have frequently been seen in water over 60 m deep, especially in the area surveyed, but only occasional individuals have been seen in water over 80 m deep. There are several records of sea otters caught in crab pots nearly 100 m deep and resting animals have been seen in water over 200 m deep, however, those regularly feeding in water over 80 m deep would appear to be unique and are usually adult males. Therefore, the 80 m depth contour was selected as the outer boundary of the survey area. Problems with the GNS 500 navigation aid caused us to under-estimate or overestimate our distance from shore. Therefore, not all areas within the 80 m contour were surveyed (Fig. 2). Sea otters were seen in the northern-most segment of three transects (15, 23, 24). Estimated depths near these sightings ranged from 70 to 80 m. Transects 10, 11, 12, 13, 16, 17, 18 and 19 were probably cut too short although the number of sea otters that would have been seen had they been extended would have been small. Transects 8 and 9 were cut short purposely because of visibility conditions. There is also a possibility that a small number of otters were beyond the 80 m depth contour.

Izembek and Moffet Lagoons were not specifically surveyed, however, the aircraft was flown over most parts of the lagoons likely to contain sea otters during refueling trips. No sea otters were seen there. We might have missed scattered individuals, however.

A line opposite the False Pass cannery was arbitrarily selected as the southern boundary of the population. Substantial numbers of sea otters exist along the south shore of Unimak Island and the Alaska Peninsula between Cape Lazaref and Cold Bay. There is a strong possibility that many of the animals repopulating this area in the late 1960's immigrated from the Bering Sea through Isanotski Strait. Small numbers are seen in the strait today and movement through the strait has been observed during periods of extremely heavy sea ice formation (Schneider and Faro 1975). Some interbreeding between sea otters in the Bering Sea and those from the Sandman Reefs and Sanak Island probably occurs. Therefore the population being discussed here is not entirely discrete. Isanotski Straits appears to be the point at which interchange is most restricted but the Bering Sea population could periodically gain or lose animals through this interchange.

In summary, small numbers of sea otters were probably farther offshore than the transects extended, northeast of the survey area or in Izembek and Moffet Lagoons. There is no evidence that inclusion of these animals would significantly increase the population estimate, however.

Population Estimate

The due date of this report limited the time available for analysis of the data. As indicated above, there were many factors influencing the survey that could not be quantified. Therefore, only a simple expansion of the data for a population estimate will be presented with no estimate of variance. It is anticipated that with additional time a more refined estimate could be produced.

An area of approximately 7175 km^2 was sampled. Of that area 506.3 km^2 fell within the limited width strip transects. A total of 811 sea otters was counted in the strips. If we expand this to the entire area we get:

	11,495
Add Bechevin Bay count	186
Unadjusted estimate	11,681

If we compensate for the poor visibility conditions along transects 8 and 9 by assuming that a total of 24 sea otters would have been seen if visibility conditions and the transect lengths were the same as transect 10 we would have an adjusted estimate of:

11,681 + 340 = 12,021

This would be an estimate of the number of sea otters that would have been counted if the entire area had been surveyed.

An unknown proportion of the population would have been under water at the time of the survey. If we use Estes and Smith's (1973) estimate of 30 percent, recognizing that this may not apply to this particular area we get:

12,021 on surface + 5,152 diving = 17,173

This estimate assumes that:

1. All sea otters on the surface in the strip transects were counted.

2. All sea otters on the surface in Bechevin Bay were counted.

3. All sea otters were within the area sampled.

4. No sampling error occurred.

5. 30 percent of the sea otters were not on the surface.

From the previous discussion of factors influencing the survey it is evident that assumptions 1-3 are incorrect and would tend to yield an underestimate of numbers. Assumption 4 could yield an overestimate or an underestimate although no gross errors were immediately obvious. Assumption 5 could yield an overestimate or an underestimate, however, it fails to consider diving in reaction to the aircraft which would tend to produce an underestimate. Therefore, the overall estimate would tend to be conservative unless sampling error was great.

The above estimate indicates a density of 2.3 sea otters/km^2. If we exclude those areas west of Cape Mordvinof and east of Cape Leontovich the overall density would be 3.0 sea otters/km^2. This is a modest density for a sea otter population when compared to those observed in other areas (Kenyon 1969, Estes and Smith 1973); however, most other estimates have assumed that sea otter habitat did not extend beyond the 60 m depth contour. The observed density within the 60 m depth contour in the primary range of the population (between transects 10 and 33) was 2.7 sea otters/km^2 or with the 30 percent correction for diving animals 3.9/km^2, still a moderate density.

There is reason to believe that both the total population and the densities of sea otters in the area surveyed were lower than in the 1960's. During the 1960's the range of the population expanded rapidly. By 1970 substantial numbers had reached Port Heiden and there was evidence of expansion to the south side of the Alaska Peninsula and Unimak Island. Such expansion usually indicates that sea otter densities have become too high in relation to food availability. Sea ice conditions in the early 1970's reduced the range of the population (Schneider and Faro 1975). Since 1972 no repopulation of former habitat to the northeast has been observed. Fragmentary surveys indicate little change in the range of sea otters on the south side of Unimak Island and fewer sea otters inhabit the area west of Cape Mordvinof. Residents of Cold Bay have observed a reduction in the number of sea otters using Izembek Lagoon (Robert Jones, USFWS, pers. comm.). These factors indicate that competition for food and hence the need to expand range have been reduced. This is probably the result of lower densities.

If this is the case, the population can be expected to increase in numbers unless some factor increases mortality or limits the food supply.

Range

The main range of the population presently extends from the vicinity of Cape Mordvinof to Cape Lieskof and includes Bechevin Bay. Izembek and Moffet Lagoons are used to a lesser extent. Small numbers may occur west of Cape Mordvinof; however, less offshore habitat exists in that area. Small numbers appear to persist near Port Moller and it is possible that scattered individuals may stray as far to the northeast as Egegik. Those animals presently northeast of Cape Lieskof are probably not contributing significantly to the growth of the population.

The population should again expand its range as its numbers increase as long as severe sea ice conditions similar to those in 1971 and 1972 do not occur. Range expansion to the northeast will probably be rapid once it begins. It is not possible to predict how long it will take for the population to reoccupy all of its 1970 range. If sea ice conditions remain moderate it should take less than 10 years, however.

When assessing the possible impacts of both offshore and onshore activities on sea otters, the potential range of the population should be considered. This extends to the Port Heiden area. Sea otters have occurred farther to the northeast in the past and will in the future, however, average sea ice conditions would eliminate most of those animals. Densities of sea otters between Port Heiden and Port Moller will probably fluctuate dramatically as sea ice conditions vary. In rare, extreme cases the range may be restricted to its present distribution.

Distribution

Sea otters were not distributed uniformly within the present range of the population. Small areas of extremely high densities were evident. The range was stratified into high, medium and low density areas on the basis of the unlimited width strip count (Table 4, Fig. 4). No attempt was made to delineate small areas of concentration although it appears

Table 4. Approximate water depth, sea otter density stratum and number of sea otters counted in 0.2 nm strip for each transect segment surveyed between Urilia Bay and Cape Lieskof.

Transect Number	Depth (m)	Density	Number of Sea Otters Counted
10 A	20-40	H	4
B	"	H	21
C	"	H	6
D	40-60	H	1
E	"	M	0
F	"	M	0
G	60+	L	0
11 A	0-20	M	0
B	20-40	H	7
C	"	H	17
D	"	H	0
E	40-60	M	0
F	"	M	0
12 A	0-20	M	1
B	"	H	28
C	20-40	H	3
D	40-60	M	0
E	"	M	0
F	"	M	0
G	"	L	0
H	"	L	0
13 A	0-20	H	15
B	20-40	H	5
C	"	H	0
D	"	M	0
E	40-60	M	0
F	"	M	0
G	"	L	0
14 A	0-20	H	4
B	20-40	H	35
C	"	H	0
D	"	H	1
E	40-60	M	0
F	"	M	1
G	"	L	0
H	60+	L	0
I	"	L	0
J	"	L	0
15 A	20-40	H	4
B	"	H	0
C	40-60	H	0
D	"	H	0
E	"	M	0
F	"	M	0
G	60+	L	1
H	"	L	0
I	"	L	0
J	"	L	0
16 A	0-20	H	3
B	20-40	H	144
C	"	H	4
D	40-60	H	4
E	"	M	1
F	"	M	0
G	"	M	0
H	"	L	0
I	60+	L	0
17 A	0-20	H	3
B	20-40	H	1
C	"	H	0
D	"	M	0
E	40-60	M	0
F	"	M	0
G	"	M	0
18 A	0-20	H	3
B	20-40	H	2
C	"	H	0
D	"	M	0
E	40-60	M	6
F	"	M	0
G	"	M	0
H	"	M	2
I	"	M	0
J	"	L	0
K	60+	L	1
L	"	L	0
19 A	0-20	H	0
B	20-40	H	0
C	"	H	7
D	40-60	M	2
E	"	M	2
F	"	M	0
G	"	M	2
H	"	M	0
I	"	M	2
J	"	M	0
K	60+	L	0
20 A	0-20	H	15
B	20-40	H	0
C	"	M	0
D	"	M	1
E	40-60	M	0
F	"	M	1
G	"	M	1
H	"	M	2
I	"	M	0

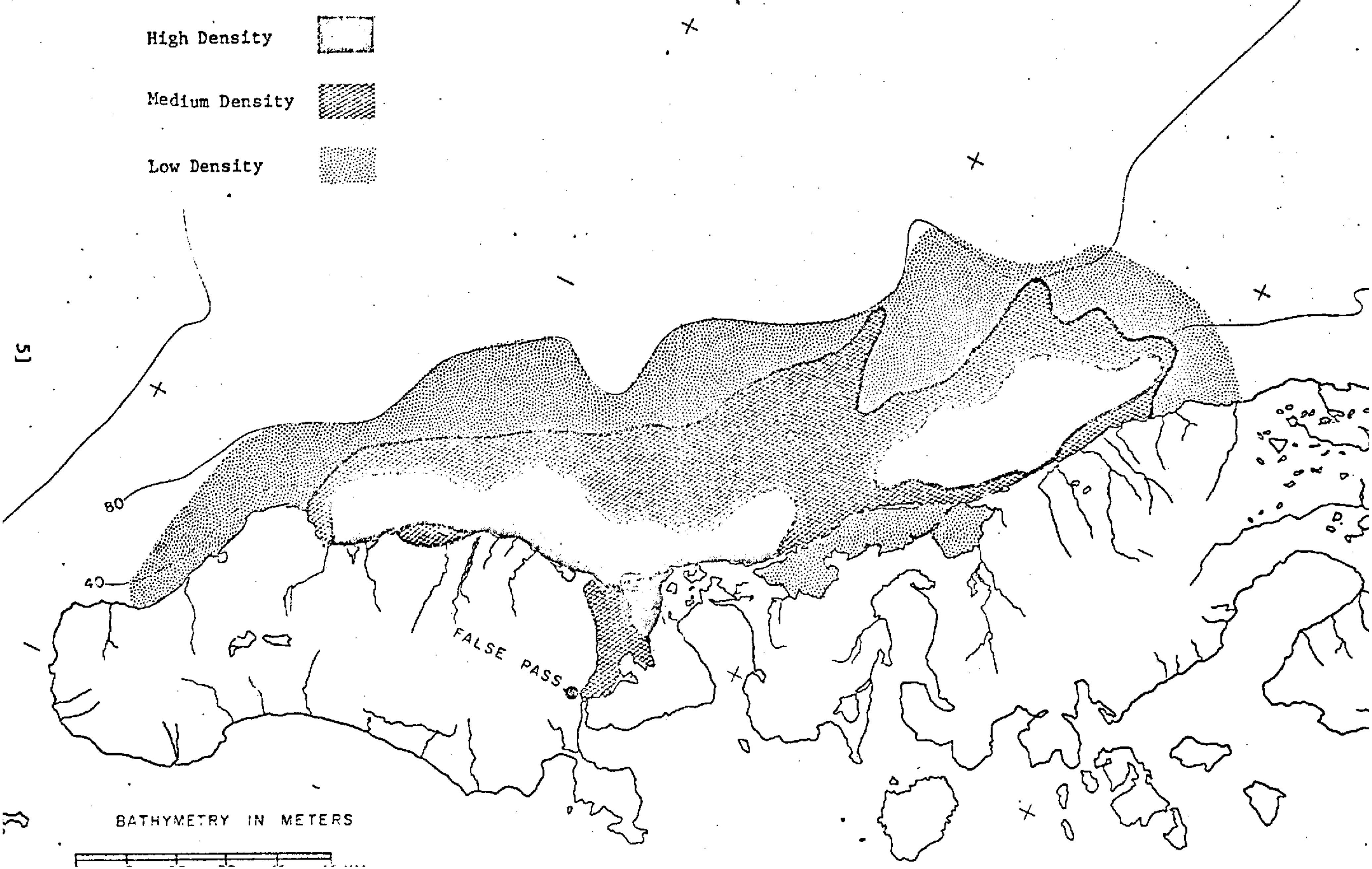
Table 4. (cont.) Approximate water depth, sea otter density stratum and number of sea otters counted in 0.2 nm strip for each transect segment surveyed between Urilia Bay and Cape Lieskof.

Transect Number	Depth (m)	Density	Number of Sea Otters Counted
20 J	40-60	M	0
K	"	L	1
L	60+	L	0
M	"	L	0
21 A	0-20	H	2
B	20-40	H	0
C	"	M	0
D	"	M	0
E	40-60	M	0
F	"	M	0
G	"	M	0
H	"	M	0
I	"	M	0
J	"	M	0
K	60+	L	0
22 A	0-20	H	2
B	20-40	H	100
C	"	H	1
D	"	H	1
E	"	M	0
F	"	M	0
G	"	M	0
H	"	M	0
I	40-60	M	0
J	"	M	0
K	"	M	1
L	60+	M	0
M	"	L	0
N	"	L	0
23 A	0-20	H	9
B	20-40	H	2
C	"	H	1
D	"	H	2
E	"	M	1
F	"	M	1
G	40-60	M	2
H	"	M	0
I	"	M	0
J	"	M	0
K	"	M	1
L	60+	M	0
M	"	M	0
N	"	M	0
O	"	M	0
24 A	0-20	M	0
B	20-40	M	5
C	"	M	0
D	"	M	0
24 E	40-60	M	0
F	"	M	0
G	"	M	0
H	"	M	0
I	"	L	1
J	"	L	0
K	"	L	1
L	"	L	0
M	60+	L	0
N	"	L	0
O	"	L	0
P	"	L	0
25 A	0-20	M	0
B	"	M	0
C	20-40	M	1
D	"	M	2
E	40-60	M	0
F	"	M	0
G	"	M	0
H	"	M	0
I	"	L	0
J	"	L	0
K	"	L	0
L	60+	L	0
26 A	0-20	M	0
B	"	H	2
C	20-40	H	1
D	"	H	2
E	"	M	0
F	"	M	1
G	40-60	M	0
H	"	L	0
I	"	L	0
J	"	L	0
K	60+	L	0
L	"	L	0
M	"	L	0
N	"	L	0
O	"	L	0
27 A	0-20	M	1
B	20-40	H	4
C	"	H	36
D	"	H	0
E	"	H	1
F	"	H	1
G	40-60	M	0
H	"	M	1
I	"	M	0

Table 4. (cont.) Approximate water depth, sea otter density stratum and number of sea otters counted in 0.2 nm strip for each transect segment surveyed between Urilia Bay and Cape Lieskof.

Transect Number	Depth (m)	Density	Number of Sea Otters Counted
27 J	40-60	L	0
K	"	L	0
L	60+	L	0
M	"	L	0
28 A	0-20	M	0
B	20-40	H	1
C	"	H	21
D	"	H	17
E	"	H	14
F	40-60	H	0
G	"	M	0
H	"	M	2
I	"	M	0
J	"	M	0
K	"	M	0
L	60+	M	0
M	"	M	0
29 A	0-20	M	0
B	20-40	H	3
C	"	H	25
D	"	H	5
E	40-60	H	8
F	"	H	11
G	"	H	1
H	"	H	4
I	"	H	0
J	"	M	0
K	60+	M	0
30 A	0-20	M	1
B	20-40	H	2
C	"	H	2
D	"	H	0
E	"	H	50
F	40-60	H	6
G	"	H	0
H	"	H	2
I	"	M	3
J	"	M	0
K	60+	M	0
L	"	L	0
M	"	L	0
31 A	0-20	H	15
B	"	H	5
C	20-40	H	36
D	"	H	0
E	"	H	1
F	"	H	3
31 G	40-60	M	0
H	"	M	0
I	"	M	0
J	60+	L	0
K	"	L	0
32 A	0-20	M	2
B	"	M	1
C	20-40	H	0
D	"	H	1
E	"	H	0
F	40-60	M	0
G	"	M	0
H	"	L	0
I	60+	L	0
J	"	L	0
K	"	L	0
L	"	L	0
M	"	L	0
33 A	0-20	M	1
B	20-40	H	2
C	"	H	8
D	"	H	8
E	40-60	M	0
F	"	L	0
G	"	L	0
H	60+	L	0
I	"	L	0
J	"	L	0
K	"	L	0
L	"	L	0

Figure 4. Distribution of sea otters north of the Alaska Peninsula and Unimak Island on 30-31 July 1976.



that such areas exist. Observed densities within the 0.2 nm strips averaged 6.5 sea otters/km^2 in high, 0.3/km^2 in medium and 0.06/km^2 in low density areas.

This distribution is only representative of the situation on 30 and 31 July 1976. Somewhat different distributions have been observed on previous surveys. This population is more mobile than those occupying typical, rocky, sea otter habitat. Differences have generally been in the degree of dispersal offshore. At times large numbers have been concentrated near shore while at other times low densities were found near shore and high densities occurred 15 to 30 km from shore. The 30-31 July 1976 distribution appears intermediate between those extremes and may be more typical. There appeared to be at least two separate areas of high density roughly separated by a line between Amak Island and Cold Bay. This separation has been observed on past surveys and may reflect varying quality of habitat.

Configuration of shoreline, offshore islands and rocks appears to strongly influence the distribution of sea otters in most populations. Many animals seek sheltered areas to rest. There is relatively little relationship between these features and distribution in this area except in Bechevin Bay. Occasionally small pods have been seen near Amak Island but that is usually not a high density area.

Water depth seems to influence distribution more than the shoreline. Each segment of transects 10-33 was classified by depth. Throughout much of the area the outer edge of "high" density areas closely conformed to the 40 m depth contour and the edge of the "medium" density conformed to the 60 m depth contour. Sea otters northeast of Amak Island were distributed slightly farther offshore with medium densities extending to the 80 m contour in one area and high densities extending to areas 50 m deep.

Densities observed in the 0.2 nm strips averaged 3.1 sea otters/km^2 in water 0 to 20 m deep, 5.8/km^2 in water 20 to 40 m deep, 0.5/km^2 in water 40 to 60 m deep and 0.03/km^2 in water over 60 m deep. True densities would have been higher because diving animals weren't counted. The observed densities in water over 60 m deep may be low. Only 0.25 percent of the sea otters counted in the limited width strips were beyond the 60 m depth contour while 0.84 percent counted in the unlimited width strips were beyond the 60 m countour. In either case only a small percentage of the population was in water deeper than 60 m. During a survey of the area west of Amak Island made on April 1969 most of the sea otters seen were in water deeper than 40 m and many were beyond the 60 m depth contour. Sea otters observed in deep areas have usually been widely scattered. Large pods usually occur in water less than 40 m deep.

Weather seems to play a role in determining offshore distribution. Concentrations near shore frequently follow sévere storms while animals tend to be farther offshore and widely dispersed after several days of calm weather. The 30-31 July 1976 survey followed a period of moderately rough weather with winds reaching 35 knots.

Deep areas are probably not available for foraging by all segments of the population and they may not be available to those segments that do use them all of the time. Most observations of sea otters in deep water have involved adult males. Young animals and females with pups prefer shallower water. Competition for food is probably greatest in waters less than 40 m deep and this may limit the size of the population even when food in deeper water remains abundant.

It is probably safe to consider the 80 m depth contour the outer limit of the range of the population in the area west of Cape Lieskof although some animals will stray farther. The 80 m depth contour swings far offshore in the vicinity of Port Moller and no deeper water occurs in Bristol Bay proper. The outer limits of potential sea otter habitat northeast of Port Moller are not known. Presumably sea ice would keep offshore densities low throughout most of the area. Without that limitation much of Bristol Bay and the northern Bering sea could be potential sea otter habitat.

Critical Areas

Those areas indicated as high density in Fig. 4 should probably be considered critical to this population. Possibly the area should be extended to the 30 fm curve and include all of Bechevin Bay. This area supported most of the population even in 1970. Most reproductive activity, rearing of young and most competion for food occurs there. Had this area not been available in 1972 the population would be virtually extinct today. Even during the most extreme sea ice conditions enough open water persisted in this area to permit survival of many healthy adult animals. No such area exists to the northeast except for limited areas near Port Moller.

The area from Cape Lieskof to Port Moller is critical for range expansion although not to the survival of the population.

VIII. Conclusions

A remnant sea otter population survived in the shallow waters north of Unimak Island and the Izembek area of the Alaska Peninsula. This population grew and expanded its range through the 1950's and 1960's. By 1970 substantial numbers had reached Port Heiden and scattered individuals occurred at Egegik. Expansion to the Pacific Ocean through Isanotski Strait had started. Most animals remained between Cape Mordvinof and Cape Lieskof, however. Extreme sea ice conditions in 1971, 1972 and 1974 restricted the range of the population to the area between Cape Mordvinof and Cape Lieskof with only small numbers to the southwest and in the vicinity of Port Moller. The size of the population was probably reduced substantially and little expansion of range has occurred in recent years. The present population probably exceeds 17,000 animals.

All waters less than 80 m deep are potential sea otter habitat, however, most of the population remains in waters less than 60 m deep. These waters extend far from shore throughout the area.

The population should grow and expand its range as far northeastward as Port Heiden in the absence of severe sea ice conditions.

All waters less than 60 m deep between Cape Lieskof and Cape Mordvinof, including Bechevin Bay, should be considered critical to the survival of this population.

IX. Needs for further study

Studies of activity patterns and movements of sea otters in the study area would greatly enhance our ability to evaluate the census. The cost of such studies probably exceeds their value to the OCSEAP program, however. Little is known about the food habits of this population and the relationship between concentrations of sea otters and the distribution of potential food species has not been examined.

The distribution of this population should be monitored to determine future patterns of range expansion. The northeastern fringe of the population should be of particular concern.

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