THE HISTORY AND STATUS OF SEA OTTERS IN ALASKA

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of

Purdue University

by

Calvin Jay Lensink

In Partial Fulfillment of the

Requirements for the Degree

of

Doctor of Philosophy

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By Calvin Jay Lensink

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Complies with the University regulations and that it meets the accepted standards of the Graduate School with respect to originality and quality

For the degree of:

Doctor of Philosophy

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Professor in charge of the thesis

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My interest in conducting research on sea otters began when I was associated with a group, investigating the physiology of sea otters during 1954, which was led by Dr. Donald E. Stullken and Dr. Charles M. Kirkpatrick of Purdue University. Dr. Kirkpatrick subsequently furnished the encouragement and means for my continuation of these studies through facilities available at Purdue. As my major professor at Purdue University, Dr. Kirkpatrick has been available to help with academic and research problems, and has furnished numerous suggestions and helpful criticisms during the preparation of this manuscript.

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ABSTRACT

Lensink, Calvin Jay. Ph.D., Purdue University, January 1962. The History and Status of Sea Otters in Alaska. Major Professor: Charles M. Kirkpatrick.

The present study proposed to define the status of existing sea otter populations by: 1) reviewing historical records to determine the size of aboriginal and post-exploitation populations; 2) tracing the growth and establishing the size and distribution of existing populations; and 3) investigating those phases of biology which were of immediate importance in indicating the future growth and welfare of existing populations. Accurate information on sea otter biology and populations was lacking and results of this investigation could be expected to facilitate the sound planning of subsequent investigations and management programs.

Field work in support of the objectives included observation of sea otters at Amchitka Island covering about 5 months between 1954 and 1956, and boat or aerial surveys of all Alaskan habitats between 1957 and 1959.

One hundred and seventy years of exploitation exterminated the sea otter in most of its original range, but small groups survived in widely scattered areas. In the

aggregate their survivors may have numbered between 200 and 500 individuals. Since 1911, when protection was extended to sea otters, they appear to have increased at a rate which may be near their maximum capacity for recruitment. The population now numbers approximately 40,000 animals.

The largest populations are found in the Rat, Delarof, and Andreanof Island groups of the western Aleutians, but smaller populations also occur in the Fox Islands, along the Alaska Peninsula, in the Kodiak Archipelago, and in Prince William Sound.

We can expect a rapid expansion in numbers from the Andreanof Islands eastward. West of the Andreanof Islands the habitat is limited, and the population may already be near the carrying capacity. Here, sea otters are perhaps as abundant as they were before exploitation by the Russians. On Amchitka Island, the evidence indicates that a high population has resulted in increased mortality and a lowered reproductive rate.

Both the historical and present distribution patterns appear to indicate that the primary factor in the sea otter's habitat is the amount of shallow water available in which they can obtain food. Beds of kelp are used extensively by sea otters as resting and foraging areas, but the coexistence of kelp and sea otters may be at least partially coincidental, both having similar depth requirements.

Sea urchins, mussels or other mollusks, crabs and fish appear to be most important food items in that order for the Aleutian area, but may vary in other habitats. The relative importance of particular food items may also vary with the individual sea otter's age.

Daily activity patterns of sea otters involve movements between resting and nearby foraging areas or, as occasion demands, to areas sheltered from storms. Seasonal movements exist, but their extent is not known. Straying of individuals or migration of groups to new habitats seems uncommon, but movements of this nature may be accelerated by crowding and subsequent deterioration of occupied habitat.

The percentage of pups in the total population indicates a potential reproductive rate in excess of 20 percent. However, the rate of increase under optimum conditions appears to be between 10 and 15 percent. Sea otters have few enemies and mortality is normally low; but under crowded conditions, such as occurs at Amchitka Island, lowered resistance as a result of food shortage, winter storms, and parasitism contribute cumulative stress which results in many deaths with typical symptoms of shock. The same factors appear to have resulted in a lowered reproductive rate.

Sea otters are now sufficiently numerous to warrant annual harvesting. Such harvest may be essential to the welfare of populations in the western Aleutians.

INTRODUCTION

Almost a century before the Rocky Mountain trappers roamed the American West in their search for beavers, Castor canadensis L., Russian fur hunters (promyshlenniki), were sailing from Kamchatka in small unseaworthy vessels toward the Aleutian Islands and Alaska in their search for sea otters, Enhydra lutris (L). Whereas the exploits of the Mountain Men in their exploration of the west won them lasting fame, the equally daring exploits of the Russians in their exploration of the Aleutians and the Northwest Coast is virtually unknown. Even less generally known are the voyages of Boston traders who carried on a lucrative three-way trade hinged on sea otter furs between New England, the Northwest Coast, and China between the years 1785 and 1825.

The heyday of the sea otter trade had ended by 1825, but remnants of the population yielded the Russians between 1,000 and 2,000 pelts annually. The acquisition of Alaska in 1867 by the United States opened a new era of sea otter hunting that yielded enough skins in 40 years to exceed in value the $7,200,000 paid for Alaska. This intensive hunting resulted in extermination of the sea otter in most of its range.

After 1911, when hunting of sea otters was forbidden, they were so rare and seldom seen that mention of them in the literature, even to the present day, is mostly in connection with vanishing species.

My interest in sea otters was aroused in 1953 by conversations with David C. Hooper, then Assistant Manager of the Aleutian Islands National Wildlife Refuge. As a result I seized upon the opportunity to visit the Aleutians from January to May 1954 as a member of the Refuge staff that assisted Dr. Donald E. Stullken and Dr. Charles M. Kirkpatrick of Purdue University in research concerned with excessive mortality among captive and wild sea otters on Amchitka Island. In 1955, I accompanied a Fish and Wildlife Service expedition to the Aleutians, in charge of Ford Wilke and Karl W. Kenyon, which attempted to transplant sea otters to the Pribilof Islands. During this trip we visited the Shumagin Islands early in March, and then proceeded to Amchitka Island where 29 animals were caught for transport to St. Paul Island. Only 19 of these animals survived to the time of their release on April 9, and the chance for survival of the remaining animals appeared negligible. I remained on the Pribilof Islands during the summer to assist with fur seal investigations, but left Alaska in September to begin graduate studies at Purdue University.

The mortality investigations of 1954 had been conducted with no conception of what proportion of the population was involved; and the study of transplant possibilities was conducted with no idea of how rapidly the existing populations might be expected to expand into new areas, although population data were necessary for the proper planning and interpretation of results for both projects. After many discussions with all persons who had participated in sea otter studies, and on the basis of my own experience, I was convinced that it was proper to begin with population studies which had thus far been neglected.

The plan for research on sea otter proposed to define the status of existing populations by: 1) reviewing historical records to estimate the size of aboriginal and post-exploitation populations; 2) tracing the growth and establishing the size and distribution of existing populations; 3) investigating those phases of biology which were of immediate importance in predicting the future growth of existing populations.

Initial field work in support of the objectives was conducted on Amchitka Island from June to September 1956. In 1957, the Fish and Wildlife Service financed boat and aerial surveys of the Kodiak Archipelago, the Alaska Peninsula, the Fox Islands, and part of the Andreanof Islands populations. In 1958, I examined Prince William Sound habitats during the course of work on other marine mammals, and in 1959 and 1960 I made aerial surveys in Prince William Sound, the Kodiak Archipelago, and along part of the Alaska

Peninsula for the Alaska Department of Fish and Game. In addition to my own field work, Karl W. Kenyon has provided me with the results of his studies and surveys for the Fish and Wildlife Service in the Aleutian Islands.

Although our present information on sea otters is far from complete, it is adequate to provide a rational evaluation of the status of existing populations.

EXPLOITATION

The original distribution of sea otters, Enhydra lutris (L), included the coastal area of the North Pacific Ocean and Bering Sea from Kamchatka south to the Kurile Islands and Hokkaido Island, thence eastward to the Commander, Aleutian, and Pribilof Islands, and the North American coast from the Alaska Peninsula to southern California. The longest gap in this distribution was the open water area of about 185 miles between the Near Islands and the Commander Islands. The return of the Bering Expedition with 900 sea otter pelts in 1742 (Golder, 1922: II, 245) initiated a period of exploitation of the sea otter in the Aleutian Islands and along the Northwest Coast, which ended 170 years later with the extermination of the sea otter throughout most of its former range.

The history of the fur trade in the Aleutian Islands and of the Northwest Coast is well documented. This documentation from the biological standpoint is in many respects better than that for the fur trade of the Rocky Mountains, although several comprehensive works (Irving, 1835 and 1843; Laut, 1923; Chittendon, 1935; DeVoto, 1947) have considered the latter in far greater detail than do corresponding accounts for the maritime trade of the Russians. The definite starting point of the Russian expansion into the Pacific with Bering's voyages, and the progressive subdivision of activities as new islands were discovered or as voyages reached new areas of the mainland coast, provide a chronological basis for analysis of the fur trade. The historical record, furthermore, can often be verified by checking the various lists of cargoes against the known distribution of the fur mammals which the Russian hunters or promyshlenniki sought.

The earliest records of sea otters for the Aleutian Islands are in the logbooks of Bering's ships, the Peter and the Paul, and the journal of the expedition's naturalist, Georg Wilhelm Steller. These records are preserved and have been made available in English by the historian, F. A. Golder (1922). In 1776, information on the early exploration of the Aleutians by Russian merchants was published by an author identified only as J. L. S. This anonymous manuscript, apparently based on logs, journals, and various contemporary documents from the Russian Central Archives (Masterson and Brower, 1948:7) provided an account of 24 voyages to the Commander and Aleutian Islands.

William Coxe (1780), in the first English account of Russian discoveries, republished an almost intact translation of the J. L. S. manuscript in addition to abstracts of various documents, among them the journals of Krenitsin and Lavshev, commanders of an official naval expedition to the Aleutian Islands in 1768 and 1769.

A third important compendium of activities in this era of exploration is provided in a series of papers by Peter Simon Pallas published between 1781 and 1786 and made available in English by Masterson and Brower (1948). These papers include a monograph on the geography of islands and coasts of the North Pacific Ocean, remarks on Coxe's work, and abstracts or translations of the accounts of several voyages to the Aleutians between 1755 and 1799.

The most important of all historical works on the early Russian period is that of Vasili N. Berkh (1823), which provides information on more than 140 voyages by the Russians to the Aleutian Islands and the Northwest Coast between 1745 and 1822. In preparing this account, Berkh had available the publications of Coxe and Pallas; material from the Russian Archives at Okhotsk; various notes and papers of the Shelikov-Golikov Company (later the Russian-American Company); reports of Siberian governors; and verbal accounts from hunters and merchants who had participated in the trade, including Alexander Baranov, the first and most important of the directors of the Russian-American Company. Berkh believed that information on at least 10 ships is lacking, but these ships were mostly in the latter part of the period that Berkh considers, and are relatively unimportant to analysis of the sea otter trade in the Aleutian Islands. Three of

Berkh's tables (I, II, IV) provide lists of furs taken by 83 ships sailing for private companies between 1745 and 1803, for 7 ships of the Shelikov-Golikov Company between 1786 and 1797, and 40 ships of the Russian-American Company between 1798 and 1822 respectively. These lists are of incomparable value in analysis of the magnitude and trend of the Russian fur trade in the Aleutians and on the Northwest Coast.

A series of papers by F. W. Howay (1930-1934) includes lists of ships for all nationalities known to have traded on the Northwest Coast between 1785 and 1825. From the biological standpoint these lists are not as important as those of Berkh (1823) because in most instances records of cargoes are not given. However, the long list of ships (over 200), with occasional record of cargoes and the additional records from contemporary or near contemporary accounts such as Meare (1791), Perouse (1799), Sturgis (n.d., about 1805), Berkh (1823), Khlebnikov (1835) and Roquefeuil (1823), provides substantial data on the magnitude and character of the maritime fur trade to 1825.

Khlebnikov (1861), who provides information on several Russian voyages between 1818 and 1825, leaves little doubt that the prosperity the sea otter brought to the fur trade was ended. The years between 1825 and 1867 are relatively unimportant to the history of exploitation of sea otters, but the purchase of Alaska by the United States in 1867 opened a new era in the fur trade, and again the sea otter was of primary importance to commerce in Alaska. Although numerous government publications documented the resulting decline in sea otter populations (Elliot, 1886; Petroff, 1884; Hooper, 1897; Jordan, 1898; and various Bureau of Fisheries reports, 1906-1913), no adequate action was taken to prevent their extinction until scarcity of otters in itself brought a virtual end to their exploitation.

The Russian Period

The early Russian period of exploitation (1742-1799) was one of intense competition among many merchants, which resulted in a rapid decline of sea otters throughout the Aleutian Islands. In each hunting area the major portion of the population was soon eliminated, and trade in sea otters only endured because new areas for hunting were discovered. Thus, from 1742 to 1755, at least 6,000 sea otters were taken from the Commander Islands, but in 1756 Adrean Tolstikh wintered the Adrean and Natalia on Bering Island and was unable to obtain a single otter. The actual number of skins known to have been sent to Kamchatka by 11 ships during this period was 3,677, but there is no account available for the cargo of 3 of these ships or of furs lost in 3 shipwrecks (Berkh, 1823). Information supplied by Berkh also shows that between 1745 and 1762 approximately 18,000 sea otters were taken from the Near Islands, and that between 1786 and 1798 about 6,500 were taken from the Pribilof Islands. A similar pattern of swift destruction followed in other areas, and because of this characteristic of the trade we can reasonably assume that the total harvest from each area approximates the size of the aboriginal population.

Although in many instances the records are not sufficient to determine the precise origin of cargoes, we can identify with reasonable accuracy the expeditions which hunted only in the Andreanof Islands and islands further west. Red foxes, Vulpes vulpes alascensis Merriam, and their various color phases were not found in this area, but invariably were present in cargoes originating in the Fox Islands or other areas further east. Thus, by using both the accounts of voyages and records of cargoes given by Berkh (1823), it is possible to construct the following list which shows both the magnitude and the decline in the sea otter population west of the Fox Islands.

Years	Number of Vessels Hunting	Sea Otter Pelts Taken
1747-56	8	10,525
1757-66	15	26,719
1767-76	8	15,706
1777-86	10	5,423
	41	58,573

During the period covered by the above list, Berkh lists 4 ships that were lost with all or a part of their cargo, and the cargoes of at least four additional ships are unknown. It is impossible also to account for furs on ships, such as those of Zaikov or Bragin sailing in the years 1770 to 1777 (Masterson and Brower, 1948), that hunted both the Fox Islands and the outer Aleutians. If we take these voyages into consideration, it appears that an estimate of 75,000 animals would be a conservative approximation of the aboriginal population of sea otters in the area. The rapid decline of the sea otter population is illustrated by the decreased number taken per ship in the latter decades, and is emphasized by the fact that as the number of sea otters declined the average duration of voyages increased. Thus, 15 ships sailing between 1757 and 1766 on an average voyage obtained 1,781 skins per ship in 2.7 years, but 8 ships sailing between 1777 and 1786 obtained only 678 skins per ship in 4.4 years.

The establishment of the Shelikov-Golikov Company in 1781 (Andreyev, 1952:10), which was reorganized as the Russian-American Company on July 8, 1799, brought a new efficiency to the fur trade which smaller private companies found difficult to continue because of intensified competition and ever lengthening voyages (Okun, 1951:22). This increased efficiency brought about an even more rapid destruction of sea otters. During 1788 and 1789, hunters on The Three Saints obtained 5,500 skins in Cook Inlet; but, in 1795, Baranov wrote Shelikov that "close to Kodiak Island and in the Kenai Inlet (Cook Inlet) the sea otters are completely extinct and I had to sail with all our forces to

Chugash Bay (Prince William Sound) where there are enough of them." (Berkh, 1823). The sea otters were soon eliminated in Prince William Sound and at Yakutat also. Khlebnikov (1835:27) says that more than 2,000 skins were obtained at Yakutat in 1794 and that "the trading post established at Yakutat was, in Baranov's opinion, the best for sea otter skins on the whole northwest coast of America." However, in 1799, less than 300 sea otters were taken at Yakutat; and Berkh (1823) comments that "seeing the sea otter had disappeared in Yakutat too, Baranov had to think of a new settlement."

The establishment in 1799 of the Russian-American Company with charters granting it the exclusive right to the American trade brought a measure of order to the exploitation of sea otters, and even resulted in certain conservation measures in the Aleutian and Kodiak areas, where the Company's complete domination over the native population prevented competition from foreign traders. Thus, during the second charter (1821-1842) harvest quotas were set for each district, attempts were made to harvest only males, and rules were established to prevent unnecessary disturbance of the sea otter (Hooper, 1897). Although these measures were at least partially successful in the Aleutians, on the mainland coast competition from foreign vessels, primarily Boston traders, resulted in continued ungoverned exploitation and the virtual extermination of the sea otters there.

Petroff (1884:61) reports that 260,790 otter skins were shipped from America by the Russians prior to 1867, but this figure does not include skins from many ships known to have engaged in hunting for which there is no record of cargo, nor does it include an estimate of skins lost in shipwrecks. In the 40 years between 1780 and 1820, British, French, Spanish and (mostly) American traders probably obtained more furs than the Russians obtained during their entire occupation of Alaska. Sturgis (n.d., about 1805) lists 26 American ships that obtained 47,800 sea otter skins in the years 1799-1802. Roquefeuil (1843:II, 308) says that in 1805 a total of 17,445 skins were taken on the Northwest Coast and provides the following list of the numbers of sea otter skins marketed in Canton between 1804 and 1818:

Years	Sea Otter Pelts Marketed
1804-07	59,346
1808-12	46,962
1813-17	18,827
In 1818	4,800
	129,935

Baranov, in a report to the Board of Governors of the Russian-American Company in 1803, estimated that British and American vessels had obtained between 10,000 and 15,000 sea otter pelts annually for the previous 10 years (Khlebnikov, 1835:43). Sea otters decreased rapidly in the face of this excessive exploitation; and, by 1825, the sea otter trade of the Americans and British on the Northwest Coast had practically ceased, and other items were sought to supplement cargoes. The Russians, however, continued to obtain about 1,000 - 2,000 skins annually, mostly from Kodiak and westward to the Aleutian Islands; and in the last five years of their occupation of Alaska, the Russian-American Company harvested 11,137 skins (Petroff, 1884:61). The following list of the numbers of sea otters taken by the Russian-American Company between 1844 and 1863 (Alaska Historical Documents, Vol. 4) indicates that the harvest was regulated to maintain a sustained yield. The apparent relaxation of quotas in 1850 suggests further that the population may even have been increasing slowly at that time.

Year	Sea Otters Taken	Year	Sea Otters Taken
1844	756	1854	1,189
1845	600	1855	-----
1846	600	1856	1,057
1847	500	1857	1,972
1848	353	1858	1,126
1849	200	1859	1,995
1850	1,352	1860	2,057
1851	1,740	1861	1,255
1852	1,523	1862	2,322
1853	1,162	1863	1,717

It is impossible to reconstruct the complete history of maritime trade of the Northwest Coast and Aleutian Islands, but the records and approximations summarized below indicate that at least 600,000 sea otter skins were marketed during the period of Russian occupation, and that the total number of sea otters that were pelted may have exceeded 800,000 animals.

Russians, 1742-1867 (Berkh, 1823; Petroff, 1884)	264,800
Foreign traders, 1785-1798 (Khlebnikov, 1835)	140,000
Americans 1799-1803 (Sturgis, n.d.)	47,800
Landed in Canton, 1804-1818 (Roquefeuil, 1823)	129,900
Hudson's Bay Company, 1825-1857 (Douglas, n.d.)	5,400
	587,900

The American Period

The purchase of Alaska in 1867 by the United States opened a new era of exploitation which centered in the Kodiak Archipelago, along the Alaska Peninsula, and in the Aleutian Islands. Conservation measures which assured the Russians a sustained yield of sea otter skins were ignored; and during the first four years after the transfer of Alaska to the United States, American hunters took 12,208 sea otters or more than the Russians had taken during the 10 years from 1857 to 1867 (Petroff, 1884:61). The increased tempo of the slaughter continued over the next two decades (1871-1891), when 88,135 skins reached the market (Cobb, 1906). The following decade, 1891-1900, showed the effect of the excessive kill, and only 6,143 sea otter skins were obtained by the Alaska Commercial Company (Reedy, 1935), which by then had nearly monopolized the Alaskan fur trade.

By the late 1890's, the end of the sea otter trade was clearly indicated. Hooper (1897) reported that only an occasional otter had been seen at Attu since 1882, and that the American schooner Challenge had hunted there for 18 days during 1896 without seeing a single animal. At Buldir Island, sea otters had not been taken since 1774. Occasional otters were found at Tanaga Pass, but Kiska and Amchitka, which were once favorite hunting grounds, were abandoned by hunters. Otters were still to be found on the Pacific side of the Fox Islands, and between Cape Lapin and Amak north of Unimak Island, but were so scarce that most hunters from these areas were brought to the Kodiak grounds. A few otters were taken at Sanak Island and in the reefs adjacent to the Alaska Peninsula between False Pass and the Shumagin Islands. Unga hunters killed 22 animals in the outer Shumagin Islands for one of the better records of the 1896 season.

The 1906 regulations for hunting required that all vessels had to clear as foreign voyages from customs and hunt not less than 9 miles from shore. This caused a reduction in the fleet and only three American vessels outfitted. Two schooners hunting the Fairweather grounds off Yakutat Bay got 16 sea otters and the Challenge, hunting

Amchitka Island, obtained four animals. Practically all hunting after 1906 was in the portion of the Kodiak grounds lying between the Trinity and Chirikof Islands, and in the Sanak area. In 1910, a crew of 40 Aleut hunters on the two American vessels left in the sea otter trade obtained only 16 otters. Two British Columbia vessels obtained 7 otters, and 11 others were killed or found dead on beaches for a season's total of only 34 animals (Marsh and Cobb, 1911). In 1911, after hunting was no longer profitable, sea otters were given protection by provisions of the Fur Seal Treaty between the governments of the United States, Great Britain, Japan, and Russia concluded at Washington on July 7. This protection was further extended with the establishment of the Aleutian Islands National Wildlife Refuge by the executive order of March 3, 1913.

Bureau of Fisheries reports by Cobb (1906) and Marsh and Cobb (1907-1911) provide a summary of the number of sea otters harvested in Alaskan waters between 1867 and 1911 which is given on the following page. The total value of the sea otter skins obtained during this period exceeded the purchase price of Alaska.

Years	Sea Otters Harvested
1868-70	12,208
1871-80	40,283
1881-90	47,842
1891-00	6,467
1901-10	572
	107,372

RECOVERY

In the first 20 years following the ban on hunting, reported observations of sea otters were scanty as might be expected considering the few remaining in remote areas. During the 1930's, reports of otters from widely scattered points became increasingly frequent, and in the course of biological surveys of the Aleutian Islands in 1936, Murie, et al. (1937) accounted for nearly all population centers that we now know to exist.

Present information on sea otter numbers and distribution is derived from several sources. In 1954, I surveyed portions of the Andreanof and the Delarof Islands by air, and in July and August of 1956, I surveyed Amchitka Island habitats from headlands with a telescope. At the same time, sample areas of Amchitka shores were examined repeatedly to determine the daily rhythm of activity and the effect of storms on local distribution patterns (Lensink, 1956). In 1957, surveys by the Fish and Wildlife Service employed both boat and aerial observations, and covered the area from Cook Inlet to the Islands of the Four Mountains in the eastern Aleutians, and Adak and part of Kanaga Island in the central Aleutians (Lensink, 1958). In 1959, the Fish and Wildlife Service completed surveys in the Aleutian Islands from the Islands of the Four Mountains westward (Kenyon and Spencer, 1960); and the Alaska Department of Fish and Game surveyed Prince William Sound and Cook Inlet, and repeated surveys in the Kodiak Archipelago and along a portion of the Alaska Peninsula (Lensink, 1959). To avoid confusion, the various surveys will be subsequently cited by date, method, and if necessary for clarity, by reference to the responsible agency by which they were conducted.

Earlier surveys which provide comparative data were made by the Fish and Wildlife Service in the Kodiak Archipelago (Chapados, 1951), the Shumagin Islands (Hooper, 1953a), the Sandman Reefs, and on Amchitka Island (Jones, 1951). Information on Amchitka Island is available also from reports of Bureau of Fisheries wardens, stationed there between 1936 and 1940, and from an aerial survey conducted by Refuge Manager Frank L. Beals and Navy Pilot G. T. Joynt in 1943 (Stiles, 1953). In addition to the various survey reports, a record of miscellaneous observations has been maintained in the Fish and Wildlife Service office at Juneau. Specific citations to much of this unpublished material have been kept to a minimum to avoid burdening the reader with references not easily obtained.

Although the various surveys may differ in their accuracy because of the time, weather conditions, or manner in which they were made (Appendix A), when supplemented with the many scattered observations they provide a reasonable basis for estimating the size of the population and for analysis of its status and distribution. Sea otters are found in several distinct population centers, which are considered by regions below. The approximate distribution of sea otters within each population center is indicated on charts (Figs. 2-12) which are oriented in the sea otter range on Figure 1. Each dot in Figures 2 to 12 represents the observation of about 25 sea otters at the approximate locality indicated. Dots at the periphery of population centers may represent less than 25 animals. The estimates for the various sea otter populations provided in the following sections are based on evidence presented by Kenyon and Spencer (1960) that approximately 25 percent of all otters may be submerged at any given time while feeding, and consequently are missed during aerial surveys. Other factors cause more animals to be missed, and estimates are predicated on the belief that no more than 50 to 75 percent of all animals were observed. Where estimates deviate from these limits, substantiating evidence is provided to show justification for changes. All locality estimates are rounded to a multiple of 25 and regional totals to the nearest 500 animals.

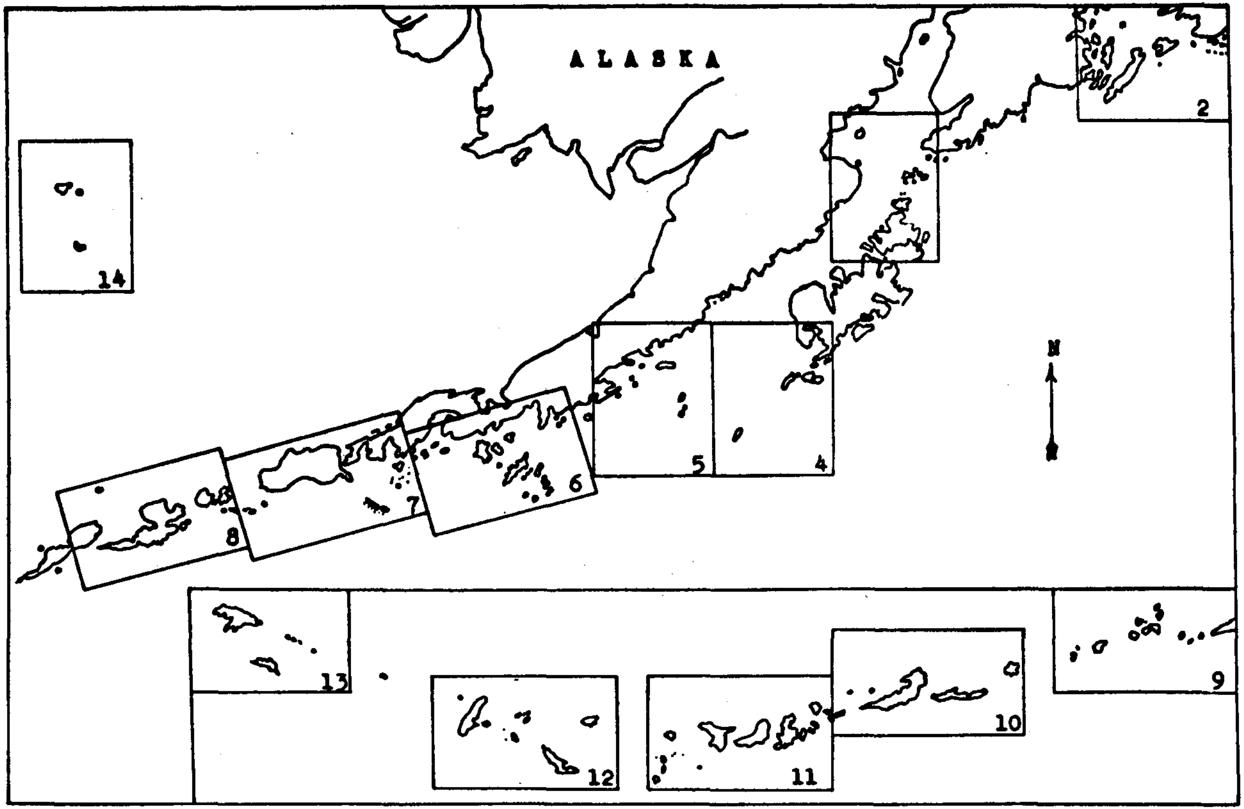

Figure 1. Sea Otter Range in Alaska with Key to Large Scale Charts Showing Observations of Sea Otters (Figures 2-14).

Southeastern Alaska

Several unverified reports of sea otters are available for the western coasts of Prince of Wales and Baranof Islands in southeastern Alaska; and Kenyon (1957, 1959b) states that there are unverified reports of sea otters on the west coast of Queen Charlotte Island in British Columbia. Although these areas were important hunting grounds, the present reports must be considered invalid until verified by observers familiar with sea otters and other marine mammals.

Kayak Island to the Kenai Peninsula

Prince William Sound, in the center of this area (Fig. 2), has long been known to support an important sea otter population. The skins from two sea otters killed illegally were seized by the government at Seward as early as 1924 (Thompson, 1949). Williams (1936) comments that there were reports of otters at Montague Island, and Dufresne (1946) mentions that animals were reported from as far south as Cape St. Elias. Observations of sea otters in Prince William Sound and vicinity, reported by Fish and Wildlife Service (FWS) or Alaska Department of Fish and Game (ADFG) personnel since 1949, are reviewed below to provide a comparison with recent surveys.

All reports involving large numbers of animals in Prince William Sound are from Montague Island, or adjacent portions of Hinchinbrook, or Latouche and Elrington Islands.

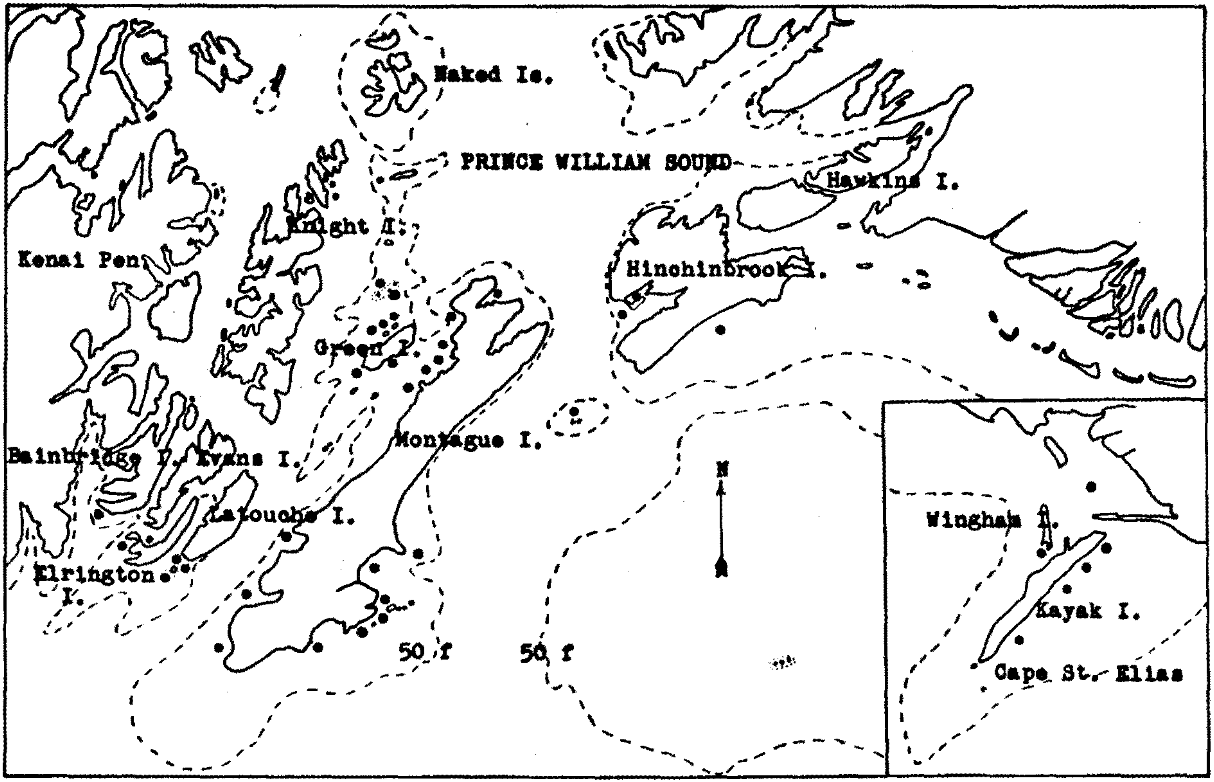

Figure 2. Sea Otter Observations between Cape Saint Elias to the Kenai Peninsula. (Scale: 1 inch = approximately 16 miles, contours in fathoms.)

The first report of large concentrations was by FWS Refuge Supervisor David L. Spencer, who saw groups of 27 and 37 animals, respectively, at Latouche and Elrington Islands in May 1949. In March 1951, FWS Agent Frederick C. Robards observed more than 150 sea otters between Johnstone Point and Bear Cape, Hinchinbrook Island; and in December, Agent Jay Stovall saw 14 animals at Port Etches and 21 in Constantine Harbor. In September 1952, Agent Stovall reported 19 animals between Montague Mountain and Clear Point. Dr. Archie S. Mossman of the Alaska Department of Fish and Game estimated that he saw about one sea otter per mile of shoreline (175 - 200) on Montague Island in August 1955, and ADFG Biologist James W. Brooks reported a year later that a group of 25 to 30 animals frequented Patton Bay during the two weeks that he spent there. Brooks observed only three sea otters between Box and Zaikof Points to the east of Patton Bay. In April 1957, FWS Biologist David R. Klein counted 78 animals along the north shores of Montague Island.

Observations of smaller numbers of animals within Prince William Sound include one animal seen in Canoe Pass, Hawkins Island, by FWS Agent Robards in March 1951, two in Herring Bay, Knight Island, and one at Salmo Point, Hawkins Island, by FWS Agent Neil T. Argy in October 1956. Dr. Francis Fay of the Arctic Health Research Center wrote me that he saw a single otter between Storey and Fairmont Islands in August 1959, and also reported that otters are seen here four or five times every summer from an excursion boat traveling between Whittier and Valdez.

Sea otters have also been seen on the east coast of the Kenai Peninsula adjacent to Prince William Sound. In May 1951 a single animal was observed by FWS Agent R. Reynoldson near Port Dick, 2 were observed at Day Harbor in 1952 by FWS Agent Doyle Cisney, 15 at Elizabeth Island in August 1955 by Blake Kinnear of Port Graham, and 3 at Rugged Island in May 1957 by Cecil Rhode of Homer.

Although residents of Cordova know that sea otters existed in the Kayak-Wingham Island area, few records for this population are available. ADFG Biologist James W. Brooks saw a female and her pup at Wingham Island in August 1955, and reported that local fishermen had seen as many as 50 or 60 animals. In September 1958, I saw about 40 animals in Controller Bay and about 25 at Wingham Island, but did not look for otters in the vicinity of Kayak Island at that time.

Aerial surveys of Prince William Sound were flown in August 1959 by the author with ADFG Biologist Ralph Pirtle assisting as observer. The survey was conducted under nearly optimum conditions of visability with a Cessna 180 at a flight speed of 85-120 miles per hour and an altitude of 150 to 500 feet. This survey also repeated a survey of the Kayak-Wingham Island area made in April 1959 with the same aircraft. A total of 545 otters were counted.

in Prince William Sound. In the Kayak-Wingham Island area, 138 animals were seen in August surveys where only 93 had been seen in April.

The survey results generally confirmed the distribution patterns and previous estimates of numbers suggested by incidental observations. The western portion of Prince William Sound and most of the Kenai Peninsula area have not been completely surveyed but it is believed that no major concentrations were missed. Practically all animals seen were found where there are extensive areas of shallow water. Thus, more animals have been reported on the Kenai Peninsula, where much shallow water is available, than from areas within Prince William Sound much nearer to the center of population, where most shorelines are precipitous. The major areas of sea otter concentration and estimates of the number of animals present are listed below.

	Observations	Estimates
Kayak-Wingham Island area	138	175 - 225
Hinchinbrook Island	58	75 - 100
Montague Island	349	450 - 575
Green and Little Green Islands	42	50 - 100
Latouche and Elrington Islands	87	125 - 150
Other, including unsurveyed areas	28	100 - 200
	702	1,000 - 1,500

Kodiak Archipelago

Observations of sea otters in the Kodiak Archipelago (Figs. 3 and 4) were rare prior to 1950. Eyderdam (1933) commented that he had seen four otters at Shuyak in 1922. Nels Christianson of Old Harbor told me that he saw two otters at Dark Island in 1928, and a single otter on Tugidak Island in the Trinity Islands at about the same time. In 1931, Capt. I. M. Hoffstead reported the observation of two otters at Sud Island in the Barren Islands. In 1933, the government confiscated 12 sea otter skins said to have been found in an oil drum floating among the Barren Islands, and eight skins were confiscated from residents of Kodiak in 1935, but in neither instance is the exact locality known from which the skins were taken (Thompson, 1949). Williams (1936) mentions unconfirmed reports, by local residents, of otters among the Latax Rocks north of Shuyak Island. FWS Refuge Manager Frank Beals (1949) confirmed the presence of sea otters in the Latax Rocks area during aerial surveys made in 1948, but actually observed only three animals. Beals (1950) also reported unconfirmed observations of sea otters in the Barren Islands, in the Trinity Islands, at Chirikof Island, and at Sea Otter Island. Bob J. Logan of Cordova told me that he saw otters frequently on the southwest side of Chirikof Island and at the Lighthouse Rocks between Chirikof and the Semidi Islands in the 1940's.

Since 1951, reports of otters in the northern

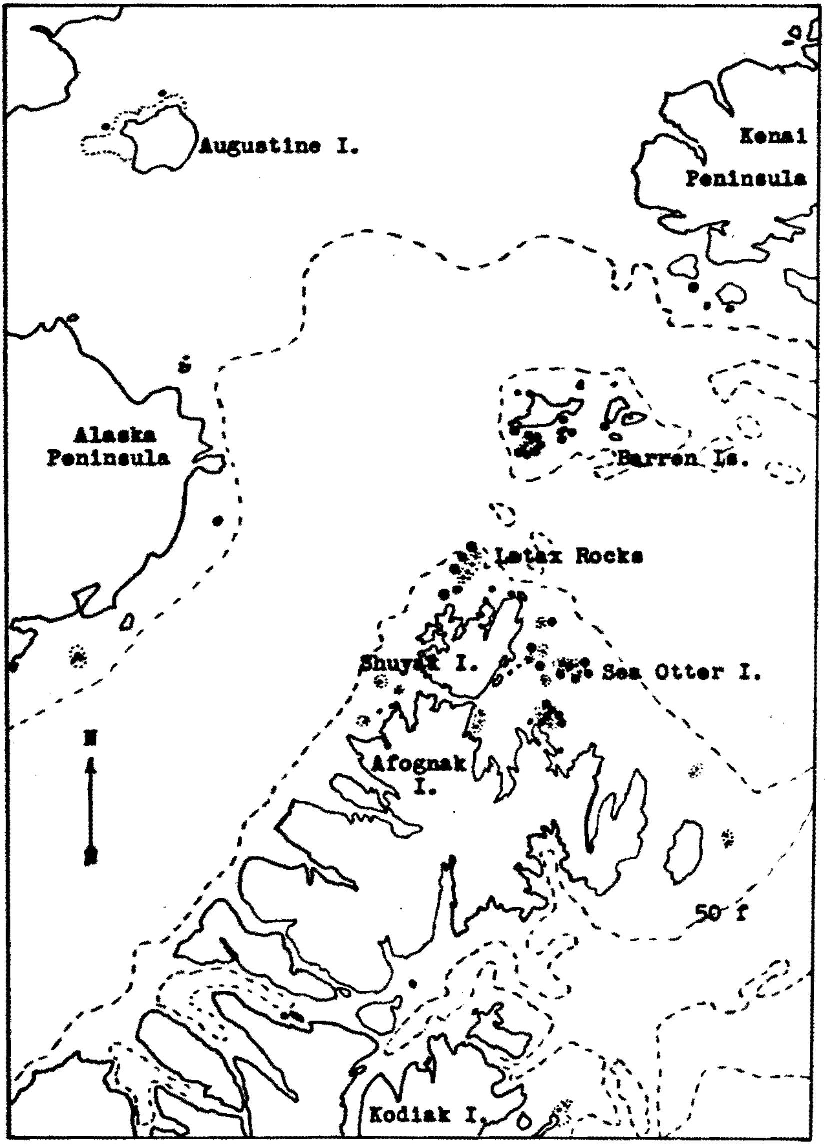

Figure 3. Sea Otter Observations in the Northern Part of the Kodiak Archipelago. (Scale: 1 inch = approximately 16 miles, contours in fathoms.)

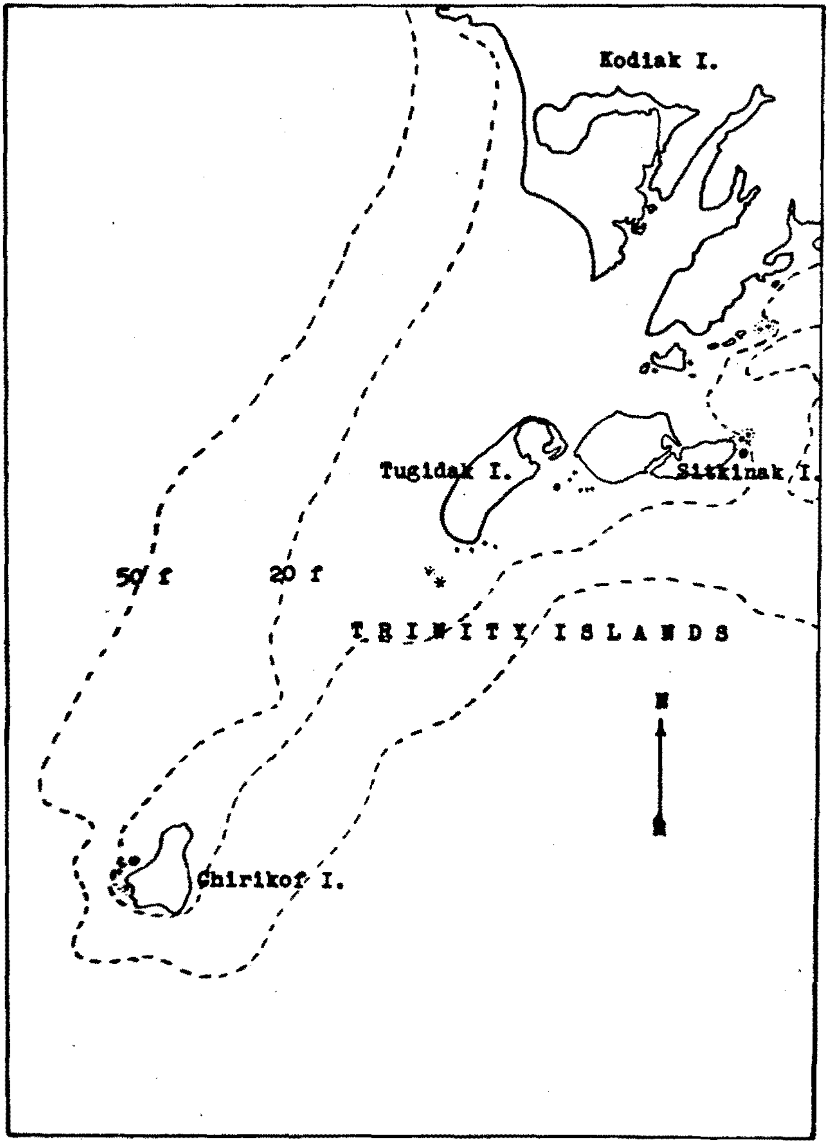

Figure 4. Sea Otter Observations in the Trinity Islands. (Scale: 1 inch = approximately 16 miles, contours in fathoms.)

Shuyak area have become increasingly frequent. FWS Refuge Manager Paul Chapados (1951) and Refuge Supervisor David L. Spencer counted 15 animals on Sea Otter Island and 67 among the Latax Rocks during July 1951 aerial surveys, but saw none in the Barren Islands, Trinity Islands, or at Chirikof Island. Several reliable reports from various points such as Sea Lion Rocks, Marmot Island, Perenosa Bay, and even as far south as Shuyak Straits indicated the growth and dispersal of the population. Additional observations were reported also for the Barren and Trinity Islands.

The first complete survey of the Kodiak Archipelago, made from a boat in May and June 1957, revealed that the population was considerably larger than the 1951 survey or the various reports had indicated (Lensink, 1958). The largest concentration was in the Barren Islands where 117 animals were counted. Eighty-nine were counted in the northern Shuyak area, and 5 on the eastern side of Shuyak Island, but none were found in the Trinity Islands.

Because it was believed that the boat surveys were inadequate, the survey of the Geese Channel - Trinity Island area was repeated on June 6 by air from a Piper Super-Cub with Lensink as observer, and the Shuyak - Barren Islands area on June 7 with FWS Refuge Manager Willard A. Troyer as observer. Troyer observed a total of 515 animals in the Shuyak - Barren Islands area, which included 75 on Sea Otter Island, 75 east of Point Banks, 12 on east shore of Shuyak

Island, 119 in the northern Shuyak - Latax Rocks area, and 234 in the Barren Islands. I did not see any in the Trinity Islands, although Fisheries Research Institute Biologist Ronald Lopp saw 15 otters there during aerial surveys of sea lion rookeries in September. The total count obtained by combining the results of both boat and air surveys was 620 animals.

An aerial survey of the Shuyak area by Refuge Manager Troyer in August 1958 resulted in a count of 581 animals. Because this count was over twice that of June 1957 for the same area, it seemed probable that there had been a movement of animals from the Barren Islands to Shuyak. Weather conditions prevented a survey of the Barren Islands in 1957 to check this possibility. Consequently, aerial surveys of the entire Kodiak Archipelago were repeated in July 1959. On this survey, 395 animals were seen in the Shuyak area and 272 in the Barren Islands for a total count of 667 animals. The discrepancy between the counts for the 1957, 1958, and 1959 aerial surveys of the Shuyak area (281, 591, and 365) strongly suggests the existence of movements by sea otters between Shuyak Island and the Barren Islands, a distance of 14 miles. If movements do not cause the discrepancy, our surveys are considerably less accurate than we suppose.

No otters were seen in the Trinity Islands during the 1959 aerial surveys. However, neither Chirikof Island nor the vast area of shallow water between Chirikof Island and the Trinity Islands has been surveyed, and I have no doubt as to the validity of Lopp's observation of 15 animals at Sitkinak Island in 1957. John Norton of Kodiak, one of the few sea otter hunters still living, told me in 1957 that otters were hunted in this area up to 15 or more miles from shore. Our surveys cover only the narrow shoreline zone, and we could easily fail to encounter even a sizable population in offshore waters. An estimate of the number of animals in this population is entirely conjectural, but it is unlikely that any distinct population could consist of less than 100 animals after 50 years without molestation and I suspect that it numbers considerably more.

Estimates for the animals in various segments of Kodiak Archipelago population are listed below. These estimates necessarily give a wide range between the minimum and maximum size of population to account for the possibility of either movement or lack of movement between the Barren Islands and Shuyak Island areas, and for the uncertainty of observations on the Trinity Islands and Chirikof Island populations.

	Observations	Estimates
Shuyak Island	581	500 - 1,000
Barren Islands	272	350 - 450
Trinity and Chirikof Islands	14	100 - 400
	681	1,000 - 2,000

Alaska Peninsula

Four distinct population centers are found on the Alaska Peninsula: Augustine Island in Cook Inlet (Fig. 3), Sutwik Island (Fig. 5), the outer Shumagin Islands (Fig. 6), and the Sanak-Sandman Reefs (Fig. 7). These areas were the last of the productive hunting grounds and as late as 1880 the Sanak area yielded over 2,000 skins annually (Petroff, 1884).

In 1948, a group of about 50 sea otters was reported at Augustine Island. Since then smaller groups have been reported from adjacent areas of the mainland coast from Shaw Island to Tuxedni Bay. Refuge Supervisor David L. Spencer counted 40 animals at Augustine Island and saw a single otter at Shaw Island during 1957 surveys. We counted 52 sea otters on aerial surveys during August 1959, but did not check areas of the mainland shore where they are occasionally seen. A boat had preceded the survey flight around the island causing a scattering of animals which may have resulted in a low aerial count. It is believed that there may be as many as 100 animals, but probably not more than 150 in the present population.

No otters were seen in the 180-mile long area from Cape Douglas to Cape Providence, which separates the margins of the Augustine Island and the Sutwik Island populations, on either the 1957 boat survey or 1959 aerial survey. However, several sites in this area appeared to be favorable habitat, and considering recent trends in adjacent populations, establishment of resident populations should occur within a few years.

Verified reports of sea otters in the Sutwik area (Fig. 5) have been available since 1936, but it was not until the 1951 surveys by Refuge Manager Robert D. Jones, Jr. that the sighting of 388 animals established the approximate distribution and size of the population. During the aerial surveys of 1957, 894 otters were counted, the greatest number of them being between Sutwik Island and Cape Kumliun. The farthest west that animals were observed was at Katmai Reef off Cape Kumliun and the farthest east was in Chiginagak Bay. However, reliable reports indicate that a few animals are present to the west as far as Castle Bay. All personnel participating in the survey agreed that many animals were missed. My estimate for this population is between 1,200 and 1,500 animals.

The Shumagin Islands (Fig. 6) population is the largest that presently exists in the Alaska Peninsula area. Occasional reports are available from the 1930's; but Mr. Peter Grundholt, a resident of the Shumagins for 80 years, says otters were seldom seen there before 1940. Recently, however, observations have become frequent, even among the northern islands. FWS Biologist Victor B. Scheffer (1947) estimated the population at Simeonof Island to be 500 animals. Assistant Refuge Manager David C. Hooper (1953a) counted

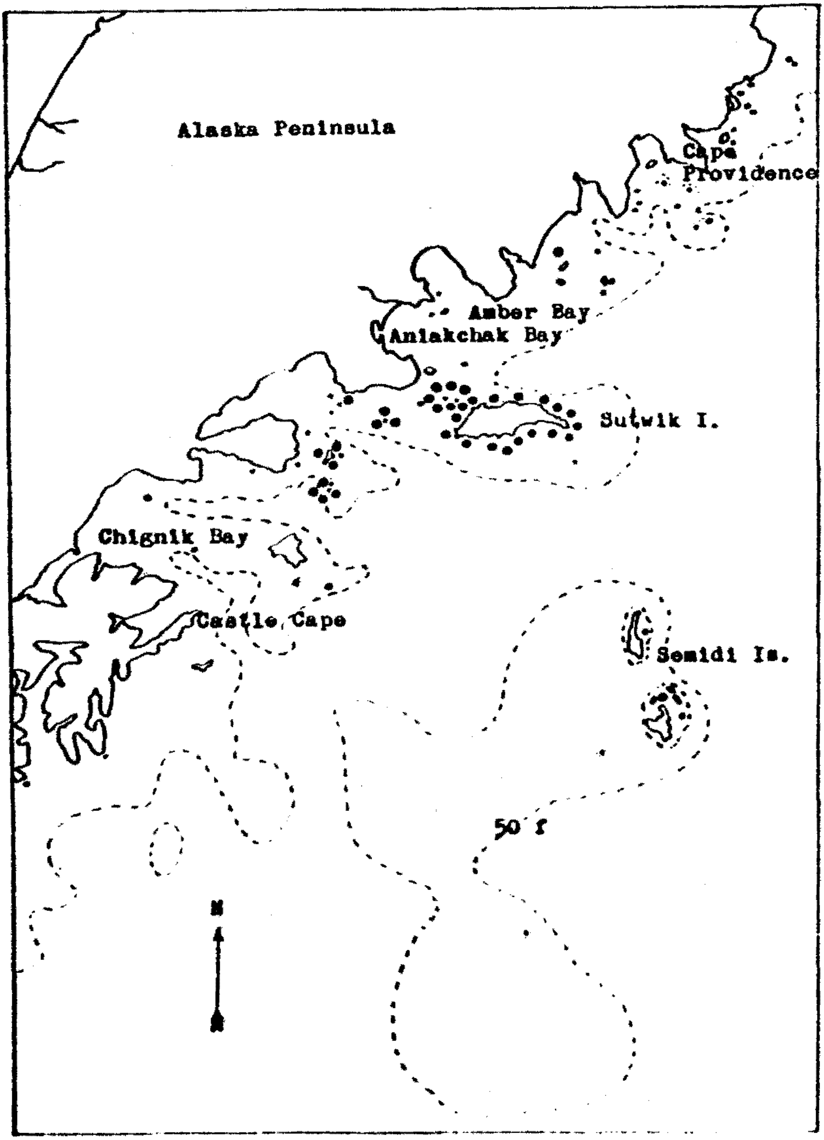

Figure 5. Sea Otter Observations at Sutwik Island and the Semidi Islands. (Scale: 1 inch = approximately 16 miles, contours in fathoms.)

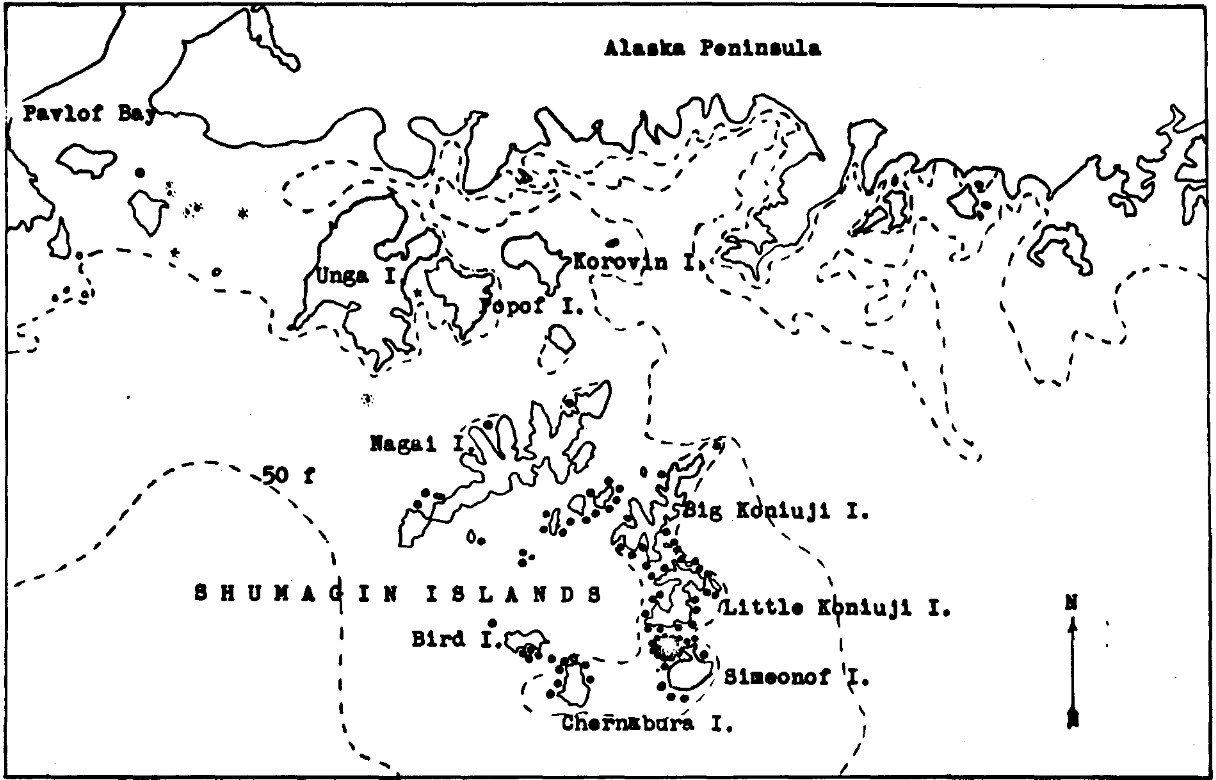

Figure 6. Sea Otter Observations in the Shumagin Islands. (Scale: 1 inch = approximately 16 miles, contours in fathoms.)

633 otters on aerial surveys of Simeonof and Little Koniuji Islands in 1953, and on the basis of this count and his observations on other islands, estimated the total Shumagin population to be 1,000 animals. In the aerial surveys of 1957, 1,831 otters were seen and the total population was considered to be between 2,000 and 2,500 animals (Lensink, 1958). Nearly all animals observed were in the vicinity of the outermost islands. A single sea otter was observed at Elephant Point on the Alaska Peninsula, and two near Wosnesenski Island in the Popof Islands, but these are as likely to have originated in the Sanak-Sandman Reefs group as in the Shumagins. Revision of the 1958 estimates in the manner suggested by Kenyon (1959a) indicates a population of 2,450 to 3,050 animals in the Shumagin Islands.

A distance of about 50 miles separates the Sanak-Sandman Reef population from that in the Shumagins, but strays, most of them probably from the Sandman Reef population (Fig. 7), have been observed at various points between. The history of this area provides an almost spectacular example of the reestablishment of otter populations. A diary that I examined of the late Axel Bendickson, who lived on Cherni Island in the Sandman Reefs in the late 1920's, was complete to the extent that daily entries included weather records and observations on birds and animals--yet no comment was found on sea otters although they might be considered to have been especially interesting. Mike Uttecht

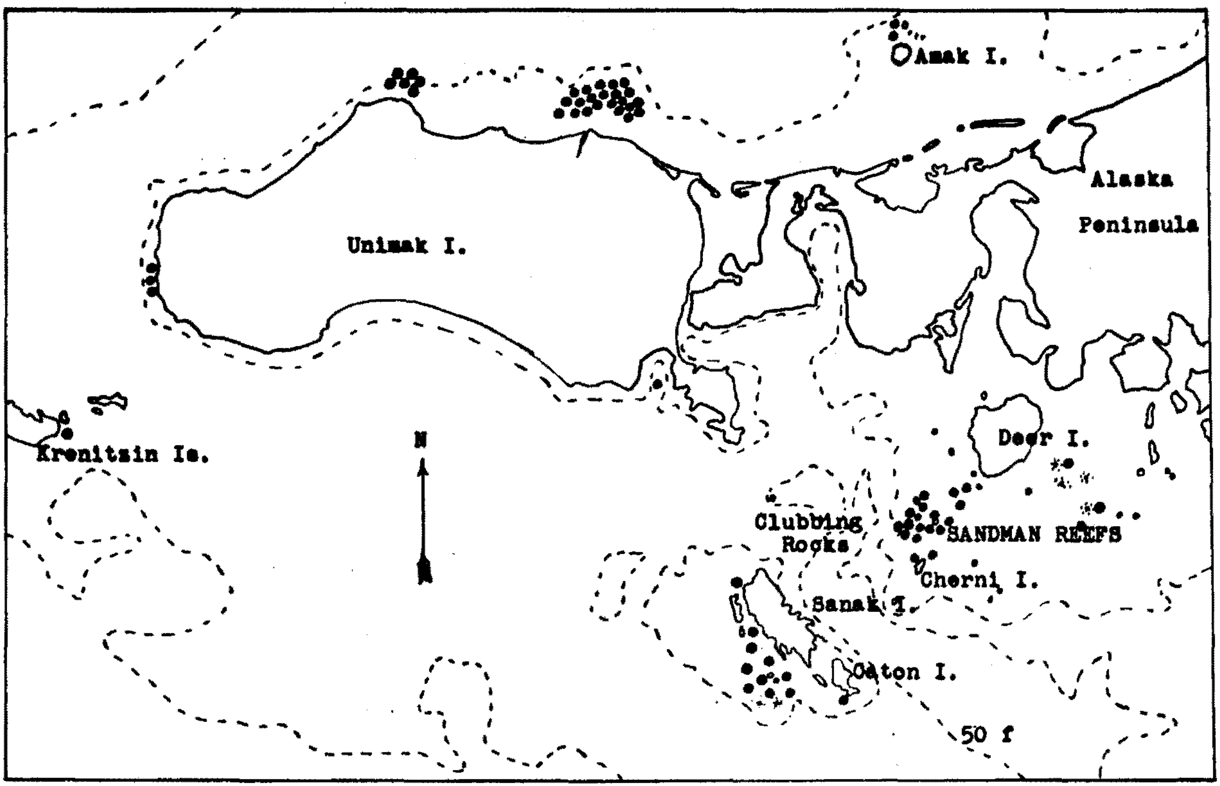

Figure 7. Sea Otter Observations at Sanak Island, Sandman Reefs, and Unimak Island. (Scale: 1 inch = approximately 16 miles, contours in fathoms.)

of King Cove, who hunted harbor seals in the Sandman Reefs between 1923 and 1936, saw no sea otters there until 1942. As early as 1922, however, Sanak residents reported otters among reefs north of that island (McCracken, 1957). Two illegal skins were seized from residents of Sanak in 1926. In 1948, Uttecht reported a group of 27 otters at Cherni Island. These animals may have come from one of the isolated islets in the Sandman Reefs, but are more likely to have come from the Sanak area. In 1951, Refuge Manager Jones surveyed the entire Sanak-Sandman Reef area by air, and counted 65 otters in the Sanak Reefs and 97 otters in the Sandman Reefs. Between 1951 and 1957, reports from fishermen indicated an increasing number of otters in the Sandman Reef area and even on adjacent portions of the Alaska Peninsula. These observations were fully corroborated in the 1957 aerial surveys when 508 otters were counted in the Sandman Reefs and 251 in the Sanak Reefs. In the entire Sanak-Sandman Reef area the population is probably between 1,050 and 1,325 animals.

In summary, for the Alaska Peninsula, four separate sea otter populations appear to have increased rapidly in size during the last decade, and now number between 5,000 and 6,000 animals as indicated on the following page.

	Observations	Estimates
Augustine Island	52	100 - 150
Sutwik Island	894	1,200 - 1,500
Shumagin Islands	1,831	2,450 - 3,050
Sanak-Sandman Reefs	759	1,050 - 1,325
	3,536	5,000 - 6,000

Fox Islands

Only four reports of sea otters were found for Fox Islands (Figs. 7-9) prior to the July 1957 surveys, and in each case the observations were of only a few animals (Lensink, 1958). During the 1957 aerial survey of Unimak Island, 786 otters were encountered at a distance of 2 to 4 miles from shore between Cape Mordvinof and Bechevin Bay, thus confirming the earlier reports. No otters were observed near shore. Crew members of the M/V Deep Sea also reported seeing this group at about the same location during summer months. In October 1957, Refuge Manager Jones attempted to relocate this group of animals, but was unable to do so although he extended his aerial search to a distance of 6 miles from land. A few days before Jones' flight, I had seen only nine otters along the shorelines of the islands to the west as far as Herbert Island. In late March 1958, Jones saw 20 otters in a cove at Cape Mordvinof, about 75 at Sennett Point in Unimak Pass, and 12 in the Krenitsin Islands. We can be reasonably certain that the group at Cape Mordvinof belongs to the population north of

Unimak, but the group at Sennett Point may belong to the Sandman Reef population because at the time they were observed, significantly fewer animals were present in the Sandman Reefs than were present in the summer. In 1949, Mike Uttecht reported that he had seen three to five otters on each of several summer trips along the north shore of Unimak but that he had not seen them on winter trips. His observations agree in general with the results of recent surveys. Available observations indicate that this group of sea otters spends a considerable part of the year farther from shore than is believed usual for sea otters in general. Offshore movement of this population is possible because of extensive areas of shallow water north of Unimak, where otters can obtain food. However, a westward movement in winter to the Krenitzin Islands is also a possibility, as reported observations and our partial surveys are not in complete agreement. More observations are needed to ascertain the seasonal movements of this group in inshore and offshore areas.

Early in September 1957, Fisheries Research Institute Biologist Ronald Lopp observed 40 sea otters in the vicinity of Amak Island. Later, I accompanied Lopp on an aerial survey of sea lions, Eumetopias jubata (Schreber), between Cold Bay and Herbert Island in the Islands of the Four Mountains; although this flight was not entirely adequate as a sea otter survey, we examined most of the immediate shoreline area. Five otters were seen in the Krenitzin

Islands, one at the east end of Unalaska Island, and three near the west end of Unimak Island. None were found in the Islands of the Four Mountains, nor were otters seen here during the 1959 aerial surveys by the Fish and Wildlife Service. Neither the 1957 nor the 1959 surveys, however, were complete in this area, and the reported observation of 15 to 20 otters here in 1945 by R. Logan of Cordova is considered valid. Reports which we have received since the survey from residents of Akutan Village in the Krenitzin Islands indicate that there were more otters than we discovered. The group seen by Lopp at Amak Island probably belongs to the offshore group seen north of Unimak Island but the animals in the Krenitzin Islands may form a distinct population.

Since the vast area of shallow water north of Unimak has not been adequately surveyed, it is difficult to say how many animals were missed; but I suspect that the otters there were grouped and that we encountered most of them. My estimate for the combined populations is 1,100 - 1,500 animals. Interestingly, a range map for sea otter distribution in 1880 prepared by Petroff (1884) corresponds exactly with the present distribution for this area.

Adequate surveys are also lacking in the other Fox Islands, and since extensive movements of otters between areas seem to occur, population estimates for various localities are conjectural. However, the estimates listed

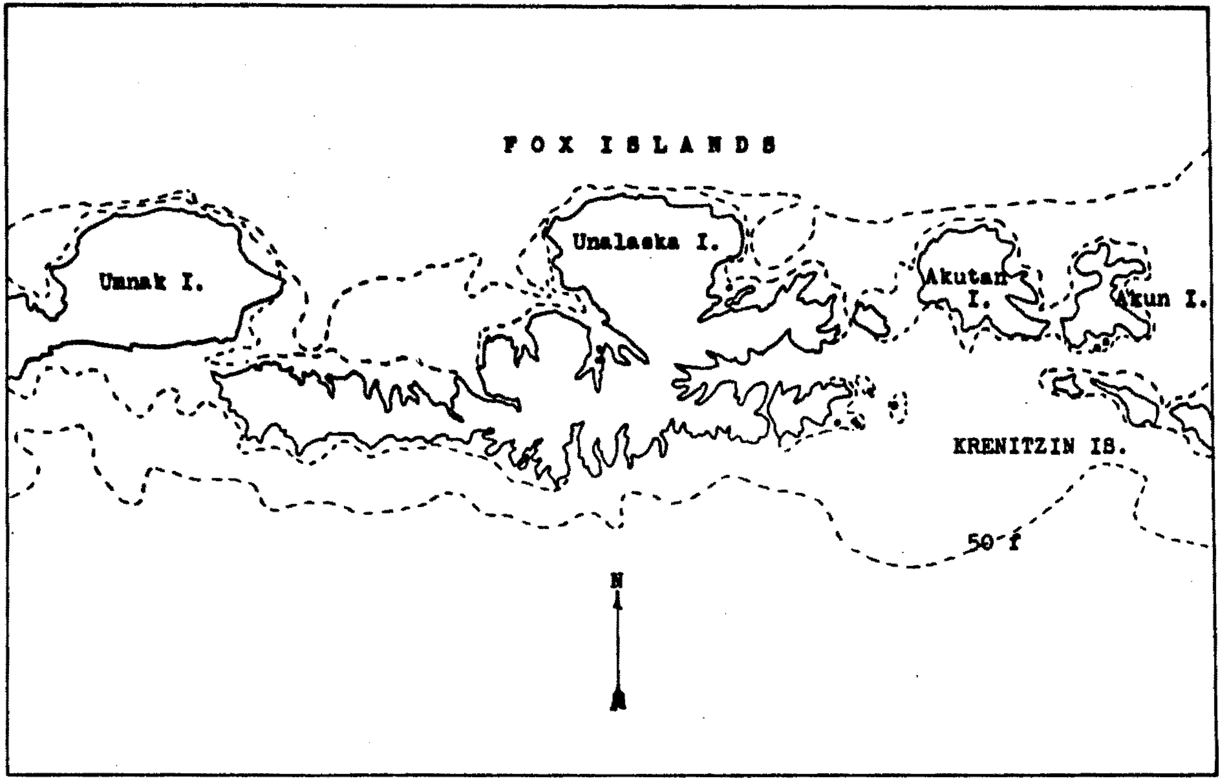

Figure 8. Sea Otter Observations in the Krenitzin Islands and at Unalaska Island. (Scale: 1 inch = approximately 16 miles, contours in fathoms.)

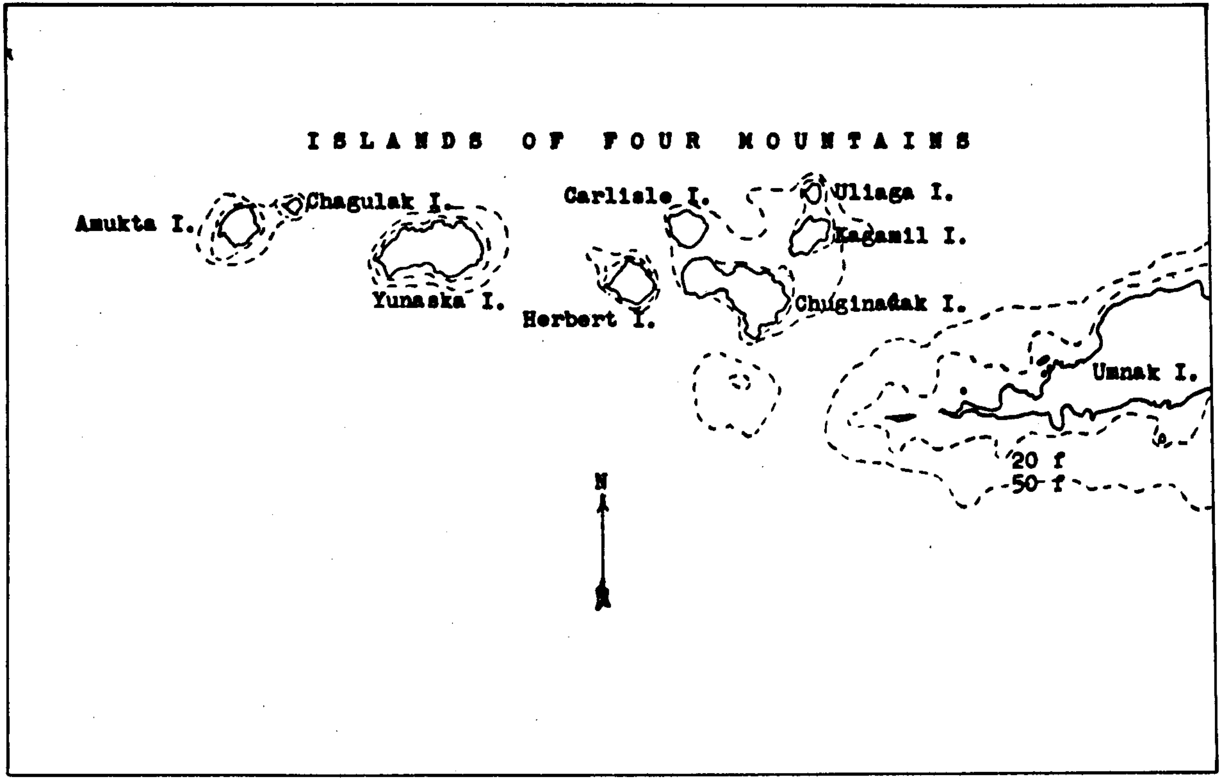

Figure 9. Sea Otter Observations at Umnak Island and in the Islands of Four Mountains. (Scale: 1 inch = approximately 16 miles, contours in fathoms.)

below will serve as a rough guide to the supposed distribution.

	Observations	Estimates
Unimak Offshore areas	781	1,050 - 1,300
Unimak Shoreline areas	95	150 - 200
Krenitzin Islands	12	50 - 100
Unalaska Island	1	50 - 100
Umnak Island	3	50 - 100
Islands of the Four Mountains	15	50 - 100
	907	1,500 - 2,000

Andreanof Islands

Sea otters are present at Atka, Amlia, and Seguam Islands in the eastern Andreanofs (Fig. 10); a few animals have been reported in the vicinity of Great Sitkin and Umak Islands in the central Andreanofs (Fig. 11), and large numbers of otters are found on Adak, Kanaga, and Tanaga Islands in the western Andreanofs (Fig. 11). Williams (1936) reported the presence of sea otters at the eastern end of Amlia and at Seguam on the basis of information received from residents of Atka. In 1939, Commander Tison of the USCGS M/V Explorer confirmed the presence of animals at Seguam. Otters are occasionally seen in Amlia Pass by residents of Atka, but they have not been reported along the coasts of Atka Island. However, during the 1959 surveys, 33 otters were found scattered around Atka, 83 were counted at Amlia and 14

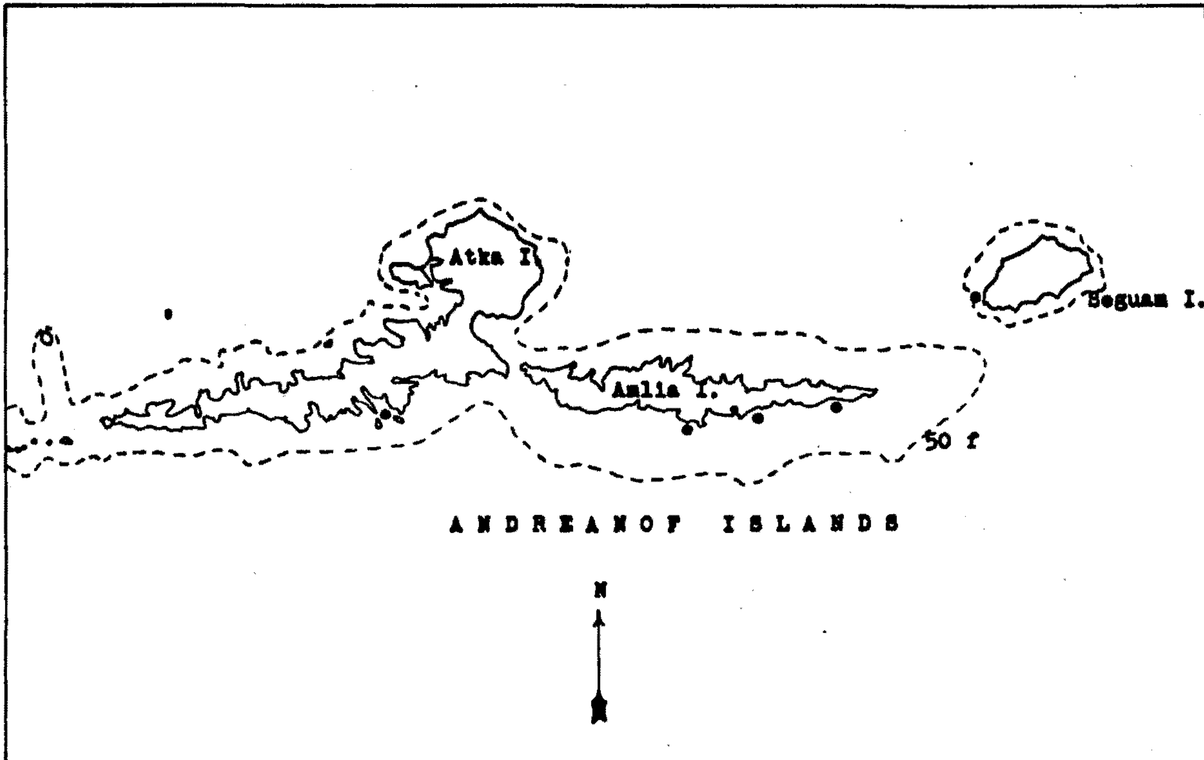

Figure 10. Sea Otter Observations in the Eastern Andreanof Islands. (Scale: 1 inch = approximately 16 miles, contours in fathoms.)

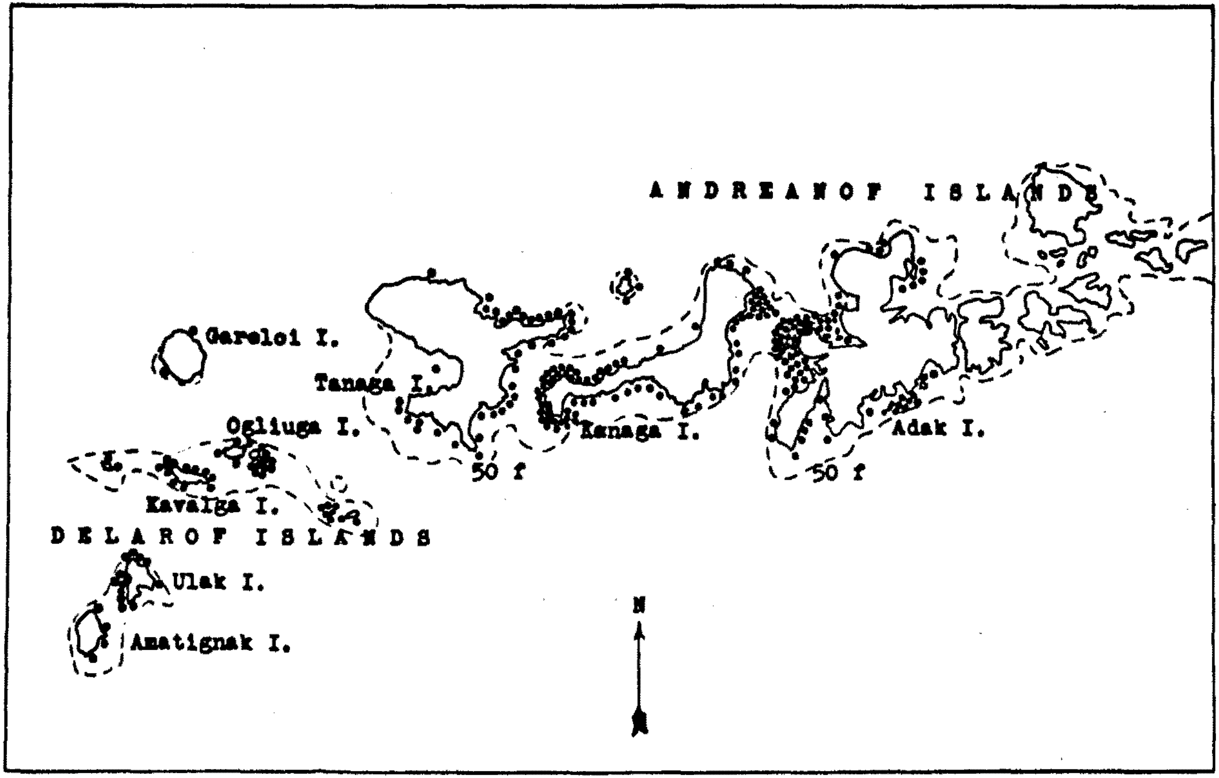

Figure 11. Sea Otter Observations in the Western Andreanof Islands. (Scale: 1 inch = approximately 16 miles, contours in fathoms.)

at Seguam. Kenyon and Spencer (1960) estimated that the population on the three islands was between 175 and 260 individuals. I find it difficult to believe that a population so long established and widely dispersed could be much different from other populations in respect to numbers. It seems, therefore, that one or more important concentration points were missed, and a figure of 200 - 500 animals is suggested as a new estimate, preserving a conservative lower margin but permitting greater latitude for error by increasing the upper limit.

It is doubtful that any significant group of animals exists among the small islands between Atka and Adak, although in 1933 the captain of the Bureau of Fisheries M/V Crane reported the observation of about 40 animals near Great Sitkin Island, and Williams (1936) mentions that members of the 1936 Aleutian Expedition saw otters at Umak Island. Allan Hartt, biologist for the North Pacific Salmon Investigation, reported the observation of a single otter at Umak Island in 1956. In 1954, I accompanied a naval patrol flight that circled Umak and Great Sitkin Islands, but saw no sea otters. During the 1959 FWS aerial surveys, only one sea otter was observed at Kagalaska Island, although the entire shorelines of Kagalaska and Great Sitkin Islands were examined. Other islands in the central Andreanofs have not been adequately surveyed. On rather uncertain bases, therefore, an estimate of 50 - 300 animals is given for the population in the central Andreanof Islands.

On Tanaga and Kanaga, estimates of otter numbers are on safer grounds. Sea otters were observed on both islands in 1936, and Murie, et al. (1937) estimated the population at Cape Amagalik on Tanaga Island at 200 animals. Assistant Refuge Manager Hooper (1953a) counted 571 otters on the southwestern third of Kanaga and about 1,000 between Cape Sasmik and Tanaga Bay on Tanaga Island. Both of these counts were made from the shoreline with binoculars. In 1954, I accompanied a Navy training flight on which it was possible to examine most of the shorelines of Kanaga and Tanaga. Although my counts were low, 471 on Kanaga and 324 on Tanaga, my general impression during the flight was that otters were about as numerous as they were on Amchitka Island. To indicate the general abundance of otters, Jones (1951a) calls the western Andreanofs, the Delarofs, and the Rat Islands the "sea otter belt." During the 1957 surveys made from a dory (Lensink, 1959, 1960), 568 otters were counted in a 19-mile sample area on the south side of Kanaga. The population on the eastern side of Kanaga, which was examined under less favorable conditions, appeared to be fully as large. The FWS 1959 aerial surveys included both Tanaga and Kanaga Islands, but population estimates based on records and surveys up to 1957 are of interest and will be considered first.

The 1957 survey estimates for the population on

Kanaga were derived in three ways: extrapolation of the 19-mile sample area figures to the entire island indicated a population of 3,430 animals; correction of the 1954 aerial survey figures on the basis of the 1957 surveys indicated a population of 3,600 animals, and application of density figures from Amchitka on the basis of square miles of water area less than 50 fathoms indicated a population of 4,000 animals. Because all these estimates were similar, it was believed they were close to the correct figure. Our records indicated that the Tanaga population was similar to that on Kanaga, and that we could use the same methods for its estimation. In round numbers, the estimate of the number of otters on Tanaga was 2,700 - 4,500, and on Kanaga 3,000 - 5,000 (Lensink, 1960).

During the 1959 aerial surveys, 902 sea otters were counted on Tanaga and 1,879 on Kanaga. On the basis of these counts, Kenyon and Spencer (1960) gave estimates of 1,200 - 1,800 and 2,400 - 3,600 animals, respectively, for the two islands. In comparing these results with those of previous counts, we find that only 236 otters were counted on Tanaga between Cape Sajaka and the eastern base of Cape Sasmik, whereas, Hooper (1953a) estimated over 1,000 animals for the same area. On Kanaga, the 1959 surveys accounted for 460 animals at Cape Chunu, where Hooper counted 571 animals from the shoreline with binoculars. Between Round Point and Kanaga Bay, 200 otters were counted during the 1959 surveys, where 568 otters were counted on a survey by dory in 1957. Because we know that since 1957 more than 1,000 sea otters have emigrated from Kanaga to Adak (see below), the lower count on Kanaga is explainable, particularly as the easternmost area reflects the greatest change. No similar explanation is available for the even greater decrease in the Tanaga count, and it appears that one or more major concentrations were missed by the 1959 survey. A characteristic of otter populations is that approximately half of all animals counted are in large groups varying from 50 to over 400 individuals; e.g., at Kanaga, the proportion was 58 percent; Adak, 60 percent; and Semisopochnoi, 48 percent. On Tanaga in 1959 only 23 percent of all animals counted were found in such concentrations. Were the expected concentrations merely missed during the 1959 survey? My estimates of 1,500 - 3,000 animals for Tanaga and 2,500 - 4,000 for Kanaga, based primarily on the 1959 aerial survey, permit somewhat greater latitude for error than those of Kenyon and Spencer (1960). My estimates are considerably reduced, however, from those based on the 1957 surveys (Lensink, 1960).

The first report of sea otters from the vicinity of Adak Island was of 14 animals in the straits between Adak and Kanaga in 1943. Refuge Manager R. D. Jones, however, did not observe any otters during dory surveys of the west side of Adak in 1951 and of the entire island in 1952.

In 1954, I saw 48 animals on the west side of Adak; and in surveys by dory with Jones in 1957, we counted 399 animals, and in addition found animals scattered across Adak Straits. Nearly all animals seen were on the western end of the island, and only one small group was found in Kulak Bay on the eastern side. During the 1959 aerial surveys by the Fish and Wildlife Service, 1,707 otters were counted. These were fairly well distributed on all sides of the island although largest concentrations were on the west and south shores. The rapid increase of sea otters on Adak can have occurred only as a result of immigration from Kanaga. Kenyon's and Spencer's estimate of 2,300 - 3,450 animals for this population has not been altered.

Overall estimates for the Andreanof Islands are summarized below.

	Observations	Estimates
Seguam, Amlia and Atka Islands	130	200 - 500
Kagalaska Island to Oglodak Island	2	50 - 300
Adak	1,718	2,300 - 3,500
Kanaga	1,822	2,500 - 4,000
Bobrof	57	75 - 125
Tanaga	902	1,500 - 3,000
	4,631	7,000 - 12,000

Delarof Islands

The 11 small islands in the Delarofs (Fig. 11) are remote and so seldom visited that records of sea otters from this region are scarce. Murie, et al. (1937) reported observations of sea otters on all islands in this group with the exception of Amatignak and Gareloi Islands. Joynt (1956) saw otters on all islands during naval patrol flights in 1943. Both Murie and Joynt observed large groups of animals (50 - 150) at Ogliuga and Kavalga Islands. On a partial aerial survey of the Delarofs in 1954, I saw at least 325 sea otters. The largest concentration was at Amatignak Island, where one group numbered between 150 and 250 animals.

A total of 1,356 sea otters were counted among the Delarofs during the 1959 aerial surveys of the Fish and Wildlife Service (Kenyon and Spencer, 1960). The report of this survey indicates that largest concentrations were found at Ogliuga and Skagul Islands (393), Ulak Island (352), and Kavalga Island (275). Only 102 sea otters were observed at Amatignak Island, where I saw 150 - 250 animals in 1954. Observations and estimates given by Kenyon and Spencer are listed on the following page with only minor changes. These estimates appear to be a conservative evaluation of the present distribution and size of the population.

	Observations	Estimates
Gareloi	41	50 - 100
Unalga	51	75 - 100
Kavalga	275	375 - 550
Ogliuga	112	150 - 225
Skagul-Tag-Ugidak	281	375 - 575
Gramp Rock	134	175 - 275
Ilak	49	75 - 100
Ulak	352	475 - 700
Amatignak	102	125 - 300
	1,397	2,000 - 3,000

Rat Islands

Sea otter populations in the Rat Islands (Fig. 12) have long been regarded as the largest extant (Jones, 1951a), although recent surveys indicate that the population in the Andreanof Islands has become equally as large. The small remote islands of this group are seldom visited, but the record of observations on Amchitka provide a more complete history than is available for any other population. In 1931, Bureau of Biological Survey Warden Frank Dufresne estimated sea otter populations aggregating about 1,000 animals on both Amchitka and Kiska Islands. Lt. Howard B. Hutchison (1933) of the USCGS Aleutian Islands Survey Expedition made an identical estimate of 1,000 animals for the Amchitka population.

In 1936, Lt. Comdr. S. P. Swicegood, USCG, and a

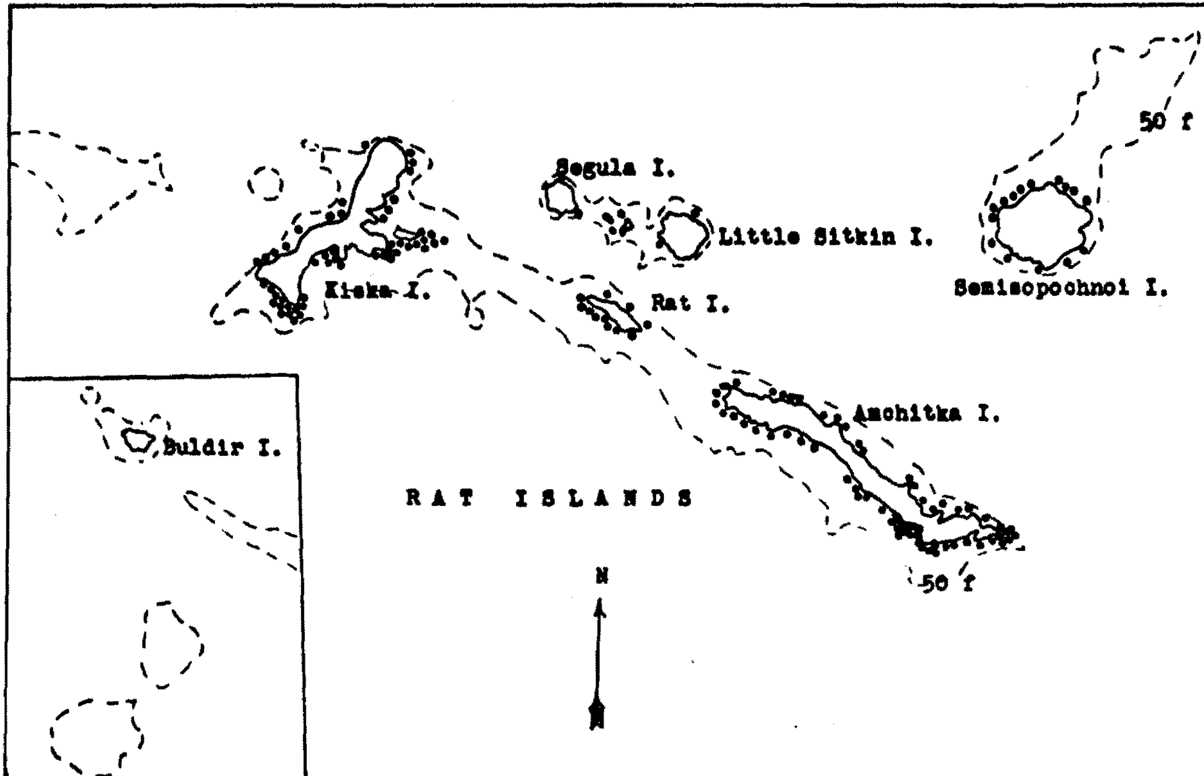

Figure 12. Sea Otter Observations in the Rat Islands. (Scale: 1 inch = approximately 16 miles, contours in fathoms.)

party of men surveyed a 24-mile section of the south shore of Amchitka and counted 804 animals (Stiles, 1953). Observations of the men conducting this survey led Swicegood to estimate that in the area they had covered there were 1,600 animals, and that there were 3,000 sea otters on the south side of the island. Swicegood's party also observed 10 sea otters in Kirilof Bay, and at least 100 animals elsewhere on the north side of Amchitka, but they made no estimate of the total population. Swicegood's estimate for the south shore is possibly excessive, but even if the actual count of the 24-mile area is extrapolated to the entire south shore, and only half their count to north shore where otters were fewer, we arrive at a figure of about 3,000 animals which would appear to be a conservative estimate of the population for that time.

Murie, et al. (1937), apparently unaware of previous counts, estimated the 1936 population for Amchitka at only 1,000 animals, but did not make an estimate of the number of sea otters on Kiska and Semisopochnoi Islands where they also encountered several animals.

Annual counts of sea otters were made between 1937 and 1940 by Bureau of Fisheries wardens stationed on Amchitka. These surveys were made from the shoreline and from small boats. Binoculars were probably available to the wardens, but it is unlikely that telescopes were used. Sample censuses conducted on Amchitka in 1956 indicated that counts made with a 20-30 power telescope were larger than those made only with binoculars by a ratio of about 1.7:1 (Lensink, 1956). Thus, the various counts cited below can perhaps be safely increased by at least 50 percent. In 1938, Carl L. Loy (1940) and Oke A. Frieden counted 1,321 otters on about two-thirds of the island between July 11 and September 1, and extrapolated this count to the entire island to arrive at their estimate of 1,761 animals. In 1939, Loy and George Hewitt counted only 1,030 animals; but in 1939, Loy counted 1,355 animals (all counts exclusive of pups) and believed the population to number about 1,700 animals, or with pups included, 1,870. This estimate is close to that of FWS Biologist Victor B. Scheffer (Stiles, 1953) who, the same year, placed the population at 2,000 animals. A map of observations prepared by Loy for his 1938 counts shows that the distribution of sea otters at that time, particularly of concentration points for males, was almost identical with the present pattern of distribution. The south side of the island, however, had a significantly larger number of animals than the north side, whereas, in 1956 sea otters were fairly evenly distributed about the entire island. In June 1940, J. B. Mangan and Grant Ritter (1940) conducted surveys and estimated the Amchitka population at 1,650 animals including 69 pups.

On June 24, 1943, Refuge Manager Frank Beals and U. S. Navy Pilot G. T. Joynt conducted an aerial survey of

Amchitka and Rat Islands with slow-flying reconnaissance type aircraft. Both men were experienced observers and their results may be considered highly reliable. On Amchitka they counted 3,420 animals and on Rat Island 720 animals, considerably larger figures than obtained on any previous survey.

In 1945, Refuge Manager Douglas Gray counted 365 animals from various check points and believed that otters had increased since previous shoreline counts, but felt that his observations did not justify an estimate for the entire population. When leaving Amchitka in September, Gray saw 60 animals beyond the first seaward mile which were unobservable from shore. Reports from military observers at this time indicated substantial increases in the population in the vicinity of Rat, Kiska, and Ogliuga Islands (Stiles, 1953).

Refuge Manager Robert D. Jones, Jr., assisted by John Ball and Winston A. Elkins of the Fish and Wildlife Service conducted aerial surveys of Amchitka and Rat Islands in August 1949, but counted only 1,087 sea otters on Amchitka and 234 on Rat Island. These counts appear low in view of all previous observations. They may result from a lack of previous experience in surveys by participating personnel, or a disadvantage in type of aircraft used (Grumman Widgeon) as compared to the reconnaissance aircraft used by Beals and Joynt in 1943.

In 1956, surveys were completed on about half of the Amchitka shoreline with binoculars and telescope (Lensink, 1956). The total count of adults and sub-adults was 2,184, and of pups was 384, for a grand total of 2,568 animals of all ages. Spot checks on unsurveyed parts of the island indicated that the survey figures could be extrapolated to the entire island. The extrapolation based on number of otters (15.7) per square mile of water area shallower than 50 fathoms indicated a total population of 5,637 animals.

Kenyon and Spencer (1960) report that in aerial surveys conducted by the Fish and Wildlife Service in 1959 only 1,560 animals were counted on Amchitka and 270 on Rat Island. Although Kenyon believed that his shoreline observations indicated a smaller number of animals present than in recent years, I believe that their survey counts of 1959 may have missed many animals. Although I have used Kenyon's counts and most of his estimates for the summary of the Rat Islands' populations given on the following page, I have substituted my own estimates for Amchitka and Rat Islands, and have been more generous in providing upper limits for some other localities.

	Observations	Estimates
Kiska	894	1,200 - 3,000
Little Kiska	83	150 - 500
Tanadak	150	200 - 300
Segula	47	75 - 100
Pyramid-Davidof	33	50 - 100
Little Sitkin	50	75 - 100
Rat Island	270	500 - 1,000
Amchitka (eastern half)	2,568	4,000 - 7,000
Semisopochnoi	393	500 - 800
	4,448	7,000 - 12,000

Near Islands

By 1880, the once large sea otter population in the Near Islands (Fig. 13) was virtually exterminated, and the last-known record of sea otters there is of two killed by natives in 1895 (Hooper, 1897). Williams (1936) says that the natives of Attu reported that otters were still on Attu and Agattu, but their presence there now seems very unlikely because Attu has been occupied since the war and not a single animal has been observed. A transplant of six animals to Attu was attempted in 1956 by Refuge Manager Jones, but is believed to have been unsuccessful. No otters were observed in the Near Islands during the 1959 FWS aerial surveys.

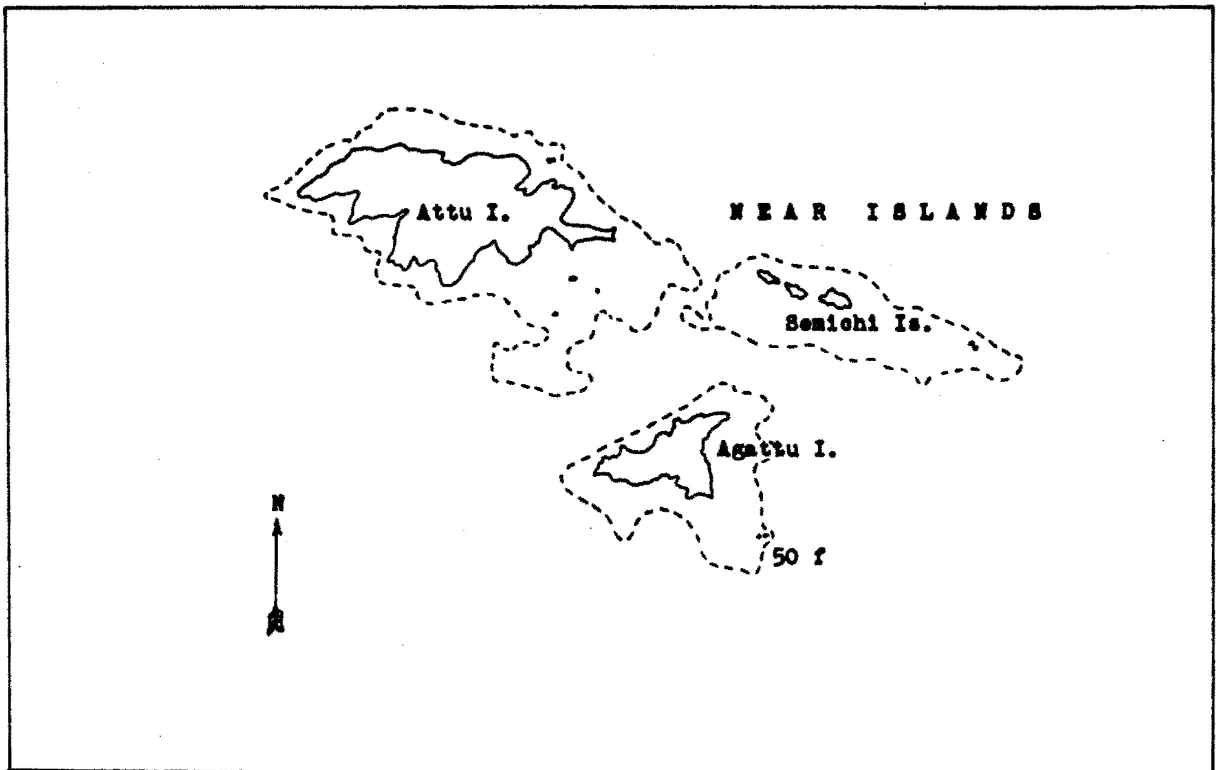

Figure 13. Near Islands. (Scale: 1 inch = approximately 16 miles, contours in fathoms.)

Pribilof Islands

The last otter vanished from the Pribilof Islands (Fig. 14) before 1900 (Hanna, 1923). A transplant of 16 animals was made in 1955, but no survivors were located, and it is assumed that the transplant was not successful. A second transplant attempt, made with seven sub-adult animals during the summer of 1959, appears to have been successful (Kenyon and Spencer, 1960).

Summary

This section has traced the growth of sea otter populations in Alaska since 1911 when hunting was banned, and has provided estimates of the present population. I have not found observations of sea otters recorded between 1911 and 1920, but by the 1920's a few animals were seen in widely separated localities. By 1936, sea otters had been observed in nearly all population centers that we know now. The reappearance of sea otters in these widely separated locations suggests that a few survivors had remained in each locality, and that emigration to form new colonies has not generally occurred.

Regional estimates for existing populations are provided in Table 1. Most of these estimates are believed to be conservative, and in the Aleutian Islands the actual population may in some localities exceed even the upper limits that our data suggest. However, until we have better means of evaluating our present censuses the conservative estimate may be favored.

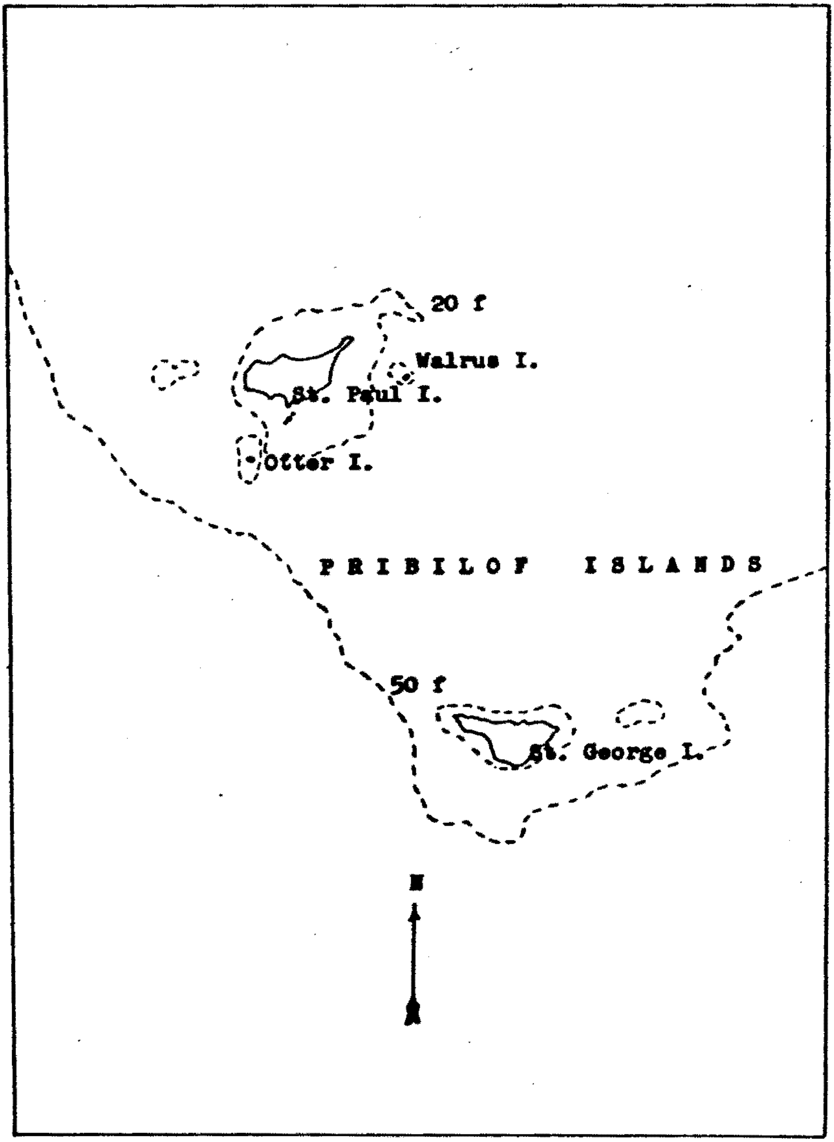

Figure 14. Pribilof Islands. (Scale: 1 inch = approximately 16 miles, contours in fathoms.)

Table 1. Summary of Recent Observations and Estimates for Sea Otter Populations in Alaska.

Region	Sea Otter Observations 1954-1959	Estimates
Southeastern Alaska	none	none
Kayak Island to the Kenai Peninsula	702	1,000 - 1,500
Kodiak Archipelago	681	1,000 - 2,000
Alaska Peninsula	3,536	5,000 - 6,000
Fox Islands	907	1,500 - 2,000
Andreanof Islands	4,631	7,000 - 12,000
Delarof Islands	1,397	2,000 - 3,000
Rat Islands	3,087	7,000 - 12,000
Near Islands 1/	none	none
Pribilof Islands 2/	none	none
Totals	14,941	25,000 - 40,000

1/ A transplant of 6 sea otters to the Near Islands in 1956 is believed unsuccessful.

2/ A transplant of 7 sea otters to the Pribilof Islands in 1959 appears to have been successful (Kenyon and Spencer, 1960).

BIOLOGY

Steller (1751) provided the most significant contribution to the basic knowledge of the sea otter's biology until Barabash-Nikiforov (1935, 1938, 1947) published the results of studies in the Commander Islands. Subsequently, a few papers have discussed the food habits and behavior of sea otters (Williams, 1938; Fisher, 1939, 1940; Murie, 1940a) from observations of Californian or Aleutian populations, but these reports are in general based on fragmentary data and are inconclusive.

The first serious study of sea otters in Alaska during February, March, and April 1954, focused attention on physiological factors, which were believed to contribute to the excessive mortality of both captive and wild animals on Amchitka Island that had been observed by Refuge Manager Robert D. Jones, Jr. (Stullken and Kirkpatrick, 1955; Kirkpatrick, et al., 1955). An important result of this study was to draw attention to the scarcity of basic information about sea otters with respect to population size, distribution and status, and the fundamental aspects of their biology. This provided the impetus and direction for initiation of current investigations by the Fish and Wildlife

Service (Kenyon and Wilke, 1956; Kenyon, 1957, 1959a, b; Kenyon and Spencer, 1960), the Purdue Research Foundation Lensink, 1956, 1960), and the Alaska Department of Fish and Game (Lensink, 1959). Although the studies by Kenyon have concentrated chiefly on the care and transportation of captive animals, and my own on the distribution and size of sea otter populations, much incidental information on the life history of sea otters has been obtained. Because such information is essential to an understanding of population status, it is discussed under appropriate headings below.

Habitat

Optimum habitat for sea otters seems to provide broken shorelines, beds of floating kelp, and an abundance of shallow water. The principle factor of the habitat is undoubtedly the shallow water, ie., to a depth of about 20 fathoms, because littoral organisms that form the vast bulk of the sea otter's food can only be obtained there by otters. This association of sea otters and shallow water is amply demonstrated on the distribution charts (Figs. 2 - 12).

In Alaskan waters the sea otter shares its habitat with the harbor seal, *Phoca vitulina* L., throughout its range, and locally with the Steller sea lion, *Eumetopias jubata* Schreber, and formerly also the fur seal, *Callorhinus ursinus* L. Although the harbor seal and sea otter both forage primarily in the shallow water zone, Wilke (1957) has shown that their food habits overlap so slightly that virtually no competition for food exists. The fur seal and sea lion forage mostly in deeper water. Other forms of interspecific competition or strife also appear to be non-existent, and areas of sea otter concentration are frequently concentration points also for harbor seals and sea lions. Occasionally, I have even observed apparent play between sea lions and sea otters.

The climate throughout the range of sea otters is relatively moderate, and mean temperatures of coldest months nowhere in the range vary more than 40 degrees Fahrenheit (usually considerably less) from those prevailing in summer. Winter storms, however, particularly in the Aleutians and other northern habitats where winds of hurricane force are frequent, may make winter conditions severe. Although sea otters were found to the edge of the pack ice in winter on the coast of Kamchatka (Steller, 1753) and in the Pribilof Islands, the southern limit of pack ice generally appears to have formed the northern boundary of the sea otter's range.

Invertebrate organisms (mollusks, echinoderms, and crustaceans) upon which sea otters forage are generally abundant in the littoral environments of the North Pacific Ocean and Bering Sea, but may vary considerably in their availability with the contour of the coast. The depth to which sea otters can forage efficiently is unknown, but probably is not much more than 20 fathoms. Most food is probably obtained at less than 10 fathoms, although Assistant Refuge Manager

David C. Hooper told me that in 1953 he saw sea otters actively feeding at a depth of 23 fathoms at Amchitka Island. I have seen sea otters feeding beyond the 10 fathom limit many times, but have not been able to determine the actual depth in most instances. In 1954, an animal was observed eating sea urchins in water of 35 fathoms between Ulak and Amatignak Islands in the Delarofs, but it is possible that the urchins had been carried from another location. On September 16, 1957, Refuge Manager Robert D. Jones, Jr. and I counted 55 sea otters mostly adult males, as we crossed from Adak to Kanaga Island on a course where the maximum depth did not exceed 28 fathoms. Crossing a few days later at a location where the water reaches 60 fathoms, we saw no animals until we were about 3 miles southwest of Eddy Island, where the water shoaled to about 20 fathoms. Although sea otters now commonly cross Adak Strait, even this narrow, relatively shallow crossing seems to have formed an effective barrier to emigration as long as food was abundant in the shallower water surrounding Kanaga Island.

Beds of floating kelp are a frequent, although not essential, component of the sea otters habitat. In Alaskan water, kelp (Alaria and Nereocystis) grows most profusely in less than 10 fathoms, the same depth that is most favorable to sea otters for finding food. Thus, the association of kelp and sea otters may be partly chance, but field observations indicate that kelp patches are preferred resting areas. This preference is probably due to the action of kelp in moderating rough seas, a conclusion shared by Barabash-Nikiforov (1938). However, during Aleutian winters when winds of hurricane force are common, the kelp beds are soon broken up and except in sheltered areas are not available when most needed.

Barabash-Nikiforov (1947) found that on the Commander Islands, offshore rocks or small islands frequently replaced kelp for protection from wave action. The sea otter's preference for rocky and broken shorelines is evident also in Alaskan habitats, regardless of the presence of kelp, and when large concentrations of animals are found, they are usually near prominent points or capes, offshore islets, and occasionally the entrance to large bays (Figs. 2-12).

The existence of the large population in offshore waters north of Unimak Island, and the probable existence of a similar population between the Trinity Islands and Chirikof Island, indicates that neither kelp nor protective shorelines are essential elements of the sea otter's habitat. In the case of the Unimak offshore population, there were no extensive kelp beds within 40 miles of the area where sea otters were observed, and much of the adjacent shoreline consisted of smooth sandy beaches. The Yakutat area, once an important hunting ground, offers similarly smooth beaches. Much more must be learned about movements, behavior, and food of such offshore populations before it is possible to evaluate fully the relative potential of various habitat types.

Food

The food habits of sea otters are perhaps more completely known than any other phase of their biology, but certain facets such as geographical and seasonal variation in food requirements or even availability have not been adequately studied, and much of the existing information is misleading. Food items identified in fecal samples from the Commander Islands (Barabash-Nikiforov, 1935) and several of the Aleutian Islands (Williams, 1938; Murie, 1940; Jones, 1951) are listed by percentage volume, frequency of occurrence, or both in Table 2.

In these studies, sea urchins, primarily *Strongylocentrotus drobachiensis*, ranked highest in both average percent volume and in frequency of occurrence, usually being present in all or nearly all samples examined. Mollusks occurred in a high percentage of samples and consisted primarily of mussels, *Mytilus edulis*, *Vosella modiolus*, and *Modiolaria vernicosa*; but other bivalves, limpets (*Tonicella* and *Shizoplax*), and several species of snail were also represented. Fish and crabs have been considered relatively unimportant by various authors with the exception of Barabash-Nikiforov (1938). Murie (1940) drew attention to the variations in samples from the various islands and even from different localities on Amchitka Island, and cautioned

Table 2. Foods of Aleutian and Commander Island Sea Otters.

Food Item	Average Percent of Volume	Frequency of Occurrence
Ogliuga Island, 70 samples, July and August 1936		
Sea urchin	78	
Mussel	6	
Crab	4	
Limpet and Snail	4	
Cryptochiton	3	
Fish	2	
Ogliuga Island, 140 samples, August 1937		
Sea urchin	81	137
Mussel	1	32
Cryptochiton	5	61
Crab	5	41
Limpet	5	60
Snail	2	63
Amchitka Island, north side, 32 samples, Summer 1937		
Sea urchin	58	27
Mussel	44	30
Crab	1	13
Limpet	trace	2
Snail	trace	6

Table 2. Foods of Aleutian and Commander Island Sea Otters (cont.).

Food Item	Average Percent of Volume	Frequency of Occurrence
Amchitka Island, south side, 21 samples, Summer 1937		
Sea urchin	78	19
Mussel	5	7
Cryptochiton	7	11
Crab	1	8
Limpet	1	8
Snail	1	16
Amchitka Island, a few samples, Winter 1949		
Sea urchin	45	
Mollusk	40	
Isopod	10	
Crab	3	
West Unalga Island, 5 samples, Summer 1937		
Sea urchin	54	5
Mussel	29	4
Crab	17	3
Commander Islands, 500 samples, 1931 and 1932		
Sea urchin	59	
Mollusk	23	
Crab	10	
Fish	7	

that samples collected from restricted localities may not be truly representative. Murie attributed the differences to variations in the availability of the various food items in different localities. Where habitat types vary markedly, Murie was probably correct, but his samples from the Aleutians and those from the Commander Islands were all from localities which are similar, and would support similar invertebrate faunas or sea otter foods. My own studies on Amchitka Island during July and August 1956 indicated that variation in analyses reflect the sex and age composition of the population in the area from which collections were made.

Food habit studies on Amchitka Island during the present investigation included the direct observation of sea otters while they were feeding, and the analysis of a sample of 60 droppings, from each of 6 different hauling grounds. Observations indicated that three of these hauling grounds were used almost exclusively by adult males, and three mostly by females, pups, and sub-adult animals. Marked differences were noted in the frequency that certain food items appeared in samples from male or female hauling grounds. Thus, in stool samples from areas used by males, the frequency of large mussels, Vosella modiolus and Mytilus edulis, ranges from 46 to 49 per sample with a mean of 48, and from areas used by females from 19 to 28 with a mean of 26. The apparent differences in preference for the large mussels by male and female sea otters are apparent also for clams and rock oysters, *Pododesmus macrochisma*, found most frequently on hauling grounds of males, and the small mussel, *Modiolaria vernicosa*, found most frequently on hauling grounds of females; but for these items, the samples are small, variable, and inconclusive. The totals for samples from each hauling ground are summarized in Table 3.

If the variety and amount of food on each area is roughly similar, why do the apparent differences occur in sex preferences? The three food items found more frequently on male hauling grounds (large mussels, clams, and rock oysters) are all thick-shelled items; but *Modiolaria*, the only item found more frequently in fecal samples from female than male hauling grounds, is thin-shelled. This difference in the character of food items suggests that the difference between samples arises not from variation in food availability, or in food selected by males and females,but by a variation of food selected by young and adults. The flesh of thick-shelled mollusks may not be available to younger animals because of their ineptness or insufficient strength to crush the valves. Karl Kenyon told me that in 1955 he broke the shells of mussels that he fed to young animals in captivity, but in 1956 older captives crushed the mussels themselves. Because older animals eat all types of food, the correlation between the frequency of *Modiolaria* in samples and the number of pups present was weak and not significant.

Table 3. Frequency of Occurrence of Food Items in Fecal Samples[1] from Amchitka Island Hauling Grounds[2] of Male and Female Sea Otters, July and August 1956.

Food Item	Female Hauling Grounds RRP	KP	SMW	Total	Male Hauling Grounds SME	EC	CR	Total	Total Frequency	Percent Frequency
Sea urchin	60	60	59	179	60	59	60	179	358	100
Large mussels	19	31	28	78	46	49	49	144	222	62
Crab	21	21	18	60	20	19	17	56	126	38
Fish	21	12	21	54	21	20	14	55	109	30
Modiolaria	28	4	11	43	9	6	1	16	59	16
Chiton	9	12	5	26	4	7	14	25	51	14
Snail	6	5	8	19	6	1	6	13	32	9
Limpet	4	1	4	9	2	0	6	8	17	5
Clam	0	0	0	0	1	2	8	11	11	3
Fish roe	4	3	1	8	0	1	0	1	9	3
Rock oyster	0	0	0	0	0	1	5	6	6	2
Octopus	0	0	0	0	0	1	0	1	1	trace

1/ A total of 60 droppings were examined from each hauling ground.

2/ RRP (Rifle Range Point); KP (Kirilof Point); SMW (St. Makarius Point, West); SME (St. Makarius Point, East); EC (East Cape); CR (Crown Reefer).

Field observations of foraging sea otters and general impressions concerning fecal samples indicate considerable bias inherent in food habit studies based on fecal residues. The sea otter seldom discriminates between digestible and undigestible parts when eating such items as mussels or sea urchins, but discards the shells when eating rock oysters. Only a small proportion of fish is not digested, even most bones being decomposed (Stullken and Kirkpatrick, 1955). Thus, shells of mussels and sea urchins form the bulk of fecal samples, and fish and rock oysters are scarcely represented in feces. Properly, each item found in fecal samples should be weighed proportionately to the digestible food it represents. Expressing results as frequency of occurrence, rather than percentage volume as Jones (1951) and Williams (1938), partially corrects for this kind of bias, but actual caloric values of items are still obscured. A comparison of 1937 food studies on Amchitka Island by Murie (1940), and my 1956 studies (Table 4), also illustrates differences arising from the manner of expressing food composition.

Table 4. Comparison of 1937[1] and 1956[2] Foods of Sea Otters on Amchitka Island.

Food Item	Percent Frequency Occurrence 1937	Percent Frequency Occurrence 1956	Average Percent Volume 1937	Average Percent Volume 1956
Sea urchin	89	95	62	67
Mussel	70	71	29	17
Crab	40	38	1	6
Cryptochiton	21	14	3	2
Snail	42	9	1	trace
Limpet	19	5	1	1

1/ Total of 53 samples in 1937.

2/ Total of 360 samples in 1956.

No marked differences occur between the 1937 and 1956 samples for sea urchins, mussels, and crabs, the three major items; the slight differences existing being less than those between Murie's north side and south side samples in 1937 (Table 2), or those between male and female hauling grounds in 1956 (Table 3). For cryptochitons, snails, and limpets, the 1937 values are higher by frequency of occurrence, but are about equal to those of 1956 in average percent volume. Murie (1940) does not state explicitly where he found his Amchitka samples, but they would be obtained most easily from the male hauling grounds at St. Makarius Point and the female hauling grounds at Kirilof Point. The composition of Murie's samples also indicates that he obtained a representation of sex and age groups comparable to the 1956 samples, thus accounting for the similar results of the 1937 and 1956 analyses. I have thus concluded that food habits of otters have not changed appreciably despite evidence suggesting a diminished food supply.

Neither Williams (1938) nor Murie (1940) considered fish to be an important part of the sea otter's diet, although Murie presents data that indicate fish or fish roe occurred in 22 percent of his samples. Murie apparently doubted the ability of otters to catch fish, and thought that some if not all was obtained as carrion. Sea otters in captivity, however, are inclined to reject fish or other food that is not fresh, and I doubt that they would be more likely to eat carrion under natural conditions. On at least three occasions I have seen wild otters holding living fish. Fish occurred in 30 percent of the 1956 samples, and since each occurrence may represent a considerable volume of digestible flesh, it seems evident that fish is an important food, although perhaps only seasonally as suggested by Barabash-Nikiforov (1938).

Observations of foraging sea otters indicate that the absence of the rock oyster residues in fecal samples results in the most serious error for this type of analysis. Murie (1940) listed only 17 occurrences of rock oysters in 198 samples, and in 1956 I found them in only 6 of 360 samples. Kenyon (1955), however, watched foraging otters for more than 8 hours between late July and October, and recorded a total consumption of 1,147 sea urchins and 227 rock oysters. The rock oysters, which measured 6 to 8 cm. (2.5 to 3 in.) in diameter, probably contained more digestible material than the sea urchins which averaged 191 per kg. (87 per lb.). However, it was not possible for Kenyon to make a direct comparison of the digestible portions of rock oysters and sea urchins. Foods eaten in approximate descending order of occurrence were:

1. Sea urchins
2. Rock oysters
3. Blue mussels
4. Horse mussels (including Modiolaria)
5. Limpets, small starfish, crabs, cryptochitons, octopus, and tunicates

Reports on the food of sea otters originating from the period of exploitation differ slightly from recent observations. Thus, Littlejohn (1916) found squid in sea otters taken in deep water (more than 60 fathoms) off the Kurile Islands. Steller (1751) also noted the presence of squid in the otter's diet. Snow (1910) reported an abundance of crabs and sea urchins in stomachs he examined, but he found only a few containing fish and none with mollusks.

Food requirements for captive sea otters are relatively high for so large an animal. Stullken and Kirkpatrick (1955) and Kirkpatrick, et al. (1955) report that 3 captive sea otters, weighing from 9.0 to 11.4 kg., consumed daily amounts of fish equal to about 25 to 36 percent of their body weight. Malkovitch (1937) found that the daily consumption of fish and meat by 3 adult sea otters, weighing from 27.6 to 37.3 kg. (60.7 to 82 lbs.), was 5.58 to 8.5 kg. or 6,774 to 10,391 calories, about 17 to 23 percent of their body weight. A young sea otter, while growing from 10.0 to 14.4 kg., consumed 3.57 to 4.3 kg. of food daily, or 29 to 35 percent of its body weight. Although food intake increased as this animal became larger, the consumption per unit of body weight decreased. In another instance, Malkovitch was forced to gradually reduce the food given to an adult male from 5,212 grams daily to only 3,340 grams. This reduction resulted in the death of the animal on the 33rd day. I believe that lack of food may also have contributed to the death of 35 animals held captive on Amchitka Island in 1951, that were each fed only 2.3 kg. (5 lbs.) frozen halibut daily (Jones, 1951b).

Reports of food consumption by other marine mammals indicate a much lower food requirement than for sea otters. Scheffer (1958) estimates the daily food consumption of the northern fur seal, _Callorhinus ursinus_, at about 7 percent of its body weight. A 600 pound sea lion, _Zalophus californianus_, in a New York Zoo consumed food amounting to only 2 percent of its body weight daily, and a harbor seal, _Phoca vitulina_, weighing about 80 pounds, about 6 percent

(Spector, 1956:Table 189). Furthermore, many of the Pinnipedia undergo prolonged fasts during the moulting or breeding seasons.

Recommendations by the Philadelphia Zoological Gardens for feeding of Mustelidae indicate a daily food consumption of 2.5 to 7.5 percent of body weight depending upon the species and age of the animal (Spector, loc. cit.). Food consumption by sea otters may be more than twice this amount.

Wild sea otters may require as much food as captive animals. In 1956, I watched an adult sea otter eat 89 sea urchins in 20 minutes. Kenyon (1955) recorded feeding rates of 55 urchins in 16 minutes, 44 in 17 minutes, 106 in 22 minutes, 46 in 14 minutes, etc. indicating an average rate of about 230 sea urchins (1.2 kgs.) per hour. The sea otter's intermittent foraging during the daylight period totals several hours, and the amount of sea urchins ingested is at least 5 to 8 kilograms.

Because sea otters are restricted to a relatively narrow shoreline zone of shallow water, a large population may place considerable pressure on the food resource. On Amchitka, for instance, an average consumption per sea otter of 5 kg. daily for 3,000 to 5,000 animals would amount to approximately 8,000 to 10,000 tons annually. There is evidence to suggest that the food supply on Amchitka has been affected by sea otters. Although sea otters appear to find sea urchins with ease, sea urchins needed to feed captive animals could be found only under the dock where the wild otters did not forage. Furthermore, the sea urchins we gathered for captives and those we watched wild otters eat on Amchitka, were much smaller (younger?) than the sea urchins I have seen on Adak. On Amchitka, relatively few empty shells were found on the beaches, but at Kanaga they were abundant, and at Adak in 1957 the bottoms of bays seemed almost paved with living urchins in many places. Rausch (1953) also noted the scarcity of sea urchins on Amchitka as compared to other areas with less dense sea otter populations.

Information concerning the foods of sea otters in other than Aleutian Island habitats is negligible. A cursory examination of a few fecal samples in the Sandman Reefs by Refuge Manager Jones, and in the Shumagin Islands by me, indicated that foods taken in these localities are about the same as on Amchitka Island. At a location where we had observed a large group of males feeding in the Sandman Reefs, Jones examined the bottom with the aid of diving gear. He found that the bottom was covered with clams (Saxidomus), mussels (Volsella), and rock oysters (Pododesmus). No sea urchins were found.

I have examined perhaps a dozen fecal samples at Wingham Island and found them to consist mainly of sea urchins. However, sea urchins are not found in silty parts of Controller Bay where many sea otters forage, and I believe that in these areas the major food items are perhaps the abundant razor clam, Siliqua patula, and the dungeness crab, Cancer magister, which is seasonally abundant. Crabs and clams of several species probably compose the bulk of the food for sea otters foraging in offshore waters north of Unimak Island, but no direct information is available on the food habits of this population. On the California coast, Fisher (1940) considered sea urchins, Strongylocentrotus franciscana, and the red abalone, Haliotes rufescens, the sea otter's most important foods; but she also watched them eat several unidentified species of clams, crabs, and small fish.

Mobility

The tendency of an animal to move from one part of its habitat to another, or to wander beyond the normal limits of its home range, is related to the ability of the animal to utilize its habitat efficiently, to cope with abnormal conditions, and to colonize unoccupied areas. The tendency for mobility thus demands a careful consideration in evaluating population status. Furthermore, movements may affect census results, particularly those of censuses based on observations from land or boats when the mobility of otters may exceed that of the observer.

Fisher (1939), in describing the habits of sea otters in California, indicated that feeding activities began early in the morning, but were interrupted by a rest period starting about 1000 hours. Foraging gradually resumed at about 1400 hours and most animals continued to forage until dark. With the coming of darkness, sea otters returned to a kelp bed for the night. Barabash-Nikiforov (1938) also indicated that sea otters are diurnal, and said that daily migrations consisted of movements from the nocturnal resting area to foraging areas and back. He reported also that strong winds curbed activities and restricted the movements of animals to sheltered areas.

Kenyon (1955) and Lensink (1956) described the activity pattern and local movements of sea otters as observed at Amchitka Island, where behavior was similar to that in other regions. Soon after daylight, animals begin moving from rocks, kelp patches, or other nocturnal resting areas to adjacent foraging areas. These movements were usually no more than a few hundred yards. The total count of otters along the 4-mile shoreline of the Kirilof study area did not vary with time of day; but early morning counts, made from a blind overlooking a foraging area north and west of Kirilof Point, averaged less than half the number observed later in the day. This indicated that most foraging animals probably came from within the study area. Movements into this foraging area continued until about 1000 hours.

Foraging activity continued intermittently with short intervals for rest and preening throughout daylight hours, but with a period of general inactivity near noon. Kenyon (1955) observed a mated pair of sea otters for 7 hours, and reported that the female spent 4 hours 6 minutes in foraging and the male 5 hours 12 minutes.

Animals began moving away from foraging areas soon after sundown, and by dark most activity had ceased. It is possible that some nocturnal foraging occurs, because captive animals appeared to find food more by touch than by sight. However, the morning and evening activity patterns suggest that nocturnal foraging is negligible.

The effect of weather conditions on the distribution and movements of sea otters was studied by means of replicate counts in several areas on Amchitka Island under varied conditions. The most important of these was a 4-mile area encompassing Kirilof Point and two small groups of islands off its tip which was selected by Kenyon in 1955 as a study area. Portions of the point are exposed to the full force of winds from the northwest to the east. The force of winds from the southeast are somewhat diminished but still have sufficient sweep across Constantine Harbor to make conditions unsatisfactory for sea otters; and there is evidence that the choppy seas produced by winds with limited sweep are less tolerable to otters than the more gradual ocean swells and seas. Some portion of the Kirilof Point study area, however, is always in the lee of wind. A kelp bed extends as a narrow band within the 10-fathom contour from the tip of the Jetty Islands to a point about 1 mile offshore near the entrance to the harbor, where it expands to a rough dumbbell shape (Fig. 15). This kelp bed (hereafter called the "outer bed" to distinguish it from kelp beds adjacent to shore) is a primary feeding area that is particularly sensitive to alterations in wind direction or velocity. The study area appears to provide all needs of sea otters, and counts of animals in it remained nearly constant throughout the day.

Changes in wind direction and intensity brought about a gradual shifting of sea otters to sheltered areas (Fig. 15). Thus, a 25-30 knot east wind, drove nearly all animals to the lee on the west side of Kirilof Point (Fig. 15A). In a southeast wind of 10-15 knots, there was still a tendency of otters to shift to the lee of Kirilof or Constantine Points, although a few otters remained in exposed positions (Fig. 15B). During a very light south wind, sea otters were scattered on all sides of Kirilof Point but were most numerous in the outer kelp bed which is exposed to winds from any direction (Fig. 15C).

The changing distribution during the rise and decline of a north-northwest storm (Fig. 16) illustrates the marked response to wind velocity. On August 14, 15, and 16, with a light southeast breeze, otters were distributed throughout the study area, but were most concentrated (22)

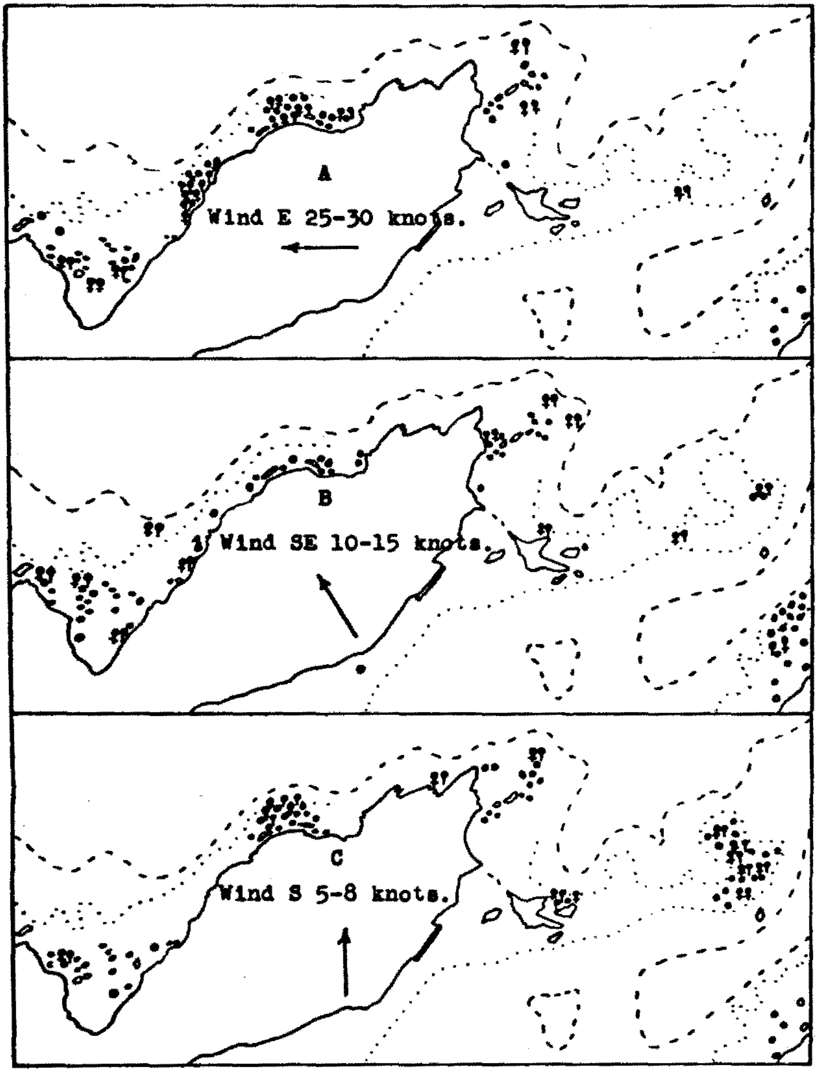

Figure 15. The Effect of Wind Direction on Distribution of Sea Otters at Kirilof Point, Amchitka Island, August 1956. [Male (♂), Female (♀), Pup (♀), and Unknown Sex or Age (•)]

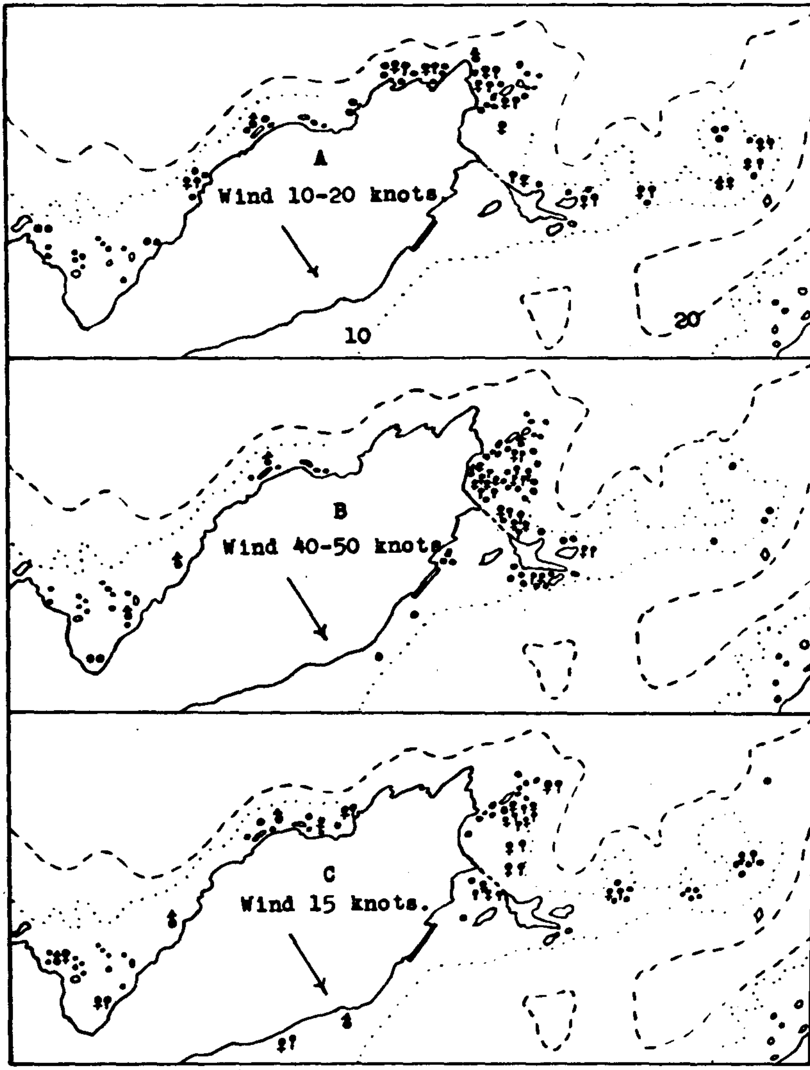

Figure 16. The Effect of Wind Velocity on Distribution of Sea Otters at Kirilof Point, Amchitka Island, on August 14 (A), 15 (B), and 16 (C), 1956. [Males (♂), Females (♀), Pups (ꝑ), and Unknown Sex or Age (•)]

in the outer kelp beds. On August 17, the wind increased to about 10 knots and shifted to the west, and by the next day had shifted to the north-northwest and was blowing at a velocity of up to 20 knots. The ground swell by this time had become heavy, and seas were breaking in offshore waters. The kelp beds, however, smoothed the seas to a considerable extent and gave protection to the otters, which were distributed almost as they were in the previous few days (Fig. 16A). On August 19, the wind increased to 50 knots, and the seas now came smashing through the kelp beds to break high on the cliffs. The distribution of sea otters was sharply altered during this peak of the storm, and all but three territorial males had left the northwest or windward side of Kirilof Point. At least four sea otters, however, were still feeding in the outer kelp bed (Fig. 16B). By August 20, the storm had considerably abated, and although the surge was still heavy, the kelp beds calmed the water sufficiently to permit almost normal distribution (Fig. 16C).

The inclination of males to retain an approximately normal distribution throughout the storm may be the result of a strong territorial attachment. Males, being larger and stronger than females and sub-adults, are perhaps also better able to cope with adverse conditions. Even at the height of the storm, the males that were observed appeared to obtain food and adjust to the conditions without difficulty.

Similarly, the males on the St. Makarius hauling grounds retained normal distribution and abundance under conditions that considerably altered the distribution of females and young. However, immediately after the storm previously described, many females and pups were found in the lee of Crown Reefer Point, but males which usually predominate there were less numerous than usual.

In other areas, variation in wind direction and velocity appears to be fully as effective in determining the distribution of sea otters as at Kirilof Point, but such changes may occur in a different manner. Two concentration areas are present at St. Makarius Point on the south side of Amchitka Island. Under favorable conditions counts exceeded 100 animals in each area, but on the east point most animals were adult males, and on the west point most were females and young. Onshore winds did not appear to cause as complete a redistribution of sea otters as might be expected from observations on Kirilof Point, although many animals are believed to have moved into deeper water and away from the breaking surf. The wide shallow shelf on the south side of Amchitka apparently permits otters to find protection of a sort offshore, where waves are not as precipitous as nearer the beach, but where the water is still sufficiently shallow for food gathering.

Northwest winds paralleling the shoreline on the south produced a sharp, irregular chop which caused a more abrupt population shift than onshore winds. Thus, on August 8 and 26, 1956, when northwest winds of about 25 knots prevailed, counts on the west point used by females dropped to 20 animals. Although similar conditions existed at the east point, which is used by males, there was no appreciable change in the number of animals present. The otters which left the west point during this period were not observed elsewhere in the vicinity of St. Makarius Point or westward 4 miles to Rifle Range Point. It was therefore assumed that offshore movements had occurred. The effect of choppy water conditions on the south compare to those at Kirilof Point on July 6 when the choppy water produced by a 10-15 knot southeast wind caused greater changes in distribution (Fig. 15B) than the 10-20 knot northwest winds on July 19 and 20 (Fig. 16A, C).

Offshore movements as suggested from Amchitka's south side may not be uncommon. Thus, the Trinity Island and Unimak Island populations described previously are thought to spend most if not all of the year some distance from land. Accounts of sea otter hunting confirm such offshore existence for animals in these areas (Hooper, 1897; Petroff, 1884) and also for the Fairweather Grounds of Yakutat Bay (Cobb, 1907) where there are now no sea otters. In the Aleutians we know that sea otters regularly cross certain passes; and Allen Hartt, biologist for the North Pacific Salmon Investigation, observed many sea otters up to 8 miles seaward on the south side of Kiska Island during the summer of 1959.

Variations in survey counts indicate movements of greater magnitude than those that have been described for otters around Amchitka Island. However, our censuses have been insufficient in scope and repetition to provide an understanding of the characteristics, causes, and extent of these movements. Examples which illustrate the existing quandary were discussed previously for the Shuyak Island-Barren Islands population (p. 32) and for the Unimak Island population (p. 42). Seasonal variations in meteorological conditions may provide motivation for movements of the populations noted in the above cases.

The recent establishment of the Adak population as a result of emigration from Kanaga Island is the only certain example of large scale movements to form a new population center. Records of sea otter observations in the Sandman Reefs suggest a similar movement from Sanak Island, but the data are inconclusive for this area. The movement of as many as 2,300 - 3,450 sea otters from Kanaga to Adak during a period of 5 years suggests several characteristics of sea otter behavior. Attachment to a familiar home range must be relatively strong because a 12-mile channel of 28 fathoms at its deepest point separating Kanaga from Adak was an effective barrier for many years. However, pioneering of new areas around Adak by a part of the Kanaga population apparently was soon followed by utilization of the new area by other individuals. Perhaps early movements between the islands were only daily visits to better foraging areas at Adak, that imparted an awareness of the new feeding grounds to other animals. However, the phenomenal growth of the Adak population can scarcely be accounted for by emigrations of individuals, but is in keeping with the strong tendency of sea otters to congregate in large groups. Fisher (1939) has shown that California sea otters habitually move as a group, and data from the Kodiak Archipelago suggest similar behavior. In the latter case only a few strays were reported from the Shuyak population at Perenosa Bay prior to the observation of about 150 animals at Seal Rocks on the south entrance of the bay in July 1959. Over 80 percent of all otters counted in the Shuyak-Barren Islands area have been in groups exceeding 50 animals.

Mass immigrations of sea otters, such as occurred at Adak, probably results from the presence of barriers which are effective in preventing movements as long as food supplies are plentiful, but which fail as barriers when the food supply diminishes and foraging movements are extended. Movements across the barrier when once initiated are probably accelerated by the limited food in the original range and the abundance of food in the new. For areas where no barrier exists, a mass exodus is not to be expected as food diminishes, but rather a gradual expansion of the existing range into adjacent habitable areas with the rate of such expansion increasing as the population grows. Sea otters generally have not tended to exploit unoccupied areas, even when adjacent regions offer suitable habitat and when no barriers exist to retard movements. Thus the present Kayak-Wingham Island population occupies an area with a radius of only 15 miles, the Shuyak-Barren Islands and the Shumagin Islands populations a radius of 20 miles, and the Sutwik Island population a radius of 25 miles. However, in most cases a dispersion from these populations is noticeable, particularly at Sutwik Island where the area of water shallower than 20 fathoms is small. Dispersal tendencies are also evident in the Sandman Reef and Prince William Sound populations.

Population Composition

Information relating to the sex and age composition of sea otter populations is limited. Barabash-Nikiforov (1935) stated that the sex ratio of otters commercially harvested in the Commander Islands averaged about 60 percent males over a period of several years. Jones (1951b) reported that 31 of 35 animals taken captive on Amchitka Island were males, and postulated either that females were more wary and did not come ashore or simply were not present where the otters were caught. The latter possibility has proven to be correct. Scheffer (1951) examined 118 complete or fragmentary sea otter skulls, mostly from

Amchitka Island, including 46 adult specimens of which 9 were males and 2 were females. The sex was unknown for 35 of the adult specimens. Of 72 immature animals represented in the collection, 12 were males, 4 were females, and for 56 the sex was unknown. Dr. Scheffer has kindly provided me with the original data for these specimens, and I have determined the sex ratio for 112 to be 66 males to 46 females. (Methods for sex and age determination are described in the Appendix.) This proportion is nearly identical with that reported by Barabash-Nikiforov, but the sample is too small to demonstrate a statistically significant deviation from a 50:50 sex ratio.

Observations of sea otters on Amchitka Island and the sex composition of animals found dead on the beaches of Amchitka confirmed the supposition that at least a partial sex segregation of the population occurs. Large concentrations of sea otters were usually present at six locations on the eastern half of Amchitka, although some animals were scattered along the entire shoreline. Three of these areas were found to be used primarily by males and three by females and young of both sexes (Table 5). All locations, as in the case of Kirilof Point described previously, are characterized by geographic features which provide some protection from winds.

The largest aggregations were those composed almost exclusively of males. At Amchitka these male groups

Table 5. Sex and Age Composition of Animals Found Dead and Captives from Known Hauling Grounds on Amchitka Island, 1953-1956.

Location	Adults Males	Adults Females	Pups and Sub-adults Males	Pups and Sub-adults Females	Totals Males	Totals Females
Male Hauling Grounds						
Crown Reefer	18	1	12	1	30	2
St. Makarius (East Point)	4	1	2	1	6	1
East Cape	4	1	16	4	20	5
Totals	26	3	30	6	56	8
Female Hauling Grounds						
Rifle Range Point	2	12	20	12	22	24
Kirilof Point	6	14	14	12	20	26
St. Makarius (West) Point	8	13	17	16	25	29
Totals	16	39	51	40	67	79
Other Shoreline Areas	2	10	8	5	10	15
Totals, all locations	44	52	89	51	133	102

usually number from 50 to 200 animals, although larger groups have been observed elsewhere. The distribution of sexes and ages on concentration points used by females does not differ appreciably from the composition in intermediate areas. Animals at female hauling grounds appear to occur in greater numbers than elsewhere merely because of better habitat conditions there. Concentrations of males, however, appear to result from territorial behavior of dominant males which are scattered throughout areas used by females. The presence of immature male sea otters in the segregated group, as observed by Jones (1951b) and indicated by the present data (Table 4), suggests that aggressiveness of territorial males may extend even to young animals, although I have never witnessed serious strife between males of any age.

Because of marked sexual segregation in sea otter populations, unbiased sex or age ratios are difficult to obtain. I do not believe that those given by Barabash-Nikiforov (1935) which are based on harvest records in the Commander Islands, or those derived from Dr. Scheffer's measurements which are mostly from Amchitka hauling grounds, provide unbiased samples of the respective populations. The mortality records from Amchitka between 1953 and 1956 (Table 5), however, seem relatively unbiased for determination of sex ratios because: (1) they include specimens from over 60 miles of beaches; (2) in effect, they sample over half of the Amchitka population: and (3) they include specimens from all habitat types present on Amchitka Island. The observed ratio of 107 females to 125 males suggests that the sexes must be nearly equal in number at birth.

If sexes are equal at birth, the composition of animals found dead on Amchitka indicates a differential sex and age specific mortality (Table 7). Mortality rates were relatively low and about equal for the sexes in Age Classes I to V (birth to about 8 months), when young are still accompanied by their mothers, but rose sharply among males of Class VI (about 9 to 15 months) which were apparently beginning to fend for themselves. Mortality rates remained relatively high for Class VII (16 to 24 months) males, but also increased to a nearly equal rate among females. Mortality declined among Class VIII young (25 to 32 months), but was again highest among males. I do not know why unless I have failed to destinguish some older sub-adult females from adults. (See a discussion of age classification in the Appendix.) The high mortality in Class VI and VIII males results in an overall proportion of deaths that is larger among young males than young females.

At puberty, which seems to occur between two or three years of age, mortality rates decrease, and most deaths among adults appear to be of old animals. If sexes are nearly equal at birth, and a higher mortality rate exists for young males than for females, the adult females must predominate in the reproductive segment of the population.

Table 6. Sex Ratios of All Animals Found Dead on Amchitka Island, 1953-1956.

Year	Number		Percent	
	Males	Females	Males	Females
1953	34	29	54	46
1954	33	28	54	46
1955	24	22	52	48
1956	33	28	54	46
Totals	125	107	54	46

This assumption is suggested also by the higher proportion of deaths among adult females than adult males (Table 7).

Table 7. Sex Ratios by Age Class in Natural Mortality Records from Amchitka Island, 1953-1956.

Age Class	Number of Deaths Males	Number of Deaths Females	Percent Deaths Males	Percent Deaths Females
Sub-adults				
I - V	12	16	43	57
VI	22 *1/	7	76	24
VII	31	27	53	47
VIII - IX	15 *	3	83	17
Not aged	8	5	62	38
Total sub-adults	89 *	58	61	39
Adults	36 *	49	42	58
Total animals	125	107	54	46

1/ Asterisks indicate Chi Square values which suggested significant deviations from 50:50 sex ratios at $p = .05$.

Mortality of the magnitude observed on Amchitka has not been observed elsewhere (p. 112). Eight adult and three immature animals found dead in other areas suggest also that age or sex specific mortality is not always as well defined as indicated for Amchitka. A lower mortality, particularly among sub-adult animals as indicated by the few specimens, would result in a more even adult sex ratio in other populations than at Amchitka Island.

The age composition of sea otter populations has not been determined beyond the categories of pup, sub-adult, and adult, nor is it possible to analyze the structure of populations in greater detail with existing age determination and sampling techniques. Maximum longevity, however, probably exceeds 10 years, and my impression from observations at Amchitka Island, and the examination of specimens is that adults are considerably more numerous than sub-adult animals. This impression is in keeping with the results of simple calculations based on census figures, which indicate pups form only 15 percent of the Amchitka population, and the conservative assumption that maturity is not reached until 3 years. The ratio of 55 adults to 45 (15 percent x 3 years = 45) sub-adults is widened by the high sub-adult and low adult mortality rates. However, the same calculations based on pup counts of 21.7 and 21.1 percent of the population on Adak and Kanaga Islands respectively, and the lower mortality observed at those places, would indicate nearly equal numbers of adult and sub-adult animals.

Reproduction

The general characteristics of reproduction in sea otters have been described by several authors, but most accounts do not vary appreciably from the first description by Steller (1751). From observations on Bering Island in 1741, Steller reported that sea otters breed at any season, have a gestation period from 8 to 9 months, and bear only one young, although females may occasionally be accompanied by young of various ages. Observations by Barabash-Nikiforov (1935, 1938, 1947) in the Commander Islands, by Fisher (1940) in California, and by the author and others in Alaska verify Steller's conclusions on the above points. However, Steller (1751) concluded that sea otters are monogamous, an error that has been perpetuated in much of the literature (Elliot, 1886; Littlejohn, 1916; Seton, 1926).

Barabash-Nikiforov (1935) observed copulation of sea otters in January, March, May, and November; Jones (1951) in February; Kenyon (1956) in May, August, and September; and Murie (1940) in July, indicating that coitus takes place throughout the year. On breeding, my observations of sea otters from February to April and June to August are in agreement with those of Kenyon (1956), who concluded that the peak of breeding is in August or September. However, an increase in reproductive activity is already evident by July when mated pairs are common.

In keeping with the fact that breeding may occur throughout the year, young may be born in any month (Steller, 1751; Barabash-Nikiforov, 1935, 1938, 1947; Fisher, 1940; Murie, 1940). This suggests that if delayed implantation occurs in sea otters, as indicated by the status of reproductive organs examined by Clinton H. Conaway (1958, in lit.), it does not completely regulate the period of birth. The peak of pupping seems to occur during March and April, although I have seen newborn pups from February through August, and other pups in February that were believed to have been born in December or January. Thus, the gestation period may normally be from 8 to 9 months. Barabash-Nikiforov (1938) reported parturition in a captive female 8 months after coitus, but since the fully-formed pup died, it was believed to have been premature.

Newborn pups are completely dependent on their mothers, but begin to forage for much of their own food a few months after birth. They may continue to nurse, however, until at least a year old, and some young may continue to accompany their mother after weaning or after a second pup is born. I suspect that in such cases the older pup is usually a female because indirect evidence based on mortality records (p. 99) suggests that males must fend for themselves earlier than females.

Sea otters are believed to reach maturity between 24 and 36 months but probably closer to the latter age. Age Class VIII specimens, obtained on Amchitka beaches as a result of late winter mortality, which are believed to be 25 to 32 months old possess few characteristics indicating approaching maturity (Appendix). Three specimens (Nos. 51-53, 62-54, 10-56) classified as Group IX, however, seemed much further advanced in development than Class VIII animals by such skull features as closed sutures, decreased porosity of bone, and development of sagittal and lambdoidal crests.

The bacula or testes of the two males from the group of three Class IX specimens were also well developed as compared to Class VIII animals, but had not reached adult size. The female was too decomposed for examination of reproductive organs.

Adult males appear to be capable of reproduction throughout the year, and all testes and epididymides from specimens examined between February and August contained abundant sperm. The periodicity of estrus in females is unknown, but on the basis of observations on Amchitka, I believe that most females do not become pregnant if they are accompanied by young that are much less than a year old. Exceptions may occur, however, since females with newborn pups are occasionally accompanied by another that seems to be no more than a year old (Steller, 1751; Ognev, 1931), but these cases are not common on Amchitka. Jones (1952) and David C. Hooper caught a pup about 6 months old (No. 11-53), and then netted simultaneously its mother and a male engrossed in copulation. Murie (1940) records another instance of coitus when the female was accompanied by a small pup. Malkovitch (1937), however, stated that mating never occurs in the presence of young, but that when a 3-month-old pup was removed from its mother the latter soon became pregnant. Kenyon (1955) observed a total of nine mated pairs and coitus on five occasions on Amchitka, but no female accompanied by a pup was observed to mate. Conaway (in lit.) examined the reproductive organs from two otters with young pups and found that neither were pregnant. One animal he examined with an older pup appeared to be entering a post-lactation estrus. My observations of mated otters also indicate that females with pups do not mate; but the proportion of young observed at Kanaga and Adak Islands (21-22 percent) suggests that many females have young more often than once in two years.

Sea otters bear but one young at a time, a characteristic in common with nearly all other marine mammals rather than other mustelids. Only two records are available for twin fetuses, once in an otter killed in the Kurile Islands (Snow, 1910:277) and another in the Commander Islands in 1910 (Ognev, 1931; Barabash-Nikiforov, 1938). There are no satisfactory records of multiple births, and if such occurred it is unlikely that two young could survive because the mother could not provide the required maternal care for both. Parturition may occur either on shore (Barabash-Nikiforov, 1935) or in water (Fisher, 1940).

The lack of accurate information on the basic biology of reproduction prevents precise calculation of reproductive rates, and it is perhaps safe to rely on the proportion of young observed in the population during censuses. Reliable pup:adult ratios are available only from Amchitka, Kanaga, and Adak Islands, where extensive surveys from boat or shore have resulted in pup counts which vary from about 15 to 22 percent of the population (Table 8). Pups cannot ordinarily be identified in aerial surveys.

Table 8. Number of Pups Observed on Land or Boat Surveys.

Area	Number of Pups	Total All Ages	Percent Pups
Amchitka Is. (Land census, 1956)	384	2,568	14.9
Adak Is. (Boat census, 1957)	84	399	21.1
Kanaga Is. (Boat census, 1957)	123	568	21.7

The calculated reproductive rate for Amchitka Island, based on an assumed population composed of 60 percent adults of which 60 percent are females each giving birth to one pup in 2 years, results in an estimated reproductive rate of 17.5 percent which is near the observed value. If the same calculations are made for Kanaga, but with the assumption that only half the population is adult and that the sexes are about equal in number as suggested previously (p. 99), the estimated reproductive rate would be only 12.5 percent which is obviously in error (Table 7). If it is assumed, however, that on Kanaga females breed every year, the estimated reproductive rate becomes 25 percent, which again seems a reasonable approximation of the observed fecundity. The wide difference in the proportion of pups in the Amchitka and Kanaga population may thus be accounted for by possible difference in the frequency that females bear young. Is it possible that the food shortage, which is believed to exist on Amchitka, and the consequent increased dependence of young on their mothers results in a reduced frequency of matings?

The rate of population increase must be some figure below the reproductive rate, but probably not much so because of the relatively low mortality rates which have been observed. Barabash-Nikiforov (1933) believed that the annual rate of increase on the Commander Islands was 10-12 percent, but subsequently (1935, 1938, 1947) gave revised estimates of 7 percent, 4-5 percent, and 5-7 percent. These rates, except for those of 10-12 percent, must be considerably below that which permitted sea otters in Alaska to have reached present population levels. If, for instance, we assume that the rate of increase for the Amchitka animals which led to a population of at least 4,000 in 1943 (p. 59) was only 5-7 percent, an estimate of the population for 1906, when hunters took only 4 sea otters, would be between 375 and 850 animals. Similar calculation for Kanaga, based on a 1957 population of 5,000 animals, indicates a 1910 population of approximately 200 to 600 animals. Since hunters were able to exterminate otters in other areas, and the last hunting returns from Amchitka and Kanaga were very small, the population estimates derived from increase rates of 5-7 percent seem far too large. With assumed rates of 10-15 percent, however, we obtain a 1906 population estimate for Amchitka of 57 to 230 animals and for Kanaga of 7 to 60 animals. These estimates seem to be reasonable approximations of the remnant populations at the end of the exploitation period. The assumed rates of population increase also agree with existing reproductive rates for Kanaga and Adak, and the relatively low mortality rates that have been observed in all populations with the exception of Amchitka Island.

A 10-15 percent rate of increase also corresponds to the estimated size of remnant sea otter populations in other areas. However, this rate applies only to populations which have been well below the carrying capacity of their habitat. The effect of population pressure is evident in the Amchitka data which indicate a diminishing food supply, diminishing reproductive rates, and increasing mortality rates. For the period since 1941, even a 5 percent rate of increase seems excessive, and it appears that the population on Amchitka is now relatively stable; Kenyon and Spencer (1960) believe with considerable justification that the population may have decreased in recent years.

Mortality

Morbid animals or their remains may be found occasionally on the beaches in the proximity of any area utilized extensively by sea otters. Perhaps if such beaches were examined with sufficient care and frequency most mortality would be accountable, because moribund animals usually come to shore and because most deaths occur during periods of onshore winds which would carry floating specimens onto the beaches. Marsh and Cobb (1908) comment that "an odd, but sometimes very profitable, business is that of patrolling certain beaches on the watch for the bodies of sea otters which may be washed up." This occupation was conducted mostly on the Alaska Peninsula, and Marsh and Cobb believed that the two important sources of mortality were from wounds inflicted by hunters and from being crushed in the pack ice that is present along the Peninsula's Bering Sea shoreline in winter. Neither of these sources of mortality can be serious for existing populations.

Fisher (1940c, d) described a sea otter that died from a gastric perforation, probably resulting from some hard object the animal had swallowed. Such an occurrence must be rare, however, and we have not found it in Alaskan specimens. Miss Fisher (n.d.) also has reported that she found few abnormalities in a collection of over 3,000 sea otter bones, mostly obtained from California shell mounds and middens, and concluded that the sea otter seldom met with serious accident or injury. Barabash-Nikiforov (1935) reported only low mortality rates in the Commander Islands, and attributed possible sources of death to old age, storm injury to the very young or very old, rock slides, unknown diseases, pathological parturition, and "some" to killer whales.

Predation. Predation upon sea otters is not considered important by most investigators, and only a few instances have been recorded. However, the amount of marine predation is difficult to determine and may be more than we suppose. Seton (1926:664), basing his account on Steller (1751) and Littlejohn (1916), vividly portrays the fear of the sea otter for its arch enemies, the killer whale, *Orca rectapina*, and the Steller's sea lion. Although similar descriptions have added to the interest of several popular accounts of the sea otter, there is neither conflict nor competition between the sea otter and the sea lion. The killer whale is known to prey on seals (Scheffer, 1958:27) and may occasionally prey on sea otters, but seldom forages in the shallow water frequented by otters nor is it so numerous that it requires serious consideration as a predator of sea otters.

The bald eagle, *Haliaeetus leucocephalus*, was implicated as a predator of sea otter by Krog (1953) who found the remains of three pups in one of three nests that he examined on Amchitka Island. Although eagles forage extensively on carrion sea otters, Krog believed that at least one of the pups had been killed by them. In 1954, I found the remains of a pup on a rock pinnacle near an eagle's nest on Amchitka Island. This pup was probably carrion as a lactating female was found dead near by.

Murie (1940), however, did not find any remains in 28 nests which he examined in the Aleutians, nor did Hooper (1953) when he examined four nests on Kanaga Island. I found no sea otter remains in four nests examined on Amchitka in 1956, or in one on Dark Island in the Kodiak Archipelago in 1957; hence, on the basis of available evidence, I have concluded that eagle predation upon sea otters is negligible.

Orr (1959) reported that of 9 sea otters found on California beaches between January and March 1958, one had been shot, six appeared to have died of wounds received from skin divers' spears, and two had died from wounds inflicted by a shark, _Carcharodon carcharias_. This shark does not occur, however, in Alaskan waters.

Mortality on Amchitka Island. Between 1949 and 1956, the remains of over 400 sea otters have been found on the beaches of the eastern half of Amchitka Island, but records or specimens of only 13 dead animals have been found in all other Alaskan habitats. Although the differences partly reflect the greater effort expended in searching Amchitka shorelines, it emphasizes the excessive mortality in the Amchitka population as compared to other populations. I examined the beaches of about half of Simeonof Island with Ford Wilke and Karl W. Kenyon in March 1955; Cherni Island in the Sandman Reefs, and about 4 miles of beaches near Kanaga Bay, Kanaga Island with Robert D. Jones in July 1957; and about 5 miles of beaches on Montague Island, Prince

William Sound in July 1958, and again in 1960. David C. Hooper (1953) examined the beaches of the western third of Kanaga Island in June 1953. Biologists of the North Pacific Salmon Investigation and members of Coast and Geodetic Survey expeditions have visited many other Aleutian beaches, and fishermen and hunters have examined beaches in Prince William Sound. If the mortality of sea otters in any of these areas was comparable to that of Amchitka, it would certainly have been discovered.

Although extensive shore patrols were conducted by Bureau of Fisheries wardens stationed on Amchitka between 1936 and 1940, there was no reported evidence of serious mortality during that period. Loy (1940) found only three skeletons between July 1939 and January 1940, although he searched beaches for evidence of mortality. During the same period, he obtained reports of three other animals from fox trappers. Mangan and Ritter (1940) reported the finding of only two animals during the 1940 surveys. Scheffer (1951), however, found six skulls on Amchitka on November 12, 1947, which may be indicative of increased mortality by that time. During November, mortality is low and most evidence of mortality from previous winter has been obliterated. Thus, six skulls probably represent a high mortality for the searched area which must have been small considering the time spent by Scheffer on the island. The first definite observation of serious mortality on Amchitka was reported by Elmer C.

Hansen, a civilian employee of the Army, in a letter of April 3, 1948, to V. B. Scheffer. Hansen estimated that at least 100 animals had died. Definite verification of serious mortality of sea otters on Amchitka came in 1949 when Hansen and Refuge Manager Robert D. Jones, Jr. salvaged about 90 skulls (Scheffer, 1951).

Parasites. The evidence of high natural mortality on Amchitka Island and the corresponding mortality of captive animals (Jones, 1951a, b) caused considerable concern and gave much of the impetus to investigations conducted in recent years (Rausch, 1953; Stullken and Kirkpatrick, 1955; Kirkpatrick, et. al., 1955; Kenyon and Wilke, 1956; Kenyon, 1957, 1959; Kenyon and Spencer, 1960; Lensink, 1959, 1960). Initial studies, which attempted to trace the source of mortality on Amchitka, were conducted by Rausch (1953) who was concerned primarily with parasitic infestations. He examined a total of 31 specimens, including animals found dead on beaches and those which died in captivity, but was unable to examine any normal animals. Rausch concluded that of eight species of parasites identified from the sea otters he examined, at least two, *Microphallus pirum* (Afanasev, 1941) found in 21 specimens, and *Porrocaecum decipiens* (Krabbe, 1878), were highly pathogenic. Cultures did not implicate any pathogenic organisms of the bacterial type. Enteritis was the predominant symptom and was ordinarily attributed to *M. pirum* infection. In a few instances, however, fatal idiopathic enteritis was noted, and Rausch cautioned that "some other disease-producing factor may be in every case superimposed upon the _M. pirum_ infection." Rausch (1957, in lit.) also concluded that a sea otter found dead in Prince William Sound on April 10, 1957 had died as a result of a severe infection of the acanthocephalan, _Corynosoma villosum_ Van Cleve 1953. A _Corynosoma_ was identified by Kenneth A. Neiland from a sea otter I shot in the Sound on June 30, 1960, but in this instance there were no obvious signs of pathology. Barabash-Nikiforov (1935), however, found the incidence of parasites very low in Commander Island sea otters.

Stress Symptoms. Stullken and Kirkpatrick (1955) studied the physiological aspects of mortality in captive animals. Comparisons were made between 12 moribund animals, most of which were captives, 7 normal animals which had been instantly killed from ambush, and 3 captives observed for about a month. The greatest difference between moribund and normal animals was the severe gastro-enteritis in the former. This finding agreed with that of Rausch (1953). Other differences found in the pathological group included a distinct eosinopenia, vasodilation, slight hemoconcentration, and increased tissue moisture content. Because all of these symptoms are recognized evidence of stress, and because most animals died after only a few days in captivity, Stullken and Kirkpatrick (1955) concluded that "captivity mortality in the sea otters studied was probably due to an acute stress or shock reaction...characterized by a rapidly developing gastro-enteritis which is precipitated by insufficient food intake, intolerable environmental temperatures, and adverse sensory stimuli."

Although parasitism or other pathological conditions undoubtedly account for a portion of the mortality on Amchitka, it appears that acute stress as described for the captive sea otters may be the ultimate cause of death in most of the wild otters. The typical symptoms revealed by gross post mortem examination of beach specimens are emaciation, congested and frequently hemorrhagic lungs, hyperemic condition of intestinal surfaces, and moderate to severe enteritis. These symptoms are similar to those of moribund captive animals.

Sources of Stress. Parallels may be seen in causes of stress in captive and wild animals. Mortality is almost confined to the stormy period of late winter (Lensink, 1958, 1959), and Kenyon (1959a) has shown a direct correlation between individual storms and sea otter mortality. Storms probably act indirectly in producing mortality by preventing effective foraging by otters, particularly of the young or the very old. The large food requirements of sea otters (p. 80), food specificity of young animals (p. 75, 76), and a shortage of sea urchins (p. 82) combine to make storm period critical. Both the studies of Malkovitch (1937) and Stullken and Kirkpatrick (1955) have demonstrated the consequence of inadequate diet; and Stullken and Kirkpatrick (1955) suggest further that mere absence of food from the digestive tract may result in rapid degenerative changes leading to severe gastro-enteritis and fatal shock or circulatory collapse. The fact that mortality is heaviest in those age groups most sensitive to food shortage, and that deaths can be correlated directly with storms of relatively short duration rather than the entire stormy period, lends support to the theory that stress resulted from acute food shortage rather than chronic starvation. Parasitism, malnutrition, tooth decay or other debilitating factors may contribute to the effect of food shortage.

Observation of captive animals led Stullken and Kirkpatrick (1955) to suggest that temperatures varying from a narrow range may be intolerable to sea otters. Shivering was common, and otters showed severe distress when placed in a tank of water after a short time in captivity. Temperature regulatory mechanisms seemed poor, for deep rectal temperatures, even those taken in normal animals a few minutes after death, varied widely among individuals. However, subsequent experience has shown (Kenyon and Wilke, 1956; Kenyon and Spencer, 1960) that inability of captive animals to tolerate temperature changes is caused by soiling of their fur with the consequent loss of its insulation value. Given an adequate food supply, sea otters usually can adjust quickly to captive conditions when sufficient water to maintain cleanliness is available (Kenyon, 1959). Thus lack of temperature control under natural conditions probably is not a contributing factor to mortality.

STATUS

All recent observations and surveys point to the conclusion that the sea otter population in Alaska has increased significantly in number and in extent of area it occupies within the last decade. This recent large increase in population is not the result of an increased rate of growth, but merely a reflection of the time interval the population has had to recover and the progressively greater annual increment as the population grows.

Because only a few animals remained in widely scattered localities at the end of the exploitation period, the subsequent recovery of the population can be identified with several distinct areas or groups of animals. Variation in the size of these area populations is more probably the result of corresponding variation in the number of individuals from which they originated than any other factor. Since the populations vary widely in size, it is possible to evaluate the effect of population density on the food supply, on fecundity, and on the rate of population increase. Information on the mobility of sea otters is limited, but sufficient examples of dispersal and immigration from existing populations exist to suggest future dispersal or migratory patterns. The history of early sea otter harvests provides a fair measure of aboriginal abundance, hence, of the carrying capacity of the habitat and the maximum populations that we may expect to attain with protection. We are thus reasonably equipped with essential facts for evaluating the status of the existing population in respect to past and future populations.

Aboriginal and Existing Population Densities

Harvest records for the Aleutian Islands indicate that the aboriginal population of sea otters in the Andreanof, Delarof, Rat and Near Islands was approximately 75,000 animals (p. 11). It may be assumed that the distribution of sea otters within this area was correlated with the amount of shallow water from which they were able to obtain food (Lensink, 1959, 1960). Thus, to calculate the density of sea otters, the total area of water less than 50 fathoms in depth was divided into the total population to derive an estimate of about 15 animals per square mile. The choice of 50 fathoms as a limiting depth for calculations was dictated by the contours on available charts and exceeds the depth at which sea otters normally forage. However, since contours are usually roughly parallel at various intervals, calculated density estimates are inversely proportionate to area, and estimates of populations are probably not much affected in the western Aleutians by use of the 50 fathom limit. Exceptions may occur at Semisopochnoi Island, in the

Pribilof Islands, in the area northeast of Unimak Island, and along part of the Alaska Peninsula where the water deepens rapidly to a depth more than that in which sea otters forage, but extends many miles at depths less than 50 fathoms.

A check of the accuracy of aboriginal population estimates is provided in the record of 18,000 pelts taken from the Near Islands between 1745 and 1762 for which the history of the harvest is nearly complete. The density estimate based on this figure is nearly equal that for the rest of the western Aleutian area (15.4 and 15.1 respectively per square mile for areas of 1,175 and 5,000 square miles). Comparison of estimates for aboriginal and existing populations in the western Aleutian Islands (Table 9) indicates that the existing populations in the western Andreanof Islands, in the Delarof Islands, and in the Rat Islands are approaching or are as large as those existing prior to exploitation. The remaining islands in the Andreanofs have only nucleus populations that are far below aboriginal densities.

There are other indications that populations approaching aboriginal densities have been attained in the western Aleutians, particularly at Amchitka Island. The high mortality, which appears to be associated primarily with food shortages in critical periods at Amchitka (p. 100), is a common characteristic of a population that has exceeded the carrying capacity of its habitat. In addition, reproductive success appears to have diminished, and the

Table 9. Comparison of Estimates for Existing and Aboriginal Sea Otter Populations in the Western Aleutian Islands.

Area	Existing Population		Aboriginal Population	
ANDREANOF ISLANDS				
Atka-Amlia-Seguam	200 - 500		17,300 - 21,000	
Kagalaska-Ulak-Great Sitkin	50 - 300		5,950 - 7,250	
Adak	2,300 - 4,000		2,550 - 3,150	
Kanaga-Bobrof	2,575 - 4,150		3,900 - 4,800	
Tanaga	1,500 - 3,000		3,100 - 3,800	
Total		7,000 - 12,000		32,800 - 40,100
DELAROF ISLANDS				
Gareloi	50 - 100		250 - 350	
Kavalga-Ogliuga-Ilak	1,200 - 2,400		2,450 - 2,950	
Amatignak-Ulak-Tanadak	600 - 1,200		800 - 1,000	
Total		2,000 - 4,000		3,500 - 4,300
RAT ISLANDS				
Semisopochnoi	525 - 1,050		1,750 - 2,150	
Amchitka	4,000 - 6,000		4,850 - 5,950	
Rat	500 - 1,000		1,750 - 2,150	
Segula-Little Sitkin	400 - 800		950 - 1,050	
Kiska-Little Kiska	1,300 - 3,500		5,500 - 6,600	
Total		7,000 - 12,000		14,700 - 18,000
NEAR ISLANDS		none		15,750 - 19,250
Totals (rounded)		16,000 - 28,000		67,000 - 82,000

population appears to have been stabilized or even to have decreased. Although mortality such as occurs at Amchitka has not been observed in other areas with equal population density, the lack of mortality in the other areas may reflect only the more recent attainment of such densities. At Kanaga in 1957, I found a greater abundance of food than at Amchitka, but a considerably poorer food supply than at Adak where sea otters were then comparatively few.

At Adak Island, the population is primarily the result of large scale immigration from Kanaga Island since 1954, and is believed already to have surpassed the aboriginal population in size. The Adak population may grow still larger, however, because distribution about the island has not stabilized, and most animals are found on the side of Adak nearest Kanaga. Such high density of the Adak sea otter population is made possible by the abundance of food developed prior to the occurrence of otters there. This food supply may be expected to decline rapidly as a result of present heavy utilization, and consequently the sea otter population also, perhaps at first by further eastward immigration rather than by increased mortality as occurs at Amchitka Island.

The sea otter populations in the Fox Islands, along the Alaska Peninsula, in the Kodiak Archipelago, and in Prince William Sound may be regarded as nucleus populations. Although these regions are far from fully occupied, populations in various centers of distribution there are relatively dense. Calculations of densities based on both 10 fathom and 50 fathom limits, however, indicate that even in population centers, densities are well below those of the western Aleutians.

Forecast of Population Trends

The rapid growth of sea otter populations has been demonstrated by all observations and surveys, and it is now pertinent to consider what additional growth of the population is to be expected. Additional growth will depend primarily on the present status of local populations, but also on reproductive rates, the quality and quantity of the habitat, and physical barriers to immigration. Such factors as unintentional disturbance by man, poaching, or future harvest programs may be of local significance, but probably should not affect general trends.

We cannot anticipate continued growth of sea otter populations in those portions of the western Aleutians which now appear to have reached aboriginal densities, and perhaps to have attained or even surpassed the normal carrying capacity of their habitat. Furthermore, the populations of the Rat and Delarof Islands are isolated from suitable areas for expansion, and population pressures cannot be relieved by immigration. Thus, if harvests do not remove surplus animals, we can anticipate a stabilization or possible regression of the population through decreased reproductive rates and increased mortality such as occurs at Amchitka Island.

Sea otters were completely exterminated from The Near Islands, the westernmost group in the Aleutians. Natural repopulation of this area is not expected because of the vast deep water barrier (150 miles) which extends to the Rat Islands. Sea otters were also exterminated in the Pribilof Islands, but seven animals were reintroduced to St. Paul in 1959. The fate of this transplant should be definitely established within a few years, but, even with optimum results, absolute increase cannot be large for several decades.

Perhaps most of the Andreanof Islands may have populations approaching aboriginal densities within the next decade. Tanaga, Kanaga, and Adak Islands already have such populations and no barriers exist which would significantly retard further expansion eastward. The phenomenal increase of the Adak population, from none to 2,300 - 3,500 animals in less than 10 years (p. 52) as a result of immigration from Kanaga, illustrates the ability of large populations to expand into unoccupied habitats. The magnitude and swiftness of population recovery on Adak is presumed to have been caused by failure of the temporary barrier presented by Adak Straits. This barrier was effective only so long as food at Kanaga was plentiful, but failed when food shortage caused extensive foraging by otters into deeper water.

Eastward expansion of the Adak population will probably be rapid, although more slowly than the immigration wave from Kanaga to Adak. As suggested earlier, the abundant food supply at Adak may permit the population to expand beyond normal carrying capacity. Such a build up in population could only result in rapid deterioration of the food supply, which in turn would give impetus to the eastward expansion of the population.

Our present estimates for populations at Atka, Amlia, and Seguam Islands in the eastern Andreanofs are not sufficiently accurate to predict with certainty their contribution to the population during the next decade. Even for the most optimistic estimate, however, it would be necessary for large scale immigration to take place for maximum density to occur within 10 years. Such immigration seems possible, and the time lag, if any, should not greatly exceed a decade.

Expansion of sea otter populations in the Fox Islands, along the Alaska Peninsula, in the Kodiak Archipelago, and in Prince William Sound will depend entirely on recruitment from within each population. However, growth of populations in all of these areas should be more apparent than that which occurred during the past decade because each population is now sufficiently large to provide marked absolute growth in numbers. Estimates for populations a decade hence based on an annual increase rate of 15 percent

(p. 108) suggest numbers approaching 4,000 - 5,000 in the Fox Islands, 20,000 - 30,000 along the Alaska Peninsula, 4,000 - 8,000 in Kodiak Archipelago, and 4,000 - 6,000 in Prince William Sound. The various populations at these sizes will not yet approach aboriginal densities, except perhaps in local areas, and their total number will probably not be as large as the number of animals in existence at the time of the purchase of Alaska by the United States. Nevertheless, the considerable increase should result also in a large expansion of occupied range, and the definition of separate populations on the Alaska Peninsula will probably be much reduced. The population in the Barren Islands and Shuyak Island may extend to Kodiak and those in Prince William Sound to adjacent portions of the Kenai Peninsula or the Gulf of Alaska. Such spreading of the population already seems to be occurring at an accelerated rate despite the fact the presently occupied habitat is not fully utilized.

Repopulation of the Alexander Archipelago by sea otters is unlikely in the near future, although suitable habitat extends without interruption to present population centers. The distance is too far and the population in Prince William Sound too small to permit frequent straying into the southeastern area, and the chance establishment of such strays would be reduced accidentally by hunters or fishermen unable to distinguish sea otters from harbor seals, the latter of which, are persecuted as a nuisance species.

Harvest Potential

Existing information on the biology and numbers of sea otters is sufficiently complete to permit harvests in most portions of the sea otter's range without harm to the population. However, logistical and economic problems resulting from the location and density of sea otter populations, the still unknown demands or requirements of the fur trade, the requirements for repopulation of unoccupied habitats, and esthetic considerations may to a large extent dictate the location and character of future harvests.

In the Rat, Delarof, and western Andreanof Islands, the present population (using minimum population estimates) could probably support a total annual harvest of at least 2,000 animals without regard to sex or age of those animals taken. The number taken could exceed this level if harvests were selective for the polygynous males. The evidence for overpopulation at Amchitka indicates that extensive harvesting would be beneficial to the population there. Population estimates also indicate that harvests should be conducted on other islands in the Rat group, in the Delarofs, and at Tanaga and Kanaga in the Andreanof Islands if increased mortality rates and decreased reproductive rates such as occur at Amchitka are to be prevented. At Adak Island, the population would also permit large scale harvesting, but because sea otters from Adak may contrubute significantly to further repopulation of the Andreanofs, harvests should perhaps at the present time be selective for males. If so, an annual take of 200 to 250 animals should not prove excessive. It is also possible that harassment of sea otters caused by a harvest program at Adak would accelerate the expansion of this population to the eastward.

Unoccupied habitat is extensive in areas adjacent to all sea otter populations from the eastern Andreanof Islands to Prince William Sound. These populations should therefore be permitted to expand as rapidly as possible. Initial annual harvests of 200 to 300 males (10 percent of the minimum estimate of males) could probably be supported by the Alaska Peninsula populations without materially reducing their rate of expansion into unoccupied habitat, and as was suggested for Adak, harvest programs may accelerate immigration from present population centers. Although the populations in the Kodiak Archipelago and in Prince William Sound could sustain a limited harvest of males, their relatively small size and considerable aesthetic attraction for adjacent human communities suggests the need for continued protection.

SUMMARY

One hundred and seventy years of exploitation exterminated the sea otter in most of its original range, but small groups survived in widely scattered areas. In the aggregate these survivors may have numbered between 200 and 500 individuals. Since 1911, when protection was extended to sea otters, they appear to have increased at a rate which may be near their maximum capacity for recruitment, and the population now numbers approximately 40,000 animals.

The largest populations are found in the Rat, Delarof, and Andreanof Island groups of the western Aleutians, but smaller populations also occur in the Fox Islands, along the Alaska Peninsula, in the Kodiak Archipelago, and in Prince William Sound.

We can expect a rapid expansion in numbers from the Andreanof Islands eastward. West of the Andreanof Islands the habitat is limited and the population may already be near the carrying capacity. Here, sea otters are perhaps as abundant as they were before exploitation by the Russians. On Amchitka Island the evidence indicates that a high population has resulted in increased mortality and a lowered reproductive rate.

Both historical and present distribution patterns appear to indicate that the primary factor in the sea otter's habitat is the amount of shallow water available in which they can obtain food. Beds of kelp are used extensively by sea otters as resting and foraging areas, but the coexistence of kelp and sea otters may be at least partially coincidental, both having similar depth requirements.

Sea urchins, mussels or other mollusks, crabs and fish appear to be most important as food items in the order named for the Aleutian area, but may vary in other habitats. The relative importance of particular food items may also vary with the individual sea otter's age.

Daily activity patterns of sea otters involve movements between resting and nearby foraging areas, or, as occasion demands, to areas sheltered from storms. Seasonal movements are believed to exist but are not well understood. Straying of individuals or migration of groups to new habitats seems uncommon, but movements of this nature may be accelerated by crowding and subsequent deterioration of occupied habitat.

The percentage of pups in the total population indicates a potential reproductive rate in excess of 20 per cent. However, the rate of increase under optimum conditions appears to be between 10 and 15 percent. Sea otters have few enemies and mortality is normally low; but under crowded conditions, such as occurs at Amchitka Island, lowered resistance as a result of food shortage, winter storms, and parasitism contribute to cumulative stress which results in many deaths with typical symptoms of shock. The same factors appear to have resulted in a lowered reproductive rate.

Sea otters are now sufficiently numerous to warrant annual harvesting. Harvests may be essential to the continued welfare of populations in the western Aleutians.

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APPENDIX

CENSUS TECHNIQUES AND LIMITATIONS

The population estimates provided in the foregoing sections are believed to be minimal, and it is the impression of the author that actual populations are near to or may even exceed the upper limits as given. However, the various census results can as yet be only poorly evaluated for their relative accuracy, and thus the conservative approach seemed desirable.

Replicate counts indicate that census figures, except perhaps under optimum conditions of weather, water surface, and animal distribution, are far below the actual population. Kenyon and Spencer (1960) believed that they counted no more than 50 to 75 percent of the otters present on their 1959 aerial survey of the Aleutian Islands. Even this low proportion seems an optimistic figure.

Censuses considered in the present study include counts made from the shoreline with binoculars and telescope, from boats, and from aircraft. Except for special conditions or where comparative data are necessary, air surveys are the only means of covering the extensive areas in which sea otters are found.

Shoreline surveys have been conducted only on

Amchitka Island where it was desirable to obtain information on sex and age distribution of the population, reproduction, behavior, and movements. Boat surveys have been employed at Amchitka, Kanaga, and Adak Islands, in part of the Sandman Reefs, and in the Kodiak Archipelago. All populations have been included in air surveys.

The relative advantages and disadvantages of various survey methods and the conduct of surveys were discussed by Kenyon and Spencer (1960) and Lensink (1956, 1958) and will, therefore, not be considered at length here. However, the relative accuracy of various surveys, particularly air surveys, is considered in detail below.

The results of replicate surveys for various populations are provided in Table 10, the characteristics of various survey aircraft in Table 11, and an evaluation of weather conditions in Table 12. The results indicate clearly that the considerable variability in census figures may be attributed to both type of aircraft used on surveys and to weather conditions. Replication of surveys, although not sufficient to fully evaluate differences arising from these two factors, do suggest the magnitude of error that may be anticipated. Thus, in the Kayak Island - Prince William Sound area, when weather conditions rated good to optimum, the mean count for surveys from the Cessna 180 was 317 and from the Widgeon only 193. Also for all types of aircraft used in the Kayak area, counts for conditions

Table 10. Replicate Surveys of Various Sea Otter Populations.

Date	Aircraft or Other Equipment	Survey Conditions	Count
Amchitka Island			
6/24/43	Naval reconnaissance aircraft	Unknown: excellent (?)	3,420
8/49	Grumman Widgeon	Unknown: excellent (?)	1,087
5/10 - 7/7/56	Shoreline survey, binoculars	Variable: fair to optimum	3,525 1/
8/1 - 8/25/56	Shoreline survey, binoculars and telescope	Variable: fair to optimum	5,637 2/
5/19/59	Douglas DC 3	Excellent	1,560
Rat Islands			
6/24/43	Naval reconnaissance aircraft	Unknown: excellent (?)	720
8/20/49	Grumman Widgeon	Unknown: excellent (?)	234
5/19/59	Douglas DC 3	Excellent	270
Shuyak Island			
6/1 - 6/4/57	Boat survey	Good; calm but clear	169 3/
6/7/57	Supercub	Unknown	281
8/26/57	Supercub	Unknown	591
7/22/59	Pacer	Excellent: mostly calm and cloudy	395
Kayak Island			
8/10/59	Cessna 180	Optimum: calm and cloudy	163 4/
4/27/59	Cessna 180	Good; calm but clear	144 4/
4/9/60	Grumman Widgeon	Good; calm but clear	97
6/21/60	Grumman Widgeon	Excellent: mostly calm and cloudy	122
6/22/60	Cessna 180	Poor - Fair: some chop and clear	78

Table 10. Replicate Surveys of Various Sea Otter Populations (cont.).

Date	Aircraft or Other Equipment	Survey Conditions	Count
Prince William Sound			
8/9/59	Cessna 180	Optimum: calm and cloudy	545
4/9 - 4/12/60	Grumman Widgeon	Good: calm but clear	361

1, 2/ Figures are extrapolations based on actual counts (1,604 and 2,568 sea otters respectively) for the eastern half of Amchitka.

3/ Corrected by inserting air survey figure (94) for area not covered.

4/ Corrected by boat observations figure (94) of the same day for area not covered.

Table 11. Characteristics of Survey Aircraft.

Type of Aircraft	Survey Speed	Remarks
Naval Reconnaissance (single engine)	"slow"	
Cessna 180 and Pacer	85-95 mph.	Highly maneuverable; visibility excellent for observer.
Supercub	86-90	Highly maneuverable; visibility ahead poor but excellent to both sides for a single observer.
Grumman Widgeon	100-155	Moderately maneuverable; visibility ahead good for one observer only. Engine noise appeared to frighten otters and made re-checking of large groups difficult. Much safer for extended open water flights than single engine aircraft.
Douglas DC 3	120	Higher speed and less maneuverable than other aircraft used. Good visibility for two observers. Long range an advantage in remote areas.

Table 12. Evaluation of Survey Condition Ratings.

Rating	Description
Optimum	Seas calm and overcast sky.
Excellent	Seas calm or calm in critical areas, sky mostly overcast.
Good	Seas calm but skies clear causing reflection from water.
Fair to Poor	Seas small to large; skies overcast or clear. Any marked disturbance of water's surface other than smooth swells seriously reduces counts to below a tolerable level.

considered excellent to optimum averaged 142 and for conditions rated as good only 120. The combined error (counts from Cessna 180 with optimum conditions, and from Widgeon with good conditions) is indicated by a count of 163 versus 97 in Kayak area and 541 versus 361 in Prince William Sound or 40 and 33 percent respectively.

Survey results from other areas cannot be compared directly to Prince William Sound data because of variation in the physical nature of the habitat, type of aircraft used, and time of surveys. Although the three Amchitka Island aerial surveys listed in Table 10 extend over a period of 16 years, the variation in counts from different aircraft corresponds to that described for Prince William Sound. The 1943 air survey with the Naval reconnaissance aircraft produced the highest count of the surveys. Both the pilot, G. T. Joynt, and observer, Frank L. Beals, were accustomed to observing sea otter, and had conducted preliminary flights to become familiar with distribution patterns and survey techniques. The survey with a Grumman Widgeon in 1949 was conducted with less care and experience by pilot and observers. The Douglas DC 3 survey in 1959 benefited from highly skilled pilots (Theron Smith and Jim Tilford) and observers (Karl W. Kenyon and David L. Spencer) but, I believe, was hindered by the large aircraft. Estimates based on the 1943 flight are nearly identical with estimates of the aboriginal population and the extrapolation of my 1956 shoreline survey. I believe the shoreline count to be quite precise for the surveyed area; and the extrapolation of this count to all of Amchitka should not be much in error, because spot checks were made in areas I did not survey to determine the relative abundance of otter there (Lensink, 1956). Although mortality of sea otters on Amchitka is unusually high, and the reproductive rate appears to be lower than in less crowded areas, there is no evidence for so drastic a reduction in the population as suggested by the 1959 air survey. The evidence from other areas of poorer results with the Grumman Widgeon (although much smaller, slower and more maneuverable than the DC 3) than the Cessna 180, or with survey conditions deviating even slightly from optimum, suggests that the 1959 estimates are considerably lower than the actual population.

A review of the factors that may affect the results of sea otter surveys include: Type of aircraft. Counts may be reduced as much as 30 to 40 percent when larger aircraft are used. Weather conditions. Even slight deviations from optimum (smooth water and overcast sky) may reduce counts by as much as 15 to 20 percent. Any roughness of the water should be considered an intolerable survey condition. Observers. Observers vary in experience and natural ability, and thus may differ in the proportion of the population they count. Distribution of animals.

Kenyon and Spencer (1960) assumed that most animals are found within one mile of shore or offshore reefs. Such distribution cannot be relied upon, and on many surveys a large number of animals, frequently the majority, have been found some distance from land. Animals found offshore tend to occur in compact groups which are easily missed on routine surveys. The number of animals in offshore waters will vary with the physical features of the habitat, particularly the width of the shallow zone surrounding the shore. Range of vision. The range of accurate observation is probably more limited than usually assumed, particularly when kelp, debris, birds or other marine animals are present to obscure outlines, or take up too much of the observer's time or attention. Animals at the margins of the field of view or near the shoreline are most likely to be missed. Failure to observe pups. Pups can rarely be counted on aerial surveys, particularly when many animals are present in a small area. Pups may form 10-20 percent of the population. Foraging otters. Kenyon and Spencer (1960) assumed that roughly 25 percent of animals in the flight path will be submerged and hence will be missed during surveys.

In view of the many factors which may act to decrease counts, I believe it is optimistic to assume that more than half of the animals present have been counted. However, for the present objectives of management we favor the more conservative estimates (counts equal half to three quarters of the population) as given in this thesis or by Kenyon and Spencer (1960). Even if these estimates are low, they do not seriously affect the evaluation of population status.

SEX AND AGE DETERMINATION

The sex and age distribution of sea otter populations is not geographically random. Although it was possible under field conditions to identify the sex and age of a sufficient number of individuals to provide a general understanding of the sex and age segregation that occurs, these observations did not provide the precise information on sex and age composition essential for evaluation of reproduction, mortality, and other facts of biology. Field identifications of sex may be made on the basis of various anatomical or morphological features and behavior (Table 13). These features, however, are satisfactory only for optimum conditions of observation, and many animals could not be classified. Frequently this unclassified segment amounted to a large majority of the animals observed.

Approximately 400 skulls of sea otters were found on Amchitka shores between 1949 and 1956. The sex of about half of these skulls could be identified with certainty from remains of animals from which they came. However, because the sex ratio of animals for which sex could be identified was biased toward males, it was necessary to find a means of determining sex and age from the skulls.

Although in sea otters there is marked difference in size between the sexes, and rapid growth continues to at least three years, polymodal distributions do not clearly show sex or age differences except for size variation separating adult males and females. The lack of distinct modes results from the fact that births may occur throughout the year, and distinct age classes as exist for most other species are lacking. As known-age specimens were not available, only broad age groups have been assigned: 1. pups, or those young which on the basis of field observations are dependent on the adult female; 2. sub-adults, which no longer need parental care but are not capable of reproduction; and 3. adults, or sexually mature individuals. In addition, pup and sub-adult groups have been divided into Classes I to IX on the basis of skeletal and dental development to demonstrate size variation between the sexes and to facilitate determination of sex. The provisional age classes as described in Table 14, thus, serve also as a description of development. The estimate for the interval covered by each age class is based on intuitive reasoning from field observations and thus may be subject to error.

The best criterion of sex was found to be the measurement of the upper canine's greatest width for which there was no overlap in a total of 60 Age Class VI or older specimens of known sex (Table 15). As in the case of other measurements, the sex differences were most apparent for adults. Animals younger than Class VI do not have sufficiently well developed canines to permit accurate identification of sex. My results generally confirm Scheffer (1951).

Measurements of canine width taken at the gumline instead of at the widest point provide a satisfactory sex criterion for adults and older sub-adults, but in animals of Class VII or younger, eruption of canines may not be completed and the resulting overlap of canine measurements is considerable (Table 16).

Frequency distributions for measurements of condylobasal length, zygomatic breadth, mastoid breadth, palatine length, rostral breadth, and skull weight are given in Tables 17 to 22. These distributions clearly indicate the smaller size of the female for all ages, but measurements of males and females overlap too greatly to assign sex categories. Adult males can be easily distinguished from immature males by the size of their bacula (Table 23), but among immature animals overlap of bacula weights between age classes precludes their use as an age criterion.

Despite overlapping of all measurements the repeated examination of individuals of known sex indicated that sex could nearly always be assigned for animals of all ages with complete confidence. Overlapping of measurements was caused by the complete range of possible ages within a class interval. Thus, if age classes are disregarded and sizes are compared with known sex skulls of identical development, females are almost invariably smaller. The differences are usually sufficiently great that a group of individuals can be quickly identified by sex without resorting to measurements.

Measurements for all Amchitka specimens are provided in Table 24. An explanation of measurements and their abbreviations follows. Numbers are Aleutian Island National Wildlife Refuge (AIWR) numbers giving annual accession number and last two digits for year of collection. Sex, male (M) and female (F) when enclosed in parenthesis were determined from measurements and are not definitely known. Ages are given as pup (P), sub-adult (S), and adult (A) with ages for pups and sub-adults further subdivided classes indicated by Roman numerals which are explained elsewhere in the text. Localities are all on Amchitka Island and include: Kirilof Bay (KB), Crown Reefer (CR), St. Makarius Bay (SMB), Kirilof Point (KP), Ivakin Point (IP), the west side of St. Makarius Point (SMW), the east side of St. Makarius Point (SME), Rifle Range Point (RRP), East Cape (EC), east of Ivakin (E of IP), and Constantine Harbor (CH). Manner of death is indicated as natural mortality (N), occurring while captive (C), or shooting (S). Natural deaths when known to have occurred one or more years previous to the time collections were made are indicated by "oN". Body measurements include total length in centimeters (TL), weight of healthy animals in pounds (W1), and weight of moribund animals or animals found dead (W2). Skull measurements include weight in grams (SW), condylobasal length (CBL), zygomatic breadth (ZB), rostral breadth at a position immediately above the alveolus of the canines (RB), interorbital breadth (IOB), postorbital constriction (POC), mastoid breadth (MB), palatine length (PL), greatest width of upper canine obtainable without extraction (UC1), and greatest width of extracted canine (UC2). All length and breadth measurements of skull features are in millimeters.

Table 13. Characteristics of Sea Otters that are Useful for Field Identification of Sex and Age.

Characteristic	Adults	Pups and Sub-adults
Color	Usually buff or grey face and head. Grey or silvery guard hair on throat and chest that is most noticeable on dry fur. Males frequently lighter than females.	Pups with light buff face and head, usually becoming darker at 8 - 12 months and in sub-adults.
Size	Males 55 - 80 and females 35 - 55 pounds. Males with larger and more muscular face, neck, and shoulders than females.	Pups 4 - 5 pounds at birth, increasing to about 20 pounds at one year. Larger sub-adults similar to adult females in size and body contour.
Genitalia	Penial eminence on males and abdominal mammary nipples on females clearly evident through wet fur when animal is floating or swimming on its back.	Penial eminence usually visible in males of about 6 months or older. Mammary nipples usually not evident.
Behavior	Males frequently swim on their bellies but females nearly always on their backs. Males usually more deeply submerged. Territorial males frequently inspect other animals in the territory.	Pups to at least 6 months of age swim and dive awkwardly. Older sub-adults are usually more active than adults. Tail frequently flips upeard when diving.

Table 13. Characteristics of Sea Otters that are Useful for Field Identification of Sex and Age.

Characteristic	Adults	Pups and Sub-adults
Associates	Territorial males usually alone or associated temportarily with a female, in the latter case frequently swimming to the rear. Females often accompanied by pups or sub-adults. Large aggregations are usually all males.	Pups and sub-adults usually with adult female. Older sub-adult males may join male aggregations, coversely older sub-adults with females are probably females also.

Table 14. Age Classification of Sea Otters [1].

Age Class	Probable Age	Skull and Dental Characteristics
Pups [2]		
I	Newborn	Dental formula: I 3/3, C 1/1, PM 1/2 = 22; all deciduous. In the upper jaw I 1 and I 2, and on the lower jaw I 1 are weak and probably non-functional. C 1/1 are only partially exposed. Cranium inflated and protruding over the zygomatic process of the squamosal, the mastoid process and the occipital condyles. Post-orbital processes distinct. Facial region short and jaws extremely swollen.
II	1 month	Dental formula: I 3/3, C 1/1, PM 2/3 = 26. All teeth on lower jaw are deciduous but on the upper jaws pI 1 and occasionally pI 2 have erupted. Cranium becoming triangular anteriorly, lengthening the facial region. Postorbital processes distinct, but breadth at post-orbital constriction much greater than the intraorbital breadth. Jaws still appear swollen.
III	2 - 3 mo.	Dental formula: I 3/3, C 1/1, PM 3/3 = 28. I 1-3 and PM 1 are permanent teeth although dPM 1 may persist anteriorly to pPM 1 in a separate alveolus. The deciduous canine on the upper jaw may be loose in its alveolus due to the growth and near eruption of the permanent canine. Facial region much lengthened, and the postorbital processes are pronounced. The breadth at the postorbital constriction is now approximately equal the intraorbital breadth, and the swelling of the upper jaw no longer constricts the eye sockets. Mastoid processes are easily

Table 14. Age Classification of Sea Otters (cont.).

Age Class	Probable Age	Skull and Dental Characteristics
		visible when the skull is viewed from above, thus accentuating the triangular appearance of the cranium. Bones may be taking on a purple coloration from a dye injected with sea urchins.
IV	4 - 5 mo.	Dental formula: I 3/3, C 1/1, PM 3/3 = 28. Permanent canines erupting and milk canines have usually been lost. Milk premolars may have small cavities on crests. All (Amchitka) skulls with definite purple coloration. Mandibles at location of molars still swollen.
V	5 - 8 mo.	Dental formula: I 3/3, C 1/1, PM 3/3, M 1/2 = 34. Molars erupting and permanent canines nearly to their final position. Milk premolars (2, 3) may have deep cavities. Lower jaws depressed and still appearing swollen.
Sub-adults		
VI	9 - 15 mo	Dental formula as in Age Class V. Permanent canines appear fully erupted in most specimens and the molars have reached the approximate level of the milk premolars. On skulls with flesh removed, the milk premolars appear as caps on the erupting permanent premolars. Breadth at the post-orbital constriction visibly less than the intraorbital breadth on all specimens. Exoccipital-basioccipital suture usually fused, but still evident.
VII	16 - 24 mo.	Dental formula: I 3/3, C 1/1, PM 3/3, M 1/2 = 34. All Perma-

Table 14. Age Classification of Sea Otters (cont.).

Age Class	Probable Age	Skull and Dental Characteristics
		nent teeth in place. Insertion of temporal muscles on parietal about 1/4 inch from sagittal plane. Evidence of exoccipital-basioccipital suture nearly obliterated.
VIII	25 - 34 mo.	Insertion of temporal muscles on parietal bones has advanced to the sagittal plane. Lambdoidal crest forming. A slight ridge is forming on maxilla just above alveolus of canines.
IX	33 - 36 mo.	Sagittal crest forming between temporal muscles. Lambdoidal crest prominent. Basioccipital-basisphenoid suture fusing.
Adults	3 years or older.	Sagittal and lambdoidal crests prominent. the latter extending to the mastoid process. Basioccipital-basisphenoid suture fused. Surface of skull smooth and glossy. In older animals teeth may have become extremely worn and pitted from abrasion and cavities. Exostoses common on maxilla and premaxilla above alveoli of incisors and canines. Purple color of bones may decrease with advance in age.

1/ Ages listed are estimates which may be quite imprecise.

2/ Animals listed as pups are those believed to be still at least partially dependent on their mother. Sub-adults include all other sexually immature animals.

Table 15. Frequency Distribution of the Maximum Widths of Upper Canines.

	Frequency by Sex and Age Class[1]					
	Sub-adults[2]		Adults		Total	
mm.	F	M	F	M	F	M
6.0-.1						
6.2-.3						
6.4-.5						
6.6-.7						
6.8-.9						
7.0-.1	2				2	
7.2-.3	1				1	
7.4-.5	0				0	
7.6-.7	1				1	
7.8-.9	0				0	
8.0-.1	0				0	
8.2-.3	1				1	
8.4-.5	1		2		3+	
8.6-.7	0+		1		1	
8.8-.9	2		1		3	
9.0-.1	1		1+		2	
9.2-.3	1		2		3	
9.4-.5			3		3	
9.6-.7		1				1
9.8-.9		1				1
10.0-.1		4				4
10.2-.3		2				2
10.4-.5		2		2		4
10.6-.7		2*		1		3
10.8-.9		4		3		7*
11.0-.1		2		4*		6
11.2-.3		1		1		2
11.4-.5		3		4		7
11.6-.7		1		1		2
11.8-.9				1		1
12.0-.1						
TOTAL	10	23	10	17	20	40

1/ Mean frequencies are indicated by an asterisk (*) for males and a plus (+) for females.

2/ Includes only animals in Class VI or older.

Table 16. Frequency Distribution of Widths of the Upper Canines at the Gumline.

	Frequency by Sex and Age Class[1]					
	Sub-adults[2]		Adults		Total	
mm.	F	M	F	M	F	M
6.0-.1						
6.2-.3						
6.4-.5						
6.6-.7	2				2	
6.8-.9	2		1		3	
7.0-.1	0		1		1	
7.2-.3	1+		2		3	
7.4-.5	2		2+		4+	
7.6-.7	1		1		2	
7.8-.9	1		1		2	
8.0-.1	0	2	2		2	2
8.2-.3	1	4			1	4
8.4-.5		5				5
8.6-.7		4*				4
8.8-.9		2				2*
9.0-.1		4				4
9.2-.3		1		1		2
9.4-.5		2		2*		4
9.6-.7				3		3
9.8-.9						
10.0-.1						
TOTAL	10	24	10	6	20	30

1/ Mean frequencies are indicated by an asterisk (*) for males and a plus (+) for females.

2/ Includes only animals in Class VI or older.

Table 17. Frequency Distribution of Condylobasal Lengths.

	Frequency by Sex and Age Class[1/]									
	V		VI		VII		VIII - IX		Adults	
mm	F	M	F	M	F	M	F	M	F	M
103	1									
104	1									
105	1									
106	0									
107	0	1	1							
108	0	0	0							
109	0+	0	0							
110	1	1	1	1						
111	4	0	0	1	1					
112	2	1	4+	1	3					
113		1*	0	0	1					
114		1	0	3	0	1				
115		1	1	4	4+	0				
116		0	3	2*	2	4				
117		1		7	0	1				
118				2	2	2	1	1		
119				1	0	5	1	0		
120				3	2	6*	0+	1	3	
121					0	4	0	3	0	
122					1	5	1	0	1	
123						1		1	1	
124						0		4*	0	
125						3		1	0	
126						1		1	0	
127								2	5	
128								0	0+	
129								0	4	
130								0	4	
131								1	3	1
132									3	1
133									1	1
134									1	6
135									1	0
136										7
137										6
138										3*
139										2
140										6
141										4

Table 17. Frequency Distribution of Condylobasal Lengths (cont.).

	Frequency by Sex and Age Class									
	V		VI		VII		VIII - IX		Adults	
mm.	F	M	F	M	F	M	F	M	F	M
142										3
143										1
	10	7	10	25	18	45	1	2	27	41

1/ Mean frequencies are indicated by an asterisk (*) for males and a plus (+) for females.

Table 18. Frequency Distribution of Zygomatic Breadths.

	Frequency by Sex and Age Class[1/]									
	V		VI		VII		VIII - IX		Adult	
mm.	F	M	F	M	F	M	F	M	F	M
75	1									
76	0									
77	0									
78	1	1								
79	1+	1								
80	2	0								
81	1	0	1							
82	3	0	1	1						
83		2	2+	0	2					
84		2*	2	2	4	1	1			
85		2	1	7	3+	1	0			
86		1		4*	3	0	1+			
87		1		3	1	2	0			
88				8	1	5	0	2		
89				1	0	6*	1	5		
90					1	7		1*		
91					1	3		1		
92						5		3	2	
93						2		3	3	
94								1	0	
95									2	
96									1	
97									6+	
98									4	
99									5	
100									2	1
101									3	5
102										3
103										3
104										8
105										6*
106										5
107										3
108										3
109										2
110										1
	9	10	7	26	16	32	3	16	28	42

1/ Mean frequencies are indicated by an asterisk (*) for males and a plus (+) for females.

Table 19. Frequency Distribution of Mastoid Breadths.

	Frequency by Sex and Age Class[1/]									
	V		VI		VII		VIII - IX		Adults	
mm.	F	M	F	M	F	M	F	M	F	M
74	1									
75	2									
76	1									
77	3+		1							
78	3	2	1	1						
79	1	1	1	1						
80		2*	1+	3	3	1				
81		1	1	2	4	0				
82		1	0	2	2	1	1			
83		1	0	4*	3+	1	0	1		
84		1	1	5	0	5	0+	1		
85				8	1	4	1	0	1	
86				2	0	7*	1	2	0	
87				1	1	3		1	1	
88					2	7		2	4	
89						4		4	2	
90						1		1*	1	
91						1		2	3+	1
92						1		2	3	0
93								1	8	0
94								2	3	2
95								2	0	5
96								1	1	4
97										4
98										6*
99										2
100										5
101										5
102										0
103										2
104										1
105+										2
	11	10	6	29	16	36	3	22	27	39

1/ Mean frequencies are indicated by an asterisk (*) for males and a plus (+) for females.

Table 20. Frequency Distribution of Palatine Lengths.

	Frequency by Sex and Age Class[1]									
	V		VI		VII		VIII - IX		Adult	
mm.	F	M	F	M	F	M	F	M	F	M
44										
45										
46										
47	1									
48	0									
49	0		2							
50	4		1							
51	5+	2	0	2						
52	5	0	5+	1						
53		7	0	4	5	5				
54		5*	1	6	2	0			2	
55		0	2	6*	6+	8	1		2	
56		2	1	3	1	8	2+	1	0	
57		0		3	1	8*	1	4	3	
58		2		3	1	5		5	4	
59					1	3		3*	5	
60						2		3	4+	
61						3		0	11	1
62								3	8	14
63									1	4
64										10*
65										9
66										2
67										5
68										3
69										
70										
	15	18	12	28	17	42	4	19	40	48

1/ Mean frequencies are indicated by an asterisk (*) for males and a plus (+) for females.

Table 21. Frequency Distribution of Rostral Breadths[1].

	Frequency by Sex and Age Class[2]									
	V		VI		VII		VIII - IX		Adult	
mm.	F	M	F	M	F	M	F	M	F	M
31.0-.4										
31.5-.9										
32.0-.4	1									
32.5-.9	0									
33.0-.4	2									
33.5-.9	1+				3					
34.0-.4	4		3		1					
34.5-.9	1		1		3		1			
35.0-.4	1	1	2+	1	2		1		2	
35.5-.9		0	1	0	1+		0		1	
36.0-.4		2	2	1	4		0+		1	
36.5-.9		2		3	1		0		0	
37.0-.4		1*		7	1	5	0		3	
37.5-.9		2		4*	0	4	1		2	
38.0-.4		2		4	1	6		3	4	
38.5-.9		0		3		5*		3	3+	
39.0-.4		1		3		7		5*	1	1
39.5-.9				0		3		2	2	0
40.0-.4				1		1		1	4	1
40.5-.9									2	1
41.0-.4									2	1
41.5-.9										2
42.0-.4										4
42.5-.9										1
43.0-.4										8*
43.5-.9										6
44.0-.4										4
44.5-.9										0
45.0-.4										3
45.5-.9										
	10	11	9	27	17	31	3	14	27	32

1/ Measurements were taken about 3 mm. above the alveolus of the canines

2/ Mean frequencies are indicated by an asterisk (*) for males and a plus (+) for females.

Table 22. Frequency Distribution of Skull Weights.

	Frequency by Sex and Age Class[1]									
	V		VI		VII		VIII - IX		Adult	
Grams	F	M	F	M	F	M	F	M	F	M
75- 79										
80- 84	1	1								
85- 89	1	0								
90- 94	0	1								
95- 99	1	0	2	2	1					
100-104	2+	1*	1	1	3					
105-109	3	1	3+	1	4					
110-114	1	1	1	5	3+					
115-119		1		5*	3	5				
120-124				5	1	9	2	1	1	
125-129				3	1	4*	0	0	0	
130-134				1	2	8	0+	2	2	
135-139					1	2	0	7*	2	
140-144						2	0	2	6+	
145-149						1	0	1	6	
150-154							1	2	1	
155-159								1	2	1
160-164									2	1
165-169										1
170-174										3
175-179										2
180-184										7
185-189										5
190-194										4*
195-199										2
100-204										2
205-209										4
210-214										11
215-219										1
220-222										1
225-229										
	9	6	7	23	19	31	3	16	22	36

1/ Mean frequencies are indicated by an asterisk (*) for males and by a plus (+) for females.

Table 23. Frequency Distribution of Bacula Weights.

Grams	IV	V	VI	VII	VIII-IX	Adult
1	1	3				
2		7	13	4		
3			7	15		
4			2	11	5	
5				1	12	
6					1	
7						
8						
9						
10						
11					1	
12						
14						
15						
16						
17						1
18						0
19						1
20						3
21						1
22						2
23						2
24						4
25						2
26						4
27						6
28						0
29						1
30						1
TOTALS	1	10	22	31	19	28

Table 24. Measurements of Sea Otters from Amchitka Island, 1953 - 1956.

Number	Sex	Age	Date	Locality	Death	Body Measurements W-1	W-2	TL	SW	CBL	ZB	Skull Measurements RB	IOB	POC	MB	PL	UC-1	UC-2	Bacula Weights
1-53	M	S VI	1/30/53	KB	C	25	-	105	110	120	89	38.7	38	34	84	58	-	-	2.9
2-53	M	A	1/31/53	CR	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-53	M	A	1/53	CR	N	-	-	-	172	134	102	41.0	41	32	91	62	-	-	20.8
4-53	(M)	A	1/53	CR	N	-	-	-	170	137	100	-	40	30	92	65	-	-	-
5-53	M	A	2/1/53	CR	C	-	70	-	-	-	-	-	-	-	-	-	-	-	-
6-53	M	A	2/4/53	CR	C	76	-	143	214	139	107	-	44	31	112	68	-	-	26.3
7-53	(F)	A	2/53	SMB	N	-	-	-	145	130	98	-	37	26	92	60	-	-	-
8-53	M	A	2/27/53	IP	C	-	-	-	-	-	-	-	-	-	-	-	-	-	25.3
9-53	M	A	3/3/53	KB	C	-	52	137	181	134	105	42.8	40	31	95	64	-	-	-
10-53	F	A	3/3/53	KB	C	-	38	129	-	129	99	-	39	31	90	63	-	-	-
11-53	F	P V	3/3/53	KB	C	-	-	-	81	107	79	33.7	33	32	75	50	-	-	-
12-53	(F)	P V	3/53	KP	N	-	-	-	-	-	81	38.0	34	33	77	-	-	-	-
13-53	(F)	S VII	3/53	KB	N	-	-	-	113	117	85	34.5	36	30	82	56	-	-	-
14-53	(M)	A	3/53	CR	oN	-	-	-	-	134	100	-	40	32	94	62	-	-	-
15-53	M	S VIII	3/53	SMW	N	-	-	-	149	127	92	39.8	39	33	88	62	-	-	6.1
16-53	(F)	A	3/53	SMB	N	-	-	-	153	132	97	-	40	27	94	61	7.2	-	-
17-53	(F)	S VI	3/53	SMB	N	-	-	-	102	116	84	37.5	35	32	82	55	-	-	-
18-53	F	S VI	3/53	SMB	N	-	-	104	-	116	84	35.0	37	34	80	55	6.9	-	-
19-53	M	A	3/53	CR	N	-	49	140	-	-	-	-	-	-	-	-	-	-	26.5
20-53	M	S VI	3/53	CR	N	-	21	99	108	112	84	36.3	34	35	83	55	-	-	2.5
21-53	(M)	S VIII	3/53	CR	N	-	-	-	147	125	91	42.2	35	33	89	61	-	-	-
22-53	M	A	3/53	CR	N	-	49	137	197	137	106	43.3	43	32	112	67	-	-	19.8
23-53	M	S VII	3/53	RRP	N	-	23	105	135	120	92	39.8	40	35	91	59	-	-	3.7

Table 24. Measurements of Sea Otters from Amchitka Island, 1953 - 1956 (cont.).

Number	Sex	Age	Date	Locality	Death	Body Measurements W-1	W-2	TL	Skull Measurements SW	CBL	ZB	RB	IOB	POC	MB	PL	UC-1	UC-2	Bacula Weights
24-53	M	P V	3/53	RRP	M	-	15	91	92	110	79	36.1	32	31	79	53	-	-	1.7
25-53	M	S	3/53	RRP	M	-	20	98	-	-	-	-	-	-	-	-	-	-	-
26-53	M	S VII	3/53	RRP	M	-	27	106	145	-	93	-	39	34	88	-	-	-	4.9
27-53	F	S VII	3/53	RRP	M	-	21	100	116	118	86	36.0	31	30	83	59	-	-	-
28-53	M	S	3/53	RRP	M	-	21	100	-	-	-	-	-	-	-	-	-	-	-
29-53	M	S VII	3/53	RRP	M	-	23	103	132	116	90	39.1	38	35	88	55	-	-	-
30-53	F	A	3/53	RRP	M	-	-	130	-	130	97	-	38	25	93	61	-	-	-
31-53	M	-	3/53	RRP	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32-53	(F)	A	3/53	RRP	M	-	-	-	149	129	99	40.6	38	25	92	60	-	-	-
33-53	(F)	A	3/53	RRP	M	-	-	-	150	126	102	37.0	40	27	90	59	-	-	-
34-53	M	S VI	3/53	SMW	M	-	20	96	115	115	85	38.2	35	32	84	55	8.7	-	2.5
35-53	M	S VIII	3/53	SMW	M	-	30	111	156	126	94	-	39	35	92	-	-	-	6.2
36-53	(F)	S	3/53	SMW	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37-53	M	S VII	3/53	SMW	M	-	-	-	130	122	-	-	38	34	87	57	-	-	4.1
38-53	M	S VI	3/53	SMW	M	-	-	-	110	114	85	37.0	38	35	79	-	-	-	2.7
39-53	F	A	3/53	SMW	M	-	39	128	-	133	97	-	36	23	89	61	-	-	-
40-53	(F)	S	3/53	SMW	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41-53	M	A	3/53	EC	M	-	57	142	188	142	107	-	44	27	99	66	-	-	24.6
42-53	M	S VII	3/53	EC	M	-	25	105	140	125	92	-	40	33	89	60	-	-	-
43-53	M	S	3/53	EC	M	-	-	103	-	-	-	-	-	-	-	-	-	-	-
44-53	(F)	S VII	3/53	EC	M	-	-	-	-	120	90	36.0	37	35	84	55	-	-	-
45-53	M	S VII	3/53	EC	M	-	-	-	132	121	89	37.8	39	35	84	57	-	-	4.2
46-53	F	P V	3/53	IP	M	-	15	92	91	111	80	34.4	33	32	75	51	-	-	-

Table 24. Measurements of Sea Otters from Amchitka Island, 1953 - 1956 (cont.).

Number	Sex	Age	Date	Locality	Death	Body Measurements			Skull Measurements										Bacula
						W-1	W-2	TL	SW	CBL	ZB	RB	IOB	POC	MB	PL	UC-1	UC-2	Weights
47-53	M	S	3/53	IP	N	-	-	100	-	-	-	-	-	-	-	-	-	-	2.8
48-53	(F)	A	3/53	IP	N	-	-	-	146	128	97	38.0	39	30	91	59	-	-	-
49-53	-	-	3/53	E of IP	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50-53	(F)	A	3/53	E of IP	N	-	-	-	164	132	101	41.5	40	27	94	60	-	-	-
51-53	M	S IX	3/21/53	CR	C	39	29	114	172	127	94	42.0	41	31	94	62	-	-	11.2
52-53	M	A	3/53	CR	N	-	-	-	192	141	105	45.0	43	29	101	68	8.1	-	26.9
53-53	M	S	3/53	CR	N	-	-	-	142	124	89	38.2	38	32	87	-	-	-	-
54-53	(F)	A	3/53	CR	N	-	-	-	169	132	99	41.5	39	30	94	61	8.2	-	-
55-53	F	S VII	3/25/53	KP	C	26	20	-	108	116	84	36.3	35	31	83	54	-	-	-
56-53	M	P IV	3/53	KP	N	-	14	94	102	109	82	31.2	35	35	78	51	-	-	-
57-53	M	S VII	3/53	RRP	N	-	23	101	117	119	87	38.0	37	33	84	58	-	-	-
58-53	M	S VII	3/53	RRP	N	-	38	124	115	119	88	38.6	37	33	83	57	8.8	-	2.7
59-53	F	S VII	3/53	RRP	N	-	-	-	104	112	83	34.5	35	31	80	55	-	-	-
60-53	F	S VII	3/53	RRP	N	-	-	-	108	113	85	34.5	37	31	81	55	-	-	-
61-53	(F)	-	3/53	RRP	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-
62-53	F	A	3/53	KB	N	-	-	-	144	127	98	37.3	38	29	88	60	-	-	-
63-53	(F)	A	3/53	SMB	oN	-	-	-	-	129	97	-	39	27	88	62	-	-	-
64-53	F	S VII	3/53	SMB	N	-	-	-	104	115	84	35.0	35	31	81	55	7.0	-	-
65-53	F	-	3/53	SMB	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-
66-53	(F)	S VII	3/53	SMW	N	-	-	-	112	119	86	37.0	37	31	84	56	-	-	-
67-53	M	S VII	3/53	SMW	N	-	-	-	123	119	91	38.7	37	34	87	59	-	-	2.4
68-53	M	A	3/53	SMW	N	-	60	144	192	137	108	44.0	42	29	101	67	-	-	20.1

Table 24. Measurements of Sea Otters from Amchitka Island, 1953 - 1956 (cont.).

Number	Sex	Age	Date	Locality	Death	Body Measurements W-1	W-2	TL	Skull Measurements SW	CBL	ZB	RB	IOB	POC	MB	PL	UC-1	UC-2	Bacula Weights
69-53	F	S	3/53	SMW	N	-	23	104	-	-	-	-	-	-	-	-	-	-	-
70-53	F	S VIII	3/53	SMW	N	-	24	105	132	119	89	37.5	38	34	85	56	-	-	-
71-53	F	S VII	3/53	SMP	N	-	19	100	112	115	85	35.0	35	32	81	54	-	-	-
72-53	M	A	4/53	CR	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-
73-53	-	-	4/53	CR	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-
74-53	-	-	4/53	SME	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-
75-53	(M)	A	4/53	KB	N	-	-	-	-	128	102	-	39	27	92	63	9.1	-	-
76-53	(F)	A	4/53	KB	N	-	-	-	-	124	-	-	41	28	92	-	-	-	-
77-53	M	S	4/53	SMB	N	-	-	-	-	-	-	-	-	-	-	-	-	-	4.1
78-53	M	-	4/53	RRP	N	-	-	-	-	-	-	-	-	-	-	-	-	-	--
79-53	M	-	4/53	CH	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80-53	(F)	A	4/53	CH	oN	-	-	-	-	-	-	39.0	38	32	-	62	-	-	-
1-54	M	A	2/54	CR	C	70	68	138	199	138	104	44.1	43	29	97	65	8.4	-	-
2-54	-	-	2/54	CH	oN	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-54	M	S VII	2/54	CR	C	25	-	106	134	118	90	38.5	37	32	86	56	8.4	-	-
4-54	M	S VII	2/54	CR	C	-	26	-	125	118	89	37.1	36	32	85	55	8.0	-	-
5-54	M	S VII	2/54	CR	C	33	-	-	133	122	91	38.5	36	33	85	58	-	-	-
6-54	F	A	2/54	CH	S	50	-	-	-	-	-	40.0	-	-	-	-	7.5	-	-
7-54	M	S VII	2/54	CR	S-C	31	30	-	134	122	88	37.0	35	30	88	58	-	-	-
8-54	F	A	2/54	RRP	C	48	44	-	147	130	99	38.0	40	25	96	61	7.4	-	-
9-54	M	S VI	2/54	RRP	C	28	25	98	120	117	86	38.0	38	35	83	58	8.5	-	-
10-54	F	S	2/54	RRP	C	20	-	-	-	-	-	-	-	-	--	-	-	-	-

Table 24. Measurements of Sea Otters from Amchitka Island, 1953 - 1956 (cont.)

Number	Sex	Age	Date	Locality	Death	Body Measurements W-1	W-2	TL	Skull Measurements SW	CBL	ZB	RB	IOB	POC	MB	PL	UC-1	UC-2	Bacula Weights
11-54	F	A	2/54	RRP	M	-	-	-	146	129	99	37.3	41	24	93	61	7.3	-	-
12-54	(F)	A	2/54	RRP	M	-	-	-	155	127	97	-	39	25	92	59	-	-	-
13-54	(F)	A	2/54	RRP	M	-	-	-	172	134	102	38.7	40	29	96	63	7.3	8.5	-
14-54	F	P V	2/54	RRP	M	-	18	96	102	111	80	34.5	34	32	78	52	-	-	-
15-54	M	S VI	2/54	RRP	C	24	-	105	122	115	88	38.0	36	34	86	55	-	-	3.9
16-54	F	S	2/54	RRP	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-54	M	A	2/54	CH	S	82	-	144	207	-	104	44.2	44	25	-	67	-	-	-
18-54	M	S VI	2/54	CH	C	25	-	100	124	114	85	37.0	37	34	84	54	-	-	3.3
19-54	M	A	2/54	SMB	M	-	60	144	167	136	104	39.3	39	29	94	61	-	-	20.4
20-54	F	P V	2/54	SMB	M	-	13	75	86	105	78	32.4	33	33	72	50	-	-	-
21-54	M	S VI	2/54	RRP	M	-	-	-	115	117	85	37.0	35	30	82	54	-	-	3.1
22-54	F	A	2/54	CH	S	43	-	135	-	-	-	-	-	-	-	-	-	-	-
23-54	M	S VI	2/54	SMW	M	-	23	100	114	119	85	36.9	38	33	85	57	-	-	3.3
24-54	F	S VI	2/54	SMW	M	-	20	101	111	115	84	34.4	34	33	79	54	7.5	-	-
25-54	M	S VII	2/54	SMW	M	-	25	110	135	123	90	38.0	36	34	86	61	-	-	5.5
26-54	M	A	2/54	SMW	M	-	-	-	160	132	101	40.5	40	28	94	62	-	-	21.0
27-54	M	S VI	2/54	CH	C	22	17	99	119	116	81	36.8	37	33	80	53	-	-	3.9
28-54	M	S VII	2/54	RRP	C	25	-	-	-	-	-	-	-	-	-	-	-	-	-
29-54	F	A	2/54	CH	S	39	-	126	-	-	97	35.6	38	29	91	57	6.8	-	-
30-54	F	P I	2/54	CH	C	4.3	-	57	26	76	58	26.3	27.3	33	53	35	-	-	-
31-54	M	S VII	2/54	SME	M	-	27	110	140	121	92	39.3	39	35	89	59	-	-	5.7
32-54	(F)	S VII	2/54	IP	oM	-	-	-	-	115	86	37.2	37	35	84	57	7.8	-	-
33-54	(M)	S VI	2/54	CH	M	-	-	-	-	-	84	35	34	34	81	52	8.5	9.6	-

Table 24. Measurements of Sea Otters from Amchitka Island, 1953 - 1956 (cont.).

Number	Sex	Age	Date	Locality	Death	Body Measurements			Skull Measurements										Bacula
						W-1	W-2	TL	SW	CBL	ZB	RB	IOB	POC	MB	PL	UC-1	UC-2	Weights
34-54	(F)	S VII	2/54	CH	oM	-	-	-	-	120	-	37	36	33	87	55	7.3	8.4	-
35-54	(F)	A	2/54	IP	oM	-	-	-	-	130	-	-	45	28	92	-	-	-	-
36-54	(F)	A	3/54	IP	oM	-	-	-	-	130	101	40	39	27	93	61	7.4	8.8	-
37-54	M	S VII	3/54	CR	M	-	31	--	132	125	92	39.5	35	32	90	60	8.4	-	3.5
38-54	F	A	3/54	RRP	M	-	31	103	144	129	98	39.7	41	29	92	62	-	-	-
39-54	M	S VIII	3/54	RRP	M	-	-	-	123	120	89	39.0	39	34	86	57	-	-	4.2
40-54	F	P V	3/54	RRP	M	-	12	87	95	103	75	33.0	34	35	71	47	6.8	7.3	-
41-54	(F)	P V	3/54	SMB	M	-	-	-	108	113	83	35	33	31	81	53	-	-	-
42-54	(F)	A	3/54	SMB	M	-	-	-	132	127	95	37	37	25	90	59	-	-	-
43-54	M	S VI	3/54	SMB	M	-	22	101	126	118	88	37.8	37	34	85	56	9.1	10.7	4.3
44-54	F	S VII	3/54	SMB	M	-	20	100	111	115	86	33.7	35	32	83	56	-	-	-
45-54	M	S VIII	3/54	SMW	M	-	-	-	140	-	92	38.3	37	32	89	58	-	-	7.0
46-54	M	S VIII	3/54	SMW	M	-	-	-	144	118	88	38.0	37	34	86	58	9.5	-	5.9
47-54	M	A	3/54	SMW	M	-	-	-	182	133	103	41.0	40	27	98	62	9.7	-	27.2
48-54	F	S VIII	3/54	SMW	M	-	22	101	123	118	84	35.1	33	32	82	55	-	-	-
49-54	M	S VIII	3/54	CH	M	-	24	109	142	121	91	39.7	38	35	83	57	-	-	4.3
50-54	M	S VII	3/28/54	CH	S	28	-	108	126	121	87	37.0	38	33	84	57	8.7	-	3.2
51-54	M	S VIII	3/29/54	CH	S	36	-	121	-	-	96	40.0	39	33	94	62	-	-	6.2
52-54	F	S VII	3/54	RRP	M	22	-	79	126	118	88	36.3	35	32	85	57	-	-	-
53-54	(F)	S VII	4/54	EC	M	-	-	-	125	123	94	38	37	35	86	58	7.9	-	-
54-54	(M)	A	4/54	EC	M	-	-	-	-	131	105	-	42	32	99	63	-	-	-
55-54	M	S VIII	4/54	EC	M	-	-	-	139	121	90	38.5	38	32	89	56	-	-	4.6
56-54	M	S VI	4/54	EC	M	-	-	-	126	117	87	37.4	38	33	86	54	8.7	-	4.6

Table 24. Measurements of Sea Otters from Amchitka Island, 1953 - 1956 (cont.).

Number	Sex	Age	Date	Locality	Death	Body Measurements W-1	W-2	TL	Skull Measurements SW	CBL	ZB	RB	IOB	POC	MB	PL	UC-1	UC-2	Bacula Weights
57-54	M	S VI	4/54	EC	N	-	-	-	132	118	88	37.8	36	36	87	55	-	-	2.9
58-54	M	P V	4/54	EC	N	-	-	-	83	107	78	35.4	35	33	71	-	9.0	11.9	2.2
59-54	M	S VII	4/54	EC	N	-	-	-	141	125	92	39.4	37	33	89	61	-	-	3.5
60-54	M	S VI	4/54	EC	N	-	-	-	125	117	87	38.7	38	35	84	57	7.1	-	3.5
61-54	F	S VII	4/54	EC	N	-	16	101	106	112	85	34.1	33	31	82	55	7.2	-	-
62-54	M	S-A IX	4/54	EC	N	-	31	122	156	131	93	40.2	36	31	92	62	9.1	10.0	6.5
63-54	M	S VII	4/54	EC	N	-	-	-	143	122	89	39.1	38	35	88	57	-	-	4.3
64-54	(F)	A	4/54	EC	N	-	-	-	154	128	98	39.0	40	29	92	61	-	-	-
65-54	M	S VI	4/15/54	CH	C	-	22	-	118	116	85	38.3	38	34	83	54	-	-	-
66-54	M	A	4/54	KB	N	-	49	142	185	137	104	43.5	41	28	98	66	-	-	24.1
67-54	(F)	A	4/54	KB	N	-	-	-	162	130	99	40.0	38	27	93	62	-	-	-
68-54	M	A	4/54	KB	N	-	-	-	181	136	103	44.1	41	29	98	65	-	-	26.0
69-54	F	S	4/54	KB	N	-	-	-	121	126	93	37.0	37	27	87	59	-	8.4	-
70-54	(F)	A	4/54	CH	N	-	-	-	-	-	-	-	-	-	-	-	7.8	9.2	-
71-54	F	A	4/54	CH	N	-	40	138	145	135	100	41.0	40	25	94	65	-	-	-
72-54	(F)	A	4/54	SME	oN	-	-	-	-	128	-	-	39	26	93	61	7.6	8.4	-
73-54	(F)	S VII	4/54	SME	N	-	-	-	119	117	84	36.0	37	32	82	54	-	-	-
74-54	M	S VI	4/54	SME	N	-	-	-	118	114	86	36.8	36	33	83	54	8.3	-	2.2
75-54	M	S VII	4/54	SMW	N	-	-	-	162	126	93	40.0	38	34	92	61	-	-	3.9
76-54	M	S VII	4/54	CH	N	-	-	-	130	120	89	37.8	34	32	88	57	-	-	4.8
77-54	F	A	4/54	CH	N	-	-	-	137	131	99	42.0	41	26	92	62	-	8.7	-
78-54	(F)	S VII	4/54	RRP	N	-	-	-	139	120	86	-	38	34	87	57	-	-	-
79-54	M	S VI	4/54	SMB	N	-	20	100	119	115	85	37.3	35	32	81	54	-	8.1	3.3

Table 24. Measurements of Sea Otters from Amchitka Island, 1953 - 1956 (cont.).

Number	Sex	Age	Date	Locality	Death	Body Measurements W-1	W-2	TL	Skull Measurements SW	CBL	ZB	RB	IOB	POC	MB	PL	UC-1	UC-2	Bacula Weights
80-54	F	A	4/54	SMB	N	-	-	134	133	127	99	37.5	37	26	88	62	7.5	9.5	-
81-54	(M)	A	4/54	SMB	oN	-	-	-	-	135	104	-	45	26	95	60	-	-	-
82-54	M	S VI	4/54	SMB	N	-	-	-	122	117	88	37.8	37	34	85	57	-	-	2.9
83-54	M	S VIII	4/54	SMW	N	-	-	-	141	124	93	39.0	37	32	89	57	-	-	6.0
84-54	F	S VI	4/54	CH	N	-	76	100	98	112	83	34.0	34	32	80	52	6.7	-	-
85-54	-	P	4/54	SMB	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86-54	M	S	4/14/54	CH	C	26.5	-	-	-	-	-	-	-	-	-	-	-	-	-
1-55	M	P V	3/55	RRP	N	-	-	-	121	115	88	36.5	36	35	83	54	-	-	2.3
2-55	M	S VII	3/55	RRP	N	-	-	-	133	119	89	38.1	37	33	86	57	-	-	3.3
3-55	M	S VIII	3/55	RRP	N	-	-	-	143	125	93	38.1	38	35	91	57	-	-	5.5
4-55	F	S VI	3/55	RRP	N	-	-	-	107	112	85	35.0	36	34	81	50	-	-	-
5-55	M	S VIII	3/55	RRP	N	-	-	-	153	124	92	38.5	39	36	88	58	8.2	-	5.3
6-55	F	A	3/55	RRP	N	-	-	-	163	132	101	38.1	43	29	93	62	-	-	-
7-55	F	A	3/55	RRP	N	-	-	-	148	127	98	-	39	29	93	59	7.7	8.8	-
8-55	M	S VII	3/55	RRP	N	-	-	-	123	117	90	38.5	39	34	86	56	-	-	4.4
9-55	F	S VII	3/55	RRP	N	-	-	-	131	120	91	36.7	36	31	88	57	-	-	-
10-55	F	S IV	3/55	CH	N	-	-	-	84	104	78	30.6	32	33	73	49	-	-	-
11-55	F	A	3/55	CH	N	-	-	-	164	132	101	38.2	39	26	93	60	-	-	-
12-55	M	A	3/55	CH	N	-	-	-	191	137	102	42.2	40	29	95	65	9.5	10.8	22.1
13-55	M	P IV	3/55	CR	N	-	-	-	93	106	82	35.0	34	35	78	51	6.5	-	1.5
14-55	M	S VI	3/55	CR	N	-	-	-	123	120	88	38.7	36	33	85	58	-	-	3.0

Table 24. Measurements of Sea Otters from Amchitka Island, 1953 - 1956 (cont.).

Number	Sex	Age	Date	Locality	Death	Body Measurements W-1	W-2	TL	SW	CBL	ZB	Skull Measurements RB	IOB	POC	MB	PL	UC-1	UC-2	Bacula Weight*
15-55	M	A	3/55	CR	M	-	-	-	219	141	106	43.5	45	29	100	67	-	-	29.1
16-55	M	A	3/55	CR	M	-	-	-	188	134	101	43.5	41	28	96	65	-	-	22.5
17-55	M	A	3/55	CR	M	-	-	-	214	140	106	43.2	43	32	100	65	9.7	10.7	24.7
18-55	(F)	A	3/55	CH	M	-	-	-	-	-	102	-	42	26	90	-	-	-	-
19-55	M	S VIII	4/7/55	-	C	31	25	107	148	123	88	39.4	37	30	87	59	8.8	-	5.8
20-55	M	S VI	4/5/55	-	C	22	-	102	110	116	87	37.3	36	34	85	55	-	-	3.2
21-55	F	S VII	4/7/55	-	C	21	16	99	106	111	84	35.5	34	31	80	53	-	-	-
22-55	F	A	4/5/55	-	C	35	-	132	150	129	97	38.4	38	25	92	61	7.3	8.9	-
23-55	M	S VII	4/5/55	-	C	26	-	102	122	120	88	37.5	34	32	86	56	-	-	3.1
24-55	F	S VIII	4/7/55	-	C	25	20	104	120	122	86	34.9	36	32	83	56	-	-	-
25-55	M	S VII	4/5/55	-	C	25	-	102	126	116	89	37.3	38	34	85	57	7.2	-	4.3
26-55	F	S VII	4/7/55	-	C	23	19	104	112	116	86	34.5	36	32	82	54	-	-	-
27-55	(M)	S VI	4/55	-	M	-	-	-	116	119	87	37.9	36	32	86	56	-	10.9	-
28-55	(M)	S VIII	4/55	-	M	-	-	-	150	126	92	40.0	38	33	91	61	8.2	9.4	-
29-55	(F)	S VII	4/55	-	M	-	-	-	108	117	88	36.8	35	32	83	57	-	-	-
30-55	(F)	S VII	4/55	-	M	-	-	-	102	118	86	36.4	34	32	84	56	-	-	-
31-55	(M)	S VII	4/55	-	M	-	-	-	129	123	90	39.0	37	34	87	60	-	-	-
32-55	(M)	S VII	4/55	-	M	-	-	-	136	122	91	39.5	38	35	89	58	-	-	-
33-55	(F)	S VII	4/55	-	M	-	-	-	114	116	87	35.0	34	31	84	52	-	-	-
34-55	(F)	S VII	4/55	-	M	-	-	-	122	124	88	38	36	30	86	57	-	-	-
35-55	(F)	P V	4/55	-	M	-	-	-	99	113	83	34.5	36	35	81	50	-	-	-
36-55	M	A	4/55	-	M	-	-	-	212	142	108	43.0	48	31	101	64	-	-	-
37-55	M	A	4/55	-	M	-	-	-	222	143	108	45.0	46	31	101	67	-	-	(32.7)

Table 24. Measurements of Sea Otters from Amchitka Island, 1953 - 1956 (cont.).

Number	Sex	Age	Date	Locality	Death	Body Measurements W-1	W-2	TL	Skull Measurements SW	CBL	ZB	RB	IOB	POC	MB	PL	UC-1	UC-2	Bacula Weight[a]
38-55	F	S VIII	4/55	-	M	-	-	-	132	123	92	39	37	30	85	57	-	-	-
39-55	F	A	4/55	-	M	-	-	-	140	132	98	39.5	39	27	94	-	7.9	9.4	-
40-55	M	S VII	4/55	-	M	-	-	-	121	114	84	37.7	36	30	80	53	-	-	4.6
41-55	M	S VI	4/55	-	M	-	-	-	112	111	86	39.1	35	35	82	52	-	-	2.6
42-55	M	S VII	4/55	-	M	-	-	-	122	121	91	39.4	36	33	89	58	8.7	10.3	3.7
43-55	M	S VII	4/55	-	M	-	-	-	124	122	90	39.0	37	36	88	58	9.4	10.4	4.2
44-55	M	S VI	4/55	-	M	-	-	-	99	115	82	37.6	36	33	80	53	8.5	9.8	2.9
45-55	(F)	P V	4/55	-	M	-	-	-	105	113	85	35.0	33	33	81	57	-	-	-
46-55	F	A	4/55	-	M	-	-	-	156	131	100	38.5	42	29	96	62	-	-	-
47-55	(F)	P V	4/55	-	M	-	-	-	92	109	82	34.4	36	33	78	52	-	-	-
48-55	(F)	S VII	4/55	-	M	-	-	-	123	121	90	37.0	35	31	88	57	-	-	-
49-55	(F)	S VII	4/55	-	M	-	-	-	112	118	87	36	32	31	83	36	-	-	-
50-55	(F)	S VII	4/55	-	M	-	-	-	125	118	90	36	39	33	82	58	-	-	-
51-55	M	A	4/55	-	M	-	-	-	182	137	104	43.1	42	25	98	65	9.3	11.5	27.5
52-55	F	A	4/55	-	M	-	-	-	204	133	-	40	40	30	92	60	-	-	-
1-56	F	S VI	4/56	-	(C)	-	17.5	105	108	116	83	35.5	35	32	81	52	-	-	-
2-56	F	S VI	4/56	-	(C)	-	16.5	97	98	112	81	34	32	30	77	52	-	9.1	-
3-56	M	P V	4/56	-	(C)	-	18.0	100	129	113	87	37.5	36	35	81	53	-	-	-
4-56	F	P V	4/56	-	(C)	-	14.5	93	-	112	78	33.3	34	34	78	51	-	-	-
5-56	F	P V	4/56	-	(C)	-	14.5	93	112	110	82	34	34	34	78	50	-	-	-
6-56	M	S VI	4/56	-	(C)	-	20.5	107	121	120	88	39	37	34	85	58	-	-	2.9
7-56	F	S VI	4/56	-	(C)	-	15.0	97	106	110	82	34.9	34	32	78	49	7.7	8.4	-

Table 24. Measurements of Sea Otters from Amchitka Island, 1953 - 1956 (cont.).

Number	Sex	Age	Date	Locality	Death	Body Measurements W-1	W-2	TL	SW	CBL	ZB	Skull Measurements RB	IOB	POC	MB	PL	UC-1	UC-2	Bacula Weight[a]
8-56	F	S VII	4/56	-	(C)	-	18.5	103	102	115	84	36	35	32	82	53	-	-	-
9-56	M	P V	4/56	-	(C)	-	18.0	97	109	112	85	39	34	34	78	54	-	-	1.6
10-56	F	S IX	4/56	-	(C)	-	27.5	116	145	123	93	37	36	31	91	57	-	-	-
11-56	F	S VI	4/56	-	(C)	-	14.0	96	107	111	81	36	33	32	76	51	-	-	-
12-56	F	S VII	4/56	-	(M)	-	18.0	98	99	112	83	33.7	33	31	81	53	6.7	7.1	-
13-56	F	P V	4/56	-	(M)	-	17.5	96	106	111	82	34.4	35	33	77	52	7.0	7.1	-
14-56	F	P IV	4/56	-	(M)	-	12.5	85	86	103	77	33.5	32	33	73	47	-	-	-
15-56	M	P V	4/56	-	(M)	-	16.5	94	-	112	83	37	34	32	78	51	-	-	-
16-56	F	A	4/56	-	(M)	-	36.0	137	140	134	101	41	40	26	94	62	-	-	-
17-56	(F)	A	4/56	-	(M)	-	30.5	128	149	127	99	37.8	37	28	88	60	-	-	-
18-56	M	S VII	4/56	-	(M)	-	-	-	120	120	89	38	35	32	85	55	-	-	3.7
19-56	(F)	A	4/56	-	(M)	-	-	-	154	134	99	41	39	27	95	62	-	-	-
20-56	M	P V	5/56	KB	M	-	-	-	-	-	83	37.5	36	34	80	56	-	-	1.9
21-56	(F)	P III	5/56	CC	M	-	-	-	-	-	71	30	31	34	68	44	-	-	-
22-56	M	S VIII	5/56	CC	M	-	-	-	-	-	89	38.5	35	32	84	59	-	-	4.4
23-56	M	P V	5/56	CC	M	-	-	-	-	-	84	36	35	34	79	53	-	-	2.1
24-56	F	A	5/56	SMPW	M	-	-	-	130	122	92	37	38	28	88	57	-	-	-
25-56	F	S VII	5/56	CH	M	-	-	-	122	120	87	37.1	39	34	86	55	8.2	8.9	-
26-56	F	A	5/56	CH	M	-	-	-	158	134	104	40.5	39	37	93	62	-	-	-
27-56	F	A	5/56	CH	M	-	26.2	119	121	120	92	35.4	36	29	85	54	-	-	-
28-56	(F)	A	5/56	KB	M	-	-	-	127	124	94	38.0	38	29	88	58	-	-	-
29-56	F	S VI	5/56	SMPW	M	-	-	-	103	116	-	36.0	33	30	84	56	-	-	-

Table 24. Measurements of Sea Otters from Amchitka Island, 1953 - 1956 (cont.).

Number	Sex	Age	Date	Locality	Death	Body Measurements W-1	W-2	TL	Skull Measurements SW	CBL	ZB	RB	IOB	POC	MB	PL	UC-1	UC-2	Bacula Weights
30-56	F	P V	5/56	SMW	N	-	-	-	105	112	82	35	35	31	79	52	-	-	-
31-56	F	P I	5/56	CH	N	2.2	-	48	13	63	47	22	23	-	42	29	-	-	-
32-56	M	P I	5/56	SME	N	2.6	-	47	18	66	51	23	24	32	46	31	-	-	-
33-56	F	A	5/56	SMW	S	55.5	-	134	145	130	97	38.5	41	28	95	60	-	-	-
34-56	F	A	5/56	SMW	S	42.0	-	124	135	122	92	38.6	36	29	90	55	-	-	-
35-56	F	A	5/56	RRP	N	-	-	-	148	130	95	40.0	38	28	91	61	8.0	9.2	-
36-56	M	S VIII	5/56	RRP	N	-	-	112	134	124	89	39.0	37	33	89	60	-	-	5.7
37-56	F	S VII	6/56	CR	N	-	-	-	136	122	90	38	36	33	88	55	-	-	-
38-56	M	A	6/56	CR	N	-	-	134	184	136	100	43.7	41	30	96	64	-	11.0	25.5
39-56	M	A	6/56	CR	N	-	-	135	177	138	105	43.2	40	27	100	64	-	-	24.4
40-56	M	A	6/56	CR	N	-	-	-	182	136	101	42.0	44	26	97	62	-	-	23.4
41-56	M	S VI	6/56	CR	N	-	-	-	103	110	84	38.8	36	33	78	51	-	-	2.2
42-56	M	P V	6/56	CH	N	-	-	-	100	114	85	38.0	34	34	80	53	-	-	2.0
43-56	M	S VII	6/56	CH	N	-	-	96	118	116	85	38.0	34	32	84	53	-	-	2.9
44-56	M	A	6/56	SMW	N	-	-	-	194	131	105	43	41	32	95	62	-	-	23.4
45-56	F	A	6/12/56	SMW	C-S	47	43	130	142	127	95	35	38	28	91	58	-	-	-
46-56	M	A	6/13/56	CH	N	76	-	137	202	136	109	43.8	43	31	100	64	-	-	-
47-56	F	S	6/56	CH	N	-	20	107	118	117	85	37	33	31	85	55	-	-	-
48-56	M	S VII	6/56	SMW	N	-	-	-	122	120	88	37.0	35	32	86	55	-	-	3.9
49-56	(F)	A	6/56	W of CR	N	-	-	-	130	127	94	36.0	37	25	93	61	-	-	-
50-56	M	A	6/23/56	SME	C	75	56	133	170	140	104	43.0	40	26	96	63	-	-	-
51-56	M	S VI	6/56	EC	N	-	-	-	99	117	87	37	33	32	84	53	-	-	2.2

Table 24. Measurements of Sea Otters from Amchitka Island, 1953 - 1956 (cont.).

Number	Sex	Age	Date	Locality	Death	Body Measurements W-1	W-2	TL	Skull Measurements SW	CBL	ZB	RB	IOB	POC	MB	PL	UC-1	UC-2	Bacula Weights
52-56	M	A	6/56	EC	M	-	-	-	205	136	106	45.1	41	32	95	62	-	-	27.1
53-56	M	S VI	6/56	EC	M	-	-	-	111	117	88	38.0	36	36	85	55	-	-	3.8
54-56	M	S VIII	6/56	EC	M	-	-	-	136	124	89	40	37	34	87	58	-	-	5.1
55-56	M	P V	6/56	EC	M	-	-	-	110	-	84	36	37	34	82	-	-	-	2.1
56-56	M	A	6/56	EC	M	-	-	-	186	138	106	43.6	45	30	95	65	9.7	11.7	27.6
57-56	(F)	P V	6/56	EC	M	-	-	-	99+	-	83	37.5	34	34	77	-	-	-	-
58-56	M	S VII	6/56	SB	M	-	-	-	119	120	88	39.6	37	32	84	56	9.0	10.0	4.5
59-56	(F)	A	6/56	CH	M	-	-	-	133	126	95	38.4	37	29	89	58	-	-	-
60-56	M	P V	6/56	CH	M	-	-	-	-	117	86	38.2	37	34	84	54	-	-	2.2
61-56	(M)	S VII	6/56	EC	M	-	-	-	-	124	88	39.2	37	35	87	56	-	-	-
62-56	(F)	P V	6/56	NW of EC	M	-	-	-	86	-	-	34.0	33	33	77	-	-	-	-
63-56	M	A	6/29/56	SME	C	72	50	136	182	136	102	42.0	43	26	96	62	-	-	-
64-56	M	S VII	6/29/56	W of RRP	M	-	-	-	127	114	90	39.0	37	35	87	53	-	-	3.9
65-56	M	S	6/29/56	W of RRP	M	-	-	-	-	-	88	39.0	37	33	87	-	-	-	4.1
66-56	(M)	S VI	6/29/56	W of RRP	M	-	-	-	-	-	88	39	39	34	85	-	-	-	-
67-56	(M)	A	6/29/56	W of RRP	M	-	-	-	148	132	102	39	38	25	95	62	-	-	-
68-56	(F)	A	6/29/56	W of RRP	M	-	-	-	143	124	97	38.4	37	28	89	58	-	-	-
69-56	F	A	6/29/56	W of RRP	M	-	-	-	174	130	99	39.2	38	26	95	59	-	-	-
70-56	M	A	6/29/56	CR	M	-	-	-	176	137	104	42.2	43	29	96	62	-	-	27.9
71-56	M	A	7/56	CP	M	-	-	-	207	140	107	43	44	30	97	64	-	-	32.7
72-56	(F)	A	7/56	W of CR	M	-	-	-	137	128	96	39	38	26	88	58	-	-	-
73-56	(F)	A	7/56	W of CR	M	-	-	-	-	122	95	39	38	30	89	59	-	-	-

Table 24. Measurements of Sea Otters from Amchitka Island, 1953 - 1956 (cont.).

Number	Sex	Age	Date	Locality	Death	Body Measurements W-1	W-2	TL	Skull Measurements SW	CBL	ZB	RB	IOB	POC	MB	PL	UC-1	UC-2	Bacula Weights
74-56	(F)	S VII	7/56	W of CR	N	-	-	-	109	117	84	37	35	32	83	54	-	-	-
75-56	M	S VI	7/56	W of CR	N	-	-	-	-	-	88	40	39	34	85	56	9.2	10.6	-
76-56	F	A	7/18/56	CP	S	49.5	-	130	135	131	96	37.8	41	24	95	61	-	-	-
77-56	F	A	7/18/56	CP	S	41.0	-	119	-	123	92	36	39	30	-	58	-	-	-
78-56	M	A	7/19/56	SME	C	74	53	139	185	134	105	41.7	41	29	98	63	-	-	27.1
79-56	F	A	7/20/56	SMW	C	53	37.5	131	136	127	99	40.5	38	29	93	59	8.0	8.4	-
80-56	M	A	7/26/56	SME	C	58	43	133	155	134	101	41.5	43	28	92	62	-	-	17.9
81-56	(F)	A	56	SMB	oN	-	-	-	-	-	91	-	42	31	89	-	-	-	-
82-56	(F)	A	56	RRP	oN	-	-	-	-	127	97	38	42	26	91	61	7.2	-	-
83-56	(M)	A	56	-	oN	-	-	-	-	133	100	-	44	29	96	62	-	-	-
84-56	(F)	A	56	-	oN	-	-	-	-	119	96	-	39	29	94	-	-	-	-
85-56	(M)	S VII	56	-	oN	-	-	-	-	-	88	39	36	32	86	-	-	-	-

VITA

VITA

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