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Title: AN EVALUATION OF ATTEMPTS TO REESTABLISH THE SEA OTTER IN OREGON

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During the summers of 1970 and 1971 a total of 95 sea otter (Enhydra lutris) were shipped to Oregon from Amchitka Island, Alaska. The 1970 shipment consisted of 31 otter which were to be released on the southern Oregon Coast near the town of Port Orford. Two of these animals died in holding pens and 29 were successfully released to the wild on 18 July 1970. A second shipment of 64 sea otter was divided into two groups. On 24 June 1971, 24 otter were released at Port Orford and 40 more were released near Cape Arago. Total documented mortality of the translocated sea otter consisted of eight animals, seven of these were found within 1 week of the releases.

During the study period reports of sea otter were distributed from Tillamook Head to Brookings, Oregon, a distance of approximately 276 miles. A single report was received from Tolvana Beach, Oregon, 181 miles north of the nearest release site.

Concentrations of otter were established at two locations during 1972, Simpson and Blanco reefs. The number of animals that could be observed at either of these sites seemed to be related to the season, with most otter using Simpson Reef during the winter months, subsequently moving to Blanco Reef 35 miles to the south as the weather subsided. The use patterns for 1972-73 were similar to those for 1971-72; however, the number of otter using Simpson Reef during the winter of 1972-73 was less than for the previous winter, suggesting that a portion of the herd may have remained in the vicinity of Cape Blanco during winter 1972-73. It is estimated that 30-35 sea otter were on the coast at the termination of this study (5 October 1973).

The first sea otter pup was sighted on 20 February 1972, 19 months after the 1970 release at Port Orford. Subsequently nine more pups were observed during the study period: three in 1972 and six in 1973.

Data on food habits were gathered at Simpson Reef. Sea urchins (Strongylocentrotus spp.) comprised the major portion of the sea otter's diet and accounted for nearly 64 percent of the total number of observations. Mollusks accounted for 14.4 percent and several species of crabs comprised 5.2 percent. Underwater surveys of 13 areas indicate that sea urchins are the most abundant macroinvertebrates normally preyed upon by sea otter. They occur at densities of up to 47 purple sea urchins (S. purpuratus) per 0.25 m^2, with red sea

urchins (S. franciscanus) occurring as high as an estimated six to eight animals per 1 m^2.

Results of this study indicate that approximately one-third of the Oregon coastline is suitable for sea otter habitation; approximately 80 percent of the suitable area is situated along the south coast from Coos Bay to the Oregon-California border, with the remainder in the central region near the town of Newport.

Both sites chosen for the translocations contain good sea otter habitat; however, because of greater probability of human-related mortality and environmental pollution and the lesser amount of contiguous sea otter habitat in the vicinity of Cape Arago than near Port Orford; the latter appears to have been the better site.

It is suggested that in the future, translocated sea otter be tagged to facilitate their identification. Recommended management of the translocated otter in Oregon includes establishment of refuges, protection of the otter and their habitat, and periodic shoreline and aerial surveys to ascertain population growth and range expansion.

An Evaluation of Attempts to Reestablish the Sea Otter in Oregon

by

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TABLE OF CONTENTS

Chapter		Page
I.	INTRODUCTION	1
	Oregon History	2
	Natural History	4
	Sea Otter Translocations	5
	Alaska	5
	California	6
	British Columbia and Washington	6
	Oregon	7
	Objectives of This Study	8
II.	METHODS AND MATERIALS	9
	Distribution and Abundance	9
	Food Habits	9
	Habitat Description	10
III.	DESCRIPTION OF STUDY AREA	12
	General View	12
	Areas of Intensive Study	14
IV.	RESULTS AND DISCUSSION	16
	Distribution and Abundance	16
	Results	16
	Discussion	24
	Reproduction of Translocated Sea Otter	30
	Results	30
	Discussion	31
	Pup Maturation and Dependency Period	35
	Food Habits and Food Availability	39
	Results	40
	Discussion	51
	Potential Sea Otter Habitat in Oregon	54
	Results	54
	North Coast	54
	Central Coast	55
	South Coast	56
	Discussion	56
V.	CONCLUSIONS AND RECOMMENDATIONS	57
	Evaluation of Translocations	57
	Future Translocations of Sea Otter	59
	Management	60
LITERATURE CITED		63

LIST OF TABLES

Table		Page
1.	Relative abundance ratings assigned to potential sea otter prey species encountered in qualitative benthic surveys.	11
2.	Criteria used to assess potential sea otter habitats in Oregon.	11
3.	Summary of sea otter sightings made in Oregon subsequent to the July 1970 release and prior to the initiation of this study on 2 November 1971.	17
4.	Sea otter use of Simpson and Blanco reefs, January 1972-September 1973.	21
5.	Sea otter sighted on aerial surveys of the Oregon Coast 1971-1973.	22
6.	Documented mortality of translocated sea otter, July 1970-October 1973.	25
7.	Sea otter sighted on 23 shoreline surveys of Simpson, Blanco and Orford reefs completed from 19 February 1972-15 August 1973.	26
8.	Summary of sightings of sea otter pups in Oregon, 1 November 1971-5 October 1973.	30
9.	Summary of relative ages and sex ratios of sea otter translocated to Oregon in 1970 and 1971.	33
10.	Elapsed time from release dates of sea otter to date of pup sighting.	34
11.	Food items ingested by sea otter at Simpson Reef, June-August 1972.	41
12.	Test diameters and weights of five red sea urchins collected at Nellie's Cove, Oregon on 17 August 1973.	42

Table		Page
13.	Test diameters and weights of 21 purple sea urchins collected at Nellie's Cove, Oregon on 28 July, 1973.	43
14.	Results of quantitative underwater surveys of macro-invertebrates occurring at Simpson Reef, Oregon.	45
15.	Abundance of macroinvertebrates encountered during 10 subtidal surveys conducted along the southern coast of Oregon during August and September 1973.	47
16.	Comparison of foods eaten by sea otter at Simpson Reef, Oregon and occurrence of these prey species in the quantitative sample from the same location.	52
17.	Percent occurrence of selected macroinvertebrates utilized as sea otter food items in California and Oregon.	52

LIST OF FIGURES

Figure		Page
1.	Map of the Oregon Coast indicating sites mentioned in this report, including release locations for the 1970 and 1971 sea otter translocations.	13
2.	Sea otter use of Simpson and Blanco reefs, January 1972-September 1973.	23

AN EVALUATION OF ATTEMPTS TO REESTABLISH THE SEA OTTER IN OREGON

I. INTRODUCTION

Before exploitation and near extirpation by Russia, Spain, Great Britain, and the United States, sea otter (Enhydra lutris) ranged from the northern islands of Japan to the central coast of Baja California. Exploitation of the otter began soon after the discovery of the Commander Islands by Vitus Bering in 1741. It was in the same year that sea otter were first described by George Wilhelm Steller (Kenyon 1969).

Exploitation continued for 170 years (Wild 1972); during this period sea otter were eliminated from much of their range. Remnant populations remained only in the Aleutian and Commander Islands of the North Pacific, and along the coast of central California. In 1911 protection was afforded the species under the International Fur Seal Treaty; and, subsequently, population numbers increased and available habitat began to fill. Current estimates put the California population at 1600-1800 and the Alaskan population at 50,000 otter (Wild and Ames 1974). Thus, it appears the species has reoccupied a portion of its former range and is not in any immediate danger of extinction, although local populations may be endangered by the threat of oil spills.

Oregon History

The presence of sea otter was first recorded in Oregon in 1772 when Robert Gray purchased 150 pelts from Indians near the mouth of the Columbia River (Scheffer 1940). Vernon Bailey (1936) lists several sea otter records for Oregon: Lewis and Clark reported that the Clatsop Indians commonly wore sea otter skins; Franchere, in 1811, also traded for otter skins with the same tribe near the mouth of the Columbia. Bailey also lists reports from: J.K. Townsend, Port Orford in 1839; George Gibbs, Port Orford and the mouth of the Columbia River in 1855 and 1856; and George Suckly and R.W. Dunbar sent skulls collected at Port Orford to the National Museum in 1856 and 1859.

Scammon (1968) states that the Cape Blanco area was a favorite hunting ground for those pursuing sea otter. According to Bailey (1936) the period of profitable hunting ended in Oregon in 1872.

Nash (1919), while traveling with Henry Moseley, former naturalist aboard the "Challenger" with Charles Darwin, observed a sea otter carcass at Newport, Oregon in 1877. No reference was made as to the location of the animal's capture; however, the only good sea otter habitat in the area extends from Newport north to Depoe Bay. Nash states that Moseley was able to obtain the otter's skeleton which he later took to England and placed in the Oxford

Museum. By 1877, according to Nash, sea otter had been nearly extirpated from Oregon and one otter might represent a year of work for a sea otter hunter.

Sherrell (1970) reported that two sea otter were taken near the mouth of the Rogue River in 1888; however, the specimens were not placed in any museum collection or otherwise documented (Olterman 1972), therefore the credibility of this report is questionable.

Kenyon (1969) cites a letter he received in 1965 which describes the taking of a sea otter near Newport in 1906. This is presumably the last sea otter taken in the area, and may have been the last of the original population in Oregon.

Prior to the translocations, Pederson and Stout (1963) published the most recent record of a sea otter in Oregon. They observed in August and November of 1961 and February of 1962 what they identified as a sea otter. All observations were made on the northern Oregon Coast near Neakanie. The only descriptive material given was that the animal was feeding and initially was thought to be an immature seal. A physical and behavioral description would have added credibility to their account, especially in view of the rarity of such a sighting. Kenyon (1969) believed the otter was probably a wandering individual from southeastern Alaska or California and did not indicate a viable sea otter population remaining in Oregon.

Bailey (1936) interpreted his sources to indicate that sea otter inhabited the entire Oregon coastline. However, other records indicate only three major areas of concentration: the mouth of the Columbia River, the Newport vicinity, and the Cape Blanco to Pistol River section (Scammon 1968, Nash 1919, Kenyon 1969). The preponderance of historical data comes from Oregon's south coast indicating that sea otter were probably most abundant in this region with smaller numbers inhabiting areas to the north.

Natural History

Sea otter are the only members of the genus Enhydra and are considered recent invaders of the marine environment (Kenyon 1969). They are the largest of the family Mustelidae and the smallest marine mammal. Adult males weigh up to 100 pounds and adult females may attain 72 pounds (Kenyon 1969).

Sea otter inhabit the nearshore marine environment, preferring areas where rocky headlands, sea stacks, and offshore reefs occur. Kelp beds are found in many areas of sea otter habitation and are preferred resting areas when present.

Sea otter are polygamous and reach sexual maturity at 3-4 years of age; females produce a single pup approximately every 2 years thereafter (Kenyon 1969, Schneider 1973).

Sea otter prey primarily on marine invertebrates and benthic fishes, and their diets may vary somewhat depending upon availability of prey species. Their energy requirements are high, and thermoregulation is accomplished by combining a high metabolic rate with an extremely dense pelage which traps a thin insulating layer of air within it (Kenyon 1969).

Sea Otter Translocations

Alaska

Early attempts to translocate sea otter were unsuccessful. Upon release into new habitat the otter suffered from and, subsequently, died of exposure (Kenyon 1969). Failure to successfully translocate sea otter before 1959 was directly attributed to inadequate knowledge of the animal's needs in captivity and transportation (Kenyon and Spencer 1960). Later studies indicated that during the interim between capture and release the otter's fur became soiled and matted, which destroyed its insulative quality. This problem was eventually alleviated by holding otter in tanks containing circulating sea water which allowed them to adequately groom their fur.

The first apparently successful translocations of sea otter were made in 1965 and 1966 when a total of 43 otter were liberated in Klag Bay, southeastern Alaska. In 1967 Alaska Department of Fish and Game biologists completed a 6-day survey of the release area and

tallied nine sea otter including a female with a young pup (Schneider 1968). No in-depth studies have been conducted on translocated sea otter in Alaska (K. Schneider personal communication).

California

The first translocations outside of Alaska took place in California from January to August 1969; 17 sea otter were moved a distance of 45 miles (Odemar and Wilson 1969). The attempt was deemed unsuccessful since tagged otter were observed near the capture site shortly after translocation, and subsequently no tagged animals were observed at the release site (Odemar and Wilson 1969, Wild and Ames 1974).

British Columbia and Washington

Translocations of sea otter from Amchitka Island, Alaska to portions of their former range, outside of Alaska, began in 1969. British Columbia received three shipments of sea otter, 29 in 1969, 14 in 1970, and 46 in 1972 (Cameron 1972). No follow-up studies were conducted although infrequent sightings have been made by biologists and coastal visitors (Ian D. Smith personal communication).

During the summers of 1969 and 1970 sea otter were released along the Washington coast near the town of La Push. Many of the otter released in 1969 died, and the success of the 1970 liberation of

30 otter is unknown (Burton Lauckhart personal communication).

Oregon

Two translocations totaling 93 sea otter have been made in Oregon. Twenty-nine were released near Port Orford, Oregon on 18 July 1970. A second release of 64 sea otter was made on 24 June 1971: 40 were liberated at Simpson Reef approximately 3 miles south of the mouth of the Coos River; and 24 were released at Port Orford.

Otter released in 1970 were flown to an airport near Port Orford. They were then transported to Port Orford and placed in floating holding pens designed by the Alaska Department of Fish and Game. After a 2-day holding period, the pens containing the otter were towed approximately 3 miles south to Redfish Rocks where they were liberated.

Two release sites were selected for the June 1971 translocation, South Cove of Cape Arago, and Port Orford. Upon arrival the otter were to be placed in holding pens; however, because of an unseasonable storm the otter were released directly to the open water from their carrying cages.

Objectives of This Study

Kenyon (1969) posed several questions regarding the fate of translocated sea otter: Will they scatter upon release thus failing to form breeding colonies? Will they attempt to return to their "home territory"? Will human encroachment and habitat pollution inhibit the establishment of a viable population? Such questions were instrumental in formulating the following objectives of this study:

1. Evaluate the short-term success of attempts to reestablish sea otter along the coast of Oregon by:
   a. documenting the distribution and abundance, and reproductive success of the translocated otter.
   b. documenting otter food habits and assess the availability and abundance of potential food species.
   c. documenting habitats favored by translocated sea otter.
2. Identify potential sea otter habitat along the Oregon Coast.

II. METHODS AND MATERIALS

Distribution and Abundance

Distribution and abundance records were obtained by several methods. Reports of sea otter sightings by coastal observers, such as fishermen and biologists were requested; and the southern Oregon Coast was periodically searched using a telescope (40-80X) from observation points. Offshore reefs were searched by boat and aerial survey. Aerial surveys were flown at altitudes ranging from 100 to 500 feet; airspeed varied, depending upon the type of aircraft, from 70 to 150 mph.

Food Habits

Sea otter characteristically bring food to the surface before eating (Murie 1940, Daughtery 1972, Kenyon 1969). With a telescope I was often able to identify the foods brought to the surface and eaten by otter at Simpson Reef. Observation periods ranging from 1-5 hours were spent at this location, depending upon the level of the tide.

To complement the food habit portion of this study an underwater survey was made of Simpson Reef to assess the relative abundance and availability of sea otter prey.

Quantitative sampling of the benthos was accomplished with the aid of SCUBA (self contained underwater breathing apparatus). A plot transect method was used. Those sites receiving foraging use by sea otter were sampled by swimming a compass transect at the surface and approximately every 10 meters dropping a 0.25 m^2 or 1.0 m^2 metal frame which settled to the bottom. I then dove and recorded the number and species of each potential otter food item that was wholly or partially inside the frame. Only invertebrates equal to or larger than turban snails (Tegula spp., 2-3 centimeters in diameter) were recorded. Also recorded for each plot were character of substrate and depth of water. Depths were taken with an oil filled depth gauge.

Qualitative underwater surveys of several areas were completed. Invertebrates encountered during the survey were assigned a relative abundance rating (Table 1). In addition, character of substrate (rock, rock-shell, shell, gravel, or sand) and depths were recorded. The areas surveyed were selected on the basis of current sea otter use or on their suitability as potential sea otter habitat.

Habitat Description

Sites utilized by sea otter were described. Descriptions included major vegetational types, physiography of shorelines and emergent reefs, depth of water, and character of benthic substrates. These data were obtained from Coast and Geodetic Survey navigational

charts, aerial photographs, and on-site observations from above and below the water surface (Table 2).

Table 1. Relative abundance ratings assigned to potential sea otter prey species encountered in qualitative benthic surveys.

A:	Abundant	- Species encountered in suitable habitats at high densities on suitable substrates.
C:	Common	- Species encountered on suitable substrates throughout sample area but at lower densities than above.
U:	Uncommon	- Species encountered, but not on all suitable substrates and at low densities.
R:	Rare	- Species encountered only one or two times during survey.
P:	Present	- Species observed but not given an abundance rating (motile and burrowing species were usually placed in this category).

Table 2. Criteria used to assess potential sea otter habitat in Oregon.

1.	Presence of rocky headlands, capes, islands and/or sea stacks.
2.	Presence of extensive submergent reefs.
3.	Presence of kelp beds.
4.	Relative abundance and availability of food resources.
5.	Presence of areas offering protection from winter and summer storms.
6.	Water depth less than 20 fathoms.
7.	Water relatively free of pollution and threat of pollution.
8.	Human encroachment minimal.

III. DESCRIPTION OF STUDY AREA

General View

The general study area included the entire coast of Oregon (Figure 1). The area extending south from the mouth of the Columbia River is characterized by rocky capes and headlands separated by low sand dunes and sand beaches of various lengths. Sea stacks are relatively common from Tillamook Head to Cape Foulweather. The ocean floor from Tillamook Head to Lincoln City is primarily mud and sand, but rock substrates predominate from Lincoln City to the mouth of the Yaquina River. Beds of bull kelp (Nereocystis luetkeana) extend over an area of approximately 625 acres in this region (Waldron 1955).

The coastline from Yaquina Bay to Heceta Head consists of intrusive basalt headlands separated by sand beaches, with sand and mud the predominating subtidal substrates. Beyond Heceta Head 53 miles of sand beaches and dunes extend south to the mouth of the Coos River (Dicken 1965). Coos Head is the southern terminus of this section of coast. Southward for approximately 7 miles, the coastline is rugged and broken and the bottom rocky.

South of Cape Arago for 13 miles the coastline is comprised of sand beach disrupted by a small sandstone intrusion and associated reef (Five-Mile Point) and a series of sea stacks and small islands at

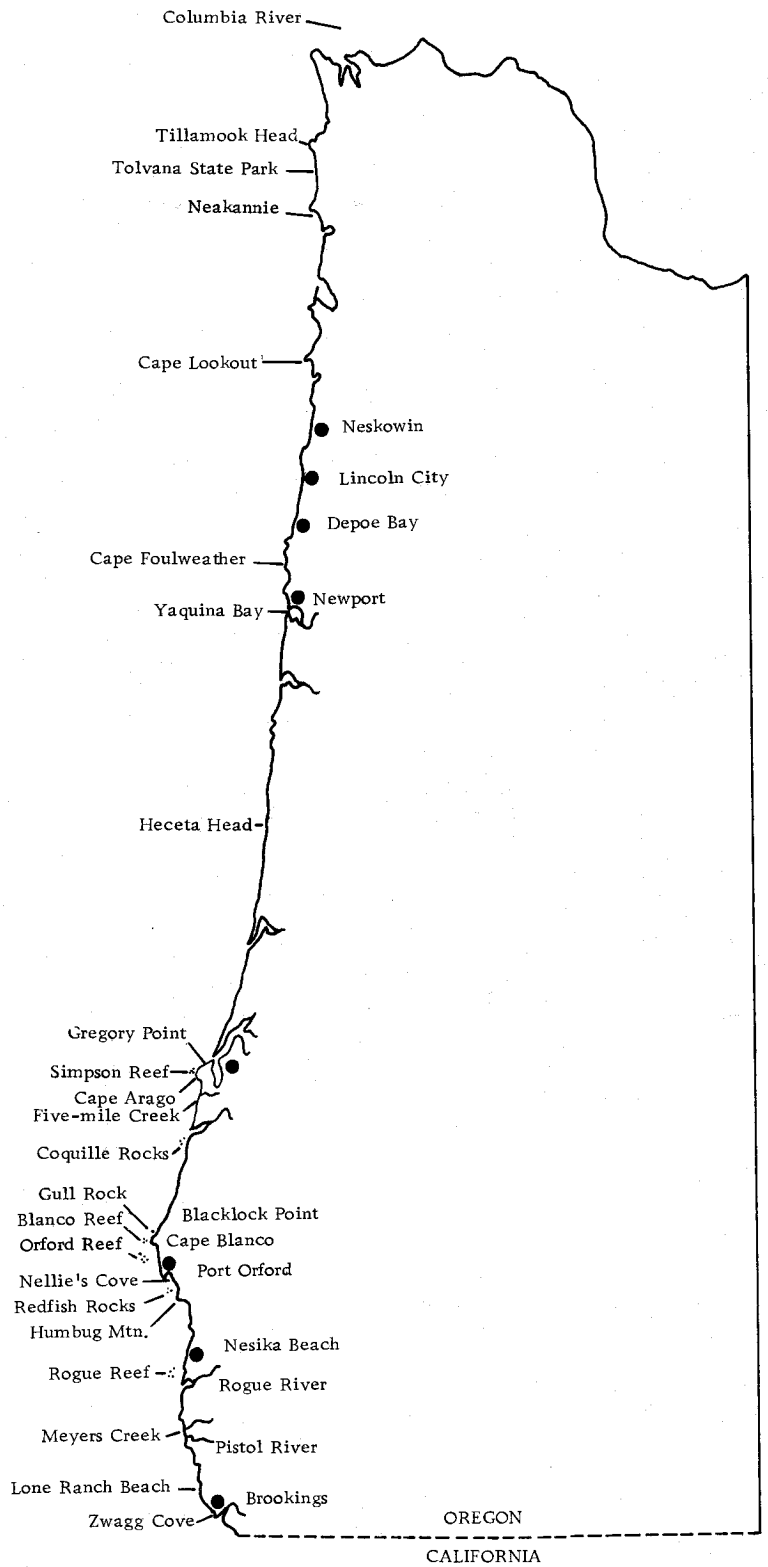

Figure 1. Map of the Oregon Coast indicating sites mentioned in this report, including release locations for the 1970 and 1971 sea otter translocations.

the mouth of the Coquille River. A sand beach, 10 miles in length, extends from Coquille Rocks to Blacklock Point. Beyond this point the coastline becomes broken, beaches are shorter, and offshore seastacks and reefs are relatively common. The coastline continues in this manner to the Oregon-California border.

Areas of Intensive Study

Two areas used by sea otter received intensive study, Simpson and Blanco reefs. Simpson Reef is an offshore rock area consisting primarily of erosion resistant sandstone (Ehlen 1967). Two emergent reefs lying roughly parallel to each other and to the mainland are the predominant physiographic features. Substrates are primarily bedrock with many depressions and crevices filled with the broken shells and tests of mollusks and sea urchins (Strongylocentrotus sp.). The mean tidal range for the vicinity is 5.2 feet (Bourke and Glenne 1971).

According to Waldron (1955) 358 acres of kelp lie between Coos Bay and Cape Arago; much of this acreage is found at Simpson Reef. Simpson Reef is the only location along the Oregon Coast that supports large beds of giant kelp (Macrocystis pyrifera). These beds account for approximately 33 percent of the total kelp acreage at Simpson Reef; bull kelp accounts for the remainder.

The invertebrate community at Simpson Reef is typical of those found in similar habitats throughout Washington, Oregon, and northern

California (Ekmen 1953). Marine birds and mammals found at these latitudes are also common at Simpson Reef.

Blanco Reef is comprised of eight emergent rocks; the outermost is 1.12 miles offshore. Blackrock is the largest, approximately 40 yards in length. The orientation of Blanco Reef is north-south which affords a considerable amount of protection from westerly seas. The entire emergent portion of the reef lies within the 10 fathom contour; the mean water depth of this area is 5.02 fathoms (30.12 feet, depths obtained from Coast and Geodetic Survey Navigational Charts). Substrates are primarily rock with some depressions and crevices containing sand and broken shells.

Blanco Reef supports floral and faunal communities similar to those of Simpson Reef. The dominant emergent alga found here is bull kelp. According to Waldron (1955) kelp beds at Blanco Reef range from thin to dense and cover an area of 223 acres.

IV. RESULTS AND DISCUSSION

Distribution and Abundance

Results

Prior to the initiation of this study (1 November 1971) several sightings of translocated sea otter were reported (Table 3). Within 7 days after the July 1970 release at Redfish Rocks at least one sea otter had moved 40 miles north of the release site into the Coos River estuary (B. Mate and B. Williams unpublished manuscript). A survey conducted on 26 August 1970 indicated that sea otter were distributed from Humbug Mountain, 3 miles south of the release site, to Simpson Reef 46 miles north of Redfish Rocks (Oregon State Game Commission 1970). This census tallied seven otter; the largest single group contained three otter. Another survey was completed by Bruce Mate (personal communication) on 19 and 20 October 1970. He observed 14 sea otter on this survey at five locations. The largest groups were seen at Orford Reef (four otter) and Humbug Mountain (four otter). The remaining three sites, Cape Blanco, Gull Rock, and Coos Bay yielded two, three, and one otter respectively.

No confirmed sightings were reported from October 1970 until 26 April 1971 when three otters were sighted at Orford Reef. A

Table 3. Summary of sea otter sightings made in Oregon subsequent to the July 1970 release and prior to the initiation of this study on 2 November 1971.

Date	Location	Number of Otter	Time Lapses From Release Date in Days	Miles Distant From Nearest Release Point
1970				
18 July: first translocation accomplished		29		
27 July	Coos Bay	1	7	50
26 August	Humbug Mountain	3	37	3
	Cape Blanco	2	37	11
	Simpson Reef	2	37	46
19-20 October	Humbug Mountain	4	49-50	3
	Cape Blanco	2	49-50	11
	Gull Rock	3	49-50	13
	Orford Reef	4	49-50	9
	Coos Bay	1	49-50	50
1971				
26 April	Orford Reef	3	188	9
2 May	Bastendorff Beach	1	194	47
24 June: second translocation accomplished		64		
25 June	Simpson Reef-Gregory Point	11	1	0-2
29 June	Meyers Creek	1	5	35
23 July	Cape Blanco	3	29	9
	Fivemile Point	2	29	6
	Simpson Reef	3	29	0
31 July	Blacklock Point	5	37	13
21 September	Simpson Reef	2	89	44

subsequent survey on 2 May 1971 yielded one otter just south of the mouth of the Coos River (Mate unpublished data).

The second release was made on 24 June 1971. One day after the liberation a survey of the Cape Arago area yielded 11 otter, all within 2 miles of the release point (B. Mate personal communication). On 29 June I observed a single sea otter 35 miles south of Port Orford near the mouth of Meyers Creek. Whether this animal was from the 1970 or 1971 release is unknown. During the 3-month period subsequent to the 24 June releases sea otter were sighted at five locations (Table 3), and were distributed from Meyers Creek to Simpson Reef a distance of approximately 75 miles.

I began field work on this study on 2 November 1971. During the 2-year study period I received 26 reports of sea otter from fishermen and coastal residents. Reports were distributed from Tillamook Head to Brookings, Oregon, a distance of 276 miles.

The validity of many of these reports is questionable due to the inexperience of many observers. River otter (Lutra canadensis), harbor seals (Phoca vitulina), fur seals (Callorhinus ursinus), and sea lions (Eumetopias jubata and Zalophus californianus) may all be observed in the nearshore marine environment and could be mistaken for sea otter by an inexperienced observer. All trips to report sites yielded no observations of sea otter, but two reported sightings do warrant consideration. On 10 June 1972 four to five sea otter were

reported near Neskowin, Oregon, 128 miles north of the nearest release site. A description of the animals and their behavior was supplied by the observer and supported his conclusion that they were sea otter. A second report of three sea otter was made by a professional naturalist with experience observing sea otter along the central coast of California. The animals were observed, with the aid of binoculars, from a distance of 50 feet near Tolovana State Park, 181 miles north of Cape Arago (Christian Nelson personal communication). I consider this report to be valid and representative of the northernmost sighting of sea otter in Oregon since the 1970, 1971 reintroductions.

The apparent distribution of the translocated sea otter is reduced when only confirmed sightings are considered. Most sea otter habitat in Oregon is located along the southern portion of the coast relatively close to the release sites; therefore, I conducted a more concerted search in this region. During 1971 sea otter were distributed over a distance of approximately 75 miles and were sighted at seven locations. In 1972 they were observed at four locations; however, three of the sites were located within 5 miles of each other. By 1972 and throughout 1973, the translocated sea otter were distributed over a 40 mile coastal section with Orford Reef the southern terminus and Simpson Reef the northern limit. Areas of otter concentration were Simpson and Blanco reefs.

Movements of sea otter are not well known. Kenyon (1969) stated that the home range of a sea otter extends over probably no more than 10 miles of coastline. Lensink (1962:95) states that "sea otters generally have not tended to exploit unoccupied areas, even when adjacent regions offer suitable habitat and no barriers exist to retard movements." This statement supports Kenyon's opinion that sea otter occupy a limited home range and further implies that a fairly strong affinity for an area may exist.

The average number of sea otter observed per observation day during January of 1972 at Simpson Reef was 6.5 (Table 4). By March of the same year the average had increased to 17.6. The April figure of 15.0 marked the initiation of a decline in use of Simpson Reef that continued throughout subsequent months reaching a low point in September. A census made at Simpson Reef on 8 October 1972 yielded three sea otter indicating little change in the number of animals using the reef since the previous month. However, counts made later in October increased, thereby increasing the average for the month to 5.8. This increase continued until December when the average was 13.3. Numbers of otter at Simpson Reef during the month of December 1972 ranged from 11 to 15, the greatest sea otter use for any period during the 1972-1973 winter. The use pattern for the

Table 4. Sea otter use of Simpson and Blanco reefs, January 1972-September 1973.

	1972						1973					
	Simpson Reef			Blanco Reef			Simpson Reef			Blanco Reef		
Month	$\bar{X}$	N	Range	$\bar{X}$	N	Range	$\bar{X}$	N	Range	$\bar{X}$	N	Range
Jan	6.5	2	5-8	--	-	-	11.0	2	10-12	--	-	-
Feb	14.3	4	8-21	--	-	-	12.0	2	12-12	--	-	-
Mar	17.6	5	14-20	--	-	-	9.8	4	9-10	7.0	2	7-7
Apr	15.0	4	12-18	--	-	-	5.3	7	1-10	12.5	6	4-19
May	9.3	6	3-16	--	-	-	1.3	6	0-4	16.7	6	14-19
Jun	3.9	7	2-6	--	-	-	0.0	5	0	14.8	4	15-18
Jul	5.7	14	4-7	--	-	-	0.5	4	0-2	17.9	7	15-21
Aug	4.4	18	2-9	14.0	6	10-16	0.0	7	0	18.3	6	16-20
Sep	1.7	7	0-3	14.7	3	12-18	--	-	-	19.0	1	19
Oct	5.8	5	3-8	0.0	1	0	--	-	-	--	-	-
Nov	10.8	5	8-13	--	-	-	--	-	-	--	-	-
Dec	13.3	6	11-15	0.0	1	0	--	-	-	--	-	-

$$\bar{X} = \frac{\text{Sum of daily census counts}}{\text{Number of census days (N)}}$$

1972-73 winter was similar, but not identical, to the one for 1971-72 (Figure 2). The 1973 maximum figure occurred at a lower level and earlier than the 1972 peak.

Surveys of Orford and Blanco reefs were limited during the 1971-72 winter; however, data from shoreline and aerial surveys indicate that sea otter were present at least until the middle of December (Table 5).

Table 5. Sea otter sighted on aerial surveys of the Oregon Coast 1971-1973.

Date	Location of Otter Sightings: Orford Reef	Blanco Reef	Gull Island	Simpson Reef	Survey Area
19 Dec. 1971	2	0	2	4	Coos Bay-Calif.
26 Apr. 1972	0	0	0	13	Coos Bay-Calif.
26 Jun. 1972	2	0	0	3	Entire Coast
4 Jun. 1973	0	10	0	0	Entire Coast
29 Jun. 1973	0	15	0	0	Entire Coast

I first observed relatively large numbers of sea otter at Blanco Reef (10 otter) on 2 August 1972 (Table 4). Surveys of Blanco Reef completed on 7 October, 28 December and 19 March 1973 were negative. Surveys of Blanco Reef on 23 and 24 March 1973 each yielded 7 otter indicating recent immigration to the area. Sea otter were observed on all subsequent surveys of Blanco Reef to the time field work was terminated on 5 October 1973, and the average number seen for the period was 16.4 (sd=3.6).

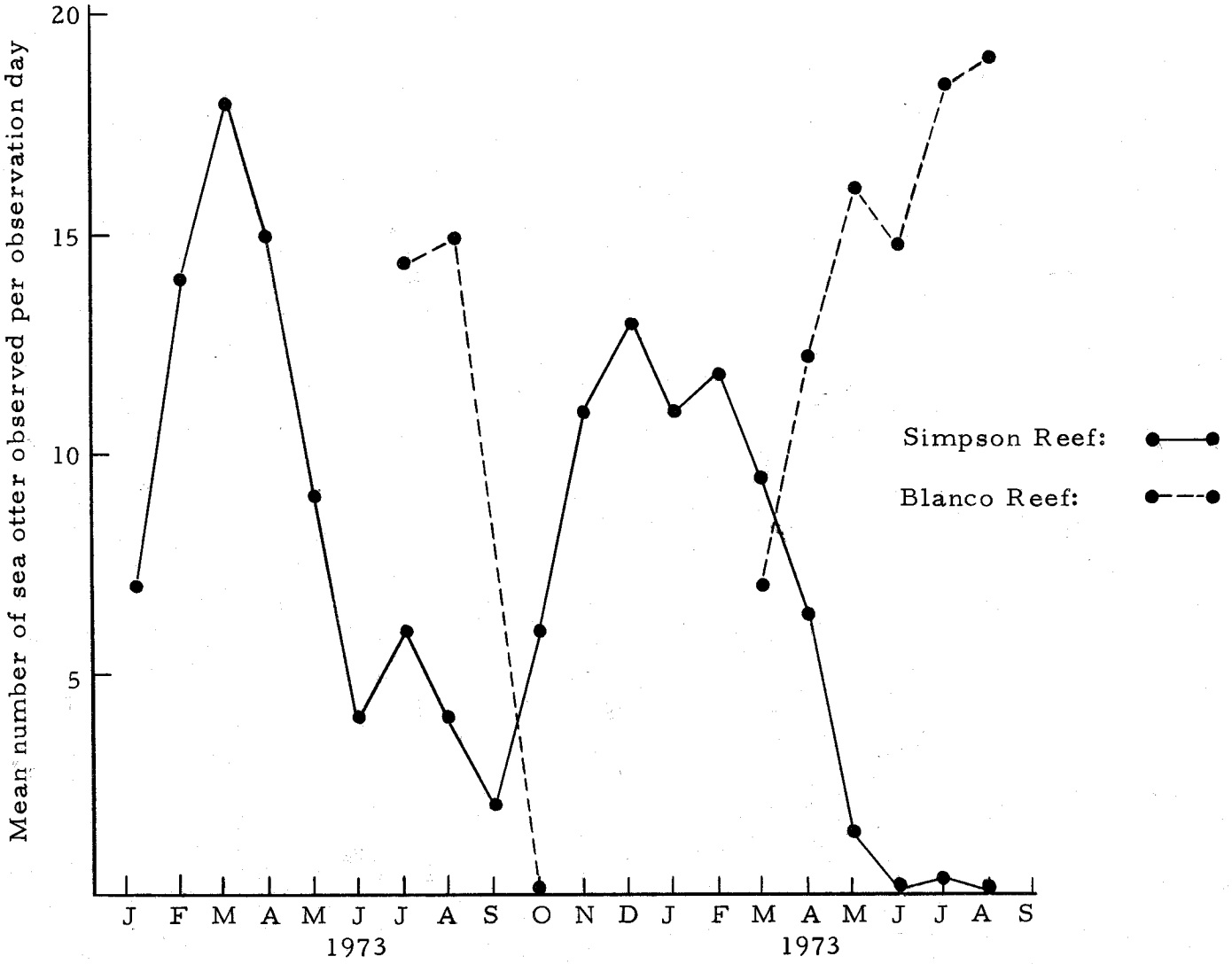

Figure 2. Sea otter use of Simpson and Blanco reefs, January 1972-September 1973.

Discussion

Upon liberation the translocated sea otter initially scattered and several moved considerable distances from the point of release. After the 1970 liberation, the otter apparently moved in small groups over a section of coast from 3 miles south to 50 miles north of Redfish Rocks. Moreover, no sea otter were observed near the release site in any of the subsequent surveys. After the 1971 release, a shoreline survey from Cape Arago north to Coos Bay yielded 11 sea otter 1 day after the June 1971 release (B. Mate unpublished manuscript). This sighting accounts for 28 percent of the 40 otter released in the area, and it raises a question regarding the fate of the remaining 29 animals. Possible explanation for this disparity include: inaccurate counts, high post-release mortality, or emigration. Surveys (129 during the study) of Simpson Reef and vicinity yielded a maximum count, excluding pups, of 20 sea otter. Thus, never more than 50 percent of the number of sea otter liberated in 1971 were observed.

Documented post-release mortality is insufficient to resolve the disparity between the number of otter released and the number observed on later surveys (Table 6). Emigration seems to be the most plausible explanation for the disappearance of a large portion of the otter released at Simpson Reef.

Table 6. Documented mortality of translocated sea otter July 1970-October 1973, Oregon: M = male, F = female, A = adult, P = pup, U = unknown.

Year of Recovery	Recovery Date	Sex	Age	Location	Cause of Death
1970	18 July	M	U	Port Orford	Exposure
	18 July	F	U	Port Orford	Exposure
1971	24 June	U	U	Port Orford	Drowned in cage
	25 June	U	U	Simpson Reef	Unknown
	24-28 June	M	P	Port Orford	Unknown
	24-28 June	U	U	Simpson Reef	Unknown
	24-28 June	U	U	Simpson Reef	Unknown
1973	3 Aug.	M	A	Cape Blanco	Unknown, carcass badly decomposed

Summary of Otter Mortality	
Females	1
Males	2
Unknown	5
Total	8
Total otter translocated	95
Percent mortality	8.4

A considerable amount of the effort was directed at determining the abundance of sea otter in Oregon after the reintroductions were completed (Table 7). I estimate that a resident population of sea otter numbering 30 to 35 animals, including pups was present at the termination of this study. Therefore, of the 93 otter successfully released in Oregon an estimated 33-38 percent of that number, including pups, were on the coast in June of 1973.

Table 7. Sea otter sighted on 23 shoreline surveys of Simpson, Blanco and Orford Reefs completed from 19 February 1972-15 August 1973.

Date	Simpson Reef	Blanco Reef	Orford Reef[b]	Total
20 February 1972	19	1	--	20
2 August 1972	9	10	--	19
15 August 1972	2	16	--	18
18 August 1972	3	15	--	18
24 August 1972	3	13	--	16
30 August 1972	3	15	--	18
13 September 1972	2	18	--	20
24-25 March 1973[a]	10	7	0	17
5 April 1973	10	4	--	14
6 April 1973	10	10	--	20
20 April 1973	3	15	--	18
26 April 1973	3	13	--	16
27 April 1973	5	14	--	19
4 May 1973	0	17	--	17
5 May 1973	0	19	--	19
18 May 1973	1	18	--	19
24 May 1973	1	15	--	16
25 May 1973	2	17	--	19
7 June 1973	0	16	0	16
29 June 1973	0	15	0	15
4 July 1973	0	15	--	15
20 July 1973	2	19	2	23
15 August 1973	0	20	--	20
Mean				18

[a]Simpson Reef was surveyed on 24 March and Blanco and Orford reefs were surveyed 25 March.

[b]Atmospheric conditions usually precluded searching Orford Reef from shore.

Sea otter appear to have an affinity for a particular home range (Lensink 1962, Khromovskikh 1968, Kenyon 1969). Translocated sea otter upon being released into an unfamiliar environment may, therefore, exhibit "homing" behavior. A California translocation of sea otter suggests that this does occur. Observations made within 2 months of the release (17 otter were translocated) indicated that at least 29 percent of the translocated otter had returned to the capture site (Odemar and Wilson 1969).

Nelson's (1972 personal communication) observation of three sea otter on 24 August 1972, 181 miles north of the nearest Oregon release site, suggests that otter may move considerable distances after being liberated. Whether these were sea otter released in Oregon, Washington, or British Columbia is a matter of conjecture; however, since no resident populations were known to exist in these areas it can safely be assumed that the otter probably came from one of the translocation sites.

Why some sea otter may scatter and move significant distances after being released and others do not is unknown. Possibly, there is a differential affinity for a home range among age classes. Range expansion in California seems to be accomplished primarily by young adult and subadult otter (Wild and Ames 1974). Perhaps subadult and younger adult otter have not yet developed a propensity for a home range and would, therefore, more readily accept a new environment.

The distributional patterns of sea otter suggests seasonal movements. The patterns of sea otter use of Simpson Reef for 1972 and 1973 are similar, but not identical, with the heaviest use occurring during the winter storm season (January-April), and the lightest use occurring during the calmer summer months.

Previous workers have stated that seasonal movements of sea otter are restricted to offshore movements during periods of calm weather with a return to more protected waters, usually closer to shore, during periods of storm activity (Barabash-Nikiforov 1947, Lensink 1962, Kenyon 1969). To my knowledge no regular long distance movements of sea otter have been reported. However, the data gathered during this study indicated a seasonal movement of 35 miles between Simpson and Blanco reefs, rather than an onshore-offshore movement described by previous workers.

Observations (Tables 4 and 5) suggest sea otter migrate between Simpson Reef and Blanco and Orford reefs in response to inclement winter weather conditions. The otter return to Blanco and Orford reefs as severe weather subsides and the frequency of human encroachment at Simpson Reef increases. Simpson Reef has good summering habitat available, but the Cape Arago-Coos Bay section receives intensive human use during the summer; therefore, human encroachment should be included here as a possible cause of emigration.

Aerial surveys completed on 4 and 29 June 1973 of the entire Oregon coastline yielded observations of sea otter only at Blanco Reef. These otter were probably the same animals that had been at Orford and Simpson reefs during the winter months.

Ten sea otter were sighted at Orford Reef on 29 December 1972. This sighting may explain the comparatively lower counts on Simpson Reef during the winter of 1972-73. Apparently a portion of the herd chose to winter at Orford Reef.

The sighting of a newborn pup at Simpson Reef on 21 October 1972 and its subsequent disappearance after 3 November, and the later sightings of a 4-5 month old pup on Blanco Reef on 30 March 1973, also suggest seasonal movements. These data do not preclude, however, the possibility that the older pup had been born in the vicinity of Cape Blanco and escaped detection. Whether these movement patterns become traditional will require further observations. Otter use of Simpson Reef in 1972-73 has declined, and a single survey of the area in February of 1974 yielded only three sea otter. Average otter use for February 1972 and 1973 was 14.3 and 12.0 respectively. Possibly the utilization of Simpson Reef by sea otter will decrease as the animals become more familiar with the Blanco Reef area.

Reproduction of Translocated Sea Otter

Results

The first sea otter pup was sighted on 20 February 1972, 19 months after the July 1970 release at Port Orford. Subsequently, three more young pups (less than 1 month old) were observed in 1972. Three of the four pups were first seen at Simpson Reef, and one was seen at Blanco Reef (Table 8).

Sightings of six otter pups were made during 1973, five at Blanco Reef and 1 at Simpson Reef.

Table 8. Summary of sightings of sea otter pups in Oregon, 1 November 1971-5 October 1973.

Year					
1972			1973		
Date	Location	Number	Date	Location	Number
20 Feb.	Simpson R.	1	5 Apr.	Simpson R.	1
24 Aug.	Blanco R.	1	6 Apr.	Blanco R.	1
21 Oct.	Simpson R.	1	19 Apr.	Blanco R.	1
27 Nov.	Simpson R.	1	17 Jul.	Blanco R.	1
			13 Aug.	Blanco R.	1
			29 Aug.	Blanco R.	1
Total		4			6

Copulation was observed on 17 occasions, nine in 1972 and six in 1973. Copulating pairs were observed on three occasions in December 1972 and March and April of 1973. No more than three such pairs

were observed in any month, with most months yielding only one observation.

The duration of copulation was timed on three occasions during 1973. Periods lasted 2.95, 5.00, and 2.18 minutes ($\bar{X}$ = 3.38).

Breeding behavior was generally in aggrement with Kenyon's description (1969). A male usually "tested" a female by approaching and nuzzling her genitalia and hindquarters. If the female were receptive, the pair would often leave the herd and begin a period of rapid swimming and vigorous play prior to coitus.

Pre-copulatory activities appeared to be led by the female with the male always the aggressor, but never the leader. The female initiated any new activity such as feeding or grooming. Copulation was often followed by a period of vigorous grooming after which the pair would return to the herd, or begin a feeding period. I was unable to determine if the otter remained together for more than the duration of a single breeding sequence. Kenyon (1969) stated that a mated pair may remain together for a 3-day period after the initial copulation; Vandevere (1973) concurred with Kenyon's statement.

Discussion

Estimates of the length of sea otter gestation range from 7.5 to 13 months (Lensink 1962, Kenyon 1969, Schneider 1973). However, in estimating the reproductive potential of a population the age of

reproductive maturity and the interim between births are of greater significance than the actual length of the gestation period. Schneider (1972:35) states that an average female sea otter "...has a pup every 2 years" and its first estrus in the third or fourth year of life.

In view of the current knowledge of the reproductive biology of sea otter, the growth rate of the translocated population will be slow. The sex ratios and relative ages of sea otter translocated to Oregon are partially known (Table 9); however, there is no way of knowing which otter survived the translocation or remained within the study area. Because of this, a prediction of the potential growth rate of the population cannot be made utilizing relative age and sex ratio data.

The first pup was observed on 20 February 1972 at Simpson Reef, 8 months after the June 1971 liberation and 19 months after the 1970 Port Orford release. This pup could have been conceived in Alaska; however, all subsequent pups would have resulted from reproductive activity by otter in Oregon, since sufficient time for a complete gestation period would have elapsed (Table 10).

The age distribution of a population is an important factor in determining its reproductive potential. Of the 95 sea otter shipped to Oregon, at least 37.9 percent were adult females and 9.5 percent were adult males.

Schneider (1972) reports that sexually mature female sea otter may develop large follicles each year but if accompanied by

Table 9. Summary of relative ages and sex ratios of sea otter translocated to Oregon in 1970 and 1971.

Year	Sex and Age Composition of Translocated Sea Otter								Grand Total
	Females				Males				
	Adult	Subadult	Unknown	Total	Adult	Subadult	Unknown	Total	
1970[a]	8	7	6	21	5	5	0	10	31
1971	28	12	3	43	4	16	1	21	64
Total	36	19	9	64	9	21	1	31	95

[a]One male and one female died in the holding pens at Port Orford in 1970; therefore, of the 31 otter shipped to Oregon in 1970, 29 were successfully released. No age information for either the male or female was located. The total number of otter successfully released for both years is 93.

dependent pups normally do not mate. Anestrous females having recently weaned a pup may not enter estrus immediately, but will "rest" for a few months before breeding again. If, however, a pregnancy fails, or the pup dies, the female may breed again within a few weeks of the pup's death.

Table 10. Elapsed time from release dates of sea otter to date of pup sighting.

Month and Year of Sighting	Time Lapse From Years of Release (Months)		Number of New Pups Sighted Each Month
	1970	1971	
February 1972	19	8	1
August 1972	25	13	1
October 1972	27	15	1
November 1972	28	16	1
April 1973	33	21	3
July 1973	36	24	1
August 1973	37	25	2
Total			10

In view of this information it appears that adult female otter released in Oregon should have bred within a relatively short time (1-4 months) after being released; and, consequently, several pups would have been produced during the first year. The data collected during this study indicate that this did not occur. The reasons for the delay in reproduction remain unknown.

Researchers in California and Alaska have noted that small sea otter pups are observed more frequently at certain times of the year than at others. Vandevere (1973) reported the peak period of pupping in California as occurring during the fall and winter months (November-March). Kenyon (1969) reported that parturition may occur at any season, although new-born pups are observed more frequently during March and April. Schneider (1973) reports a more well defined period of pupping for otter in Alaska. His results, which were based on the examination of 1178 female reproductive tracts, suggest a primary pupping season beginning in April, peaking in May, and falling off in June.

The translocated otter have produced at least 10 pups; 70 percent of these were born during the period from April to August. These data seem to suggest a temporal pattern, with most births occurring during the mid-spring to late summer period, with a possible peak in April.

Pup Maturation and Dependency Period

A pup first observed on 20 February 1972 remained at Simpson Reef until 11 August 1972. During this period I made regular visits to the area and recorded the physical and behavioral development of the young otter.

A considerable body of literature exists regarding the female-pup relationship; however, none of these reports deal with the development of a single known age pup (Fisher 1940, Lensink 1962, Kenyon 1969, Sandegren et al. 1973). The pup discussed here was observed on a weekly basis, excepting a 30 day period from 14 May-14 June. Female and pup were not observed at Simpson Reef after 11 August.

At the initial sighting, the pup was helpless and could only nurse and move its head weakly while lying on the female's abdomen. According to Kenyon (1969), sea otter pups remain helpless during the first few weeks of life. Based upon descriptions of sea otter pups given by Pearson (1952) and Kenyon (1969) I estimated the age of the pup discussed here as 2-3 weeks at the time of the initial sighting, and it was probably born in early February.

By 25 February the pup, when in the water, was able to make uncoordinated movements of its limbs but was unable to swim. Swimming was first noted on 19 March, and was accomplished in a belly down position. Although awkward and inefficient the pup was able to swim in a non-random direction by this time.

The female appeared to offer the pup solid food once during this early period, but subsequently gave solid food only on demand. The pup was first noted soliciting for solid food on 31 March and made its first attempts to dive, although unsuccessfully, on this date.

In early April the pup began resting in the water perpendicular to the female with its head supported by the mother's chest. However, when the pair moved to a new location the female still carried the pup even for short distances.

By mid-April the pup could swim poorly on its back and by early May it was diving and procuring nonfood items. Upon surfacing with an object the pup would, bite it a few times or pound it against its chest, discard the item, and dive again. This sequence was usually repeated several times, and a series was often terminated by the pup soliciting food from the female. No obvious changes in the pup's behavior were noted during the remainder of May.

By late June the pup was still taking food, and was occasionally groomed by the female, although it was capable of grooming itself. The pounding behavior had become more refined: rather than pounding a single item against its chest, two items, still nonedibles, were pounded one against the other. No objects obtained by the pup were observed to be ingested.

I first observed the pup capturing and consuming small prey items during its fifth month; however, it still depended on the female to supply much of its food. Purple sea urchins (Strongylocentrotus purpuratus) were being gathered by the young otter, but it was unable to penetrate the urchin's test. Consequently, they were not ingested but were discarded. By the end of July, when slightly over 6 months

old, the pup was obtaining much of its own food, could open purple sea urchins with the aid of a stone, and appeared more independent of the female. The female, however, would still surrender food to the pup upon demand. Little change in the pup's development was noticed between 31 July and 11 August.

Kenyon (1969) states that sea otter pups remain with their mothers for as long as a year. Lensink (1962) suggests a somewhat shorter period for male pups. According to Vandevere (1973) sea otter in California may have a dependency period of less than a full year. The Oregon pup was dependent upon its mother for at least 6 months. At the end of that time, it was obtaining a significant proportion of its own food, but was also soliciting and receiving both solids and milk from the female. Unfortunately, the pair left Simpson Reef when the pup was approximately 6 months old and observations were therefore terminated.

A series of observations made at Simpson Reef during December 1972 suggest that the duration of the pup dependency period is at least 10 months. On 20, 24, and 27 December a female and large pup were sighted on the reef. In the water only a slight size difference was discernible; but the behavior of the smaller animal, taking of food and on one occasion nursing, indicated it was a large pup. These observations were made over 10 months after the sighting of the first pup on 20 February 1972. During the interim period 3 other pups had

been observed but the oldest of these would only have been 4 months old by this time. Therefore, assuming the large pup observed during December to be the same animal first observed during February, the dependency period would be at least 10 months long.

Food Habits and Food Availability

The feeding habits of sea otter have been studied in both the northern and southern portions of its range. Williams (1938), Wilke (1957), Lensink (1962), Kenyon (1969), and Calkins (1972) completed food habit studies of sea otter in the Alaskan portion of the species range. None of these studies incorporated an assessment of food availability.

Numerous food habit studies have been done in California. Fisher (1939) published one of the earliest accounts of sea otter food habits. More recently, several other food habit studies have been completed. Hall and Schaller (1964) reported that California mussels (Mytilus californianus) and purple sea urchins comprised over 70 percent of the diet of a group of otter near Point Lobos, California. Ebert (1968) studied food habits near Pico Creek, California. His results indicate that abalone (Haliotus sp.) and crabs comprised nearly 90 percent of the otter's diet. Ebert's study also incorporated SCUBA surveys to determine the relative abundance and availability of potential food resources. Wild and Ames (1974) have presented food habit

data from several sites in California that indicate sea otter diets may vary from area to area and within the same area over an extended period of time.

The marine invertebrate communities of Oregon are similar to those found in central California; therefore, the results of my study are compared with those of California researchers.

Results

Purple and red sea urchins occurred most frequently in the diet of the otter comprising nearly 64 percent of the total number of observations. Mollusks accounted for 14.4 percent of the total, with rock scallops (Hinnites multirugosus), California mussels, and turban snails occurring most frequently. The remaining 5.2 percent of the diet consisted of several species of crabs (Table 11). Large Cancer crabs which were not identified to species were probably rock crabs (Cancer antennarius or Cancer productus). Kelp crabs (Pugettia producta) probably occurred more frequently in the otter's diet, but because of their relatively small size could not be identified as readily as larger crabs.

Sea otter require an amount equaling approximately 20 percent of their total weight in food per day (Kenyon 1969). Kenyon has stated that this amount of food would have a caloric content of 3000 plus calories. He concluded that green sea urchins (S. drobachiensis) at

Table 11. Food items ingested by sea otter at Simpson Reef, June-August 1972.

Group	Number of Observations	Percentage of Observations
Echinodermata:		
Strongylocentrotus purpuratus	223	52.47
Strongylocentrotus franciscanus	48	11.29
Cucumaria miniata	7	1.64
Pisaster ochraceus	2	.47
Total	280	65.88
Mollusca:		
Saxidomis sp. and Protothaca sp.	7	1.64
Hinnites multirugosus	10	2.35
Mytilus californianus	13	3.05
Tegula sp.	25	5.88
Haliotus sp.	1	.23
Cryptochiton stelleri	1	.23
Octopus sp.	4	.94
Total	61	14.35
Crustacea:		
Cancer magister	5	1.17
Cancer productus and antennarius	4	.94
Pugettia producta	2	.47
Unidentified crabs	11	2.58
Total	22	5.17
Unidentified items	62	14.58
Grand Total	425	100.00

Amchitka Island, Alaska were nutritionally unimportant to the otter since nearly 6500 urchins of the size most commonly encountered in the area would be required to satisfy a sea otter's daily energy demand. Because sea urchins accounted for a major portion of the otter's diet at Simpson Reef I estimated the number needed to satisfy an otter's daily energy needs.

Sea urchins occurring in Oregon are congeneric with those in Alaska. I calculated the average caloric content of local urchins from values given by Kenyon (1969) for green sea urchins assuming no differences in caloric content between congeneric organisms.

The mean caloric value calculated for five adult red sea urchins collected at Nellie's Cove was 127.8 calories (Table 12). Assuming an average daily energy demand of 3000 calories, 23.5 red sea urchins of the size collected would satisfy the daily energy needs of a sea otter for a 24 hour period.

Table 12. Test diameters and weights of five red sea urchins collected at Nellie's Cove, Oregon on 17 August 1973.

Test Diameter (mm)	Whole Weight (g)	Viscera Plus Gonad Weight (g)	Gonad Weight (g)
111.2	625.2	156.7	92.9
128.6	--	280.6	185.0
143.0	--	383.3	206.2
141.0	--	331.6	173.7
152.0	1060.9	431.8	260.3
$\bar{X}$ 135.2 (sd=15.8)		316.8 (sd=105.8)	183.6 (sd=60.7)

Analysis of 21 purple urchins collected at Nellie's Cove indicates that approximately 326 would meet an otter's daily energy needs (Table 13). However, 3 purple urchin tests, collected at Simpson Reef, which evidenced sea otter predation all had a diameter of greater than 70 mm. These urchins were collected postmortum; but based on the estimated caloric value of the largest live purple urchin collected (test diameter = 72.4 mm), approximately 125 urchins of this size would fulfill a sea otter's daily energy demand.

Table 13. Test diameters and weights of 21 purple sea urchins collected at Nellie's Cove, Oregon on 28 July, 1973.

Test Diameter (mm)	Whole Weight (g)	Weight of Viscera Plus Gonads (g)
60.2	99.5	33.0
50.5	89.4	30.8
65.5	129.1	56.4
48.1	52.3	14.2
32.1	21.0	3.2
33.4	17.5	3.5
41.8	30.3	8.5
48.5	48.5	21.6
48.4	59.1	16.8
49.4	55.2	18.0
47.0	53.0	15.0
38.5	24.8	6.8
58.3	104.6	39.5
55.9	86.6	30.2
72.4	164.8	59.0
66.6	149.3	53.3
44.2	41.4	13.7
52.9	66.9	22.8
36.8	22.1	5.2
49.0	61.2	22.4
35.6	19.4	5.1
$\bar{X}$ = 49.3 (sd=11.1)	66.5 (sd=43.11)	22.9 (sd=17.31)

A total of 67 plots was quantitatively sampled at Simpson Reef to assess the relative abundance and availability of potential sea otter prey items. Fifty 0.25 m^2 plots and seventeen 1 m^2 plots were sampled (Table 14).

Purple sea urchins occur at high densities at Simpson Reef comprising 75 percent of all organisms enumerated. The average number of purple sea urchins occurring per 0.25 m^2 was 1.7. However, these urchins have clumped distribution patterns and occurred in only 12.0 percent of the 0.25 m^2 plots sampled. Densities of as high as 47 urchins per 0.25 m^2 were found. On suitable substrates purple urchin beds often extended over large areas, virtually excluding all other macroinvertebrates and flora. Ebert (1967) has reported urchin densities of up to 200 per m^2 at Sunset Bay (1 mile north of Simpson Reef).

The average number of red sea urchins per 0.25 m^2 was 0.08, and they were represented in 6 percent of the sample plots. The highest red urchin density observed was 2 per 0.25 m^2.

No crabs occurred in the quantitative sample. This was probably due to the sampling method which might frighten any mobile organisms from the confines of the quadrate. Moreover, crabs tend to be nocturnal, retreating to dark crevices or hiding beneath rocks during daylight hours increasing the probability of their being overlooked.

Table 14. Results of quantitative underwater surveys of macroinvertebrates occurring at Simpson Reef, Oregon.

Species	Quadrat Size: 0.25 m^2 (N=50) Total	$\bar{X}$	% Total	1.0 m^2 (N=17) Total	$\bar{X}$	% Total	Combined Percentage
Purple sea urchins	86	1.72	69.9	103	6.06	80.5	75.3
Red sea urchins	4	0.08	3.3	0	0.00	00.0	1.6
Brown turban snails	8	0.16	6.5	1	0.05	0.8	3.6
Gumboot chiton	6	0.12	4.9	3	0.18	2.3	3.6
Common seastar	6	0.12	4.9	3	0.18	2.3	3.6
Keyhole limpet	2	0.04	1.6	0	0.00	0.0	0.8
Rock snails	9	0.18	7.3	16	0.94	12.5	10.0
Barnacle	1	0.02	0.8	0	0.00	0.0	0.4
Sea squirt	1	0.02	0.8	0	0.00	0.0	0.4
California mussel	0	0.00	0.0	1	0.05	0.8	0.4
Little-neck clam	0	0.00	0.0	1	0.05	0.8	0.4
Total	123		100	128		100	100

The results of the 1 m^2 sampling are similar to those obtained with the smaller device.

Macroinvertebrates were observed most frequently on solid rock substrates and did not occur on gravel or shell-sand. Ninety-five percent of the total number of individual organisms in the samples occurred on rock substratum (74.6 percent of all substrates encountered).

Purple sea urchins were observed at depths ranging from 7-25 feet ($\overline{X}$=10.4 ft). Red sea urchins may occur in the low intertidal zone but are normally more common in the sublittoral (Ebert 1968). At Simpson Reef red urchins were observed from 16-21 feet ($\overline{X}$ =18.0). Brown turban snails, which probably were the predominant Tegula occurring in the otter's diet, occurred at depths ranging from 7-23 feet ($\overline{X}$ = 11.4).

Several qualitative benthic surveys were completed in August and September of 1973 (Table 15). Survey sites were selected on the basis of current otter use, or the possibility of potential use as the animals' range expands.

Red sea urchins were the most commonly occurring large inveertebrate at eight of the ten sites surveyed.

Nellie's Cove was surveyed on 5 August 1973. The area consisted of approximately 75 percent rock substrates, with the remainder shell sand, and averaged 40 feet in depth. Purple sea urchins were

Table 15. Abundance of macroinvertebrates encountered during 10 subtidal surveys conducted along the southern coast of Oregon during August and September 1973: A = abundant, C = common, U = uncommon, R = rare, P = present. **

	Location of Survey									
	Nellie's Cove	Zwagg Cove	Orford Reef	Redfish Rocks	Redfish Rocks-2	Humbug Mountain	Port Orford	Lone Ranch	Blanco Reef	Simpson Reef Gregory Point
Strongylocentrotus purpuratus*	U						U	R	C	A
Strongylocentrotus franciscanus*	A		A	A		A	A	C	C	A
Cucumaria miniata*	C	C				C	U	U	U	C
Pisaster ochraceus*	C	U	U		U		C	C	C	C
Pycnopodia helianthoides	C	U	U	C	C	C	C	C	C	C
Solaster sp.	U	U						U		
Henrcia leviuscula	C	U	U	C	C	C	C	U	C	U
Dermasterias imbricata		U	U	U	U			U	C	
Stichopus californicus	C			C						
Hinnites multirugosus*			C	C		U	U	C	A	U
Prototheca staminea*										U
Mytilus californianus*	U						U		C	A
Tegula funebralis		A						A		A
Tegula brunnea*		C								C
Muricidae (rock snails)	U			U	U		C	C		C
Haliotis walallensis	U						U			R
Haliotis rufescens								U		
Cryptochiton stelleri*	C	C		C	U		C	C	C	C
Small chitons	U									C
Diodora aspera		U			U		C	U	A	C
Nudibranchia		U		C		U				
Octopus sp. *							P			P
Cancer sp. *							P			P
Pugettia producta*		P					P			P
Balanus nubilus	P						U			

*Species noted in the sea otter's diet at Simpson Reef.

**Motile organisms were placed in this category.

uncommon, while the larger red sea urchin was abundant. Bull kelp was the predominant emergent kelp at this location and occurred to depths of 45 feet.

Zwagg Cove was surveyed on 6 August 1973. The average depth of the survey area was 21 feet, and the substrates were an estimated 60 percent rock and 40 percent sand. No sea urchins were observed at this site and the most abundant prey species encountered here was brown turban snails. Brown algae were common on suitable substrates, with bull kelp predominating. Basket grass (Phyllospaddix sp.) was also abundant at this location.

Orford Reef was surveyed on 7 August 1973. The mean depth of the survey area was 54 feet. Red sea urchins were abundant and rock scallops (Hinnetes multirugosus) were common. Substrate composition was 75 percent rock and 25 percent gravel. Brown algae consisted primarily of a few scattered junveile bull kelp sporophytes.

Red Fish Rocks are located approximately 5 miles south of Port Orford and were surveyed on 8 August 1973. The mean depth was 46 feet. Red sea urchins were abundant to 65 feet and rock scallops were common. Substrates were 100 percent rock to the 65 foot level where large boulders 4-6 feet in diameter were encountered. Bull kelp was abundant to a depth of 50 feet and the lower limit for brown algae appeared to be approximately 55 feet with few if any plants found beyond this depth.

A survey was completed on the south side of Humbug Mountain on 8 August. The mean depth of the area was 29 feet. Red sea urchins were abundant throughout the area. Substrates consisted of large boulders 3-6 feet in diameter surrounded at the base with broken shell and sand. Bull kelp was abundant enough to provide a thin surface canopy.

A second dive was made at Nellie's Cove on 26 August 1973. The mean water depth of the sample area was 26 feet. Red sea urchins were abundant; purple sea urchins were uncommon. Substrates were primarily rock with sand filling many of the depressions and crevices. Bull kelp was abundant, forming a dense surface canopy in some areas.

A single survey dive was completed at Lone Ranch Beach on 12 September 1973. Purple and red urchins were observed and rated, respectively, as uncommon and common. The mean depth of the area surveyed was 21 feet. Seventy percent of the substrates were rock, and 30 percent were sand types. Only a few scattered bull kelp plants were encountered in the area.

The second survey at Redfish Rocks was made on 14 September 1973 near the site of the 1970 otter release. The mean depth of the area surveyed was 43 feet; the predominant substratum was rock. Very few macroinvertebrates were found, the most abundant being sea squirts (Styella sp.). Bull kelp was very dense consisting

primarily of young sporophytes that at times were so abundant they hindered our forward progress.

A portion of Blanco Reef was surveyed on 16 September 1973. The survey area had been used by otter throughout the summer of 1973 and may have been used by sea otter for 3 years. The mean depth of the area surveyed was 27 feet (sd=4.43). Ninety percent of the substrates were rock and 10 percent were shell-sand. Purple and red sea urchins were common in the area, as were rock scallops. Red urchins were somewhat restricted in their distribution and rather than occurring on exposed areas, as they do at sites not being exploited by sea otter, they were restricted to overhanging projections and crevices. Red sea urchin tests were abundant on the bottom, and the majority of those examined exhibited the broken oral surface indicative of sea otter predation. Bull kelp formed a dense surface canopy at Blanco Reef and was observed throughout the survey area.

Surveys were conducted from Cape Arago to Gregory Point on 5, 7, and 9 August 1972. The mean depth of the area surveyed was 18 feet. Red and purple sea urchins were abundant except in areas where otter had been foraging heavily, there, red urchins were noticeably absent. In areas that had not been subjected to otter predation red urchins were still abundant with estimated densities of up to 6-8 per m^2. Sea urchin tests showing a broken oral surface were in evidence in those areas where otter frequently foraged.

Substrates encountered during these dives ranged from sand to rock, with rock predominating. As in all other areas the major portion of the invertebrates encountered were associated with rock substrates. Both bull and giant kelp were noted, with both species forming dense surface canopies at Simpson Reef.

Discussion

Sea urchins constitute the greatest percentage of food items in the otter's diet and seem to be taken relative to their abundance and availability (Table 16). The quantitative and qualitative food availability data suggest that sea urchins are the predominant large marine invertebrates in Oregon waters. Ebert (1968) suggested that when sea otter occupy a new habitat they will forage heavily on red sea urchins. He supported his statement with an underwater survey of the sea otter's range in California, and his findings indicated that red urchins were uncommon in areas that had been exploited by sea otter for an extended period. Conversely, they were common and readily available in areas where otter had not foraged in recent times.

Wild and Ames (1974), Hall and Schaller (1964), and Boolootian (Senate Permanent Factfinding Committee on Natural Resources 1965) have presented data which indicate that in newly exploited areas sea otter prey heavily on sea urchins (Table 17). However, where a population of sea otter has been established for a long period of time sea urchins will constitute only a minor percentage of, or be

Table 16. Comparison of foods eaten by sea otter at Simpson Reef, Oregon and the occurrence of these prey species in the quantitative sample from the same location.

Species	% of Diet	% of Quantitative Sample
Purple sea urchins	52.5	75.3
Red sea urchins	11.3	1.6
Red sea cucumber	1.6	0.0
Common seastar	0.5	3.6
Clams*	1.6	0.4
Rock scallop	2.4	0.0
California mussel	3.1	0.4
Brown turban snail	5.9	3.6
Abalone	0.2	0.0
Gumboot chiton	0.2	3.6
Octopus*	0.9	0.0
Crabs*	5.2	0.0

* The sampling technique used is probably biased against clams and motile organisms, therefore not indicating their relative abundance.

Table 17. Percent occurrence of selected macroinvertebrates utilized as sea otter food items in California and Oregon. Otters had only recently occupied all study areas.

Food Items Observed	This Study	Hall and Schaller (1964)	Wild and Ames (1974)	Boolootian (1965)
Purple sea urchin	52.5	32.4	--	13.0
Red sea urchin	11.3	0.4	48.9	43.4
California mussel	3.1	40.0	7.1	33.8
Abalone	0.2	9.9	26.1	8.2
Other mollusks	11.1	1.2	--	0.3
Crabs	2.6	14.5	17.4	0.8
Totals	80.8	98.4	99.5	99.5

completely absent from, the animal's diet (Ebert 1968, Vandevere 1969, 1971, Wild and Ames 1974).

The effects of sea otter predation on red sea urchins are evidenced at Simpson and Blanco Reefs. Although red urchins are abundant in areas that have received little or no otter foraging, they were not encountered at Simpson Reef where heavy foraging has occurred, and appear to have been reduced in numbers at Blanco Reef. Purple urchin densities are still quite high at Simpson Reef, although a few localized beds show evidence of being reduced (broken tests, many empty urchin created depressions). Other areas surveyed have estimated densities of 6-8 red urchins per m^2.

Paine and Vadas (1969) have shown that both red and purple sea urchins, which are algal grazers, can effectively reduce the diversity and biomass of algae at a foraging site. McLean (1962:102) suggests that when sea otter were absent or at low population levels, sea urchins were abundant and the "...Nereocystis-Pterygophora association...is at a minimal level of development as a result of grazing." Ebert (1968:41) states that sea urchins were probably "...minor faunal constituents" of the nearshore marine ecosystem when sea otter were abundant in California. He further relates that removal of algal grazers such as sea urchins and abalones will result in a notable rejuvenation of the plant community. This suggests that the current species composition of Oregon's reef communities probably differs

considerably from what it was during pristine times. As the otter population grows sea urchins will become less important constituents of the animal's diet.

The floral community may also exhibit some profound changes, and this may already be evidenced at Blanco Reef. Plant life here is extremely profuse, especially on the more exposed portions of rock substratum. At other sites this type of habitat is occupied by red urchins; and algal densities are extremely low, with many areas cropped to bare rock.

Sea otter may be part of a climax marine community (Faro 1970) and conceivably could function in maintaining the diversity and stability of the community by controlling sea urchin populations in much the same way that sea stars (Pisaster spp.) seem to affect the intertidal zone by preying upon mussels (Paine 1966). In any event, I suggest that sea otter will have a substantial effect on the sublittoral reef communities of Oregon; and this effect will become more evident as the population grows.

Potential Sea Otter Habitat in Oregon

Results

North Coast. The north coast region extends from the mouth of the Columbia River to Lincoln City, a distance of approximately

90 miles (Figure 1). Superficially the area appears to have several potential sea otter habitats and the historical record indicates that sea otter once occurred here (Bailey 1936, Scheffer 1940, Scammon 1968). However, data obtained from nautical charts indicate that most of the substrates are sand or shell-sand with very limited rocky areas. Moreover, Waldron's (1955) survey of the kelp beds of Oregon yielded none on the north coast, and I located only one sparse kelp bed on the south side of Cape Lookout. These data suggest a limited amount of rock substrate along the north coast.

Central Coast. The central coast region extends from Lincoln City to Coos Bay a distance of approximately 115 miles. Aerial and shoreline surveys, plus data obtained from nautical charts indicate that approximately 83 percent of the region would be poor to unsuitable sea otter habitat (Table 2). However, I judge a 20-mile section of coast extending from Lincoln City to the north jetty at the mouth of the Yaquina River to be good to excellent otter habitat. Kelp beds of varying size and density occur throughout the area (Waldron 1955, and this study) and rock substrates occur to the 20 fathom contour. The offshore reefs have a rich and varied invertebrate fauna (Freeman Button personal communication). The region was also the location of one of the last reports made of the original Oregon sea otter population (Nash 1919).

South Coast. The south coast region extends from the entrance of Coos Bay south to the Oregon-California border (approximately 100 miles). Approximately 85 percent of the area contains good to excellent sea otter habitat. Six offshore reefs are situated in this section, of these Blanco and Simpson reefs were surveyed and were found to have abundant sea otter food resources. This region, which represents about 33 percent of the coastline, encompasses approximately 80 percent of the sea otter habitat in Oregon. Waldron (1955) reported 3079 acres of kelp in this region, over 83 percent of all the beds he had sighted within the boundaries of the state.

Discussion

Results of this study indicate that approximately one-third of the Oregon coastline is suitable for sea otter habitation; approximately 80 percent of the suitable area is situated along the south coast, with the remainder in the central region. Based on the criteria set forth in this study to describe optimum habitat (Table 2), I believe that all the suitable habitat along the southern and central portion of the coast will be occupied before any significant use of the other areas will be evidenced.

V. CONCLUSIONS AND RECOMMENDATIONS

Evaluation of Translocations

The sites chosen for the 1970 and 1971 releases were Port Orford and Cape Arago (South Cove) (Figure 1). Both locations offered good to excellent sea otter habitat. The amount of contiguous habitat available at each site, however, differs considerably. Approximately 4 square miles of sea otter habitat exists within a 10 mile radius of Cape Arago, while approximately 18 square miles of contiguous habitat can be found within a 10 mile radius of Port Orford. Moreover, the distance to the nearest section of good otter habitat north of Cape Arago is just under 100 miles while to the south 30 miles of sand beach occurs before good otter habitat is again available. In contrast, Port Orford lies within a 75 mile section of coast consisting of nearly contiguous sea otter habitat. Thus, the probability of encountering optimal habitat would be greatest if the population were located within a relatively contiguous section of habitat such as that found in the vicinity of Port Orford.

When dealing with a small number of animals, such as the translocated otter population, minimization of mortality both during and after the introduction should be of prime consideration. Natural predation of sea otter is probably of little consequence to the species (Kenyon 1969, Wild and Ames 1974).

Although the effects of natural predation are probably negligible, the effects of human encroachment may not be, especially when the number of otter is small. Wild and Ames (1974) list shootings and boating accidents as important man-related mortality factors of sea otter in California; Kenyon (1969) has suggested that pollution of sea otter habitat might preclude the reestablishment of the species within portions of its former range. Therefore, in order to minimize mortality the reestablishment site should be as free as possible of potential man-related mortality factors. The Coos Bay, Empire, North Bend metropolitan complex (located 4 miles north of Cape Arago) has the highest human population on the Oregon Coast and is also a major shipping port (Highsmith and Liverenz 1962). The probability of sea otter dying due to human related factors would appear to be higher here than in the Port Orford area, located in Curry County. Curry County has the lowest human population density on the Oregon Coast (Dicken 1965). I concluded, therefore, that Port Orford was the better of the release sites.

The data presented in this report indicate that the attempt to reestablish sea otter in Oregon has succeeded at least from a short term viewpoint. Reproduction has resulted in at least ten pups born since the 1971 release.

The most perplexing question suggested by this study relates to the number of sea otter released and the number remaining in the

reestablishment area. Ninety-five sea otter were shipped to Oregon; seven were known to have died before or soon after the liberations, leaving a potential population of 88 sea otter on the coast. It would certainly be presumptive to believe that all dead otter were recovered; however, if massive mortality did occur more than 6 otter should have been found. With 88 otter potentially surviving the translocations, and 10 pups produced during the study period the colony would have numbered 98 sea otter at the termination of the study. Moreover, a group of 88 otter with the same sex and age ratios of the released otter should have produced approximately 33 pups during the study period. I have estimated that 30-35 otter were on the Oregon Coast at the conclusion of this study. This disparity in potential and estimated numbers remains an unanswered question. Nelson's report, however, of sea otter 181 miles north of Cape Arago suggests that emigration may be a partial explanation.

Future Translocations of Sea Otter

Translocation sites should be selected using criteria which characterize optimum sea otter habitat (Table 2). Potential sites can initially be located by studying coastal maps and navigation charts. In this way unsuitable areas can quickly be eliminated. Once several tentative release sites have been located, a reconnaissance should be made to assess conditions that are not discernable on maps and

charts, such as the availability of areas providing respite from storms and the availability of food. The latter could be assessed quickly and inexpensively by diver-biologists familiar with sea otter food preferences. The results of this study have shown that areas superficially appearing to be excellent otter habitat may have limited available otter forage (Table 15). Once all other factors have been considered, the final choice should be based upon the threat of potential human encroachment and the probability of, or existence of, environmental pollution.

In view of the polygamous nature of sea otter a 2:1 sex ratio favoring females, such as was done in the Oregon translocation, will probably enhance initial reproduction.

Sea otter translocated in the future should be marked so that individuals can be identified at a later date. The resting posture of sea otter when in the water facilitates observing a colored tag on the animal's rear flipper; if the otter is in close proximity to the viewer a number on the tag may also be read.

Management

Management of the Oregon sea otter population should include protection of the otter and their habitat. Sea otter were afforded full protection under the Marine Mammals Act of 1972. Enforcement will require routine surveillance of areas inhabited by sea otter and

apprehension of offenders. Since Oregon has no commercial fisheries on invertebrates exploited by sea otter, other than the dungeness crab which constitutes a relatively minor portion of the otter's diet, a problem similar to the sea otter-abalone controversy in California should not develop. Of greater import is the protection and preservation of Oregon's sea otter habitat. This could be done by establishing refuges along the south coast of Oregon, coupled with strict enforcement of established and proposed laws.

Presently, 28 small offshore islands and sea stacks are part of the Oregon Islands National Wildlife Refuge and 28 more have been proposed for addition (USBSFW 1972). Already included in the refuge are Orford and Blanco reefs; Simpson Reef has been proposed for inclusion. Federal permits must be obtained to gain legal access to those areas already within the system. Sea otter may occasionally haul out on these rocks but are more dependent on the associated subtidal reef areas and their fauna than upon the islands and stacks themselves. For this reason the protected areas should be extended subtidally, not only affording protection to the otter but to their food resource and aquatic habitat. These areas could be delineated on shore by some landmark such as a cape, headland or jetty. Seaward the boundaries could be delineated by depth contours. The 20 fathom contour would be inclusive of all areas likely to receive use by sea otter plus provide a horizontal buffer zone around the emergent

portions of the reefs. Restrictions within these zones would include:

1. A ten knot speed limit to minimize boat-related mortality and harassment of the resident animals.
2. A restriction on the taking of all invertebrates, except by special permit, excluding dungeness crab and intertidal clams.
3. A restriction on the carrying of firearms within the refuge boundary.

The refuges would not only protect sea otter, but would give added protection to other marine mammals and marine birds inhabiting the areas.

Areas recommended for refuge status would include: the section of coast from Blacklock Point south to 2 miles south of Humbug Mountain, including all the seaward area to the 20 fathom contour; the area south from the town of Nesika Beach to the seaward tip of North Jetty at the mouth of the Rogue River inclusive of all seaward area to the 20 fathom contour; and the area from Gregory Point south to the mouth of Fivemile Creek seaward to the 20 fathom contour (Figure 1).

The Oregon sea otter colony should also continue to be monitored. This program should include a minimum of two shoreline surveys a year to assess population growth and at least one aerial survey to determine distribution and range expansion. The shoreline surveys should be conducted in June and in the fall before the onset of the winter storm season.

LITERATURE CITED

Bailey, V. 1936. The mammals and life zones of Oregon. North Am. Fauna, 55. 416pp.

Barabash-Nikiforov, I.I. 1947. Kalan (The sea otter, in Russian, translated by Dr. A. Birron and Z.S. Cole, 1962) Israel Program for Scientific Translations, Jerusalem. 227pp.

Bourke, R.H. and B. Glenne. 1971. Coastal currents. Pages 87-110 in Oceanography of the nearshore coastal waters of the Pacific Northwest relating to possible pollution, Volume 1. E.P.A. 615pp.

Calkins, D.G. 1972. Some aspects of the behavior and ecology of the sea otter, Enhydra lutris, in Montague Straight, Prince William Sound, Alaska. M.S. Thesis. Univ. of Alaska. 55pp.

Cameron, R. 1972. More sea otters come home. British Columbia Wildl. Rev. 6(6):8-9.

Daugherty, A.E. 1972. Marine mammals of California. 2nd ed. California Dept. Fish and Game, Sacramento. 90pp.

Dicken, S.N. 1962. Oregon geography the people the place and the time. Edward Brothers, Inc., Ann Arbor, Mich. 147pp.

Ebert, E.E. 1968. A food habits study of the southern sea otter, Enhydra lutris nereis. California Fish Game 54(1):33-42.

Ebert, T.A. 1967. Negative growth and longevity in the purple sea urchin Strongylocentrotus purpuratus (Stimpson). Science 157:557-558.

Ehlen, J. 1967. Geology of state parks near Cape Arago, Coos County, Oregon. Ore Bin 29(4):61-82.

Ekmen, S. 1953. Zoogeography of the sea. Sidgwick and Jackson Ltd., London. 417pp.

Faro, J.B. 1970. Subtidal sea otter habitat off Point Pinos, California. M.S. Thesis. Humbolt State College. 278pp.

Fisher, E.M. 1939. Habits of the southern sea otter. J. Mammal. 20(1):21-36.

_____ 1940. Early life of a sea otter pup. J. Mammal. 21(2):132-137.

Hall, K.R.L. and G.B. Schaller. 1964. Tool-using behavior of the California sea otter. J. Mammal. 45(2):287-298.

Highsmith, R.M. and J.M. Liverenz. 1962. Atlas of the Pacific Northwest. Oregon State Univ. Press, Corvallis. 168pp.

Kenyon, K.W. 1969. The sea otter in the Eastern Pacific Ocean. North Am. Fauna. 68. U.S. Gov. Printing Office, Washington. 352pp.

Kenyon, K.W. and D.L. Spencer. 1960. Sea otter population and transplant studies in Alaska, 1959. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Wildl. 48. 29pp.

Khromovskikh, B.V. 1968. Ecology and population numbers of sea otters on Medny Island. Pages 167-174 in V.A. Arsen'ev and K.I. Panin, eds. Pinnipeds of the North Pacific. Israel Prog. Sci. Translations, Jerusalem. 274pp.

Lensink, C.J. 1962. The history and status of sea otters in Alaska. Ph.D. Thesis. Purdue Univ. 141pp.

McLean, J.H. 1962. Sublittoral ecology of kelp beds of the open coast area near Carmel, California. Bio. Bull. 122(1):95-114.

Murie, O.J. 1940. Notes on the sea otter. J. Mammal 21(2):119-131.

Nash, W. 1919. A lawyer's life on two continents. Richard G. Badger. The Garham Press, Boston, Mass. 212pp.

Odemar, M.W. and K.C. Wilson. 1969. Results of sea otter capturing, tagging and transplanting operations by the California Department of Fish and Game. California Dept. Fish Game. Marine Resour. Oper. MRR Ref. No. 70-5. 9pp.

Olterman, J.H. 1972. Rare, endangered, and recently extirpated mammals in Oregon. M.S. Thesis. Oregon State Univ. 134pp.

Oregon State Game Commission. 1970. Sea otter. Pages 151-152 in Annual Report. Oregon State Game Commission. Portland. 201pp.

Paine, R.T. 1966. Food web complexity and species diversity. Am. Nat. 100(910):65-75.

Paine, R.T. and R.L. Vadas. 1969. The effects of grazing by sea urchins, Strongylocentrotus spp., on benthic algal populations. Limnol. Oceanogr. 14:710-719.

Pearson, O.P. 1952. Notes on a pregnant sea otter. J. Mammal. 33(3):387.

Pederson, R.J. and J. Stout. 1963. Oregon sea otter sighting. J. Mammal. 44(3):415.

Sandegren, F.E., E.W. Schu, and J.E. Vandevere. 1973. Maternal behavior in the California sea otter. J. Mammal. 54(3):668-679.

Scammon, C.M. 1968. [First published in 1874]. The marine mammals of the north-western coast of North America. Dover Publications, Inc. New York, N.Y. 319pp.

Scheffer, V.B. 1940. The sea otter on the Washington Coast. Pacific Northwest Quarterly. 3:370-388.

Schneider, K.B. 1968. Sea Otter. Alaska Dept. Fish and Game. Fed. Aid in Wildl. Restor. Proj. Rep., W-14-R-2. 26 pp.

_____. 1972. Sex and age segregation of sea otters. Alaska Dept. Fish and Game. Fed. Aid in Wildl. Restor. Proj. Rep., W-17-4-8.9R. 26pp.

_____, 1973. Reproduction in the female sea otter. Alaska Dept. Fish and Game. Fed. Aid in Wildl. Restor. Proj. Rep., W-17-4 and 5.8.11R. 13 pp.

Senate Permanent Factfinding Committee on Natural Resources. 1965. The sea otter and its effect upon the abalone resource. in Third Prog. Rep. to the Senate, Section I, Sacramento, Calif. 144pp.

Sherrell, P.E. 1970. An annotated check list of the land mammals of Curry County, Oregon. M.S. Thesis. Central Washington State College, Ellensberg. 150pp.

U.S. Bureau of Sports Fisheries and Wildlife. 1972. Oregon Islands wilderness proposal. 20pp. Rep.

Vandevere, J.E. 1969. Feeding behavior of the southern sea otter. Proc. Annu. Conf. Biol. Sonar and Diving Mammals. 6:87-94.

_____. 1971. Fecal analysis of the southern sea otter. Proc. Annu. Conf. Biol. Sonar, and Diving Mammals. 8:1-7.

_____. 1973. Behavior of the southern sea otter Enhydra lutris nereis. Annu. Meet. Am. Soc. Mammal. 53. 11pp. Typescript.

Waldron, K.D. 1955. A survey of the bull kelp resources of Oregon. Res. Briefs, Fish. Comm. Oregon 6(2):15-20.

Wild, P.W. 1972. Introduction. Pages 1-4 in A. Seed, compiler. Sea otter in eastern North Pacific waters. Pacific Search, Seattle, Wash. 37pp.

Wild, P.W. and J.A. Ames. 1974. A report on the sea otter, Enhydra lutris L. in California. California Dept. Fish. Game, Marine Resour. Tech. Rep. 20. 94pp.

Wilke, F. 1957. Food of sea otters and harbor seals at Amchitka Island. J. Wildl. Manage. 21(2):241-242.

Williams, C.S. 1938. Notes on food of the sea otter. J. Mammal. 19(1):105-107.