Steller Sea Lion Research Peer Review:
Behavior/Rookery Studies Workshop,
Seattle, Washington, December 5-7, 1997

Review Panel: Daryl Boness, Don Bowen, Bill Gilmartin, Robert Gisiner, Carolyn Heath (chair) , Katherine Ralls, Don Siniff, Cindy Zabel

Rapporteur Al Didier

1. Introduction

The Steller Sea Lion Recovery Plan was drafted by the Steller Sea Lion Recovery Team in 1990-1991, and approved and published by the National Marine Fisheries Service (NMFS) in December 1992. A key component of the Recovery Plan is an extensive research program intended to elucidate the causes of the current Steller sea lion (SSL), *Eumetopias jubatus*, population decline in Alaska. Since 1992, the U. S. Congress has provided funding for a SSL recovery program. Most of the research conducted under that program has been cooperatively implemented by the NMFS and the Alaska Department of Fish and Game (ADFG). During a meeting of the Steller Sea Lion Recovery Team held February 20-21, 1996, the Team concluded that individual peer review workshops were needed to review research conducted to date, and to identify necessary changes in research program emphasis. This peer review process is considered an essential precursor to a revision of the Recovery Plan.

The Team identified four subject areas to be dealt with in workshops: land-based observational studies of behavior; telemetry studies; physiological studies; and feeding ecology studies. The first of these workshops was held December 5-7, 1997 at the National Marine Mammal Laboratory (NMML), Seattle, Washington to consider behavioral and rookery-based research. Its approach was to bring together a review panel consisting of members of the Recovery Team along with a group of "outside" scientists whose research has focused on species other than Steller sea lions.(Appendix A). These outside reviewers were selected for their expertise in behavioral, conservation, and/or ecology, with the hope that their differing research experiences would offer fresh, objective perspectives on how to recover the Steller sea lion population. Scientists currently or recently involved in SSL investigations were invited to compile and present their data and research results.(Part 2). Several of these studies are ongoing, and the research results must be considered preliminary. Discussions of the research were held both with the researchers and in closed session among the review panel members. Part 3.1 presents the discussions based on research summaries and related topics. The review panel's closed discussion session is summarized in Part 3.2, and their comments and recommendations for behavioral or rookery-based research expected to aid the recovery of Steller sea lions are presented in Part 4.

2. Presentations of Current Research

The following presentations are not intended to represent a complete summary of Steller sea lion research. They are informal overviews or preliminary summaries of recent research, and

as such were part of the information used by the review panel to formulate their recommendations.

John Sease. NMFS National Marine Mammal Laboratory

The United States population of Steller sea lions declined by about 65 percent from almost 200,000 non-pups (adults and juveniles) three decades ago to fewer than 70,000 by 1989 (Fig. 1). Sea lion numbers continued to decline in Alaska as a whole, by about 25 percent from 1989 to 1994 and an additional 7-8 percent from 1994 to 1996. The U.S. population may now number fewer than 50,000 non-pups. It is the western stock that has experienced severe decline while the eastern stock has remained stable and increased during the past decade or so. These population estimates are all based on June aerial surveys, including an estimate for the numbers of animals at sites not surveyed or at sea. The western stock includes an additional 3,000-3,500 animals in the Kuril and Commander Islands, and the Okhotsk Sea, Russia; the eastern stock includes an additional 6,000-7,000 in British Columbia, Canada.

The NMFS and the ADFG conducted an Alaska-wide aerial survey for non-pups in 1996 and the NMFS conducted a limited aerial survey during June 1997 that covered the central and western Gulf of Alaska and the eastern Aleutian Islands. The combined result of these surveys was verification that numbers of non-pups continued to decline in the eastern and central Gulf of Alaska, and in the central Aleutians, whereas numbers have stabilized during recent years in the western Gulf of Alaska and perhaps in the western Aleutians. Numbers of non-pups declined during the last surveys in Southeast Alaska (1994 to 1996) and the eastern Aleutians (1996 to 1997) although both areas had been stable or increasing during the early 1990s. A full, range-wide aerial survey is scheduled for June 1998.

The general discussion during the workshop about trends and status of sea lions in Alaska returned several times to the different population trajectories in different regions, and the changes in those trajectories over time. That is, the decline has not been constant across all regions for the western stock. Declines were observed early and have been severe in the eastern Aleutian Islands, but numbers have been generally increasing there since 1989-90. Declines were observed a decade later in the central Gulf of Alaska but numbers of non-pups appear to be continuing to decline sharply there. The implication here was that the forces acting on the decline possibly have been different in different regions and likely have changed over time.

The factors potentially contributing to the observed population declines include: redistribution-emigration; declining reproductive rates; declining adult survival; declining juvenile survival; predation; commercial harvests; subsistence harvests; incidental takes; shooting; entanglement in marine debris; viral and bacterial diseases; pollution; environmental change; and, fishery interactions - competition for food. Although many may have had significant local effects at some point in time, most do not satisfactorily explain declines across a wide geographical range or over long periods of time.

The proximate cause of the Alaskan population decline appears to be chronically reduced juvenile survival coupled with episodic acute declines in adult survival. This hypothesis is supported by several observations. First, the relative numbers ofjuvenile sea lions at haulouts and rookeries in decline areas appears to have declined. At Marmot Island, in the central Gulf of Alaska, for example, the proportion ofjuvenile sea lions on rookery and haulout beaches during June has dropped from 15-20 percent during the 1970s to five percent or less during the 1990s. Second, observations of branded animals from Marmot Island suggest that survival of juveniles

has been low. Steller sea lions demonstrate strong fidelity to the rookery where they were born. Of 800 pups branded in 1987 and 1988, however, the number returning to the island as sub-adults and adults (5- to 10-year-olds) has been about an order of magnitude lower than might be expected. Finally, population modeling has shown that chronic reduced juvenile survival can explain the observed population declines *more* easily than can changes in other population vital rates, particularly when it is coupled with occasional episodes of acute reduced adult survival.

Much of the existing evidence suggests that food limitation likely is an important factor in sea lion declines. (Environmental change or competition with commercial fisheries certainly could affect food availability, although these relationships are difficult to assess. An environmental regime shift occurred in the North Pacific during the mid-1970s that included changes in the physical oceanographic characteristics of the region. Some changes in the species assemblages in the region were observed to take place at the same time. For example, along the south side of the Alaska Peninsula, a small bay shifted from a community dominated by shrimps, crabs, and herring to one dominated by flatfishes and gadids (cod, and pollock). The biomass of gadids and flatfishes generally has increased during recent years.

The fishery for pollock has become one of the major industries in the Bering Sea and Gulf of Alaska. Pollock has been a major food item for Steller sea lions in the Gulf of Alaska and the Aleutian Islands. Although there is some overlap, sea lions largely feed on pollock that is smaller that the fish targeted by the commercial fishery. But the relationship between the harvest of pollock its effect on sea lions has been difficult to determine; several attempts have been unsuccessful in describing a consistent relationship between amounts of pollock harvested and the population trends of sea lions within a given region. Our inability to detect consistent relationships could be more a function of the quality of available data than the effect commercial fisheries have on sea lions. Juvenile (age-0 and age-1) pollock are an important prey item for juvenile sea lions. The effect of commercial fisheries on the abundance and distribution ofjuvenile pollock also is poorly understood.

Comments, questions, and discussion following Sease's presentation:

- Causes of the initial phases of the decline in a given region are not necessarily the same factors that are at work at present. Similarly, factors that exerted negligible impact in the past (e.g., predation) may be significant now.
- There has been a distinct change in population trend patterns since the mid- to late-1980s. Declines do not appear to be as dramatic now, though this may in part be due to smaller population size. Numbers have stabilized in some areas.
- The diet of SSL in SE Alaska is much more diverse than in the Western Gulf
- It is possibly incorrect to characterize samples from the 1970s as pre-decline. There were a lot of animals present, but the environment may already have changed and conditions might not have been optimal.
- There is a need for studies of animals that may not be visiting breeding sites. Behavioral studies on rookeries may be biased toward animals that are better able to succeed in a stressful situation.

John Sease. NMFS. NMML (summarizing Richard Merrick's behavioral studies)

As part of a graduate research program at Oregon State University, Richard Merrick focused on the behavior of adult female sea lions at three Steller sea lion rookeries: Rogue Reef,

Oregon (1982); Marmot Island, Alaska (1983); and Ugamak Island, Alaska (1985-1986). Merrick investigated three hypotheses: (1) behavior differed among females by reproductive status, (2) behavior differed between rookeries, and (3) behavior differed by time of day. Methods used during the study included building a catalogue of behaviors of adult females and comparing activity budgets, attendance patterns, general movements, etc. Merrick followed focal animals using both natural and dye marks, but also made general observations of the entire rookery. He also described demographics and the general, daily changes as well as the overall seasonal changes in rookery populations and attendance. Merrick's study units were the rookery sections of larger sites (e.g., beach A2 at Ugamak, or Beach 3 at Marmot, not Ugamak Island or Marmot Island as a whole).

In general, the similarities among the three rookeries far outweighed the differences, Merrick's observations were consistent with those made about 15 years earlier by Gentry at Año Nuevo, California, and Sandegren at Fish Island, Alaska. There were some observed differences, however, particularly in the time of day with greatest activity by adult females and the overall degree of activity and aggression between individual animals. Merrick speculated that these differences were related to differences in ambient temperatures, weather, and tide height.

Michael Strick. NMFS National Marine Mammal Laboratory

This study represents the first team back to Marmot Island in the winter since the studies of 1987-88. Its objective was to conduct a pilot study to gain insight into Steller sea lion weaning behavior. The study site at Marmot Island was Beach 32, and the study period was September - December 1996 (NMFS/NMML), and February - March 1997 (ADFG/NPUMMC). The study group consisted of 32 pups tagged on Marmot Island (Beach 4) during July. - Focal scans of the tagged cohort were make every 15 minutes, and their activity was recorded.

The maximum resights of these animals per month on Beach 32 was: September, 13; October, 22 (10 new resights, lost 1); November, 18 (1 new resight, lost 5); and December, 11 (0 new resights, lost 7). In the previous listing, animals considered "lost" were unobserved during the month due to either mortality or emigration. Individual animal results are shown in Table 1.

Comments, questions, and discussion following Strick's presentation:

- Mothers were not tagged during this study -they were spooked off the rookery before the pups were tagged. As a result, it is not known whether the mother of a "lost" pup was also "lost".
- Weaning patterns are variable, and it is not known with certainty when weaning takes place. Some animals 1 to 3 years of age are still seen nursing.
- There are female SSL lactating at all times of the year. Data from the 1970s suggests that weaning may increase in April/May because the percentage of lactating females in the population seems to decrease from 80% to 60%.
- There is a need to determine the effects of stress on lactation, and its possible links to juvenile mortality.
- Is there an impact on the lactation pattern based on the gender of the pup? We do not know. (California sea lions show differences in age of weaning with location and gender.)
- What is the success of a pup if the mother is still nursing a juvenile? Some information suggests that the pup will be smaller. Sometimes the female tries to assist the pup by discouraging the juvenile. However, we lack sufficient data to answer this question.

[Table 1. Resights of tagged SSL on Marmot Island Beach 32, September - December 1996.

Tag Number	Month			
	September	October	November	December
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Total Resights	13	22	18	11

= Sighted during that month

= Sighted during the entire observation period

Boyd Porter, Alaska Department of Fish and Game. and University of British Columbia

The goal of this study was to describe aspects of the winter ecology of Steller sea lions *(Eumetopias jubatus)* from behavioral observations made at a winter haulout between January and April 1996 in Southeast Alaska (Timbered Island, 133° 48' W, 55° 41' 45" N). My major hypotheses were: 1) Mothers suckle male offspring more than female offspring, and spend less time on shore to provide for the higher metabolic needs of males. 2) Mothers with yearlings have higher demands than those with pups and should spend more time nursing and more time at sea foraging. Another important goal was to describe the weaning process.

Mature females and their dependent young (pups age < 1 y and yearlings 1-2 y) predominated on the winter haulout while numbers of mature male and sub-adult males remained low. There was considerable variability in numbers of animals on shore from one day to the next. A Drop-one Stepwise regression showed numbers on shore were correlated with weather and sea conditions. The ranked order of important variables included: wave height, air temperature, wind speed, wind direction, sky cover, barometric pressure, ocean swell, and tide height. Haul-out patterns were negatively correlated with poor weather and rough sea conditions. No diurnal haul-out pattern was detected.

Two measures of maternal investment were made: the time spent suckling by male and female pups and yearlings, and the time adult females spent on land compared to that spent at sea foraging.

Male pup-suckling bouts (X = 37.2 ± 2.8 min. SE, n=12) were not significantly longer than female-suckling bouts (X = 35.9 ± 2.3 min., n=12). However, yearlings suckled significantly longer (X = 44.0 ± 2.8 min. SE, n=5) than pups (X= 36.5 ± 1.8 min., n=24). Males pups spent an average of 33.9% (± 11 SE) of the time they were with their mothers onshore suckling compared to 29.9% (± 4.4) by female offspring, but the difference was not statistically significant, and the proportions did not change during the 3 month study period.

'Average trips to sea by mothers with yearlings lasted 2.3 d (X = 59.7 ± 4.7 h SE, n=6) and were significantly longer than the 1.9 d average trips of mothers with pups (X = 48.0 ± 6.3 h, n=18). Mothers with male pups (< 1 y) were away for an average of 2.2 d (X = 52.5 ± 15.2 h SE, n=12) compared to 1.8 d (X = 43.5 ± 12.6 h, n=12) for those with female pups. Mothers spent an average of 35.2 h (± 7.0) on land with male offspring and 34.5 h (± 6.0) with females before departing on foraging trips. Lactating females (n=30) showed little seasonal variation in trip duration. Shore visits averaged 19.4 h between trips to sea (n=30, SE=0.90, range 11.2-29.2h). Differences in time spent on shore by male and female pups and juveniles were not statistically significant. Lactating females spent an average of 14.2 ± 1.1% SE (n=30) of their time on shore while immature animals spent three times as long (40.2 ±. 2.1%).

Average foraging cycle duration (the sum of time at sea and time at the rookery with offspring) by mature females was 3.0 days and was consistent through the season. Weaning of pups and juveniles was not observed between January and April. Haul-out patterns during the winter were influenced more by disturbance, sea and weather conditions than by diurnal patterns.

Comments, questions, and discussion following Porter's presentation:

- Branded animals were present and attempts were made to mark more, but winter animals proved to be intolerant of disturbance. They showed little site fidelity, and if disturbed

sometimes left for extended periods. Additional marking efforts were terminated early in the study, and identification depended only on presence of animals branded earlier.

- Attendance patterns of females varied widely. Foraging trips ranged from 3 to 200 hours.
- No females at this site nursed both a pup and a juvenile. In the case of females nursing juveniles, it is not known whether a pup died or none was born that year.
- More of these haulout sites need to be examined during both the breeding and non-breeding seasons.
- This or a similar study should be extended into spring to obtain data on weaning.
- Females probably do not allow pups or juveniles other than their own to suckle. This is not known with certainty because females are not marked. However, abandoned pups are not suckled by other females, and other otariids show a low likelihood of fostering other pups.
- Under periods of food stress, nursing could be either longer or shorter. There are arguments both ways. It may depend on the severity of the food stress. It may be more common for females that are nursing juveniles to abort or resorb a fetus, or abandon a newborn.
- How much milk are females producing if they are nutritionally stressed?
- Based on very limited observations, abortions seem more prevalent in populations that are in decline. Qualitative information on California sea lions suggests more abortions during El Niño years.
- Females that abort or lose young pups may possibly not come ashore during the period of some studies.
- More resighting coverage is needed to determine the survival, movements, and behavior of branded animals.
- There needs to be an overall list of the hypotheses of decline that can be tested, and an assessment of how behavior studies are testing them.
- In some studies, more nocturnal observations would be helpful to validate the results of daytime data (e.g., presence of nursing female/juvenile pairs).

Kathryn Chumbley. NMFS National Marine Mammal Laboratory

Marmot Island has been the site of land-based Steller sea lion research since the 1970s. Research conducted on the island included daily counts by age and sex class; hourly counts of age and sex classes; resighting of branded and tagged animals; collecting of scats for food habits data; recording of marine mammal/fishery interactions; and, recording presence of other marine mammals and wildlife. Objectives of the current study were: (a) census Steller sea lions by age group (non-pups, juveniles, and pups) and sex during the breeding season; (b) identify year-to-year trends in numbers and composition of sea lions; (c) describe seasonal and daily occupancy patterns; (d) compare aerial survey counts to ground counts; and (e) identify optimal dates and hours for conducting aerial surveys and pup counts.

The maximum number of non-pups counted from aerial surveys for the entire island ranged from 9,862 in 1976 to 1,091 in 1994; 1102 in 1996 to 781 in 1997. Maximum numbers of non-pups counted from cliffs on Beaches 1-4 ranged from 6,391 in 1979 to 815 in 1994. In 1995, 597 non-pups were counted at Beaches 1-4 and 691 were counted in 1996. In 1997 a maximum 384 non-pups were counted at Beaches 1-4. From 1991-94 weekly non-pup counts from cliff tops on Beach 3Z ranged from 63-217; on Beach 7 from 348-586;

Beaches 5 and 6 were rarely observed with more than 100 non-pups. In 1997, 589 non-pups were counted Beach 7.

Total pup counts (beach counts) for all rookeries ranged from 6,741 pups in 1979 to 804 pups in 1994. From 1991-94 weekly cliff top counts of pups on Beach 32 ranged from 38-128 pups. Counts on Beach 7 ranged from 291-586 pups, and Beaches 5 and 6 were rarely observed with more than 25 pups. In 1995 there were 742 pups counted at all rookeries, and in 1996 there were 824 pups counted. In 1997 a 2 day count observed 363 pups on Beach 4 and 399 pups on Beach 7. Numbers of pups counted from cliff tops declined 10.4% annually from 1979-94. For beach counts the estimated rate of decline was 15.3% from 1979-94.

Numbers of juveniles decreased dramatically at Beach 4 after 1979. From 1987-94 juveniles represented 5% of all non-pups at Beach 4, compared to 1535% in 1979 and 10-15% in 1987.

Adult females accounted for 75-95% of all non-pups on rookery beaches during the breeding season. From 1979-88, there were 15-20 adult females per territorial male at Beaches 3 and 4. This ratio dropped to 5-10 per territorial male at Beach 4 from 1991-94. The number of territorial males generally followed similar pattern to those of adult females and all non-pups. They appeared on the rookery beaches slightly earlier in the season. The peak in abundance was less pronounced and the decline in numbers took place later. No year-to-year trend was apparent in numbers of territorial males.

In 1979 counts of juveniles represented 20-50% of all non-pups, and from 1991-94 they decreased to 5-10% of all non-pups. Pup births began on rookery beaches in mid-to late May, Median pupping dates were 10-13 June at Beach 4 from 1979-94. The ratio of pups per adult female on Beach 4 ranged from 1.2 to 1.8, was consistently lower on Beach 3 at 0.5 to 1.0 and lowest at Beach 2 from 0.2 to 0.4. From 1979-87 the number of pups per territorial male declined from 35 to 10. At Beach 3 peak numbers were approximately 10-15 pups per territorial male during the same period. Cliff counts of non-pups averaged about 16% below the aerial survey counts. The earlier in time that a cliff count was made in advance of the aerial count, the lower the count.

Cliff counts were made on a regular basis from November 1987 to March 1988 in order to follow branded/tagged pup progress and monitor survival. Daily variability was much greater than during the breeding season. The total number of non-pups counted at all beaches ranged from 8 to 756 during 1987-88. The total number of pups from cliff counts for all beaches ranged from 4 to 981 during 1987-88. Numbers of sea lions on beaches appeared to be governed by weather conditions, with the fewest on the beach during stormy weather and high surf.

Redistribution was observed twice from November 1987 to March 1988, with animals moving from Beach 4 to Beach 3Z. On 31 July 1993 substantial redistribution was observed during counts made from a skiff along Marmot Island beaches from Beach 4 to Beach 5. Aerial surveys and opportunistic observations made between March 1993 and December 1994 support the supposition that Beach 32 is a preferred haulout during the fall, winter and early spring.

Through December 1994, 147 (20.1%) individually identifiable sea lions of the 75 1 branded pups were resighted on 202 occasions. Of these, 114 (77.6%) have been resighted once, 19 (12.9 %) have been resighted twice, 9 (6.1%) have been resighted three times, 3 (2.0%) have been resighted four times, and 1 each (0.7%) have been resighted five and six

times. The greatest number of resightings occurred when the animals were about 1 year old. Yearlings accounted for 72 (38.5%) of the 187 individually identifiable resightings where resight date and location were known, and branded sea lions were observed at 23 different locations through 1994. Marmot Island had the greatest number of resightings (56.9%), while Kodiak Archipelago or Sugarloaf Island had 33 resightings (16.2%) and Loretta Island, British Columbia (1,700 km) had the most distant resighting of one tagged female (no brand). Tags from 13 animals that were branded/tagged as pups were recovered from the stomach of a dead killer whale in Prince William Sound, and two animals were killed in gill nets.

The decline in abundance was consistent from the 1970s through 1994 for both non-pups and pups and reflected a trend that was observed from the Gulf of Alaska westward. The decline in abundance was more severe at Marmot Island than in the central Gulf of Alaska as a whole. From 1976-94 the number of non-pups at Marmot Island declined by 88.9% compared with a 76.9% decline at the other 14 trend sites and a 79.1% decline at three other trend rookeries (Sugarloaf, Chirikof, and Chowiet Islands). From 1976-94 estimated annual rates of decline were 12.8% at Marmot Island, 8.8% for the other trend sites, and 8.9% for the other trend rookeries. The number of territorial males appeared to be independent of population size. While the population of adult females decreased, territorial males either had fewer females in their territories or held territories containing no females.

The decline in pup production at Marmot Island was comparable to those observed for pups in the central Gulf of Alaska. From 1979-94 pup numbers declined 88.1% at Marmot Island and 84.4% at Sugarloaf, Chirikof, and Chowiet Islands combined.

Resighting efforts on Marmot Island from November 1987 through March 1988 indicated that there was no significant difference in mortality between branded and unbranded pups. Concerted effort to resight branded/tagged animals has taken place on Marmot Island during the breeding season each year since 1991. Similar effort was made on Sugarloaf Island during the breeding seasons for 1994-95 (by Millete). Juveniles appear to have declined more precipitously than other age groups both in absolute numbers and relative to the numbers to all non-pups. The low return rate of branded sea lions suggests low juvenile survival during recent years. For any given age group and sex, the number of branded animals that have been resighted was an order of magnitude lower than the number expected to be alive, as estimated by age specific survival rates. By 1994, the expected number of resighted (branded) 6 year old females was 140-150 but only 10 of these animals were resighted through 1993-94.

Observations at Marmot Island from 1979-94 suggest that the optimal aerial survey dates are from 12 to 29 June. Survey dates after 9 July are unsatisfactory[1,2]. Dawn to dusk observations at Beach 4 suggest that aerial surveys should be conducted between 1000-1300 hours (ADT) to include 90% of the daily maximum number of animals. The optimal dates for pup counts on Marmot Island were between 29 June and 9 July.

[1] Withrow, D.E. 1982. Using aerial surveys, ground truth methodology, and haul out behavior to census Steller *sea* lions, *Eumetopias jubatus.* M.S. Thesis, University of Washington. Seattle, WA, 102 pp.

[2] Merrick, R.L. 1987. Behavioral and demographic characteristics of northern sea lion rookeries. M.S. Thesis, Oregon State University, Corvallis, OR 124 pp.

Comments, questions, and discussion following Chumbley's presentation:

- Why are there redistributions between beaches? Movements from Beach 4 to Beach 3 may be due to sea state and the exposed conditions at Beach 4. Beach 4 is also subject to landslides, and these may spook animals to other areas.
- There was extensive discussion about a statement suggesting that resightings of 140 to 150 pups were expected and only 10 were seen. Expected numbers were based on life tables. Efforts to resight branded animals have been extensive since 1991, but these efforts have been concentrated at the branding sites and there is not good coverage at broader spatial scales needed to be confident that movement has not occurred. The expected number ofbranded SSL is based on the additional assumptions that SSL show high site fidelity and that branding does not reduce survival probability. Some believe that lack of resighting effort and lower than expected site fidelity could account for the differences between the numbers of animals observed and expected.
- There were questions whether the assumptions of site fidelity are accurate. Females bearing Marmot brands have shown up on Sugarloaf Island and have pupped there. However, there are lots of marked animals and only a few are seen pupping on other rookeries. There appears to be a linkage between the Marmot and Sugarloaf sites that does not exist between other sites.
- There was discussion of the significance of the ratios of SSL pups to adults on haulout sites, and whether these ratios might be a window into local demographics.
- Are there any indications that site fidelity is changing over time with the continued food stress? Is there more movement? These data are not available.

Una Swain. Alaska Department of Fish and Came

Studies at several rookeries and haulouts have investigated haulout use, population composition and pupping chronology, One of these sites is Fish Island. Fish Island is located in the Wooded Islands in the eastern Gulf of Alaska. It is a small island, approximately 500m x 150 m in size, and its shoreline is characterized by boulder-strewn beaches and rocky points. The island has a central plateau which is an ideal base for observation. It was used by SSL as a rookery before the 1964 earthquake, but SSL dependence on the site appears to have lessened after that event. The island is in the area of the SSL population decline. In the 1960s and 1970s it appears to have been used primarily as a haulout, although it has been described as a "rearing rookery" because of the high proportion ofjuveniles. Pup counts during this time numbered less than 50 pup births per year. There is little data available from the 1980s but a pup count in 1993 reported more than 500 animals. The total in 1994 was 305 pups. Pup numbers may have remained low until 1993, although aerial surveys for adults and juveniles from 1989 through 1992 may have not seen the pups. It is not known whether the breeding population has grown by increased reproduction, immigration of younger breeding animals, or both

The objectives of studies at Fish Island are to investigate the demography of the island, to investigate haulout use patterns, and to investigate the behavior and ecology of juvenile sea lions. Methods include composition counts (of the different sex and age classes, including the proportion of nursing juveniles), behavioral observations (both group scans and focal scans), and measurements of environmental factors (tide, temperature, barometric pressure, cloud cover, precipitation, wind, and sea conditions). Some branded animals from other sites are present for behavioral observations, but most identification is based on natural marks.

Numbers of Steller sea lions have been declining steadily at Fish Island. The number of pups counted on Fish Island has also declined since 1993 to approximately 150 in 1997. Females are no longer using the north side of the island to pup, nor the Pinnacle Rocks 0.25 mile away. An investigation of pupping chronology shows no significant difference between the mean pupping dates at Fish Island and Sugarloaf Island in the central Gulf of Alaska, but pupping at Forrester Island in Southeast Alaska occurs approximately 10 days earlier. Based on the literature, there appear to be both genetic and nutritional components to the timing of pupping.[3,4,5,6] Later pupping at Sugarloaf and Fish islands may be indicative of undernutrition.

Composition counts showed the proportion ofjuveniles to adult females to be lower on Forrester and Sugarloaf Islands than at Fish Island. Fish Island is probably used by young sea lions from other areas. A significant proportion of the juveniles were still nursing (0.24 in 1995, and 0.33 in 1996). The mean ratio of subadult males to adult females was higher for Sugarloaf than for Forrester Island. No differences were observed in the ratios ofjuveniles or pups to adult females at the two sites, and the ratio of pups to adult females differed among years at both locations. These data do not indicate reduced juvenile survival or reduced productivity in the Gulf of Alaska, as measured by the proportions of juveniles and pups. Interannual differences in the pup ratios suggest that annual variations may affect female reproductive performances. One of the main conclusions of the population composition analysis is that it appears to have limited value in evaluating SSL population demography between different areas. Limitations and biases of the composition data include: (a) differential use of the haulout areas by different sex and age classes; (b) biases associated with differential sampling of sites; (c) the potential that comparisons to the late-1970s data may be invalid if sub-optimal conditions were already prevalent during that period; and, (d) the small sample sizes limit the power of the analysis.

Behavioral observations have focused on juveniles, especially on weaning. Numerous "triad" observations, where a juvenile is still accompanying a female when she gives birth, suggest the mother will nurse both offspring for one to three days before weaning the juvenile. The proportion of juveniles nursing may indicate prolonged maternal investment to ensure survival of the offspring, and it has been hypothesized that there may be a higher proportion of dependent juveniles in the western stock.

Some information on juveniles sea lion movements in the Gulf of Alaska is available from the 799 pups (362 females, 437 males) that were branded on Forrester Island during 1994-95. There have been 332 resightings to date, representing 194 individuals (102 females, 92 males). The resightings have ranged from Seattle to Jude Island in the Shumagin Islands, and the maximum distance traveled is 941 nautical miles. Males appear to travel further than females (mean distance 191 vs. 137 nautical miles). Eighty percent of the 27 resightings showing movements greater than 500 nautical miles were of males. A large resighting effort for these individuals is planned for 1999-2002 in order to estimate rates of emigration and survival.

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[3] Bickham, J.W., J.C. Patton, and T.R. Loughlin. 1996. High variability for control-region sequences in a marine mammal: Implications for conservation and biogeography of Steller sea lions *(Eumetopias jubatus).* Journal of Mammalogy 77:95-108.

[4] Boyd, I.L. 1984. The relationship between body condition and the timing of implantation in pregnant grey seals *(Halichoerus grypus).* Journal of Zoology (London) 203: 113-123.

[5] Boyd, I.L. 1991. Environmental and physiological factors controlling the reproductive cycles of pinnipeds. Canadian Journal of Zoology 69: 1135-1148.

[6] Boyd, I.L. 1996. Individual variation in the duration of pregnancy and birth date in Antarctic fur seals: the role of environment, age, and sex of fetus. Journal of Mammalogy 77:124-133.

Comments, questions, and discussion following Swain's presentation:

- Are copulation rates about the same from year to year?
- Data on pupping chronology contains no information on age classes of the female SSL. Older females pup earlier in some other pinniped species.
- The late June pupping dates for Western stock SSL are similar to the pupping dates for SSL on Añ0 Nuevo Island and Rogue Reef
- Methods used to collect composition data are unsuitable for comparisons between areas because there are numerous confounding variables that cannot be controlled. However, such data may be useful to compare differences within a single site.
- The proportion of females still nursing juveniles should be examined, not the proportion of juveniles still nursing. The latter is affected by the influx of non-nursing juveniles, and Fish Island is unusual because it has such an influx. However, the former approach may be biased if females use different areas when they have a pup versus a juvenile.
- There is a need to assess whether study sites are representative of the areas or regions being compared, and drop those which are not representative.

Andrew Trites. North Pacific Universities Marine Mammal Research Consortium

Part of the Consortium's program seeks to learn how SSL behavior can be used to assess nutritional stress. It seeks to understand the life history of SSL juveniles, and address such questions as when do they wean. The Consortium works at sites at Timbered Island, Cape St. Elias, and Marmot Island. These sites have similar exposures to the ocean, and can safely accommodate an observer. Methods have been standardized at these sites.

The camp and haulout site at Marmot Island were described. Aspects of the haulout reproduce rookery structure, with adult males holding territory against sub-adult males. The view of a rookery through a recent generation of night vision scope was presented. Bulls, females, and juveniles were identifiable. It is possible that even nursing could be observed at night using the latest equipment. Over the May - August 1997 summer season, the number of adult females declined from approximately 70 to approximately 10, while the number of juveniles remained relatively constant between 107 and 142. Matings occurred at the haulout during the summer season, and 1 to 8 copulations by the 9 identified bulls were observed. The only births observed consisted of 4 stillboms. The population at the haulout included 36 branded juveniles from Forrester Island.

Comments, questions, and discussion following Trites' presentation:

- When is does weaning occur? It could be occurring during the spring-summer period following the work of Porter.
- There is a need to evaluate the importance of areas that are not rookeries, such as haulouts.
- How is it possible to evaluate sites versus demography when only 2 sites are examined? It is not possible. There is no replication. Much of the current work must therefore be considered exploratory.
- The presence of big males in the summer provides stability to the haulout social structure. When males are present, females appear to return more readily if disturbed. The females may be less susceptible to disturbance stress at this time.

Kathryn Ono. University of New England

Summaries of three Steller sea lions studies were presented, including: (1) a long-term look at population change on Año Nuevo Island; (2) the effects of human disturbance on Año Nuevo Island; and (3) a comparative behavioral study between Año Nuevo Island, and Lowrie Island and Marmot Island in Alaska.

Census studies at Año Nuevo Island, CA., conducted in conjunction with B. LeBoeuf and J. Reiter, examine the dynamics of a declining SSL population. To evaluate the reproductive rate of females, researchers note which females have pups of the year, yearlings, both, or neither. A regular census taken on Año Nuevo Island documents presence of all pinniped species over time. Harbor seals, California sea lions, and elephant seals all share the island. There is no correlation between the daily numbers of California sea lions and SSL, but there is a positive correlation with numbers of Elephant seals. The maximum number of SSL haulouts is positively correlated with time of day, low tide, and moderate temperatures. The numbers of all other pinniped species on the island are increasing, and only SSL are declining. There have been no relationships demonstrated between the annual numbers of SSL and the numbers of harbor seals or California sea lions, or the yearly numbers of elephant seals. There has been little marking of SSL on Año Nuevo Island because the numbers are so low and accessibility is difficult.

As the SSL population on Año Nuevo Island has declined, the breeding area has collapsed in an orderly pattern. There has been an 80% decline in the numbers of females and pups, which seems to have started in the 1960s. The numbers of males declined 84%, but recently leveled and have begun to increase. The proportions of males, females, and pups on the beach have not changed over time, and neither has the proportion of females with pups.

There are several possible causes of the SSL decline on Año Nuevo Island. Changes in prey abundance are difficult to assess, since there have been few studies on the feeding habits of SSL in this area and scats are hard to collect on offshore rocks without causing a major disturbance. A decline in immigration from Alaska or an increase in emigration to Alaska is unlikely, although the Año Nuevo population is genetically similar to the Southeast Alaska population. Interaction or competition with other pinniped species could occur over food or through disease. Increases in sea temperature (El Niño or global warming) are also a possibility. Finally, it is possible that an increase in human traffic and disturbance is responsible.

Human disturbance has-been monitored for the years 1992-1996, comes in the form of aircraft or watercraft. Boats are approximately twice as common as a source of disturbance than other craft. Female SSL react significantly more to aircraft than to boats. Pups react to very little, and all other animals (this category includes primarily territorial males) react more to watercraft than to aircraft. The most common reactions are to lift the head, move from rest to upright position, and to orient toward the vessel. Animals were less likely to change behavior, move toward the water, or enter the water.

Studies begun in 1993 have attempted to compare SSL populations at three island sites: Año Nuevo, Marmot, and For-rester. The objective has been to determine if differences in the physical environment have contributed to the decline, and whether there is any indication of a diminished prey base for lactating females during the breeding season Physical parameters measured during the first year include air temperature, substrate temperature, sky condition, tide, and wind. The thermal behavior of animals was recorded. Behaviors that would suggest that animals were cold include huddling which involved greater than 50% of the body in contact,

flippers curled under the body, and a tendency to avoid entering the water to wet themselves'. Female animals showed a greater tendency to remain in contact at Marmot Island, but there were no differences in curling behavior or the tendency to remain dry. However, pups showed less curling behavior at Marmot Island, and there were no differences in curling behavior or the tendency to remain dry. There is a significant correlation of these "cold" behaviors with ambient temperature, but no winter-summer comparisons have been made. When "hot", SSL hold their flippers in a raised position, go into the water to cool, or are wet because they have recently been in the water. More females and pups were observed at Año Nuevo Island with their flippers in the raised position. There were more animals wet or recently in the water at Fox-rester (Lowrie) Island, but the observation period includes an episode of unusually warm weather.

Female and juvenile SSL at each site were scanned for the following behaviors: nursing (females), suckling (pups), resting, activity, and low activity. For the 1993 data set, females were more often observed nursing at Marmot Island than the other sites, but possibly because there were more juveniles on Marmot than on the other islands. Females were more active on Lowrie Island than Año Nuevo Island, and there was more "low activity" reported on Marmot Island. Pups suckled more often on Año Nuevo Island. There were no differences in the recorded "resting" behavior, but animals were less active on Lowrie Island and there was more "low activity" recorded on Lowrie Island.

Data have been collected at all three sites in 1993, 1994, and 1,995, and there are data from Lowrie Island in 1996. Presence or absence of identifiable female SSL was scored daily. An ANOVA examining the duration of feeding trips with year and site as independent variables was highly significant ($p<0.0001$). Feeding trips were significantly longer at Año Nuevo Island than at Marmot or Lowrie islands, and trips were significantly longer in 1993 than in 1994 or 1995. Non-parametric statistics were used to analyze the periods present (i.e., time spent on the rookery) since those periods were not homogeneous; no difference between sites was found. Finally, an ANOVA examining post-par-turn stay (birth to first foraging trip) with year and site as independent variables was significant ($p<0.001$; year=0.002; site=0.04). Post-par-turn stay was significantly shorter in 1993 than in 1994 or 1995. Due to small sample size, data from Año Nuevo Island were deleted from this analysis.

Comments, questions, and discussion following Ono's presentation:

- It would be helpful to separate nursing times of females with pups versus juveniles.

Linda Milette. University of British Columbia

The world population of Steller sea lions *(Eumetopias jubatus)* has been declining since the late 1970s. In the United States, the Steller sea lion is listed as a *threatened* species under the U.S. Endangered Species Act and has recently been reclassified as *endangered* in parts of their range. One of the leading hypotheses to explain the overall decline is that Steller sea lions are nutritionally stressed. A two-year study was therefore initiated in 1994 to contrast the breeding behavior of lactating females during the summer at two sites: Forrester Island in Southeast Alaska where sea lion abundance has been stable or increasing, and the Barren Islands in the Gulf of Alaska where sea lion numbers are declining.

[7] See: Gentry, R.L. 1970 Social behavior of the Steller sea lion. Ph.D. Dissertation, University of California, Santa Cruz, CA 113 pp.

The study focused on behaviors that have been reported to change during periods of nutritional stress, namely: maternal attendance patterns, activity budgets, and mother-pup associations. In particular, nutritionally stressed females are expected to have shorter perinatal periods, spend more time foraging at sea, spend less time close to their pup, be less active, more aggressive, and decrease their total milk production. Assuming that suckling time correlates to milk intake in pups, we would also expect a decrease in time spent nursing in a nutritionally stressed population.

Focal animals were scanned for behaviors every 15 minutes for about 12 hours each day. Sample sizes for females ranged from 17 to 47, and individuals with total observation efforts less than 170 hours were excluded from the analysis. For both sites and years combined, the perinatal period was about 9.3 days. The overall length of trips to sea and visits ashore averaged 22.0 hours and 26.4 hours respectively. Results show that maternal attendance patterns differ significantly between sites and years. Perinatal periods were 2.1 days longer and visits ashore were 4.2 hours longer for the decreasing population compared to the stable population. Trips to sea were 4.7 hours shorter for the declining population. In 1994, both sites had significantly shorter perinatal periods (1.6 days shorter), visits ashore (7.4 h shorter), and trips to sea (4.9 h shorter) than in 1995. The duration of foraging trips increased at both sites as the pups grew older, while time spent on shore decreased. The number of females leaving on foraging trips during the day (0600 - 2000 h) increased as a function of time at both sites. In contrast, the number of females returning from foraging trips was variable over time. In 1994, there were 15 % more departures and 11.5 % more arrivals during the afternoon (1300 - 1800 h) than in 1995. The increased number of afternoon departures and arrivals in 1994, probably reflects short 1 - 3 hour trips away from the rookery during the day. Observations are needed to determine whether or not departure and arrival times have similar trends during the night (2000 - 0600 h).

Female activity budgets differed significantly between sites and years. Females from the declining population spent less total time at sea and upright, but spent more total time resting, nursing, being aggressive and interacting passively with other individuals than females from the stable population. Females from both sites spent similar amounts of total time vocalizing, grooming, swimming and walking. In 1994, females spent more total time at sea, were more aggressive and interacted passively more often with others, but they spent less time resting, upright, nursing, and vocalizing. The combined total time spent at sea and resting ashore was remarkably similar for both sites and years (X range: 84.6 - 86.2 %). Mother-pup associations were also similar between sites and years. Females spent 37.1% of their total time with their pup. Assuming that 1) the distance to foraging areas is similar between the study sites and 2) suckling time reflects milk intake, then longer perinatal periods, less total time at sea, and more time spent nursing pups in the declining area are inconsistent with behavioral changes expected in a nutritionally stressed adult female population.

Comments, questions, and discussion following Milette's presentation:

- Are the results biased by excluding individuals for which there are less than 170 hours of information? Might these animals be those that are at sea longer? All observation efforts (even those that were excluded) included both time at sea and on shore during the observation period. Females with less than 170 hours of recorded effort were excluded because these individuals did not have very good markings and could not be reliably followed; observation

of these animals was terminated after a couple of weeks. These were not animals that spent more time at sea.

- Re-examine the data to see if results are similar when the sample size is changed to the numbers of females rather than the number of trips.
- It may be possible through captive studies to test the behavioral response (e.g., suckling time) of pups to reduced milk fat content and reduced milk flow/volume.
- Compare the means generated when both the arrival and departure times of individuals are known with those obtained from the overall sample.
- Unless it is possible to correlate behavior differences to factors that significantly impact survival, then the differences are simply within the normal range of variation for this species.
- Examine differences based on female age and size.
- More than one site is needed in the stable/decline areas in order to account for variability within those areas.
- Does the reliance on scarred animals bias the study toward older animals? Artificial marks would be preferable to identify age of the individuals and avoid mark bias. Acoustic identification of individuals (vocalizations) may also be helpful to supplement visual observations.

Elisif Brandon. Texas A&M University

Objectives of these studies were to compare populations in the area of stability to those in the area of decline based on the length of time adult females spend at sea versus on shore during early lactation (3-7 weeks after parturition). If food availability is lower for females in the area of decline, we expect those females to spend more time at sea. The null hypothesis is that there are no differences in the duration of time spent at sea, time spent on shore, or percentage of time spent at sea or on shore in the two areas. An alternate hypothesis is that females in the area of decline spend more time at sea and less time on shore.

The site used to represent the stable area was Lowrie Island (1993, 1994, 1996, and 1997), and the sites used to represent the decline area were Chirikof Island (1993) Fish Island (1995) and Seguam Island (1997). The initial collection goal was 10 animals at each site, but fewer than 10 were actually captured on Fish Island in 1995, Lowrie Island in 1996, and Sequam Island in 1997. Each animal was darted with Telazol and anesthetized with Isoflurane. A VHF transmitter was attached to the hair with epoxy. A receiving station was established with an antenna and a data-logging computer, and the computer scanned every 15 minutes for signals (every 30 minutes at Lowrie in 1994 to save battery power and data space).

If a signal was received for longer than one hour, the female was presumed to be on land. If a signal was not received for more than 3 hours, a female was presumed to be at sea. The 3-hour criterion was chosen following a frequency distribution analysis of signal reception gaps to determine a minimum in the distribution separating the gaps into: (1) a group of short gaps probably due to bad reception, the female behind a rock, lying on her transmitter, or cooling off in the water; and (2) a group of longer gaps which are likely foraging trips'. Data from a female were excluded if she went on fewer than four trips to sea, or if it was clear that the signal reception was unreliable. In statistical analyses, each year of data from each study site was

[8] Method from: Boyd, I.L., N.J. Lunn, and T. Barton. 1991. Time budgets and foraging characteristics of lactating Antarctic fur seals. Journal of Animal Ecology 60:577-592.

treated as a separate "location". Data were also analyzed with all decline locations combined and all stable locations combined. Analysis used one-way ANOVA and Tukey tests for multiple comparisons. Table 2 characterizes the physical parameters of female SSL for which radio tracking data were used. Female SSL selected for darting in the area of decline tended to be larger in both mass and standard length than were those in the stable area. Table 3 describes mean attendance patterns for these individuals.

Females in the stable area had longer trips and spent a higher percentage of their time at sea. There was no evidence that females in the area of decline had to spend more time at sea to provision their pups. There was some tendency for females to take trips to sea at night. More detailed information is needed on what effort and success really are during all trips. Information from later in the lactation period is desirable but logistically difficult, since the transmitters fall off during the molt.

In a related pup growth study, neonatal size (mass, standard length, axillary girth) of pups did not differ significantly in the two areas. Pups in the decline area grew at a significantly faster rate than pups in the stable area.

Table 2. Steller sea lion adult female size, means ± standard errors (* indicates significant difference between stable and decline sites).

Location	n	Body Mass (kg)	Standard Length (cm)	Axillary Girth (cm)
Lowrie Island (STABLE)	**23 (25 for SL & AG)**	**252.1 ± 6.68**	**227.2 ± 2.08**	**157.1 ± 3.92**
Chirikof Island	4	289.4 ± 19.4	234.5 ± 4.29	164.2 ± 6.49
Fish Island	3	292.9 ± 12.3	232.0 ± 2.52	159.0 ± 1.53
Aleutian Islands	3	295.0 ± 5.71	246.7 ± 3.18	162.7 ± 1.20
COMBINED (DECLINE)	**10**	**292.1 ± 7.93 ***	**237.4 ± 2.79 ***	**162.2 ± 2.53**

Table 3. Steller sea lion attendance patterns, means ± standard errors.

Location	n	Time Onshore (hrs)	Time at Sea (hrs)	Total Cycle Time (hrs)	Pct. Of Cycle Time Onshore	Pct. Of Cycle Time at Sea
Lowrie Island (STABLE)	**25**	**20.3 ± 1.33**	**23.6 ± 1.72**	**43.6 ± 2.79**	**48.6 ± 1.60**	**51.4 ± 1.60**
Chirikof Island	4	20.7 ± 2.79	11.2 ± 1.67	31.7 ± 1.67	63.0 ± 4.76	37.0 ± 4.76
Fish Island	5	25.0 ± 2.84	18.2 ± 2.31	43.5 ± 2.88	55.1 ± 4.44	44.9 ± 4.44
Aleutian Islands	3	25.7 ± 2.14	7.1 ± 0.81	32.9 ± 1.93	76.5 ± 1.99	23.5 ± 1.99
COMBINED (DECLINE)	**12**	**23.7 ± 1.60**	**13.1 ± 1.74**	**36.9 ± 2.13**	**63.1 ± 3.43**	**36.9 ± 3.43**
RESULTS (STABLE VS. DECLINE)		**NS**	**p<0.0006**	**NS**	**p<0.0001**	**p<0.0001**

Comments, questions, and discussion following Brandon's presentation:

- Is there a correlation between maternal size and the attendance characteristics?
- Are there correlations between growth rate differences in the pups and maternal size differences? If so, the large among-site difference in maternal size could seriously bias the conclusion. One could investigate this by using an ANCOVA.

- There was a discussion of the merits of using natural scars versus telemetry for individual animal identification. Observations on females with transmitters are needed. Telemetry provides more information on animal movements at night. Both methods generally seem to provide the same trend information. The use of natural marks provides the opportunity to get larger sample sizes with less disturbance to the population.
- Were sample sizes in the area of decline biased toward older females? This could account for shorter trip duration because older females may have more experience.

Andrew Trites, North Pacific Universities Marine Mammal Research Consortium

The numbers of female SSL and pups over time were examined at two sites on Lowrie Island during 1993-1996 to assess the impacts of research-related rookery disturbance on use patterns. Disturbance early in the summer season had little effect on the numbers of animals present at the sites, but disturbances later in the season appeared to prompt SSL to leave those sites earlier than they otherwise would. The animals appeared to move to more isolated sites. Female SSL may bite or throw pups into the water during these disturbances, and some pups may be injured at that time. During one series of successive disturbances in 1993, a second disturbance at a site caused a small decline, while a third disturbance produced a marked reduction in the numbers of SSL at the site. It is not known whether the effect is cumulative, or whether a single late-season disturbance would produce the same result.

Comments, questions, and discussion following Trites' presentation:
- Did style of capture or the intensity of recapture effort influence the response to the disturbance? There are indications that prolonged time on the rookery or other factors may increase disturbance; more study is needed.
- Does the length of time that people are on the beach affect the response?
- What impacts do disturbances at different times of the year have on the survival of pups?

3. Discussion

3.1 Discussions Between Researchers and the Review Panel

The male SSL story is currently absent from most behavioral studies, even though male behavioral data are relatively easy to collect. SSL are a highly sexually dimorphic species, which suggest highly skewed male reproductive success. Under conditions of food stress, only males in peak condition might return to the rookeries to hold territories. If food-stressed males also return, then male tenure on rookeries may be shorter and dominant males may copulate less frequently. Since males are fasting throughout the breeding period, male condition during the breeding season may be a good indicator of nutritional stress during the winter. It may be as significant to identify which males come back to the rookery and lose their territory, as it is to identify which ones fail to return at all. If SSL males forage in different areas from females during the winter, as occurs in other otariid species, it may also suggest something about the spatial scale of any food availability problem. The history of individual male SSL should be considered in such studies, because individual animals will expend energy differently depending on

how many seasons they have held territory. Such data are difficult to evaluate without knowledge of where each animal has been and what reserves each brings with it.

Reproductive life histories of female SSL are also important. The energetic costs of reproduction for SSL are minimal from copulation through implantation. After implantation, female SSLs may "evaluate" the likelihood of a successful rearing. If survival of the pup is unlikely, the female may spontaneously abort or resorb the fetus. Such a scenario accounts for pups not born, but does not explain why pups that are born die at a later time. Although there are few data on survival from birth to the end of summer beyond subjective estimates of pup deaths on the beach, this topic was not viewed as of critical research importance for behavioral studies. Focal pairs in current studies rarely lose pups, and it is difficult to monitor numbers of dead pups due to losses in the sea or to scavengers such as foxes.

There was general discussion of non-invasive procedures that could be used to compare the sizes of individual animals. Stereo-photography may be possible. Flat photography using grid systems and photographs taken from the same place has not proven useful. Researchers are attempting to use a theodolite to compare the size of animals on a daily basis and between areas, but the angle at which the animal is examined and the substrate on which they are laying affect the result. It may be necessary to use only the measurement between relatively immobile body parts, like the distance between the eye and ear. If these are determined to be age-related characteristics, they could also provide information about the age structure of the population. Such measurements must first be tested on a captive population to verify their accuracy.

Members of the review panel believed that current studies of adult female SSL on rookeries generally do not demonstrate nutritional stress. However, variability in maternal performance, inadequate controls on maternal mass or age, and confounding environmental factors, make it difficult to conclusively preclude food stress. Maternal condition is likely to have a strong effect on pup survival. Most previous studies have looked at the "maternity ward" animals which have successfully reproduced. Researchers were asked to consider how they could obtain information about those female SSL that are not in the "maternity ward" and potentially are not in as good condition. Additional satellite tagging was suggested as a possible method, but given the high cost of this research, researchers must assess the value of placing tags on these animals relative to the information needed from other types of animals.

There was general agreement that early pup mortality (i.e., over the first two months) is not a problem or a research priority.

The period immediately following weaning is considered critical to the survival ofjuvenile animals, but variability in weaning patterns and the arduous nature of winter field studies make it difficult to determine precisely when juvenile SSL become nutritionally independent. It is feasible to place monitoring devices on both the mother and pup while in the rookery to monitor association patterns, but units currently in use are lost when the animals molt in the fall. It is currently not feasible to reliably measure lactation length without further instrumentation and/or winter/spring field studies to track association and nursing of well-marked mother/juvenile pairs. Chylomicrons in blood samples could indicate ifjuvenile animals have fed within the previous 12 hours and fatty acids might be used to infer diet, but it would be difficult to distinguish milk fatty acids from those from solid food. Milk-based scat are usually distinguishable from fish-based scat, but to lesser extent if a combination of foods has been consumed. It may be best to ask the physiologists to identify the best indicators of diet, and then develop behavioral tests to evaluate those parameters.

Individual life histories are important in order to interpret many SSL research results, so animals should be marked in some manner and followed over time. Brands are only useful when the animals are at sites where and when observers are present. Development of a projectile deployed tag/transmitter has begun, and may hold promise as a technique to quickly deploy large numbers of telemetry devices with minimal disturbance. If those tags could be applied on a broad scale, receivers could be placed at rookeries and haulouts along the coast to record animal movements. However, it was noted that such data-logging systems are difficult to maintain over large areas. The choice of study sites will be critical.

When researchers were asked to identify the most promising areas for future behavior research, and developments that would be needed to permit this research, the following were mentioned:

- Juvenile survival studies, especially if comparisons between decline and stable areas could be made;
- Development of new technologies. This list included a long-lasting telemetry device that will overcome the current short-term attachment problems due to molt, and a system of remote sensing devices or stations for telemetry data;
- An extensive branding program (after evaluating the costs of associated disturbance and mortality) with a long-term commitment to resighting, combined with satellite or other telemetry studies;
- Behavior studies to determine age-specific survival and fecundity, and help researchers understand the effect of nutritional changes on reproduction and survival;
- Studies designed to achieve a better understanding of the significance of haulout sites;
- Long term reproductive histories of individually known animals;
- Diving behavior of adult females; and
- Lactation physiology and nursing behavior.

3.2 Discussions Among. Members of the Review Panel

Recommendations for future recovery-related Steller sea lion research were generated by the review team during a closed session following the research presentations and discussions. These recommendations are presented in Part 4. However, a brief summary of the closed session is presented below in order to give a broader range of topics and perspectives discussed by the panel.

Behavior research should be formulated to test hypotheses either about the causes of the declines or should be designed to provide basic information which could be useful in promoting recovery. The studies need not necessarily be associated with stable/decline scenarios; basic life history information is needed in some cases. Behavior studies need to be integrated with studies conducted by other groups and/or disciplines in order to develop a strong, coordinated package. Despite considerable effort, studies of nursing time and maternal attendance are not producing data that are likely to lead to the recovery of Steller sea lions, although they are providing basic biological information. Live-capture of adult males may not be worth the effort, but behavioral research patterns of tenure over time may be valuable. Some suggest that there may be a reason to evaluate the suckling time ofjuveniles, and to determine how effective suckling is for those animals. At some point, the juvenile is to big to obtain all of its nutrition from its mother alone. It

is an interesting question, but difficult to study. Is it useful for addressing recovery plan questions? Some question whether the permit office should give permits for work that does not fit into the overall recovery plan framework.

The concept that there are areas of population decline and stability may itself be dated. The rate of the overall decline is slowing. Studies should not adopt a model based on current regional trends which may be outdated in five years.

Nearly all studies examined during the course of this review have not been replicated such that it is not possible to distinguish differences in demography from inter-regional variability. Future studies must avoid such confounding problems. It may be useful to drop the declining/stable comparisons until the regional variability that confounds this approach can be more effectively measured. It may be advisable to consider the addition of a study site in the Aleutians to broaden stock coverage. In addition, all studies to date have failed to calibrate behavior with characteristics of SSL that should affect survival. The characteristics measured must be related to something that is important to the animals (e.g., growth rate), otherwise there is simply no way to evaluate the behavioral results with respect to limiting factors in the population.

All of the information presented to the review panel would be strengthened by knowing histories of the study animals. This will require the marking of animals with permanent marks such as hot brands. During the next five years, branding is probably the most feasible technique. Large numbers of marks can be applied at relatively low cost, and the marks can be resighted by anyone. By marking several cohorts, this effort will support a wide range of studies. Several branding sites will be necessary because of site variability and the need to provide sufficient replicates. Branded SSLs could be used to study age-specific recruitment patterns, reproductive performance, and survival probability.

After the animals are marked, there needs to be a consistent, intensive all-season resight effort for several years. The methods must be comparable among research groups and studies, and should include observations at rookeries and haulouts. Current population models should be used to determine the sample size needed to evaluated the decline, and enough tagging should be conducted at each site to address the levels of expected mortality. Island cluster branding is preferable to just discrete sites, and enough marking should be done to account for intra-regional variability. There should also be an attempt to look at the immediate effects of the marking activity. The marking needs to be done in any event, but there should be an attempt to determine the effect. Researchers should focus on getting the marking done, and place behavior studies on hold for awhile unless they can be done concurrently.

Researchers should look at juvenile survival, but extend the view beyond the first 50 days after birth. There is a need to know the time of weaning and the timing ofjuvenile losses. Look for marked animals. Determining the time at which a loss occurred gives researchers an idea whether juvenile mortality is indeed high, and whether that loss is part of a slow overall decline or the sudden loss of an animal in good condition. It is an area we know nothing about. A good study would involve instrumentation of both mothers and pups to better understand the spatial and temporal dynamics. Satellite transmitters are preferred, but new technologies may need to be applied. Researchers may need to find a way to instrument mothers and pups early, and then again after the molt. That would enable a determination of whether the activities of mothers and pups are coordinated at sea and on land. We currently do not know if mothers and pups forage together, and if there is some value in that association. There is a need to determine basic life

history. Changes in the proportion of time that mother/pup pairs spend together may give some indication of relative nutritional dependence. Conduct a pilot study on weaning, which extends the current winter work into the period for which information is lacking. An operational definition of weaning is needed, but new technology may be needed to address this issue. Behavioral data alone will not link nursing duration to nutritional intake.

4. Recommendations:

Much of the recent research effort has taken the general approach of comparing rookeries from stable versus decline areas to determine the cause(s) of the decline. This appears to be impractical due to numerous confounding, uncontrollable variables that make pairing comparable sites extremely difficult. If such an approach is used, care must be taken to relate behavior and ecological conditions to the current population trends at given islands (or clusters of islands, depending on the nature of movements among them). Population status cannot just be assumed because of a rookery's or haulout's location.

Another difficulty encountered by many research projects was the inability to recognize individual animals. A branding program is highly recommended (see below) to help alleviate this problem.

Female attendance patterns

Much of the recent research effort has focused on detecting indications of nutritional stress, especially in adult females. Several studies measured female attendance patterns at rookeries through telemetry or observations of recognizable individuals. To date, these studies have given no indication of nutritional stress among adult females on rookeries in the area of decline. In fact, attendance patterns were typically the opposite of what was predicted relative to the decline (e.g., shorter trips to sea in the decline area compared to the stable area). It appears that these studies have thus fulfilled their purpose, and should generally be discontinued at this point. However, there is some advantage to obtaining long-term records of attendance. patterns at a given site. Therefore, this work should perhaps be continued when it can easily be conducted incidentally to other research. If future independent data show nutritional stress to be prevalent among adult females, and attendance pattern studies are resumed, great effort should be made to replicate them at multiple sites at which the current population trend and other influential factors are also determined.

Another limitation of the present approach to rookery-based attendance pattern research is that it cannot determine whether the good nutritional health apparent in the females using the rookeries is representative of all females in the population, or whether those that are in poor health have no reason to visit the rookeries (i.e., their condition is too poor to pup or mate). This question could theoretically be addressed by comparing: (1) the proportion of females on rookeries versus on haulouts between stable and decline areas; and (2) the attendance patterns on haulouts in decline and stable areas. However, these comparisons would be valid ONLY if the problem of pairing comparable rookeries in the decline versus stable area is first solved.

Juvenile studies

The hypothesis that mortality of nutritionally-stressed juveniles is mainly responsible for heading the decline warrants more research. There are two facets to this: (1) we need more

information on the basic life history and ecology ofjuveniles (e.g., when weaning occurs, their movements in their first four years of life, what they eat and where, and their survival rates); and (2) once these data are obtained, we can look at ways to compare decline versus stable areas.

Branding program

To accomplish the juvenile and other studies, we recommend a major branding effort supported by consistent resight effort. The number of branding locations should be increased to control for intra-regional variability and about five cohorts should be branded.

Effects of branding

A study of the effects of branding (both the disturbance caused by branding and the brands themselves) should be conducted to anticipate its effects on data.

Telemetry

Mother/pup pairs should be tracked with telemetry devices (the number, type, etc. to be determined by the Telemetry Workshop panel). If possible, this should also be done after the molt to hopefully catch the weaning period and transition to independent foraging by the juveniles.

Winter/Spring observations of female/juvenile pairs

These studies should be continued and extended. Boyd Porter's approach seems likely to give an indication of the onset of weaning if the study extends into the spring.

Scat analysis

Analysis should be completed of scats already collected (e.g., from Año Nuevo), and collections continued;

Develop technologies

The panel encourages the development of technologies necessary for the capture, handling, tracking, and other studies of Steller sea lions.

El Niño

The review panel recommends that researchers capitalize on the probable El Niño effects this year to see what insights they give into nutritional stress, prey availability, and the decline of Steller sea lions. This may take some fast planning.

The review panel believes that the combined results of the above recommended studies will improve our understanding ofjuvenile ecology and behavior. The branding is seen as the most important tool with which to accomplish this in the near future. It needs a widespread, consistent, all-season resight effort to work.

The panel stressed three recommendations regarding the general approach to studying the Steller sea lion decline: (1) replication of data is very important. There are too many fluctuating variables to allow just one rookery in the decline area to be compared to one in the stable area while investigating those areas' effects on a single factor (e.g., attendance patterns); (2) the research effort as a whole would be improved by further integration and coordination of various research groups and fields (e.g., behavior and physiology, or similar studies conducted on

different islands by different groups). An annual meeting of all researchers is one possible means to achieve this; and (3) much greater effort needs to be made to design behavioral studies with explicit research questions that are relevant to understanding the causes of the declines or, perhaps more importantly, that can help managers promote recovery of the population through the implementation of closed areas and other management tools that could mitigate known or suspected limiting factors.

Appendix A: Participants in the Behavior/Rookery Studies Workshop held at the National Marine Mammal Laboratory, Seattle, Washington on December 5-7, 1997.

Name	Representing
* Daryl Boness	Department of Zoological Research, National Zoological Park, Washington, DC
* Don Bowen	Bedford Institute of Oceanography, Dartmouth, NS
Elisif Brandon	Texas A&M University (current address Newton, MA)
Kathryn Chumbley	NMFS National Marine Mammal Laboratory/Alaska Fisheries Science Center, Seattle, WA
*** Al Didier	Pacific States Marine Fisheries Commission, Portland, OR
* Bill Gilmartin	Hawaii Wildlife Fund, Volcano, HI
* Robert Gisiner	Office of Naval Research, Arlington, VA
** Carolyn Heath	Fullerton College, Fullerton, CA
Tom Loughlin	NMFS National Marine Mammal Laboratory/Alaska Fisheries Science Center, Seattle, WA
Linda Milette	Marine Mammal Research Unit, University of British Columbia, Vancouver, BC
Kathryn Ono	Department of Life Science, University of New England, Biddeford, ME
Ken Pitcher	Alaska Department of Fish and Game, Anchorage, AK
Boyd Porter	Alaska Department of Fish and Game, Anchorage, AK -and- Marine Mammal Research Unit, University of British Columbia, Vancouver, BC
Tim Ragen	NMFS, Honolulu, HI
* Katherine Ralls	Department of Zoological Research, National Zoological Park
John Sease	NMFS National Marine Mammal Laboratory/Alaska Fisheries Science Center, Seattle, WA
* Don Siniff	University of Minnesota, St. Paul, MN
Michael Strick	NMFS National Marine Mammal Laboratory/Alaska Fisheries Science Center, Seattle, WA
Una Swain	Alaska Department of Fish and Game, Anchorage, AK
Andrew Trites	North Pacific Universities Marine Mammal Research Consortium/University of British Columbia, Vancouver, BC
* Cindy Zabel	U.S. Forest Service, Redwood Science Lab, Arcata, CA

* Member of the Review Panel
** Chair of the Review Panel
*** Rapporteur

Appendix B: List of commonly used acronyms

ADFG	Alaska Department of Fish and Game
ANOVA	Analysis of variance
ESA	Endangered Species Act
MMPA	Marine Mammal Protection Act
NMFS	National Marine Fisheries Service, NOAA
NMML	National Marine Mammal Laboratory, Seattle, Washington
NOAA	National Oceanic and Atmospheric Administration
NPUMMC	North Pacific Universities Marine Mammal Research Consortium
SSL	Steller sea lion, *Eumetopius jubatus*
UBC	University of British Columbia, Vancouver, British Columbia, Canada
VHF	Very High Frequency-refers to a radio frequency tag that usually transmits to receivers on land or in aircraft