Appendix C

2006 Draft Steller Sea Lion Recovery Plan

2006 Draft Northern Fur Seal Conservation Plan

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2006 Draft Steller Sea Lion Recovery Plan

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DRAFT
STELLER SEA LION RECOVERY PLAN

Eastern and Western Distinct Population Segments
(*Eumetopias jubatus*)

FIRST REVISION
Original Approval: December, 1992

Prepared by

The Steller Sea Lion Recovery Team

for

National Oceanic and Atmospheric Administration
National Marine Fisheries Services
Office of Protected Resources

May 2006

PREFACE

Congress passed the Endangered Species Act of 1973 (16 USC 1531 *et seq.*) (ESA) to protect species of plants and animals endangered or threatened with extinction. The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) share responsibility for the administration of the Act. NMFS is responsible for most marine mammals including the Steller sea lion.

Section 4(f) of the ESA directs the responsible agency to develop and implement a Recovery Plan, unless such a plan will not promote the conservation of a species. NMFS has determined that a Recovery Plan would promote the conservation of the eastern and western distinct population segments of Steller sea lion.

This plan was written by the Steller Sea Lion Recovery Team (Team) at the request of the Assistant Administrator for Fisheries to promote the conservation of the Steller sea lion. The recovery team includes experts on marine mammals from the private sector, academia, and government, experts on endangered species conservation, and representatives of the commercial fishing industry. The members of the recovery team are listed on page iii.

Data included in the Plan were the most up-to-date available as of May, 2006. While data collection and management actions continue, the Team does not believe that any recently collected information changes in any way our recommendations.

The Team members believe that the goals and objectives of the Plan can be achieved only if a long-term commitment is made to support the actions recommended here. Achievement of these goals and objectives will require the continued cooperation of the governments of the United States (especially the State of Alaska), Canada, and Russia. Within the United States, the shared resources and cooperative involvement of federal, state and local governments, industry, academia, non-government organizations and individual citizens will be required throughout the recovery period.

DISCLAIMER

Recovery plans delineate actions which the best available science indicates are required to recover and protect listed species. Plans are published by the National Marine Fisheries Service, sometimes prepared with the assistance of recovery teams, contractors, state agencies and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Nothing in this plan should be construed as a commitment or requirement that any federal agency obligate or pay funds in contravention of the Anti-Deficiency Act, 31, U.S.C. 1341, or any other law or regulation. Recovery plans do not necessarily represent the view of the official positions or approval of any individuals or agencies involved in the plan formulation, other than National Marine Fisheries Service. They represent the official position of the National Marine Fisheries Service only after they have been signed by the Assistant Administrator. Approved recovery plans are subject to modification as dictated by new information, changes in species status, and the completion of recovery actions. Please check for updates or revisions at the website before using this plan or implementing any of its recommendations.

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Recovery plans can be downloaded at no cost from:
http://www.nmfs.noaa.gov/pr/recovery/plans.htm

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Shane Capron, the Steller sea lion recovery coordinator for NMFS invested a tremendous amount of time and energy in guiding the Team through the recovery planning process, and also engaged the Team in critically important discussions that resulted in substantial improvements to the Plan. Don Calkins, Doug Eggers, Tom Loughlin, and Robin Samuelsen all contributed as members of the Team when our endeavor began. Al Didier demonstrated an amazing ability to accurately transcribe the important and pertinent points of the discussions at our meetings into useful meeting summaries. The following NMFS staff, especially of the Alaska Region and Science Center, provided unpublished data and reports, and substantial time and advice on most aspects of the Plan: Tammy Adams, Robyn Angliss, Vladimir Burkanov, Marilyn Dalheim, Robert DeLong, John Durbin, Tom Eagle, Brandee Gerke, Jim Hale, Lee Hulbert, Peggy Krahn, Marina Lindsey, Libby Loggerwell, Mark Lowry, Greg O'Corry-Crowe, Erika Phillips, Sharon Melin, Mike Payne, Susan Pultz, Mike Sigler, Beth Sinclair, Barbara Taylor, Johanna Vollenweider, Paul Wade, Bill Wilson, and Anne York. Several other individuals provided expert advice, including Lance Barrett-Lennard (Vancouver Aquarium), Kimberlee Beckmen (ADF&G), John Bickham (Texas A&M University), Kathy Burek (Alaska Veterinary Pathology Services), Michael Castellini (University of Alaska), Dan Hennen (Montana State University), Ken Goldman (California State University - Long Beach), Tracey Goldstein (Alaska SeaLife Center) Judy Jacobs (USFWS), Lloyd Lowry (Marine Mammal Commission), Nate Mantua (University of Washington), Craig Matkin (North Gulf Oceanic Society), Lorrie Rea (ADF&G), David Rosen (University of British Columbia), and Arliss Winship (University of British Columbia). Dan Goodman (Montana State University) developed a Population Viability Analysis that required the Team to transparently integrate their knowledge. Ed Bangs (USFWS), Don Siniff (University of Minnesota), Don Bowen (Bedford Institute of Oceanography), Bob Hofman (Marine Mammal Commission – retired), and Terry Quinn (University of Alaska) reviewed the Plan and provided comments that improved them. Teresa Fairchild and Sharon Perkins of the Pacific States Marine Fisheries Commission undertook the numerous tasks associated with putting on our meetings, including travel arrangements and lodging. Brock Bernstein (Consultant) facilitated the final two meetings.

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ACRONYM LIST

The following is a list of acronyms and terms used throughout the plan

ADF&G – Alaska Department of Fish and Game
AKR – Alaska Regional Office
AFSC – Alaska Fisheries Science Center
BEST – Bering Ecosystem Study
DEIS – Draft Environmental Impact Statement
DPS – Distinct population segment
Delisting – removal from the List of Endangered and Threatened Wildlife and Plants
EBS – Eastern Bering Sea
EEZ – Exclusive Economic Zone
EIS – Environmental Impact Statement
EPA – U.S. Environmental Protection Agency
ESA – Endangered Species Act
FOCI – Fisheries-Oceanography Coordinated Investigations (NOAA)
FMP – Fisheries Management Plan
FWS – Fish and Wildlife Service
Team – Steller sea lion recovery team
List – Federal List of Endangered and Threatened Wildlife and Plants
MARPOL – International Convention for the Prevention of Pollution from Ships
MMC – Marine Mammal Commission
MMPA – Marine Mammal Protection Act
mtDNA – Mitochondrail DNA
nm – Nautical Miles
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NPFMC - North Pacific Fishery Management Council
PBR – Potential Biological Removal
Plan – Steller sea lion recovery plan
PVA – Population viability analysis
TDR – Time-depth recorder
UME – Unusual mortality event
USCG – United States Coast Guard
USFWS – United States Fish and Wildlife Service
VMS – Vessel monitoring system

EXECUTIVE SUMMARY

CURRENT SPECIES STATUS: The Steller sea lion (*Eumetopias jubatus)* was listed as a threatened species under the ESA on April 5, 1990 (55 FR 12645) due to substantial declines in the western portion of the range. In contrast, the eastern portion of the range (in southeastern Alaska and Canada) was increasing at 3% per year. Critical habitat was designated on August 27, 1993 (58 FR 45269) based on the location of terrestrial rookery and haulout sites, spatial extent of foraging trips, and availability of prey items. In 1997, the Steller sea lion population was split into a western distinct population segment (DPS) and an eastern DPS based on demographic and genetic dissimilarities (62 FR 30772). Due to the persistent decline, the western DPS was reclassified as endangered, while the increasing eastern DPS remained classified as threatened. Through the 1990s the western DPS continued to decline. However, the western population has shown as increase of approximately 3% per year between 2000 and 2004. This was the first recorded increase in the population since the 1970s. Based on recent counts, the western DPS is currently about 44,800 animals and may be increasing due to higher juvenile and adult survival. However, it remains unclear whether Steller sea lion reproduction has also improved and whether the observed 3% annual population growth will continue. The eastern DPS is currently between 45,000 and 51,000 animals, and has been increasing at 3% per year for 30 years.

RECOVERY PLAN: The first recovery plan was completed in December 1992 and covered the entire range of the threatened species. However, the recovery plan became obsolete after the split into two DPSs in 1997. Nearly all of the recovery actions contained in the plan had also been completed. Therefore, in 2001, NMFS assembled a new recovery team to revise the Plan. The recovery team completed the draft revision in March 2006 and forwarded the Plan to NMFS with unanimous endorsement by the 17 team members who represented the fishing industry, Alaska Natives, fishery and marine mammal scientists, and environmental organizations. The Plan contains: (1) a comprehensive review of Steller sea lion status and ecology, (2) a review of previous conservation actions, (3) a threats assessment, (4) biological and recovery criteria for downlisting and delisting, (4) actions necessary for the recovery of the species, and (5) estimates of time and cost to recovery.

OVERVIEW: There appear to be two very distinct phases in the decline of the western DPS. The population declined about 70% between the late 1970s and 1990, but the initial decline likely began as early as the late 1950s in some areas. The rate of decline in the 1980s was very rapid, reaching about 15% per year during 1985-89. During this period, mortality incidental to commercial fishing was thought to contribute to perhaps as much as 25% of the observed decline. In addition, during that period it was legal for fishermen to protect their gear and catch by shooting Steller sea lions. Unfortunately, adequate records on the magnitude of such takes are not available. Some evidence indicates that animals in this population were nutritionally stressed during this time period, while other sources of mortality (e.g., predation by killer whales, mortality associated with disease) cannot be quantified due to a lack of information. There were distinct differences in the rates and pattern of decline in the six subareas used to monitor this population; eastern Gulf, central Gulf, western Gulf, eastern Aleutians, central Aleutians, and western Aleutians. Therefore, it is possible that several factors were important in driving the population decline during this time period.

In the 1990s, the rate of decline decreased from 15% to 5% per year. This followed further environemental changes in the 1990s and the implementation of extensive fishery regulations intended to reduce direct impacts such as shooting and indirect impacts such as competition for prey. During this decade, the Steller sea lions did not appear to be nutritionally stressed. The primary factors associated with the decline during this period have not been identified. As was the case in the 1980s, the pattern and rate of declines in abundance varied significantly by subregion.

In the late 1990s and early 2000s NMFS reviewed federally managed groundfish fisheries in Alaska, in a series of consultations under section 7 of the ESA. Two of those consultations resulted in a determination that the commercial fisheries were likely to jeopardize the continued existence of the western DPS of Steller sea lion and adversely modify its critical habitat. Therefore, as required under the ESA, additional conservation measures were implemented to avoid jeopardy and adverse modification. These measures were expected to promote the recovery of Steller sea lions in areas where potential competition from commercial fisheries may have contributed to the population decline.

It is plausible that the conservation measures implemented since 1990 are positively affecting the recovery of the western DPS. A positive correlation exists between increasing trends and fishery conservation measures; however, it is not known whether the increasing trend is a result of management actions, natural changes in the ecosystem, or some other factor.

COMPLETED RECOVERY ACTIONS: The 1992 recovery plan included 61 discrete recovery actions (or tasks) with estimated costs and responsible parties associated with those tasks. In our review, each of the 61 tasks has been accomplished to a substantial degree with one exception, which was to develop international conservation agreements. Much of the effort was focused on eliminating the most direct, and likely, causes of the decline (e.g., shooting, incidental take). These efforts are detailed in the Plan, and include the following:

- substantial reduction in disturbance of important rookeries and haulouts;
- substantial reduction in the incidental catch of Steller sea lions in commercial fishing operations, particularly the groundfish trawl fishery;
- significant efforts to reduce intentional take by prohibiting shooting at or near Steller sea lions
- intensive research to better describe the threats to Steller sea lions and provide management with options for recovery actions;
- substantial reduction in the potential for competitive interactions between commercial fisheries for pollock, Atka mackerel, and Pacific cod in Alaska;
- acquired additional information on the status, foraging ecology, and survivorship of Steller sea lions.

THREATS TO THE RECOVERY OF STELLER SEA LIONS: The extensive research program has increased the understanding of the relative impacts of threats that potentially impede the recovery of Steller sea lions. For the western DPS, the threats assessment concludes that the following threats are relatively minor: (1) Alaska Native subsistence harvest, (2) illegal shooting,

(3) entanglement in marine debris, (4) disease, and (5) disturbance from vessel traffic and scientific research. Although much has been learned about Steller sea lions and the North Pacific ecosystem, considerable uncertainty remains about the magnitude and likelihood of the following potential threats to recovery of the western DPS (relative impacts in parenthesis): competition with fisheries (potentially high), environmental variability (potentially high), killer whale predation (potentially high), incidental take by fisheries (medium), and toxic substances (medium).

In contrast, no threats were identified for the eastern DPS. Although several factors affecting the western DPS also affect the eastern DPS (e.g., environmental variability, killer whale predation, toxic substances, disturbance), these threats do not appear to be limiting recovery given the long term sustained growth of the population. However, concerns exist regarding global climate change and the potential for the southern part of the range (i.e., California) to be adversely affected. Future monitoring should target this southern portion of the range.

RECOVERY GOAL: The goal of this recovery plan is to restore endangered and threatened Steller sea lion populations to the point where they are again secure, self-sustaining members of their ecosystems, allowing initially for reclassification of the western DPS to threatened status and, ultimately, removal from the List of Endangered and Threatened Wildlife (List). The eastern DPS has been recovering for about 30 years and should be considered for removal from the List.

RECOVERY CRITERIA:

The western DPS of Steller sea lion will be considered for reclassification to "threatened" if all the following conditions are met:

1. The population for the U.S. region has increased (statistically significant) for 15 years on average, based on counts of non-pups (i.e., juveniles and adults).

2. The population ecology and vital rates in the U.S. region are consistent with the trend observed under criterion 1. Certain vital rates are assumed necessary for long term growth. As a check on criterion 1, available information on pup counts, production (fecundity), juvenile survival rates, population age structure, gender ratios, and other observations should be examined to determine whether they support the observed population trend under criterion 1.

3. The trends in non-pups in at least 5 of the 7 sub-regions are consistent with the trend observed under criterion #1. The population trend in any two adjacent sub-regions can not be declining significantly. Available information on the population ecology and vital rates for the sub-regions is consistent with the respective sub-region trend. The 7 sub-regions are:
    a. Eastern Gulf of Alaska (US)
    b. Central Gulf of Alaska (US)
    c. Western Gulf of Alaska (US)
    d. Eastern Aleutian Islands (including the eastern Bering Sea) (US)

e. Central Aleutian Islands (US)
f. Western Aleutian Islands (US)
g. Russia/Asia

4. The ESA listing factor criteria in Section V.C.2 are met.

The western DPS of Steller sea lion will be considered for delisting if all the following conditions are met:

1. The population for the U.S. region has increased at an average annual growth rate of 3% per year for 30 years (i.e., 3 generations) based on counts of non-pups (i.e., juveniles and adults).

2. The population ecology and vital rates in the U.S. region are consistent with the trend observed under criterion 1. Certain vital rates are assumed necessary for long term growth. As a check on criterion 1, available information on pup counts, production (fecundity), juvenile survival rates, population age structure, gender ratios, and other observations should be examined to determine whether they support the observed population trend under criterion 1.

3. The trends in non-pups in at least 5 of the 7 sub-regions are stable or increasing, consistent with the trend observed under criterion #1. The population trend in any two adjacent sub-regions can not be declining significantly. The population trend in any sub-region can not have declined by more than 50%. Available information on the population ecology and vital rates for the sub-regions is consistent with the respective sub-region trend. The 7 sub-regions are:
   a. Eastern Gulf of Alaska (US)
   b. Central Gulf of Alaska (US)
   c. Western Gulf of Alaska (US)
   d. Eastern Aleutian Islands (including the eastern Bering Sea) (US)
   e. Central Aleutian Islands (US)
   f. Western Aleutian Islands (US)
   g. Russia/Asia

4. The ESA listing factor criteria in Section V.C.3 are met.

The eastern DPS of Steller sea lion will be considered for delisting if all the following conditions are met:

1. The population has increased at 3% per year for 30 years.

2. The population ecology and vital rates in the U.S. region are consistent with the trend observed under criterion 1, to ensure the population is increasing in a sustainable manner. Specifically, available information on pup counts, fecundity, juvenile survival rates, population age structure, gender ratios, and other observations should be examined to determine that they indicate an increasing population.

3. The ESA listing factor criteria in Section VII.C.1 are met.

ACTIONS NEEDED: The Plan identifies 78 substantive actions needed to achieve recovery of the western DPS by addressing the broad range of threats, and is geared toward three main objectives: (1) the collection of information on status and vital rates, (2) research programs to collect information on the remaining threats to recovery, including fisheries and other anthropogenic factors, and (3) the implementation of conservation measures to remove impacts of remaining threats to recovery. The Plan highlights three actions (below) that are especially important to the recovery program for the western DPS:

Maintain current fishery conservation measures (Action 2.6.6)
After a long term decline, the western DPS appears to be stabilizing. The first slowing of the decline began in the 1990s suggesting that the management measures implemented in the early 1990s may have been effective in reducing anthropogenic effects (e.g., shooting, harassment, and incidental take). The apparent population stability observed in the last 6 years is correlated with comprehensive fishery management measures implemented since the late 1990s. The current suite of management actions (or their equivalent protection) should be maintained until substantive evidence demonstrates that these measures can be reduced without limiting recovery.

Design and implement an adaptive management program to evaluate fishery conservation measures (Action 2.6.8)
Due to the uncertainty in how fisheries affect Steller sea lions and their habitat, and the difficulty in extrapolating from individual scientific experiments, a properly designed adaptive management program should be implemented. This type of program has the potential to assess the relative impact of commercial fisheries and to better distinguish the impacts of other threats (including killer whale predation). This program will require a robust experimental design with replication at the proper temporal and spatial scales with the appropriate levels of commercial fishing as experimental treatments. It will be a challenge to construct an adaptive management plan that meets the requirements of the ESA, is statistically sufficient, and can be implemented by the commercial fisheries. Acknowledging these hurdles, we must make a significant effort to determine the feasibility of such a program.

Continue population monitoring and research on the key threats potentially impeding sea lion recovery
Estimates of population abundance, trend, distribution, health, and essential habitat characteristics are fundamental to Steller sea lion management and recovery. Further, current information on the primary threats is insufficient to assess their impact on recovery. Focused research is needed on how these threats impact sea lion population growth and how they may be mitigated in order to facilitate recovery. In addition to studies on individual threats, the dynamics between threats needs to be better understood to assess the cumulative effects on sea lions.

TOTAL ESTIMATED COST OF RECOVERY:

Western DPS: $93,840,000 for the first 5 fiscal years; $430,425,000 to full recovery assuming 30 years for recovery starting in 2000 and using year 5 costs in this Plan as the cost for all future years

Eastern DPS: $ 150,000 for the first year; $1,050,000 total for 10 years post-delisting monitoring

ANTICIPATED DATE OF RECOVERY: For the western DPS, the time to recovery is somewhat predictable if the current population trajectory continues. If the population continues to increase (based on the 3% increasing trend counts since 2000), it would be eligible for consideration for downlisting to threatened status within 9 years (i.e., by 2015). If that trend continues further, as has been the case for the eastern DPS, then consideration for delisting is possible by 2030. As more information is obtained on the threats, their impact on sea lions, and how they can be effectively mitigated, more robust projections about the time to recovery, and its expense, will be developed.

The eastern DPS appears to have recovered from predator control programs in the 20th century which extirpated animals at rookeries and haulouts. Currently, no substantial threats are evident, and the population continues to increase at approximately 3% per year. The primary action in the plan is to initiate a status review for the eastern DPS and consider removing it from the federal List of Endangered Wildlife and Plants (potentially in 2006 or 2007).

I. BACKGROUND

In the 1950s, the worldwide abundance of Steller sea lions (*Eumetopias jubatus*) was estimated at 240,000 to 300,000 animals, with a range which stretched across the Pacific rim from southern California, Canada, Alaska, and into Russia and northern Japan (Figure I-1). By 1990, the U.S. portion of the population had declined by about 80%, which prompted NMFS to list the Steller sea lion as threatened under the ESA. The listing was based primarily on substantial declines that occurred in the 1980s (as high as 15% per year) in the population currently designated as the western distinct population segment (DPS) as well as on a reduced population size in the population now designated as the eastern DPS. After listing in 1990, the rate of decline decreased to about 5% per year.

In 1997, after continued declines in Alaska and the availability of new genetics information that revealed further population structure, NMFS split the population into two distinct population segments (Figure I-1). The western DPS, extending from Japan around the Pacific rim to Cape Suckling in Alaska (144°W), was up-listed to endangered due to the continuous decline and lack of recovery. The eastern DPS, extending from Cape Suckling east to British Columbia and south to California, remained on the list as threatened because of concern over western DPS animals ranging into the east, human interactions, and the lack of recovery in California.

The decline continued in the western DPS until about 2000. Since then, the population has increased at about 3% per year and has been relatively consistent across the U.S. portion of the range with the exception of the central Gulf of Alaska and the western Aleutian Islands areas. The Asian component of the western DPS has been relatively stable overall, but with regional differences. The eastern DPS has been increasing for over 20 years with the greatest increases in southeast Alaska and British Columbia, but generally poor performance in California at the southernmost extent of its range.

A. Species Description

Sea lions belong to the Order Carnivora, Suborder Pinnipedia, Family Otariidae, and Subfamily Otariinae. The family contains the extant genera *Arctocephalus, Callorhinus, Eumetopias, Neophoca, Otaria, Phocarctos,* and *Zalophus*. The genus *Eumetopias* contains one species, the Steller (also called northern) sea lion, *E. jubatus*. Unless noted otherwise, all references to sea lions in this document are to Steller sea lions.

Steller sea lions are the largest otariid and show marked sexual dimorphism with males larger than females. The average standard length is 282 cm for adult males and 228 cm for adult females (maximum of about 325 cm and 290 cm, respectively); weight of males averages 566 kg and females 263 kg (maximum of about 1,120 kg and 350 kg) (Fiscus 1961, Calkins and Pitcher 1982, Loughlin and Nelson 1986, Winship *et al.* 2001). The pelage is light buff to reddish brown and slightly darker on the chest and abdomen. Naked parts of the skin are black (King 1954). Adult males have long, coarse hair on the chest, shoulders, and back; the chest and neck are massive and muscular. Newborn pups are about 1 m long, weigh 16-23 kg, and have a thick, dark-brown coat that molts to lighter brown after 6 months (Daniel 2003). A more detailed physical description is given in Loughlin *et al.* (1987) and Hoover (1988).

Female Steller sea lions attain sexual maturity and first breed between 3 and 8 years of age (Pitcher and Calkins 1981). The average age of reproducing females (i.e., generation time) is about 10 years based on the life tables from Calkins and Pitcher (1982) and York (1994). They normally ovulate and breed annually after maturity although because of a high rate of reproductive failures, estimated birth rates have ranged from 55% to 63% (Calkins and Goodwin 1988, Pitcher and Calkins 1981). They give birth to a single pup from late May through early July and then breed about 11 days after giving birth. They undergo delayed implantation and the blastocyst implants about 3.5 months after breeding. Some offspring are weaned near their first birthday while others continue suckling for an additional year or more. While males may attain physiological maturity before 7 years of age, they are seldom able to establish and defend a territory until 8 years or older (Thorsteinson and Lensink 1962, Pitcher and Calkins 1981).

B. Distribution and Population Structure

The present range of Steller sea lions (Figure I-1) extends around the North Pacific Ocean rim from northern Japan, the Kuril Islands and Okhotsk Sea, through the Aleutian Islands and Bering Sea, along Alaska's southern coast, and south to California (Kenyon and Rice 1961, Loughlin *et al.* 1984, 1992). Seal Rocks, at the entrance to Prince William Sound, Alaska, is the northernmost rookery (60°09'N). Año Nuevo Island off central California is the southernmost rookery (37°06'N), although some pups were born at San Miguel Island (34°05'N) up until 1981. Prior to the decline in the west, most large rookeries were in the Gulf of Alaska and Aleutian Islands (Kenyon and Rice 1961, Calkins and Pitcher 1982, Loughlin *et al.* 1984, 1992, Merrick *et al.* 1987). As the decline continued, rookeries in the west became progressively smaller; consequently, the largest rookeries are now in Southeast Alaska and British Columbia. In 2005, the Forrester Island complex produced 3,429 pups and Hazy Islands 1,286 pups (both in Southeast Alaska). About 2,500 pups were counted at the Scott Islands rookery in British Columbia in 2002. In 2005, Ugamak Island (687 pups) and Pinnacle Rock (643 pups) were the largest rookeries in the Gulf of Alaska and Aleutian Islands.

Most adult Steller sea lions occupy rookeries[1] during the pupping and breeding season, which extends from late May to early July (Pitcher and Calkins 1981, Gisiner 1985). During the breeding season some juveniles and non-breeding adults occur at or near the rookeries, but most are on haulouts. Adult males, in particular, may disperse widely after the breeding season. Males that breed in California move north after the breeding season and are rarely seen in California or Oregon except from May through August (Mate 1973). During fall and winter many sea lions disperse from rookeries and increase use of haulouts, particularly terrestrial sites but also sea ice in the Bering Sea.

Steller sea lions are not known to make regular migrations, but they do move considerable distances (Baba *et al.* 2000). Animals marked as pups on rookeries in the Gulf of Alaska have been sighted in Southeast Alaska and British Columbia; some marked in British Columbia have been

[1] Throughout this document a rookery refers to a site where breeding occurs and sea lions may haulout during the non-breeding period; a site designated as a rookery will be called a rookery the entire year, even though breeding occurs there only from late May to early July.

seen at Cape Saint Elias, Alaska; some marked in the eastern Aleutians have been seen in eastern Bristol Bay, Alaska; and some marked in Oregon have been seen in northern California, Washington, British Columbia, Southeast Alaska, and the northern Gulf of Alaska (Calkins and Pitcher 1982, Calkins 1986, Loughlin 1997). Raum-Suryan *et al.* (2002) analyzed resightings of 8,596 pups that were branded from 1975-1995 on rookeries in Alaska and reported that almost all resightings of young-of-the-year were within 500 km of the rookery where the pup was born, although subsequent observations documented movements of 11 month-old pups with their mothers of over 800 km. Juvenile animals were seen at much greater distances from their rookery of birth (up to 1785 km). Sightings of adults were generally less than 500 km away from the natal rookery although adult males have since been seen over 1000 km from the rookery where they held a territory (also their natal rookery).

Steller sea lion pups tagged in the Kuril Islands commonly moved northward to the east and west coasts of Kamchatka (Burkanov *et al.* 1997) and have also been seen as far south as Yokahama, Japan (Baba *et al.* 2000, NMFS unpublished data). Pups tagged on the Commander Islands have moved to the east coast of Kamchatka (Burkanov *et al.* 1997). Juveniles marked in the central Aleutian Islands have been observed in the Commander Islands.

NMFS designated two DPSs of Steller sea lion based on genetic studies and phylogeographical analyses from across the sea lion's range (62 FR 24345). The eastern DPS includes sea lions born on rookeries from California north through Southeast Alaska; the western DPS includes those animals born on rookeries from Prince William Sound westward (Bickham *et al.* 1996, Loughlin 1997). The regulatory division between DPSs is Cape Suckling (144º west longitude) in the northeast Gulf of Alaska. However, frequent movement is seen across this boundary by animals from both populations, particularly juvenile animals (Raum-Suryan *et al.* 2002).

Mitochondrial DNA (mtDNA) has been the primary marker used to examine Steller sea lion genetics. This marker is maternally inherited, so individuals inherit the same sequence as their mother (barring mutation) and pass that marker on to their offspring and so on. Bickham *et al.* (1996) reported on analyses of characteristics of mtDNA from 224 Steller sea lions sampled between the Commander Islands and Oregon. The researchers found a high level of genetic diversity with a large number of haplotypes occurring at a relatively low frequency (46 of 52 haplotypes with a frequency less than 0.03). Additional analyses from over 1200 sea lions identified over 130 haplotypes range-wide (Bickham *et al.* 1998a, Ream 2002). A distinct break in the distribution of haplotypes was found between locations sampled in the western part of the range (Russia to the eastern Gulf of Alaska) and eastern locations (Southeast Alaska and Oregon), indicating restricted gene flow between two populations (Figure I-1). These researchers speculated that the two populations did not evolve from a single maternal ancestor but rather descended from the genetic makeup of two populations that inhabited separate glacial refugia during the last ice age.

Loughlin (1997) reviewed information on genetics, together with what is known about distribution, population response, and phenotypic characteristics, to identify Steller sea lion populations. He found that the strongest support for multiple populations came from the genetics results described above, but information on distribution and movement patterns and population responses provided additional support. Loughlin concluded that Steller sea lions should be

managed as two populations, an eastern population that includes all animals born on rookeries east of Cape Suckling, Alaska, and a western DPS that includes all animals born at rookeries west of Cape Suckling. NMFS accepted this recommendation and in 1997 reclassified Steller sea lions as two distinct population segments under the ESA (62 FR 24345).

Bickham *et al.* (1998a) analyzed mtDNA from an additional 191 Steller sea lions, mostly from regions not sampled in their previous study, e.g., Kuril Islands, British Columbia, and California. The results from those samples combined with previous results confirmed the high degree of genetic differentiation between eastern and western DPSs. Bickham *et al.* (1998b) also analyzed mtDNA from 36 Steller sea lions sampled in the Gulf of Alaska in 1976-1978 and compared the results with samples collected in the 1990s following the steepest population decline (Bickham *et al.* 1996). They found that the high level of haplotypic diversity previously noted for the present population had been maintained between the two sampling periods. Thus, genetic diversity of Gulf of Alaska sea lions had been maintained in spite of the recent major decline in abundance.

Substantial additional genetic research was conducted with larger sample from throughout the of Steller sea lion range, including most rookeries in Asia. While the results of these studies generally confirm the strong east/west population delineation there is evidence that additional structure exists in the western DPS (Trujillo *et al.* 2004, Baker *et al.* 2005, NMFS unpublished data) and that the geographic boundary between the western and eastern populations may be shifting to the east and mixed DPS rookeries forming (NMFS unpublished). Baker *et al.* (2005) found that a third population exists just west of the Commander Islands in Russia.

Trujillo *et al.* (2004) examined mtDNA and nuclear DNA (which is contributed by both parents) from the same samples to show that the population separation apparent from the mtDNA work was not clearly defined when males were taken into account. There was not a clear separation of populations based on genetics when markers from both parents were included. They suggested that the difference was either due to a faster population divergence at the mtDNA locus or that, like many other mammals, Steller sea lions show a greater level of male-mediated gene flow via immigration than in females, e.g. males tend to disperse more than females and do not show the same philopatry for their natal areas as females.

Support for this result comes from observational work in the eastern DPS with the monitoring of branded animals. Resights of animals branded as pups in one DPS have occasionally been reported at haulouts and rookeries within the other DPS. In addition, recent mtDNA work with large samples of pups from newly established rookeries in the eastern DPS has shown that some females born in the western DPS are pupping in the eastern DPS (NMFS unpublished data). Because these samples were collected from rookeries that were not yet established at the time of the ESA designation, they were not included in the original genetic studies.

Steller sea lions may sometimes disperse from their rookeries of birth and breed at other rookeries within their parent populations; this has the potential to affect local population dynamics and thus conforms to the concept of a "metapopulation" (Hanski and Simberloff 1997). In the case of Steller sea lions, a metapopulation may be considered a rookery or cluster of rookeries (York *et al.* 1996). Occasional dispersal of animals from their natal rookeries may have important consequences for expansion of the eastern population and possible recovery of the western DPS, as it provides a

mechanism for occupying new territory or re-occupying vacant areas (Raum-Suryan *et al.* 2002). In Southeast Alaska, new rookeries were established as population size increased, at least partially the result of dispersal from the large Forrester Island rookery (Calkins *et al.* 1999, Raum-Suryan *et al.* 2002, ADF&G unpublished data).

C. Overview of Population Status

Count data used to estimate population trend and evaluate status are of two types: counts of pups about 1 month of age and counts of animals over 1 year of age (i.e., non-pups). Counts of pups were usually made by observers on rookeries, herding the non-pups into the water, and walking through the rookery and counting the pups (Calkins and Pitcher 1982, Sease *et al.* 2001). Beginning in 2002, 126mm format aerial photography has also been used to count pups (Westlake *et al.* 1997, Snyder *et al.* 2001). In British Columbia, pup counts were made from 35mm slides taken during aerial surveys flown specifically to facilitate pup counts (vertical orientation).

Counts of pups on rookeries conducted near the end of the birthing season are nearly complete counts of pup production. These counts can be expanded to estimate approximate total population size based on an estimated ratio of pups to non-pups in the population (Calkins and Pitcher 1982, Trites and Larkin 1996). Based on estimates of birth rate and sex and age structure of a stable sea lion population from the Gulf of Alaska, Calkins and Pitcher (1982) estimated total population size was 4.5 times the number of pups born. Some pups die and disappear before the counts are made and a few are born after the counts are conducted (Trites and Larkin 1996); because of this the researchers selected 5.1 as a correction factor. It should be emphasized that this is a very general estimate of population size as several factors can affect the accuracy of this correction factor. Sex and age structure and mortality and birth rates may vary over time and among populations and require different correction factors.

Non-pups were counted in most instances from 35 mm color slides taken from aircraft during the breeding season (Calkins and Pitcher 1982, Merrick *et al.* 1987, Sease *et al.* 2001), although in recent years some counts were made from 126mm format aerial photographs. Counts from 35 mm slides and medium format photographs were highly correlated but, on average, slightly higher counts were obtained from medium-format photographs (Fritz and Stinchcomb 2005).

Counts of both pups and non-pups were used to estimate trend for the various geographic areas depending on availability of data. Trend analysis was conducted by linear regression of the natural logarithms of the counts by year. For the western DPS, estimates of population trend, an index to changes in absolute population abundance, were based on comparisons of counts among years at a group of sites consistently monitored since the 1970s (trend sites). Trend sites include the majority of animals observed in each survey (e.g., 72% in 1998, 75% in 2000; Sease *et al.* 2001). "Trend rookeries" are a subset of all trend sites and include all major rookeries except those on Outer and Attu Islands. Counts of pups on rookeries are also used to estimate population trend.

From the late 1960s through 2000, the western DPS declined over 80% in abundance, with steepest declines of approximately 15% per year occurring in the late 1980s and slower declines of about 5% per year in the 1990s (based on non-pup counts; Loughlin *et al.* 1992, Trites and

Larkin 1996, Loughlin 1997, Sease and Loughlin 1999). Between 2000 and 2004, counts of non-pups on western DPS trend sites increased or were stable through much of the Alaskan range, suggesting that the decline may have stopped (Sease and Gudmundson 2002, Fritz and Stinchcomb 2005). The western DPS is now composed of about 44,800 sea lions in Alaska and approximately 16,000 in Asia. The magnitude and continuous nature of the decline resulted in NMFS listing the western DPS as endangered in 1997 (62 FR 24345).

The specific causes of the decline are not known, and the relative importance of various factors may have changed over time. While there is no consensus on the causes of the sharp decline in the 1980s or consensus on why the population declined at a slower rate through the 1990s, several factors have been proposed and have some degree of support. Direct mortality through incidental take in fisheries, commercial harvests, and illegal shooting (Perez and Loughlin 1991, Alverson 1992, Trites and Larkin 1992) has been proposed as one mechanism in the decline. A reduction in survival and possibly fecundity due to a reduced or modified prey base has frequently been proposed as a factor in the decline. This could have resulted from commercial fisheries (Fritz *et al*. 1995, Loughlin 1998) or by a major regime shift in the mid-1970s (Trenberth 1990, Springer 1998, Benson and Trites 2002, Le Boeuf and Crocker 2005, Trites *et al*. 2006a). Predation by killer whales, alone or in conjunction with other factors, may also have contributed to the declines of sea lions and other species of marine mammals in Alaska (Barrett-Lennard *et al.* 1995, Springer *et al*. 2003). It should be noted that Steller sea lions are not the only population of marine mammals to undergo a substantial decline in portions of western Alaska. Harbor seals (Pitcher 1990, Frost *et al.* 1999, Small *et al.* 2003, Ver Hoef 2003), northern fur seals (Trites 1992, Towell *et al.* 2006), and sea otters (Estes *et al.* 1998, Doroff *et al*. 2003) have all declined substantially over at least portions of the range of the western DPS of Steller sea lion.

During approximately the same period, the eastern DPS has more than doubled in size and is at its highest level in recent history, numbering 45,000 to 51,000 animals in 2002 (Pitcher *et al.* submitted). This population increased at about 3% per year from the late 1970s through 2002. Recent data from Southeast Alaska (2005) and California (2004) suggest continued population growth. Legal protection, both in the United States and Canada, probably played an important role in population growth.

D. Western DPS Status and Trend

The western DPS of Steller sea lion breeds on rookeries in Alaska (the U.S. portion of the western DPS) from Prince William Sound (144°W) west through the Aleutian Islands and in Russia on the Kamchatka peninsula, Kuril Islands and the Sea of Okhotsk (Bickham *et al.* 1996, Loughlin 1997). Loughlin *et al.* (1984) estimated the worldwide population of Steller sea lions was between 245,000 and 290,000 animals (including pups) in the late 1970s (1974-80). Though the genetic differences between the eastern and western DPSs were not known at the time, Loughlin *et al.* (1984) noted that 90% of the worldwide population of Steller sea lions was in the western DPS in the early 1980s (75% in the U.S. and 15% in Russia) and 10% in the eastern DPS. Loughlin *et al.* (1984) concluded that the total worldwide population size (both DPSs) was not significantly different from that estimated by Kenyon and Rice (1961) for the years 1959 and 1960, though the distribution of animals had changed. After conducting a range-wide survey in 1989, Loughlin *et al.* (1992) noted that the worldwide Steller sea lion population had declined by over 50% in the

1980s, to approximately 116,000 animals, with the entire decline occurring in the range of the western DPS.

1. Alaska (U.S. portion of the range)

Steller sea lions use 38 rookeries and hundreds of haul-out sites within the range of the western DPS in Alaska (Figures I-2 and I-3). The first reported counts of Steller sea lions in Alaska were made in 1956-1960 (Kenyon and Rice 1961, Mathisen and Lopp 1963), and these totaled approximately 140,000 for the Gulf of Alaska (GOA) and Aleutian Islands (AI) regions (Merrick *et al.* 1987)[2]. Subsequent surveys showed a major decline in numbers first detected in the eastern AI in the mid-1970s (Braham *et al.* 1980). The decline spread eastward to the central GOA during the late 1970s and early 1980s and westward to the central and western AI during the early and mid 1980s (Merrick *et al.* 1987, Byrd 1989). Approximately 110,000 adult and juvenile sea lions were counted in the Kenai-Kiska region in 1976-1979, and by 1985 and 1989, counts had dropped to about 68,000 (Merrick *et al.* 1987) and 25,000 (Loughlin *et al.* 1990), respectively. Since 1990 when Steller sea lions were listed under the ESA, complete surveys have been conducted throughout their range in Alaska every one or two years (Merrick *et al.* 1991, 1992, Sease *et al.* 1993, 1999, 2001, Strick *et al.* 1997, Sease and Loughlin 1999, Sease and Gudmundson 2002, Sease and York 2003, Fritz and Stinchcomb 2005).

Steller sea lion populations in parts of the Alaskan range of the western DPS may have begun to drop between the late 1950s and the mid 1970s (Table I-1[3]). From the mid-1970s to 1990 the overall western DPS in Alaska declined by over 70%, with the largest declines in the AI (76% to 84%) and smaller declines in the GOA (23% to 71%; Table I-1). Between 1990 and 2000, trend site counts continued to decline, though more slowly than in the 1980s, resulting in a total reduction of almost 90% since the 1950s and 83% since the 1970. Sub-area declines from 1990 to 2000 had a different pattern than in the 1970s-1990 period, with smaller changes in the center of the Alaskan range (western GOA and eastern and central Aleutians: -32% to +1%) and larger declines at the edges (eastern and central GOA and western Aleutians: -54% to –64%). The average rate of decline between 1990 and 2000 for all trend sites in the western DPS was 5.1% per year (Sease *et al.* 2001).

Between 2000 and 2004, Kenai-Kiska and western Alaska population trend site counts of non-pup Steller sea lions increased by 12% (Table I-1; Fritz and Stinchcomb 2005). Increases were not spread evenly across the range in Alaska, however. Non-pup counts increased by over 20% in the eastern Aleutian Islands and in the eastern and western GOA, and by 10% in the central Aleutian Islands, but were lower by as much as 16% in the central GOA and western Aleutians (Table I-1; Figures I-2 and I-3). While overall non-pup counts from 2000 to 2004 increased, counts in the

[2] For the western DPS of Steller sea lion in Alaska, count data have generally been combined and analyzed in six subareas (Figures I-2 and I-3), which are geographically convenient but do not necessarily reflect biologically important units. Because earlier efforts to count sea lions were concentrated in the center of their Alaskan range, evaluations of long-term trends have often been calculated for the "Kenai to Kiska" index area, which includes the central and western Gulf of Alaska and the eastern and central Aleutian Islands.

[3] In some cases the counts shown in this table are lower than total survey counts given above (and used in some other reports) because not all sites counted in a survey are trend sites.

western GOA and eastern AI had essentially no trend between 1990 and 2004, suggesting that western Steller sea lions in the core of their Alaskan range may currently be oscillating around a new lower mean level.

Using the methods described in Loughlin *et al.* (1992), Loughlin (1997) estimated that the non-pup U.S. portion of the western DPS totaled approximately 177,000 animals in the 1960s; 149,000 in the 1970s; 102,000 in 1985; 51,500 in 1989; and only 33,600 in 1994. Using similar methods, Loughlin and York (2000) estimated the number of non-pups in the U.S. portion of the western DPS in 2000 at about 33,000 animals. Using a different method[4], Ferrero *et al.* (2000) and Angliss and Outlaw (2005) estimated the minimum abundance of the U.S. portion of the western DPS in 1998 at 39,031 and in 2001-2004 at 38,206, respectively, a decline of over 80% since the late 1970s.

Pups have been counted less frequently than non-pups, but the overall trends since the late 1970s have been similar to counts of non-pups (Table I-2). The number of pups counted in the Kenai-Kiska region declined by 70% from the mid-1980s to 1994, with large declines (63% to 81%) in each of the four sub-areas. From 1994 to 2001-02, Kenai-Kiska pup counts decreased another 19%, with the largest change (-39%) observed in the central GOA. The overall decline in the number of pups in the Kenai-Kiska region from the mid-1980s through 2002 was 76%. Pup counts in the eastern GOA (not included in the Kenai-Kiska region) declined by 35% from 1994 to 2002, while in the western Aleutian Islands, pup counts declined by 50% between 1997 and 2002 (Table I-2). Between 2001-02 and 2005, increases in pup counts were noted in the eastern and western GOA and eastern AI, while pup counts declined in the central GOA and central and western AI. In June-July 2005, a medium format aerial survey for pups was conducted from Prince William Sound to Attu Island, which provided the first complete pup count for all western DPS rookeries in Alaska (n = 9,951 pups; NMFS unpublished data). Using the "pup" estimator (4.5) yields an estimate of approximately 44,800 Steller sea lions in the range of the western DPS in Alaska.

The population of Steller sea lions on the Pribilof Islands has seen similar declines, although the trends were initiated much earlier. Elliott (1880) reported that approximately 10,000 to 12,000 animals were distributed at rookeries on both St. Paul and St. George Islands in the 1870s. Osgood *et al.* (1916) described the importance of Steller sea lions to the local community for both food and material for clothing and boats. The pups especially were favored for their meat. Between 1870 and 1890, at least 4,000 sea lions were killed on St. Paul Island and by the early 1900s the local agent noted that the hunt should cease do to a reduced population (Osgood *et al.* 1916). In 1940, Scheffer counted 800-900 adults and 300-400 pups on St. Paul and noted that the population was growing and that the sea lions interfered with the management of the fur seal herd by competing for both food and space and "creating a nuisance to the men who drive and kill the seals" (Scheffer 1946). This competition initiated a request to cull part of the population. The recommendation was to kill 50 pups a month during June, July, and August to assess the seasonal quality of the pelts.

[4] Estimated population numbers were based on a pup multiplier (e.g., 5.1 and 4.5 were used), while the minimum population estimates were based on adding the total number of non-pups counted in an aerial survey with the "best" estimate of pups counted.

The combination of hunting and culling appears to have kept the Pribilof sea lion population at reduced numbers, and Loughlin *et al.* (1984) reported that the breeding rookeries on St. George Island were extirpated by 1916. No pups have been reported on St. George since. In the summer of 1960, 4,000 to 5,000 non-pups and 2,866 pups were counted on Walrus Island, just offshore of St. Paul (Kenyon 1962). Between the 1960s and 2005, however, numbers of non-pups and pups on Walrus Island declined over 90%, to 322 non-pups in 2001 and only 29 pups in 2005 (Figure I-3 and Table I-2; Loughlin *et al.* 1984, NMFS unpublished data). The cause of the declines during the last 50 years remains unexplained. Subsistence takes of non-pups have continued on the main islands of St. Paul and St. George averaging 141 during 1992-1998, but declined to less than 100 sea lions in the latter half of the 1990s (Wolfe and L.B. Hutchinson-Scarbrough 1999). Walrus Island is the only Steller sea lion rookery still active in the Pribilofs, but pup production has declined steadily from 2,866 in 1960 to approximately 334 in 1982, 50 in 1991, 39 in 2001, and only 29 in 2005 (NMFS 1992, NMFS unpublished data, Fritz and Stinchcomb 2005).

Modeling studies based primarily on data collected in the central GOA indicate that the decline experienced by the western sea lion population in Alaska in the 1980s may have been caused by a steep drop in the survival rate of juveniles, perhaps by as much as 20-30% (York 1994, Pascual and Adkison 1994, Holmes and York 2003). However, the models suggest that the decline at this time was also associated with smaller decreases in adult survival and female fecundity (Holmes and York 2003). The drop in fecundity would not have been predicted based on density-dependence alone. Subsequent to the 1980s, demographic models indicate that juvenile and adult survival rates rebounded to levels similar to those of the stable equilibrium population of the 1970s, but that fecundity continued to decline into the 1990s (Holmes and York 2003).

2. Russia and Asia

Steller sea lions use 10 rookeries and approximately 77 haul-out sites within the range of the western DPS in Russia (Figure I-5). Of these 77 haul-outs, three had been rookeries, but presently no breeding occurs there, 49 are active haul-out sites, 20 have been abandoned (no sea lions seen there for the past 5-10 years), and five have inadequate information to assess their status. Analysis of available data collected in the former Soviet Union indicates that in the 1960s, the Steller sea lion population totaled about 27,000 (including pups), most of which were in the Kuril Islands. Between 1969 and 1989, numbers of adult and juvenile sea lions at major rookeries and haul-outs in the Kuril Islands alone declined 74% (Merrick *et al.* 1990). By the late 1980s and early 1990s, the total Russian population had declined by approximately 50% to about 13,000 (including pups) (Burkanov and Loughlin *in press*). Since the early 1990s, the population has increased in most areas and, in 2005, is estimated to number approximately 16,000 (including pups)(Burkanov and Loughlin *in press*).

Trends in counts of non-pup and pup Steller sea lions on selected rookeries and haulout sites have varied by subarea within Russian waters (Tables I-3 and I-4; Figure I-5). In the Kuril and Commander Islands and in eastern Kamchatka, Steller sea lion numbers declined through the 1970s and 1980s, but increased slightly or were stable from the early 1990s through 2005. In the western Bering Sea, there are no rookeries; numbers of non-pups have plunged over 90% and since 2000, have totaled less than 100 (Table I-3). By contrast, Steller sea lion numbers on Tuleny Island and at two rookeries in the Sea of Okhotsk (on Iony and Yamsky Islands) have increased

considerably in the last 15 years. Overall, counts of non-pups on all Russian trend sites were essentially stable between 1989 and 2004 (an annual rate of change of -0.02%, which is not significantly different from 0; p=0.96).

The Steller sea lion is listed as an endangered species under Russian legislation. While the Russian government currently has no organized program of monitoring and research, both NMFS and the Alaska SeaLife Center have programs to monitor population trends (non-pup and pup counts), estimate vital rates (branding and re-sighting), collect food habits data, and conduct other research on Steller sea lions in Russia. It is anticipated that research on Russian-Asian sea lions will continue to be supported by both institutions in the near future.

3. Western DPS overall

The western DPS of Steller sea lions decreased from an estimated 220,000-265,000 animals in the late 1970s to less than 50,000 in 2000. The decline began in the 1970s in the eastern Aleutian Islands (Braham *et al.* 1980), western Bering Sea/Kamchatka and the Kuril Islands. In Alaska, the decline spread and intensified east and west of the eastern Aleutians in the 1980s and persisted at a slower rate through 2000 (Sease *et al.* 2001). The 12% increase in numbers of non-pups counted in the Alaskan range of the western DPS between 2000 and 2004 was the first region-wide increase observed during more than two decades of systematic surveys. The observed increase, however, has not been spread evenly among all regions of Alaska. Increases were noted in the eastern and western Gulf of Alaska and in the eastern and central Aleutian Islands, while the decline persisted through 2004 in the central Gulf of Alaska and the western Aleutian Islands. Non-pup counts at all western DPS trend sites in Alaska in 2004 were similar to the 1998 total, but were still 33% lower than the number counted in 1990. In Russia, both pup and non-pup data indicate that sea lion numbers are increasing at Sakhalin Island and in the Sea of Okhotsk and likely at the Commander Islands. However, non-pup numbers in Kamchatka and the Kuril Islands, the former core of the Russian range, declined substantially through the late 1980s, but have increased slightly through 2005. The number of western Steller sea lions throughout its range in Alaska and Russia in 2005 is estimated at approximately 60,000 (44,800 in Alaska and 16,000 in Russia).

E. Eastern DPS Status and Trend

1. Overview

The available historical records of Steller sea lion abundance were reviewed for the eastern DPS in an attempt to relate current population size with levels prior to the initiation of standardized surveys (Figure I-6). These records provide interesting insights into relative population levels but must be interpreted with caution because the older counts were obtained by a variety of methods and during varying times of the year. Count data obtained prior to 1970 were not subjected to quantitative analyses because of intermittent availability and concerns about comparability with more recent count data. Counts of both pups and non-pups were used to estimate trends for the various geographic areas depending on availability of data (Figures I-7 and I-8). Trend analysis was conducted by linear regression of the natural logarithms of the counts by year.

Population trend was analyzed by geographic regions (Southeast Alaska, British Columbia, Washington, Oregon, and California) as the data were collected by various state and federal agencies in each area. Steller sea lions, particularly juveniles, range widely (Raum-Suryan *et al.* 2002), and therefore population estimates for a particular geographic area represent the number of animals supported by the rookeries in that area and not the exact number of animals present in the area at any time. This is particularly true when large rookeries are located near jurisdictional borders such as the boundaries between Southeast Alaska and British Columbia and between Oregon and California.

2. Southeast Alaska

Numbers of pups counted on rookeries increased from 2,219 in 1979 to 5,510 in 2005, an annual rate of increase of 3.1% (Table I-5). In 1979, the Forrester Island rookery complex was the only rookery in Southeast Alaska. During the early 1980s, a rookery developed at Hazy Islands, and in the early 1990s at White Sisters. Recently, two additional sites, Graves Rocks and Biali Rocks, appear to have developed into rookeries with 175 and 100 pups counted respectively at the two sites in 2005. Since 1990, nearly all the increase in pup numbers has been at the newer rookeries, as pup numbers at the Forrester Island rookery were stable ($P = 0.302$). In addition to the five rookeries, sea lions used 30 major haulouts, plus several other sites for brief periods each year, probably in conjunction with seasonal prey concentrations.

At four of five rookeries in Southeast Alaska, counts of non-pups increased substantially from 1979 to 2005 (Table I-6). Based on 2002 pup counts, estimated Steller sea lion abundance (all age classes) in Southeast Alaska was 21,947 animals (with the 4.5 pup multiplier) or 24,873 (with the 5.1 pup multiplier); by comparison, a total of 20,160 sea lions (pups plus non-pups) were counted during the 2002 survey.

Historical data for this region are scant, yet numbers of Steller sea lions were likely relatively low during the early 1900s when there may not have been any rookeries in Southeast Alaska (Rowley 1929, Imler and Sarber 1947). Numbers have progressively increased since that time (Calkins *et al.* 1999) and are now believed to be at a historical high.

3. British Columbia

Counts of Steller sea lion pups increased from 941 in 1971 to 3,281 in 2002 (Table I-7; Olesiuk and Trites 2003), an annual rate of increase of 3.2% closely paralleling the trend in Southeast Alaska. Rookeries occur at North Danger Rocks, Cape St. James, and the Scott Islands (Maggot, Triangle, Sartine, and Beresford Islands). Sea lions also use 24 major haulout sites in British Columbia (Olesiuk 2001) plus a number of other seasonal haulouts (Bigg 1988).

Extensive sea lion reduction programs were conducted at many locations in British Columbia from 1912 through 1966, and sea lions were commercially exploited during the 1960s, resulting in the population being reduced to about 30% of peak levels of the early 1900s (Bigg 1988). A major rookery, the Sea Otter Group, was eradicated by about 1940 as a result of intensive control efforts and while sea lions still used it as a haulout it no longer serves as a rookery.

The most recent survey occurred in summer, 2002 and counted 15,402 sea lions including 3,281 pups and 12,121 non-pups (Table I-7; Olesiuk and Trites 2003). Steller sea lion abundance (all age classes) in British Columbia, based on 2002 pup counts at rookeries, was 14,765 animals (with the 4.5 pup multiplier) or 16,733 (with the 5.1 pup multiplier). Olesiuk and Trites (2003) used the raw counts and a multiplier to estimate the total number of animals present in British Columbia waters during the breeding season of 2002 at 18,400 – 19,700 individuals of all ages, including non-breeding animals associated with rookeries in Southeast Alaska and Oregon. It appears that the British Columbia Steller sea lion population has largely recovered from the low levels of the 1970s, particularly when considered in conjunction with the adjoining Southeast Alaska population (Olesiuk 2001).

4. Washington

No rookeries exist in the state of Washington, but Steller sea lions are present along the coast throughout the year. Four major haulouts are used, and counts of non-pups have been made during the breeding season during most years since 1991, when numbers of sea lions increased at an average of 9.2% annually (Table I-8). These animals are assumed to be immature animals and non-breeding adults associated with rookeries from other areas. Branded juvenile sea lions from the Forrester Island rookery in Southeast Alaska (Raum-Suryan *et al.* 2002) and from the Rogue Reef rookery in Oregon (Brown unpublished data) have been observed in Washington. Older records suggest that current numbers are reduced from historical levels. Between 2,000 and 3,000 Steller sea lions were reported during August and September of 1914, 1915, and 1916 in the Carroll Island area (Kenyon and Scheffer 1959, Scheffer 1950) while the maximum observed during 60 complete surveys of Washington haulouts between 1980 and 2001 was 1,458 in October, 2000 (non-breeding season count).

5. Oregon

Steller sea lions occupy two rookeries, located at Rogue Reef and Orford Reef, and eight haulout sites in Oregon. The total number of non-pup sea lions counted during the breeding season surveys at all of these sites has increased from 1,461 in 1977 to 4,169 in 2002 (Table I-8; Brown *et al.* 2002), an annual rate of increase of about 3.7%. Although not nearly as well documented, pup numbers also appear to have increased. In 1996, 685 and 335 pups were counted at Rouge Reef and Orford Reef respectively, whereas in 2002, 746 and 382 pups were counted at the two sites. These counts were made from 126mm format, aerial photographs. Steller sea lion abundance (all age classes) in Oregon, based on 2002 pup counts at rookeries, was 5,076 animals (with the 4.5 pup multiplier) or 5,753 (with the 5.1 pup multiplier). A total of 5,297 animals were actually counted during the 2002 surveys.

Historical data on Steller sea lion abundance in Oregon are sketchy. Pearson and Verts (1970) estimated the population at 1,078 animals in 1968, somewhat lower than the 1977 count of 1,461. Population size was believed to be substantially smaller than in 1925 due to extensive human-caused mortality, in part stimulated by a bounty (Pearson and Verts 1970). After 3 decades of growth, this population has recovered substantially, but the relationship of present numbers to levels during the 1800s and early 1900s is not known.

6. California

Steller sea lions historically occupied five major rookeries and haulouts in California (San Miquel Island, Año Nuevo Island, the Farallon Islands, Sugarloaf Island/Cape Mendocino, and Saint George Reef) that have been surveyed periodically over the last 75 years. While there is a long, intermittent time series of counts for California (Bonnot 1928, Bonnot and Ripley 1948, Bartholomew and Boolootian 1960, Orr and Poulter 1967, LeBoeuf *et al.* 1991, Westlake *et al.* 1997), standardized counting techniques for state-wide surveys were not implemented until 1996. For this reason some caution is warranted when attempting to evaluate population trend from the older data. Population trends have differed markedly at the major sites; therefore, each site is discussed separately.

Previously, Steller sea lions ranged to the Channel Islands in Southern California, primarily using San Miguel Island but also Santa Rosa Island, which were considered the southernmost rookeries and haulouts (Bonnot 1928, Rowley 1929). It appears that sea lions used these sites seasonally and bred in small numbers (Stewart *et al.* 1993). In the early and middle 20th century, perhaps 2,000 Steller sea lions occupied the Channel Islands (Bonnot and Ripley 1948). Numbers appear to have begun declining about 1938 (Bartholomew 1967), and no adults have been seen there since 1983 and no births recorded since 1982 (Stewart *et al.* 1993). Additionally, several rookery and haulout sites along the California coast, primarily south of Año Nuevo, have been abandoned, as well as a documented rookery at Seal Rocks near San Francisco (Bartholomew and Boolootian 1967, Bonnot 1928, Bonnot and Ripley 1948, Rowley 1929).

Numbers of non-pup Steller sea lions at the two central California sites, Año Nuevo and the Farallon Islands, are currently only about 20% of the levels reported between 1927 and 1964 (Table I-9). There appears to have been a particularly steep decline in the 1960s and 1970s. Counts appear to have recently stabilized or at least the rate of decline has lessened (Hastings and Sydeman 2002). Numbers of pups born on Año Nuevo declined from about 600 to 800 during the 1960s Le Boeuf *et al.* 1991, Orr and Poulter 1967) to 152 in 1999. However, between 1996 and 2004 the number of pups counted stabilized ($P = 0.656$). In 2004, 221 pups were counted at Año Nuevo. Recent pup production on the Farallons has been low (Hastings and Sydeman 2002) with a maximum of 22 pups counted in 2004. During the 1920s, the Farallon Islands and Año Nuevo were identified as the most important rookeries in California (Rowley 1929), with estimates of pup production at 400 and 625, respectively (Bonnot 1928).

Steller sea lions have been counted sporadically at the Sugarloaf/Cape Mendocino rookery and haulout during breeding seasons since 1927. Non-pup numbers appear to have been relatively stable, although highly variable, since 1996. The two highest counts were 900 in 1930 and 740 in 2001 suggesting that the current population is comparable to historical levels. Pups have been counted in recent years and numbers have increased (62 in 1996 to 131 in 2004; +12.9% per year, $R^2 = 0.725$, $P = 0.007$).

The Saint George Reef rookery, located near the California/Oregon border, appears to be at a fairly high level relative to historical measures and counts of non-pups have been stable, although variable, since 1990 (Table I-10). During 2004, 444 pups and 738 non-pups were counted at this

site. Bonnot (1928) reported 1,500 Steller sea lions at Saint George Reef in 1927 and Bonnot and Ripley (1948) counted 700 animals in 1930. Pups have been counted since 1996 (except for 1997) and have increased (243 in 1996 to 444 in 2004; +9.8% per year, $R^2 = 0.703$, $P = 0.009$).

Statewide in California, total non-pup counts at these five major rookery and haulouts during the first half of the last century ranged from 4,500 to 5,600. The 2004 count at these same five sites was 1,578 non-pups and 818 pups suggesting that only about a third as many animals are currently present in the state. Nearly all of the reduction has occurred at the three southern sites. From 1996 through 2004, statewide non-pups numbers were stable, while pup numbers increased at 7.5% per year, $R^2 = 0.679$, $P = 0.112$).

An additional 1,418 Steller sea lions were counted during the 2002 survey at 41 haulout sites (with counts raging from 1 to 692 animals on these haulouts and with 15 sites with more than 25 animals) along the California coast between Saint George Reef and Año Nuevo Island. Steller sea lion abundance (all age classes) in California, based on 2002 pup counts at rookeries, was 3,209 animals (with the 4.5 pup multiplier) or 3,636 (with the 5.1 pup multiplier). However, 3,815 animals were actually counted during the 2002 survey.

7. Eastern DPS Overall

Overall, the eastern DPS has increased at over 3% per year since the 1970s, more than doubling in Southeast Alaska, British Columbia, and Oregon. The robustness of the observed positive trend for the eastern population over the past 25-30 years was confirmed by Bayesian trend analyses conducted by Goodman (Appendix 3). He estimated annual growth at 3.64% for nonpups in Oregon with a 95% confidence interval of 2.42 to 4.44% and concluded that there was an extremely low probability (0.01) that the actual growth rate was lower than 2% per year. For pups in Southeast Alaska he estimated annual growth at 3.13% (95% confidence interval of 2.29 to 3.95%). The probability of a growth rate below 1.5% per year was estimated at 0.1% for the Southeast counts.

Saint George Reef rookery and Sugarloaf rookery in northern California are near levels recorded early in the 20th century, and pup production has increased since 1996. This increase is probably at least partially the result of protective legislation, enacted in both the United States and Canada during the early 1970s, that reduced mortality at a time when the population was below carrying capacity. However, numbers of animals at the Año Nuevo rookery and the Farallon Islands in central California are substantially reduced (-90%) from those reported early in the 20th century (Bonnot 1928), despite legal protection from directed human take. The former haulout/rookery at San Miguel Island is now extinct, as are several other sites previously used in California (Rowley 1929). The reason for the large declines, since the mid-1900s, in southern and central California are not known. However, sympatric populations of other pinnipeds have grown greatly over the past 75 years (Stewart *et al.* 1993). In particular, a closely related species, the California sea lion (*Zalophus californianus*), has increased greatly from at most a few thousand in the 1920s (Bonnot 1928) to between 237,000 and 244,000 in 2004 (Carretta *et al.* 2005); some aspect of a competitive relationship may have been involved in the Steller sea lion decline. Changes in the ocean environment, particularly warmer water temperatures, have also been proposed as possible factors

that favored California sea lions and other pinnipeds over Steller sea lions through changes in the distribution of favored prey (Bartholomew and Boolootian 1960).

The eastern population was subjected to substantial mortality by humans, primarily due to commercial exploitation and both sanctioned and unsanctioned predator control, (Bonnot 1928, Scheffer 1946, Rowley 1929, Bonnot and Ripley 1948, Pearson and Verts 1970, Bigg 1988, Scheffer 1950). Commercial exploitation occurred primarily in the 1800s and early 1900s while unsanctioned predator control probably persisted into the 1970s in some locations. Although not well documented, there is little doubt that numbers of Stellers sea lions were greatly reduced in many locations.

Within the eastern DPS, 13 rookeries and about 85 major haulout sites currently exist from Cape Fairweather (58.8°N, 137.9°W) to Año Nuevo Island (37.1°N, 122.3°W). Populations associated with 12 of these rookeries have either increased or stabilized at relatively high levels in recent years. Total population size of the eastern DPS in 2002 was estimated to range between 45,000 and 51,000 animals of all ages (Table I-11). Additional surveys in California during 2003 and 2004 and in Southeast Alaska during 2005 suggest the population has continued to increase since the 2002 survey and likely exceeds 50,000 animals.

Conditions for Steller sea lions in the eastern DPS appear to be most favorable in the northern portion of their range. Southeast Alaska and British Columbia together account for nearly 82% of total pup production. All four rookeries founded in the past 25 years are located in northern Southeast Alaska at the northern extent of the population range. The southernmost portion of the range has contracted and the southernmost active rookery, at Año Nuevo Island, appears to have stabilized at a low population size. A somewhat similar change in Steller sea lion distribution and the establishment of new breeding sites have been noted along the Asian coast, where the southern range limit moved northward by 500-900 km over the past 50 years and several new rookeries were established (Burkanov and Loughlin *in press*).

Currently, no Steller sea lion rookeries exist within a geographical gap (993 km) between the Scott Islands Rookery off northwest Vancouver Island and Orford and Rogue Reef Rookeries in southern Oregon. It is possible that additional rookeries were once located along this coastline, and it would not be surprising to see new rookeries founded or re-established, as has occurred in Southeast Alaska, if the population continues to increase. Steller sea lion rookeries are normally located on remote, offshore islands or reefs and require adequate areas above high water levels where young pups can survive most weather conditions and adequate prey is available on a consistent basis within the foraging range of lactating females. Perhaps the limited availability of such sites has prevented the establishment of additional new rookeries.

During the 1970s the eastern DPS contained only about 10% of the total number of Steller sea lions in the U.S. With the large decline in the western DPS in conjunction with the increase in the east, this has changed dramatically with over half of U.S. Steller sea lions now belonging to the eastern DPS.

F. Habitat Characteristics and Use

Steller sea lions use a variety of marine and terrestrial habitats. Haulouts and rookeries tend to be preferentially located on exposed rocky shoreline and wave-cut platforms (Ban 2005, Call and Loughlin 2005). Some rookeries and haulouts are also located on gravel beaches. Rookeries are nearly exclusively located on offshore islands and reefs. Terrestrial sites used by Steller sea lions tend to be associated with waters that are relatively shallow and well-mixed, with average tidal speeds and gradual bottom slopes (Ban 2005). When not on land, Steller sea lions are seen near shore and out to the edge of the continental shelf and beyond.

1. Terrestrial habitat use

Female sea lions appear to select places for giving birth that are gently sloping and protected from waves (Sandegren 1970, Edie 1977). Pups normally stay on land for about two weeks, then spend an increasing amount of time in intertidal areas and swimming near shore. Mothers spend more time foraging as pups grow older and less time on shore nursing (Milette and Trites 2003). Females with pups begin dispersing from rookeries to haulouts when the pups are about 2.5 months-of-age (Raum-Suryan *et al.* 2004, Maniscalco *et al.* 2002, 2006).

Haulout is the term used to describe terrestrial areas used by adult sea lions during times other than the breeding season and by non-breeding adults and subadults throughout the year. Sites used as rookeries in the breeding season may also be used as haulouts during other times of year. Some haulouts are used year-around while others only on a seasonal basis. Sea lions are sometimes seen hauled out on jetties and breakwaters, navigational aids, floating docks, and sea ice. Many animals also use traditional rafting sites, which are places where they rest on the ocean surface in a tightly packed group (Bigg 1985, NMFS unpublished data).

Although rookeries and haulouts occur in many types of areas, sea lions display strong site fidelity to specific locations from year to year. Factors that influence the suitability of a particular area may include substrate, exposure, proximity to food resources, oceanographic conditions, tradition of use, and season (Calkins and Pitcher 1982, Ban 2005), as well as the extent and type of human activities in the region (Johnson *et al.* 1989). Thermoregulatory factors may play an important role in site selection (Gentry 1970, Sandegren 1970).

2. Marine habitat use

Telemetry studies show that in winter adult females may travel far out to sea into water greater than 1,000 m deep (Merrick and Loughlin 1997), and juveniles less than 3 years of age travel nearly as far (Loughlin *et al.* 2003). The Platforms of Opportunity (POP) data base maintained by NMFS shows that sea lions commonly occur near and beyond the 200 m depth contour (Kajimura and Loughlin 1988, NMFS POP data). Some individuals may enter rivers in pursuit of prey (Jameson and Kenyon 1977). In summer while on breeding rookeries, adult females attending pups tend to stay within 20 nm of the rookery (Calkins 1996, Merrick and Loughlin 1997).

Studies using satellite-linked telemetry have provided detailed information on movements of adult females and juveniles (Table I-12). Merrick and Loughlin (1997) found that adult females tagged at rookeries in the central Gulf of Alaska and Aleutian Islands in summer made short trips to sea (mean distance 17 km, maximum 49 km) and generally stayed on the continental

shelf. In winter, adult females ranged more widely (mean distance 133 km, maximum 543 km) with some moving to seamounts far offshore. Most of the pups tracked during the winter made relatively short trips to sea (mean distance 30 km), but one moved 320 km from the eastern Aleutians to the Pribilof Islands. Adult females with satellite transmitters in the Kuril Islands in summer made short at-sea movements similar to those seen in Alaska (Loughlin *et al.* 1998).

Behavioral observations indicate that lactating females spend more time at sea during winter than in the summer. Attendance cycles (consisting of one trip to sea and one visit on land) averaged about 3 days in winter and 2 days in summer (Trites and Porter 2002, Milette and Trites 2003, Trites *et al.* 2006b, Maniscalco *et al.* 2006). Time spent on shore between trips to sea averaged about 24 hours in both seasons. The winter attendance cycle of dependent pups and yearlings averaged just over 2 days, suggesting that sea lions do not accompany their mothers on foraging trips (Trites and Porter 2002, Trites *et al.* 2006b). Foraging trips by mothers of yearlings were longer on average than those by mothers of pups (Trites and Porter 2002).

Additional studies on immature Steller sea lions indicate three types of movements: long-range trips (greater than 15 km and greater than 20 h), short-range trips (less than 15 km and less than 20 h), and transits to other sites. Long-range trips started around 9 months of age and likely occurred most frequently around the time of weaning while short-range trips happened almost daily (0.9 trips/day, n = 426 trips). Transits began as early as 2.5-3 months of age, occurred more often after 9 months of age, and ranged between 6.5 - 454 km (ADF&G unpublished data, Loughlin *et al.* 2003). Some of the transit and short-range trips occurred along shore, while long-range trips were often offshore, particularly as ontogenetic changes occurred.

Overall, the available data suggest two types of distribution at sea by Steller sea lions: 1) less than 20 km from rookeries and haulout sites for adult females with pups, pups, and juveniles, and 2) much larger areas (greater than 20 km) where these and other animals may range to find optimal foraging conditions once they are no longer tied to rookeries and haulout sites for nursing and reproduction. Loughlin (1993) observed large seasonal differences in foraging ranges that may have been associated with seasonal movements of prey, and Merrick (1995) concluded on the basis of available telemetry data that seasonal changes in home range were related to prey availability.

3. Designated critical habitat

On August 27, 1993 NMFS published a final rule to designate critical habitat for the threatened and endangered populations of Steller sea lions (58 FR 45269). The areas designated as critical habitat for the Steller sea lion were determined using the best information available at the time (see regulations at 50 CFR part 226.202), including information on land use patterns, the extent of foraging trips, and the availability of prey items. Particular attention was paid to life history patterns and the areas where animals haul out to rest, pup, nurse their pups, mate, and molt. Critical habitat areas were finally determined based upon input from NMFS scientists and managers, the Steller Sea Lion Recovery Team, independent marine mammal scientists invited to participate in the discussion, and the public (Figures I-9 and I-10).

Physical and biological features of Steller sea lion critical habitat:

Two kinds of marine habitat were designated as critical. First, areas around rookeries and haulout sites were chosen based on evidence that many foraging trips by lactating adult females in summer may be relatively short (20 km or less; Merrick and Loughlin 1997). Also, mean distances for young-of-the-year in winter may be relatively short (about 30 km; Merrick and Loughlin 1997, Loughlin *et al.* 2003). These young animals are just learning to feed on their own, and the availability of prey in the vicinity of rookeries and haulout sites must be crucial to their transition to independent feeding after weaning. Similarly, haulouts around rookeries are important for juveniles, because most juveniles are found at haulouts not rookeries. Evidence indicates that decreased juvenile survival may be an important proximate cause of the sea lion decline (York 1994, Chumbley *et al.* 1997) and that the growth rate of individual young sea lions was depressed in the 1980s (Calkins and Goodwin 1988). These findings are consistent with the hypothesis that young animals were nutritionally stressed. Furthermore, young animals are almost certainly less efficient foragers and may have relatively greater food requirements, which, again, suggests that they may be more easily limited or affected by reduced prey resources or greater energetic requirements associated with foraging at distant locations. Therefore, the areas around rookeries and haulout sites must contain essential prey resources for at least lactating adult females, young-of-the-year, and juveniles, and those areas were deemed essential to protect.

Second, three marine areas were chosen based on 1) at-sea observations indicating that sea lions commonly used these areas for foraging, 2) records of animals killed incidentally in fisheries in the 1980s, 3) knowledge of sea lion prey and their life histories and distributions, and 4) foraging studies. In 1980, Shelikof Strait was identified as a site of extensive spawning aggregations of pollock in winter months. Records of incidental take of sea lions in the pollock fishery in this region provide evidence that Shelikof Strait is an important foraging site (Loughlin and Nelson 1986, Perez and Loughlin 1991). The southeastern Bering Sea north of the Aleutian Islands from Unimak Island past Bogoslof Island to the Islands of Four Mountains is also considered a site that has historically supported a large aggregation of spawning pollock, and is also an area where sighting information and incidental take records support the notion that this is an important foraging area for sea lions (Fiscus and Baines 1966, Kajimura and Loughlin 1988). Finally, large aggregations of Atka mackerel are found in the area around Seguam Pass. These aggregations have supported a fishery since the 1970s and are in close proximity to a major sea lion rookery on Seguam Island and a smaller rookery on Agligadak Island. Atka mackerel are an important prey of sea lions in the central and western Aleutian Islands. Records of incidental take in fisheries also indicate that the Seguam area is important for sea lion foraging (Perez and Loughlin 1991).

G. Vital Rates

Changes in the size of a population are ultimately due to changes in one or more of its vital demographic rates. Inputs to the population are provided by reproduction of adults (e.g., birth rates, natality, fecundity; probability that a female of a given age will give birth to a pup each year) and immigration. Outputs from the population include those that leave the population through emigration or death, which can also be inversely described by rates of adult and juvenile survivorship. Estimates of vital rates are best determined in longitudinal studies of marked animals, but can also be estimated through population models fit to time series of counts of sea lions at different ages or stages (e.g., pups, non-pups).

1. Survival

Causes of pup mortality include drowning, starvation caused by separation from the mother, disease, parasitism, predation, crushing by larger animals, biting by other sea lions, and complications during parturition (Orr and Poulter 1967, Edie 1977, Maniscalco *et al.* 2002, 2006 ADF&G and NMFS unpublished data). Older animals may die from starvation, injuries, disease, predation, subsistence harvests, intentional shooting by humans, entanglement in marine debris, and fishery interactions (Merrick *et al.* 1987).

Calkins and Pitcher (1982) estimated mortality rates using life tables constructed from samples collected in the Gulf of Alaska in 1975-1978. The estimated overall mortality from birth to age 3 was 0.53 for females and 0.74 for males; i.e., 47% of females and 26% of males survived the first 3 years of life. Annual mortality rate decreased from 0.132 for females 3-4 years of age, to 0.121 for females 4-5 years old, to 0.112 for females 5-6 years old, and to 0.11 by the seventh year; it remained at about that level in older age classes. Male mortality rates decreased from 0.14 in the third year to 0.12 in the fifth year. Females may live to 30 years and males to about 20 (Calkins and Pitcher 1982).

York (1994) produced a revised life table for female Steller sea lions using the same data as Calkins and Pitcher (1982) but a different model. The estimated annual mortality from York's life table was 0.22 for ages 0-2, dropping to 0.07 at age 3, then increasing gradually to 0.15 by age 10 and 0.20 by age 20. Population modeling suggested that decreased juvenile survival likely played a major role in the decline of sea lions in the central Gulf of Alaska during 1975-1985 (Pascual and Adkison 1994, York 1994, Holmes and York 2003). This is supported by field observations on two major rookeries in the western DPS. The proportion of juvenile sea lions counted at Ugamak Island was much lower in 1985 and 1986 than during the 1970s, suggesting that the mortality of pups/juveniles increased between the two periods (Merrick *et al.* 1988). A decline in the proportion of juvenile animals also occurred at Marmot Island during the period 1979-1994. A very low resighting rate for pups marked at Marmot Island in 1987 and 1988 suggested that the change in proportions of age classes was due to a high rate of juvenile mortality (Chumbley *et al.* 1997).

2. Reproduction

Detailed information on Steller sea lion reproduction has been obtained from examinations of reproductive tracts of dead animals. These studies have shown that female Steller sea lions reach sexual maturity at 3-6 years of age and may produce young into their early 20s (Mathisen *et al.* 1962, Pitcher and Calkins 1981). Adult females normally ovulate once each year, and most breed annually (Pitcher and Calkins 1981). Males reach sexual maturity between 3 and 7 years of age and physical maturity by age 10 (Perlov 1971, Pitcher and Calkins 1981). Males are territorial during the breeding season, and one male may breed with several females. Thorsteinson and Lensink (1962) found that 90% of males holding territories on rookeries in the western Gulf of Alaska were between 9 and 13 years of age, while Raum-Suryan *et al.* (2002) found that males marked on Marmot Island as pups first became territorial at 10 and 11 years of age.

One of the key parameters governing population growth is reproductive output (birth rate). Reproductive output may be affected by nutrition, diseases, contaminants, and other factors (Merrick *et al.* 1987, Pitcher *et al.* 1998) that are discussed below and in detail in Sections III and IV.

In samples collected in the Gulf of Alaska in the mid-1980s, Calkins and Goodwin (1988) found that 97% of females aged 6 years and older had ovulated. Ninety-two percent of females 7-20 years old were pregnant when they were collected in October during early implantation. The pregnancy rate of sexually mature females collected during April-May (late gestation) was only 60%, indicating that a considerable amount of intrauterine mortality and/or premature births occurred after implantation. Estimates of near-term pregnancy rates of all adult females were 67% from a collection of females taken from 1975-1978 and 55% from a similar collection during the mid-1980s (Pitcher *et al.* 1998), the difference was not statistically significant between periods ($P = 0.34$), yet the statistical power to detect the difference was less than 0.50. However, the difference in pregnancy rates of the lactating females between the 1970s (63%) and 1980s (30%) was significant ($P = 0.059$). Examination of reproductive tracts from female Steller sea lions killed near Hokkaido, Japan in 1995-96 showed that the pregnancy rate for females that had ovulated was 88% (23/26) (Ishinazaka and Endo 1999). These samples were collected in January and February, so this estimated pregnancy rate was much higher compared to the late-term rates of 55-67% estimated for sea lions from Alaska.

It is important to obtain current estimates of birth rate since the most recent estimates are from 1985-86. Historically, birth rates were estimated from the examination of reproductive tracts from collected animals, which is not currently feasible. Estimates will need to be derived from alternative techniques such as mark-resight estimation, analysis of reproductive hormone levels in feces or tissue samples, or population modeling.

Steller sea lions collected in the Gulf of Alaska during the early 1980s showed evidence of reproductive failure and reduced rates of body growth that were consistent with nutritional stress (Calkins and Goodwin 1988, Pitcher *et al.* 1998, Calkins *et al.* 1998). Lactating females were less likely to become pregnant than non-lactating females during the early decline, indicating that the energetic stress of nursing while being pregnant with another pup may have prevented some females from giving birth each year (Pitcher *et al.* 1998). During the 1970s and 1980s, 97% of sexually mature females in the Western DPS were pregnant in early gestation. However, the

percentage of those females that carried their pregnancy to late gestation fell to 67% during the 1970s and to 55% in the 1980s; the difference was statistically insignificant, yet the statistical power to detect the difference was less than 0.50 (Pitcher *et al.* 1998). Better body condition was found to increase the probability that a female would maintain pregnancy. Comparatively low birth rates for females from the Western DPS during the 1970s and 1980s (Pitcher and Calkins 1981) coupled with elevated embryonic and fetal mortality appear to have contributed to decreased reproductive performance during the period of early decline (Pitcher and Calkins 1981, Calkins and Goodwin 1988, Pitcher *et al.* 1998, NMFS 1998a, 1998b, 2000). Age-structured models fit to observed time series of pup and non-pup counts suggest that declines in reproductive performance of females in the western DPS continued into the 1990s in some or major parts of the Alaskan range (Holmes and York 2003, Fay 2004), but may have increased in the late 1990s and 2000s in most areas (Winship and Trites 2006).

3. Demographic modeling

Estimates of birth rates and survival rates

Demographic analysis of age distribution information has been used to estimate demographic rates in an attempt to identify the combination of changes in birth and survival rates that might account for the observed past changes in pup and non-pup numbers across the range of the western DPS in Alaska. These analyses are hampered by sparseness and spottiness of data. The only large sample of Steller sea lion that has been submitted for tooth-ring age determinations was a collection from one location, Marmot Island, in a very restricted time frame (2 years in the 1970s) in circumstances that primarily sampled breeding age animals at a rookery. The females in the same sample were examined for reproductive status. York (1994) created a life table estimate from these data by assuming (1) that this collection was representative of age distributions and reproductive frequencies in the entire population, (2) that the population was in stable age distribution, and (3) that there was no population growth.

At a much less detailed level, some censusing techniques distinguish between pups and non-pups in the counts at many rookeries. There are over 30 rookeries that have been censused over the years in a regular, but much less frequent than annual, rotation. If assumptions are made about the tendency of non-breeding animals of breeding age, as well as animals of below breeding age, to be present on rookeries and be included in the counts (this is not actually known yet, and is a matter of ongoing investigation in the analysis of sighting records of branded animals), the time series of counts of pups and non-pups allow some inference about crude per capita birth rates to adults, crude per capita survival rates of the adults, and rates of survival from birth untill recruitment to the breeding segment of the population.

York (1994) concluded from her life table analysis that the population decline observed in the 1980s at Marmot likely was primarily owing to a large drop in juvenile survivorship compared to the 1970s, a conclusion also reached by Pascual and Adkison (1994). Holmes and York (2003) extended these analyses of central Gulf of Alaska sea lions through the late 1990s and added an index of juvenile recruitment to the model. Their results, along with those of Fay (2004), continued to show a likely drop in juvenile survivorship from the 1970s to the 1980s, and also indicated that the continued slower decline in sea lion numbers through the 1990s was

associated with increases in juvenile and adult survivorship compared to the 1980s along with an apparent erosion in fecundity (birth rates plus pup mortality through 1 month) that began in the late 1970s and early 1980s.

Fay (2004) and Winship and Trites (2006) broadened the geographic scope by estimating time series of vital rates for metapopulations or at each rookery in the Gulf of Alaska and Aleutian Islands from 1978-2002. Results of these studies suggest that the changes in vital rates responsible for the declines likely varied among subpopulations and with time. Juvenile and adult survival rates appear to have been lowest during the 1980s for many, but not all subpopulations, while juvenile survival in the western Aleutians appears to have been lower during the 1990s than during the 1980s. With regard to changes in fecundity, Fay (2004) found evidence of DPS-wide declines in birth rates beginning in the early 1980s with little or no rebound through 2000. Winship and Trites (2006) found declines in fecundity in the central Gulf of Alaska (similar to Holmes and York 2003, Fay 2004), but not elsewhere in the range of the western Steller sea lion.

The studies attempting to estimate past demographic rates were motivated in part by a hope that these could shed light on the various possible causes for the changes in vital rates responsible for the population decline. In this, the retrospective studies have been largely inconclusive. One exception is the study by Hennen (2006) which found an association between rate of by-rookery decline and the fishing activity around the respective rookies, for the period of the 1980s but not continuing into the 1990s. Hennen (2006) did not investigate how this effect might have been partitioned among birth rates and survival rates of various age classes.

Models extrapolating the population into the future

Population viability analysis (PVA) attempts to predict the probability of a population going extinct, or crossing a specified threshold, over a specified period. Four simulation models of varying complexity have been constructed to assess the likelihood that Steller sea lions will go extinct in western Alaska (Appendix 3; York *et al.* 1996, Gerber and VanBlaricom 2001, Winship and Trites 2006). Some of the models treated each rookery as independent populations, while others considered metapopulations (i.e., groups of rookeries), or combined counts from all rookeries between the eastern Gulf of Alaska and the western tip of the Aleutian Islands into a single population estimate.

The rookery-based and metapopulation modeling requires assumptions about rates of migration and recolonization. Those rates are not presently known, though they are the subject of ongoing monitoring of branded animals. Each of the models used information about rates of population change that occurred in the past to infer what might happen to sea lion populations in the future.

York *et al.* (1996) developed three models corresponding to three spatial scales (a rookery model, a cluster of rookeries model, and an aggregate model for the Kenai – Kiska area). They used a model of exponential growth randomly changing annually from a distribution that remains constant over time to model counts of adult female sea lions made at the peak of the breeding season. Using counts from 1976-1994 in their retrospective analysis, the rookery

model predicted that the median number of adult females on each rookery between Kenai-Kiska would decline to fewer than 50 animals with 80% of the rookeries disappearing within 100 years, and fewer than 5,000 females remaining by 2015. However, some sites (Akutan, Clubbing Rocks, Ugamak Island, Sea Lion Rocks, and Akun Island) were predicted to persist beyond 100 years despite extinctions at other rookeries. The cluster model grouped Steller sea lion rookeries into 5 clusters and found a relatively high probability of persistence of the western DPS due to positive growth rates in the western Gulf of Alaska cluster. However, pooling all rookery counts within the Kenai – Kiska area to form a single breeding population, and using the rates of decline that occurred from 1976-1994 to project the future, resulted in a predictable continued decline of the western DPS. York *et al.* (1996) concluded that there was no indication that the entire population would likely go extinct within 30 years, but that populations on some rookeries would probably be reduced to low levels (fewer than 200 adult females). The rookery-based model predicted the longest mean persistence time for the Kenai-Kiska population, while the geographic model (pooling all rookery counts) predicted the shortest.

Gerber and VanBlaricom (2001) used count data from 1965-1997 to develop two viability models that evaluated the sensitivity of extinction risk to various levels of stochasticity, spatial scale, and density dependence, again assuming annual variation was the predominant process driver. The first was a metapopulation simulation model that suggested a median time to extinction of about 85 years based the dynamics of groups of rookeries in the Central Gulf of Alaska, Western Gulf of Alaska, Eastern Aleutian Islands, and the Central Aleutian Islands. The second model was exploratory rather than tied strictly to the retrospective analysis and considered population size and population growth rates corresponding to the lowest 5% of the frequency distribution of likely growth rates. This model suggested the time to extinction was about 62 years. Gerber and VanBlaricom (2001) concluded that results from their analysis were consistent with a population threatened with extinction.

Winship and Trites (2006) used counts of both pups and non-pups from 33 rookeries between 1978 and 2002 to estimate the combination of birth and survival rates operating during the population decline. They then projected each of the 33 rookery populations into the future using these estimated site-specific life tables (with associated uncertainties). Using Bayesian statistical methods to quantify uncertainty, Winship and Trites (2006) explored 3 scenarios that incorporated different assumptions about carrying capacities and the presence or absence of density-dependent regulation. Results of all 3 scenarios indicated an overall low risk of extirpation of Steller sea lions as a species in western Alaska in the next 100 years. However, most rookeries had high probabilities of going extinct if trends observed in the 1990s continued — while fewer were predicted to go extinct if trends observed since the late 1990s persisted. All simulations identified two clusters of contiguous rookeries that had relatively low risks of extinction if their dynamics continued to be independent of the rest— the Unimak Pass area in the western Gulf of Alaska / eastern Aleutian Islands, and the Seguam – Adak region in the central Aleutian Islands. Risks of rookeries going extinct were particularly small when density-dependent compensation in birth and survival rates was assumed.

Goodman (Appendix 3) also used a Bayesian framework to quantify uncertainty in model parameters and propagate this through the risk calculation. However, he treated the western

Steller sea lions as a single population by combining counts made at all rookeries and regions of western Alaska, and treated the dominant environmental variation as occurring on a larger than annual time scale. Such population-wide estimates were available for 6 years over the 46 years that sea lions have been counted (i.e., 1958, 1977, 1985, 1989, 2000 and 2004). In this analysis the probability of sea lions persisting for 100 to 500 years depended upon assumptions about the past operation of anthropogenic factors that will not play such a large role in the future. These specific assumptions were a joint product of a subgroup of the recovery team. Overall, this model suggested significant probabilities of sea lions declining below a threshold of 4,743 individuals (i.e., quasi-extinction) for the population as a whole within 100 years. This model allows a parsing of how unfavorable parameter values and uncertainty about parameter values both play a role in the calculated risk.

There is some degree of consistency between the predictions of all four sets of PVA models (Appendix 3; York *et al.* 1996, Gerber and VanBlaricom 2001, Winship and Trites 2006) due in large part to their use of some of the same base population data and to the fundamental assumption of all PVA models that populations will continue to behave as they have in the past after correction for factors that will be different in the future. As such, sea lion populations (i.e., individual rookeries, clusters of rookeries, or the entire western DPS) that declined at fast rates were predicted to go extinct sooner than populations that had declined slowly. Results from the four PVAs conducted to date indicate that the western Steller sea lions have a high probability of declining to a low level if they are considered as a single homogeneous population (by combining all rookery counts and assuming an overarching population trend). However, the prognosis for the species is considerably more optimistic if each of the 33 rookeries is considered as distinct, independent populations with its own probability of persistence, and assuming that differing environmental factors around the respective rookeries remain stationary for the long term (as opposed to the possibility of rolling declines). Under this scenario, PVA models at a spatial scale smaller than the DPS predict that many rookeries will go extinct, but that the species will persist on the time frame considered, most especially if assumed density dependence plays a positive role.

The large potential influence of assumed density dependence is a common feature in the literature of PVA applications, but the statistical estimation of the strength of operation of density dependence in any particular population is notoriously problematic. Density dependence has not been established empirically in the dynamics observed in the Steller sea lion western DPS over the past 40 years.

H. Feeding Ecology

The feeding ecology of Steller sea lions has been described in detail in the initial Steller Sea Lion Recovery Plan (NMFS 1992), and the ESA Biological Opinion on Groundfish Fisheries in the Gulf of Alaska, and Bering Sea and Aleutian Islands area (NMFS 2000). Readers are referred to those documents for additional information.

1. Foods consumed

Steller sea lions are generalist predators that eat a variety of fishes and cephalopods (Pitcher 1981, Calkins and Goodwin 1988, NMFS 2000, Sinclair and Zeppelin 2002), and occasionally other marine mammals and birds (Gentry and Johnson 1981, Pitcher and Fay 1982, Daniel and Schneeweis 1992, Calkins 1988).

The diet of Steller sea lions in the eastern part of their range was not well studied prior to the early 1990s. In California and Oregon they are known to have eaten rockfish, hake, flatfish, salmon, herring, skates, cusk eel, lamprey, squid, and octopus (Fiscus and Baines 1966, Jameson and Kenyon 1977, Jones 1981, Treacy 1985, Brown *et al.* 2002). Principal prey in British Columbia has included hake, herring, octopus, Pacific cod, rockfish, and salmon (Spalding 1964, Olesiuk *et al.* 1990). The most commonly identified prey items in Southeast Alaska were walleye pollock, Pacific cod, flatfishes, rockfishes, herring, salmon, sand lance, skates, squid, and octopus (Calkins and Goodwin 1988, Trites *et al.* 2006d).

Considerable effort has been devoted to describing the diet of Steller sea lions in the Gulf of Alaska, Aleutian Islands, and Bering Sea (Table I-13). In the mid 1970s and mid 1980s, Pitcher (1981; n = 250) and Calkins and Goodwin (1988; n = 178) described Steller sea lion diet in the Gulf of Alaska by examining stomach contents of animals collected for scientific studies. Walleye pollock was the principal prey in both studies; octopus, squid, herring, Pacific cod, flatfishes, capelin, and sand lance were also consumed frequently. Stomachs of Steller sea lions collected in the central and western Bering Sea in March-April 1981 contained mostly pollock and also Pacific cod, herring, sculpins, octopus, and squid (Calkins 1998).

Merrick and Calkins (1996) analyzed Kodiak Island region sea lion stomach contents (n = 263) data from the 1970s and 1980s for seasonal patterns of prey use. They found a significant seasonal difference in diet for the 1970s. Walleye pollock was the most important prey in all seasons except summer in the 1970s, when the most frequently eaten prey type was small forage fishes (capelin, herring, and sand lance). No significant seasonal differences were found in the 1980s. Researchers noted that, overall, small forage fishes and salmon were eaten almost exclusively during summer, while other fishes and cephalopods were eaten more frequently in spring and fall.

Since 1990, additional information on Steller sea lion diet in Alaska has been obtained by analyzing scats collected on rookeries and haulouts (Merrick *et al.* 1997, NMFS 2000, Sinclair and Zeppelin 2002). Scat data, like stomach contents, may be biased (e.g., prey species may have hard parts that are more or less likely to make it though the digestive tract; see Cottrell and Trites 2002, Tollit *et al.* 2003, 2004a), but they allow a description of prey used over a wide geographic range from Kodiak Island through the western Aleutian Islands and for both summer and winter (Table I-13). Analysis of scats collected in the 1990s showed that pollock continue to be a dominant prey in the Gulf of Alaska and that Atka mackerel was the most frequently occurring prey in central and western Aleutian Islands scats. Pacific cod has also been an important food, especially in winter in the Gulf of Alaska, while salmon was eaten most frequently during summer months. Results also indicated a wide variation; certain species that appear to be minor dietary items when data are tabulated for large regions may actually be highly ranked prey for specific rookeries and seasons.

At the far western end of the Steller sea lion range, Atka mackerel, sand lance, rockfish, and octopus were identified as important foods at the Kuril Islands in colletions made in 1962 (Panina

1966), and pollock, Pacific cod, saffron cod, cephalopods, and flatfish were the main prey of 62 animals collected near Hokkaido, Japan in 1994 - 1996 (Goto and Shimazaki 1998).

NMFS (2000) compiled all the available data on prey occurrence in stomach contents samples for the eastern and western Steller sea lion populations for the 1950s - 1970s and the 1980s. For both populations the occurrences of pollock, Pacific cod, and herring were higher in the 1980s than in the 1950s -1970s. These results suggest that the dominance of pollock in the Steller sea lion diet over much of its range may have changed over time. However, studies completed prior to the mid-1970s had small sample sizes and more limited geographic scope. As such, caution should be exercised when extrapolating from these limited samples to a description of the diet composition of Steller sea lions in the 1950s - 1970s.

Stomach contents analysis indicates that Steller sea lions have a mixed diet. Although it is not uncommon to find stomachs that contain only one prey species, most collected stomachs contained more than one type of prey (Merrick and Calkins 1996, Calkins 1998). Merrick and Calkins (1996) found that the probability of stomachs containing only pollock was higher for juveniles than for adults, and small forage fish were eaten more frequently by juveniles while flatfish and cephalopods were eaten by adults more frequently.

Steller sea lion scat and stomach contents data have not been extensively examined for possible sex-related differences in diet. However, Trites and Calkins (unpublished data) collected scat on three rookeries and a nearby male haulout and found that salmon and herring dominated the summer scats of lactating females, while pollock and rockfish dominated the scat of breeding-age males.

2. Prey characteristics

The primary prey of Steller sea lions are fish and cephalopods, which tend to have a broad, but predictable range in temporal, spatial, and seasonal nearshore availability. Typically, many prey species make predictable seasonal migrations from pelagic to nearshore waters where they form large spawning concentrations. Prey is then further concentrated by local transition boundaries such as frontal zones and bathymetric features such as submarine channels (Sinclair *et al.* 1994). Steller sea lions appear to have the foraging flexibility to take advantage of both the predictable behavioral traits of these prey species (Sigler *et al.* 2004), as well as the localized oceanographic conditions that enhance prey concentrations (Sinclair and Zeppelin 2002, Trites *et al.* 2006a). Steller sea lions are able to respond to changes in prey abundance. An example is the increase in consumption of arrowtooth flounder in the Gulf of Alaska between the 1970s (Pitcher 1981) and the 1990s (Sinclair and Zeppelin 2002). Another example is the geographic variation in diet observed during the 1980s and 1990s; east to west the primary prey varies from Pacific hake (Brown *et al.* 2002) to walleye pollock and then to Atka mackerel (Sinclair and Zeppelin 2002).

Prey species can be grouped into those that tend to be consumed seasonally, when they become locally abundant or aggregated when spawning (e.g., herring, Pacific cod, eulachon, capelin, salmon and Irish lords), and those that are consumed and available to sea lions more or less year-round (e.g., pollock, cephalopods, Atka mackerel, arrowtooth flounder, rock sole and sand lance, based on Pitcher 1981, Calkins and Goodwin 1988, Sinclair and Zeppelin 2002, Trites *et al.*

2006d). Some of the seasonal prey species occur most frequently in summer and fall (e.g., salmon and Irish lords) or winter and spring (e.g., herring, Pacific cod, eulachon, capelin). There are also significant regional differences in the occurrences of some species (e.g., Atka mackerel are only in the Aleutian Islands, and arrowtooth flounder occur in the Gulf of Alaska).

Prey size varies greatly ranging from several centimeters in length for species such as sandlance and capelin to over 60 cm in length such as salmon, skates, Pollock and cod. Remains of pollock exceeding 70 cm in length have been recovered in Steller sea lion scats (Tollit *et al.* 2004b, Zeppelin *et al.* 2004). Walleye pollock otoliths recovered from stomachs collected in the Bering Sea and Gulf of Alaska have shown that all age classes of sea lions eat a wide range of sizes (Calkins and Goodwin 1988, Frost and Lowry 1986, Lowry *et al.* 1989, Merrick and Calkins 1996, Calkins 1998).

3. Foraging behavior based on telemetry studies

Adults

Limited data are available concerning the foraging behavior of adult Steller sea lions. Adult females alternate trips to sea to feed with periods on shore when they haul out to rest, care for pups, breed, and avoid marine predators. Conversely, territorial males may fast for extended periods during the breeding season when they mostly remain on land (Spalding 1964, Gentry 1970, Withrow 1982, Gisiner 1985). Females with dependent young are constrained to feeding relatively close to rookeries and haulouts because they must return at regular intervals to feed their offspring.

Merrick *et al.* (1994) and Merrick and Loughlin (1997) present information on the dive characteristics and foraging behavior of a small sample of adult Steller sea lions in Alaska; Loughlin *et al.* (1998) provided similar information for the Kuril Islands, Russia. Merrick *et al.* (1990) and Brandon (2000) presented information on attendance behavior of adult females with VHF radio-transmitters in the Kuril Islands and Alaska, respectively. Trites and Porter (2002) and Milette and Trites (2003) documented attendance patterns from behavioral observations. These studies showed that during the breeding season, adult female Steller sea lions generally spent about half their time at sea on relatively brief (about 0.8 days) foraging trips. Dives tended to be shallow (mean = 21 m), brief (mean = 1.4 min), and frequent (about 13 per hour) (Table I-14). Observations during winter showed that females with suckling yearlings (19-21 months of age) had feeding trips of about 2.5 d while those with young-of-the-years (7-9 months of age) had trips lasting 2.0 d; time on shore for lactating females averaged 15.4 h (Trites and Porter 2002). Merrick and Loughlin (1997) found that during summer adult females made trips to sea that averaged 17 km from the rookery (range 3-49 km; SE = 4.6; Table I-12). Outside of the breeding and pupping season, movements may be less constrained although animals still return to coastal haulouts to rest. For adult females tracked during winter by Merrick and Loughlin (1997), the mean trip duration was 204 hours and average distance moved offshore was 133 km (range 5-543 km; SE = 59.9).

In Southeast Alaska, adult females with pups made relatively brief foraging trips (mean 19.1 hr) while those with yearlings or without pups were much longer in duration; during winter female trips to sea had a mean of 56.1 hr with a maximum of 169 hr. (Swain 1996). Those females with

pups remained within 20 nm of the rookery and mean foraging distance from the Hazy Island and Forrester island rookery complex was 14.5 km offshore (Calkins 1996).

Additional research integrating three separate electronic devices has provided some fine-scale information on Steller sea lion foraging. The combined data (collected from a stomach temperature transmitter that indicates when Steller sea lions ingest prey, a data logger that records depth and velocity, and a SDR to determine locations) provide insights to when and where Steller sea lions may be foraging. Andrews *et al.* (2002) used this approach on adult females in summer at Forrester Island (SE) and Seguam Island (BSAI) in 1994 and 1997; the data indicated nearly all prey ingestion occurred when animals repeatedly exhibited deep dives (greater than 10m), and that prey was ingested during all at-sea trips that included such foraging dives. However, long periods of time often elapsed and large distances were covered between successful foraging events. Adult females began foraging dives greater than 10 m within 8-26 minutes after departing a rookery, yet the first prey was not ingested until 0.9 to 5.1 hours after departure.

Juveniles

The need to understand the behavior of juvenile Steller sea lions has focused research effort in recent years and resulted in a relatively large sample data set for animals less than 3 years of age (Loughlin *et al.* 2003, Raum-Suryan *et al.* 2004, Rehberg 2005, Pitcher *et al.* 2005, Fadely *et al.* 2005) (Tables I-12 and I-14). In general, juveniles in their second year are capable of diving to adult depths but tend not to as often as older animals (Loughlin *et al.* 2003, Rehberg 2005). Rehberg (2005) found that young-of-year sea lions also tend to increase the greater relative proportion of their swimming and diving behavior from diurnal to nocturnal periods. Mean dive depth and duration increases with age and is predicted to increase in a positive relationship with body mass up to about 10 years of age (Pitcher *et al.* 2005). Tagged young-of-the-year animals during winter made trips offshore and along shore that averaged 15 hours long and extended to an average of 30 km (range 1-320 km; SE = 14.5). Loughlin *et al.* (2003) defined three types of movements that vary with age and body mass for juvenile Steller sea lions at sea: 1) transits between land sites with a mean distance of 66.6 km; 2), long-range trips (less than 15 km and greater than 20 hours); and 3) short-range trips (less than 15 km and less than 20 hours). Likewise, Raum-Suryan *et al.* (2002) reported that greater than 90% of round trips were less than 15 km from haul-outs and 84% were less than 20 hours in duration.

4. Nutritional requirements

The amount of food required to provide for energetic needs can vary greatly depending on the energy content of the food and physiological status of the animal (Innes *et al.* 1987). Steller sea lions pups grow rapidly during their first weeks of life and require a substantial intake of energy that is supplied by the mother. Nursing Steller sea lions pups at Año Nuevo Island consumed 1.5 to 2.4 liters of milk per day with a fat content of 23 to 25% (Higgins *et al.* 1988).

Nutritional requirements for free-ranging Steller sea lions have not been measured. Kastelein *et al.* (1990) provided data on food consumption of 10 animals kept in captivity and fed a diet that included several fish species and squid. Average daily consumption increased from 4 to 6 kg per day for 1 year olds to 10-13 kg per day at age 5, with males generally eating more than females. An

adult male ate 18kg per day on average, and females increased their daily requirement by approximately 30% when they became sexually mature and produced pups

Keyes (1968) concluded that adult, nonpregnant, nonlactating pinnipeds would require 6 to 10% of their body weight in food per day. Similarly, captive feeding experiments with 1 to 2 year olds indicate that the daily maximum digestive limit of Steller sea lions (in terms of weight of prey consumed) is equivalent to about 14 to 16% of their body weight (Rosen and Trites 2004).

Kastelein *et al.* (1990) estimated that the amount of food found in Steller sea lion stomachs has usually been on the order of one-fourth of their average daily requirements but did not account for digestion suggesting that meal sizes may at times be much larger. The stomach of a 311 kg sea lion collected in the Bering Sea contained 24 kg of partially digested pollock, which amounted to 7.7% of the animal's body weight (L. Lowry unpublished data). Kastelein *et al.* (1990) also reported that after a day of fasting, captive Steller sea lions ate meals that were about 25% larger than their daily average leading the authors to surmise that large sea lions have a relatively large stomach capacity, which is probably an adaptation that allows them to feed at infrequent intervals.

Winship *et al.* (2002) used bioenergetic modeling to estimate the food requirements of free-ranging Steller sea lions. The model incorporated information on age- and sex-specific bioenergetics of individual animals, population size and composition, and the composition and energy content of the diet. Their model predicted that juvenile animals have higher mass-specific food requirements than adults (greater than 10% versus 5 to 6% of body mass per day) and that a lactating female needs to consume about 70% more food on average if her pup is entirely dependent on her for energy during its first year of life. The mean predicted food requirement of an average Steller sea lion consuming an average Alaskan diet was 17 kg per day.

When assessing the suitability of prey for Steller sea lions in the wild, the important issue is the net amount of nutrition that can be gained from time spent feeding. Nutrition to be gained must take into account energy value of the prey as well as protein, vitamins, minerals, and micronutrients. Quantifying the biological value of prey species and the physiological consequences of inadequate prey is an area where laboratory studies can provide important data. For example, the energetic differences between prey species cannot be solely calculated from measures of gross energy content. The differences in energy due to lipid and protein composition are exaggerated by even higher losses from the heat increment of feeding and digestive efficiency of pollock (Rosen and Trites 1997, 2000b).

I. Ecosystem Interactions

In the North Pacific Ocean, Steller sea lions inhabit a diverse and complex ecosystem, which they share with many other species. Detailed descriptions of physical and biological characteristics of the Gulf of Alaska and Bering Sea have been compiled by Hood and Calder (1981), Hood and Zimmerman (1986), National Research Council (1996), Trites *et al.* (1999, 2006a), Loughlin and Ohtani (1999), and Guenette and Christensen (2005).

Physical aspects of the environment obviously determine whether or not an area is suitable for sustaining Steller sea lions, or any other life form. Physical parameters that may be important to

sea lions include coastal geomorphology, air and water temperatures, wind speeds, wave conditions, tides, currents, etc. A few recent studies have addressed how such factors may influence sea lion distribution and abundance. One showed that the terrestrial sites used by Steller sea lions tend to be associated with waters that are relatively shallow and well-mixed, with average tidal speeds and less-steep bottom slopes (Ban 2005). Another study identified patterns in ocean climate that are consistent with the patterns of sea lion distributions, population trends, numbers and diets (Trites *et al.* 2006a). Thus, there appears to be a linkage between Steller sea lions and the physical environment, which likely plays a major role in determining the northern and southern limits of the Steller sea lion range.

Physical characteristics of the ecosystems inhabited by sea lions are not static, but rather show variations on several time scales (Schumacher and Alexander 1999, Trites *et al.* 2006a). Considerable attention has recently been given to abrupt decadal scale changes in long term data series that describe the climate, oceanic conditions and abundances of a number of species in the North Pacific. The largest such change recorded this past century occurred in the mid 1970s (Ebbesmeyer *et al.* 1991, Graham 1994, Francis *et al.* 1998). In some cases fluctuations in fish, bird, and mammal populations seem to correlate with these decadal scale climate changes (Springer 1998, 2004, Benson and Trites 2002, Trites *et al.* 2006a).

Food web interactions (Trites 2003), predation (Barrett-Lennard *et al.* 1995) and disease (Burek *et al.* 2003, Goldstein 2004) are all biotic components of the ecosystem that are important to Steller sea lions as they function as food, competitors, predators, parasites, and disease agents. Ways in which such ecosystem relationships may influence Steller sea lion populations are discussed in detail in Sections V.A. and VI.A.

Human exploitation of marine mammals and fishes in the North Pacific Ocean over the past 250 years has undoubtedly modified the environment that Steller sea lions occupy. The precise effects on Steller sea lions have been impossible to determine, but have likely been substantial, variable over time, and both top-down and bottom-up in nature. Large-scale removals of competitors of prey, such as some species of great whales, northern fur seals, and perhaps some fishes may have provided additional food and for some period of time may have increased sea lion carrying capacity. The relationship of Steller sea lions with their primary predator, killer whales, has also likely varied over time with the exploitation of alternative prey such as great whales, northern fur seals, and sea otters and perhaps with the exploitation and recovery of killer whales themselves. Combining this with climatic variability and commercial fisheries that could potentially affect the carrying capacity for Steller sea lions yields an extremely complex history.

Ecosystem models are available for the Aleutian Islands, Eastern Bering Sea and Southeast Alaska; these models can be used to decipher the combined effects that fishing, predation, ocean climate change, and interspecies interactions have had on Steller sea lions and their ecosystems as a whole (Trites *et al.* 1999, Guenette and Christensen 2005). These models indicate that bottom-up and top-down processes occur simultaneously and suggest that Steller sea lions have been both positively and negatively affected by changes in their food base (due to fishing and ocean climate change), as well as by competition with large flatfish, and by the effects of predation by killer whales (particularly when sea lion numbers are low). Further work is continuing with these models to assist in better understanding the complex ecosystem interactions underway in the North Pacific.

Table I-1. Counts of adult and juvenile (non-pup) Steller sea lions at western DPS rookery and haul-out trend sites in Alaska during June-July surveys from 1976 to 2004 (NMFS 2000, Sease *et al.* 2001, Sease and Gudmundson 2002, and Fritz and Stinchcomb 2005). Numbers in parentheses are the number of trend sites counted in each sub-area. Percentage changes between years are shown in bold.

Year(s)	Gulf of Alaska			Aleutian Islands			Kenai-Kiska (69)	Western DPS in Alaska (82)
	Eastern (9)	Central (15)	Western (9)	Eastern (11)	Central (34)	Western (4)		
1956-60[1]		34,792	15,772	44,020	17,120		111,704	
1962					23,175			
1976-79[2]	7,053	24,678	8,311	19,743	36,632	14,011	89,364	110,428
1985		19,002	6,275	7,505	23,042		55,824	
1989	7,241	8,552	3,908	3,032	7,572		23,064	
1990	5,444	7,050	3,915	3,801	7,988	2,327[3]	22,754	30,525
1991	4,596	6,270	3,732	4,228	7,496	3,083	21,726	29,405
1992	3,738	5,739	3,716	4,839	6,398	2,869	20,692	27,299
1994	3,365	4,516	3,981	4,419	5,820	2,035	18,736	24,136
1996	2,132	3,913	3,739	4,715	5,524	2,187	17,891	22,210
1998	2,110[4]	3,467	3,360	3,841	5,749	1,911	16,417	20,438
2000	1,975	3,180	2,840	3,840	5,419	1,071	15,279	18,325
2002	2,500	3,366	3,221	3,956	5,480	817	16,023	19,340
2004[5]	2,536	2,944	3,512	4,707	5,936	898	17,099	20,533
1950s to 2000		**-91%**	**-82%**	**-91%**	**-68%**		**-86%**	
1970s to 2000	**-72%**	**-87%**	**-66%**	**-81%**	**-85%**	**-92%**	**-83%**	**-83%**
1970s to 1990	**-23%**	**-71%**	**-53%**	**-81%**	**-78%**	**-83%**	**-75%**	**-72%**
1990 to 2000	**-64%**	**-55%**	**-27%**	**+1%**	**-32%**	**-54%**	**-33%**	**-40%**
2000 to 2004	**+28%**	**-7%**	**+24%**	**+23%**	**+10%**	**-16%**	**+12%**	**+12%**

[1] 1956 counts for the western GOA, 1957 counts for the central GOA, 1959 counts for the central Aleutians and 1960 counts for the eastern Aleutians.

[2] 1976 counts for the eastern, central, and western GOA and the eastern Aleutians, and 1979 counts for the central and western Aleutians.

[3] Gillon Point rookery, Agattu Island not surveyed in 1990.

[4] 1999 counts substituted for sites in the eastern Gulf of Alaska not surveyed in 1998.

[5] 2004 counts were from medium format photographs, while all others were from 35 mm photographs, aerial counts or beach counts. 2004 data reflect a –3.64% adjustment to account for film format resolution and count differences (Fritz and Stinchcomb 2005).

Table I-2. Counts of Steller sea lion pups at western DPS rookeries in Alaska during 1979 to 2004 (NMFS 1992, Sease and Loughlin 1999, Fritz and Stinchcomb 2005, NMFS unpublished). Percentage changes between years are shown in bold.

	Gulf of Alaska			Aleutian Islands			Eastern Bering Sea	Kenai-Kiska[7]	Western DPS in Alaska
Year(s)	Eastern[1]	Central[2]	Western[3]	Eastern[4]	Central[5]	Western[6]	Walrus Island		
1979			8,616						
1982							334		
1984			6,435						
1985-89		10,254		4,778	9,428		250	30,895[7]	
1990-92		4,904	1,923	2,115	3,568		63	12,510	
1994	903	2,831	1,662	1,756	3,109		61	9,358	
1996	584								
1997	611					979	35		
1998	689	1,876	1,493	1,474	2,834	803		7,677	9,169
2001-02	586	1,721	1,671	1,561	2,612	488	39	7,565	8,678
2003-04	716	1,609	1,577	1,731					
2005	715	1,651	1,707	1,921	2,551	343	29	7,830	8,917
Earliest count to 1994		**-72%**	**-81%**	**-63%**	**-67%**			**-70%**	
Earliest count to 2001-02	**-35%**	**-83%**	**-81%**	**-67%**	**-72%**	**-50%**	**-88%**	**-76%**	**-5%**
1994 to 2001-02	**-35%**	**-39%**	**+1%**	**-11%**	**-16%**		**-36%**	**-19%**	
2001-02 to 2005	**+22%**	**-4%**	**+2%**	**+23%**	**-2%**	**-30%**	**-25%**	**+4%**	**+3%**

[1] Seal Rocks and Fish (Wooded) Island
[2] Outer, Sugarloaf, Marmot, Chowiet and Chirikof Islands
[3] Atkins and Chernabura Islands, and Pinnacle Rock and Clubbing Rocks
[4] Ugamak, Akun, Akutan, Bogoslof and Adugak Islands
[5] Yunaska, Seguam, Kasatochi, Adak, Tag, Ulak, Ayugadak and Kiska (2) Islands, and Gramp and Column Rocks.
[6] Buldir, Agattu (2), and Attu Islands
[7] Rookeries in the Central and Western Gulf of Alaska, and Eastern and Central Aleutian Islands

Table I-3. Counts of adult and juvenile (non-pup) Steller sea lions on terrestrial trend sites in Russia.

Year	W. Bering Sea	Commander Islands	E. Kamchatka	Kuril Islands	Tuleny Island	Sea of Okhotsk
1963		2,920[1]		14,660	60[2]	
1969				14,184		
1971		2,920				
1973		3,503				
1974					49	1,208
1975				8,397		
1977		4,480				
1978		2,807			26	
1981		2,101		5,921		
1982	4,910	1,577				
1983	3,230	1,761	2,073		65	
1984		1,930				
1985	3,370	1,700			137	
1986		2,633			450	
1987	1,231	2,267	1,690			
1988		1,221			171	1,691[3]
1989	1,199	896	1,519	4,488	190	
1990		865			410	
1991	427	752	794		350	
1992		843			463	
1993		569			549	
1994	200	543	642		557	
1995		653				
1996		804			615	2,429[4]
1997		812			679	
1998		900			836	
1999	180	860	720		770	
2000		741			1,155	
2001		718	669	5,129	857	2,324
2002	16	581	491		1,041	2,072
2003		530		5,178	1,119	
2004	91	674	548		1,084	2,357
2005				5,544	1,218	

[1]1962 data. [2]1964 data. [3]1989 data for Iony Island. [4]1995 data for Yamsky Islands and 1997 data for Iony Island.

Table I-4. Counts of Steller sea lion pups on rookery trend sites in Russia.

Year	Commander Islands	E. Kamchatka	Kuril Islands	Tuleny Island	Sea of Okhotsk
1962	1				
1963			3,673		
1969	0		3,250		
1970	3				
1971	4				
1972	9				
1973	26				
1974				1	607
1977	19				
1978	26			0	
1980				6	
1981	48				
1982	83			0	
1983	104		1,992	5	
1984	141			0	
1986	151		1,560	25	
1987	197	211			
1988	141			38	712[1]
1989	195		1,442	45	
1990				59	
1991	229			63	
1992	222	108	1,623	90	
1993	224	115		120	
1994	226	93		146	
1995	248	84	1,972		
1996	261	87		219	1,250[2]
1997	244	96		256	
1998	280	91		303	
1999	271	87		291	
2000	180	76	1,824	340	
2001	228	61	1,807	303	1,231
2002	210	84	1,973	410	980
2003	216		2,086	480	
2004	221	107		508	1,868
2005	236		2,306	407	

[1]1989 data for Iony Island. [2]1995 data for Yamsky Islands and 1997 data for Iony Island.

Table I-5. Counts of one-month-old Steller sea lion pups on rookeries in southeast Alaska, 1979-2005 (ADF&G and NMFS unpublished data).

Year	Forrester Island	Hazy Island	White Sisters	Graves Rocks	Biali Rocks	Total Pups
1979	2,187	32				2,219
1990	2,932	638	30			3,600
1991	3,261	808	95			4,164
1994	2,757	862	151			3,770
1996	2,764	768	182			3,714
1997	2,798	1,157	205			4,160
1998	2,753	1,199	282	1		4,235
2001	3,152	1,091	371	89	38	4,741
2002	3,060	1,257	403	98	59	4,877
2005	3,429	1,286	520	175	100	5,510

Table I-6. Counts of adult and juvenile (non-pup) Steller sea lions observed at individual rookeries and rookery and haulout trend sites combined in southeast Alaska during June-July aerial surveys from 1979 to 2005 (Sease *et al.* 2001, ADF&G and NMFS unpublished data).

Year	Forrester Island	Hazy Island	White Sisters	Graves Rocks	Biali Rocks
1979	3,121	893	761	-	810
1982	3,777	1,268	934	-	722
1989	4,648	1,462	734	475	794
1990	3,324	1,187	980	937	596
1991	3,970	1,496	975	470	494
1992	3,508	1,576	860	366	398
1994	4,010	1,615	868	733	410
1996	3,551	1,759	894	475	342
1998	3,788	1,962	858	445	476
2000	3,674	1,824	1,398	558	690
2002	3,699	2,050	1,156	1,001	624
2005	5,557	2,293	1,078		598

Table I-7. Counts of Steller sea lions on rookeries and haulouts in British Columbia, 1971-2002 (Olesiuk and Trites 2003).

Year	Non-pups	Pups	Total
1971	4,617	941	5,475
1977	5,219	963	6,274
1982	4,713	1,245	5,956
1987	6,109	1,084	7,193
1992	7,376	1,468	8,844
1994	8,091	1,186	9,277
1998	9,818	2,073	11,891
2002	12,121	3,281	15,402

Table I-8. Counts of non-pup Steller in sea lions on rookeries and haulouts in Oregon and of pups counted during ground counts or from medium-format photographs on the Rogue Reef and Orford Reef rookeries 1976-2001 (Brown *et al.* 2002). Mean counts of Steller sea lion non-pups on Washington haulouts during the breeding season, June 16 through July 15, 1991 – 2001 (Washington Department of Fisheries and Wildlife unpublished data).

Year	Oregon Total Non-pups	Rogue Reef Pups	Orford Reef Pups	Washington Total Non-pups
1977	1,461	--	--	--
1979	1,542	--	--	--
1980	1,632	--	--	--
1981	2,105	--	--	--
1982	2,604	--	--	--
1983	2,106	--	--	--
1984	1,867	--	--	--
1985	2,210	--	--	--
1986	2,289	--	--	--
1987	2,709	--	--	--
1988	2,825	--	--	--
1989	2,183	--	--	89
1990	2,414	492	298	--
1991	--	--	--	274
1992	3,581	--	--	278
1993	2,838	--	--	--
1994	3,293	--	--	384
1995	3,837	--	--	409
1996	3,205	685	335	594
1997	3,897	--	--	352
1998	3,971	--	--	470
1999	3,275	--	--	806
2000	2,927	--	--	778
2001	3,648	600	--	516
2002	4,169	746	382	--

Table I-9. Historical compilation of counts of adult and juvenile (non-pup) Steller sea lions on rookeries (current and former) and associated haulouts in California, 1927-2004.

Year	San Miguel Island	Año Nuevo Island	Farallon Islands	Sugarloaf Island/ Cape Mendocino	Saint George Reef	Total
1927	595[a]	1,500[a]	700[a]	700[a]	1,500[a]	4,995
1930	620[b]	2,500[b]	900[b]	900[b]	700[b]	5,620
1936	1,359	1,000	500	700	652	4,211
1938	1,902	2,000	357	500	325	5,084
1947	950[b]	2,050[b]	750[b]	625[b]	200[b]	4,575
1962	–	2,265[c]	–	–	–	--
1964	61[d]	–	–	–	–	--
1974	–	673[e]	133[f]	–	–	--
1983	–	319[e]	141[f]	–	–	--
1990	–	449[g]	206[f]	–	674[g]	--
1991	0	359[g]	178[f]	–	626[h]	--
1992	–	189[g]	87[f]	–	693[h]	--
1993	–	218[g]	107[f]	–	496[g]	--
1994	–	387[g]	121[f]	–	538[g]	--
1995	–	288[g]	138[f]	–	–	--
1996	–	306[g]	76[f]	501[g]	987[g]	1,870
1997	–	--	–	–	937[h]	
1998	–	179[g]	–	256[g]	493[g]	
1999	0	350[g]	214[g]	270[g]	713[g]	1,547
2000	0	270[g]	79[g]	489[g]	866[g]	1,704
2001	0	227[g]	60[g]	740[g]	790[g]	1,817
2002	0	255[g]	125[g]	588[g]	716[g]	1,684
2003	0	254[g]	136[g]	513[g]	803[g]	1,706
2004	0	340[g]	85[g]	415[g]	738[g]	1,578

[a]Bonnot 1928
[b] Bonnot and Ripley 1948
[c]Orr and Poulter 1965
[d]Odell 1971
[e]LeBoeuf *et al.* 1991
[f]Point Reyes Bird Observatory, unpublished data
[g]Southwest Fisheries Science Center, unpublished data
[h]Oregon Department of Fish and Wildlife, unpublished data

Table I-10. Recent counts of Steller sea lion pups on rookeries in California, 1990-2004.

Year	Año Nuevo	Farallons	Sugarloaf/ Cape Mendocino	Saint George Reef	Total Pups
1990	312[a]	4[c]			
1991	287[b]	2[c]			
1992	263[b]	4[c]			
1993	230[b]	5[c]			
1994	244[a]	7[c]		115[a]	
1995	226[a]	6[a]			
1996	236[a]	5[c]	62[a]	243[a]	546
1997	210[a]				
1998	186[a]		61[a]	256[a]	
1999	152[a]	10[a]	86[a]	184[a]	432
2000	184[a]	4[a]	138[a]	293[a]	619
2001	230[a]	2[a]	152[a]	338[a]	722
2002	189[a]	7[a]	150[a]	367[a]	713
2003	226	13[a]	158[a]	458[a]	855
2004	221	22[a]	131[a]	444[a]	818

[a]Southwest Fisheries Science Center, unpublished data
[b] Westlake *et al.* 1997
[c]Point Reyes Bird Observatory, unpublished data

Table I-11. Estimates of the total number of Steller sea lions (pups and non-pups) in the eastern DPS in 2002 based on number of pups counted multiplied by the 4.5 multiplier (Calkins and Pitcher 1982) and the 5.1 multiplier (Trites and Larkin 1996).

Region	Pups Counted	Estimate with 4.5 multiplier	Estimate with 5.1 multiplier
Southeast Alaska	4,877	21,947	24,873
British Columbia	3,281	14,765	16,733
Oregon	1,128	5,076	5,753
California	713	3,209	3,636
Total	9,999	44,997	50,995

Table I-12. Source of literature, age class/group, sample size (n), capture location, season captured, instrument deployed, and mean trip duration, distance, and time at sea for Steller sea lions tagged with radio (VHF) and satellite (e.g. SLTDR) transmitters. Error is standard deviation unless otherwise indicated.

Source	Age Class/Group	n	Capture Location	Season	Instrument	Mean Trip Duration (h)	Mean Trip Distance (km)	Mean % Time @ Sea
Merrick and Loughlin (1997)	Adult Female	7	Marmot (CGOA)	Summer	VHF	21.0 ± 3.7 (SE)		53
	Adult Female	3	Ugamak (EAI)	Summer	VHF	25.0 ± 3.9		58
	Adult Female	4	EAI to CGOA	Summer	SLTDR	18.0 ± 3.1		50
	Adult Female	5	EAI to CGOA	Winter	SLTDR	204.0 ± 104.6		90
	YOY	5	EAI to CGOA	Winter	SLTDR	15.0 ± 2.2		38
Loughlin *et al.* (1998)	Adult F	8	Kuril Islands, Russia	Summer	SLTDR	short; max = 94 h	94% trips ≤ 10 km (max=263 km)	
Loughlin *et al.* (2003)[1]	YOY	12	CAI, EAI, EGOA, CGOA, and WA	All	SLTDR/SDR	7.5 ± 7.5	7.0 ± 19.0	
	Juv (>10 mo.)	13	CAI, EAI, EGOA, CGOA, and WA	All	SLTDR/SDR	18.1 ± 34.2	24.6 ± 57.2	
	Combined	25	CAI, EAI, EGOA, CGOA, and WA	All	SLTDR/SDR	12.1 ± 23.8		
Raum-Suryan *et al.*(2004)[2]	YOY (75), Juv (28)	103	see below	Spr/Sum/Win	SDR	84% trips ≤ 20 h	90% trips ≤ 15 km	
	Western DPS	29	EAI, CGOA, EGOA	Spr/Sum/Win	SDR		6.5 (5.08-8.26) CI	
	Eastern DPS	74	North, South, and Central SE	Spr/Sum/Win	SDR		4.7 (3.92-5.53)	
Fadely *et al.* (2005)[3]	YOY/Juv	30	CAI, EAI, and CGOA	Feb-April	SDR	8.9 (8.4-9.4) CI	0.56 (0.56-0.74) CI	
				May-July	SDR	12.5 (11.3-13.9)	1.30 (0.93-1.49)	
				Nov-Jan	SDR	10.1 (8.2-12.5)	1.11 (0.74-1.67)	
Rehberg (2005)	YOY	11	CAI and GOA	Spring/Winter	SRDL			42 (38-45) CI
	Juv	12	CAI and GOA	Spring/Winter	SRDL			51 (49-54) CI

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Table I-12. Continued.

[1]Trip duration ranged from 1.0 h to 81.3 h (YOY) and 344.0 h (Juv) and trip distance ranged from 1.0 km to 260.7 km (YOY) and 447.3 km (Juv).
[2]Inter-haulout distance averaged 79.3 ± 7.7 km (max = 127 km) and dispersal distances (2 YOY, 2 Juv) included 76, 120, 500, and 1300 km, respectively.
Sea lions in the western and eastern DPSs used an average of 1.6 and 2.1 haulouts, respectively.
[3]Most locations associated with diving were within 9 to 19 km (5-10 nm) of shore and in waters less than 100 m. Trip duration and use of offshore waters increased with age and coincided with spring.
YOY: young-of-the-year; Juv: juvenile (> 1 year unless otherwise specified); VHF: very high frequency radio transmitter; SLTDR: satellite-linked time-depth recorder; SDR: satellite depth recorder; SRDL: satellite relayed dive logger; CAI: central Aleutian Islands; EAI: eastern Aleutian Islands; EGOA: eastern Gulf of Alaska; CGOA: central Gulf of Alaska; SE: Southeast Alaska; WA: Washington State; CI: 95% confidence interval

Table I-13. Food habits information for Steller sea lions collected in the range of the western DPS, 1945-1998. (Reprinted from Fritz and Hinckley 2005).

A. Sample Sizes and Characteristics		Months				Region						
Reference	Years	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	CGOA	WGOA	EBS	EAI	CAI	WAI	Russia
Imler and Sarber (1947)	1945			7		7						
Wilke and Kenyon (1952)	1949, 51			3				3				
Mathisen *et al.* (1962)	1958		94				94					
Thorsteinson and Lensink (1962)	1959		56			9	27		20			
Tikhomirov (1964)	1962	X	X					X				
Fiscus and Baines (1966)	1960, 62		16			4	2	1	9			
Perlov (1975)	1966-69			?								X
Lowry *et al.* (1982)	1976	4						4				
Pitcher (1981)	1975-78	43	54	9	47	136	17					
Calkins (1998) a	1981	60										60
Calkins (1998) b	1981	32						32				
Frost and Lowry (1986)	1985	13						13				
Gearin (unpub)	1985, 86			3	8			11				
Calkins and Goodwin (1988)	1985, 86		X		X	74						
Merrick *et al.* (1997) a	1990-93			76		76						
Merrick *et al.* (1997) b	1990-93			67					67			
Merrick *et al.* (1997) c	1990-93			167						167		
Merrick *et al.* (1997) d	1990-93			28							28	
Goto and Shimazaki (1997)	1994-96	62										62
Sinclair and Zeppelin (2002) a	1990-98	X	X	X	X	574						
Sinclair and Zeppelin (2002) b	1990-98	X	X	X	X		929					
Sinclair and Zeppelin (2002) c	1990-98	X	X	X	X				889			
Sinclair and Zeppelin (2002) d	1990-98	X	X	X	X					1370		

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Table I-13. Food habits information of Steller sea lions collected in the range of the western DPS, 1945-1998 (continued).

B. Food habits data	Sample	Sample	Data	Percent of Sample with Prey Item (x=present)												
Reference	Type	Location	Type	Pollock	Cod	Flatfish	Greenling	Rockfish	Smelts	Sandlance	Herring	Salmon	Sculpin	Shrimp/Crab	Squid	Octopus
Imler and Sarber (1947)	Stomach	Land	FO	57		71						28				43
Wilke and Kenyon (1952)	Stomach	Land	PW	7	10	49				32			<1			2
Mathisen *et al.* (1962)	Stomach	Land	FO				13	9	14	1		1	6	10	44	
Thorsteinson and Lensink (1962)	Stomach	Land	FO			6	4	11		25			4	2	20	
Tikhomirov (1968)	Visual	At-sea									D					
Fiscus and Baines (1966)	Stomach	At-sea	FO	6		12	6	6	56	25			19			
Perlov (1975)	Stomach	At-sea	FO	63			10						1		>30	25
Lowry *et al.* (1982)	Stomach	At-sea	PV	97		1									1	1
Pitcher (1981)	Stomach	Land	FO	67	12	5		3	11		11	4	4	7	23	13
Calkins (1998) a	Stomach	At-sea	FO	83	43	3					17		>12	2	2	18
Calkins (1998) b	Stomach	At-sea	FO	100	28	>19		3			6		6	>10	19	19
Frost and Lowry (1987)	Stomach	At-sea	PV	48							48					
Gearin (unpub)	Stomach	Land	FO	>36	>45	54								18		45
Calkins and Goodwin (1988)	Stomach	Land	FO	58	7	14				7	3	3	1	>1	4	32
Merrick *et al.* (1997) a	Scat	Land	FOSS	66		4	<1		6			20	0		3	
Merrick *et al.* (1997) b	Scat	Land	FOSS	33		2	31		8			17	7		2	
Merrick *et al.* (1997) c	Scat	Land	FOSS	13		0	69		1			6	4		8	
Merrick *et al.* (1997) d	Scat	Land	FOSS	7		0	77					5	5		7	
Goto and Shimazaki (1997)	Stomach	At-sea	FO	89	76	24									69	11
Sinclair and Zeppelin (2002) a	Scat	Land	FO	>50	>5	>20	<5	x	x	>10	>10	>10	<10		<10	<10
Sinclair and Zeppelin (2002) b	Scat	Land	FO	>70	>10	>10	<5	x	x	>10	<10	>10	>10		<5	<5
Sinclair and Zeppelin (2002) c	Scat	Land	FO	>50	>10	<5	>20	x	x	<5	>5	>20	>10		<10	<10
Sinclair and Zeppelin (2002) d	Scat	Land	FO	<10	>10	<5	>60	x		<5	<5	>20	>10		<20	<20

Table I-13 (continued). Abbreviations: CGOA – central Gulf of Alaska; WGOA – western Gulf of Alaska; EBS – eastern Bering Sea; EAI – eastern Aleutian Islands; CAI – central Aleutian Islands; WAI – western Aleutian Islands; X – number for cell is unknown; ? – season of sample collection is unknown but likely to be as indicated; FO=frequency of occurrence; PW=percent by weight; PV=percent by volume; FOSS=Split sample FO.

Table I-14. Source of literature, age class/group, sample size (n), capture location, season captured, instrument deployed, mean depth of dives, mean depth of maximum dives, maximum depth, mean duration of dives, and maximum duration of dives for Steller sea lions tagged with satellite (e.g. SLTDR) transmitters. Units for data coincide with those in the table header unless otherwise indicated and error is standard deviation unless otherwise indicated.

Source	Age Class/Group	n	Capture Location	Season	Instrument	Mean Dive Depth (m)	Mean Max Depth (m)	Max Depth (m)	Mean Dive Duration (min)	Max Dur (min)
Merrick and Loughlin (199	Adult F	4	Alaska (EAI to CGOA)	Summer	SLTDR	21.0 (med)		150-250		
	Adult F	5	Alaska (EAI to CGOA)	Winter	SLTDR	24.0		> 250		
	YOY	5	Alaska (EAI to CGOA)	Winter	SLTDR	9.0		72		
Loughlin *et al.* (1998)	Adult F	8	Kuril Islands, Russia	Summer	SLTDR	53.0		250	1.9	8
Loughlin *et al.* (2003)[1]	YOY	13	CAI, EAI, EGOA, and CGOA	All	SLTDR/SDR	7.7 ± 1.7	25.7 ± 16.9	252	0.8 ± 0.1	
	Juv	5	EAI, EGOA, and CGOA	All	SLTDR/SDR	16.6 ± 10.9	63.4 ± 37.7	288	1.1 ± 0.4	
	Juv	7	WA	All	SLTDR/SDR	39.4 ± 14.9	144.5 ± 32.6	328	1.8 ± 0.6	
Pitcher *et al.* (2005)	YOY	75	Alaska (EAI to SE)	All	SDR	87% dives < 10 m		252	82% dives < 2 min	>12
	Juv	36	Alaska (EAI to SE)	All	SDR			452		
Fadely *et al.* (2005)[2]	YOY	26	CAI, EAI, and GOA	Spr/Sum/Win	SDR	10.3				
	Juv	4				13.0				
Rehberg (2005)	YOY	11	CAI and GOA	Spring/Winter	SRDL	12.4 (11.0-14.0) CI			0.87 (0.7-1.0) CI	
	Juv	12	CAI and GOA	Spring/Winter	SRDL	22.9 (20.0-28.0)			1.71 (1.5-2.0	

[1]Dive parameters did not differ among regions in the Aleutian Islands and Gulf of Alaska.
[2]Increase in diving activity coincided with increases in SST and chlorophylll-a, but also with age.
YOY: young-of-the-year; Juv: juvenile (> 1 year unless otherwise specified); VHF: very high frequency radio transmitter; SLTDR: satellite-linked time-depth recorder; SDR: satellite depth recorder; SRDL: satellite relayed dive logger; CAI: central Aleutian Islands; EAI: eastern Aleutian Islands; EGOA: eastern Gulf of Alaska; CGOA: central Gulf of Alaska; SE: Southeast Alaska; WA: Washington State; CI: 95% confidence interval

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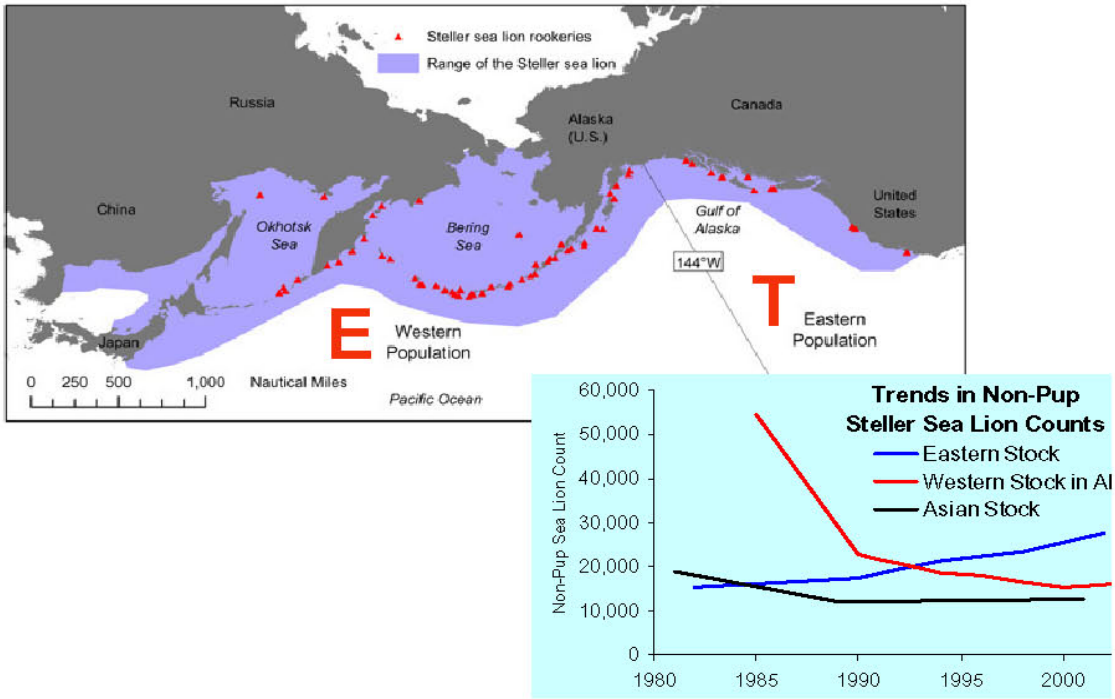

Figure I-1. Breeding ranges of the western and eastern DPSs of Steller sea lions (triangles = terrestrial locations of major rookeries) in the North Pacific. Trends in index counts of adult and juvenile (non-pup) sea lions on rookery and haulout sites within the breeding ranges of the eastern and western (Alaska only) DPSs are also shown.

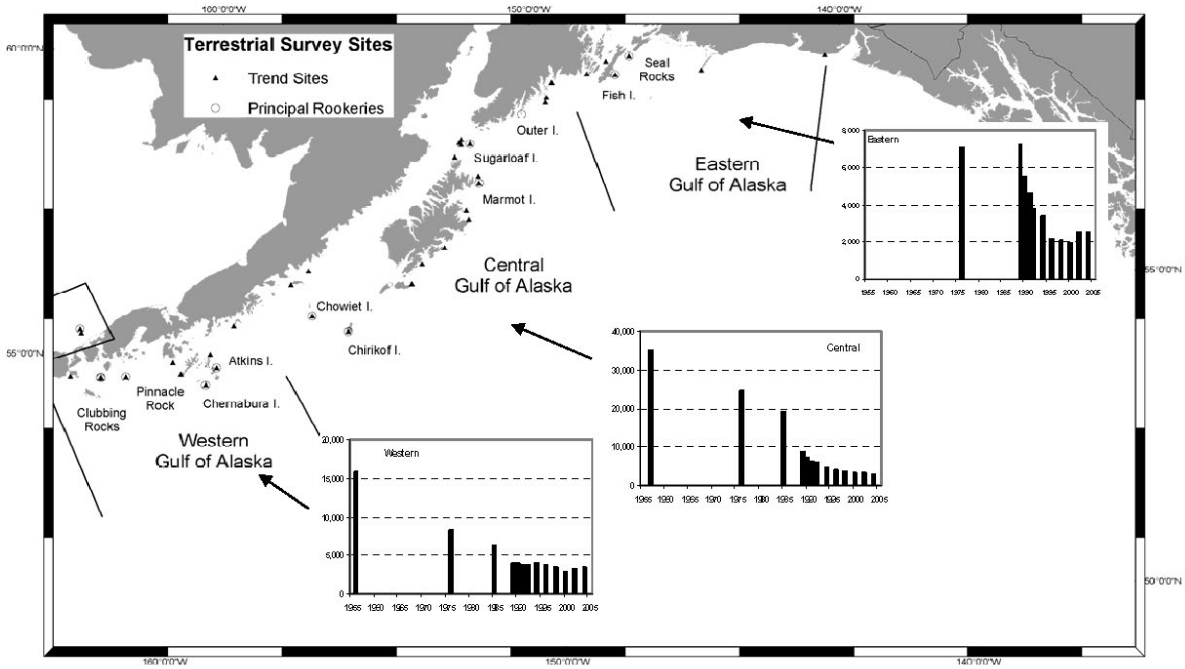

Figure I-2. Counts of adult and juvenile Steller sea lions on western DPS trend sites in three sub-areas of the Gulf of Alaska, 1950s through 2004. Principal rookeries (named) and major terrestrial haul-out trend sites are shown (NMFS 1992; Fritz and Stinchcomb 2005).

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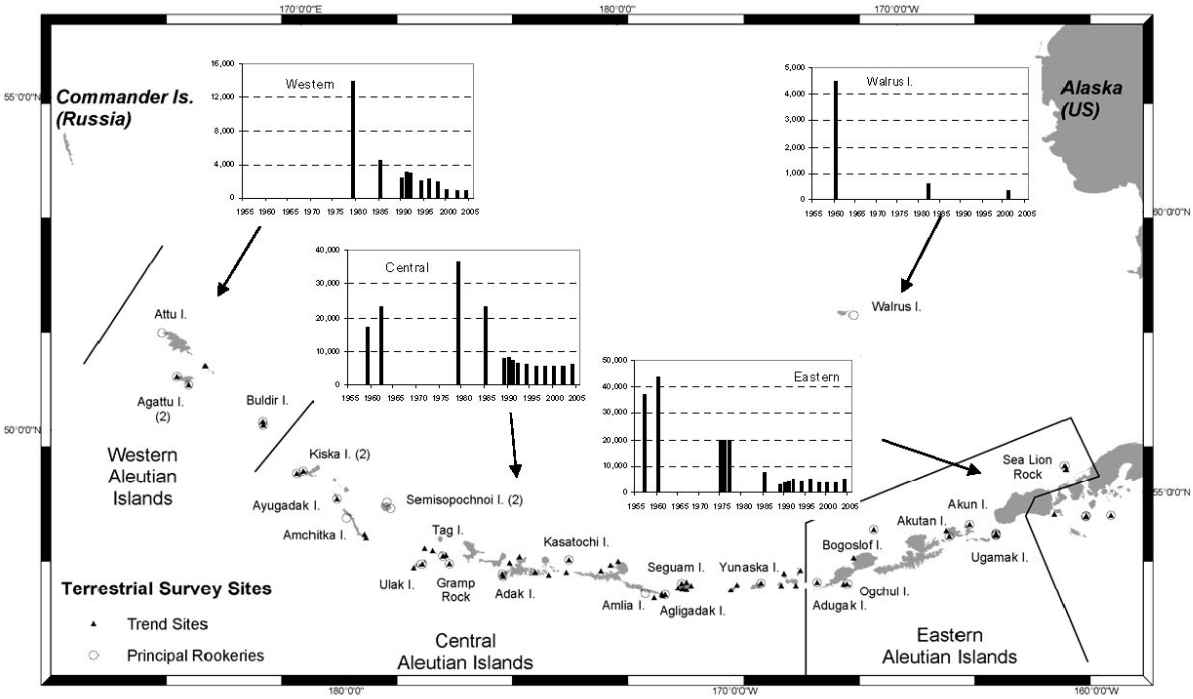

Figure I-3. Counts of adult and juvenile Steller sea lions on western DPS trend sites in three sub-areas of the Aleutian Islands, 1950s through 2004. Counts on Walrus Island in the eastern Bering Sea are also shown, as are the location of principal rookeries (named) and major terrestrial haulout trend sites (NMFS 1992; Fritz and

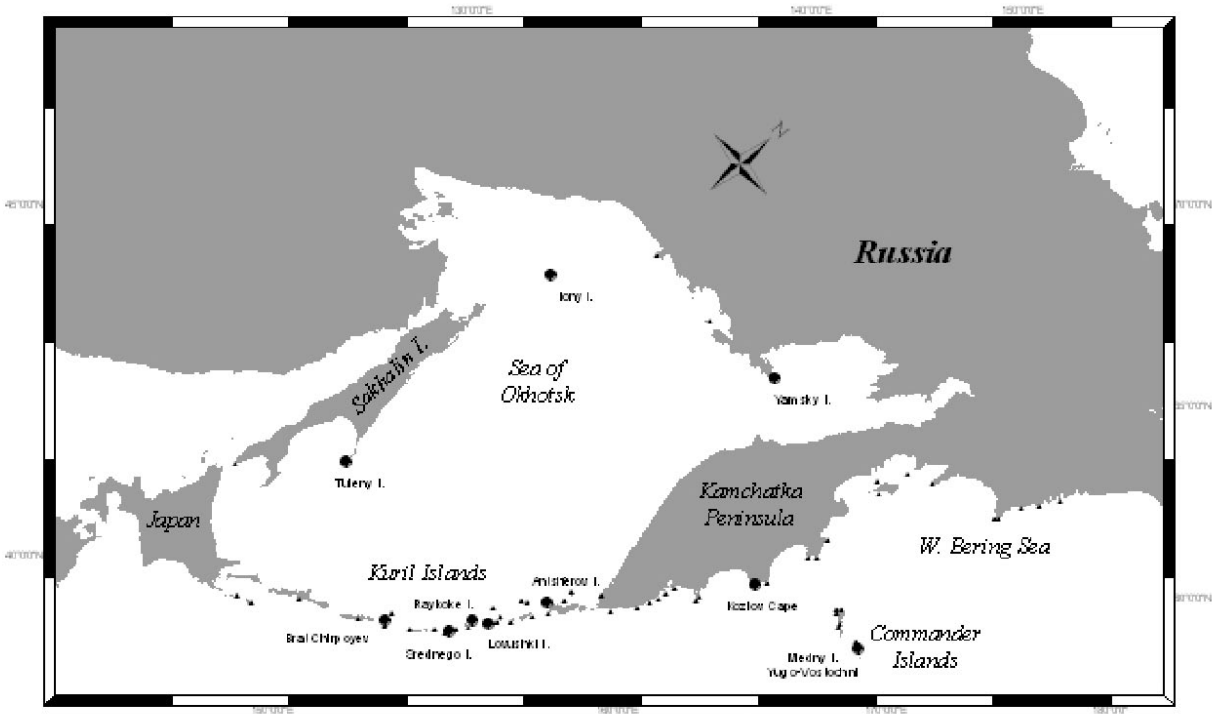

Figure I-4. Locations of Steller sea lion rookeries (named) and haul-out sites in Russia.

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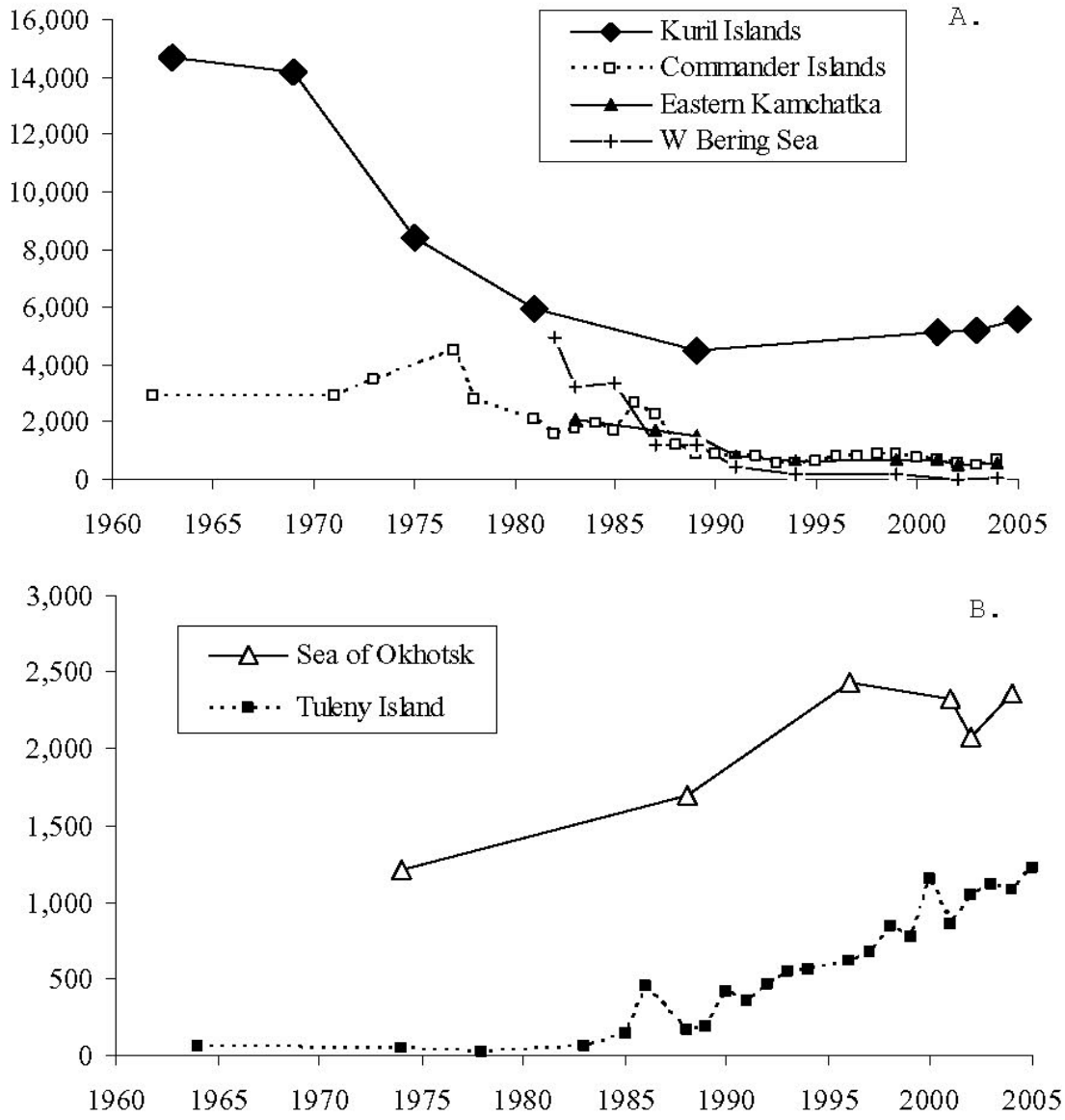

Figure I-5. Counts of non-pup Steller sea lions in Russia at trend haul-out and rookey sites by sub-area. A. Kuril Islands, eastern Kamchatka Peninsula, western Bering Sea (no rookeries) and the Commander Islands. B. Sea of Okhotsk and Tuleny Island near Sakhalin Island (only rookeries).

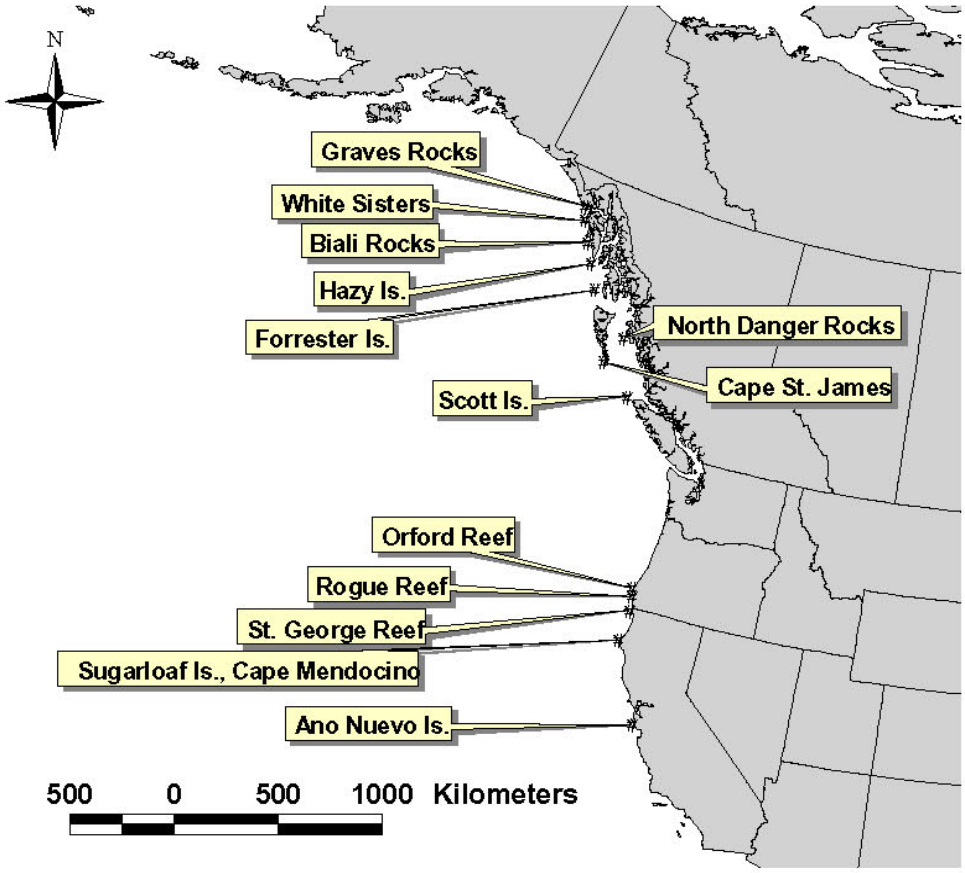

Figure I-6 Geographic range of the eastern DPS of Steller sea lion showing locations of current rookeries (sites where > 50 pups were born)

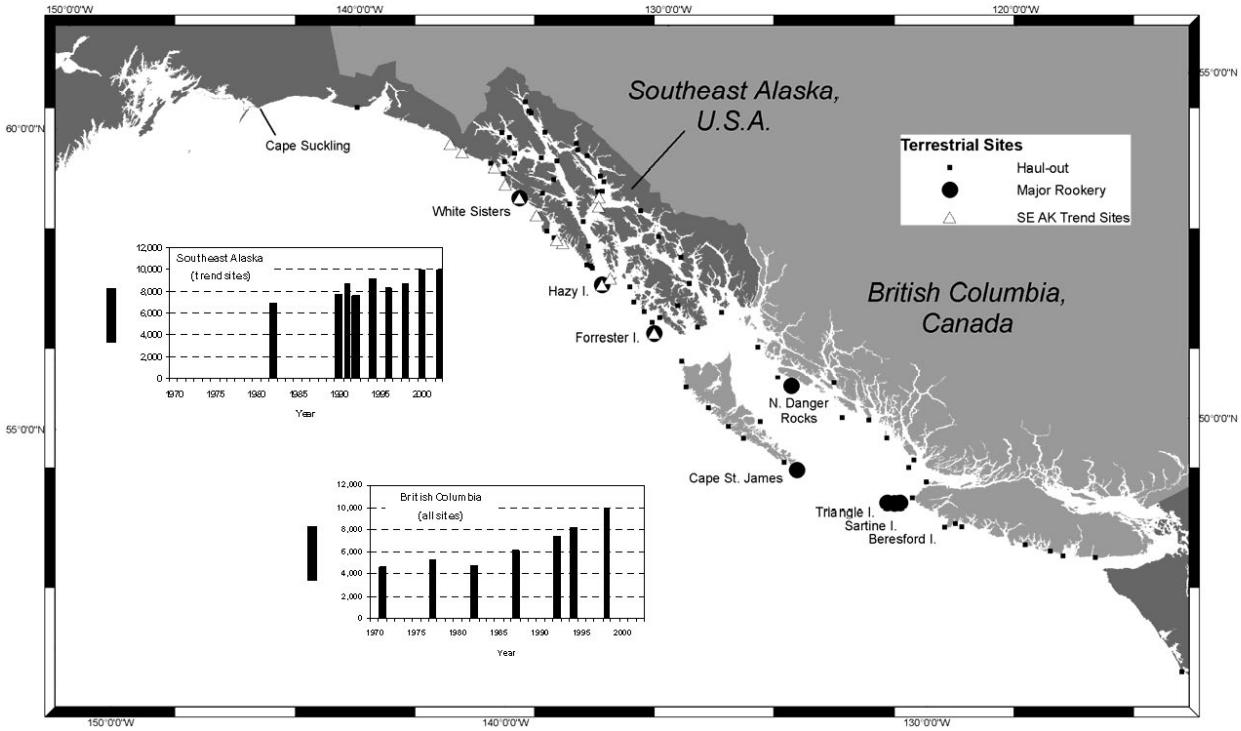

Figure I-7 Counts of adult and juvenile Steller sea lions (non-pups) on eastern DPS terrestrial sites in Southeast Alaska (SE AK; trend sites) and British Columbia (all sites), 1971-2002. Major rookeries are named in both sub-areas (Olesiuk et al. ADF&G references), as is the boundary between the eastern and western distinct population segments (Cape Suckling).

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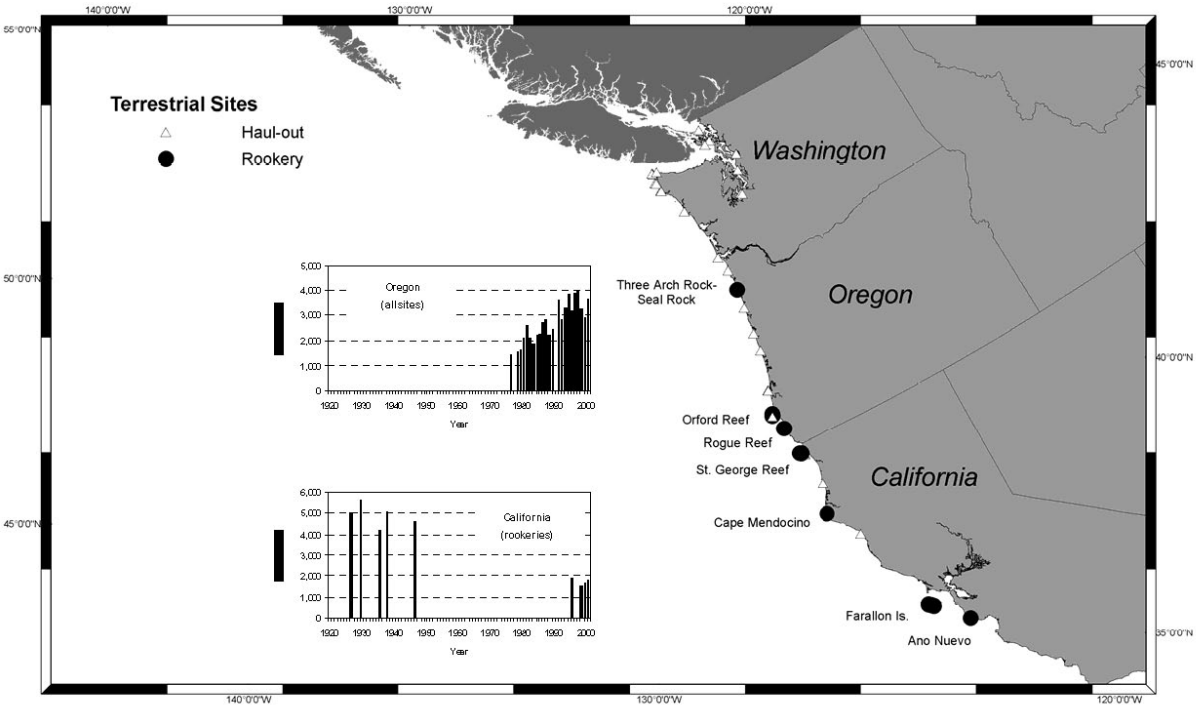

Figure I-8 Counts of adult and juvenile Steller sea lions (non-pups) on eastern DPS terrestrial sites in Oregon (all sites) and California (rookeries), 1927-2001. Major rookeries are named in Oregon and California; there are no rookeries in Washington.

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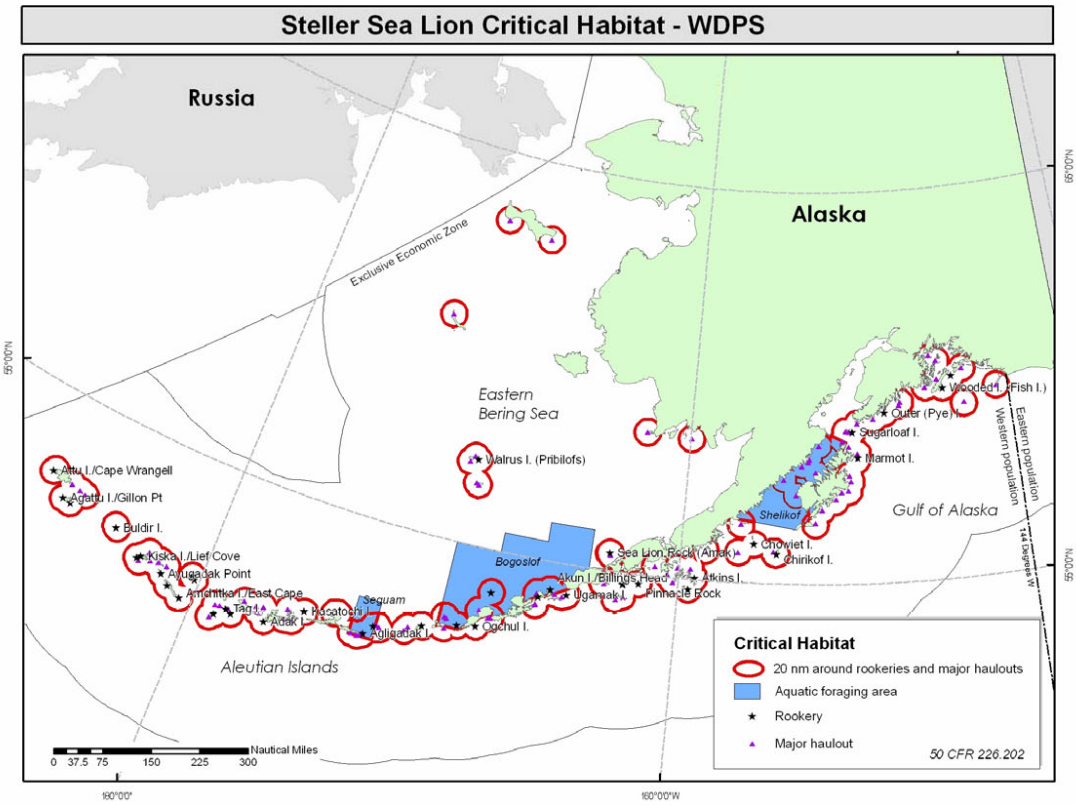

Figure I-9 Designated critical habitat for the western DPS of Steller sea lion in Alaska. 50 CFR 226.202

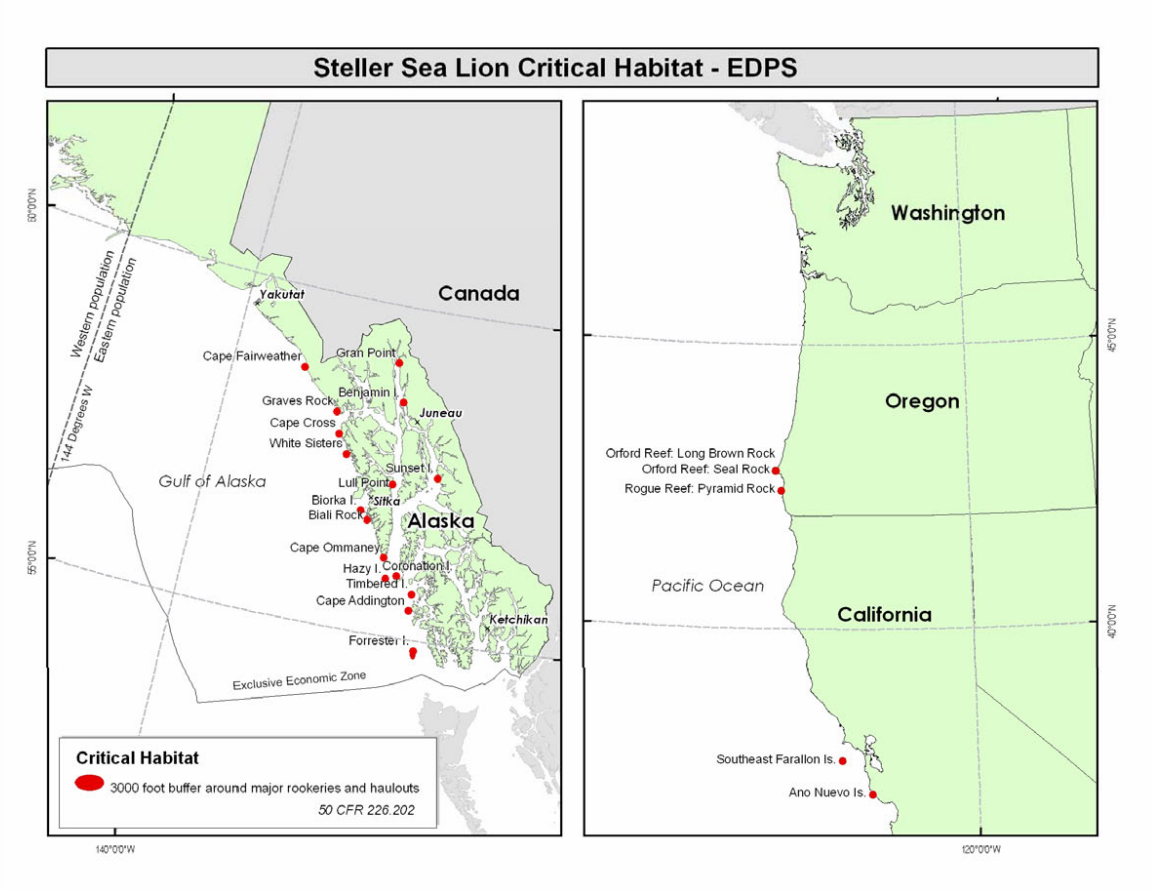

Figure I-10 Designated critical habitat for the eastern DPS of Steller sea lion. 50 CFR 226.202

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II. CONSERVATION MEASURES

The objective of this section is to briefly describe the conservation measures that have been undertaken to reduce threats. Not all threats have been addresses with conservation actions. For example, predation has been identified as a known cause of sea lion mortality and as a potential threat to recovery but is not discussed here because no actions have been taken to reduce the threat. This section is primarily focused on the western DPS due to the fact that most of the actions have been taken to protect those animals. In the following discussion, the conservation measures are organized by threats and are usually common to both the eastern and western DPSs.

The incidental take of Steller sea lions in fishing gear and the shooting of sea lions by fisherman and others were factors in the decline during the 1970s and 1980s. However, by the early 1990s, laws implemented under the Marine Mammal Protection Act (MMPA), ESA, and MSFCMA had reduced these levels to negligible amounts. From the mid-1990s to the present, conservation efforts have focused largely on federal fishery restrictions, disturbance issues, and subsistence harvests. Although actions to reduce intentional take have been effective, it is unknown whether fishery conservation measures have been effective in reducing threats to Steller sea lions. Nevertheless, moderating declines and recent population increases following these measures has resulted in debates about cause and effect. Unlike the direct take of a species, indirect take through competitive interactions is nearly impossible to either prove or disprove. The increasing trend is correlated with fishery conservation measures taken since the 1990's but it is unknown whether the relationship is causal (Hennen 2006).

A. Intentional and Illegal Killing

Prior to 1972, approximately 45,000 Steller sea lions were intentionally killed in Alaska during state-sanctioned commercial harvest and predator control programs (Merrick *et al.* 1987). A large but unknown number of Steller sea lions are believed to have been shot throughout the state between 1972 and 1990 (Trites and Larkin 1992).

These sources of direct intentional killing of Steller sea lions were banned following passage of MMPA in 1972. A provision under section 118 of the MMPA, however, allowed fishermen to lethally deter Steller sea lions from interfering with commercial fishing operations. The provision allowing lethal deterrence was eliminated in 1990 when sea lions were listed as threatened under the ESA. Following this protection, both NOAA and fishing industry representatives supported a "Don't Shoot Sea Lions" campaign and two cases of illegal shootings were successfully prosecuted in 1998. Increased public scrutiny and the threat of fishery closures curbed illegal killings, and the current level of illegal shooting is believed to be minimal (Angliss and Outlaw 2002).

Because it is illegal, intentional killing of Steller sea lions is rarely observed, and no formal reports of lethal deterrence in commercial fisheries have been recorded by fishermen or observers since the practice was banned. The two convictions cited above however resulted from confidential voluntary reports from commercial fishermen who witnessed and reported the violations to NMFS Enforcement agents.

Systematic surveys of shorelines have successfully located carcasses of gunshot Steller sea lions (Wynne 1990). In areas where subsistence hunting occurs, it is impossible to determine whether the gunshot sea lions were shot illegally or legally, in a subsistence harvest, and subsequently lost.

B. Incidental Takes in Commercial Fishing

Steller sea lions have been incidentally caught in a variety of commercial fishing gear including gillnets (Wynne 1990), trawls (Loughlin and DeLong 1983), and longlines (Angliss and Outlaw 2005). Steller sea lions may also ingest baited hooks set for salmon by commercial or recreational trollers (Angliss and Outlaw 2005). The frequency of lethal entanglements varies annually, by gear type and method, but the minimum estimate between 1996 and 2000 averaged 29.5 animals a year (Angliss and Outlaw 2005) and was 30.5 and 3.6 in 2005 for the western and eastern DPSs respectively (Angliss and Outlaw 2005).

The MMPA authorized the incidental take (serious injury and death) of marine mammals in the course of commercial fishing operations while striving to reduce that mortality to an insignificant level. The MMPA was amended in 1988 to better monitor the cumulative effects of fishery-specific incidental takes. As a result, each US fishery is designated as being in one of three categories based on its frequency of marine mammal interaction; this "List of Fisheries" is reviewed annually. Vessel owners in Category I or II fisheries (frequent or occasional interactions) are required to register with the NMFS Marine Mammal Authorization Program and to record all lethal marine mammal interactions in a logbook (originally) or self-reports (currently). The 1988 amendments also required the Secretary to implement emergency regulations to prevent further taking of Steller sea lions if more than 1,350 were taken during a calendar year.

In addition, NMFS may place observers on Category I and II vessels to 1) obtain reliable estimates of incidental serious injury and mortality of marine mammals; 2) determine the reliability of reports submitted by vessel owners and operators; 3) identify changes in fishing methods or technology that may decrease incidental serious injury or mortality if necessary; 4) collect biological samples that may otherwise be unobtainable for scientific studies; and 5) record data on bycatch and discard levels of all species.

The 1994 amendments to the MMPA presented a new means of identifying and weighing the cumulative anthropogenic threats to each marine mammal stock and a process for reducing fishery-specific impacts. For each stock, a Potential Biological Removal (PBR) level is calculated that represents the annual human-induced mortality the stock can sustain, based on conservative estimates of minimum population level and net productivity and then reduced by a scaled recovery factor (Angliss and Outlaw 2005). Total annual human-related mortality is then compared to PBR to determine "Strategic Stocks" and identify those fisheries for which incidental take must be reduced. If incidental mortality of a stock in commercial fisheries exceeds PBR, NMFS is required to convene a Take Reduction Team and develop a Take Reduction Plan to reduce the level of incidental fishing-related mortality. Although the western

stock of Steller sea lions is considered "strategic," the current level of incidental take is lower than the PBR; no Take Reduction Team has been convened for either stock.

Observer programs already collecting catch data under provisions of the MSFCMA in Category I fisheries were assigned the additional task of reporting incidental marine mammal take in those fisheries. Under this program, incidental take of Steller sea lions is monitored by NMFS observers on 33-76% of groundfish trawl vessels fishing in AK, WA, OR, and CA (Angliss and Outlaw 2005).

For Category I and II state fisheries, NMFS developed a Marine Mammal Observer Program under the MMPA mandates. The Alaska Marine Mammal Observer Program has monitored the incidental take of Steller sea lions and other marine mammals and birds in state-managed set and drift gillnet fisheries for salmon occurring in Prince William Sound, S. Alaska Peninsula, Cook Inlet, and Kodiak. Observers continue to document the incidental take of Steller sea lions from the eastern DPS occurring in the CA/OR thresher shark and swordfish drift gillnet and Northern WA set gillnet fishery. Updated information on incidental fishing-related mortality is incorporated into annual NMFS reviews of the status of marine mammal stocks, including Steller sea lions[5].

C. Subsistence Takes

Alaska Natives were exempted from the 1972 MMPA and ESA ban on taking marine mammals. This exemption allowed Alaska Natives to continue taking marine mammals for subsistence or handicraft purposes. The mean annual harvest of Steller sea lions (including struck and lost – those animals killed but not recovered) by Alaska Natives for 2000 - 2004 was estimated by the subsistence division of the Alaska Dept. of Fish & Game to be 190.4 (Angliss and Outlaw 2005).

In 1994, section 119 of the MMPA was amended to allow for the co-management of marine mammal stocks used for subsistence purposes by Alaska Natives. Co-management provides a mechanism for NMFS to work with Alaskan Native Organizations (ANO) to manage use of marine mammal species listed under the ESA and to participate in research efforts. For example, the Tribal Government of St. Paul and the Aleut Community of St. George located in the Pribilof Islands, have each signed co-management agreements with NMFS for Steller sea lions. NMFS expects to enter into additional co-management agreements for sea lion conservation with other ANOs in the future.

The Tribal Governments of St. Paul and of St. George each monitor sea lion subsistence harvest as a function of the co-management agreement in place, and provide harvest information to NMFS. The Tribal Government of St. Paul has implemented a real-time harvest monitoring method to increase the accuracy in reporting. This method is also being adopted on St. George in 2005. Annual estimation of harvest, including those struck-and-lost, for other ANOs, is not available

[5] The last observed take of a Steller sea lion in the CA/OR drift gillnet fishery was in 1994. The Offshore Cetacean Take Reduction Plan for this fishery was implemented through regulations in 1997. Under this plan, skippers are required to use a minimum extender length (36 feet), place pingers on their nets, and attend skipper workshops, when scheduled. These requirements have likely reduced the incidental take of Steller sea lions.

D. Research-related mortality

Intentional lethal sampling of Steller sea lions was a primary means of collecting reproductive, morphometric, dietary, and histologic samples for scientific research in the 1960s and 1970s. This sampling method was strictly regulated after passage of the MMPA and was discontinued once the species was listed as Threatened under the ESA.

Activities authorized under the MMPA and ESA are highly regulated and closely monitored and may include the incidental taking or harassment of Steller sea lions in the course of bonafide research. These research activities, including counting, capturing, and handling animals, may result in inadvertent or indirect Steller sea lion mortality.

Efforts are underway to reduce the amount of disturbance on rookeries caused by the presence of researchers for the purpose of counting. Aerial surveys may serve as an alternative to some of the work currently necessitating human presence.

The NMFS Permit office reviews permit applications, which are also reviewed by the Marine Mammal Commission and made available for public review through notice in the federal Register. Researchers are required to submit annual plans and reports of research activities and real-time reports of research-related mortality. Cumulative impacts of multiple projects are monitored by a Regional Coordinator, and all research may be curtailed if incidental mortalities reach a pre-determined cap.

E. Pollution, Contaminants, and Entanglement in Marine Debris

Steller sea lions are exposed to local and system-wide contaminants and pollutants as they traverse the North Pacific basin. Effects on other pinnipeds have included acute mortality, reduced pregnancy rates, immuno-suppression, and reduced survival of first born pups (see Section III), but there have been no published reports of contaminants or pollutants representing a mortality source for Steller sea lions.

Steller sea lions have been observed with packing bands, discarded netting, and other debris around their necks. Such debris can be lethal if the debris is not degradable. Annex V of the MARPOL Treaty bans the dumping of plastic trash in the ocean or navigable waters of the U.S. (outside 3 nm from shore). Information and education combined with voluntary community-based efforts have resulted in the retrieval, recovery, and disposal of discarded nets and gear in several fishing areas (e.g. Oregon, St. Paul Island, Puget Sound).

Researchers record the frequency and type of debris observed on Steller sea lions during resight surveys and, infrequently, the relative amount and type of debris seen on haulouts and rookeries they visit.

F. Disturbance on Terrestrial Sites and Critical Habitat

Disturbance of Steller sea lion haulouts and rookeries can potentially cause disruption of reproduction, stampeding, or increased exposure to predation by marine predators. Terrestrial habitat has been protected throughout the range by a variety of agencies, and by the fact that sea lions generally inhabit remote, unpopulated areas. Many haulouts and rookeries used by the western DPS are afforded protection from disturbance because they are located on land whose access is regulated by the Alaska Maritime National Wildlife Refuge and other agencies.

No transit zones for vessels within 3 nm of listed rookeries were implemented under the ESA during the initial listing of the species as threatened under the ESA in 1990. These 3 nm buffer zones around all Steller sea lion rookeries west of 150°W were designed to prevent shooting of sea lions at rookeries. Today, these measures are important in protecting sensitive rookeries in the western DPS from disturbance from vessel traffic. In addition, NMFS has provided "Guidelines for Approaching Marine Mammals" that discourage approaching any closer than 100 yards to sea lion haulouts.

Since the listing of Steller sea lions in 1990, NMFS has commented on hundreds of federal actions through the informal consultation process. NMFS commonly consults informally with the US Forest Service on logging projects, with the EPA on discharge permits, and with the Minerals Management Service on oil and gas lease sites. NMFS comments on actions that may take place in sensitive Steller sea lion critical habitat and suggests means to avoid the most sensitive areas or minimize the likelihood of having adverse impacts.

In 2002, NMFS implemented the North Pacific Fishery Management Council (NPFMC) recommendation to require a Vessel Monitoring System (VMS) on federally licensed groundfish vessels involved in pollock, cod and Atka mackerel fisheries. The VMS tracks fishing vessels, providing real-time information on vessel location and violation of no-transit and no-trawl areas.

G. Reduced Prey Availability due to Fisheries

Steller sea lions prey upon some fish species that are also harvested by commercial, subsistence, and recreational fisheries (e.g. pollock, Pacific cod, Atka mackerel, salmon, and herring). Fishery removals have the potential to reduce the availability of these species to sea lions at a variety of spatial and temporal scales (Figures II-1, 2, and 3). Reduced prey availability can represent an acute or chronic threat to sea lion populations. Acute prey shortages may lead to starvation while chronic (or sub-lethal) prey shortages have been shown in other mammals to reduce reproductive fitness, increase offspring mortality, and increase the susceptibility to disease and predation.

Immediately after listing in the early to mid-1990s, NMFS implemented a number of conservation measures intended to ensure that commercial harvests of pollock, Pacific cod, and Atka mackerel would not limit the recovery of Steller sea lions (Ferrero *et al.* 1994, Fritz *et al.* 1995). In addition to those direct actions, many other fishery management measures

recommended by the NPFMC and implemented by NMFS may have indirectly contributed to Steller sea lion conservation efforts.

In the late 1990s and early 2000s, NMFS reviewed federally managed groundfish fisheries in a series of consultations under section 7 of the ESA. Two of those consultations resulted in a determination that the commercial fisheries were likely to jeopardize the continued existence of the western DPS of Steller sea lion and adversely modify its critical habitat. Therefore, as required under the ESA, additional conservation measures were implemented to avoid jeopardy and adverse modification (NMFS 1998a, NMFS 2000). The expectation was that these measures would promote the recovery of Steller sea lions in areas where potential competition from commercial fisheries may have contributed to the population decline.

The implementation of conservation measures, in both the early 1990s and the late 1990s early 2000s, is correlated with a reduction in the rate of decline of the western DPS of sea lions. However, the information necessary to determine if the conservation measures actually contributed to the reduced rate of decline is not currently available.

A suite of fishery conservation measures was implemented in 2002 after being reviewed under a ESA section 7 consultation (NMFS 2001). These measures are described in detail in the 2001 Biological Opinion (NMFS 2001) and its Supplement (NMFS 2003). The measures were intended to reduce fishing in near-shore critical habitat, reduce seasonal competition for prey during critical winter months, and disperse fisheries spatially and temporally to avoid local depletions of prey.

The 2002 measures provided increased protection for near-shore critical habitat areas based on an analysis that closely examined satellite telemetry data and on information on foraging behavior, diet, nutritional stress, and population distribution. The analysis placed increased importance on near-shore critical habitat, specifically identifying those areas within 0-10 nm of listed haulouts and rookeries as more important for foraging sea lions than waters from 10-20 nm offshore.

NMFS (2003), re-evaluated each of the conservation measures after they had been implemented in 2002 and concluded that despite various levels of effectiveness in achieving specific goals, the conservation measures were, in aggregate, successful in avoiding jeopardy and adverse modification of critical habitat. A summary table of the effectiveness of each of the actions can be found in Table IV-1 of NMFS (2003). NMFS (2003) provides an in-depth review of each of the conservation measures, a review of the satellite telemetry data, and an analysis of the important foraging areas for sea lions based on those data. Further, a summary of the federal fishery management measures that may have affected Steller sea lions is provided in NPFMC (2005a, 2005b).

Additional fine-scale analyses (similar to NMFS (2003)), on the adequacy and effectiveness of fishery regulations are needed to develop a robust recovery program for sea lions (see recovery action 2.6.6). In general, more frequent analyses need to be conducted at the spatial and temporal scales essential to foraging sea lions to examine the potential for fisheries to reduce prey at the local, regional, and global scale. Such an approach will enhance assessments of how

regulations designed to disperse (both spatially and temporally) and limit the catch are reducing potential competition, and help NMFS determine what modifications are appropriate.

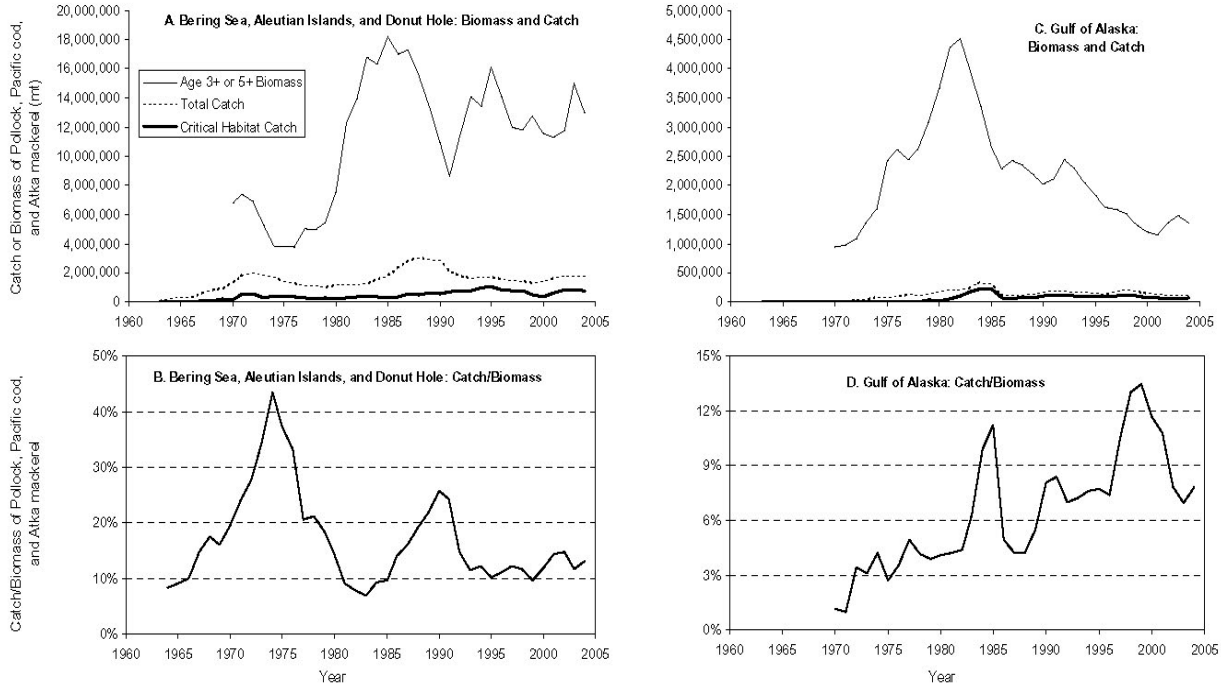
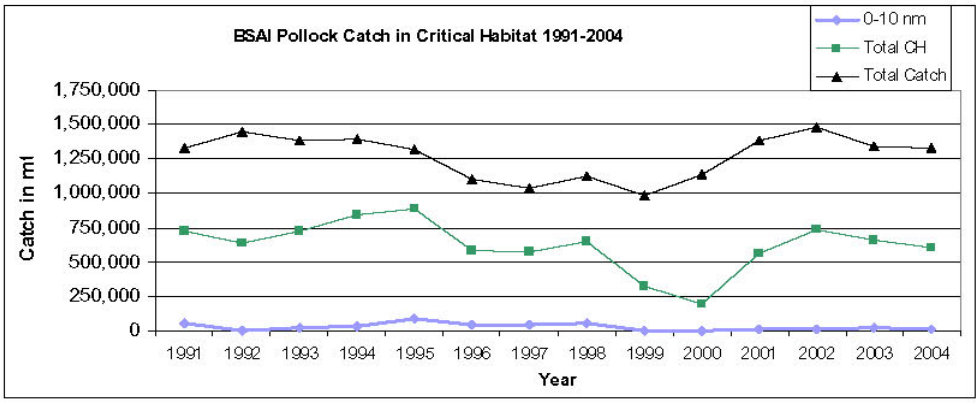
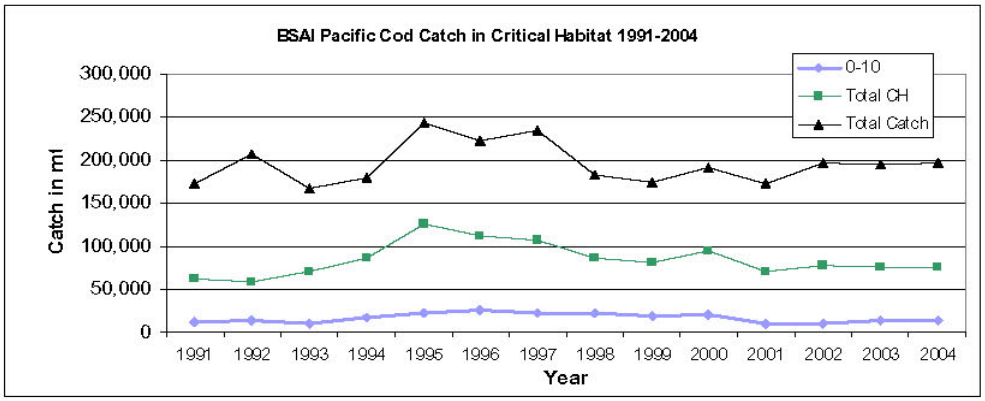


Figure II-1. (A) Catch and estimated age 3+ biomass of walleye pollock, Pacific cod and Atka mackerel in the eastern Bering Sea, Aleutian Islands and "Donut Hole" (international waters of the central Bering Sea) from 1964-2004. Estimated biomass is from stock assessments and includes Bogoslof pollock biomass (Ianelli et al. 2005, Lowe et al. 2005, Thompson et al. 2005). (B) Annual harvest rates calculated from panel (A). (C). Catch and estimated age 3+ biomass of walleye pollock and Pacific cod in the Gulf of Alaska from 1964-2004. Estimated biomass is from stock assessments (Dorn et al. 2005, Thompson et al. 2005). Total catch as well as that portion removed from Steller sea lion critical habitat are shown. (D) Annual harvest rates for the GOA fisheries from panel (C).





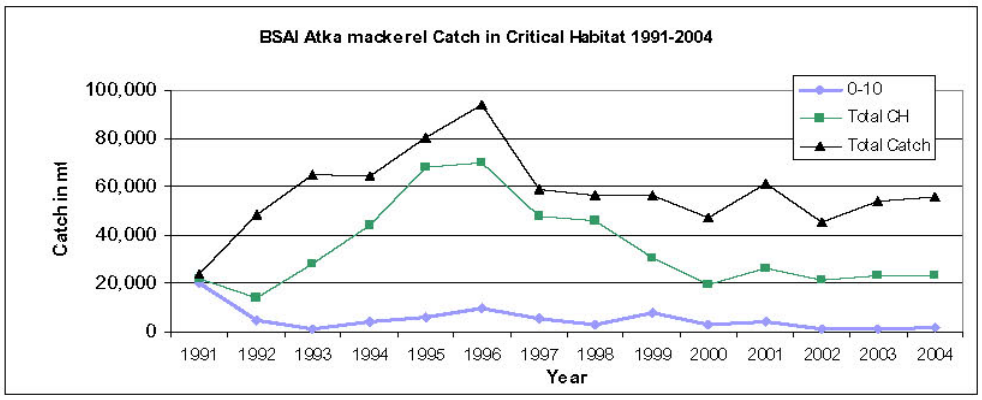
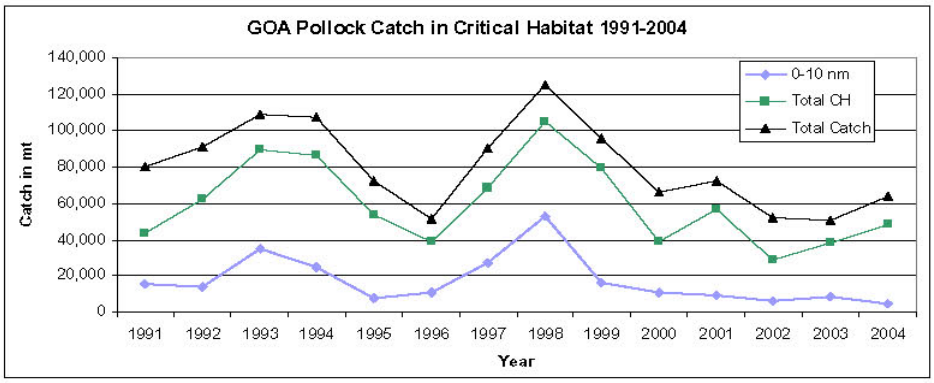


Figure II-2. Catch of Pollock, Pacific cod, and Atka mackerel in critical habitat in the Bering Sea Aleutian Islands (BSAI) from 1991-2004.



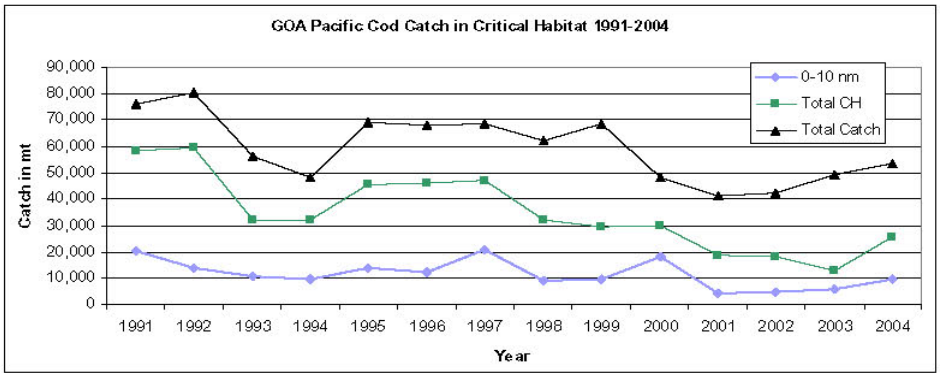


Figure II-3. Catch of Pollock and Pacific cod in critical habitat in the Gulf of Alaska (GOA) from 1991-2004.

III. FACTORS POTENTIALLY INFLUENCING THE WESTERN POPULATION

Important life history and population assessment research has been conducted on Steller sea lions over the last 25 years increasing the knowledge of which factors contributed to the severe population decline. The following sections provide the information needed to understand how different factors may influence sea lion population growth and how that information is assessed to determine the level at which those factors represent a current threat to sea lion recovery

A. Predation

1. Killer whales

In the North Pacific Ocean three ecotypes of killer whales have been recognized by their genetics, morphology, acoustics, association patterns, and feeding ecology, including their prey (Bigg *et al.* 1987, Frost *et al.* 1992, Ford *et al.* 1998, Ford *et al.* 2000, Ford and Ellis 1999, Barrett-Lennard 2000, Hoelzel *et al.* 1998, Matkin *et al.* 2006). Differences in the movement patterns among killer whale ecotypes have led, in part, to their names; i.e., "resident", "transient", and "offshore." Specifically, residents have the smallest home range and typically return each year to predictable locations, transients have larger home ranges and have less predictable movements as they transit through local areas quickly, and offshores have the largest home ranges that include areas farther offshore.

Resident killer whales are known to be fish-eaters, in contrast to transients that feed on marine mammals. For offshores, relatively few feeding observations are available, and the limited data indicate these whales appear to prey primarily on fishes, including sharks. However, until the diet of offshores is better understood, the possibility exists that offshores may kill other marine mammals, including Steller sea lions, at least in some regions or seasons. As the currently available information indicates that transient killer whales are the only ecotype that influences the abundance of sea lions, the remaining information on abundance, movements, and diet pertains primarily to transients.

Limited information is available to assess the population structure of transient killer whales within the range of the western DPS, and less information is available for Russian waters. Currently two stocks of transient killer whales have been recognized: (1) the AT1 stock, which occurs from Prince William Sound west through the Kenai Fjords, and (2) the Gulf of Alaska, Aleutian Islands, and Bering Sea (GOA/AI/BS) stock (2004 SAR's). The abundance and stock structure of the AT1 stock have been well documented, and the abundance of this isolated population has declined from 22 whales in 1989 to only 8 whales in 2004 (Matkin *et al.* 1999, Angliss and Outlaw 2005). In contrast, relatively little data exist for the GOA/AI/BS transient stock, particularly for waters west of Kodiak Island.

Surveys conducted by NMFS in the western Gulf of Alaska, Aleutian Islands, and Bering Sea since 2001 have documented that all three ecotypes use these western Alaska waters. Preliminary analyses of photo-id and genetic data from within the coastal survey area from Kenai Fjords to Tanaga Pass provide insights on possible movements of transient killer whales, and also suggest that there may be some finer scale population structuring of transients.

Specifically, no movements of individual transients have been documented by photo-id between the central and eastern Aleutians (NMFS unpublished data), with a preliminary dividing line at Samalga Pass (170 degrees West longitude). Preliminary analysis of mtDNA sequences supports this inference, as different haplotypes have been sampled on either side of this possible structural boundary (NMFS unpublished data). However, both genetic and photographic sample sizes are low for the central Aleutians. Similarly, whales from the Gulf of Alaska and those from the Aleutian Islands do not generally appear to overlap in distribution, with a gap in distribution between the Shumagin Islands and Kodiak (NMFS unpublished data). However, there have been a small number of photographic matches of individual whales from the Unimak Pass area in the eastern Aleutians to the northeast side of Kodiak Island (NMFS and North Gulf Oceanic Society, unpublished data). Further samples and analyses are needed to assess the significance of these preliminary findings.

The abundance of transient killer whales has recently been estimated through (1) line transect surveys, which provide an estimate of the number of whales present, during the sampling period, in the region surveyed and (2) mark-recapture analyses based on whales identified through photo-id, which provide an estimate of the total number of individual killer whales in the region surveyed across the entire survey period. Analysis of line transect survey data collected between 2001 and 2003 indicate that the abundance of transients in the coastal waters between the Kenai Fjords in south-central Alaska and Tanaga Pass in the central Aleutians is approximately 251 whales (95% CI 97-644) during the summer months (Zerbini *et al.* in prep.). The density of transients appears to vary regionally, with higher densities from the Shumagin Islands through the eastern Aleutians. However, the minimum count of transients in this area from the combined NMFS and North Gulf Oceanic Society (NGOS) photo-id catalogues is currently 314 whales (Angliss and Outlaw 2005), and preliminary mark-recapture estimates for transients based on photo-identification data are also higher than the line transect estimates (NMFS unpublished data). Current abundance estimates and photo-id cataloguing only refer to coastal waters within approximately 30nm of the Aleutian Islands and adjacent coasts of southwestern Alaska. The abundance and population structure of transient killer whales in offshore areas in the Pacific and Bering Sea are still relatively unknown. Thus, the minimum number of transient killer whales in the U.S. portion of the western DPS is 314, and the estimated abundance will increase when analyses are completed and survey effort increases.

The diet of AT1 transients is relatively well understood. Based on more than 20 years of field observations, these whales are thought to feed primarily on harbor seals and Dall's porpoise (Saulitis *et al.* 2000, Heise *et al.* 2003). The feeding habits of GOA/AI/BS transients are less well known in general and essentially unknown during the period fall-spring. Stomach contents of two stranded carcasses contained a harbor seal, Dall's porpoise, and Steller sea lion remains (Heise *et al.* 2003). Observations of feeding by GOA/AI/BS transients have been limited to date, but observed prey include fur seals, gray whales, minke whales, and Steller sea lions (Matkin *et al.* 2006, NMFS unpublished data). The analysis by Herman *et al.* (2005) of blubber biopsy samples from eastern North Pacific killer whales indicate that profiles for fatty acids, carbon and nitrogen stable isotopes, and organochlorine contaminants were consistent with previously reported dietary preferences; i.e., fish for resident whales and marine mammals for transients. Regional stable isotope ratios varied considerably, indicating prey preferences may be region-specific, in addition to ecotype-specific. Thus, some groups of GOA/AI/BS transients may

specialize on certain prey species, including sea lions, as AT1 transients specialize on harbor seals and Dall's porpoise. The measured stable isotope values, which reflected diet for the mid-April through mid-July period, for all three killer whale ecotypes were consistent with published dietary preferences based on visual observations. For example, measured stable isotope values for AT1 transients were very similar to modeled stable isotope values, which were based on visual observations (i.e., primarily harbor seals (56%), Dall's porpoises (38%) and harbor porpoises (6%); Herman *et al.* 2005). Measured stable isotope values for GOA, AI, and BS transients indicated the primary prey items were dominated by animals at lower trophic levels than Steller sea lions and harbor seals (Herman *et al.* 2005).

To explore the potential impact of killer whale predation on Steller sea lions, Barrett-Lennard *et al.* (1995) constructed a simulation model. A range of values for transient killer whale abundance, killer whale energy requirements, and killer whale prey selection parameters was explored because of the substantial uncertainty in the current empirical data for these parameters. Steller sea lion parameters in the model include initial population abundance, sex and age distributions, age specific vulnerability to predation, and a density dependent growth rate. The model assumes an unknown 'baseline' level of sea lion mortality due to killer whale predation in a stable sea lion population. Simulations examine changes in sea lion abundance, due to mortality completely additive to baseline mortality, from an increase in either killer whale abundance or the percentage of sea lions in the diet of killer whales. Based on parameter values consistent with current empirical data from the range of the western DPS of sea lions, simulation results suggest that: 1) killer whale predation did not initiate the decline of the sea lion population; 2) killer whale predation could cause a continued decline in sea lion numbers in western Alaska based on the estimated abundance of sea lions in 2000; and 3) killer whale predation is not likely to drive the sea lion population to extinction (Barrett-Lennard *et al.* 1995). Further, when the abundance of sea lions declined to 100,000 to 150,000, the additional mortality (above baseline mortality) from killer whale predation could have been sufficient to drive the decline. Sensitivity analyses indicate changes in sea lion abundance were influenced primarily, and equally, by the number of transient killer whales and the proportion of their diet provided by sea lions, followed by sea lion age-specific vulnerability to predation. When the estimated abundance of sea lions and killer whales in the range of the eastern DPS is used with the parameter combinations that cause a moderate impact on the western DPS of sea lions, the model predicts that killer whale predation would result in a fairly rapid decline of eastern DPS sea lions.

A comparative bioenergetics and demographic model was used by Williams *et al.* (2004) to assess the potential impacts of killer whales on Steller sea lion populations in the Aleutian Islands. Four types of energetic information were measured or estimated: 1) the caloric needs of individual killer whales, taking into account differences in body mass and reproductive status; 2) the caloric value of individual prey including adult sea lions and pups; 3) the digestive efficiency of killer whales, which determined the ability of the animal to utilize energy in prey tissue; and 4) the likely or possible prey preferences of individual killer whales. This information on individual bioenergetics was then compared to population-level estimates of the number of killer whales (NMFS unpublished data), the abundance of sea lions before and during the decline (see Section I.B), and the demographic rates governing the sea lion population (York 1994). The population-wide losses to predation needed to generate the observed changes in the Steller sea lion population, if all losses occurred from predation, were

then estimated. From these data, Williams *et al.* (2004) reported that an average adult killer whale would require 2 - 3 sea lion pups per day or approximately 840 pups per year when feeding exclusively on young Steller sea lions. In comparison, only one third to one half of an adult female sea lion per day (approximately 160 per year) would be needed to satisfy the killer whale's metabolic needs. Nearly 1,200 Steller sea lions would be eaten per year to meet the caloric requirements of one killer whale pod consisting of 5 individuals, assuming 16% pups and 84% juvenile and adult sea lions consumed, based on the life table for sea lions (York 1994). The annual number of sea lions eaten increases to 39,644 for an estimated population of 170 transient killer whales, approximately three times the highest annual removal rate needed to drive the observed sea lion declines in the 1980s. Despite the conservative estimates of energetic needs and the abundance of transient killer whales, the model calculations demonstrated that relatively minor changes in killer whale feeding habits could account for the decline of Steller sea lion populations observed for the Aleutian Islands. The caloric demands of as few as 27 male or 40 female killer whales (minimally 23% of transients) could account for the estimated 10,885-11,575 sea lions lost per year at the height of the decline. Furthermore, predation losses to a single pod of five killer whales could theoretically prevent the present Steller sea lion population from recovering.

Examining the potential impact of killer whale predation on Steller sea lions on a broad ecosystem basis, Springer *et al.* (2003) presented a hypothesis that predation was paramount among top-down forces contributing to the sea lion decline. Their "Sequential Megafaunal Collapse" hypothesis is based on the premise that post-World War II industrial whaling depleted large whale populations in the North Pacific, depriving killer whales of an important prey resource. Killer whales thus began feeding more intensively on smaller marine mammals, and this predation resulted in the sequential decline of harbor seals, northern fur seals, Steller sea lions, and northern sea otters in the northern North Pacific Ocean and southern Bering Sea. Due to the acknowledged lack of direct evidence that killer whale predation drove the pinniped declines, Springer *et al.* (2003) explain the declines based on a logical interpretation of known patterns and feasibility analyses of the hypothesized causal process. They suggest current predator prey dynamics are unlikely to provide evidence for the sequential pinniped declines, because prey populations are relatively smaller and comparatively stable, and the abundance of killer whales also may be much reduced.

The Sequential Megafaunal Collapse hypothesis has generated considerable interest and debate concerning the role of killer whale predation in the ecosystem dynamics of the North Pacific. Several studies examined the hypothesis, and indicate alternative interpretations of available data. DeMaster *et al.* (2006) concluded that the available data do not support the assumption that some species of large whales were important prey for killer whales, and the available qualitative data indicate that although the biomass of some large whale species likely declined in abundance, those declines were offset by increasing abundances of other large whale species in the 1960s and 1970s. Further, DeMaster *et al.* concluded that statistical tests do not support the assumption that the pinniped declines were sequential. Mizroch and Rice (2006) examined data on the contents of killer whale stomachs, and observational records of killer whale interactions with large whales, to infer that large whales were not primary prey for killer whales. Further, they believe commercial catches of whales decreased substantially by 1968, and any whaling-related prey shift by killer whales should have begun soon thereafter, rather than

in the mid-1970s as proposed by Springer *et al.* (2003). Trites *et al.* (2006c) proposed that although killer whales are a significant predator of seals, sea lions and sea otters, the Sequential Megafaunal Collapse hypothesis is not supported by the biology of large whales, the ecology of killer whales and the patterns of ecosystem change that took place in Alaska, British Columbia, and elsewhere in the world following whaling. Finally, Wade *et al.* (*in press*) believe that much of the reduction in large whale biomass occurred 50 to 100 years ago, and thus the need to switch prey starting in the 1970s is doubtful. They also provided evidence that observed killer whale predation has largely involved pinnipeds and small cetaceans, the later of which were likely abundant throughout the period, but not considered in the Sequential Megafaunal Collapse hypothesis.

Data gaps

Obtaining the following information would substantially reduce the uncertainty about the potential impact of killer predation on Steller sea lions: (1) Diet preferences of GOA/AI/BS transients on a seasonal, multi-annual, and geographical basis, as well as data on prey specializations by individual groups of whales; (2) Improved estimates of the field metabolic rate for transients, the variance in the field metabolic rate among individuals whales, and the factors that may influence that variance; e.g., age, sex, season, reproductive status; (3) abundance and distribution of transients in offshore waters of the Gulf of Alaska, Pacific Ocean and Bering Sea, as well as around the central and western Aleutians; (4) population structure of transients in the North Pacific: relating the Bering Sea, offshore Pacific and offshore Gulf of Alaska to coastal areas of Aleutians and Gulf of Alaska used by Steller sea lions; and (5) data on the patterns of occupancy (e.g., short and long term, seasonal) of transients within sea lion haul-out and foraging areas, and data on movement patterns to and from these areas. Further, the draft research plan for assessing the role of transient killer whales in North Pacific Ecosystems prepared by the Marine Mammal Commission identifies additional information that should be obtained.

2. Sharks

Sharks represent another potential predator that may attack Steller sea lions. Although white shark predation on North Pacific pinnipeds has been well documented (LeBoeuf *et al.* 1982, Ainley *et al.* 1985, Long *et al.* 1996), these sharks occur rarely, if at all, in the range of the western Steller sea lion population. Although salmon shark populations have increased since 1990, they are considered piscivorous and have not been reported to prey on Steller sea lions. Another species of large shark, the Pacific sleeper shark (*Somniosus pacificus*), is common in the Gulf of Alaska, Aleutian Islands, and Bering Sea (Orlov 1999). Current indices to sleeper shark relative abundance are based on a recent analysis of sleeper shark bycatch from sablefish longline surveys conducted on the upper continental slope and deepwater gullies of the continental shelf in the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska from 1979-2000 (Courtney and Sigler unpublished data, also see Mueter and Norcross 2002). This analysis indicates sleeper sharks are substantially (about 10x) more abundant in the Gulf of Alaska than in the BSAI region. Further, a significant increase in the relative abundance of sleeper sharks occurred during 1989-2000 in the central Gulf of Alaska, driven largely by the increase of sharks in Shelikof Trough during 1992 and 1993. Most Pacific sleeper shark stomachs that have been examined contained remains of fish and invertebrates (Yang and Page 1998, Orlov 1999), but the remains of harbor seals and

porpoises have also been reported (Bright 1959). A recent analysis of sleeper shark stomachs (n=198) collected in the GOA near sea lion rookeries when pups may be most vulnerable to predation (i.e., first water entrance and weaning) found that teleost fishes and cephalopods were the dominant prey (Sigler *et al.* in press). Tissues of marine mammals were found in 15% of the shark stomachs, but no sea lion tissue was detected. Overall, the study concluded that sea lions are unlikely prey of sleeper sharks, harbor seals are infrequent prey and may be consumed alive, and that cetaceans are a frequent diet item for larger sleeper sharks and commonly scavenged. A companion study documented that shark and sea lion home ranges overlapped (Hulbert *et al.* in review), and thus the results of these two studies, and others, indicate no scientific evidence presently exists to suggest that sleeper sharks actively prey on Steller sea lions.

Data Gaps

The available evidence does not indicate sharks are a threat to sea lion recovery. However, he diet of sleep sharks should continue to be estimated through stomach remains, fatty acids, and stable isotopes.

B. Harvests and Other Direct Mortality by Humans

1. Commercial harvest

Currently, no commercial harvest for Steller sea lions exists in the United States, but sea lions were commercially harvested prior to 1973. A total of 616 adult males and 45,178 pups of both sexes were harvested in the eastern Aleutian Islands and Gulf of Alaska between 1959 and 1972 (Thorsteinson and Lensink 1962, Havens 1965, Merrick *et al.* 1987). The pup harvests, which sometimes reached 50% of the total pup production from a rookery, could have depressed recruitment in the short term and may partially explain the declines at some sites through the mid-1970s. However, these harvests do not explain why numbers declined in regions where no harvest occurred, or why in some regions declines occurred approximately 20 years after harvests ceased (Merrick *et al.* 1987). A comparative analysis of the ecology and population status of four species of pinnipeds in similar environments (Steller sea lions in the Gulf of Alaska, Cape fur seals in the Benguela Current, harp seals in the Barents Sea, and California sea lions in the California Current) indicates that directed commercial harvest was not a major factor in the Gulf of Alaska Steller sea lion decline (Shima *et al.* 2000).

Steller sea lions are hunted in Hokkaido, Japan to reduce interaction with local fisheries, with an average of 631 animals killed per year during 1958-1993 (Takahashi and Wada 1998). The animals killed had probably migrated southward from the Kuril Islands. Demographic modeling shows that kills were sufficient to deplete the Kuril population, especially in combination with incidental catches in fisheries (Takahashi and Wada 1998). More current information on the level of kill since 1993 is not available.

2. Subsistence harvest

Both the ESA and the MMPA contain provisions that allow coastal Alaska Natives to harvest endangered, threatened, or depleted species for subsistence purposes. Prior to 1992, no

comprehensive program estimated the level of subsistence harvest of sea lions in Alaska. However, available information indicates that sea lions were being harvested at several villages on the Bering Sea, in the Aleutian Islands, and on the Gulf of Alaska (Haynes and Mishler 1991). During 1992-2004, harvest data were collected through systematic retrospective interviews with hunters in at least 60 coastal communities throughout the range of sea lions in Alaska (Wolfe *et al.* 2005). Results show the annual take (i.e., harvest plus struck and loss) decreasing substantially from about 550 sea lions in 1992 to about 200 in 1996 followed by annual takes between 165 and 215 from 1997 to 2004. (Table III-1).

Table III-1. Estimated takes of western DPS Steller sea lions by Alaska Natives in five regions. Values include both retrieved harvest and reported struck and lost (Wolfe *et al.* 2005). PWS = Prince William Sound; AK = Alaska.

Year	PWS-Cook Inlet	Kodiak & AK Peninsula	Aleutian Islands	Pribilof Islands	Bristol Bay	Total
1992	40	60	135	297	9	541
1993	46	64	124	245	6	485
1994	27	67	122	193	1	410
1995	31	144	96	68	0	339
1996	17	65	58	46	0	186
1997	6	46	52	56	4	164
1998	28	27	37	78	0	170
2000	17	32	76	43	0	168
2001	16	47	98	38	0	199
2002	6	24	105	43	0	178
2003	25	41	107	32	0	205
2004	54	21	96	32	1	204
Averages						
1992-95	36	84	119	201	4	444
1996-04	21	38	79	46	1	184

In the early 1990s, juveniles were harvested at least twice as much as adults, yet that ratio declined beginning in 1996, and during 2000 to 2004 the ratio of juveniles to adults in the harvest ranged from 0.5 to 1.0. The ratio of males to females harvested in 2004 was 1.8, below the 5-year average of 4.1 during the previous five years. In 2004, 24 adult females were harvested, representing about 20% of the total harvest of known sex and age. During 1992-1995, the greatest numbers of sea lions harvested were in the Pribilof Islands, whereas during 1996-2004 the harvest was greatest in the Aleutian Islands. The surveys that produced these estimates covered all Alaskan communities that regularly hunt Steller sea lions, but a few additional animals are taken occasionally at other locations (Coffing *et al.* 1998, ADF&G unpublished data).

In 1998, the Tribal Government of St. Paul's Ecosystem Conservation Office implemented a real-time data collection program to estimate the take of sea lions, due to concerns by hunters and the

local community in the uncertainty of harvest results based on retrospective surveys. Results of the real-time harvest monitoring indicated a sea lion take of about 25-35 per year from 1998-2002, followed by a reduced take of 18 sea lions in both 2003 and 2004 (Zavadil *et al.* 2005). The Tribal government also implemented a new subsistence harvest management scheme that likely may have resulted in fewer animals taken. Factors that may be responsible for this decreased take include fewer hunters, fewer animals to hunt in the communities' hunting areas, and voluntary restraint from hunting because of perceived problems with the sea lion population (Wolfe and Hutchinson-Scarbrough 1999).

Information on the harvest of Steller sea lions in Russia is fragmentary. In 1932 and 1933, newborn pups were harvested on Iony Island in the Sea of Okhotsk (1,198 and 805 respectively), and in 1935 about 30 pups were taken on the Shipunsky Cape (Kamchatka) rookery (Nikulin 1937). In 1974, an experimental harvest was conducted on Brat Chirpoev rookery in the Kuril Islands that took 296 pups (Perlov 1975). During the period when the government of the Soviet Union conducted commercial sealing (1960-1990), sea lions were not a target species, but they were taken occasionally with annual harvests ranging from 37 to 650 animals (Perlov 1996). During the 1950s to 1980s, a subsistence harvest was conducted on the Commander Islands and Kamchatka that usually took fewer than 100 animals a year, but this harvest has stopped completely in the late 1980s (Burkanov personal communication). Some sea lions are taken in Chukotka by native hunters, but the number killed is unknown.

3. Incidental take by fisheries

Many Steller sea lions have been killed incidental to commercial fishing operations in the Bering Sea and North Pacific Ocean. The total estimated incidental catch of Steller sea lions during 1966-1988 in foreign and joint-venture trawl fisheries operating off Alaska was over 20,000 animals (Perez and Loughlin 1991). A particularly high level of take occurred in the 1982 Shelikof Strait walleye pollock joint venture fishery when U.S. trawlers killed an estimated 958 to 1,436 sea lions (Loughlin and Nelson 1986). The estimated take in this fishery declined to fewer than 400 animals per season in 1983 and 1984, probably due to changes in fishing techniques and in the area and times fished. Most of the animals taken were sexually mature females. Fewer than 100 per year were estimated to have been taken during 1985-1987. The level of incidental mortality has continued to decline. The minimum estimated mortality rate incidental to commercial fisheries in 2002 was 29.5 sea lions per year, based on observer data (24.1) and self-reported fisheries information (5.2) or stranded data (0.2) where observer data were not available (Angliss and Outlaw 2005).

During October-December 2002, observers recorded the incidental take of sea lions during a herring trawl fishery in the western Bering Sea. Preliminary estimates of the total number of sea lions caught were 35-60, with 32-50 killed (Burkanov and Trukhin unpublished). The genetic analysis of skin samples from sea lions caught in this trawl fishery will provide insight on which regions the sea lions may be from (i.e., Aleutian, Commander, and Kuril Islands, and Kamchatka). The majority, if not all, of these sea lions were subadult males.

Amendments to the MMPA in 1988 and 1994 required observer programs to monitor marine mammal incidental take in some domestic fisheries. Observers monitored the Prince William

Sound drift gillnet fishery in 1990 and 1991 and estimated a mean annual kill of 14.5 Steller sea lions (Wynne *et al.* 1992). Hill and DeMaster (1999) provide observer-based estimates of average annual Steller sea lion incidental mortality for fisheries operating in the range of the western DPS between 1993 and 97 as follows: 6.8 animals in the Bering Sea groundfish trawl fishery; 1.2 animals in the Gulf of Alaska groundfish trawl fishery; 0.2 animals in the Bering Sea groundfish longline fishery; and 1.0 animals in the Gulf of Alaska groundfish longline fishery. These numbers are minimum estimates of the incidental kill and serious injury in fisheries, because not all fisheries that might take sea lions are covered by observer programs.

Nikulin and Burkanov (2000) documented marine mammal bycatch in Japanese salmon driftnet fishing in the Russian exclusive economic zone of the southwestern Bering Sea. Catch of only one Steller sea lion was observed during 1992-1999, and it was released alive. Quantitative information on sea lion incidental catch in other fisheries that occur in Russian and Japanese waters is not available, but it is possible that some animals have been killed in trawl fisheries for herring and pollock.

4. Illegal shooting

In some areas Steller sea lions are known to have been shot deliberately by fishermen (and perhaps other people), but it is unclear how such mortality may affect the population because the overall magnitude of the take is unknown (Alverson 1992). One of the few estimates of shooting mortality was reported by Matkin and Fay (1980), who calculated that 305 Steller sea lions were shot and killed while interfering with fishing operations in the spring 1978 Copper River Delta salmon gillnet fishery. Data from a 1988-1989 study of the Copper River salmon gillnet fishery indicated that the level of directed kill of sea lions was significantly less than during 1978 (Wynne 1990). During the 1960s, sea lions were sometimes killed and used as bait by crab fishermen (Alverson 1992). Such killing may have had a significant effect in local regions and might have caused animals to move away from certain rookeries and haulout sites (Loughlin and Nelson 1986, Merrick *et al.* 1987, NRC 2003). In 1990, a regulation was implemented to prohibit fishermen from discharging firearms near Steller sea lions, but nonetheless some shooting, resulting in an unknown level of mortality, likely occurs (NMFS 2001, Loughlin and York 2000, NRC 2003).

Simulation modeling suggests that a combination of commercial harvests, subsistence harvests, and intentional and incidental take in fisheries may explain a large portion of the western Steller sea lion population decline that occurred through 1980 (Trites and Larkin 1992). However, the annual decline since 1990 has been much greater than can be accounted for by such direct causes (Loughlin and York 2000).

Data gaps

The primary data gaps are estimates of the magnitude of illegal shooting and incidental take in fisheries for which observer data are not available. Knowledge of the age and gender of such sea lion mortality, and the seasons in which it occurs, would help reduce the uncertainty associated with these factors. Available data suggests that the possible impact of this mortality on the population is equivocal. At a lower priority is the documentation of native subsistence harvest at sites other than the Pribilof Islands. The harvest management scheme implemented on St. Paul

and St. George islands, or one like it, should be explored by other Alaska Native Organizations to provide documentation of the level of mortality and the age and sex of collected sea lions. This, along with an improved reporting system, will enhance the information available to better assess the sources of sea lion mortality state-wide.

C. Entanglement in Marine Debris

Steller sea lions may become entangled in lost and discarded fishing gear and other marine debris, including items such as closed packing bands and net material (Calkins 1985). A study conducted in the Aleutian Islands during June-July 1985 to investigate the rate of entanglement found that a very low percentage (approximately 0.07%) of observed sea lions were entangled in net or twine; none were entangled in packing bands (Loughlin *et al.* 1986). A follow-up study was conducted during November 1986 to assess the possibility that sea lion pups were becoming entangled in debris. Researchers saw no entangled pups and only one entangled juvenile out of a total of 3,847 sea lions examined (Loughlin *et al.* 1986). However, these observational studies cannot fully evaluate the frequency of entanglement because entangled animals may die at sea and thus not be observed on land.

Data Gaps

The level of mortality from entanglement is unknown. More current estimates of the frequency and extent of entanglement are needed, including the probability of mortality for entangled sea lions. A more accurate estimate of this mortality is required to determine the potential benefits of cleaning beaches of debris and by intensifying enforcement of regulations governing debris discard.

D. Disease and Parasitism

Disease may include any pathogen of viral, bacterial, protozoan, or fungal origins, which are either known to Steller sea lions and related species or are unknown to Steller sea lions but zoonotic. Whereas disease occurs naturally in all animal populations, there are two ways in which disease could have negatively impacted Steller sea lion populations. Firstly, the occurrence of a contagious pathogen to a naive population could lead to a mass or unusual mortality event. Such events have been documented in other pinniped populations and are mentioned below. Secondly, several pathogens are known to result in reproductive loss, either through spontaneous abortions, embryonic or fetal resorption, or through rendering the female infertile. Both of these disease impacts have the ability to result in population level decreases, yet neither has been observed or measured in Steller sea lions. In addition, one of the reasons that diseases, or at least the diseases that have been examined, do not appear to be a major factor in the population decline is that the same diseases occurred at about the same rate in both the western and eastern DPSs. Nevertheless, with the current low abundance of sea lions the potential for disease to impede recovery should not be ignored.

Disease is a natural process, and the mechanism by which many animals die. The important question for sea lions is whether disease agents currently have the potential to reduce population growth through increased mortality or decreased reproductive output. Without

question, an epidemic of phocine distemper virus was responsible for the deaths of thousands of seals in the northwest Atlantic during the 1980s (Heide-Jørgensen *et al.* 1992). Investigators have not seen large numbers of dying or dead Steller sea lions, although sick individuals are found on rare occasions. For example, two sick Steller sea lions that stranded in northern California and were brought in for treatment later died of acute bronchopneumonia of unknown etiology (Morgan *et al.* 1996).

There are two basic methods for determining the prevalence of disease in animal populations: either by necropsy of dead animals and analysis of their tissues to identify pathologies, or by serologic screening of blood samples taken from live or dead animals. Serologic screening requires that a specific disease be identified and antigenic agents developed for testing to detect the presence of an antibody to the disease in the animal's blood. In most cases antigen agents have not been developed specific to Steller sea lions but have been adapted from those developed for other species. This may introduce some inaccuracy in test results, but such tests probably are adequate to indicate presence or absence of a particular disease at some time in the subject's life. The presence of antibodies detected in a serological test shows that an animal has been exposed to a disease agent, but does not indicate that it is unhealthy, or that the pathogen is currently in the animal.

Analysis of components of blood can give insight into the general health of animals. Bishop and Morado (1995) examined blood characteristics of Steller sea lions pups captured live on rookeries in Southeast Alaska and the Gulf of Alaska. White blood cell counts suggested mild physiological stress responses that were perhaps due to capture and handling. Red blood cell counts were suggestive of anemia, especially in animals sampled in the Gulf of Alaska. Zenteno-Savin *et al.* (1997) found higher levels of haptoglobin in Steller sea lion blood in the Aleutian Islands than in Southeast Alaska sea lions. In other animals, elevated haptoglobin levels are known to be associated with stress (e.g., trauma, infection), but no explanation was suggested for the results in Steller sea lions.

As noted in Section I.G, decreased reproduction may occur at a relatively high rate in sea lions. Several of the disease agents that sea lions have been exposed to are known to affect reproduction in other species. Alaskan Steller sea lions have been exposed to two types of bacteria, *Leptospira* and *Chlamydia* (Calkins and Goodwin 1988, Sheffield and Zarnke 1997, Burek *et al.* 2003), and one virus, the San Miguel sea lion virus, that have caused reproductive problems in other species. Specifically, San Miguel Sea Lion Virus and *Leptospira* have been associated with reproductive failures or neonatal deaths in California sea lions and northern fur seals (Smith *et al.* 1974, Gilmartin *et al.* 1976). Virtually nothing is known about the possible effects of *Chlamydia* on pinnipeds, but in other animals *Chlamydia* is known to cause abortion, stillbirths, and production of weak young (Shewen 1980).

In addition to the three disease agents listed above, other disease agents that Steller sea lions have been tested for include phocid herpesvirus, phocine and canine distemper viruses (Barlough *et al.* 1987, Zarnke *et al.* 1997, Sheffield and Zarnke 1997), morbilliviruses, canine parvovirus, *Brucella, Toxoplasma,* and influenza A (Sheffield and Zarnke 1997). There is no convincing evidence for significant exposure to influenza A, morbilliviruses, *Brucella,* canine parvovirus, or *Leptospira* (Burek *et al.* 2003, 2005). Examination and necropsy of dead Steller sea

lions has shown some occurrences of hepatitis, *Chlamydia*, myocarditis, endometritis, tumors, and pneumonia (Gerber *et al.* 1993).

Burek *et al.* (2003, 2005) concluded that available serologic evidence does not support the possibility that a disease epidemic occurred during the sea lion decline of the late 1970s and 1980s. They noted, however, that due to sampling limitations the possibility could not be excluded completely. Further, although sea lions have been exposed to several endemic disease agents that could potentially impede recovery, the only available data are the prevalence of antibodies to the disease agents, and the potential for those agents to cause disease among Steller sea lions has not been documented (Burek *et al.* 2005).

Parasites of Steller sea lions include intestinal cestodes; trematodes in the intestine and bile duct of the liver; nematodes in the stomach, intestine, and lungs; acanthocephalans in the intestine; acarian mites in the nasopharynx and lungs; and an anopluran skin louse (Dailey and Hill 1970, Dailey and Brownell 1972, Fay and Furman 1982, Shults 1986, Gerber *et al.* 1993). The potential for parasitism to have a population level affect on sea lions is largely unknown. Whereas parasites may have little impact on otherwise healthy animals, effects could become significant if combined with other stresses (Haebler and Moeller 1993). Available information does not suggest that the sea lion decline was caused by parasitic infections, although there has not been adequate research to assess the relative nature and magnitude of parasitism in sea lion populations. Investigations of parasites require necropsy of carcasses that only occurs on a sporadic basis on beach cast animals.

Data Gaps

To assess the potential for disease and parasitism to impede the recovery of sea lions, systematic protocols need to be implemented to collect and analyze samples obtained from live and dead animals. Further, remaining available samples should be analyzed to establish solid baselines for comparison with future studies.

E. Toxic Substances

Toxic substances have two major modes by which they can impact animals. Firstly, the acute toxicity caused by a major point source of a pollutant (such as an oil spill or hazardous waste) can lead to acute mortality and moribund animals with a variety of neurological, digestive and reproductive problems. Secondly, toxic substances can impair animal populations through complex biochemical pathways that suppress immune functions and disrupt the endocrine balance of the body, causing poor growth, development, reproduction and reduced fitness. Toxic substances come in numerous forms, with the most recognized being the organochlorines (mainly PCBs and DDTs), heavy metals, polycyclic aromatic hydrocarbons (PAHs) and the newer polybrominated diphenyl ethers (PBDEs).

Aside from the *Exxon Valdez* Oil Spill in 1989, which occurred well after the Steller sea lion decline was underway, no other events have been recorded that support the possibility of acute toxicity leading to substantial mortality of Steller sea lions (Calkins *et al.* 1994). However, results from several studies, both published and still being conducted, do not permit the

complete rejection of toxic substances as a factor that may currently impact sea lion vital rates. These studies have been conducted on both Steller sea lions and other pinniped species, both sympatric and unrelated, and are briefly reviewed below by toxic category.

Sea lions exposed to oil spills may become contaminated with PAHs through inhalation, dermal contact and absorption, direct ingestion, or by ingestion of contaminated prey (Albers and Loughlin 2003). After the *Exxon Valdez* oil spill, Calkins *et al.* (1994) recovered 12 Steller sea lion carcasses from the beaches of Prince William Sound and collected an additional 16 Seller sea lions from haul out sites in the vicinity of Prince William Sound and the Kenai coast. The highest levels of PAHs were in animals found dead following the oil spill. Sea lions collected seven months after the spill had levels of PAH metabolites in the bile consistent with exposure and metabolism of PAH compounds (Calkins *et al.* 1994). However, histological examinations found no lesions that could be attributed to hydrocarbon contamination and, hence, no evidence of damage due to oil toxicity (Calkins *et al.* 1994).

Heavy metals are also contaminants of concern. Heavy metal concentrations measured in Steller sea lion livers were generally much lower than in northern fur seals (Noda *et al.* 1995). Mercury levels in the hair of young Steller sea lions from both the western and eastern DPSs were lower than for northern fur seals and were considered "relatively low" (Beckmen *et al.* 2002), yet concerns remained about possible effects on fetal development and interactive effects with other contaminants. Vanadium concentrations in Steller sea lion livers were positively correlated with levels of selenium, silver, and mercury (Saeki *et al.* 1999). Castellini (1999) found that zinc, copper, and metallothionien (a chelating compound) levels were comparable between sea lion pups sampled from both the western and eastern DPSs, and were lower than for captive sea lions. Kim *et al.* (1996) reported on the accumulation of butyltin in the liver of Steller sea lions from Alaska and Japan and found much lower levels in the Alaska samples than in those from Japan; they also suggested that butyltin degrades rapidly in sea lions and does not bioaccumulate. Although these studies are not comprehensive, they do not indicate that heavy metals were a significant factor in the decline of the Steller sea lions.

Organochlorine contaminants in marine mammals and other wildlife have been associated with reproductive failures (Helle *et al.* 1976, Reijnders 1986), population declines (Martineau *et al.* 1987), carcinomas, and immune suppression (de Swart *et al.* 1994, Ross *et al.* 1996). No toxicological studies have been performed on Steller sea lions to determine clinical ramifications of organochlorine contaminant burdens. However, organochlorines that cause health impacts in other species have been measured in subsets of Steller sea lion populations from Japan, the Russian far east, Aleutian Islands, Pribilof Islands, Gulf of Alaska and Southeast Alaska (Lee *et al.* 1996, Varanasi *et al.* 1992, Hoshino *et al.* 2006, Hong *et al.* 2005, Myers 2005). Most of these studies measured contaminants in the blubber or blood, although Krahn *et al.* (2001) used feces as the medium to measure organochlorines. Overall, the studies suggest a decline in organochlorine concentrations over time, which is consistent with that reported for other wildlife species. Organochlorine concentrations have been significantly different among some regions (Myers and Atkinson 2005, Hoshino *et al.* 2006), although not consistently so throughout all studies (Hong *et al.* 2005). Typically a few individuals with particularly high concentrations will skew the mean results, giving high deviations that render non-significant or in conclusive results. The studies that measured more than one organochlorine generally found that the PCB

congeners and DDT metabolites were the most prevalent organochlorines measured in Steller sea lions. No studies have been published that report any PBDE congeners, however this is likely to change in coming years.

Studies of effects of known organochlorine contaminants have not been conducted on marine mammals in the US. Studies from Europe have provided threshold levels of organochlorines above which immunosuppression or reproductive problems can be expected (de Swart *et al.* 1994, Ross *et al.* 1996). Whereas these studies were conducted on harbor seals, the thresholds are often used for related species such as Steller sea lions. Several individual sea lions have been sampled and had concentrations above this threshold. Likewise, a threshold for reproductive failures (i.e., spontaneous abortions) has been extracted from the mass toxicity event of California sea lions reported in the 70's (DeLong *et al.* 1973, Gilmartin *et al.* 1976). No recent samples from Steller sea lions have approached this threshold, indicating a mass mortality from an acute toxicity event was not the cause of the sea lion decline.

Data Gaps

The primary data gap is an understanding of what levels of contaminants affect sea lion health, and subsequently vital rates, especially reproduction. Further, the possible influence on reproduction from chronic exposure to relatively low concentrations of toxic substances and the potential for reactive metabolites to cause damage to target tissues is needed.

F. Reduced Prey Biomass and Quality

1. Overview

The survival of large predatory mammals such as Steller sea lions is dependent on the availability of abundant, high quality prey (Stephens and Krebs 1986). Due to the high energetic demands of Steller sea lions relative to terrestrial mammals (Section I.H) and the large number of sea lions seasonally concentrated on rookeries, this species may be especially vulnerable to reduced prey biomass and quality. As a result, natural and anthropogenic factors that substantially influence prey availability, particularly during critical life history stages (e.g., pregnant females with a nursing pup, or recently weaned juveniles), have the potential to affect Steller sea lion vital rates and impede their recovery.

A reduction in prey resources may result in (1) a reduction in population growth rate, and (2) a lower carrying capacity. Specifically, reduced prey biomass and quality can lead to physiological responses by sea lions that directly (e.g., reduced fecundity) or indirectly (e.g., increased mortality from predators due to increased foraging) reduces their population growth. A sustained reduction of prey resources across a broad geographic region (i.e., ecosystem) would thus reduce the carrying capacity of sea lions.

Three sources of reduced prey biomass and quality that may impede sea lion recovery are environmental variability (e.g., regime shifts), commercial fisheries, and interspecific competition. In this section, the available information on how each of these sources may have caused and may currently be causing a reduction in sea lion prey resources is examined, and

further, how these sources may have affected sea lion population growth rates and carrying capacity. This evidence is examined, to the extent possible, to delineate the relative impacts on the sea lion population from the three separate sources of reduced prey resources and to help guide recovery actions.

As noted in Section I.H.1, Steller sea lions eat a wide variety of marine fish and cephalopods, some of which are densely schooled in spawning, migratory, or feeding aggregations (Sinclair and Zeppelin 2002). The abundances of many of the primary prey species of Steller sea lions have undergone substantial changes during the past 30 years (NRC 1996, 2003, NPFMC 2005a, b). Thus, during the period of decline of Steller sea lion populations in the western DPS, many primary prey species increased in abundance, while others decreased or remained relatively stable. Several factors have been implicated in these changes in prey biomass for Steller sea lions: 1) natural or environmental variability, 2) anthropogenic (fisheries) affects, and 3) ecosystem disruption resulting in interspecific competition (Anderson and Piatt 1999, Trites *et al.* 1999, Benson and Trites 2002). These factors may act individually or collectively to affect the availability of prey for Steller sea lions.

2. Environmental variability

Periodic shifts in oceanic and atmospheric conditions appear to have had major effects on the productivity and structure of North Pacific ecosystems (Francis and Hare 1994, Francis *et al.* 1998, Hunt *et al.* 2002, Mackas *et al.* 1998, Anderson and Piatt 1999, Trites *et al.* 2006a) with cascading effects on some prey fish populations (Quinn and Niebauer 1995, Hollowed and Wooster 1992, 1995). For example, the size of available habitat for pollock, one of the primary prey species of Steller sea lions, reportedly increased with changes in the mixed layer depth in the Gulf of Alaska associated with climatic changes during the 1980s (Shima *et al.* 2000). Increases in pollock and other gadids (e.g. Pacific cod) in the Gulf of Alaska and Bering Sea (Alverson 1992), and their relatively low nutritional quality (Alverson 1992, Rosen and Trites 2000a) led to the "junk food hypothesis" for the decline of the western DPS of Steller sea lion.

In the junk food hypothesis, the quantity of prey available to the declining population of Steller sea lions was thought to be high overall, but the prey community switched from one dominated by high energy prey (e.g., herring and osmerids) to low energy species (e.g., gadids and flatfish; Alverson 1992, Rosen and Trites 2000a). As originally articulated by Alverson (1992), pollock and other gadids were presumed to be equally poor foods for all age classes of sea lions (i.e., both juveniles and adults). However, results of subsequent feeding experiments, mathematical models, and field observations suggested that adult sea lion growth and condition should be relatively unaffected by the low energy content of gadids (Rosen and Trites 2000b, 2004, Trites 2003, Trites *et al.* 2006a, Malavear 2002). Instead, low energy prey may detrimentally affect juvenile Steller sea lions more than mature individuals due to their relative inexperience at foraging (Merrick and Loughlin 1997), their higher relative energy requirements (Winship *et al.* 2002), an upper limitation on the amount of food that a sea lion can physically digest to meet its daily energy requirements (Rosen and Trites 2004), or the availability of sufficient prey (Malavear 2002).

Fritz and Hinckley (2005) concluded that patterns and time series of fish abundance, fish recruitment, and sea lion food habits did not support the hypothesis that the regime shift triggered changes in the prey community that would have been deleterious to Steller sea lions. In addition, unpublished feeding experiments at the Alaska SeaLife Center are believed to show no negative consequences to juvenile sea lions fed only pollock (Calkins and Trites unpublished data). This is consistent with published studies showing that there are no different effects between high-lipid and low-lipid (or low-protein and high-protein) prey on sea lion body composition when animals are able to consume sufficient prey to meet their energy demands (Rosen and Trites 2004, 2005; Appendix 2).

3. Fishing

In addition to environmental factors, fishing can affect the availability of prey on localized and ecosystem-wide scales (Trites *et al.* 2006e), which is of concern for the stability and recovery of Steller sea lion populations (Lowry *et al.* 1982). Fisheries in Alaska are some of the largest in the world. In 2003, approximately 2 million metric tons of groundfish were caught, which is equivalent to a harvest rate of approximately 10% (NMFS 2004). Fishing has the potential to affect Steller sea lion recovery in several ways, including overall ecosystem-wide reductions in prey biomass, local and temporal depletions of prey, and reduced quality (size, age and caloric value) of individual prey by selective removal of larger, older individuals (Goodman *et al.* 2002, *Trites et al.* 2006e).

Many fisheries in the North Pacific are managed using a maximum sustainable yield (MSY) single-species strategy. MSY is based on the assumption that production of fish recruits, on average, is in excess of the level needed for replacement and that fisheries can remove the surplus of adults without jeopardizing future stock recruitment. Fishing mortality rates (F) set using single-species, MSY methodologies are designed to maximize yield (weight of catch) before it is lost to natural mortality (M) and minimize the likelihood of overfishing the target stock. Fishing at $F_{40\%}$ will, over the long run, reduce the average spawning stock size to 40% and total biomass to approximately 50% of their theoretical pristine levels (Appendix 1).

While single species catch quotas are set for relatively large management areas (e.g., the Gulf of Alaska), individual vessels that fish for these species work in discrete areas. The potential for fisheries to reduce local abundances of fish was shown for Atka mackerel (Lowe and Fritz 1997) and Pacific cod fisheries (Fritz and Brown 2005), where local, short-term harvest rates were much greater than the annual target harvest rates on the stocks as a whole. Many of the areas fished by the Atka mackerel fishery in the Aleutian Islands and all of the Pacific cod fishery data analyzed by Fritz and Brown (2005) were collected within designated sea lion critical habitat. Statistical and correlative analyses of fishery effort/catch with trends in local sea lion populations have yielded equivocal results, some indicating a positive and some a negative relationship between catch and sea lion population trends (Loughlin and Merrick 1989, Ferrero and Fritz 1994, Dillingham *et al.* 2006). The utility of these analyses is diminished by issues of temporal and spatial scale mismatch between the treatment (magnitude of fish catch around a rookery) and response (population trend at that rookery), since animals breeding at a particular rookery range much farther during the year than the area encompassed by the catch data. One study (Hennen 2006), found significant positive relationships between several metrics of fishing

and the steep rates of population decline in the 1980s. This relationship vanished in the 1990s, leading to the conclusion by Hennen (2006) that measures taken in the early 1990s (e.g., trawl exclusion zones, spatial-temporal management, shooting ban, reduction in incidental catch) may have been effective in slowing the decline.

Fisheries generally target larger, older individuals. As a result, a fished population will be composed of smaller, younger individuals, and have a smaller average size and age than an unfished population of the same species (NMFS 2000, Walsh *et al.* 2005, Trites *et al.* 2006e). These fishery-related changes may have two consequences for foraging sea lions. First, the distribution of fish within the water column and geographically, which often correlates with age (Ianelli *et al.* 2005), will be altered in a way that potentially affects availability to foraging sea lions. Second, a reduction in the average size of individual fish will reduce the per capita energy content and may necessitate increased foraging effort by sea lions to obtain the equivalent amount of energy in a larger number of small fish (Calkins and Goodwin 1988, NMFS 2000).

The objective of fisheries management measures implemented in 2002 (NMFS 2001, 2003) was to remove or mitigate the effects of fisheries that could lead to adverse impacts on Steller sea lions. These measures were intended to address both ecosystem-level effects (e.g., biomass reduction) as well as the temporal and spatial effects of fishing by raising minimum fish stock size thresholds, reducing fishing in near-shore portions of critical habitat, reducing seasonal competition for prey and reducing the likelihood of fishery-related localized prey depletions. The spatial-temporal fishery management measures were based largely on an analysis of the at-sea distribution of sea lions recorded by satellite linked time-depth recorders. The analysis led to the development of a "zonal approach" to management for the 2002 measures (NMFS 2001), in which near-shore portions of critical habitat were considered more important to foraging sea lions than offshore areas. However, most of the data used in the telemetry analysis was collected from juvenile sea lions less than 2 years of age, many of which were likely not completely weaned. As a consequence, the foraging habitat of adult animals, particularly females, is underrepresented in the telemetry data that formed the basis of the management measures implemented in 2002.

Direct impacts of fisheries on Steller sea lion foraging will depend on spatial, temporal, and targeted species overlap for which little data is currently available (Baraff and Loughlin 2000). The potential for competition between fisheries and Steller sea lions, as indicated by energetic models, differs for each prey species considered. For instance, the estimated consumption of gadids based on the energetic demands and diets of wild sea lions was 179,000 ± 36,700 t in all regions of Alaska in 1998. This represented approximately 12% of the total commercial catch (Winship and Trites 2003). In the same study, it was estimated that Steller sea lions consumed a total of 104,000 ± 20,600 t of Atka mackerel in 1998, but this was equivalent to 181% of the fishery catches off Alaska. At this level, Steller sea lion predation would have also accounted for a large proportion of the total natural Atka mackerel mortality.

Management measures to address potential fishery effects on Steller sea lions were first promulgated in 1991-1993, and then extensively modified in 2002 (Fritz *et al.* 1995, NMFS 2003). These included several: spatial and temporal allocations of harvest quotas to reduce the

likelihood of localized depletions of groundfish prey, fishery exclusion zones to limit spatial overlap between fisheries and sea lions, and modified harvest control rules to reduce the likelihood of overall prey abundance being reduced to less than 20% of pristine levels (see Section II). NMFS (2001, 2003) concluded that the current suite of management measures avoids jeopardy to the species and adverse modification of critical habitat.

4. Inter-specific competition

Piscivorous fish consume many of the same species and sizes of prey as Steller sea lions. The strength of these food-web interactions has likely changed during the past 30 years in response to both natural and anthropogenic factors. For instance, annual differences in the size and distribution of young-of-the-year as well as adult pollock affect annual levels of cannibalism (Livingston 1991, Wespestad *et al.* 2000). Differential rates of fishing within the groundfish community may have also indirectly contributed to increased in arrowtooth flounder populations, a species with considerable diet overlap with Steller sea lions (NMFS 2000, 2001). How these changes as well as substantial increases in the population of Pacific halibut since the 1980s (Hollowed *et al.* 2000, IPHC 2000, Wilderbuer and Sample 2000, Trites *et al.* 1999) affect the prey field and foraging patterns of Steller sea lions or relate to population level impacts remain to be determined.

The diets and distribution of many marine mammals and birds also overlap those of the western DPS of Steller sea lions. As consumers of common prey resources, the dynamics and concomitant prey biomass removed by these sympatric piscivore populations may therefore affect the quantity and quality of prey available to Steller sea lions. As such, recovery of Steller sea lions may be affected by changes in the abundance, distribution, and prey removal by other apex predators. Whales are considered significant consumers in many marine systems and models estimate that prey consumption by cetaceans approaches or exceeds removals by commercial fisheries (Laws 1977, Laevastu and Larkins 1981, Bax 1991, Markussen *et al.* 1992, Kenney *et al.* 1997, Trites *et al.* 1997, Witteveen *et al.* 2006). Such high levels of consumption can have significant effects on the distribution and abundance of prey species and the structure of marine communities (Perez and McAlister 1993, Kenney *et al.* 1997). Likewise, removals and recovery of cetacean populations may affect marine ecosystems through complex trophic cascades (Laws 1985, NRC 1996, Merrick 1997, Trites *et al.* 1997, Springer *et al.* 2003, Witteveen *et al.* 2006). Shore-based and pelagic whaling in the 1900's significantly reduced the number of large whales in the North Pacific, reducing their consumption (biomass removal) of certain fish, cephalopods, and zooplankton within marine ecosystems (Rice 1978) and effectively increasing prey available to other consumers in the system (Springer *et al.* 2006). Following decades of international protection, the abundance of some whale stocks has increased, including an apparent 10% increase in central North Pacific humpbacks between the early 1980's and early 1990's (Baker and Herman 1987, Calambokidis *et al.* 1997). It has been hypothesized that whale stock resurgence may have reduced prey availability and contributed to declines of piscivorous pinnipeds and birds in the Gulf of Alaska and Bering Sea ecosystems (Merrick 1995, 1997, NRC 1996, Trites *et al.* 1999).

Several large piscivorous whales are migratory and fulfill their annual consumption needs on high latitude feeding ground, including waters found within Critical Habitat of the western

DPS of the Steller sea lion. Substantial seasonal feeding aggregations of humpback (Waite *et al.* 1998, Witteveen 2003), fin, and gray whales occur within the Gulf of Alaska and Bering Sea. Their diets include large zooplankton species and a variety of schooling fish (Thompson 1947, Nemoto 1957, Moore *et al.* 2000, Tamura and Ohsumi 2000) that are also consumed by Steller sea lions (capelin, herring, sandlance, smelts, small pollock) (Pitcher 1981, Sinclair and Zeppelin 2002) or by the prey of sea lions (pollock, cod, arrowtooth flounder) (Livingston 1993). As such, piscivorous whales have the potential to compete with Steller sea lions both directly when feeding on common prey and indirectly when consuming zooplankton and forage fish upon which other sea lion prey species feed. As populations of piscivorous cetaceans recover, this potential would be expected to increase.

5. Nutritional stress

Regardless of the source, inadequate prey intake by Steller sea lions will eventually be manifested at some level as nutritional stress. Nutritional stress is a physiological response to suboptimal quantity and/or quality of available food, and may be acute (e.g., starvation occurring over a period of weeks) or chronic (e.g., suboptimal consumption over a period of months or years) (Trites and Donnelly 2003). Nutritional stress has been considered a leading hypothesis to explain the rapid decline of the western DPS of Steller sea lion (Appendix 2), and has been the subject of considerable debate (NRC 2003, Trites and Donnelly 2003). However, it has been a difficult hypothesis to test due to a lack of data for Steller sea lions during the period of decline, the difficulty of working with these animals in remote locations, the long-term nature of the problem, and a poor understanding of the basic nutritional biology of Steller sea lions. The marked acute nutritional effects observed for immature and adult otariids when prey biomass is reduced during El Niño events (Trillmich and Ono 1991, Soto *et al.* 2004) have not been observed for Steller sea lions (Table III-2).

Steller sea lions collected in the Gulf of Alaska during the early 1980s showed evidence of reproductive failure and reduced rates of body growth that were consistent with nutritional limitation (Calkins and Goodwin 1988, Pitcher *et al.* 1998, Calkins *et al.* 1998). Lactating females were less likely to become pregnant than non-lactating females during the early decline, indicating that the energetic stress of nursing while being pregnant with another pup may have prevented some females from giving birth each year (Pitcher *et al.* 1998). During the 1970s and 1980s, 100% and 95%, respectively, of all sexually mature females in the Western DPS were pregnant in early gestation. The percentage of those females that carried their pregnancy to late gestation was only 55% to 67% during the 1970s and 1980s and was not statistically different between periods (Pitcher *et al.* 1998). Among lactating females with higher energy demands, 63% carried their pregnancies to late gestation in the 1970s compared to only 30% in the 1980s, and this difference was significant. Better body condition was found to increase the probability that a female would maintain pregnancy. Comparatively low birth rates for females from the Western DPS during the 1970s and 1980s (Pitcher and Calkins 1981) coupled with elevated embryonic and fetal mortality, appear to have contributed to decreased reproductive performance during the period of early decline (Pitcher and Calkins 1981, Calkins and Goodwin 1988, Pitcher *et al.* 1998, NMFS 1998b, 2000). Age-structured models fit to observed time series of pup and non-pup counts suggest that declines in reproductive performance of females in the

western DPS continued through the 1990s in some or major parts of the Alaskan range (Holmes and York 2003, Fay 2004, Winship and Trites 2006).

Another indication that the western DPS may have been nutritionally compromised during the period of marked decline was a reduction in average body size of Steller sea lions during the 1980s. Steller sea lions from the central Gulf of Alaska during this period were smaller in length, girth, and weight compared to the 1970s (Calkins and Goodwin 1988) and early 1990s (Williams, unpublished data). Such a change in morphological indices from animals in the wild (Pitcher *et al.* 2000) is consistent with sub-optimal nutritional status in the 1980s compared with the 1970s. However, it must be noted that adult females in the 1970s were themselves smaller than in the late 1950s (Calkins *et al.* 1998), indicating that nutritional stress was not a characteristic only of the 1980s or the result of the regime shift of the mid-1970s.

Evidence that Steller sea lions were nutritionally stressed in the 1990s or are currently food limited has been inconclusive. However, dietary studies show little change in prey species consumed between the 1980s and 1990s. Pollock and Atka mackerel continued to dominate the diet of sea lions in the Gulf of Alaska and Aleutian Islands in the 1990s (Sinclair and Zeppelin 2002). Differences in summer diet (diversity and energy content) also correlate with different regional rates of population decline in the 1990s (Merrick *et al.* 1997, Trites et al. 2006d, Waite and Burkanov 2003, Winship and Trites 2003).

Sea lions in the 1970s and 1980s exhibited possible symptoms of nutritional stress (Calkins *et al.* 1998, Pitcher *et al.* 1998, Trites and Donnelly 2003), but there is no direct evidence that nutritional stress was responsible for the continued decline of the western DPS during the 1990s. This may be due in part to differences in methodologies between decades, and the focus on comparing increasing and decreasing populations of sea lions during the 1990s rather than comparing pre- and post-decline conditions.

In terms of acute nutritional stress, there is no indication at any time (1970s–2005) of emaciated juveniles or adults, of a decrease in pup body size, or of lactating females spending more time searching for prey (Table III-2). However, total birth rates at some rookeries and overall survival rates appeared to be lower during the 1990s. This and a well-documented continued drop in the number of pups and adults counted through the 1990s could be caused by chronic poor nutrition among other causes. The 1990s data suggest that (1) although diet composition of western animals had not changed, adult females appeared to secure enough food to adequately nurse their pups within the first 4-6 weeks of lactation, and (2) if food limitation was a major cause of continued declines (either through a shortage of prey or a low abundance of high energy prey) it may have affected reproductive performance of adult females. Analysis and synthesis of data collected more recently (2000-2005) is underway, but information that could be used to directly assess the nutritional status of Steller sea lions during this period is not yet available.

Data Gaps

A critical research challenge for Steller sea lion researchers is demonstrating the mechanistic links between prey availability, nutritional stress of the individual, and changes in survival and reproductive rates that would lead to population level effects. Table III-2 illustrates the myriad

potential biological effects that could occur in immature and adult Steller sea lions if individuals were nutritionally limited. The effects range from morphological, physiological, and behavioral changes to alterations in vital rates that would affect population trends. A comparison of how these effects may have changed across the 1980s, 1990s, and 2000-2004 identifies many of the data gaps that need to be filled to assess current nutritional status for the western DPS of Steller sea lions. For most categories, available data sets are of such limited geographical and temporal scope that evaluating the role of nutritional stress in the decline of Steller sea lion populations or in its recovery has been hampered. For example, other than numbers of individuals from population counts, no measurements have been made for adult Steller sea lions since the 1990s. Consequently, changes in body condition, reproductive success or foraging parameters that would be direct indicators of acute or chronic nutritional stress are currently unknown for adults.

To date, the focus of nutritional research has been on the effects of nutritional status on individual sea lion behavior, health, and physiology. Proximate dietary mechanisms under investigation include: 1) decreased energy intake due to changes in the availability or energy content of prey, 2) changes in the energy requirements of the predator, 3) deficiency of other nutrients (i.e., protein or specific aminoacids) or essential elements, 4) physiology of metabolic homeostasis, and 5) assessment of nutritional stress responses for different age classes. Part of the difficulty in assessing chronic nutritional stress lies in determining the temporal or spatial scale of study: i.e., how does system wide or localized availability of prey affect Steller sea lion foraging ecology?

The evaluation of body condition in Steller sea lions remains problematic due to inaccurate methodologies, difficulty of working in remote locations, and poor knowledge of natural variation in body condition that occurs between seasons, geographical region, age, and gender. Indices of body condition include body mass, standard length, axillary girth and additional girth rings, and percent body fat. Good evidence exists for losses in body mass during complete fasting, but there are difficulties associated with the criterion of body mass in a sexually dimorphic species. The sexes must be examined separately in each geographic area, and longitudinal data (e.g., mean growth rates of branded pups recaptured as juveniles) should be examined. Steller sea lions lose body fat while fasting, but there are also problems peculiar to each of the methods used to measure blubber reserves (direct measure, ultrasound, skinfold calipers, isotope dilution, and bioelectrical impedance analysis).

Fatty acid analysis identifies diet composition by matching prey fatty acid profiles with those deposited in the blubber (fat) of the predator. This is a labor intensive process, but shows promise in distinguishing animals dependent on milk and those ingesting different types of prey. Stable isotope analyses of vibrissae, ingested milk, and blood can also be used to identify trends in the trophic level of the diet. Although less specific about individual prey items, isotope analysis may provide a timeline through analysis of the vibrissae. As expected, nitrogen isotope ratios for pup vibrissae roots were at a trophic level higher than the milk signature, suggesting another potential weaning indicator.

A series of critical data gaps exist regarding the determination of 1) whether fecundity has indeed continued to decline, 2) whether it is due to reduced prey biomass, abundance, and

nutritional stress, and 3) how females respond to nutritional stress in their relative energy expenditures on lactation, pregnancy and their own maintenance. Declines in fecundity estimated in the 1990s at a few rookeries were significant (about 30%; Holmes and York 2003, Winship and Trites 2006a), but the mechanisms involved (e.g., nutritional stress, disease contaminants) are unknown.

Table III-2. Data gaps for assessing potential biological manifestations of nutritional stress in the western DPS of Steller sea lions. Evidence is based on a comparison with the previous decade (H=historical) or with the eastern DPS (G=Geographic). Y=Yes, data are available to make a comparison and an effect was as indicated; N=No, data are available to make a comparison but the effect was opposite to that indicated; U=Unknown, no data are available; U*=Unknown, data available but not analyzed. Range-wide versus local data sets are identified by superscript "R" and "L", respectively. See text and Appendix 3 for details and references.

Potential Biological Effects	**1980s**	**1990s**	**2000-2004**
More emaciated pups (<4 wks)	U	U*	N(H)
More emaciated pups (>4 wks)	U	U	U
More emaciated juveniles	U	N(H,G)	U
More emaciated adults	U	N(H,G)	U
Reduced pup survival (to 4 wks)	U*	U*	U
Reduced adult body size	Y(H)	U	U
Reduced juvenile body size	Y(H)	U*	U
Reduced pup body size	U	N(G), U*(H)	N(H)
Reduced birth weight	N or U?	U	U
Reduced pup weight	?	N(G),U*(H)	N(H)
Reduced growth rate	Y(H)	N(G)	N(H)
Reduced pup survival	? OR U	U*	N(H)
Reduced juvenile survival	Y(H)	Y	N(H)
Reduced adult survival	Y(H)	N	N(H)
Reduced overall survival	Y(H)	Y(H,G)	N(H)
Reduced birth rate	Y(H)	Y(H)	Y(H)
Reduced pup counts	Y(H)	Y(H)	N(H)
Reduced non-pup counts	Y(H)	Y(H)	N(H)
Increased reproductive failure	Y(H)	U	U
Change in pup blood chemistry (increased fasting)	U	N(G)	N
Change in juvenile blood chemistry (increased fasting)	U	U*	N
Delayed sexual maturity	U	U	U
Change in metabolic rate	U	U	U
Decreased body condition (adult females on rookeries)	U	U* (N(G))	U
Reduced adult perinatal fast	U	N(G)	U
Longer foraging trip duration	U	N(G)	U*
Increased susceptibility to disease (haptoglobin)	U	U*	U
Increased incidence of disease	U	N(G)	N(H,G)
Increased susceptibility to predation	U	U	U
Altered weaning age	U	U*(G)	U*
Decreased weaning size	U	U	U
Traditional ecological knowledge re. body condition	?	U*	U*

G. Disturbance

The possible impacts of various types of disturbance on Steller sea lions have not been well studied, yet the response by sea lions to disturbance will likely depend on season, and their stage in the reproductive cycle (Kucey and Trites 2006). Close approach by humans, boats, or aircraft will cause hauled out sea lions to go into the water, and can cause some animals to move to other haulouts (Kucey 2005). The discharge of firearms at or near hauled out animals may have a particularly dramatic effect. Vessels that approach rookeries and haulouts at slow speed, in a manner that sea lions can observe the approach have less effect than fast approaches and a sudden appearance. Sea lions may become accustomed to repeated slow vessel approaches, resulting in minimal response. Although low levels of occasional disturbance may have little long-term effect, areas subjected to repeated disturbance may be permanently abandoned (Kenyon 1962). When humans set foot on a rookery or haulout, the response by sea lions is typically much greater, often resulting in stampedes that may cause trampling or abandonment of pups (Calkins and Pitcher 1982, Kucey 2005, Lewis 1987, Kucey 2005). In British Columbia, harassment and killing that occurred prior to 1970 resulted in the abandonment of one major rookery, although it is now used as a haulout (Bigg 1988). Repeated disturbances that result in abandonment or reduced use of rookeries by lactating females could negatively affect body condition and survival of pups through interruption of normal nursing cycles.

Since Steller sea lions were afforded ESA protection in 1990, regulations have been in place to minimize disturbance of animals by humans, especially on rookeries. An unknown level of disturbance still occurs with current regulations. Disturbance by research activities includes aerial surveys, capturing of animals for branding, tagging, and sample collection, and close vessel approaches to rookeries and haulouts to observe branded animals. Sea lions are occasionally killed accidentally in the course of such scientific research activities, estimated at about three animals per year (Loughlin and York 2000).

H. Global Climate Change

Climate change has received considerable attention in recent years, with growing concerns about global warming and the recognition of natural climatic oscillations on varying time scales. Global air and ocean temperatures during this century and before are warming, and evidence suggests that the productivity of the North Pacific is affected by changes in the environment (Quinn and Niebauer 1995, Mackas *et al.* 1998).

Increases in global temperatures are expected to have profound impacts on arctic and sub-arctic ecosystems, and some of these impacts have been documented over the last several decades. Specifically, (1) winter temperatures in Alaska and western Canada have increased as much as 3-4 °C over the past half century, (2) precipitation, mostly in the form of rain, has increased primarily in winter resulting in faster snowmelt, (3) sea ice extent has decreased about 8% over the past 30 years, with a loss of 15 to 20% of the late-summer ice coverage in the arctic, and (4) glacial retreat, particularly in Alaska, has accelerated contributing to sea level rise (ACIA 2004). These impacts, and others, are projected to accelerate during this century.

The effects of these changes to the marine ecosystems of the Bering Sea, Aleutian Islands, and the Gulf of Alaska, and how they may specifically affect Steller sea lions are uncertain. Warmer waters could favor productivity of certain species of forage fish, but the impact on recruitment dynamics of fish of importance to sea lions is unpredictable. Recruitment of large year-classes of gadids (e.g., pollock) and herring has occurred more often in warm than cool years, while the distribution (with respect to foraging sea lions) and recruitment of other fish (e.g., osmerids) could be negatively affected. Whether these patterns will continue as overall temperatures increase is uncertain, as are the effects on the duration and strength of atmospheric and oceanographic regimes (Trenburth and Hurrell 1994, Hare and Mantua 2000).

Climate-driven changes in productivity and community structure due to warming oceans may already be underway in the northern portion of the Bering Sea and Bering Strait, where sea ice plays a major role in structuring the food web and the ecosystem is particularly vulnerable to rapid system reorganization under global warming. Reduced seasonal sea ice cover, changing hydrographic conditions, and reduced primary production in the northern Bering Sea may be associated with apparent declines in ice-associated benthic species of mollusks and amphipods since the 1990s (Grebmeier *et al.* 2006). Benthic-feeding walrus, bearded seals, gray whales and diving sea-ducks such as Spectacled eider are all threatened by these changes, as are Arctic Native communities whose traditional subsistence culture has relied on these ice-associated mammals and birds for thousands of years. This ecosystem has short, simplified food chains; thus the potential for trophic cascades is higher. Warming seawater in the north could expand the range of groundfish from the south, putting more pressure on the benthic prey base. The northern Bering Sea may be poised for the sort of trophic cascade and system reorganization anticipated by GLOBEC as a consequence of global warming at high latitudes (Grebmeier *et al.* 2006).

Warmer temperatures could shift the distribution of sea lions northward. The eastern DPS increased in size at a rate of approximately 3% per year from the early 1980s through 2004, despite a decline in the size of the breeding population at the southern extent of its range in California. All of the increase in the eastern DPS occurred north of California, and new rookeries established in the 1990s (White Sisters and Hazy Island) were near its northernmost extent in southeast Alaska.

As temperatures warm and global ice coverage decreases, sea levels will rise. This will directly affect terrestrial rookery and haulout sites currently used by Steller sea lions as well as those that may be used by a recovering population. Presumably, sea lions using terrestrial sites will simply move upslope as sea levels rise, assuming that the terrain at the site is suitable. However, sites on some islands with low relief (e.g., Agligadak Island) may be submerged. The net effect of a rise in sea level on overall terrestrial sea lion habitat amount or availability is uncertain, but at the projected rate it is unlikely to have a significant effect for many years.

Fluctuations or cycles in physical and biological characteristics of marine ecosystems may not necessarily affect higher trophic levels because of strategies for survival they have evolved to buffer them against environmental uncertainty. Based on their analyses of possible causes of the sea lion decline, Pascual and Adkison (1994) concluded that environmental cycles were unlikely to have caused declines of the magnitude and duration observed. Shima *et al.* (2000)

did a comparative analysis of population dynamics of four species of pinnipeds in similar variable environments (Steller sea lions in the Gulf of Alaska, Cape fur seals in the Benguela Current, harp seals in the Barents Sea, and California sea lions in the California Current) and found a major decline only for Gulf of Alaska Steller sea lions. They concluded that the success of the other populations suggests that pinnipeds in general have the ability to adapt to environmentally driven changes in prey resources, and that other factors were involved in the decline of Steller sea lions.

Data gaps

More research is necessary to describe linkages between changes in the environment and the dynamics of apex predators such as Steller sea lions. Distinguishing between anthropogenic and environmentally-driven changes in the abundance and distribution of prey resources has eluded scientists and managers, but is necessary in order to understand the forces underlying change in population size and demographics. Furthermore, the direct effects of temperature increases on sea lion metabolic rates, foraging efficiencies, and disease transmission are unknown.

IV. THREATS ASSESSMENT FOR THE WESTERN POPULATION

In Section III, the available information on how various factors could potentially influence the western DPS of Steller sea lions was presented. In this section, that information is examined to determine the level at which those factors represent a current threat to sea lion recovery. First, an assessment is conducted on the impact to recovery from individual threats, independent of interactions with other threats. Second, possible scenarios in which threats may interact and have a cumulative impact on recovery are described. Third, the difficulty in identifying and isolating those threats that are the largest impediments to recovery is briefly discussed.

A. Overview of the Assessment

A "weight of evidence" approach was used to assess the relative impact of each threat, using an evaluation of the following parameters: (1) the mechanism by which each threat operates; (2) the age-class most vulnerable to the threat; (3) the relative frequency that the threat occurs; and (4) the level of uncertainty in the evidence used to determine the relative impact.

The mechanism by which each threat operates is considered "direct" if it kills individual sea lions directly and reduces survival rates and "indirect" if it reduces sea lion body condition and leads to reduced rates of reproduction and survival. Additional evidence to assess the impact of threats was obtained by examining whether recent estimates of sea lion survival and reproduction (see Section I.G) are consistent with the population dynamics expected from the mechanism by which the threat operates; i.e., direct or indirect, as described above.

1. Direct threats

Several threats act as direct sources of sea lion mortality: commercial harvest, intentional shooting, entanglements or incidental catch by fishing gear, disturbance, and predation. Direct sources of mortality were significant contributors to the sea lion population declines observed prior to the 1990s, when there were relatively large reductions in juvenile survival rates and smaller reductions for adults (Pasqual and Adkison 1994, York 1994, Holmes and York 2003, Fay 2004). Since 1990, rates of mortality from harvests, shooting, entanglement and incidental catch have been much less, and that has been reflected in a rebound in both juvenile and adult survival rates (Holmes and York 2003, Fay 2004). Subsistence harvests of Steller sea lions continue but have declined substantially. As previously described, predation by killer whales has the potential to be a significant additional direct source of mortality (Williams *et al.* 2004). Springer *et al.* (2003) proposed a hypothesis in which killer whales shifted their diet from large whales (following extensive commercial whaling in the 1950s and 1960s) to pinnipeds, resulting in sequential and substantial declines of northern fur seals, harbor seals, and Steller sea lions. This hypothesis, however, has been called into question because of inconsistencies with data on large whale catches, killer whale diets, and the spatial-temporal patterns of pinniped declines (Trites *et al.* 2006c, DeMaster *et al.* 2006). The effects of toxic substances, disease, and parasitism can result in the direct mortality of individual sea lions, and also operate indirectly by affecting condition and reproductive rates.

If one or more direct threats were major impediments to recovery for the western DPS, continued low rates of juvenile and/or adult survivorship would be expected or observed,

potentially with little or no change in fecundity, birth rates or condition. Current estimates of sea lion vital rates do not follow these expected trends.

2. Indirect threats

Indirect threats can lead to decreased rates of reproduction or survivorship (e.g., by making them more vulnerable to direct threats, such as predation) by reducing individual condition or fitness. Diseases, parasites, and toxic substances (contaminants) can indirectly threaten sea lion populations. , while two other threats have the potential to cause nutritional stress through reductions in prey biomass, availability or quality: environmental variability and competition with fisheries. Natural, environmental variability may lead to changes in the species composition, distribution or nutritional quality of the sea lion prey community (see review by Trites and Donnelly 2003). Alternatively, competition with fisheries may reduce localized or overall prey abundance and cause nutritional stress (Braham *et al.* 1980, NMFS 1998a, 2000). Both climate shift and fisheries-induced changes in prey communities may have affected the condition of Steller sea lions over the last 30 years, but the relative importance of each is a matter of considerable debate.

Evidence that indirect threats may have contributed to the decline observed from the mid-1970s through the late 1990s include reductions in size at age (Calkins and Goodwin 1988), possible decreased late-term pregnancy rates (Pitcher *et al.* 1998), and a decline in per capita fecundity of female sea lions (Holmes and York 2003, Fay 2004). These responses by sea lions are opposite of those predicted from direct threats (Bowen *et al.* 2001, NRC 2003), since body condition, growth rates, and fecundity should increase or remain the same when population abundance is reduced. Therefore, indirect factor(s) were likely negatively affecting sea lions at least as early as the 1980s, at the same time that large numbers of sea lions were also killed directly. The combination of reduced population abundance and poor body condition indices is consistent with a substantial reduction in carrying capacity (Gerrodette and DeMaster 1990).

The carrying capacity of the North Pacific for Steller sea lions likely fluctuates in response to changes in the environment (Hare *et al.* 1999, Overland *et al.* 1999, Stabeno *et al.* 2001, Benson and Trites 2002, Hunt *et al.* 2002, Shima *et al.* 2002, Trites and Donnelly 2003). In addition, overall and localized removals of prey by many fisheries increased markedly in the 1980s and could have exacerbated natural changes in carrying capacity, possibly in non-linear and unpredictable ways (Goodman *et al.* 2002). Reductions in carrying capacity may have contributed to declines in fecundity observed through at least 2002 (Holmes and York 2003, Fay 2004, Holmes *et. al. in review*) despite shifts to potentially more favorable environmental conditions that may have occurred in 1989 and 1998 (Hare and Mantua 2000, Bond *et al.* 2003).

If one or more indirect threats were major impediments to recovery for the western DPS, we would expect to observe a reduction in fecundity, reduction in body condition, and/or possible reduction in juvenile and adult survival. Current estimates of sea lion vital rates follow some but not all of these expected trends.

3. Relative impacts between threats

We estimated the relative impact of each threat on sea lion population dynamics in the previous 5 years (2001-2005) in order to rank the potential threat to recovery each threat represents in the next 5 year period (2006-2010). Specifically, each threat was ranked, relative to all threats identified, as Low, Medium, or High, with recovery defined by both the biological and listing factor criteria in Section V. This qualitative assessment approach was selected rather than a quantitative approach because of the substantial uncertainty in the understanding of each threat's influence on sea lion population dynamics. Finally, the feasibility to mitigate the effects of each threat was also ranked, but was not included in the relative impact assessment. A summary of the threat assessment is presented in Table IV-1; the rationale for the rank of each threat is presented below.

The Team had difficulty reaching consensus on the relative impact on the recovery of the western DPS of Steller sea lion for three threats: killer whales, environmental variability, and competition with fisheries. Team members ranked the threat HIGH or LOW for reasons explained in each section. To address the high uncertainty about these threats and the competing hypotheses, the tem "potential high" was assigned. This qualified ranking reflects the Team's intention of adopting a precautionary approach and highlighting research needs that could reduce critical uncertainties.

Table IV-1. Factors identified as Threats to the recovery of the western DPS of Steller sea lion in the next 5 years (2006-2010), and the information used as evidence to rank the relative impact of those threats as High, Medium, or Low. The mechanism of each threat either directly reduces survivorship of individual sea lions (i.e., Direct; more likely to be top-down) or indirectly reduces body condition and subsequently reproduction and survival (i.e., Indirect; more likely to be top-down).

Threat	Mechanism	Most Vulnerable Age-Class	Frequency of Threat Occurring	Uncertainty	Relative Impact to Recovery	Feasibility of Mitigation
Killer Whales	Direct	Pups & Juveniles	High	High	Potentially High	Low
Environmental Variability	Indirect	Adult Females & Juveniles	High	High	Potentially High	Low
Competition with Fisheries	Indirect	Adult Females & Juveniles	High	High	Potentially High	High
Incidental Take by Fisheries	Direct	Juveniles	Medium	Medium	Medium	Medium
Toxic Substances	Direct and Indirect	Adult Females & Pups	High	High	Medium	Medium
Alaska Native Subsistence Harvest	Direct	Adult & Juvenile Males	Medium	Low	Low	High
Illegal Shooting	Direct	Non-pups	Low	Medium	Low	Medium
Entanglement in Marine Debris	Direct	Juveniles	Medium	Medium	Low	Medium
Disease and Parasitism	Direct and Indirect	Adult Females & Pups	High	Medium	Low	Low
Disturbance from Vessel Traffic and Tourism	Direct	Pups	Medium	Medium	Low	High
Disturbance from Research	Direct	Pups	Medium	Low	Low	High

B. Impact of Individual Threats

1. Predation by killer whales – POTENTIALLY HIGH

The potential impact of predation by transient killer whales on the dynamics of Steller sea lions and the North Pacific marine ecosystem over the last several decades has recently received substantial attention and study within the scientific community. Information on killer whale abundance, diet, and movements has increased, and new hypotheses have been developed within the scientific community on how predation by killer whales has influenced marine mammal populations, including sea lions. Major limitations in the available data result in substantial uncertainty, and thus permit many inferences and interpretations. In assessing the relative impact of predation by killer whales on sea lions, the Team determined that pups and juveniles are likely the most vulnerable age-class, that the threat occurs at a high frequency, that there is a high level of uncertainty associated with the available evidence, and that there is a low feasibility of mitigation. However, the Team did not reach consensus on the relative impact on the recovery of the western DPS of Steller sea lion due to killer whale predation, and the threat was ranked potentially high; the rationale for both a high and low rank is described below.

The threat posed by killer whale predation to sea lion recovery was ranked high based primarily on (1) the Sequential Megafaunal Collapse Hypothesis, and (2) the results of bioenergetic and demographic modeling that indicate predation by killer whales could have caused the decline of sea lions in the Aleutian Islands and may continue to suppress the larger population. A high rank is also based on the assumption that the proportion of sea lions in the diet of killer whales has remained relatively constant throughout the sea lion decline, and thus the relative impact of that predation may now be greater on a substantially smaller sea lion population. Combined, this evidence indicates that sea lions will continue to experience substantial levels of mortality due to predation. The high predation rate may be due to dramatic changes in the north Pacific ecosystem caused by commercial whaling of baleen whales and the absence of a density dependent response, in both abundance and diet, by killer whales in the presence of a much lower abundance of Steller sea lions.

The threat posed by killer whale predation to sea lion recovery was ranked low based on multiple lines of evidence. Several studies have determined that the available data are not consistent with the major assumptions of the Sequential Megafaunal Collapse Hypothesis. Also, in comparison, that hypothesis is not supported by the evidence for the eastern DPS, which has increased at approximately 3% per year for at least 20 years while co-existing with a larger population of transient killer whales in an environment exposed to similar commercial whaling and environmental impacts. Some groups of killer whales may specialize on certain prey species, including sea lions, yet available evidence indicates the primary prey species of killer whales are dominated at lower trophic levels than sea lions. Further, juvenile and adult survivorship of sea lions has recently increased, for those regions in which data are currently available, contrary to that expected if predation remained a substantial threat. Combined, this evidence indicates that the predator-prey dynamics between killer whales and sea lions has not changed appreciably from that which has sustained populations of both species in coexistence in the North Pacific for thousands of years, and, there is an absence of evidence indicating predation will limit sea lion recovery in the near term.

Based on the high uncertainty regarding this threat (competing hypotheses which support a high or low ranking), a precautionary approach is to describe this as a potentially high threat.

2. Environmental variability – POTENTIALLY HIGH

The potential impact of environmental variability, through a reduction in the biomass and quality of sea lion prey species, has also recently received substantial attention and study within the scientific community. Periodic shifts in oceanic and atmospheric conditions may have major effects on the productivity and structure of North Pacific ecosystems, with cascading effects on some prey fish populations. The manner and mechanism by which such "regime shifts" and altered fish populations would affect marine mammals, including Steller sea lions, is poorly understood and remains unresolved. In assessing the relative impact of environmental variability on sea lions, the Recovery Team determined adult females and juveniles are likely the most vulnerable age-classes, the threat occurs at a high frequency, there is a high level of uncertainty associated with the available evidence, and there is a low feasibility of mitigation. However, the Team did not reach consensus on the relative impact on the recovery of the western DPS of Steller sea lion due to environmental variability, and the threat was ranked potentially high; the rationale for a high and low rank is described below.

The threat posed by environmental variability to sea lion recovery was ranked high based on the assertion that changes in the North Pacific fish community structure stemming from the regime shift in 1976-77 were substantial enough to alter the quality and availability of prey for Steller sea lions, resulting in a dominance of pollock and other gadids, which resulted in the nutritional stress of juvenile sea lions. The climate and associated diet shifts were outside the limits of natural variability in the history of Steller sea lions in the North Pacific and were principal factors in their population decline. The potential of such environmental variability will remain a substantial threat to sea lion recovery in the near term.

The threat posed by environmental variability to sea lion recovery was ranked low based on the assertion that although oceanographic and atmospheric conditions have changed over the last several decades, those changes have not been outside the range of natural fluctuation previously experienced by sea lions. Gadids have been and will continue to be a principal component of the diet of sea lions, and there are not likely to be significant consequences to Steller sea lion health or vital rates from such a diet. Further, available evidence indicates that the current fish community structure is very similar to that just prior to the 1976-77 regime shift, and changes in sea lion diets between regimes were unremarkable, thus the potential impact of environmental variability on recovery in the near term is minimal.

Based on the high uncertainty regarding this threat (competing hypotheses which support a high or low ranking), a precautionary approach is to describe this as a potentially high threat.

3. Competition with Fisheries – POTENTIALLY HIGH

The potential impact of competition with fisheries, through a reduction in the biomass and quality of sea lion prey species, has caused considerable debate among the scientific community. The primary issue of contention is whether fisheries reduce sea lion prey biomass and quality at both the local and regional spatial scales that may lead to a reduction in sea lion

survival and reproduction, and if sustained, their carrying capacity. The effect of fisheries on the distribution, abundance, and age structure of the sea lion prey field, at the spatial scale of foraging sea lions and over short and long temporal scales, is largely unknown. Further, uncertainty in the available information, including the efficacy of management regulations implemented to mitigate possible adverse effects of fisheries, permits disparate interpretations and inferences. In assessing the relative impact of competition with fisheries (i.e., all fisheries including commercial and sport) on sea lions, the Team determined adult females and juveniles to be the most vulnerable age-classes, fishing activities occur at a high frequency, there is a high level of uncertainty associated with the available evidence, and there is a high feasibility of mitigation. However, the Team did not reach consensus on the relative impact on the recovery of the western DPS of Steller sea lion due to competition with fisheries, and the threat was ranked potentially high; the rationale for both a high and low rank is described below.

The threat posed by competition with fisheries to sea lion recovery was ranked high based on the assertion that combined effects of seasonally compressed fishing in sea lion foraging areas and the long term impacts of exploitation of sea lion prey since the 1960s, resulted in changes in the location, density, distribution, availability, quality, and energy value of the sea lion prey field. The adverse impact of these changes is of concern because of the substantial overlap that exists between the size of fish species targeted by groundfish fisheries and consumed by sea lions. The primary objective of the commercial fishery conservations measures for Steller sea lions developed in 2001 by the North Pacific Fishery Management Council and NMFS was to avoid jeopardy and adverse modification of critical habitat (under the ESA), and these measures may have contributed to the slower rate of the sea lion population decline. However, there are significant uncertainties in the understanding of how the specific sea lion measures and the overall management of North Pacific groundfish fisheries promote sea lion recovery. Specifically, how the needs of competitor apex predators, such as sea lions, are accounted for when the long-term equilibrium spawning biomasses of multiple prey species are reduced by as much as 60% is not evident. There is also concern about the potential effects of concentrated fishing activities in sea lion foraging areas derived from the localized depletion, even if temporary, of fish stocks. Based on this combined evidence, the current and expected threat of the competitive effects of fishing on the recovery of the western DPS of Steller sea lion was ranked high.

The threat to recovery of the western DPS due to competition with fisheries was ranked low based on the assertion that, by definition, competition occurs only if prey is limited. Even large human harvests of a known prey species may have limited effect on availability to Steller sea lions if a large biomass remains unharvested and accessible. In addition, it can be argued that commercial harvest of adult pollock and other piscivorous fish species might reduce the threat to Steller sea lion recovery posed by these potential competitors. Therefore commercial removals of these species from critical habitat may reduce their potential for competing with Steller sea lions for smaller forage species. The potential for localized depletion of prey by commercial fisheries could be minimal because sea lions are opportunists, feed on a diverse diet, and are known to exploit seasonally available prey, suggesting prey switching may be a natural foraging strategy. The physiological consequences of switching to alternate prey in response to localized depletion of a target species (whether a natural or fishery-induced diet change) are not necessarily detrimental. In addition, the effects on sea lion foraging efficiency due to the mechanical disruption of large fish aggregations by trawls and other commercial

fishing gear are equivocal. The species-specific duration and degree of fish school disruption due to commercial harvest are unknown and worthy of further fish behavior studies. Disruption of large aggregations into multiple smaller groups could enhance Steller sea lion foraging success by increasing the surface-to-volume ratios of the prey aggregations. Therefore, the potential threat to sea lions by disrupting large prey aggregations is uncertain but relatively low.

Based on the high uncertainty regarding this threat (competing hypotheses which support a high or low ranking), a precautionary approach is to describe this as a potentially high threat. Specific to the threat that fisheries may pose to Steller sea lions, there is an especially high need to conduct research to reduce uncertainties and to evaluate the efficacy of fishery conservation measures for Steller sea lions. Reviews should be conducted at the scale appropriate to sea lion foraging patterns.

4. Incidental take due to interactions with active fishing gear - MEDIUM

The primary documented sources of information used to assess the impact of incidental take are estimates of mortality based on fishery observer data, self-reported fisheries data, and data on stranded animals. The mean number of lethal entanglements in active U.S. fishing gear was estimated at 31 sea lions per year between 1990 and 2001. Information is not available from several fisheries known to interact with sea lions; thus 31 is a minimum estimate. In addition, as many as 50 sea lions were killed incidental to herring fishery operations in Russia, but this is based solely on observer records during a single 3-month period in 2002; this too should be considered a minimum estimate. Additional information on incidental take is available from observations of sea lions suffering from injuries caused by both commercial and sport fishing operations. However, there are large segments of the fishing industry (e.g., longline fleet for Pacific cod, halibut and sablefish, salmon and herring fisheries) that have either no or limited observer coverage, possibly leading to underestimates of incidental take.

Juvenile sea lions are the age-class most vulnerable to incidental take, the threat occurs at a medium frequency, and there is a medium level of uncertainty associated with the evidence above. Thus, the relative impact on the recovery of the western DPS of Steller sea lion due to interactions with active fishing gear is ranked medium, with a medium feasibility of mitigation.

5. Toxic substances - MEDIUM

Steller sea lions have shown relatively low levels of toxic substances as well as heavy metals, and these substances are not believed to have caused high levels of mortality or reproductive failure. However, there are no studies on the effects of toxic substances at the population level to determine their impact on vital rates and population trends. Chronic exposure to toxic substances may result in reactive metabolites that could cause damage to DNA, RNA, and cellular proteins. Sea lions exposed to oil spills may become contaminated with polycyclic aromatic hydrocarbons (PAHs) through inhalation, dermal contact and absorption, direct ingestion, or by ingestion of contaminated prey. Newer contaminants such as PBDEs have not been measured in Steller sea lions. Thus, overall, there is still some concern that toxic substances may have indirect impacts on individual vital rates.

Adult females and pups are likely the age-classes most vulnerable to toxic substances, the threat occurs at a high frequency (i.e., toxins are commonly found in the North Pacific), and there is a high level of uncertainty associated with the evidence described above. Thus, the relative impact on the recovery of the western DPS of Steller sea lion due to toxic substances is ranked medium, with a medium feasibility of mitigation.

6. Alaska native subsistence harvest – LOW

Both the ESA and the MMPA contain provisions that allow coastal Alaska Natives to harvest endangered, threatened, or depleted species for subsistence purposes. Based on retrospective surveys, the annual subsistence harvest (including struck and loss) decreased substantially from about 550 sea lions in 1992 to about 200 in 1996 followed by annual takes between 165 and 215 from 1997 to 2004. In the early 1990s, juveniles were harvested at least twice as much as adults, yet that ratio declined beginning in 1996, and between 2000 and 2004, the ratio of juveniles to adults in the harvest ranged from 0.5 to 1.0. The ratio of males to females harvested in 2004 was 1.8, below the 5-year average of 4.1 during the previous five years. In 2004, 24 adult females were harvested, representing about 20% of the total harvest of known sex and age. The greatest numbers of sea lions harvested were in the Pribilof Islands and the Aleutian Islands. The surveys that produced these estimates covered all Alaskan communities that regularly hunt Steller sea lions, but a few additional animals are taken occasionally at other locations as well. Native hunters may currently take some sea lions in Chukotka, but the number killed is unknown. No other subsistence harvests are currently conducted.

Males, both juvenile and adult, are the age-class most vulnerable to subsistence harvests, the threat occurs at a medium frequency, and there is a low level of uncertainty associated with the evidence above. Thus, the relative impact on the recovery of the western DPS of Steller sea lion due to the Alaska Native subsistence harvest is ranked low, with a high feasibility of mitigation.

7. Illegal shooting – LOW

Historical accounts document substantial mortality due to illegal shooting (Alverson 1992, Matkin and Fay, 1980), whereas one study conducted in 1988-1989 in the Copper River Delta indicates that the frequency of occurrence may have declined substantially (Wynne, 1990). Such killing may have had a significant effect in local areas and may have caused animals to move away from certain rookeries and haulout sites. Amendments to the MMPA in 1988 and 1994, and sea lion specific regulations in 1990, increasingly prohibited fishermen from discharging firearms near Steller sea lions and likely reduced the impact from this threat substantially. However, some shooting, resulting in an unknown level of mortality, still occurs (NMFS 2001, Loughlin and York 2000, NRC 2003). While legal, Steller sea lions are hunted in Hokkaido, Japan to reduce damage to local fisheries, with an average of 631 animals killed per year during 1958-1993. Animals killed are mostly from the Kuril Islands and Sea of Okhotsk, and overwinter in Japanese waters.

Non-pups are the age-class most vulnerable to illegal shooting, the threat occurs at a low frequency, and there is a medium level of uncertainty associated with the evidence above. Thus, the relative impact on the recovery of the western DPS of Steller sea lion due to illegal shooting is ranked low, with a medium feasibility of mitigation.

8. Entanglement in marine debris – LOW

Observational studies cannot fully evaluate the potential for entanglement because entangled animals may die at sea and thus not be seen. A study conducted in the Aleutian Islands during June-July 1985 found that a very low percentage of observed sea lions were entangled in net or twine; none were entangled in packing bands. A follow-up study was conducted during November 1986 and researchers saw no entangled pups and only one entangled juvenile out of a total of 3,847 sea lions examined. Currently, there is incomplete information available on the number of animals lost at sea, and marine debris will likely continue to be common.

Juveniles are likely the age-class most vulnerable to entanglement in marine debris, the threat occurs at a medium frequency, and there is a medium level of uncertainty associated with the evidence above. Thus, the relative impact on the recovery of the western DPS of Steller sea lion due to entanglement in marine debris is ranked low, with a medium feasibility of mitigation.

9. Disease and parasites - LOW

Available serologic evidence does not support the possibility that a disease epidemic occurred during the sea lion decline of the late 1970s and 1980s; however, due to sampling limitations the possibility can not be excluded completely. Although sea lions have recently been exposed to several endemic disease agents that could potentially impede recovery, the only available data are the prevalence of antibodies to the disease agents, and the potential for those agents to cause disease among Steller sea lions has not been documented. The potential for parasitism to have a population level affect on sea lions is largely unknown. Although parasites may have little impact on otherwise healthy animals, effects could become significant if combined with other stresses. Available information does not suggest that the sea lion decline was caused by parasitic infections, although there has not been adequate research to assess the current relative nature and magnitude of parasitism in sea lion populations.

Adult females and pups are likely the age-classes most vulnerable to disease and parasitism, the threat occurs at a high frequency, and there is a medium level of uncertainty associated with the evidence above. Thus, the relative impact on the recovery of the western DPS of Steller sea lion due to disease and parasitism is ranked low, with a low feasibility of mitigation.

10. Disturbance from vessel traffic and tourism – LOW

The possible impacts of various types of disturbance on Steller sea lions have not been well studied, yet the response by sea lions to disturbance will likely depend on season and their stage in the reproductive cycle. Close approach by humans, boats, or aircraft will cause hauled out sea lions to go into the water, and the discharge of firearms at or near hauled out animals may have a particularly dramatic effect. Vessels that approach rookeries and haulouts at slow speed, in a manner that allows sea lions to observe the approach, have less effect than vessles that appear suddenly and approach fast. Sea lions may become accustomed to repeated slow vessel approaches, resulting in minimal response. Although low levels of occasional disturbance may have little long-term effect, areas subjected to repeated disturbance may be permanently abandoned. When humans set foot on a rookery or haulout, the response by sea lions is typically

much greater, often resulting in stampedes that may cause trampling or abandonment of pups. Repeated disturbances that result in abandonment or reduced use of rookeries by lactating females could negatively affect body condition and survival of pups through interruption of normal nursing cycles.

Pups are the age-class most vulnerable to disturbance from vessel traffic and tourism, the threat occurs at a medium frequency, and there is a medium level of uncertainty associated with the evidence above. Thus, the relative impact on the recovery of the western DPS of Steller sea lion due to disturbance from research activities is ranked low, with a high feasibility of mitigation.

11. Disturbance due to research activities - LOW

Research activities result in disturbance but are closely monitored and evaluated in an attempt to minimize any impacts of research necessary to recover sea lions. Research activities result in the mortality of 1-3 sea lions annually, often due to accidental death during anesthesia or suffocation when animals are herded. However, the potential exists for additional unobserved mortality to occur following the completion of research activities, yet no estimates are available.

Pups are the age-class most vulnerable to disturbance from research activities, the threat occurs at a medium frequency, and there is a low level of uncertainty associated with the evidence above. Thus, the relative impact on the recovery of the western DPS of Steller sea lion due to disturbance from research activities is ranked low, with a high feasibility of mitigation.

C. Cumulative Effects of Threats

Differences in the timing and magnitude of the regional population trajectories in the 1970s, 1980s, and 1990s suggest that the overall western DPS decline was not caused by a single factor, but rather by the cumulative effect of multiple factors that had different relative spatial and temporal magnitudes. Indeed, the marked change in the rate of the decline since 1990 suggests that the factors that contributed to the more rapid prior declines may not be the most significant factors operating today (Bowen *et al.* 2001); in addition, there may have been density-dependent responses at lower population levels. The purpose of this section is to provide a general description of how direct and indirect threats may have interacted to substantially reduce the Steller sea lion population, and how their aggregate impacts may affect sea lions now and in the near future.

We have only a limited or qualitative understanding of how multiple factors interact to create an overall cumulative effect on sea lion populations. In addition, data are insufficient to show what the natural dynamics of Steller sea lion populations have been. Such dynamics would be driven primarily by changes in the North Pacific ecosystem that affect carrying capacity (e.g., prey abundance), but would also be affected by changes in rates of predation and disease. Increased knowledge of both natural ecosystem dynamics and how human activities influence those dynamics is required before their respective impacts on sea lions can be delineated with certainty (NRC 1996, NMFS, 2001, NRC 2003). Yet, a number of theories attempting to explain the decline in sea lions and apparent changes in the structure of North Pacific ecosystems since the 1970s have been developed, and these involve top-down (e.g., direct), bottom-up (e.g., indirect) or a combination of both types of forces (NRC 1996, Anderson and Piatt 1999, Merrick

1997, Orensanz *et al.* 1998, Estes *et al.* 1998, Francis *et al.* 1998, Trites *et al.* 1999, NMFS 1998a, NMFS 2000, Jackson *et al.* 2001, Hunt *et al.* 2002, NRC 2003, Springer *et al.* 2003). Depending on the emphasis placed within each individual theory, trophic cascades and systemic modifications were triggered alone or in various combinations by whaling, fishing, predation, or atmospheric and oceanographic changes.

1. Top-down factors

As listed above, several factors act as top-down sources of direct sea lion mortality; i.e., commercial harvest, intentional shooting, entanglements or incidental catch by fishing gear, disturbance, and predation. Top-down sources of mortality were significant contributors to the sea lion population declines observed prior to the 1990s, when there were relatively large reductions in juvenile survival rates, and smaller reductions for adults (Pasqual and Adkison 1994, York 1994, Holmes and York 2003, Fay 2004). Since 1990, rates of mortality from harvests, shooting, and entanglement and incidental catch have been much less, and that has been reflected in a rebound in both juvenile and adult survival rates (Holmes and York 2003, Fay 2004). Subsistence harvests of Steller sea lions continue but have declined substantially. As previously described, predation by killer whales has the potential to be a significant additional top-down source of mortality (Williams *et al.* 2004). Springer *et al.* (2003) proposed a hypothesis in which killer whales shifted their diet from large whales (following extensive commercial whaling in the 1950s and 1960s) to pinnipeds, resulting in sequential collapses of northern fur seals, harbor seals, and Steller sea lions, and culminating in the collapse of sea otter populations (see also Estes *et al.* 1998). This hypothesis, however, has been called into question because of inconsistencies with data on large whale catches, killer whale diets, and the spatial-temporal patterns of pinniped declines (Barrett-Lennard *et al.* 1995, Trites *et al.* 2006c, DeMaster *et al.* 2006, and Wade *et al. in press*).

2. Bottom-up factors

Evidence that bottom-up factors may have contributed to the decline observed from the mid-1970s through the late 1990s include reductions in size at age (Calkins and Goodwin 1988), possible depressed late-term pregnancy rates (Pitcher *et al.* 1998), and a decline in per capita fecundity of female sea lions at some rookeries (Holmes and York 2003, Fay 2004, Winship and Trites 2006). These responses by sea lions are opposite to those predicted by top-down factors (Bowen *et al.* 2001, NRC 2003), as body condition, growth rates, and fecundity should increase or remain the same when population abundance is reduced. Therefore, bottom-up factor(s) appeared to be affecting sea lions at least as early as the 1970s, at the same time that large numbers of sea lions were also killed directly. The combination of reduced population abundance and poor body condition indices is consistent with a substantial reduction in carrying capacity (Gerrodette and DeMaster 1990).

The two bottom-up factors or threats hypothesized to have contributed most to the population decline are likely to affect sea lions by reducing prey biomass and quality resulting in nutritional stress (proximate cause) that subsequently decreases vital rates (Trites *et al.* 2006a). However, there are two hypotheses about the ultimate causes of nutritional stress. In one, nutritional stress stems from climate induced changes in the species composition, distribution or nutritional quality of the sea lion prey community (see review by Trites and Donnelly 2003

and Trites *et al.* 2006a). In the other, fishery-induced reductions in localized or overall prey abundance cause nutritional stress (Braham *et al.* 1980, NMFS 1998a, 2000). Both climate shift and fisheries induced changes in prey communities may have affected the condition of Steller sea lions over the last 40 years, but the relative importance of each is a matter of considerable debate.

The carrying capacity of the North Pacific for Steller sea lions likely fluctuates in response to changes in the environment (Hare *et al.* 1999, Overland *et al.* 1999, Stabeno *et al.* 2001, Benson and Trites 2002, Hunt *et al.* 2002, Shima *et al.* 2002, Trites and Donnelly 2003, Trites *et al.* 2006a), yet what may have been unusual about the decline in sea lions observed through 2000 is the introduction of large-scale commercial fisheries on sea lion prey. While large-scale groundfish fisheries began in the 1960s, their potential for competitive overlap with Steller sea lions (e.g., catches within what would be designated as critical habitat) increased markedly in the 1980s. Overall and localized fisheries removals of prey could have exacerbated natural changes in carrying capacity, possibly in non-linear and unpredictable ways (Goodman *et al.* 2002). Reductions in carrying capacity may have contributed to declines in fecundity that are believed to have occurred at some rookeries through at least 2002 (Holmes and York 2003, Fay 2004, Winship and Trites 2006, Holmes *et. al. in review*) despite shifts to potentially more favorable environmental conditions that may have occurred in 1989 and 1998 (Hare and Mantua 2000, Bond *et al.* 2003).

D. Summary and Scenarios

Both direct and indirect threats can affect Steller sea lion population growth and vital rates. In addition, both types of threats can operate simultaneously and at various levels. Steller sea lions have been affected by environmental variability (e.g., "regime shifts"), diseases, parasites, and predation for their entire existence, and humans have hunted them for food and for other uses for thousands of years. The impact of each of these factors has likely varied over time in response to marine ecosystem dynamics and predator abundance (e.g., killer whales and humans), as well as in response to the size of the sea lion population itself. Steller sea lions persisted in the North Pacific despite the adverse impact of these threats, and they did so without a significant loss of genetic diversity: there is evidence that previous population declines were not severe enough to cause a "genetic bottleneck". Therefore, for tens of thousands of years prior to the 1970s, Steller sea lions had adapted to and accommodated fluctuations in their carrying capacity due to natural variability, disease and parasitism, killer whale predation, human-related kills, and apparently maintained, on average, a relatively large population size.

In the last several decades, several new threats have developed; i.e., contaminants, global climate change, and both direct (e.g., incidental take) and indirect (reduced prey biomass and quality) effects of fisheries. The absolute levels of decreased survival and reproduction associated with each threat during the sea lion population decline are unknown. Yet, based on a population viability analysis (PVA) using existing empirical data and accounting for the complete suite of conservation actions to date, if the combined impact of all the threats were to continue, in the absence of a substantial density dependent response, the probability that the western DPS of Steller sea lions would go extinct in the next 100 years is relatively high (Section V, Appendix 3).

Recognizing the limited understanding, and associated uncertainty, in the cumulative effects of direct and indirect threats on sea lions and their environment, four alternative scenarios were developed. Although neither exhaustive nor conclusive, these four scenarios serve two purposes. First, the scenarios attempt to describe, in a general manner, how various threats may have combined to cause the sea lion decline, and subsequently how those threats may influence future sea lion population dynamics. The influence of global climate change and inter-specific competition, which were not included in the assessment of individual threats above, are considered to influence each of the four alternative scenarios. Second, the scenarios explore how some threats may influence the broader marine ecosystem of the North Pacific. The latter is intended to address the 1994 USFWS and NMFS ecosystem conservation policy relative to recovery plans. Specifically, the ESA and 1994 interagency ecosystem policy imply that maintaining the health of sea lion habitat and ecosystem functions will promote the species recovery and long term viability. Further, recovery plans should be developed and implemented "…in a manner that restores, reconstructs, or rehabilitates the structure, distribution, connectivity and function upon which those listed species depend." Thus, the alternative scenarios may provide insights to how ecosystem integrity has been affected, and what mitigation actions may be warranted.

1. Predation scenario

In this scenario, it is hypothesized that sea lion population declines would be primarily driven by killer whale predation that was greater than that experienced previously by Steller sea lions in the western DPS. The increased level of predation was triggered by commercial whaling, commercial fishing on sea lion prey, or some other unknown cause. Changes in the sea lion prey base, from natural causes (environmental variability; e.g., 1976-77 regime shift) or increased fishing effort in sea lion critical habitat areas may have resulted in sea lions foraging longer and increased their exposure to and mortality from predators. Predation rates presumably declined since about 1990 due to a density dependent response to the reduced abundance of Steller sea lions. For killer whale predation to remain a serious threat to recovery, conditions that led to atypically high rates of predation, such as a trophic cascade following intense periods of whaling, fishing, or environmental change, would need to persist.

Factors that could be confounded with predation include any other direct factor such as legal or illegal shooting, incidental take in fisheries, subsistence hunting, and the direct effects of diseases and contaminants. A largely predation-driven decline or threat to recovery should not be associated with responses in the sea lion population typical of indirect threats (e.g., reduced birth rates).

2. Environmental variability or regime shift scenario

In this scenario, it is hypothesized that sea lion population declines would be largely driven by changes to the sea lion prey community that decreased the nutritional quality (energy density) of their diet. The 1976-77 regime shift is hypothesized to have changed the recruitment dynamics or distributions (or both) of multiple fish species across the North Pacific Ocean, resulting in increases in low energy prey (e.g. gadids) and decreases in high energy prey (e.g., herring), which in turn reduced sea lion vital rates. In this scenario, the magnitude of the

change to the North Pacific ecosystem caused by the 1976-77 regime shift is thought to be larger than previously experienced by sea lions during the 1900s. If it were within the 'normal' range and sea lions have a high likelihood of occasionally declining more than 80%, modeling suggests that they would have likely gone extinct given their life history characteristics. Fishing could have exacerbated the regime shift related impacts through relatively high local harvest rates of sea lion prey species, increasing their foraging costs. These changes would decrease carrying capacity, yet their impact on sea lions should decrease as their population declined. However, a threat to recovery will persist until the environment, and associated fish distributions and populations, change again to favor sea lions, increasing their carrying capacity and subsequently sea lion survivorship and birth rates.

Threats that could be confounded with environmental variability include inter-specific competition and the effects of fishing. An indirectly driven decline or threat to recovery may not be associated with responses in the sea lion population typically associated with direct threats e.g., reduced survivorship.

3. Fishing scenario

In this scenario, it is hypothesized that sea lion population declines would be largely driven by reductions in the quality and quantity of available sea lion prey initially caused by the development of groundfish fisheries in the mid-1960s, and then intensified as fishing effort for several prey species increased within sea lion foraging habitats in the 1970s and 1980s. The 1976-77 regime shift could have exacerbated fishing-related impacts by reducing the availability of alternative, non-commercial prey; e.g., osmerids. These adverse changes could cause both nutritional stress in the short-term and a decline in sea lion carrying capacity in the long-term. Some impacts of fishing may have been reduced through various fishery management measures taken in the 1990s and early 2000s. However, the long-term impact of a reduction in carrying capacity could limit potential density dependent responses by sea lions and limit recovery.

Threats that could be confounded with fishing include other indirect factors such as environmental variability and increased inter-specific competition. An indirectly driven decline or threat to recovery may not be associated with responses in the sea lion population typically associated with direct threats e.g., reduced survivorship.

4. Multiple threat scenario

In this scenario, it is hypothesized that both direct and indirect threats affected sea lions to varying degrees at different times to cause the sea lion population declines. Increases in both direct and indirect threats were necessary to account for the rapid rates of population decline in the 1980s that were accompanied by declines in juvenile survivorship, body size and birth rate. Specifically, high rates of direct mortality from humans (e.g., legal and illegal shooting, incidental take, subsistence hunting) and killer whales were augmented by declines in carrying capacity associated with regime shifts, increased interspecific competition, and/or fishing. A reduction in the rate of population decline in the 1990s suggests that the effect of one or more threats also declined, possibly through density dependence. This coincides with the listing of Steller sea lions under the ESA and the imposition of a ban on shooting at or near Steller sea

lions as well as a change in oceanographic conditions. Thus, there may have been a reduction in direct mortality from humans, a hypothesis supported by time series of juvenile and adult survivorship, as well as a shift to more favorable environmental conditions. In addition, rates of predation may also have decreased through density dependence. The lower rate of population decline since about 1990 and the associated improvement in survivorship, but possible continued erosion in birth rate, suggest the sustained effect of indirect threats and a reduction in the magnitude of direct threats.

5. Distinguishing the relative impact of threats

The assessment of the threats to the recovery of the western DPS of Steller sea lion described above provides the basis for the recovery criteria and recovery actions in Section V. Certainly, our limited understanding of the threats and their dynamics within the environment where Steller sea lions live must be improved. Further, increased knowledge of how sea lions respond to threats is required, which is problematic due to the similar responses exhibited to several different threats. This response overlap makes it difficult to distinguish which threats have the greatest impact on sea lions and which are the largest impediments to recovery.

In the threat assessment above, threats were delineated as either director indirect to examine evidence for expected responses in sea lion vital rates. Trends in survivorship and fecundity can be used to infer the current relative magnitude of threats. For instance, evidence of a decline in survivorship would suggest that threats such as predation or incidental catch in fisheries were the largest impediments to recovery. Alternatively, indirect threats may be implicated if reductions in fitness or fecundity were observed. Bowen *et al.* (2001; their Table 1) considered the primary hypotheses explaining the sea lion decline and summarized the likely direction of change in sea lion response variables (e.g., birth mass, pup growth rate, foraging effort, body condition) under those hypotheses. The NRC (2003; their Table 6.2) modified the Bowen *et al.* table by (1) reducing the number of response variables, (2) assigning hypotheses as acting under either bottom-up or top-down forcing, and (3) adding the observed direction of the response variables to subsequently assess if the expected and observed responses matched. The expected direction of sea lion responses differed between the Bowen *et al.* and NRC tables for several threats, illustrating the uncertainty associated with the understanding of how sea lions respond under various hypotheses. Acknowledging that uncertainty, both tables show that sea lions are expected to exhibit the same response to several hypotheses. For example, under effects on food (prey) from fisheries and climate/regime shifts, sea lion birth mass, pup growth rate, and body condition will decrease, whereas foraging effort would decrease. This particular response overlap is best explained by considering that both climate/regime shifts and fisheries would affect the prey available to sea lions, which could, in turn, affect reproductive success or failure, body condition or starvation, and morbidity.

V. RECOVERY PLAN FOR THE WESTERN POPULATION

When a species is listed as threatened or endangered under the ESA, NMFS is required to develop and implement a recovery plan for the conservation and survival of that species. The three specific statutory requirements, set forth in section 4(f)(1)(B) of the ESA, are that each plan incorporates the following:

1. A description of site-specific management actions necessary to achieve the plan's goal for the conservation and survival of the species;
2. Objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this section, that the species be removed from the list; and
3. Estimates of the time required and cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.

These statutory requirements, along with additional guidelines regarding the prioritization of actions, and a strategy for recovery are discussed below.

A. Goals

The ultimate goal of this recovery plan is to promote the recovery of the western DPS of Steller sea lion, and its ecosystem, to a level sufficient to warrant its removal from the federal List of Endangered and Threatened Wildlife and Plants (List) under the ESA. The intermediate goal is to reclassify the species from endangered to threatened.

B. Recovery Strategy

The worldwide population of Steller sea lions was listed as threatened under the ESA in 1990 after severe declines in the 1980s. The first Recovery Plan was published in 1992 and contained 61 discreet recovery actions. In 1997, after continued declines in the core of the range, the western DPS of Steller sea lion was reclassified as endangered. Several factors were identified in the 1997 listing document that could potentially have a negative impact on the western DPS of Steller sea lion, including changes in the availability or quality of prey (due to commercial fisheries or natural phenomena), disturbance, illegal shooting, incidental take in fisheries, subsistence harvest, and contaminants.

Beginning in the 1990s and continuing extensively in the 2000s, a research program has been conducted on Steller sea lions, a species that presents extensive logistical challenges in often severe environmental conditions. Despite these difficulties, these efforts have achieved significant advances in understanding sea lion biology and the factors that influence their population dynamics. Further, knowledge of the complex ecosystem of the North Pacific Ocean has provided insight into the interactions between sea lions and their environment.

By the early 1990s, a series of management actions were successful in reducing the previously high levels of incidental take in commercial fisheries and shooting (legal and illegal) to negligible levels. Since then, conservation efforts have focused on reducing the potential impact of commercial fisheries on sea lion prey through the implementation of fishery management

actions. Additional conservation measures have been implemented to reduce the impact of disturbance and subsistence harvest on sea lions.

The documented variation in the rate of population decline across decades and among regions within the western DPS demonstrates the need to employ a recovery strategy that accounts for spatial and temporal differences. These spatial and temporal differences in population dynamics also suggest that the causes of the decline did not act uniformly across the range. A substantial effort has been devoted toward understanding the causes of the decline and some potential does exist to gain some insight into those factors. However, the recovery strategy must focus on those factors that are currently impeding recovery of Steller sea lions and the actions necessary to promote recovery.

As described in the threats assessment (Section IV; Table IV-1), substantial uncertainty affects our ability to determine the relative impact of the primary threats to sea lion recovery. Unfortunately, fishery management actions which were implemented to reduce competitive interactions between fisheries and sea lions did not include a monitoring program to assess the efficacy of those measures. Therefore, although the conservation measures have been in place for a substantial amount of time, and the trend of the western DPS of Steller sea lion appears to have changed, we cannot infer whether those measures resulted in those population changes. To reduce the uncertainty in the relative impact of the major threats and the efficacy fishery management measures, the Team believes the following three actions are necessary for recovery:

Maintain current fishery conservation measures (Action 2.6.6)
After a long term decline, the western DPS appears to be stabilizing. The first slowing of the decline began in the 1990s suggesting that the management measures implemented in the early 1990s may have been effective in reducing anthropogenic effects (e.g., shooting, harassment, and incidental take). The apparent population stability observed in the last 6 years is correlated with comprehensive fishery management measures implemented since the late 1990s. The current suite of management actions (or their equivalent protection) should be maintained until substantive evidence demonstrates that these measures can be reduced without limiting recovery.

Design and implement an adaptive management program to evaluate fishery conservation measures (Action 2.6.8)
Due to the uncertainty in how fisheries affect Steller sea lions and their habitat, and the difficulty in extrapolating from individual scientific experiments, a properly designed adaptive management program should be implemented. This type of program has the potential to assess the relative impact of commercial fisheries and to better distinguish the impacts of other threats (including killer whale predation). This program will require a robust experimental design with replication at the proper temporal and spatial scales with the appropriate levels of commercial fishing as experimental treatments. It will be a challenge to construct an adaptive management plan that meets the requirements of the ESA, is statistically sufficient, and can be implemented by the commercial fisheries. Acknowledging these hurdles, we must make a significant effort to determine the feasibility of such a program.

Continue population monitoring and research on the key threats potentially impeding sea lion recovery
Estimates of population abundance, trend, distribution, health, and essential habitat characteristics are fundamental to Steller sea lion management and recovery. Further, current information on the primary threats is insufficient to assess their impact on recovery. Focused research is needed on how these threats impact sea lion population growth and how they may be mitigated in order to facilitate recovery. In addition to studies on individual threats, the dynamics between threats needs to be better understood to assess the cumulative effects on sea lions.

The Recovery Criteria and Recovery Actions in the following sections describe how the Recovery Strategy should be implemented to reduce the uncertainty associated with the relative impact of both the natural and anthropogenic threats to Steller sea lions and their marine ecosystem. Information gained from these actions will increase the effectiveness of management measures implemented to recover Steller sea lions.

C. Reclassification Criteria

To reclassify the western DPS of Steller sea lion as threatened, NMFS must determine that the species' abundance, survival, and distribution, taken together with the five potential sources of threats (i.e., the 5 factors considered during ESA listing), no longer render the species "in danger of extinction throughout all or a significant portion of its range." To remove the western DPS of Steller sea lion from the federal List of Endangered and Threatened Wildlife and Plants (List) (50 CFR 17.11 and 17.12), NMFS must determine that the species is not likely to "become an endangered species in the foreseeable future throughout all or a significant portion of its range."

The ESA requires that recovery plans, to the maximum extent practicable, incorporate objective, measurable criteria which, when met, would result in a determination in accordance with the provisions of the ESA that the species be removed from the List (or reclassified). These recovery criteria comprise the core standards upon which a decision will be based to reclassify the western DPS of Steller sea lion as threatened.

Recovery criteria must include measures of demographic health (biological criteria) as well as measures that indicate the elimination of threats to the species (listing factor criteria). Both the biological and listing factor criteria must be met for the western DPS of Steller sea lion to be reclassified. The biological criteria require evidence that the population status has improved in response to the reduction of threats, while the listing factor criteria require evidence that the threats have been eliminated or controlled and are not likely to recur. Any new factors or threats identified since listing must also be addressed in this analysis to ensure that the species no longer requires protection as an endangered species.

1. Development of the biological criteria

A modeling approach using a population viability analysis (PVA) was explored in an attempt to derive a quantitative recovery criterion for the western DPS which was based on explicit choices for risk and the incorporation of uncertainty (see Appendix 3). Although the PVA results were

not used explicitly in the criteria, the process provided valuable information to the Team regarding uncertainty and the need to understand the threats affecting sea lions, and the time period necessary for recovery. This discussion provides an overview of the PVA development process, a detailed discussion of the PVA is found in Appendix 3.

In developing this recovery plan, it became evident that the eastern DPS has been recovering for nearly 30 years, increasing at about 3% per year throughout much of its range (see Section VII). In effect, the response of the eastern DPS to large reductions in population numbers during the mid-1900s and the subsequent recovery over the last 30 years has provided a possible recovery scenario for the western DPS. From the eastern DPS, we know that Steller sea lions in the Pacific ecosystem can recover from relatively low numbers at a rate of 3% per year and sustain this for many years. Since 2000, the western DPS has also been increasing at about 3% per year (based on surveys in 2000, 2002 and 2004). Therefore the Team has concluded that a reasonable recovery scenario for the western DPS is a 3% population increase over some relatively long time period.

Steller sea lions were originally listed in 1990 due to a sharp rate of decline, especially in the mid to late-1980s when annual declines reached 16%. In 1997, when the species was split into an eastern and western DPS, the western DPS was uplisted to endangered due to a continued decline and the lack of any evidence that the threats to the species had been substantially reduced or eliminated. It is important to note that the population was not listed due to low numbers, but the expectation that continued declines over a relatively long time period would, within the foreseeable future (e.g., 100 years), result in a high risk of extinction.

Thus, the Team developed biological criteria while considering the reasons for listing (primarily the relatively high rate of decline) and the most likely scenario for recovery (an annual population increase of 3%). This does not eliminate the possibility that other scenarios might in fact occur - those scenarios will of course be reviewed by NMFS and considered at that time.

This approach to recovery focuses on two main areas: performance of the population over a substantial period of time, and the reduction of threats which are likely to be limiting recovery either now or potentially in the future. Given that we have a reasonable estimate of what rate of increase to expect from this population (about 3%), the question then becomes what time period is necessary to observe this performance? In general, NMFS expects to see that both juvenile survival and pup production (natality) has increased to the point that the population is not only able to sustain itself, but is able to grow at a modest rate. Beyond the uncertainty of the major threats to recovery (e.g., predation, fisheries, incidental take), the most influential component in the North Pacific is decadal scale climate change which appears to have ecosystem scale ramifications, and may potentially influence the recovery of Steller sea lions. Therefore, the choice of a time period is influenced not only by the need to be confident that juvenile survival and natality have increased and are supporting the population growth rate, but that the recovery scenario has been maintained for a sufficient time period to have a reasonable likelihood of occurring over multiple regimes. This is not a guarantee that sea lions can increase in all regimes, but it does lend further evidence that this population is robust enough to either downlist or delist (depending upon the criteria obtained; see below for specific criteria for downlisting to threatened and delisting).

2. Downlisting to threatened

These criteria are based upon the current estimated population abundance of 44,000 animals for the U.S. portion of the western DPS, trends in population abundance, the continued human-caused threats to the species, and natural environmental conditions and variability. When determining whether the western DPS should be reclassified to threatened, NMFS will first assess whether the biological criteria have been met, and then will consider the listing factor criteria.

Biological Criteria: threatened

The western DPS of Steller sea lion will be considered for reclassification to threatened when all of the following have been met:

1. The population for the U.S. region has increased (statistically significant) for 15 years on average, based on counts of non-pups (i.e., juveniles and adults).
   Rationale: The generation time (i.e., mean age of females that give birth) for Steller sea lions is about 10 years, and the dominant natural processes within the North Pacific ecosystem that influence sea lion population dynamics operate on a decadal scale. Population growth for 15 years would reflect sustained growth by two generations of sea lions during two environmental regimes. Such growth provides assurance the population is recovering and not experiencing the unsustainable conditions of the past 40-50 years.

2. The population ecology and vital rates in the U.S. region are consistent with the trend observed under criterion 1. Certain vital rates are required in order to allow for long term growth. As a check on criterion 1, available information on pup counts, production (fecundity), juvenile survival rates, population age structure, gender ratios, and other observations should be examined to determine that whether they are indicative of an increasing population trend observed under criterion 1 is robust.

3. The trends in non-pups in at least 5 of the 7 sub-regions are consistent with the trend observed under criterion #1. The population trend in any two adjacent sub-regions can not be declining significantly. Available information on the population ecology and vital rates for the sub-regions is consistent with the respective sub-region trend. The 7 sub-regions are:
   a. Eastern Gulf of Alaska (US)
   b. Central Gulf of Alaska (US)
   c. Western Gulf of Alaska (US)
   d. Eastern Aleutian Islands (including the eastern Bering Sea) (US)
   e. Central Aleutian Islands (US)
   f. Western Aleutian Islands (US)
   g. Russia/Asia

Listing Factor Criteria: threatened

Eliminating or controlling the threats to the western DPS of Steller sea lion is imperative prior to downlisting to threatened, including all threats identified at the time of listing and any new

threats identified after listing. An inclusive list of the threats to recovery is found in Section IV of the Plan. The Plan describes the lack of recovery of Steller sea lions due to changes in the environment, predation, direct takes by humans, and competition for prey resources with fisheries.

In order to reclassify the western DPS of Steller sea lion the following threats-based criteria should be achieved in such a way that the threats do not re-emerge. The best available information indicates that achieving the following threats criteria is necessary in order to recover Steller sea lions. Yet, it is possible that current perceived threats become insignificant in the future due to changes in the natural environment, or changes in the way that the threats affect the entire life cycle of Steller sea lions. When the biological criteria for downlisting are met, NMFS will evaluate and review the criteria under these listing factors to determine their relevance under the current conditions.

Factor A: The present or threatened destruction, modification, or curtailment of a species' habitat or range

Modification of the foraging habitat of the western DPS of Steller sea lion, through both natural and anthropogenic sources, likely resulted in decreased survival and reproduction and may currently limit recovery. Reducing the threats to sea lion foraging habitat will be accomplished through a broad application of recovery actions that protect and improve their habitat. To provide assurance that reclassification is warranted for the western DPS of Steller sea lion, threats to its habitat should be reduced as specified under this factor:

1. Knowledge of the foraging ecology of Steller sea lions and the impacts of fisheries on sea lion prey is sufficient to determine whether fisheries are likely to limit recovery.
2. Federal and state fishery management measures, especially for pollock, Pacific cod, and Atka mackerel fisheries, are maintained in order to allow for the recovery of Steller sea lions. Modification of the conservation measures is based on the foraging requirements of Steller sea lions.
3. State of Alaska fishery management is reviewed, and those state fisheries that adversely affect Steller sea lions or their critical habitat should be authorized under the MMPA and ESA; habitat conservation plan under section 10 of the ESA or through section 7 consultations.
4. The designation of sea lion critical habitat is adequate to allow for recovery.

Factor B: Overutilization for commercial, recreational, or educational purposes

Human caused mortality for Steller sea lions results from incidental takes in fisheries, illegal shooting, harassment from tourism related activities, and take during scientific research. To provide assurance that reclassification is warranted for the western DPS of Steller sea lion, any overutilization for commercial, recreational, scientific, or educational purposes that threatens its continued existence should be reduced as specified under this factor:

1. Incidental takes are limited in commercial and recreational fisheries such that the effect of the take does not appreciably increase the time to recovery.

2. The occurrence of illegal shooting of sea lions remains low through awareness of regulations and enforcement.
3. Methods are developed and utilized to minimize the impacts of the research program, and those impacts do not limit the time to recovery of the population.

Factor C: Disease or predation
Throughout their range Steller sea lions are prey for killer whales. The impact of predation may be greater when sea lion abundance is reduced or when other factors increase their susceptibility to predation (e.g., reduced prey availability may increase foraging time thereby increasing vulnerability to predation). Currently, disease is considered to have a relatively minor impact on sea lions, but may present greater risks if population abundance declines further. To provide assurance that reclassification is warranted for the western DPS of Steller sea lion, any disease or predation that threatens its continued existence should be reduced as specified under this factor:

1. Methods have been developed and utilized to test sea lions for health related illness that may be limiting recovery and that information is adequate to conclude that disease is not limiting recovery.
2. Knowledge of the impacts of killer whale predation on sea lions is sufficient to determine that predation is not limiting recovery.

Factor D: The inadequacy of existing regulatory mechanisms
To provide assurance that reclassification is warranted for the western DPS of Steller sea lion, any inadequacy of existing regulatory mechanisms that threatens its continued existence should be reduced as specified under this factor:

1. Continue to implement fisheries regulations in 50 CFR part 679, following threats criterion A.1.
2. Update critical habitat by correcting erroneous locations for major rookery and haulout sites listed in 50 CFR parts 223 and 226.
3. Pursue international agreements and develop cooperative recovery programs with Russia and Japan.

Factor E: Other natural or manmade factors affecting its continued existence
To provide assurance that reclassification is warranted for the western DPS of Steller sea lion, several natural and man-made threats to its continued existence including subsistence harvest, pollution, toxins, and management should be reduced as specified under this factor:

1. Co-management agreements are in place with Alaska Native Organizations (ANOs) and a working relationship between the ANOs and NMFS results in an accurate accounting of the subsistence harvest, and the harvest levels do not likely limit sea lion recovery.
2. Sources of known pollution, including offshore oil and gas development, are known and they are not likely to pose significant health risks to the sea lion population.

3. The influence of global climate change and oceanographic variability is examined, including in combination with other human influenced factors, and is determined unlikely to limit recovery.
4. An Alaska stranding network is in place and functional.
5. NMFS maintains sufficient staff to manage the Steller sea lion recovery program.
6. There is an outreach program to educate the public, commercial fishermen, and others to the continued need to conserve and protect Steller sea lions, including avoidance of rookery and haulout sites and the no-feeding rule around boats and harbors.
7. Catch and effort statistics of state and federal commercial fisheries for Steller sea lion prey species within designated critical habitat are collected and described annually.

3. Delisting

These criteria are based upon the current estimated population abundance of 44,000 animals for the U.S. portion of the western DPS, trends in population abundance, the continued human-caused threats to the species, and natural environmental conditions and variability. When determining whether the western DPS should be delisted, NMFS will first assess whether the biological criteria have been met, and then will consider the listing factor criteria.

Biological Criteria: delisting

The western DPS of Steller sea lion will be considered for removal from the List when the likelihood of its becoming endangered in the foreseeable future has been eliminated by achieving the following biological criteria:

1. The population for the U.S. region has increased at an average annual growth rate of 3% per year for 30 years (i.e., 3 generations) based on counts of non-pups (i.e., juveniles and adults).
   Rationale: The generation time (i.e., mean age of females that give birth) for Steller sea lions is about 10 years, and the dominant natural processes within the North Pacific ecosystem that influence sea lion population dynamics operate on a decadal scale. Population growth for 30 years would reflect sustained growth by three generations of sea lions during multiple environmental regimes. Such growth provides assurance the population is recovering and not experiencing the unsustainable conditions of the past 40-50 years.

2. The population ecology and vital rates in the U.S. region are consistent with the trend observed under criterion 1. Certain vital rates are required in order to allow for long term growth. As a check on criterion 1, available information on pup counts, production (fecundity), juvenile survival rates, population age structure, gender ratios, and other observations should be examined to determine that whether they are indicative of an increasing population trend observed under criterion 1 is robust.

3. The trends in non-pups in at least 5 of the 7 sub-regions are stable or increasing, consistent with the trend observed under criterion #1. The population trend in any two adjacent sub-regions can not be declining significantly. The population trend in any

sub-region can not have declined by more than 50%. Available information on the population ecology and vital rates for the sub-regions is consistent with the respective sub-region trend. The 7 sub-regions are:

a. Eastern Gulf of Alaska (US)
b. Central Gulf of Alaska (US)
c. Western Gulf of Alaska (US)
d. Eastern Aleutian Islands (including the eastern Bering Sea) (US)
e. Central Aleutian Islands (US)
f. Western Aleutian Islands (US)
g. Russia/Asia

Listing Factor Criteria: delisting

Eliminating or controlling the threats to the western DPS of Steller sea lion is imperative prior to delisting, including all threats identified at the time of listing and any new threats identified after listing. An inclusive list of the threats to recovery is found in Section IV of the Plan. The Plan describes the lack of recovery of Steller sea lions due to changes in the environment, predation, direct takes by humans, and competition for prey resources with fisheries.

In order to delist the western DPS of Steller sea lion the following threats-based criteria should be achieved in such a way that the threats do not re-emerge. The best available information indicates that achieving the following threats criteria is necessary in order to recover Steller sea lions. Yet, it is possible that current perceived threats become insignificant in the future due to changes in the natural environment, or changes in the way that the threats affect the entire life cycle of Steller sea lions. When the biological delisting criteria are met, NMFS will evaluate and review the criteria under these listing factors to determine their relevance under the current conditions.

Factor A: The present or threatened destruction, modification, or curtailment of a species' habitat or range

Modification of the habitat of the western DPS of Steller sea lion, through both natural and anthropogenic sources, likely resulted in decreased survival and reproduction and may currently limit recovery. Reducing the threats to sea lion habitat will be accomplished through a broad application of recovery actions that protect and improve their habitat. To provide assurance that delisting is warranted for the western DPS of Steller sea lion, threats to its habitat should be reduced as specified under this factor:

1. Aquatic habitats are protected through appropriate management measures, to provide a prey base adequate to support recovered populations of Steller Sea lions. Conservation measures are based on the foraging requirements of Steller sea lions.
2. Rookery and haulout sites are adequately protected (through state, federal, or private measures) to insure the continued use of these sites for pupping, breeding, attending young, and resting. Research and monitoring plans are in place for all projects that have a high probability of negatively impacting sea lions.

Factor B: Overutilization for commercial, recreational, or educational purposes
Human caused mortality for Steller sea lions results from incidental takes in fisheries, illegal shooting, harassment from tourism related activities, and take during scientific research. To provide assurance that delisting is warranted for the western DPS of Steller sea lion, any overutilization for commercial, recreational, scientific, or educational purposes that threatens its continued existence should be reduced as specified under this factor:

1. Marine Mammal Protection Act (MMPA) enforcement is adequate to restrict illegal shooting to negligible levels.
2. A mechanism (e.g., fishery management) is and will remain in place that ensures incidental take at less than 10% of PBR (as defined under the MMPA).
3. Methods have been implemented and will remain in place to minimize the negative impacts of research.
4. Recreation fisheries, tourism, and other types of disturbance are controlled sufficiently to minimize negative impacts on recovered populations.

Factor C: Disease or predation
Throughout their range Steller sea lions are prey for killer whales. The impact of predation may be greater when sea lion abundance is reduced or when other factors increase their susceptibility to predation (e.g., reduced prey availability may increase foraging time thereby increasing vulnerability to predation). Currently, disease is considered to have a relatively minor impact on sea lions, but may present greater risks if population abundance declines further. To provide assurance that delisting is warranted for the western DPS of Steller sea lion, any disease or predation that threatens its continued existence should be reduced as specified under this factor:

1. Knowledge of the impacts of killer whale predation on sea lions is sufficient to determine that predation is not a threat to the recovered status.
2. Information is adequate to conclude that disease is not compromising the recovered status of sea lions.

Factor D: The inadequacy of existing regulatory mechanisms
To provide assurance that reclassification is warranted for the western DPS of Steller sea lion, any inadequacy of existing regulatory mechanisms that threatens its continued existence should be reduced as specified under this factor:

1. Continue to implement fisheries regulations in 50 CFR part 679, following threats criterion A.1.
2. Adequate international agreements with Russia and Japan are in place to maintain recovered status.

Factor E: Other natural or manmade factors affecting its continued existence
To provide assurance that delisting is warranted for the western DPS of Steller sea lion, several natural and man-made threats to its continued existence including subsistence harvest, pollution, and management should be reduced as specified under this factor:

1. Co-management agreements are in place with Alaska Native Organizations (ANOs) and a working relationship between the ANOs and NMFS have resulted in an accurate accounting of the subsistence harvest, and the harvest levels do not compromise recovered status.
2. Sources of toxins including offshore oil and gas development and other pollution and contaminants are known and they do not pose significant health risks to the recovered sea lion population.
3. An outreach program is established to educate the public, fishermen, and others to the continued need to conserve and protect Steller sea lions.
4. An agreement has been reached with the State of Alaska which describes their fishery management plan, minimizes the take of Steller sea lions, and describes how future actions taken by the State will comport with the ESA and MMPA.
5. Knowledge about impacts of climate change and oceanographic variable is sufficient to determine that their impacts will not likely threaten the recovered status of sea lions.
6. Adequate monitoring programs are in place to detect population changes in the future.

D. Recovery Action Outline and Narrative

The recovery actions outlined below reflect the best scientific and commercial information currently available. Estimated time and cost required, task priority and those responsible for carrying out each recovery action are identified in the Implementation Schedule (see Section V.E.).

Following the approval of the recovery plan, NMFS will work with its partners to implement this plan and monitor recovery action implementation. Recovery action 1.5 calls for the development of an implementation plan which will provide a broader and more systematic approach to the research program and other conservation actions. This plan defines the individual actions necessary for recovery but does not provide the further refinement in priorities and timeing of events necessary for an effective research program of this large scale. The effectiveness of various recovery measures will be assessed and appropriate modifications implemented to accelerate progress towards the recovery goal. While many factors can confound efforts to evaluate the effects of discrete actions on wild populations, carefully designed monitoring is key to assessing and improving the effectiveness of recovery actions. Results of this type of monitoring will be considered during biennial reviews of recovery plan implementation (under action 1.5) to assure timely adjustment of ongoing efforts and priorities. All recommended recovery actions should incorporate monitoring and evaluation to assess their effectiveness in furthering the recovery of the western DPS. The results of research tasks described below will be used to evaluate and refine other recovery actions. The response of populations to recovery measures will be used to revise research priorities.

1 BASELINE POPULATION MONITORING

1.1 Continue to estimate population trends for pups and non-pups

- 1.1.1 Estimate trends for pups and non-pups via aerial surveys
- 1.1.2 Continue to monitor population trends on Pribilof Islands (particularly the Walrus Island rookery) via aerial surveys or land-based pup counts

1.2 Estimate vital rates

- 1.2.1 Continue to estimate survival, fecundity, and immigration/emigration rates through a branding/resight program
- 1.2.2 Promote cooperative pup branding/resight programs in Russia
- 1.2.3 Develop an age-structured population model using medium format photos from aerial surveys
- 1.2.4 Develop methods and determine reproductive rates including pregnancy and parturition rates

1.3 Monitor health, body condition, and reproductive status

- 1.3.1 Examine the effects of season, age, and sex on body condition
- 1.3.2 Develop improved indices of health, body condition, and reproductive status using chemical methods (e.g., hematology serum chemistries, and endocrine monitoring)

1.4 Develop and implement live capture methods and non-lethal sampling techniques

- 1.4.1 Develop improved live capture techniques for general research needs

1.4.2 Develop improved non-lethal sampling techniques to assess health

1.5 Develop an implementation plan

2 INSURE ADEQUATE HABITAT AND RANGE FOR RECOVERY

2.1 Maintain, and modify as needed, critical habitat designations

2.2 Redefine and catalog rookery and haulout sites and ensure their protection

2.3 Estimate prey consumption and essential characteristics of marine habitat

- 2.3.1 Collect and analyze scat samples and stomach contents to determine prey consumption
- 2.3.2 Develop stable isotope and fatty acid methodologies to assess prey consumption
- 2.3.3 Deploy instruments to obtain fine scale data on sea lion foraging habitat
- 2.3.4 Evaluate all information on sea lion foraging areas and develop a description of foraging needs

2.4 Determine the environmental factors influencing sea lion foraging and survival

- 2.4.1 Assess the relationships between oceanographic profiles or features and sea lion foraging ecology
- 2.4.2 Examine the influence of ecosystem variability on non-commercial prey species as an index to sea lion carrying capacity
- 2.4.3 Distinguish how natural and anthropogenic factors influence marine ecosystem dynamics and subsequently sea lion population dynamics

2.5 Investigate sea lion bioenergetics

- 2.5.1 Determine the physiological diving capabilities and evaluate how this limits the ability to forage successfully
- 2.5.2 Determine the energetic costs to foraging sea lions
- 2.5.3 Assess the nutritional value of prey by species, season, and area including digestibility and overall value to sea lions
- 2.5.4 Develop an energetics model to investigate the interrelationships between prey availability and sea lion growth, condition, and vital rates

2.6 Assess and protect important prey resources for sea lions

- 2.6.1 Improve groundfish stock assessment surveys to determine seasonal and inter-annual patterns of prey abundance, distribution, and movement at scales relevant to sea lions
- 2.6.2 Assess competition for prey with sympatric consumers (e.g., gadids and flatfish, fur seals, harbor seals, other marine mammals, and seabirds)
- 2.6.3 Utilize groundfish fishery observer data to assess the spatial-temporal distribution of the fishery
- 2.6.4 Assess effectiveness of sea lion closure zones around rookeries and haulouts using small-scale experiments
- 2.6.5 Assess the response of sea lions to changes in prey distribution and availability
- 2.6.6 Evaluate and implement appropriate fishery regulations to protect foraging habitat and prey resources for sea lions
- 2.6.7 Explore the use of ecosystem based (multi-species) stock assessment models to set fishery catch limits to ensure adequate prey resources for a recovered sea lion population

2.6.8 Design and implement an adaptive management program for fisheries, climate change, and predation
2.6.9 Prepare a habitat conservation plan under section 10 of the ESA for fisheries authorized by the State of Alaska
2.6.10 Consider and implement conservation measures in herring and salmon fisheries in Alaska as appropriate

3 PROTECT FROM OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC, OR EDUCATIONAL PURPOSES

3.1 Minimize threat of incidental take in fisheries
3.1.1 Monitor and evaluate incidental take in commercial and recreational fisheries through observer and self-reporting programs
3.1.2 Monitor and evaluate incidental take in non-commercial fisheries

3.2 Minimize threat of intentional killing in fisheries
3.2.1 Monitor intentional take via shoreline surveys for carcasses near suspected conflict "hotspots" and by encouraging reporting of illegal shooting through NMFS's Enforcement hotline
3.2.2 Reduce threat of illegal shooting by developing and promoting use of non-lethal deterrents for commercial fisherman

3.3 Minimize frequency and severity of sea lion-human interactions in ports and harbors
3.3.1 Develop and promote non-lethal means of deterring sea lions from hauling out on docks
3.3.2 Continue to publicize "No feeding" regulations in harbor areas and keep active programs for notification and enforcement

3.4 Minimize take by recreational and commercial viewing operations
3.4.1 Publicize and enforce existing no-transit areas to minimize vessel and aircraft disturbance of rookery sites
3.4.2 Review and revise existing Marine Mammal Approach Guidelines and provide to charter operators and other mariners to minimize disturbance at haulouts

3.5 Evaluate and reduce the direct and indirect impacts of research activities
3.5.1 Coordinate research efforts to reduce potential for unnecessary or duplicative research-related takes
3.5.2 Monitor and minimize unintentional takes associated with research activities

4 PROTECT FROM DISEASES, CONTAMINANTS, AND PREDATION

4.1 Protect Steller sea lions from disease
4.1.1 Conduct epidemiological surveys
4.1.2 Develop and implement methods for parasite evaluations
4.1.3 Develop and implement methods to test immune system functioning
4.1.4 Evaluate causes of mortality by examining dead and live animals of all age and sex classes for disease from various sources across the geographic range and in all seasons
4.1.5 Develop disease management plans

4.1.6 Develop an unusual mortality event (UME) management plan
4.1.7 Develop models to simulate disease impacts based on energetics, physiology abundance and demographics.

4.2 Protect sea lions from contaminants

4.2.1 Design a contaminant research and management plan
4.2.2 Collect samples from free-ranging sea lions and in environmental 'hotspots'
4.2.3 Examine blood and tissue samples for evidence of contaminant-linked endocrine effects including free-ranging and captive work
4.2.4 Develop models to simulate contaminant impacts and effects based on energetics, physiology, abundance and demographics

4.3 Predation

4.3.1 Understand predator life histories, biology and ecology – captive work
4.3.2 Determine killer whale diets
4.3.3 Develop methods to obtain samples from live killer whales
4.3.4 Expand the stranding network to increase samples of killer whales available for research
4.3.5 Determine killer whale distribution and behavior across the North Pacific
4.3.6 Estimate numbers of killer whale ecotypes in time and space
4.3.7 Develop models to simulate predation rates based on killer whale energetics and abundance of Steller sea lion demographics

5 PROTECT FROM OTHER NATURAL OR MANMADE FACTORS AND ADMINISTER THE RECOVERY PROGRAM

5.1 Reduce damage to sea lions and their habitat from discharges of pollutants by developing preventive measures

5.2 Reduce the potential for sea lion entanglement by improving and continuing programs aimed at reducing marine debris

5.2.1 Reduce discards of debris (e.g., trawl web and packing bands)
5.2.2 Cleanup derelict gear and beached debris

5.3 Monitor causes of sea lion mortality and use data to direct management actions

5.3.1 Continue and expand the Alaska stranding network to increase coastal coverage and community involvement in monitoring sea lion mortality
5.3.2 Survey selected areas for stranded animals
5.3.3 Expand tissue sampling efforts to improve the information obtained from dead sea lions
5.3.4 Monitor the incidence and impact of entanglement in marine debris

5.4 Effectively administer the Steller sea lion recovery program by continuing to provide a recovery coordinator staff position

5.5 Improve sea lion conservation by consulting with the State of Alaska on actions that are likely to adversely impact Steller sea lions

5.6 Conduct an effective outreach program to inform the public about Steller sea lion biology, habitat utilization, and conservation issues

5.6.1 Encourage and facilitate public reporting of sea lion observations
5.6.2 Publicize current conservation efforts and protective measures.

5.7 Co-manage Steller sea lion subsistence harvests in Alaska by developing co-management agreements as appropriate with Alaska tribes and tribally authorized Alaska Native Organizations (ANO)

- 5.7.1 Manage subsistence harvests and evaluate the efficacy and accuracy of using retrospective subsistence harvest surveys
- 5.7.2 Support Alaska Native subsistence use information programs
- 5.7.3 Analyze carcasses from subsistence harvest to assess age, body condition, and other relevant information to ensure safety of carcasses for human consumption
- 5.7.4 Document local knowledge and cultural science (Traditional Ecological Knowledge, TEK) pertaining to sea lions to better understand changes in sea lion movement (local and seasonal), feeding patterns and prey, seasonal haulouts, predation and ecosystem dynamics

5.8 Improve the effectiveness of research for Steller sea lion recovery by instituting a "fast track" process for expediting NMFS research permits for Steller sea lions.

1 Baseline population monitoring

Baseline population monitoring is necessary to support all of the recovery actions. These actions describe the status and trends of the western DPS of Steller sea lions, their vital rates, and the health and body condition of individuals.

1.1 Continue to estimate population trends for pups and non-pups

1.1.1 Estimate trends for pups and non-pups via aerial surveys

Conduct aerial surveys for pups and non-pups biennially at trend sites, and at least every 4 years at all rookeries and haul outs in the western DPS. Surveys using aerial photography have been conducted biennially since 1994. Medium format photogrammetry began in 2002 and this change now allows for counting pups as well as non-pups. Continue aerial surveys for pups and non-pups, population size and trend using medium format photography. Information from trend sites forms the basis of the stock assessment reports.

1.1.2 Continue to monitor population trends on Pribilof Islands (particularly the Walrus Island rookery) via aerial surveys or land-based pup counts

Population numbers have declined dramatically on the Pribilof Islands and only one rookery remains on Walrus Island. This area is not part of the usual aerial survey route or trend sites but on occasion can be included in the flight plan. In addition, researchers can access Walrus island by small boat.

1.2 Estimate vital rates

1.2.1 Continue to estimate survival, fecundity, and immigration/emigration rates through a branding/resight program

The current branding/resighting program should be continued. Additional branding at rookeries in the central and western Aleutian Islands would be valuable, but the logistics and costs, particularly of an adequate resighting effort, may make this impractical. The disruptive nature of branding young pups on rookeries and the probability of causing some low level of mortality are recognized. However, the importance of obtaining estimates of vital rates and the lack of alternative methods of obtaining these estimates justify this activity. Less invasive methods of marking should be investigated if new technology becomes available. Annual resighting surveys should be conducted even if branding is reduced in frequency. Resighting surveys should be coordinated among all research groups conducting work and a central database created.

In addition to estimating vital rates, both the handling of pups at branding and the resighting of branded individuals present the opportunity for collection of data on growth, condition, health status, genetics, weaning status, range of movements, attainment of sexual maturity, individual variations in terrestrial site use, diet and many other aspects of natural history. Tissue samples for genetic work should be collected from all handled pups and blood samples for archiving and health and condition studies should be collected whenever possible. This work should be promoted for all Russian branded sea lions as well. In addition, protocols should be distributed that direct the sample collection from stranded animals, subsistence-harvested, and fishery by-catch. Data should be recorded and managed in a manner that these ancillary products can be obtained.

1.2.2 Promote cooperative pup branding/resight programs in Russia

The distribution of Steller sea lions in the North Pacific and Bering Seas extends beyond international boundaries, and previous branding work has shown that sea lions move in both directions. Therefore, any investigation of sea lion population trends in the U.S., especially the western Aleutian Islands, should incorporate information on what is known of the population trends and life history studies of sea lions in Russia.

1.2.3 Develop an age-structured population model using medium format photos from aerial surveys

The classification of sex and age classes from the medium-format photographic surveys provides an opportunity to examine patterns of fecundity and recruitment, important in understanding the dynamics of the population. If past 35mm photos are found to provide similar opportunities, a retrospective analysis of population age structure may be possible.

1.2.4 Develop methods and determine reproductive rates including pregnancy and parturition rates

The use of tissue samples collected from feces or from the tissue of a pup to indicate the pregnancy status of its nursing mother should be validated. If appropriate protocols can be established, this may provide a rapid and sensitive indicator of changing environmental conditions. Likewise, any sensor technology, including ultrasonography that may assist in developing the methodology to determine pregnancy status or parturition rates should be investigated.

1.3 Monitor health, body condition, and reproductive status

1.3.1 Examine the effects of season, age, and sex on body condition

Seasonal environmental changes result in fluctuations in available prey resources and energetic demands for Steller sea lions. In the last few years sampling of sea lions during autumn, winter and spring has increased. Sampling at these times provides access to different age classes, and during periods when foraging ranges for older juveniles and adults are greatest. This sampling across seasons and age classes should be continued and expanded to include areas in the central and western Aleutian Islands, and western Gulf of Alaska. Sample collections should be coordinated with groups capturing Steller sea lions.

For various age classes, differences in the rate of growth, specific caloric demands, and foraging (diving) capabilities will alter nutritional needs of Steller sea lions. Consequently, we have learned that different stages in life history may be more susceptible than others to the effects of nutritional limitation, exposure to diseases, or pollutants. Sampling and monitoring schemes for Steller sea lions should be expanded to include all age classes across seasons in order to determine the relative vulnerability of pups, juveniles, and adult male and females at different stages in the reproductive cycle.

1.3.2 Develop improved indices of health, body condition, and reproductive status using chemical methods (e.g., hematology serum chemistries, and endocrine monitoring)

To date most studies of wild Steller sea lions have focused on "snapshots" in the lifecycle rather than long-term monitoring of individuals. Longitudinal monitoring that recaptures individuals at several points throughout their life is needed to understand the relationships between

condition indices, true condition, and how indices ultimately reflect growth, metabolism, reproductive output, and survival.

A suite of hematological parameters may provide insight into the general health of an animal as well as exposure to disease or contaminants. Blood sampling schemes should include multiple seasons and age classes (1.3.1) to provide insight into changes in health and condition over seasons and ages. New blood parameters (i.e. stress proteins) and the relationship between parameters in blood panels should be investigated. For sampling on summer rookeries, health and condition data should be evaluated to develop a monitoring plan to detect interannual or regional changes in health or condition among pups, juveniles and adults. Captive sea lions may be used to enhance these efforts, and to test or validate new assays or techniques that may give better insight into health and body condition.

Endocrine studies should be used to monitor reproductive status and condition. Circulating or excreted concentrations of hormones can provide information on the reproductive health of individuals. By expanding sampling of blood, urine, feces, and saliva across seasons and age classes, opportunities will be improved to describe sea lion reproductive status and health among more age classes. If endocrine levels can be related to concentrations found in feces, urine, saliva or other less invasive samples then broad-scale collections may become useful for population monitoring. Continued work with captive sea lions may provide baseline data for these types of studies. The potential to relate endocrine function with contaminants, environmental conditions, immune function and behavior should be investigated.

1.4 Develop and implement live capture methods and non-lethal sampling techniques

1.4.1 Develop improved live capture techniques for general research needs

A great deal of work has been done on techniques for capturing and immobilizing marine mammals. Techniques such as dive captures, floating trap captures, and land captures, as well as chemical immobilization, have been developed in the last decade. However, there is a possibility of an accidental sea lion mortality even with the best methods currently available, so efforts to improve techniques should be continued. Current capture methods have been extremely successful in capturing young animals but largely ineffective at capturing the older ages or larger animals. Thus, a critical gap in understanding sea lion foraging behavior has developed and alternative methods should be explored to safely and effectively capture older animals. Two potential methods include the use of floating structures and large nets to capture sea lions. The most important areas to access include the Aleutian Islands which has proven to be a difficult place to use these alternative techniques due to poor weather conditions and difficult terrain.

Special studies need not be conducted for the specific purpose of improving such techniques. Most of the development and evaluation of new techniques should be possible during research conducted for other purposes. Careful monitoring and documenting of vital signs of animals under anesthesia and their responses to anesthesia are needed to regularly reassess and evaluate current methods and for comparison to new methods as they become available. Likewise, thorough disease screening and quarantine protocols should be used for animals being brought into captivity and upon release back into the wild

1.4.2 Develop improved non-lethal sampling techniques to assess health

Non-lethal sampling is used to monitor health, disease, body condition and other vital parameters in Steller sea lions. Some techniques such as chemical immobilization may pose a risk of mortality. However, the potential impact of this technique has not been borne in the studies that have used chemical immobilization in pinnipeds, particularly otariids. This potential impact does not appear to exceed the benefit to the species from knowledge gained at this time. The large size of Steller sea lions, which makes them difficult to work on otherwise, and improved quality of data obtained from anesthetized animals warrants continuing to use these methods and validates the use of new chemical immobilizing agents for future studies.

A variety of studies require temporary restraint of animals and this includes those focused on disease and contaminant research. Relatively non-invasive sampling techniques can be used for disease surveys, such as the collection of blood samples, swabs of body fluids (oral, nasal, rectal, vaginal or preputial, or tracheal), and feces and urine. Additionally, biopsies of lesions can be collected when present. Samples should be collected from the relatively few Steller sea lions maintained in captivity, for comparison and longitudinal sampling with free- ranging sea lions, when possible.

1.5 Develop an implementation plan

An implementation plan should be developed that includes a comprehensive ecological and conceptual framework that integrates and further prioritizes the numerous recovery actions provided in this plan. The implantation plan should provide a synthesis of the individual actions, and coordinates their implementation in a cohesive strategy (Section V.B). Clearly lacking in this plan is a finer scale analysis of priorities, a synthesis of how the actions should be implemented and in what order, and which actions are more important to the scientific process of understanding the decline of the western DPS of Steller sea lion.

The conceptual framework of the implementation plan must integrate several components: (1) the complex dynamics of the North Pacific marine ecosystem, (2) multiple causation in those systems, (3) the need for long-term research, (4) the monitoring required to assess the effectiveness of management regulations, and (5) the development of a modeling approach that examines possibly effects of multiple threats on sea lion population dynamics to evaluate the strength of the evidence for different hypotheses. This framework will establish priorities among the multitude of recovery actions, distinguishing between those actions that will provide the information key to promoting recovery versus expanding the knowledge of sea lion biology and ecology. For example, to provide insights on those factors limiting recovery, physiological and behavioral indices must be directly associated with a mechanism that can be quantified in changes in survival or reproduction. Focusing the top priorities on actions that will promote recovery should also ensure that the new information gained will assist the consultation process under the ESA.

2 Insure adequate habitat and range for recovery

2.1 Maintain, and modify as needed, critical habitat designations

Critical habitat for Steller sea lions is currently designated at 50 CFR 226.202, and includes both terrestrial and marine habitat. Marine foraging areas were designated based on sea lion distribution and abundance, ship-based observations, movements and dive behavior derived from satellite telemetry, historical records of regional sea lion concentration, and distribution of

primary prey species. Terrestrial rookery and haulout sites were designated from historic counts of sea lions on land.

Since designation in 1993, critical habitat has been an essential component of Steller sea lion conservation and appears to have generally been effective. However, new information on the foraging ecology of Steller sea lions, potential changes in habitat use, and the application of new technology has revealed areas for enhancement. For example, improvement in satellite mapping technology has allowed greater accuracy in determining the locations of rookery and haulout sites. Some technical errors have been discovered which should be fixed. As population abundance declined, the distribution of sea lions among haulout and rookery sites has changed substantially. These considerations should be taken into account when considering an update to critical habitat.

A revised critical habitat designation should also consider spatial and temporal variation of essential habitat characteristics. Specifically, in addition to stationary habitat features such as bathymetry and the continental shelf, dynamic features such as seasonal distribution and abundance of prey, and the oceanographic features and parameters that influence those prey species should be considered. More refined information on sea lion foraging ecology and seasonal movement patterns may be obtained through advanced telemetry equipment. Further, advances in the statistical analysis of such data should be applied to those data when the designation of critical habitat is revised. In summary, critical habitat designations should be revisited in the next 5 years, yet current designations are sufficient to promote recovery in the short term.

2.2 Redefine and catalog rookery and haulout sites and ensure their protection

Most rookery and haulout sites are adequately protected, yet new threats (e.g., oil and gas development) may subject some sites to additional risk. A catalog of current and historical rookeries and haulouts, their locations, and range of numbers counted at each site should be compiled. Communication channels between NMFS and the land managers of all rookeries and major haulouts should be formalized to ensure that land managers are aware of all applicable protection measures and that NMFS is notified of any potential action that could affect habitat quality.

2.3 Estimate prey consumption and essential characteristics of marine habitat

2.3.1 Collect and analyze scat samples and stomach contents to determine prey consumption

Scat analysis has been used as a relatively inexpensive and non-invasive technique to estimate spatial and temporal trends in sea lion diet since the late 1980s. Currently, scats are the only technique available for estimating size and age of prey species consumed. However, several known biases exist in scat analysis, primarily related to the digestion-resistance and differential rates of digestion of some hard parts, which has lead to the development of alternative methods to understanding diet in marine mammals (see 2.3.2). In order to estimate long-term trends in diet, in part to assist in the evaluation of the impacts of environmental change and management actions, scat samples should continue to be collected, especially in conjunction with other research activities that require disturbing rookeries and haulouts. Identification and analytical methods should be standardized among researchers so data are directly comparable. Methods

to calibrate results to accurately reflect the quantity and composition of prey consumed should be further developed to minimize. Likewise, stomach contents from subsistence-harvested animals should also be collected when possible, and stomach samples should be used to help validate diet estimates from scat collections.

2.3.2 Develop stable isotope and fatty acid methodologies to assess prey consumption

Scat analyses provide limited data about the amount and type of prey consumed, and the age-specific diet of sea lions cannot be determined from scats. Indirect methods such as the analysis of stable isotopes and fatty acid (FA) signatures may be useful in determining the diet of sea lions, at both the individual and population level, and thus should be further developed and applied.

The FA profile represents an integration of a sea lion's diet over several weeks to months and represents all species eaten. Further, when adequate data are available on the FA composition of the predator's potential prey species, quantitative estimation of diet is possible. In the absence of prey FA information, FA profiles of a predator can detect dietary changes and differences between demographic groups. In addition, because tissue samples are collected directly from an individual sea lion, relationships between phenotypic and demographic characteristics of the animal can be tested. Fatty acids have been successfully used to describe regional and age-related differences in fatty acid profiles, and research is currently underway to develop appropriate statistical models to use this data to quantitatively estimate diet composition.

An additional approach to the evaluation of diet in marine mammals is the use of stable isotopes of carbon and nitrogen to evaluate the trophic level of the diet. Specifically, nitrogen isotope ratios change with trophic level in a predictable manner through a step-wise enrichment within marine food webs. In contrast, carbon isotope ratios are more influenced by geographic location of feeding, and may distinguish inshore versus offshore foraging locations. The isotopic measurement of several tissues from the same individual can provide short-, intermediate-, and long-term dietary information depending upon their rates of metabolic activity. Serum and milk provide a short-term integrated diet signature, whereas relatively metabolically inactive tissues such as whiskers can provide a longer-term integration of the isotopic signature for the period of growth of that tissue.

2.3.3 Deploy instruments to obtain fine scale data on sea lion foraging habitat

A vast amount of data on the movements and diving and haulout behavior of sea lions has been obtained through the use of a variety of telemetry instruments, which forms the basis for the current understanding of sea lion foraging ecology and the essential characteristics of sea lion foraging habitat. Information gained in recent years has been primarily from pups (young of the year) and juveniles, many of which were still nursing and thus not foraging 100% on their own. This information was described in detail, including the important caveats and potential problems with using the data to describe foraging habitat, in NMFS (2001 and 2003) from which current fishery conservation measures were developed. However, information is limited on the foraging characteristics of older juveniles (ages 2-4) and adult females from most geographic areas. Because, in general, juveniles (ages 1-4) tend to travel further offshore, make longer foraging trips, and dive deeper than pups, future tagging efforts should focus on juveniles and adult females. These animals are more susceptible to most threats impeding recovery, and thus

information on their foraging ecology and habitat use is essential, and that information should be used when fishery conservation measures are revised.

The precision of most dive behavior and location data obtained from nearly all telemetry studies to date has been relatively poor due to instrument limitations, and subsequently accurate information on the locations and depths where sea lions actually consume prey has not been determined. Technological advances integrated in new telemetry instruments may now permit the acquisition of more precise and accurate data on dive patterns, dive depths, and foraging locations. Useful technologies include GPS, stomach temperature telemetry in conjunction with satellite-linked time-depth recorders, and sonar tracking of sea lions. Further, reliable remote release devices or dependable recapture methods may allow the use of more sophisticated satellite telemetry or other devices to obtain finer scale movement and dive data.

2.3.4 Evaluate all information on sea lion foraging areas and develop a description of foraging needs

Data obtained from telemetry studies requires substantial processing and database management prior to conducting statistical analyses. Such data management needs to be completed promptly and in a manner that will allow the integration of databases generated by different researchers and projects. Recently developed advanced analytical and statistical techniques should be applied, as appropriate, to obtain the most informative results pertaining to foraging ecology and habitat use, at the individual and population level, to further understand the potential impact of those threats that result in a reduction of prey biomass and quality. Available telemetry data should be collected from all agencies and research organizations and synthesized into one database, enabling a more complete description of sea lion foraging ecology and habitat preferences.

2.4 Determine the environmental factors influencing sea lion foraging and survival

The dynamics of the North Pacific marine ecosystem influences the biology and ecology of sea lions, and thus has implications for sea lion recovery. Knowledge of the spatial and temporal patterns of the marine ecosystem is limited, as is the understanding of the factors that influence those patterns. Thus, integrated studies at the ecosystem and community ecology level are needed to better assess how sea lion population dynamics and their carrying capacity are influenced by ecosystem variability, and to determine how natural and anthropogenic factors may affect that variability.

2.4.1 Assess the relationships between oceanographic profiles or features and sea lion foraging ecology

Recent studies using satellite and radio telemetry suggest that otariid may cue on various oceanographic features (e.g., eddies and currents) to locate prey and to navigate in the open ocean. Oceanographic features are also critical to prey life stages and likely influence both fish stock recruitment, fish distribution, and abundance. There is a growing recognition of the need to integrate existing and future physical and biological oceanographic data into upper trophic level predator/prey studies and to determine the features that influence the distributions of both predator and prey. Such integration may allow predictions of how environmental perturbations influence upper trophic level predators.

Within the next 2-5 years, review studies should be conducted to integrate data collected on similar spatial and temporal scales by physical and biological oceanographers and sea lion biologists. Specific ecological data on sea lions should include age- and sex-specific foraging behavior, reproductive status, and energetic demands. These integrative efforts should determine if available data permits enhanced understanding of the physical forces that influence sea lion prey distribution, foraging decisions, and subsequently health and condition.

2.4.2 Examine the influence of ecosystem variability on non-commercial prey species as an index to sea lion carrying capacity

Some non-commercial fish species, 'forage fish' in particular, may play an important seasonal role in the diet, condition, and population dynamics of sea lions in some regions. Information on the seasonal and annual distribution and abundance of these fish species is very limited because they are not included in assessment studies of commercial species. Understanding how changing environmental conditions affect the distribution and abundance of these species, and subsequently the foraging ecology of sea lions, may be used to project how sea lion health and condition, and ultimately population growth, will be effected under different environmental conditions.

Thus, currently available data should be combined with new studies to improve the understanding of how the distribution and abundance of these important prey species is influenced by environmental variability. Existing NMFS and ADF&G trawl data will provide some guidance on whether current assessment methodology is effective for these species, or if sampling techniques need to be modified. Subsequently, periodic long-term assessment programs should be implemented to provide adequate baseline and monitoring data.

2.4.3 Distinguish how natural and anthropogenic factors influence marine ecosystem dynamics and subsequently sea lion population dynamics

The distribution and abundance of marine mammal populations are influenced by changes within their marine environment, yet the understanding of the factors and mechanisms that drive those changes is quite limited. Further, distinguishing between changes from natural versus anthropogenic factors is needed to determine the feasibility and efficacy of management strategies. Certainly, natural ecosystem dynamics are complex and will confound efforts to assess anthropogenic effects. Integrated ecosystem studies (e.g., FOCI, BEST) need to be continued and expanded to obtain baseline information on the factors that most influence ecosystem components and processes. Such information should improve the understanding of the primary ecosystem characteristics that most influence sea lion prey distribution and distribution, and subsequently sea lion foraging and population dynamics. Adaptive management experiments (see 2.6.8) can be designed to examine more specific ecosystem and sea lion attributes and parameters.

Integrative modeling and field studies that link physical and biological oceanography with sea lion foraging and physiology need to be conducted. Expansion of ongoing ecosystem modeling studies (e.g., Ecosym, Ecopath) should occur prior to initiation of new field studies to help guide those studies and to determine where data deficiencies and biological links occur. Field studies then need to be conducted in all seasons and in areas of declining and increasing Steller sea lion populations. These studies should be conducted in association with existing or planned

cohesive sea lion prey studies (e.g., those in the Kodiak area and the Shumagin Islands regions) to take advantage of the synergistic benefits of linking related research programs.

2.5 Investigate sea lion bioenergetics

2.5.1 Determine the physiological diving capabilities and evaluate how this limits the ability to forage successfully

The ability of sea lions to exploit various prey resources in an energetically efficient manner is limited by their diving ability. This will almost certainly vary with age, gender, and reproductive status; e.g. a female with a young pup will be limited in the distance she can travel from the rookery in search of food. Adult male and female sea lions have different strategies for storage and utilization of energy and thus may differ in their ability to thrive under differing environmental conditions that affect availability of prey.

2.5.2 Determine the energetic costs to foraging sea lions

The energetic costs of foraging have not been adequately determined for either sex or for any age group or for different life history events such as reproduction and molting and will vary depending on the availability of prey in both a spatial and temporal scale. If prey are difficult to locate and capture, more energy will be required; if that expenditure exceeds available body stores the animal's homeostasis is disrupted, especially for young animals that do not have sufficient energy stores for prolonged periods of fasting. It has been postulated that young sea lions may be energetically stressed while feeding during winter storm periods if adequate prey are not easily available in a reasonable time period. The result of this postulated stress is reduced overall fitness and higher susceptibility to predation, disease, or other factors increasing mortality.

Methods to measure energetic costs and the physiological diving capabilities of foraging pinnipeds have been tested on sea lions during pilot studies, yet thorough studies have not been conducted. Capture and holding techniques have been developed, and a research program should be implemented that reviews past studies, incorporates modifications of methods previously used, and includes seasonal sampling of both sexes and all age groups from both captive and free ranging sea lions.

2.5.3 Assess the nutritional value of prey by species, season, and area including digestibility and overall value to sea lions

The nutritional value of a particular prey type can be viewed as the net energy obtained by its capture and assimilation. An assessment of net nutritional values requires the integration of all costs associated with foraging combined with information on the quality and quantity of prey consumed during a foraging trip, and subsequently digested and assimilated. The energy density of sea lion prey species varies widely spatially and temporally. Information on the energy density for some sea lion prey species is available, yet additional data is needed for a more comprehensive understanding among prey species across regions and seasons. Such information will increase the understanding of the relative nutritional value of sea lion prey, which in turn will improve efforts to model the bioenergetics of sea lion foraging and food requirements.

2.5.4 Develop an energetics model to investigate the interrelationships between prey availability and sea lion growth, condition, and vital rates

Energetics data should be integrated with population status and vital statistics data to develop a foraging model that can be used to test the relationship between prey availability and population growth rate. This analysis will likely require improved knowledge of the specific energetic requirements of sea lions during different life stages including periods of rapid growth, pregnancy and lactation. The effects of seasonal changes in available prey resources, population composition, and spatial relationships should be included in the models. Specific questions to be addressed include the effects of 1) reproductive status on local foraging requirements, 2) potential competition for specific prey with fisheries, and 3) changes in population size on overall prey requirements.

Simulations can also be used to evaluate disease and contaminant impacts on energetics, physiology, abundance, and demographics. A growing need exists to integrate the biological data with population-scale dynamics.

2.6 Assess and protect important prey resources for sea lions

For the endangered Steller sea lion population to recover, prey availability must be adequate to support a growing population. An adequate level of prey includes the energetic cost of obtaining prey, such that the energy expended in capturing prey does not exceed the energy gained. Because the most important feature of marine sea lion habitat is the prey base, measures must be taken to ensure that prey abundance is adequate to support a growing population. All of the tasks under this section are related to Listing Factor A, which addresses the present or threatened destruction, modification, or curtailment of its habitat or range. These tasks also relate to Listing Factor D, which addresses the adequacy or inadequacy of existing regulatory mechanisms.

Threats related to reduced prey availability and food limitation may include reductions of the prey base or changes in its distribution due to fishing, natural environmental fluctuations in prey biomass or changes in its distribution, and competition from other predators in the ecosystem. Currently, it is not possible to determine the relative contribution of these factors, but fishing is the only factor over which humans have direct control. Existing fishery regulations must be monitored and evaluated on a regular, ongoing basis in order to determine their impact on sea lion foraging areas and prey availability, and additional regulations should be adopted as necessary to ensure that sea lion food supplies are adequate to support a recovered population. Moreover, the ability to distinguish between fishing and non-fishing effects on sea lion prey availability will require an experimental framework of treatment and control areas in which fishing is permitted or prohibited so that researchers can more readily distinguish the relative impacts of fishing and non-fishing threats to sea lion prey availability.

2.6.1 Improve groundfish stock assessment surveys to determine seasonal and inter-annual patterns of prey abundance, distribution, and movement at scales relevant to sea lions

Currently NMFS conducts regular (annual or biennial) groundfish surveys, which provide limited information on abundance, distribution, and movements over broad areas. However, the groundfish surveys are not designed to provide information at the spatial and temporal scales relevant to foraging sea lions. Lack of precise information on the distribution of fish stock biomass at both small and large spatial-temporal scales is a major impediment to quantifying the impact of commercial fisheries on sea lion prey and foraging success. Fish survey information is lacking for most areas outside the summer season, and the surveys are not

intended to provide estimates of prey biomass in specific locales within sea lion critical habitat. New surveys should be designed and conducted to determine the abundance, distribution and movement of fish at smaller temporal and spatial scales than done currently, and throughout the year.

2.6.2 Assess competition for prey with sympatric consumers (e.g., gadids and flatfish, fur seals, harbor seals, other marine mammals, and seabirds)

Food habits data has been collected in the North Pacific region and analyzed over many years, notably for species such as the northern fur seal and more recently for sea lions. Data have also been collected for seals, cetaceans, major seabird species, and some fish species. In addition, the fishery observer database provides information on the distribution of catch inside and outside of sea lion foraging areas, as well as estimates of the composition and weight of the catch by species. Including these data in ecosystem food web models should be continued in order to evaluate the potential effects of fisheries removals of other species (e.g., cod or halibut) which may compete directly or indirectly with sea lions for common prey (e.g., pollock).

Food web models can provide valuable insights into potential food web dynamics and identify information gaps for future research, and as such they are useful tools for assessing the potential competitive linkages between Steller sea lions and other consumers in the ecosystem. However, these models are not substitutes for gathering more diet and food habits data. Much of the food habits data collected prior to the 1990s was gathered opportunistically and provides limited insights, yet this information is driving the ecosystem models in use today. Thus there is a need for more and better food habits data and analyses to understand more fully the potential impacts of interspecific competition within the ecosystem. Fishery observers should be tasked with collecting stomach samples from target and incidental catch species to improve the data used in ecosystem food web models. In addition, marine mammal biologists should also continue to collect food habits information either directly (e.g., scat) or indirectly (e.g., biopsy for fatty acid and stable isotope analyses).

2.6.3 Utilize groundfish fishery observer data to assess the spatial-temporal distribution of the fishery

Commercial groundfish fisheries can have significant short and long term effects on prey availability for sea lions, including depletion of the target species in the immediate vicinity of the fished area. The fishery observer database provides valuable information on the distribution of fishing effort inside and outside of critical habitat as well as a description of the amount of fish harvested and the method employed. NMFS has utilized this database extensively in the past to document trends and patterns of fishing within sea lion critical habitat and to evaluate the performance of fisheries regulations. NMFS should continue to compile and update this information on a regular basis in order to evaluate the performance of fisheries regulations and to identify potential concerns. Data on catch in critical habitat (e.g., zones such as 0-10 nm, 10-20 nm, critical habitat foraging areas) should be provided as part of the NMFS's Office of Sustainable Fisheries' catch accounting responsibilities.

2.6.4 Assess effectiveness of sea lion closure zones around rookeries and haulouts using small-scale experiments

Small-scale research experiments have been undertaken by NMFS to evaluate whether fishing has the potential to impact sea lion prey resources within critical habitat and whether subsequent closure zones are effective in mitigating potential effects. Preliminary field

experiments have been conducted for pollock, Pacific cod, and Atka mackerel fisheries with mixed results. Some of these efforts should be continued or modified as described below.

For pollock, at least one more year of a field experiment off Kodiak Island in the GOA is needed in order to reach an initial conclusion about the effects of fishing on pollock in this area. Of the two years during which there were sufficient commercial removals, one year showed a pollock response to fishing and one year did not. Field work beyond this minimal additional year is also needed to understand the observed interannual variability in the fishery response.

For Pacific cod, three years of field experimentation off Cape Sarichef in the EBS showed no statistically significant fishery effect. One conclusion is that fish movement through the study area displaced or dispersed a fishery effect. Some of that movement may be linked to spawning behavior. In order to understand the space and time scales that fisheries can impact a fish like Pacific cod, further study is needed to understand their movement patterns and spawning behavior. Movement could be studied through tagging and spawning through the collection of maturity data (primarily through the fishery observer program).

For Atka mackerel, the tag release-recovery studies in the eastern and central Aleutians (Seguam and Tanaga areas) showed high Atka mackerel biomass and low movement across trawl exclusion zone boundaries. These are conditions that would maintain localized quantities of forage for sea lions. However, further west, at Amchitka, tagging data shows much lower biomass and high movement rates across trawl exclusion zone boundaries. In this area, fisheries have a greater potential to impact local abundance of Atka mackerel. This is of concern because pup counts are still showing declines in the western Aleutians (compared to increases in nearly all other areas). Further tag release and recovery work needs to be done in the western Aleutians to determine whether there are regional scale differences in Atka mackerel abundance and local movement patterns.

2.6.5 Assess the response of sea lions to changes in prey distribution and availability

Efforts to protect Steller sea lion prey within critical foraging areas will be enhanced by an improved understanding of how sea lions use that habitat and how they respond to changes in the prey field. This entails further deployments of telemetry tracking instruments on sea lions (2.3.3), as well as improved assessments of prey biomass within critical foraging areas (2.6.1) and continued monitoring and documentation of fishery operations within these areas (2.6.3 and 2.6.4). Further efforts should be made to integrate these activities so that changes in the prey field are monitored and manipulated at the same time Steller sea lions are observed to determine if there are any changes in foraging activity or body condition.

2.6.6 Evaluate and implement appropriate fishery regulations to protect foraging habitat and prey resources for sea lions

In the late 1990s and early 2000s NMFS reviewed federally managed groundfish fisheries in a series of consultations under section 7 of the ESA. Two of those consultations resulted in a determination that these commercial fisheries were likely to jeopardize the continued existence of the western DPS of Steller sea lion and adversely modify its critical habitat. Therefore, as required under the ESA, additional conservation measures were implemented to avoid jeopardy and adverse modification. The expectation was that these measures would promote

the recovery of Steller sea lions in areas where potential competition from commercial fisheries may have contributed to the population decline.

The increase in Steller sea lion numbers in the early 2000's corresponds to implementation of a suite of fishery conservation measures. Such conservation measures should be maintained until it can be positively determined that reducing those protections for Steller sea lions would not reduce the likelihood for or increase the time to recovery. This includes protections developed to 1) avoid disturbance and competition around rookeries and major haulouts, 2) avoid competition during the early winter season , 3) disperse the fisheries spatially, and 4) disperse the fisheries temporally. New information on the foraging needs of juvenile and adult female sea lions should be integrated into these conservation measures at regular intervals such that they are successful in protecting the important and potentially vulnerable components of the sea lion population.

Fishery management policies and plans must take into account the types and amounts of food needed to support a recovering sea lion population. Sea lion food requirements should be explicitly accounted for in setting acceptable biological catches of groundfish, and the methods used in these calculations should be described.

2.6.7 Explore the use of ecosystem based (multi-species) stock assessment models to set fishery catch limits to ensure adequate prey resources for a recovered sea lion population

Although NMFS supports the development of ecosystem-based stock assessments, all Alaska groundfish stock assessments are based on single species methodologies that do not explicitly consider other consumers in the ecosystem. NMFS should ensure that fisheries for important sea lion prey (e.g., Pacific cod, pollock, Atka mackerel) are not limiting recovery of sea lion populations by exploring ways to explicitly account for the needs of Steller sea lions or other consumers in the ecosystem.

2.6.8 Design and implement an adaptive management program for fisheries, climate change, and predation

The mechanisms by which different threats affect sea lions can be similar, as are the responses that sea lions exhibit to these different threats. This represents a fundamental difficulty in identifying which threats are impeding recovery and which mitigation measures would be effective. A properly designed and implemented adaptive management program is needed to assess the relative impact of fisheries, climate change, and predation (Bowen *et al.* 2001, NRC 2003). This program will require a robust experimental design with replication at the proper temporal and spatial scales, and significant amounts of commercial fishing such that an effect (if it exists) could be detected. Given signs of a recovery in the western DPS, it is important to take this opportunity to implement an adaptive management program to test the underlying hypotheses of the conservation measures. With an increasing population, NMFS will have more latitude under the ESA and MMPA to implement a fisheries program which might result in more take of sea lions in order to attain valuable information about the efficacy of conservation measures and the relative contribution of climate change and predation as threats to recovery.

As noted by Bowen *et al.* (2001), field experiments in the open ocean at this spatial scale have not been attempted before, and any experiment must be carefully designed to address a host of difficult issues regarding the size and numbers of experimental units, the length of time to run the experiment, the response variables to be measured, the means of detecting change in those variables, and the likelihood of distinguishing between fishing and natural factors. Coordination among agencies and organizations involved in the development and design of such an experiment should be provided by the Steller sea lion Recovery Plan Coordinator.

2.6.9 Prepare a habitat conservation plan under section 10 of the ESA for fisheries authorized by the State of Alaska

Near shore fisheries authorized by the State of Alaska interact with Steller sea lions and are likely to result in adverse effects including both sub-lethal and lethal takes. These fisheries (e.g., salmon, herring, and groundfish) are not currently authorized to take Steller sea lions under the ESA. Studies have been funded through the Alaska Department of Fish and Game to look into the competitive overlap between State-managed fisheries and Steller sea lions. These analyses should provide the basis for an ESA habitat conservation plan (section 10) to minimize the take of Steller sea lions while providing the legal authority for incidental take under a section 10(a)(1)(B) permit for commercial and sport fisheries. If adverse impacts are found during the development of the habitat conservation plan, conservation measures should be determined and adopted in order to mitigate fisheries impacts.

2.6.10 Consider and implement conservation measures in herring and salmon fisheries in Alaska as appropriate

Sea lion mitigation measures in state waters have been implemented only for pollock, Pacific cod, and Atka mackerel parallel fisheries. Conservation measures for other fisheries which affect Steller sea lion prey should also be considered (as described above under a section 10 habitat conservation plan). State fisheries for herring and salmon should be further investigated for potential competitive overlap with Steller sea lions. Both herring and salmon are important prey items for sea lions at various locations and times of the year. Relatively high harvest rates in the herring fisheries may also impact sea lions through the local depletion of the herring stocks. The relationship between the herring fishery and foraging sea lions should be investigated further as these ephemeral foraging events on spawning herring, as well as foraging on over-wintering herring, may be critical to sea lion health, condition and reproduction.

3 Protect from over-utilization for commercial, recreational, scientific, or educational purposes

3.1 Minimize threat of incidental take in fisheries

The threat of incidental mortality in fisheries is considered medium both in "Frequency of Occurrence" and "Relative Impact." Although some Alaska fisheries have extensive observer coverage, some have insufficient observer coverage to estimate or monitor the rate of incidental mortality needed to adequately assess incidental mortality's impact on the sea lion population. Reducing the potential threat of incidental mortality will require understanding the conditions that result in entanglement, information that can be gathered by fishery observers or cooperative research programs. Knowledge of the nature of entanglement is key to developing mitigation strategies whose implementation should be encouraged through outreach and enforcement.

3.1.1 Monitor and evaluate incidental take in commercial and recreational fisheries through observer and self-reporting programs

Observers have collected data on the incidental take rates of Steller sea lion in several state and federal fisheries. Many Category II and III fisheries under the MMPA, however, have had no dedicated observer programs to assess their potential threat to Steller sea lions. Fishery-specific observers can gather data on the frequency, circumstances, and species caught incidentally in many fisheries. These data can be used to derive mortality estimates and document the conditions in which sea lions are most vulnerable to incidental entanglement, injury, or death.

In fisheries where the rate of incidental mortality is low, deriving statistically reliable mortality estimates may be cost-prohibitive. In such cases, NMFS should seek cost-effective means such as repeated beachcast carcass surveys to detect fishery-related mortality. Dedicated observer effort could subsequently be focused on the fisheries, areas, and seasons most needed.

The NMFS Incidental Marine Mammal Take Report Form allows fishermen to document the circumstances surrounding incidental take in commercial fishing gear. Although the form is available on the web, additional effort should be made to advertise the reporting requirements and provide hard copies to commercial fishermen. Copies of this form should be distributed at commercial fishery trade shows and in port offices. An annual reminder of reporting requirements and at least one copy of the Incidental Marine Mammal Take Reporting form should be sent to each state and federal fishery permit holder, possibly with Marine Mammal Exemption Program registration information. There is no incentive for fishers to report incidental takes and draw attention to their fishery so few have been submitted to NMFS. Cooperative Research Programs could be developed within regions where multiple fisheries are suspected of incidentally taking Steller sea lions in order to collect necessary data on gear interactions and potential mitigation measures while providing a degree of anonymity to fishers experiencing takes.

3.1.2 Monitor and evaluate incidental take in non-commercial fisheries

A number of non-commercial fisheries are conducted in state waters that have the potential for interacting with Steller sea lions, including recreational and personal use fisheries, as well as scientific sampling (test fishing). Steller sea lions may become entangled in gillnets or swallow baited hooks used in recreational and personal-use fisheries, at salmon hatcheries, and in state-managed test fisheries. Currently, no system exists that provides for or encourages standardized reporting of Steller sea lion injury or mortality in these fisheries. NMFS should work with ADF&G to develop a system for documenting the frequency, location, and outcome

of reported incidental entanglement. The resulting database should be linked to NMFS's Alaska Marine Mammal Observer Program and Alaska Marine Mammal Stranding Network databases. NMFS should issue an MMPA section 101(a)(5)(E) permit to the State of Alaska to authorize the incidental take of listed marine mammals in state-managed fisheries. This will require the preparation of a National Environmental Policy Act document and completion of an ESA section 7 consultation.

3.2 Minimize threat of intentional killing in fisheries

Although the direct killing of Steller sea lions in the course of commercial fisheries has been banned since 1990, occasional cases of intentional illegal shooting are reported and prosecuted. Some have involved shooting as a lethal means of actively deterring Steller sea lions that are stealing fish from commercial fishing gear. Other cases have involved proactive and lethal efforts to remove Steller sea lions from broad fishing areas. Therefore minimizing the threat of intentional take may involve regionally-oriented education, mitigation, and/or prosecution of offenders.

3.2.1 Monitor intentional take via shoreline surveys for carcasses near suspected conflict "hotspots" and by encouraging reporting of illegal shooting through NMFS's Enforcement hotline

Because it is illegal, intentional killing of Steller sea lions is rarely documented by observers and no reports of lethal deterrence in commercial fisheries have been recorded by fishermen or observers since the practice was banned. Therefore, alternative efforts may be needed to detect and monitor the occurrence of illegal, intentional shooting of Steller sea lions (if it occurs). Since 1990, two convictions have resulted from confidential voluntary reports from commercial fishermen who witnessed and reported the violations to NMFS Enforcement agents. NMFS should encourage such confidential reporting by publicizing hotline numbers at fishery trade shows and in Marine Mammal Exemption Program mail-outs. Systematic surveys of shorelines have successfully located gunshot carcasses of Steller sea lions in several regions of Alaska (see 5.3). In addition to using these surveys to focus further enforcement surveillance, forensic examination of carcasses may yield ballistic information with which to convict illegal shooters. All violations should be prosecuted to the fullest degree possible.

3.2.2 Reduce threat of illegal shooting by developing and promoting use of non-lethal deterrents for commercial fisherman

In some areas Steller sea lions are adept predators on fish caught in commercial fishing gear. Shooting at sea lions to deter them from stealing fish and damaging gear has been banned since 1990 but no non-lethal deterrents have been promoted as alternatives. Such alternatives should be developed, tested, and promoted for use by commercial fishermen in areas where conflicts between sea lions and fisheries exist. A viable deterrent would reduce the threat of incidental capture and illegal shooting in several commercial fisheries.

3.3 Minimize frequency and severity of sea lion-human interactions in ports and harbors

Human encounters with Steller sea lions have occurred in several harbors where Steller sea lions have become habituated to human activities. Fishermen and dock workers may both intentionally and inadvertently feed Steller sea lions with fish from boat decks and at processing stations. This attraction to harbors may increase Steller sea lion vulnerability to ship-strikes, coastal pollutants, and potential predation by killer whales. In addition, habituated sea

lions have hauled out on public and commercial docks, obstructed harbor structures, or posed a threat to human safety by charging and biting people.

3.3.1 Develop and promote non-lethal means of deterring sea lions from hauling out on docks

Currently, enforcement agents may shoot sea lions that pose an immediate threat to human safety. Although this has not yet occurred, the frequency and severity of human-sea lion encounters may intensify as local Steller sea lion numbers and harbor use increase. Non-lethal deterrent techniques or devices need to be developed (see 3.2.2) and made available to harbor enforcement officials to minimize the possibility that deadly force will be needed when sea lions pose a threat to human safety. Port and harbor personnel should be assisted in identifying and providing alternative haulout opportunities for Steller sea lions in harbors where they currently use public facilities and pose a threat to human users.

3.3.2 Continue to publicize "No feeding" regulations in harbor areas and keep active programs for notification and enforcement

Steller sea lions have been drawn to some Alaskan harbors to scavenge fish remains discarded by sport and commercial fishermen. NMFS should remind fish processors and the public of the potential hazards of and prohibition on feeding Steller sea lions at the beginning of each boating or fishing season. Harbor personnel should be encouraged to provide and maintain fish waste stations for processing sport-caught fish. NMFS should continue posting "Do Not Feed Steller sea lions" signs near fish waste stations and processing docks and enforce violations of this prohibited take.

3.4 Minimize take by recreational and commercial viewing operations

The potential exists for recreational and commercial wildlife viewing activities to incidentally take Steller sea lions. Boaters and pilots that approach haulouts and rookeries may disrupt sea lion resting, breeding, and nursing activities or spook animals into the water where they may be more susceptible to predation and ship strike. The potential for disturbance from such approaches varies with the type of approach (vehicle, proximity, speed, duration) as well as seasonal and site-specific Steller sea lion behavior. Although 3-mile no-transit zones are established and enforced around rookeries, restrictions on approaching Steller sea lions on haulouts are poorly defined and publicized in minimum approach guidelines

3.4.1 Publicize and enforce existing no-transit areas to minimize vessel and aircraft disturbance of rookery sites

Commercial and recreational mariners should be reminded annually of the existence and location of the 3 nm No-Transit areas around rookeries via print media and seasonal Notice to Mariners announcements. U.S. Coast Guard and coastal air charter pilots should be reminded annually of the rationale and limits to minimum altitudinal passage over Steller sea lion rookery sites. NMFS Enforcement agents should investigate reported violations and prosecute offenders when possible.

3.4.2 Review and revise existing Marine Mammal Approach Guidelines and provide to charter operators and other mariners to minimize disturbance at haulouts

Mariners in many areas have the opportunity to approach and view Steller sea lions resting on terrestrial haulouts. Although the MMPA and ESA prohibit the harassment of Steller sea lions during such approach, this activity is not clearly restricted or regulated. NMFS has provided

guidelines for mariners to stay at least 100 yds from the animals in order to prevent harassment. However, in areas where Steller sea lions are habituated to humans and vessel traffic, approaches closer than 100yds may not elicit a response from animals on haulouts. On more remote sites and under other circumstance, animals may spook at greater distances. NMFS should review approach guidelines specific to Steller sea lions, update or modify them as appropriate, and consider developing guidelines into formal regulations. NMFS should then post guidelines and regulations for viewing Steller sea lions online and make printed versions available to mariners and charter operators at the onset of each boating season.

3.5 Evaluate and reduce the direct and indirect impacts of research activities

Lethal or non-lethal incidental take of Steller sea lions may occur in the course of bona fide research. These activities are authorized under the MMPA and ESA and are regulated through a Scientific Permit process. Permit applications are reviewed by NMFS Permit office and the Marine Mammal Commission and are available for public review in the Federal Register. Researchers are required to submit annual plans and reports of research activities and real-time reports of research-related mortality. A Regional Coordinator monitors the cumulative impacts of multiple projects and may curtail such research if incidental mortalities reach a permitted cap.

3.5.1 Coordinate research efforts to reduce potential for unnecessary or duplicative research-related takes

The Regional Coordinator should continue to maximize coordination, minimize duplication, and enhance collaboration of Steller sea lion research efforts. NMFS should consider convening periodic regional meetings of authorized Steller sea lion researchers to help coordinate collaborative efforts, discuss emerging technologies, and minimize cumulative effects of permitted research.

3.5.2 Monitor and minimize unintentional takes associated with research activities

When possible, researchers should use new technologies that reduce disturbance, potential mortality, and the need for invasive methods (e.g. safer drugs for anesthesia, photography for census work). Approach and handling methods should be reviewed periodically to minimize the potential for injury or mortality from permitted activities. In addition, studies should be undertaken where possible to evaluate the effects of disturbance caused by particular research activities with the objective of quantifying what if any unintended takes occur and how they could be minimized.

4 Protect from diseases, contaminants, and predation

4.1 Protect Steller sea lions from disease

Disease agents can affect a population directly by affecting survival, growth and body condition; and indirectly by having reproductive effects. Monitoring diseases in a population is important, because diseases rarely occur apart from the influence of other factors such as nutritional status. Therefore, monitoring changes in disease and the appearance of new diseases is another way to monitor populations. Disease agents can affect a population directly by affecting survival, growth, and body condition and indirectly by affecting reproduction.

4.1.1 Conduct epidemiological surveys

Periodic analysis for agents and exposure to agents with potential to affect survival, growth and body condition (eg. nematodes, leptospirosis, viruses) and those with potential to cause reproductive effects (eg. Chlamydia, Toxoplasma gondii, herpesvirus, caliciviruses, Brucella) should be monitored. To date, a collective survey for most of these has been conducted and published (Burek *et al.* 2003, 2005). In addition a survey of young age classes in all seasons has been completed in Southeast Alaska and can serve as baseline data. Continued analysis of blood samples collected in the western DPS should continue to reach similar baseline levels. Blood samples from all handled sea lions should be archived for retrospective analyses if necessary. Monitoring should include analysis for agents and exposure to agents with potential to affect survival, growth, and body condition (eg. nematodes, leptospirosis, viruses) and those with potential to cause reproductive effects (eg. Chlamydia, Toxoplasma gondii, herpesvirus, caliciviruses, Brucella).

4.1.2 Develop and implement methods for parasite evaluations

Information is needed on the prevalence and intensity of parasite infections in Steller sea lions to determine the pathogenicity of these parasites and whether the parasites are causing significant mortality or other effects on the overall condition of the animals. Collecting samples of feces and other bodily fluids from live animals is needed for assessment of the intensity and effects of infestations in dead animals.

Specifically, focused work is needed to assess the prevalence and intensity of hookworm (Uncineria spp.) in Steller sea lions. Hookworm infestation has been documented in this species (Olsen 1958) and has been associated with decreased body condition and increased mortality in other pinniped pups, such as California sea lions (Lyons *et al.* 2001). To gain an understanding of this infection in Steller sea lions, we need to determine the prevalence of infection at the time of branding based upon fecal loop samples, the prevalence and duration of infections based upon fecal samples, the prevalence and duration of infections based upon fecal samples of older pups (2-10 months of age), and the intensity of infections from necropsies.

4.1.3 Develop and implement methods to test immune system functioning

Factors such as infectious disease, diet, endocrine hormones, and stress have effects on the immune system and its response. Methods are needed to assess both humoral and cellular immune function in this species. The development of Steller sea lion specific reagents and diagnostic tests is needed to improve our ability to monitor their health and immune responses. Humoral immune function can be evaluated by measuring isotype levels in serum as part of assessing general health status and by measuring antibodies to assess past and present exposure to pathogens. Lymphocyte function assays can be used to assess cellular immunity. Major histocompatibility complex (MHC) gene analysis (immune response genes) can be performed to identify the different genotypes and phenotypes on the population. Polymorphism of these genes within a population is thought to be needed for immunologic vigor (i.e. a correlation with population health).

4.1.4 Evaluate causes of mortality by examining dead and live animals of all age and sex classes for disease from various sources across the geographic range and in all seasons

A better understanding of the causes of mortality of Steller sea lions is needed. To accomplish this, the number of dead and moribund animals examined annually needs to increase. Necropsy is one of the best tools for determining causes of mortality. This can be accomplished

through further development of the stranding network in Alaska, examination of fisheries by-catch animals, subsistence harvested animals and through rehabilitation efforts. Existing organizations and individuals should be informed of Steller sea lion strandings, and the data should be catalogued and maintained by a central agency. Necropsies should be performed in a systematic manner and accompanied by histologic examination and processing of tissues collected from all age classes of animals. To facilitate this, standardized necropsy protocols need to be developed; protocols and sample collection kits should be made available to biologists on capture cruises and at field stations, observers on boats, subsistence hunters and others; and training opportunities should be provided where needed. Samples to be collected should include tissues for histology, contaminant analysis, archived for future disease studies, DNA analysis for stock identification, stomach contents for diet analysis, female reproductive tracts to monitor reproductive status, feces, blood, and other body fluids.

A priority list for observations, measurements, and specimens to be collected should be made available to state fish and game agencies, federal research and management teams, subsistence hunters, rehabilitation organizations and other appropriate groups throughout the Steller sea lion range.

4.1.5 Develop disease management plans

To monitor changes in health and disease over time, and to compare future work to current data, a central database should be developed. Methods for sample collection and analysis and for data analysis should be standardized. This will help to ensure that all data collected by different groups is comparable. Future health investigation should be in monitoring for detection of future events. Disease surveillance studies should be based on expected routes of introduction of the disease into the population and should be adaptable as new diseases emerge or techniques become available. Consideration should be given to design studies based on geographic and oceanographic features rather than on population based on point of capture.

Due to the difficulties associated with obtaining large numbers of samples from all ages of Steller sea lions, the use of data collected (or that could be collected) and analyzed from sympatric species (California sea lions, northern fur seals, harbor seals) should be considered. A comprehensive disease monitoring plan should include monitoring of changes in specific diseases and detection of new and emerging disease agents.

4.1.6 Develop an unusual mortality event (UME) management plan

Having a UME management plan would facilitate a response to any emergent UMEs that may occur in Steller sea lions. Identifying high risk events resulting from natural or anthropogenic causes (e.g. oil spill, biotoxin, contaminants, disease) and developing specific plans will allow resources (funds, personnel, diagnostic labs, equipment) to be mobilized for immediate response to the emergence of such events. Such contingency plans have been developed for other species and could be used as a template for the Steller sea lion plan. The plan should include: 1) criteria to determine what the triggers should be to initiate such a response, as well as criteria that would lead to increased sampling consideration versus monitoring; 2) protocols for capturing and marking live animals to monitor the event and to determine when it is over; and 3) protocols for debriefing and disinfection of supplies and instruments to prevent any disturbance or spread of disease as a result of the response.

4.1.7 Develop models to simulate disease impacts based on energetics, physiology abundance and demographics.

Simulations can be used to evaluate disease impacts and effects on the abundance of Steller sea lions at small spatial scales (rookeries) and large (populations). A growing need exists to integrate the biological data with population-scale dynamics. But modeling efforts have lagged behind. This is likely due to the inability of scientists and resource managers to provide the necessary information for mathematicians and modelers to be able to develop meaningful models. As our ability to obtain and provide useful data improves, so should the ability to create useful models.

4.2 Protect sea lions from contaminants

The number of potentially toxic compounds that are being developed is growing rapidly, and these compounds can potentially impact many marine animals, including Steller sea lions, in a myriad of ways

4.2.1 Design a contaminant research and management plan

To assess any potential health impacts, scientists should develop methods to assess health related to contaminants and collect and analyze samples for potential contaminants, including endocrine disrupting and immunosuppressive chemicals. Contaminant management plans should be developed to prepare for the mitigation of any contaminants that have the potential to be released in the natural habitat of Steller sea lions.

4.2.2 Collect samples from free-ranging sea lions and in environmental "hotspots"

Collect and analyze samples for organochlorines, other persistent organic compounds, heavy metals, and other potential contaminants including endocrine disrupting and immunosuppressive chemicals from dead and live animals of all age and sex classes from various sources across the geographic range for disease in all seasons. Compare to environmental samples collected from 'hot spots' that could be used to help identify the source of the contamination, which could assist with mitigation measures. Non-point sources of contamination will be more difficult to identify or mitigate, but any environmental sampling that can assist with the process should be encouraged.

4.2.3 Examine blood and tissue samples for evidence of contaminant-linked endocrine effects including free-ranging and captive work

One of the primary mechanisms by which contaminants affect an animal is through the endocrine system. Although much work has been done on developing baseline endocrine values for many terrestrial mammals, little work has been done on marine mammals. Given that some hormones are highly conserved across species (ie, sex steroids), the development of baseline concentrations of these hormones for marine mammals, particularly Steller sea lions, should be readily obtained. Peptide hormones, however, tend to be species-specific, and the development of validated assays and subsequent baseline concentrations for these will be more difficult. The mechanism by which endocrine disruption due to contaminants impacts the overall health of the animal can be very complex. In addition to baseline concentrations, alterations in endocrine profiles due to altered physiological states (during gestation, lactation, or fasting), are virtually unknown. Once these profiles are established, the impact of endocrine disruption from contamination can be better evaluated.

4.2.4 Develop models to simulate contaminant impacts and effects based on energetics, physiology, abundance and demographics

Simulations can be used to evaluate the impacts of contaminants and effects on the abundance of sea lions on small spatial scales (rookeries) and large (populations).

4.3 Predation

Predation may be a significant source of mortality of pinnipeds, including Steller sea lions. Predation rates on particular prey species can be affected by the health status of individuals and the availability of alternate prey. The effect of predation on prey populations can increase when those populations are small. Thus, predation as a factor in the dynamics of Steller sea lions must be evaluated.

4.3.1 Understand predator life histories, biology and ecology – captive work

The principal predators of Steller sea lions are killer whales. Of the three ecotypes of killer whales, only transient killer whales are thought to prey on marine mammals. Among transient killer whales, diets vary by region and pod, and pods may travel over long distances. It is necessary to identify transient killer whales within the range of Steller sea lions and determine their diets, distribution, movements, and abundance. Likewise, scientists need to understand the behavior of killer whales when foraging, especially as it may relate to prey switching or seasonal changes, to assess any potential impact on prey populations. The study of captive killer whales to better understand the bioenergetics or physiology of this species should be encouraged. These animals have the ability to support longitudinal studies that would not be feasible in the free-ranging setting.

4.3.2 Determine killer whale diets

Knowledge of diets of transient killer whales is critical to evaluating effects they may have on prey populations. Three primary means of estimating diet are analysis of stomach contents of stranded whales, analyzing ratios of stable isotopes of carbon and nitrogen in bone and soft tissues, and using fatty acids in blubber to infer the composition of prey. While these are established methods, other methods to identify diet should be encouraged. Observations of feeding killer whales at sea can provide additional valuable information on diet.

4.3.3 Develop methods to obtain samples from live killer whales

New and refined methods to obtain samples from live killer whales need to be developed. Biopsy samples used to obtain tissue samples for use in studies of genetics and diet determination are currently the primary method of collection and limited by range. Continued development of methods would assist in increasing the sample size.

4.3.4 Expand the stranding network to increase samples of killer whales available for research

Killer whales die and wash ashore in various places. Many locations are remote and populated by few people. People who observe beached killer whales might not report it to scientists. However, stranded killer whales can be of significant value in determining the diet of killer whales. The existing stranding network should be increased to accommodate killer whale samples including the outsourcing of samples for diet analysis.

4.3.5 Determine killer whale distribution and behavior across the North Pacific

Killer whales are common in coastal waters and can be viewed by following them in vessels while they forage and by recording them with remote cameras at rookeries and haulouts. Much can be learned about predation behavior and rates, diets, and distributions of transient killer whales by following pods of foraging whales. This method is most successful in summer when weather conditions are favorable, but is needed during other seasons, as well. Cameras deployed at Steller sea lion rookeries may provide important information on predation rates, the age structure and behaviors of animals preyed upon, the numbers of whales involved, the pod composition, and identities of individual killer whales. Other technologies, such as acoustic sensors and satellite-linked UHF tags, should be developed to enhance our knowledge of the long- term movement and foraging ecology of killer whales. Included in this task is the continued development of tags and tag delivery methods to increase deployment duration.

4.3.6 Estimate numbers of killer whale ecotypes in time and space

As only transient killer whales are thought to prey on marine mammals, it is necessary to identify and census them to calculate their proportion of the killer whale population Information on their abundance and distribution in space and time is needed to assess the impact of predation. Killer whale ecotypes can be recognized by their distinctive physical markings and genetic characteristics.

4.3.7 Develop models to simulate predation rates based on killer whale energetics and abundance of Steller sea lion demographics

Simulations can be used to evaluate predation pressure and effects on the abundance of Steller sea lions at small (rookeries) and large spatial scales (populations).

5 Protect from other natural or manmade factors and administer the recovery program

Principal responsibility for implementation of the Steller Sea Lion Recovery Plan lies with the NMFS Office of Protected Resources. Recovery actions will need to be coordinated with the NMFS regional offices as well as with other federal and state resource management agencies and user groups. Moreover, education and public outreach will be vital to full operation of this plan. Estimated costs outlined in this section are those attributed to the NMFS; costs that may accrue to other agencies and user groups are not estimated here.

5.1 Reduce damage to sea lions and their habitat from discharges of pollutants by developing preventive measures

The discharge of pollutants poses a threat to sea lions but can be mitigated through the monitoring and evaluation of potential sources of pollution and the implementation of preventative measures by regulatory agencies. Industrial, agricultural, and urban sources of pollution are relatively uncommon in areas of Alaska adjacent to Steller sea lion habitat, but offshore oil and gas leasing and the marine transport of oil pose threats that should be continuously monitored and evaluated. This should be accomplished through the Office of Protected Resources' review of oil and gas lease sales, oil spill contingency plans and other permitting and approval processes.

5.2 Reduce the potential for sea lion entanglement by improving and continuing programs aimed at reducing marine debris

Observations of sea lions at sea and on land indicate that entanglement in debris is continuous if infrequent. Efforts to estimate the extent and type of such entanglement are important to help identify the entangling material and its source, to foster the reduction of such debris when

possible. Current programs focused upon the generalized reduction of discard at sea (e.g., MARPOL) and those focused upon the commercial fishing industry need to be continued and expanded.

5.2.1 Reduce discards of debris (e.g., trawl web and packing bands)

Previous efforts should be resurrected to educate fishermen and other mariners on various prohibitions against discarding refuse at sea and on the effects of such materials in strangling and otherwise adversely affecting sea lions, similar to the "Don't teach your trash to swim" campaign of the Pacific States Marine Fisheries Commission.

5.2.2 Cleanup derelict gear and beached debris

In particularly sensitive areas surrounding major and accessible rookeries and haul-outs, beach cleanup initiatives should be promoted in order both to remove marine debris that might affect sea lions and to educate the public on the need to prevent such debris from being discarded in the first place.

5.3 Monitor causes of sea lion mortality and use data to direct management actions

This section focuses on the general need to monitor sea lion mortality and strandings and use that information to promote recovery.

5.3.1 Continue and expand the Alaska stranding network to increase coastal coverage and community involvement in monitoring sea lion mortality

Marine mammal stranding networks have provided valuable data for determining regional, seasonal, and annual patterns of marine mammal mortality. By locating sick and dead animals, samples and data from stranding networks have been used to detect and monitor the incidence of both anthropogenic (e.g. gunshot, fishing gear entanglement) and natural agents of mortality (e.g. episodic outbreaks of leptospirosis, domoic acid toxicity, and San Miguel sea lion virus) in pinniped populations.

Through aggressive public notices, people in coastal communities should be informed that Steller sea lion strandings, regardless of condition, are of particular significance and should be reported to local stranding responders (identified) immediately. The number of organizations and individuals trained to respond to strandings and collect Level A stranding data has increased in Alaska with the growing involvement of Alaska Native NGOs and others in the Alaska Marine Mammal Stranding Network. However, efforts should be made to train and support additional stranding responders in remote Alaskan communities and provide them the tools and support needed to contribute viable samples and data collected from stranded Steller sea lions. Continued training, guidelines, and protocols should be provided

5.3.2 Survey selected areas for stranded animals

Efforts should be made to identify sites where there is a high probability of being able to locate and sample dead animals. This effort will need to be coordinated with activities of stranding networks, aerial survey crews, field enforcement, and other field activities. For example, dead pups should be counted and sampled during pup counts when pups have been separated from adults, but rookeries should not be disturbed solely to recover dead pups. If identified sites are not visited regularly as part of the activities listed above, it may be desirable to conduct special field efforts to examine and sample dead animals.

5.3.3 Expand tissue sampling efforts to improve the information obtained from dead sea lions

Accurately determining the cause of death of sea lions often requires collection of tissue samples. These samples need to be properly stored or transferred to a storage facility soon after death. Local stranding network members should be encouraged to respond immediately to reports of dead or moribund sea lions. In areas where such reports are frequent, these responders should be provided with adequate collection, storage, and shipping support to maximize the analytical value of the samples collected. Such efforts should be coordinated through the regional NMFS Stranding Networks.

5.3.4 Monitor the incidence and impact of entanglement in marine debris

Entanglement of sea lions in marine debris occurs. There needs to be a continued effort to estimate the relative number of entangled animals in stranding data, by observers aboard vessels at sea, and during field research activities such as pup counts and observations at intensive study sites. When possible, the entangling material should be identified as this may provide clues about the circumstances under which sea lions become entangled. Literature surveys should be conducted regularly to update information on related marine mammal and bird entanglement incidents, and surveys of occurrence of entangling materials (packing bands, net fragments, etc.) at sea. Data should be used to support efforts to mitigate mortality.

5.4 Effectively administer the Steller sea lion recovery program by continuing to provide a recovery coordinator staff position

NMFS should maintain a full-time person to coordinate recovery efforts for Steller sea lions. Duties of the sea lion coordinator should include:

a. Coordinate all aspects of NMFS sea lion recovery efforts, such as evaluation and development of regulations, designation of critical habitat, and section 7 consultations;
b. Provide liaison with regional fishery management councils, state fishery managers, FWS wildlife refuge managers, enforcement agencies, researchers, and other interested parties;
c. Publish annual activity reports and work plans;
d. Facilitate and coordinate research activities, including development of scopes of work for contracts;
e. Coordinate data management, and facilitate data analysis and distribution.

5.5 Improve sea lion conservation by consulting with the State of Alaska on actions that are likely to adversely impact Steller sea lions

The State of Alaska exerts sovereignty over many activities within the territorial sea (0-3 miles from shore). To the extent that the management of fisheries, development of oil, gas, and minerals, or other activities might affect the recovery of Steller sea lions, it will be important that active consultation between NMFS and the State of Alaska continue. Direct liaison with the Alaska Department of Fish and Game and the Alaska Board of Fisheries has been successful and should be continued and expanded (see 2.6.9; 2.6.10). Interaction with the Alaska Department of Natural Resources, Alaska Department of Environmental Conservation, and the Alaska Department of Transportation and Public Facilities, among others, may be necessary on a case-by-case basis.

5.6 Conduct an effective outreach program to inform the public about Steller sea lion biology, habitat utilization, and conservation issues

Many of the regulations put into place to protect Steller sea lions will apply to all members of the public. Some conservation measures broadly affect mariners while others are specific to commercial fishermen. Public affairs personnel in responsible agencies should plan and implement well-rounded public awareness programs that describe the status of sea lions and the protective regulations that are in place. Types of coverage that have proven effective include websites, news releases, mail-outs, signs, public service announcements, interpretive programs, films, and environmental education lesson plans featuring sea lions.

5.6.1 Encourage and facilitate public reporting of sea lion observations

Coastal residents can provide valuable sea lion observational data if made aware of the need and provided a means to do so. The public should be made aware that they can aid in the Steller sea lion recovery effort by reporting observations of sea lion strandings and entanglement (see 5.3.1), branded and tagged animals (see 1.2.1), regulatory violations (see 3.2.1), and predation by killer whales (see 4.3.5). To facilitate public involvement, a local coordinator should encourage public reporting of observations, then coordinate and standardize the collection of resulting data. This coordinator may be a local stranding network member, enforcement officer, extension agent, or researcher. The coordinator should be familiar with sea lion conservation efforts and research needs to ensure that pertinent details are recorded and that appropriate entities receive the information. One avenue for the reporting of real-time observations of strandings and branded animals through the promotion of public outreach would be the creation and maintenance by the Office of Protected Resources of a dedicated website with instructions for the submission of local observations.

5.6.2 Publicize current conservation efforts and protective measures.

Many sea lion protective measures affect the activities of commercial fishermen, so it is particularly important that they be updated on the rationale and details of these measures. Information can be distributed as part of ongoing regulatory programs (e.g., in permit mail-outs, logbooks and regulation books), as well as through media directed specifically at the fishing industry (e.g., trade magazines). Materials and trained personnel should be made available to assist industry in developing its own additional educational programs. Fishermen and their representatives should be encouraged to continue their involvement in the development, evaluation, and implementation of sea lion conservation measures. To minimize disturbance at rookeries, all mariners and pilots should be reminded of no-transit zone boundaries through periodic media updates, Notices to Mariners, and updates to the Coast Pilot. Recreational and charter operators should be presented updates and reminders of 'approach guidelines' through pre-season meetings and/or press releases. Efforts to reduce human-sea lion interactions in harbors should be continued through posting of DO NOT FEED SEA LION signs and providing fish waste disposal options to recreational fishermen.

5.7 Co-manage Steller sea lion subsistence harvests in Alaska by developing co-management agreements as appropriate with Alaska tribes and tribally authorized Alaska Native Organizations (ANO)

Involving indigenous people in resource management has shown substantial benefits to the conservation of the species, and co-management regimes commonly occur throughout the

circumpolar north for many different species. In Alaska, co- management agreements have been developed between the federal managing agencies and with tribes or tribally authorized organizations for many marine mammal species taken for subsistence in Alaska. Specifically, these agreements have provided a means for 1) collecting and analyzing data on marine populations, 2) monitoring harvest of marine mammals for subsistence, 3) participating in research, and 4) developing co-management structures.

The tribal governments of St. Paul and of St. George currently have co- management agreements in place with NMFS, but these only affect Steller sea lions in proximity to the Pribilof Islands. Co-management agreements should be established between NMFS and Alaska tribal governments and/or tribally authorized ANOs for other areas used by both Steller sea lions and Alaska Natives.

5.7.1 Manage subsistence harvests and evaluate the efficacy and accuracy of using retrospective subsistence harvest surveys

Documenting the number, sex and age of Steller sea lions taken by Alaska Natives is critical to understanding the impact of the subsistence harvest on the population. Subsistence harvest monitoring should continue on an annual basis through co- management partnerships with Alaska Native Organizations and with Alaska tribal governments. Sea lion subsistence harvest has traditionally been monitored via retrospective volunteer survey of identified informants in approximately 60 coastal communities. Questions have been raised about the accuracy of the method and if it is the most appropriate monitoring method for an ESA listed species. These monitoring methods should be evaluated in conjunction with Alaska Tribes and tribally authorized ANOs. If necessary, adjustments to the method should be made.

5.7.2 Support Alaska Native subsistence use information programs

These programs may work to promote sound hunting techniques by developing culturally appropriate educational materials that recognize the traditional importance and uses of sea lions and the best hunting techniques and practices, through elder-youth mentoring and through cultural activities such as spirit camps and community celebrations. Alaska Native subsistence use of sea lions is rooted in the Alaska Native culture. Effective local conservation and management actions will be those that minimize conflicts with the local culture. Working with Alaska Natives to develop culturally appropriate educational materials that recognize the importance of sea lion subsistence use can provide a foundation for local management plans and conservation efforts. For example, elder-youth mentorship programs should be developed in the villages to train younger hunters in sound hunting practices, traditional uses, and cultural values such as respect for the resource and conservation. Cultural activities such as spirit camps, community celebrations, cultural revitalization activities including brochures, videos, other materials may also provide avenues for encouraging responsible hunting.

5.7.3 Analyze carcasses from subsistence harvest to assess age, body condition, and other relevant information to ensure safety of carcasses for human consumption

Most of the marine mammal co-management agreements in Alaska include biological sampling programs whereby hunters and subsistence users are involved in data and sample collection of those animals taken for subsistence. A standardized necropsy protocol is needed from federal, State, and Tribal governments, including ANOs and NGOs. As part of the process, prior sea

lion biosampling programs should be evaluated, and if necessary, locals retrained in standard protocols for data and tissue collection for continued monitoring. Sampling kits and shipping support should be provided to hunters that includes a list of samples needed.

5.7.4 Document local knowledge and cultural science (Traditional Ecological Knowledge, TEK) pertaining to sea lions to better understand changes in sea lion movement (local and seasonal), feeding patterns and prey, seasonal haulouts, predation and ecosystem dynamics

Local and traditional knowledge studies have provided many insights into marine mammal life history and behavior, including movement, migration pattern, geographic expansion, seasonal and annual prey species, predators, etc. These surveys can provide a longer time perspective than commonly available. Current local and traditional knowledge surveys are underway in select places to document knowledge about movement, seasonal behavior and haulouts, and predator and prey interactions. These surveys should continue, and the geographic scale should be expanded throughout the state.

5.8 Improve the effectiveness of research for Steller sea lion recovery by instituting a "fast track" process for expediting NMFS research permits for Steller sea lions.

This recovery plan has noted that scientific research is essential for understanding and mitigating the threats to Steller sea lion recovery. However, delays in the current permitting process by NMFS has slowed research activities and in some cases resuled in lost research opportunities. A new streamlined process should be investigated to reduce the permitting process for Steller sea lion related research to less than 6 months.

E. Recovery Action Implementation Schedule

The Implementation Schedule that follows outlines actions and estimated costs for the recovery program for the western DPS of Steller sea lion, as set forth in this recovery plan. It is a guide for meeting the recovery goal and criteria outlined in this plan. This schedule indicates action priorities, action numbers, action descriptions, duration of actions, the parties potentially responsible for actions (either funding or carrying out), and estimated costs. Parties believed to have authority or responsibility for implementing a specific recovery action are identified in the Implementation Schedule. When more than one party has been identified, the proposed lead party is indicated by an asterisk (*). The listing of a party in the Implementation Schedule does not require the identified party to implement the action(s) or to secure funding for implementing the action(s). Priority numbers are assigned as described below, which follow the NMFS interim Recovery Planning Guidance.

Priority Number

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be taken to prevent a significant decline in species population / habitat quality or some other significant impact short of extinction.

Priority 3 - All other actions necessary to provide for full recovery of the species.

Plan Task	Priority	Responsible Parties	Task Duration	Fiscal Year Costs ($K)					Threats*
				FY 1	FY 2	FY 3	FY 4	FY 5	
1. BASELINE POPULATION MONITORING									
1.1.1 Estimate trends for pups and non-pups via aerial surveys	1	NMFS	annual	*250*	*250*	*250*	*250*	*250*	M
1.1.2 Monitor population trends in the Pribilof Islands (particularly the Walrus Island rookery) via aerial surveys or land-based counts	2	NMFS	annual	*50*	*50*	*50*	*50*	*50*	M
1.2.1 Continue to estimate survival, fecundity, and immigration/emigration rates through a branding/resight program	2	NMFS, ADF&G	annual	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*	M
1.2.2 Promote cooperative pup branding/resight programs in Russia	2	NMFS, Russia	annual	*500*	*500*	*500*	*500*	*500*	M
1.2.3 Develop an age-structured population model using medium format photos from aerial surveys	2	NMFS	1 yr	*20*					M
1.2.4 Determine pregnancy and parturition rates	2	NMFS	annual	*30*	*30*	*30*	*30*	*30*	M
1.3.1 Examine the effects of season, age, and sex on	2	NMFS	annual	*500*	*500*	*500*	*500*	*500*	M,F,EV

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Plan Task	Priority	Responsible Parties	Task Duration	Fiscal Year Costs ($K)					Threats*
				FY 1	FY 2	FY 3	FY 4	FY 5	
body condition									
1.3.2 Develop improved indices of health, body condition, and reproductive status using chemical methods (e.g., hematology serum chemistries, and endocrine monitoring)	2	NMFS	10 yrs	*250*	*250*	*250*	*250*	*250*	M,D/P
1.4.1 Develop improved live capture techniques for general research needs	2	NMFS	5 yrs	*250*	*250*	*250*	*250*	*250*	M,D/P
1.4.2 Develop improved non-lethal sampling techniques to assess health	2	NMFS	5 yrs	*200*	*200*	*200*	*200*	*200*	M,D/P
1.5 Develop an implementation plan	2	NMFS	1 yr with biennial updates	***50***		***10***		***10***	M
TOTAL – ACTION 1				***3,100***	***3,300***	***3,040***	***3,030***	***3,040***	
2.1 Maintain critical habitat designations	3	NMFS	5 yrs	*100*	*100*	*100*	*100*	*100*	F,EV
2.2 Protect rookery and haulout sites (terrestrial habitat)	3	NMFS, USFWS, BLM, USFS	1 yr with 5 yr updates	*5*					DVT,IS,DR
2.3.1 Collect and analyze scat samples and stomach contents to determine prey consumption	2	NMFS	annual	*400*	*400*	*400*	*400*	*400*	F,EV
2.3.2 Develop stable isotope and fatty acid methodologies to assess prey consumption	2	NMFS	annual	*150*	*150*	*150*	*150*	*150*	F,EV
2.3.3 Deploy instruments to obtain finer scale data on sea lion foraging habitat	2	NMFS	annual	*500*	*500*	*500*	*500*	*500*	F,EV
2.3.4 Evaluate all information on sea lion foraging areas and develop a description of foraging needs	2	NMFS	2 yrs with updates	*200*	*200*				F,EV
2.4.1 Assess the relationships between oceanographic features and sea lion foraging ecology	2	NMFS	2 yrs	*125*	*125*				F,EV
2.4.2 Examine the influence of ecosystem variability on non-commercial prey species as an index to sea lion carrying capacity	3	NMFS	5 yrs	*300*	*300*	*300*	*300*	*300*	F,EV
2.4.3 Distinguish how natural and anthropogenic factors influence marine ecosystem dynamics and subsequently sea lion population dynamics	2	NMFS	5 yrs	*500*	*500*	*500*	*500*	*500*	F,EV
2.5.1 Determine the physiological diving	3	NMFS	5 yrs	*500*	*500*	*500*	*500*	*500*	F,EV

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Plan Task	Priority	Responsible Parties	Task Duration	Fiscal Year Costs ($K)					Threats*
				FY 1	FY 2	FY 3	FY 4	FY 5	
capabilities and evaluate how this limits the ability to forage successfully									
2.5.2 Determine the energetic costs of foraging to sea lions	2	NMFS	5 yrs	1,500	1,500	1,500	1,500	1,500	F,EV
2.5.3 Assess the nutritional value of prey by species, season, and area including digestibility and overall value to sea lions	2	NMFS	3 yrs	150	150	150			F,EV
2.5.4 Develop an energetics model to investigate the interrelationships…and sea lion growth, condition, and vital rates	2	NMFS	5 yrs	100	100	100	100	100	F,EV
2.6.1 Improve groundfish stock assessment surveys to determine seasonal and inter-annual patterns of prey abundance, distribution, and movement at scales relevant to sea lions	2	NMFS, ADF&G	annual	1,500	1,500	1,500	1,500	1,500	F,EV
2.6.2 Assess competition for prey with sympatric consumers (e.g., gadids and flatfish, fur seals, harbor seals, other marine mammals, and seabirds)	3	NMFS	5 yrs	250	250	250	250	250	F,EV
2.6.3 Utilize groundfish fishery observer data to assess the spatial-temporal distribution of the fishery	2	NMFS, ADF&G	annual	20	20	20	20	20	F
2.6.4 Assess effectiveness of sea lion closure zones around rookeries and haulouts using small-scale experiments	2	NMFS, ADF&G	3 yrs	750	750	500			F, DVT
2.6.5 Assess the response of sea lions to changes in prey distribution and availability	2	NMFS	5 yrs	200	200	200	200	200	F,EV
2.6.6 Evaluate and implement appropriate fishery regulations to protect foraging habitat and prey resources for sea lions	2	NMFS, ADF&G	annual	2000	2000	2000	2000	2000	F
2.6.7 Explore the use of ecosystem based (multi-species) stock assessment models to set fishery catch limits to ensure adequate prey resources for a recovered sea lion population	2	NMFS, ADF&G	5 yrs	60	60	60	60	60	F,EV
2.6.8 Design and implement an adaptive management program for fisheries, climate change, and predation	1	NMFS, ADF&G	3 yrs dev. 10 yrs impl.	500	500	500	200	200	F,EV,KW
2.6.9 Prepare a habitat conservation plan under	2	ADF&G	3 yrs	100	100	50			F

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Plan Task	Priority	Responsible Parties	Task Duration	Fiscal Year Costs ($K)					Threats*
				FY 1	FY 2	FY 3	FY 4	FY 5	
section 10 of the ESA for fisheries authorized by the State of Alaska									
2.6.10 Consider and implement conservation measures in herring and salmon fisheries in Alaska as appropriate	2	ADF&G	annual	*200*	*200*	*200*	*200*	*200*	F
TOTAL – ACTION 2				***10,110***	***10,105***	***9,480***	***8,780***	***8,780***	
3.1.1 Monitor and evaluate incidental take in commercial fisheries through observer and self-reporting programs	3	NMFS, ADF&G, USCG	annual	*500*	*500*	*500*	*500*	*500*	IT
3.1.2 Monitor and evaluate incidental take in non-commercial fisheries	3	NMFS, ADF&G, USCG	1 yr	*300*					IT
3.2.1 Monitor intentional take via shoreline surveys for carcasses near suspected conflict 'hotspots' and by encouraging reporting of illegal shooting through NMFS's Enforcement hotline	3	NMFS, ADF&G, USCG	annual	*250*	*250*	*250*	*250*	*250*	IS
3.2.2 Reduce threat of illegal shooting by developing and promoting use of non-lethal deterrents for commercial fisherman	3	NMFS	2 yrs	*300*	*300*				IS
3.3.1 Develop and promote non-lethal means of deterring sea lions from hauling out on docks	3	NMFS, USCG	2 yrs	*100*	*100*				DVT,IS
3.3.2 Continue to publicize "No feeding" regulations in harbor areas and keep active programs for notification and enforcement	3	NMFS, USCG	annual	*50*	*50*	*50*	*50*	*50*	DVT
3.4.1 Publicize and enforce existing no-transit areas to minimize vessel and aircraft disturbance of rookery sites	3	NMFS, USCG	annual	*20*	*20*	*20*	*20*	*20*	DVT
3.4.2 Review and revise existing Marine Mammal Approach Guidelines and provide to charter operators and other mariners to minimize disturbance at haulouts	3	NMFS	annual	*25*	*25*	*25*	*25*	*25*	DVT
3.5.1 Coordinate research efforts to reduce potential for unnecessary or duplicative research-related take	3	NMFS	Annual	*25*	*25*	*25*	*25*	*25*	DR
3.5.2 Monitor and minimize unintentional take	3	NMFS, USCG	5 yrs	*200*	*200*	*200*	*200*	*200*	DR

Plan Task	Priority	Responsible Parties	Task Duration	Fiscal Year Costs ($K)					Threats*
				FY 1	FY 2	FY 3	FY 4	FY 5	
TOTAL – ACTION 3				*1,770*	*1,470*	*1,070*	*1,070*	*1,070*	
4.1.1 Conduct epidemiological surveys	2	NMFS	5 yrs	*250*	*250*	*250*	*250*	*250*	D/P
4.1.2 Develop and implement methods for parasite evaluations	2	NMFS	5 yrs	*50*	*50*	*50*	*50*	*50*	D/P
4.1.3 Develop and implement methods to test immune system functioning	2	NMFS	5 yrs	*25*	*25*	*25*	*25*	*25*	D/P
4.1.4 Evaluate causes of mortality by examining dead and live animals of all age and sex classes	2	NMFS	10 yrs	*50*	*50*	*50*	*50*	*50*	all
4.1.5 Develop disease management plans	2	NMFS	2 yrs	*30*	*30*				D/P
4.1.6 Develop an unusual mortality events (UMEs) management plan	2	NMFS	2 yrs	*50*	*50*				D/P,DVT,IT
4.1.7 Develop models to simulate disease impacts on energetics, physiology, abundance and demographics	2	NMFS	5 yrs	*100*	*100*	*100*	*100*	*100*	D/P
4.2.1 Design a contaminant research and management plan	2	NMFS	2 yrs	*30*	*30*				T
4.2.2 Collect samples from free-ranging sea lions and environmental 'hotspots'	2	NMFS	5 yrs	*200*	*200*	*200*	*200*	*200*	T
4.2.3 Examine blood and tissue samples for evidence of contaminant-linked endocrine effects	2	NMFS	5 yrs	*100*	*100*	*100*	*100*	*100*	T
4.2.4 Modeling contaminant impact and effect	2	NMFS	5 yrs	*100*	*100*	*100*	*100*	*100*	T
4.3.1 Understand predator life histories, biology, and ecology – captive work	2	NMFS	5 yrs	*400*	*400*	*400*	*400*	*400*	KW
4.3.2 Determine killer whale diets	2	NMFS	5 yrs	*300*	*300*	*300*	*300*	*300*	KW
4.3.3 Develop methods to obtain samples from live killer whales	2	NMFS	5 yrs	*100*	*100*	*100*	*100*	*100*	KW
4.3.4 Expand the stranding network	2	NMFS	2 yrs	*25*	*25*				KW, M
4.3.5 Determine killer whale distribution and behavior across the North Pacific	2	NMFS	5 yrs	*500*	*500*	*500*	*500*	*500*	KW
4.3.6 Estimate numbers of killer whale ecotypes in time and space	2	NMFS	5 yrs	*500*	*500*	*500*	*500*	*500*	KW
4.3.7 Develop models to simulate predation rates based on killer whale energetics and abundance and Steller sea lion demographics	2	NMFS	5 yrs	*100*	*100*	*50*	*50*	*50*	KW

Plan Task	Priority	Responsible Parties	Task Duration	Fiscal Year Costs ($K)					Threats*
				FY 1	FY 2	FY 3	FY 4	FY 5	
TOTAL – ACTION 4				*2,910*	*2,910*	*2,725*	*2,725*	*2,725*	
5.1 Reduce damage to sea lions and their habitat from discharges of pollutants by developing preventive measures	2	NMFS, USCG	5 yrs	*25*	*25*	*25*	*25*	*25*	T
5.2.1 Reduce discards of debris (e.g., trawl web, packing bands)	2	NMFS, USCG	5 yrs	*100*	*100*	*100*	*100*	*100*	E
5.2.2 Cleanup derelict gear and beached debris	3	NMFS	5 yrs	*100*	*100*	*100*	*100*	*100*	E
5.3.1 Continue and expand the Alaska stranding network to increase coastal coverage and community involvement in monitoring sea lion mortality	2	NMFS, ADF&G	5 yrs	*100*	*100*	*100*	*100*	*100*	all
5.3.2 Survey selected areas for dead stranded animals	2	NMFS	5 yrs	*50*	*50*	*50*	*50*	*50*	all
5.3.3 Expand tissue sampling efforts to improve the information obtained from dead sea lions	2	NMFs	5 yrs	*100*	*100*	*100*	*100*	*100*	all
5.3.4 Monitor the incidence and impact of entanglement in marine debris	2	NMFS	5 yrs	*100*	*100*	*100*	*100*	*100*	all
5.4 Effectively administer the Steller sea lion recovery program by continuing to provide a recovery coordinator staff position	2	NMFS	annual	*850*	*850*	*850*	*850*	*850*	all
5.5 Improve sea lion conservation by consulting with the State of Alaska on actions that are likely to adversely impact Steller sea lions	2	NMFS, ADF&G	annual	*250*	*250*	*250*	*250*	*250*	F,IT,IS,E,DVT
5.6.1 Encourage and facilitate public reporting of sea lion observations	3	NMFS, ADF&G	5 yrs	*50*	*50*	*50*	*50*	*50*	M
5.6.2 Publicize current conservation efforts and protective measures	3	NMFS	annual	*50*	*50*	*50*	*50*	*50*	all
5.7.1 Manage subsistence harvests and evaluate the efficacy and accuracy of using retrospective subsistence harvest surveys	2	NMFS, ADF&G	annual	*150*	*150*	*150*	*150*	*150*	SUB
5.7.2 Support Alaska Native subsistence use information programs	2	NMFS, ADF&G	annual	*75*	*75*	*75*	*75*	*75*	SUB
5.7.3 Analyze carcasses from subsistence harvest to assess age, body condition, and other relevant information to ensure safety of carcasses for human	2	NMFS	annual	*100*	*100*	*100*	*100*	*100*	D/P,T

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Plan Task	Priority	Responsible Parties	Task Duration	Fiscal Year Costs ($K)					Threats*
				FY 1	FY 2	FY 3	FY 4	FY 5	
consumption									
5.7.4 Document local knowledge and cultural science (Traditional Ecological Knowledge - TEK) pertaining to sea lions to better understand changes in sea lion movement (local and seasonal), feeding patterns and prey, seasonal haulouts, predation and ecosystem dynamics	2	NMFS	2 yrs	*100*	*100*				all
5.8 Improve the effectiveness of research for Steller sea lion recovery by instituting a "fast track" process for expediting NMFS research permits for Steller sea lions.	2	NMFS	2 yrs	*100*	*100*				all
TOTAL - ACTION 5				*2,300*	*2,300*	*2,100*	*2,100*	*2,100*	
TOTAL - ALL ACTIONS				*20,190*	*19,815*	*18,415*	*17,705*	*17,715*	*93,840*

* IT=incidental take by fisheries; SUB=Alaska native subsistence harvest; IS=illegal shooting; E=entanglement in marine debris; D/P=disease and parasitism; T=toxic substances; DVT=disturbance from vessel traffic and tourism; DR=disturbance from research; KW=killer whales; EV=environmental variability; F=competition with fisheries

VI. FACTORS POTENTIALLY INFLUENCING THE EASTERN POPULATION

With the widespread, long-term decline in the western DPS of Steller sea lion, attention has been focused on identifying factors that may have resulted in reduced productivity or increased mortality. The situation is much different with the eastern DPS, in which (with the exception of the southern end of the range) the number of sea lions has been increasing. In this situation, the relationship between births and deaths has clearly been favorable, with the result that the population has shown a positive growth rate. Because of the long-term positive population growth of the eastern DPS no threats to recovery have been identified. However we recognize that certain factors are, or have the potential, to affect the dynamics of the population.

A. Impact of Individual Threats

Section III of the Plan presents a detailed discussion of a number of factors that could influence Steller sea lions in general, with emphasis on data specific to the western DPS. This section of the Plan includes only information on such factors that are specific to the eastern DPS of Steller sea lion.

1. Predation

North Pacific killer whales can be categorized into three distinct eco-types that differ in morphology, ecology, behavior and genetics (Stevens *et al.* 1989, Hoelzel and Dover 1991, Hoelzel *et al.* 1998, Baird 2000, Barrett-Lennard 2000, Ford *et al.* 1998, 2000). Notably, feeding ecology varies among the three forms with "resident" whales targeting fish and "transient" whales targeting other marine mammals (Dahlheim and Heyning 1999, Ford *et al.* 1998, 2000). Feeding observations on "offshore" whales are more limited; but initial observations suggest that fish and shark appear to be targeted.

Three stocks of transient killer whales are currently recognized to use the waters within the range of the Steller sea lion (Angliss and Outlaw 2005). Two transient killer whale stocks occupy the range of the western DPS of Steller sea lion (i.e., AT1 stock and the Gulf of Alaska, Aleutian Islands and Bering Sea transient stock) and one stock termed the "West Coast transients" occupy the range of the eastern DPS of Steller sea lion. The abundance and stock structure of the "West Coast transients" have been well documented and are described below.

"West Coast transients" occur between Southeast Alaska and California (Barrett-Lennard 2000). West Coast transients have significant differences in mtDNA and nuclear (microsatellite) DNA and are considered a discrete population from the two, transient killer whale stocks described in western Alaska (Barrett-Lennard 2000). Based on photo-identification studies, an estimated 323 whales comprise the community of West Coast transients (Black *et al.* 1997, Dahlheim *et al.* 1997, Ford and Ellis 1999). Of these, 105 whales are known to occur in California waters (Black *et al.* 1997). Another 218 whales occur in the waters of Washington State, British Columbia, and Southeast Alaska (Dahlheim *et al.* 1997, Ford and Ellis 1999).

Most of the transient whales identified from Washington State, British Columbia, and Southeast Alaska are known to frequently move among the three regions (e.g., 77% of the whales seen in Southeast Alaska are also seen in British Columbia and Washington State); representing a range of 950 miles [1,759 km] (Dahlheim and White submitted). However, there are some individual transient groups that have a more limited range and have only been seen in either Southeast Alaska or British Columbia or Washington State (Dahlheim *et al.* 1997, Ford and Ellis 1999). Conversely, there are some individuals that have an expanded range. For example, a transient group, well known from Southeast Alaska, was also documented off Coos Bay, Oregon (a distance of approximately 1,150 miles [2,129 km]; Dahlheim and White submitted). Four whales frequently seen off Central California were seen once in Southeast Alaska; a distance of 1,436 miles [2,660 km] (Goley and Straley 1994); representing the longest movement documented for transient whales. Out of the 105 whales described from California, only 14 have been seen in Washington, British Columbia, and Southeast Alaska (Black *et al.* 1997). Given the reduced number of photographic matches between California and the more northern regions, there has been some suggestion that these two groups of transient whales (i.e., California transient whales versus the Washington/British Columbia /Southeast Alaskan transient whales) comprise different communities. In summary, only 13% of the California transient population is seen in northern waters (i.e., Washington, British Columbia, and Southeast Alaska). Conversely, transient whales frequently move between Southeast Alaska, British Columbia, and Washington State waters with 77% of the population observed in all three areas. With the exception of four individuals, movements between Prince William Sound and Southeast Alaska do not occur.

The diet of West Coast transient killer whales includes a variety of marine mammal prey. Based on nearly 30 years of field observations, these whales have been seen to feed on harbor seals, Steller sea lions, elephant seals, gray whales, minke whales, Dall's porpoise, harbor porpoise, Pacific-white sided dolphins, and sea birds (Baird and Dill 1995, 1996, Ford *et al.* 1998, Dahlheim and White submitted). Prey specialization by individual pods of killer whales has been documented for a few groups by Baird and Dill (1995, 1996). However, Ford *et al.* (2000) and Dahlheim and White (submitted) documented individual pods of killer whales predating on a variety of prey items.

Based on the mortality rates used in Loughlin and York (2000), about 5,500-6,200 sea lions will die each year in a stable or increasing population of approximately 40,000 animals (see above). An unknown portion of these mortalities will result from predation by transient killer whales residing in the range of the eastern DPS of Steller sea lion.

Long *et al.* (1996) reported white shark bites on 548 live and dead pinnipeds in central California, of which 53 were Steller sea lions. For the period from 1970 to 1992 the number of shark-bitten pinnipeds shows an overall increase attributable to increases in both the predators and their primary prey (California sea lions and elephant seals). Long and Hanni (1993) speculated that white shark predation could impede recovery of Steller sea lions in California if the number of sea lions declines further and the shark population continues to increase.

2. Harvests, killing, and other human impacts

The United States has not conducted any commercial harvests of Steller sea lions in the range of the eastern DPS. During the period from 1912 through 1968, government control programs killed thousands of Steller sea lions on rookeries and haulouts in British Columbia (Bigg 1985). By 1970, when sea lions were given protection in Canada, the population had been reduced by about 70%, and one rookery had been eliminated (Olesiuk 2001). In the U.S., prior to the MMPA, there were both sanctioned and unsanctioned control efforts and the killing of Steller sea lions by fishermen and others was commonplace.

Both the ESA and the MMPA contain provisions that allow coastal Alaska Natives to harvest endangered, threatened, or depleted species for subsistence purposes. During 1992-1998, harvest data were collected through systematic interviews with hunters in at least 60 coastal communities throughout the range of Steller sea lions in Alaska (e.g., Wolfe and Mishler 1998, Wolfe and Hutchinson-Scarbrough 1999). Only 20 animals were reported taken in the range of the eastern DPS during the entire 1992-1998 period.

Amendments to the MMPA in 1988 and 1994 required observer programs to monitor marine mammal incidental take in some domestic fisheries. Observer programs during 1993-97 provided an estimate of 1.2 Steller sea lions killed per year in the California/Oregon thresher shark and swordfish drift gillnet fishery (Hill and DeMaster 1999). Three mortalities were recorded in the California/Oregon/Washington groundfish trawl fishery in 1994 and 1997, and one was recorded in the northern Washington marine set gillnet fishery. Injuries to Steller sea lions have been reported in logbooks from Southeast Alaska and California/Oregon/Washington salmon troll fisheries (Hill and DeMaster 1999). The numbers above are minimum estimates of the incidental kill and serious injury in fisheries, because not all fisheries that might take sea lions are covered by observer programs nor do fishers often report injuries or mortalities.

Incidental take in Canadian fishery operations has not been estimated. Some Steller sea lions are killed as part of an aquaculture predator control program in British Columbia. Preliminary values indicate a mean annual kill of 12.4 animals between 1993 and 97. Trawl fisheries have not occurred in Southeast Alaska since the 1990s thereby eliminating another historic mortality source.

The level of intentional and incidental killing of Steller sea lions by humans has apparently been relatively small as the population has been increasing for about 30 years. It is quite possible that, if these sources of direct mortality were eliminated or reduced, the eastern DPS would increase at a higher rate.

3. Entanglement in debris

Steller sea lions become entangled in a variety of debris including many types of fishing gear, loops of line, and packing bands. All of these may cause mortality however the extent is unknown and may range from a fraction of a percentage to several percent a year. In the Gulf of Alaska and Aleutian Island, Steller sea lions have been seen entangled in lost and

discarded fishing gear, including items such as packing bands and net material (Calkins 1985, Loughlin *et al.* 1986). Between 2000 and 2005 ADF&G recorded all entangled sea lions during brand-resighting surveys in Southeast Alaska. These surveys occur in the summer and visit virtually all rookeries and haulouts in Southeast. ADF&G reported that 0.21% of the animals observed had some sort of entanglement including packing bands and netting around the neck or fishing gear hanging from the mouth (ADF&G unpublished data). This is a minimum estimate as not all entanglements are visible (such as swallowed hooks) and on an annual basis some entanglements and deaths occur before and after the survey period. It is not known what percentage of entangled animals die as the severity of the injuries varies. This source of mortality could probably be reduced by cleaning beaches, increasing public awareness, and by aggressive enforcement of regulations governing debris discard.

4. Parasitism and disease

Parasites that have been reported in Steller sea lions include (1) intestinal cestodes; (2) trematodes in the intestine and bile duct; (3) nematodes in the stomach, intestine and lungs; (4) acanthocephalans in the intestine; (5) acarian mites in the nasopharynx and lungs; and (6) an anopluran skin louse (Dailey and Brownell 1972, Dailey and Hill 1970). In California sea lions, a serious infection of nematodes causes ulcers that may lead to massive stomach bleeding and death. However, the number of deaths attributed to this cause is not known. Parasites have been found in Steller sea lions and may cause mortality in malnourished animals. To date, adequate research has not been conducted to assess the relative nature and magnitude of parasitism in sea lion populations; however, the available information does not suggest that parasitic infections are limiting population growth. Investigation and identification of parasites requires either necropsy of carcasses, which only occurs sporadically on beach cast animals, or collection of fresh feces.

As discussed for the western DPS, some preliminary surveys have been done on fecal examinations from live captured animals in both western and eastern DPSs. Similar parasites are generally detected in both DPSs; however, little information is available on the parasite loads or effects on the animals. Hookworms are of particular interest because of their ability to cause morbidity and mortality in other pinnipeds. Some work has been done on hookworm loads in eastern DPS pups. In pups less than 3 months old examined in 2003 and 2004, total intestinal worm burdens ranged from 18 to 3,477 (Burek *et al.* 2003, 2005). These levels can cause mortality due to anemia in northern fur seals (*C. ursinus*) (Olsen 1958).

Diseases have been studied on Steller sea lions in both eastern and western DPSs, mostly as serologic surveys of prevalence and occurrence in the population (Barlough *et al.* 1987, Burek *et al.* 2003, 2005, Zarnke *et al.* 1997). Whereas exposure to many disease agents has been identified in Steller sea lions, little is known about the disease agents themselves or how they may impact the sea lion populations and no evidence has been found of disease limiting population growth

5. Toxic substances

The NMFS Northwest Fishery Science Center examined blubber samples from 24 Steller sea lions from southeast Alaska and reported PCB levels of 630-9,900 ng/g wet weight and DDT levels of 400-8,200 ng/g wet weight (NMFS unpublished data). PCB levels at the upper end of this range have been shown to reduce juvenile survival in sea otters (AMAP 2002), but the consequences for Steller sea lions are not known.

Castellini (1999) found that the levels of zinc, copper, and metallothionein (a chelating compound) were comparable between Steller sea lion pups sampled from the eastern and western DPS, and were lower than for captive sea lions. Castellini also found that circulating zinc and metallothionein levels were elevated in southeast Alaska sea lion pups during the early 1990s, but returned to values comparable to Aleutian Island pups by 1997. Metallothionein levels are one measure of exposure of sea lions to heavy metal contamination. The similarity of levels in both eastern and western DPSs suggests that heavy metal contamination may be having similar effects on both DPSs. Sydeman and Jarman (1998) found elevated levels of copper, mercury, and selenium in tissues (type not specified) from eight pups found dead at Ano Nuevo Island and Southeast Farallon Island. Existing studies on Steller sea lions have shown relatively low levels of toxic substances (with few exceptions), as well as heavy metals, and these levels are not believed to have caused high mortality or reproductive failure (Lee *et al.* 1996) and are not considered significant contributors to observed Steller sea lion declines.

6. Global climate change

Characteristics of recent climate change in the North Pacific were discussed in detail in Section III.H. In that section it was noted that some features of the ecosystems of the Pacific Northwest (California to British Columbia and southeast Alaska) and the northern North Pacific (Gulf of Alaska and Bering Sea) are out of phase, including recruitment of Pacific salmon and some groundfish stocks (Hollowed and Wooster 1992, Hare *et al.* 1999), and zooplankton biomass (Brodeur *et al.* 1996, Roemmich and McGowan 1995). Such variability may be due to patterns of transport in the North Pacific Current when it bifurcates off the coast of British Columbia to form the northward-flowing Alaska Current and the southward-flowing California Current (Wickett 1966, Hollowed and Wooster 1992). How such variations may affect organisms at the top of the trophic system, such as Steller sea lions, is unknown.

Sydeman and Allen (1999) investigated correlations between oceanographic features and population dynamics of central California pinnipeds Multiple regression analysis of sea surface temperatures and upwelling index versus abundance found no relationship for Steller sea lions. Additionally, despite documented shifts in climate and oceanographic processes that may have affected productivity at multiple trophic levels, California sea lion pup production along the US west coast has increased at approximately 5% per year since 1975 and the eastern DPS of Steller sea lion has also increased at approximately 3%/year with no apparent variability associated with climatic variation. Thus, although there have been documented and perhaps more frequent oceanographic and climatic changes, the population of Steller sea lions has not responded negatively from a population perspective. The most evident change is that all of the new rookeries in the

eastern DPS have been established in Alaska at the northern end of the range suggesting a population shift to the north.

7. Reduced prey biomass and quality

In contrast with the situation with the western DPS, no evidence suggests that Steller sea lions in the eastern DPS were nutritionally limited during the 1970s and 1980s. The potential for competition for prey exists as there are several commercial fish species that are also prey for sea lion in the eastern DPS. These include Pacific cod, walleye pollock, Pacific hake, salmon, and herring. Although many of these species are also both commercially fished and prey for the western DPS Steller sea lions, the two areas differ significantly both in the magnitude and distribution of the fisheries and in the fish communities themselves. For example, the range of one of the most important prey items of the western DPS, Atka mackerel, does not extend into the eastern DPS (see Mueter 1999).

Pollock, as a species, range throughout Alaska, British Columbia, and the northern portions of the American west coast; however, the bulk of the population is located in the range of the western DPS. Commercial fisheries for pollock in the range of the eastern DPS have been sporadically pursued since the 1970s (primarily by foreign fleets) but have been much smaller in magnitude than those in the range of the western DPS. Since the early 1990s, fishing with trawls has been prohibited in all portions of the EEZ off Southeast Alaska. This effectively precludes a pollock fishery in the range of the eastern DPS, though a small trawl pollock fishery continues off British Columbia each year. Other fisheries in SE Alaska for Pacific cod, salmon, and herring commonly use fixed gear (e.g., hook and line, pots) or mobile, non-trawl gear such as seines and trolling. This reduces the rate at which fish can be caught (for most species and gears), and could reduce the likelihood of fishery-induced local depletions of commercially important prey species.

Along the U.S. West Coast, Pacific hake (Pacific whiting) is the dominant groundfish biomass in the California Current, supporting the largest fishery on the west coast south of Alaska. Pacific hake ranges from southern and central California spawning grounds during January-March to summer and fall feeding grounds off Washington State, British Columbia, and Alaska. Pacific hake is an important prey fish for many marine mammal predators, including California sea lions, Steller sea lions, northern fur seals, northern elephant seals, Pacific white-sided dolphins, Dall's porpoises, killer whales, and sperm whales (Livingston and Bailey 1985). Based on scats collected during summer and early fall, Pacific hake appears to be a major prey item of Steller sea lions along the Oregon and Washington coast, just as pollock is a major prey in Alaska (Gearin *et al.* 1999).

Steller sea lions no longer breed on the Channel Islands and have declined at Ano Nuevo Island and the Farallons Islands since the 1970s, while Steller sea lion numbers at the northern California and southern Oregon rookeries (between 42-43 N. lat., where the summer-fall diet appears dominated by hake) have increased significantly in recent years. Meanwhile the Pacific hake stock (age 3+ fish) has declined steadily from an

estimated high of 5.8 million metric tons in 1987 to the lowest levels on record in 2001, only 800,000 tons with no concurrent change in Steller sea lion population trajectory.

Steller sea lion trend counts at the largest rookeries in southern Oregon (clustered between 42-43 N. Lat.) increased nearly 4% per year during the 1990s. Under U.S. regulations, the shore-based fishing season opens March 1 and offshore fishing season opens May 15; at-sea processing and night fishing are prohibited south of 42 N. lat. and fishing effort is typically concentrated between central Oregon and Cape Flattery, Washington (Helser *et al.* 2002). Thus, the typical distribution of hake fishing effort is well north of the major Steller sea lion breeding and pupping grounds in southern Oregon and northern California.

Fishery regulations and the typical distribution of the fishery north of 44 N. Lat. may minimize the potential for competition between foraging Steller sea lions and the hake fishery during the summer months when the Steller sea lion population is concentrated on rookeries in southern Oregon and northern California. However, the migratory summer-fall distribution of the hake stock varies widely depending on annual environmental conditions, extending as far north as the Queen Charlotte Islands and southeast Alaska during the warm El Niño ocean conditions of 1998, but concentrated south of Cape Blanco in southern Oregon (approx. 43 degrees N. lat.) during the cool La Niña conditions of 2001 (Helser *et al.* 2002). It is perhaps noteworthy that the increasing northern California-southern Oregon Steller sea lion breeding populations occupy a midpoint in the migratory distribution of the West Coast hake stock, a geographic position that may serve to buffer those populations from the worst effects of ENSO events on the annual distribution of the hake stock.

8. Disturbance

A recent MS thesis by L. Kucey at the University of British Columbia noted that Stellers sea lions in Southeast Alaska are sensitive to various types of disturbance and respond with temporary movements from the area. In British Columbia, harassment and killing of Steller sea lions prior to 1970 resulted in the abandonment of a rookery, although it is now used as a haulout (Bigg 1988). Animals in the eastern DPS are protected from disturbance by the ESA, and effects from disturbance should be minimal at the present time. However, increased human use of areas adjacent to Steller sea lion haulouts in Southeast Alaska does represent a potential threat in the future but the level of those effects is unknown. Recent applications for development in Southeast Alaska are illustrative of the potential for cumulative effects to become a threat in the future however. In spring 2005, NMFS issued a finding of "not likely to adversely affect" for a proposal known as the Juneau Access Improvements project. This project proposes to build a road on the east side of Lynn canal between Juneau and Skagway that would require construction and ultimately road placement less than 300 feet from the Gran Pt. haulout. In addition, the Kensington Gold Project has also been evaluated for its potential to disturb Steller sea lions in Lynn Canal with the construction and use of two marine terminals. The Biological Evaluation for this project identifies potential impacts such as oil spills, noise disturbance, vessel /marine mammal collisions and effects on spawning prey bases. Individually, the NMFS has determined that these projects do not

jeopardize the existence of Steller sea lions. However, the continued pressure of developments in otherwise wilderness areas may ultimately result in the abandonment of haulouts.

B. Cumulative Effects

The potential for cumulative effects in the eastern Steller sea lion population is the same as for the western DPS as described in Section V.C. However, given that sea lion numbers are increasing in Oregon, British Columbia, and southeast Alaska, any individual or combined effects currently occurring in that region are apparently not significant enough to prevent the population's growth in those areas. In contrast, the low numbers of sea lions in central California should trigger some investigation of the possible negative consequences of cumulative and synergistic effects. Sydeman and Allen (1999) speculated that the decline of Steller sea lions in central California may be due to the combined effects of oceanic warming affecting prey availability, competition for prey with California sea lions, contaminants, and disease.

C. Threats Assessment

The purpose of this section is to assess the relative impact of all previously identified threats to the eastern DPS of Steller sea lion. Unlike the western DPS where apparent threats have been identified as potentially limiting the population's recovery, there is no similar evidence of limiting factors in the eastern DPS. For example, although threats listed for the western DPS such as predation, disturbance, incidental take, contaminants etc. are present and could certainly act upon the eastern DPS in similar negative ways, there is no evidence to support that any either individually or collectively are current threats to recovery. In addition to the threats and mechanisms in the western DPS table being present to some degree, the most vulnerable cohorts within the eastern DPS would also likely be the same. Because of the lack of identified threats to recovery a threats table was not created for the eastern DPS.

Similar to the western DPS, there is also uncertainty as to the level of current and historical impact of various threats and whether there have been changes in the magnitude of those threats to the eastern DPS. It is thought the prior threats, primarily in the form of directed human take (shooting), have been adequately addressed. As the breeding range and center of the eastern DPS has moved northward, prior threats associated with the previous southern range extent such as competition with other increasing pinniped populations and activities associated with a high human population density may have been largely ameliorated.

VII. RECOVERY PLAN FOR THE EASTERN POPULATION

A. Goals

The ultimate goal of this recovery plan is to promote the recovery of Steller sea lions to a level sufficient to warrant their removal from the List of Endangered and Threatened Wildlife and Plants (List) under the ESA.

B. Recovery Strategy

In 1990, Steller sea lions were designated as one threatened population across the range which stretched from southern California to Canada, Alaska, and across into Russia and northern Japan. The listing was primarily based on a substantial decline of the western DPS as well as contraction of the southern extent of the eastern population range.

In 1997, after continued declines in Alaska and new genetics information which revealed further population structure, NMFS split the population into two DPSs, and reclassified the western DPS as endangered while keeping the eastern DPS as threatened. At the time, few threats were described for the eastern population while population counts indicated an increasing trend throughout much of the population. However, concern over possible interactions between sea lions from the western DPS and the eastern DPS, a contraction in the very southern part of the range of the eastern DPS, and the potential impacts from fisheries led NMFS to maintain the eastern DPS as threatened until a longer time series of population increases could be observed with other positive confirmation that human activities were not a threat to recovery. Protection for the eastern population has been provided primarily by the MMPA, MSFCMA, and the Fisheries Act of Canada. The most important protection has likely been prohibitions on lethal takes. Since 1997, the population has continued to increase and is thought to be relatively large compared to historical levels, particularly in the northern portion of the range.

At present, the most likely threats are development, increased disturbance and habitat destruction, increases in magnitude or distribution of commercial or recreation fisheries, and environmental change. Fortunately rookeries are located at remote sites, normally isolated offshore reefs and islands unsuitable for development. In addition many rookeries are in protected status as parks, refuges, wilderness areas, and ecological reserves that make future development unlikely. Other impacts include entanglement in fishing gear and other marine debris that appears to be affecting sea lions in substantial numbers. None of these impacts is likely to affect the recovery of the species, but should be monitored in the future to make sure that important sea lion habitat is sufficiently protected. The MMPA is the primary law other than the ESA providing protection for sea lions and their habitat. Further work should be pursued through federal, state, and local governments to ensure that rookery and haulout sites are protected and that fisheries and other human actions do not adversely affect sea lion prey resources.

Given the current status and lack of significant threats to recovery, the primary recovery actions provided in this plan are to ensure management agreements are in place with the states, and develop a post-delsiting monitoring plan to ensure re-listing is not necessary after removal from the List. We also recommend the initiation of a status review and consideration of whether the eastern DPS should be removed from the List. Provided in Section VII.F below is an outline of the post-delisting monitoring plan, which should be developed prior to any proposed delisting notice.

C. Reclassification Criteria

The ESA requires that recovery plans, to the maximum extent practicable, incorporate objective, measurable criteria which, when met, would result in a determination in accordance with the provisions of the ESA that the species be removed from the List (50 CFR 17.11 and 17.12). The recovery criteria comprise the core standards upon which the decision to delist a species will be based.

1. Delisting criteria

To remove the eastern DPS of Steller sea lion from the List, NMFS must determine that the species' abundance, survival, and distribution, taken together with the threats (i.e., ESA listing factors), no longer render the species "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." Any new factors identified since listing must also be addressed in this analysis to ensure that the species no longer requires protection under the ESA.

Recovery criteria must include the elimination of threats to the species as well as measures of demographic health. Both sets of criteria serve as checks on one another – one set of criteria requires evidence that the threats to Steller sea lions have been eliminated or controlled and are not likely to recur (listing factor criteria), and the other set of criteria requires evidence that the population status of Steller sea lions has improved in response to the reduction in threats (biological criteria).

Development of the criteria

There has been some concern over the performance of rookeries and haulouts at the very southern end of the range in California especially in contrast to the growth observed in southeast Alaska. However, no criteria are provided here for sub-regions within the range. It is not unusual for the geographical limit of a species range to perform less than the core regions. A somewhat similar change in Steller sea lion distribution and the establishment of new breeding sites have been noted along the Asian coast. The question of whether an area constitutes a "significant portion of the range" relates to the biological importance rather than the geographical extent and although the population trend at the southern limit of the range has not followed the same trajectory as the Alaska portion there is not data available to suggest it is biologically unique (Ono 1993); however, given the limited genetic studies done in the southern part of the range this cannot be rule out. The southern range limit has moved northward by 500-900 km over the past 50 years and several new rookeries were established (Burkanov and Loughlin *in press*). This demography does not

increase the risk of extinction for this species and therefore, it seems appropriate to evaluate the eastern DPS as a whole when establishing recovery criteria.

Goodman (Appendix 3) evaluated the risk of extinction for the eastern DPS based on currently available information. For the past 25-30 years, the eastern DPS has been growing steadily at about 3%, a rate which is about 1/3 of the rate that would represent the common understanding of the biological potential of a pinniped population under similar circumstances. During this time, the population size has more than doubled and is now estimated to be about 46,000 animals. There has been no evidence of appreciable effects of environmental variation, or of appreciable variation in whatever human–caused influences may be affecting this population (Appendix 3).

The present size size of the California portion of the population, which occupies the southern edge of the species range, is about 20% of that recorded there in the middle of 20th century, and it is believed that the population may have been larger yet in the 19th century (Appendix 3). In recent times, consistent California-wide counts began in 1996. During the recent decade of monitoring pup production in California has trended upward, while non-pup numbers have varied from one census to the next, but with no clear trend (Tables I-9 and I-10).

If these conditions continue, the risk of near- or medium-term extinction for this population is very low (Appendix 3). While there is no evidence to the contrary, conclusive information is not available that this hypothesis is true, or that these conditions will continue in the future. Therefore, if current protection measures are maintained, then we would expect that this population would remain at low risk of extinction.

Biological Criteria

The eastern DPS of Steller sea lion will be considered for removal from the List when the likelihood of its becoming endangered in the foreseeable future has been eliminated by achieving the following biological criteria:

1. The population has increased at 3% per year for 30 years.

   In 1997, the listing of the eastern population was based in large part in the uncertainty regarding the population trend, although even at that at that time it appeared to be increasing. However, NMFS was concerned that not enough years had been observed to assure that the population was in fact increasing. The time period chosen for this criterion reflects three generations such that we would be assured that survival and reproduction was robust. NMFS should use scientifically valid tests for significance to determine whether the observed counts reflect actual increases in the population.

2. The population ecology and vital rates in the U.S. region are consistent with the trend observed under criterion 1, to ensure the population is increasing in a sustainable manner. Specifically, available information on pup counts, fecundity, juvenile survival rates, population age structure, gender ratios, and other

observations should be examined to determine that they are indicative of an increasing population.

ESA Listing Factor Criteria

It is imperative that threats to the species be controlled prior to removal from the List. This includes all threats identified at the time of listing, as well as any new threats identified since listing. An inclusive list of those threats and limiting factors is found in the Plan. The Plan describes the decline of Steller sea lions due to changes in the environment, predation, direct takes by humans, and indirect effects such as competition for prey resources with fisheries and with other increasing populations of pinnipeds.

In order to remove the threatened eastern population of Steller sea lion, the following threats-based criteria should be achieved. In addition, the criteria should be achieved in such a way that the delisting of the eastern population is not likely to result in the re-emergence of the threat. The best available information indicates that achieving the following threats criteria are necessary in order to recover Steller sea lions. Yet, it is possible that current perceived threats become insignificant in the future due to changes in the natural environment, or changes in the way that the threats affect the entire life cycle of Steller sea lions.

When the biological criteria (above) are met, NMFS will evaluate and review the criteria under these listing factors to determine their relevance under the current conditions and whether they have been met.

Factor A: The present or threatened destruction, modification, or curtailment of a species' habitat or range

The eastern population of Steller sea lion declined in large part in response to direct mortality from predator control programs and shooting by fishermen and others that was a generally accepted behavior until recent years. In general, terrestrial habitat for the eastern population has been either protected or not impacted to any large degree based in large part to the remote areas occupied by sea lions. There may be some exceptions along the southern California coast. Prey resources currently appear to be adequate to support recovery. Future fisheries management and other marine resource management should specifically consider sea lion needs in their planning.

To provide assurance that delisting is warranted for the eastern population of Steller sea lion, threats to its habitat should be reduced as specified under this factor:

1. Marine habitats, particularly in regard to prey populations, must be maintained through appropriate fisheries management and control of contaminants.

2. Rookery and haulout sites need to be adequately protected (through state, federal, or private measures) to insure the continued use of these sites for pupping, breeding, attending young, and resting. Research and monitoring plans should be in place for all projects that have a high probability of negatively impacting sea lions in order to make sure that these activities do not result harm to sea lions or their habitat.

Factor B: Overutilization for commercial, recreational, or educational purposes

Human-caused mortality of Steller sea lions includes subsistence harvest, incidental takes in fisheries, illegal shooting, entanglement in marine debris, and take during scientific research. In general, the MMPA provides adequate protection for sea lions from the eastern population. None of these factors now appear to be preventing recovery, although it would be appropriate to reduce the magnitude of these when possible.

Factor C: Disease or predation

Although Steller sea lions are taken by killer whales throughout their range there is no indication that killer whale predation is outside of normal or background levels expected in this population at this abundance level. The final evaluation is that predation is not limiting recovery. Diseases are know to occur within this population but appear to be limited to those endemic to the population and are unlikely to have population level impacts. Therefore no criteria are necessary to reduce disease and predation.

Factor D: The inadequacy of existing regulatory mechanisms

One potential threat to Steller sea lions is increased human disturbance in previously remote areas. Little is known about the potential impacts from changes to the physical environment, disturbance due to vessel traffic, or tourism related activities, therefore we cannot quantify these threats other than to highlight the need to keep regulatory mechanisms such as the MMPA in place to protect sea lions. Research and/or monitoring programs should be put into place activities are conducted that have the potential to negatively impact Steller sea lions. Other actions to protect haulout and pupping areas (as describe under factor A) would provide substantial insurance against future impacts due to development and disturbance from human activities.

1. An agreement is reached with the State of Alaska which describes their fishery management plan, minimizes the take of Steller sea lions, and describes how future actions taken by the State will comport with the ESA and MMPA.
2. A Steller sea lion recovery coordinator is on staff at NMFS.

Factor E: Other natural or manmade factors affecting its continued existence

To provide assurance that delisting is warranted for the eastern population of Steller sea lions, several actions are recommended to assure that factors do not develop that would threaten its persistence.

1. An outreach program is established to educate the public, commercial fishermen, and others to the continued need to conserve and protect Steller sea lions.
2. An Alaska stranding network is in place and functional.

D. Recovery Actions Outline and Narrative

At the time of initial listing (1990), it was not recognized that there were two genetically distinct populations of Steller sea lions in North America. What is now recognized as the western DPS was undergoing a major decline while the trend of the eastern DPS was uncertain. It was also of concern that the southern portion of the eastern DPS had contracted and several haulout sites and at least two rookeries were no longer used by Steller sea lions. There was also apprehension that whatever factor was responsible for the decline, e.g. disease, might spread to the east. In retrospect we now know that the eastern DPS has been consistently increasing at about 3% per year throughout its range for about 25 years, with the exception of central California. The southernmost sites appear to have stabilized, albeit at levels far below their historical maximums. The eastern DPS has increased by about 225% over the last 25 years and four new rookeries have been established in Southeast Alaska. With the exception of the southern portion of the range, the reduced population size in the 1970s was thought to be the result of direct human related mortality, largely in the form of shooting by fisherman and others who viewed them as competitors for fishery resources. With the passage of protective legislation in both the U.S. and Canada and with changing social values, this source of mortality has been substantially reduced. Although there are still a number of factors that negatively impact the dynamics of the eastern DPS, none of these either alone or in combination appear to pose a threat to recovery.

Based upon the lack of threats to the eastern DPS and the population status and trends, the following two recovery actions are provided.

1. Monitoring

1.1 Develop a post de-listing monitoring plan

A post de-listing monitoring plan should be developed (see Section VII.F below) which would guide monitoring activities for 10 years post delisting. The objective should be to ensure that necessary recovery actions remain in place and that it can be confirmed that there are no threats to the population's continued existence.

2. Protect from other natural or manmade factors and administer the recovery program

2.1 Initiate a status review to determine whether to de-list the eastern DPS of Steller sea lions.

NMFS should initiate a status review and determine whether the eastern DPS has met the recovery criteria found in this plan and should be removed from the list of threatened species. No threats to recovery have been identified and the population has been increasing for over 25 years, new rookeries have been created, and the population is at historical high levels.

E. Recovery Actions Implementation Schedule

NMFS should implement the recovery actions within one year after the completion of this plan. A post de-listing monitoring plan is an essential part of the de-listing package and should be developed during the status review process. The process should take about one year to complete.

Costs:

1.1 Develop a post de-listing monitoring plan; $50,000. Implementation of the monitoring plan would require an annual cost of about $100,000 for population surveys and health monitoring

2.1 Initiate a status review to determine whether to de-list the eastern DPS of Steller sea lions; $100,000

F. Post-Delisting Monitoring Plan

Post-delisting monitoring (PDM) refers to activities undertaken to verify that a species de-listed due to recovery remains secure from risk of extinction after it has been removed from the protections of the ESA. The primary goal of PDM is to confirm that the species does not require re-listing as threatened or endangered during the period following removal of ESA protections. Section 4(g), added to the ESA in the 1988 reauthorization, requires NMFS to implement a system in cooperation with the states to monitor for not less than five years the status of all species that have recovered and been removed from the lists of threatened and endangered plants and animals (50 CFR 17.11, 17.12, 224.101, and 227.4). Section 4(g) directs NMFS to make prompt use of their emergency listing authorities under section 4(b)(7) to prevent a significant risk to the well-being of any recovered species. While not specifically mentioned in section 4(g), authorities to list species in accordance with the process prescribed in section 4(b)(5) and 4(b)(6) may also be utilized to reinstate species on the list of threatened and endangered plants and animals, if such an action is found to be appropriate.

The ESA does not require the development of a formal PDM "plan." However, for the eastern DPS of Steller sea lion, a 10-year plan is likely to be very helpful to NMFS in ensuring that the species has recovered and that the protections of the ESA are no longer necessary. The key components of the plan should include population trend monitoring (biennial or triennial), monitoring of development near terrestrial habitats, monitoring for unusual mortality events, and monitoring of fishery management plans to ensure they stay consistent with sea lion requirements. A PDM plan should be developed by NMFS in collaboration with the States and Canada before the species is proposed for de-listing (if warranted).

Key components of the plan should include:

- Continue to estimate population trends (biennial or triennial) for pups and non-pups
- Closely monitor trend and status of rookeries and haulouts at southern end of range (California)
- Monitor for unusual mortality events via a stranding network including impacts from fishing gear and other human related materials (e.g., plastic bands, discarded fishing nets, flashers)
- Continue to ensure the protection of important terrestrial habitat (rookery and haulout sites)
- Monitor the magnitude and distribution of commercial and recreational fisheries to ensure the continued protection of important sea lion prey resources
- Conduct additional research on the genetic structure of the eastern population
- Monitor incidental takes in fisheries
- Monitor direct takes
- Monitor frequency and severity of Steller sea lion-human interactions in ports and harbors
- Monitor impacts of recreational and commercial viewing operation
- Monitor impacts of research activities
- Monitor for disease and health related to contaminants
- Monitor predation as a significant sources of mortality
- Conduct an effective outreach program to inform the public about Steller sea lion biology, habitat utilization, and conservation issues

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APPENDIX 1. Managing and Maintaining Steller Sea Lion Prey Fields

A. Ecosystem Scale

While North Pacific groundfish fisheries are managed using F_{MSY} or $F_{40\%}$ strategies, these rates are often not reached in practice because of other constraints on total catch. These include caps on total annual groundfish catch (optimum yield) and bycatch of other species (e.g., Pacific halibut, Pacific herring, salmon and various crab species). Constraints on groundfish catch such as these have resulted in an estimated, long-term (through 1999) reduction of about 40% (instead of the target of approximately 50%) in total biomass of five fished species in the north Pacific for which long time series exist (NMFS 2000; their Figures 6.16 and 6.17). Two of these time series are for pollock stocks in the eastern Bering Sea and Gulf of Alaska. High harvest rates on pollock in the eastern Bering Sea in the early-mid 1970s resulted in 60-70% reductions in pollock biomass from theoretical unfished levels from 1973-79. Catch and effort controls established with the passage of the Magnusun Fishery Conservation and Management Act in 1976 along with strong pollock recruitment reduced this level of depletion to between 30-40% through the 1990s.

The short and long-term effects of current fishery management strategies on other species in the ecosystem are largely unknown. The NPFMC commissioned a review of the harvest control policies used to set catch quotas for groundfish in the North Pacific Ocean (Goodman *et al.* 2002). Among other requests, the review panel was asked "to determine if the current [single-species] quota setting approach is considerate of ecosystem needs" in the eastern Bering Sea, Aleutian Islands and the Gulf of Alaska. Goodman *et al.* (2002) noted (as did NRC 1996, Murawski 2000, NMFS 2000, Pikitch *et al.* 2004) that conventional, single-species approaches assume that stocks can be assessed and managed outside of the context of their role in the ecosystem as competitors, predators and prey:

> The conventional assessment world view does recognize that there is a natural mortality rate, *M*, operating on a target stock, and this natural mortality is assumed largely to be the result of consumption in the food web. Generally, *M* is assumed to be constant in the conventional assessment models, but it must be understood that this does not assume (or assign) a constant total consumption by higher trophic levels. The constant natural mortality rate, *M*, is in units *per capita* of the target species. Thus, the total consumption by higher trophic levels, when *M* is assumed to be constant, will vary in proportion to the target stock size (or biomass). A harvest management strategy, such as $F_{40\%}$, that by design reduces the biomass of the target stock biomass [*sic*] by a significant fraction, will, all other things being equal, reduce the total consumption by higher trophic levels by a similar large fraction, and we would expect the predator populations to be reduced accordingly. This may or may not be deemed a desirable, or acceptable, outcome from the standpoint of policy. And, in fact, all other things often are not equal, especially in ecosystems, and there are a variety of mechanisms whereby the reduction in target stock biomass by a harvest strategy such as $F_{40\%}$ could cause a more than proportional reduction in the populations of predators

dependent on those same stocks for prey, as is recognized in the ecosystem-effects world view.

Pikitch *et al.* (2004) describe an evolution toward ecosystem-based fishery management (EBFM) in which needs of other elements of the ecosystem are considered more directly in the quota-setting process. Ecosystem over-fishing could occur in the absence of single-species over-fishing if food web shifts or changes in predator populations resulted from fishery competition (Pikitch *et al.* 2004), or, more explicitly, if harvests of prey species impaired the long-term viability of ecologically important, non-resource species (Murawski 2000). As a step toward EBFM, Goodman *et al.* (2002) recommended alternative approaches to quota-setting and fisheries management, including the use of lower fishing mortality rates (e.g., $F_{50\%}$ or $F_{60\%}$), the creation of marine reserves (Dayton *et al.* 2000), and the introduction of risk analysis into the decision-making framework.

B. Local and Short-term Scales

In the 1980s and 1990, catch levels of pollock , Pacific cod and Atka mackerel increased from sea lion critical habitat as the groundfish fisheries evolved from foreign to domestic participants (Fritz 1995, Fritz *et al.* 1995, Fritz and Ferrero 1998; Figures II-2 and II-3). In some parts of critical habitat and in some seasons, this led to greater rates of harvest (catch divided by available biomass) inside critical habitat than outside (e.g., Fritz *et al.* 1995, NMFS 1998a), and suggests that in certain circumstances, fisheries reduced prey availability more in sea lion foraging habitats than in other areas outside. While this does not prove that prey densities were reduced to levels that affected sea lion foraging efficiencies, it suggests a disproportionate impact of fisheries within critical habitat than in areas outside at certain times. This was a central finding in support of two jeopardy and adverse modification determinations for groundfish fisheries in the North Pacific (NMFS 1998a, 2000).

Because of the potential impact shown by the groundfish fishery analyses, studies were initiated by NMFS Alaska Fishery Science Center to investigate the localized effects of fisheries on fish abundance and distribution (described at http://www.afsc.noaa.gov/refm/stocks/fit/FIT.htm). Each study was designed to address a specific question regarding fishery impacts. The Atka mackerel tagging study in the Aleutian Islands addressed the efficacy of trawl exclusion zones, specifically whether fish populations within the zone are isolated from those fished outside. Results to date (through late 2004) suggest that some trawl exclusion zones protect natural assemblages of fish because the zone and fish habitat boundaries were similar. These zones (e.g., 20 nm around Seguam Island and 10 nm around Tag Island) appear to be effective in creating 'oases' where Atka mackerel inside have little interchange with fished aggregations outside during the course of a single fishing season. Other zone boundaries cut Atka mackerel habitat in half (e.g., near Amchitka Island) which results in considerable fish movement between areas open and closed to the fishery. Thus, distribution of prey habitat around sea lion rookeries and haulouts should be an important consideration in the design of exclusion zone boundaries if they are to be effective in isolating local fishery effects.

NMFS's study of local pollock fishery effects near Kodiak Island was designed to detect differences in pollock abundance and distribution in fished and non-fished gullies. Pollock populations in the two gullies were not contiguous and separated by an area of low pollock abundance. To date, the study has yielded variable results because of patchiness and variability in fish as well as fishery distributions (Wilson *et al.* 2003). Results from the 2001 experiment revealed high temporal variability in adult pollock biomass in the treatment area, but not in response to the low levels of fishing effort that occurred that year. In 2002, little fishing occurred in the treatment area, while in 2004, there was a statistically significant decrease in pollock biomass in the treatment area following the start of commercial fishing (NMFS unpublished data).

The objectives of NMFS study of local fishery effects on the abundance of Pacific cod were similar to those of the pollock study. To date, the study has been characterized as yielding results that "overwhelmingly indicated no difference between sites in the trawled and un-trawled areas" (Conners *et al.* 2004). However, the trawled and untrawled areas in the cod study are directly adjacent to each other. The conclusion of 'no difference' was dependent on the assumption that cod populations in the two areas were completely independent, and that fishery effects would be entirely limited to the trawled area. This assumption is likely not met because there was substantial movement of fish into and out of the study area as well as with the larger fished area surrounding it. Thus, the conclusion of 'no difference' is limited to the specific assumptions used in the study and statistical designs.

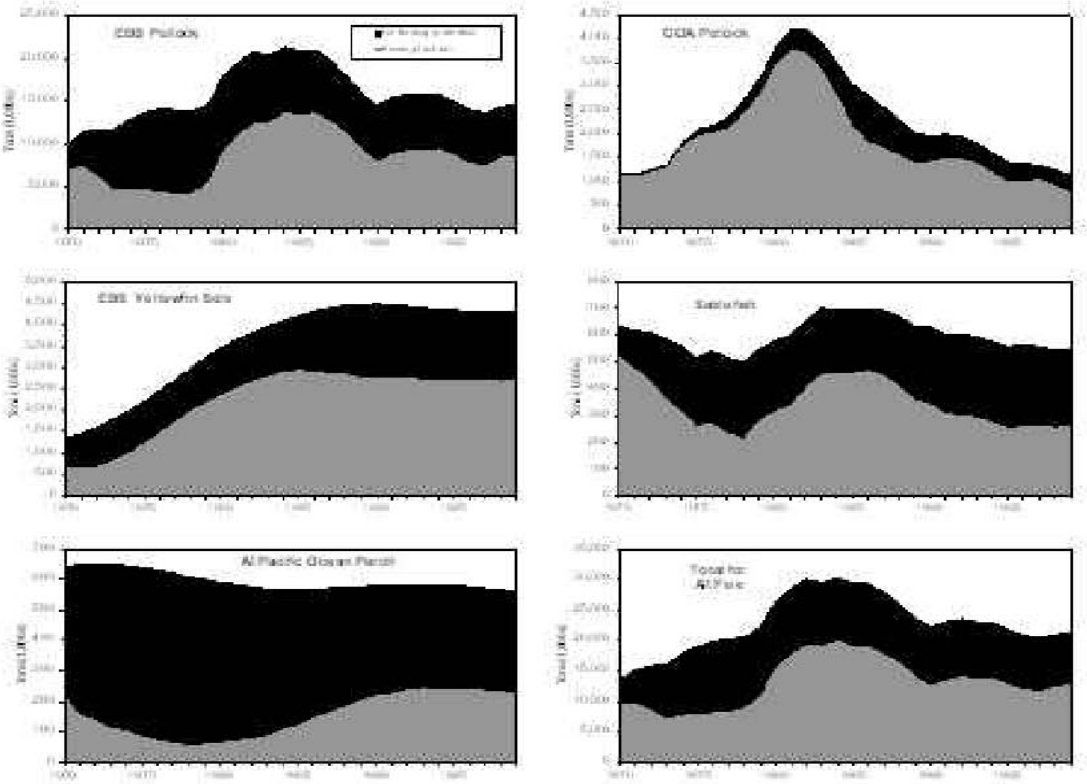

Figure 1. Estimated total biomass of various groundfish species in the eastern Bering Sea (EBS), Aleutian Islands (AI) and Gulf of Alaska (GOA) with and without fishing. The 'fished' scenarios are the results of age-structured modeling of these stocks through 1999 (NPFMC 1999), while the 'unfished' scenarios were constructed using the same recruitment time series but subjecting them only to natural, and no fishing, mortality.

APPENDIX 2. Nutritional Stress in Steller Sea Lions

A. Assessing Biological Manifestations of Nutritional Stress in Steller sea lions

When assessing the potential for nutritional stress in Steller sea lions it is important to distinguish between early and late periods of the decline as well as recent population trends. The decline in the number of Steller sea lions in the western DPS was rapid through the 1980s, but slowed during the 1990s. In terms of testing the nutritional stress hypothesis, this means that the animals currently available for study in the wild may no longer be affected by the factors that caused their initial population decline. Many of the biological indicators of past nutritional stress may therefore no longer be measurable. Nutritional limitation as indicated by reduced body size and possibly reduced reproductive performance during the early decline in the 1980s contrasts with more recent studies of Steller sea lions from the western DPS (Table 1). No evidence of acute nutritional stress currently exists for this population, nor has it at any time during the decline.

Much of the research from 1990-2004 to determine the extent to which nutritional stress could be a factor in the decline of the Western DPS Steller sea lions involved comparing individual animals from the Western and Eastern DPS. Many of the studies focused on pup condition, as well as maternal attendance patterns, foraging biology and adult dietary analyses. Contrary to what would be expected for animals experiencing acute nutritional stress, Steller sea lion pups in the early 1990s were heavier in the areas of population decline (i.e. the western DPS) than in rookeries where the population was increasing (Merrick *et al.* 1995). Pups at two rookeries within the area of decline were heavier in 1992-93 than prior to the decline in 1965 and 1975. Similar results were reported by Davis *et al.* (1996, 2004) who found no significant differences in pup birth sizes between declining and stable populations in the 1990s; nor were there differences in adult female body mass or composition. Rea *et al.* (2003) found no indication of poor body condition (based on percent total body lipid) in pups from either area. Paradoxically, Adams (2000) found pup growth rates were higher and females were larger by mass and length in declining western DPS areas (see also Brandon 2000).

Using a similar comparative protocol, researchers observed no differences or opposite than expected trends for Steller sea lion milk composition (Davis *et al.* 1996, Adams 2000), pup milk intake rates (Adams 2000), pup growth rates (Davis *et al.* 1996, Adams 2000), maternal attendance patterns and foraging trip duration (Brandon 2000, Milette and Trites 2003, Andrews *et al.* 2002) between the Western and Eastern DPS for Steller sea lions. All of these studies suggest that adult females at rookeries in the declining population did not have difficulty finding prey during the summer. Furthermore, no apparent difference was observed between average winter attendance cycles of females from the declining western DPS (Marmot Island and Cape St. Elias) and increasing eastern DPS (Timbered Island) haul out populations (Trites *et al.* 2006b). In the 21st century, no evidence has yet been found of exceptional pup mortality, low birth weights in the western DPS, or poor growth of pups in the area of decline. Body fat contents were highly variable in both areas at 15 months of age (Rea *et al.* 2003).

Blood chemistry and hematological parameters, including blood urea nitrogen (BUN), ketone bodies (e.g., b-HBA), hematocrit and hemoglobin concentration, show characteristic patterns

with changes in nutrition (Keyes 1968, Rea 1995), and have been experimentally induced in fasted Steller sea lion pups and juveniles (Rea *et al.* 1998b, Rea *et al.* 2000). However, Rea *et al.* (1998a) found no evidence of nutritional stress based on these parameters in wild Steller sea lions from areas with the greatest population declines. Red blood cell data from a study by Bishop and Morado (1995) reported elevated target cells and depressed poikilocyte levels in pups from the Western DPS compared to those in the Eastern DPS, indicative of anemia. Conversely, Castellini *et al.* (1993) reported no obvious differences in hematocrit or hemoglobin levels in pups during the 1990s from the western DPS compared to reference values. In evaluating serum haptoglobin levels (an indicator of acute stress response) in Steller sea lions, Zenteno-Savin *et al.* (1997) reported elevated serum levels in the western DPS compared to the east, but were careful to avoid speculation on the cause of these differences.

The general conclusion from these physiological studies comparing the eastern and western DPS during the 1990s has been that nutritional stress was not evident in the adult females or pups. Whether this was due to inherent biases in the study design or actual changes in the nutritional status of Steller sea lions in the western DPS is not known. One potential confounding factor in these studies may be habitat differences between the study sites. This would affect foraging times for sea lions (Andrews *et al.* 2002) as well as the aggregation of prey (Lowe and Fritz 1997). The large reduction in the western DPS Steller sea lion population by 1990 would likely affect relative prey availability for individuals through reduced competition. Despite poor knowledge of the underlying mechanisms, morphological (Williams unpublished data) and survey (Fritz and Stinchcomb 2005) data indicate a trend towards improvement for Steller sea lions in the western DPS relative to conditions in the late 1970s and 1980s, while other demographic evidence (Holmes and York 2003, Fay 2004) suggests a lingering chronic impact that could affect recovery.

1. Energetic Demands of Steller Sea Lions: Captive Diet Studies

A number of short-term diet manipulation studies on captive pinnipeds have been conducted to determine the effect of nutritional status on sea lion health. One such study reported that young Steller sea lions raised in captivity did not substantially increase food intake when switched from an *ad libitum* diet of herring to one of pollock (Rosen and Trites 2000a). The implication from this study was that the captive immature sea lions did not consume sufficient quantities of low-energy fish to maintain energy homeostasis, and thus lost weight during the experiments. A similar finding was reported for immature harp seals (Kirsch *et al.* 2000). When mature harbor seals were switched from high-fat herring to low fat herring, there was no difference in digestibility values, suggesting that digestibility may be more dependant on prey species and less dependant on nutrient composition of any particular type of prey (Stanberry 2003). In addition this harbor seal study showed that adult harbor seals can maintain body condition and health over a short period on a low-fat diet, mainly by slightly increasing their food intake (Stanberry 2003).

The maximum weight that a Steller sea lion can digest per day on a sustainable basis appears to be about 14-16% of their body mass (Rosen and Trites 2004). This finding is based on offering 1-2 year old captive Steller sea lions as much high-energy (herring) or low-energy (capelin) fish as they could eat every day, or every second day. In this study, young sea lions feeding on low energy prey needed to consume more fish than they were physically capable of to meet their

energy requirements. In contrast, older sea lions could consume the extra calories required without hitting the upper ceiling on digestive capacity. This was due in part to the lower relative energy needs of the older sea lions compared to young animals (Winship *et al.* 2002). Rosen and Trites (2002, 2004, 2005) found that Steller sea lions could alter their food intake in response to short-term changes in prey quality or availability. However, a diet composed of predominantly low energy prey combined with an interrupted schedule of feeding (i.e. on alternate days) necessitated food intake levels that apparently exceeded the physiological digestive capacities of young animals (Rosen and Trites 2004).

In comparison to adults, juvenile Steller sea lions on a constant "maintenance" level diet of either pollock or herring for 5 weeks over several seasons demonstrated marked seasonal effect on both body mass and composition (Rosen and Trites 2002, Kumagai 2004, Kumagai *et al.* in press). Sea lions maintained on a low-lipid pollock diet lost significantly more body lipid reserves during periods of high-energy utilization (i.e., growth) than animals on a high-lipid herring diet. Similarly, juvenile Steller sea lions on calorically equivalent, submaintenance diets of low lipid Atka mackerel showed a greater reduction in lipid reserves than when fed high lipid herring diets (Rosen and Trites 2002, 2005). If sea lions in the wild are similarly restricted in their energy intake, it could have detrimental effects on individual fitness. However, these theoretical effects remain to be demonstrated in free-ranging populations.

The duration of nutritional limitation, age of the animals, seasonal changes in energetic demands and effects of captivity appear to be important factors when evaluating the effects of diet on pinniped physiological responses. The aforementioned studies involved relatively short-term (2-6 week) changes in the diets of juvenile pinnipeds held in permanent captivity. Calkins and Trites (unpublished data) evaluated the effects of diet on free-ranging juvenile sea lions held in temporary captivity. One group of seven 1-2 year old sea lions was fed only pollock while another group of eight was fed a mixed diet composed primarily of herring for 2 months. All animals gained weight on both diets, and there were no significant differences in the rate of mass increase between the two groups, nor were there any negative health consequences detected in the treatment (pollock) group. In a four-month study of juvenile and adult harbor seals, Trumble *et al.* (2003) found no overall changes in body mass or composition attributed to *ad libitum* pollock/herring diet changes. The longest study conducted to date was conducted by Castellini (2002) and Calkins *et al.* (2005) and evaluated three different diets on three sea lions over a three-year period. The diets were designed to reflect the pre- and post-decline diets in the Kodiak area and that of sea lions in Southeast Alaska where the population has increased. Changes in body mass of one adult male and two adult females were not significantly different on the three diet regimes, which led the authors to conclude that sea lions could compensate for low energy prey by increasing their ingestion provided sufficient quantity was available.

Despite the differences in study designs and limited sample sizes, concurrence is developing between the various captive animal feeding trials. It appears that there are no differential effects between high-lipid and low-lipid (or low-protein and high-protein) prey on sea lion body composition when animals are able to consume sufficient prey to meet their energy demands. However, sea lions may not be able to consume sufficient prey due to increased energetic demands (e.g., seasonal growth or reproduction), digestive capacity limitations, and/or decreased prey availability.

2. Correlation of Diet Studies with Wild Steller Sea Lions and Other Otariids

Low energy prey such as pollock or capelin is part of normal Steller sea lion diets. For example, pollock makes up a significant portion of the diet of increasing populations of sea lions in Southeast Alaska (Trites *et al.* 2006d), and Pacific hake (*Merluccius productus*) is dominant in the diet of sea lions in Oregon (Riemer and Brown 1997). The key difference between the diets of increasing and decreasing sea lion populations in the North Pacific is the overall amount of low energy prey consumed by sea lions in each region (i.e., the average energy density of each meal; Winship and Trites 2003). Dietary data available for the 1990s (Sinclair and Zepplin 2002) further indicates that higher rates of population decline correlated with meals that had overall lower energy densities (Winship and Trites 2003). Conversely, several stable and increasing populations of otariids including California sea lions (Bailey and Ainley 1982, Riemer and Brown 1997, Gearin *et al.* 1999), Cape fur seals (Punt *et al.* 1995), and South American sea lions (Dans *et al.* 2004) have diets with a high proportion of relatively low energy prey (e.g., gadids).

APPENDIX 3 A PVA Model for Evaluating Recovery Criteria for Steller Sea Lions

A. Overview from the Steller Sea Lion Recovery Team

The primary intent of the ESA is to recover listed species, and the ecosytems on which they depend, such that the protections of the ESA are no longer necessary. Biological recovery criteria (criteria) form the basis from which to gauge a species' recovery and subsequent risk of extinction, whereas listing factor criteria ensure that the threats have been controlled or eliminated.

Recovery criteria are required under the ESA to be both measurable and objective. However, the ESA does not provide an explicit standard for those criteria, nor is there accepted agency policy regarding choices of risk. A probability (chance) of extinction over some period of time (e.g., 1% probability of extinction in 100 years) has been recommended by some as the quantitative standard for a species to be considered in high risk of extinction (Angliss and *et al.* 2002, DeMaster *et al.* 2004). The integration of such a standard in a modeling approach provides a definitive means to measure the risk of extinction. However, selection of the extinction value is a policy decision based on the acceptance of risk. Alternatively, criteria can be, and has traditionally been derived from a weight of evidence approach. This approach requires a thorough review and synthesis of all the available biological and ecological information regarding the species (or surrogate species), and the determination of essential demographic parameters (e.g., population abundance and trend, birth rates, age ratios, etc.) that would reflect that the species is no longer at high risk of extinction. The Team explored both approaches to develop criteria. This appendix is a brief overview of the quantitative approach using a population viability analysis (PVA) which employed a specific probability of extinction (>1% chance of extinction within 100 years). The PVA was developed by Dr. Dan Goodman (Montanna State University) under contract from NMFS. In contrast, the weight of evidence approach is provided in Section V.

1. Development of the PVA analyses

Substantial efforts have recently been directed towards developing rationale for determining extinction standards. Specifically, NMFS conducted a workshop to consider recovery criteria for large whales (Angliss *et al.* 2002) and a NMFS Quantitative Working Group has proposed guidelines on ESA listing criteria (DeMaster *et al.* 2004). Additionally, the issue has been discussed in peer reviewed literature (Goodman 2002, Reed *et al.* 2002). Although NMFS or the USFWS have not adopted specific guidelines for criteria, the recommendations from these efforts were used as the starting point in the development of criteria. The general principles that the Team used were:

- A probabilistic threshold is appropriate to describe the risk of extinction in the criteria;
- A long lived species shall no longer be considered endangered when, given current and projected conditions, the probability of quasi extinction is less than 1% in 100 years;
- A long lived species shall no longer be considered threatened when, given current and projected conditions, the probability of becoming endangered is less than 10% in 20 years;

- Current threats to the species, as well as those that brought the species to the point of listing, must be addressed in the criteria;

The PVA developed for the Team makes the assumption that the recorded history (roughly the last 50 years) of the western DPS is a combined result of natural variation and extraneous influences (i.e., incidental mortality to fisheries, illegal shooting and subsistence harvest, and reduced prey biomass and quality from fisheries). Based on available sea lion population counts, five time periods were selected to represent the population trajectory; 1958-77, 1977-85, 1985-1989, 1989-2000, and 2000-2004. However, these individual population trajectories are affected by human related impacts (e.g., shooting, harvest, fisheries). Because successful management measures have been implemented in the recent past, its is inappropriate to predicte future population trajectories based on historical conditions which are likely to be pessimistic (i.e., some of the previous sea lion mortality is unlikely to occur in the future due to the implementation of management measures such as a ban on shooting). Thus, the Team estimated the mitigated mortality attributed to some of the extraneous influences using best available empirical evidence and expert opinion.

In the model, the population trajectory of previous time periods was modified to reflect the mitigation measures currently in place. This was done for the 4 time periods prior to the current time period (2000-2004) which was not modified because this represents the base case of the current suite of mitigation measures. Therefore, the future population projections were based on the recorded sea lion population trend over the last 50 years, as modified by the effect of current mitigation measures. For example, we know that incidental take was a substantial mortality factor during the steep declines in the 1985-1989 time period. Based on current fishery management measures and restrictions on take, it is extremely unlikely that these high levels of take would occur again in the future. Thus, the trajectory in the model for this time period was modified to remove the amount of incidental take that the Team considered extremely unlikely to occur again. The mortality that remained during that time period (still a substantial rate of decline) was due to other factors that the Team could not identify with any quantitative assessment. The effect of making these changes is to decrease the future extinction risk, and decrease the potential time to recovery.

With estimates of intrinsic mean growth rate and associated variance, the model then probabilistically predicts future population trajectories. The Bayesian framework allows for specifying uncertain inputs as distributions, quantifies uncertainty associated with the estimation mechanism itself, and tracks the propagation of uncertainty through all the steps of the estimation and prediction.

Two complications particular to the western DPS presented substantial challenges to the PVA. First, is the sustained population decline (1970s through 2000s) which cannot be explained. Second, the North Pacific ecosystem is subject to naturally large physical and biological variation that likely constitutes the dominant process that drives sea lion population dynamics over long time scales (though this is not evident in the recent history of the eastern DPS).

The estimated magnitude of the extraneous factors (mitigation) did not account for much of the period of rapid decline in the late 1980s. Not unexpectedly, the initial model projections resulted in a relatively high probability of extinction in the next 100 years. Acknowledging the

possibility that factors beyond the extraneous influences may have affected sea lion population dynamics, the alternative scenarios described in the threats assessment (see Section IV) were then considered. These alternative scenarios, or hypotheses, represent how the cumulative and synergistic impact of various threats could have caused the past population decline. These alternative scenarios (as well as others not described here) are each scientifically plausible, yet the available evidence does not allow us to determine which of them is more likely. Thus, based on the expert opinon o f the Team, a probability of 0.2 (must be between 0 and 1) was assigned to *all* the alternative scenarios. In essence, this probability represents the likelihood that the assumptions of the PVA are incorrectand the western DPS is not likely to become extinct. The 0.2 probablity was then factored into the model results to determine extinction risk.

Model projections using the modified trajectories (mitigation measures) and the alternative scenarios (probability of 0.2) still resulted in a high probability of extinction. For a hypothesized future assessment in 2034 after 3 decades of 3% annual growth to a population size of 110,434 sea lions, the probability of quasi-extinction within 100 years is 9.71%. Review of the PVA revealed that the probability of extinction was most sensitive to the period of rapid population decline (about 15% per year) observed in the 1985 to 1989 period. Considering the possibility that the 1985-1989 period of decline was unlikely to occur in the future, another model run was completed with the 1985-89 time interval deleted from the time series. In those projections, after a period of 3% growth until 2024, the western DPS would have a 1.79% probability of extinction in 100 years.

2. Approch to the development of biological criteria for Steller sea lions

The Team reviewed the overall model structure, assumptions, and parameter values used in the PVA, and decided to use a weight of evidence approach for the criteria instead the quantitative probability of extinction approach. The rationale for that decision was based on the substantial uncertainty associated with the estimates of mortality due to extraneous influences, the uncertainty in the alternative scenarios, and the weak rationale for removing the 1985-1989 time period from the time series. Discounting the 1985-1989 time period as a catastrophe that is unlikely to be repeated is inconsistent with a precautionary approach. Further, the uncertainty in the strength of a density dependent response by sea lions is an important consideration. Although the alternative scenarios provide for a potential density dependence response, there is no evidence that such a response has occurred for sea lions, and the scientific literature provides little evidence to support that assumption.

Thus, the PVA was instrumental in providing the Team with insights on how the threats need to be addressed in order to develop downlisting and delisting criteria. Those insights were applied in using the weight of evidence approach in selecting the criteria, and especially in developing the listing factor criteria that determine how the threats must be controled or eliminated.

3. Discussion of various analytical approaches to estiamate Steller sea lion persistence

As discussed in Chapter I, several demographic models have been used to explore the population dynamics and persistence of Steller sea lions. Unlike previous exercises, this PVA is unique because it was developed specifically for the Team based on the explicit guidance and

input from the Team with the goal of generating recovery criteria. To accomplish this, decisions were made on important input parameters that were not obligatory in other models. Specifically, the extinction standard of 1% in 100 years was selected to provide a definitive measure of risk, while a quasi-extinction level of an effective population size of 1,000 was selected to maintain long term genetic viability. Other differences in fundamental assumptions were different between the PVA described here and those prepared earlier. For example, Winship and Trites (2006) based future simulations on population trends observed in the 3-4 intervals between 1978 and 2002. By contrast, projections in the Team's PVA were based population trends in 5 intervals over the 1958-2004 time period. Winship and Trites (2006) also examined the risk of extirpation separately for each rookery, assumed in one of three scenarios that density dependence would regulate those individual rookeries about their estimated 1990s carrying capacities, and modeled the 1985-1989 decline as a catastrophe that would not influence future trajectories. These differences in model structure and assumptions are important to recognize when comparing model projections.

A PVA MODEL FOR EVALUATING RECOVERY CRITERIA FOR THE WESTERN STELLER SEA LION POPULATION

Report to the Steller Sea Lion Recovery Team

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ABSTRACT

This is the report of a project to explore the use of a Bayesian population viability analysis, in a decision theory framework, to define recovery criteria that satisfy the requirements of the Endangered Species Act, for the western US distinct population segment of Steller sea lion. The project was undertaken by the author, as a consultant to the Steller Sea Lion Recovery Team that was in the process of writing a draft for a new Recovery Plan.

A subgroup of the Recovery Team provided three crucial inputs as expert opinion. These were: (1) quantification of necessary policy elements that are not fully specified in existing agency guidelines, (2) specification of some uncertain factual elements that were needed for the modeling but could not be fully determined by statistical analysis of hard data, and (3) specification of the probability of the essential correctness of the core assumptions of the PVA model that was used versus alternative hypotheses that greatly discount the risk to the population.

The standard adopted for downlisting from Endangered to Threatened was 99% probability of the population persisting for 100 years without declining below a quasi-extinction threshold. The quasi-extinction threshold adopted was 4743 individuals, corresponding to a genetically effective population size of 1000. The belief in the essential correctness of the model was quantified at 80% probability that the alternative hypotheses discounting the risk to the population are not correct. The subgroup drew up a table representing their opinion of the intensity, during respective past time intervals, of factors responsible for past threats to the population as used in the model.

The central hard data used in the modeling were the 6 available population wide estimates of population size, that span time intervals averaging approximately 10 years in duration. The salient features of the available information, from the standpoint of assessing extinction risk, are the combination of large, but much reduced population size, continuing and volatile decline for many decades until just a few years ago, unexplained dynamics, failure to recover as expected, and a context of very large fisheries operations and large natural ecosystem

variability.

The basic PVA model captures this state of knowledge by assuming that the population is subject to random changes in its growth rate, at random intervals, where the distribution of exponential growth rates is normal, and the distribution of interval length is exponential with a mean duration of 10 years. The dynamics in the model are not density dependent, and a specific analysis was done to elucidate the circumstances under which a population might go through such a wide range of population sizes without displaying density dependence.

The PVA model represents process variation through stochasticity of the changes in population growth rate and stochasticity of the time intervals between changes. The PVA model incorporates parameter uncertainty by representing the parameters of the distribution of population growth rates as a joint distribution of the uncertain mean and uncertain standard deviation. The joint distribution of these uncertain parameters was obtained by Bayesian inference from the past data, as adjusted by the subgroup's expert opinion concerning correction for threat factors that are believed to have had different intensity in the past than they will in the future. The primary reason for belief in these differences is the changes in implementation of regulatory protection for sea lions, and changes in the operation of the fisheries.

The basic model, applied to the data as adjusted by the subroup's inputs, and using the subgroup's policy specifications and appraisal of overall correctness, predicts almost 30% probability of quasi-exinction within 100 yrs from 2004, if the current level of protections is maintained. The population grew at roughly 2.8% per year in the interval 2000-2004. If that growth continues till 2024, the population size will then be 83,352 (roughly doubling the population size from 2004, in a little less than two generations). At that population size, and if the population growth were known to have stayed constant at 2.8% through two intervals, with all the other inputs the same, the assessment becomes almost 13% probability of quasi-exinction within 100 yrs from 2024, if the current level of protections is maintained. Absent knowledge of the rates of growth between 2004 and 2024, the attainment of a population size of at least 83,352 in 2024, with all other inputs the same, the assessment becomes about 19% probability of quasi-exinction within 100 yrs from 2024, if the current level of protections is maintained. All these scenarios fail to meet the risk standard for a downlisting criterion.

Sensitivity analysis shows that the observed, but unaccounted for, steep rate of decline in the period 1985-1989, contributes a very large component of the calculated risk, both through its influence on the inferred mean rate of population growth and its influence on the inferred random variation in growth rate. If this interval were removed from the analysis, a recovery criterion of 83,352 as the population size in 2024, with all other inputs the same nearly meets the standard (achieving 1.43% probability of quasi-exinction within 100 yrs from 2024, if the current level of protections is maintained). The subgroup was not able to justify exclusion of the 1985-1989 decline rate from the analysis, though it is acknowledged that there may have been some peculiarities in the fishery unique to this interval.

The large role of uncertainty in forcing the analysis toward very stringent recovery criteria (high population values), indicates that a new approach to extinction risk assessment, taking account of planned experimentation and a firm commitment to adjust management in response to future monitoring and results of experiments, may be the only way to obtain more readily attained recovery criteria while still satisfying the chosen standards. Reconciling this approach to present interpretations of the legal requirements of the Endangered Species Act may take some careful examination, particularly of the legal nature of commitments to future

implementation of a plan with contingencies based on results of future monitoring and experimentation, and the required demonstration that management measures built into the plan really are adequate to contain the risk. The theory of how to technically quantify the total risk of such a plan is known.

INTRODUCTION

Background to this Project

The western US distinct population segment (DPS) of Steller sea lions (SSL) was listed as Threatened under the Endangered Species Act (ESA) in 1990, and uplisted to Endangered in 1997. The current population is still rather numerous compared to most ESA large mammal populations that are listed as Endangered. The very dramatic decline, documented from 1958, from a population size that was an order of magnitude larger, is not accounted for by available quantitative data on factors affecting mortality or reproduction. The rates of decline themselves were highly variable over time, and the variation is not accounted for by available quantitative data on factors affecting mortality or reproduction. The marine system where these sea lions live has been subject to large scale commercial fishing activities, and the nature of the fisheries changed considerably in the era when the SSL decline was documented. The marine ecosystem where the western DPS SSL live is subject to considerable natural variation on a longer than annual time scale. Despite the institution of some protective measures at the time of first listing, the decline continued through the time of uplisting. After institution of more protective measures a few years after uplisting, the population, in the interval 2000 to present, has shown a definitely positive growth rate that is still much smaller than would be expected for a pinniped population that is far below carrying capacity. The eastern population of the same species, occupying a somewhat different ecosystem where different fisheries operate, showed consistent positive population growth over the past three decades, at a rate that is much smaller than would be expected for a pinniped population that is far below carrying capacity.

The combination of large, but much reduced population size, continuing and volatile decline for decades until just a few years ago, unexplained dynamics, failure to recover as expected, and a context of very large fisheries operations and large natural ecosystem variability presents a case that is a bit of a challenge to informal methods for developing decision rules for purposes of ESA regulation. In part this is owing simply to the unfamiliarity and ambiguity of this combination of circumstances. The prominence of uncertainty in this summary of the facts also adds to the challenge, for intuitive, non-quantitative approaches are not notably effective in factoring uncertainty into a decision process.

The decisions required under the ESA are verbally described, in legislation and regulation, in terms which can be re-expressed in the technical framework of statistical decision theory (Goodman, 2002a; Goodman, 2005), and the core quantitative population risk status assessments can be carried out by the methodology of Bayesian population viability analysis (Goodman, 2002b). In principle, a decision theory formulation and quantitative risk assessment approach might promote consistency and transparency, reduce ambiguities, and provide a structured and technically defensible approach for the scientific determinations required by the ESA.

When a new Steller Sea Lion Recovery Team (SSLRT) was convened, and charged with

producing a new draft Recovery Plan (SSLRP) for consideration by NOAA, a project was initated in 2002, funded by NOAA, for this author to consult with the new recovery team on development specifically of possible recovery criteria by means of a Bayesian population viability analysis in a decision theory framework.

The new SSLRT team is a large group, with representation of stakeholders as well as biological experts. A subgroup of members of the new recovery team, with quantitative interests and biological expertise and experience with SSL, was formed to serve as an expert panel during the course of this project. They had two primary formal roles in addition to providing a general wealth of knowledge about the Steller sea lion, its environment, and the available hard data. These formal roles were the quantification of policy elements that are not fully specified in existing agency guidelines, and the specification of expert opinion for uncertain factual elements that could not be fully determined by statistical analysis of hard data.

In particular

1. The expert panel provided the quantitative interpretation for the verbal standard corresponding to *not in danger of extinction*, and this was encapsulated in an explicit statement of the required probability for the population persisting above a stipulated numerical threshold for a stipulated period of time.
2. The expert panel provided the expert opinion on what would constitute reasonable assumptions about the quantitative magnitudes of a set of factors (used by the model) that historically influenced the population decline but that had not been monitored well enough to be estimated directly from data.
3. The expert panel provided the expert opinion quantifying the overall reasonabless of the assumptions of the model versus alternative hypotheses that would lead to a conclusion of much lower risk to the population.

These inputs from the expert panel are noted specifically in this report. In this sense, the resulting analysis constitutes a formal, quantitative and logical merging of the available pertinent population data, the subgroup's operationalization of otherwise ambiguous verbal policy constraints, the subgroup's expert opinion on some needed factual inputs about the past intensity of some of the threats to the population, and the subgroup's expert opinion about the suite of applicable hypotheses concerning the causes of the decline and the forces that will be operating in the future. The analysis takes account of both the data and the uncertainties. The analysis is documented in sufficient detail to show the influence of the data, the assumptions, the expert opinion, and the quantification of policy thresholds, on the calculated recovery criterion that results.

Recovery Criteria

A recovery criterion states a set of measurable and objective conditions which, if they actually are achieved, are believed, with high confidence, to indicate that the population will have a high probability of survival thereafter. The set of measurable and objective conditions may include evidence ensuring that specified threats have been controlled, and it may include

requirements for having attained a specified population size or having demonstrated some specified demographic rates for some specified period of time.

As a verbal narrative, the justification for a recovery criterion, or list of recovery criteria, will involve some account of how the population came to be endangered, an explanation of how the criteria will indicate that the original causes for the endangered status have been sufficiently controlled, and a description of why it is believed that, with the threats reduced to that level, and with the population having attained the stipulated status, the prospects really are high for continued persistence. Because of the complexity of ecological phenomena, and the incompleteness of our scientific knowledge, the coherence of this narrative may be difficult to judge if it is purely verbal.

A quantitative representation offers the advantage of unambiguous capture of all the details of knowledge, and assumptions, and acknowledged knowledge gaps, in a form that allows precise testing of whether they are indeed consistent with the available facts in accounting for the past, and in meeting the standard of predicting an acceptably high probability of population persistence for the future with a defined set of management measures in place. Further, a quantitative representation provides a means for calculating the probability that the recovery criteria will be attained, from the current state, in a specified amount of time, under a defined management scenario, given the evidence and the assumptions. A Bayesian population viability analysis (PVA) is the general statistical and modeling framework for accomplishing these simultaneous retrospective and prospective analyses.

A PVA for the western US population of the SSL will need to address two particular complications that are somewhat novel for the PVA enterprise, as it has been developed to date. One is that the most striking feature about the dynamics of this population is a very large chronic decline that is largely unexplained. The second is that the population occupies a portion of the North Pacific ecosystem that is now known to be subject to large, natural, long time scale, physical and biological variation, called oceanographic "regimes," so that the dominant process variation in the natural dynamics of the Steller Sea Lion population could conceivably be driven by these regimes on a time scale, roughly, of decades, rather than by interannual variation that is independent from one year to the next. A final major complication for analysis is that the period of well documented fast decline for the western SSL began more or less coincident with a well documented dramatic regime shift indexed by the Pacific Decadal Oscillation (PDO), but fisheries activities also changed greatly at about that time.

A PVA Approach for the Western US Steller Sea Lion

There are no direct recorded observations from which the numbers of the Steller Sea Lion could be estimated previous to the 1950's. It is not in dispute that the western US population of the Steller Sea Lion declined by approximately 80% between the 1950's and the year 2000. But there are several fundamentally different visions of why the population declined, and these portend very different predictions of how the population will fare in the future. Several of these different visions are scientifically plausible, but there is insufficient objective information now available for selecting one to the exclusion of the others.

The SSL population has persisted in substantial numbers in the north Pacific for the roughly 10,000 years since the last ice age, and the species is much older than that. The latest genetic data suggest that, up until the present decline, the population had not previously undergone severe genetic bottlenecks during the time since the last ice age, but it is not known

how much this constrains the possible long-past history of population swings. It also is not known how much the forces driving the population dynamics during the past 50 years depart from those that dominated the previous 10,000 years.

It is reasonable, but not certain, to assume that the dynamics of the population in the foreseeable future will be an extension of the recent dynamics, corrected for the effects of possibly unique ecosystem events that occurred during the last 50 years, and corrected for the effects of controllable human activities that, as a matter of policy, assuredly will not be repeated, or at least will be deployed differently in the future than they were in the recent past.

This does not deny a role for oceanographic regime shifts. The reality of large scale oceanographic variation is acknowledged, but forecasting of that variation for the future can only be probabilistic (stochastic), and the translation of the oceanographic variation to an effect on the SSL population can only be estimated from a very limited sample of recent observations.

In essence, this modeling approach treats the recorded history of the population as a combined result of natural variation, including the influences of regime shifts, and extraneous influences that were particular to the period. It attempts to factor out the effects of the extraneous influences, and then estimates the properties of the natural variation in terms of a mean growth rate and a pattern of long-term variance in the population growth rate. With estimates of intrinsic mean growth rate and its variance in hand, the model can then probabilisticly predict future population trajectories under scenarios of specified future extraneous influences (including management and regulation), which may depart from the known or assumed past. The Bayesian framework allows for specifying uncertain inputs as distributions, quantifies uncertainty associated with the estimation mechanism itself from the retrospective analysis (parameter uncertainty), and it tracks the propagation of uncertainty (both process variation and parameter uncertainty) through all the steps of the estimation and prediction.

The apparent dynamics of the Western US SSL differ fundamentally from those of the Eastern DPS. The Eastern population was considerably reduced, presumably primarily by shooting, earlier in the 20'th century, but since the institution of protection, this population, except for its southernmost portion (California), has been recovering fairly steadily at about 3% to 3.5%, with no evidence of decade-scale regime-like variation, and only slight environmental variation at shorter time scales. An analysis of the Eastern population data is given in Appendix A.

AVAILABLE POPULATION INFORMATION

Population Estimates

Six population-wide estimates for the Western US DPS of SSL are available at intervals of from 4 to 18 years, averaging 9.2 years. The estimates were put on a common basis in a draft analysis by a subgroup of the current SSLRT drawing on non-pup population estimates from Loughlin et al. (1992), Loughlin (1997), and Loughlin and York (2000), total population estimates in Fritz and Stinchcomb (2005), and reconciled with expansions for pup to non-pup ratios based on information in Calkins and Pitcher (1983) and Fritz and Stinchcomb (2005). From these census estimates, the realized (net) population growth rates for those five intervals

may be calculated.

year of census	population size estimate	realized (net) annual exponential growth rate
1958	227571	-0.00906
1977	191571	-0.04737
1985	131143	-0.16843
1989	66857	-0.04134
2000	42429	+0.02813
2004	47483	

Table 1.

We will assume that the censuses took place at or near regime phase transitions, so that the 5 growth rate estimates may be treated as independent samples from the distribution of growth rates. If in fact the census intervals straddle some regime shifts, the above assumption will result in an underestimate of the true process variation in growth rates, and will therefore underestimate the extinction risk.

Figure 1 shows the 6 census estimates as dots, plotted against year, and the line connecting the census estimates shows the trajectory corresponding to constant exponential growth within each interval, at the by-interval rates calculated in Table 1. This trajectory manifests the combined effects of uncontrollable ongoing environmental variation operating on the population, possible uncontrollable but unique events that will not recur, and mortality factors attributable to human activities that have been regulated and modified to some extent recently, and potentially can be controlled by regulation in the future.

For purposes of the PVA we will attempt to differentiate, both conceptually and numerically, between the population's underlying dynamics (including effects of natural, possibly regime-like, environmental variation) which we expect to continue to operate in the foreseeable future, and the extraneous factors that affected the dynamics over the period of record, but which we do not expect to operate in the same way in the future.

The very rapid decline in the 5 year 1985-1989 period is a matter of particular concern. A decline of 16% per year will doom any population if the decline continues or occurs too frequently without being balanced by enough episodes of compensating growth. In fact, available quantitative estimates of the magnitude of extraneous mortality factors during 1985-1989 only account for a modest portion of the 16% decline rate, leaving a considerable decline still unaccounted for. There were some peculiarities in the operation of the fisheries during this time that greatly increase the uncertainty about the magnitude of their influence. It is suggestive that the big decline in the 1985-1989 interval followed a short-lived, large winter pollock fishery in Shelikof Strait, Gulf of Alaska, and more or less coincided with the beginning of major winter fishing for pollock in the Bering Sea. Winter pollock fishing had not been pursued in either area to a large extent prior to the early 1980s. Both winter fisheries took

place in areas thought to be important for SSL foraging, and there is suspicion that winter foraging may be a critical factor for SSLs, especially for the young and adult females with pups. There was also a roe stripping operation at that time, where the entire stripped carcasses of adult pollock were discarded overboard, attracting SSLs and possibly increasing incidental catch. Subsequently, regulations prohibiting roe-stripping were enacted. The joint venture operations were at their height then, and there were very few observers on the domestic catcher vessels that delivered to foreign-owned motherships and processors. SSLs in the mid-1980s in the Gulf of Alaska may have been nutritionally stressed, as indicated by decreased growth rates and a possible reduction in late-term rates of pregnancy compared to SSLs collected in the mid-1970s (Calkins and Goodwin 1988; Pitcher et al. 1998).

Harvests, Shooting, and Incidental Catch

There is some information bearing on possible magnitudes for some of the mortality factors comprising the extraneous influences during the intervals for which growth rates can be estimated. Incidental catch estimates for the trawl fisheries based on observer data, were calculated by Perez and Loughlin (1990). Available quantitative information bearing on harvests, shooting, and incidental catch was compiled and analyzed by Trites and Larkin (1992). A draft analysis by a subgroup of the SSLRT extended and extrapolated the Trites and Larkin estimates. This resulted in the values in Table 2, where the cell entries are the accumulated number of deaths attributed to each cause over the interval.

	period				
	1958-1977	1977-1985	1985-1989	1989-2000	2000-2004
factor					
Non-subsistence					
direct harvest	45,178	0	0	0	0
Subsistence					
harvest	9,995	2,900	850	3,300	750
Non-harvest					
shooting	12,716	8,277	1,870	2,200	1,000
Incidental					
catch and gear					
entanglement	28,191	14,461	2,255	330	150

Table 2.

The historic non-subsistence direct harvest was confined to pups, and took place during a discrete subinterval, 1963-1972, of the period to which it is assigned.

Based on the Calkins and Pitcher (1982) analysis of sex ratio, age distribution, pregnancy

rates, and female reproductive history, of the individuals aged 3 and older in their sample of 250 sea lions collected between 1975-1978 from various sites in the Gulf of Alaska, and assuming stable age distribution and zero population growth, an adjusted model life table (Rebecca Taylor, pers. com.) for the SSL is developed in Table 3.

age class	survival rate	fecundity	stable age distribution	reproductive value
1	0.756	0.000	0.1650	1.000
2	0.756	0.000	0.1247	1.323
3	0.756	0.000	0.0943	1.749
4	0.867	0.100	0.0713	2.313
5	0.880	0.178	0.0618	2.552
6	0.888	0.257	0.0544	2.698
7	0.893	0.310	0.0483	2.748
8	0.896	0.310	0.0432	2.730
9	0.897	0.310	0.0387	2.700
10	0.898	0.310	0.0347	2.664
11	0.896	0.310	0.0311	2.621
12	0.894	0.310	0.0279	2.579
13	0.894	0.310	0.0250	2.538
14	0.894	0.310	0.0223	2.492
15	0.894	0.310	0.0200	2.440
16	0.894	0.310	0.0179	2.382
17	0.894	0.310	0.0160	2.317
18	0.894	0.310	0.0143	2.245
19	0.894	0.310	0.0128	2.164
20	0.894	0.310	0.0114	2.073
21	0.894	0.310	0.0102	1.972
22	0.894	0.310	0.0091	1.859
23	0.894	0.310	0.0082	1.732
24	0.894	0.310	0.0073	1.591
25	0.894	0.310	0.0065	1.432
26	0.894	0.310	0.0058	1.057
27	0.894	0.310	0.0058	1.255
28	0.894	0.310	0.0047	0.835
29	0.894	0.310	0.0042	0.587
30	0.894	0.310	0.0037	0.310

Table 3.

This model life table embodies more detail than can be supported specifically by the available data. Further, it is based on samples from a particular restricted spatial area and time period. Its only use here will be to correct for the effect of the age selectivity of the non-subsistence pup harvest, getting the pup harvest expressed in units dynamically commensurate with the mortality counts from the non-selective extraneous mortality factors.

In this model life table, the mean per capita reproductive value in the population, at stable age distribution, would have been 1.98893 and the cohort generation time would have been 12.05 (in units of age class). Accordingly, a pup harvest of 1 individual would have been demographically equivalent to an unselective harvest of 1/1.98893 individuals.

With the exception of the non-subsistence pup harvest, we will assume that all the other extraneous mortalities in Table 3 are unselective with respect to age and sex, and operated at constant per capita rates within each respective time period,

Prey Competition from Fisheries

Retrospective consideration of the history of the fisheries during the period 1958-2004 allows reasoned assignment of relative magnitudes of the mortalities that might be attributed to prey-competition fishery effects in the respective intervals. In this fashion, a subgroup of the SSLRT proposed a relative schedule of prey-competition fishery effects, expressed as instantaneous per capita mortality on a per year basis. These are listed below in Table 4. Note that from the history of the fishery it is believed that the prey competition effect was negligible in the first 10 years of the 1958-1977 period.

Start year of period	**Prey competition fishery effect (relative)**
1958	0.0
1968	0.015
1977	0.050
1985	0.060
1989	0.025
2000	——

Table 4.

As of 2000, the protections afforded around the rookeries, in critical habitat, and by the time area closures, under the terms of the Biological Opinion, were thought to have reduced to

a low level the fisheries prey competition effect due to local interactions, so all the fishery competition effect then remaining would have been the spatially diffuse effect of the TAC itself. The SSLRT subgroup was not able to put a quantitative estimate on that effect, even relative to the other components of the prey-competition fishery effect.

If it is assumed, as per the 2000 Biological Opinion, that the fishery restrictions imposed by the chosen Reasonable and Prudent Alternative in 2000 achieved a reduction of the prey-competition fishery-related depression of population growth by an amount corresponding to an absolute increment of 2.5% in annual growth rate compared to the prey competition fishery effect operating in the 1989-2000 interval, the assumed by-interval prey competition fishery effects may be scaled absolutely. With this assumption, the fishery prey competition effect, exclusive of the spatially diffuse TAC effect, could be read at face value from Table 4. The SSLRT PVA workgroup did not adopt this assumption, but we shall pursue it as a scenario in the analysis here.

CORRECTING POPULATION GROWTH FOR COUNT OF EXTRANEOUS DEATHS AND FISHING MORTALITY

Our interest is to calculate an underlying natural growth rate r_n for each interval, from the observations on net population growth and estimates of the count of deaths from extraneous factors and assumptions about mortality owing to prey competition from the effects of the fishery.

Consider an interval where the known sum of extraneous deaths q_x was the result of a constant instantaneous per capita extraneous mortality rate ρ_x operating within that interval, and where the assumed mortality rate attributed to the fishery-caused prey competition ρ_f also operated as a constant instantaneous per capita extraneous mortality rate, and where the observed population sizes at the beginning N_{t_b} and end N_{t_e} of the interval resulted from operation of a constant net per capita instantaneous growth rate r_Σ during the interval.

Within the interval, at time t, the population size may be interpolated as

$$N_t = N_{t_b} e^{r_\Sigma (t - t_b)} \quad . \qquad \text{eq[1]}$$

The instantaneous change in population size may be parsed as

$$\frac{dN}{dt} = r_n N_t - \rho_x N_t - \rho_f N_t \quad , \qquad \text{eq[2]}$$

where the first term is the net contribution of the underlying natural growth, the second term is the deaths and suppression of reproduction owing to the extraneous mortality tallied in the counts, and the third term is the prey competition fishery effect.

Then, q_x, the presumed known sum of extraneous deaths during the interval, must be equal to the integral of the deaths owing to ρ_x over the interval

$$
\begin{aligned}
q_x &= \int_{t_b}^{t_e} \rho_x N_t dt \\
&= \int_{t_b}^{t_e} \rho_x N_{t_b} e^{r_\Sigma (t - t_b} dt \\
&= \rho_x N_{t_b} e^{-r_\Sigma t_b} \int_{t_b}^{t_e} e^{r_\Sigma t} dt \\
&= \frac{\rho_x N_{t_b} e^{-r_\Sigma t_b}}{r_\Sigma} (e^{r_\Sigma t_e} - e^{r_\Sigma t_b}) \\
&= \frac{\rho_x}{r_\Sigma} (N_{t_e} - N_{t_b}) \quad . \qquad \text{eq[3]}
\end{aligned}
$$

From

$$r_\Sigma = r_n - \rho_x - \rho_f \quad , \qquad \text{eq[4]}$$

and

$$r_\Sigma = \frac{1}{t_e - t_b} \ln(\frac{N_{t_e}}{N_{t_b}}) \quad , \qquad \text{eq[5]}$$

we have, therefore,

$$r_n = \frac{1}{t_e - t_b} \ln(\frac{N_{t_e}}{N_{t_b}})(1 + \frac{q_x}{N_{t_e} - N_{t_b}}) + \rho_f \quad , \qquad \text{eq[6]}$$

which may be calculated directly for all intervals in the SSL data series except the first.

The first census interval, 1958-1977, presents some additional complications because the non-subsistence pup harvest was confined to the subinterval 1963-1972, and the fishery prey competition effect is presumed to have operated only for the subinterval 1968-1977. Therefore we have 4 effective subintervals, 1958-1963, 1963-1968, 1968-1972, 1972-1977, with different r_Σ, ρ_x, and ρ_f operating in each, but with an actual census available only for 1958 and 1977. This required numerical solution.

For notational compactness, designate the 4 respective subintervals with the subscripts $\alpha, \beta, \gamma, \nu$, referring also to the start year of the subinterval. Let ρ_x be the presumed constant extraneous mortality rate, exclusive of the pup harvest and the fishery prey competition effect, presumed operating at the same intensity in all 4 subintervals. Designate q_x as the tally of these deaths over all 4 subintervals. Let ρ_p be the presumed constant mortality rate owing to the pup harvest and operating only in subintervals β and γ. Designate q_p as the tally of the pup harvest deaths corrected for the age selectivity. Designate ρ_f as the presumed known growth rate reduction owing to fishery caused prey competition, presumed constant, but operating only in subintervals γ and ν.

The net realized growth rates for the respective subintervals, then, are

$$r_{\Sigma\alpha} = r_n - \rho_x \quad , \qquad \text{eq[7]}$$

$$r_{\Sigma\beta} = r_n - \rho_x - \rho_p \quad , \qquad \text{eq[8]}$$

$$r_{\Sigma\gamma} = r_n - \rho_x - \rho_p - \rho_f \quad , \qquad \text{eq[9]}$$

$$r_{\Sigma\nu} = r_n - \rho_x - \rho_f \quad . \qquad \text{eq[10]}$$

With a set of trial values for $(r_n, \rho_x \rho_p)$ these relationships allow a calculation of the associated intermediate population sizes

$$N_\beta = N_{1958} e^{5 r_{\Sigma\alpha}} \quad , \quad \text{eq[11]}$$

$$N_\gamma = N_\beta e^{5 r_{\Sigma\beta}} \quad , \quad \text{eq[12]}$$

$$N_v = N_\gamma e^{4 r_{\Sigma\gamma}} \quad , \quad \text{eq[13]}$$

and an associated "prediction" of N_{1977} that can be compared to the observed for a calculated discrepancy

$$\Delta N_{1977} = |N_{1977} - N_v e^{5 r_{\Sigma v}}| \quad . \quad \text{eq[14]}$$

Similarly, calculations following the logic of eq [3] can be used to "predict" associated values of ρ_x and ρ_p that can be compared to the trial values for calculated discrepancies

$$\Delta\rho_x = |\rho_x - \frac{q_x}{(N_\alpha - N_{1958})/r_{\Sigma\alpha} + (N_\beta - N_\alpha)/r_{\Sigma\beta} + (N_\gamma - N_\beta)/r_{\Sigma\gamma} + (N_{1977} - N_\gamma)/r_{\Sigma v}}| \quad , \quad \text{eq[15]}$$

$$\Delta\rho_p = |\rho_p - \frac{q_p}{(N_\beta - N_\alpha)/r_{\Sigma\beta} + (N_\gamma - N_\beta)/r_{\Sigma\gamma}}| \quad , \quad \text{eq[16]}$$

The quantity of interest is solved by a numeric search for the combination (r_n, ρ_x, ρ_p) that minimizes a weighted sum of the discrepancy terms. To adjust for the difference in scale between the mortality rate terms and the population size term, the latter was divided by 1000 in forming the weighted sum. The best combination found resulted in $7x10^{-4}$ as the weighted sum of discrepancy terms.

The set of calculated values of the by-period underlying natural growth rates, under the set of estimates for the extraneous mortality factors in Tables 2 and 4, in the base scenario taking the estimates in Table 4 at face value as absolute magnitudes, is given in Table 5.

Year of census	**Population size estimate**	**Realized (net) annual influences growth rate**	**Extraneous exponential growth rate**	**Underlying exponential**
1958	227571	-0.00906	0.02603	+0.01697
1977	191571	-0.04737	0.07010	+0.02273
1985	131143	-0.16843	0.07304	-0.09540
1989	66857	-0.04134	0.03487	-0.00647
2000	42429	+0.02813	0.01058	+0.03871
2004	47483			

Table 5.

The values in Tables 2 and 4 are open to question, so there is uncertainty attached to the last column in Table 5. The PVA subgroup of the SSLRT thought the methods used to arrive at estimates for the harvests, shooting, and incidental take, probably gave rise to defensible *minimum* values, but it was not clear what basis was available for expanding these to

defensible central estimates. The absolute magnitudes of the values for the fishery prey competition effects are speculative, but their relative magnitudes are indirectly supported by historical knowledge of the fishery.

It is sobering, in this connection, that for 3 of the 5 periods the estimated net effect of the extraneous influences is larger than the absolute magnitude of the estimated underlying growth rate. So the uncertain estimates of the components of the extraneous influences will matter to the analysis, and this uncertainty must be borne in mind in interpreting the results.

Figure 2 shows the 6 census estimates as circles, plotted against year, and the heavy line connecting the census estimates shows the trajectory corresponding to constant exponential growth within each interval, at the by-interval realized rates calculated in Table 1, while the thin trajectory shows a projection of a population initiated at the observed population size in 1958, and growing subsequently according to the calculated underlying growth rates for each respective period, as given in Table 5. This projected trajectory represents what would have happened, in the absence of density dependence, if, from 1958 on, the population had been released from the extraneous influences attributable to human activities as estimated in Tables 2 and 4.

The credibility of the underlying rates calculated to form Figure 2 rests on the estimates of extraneous mortality and reproduction suppression in Tables 2 and 4. The plausibility of the hypothetical trajectory shown in Figure 2, in particular the plausibility of whether the population would have reached the high densities shown, rests on whether density dependence would have kicked in at these high densities. The applicability of the calculated underlying rates at densities such as have been observed in the last 50 years is not connected to the question of density dependence at higher population levels.

ASSUMPTIONS AND ALTERNATIVE HYPOTHESES

Assumptions of the PVA

The PVA model assumes that the population dynamics in the foreseeable future will be governed by growth rates that change randomly at random intervals, where the lengths of the intervals represent environmental phases which have a characteristic average duration, and where the distribution of the growth rates is consistent with the sample observed in the past 50 years, adjusted for known extraneous factors that will not be represented in the future. This random growth is not density dependent. This kind of random walk in the population dynamics leads eventually either to extinction or impossibly large population sizes, so the very long history of the SSL could not have been governed by such dynamics.

In other words, the PVA model makes the two very particular assumptions, that (1) something in the SSL ecosystem changed in recent times and this is responsible for these ultimately unsustainable random density independent dynamics, and that (2) this change will continue into the foreseeable future.

These two assumptions do not commit to the details of what it is that changed. There are several possibilities such as effects of long term climate change, or community restructuring as a result of more than a century of harvesting heavily at certain levels of the marine food web. This could be consistent with some, but not all, of the hypotheses that have been advanced to attempt to explain the recent SSL decline.

From the standpoint of the PVA analysis, there are four main clusterings of pertinent hypotheses. These are

Hypothesis I.

Recently significantly altered ecosystem; the changed ecosystem condition will persist; the dynamics of the SSL observed in the last 50 years (after adjustment for identified extraneous mortalities that will not be repeated) are representative of the dynamics that will be manifested in this new ecosystem state; the dynamics are not significantly stabilized by density dependence in the range of population sizes between the recent levels and the level where Allee effects and loss of genetic diversity could become significant

Hypothesis II.

Recently significantly altered ecosystem; the changed ecosystem condition will persist; the dynamics of the SSL observed in the last 50 years (after adjustment for identified extraneous mortalities that will not be repeated) constitute a transition to a new lower carrying capacity; the future dynamics will exhibit sufficient density dependence around this new lower carrying capacity that, provided the identified extraneous mortalities of the past 50 years are not repeated, the population will not be at risk of declining within a 100 year time frame to a level where Allee effects and loss of genetic diversity could become significant

Hypothesis III.

Recently significantly altered ecosystem; the ecosystem condition will restore itself in the near future and stay in the restored (normal) state; in the restored state the SSL dynamics will themselves return to normal, and provided the identified extraneous mortalities of the past 50 years are not repeated, the population will not be at risk

Hypothesis IV.

The recent ecosystem dynamics are not abnormal in the long run for this population; the dynamics of the SSL observed in the last 50 years (after adjustment for identified extraneous mortalities that will not be repeated) are not abnormal for the population; the SSL population dynamics are sufficiently density dependent at population levels below the recent range that, provided the identified extraneous mortalities of the past 50 years are not repeated, the population will not be at risk of declining within a 100 year time frame to a level where Allee effects and loss of genetic diversity could become significant

Hypothesis **I** is the hypothesis underlying the PVA. Hypothesis **II** is distinguished from it by the interpretation that the recent SSL decline was a one-time transition and the assumption of strong density dependence. Hypothesis **III** is distinguished from the hypothesis underlying the PVA by the assumption that the recent dynamics will not be repeated and that the ecosystem conditions responsible for the recent dynamics will not be repeated. Hypothesis **IV** is distinguished by the assumption of very strong density dependence manifesting itself at lower population levels but not throughout most of the range of population levels experienced by the SSL.

All four hypotheses in the abstract have at least the plausibility of being scientifically possible. Hypothesis **IV** is perhaps undermined by the current genetic evidence probably being inconsistent with a history of such wide population swings, but this interpretation needs to be pursued with explicit genetic modeling. Otherwise, the available evidence is not compelling for selecting among the hypotheses.

The effective strength of density dependence and the carrying capacity that it confers play an important role in three of the hypotheses (**I**, **II** and **IV**). The recent dynamics of the SSL do not display density dependence. Thus, there is no basis in evidence specific to the SSL for justifying the assumption that density dependence is operating with the strength that would

need to be assumed under hypotheses **II** and **III** (but modeling can quantify the strength of density dependence that is assumed under each hypothesis). On the other hand, it is generally assumed that normal population dynamics for populations in normal circumstances will be density dependent. So the adoption of hypothesis **I** assumes that the recent (and foreseeable) circumstances of the SSL are not normal, which of course is possible. The plausibility of circumstances that can cause population dynamics to appear density independent is explored theoretically in Appendix B.

We are left then with conclusion that assigning relative probabilities to the four hypothesis clusters will be largely a matter of expert judgment tempered by the precautionary principle which would give greater weight to the more pessimistic Hypothesis **I** (which is the basis of the PVA) and also buttressed by the scientific principle of parsimony which would also give greater weight to Hypothesis **I**, in that Hypothesis **I** extrapolates most directly from the actual evidence, and so introduces fewer new assumptions.

Combining the PVA with the Alternative Hypotheses

Because the defining metric in the PVA result is a probability, analyses can be combined across scenarios by simply averaging the results weighted by probabilities assigned to the scenarios. This extends to consideration of some alternative core models as might be embodied in some of the hypotheses described above.

In particular, the three alternative hypotheses that depart from the assumptions of the PVA model can be distilled in modeling terms to two pertinent alternative conceptualizations: (1) that the population is subject to sufficiently strong density dependence that will over-ride the effects of fisheries and natural environmental variation to confer a very high probability that the population will not decline to or below the quasi-extinction level, or (2) that the recent history of the population was a consequence of freak conditions, not directly related to the local fishery operations, and these conditions have a negligibly small probability of recurring within the next 100 years.

While there is no compelling evidence for adopting either of these conceptualizations with high confidence, these alternatives cannot be entirely dismissed either. A precautionary approach would accord them low, but not necessarily zero, prior probability.

Since each of these alternatives predicts zero probability of quasi-extinction within 100 years, within a wide spectrum of management scenarios, it is a simple matter to average this together with the numerical result of the PVA as described here. Formally, if the PVA, which assumes that both alternatives are not true, yields a predicted probability of quasi-extinction of $X\%$; and the prior probability assigned to either or both of the alternatives being true is $Y\%$; then the overall probability of quasi-extinction is

$$Z = (1 - Y * 100) * X\% \quad . \qquad \text{eq[17]}$$

The PVA subgroup of the SSLRT adopted the value 20% for Y, to discount the risk estimate from the PVA for the probability that the model assumptions used in the PVA are fundamentally wrong.

MODEL STRUCTURE

Assume that, episodically, the population exponential growth rate r is drawn from a normal distribution with unknown, but stationary, mean μ_r and standard deviation σ_r. Assume that this growth rate r governs the population dynamics for the duration of the regime phase. Assume that the regime persistence is controlled by a constant Markovian annual persistence probability, so the persistence time will have a geometric distribution, and for annual persistence probability p_1, the mean phase duration $\overline{t}$ will be

$$\overline{t} = \frac{p_1}{1 - p_1} \quad . \qquad \text{eq[18]}$$

At each phase transition, the new value of r is drawn from the underlying normal distribution.

This is essentially the Brownian motion model used by Dennis, Munholland and Scott (1991), modified for predominantly "regime-like" variation in growth rates. The Dennis et al model has been widely used (reviewed by Kareiva in an NCEAS session). Of the plausible stochastic PVA approaches, the Dennis et al model makes the least data demands. Because it is highly simplified, it represents a kind of "null" model which is used by default unless data are available to support a more complicated model, or unless available data convincingly contradict the assumptions of the model in the context of its use.

In deference to the more or less decadal time scale of the PDO, the model was run with a specified mean phase persistence time of 10 years. This also corresponds roughly to the temporal resolution of the available population-wide estimates for the US portion of the western DPS of the SSL.

ESTIMATION OF MODEL PARAMETERS

Treat the 5 calculated underlying growth rates, based on the 6 population-wide census estimates and the estimates of extraneous influences, as representing an iid sample of 5 realizations from this process, and carry out a Bayesian inference, with conventional vague priors, on this basis, for the unknown mean and standard deviation of the underlying normal distribution of the exponential growth rates. The prior used for the mean μ_r was a uniform over a broad enough range so that the range did not influence the posterior. The conventional vague prior used for the process standard deviation σ_r had the probability of the variance σ_r^2 proportional to the reciprocal of the variance over a broad enough range so that the range did not influence the posterior.

The joint posterior distribution for (μ_r, σ_r) encompasses the parameter uncertainty pertaining to the distribution from which actual growth rates are drawn. Any particular value of the standard deviation σ_r represents the process variation for the stochastic population model. This estimation approach extends the Dennis et al procedure by incorporating parameter uncertainty, in the spirit of Ludwig (1996).

In the actual event, the available sample size of observed population-wide decadal growth rates is small for the SSL, so the parameter uncertainty in the estimation of μ_r and σ_r is large. Numerical exploration reveals that the uncertainty in μ_r is especially influential on the PVA results.

If the inference is carried out directly on the sample of growth rate values listed in Table 1, the resulting estimate of the parameters of the growth rate distribution will apply to the set of

extraneous influences that were operating at the time of those censuses. So, use of these estimates for future projection either assumes that those extraneous influences will continue to operate similarly in the future, or requires adjustment for the different operation of extraneous influences in the future.

If the inference is carried out directly on the calculated sample of underlying growth rate values listed in Table 5, the resulting estimate of the parameters of the growth rate distribution will apply for a future in which all the extraneous influences, estimated in Tables 2 and 4 and accounted for in calculating Table 5, are eliminated. Other scenarios may be created by estimating parameters from the underlying sample (Table 5) for the retrospective analysis, and, for the prospective analysis, adding to these estimates the effects of the assumed values for the future operation of extraneous influences. In particular, analyses to evaluate the adequacy of downlisting or delisting criteria need to be explicit about what level of protections–and therefore what magnitude of extraneous influences–are presumed to be operating *after* the downlisting or delisting, so that these are reflected correctly in the risk assessment.

USE OF THE MODEL FOR ASSESSING PROBABILITY OF PERSISTING FROM PRESENT STATE

The algorithm for use of the model for assessing the probability of persistence is as follows:

1. Conduct a retrospective analysis from the data and estimates of the history of extraneous influences, to obtain a posterior distribution of the parameters (μ_r, σ_r) that define the distribution of the underlying growth rates.
2. Then, for the prospective analysis, compute a sample of population trajectories, each spanning the time horizon of interest (100 years), and each initialized at a specified population size. For each trajectory draw one realization of (μ_r, σ_r) from the posterior distribution obtained by the Bayesian inference, and adjust that value for whatever is assumed about the extraneous influences (and management) operating in the future. Initialize the environmental state with the last growth rate observed in the data series (adjusted as per the assumptions about future extraneous influences). For each time step in the model, project the population according to the prevailing growth rate, and sample a binomial with parameter $(1 - p_1)$ for regime phase transition. At each transition draw a new value of r from the normal with parameters (μ_r, σ_r) as assigned to that trajectory. At each time step test whether the population size has declined below the quasi-extinction level. Record the fraction of trajectories which have declined below the quasi-extinction level at least once before reaching the time horizon. One minus this fraction is the probability that the population will persist till the time horizon without quasi-extinction.

Quasi-extinction Level

From genetic considerations, the quasi-extinction level chosen by the PVA subgroup as the reference point for a standard is an *effective* population size of 1000. This value is in the range of the values currently proposed in the conservation genetics literature for maintaining long term genetic viability (reviewed by Allendorf and Ryman, 2002). Taking into account the

fraction adult, fraction reproductive, and sex ratio among reproductive individuals in the population, as estimated in a draft analysis by a subgroup of the SSLRT, an effective population size of 1000 for the SSL corresponds to a total population size of 4743 individuals. This will define quasi-extinction in the analyses conducted here.

Persistence Standard

The PVA subgroup of the SSLRT adopted a standard of less than 1% probability of quasi-extinction within 100 years as the risk threshold for downlisting from ESA Endangered to ESA Threatened. This standard and its rationale are documented in an earlier NMFS workshop considering recovery criteria for large whales (Angliss, et al., 2002).

PVA STANDARD FOR DOWNLISTING FROM ENDANGERED TO THREATENED

PVA standards for persistence generally are stated in terms of a probability for persisting a specified period of time without declining below an extinction, or quasi-extinction, threshold. The standard adopted by the SSLRT PVA subgroup for downlisting from ESA Endangered to Threatened is:

Greater than 99% probability that the population will persist for 100 years without declining below the quasi-extinction level.

That standard will be used in this analysis.

Base Scenario

The base scenario considered here estimates dynamic parameters from the underlying sample (Table 5) for the retrospective analysis, and, for the prospective analysis, adds to these estimates the extraneous influence rates associated with the 2000-2004 period. This assumes that the protections of the RPA adopted under the 2000 BiOp, and the spatially diffuse effects of the current TAC, will continue into the future, even after downlisting and delisting, should these occur.

Time to Quasi-extinction from 2004

Under the base scenario, the inference on the parameters of the distribution of underlying growth rates yields the posterior marginals for (μ_r, σ_r) shown in Figures 3 and 4. The distribution of μ_r is approximately normal (theoretically it is expected to be t-distributed), and the distribution of σ_r is gamma-like, and their posterior correlation is approximately 0, showing that this Bayesian inference has properties rather like a t-test (which would be expected theoretically).

The posterior distribution of the derived quantity, time to quasi-extinction (truncated at 500 yr), is shown in Figure 5, with a blow up for times up to 100 years in Figure 6, and a cumulative for times up to 100 years in Figure 7. The probability of quasi-extinction within

500 years from the date of the assessment, 2004 (the date of the last census in the data series used), is 73.13% (Figure 5). The probability of quasi-extinction within 100 years from the date of the assessment is 37.23% (Figures 6 and 7), so the present state is far from qualifying for the recovery standard.

The distribution of population size at the 100 year time horizon in this analysis is shown in Figure 8. This shows a 83.20% probability of numbers less than 500,000 so the absence of density dependence is allowing some degree of optimistic "escape" very high population size by some modest fraction of the trajectories. If we consider 500,000 to be the plausible ecological limit for the SSL population size, then the model allows 16.8% of the trajectories to escape to unreasonably large population sizes, but even if density dependence held these trajectories below 500,000 very few of them would give rise to quasi-extinctions, because these are predominantly trajectories driven by more favorable values of (μ_r, σ_r).

Diagnosis of the Sources of the Present Risk

Much of the extinction risk emerging from the results of the inference in the retrospective analysis is owing to the presence in the sample of the 1985-1989 period where the estimate of the underlying growth rate is a disconcerting -9.45% after correction for the estimates of the extraneous influences during this period. If this period were omitted from the sample used in the sample for the retrospective analysis, the remaining sample of underlying growth rates would have a definitely positive mean and a much reduced variance. Such a retrospective inference would lead to a more favorable prospective analysis. The effect is dramatic: the assessment in 2004 would be that the probability of quasi-extinction within 100 years would be 3.47%, roughly one tenth the risk calculated when 1985-1989 is included in the sample.

USE OF THE MODEL FOR EVALUATING RECOVERY CRITERIA

Meeting the Standard in the Abstract

The standard generally is understood to be a threshold probability for persisting a specified period of time without dropping below the quasi-extinction level. Therefore, the most generalized statement of a recovery criterion, given a PVA model that calculates the probability of quasi-extinction, would be:

Any set of circumstances which the PVA calculates to have a probability of quasi-extinction that meets the standard, qualifies for a determination of "recovered."

This approach is certainly logically coherent, and it also has the property of *efficiency*, as will be discussed below, but it does not have the motivating appeal of superficial simplicity and concreteness. In other words, intuitive comfort with a generalized criterion of this sort requires a degree of technical understanding.

Simple concrete criteria, expressed in terms of a threshold population level and/or a period of threshold population growth, can serve as more readily understood targets. Conceivably, such targets could help to guide recovery strategy for a population where there are opportunities for various sorts of interventions with predictable effects on age-specific vital

rates.

There are two types of approach to simple concrete criteria. One is a sample list of scenarios, that have been pre-analyzed to determine which do, and which do not, meet the standard. If the list of scenarios is not exhaustive, the list will not constitute a comprehensive decision rule, because circumstances can be encountered which are not categorized by the list of scenarios. Essentially, they function as illustrations, which may suffice to convince an audience about the reasonableness of use of the PVA to test for meeting the standard; and the list may suggest a pattern for guiding recovery strategy.

The second type of approach to concrete criteria collapses the dimensionality of the pertinent description of the population to a single orderable measure, and identifies a critical value such that above that value it is predicted that the standard will be met, and below that value it is predicted that the standard will not be met. For the collapsed description to be intuitively satisfying, the combining formula needs to be very simple, and the inputs need to be very simple. It remains to be determined whether such a collapsed description will actually be an effective predictor. If the predictive power is degraded by the collapsed description, maintaining a constant level of precautionary performance will require a wider safety margin. This will be inefficient.

Consider that a PVA making full use of the information available delivers a distribution of time to extinction as in the thick curve in Figure 9, where the spread of the distribution reflects both the real process variation in the projected stochastic population growth, and the uncertainty about the parameters of that projection. Imagine that this result just meets a particular standard, in that the tail of the distribution to the left of threshold level T_h has area A_c, where the standard is that the probability of extinction by time horizon T_h must not exceed A_c.

Increases in the parameter uncertainty, as would occur through use of some "index" rather than using all the available information, will increase the spread in the distribution, as in the medium curve in Figure 9. Because the tails of the medium curve are extended compared to the thick curve, more area under the medium curve will spill over into the tail to the left of T_h, giving a higher probability A_i of extinction before T_h, thus failing to meet the standard.

Therefore, to meet the standard, the simpler index needs to indicate a more favorable central value, for example a higher population level if the index is based just on population level, shifting the curve to the right till the tail area left of T_h again equals the standard A_c, as in the thin curve in Figure 9. This shift to a more demanding value of the less informative index is the added margin of safety that is the practical cost imposed by abandoning pertinent information.

These theoretical issues are explored in greater detail in Goodman (2002b). Figure 9 was created using the theoretical, Poisson failure process, model from that analysis, where the medium curve represents a scenario that differs from the thick curve only in the length of the observation period, affecting the uncertainty in the "data," but with the same raw failure event rate in the data, and the mean time to quasi-extinction in the two scenarios is very similar (161 versus 153 years). But the scenario with the greater uncertainty has a considerably larger tail area for times less than 100 years. The thin line represents a scenario with the same length of observation period as the medium line, but with a substantially lower (40% smaller) raw failure event rate, giving about the same tail area below 100 years as the thick curve, and a considerably longer mean time, about 233 years.

Fully Specified Example Scenario Approach

The algorithm for use of the model for assessing the probability of persistence in a fully specified future scenario is as follows:

1. Express the candidate recovery scenario as a concrete population trajectory into the future, in terms of the quantities that the model uses as input. In the case of the Brownian motion model, these consist of (a) a certain number of regime phases with particular growth rates manifested, as inputs to the inference component, and (b) a particular population size reached, as input to the stochastic projection component.
2. Treat the stipulated future trajectory as if it were observed, and append it to the actual data series.
3. Carry out the PVA analysis for a projection from the end of the combined series of actual and stipulated "data," for a duration specified by the chosen standard. Compare the calculated probability of persistence to the standard: if it meets the standard, the candidate scenario can serve as a sufficient recovery criterion. I.e., if that scenario materializes, a determination of recovery would be justified.

But this would not be a necessary criterion, since there would be many possible ways of *not* matching this scenario, involving different population levels and different future growth rates–some might meet the standard, and some might not.

This fully specified example approach allows the postulated "example criterion" to influence the prospective PVA analysis both by setting a starting population size and by adding the stipulated trajectory between the present and that future starting time to the sample of observations that condition the inference on (μ_r, σ_r).

The only period of observed positive net population-wide growth for the Western US DPS showed an annual growth rate of just under 3% per year (2.813%). This is also roughly equal to the long term growth rate observed for the Eastern population, north of California. For these reasons it is reasonable to first explore recovery criteria premised on observing a continuing 2.813% growth for different periods of time.

To explore the adequacy of a recovery criterion based on a stipulated number of decadal "regime phases" of continued growth at 2.813%/yr (the current apparent growth rate), premised on all the present protections represented in the 2000-2004 period continuing into the future (including the 100 year period over which the projection is conducted to assess extinction probability), we add decadal intervals with 2.814% growth to the analysis, and redo the inference on (μ_r, σ_r) conditioned on those future observations, and redo the 100 year stochastic projection based on the new inference and with the new starting population size based on continued 2.813% growth.

This scenario premised on particular future data, yields a future inference with less uncertainty about (μ_r, σ_r) compared to the present, and a larger posterior mean for μ_r and a lower posterior mean for σ_r.

The result for the hypothesized future assessment in 2014, after one decade of growth to a population size of 62,911 is a higher probability of persistence from that time. Compared to the present base scenario, the probability of quasi-extinction within 100 years from the time of the assessment is reduced by roughly one third to 25.01%. For a hypothesized future assessment in 2024 after 2 decades of growth to a population size of 83,352 the probability of

quasi-extinction within 100 years from the time of the assessment is reduced roughly by one third again to 15.97%. For a hypothesized future assessment in 2034 after 3 decades of growth to a population size of 110,434 the probability of quasi-extinction within 100 years from the time of the assessment is reduced by roughly one third yet again to 9.71%.

Concrete Criterion Approach

The algorithm for use of the model for assessing the probability of persistence from the time of future assessment conditional on having attained a concrete specified criterion is as follows:

1. Express the candidate concrete specified criterion as a threshold population size at a specified check in time. This is an unambiguous criterion since it partitions the set of all future trajectories into a subset that meet the criterion and the remainder that do not. The probability of falling in each subset, based on current information, can be calculated, as can the probability of meeting the actual standard, subsequently, conditional on falling in the subset that meets the criterion.
2. For the present case, analyze the existing data (through 2004), with the likelihood function modified to assign zero likelihood to all (μ_r, σ_r) combinations that give rise to trajectories that do not meet the specified criterion (assuming that the protections and extraneous influences of the 2000-2004 period continue into the indefinite future), while allowing the fit to the data for the 5 observed intervals to determine the likelihood for all (μ_r, σ_r) combinations that do meet the specified criterion. This is equivalent to inference on the combined data set of the 6 existing censuses assuming that each occurs at a regime transition, assuming the estimates of extraneous factors for those intervals assuming those values are exact, and using the incomplete hypothesized future information that the population exceeds the criterion threshold size at the specified check in time (but without knowledge of the particular population size at check in time, and without knowledge of the regime transitions between 2004 and the check in time or of the intermediate details of the population trajectory). The resulting inference on (μ_r, σ_r) then will be conditional on having met the specified criterion, and so the derived parameter, time to quasi-extinction, will also be conditional on having met the specified criterion.

Comparing the calculated probability of persistence to the standard will reveal the adequacy of the candidate concrete specified criterion.

For the example criterion of a population size of at least 83,352 individuals in 2024 (for comparison to the fully specified scenario of 2 regimes of constant growth at 2.813% to that same population size at that date), the resulting performance is 23.92% probability of quasi-extinction within 100 years of the check in time for the candidate concrete criterion. As expected, this performance is inferior to that of the comparison fully specified scenario, which yields a 15.97% probability of quasi-extinction within 100 years of the assessment in 2024.

For the scenario where the 1985-1989 period is excluded from the retrospective analysis, the performance for a criterion of a population size of at least 83,352 individuals in 2024, the resulting performance is 1.79% probability of quasi-extinction within 100 years of the check in time for the candidate concrete criterion. For the scenario where the 1985-1989 period is excluded from the retrospective analysis, the performance for a criterion of a population size of

at least 62,911 individuals in 2014, the resulting performance is 2.55% probability of quasi-extinction within 100 years of the check in time for the candidate concrete criterion.

USE OF THE MODEL FOR ASSESSING THE PROBABILITY OF ATTAINMENT

The algorithm for assessing the probability of attainment of a concrete criterion is as follows:

1. Compute a sample of population trajectories, each spanning the time allotted for the recovery criterion, from present, and each initialized at the present population size. For each trajectory draw one realization of (μ_r, σ_r) from the posterior distribution obtained by the Bayesian inference from just the actual observations. For each time step in the trajectory, sample for regime shift; and at each regime shift draw the governing growth rate for that regime phase from a normal distribution with parameters (μ_r, σ_r), and project the population size accordingly until the next regime shift.
2. For each trajectory test whether the recovery criterion is satisfied within the allotted time. This fraction of trajectories that meet the criterion is the probability of attainment, from the present, of a state satisfying the recovery criteria.

It is worth noting, that this analytical mechanism could also be used for evaluating jeopardy, since jeopardy is defined as reducing the prospects for recovery.

For the example criterion of a population size of at least 83,352 individuals in 2024, the probability of attainment, assessed from 2004, is 40.45%. For the scenario where the 1985-1989 period is excluded from the retrospective analysis, the probability of attainment, assessed from 2004, is 42.86%.

STRATEGIES FOR REDUCING UNCERTAINTIES

The numerical values used for taking account of anthropogenic effects and regulation in the past data have a large influence on the outcome of the analysis. Uncertainties, because they introduce more spread into the distributions in the stochastic projection, increase the probability of quasi-extinction, and therefore force larger margins of safety into the calculated recovery criterion.

The exploratory removal of the underlying growth rate estimate for 1985-1989 from the sample used for this retrospective analysis was shown to be highly influential. Such removal cannot be justified from the present position, without greatly revising the judgment about the probability of alternative hypotheses (i.e., either this is encompassed in the alternative hypothesis of freak conditions that will not be repeated, or it constitutes a new alternative hypothesis about the uncertainty of the extraneous influences estimates for 1985-1989 compared to their uncertainty in the other periods in the data record). Of course, if new information were to come to light about a higher magnitude (than estimated in Tables 2 and 4) for the extraneous influences operating in 1985-1989, this could be used directly to obtain a new estimate for the underlying growth rate in this period, which would increase the estimate of the mean growth rate and decrease the estimate of its variance, leading to a lower calculated

risk in the prospective analysis.

There probably is not much that can be done about the uncertainty surrounding past events, such as shooting, which were not actually monitored or reported.

The effects of the 10 and 20 nm trawling closures and the time-area closures are not known. Knowledge of these rates will also be crucial to evaluation of the circumstances under which such protections might be lifted. These rates could be addressed in the future with large scale experiments. The outcomes of those experiments might lead to less restrictive recovery criteria, and more generous regulations.

SUMMARY AND CONCLUSIONS

The representation of environmental variation in this PVA analysis, often downplayed in PVA models, introduces a large source of extinction risk with the parameter values estimated from the data for the western DPS of SSL (but not the eastern DPS). Even taking all the expert opinion estimates at face value, to attempt to account for some components of the observed population decline in the respective periods bracketed by survey estimates, the resulting sample of calculated regimal underlying growth rates has a negative mean and a large variance (sample variance), so the growth rate distribution inferred in the retrospective analysis drives the prospective analysis to high extinction probability. The negative mean and high variance in the sample of estimated underlying growth rates is owing in substantial part to the presence in the sample of the large negative value for the 1985-1989 period.

Assumptions and Sensitivity

The only scenario, encountered in this limited analysis, which offers some prospect for downlisting in the time frame of two decades, sets the downlisting criterion at a population size of 83,352 in 2024; and is subject to some significant side conditions. To obtain a risk estimate near the standard of 1% probability (1.43% is achieved) of quasi-extinction within 100 years, this criterion requires the following:

1. omission of the 1985-1989 estimate of underlying growth rate from the retrospective analysis, (restoring this period to the sample multiplies the calculated risk by a factor of 13.4),
2. acceptance of the harvest, shooting, and incidental catch estimates for the other periods as correct, (if these estimates are 25% too high, the calculated risk is multiplied by a factor of 1.056)
3. acceptance of the prey-competition fishery-effects relative estimates for the other periods as absolute and correct, (if these estimates are 25% too high, the calculated risk is multiplied by a factor of 1.54),
4. acceptance of the combined 20% probability of the alternative hypotheses for the core model, (if the true probability of the alternative hypotheses is 0, the calculated risk is multiplied by a factor of 1.25), and
5. assumption that the extraneous influences in the future will continue at the 2000-2004 level, even after downlisting, (if the sum of extraneous influences operating in the future is increased by a factor of 1.25, the calculated risk is multiplied by a factor of 1.21)

We see, from a sensitivity standpoint, that the key requirement, for the favorable assessment of this downlisting criterion, is the discarding of the data for the 1985-1989 period from the retrospective analysis. But the justification for this manipulation is obscure. The possibility that the natural conditions during 1985-1989 were abnormal (and will not recur) is already represented in one of the "alternative hypotheses," which has already been taken into account, and assigned a probability in the expert opinion of the PVA subgroup.

The remaining possibility is an additional "hypothesis" about the data. This is the possibility that the estimates (in Tables 2 and 4) of extraneous influences and prey competition effects for the 1985-1989 period are wildly unreliable (and grossly under-represent the true values), but the estimates for the other periods are reasonably accurate. This is *possible*, as it is known that the nature of the fishery activity during 1985-1989 was quite different from what it was in the other periods, and there was essentially no monitoring of the effects. On the other hand, there is no basis in evidence to assign a really high probability to this possibility.

Risk Control through Adaptive Policy

We are left then with a superficially attractive recovery criterion whose performance depends on an unsupported, but possible, hypothesis. If this criterion were adopted, and acted upon for downlisting in 2024, with current information, this would not control risk to the level demanded by the standard. A much more stringent criterion would be required to meet the standard, but this would entail a considerably longer wait for downlisting.

The resolution to this impasse is to accept the uncertain downlisting *conditionally*, and build into the plan for the management after downlisting a set of monitoring and protection contingencies that will control risk to a finer level than is attained by the criterion itself. The basic idea is to use the future monitoring to provide a level of certainty about the presently uncertain key assumptions, and to use the commitment for management responses to the results of that monitoring as a guarantee that the actual risk will be kept to an acceptable level. The risk containment effect would be achieved by the three-fold commitment:

1. that downlisting does not reduce any protections until experimentation and monitoring proves (to a precautionary standard) that this lifting of protections will not raise the risk above the downlisting standard,
2. that there will be adequate monitoring for any indications of a departure from the critical assumptions, most especially a high resolution monitoring to detect any return of a period of rapid unaccounted for decline,
3. and a firm plan for increasing protections by an amount predicted to compensate adequately, should such a decline be detected.

The design, optimization, and rigorous evaluation of such an adaptive system is the next technical challenge to pursue in the development of the mathematics and computational implementation of Bayesian PVA analysis, building on the methods presented here for assessing conditional probabilities of extinction.

In pursuing the potential of adaptive recovery plans, the distinction between verbal and mathematical standards becomes extremely important. The label "adaptive management" has

had some currency for over a quarter century, during which time it has suffered from denoting a wide spectrum of actually different enterprises. At one end of this spectrum is the rigorous theory of optimizing the trade-offs among experimentation, risk, and action under uncertainty (Walters and Hilborn, 1976). At the other end of the spectrum is the temptation to call any improvisational approach to management "adaptive." In practice, this latter has not proven helpful (Ludwig, Hilborn and Walters, 1993).

The crucial difference is that genuine adaptive management–far from being improvisational–develops, in advance, a plan that covers all contingencies, and has verified the optimization of the path that will be chosen in response to each possible outcome of the experiments and monitoring, including damage control for the eventuality of experiments with unfavorable outcomes. The Bayesian machinery illustrated in this PVA analysis offers the computational basis for calculating the probabilities that are used for driving the decision rules at each branchpoint in the plan path, and for evaluating whether a given plan, overall, controls risk to the desired level.

For legitimate use in the ESA context, an adaptive plan should be required to demonstrate in advance that the overall plan meets the recovery standard for risk when all possible paths are considered in relation to their respective probabilities, and taking into account the reduction in uncertainty that will be achieved from the results of the experiments (Goodman, 2005).

Grounds for Rejection

The Bayesian PVA approach, as employed in this example with the participation of the SSLRT PVA subgroup, provided a structured framework for orderly discussion of the critical elements necessary for reasoned development of many components of the recovery plan. This went beyond the recovery criteria section, linking it to the threats assessment, and the management and research planning as well.

Bayesian analysis and decision theory, as employed here for operationalizing value preferences and analyzing evidence to make decisions to satisfy the standard, constitutes a system with the property of "coherence" (Berger, 1985). Roughly, this means that the system will generate decisions that are consistent with the synthesis of values, beliefs, and evidence. In other words there is no logic for improving upon this system if a decision rule has been implemented with correct self-awareness of values and expert opinion, and competent use of modeling and statistics on all the available data.

This raises the question of what rationale might justify *not* following through with the results of such an analysis. In the present case, the persistence standard, the quasi-extinction definition, the population-wide census data, the estimates of the extraneous influences, and the judgment that the basic PVA model has an 80% probability of being correct, all were developed and/or reviewed by the same group of experts. Therefore, *this* group could not logically reject the result without exhibiting inconsistency with their own values and judgment and data. More broadly, rejection of the result raises the possibility that the recovery criterion will not be consistent with the threats assessment section of the Recovery Plan, if the PVA subgroup's expert input to this analysis was consistent with the threats assessment.

Some other group, of course, could reject the result if they genuinely disagreed with the initial value judgments (policy) or had a sound basis in defensible expert opinion for disagreeing with the estimates of the extraneous influences or the basic premise of the PVA model. Presumably there is not much scope for scientific disagreement about the objective data

used in the analysis–but if new information were to come to light revising the data, the analysis should be revised accordingly.

Notwithstanding the recognized usefulness of the Bayesian PVA framework for structuring the efforts of the SSLRT PVA subgroup, and notwithstanding the degree of consensus achieved about the inputs, there was some discomfort within the group about the result. This bears closer diagnosis. In particular it would be valuable to elicit whether the discomfort primarily reflected disappointment or primarily disbelief.

If the problem is disbelief, this would warrant further review of the PVA to confirm the degree of confidence placed on the technicalities of the modeling and analysis. If the problem is disappointment, this too warrants further discussion. If the disappointment is simply an expression of impatience at how long a time might have to pass until downlisting or delisting were allowed under the strict criterion, it might be worth some discussion to discover why there is such a strong desire for earlier downlisting and delisting, given the premise that the present protections will be continued regardless. If earlier downlisting would remove the discomfort, even if the present protections are continued, the natural resolution is to accept the PVA, and opt for conditional downlisting and adaptive recovery planning as the means to allow earlier downlisting without disavowing the PVA inputs or the PVA result, and without compromising the standard.

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APPENDIX A.
ANALYSIS OF EASTERN POPULATION OF STELLER SEA LIONS

Introduction

The eastern population of Steller sea lions breeds on rookeries from SE Alaska to northern California. These subpopulations were dramatically reduced by human activities, primarily direct take, it is believed, in the period before protection under the MMPA. This reduction was probably at least as severe as that experienced by the western DPS during the same time period. With the institution of protection, the eastern DPS, unlike the western DPS, rapidly showed signs of gradually recovering throughout most, but not all, of its range. The exception is the southernmost portion of the range, in California.

The area occupied by the eastern DPS is a substantially different ecosystem from the area of the western DPS. There are different fisheries. The sea lions, as revealed from scat analysis, eat a different diet. Both areas are subject to oceanographic "regimes" but the regimes express themselves differently in their biological effects. From the standpoint of salmon production, for example, the biological effects appear to be reversed in phase.

The longest monitoring series available for the eastern population are the records of non-pup counts from Oregon, and the pup count series from SE Alaska, starting in 1977 and 1979 respectively. These two portions of the subpopulation area account for the bulk of the eastern DPS. Both time series of counts show consistent exponential growth estimates of about the same magnitude, centered around 3 to 3.5%, SE Alaska being the lower, with similar confidence interval widths, and with no indication of large environmental variation (or varying extraneous influences). This is quite different from the Western Alaskan population. The apparent difference between the SE Alaska and Oregon growth rate estimates is considerably smaller than the respective confidence interval widths.

Oregon Non-pup Counts

The 24 counts of non-pups at Oregon sites span the years 1977-2002, and are annual except for missing 1978 and 1991. The census estimate series was analyzed by Bayes fitting of a simple exponential, treating all the variation as observation (census) error, treated as multiplicative log normal, and assuming an exact underlying exponential trajectory with unknown growth rate, unknown true starting population size and unknown census error standard deviation. The priors on growth rate and starting population size were uniform, and the prior on the log space variance of the census error was proportional to its reciprocal. The posterior mean for the growth rate was 3.64%, the posterior standard deviation was 0.405%, and the posterior mode was 3.68%. The 95% posterior interval was from 2.42% to 4.44%. The posterior probability that the growth rate is less than 2% is about 0.01%. The posterior distribution for the growth rate is shown in Figure A1.

Figure A2 shows the trajectory from the posterior mode on growth rate and starting population, with the census values shown as dots about the trajectory, and with the log space residuals (the log of the multiplicative factor of departure from the exact exponential trajectory) shown below as dots about the $y = 0$ line. The residual analysis shows a slight tendency to cycle with a wave length of around 5 years, but overall the residuals appear to have a very stationary distribution with no systematic lack of fit to a simple exponential. This supports the assumption of essentially no environmental variation.

SE Alaska Pup Counts

The 9 counts of pups at SE Alaska sites span the years 1979-2002, and are generally less frequent than annual. The census estimate series was analyzed by Bayes fitting of a simple exponential, treating all the variation as observation (census) error, treated as multiplicative log normal, and assuming an exact underlying exponential trajectory with unknown growth rate, unknown true starting population size, and unknown census error standard deviation. The priors on growth rate and starting population size were uniform, and the prior on the log space variance of the census error was proportional to its reciprocal. The posterior mean for the growth rate was 3.13%, the posterior standard deviation was 0.413%, and the posterior mode was 3.14%. The 95% posterior interval was from 2.29% to 3.95%. The posterior probability that the growth rate is less than 2% is about 0.7% and the probability of growth rate less than 1.5% is about 0.1%. The posterior distribution for the growth rate is shown in Figure A3.

Figure A4 shows the trajectory from the posterior mode on growth rate and starting population, with the census values shown as dots about the trajectory, and with the log space residual (the log of the multiplicative factor of departure from the exact exponential trajectory) shown below as dots about the $y = 0$ line. The residual analysis shows no systematic lack of fit to a simple exponential, supporting the assumption of essentially no environmental variation.

The Theory of Inference with Census Error and Environmental Variation

For census error with no environmental (process) variation, the elementary model is for an underlying population trajectory that is a simple exponential. For constant multiplicative log normal census error, the log of the censuses will have a normal distribution about the log of the true population size. The census deviations, in the log space, under this model, will be iid,

showing no serial correlation and no trend in mean or variance. This is the basis of the Bayesian inference used here for the eastern DPS of US SSL.

For process variation, but with no census error, the elementary model is for an underlying trajectory, in the log space, that is a 1-d random walk (Brownian motion). When viewed at regular time steps, the series of snapshots of population sizes corresponds to by-interval growth that samples a normal distribution of exponential growth rates with a stationary mean and variance. With the modification for regime-like variation, so that the intervals at which the population is observed are also intervals over which the population growth rate really is constant and the interval length itself samples an exponential distribution, this is the basis of the Bayesian inference used here for the western DPS of US SSL.

The elementary model allowing for both census error and process variation superimposes a multiplicative lognormal stochastic observation process on the underlying discrete time population growth process which samples a normal distribution of actual growth rates. For inference with this model, it is assumed that the trajectory of actual population size is unknown, and a likelihood function must be constructed around the series of censuses as observables. This could form the basis of a Bayesian evaluation of whether the underlying process variation really is negligible for a population where it is not known whether there is appreciable process variation and where there is substantial random census error.

The most thorough approach to implementation of this in a likelihood function for inference on the distribution of actual exponential growth rates would be by a state-space model that represents the unknown time series of actual population sizes as parameters that must be inferred jointly along with the mean and standard deviation of the growth rates and the standard deviation of the log space census error. The model would be hierarchical, since some of the unknown parameters (the parameters of the distribution of the growth rate) bear on the distribution of some of the other unknown parameters (the time series of actual population sizes).

Since the interest is in obtaining inference on the mean and standard deviation of the distribution of exponential growth rates, it is more natural to formulate the model in the state-space of the time series of unknown actual realized growth rates. This also has the advantage of clarity in that the hyperparameters specifying the distribution of growth rates directly express a probabilistic relationship among the growth rates which are themselves parameters. The state spaces of the trajectory of population sizes and actual realized growth rates are of course mathematically interconvertible as long as the population size at one point in the trajectory is included among the set of parameters.

Notation for the realized-growth-rate-space model is given in Table A1.

Observables	
m	number of observations in the possibly irregular time series of censuses
$\underline{n}$	m-element vector of censuses, in order
$\underline{t}$	m-element vector of times of censuses, in units of time steps so that $t_1 = 1$ and $t_m = k$
Primary Parameters	
$N_{t(m)}$	population size at end of census time series
σ_ε	standard deviation of the log of the multiplicative census error
$\underline{r}$	$(k-1)$-element vector of exponential rate of increase by time step
r_j	exponential rate of increase for time step j, iid normal
Hyper-parameters	
μ_r	mean of the distribution of r
σ_r	standard deviation of the distribution of r
Derived Parameters	
$\underline{N}$	$(k-1)$-element vector of population trajectory, one value per time step, starting at time of first census, derived from $N_{t(m)}$ and $\underline{r}$
N_j	population size at time step j
$\underline{\boldsymbol{\varepsilon}}$	$(k-1)$-element vector of multiplicative census errors, one value per census, starting at time of first census, derived from $N_{t(m)}$ and $\underline{r}$, and $\underline{n}$
$\boldsymbol{\varepsilon}_j$	multiplicative lognormal census error at census j, sampled from distribution with mean of 0 and standard deviation σ_ε in the log space

Table A1

Equivalently, the vector $\underline{r}$ could be designated derived, and the trajectory $\underline{N}$ designated among the primary parameters, giving the population size state-space model.

The dynamics of population growth with this model are

$$N_{j+1} = N_j e^{r_j} \quad , \quad \text{eq[A1]}$$

$$r_j = \ln(N_{j+1}/N_j) \quad , \quad \text{eq[A2]}$$

$$r \sim Gaus(\mu_r, \sigma_r) \quad . \quad \text{eq[A3]}$$

So the corresponding prior component is

$$p(r_j) = \frac{e^{-\frac{1}{2}(\frac{r_j-\mu_r}{\sigma_r})^2}}{\sigma_r\sqrt{2\pi}} \quad . \quad \text{eq[A4]}$$

The above is prior because it represents a relationship among parameters, and involves no observables.

Censusing and census error then give rise to

$$\ln(n_i) \sim Gaus(\ln(N_{t(i)}), \sigma_\varepsilon) \quad . \quad \text{eq[A5]}$$

So the corresponding likelihood component is

$$p(n_i) = \frac{e^{-\frac{1}{2}(\frac{\ln(n_i)-\ln(N_{t(i)})}{\sigma_\varepsilon})^2}}{n_i\sigma_\varepsilon\sqrt{2\pi}} \quad . \quad \text{eq[A6]}$$

The joint likelihood then is

$$p(\underline{n}|\underline{N}, \sigma_\varepsilon) \propto \prod_{j=1}^{m} \frac{e^{-\frac{1}{2}(\frac{\ln(n_j)-\ln(N_{t_j})}{\sigma_\varepsilon})^2}}{n_j\sigma_\varepsilon\sqrt{2\pi}} \quad , \quad \text{eq[A7]}$$

where

$$N_{t_j} = N_{t_m} \prod_{i=t_j}^{t_m-1} e^{-r_i} \quad , \quad \text{eq[A8]}$$

$$\ln(N_{t_j}) = \ln(N_{t_m}) - \sum_{i=t_j}^{t_m-1} r_i \quad . \quad \text{eq[A8]}$$

So

$$\ln(p(\underline{n}|\underline{N}, \sigma_\varepsilon)) \propto -\sum_{j=1}^{m}\left(\frac{1}{2}(\frac{\ln(n_j)-\ln(N_{t_j})}{\sigma_\varepsilon})^2 + \ln(n_j\sigma_\varepsilon\sqrt{2\pi})\right) \quad . \quad \text{eq[A10]}$$

The model-driven joint prior elements then are

$$p(\underline{r}, \mu_r, \sigma_r) \propto \prod_{i=1}^{k-1} \frac{e^{-\frac{1}{2}(\frac{r_i-\mu_r}{\sigma_r})^2}}{\sigma_r\sqrt{2\pi}} \quad . \quad \text{eq[A11]}$$

So

$$\ln(p(\underline{n}|\underline{N},\sigma_\varepsilon)) \quad \propto -\sum_{j=1}^{m}\left(\frac{1}{2}\left(\frac{\ln(n_j)-\ln(N_{t_j})}{\sigma_\varepsilon}\right)^2 + \ln(n_j\sigma_\varepsilon\sqrt{2\pi})\right)$$

. eq[A12]

If we adopt conventional vague priors for the primary parameters, the log of the joint proportional posterior distribution is

$$\begin{aligned}\ln(p(\mu_r,\sigma_r,\sigma_\varepsilon,N_{t(m)},\underline{r}|\underline{n})) \quad \propto & -\frac{1}{2\sigma_\varepsilon^2}\sum_{j=1}^{m}\left((\ln(n_j)-\ln(N_{t_m})-\sum_{i=t_j}^{t_m-1}r_i)\right)^2 \\ & -\sigma_\varepsilon\sum_{j=1}^{m}\ln(n_j) \\ & -\frac{1}{2\sigma_r^2}\sum_{i=1}^{k-1}(r_i-\mu_r)^2 \\ & -k\ln(\sigma_r)-\ln(\sigma_\varepsilon) \qquad . \qquad \text{eq[A13]}\end{aligned}$$

Numerical implementation of the Bayesian inference may be carried out by simulating the posterior distribution with a MCMC algorithm such as Metropolis. For the best case of a series of m censuses (observables) that are entirely consecutive, this model involves 2 necessary hyperparameters and $m + 1$ primary parameters. We see, therefore, that from the standpoint of the number of observations relative to the number of irreducible parameters, this is not a promising system for inference. Accordingly, we are assured that the priors will in fact be influential.

Further, we must consider robustness of the inference to details of the model. The most tenuous appearing aspect of this inference is the resolution of process variation from census error when both are conflated to an extent in the time series of the observable census estimates. The two kinds of variance do give rise to somewhat different looking patterns in the time series of census estimates. Figure A5 shows a typical realization from a simulation of the assumed model with the parameter values from Table A2 to illustrate a census trajectory with census error but no process variation. We see a high frequency variation about a simple exponential trend.

N_{1977}	1600
σ_ε	0.2
μ_r	0.035
σ_r	0.0

Table A2

Figure A6 shows a typical realization from a simulation of the assumed model with parameter values from Table A3 to illustrate a census trajectory with process variation but no census

error. We see that the trajectory wanders, on a fairly long wavelength, giving rise to a systematic lack of fit to a simple exponential. This difference in pattern has formed the basis for some statistical attempts to separate the two kinds of variance (Holmes, 2001) by frequentist methods.

N_{1977}	1600
σ_ε	0.0
μ_r	0.035
σ_r	0.1

Table A3

Figure A7 shows a typical realization from a simulation of the assumed model with parameter values from Table A4 to illustrate a census trajectory with both census error and process variation. We note that of the three simulations (Figures A5, A6, A7), the case with no process variation looks most similar to the real data trajectory for the Oregon non-pup counts (Figure A2). But we also note that even this case has a somewhat different pattern from the actual data–the actual data show a slightly more consistent pattern of residual variance over the length of the trajectory, but a longer wavelength to the variation. We will return to a diagnosis of this difference in appearance after a mathematical dissection of the prospects for statistical separation of census error and process variation variances.

N_{1977}	1600
σ_ε	0.2
μ_r	0.035
σ_r	0.1

Table A4

The Mathematics of Distinguishing Census Error from Process Variation

Consider the derived quantity

$$q_j = \ln(\frac{n_{j+1}}{n_j}) \quad . \quad \text{eq[A14]}$$

for a pair of consecutive censuses that are separated by a single time step (at whatever time scale is chosen for the analysis). This new quantity is a transformation just of the observables, the census estimates.

Under the model assumed here, the variable q will form a stationary stochastic time series sampling a normal distribution with properties: mean μ_r, variance $\sigma_r^2 + 2\sigma_\varepsilon^2$, lag-1 autocovariance $-\sigma_\varepsilon^2$, and zero autocovariance at all other lags. This gives rise to a joint likelihood for a time series of q, with just the three parameters $(\mu_r, \sigma_r, \sigma_\varepsilon)$, as a multivariate

normal with a highly structured covariance matrix. For a sequence $\underline{q}$ of consecutive values, of length s, all separated by one time step, the likelihood is

$$p(\underline{q}|\mu_r, \sigma_r, \sigma_\varepsilon) = \frac{e^{-((\underline{q}-\underline{\mu_r})'\Sigma_q^{-1}(\underline{q}-\underline{\mu_r}))/2}}{|\Sigma_q|(2\pi)^{k/2}} \quad , \qquad \text{eq[A15]}$$

where Σ_q has, for all i, elements

$$\sigma_{(i,i)} = \sigma_r^2 + 2\sigma_\varepsilon^2 \quad , \qquad \text{eq[A16]}$$

$$\sigma_{(i,(i+1))} = \sigma_{((i+1),i)} = -\sigma_\varepsilon^2 \quad , \qquad \text{eq[A17]}$$

and 0 everywhere else. For a sequence of q with some time gaps, the likelihood is a product of such expressions for each segment without gaps.

This formulation makes possible numerical solution for the Bayes posterior distribution by means of a SIR algorithm, which will avoid the convergence issues to be expected with MCMC for the state-space formulation. For a data series with no gaps, the only difference in information provided to the two formulations will be the prior on N_m in the state-space model. For a data series with gaps, the state-space model derives some limited information, not available to the multinormal model, from the possible growth rates bridging each gap. In practice, the difference between the inferences should be slight.

The diagnostic insight provided by the formulation for inference with the data transformed to $\underline{q}$ is that the partitioning of the total variance into process variation and census error depends entirely on the serial correlation structure of $\underline{q}$. This, in turn, depends entirely on the assumed model having no serial correlation in the census error and no serial correlation in the process variation. Any departure from these time series properties of the census error and process variation will give rise to a different actual autocovariance structure for $\underline{q}$, so that a force fit to the structure presumed for the matrix Σ_q will misallocate the variance between σ_r and σ_ε in the inference.

In reality, we generally would *not* expect environmental variation to be free from serial correlation, and we would not be surprised at high serial correlation. The reasonableness of an assumption of no serial correlation in the census error depends on the mechanism of censusing. If the censusing (e.g. "sightability" or "availability") is affected by age distribution in the population, or by breeding status, or by geographic distribution or behavior that might be affected by environmental variables, the census error can exhibit considerable serial correlation.

Serial Correlation in the Oregon SSL Data

Figure A8 shows the time series of the apparent exponential "growth rate" in the census estimates of non-pups from the Oregon sites. This is the vector of the quantity q calculated from these data. If the data conform to the assumptions of the model, the calculated time series should exhibit no serial correlation at lags greater than 1, and a negative serial correlation at lag 1 corresponding to the ratio of the census error variance to the sum of the process variance and twice the census error variance. The negative serial correlation at lag 1 should give rise to a preponderance of simple alternation between high and low values. Instead we see a high frequency of peaks and troughs that each persist for two years, and also there is considerable representation of intermediate values in the year between a high and a low.

In fact, the calculated time series of q shows a small negative serial correlation at lag 1, a

large negative serial correlation at lag 2, and a small positive correlation at lag 3. From the model,we could obtain nominal point estimates of the census error and process variation standard deviations according to

$$\sigma_\varepsilon = \sqrt{-\gamma_q(1)} \quad , \qquad \text{eq[A18]}$$

$$\sigma_r = \sqrt{\sigma_q^2 - \sigma_\varepsilon^2} \quad , \qquad \text{eq[A19]}$$

where σ_q^2 is the variance in the time series of q, and $\gamma_q(1)$ is the lag-1 autocovariance.

Table A5 shows the sample serial correlation at the 3 lags, along with the total variance calculated as the geometric mean of the variances of the two series formed to compute the serial correlation at each lag, along with the "nominal" point estimates for the census error standard deviation and process variation standard deviation calculated by treating the serial correlation as if it were lag-1 and assuming the data conform to the model (which they definitely do not). [Program SERLAG and STDS]

lag	**serial correlation**	**total variance**	**nominal** σ_ε	**nominal** σ_r
1	-0.0981	0.0281	0.0525	0.1502
2	-0.5837	0.0261	0.1234	0.0661 **i**
3	0.1120	0.0269	0.0548 **i**	0.1813

Table A5

The imaginary values for nominal standard deviations arise when the partitioning of the variance according to the model gives rise to a negative point estimate for one of the variances, which might more properly be thought of as zero variance.

We see that if the population had been censused every other year, rather than annually, the data would have appeared to agree with the assumptions of the model, and the conclusion from inference with the model would be that there is little environmental variation, and the residuals from a fit to a simple exponential are almost entirely census error. As it is, the annual censuses show that the data do not conform to the assumptions of the model, for reasons that are undetermined, but there are many possible mechanisms that might be responsible for what almost certainly is serial correlation in the census error.

Risk Evaluation for the Eastern Population

Based on the monitoring of SE Alaska and Oregon subsets of the population, the eastern DPS, north of California, for the past 25 or 30 years, appears to have been growing steadily, but at a modest rate that is perhaps 1/3 of the rate that would represent the common understanding of the biological potential for a pinniped population that is not experiencing crowding effects, impaired habitat, or ongoing harvest or incidental take. During this time, the population size has more than doubled, and the total population size for the DPS is now estimated to be around 46,000. During this time, there has been no evidence of appreciable effects of environmental variation, or of appreciable variation in whatever human-caused

extraneous influences may be affecting this population.

The present size size of the California portion of the population, which occupies the southern edge of the species range, is about 20% of that recorded there in the middle of 20th century, and it is believed that the population may have been larger yet in the 19th century. In recent times, consistent California-wide counts began in 1996. During the recent decade of monitoring pup production in California has trended upward, while non-pup numbers have varied from one census to the next, but with no clear trend.

A working hypothesis to account for these observations on the eastern DPS is that:

1. the population is not sensitive to ongoing regime-frequency environmental variation,
2. the depressed, but steady and positive, growth rate north of California is owing to a combination of ecosystem modification and possible incidental take that is stable and sustainable,
3. the carrying capacity is not less than 46,000 total individuals, and
4. the lack recovery of the California portion of the population is owing to a range contraction responding to the warming trend of the past several decades.

If all this is true, and continues to be true, the risk of near- or medium-term extinction for this population is very low. While there is no evidence to the contrary, we do not have conclusive information that this hypothesis complex is true, or that it will continue to hold in the future. Accordingly we could judge this population to be at low risk provided management maintains the current level of protection, keeps human impact at no more than its present level, and monitors to make sure that evidence contrary to the hypothesis complex will be detected and the risk classification and management will be revised as indicated. The most critical contingencies to monitor for would be a northward extension of the region of the shift to a much reduced population density, or a shift to negative apparent census growth for more years than might be attributable to chance census error.

APPENDIX B. DENSITY DEPENDENCE IN RELATION TO HABITAT, RESOURCE AVAILABILITY AND PREDATION PRESSURE

INTRODUCTION

Classic Density Dependence

A standard example of apparent density dependent population growth from marine mammal dynamics is the case of the Antarctic, where many of the seal populations and almost all of the great whale populations were severely reduced through direct harvest by mid 20'th century. Almost all of these species feed predominantly on krill (Laws, 1977). Upon cessation of the harvests, both the seal and whale populations rebounded at rates at the upper end of what

is thought to be the biologically feasible range for their life histories. Sustained fur seal population growth rates from roughly 10% to 17% annually were estimated (Payne, 1977; Boyd, 1993). And even great whales, with their much later age at maturity and longer interval between births, showed high annual growth rates, from 7% for blue whales (Branch, Matsuoka, Miyashita, 2004) to nearly 11% for humpback whales (Bannister, 1994).

Steller seal lion population dynamics certainly do not look like that. Neither the eastern nor western US population has yet to grow at greater than 3.5% annually, though they too were reduced far below their earlier numbers, and the present role of incidental catch and direct take is thought to be small.

Relation to the PVA

The Brownian motion PVA model does not incorporate density dependence. This deserves some scrutiny, since it is known mathematically that very long term persistence requires some degree of density dependence in otherwise random growth dynamics (Royama, 1977); elementary considerations of the effects of crowding and availability of limited resources give rise to population growth models with some degree of density dependence (Lotka, 1937); and some degree of density dependence has been demonstrated empirically in a variety of populations (Dennis and Taper, 1994).

The tactical *choice* to use a model without density dependence may be more or less forced as a practical expedient if the key parameters that quantitatively represent density dependence are not known, and cannot effectively be estimated from the available data, which is most often the case (Ginzburg, Ferson, and Akcakaya, 1990). But these reasons for the choice do not address the question of what bias or unrealism may be introduced by the choice, nor do they really explain what underlying assumptions are implied. Here we review these issues.

Evolutionary ecological history plays out on a time scale of the half-lives of species and the persistence times of large scale configurations of environments, generally on the order of tens of thousands of years, or more. From this perspective, the application of a PVA to project 100 years into the future is actually a *short* term prediction, however much it may strain our scientific predictive capabilities.

For this reason, some of the unreasonable long term features of the Brownian motion model may be reasonable enough in an actual PVA application. In the very long run, the Brownian motion model generates two main categories of trajectories: those that absorb at extinction, and those that go to unlimitedly large population sizes. In the shorter term, for a population that is experiencing problems, the predicted excursions below some threshold level may well be realistic, and the time horizon could be short enough to keep the predicted high excursions within reasonable limits; and if unreasonably high predicted excursions are encountered they should be interpreted simply as escape from the extinction vortex.

When a population comes to our attention as a subject for PVA, this is often because its numbers and/or dynamics do *not* look normal. PVA assessments are usually motivated by conservation concern for a population that has declined to very low levels compared to its evolutionary and ecological history, or because it is exhibiting dynamics that seem unusually volatile. These dynamics are often thought, or hypothesized, to be affected by recent habitat loss or habitat modification or ecosystem disruption that may have dramatically changed the operation of density dependence for the population; or fluctuating exogenous mortality forces may have overwhelmed the presumed stabilizing influence of density dependence.

In these circumstances, there is no strong a priori basis for assuming that density dependence will rescue a population from further decline, either as a continuing trend or as a random walk. The effective carrying capacity may itself have declined to zero or entered a phase where it fluctuates erratically and widely. In such a case, the population dynamics, at least for the time scale of the PVA projection, may behave pretty much as the Brownian motion model represents them. The following mathematical exploration will pay particular attention to the way various factors can greatly change carrying capacity.

Carrying Capacity

The term "carrying capacity" is roughly used to signify the number of animals a particular piece of real estate can support. If this is understood to be strongly context dependent, no harm is done by the rough definition. If, on the other hand, this encourages a belief that "carrying capacity" can be measured simply as an inventory of habitat, the rough definition will be severely misleading. The mathematically precise definition of "carrying capacity," which we will label K for purposes of this discussion, is the equilibrium population level, above which the population declines and below which the population grows. The purpose of the analysis developed here is to show how habitat quantity, resource availability and predation pressure interact to determine K.

MODEL

General Model for Population Growth

Population size, N, is governed by the balance between the inherent resource driven component of per capita growth rate, r, and exogenous mortality factors, some of which operate in a constant per capita fashion represented by u, and some of which are simply a constant absolute drain on the population represented by w,

$$\frac{dN}{dt} = rN - uN - w \quad . \qquad \text{eq[B1]}$$

For example, a loss to predation that is proportional to the encounter rate would appear in u, where a predation loss that is the same regardless of population size would appear in w.

Let the inherent resource-driven component of the per capita growth rate be proportional to the surplus of usable resources above the constant per capita maintenance demand of the organism. Let the amount of habitat be h, the resource concentration per unit habitat be s, the threshold concentration for usability at which foraging intake exceeds foraging costs be f, and let the per capita resource demand for maintenance be m. Then,

$$r = c(h(s - f) - mN) \quad , \qquad \text{eq[B2]}$$

where c is the proportionality constant converting free resources to growth.
Combining equations [B1] and [B2] gives

$$\frac{dN}{dt} = c(h(s-f) - mN)N - uN - w$$
$$= -(cm)N^2 + (ch(s-f) - u)N - w$$
$$= -\beta N^2 + \alpha N - w \quad , \quad \text{eq[B3]}$$

where the Greek letters

$$\alpha = ch(s-f) - u \quad , \quad \text{eq[B4]} \qquad \#$$

and

$$\beta = cm \quad , \quad \text{eq[B5]}$$

simply collect terms that will be phenomenologically revealing.

In the absence of the effects of w, the per capita instantaneous growth rate at vanishing population size (essentially the logarithm of what is usually called R_{max} would be α and the carrying capacity would be α/β. We note that u figures in α, so even without consideration of the constant drain w or the resource concentration threshold f we have an effect of an exogenous mortality on the expressed carrying capacity.

Graphical Diagnosis of the General Model

In units of net per capita growth, equation [B3] becomes

$$\frac{1}{N}\frac{dN}{dt} = -\beta N + \alpha - \frac{w}{N} \quad , \quad \text{eq[B6]} \qquad \#$$

from which we see that the net per capita growth rate, as a function of population size, is a difference between two functions: one is a straight line with slope $-\beta$ and intercept α

$$y = -\beta N + \alpha \quad , \quad \text{eq[B7]}$$

and the other is an equilateral hyperbola

$$y = \frac{w}{N} \quad , \quad \text{eq[B8]} \qquad \#$$

with vertex at

$$y = N = \sqrt{w} \quad . \quad \text{eq[B9]}$$

We may graph these two lines, as in Figure B1, with the geometric reference points labeled. Where the two lines intersect, their difference is zero, so these are points where the net growth rate is zero. They may be solved for directly as the two roots of the quadratic obtained from setting equation [B3] to zero.

The larger of the two roots is at an intersection above which the hyperbola is larger valued than the straight line, so this is a stable equilibrium, which therefore is the mathematical carrying capacity:

$$K = \frac{\alpha + \sqrt{\alpha^2 - 4\beta w}}{2\beta} \quad . \quad \text{eq[B10]} \qquad \#$$

The smaller of the two roots is at an intersection *below* which the hyperbola is larger valued than the straight line, so this is an unstable equilibrium, a repelling point, which therefore is the critical depensation level, Q:

$$Q = \frac{\alpha - \sqrt{\alpha^2 - 4\beta w}}{2\beta} \quad . \qquad \text{eq[B11]}$$

If the population is reduced below Q, it cannot recover under its own dynamics, and it will decline to extinction. Thus Q is the population level where the mathematical Allee effect becomes over-riding.

ANALYSIS

Properties of the Species and Properties of the Environment

From equations [B10], [B4], and [B5] we see that K actually is a function of a long list of parameters, one of which h is a direct inventory of available habitat, one of which s is a direct measure of productivity of the habitat, three of which c, f and m are properties of the species which scale the habitat measures to units of population growth, and two of which u and w are mortality factors which could change with changing conditions, so they are not strictly measures of either habitat or the species properties. As any of the parameters exogenous to the species–namely h, s, u or w–change, K will change. But simply observing a change in K will not reveal which factors were involved in the change. If we had direct information on the various factors, we might parse the exogenous from environmental influences on effective carrying capacity. In the absence of that level of detailed information, carrying capacity itself is phenomenological– it is simply the equilibrium population size, regardless of its components.

In practice, if K fluctuates, the actual changes in K generally will not be observed directly, unless the carrying capacity remains nearly constant long enough for the density dependent approach to carrying capacity to be resolvable from the population censuses. More usually, all we will observe, without very detailed research into mechanisms, are the transient changes in the growth rate of the population.

If we had enough information about the variation in K to construct a stochastic model for it, that would provide an intellectually satisfying basis for a PVA. Absent that information, we build a PVA around the observable variation in population growth rate.

Carrying Capacity as a Function of Conditions

From Figure B1 we see that the carrying capacity, as the right-most of the two intersection points, will vary in position as the two lines move. The straight line will move in response to changes in its slope and intercept, given by β and α, and the hyperbola will move outward from the origin as w increases. The two lines will pull apart with steepening slope of the straight line (larger β), downward translation of the straight line (smaller α), or outward translation of the hyperbola. As the two lines pull apart, the two intersection points draw closer together, so the critical depensation level and K draw closer together.

Just as the two lines separate, Q and K merge, the stable equilibrium point vanishes, and the effective carrying capacity collapses in a mathematical discontinuity. At that collapse, the population will decline to extinction unless conditions change to restore a positive carrying capacity. The approach to collapse of K comes without phenomenological warning, as it can

occur at non-zero values of K, and it occurs as a discontinuous response to the driving factor.

From equation [B10], keeping the effective carrying capacity above collapse requires

$$hs > hf + \frac{u + 2\sqrt{mw}}{c} \quad . \qquad \text{eq[B12]}$$

The collapse can occur under conditions where available habitat and resource concentration are well above zero.

In the absence of an effect of w, the response of K to conditions will not exhibit a discontinuity, but K can still go to zero while habitat is available and resource concentration is above zero. For w equal zero, the condition for non-zero carrying capacity is

$$hs > hf + \frac{u}{c} \quad . \qquad \text{eq[B13]}$$

Numerical Illustration

The following is only for illustration. The parameter values are those used to generate Figure B1.

Parameter		**value**
Resource to growth conversion	$c =$	0.00002
Habitat area	$h =$	10,000
Resources per unit habitat area	$s =$	2.5
Foraging cost	$f =$	1.5
Per capita maintenance demand	$m =$	1
exogenous per capita mortality	$u =$	0.05
Fixed mortality drain	$w =$	1000
Results		**Value**
Effective carrying capacity	$K =$	67,604
Critical depensation level	$Q =$	7,396
Maximum growth rate, absent constant mortality drain	$R_{max}\|_{w=0}$	1.16
Intrinsic carrying capacity	$K\|_{u=0,w=0}$	100,000
Carrying capacity absent effect of exogenous per capita mortality	$K\|_{u=0}$	94,721
Carrying capacity absent effect of exogenous constant mortality drain	$K\|_{w=0}$	75,000
Critical level for collapse of *K*		**Value**
Habitat area	$h_{crit} =$	6,972
Resources per unit habitat area	$s_{crit} =$	2.20
exogenous per capita mortality	$u_{crit} =$	0.111
Fixed mortality drain	$w_{crit} =$	2,813

Table B1

It may be tempting to look for direct numeric parallels to the SSL example, but far too many of the parameters in the illustration are completely unknown for the SSL for this to be meaningful. The point simply is to illustrate how the elementary density dependence model with environmental influences can readily give rise to extremely volatile fluctuation in *K*, which, from the perspective of observations only on the population trajectory, could appear (and function) like random population growth without effective density dependence. This could be the case for the recent dynamics of the SSL.

A PVA MODEL FOR EVALUATING RECOVERY CRITERIA FOR THE WESTERN SSL POPULATION

Daniel Goodman
March 30, 2006

FIGURES

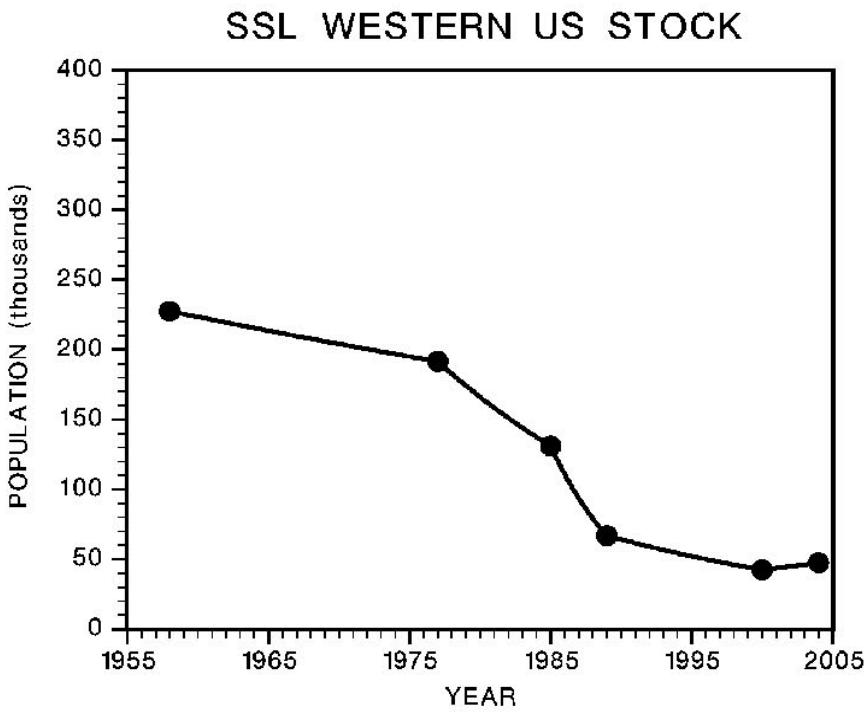

Figure 1

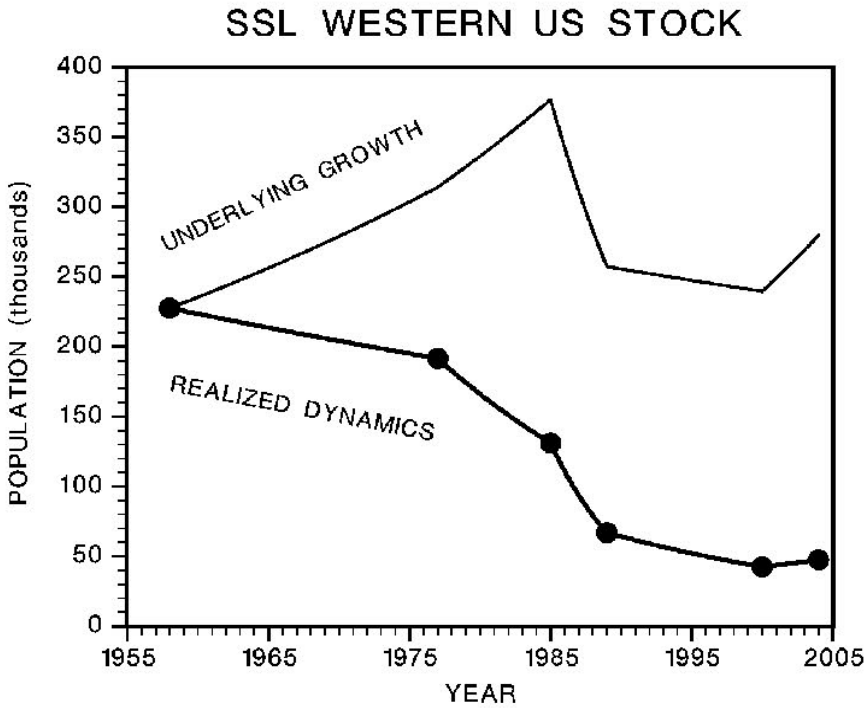
SSL WESTERN US STOCK
POPULATION (thousands)
400
350
300
250
200
150
100
50
0
UNDERLYING GROWTH
REALIZED DYNAMICS
1955
1965
1975
1985
1995
2005
YEAR

Figure 2

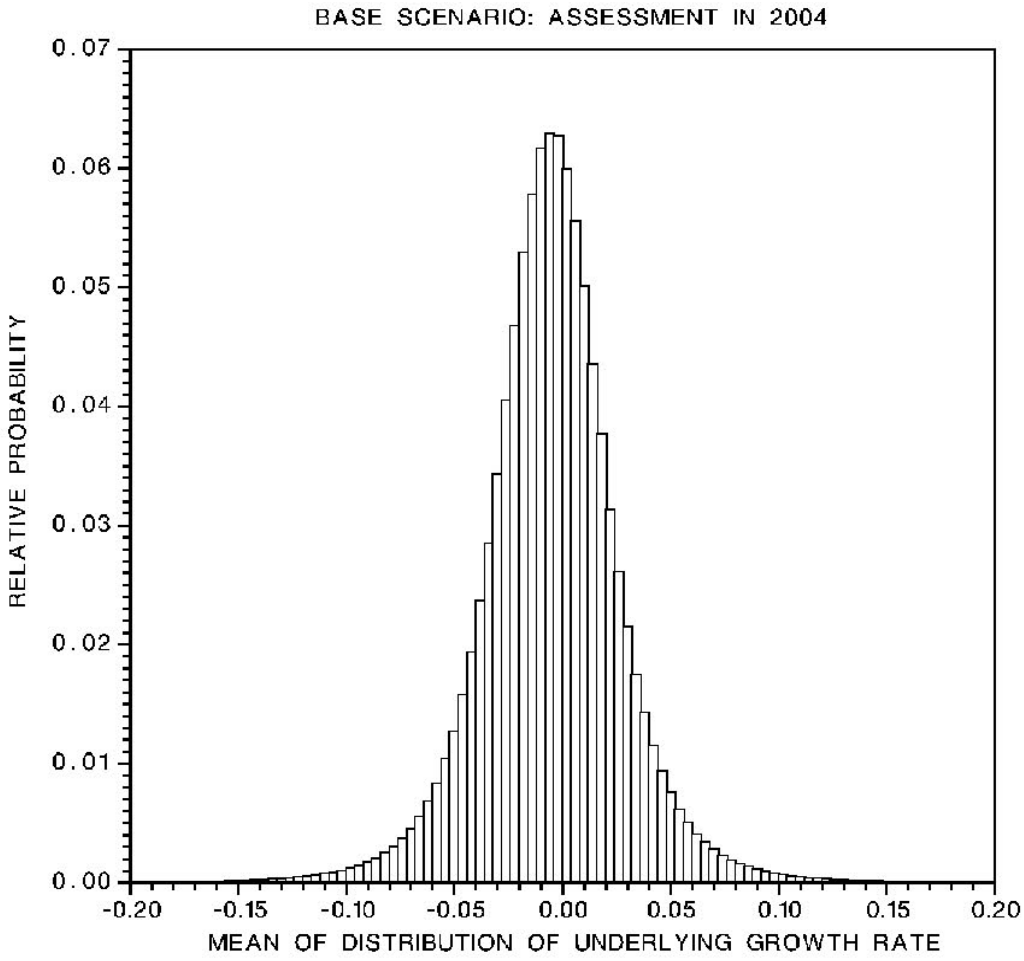
BASE SCENARIO: ASSESSMENT IN 2004
RELATIVE PROBABILITY
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
MEAN OF DISTRIBUTION OF UNDERLYING GROWTH RATE

Figure 3

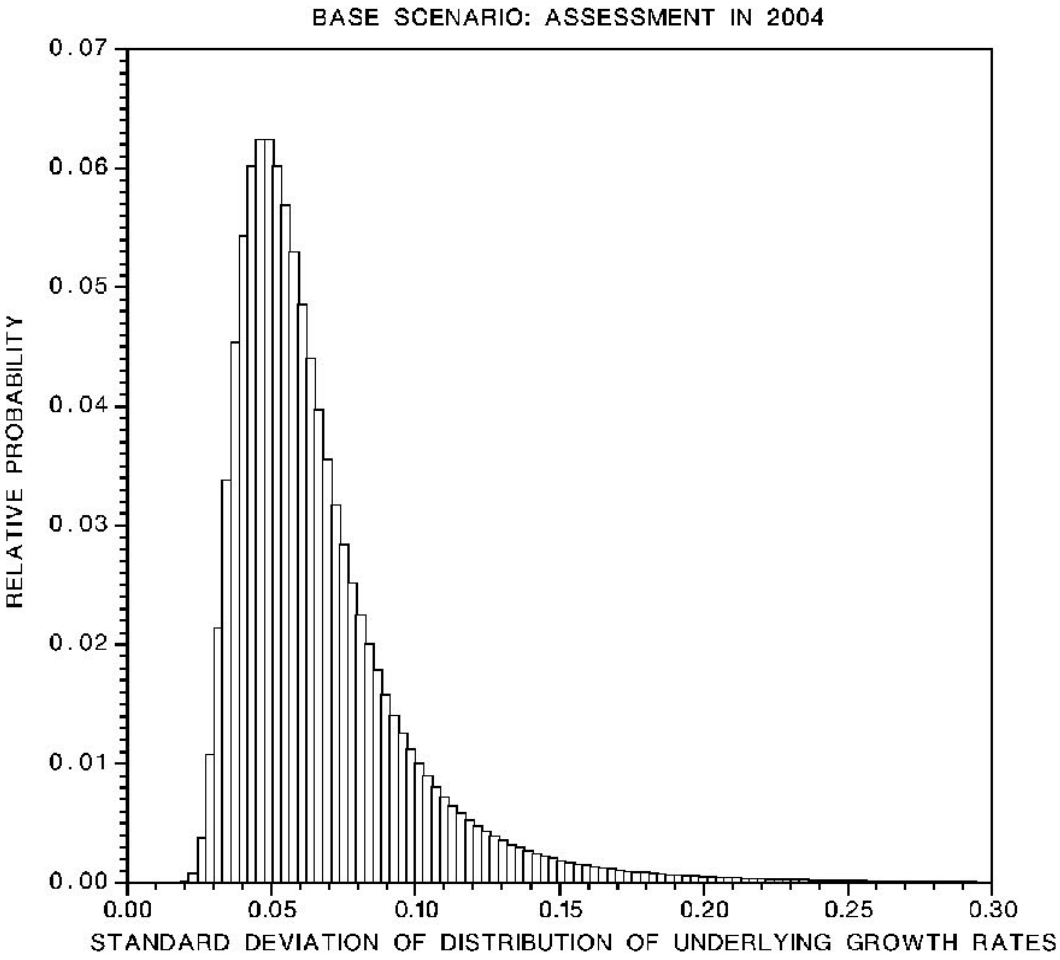
BASE SCENARIO: ASSESSMENT IN 2004
RELATIVE PROBABILITY
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.00
0.05
0.10
0.15
0.20
0.25
0.30
STANDARD DEVIATION OF DISTRIBUTION OF UNDERLYING GROWTH RATES

Figure 4

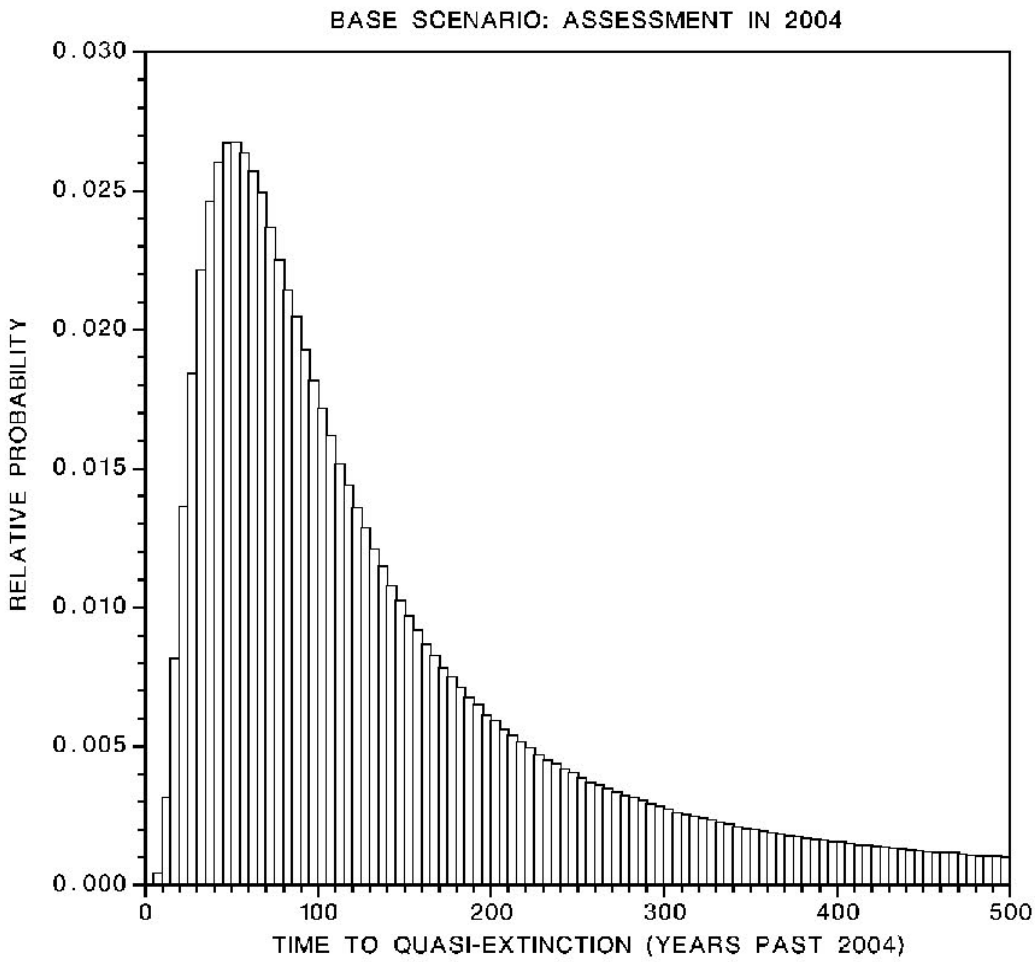
BASE SCENARIO: ASSESSMENT IN 2004
RELATIVE PROBABILITY
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
100
200
300
400
500
TIME TO QUASI-EXTINCTION (YEARS PAST 2004)

Figure 5

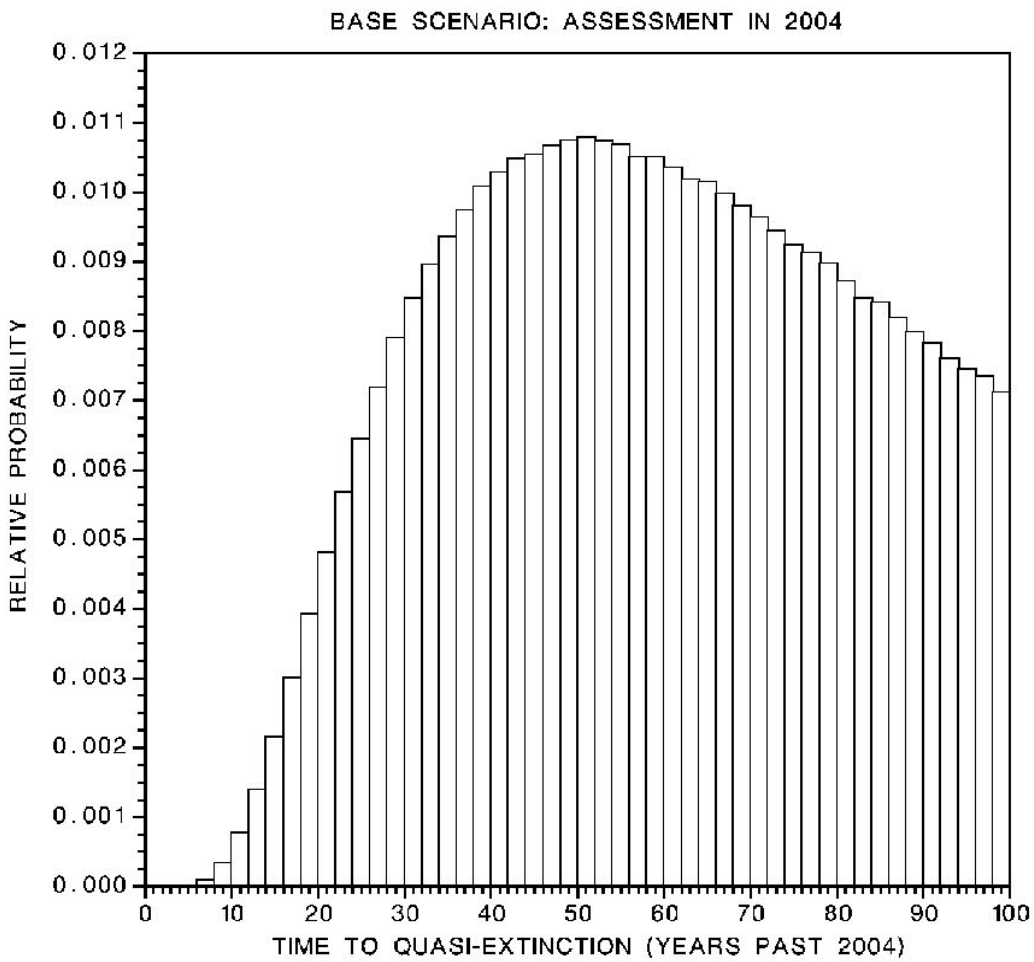
BASE SCENARIO: ASSESSMENT IN 2004
RELATIVE PROBABILITY
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0
10
20
30
40
50
60
70
80
90
100
TIME TO QUASI-EXTINCTION (YEARS PAST 2004)

Figure 6

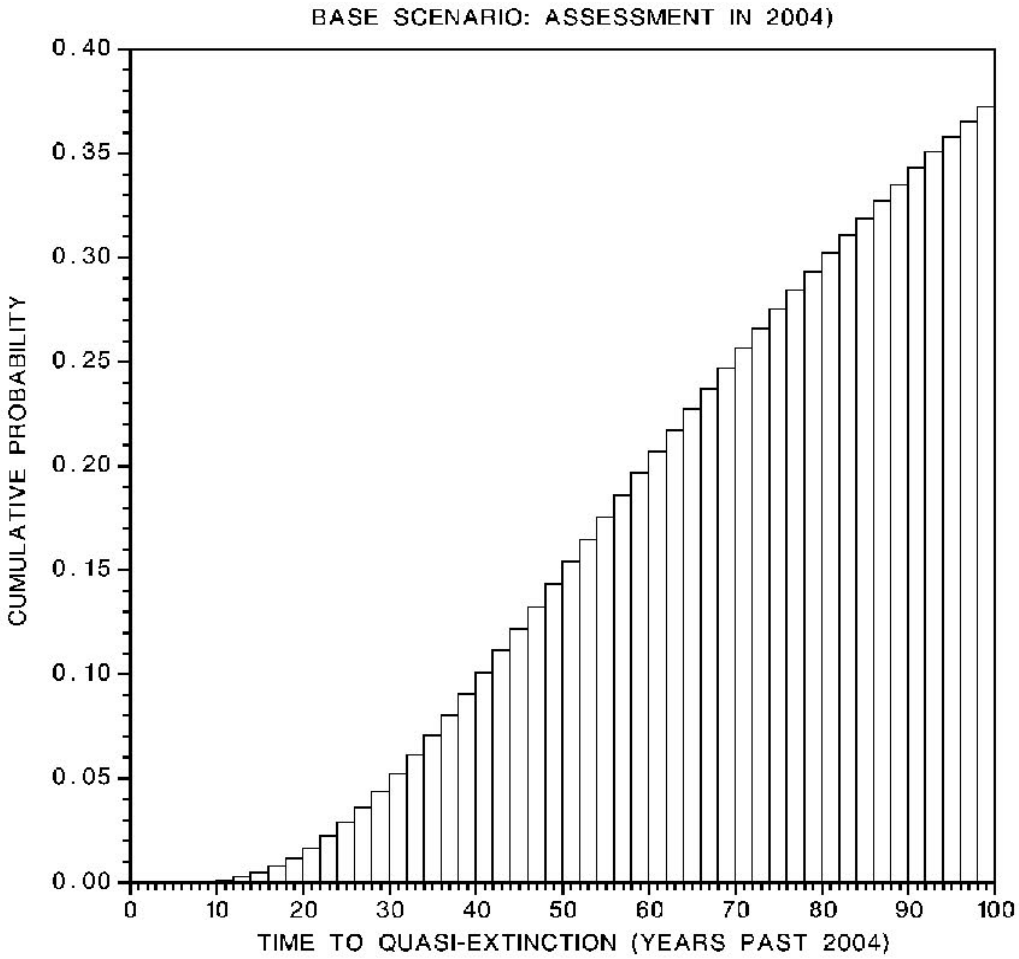
BASE SCENARIO: ASSESSMENT IN 2004)
CUMULATIVE PROBABILITY
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
70
80
90
100
TIME TO QUASI-EXTINCTION (YEARS PAST 2004)

Figure 7

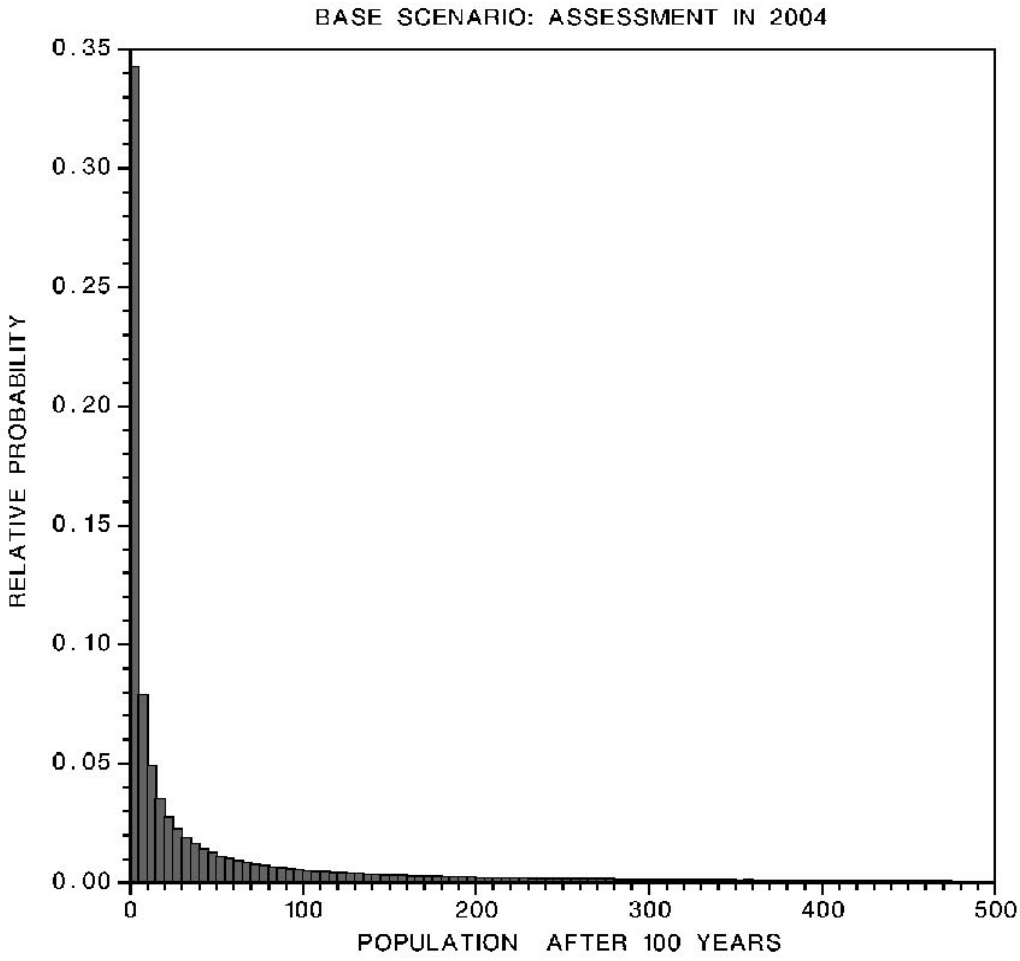
BASE SCENARIO: ASSESSMENT IN 2004
RELATIVE PROBABILITY
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
100
200
300
400
500
POPULATION AFTER 100 YEARS

Figure 8

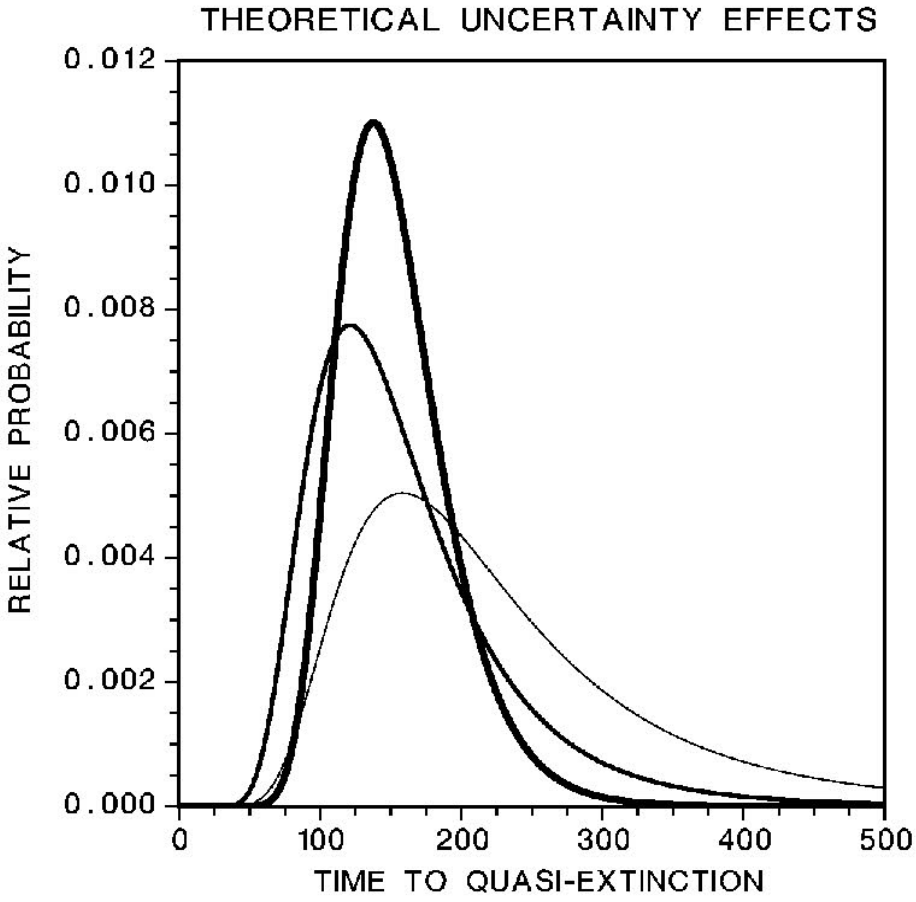
THEORETICAL UNCERTAINTY EFFECTS
RELATIVE PROBABILITY
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0
100
200
300
400
500
TIME TO QUASI-EXTINCTION

Figure 9

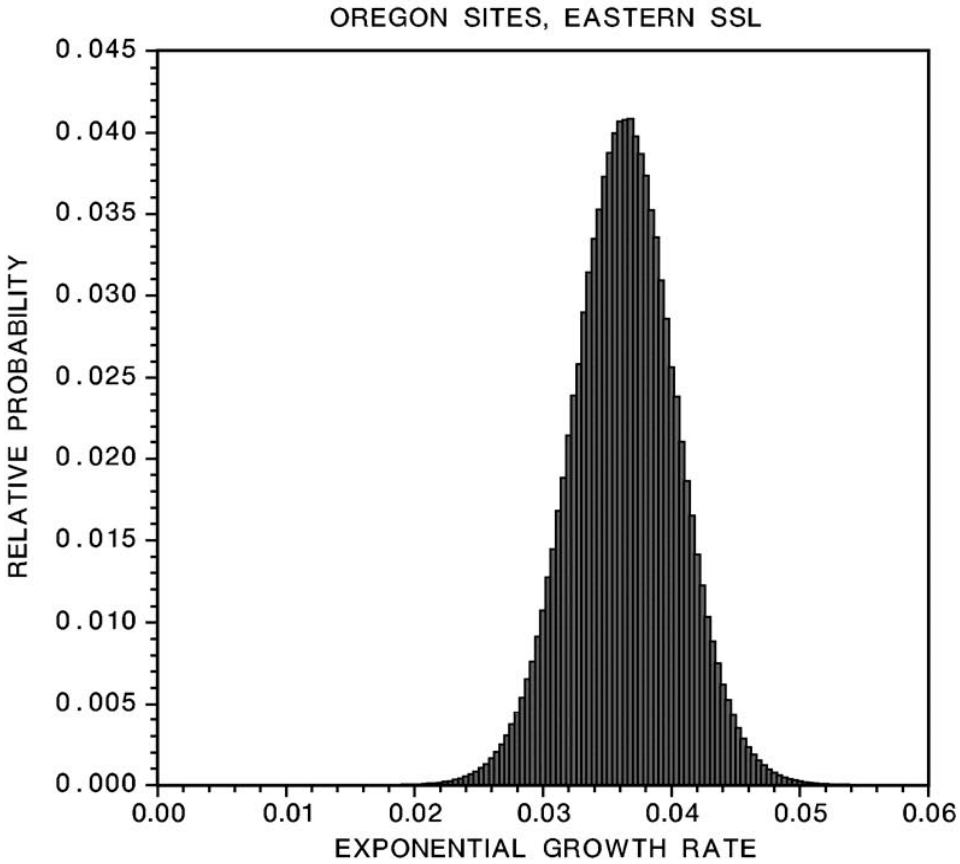
OREGON SITES, EASTERN SSL
RELATIVE PROBABILITY
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0.00
0.01
0.02
0.03
0.04
0.05
0.06
EXPONENTIAL GROWTH RATE

Figure A1

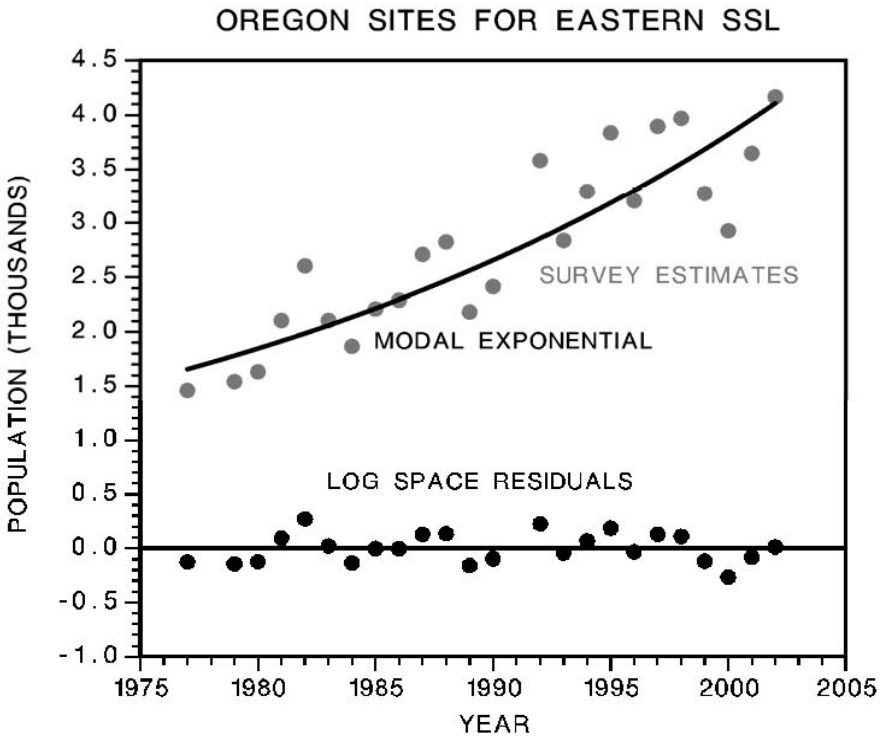
OREGON SITES FOR EASTERN SSL
POPULATION (THOUSANDS)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
SURVEY ESTIMATES
MODAL EXPONENTIAL
LOG SPACE RESIDUALS
1975
1980
1985
1990
1995
2000
2005
YEAR

Figure A2

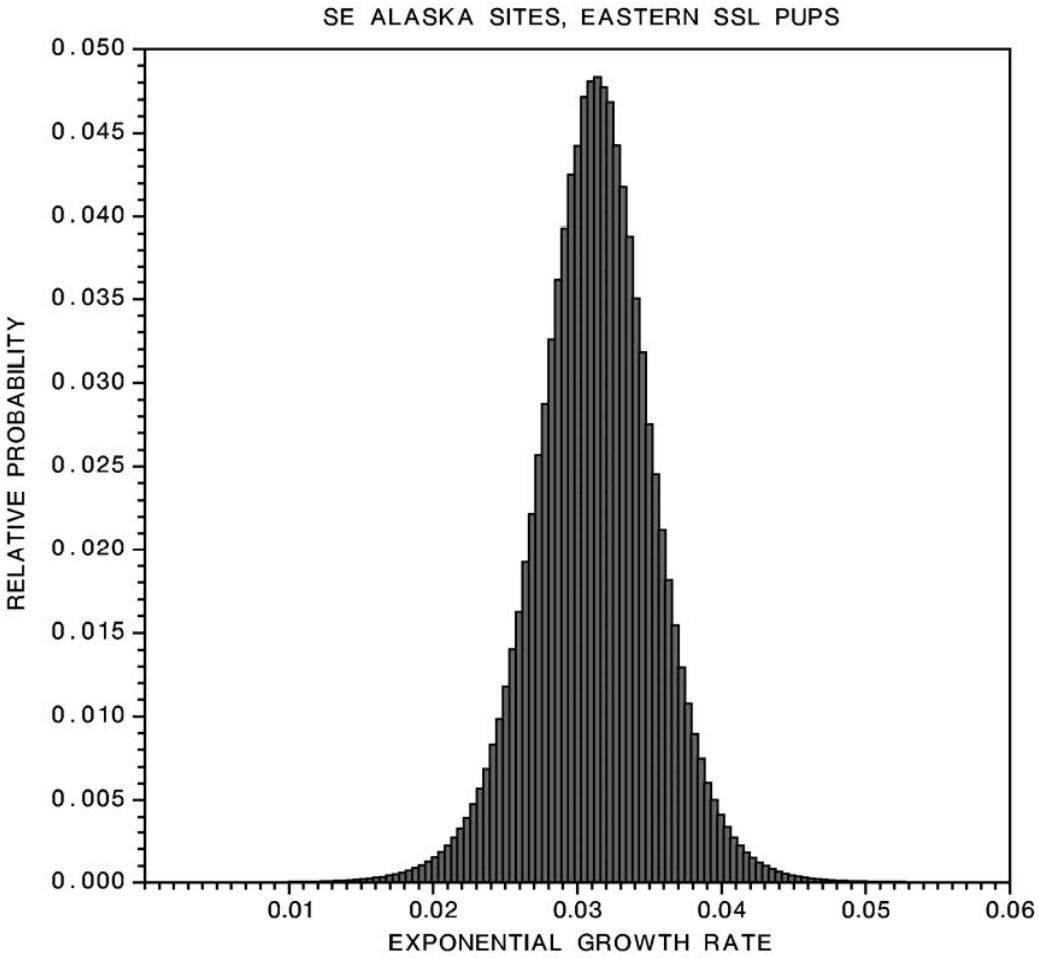
SE ALASKA SITES, EASTERN SSL PUPS
RELATIVE PROBABILITY
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0.01
0.02
0.03
0.04
0.05
0.06
EXPONENTIAL GROWTH RATE

Figure A3

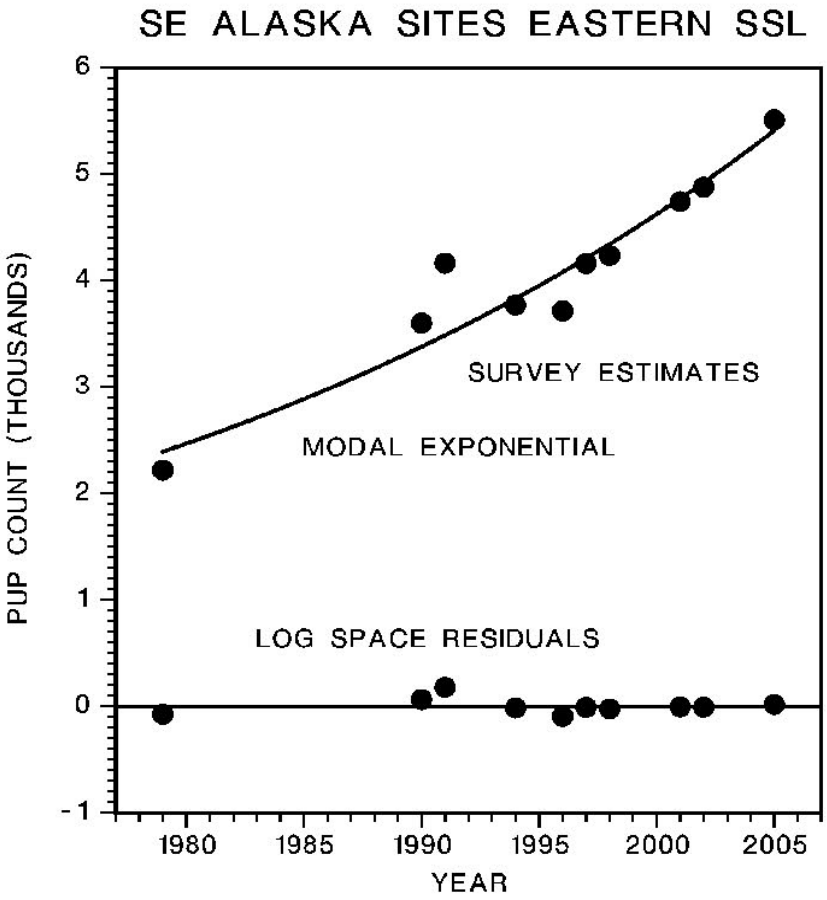
SE ALASKA SITES EASTERN SSL
PUP COUNT (THOUSANDS)
6
5
4
3
2
1
0
-1
SURVEY ESTIMATES
MODAL EXPONENTIAL
LOG SPACE RESIDUALS
1980
1985
1990
1995
2000
2005
YEAR

Figure A4

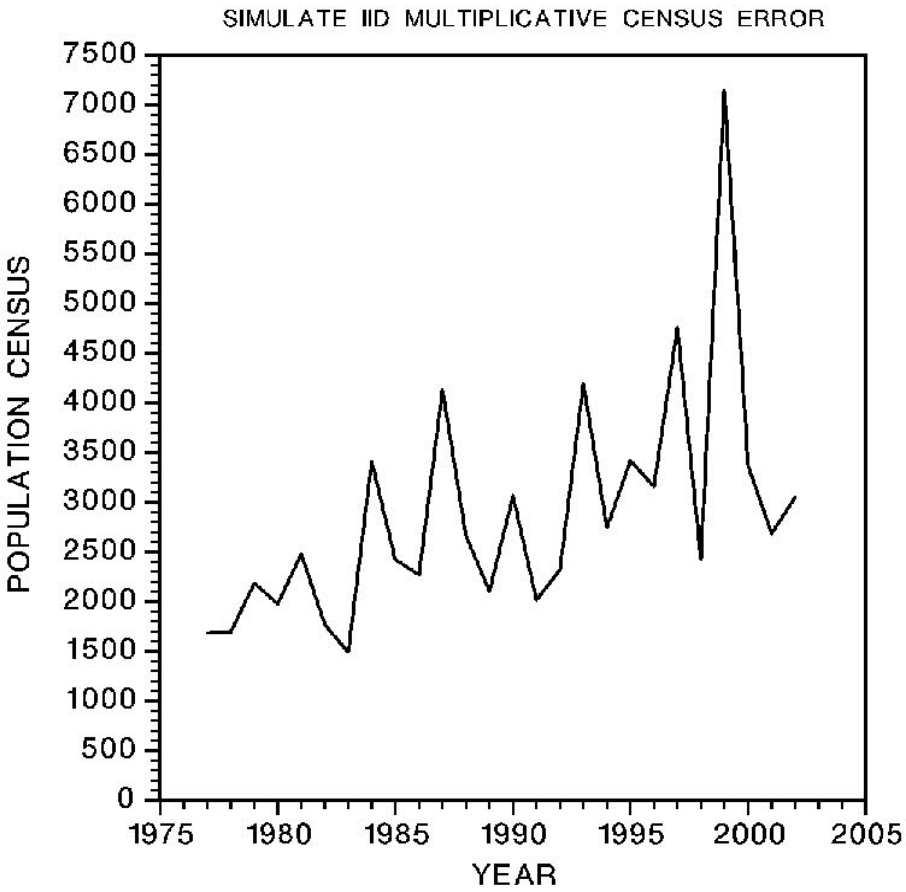
SIMULATE IID MULTIPLICATIVE CENSUS ERROR
POPULATION CENSUS
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1975
1980
1985
1990
1995
2000
2005
YEAR

Figure A5

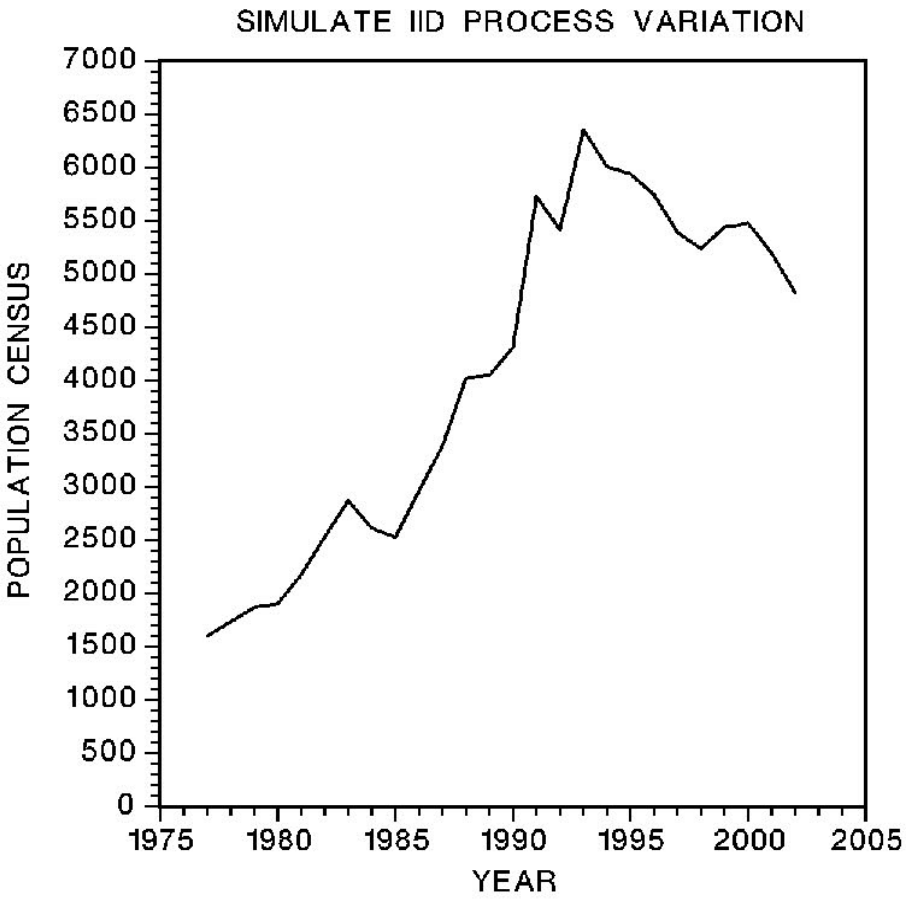
SIMULATE IID PROCESS VARIATION
POPULATION CENSUS
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1975
1980
1985
1990
1995
2000
2005
YEAR

Figure A6

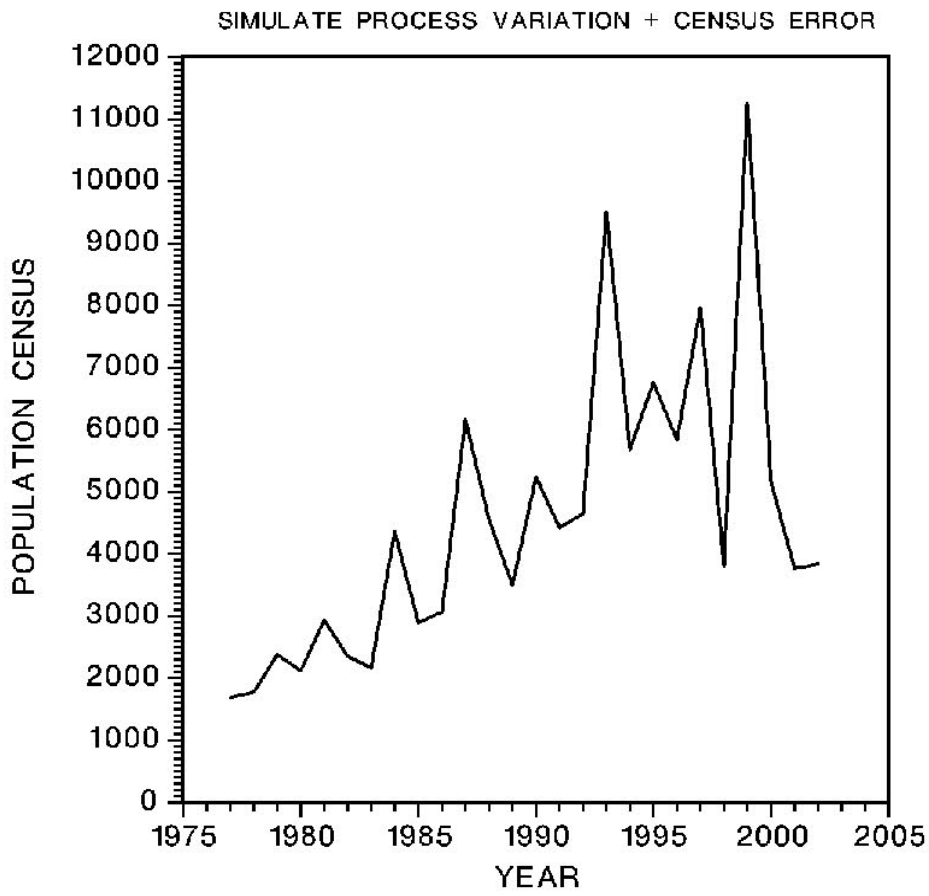
SIMULATE PROCESS VARIATION + CENSUS ERROR
POPULATION CENSUS
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1975
1980
1985
1990
1995
2000
2005
YEAR

Figure A7

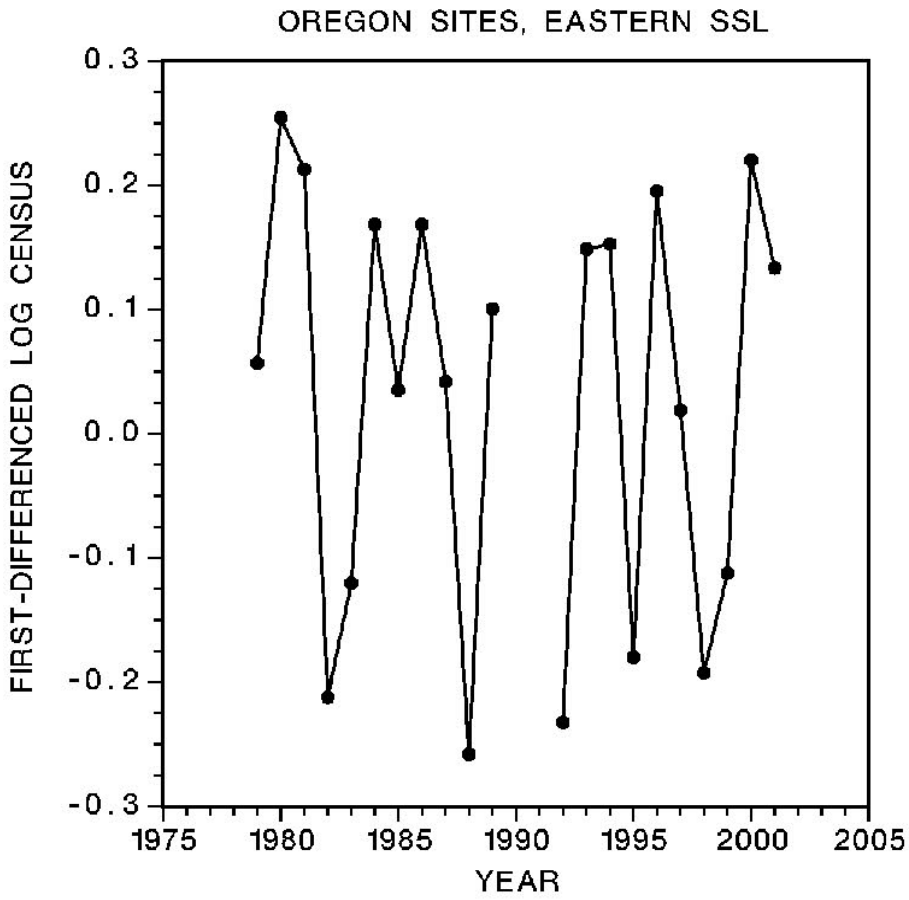
OREGON SITES, EASTERN SSL
FIRST-DIFFERENCED LOG CENSUS
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
1975
1980
1985
1990
1995
2000
2005
YEAR

Figure A8

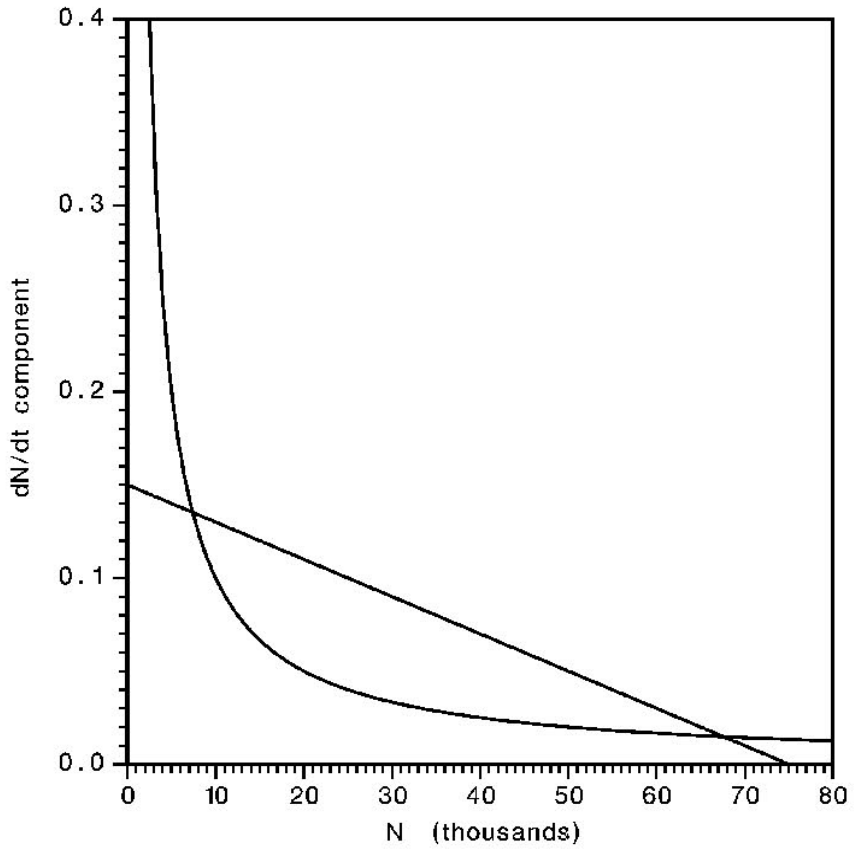
0.4
0.3
0.2
0.1
0.0
dN/dt component
0
10
20
30
40
50
60
70
80
N (thousands)

Figure 1B

2006 Draft Northern Fur Seal Conservation Plan

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DRAFT
CONSERVATION PLAN

for the

EASTERN PACIFIC STOCK OF NORTHERN FUR SEAL (Callorhinus ursinus)

May 2006

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NATIONAL MARINE FISHERIES SERVICE
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DRAFT CONSERVATION PLAN
for the
EASTERN PACIFIC STOCK of NORTHERN FUR SEAL (Callorhinus ursinus)

May 2006

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PREFACE

On June 17, 1988, the National Marine Fisheries Service (NMFS) declared northern fur seal stock of the Pribilof Islands, Alaska (St. Paul and St. George Islands) (Callorhinus ursinus), to be depleted under the Marine Mammal Protection Act (MMPA) of 1972. Amendments to the MMPA on November 23, 1988 (Public Law 100-711), directed the Secretary of Commerce to develop a conservation plan on northern fur seals for "conserving and restoring the species or stock to its optimum sustainable population." The amendments further specified that the plan include information on the status of fur seals on the Pribilof Islands, causes of declines, threats to the species, critical information gaps, and recommended research and management actions for meeting the objectives of the plan. NMFS designated the Pribilof Islands northern fur seal population depleted because it declined to less than 50 percent of levels observed in the late 1950s.

Accordingly, NMFS published a conservation plan for the northern fur seal in 1993. Having acquired substantial new information and with the greater inclusion of tribal governments in management of the stock, NMFS now publishes this revision of the 1993 conservation plan. This revision has been prepared with valuable input from the Tribal Governments of St. Paul and St. George Island and incorporates all substantial new information, research results, and management structures to serve as a guide for interested parties to assist in the implementation of conservation actions.

In 1994, NMFS reclassified the Pribilof Islands population as the Eastern Pacific Stock and included Bogoslof Island, but not San Miguel based on the phylogeographic approach proposed by Dizon et al. (1992). The Eastern Pacific stock is presently declining for unknown reasons after a period of stability in pup production from 1984 to 1998. Harvest practices contributed significantly to the declines of fur seal abundance in the Pribilof Islands prior to the 1970s.

The goal of this revised conservation plan will be met when northern fur seals are at abundance levels that justify their re-designation as a non-depleted stock. The shared resources and cooperative involvement of Federal, state, and local governments, fishing industry, Alaska Natives, academia, non-governmental organizations, and other interested individuals will be required throughout the recovery period. NMFS makes this conservation plan available to the public for review and comment.

Disclaimer

Conservation plans delineate reasonable actions that, according to the best available science, are required to recover and/or protect listed species. Plans are published by the National Marine Fisheries Service, sometimes prepared with the assistance of other stakeholders, State agencies, and contractors. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Nothing in the this plan should be construed as a commitment or requirement that any federal agency obligate or pay funds in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Conservation plans do not necessarily represent the views or the official positions or approval of any individuals or agencies involved in the plan formulation, other than the National Marine Fisheries Service. They represent the official position of the National Marine Fisheries Service only after they have been signed by the Assistant Administrator. Approved conservation plans are subject to modification as dictated by new findings, changes in species status, and the completion of conservation actions.

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EXECUTIVE SUMMARY

On June 17, 1988, the National Marine Fisheries Service (NMFS) declared stock of northern fur seals (Callorhinus ursinus) on the Pribilof Islands, Alaska (St. Paul and St. George Islands) to be depleted under the Marine Mammal Protection Act (MMPA) of 1972. The MMPA defines a species, population, or stock as depleted if it falls below its optimum sustainable population (OSP). The lower bound of OSP for northern fur seals is thought to be at least 60 percent of the carrying capacity level. The Pribilof Islands population was designated depleted because it declined to less than 50 percent of levels observed in the late 1950s, and no compelling evidence suggested that carrying capacity has changed substantially since the late 1950s.

Amendments to the MMPA on November 23, 1988 (Public Law 100-711), directed the Secretary of Commerce to develop a conservation plan on northern fur seals for "conserving and restoring the species or stock to its optimum sustainable population." The amendments further specified that the plan include information on the status of fur seals on the Pribilof Islands, possible causes of declines, threats to the species, critical information gaps, and recommended research and management actions for meeting the objectives of the plan.

Accordingly, NMFS published a conservation plan for the northern fur seal stock of the Pribilof Islands in 1993. In 1994 NMFS redefined the Pribilof Islands population as the Eastern Pacific stock to include the new population on Bogoslof Island identified as separate from those populations on islands in the western Bering Sea, Sea of Okhotsk, and Pacific Ocean. In addition, MMPA amendments included numerous changes in management structure including the development of agreements with Alaska Native Organizations for marine mammal species used for subsistence. NMFS has studied and supported studies of numerous aspects of the ecology of northern fur seals and obtained substantial new information about the stock. With the additional science and new management structures to consider, NMFS has prepared this revised northern fur seal conservation plan with valuable input from the Tribal Governments of St. Paul and St. George Island. This revision reflects the new management structure, interpretation of new information, identification of important research, and continued management of human activities that are thought to affect the Eastern Pacific stock of northern fur seals.

The Pribilof Islands population has continued to decline since the depleted listing. Between 1998 and 2004 estimated pup production declined at 6.2 percent per year (SE = 0.78 percent, P = 0.01) on St. Paul Island, and at 4.5 percent per year (SE = 0.45 percent, P = 0.01) on St. George Island. The 2004 estimate of pup production on St. Paul Island is comparable with the level observed in 1921, while on St. George it is below the level observed in 1916. Recent satellite telemetry studies indicate lactating female and juvenile male northern fur seals are central place foragers while in the Bering Sea. These studies also suggest separation of Bering Sea foraging areas defined by the central breeding area of departure.

Harvest management has played a significant role in the historic abundance of northern fur seals in the Pribilof Islands. Pelagic and terrestrial harvests of fur seals contributed to major declines in historic abundance. From 1956 to 1968 the commercial harvest of adult females contributed

to a majority of the subsequent decline of fur seal abundance in the Pribilof Islands. Subsistence harvest levels are currently below levels believed to influence the Pribilof Island fur seals. Scientists observed an increase in the number of fur seals entangled in marine debris following the mid 1960s when fishing effort in the North Pacific Ocean and Bering Sea increased. Concurrently, the fishing industry began using fishing gear (nets and line) and associated fishing materials (packaging bands, bait containers) made more from plastics rather than other materials, at a level at least two orders of magnitude greater than that observed in the 1940s. Between 1970 and 1982, the mortality of 2- to 5-year-old male seals was correlated with increased rates of entanglement in marine debris. The significant correlation between entanglement rate and rate of pup mortality suggested that entanglement in marine debris may have contributed significantly to declining trends of the population on the Pribilof Islands during the late 1970s.

Changes in the quantity and/or quality of available prey may also influence the health and fitness of individual fur seals. Important fur seal prey includes pollock, small schooling fish, and gonatid squid. The importance of any particular prey category depends on the sampling location and may be related to biases in the method used to assess prey importance. Walleye pollock and squid are important fur seal prey in the eastern Bering Sea with the addition of Pacific herring, Pacific sandlance, and capelin in the Gulf of Alaska and Pacific Ocean. The abundance has changed for major fish species across the entire range of fur seals. Whether and what extent fish abundance was affected by fishing or environmental change is unknown. How alteration of fish abundance influences population trends of the Eastern Pacific stock is also unknown. The complexity of ecosystem interactions and limitations of data and models make it difficult to determine specific effects on the fur seal population.

This Conservation Plan reviews and assesses the known and possible factors influencing northern fur seals in Alaska; it also contains pertinent information on fur seals breeding in California and Russia. Natural factors influencing the population include predation, parasitism, disease, and environmental change. Human-related factors influencing the population include subsistence harvests, direct and indirect effects of commercial fishing, marine debris, poaching, pollution, vessel and aircraft traffic, tourism, coastal development, noise, and oil and gas activities.

Four objectives are proposed that are aimed at restoring and maintaining the Eastern Pacific stock of fur seals to its OSP level, consistent with the 1988 amendments to the MMPA.

Objective 1. Identify and eliminate or mitigate the cause or causes of human related mortality of the Eastern Pacific stock of northern fur seals;

Objective 2. Assess and avoid or mitigate adverse effects of human related activities on or near the Pribilof Islands and other habitat essential to the survival and recovery of the Eastern Pacific stock of northern fur seals;

Objective 3. Continue and, as necessary, expand research or management programs to monitor trends and detect natural or human-related causes of change in the northern fur seal population and habitats essential to its survival and recovery;

Objective 4. Coordinate and assess the implementation of the conservation plan, based on implementation of Conservation Actions and completion of high priority studies.

The goal of this Plan is to recover the Eastern Pacific stock of northern fur seals to a level such that it is no longer designated as depleted. NMFS notes that as of the writing of this plan the stock is declining and stopping this decline is of paramount importance. Meeting the goal of recovery to OSP and reclassification as not depleted may take many decades.

I. Background

Amendments to the MMPA on November 23, 1988 (Public Law 100-711), directed the Secretary of Commerce to develop a Conservation Plan for the northern fur seal (Callorhinus ursinus). Conservation Plans identify specific management actions that must be taken to ensure that the species of concern recovers to the point that it is no longer depleted. Conservation plans also serve as advisory documents to identify conservation threats and to recommend research and management actions to promote recovery. The Senate report accompanying the 1998 amendments (Senate 100-592, October 7, 1998) further stated that conservation plans include the following essential elements:

(1) an assessment of the status of the stock;

(2) a description of the causes of any population declines or loss of essential habitat, including rookeries, beaches, and offshore foraging habitats;

(3) an assessment of existing and possible threats to the species or its habitat;

(4) a discussion of critical information gaps;

(5) a description of research and management to be undertaken to meet the objectives of the plan; and

(6) an implementation schedule of the proposed action to promote recovery activities.

National Marine Fisheries Service (NMFS) published the first northern fur seal conservation plan in 1993 after the depleted designation. NMFS has now prepared a revision of that conservation plan to incorporate substantial new information and account for changes in the management structure to include co-management agreements with the Tribal Governments. NMFS will continue to revise this plan at regular intervals as new information is accumulated, management actions are evaluated, and population status changes.

Some of the decline in the northern fur seal population since the 1950s can be explained as a direct result of harvesting practices that caused high adult female mortality on land or at sea (York and Hartley 1981). However, recent declining trends in fur seal abundance cannot be explained solely as a result of commercial harvesting or other known sources of adult female or

juvenile mortality. The decline in fur seal abundance is similar to the continued decline in Steller sea lion (Eumetopias jubatus) abundance throughout the Gulf of Alaska and Bering Sea (Merrick et al. 1987; Sease and Gudmundson 2002) in that causes cannot be easily identified due to the ecological complexity of the problem and lack of a continuous time-series of relevant biological data (e.g., population vital rates).

NMFS manages numerous human activities known and suspected to influence the northern fur seal population. Appropriate management is predicated on understanding the contribution of human and natural influences on the Eastern Pacific northern fur seal population status, and managing those human influences using the best available science. NMFS recommends continuation of ongoing research and development of new programs designed to improve our understanding of fur seal ecology, to provide a basis for management actions, and to identify conservation needs. It will take many years before we understand the role of most factors that influence the population. NMFS recommends continued harvest and fisheries management incorporating ecosystem approaches to management. NMFS recommends continued investigations into reducing poaching and marine debris. To evaluate the trend and status of fur seals, NMFS has monitored the populations on St. Paul and St. George Islands to create a near-continuous data record. The fur seal population breeding on Bogoslof Island has been monitored and studied intermittently since 1980. Bogoslof Island fur seals provide a unique opportunity to study and gain important insight into the ecology of a growing population. NMFS has also studied or supported studies of various aspects of the life history of Pribilof and San Miguel fur seals that have contributed to our understanding of their ecology. It is important that relevant programs continue, data be analyzed and interpreted, and that the information from all studies continue to be made available to stakeholders in a timely manner.

A. Brief Overview

Northern fur seals are colonial breeding pinnipeds that exhibit strong site fidelity and currently breed on a few islands in the North Pacific Ocean and Bering Sea. Adult male fur seals, about 3-5 times larger than females, arrive at rookeries prior to the breeding season and defend territories within the rookery. Beginning in mid-June the rookeries are occupied by breeding females, who within a few days give birth and begin nursing their single pup. Lactating females cycle between on shore attendance and at-sea foraging trips for the ~4-month nursing period (July-October). Over 50 percent of the worldwide population of fur seals is found on the Pribilof Islands.

NMFS designated the Pribilof Islands northern fur seal population depleted on 17 June 1988 because it declined to less than 50 percent of levels observed in the late 1950s and no compelling evidence suggested that the northern fur seal carrying capacity (K) of the Bering Sea had changed substantially since the late 1950s. The MMPA defines the term "depletion" or "depleted" (16 U.S.C.1362 (1)) as meaning any case in which

(A) the Secretary of Commerce, after consultation with the Marine Mammal Commission and the Committee of Scientific Advisors on Marine Mammals, determines that a species or population stock is below its optimum sustainable population; (B) a State, to which authority for the conservation and management of a species or population stock is transferred under section

1379 of this title, determines that such species or stock is below its optimum sustainable population; or (C) a species or population stock is listed as an endangered species or a threatened species under the Endangered Species Act of 1973 (16 U.S.C. §1531).

Northern fur seals have been harvested across their range, with a majority of the harvest occurring on the Pribilof Islands. The Aleut people and other coastal indigenous peoples have harvested fur seals for food, clothing and raw materials. Aleuts and other indigenous peoples were captured by Russians and enslaved on the Pribilof Islands to harvest fur seals for their pelts. The United States government continued the commercial harvest of fur seals, developed the North Pacific Fur Seal Convention, and subsequently passed the Fur Seal Act to provide for the management of the fur seal population, administration of the islands and Pribilovians, and enforcement of the regulations to implement the Act. Management of the fur seal population included the development of the Fur Seal Commission and later the Standing Scientific Committee to help prioritize research and exchange results among the signatories. The harvest has been primarily focused on juvenile males due to their high quality fur and because dense aggregations on land facilitated harvesting and processing. Harvests have also occurred intermittently at sea and, relative to harvests on land, often result in high numbers of animals killed but not retrieved and in high mortality of females. About 45,000 to 126,000 fur seals were harvested annually on land during the peak from about 1945 to 1965. Commercial harvest of fur seals for their pelts was discontinued on St. George in 1972 and on St. Paul in 1984. Since the cessation of the commercial harvests on the Pribilof Islands, local residents have harvested fur seals to meet their subsistence needs. Pribilovians have harvested fewer than 1000 juvenile male fur seals since 2000.

Commercial fishery interactions and subsistence harvests are the primary manageable sources of mortality to the northern fur seal population. Fishery interactions can include direct bycatch, entanglement in derelict fishing gear, and more difficult to detect indirect effects. Other manageable threats include oil spills, chronic pollution, collisions, habitat degradation, illegal harvests, and harassment. Research, vehicles, vessels, and noise in general can cause harassment of fur seals. Natural factors strongly influence fur seal behavior and ultimately population vital rates such as survival and reproductive rates.

Studies of northern fur seal behavior, growth, mortality, migration, and foraging ecology have been an important component of fur seal management. Regular abundance estimation is a critical aspect to identifying population trends. The integration of comprehensive population abundance estimates with concurrent behavioral and ecological studies gives researchers the potential for insight into the mechanisms that may be changing the population. Current fur seal population vital rates are unknown and historic estimates of age class survival and reproduction are not appropriate to use on a declining population with a small harvest. Estimating survival and reproduction of females will be an important aspect to evaluate possible mechanisms underlying the current population decline on the Pribilof Islands.

B. Description and Taxonomy

Northern fur seals belong to the Order Carnivora, Suborder Pinnipedia, Family Otariidae, and Subfamily Otariinae. The family contains the extant genera Arctocephalus, Callorhinus, Eumetopias, Neophoca, Otaria, Phocarctos, and Zalophus. The genus Callorhinus contains one species, the northern fur seal, C. ursinus (Rice, 1998). Little evidence of genetic differentiation among breeding sites has been found (Ream, 2002; Rice, 1998), but for management purposes five stocks (populations) of northern fur seals are recognized that breed on at least six island groups in the North Pacific (Figure 1); the eastern Pacific stock includes the Pribilof Islands and Bogoslof Island, San Miguel Island stock located off the coast of southern California, the Commander Islands stock (Russia), the Kuril Islands stock (Russia), and the Robben (Tuleniy) Island stock in the Okhotsk Sea (Russia). Stock designation is based principally on geographic separation during the breeding season (Dizon et al., 1992) but considerable interchange of individuals takes place between rookeries; therefore, northern fur seals are considered one biological species. This conservation plan pertains to the eastern Pacific stock, with relevant information from other stocks included. Unless noted otherwise, all references to fur seals in this document are to northern fur seals.

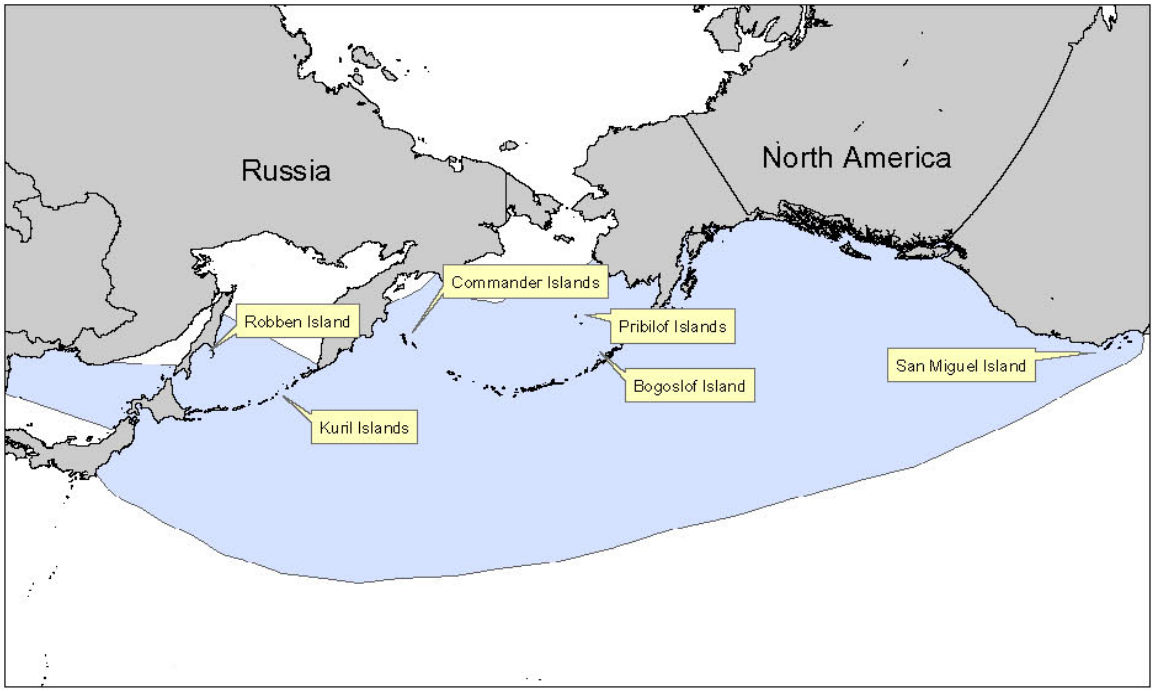

FIGURE 1. NORTHERN FUR SEAL BREEDING COLONIES AND EXTENT OF THEIR WINTER RANGE.

C. Abundance and Trends

Kenyon et al. (1954) presented the history of fur seal population estimation and the reliability of methods for the first half of the 20th century. York and Kozloff (1987) described the mark-recapture (shear-sampling) method for estimating pup production and York (1989) presented biases of the method. Pup production is estimated every two years and is the most accurate

indicator of population size. Adult male fur seals are counted every year, and serve as a very rudimentary index of population size. Adult male counts have been collected since 1909 (Lander, 1980). NMML computes a total population estimate from the pup production estimate using a multiplier adjusted for the cessation of the commercial harvest.

C.1. Current Trends

The eastern Pacific stock of fur seals has declined to an estimated 721,935 in 2005 (draft Stock Assessment Report) from a historical high of about 2.1 million during the late 1940s to early 1950s (Briggs and Fowler, 1984). Towell et al. (in press) report that the 2004 pup production estimate for St. Paul Island was 15.7 percent less than the estimate in 2002 and 22.6 percent less than the estimate in 2000 (Table 1; Figure 2). The 2004 pup production estimate for St. George Island was 4.1 percent less than the estimate in 2002 and 16.4 percent less than the estimate in 2000. Estimated pup production has declined at 6.2 percent per year (SE = 0.78 percent, P = 0.01) on St. Paul Island, and at 4.5 percent per year (SE = 0.45 percent, P = 0.01) on St. George Island, from the estimated pup production in 1998 (Table 1). Estimated pup production on the two islands, as a whole, has declined at 6.0 percent per year (SE = 0.59 percent, P = 0.01) since 1998. Estimated pup production is now below the 1921 level on St. Paul Island and below the 1916 level on St. George. During those years the northern fur seal population was increasing at about 8 percent per year as it was recovering from a pelagic harvest that took place in the 19th and early 20th centuries (Figure 2).

TABLE 1. ESTIMATE OF THE NUMBER OF PUPS BORN ON THE PRIBILOF ISLANDS 1998-2004, INCLUDING THE STANDARD ERROR OF THE COUNT AND THE 95% CONFIDENCE INTERVAL. TOTAL INCLUDES LIVE AND DEAD PUPS COUNTED.

Location and year	Estimated number of pups born	Standard error	95% Confidence interval
	St. Paul Island		
1998	179,149	6,193	164,503-193,795
2000	158,766	17,248	116,445-201,027
2002	145,701	1,629	142,182-149,220
2004	122,825	1,289	120,039-125,611
	St. George Island		
1998	22,090	222	21,547-22,633
2000	20,176	271	19,513-20,839
2002	17,593	527	15,890-18,238
2004	16,876	238	16,291-17,461
Total pups born in 2004	139,701	1311	136,489-142,913

Adult males are counted annually and categorized as territorial with females (harem), territorial without females and non-territorial. Numbers of harem males are highly correlated with the number of pups born (York et al., 2005). After cessation of the commercial harvest on St. Paul Island until 1993 the total number of adult males increased to 1993 (Fowler and Robson, 1994). Recent adult male counts on St. Paul and St. George are lower than any period in the last 50 to 100 years.

Fur seal abundance on Bogoslof Island (Figure 3) is growing rapidly in contrast to the Pribilof Island population trend (Figure 2). From 1976 to 1981, small numbers of fur seals were observed on Bogoslof Island (Loughlin and Miller, 1989). Since the first evidence of pup production in 1980 (Lloyd et al., 1981), the population has continued to grow rapidly (Ream et al., 1999; Figure 3). Ream et al. (1999) speculated that such a rapid growth rate is largely influenced by immigration from the Pribilof Island populations.

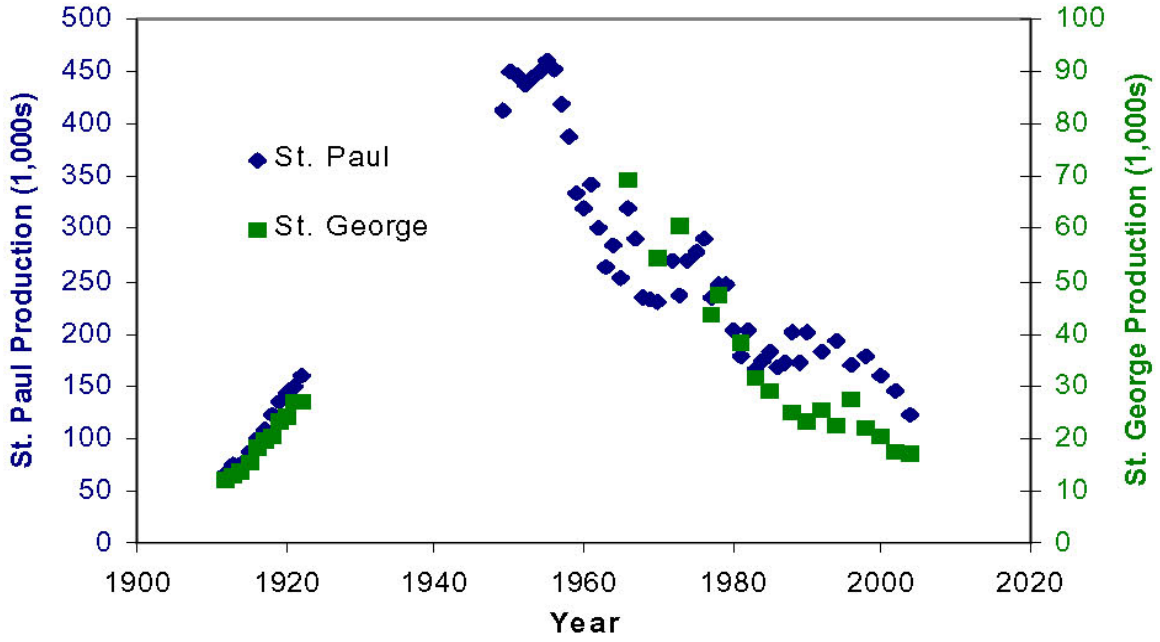

FIGURE 2. ESTIMATES OF NORTHERN FUR SEAL PUP PRODUCTION ON THE PRIBILOF ISLANDS FROM 1909-2004.

While this Conservation Plan concerns the eastern Pacific stock, it is important from an ecological perspective to consider the population status of other stocks. The San Miguel Island population originated from colonization by individuals from the Pribilof Islands population during the 1950s or early 1960s (Peterson et al., 1968; DeLong, 1982). Since the discovery of the San Miguel Island rookery, the fur seal population there has grown steadily but has had

TABLE 2. NUMBER OF HAREM AND IDLE MALE NORTHERN FUR SEALS COUNTED IN MID-JULY, PRIBILOF ISLANDS, ALASKA, 1995-2004.

	St. Paul		St. George		Total	
Year	Harem	Idle	Harem	Idle	Harem	Idle
1995	5,154	8,459	1,242	1,054	6,396	9,513
1996	5,643	9,239	1,248	790	6,891	10,029
1997	5,064	8,560	910	1,503	5,974	10,063
1998	4,718	8,280	1,113	1,081	5,831	9,361
1999	3,801	7,589	1,052	916	4,819	8,505
2000	3,646	6,998	869	1,295	4,515	8,293

2001	3,388	7,174	779	1,477	4,167	8,651
2002	3,669	7,877	899	1,235	4,568	9,112
2003	3,652	7,572	716	1,158	4,368	8,730
2004	3,286	5,027	760	905	4,046	5,932

major short-term declines associated with strong El Niño events. The San Miguel Island stock reached a high in 1997 when pup production was estimated at just over 3,000 (DeLong and Melin, 1999; Melin and DeLong, 2000), with a total population estimated between 12,272 and 12,408 (Carretta et al., 2002). In 1999, the San Miguel population again began to recover with a total pup count of 1,084, and a stock estimate of 4,336 seals (Carretta et al., 2002), although the number of territorial bulls (106) was lower than the 1997 count (Melin and DeLong, 2001). This recovery continued through 2001 but remained below the 1997 level by 24 percent. Other signs of population recovery in 2000 and 2001 included good condition of 4-month-old pups and reduced late-season pup mortality, but the reduced number of adult females in the population after 1998 and the loss of most of the 1997 cohort suggest that fur seal pup production at San Miguel Island may remain depressed for several more years.

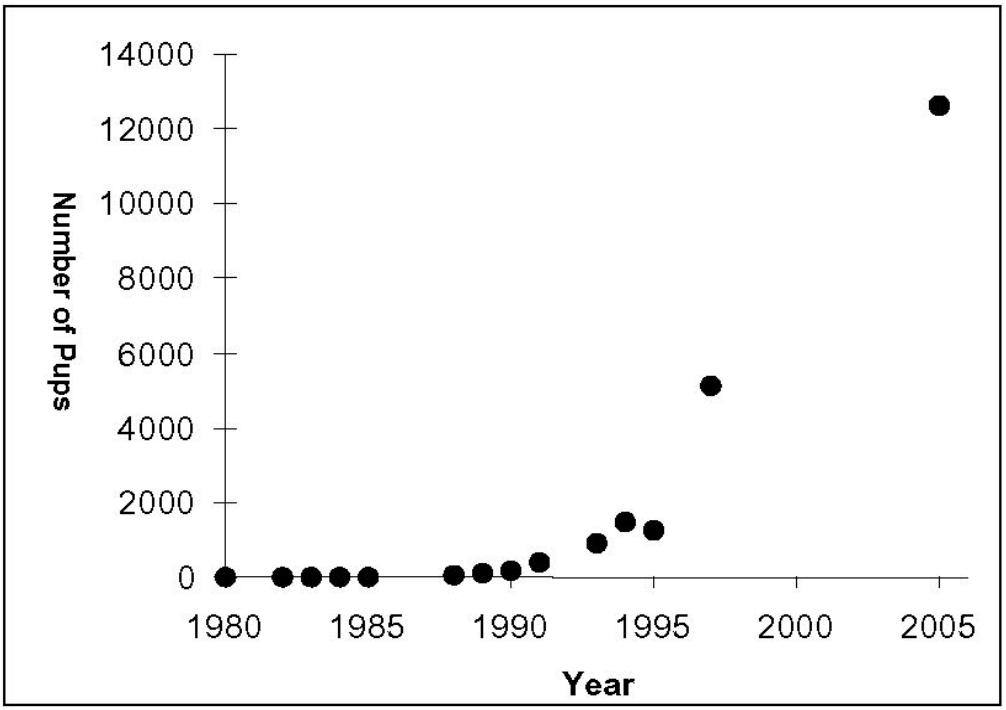

FIGURE 3. BOGOSLOF ISLAND NORTHERN FUR SEAL PUP PRODUCTION FROM 1980-2005.

Fur seal numbers in the Commander and Kuril Islands and on Robben Island were greatly reduced in the early 1900s as a result of commercial sealing (Lander and Kajimura, 1982). Fur seal populations have generally decreased or remained stable from the 1960s to the late 1980s on the Commander and Kuril Islands (Gentry, 1998). The Commander Island population was estimated at 225,000 to 230,000 in 1988-1990, which is slightly less than the maximum of

255,000 in the late 1970s. The Kuril Island population was estimated to be 45,000 to 50,000 in 1988, a reduction from the peak of 60,000 in 1977-1978 (Vladimirov and Nikulin, 1991). The Robben Island stock declined from about 60,000 pups born in the 1960s to annual pup production of about 20,000 in 1990 (Yoshida and Baba 1982 in NRC, 1996; Gentry, 1998) but appears to be recovering; in 2002 the rookery was estimated to number 88,000 individuals and 26,400 pups (Kuzin 2002, pers. comm. to members at US/Russia meetings, Santa Cruz, CA). In recent years a small population that apparently originated from the San Miguel Island stock has also been reported on South Farallon Island off the central California coast (Pyle et al., 2001).

C.2. Abundance

Loughlin et al. (1994) estimated ~ 1.3 million northern fur seals worldwide, and the Pribilof Islands represented about 982,000 (74 percent) in 1992. The population estimate for the Eastern Pacific stock of northern fur seals is calculated as the estimated number of pups at rookeries multiplied by a series of different expansion factors determined from a life table analysis to estimate the number of yearlings, 2 year olds, 3 year olds, and animals at least 4 years old (Lander 1981). The resulting population estimate is equal to the pup count multiplied by 4.5. The expansion factor is based on a sex and age distribution estimated after the harvest of juvenile males was terminated. Currently, CVs are unavailable for the expansion factor. As the great majority of pups are born on the Pribilof Islands, pup estimates are concentrated on these islands, though additional counts have been made on Bogoslof Island. Since 1990, pup counts have occurred biennially on St. Paul and St. George Islands, although less frequently on Sea Lion Rock and Bogoslof Island. The most recent estimate for the number of fur seals in the Eastern Pacific stock, based on pup counts from 2002 on Sea Lion Rock, from 2004 on the Pribilof Islands, and from 2005 on Bogoslof Island, is 721,935 (4.5 x 160,430). NMML calculated preliminary estimates of the 2004-5 worldwide population at 1.1 million, and the Pribilof Islands accounted for ~ 55 percent of the annual production, down from 74 percent in 1992.

C.3. Carrying Capacity

Both carrying capacity (K) and optimum sustainable population (OSP) are difficult to measure; K is especially hard if the ecosystem has changed significantly since historic high population levels. Pribilof Islands northern fur seal carrying capacity was estimated at 1.8 million (Kenyon et al., 1954) during the depleted listing (51 FR 47156). Subsequent analyses of the population data suggested that the population might have been closer to 2.1 million during the late 1940 to early 1950 period (Briggs and Fowler, 1984). Gerrodette and DeMaster (1990) suggest natural changes in carrying capacity are a more accurate reflection of environmental complexity than assuming a constant environment. Fowler and Siniff (1992) further discuss the importance of differentiating and defining "natural K," from "current K" and "altered K." One of the major challenges to assessing the current carrying capacity of a population is determining what influence human activities may have on the "natural K" (i.e., historical carrying capacity) and whether an "altered K" exists and can be restored to the "natural K" through management and restoration actions.

The MMPA defines optimum sustainable population as "...the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the optimum carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element (16 U.S.C. §1362(9))." NMFS regulations at 50 Code of Federal Regulations (CFR) 216.3 define OSP as

> ...a population size which falls within a range from the population level of a given species

> or stock which is the largest supportable within the ecosystem, to the population level that results in maximum net productivity. Maximum net productivity is the greatest net annual increment in population numbers or biomass resulting from additions to the population due to reproduction and/or growth less losses due to natural mortality.

Section 1361(2) of the MMPA states that marine mammal species, populations, and stocks should not be permitted to fall below their OSP level. The maximum net productivity level (MNPL) is the lower end of OSP. Historically, MNPL has been expressed as a range of values (generally 50-70 percent of K) determined theoretically by estimating what stock size in relation to the original stock size will produce the maximum net increase in population (42 Federal Register (FR) 12010, March 1, 1977). MNPL for marine mammals is at least 50 percent of carrying capacity (Eberhardt and Siniff, 1977), and may be as high as 80 percent (Fowler 1981, 1988). In 1977, the mid-range value of 60 percent was used to determine if a stock of dolphins was depleted (42 FR 64548, Dec. 27, 1977). The 60 percent value was supported by NMFS in the final rule governing the taking of marine mammals incidental to commercial fishing operations (45 FR 72178, Oct. 31, 1980). The lower bound of OSP for northern fur seals is also considered to be at 60 percent of K (Fowler, 1981). The lower bound of OSP would be 1,080,000 if K was 1.8 million northern fur seals and 1,260,000 if K was 2.1 million.

Fowler (1986) stated that

> given the available data and analyses, it is not possible to clearly determine whether the Pribilof fur seal population is currently at, above, or below carrying capacity levels; whether carrying capacity has changed significantly in the last two or three decades; or whether the observed population decline is due to declining carrying capacity, increased mortality, or some combination of both.

Gerrodette and DeMaster (1990) used Goodman's (1988) dynamic response analysis and a condition index to evaluate northern fur seal population status. They determined that the population was below OSP, and evidence suggested that carrying capacity was unchanged. Fowler and Siniff (1992) used a variant of the approach used by Gerrodette and DeMaster (1990); they suggested that carrying capacity might be reduced on the order of 13 percent based on a proportional reduction of mortality estimates from 1911 to 1990 (Fowler and Siniff, 1992).

Carrying capacity estimates for other seasonal occupants of the Bering Sea may provide insight towards the uncertainty in estimating carrying capacity of the eastern North Pacific northern fur seal stock. Schell (2000) suggested that the overall carrying capacity in the Bering Sea declined during the past two decades based on primary and secondary production estimates. Swartzman and Haar (1983; 1985) reviewed pollock fisheries data for the Bering Sea and concluded that an increase of juvenile walleye pollock may have resulted in an increase of total pollock (i.e., increased K), potentially benefiting foraging northern fur seals. Some researchers have suggested that gray whales are approaching or have reached their carrying capacity for the Bering Sea (e.g. Moore et al., 2001). Hobson et al. (2004) disagreed with Schell's hypothesis of a reduction of Bering Sea productivity.

D. Life History

D.1. Reproduction

Some males and most females probably return to their natal sites to breed (Baker et al., 1995; Gentry, 1998). Male fur seals become sexually mature at 5-7 years of age and begin competing for a territory after about 7-9 years of age (Johnson, 1968). Adult males arrive on rookeries in mid-May, and territorial males fast while defending territories until early August. Territories are small, averaging a maximum area of approximately 110 m^2 (Gentry, 1998). Male displays and calls appear to be directed at other males and are probably not used to attract females. Immature male fur seals also fast while resting on the haulout sites and may lose an estimated 20-30 percent of their body weight during the breeding season, which is somewhat less than that lost by territorial males during the same period (Baker et al., 1994).

Most females become sexually mature between 4 and 7 years of age (average about 5) (York, 1983) and are known to give birth up to at least 23 years of age (Lander, 1981). Pregnant females begin to arrive in mid-June; non-pregnant adult females arrive later (Bartholomew and Hoel, 1953; Gentry and Holt, 1986; Gentry, 1998). Arrival of pregnant females peaks in early July, followed by a progressive decline in numbers of new arrivals through August (Gentry and Holt, 1986; Gentry, 1998). Females give birth to a single pup within 2 days of arriving on shore, and mate 3-8 days after parturition (Petersen, 1968; Gentry and Holt, 1986; Gentry, 1998). Female fur seals exhibit a delayed implantation of the blastocyst with implantation occurring between mid November to early December (York and Scheffer, 1997). Lactating females make three- to ten-day foraging trips from the island, punctuated by one- to two-day visits to the rookery to feed pups. Upon the female's return from foraging, pups and females recognize each other initially by vocalization. Mother-offspring pairs recognize each other's vocalization during the course of the breeding season and are able to retain these memories for at least 4 years (Insley, 2000). Pups are weaned at approximately 4 months of age. After pupping, mating, and weaning of pups, adult females from the Pribilof Islands migrate south through passes in the Aleutian Islands into the North Pacific Ocean (Ream et al., 2005).

D.2 Migration

The typical migratory pattern of northern fur seals has been described by numerous authors (e.g., Bigg 1990; Fiscus, 1978; Fowler, 1998). Northern fur seals begin to return to the breeding islands from their pelagic winter foraging in the spring of each year. Adult males arrive first and establish territories on the breeding rookeries. On the Pribilof Islands they arrive in descending order by age, beginning in early May. The youngest males may not return to the breeding areas until mid-August or later. Some yearlings arrive as late as September or October; however, most remain at sea. The older pregnant females arrive about mid-June; the peak of pupping occurs in early July. Pups leave the islands in early November after the older animals.

Fur seals migrate during early winter through the eastern Aleutian Islands into the North Pacific Ocean then into the waters off the coasts of British Columbia, Washington, Oregon, and California (Figure4). Older males appear to remain in the northern part of the range, while young males and females of all ages spend the winter feeding in the southern part. While feeding at sea, the daily feeding rate for pregnant females is 1.6 times that of nonpregnant females (Perez and Mooney, 1986). The northward migration begins in March. This migration brings the animals back to the breeding colonies where the cycle is repeated.

Adult males are believed to migrate only as far south as the Gulf of Alaska (Kajimura, 1984). Loughlin et al., (1999) used satellite telemetry to monitor the movements of 8 adult male fur seals from the Pribilof Islands and reported that 7 of 8 males eventually left the Bering Sea and fed either in the eastern Pacific Ocean and Gulf of Alaska or to the west off the Kuril Islands and Japan.

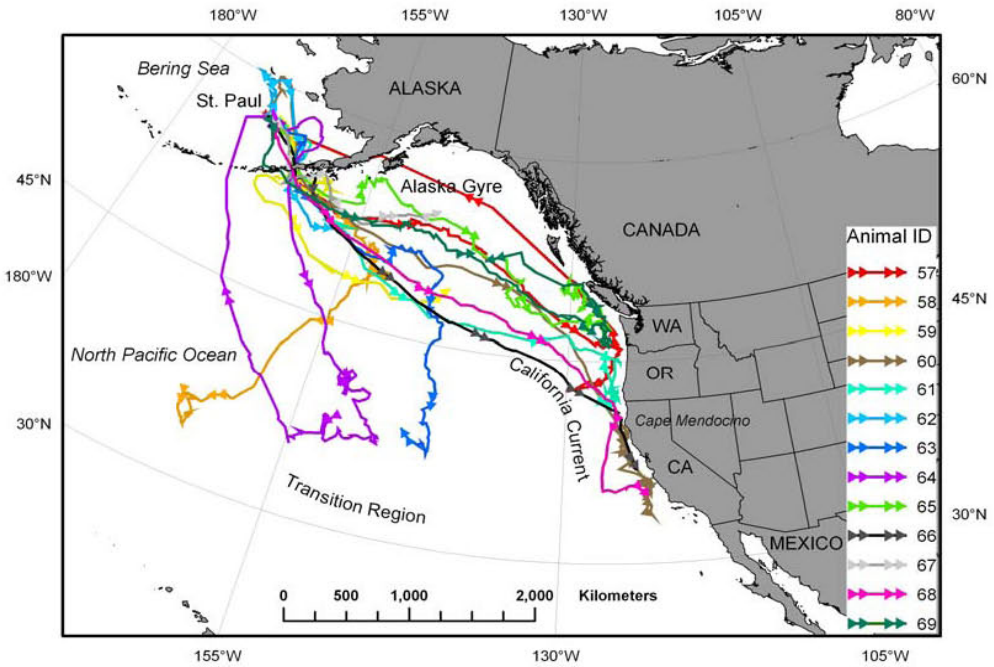

FIGURE 4. WINTER MIGRATION ROUTES OF 13 ADULT FEMALE NORTHERN FUR SEALS TO FEEDING AREAS IN THE NORTH PACIFIC OCEAN (*from REAM et al., 2005*).

Pups begin swimming at about 26 days of age, spend a substantial amount of time in the water by 40-50 days of age, and by 100 days old are making shallow dives for short durations (Baker and Donohue, 2000). They begin leaving the Pribilof Islands in October and are widely dispersed by the time they reach the Aleutian Islands (Ragen et al., 1995). It is thought that pups from the Pribilof Islands travel through Aleutian Island passes after leaving their birth islands and remain at sea in the North Pacific Ocean for about 22 months before returning to their islands of origin as 2 year-olds. Baker et al. (1994) and Baker and Fowler (1992) showed that larger-than-average male pups were more likely to survive to at least 2 years of age.

Ream et al. (2005) monitored 13 adult female fur seals from St. Paul Island during their migration in 2003 and found that seals departed from the Pribilof Islands in November and moved in a southeasterly direction over the continental shelf as they left the Bering Sea (Fig. 4). Their travel routes did not follow coastal or bathymetric features as they crossed the North Pacific Ocean, and instead corresponded to complementary water movement of the Alaska Gyre and the North Pacific Current. Feeding locations during winter are generally unknown, but Ream et al. (2005) demonstrate that the fur seals cue on significant oceanographic features to navigate in the open ocean and to locate prey. It is believed that fur seals from all eastern Bering Sea rookeries intermix with fur seals from other rookeries in the Bering Sea and North Pacific.

San Miguel Island fur seals are present in the eastern Pacific Ocean predominantly offshore California during the winter.

E. Diet and Foraging Behavior

Northern fur seals consume schooling fish and gonatid squid, although the species eaten vary with location and season (Kajimura, 1984; Sinclair et al., 1994; Ream et al., 2005) (Table 3; Figs. 5 & 6). The subsequent sections describe details of diet information based on fur seals sampled from the main geographic regions occupied by fur seals, trophic levels of fur seals, and foraging behavior. The greatest volume of information describing the feeding ecology of northern fur seals is based on stomach contents taken in pelagic collections of adult female and juvenile seals from the 1950s to the 1970s (Kajimura, 1984). The stomach content data is at least 30 years old and it's applicability to present day fur seal diet estimates is unknown. More recent diet information has been obtained from fecal analyses, stable isotope analysis, and fatty acid signature analysis (Antonelis et al., 1997; Sinclair et al., 1996; Kurle and Worthy, 2001; Goebel, 2002; Gudmundson et al., In Press; Zeppelin and Ream, in Review.). All methods of analysis to estimate species and size composition of pinniped diets are limited by some form of bias (Pierce et al., 1991; Sinclair et al., 2000; Tollit et al., 2004; Yonezaki et al., 2003; Yonezaki et al., 2005).

E.1. Diet: Bering Sea

Walleye pollock, squid, and bathylagid fish (northern smoothtongue, Leuroglossus schmidti, a.k.a. seal-fish) were the predominant prey of fur seals in the Bering Sea during the first half of the 20th century (Scheffer, 1950). The stomach contents of female northern fur seals in the eastern Bering Sea between 1958 and 1974 consisted of juvenile walleye pollock (35 percent), capelin (Mallotus villosus;16 percent), Pacific herring (11 percent), and squid (30 percent) (Perez and Bigg, 1986). Considerable variation in the importance of each of these species and groups existed among areas, and by season and year sampled. Kajimura (1984) found that deep-sea smelts of the family Bathylagidae ranked fourth in importance by volume in the Bering Sea during the years 1963, 1964, 1968, 1973 and 1974. Deep-sea smelts may be under represented in volumetric summaries that combine all years because oceanic habitat was sampled less frequently during the pelagic collection period. However the relative use of oceanic habitat by fur seals is also poorly understood. Pollock was particularly important around the Pribilof Islands and other inshore areas from July to September. Capelin was the main prey consumed near Unimak Pass during June to October. A large number of other prey species occurred in small quantities. Sinclair et al. (1994) reported that fur seal stomachs and GI tracts collected during pelagic studies conducted during the 1980's in the eastern Bering Sea contained mostly juvenile walleye pollock from the age-0 group (65 percent) or from the age-1 group (31 percent), while only 4 percent were from the age-2 group and older. The percentage of the various age groups of walleye pollock consumed by fur seals varied among years and was apparently a reflection of differences in the strengths of year classes before and during the course of the study. Adult walleye pollock were most frequently found in the stomachs of fur seals collected over the outer domain of the continental shelf, while juvenile pollock were found in fur seals collected both over the midshelf and outer domain. Atka mackerel (Pleurogrannus monopterygius) was found only in fur seals collected over the outer shelf domain north of Unimak Island. Northern smoothtongue and gonatid squid were the dominant species found in stomach samples collected

TABLE 3. FREQUENCY OF OCCURRENCE (FO) OF PRIMARY PREY (>5% ON ANY ROOKERY) BY ROOKERY FOR 1988-2000. FO VALUES >10% ARE BOLD. GB/BM SQUID ARE *GONATOPSIS borealis* OR *BERRYTEUTHIS magister* AND GM/GM SQUID ARE *GONATUS madokai* OR *GONATUS middendorffi*.

Rookery (n)	Walleye pollock	Pacific sand lance	Gm/Gm squid	Gb/Bm squid	Gonatus tinro	Pacific salmon	Northern smoothtongue	Pacific herring	Atka mackerel
Morjovi (219)	**66.21**	**11.42**	8.68	<1	0.00	3.20	0.00	7.76	1.37
Vostochni (539)	**69.39**	**11.69**	6.49	1.30	<1	5.38	<1	6.12	1.86
Pol & PolCfs (262)	**70.23**	**12.98**	5.73	1.91	0.00	**10.31**	<1	6.49	3.05
Kitovi (228)	**68.42**	**10.96**	6.58	7.02	1.75	7.89	3.07	2.63	0.00
Lukanin (84)	**65.48**	**15.48**	8.33	8.33	0.00	8.33	3.57	5.95	0.00
Little Zapadni (236)	**83.90**	4.24	**20.76**	4.66	<1	7.63	<1	3.81	2.54
St. Paul, Zapadni (334)	**75.15**	6.29	**21.56**	5.99	<1	4.79	2.99	2.99	3.59
Tolstoi (395)	**68.86**	3.04	**17.22**	7.59	<1	7.59	1.52	2.78	5.32
Zapadni Reef (92)	**76.09**	8.70	**15.22**	1.09	0.00	**11.96**	1.09	5.43	5.43
ArdGorbatch (260)	**70.38**	8.46	**16.15**	**13.08**	3.46	5.00	3.85	3.08	5.38
Reef (319)	**64.26**	7.52	**10.97**	**11.91**	2.19	6.27	2.82	4.70	5.64
North (309)	**66.02**	3.56	6.15	**17.80**	1.94	**14.56**	1.29	1.29	1.29
East Cliffs (196)	**65.31**	2.55	7.65	**19.39**	5.61	**18.88**	5.61	3.06	3.06
East Reef (139)	**70.50**	2.16	4.32	8.63	1.44	**10.07**	<1	2.16	2.16
Staraya Artil (169)	**61.54**	1.18	5.33	**16.57**	1.18	**10.06**	5.33	4.73	1.18
South (226)	**47.79**	3.10	**10.18**	**34.96**	4.42	**15.93**	**14.16**	2.21	3.98
St. George, Zapadni (164)	**42.68**	3.66	**12.80**	**38.41**	7.93	**14.63**	**15.85**	1.22	<1

over continental slope and oceanic waters (Sinclair et al., 1994). Herring, eulachon, and capelin were largely absent from fur seal diet in the Bering Sea during the 1980's (Sinclair et al., 1994). Sinclair et al. (1996) reported that juvenile pollock was the predominant prey found in scat of Pribilof Island fur seals from 1987 to 1990. In a recent survey of mesopelagic nekton in the slope and oceanic waters of the southeastern Bering Sea, Sinclair and Stabeno (2002) reported that as a family, the bathylagids were the dominant group throughout the water column and that nearly half of the total catch weight values were comprised of northern smoothtongue.

Antonelis et al. (1997) examined scats collected at rookeries during the breeding season to compare prey species taken by female northern fur seals on St. Paul and St. George islands with those taken at Medny Island (Russia). Juvenile walleye pollock was the most common prey of fur seals on St. Paul Island; a combination of walleye pollock and squid was consumed by seals on St. George Island; and gonatid squid, was the primary prey consumed on Medny Island. The reasons for these differences were apparently related to the physical and biological environment surrounding each island. St. Paul Island is surrounded by a broad neritic environment and is farther from the continental slope than either St. George or Medny Island. Medny Island is surrounded by a compressed neritic environment and is adjacent to the continental shelf edge. The environment surrounding St. George Island is intermediate to that of the other two islands. Zeppelin and Ream (in review) have examined scats from St. Paul and St. George breeding areas from 1988-2000 (Table 3). As with earlier Pribilof fur seal diet estimates, pollock was the most frequent item found in scat from either island. Squid were found second most frequently for many rookeries, and when combined comprise a majority of the diet for St. George fur seals from southern rookeries. Zeppelin and Ream (in review) used cluster analysis on the frequency

of occurrence of primary prey by rookery. Their results support the hypothesis of foraging habitat partitioning by central breeding area (Robson et al., 2004; Sterling and Ream, 2004), but also provide evidence for further partitioning of foraging resources by groups of rookeries.

Robson (2001) compared fecal samples of seals from St. Paul and St. George islands and reported results similar to those of Antonelis et al. (1997): pollock occurred more frequently than any other prey species in fecal samples for seals from both islands, however, squid occurred more frequently in the diet of fur seals from St. George than from St. Paul. Walleye pollock was the principal prey identified by Goebel (2002) using fatty acid signature analysis on milk from lactating females to examine dietary shifts related to changes in physical oceanography, dive pattern, and foraging location in female northern fur seals during 1995-1996.

E.2. Diet: Gulf of Alaska

Although the species of prey consumed by northern fur seals varies throughout their range, the characteristic habit of selecting small schooling forage fishes and squids with similar habits does not change (Kajimura, 1984; Sinclair et al., 1994). The dominant prey for fur seals in the Gulf of Alaska from February to April was Pacific herring and from April to July it was Pacific sandlance (Ammodytes hexapterus) and capelin (Perez and Bigg, 1986). Kajimura (1984) reported that the principal prey in the Gulf of Alaska from 1958 to 1968 included Pacific herring, capelin, salmon (Oncorhynchus spp.), walleye pollock, Pacific sandlance, rockfish (Sebastes spp.), Atka mackerel, and squid. Scheffer (1950) identified squid and rockfishes as fur seal prey in the Gulf of Alaska during the first half of the 20th century although sample sizes were small.

Ream et al. (2005) summarized data from stomach contents of fur seals collected in the North Pacific Ocean and found that in the Gulf of Alaska (Feb. - May) Pacific herring, capelin and Pacific sand lance were the most frequently observed items from 1958 to 1974 (Figure 5, top left panel). Differences in diet between juvenile males and females in the Gulf of Alaska (Figure 6) may have been present and possibly related to differences in diving capacity (Ream et al., 2005).

E.3. Diet: Pacific Ocean

A wide variety of prey species occurred in stomach contents of female fur seals in the North Pacific, and prey composition varied by location and time of year (Kajimura, 1984; Perez and Bigg, 1986). Fur seals in the waters off California fed primarily on northern anchovy (Engraulis mordax) during January to March, and Pacific whiting (Merluccius productus) during April and May. Pacific herring was consumed in neritic areas off the Washington coast during December to January and May to June. Rockfishes, northern anchovy, and squid were more prominent in fur seal stomachs off Washington during February and March. Off British Columbia, Pacific herring was the primary prey from February to June, although market squid (Loligo opalescens) was important in coastal inlets and onychoteuthid squids and salmonids were important in oceanic waters during May and June. Important prey species in the northern portion of the North Pacific included Pacific sand lance, capelin, Atka mackerel, salmonids, walleye pollock, and squid.

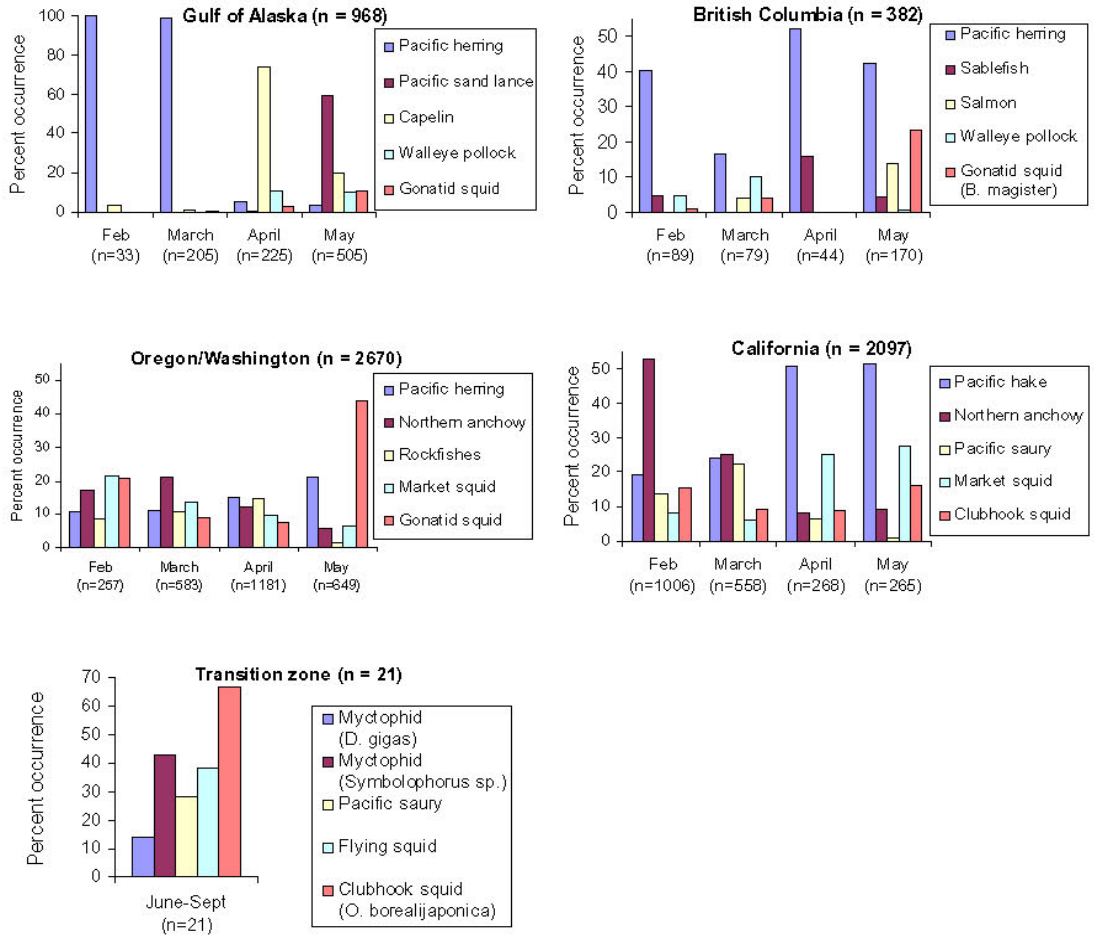

FIGURE 5. PERCENT OCCURRENCE OF PRIMARY PREY SPECIES (TOP 5 SPECIES) IN STOMACHS OF NORTHERN FUR SEALS COLLECTED AT SEA. PREY IS LISTED BY MONTH AND REGION OF COLLECTIONS (*from REAM et al., 2005*).

Northern fur seals collected in continental shelf waters off the California and Washington coast between 1958 and 1972 fed primarily on fishes, while those collected beyond the shelf fed primarily on squids (Kajimura, 1984). Prey species were similar to those reported by Perez and Bigg (1986). Adult female northern fur seals breeding on San Miguel Island fed on Pacific whiting, northern anchovy, juvenile rockfish, and several squid species in the oceanic zone northwest of the island (DeLong and Antonelis, 1991). Ream et al. (2005) suggested differences between female and male diets in across their winter range during 1958 to 1974 (Figure 6). Kajimura (1984) suggested that northern fur seals in the eastern Pacific are opportunistic feeders, preying on the most abundant species throughout their range. However, Sinclair et al. (1994) concluded that fur seals in the eastern Bering Sea were size-selective, mid-water feeders.

Stomachs collected from fur seals taken in the Japanese high seas fishery in the late 1990s contained 15 squid species in the near-shore waters of the western North Pacific compared to only 4 species in the central North Pacific (Mori et al., 2001). Watasenia scintillans was the dominant squid species in the western North Pacific from January to May, while Onychoteuthis

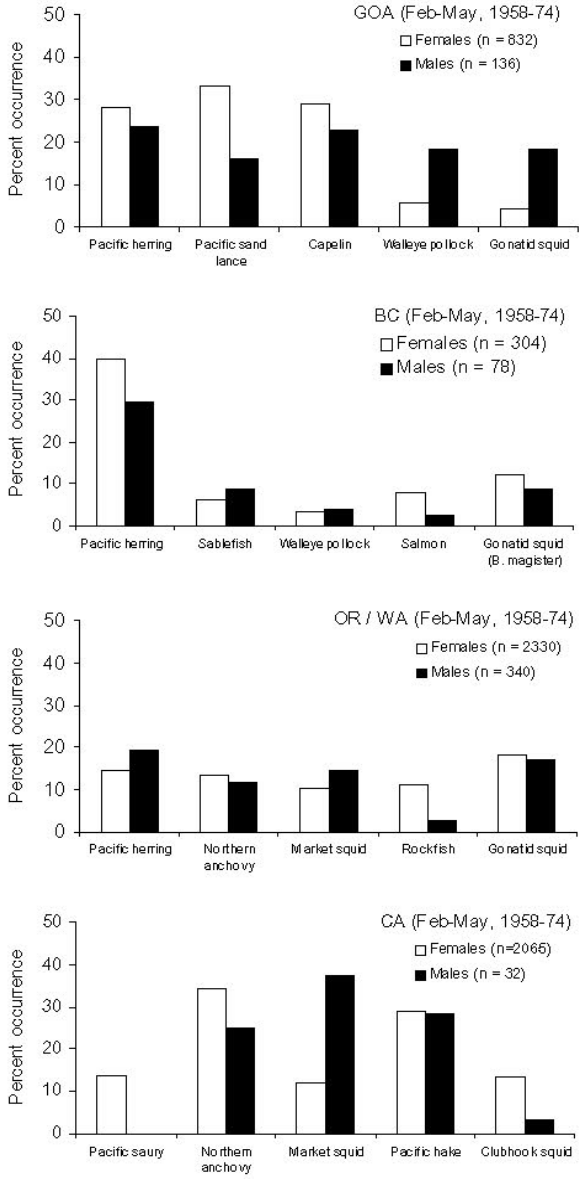

FIGURE 6. PERCENT OCCURRENCE OF PRIMARY PREY IN STOMACHS OF MALE AND FEMALE NORTHERN FUR SEALS, BY REGION (GOA=GULF OF ALASKA; BC=BRITISH COLUMBIA; OR/WA=OREGON AND WASHINGTON; CA=CALIFORNIA, *from REAM et al., 2005*).

borealijaponica and Ommastrephes bartramii were important in the central North Pacific from May to August. Mori et al. (2001) did not quantify fish consumption.

Walker and Jones (1993) analyzed stomach contents of 21 northern fur seals taken from the North Pacific Transition Zone in the Japanese high seas squid driftnet fishery in 1990. They found a higher frequency of occurrence of squid and bathylagids versus groundfish and forage

fish in the fur seal diet from the transition zone than from other regions.

E.4. Trophic Analysis of Diet

Hirons et al. (2001) found no significant change in stable nitrogen isotope ratios from fur seal, harbor seal, or Steller sea lion bone collagen for samples from animals that died between 1951 and 1997. These results did not support the hypothesis that a change in pinniped trophic level may have occurred during this time that contributed to population declines. Hirons et al. (2001) suggested that a change in the stable carbon isotope ratio, with no accompanying change in the stable nitrogen isotope ratio, may indicate an environmental change that affected the base of the food web, rather than a change in the trophic level (i.e., prey switching) where sea lions were foraging.

Based on the concentration of stable nitrogen isotopes in the skin of Pribilof Island fur seals, Kurle and Worthy (2001, 2002) suggested that pregnant females fed coastally during the spring migration, while juvenile males and nulliparous females fed offshore. Similar values for stable carbon isotopes indicated that pregnant and nulliparous females fed at similar trophic levels despite feeding in different areas during migration. The analysis of enriched carbon and nitrogen isotopes in fur seal tissues further suggest that the diet of lactating females includes prey at trophic levels equivalent to 2 - 4 year-old walleye pollock and small Pacific herring during the fall (Kurle and Worthy, 2001; 2002). Hobson et al. (1997) suggested that female fur seals fed at a higher trophic level than juvenile males.

E.5. Foraging Behavior

Fourteen adult male fur seals captured on St. Paul and St. George in 1991-92 were fitted with satellite linked time-depth recorders (Loughlin et al., 1999). The seals remained in the Bering Sea for an average of approximately 30 days after tag attachment. While in the Bering Sea the male fur seals foraged in areas associated with the outer domain of the continental slope and northwest of the Pribilof Islands on the continental shelf in water ranging from 100 to 250 m in depth. Relatively little time was spent foraging in deep water (>1000m) or shallow water (<100m). Eventually the male fur seals left the Bering Sea and entered the North Pacific through Aleutian Island passes and fed either in the eastern Pacific Ocean and Gulf of Alaska or to the west off the Kuril Islands and the coast of Japan. Most dives were shallow: 68% were between 4 and 50m, 14% were between 51 and 100m, and 17% were between 101 and 350m (Loughlin et al., 1999). Only 2.5% of all dives were greater than 250m and no dives were deeper than 350m. Duration of dives was usually < 6 minutes (90%), 43% were 1 minute or less and fewer than 1% of the dives were over 11 minutes.

Thirty-one juvenile male fur seals tagged on the Pribilof Islands had trip durations ranging from 8.7 to 28.8 days with trip distances from 171 to 681 km (Sterling and Ream, 2004). Diving tended to reflect patterns associated with different bathymetric domains: shallow nighttime diving was common in water ~3000 meters deep, whereas deeper diving was generally observed in <200 m deep waters. Juvenile male fur seals can forage at greater maximum distances from the island of departure than lactating females.

Two diving patterns were described for female northern fur seals from St. Paul during the breeding season: (1) deep-diving that occurred at all hours of the day over the continental shelf in water less than 200m depth, and (2) shallow-diving that occurred primarily at night over deep

water (Goebel et al., 1991). Gentry (1998) described thirteen diving patterns based on the timing and number of depth reversals within a given dive, but questioned whether this number was an artifact of scoring dive reversals. Shallow divers foraged more frequently at night and made more dives per foraging trip than deep divers. The primary prey of fur seals in deep water beyond the continental shelf (gonatid squid, deep-sea smelt) exhibit diel vertical migration and are at relatively shallow depths at night, which would allow fur seals to efficiently capture prey with shallow, night-time dives. Costa and Gentry (1986) reported that shallow-diving female fur seals had higher food and energy consumption than deep-diving seals. Deep-diving seals obtained a smaller mass of food but gained similar body mass during a feeding trip, suggesting that their prey is of higher energy content than that of shallow divers. Goebel et al. (1991) further reported that deep divers expended less energy than shallow divers and apparently obtain greater energy per dive. The female fur seals tracked by Goebel et al. (1991) fed as far as 160 km to the northwest, southwest, and south of St. Paul Island. At San Miguel Island, postpartum fur seals foraged approximately 70 km northwest of the island in oceanic waters with a mean depth of 933 m (Antonelis et al., 1990).

Loughlin et al. (1987) followed adult female fur seals equipped with radio transmitters and found that some had round-trip foraging trips of over 400 km and one had a round trip of 740 km. Robson (2001) used satellite telemetry to compare feeding locations of 97 lactating female fur seals on St. Paul and St. George islands and reported a strong tendency for separation of foraging areas by breeding location on the islands. Females from St. Paul Island dispersed in all directions except southeast where St. George Island females foraged. Foraging locations were also separated for female fur seals departing from different groups of rookeries on St. Paul Island. Females from Tolstoi and Reef rookeries on the southwest side of the island foraged in areas on the southwest to northwest sides of the island, whereas those seals from Vostochni and Polovina Cliffs rookeries on the northeast side of the island foraged from the northwest to the east of the island. Robson et al. (2004) measured the mean maximum vector distances of foraging trips and reported they were significantly farther (260 km) in 1995 than in 1996 (229 km).

Winter foraging areas are suspected to vary geographically. Ream et al. (2005) showed female fur seal are closely associated with eddies, the subarctic-subtropical transition region, and areas that undergo coastal mixing due to the California Current during the winter and spring. Ream et al. (2005) indicated that fur seals may cue on a variety of oceanographic features thereby reducing energetic expenditures and optimizing foraging.

F. Distribution and Habitat Use

Northern fur seals are endemic to the North Pacific Ocean. Northern fur seals migrate seasonally from summer breeding grounds where they regularly haul out on their breeding islands. Northern fur seals are primarily pelagic in the winter months, but occasionally haul out onto land for brief periods at sites in Alaska, British Columbia, Canada, and on islets along the west coast of the continental United States (Fiscus, 1983).

F.1. Seasonal Distribution

During the winter the southern limit of their range extends across the Pacific Ocean from southern California to the Okhotsk Sea and Honshu Island, Japan (Kajimura and Loughlin, 1988; Figure 1). In the spring most northern fur seals migrate north to breeding colonies. The largest breeding colonies are located in the Pribilof Islands and comprise approximately 74 percent of

the worldwide fur seal population (Fowler, 1998; Gentry, 1998). The rookeries at the Commander Islands and Robben Island comprise approximately 15percent and 9 percent of the world population, respectively (Gentry, 2002). Pribilof fur seal populations account for approximately 55 percent of the worldwide abundance based on preliminary estimates from all breeding colonies in 2005 (NMML unpublished data). Historically, northern fur seal breeding colonies may have been more widely distributed based on seal remains at ancient human occupation sites found coastally on Vancouver Island, in Washington, Oregon, and California (Burton and Koch, 1999; Lyman 1988; Clark, 1986).

F.2. Emigration and Immigration

Less than 1 percent of northern fur seals harvested on the Pribilof Islands came from other islands in the North Pacific Ocean (Lander and Kajimura, 1982). However, movement from the Pribilof Islands population to other areas has been documented range-wide. An estimated 12-21 percent of the tagged, young males harvested on the Commander Islands were tagged as pups on the Pribilof Islands in 1958-63, and only 0.1-1.0 percent were tagged on Robben Island. Northern fur seals re-colonized San Miguel Island, California Channel Islands, in the 1950s or early 1960s and increased 46 percent annually from 1969 to 1978 (DeLong, 1982). Some of this high production was attributed to immigration of females from the Pribilof Islands, Robben Island, and the Commander Islands (DeLong, 1982; Antonelis and Delong, 1985).

From 1976 to 1981, small numbers of fur seals were observed on Bogoslof Island (Loughlin and Miller, 1989). Pups were first seen on Bogoslof in 1980 (Lloyd et al., 1981). Ream et al. (1999) reported pup production increased at 58 percent per year between 1988 and 1997. In 2005 the Bogoslof Island population continued significant growth (NMML unpublished data). The growth rate at Bogoslof Island is greatly influenced by immigration, probably from the Pribilof Islands (Ream et al., 1999). Experimental manipulation of post-parturient females and their pups between rookery sites on St. Paul and St. George and between extinct and current rookery sites on St. George indicate that females are able to and do voluntarily move to other sites (Gentry, 1998). Sixty-seven percent (12 of 18 females) of translocated females remained with their young at the new site and made multiple feeding trips until at least late August when observations ceased (Gentry, 1998). The remaining females and their pups were returned to their original rookery and reunited (Gentry, 1998). The rate of females moving among rookery sites for pup rearing is thought to be small, but females also use other sites to rest during the breeding season intermittently, further confounding estimates of emigration (Gentry, 1998). Thus, emigration does occur between all fur seal populations in the North Pacific, but not at a rate that could have influenced the decline observed on the Pribilof Islands during the 1960s and 1970s (York, 1987b; Loughlin et. al., 1994).

F.3. Habitat Use

The Pribilof Islands are essential for pupping, mating and rearing of pups and represent habitat for the majority of population. The surrounding summer and fall feeding grounds out to at least 200-300 km from the islands are important for lactating females (Loughlin et al., 1987; Goebel et al., 1991; Robson, 2001; Robson et al., 2004). Juvenile male fur seals forage out to mean maximum straight-line distances about 367 km (range 171-680 km) from the islands during the summer (Sterling and Ream, 2004). Aleutian Island passes are also important due to their use by a majority of the Eastern Pacific stock for their annual migration between the Bering Sea and North Pacific Ocean (Bigg, 1990; Ragen et al., 1995). It is unknown to what extent some passes may be used more than others, though Unimak Pass continues to be a primary migration

corridor. These passes are used at least twice each year as seals move into and out of the Bering Sea for the summer breeding season.

Many fur seals have been seen far out to sea, as indicated by sighting data collected from 1958 to 1997 (Fig. 7); bycatch data on fur seals collected from June through September (Zeusler, 1936; Loughlin et al., 1983); and telemetry data (Loughlin et al., 1987; Goebel et al., 1991; Loughlin et al., 1999; Robson, 2001; Sterling and Ream, 2004; Ream et al., 2005). A clear

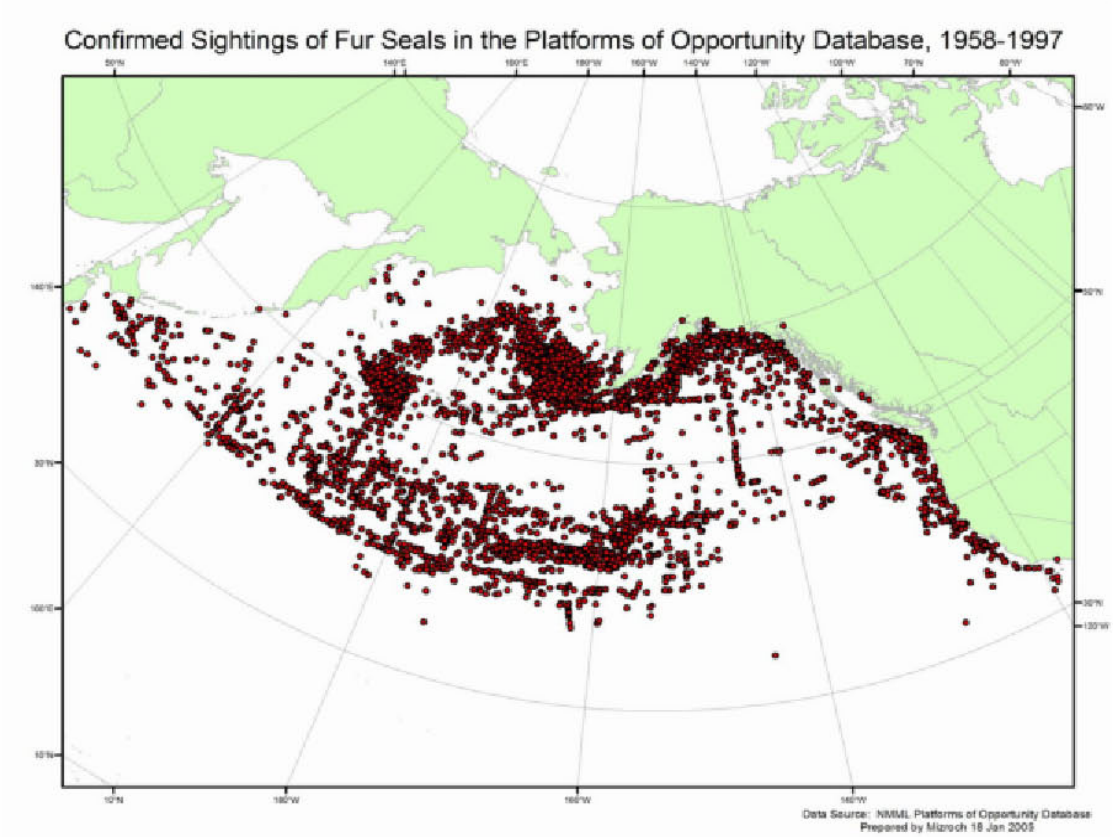

FIGURE 7. DISTRIBUTION OF ALL NORTHERN FUR SEAL SIGHTINGS IN THE NORTH PACIFIC OCEAN AND BERING SEA BASED ON OBSERVATIONS IN THE NMFS PLATFORMS OF OPPORTUNITY SIGHTING DATABASE 1958-1997.

understanding of fur seal use of pelagic habitat across years or seasons is unknown. The subpolar continental shelf and shelf break from the Bering Sea to California are feeding grounds for fur seals while at sea. It has been suggested that highest fur seal densities in the open ocean occur in association with major oceanographic frontal features such as sea mounts, valleys, canyons and along the continental shelf break (Lander and Kajimura, 1982; Kajimura, 1984; Loughlin et al. 1999). It should be noted that principal prey of fur seals may be concentrated or most accessible in such areas, and the association may be due to a combination of biological and physical factors (Sinclair, 1988; Sinclair et al., 1994). The transition zone may bound the pelagic distribution of fur seals in the North Pacific Ocean on the south between subarctic and subtropic water masses, possibly because these fronts serve as physical barriers to fur seal prey (Sinclair, 1990; Beamish et al., 1999; Ream et al., 2005).

G. Threats

The Eastern Pacific northern fur seal stock is threatened by both natural and human-related factors. NMFS cannot manage to any practical degree natural threats to fur seals such as, predation, disease, or El Niño Southern Oscillation events. NMFS can manage human-related threats and that is the basis for 3 of the four objectives of this conservation plan. Table 4 presents several likely human-related threats thought to contribute to the recent decline and may be acting on the Eastern Pacific stock of fur seals. It should be emphasized that we may never know the cause(s) of previous declines in fur seal production and it is likely that human and natural threats interact in unknown but potentially significant ways. These interactions may never be separated distinctly and thus complicate determining causation. Understanding the causes of historic declines; however, may have long-term predictive value allowing researchers to anticipate similar events in the future. York and Kozloff (1987) showed that unless a population decline is sudden and dramatic, the estimates of population size are sufficiently variable that a statistically significant decline cannot be observed until several years following its initiation. While more recent population abundance estimates may be more precise, it may be only by comparing the changes of population structure, diet, foraging behavior, habitat use, incidence of diseases, and entanglement rates of fur seals with other pinniped species which share their habitat (e.g., Steller sea lions), or fur seals from the polar regions of the southern hemisphere, that the importance of these factors will be better understood. Natural threats will be discussed first followed by human-related threats in the subsequent sections.

G.1. Natural Mortality Excluding Disease

York (1985) reported neonatal mortality on St. George Island is lower than on St. Paul Island, where the population is higher. Contrary to earlier evidence, Gentry (1998) suggested that neonatal mortality due to trauma is not density dependent because of female spacing tendencies. Females form dense groups at all population levels and female induced pup trauma causes 17 percent of the on-land mortality. Several factors, including emaciation, trauma, various infections, and increased incidence of disease and parasites, contribute to neonatal mortality rates (York, 1985, Fowler, 1985, Fowler, 1987). In the 1940s and 1950s on-land pup mortality ranged from 10 to 22 percent. Between 1990 and 1999, pup mortality ranged from 4.69 percent to 2.82 percent on St. Paul, and 3.97 percent to 2.05 percent on St. George (Antonelis et al., 1994; York et al., 2000).

Mortality at sea is highest during the first 2 years, when mortality may reach 60-80 percent (Keyes, 1965; Lander 1981; Fowler, 1985; York, 1987). Most of this mortality is assumed to occur during the first winter (Lander, 1979). Lander (1980) estimated that at-sea mortality of 0-2 year olds from 1950 to 1970 was 60-65 percent. York (1994) estimated that survival for the 1987 and 1988 cohorts from age 0-2 was 0.246 and 0.285 respectively (71 percent-75 percent mortality), while survival for the same cohorts averaged 0.75 and 0.77 (25 percent and 23 percent mortality) from age 2-4. Some evidence suggests that mortality rates of 0-2 year olds (York, 1985), 2-5 year olds (Fowler, 1985a), and adult females (Trites and Larkin, 1989) may have increased through the 1960s and 1970s. Cohort survival has not been studied in recent years.

Survival of adult females remains high (> 80 percent) until age 14, after which it decreases to about 30 percent by age 19 (Smith and Polachek, 1981). Males have a higher mortality rate than females after 2 years of age, and particularly after 7 years when males begin to defend territories

(Lander and Kajimura, 1982). Factors involved in juvenile and adult mortality are numerous and are discussed in other sections of this document. No comprehensive studies of male or female survival have been completed since the cessation of the commercial harvest on St. Paul.

Spraker et al. (in review) determined the cause of death for 104 adult female fur seals on St. Paul Island between 1986 and 2003. The subsistence harvest accidentally killed 17 of the 104 adult females necropsied from 1986 to 2003; therefore 87 female fur seals died from natural causes over this period. Seventy-two percent (63 of 87) of female deaths were the result of bite wounds. The remaining deaths were caused by a variety of factors. Spraker et al. (in review) also examined 40 dead adult males to determine the cause of death. Eighty-seven percent of male mortality on land was the result of bite wounds and secondary infections (Spraker et al., in review). Spraker et al. (in review) necropsied 2,608 northern fur seal pups during the breeding season on St. Paul from 1986 - 2003. Five general categories of mortality were found: emaciation, trauma, perinatal mortality, infections, and a rare anomalous condition. Emaciation was found in 52 percent of the pups. Trauma was the primary cause of death in 19 percent of the pups (blunt trauma-12 percent and sharp trauma-7 percent) and is consistent with the findings of Gentry (1998). Perinatal mortality accounted for the death of 18 percent of the pups.

G.2. Disease and Parasites

The effect of diseases and parasites between the late 1970s and the present are unknown. Necropsies of juvenile seals taken in the St. Paul subsistence harvest during the 1980s suggest that the population is relatively disease free compared to the period from the 1950s to early 1970s (NMML, unpublished data). For example, fur seal mortality from ascarid (nematode worm) infection may have been important during the 1950s and 1960s (Neiland 1961; Keyes 1965), and Leptospirosis was not identified until the 1970s (Smith et al. 1977). Thus, fur seals do succumb to disease, as do all mammals. The prevalence of disease and parasites has not been a significant threat to fur seals in recent years. High mortality from disease should be considered a constant threat given the high densities of fur seals during the breeding season that would facilitate transmission. In addition, Baker et al. (1995) and Gentry (1998) reported that about 20 percent of individuals from a particular island visit other islands intermittently during the year, thus facilitating disease transmission between islands.

Hookworm disease was responsible for 45 percent of the fur seal pup mortality in a study conducted between 1974 and 1977 (Gentry, 1981). Lyons et al. (2001) indicated a dramatic decline in the incidence of hookworm disease in fur seal pups on St. Paul Island in recent years. Infectious diseases were found in 4 percent of the pups on St. Paul. Spraker et al. (in review) found no evidence over the past 27 years to implicate diseases or mortality of pups prior to weaning as an important factor in the current population decline on St. Paul. In 2003, hookworm mortality at San Miguel Island exceeded 50 percent and was a significant cause of mortality of pups in the first 3 months of life (Melin et al., 2005).

TABLE 4: MATRIX OF THREATS TO THE EASTERN PACIFIC NORTHERN FUR SEAL STOCK

ORIGIN OF THREAT	SOURCE[A]	SCALE OF EFFECT[B]	SEVERITY[C]	PROBABILITY OF OCCURRENCE	GEOGRAPHIC SCOPE[D]
NATURAL	Trauma (3.1.3)	STOCK	DEATH	LOW	RANGEWIDE
	Starvation (3.1.3)	POP	DEATH	LOW	RANGEWIDE
	Disease (3.2)	POP	INJURY	LOW	RANGEWIDE
	Predation (3.1.8)	POP	DEATH	HIGH	RANGEWIDE
	Environ. Change (3.4)	STOCK	LONG	MED	RANGEWIDE
HARVEST	Commercial	POP	UNK	LOW	BERING SEA
	Subsistence (1.3)	POP	DEATH	LOW	BERING SEA
POACHING	Terrestrial (1.3)	INDIV	DEATH	MED	BERING SEA
	At-Sea (1.2)	INDIV	DEATH	MED	RANGEWIDE
OMM. FISHING	Bycatch (1.2)	POP	DEATH	LOW	RANGEWIDE
	Entanglement (1.1)	STOCK	INJURY	MED	RANGEWIDE
	Indirect Effect (2.7)	STOCK	UNK	HIGH	RANGEWIDE
HARASSMENT	Aircraft (2.4)	STOCK	SHORT	LOW	RANGEWIDE
	Airborne Noise (2.4)	STOCK	SHORT	MED	RANGEWIDE
	Vessels (2.4)	STOCK	UNK	HIGH	RANGEWIDE
	Underwater Noise (2.4)	STOCK	UNK	MED	RANGEWIDE
	Human Presence (2.4)	POP	LONG	HIGH	BERING SEA
	Research (2.4)	POP	LONG	MED	RANGEWIDE
OAST. DEVELOP	Construction (2.4)	INDIV	SHORT	MED	BERING SEA
	Vehicles (2.4)	INDIV	SHORT	HIGH	BERING SEA
NVIRONMENTAL CONTAM.	Various (2.6)	STOCK	LONG	HIGH	RANGEWIDE
OIL & GAS	Spills (2.6)	STOCK	DEATH	LOW	RANGEWIDE

[A] Number in parentheses corresponds to the Conservation Action described in Section II.
[B] Scale of Effect indicates what portion of the population is affected by the threat: STOCK=entire E. Pac. stock; POP=at least an entire breeding area; INDIV=individuals within a breeding or resting area.
[C] Severity describes the most likely outcome of the threat: DEATH=mortality; INJURY=physical harm; LONG=unknown reduction in survival or reproduction for at least 1 year; SHORT=unknown reduction in survival or reproduction for less than 1 year.
[D] Geographic Scope describes the extent of where this threat exists: RANGEWIDE=the entire range of the stock; BERING SEA=only the Bering Sea.

G.3. Predation

Killer whales, Steller sea lions, and foxes prey on fur seals, but fur seal population impacts have not been detected. Killer whales (Orcinus orca) are probably the most important predator of

northern fur seals. The only authenticated stomach examination of a killer whale from the Pribilof area occurred in 1868 when a killer whale was seen "swimming with such force that he ran aground and was unable to get off. When the tides went out the whale was cut open and three seals were found in its stomach" (original record reported in Scheffer et al., 1984). Killer whales have also been observed to attack fur seals near Robben Island, Russia (Bychkov, 1967), but no published information is available for the Pribilof Islands in recent years. Anecdotal reports by local fishermen to the Tribal Government of St. Paul's Ecosystem Conservation Office (Tribal ECO) and others indicate that killer whales continue to be seen around the islands. Since 1996, the Tribal ECO reports that 1-5 sightings of killer whales feeding on fur seals are made each year (Island Sentinel database, St. Paul). Killer whales are seen around St. Paul in early and late summer, but fishermen see killer whales offshore from June-August.

Springer et al. (2003) hypothesized that sequential declines in North Pacific populations of seals (including fur seals), Steller sea lions, and sea otters were due to increased predation by killer whales, following the removal by commercial whaling of baleen whales as the killer whales primary food source. Wade et al. (2003) disagreed with the hypothesis of Springer et al. (2003) and proposed that killer whales may have caused or contributed to the decline of species like sea otters, but suggested that little evidence indicates that this predation occurred due to a lack of available cetacean prey. Melnikov and Zagrebin (2005) reported killer whale predation along the Chukotka coast collected systematically by local hunters. Annually, killer whales attacked gray whales (66 percent of incidents) and walrus (26 percent) during the 10-year observation period on the Chukotkan Peninsula (Melnikov and Zagrebin, 2005). Melnikov and Zagrebin (2005) reported low pinniped predation rates by killer whales, although ringed and spotted seals were quite numerous in the region.

Foxes on the Pribilof Islands are primarily scavengers, and attacks on live pups are rare (Roppel, 1984). Steller sea lions kill weaned fur seal pups close to shore on St. George Island (Gentry and Johnson, 1981), and were seen killing fur seal pups in 1992 (reported in NMFS 1993). Attacks on northern fur seals by Steller sea lions may be lower in recent years due to concurrent and sustained declines of both species.

G.4. Environmental Change

Changes in environmental and oceanographic features may influence mortality rates of fur seals and the distribution and abundance of prey. In 1950, severe storms and low temperatures may have contributed to the deaths of 700 fur seals in Oregon and Washington (Scheffer, 1950). York (1991) reported a significant positive correlation between sea surface temperatures (SST) off British Columbia and early survival of male fur seals 4 months to 2 years old, and suggested that SST may influence Pacific herring (Clupea pallasi, a common fur seal prey in winter and spring), abundance and availability, thus affecting early survival of fur seals. From 1977 to 1986, there was a very large North Pacific basin temperature anomaly, with temperatures in Alaska warming more than 1.5°C (Trenberth 1990), that might have resulted in a regime shift or a community level reorganization of the marine biota (Anderson and Piatt 1999). Pribilof female feeding trip duration during 1979-1985 decreased relative to the period from 1974-1978 suggesting that prey may have been more abundant or located closer to the colony during the post-1977 regime (Gentry, 1998).

Fauquier et al. (1998) report that the peak years of fur seal strandings off the central California coast from 1975 to 1997 were during the El Niño events of 1992 and 1997. Most stranded fur seals were recently weaned pups that were emaciated and malnourished. El Niño events of 1972, 1983, 1992, and 1997 had dramatic impacts on birth rates, and pup growth and survival for fur

seals on San Miguel Island (NMML, unpublished data). The El Niño events of 1983 and 1997-98 were particularly powerful. It was estimated that no pups born in 1983 survived, and that fur seal pup production on San Miguel Island declined by 60 percent after 1983. In 1997, pup mortality on San Miguel Island was estimated at 87 percent, and pup production declined 80 percent in 1998. California sea lion pup production also declined on all rookery islands in the Channel Islands in 1983. Fur seal pup survival on San Miguel is lower during El Niño events, but survival of Pribilof juvenile males over longer time periods is positively correlated with El Niño (York, 1991) and higher air and sea surface temperature trends (York, 1995). However, the individual El Niño events of 1983 and 1997-98 appeared to have little detectable effect on fur seals in the Pribilof Islands (Gentry, 1991; York et al., 2000).

Trites and Antonelis (1994) investigated the timing of births of fur seal pups in the Pribilof Islands in relation to climatic factors and determined that although sufficient food was available in June for lactating females to successfully begin nursing, births occurred during the first three weeks of July coincident with lower rain and wind conditions and elevated temperatures. Their model predicted that pups born earlier in the year (June) would succumb to hypothermia during periods of generally colder, wetter, and windier weather than conditions in July (Trites and Antonelis, 1994).

Major shifts have occurred in the abundance of fish and shellfish in the Bering Sea over the past several decades (Anderson and Piatt 1999). The possibility that these shifts in prey may be related to climatic regime shifts is well documented (e.g., Beamish and Bouillon 1993; Benson and Trites 2002). The fish community in the Bering Sea appears to have shifted from one dominated by pelagic and semi-demersal species to one with fewer pelagic species and a larger biomass of semi-demersal (walleye pollock and Atka mackerel) and demersal (all flatfishes) species (Anderson 2002). Important fur seal prey species continue to include pollock (Gudmundson et al., in press; Zeppelin and Ream, in review) and the number of pollock consumed by fur seals in the Bering Sea is directly related to pollock year-class strength (Sinclair et al. 1994; 1996).

If environmental conditions strongly influence pollock year-class success, fur seals could be directly impacted. Such factors could also influence the foraging success of fur seals as they prey on other species (e.g., Pacific herring, Pacific whiting (hake), and anchovy) during their migration south into the North Pacific. Recent studies reported long-term fluctuations in fish populations in the North Pacific and Bering Sea regions that may have affected the availability of fur seal prey. Naumenko (1996) identified four periods with differing ichthyofaunal community structures from 1958 to 1993 in the western Bering Sea. The causes of this structuring were apparently related to commercial fishing pressure and to environmental conditions. The first period (1958-1964) was dominated by herring, the second was a transitional period (1965-1974), the third period (1975-1987) was dominated by pollock, and the fourth period (1988-1993) was dominated by groundfish (pollock and large flatfish) or may have been another transitional period.

Merrick (1997) suggested that the adult groundfish biomass has been at high levels since the decline of the whale and fur seal populations, and that adult groundfish may be out-competing other predators, such as seals and seabirds. Factors that may have precipitated increases in adult groundfish abundance include changes in environmental conditions, commercial fishing practices, and predator release resulting from the over-harvest of marine mammals and some fish species during 1955-1975. As the numbers of marine mammals declined more prey became available for groundfish, thereby increasing groundfish abundance. The current high population of groundfish (e.g. adult walleye pollock) might have resulted in a reduction in the availability of

marine mammal and seabird prey (e.g. capelin and juvenile pollock). Declines in the abundance of some key prey species that are the primary food sources for marine mammals and seabirds could have caused declines in the numbers of these apex predators (Hunt et al., 2002, Sinclair, 1988, Sinclair et al., 1994). Fritz and Hinckley (2005) indicate limited, if any, evidence supporting the nutritional stress hypothesis and the variation in fur seal foraging data is more consistent with variation in regional prey abundance consumed by fur seals sampled at different locations, than an indication of nutritional stress.

Evidence suggests that some key prey species were more available to marine mammals and seabirds before the decline of these apex predators. Peaks in adult pollock biomass that occurred in 1972 and 1985 coincided with two periods of decline in Steller sea lion numbers, while low points in pollock abundance in the late 1970s and early 1990s coincided with periods of relative stability in sea lion numbers (Merrick, 1997). Adult pollock consume many of the same forage fish species as marine mammals and seabirds, including juvenile pollock. A five-fold increase in the adult pollock biomass from 1962 to 1972 undoubtedly increased the amount of prey consumed by adult pollock and might have reduced the availability of prey for marine mammals and seabirds. Fur seal diets estimated from pelagic Bering Sea collections indicate pollock, capelin, and squid the most frequent items found in stomachs in 1960, 1962, 1963, and 1964 respectively (NMML unpublished data). In 1968, 1973, and 1974, squid was the most common item found in fur seal stomachs collected in the Bering Sea followed by pollock (NMML unpublished data).

Kuzin and Shatilina (1990) reported a significant correlation between the survival of fur seals less than two years of age and the temperature of the sea water near Hokkaido where fur seals winter. Sea surface temperature strongly influences the distribution and abundance of fish and squid thereby altering their availability for consumption by juvenile fur seals. It was suspected that fur seal food sources may have decreased near Hokkaido during warmer years.

G.5. Commercial Harvest

Russian explorers first visited the Pribilof Islands and their fur seal populations in June 1786, and the exploitation of fur seals began almost immediately thereafter. From 1786 to 1828, the Russians, with enslaved Aleut labor, harvested an average of 100,000 fur seals annually, primarily pups (Roppel, 1984). It was not until 1822 that bulls were protected and restrictions were placed on the number of pups killed (Scheffer et al., 1984). From 1835 to 1839 an average of 70,000 seals were harvested annually. Beginning in 1847, the number of males taken was controlled and the harvest of females was stopped. About 30,000 to 35,000 fur seals were killed annually during the last 10 years of Russian occupation. The population was reportedly thriving and was sustaining an annual harvest of several thousand males when the United States purchased Alaska in 1867 (York and Hartley, 1981). During the first 2 years following the purchase of Alaska by the United States, the fur seal harvest ensued without regulations. Approximately 240,000 fur seals were taken on land in 1868. Meanwhile, many fur seals were also harvested or killed and lost at sea (pelagic sealing).

Roppel and Davey (1965) report the history of pelagic sealing from 1875 to 1909, its impact on the fur seal population, and a discussion of a treaty banning pelagic sealing. At the peak of pelagic sealing (1891-1900), more than 42,000 fur seals (mostly lactating females) were taken annually in the Bering Sea (Scheffer et al., 1984). In addition, pelagic sealing removed a large but unknown number of fur seals from waters off British Columbia (Scheffer et al., 1984). Because the takes greatly reduced the fur seal stock, Great Britain (for Canada), Japan, Russia, and the United States ratified the Treaty for the Preservation and Protection of Fur Seals and Sea

Otters in 1911, which was the first international wildlife management agreement of its type in modern history. The treaty prohibited pelagic sealing and required a reduction in the harvest of seals on land. There was no commercial harvest from 1912 to 1917. From 1918 to about 1941, the Pribilof Island fur seal stock grew at 8 percent per year under a harvest that ranged from 15,862 in 1923 to 95,016 in 1941 (NMML, unpublished data). In 1941, Japan abrogated the 1911 Convention on the grounds that fur seals were too numerous and were damaging their fisheries; after World War II, a similar concern on the part of Japan was important in negotiating the 1957 Fur Seal Convention (Scheffer, 1980). No commercial harvest took place in 1942. The take from 1943 to 1955 averaged about 70,000 per year.

In 1957, the signatories of the 1911 Treaty ratified a new agreement, the Interim Convention on the Conservation of North Pacific Fur Seals, for the conservation, research, and harvesting of fur seals. During those negotiations, calculations presented by the United States suggested that maximum sustained productivity would occur at lower female population levels than those of the early 1950s. These projections postulated higher pregnancy and survival rates from a smaller herd (Anonymous, 1955). Consistent with that analysis, from 1956 to 1968, a total of about 300,000 female fur seals were killed on the Pribilof Islands and a pelagic collection of about 16,000 females was taken for research purposes by the United States and Canada during 1958 to 1974 (York and Hartley, 1981). Concurrently, 30,000 to 96,000 juvenile males were harvested each year (Lander and Kajimura, 1982).

The Pribilof Islands fur seal population did not react as expected to the herd reduction program initiated in the 1950s. Kajimura (1980) reported that neither a substantial decrease in age at first pregnancy nor an increase in pregnancy rates occurred as the population was reduced. Additionally, survival rates did not overcome population losses resulting from intentional herd reduction. The inability of the herd to recover generated speculation that some natural or anthropogenic factor, or combination of factors, may have adversely affected the recovery of the herd and caused extreme fluctuations in year class survival and a reduced production of young males (Roppel, 1984). The United States established a research sanctuary and commercial harvest moratorium on St. George while continuing the commercial harvest on St. Paul to study the effects of harvest regimes on fur seal population dynamics. Thus, NMFS began the first long-term study of behavior in the history of fur seals on the Pribilof Islands in 1973 (Roppel, 1984). St. Paul Island harvest management regulations changed very little from 1973 to 1979, and harvests ranged from 24,000 to 27,000 animals per year (Harry and Hartley, 1981).

The level of commercial juvenile male harvests on the Pribilof Islands in the 1970s and 1980s was not believed to have deleteriously affected the population. It is therefore unlikely that the present fur seal population is now influenced by any residual effects from the past commercial (or subsistence) harvest. A thorough summary of the harvest and its effects on the fur seal population can be found in the 1993 Conservation Plan for the Northern Fur Seal and in numerous publications (e.g., Roppel, 1984, Roppel and Davey, 1965; York and Hartley, 1981).

The authority of the 1957 Convention was extended in 1963, 1969, 1976, and 1980. Under the terms of the 1980 extension, the Convention expired on 14 October 1984. In consultation with the U.S. Departments of State and Justice, and the Marine Mammal Commission, the United States declined to sign an extension after 1984. It was determined that no commercial harvest could be conducted under existing domestic law, and, therefore, the commercial harvest on St. Paul Island was terminated. Management of the fur seal then came under the authority of the MMPA. Accordingly, on July 8, 1985, NMFS issued an emergency interim rule to govern the subsistence harvest of fur seals for the 1985 season under the authority of section 105(a) of the Fur Seal Act. A final rule was published on July 9, 1985, and the regulations provide the basis

for the subsistence use of fur seals on the Pribilof Islands.

G.6. Subsistence Harvest

Historically Native Alaskans harvested fur seals for consumption throughout the year as they were available. Harvests prior to the discovery of the Pribilof Islands were likely pelagic throughout coastal Alaska. On the Pribilof Islands, subsistence harvests from 1870 to 1917 were first recorded during leases to the Alaska Commercial Company and North American Commercial Company. These early reports provide the number of "seals killed for Native food" from all months of the year. Seals harvested for food in the Pribilofs were primarily juveniles and pups. The practice of killing pups for food was banned under the new lease arrangement in 1881. Pups were not harvested for food in 1882, but harvests were initiated again in 1883 and subsequent years until the prohibition in 1891 (Jordan, 1898). For the period from 1912 to 1916 all commercial harvests on the Pribilof Islands were banned except to meet the needs of the Native population. Harvest estimates for this five-year period represent annual subsistence use (Zimmerman and Letcher, 1986). An estimate of the subsistence harvest on the Pribilof Islands for the period after the sealing moratorium is estimated by counting those seals killed before June 1st and after August 31st as well as those specifically noted as food killings during the commercial harvest period. Killing of seals outside the general summer harvest season was halted in 1930 after the expansion and modernization of the by-products plant in 1930.

Many of the records for food harvests are incomplete or inconsistently reported. Records of seals killed for food after 1895 were those harvested in the spring and fall months or illegal harvests during the commercial season. Numbers of seals reported as killed for food are significantly lower after 1895 than in earlier years, possibly reflecting seals used for food during the harvest season that are not recorded as in other years. Average consumption of seal meat on the Pribilofs in 1881 was calculated as 600 pounds of seal-meat annually per person by Elliott (1881) and in 1914 as 17.5 carcasses or 612.5 pounds annually per person (Osgood, 1914).

During the 1950s and afterwards, harvests for food became less the duty of the lessee or the government and more a responsibility of local residents. Records are incomplete and may represent a subset of those seals harvested for skins. Seal carcasses were available on the killing ground following the commercial harvest for anyone who needed food (Veltre and Veltre, 1981). Residents took meat for immediate needs and for the winter season. Residents of St. George, where commercial sealing was banned in 1972, conducted a small subsistence harvest of their own and obtained meat from the St. Paul commercial harvest. Zimmerman and Letcher (1986) and Zimmerman and Melividov (1987) reported the subsistence harvests of 3,384 and 1,299 on St. Paul Island in 1985 and 1986, respectively. The higher harvest in 1985 is likely related to the distribution of about 10,000 lbs of seal meat to St. George and other Aleut communities (Zimmerman and Letcher, 1986). There was no indication of fur seal meat being distributed to other communities in 1986 (Zimmerman and Melividov, 1987).

Pelagic harvests of northern fur seals in other areas of coastal Alaska, British Columbia, Washington and Oregon during the first half of the 1900s are recorded in various reports. After 1912, Native hunters were specifically given the right to hunt seals at sea as needed for food and clothing using aboriginal methods. The native harvest exemption was maintained in the Marine Mammal Protection Act, and further specified in the regulations promulgated after the cessation of the commercial harvest (50 CFR 216.71-216.74). It is likely that harvest levels in Sitka were primarily driven by sales of skins to fur buyers in the region. The harvests from the Sitka area were estimated based on the numbers of skins authenticated and sold. Skins from these hunts were prized and the harvest increased through the 1920s to a maximum of about 1000 skins and

declined due to the lack of market for skins in 1940 (USFWS, 1940). The majority of fur seals harvested in southeastern Alaska were taken during their migration north in April or May by hunters and fishermen from Sitka and the skins were sold in Sitka. Composition of the harvest in the Sitka region included pregnant females, juvenile males and yearlings (Marsh and Cobb, 1909).

G.7. Commercial Fishing

Commercial fisheries have the potential to affect northern fur seals in several ways: (1) from incidental take during fishing operations, (2) from entanglement in marine debris lost or discarded from fishing activities, (3) from disturbance related to boat traffic, fishing activities, and the presence of fishing gear, and (4) from changes in prey availability (abundance, density and distribution) or competition that may result from commercial fisheries. The policies and management strategies that govern the Alaska groundfish fisheries are regularly reviewed by the North Pacific Fisheries Management Council and NMFS, and changes to the policies or strategies could influence the northern fur seal population. Few data exist to indicate the level or probability of commercial fishery impacts through the proposed mechanisms described above.

Currently, all marine areas used by fur seals are commercially fished. Fur seal presence in the Bering Sea coincides with numerous commercial fisheries on species found in the fur seal diet from May through November. These fisheries include a variety of gear types directed at pollock, Pacific cod, Pacific herring, Atka mackerel, squid, and salmon. In addition there are Bering Sea commercial fisheries directed at species (yellowfin sole, flathead sole, rock sole, Alaska plaice, Greenland turbot, halibut, and pollock) considered competitors with fur seals. In the Pacific Ocean there are also commercial fisheries directed at fur seal prey and fish that compete with fur seals. Therefore commercial fisheries in the Pacific Ocean could reduce, alter or redistribute the prey field of northern fur seals similarly to that postulated in the Bering Sea. Alternatively, removal of competitor species due to fishing may increase the availability of fur seal prey; however, the relationship between fur seals, fisheries, and fur seal prey varies by region and to the extent one species is able to out-compete another for common prey is unclear.

G.7.1. Incidental catch (Bycatch)

Fur seals taken as bycatch may die, be injured, or released unharmed. In the late 1970s, incidental take of fur seals in commercial fisheries in the North Pacific Ocean was not considered large enough to have been a significant factor in the decline of the Pribilof Islands fur seal stock. Loughlin et al. (1983) reported that 8 fur seals were caught in foreign trawl fisheries in the eastern North Pacific between 1978 and 1981. Perez and Loughlin (1991) reported that 48 fur seals were incidentally killed in foreign and joint-venture trawl fishing operations in U.S. waters from 1973 to 1987. They estimated a total incidental take mortality of 246 fur seals in both the foreign and joint U.S.-foreign commercial groundfish trawl fisheries from 1978 to 1988. Similar numbers of fur seals probably suffered incidental mortality from 1966 to 1977 (Perez and Loughlin, 1991). Illegal fishing in international waters may have declined significantly in recent years, and bycatch by these illegal activities is unknown. The following descriptions of past fisheries are provided as context for the historic levels of northern fur seal bycatch. Data from more recent fisheries are presented in a subsequent section.

High-seas Squid Gill-Net Fishery--Drift gill-net fishing for squid in the North Pacific began in 1978 and the rapid expansion of this high-seas gill-net fishery in the 1980s raised concerns that large numbers of marine mammals were being incidentally killed (Hobbs and Jones, 1993). By

the early 1980s, more than 700 commercial drift gill-net vessels fished about 10 months of the year and set approximately 40-60 km of gill-net per boat per night (representing 35,000 linear km of gill-net per night). In 1988, 134 fur seals (43 dead/91 alive) were incidentally taken (INPFC, 1989) and in 1989, 80 fur seals (dead or unknown status) were incidentally taken (Hobbs and Jones 1993). Nine hundred fur seals were incidentally taken during the 1990 and 1991 seasons of the high-seas squid fishery (INPFC, 1991, 1992; Hobbs and Jones, 1993). Based on the observed number of fur seals taken in 1989 and 1990, Hobbs and Jones (1993) estimated the total incidental take to be 1,579-1,927 and 4,960 fur seals in these years, respectively. Although these fisheries operated from late May to December, most incidental take occurred during July and August. Hobbs and Jones (1993) indicated that the estimated mortality of fur seals in the drift-net fisheries was low in comparison to their abundance and concluded that impacts to the population were not sufficient to cause significant declines. The foreign high seas driftnet fisheries incidentally killed large numbers of northern fur seals, with an estimated 5,200 (95 percent CI: 4,500-6,000) animals taken during 1991 (Larntz and Garrott, 1993). In 1992 commercial drift-net fishing in the North Pacific was halted, as a result of a 1991 United Nations resolution that called for a global moratorium on large-scale high-seas drift-net fishing.

Japanese Salmon Gill-Net Fishery--The Japanese high-seas salmon gill-net fishery reported taking from 7 to 11 fur seals per year between 1981 and 1989 (e.g., INPFC, 1989). In 1988, Japanese high-seas salmon gill-net fisheries were terminated in the U.S. Exclusive Economic Zone (EEZ) and part of the Bering Sea.

Domestic and Joint-venture Groundfish Fishery--Fur seal mortality related to trawl fisheries in the U.S. EEZ has been relatively low; 31 fur seals were taken by the domestic trawl fishery in Alaska and the North Pacific Ocean between 1989 and 2001 (Perez, 2003). A total of 3 fur seals were killed in the joint-venture trawl fisheries in Alaska during 1989 and 1990 (Perez, 2003). NMFS manages the current groundfish fisheries in Alaska with input from the North Pacific Fisheries Management Council (NPFMC) under a series of fishery management plans (FMP). The Bering Sea Aleutian Islands groundfish FMP and the Gulf of Alaska groundfish FMP regulate fisheries in waters used by northern fur seals during the spring, summer, and fall. During the winter various fisheries in the Pacific Ocean coincide with fur seal presence in both coastal and pelagic waters. The pelagic fisheries include international high seas driftnet, longline, and trawl fisheries that are poorly understood or described. Coastal fisheries within US and Canadian waters are better understood.

Marine Mammal/Fishery Observer Program--More recent estimates of interactions between fur seals and commercial fisheries are summarized in Angliss and Lodge (2003) and Perez (2003). Federally-managed target fisheries in Alaska include both pelagic and bottom trawls, fixed gear, and scallop dredging. From 1990 to 2001, six commercial fisheries were monitored by the observer program (Angliss and Lodge, 2003). The average annual bycatch for the Bering Sea Aleutian Islands (BSAI) trawl fishery is 1.4 fur seals from 1994 to 1998 (Angliss and Lodge 2003). Self-reporting from other commercial fisheries plus the BSAI rounded average indicates a minimum total annual mortality of about 15 fur seals (Angliss and Lodge, 2002). Perez (2003) accounted for recent genetic and tooth identification to evaluate the incidental take of marine mammals in the domestic and joint venture groundfish fisheries in the U.S. EEZ from 1989-2001. Perez (2003) estimated about 0-2 northern fur seals were taken annually in the North Pacific U.S. EEZ. To what extent this value underestimates the actual annual mortality is unknown, but Perez (2003) accounted for observer coverage and fishery effort. Fisheries in the North Pacific U.S. EEZ appear to be causing very few direct fur seal mortalities in recent years.

Numerous northern fur seal sightings are made outside the North Pacific U.S. EEZ (Figure 7) thus for fisheries outside the U.S. EEZ bycatch rates are unknown due to low observer coverage.

G.7.2. Entanglement in Debris

Fur seals become entangled at sea in debris from the commercial fishing industry (Fig. 8). Fur seals were first seen entangled in marine debris just after World War II (Fowler et al., 1990), and records of entanglement of northern fur seals in marine debris have been kept since the late 1960s. Most data come from studies of juvenile males collected during the commercial harvest between 1967 and 1985 (e.g., Scordino and Fisher, 1983), and scientific roundups conducted after the cessation of the commercial harvest (e. g., Fowler, 1987; Fowler et al., 1992). The most common types of debris include trawl net webbing, plastic packing materials, and monofilament line.

The juvenile male fur seal entanglement rate has fluctuated over time but was generally lower in the 1990s (~0.2 percent) than in the 1970s and 1980s (~0.4 percent). Robson et al. (1999) reported no difference between entanglement rates on St. Paul and St. George Islands over a three year period. Williams et al. (2004) reported that entanglement rates remained generally consistent from 1995 to 2003, and determined that approximately 20,000 seals would need to be sampled to detect a 50 percent change in the proportion of juvenile males entangled. Williams et al. (2004) suggested consistent counting procedures and adequate sample size are important considerations when reporting trends in juvenile male entanglement. The entanglement rate is less than 1 percent annually (Fig. 8) for juvenile (2-4 yr-old) male seals that are observed on the Pribilof Islands. However, this rate does not account for seals that become entangled at sea and are unable to return to the breeding grounds, nor does it account for the percentage of adult fur seals that are entangled.

The rates of entanglement for adult females may be higher than that of adult males because of their smaller size and slower rate of growth. In 1985, DeLong et al. (1988) estimated between 0.06 and 0.23 percent of adult females on select St. Paul rookeries were observed entangled in marine debris. Mass and survival of pups with entangled mothers were significantly lower than other pups. Entangled lactating females spent more time at sea feeding than non-entangled females or did not return to the rookeries at all (DeLong et al., 1988). A sample of adult females has been counted since 1991 during the counting of adult males on St. Paul to determine the percentage of adult females entangled (Figure 8). The percentage of adult females entangled in recent years is lower than for juvenile males, suggesting that either adult female fur seals are less likely to become entangled or their survival once entangled is lower than juvenile males.

Observations of fur seal entanglement at sea are limited, and the actual extent and significance of entanglement at sea is unknown (Fowler, 1987). Captive studies on three juvenile male fur seals

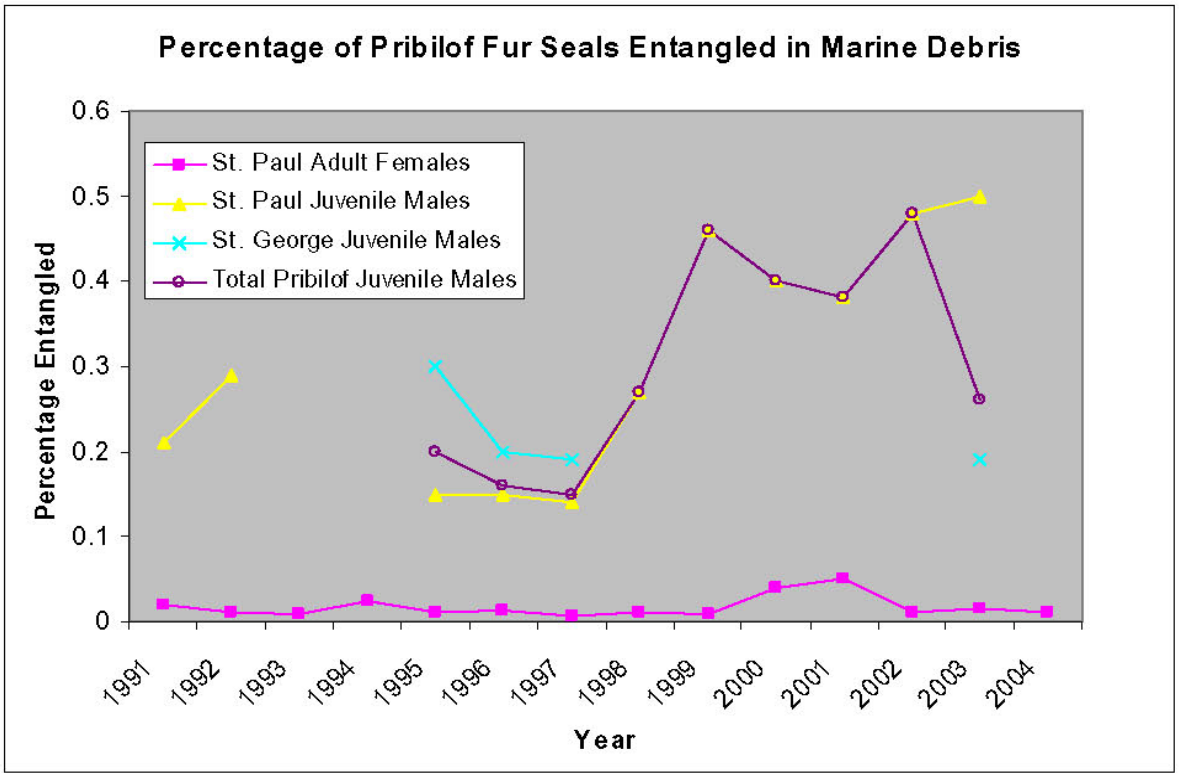

FIGURE 8. SUMMARY OF NORTHERN FUR SEAL ENTANGLEMENT ON THE PRIBILOF ISLANDS FROM 1991-2004, *from FOWLER et al., (1994); WILLIAMS et al., (2004); AND NMML, UNPUBLISHED DATA.*

showed that a free-swimming animal entangled in a net fragment of 200 g or larger will experience considerable difficulty swimming (Feldcamp et al., 1988). The relative size of females and juvenile males (2-4 year old) correlates well with the common mesh sizes of trawl net material. Females due to their smaller size at age may have a longer opportunity to become entangled in the prevalent net material than subadult (5+ years old) and older males. Juveniles of both sexes may be more likely to become entangled than adults.

Laist (1997) suggested that while the entanglement rates seen on land are too low to account for the fur seal population decline, the unrecorded number of animals entangled and killed at sea may be a potentially significant factor. Trites and Larkin (1989) modeled fur seal population trends and speculated that entanglement related mortality was likely contributing significantly to the decline observed through 1987. Trites and Larkin (1989) indicated a 2-5% reduction in adult female survival provided the best fit of model choices to the available trend data. Entanglement in marine debris is a plausible mechanism for the reduction in adult female survival in the late 1980s. Fowler (1985; 1987) estimated entanglement mortality could be as high as 15% for seals from birth to age 3.

G.7.3. Indirect Fishing Effects

The indirect commercial fishing effects on marine mammals in general or northern fur seals specifically, could include a reduction, redistribution, alteration, or increase in the availability of

prey. Fisheries could affect fur seal prey on either a local (e.g. "localized depletion") or ecosystem-wide scales (NMFS, 2000) by removing fish. Fisheries may reduce the density of individual patches (through dispersion) or change the distribution, size, or number of patches in space (e.g., deeper, greater patch separation, smaller, fewer). In addition, fisheries may affect fur seals through interactive competition (Baraff and Loughlin, 2000). Interactive competition may include disruption of normal fur seal foraging patterns from the presence and movements of vessels and gear in the water, abandonment of prime foraging areas by fur seals because of fishing activities, and disruption of prey schools in a manner that reduces the effectiveness of fur seal foraging. Fishery removals may influence fur seals in numerous ways. Ecosystem complexity, data and model limitations, and direct linkages may confound quantification of interactions between northern fur seal seals, their prey, and commercial fisheries.

Commercial fisheries removals have been studied to a greater degree with respect to the impact on Steller sea lions than northern fur seals. Little information exists on the indirect effects of commercial groundfish fisheries on northern fur seals. Commercial fisheries may affect northern fur seals in ways similar to or different than those for Steller sea lions. Numerous conservation actions are described in Section II of the conservation plan to increase our understanding of the relationships between fur seals, fish, and commercial fisheries. Future fur seal and fisheries research results may inform future management actions.

G.8. Disturbance and Coastal Development

Organizations have proposed development of on-land infrastructure to create economic opportunities on the Pribilof Islands. These on-land developments have the potential to impact northern fur seals. Some of the projects proposed for the Pribilof Islands are upgrades to small boat harbors and airports; dock facilities for vessel repair, maintenance, and storage; and multi-species seafood processing plants. NMFS participates in oversight of economic development projects in the Pribilof Islands for consistency with the goals of this plan and the MMPA. NMFS authorizes a fisheries-related Western Alaska Community Development Quota (CDQ) program in the Pribilof Islands. CDQ groups represent St. Paul (exclusively) and St. George (with other Aleutian Island communities) in applying for allocations, managing the harvest or lease of the allocations, and investing money earned in projects to develop or support economic opportunities related to commercial fisheries. NMFS allocates a percentage of the groundfish fisheries total allowable catch to fund the CDQ program. Crab and halibut processing waste is discharged into the nearshore environment on both St. Paul and St. George islands. Wastes discharged from processing other fish species may contain greater amounts of oils and grease that may compromise the fur seal's pelage if discharged during their presence on the Pribilofs. High-volume processing such as bottomfish/surimi may discharge waste particularly detrimental to fur seal pelage. A complete description of processing options and the timing of discharges will need to be considered prior to determining effects on fur seals.

G.8.1. Aircraft Overflights and Noise

Insley (1992, 1993) concluded that aircraft activity could adversely affect fur seals because the sound spectra of aircraft noise and fur seal vocalizations on land overlap, and some fur seals oriented towards aircraft noise during overflights. Johnson et al. (1989) reported that in 1981 a large twin-engine aircraft passed approximately 300-500 ft. over the Gorbatch haul-out on St. Paul Island and caused a large stampede of bachelor bulls into the water, while a large twin-engine cargo plane passing at low altitude over a group of sleeping subadult male fur seals at a haul-out adjacent to East Rookery on St. George Island caused little disturbance other than some seals lifting their heads. Similarly, observed flights of large helicopters over the Kitovi rookery

on St. Paul did not cause a stampede of fur seals.

Despite the variability in fur seal response to aircraft overflights, some biologists in the late 1980s speculated that the Little Polovina rookery/haul-out (5 km from the St. Paul airport) could be negatively impacted by aircraft disturbance (Johnson et al. 1989). Although fur seal use of the Little Polovina breeding and resting area has remained low, the rookery has not been abandoned, and whether these low numbers are related to aircraft disturbance or to some other factor is unclear.

Activity levels of juvenile males near the old and new airports on St. George Island were higher for approximately 5 minutes following aircraft overflights (Williams 1997). Williams (1997) did not find evidence of population-level effects (e.g., pup production, pup health indices, and shifts in the distribution of the breeding population) on fur seals during the peak of aircraft overflights on the southern breeding areas on St. George in 1993 and 1994. The potential for fur seals to habituate to aircraft disturbance has not been studied in detail, and subtle evidence of habituation may have occurred on St. George in 1994 (Williams 1997).

Attempts to reduce aircraft disturbance to fur seals have included the establishment of Aircraft Advisory Zones and Requested Aircraft Flight Paths, which have reduced overflights of fur seal rookeries on St. George and St. Paul Islands, including the Polovina Complex.

G.8.2. Vessel Traffic and Noise

Few studies have described fur seal responses to vessel traffic. Johnson et al. (1989) reported observations of fur seals approaching vessels at sea, but also reported that seals avoided ships at distances of up to a mile if they were engaged in seal hunting. The potential for fur seal disturbance from fishing vessels and underwater and airborne noise appears to be low (Johnson et al. 1989 and references therein). Some evidence suggests that fur seals in the water are curious and may be attracted to vessel traffic or to engine and propeller noise. On some occasions, fur seals have been observed to approach fishing vessels, and to swim away from vessels on other occasions. Fur seal interactions with fishing vessels have not been documented systematically, and fur seal response to vessel traffic may be related to past experiences of individual animals. Whether fishing vessels may temporarily displace some fur seals from preferred feeding areas is unknown, but the limited number of recent interactions reported by fisheries observers during the trawl fishery would suggest that fur seals avoid large actively-fishing vessels, but not general vessel traffic.

Vessel presence and shipwrecks on the Pribilof Islands poses both the threat of oil spills and resultant effects, but also rat-infested ships pose a threat to fur seals due to disease transmission and alteration of the terrestrial ecosystem of the Pribilof Islands. The potential effects of the introduction of invasive species such as rats have not been evaluated. The presence of rats on other breeding islands and their interactions with fur seals are unknown.

G.8.3. Construction Activities

Based on observations of fur seal behavior in response to quarrying activities on St. George Island, Gentry et al. (1990) concluded that over the duration of project activities, non-breeding fur seals did not avoid prolonged, airborne construction sounds of about 85 dB re 20 μPa peak source level. Additionally, fur seals did not avoid ground vibrations from heavy equipment working within 100 m, and showed no response to subterranean blasts 0.6 to 2 km away (75 dB

re 20 μPa at 50 m from the source) or to heavy construction 500 m away (Gentry et al., 1990). No fur seals were observed in the harbor during excavation and expansion activities on St. George, and no seals were observed to respond (either by changing behavior or orienting towards the source or water) to upland blasting approximately 1 km from a resting area at Zapadni. Due to wind conditions, however, the blast was not distinctly audible to the observer at the haul-out near the seals (M.T. Williams pers. obs. Aug. 1996).

G.8.4. Human Presence and Research

Human presence at breeding and resting areas harasses fur seals. Such presence includes research activities, ecotourism, and activities of residents of St. Paul and St. George. The presence and activities of humans near or in fur seal rookeries/haul-outs can cause major disturbances. As a result regulatory closures (50 CFR 216, subpart J) preclude human access to fur seal breeding and resting areas from 15 May until 15 October without prior authorization. A special exemption was provided for opening Northeast Point on 15 September to allow Steller sea lion hunters access to a primary fall hunting location at Sea Lion Neck. Some have suggested that the abandonment of the Lagoon rookery on St. Paul in the late 1940s may have been caused by increased activities (including the operation of a fur seal by-products processing plant) and by hunting pressure from residents of the village of St. Paul (Johnson et al. 1989). Little Eastern rookery was abandoned by about 1914 and was close to the village on St. George; however, the eastern portion of North rookery is closer (Gentry 1998). Ream et al., (1994) suggested that rookeries with road access had higher rates of decline than those without road access. Similar analyses may provide insight into the effects of different levels of human presence at fur seal breeding and resting areas.

A detailed analysis of the influence of human caused disturbances has not been undertaken. Experiments conducted by Gentry (1998) indicate that fur seals are resilient to extreme disturbances during the breeding season. Prior to the arrival of adult females, Gentry (1998) drove all territorial males from the breeding area they occupied on two different rookeries. About 80 percent of all males reoccupied their former sites within 7 hours and with fewer aggressive interactions than during the initial formation of their territory. Gentry (1998) translocated lactating females to other breeding areas with their pups and about 70 percent remained with their pups, making multiple feeding trips similar in duration to unmoved lactating females.

The biological effects of disturbance are strongly related to the season, type of disturbance, and frequency. During the peak of the breeding season, fur seals are reluctant to leave the breeding areas. Fur seals seem to tolerate disturbances in the breeding areas during the peak of the breeding season. Fur seals often detect human scent, and become vigilant prior to detecting a visual stimulus, like the silhouette of a person. Outside of the peak breeding season, mothers will separate from their young once human presence is detected in the breeding area, but often return within a few hours or less depending on the season. Displacement of females and pups from breeding areas during the later portions of the lactation period might result in longer periods of separation between mothers and pups. Repeated displacement of adult females might result in permanent abandonment of sites. Juvenile males are less tolerant of human presence in the resting areas and are displaced from land easily. Juvenile males may return to the original or nearby resting areas within a few hours. Juvenile males were displaced repeatedly for the commercial pelt harvest, and no evidence of a redistribution of juvenile male seals from St. Paul to St. George was detected (Gentry, 1998). The energetic cost of such displacement from resting and breeding areas is unknown.

The dates for closing and opening the breeding and resting areas to human presence are not based on the absolute lack of fur seals being present but represent a compromise between community access and the suspected biological consequences of late season human-related harassment. In the fall, Steller sea lion hunters, tourists, and beachcombers can unknowingly displace breeding females and their dependent young. The 15 September exemption for Sea Lion Neck was implemented to avoid undue hardship on hunters with limited transportation options, when few personal vehicles were owned within the community. The prevalence of motorized vehicles may have resulted in more individual hunting and incidentally harassing nearby fur seals multiple times during a week or even a day. Reassessing the number of incidental disturbances and the consequences of repeated events late in the lactation period are important to managing human interactions with fur seals.

Early studies suggested that some research had detectable effects on the animals involved. Gentry and Kooyman (1986) found that lactating females who were outfitted with straps to secure dive recording instruments had significantly longer foraging trips than those that were flipper tagged but not instrumented. These findings resulted in significant alteration of the procedure for attaching instruments and efforts to reduce the mass and drag of instruments. Similarly, Walker and Boveng (1995) reported that lactating female Antarctic fur seals (Arctocephalus gazelle) had significantly longer foraging trips and nursing bouts when instrumented with a time depth recorder and radio transmitter versus a radio transmitter alone. An inspection of the current data may provide insight into the effects of various tag attachments in addition to broader scale changes in distribution related to repeated harassment due to research.

G.8.5. Motorized Vehicle Traffic

The impact of motorized vehicle traffic may result from visual stimulus, noise or pollution. Vehicle exhaust fumes and leaking fluids add pollutants into the habitat used by fur seals on the Pribilofs. Fur seals may respond to passing vehicles or audible noise by becoming vigilant, departing, or vocalizing. Ream et al. (1994) suggested St. George rookeries with road access declined faster from 1914 to 1992 and contributed a smaller proportion to pup production than those rookeries with no road access. Whether the results were related to vehicle traffic, human presence, or both is unknown. Increased vehicle traffic near rookeries is often related to opening some rookeries on 15 September to hunting or opening all rookeries on 15 October. Automobile and all-terrain vehicle traffic on roads and trails adjacent to fur seal breeding and resting areas may affect the continued use of these areas.

G.9. Environmental Contaminants

Environmental pollutants are a possible factor influencing the decline in the populations of some marine mammals. Some studies have suggested organochlorine pollutants may have been associated with reproductive failures of California sea lions and harbor seals (DeLong et al., 1973; Gilmartin et al., 1976; Reijnders, 1986). Loughlin et al. (2002) reported that organochlorine concentrations in the blubber of fur seals on St. George Island were higher than in seals on St. Paul Island. The toxic equivalency levels of raw blubber from St. George juvenile male fur seals exceeded the levels recommended for consumption by humans. However, milk samples from seals on St. Paul Island had higher PCB levels than samples from St. George Island seals (Loughlin et al., 2002).

Tanabe et al. (1994) measured the levels of persistent organochlorine residues in the blubber of female northern fur seals off the coast of Japan. PCBs and DDTs were found to be high in all samples. These residues showed a drastic reduction after maturity and then increased again after the menopause. Beckmen et al. (1999) reported that fur seal pups from young (less than 5 years) females had significantly higher organochlorine concentrations in their blood than pups born to older (greater than 7 years) females, and organochlorine contaminants were significantly more concentrated in early lactation milk of young females than older females. Mean concentrations of PCB congeners were higher in pup blood than in that of reproductively active females. Beckmen et al. (1999) suggested that northern fur seal pups, especially pups born to first-time mothers, have a substantial exposure to organochlorine contaminants at a critical developmental stage and suggested that this exposure could impact neurological and immune system development.

Krahn et al. (1997) reported concentrations of certain organochlorine contaminants in blubber from Pribilof Island fur seals that were about an order of magnitude higher than those found in other seal species. Age and sex did not account for differences in contaminant concentrations, and it was suspected that the differences may be due to differences in feeding habits and migratory patterns among species.

Kim et al. (1974) found mercury in adult female fur seal blood and hair, and Anas (1974) reported high mercury concentration in fur seal liver, followed by kidney and muscle. Concentrations of cadmium and lead were highest in kidney. Noda et al. (1995) measured the concentrations of various heavy metals in muscle, liver and kidney tissues of northern fur seals caught off the coast of Japan and from the Pribilof Islands. Concentrations of heavy metals varied depending on the particular metal in question, the tissue involved, and the age and location of the seal, but no consistent trends among areas were detected. Beckmen et al. (2002) reported higher total mercury concentrations in the fur of northern fur seals from the depleted Pribilof Island population when compared to both declining and thriving populations of Steller sea lions from Prince William Sound and Southeast Alaska. Saeki et al. (2001) reported relatively high concentrations of silver and vanadium in northern fur seals.

Major information and data gaps regarding the effect of toxic substances on northern fur seals include information to assess the effect at the individual, population, and species levels. Of primary concern is chronic exposure to toxic substances and the potential for reactive metabolites to cause damage to DNA, RNA, and cellular proteins. But more importantly, there are no studies on the effects of toxic substances at the population level to determination their impact on vital rates, population trends, or the human consumers.

Contaminant studies on fur seals have shown exposure to various toxic substances and evidence of accumulation in various tissues. Whether lingering effects on vital rates from exposure to these substances are occurring at the individual or population is unknown. Of lesser importance, but a recognized data gap, is the determination of the level of contaminant load (organochlorine pesticide residues, polychlorinated biphenals, and heavy metals) for discriminating between populations.

G.10. Oil and Gas

An oil spill coincident with northern fur seal presence would be the most severe direct impact within the Pribilof Islands region and winter fur seal range. Unlike many other marine mammals, fur seals rely on the water-repellent quality of their fur rather than a thick layer of

blubber to provide insulation from the cold temperatures of Bering Sea and North Pacific Ocean waters. Oil that comes in contact with fur seals will diminish the insulating capacity of the fur resulting in death from hypothermia (Kooyman et al., 1976).

From June to December, northern fur seals concentrate on the breeding grounds of the Pribilofs. Sub-adult animals, adult females, and non-breeding males all frequently return to the sea to feed during this period, and could be exposed to floating oil. By early September, all animals including pups regularly enter the water and would be potentially vulnerable to a marine spill. Fur seal pups often congregate in tidal pools and shallow nearshore waters where oil may become trapped or concentrated. The risk of oiling may therefore be greater to pups than adults.

Inhalation of petroleum product vapors may result in increased levels of hydrocarbons within blood and tissues of northern fur seals. The toxic effect of inhalation may be serious, particularly during the first few hours of a spill when volatile fractions are given off, or for spills of refined products (i.e., gasoline or diesel fuel), which contain higher percentages of these compounds. Possible effects include lethargy, sickness, and destruction of the central nervous system. Exposure to high concentrations of volatiles may result in the mortality of some northern fur seals.

Direct exposure to hydrocarbons has been observed to cause irritation to eyes and mucous membranes in pinnipeds. Ingestion of oil may also have deleterious effects, although it is not anticipated that this would be a significant concern for northern fur seals relative to heat loss due to oiling of their fur.

In the event that oil approaches or contacts a rookery, clean up efforts may be directed to both nearshore and offshore regions. Disturbance to northern fur seals may result from the presence of oil-spill response workers and associated aircraft, vessel, and ground support vehicles. Northern fur seals may respond to human presence by immediate departure from the area. Prolonged or intense disturbance could result in abandonment of the site. Harassment from oil response activities on breeding fur seals on the rookeries could result in increased mortality of fur seal pups due to disrupted nursing, early weaning, or crushing due to stampedes of frightened animals. This harassment; however, is small relative to the direct mortality as a result of contact with oil.

Approximately 5,000 South American fur seal (Arctocephalus australis) pups were known to have died as a result of a crude oil spill off the coast of Uruguay in February 1997 (Mearns et al., 1999). The spill occurred during the peak of the pupping season and pups became oiled as the oil reached the beaches of the breeding colony. Fur seals were not affected by the Exxon Valdez oil spill (EVOS) (Loughlin, 1994), although an estimated 2,800 sea otters may have perished as a result of the spill and many more probably died and were not recovered (Garrott et al., 1993; Loughlin et al., 1996).

Several mathematical models have been developed to predict fur seal mortality from a hypothetical spill (French et al., 1989; Neff, 1990). A modeled spill of 10,000 barrels of Prudhoe Bay crude oil in Unimak Pass during spring fur seal migration fouled 0.05 percent of the males and 3.7 percent of the females in the population (Reed et al., 1986 in Neff, 1990). The model assumed a population of 1.16 million animals, and the number of oiled seals averaged 29,364 in 8 simulations. Another spill scenario south of St. Paul Island in mid-July, also involving 10,000 barrels of crude oil, fouled 4.0 to 6.2 percent of the females and 5.3 to 6.4 percent of the males depending on the assumptions of the model. The model projected that 10,603 to 73,948 seals would be oiled, depending on the initial size of the population and

whether or not the island was oiled. French et al. (1989) used a similar scenario to that of Reed et al. (1986) to predict mortality of 4,772 to 14,235 seals for the Unimak Pass spill depending on the mortality rate once the animal was oiled. The St. Paul spill model predicted seal mortality ranging from 3,562 to 30,724 animals depending on the mortality rate once the animal was oiled and also whether rookeries on the island were oiled.

Whitney and Yender (1997) reported on 14 oil spills, primarily of diesel fuel, near the Pribilof Islands from 1979 to 1996. The largest spills were approximately 40,000 gallons in November 1979, 25,000 gallons in March 1990, and 15,000 gallons in March 1987. Most of the spills occurred in February and March, one spill occurred in May, one in October, and no spills occurred during June through September when the greatest numbers of fur seals are on the Pribilof Islands. Few impacts to marine birds and mammals were reported in association with these spills, although approximately 1,500 birds (mostly king eiders) were oiled during a spill off St. Paul Island in February 1996 (Whitney and Yender, 1997). Approximately 50 percent of the micro organisms and invertebrates in Salt Lagoon, St. Paul Island, were killed as a result of the large spill in November 1979 (Whitney and Yender, 1997).

A spill that occurred in the Aleutian Islands as a result of the grounding of a large cargo ship in December 2004 had the potential to affect fur seal breeding sites at Bogoslof Island. Had it occurred during spring or fall during fur seal migration, it could have had detrimental impacts on female and pups migrating south through Aleutian Islands passes. The number of seals affected by an oil spill in an Aleutian Island pass would depend on the amount and type of spill, the location, and the time of year (French et al., 1989; Neff, 1990).

Contingency plans to deal with unexpected oil spills from tankers en-route to West Coast refineries or from spills in the Aleutian Island passes may be difficult to implement because of the large area involved. General oil spill response activities similar to those that have been implemented for previous oil spills would be conducted. Due to the concentration of a significant proportion of the fur seal population in the Pribilof Islands, an oil spill here could have a catastrophic effect. Mearns et al. (1999) suggest that the remoteness of the Pribilof Islands and other fur seal rookery sites demands on-site preparedness. Low-technology strategies, such as those employed for the spill in Uruguay, may be the most effective way of responding to a spill in the Pribilof Islands. NMFS has purchased a natural fiber-based sorbent material, used in the Uruguay spill, for such response. This material is warehoused on St. Paul Island. NMFS will continue to pursue effective response and preparedness strategies on the Pribilofs as necessary to conserve the northern fur seal. NMFS has also worked with the U.S. Coast Guard, U.S. Fish and Wildlife Service, and the Alaska Department of Fish and Game to prepare the Wildlife Protection Guidelines for the Pribilof Islands. Those guidelines provide recommendations to responders and provide a hierarchy of response actions.

II. CONSERVATION STRATEGY

NMFS provides the history of northern fur seal life history, ecology, management, and research in the first section of the Conservation Plan. In addition the first section of the plan provided and assessment of the likely natural and anthropogenic threats to the Eastern Pacific northern fur seal stock. NMFS describes the conservation strategy here as the framework for future northern fur seal recovery and conservation. This recent and historical context will differentiate the traditional maximum sustained yield management approach during the commercial harvest (through 1984) from the single species management approach through early 2000. NMFS is initiating the

transition towards ecosystem approaches to management as identified in the NOAA Strategic Plan (http://www.ppi.noaa.gov). NOAA must take steps to integrate the diverse research projects within the range of the Eastern Pacific northern fur seal stock. NOAA research integration will better inform commercial fisheries, harvest and island development management. As part of the conservation strategy, NMFS identifies recent management and research progress, biological constraints on research and management, and conservation measures, goals and criteria in the remainder of this section of the plan.

A. Summary of Progress since 1993

The original Conservation Plan for northern fur seals was completed in 1993 (NMFS 1993). NMFS has managed numerous projects and worked with a diverse group of constituents, partners, and agencies on the Pribilof Islands. The following summary describes the accomplishments of northern fur seal management and research primarily in the Pribilof Islands since 1993.

A.1. Comanagement Agreements

Comanagement agreements were signed between NMFS and tribal governments of St. Paul Island in 2000 (Appendix 1) and St. George Island in 2001 (Appendix 2). These agreements are comprehensive, outlining the government to government relationship for cooperative management of northern fur seals (and Steller sea lions). Northern fur seal (and Steller sea lion) subsistence harvest monitoring is a cornerstone of the agreements and includes specific items such as supporting and continuing the harvest monitoring and reporting. The tribal governments of both islands have implemented programs that promote full utilization of edible and inedible seal parts for traditional arts, crafts, and other legal uses. The result has been an expanded use of these materials by the Aleut residents and increased fulfillment of the non-wasteful provisions of the MMPA.

Fur seal viewing blind permits and marine mammal parts registration forms are distributed and processed by the Tribal Governments. The Island Sentinel and Conservation officer intensively monitor rookeries and haulouts while fur seals are present and assist with compliance of federal regulations at 50 CFR 216, subparts F & G.

The Island Sentinel Program monitors fur seal rookeries and shorelines year round to document habitat degradation or alteration such as oil or fuel spills, trash or garbage accumulation, human disturbances, abnormal sheens on the surface of the water, or fish waste accumulation. They also observe and record natural changes and processes, such as presence of all marine mammals, redistribution of fur seals on rookeries and haulouts, and the timing of various life history events for fur seals.

Tribal staff implements community outreach and education programs through newsletters, curriculum development, radio and television public service announcements, and bulletin board postings. Educational and interpretive sessions with teachers, students, and visitors are done multiple times per year. The Tribal Governments maintain and repair fur seal research infrastructure on Federal lands designated as fur seal rookeries under contract to the NMFS.

A.2. Marine Debris

NMFS, NMML, and the Tribal governments have conducted disentanglement studies on the Pribilof Islands for the past decade. These studies provide entanglement estimates and remove debris from captured animals. Because of logistical constraints, the primary focus has been disentanglement of immature male fur seals seen at the resting sites, but adult females, adult males and pups may be captured and the debris removed when practical and authorized.

For the past 10 years the Tribal Government of St. Paul has coordinated beach clean up and derelict fishing debris removal on an annual basis at select locations. Early clean-up programs were conducted by volunteers collecting derelict fishing gear and marine debris from northern fur seal habitat. Subsequent clean-up programs and funding have been implemented with support from various organizations resulting in many tons of debris removed from nearshore habitat. In addition funding has provided for the disposal of debris stock-piled on St. Paul. The Tribal Government of St. George is working to develop and fund similar clean-up projects on St. George.

A.3. Rat Prevention Program

The U.S. Fish and Wildlife Service along with NMFS and a variety of local community organizations and other federal agencies work collectively to prevent the introduction of rats onto the Pribilof Islands. The occurrence of rats would rapidly devastate the abundant seabird populations and has the potential to introduce disease to marine mammals. Rat prevention training occurs on a periodic basis. Activities include the setup and regular maintenance of trapping stations, visitor education programs, identification of rat introduction risks, and emergency response.

A.4. Oil Spill Contingency Plans

NMFS in cooperation with numerous agencies developed an area oil spill contingency plan which has been extant for nearly ten years (Whitney and Yender 1997). The Alaska Regional Response Team plan can be found at: http://www.akrrt.org/index.shtml. This plan is reviewed and updated as needed to insure its applicability to ever-changing oil spill risks and experience gained from response in other regions. State, federal and local agencies identified sensitive habitats in the Pribilof wildlife protection guidelines with the creation of a sensitive habitat map. USFWS and NMFS distributed the map to the public with descriptive text in Russian, Japanese and English.

A.5. Observer Program and Incidental Take

NMFS monitors domestic fisheries to identify sources of marine mammal mortality including fur seals. Marine mammal program observers placed on fishing vessels record fishing effort (e.g., number of sets, size of nets, time and location of sets) bycatch of non-target species and document the number, sex, and age of all marine mammals observed and caught. Incidental take of marine mammals is summarized in the annual Stock Assessment Reports.

A.6. Development Review, Environmental Analyses, and Mitigation Identification

NMFS regularly reviews proposed state and federal permits and actions that may affect northern fur seals. NMFS works with agencies and applicants to determine whether such actions could harm fur seals, damage habitats essential to their survival, and to identify measures to avoid or minimize possible adverse effects. Activities are analyzed under the National Environmental Policy Act. Marine mammal scientific research permits are also reviewed.

A.7. Marine Mammal Stock Assessments

On April 30, 1994, Public Law 103-238 was enacted amending the Marine Mammal Protection Act. The amendments mandate that NMFS regularly evaluate interactions between marine mammals and commercial fisheries. The amendments established three regional scientific review groups to advise and report on the status of marine mammal stocks offshore of Alaska, along the Pacific Coast and Hawaii, and the Atlantic Coast (including the Gulf of Mexico). NMML prepares a stock assessment for northern fur seals.

A.8. Research

The NMML reports the results of their fur seal studies in the NOAA Technical Memorandum series, Fur Seal Investigations. Fur Seal Investigations is currently published biennially and thus provides an expeditious dissemination of fur seal research results. Comprehensive findings, as well as individual studies, are published by NMML staff in the peer-reviewed literature. Interim results may be published on the NOAA Fisheries website.

NMFS long-term conservation planning with internal and external funding is the most likely way to provide a stable time-series of biological and ecological data to implement an ecosystem approach to management. The North Pacific Fur Seal Commission proposed, reviewed, and approved early long-term fur seal studies and related management through 1984. The lapse of the Fur Seal Convention in 1985 significantly reduced research funding into the causes of the fur seal decline and limited the subsequent scope of that broad fur seal research program (Gentry, 1998). The following brief fur seal research summaries are provided as the fundamental core of continuing research needed to document population changes. Only through continued integration and collaboration with other research programs (e.g., North Pacific Marine Science Organization, Pacific Marine Environmental Lab, Bering Ecosystem Study, and North Pacific Research Board) will we gain adequate understanding of the processes and interactions between northern fur seals and their ecosystem to effectively manage human activities.

A.8.1. Abundance Estimation

The NMML conducts field investigations on the population status of northern fur seals annually on the Pribilof Islands. Adult male seals have been counted annually since 1909 on the Pribilof Islands, and will continue on an annual basis.

Pup production is considered the most accurate method for monitoring population trends and is estimated by mark-recapture. All rookeries on St. Paul and St. George Islands were shear-sampled in 1990, 1992 and 1994. In 1996 sub-sampling rookeries on St. Paul Island was instituted, but has been discontinued in recent years due to high variance. Towell et al. (in press) reports the decline in northern fur seal pup production on the Pribilof Islands from 1973 to the present. NMML continues biennial estimates of Pribilof pup production and intermittent estimates of pup production on Bogoslof Island.

A.8.2. Basic Life History and Health

The NMML measures the mass and length, and records the sex of pups on St. Paul and St. George Islands concurrent with estimates of pup production. These data serve as indices of health and condition over time. Sex ratios of pups born on both islands are either equal or skewed towards fewer females (Antonelis et al., 1994). St. George pups are typically heavier and longer than those born on St. Paul. However, comparisons of pup mass and length by specific breeding areas on both islands have not indicated consistent trends (latest information in Towell et al., 2005). Baker et al. (1994) reported that larger than average male pups were more likely to survive to age 5 from 1987-1990, suggesting that pup mass and length are useful indicators of health. Spraker et al. (in review) evaluated northern fur seal pup mortality at select St. Paul rookeries.

Biologists collect tissues from dead fur seals found on rookeries and haulouts when practical. These tissues are archived for later analysis and can assist with estimates of age-specific mortality. Fur seals harvested for subsistence purposes are also sampled. Biologists collect teeth and tissues in cooperation with subsistence harvests.

A.8.3. Feeding Ecology

The NMML studied the foraging ecology of 97 adult females on St. Paul and St. George Islands over the 1995 & 1996 breeding seasons (Robson et al., 2004). Robson et al. (2004) defined foraging areas and estimated home ranges of lactating females among breeding sites. Sterling and Ream (2005) described at-sea locations, dive behavior and changes in body mass in juvenile male fur seals from various haul-outs. Goebel (2002) examined adult female reproductive behavior during two years of contrasting oceanography. Analysis of additional lactating female tracking and diving data collected during these studies is being investigated.

A method was derived to improve size estimates of walleye pollock and Atka mackerel (Pleurogrammus monopterygius) consumed by pinnipeds from captive feeding experiments (Tollit et al., 2004). Ream et al. (2005) examined female foraging in the North Pacific Ocean. Gudmundson et al. (in press) analyzed the variability of fish and squid remains in scat and regurgitations. Antonelis et al. (1997) found differences in female fur seal diet among breeding islands, and suggested that the differences were related to the hydrographic structure surrounding each island. Zeppelin et al. (in review) analyzed scats and examined variation in the composition of prey remains among the individual rookeries on the Pribilof Islands.

Kurle and Worthy (2002) used stable nitrogen (δ15N) and carbon (δ13C) isotope analyses of juvenile male fur seal's fur, muscle, blubber, brain, liver, and kidney tissues to examine trophic

level changes over time from the Pribilof Island stocks. Kurle and Worthy (2002) suggest changing isotopic ratios have implications for fur seal foraging ecology and migratory patterns.

A.8.4. Disturbance, Harassment, and Displacement

Insley (1992; 1993) reported aircraft sound pressure levels strong enough to be detected above background levels by northern fur seals, and hypothesized the potential for effects of repeated flights over fur seal breeding and resting areas on St. George Island. Insley (1993) reported that the adherence to previously described flight corridors will minimize the likelihood for negative effects on the behavior, productivity, and survival. Williams (1997) estimated behavioral responses of non-breeding seals lasted for fewer than 10 minutes after the visual or acoustic stimulus from aircraft subsided. Williams (1997) did not detect effects from aircraft overflights on the behavior, productivity, or abundance of breeding northern fur seals on St. George. Ream et al. (1994) suggested the declining trend for fur seal breeding areas on St. George was related to the proximity of roads leading to those breeding areas and the resultant human intrusions. Gentry (1998) speculated that greater numbers of human intrusions into breeding areas could reduce survival. Gentry (1998) reported that most lactating females tolerate being physically moved to an alternate breeding area or island with their young and still maintain the maternal bond within a season. It is not known if there is a seasonal influence on fur seal sensitivity to human intrusions into breeding or resting areas.

A.8.5. Contaminants

Since 1992, the National Marine Mammal Laboratory has collected and archived tissues from northern fur seals on the Pribilof Islands. These tissues are available for analyses to answer various questions about the fate and impacts of organochlorine pollution on local fur seal populations and the implications of consuming subsistence harvested animals. Loughlin et al. (2002) examined organochlorine contamination in blubber and milk from pups, subadult males and adult females. Beckmen et al. (1999) examined the exchange of contaminants from mothers to their pups via milk. Beckmen et al. (2002) examined heavy metal concentrations in fur seal tissues.

A.8.6. Migration and Site Fidelity

Baker et al. (1995) found that natal site fidelity in northern fur seals increased with age. Female northern fur seals exhibited stronger natal site fidelity than males of the same age suggesting site fidelity was related to age at sexual maturity (Baker et al., 1995). The strong site fidelity reported by Baker et al. (1995) does not preclude females from using alternative breeding areas in subsequent seasons or when conditions warrant (Gentry, 1998). The high rate of growth of breeding fur seals on Bogoslof Islands supports the results of Gentry's (1998) translocation experiments. Ragen et al. (1996) studied the early migration of northern fur seal pups from St. Paul. Ream et al. (2005) described the winter migration of adult female northern fur seals into the North Pacific Ocean. The mechanisms and thresholds for changes in breeding site fidelity, emigration and immigration are not understood, but may be linked to any number of factors described in previous parts of this plan.

B. Biological Constraints

Biological constraints refer to the life history and ecological aspects of a species that are poorly understood with respect to how a species interacts within its environment. Effective management depends on a reasonable understanding of a species interaction with its environment and human activities. These constraints increase our uncertainty and confound efforts to effectively implement appropriate management measures. A marine predator with a long life span, delayed reproductive maturity, no individual markings, segregation and philopatry, high density aggregations, and complicated site-specific foraging are the major biological constraints for the Eastern Pacific northern fur seal stock. Clarifying these constraints will be the focus of the remainder of this section.

B.1. Marine predator

Northern fur seals spend a significant portion of their life underwater and a varying portion of their life on land. As a marine predator, northern fur seal foraging cannot be observed directly and must be inferred. The ability to understand northern fur seal ecology is constrained by our ability to track individual fur seals at seas, determine successful foraging and extrapolate success to other segments of the population. The effectiveness of conservation measures, management actions, and studies are complicated by constraints described here and in subsequent sections.

B.2. Long life span

Northern fur seal's life span is about 25-30 and 9-12 years for females and males, respectively. Survival is highly variable and the last estimates were computed during the commercial harvest period. Juvenile fur seals do not return to the Pribilof Islands in direct proportion to their abundance until they are three years old. Very few 2-year-old fur seals return to the Pribilof Islands and even fewer yearlings return. Adults can only be aged into broad categories based on visual characteristics. Recent estimates of northern fur seal survival are lacking. NMFS must estimate fur seal survival to properly evaluate the causes of the current population decline. Juvenile survival has been identified as a significant factor of recent declines requiring further investigation (Swartzman and Haar, 1983; Roppel, 1984; Trites and Larkin, 1989; Trites, 1992). Thus the long life of northern fur seals necessitates long-term studies to estimate age- and sex-specific survival.

B.3. Delayed reproductive maturity

Northern fur seals do not begin breeding until about 3 and 8 years for females and males, respectively. Multiple years of reproductive data collection are required prior to computing early reproductive estimates. A substantial time lag exists between age- and sex- specific reproductive estimates and long-term data collection similar to the long life constraints.

B.4. No individual markings

Northern fur seals do not have any distinguishable markings that can be used to identify individuals from one year to the next. Permanent marking methods of pre-weaned pups and reliable techniques for detection of those marked pups as two- or three-year-olds have not been advanced beyond those used with limited success in the 1980s (Gentry, 1998). Flipper-tagging,

hot and freeze-branding, and implanting electronic tags were all considered at a workshop of pinniped biologists and select tag manufacturers convened by the NMML in September 2005.

B.5. Segregation and philopatry

Northern fur seals are present on land from June through October. The duration of land visits varies for all ages and sexes. Visits to land are intermittent during the summer and abbreviated by marine foraging trips. Trips to marine foraging areas extend across great distances during the breeding season. During the non-breeding season fur seals are pelagic foragers across broad marine areas. Northern fur seals do not visit terrestrial sites during the winter and spring until their return to their summer breeding islands.

Northern fur seals exhibit segregation and fidelity on land (Gentry, 1998) and at sea (Robson et al., 2004; Sterling and Ream, 2004). For example, juvenile and adult male fur seals are generally thought to winter in the Bering Sea and northern Gulf of Alaska while adult females, weaned pups and yearlings are thought to travel further south into the North Pacific Ocean. On land 2 – 6 year old males are predominantly found in resting areas, while adults and pups are found at breeding areas distinct from the resting areas. Thus important environmental and human-related factors might act on one segment of the stock due to age- and sex-segregation. Gentry (1998) summarized the degree of philopatry (fidelity to the birth site) in northern fur seals and the results of translocation experiments. Philopatry may confound interpretation or extrapolation of results from studies sampling discreet breeding areas. Accounting for these differences may be possible if quantitative measures of these differences can be computed and used in study design and analysis. Alternatively, ecological and impact studies may need to reconsider sampling designs as more is learned.

B.6. High density aggregations

Northern fur seal breeding and resting aggregations contain high densities of individuals. The high density aggregations result in incidental harassment and reduced access to seals for study and monitoring. Harassment must be quantified at the individual and population level. Harassment duration, timing and intensity are important to differentiate as the effects of low-level and chronic (e.g., noise, vehicle, and vessel traffic), intensive and intermittent (e.g., round-ups, bull counts, pup counts, other human intrusions), and invasive (e.g., capturing, handling, tagging) activities are going to be detectable and measurable at different scales.

B.7. Complicated site-specific foraging

Food availability has become an important consideration related to the decline of Pribilof fur seals. Technological advances have resulted in reliable estimates of fur seal locations at sea and dive behavior while at those feeding locations. Northern fur seals select prey depending on numerous factors few of which are clearly measured or quantified. Comprehensive data on prey (commercially targeted and non-targeted species) availability and environmental and oceanographic conditions will be required to address interactions between fur seals, their prey, and human activities (e.g., commercial fisheries) accurately.

NMFS has described the primary biological constraints because living marine resource management is often faced with substantial uncertainty in both the ecology and human-interactions. When human activities are thought to negatively influence the health, survival, or

reproduction of a species it is the managers responsibility to examine and evaluate the contribution of human-related and natural effects. Managers subsequently determine how to manage those activities in the appropriate environmental and regulatory context. NMFS intends to reduce the uncertainty by identifying northern fur seal life history parameters that are measurable, sensitive to human interactions and can serve as long-term health, survival or reproductive indices. NMFS must also identify and measure the extent and duration of human interactions to evaluate and attribute the proportion of detected variability to natural and human induced changes.

C. Conservation Measures

NMFS believes implementing conservation measures and continuing ongoing harvest, fisheries, and island development management will reduce human-related northern fur seal mortality. Research is needed to resolve the biological uncertainty and assist in identifying measures most likely to promote the recovery of the Eastern Pacific northern fur seal stock. NMFS will continue to work towards integrating species-based research and project-based monitoring programs into a place-based research and monitoring program as the foundation for applying ecosystem approaches to management. The place-based research and monitoring program will evaluate both the effectiveness of the measures implemented and the general trends of various population parameters and vital rates, and identify additional measures to promote recovery. The redistribution of fur seal abundance at alternative breeding areas and reduction in population abundance on the Pribilofs suggests some factors are acting on a large scale. Identifying what ecological factors have changed for the Pribilof Islands relative to the other populations will be a key aspect to determining the contribution of human-related and environmental processes to the observed changes in abundance.

Often environmental complexity complicates clear interpretation of living marine resource studies. Marine mammal research is no exception, and management actions are implemented and subsequently revised using the available data, analyses, and interpretations. Successful management of many large whale populations occurred as a result of the cessation of commercial harvesting. The cessation of commercial harvesting of Pribilof Island northern fur seals did not achieve similar results and the recent population decline suggests other important factors may be influencing the Eastern Pacific fur seal stock. Developing proactive management actions will optimize funding and promote agency collaborations and partnerships with commercial fishing, oil and gas, and island development interests.

Federal, Tribal, State, international and private entities must work together to ensure that research, management, and recovery efforts are coordinated. Collaborations with commercial fishing organizations will help identify practical research and management opportunities. One of the most productive management actions is to continue and strengthen the relationship and capacity of the Tribal Governments of St. Paul and St. George through the co-management process. Availability of local expertise will assist NMFS to implement various measures identified in the conservation plan. Management and monitoring of fur seal harvests for subsistence purposes are a requirement of current regulations. Alternative harvest management and regulatory structure will be evaluated at regular intervals through the co-management process.

NMFS described numerous conservation measures for the Pribilof Islands and defined some measures related to habitat and subsistence harvests in the Federal regulations. The Federal

regulations (50 CFR 216, subparts F and G) identify the following measures to protect northern fur seals:

- Pribilovians may take fur seals if the harvests are for subsistence uses and not wasteful;
- Harvests on St. Paul and St. George are treated separately; allowed at specific locations during a 6-week period; and target juvenile male seals;
- Access to northern fur seal breeding and resting areas is restricted from 1 June through 15 October;
- Dogs are prohibited on the Pribilof Islands; and
- Research must be coordinated with Federal representatives prior to conducting studies.

NMFS manages northern fur seal research activities under the provisions of the MMPA.

Identifying and quantifying human-related deaths and injuries to northern fur seals will direct conservation measures towards appropriate short-term management actions. At present, fur seal mortality is caused by entanglement, subsistence harvest, poaching, direct fisheries bycatch, and research. None of these human-related sources of mortality are thought to cause the current population declines; however biases associated with some of the available mortality estimates are not adequately characterized and further analyses are needed. Conservation measures implemented in the past have reduced the rate of human-related mortality and serious injury. Reducing high seas drift-net fisheries, implementing MARPOL, implementing fishery observer programs, regulating subsistence harvests, and reviewing federally-permitted activities on the Pribilof Islands are some examples of current conservation measures. In addition a process for reviewing local activities that have the potential for adversely affecting fur seals must be developed and implemented. Continued efforts are needed to quantify and minimize other mortality sources. The biological consequences of modest chronic, intermittent intense, and invasive human harassment of fur seals on and near breeding and resting areas are of growing conservation interest.

NMFS must monitor and quantify the effect of northern fur seal conservation measures. Education and outreach programs need to be continued and improved, and regulations need to be enforced. Identification, monitoring and protection of important fur seal marine and terrestrial habitats beyond those currently identified are also needed. Reducing marine debris is a practical conservation measure that can be immediately employed. Educational outreach targeting the sources of marine debris and actual removal of beachcast marine debris on the Pribilof Islands are the most cost-effective ways to reduce this source of mortality for fur seals.

One of the most significant research needs for the recovery of the Eastern Pacific northern fur seal stock is the development of a method to estimate survival and reproductive rates of the population. The development of demographically-based models accounting for environmental and anthropogenic covariates will be important to direct subsequent research focus towards the segment(s) of the population that are identified as contributing to the current decline. Analysis of archived data and tissues may assist with study design. Estimating population abundance and trends using established methods must continue, and consideration of alternative methods will be assessed as appropriate. Research into fur seal behavior and ecology has provided insight into important factors influencing population size. In order to properly manage human activities it is critical to resolve the contribution of environmental versus human influences on fur seal abundance, survival, reproduction, and behavior. The best way to resolve the contribution of these influences is with hypothesis-driven studies.

D. Conservation Goals and Criteria

The goal of this Conservation Plan is to promote the recovery of the eastern Pacific northern fur seal stock to a non-depleted level. The population level at which NMFS would reconsider the depleted classification is at the lower bound of OSP. For northern fur seals, this is at a sustained population level (total abundance estimate) or a sustained level of pup production of 60 percent of the peak historical estimates (i.e., carrying capacity). This could occur by population growth to the historical ranges of carrying capacity or evidence to suggest that carrying capacity is lower than earlier estimates and human-related effects do not limit the population.

III. CONSERVATION PROGRAM

NMFS believes that the Conservation Plan should be a dynamic document and thus has focused the plan on many short-term actions needed in the next 5 years. As new information is obtained, new actions will be identified and incorporated into the program outlined here. As is the case for all plans, this plan will be reviewed and revised periodically, assessing the success of actions taken to recover the stock and prioritizing new actions as needed. The goal of this Conservation Plan is to promote the recovery of the eastern Pacific northern fur seal stock to a level appropriate to justify removal from MMPA depleted listing. NMFS will focus management using a science-based ecosystem approach to determine how and when to implement and monitor those conservation actions described here.

To the maximum extent possible, future research efforts should collect data that can be compared with historical data. The importance of time-series data is consistent with the local tribal perspective based on long-term observation and interaction with fur seals and the Bering Sea ecosystem, as well as research and policy recommendations made by a broad array of government, academic and non-government organizations (e.g. NRC 1996; Mangel et al. 1996; NMFS 2000; NRC 2003). Studies necessary to calibrate results from newly developed techniques with those obtained by previous techniques should be carefully designed to facilitate future comparison of important ecological parameters for both fur seals (e.g. population trends, fecundity and survival, foraging effort, growth rates, and maternal investment) and the Bering Sea ecosystem. Data analyses should examine trends over time and must evaluate the relationships among observed changes in fur seal parameters with physical, biological and anthropogenic factors known or suspected to influence the parameter of consideration.

Research and monitoring efforts should, as much as possible, be coordinated between multiple locations (St. Paul, St. George, Bogoslof, San Miguel, and the rookeries in Russia when feasible) to investigate regional differences in fur seal population dynamics and the range of responses. Scientists and managers must examine the contribution of oceanography, food resources, and human activities (e.g., harvesting, disturbance, fishing and limits to fishing) in their analyses to understand regional differences in abundance and population parameters.

Enhancing participation by Alaskan Natives and other interested stakeholders is a cost-effective means to facilitate the long-term continuity of some programs. Pribilof Island residents have a

long history of interactions with northern fur seals. Pribilovians have and will continue their involvement in many aspects of fur seal conservation, consumption, management, and research.

Four objectives are proposed which are aimed at restoring and maintaining the Eastern Pacific northern fur seal stock at its OSP level. These objectives are the basis for the following conservation action outline and narrative.

Objective 1. Identify and eliminate or mitigate the cause or causes of human related mortality of the Eastern Pacific stock of northern fur seals,

Objective 2. Assess and avoid or mitigate adverse effects of human related activities on or near the Pribilof Islands and other habitat essential to the survival and recovery of the Eastern Pacific stock of northern fur seals,

Objective 3. Continue and, as necessary, expand research or management programs to monitor trends and detect natural or human-related causes of change in the northern fur seal population and habitats essential to its survival and recovery, and

Objective 4. Coordinate and assess the implementation of the conservation plan, based on implementation of Conservation Actions and completion of high priority studies.

A. Conservation Action Outline

NMFS intends to implement the following conservation actions based on the current understanding of northern fur seal ecology. Many of these actions relate to either interim management of anthropogenic threats or increasing our understanding of northern fur seal ecology and life history to support future management. As new data are collected, analyzed, integrated, and interpreted conservation measures and subsequent actions will change. NMFS will adapt its conservation measures and management consistent with the understanding of northern fur seal's sensitivity various threats described previously. Northern fur seal conservation and management drives the actions below rather than general scientific interest.

Items in this outline are not in order of priority. Priorities are identified in the Implementation Schedule that follows.

Objective 1. Identify and eliminate or mitigate the cause or causes of human related mortality of the Eastern Pacific stock of northern fur seals.

1.1 Improve understanding of the sources, fates, and effects of marine debris

1.1.1 Continue disentanglement program to reduce mortality and harm to fur seals entangled in marine debris

1.1.2 Remove marine debris and incorporate surveys of debris in northern fur seal habitat

1.1.3 Examine the fate of entangling debris

1.1.4 Develop and implement additional statutes, regulations, education and enforcement of marine debris reduction programs

1.1.5 Determine the sources of marine debris

1.2 Improve assessments of incidental take of fur seals in commercial fishing operations

1.2.1 Implement and evaluate fishery and marine mammal observation programs in the North Pacific Ocean and Bering Sea

1.2.2 Review observer and incidental take data

1.3 Evaluate harvests and harvest practices

1.3.1 Monitor and manage subsistence harvests

1.3.2 Develop and implement harvest sampling program

1.3.3 Compile and evaluate existing data

1.3.4 Identify and evaluate illegal harvests

Objective 2. Assess and avoid or mitigate adverse effects of human related activities on or near the Pribilof Islands and other habitat essential to the survival and recovery of the Eastern Pacific stock of northern fur seals.

2.1 Work with the Tribal governments under co-management agreements

2.2 Advise and consult with the relevant action agencies and industries

2.3 Review and make recommendations on proposed activities and actions that have the potential for adversely affecting northern fur seals (e.g. local development, industrial expansion, regulatory actions, research activities, and permitting)

2.4 Conduct studies to quantify effects of human activities (e.g. research, hunting, tourism, vehicles, discharges, facilities) at or near breeding and resting areas

2.5 Undertake conservation or management measures as necessary to eliminate or minimize deleterious impacts to fur seals

2.6 Assess and monitor pollutants

2.6.1 Compile and evaluate existing data

2.6.2 Monitor and study environmental pollutant exposure

2.6.3 Evaluate carcass salvage programs

2.6.4 Develop oil spill response plans and mitigation strategies specific to fur seal breeding and resting areas on the Pribilof Islands and Bogoslof Island

2.7 Quantify relationships between fur seals, fisheries, and fish resources

2.7.1 Study the natural and anthropogenic influences on fur seal feeding ecology

2.7.2 Evaluate pelagic fur seal sampling

2.7.3 Report fishery interactions

2.7.4 Determine impact of fisheries

Objective 3. Continue and, as necessary, expand research or management programs to monitor trends and detect natural or human-related causes of change in the northern fur seal population and habitats essential to its survival and recovery.

3.1 Monitor and study changes in the fur seal population

3.1.1 Analyze fur seal teeth

3.1.2 Continue regular counts of adult males and estimates of pup production on both St. Paul and St. George Islands

3.1.3 Estimate pup survival

3.1.4 Evaluate marking programs

3.1.5 Study vital rates

3.1.6 Evaluate Behavioral/physiological studies

3.1.7 Continue comparative studies on other islands

3.1.8 Conduct appropriate studies to assess the impact of predation (e.g., killer whales, Steller sea lions, sharks) on fur seal populations

3.1.9 Promote joint research and collaborative programs

3.2 Improve assessment of the effects of disease

3.2.1 Compile and evaluate existing data

3.2.2 Determine and mitigate disease effects

3.2.3 Continue management program to prohibit disease transmission to fur seals from introduced species

3.3 Describe and monitor essential fur seal habitats

3.3.1 Compile and evaluate available habitat-use data

3.3.2 Conduct oceanographic and fishery surveys based on pelagic fur seal habitat use

3.4 Identify and evaluate natural ecosystem changes

3.4.1 Reevaluate carrying capacity

3.4.2 Continue and evaluate Pribilof Islands Sentinel Program

3.4.3 Compile and evaluate existing physical environmental data

3.4.4 Select appropriate environmental indices

3.4.5 Quantify environmental effect on behavior and productivity

3.4.6 Ecosystem modeling

Objective 4. Coordinate and assess the implementation of the conservation plan, based on implementation of Conservation Actions and completion of high priority studies.

4.1 Establish conservation plan coordinator position

4.2 Develop and implement education and outreach programs

4.3 Develop and promote international conservation efforts

4.4 Enforce existing regulations

B. Conservation Action Narrative

The conservation action narrative clarifies the outline and summarizes the key elements or justification for the actions. The conservation actions include management, monitoring and

research. Data collected through any research outlined in this plan should be analyzed and reported in a timely manner. Reports should be thoroughly referenced, independently reviewed and be organized to facilitate comparison with existing reports. As much as possible, data should be presented in peer-reviewed periodicals and other open publications to ensure that research programs benefit from regular peer commentary.

To the maximum extent possible, research efforts should collect data that can be compared with historical data. Studies may need to be conducted to calibrate results from newly developed techniques with those obtained by previous methods. Data analysis should examine trends over time and attempt to correlate observed changes with physical, biological, or human-induced changes in the environment.

Analysis should emphasize correlations between regional differences in fur seal population trends with factors such as physical oceanography, food resources, and human activities (e.g., fishing, habitat degradation, harassment). Such correlations can indicate causes of declines which may lead to more effective management.

Objective 1. Identify and eliminate or mitigate the cause or causes of human related mortality of the Eastern Pacific stock of northern fur seals.

Reducing human related mortality of fur seals will provide the most direct positive benefit to the eastern Pacific northern fur seal stock. There are numerous known sources of human related mortality including: subsistence harvests, entanglement in marine debris, illegal harvests, direct bycatch in commercial fisheries, illegal shooting, and research. Some of these sources of mortality are understood, while the extent of others is largely unknown. Quantifying the contribution of these mortality sources will identify appropriate conservation and management actions to implement.

1.1 Improve understanding of the sources, fates, and effects of marine debris

The role of entanglement in mortality of fur seals cannot be fully evaluated without information on the amount of debris in the marine environment and the rates and effects of debris entanglement on fur seals at sea. Information is needed to test the null hypotheses that (1) most entanglement of juveniles does not occur near the Pribilof Islands, and (2) rates of entanglement at sea are not sufficient to cause the population to decline. Ideally, the best time to conduct these studies is in late fall and early spring. However, due to the low probability of encountering seals at sea, and because of poor weather conditions during this time, studies to test these hypotheses will be very difficult to carry out and will be very costly. Nevertheless, it is at this time of year when fur seals are probably the most vulnerable to mortality, and thus a study of this problem is warranted. Improved education and enforcement programs are needed to minimize the impact of debris on fur seal entanglement and subsequent survival. It is worthy to note that NMFS and the Tribal government have conducted disentanglement efforts on the Pribilof Islands for the past decade in an effort to remove debris from animals of all ages and sex. Because of logistical constraints, the primary focus has been disentanglement of immature males seen at the haulout sites, but where possible and authorized entangled pups, adult female, and adult male fur seals are captured and the debris removed.

1.1.1 Continue disentanglement program to reduce mortality and harm to fur seals entangled in marine debris

The disentanglement program on St. Paul Island implemented through collaborative research and the co-

management structure has proven to be a success in reducing fur seal mortality and pain and suffering to entangled fur seals. This program must be continued and expanded to St. George Island when feasible. Comanagement agreements with both tribal governments identify the importance and value of continued and expanded local involvement in fur seal disentanglement programs. From 1995-1997, surveys were conducted in cooperation with the St. Paul Tribal Government and the Traditional Council of St. George during the Pribilof subsistence harvest (e. g. Robson et al., 1997; 1999). Subsequent entanglement studies were conducted in association with the subsistence harvest, and managed by the Tribal Government of St. Paul's Ecosystem Conservation Office with the assistance of the Pribilof Islands Stewardship Program under terms of the co-management agreement between NOAA and the Tribal Government of St. Paul (Stepetin et al., 2000; Zavadil et al., 2003). Funding through the Prescott Stranding Grant Program was obtained by St. Paul in 2003 to continue entanglement studies and expand them to include St. George (Williams et al., 2004). Funding was again received in 2005 from the same source and these data are being collected and verified as this revision is being prepared. Assessment of alternative sampling designs to those used previously will be important to quantify biases and determine appropriate long-term methods to determine trends in entanglement.

1.1.2 Remove marine debris and incorporate surveys of debris in northern fur seal habitat

The amount of debris on beaches and at sea is only partially known. The rate of fur seal entanglement at sea and subsequent death is unknown. Presumably, most entanglements occur in the Bering Sea and near the subarctic boundary (about 40°-46°N) where fur seals and oceanic debris tend to concentrate (cf., Shomura and Yoshida 1985; Ribic and Swartzman 1989). A study to examine the distribution and abundance of debris on shore and at sea relative to juvenile and female fur seals could be carried out at the beginning of the reproductive season (May-June), during the peak of lactation (July-September), and when most females depart the islands (October-November). The Tribal government of St. Paul has coordinated and participated in the removal of 100's of tons of marine debris from fur seal rookeries and adjacent areas on St. Paul during the past 10 years. Any efforts to develop programs will build on those methods developed by Pribilof residents.

1.1.3 Examine the fate of entangling debris

Design and conduct field and laboratory experiments to determine the probable fate (longevity, rates of accumulation, exchange between terrestrial and marine debris, deterioration, and fouling, and movements) of lost and discarded fishing gear and other potentially hazardous debris in and near areas inhabited by fur seals, particularly the juvenile age classes. The fate of different types of marine debris is generally unknown. Entrainment of debris around the Pribilof Islands is of particular concern due to circulation and current patterns.

1.1.4 Develop and implement additional statutes, regulations, education and enforcement of marine debris reduction programs

Federal legislation and enforcement programs have substantially changed the attitudes of commercial fishermen and others regarding their responsibilities to reduce and dispose of marine debris. Reduced rates of entanglement on subadult male fur seals on St. Paul Island may be a result of these changed attitudes since the drop in entanglement rates seems to be a result of reduced entanglement in trawl webbing (Fowler and Ragen 1990). Continued efforts in this area are needed in regards to education programs, enforcement, and regulations to further reduce the amount of marine debris and disposition of hazardous materials in the marine environment.

1.1.5 Determine the sources of marine debris

Substantial marine debris removal projects in the northwest Hawaiian Islands have determined that removal rates may only slightly exceed the rate at which new derelict fishing gear enters nearshore areas and is an unsustainable long-term marine debris solution (Boland and Donohue, 2003). Determining the sources of marine debris and reducing or mitigating the source may be the most effective means of reducing marine debris in fur seal habitat and fur seal entanglement in marine debris.

1.2 Improve assessments of incidental take of fur seals in commercial fishing operations

The impact of incidental take of fur seals in international high seas commercial fisheries is unknown, but could be significant. The take in U.S. domestic fisheries is probably not significant, but should be monitored at regular intervals. Based on pelagic sealing data, and recent observations, juvenile animals may be the most likely age-group caught in fishing gear, especially in illegal drift-net fisheries.

1.2.1 Implement and evaluate fishery and marine mammal observation programs in the North Pacific Ocean and Bering Sea

Implement and evaluate fishery and marine mammal observation programs in the North Pacific Ocean and Bering Sea, and elsewhere to better determine and monitor the level of incidental take and to identify changes in fishing gear or practices that might reduce the direct impacts, if any, of fisheries upon the eastern Pacific northern fur seal stock. Continued monitoring of domestic and foreign fisheries is recommended to identify sources of mortality of fur seals, and seek ways to eliminate the causes. A program with the United States domestic fishing fleet has been ongoing to obtain information on incidental takes within the U.S. Exclusive Economic Zone (EEZ). These programs should be expanded to include biological data gathering to assess the status of marine mammal populations, and especially fur seals, for use in determining the impact of incidental take.

Observers placed on fishing vessels should record fishing effort (e.g., number of sets, size of nets, time and location of sets) and document the number, sex, and age of all fur seals caught. Samples of teeth, stomach contents, blubber thickness, reproductive tracts, blood, and tissues and weight from incidentally caught fur seals would help in assessing the animal's physiological condition, composition of the take compared to the population, and possibly allow for an analysis of stock structure by area. Properly collected samples from fisheries can be of great use in evaluating the role of disease, starvation, and other factors in the at-sea survival of fur seals.

1.2.2 Review observer and incidental take data

Monitoring and reviewing existing and future data collected in the foreign high-seas fisheries and domestic fisheries is essential for assessing the effects, if any, of incidental take. The incidental take of female fur seals is apparently low near the Pribilof Islands, but unknown elsewhere in the North Pacific Ocean and Bering Sea. Needed are data on the number, location, sex, age, and physical and reproductive condition of each seal taken to help estimate the impact on the female component of the stock. The null hypothesis to test is that incidental take does not contribute significantly to the mortality of female fur seals (all ages). Assessing the impacts of

incidental take is both feasible and practical assuming observer data and directed research on fur seal distribution is carried out.

1.3 Evaluate harvests and harvest practices

Assess the possible effects of past and ongoing harvest practices and alter those practices, as determined necessary to facilitate population recovery.

1.3.1 Monitor and manage subsistence harvests

Monitor subsistence harvest and modify or suspend harvesting practices, as determined necessary, to facilitate population recovery. St. Paul and St. George residents can harvest 2000 juvenile male fur seals under the current regulations. The subsistence harvest is witnessed by observers. Observers report on consistency with the humane and non-wasteful provisions of the harvest regulations and consult with NMFS staff and harvest crews during the season. This harvest must be monitored and the level of take analyzed in relation to the expected recovery of the fur seal population.

Heat stress and accidental mortalities of seals must be minimized during harvests and round-ups. Analysis of the humane observer data on St. Paul accumulated since 1986 could provide insight into effective operational criteria and thresholds. NMFS and the harvest crews could develop harvest operation criteria based on correlations between heat stress to air temperature, wind speed, cloud cover, humidity, duration of harvest and other factors recorded by humane observers.

1.3.2 Develop and implement harvest sampling program

Subsistence harvests provide annual opportunities to collect a wide range of tissues from juvenile male seals. Sampling protocols should be developed and implemented to provide long-term collection of tissues useful for a variety of ecological studies. There are several types of information to be collected from harvested seals, each with an inherent source of variation and bias. Development of a sampling program must determine minimum sample sizes for each data type needed to detect trends. Any harvest sampling programs must first consult with harvesters, consider alternatives, and minimize the intrusive nature of sampling resident's food.

Subsistence harvest sampling and necropsy programs can provide data to determine and monitor the levels of environmental contaminants in various organs and tissues (action 1.5). Properly trained staff should participate under the supervision of a qualified veterinarian pathologist.

Whole body weights, canine teeth, and other measures of condition can be collected from a representative sample of the harvest. Annual indices of animal/cohort health could be developed and monitored from an analysis of the age (from the upper canines), weight, and condition data.

1.3.3 Compile and evaluate existing data

Compile and evaluate existing data on population and genetic theory to determine how and to what extent harvest practices may have altered the biological fitness of the eastern Pacific northern fur seal stock.

1.3.4 Identify and evaluate illegal harvests

Assess and quantify the nature and extent of illegal harvest to determine whether these harvests may be influencing the population. Harvests of northern fur seals for subsistence purposes have occurred historically throughout the range of northern fur seals. The extent of illegal and unmonitored harvests of fur seals is not known. Identifying locations of illegal harvests will assist NMFS in evaluating the consequences of those harvests on the population, and facilitate enforcement actions as necessary.

Objective 2. Assess and avoid or mitigate adverse effects of human related activities on or near the Pribilof Islands and other habitat essential to the survival and recovery of the Eastern Pacific stock of northern fur seals.

There are a number of activities such as offshore oil and gas development and harbor development which have probably not caused or contributed to the population decline, but which could further jeopardize or hamper recovery of the Pribilof Islands fur seal population. Plans and proposals for such activities need to be carefully evaluated and revised, as necessary, to avoid or minimize possible adverse effects on fur seals or their habitat. It is also possible that the decreased survival of fur seals is due in part to commercial groundfish fisheries or other fisheries targeting important species in the fur seals' diet; past harvest practices; environmental pollution in one or more parts of the population's range or some combination of these human related factors and natural factors beyond our control. Effort is therefore needed to determine and eliminate or mitigate human related mortality as it contributes to the current population decline.

2.1 Work with the Tribal governments under co-management agreements

The Federal government must continue and strengthen existing cooperative management agreements with tribes and tribally-recognized organizations to further enhance the probability of fur seal recovery and to make optimal use of Alaska Native traditional knowledge and wisdom. Continue work with the Tribal governments to address changes in subsistence use. The existing co-management agreement (Appendices I&II) must be implemented in such a way as to utilize and integrate traditional knowledge, local wisdom and values, and science. NMFS and the tribal governments will establish the best possible management actions for the protection and conservation of fur seals by continued tribal involvement in research, observation, and monitoring efforts. Comanagement agreements have established a process of shared local responsibilities regarding the management and research of fur seals. The co-management process will identify and resolve conflicts that may arise in association with fur seals and provide information to the affected community, as a means of increasing the understanding of the sustainable use, management, and conservation of fur seals.

2.2 Advise and consult with the relevant action agencies and industries

Advise the relevant action agencies and industries to consult with the National Marine Fisheries Service to determine whether proposed, planned, or contemplated actions could harm fur seals or damage habitats essential to their survival and, if so, steps that could be taken to avoid or minimize possible adverse effects. Various action agencies have responsibility for oversight, issuance of permits, etc., regarding activities that may affect fur seals. These agencies include NMFS's Sustainable Fisheries Division which is responsible for oversight of the CDQ Program and related economic development projects in the Pribilofs. The agencies and industries need to consult (but not in the sense of an Endangered Species Act Section 7 consultation) with the National Marine Fisheries Service to determine whether proposed, planned, or contemplated actions could harm fur seals or damage habitats essential to their survival and, if so, steps that could be taken to avoid or minimize possible adverse effects.

The NMFS, Tribal governments, and stakeholders developed a spill response plan (1.5.4) in the event of a petroleum spill on the Pribilof Islands or at Bogoslof Island. Fur seals, like sea otters, are not likely to survive being oiled in an oil spill. Transportation of oil needs to be closely monitored to prevent accidents or to quickly respond to spills. Areas of concern at present are the Aleutians islands, Gulf of Alaska, and along the west coast of Canada and continental U.S. Future areas of concern, related to oil field exploration and development, are Unimak Pass and the St. George Basin.

2.3 Review and make recommendations on proposed activities and actions that have the potential for adversely affecting northern fur seals (e.g. local development, industrial expansion, regulatory actions, research activities, and permitting)

Solicit and review proposed development plans (e.g., OCS exploration and developmental plans), fishery management plans, or any other plans, as needed to determine and recommend measures necessary to avoid or minimize possible adverse effects on fur seals or their habitat.

NMFS, other Federal agencies, and the Tribal governments (through co-management plans) must evaluate construction activities, and coastal/ harbor development plans to determine the possible impact of these activities on fur seals and take appropriate management actions to minimize and mitigate the effects of such activities.

There is concern regarding the development of the Pribilof Islands as a fish processing center. Seafood processing presently occurs on both St. Paul and St. George islands, mainly for crab and halibut. Process wastes are discharged into the nearshore environment. Certain process wastes may contain oils and grease which may compromise the insulative properties of fur seal pelage. High-volume process lines such as bottomfish/surimi may be particularly significant in this respect. While NMFS does not oppose fish processing, we will continue to advocate discharge technologies which minimize pollution and are consistent with the goals of this plan. Any proposed discharges near seal haul outs or rookeries should be prohibited unless it can be demonstrated they would result in no increased threat to seals or their habitat. Recovery of fish oils will be strongly advocated during our review of any EPA permits for these discharges.

NMFS participates in oversight of economic development projects in the Pribilof Islands that must be evaluated to ensure that they are consistent with the goals of this plan. Through the Western Alaska Community Development Quota (CDQ) Program, NMFS authorizes and regulates a fisheries-related economic development program that provides funds for development projects in the Pribilof Islands. The CDQ Program was created by the North Pacific Fishery Management Council in 1992 and mandated by the Magnuson-Stevens Fishery Conservation and Management Act in 1996. It is jointly managed by NMFS and the State of Alaska. Through the CDQ Program, NMFS allocates a portion of groundfish, prohibited species, halibut, and crab quotas in the Bering Sea and Aleutian Islands management area to St. Paul and St. George along with other eligible western Alaska communities. Six non-profit corporations (CDQ groups) represent the eligible communities in applying for allocations, managing the harvest or lease of the allocations, and investing money earned through the allocations in projects that start or support commercial fisheries business activities.

Some of the projects proposed for the Pribilof Islands are small boat harbor construction; vessel repair, maintenance, and storage facilities; and seafood processing plants. The environmental impact of these proposed economic development projects must be assessed by any federal

agency taking an action related to funding, permitting, or authorizing these projects. For example, seafood processing plants often involve action by a number of different federal agencies including the Environmental Protection Agency (discharge permits), the Economic Development Administration (funding), and the Corps of Engineers (permitting for any dredging or filling). NMFS is involved in authorization of CDQ projects through review and approval of the CDQ group's community development plans and specific economic development projects. NMFS is developing a process to coordinate with the CDQ groups and other federal agencies to ensure that the required environmental review and consultations are completed and that any activities supported by NMFS through the CDQ Program also are consistent with the goals of this conservation plan.

2.4 Conduct studies to quantify effects of human activities (e.g. research, hunting, tourism, vehicles, discharges, facilities) at or near breeding and resting areas

Determine and undertake such studies as may be necessary to better predict or detect and to avoid or minimize the possible adverse effects of human activities on the eastern Pacific northern fur seal stock and habitats essential to its survival. NMFS and the Tribal governments must assess the effects of motorized vehicles and other traffic on fur seal behavior, rookery and haulout structure, and seal survival. There is circumstantial evidence that rookeries near observation blinds on St. Paul Island may cause fur seal disruption by vehicle traffic and human presence. These and similar activities should be monitored and modified as appropriate.

The potential vulnerability of fur seals to vessel traffic and oil spills needs to be investigated. A detailed study of the distribution, movements and habitat use of fur seal pups and adult females is recommended by monitoring radio tagged animals after they leave the Pribilof Islands and migrate into the North Pacific Ocean in autumn and winter (see earlier recommendation). The study on pup migration in 1989/1990 (Ragen et al., 1995) should be expanded into spring and include adult females to identify the importance of areas such as off shore lease areas or important Aleutian Island passes where the seals may concentrate.

The importance of disturbance on the survival of pups needs to be studied at various rookeries on the Pribilof Islands. This can be done by comparing the rate of pup production, territory structure, trauma to pups, and changes in total number of animals on various rookeries monitored for varying rates of disturbance.

If disturbance at fur seal rookeries is found to affect the potential survival of fur seal pups, then it may be necessary to institute more restrictive measures regarding human activities, especially after the breeding season. For example, regulations protecting fur seals from disturbance may have to be more strictly enforced.

2.5 Undertake conservation or management measures as necessary to eliminate or minimize deleterious impacts to fur seals

Once effects have been quantified (action 2.4) conservation and management measures can be determined and implemented. NMFS and all interested stakeholders should undertake appropriate conservation or management measures as necessary to eliminate or minimize biologically significant impacts to fur seals. Management designed to provide the continued protection and recovery of the fur seal population should be based on biological principles and ecological understanding. Despite existing information needs, efforts must be taken to reduce human-induced mortality to the lowest level practicable, to protect important habitats, and to

enhance population productivity. Immediate objectives are to be actively involved in the early stages of planning to consider potential effects on fur seals and mitigate those effects prior to implementation.

2.6 Assess and monitor pollutants

Assess, monitor and mitigate the levels of potentially harmful pollutants in fur seal tissue and in the marine ecosystems of which fur seals are a part.

2.6.1 Compile and evaluate existing data

Compile, synthesize, and evaluate the adequacy of existing data concerning the presence, levels, and possible effects of heavy metals, petroleum compounds, PCBs, chlorinated hydrocarbons and other environmental pollutants on northern fur seals. In the eastern North Pacific Ocean, pollutants from many sources have been identified in marine mammals since the 1960s. These primarily include heavy metals and organochlorine compounds. A large amount of literature exists on this subject hence a thorough review would provide perspective on potential effects and specific studies needed. A brief summary of pollution studies has already been undertaken as part of this conservation plan and this work should be built upon with further assessment of past data and an analysis of existing tissues in storage.

2.6.2 Monitor and study environmental pollutant exposure

Design and conduct such laboratory or field studies as may be necessary to fill critical data gaps concerning the possible acute and chronic effects of environmental pollutant exposure levels found in fur seal tissues. The effect of pollutants on the health and status of individual fur seals is equivocal, in most cases. Since high concentrations of some contaminants may be associated with failures in reproductive parameters, periodic biopsies of adult females may be warranted as a long-term tool to assess changes in environmental input. Sources of some pollutants may be identified by sampling and analyzing pollutant burdens in fur seal prey.

After a thorough review of the contaminant literature (action 2.6.1), a study design should be undertaken to determine how frequently, and which tissues to collect for periodic monitoring. Periodic comparisons between samples from harvests (action 1.3.2) and from seals of all ages found dead on the rookeries (action 3.1) may provide insight into effects of environmental pollutant exposure. Also, routine monitoring may be necessary to reduce exposure of Aleuts who subsist on fur seals.

2.6.3 Evaluate carcass salvage programs

Evaluate the usefulness of carcass salvage and necropsy programs to determine and monitor the levels of environmental contaminants in selected tissues. Collection of dead fur seals taken in fisheries and found dead on the shores of the eastern North Pacific Ocean may be of value in determining the cause of death and contaminant burdens. The highest rate of mortality in fur seals occurs during the first year of life. Some studies have shown that organochlorine and PCB levels are highest in juvenile animals, suggesting that a synergistic relationship could exist between pollutant exposure and nutritional stress. Studies of presumably "healthy" seals collected in fisheries and dead animals on the beach may be of some value for comparison of certain tissues, however, careful study design is warranted because of the metabolic changes that take place in moribund animals, and the possible misinterpretation of the levels of contaminants in the animal's system at the time of death.

2.6.4 Develop oil spill response plans and mitigation strategies specific to fur seal breeding and resting areas on the Pribilof Islands and Bogoslof Island

Review oil spill response plans and mitigation strategies specific to the Pribilof Islands and Bogoslof Islands. The Federal government through numerous agencies developed an oil spill contingency plan which has been extant for nearly ten years. This plan must be reviewed and updated as needed to insure its applicability to recent events (tanker grounding and resultant fuel spill in the eastern Aleutian Islands). Additional management efforts must be implemented to insure that all breeding and resting areas on the Pribilof Islands and Bogoslof Island are adequately protected from petroleum-related spills or other toxic substances.

Primary response measures, intended to prevent oil from reaching seals or their habitat, are the most effective and realistic means of protecting and maintaining the Pribilof's northern fur seals. Sorbent materials such as pads and sausage booms are effective when used on refined product spills, such as diesel and gasoline. These devices would be the first line of defense for spills in the St. Paul and St. George boat harbors and in Salt Lagoon on St. Paul Island. Heavier oils such as crude or Bunker C may be picked up with containment booms, oleophilic materials such as pom poms, and natural sorbent materials. A peat moss-based material, Sphag-sorb, was successfully used on a February 1997 oiled fur seal rookery in Uruguay and has now been stockpiled on St. Paul Island.

High-volume, low pressure flushing with ambient temperature water may be the most effective means of oil removal from many Pribilof shorelines. High temperature/high pressure washing is discouraged, as it may change the substrate on a rookery beach and may also alter the ability of a fur seal to locate a rookery using its sense of smell.

The use of chemical shoreline cleaning agents has been shown to be only marginally effective, and introduces additional chemicals and odors onto the rookeries. Therefore, NMFS does not support the use of chemical shoreline cleaning agents on fur seal beaches.

Field activities associated with oil spills have the potential for causing unnecessary and illegal disturbance to fur seals and their habitats. To reduce disturbance and improve the chances for fur seal survival, NMFS will reiterate, through the Federal Aviation Administration (FAA) and Federal On-Scene Coordinator (OSC), the importance of abiding by existing notices to aircraft currently in place for the Pribilofs. Those advisories request pilots to remain at a certain distance from fur seal concentration areas and critical habitats, such as rookeries. Information on aircraft advisories for St. Paul and St. George Islands, respectively, may be found on Environmental Sensitivity Index maps for the islands.

In addition, NMFS will provide, through the Federal OSC, notices to mariners for areas affected by an oil spill. These advisories may request vessel operators to remain at a certain distance from fur seal concentration areas and critical habitats. Copies of any advisories will be sent by the Federal OSC to all federal and state agency and agency-contracted spill-response personnel. A news release will be prepared by NMFS on this subject for distribution by the Federal OSC to appropriate news media representatives. In addition, oiled debris -- particularly contaminated food sources and dead oiled fur seals -- should be removed from the environment as soon as possible to prevent scavenging by other wildlife, which may result in secondary effects due to the ingestion of oil.

Secondary response strategies are intended to prevent an animal from reaching an oiled area. It may be feasible to deter northern fur seals from a particular area in some situations. Spills within the St. Paul Island harbor and Village Cove area may put several hundred northern fur seals at risk, many of which are likely to be pups or juveniles. NMFS personnel or other designated individuals may use acoustic deterrents to prevent these animals from entering oiled areas of the harbors.

Likewise, northern fur seals may be herded by small boats into the outer portions of Village Cove or into Salt Lagoon. It may also be possible to move animals off or to one portion of a beach or rookery to prevent oiling or to clean up oiled shorelines. However, this would not be feasible for territorial animals and would risk separating mother/pup pairs. Because pups in the harbor are not suckling, mother-pup reunions would not be disrupted during any hazing efforts. Only on-site NMFS personnel will be authorized to initiate and direct any deterrent actions in order to avoid driving animals into oiled areas, causing stampedes or displacement into the water, or increasing metabolic stress.

During commercial fishing, it is common for fuel barges to anchor off the coastline of the Pribilof Islands, and for at-sea fuel transfers to occur. The proximity of these barges and fueling activity to fur seal haul outs and rookeries is a significant concern. NMFS will continue to work with the local governments and industry to insure these activities do not predispose fur seals to potential harm.

Finally, tertiary measures were considered; these are actions to capture, clean, and rehabilitate oiled wildlife. The *guidelines* recognize that capture and cleaning of oiled northern fur seals is generally not feasible. Adult northern fur seals are aggressive by nature, particularly territorial males, and typically could not be safely approached while ashore. It is not presently known to what extent an adult fur seal would be affected by oiling, and most efforts to capture are likely to present greater risk to the animal. Tranquilization, for example, may itself cause the death of an animal even when administered by a veterinarian, and would certainly diminish an animal's resistance to the effects of oiling and exposure. In addition, transportation of animals across rough terrain to treatment centers would also be difficult or impossible, and very dangerous to personnel. Finally, many logistical requirements for the treatment of northern fur seals, such as a large heated building, holding pens for large animals, and high-capacity hot water systems, cannot be met at this time on the Pribilofs.

Although fur seal pups could be captured during certain times of the year, such actions would rarely be justified. Seal pups are wholly dependent upon their mother's milk and cannot digest solid food. Pups removed from a rookery for several days may never reunite with their mothers and would likely die of starvation. If pups were transferred off-island for treatment, the mother-pup bond would be lost. During the 1997 T/V *San Jorge* spill in Uruguay, oiled fur seal pups left on site continued to receive attention and be suckled. If northern fur seal pups are oiled, their condition may improve after they molt in September and October.

Past attempts to rehabilitate oiled pinnipeds have been very expensive and not very successful. When time, labor, and resources are limited, captive cleaning and rehabilitation would not only be of dubious value, but could detract from more humane or effective measures such as hazing, booming, and oil recovery. Humane euthanasia under the supervision of a veterinarian should be followed to alleviate suffering for individual animals with no chance of survival.

Finally, should oil exploration or commercial oil development occur in the eastern Bering Sea, developers should be required to have a specific oil spill contingency plan that includes fur seal

response measures for the Aleutian Islands and Alaska Peninsula.

2.7 Quantify relationships between fur seals, fisheries, and fish resources

Improve knowledge of the numerical and functional relationships between fur seals, fisheries, and fish resources in the North Pacific Ocean and Bering Sea, and elsewhere, and institute such measures as may be necessary to avoid or mitigate possible adverse effects. The direct and indirect relationship between fur seal growth and survival and the removal of prey by commercial fisheries and fishery bycatch is not understood. The distribution and abundance of fish resources vary by area, season, and year depending on oceanographic conditions, success of recruitment of different cohorts of fish, and other factors. This variation, in concert with removals by commercial fisheries, need to be studied to understand the complex relationship between fur seal feeding behavior, growth, and survival. While the complexity of the fishery interaction and ecosystem may obscure findings, we must analyze fisheries removals and fur seal presence at similar times and at the appropriate spatial scales in order to evaluate the commercial fishery influence on fur seal food availability. Continuing and refining analyses of concurrent fur seal foraging data, prey availability, fisheries removals, and environmental data will assist in the development of appropriate fisheries management actions as interactions are better understood.

2.7.1 Study the natural and anthropogenic influences on fur seal feeding ecology

Continue studies and oceanographic surveys to identify and characterize fur seal feeding areas in the Bering Sea, Gulf of Alaska, and other areas of the North Pacific Ocean where there may be significant interactions among fur seals, fisheries, and fish resources. Radio or satellite tracking individual seals equipped with dive recorders is recommended to determine the oceanic areas where seals feed, for determining critical feeding habitats. This work is important for understanding the behavior and distribution of seals in relation to data collected over the past 30 years, and to the distribution and potential impacts of commercial fisheries. Radio telemetry was used successfully in 1985 and 1986 to determine the rates and distances fur seals traveled to feeding areas off the Pribilof Islands during the breeding season (Loughlin et al. 1987; Goebel et al. 1991). Other instruments have proven effective in studying diving and foraging strategies (cf., Gentry and Kooyman 1986; Robson et al., 2002; Sterling and Ream 2004; Ream et al., 2005). Expand diet studies to include adult male and juvenile fur seals. These studies should continue and be directed toward the high seas fishing areas and in the North Pacific Ocean and Bering Sea where domestic and international fisheries are active.

2.7.2 Evaluate pelagic fur seal sampling

Evaluate the practicality of sampling fur seals by various methods in selected parts of their range. Study designs can focus on detecting changes in diet (prey size and species composition), in condition, growth rates, pregnancy rates, or other biological variables. Pelagic sampling designs need to incorporate changes in the quantity or quality of available food (prey) resources. Infrequent but dedicated collections of fur seals at sea in areas where they feed may be required to detect changes in diet and provide ecological data related to condition, growth, and reproduction that are important to implementing 2.7.4.

2.7.3 Report fishery interactions

The collection of commercial fishery data occurs through observer programs, log book programs,

and participant reporting systems. The data include species, size, location, date, gear type, and other relevant information that is useful in assessing the possible impact of commercial fisheries on fur seals. These reporting systems should be continued and expanded when necessary, to provide information relevant to the status of exploited fish stocks and the recovery of the fur seal population as important to 2.7.4.

2.7.4 Determine impact of fisheries

Determine and take such action as may be necessary to assure that fisheries are not causing or contributing to the continuing decline of northern fur seals in the Pribilof Islands and, as possible, to avoid or mitigate the possible impacts of commercial fishery on fur seals. This effort should include, measuring effects of fishing on prey (both commercial and non-commercial) composition, distribution, abundance, and schooling behavior, model effects of fishing on prey (both commercial and non-commercial) composition, distribution, abundance, and schooling behavior, evaluating model sensitivity, validity and conformity to known data sets, and evaluate existing fisheries closures and protected areas.

Insufficient or poor quality food resources can make seals vulnerable to diseases, predation, and starvation. Natural changes in the environment or human-related activities that reduce the supply of prey may affect survival. Relevant information regarding the distribution and abundance of fish resources, exploitation of fisheries, and the energetic requirements of fur seals must be analyzed and reviewed to determine the necessary resources for the recovery of the fur seal population. Fishery management plans need to fully incorporate, as necessary, the requirements of fur seals (and other marine mammals).

Objective 3. Continue and, as necessary, expand research or management programs to monitor trends and detect natural or human-related causes of change in the northern fur seal population and habitats essential to its survival and recovery.

The activities described in the previous two sections are intended to address the first and second conservation plan objectives (i.e., reduce human-related mortality and adverse effects). Understanding human-related mortality and adverse effects will provide the basis for managers to determine and eliminate or mitigate the cause(s) of the continuing decline of the Pribilof Islands fur seal population. Both the population and habitats essential to its survival and recovery must be monitored to determine the effectiveness of conservation measures which are instituted and to detect natural variation and the possible unforeseen effects of human activities.

3.1 Monitor and study changes in the fur seal population

Develop and implement a program to effectively detect and monitor changes in the size, productivity, and vital rates of the eastern Pacific northern fur seal stock. A systematic study of the reproductive rates and survival of individually identified adult female fur seals has not been done in sufficient detail to be of use in predicting population recovery. This information is central to understanding some of the mechanisms in population change, and the future reproductive potential of the population. Collection of samples from adult females at sea or those incidentally taken in fisheries operations, and long-term marking and re-sighting study will generate needed information for assessing the important population parameters accounting for population change.

The long-term recovery of the Pribilof population is largely dependent on the recruitment of young females into the reproductive population. Information on recruitment is lacking, however.

NMFS needs to further evaluate and develop long-term marks.

3.1.1 Analyze fur seal teeth

Section and analyze fur seal teeth collected and archived to identify possible changes and trends in fur seal age structure, growth rates, pregnancy rates, longevity, or other variables indicative of the general health and condition of individuals in the population. A study of the differential deposition in the fine growth layers of the canine teeth of females is recommended to evaluate reproduction and feeding behavior. Teeth from males collected in the subsistence harvest would also be used to evaluate food availability based on nursing lines (Baker 1991). If a better seal marking method (e.g., tag) is not developed, then examining teeth of females with known reproductive histories may be an effective alternative to determine age-specific reproductive rates and possibly survival. Also, the technique might be applied to the teeth collected over the past 50 years providing a means of evaluating long-term density dependent changes in the population (cf., Fowler 1981; Baker and Fowler 1991).

3.1.2 Continue regular counts of adult males and estimates of pup production on both St. Paul and St. George Islands

Continue annual counts of adult males and biennial estimates of pup production and health on both St. Paul and St. George Islands to detect and monitor trends in pup production and population size. When practical support concurrent studies of pup production and health in addition to adult male counts on Bogoslof Island. Continuation of estimating the number of pups born and adult male counts is required as the best current index of population trends. These data should be collected on a schedule to provide the best possible database for evaluating recovery of the stock. NMFS should regularly evaluate of the sensitivity of these methods to detect changes and the potential use of alternative methods for population abundance estimation.

3.1.3 Estimate pup survival

Continue regular post breeding season beach surveys to determine the number of pups that die before leaving the pupping islands and the causes of on-land pup mortality on St. Paul, St. George, and Bogoslof (when practical). Continuation of the regular post breeding season beach surveys to determine the number of pups that die before leaving the islands is required to both determine the number of pups born and to monitor the level of pup mortality through time.

Comparison of currently collected condition indices, in addition to weaning weight and blubber thickness of live pups with subsequent survival to age 2 may provide further insight into pup survival. These data should be compared to other rookery islands (action 3.1.7) for study of differential survival.

3.1.4 Evaluate marking programs

Evaluate implementation of fur seal marking programs to detect annual variation and monitor long-term trends in age-specific survival and reproductive success. Approximately 10,000 to 15,000 female pups were tagged on St. Paul Island over from 1987-89 for long-term analysis of survival and recruitment. Those animals are now nearing the end of their reproductive life and have not been adequately monitored through a re-sighting program. To test what effect changes in female survival and reproductive rates have on population recovery, follow up on these animals may be warranted and an expanded tagging and resighting program is necessary. The tags presently used, however, are not easily read from greater than 5 m. A new tag needs to be

tested for durability and readability. A review of the historical tagging data is under way to determine what effect past tagging activities has had on return rates and estimates of pup production.

3.1.5 Study vital rates

A study of the long-term survival and reproduction of individually-identified females is recommended. Once a better tag is tested (action 3.1.4), an expanded tagging and re-sighting program is recommended to obtain an improved estimate of age-specific female survival and reproductive rates. Conduct periodic tissue and scat collection in selected parts of the species range, as may be necessary, to detect and monitor changes and trends in age structure and age specific pregnancy rates. A study of trends in age structure, age specific reproductive rates, prey taken by fur seals during the breeding season and in other parts of the range is recommended. This will require collecting animals at sea, collecting feces on land, lavaging individuals and examining stomach contents of seals taken incidentally in fishing operations, stranded and dead on the rookeries. Long-term collections of data regarding food habits can provide information on yearly changes in prey consumption and possibly energetics. These data may be useful in assessing survival, and whether any changes are taking place in the availability in prey resources within the ecosystem. The number of juvenile male fur seals surviving since the cessation of the commercial harvest in 1985 may have altered population composition.

3.1.6 Evaluate Behavioral/physiological studies

Design and conduct behavioral studies and sampling programs to detect and monitor changes and trends in pup attendance cycles, weaning weight of pups, parasite loads, and other variables that may reflect the general condition and health of the eastern Pacific northern fur seal stock. Long-term behavioral and physiological studies are recommended to assess the current foraging effort of post-parturient females and their ability to transfer energy to their offspring. Harassment effects must be studied to properly incorporate the expected variability in effects of harassment that is low-level and chronic (e.g., noise, vehicle, and vessel traffic), intensive and intermittent (e.g., round-ups, bull counts, pup counts), and invasive (e.g., capturing, handling, tagging). Telemetry instrumentation, remote behavioral sensing devices, and radio isotopic techniques would be employed to provide information needed to estimate the food requirements of the fur seal population. This work would be done in conjunction with growth and survival studies of pups (action 3.1.3) to assess those factors having the greatest influence on year class survival. Also, foraging locations of parturient females and juvenile males need to be defined and compared to earlier studies and coordinated with fishery evaluations (1.3). This study would include an estimate of the food requirements and foraging locations of the male fur seal population.

3.1.7 Continue comparative studies on other islands

Predicting, detecting, understanding and mitigating the factors influencing a particular population may not be practical due to limits on the control of those factors. Experimental manipulation can often lend great insight into understanding the most influential factors for a particular population. Experiments on free-ranging animals are limited by logistical and funding constraints, therefore comparative studies with adequate knowledge of the factors under consideration may provide data necessary to determine those most influential (i.e., biologically important) factors. Continue and expand comparative genetic, diet, and behavioral studies of fur seals on the Commander Islands, Robben Island, Bogoslof Island and San Miguel Island to evaluate population differences with the Pribilof Islands fur seal populations. Also support

collection of concurrent data on environmental conditions to apportion the variation seen in these ecological traits. Comparisons of population growth rates of fur seals on different islands provide a valuable resource for identifying locations where different factors influence population change. Prior to the expiration of Interim Convention on the Conservation of North Pacific Fur Seals in 1984, population assessments of the fur seal colonies in U.S. and Russian waters were compared annually. In the absence of this international agreement, it has been difficult for scientists from the two countries to assess the current status of the world fur seal population and examine the factors which influence regional population changes. A workshop of U.S. and Russian specialists was held to redefine and standardize the techniques used to assess population change (Antonelis 1990). This workshop set priorities on the monitoring programs used to evaluate and compare those factors thought to have the greatest influence on population growth. Such monitoring programs included pup production estimates, bull counts, dietary studies based on scat analysis, estimates of age specific natality rates, and evaluations of early pup growth and survival. The evaluation of stock identification and intermixture from genetic studies was also recommended as a research project worthy of investigation.

The physiological condition of foraging adult female fur seals may be affected by changes in the distribution or abundance of food resources. Information on the distribution and abundance of prey is needed, primarily over the continental shelf and shelf break in the southern Bering Sea and in the eastern North Pacific Ocean from the Gulf of Alaska to California. Simultaneous collection of oceanographic and atmospheric data is essential to understand the factors governing the location of animals at sea, their migratory pathways, their foraging efforts and habits, and the relationships between distribution of seals, physical environment, and prey resources.

3.1.8 Conduct appropriate studies to assess the impact of predation (e.g., killer whales, Steller sea lions, sharks) on fur seal populations

Predation by killer whales, Steller sea lions, and sharks in the Bering Sea and North Pacific Ocean may presently have an affect on fur seal populations. That these predators consume fur seals is not in doubt, but the relative nature and magnitude of the impact of this predation may have changed. Studies need to be designed to determine the overall effect of predation on fur seals and, when feasible, appropriate management measures implemented to reduce or mitigate this impact. Predation of fur seal pups may play an important role in first year pup survival. Pups concentrate around the Pribilof Islands when they first enter the water, and because they are inexperienced, they are likely to be susceptible to predation. Predation on fur seal pups by adult Steller sea lions has been studied only at St. George Island (Gentry and Johnson 1981). A study at St. Paul Island is warranted, particularly to assess predation by killer whales on seal pups.

3.1.9 Promote joint research and collaborative programs

NMFS should foster comparative research between northern fur seals and other Bering Sea and North Pacific marine species. Working jointly with organizations interested in and affected by fur seal research promotes the highest quality results. Collaboration among Tribes, academic institutions, federal agencies, international research organizations, and environmental groups promotes efficient use of resources and expertise as well as utilizing cutting-edge research techniques and information exchange. Collaboration also promotes local capacity-building supportive of research aimed at answering critical local and regional management issues.

3.2 Improve assessment of the effects of disease

A comprehensive study of diseases is recommended. Although many dead pups have been collected annually since 1986 on St. Paul Island to assess the presence of disease, body condition and cause of death, routine collections have not been made of adult fur seals. Future studies should be done throughout the breeding season and expanded to all age-classes to determine the types of pathogens in the population, and their potential effect on population recovery. Blood, and oral and anal smears are needed from a small sample of adult females and their pups each year to assess disease (and contaminant transfer: action 1.5.2) between mother and pup. Samples should come from juvenile males killed during the subsistence harvest, from animals found dead on the beach, from those taken incidentally in fisheries, or possibly from collecting animals directly if no other source is available. Initially, a screening test will be used to determine if a large-scale study is warranted.

3.2.1 Compile and evaluate existing data

Compile and evaluate existing data and theory to determine whether and how diseases may have caused or contributed to the eastern Pacific northern fur seal stock decline. Some pathogens have a history of impacting pinniped populations. *Leptospirosis* killed approximately 15% of the California sea lions (*Zalophus californianus*) passing through Oregon in 1984-85. The San Miguel sea lion virus may also have been important in an increase in miscarriages in California sea lions off California (DeLong et al. 1973). A canine distemper-like virus caused the deaths of 50% of the harbor seal populations in the North Sea in 1987-89 (Osterhaus et al. 1988a, b). No such known major events have occurred in Pribilof fur seals, but a full evaluation of disease conditions over the past decade has not been made.

3.2.2 Determine and mitigate disease effects

Maintain long-term disease monitoring studies and undertake such additional studies or conservation actions as may be necessary to better determine and mitigate the effects of disease. If additional studies indicate that disease is inhibiting the recovery of the fur seal population, additional conservation measures may be necessary to eliminate or mitigate the effects of disease. These measures can not be identified until the disease is known and appropriate actions identified.

3.2.3 Continue management program to prohibit disease transmission to fur seals from introduced species

That fur seals are declining suggests that the population is susceptible to numerous diseases that may exacerbate the decline. Exposure to virulent diseases concurrent with the present decline may have devastating effects. Disease transmitted to fur seals from dogs, rats or other mammalian vectors must be prohibited. NMFS, other Federal agencies, and the Tribal governments must take appropriate and necessary management actions to prohibit exposure of fur seals to these animals and the diseases that they transmit.

3.3 Describe and monitor essential fur seal habitats

Develop and implement a program to effectively detect and monitor possible deleterious changes in habitats essential to the survival and recovery of the eastern Pacific northern fur seal stock.

3.3.1 Compile and evaluate available habitat-use data

Investigate changes in distribution of breeding northern fur seals on the rookeries. Investigate

various surveys and platform of opportunity sighting data to reliably estimate the at-sea density of northern fur seals. Develop and implement a program to effectively detect and monitor possible deleterious changes in habitats essential to the survival and recovery of the eastern Pacific northern fur seal stock.

3.3.2 Conduct oceanographic and fishery surveys based on pelagic fur seal habitat use

Coordinate with actions described in action 1.3.1 (*Study the natural and anthropogenic influences on fur seal feeding ecology)* to determine and conduct such additional oceanographic and fishery surveys or other studies to delineate and characterize areas of special biological importance to the eastern Pacific northern fur seal stock. The physiological condition of foraging adult female fur seals may be affected by changes in the distribution or abundance of food resources. Information on the distribution and abundance of prey is needed, primarily over the continental shelf and shelf break in the southern Bering Sea and in coastal and offshore regions of the North Pacific Ocean. Simultaneous collection of oceanographic and atmospheric data is essential to understand the factors governing the location of animals at sea, their migratory pathways, their foraging efforts and habits, and the relationships between distribution of seals, physical environment, and prey resources.

3.4 Identify and evaluate natural ecosystem changes

Identify and evaluate the likelihood of natural changes in the marine ecosystem accounting for the changes in abundance and distribution of northern fur seals in the eastern Pacific stock.

3.4.1 Reevaluate carrying capacity

The Alaska Scientific Review Group suggests NMFS reevaluate carrying capacity of the Bering Sea for managing threats to northern fur seals. Changes in carrying capacity could alter management actions and recovery criteria depending on the outcome. NMFS needs to evaluate current methods, available data, and the level of certainty required to determine how carrying capacity differs from the current estimates.

3.4.2 Continue and evaluate Pribilof Islands Sentinel Program

Local resident's biological and environmental observations are optimized by the Pribilof Island Sentinel Program. It provides year-round observations of marine mammal abundance and distribution on and around the islands, while identifying environmental anomalies. It has engaged local residents as sentinels promoting the importance of stewardship and responsibility for understanding the Pribilof Islands many life systems in a holistic fashion. The Pribilof Island Sentinel Program is currently a local repository for a significant number of interrelated environmental observations of the Pribilof ecosystem. The value of this program is its integration of observations based on practices of indigenous cultures, with systematic recording of those observations. Standardization of data collection to support comparisons among areas and different times of years is going to be a key element for continuing (and expanding) the Sentinel Program at other locations. Evaluation of the database and the ability of users to generate meaningful summaries and reports is a critical element to its continuation.

3.4.3 Compile and evaluate existing physical environmental data

Numerous organizations compile and archive physical environmental data relevant to

understanding northern fur seal behavior, biology, and abundance. NMFS should compile and evaluate existing oceanographic, climate, and environmental data for the Bering Sea and North Pacific. These data are also relevant to estimates of fur seal prey abundance and other predators in the ecosystem (seabirds and other marine mammals).

3.4.4 Select appropriate environmental indices

Select the most appropriate environmental indices and sampling schedules (based on action 3.4.3), and initiate periodic, long-term sampling programs to detect changes and monitor trends in key components and characteristics of essential fur seal habitats. Early oceanic survival of northern fur seals has been shown to be correlated with near-shore surface temperature in the Gulf of Alaska. Published accounts indicate that the Southern Hemisphere Oscillation Index and the North Eastern Pacific Index (NEPI) of atmospheric pressures are also related to survival of northern fur seals at sea. The North Pacific Ocean has undergone periodic large-scale climate shifts (regime shifts). An analysis of this relationship of these shifts and population indices of northern fur seals is warranted.

3.4.5 Quantify environmental effect on behavior and productivity

In general, it is advisable to determine how abiotic and biotic factors affect fur seals either directly or through their prey. Studies should be started to investigate the effects of environmental conditions and climate on pup survival, health, weaning, and migratory behavior. Studies should be conducted to investigate how these factors influences female foraging behavior, reproduction, and survival. Establishing links between fur seals (and other top predators) and dynamics of prey species is suggested as well as monitoring fur seal food habits and foraging cycles and to compare with ongoing surveys of commercial fish species in the Bering Sea. Surveys should be expanded to include non-commercial marine mammals and seabird prey species (i.e., osmerids, cephalopods).

3.4.6 Ecosystem modeling

Integrating data from fur seals and other species may provide insight into mechanisms of population regulation that are currently not understood. Determine and undertake such studies and ecosystem modeling as may be necessary based on actions 3.4.3, 3.4.5, and others to fill critical data gaps concerning the nature, magnitude, or possible effects of natural changes or long-term trends in the marine ecosystem throughout northern fur seal range.

Objective 4. Coordinate and assess the implementation of the conservation plan, based on implementation of Conservation Actions and completion of high priority studies.

4.1 Establish conservation plan coordinator position

NMFS should support a full-time person to coordinate and as practical implement the conservation actions outlined in this plan. The conservation plan coordinator would be based in the Alaska Regional Office or the Alaska Fisheries Science Center. The coordinator would act as the principal agency personnel on St. Paul and St. George Islands and represent the agency during marine mammal harvest activities. The coordinator would be responsible for determining whether Endangered Species Act Section 7 consultations might have relevance to northern fur seals, and take action as appropriate. The coordinator would annually assess the implementation of the conservation plan.

4.2 Develop and implement education and outreach programs

The plan coordinator must coordinate the education and outreach of the affected public to successfully implementing management actions. Effective education programs foster public support regarding the integrated science-based program being implemented. Communicating the results of research is important, but conveying them in a manner appropriate to the particular audience is the key aspect of educational programs for various stakeholder groups. The coordinator would provide information to regional Fisheries Management Councils, enforcement agencies, state agencies, researchers and other stakeholders of emerging issues.

4.3 Develop and promote international conservation efforts

The United States and Russia share conservation interests of northern fur seals because all known rookeries occur within their territorial waters. Because fur seals move freely across the boundaries separating these and other nations, conservation efforts and research activities put in place by those nations should be closely coordinated. Close coordination of research activities is also desirable to maintain consistency and comparability of data collected across the species range. In this regard, Federal agencies should develop and implement agreements to coordinate conservation and research efforts for northern fur seals with Canada, Russia and Japan. The approved Conservation Plan and implementation schedule should be sent to appropriate agencies and organizations in Canada, Russia and Japan. Management issues that should be considered include adequacy of protective regulations, and mechanisms for allocating allowable take of fur seals between jurisdictions. Joint research programs to examine interchange of animals between areas and to compare biological characteristics and population parameters among regions are needed.

4.4 Enforce existing regulations

In addition to its role in directly protecting animals, enforcement of regulations is an important educational tool. However, the successful enforcement of regulations around the rookeries requires extensive field work and is expensive. If information is gathered that is likely to result in successful conviction of violators of fur seal protective regulations, such cases should be given high priority by appropriate enforcement entities. It is essential that violators are prosecuted in a timely fashion so that the seriousness of regulations and the effectiveness of enforcement are made evident.

IV. IMPLEMENTATION SCHEDULE

The implementation schedule (Table 5) provides a specified listing of the priority, anticipated duration, and regularity of the conservation actions. NMFS has estimated rough costs to implement these conservation actions over the five years subsequent to finalization of the revised conservation plan. NMFS has included annual cost increases for many of the proposed conservation actions and an annual inflation adjustment of 7% to reflect the reality of the marketplace. Actual costs for specific projects will vary from those indicated here.

TABLE 5. NORTHERN FUR SEAL IMPLEMENTATION SCHEDULE

				Est. Fiscal Year Costs					
	Task		Task		(thousands of $)				
Plan Task	Number	Priority	Duration	FY 1	FY 2	FY 3	FY 4	FY 5	Comments
1. Identify/eliminate causes of human-related mortality									
1.1 Marine Debris									
disentanglement	1.1.1	2	Ann.	75	75	75	75	75	
debris removal and surveys	1.1.2	2	Ann.	20	20	20	20	20	
laboratory and field debris studies	1.1.3	3	Tri.		40			40	
statutes, regulations, education, enforcement	1.1.4	2	Ann.[2]	10	10	10	10	10	
Determine marine debris sources	1.1.5	2	Ann.	10	10	10	10	10	
1.2 Monitor incidental take									
observer programs	1.2.1	3	Ann.[2]	20		20		20	
review observer data	1.2.2	2	Ann.[2]	15	10		10		
1.3 Evaluate harvests and harvest practices									
monitor and manage subsistence harvest	1.3.1	1	Ann.	75	50	55	60	65	
Develop & implement harvest sampling program	1.3.2	2	Ann.	15	15	15	15	15	
compile and evaluate existing data	1.3.3	2	1 yr	30					
identify and evaluate illegal harvests	1.3.4	1	Ann.	10	10	10	10	10	
2. Assess and avoid adverse effects of development									
Tribal consultation & Co-management agreements	2.1	1		200	220	245	270	300	
Advise the relevant action agencies and industries	2.2	1	Ann.						existing staff work
Review plans and make recommendations	2.3	1	Ann.						existing staff work & NEPA
Conduct studies to quantify effects	2.4	2	Per.	25	75	50		50	costs depend on development
Undertake conservation or management measures	2.5	2	Ann.	?	?	?	?	?	costs depend on projects

				Est. Fiscal Year Costs					
	Task		Task		(thousands of $)				
Plan Task	Number	Priority	Duration	FY 1	FY 2	FY 3	FY 4	FY 5	Comments
2.6 Assess and monitor pollutants									
compile and evaluate existing data	2.6.1	1	1 yr	20					
evaluate environmental pollutant exposure	2.6.2	2	Per.	50		50			every fifth year
evaluate carcass salvage programs	2.6.3	3	Per.	25				25	every fifth year
oil spill response plans	2.6.4	2	Per.	10		10		10	
2.7 Fur seals/fisheries/resources									
fur seal feeding ecology	2.7.1	1	Ann.	200	220	245	270	300	
evaluate pelagic fur seal sampling	2.7.2	3	Per.[3]		150				every fifth year
report fishery interactions	2.7.3	2	Ann.	20	20	20	20	20	
determine impact of fisheries	2.7.4	1	Per.	100	100	150	200	200	concurrent studies with fisheries
3. Monitor trends and essential habitat									
3.1 Monitor changes in the fur seal population									
analyze fur seal teeth	3.1.1	2	5 yrs	35	25	25	25	25	
monitor male and pup abundance at Pribilof Islands	3.1.2	1	Ann.	85	10	85	10	85	
estimate pup survival	3.1.3	1	Ann.	25	25	25	25	25	
evaluate marking & resighting program	3.1.4	1	5 yrs	100	25	25	25	25	
study vital rates	3.1.5	1	Per.		100	110	120	130	Resighting and retagging annually
behavioral/physiological studies	3.1.6	1	Per.	50	55	60	65	70	
comparative studies on other islands	3.1.7	1	Ann.	150	165	180	200	220	
predation studies	3.1.8	2	Per.	150		150		150	
Promote joint research	3.1.9	2	Ann	15	15	15	15	15	
3.2 Improve assessment of disease effects									
compile and evaluate existing data	3.2.1	2	Per.	20				20	
determine and mitigate disease effects	3.2.2	2	Ann.		25	15	15	15	long-term monitoring

				Est. Fiscal Year Costs					
	Task		Task		(thousands of $)				
Plan Task	Number	Priority	Duration	FY 1	FY 2	FY 3	FY 4	FY 5	Comments
manage introduced species	3.2.3	2	Ann.						Existing staff work
3.3 Monitor essential habitat									
compile and evaluate available habitat use data	3.3.1	1	1 yr	50			50		
conduct oceanographic and fishery surveys	3.3.2	1	Tri.		200			200	
3.4 Identify and evaluate natural ecosystem changes									
Reevaluate carrying capacity	3.4.1	1	1 yr		75			75	
Continue Sentinel program	3.4.2	2	Ann	75	85	95	105	120	
compile and evaluate existing data	3.4.3	1	5 yrs	25	50	25	50	25	
select appropriate environmental indices	3.4.4	2	5 yrs			50	50	50	
physiological/survival studies	3.4.5	2	5 yrs			50	50	50	
ecosystem modeling	3.4.6	2	5 yrs			50	50	50	
4. Implement Plan									
Conservation Plan Coordinator	4.1	1	Ann				50		Update Plan in FY 4
Education & Outreach Programs	4.2	2	Ann	25	25	25	25	25	
International Conservation	4.3	2	Ann	20	15	15	15	20	
Enforce Regulations	4.4	3	Ann	50	50	50	50	50	
Total costs ($K)[4]				1810	1975	2040	1970	2620	
Inflation Adjustment (7% of total)					138	142.8	137.9	183.4	

Priority: 1= highest, 2 = moderate, 3 =lowest
[1] Triennial
[2] Annual Periodic as needed
[3] Periodic as needed

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VI. LIST OF PREPARERS

This Conservation Plan for the Northern Fur Seal relies heavily on the original Plan prepared by the National Marine Mammal Laboratory, Alaska Fisheries Science Center, Seattle, WA, and the Office of Protected Resources, National Marine Fisheries Service, Silver Spring, MD.

Early revisions of this plan were prepared under contracts to LGL Alaska Research Associates, Inc. from the Pribilof Islands communities of St. George and St. Paul islands through their comanagement agreements. Subsequent revisions were made by the National Marine Mammal Laboratory, Alaska Fisheries Science Center, Seattle, WA, and by TRL Wildlife Consulting, Redmond, WA. Final revisions and preparations were made by NOAA Fisheries, Alaska Region, Anchorage, AK.

Appendix A. St. Paul Co-management Agreement

AGREEMENT
BETWEEN THE
ALEUT COMMUNITY OF ST. PAUL ISLAND
AND THE
NATIONAL MARINE FISHERIES SERVICE

I. PARTIES AND SCOPE

This document constitutes an agreement between the National Marine Fisheries Service (NMFS) and The Aleut (Unangan) Community of St. Paul Island, Alaska, otherwise referred to as the Parties.

A. This Agreement covers the species *Callorhinus ursinus* and *Eumetopias jubatus*, referred to as the laaqun (Unangan) or northern fur seal, and the qawan (Unangan) or Steller sea lion, hereafter referred to as fur seal and sea lion, respectively. It encompasses St. Paul Island, Alaska and associated interaction areas (Walrus, Otter Islands and Sea Lion Rock). However, specific actions taken or recommendations made pursuant to this Agreement may be limited to certain regions or sub-areas, as deemed appropriate.

B. NMFS is the congressionally mandated federal agency responsible for the protection, conservation and management of fur seals and sea lions within jurisdiction of the United States of America.

C. The Tribal Government of St. Paul (TGSNP) represents the conservation and co-management interests of fur seal and sea lion hunters and customary/traditional practices of the Aleut Community of St. Paul Island, Alaska.

II. AUTHORITIES

The Parties recognize and acknowledge that:

A. NMFS has the authority to enter into this Agreement with the TGSNP under Section 119 (16 U.S.C. 1388) of the Marine Mammal Protection Act of 1972, as amended (MMPA), and the Endangered Species Act of 1973, as amended (ESA) (16 U.S.C. 1531 et seq.).

B. The TGSNP has the authority to enter into this Agreement according to its constitution and bylaws for the Aleut Community of St. Paul Island.

III. PURPOSE

The TGSNP, representing the interests of the Unangan (Aleuts) of St. Paul Island and NMFS, representing the interests of the citizens of the United States of America, desire to work in partnership for the purpose of:

A. Promoting the conservation and preservation of fur seals and sea lions;

B. Utilizing traditional knowledge, wisdom and values, and conventional science in research, observation, and monitoring efforts to establish the best possible management actions for the protection and conservation of fur seals and sea lions;

C. Establishing a process of shared local responsibilities regarding the management and research of fur seals and sea lions on behalf of the citizens of the United States;

D. Identifying and resolving through a consultative process any management conflicts that may arise in association with fur seals and sea lions; and

E. Providing information to hunters and the affected community, as a means of increasing the understanding of the sustainable use, management, and conservation of fur seals and sea lions.

To achieve these purposes, this Agreement provides for:

1. Cooperation between members of the TGSNP and NMFS in the conservation and management of fur seals and sea lions for the year 2000 and thereafter; and

2. The establishment of a St. Paul Island Co-Management Council under this Agreement.

IV. BACKGROUND

In April 1994, the MMPA was amended to include Section 119 "Marine Mammal Cooperative Agreements in Alaska." Section 119 formalizes the rights of Alaska Native Organizations to participate in conservation-related co-management of subsistence resources and their use. Section 119 also authorized the appropriation of funds to be transferred by NMFS to Alaska Native Organizations to accomplish these activities.

V. GUIDING PRINCIPLES

A. The best way to conserve and provide for stewardship of fur seals and sea lions critical to traditional practices and the Unangan way of life is through a partnership between the TGSNP and NMFS that provides for full participation by the Unangan of St. Paul, through the TGSNP, in decisions affecting the management of marine mammals used for subsistence purposes .

B. As the primary customary/traditional users of the fur seals and sea lions in the Bering Sea Region, the Aleut Community of St. Paul is committed to long term sustainable use of these animals for cultural continuity, food, clothing, arts, and crafts. The rich Unangan tradition and ancestral interaction with fur seals and sea lions provides a unique understanding and knowledge of these animals.

C. Under the MMPA as amended, NMFS is mandated to employ the best conventional science and natural resource management practices available to maintain marine mammal stocks and populations at levels necessary to sustain customary/traditional uses by indigenous peoples of Alaska, including the Unangan of St. Paul.

D. A key to the success of this partnership is to incorporate the spirit and intent of co-management by building trust and by establishing close cooperation and communication between the two Parties. Shared decision making shall be through consensus, based on mutual respect and understanding the cultural perspective of each party.

VI. CO-MANAGEMENT OF FUR SEALS AND SEA LIONS ON ST. PAUL ISLAND, ALASKA

Understanding that the structure, process and responsibilities associated with the successful implementation of this Agreement and effective co-management of fur seals and sea lions on St. Paul must be clearly defined, the Parties agree that:

A. Operational Structure

1. Regarding the need for a cooperative effort to conserve fur seal and sea lion populations and to maintain a sustainable harvest for traditional uses, the Parties agree to establish a St. Paul Island Co-Management Council (hereafter referred to as Council).

2. Upon the effectness of this Agreement, the TGSNP and NMFS shall each

appoint three (3) members to the Council. The members of the Council shall serve at the pleasure of the Party by which they were appointed. The Council shall select co-chairs by consensus. One (1) co-chair shall be a representative of the TGSNP and one (1) a representative of NMFS.

3. The Council shall hold at least two (2) meetings a year and may hold other meetings, as necessary, at the request of either Party. Council meetings shall be held and conducted on St. Paul Island Alaska, unless mutually agreed otherwise. The Co- Chairs shall circulate a draft agenda for comment two (2) weeks prior to each meeting. A quorum of four (4) members is required to conduct a meeting. Decisions of the Council shall be through consensus, based on mutual respect. Meetings of the Council shall be open to the public.

4. The Council shall perform the following actions:

a. Develop annual management plans, monitoring programs, and research programs for St. Paul Island;

b. Review annually the contents, performance and responsibilities in this Agreement;

c. Review and assess progress towards implementation of this Agreement;

d. Identify challenges to achieving the purpose of this Agreement;

e. Recommend solutions to any identified challenges;

f. Identify future courses of action; and

g. Review laws and regulations governing the subsistence take and use of fur seals and sea lions.

B. Cooperative Responsibilities:

Guided by the Council, the TGSNP and NMFS will share the following responsibilities in each of the subject areas identified:

1. Management Plans: Develop local management plans for fur seals, sea lions, and their associated haul-out and rookery areas. The management plans will be reviewed annually. The management plans will include the topics and items deemed appropriate and necessary by the Council such as:

a. Monitoring and Research Programs; Harvest and Rookery

Management; Local Regulations and Enforcement Plans for the protection of fur seals, sea lions and their haulouts or rookeries;

b. Education and Information; Training; Funding; Summary of recent progress and new information;

c. Outline of future goals and activities; Identify information and conservation needs and; and

d. Other items as deemed necessary.

2. Monitoring Programs: To establish consistent year-round rookery and shoreline observations to document and respond to activities on the rookeries that might include, but not be limited to, wildlife behavior, disturbance, oil spills, and other activities as appropriate. The Parties agree to:

a. Develop and implement long term monitoring programs for local fur seal and sea lion populations, associated rookeries and haul out areas to document and respond to any observed changes;

b. Conduct seasonal debris clean-ups and surveys at rookeries and beaches identified by the Council; and

c. Identify the appropriate equipment, facilities, and technical assistance to conduct rookery and beach clean up programs and surveys as necessary.

3. Research Programs: As advised and monitored by the Council, the Parties agree to promote and continue the following specific research efforts:

a. Assessment of population abundance and trends by stock and, as possible, by sub-areas within those stocks using conventional science methods;

b. Assessment of habitat use and seasonal movements (including information on preferred haulout sites, foraging areas, and prey composition);

c. Assessment of sources of mortality and the extent, timing, and location of such mortality; and

d. Assessment of population status (including age structure, vital rates, and indices of physical condition).

4. Disentanglement Program: To reduce the level of entanglement and effect the release of fur seals and sea lions from marine debris, the Parties agree to promote and continue the following efforts and activities :

a. Collection of information regarding date, location, sex, age, age class, debris type, capture attempts, disentanglements, degree of wound, re-sightings, animals sheared, animals with shear marks, scarred animals, and tagged animals and numbers;

b. Calculation of entanglement rates incorporating data from the annual subsistence fur seal harvest including debris type, width, mesh diameter, twine size and other information as appropriate; and

c. Maintenance of existing research and identification of the appropriate equipment, facilities, and technical assistance to conduct the disentanglement program.

5. Local Opportunities for Scientific Research Projects: Recognizing the need for and value of community awareness and involvement regarding the protection and conservation of fur seals and sea lions, the Parties agree to undertake a collaborative effort to accomplish the following:

a. Establish mentoring opportunities for local youth regarding environmental science and natural resource management;

b. Work with the local school district regarding support of and participation in science fairs and special projects regarding environmental education and natural resource management; and

c. Coordinate with local entities and programs to establish employment opportunities regarding environmental science and natural resource management.

6. Maintenance of Fur Seal Rookeries: To improve the condition and ensure continued use of the fur seal rookery and haulout areas, the Parties agree to:

a. Design, construct, and maintain permanent signs for each rookery;

b. Put up road barricades at Reef, Ketovi, and Northeast Point Rookeries as specified by the governing regulations;

c. Identify the appropriate equipment and materials to maintain the rookery catwalks, tripods, signs, and barricades; and

d. Repair and maintain annually, all catwalks and tripods identified by the Council.

7. Co-Managing the Harvest: To improve and advance the viability and sustainability of the subsistence take of fur seals the Parties agree:

a. To support and continue the annual Humane Observer contract for the subsistence fur seal harvest to ensure that the harvest continues to be conducted in a humane manner;

b. To negotiate and establish the beginning date of each annual fur seal harvest, in accordance with current regulations;

c. That the Tribal Ecosystem Conservation Office (ECO) Co-Directors, in consultation with the Harvest Foreman and the NMFS Representative, and in accordance with current regulations, will determine which fur seal rookery to harvest on a daily basis;

d. That the ECO Co-Directors and Harvest Foreman will accept responsibility for ensuring an absolute minimum of heat stressed animals as is possible. Jointly with the Humane Observer and NMFS Representative, they will have the authority to shut down the harvest for that day due to temperature or other factors contributing to heat stress;

e. The ECO Co-Directors and Harvest Foreman will accept responsibility for keeping the number of females taken to the following levels;

(i). When five (5) females have been killed the harvest will stop for a period of two (2) days so that the harvest workers can discuss the reasons why females were harvested and correct problems contributing to the take of females, and

(ii). When eight (8) females have been killed the harvest may be stopped for that season.

f. The ECO Co-Directors and Harvest Foreman will insure the entire harvest operation is done in an efficient manner to avoid or minimize unnecessary injury and mortality, and also that the harvest fields are left litter-free;

g. The ECO Co-Directors will work with NMFS to promote and establish "full utilization" by making every attempt within the law to use all parts of the animals taken at the harvest. All parts means the pelts, teeth, guts,

bacula ("seal sticks"), carcasses and other inedible by-products of the subsistence harvest the Tribe can use within existing laws and regulations to cover harvest and processing costs;

h. The ECO will conduct local surveys of the subsistence take of fur seals and sea lions. The surveys will include:

(i). Number harvested;
(ii). Number struck and/or lost;
(iii). Total take (harvest plus struck and lost);
(iv). Sex of harvested or recovered animals;
(v). Categories harvested or recovered (number of pups, subadults, or adults);
(vi). Designated fur seal haul outs and sea lion hunting sites as determined annually by the Council; and
(vii). The collection of biological samples if deemed necessary by the Council;

8. Providing Education and Information: Recognizing the value of an informed public regarding the protection, conservation and management of fur seals and sea lions, the Parties agree to:

a. Educate and inform subsistence harvest workers in the most appropriate methods for harvesting and processing fur seals;

b. Educate and inform the Aleut Community of St. Paul about the health and status of northern fur seals and sea lion populations on St. Paul Island including factors contributing to the sea lion's decline or increase;

c. Educate and inform St. Paul sea lion hunters in the proper methods for hunting sea lions;

d. Develop a training and internship program to directly involve local people in harvest monitoring, bio-sampling, and research programs;

e. Involve hunters and customary/traditional users in the development of regulatory and management decisions affecting the subsistence use of fur seals and sea lions through representation on the Council; and

f. Designate the TGSNP as the primary local contact for exchange of information regarding fur seals and sea lions.

C. Training

To establish a fair and equitable co-management relationship and a level of practical experience and technical expertise, the Parties agree to:

1. Work in partnership to develop and provide cross cultural information, including understanding of Unangan ways of life, traditional ways of knowing, local concerns and issues regarding fur seal and sea lion use by the Aleut Community of St. Paul (e.g., food, medicinal, handicraft, arts, and spiritual uses), as well as agency policies, legal and administrative constraints, and scientific approaches for managers, researchers and others coming to the island;

2. Obtain appropriate training for local Conservation Officers in Tribal and federal regulations;

3. Provide mentors and research opportunities for local individuals whenever possible; and

4. Share TGSNP/NMFS planning, research, and data collection procedures and provide appropriate training in those procedures.

VII. CONSULTATION

To facilitate the implementation of this Agreement and ensure an equitable working relationship, the Parties agree that:

A. The TGSNP and NMFS shall consult on a routine basis as set forth in this Agreement. In addition, the TGSNP President and NMFS Representative for St. Paul Island shall communicate on an as needed basis concerning matters related to northern fur seals and sea lions; and

B. Should disagreement arise on interpretation of the provisions of this Agreement (or amendments and/or revisions thereto) that cannot be resolved at the operating level, the Parties shall submit written statements regarding the disagreement to the Council. Within thirty (30) days from receipt of the written statements, the Council shall provide copies to each Party and convene a meeting of the Council for the purpose of resolving the disagreement. If disagreement remains unresolved after the thirty day period and absent a mutual agreement by the Parties to extend the time period, the Council shall refer the matter to higher levels of the respective Parties for appropriate action.

VIII. REGULATION AND ENFORCEMENT

To effectively implement this Agreement, the Parties agree that:

A. The TGSNP recognizes the Secretary of Commerce's authority to enforce the provisions of the MMPA, ESA and Fur Seal Act applicable to the subsistence harvest of fur seals and sea lions; and

B. NMFS recognizes the existing Tribal authority to govern and regulate their members and conduct regarding the traditional uses of fur seals and sea lions, and acknowledges tribal authority to conduct the following in cooperation with NMFS:

1. Conduct rookery disturbance monitoring and local enforcement upon closing of the rookeries and to monitor sea lion hunting activities;

2. Conduct access permitting for the fur seal viewing blinds and fur seal harvest;

3. Develop and implement Tribal ordinances governing the hunting of sea lions and harvesting of fur seal and provide NMFS with up to date Tribal ordinances;

4. Develop and implement effective local processes for informing the public regarding applicable Federal and Tribal laws and regulations;

5. Develop and implement cooperative enforcement plans between Federal, local and Tribal authorities; and

6. Review, recommend, and advise on revisions to federal regulations governing fur seals and sea lions.

IX. FUNDING

A. Recognizing that certain costs may be associated with the implementation of this Agreement, both Parties agree that long term funding for sustained co-management and conservation programs is important for the health of fur seals and sea lions. No financial commitment on the part of any Party is required by this Agreement. Any requirement of this Agreement for the obligation or expenditure of funds by NMFS or TGSNP shall be subject to the availability of appropriated funds.

B. The TGSNP and NMFS will assist each other in seeking funding from a variety of sources to support research and management projects of mutual benefit regarding fur seals and sea lions.

C. TGSNP will submit a yearly budget to NMFS to fulfill specific responsibilities stated in this Agreement for each fiscal year the Agreement is in effect.

D. NMFS will review the annual budget and, after consultation with the TGSNP, will assist with the obligation and provision of funding as deemed appropriate under the authorities specified in Section II (A) of this Agreement.

X. OTHER PROVISIONS

A. Nothing in this Agreement is intended or shall be construed to authorize any expansion or change in the respective jurisdiction of Tribal, Federal, or State Governments over fish and wildlife resources, or alter in any respect the existing political or legal status of Alaska Native entities.

B. Except as expressly provided herein, nothing in this Agreement shall restrict or limit any right or privilege of the TGSNP (Unangan Community of St. Paul) with respect to fisheries, customary/traditional uses, or other use of any species.

C. Nothing herein is intended to conflict with current National Oceanic and Atmospheric Administration or NMFS directives. If the terms of this Agreement are inconsistent with existing laws, regulations, or directives of either of the Parties entering into this Agreement, then those portions of this Agreement which are determined to be inconsistent shall be invalid, but the remaining terms and conditions not affected by the inconsistency shall remain in full force and effect. At the first opportunity for revision of this Agreement, all necessary changes will be accomplished by either an amendment to this Agreement or by entering into a new Agreement, whichever is deemed expedient to the interests of both Parties.

D. This Agreement will stand as an official management tool for fur seals and sea lions as identified in Section I (A) of this Agreement.

E. Both Parties shall strive to support a policy of "no surprises" concerning contact with the media on potentially sensitive issues pertaining to northern fur seals and Steller sea lions. Each Party shall endeavor to consult with the other prior to initiating contact with the media on topics contained within this Agreement. Under circumstances in which the media initiates contact with one Party, the contacted Party shall inform the other Party and provide details on the nature of the information communicated. In addition, when a Party is contacted by the media concerning issues relevant to this Agreement, that Party shall provide the other Party's contact information to the media representative and request that the media representative contact the other Party.

F. Whenever possible, all scientists who plan to conduct research on behalf of either Party on or around St. Paul (as defined in Section I of this agreement) are required to advise the Council established herein in a timely manner as to the purpose, goals, and time-frame of the research, data gathering techniques, expected results and possible adverse impacts of the proposed research. The Council shall review this information and upon reaching a consensus, may provide comments and recommendations accordingly.

XI. ADOPTION, DURATION, AND MODIFICATION

A. This Agreement shall take effect upon the latest date of signature of the respective Parties and shall remain in effect until terminated by either of the Parties in accordance with the termination provision of this Agreement.

B. Modification of this agreement may be proposed at any time by either Party and shall become effective upon written approval by both Parties.

C. This Agreement may be terminated by either Party by providing forty-five (45) days prior written Notice of Termination to the other Party. Such Notice shall be addressed to the principal contact for the receiving Party.

XII. SIGNATORIES

In Witness Whereof, the Parties hereto have executed this Agreement to be effective as of the last written date below:

National Marine Fisheries Service

6.13.00

James W. Balsiger Date
Administrator, Alaska Region
National Marine Fisheries Service
U. S. Department of Commerce
P. O. Box 21668
Juneau, Alaska 99801

Aleut Community of St. Paul Island

M. Richard Zacharof

Richard Zacharof Date
President, Tribal Government of St. Paul
P.O. Box 86
St. Paul Island, Alaska 99660

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Appendix B. St. George Co-management Agreement

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NATIONAL MARINE FISHERIES
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CO-MANAGEMENT AGREEMENT BETWEEN THE ALEUT COMMUNITY OF ST. GEORGE ISLAND AND THE NATIONAL MARINE FISHERIES SERVICE

I. PARTIES AND SCOPE

This document constitutes an agreement between the National Marine Fisheries Service and The Aleut (Unangan) Community of St. George Island, Alaska, otherwise referred to as the Parties.

A. This Agreement covers the species *Callorhinus ursinus* and *Eumetopias jubatus*, referred to as the laaqux (Unangan) or northern fur seal, and the qawax (Unangan) or Steller sea lion, hereafter referred to as fur seal and sea lion, respectively; and in addition, the use and management of the structure referred to locally as the old sealing plant. This Agreement encompasses activities and program developed and/or conducted by the parties on and adjacent to St. George Island, Alaska in the geographical and topical areas specified by the Co-management Council established pursuant to this Agreement.

B. The National Marine Fisheries Service (NMFS) is the congressionally mandated federal agency responsible for the protection, conservation and management of fur seals and sea lions within jurisdiction of the United States of America.

C. The St. George Traditional Council (STGTC), organized pursuant to the Indian Reorganization Act of 1934, is the legally recognized tribal organization for the Aleut people of St. George and it represents the conservation and co-management interests of fur seal and sea lion hunters and customary/traditional practices of the Aleut Community of St. George Island, Alaska.

II. AUTHORITIES

The Parties recognize and acknowledge that:

A. NMFS has the authority to enter into this Agreement with the STGTC under Section 119 (16 U.S.C. 1388) of the Marine Mammal Protection Act of 1972, as amended (MMPA), and the Endangered Species Act of 1973, as amended (ESA) (16 U.S.C. 1531 et seq.), and the Department of Commerce Joint Project Authority (15 U.S.C. 1525).

B. The STGTC has the authority to enter into this Agreement according to its constitution and bylaws for the Aleut Community of St. George Island. Additional guidance is provided by Executive Order #13084, May 14, 1998 ("Consultation and Coordination with Indian Tribal Governments"; 63 FR 27655"); Presidential Memorandum, April 29, 1994 ("Government-to-Government Relations with Native American Tribal Governments"; 59 FR No.85).

III. PURPOSE

The STGTC, representing the interests of the Unangan (Aleuts) of St. George Island and NMFS, representing the interests of the citizens of the United States of America, desire to work in partnership for the purpose of:

A. Promoting the conservation and preservation of fur seals and sea lions;

B. Utilizing traditional knowledge, wisdom and values, and the best available science in research, observation, and monitoring efforts to establish the best possible management actions for the protection and conservation of fur seals and sea lions;

C. Establishing a process of shared local responsibilities regarding the management and research of fur seals and sea lions.

D. Identifying and resolving, through a consultative process, any conflicts that may arise in association with the management and conservation of fur seals and sea lions on and adjacent to St. George Island, Alaska.

E. Providing information to hunters and the affected community, as a means for increasing the understanding of sustainable use, management, and conservation of fur seals and sea lions.

F. Establishing a process of shared responsibility for the use, management, operation, and upkeep of the structure locally known as the old sealing plant.

To achieve these purposes, this Agreement provides for:

1. Cooperation between members of the STGTC and NMFS in the conservation and management of fur seals and sea lions for the year 2001 and thereafter, and;

2. The establishment of a St.George Island Co-Management Council under this Agreement.

IV. BACKGROUND

In April 1994, the MMPA was amended to include Section 119 "Marine Mammal Cooperative Agreements in Alaska." Section 119 formalizes the rights of Alaska Native Organizations to participate in conservation-related co-management of subsistence resources and their use. Section 119 also authorized the appropriation of funds to be transferred by NMFS to Alaska Native Organizations to accomplish these activities.

V. GUIDING PRINCIPLES

A. The best way to conserve and provide for stewardship of fur seals and sea lions critical to traditional practices and Unangan way of life, is through a partnership between the STGTC and the federal statutory management authority, which to the maximum extent allowed by law, provides for full participation by Unangan of St. George, through the STGTC, in decisions affecting the management of marine mammals used for subsistence purposes.

B. As the primary customary/traditional users of the fur seals and sea lions on and adjacent to St. George Island, Alaska, the Aleut Community of St. George is committed to long term sustainable use of these animals for cultural continuity, food, clothing, arts, and crafts. The rich Unangan tradition and ancestral interaction with fur seals and sea lions provides a unique understanding and knowledge of these animals.

C. Under the MMPA as amended, NMFS is mandated to employ the best available science and natural resource management practices to maintain marine mammal stocks and populations at levels necessary to sustain customary/traditional uses by Unangan of St. George Island and other indigenous peoples of Alaska.

D. A key to the success of this partnership is to incorporate the spirit and intent of co-management by building trust and by establishing close cooperation and communication between the two Parties. Shared decision making shall be through consensus, based on mutual respect and understanding of each Party's cultural perspectives.

VI. CO-MANAGEMENT OF FUR SEALS AND SEA LIONS ON ST. GEORGE ISLAND, ALASKA

Understanding that the structure, process and responsibilities associated with the

successful implementation of this Agreement and effective co-management of fur seals and sea lions on St. George Island must be clearly defined, the Parties agree that;

A. Operational Structure

1. Regarding the need for a cooperative effort to conserve fur seal and sea lion populations and to maintain a sustainable harvest for traditional uses, the Parties agree to establish a co-management body to be called the St. George Island Co-Management Council (here after referred to as the Co-Management Council).

2. Upon effect of this Agreement, the STGTC and NMFS shall each appoint three (3) members to the Co-Management Council. The members of the Co-Management Council shall serve at the pleasure of the Party by which they were appointed. The Co-Management Council shall select co-chairs by consensus. One (1) co-chair shall be a representative of the STGTC and one (1) a representative of NMFS.

3. The Co-Management Council shall hold at least two (2) meetings a year and may hold other meetings, as necessary, at the request of either Party. Co-Management Council meetings shall be held and conducted on St. George Island Alaska, unless mutually agreed otherwise. The Co- Chairs shall circulate a draft agenda for comment two (2) weeks prior to each meeting. A quorum of four (4) members is required to conduct a meeting. Decisions of the Co-Management Council shall be through consensus, based on mutual respect. Meetings of the Co-Management Council shall be open to the public. The Co-Management Council may also hold executive sessions.

4. The Co-Management Council shall perform the following actions:

   a. Develop annual management plans, monitoring programs, and research programs for St. George Island.

   b. Annually review the contents, performance and responsibilities in this Agreement.

   c. Review and assess progress towards implementation of this Agreement.

   d. Identify challenges to achieving the purpose of this Agreement.

   e. Recommend solutions to any identified challenges.

   f. Identify future courses of action.

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g. Review applicable laws and regulations governing the subsistence take and use of fur seals and sea lions for the purpose of making recommendations for appropriate change to NMFS.

B. Cooperative Responsibilities:

Guided by the Co-Management Council and process, the STGTC and NMFS will share the following responsibilities in each of the subject areas identified:

1. **Management Plans:** Develop local management plans for fur seals, sea lions, and their associated haul-out and rookery areas. Develop a management plan for the sealing plant. The management plans will be reviewed annually. The management plans will include the topics and items deemed appropriate and necessary by the Co-Management Council such as:

a. Monitoring and Research Programs; Harvest and Rookery Management; Local Regulations and Enforcement for the protection of fur seals, sea lions and their haul-outs or rookeries;

b. Education and Information; Training; Funding; Summary of recent progress and new information;

c. Outline of future goals and activities; Identify information and conservation needs;

d. A joint-use agreement for the use of the structure locally known as the old sealing plant for fur seal pelt processing, research, and interpretation and:

e. Other items as deemed necessary.

2. **Monitoring Programs:** To establish consistent year-round rookery and shoreline observations to document and respond to unusual or specific events including wildlife behavior, disturbance, oil spills, etc. the Parties agree to;

a. Develop and implement long term monitoring programs for local fur seal and sea lion populations, associated rookeries and haul out areas to document and respond to any observed changes;

b. Conduct seasonal debris clean-ups and surveys at rookeries and beaches identified by the Co-Management Council; and

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c. Identify the appropriate equipment, facilities, and technical assistance necessary to conduct rookery and beach clean up programs and surveys.

3. **Research Programs:** As directed by the Co-Management Council, the Parties agree to promote and continue the following specific fur seal and sea lion research efforts, including, but not limited to:

a. Assessment of population abundance and trends by stock and, as possible, by sub-areas within those stocks using conventional science methods;

b. Assessment of habitat use and seasonal movements (including information on preferred haul-out sites, foraging areas, and prey composition);

c. Assessment of sources of mortality and the extent, timing, and location of such mortality;

d. Assessment of population status (including age structure, vital rates, and indices of physical condition);

4. **Disentanglement Program:** To reduce the level of entanglement and effect the release of fur seals and sea lions from marine debris, the Parties agree to promote and continue the following efforts and activities:

a. Collection of information regarding date, location, sex, age, age class, debris type, capture attempts, disentanglements, degree of wound, re-sightings, animals sheared, animals with shear marks, scarred animals, and tagged animals and numbers;

b. Calculation of entanglement rates incorporating data from the annual subsistence fur seal harvest including debris type, width, mesh diameter, twine size and other information as appropriate;

c. Maintenance of existing research and identify the appropriate equipment, facilities, and technical assistance to conduct the disentanglement program.

5. **Local Opportunities for Scientific Research Projects:** Recognizing the need for and value of community awareness and involvement regarding the protection

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and conservation of fur seals and sea lions, the Parties agree to undertake a collaborative effort to accomplish the following:

a. Establish mentoring opportunities for local youth regarding environmental science and natural resource management;

b. Work with the local school district regarding support of and participation in science fairs and special projects regarding environmental education and natural resource management;

c. Coordinate with local entities and programs to establish employment opportunities regarding environmental science and natural resource management.

d. Annually meet for the purpose of assessing progress under this section, and to strategically plan new initiatives.

e. Develop such other activities, projects, and/or programs as the parties may agree to undertake from time to time.

6. **Maintenance of Fur Seal Rookeries:** To improve the condition and ensure continued use of the fur seal rookery and haul-out areas by local people and visitors, the Parties agree to:

a. Design, construct, and maintain permanent signs for each rookery.

b. Such other actions as deemed appropriate by the Co-Management Council.

7. **Co-Managing the Harvest:** To improve and advance the viability and sustainability of the subsistence take of fur seals the Parties agree:

a. To negotiate and establish the beginning date of each annual fur seal harvest, in accordance with applicable federal regulations;

b. That the Harvest Foreman and NMFS Representative will, in accordance with applicable federal regulations determine which fur seal rookery subsistence seal harvesting will be conducted on a daily basis;

c. That the Harvest Foreman will accept responsibility to ensure that the number of fur seals experiencing heat stressed is kept to the absolute minimum number as possible. The Harvest Foreman and the NMFS

Representative, will have the authority to shut down the subsistence harvest any day when the temperature or other factors contributing to heat stress;

d. The Harvest Foreman will accept responsibility for keeping the number of females taken to the following levels:

(i). When five (5) females have been killed the subsistence harvest will stop for a period of two (2) days so that the subsistence harvest workers can discuss the reasons why females were harvested and correct problems contributing to the take of females.

(ii). When eight (8) females have been killed the subsistence harvest may be stopped for that season.

e. The Harvest Foreman will insure the entire subsistence harvest operation is done in an efficient manner, and which avoids or minimizes unnecessary injury and mortality to the fur seals and the subsistence harvest workers;

f. The Harvest Foreman will ensure that the subsistence harvesting activities will not result in litter or undue damage to habitat and tundra;

g. The Co-Management Council will work with NMFS to promote and establish "full utilization" of fur seals taken in the subsistence harvest by making every attempt to use, to the maximum extent practical and allowed by law, all parts of the animals taken at the subsistence harvest. In addition to edible parts, the term "all parts" includes the pelts, teeth, guts, bacula ("seal sticks"), carcasses and other inedible by-products of the subsistence harvest which may be legally utilized to cover subsistence seal harvest and processing costs.

h. The Co-Management Council will conduct local surveys of the subsistence take of fur seals and sea lions on an annual basis. The surveys will include:

(i). Number harvested.
(ii). Number struck and/or lost.
(iii). Total take (harvest plus struck and lost).
(iv). Sex of harvested or recovered animals.
(v). Categories harvested or recovered (number of pups, sub-adults, or adults).

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(vi). Designated fur seal haul outs and sea lion hunting sites as determined annually by the Co-Management Council.

(vii). The collection of biological samples if deemed necessary by the Co-Management Council.

i. Identify the appropriate equipment, facilities, and technical assistance necessary to conduct the subsistence fur seal harvest.

8. **Providing Education and Information:** Recognizing the imperative and value of an informed public regarding the protection, conservation and management of fur seals and sea lions, the Parties agree to:

a. Educate and inform subsistence harvest workers as to the most appropriate and best available methods for harvesting and processing fur seals;

b. Educate and inform the Aleut Community of St. George as to the health and status of northern fur seals and sea lion populations on St. George Island including factors contributing to the fur seal's and/or sea lion's decline or increase;

c. Educate and inform St. George Island sea lion hunters in the proper methods for hunting sea lions;

d. Develop a training and internship program to directly involve local people in harvest monitoring, bio-sampling, and research programs;

e. Involve hunters and customary/traditional users in the development of regulatory and management decisions affecting the subsistence use of fur seals and sea lions through representation on the Co-Management Council;

f. Designate the STGTC as the primary local contact for exchange of information regarding fur seals and sea lions.

C. Training

To establish a fair and equitable co-management relationship and an appropriate level of practical experience and technical expertise, the Parties agree to:

1. Work in partnership to develop and provide cross cultural training and information for efforts to increase understanding of Unangan ways of life,

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traditional ways of knowing, local concerns and issues regarding fur seal and sea lion use by the Aleut Community of St. George (i.e. food, medicinal, handicraft, arts, and spiritual uses). In addition, the training will involve orientation on such issues as agency policies, legal and administrative constraints, and scientific approaches;

2. Obtain appropriate training for a local Conservation Officer, especially regarding the identification and proper documentation of Tribal and federal regulations;

3. Provide mentors and research opportunities for local individuals whenever possible;

4. Network and share STGTC/NMFS planning, research, and data collection procedures with the community of St. George and to provide the appropriate training in those procedures.

VII. CONSULTATION

To facilitate the implementation of this Agreement and ensure an equitable working relationship, the Parties agree that:

A. The STGTC and NMFS shall consult on a routine basis as set forth in this Agreement. In addition, the STGTC President and NMFS Representative for St. George Island shall communicate on an "as needed basis" concerning matters related to northern fur seals and sea lions that either Party deems suitable for such consultation.

B. Should disagreement arise on the interpretation of the provisions of this Agreement, or amendments and/or revisions thereto, that cannot be resolved at the operating level, the Parties shall submit written statements regarding the disagreement to the Co-Management Council created herein. Within thirty (30) days from receipt of the written statements, the Co-Management Council shall provide copies to each Party and convene a meeting of the Co-Management Council for the purpose of resolving the disagreement. In the event that the disagreement remains unresolved after the thirty day period and absent a mutual agreement by the Parties to extend the time period, the Co-Management Council shall refer the matter to higher levels of the respective Parties for appropriate action.

VIII. REGULATION AND ENFORCEMENT

To effectively implement this Agreement, the Parties agree that:

A. The STGTC recognizes the Secretary of Commerce's authority to enforce the provisions of the MMPA, ESA and Fur Seal Act applicable to the subsistence harvest of fur seals and sea lions.

B. NMFS recognizes the existing STGTC authority to govern and regulate their own members and their conduct regarding the traditional uses of fur seals and sea lions, and all parties acknowledge the authority of the tribe to conduct the following in cooperation with NMFS:

1. Conduct rookery disturbance monitoring and local enforcement upon closing of the rookeries and to monitor sea lion hunting activities;

2. Conduct access permitting for the fur seal viewing blinds and subsistence fur seal harvest;

3. Develop and implement Tribal ordinances governing the hunting of sea lions and harvesting of fur seal and provide NMFS with up to date Tribal ordinances;

4. Develop and implement an effective local processes for informing the public regarding fur seal and sea lion federal and tribal laws and regulations;

5. Review, recommend, and advise on revisions to federal regulations governing fur seals and sea lions.

IX. FUNDING

Recognizing that certain costs may be associated with the implementation of this Agreement, both Parties agree:

A. That long term funding for sustained co-management and conservation programs is important for the health of fur seals and sea lions. No financial commitment on the part of any Party is required by this Agreement. Any requirement of this Agreement for the obligation or expenditure of funds by NMFS or STGTC for the use of staff or agency resources provided by specific appropriations, shall be subject to the availability of appropriated funds.

B. The STGTC and NMFS will assist each other in seeking funding from a variety of sources to support research and management projects of mutual benefit regarding

fur seals and sea lions, as stated in this Agreement.

C. The STGTC will submit a yearly budget to NMFS to fulfill specific responsibilities stated in this Agreement for each fiscal year the Agreement is in effect.

D. The NMFS will review the annual budget and after consultation with the STGTC, will assist with the obligation and provision of funding as deemed appropriate under the authorities specified in Section II (A) of this Agreement.

X. OTHER PROVISIONS

A. Nothing in this Agreement is intended or shall be construed to authorize any expansion or change in the respective jurisdiction of Tribal, Federal, or State Governments over fish and wildlife resources, or alter in any respect the existing political or legal status of Alaska Native entities.

B. Except as expressly provided herein, nothing in this Agreement shall restrict or limit any right or privilege of the STGTC (Unangan Community of St. George Island) with respect to fisheries, customary/traditional uses, or other use of any species.

C. Nothing herein is intended to conflict with current National Oceanic and Atmospheric Administration or NMFS statutory requirement and mandate. If the terms of this Agreement are inconsistent with existing laws, regulations, or legal mandates of either of the Parties entering into this Agreement, then those portions of this Agreement which are determined to be inconsistent shall be invalid, but the remaining terms and conditions not affected by the inconsistency shall remain in full force and effect. At the first opportunity for revision of this Agreement, all necessary changes will be accomplished by either an amendment to this Agreement or by entering into a new Agreement, whichever is deemed appropriate to the interests of both Parties.

D. This Agreement will stand as an official management tool for fur seals, sea lions and the structure locally know as the old seal plant as identified in Section I (A) of this Agreement.

E. Both Parties shall strive to support a policy of "no surprises" concerning contact with the media on potentially sensitive issues pertaining to northern fur seals and Steller sea lions. Each Party shall endeavor to consult with the other prior to initiating contact with the media on topics

contained within this Agreement. Under circumstances in which the media initiates contact with one Party, the contacted Party shall inform the other Party and provide details on the nature of the information communicated. In addition, when a Party is contacted by the media concerning issues relevant to this Agreement, that Party shall provide the other Party's contact information to the media representative and request that the media representative to contact the other Party.

F. All scientists who plan to conduct research on behalf of either Party on or around St. George Island as defined in Section I of this agreement are required to advise the Co-Management Council established herein in a timely manner as to the purpose, goals, and time frame of the research, data gathering techniques, expected results and possible adverse impacts of the proposed research. The Co-Management Council shall review this information and upon reaching a consensus, may provide comments and recommendations accordingly.

XI. ADOPTION, DURATION, AND MODIFICATION

A. This Agreement shall take effect upon the latest date of signature of the respective Parties and shall remain in effect until terminated by either of the Parties in accordance with the termination provision of this Agreement.

B. Modification of this agreement may be proposed at any time by either Party and shall become effective upon approval by both Parties.

C. This Agreement may be terminated by either Party by providing forty-five (45) days prior written Notice of Termination to the other Party. Such Notice shall be addressed to the principal contact for the receiving Party.

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XII. SIGNATORIES

In Witness Whereof, the Parties hereto have executed this Agreement to be effective as of the last written date below:

National Marine Fisheries Service

7/27/01

for James Balsinger — Date
Administrator, Alaska Region
National Marine Fisheries Service
U. S. Department of Commerce
P. O. Box 21668
Juneau, Alaska 99801

Aleut Community of St. George Island

Boris Merculief — Date
President, St. George Traditional Council
P.O. Box 940
St. George Island, Alaska 99591

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