Title: Population Assessment of the Prince William Sound Sea Otter Population

Study No.: 3

Submitted to: Restoration Planning Work Group

Principal Investigators: James L. Bodkin and Mark S. Udevitz

Study Period: 1, March 1991 to 1, March 1994

Lead Agency: U.S. Fish and Wildlife Service

Cost of Proposal: First Year; 176.6K

Cost Allocation:	R7 Oil Spill Restoration	150.0K
	R8 Sea Otter Research Project (research based funding)	26.6K

Date of Plan: 12, June 1991

Project Leader:

James L. Bodkin
Wildlife Biologist
(907) 786-3550

Supervisor:

Larry Pank
Chief, Mammals Branch, AFWRC
(907) 786-3434

Oil Spill Coordinator: Paul E Gertler 6/14/91

Paul Gertler, Chief
Office of the Oil Spill

Financial Officer: J Kehr 6/14/91

John Kehr, Budget Assistant
Office of the Oil Spill

Biometrician:

Mark Udevitz
Statistician (Biology)
(907) 786-3365

Address: U.S. Fish and Wildlife Service
Alaska Fish and Wildlife Research Center
1011 E. Tudor Rd.

1. INTRODUCTION

Initial damages to the sea otter population resulting from the T/V Exxon Valdez oil spill included lethal and sub-lethal levels of direct exposure. One method used to estimate the total immediate loss to the sea otter population in Prince William Sound was a comparison of estimates of sea otter abundance based on boat surveys conducted before and after the spill. Boat surveys were used to estimate sea otter density in 1989 and 1990 in order to be consistent with the method used before the spill.

Changes that may occur in the western Prince William Sound sea otter population following the initial mortality resulting from exposure to oil are unknown. Initial and chronic, sub-lethal exposure of sea otters to hydrocarbons through the environment or their prey base may cause population losses that will not become evident for many years. Alternatively, the removal of a large percentage of the western Prince William Sound sea otter population by the spill may release the survivors and immigrants from density dependent factors regulating sea otter density. It is likely that annual changes in post-spill density will be of a lesser magnitude than initial spill induced mortality.

Methods used in the past to obtain estimates of sea otter abundance and distribution include counts from the ground (Estes and Jameson 1988), small and large vessels (Jameson et al. 1982) and fixed (Ebert 1968, Simon-Jackson et al. 1986) or rotary wing (Douglas et al. 1990) aircraft, or a combination of two or more methods. Ground counts probably provide the most accurate estimates of nearshore sea otter abundance (Schneider 1971). Udevitz et al. (1990) determined that detection of sea otters in boat based surveys is reduced due to avoidance behavior of the otters as well as sightability problems. In addition to surveying sea otter abundance, boat surveys have been used to provide indices of reproductive rates in sea otter populations (Estes 1990).

Preliminary studies reported by Douglas et al. (1990) suggest that rotary-winged aircraft might be suitable as an observation platform. Schnieder (1971) suggests that rotary-winged aircraft surveys may provide counts two to four times greater than fixed-wing aircraft. However cost and saftey considerations of rotary-wing aircraft over water may preclude their wide spread use in sea otter surveys.

Fixed-winged aircraft may be the most cost effective and broadly applicable survey platform for sea otters. A float equipped, single engine aircraft should provide the necessary safety factor for surveying sea otter habitat that may occur considerable distances from shore. Aerial counts of sea otters have been used for several decades throughout their range. Kenyon (1969) felt aerial surveys provided higher counts than those obtained from small boats. Traditionally, fixed-winged surveys have been conducted without standardized protocols, using different aircraft (eg. DC-3, Grumman Goose) and procedures (eg. airspeed, altitude, number of observers, weather conditions, area surveyed, etc.). Aircraft speed has been identified as one of the most important variables in defining the probability of detection of an animal from the air (Caughley 1974). The Piper PA-18 "Super-Cub" has been selected repeatedly for wildlife survey work based on its slow stall speed and high degree of maneuverability (Erickson and Siniff 1964, LeResche and Rausch 1974, Gasaway et al 1986). It seats one pilot and one passenger in tandem, an arrangement recommended by Erickson and Siniff (1964) as allowing navigation and observation to occur from the same spatial orientation in the plane.

Line transect and strip transect methods are widely used in aerial surveys to estimate population density. They rely on being able to observe all of the animals in some region (e.g., on the line or in the strip) with a probability of 1.0. Due to otter behavior this is not possible using standard line or strip transect methodologies. To obtain valid density estimates, the standard methodologies would have to be supplemented with a technique to provide an estimate of the actual detectability of animals in some region covered by the survey. One approach could be for the plane to conduct circling maneuvers along the transect at intervals, searching a specified area at a level of intensity necessary to observe all of the otters and thus obtain an estimate of the proportion seen with the standard methodology. This approach depends on the ability to actually observe all of the otters in a specified area at some level of search intensity. We will evaluate the effect of this search intensity on sea otter detectability.

Another method of aerial survey we will evaluate, in terms of application to sea otters, involves estimating density based on systematically searching relatively large segments of habitat within a study area. This method, described by Gasaway et al. (1986) has been successfully used for estimating moose density from aerial surveys. The method involves an aerial search of sample units of moose habitat at a defined search intensity. A sub-sample of these units is searched at a higher intensity at which it is assumed that all moose are observed. We will evaluate the effect of search intensity on sea otter detectability using Gasaway et al. (1986) type search patterns. If it is possible to observe all of the otters in a sample unit with some search intensity, then we would be able to use that intensity on a sub-sample of units to adjust for detectability bias in a full survey (Gasaway 1985, Douglas et al. 1990).

The purpose of this study is to develop a survey methodology that will provide unbiased estimates of sea otter density and is applicable throughout the species' range. This will require a quantitative evaluation of factors contributing to detectabilities of less than 1.0 for sea otters from potential survey platforms. We will initially conduct a ground-truth study to assess sea otter detectability from a fixed-wing aerial platform under different search patterns, intensities and altitudes. If the aircraft and methodology tested in the first year proves to be effective, then information from the first year will be used to design a survey to be implemented in the second and third years. Otherwise, additional platforms and/or methodologies will be tested in the second year with the intent to design and implement a survey in the third year. Replication to provide information on variability over time will be obtained as a part of the second or third year's work and this information will be used to refine the design of subsequent surveys. Following development of the necessary methodologies, surveys will be initiated to monitor changes in the density of the Prince William Sound sea otter population and describe patterns of habitat use within the Sound.

Another purpose of this study is to begin a systematic survey of the western Prince William Sound sea otter population by boat to document annual rates of reproduction (Estes 1990). To accomplish this, we will design and implement a survey to provide annual estimates of pup to non-pup ratios for subpopulations in oiled and non-oiled portions of the western sound. Possible long term effects on reproduction will be monitored by comparing pup ratios in oiled and non-oiled regions.

<u>Objectives:</u>

<u>1991</u>

1) Evaluate the feasibility of using the Piper PA-18 aircraft as a sea otter survey platform.

2) Design and implement a small boat survey to estimate pup to non-pup ratios and describe patterns of habitat use by adult female sea otters with pups in oiled and non-oiled portions of western Prince William Sound.

<u>1992</u>

1) Develop a procedure for estimating the density of sea otters in Prince William Sound.

2) Implement an initial sea otter survey method in Prince William Sound.

3) Evaluate survey variability over time by replicating surveys within and between seasons.

4) Estimate pup to non-pup ratios in sea otters in oiled and non-

oiled portions of western Prince William Sound.

5) Compare patterns of habitat use by adult female sea otters with pups between nearshore and shallow offshore areas.

1993

1) Monitor trends in sea otter density and distribution in Prince William Sound.

2) Estimate pup to non-pup ratios in sea otters in oiled and non-oiled portions of western Prince William Sound.

3) Evaluate the application of the survey technique to an area or areas outside Prince William Sound.

This study plan addresses only 1991 objectives. 1992 and 1993 objectives are contingent on 1991 results and continued funding. Detailed study plans for 1992 and 1993 objectives will be developed, based on the results of this study plan.

Hypotheses

1. H_0: Altitude of survey platform has no effect on sea otter detectability.

2. H_0: Search intensity has no effect on sea otter detectability from an aerial platform.

3. H_0: The search pattern of an aerial platform has no effect on sea otter detectability

4. H_0: The pup to non-pup ratio does not differ between oiled and non-oiled areas in western Prince william Sound

Data Needs

The following data are critical to accomplishing objectives:

1. Detectability of sea otters as a function of survey altitude.

2. Detectability of sea otters as a function of search intensity.

3. Detectability of sea otters as a function of survey search pattern.

4. The number of sea otter pups and non-pups and their

location in a sample from oiled and non-oiled sea otter habitat in western Prince William Sound.

2. METHODS

Study Design

Year one study design will incorporate a replicated Latin square design controlling for time period and site, conducted in two phases. Time periods will be approximately half-days. Phase one will measure the effect of altitude and search intensity for the circling maneuver on a line transect. Each of three survey units will be flown at three altitudes over three half-day time periods, with 1 flight per unit per time period. The design will be replicated four times. Phase one will occur in May of 1991. Results of Phase one will provide direction in completing the design of Phase two.

Phase two will measure the effect of four search methods on sea otter detectability. These will consist of Gasaway et al. (1986) type search patterns at three intensities and the transect pattern with circling maneuvers. The altitude of these flights will be established based on the results of phase 1. Each of 4 survey units will receive each of the 4 methods over four half-day time periods, with one method per unit per time period. The design will be replicated 4 times. Phase two will occur in July of 1991.

Study Site Selection

Survey units will be selected in Prince William Sound based on the presence of sea otters and the lack of canopy forming kelps. These survey units must be adjacent to an accessible vantage point with an elevation greater than 3m that offers unrestricted visibility over the site. The size of each unit will be established based on the observation team's ability to count and locate with complete confidence all sea otters observed within its boundaries. Boundaries will be defined using prominent geographical features of the coastline such as offshore rocks, points of land and coves or bays. These boundaries will be accurately drawn on charts identical to those used by the air survey crew. The offshore boundary will be determined with range finders and navigational charts.

Ground Truth Crews

Ground truth crews will consist of two members each. At least one member of each team will have extensive experience in observing and counting sea otters with the use of Questar telescopes and binoculars, and will serve as the primary observer. The second team member will have some experience and training in sea otter observation. Ground observations will follow protocols established by Estes and Jameson (1988).

Ground Truth Procedures

Each crew will be transported to a survey unit at least one hour prior to the arrival of the aerial survey crew. The ground crew will approach the survey unit after a thorough study of the area from offshore to locate sea otters within the survey area. The ground crew, aboard the transport vessel, will approach the coastline in a manner to minimize disturbance to sea otters. Ground crews will be deployed outside the survey area and will walk into the observation site as far from the shore as possible. Every effort will be taken to minimize disturbance to the survey area. Timing of survey crew deployment will allow each crew a minimum of one hour to locate and map the position of each otter in the survey area. Ground crews will be responsible for defining the boundaries of their unit and establishing a circumference point for the aerial circling maneuver prior to the arrival of the survey craft. At 15 minute intervals and once immediately prior to survey craft arrival, ground crews will record the location, group size, and activity of each otter or group of otters. Activity categories will include resting, grooming, foraging, swimming or hauled out. High quality range finders will be used to determine the distance to each otter and distance to the unit boundaries. Ground crews will also record the location and behavior of all otters observed outside the boundaries of the unit, observations regarding changes in sea otter activity associated with the approach of the survey craft, the time the survey craft enters and departs the unit, and environmental conditions (wind speed/direction, cloud cover and tidal level and sea state).

Following the departure of the survey crew, the ground crew will call via hand held VHF radio for the transport vessel to pick them up and transport them to the next site. Each ground crew will survey two units per day.

Aerial survey procedures

Two search patterns will be evaluated. In one, the plane will follow a linear path along the edge of the survey unit, recording information about all otters observed in the unit. When the circumference point established by the ground crew is reached, the aircraft will circle on a .5 km radius inside the line. The information about any additional otters observed within this radius will be recorded separately. The circling will be continued until 5 minutes with no new otter sightings have elapsed.

The other search pattern will cover the entire unit following the general guidelines of Gasaway et al. (1986). The pattern used will depend on the shape of the unit, but will generally consist of a rolling spiral. Search intensity will be varied by decreasing the radius of the spirals and therefore increasing the time spent in the unit. Information about all otters observed in the unit will be recorded.

Information to be recorded by the aerial observer will include the location, time, group size and activity of each sea otter or group of sea otters observed. The aircraft pilot may assist in observations as flight responsibilities allow. Aircraft speed during the surveys will be maintained as close as possible to 55 mph. Survey activities will begin when ground observations indicate that most otters have resumed normal behavior following deployment of the ground crews and will continue throughout the day.

Caughley (1974) identified altitude as an important variable in defining detectability from aerial surveys. It is assumed that altitude will affect detectability similarly in both of the approaches. As altitude increases, above some minimum, sea otter detectability should decrease. At low altitudes, habitat will pass by too quickly to be adequately observed. Also, at low altitudes, avoidance behavior may become a problem. We will evaluate the effect of altitude on detectability to indicate the optimum altitude for surveys. Typically, aerial surveys of sea otters have been conducted from about 150 ft. to 300 ft. above sea level (Schneider 1971). We will evaluate the effect of this variable on detectability with the transect-circling pasttern at three altitudes (150 ft., 250 ft., and 350 ft.).

Several environmental variables are believed to effect the detectability of sea otters (Schneider 1971). Those tat will be recorded include time of day, wind velocity, wave height, swell height, cloud cover, precipitation, glare and elevation of the sun. While we will be unable to control these variables, we will only conduct surveys under those conditions considered to create good to excellent observational conditions, eg. wind < 8 knots, little or no surface chop, or poor visibility as outlined by Schnieder (1971) and Estes and Jameson (1988).

Reconciliation

At the end of each survey day, ground and aerial crews will compare the mapped locations of all observed otters. For the otters present in segment i, $i=1,\cdots,r$, when the craft arrived, the number observed by both crews (b_i), the number observed only by the ground crew (g_i), and the number observed only by the survey craft (s_i) will be determined. The number of otters in the segment before any response to the approaching survey craft (a_i) will be determined based on ground crew observations prior to the arrival of the survey craft. Resolution of apparent differences between aerial and ground maps will be facilitated by the recorded times and activities.

Reproduction and Distribution

Estimates of annual reproduction, as indicated by pup to non-pup ratios of sea otters and patterns of habitat use will be obtained from small (<10m) boat surveys. Surveys will be conducted once per year, in June or July, following the peak pupping period. We will survey from all heavily oiled and non-oiled nearshore habitat in western Prince William Sound within a continuous strip, .5 km wide, 250 m offshore and parallel to the shoreline. Additionally, shallow offshore habitat will be sampled with randomly placed transects of similar dimensions perpendicular to, and extending away from, the shoreline. Shallow offshore habitat will be defined by water depths < 50 fathoms extending more than 1 km offshore. Surveys will incorporate a random sampling design within the heavily oiled and non-oiled areas of western Prince William Sound. Each area will be divided into sample units of sea otter habitat from which samples will be drawn. Defnition of sample units and allocation of effort will be based on GIS analysis of bathymetry and oiling in western Prince William Sound. We anticipate sampling about 200 linear km of both heavily oiled and non-oiled shoreline. At a search intensity of about 80 km of shoreline per day, about 5 days effort would be required to complete the reproduction surveys.

Sampling methods will consist of classifying and mapping the location of each sea otter observed within each sample unit as either a dependent pup or a non-pup. Dependent pups will be defined as a sea otter smaller than an adult and in close association with an adult. This definition will include, but not be limited to, a pup in close physical contact, nursing, receiving food from, swimming with or being groomed by an adult sea otter. Non-pups will be defined as all other sea otters.

Surveys crews will consist of two observers, including the boat operator. Boat speed will be less than 15 mph. Surveys will be conducted only when viewing conditions are considered good or better (calm to light winds, sea state less than Beaufort 2). Observers will each have the use of high quality binoculars. Each otter or group of otters will be approached as close as necessary to accurately classify each sea otter as either a pup or non-pup prior to returning to the transect line.

Safety requirements:

All staff scheduled for aircraft survey work will have current basic aircraft safety, first aid, CPR and survival courses.

All staff scheduled for field work will have current first aid, CPR and survival courses.

3. INFORMATION REQUIRED FROM OTHER INVESTIGATORS

The successful completion of this study may depend on available information from past boat surveys of sea otters in Prince William Sound describing distribution and abundance.

4. DATA ANALYSIS

Estimation of detectability and its component probabilities will follow Udevitz et al. (1990). Detectability will be estimated separately for resting and active sea otters. The proportion of the otters that leave the segments in response to the approaching aircraft and are therefore not available to be counted (avoidance probability) will be estimated as

$$\hat{P}_a = \frac{\sum_{i=1}^{r} (a_i - b_i - s_i - g_i)}{\sum_{i=1}^{r} a_i}$$

with variance estimated as (following Cochran 1977; pg. 305)

$$Var(\hat{P}_a) = \frac{\sum_{i=1}^{r} (-b_i - s_i - g_i + a_i(1-\hat{P}_a))^2}{r(r-1)\overline{a}^2}$$

where

$$\overline{a} = \frac{\sum_{i=1}^{r} a_i}{r}$$

The proportion of the otters remaining in the segments while they are surveyed that are observed by the air crews (sighting probability) will be estimated as

$$\hat{P}_s = \frac{\sum_{i=1}^{r} b_i}{\sum_{i=1}^{r} m_i}$$

with variance estimated as

$$Var(\hat{P}_s) = \frac{\sum_{i=1}^{r} (b_i - m_i\hat{P}_s)^2}{r(r-1)\overline{m}^2}$$

where $m_i = b_i + g_i$ and

$$\overline{m} = \frac{\sum_{i=1}^{r} m_i}{r}$$

The proportion of the otters present in the segments before any response to the aircraft that are observed by the air crews during the survey (detection probability) will be estimated as

$$\hat{P}_d = \frac{\sum_{i=1}^{r} (b_i + s_i)}{\sum_{i=1}^{r} a_i}$$

with variance estimated by

$$Var(\hat{P}_d) = \frac{\sum_{i=1}^{r} (b_i + s_i - a_i \hat{P}_d)^2}{r(r-1)\bar{a}^2}$$

The sighting probability estimate is equivalent to the Peterson-type estimates used by Magnusson et al. (1978) for aerial surveys of crocodile nests and modified by Estes and Jameson (1988) for ground based surveys of sea otters. This estimate is based on the following assumptions:

1. The presence and activities of the ground crews do not affect the distribution or sightability of the otters.

2. The probability of observing an otter from shore is independent of the probability of observing it from the air.

3. Ground crews are able to make accurate determinations of ground truth segment boundaries and the locations of otters within those segments immediately before they exhibit any response to the aircraft.

4. Comparisons of otter location maps produced by ground and air crews will provide accurate determinations of b_i, g_i, and $s_i, i=1,\cdots,r$.

The estimates of avoidance and detection probabilities are extensions of these that assume all otters observed in a segment by an air crew were among the otters observed by the ground crew on that segment before or during the time when the aircraft was present. The detection probability represents the overall proportion of the otters detected by the air survey. It accounts for otters that leave the segment in response to the aircraft before the aircraft arrives as well as otters that are in the segment when the aircraft arrives but are not observed.

Latin square analysis of variance with appropriate transformation of the dependent variable will be used to assess the effects of altitude, pattern and intensity on detectability. The test for altitude effect will be based on the maximum detectability obtained during each set of circling maneuvers. The search intensity for the transect-circling pattern and the altitude for both search patterns to be used in phase 2 will be determined from phase 1 data. The circling maneuver is assumed to be similar enough to the maneuvers used in the Gasaway et al. (1986) search patterns, that the effect of altitude will be the same for both methods. Phase 2 will compare the transect-circling pattern with Gasaway et al. (1986) patterns at three intensities.

All hypothesis tests will be conducted at $\alpha=.05$. If differences in detectability are significant, then the levels with the highest detectability will be selected for further investigation. Where differences are not significant, the highest altitude (for safety considerations) and the most efficient pattern and intensity (based on time and fuel requirements) will be selected. Upon completion of each phase of field work, a power analysis will be conducted. If the power analysis indicates that there was less than a 20% chance of detecting a 5% difference in detectability, then the tests will be judged inconclusive and further research on that factor will be proposed.

Application of any of these approaches to sea otter surveys will rely on the assumption that all otters in specified circles or units are detected, using the selected altitude, pattern and intensity. Criteria for rejecting the selected method as unsuitable will be a normal theory test of the null hypothesis that the detection probability is greater than or equal to .90.

We will investigate the use of logistic regression to estimate detectability as a function of viewing conditions, otter activity and group size. Each of the sea otters or groups of otters observed by the ground crews will be treated as independent observations for the logistic regression.

Pup ratios for the oiled and non-oiled shallow offshore habitat will be obtained with standard ratio estimates and associated variance estimates (Cochran 1977). Nearshore ratios will be estimated with binomial variance. Tests of differences between oiled and non-oiled areas will be obtained with normal theory tests based on these variance estimates.

5. SCHEDULE

March through April 1991: Evaluate available literature on wildlife census procedures, particularly that pertaining to sea otters.

May through October 1991: Conduct initial field tests of the PA-18 survey platform. Conduct reproduction survey.

November through February 1992: Analyze and prepare findings.

1992 Implement census procedure, dependent on satisfactory results in FY1991, refine methodology, test procedures at second location. Continue reproduction surveys.

1993 Continue implementation and refinement of procedures. Continue reproduction surveys.

6. ANIMAL HEALTH AND WELFARE

We do not anticipate the handling of live animals in this project. Disturbance to animals in the wild will be minimized. Activities will be discontinued if large scale influence on animal behavior is observed.

7. STAFFING

Staffing requirements will be met by the principal investigator, project staff, FWS cooperators, OAS and private contractors as necessary.

8. LOGISTICS

Study implementation will depend on close coordination between ground and aerial crews. Field camps will be established to supply basic services for staff. Fuel will be purchased in bulk and transported to fuel caches prior to the initiation of field work. Travel to and between study sites will be by suitable vessels (eg., 25' Boston Whalers and Super Cub aircraft).

9. BUDGET

A. Costs

	Line					
	100	200	300	400	500	Total
Year 1 Projected Expenses	78.7K	18.1K	64.2K	8.6K	7K	176.6

Year 1 allocations: 150K Restoration
26.6K 87200-1411

Projected Expenditure Breakdown

Line 100 - Salaries (does not include full-time permanent staff, 6 months of staff time are being paid under other studies.

Monthly Salary Person

Grade	Name	and Benefits	FTE	Months	Costs
GS 9	staff	$3,192	1	12	$38,304
GS 7	staff	$2,300	1	12	$27,600
GS 9 (non-staff field crew time)	staff	$3,192	0	4	$12,768
			Total		$78,672

Position	Location	Time Frame	Person Months
GS 9	Office	3/91-4/91	2
GS 9	Field	5/91-10/91	15
GS 9	Office	11/91-2-92	4

(GS 9 field includes 4 non-staff months and 5 non-study staff months)

Position	Location	Time Frame	Person Months
GS 7	Office	3/91-4/91	2
GS 7	Field	5/91-10-91	6
GS 7	Office	11/91-2/92	4

Line 200 - Travel

In state Travel and per diem — Costs

Total $18,050

Line 300 - Commodities

Total $64,200

Line 400 - Equipment

Total $8,600

Line 500 - Analysis

Salary time included in Line-100

Total $7,000

B. Personnel qualifications

James Bodkin received a B.S. in Biology from California State University at Long Beach in 1976. He received an M.S. in Wildlife Biology from California Polytechnic University, San Luis Obispo in 1986. Since 1980 he has been employed by the U.S. Fish and Wildlife Service in Alaska and California. He worked on the California Sea Otter Project from 1980-1989. He is currently the Sea Otter Research Project Leader for the Alaska Fish and Wildlife Research Center. Jim has conducted sea otter research along the coast of North America between Attu, AK and Southern California, for nearly a decade.

Mark Udevitz received a B.S. degree in Wildlife Biology from Colorado State University in 1979, an M.S. degree in Wildlife Management from West Virginia University in 1982 and a Master of Statistics degree from North Carolina State University in 1986. He earned a Ph.D. in Biomathematics and Statistics in 1990 from North Carolina State University with a dissertation in the area of wildlife population estimation. He worked as a statistical consultant with the Southeastern Cooperative Wildlife and Fisheries Statistics Project from 1983-1989 and is currently working as the Statistician for the Mammals Branch of the Alaska Fish and Wildlife Research Center.

10. ANTICIPATED PRODUCTS

It is anticipated that the results of this study will lead to the implementation of an accurate and precise sea otter census methodology in Prince William Sound. We anticipate results of this study to lead to the development of a standardized procedure that may be used throughout the North Pacific Ocean to evaluate sea otter density. We anticipate the results to be published in a refereed journal or as a monograph. This study will end with the development and implementation of a sea otter census protocol. For the purpose of the restoration process, continuation of the established protocols may be continued under a separate study plan.

Data storage:

Data will be managed and stored by sea otter project staff, under direction of the sea otter research project leader, at the Alaska Fish and Wildlife Research Center. Back-up copies of electronic data will be regularly maintained and original hard copies of data will be stored at a separate location.

Relationship to other FWS work:

The results of this study will potentially have broad applications within the Fish and Wildlife Service. Sea otters presently occur at three separate locations in the continuous US and several separate populations in Alaska as well as Canada and the Soviet Union. Current censuses of sea otter populations are not standardized and evaluation of sea otter populations are difficult. We anticipate the results of this study to have significant value to managers and scientists from both within Fish and Wildlife Service and other public agencies and private interests.

11. LITERATURE CITED

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