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Steller Sea Lion Investigations, 2000

edited by
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INTRODUCTION

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This report summarizes much of the research conducted on Steller sea lions (*Eumetopias jubatus*) during 2000 by scientists of the Alaska Fisheries Science Center's National Marine Mammal Laboratory (NMML), and by researchers directly contracted by NMML. Other groups receiving NOAA funding were invited to contribute brief summaries of their year 2000 research activities, and summaries not originally produced for this report were provided by the Alaska Department of Fish and Game (ADF&G) and the Alaska Sea Life Center (ASLC). Additional information on research activities conducted utilizing NOAA funds can be obtained by directly contacting ADF&G, the Alaska Sea Life Center, and the North Pacific Universities Marine Mammal Research Consortium (NPUMMRC). An annual report summarizing 1999-2000 research is available from NPUMMRC.

This first version of *Steller Sea Lion Investigations* intends to provide a medium through which current research, and preliminary results if appropriate, can be rapidly communicated. In cases where a manuscript has been submitted to a journal for review, only the abstract is provided. Different levels of editing were conducted; reports with AFSC authors have received more editing, while reports from contractors, ADF&G and the ASLC received minor editing for citation style and table and figure numbering. Information presented in this report should be considered provisional, and should not be used without consent of the authors. Opinions expressed by authors of contract, ADF&G, or ASLC reports may not reflect the opinion of the National Marine Fisheries Service. References to trade names does not imply endorsement by the National Marine Fisheries Service.

Updated and additional information and databases may be found on the NMML (http://nmml.afsc.noaa.gov/), ASLC (http://www.alaskasealife.org/), ADF&G (http://www.state.ak.us/adfg/wildlife/mm/mm.htm), and the NPUMMRC (http://www.marinemammal.org/) web pages. The location of authors within the AFSC organizational structure is presented in Appendix I, and a map of the Bering Sea and Gulf of Alaska showing selected rookeries and haulouts referred to within this volume is in Appendix II. I thank John Jansen, Sharon Melin, Gary Duker and James Lee for manuscript reviews, and to Keri Lodge for editorial assistance.

Reports from the

Alaska Fisheries Science Center

AERIAL SURVEY OF ADULT AND JUVENILE STELLER SEA LIONS IN ALASKA, JUNE 2000

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ABSTRACT

The National Marine Fisheries Service and the Alaska Department of Fish and Game conducted an Alaska-wide aerial survey of non-pup (adult and juvenile) Steller sea lions (*Eumetopias jubatus*) during June 2000. This was the most recent in a series of surveys in Alaska that began in the mid-1970s. This survey enumerated Steller sea lions from both the eastern and western stocks, which are separated at 144° W longitude. Adhering to protocols of earlier surveys, traditional sea lion rookeries and haul-out sites were photographed using a 35-mm, manual-focus camera and color transparency film. Adult and juvenile sea lions were later counted from projected images. Five rookeries in the Gulf of Alaska were surveyed twice, once by each of two survey teams.

The decline of Steller sea lions in Alaska continues to be restricted to the western stock. The number of non-pups at 30 rookery trend sites declined by 7.5% since 1998 and 40.0% since 1989. For all 83 western-stock rookery and haul-out trend sites in Alaska, numbers of non-pups 10.3% since 1998 and 41.6% since 1989. The average annual rates of decline from 1989 to 2000 was 5.0% for both the trend rookeries and for all trend sites. The eastern stock in Alaska (Southeast Alaska) remained stable or increased slightly. Numbers of non-pups at three trend rookeries increased by 4% from 1998 but changed less than 1% from 1989. For all trend rookery and haul-out sites in Southeast Alaska numbers of non-pups increased by 13% from 1998 and 17% from 1989. The average annual rate of change from 1989 to 2000 in Southeast Alaska, however, was not significantly different from zero.

In summary, overall trends remain unchanged over the last several years. The western stock continues to decline by about 5% per year whereas counts for the eastern stock in Southeast Alaska continue to increase by almost 2% per year.

INTRODUCTION

The National Marine Fisheries Service (NMFS) and the Alaska Department of Fish and Game (ADF&G) conducted an aerial survey of non-pup (adult and juvenile) Steller sea lions (*Eumetopias jubatus*) in Alaska during June 2000. This was the most recent in a series of surveys in Alaska since the mid-1970s (Braham et al. 1980, Calkins and Pitcher 1982, Loughlin et al. 1984; 1990; 1992, Merrick et al. 1987; 1991; 1992, Sease et al. 1993; 1999, Strick et al. 1997, and Sease and Loughlin 1999).

The Final Recovery Plan for Steller sea lions (NMFS 1992) recommended annual aerial surveys of Steller sea lions in Alaska as the best tool for assessing population status and trends. Two peer reviews of the aerial survey protocol in 1992 concluded that a biennial schedule would result in reduced risk for survey personnel and considerable monetary savings with minimal loss of statistical power for trend analysis (Sease et al. 1993). The biennial schedule was adopted, beginning with the 1992 survey. In June 1997 the population was differentiated into two stocks at 144° W longitude, based primarily on genetic differences (Bickham et al. 1996), but also on the different population trajectories for the two stocks (Loughlin 1997). Steller sea lions in Southeast Alaska are from the eastern stock; those from all other regions of Alaska are from the western stock. This report presents a general summary of results from the June 2000 aerial survey. More detailed analyses will be published separately in the Alaska Fisheries Science Center's NOAA Technical Memorandum series[1].

METHODS

The 2000 aerial surveys adhered to protocols of earlier surveys (Braham et al. 1980, Calkins and Pitcher 1982, Merrick et al. 1991, Merrick et al. 1992, Loughlin et al. 1992, Sease et al. 1993, Strick et al. 1997, Sease et al. 1999, and Sease and Loughlin 1999) and were conducted during June and July. We targeted sea lion rookeries and haul-out sites traditionally surveyed in past studies, but potential haul-out sites along the flight path also were examined en route. When possible, we surveyed each site at 90-150 knots air speed, 150-200 m (500-650 ft) altitude, and 500 m (¼ nautical mile) offshore, depending on the topography of the site. Strong winds occasionally required flying at higher altitudes or farther offshore, whereas fog or low clouds sometimes required flying at a lower altitude or closer inshore. NMFS personnel surveyed from Cape St. Elias in the eastern Gulf of Alaska to the western-most point in the Aleutian Islands. ADF&G personnel surveyed Southeast Alaska and several selected sites in the eastern and central Gulf of Alaska.

We photographed sea lions at most sites using 35-mm, manual-focus cameras with motor drives and zoom lenses (70-210 mm or equivalent) and moderately fast (e.g., ISO 200 or 400)

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[1]Now available: Sease, J.L., W.P. Taylor, T.R. Loughlin and K.W. Pitcher. 2001. Aerial and land-based surveys of Steller sea lions (*Eumetopias jubatus*) in Alaska, June and July 1999 and 2000. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-122, 52 p.

color slide film. Where appropriate, we took sequential, overlapping photographs to guarantee complete coverage of a site. In the laboratory, we counted adult and juvenile (non-pup) sea lions from projected images. The final count of non-pup sea lions for each rookery or haulout was the mean for two independent counters. If the individual results for a particular site differed by 10% or more, we re-counted the images for that site. We used direct visual counts instead of photographs for sites with few animals (e.g., 10 or fewer sea lions). Five rookeries in the Gulf of Alaska (Seal Rocks, Wooded I., Outer I., Sugarloaf I., and Marmot I.) were surveyed twice, once by each survey team. For each of these sites, we averaged the final counts from each survey.

This report focuses on counts at "trend sites." Trend sites are those rookery and haul-out sites surveyed consistently from the 1970s to the present, thus allowing analysis of population trends on a decadal scale. Trend sites comprised the majority of animals surveyed (71.7% in 1998, 74.6% in 2000). Rookeries are those sites where adult males actively defend territories, pups are born, and mating takes place. Haul-out sites are those where sea lions predictably rest on land (haul out), but where few or no pups are born (Calkins and Pitcher 1982, Loughlin et al. 1984).

Analyses for population trends included subtotals of non-pups a) Alaska-wide, b) for the eastern and western stocks, and c) for the Kenai Peninsula to Kiska Island index area. We estimated annual rate of change for 1990 to 2000 or 1991 to 2000 using the slope of a linear regression of the natural log of counts on survey year. Testing of the significance was conducted on the slope of the regression.

RESULTS AND DISCUSSION

NMFS and ADF&G counted an overall total of 37,801 adult and juvenile Steller sea lions on 279 rookery and haul-out sites in Alaska in June 2000. Almost three-quarters of the animals were on the 95 rookery and haul-out trend sites. The count at trend sites declined 3.2% since June 1998 (29,131) and 7.4% since 1996 (30,441). The count for 33 trend rookeries Alaska-wide was 20,298, or 53.7% of the June 2000 total. This was a decline of 3.8% since 1998 (21,097) and 10.0% since 1996 (22,557).

The decline in Steller sea lion numbers in Alaska continues to be restricted to the western stock (Fig. 1). Counts at the 30 rookery trend sites (13,402: Table 1) declined by 7.5% since 1998 (14,489) and 40.0% since 1989 (22,470). For all 83 western-stock rookery and haul-out trend sites in Alaska, numbers of non-pups (18,325: Table 2) showed a decline of 10.3% since 1998 (20,438) and 41.6% since 1989 (31,356). The average annual rates of decline from 1989 to 2000, based on linear regression, was 5.0% ($P < 0.001$) for both the trend rookeries and for all trend sites (Table 3).

The Kenai to Kiska region is a geographical sub-division of the western stock used by the Steller sea lion Recovery Team as a population index (NMFS 1992). For 26 trend rookeries, the June 2000 count (11,738: Table 1) was a decline of 3.1% from 1998 (12,116) and 39.0% from 1989 (19,253). The average annual decline at trend rookeries in the Kenai to Kiska region was 4.7% ($P < 0.001$) for 1989 to 2000 (Table 3). Non-pup numbers at 70 rookery and haul-out trend sites (15,279: Table 2) decreased by 6.9% from 1998 (16,417) and 33.7% from 1989 (23,057).

The average annual decline from 1989 to 2000 at all trend sites was 3.9% (P < 0.001: Table 3).

The eastern stock, represented in Alaska only by Southeast Alaska, remained stable or increased slightly (Fig. 1). Counts at the 3 trend rookeries (6,896 in June 2000) showed equivocal change from previous survey results since 1989 (Table 1). Numbers of non-pups at all trend rookery and haul-out sites in Southeast Alaska (9,862: Table 2) increased by 13% from 1998 and 17% from 1989, but these were differences of only 1,169 and 1,450 animals, respectively. The average annual increase from 1989 to 2000 in Southeast Alaska was less than 1% (P = 0.29) for trend rookeries and 1.5% (P = 0.074) for all trend sites (Table 3).

In summary, large-scale trends remain unchanged from the 1996 and 1998 surveys (Sease et al. 1999, Sease and Loughlin 1999). The western stock continues to decline by about 5% per year whereas counts for the eastern stock in Southeast Alaska continue to increase by 1% or 2% per year. The relatively greater decline for the western stock as a whole compared to the Kenai to Kiska index area was driven by the large declines in the western Aleutian Islands (Buldir and the Near Islands): 44% from 1998 to 2000 and about 50% since 1996.

ACKNOWLEDGMENTS

NMFS and ADF&G thank Aero Commander NW, Wenatchee, Washington, and pilots Tom Blaesing, Dick Stefanski, and David Weintraub for aircraft support. K. Chumbley and S. Capron participated in the NMML survey. C. Kurle (NMFS) and E. Schoen (ADF&G) counted sea lions from slides. We greatly appreciate the wide-ranging assistance from personnel of the Alaska Maritime National Wildlife Refuge, Aleutian Islands Unit on Adak Island. The National Marine Fisheries Service Observer Program, the Dutch Harbor Airport Manager, and Delta Western Fuels, provided assistance in overcoming a fuel crisis for in Dutch Harbor, Alaska. The Izembek National Wildlife Refuge in Cold Bay, Alaska, provided housing for NMFS survey personnel. This survey was conducted under the authority of NOAA MMPA/ESA permit No. 782-1532-00 and Special Use Permit No. 51576 from the Alaska Maritime National Wildlife Refuge.

CITATIONS

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 lion (*Eumetopias jubatus*). J. Mammal. 77:95-108.

Braham, H. W., R. D. Everitt, and D. J. Rugh. 1980. Northern sea lion population decline in the eastern Aleutian Islands. J. Wildl. Manage. 44:25-33.

Calkins, D. G., and K. W. Pitcher. 1982. Population assessment, ecology and trophic relationships of Steller sea lions in the Gulf of Alaska. Alaska Department of Fish and Game, Final Report RU243. Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99502, 76 p.

Loughlin, T. R. 1997. Using the phylogeographic method to identify Steller sea lion stocks, p. 159-171. *In* A.E. Dizon, S. J. Chivers, and W. F. Perrin (editors), Molecular genetics of marine mammals. Soc. Mar. Mammal., Spec. Publ. No. 3.

Loughlin, T. R., A. S. Perlov, and V. A. Vladimirov. 1990. Survey of northern sea lions (*Eumetopias jubatus*) in the Gulf of Alaska and Aleutian Islands during June 1989. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-176, 26 p.

Loughlin, T. R., A. S. Perlov, and V. A. Vladimirov. 1992. Range-wide survey and estimation of total number of Steller sea lions in 1989. Mar. Mammal Sci. 8:220-239.

Loughlin, T. R., D. J. Rugh, and C. H. Fiscus. 1984. Northern sea lion distribution and abundance: 1956-80. J. Wildl. Manage. 48:729-740.

Merrick, R. L., D. G. Calkins, and D. C. McAllister. 1992. Aerial and ship-based surveys of Steller sea lions in Southeast, Alaska, the Gulf of Alaska, and Aleutian Islands during June and July 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-1, 37 p.

Merrick, R. L., L. M. Ferm, R. D. Everitt, R. R. Ream, and L. A. Lessard. 1991. Aerial and ship-based surveys of northern sea lions, (*Eumetopias jubatus*) in the Gulf of Alaska and Aleutian Islands during June and July 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-196, 34 p.

Merrick, R. L., T. R. Loughlin, and D. G. Calkins. 1987. Decline in abundance of the northern sea lion, *Eumetopias jubatus*, in Alaska, 1956-86. Fish. Bull., U.S. 85:351-365.

NMFS (National Marine Fisheries Service). 1992. Recovery plan for the Steller sea lion (*Eumetopias jubatus*). Prepared by the Steller Sea Lion Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland, 92 p.

Sease, J. L. and T. R. Loughlin. 1999. Aerial and land-based surveys of Steller sea lions (*Eumetopias jubatus*) in Alaska, June and July 1997 and 1998. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-100, 61 p.

Sease, J. L., J. P. Lewis, D. C. McAllister, R. L. Merrick, and S. M. Mello. 1993. Aerial and ship-based surveys of Steller sea lions (*Eumetopias jubatus*) in Southeast Alaska, the Gulf of Alaska, and Aleutian Islands during June and July 1992. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-17, 57 p.

Sease, J. L., J. M. Strick, R. L. Merrick, and J. P. Lewis. 1999. Aerial and land-based surveys of Steller sea lions (*Eumetopias jubatus*) in Alaska, June and July 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-99, 43 p.

Strick, J. M., L. W. Fritz, and J. P. Lewis. 1997. Aerial and ship-based surveys of Steller sea lions (*Eumetopias jubatus*) in Southeast Alaska, the Gulf of Alaska, and Aleutian Islands during June and July 1994. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-71, 55 p.

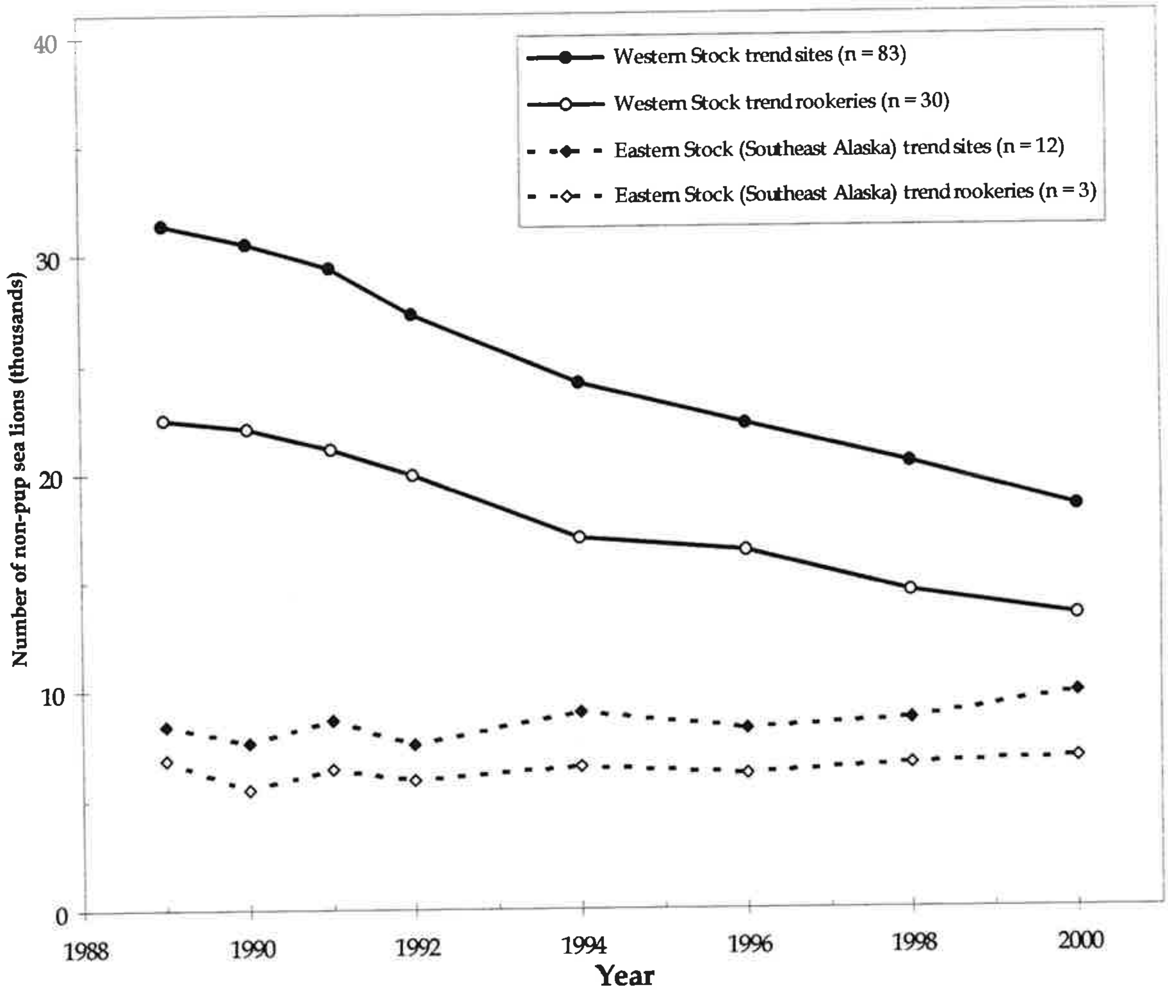

Figure 1.--Counts of non-pup (adult and juvenile) Steller sea lions at all trend sites (rookeries and major haulouts), and trend rookeries for the western stock and for the eastern stock (Southeast Alaska), 1989 to 2000. All counts are from June-July aerial surveys.

Table 1.--Counts of adult and juvenile (non-pup) Steller sea lions observed at rookery trend sites in seven subareas of Alaska during June and July aerial surveys from 1989 to 2000, including overall percent change between the count for each year and the count for 2000.

	Eastern Stock	Western Stock							
		Gulf of Alaska			Aleutian Islands				
Year	Southeast Alaska (n = 3)	Eastern (n = 1)	Central (n = 4)	Western (n = 4)	Eastern (n = 7)	Central (n = 11)	Western (n = 3)	Kenai to Kiska subtotal (n = 26)	Western stock Subtotal (n = 30)
1989	6,844 (<1%)	2,159 (−65%)	6,813 (−68%)	3,521 (−26%)	2,813 (−3%)	6,106 (−31%)	1,058[1] (−14%)	19,253 (−39.0%)	22,470[1] (−40.0%)
1990	5,491 (+26%)	1,471 (−49%)	5,043 (−57%)	3,496 (−25%)	3,417 (−20%)	6,738 (−37%)	1,907[2] (−52%)	18,694 (−37.2%)	22,072[2] (−39.3%)
1991	6,441 (+ 7%)	1,220 (−39%)	4,336 (−50%)	3,234 (−19%)	3,516 (−22%)	6,095 (−30%)	2,685 (−66%)	17,181 (−31.7%)	21,086 (−36.4%)
1992	5,944 (+16%)	784 (− 4%)	4,308 (−50%)	3,313 (−21%)	3,712 (−26%)	5,260 (−19%)	2,531 (−64%)	16,593 (−29.3%)	19,908 (−32.7%)
1994	6,493 (+ 6%)	636 (+18%)	3,098 (−30%)	3,155 (−17%)	3,514 (−22%)	4,767 (−11%)	1,813 (−50%)	14,534 (−19.2%)	16,983 (−21.1%)
1996	6,204 (+11%)	544 (+38%)	2,795 (−23%)	3,029 (−14%)	3,538 (−23%)	4,540 (− 7%)	1,907 (−52%)	13,902 (−15.6%)	16,353 (−18.0%)
1998	6,608 (+ 4%)	730[3] (+ 3%)	2,255 (− 4%)	2,948 (−11%)	2,719 (< 1%)	4,194 (+ 1%)	1,643 (−44%)	12,116 (− 3.1%)	14,489[3] (− 7.5%)
2000	6,896	749	2,157	2,613	2,731	4,237	915	11,738	13,402

[1] Cape Sabak and Gillon Point rookeries, Agattu Island, not surveyed in 1989.
[2] Gillon Point rookery, Agattu Island, not surveyed in 1990.
[3] Includes 1999 counts for most sites in the eastern Gulf of Alaska.

Table 2.--Counts of adult and juvenile (non-pup) Steller sea lions observed at rookery and haul-out trend sites in seven subareas of Alaska during June and July aerial surveys from 1989 to 2000, including overall percent change between the count for each year and the count for 2000.

	Eastern Stock	Western Stock							
		Gulf of Alaska			Aleutian Islands			Kenai to Kiska subtotal (n = 70)	Western stock subtotal (n = 83)
Year	Southeast Alaska (n = 12)	Eastern (n = 9)	Central (n = 15)	Western (n = 9)	Eastern (n = 11)	Central (n = 35	Western (n = 4)		
1989	8,412 (+17%)	7,241 (−73%)	8,524 (−63%)	3,908 (−27%)	3,032 (+27%)	7,593 (−29%)	1,058[1] (+ 1%)	23,057 (−33.7%)	31,356[1] (−41.6%)
1990	7,629 (+29%)	5,444 (−64%)	7,050 (−55%)	3,915 (−27%)	3,801 (+ 1%)	7,988 (−32%)	2,327[2] (−54%)	22,754 (−32.9%)	30,525[2] (−40.0%)
1991	8,621 (+14%)	4,596 (−57%)	6,270 (−49%)	3,732 (−24%)	4,228 (− 9%)	7,496 (−28%)	3,083 (−65%)	21,726 (−29.7%)	29,405 (−37.7%)
1992	7,555 (+31%)	3,738 (−47%)	5,739 (−45%)	3,716 (−24%)	4,839 (−21%)	6,398 (−15%)	2,869 (−63%)	20,692 (−26.2%)	27,299 (−32.9%)
1994	9,001 (+10%)	3,365 (−41%)	4,516 (−30%)	3,981 (−29%)	4,419 (−13%)	5,820 (− 7%)	2,035 (−47%)	18,736 (−18.5%)	24,136 (−24.1%)
1996	8,231 (+20%)	2,132 (− 7%)	3,913 (−19%)	3,739 (−24%)	4,715 (−19%)	5,524 (− 2%)	2,187 (−51%)	17,891 (−14.6%)	22,210 (−17.5%)
1998	8,693 (+13%)	2,110[3] (− 6%)	3,467 (− 8%)	3,360 (−15%)	3,841 (<1%)	5,749 (− 6%)	1,911 (−44%)	16,417 (− 6.9%)	20,438[3] (−10.3%)
2000	9,862	1,975	3,180	2,840	3,840	5,419	1,071	15,279	18,325

[1] Cape Sabak and Gillon Point rookeries, Agattu Island, not surveyed in 1989.
[2] Gillon Point rookery, Agattu Island, not surveyed in 1990.
[3] Includes 1999 counts for most sites in the eastern Gulf of Alaska.

Table 3.--Estimated annual rates of change in numbers of adult and juvenile (non-pup) Steller sea lions at trend rookeries and at all trend sites (rookeries and haulouts) in Alaska during June and July aerial surveys from 1989 to 2000. Upper and lower limits for the 95% confidence interval and significance (P) from linear regression (see text) are also shown.

	Eastern Stock (Southeast Alaska)		Western Stock (eastern Gulf of Alaska to western Aleutian Is.)		Kenai Peninsula to Kiska I. index area		Alaska-wide	
Years	Trend rook. (n = 3)	All trend sites (n = 12)	Trend rook. (n = 30)	All trend sites (n = 83)	Trend rook. (n = 26)	All trend sites (n = 70)	Trend rookeries (n = 33)	All trend sites (n = 97)
Estimated annual rate of change								
1989 to 2000	< 1%	+ 1.5%	- 5.0%	- 5.0%	- 4.7%	- 3.9%	- 3.4%	- 4.0%
Upper 95%	+ 2.6%	+ 3.1%	- 4.4%	- 4.6%	- 4.1%	- 3.6%	- 2.9%	- 3.6%
Lower 95%	- 0.9%	- 0.02%	- 5.5%	- 5.4%	- 5.4%	- 4.2%	- 3.9%	- 4.3%
P	0.29	0.074	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001

STELLER SEA LION PUP COUNTS, TAGGING, AND BRANDING: YUNASKA ISLAND TO FISH ISLAND, 20 JUNE - 6 JULY 2000

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ABSTRACT

The National Marine Mammal Laboratory contracted with the U.S. Fish and Wildlife Service research vessel *Tiglax* to conduct pup counts at numerous Steller sea lion rookeries in the Gulf of Alaska (GOA) and Aleutian Islands between 20 June - 6 July 2000. Pup numbers at some sites remain low, but overall pup production appeared stable from 1998. Numerous observations of small capelin in the GOA, especially at Pinnacle Rock, suggest a good prey recruitment year that may augment prey availability in the near future. Individual marking of pups using hot brands occurred at Marmot (107 branded pups) and Sugarloaf (151 branded pups) Islands.

INTRODUCTION

Studies of Steller sea lion (*Eumetopias jubatus*) mitochondrial DNA suggest that at least two populations exist: an eastern population (California through southeastern Alaska) and a western population (Prince William Sound and areas west) (Bickham et al. 1996, Loughlin 1997). For the western U.S. population (west of 144°W), counts of adults and juveniles have fallen from 109,880 non pups in the late 1970s to 13,402 non pups in 2000, a decline of over 80%. Although the number of sea lions lost was greater from the late 1970s to the early 1990s, the rate of decline has remained high. The 2000 count was 39% lower than in 1990, with an estimated annual rate of decline of 5.1% (Sease and Taylor, this volume).

The Steller Sea Lion Recovery Plan (NMFS 1992) requires systematic surveys at specific locations each year during the breeding season to monitor pup production and health. These pup surveys are not as inclusive as the Alaska-wide aerial surveys and are intended to provide an indication of pup production at index rookeries; pup count trends are similar to non pup count trends (York et al. 1996). During 2000, pup counts were conducted at rookeries from the central Aleutian Islands to the eastern Gulf of Alaska. This report summarizes results of pup counts at these rookeries and the initiation of studies to determine age-specific vital rates and movement patterns using long-term individual marks. Pup counts for southeastern Alaska will be presented separately by the Alaska Department of Fish and Game.

METHODS

The study was divided into two legs, the first during 20-30 June with the objectives to count pups at selected rookeries, and at those rookeries weigh, measure, and tag 50 pups and collect blood and genetic samples from 10 pups. The scientific crew of Leg 1 consisted of T. Loughlin, J. Sterling, R. Caruso, P. Browne, D. Hennen, V. Burkanov, A. Burdin, J.-A. Mellish, M. Lander, and P. Nicklen (photographer). Objectives of Leg 2 during June 31-July 6 were to brand and measure 150 female pups each at Marmot and Sugarloaf Islands and all pups at Chiswell Island, and to take blood samples from every fifth branded pup and genetic samples from the first ten at each site. Scats were collected when possible. The scientific crew of Leg 2 consisted of T. Loughlin. P. Browne, V. Burkanov, A. Burdin, A. Towell, J. Thomason, B. Fadely, D. Calkins, J. Wilson, F. Guilland. S. Atkinson, and M. Gray.

Collection of pup weights were based on procedures in Merrick et al. (1995), genetic sample collections were based on procedures in Bickham et al. (1996), and pup branding followed Merrick et al. (1996). Methods were improved by using isoflurane to immobilize pups during the brand application, and recovery from the anaesthesia was typically less than 10 sec. Pup girth and standard length measurements followed Calkins et al. (1998).

RESULTS

The combined totals of pups handled and counted for Legs 1 and 2 are summarized in Table 4. All objectives of Leg 1 (pup counts, tagging and sampling), were accomplished at Yunaska, Adugak, Akun, Pinnacle, Atkins, and Chirikof Islands. Visits to other rookeries and haul-out sites occurred (Table 5), but only counts were conducted. During Leg 2, 107 pups were branded at Marmot and 151 pups at Sugarloaf. Blood and genetic samples were collected as proposed. No pups were branded at Chiswell Island but 30 had flipper tags attached to the trailing edge of the front flipper. Tables 6-11 provide information on tag color and number, animal morphometrics, and the place and date when animals were tagged.

Branding occurred at Beach 4, Marmot Island, on 2 July and lasted from 0940-1700h. A total of 107 (58 males, 47 female) pups were branded with the letter "T" and an individual number sequentially from 1 to 107 (e.g., the last pup had brand "T107"). These branded pups were monitored from shore during and after the branding operations (see Chumbley et al., this volume).

On Sugarloaf Island, branding occurred at the north, sandy rookery at Sugarloaf Island on 4 July from 0900-1700h. A total of 151 (73 males, 78 females) were branded with the letter "X" and a sequential individual number from 1 to 151 (e.g., the last pup had brand "X151"). Information on branded animals is available by contacting T. Loughlin at the NMML.

DISCUSSION

Although production at some sites decreased (Table 5), overall impressions are that pup counts showed signs of stability, as the number of pups counted at comparable sites in this survey (1929) was similar to that counted in 1998 (1999). Pups handled at rookeries visually appeared robust. Frequent observations by us of small capelin in nearshore areas, especially at Pinnacle Rock, suggest a high prey recruitment year that may augment prey availability. The two sites that had the greatest decreases represented a combined loss of only 100 pups, or about 25% (85 at

Atkins and 15 from Akun; but Atkins was likely an under count). The two sites showing increases were up only a combined 50 pups, or about 13% (Table 5). Thus there was a net change of about 50 pups less in 2000 compared to 1998 at the same sites. Considering that the reported pup counts are the average of three counts (all within 10% of the other), the overall count suggests no appreciable change in pup counts at these sites over the past 2 years.

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CITATIONS

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*). J. Mammal. 77(1):95-108.

Calkins, D. G., E. Becker, and K. W. Pitcher. 1998. Reduced body size of female Steller sea lions from a declining population in the Gulf of Alaska. Mar. Mammal Sci. 14(2):232-244.

Loughlin, T. R. 1997. Using the phylogeographic method to identify Steller sea lion stocks. p. 159-171. *In* A. Dizon, S. J. Chivers, and W. F. Perrin (editors), Molecular genetics of marine mammals. Special Publication #3 of the Society for Marine Mammalogy.

Merrick, R. L., T. R. Loughlin, and D. G. Calkins. 1996. Hot branding: a technique for long-term marking of pinnipeds. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-68, 21 p.

Merrick, R. L., R. Brown, D. G. Calkins, and T. R. Loughlin. 1995. A comparison of Steller sea lion, *Eumetopias jubatus*, pup masses between rookeries with increasing and decreasing populations. Fish. Bull., U.S. 94(4):753-758.

NMFS (National Marine Fisheries Service). 1992. Recovery plan for the Steller sea lion (*Eumetopias jubatus*). Prepared by the Steller Sea Lion Recovery Team for the NMFS, Silver Spring, Maryland. 92 p.

York, A. E., R. L. Merrick, and T. R. Loughlin. 1996. An analysis of the Steller sea lion metapopulation in Alaska. Chapter 12, p. 259-292. *In* D. R. McCullough (editor), Metapopulations and wildlife conservation. Island Press, Covelo, CA.

Table 4.--Summary of pups counted and handled during 20 June- 6 July 2000 in the central Aleutian Islands and Gulf of Alaska.

Parameter	Number of pups	
Live pups counted	2104	
Dead pups counted	62	(3% of all pups counted)
Pups handled	515	(256 males; 259 females)
Pups tagged	230	
Pups branded	258	
Scat samples	219	
Blood samples	113	
Genetic samples	76	

Table 5.--Count of live pups at rookeries in the Gulf of Alaska and Bering Sea during 20 June to 6 July 2000. Counts are the average of three counts at each site. (These data are provisional and should be used for reference only. Please do not cite or use without permission from T. Loughlin, NMML).

Rookery/haul site	Count	Date	Trend/Status	% change[a]	
Yunaska	136	21 June	decrease	-16	(161/1998)
Adugak	153	22 June	increase	+13	(135/1998)
Bogoslof	249	22 June	increase	+13	(220/1998)
Akun	41	23 June	decrease	-27	(56/1998)
Pinnacle	638	26 June	no change	0	(637/1998)
Whaleback	12	27 June	new count	N/A	
Atkins	262	28 June	decrease[b]	-25	(347/1998)
Lighthouse Rk	5	28 June	new count	N/A	
Chirikof	188	29 June	no change	0	(183/1998)
Marmot	no count	2 July	branded all day, see Chumbley et al.		
Sugarloaf	no count	4 July	branded all day, see ADF&G		
Outer	108	3 July	no change	0	(113/1998)
Fish	149	5 July	no change	0	(147/1998)
Chiswell	58	6 July	new count	N/A	

[a] Change from most recent survey (count/year)

[b] Atkins pup count is likely low; we avoided counting in some areas of the rookery to keep from pushing pups off a high rock ledge.

Table 6.--Tag number, weight, and measurements of Steller sea lion pups tagged at Atkins Island, Alaska, 28 June 2000. (These data are provisional and should be used for reference only. Please do not cite or use without permission from T. Loughlin, NMML).

Left Tag	Right Tag	Tag Color	Sex	Mass (kg)	Standard Length (cm)	Axillary Girth (cm)	Flipper Length (cm)	Genetic Sample Taken?	Blood Sample Taken?
851	851	white	m	32.4	110	74	40	y	n
901	901	white	m	23.8	104	65	38	y	y
902	902	white	m	28.0	106	71	39	y	n
903	904	white	m	30.8	109	72	39	y	n
(904 discarded)									
905	905	white	m	23.4	100	70	38	y	n
906	906	white	m	23.8	98	64	37	y	n
907	907	white	m	26.6	104	69	36	y	n
908	908	white	m	33.6	112	76	38	y	n
909	909	white	f	23.4	98	67	35	y	n
910	910	white	f	31.6	112	73	39	n	y
911	911	white	f	22.2	100	66	36	n	n
912	912	white	m	29.8	106	69	41	n	y
913	913	white	m	24.4	105	66	38	n	n
914	914	white	m	29.9	108	69	39	n	n
915	915	white	m	35.4	111	74	40	n	n
916	916	white	m	29.0	107	67	39	n	n
917	917	white	m	25.6	103	66	37	n	n
918	918	white	m	38.0	115	80	40	n	n
919	919	white	f	31.6	108	79	41	n	n
920	920	white	f	24.6	102	61	38	n	y
921	921	white	f	27.0	102	73	34	n	n
922	922	white	m	33.4	106	82	39	n	n
923	923	white	f	31.6	102	73	34	n	n
924	924	white	f	27.2	104	75	38	n	n
925	925	white	m	37.6	111	81	40	n	n
926	926	white	m	36.0	111	76	40	n	y
927	927	white	f	26.2	105	75	34	n	n
928	928	white	m	29.8	107	77	35	n	n
929	929	white	f	27.8	107	70	34	n	n
930	930	white	m	27.4	107	74	39	n	y
931	931	white	m	31.0	107	77	39	n	n
932	932	white	f	25.8	102	73	35	n	n
933	933	white	f	25.8	107	68	38	n	y
934	934	white	f	31.4	110	78	38	n	n

Table 6. Cont.

Left Tag	Right Tag	Tag Color	Sex	Mass (kg)	Standard Length (cm)	Axillary Girth (cm)	Flipper Length (cm)	Genetic Sample Taken?	Blood Sample Taken?
935	935	white	m	28.0	103	75	38	n	n
936	936	white	f	31.6	106	76	39	n	n
937	937	white	f	31.0	106	76	36	n	y
938	938	white	m	29.4	102	73	37	n	n
no tag			m	20.4	99	57	37	y	y

Table 7.--Tag number, weight, and measurements of Steller sea lion pups tagged at Adugak Island, Alaska, 22 June 2000. (These data are provisional and should be used for reference only. Please do not cite or use without permission from T. Loughlin, NMML).

Left Tag	Right Tag	Tag Color	Sex	Mass (kg)	Standard Length (cm)	Axillary Girth (cm)	Flipper Length (cm)	Genetic Sample Taken?	Blood Sample Taken?
1555	1555	red	f	23.4	97	67	34	y	y
1556	1556	red	m	29.4	99	71	37	y	n
1557	1557	red	m	37.4	103	80	42	y	n
1558	1558	red	f	24.2	100	67	34	y	y
1559	1559	red	f	29.4	101	70	36	y	n
1560	1560	red	f	23.2	96	69	36	y	n
1561	1561	red	f	22.2	101	62	36	y	n
1562	1562	red	m	28.4	95	71	39	y	n
1563	1563	red	f	25.0	100	67	39	y	y
1564	1564	red	m	26.4	94	71	40	y	n
1565	1565	red	m	37.2	105	77	42	n	n
1566	1566	red	m	28.4	108	72	36	n	y
1567	1567	red	f	19.8	83	65	32	n	n
1568	1568	red	m	25.2	93	71	37	n	n
1569	1569	red	f	28.6	96	73	38	n	n
no tag	1570	red	f	26.2	103	64	36	n	y
1571	1571	red	f	29.2	103	68	40	n	y
1572	1572	red	f	26.8	94	72	37	n	n
1573	1573	red	m	26.6	97	69	39	n	n
1574	1574	red	m	28.0	97	73	39	n	n
1575	1575	red	f	26.6	98	70	42	n	n
1576	1576	red	m	26.2	101	68	39	n	n
no tag	1577	red	m	41.4	117	77	42	n	y
1578	1578	red	m	25.2	100	69	37	n	n
1579	1579	red	m	31.6	109	71	35	n	y
1580	1580	red	m	31.0	102	77	36	n	n
1581	1581	red	f	27.2	100	69	37	n	n
1582	1582	red	m	32.0	104	72	38	n	n
1583	1583	red	m	41.4	118	80	39	n	y
1584	1584	red	m	25.0	105	66	35	n	y
1585	1585	red	f	22.4	90	63	37	n	n
1586	1586	red	f	28.0	101	70	36	n	n
1587	1587	red	f	23.0	97	65	36	n	n

Table 7. Cont.

Left Tag	Right Tag	Tag Color	Sex	Mass (kg)	Standard Length (cm)	Axillary Girth (cm)	Flipper Length (cm)	Genetic Sample Taken?	Blood Sample Taken?
1588	1588	red	f	26.2	100	70	36	n	n
1589	1589	red	m	38.2	107	83	41	n	n
1590	1590	red	m	31.6	105	76	37	n	n
1591	1591	red	f	31.2	105	80	38	n	n
1592	1592	red	m	37.4	105	82	39	n	n
1593	1593	red	f	25.8	101	70	36	n	n
1594	1594	red	f	32.2	109	73	36	n	n
1595	1595	red	f	31.6	107	77	36	n	n
1596	1596	red	f	21.2	91	65	36	n	n
1597	1597	red	f	27.6	98	74	38	n	n
1598	1598	red	m	39.2	111	79	37	n	n
1599	1599	red	m	32.4	103	80	35	n	n
1600	1600	red	f	33.8	107	75	35	n	n
1601	1601	red	m	30.2	102	77	36	n	n
1602	1602	red	m	33.6	104	75	42	n	n
1603	1603	red	f	25.8	97	71	35	n	n
no tag	no tag		f	1	92	64	33	n	n

Table 8.--Tag number, weight, and measurements of Steller sea lion pups tagged at Chirikof Island, Alaska, 29 June 2000. (These data are provisional and should be used for reference only. Please do not cite or use without permission from T. Loughlin, NMML).

Left Tag	Right Tag	Tag Color	Sex	Mass (kg)	Standard Length (cm)	Axillary Girth (cm)	Flipper Length (cm)	Genetic Sample Taken?	Blood Sample Taken?
939	939	white	m	26.8	101	66	35	y	y
940	940	white	f	26.2	98	70	36	y	n
941	941	white	m	19.0	96	65	25	y	n
942	942	white	m	38.0	112	77	42	y	n
943	943	white	f	19.0	98	62	37	y	y
944	944	white	m	23.0	99	62	49	y	n
945	945	white	m	31.8	107	71	40	y	n
946	946	white	m	25.0	99	71	39	y	n
947	947	white	m	27.8	108	71	35	y	n
948	948	white	m	25.8	104	54	34	n	y
949	949	white	m	22.8	97	67	37	y	n
950	950	white	m	19.4	92	63	39	n	n
951	951	white	m	29.8	111	74	34	n	y
952	952	white	m	34.0	108	71	39	n	y
no tag	no tag		m	18.4	97	64	35	n	n
no tag	no tag		f	17.4	89	61	34	n	n
no tag	no tag		f	14.8	89	57	33	n	n

Table 9.--Tag number, weight, and measurements of Steller sea lion pups tagged at Chiswell Island, Alaska, 6 July 2000. (These data are provisional and should be used for reference only. Please do not cite or use without permission from T. Loughlin, NMML).

Left Tag	Right Tag	Tag Color	Sex	Mass (kg)	Standard Length (cm)	Axillary Girth (cm)	Flipper Length (cm)	Genetic Sample Taken?	Blood Sample Taken?
954	954	white	m	33.4	109	74		n	n
955	955	white	m	32.2	105	70		n	n
956	956	white	f	28.4	103	71		n	n
957	957	white	m	27.2	106	66		n	n
958	958	white	f	26.4	103	65		n	n
959	959	white	m	29.8	106	70		n	n
960	960	white	m	29.4	107	65		y	y
961	961	white	f	26.6	101	65		n	n
962	962	white	m	36.0	113	72		n	n
963	963	white	m	40.2	117	74		n	n
964	964	white	m	38.6	113	74		n	n
965	965	white	f	32.0	108	71		n	n
966	966	white	m	35.8	110	74		n	n
967	967	white	m	36.0	111	72		n	n
968	968	white	m	41.4	118	78		y	y
969	969	white	m	37.0	109	70		n	n
970	970	white	f	28.8	108	66		n	n
971	971	white	f	29.0	107	68		n	n
972	972	white	f	28.2	108	65		n	n
973	973	white	f	33.0	107	73		n	n
974	974	white	f	30.8	106	69		n	n
975	975	white	m	39.0	116	80		y	y
976	976	white	f	19.8	95	63		n	n
977	977	white	f	30.0	105	71		n	n
978	978	white	m	33.4	112	72		n	n
979	979	white	f	32.6	108	67		y	y
980	980	white	f	29.8	102	67		y	y
981	981	white	f	31.6	108	71		n	n
982	982	white	f	32.2	112	72		n	n
983	983	white	f	38.3	106	67		y	y

Table 10.--Tag number, weight, and measurements of Steller sea lion pups tagged at Pinnacle Rock, Alaska, 26 June 2000. (These data are provisional and should be used for reference only. Please do not cite or use without permission from T. Loughlin, NMML).

Left Tag	Right Tag	Tag Color	Sex	Mass (kg)	Standard Length (cm)	Axillary Girth (cm)	Flipper Length (cm)	Genetic Sample Taken?	Blood Sample Taken?
852	852	white	m	35.2	106	78	35	n	y
853	853	white	m	34.8	108	75	35	n	y
854	854	white	f	26.8	104	67	38	n	n
855	855	white	m	38.2	108	84	44	n	n
856	856	white	f	30.6	101	75	38	n	n
857	857	white	m	32.2	110	71	38	n	y
858	858	white	f	29.0	99	75	36	n	n
859	859	white	f	30.4	103	75	36	n	n
860	860	white	f	25.2	100	69	35	n	y
861	861	white	m	29.6	102	71	41	n	n
862	862	white	f	33.3	111	72	40	n	n
863	863	white	m	30.4	105	72	32	n	y
864	864	white	f	28.0	103	69	38	n	n
865	865	white	m	28.4	107	70	39	n	n
866	866	white	m	29.8	104	71	40	n	n
867	867	white	f	29.8	107	69	35	n	n
868	868	white	m	34.4	107	72	35	n	y
869	869	white	m	35.6	111	75	37	n	y
870	870	white	m	39.0	115	77	42	n	n
871	871	white	m	36.8	106	80	37	n	y
872	872	white	f	30.2	107	67	36	n	y
873	873	white	f	32.8	105	74	37	y	y
874	874	white	f	25.8	104	66	35	y	n
875	875	white	m	32.2	108	76	37	y	n
876	876	white	f	27.0	103	70	40	y	n
877	877	white	f	26.6	100	73	37	y	n
878	878	white	f	20.8	98	63	38	y	n
879	879	white	f	30.0	103	74	36	y	n
880	880	white	f	22.4	100	67	39	y	n
881	881	white	m	32.6	106	70	38	y	n
882	882	white	f	41.6	114	82	42	y	n
883	883	white	f	30.8	103	75	39	n	n
884	884	white	f	34.6	103	75	38	n	n
885	885	white	f	25.6	102	68	36	n	n

Table 10 Cont.

Left Tag	Right Tag	Tag Color	Sex	Mass (kg)	Standard Length (cm)	Axillary Girth (cm)	Flipper Length (cm)	Genetic Sample Taken?	Blood Sample Taken?
886	886	white	f	29.8	109	71	35	n	n
887	887	white	f	28.8	101	70	37	n	n
888	888	white	m	38.2	109	81	38	n	n
889	889	white	f	23.0	88	66	38	n	n
890	890	white	f	24.8	97	71	39	n	n
891	891	white	f	29.4	102	73	40	n	n
892	892	white	f	28.0	102	70	37	n	n
893	893	white	m	33.0	103	73	41	n	n
894	894	white	m	33.6	105	77	39	n	n
895	895	white	f	30.2	104	70	37	n	n
896	896	white	m	36.4	107	77	39	n	n
897	897	white	f	27.4	100	75	36	n	n
898	898	white	f	26.0	97	67	37	n	n
899	899	white	m	39.0	105	81	38	n	n
900	900	white	m	35.0	106	82	38	n	n
no tag	no tag		f	15.4	79	58	33	n	n

Table 11.--Tag number, weight, and measurements of Steller sea lion pups tagged at Yunaska Island, Alaska, 21 June 2000. (These data are provisional and should be used for reference only. Please do not cite or use without permission from T. Loughlin, NMML).

Left Tag	Right Tag	Tag Color	Sex	Mass (kg)	Standard Length (cm)	Axillary Girth (cm)	Flipper Length (cm)	Genetic Sample Taken?	Blood Sample Taken?
1504	1504	red	m	24.0	101	70	45	y	n
1505	1505	red	f	23.0	99	66	35	y	y
1506	1506	red	m	23.8	101	70	42	y	n
1507	1507	red	f	24.8	100	71	41.5	y	n
1508	1508	red	m	31.4	110	85	42	y	n
1509	1509	red	m	24.6	105	64	32	y	y
1510	1510	red	m	20.8	94	59	36	y	n
1511	1511	red	f	20.6	98	60	42	y	n
1512	1512	red	m	23.8	96	69	42	y	n
1513	1513	red	m	28.6	107	69	38	y	n
1514	1514	red	m	34.8	105	81	42	n	n
1515	1515	red	m	24.8	99	65	40	n	n
1516	1516	red	f	26.0	99	69	39	n	n
no tag	no tag		f	17.6	96	54	31	n	n
1518	1518	red	m	27.0	105	67	38	n	y
1519	1519	red	m	33.6	102	78	43	n	n
1520	1520	red	m	29.0	102	75	40	n	n
1521	1521	red	m	30.4	104	77	41	n	n
1522	1522	red	f	22.8	102	67	39	n	n
1523	1523	red	m	30.4	108	71	39	n	y
1524	1524	red	f	29.8	103	79	39	n	n
1525	1525	red	m	23.8	97	68	35	n	n
1526	1526	red	m	34.8	108	76	38	n	n
1527	see 1529								
1528	1528	red	f	25.4	100	66	36	n	n
1529	1527	red	f	22.4	94	66	38	n	n
1530	1530	red	m	32.8	107	77	38	n	y
1531	1531	red	m	36.8	113	77	42	n	n
1532	1532	red	f	18.2	93	59	39	n	n
1533	1533	red	m	25.6	95	70	36	n	y/p
no tag	1534	red	f	32.0	100	77	37.5	n	n
1535	1535	red	f	21.6	86	67	35	n	n
1536	1536	red	f	22.4	92	63	38	n	n
1537	1537	red	f	29.0	97	76	39	n	n

Table 11 Cont.

Left Tag	Right Tag	Tag Color	Sex	Mass (kg)	Standard Length (cm)	Axillary Girth (cm)	Flipper Length (cm)	Genetic Sample Taken?	Blood Sample Taken?
1538	1538	red	m	28.0	108	72	43	n	n
1539	1539	red	m	28.6	102	67	39	n	y
1540	1540	red	f	23.0	98	65	35	n	n
1541	1541	red	m	26.4	103	70.5	38	n	n
1542	1542	red	f	24.0	102	62	37	n	y
1543	1543	red	f	27.4	105	71	39	n	n
1544	1544	red	f	22.0	103	65	30	n	n
1545	1545	red	f	25.4	100	70.5	38	n	n
1546	1546	red	f	25.2	96	68	40	n	y
1547	1547	red	m	25.2	100	68	37	n	n
1548	1548	red	m	35.0	106	78	38	n	n
1549	1549	red	m	32.0	107	74	41	n	n
1550	1550	red	f	30.6	102	67	36	n	y
1551	1551	red	f	27.4	102	70	39	n	n
1552	1552	red	f	17.2	92	60	34	n	n
1553	1553	red	f	25.8	99	66	36	n	y
1554	1554	red	f	23.8	100	66	36	n	n

STELLER SEA LION (*EUMETOPIAS JUBATUS*) DEMOGRAPHIC STUDIES AT MARMOT ISLAND, ALASKA JUNE-JULY 2000

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ABSTRACT

There has been a 70% overall decline in the number of Steller sea lions (*Eumetopias jubatus*) throughout most of Alaska since the 1970s. Surveys conducted since 1990 indicate that the current rate of decline is about 5% per year in the Gulf of Alaska and Aleutian Islands. The National Marine Fisheries Service and the Alaska Department of Fish and Game have conducted field studies of Steller sea lions on Marmot Island, Alaska, since 1979. Marmot Island is one of 15 trend sites and 4 trend rookeries used to identify population trends in the central Gulf of Alaska. Prior to the 1970s, Marmot Island was one of the largest Steller sea lion rookeries in Alaska. The number of non-pup (adults, sub-adults, and juveniles) sea lions observed there during the breeding season (late May to mid-July) has declined 94.1% since 1979 and the number of pups has declined by 91% during the same period. Demographic studies show that juvenile sea lions in the population declined from 15% of all non-pups during 1979, to 5% or less since 1987. Since 1979, four rookery sites on Marmot Island are no longer used for breeding or have been abandoned entirely. Declines in juvenile survival appear to be an important cause of the Steller sea lion population decline throughout Alaska including that at Marmot Island. Emigration and redistribution of animals have not generally been observed. Although current estimates of reproductive rates for adult females are unknown, the number of pups on rookeries relative to the number of adult females remains high, and pups on rookeries appear healthy.

INTRODUCTION

A 70% overall decline in the number of Steller sea lions (*Eumetopias jubatus*) has occurred throughout most of Alaska since the 1970s (Loughlin et al. 1992, Merrick et al. 1987, Sease et al. 1993, NMFS 1992, Sease and Loughlin 1999, and York et al. 1996). On 26 November 1990, Steller sea lions were listed as a threatened species under the U.S. Endangered Species Act (55 FR 49204). Surveys conducted since 1990 indicate a long-term decline in the Gulf of Alaska and Aleutian Islands (Merrick et al. 1991, Merrick et al. 1992, Sease et al. 1993, Sease et al. 1999, Sease and Loughlin 1999, and Strick et al. 1997). The Alaska population census data were gathered by aerial and ship-based surveys except at Marmot Island, where surveys were conducted from land. During the 1980s, rookeries on Marmot and Sugarloaf Islands (in the central Gulf of Alaska) were the largest with respect to pup production, producing approximately

40% of the total number of pups born annually (Calkins and Pitcher 1982).

Marmot Island has been the site of land-based research on Steller sea lions since the 1970s, primarily as a cooperative effort between the Alaska Department of Fish and Game (ADF&G) and the National Marine Fisheries Service (NMFS) (Chumbley et al. 1997). Research activities conducted on the island has included:

1. Daily counts by age (adult males, other males, females, juveniles, and pups) and sex groups.
2. Hourly counts of age and sex groups performed weekly from dawn to dusk.
3. Resighting of branded and tagged animals.
4. Recording of marine mammal/fishery interactions.
5. Recording presence of other marine mammals and wildlife.

This report summarizes summer field research conducted on Marmot Island from 23 June to 31 July 2000. Due to other field research commitments, studies began later in June than usual and continued later into July than in past years. Two field teams conducted demographic studies during the summer 2000 season: Kathryn Chumbley (NMML) and Julie Harper (contract) from 23 June to 15 July 2000 and Anne York (NMML) and Harvey Friedman (volunteer) from 14 July to 31 July 2000. Transportation to and from Marmot Island was provided by Maritime Helicopters from Kodiak, Alaska.

METHODS

Study Site

Marmot Island is located 45 km northeast of Kodiak Island and approximately 5 km off the easternmost shore of Afognak Island (Fig. 2). The Marmot Island rookery is defined as 58°14' N, 151°47' W to 58°10' N, 151°51' W (50 CFR 227.12). The island is 3,800 hectares with the highest elevation rising to 385 m.

Marmot Island includes several Steller sea lion rookery and haul-out beaches. Rookeries are sites where adult males defend territories, pups are born, and mating takes place. Haulouts are sites where sea lions predictably rest, but where few pups are born and mating typically does not occur (Calkins and Pitcher 1982, Loughlin et al. 1984). On Marmot Island, rookery and haul-out areas are located along on the southeastern side of the island (Fig. 2). Steller sea lion rookeries and haulouts in Alaska often are located on isolated rocky islands or outcrops. On Marmot Island, however, the rookery beaches are typically composed of black sand and cobble and are bordered by talus cliffs ranging in height from 50 m to over 300 m. In 1979, Aumiller and Orth (ADF&G[1]) described seven separate rookery and haul-out beaches on the island. Rookeries and haulouts were considered distinct sites if they were geographically isolated from adjoining beaches by natural barriers. Sea lion use of beaches has not remained constant over time; some rookeries have become haulouts while others have been abandoned altogether. Beach 4 is one of

[1]ADF&G, unpublished report, Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99518.

the major rookeries occupied by sea lions on Marmot Island, the only one observed consistently since 1979, and was the primary observation site during the 2000 study. The counts made at Beach 4 make up the longest and most continuous data set available for Marmot Island.

Composition Counts

As in past years, counts and observations of Steller sea lions were conducted during the breeding season. Observations were made from the edge of the cliffs overlooking each rookery or haul-out site. More than one overlook was required at several beaches due to natural obstructions or the length of the beach. Counts were made using binoculars or variable-power spotting scopes and recorded on hand tally counters. Generally, counts by age group and sex were made using binoculars while spotting scopes were used to look for branded and tagged animals. Spotting scopes were also used at beaches where counting was done from great distances (e.g., Beach 7), especially for counting pups.

Because counts were made from cliff tops, fog and low-lying clouds were the greatest potential obstacle to successful counts, especially at the higher observation posts (e.g., Beaches 4 through 7).

Typically, counts were conducted from early to mid-May through mid-July and include composition by age group and sex. During the 2000 breeding season, daily counts began on 25 June and ended on 30 July. Daily counts of sea lions were made at Beaches 1, 2, 3, 3Z, and 4, weather permitting. Daily counts were generally made between 1000 and 1600 ADT (Alaska daylight time) in an effort to coincide with peak abundance, although some counts were made as later than 1600 due to weather conditions (Withrow 1982). Weekly counts were made at Beach 7 on 30 June, 10 July, 19 July, 23 July, 25 July and 30 July 2000. When two observers were present, both observers counted simultaneously and independently. Counts were recorded for each observer.

Hourly counts were conducted at Beach 4 on 4 July and 12 July 2000. Counts were made each hour from dawn to dusk (0600 to 2300 ADT), weather permitting. On 4 July 2000 counts were terminated at 1900 hours due to heavy fog. On 12 July 2000 hourly counts were ended at 2200 due to low light conditions. Animals on the beach, as well as those lying or walking in the surf zone were counted; animals free-swimming in the water were not counted. Sea lions were tallied by the following age and sex classifications:

1. Territorial males - adult males (approximately age 8 years or older) actively maintaining a territory on a rookery.
2. Other adult males - adult or subadult males (approximately ages 5 to 8 years) not maintaining a territory on a rookery.
3. Adult females - (approximately age 4 years or older) based primarily on size, pelage color and characteristics, and frequently confirmed by the presence of a pup.
4. Juveniles - animals of either sex, smaller than adults but older and larger than pups of the year (ages 1 to 4 years), identified primarily by size, pelage color and characteristics, and behavior. The number of suckling juveniles was also recorded.
5. Pups - live pups of the year.
6. Dead pups.

Resighting of Branded and Tagged Animals

On 2 July 2000, 107 pups were branded at Beach 4 (Table 12). Brand resight information was collected on all branded pups and non-pups sighted throughout the June- July 2000 field season. These data were collected in conjunction with the daily census of Beaches 1 through 4 and weekly census of Beaches 5 through 7. Although branded animals were detected during counting, additional daily observation time was devoted solely to systematic searching for branded or tagged animals. Resightings of animals branded in other years and at other locations have been opportunistic, reported by biologists from numerous state and federal agencies, and by the general public.

RESULTS AND DISCUSSION

Composition Counts

Non-pup counts

The number and age group composition of sea lions varied between beaches during the summer 2000 breeding season. Beaches 2, 3Z, 5 and 6 had no animals present while Beach 1 was visited on several occasions by a lone animal. Beach 3 is a haulout containing males with no females present, however, branded pup T1 was observed there for several days before returning to Beach 4. Numbers of animals counted at Beach 3 ranged from 0 to 127 non-pups. Numbers of non-pups at Beach 4 continued to decline from previous years and ranged from 8 to 345 animals. At Beach 7 numbers of non-pups were higher than at Beach 4 ranging from 247 to 583 animals. After branding was conducted on Beach 4, an increase in the numbers of non-pups was observed at Beach 7. Numbers of juvenile sea lions at Beach 4 ranged from 0 to 18 animals and ranged higher at Beach 7 from 0 to 37 animals (Fig. 3).

Pup counts

During the 2000 breeding season, numbers of pups counted from cliff top observation stations at Beach 4 ranged from 0 to 233 pups and at Beach 7 from 145 to 307 pups (Fig. 3). No pups were present at Beaches 1, 2, 3, 3Z, 5 or 6, with the exception of a short visit by branded pup #T1 to Beach 3. In general, pups at Beaches 4 and 7 appeared healthy and mortality was low. However, the presence of foraging bald eagles and fox on the island may contribute to low numbers of dead pups seen.

Resighting of Branded and Tagged Animals

During the summer 2000 breeding season, six branded animals from the 1987 and 1988 cohorts were resighted at Marmot on Beaches 4 and 7; four were males and two were females. Of the four branded males, two had females present within their territories. Two branded adult females were resighted during the season, one with a pup and one without a pup. A branded male, F84, was resighted on Marmot Beaches 3, 3Z, 4 and 7 on ten occasions from 21-30 July 2000.

Newly branded pup mortality was low. Of the 107 pups branded on 2 July 2000 on Beach 4, 103 (96.3 %) were resighted after branding at least once during July on either Beach 4 or Beach 7

(Fig.5). Eleven (10.3 %) of the 107 branded pups, were never sighted with a female, and 3 (2.8%) were always sighted with a female but were not seen suckling. Of the 96 branded pups sighted with a female, 34 (31.8 %), were seen suckling at least once. Of the 107 pups branded on Beach 4 this season, 4 (3.7 %) have yet to be resighted and were listed as status "unknown". Two (1.9 %) were dead, however, one was identifiable as a branded pup but the brand number was unreadable due to the position of the animal on the beach. Therefore, this animal was listed as status "unknown" (Table 12). Daily resightings of branded pups at Beach 4 ranged from 0 to 81 animals while resightings at Beach 7 were more sporadic and ranged from 0 to 6 animals. The percent cumulative number of branded pups resighted on Beach 4 between 2 and 11 July ranged from 74-93% (Fig. 4).

The summer 2000 field season reintroduces branding research at Marmot Island as well as in the central Gulf of Alaska region. This work continues the research on known-age individually identifiable animals that began with the 1987 and 1988 cohorts. With the increase in numbers of non-pups at Beach 7, and the sighting of newly branded pups there, it will be important to closely monitor attendance at Beach 7 in addition to Beach 4 in the years to come. Valuable information from this work should contribute knowledge to Steller sea lion life history questions such as site fidelity, age and periodicity of reproduction, and survival.

ACKNOWLEDGMENTS

Pup branding work in July 2000 was directed by T. Loughlin (NMFS). K. Ono from University of New England and S. Melin (NMFS) provided valuable behavioral observation and brand resight advice. R. MacIntosh, C. Armistead, L. Chilton and others (NMFS Kodiak Fisheries Science Center) and K. Wynne (Alaska Sea Grant Kodiak) provided invaluable logistical support. K. Brennan of the Commercial Fisheries Division, Alaska Department of Fish and Game, Kodiak, Alaska, provided much appreciated radio contact. T. Walters of Maritime Helicopters provided air transport of personnel and field gear to and from Marmot Island. This work was authorized under NMFS permit 782-1532-00 and Marine Mammal Protection Act permit 782-1532-00.

CITATIONS

Calkins, D. G. and K. W. Pitcher. 1982. Population assessment, ecology and trophic relationships of Steller sea lions in the Gulf of Alaska, p. 447-546. *In* Environmental assessment of the Alaskan continental shelf. U.S. Dept. Commer. and U.S. Dept. Int., Final Rep. Prin. Invest. 19.

Chumbley, K., J. Sease, M. Strick, and R. Towell. 1997. Field studies of Steller sea lions (*Eumetopias jubatus*) at Marmot Island, Alaska 1979 through 1994. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-77, 99 p.

Loughlin, T. R., A. S. Perlov, and V. V. Vladimirov. 1992. Range-wide survey and estimation of total number of Steller sea lions in 1989. Mar. Mammal Sci., 83:220-239.

Loughlin, T. R., D.J. Rugh, and C. H. Fiscus. 1984. Northern sea lion distribution and abundance: 1956-80. J. Wildl. Manage. 48:729-740.

Merrick, R. L. , D. G. Calkins, and D. C. McAllister. 1992. Aerial and ship-based surveys of Steller sea lions in Southeast, Alaska, the Gulf of Alaska, and Aleutian Islands during June and July 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-1, 37 p.

Merrick, R. L., T. R. Loughlin, and D. G. Calkins. 1987. Decline in abundance of the northern sea lion, Eumetopias jubatus, in Alaska. 1956-86. Fish. Bull., U.S. 85:351-365.

Merrick, R. L., L. M. Ferm, R. D. Everitt, R. R. Ream, and L. A. Lessard. 1991. Aerial and ship-based surveys of northern sea lions, (*Eumetopias jubatus*) in the Gulf of Alaska and Aleutian Islands during June and July 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-196, 34 p.

NMFS (National Marine Fisheries Service). 1992. Recovery plan for the Steller sea lion (*Eumetopias jubatus*). Prepared by the Steller Sea Lion Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland, 92 p.

Sease, J. L. and T. R. Loughlin. 1999. Aerial and land-based surveys of Steller sea lions (*Eumetopias jubatus*) in Alaska, June and July 1997 and 1998. U.S. Dep. of Commer., NOAA Tech. Memo. NMFS-AFSC-100, 61 p.

Sease, J. L., J. M. Strick, R. L. Merrick, and J. P. Lewis. 1999. Aerial and ship-based surveys of Steller sea lions (*Eumetopias jubatus*) in Alaska, June and July 1996. U.S. Dep. of Commer., NOAA Tech. Memo. NMFS-AFSC-99, 43 p.

Sease, J. L., J. P. Lewis, D. C. McAllister, R. L. Merrick, and S. M. Mello. 1993. Aerial and ship-based surveys of Steller sea lions (*Eumetopias jubatus*) in Southeast Alaska, the Gulf of Alaska, and Aleutian Islands during June and July 1992. U.S. Dep. of Commer., NOAA Tech. Memo. NMFS F/NWC-17, 57 p.

Strick, J. M., L. W. Fritz, and J. P. Lewis. 1997. Aerial and ship-based surveys of Steller sea lions (*Eumetopias jubatus*) in Southeast Alaska, the Gulf of Alaska, and Aleutian Islands during June and July 1994. U.S. Dep. of Commer., NOAA Tech. Memo. NMFS-AFSC-71, 55 p.

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

York, A. E., R. L. Merrick, and T. R. Loughlin. 1996. An analysis of the Steller sea lion metapopulation in Alaska, p. 259-292. *In* Dale R. McCullough (editor), Metapopulations and wildlife conservation. Island Press, Washington, DC. 429 p.

Table 12.–Brand number, mass, measurements and resight status of pups branded on Beach 4 at Marmot Island, Alaska, July 2, 2000; (F = female; M = male; WF = seen with a female; NF = not seen with a female; S = seen suckling; U = unknown; D = dead).

Brand	Sex	Weight (kg)	Length (cm)	Girth(cm)	Status
T1	F	27.6	102	72	WF/S
T2	M	31.4	102	68	WF
T3	F	33.6	107	73	WF
T4	F	32.4	102	76	WF
T5	M	34.4	106	74	WF
T6	M	31.4	103	78	WF
T7	M	34.0	107	69	WF
T8	F	31.2	104	80	WF/S
T9	F	31.2	107	83	WF
T10	F	25.0	96	74	WF
T11	M	34.2	108	74	WF
T12	M	38.4	115	70	NF
T13	F	29.8	103	81	U
T14	M	32.4	109	74	WF/S
T15	M	40.0	115	79	WF
T16	F	25.8	99	69	NF
T17	M	40.8	110	83	NF
T18	F	29.4	101	75	WF/S
T19	M	41.2	116	84	U
T20	M	41.4	111	82	NF
T21	M	30.2	108	76	WF/S
T22	M	37.4	109	81	WF/S
T23	F	33.2	101	75	WF
T24	F	30.2	103	77	WF
T25	M	34.2	112	70	WF
T26	F	35.0	112	75	WF/S
T27	M	40.2	111	83	WF/S
T28	M	23.4	106	66	WF
T29	F	30.6	102	71	WF
T30	F	34.0	104	81	WF
T31	F	26.0	100	71	WF
T32	M	42.0	110	81	NF
T33	F	30.8	108	76	WF
T34	F	31.4	110	75	NF
T35	M	32.8	106	72	WF/S
T36	F	32.0	102	75	WF

Table 12.–Continued.

Brand	Sex	Weight (kg)	Length (cm)	Girth(cm)	Status
T75	M	34.2	106	80	WF/S
T37	F	31.6	104	74	WF
T38	F	23.2	99	67	U
T39	M	26.0	103	65	WF
T40	F	21.6	101	61	WF/S
T41	M	29.6	110	68	WF/S
T42	M	26.8	100	68	WF
T43	F	27.4	100	75	WF/S
T44	M	38.8	115	84	WF/S
T45	F	25.2	98	70	WF
T46	F	26.2	101	72	WF/S
T47	M	25.2	104	73	WF
T48	M	29.6	108	70	NF
T49	M	30.0	105	73	WF
T50	M	40.2	116	81	WF
T51	M	30.2	104	70	WF
T52	F	24.6	101	56	WF/S
T53	F	28.2	106	69	WF
T54	F	27.0	106	70	NF
T55	F	27.4	108	71	WF
T56	M	29.6	96	75	WF/S
T57	F	24.0	98	71	WF
T58	M	37.0	105	71	WF/S
T59	M	33.4	112	71	WF
T60	M	35.0	114	81	WF
T61	F	32.2	116	79	WF
T62	F	22.6	98	68	WF/S
T63	F	27.4	102	73	WF
T64	M	28.0	100	77	WF
T65	F	26.6	102	74	WF
T66	M	28.4	106	72	WF
T67	M	35.6	113	83	NF
T68	M	30.2	108	74	WF/S
T69	F	21.2	95	63	WF
T70	F	36.0	110	77	WF/S
T71	M	29.4	104	74	WF
T72	F	18.8	94	64	WF
T73	M	29.8	102	72	WF

Table 12.–Continued.

Brand	Sex	Weight (kg)	Length (cm)	Girth(cm)	Status
T74	M	32.6	110	77	WF/S
T76	M	40.8	114	80	WF/S
T77	M	38.0	120	76	WF
T78	M	36.0	110	78	WF
T79	F	27.2	101	70	U
T80	F	21.2	95	62	WF
T81	M	26.6	102	69	WF
T82	F	20.0	101	62	NF
T83	F	36.8	105	84	NF
T84	M	35.2	112	79	WF
T85	M	29.4	104	76	WF
T86	F	33.0	109	77	WF/S
T87	M	30.2	105	72	WF
T88	M	35.7	110	82	WF
T89	M	31.4	105	75	WF
T90	M	36.4	112	79	WF/S
T91	M	33.6	105	78	WF/S
T92	M	40.4	115	87	WF
T93	M	41.0	108	87	WF
T94	M	32.6	112	78	WF/S
T95	F	32.6	108	74	WF/S
T96	F	34.2	105	82	WF/S
T97	M	34.0	111	70	WF/S
T98	M	27.0	106	70	WF
T99	F	16.4	88	60	WF
T100	F	22.8	102	64	WF/S
T101	F	33.8	114	72	WF/S
T102	F	31.4	107	75	WF
T103	F	30.0	104	78	WF
T104	M	23.6	100	67	WF/S
T105	M	29.4	102	78	WF
T106	M	31.2	112	72	D
T107	F	23.7	95	70	WF/S

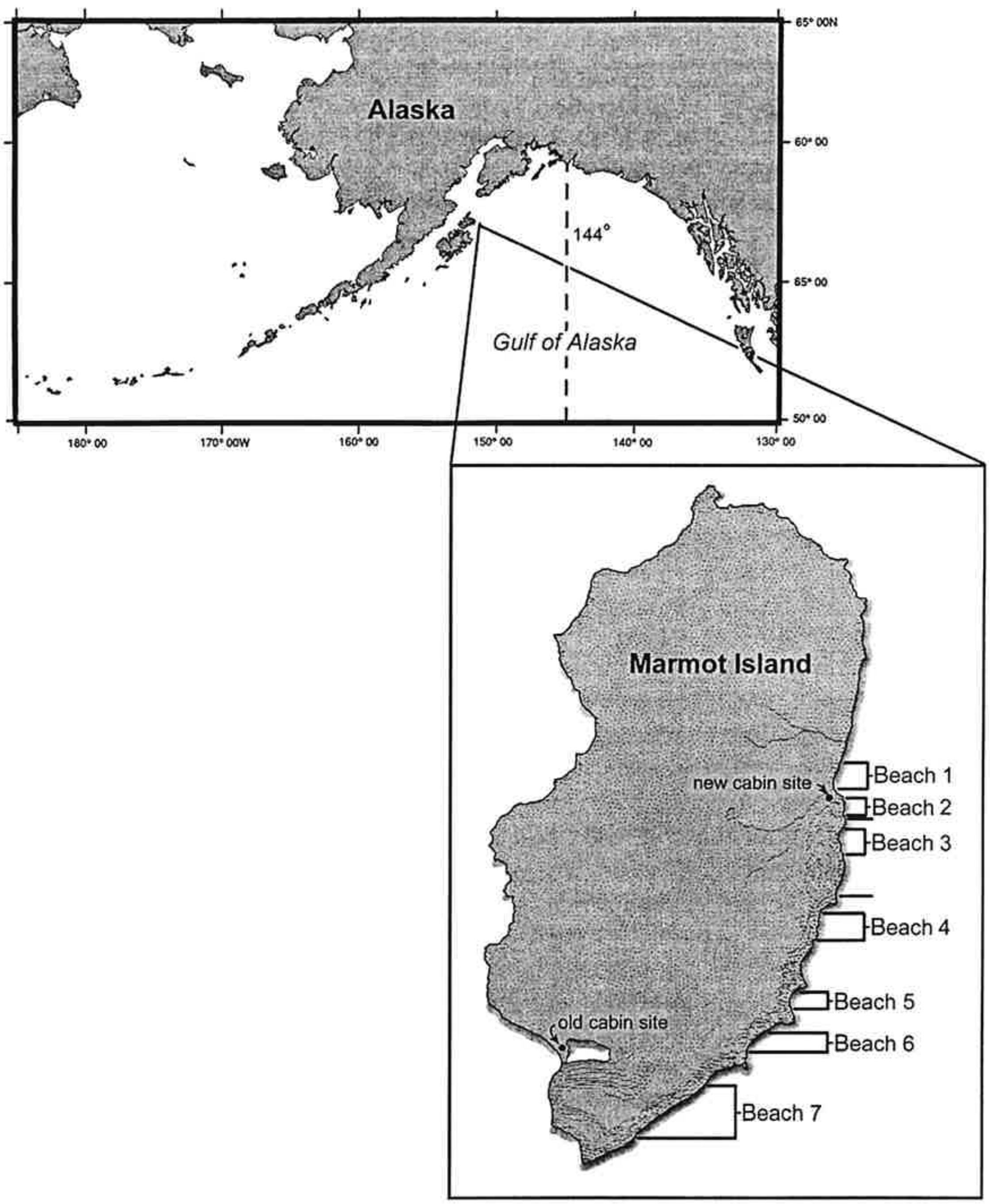

Figure 2.–Map of Marmot Island, Alaska, and the 144°W longitude separating the eastern and western stocks of Steller sea lions.

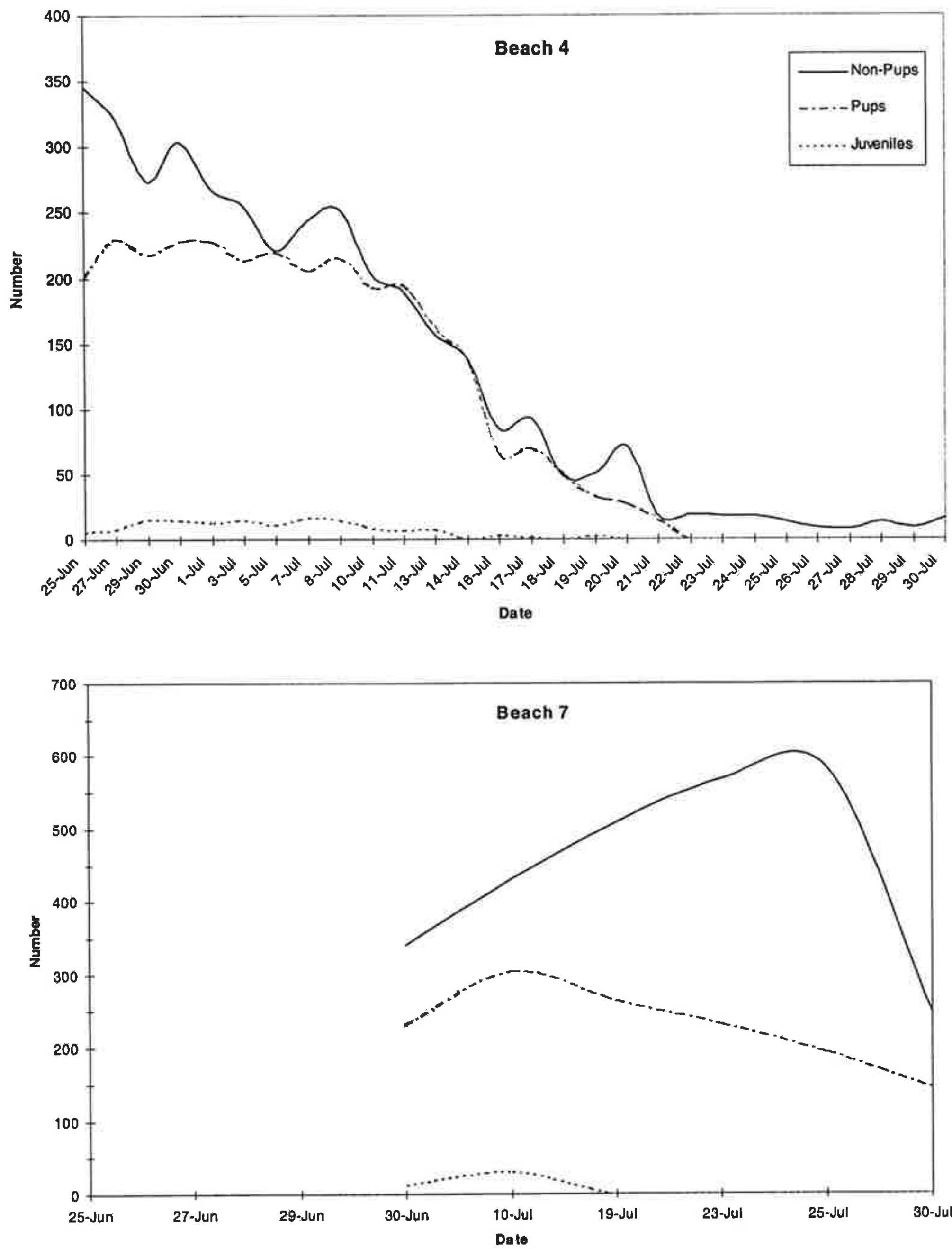

Figure 3.-- Numbers of nonpup, pup, and juvenile Steller sea lions counted at Beaches 4 and 7, Marmot Island, Alaska, June-July 2000.

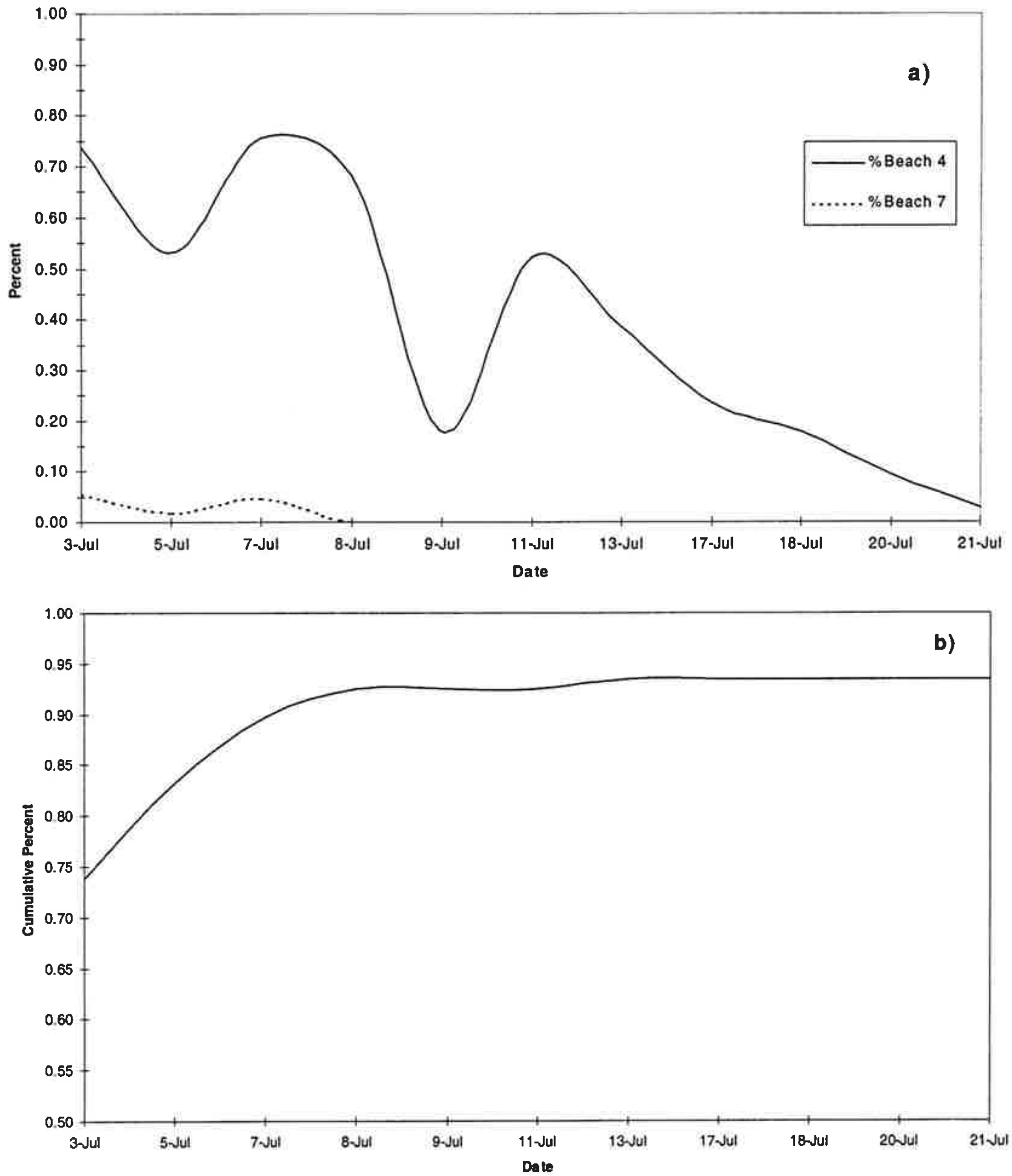

Figure 4.–Percent (a) and cumulative percent (b) of branded Steller sea lion pups resighted at Beaches 4 and 7, Marmot Island, Alaska, July 2000.

USING AGE-STRUCTURE TO DETECT IMPACTS ON THREATENED POPULATIONS: A CASE STUDY USING STELLER SEA LIONS[1]

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ABSTRACT

A slow response of population size to change is a common characteristic of long-lived species and presents one of the major challenges for their conservation. In contrast to population size, rapid age structure shifts in response to perturbations are well known. In this paper, matrix models were used to study transient spikes in age-structure as a tool for rapidly detecting the effects of management actions. The methods were applied to Steller sea lions, a long-lived endangered otariid found throughout the north Pacific Rim. For this species, it is impractical to measure age-structure in the field. A matrix model for Steller sea lions was used to develop surrogate stage-ratio metrics that would be both sensitive to survivorship changes and practical to measure in the field. These methods and metrics were tested for their ability to detect a known perturbation to survivorships and/or fecundity that occurred in the early 1980s and mid-1980s. Using historical aerial photographs taken during population censuses, historical changes in stage-ratios were estimated between 1985 and 1998. The observed changes strongly resembled the transitory spikes in age structure that occur after a large perturbation as predicted by the matrix model. The model was then fit to the observed changes in stage-ratios, pup numbers, and population sizes. The maximum likelihood fits corroborated previous evidence that declines in juvenile survivorship and adult fecundity drove the precipitous declines in the 1980s and a subsequent moderate increase in the same led to the lessened rate of decline in the 1990s.

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[1]Abstract of a manuscript submitted to *Conservation Biology* for review. Please contact the authors for additional information or reprints when available.

SIMULATED BRAND READING TEST

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INTRODUCTION

An experiment was designed to test different combinations of digits and letters which could be used for branding Steller sea lions. All brands were legible so as not to test the readability of the brands but rather the accuracy and recording of observers reading different combinations of letters and digits.

METHODS

Simulated brands were created electronically using Adobe Photoshop[1] and Microsoft PowerPoint software. Digital photos were taken of existing brands on a board and then modified in Photoshop to obtain a template of brand digits. Letters were taken from existing fonts in Photoshop. All letters and digits were scaled down to similar size to enhance consistency and readability. Four digit, letter schemes were used in the experiment. The first was simply 3 digits (ddd), second, a leading 'M' followed by 3 digits (Mddd), next was a leading 'M' followed by digit, letter, digit (Mdld), and the last combination was a leading 'M' followed by letter, digit, letter (Mldl). Not all letters of the alphabet were used because some characters have already been used in prior branding protocols some are more easily confused with other letters or digits.

A section of a photograph of Steller sea lion fur was cut from a digitized photo and used for a background on each slide of a PowerPoint presentation. Letters and digits were selected randomly using S+ to form 10 examples of each branding scheme. The combinations were made and then each was pasted somewhere on its own slide in the PowerPoint presentation for a total of forty slides. The order of the slides was then randomized so observers were not viewing one branding scheme at a time.

The large NMML conference room (Bldg. 4, Rm. 2039) was used for viewing the slides. Brands were small enough that they were not readable with the naked eye from the back of the room but were readable using binoculars. Observers volunteered, subject to availability, to participate in the experiment. Observers were each given a pencil, data form and binoculars to use for the experiment. Each observer was told that they would see a combination of letters and digits somewhere on the screen and the experiments protocol. Observers were given approximately 5 to 10 seconds to view each slide. Once the observer lowered the binoculars to

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[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

record their observations the slide was changed to the next brand slide. Once a slide had been viewed, there was no second chance to check for accuracy.

RESULTS

Twenty observers viewed the experimental slide show. Each observer viewed all 40 slides and only on one occasion was a brand not recorded. Eight observers recorded all brands correctly, 9 viewers recorded only one mistake, and single observers each made 2, 3, and 4 errors. Errors of 1 to 1.5% occurred for the ddd, Mddd and Mldl combinations and 5.5% error for Mdld (Table 13). Percent error was calculated as the number of brands recorded incorrectly divided by the total number of that branding scheme viewed (i.e., Mdld error = 11 mistakes / 200 slides viewed).

The data were modeled as a binomial distribution. The Null model was an average over all brand types. Next, brand type was considered as a factor (4 Level) and finally all brand types were collapsed with the exception of Mdld (2 Level). There was no difference between the 4 level model and the 2 level model (P = 0.870, Table 14). There was a significant difference between the Null model and 2 level model (P = 0.001, Table 14).

DISCUSSION

No difference between the 4 level and 2 level models indicates that there is no difference in the readability of brand types ddd, Mddd, and Mldl. The difference between the null model and the 2 level model signifies that brand type Mdld is different than the other brand types tested. These results are consistent with observer comments. Four observers commented that letter, number combinations caused confusion or were harder to read than straight digit combinations. Several commented that it was difficult to distinguish between '8' and 'B'. The leading 'M' was quite common and some observers said that after a few slides they assumed the leading character was 'M' if a leading letter was present. Observers had fewer errors with the Mldl combinations than the Mdld combinations; this was not consistent with their comments of confusion over mixed letters and digits. I hypothesize that the Mdld was more likely to be recorded incorrectly because people expect another digit between 2 other digits. People have a well practiced scheme for reading digits in order but not combinations of digits and letters. The Mldl scheme was not read in error as much perhaps because there was not a number pattern to misinterpret.

Table 13.–Brands, brand scheme and percent misread are listed below. Brand schemes are 3 digits (ddd), leading 'M' with 3 digits (Mddd), leading 'M' followed by digit, letter, digit (Mdld), and leading 'M' followed by letter, digit, letter (Mldl). Percent error is the number of times the brand was misread divided by the total number of observations.

Brand	Type	% Error	Brand	Type	% Error
139	ddd	0	M0U7	Mdld	0
539	ddd	0	M2A1	Mdld	0
553	ddd	5	M2X4	Mdld	0
592	ddd	5	M4U1	Mdld	20
735	ddd	0	M5E0	Mdld	15
788	ddd	0	M6C3	Mdld	5
856	ddd	0	M7J7	Mdld	5
935	ddd	0	M7J8	Mdld	0
943	ddd	0	M8T7	Mdld	5
964	ddd	0	M9J7	Mdld	5
All ddd		1.0	All Mdld		5.5
M243	Mddd	0	MA2X	Mldl	0
M264	Mddd	0	MA5R	Mldl	10
M337	Mddd	10	ME2P	Mldl	0
M368	Mddd	0	MJ5V	Mldl	0
M459	Mddd	0	MK4R	Mldl	0
M485	Mddd	0	MN0R	Mldl	0
M539	Mddd	0	MT4K	Mldl	0
M619	Mddd	0	MU8E	Mldl	0
M933	Mddd	0	MU8P	Mldl	0
M964	Mddd	0	MX8R	Mldl	5
All Mddd		1.0	All Mldl		1.5

Table 14.–Analysis of variance for comparisons of the models used on the outcome of the branding experiment. The Null model is an average of all the data modeled as a binomial. The 4 Level model is the same data with the brand type as a factor and the 2 Level model is the Mdld brands as one level and all other brand type as another level. Degrees of freedom (d.f.) and residual deviance (Resid. Dev.) are also presented. *P*-values represent the difference between the model and the model listed prior.

Model	d.f.	Resid. Dev.	P
Null	39	53.67	
2 Level (level 1 - ddd, Mddd and Mldl; level 2 - Mdld)	38	42.91	0.001
4 Level (ddd, Mddd, Mdld, and Mldl)	36	42.63	0.870

CAPTURE AND INSTRUMENTATION OF PUP AND JUVENILE STELLER SEA LIONS IN THE ALEUTIAN ISLANDS AND GULF OF ALASKA, FEBRUARY-MARCH 2000

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ABSTRACT

Scientists from the National Marine Fisheries Service's Alaska Fisheries Science Center, Colorado State University, and the University of Alaska Sea Grant Program captured pup and juvenile Steller sea lions (*Eumetopias jubatus*) in the Aleutian Islands and Gulf of Alaska during a cruise aboard the U.S. Fish and Wildlife Service's research vessel M/V *Tiĝlax̂* from 24 February through 15 March 2000. The primary objective of this expedition was to collect blood and other biological samples from juvenile and pup sea lions and to deploy satellite-linked time-depth recorders. Secondary objectives included estimating numbers of sea lions on individual haul-out sites, searching for tagged and branded sea lions, and going ashore at all accessible haul-out sites to collect sea lion scats for food habits analyses. We visited or observed 29 Steller sea lion haul-out sites from Lake Point, on southwestern Adak Island, to Flat Island in lower Cook Inlet. We captured of total of nine pup and yearling sea lions from Seguam Island, Aiktak Island in Unimak Pass, and Long Island, near Kodiak. Mean mass was 82.2 kg (SD=14.3, range 61.8–100.2 kg) for five females and 83.6 kg (SD=23.7, range 62.2–109.0 kg) for three males. We successfully obtained a tissue sample for genetic analyses and blood from all captured animals, and a blubber biopsy from seven animals. White-cell counts were very low for the two smallest pups. Two pups, including one with a low white-cell count, exhibited ulcers that may have been indicative of calici virus infection. In all other respects, captured animals appeared to be in good condition. We deployed satellite-linked time-depth recorders and VHF transmitters on eight of the nine captured sea lions, all except the smallest female pup from Seguam Island. We collected a total of 219 scats from nine different sites. We sub-sampled 58 of the scats for hormonal analyses.

INTRODUCTION

Scientists from the National Marine Mammal Laboratory (NMML), Colorado State University (CSU), and the University of Alaska Sea Grant Program (Appendix 1)conducted research on Steller sea lions (*Eumetopias jubatus*) in the Aleutian Islands and Gulf of Alaska from 24 February through 15 March 2000 aboard the U.S. Fish and Wildlife Service's research vessel M/V *Tiĝlax̂*. This work was part of the NMML's ongoing investigations of the feeding ecology and physical condition of pup and juvenile sea lions during winter. Juvenile survival is likely a key element in the continuing decline of the western stock of Steller sea lions (York 1994, NMML 1995), and it may be key to the recovery, as well. Assessing the condition, status, and foraging behavior of pups during winter, as they are weaned, and of juvenile sea lions that are foraging for themselves may provide the most direct means to understand this critical time in a sea lion's life (NMFS 1992).

The Final Recovery Plan for Steller Sea Lions (NMFS 1992) specified the need to identify habitat requirements and areas of biological significance for Steller sea lions and to investigate feeding ecology. A variety of telemetry instruments are available for these kinds of investigations (Merrick et al. 1994, Merrick and Loughlin 1997), but field work targeting Steller sea lions in the Aleutian Islands and Gulf of Alaska poses logistical difficulties. Rookery and haul-out sites typically are located on isolated islands and offshore rocks where access is difficult (Loughlin et al. 1987). Access is further hampered by poor weather, especially during winter. Capturing animals older than new-born pups is difficult; the likelihood of recapturing animals to remove recording instruments is low. For these reasons, satellite-linked time depth recorders (SLTDRs) are the only practical tool for following the movements of Steller sea lions during foraging trips and for monitoring diving behavior. Gross physical examination, including weights and measurements, and collection of tissue samples from individual animals provide the best information about the condition of animals. Clinical blood chemistries, in particular, are useful for assessing the gross physiological status of individual animals. Accordingly, the primary goals of this research cruise were to capture juvenile and pup sea lions for collection of blood and other biological samples and for deployment of SLTDRs. We concentrated our capture effort in three geographical regions: Seguam Island, the Krenitzen Islands and Unimak Pass, and eastern Kodiak. Secondary goals included estimating the numbers of sea lions on individual haul-out sites, searching those sites for sea lions tagged or branded during previous field operations, and going ashore at all accessible haul-out sites to collect sea lion scats (fecal material) for food habits analyses.

METHODS

The M/V *Tiĝlax̂* is a 121-foot (37-m) research vessel operated by the Alaska Maritime National Wildlife Refuge, U.S. Fish and Wildlife Service, in Homer, Alaska. The scientific party boarded the M/V *Tiĝlax̂* at Adak, Alaska, on 24 February and departed within a few hours. Personnel included six crew members and a scientific party of six (Appendix 1). The scientific party lived aboard the ship, traveling to shore in skiffs as weather and sea conditions allowed. All animal handling, collection of biological samples, and attachment of instruments took place on the beach. We brought scats and other biological samples back to the ship for preliminary work-up (blood) and storage.

We captured pup and juvenile sea lions using hoop nets (75 cm diameter with 135 cm handles), stalking as close as possible to the pups and then running after them in an attempt to catch them with hoop nets before they could flee into the water. This technique required adaptation and improvisation at each capture site to adjust to weather conditions (particularly wind direction), numbers of animals onshore, and physiography of the site, which affected potential avenues of approach and cover during stalking. At most, we attempted to capture two sea lions at one time. We used the capture nets both as a temporary holding device and as an aid for restraint during handling. When we successfully captured two animals, we held the second animal in the net by twisting the hoop to tie off the bag while we worked on the first. If the bagged animal was removed from the area of greatest activity, it usually remained reasonably quiet for the 60-70 minutes required to finish the first animal. A veterinarian administered a dose of Valium (1.1–2.0cc depending on the animal's estimated weight: 0.5 mg/kg at dilution of 5 mg/ml) to each animal about 10 minutes before we started handling it. Valium was used only to lightly sedate the animals to minimize struggling. This minimized the total handling time and seemed to reduce the stress experienced by the animals.

We employed several restraint methods and tools. We used a double-length automobile seat belt as a flipper restraint, pinning the animal's foreflippers against its torso. We then transferred the partially-restrained animal to a 85 x 160 cm weighing harness fitted with six sewn-in seat belts. The seat belts were locked and tightened to restrain the animal's head, torso, and hind flippers. Individual belts on the harness could be unbuckled and moved out of the way to facilitate drawing blood, attaching a SLTDR, or taking a blubber biopsy, then re-tightened. When all work on an animal was completed, the seat belts were easy to unfasten and clear out of the way, facilitating quick and easy release of the animal.

In most cases, we kept the animal's head enclosed in the capture net with the hoop positioned under its chest. The net offered handlers some protection from bites and seemed to calm the animal by restricting its vision and keeping its head in relative darkness. We also draped a folded piece of net (trawl net liner) over the animal's head, which offered additional protection to handlers and seemed to help calm the animals. We weighed each animal by suspending it (along with the harness, capture net, and restraining belts) from a portable tripod, later subtracting the weight of the harness and restraints.

We attached a satellite-linked time depth recorder (SLTDR: approximately 2.8 x 4.5 x 11.5 cm) to the hair over the mid-dorsal region, just anterior to the shoulders, using fast-curing epoxy adhesive. We glued a smaller VHF transmitter (approximately 2.0 x 2.5 x 6.0 cm) immediately behind the SLTDR. We deployed the VHF transmitters to allow us to detect the presence of an instrumented animal during our continuing work in the area and to aid in the recovery of SLTDRs when working in the same regions at a later date.

From each captured sea lion, we drew approximately 40 cc of blood from the pelvic venous plexus. We performed preliminary blood work-up in the laboratory onboard the ship, including serum and plasma extraction, hematocrit, and white cell counts. Samples retained for later analyses in the laboratory included frozen serum and plasma, hemoglobin preserved in reagent, and blood smears on slides. We collected a small sample of blubber from a surgical incision (approximately 2 cm long) at the base of the neck, 8-10 cm anterior to the telemetry instruments. The veterinarian injected lidocaine (1 cc of 2% solution) in a rosette around the biopsy site as a local anesthetic and to reduce bleeding. Incisions were sutured closed after the sample was removed. We removed a small (approximately 5 mm in diameter) sample of skin, punched from the webbing of the hind flipper, for genetic analyses. These samples were preserved in a saline/DMSO solution for future analysis of mitochondrial and nucleic DNA. We also applied plastic tags (Allflex® medium cattle ear tags) to the trailing edge of each foreflipper of each captured animals.

Whenever members of the scientific party went ashore at a sea lion haul-out site, we visually surveyed the sea lions onshore, both to estimate their numbers and to search for any animals branded or tagged during previous field operations. After all other on-site work was completed, we collected scats (fecal material) for food habits analysis. When appropriate, small sub-samples of scats were extracted and frozen for hormonal analyses. When weather or sea conditions prevented access to shore, we attempted to estimate numbers of animals while viewing from the ship or a skiff.

RESULTS

Cruise Conditions and Itinerary

Most of the cruise was conducted under storm- or gale-warnings, as a succession of low-pressure weather systems swept across the North Pacific and Bering Sea, bringing high winds and heavy seas. Several intended research sites were fully exposed to weather (e.g., southwest winds and seas washing directly onto Lake Point, Adak Island). Other sites may have been on the leeward sides of islands, but the lack of protection from surging waves made them unworkable on most days because the scientific party was unable to get ashore. In the relative protection of the Krenitzen Islands (Unimak Pass region), we constantly changed anchorages and target haul-out sites in reaction to changes in wind direction. Consequently, we spent much of our time at anchor in shelter when conditions precluded safe landings at sea lion haul-out sites, striving to be in position to go ashore and work when the weather did let up. This strategy worked well at Turf Point, Seguam Island.

Although we were able to land at haul-out sites in the Krenitzen Islands, captures were hampered by the predominantly southerly winds, which made down-wind capture approaches difficult or impossible. On several occasions, all animals spooked and departed from the haulout before a capture could be attempted. We were unable to get ashore at haul-out sites along the eastern coastline of Kodiak Island (Twoheaded Island, Cape Barnabas, Gull Point, Cape Chiniak) because of easterly winds and seas, but we did have one workable day at Long Island near Kodiak city and one day in the northern Kodiak Archipelago (Sea Otter Island and Latax Rocks). The approach of a severe winter storm caused us to curtail our work a day early. We concluded the cruise at Homer, Alaska, on 15 March. A day-by-day itinerary for the cruise is provided in Table 15.

In all, we visited 29 Steller sea lion rookery and haul-out sites, including multiple visits to five sites. Latitude and longitude for all sites are listed in Table 16. We went ashore at nine different sites; the only multiple landings were three visits at Aiktak Island in Unimak Pass. On one occasion, we went ashore but were unable to reach the haul-out site (Silak Island in Little Tanaga Strait), and three times we launched the skiff but were unable to get ashore (Lake Point on Adak Island, Jude Island, and the first visit to Basalt Rock). We collected a total of 219 scats: 13 from Seguam Island, 174 from the Krenitzen Islands (5 sites), and 32 from the northern Kodiak Archipelago (3 sites). We sub-sampled 58 of the scats for hormonal analyses. A site-by-site summary of counts and scat samples is included in Table 17.

Captures and Samples

We captured nine pup and yearling sea lions: five at Seguam Island (Turf Point: 4♀, 1♂), two at Aiktak Island (1♀, 1♂), and two at Long Island (2♂). Mean mass was 82.2 kg (SD=14.3, range 61.8–100.2 kg) for five females and 83.6 kg (SD=23.7, range 62.2–109.0 kg) for three males. Mean mass for all eight animals of both sexes was 82.7 kg (SD=16.6). We were unable to weigh one male (white 586: estimated to be 95-100 kg) due to struggling and the difficult position where he lay. This male probably was 21-22 months old, based on the length of his canine teeth. All others were pups of the year, approximately 9-10 months old. We deployed SLTDRs and VHF transmitters on eight of the nine captured sea lions, not attaching instruments to the smallest of the female pups captured at Seguam Island. We notified colleagues at NMML via e-mail immediately after SLTDR deployment, receiving confirmation within a few hours that each instrument was working and that each animal had shown some movement. Complete measurements, SLTDR identification numbers, and VHF frequencies for all captured animals are listed in Table 18.

We successfully obtained blood from all captured animals. Only the last animal (white tag 587, ♂) proved difficult to get a blood sample from, but we were able to get one large and one small (heparinized) tube of blood. The white-cell counts were very low for the two smallest pups (red tag 939, ♀, 61.8 kg, from Seguam Island; white tag 587, ♂, 62.2 kg, from Long Island). Dr. Terry Spraker (CSU) thought this could be an indication of viral infection. This small male also had ulcers on his foreflippers, possibly indicative of calicivirus infection. The largest female captured (red tag 942, 100.2 kg, from Aiktak Island) had an ulcer on her vulva that also may have been caused by calicivirus; however, her white cell count appeared within normal limits. We collected a genetic sample (flipper punch) from each captured animal, and a blubber biopsy from all five Seguam animals and both from Long Island The two animals at Aiktak Island were marginally restrained in an awkward setting and we decided to forgo biopsy. We also took a small biopsy from one of the smaller flipper ulcers on the male pup at Long Island (white tag 587).

Other Observations[1]

We collected a recently-aborted sea lion fetus on Sea Otter Island at the northern end of the Kodiak Archipelago. Judging from the overall condition of the fetus, Dr. Spraker estimated that it had been born a few hours prior to our arrival (but not during our capture attempt). Partial

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[1]A notable bird observation was of a male spectacled eider off the sea lion haulout on the Rocks Northeast of Tigalda, a site identified as "Kaligagan Rocks" by the Alaska Maritime Wildlife Refuge biologists. It is thought that most spectacled eiders winter in polynyas (large areas of open water surrounded by sea ice) in the Bering Sea near St. Lawrence and St. Matthew Islands. It is possible that the few sightings of these birds in the Aleutian Islands during winter is primarily a function of low observer effort.

inflation of the lungs implied that the pup had been born alive but had not survived more than 15-30 minutes. Dr. Spraker performed a post mortem examination onboard the ship and collected a full suite of formalin-preserved and frozen tissues for laboratory analyses (Appendix 2). We also collected blood from the fetus, which we worked up according to the same protocols as for the live pups.

We had only two resightings of tagged animals: red tag 961 at the rocks northeast of Tigalda on 4 March and red tag 995 at Aiktak Island on 6 March. Both were tagged as pups at Ugamak Island on 2 July 1998. We saw no branded sea lions during the cruise.

There were surprisingly few observations of other marine mammals during the cruise. We saw killer whales on only three occasions: two whales in Amukta Pass on 3 March, four whales in Tigalda Bay on 7 March, and five whales cruising adjacent to the docks and processing plants in Kodiak harbor on 12 March. We were unable to obtain photographs of any killer whales. On 3 March a group of six to ten Pacific white-sided dolphins rode our bow for several minutes along the north side of Akutan Island, near Unimak Pass.

DISCUSSION

The capture technique of using hand-held hoop nets on land has been rarely used in Alaska, especially during winter. It proved to worked very well, although the technique does require adaptation to the terrain at each site, and improvisation to cope with local weather conditions (particularly wind direction), and haul-out distribution of the animals. The Turf Point haulout on Seguam Island was the easiest and most productive site for capturing animals. In each of the last two years, the number of animals captured and handled was limited by the number of personnel available to work them up. We probably could have caught animals at Jude Island, as we did in 1999, but we decided not to attempt a landing due to deteriorating weather. Although we did successfully capture two animals at Long Island, this is not a very suitable site for future on-land net captures. The haulout is very steep and rocky. If animals are pushed gently, they can find their way carefully down the slope. When pushed suddenly, as during a hoop-net capture, they may crash into rocks in their haste to escape. Underwater lasso captures, as developed by the Alaska Department of Fish and Game, may prove more suitable at Long Island. On three occasions, we experimented with using the skiff immediately in front of the haulout to distract animals and drive them towards the capture team, who crept up from behind. This technique worked at Aiktak Island but resulted in near misses at Sea Otter Island and Latax Rocks.

The "full Nelson" belt and the six seat belts sewn into the weighing harness worked very well for restraining animals. Individual belts on the harness could be unbuckled and moved out of the way to facilitate drawing blood, attaching an SLTDR, or taking a blubber biopsy, then re-tightened. The valium also contributed to the success of the restraint system. Each animal struggled while we attached the various restraints, but calmed down quickly thereafter, under the combined effect of the tranquilizer, the physical restraint, and restricted vision. All animals lay still while we attached SLTDRs and took blubber biopsies; several appeared to sleep through much of the procedure, suggesting that we had successfully minimized the stress experienced by the animals.

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CITATIONS

Loughlin, T. R., M. A. Perez, and R. L. Merrick. 1987. *Eumetopias jubatus*. Am. Soc. Mammal. 238:1-7.

Merrick, R. L., and T. R. Loughlin. 1997. Foraging behavior of adult female and young-of-the-year Steller sea lions (*Eumetopias jubatus*) in Alaskan waters. Can. J. Zool. 75 (5):776-786.

Merrick, R. L., T. R. Loughlin, G. A. Antonelis, and R. Hill. 1994. Use of satellite-linked telemetry to study Steller sea lion and northern fur seal foraging. Polar Res.13:105-114.

NMFS (National Marine Fisheries Service). 1992. Recovery plan for the Steller sea lion (*Eumetopias jubatus*). Report to National Marine Fisheries Service, 92 p.

NMML (National Marine Mammal Laboratory). 1995. Status review of the United States Steller sea lion (*Eumetopias jubatus*) population. Prepared by the National Marine Mammal Laboratory, Alaska Fisheries Science Center, Seattle, Washington, 45 p.

York, A. E. 1994. The population dynamics of northern sea lions, 1975-1985. Mar.Mammal Sci. 10:38-51.

Table 15.--Day-by-day itinerary of the research cruise aboard the M/V *Tiĝlax̂* in the Aleutian Islands and Gulf of Alaska, 24 February to 15 March 2000.

Date	Location and activity
24 February	NMML scientific party arrived in Adak, boarded the *Tiĝlax̂* and departed for the Bay of Waterfalls, southwest Adak. En route, unable to land at Crone I. haulout. Anchored in the Bay of Waterfalls, Adak I.
25-27 February	Unable to land at Lake Point rookery because of prevailing SW wind and seas. Conditions not good for transit eastward. Anchored two days in the Bay of Islands, N of Lake Pt., and one more in the Bay of Waterfalls. Ca. 250-300 sea lions at Lake Point.
28 February	Again unable to land at Lake Point, weather okay to transit eastward. Unsuccessful landing at 2 haulouts in Little Tanaga Strait. Count sea lions at Chagul, Tagalak, Fenimore.
29 February	Turf Point, Seguam I., captured five sea lions (4♀♀, 1♂), attaching SLTDR and VHF transmitters to all except the smallest female.
1 March	Anchor at Korovin Bay, Atka, to hide from strong east winds, moving at night to Atka village when wind shifts west.
2 March	Forecast of wind and seas from west, highly unlikely that the relatively unprotected sites of Seguam I. through Yunaska were workable. Transit to eastern Aleutian Islands, looking at sites on the north side of Seguam I.
3 March	Pass by haulouts at Cape Aslik (Umnak), Bishop Point (Unalaska), and Billingshead (Akun). Only sea lions were on a haulout about 3 miles east of the Billingshead rookery beach. Anchor in Akun Bay.
4 March	Collect scats at Tanginak I., look at Basalt Rock and decide to leave it undisturbed for future capture attempt. Collect scats at the Rocks NE of Tigalda after unsuccessful capture attempt. Anchor in Tigalda Bay.
5 March	Morning at anchor in 50kt SE winds. Depart mid-day for Akun Bay anticipating shift to W wind. Attempt but unable to land on Basalt Rock.
6 March	Transit to Aiktak. Near capture misses at 2 different locations on Aiktak. Collect scats and return to Tanaga Bay to hide from 50 kt SE wind.
7 March	Close but unsuccessful capture attempt at Basalt Rock. 260-300 sea lions at 6 different locations around Billingshead, but none on the rookery beach and none in potential capture sites. Collect scats at Basalt and 2 Billingshead sites. Return to Tigalda Bay.

Table 15.–Continued.

Date	Location and activity
8 March	Sea lions at first site on NE side of Aiktak spook. Capture team stay ashore hoping sea lions will return. At 1420 capture male pup on ledge of main haulout. Attach SLTDR and VHF, collect scats. Remain anchored off Aiktak cabin site.
9 March	A few young sea lions remained on haulout ledge when we tried grappling for lost net. Returned with 2 people on shore and 2 in skiff. Caught female pup that was more afraid of the skiff than of the people on shore. Attached SLTDR and VHF and collected fresh scats. Depart for Jude I. after working up blood.
10 March	About 200 on Jude I. but abort capture attempt. Could have landed, but building wind and seas forecast difficulty getting off the very exposed and small island. Cruise by The Whaleback, Unga (Acheredin Point and Unga Cape).
11 March	Bucking into heavy seas and occasional strong winds out of NE. No chance to work sites between Shumagins and Kodiak as all are exposed to seas. Continue to Kodiak.
12 March	Leave anchorage in Kalsin Bay, Kodiak, for Long I. Sea lions on Long inaccessible from water. Arrange helicopter airlift from nearby beach. Capture pup/yearling and pup, fitting each with SLTDR. Tie up at Kodiak city dock overnight
13 March	Winds east 30 kts, run errands in Kodiak. Depart mid-day for north end of Afognak I., passing inaccessible sea lions on Marmot I. and Sea Lion Rocks en route.
14 March	Attempt captures at Sea Otter I. and Latax Rocks. Position of sea lions on haul outs and wind direction not entirely suitable for captures. Fresh fetus (premature birth) found on Sea Otter I.; collected complete suite of samples and blood for analyses. Anchor overnight in Koyuktolik Bay, Kenai Peninsula.
15 March	Conditions unworkable in Barren Is. and Elizabeth Is., depart for Homer, arriving by mid-day to conclude cruise.
15-17 March	Scientific party returns home.

Table 16.--Latitude and longitude for Steller sea lion haul-out sites in the Aleutian Islands and Gulf of Alaska visited during the research cruise, 24 February to 15 March 2000.

Site Name	Latitude			Longitude		
Crone Island	51	40.24	N	176	36.47	W
Adak Island-Cape Yakak	51	35.5	N	176	57.1	W
Adak Island-Lake Point	51	37.4	N	176	59.59	W
Little Tanaga Strait	51	49.09	N	176	13.9	W
Silak Island	51	48.9	N	176	14.8	W
Anagaksik Island	51	50.86	N	175	53.0	W
Tagalak Island	51	57.4	N	175	36.8	W
Fenimore Island	54	58.7	N	175	32.64	W
Oglodak Island	51	59.0	N	175	26.5	W
Seguam Island-Wharf Point	52	21.5	N	172	19.5	W
Seguam Island-Turf Point	52	15.55	N	172	31.2	W
Seguam Island-Saddleridge Rookery	52	21.0	N	172	34.0	W
Seguam Island-Finch Point	52	23.4	N	172	27.7	W
Umnak Island-Cape Aslik	53	25.0	N	168	24.5	W
Unalaska Island-Bishop Point	53	58.4	N	166	57.5	W
Akun Island-Billings Head	54	17.5	N	165	32	W
Akun Island-Akun Bay	54	12.8	N	165	24.3	W
Tanginak Island	54	12.0	N	165	19.395	W
Basalt Rock	54	6.45	N	165	22.533	W
Rocks NE of Tigalda Island	54	9.6	N	164	59.0	W
Aiktak Island	54	10.99	N	164	51.15	W
Ugamak Island-Ugamak Bay	54	12.82	N	164	47.11	W
Jude Island	55	15.75	N	161	6.27	W
Unga Island-Acheredin Point	55	7.24	N	160	49.04	W
Kupreanof Point	55	33.78	N	159	36.24	W
Sitkinak Island-Cape Sitkinak	56	34.3	N	153	50.96	W
Long Island	57	46.82	N	152	12.9	W
Marmot Island	58	11.5	N	151	48.3	W
Sea Lion Rocks (Marmot)	58	20.53	N	151	48.83	W
Sea Otter Island	58	31.15	N	152	13.3	W
Latax Rocks	58	40.1	N	152	31.3	W
Flat Island	59	19.8	N	151	39.75	W

Table 17.--Estimated numbers of Steller sea lions occupying each site and numbers of animals captured, total scats collected, and scats sub-sampled for hormonal analyses in the Aleutian Islands and Gulf of Alaska, February and March 2000.

					Numbers of			
Site	Day	Mon.	Time	Est. no. sea lions	captures	scats collected	scats sub-sampl.	Comments
Crone Island	24	Feb.	1910	30				could not land
Adak I.-Lake Point	25	Feb.	947	200-250				200 on rookery, 50 to S
Adak I.-Lake Point	27	Feb.	1150	250-300				250 on rookery, 50 to S
Adak I.-Cape Yakak	27	Feb.	1215	< 5				
Adak I.-Lake Point	28	Feb.	930	350				250 on rookery, 100 to S
Adak I.-Cape Yakak	28	Feb.	1030	10-12				
Little Tanaga Strait	28	Feb.	1345	75				
L.Tanaga Str./Silak	28	Feb.	1430	25-35				17 females, 8 pups, plus others
Chagul I.-Cape Kagalus	28	Feb.	1750	15				
Tagalak	28	Feb.	1830	80				
Fenimore	28	Feb.	1900	20				15+5
Seguam I.-Turf Point	29	Feb.	900	150-200?	5	13	0	4 SLTDRs deployed
Seguam I.-Saddleridge	2	Mar.	1430	0				
Seguam I.-Finch Point	2	Mar.	1517	4				
Seguam I.-Wharf Point	2	Mar.	1550	75				
Umnak I.-Cape Aslik	3	Mar.	800	0				10ft seas W25-30, HO awash
Unalaska I.-Bishop Point	3	Mar.	1320	0				10ft seas W25-30, snow, HO awash
Akun I.-Billingshead Rkry	3	Mar.	1850	0				no animals on rookery beach
Akun I.-Billingshead HO	3	Mar.	1855	10				on slab rock E of rookery bight
Tanginak	4	Mar.	845	155		11	2	115 on W side, 40 on E
Basalt Rock	4	Mar.	1024	70				did not go ashore
Rocks NE of Tigalda	4	Mar.	1215	40		33	7	unsuccessful capture attempt
Aiktak	4	Mar.	1445	100				in 4 spots, including boat landing

Table 17.–Continued.

Site	Day	Mon.	Time	Est. no. sea lions	Numbers of captures	Numbers of scats collected	Numbers of scats sub-sampl.	Comments
Ugamak Bay	4	Mar.	1500	10				on E side of bay
Akun Bay	5	Mar.	1700	7				
Aiktak	6	Mar.	920	125		17	9	25+60+40 EJs
Basalt Rock	7	Mar.	1200			25	5	unsuccessful capture attempt
Akun I.-Billingshead Rkry	7	Mar.	1430	0				
Akun I.-Billingshead HO	7	Mar.	1430	300		38	12	
Aiktak	8	Mar.	1420		1	38	6	no estimate of numbers, 1 capture
Aiktak	9	Mar.	945		1	12	4	no estimate of numbers, 1 capture
Jude	10	Mar.	820	200				did not land
Unga I.-Acheredin Point	10	Mar.	1010	80				75 + 5
Unga I.-Unga Cape	10	Mar.	1115	0				
The Whaleback	10	Mar.	1315	150+				could not see S side, total = 200 ??
Long	12	Mar.	1500		2	2	0	no estimate of numbers, 2 captures
Sea Otter	14	Mar.	840	40		23	10	unsucc. capture attempt, fresh fetus
Latax Rocks	14	Mar.	1245	100		7	3	unsuccessful capture attempt
Flat	15	Mar.	800	5				did not land
Total captures and scat samples					9	219	58	

Table 18.--Details of sea lions captured in the Aleutian Islands and Gulf of Alaska during 24 February to 15 March 2000. We successfully collected blood and a sample of flipper tissue for genetic analyses from each animal. Biopsies were of blubber, taken at the base of the neck, just anterior to the SLTDR.

Tag	Location	Date	Sex	Age	Mass (kg)	Std.L. (cm)	Curv.L. (cm)	Axil.G. (cm)	Flipper (cm)	Valium (cc)	Tetracy. (cc)	Biopsy	SLTDR	VHF
937 Red	Seguam/Turf Pt.	29 Feb.	F	P	87.0	151.0	160.0	108.5	46.0	1.5		Y	14111	164.903
Comments: Suckling just prior to capture.														
938 Red	Seguam/Turf Pt.	29 Feb.	F	U	85.8	157.0	162.0	108.0	46.5	1.5		Y	14114	164.297
Comments: Probably pup of the year.														
939 Red	Seguam/Turf Pt.	29 Feb.	F	P	61.8	138.0	149.0	90.5	45.0	1.5		Y	no	no
Comments: Low white-cell count - virus infection (??). Did not attach SLTDR or VHF.														
940 Red	Seguam/Turf Pt.	29 Feb.	F		76.2	148.0	155.0	102.5	49.0	1.5		Y	14116	164.200
941 Red	Seguam/Turf Pt.	29 Feb.	M	P	109.0	156.0	163.0	113.0	56.0	2.0		Y	14163	164.780
Comments: Canines not longer than incisors.														
946 Red	Aiktak	8 Mar.	M	P	79.6					1.1	4.0	N	14164	164.76
Comments: Tags destroyed not applied. Unable to take measurements, animal too mobile.														
942 Red	Aiktak	9 Mar.	F	P	100.2	155	164			2.0	4.0	N	14167	164.102
Comments: 1-mm ulcer on right lip of vulva - probably calici virus. Lengths not ideal because of animal's position and slope.														
586 White	Long	12 Mar.	M	P-1		150	165			2.0	4.0	Y	14170	166.24
Comments: Mass est. at 95-100 kg. Maybe yearling, canines extended past other teeth. Difficult to handle, not all measurements taken.														

Table 18.--Continued.

Tag	Location	Date	Sex	Age	Mass (kg)	Std.L. (cm)	Curv.L. (cm)	Axil.G. (cm)	Flipper (cm)	Valium (cc)	Tetracy. (cc)	Biopsy	SLTDR	VHF
587 White	Long	12 Mar.	M	P	62.2	145	150	90	47.5	1.5	4.0	Y	21094	164.83
Comments: 2-cm ulcer on left fore flipper, 2 smaller ulcers on right fore flipper, probably calici virus. Biopsy of ulcer on right. Hard to get blood only, 1 large and 1 small tube. Suckling just prior to capture. Low white-cell count - virus infection (??).														

Appendix 1. Personnel for the research cruise aboard the M/V *Tiĝlax̂* in the Aleutian Islands and Gulf of Alaska, 24 February to 15 March 2000.

Scientific Personnel	
John Sease (Party Chief)	NMFS, NMML, Seattle, WA
Jim Thomason	NMFS, NMML, Seattle, WA
Jeremy Sterling	NMFS, NMML, Seattle, WA
Kate Call	NMFS, NMML, Seattle, WA
Dr. Terry Spraker	Colorado State University, Fort Collins, CO
Kate Wynne	University of Alaska Sea Grant, Kodiak, AK
M/V *Tiĝlax̂* crew	
Kevin Bell	Captain
Tom Cunningham	Mate
Eric Nelson	Chief Engineer
Dan Ericson	AB, skiff driver extra ordinaire
Dan Peterbough	AB, skiff driver
Bob Ward	cook, AB

Appendix 2. Measurements and samples collected from a Steller sea lion fetus found at Sea Otter Island, 14 March 2000.

Specimen:	EJF-2001
Date:	14 March 2000
Site:	Sea Otter Island, Kodiak Archipelago, Gulf of Alaska
Position:	58° 31.15N, 152° 13.3W
Sex:	female
Curvilinear length	67 cm
Standard length	62 cm
Mass:	6.25 kg
Sternal blubber:	4 mm
Blood collected:	5 red top, 2 green top

General Comments:
Very fresh - only a few hours old
Slight congestion over pelvic region
Slight congestion & hemorrhage over skull
Lungs slightly inflated
No gross lesions
Thymus large and normal

Tissues Collected:

Frozen	In formalin	
umbilicus (2 whirl packs)	skin	vibrissa
blubber (in foil - 2 whirl packs)	umbilicus	eye (one)
muscle (2 whirl packs)	muscle	salivary gland
thymus	thymus	tonsil
lung (2 whirl packs)	lung	thyroid gland
heart	heart	tongue
liver (3 whirl packs)	diaphragm	brain
spleen (2 whirl packs)	kidney	spinal cord
kidney (2 whirl packs)	liver	nasal turbinate (one side)
small intestine	spleen	aorta
fore flipper	adrenal gland	
stomach and small intestine	pancreas	
eye (one)	ovaries and uterus	
brain	small intestine	
meconium (in large intestine)	bladder	
nasal turbinates (1 side)	sternum	
stomach contents (liquid)	fore flipper tip	

SEASONAL DIET TRENDS AMONG THE WESTERN STOCK OF STELLER SEA LIONS (*EUMETOPIAS JUBATUS*)[1]

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This study is based on scat (fecal) material collected throughout the 1990s on rookeries and haulouts across the range of the U.S. western stock of Steller sea lions. It is the first study to evaluate long-term regional trends in Steller sea lion diet and document long-term diet trends during winter months, a time considered to be important for juvenile survival.

Steller sea lion scats were collected (1990-1998) from 31 rookeries (May-September) and 31 haul-outs (December-April) across the U.S. range of the western stock resulting in a sample of 3,762 scats with identifiable prey remains. Fish (bones, scales, otoliths) and cephalopod (beaks) remains were identified using reference collection specimens and the relative 'importance' of each prey species was based on their frequency of occurrence (FO). Frequency of occurrence is calculated by dividing the number of scats in which a prey item occurred by the total number of scats that contained identifiable prey. Frequency of occurrence values combined across years, seasons, and sites depict walleye pollock (*Theragra chalcogramma*) and Atka mackerel (*Pleurogrammus monopterygius*) as the two dominant prey species, followed by Pacific salmon (Salmonidae) and Pacific cod (*Gadus macrocephalus*). Other primary prey species consistently occurring at frequencies of 5% or greater included arrowtooth flounder (*Atheresthes stomias*), Pacific herring (*Clupea pallasi*), Pacific sand lance (*Ammodytes hexapterus*), Irish lord (*Hemilepidotus* sp.), and cephalopods (squid and octopus). Species that occurred among the top three prey items on select islands included: snailfish (Liparididae), rock greenling (*Hexagrammos lagocephalus*), kelp greenling (*Hexagrammos decagrammus*), sandfish (*Trichodon trichodon*), rock sole (*Lepidopsetta bilineata*), northern smoothtongue (*Leuroglossus schmidti*), skate (Rajidae), and smelt (Osmeridae).

Sites where the frequency of occurrence of prey species were most similar were identified using Principal Components and Agglomerative Hierarchical Cluster Analysis resulting in regions of diet similarity. These newly defined diet regions were used to compare regional and seasonal differences in prey. The diet divisions closely parallel those defined as metapopulations based on patterns in population decline by York et al. (1996). To be consistent, the regional names defined by York et al. (1996) are used here.

Chi-square analysis demonstrated significantly ($P = 0.01$) strong seasonal patterns in diet within each of the defined diet regions (island groupings as defined by cluster analysis). Pacific cod FO was significantly larger in winter in every region. Salmon FO was significantly lower

[1]This is an abstract from a manuscript being submitted to the *Journal of Mammalogy*, and contents are therefore subject to change. Please contact the authors for citation permission.

during winter in the western Gulf of Alaska through the eastern Aleutian Islands, and higher in winter throughout the central and western Aleutian Islands. In the western Gulf, where arrowtooth flounder is most abundant in scats and well represented year-round, its FO was significantly lower in winter. Atka mackerel was significantly lower in the winter in the central and western Aleutians where it is the dominant prey species year-round. Forage fishes (herring and Pacific sand lance) were significantly different between seasons; however, there was no general trend among the regions. Walleye pollock was an important prey year-round in all regions up to the central Aleutian Islands where it is replaced by Atka mackerel. Likewise, cephalopod FO was not significantly different between seasons in any region. Irish lord FO was generally higher in winter than in summer. Though rarely occurring during summer and not included in the Chi-square analysis, sandfish and snailfish have relatively high occurrences during the winter across all regions.

Based on the prey matrix described here and in earlier studies (Fiscus and Baines 1966, Pitcher 1981, Calkins 1998) Steller sea lions specialize feeding throughout the water column in the epipelagic (herring), demersal (arrowtooth flounder), and semi-demersal (pollock, Atka mackerel) zones. While the size of prey consumed undoubtedly varies with the age and sex of sea lion sampled, the remains of primary prey represented in this study are largely from adult fish (Zeppelin et al. *in prep*). The seasonal and regional patterns in prey consumption by Steller sea lions presented in this study, along with known distributions of their primary prey, indicate that Steller sea lions target prey when they are densely schooled in spawning aggregation near shore (over or near the continental shelf) or along oceanographic boundary zones. This is true in summer when collected scats are primarily from adult females, and in winter when scats are presumably from some increased proportion of juveniles and adult males as well as females.

Based on the close parallel of these data with those of metapopulation patterns of decline (York et al. 1996), we suggest that regional diet patterns reflect regional foraging strategies learned at or near the natal rookery site on seasonally dense prey patches characteristic of that area. These data do not reflect Steller sea lion diet during periods when they are foraging at distant pelagic feeding sites, nor do they reflect diet outside the range of the U.S. western stock.

CITATIONS

Calkins, D. G. 1998. Prey of Steller sea lions in the Bering Sea. Biosphere Conservation 1(1):33-44.

Fiscus, C. H. and G. A. Baines 1966. Food and feeding behavior of Steller and California sea lions. J. Mammal. 42:218-223.

Pitcher, K. W. 1981. Prey of the Steller sea lion, *Eumetopias jubatus*, in the Gulf of Alaska. Fishery Bulletin, US, 79:467-472.

York, A. E., R. L. Merrick, and T. R. Loughlin. 1996. An analysis of the Steller sea lion metapopulation in Alaska, p. 259-292. *In* Metapopulations and Wildlife Conservation and Management (D. McCullough, ed.). Island Press, Covelo, California, 432 pp.

Zeppelin, T. K., K. A. Call, and T. Orchard. *In prep*. Size of prey consumed by Steller sea lions (*Eumetopias jubatus*) in the Gulf of Alaska and Aleutian Islands.

THE USE OF FATTY ACID SIGNATURE PROFILES TO OBTAIN DIETARY AND OTHER INFORMATION FROM OTARIIDS

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INTRODUCTION

The potential of using the fatty acid composition of marine mammal blubber as a tool to determine diet (Borobia et al. 1995, Iverson et al. 1997, Dahl et al. 2000, Walton et al. 2000) and to identify populations (Grahl-Nielsen and Mjaavatten 1995) has been examined extensively. However, fatty acid studies have targeted mostly cetaceans and North Atlantic Ocean phocids. Similar information is largely unavailable for otariids and their prey, particularly in the North Pacific Ocean and Bering Sea. Previous studies have shown considerable variation in the fatty acid profiles for prey and predators, but many factors other than diet (e.g., gender, age, and lactation) can also contribute to an animal's fatty acid signature (see Grahl-Nielsen and Mjaavatten 1991). The role of diet in affecting the blubber fatty acid composition of otariids, relative to these other factors, needs to be understood before this technique can be used as a definitive indicator of their diet.

This study was designed to address the factors affecting fatty acid signatures through a three-year collaboration between the National Marine Mammal Laboratory (NMML) and the Auke Bay Laboratory (ABL) of the NMFS/AFSC. The first year was used for development of sampling techniques and collection of northern fur seal tissues for preliminary testing. The second and third years were focused on developing fatty acid profiles for blubber collected from juvenile male and female northern fur seals St. Paul Island, AK. Three body locations and two depths were tested to assess the best body areas from which to collect tissue on an otariid. Similar work will be completed on northern fur seal prey and fur seals from St. George Island, AK. The accessibility of samples from northern fur seals led to their use for this pilot study, and subsequently developed techniques will be readily adaptable to address hypotheses regarding Steller sea lion diets.

METHODS

Fur seal blubber was collected in 1997 during the annual harvest on the Pribilof Islands. Blubber samples were collected from 16 juvenile males and 3 females on St. Paul Island and from 18 juvenile males on St. George Island. Each animal was sampled in three locations: neck, pelvis and shoulder. All samples were subsequently cut in half, and surface and deep layer blubber analysis was performed on all tissues. Utilizing the 164 blubber samples from animals from St. Paul Island, all lipids were initially extracted using a modification of Folch's method as outlined in Christie (1989). The non-polar lipid composition of the samples were then analyzed with high performance liquid chromatography (the HPLC method; see Christie, 1989), and the fatty acid composition was determined using a gas chromatograph equipped with a mass selective detector (GC/MS). Blubber from the juvenile males from St. George Island has been prepared and is currently stored at -40 °C awaiting fatty acid composition analysis.

A total of 95 fur seal prey items from six species of fish and squid were collected in trawls by National Marine Fisheries Service (NMFS) research cruises in the Bering Sea during summer of 1997. Prey items were frozen whole upon collection, processed for analysis, and are being held at -40 °C awaiting final analysis.

Statistical analysis was used to compare fatty acid and non-polar lipid contents between sexes and blubber layers, and among body locations and individuals. Differences in the non-polar lipid content of the entire blubber layer and between the three body locations were examined using analysis of variance (ANOVA). Statistical analysis to compare fatty acid compositions of blubber from St. Paul Island animals followed the procedures of Grahl-Nielsen (1999) using soft independent modeling by class analogy (SIMCA) (Wold and Sjöström 1977) with SIMCA-P version 8.0 from Umetrics AB[1]. SIMCA is a multivariate technique based on principal components analysis (PCA). In addition, fatty acid compositions will be analyzed following the procedures of Smith et al. (1997; 1999) using classification and regression tree analysis (CART).

RESULTS AND DISCUSSION

Data interpretation and statistical analysis of blubber from northern fur seals on St. Paul Island has begun, and will continue in the upcoming year with the addition of juvenile males from St. George Island and corresponding prey items. Preliminary results indicate no differences between areas or depths sampled. In addition, both juvenile male and female samples show a high level of wax esters and a high level of non-extractable dry weight in the blubber indicating that fur seal fat is high in protein. Non-polar lipid content appears highly variable among individuals and between sexes. The samples from females may have been overly influenced by the inclusion of a post-parturient female (female C) whose non-polar lipid content was especially low. Non-polar lipid content also varied with body location of sampled blubber in the juvenile males, with pelvic samples having the highest content and shoulder samples containing the lowest content. Pelvic samples were the best overall indicators of overall mean non-polar lipid content for individuals. There were no differences in non-polar lipids between inner and outer layers of blubber.

All juvenile males had unique fatty acid compositions, and the PCA models successfully discriminated between samples from different individuals 100% of the time. Female C had a distinct fatty acid composition from the two nulliparous females and all of the juvenile males. Juvenile males and the two nulliparous females overlapped in their fatty acid compositions, with only neck samples correctly classifying the sexes separately. The PCA models indicated that

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[1]Use of this trademark does not imply endorsement by the NMFS/NMML/AFSC

neck, shoulder, and pelvic samples had fatty acid compositions that were not distinguishable from each other. However, when a model was built using the fatty acid compositions of the inner and outer layers of a particular set of samples (i.e. neck), and the corresponding set of entire blubber layers was applied to that model, the PCA model correctly identified the sample location 100% (neck) and 93.8% (shoulder and pelvis) of the time. Thus, a model created to predict a particular tissue did so with a high degree of accuracy. Finally, the models indicated that there was no difference in fatty acid compositions between outer and inner blubber layers.

Non-polar lipid and fatty acid compositions of the prey items and blubber from animals collected on St. George Island is underway with expected completion within the upcoming year.

CITATIONS

Borobia M., P. J. Gearing, Y. Simard, J. N. Gearing, and P. Béland. 1995. Blubber fatty acids of finback and humpback whales from the Gulf of St. Lawrence. Mar. Biol. 122:341-353

Christie W. W. 1989. Fatty acids and lipids: structures, extraction and fractionation into classes, p. 27-30. *In*: Gas Chromatography and Lipids. The Oily Press Ltd., Dundee, Scotland.

Dahl, T. M., C. Lydersen, K. M. Kovacs, S. Falk-Petersen, J. Sargent, I. Gjertz, and B. Gulliksen. 2000. Fatty acid composition of the blubber in white whales (*Delphinapterus leucas*). Polar Biol. 23:401-409.

Grahl-Nielsen, O. 1999. Comment: Fatty acid signatures and classification trees: new tools for investigating the foraging ecology of seals. Can. J. Fish. Aquat. Sci. 56:2219-2223.

Grahl-Nielsen, O., and O. Mjaavatten. 1991. Dietary influence on fatty acid composition of blubber fat of seals as determined by biopsy: a multivariate approach. Mar. Biol. 110:59-64.

Grahl-Nielsen, O., and O. Mjaavatten. 1995. Marine mammalian fatty acids: a source of information, p. 141-152. *In* Blix A.S., L. Walløe, Ø. Ulltang (editors), Developments in Marine Biology 4: Whales, Seals, Fish and Man. Amsterdam. Elsevier Science.

Iverson, S. J., K. J. Frost, and L.F. Lowry. 1997. Fatty acid signatures reveal fine scale structure of foraging distribution of harbor seals and their prey in Prince William Sound, Alaska. Mar. Ecol. Prog. Ser. 151:255-271.

Smith, S. J., Iverson, S. J., and W. D. Bowen. 1997. Fatty acid signatures and classification trees: new tools for investigating the foraging ecology of seals. Can. J. Fish. Aquat. Sci. 54:1377-1386.

Smith, S. J., S. J. Iverson, and W. D. Bowen. 1999. Reply: Fatty acid signatures and classification trees: new tools for investigating the foraging ecology of seals. Can. J. Fish. Aquat. Sci. 56:2224-2226.

Walton, M. J., R. J. Henderson, and P. P. Pomeroy. 2000. Use of blubber fatty acid profiles to distinguish dietary differences between grey seals *Halichoerus grypus* from two UK breeding colonies. Mar. Ecol. Prog. Ser. 193:201-208.

Wold, S., and M. Sjöström. 1977. SIMCA: A method for analyzing chemical data in terms of similarity and analogy. Am. Chem. Soc. Symp. Ser. 52:243-282.

METHODS TO DETERMINE GENDER AND MITOCHONDRIAL DNA HAPLOTYPES OF STELLER SEA LIONS FROM FECAL SAMPLES

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INTRODUCTION

Fecal samples, or scats, provide valuable information about the food habits of pinnipeds. For Steller sea lions, these samples can be used to characterize their general diet, and also the diet of sea lions at particular locations and over time. In addition to containing identifiable prey parts, scats also contain small quantities of the sea lion's DNA, which makes them a valuable source of information for studies of conservation genetics and behavioral ecology.

I have developed methods that use DNA from Steller sea lion fecal samples for identification of gender and mitochondrial haplotypes. Gender determination provides an indication of the sex composition at sites where the scats were collected. This information can be applied to diet studies and provides insight on the spatial and temporal distribution of the sexes. Combined with prey identification from fecal samples, gender determination will also allow the examination of sex-specific diet. Analysis of mitochondrial haplotypes from fecal samples allows for a non-invasive approach to the population genetics of the species and will help determine if broad-scale movements occur during winter.

METHODS

Fecal samples were collected from rookeries and haulouts in the Aleutian Islands and the Gulf of Alaska during March (n = 227) and June (n = 99), 1999 and then subsampled for molecular work. Samples were either frozen or stored in 95% ethanol. DNA was extracted using the Qiagen DNEasy Kit (Qiagen, Inc).

Gender Determination

Gender identification was accomplished using the polymerase chain reaction (PCR) to amplify DNA sequences located on the mammalian protein encoding genes ZFX/Y (the zinc finger genes) and SRY (the sex-determining region Y gene). Three primer pairs were chosen for gender identification in this study. The first pair, P1-5EZ and Mardon (Aasen and Medrano 1990, Mardon et al. 1990), is specific to the ZFX/Y genes and amplifies male and female DNA. The second pair, SRY41 and SRY121 (Taberlet et al. 1993) and third pair (Richard et al. 1994) are specific to different regions of the SRY gene and amplify male DNA. After amplification, the PCR products were resolved by electrophoresis on polyacrylamide gels, and scored (presence/absence). The gender of the defecator was identified as male if either of the SRY regions amplified and female if only the ZFX/Y genes amplified. Two SRY primer sets were used to prevent misclassification of males as females, in the event that non-amplification of the SRY region occurred using only one primer pair. PCR amplification and scoring were first validated using known sex fecal samples obtained from the Seward Sea Life Center.

Determination of Mitochondrial Haplotypes

Identification of sea lion haplotypes was accomplished by sequencing an amplified segment of mitochondrial DNA (mtDNA) control region, or D-loop, and then aligning the DNA sequence data with known haplotypes. Primers employed by Bickham et al. (1996) in a previous survey of the population genetics of this species amplify a fragment over 500 base pairs in length and were designed from conserved sequences that may amplify in a number of taxa. Initial attempts to amplify this fragment using DNA extracted from fecal samples produced poor results. Because of the poor quality (short length) of DNA recovered from fecal samples and to avoid amplification of prey DNA, new primers were designed using Steller sea lion and other pinniped sequences to amplify a smaller fragment of the control region without losing critical sequence data.

RESULTS AND DISCUSSION

Gender Determination

I was able to score 172 of the 326 fecal samples (52.8%), including 51.5% of the summer samples and 53.3% of the winter samples. Summer (all rookery) collections that were successfully scored were composed of 72.5% female and 27.5% male scats. This was a surprising finding considering scats collected at rookeries (and, by extension, food habits information) were thought to represent females. Of all scored winter scat samples, 61.2% were found to be from females and 38.8% from males. The percentage of winter samples scored as female at rookeries (63.3%) and haul-outs (59.0%), based on summer site designations, was found to be similar. This indicates that movement among sites, at least locally, is extensive and that females may use terrestrial sites to a larger degree than males. Future analyses will incorporate prey identification from individual scat samples to determine sex-specific food habits.

Determination of Mitochondrial Haplotypes

PCR amplifications using the new primers, designed from Steller sea lions and other pinnipeds, were tested with DNA recovered from feces. The amplifications yielded successful and clean products that were shorter in length by about 100 base pairs than the products amplified with the original primers. Sequencing is currently being conducted, and haplotypes identified, using DNA from winter fecal samples. The haplotypes will be compared to the known distribution of haplotypes obtained by Bickham et al. (1996; 1998a; 1998b) from pup samples collected during the breeding season.

CITATIONS

Aasen, E., and J. F. Medrano. 1990. Amplification of the ZFY and ZFX genes for sex identification in humans, cattle, sheep and goats. Bio/Technology 8:1279-1281.

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*). J. Mammal. 77(1):95-108.

Bickham, J. W., T. R. Loughlin, D. G. Calkins, J. K. Wickliffe, and J. C. Patton. 1998a. Genetic variability and population decline in Steller sea lions from the Gulf of Alaska. J. Mammal. 79(4):1390-1395.

Bickham, J. W., T. R. Loughlin, J. K. Wickliffe, and V. N. Burkanov. 1998b. Geographic variation in the mitochondrial DNA of Steller sea lions: Haplotype diversity and endemism in the Kuril Islands. Bio. Cons. 1(2):107-117.

Mardon, G., R. Mosher, C. M. Disteche, Y. Nishioke, A. McLaren, and D. C. Page. 1989. Duplication, deletion, and polymorphism in the sex-determining region of the mouse Y chromosome. Science 243:78-80.

Richard, K. R., S. W. McCarrey, and J. M. Wright. 1994. DNA sequence from the *SRY* gene of the sperm whale (*Physeter macrocephalus*) for use in molecular sexing. Can. J. Zool. 72:873-877.

Taberlet, P., H. Mattock, C. Dubois-Paganon, and J. Bouvet. 1993. Sexing free-ranging brown bears *Ursus arctos* using hairs found in the field. Mol. Ecol. 2:399-403.

EFFICACY OF TRAWL FISHERY EXCLUSION ZONES IN MAINTAINING PREY AVAILABILITY FOR STELLER SEA LIONS: DESCRIPTION OF ATKA MACKEREL TAGGING PROJECT IN SEGUAM PASS, ALEUTIAN ISLANDS, AK, IN 1999 AND 2000

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ABSTRACT

Atka mackerel is the principal prey species for the endangered Steller sea lion in the Aleutian Islands and a target for commercial fisheries. The objective of this project is to determine the impact of fishing on localized abundances and distributions of Atka mackerel inside and outside of trawl exclusion zones around Steller sea lion haulouts or rookeries. A pilot tagging project was conducted in August 1999, during which 2,340 Atka mackerel were tagged with spaghetti tags and released in the Seguam Pass area of the Aleutian Islands. Another tagging cruise in the same area was conducted in July-August 2000 during which 8,773 Atka mackerel were tagged and released. As of December 2000, 78 of the tagged fish released in 1999 and 104 released in 2000 were recovered. Recovery effort in both years was supplied by the fishery in the open area outside the trawl exclusion zone, with supplementation by a chartered cruise within the closed area in 2000 only. Preliminary results suggest that there was little or no movement of Atka mackerel into or out of the trawl exclusion zone within 40 days of their release in late July to mid-August. By 64 days after release, however, a small proportion of fish moved between areas, particularly from outside to inside the trawl exclusion zone.

INTRODUCTION

Lowe and Fritz (1997) described localized depletions of Atka mackerel in the Aleutian Islands caused by trawl fisheries. Since this fish is the most common prey in the diet of the endangered Steller sea lion, the fishery could negatively affect Steller sea lion foraging success. This, along with the considerable overlap in distributions of the Atka mackerel fishery and critical habitat for Steller sea lions have raised concerns about the impact the fishery may have on sea lion recovery. One of the principal tools used to reduce interactions between Steller sea lions and groundfish fisheries has been trawl exclusion zones around important sea lion terrestrial habitats such as rookeries, where sea lions breed and give birth. While trawl exclusion zones have intuitive appeal as sea lion conservation measures, there has been no field work to verify that prey fields inside are adequate for sea lions and undisturbed by fishing activity occurring outside.

This project was conceived to determine the changes in distribution and abundance of Atka mackerel in response to a fishery occurring outside a trawl exclusion zone. Initially, several different fish abundance estimation techniques, including fishery depletion, bottom trawl surveys, and mark and recapture, were to be employed simultaneously. The fishery depletion methods involve analysis of data on catch and effort collected by groundfish fishery observers and did not require additional dedicated field work. A pilot survey to test the feasibility of the other techniques was conducted in August 1999. Results from the pilot bottom trawl survey suggested that factors other than location were contributing significantly to the high variance observed in catches. Such factors were likely to include time of day (light levels) and stage of tide (current speed and direction); their effect on Atka mackerel distribution must be known in order to compare trawl survey estimates of fish abundance at two different times (e.g., before and after a fishery). This technique was subsequently abandoned because of costs associated with the large numbers of samples necessary to detect changes in abundance and distribution, and the large amount of preliminary work necessary to control for current and light effects on trawl survey mackerel catches. On the other hand, the results from the 1999 work on tagging, including estimation of the rates of tagged fish mortality, tag shedding, and tag recovery by the fishery, were encouraging enough to conduct a dedicated tagging cruise in 2000. This report summarizes some of the preliminary results of the Atka mackerel mark-recapture project near Seguam Pass in the Aleutian Islands.

METHODS

The 300-foot factory trawler F/T *SeaFreeze Alaska* and the 148-foot F/V *Morning Star* were chartered in August 1999 and July-August 2000, respectively, to collect Atka mackerel from the Seguam Pass area for tagging. Collections of live fish were made using research bottom trawls constructed by the AFSC and relatively short tow times (usually less than 15 minutes). Live tanks, located on the trawl deck, were supplied continuously with fresh seawater and used to hold Atka mackerel for short periods (hours) prior to tagging and release, and up to 12 days as part of a tagging mortality study conducted in 1999. Spaghetti tags (Floy, Inc., Seattle, WA[1]) were attached to Atka mackerel below the anterior end of the dorsal fin. Approximately 10% and 18% of the fish tagged in 1999 and 2000, respectively, were doubly tagged to permit estimation of tag shedding rates. Length measurements and visual sex determinations were obtained on each tagged fish prior to release. To release tagged fish, they were placed in a 8-inch diameter tube (supplied with running seawater) that had a gradual descent from the trawl deck to the ocean's surface. Release locations were estimated using the continuous recording of time and location (from a GPS) and the occasional recording of time

[1] Mention of the manufacturer does not constitute an endorsement by NMFS.

(approximately every 5th fish) on the tagging forms (Figs. 5 and 6). Numbers of Atka mackerel tagged and released by area (1 = inside trawl exclusion zone, 2 = outside of trawl exclusion zone) and year are shown in Table 19.

In both 1999 and 2000, Atka mackerel caught in Area 1 for tagging were released in Area 1 after tagging. Similarly, all Atka mackerel caught in Area 2 were released in Area 2 after tagging, except those caught on Haul 13 in 2000 (Fig. 6). Atka mackerel caught on Haul 13 were caught in Area 2 and released in Area 1. The location of recapture of fish tagged from Haul 13 (n = 11) suggested that they all returned to Area 2 near where they were originally captured. Because of the potential bias presented by Haul 13 fish in the direction and magnitude of movement, they were excluded from the figure showing tag recovery and movement (Fig. 10). However, in the tag recovery data summary presented in Table 21, all Haul 13 fish are assumed to have been released in Area 2.

Tag recoveries in 1999 were accomplished by the commercial trawl fishery that operated only in Area 2 outside of the trawl exclusion zone (Table 20; Fig. 7). This fishery occurred in early September 1999, approximately 3 weeks after the fish were tagged and released. In 2000, tag recoveries occurred in both Areas 1 and 2 (Table 20; Fig. 8). Tag recoveries in Area 2 were provided by fishery effort in January, early September, and November 2000. In order to observe and model movement from the open to the closed area, a no-cost charter on the F/T *Seafisher* was conducted in late September 2000 to collect and examine approximately 500,000 Atka mackerel for tags from the closed area (Area 1).

Estimates of the tag recovery rate, defined as the proportion of tagged fish landed by the vessel that are found by vessel personnel (observers, scientists, or factory workers) within the ship's factory, were obtained in order to estimate actual tag recoveries. In September 2000, tag recovery rate was estimated on each commercial vessel by the fishery observer and on the charter vessel by scientific personnel. Known numbers of tagged fish (n = 9 or 10) were "seeded" into the catch of individual hauls, and the number of recoveries noted. Tags were identical in size and color to those placed on fish released into the ocean. Multiple estimates of the tag recovery rate were obtained on each of the eight commercial vessels participating in the September 2000 fishery (range of 2-11, mean of 5.5 per vessel), and on the F/T *Seafisher* charter (n = 35).

RESULTS AND DISCUSSION

The rate of mortality due to tagging was estimated at 5%, based on the death of 2 of 40 fish tagged and held in live tanks for 12 days aboard the F/T *SeaFreeze Alaska* in 1999. The rate of tag shedding by fish tagged and released in 1999 was estimated at 20% (3 of 9 doubly-tagged fish recovered lost a tag). The tag shedding rate was lower, 5%, for fish tagged and released in 2000 (2 of 21 doubly-tagged fish recovered lost a tag). Tag recovery rates on board the eight commercial vessels in the September 2000 fishery averaged 75%, and were estimated at 95% during the F/T *Seafisher* charter to examine fish for tags in Area 1. These estimates will be used in modeling short-term movements and calculating abundance estimates for Areas 1 and 2, the results of which will be reported in another paper.

Tag recoveries through December 2000 are summarized in Table 21, and shown in

Figures 9 and 10 for fish tagged in 1999 and 2000, respectively. Through early September 2000, all of the effort for tag recovery was provided by the commercial fishery in Area 2. Consequently, for fish tagged and released in1999, there was no potential to observe movement into the trawl exclusion zone (from Area 2 to Area 1). All 1999 tagged fish recovered in September 1999 (15-21 days after release) were released in Area 2, and the maximum distance between release and recapture was only 13 km. By January 2000 (160-170 days after release), 4 of 9 recovered fish had moved from Area 1 to Area 2 (maximum distance between release and recapture was 57 km), while the remaining 5 remained in Area 2. Through the remainder of 2000, (382-473 days at large), only 4 of 19 fish were recovered in a different area than they were released, 3 moving out and one moving in, and the maximum distance between release and recapture was 77 km.

For fish tagged and released in 2000, all 71 recoveries by the fishery in 2 in early September (32-43 days after release) were fish that had been released in Area 2 (n = 62) or were from Haul 13 (n = 9). Of the 62 fish actually released in Area 2, the maximum distance between release and recapture was 22 km. In the late September 2000 recovery charter (53-64 days after release), most of the recoveries (23 of 27) were of fish released and recovered in the same area, most of which had moved less than 20 km. For the four fish that had moved between areas, three moved in and one moved out, and their movements ranged between 47-69 km. In the November 2000 fishery (103-110 days after release), all six recoveries in Area 2 were fish that had been released in Area 2 (n = 4, with a maximum distance of only 17 km) or were from Haul 13 (n = 2).

Most (158 of 171, or 92%) Atka mackerel were recovered within 25 km of their release location regardless of how long they were at large (Fig. 11). Of the 13 fish that were recovered more than 25 km from their release location (31-77 km), all had been at large 53 days or longer, but there was no correlation between distance and time at large ($r^2 = 0.16$). Similarly, of those fish at large longer than 53 days, most (46 of 59, or 78%) were recovered within 25 km of their release location. These data suggest that Atka mackerel aggregations in Areas 1 and 2 may have relatively little exchange between them at time periods less than about 50 days in mid- to late summer. At time periods of about 50 days and longer, a small percentage of the population moved greater distances, but most of the fish remained within 25 km of their release location. Preliminary results from the tag model under development suggest that while movement rates in any direction were small, movement of fish from Area 2 to Area 1 (movement in) in 2000 was greater than from Area 1 to Area 2 (out). Reasons for this movement are unknown, but include movement to nearshore, shallow spawning locations in Area 1 during the mid-late summer, random movement of fish, or dispersal of fish schools in Area 2 as a result of fishing. Quantitative estimates of population sizes in Areas 1 and 2 and movement rates between them will be provided upon completion and testing of the tagging model.

ACKNOWLEDGMENTS

Without the cooperation and efforts of the captains and crews of the three chartered fishing vessels, F/T *SeaFreeze Alaska*, F/V *Morning Star*, and F/T *Seafisher*, this work would not have been possible. Their dedication and interest in the success of the project was invaluable, and we thank them. We also thank and acknowledge the efforts of the fishery observers aboard vessels fishing for Atka mackerel, and the following NMFS personnel who participated on the tagging and recovery cruises: Erika Acuna, Steve Barbeaux, Dennis Benjamin, Liz Chilton, Jerry Hoff, Scott McKillip, Peter Munro, Dan Nichol, Sarah Pautzke, Katherine Pearson, Nate Raring, Rebecca Reuter, Pete Risse, Gary Shaw, Destry Wion, and Anne York (aka Florida Pippilini).

CITATIONS

Lowe, S. A., and L. W. Fritz. 1997. Atka mackerel. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands Region as projected for 1998. North Pacific Fisheries Management Council, P.O. Box 103136, Anchorage, AK 99510.

Table 19.--Numbers of Atka mackerel tagged and released by area and year.

Year	Area Released 1-Inside	2-Outside	Total
1999	965	1,375	2,340
2000	6,096	2,677	8,773

Table 20.--Number of Atka mackerel examined for tags by year, effort type, date and area.

Year	Effort Type	Dates	Area 1-Inside	2-Outside	Total
1999	Fishery	1-7 Sep	0	5,517,464	5,517,464
2000	Fishery	20-29 Jan	0	10,163,239	10,163,239
	Fishery	1-5 Sep	0	3,512,641	3,512,641
	Charter	23-28 Sep	314,891	155,003	469,894
	Fishery	Nov-Dec	0	481,597	481,597
	All		314,891	14,312,480	14,627,371

Table 21.--Number of tagged Atka mackerel recovered by year tagged, date recovered, area released, and area recovered. "-" indicates no effort in area.

Year Tagged	Dates Recovered	Area Recovered 1	2	Total	Number of Tagged Fish Staying in: Area 1	Area 2	Number of Tagged Fish Moving: Out (1 to 2)	In (2 to 1)
1999	Sep-99	-	50	50	-	50	0	-
	Jan-00	-	9	9	-	5	4	-
	1-5 Sep-00	-	13	13	-	11	2	-
	23-28 Sep-00	2	3	5	1	3	0	1
	Nov&Dec-00	-	1	1	-	0	1	-
	Total	2	76	78	1	69	7	1
2000	1-5 Sep-00	-	71	71	-	71	0	-
	23-28 Sep-00	12	15	27	11	12	1	3
	Nov&Dec-00	-	6	6	-	6	0	-
	Total	12	92	104	11	89	1	3

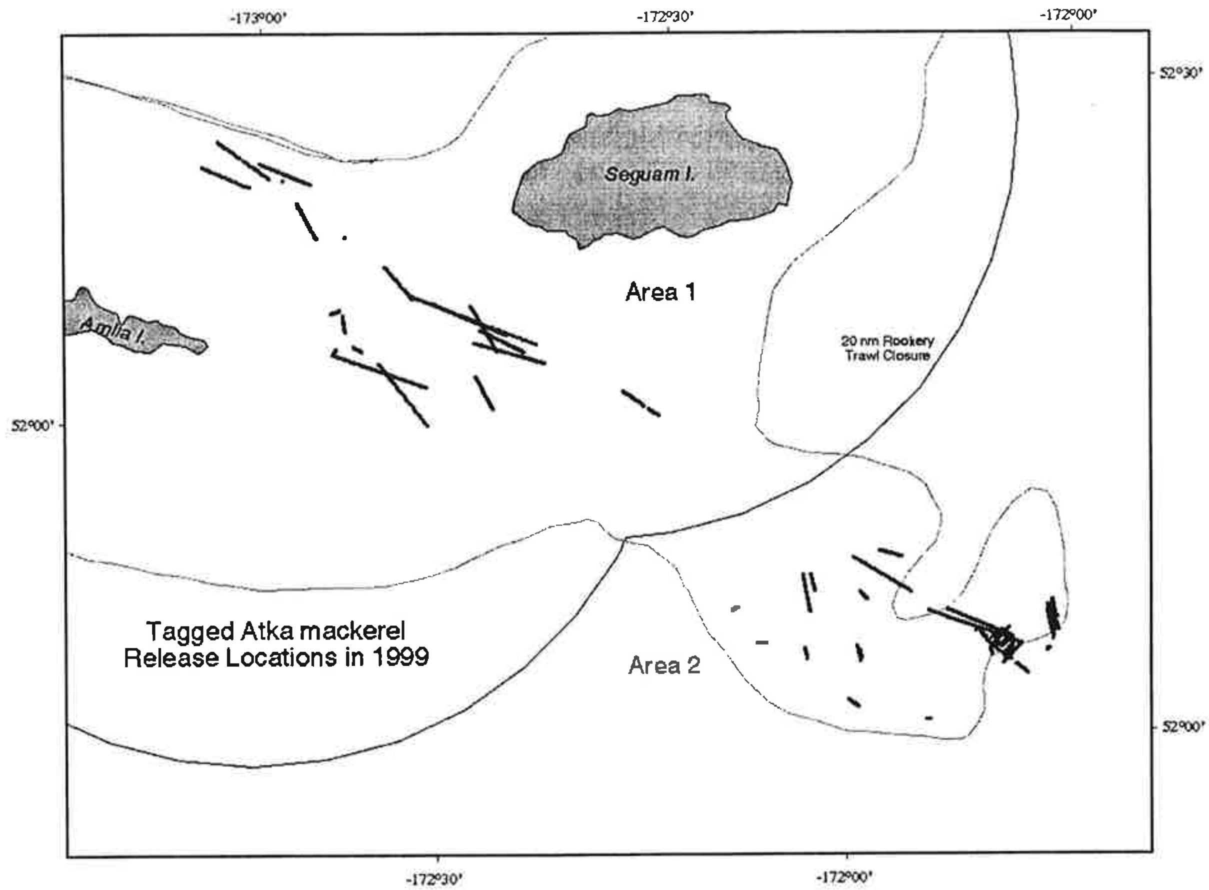

Figure 5.--Locations of 2,340 Atka mackerel tagged and released in August 1999.

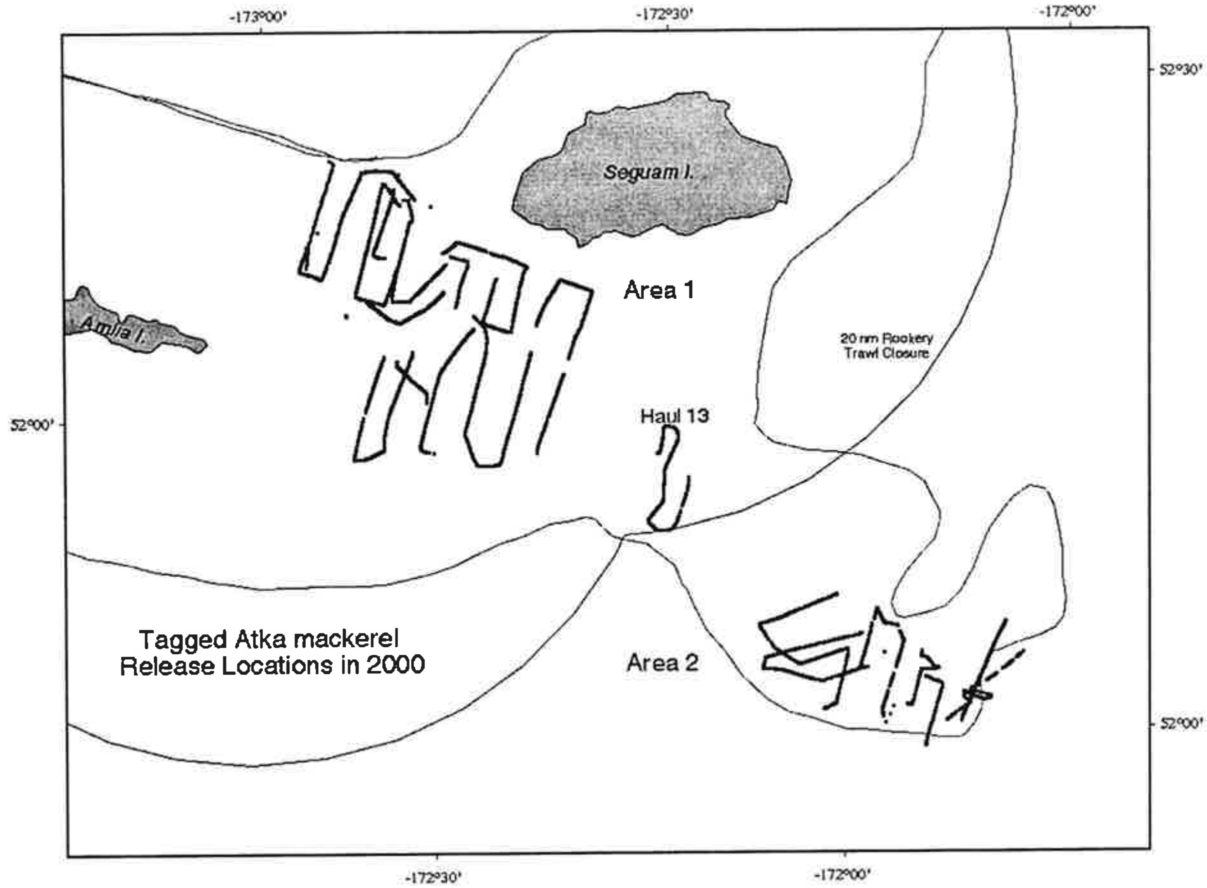

Figure 6.--Locations of 8,773 Atka mackerel tagged and released in July-August 2000.

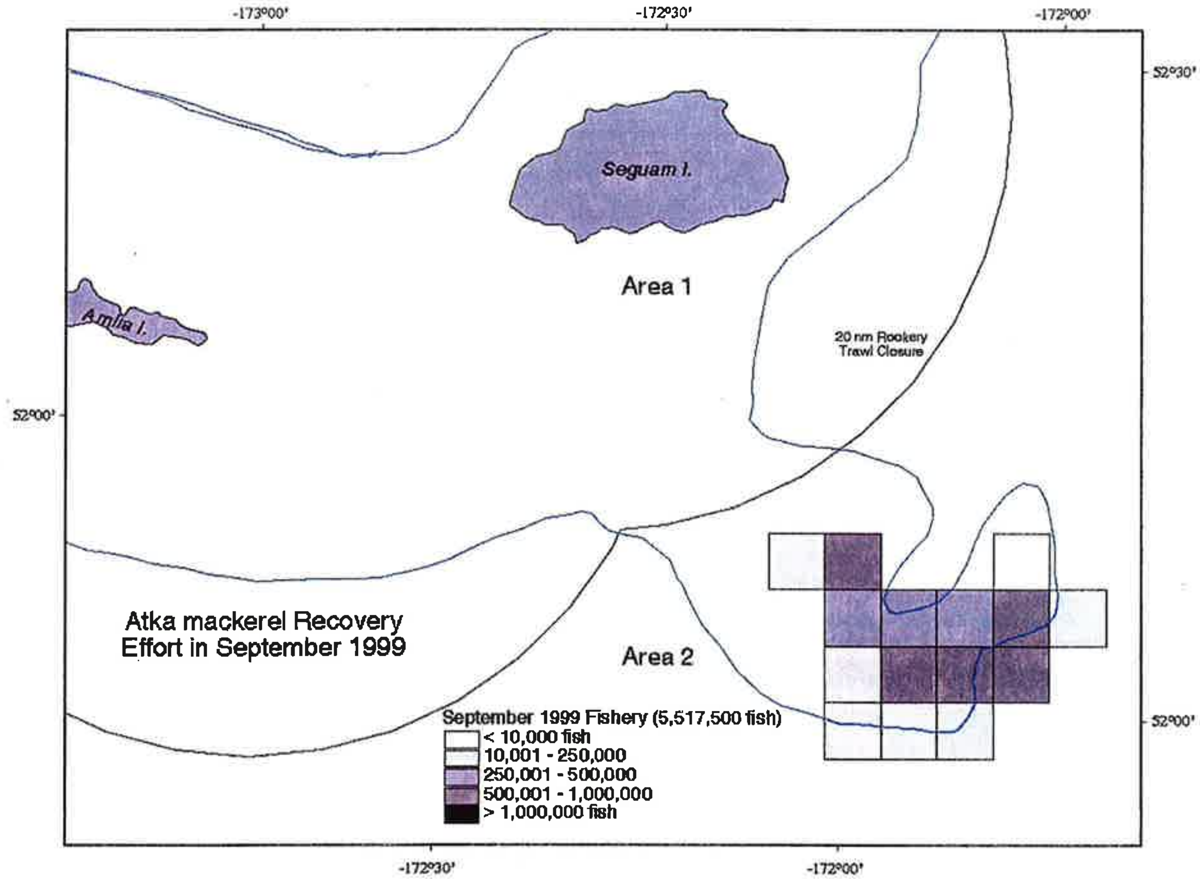

Figure 7.--Distribution of the recovery effort (commercial fishery) in September 1999 south of Seguam Island (grid cell size is 25 km^2, 5 km x 5 km). Atka mackerel averaged 1.007 kg apiece at this time.

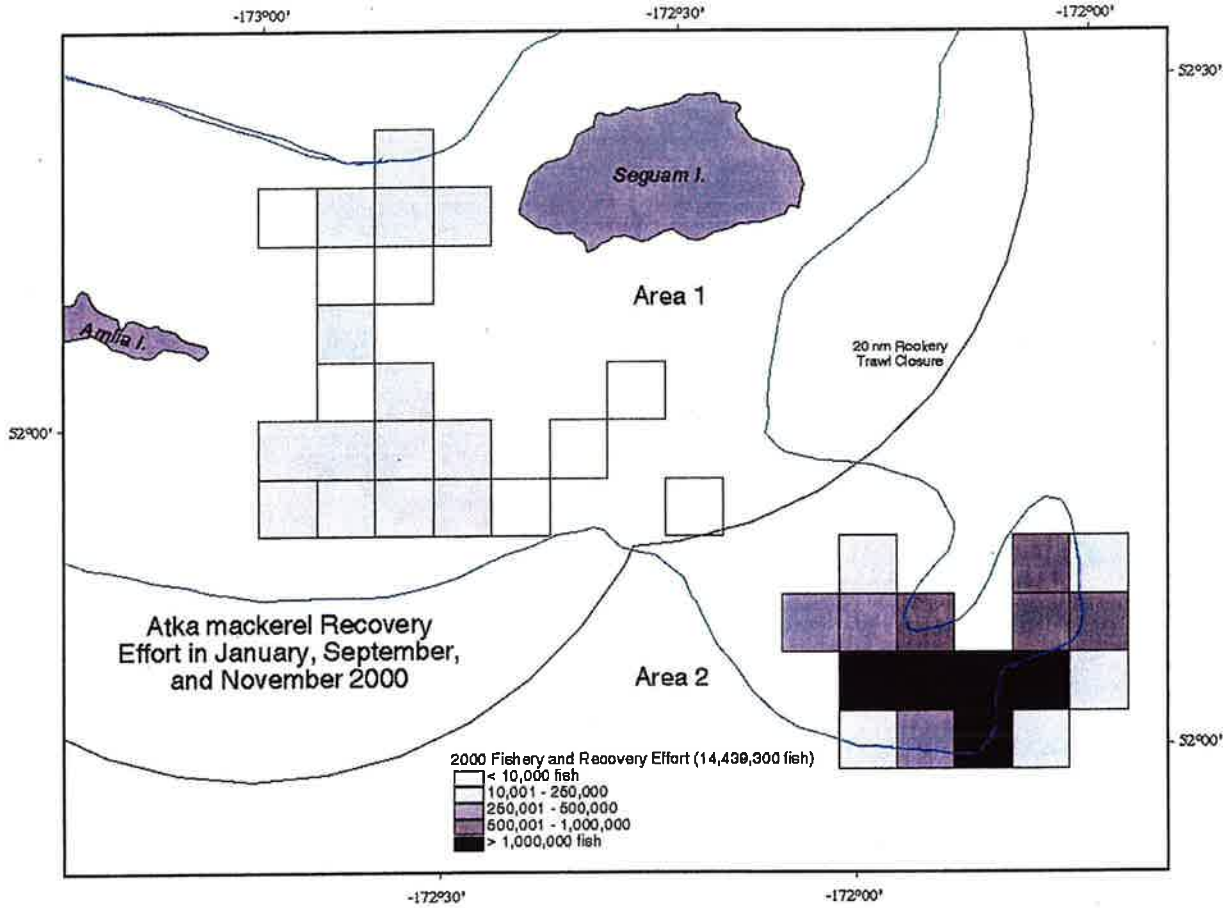

Figure 8.--Distribution of the recovery effort (charter in Area 1 and commercial fishery in Area 2) in January, September, and November 2000 in Seguam Pass area (grid cell size is 25 km^2, 5 km x 5 km). Atka mackerel averaged 0.940 kg apiece in 2000.

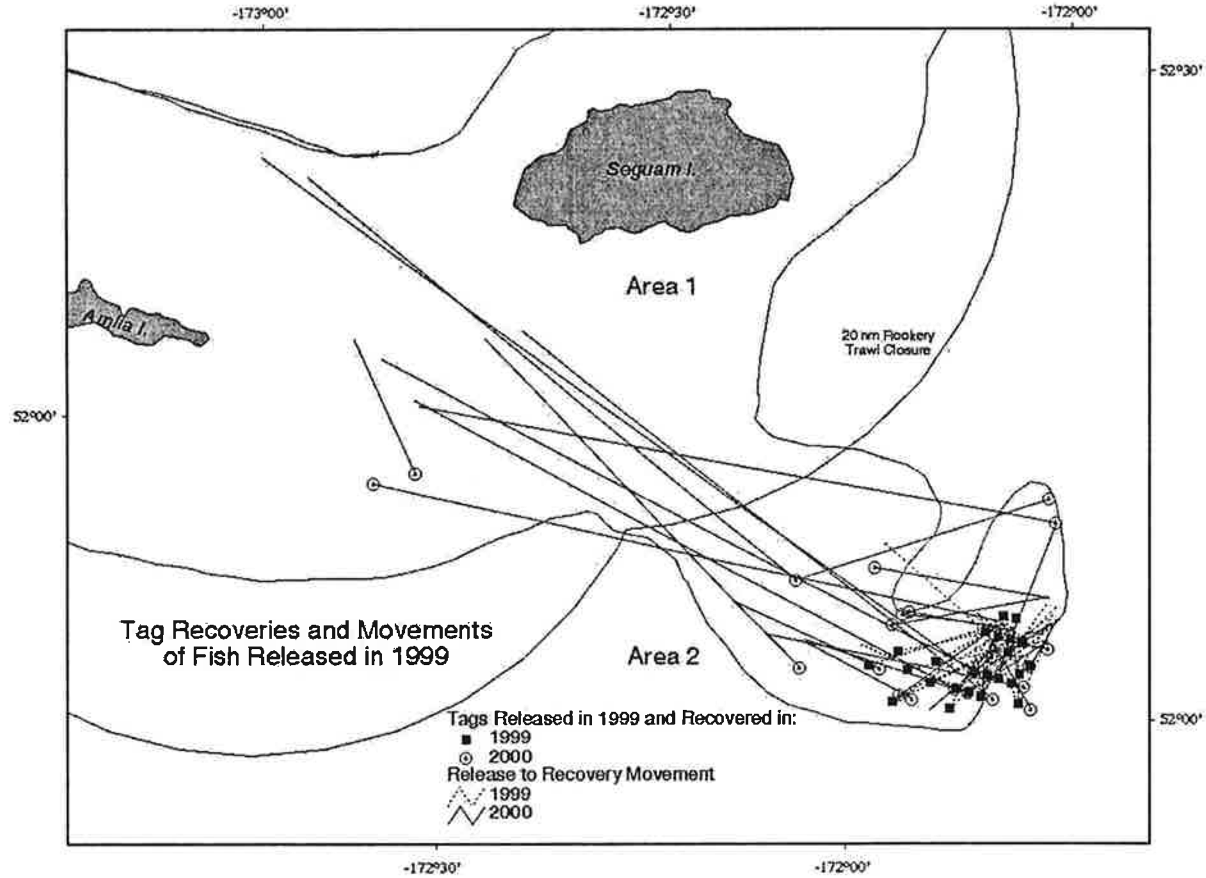

Figure 9.--Location of recoveries and movements of fish tagged and released in 1999 and recovered in 1999 and 2000.

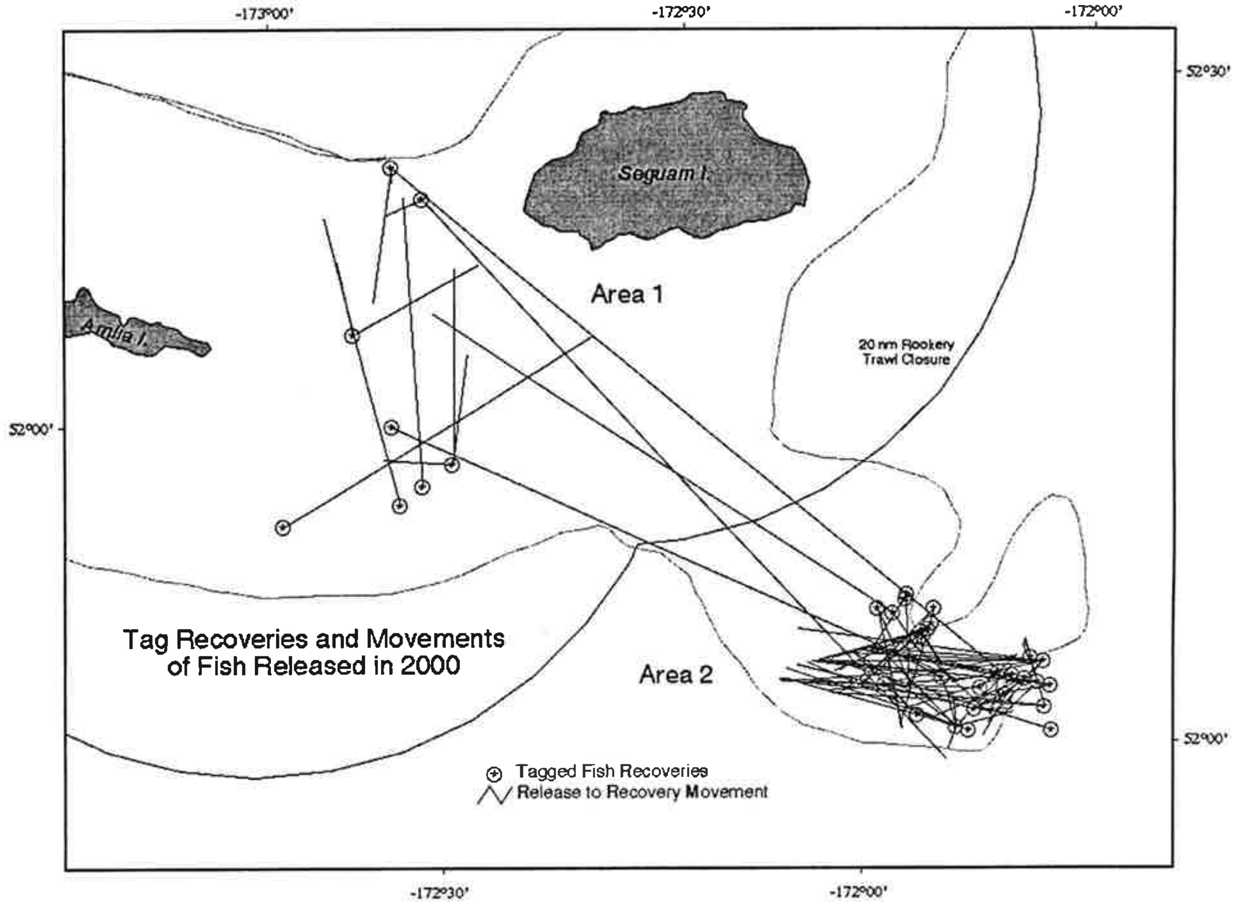

Figure 10.--Location of recoveries and movements of fish tagged and released in 2000 and recovered in 2000.

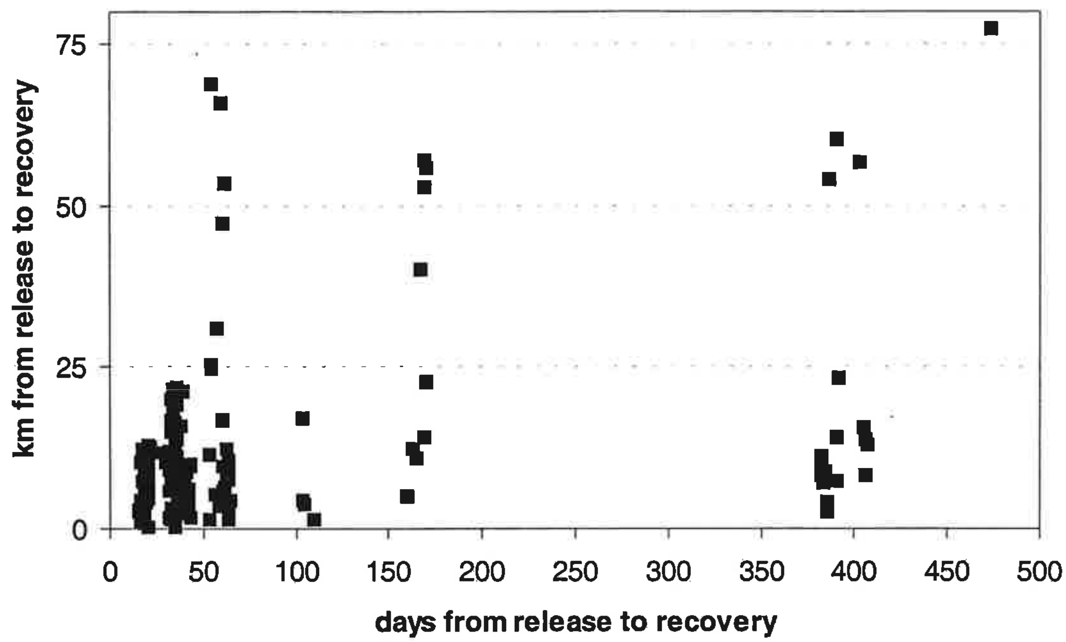

Figure 11.--Time and distance between release and recovery of tagged Atka mackerel in Seguam Pass area in 1999 and 2000 (n = 171). Recoveries from fish tagged on Haul 13 in 2000 were excluded (n = 11).

STUDY TO DETERMINE THE EFFECT OF COMMERCIAL FISHING ON WALLEYE POLLOCK DISTRIBUTION AND ABUNDANCE

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INTRODUCTION

Research is needed to determine how commercial fishing activity affects the availability of walleye pollock (*Theragra chalcogramma*) to Steller sea lions (*Eumetopias jubatus*). A primary concern is how to distinguish between changes in prey availability due to fishing activity versus those changes due to environmental effects or natural variability. NMFS plans a multi-year research program to examine the spatiotemporal characteristics of prey aggregations of pollock before, during, and after a commercial fishing season. This effort was initiated in 2000 with a feasibility study which is described in this document. Results of the work will be used to investigate whether pollock commercial fishing activities cause measurable reductions in the abundance or a redistribution of sea lion prey.

The feasibility study was conducted between 9-19 August 2000 off the east side of Kodiak Island in the absence of a fishery. There were several purposes for the feasibility study. Echo integration-trawl (EIT) methods (Traynor et al. 1990) had not been used in this area during the summer, thus the suitability of using these methods during the summer off Kodiak required testing. For example, the presence of acoustic backscatter from non-pollock scatterers could potentially prevent the discrimination of pollock echosign. In addition, the variability in the temporal and spatial patterns of the pollock distribution and abundance over the proposed 2-4 week duration of the field study needed to be characterized. Finally, the result of the feasibility study would be used to determine whether the proposed experimental design was adequate or would need to be modified for the more comprehensive work planned during the 3 subsequent years. The feasibility work did not include surveys during or following the August fishery. Work in subsequent years will include EIT surveys before and during the fishery as well as surveys following the closure of the August fishery to monitor the duration of a potential fishery effect on pollock.

EXPERIMENTAL DESIGN

Study Area

The experimental design called for two adjacent sites with similar topographical features that could be assigned as treatment (where commercial fishing activities are allowed) and control (where commercial fishing is prohibited) areas. The network of submarine canyons off the east side of Kodiak Island in the Gulf of Alaska (GOA) offered the best selection of sites based on bathymetry, research survey, and commercial fishing data. Barnabas Gully was selected as the treatment site and Chiniak Gully the control site (Fig. 12). These sites were selected due to the similarity in topographical features, the proximity of the sites to each other, the stability of fishing effort, and the similarity in catch per unit effort (CPUE) trends as seen in the research survey data (Fig. 13). The suitability of these two gullies as treatment and control sites was tested during the feasibility study.

Data Analysis

The main focus of the 2000 feasibility study was to monitor potential changes in average depth and spatial distributions of the fish aggregations, as well as changes in biomass and abundance. Data were collected during the feasibility study to estimate the power to detect statistically significant differences between changes in biomass and abundance, which occur with the treatment and control areas during the study.

During the feasibility study, a total of four survey passes were conducted in the treatment (n = 2) and control sites (n = 2) where $\hat{B}_1$ and $\hat{C}_1$ represent estimates of either biomass or abundance in the treatment and control area, respectively. However, similar comparisons could also be used for evaluating changes in aggregation characteristics. This design allowed for comparisons within a site and between sites. The use of proportions allowed for comparisons in fish behavior if fish densities differed between sites. Thus:

Survey order:

1) Treatment survey I ($\hat{B}_1$),
2) Control survey I ($\hat{C}_1$),
3) Treatment survey II ($\hat{B}_2$),
4) Control survey II ($\hat{C}_2$),

where B_1 = fish biomass from Treatment survey I ,

B_2 = fish biomass from Treatment survey II,

C_1 = fish biomass from Control survey I,

C_2 = fish biomass from Control survey II.

The above null hypothesis is contingent upon our ability to account for sources of variability between the treatment and control site that are unrelated to fishing. To evaluate whether there is high correlation between the treatment and control sites, Treatment surveys I and II will be compared with Control surveys I and II. The null hypothesis is that the proportional change observed in the treatment site is equal to the change in the control site:

$$H_0: \quad \frac{B_2 - B_1}{B_1} = \frac{C_2 - C_1}{C_1} \quad .$$

It is assumed that any potential disturbance to pollock in response to the fishery will not influence C_2. Results of the feasibility study will enable evaluation of these conditions, but these measurements will also need to be collected in subsequent years to account for inter-annual variability. If significant differences are observed, then the experimental design may need revision.

Field Methods

An EIT survey of the control and treatment sites was conducted during daylight hours (about 15 hours/day in August) along a series of uniformly-spaced 3 nautical mile (nmi) parallel transects to describe patterns in the distribution and abundance of the dominant fish scatterers (Fig. 12). Briefly, an EIT survey involves collecting echo integration data for fish density estimation assuming a linear relationship between the sum of the received intensities of echoes from fish insonified by an echo sounder and the density of these fish (Williamson and Traynor 1984).

The survey methods were similar to those used during other routine EIT surveys conducted on pollock by Alaska Fisheries Science Center (AFSC) scientists (Traynor et al. 1990, Guttormsen and Wilson 1998, Ianelli et al. 1998). The acoustic data were collected with an EK 500 echo sounder operating at 38 and 120 kHz. Ship speed averaged 11 knots in favorable weather conditions. Calibration of the 38 and 120 kHz acoustic systems, using standard sphere techniques, occurred just prior to the beginning and at the end of the survey.

The 9 hours per day of darkness were used to: rerun trackline sections for diel comparisons, conduct additional trawls to identify the species composition of the dominant scatterers, collect additional CTD data, or collect target strength data. The treatment and control sites were each surveyed two times during the feasibility study. Approximately 4 days elapsed between the first and second surveys of each gully. Temporal variability in estimates of distributional patterns and abundance were evaluated within and between the gullies.

Trawls were conducted during all EIT surveys to identify the species composition of selected echosign and collect biological samples needed to estimate abundance and distribution patterns. Both midwater and bottom trawl hauls were employed. An Aleutian wing trawl (AWT) and Marinovich trawl with restrictor cables were used to target midwater echosign, and a poly Nor'eastern (PNE) bottom trawl was used to target near-bottom echosign (Wilson and Guttormsen 1997). The codends of the AWT and PNE were rigged with a 1 1/4 inch codend liner and the Marinovich with a 1/8 inch liner. Fish buster doors were used with all the trawls. Temperature and depth data were collected by using a micro-bathythermograph (MBT) attached to the headrope during each trawl. Additional CTD data were collected with an AFSC Seabird SeaCat system at trawl locations and at other selected locations. Vertical temperature profiles were collected at selected locations along transects by using expendable bathythermographs (XBTs).

Standard catch sorting and biological sampling procedures were used to provide weight and number by species for all hauls (Traynor et al. 1990, Wilson and Guttormsen 1997). Most hauls were sub-sampled. Whole-haul samples were taken of the following species: Pacific halibut (*Hippoglossus stenolepis*), Pacific cod (*Gadus macrocephalus*), rockfish (*Sebastes* sp.), salmon (*Oncorhynchus* sp.), and crab (*Cancer* sp.). Each haul was kept to the minimum duration necessary to ensure an adequate sample. Because the acoustic data were only collected to within 0.5 m of the bottom, the resulting biomass estimates may not reflect the total biomass within the gullies. Pollock were further sampled to determine sex, fork length, age, maturity, and body and ovary weights. Pollock stomachs were collected and preserved in 10% formalin for an ancillary food habits project.

Biomass estimates for the mix of capelin (*Mallotus villosus*) and age-0 pollock were determined based on a target strength (TS) to fish length (L) model of TS = 19.1LogL-74.0 for capelin (Dalen and Nakken 1983). It was not possible to determine the proportion of age-0 pollock to capelin based on trawl data. Capelin were much more abundant in trawl catches than age-0 pollock, but both species were most often caught in the meshes of the intermediate section of the net and rarely in the codend. To estimate the relative proportion of capelin to age-0 pollock based on these data would have been tenuous at best. A smaller mesh codend liner will be used with the AWT in August 2001 in an attempt to estimate the relative abundance of these two groups and apportion the echosign accordingly.

<u>Sources of Variability</u>

EIT survey abundance estimates are subject to sampling errors as well as other errors (MacLennan and Simmonds1992). An estimate of the sampling error for each survey was generated using a one-dimensional geostatistical procedure, which is an accepted method employed in the analysis of EIT survey data (Petitgas 1993, Williamson and Traynor 1996). Other sources of error include those associated with assumed target strength values, fish avoidance, species identification, and instrument calibration and performance characteristics. Developing methods for measuring error is an active area of research in fisheries acoustics (Anon. 1998) and the applicability of these techniques for use in this study will be evaluated in future reports.

Natural shifts in ocean conditions and/or variations in the age composition of the population may influence interannual variability in pollock response to fishing activities. Analyses to determine the age composition of the population within the control and treatments sites during the feasibility study are currently in progress and the results will be reported in a later document. Typically, younger age pollock form pelagic aggregations at depths that are shallower than adults. Historical data show that strong year classes of pollock typically occur every 3–5 years. Thus, the 3 year comprehensive study design should provide an opportunity to evaluate differences in fish response that may be associated with differences in the age composition of the stock. Differences in ocean conditions will be evaluated by comparing trends in fish spatial aggregation patterns with the physical data that are collected to describe water column properties and oceanographic features that may differ within the experimental area during each year of the study.

RESULTS

A total of 1113 nmi of trackline were surveyed in Barnabas (average 313 nmi/pass) and Chiniak Gullies (average 244 nmi/pass) during the two passes. Trawl hauls were conducted a total of 35 times with the AWT, 5 times with the PNE, and 5 times with the Marinovich trawl.

Acoustic Echosign

Backscattering from non-targetted species was generally not a problem during the August, 2000 feasibility study in Barnabas and Chiniak Gullies. Acoustic backscatter was divided into four types of fish echosign; 1) adult pollock, 2) age-1 pollock*, 3) a mix of age-0* pollock and capelin, and 4) other fishes. Adult pollock were distributed throughout the gully in Chiniak whereas in Barnabas, they tended to concentrate more towards the northern half of the gully. This pattern was consistent during both passes (Fig. 14a and b). Age-1 pollock were broadly distributed in Chiniak Gully but largely absent in Barnabas Gully (Figs. 15a and b). The fish exhibited a bimodal distribution pattern in Chiniak with relatively lesser amounts near the middle of the gully. This pattern persisted during Pass 2. The mix of age-0 pollock and capelin were broadly distributed in both gullies during both passes (not shown). The co-occurrence and similarity in echosign types of juvenile pollock (age-0 and age-1) and capelin often made identification of the echosign very difficult and required additional hauls to groundtruth the

* Because pollock age data have not yet been analyzed, a general pollock length-age relationship was used to provisionally identify juvenile fish as either young-of-the-year (age 0) or 1 year olds (age 1) on the basis of length.

echosign. The identification of the age-0 pollock/capelin aggregations was compounded by the lack of appropriate small-mesh trawls, on board the vessel, to capture animals in this size range.

Abundance and Distribution

Biomass estimates were calculated for the pollock and pollock/capelin mix acoustic echosign types (Table 22). Adult pollock were about twice as abundant in Barnabas Gully compared to Chiniak Gully. Age-1 pollock were negligible in Barnabas Gully but present in Chiniak Gully in numbers comparable to adult pollock. The age-0/capelin mix was common in both gullies. Pollock biomass estimates between the 2 passes were similar with differences ranging from 12-28%, although the 95% confidence intervals suggested the differences were not statistically significant.

The dominant length mode of adult pollock was greater than 45 cm in both gullies (Fig. 16). Very few pollock between 26 and 44 cm were observed in either gully.

The frequency distribution of bottom depths surveyed between Chiniak and Barnabas Gullies were very similar. The average depths were 113 m in Chiniak Gully and 117 m in Barnabas Gully. Adult pollock vertical distribution differed only slightly between the two passes in Barnabas and Chiniak Gullies. In Chiniak Gully, there was a unimodal peak of adult pollock at about 150 m and most were generally within 20 m of the bottom (Fig. 17). There were multiple modes of adult pollock in Barnabas Gully, between 50 and 150 m depth, with the largest mode around 150 m. Most of these adults were within about 12 m of the bottom (Fig. 17). Juvenile (age-1) pollock in Chiniak were shallower and distributed over a wider range (20-120 m) than the adults (Fig. 17). The average age-1 distance above bottom was about 60 m. Confidence bounds overlapped for age-1 and adult pollock and suggested that there was no significant difference between estimates during each pass.

Spatial pattern was explored through the use of variograms. These revealed that there was little large-scale pattern to the adult pollock distribution in either gully. There was correlation on a smaller scale but the 3 nmi spacing between transects was large enough for the individual transects to be considered independent samples.

Several diel comparisons were made to assess whether there was a possibility of conducting the survey 24 hrs per day. The fish echosign typically dispersed from their aggregated daytime layers and rose in the water column during darkness. The adult pollock exhibited relatively little dispersion and typically did not rise in the water column but remained within 30 m off bottom. The juvenile pollock echosign was more difficult to distinguish due to the high degree of dispersal during the night. Generally, the age-0 pollock/capelin mix rose to within 20 m of the surface while the age-1 pollock echosign was immediately below. There were many occasions at night however, when the two types of juvenile pollock echosign were indistinguishable from one another. Low amounts of plankton echosign visible during the day were often indistinguishable from other echosign during the night.

DISCUSSION

A fundamental question asked during the feasibility study was whether an EIT survey of pollock could be conducted off the east side of Kodiak during the summer. Summer EIT survey data from the Bering Sea and along the U.S. west coast suggested that acoustic backscatter from nontargetted animals might obscure the pollock echosign. Results from the feasibility study indicate that this is not likely a problem.

A major objective of the feasibility study was to examine whether Barnabas and Chiniak Gullies were appropriate treatment and control sites. Retrospective analysis of the survey data revealed that large concentrations of pollock were consistently observed in Chiniak and Barnabas Gullies. However, the fishery data indicated that less fishing effort occurred in Chiniak Gully. Adult pollock biomass estimates from both passes were not significantly different in either Barnabas or Chiniak Gully (Table 22). This implies that the amount of adult pollock was relatively stable over a period of about a week. The adult pollock biomass estimates from Chiniak Gully were about half of the estimates from Barnabas Gully. However, neither gully exhibited significant change in adult pollock biomass estimates during the study. These similarities within and between each gully, over the duration of the study, support using the two gullies as treatment and control sites.

Adult pollock acoustic echosign was fairly easy to identify in both gullies; most adults were within 20 m of the bottom (Fig. 17). The shallower distribution of adult pollock in Barnabas Gully may be explained by the possibility that age-1 pollock may have been inadvertently included with the adult echosign. Comparison of the distribution patterns between day and night show that the adult pollock remain mostly within 20 m of the bottom during the day and rise only slightly into the water column during the night. Therefore, the distribution of adult pollock in both Chiniak and Barnabas Gullies is closely associated with the bottom regardless of the time of day. Additional trawling during the night is needed to verify these patterns.

The abundance of age 2-4 pollock (~25-35 cm fork length) in both gullies was low, consistent with recent patterns in year-class strength (Dorn et al. 1999). One important difference between the two gullies is the apparent absence of age-1 fish in Barnabas Gully. The spatial distribution pattern of adult pollock within a gully was similar between passes and can probably be considered stable (Figs. 14a and b). The study can therefore be focused on the effects of commercial fishing activity on adult pollock distribution.

In summary, our feasibility study results suggest that the similarities between the two gullies make them appropriate as treatment and control sites. The experimental design based on treatment and control sites will increase the ability to distinguish between differences in abundance and distribution patterns of pollock due to commercial fishing activity and natural variability. The consistency in abundance and distribution of adult pollock between the two passes suggests that these patterns for pollock within these areas are relatively stable over periods on the order of days. Thus perturbations to the system by commercial fishing activity, occurring over time scales similar to this study, could be characterized by this type of research effort.

Based on these results, we anticipate that the subsequent 3 years of comprehensive surveys will follow the same general survey design with added sampling during and after the fishing season. There will be additional coordination with the NMML in an effort to understand the linkage between changes in pollock abundance and distribution and Steller sea lion foraging efficiency.

COORDINATION WITH OTHER PROJECTS

The University of Alaska, Fairbanks (UAF) is conducting quarterly trawl surveys of the temporal and spatial composition, abundance, and distribution of Steller sea lion prey around five haulouts along the eastern side of Kodiak Island. The main objective of their work is to compare areas inside and outside of buffer zones. Because there is considerable spatial overlap between their survey area and Barnabas and Chiniak Gullies, there is the possibility for collaborative work to be done using data from these two programs.

UAF is also collaborating with NMML on conducting monthly aerial surveys of Steller sea lion abundance and distribution, as well as scat collections for diet analysis. Weather and availability issues have made it difficult to predict when the trawl and aerial surveys occur but plans are in progress to coordinate these surveys in August. There has been some difficulty accessing the haulouts on Cape Barnabas, Gull Point, and Cape Chiniak but scat collection has been successful on Long Island and should not be a problem on Ugak Island. The proximity of these areas to our treatment and control sites will enable us to compare changes in Steller sea lion diet with known changes in the abundance and distribution of pollock in the two gullies.

The data collected during our survey will complement several other initiatives currently being conducted at the NMFS. In particular, the Steller sea lion tagging study being conducted by NMML will provide information necessary to assess how changes in fish distribution and abundance affect the sea lions. The analysis products provided from this survey will also be used to develop algorithms to describe pollock movements using Individual Based Modeling techniques.

CITATIONS

Anon. 1998. The relative importance of sources of variability in acoustic surveys. Report of the working group on fisheries acoustics science and technology. ICES CM 1998/B:4.

Dalen, J., and O. Nakken. 1983. On the application of the echo integration method. Council Meeting ICES 1983 (B:19): 30 p.

Dorn, M. D., A.B. Hollowed, E. Brown, B. Megrey, C. D. Wilson, and J.Blackburn. 1999. Walleye pollock. In: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska, 1999. North Pacific Fishery Management Council, 605 W 4th Avenue, Suite 306, Anchorage, Alaska 99501.

Guttormsen, M. A., and C. D. Wilson. 1998. Echo integration-trawl survey results for walleye pollock in the Gulf of Alaska during 1998. In: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska, 1998, pp.509-530. North Pacific Fishery Management Council, 605 W 4th Avenue, Suite 306, Anchorage, Alaska 99501.

Ianelli, J., L. Fritz, T. Honkalehto, N. Williamson, and G. Walters. 1998. Eastern Bering Sea walleye pollock stock assessment with yield considerations for 1999 (with Appendix 1.A walleye pollock abundance in the southeastern Aleutian Basin near Bogoslof Island during March, 1998). In: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands regions, 1998, pp. 31-111. North Pacific Fishery Management Council, 605 W 4th Avenue, Suite 306, Anchorage, Alaska 99501.

Petitgas, P. 1993. Geostatistics for fish stock assessments: a review and an acoustic application. ICES J. Mar. Sci. 50:285-298.

MacLennan, D. N. and E. J. Simmonds. 1992. Fisheries Acoustics. Chapman and Hall, London. 325 p.

Rose, G. A. 1998. Acoustic target strength of capelin in Newfoundland waters. ICES J. Mar. Sci. 55:918-923.

Traynor, J. J., N. J. Williamson, and W. A. Karp. 1990. A consideration of the accuracy and precision of fish-abundance estimates derived from echo-integration surveys. Rapp. P.-v. Reun. Cons. Int. Explor. Mer 189:101-111.

Williamson, N. J., and J. J. Traynor. 1984. In situ target-strength estimation of Pacific whiting (*Merluccius productus*) using a dual-beam transducer. J. Cons. int. Explor. Mer 41:285-292.

Williamson, N. J., and J. J. Traynor. 1996. Application of a one-dimensional geostatistical procedure to fisheries acoustic surveys of Alaskan pollock. ICES J. Mar. Sci. 53: 423-428.

Wilson, C. D., and M. A. Guttormsen. 1997. Echo integration –trawl survey of Pacific whiting, *Merluccius productus*, off the West Coasts of the United States and Canada during July-September 1995. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-74, 70 p.

Table 22.--Biomass estimates for pollock and capelin.

		PASS 1		PASS 2	
FISH CATEGORY	AREA	Biomass	95% CI	Biomass	95% CI
Adult pollock	Chiniak	6700	785	6200	805
	Barnabas	13100	2387	10800	2627
Age-1 pollock	Chiniak	5900	1638	8000	2221
	Barnabas	0		0	
Capelin/Age-0**	Chiniak	38200		52000	
	Barnabas	34300		52700	
TOTAL ADULT POLLOCK		19800		17000	
TOTAL AGE-1 POLLOCK		5900		8000	
TOTAL POLLOCK		25700		25000	
TOTAL POLLOCK + CAPELIN		98200		129700	

**Biomass of capelin/age-0 pollock based on TS = 19.1LogL-74.0 (Dalen and Nakken 1983). If TS = 20LogL-73.1 (Rose 1998) had been used, the biomass would have decreased by ~50%.

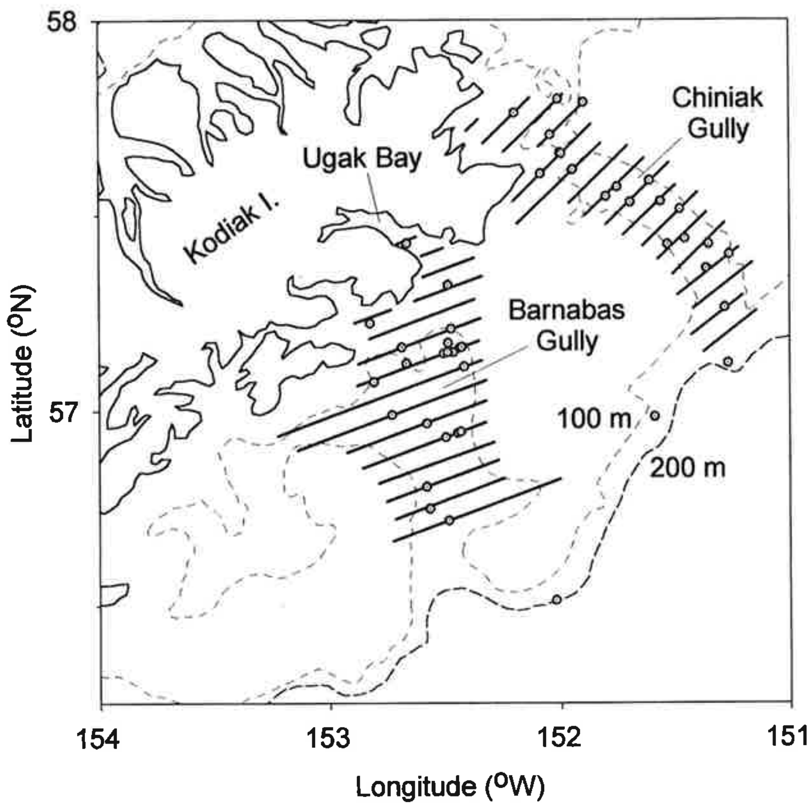


Figure 12.--Map of survey area with survey tracklines. Circles indicate trawl locations.

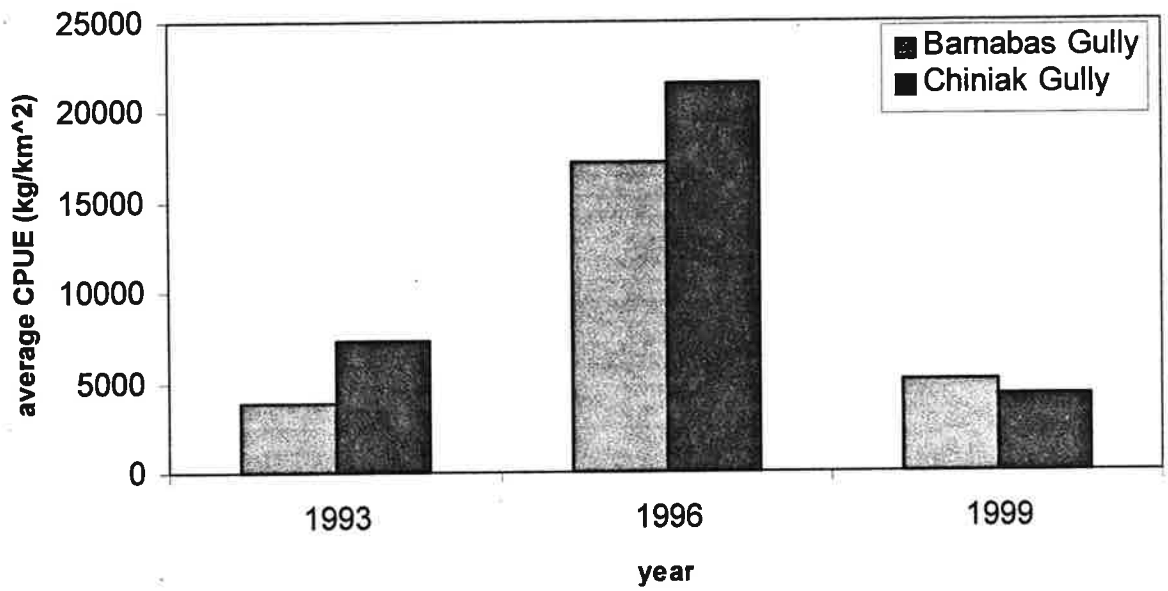
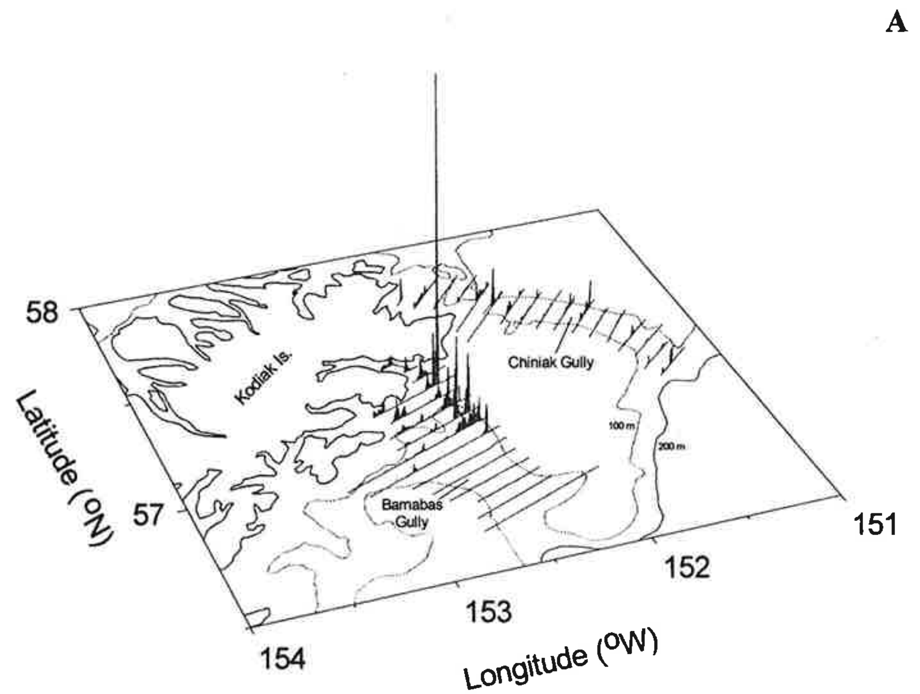


Figure 13.–Catch per unit effort (CPUE) estimates from triennial bottom trawl research surveys.



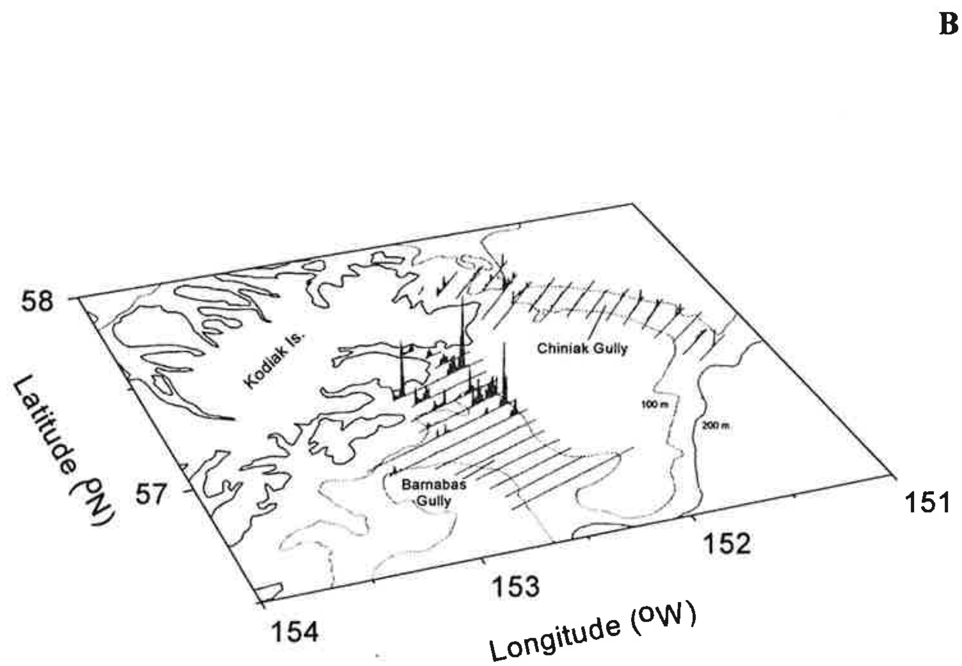
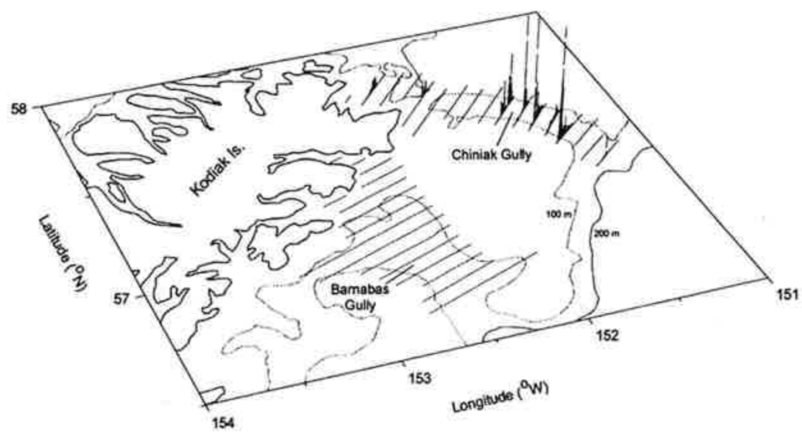


Figure 14.--Acoustic backscatter attributed to adult pollock during a) Pass 1, and b) Pass 2.

A



B

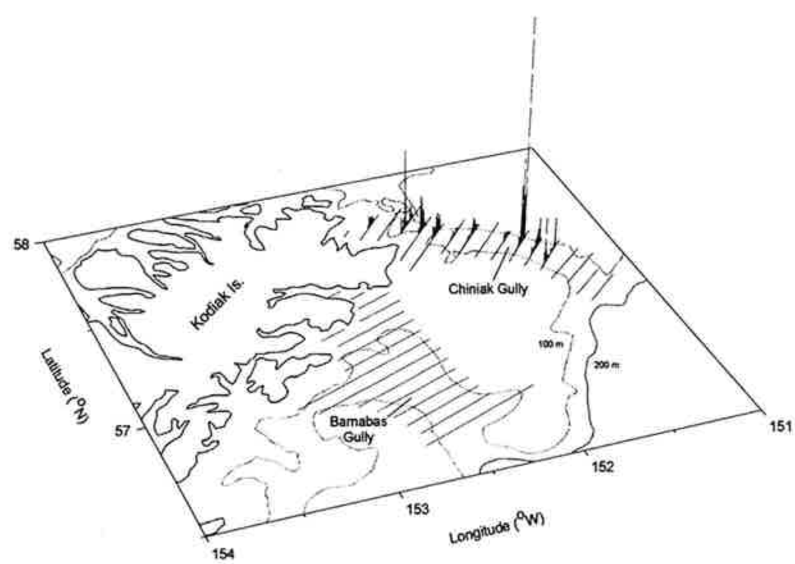


Figure 15.--Acoustic backscatter attributed to age-1 pollock during a) Pass 1, and b) Pass 2.

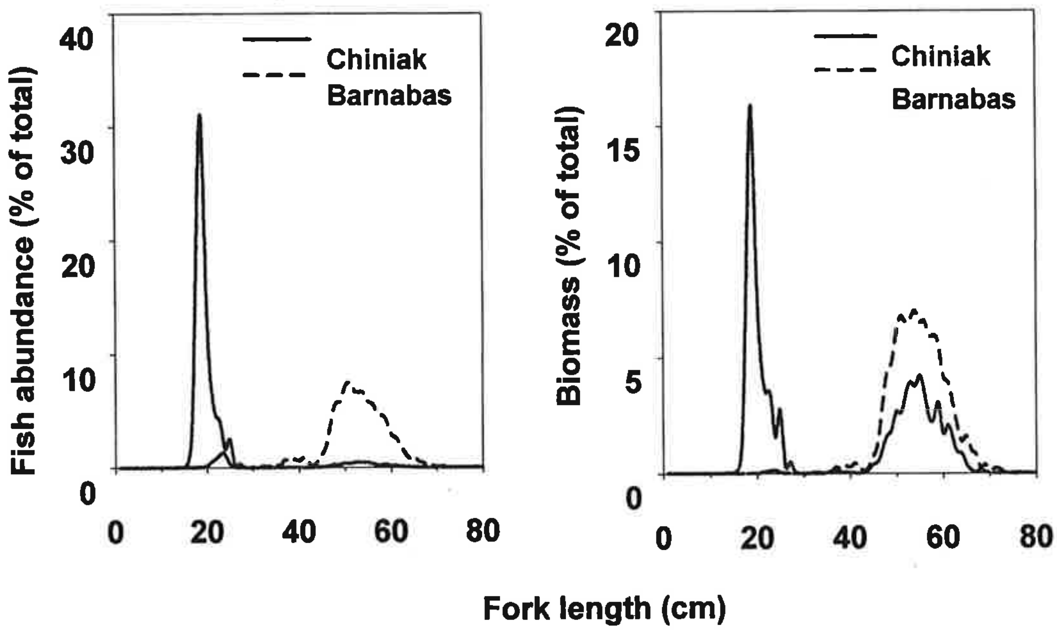


Figure 16.--Pollock size composition in Chiniak and Barnabas Gullies.

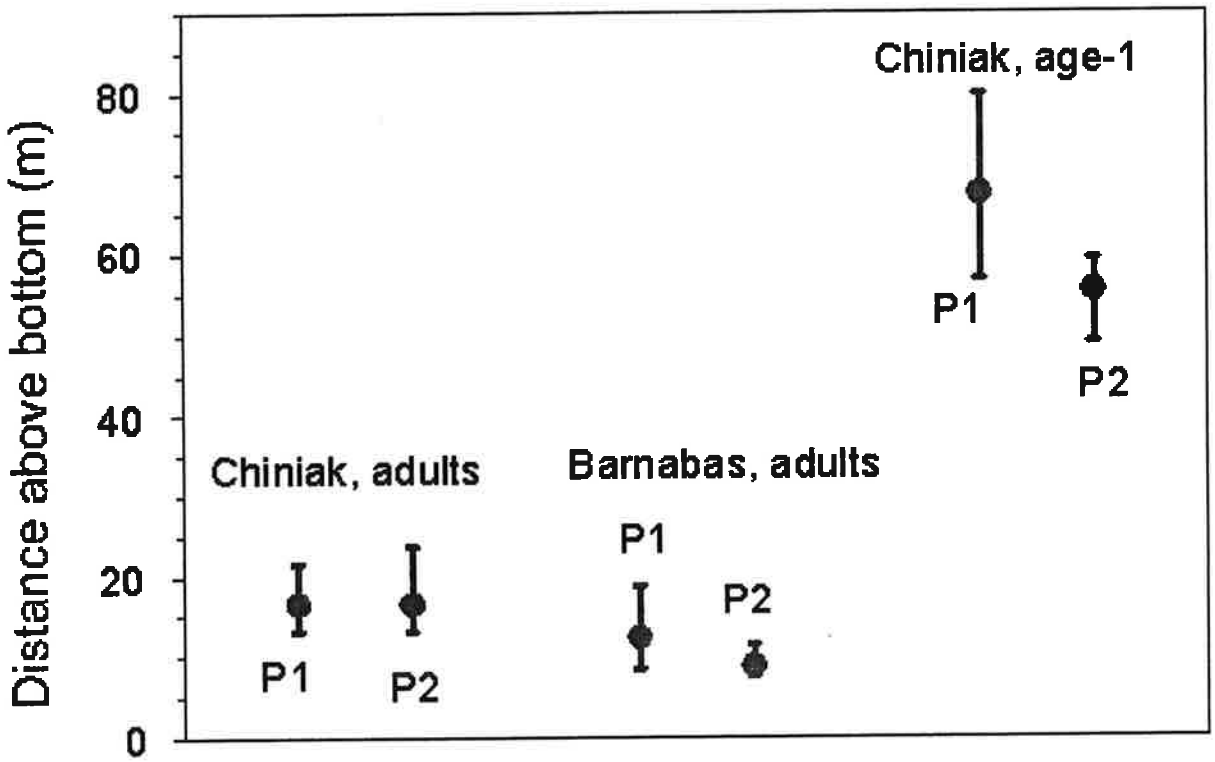


Figure 17.--Weighted mean distance off the bottom (m) for pollock in Chiniak and Barnabas Gullies during Pass 1 (P1) and Pass 2 (P2).

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SUMMARY OF STELLER SEA LION STUDIES IN RUSSIA, 2000

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The population dynamics of Steller sea lions in Russian waters showed some important changes in 2000 compared to the past several years. The number of animals on the Medny Island rookery was lower (-16.4%) than during the last few years, but most importantly this decline coincided with a decreasing number of mature females (-19.3% compared with the average of the 1996-1999 counts, Table 23, Fig. 18). Consequently, counts of newborn pups were the lowest in the last 10 years (Fig. 18), down by more than 31.8% (Table 23). On average, the number of young animals stayed level, but the proportion of females with one-year-old dependent pups increased compared to other years (Fig. 19). Survival rate of newborn pups during their first 2 months of their life on the rookery was the same as previous years (pup mortality on the rookery was 5.03%). The reason for the decreased number of females is unclear.

Numbers of newborn pups at Kozlova Cape in 2000 were the lowest of the 3 years of observation since 1992, decreasing by 12.6% compared with 1999 (Fig. 20). The number of non-pups on this rookery was also lower in 2000 (–8.8% compared with 1999).

An important effort made during the 2000 Steller sea lion observations in Russian waters was the census of sea lions conducted over the entire Kuril Islands range, including all rookeries and haul-out sites (Table 24). This was the first time haul-out sites in this region were surveyed since 1982. Numbers of non-pups on five major rookeries in 2000 were lower (–25.5%) compared to 1999, but the difference from 1999 can be explained by undercounts of animals on Lovushki, Raikoke, and Srednego rookeries. Numbers of non-pups and newborn pups on rookeries in 2000 were similar to the average level observed during the 1990s (Burkanov 2000). Comparing the number of non-pup sea lions on major haulout sites (Table 24), it is clear that numbers decreased dramatically since last counted in 1982 (-61.7%, Fig. 21).

In contrast, the abundance of Steller sea lions on Tuleny Island (Roben Island, near Sakhalin Island) and the northern part of the Sea of Okhotsk increased in 2000. On Tuleny Island pups increased 14.5% and non-pups increased 11.7% compared to 1999 (Fig. 22). A detailed survey at the Yamsky Islands (near Magadan) found increasing numbers of non-pups (41.2%) and newborn pups (127.5%) compared to 1998 (Zadal'sky 2000; Fig. 23). Increasing sea lion abundance in both areas may be the result of increased reproductive success and migration of animals from the Kuril Islands (based on observations in this area of sea lions branded at Kuril Island).

Based on the past 10 years of Steller sea lion counts in Russian waters, it appears that the Russian Far East region can be divided into three areas with different population trends: the eastern coast of Kamchatka Peninsula and Commander Islands (western Bering Sea) with a large declining trend; the Kuril Islands which show fluctuations in numbers of animals on rookeries, but perhaps with a slight decline (especially on haulouts); and Tuleny Island and the northern part of the Sea of Okhotsk which show an increase in numbers of Steller sea lions. To better understand the nature of sea lion declines it is important to study variation in population dynamics, and environmental trends in these distinct areas through continued monitoring of major rookeries and haul-out sites.

CITATIONS

Annual Report. 1984. Annual report on conservation and harvest monitoring of marine mammals in Sakhalino-Kurilsky basin in 1983. 37p. (in Russian).

Annual Report . 1985. Annual report on conservation and harvest monitoring of marine mammals in Sakhalino-Kurilsky basin in 1985. 29p. (in Russian).

Belkin, A. N. 1966. Summer distribution, stocks, prospects of harvest, and some features of biology of the sea lions inhabiting the Kuril Islands. Izv. TINRO 58:69-95 (in Russian).

Burkanov, V. N. 2000. Dinamika i sovremennoe sostoyanie chislennosti sivucha v vodah Rossii, 1989-1999 gg. (Steller's sea lion population status and dynamics in Russian waters in 1989-1999), p. 55-65. *In* Marine Mammals of the Holarctic Regions: Materials from international Conference, Archangelsk, Russia, 21-23 September, 2000. Archangelsk (in Russian).

Kornev, S. I., A. M. Trukhin, Y. B. Artukhin, and C. Y. Purtov. In press. Results of marine mammal census on south Kamchatka and Kuril Islands in June-August, 2000. Submitted to VNIRO marine mammal issue. Moscow (in Russian)

Kuzin, A. E., M. K. Maminov, and A. S. Perlov. 1984. Chislennost' lastonogikh I kalana and Kurilskikh oskrovakh (Abundance of pinnipeds and sea otter on Kuril Islands), p. 54-72. *In* Morskie mlekopitayuschie Dalnego Vostoka. Vladivostok (in Russian).

Loughlin, T. R., A. S. Perlov, and V. A. Vladimirov. 1992. Range-wide survey and estimation of total number of Steller sea lions in 1989. Mar. Mammal Sci. 83(3):220-239.

Perlov, A. S. 1970. Distribution and number of sea lions on the Kuril Islands rookeries. Izvestiya Nauchno issledovatel'skii Institut Rybnogo Khozyalstva i Okeanografii (TNIRO) 70:96-102 (in Russian).

Voronov, V. G. 1974. Pinnipedia: *Eumetopias jubatus*, p. 119-130. *In* Mammals of the Kuril Islands. Science Publishers, Leningrad (in Russian).

Zadal'sky, S. V. 2000. Prostranstvennoe pazmeschenie i struktura letnikh lezhbisch sivuchey *(Eumitopias jubatus Scheb., 1776)* i severnoy chasti Okhotskogo morya i ikh chislennost' (Distribution and abundance of the Steller sea lion *(Eumitopias jubatus Scheb., 1776)* on summer rookeries and haul out sites in the northern part of the Sea of Okhotsk), p. 123-126. *In* Marine Mammals of the Holarctic Regions: Materials from international Conference, Archangelsk, Russia, 21-23 September, 2000. Archangelsk (in Russian).

Table 23.--Changing Steller sea lion age-sex structures on Medny Island rookery in mid-breeding season, 1991-2000 (maximum counts).

Age-sex group	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Trend 2000 to 1996-99 mean	Trend 2000 to 1999
Bulls	76	76	65	85	65	74	87	94	117	90	-3.2%	-23.1%
Subadult males	11	26	9	31	44	47	125	121	102	113	14.4%	10.8%
Females	278	232	238	252	258	334	404	413	415	316	-19.3%	-23.9%
Young	51	35	26	41	36	83	128	112	101	117	10.4%	15.8%
Daily max all groups	385		341	378	414	529	744	723	725	569	-16.4%	-21.5%
Pups born	227	219	220	224	248	261	244	276	269	179	-31.8%	-33.5%
% females gave birth	82%	94%	92%	89%	96%	78%	60%	67%	65%	57%	-16.1%	-12.6%

Table 24.--Counts of Steller sea lions on five major rookeries and haul-out sites on Kuril Islands, 1960-2000.

		Non- pups		
Year	Pups	Haulouts	Rookeries	Source
1960			5965	Voronov 1974
1963	3687		8371	Belkin 1966
1968			7948	Perlov 1970
1969	3230	4993	6916	Kuzin et al., 1984
1975	1970		4366	Kuzin et al., 1984
1980			3422	Kuzin et al., 1984
1981	1757		3591	Annual rep. 1984
1982	1071	2895	2846	Annual rep. 1984
1983	1990		2952	Annual rep. 1984
1984			3877	Annual rep. 1985
1989	1445		2719	Loughlin et al., 1992
1995[1]	1931		3016	Burkanov V. N. pers.
1996[1]	1904		2730	Pavlov N. N. pers.
1997[1]	1816		2092	Pavlov N. N. pers.
1998[1]	1931		2968	Pavlov N. N. pers.
1999	1235		2799	Pavlov N. N. pers.
2000	1820	1108	2085	Kornev et al., in press

[1]Estimated data.

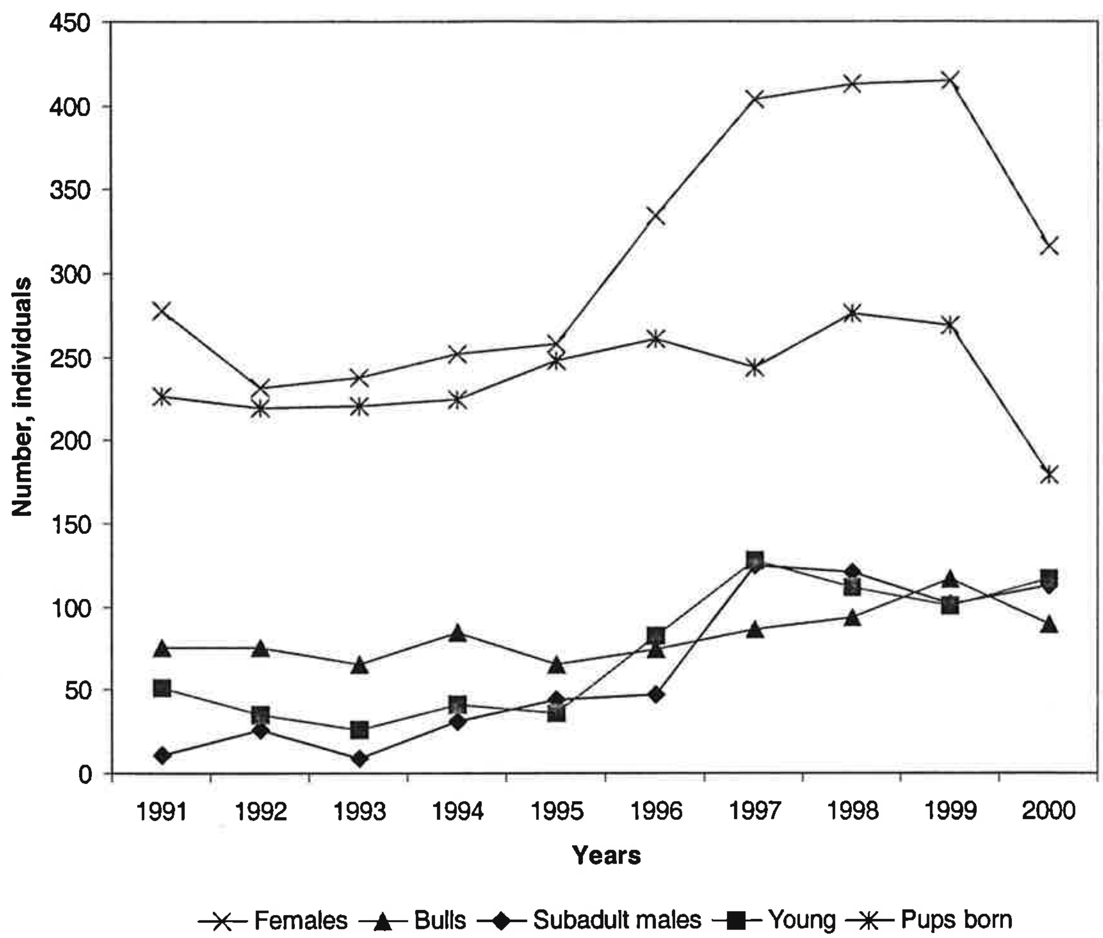

Figure 18.--Number of Steller sea lion on Medny Island by sex-age groups in the middle of breeding season, 1991-2000.

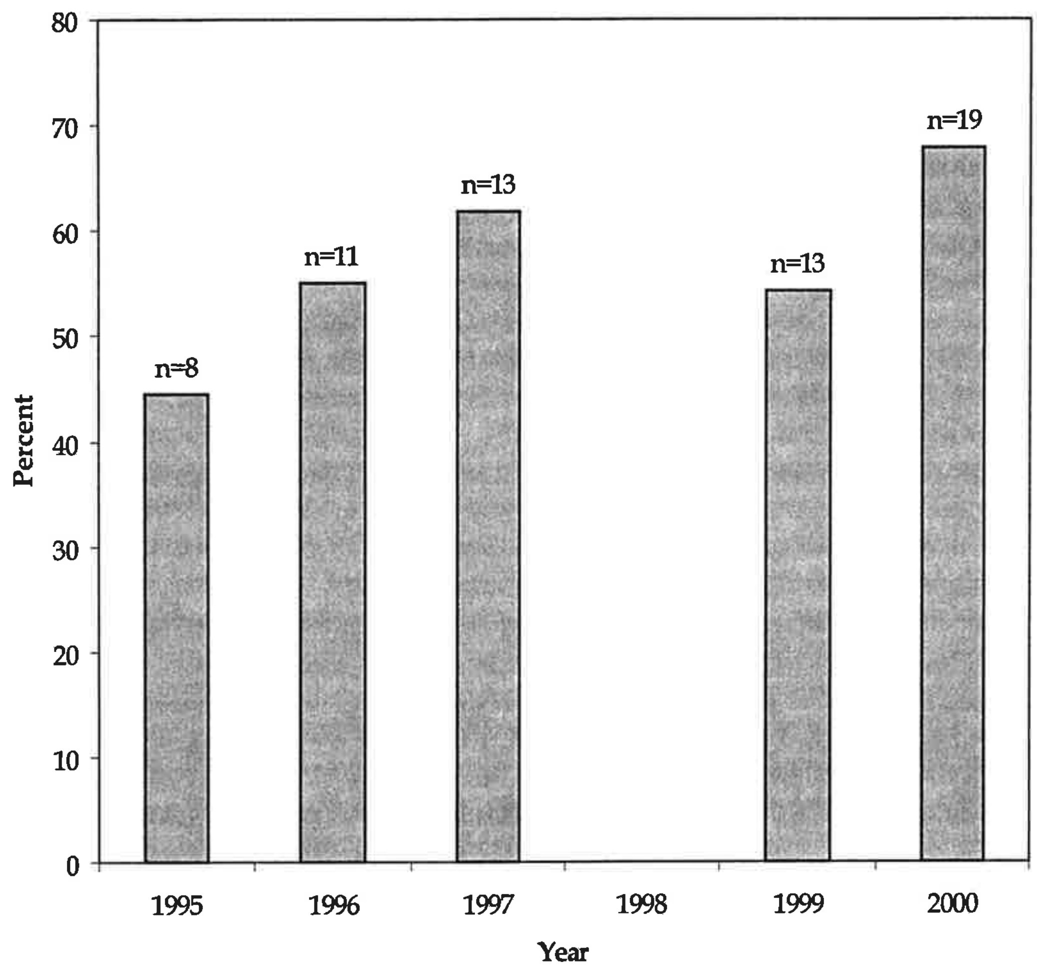

Figure 19.--Proportion of known females with dependent yearlings on Medny Island rookery.

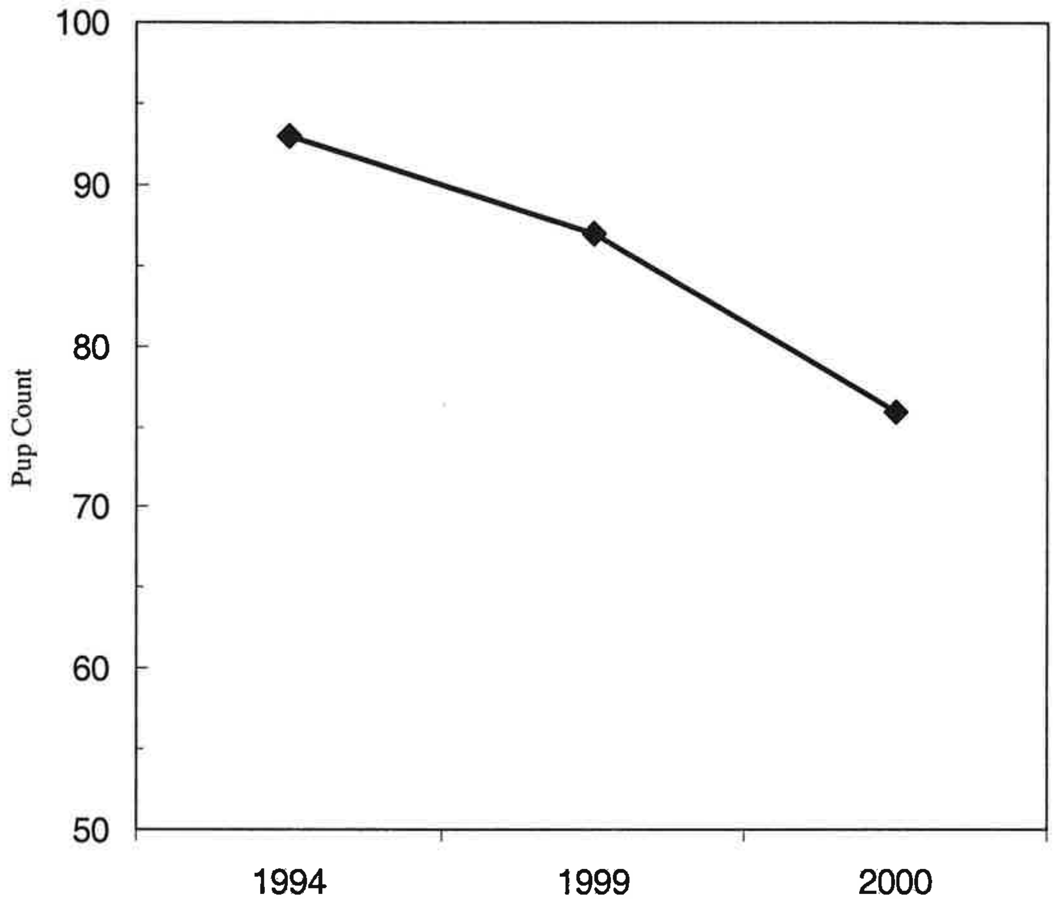

Figure 20.–Numbers of newborn pups of Steller sea lions on Kozlova Cape, Kamchatka, 1994-2000.

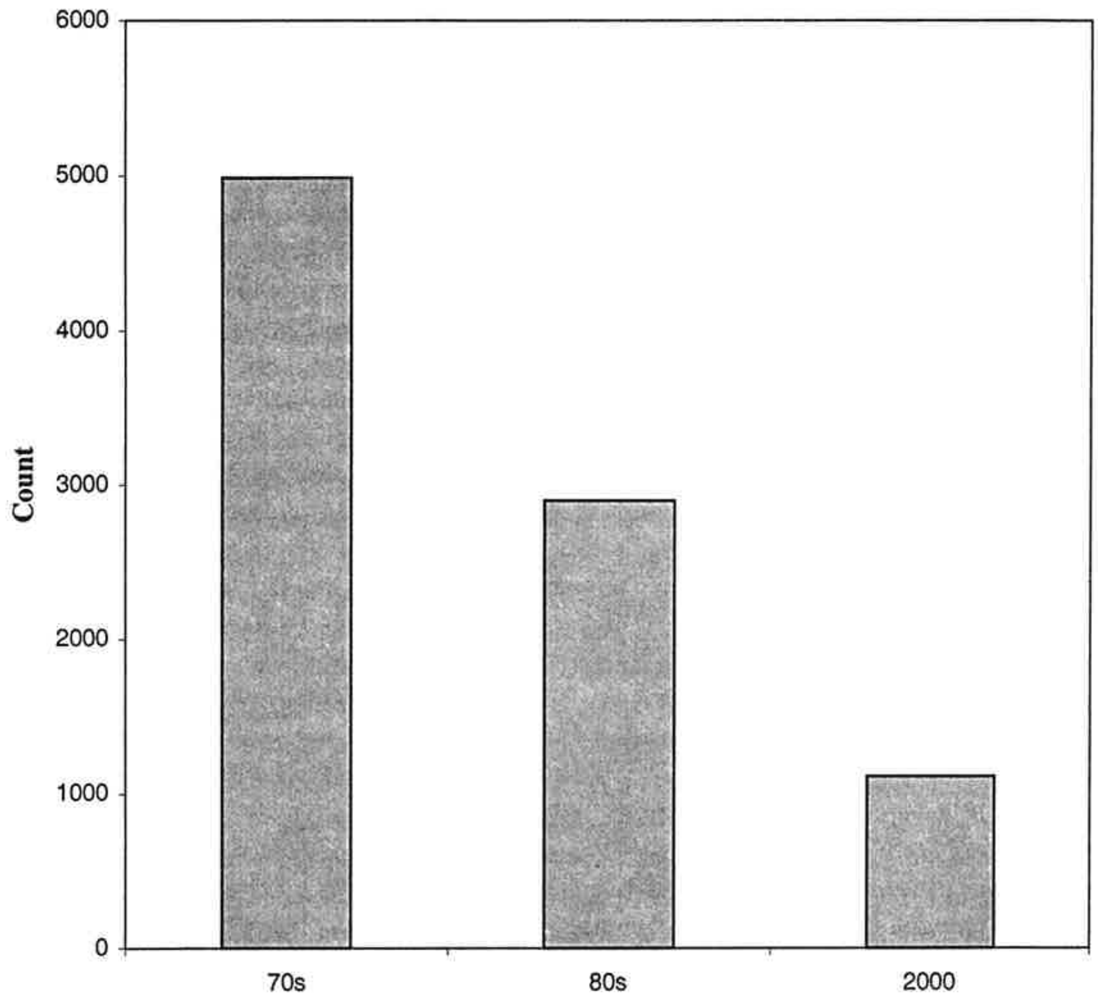

Figure 21.--Changes in abundance of non-pup Steller sea lions on major haul-out sites in Kuril Islands, 70s-80s-2000.(Kuzin et al. 1984, Annual report 1984; 1985, Kornev et al. in press).

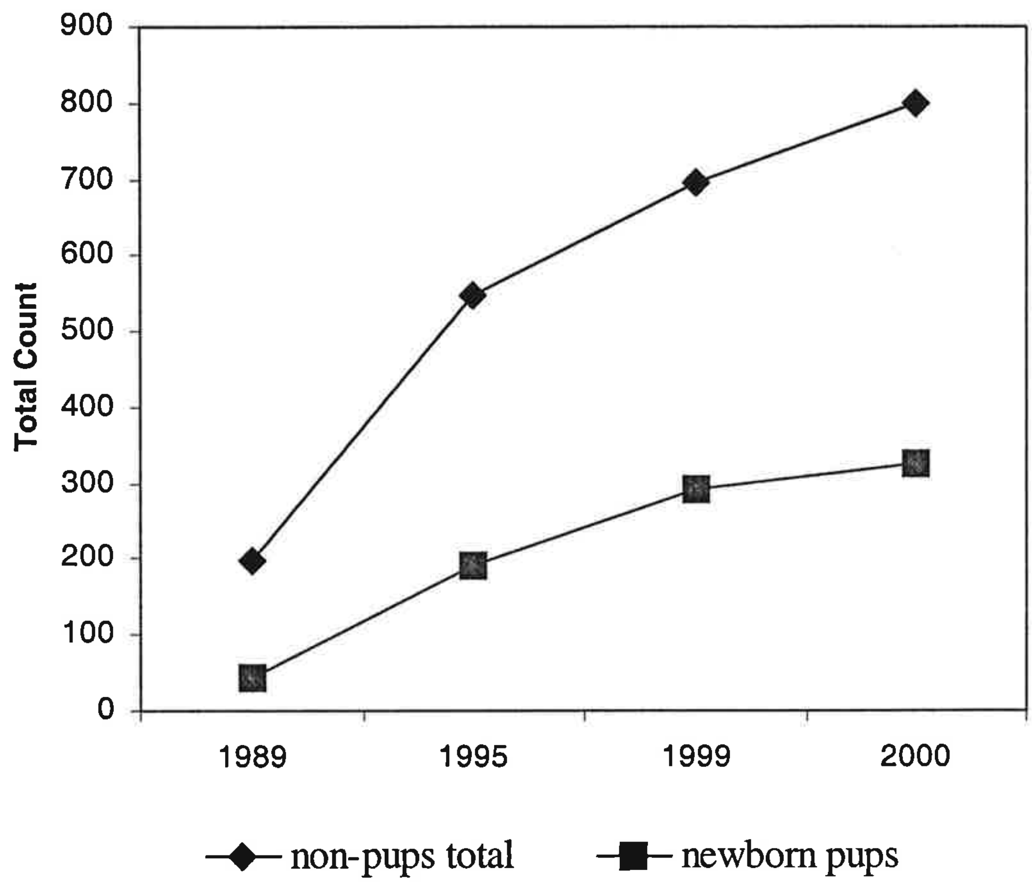

Figure 22.--Changes in number of Steller sea lions on Tuleny Island, 1989-2000 (Kuzin A. E., pers. comm).

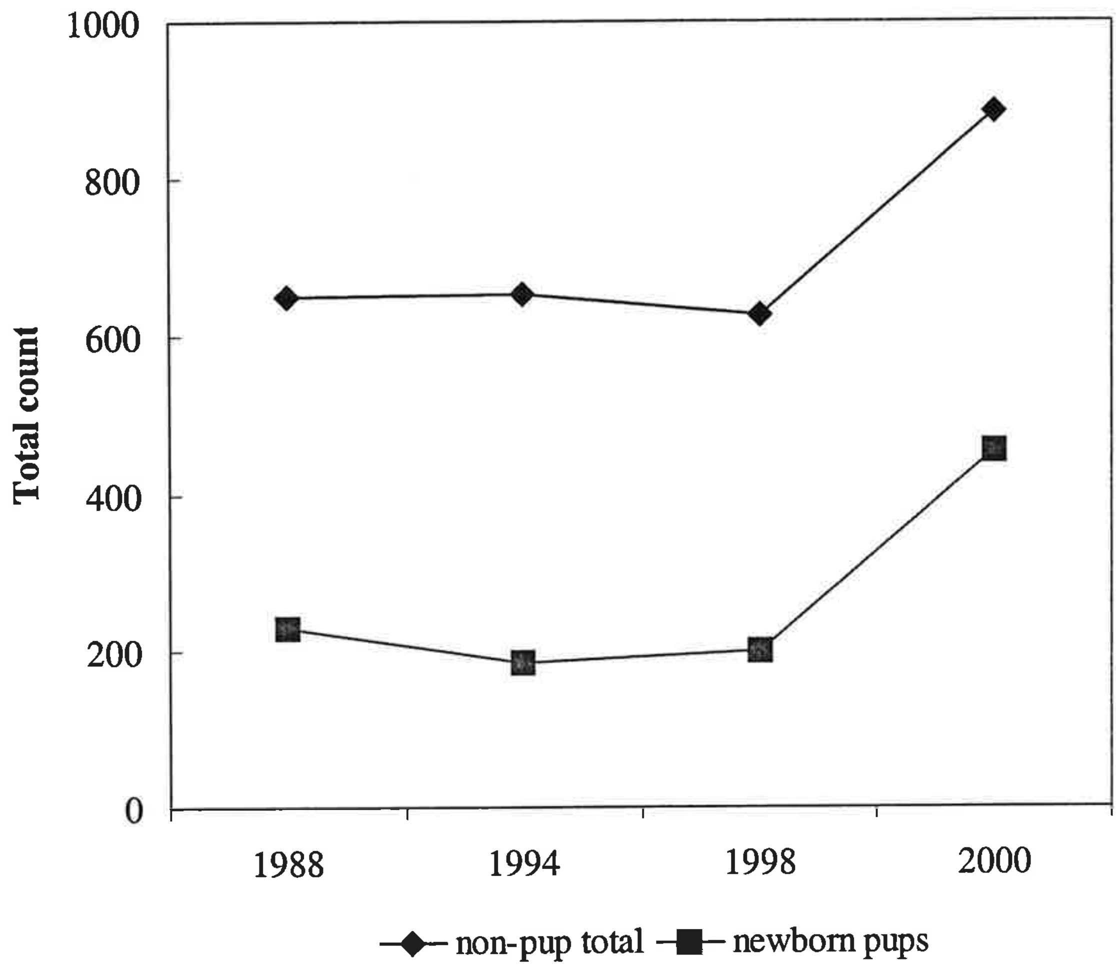

Figure 23.--Changes in number of Steller sea lions on Yamsky Islands, 1988-2000.

POPULATION GENETIC ANALYSIS ACROSS THE DISTRIBUTIONAL RANGE OF AN ENDANGERED MARINE MAMMAL (STELLER SEA LION, *EUMETOPIAS JUBATUS*)

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ABSTRACT

Steller sea lions (*Eumetopias jubatus*)are distributed throughout much of the North Pacific and Bering Sea. They congregate at rookeries during the breeding season and presumably have high site fidelity to their natal rookery. Thus, a population can be defined as the individuals that breed at a particular rookery. Genetic divergence is expected to occur among rookeries as a result of behavioral isolation, even though animals might move great distances and intermingle with individuals from other rookeries outside the breeding season. Sea lion rookeries are distributed as an arch extending from the Sea of Okhotsk and the Kuril Islands in Asia, north and eastward across the Aleutian Island chain to the Gulf of Alaska and Prince William Sound, with one population in the Pribilof Islands in the Bering Sea. There is a gap between Prince William Sound and the nearest rookeries in southeastern Alaska, British Columbia, Washington, Oregon, and California. Previous genetic studies have shown high variability in the mtDNA control region and a significant difference in haplotype frequencies to the east and west of the distributional gap. The recognition of two genetically differentiated stocks was proposed based on these data. The western stock, which has declined in numbers by more than 80% since the 1960s, is now listed as endangered while the eastern stock, which has remained stable, is listed as threatened under the U.S. Endangered Species Act. This paper reports new data for 87 animals from the 2000 Steller sea lion genetics study funded by NOAA, and summarizes our previous findings from 658 Steller sea lions taken at rookeries throughout the range of the species.

INTRODUCTION

In 1997, the western stock of the Steller sea lion (*Eumetopius jubatus*) was listed as endangered under the U. S. Endangered Species Act. This action was taken due to the continued decline in numbers in all U. S. rookeries ranging from the Gulf of Alaska west through the Aleutian Islands and the Bering Sea. It has been reported that the U.S. population of Steller sea lions has declined from an estimated 192,000 in the 1960s to 52,200 in 1994 (NMFS 1995).

Genetic studies of the mitochondrial DNA (mtDNA) molecule have been conducted in order to determine to what degree local populations (rookeries) and regional areas have diverged. These studies have contributed to a better understanding of the process of decline by identifying two genetically distinct stocks. A western stock includes all U.S. rookeries distributed from Cape Suckling to the west including Prince William Sound, the Gulf of Alaska, the Aleutian Islands, and the Bering Sea. An eastern stock is distributed from southeastern Alaska south through British Columbia, Washington, Oregon, and California (Bickham et al. 1996; 1998b). These stocks differ significantly in their haplotype frequencies, although they share certain haplotypes in common. Moreover, phylogenetic analysis indicates that haplotypes found only in the eastern stock originate mostly from near the base of the tree whereas all western stock haplotypes trace their origin to a single lineage that originates farther up the tree.

The status of the Asian populations is somewhat problematical. The rookeries in the Commander Islands, Kamchatka Peninsula, Kuril Islands, and the Sea of Okhotsk form a divergent cluster based upon mtDNA haplotype frequencies. Thus, the Asian populations may represent a third genetically distinct stock, or at least a divergent subset of the western stock (Bickham et al., 1998b; Bickham and Wickliffe, 1999). The western stock (including the Asian populations) has declined, while the eastern stock has remained stable or increased and is listed as threatened, not endangered. Another study (Bickham et al. 1998a) showed that genetic diversity in animals from the Gulf of Alaska, an area in which sea lion rookeries have declined, has not changed significantly when animals collected in the 1970s were compared to animals collected in the 1990s. Thus, despite the decline, appreciable levels of genetic diversity still exist within the western stock of Steller sea lions.

This report analyzes and interprets the results of the 2000 Steller sea lion genetics project conducted at Texas A&M University. We studied 87 Steller sea lions representing 12 rookeries in the eastern Aleutian Islands, central Aleutian Islands, western Aleutian Islands, western Gulf of Alaska, and central Gulf of Alaska, as well as individuals taken from the native harvests in the Pribilof Islands of the Bering Sea. We also summarize all previous data and analyze the relationships of the regional populations based upon a total of 658 Steller sea lions taken from rookeries.

METHODS

For the mitochondrial DNA analysis, DNA was isolated from skin samples from 87 Steller sea lion pups taken from the following rookeries: Atkins Island (n = 8), Agattu Island (n = 15), Akun Island (n = 1), Buldir Island (n = 11), Chirikof Island (n = 11), Clubbing Rocks (n = 4), Kasatoshi Island (n = 1), Kiska Island (n = 11), Pinnacle Rocks (n = 2), Seguam Island (n = 11), Ulak Island (n = 9), and Yunaska (n = 3). A 238-bp (base pair) segment of the control region was amplified using polymerase chain reaction (PCR) and sequenced by automated sequence procedures as previously described (Bickham et al., 1996).

MtDNA haplotypes were determined for all individuals using previously described methods (Bickham et al., 1996). Phylogenetic relationships among haplotypes were estimated using the Neighbor Joining method with Tamura-Nei distances in the program Phylogenetic Analysis

Using Parsimony (PAUP, ver. 4.02). Genetic relationships among populations were assessed by the Neighbor Joining method using Fst estimates. Population genetic parameters, including Fst, Nm, and gene diversity, were estimated using the program Arlequin.

RESULTS AND DISCUSSION

Mitochondrial DNA haplotypes were obtained for 87 specimens representing 12 rookeries. The observed haplotypes (Table 25) included the two widely distributed haplotypes, A (n = 5) and BB (16). We observed three previously unknown haplotypes, NNNN (n = 1), and OOOO (n = 1), and PPPP (n = 1), and QQQQ (n = 1), and 11 haplotypes that are characteristic of the western stock, CC (n = 15), DD (n = 1), E (n = 6), G (n = 2), HH (n = 1), JJJ (n = 2), KKK (n = 1), S (n = 24), T (n = 1), W (n = 4), and Z (n = 18). No haplotypes that are characteristic of the eastern stock were observed. In order to determine if the four previously unknown haplotypes are likely derived from the western stock, a phylogenetic analysis was performed using the computer program PAUP. The program produced a distance matrix using the 238 bp sequence of the control region for each haplotype, and using haplotype 1 of the California sea lion as the outgroup. The addition of the new haplotypes have not changed the tree appreciably from that reported last year (Bickham, 1999). Most of the haplotypes that characterize the eastern stock cluster at the base of the tree, with a few exceptions. The haplotypes characteristic of the western stock trace their lineage to a common ancestor that is more derived (found higher up the tree away from the branch leading to the outgroup) than most of the eastern stock haplotypes. A few eastern stock haplotypes are found within this western haplotype lineage including UU, P, Q, R, and B, as well as the widespread haplotypes BB and A. The new haplotypes all fall well within this western lineage and this is consistent with the conclusion that these are simply rare western haplotypes not previously observed due to the limited sample sizes in the previous studies. The total number of haplotypes now known in Steller sea lions is 95.

Table 26 presents the 91 haplotype frequencies for all 658 Steller sea lions sampled from rookeries (four others are from sea lions sampled off of rookeries). The rookeries are combined into 14 grouped localities. Slatkins linearized Fst estimates were computed for all pairwise comparisons of the 14 grouped localities (Table 27). Fst estimates are a measure of the differentiation between two populations with higher values indicating greater differentiation. The maximum value of 1 indicates complete differentiation and the minimum value of 0 indicates identity. The Fst estimates were analyzed by the Neighbor Joining method to generate a tree representing the genetic relationships of the populations (Fig. 24). Two versions of the tree, one with midpoint rooting and the other unrooted are presented. As can be seen from these trees, the western stock populations of Alaska, ranging from Prince William Sound west to the Western Aleutian Islands, cluster together with very low Fst values (Table 27). The Asian populations (Russia, Kuril Islands, and Sea of Okhotsk) cluster closer to the Alaskan western stock populations and together these are separated considerably from the eastern stock populations (Southeastern Alaska to Northern California). The addition of the 87 samples in this report, together with a different analytical approach (in this report we have clustered Fst values compared to genetic identity estimates in Bickham and Wickliffe [1999]) has somewhat changed the relationships among populations. Specifically, the Asian populations now cluster on the branch leading to the Alaskan western stock populations, instead of on the branch leading to the eastern stock. These data are consistent with a strong genetic differentiation between the eastern and western stocks, and the possible recognition of two groups within the western stock (i.e., the Asian populations versus the remaining U.S. populations) as was suggested by Bickham et al. (1998b).

As in all previous studies of mtDNA in Steller sea lions, high haplotype diversity was observed. Figure 25 illustrates Nei's gene diversity for the 14 grouped localities. Gene diversity estimates range from 0.79 to 0.95, indicating high haplotype diversity for all populations despite the decline in population numbers. Populations were combined into three geographic regions representing the eastern stock (eastern), the Asian populations (western), and the Alaskan portion of the western stock (central) and analyzed for Nei's gene diversity (Fig. 25). From this it can be seen that the eastern stock has the highest gene diversity, and the central region has the lowest. All three of these regions are statistically significantly different for gene diversity. In order to estimate levels of female dispersal among the grouped localities we estimated Nm , the number of effective female migrants per generation, from the F statistics reported in Table 27. It can be seen from these estimates that the exchange of female migrants is much greater between populations within stocks, compared to between stocks (Table 27).

A total of 658 Steller sea lions from rookeries now have known genotypes for mtDNA. This data set clearly contributes to an understanding of the macrogeographic patterns of the species. Additional mtDNA studies need to be performed on the few rookeries that have not yet been examined, and given the low frequency of many haplotypes, sample sizes larger than 10 individuals per rookery are desirable. We now have data from 19 rookeries with sample sizes of 20 or greater that can be analyzed to determine if this is sufficient to adequately characterize genetic diversity in this species. Because many haplotypes are known only from single rookeries or regions, they are potentially extremely valuable as genetic tags. But, our degree of confidence that they are truly restricted to the observed distribution is proportional to how thorough the population sampling has been done. It is recommended that continued efforts be focused on increasing the mtDNA database by examining samples from the few remaining unstudied rookeries and by increasing sample sizes in already studied areas for which sample sizes are low. In particular, it is recommended that efforts be made to increase the sample sizes from the eastern stock rookeries so that statistical comparisons among regions will be stronger. We have also begun a preliminary investigation of the mtDNA cytochrome *b* gene funded by World Wildlife Fund. We examined several animals with the BB haplotype and were able to divide them into two groups based on this gene. It would be invaluable to do this for all BB individuals as well as to investigate such cryptic variability in the other two most-common haplotypes, A and S.

ACKNOWLEDGMENTS

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CITATIONS

Bickham, J. W. 1999. Untitled report to National Marine Mammal Laboratory. Texas A&M University, College Station, TX, 7 p.

Bickham, J. W., T. R. Loughlin, D. G. Calkins, J. K. Wickliffe, and J. C. Patton. 1998a. Genetic variability and population decline in Steller sea lions from the Gulf of Alaska. J. of Mammal., 79:1390-1395.

Bickham, J. W., T. R. Loughlin, J. K. Wickliffe, and V. N. Burkanov. 1998b. Geographic variation in the mitochondrial DNA of Steller sea lions: haplotype diversity and endemism in the Kuril Islands. Bio. Con., 1:107-117.

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 maternal phylogeny of Steller sea lions (*Eumetopias jubatus*). J. of Mammal. 77:95-108.

Bickham, J. W., and J. K. Wickliffe. 1999. Geographic variation in nuclear microsatellites and mtDNA of Steller sea lions. Unpublished report to National Marine Mammal Laboratory, 19 p.

NMFS (National Marine Fisheries Service). 1995. Status review of the United States Steller sea lion (*Eumetopias jubatus*) population. Prepared by the National Marine Mammal Laboratory, Alaska Fisheries Science Center, Seattle, Washington, 45 p.

Table 25.–MtDNA haplotypes for 87 Steller sea lions: haplotypes were determined from a 238 bp fragment of the control region by nucleotide sequence analysis.

Sample	Rookery	Region	Haplotype	Capture Date	Comments
9	Atkins Island	Western Gulf of Alaska	A	29-Jun-98	
1	Atkins Island	Western Gulf of Alaska	BB	29-Jun-98	
2	Atkins Island	Western Gulf of Alaska	G	29-Jun-98	
7	Atkins Island	Western Gulf of Alaska	S	29-Jun-98	
8	Atkins Island	Western Gulf of Alaska	S	29-Jun-98	
10	Atkins Island	Western Gulf of Alaska	S	29-Jun-98	
3	Atkins Island	Western Gulf of Alaska	Z	29-Jun-98	
4	Atkins Island	Western Gulf of Alaska	Z	29-Jun-98	
ACS 1018	Agattu I.	Western Aleutian Islands	A	24-Jun-98	Cape Sebak, tagged pups
ACS 1033	Agattu I.	Western Aleutian Islands	BB	24-Jun-98	Cape Sebak, tagged pups
ACS DP2	Agattu I.	Western Aleutian Islands	BB	24-Jun-98	Cape Sebak, dead pup
ACS 1039	Agattu I.	Western Aleutian Islands	BB	24-Jun-98	Cape Sebak, tagged pups
ACS 1015	Agattu I.	Western Aleutian Islands	CC	24-Jun-98	Cape Sebak, tagged pups
ACS 1044	Agattu I.	Western Aleutian Islands	CC	24-Jun-98	Cape Sebak, tagged pups
ACS 1047	Agattu I.	Western Aleutian Islands	CC	24-Jun-98	Cape Sebak, tagged pups
ACS 1051	Agattu I.	Western Aleutian Islands	CC	24-Jun-98	Cape Sebak, tagged pups
ACS 1030	Agattu I.	Western Aleutian Islands	E	24-Jun-98	Cape Sebak, tagged pups
ACS 4	Agatu I.	Western Aleutian Islands	JJJ	24-Jun-98	Cape Sebak, tagged pups
ACS DP3	Agattu I.	Western Aleutian Islands	JJJ	24-Jun-98	Cape Sebak, dead pup
ACS 1036	Agattu I.	Western Aleutian Islands	S	24-Jun-98	Cape Sebak, tagged pups
ACS 1	Agatu I.	Western Aleutian Islands	S	24-Jun-98	Cape Sebak, tagged pups
ADP1	Agatu I.	Western Aleutian Islands	S	24-Jun-98	Cape Sebak, dead pup
ACS 1011	Agattu I.	Western Aleutian Islands	W	24-Jun-98	Cape Sebak, tagged pups
BB 6	Akun Island	Eastern Aleutian Islands	S	3-Jul-98	Billingshead Bight

Table 25. Cont.

Sample	Rookery	Region	Haplotype	Capture Date	Comments
Buld 1102	Buldir	Western Aleutian Islands	A	26-Jun-98	Tagged pup
Buld 1110	Buldir	Western Aleutian Islands	BB	26-Jun-98	Tagged pup
Buld 1101	Buldir	Western Aleutian Islands	CC	26-Jun-98	Tagged pup
Buld 1104	Buldir	Western Aleutian Islands	CC	26-Jun-98	Tagged pup
Buld 1108	Buldir	Western Aleutian Islands	CC	26-Jun-98	Tagged pup
Buld 1100	Buldir	Western Aleutian Islands	E	26-Jun-98	Tagged pup
Buldir 1	Buldir	Western Aleutian Islands	KKK	26-Jun-98	Tagged pup
Buld 1107	Buldir	Western Aleutian Islands	W	26-Jun-98	Tagged pup
Buld 1098	Buldir	Western Aleutian Islands	Z	26-Jun-98	Tagged pup
Buld 1109	Buldir	Western Aleutian Islands	Z	26-Jun-98	Tagged pup
RED 1090	Buldir	Western Aleutian Islands	Z	26-Jun-98	Tagged pup
Chir 7	Chirikof Island	Central Gulf of Alaska	DD	27-Jun-98	Tagged pup
Chir 8	Chirikof Island	Central Gulf of Alaska	E	27-Jun-98	Tagged pup
Chir 4	Chirikof Island	Central Gulf of Alaska	G	27-Jun-98	Tagged pup
Chir 3	Chirikof Island	Central Gulf of Alaska	S	27-Jun-98	Tagged pup
Chir 5	Chirikof Island	Central Gulf of Alaska	S	27-Jun-98	Tagged pup
Chir 6	Chirikof Island	Central Gulf of Alaska	S	27-Jun-98	Tagged pup
Chir 9	Chirikof Island	Central Gulf of Alaska	S	27-Jun-98	Tagged pup
Chir 1	Chirikof Island	Central Gulf of Alaska	Z	27-Jun-98	Tagged pup
Chir 2	Chirikof Island	Central Gulf of Alaska	Z	27-Jun-98	Tagged pup
Chir 10	Chirikof Island	Central Gulf of Alaska	Z	27-Jun-98	Tagged pup
CI 3	Chowiet Island	Central Gulf of Alaska	S	28-Jun-98	
Club 2	Clubbing Rocks	Western Gulf of Alaska	BB	30-Jun-98	
Club 4	Clubbing Rocks	Western Gulf of Alaska	BB	30-Jun-98	
Club 10	Clubbing Rocks	Western Gulf of Alaska	E	30-Jun-98	
Club 9	Clubbing Rocks	Western Gulf of Alaska	S	30-Jun-98	

Table 25. Cont.

Sample	Rookery	Region	Haplotype	Capture Date	Comments
KAS 2	Kasatoshi	Central Aleutian Islands	S	1-Jul-98	
KI 1116	Kiska Island	Central Aleutian Islands	A	27-Jun-98	Tagged pup
KI 1126	Kiska Island	Central Aleutian Islands	BB	27-Jun-98	Tagged pup
KI 1155	Kiska Island	Central Aleutian Islands	BB	27-Jun-98	Tagged pup
KI 1121	Kiska Island	Central Aleutian Islands	CC	27-Jun-98	Tagged pup
KI 1129	Kiska Island	Central Aleutian Islands	CC	27-Jun-98	Tagged pup
KI 1148	Kiska Island	Central Aleutian Islands	CC	27-Jun-98	Tagged pup
KI 1152	Kiska Island	Central Aleutian Islands	CC	27-Jun-98	Tagged pup
KI 1132	Kiska Island	Central Aleutian Islands	S	27-Jun-98	Tagged pup
KI 1141	Kiska Island	Central Aleutian Islands	Z	27-Jun-98	Tagged pup
KI 1160	Kiska Island	Central Aleutian Islands	Z	27-Jun-98	Tagged pup
KI 1164	Kiska Island	Central Aleutian Islands	Z	27-Jun-98	Tagged pup
PR 7	Pinnacle Rocks	Western Gulf of Alaska	CC	30-Jun-98	
PR2	Pinnacle Rocks	Western Gulf of Alaska	Z	30-Jun-98	
Segu 1216	Seguam Island	Central Aleutian Islands	BB	2-Jul-98	
Segu 1234	Seguam Island	Central Aleutian Islands	BB	2-Jul-98	
Segu 1214	Seguam Island	Central Aleutian Islands	BB	2-Jul-98	
Segu 1220	Seguam Island	Central Aleutian Islands	CC	2-Jul-98	
Segu 1224	Seguam Island	Central Aleutian Islands	CC	2-Jul-98	
Segu 1226	Seguam Island	Central Aleutian Islands	E	2-Jul-98	
Segu 1219	Seguam Island	Central Aleutian Islands	HH	2-Jul-98	
Segu 1222	Seguam Island	Central Aleutian Islands	S	2-Jul-98	
Segu 1228	Seguam Island	Central Aleutian Islands	Z	2-Jul-98	
Segu 1231	Seguam Island	Central Aleutian Islands	Z	2-Jul-98	
SDP 3	Seguam Island	Central Aleutian Islands	Z	2-Jul-98	Dead pup
Ulak 1189	Ulak Island	Central Aleutian Islands	A	29-Jun-98	Tagged pup

Table 25. Cont.

Sample	Rookery	Region	Haplotype	Capture Date	Comments
Ulak 1165	Ulak Island	Central Aleutian Islands	BB	29-Jun-98	Tagged pup
Ulak 1181	Ulak Island	Central Aleutian Islands	BB	29-Jun-98	Tagged pup
Ulak 1191	Ulak Island	Central Aleutian Islands	BB	29-Jun-98	Tagged pup
Ulak 1187	Ulak Island	Central Aleutian Islands	CC	29-Jun-98	Tagged pup
Ulak 1168	Ulak Island	Central Aleutian Islands	PPPP	29-Jun-98	Tagged pup
Ulak 1193	Ulak Island	Central Aleutian Islands	T	29-Jun-98	Tagged pup
Ulak 1185	Ulak Island	Central Aleutian Islands	Z	29-Jun-98	Tagged pup
Ulak 1186	Ulak Island	Central Aleutian Islands	Z	29-Jun-98	Tagged pup
Yun 2	Yunaska Island	Central Aleutian Islands	S	3-Jul-98	
Yun 4	Yunaska Island	Central Aleutian Islands	W	3-Jul-98	
Yun 4-2	Yunaska Island	Central Aleutian Islands	W	3-Jul-98	

Table 26.–MtDNA haplotype frequencies observed among 14 grouped localities of Steller sea lions. Abbreviations are: KUR-Kuril Islands, RUS-Commander Islands and Kamchatka Peninsula, OKH-Sea of Okhotsk, WAL-Western Aleutian Islands, CAL-Central Aleutian Islands, EAL-Eastern Aleutian Islands, WGA-Western Gulf of Alaska, CGA-Central Gulf of Alaska, BER-Bering Sea, PWS-Prince William Sound, SEA-Southeastern Alaska, BRC-British Columbia, ORE-Oregon, NCA-Northern California.

Haplotype	KUR	RUS	OKH	WAL	CAL	EAL	WGA	CGA	BER	PWS	SEA	BRC	ORE	NCA
A	0.156	0.159	0.091	0.067	0.041	0.026	0.111		0.056	0.059	0.138			0.1
B													0.067	
C						0.026								
D											0.034			
E		0.045		0.044	0.025	0.039	0.148	0.069	0.056	0.059				
F						0.013								
G	0.018					0.039	0.037	0.034		0.02				
H											0.138		0.133	0.4
I													0.067	
J													0.067	
K											0.103			
L											0.069	0.2		
M													0.067	0.1
N													0.2	0.1
O											0.034			
P													0.067	
Q											0.069	0.2	0.067	0.2
R											0.034		0.067	
S	0.037	0.068		0.178	0.289	0.312	0.241	0.397	0.278	0.314	0.034			
T					0.017		0.019							
U	0.009	0.023				0.039		0.017		0.02				
V						0.013								
W	0.009			0.044	0.041	0.039		0.017	0.056	0.02				
X	0.009	0.023												
Y								0.017						
Z	0.018	0.068		0.111	0.124	0.104	0.204	0.224	0.278	0.078				

Table 26.-- Contd.

Haplotype	KUR	RUS	OKH	WAL	CAL	EAL	WGA	CGA	BER	PWS	SEA	BRC	ORE	NCA
AA		0.045												
BB	0.266	0.273	0.455	0.133	0.099	0.104	0.111	0.069	0.056	0.118	0.103	0.4	0.2	0.1
CC	0.009	0.045		0.2	0.182	0.078	0.056	0.034		0.039				
DD		0.023		0.022	0.008	0.039		0.052	0.056	0.118				
EE		0.023			0.008	0.013		0.017		0.078				
FF	0.064	0.045	0.091		0.033	0.013					0.034			
GG		0.023												
HH		0.045		0.022	0.05									
II						0.013								
JJ		0.045				0.039								
MM							0.019							
NN							0.019							
OO						0.013								
PP		0.023												
QQ							0.019							
RR								0.017						
SS											0.034			
TT						0.013								
UU											0.034			
VV		0.023												
WW	0.009				0.017			0.017						
YY											0.069			
ZZ											0.069			
AAA	0.101			0.022	0.017									
BBB					0.008									
CCC												0.2		
DDD				0.022	0.008									
EEE			0.091						0.056					
FFF					0.008	0.013				0.039				
GGG					0.008									

Table 26.-- Contd.

Haplotype	KUR	RUS	OKH	WAL	CAL	EAL	WGA	CGA	BER	PWS	SEA	BRC	ORE	NCA
HHH					0.008									
III	0.018								0.056					
JJJ				0.044					0.056					
KKK	0.009			0.022										
LLL	0.073													
MMM	0.018		0.091											
NNN	0.009													
OOO	0.009													
PPP	0.009													
QQQ	0.009													
RRR	0.009													
SSS	0.009													
TTT	0.009													
UUU	0.018		0.045											
VVV	0.018													
WWW	0.009													
ZZZ						0.013								
AAAA	0.009		0.045											
BBBB	0.009													
CCCC	0.009													
DDDD	0.009													
EEEE	0.009													
FFFF	0.018			0.022										
GGGG										0.039				
HHHH			0.045											
IIII				0.044										
JJJJ			0.045											
KKKK								0.017						
LLLL							0.019							
PPPP					0.008									
Total	1	1	0.999	1	1	1	1	0.998	1	1	0.996	1	1	1

Table 27—Pair-wise estimates of genetic differentiation among populations (Slatkin's Linearized Population Fst, below the diagonal) and the number of effective migrants per generation between populations (above the diagonal). Statistically significant Fst values, meaning the two populations differ significantly in haplotype frequencies ($P \leq 0.05$), are in bold.

	OKH	**KUR**	**RUS**	**WAL**	**CAL**	**EAL**	**WGA**	**CAL**	**BER**	**PWS**	**SEA**	**BRC**	**ORE**	**NCA**
OKH	-	13.0	8.3	6.5	4.3	3.9	4.1	3.0	4.5	5.5	1.9	2.5	1.8	1.1
KUR	**0.038**	-	11.5	6.8	4.3	4.7	6.5	3.4	6.1	6.3	2.4	3.2	2.3	1.9
RUS	**0.060**	**0.043**	-	140.5	24.8	37.2	33.1	14.0	∞	38.4	1.9	2.5	2.0	1.6
WAL	**0.077**	**0.073**	0.004	-	123.4	36.1	53.3	25.4	∞	∞	1.7	2.1	1.8	1.5
CAL	**0.113**	**0.111**	**0.018**	0.002	-	284.6	14.8	64.3	54.7	75.0	1.3	1.6	1.3	1.1
EAL	**0.129**	**0.106**	0.013	0.014	0.002	-	31.3	∞	145.1	115.9	1.4	1.8	1.5	1.3
WGA	**0.121**	**0.077**	0.015	0.009	**0.033**	0.016	-	37.4	∞	26.2	1.7	1.9	1.8	1.4
CAL	**0.168**	**0.146**	**0.036**	0.020	0.009	0	0.013	-	∞	33.8	1.2	1.4	1.3	1.0
BER	**0.110**	**0.082**	0	0	0.008	0.003	0	0	-	∞	2.3	3.1	2.5	1.8
PWS	**0.091**	**0.079**	0.013	0	0.006	0.004	0.019	0.015	0	-	1.9	2.5	2.0	1.7
SEA	**0.269**	**0.212**	**0.261**	**0.290**	**0.387**	**0.346**	**0.297**	**0.410**	**0.221**	**0.261**	-	∞	∞	∞
BRC	**0.198**	**0.158**	**0.204**	**0.237**	**0.303**	**0.281**	**0.266**	**0.361**	**0.162**	**0.200**	0	-	∞	∞
ORE	**0.278**	**0.217**	**0.256**	**0.274**	**0.370**	**0.334**	**0.282**	**0.399**	**0.197**	**0.246**	0	0	-	∞
NCA	**0.436**	**0.260**	**0.321**	**0.343**	**0.430**	**0.390**	**0.347**	**0.496**	**0.276**	**0.298**	0	0	0	-

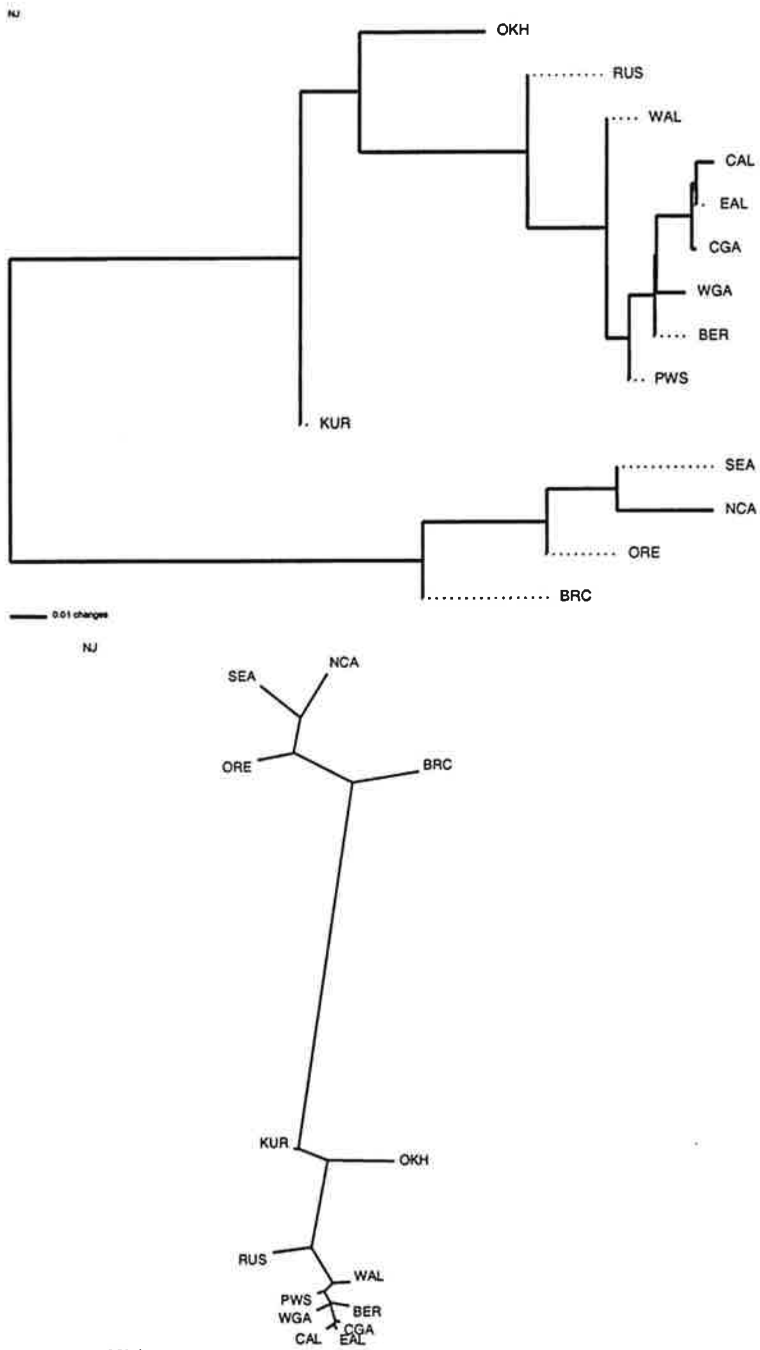
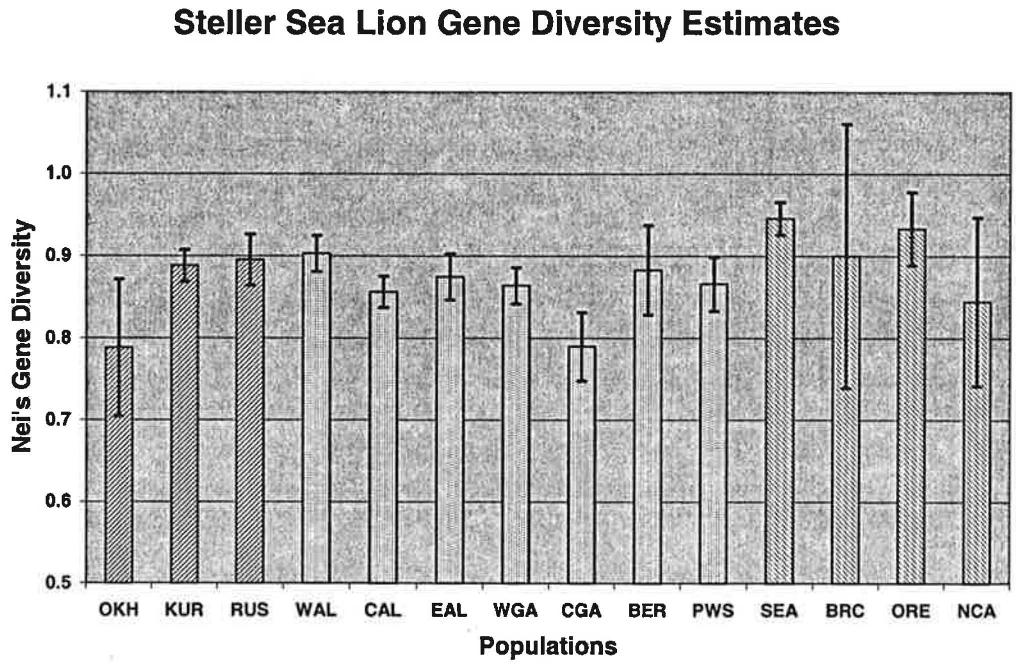


Figure 24.—Neighbor joining trees showing the relationships of the 14 grouped localities. Slatkin's Linearized Population Fst values from Table 5 were used to estimate the genetic differentiation among regions. The upper tree was constructed using midpoint rooting and the lower tree is unrooted.



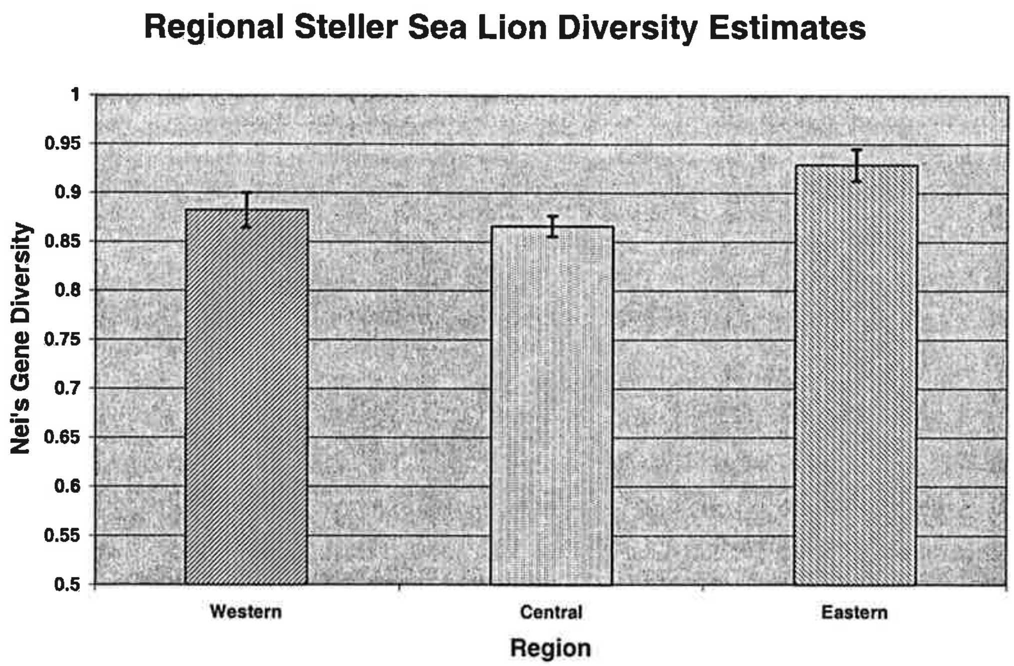


Figure 25.—Estimates of gene diversity for 14 grouped localities (populations, top chart) and three geographic regions (bottom) of Steller sea lions. Abbreviations for grouped localities are as in Table 27. Data were produced by the program Arlequin and are based upon mtDNA haplotype frequencies.

TOWARDS ESTIMATING THE EFFICACY OF FISHERIES RESTRICTIONS AROUND STELLER SEA LION CRITICAL HABITAT

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ABSTRACT

The Steller sea lion (*Eumetopias jubatus)* population has experienced an approximate 80% decline in the last 40 years. Much of the decline is centered in the "Western Stock" that exists in the western Aleutian Islands of Alaska. In 1990, the National Marine Fisheries Service established a three nautical mile (nmI) no-entry buffer zone around rookeries west of 150° W longitude. In 1992 groundfish trawling was prohibited within 10 nmi of those same rookeries. These restrictions were altered in 1998. The purpose of this investigation is to determine if the early restrictions had any effect on SSL population.

INTRODUCTION

Answering questions about Steller sea lion (SSL) population is difficult for several reasons. Much of the data on SSL is taken from fly-over counts, which has been the most economical method of collecting information. However, instantaneous counts of mobile, marine species do not directly indicate population size. Counts are generally of animals found on land during the breeding season (some counts are made at other times of year). This is probably a reliable method for counting sexually mature adult males who tend to stay on shore once they have established a territory, since leaving to forage means they will have to fight for territory again when they return. However, if there are more males than territories, which could happen at high tide, or on rookeries that have steep and narrow beaches, for example, then there will inevitably be some opportunistic mature males found in the near-shore waters. At any given time there are usually some females in the ocean, as they tend to leave periodically for foraging trips throughout the breeding season. Furthermore, juvenile male sea lions will not be able to establish territories and though they may be hauled out on nearby rocks, the probability of them being in the water and therefore not counted, is significant.

Given the fact that an unknown and changing proportion of the total population of sea lions are found on land at any time, estimating population size from counts can be difficult. There are many factors that might influence this on-land proportion. Previously identified factors include: time of year, tide height, time of day, weather, wind speed, on land, or near-shore disturbances, air and sea surface temperature (Calkins et al. 1999; Loughlin, personal communication 1999).

Another hurdle in estimating population size from counts is the mobility of the population. Previous work has shown that female pups tend to return to the place of their birth (or a near by rookery), to breed as adults (numerous references, including; Kenyon and Rice 1961, Calkins and Pitcher 1982, and Loughlin et al. 1984). However, males may travel as far 3000 km (NMFS 1995) during their juvenile years and may establish territories wherever they are available. Reductions in population size and habitat quality might increase this penchant for travel. It therefore becomes necessary to consider nearby rookeries as connected populations rather than separate entities.

The question of how to group the count data then becomes an issue. Previous studies (Merrick et al. 1997) have given some indication as to the foraging-distance traveled by female SSL during different seasons. It has been shown that humans and SSL fish for the same prey (numerous references). The effect of this interaction on SSL has yet to be conclusively determined, but it is reasonable to assume that if competition exists, it would be detectable in the population trend of SSL. One possibility is a reduction of population following a large fishing event. One would not expect this reduction to be apparent right away (in count data), as mature, savvy adults would probably find a way to survive despite depleted food supply. These adults are also the individuals who are most likely to be counted using the aerial survey method. Food depletion would be more likely to manifest itself as reduced reproductive success and juvenile survival. Post-partum SSL would need to spend more time foraging, which would result in less nursing and lower quality milk for their offspring. Reduced juvenile survival means reduced recruitment later on and thus the aerial survey method would be unlikely to detect any change until a few years after a large fishing event. An appropriate lag time might be 3 to 6 years, the average time to sexual maturity for females (Mathisen et al. 1962; Calkins and Pitcher 1982). If fishing has affected SSL population then a comparison of areas within the foraging-distance of heavy fishing (used as the radius of a circle) should show more depletion than areas of lower fishing, after a 3 to 6 year time lag.

METHODS

Counts will have to be weighted for the environmental factors described above and for relative size of the rookeries and haul-outs affected. The weighting scheme will be determined empirically using the entire dataset as a single population and stratifying based on each of these factors individually. These weights will allow us to make an estimate of "availability". Availability, as described by Calkins et al. (1999) is the probability of observing an animal during a survey event. If the number of SSL sighted is taken as a random variable X, its distribution might be modeled as approximately binomial. An animal is either is on land and counted, or it is at sea and not counted (a binomial random variable can have only two possible values). Availability can be considered a binomial parameter 'p', the probability of an "event" occurring. An event in this case is sighting an animal. The other binomial parameter 'n' can be considered the total population. The equation for E(x) (easily calculated from the data) will give us the means to solve for n. Calkins et al. (1999) offers another way to estimate availability for comparison.

Using the binomial or Calkins et al. (1999) method of estimating availability gives an estimate of the total population, which allows us to more accurately compare different sub-populations. For example, I will look at rookeries where fishing was restricted versus rookeries without restrictions, and the entire population before the restrictions versus the population after and during the restrictions.

CURRENT STATUS

The project is still in the preliminary analysis and data compilation phase. Currently I am designing software to group and stratify the data. The grouped data can then be analyzed for trend, or regressed against various factors. The software will allow the user to choose a variety of methods for each step. Hopefully, this software will be useful in answering future questions about the effect of various environmental and human-initiated covariates on the SSL population.

CITATIONS

Calkins, D. G., McAllister, D. C., Pitcher, K. W. 1999. Steller sea lion status and trend in southeast Alaska: 1979-1997. Mar. Mammal Sci. 15(2):462-477.

Calkins D. G., and K. W. Pitcher. 1982. Population assessment, ecology and trophic relationships of Steller sea lions in the Gulf of Alaska, p. 447-546. *In*: Environmental assessment of the Alaskan continental shelf. U.S. Dept. Commer. and U.S. Dept. Int., Final Report. Principal Investigators 19.

Kenyon, K. W., and D. W. Rice. 1961. Abundance and distribution of the Steller sea lion. J. Mamm. 42:223-234.

Loughlin, T. R., Rugh, D. J., Fiscus, C. H. 1984. Northern sea lion distribution and abundance: 1956-80. J. Wildl. Manage. 48:729-740.

Mathisen, O. A., Baade, R. T., Lopp, R. J. 1962. Breeding habits, growth and stomach contents of the Steller sea lion in Alaska. J. Mamm. 43:469-477.

Merrick, R. L., and T. R. Loughlin. 1997. Foraging behavior of adult female and young-of-the-year Steller sea lions (*Eumetopias jubatus*) in Alaskan waters. Can J. Zool. 75(5):776-786.

NMFS (National Marine Fisheries Service). 1995. Status review of the United States Steller sea lion (*Eumetopias jubatus*) population. Prepared by: National Marine Fisheries Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration. 7600 Sand Point Way NE, Seattle, WA 98115-0070.

TRENDS AND POTENTIAL INTERACTIONS BETWEEN PINNIPEDS AND FISHERIES OF NEW ENGLAND AND THE U.S. WEST COAST[1]

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ABSTRACT

Long-term trends in the abundance and distribution of several pinniped species and commercially important fisheries of New England and the contiguous U.S. West Coast are reviewed, and their actual and potential interactions discussed. Emphasis is on biological interactions, or competition. The pinnipeds include the western North Atlantic stock of harbor seals, *Phoca vitulina concolor*; western North Atlantic gray seals, *Halochoerus grypus*; the U.S. stock of California sea lions, *Zalophus californianus californianus*; the eastern stock of Steller sea lions, *Eumetopias jubatus*; and Pacific harbor seals, *Phoca vitulina richardii*. Fisheries included are those for Atlantic cod, *Gadhus morhua*; silver hake, *Merluccius bilinearis*; Atlantic herring, *Clupea harengus*; the coastal stock of Pacific hake, *Merluccius productus*; market squid, *Loligo opalescens*; northern anchovy, *Engraulis mordax*; Pacific herring, *Clupea pallasi*; and Pacific sardine, *Sardinops sagax*. Most of these pinniped populations have grown exponentially since passage of the U.S. Marine Mammal Protection Act in 1972. In addition, they exploit a broad prey assemblage that includes several commercially valuable species. Direct competition with fisheries is therefore possible, as is competition for the prey of commercially valuable fish. The expanding pinniped populations, fluctuations in commercial fish biomass, and level of exploitation by the fisheries may affect this potential for competition. Concerns over pinnipeds impacting fisheries (especially those with localized spawning stocks or at low biomass levels) are more prevalent than concerns over fisheries' impacts on pinnipeds. This preliminary review provides a framework to further evaluate potential biological interactions between these pinniped populations and the commercial fisheries with which they occur.

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[1]Abstract of paper submitted to *Marine Fisheries Review* for publication. For additional information, or reprints when available, please contact the authors.

INTERANNUAL AND REGIONAL DIFFERENCES IN CLINICAL BLOOD PARAMETERS AS AN INDICATION OF ALASKAN STELLER SEA LION CONDITION[1]

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ABSTRACT

Blood chemistries and hematologies were examined from 245 Steller sea lion pups (*Eumetopias jubatus*) estimated to be less than one month of age to evaluate physiological condition. Pups were sampled on Aleutian Island and Gulf of Alaska rookeries, part of the endangered western stock, from 24 June to 6 July, 1998 through 2000. The Alaskan population of Steller sea lions has declined by over 80% in 30 years, and although precise causes of the decline are unknown, nutritional limitations of young animals is the leading hypothesis. Our objectives were to investigate regional and temporal differences in the condition sea lion pups at birth and to establish normal ranges of biochemical and hematological parameters for pups of this species. Results indicated some degree of interannual and regional differences in all parameters tested. Morphometry suggest a decline in size and possible physiological condition of Steller sea lion pups over the duration of our study, particularly among males. We were unable to distinguish potential changes in timing of parturition from an absolute decline in the condition in body size of sea lion pups, however, either cause or a combination of the two factors is a proximate indicator of nutritional limitations among parturient females.

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[1]Abstract of a manuscript submitted to *Biological Conservation* for review, and is subject to change. Please contact lead author for additional information, or reprints when available.

Reports from the

Alaska Department of Fish and Game

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ALASKA DEPARTMENT OF FISH AND GAME
STELLER SEA LION RESEARCH PROJECT SUMMARY[1]

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ABSTRACT

Steller sea lion research tasks completed by the Alaska Department of Fish and Game in the year 2000 were as follows: aerial photographic surveys for trend monitoring, intensive observations at Lowrie Island field camp, brand resightings in Southeast Alaska and British Columbia, and captures of pups and juveniles in eastern and western populations. Aerial surveys utilizing both medium-format and 35mm photography were conducted at rookeries and haulouts in Southeast Alaska from 24-29 June. Images from the 35mm slides have been counted and are summarized in Table 28. A field camp was manned at Lowrie Island of the Forrester Island rookery complex from 4-28 June. An intensive resight effort for branded animals was made and a digital camera was used to record images of adult females for evaluation for individual identification. We utilized the U.S. Fish and Wildlife Service vessel "*Curlew*" from 19 June through 10 July to visit 42 rookery and haul-out sites in Southeast Alaska and British Columbia for the resighting of Steller sea lions branded as pups at the Forrester Island rookery complex during 1994 and 1995. Details of that cruise are presented in Raum-Suryan and Pitcher (this report). We captured and sampled 61 pup and juvenile Steller sea lions in Southeast Alaska and Prince William Sound during August and September. Details of this activity are provided in Raum-Suryan et al. (this report).

ACTIVITIES

Population trend monitoring is conducted by counts of Steller sea lions (SSL) on rookeries and haulouts. Two approaches are used: (1) 35mm aerial photo counts of animals older than pups (nonpups) during June, and (2) direct counts of pups on rookeries (drive counts) during late June and early July. Traditionally, the National Marine Mammal Laboratory (NMML) of the NOAA Alaska Fisheries Science Center has assumed the lead responsibility for the survey work. The Alaska Department of Fish and Game (ADF&G) has conducted surveys in Southeast Alaska and sometimes in the northeast Gulf, east of Kodiak. The nonpup surveys are conducted every

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[1]This research summary was taken from an ADF&G report of work conducted during 2000. Do not cite without permission of the author, and contact him for additional information, final reports, or publications resulting from this work.

other year; the last survey was during 2000. Pup counts have been conducted on a less rigorous schedule, often depending on vessel availability and other factors. ADF&G, working with Wayne Perryman at the NOAA Southwest Fisheries Science Center (SWFSC) and Gary Snyder (University of Alaska, Anchorage graduate student), experimented with medium-format aerial photography in counting pups. The results of this study indicated that counts by this method did not differ from those obtained by the traditional drive counts and unlike the drive counts were not disruptive to the rookery (see Snyder et al. 2001). I am promoting using medium-format photographic surveys to replace both the pup and nonpup surveys, but concerns about comparability between these surveys and historical data need to be resolved before such a switch is made. An analysis that can be made after all photos are counted from the ADF&G 2000 survey is a comparison of paired-counts from 35mm photos and medium-format photos to see if the counts differ and if there is a consistent bias between techniques.

An outgrowth of the medium-format survey work is research into the feasibility of using the images from the photographs to develop indices of juvenile recruitment and physical growth. The idea behind this work is to be able to make comparisons between populations (e.g., between east and west stocks) or within populations over time. During the summer of 2000 we conducted a medium-format survey of Southeast Alaska and the rookeries in the Gulf of Alaska (Marmot Island and east). Wayne Perryman at the SWFSC analyzed the images from these photos and evaluated their utility for recruitment and growth indices. We are planning a meeting at the SWFSC in February 2001 with NMML scientists to review the results of this research and to decide on future direction.

During 1994 and 1995 about 800 pups were branded with individually numbered brands at the Forrester Island rookery in Southeast Alaska. We have been resighting these animals to collect information on extent of movements and breeding rookery fidelity and to make estimates of survival rates using mark/resight methodology. Collection of data from this group of marked animals contribute to estimates of survival rates and rookery fidelity. Grey Pendleton is estimating survivorship from the resight database, and may attempt a comparison of survival rates from Forrester marked animals (a stable or increasing population) with Marmot Island marked animals (a rapidly declining population). Outside reviewers of the SSL research program have strongly recommended a branding program be initiated in order to estimate survival. Based on analyses of data from branded animals at Marmot (Hastings report) and Forrester Island (Pendleton analysis), it appears that it is possible to obtain reasonably precise estimates of survival with such a program. A concern about such a program is the disturbance and possible mortality that branding might cause. Also the results of such a program provide little if any information on what is causing mortality. Kim Raum-Suryan is taking the lead in developing a manuscript on SSL dispersal and rookery fidelity based on animals branded during the 1970s (ADF&G), 1980s (NMML), and 1990s (ADF&G). This is a cooperative effort between ADF&G and NMML

We started a small-scale pilot program this past summer to evaluate if it is possible to identify individual adult females from photographs of the left shoulder. Work done by Brendan Kelly (University of Alaska, Southeast) and a student suggested that this might be possible.

Digital photographs were taken at Lowrie Island and are now being organized by Eric Schoen. Lex Hiby, who is doing similar harbor seal photo identification work, is examining the photos for individual identification potential using his modeling approach. The application of this methodology, should it work out, would be to develop of pool of identifiable adult females and from resights of these animals use mark/recapture methodology to estimate adult female survival and to estimate birth rates for adult females.

Mike Rehberg and Russ Andrews (University of British Columbia) are working on a manuscript on foraging of adult female SSLs based on data collected from Platform Transmitter Terminals (PTTs), Time-Depth Recorders (TDRs), and stomach temperature recorders deployed at Forrester Island. These data should provide considerable insight into what can be inferred about actual foraging from data obtained with PTTs. An attempt is being made to compare foraging effort between the animals in this study and those from the western stock studied by Merrick and Loughlin earlier.

A major accomplishment over the past 5 years or so has been the development and refinement of the underwater capture technique and subsequent handling of juvenile Steller sea lions. The development of this concept can be mainly credited to Don Calkins, Dennis McAllister, and Walt Cunningham, but several others including Boyd Porter, Dave VanDenBosch, Kim Raum-Suryan, Bruce Heath, and Chris Curgus have made major contributions. This technique has allowed the capture and processing of over 125 juveniles in Southeast Alaska and Prince William Sound with only a single sea lion mortality (which was anesthesia related).

Many of these juveniles were fitted with satellite-linked PTTs that are providing data on movements, haul-out, and dive frequency, duration, and depth. These data are now being analyzed in anticipation of producing a manuscript titled "Ontogeny of Diving Behavior in Steller Sea Lion". This analysis, when combined with data on nutritional independence, will provide information on "critical" foraging habitat for juvenile SSLs and will be useful in the development of sea lion conservation-oriented fishery management practices. We will also try to evaluate relative foraging effort by juveniles in eastern and western stocks to gain insight into the nutritional limitation hypothesis.

A critical component of understanding the life history of juvenile SSLs and their foraging habitat requirements is gaining knowledge of the weaning process and when these animals reach nutritional independence. We are working with Sara Iverson (Dalhousie University) to determine if we can establish the degree of nutritional independence of an individual by the analysis of fatty acids in a blubber sample. There is a suggestion of differences between juveniles we have sampled from the eastern and western stocks.

Through cross-sectional sampling of juveniles of various ages, we are obtaining data on growth, body composition and other "health" parameters. After determining and controlling for age- and sex-related influences, we will make comparisons between the eastern and western stocks to gain insight into the nutritional limitation hypothesis. This is the "core" of our research program and I believe the best hope we currently have in gaining understanding into what is or isn't going on with the western stock. Wendy Dunlap-Harding is preparing a report on body composition. We should take a preliminary look at pup and juvenile growth data from animals sampled from both east and west sometime fairly soon.

All captured animals are routinely screened (serology and cultures) for exposure to several diseases. While exposure to several potentially serious diseases has been demonstrated, there is no strong evidence that it played a major role in the decline or is currently limiting population growth. The primary logic for this conclusion is that similar disease agents and levels of occurrence were found in both eastern and western stocks. Cooperators (Beckman, Burek and Stott) are comparing immune function between juveniles from the eastern and western stocks.

We have a project funded by the National Fish and Wildlife Foundation to look at relative levels of DDTs, PCBs, and the bio-marker porphyrin in fecal samples from rookeries in both the eastern and western stocks. We had hypothesized that levels of the contaminants would be higher in the western stock based on the results of a study on sea otters and from a few SSL tissue samples that had been analyzed. While not all samples have been analyzed it appears that for at least PCBs, levels from rookeries in the northern Gulf of Alaska (western stock) and Southeast Alaska (eastern stock) are low while levels from eastern Aleutian Island rookeries (western stock) were relatively and consistently high.

Knowledge of patterns of historic abundance would be useful in trying to put the current status of the western stock in perspective. Is this decline and low population an unique event or is it something that has occurred previously, perhaps as a result of environmental variation? I have explored two methods (relative abundance of hairs in varved sediments and relative abundance of skeletal materials in archeological excavations) that have been used to reconstruct historical patterns of abundance for other species, and pretty much came to the conclusion that neither had much potential for SSLs in Alaska. I still think that it would be extremely valuable to determine if historical population levels of SSLs have been variable or if the current situation is an unique event and encourage folks to think about ways to evaluate this.

CITATIONS

Snyder, G. M., K. W. Pitcher, W. L. Perryman, and M. S. Lynn. 2001. Counting Steller sea lion pups in Alaska: An evaluation of medium-format, color aerial photography. Mar. Mammal Sci. 17:136-146.

Table 28.–Steller sea lion aerial slide counts conducted in Southeast and portions of Southcentral Alaska, 24-29 June.

Location	Date	Time	Count
Southeast (Total)			12418.5
Cape Fairweather	24-Jun	13:50	0
Harbor Point	24-Jun	13:55	44.5
Venisa Point	24-Jun	14:15	0
Graves Rock	24-Jun	14:25	491.5
NW Inian I.	24-Jun	14:32	2
Cape Cross	24-Jun	14:46	0
White Sisters	24-Jun	15:10	1397.5
Sea Lion I.	24-Jun	15:28	7
Kaiuchali I.	24-Jun	15:43	0
Jacob Rock	24-Jun	15:52	232.5
Biali Rock	24-Jun	16:10	661.5
Sea Lion Rock (Puffin)	24-Jun	16:38	211.5
Cape Ommaney	24-Jun	16:54	288.5
Yasha I.	24-Jun	17:20	17
Wolf Rock	25-Jun	10:30	24
Point Marsh	25-Jun	11:02	0
West Rock	25-Jun	11:24	624.5
Sail I.	28-Jun	18:17	1
SW Brother	28-Jun	18:12	1498.5
Hazy I.	28-Jun	17:18	1824
Coronation I.	28-Jun	17:03	31
Timbered I.	28-Jun	16:50	266.5
Cape Addington	28-Jun	16:26	1116
Cape Bartolome	28-Jun	16:20	5
Forester Island Group (Total)	28-Jun		3674.5
North Rock	28-Jun	15:35	1202
Cape Horn Rock	28-Jun	15:28	545
Sea Lion Rock	28-Jun	15:25	507
East Rock	28-Jun	15:43	192.5
Lowrie I.	28-Jun	15:50	1213
Forrester I.	28-Jun	15:22	15
Gulf of Alaska[1]			
Fish I.	24-Jun	10:10	407.5
Seal Rocks (PWS)	24-Jun	10:30	819.5
Outer I.	29-Jun	11:37	307.5
Sugarloaf I.	29-Jun	12:55	746
Marmot I.	29-Jun	13:50	698.5

[1]Benjamin I. and Gran Point were instrument flight rule (IFR) conditions when we tried to reach them on 28 June and Chiswell I. was fogged in on 29 June.

TRIP REPORT: BRAND RESIGHTS OF STELLER SEA LIONS WITHIN SOUTHEAST ALASKA AND NORTHERN BRITISH COLUMBIA FROM 19 JUNE TO 10 JULY 2000[1]

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OBJECTIVE

The purpose of the trip was to conduct an extensive survey of rookeries and haul-out sites throughout Southeast Alaska (S.E.) and Northern British Columbia (B.C.) to resight Steller sea lions (*Eumetopias jubatus*) branded as pups at the Forrester Island complex during 1994 and 1995.

STUDY AREA

The U.S. Fish and Wildlife Service vessel *Curlew* (Capt. Joe Spicciani) was contracted for the three-week excursion. We left from Juneau, traveled northwest to Graves Rocks, south along the outside coast to Forrester Island, south to the Queen Charlotte Islands, southeast to Scott Islands north of Vancouver Island, then north along the Inside Passage back to Juneau. We visited 42 haul-out and rookery sites from 20 June to 10 July (Table 29).

METHODS

Personnel in small boats (17' and 20' Boston Whalers) observed Steller sea lions at each haul-out or rookery site. Haul-outs were approached at a slow speed and initially surveyed from a distance to allow sea lions to become accustomed to the boat. All sea lions were counted and observers used binoculars (8 X to 14 X) to read brands. Once a branded animal was detected, the boat approached closer to the haul-out and if possible, digital photographs were taken of the animal. An attempt was made to photograph each branded animal several times and once out of the field, one to four of the best photographs were saved. When a branded animal was observed, the brand number, side of the animal branded, quality of the brand, and if applicable, the tag number or color was recorded. If not all sea lions could be adequately surveyed by boat, observers went ashore and surveyed from a high point above the haul-out or rookery. If a female was observed nursing a pup or juvenile, that was recorded as well.

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[1]This research summary was taken from an ADF&G report of work conducted during 2000. Do not cite without permission of the authors, and contact them for additional information, final reports, or publications resulting from this work.

The location, date, observers, photographer, start and end time, total count, and weather data was recorded at each site. Any unusual sightings of other pinnipeds or injured sea lions were recorded. An attempt was made to photograph all sea lions with any injuries, rope, net scars, or entanglements, and other species of pinnipeds on the haul-outs or rookeries.

RESULTS

Brands

Branded Steller sea lions were observed at 21 (50%) of the 42 locations surveyed (Table 29). A total of 121 branded individuals were observed; 94 individuals (78%) with readable brands (Table 30) and 27 individuals (22%) with unreadable brands (Table 31). Although tags were applied to the foreflippers of all sea lions branded during 1996 (n = 400), only one individual was observed with tags (F241). Of the 121 individual brand resights, 43 (39 readable and 4 unreadable brands) branded animals were observed for the first time since branding (Tables 29, 30). Most branded individuals (n = 112, 92.6%) were observed at haul-outs and rookeries in S.E. More than half (n = 60, 54%) of these were seen at Forrester Island complex, where they were branded as pups. Only nine branded individuals were observed in B.C. waters.

Two individuals, one male and one female, were observed at two different locations during brand resight observations. A male (F447) was first observed and photographed at Cape Addington on 25 June and observed and photographed again at Forrester Island complex (73 km away) on 28 June. A female (F826) was first observed and photographed at Forrester Island complex on 27 June and observed and photographed again at Warrior Rocks, B.C. (195 km away) on 6 July.

Independent Sightings/Brand Misidentification

During past brand resight efforts, observations of branded animals were not usually independently reported by independent observers. During this study, an attempt was made for two or more observers to record the number of the brand before discussing the number. Independent observers recorded 105 (87%) of the 121 brands observed. In all cases, the observers recorded the same numbers. However, the digital photographs also provided a tool of independence. In five cases (4%), brands that were unreadable or questionable were later given positive brand identifications using several sources (photographs, original brand database, past brand resight data, sex of individual observed). For example, one unreadable brand that was either a F351 or F551 was given a positive identification as F351 because F551 had been photographed on a previous day. Additionally, F?54 was given a positive identification as F854 when the photograph was studied in detail and the original brand data indicated that brand F854 had a smeared 8 when branded. The digital photographs proved to be an important tool in brand clarification.

Photographs

An attempt was made to photograph most branded sea lions. Of the 121 unique brands observed, 104 individuals (86%, 85 readable and 19 unreadable brands) were photographed. The best one to four photographs of each branded individual were saved. If a brand was unidentifiable, several photographs from different angles were saved for future reference. Other marks on the body, such as fungal patches, scars, and spots aided in confirming identification of individuals that were photographed on separate occasions when the brand was difficult to read. Several Steller sea lions with net and rope scars and entanglements, and three other pinniped species (elephant seal, *Mirounga angustirostris*; fur seal, *Callorhinus ursinus*; and California sea lion, *Zalophus californianus*) also were photographed.

Counts

Sea lions were observed at 40 of the 42 sites surveyed. Within S.E., approximately 7,700 sea lions were counted at rookeries and haul-outs (Table 29). Approximately 2,200 of these were at the Forrester Island complex. Within B.C. waters, approximately 5,100 sea lions were counted. More sea lions were observed with brands per animal counted in S.E. than in B.C. Of the total sea lions counted in S.E., 1.5 % of individuals were observed with brands. Excluding Forrester Island, 1.0 % of individuals counted in S.E. were observed with brands. This contrasts with only 0.2% of animals counted in B.C. with brands.

The presence of pups was noted for each rookery and haul-out site (Table 29). As the population of Steller sea lions had increased in Southeast Alaska, the number of pups born on sites north of Forrester Island complex has also increased. Ten years ago, no pups were observed on Graves Rocks. During June 2000, however, 30 pups (minimum number) were counted on Graves Rocks, which is considered a haul-out. Biali Rocks, also a haul-out, had a minimum of 21 pups.

Females with Pups and Juveniles

Nineteen branded females were observed nursing pups. Most (n = 15, 79%) were observed at Forrester Island complex. However, four females were observed nursing pups at locations other than Forrester Island. One female with a newly born pup was observed at White Sisters rookery (357 km away), two at Hazy Island rookery (136 km away), and one at Cape St. James, B.C. (360 km away). These were the first observations of females branded at Forrester Island giving birth to pups at Hazy Island and Cape St. James. Two females with newly born pups were observed at White Sisters rookery in 1999.

One branded female (F262) was observed nursing a yearling at Cape Addington. This female was not observed in 1999, therefore we do not know the location of her yearling's birth. The last sighting of F262 was at Timbered Island in April of 1998.

Entanglement/Injury

Several Steller sea lions were observed with injuries as a result of fishing line, rope or net entanglement, and other unknown injuries. One individual was observed on Hazy Island with several fresh wounds, possibly shark bites. Five individuals were observed with rope scars or rope/nets still around their necks. All of these individuals had deep wounds cutting into the blubber of the neck. Three individuals had fishing line (two with flashers attached near the lip) coming from their mouths. One female with a newly born pup on Triangle Island had a rope cutting deep into her neck. Photographs were taken of all the above individuals.

Table 29.--Dates, locations of haul-outs and rookeries, estimated number of non-pup sea lions from which branded animals observed, and brand observations (Y-Yes, N-No) at each location surveyed during 20 June to 10 July 2000.

Date	Location	Est. No. SSLs	Brands Observed
20 June	Graves Rocks	400**	Y
	North Inian I.	18	N
	Cape Cross	3	N
21 June	White Sisters (rookery)	500**	Y
22 June	White Sisters (rookery)	500**	Y
	Sea Lion Is.	10	N
23 June	Kaiuchali I.	1	N
	Jacob Rock	126	Y
	Biali Rock	500**	Y
	Sea Lion Rocks	180	Y
	Cape Ommaney	243	Y
24 June	Hazy I. (rookery)	794**	Y
	Timbered I.	148	Y*
25 June	Cape Addington	448	Y
26 June	Wolf Rock	6	N
26 June	Forrester I. Complex (rookery)	1,554**	Y
27 June	Forrester I. Complex (rookery)	1,440**	Y
28 June	Forrester I. Complex (rookery)	2,233**	Y
29 June	Langara Rock	6	N
01 July	Skedans I., B.C.	1	N
	Reef I., B.C.	340	Y*
	Tatsung Rocks, B.C.	0	N
	Garcin Rocks, B.C.	200	Y
	Cape St. James, B.C. (rookery)	650**	Y
02 July	Cape St. James, B.C. (rookery)	600**	Y
03 July	Beresford I., B.C.	54	N
	Maggot I., B.C. (rookery)	203**	N
	Sartine I., B.C. (rookery)	350**	N
	Triangle I., B.C. (rookery)	1,402**	N
04 July	Pearl I., B.C.	230**	N
	Virgin I., B.C.	307**	Y
05 July	Gosling Rocks, B.C.	119	N
	McInnes I., B.C.	91	N
	Steele I., B.C.	186	N
	North Danger Rocks, B.C. (rookery)	271**	N

Table 29. Cont.

Date	Location	Est. No. SSLs	Brands Observed
06 July	Bonilla Rocks, B.C.	138**	N
	Warrior Rocks, B.C.	534**	Y
07 July	West Rocks	485**	Y
08 July	Grindall I.	8	N
09 July	Southwest Brothers I.	1,002	Y
10 July	Benjamin I.	0	N
10 July	Gran Pt.	60	N

* Branded animal observed briefly, but went into water before brand was read.

** Indicates pups were observed at this location.

Table 30.--Steller sea lions observed during 19 June to 10 July with readable brands. Sex (F = female, M = male), date, location, age (in years), association with a pup (w/juv indicates female is nursing a juvenile; w/pup indicates female is nursing a pup), photo taken (Y = yes, N = no), and if the animal was observed for the first time since branding.

Brand	Sex	Month	Day	Year	Location	Age	Assoc	Photo	New2000
F206	F	6	28	2000	Lowrie Is.	6.1		Y	
F207	F	6	27	2000	North Rocks - Forrester	6.1		Y	Y
F220	M	6	26	2000	West Rock - Forrester Is.	6.1		Y	
F226	M	6	28	2000	West Rock - Forrester Is.	6.1		Y	
F226	M	6	28	2000	West Rock - Forrester Is.	6.1		Y	
F231	F	6	28	2000	Lowrie Is.	6.1		Y	Y
F241	M	6	25	2000	Cape Addington	6.1		Y	
F262	F	6	25	2000	Cape Addington	6.1	w/juv	Y	
F270	M	6	23	2000	Jacob Rock	6.1		Y	Y
F294	F	6	28	2000	Lowrie Is.	6.1	w/pup	Y	Y
F301	F	6	25	2000	Cape Addington	6.1		Y	
F306	F	7	9	2000	Southwest Brothers Island h-o	6.1		N	
F324	F	6	28	2000	North Rocks - Forrester	6.1		Y	
F326	F	6	27	2000	North Rocks - Forrester	6.1	w/pup	Y	
F343	M	6	25	2000	Cape Addington	6.1		Y	Y
F349	F	6	27	2000	Cape Horn Rocks - Forrester	6.1		Y	Y
F351	M	6	23	2000	Biali Rocks	6.1		Y	Y
F355	F	6	26	2000	Cape Horn Rocks - Forrester	6.1		Y	Y
F355	F	6	27	2000	Cape Horn Rocks - Forrester	6.1		Y	
F361	M	7	7	2000	West Rock Rookery	6.1		Y	Y
F377	M	6	25	2000	Cape Addington	6.1		Y	Y
F396	F	6	28	2000	North Rocks - Forrester	6.1		Y	Y
F404	F	6	26	2000	East Rock - Forrester Is.	6.1		Y	Y
F404	F	6	27	2000	East Rock - Forrester Is.	6.1	w/pup	Y	
F412	F	6	27	2000	North Rocks - Forrester	6.1	w/pup	Y	
F412	F	6	28	2000	North Rocks - Forrester	6.1		Y	
F432	F	6	26	2000	North Rocks - Forrester	6.1		Y	Y
F431	F	6	27	2000	North Rocks - Forrester	6.1		Y	Y

Table 30

Brand	Sex	Month	Day	Year	Location	Age	Assoc	Photo	New2000
F442	F	6	27	2000	North Rocks - Forrester	6.1	w/pup	Y	
F442	F	6	28	2000	North Rocks - Forrester	6.1		N	
F443	M	6	23	2000	Biali Rocks	6.1		Y	
F444	M	6	26	2000	West Rock - Forrester Is.	6.1		Y	
F446	M	6	21	2000	White Sisters	6.1		Y	
F447	M	6	25	2000	Cape Addington	6.1		Y	
F447	M	6	28	2000	Lowrie Is.	6.1		Y	
F461	M	6	28	2000	North Rocks - Forrester	6.1		Y	Y
F469	F	6	26	2000	Cape Horn Rocks - Forrester	6.1		N	
F469	F	6	28	2000	Cape Horn Rocks - Forrester	6.1		Y	
F473	F	6	26	2000	North Rocks - Forrester	6.1		Y	
F473	F	6	28	2000	North Rocks - Forrester	6.1		N	
F477	M	6	25	2000	Cape Addington	6.1		N	
F483	M	6	23	2000	Sea Lion Rock-Puffin Bay	6.1		Y	
F504	F	6	24	2000	Hazy Is.	6.1		N	Y
F509	F	6	26	2000	Sea Lion Rocks - Forrester	6.1		Y	Y
F527	F	7	1	2000	Cape St. James	6.1	w/pup	Y	Y
F527	F	7	2	2000	Cape St. James	6.1	w/pup	Y	
F528	F	6	28	2000	Cape Horn Rocks - Forrester	6.1		Y	
F538	F	6	26	2000	Sea Lion Rocks - Forrester	6.1		Y	
F538	F	6	27	2000	Sea Lion Rocks - Forrester	6.1	w/pup	N	
F539	M	6	24	2000	Hazy Is.	6.1		Y	
F542	M	6	28	2000	Sea Lion Rocks - Forrester	6.1		Y	
F551	M	6	21	2000	White Sisters	6.1		Y	
F551	M	6	21	2000	White Sisters	6.1		Y	
F565	F	6	26	2000	Cape Horn Rocks - Forrester	6.1		Y	Y
F569	F	6	27	2000	Lowrie Is.	6.1	w/pup	Y	
F576	M	6	26	2000	West Rock - Forrester Is.	6.1		Y	
F579	M	6	28	2000	Cape Horn Rocks - Forrester	6.1		Y	
F582	F	6	24	2000	Hazy Is.	6.1	w/pup	Y	
F593	M	6	25	2000	Cape Addington	6.1		Y	Y
F599	M	6	26	2000	Sea Lion Rocks - Forrester	6.1		Y	

Table 30.

Brand	Sex	Month	Day	Year	Location	Age	Assoc	Photo	New2000
F599	M	6	27	2000	Cape Horn Rocks - Forrester	6.1		N	
F5351	F	6	26	2000	Sea Lion Rocks - Forrester	6.1		Y	
F5351	F	6	27	2000	Sea Lion Rocks - Forrester	6.1		N	
F5611	F	6	28	2000	Cape Horn Rocks - Forrester	6.1		Y	
F613	F	6	25	2000	Cape Addington	5.1		N	
F619	F	6	27	2000	Cape Horn Rocks - Forrester	5.1		Y	Y
F623	F	6	26	2000	Lowrie Is.	5.1		N	Y
F625	F	6	26	2000	Cape Horn Rocks - Forrester	5.1	w/pup	Y	Y
F625	F	6	27	2000	Cape Horn Rocks - Forrester	5.1		N	
F637	M	6	28	2000	East Rock - Forrester Is.	5.1		Y	
F641	F	6	27	2000	North Rocks - Forrester	5.1		Y	Y
F641	F	6	28	2000	North Rocks - Forrester	5.1		Y	
F682	M	6	23	2000	Jacob Rock	5.1		Y	
F686	F	6	26	2000	Cape Horn Rocks - Forrester	5.1		Y	
F686	F	6	27	2000	Cape Horn Rocks - Forrester	5.1		Y	
F686	F	6	28	2000	Cape Horn Rocks - Forrester	5.1		Y	
F6461	M	6	28	2000	Cape Horn Rocks - Forrester	5.1		Y	Y
F6621	F	6	27	2000	Cape Horn Rocks - Forrester	5.1		Y	Y
F6621	F	6	28	2000	Cape Horn Rocks - Forrester	5.1		Y	
F712	M	6	25	2000	Cape Addington	5.1		Y	
F732	M	6	24	2000	Hazy Is.	5.1		Y	
F753	M	6	21	2000	White Sisters	5.1		N	
F753	M	6	21	2000	White Sisters	5.1		N	
F765	M	7	9	2000	Southwest Brothers Island h-o	5.1		Y	
F767	F	6	23	2000	Biali Rocks	5.1		Y	
F805	M	6	23	2000	Jacob Rock	5.1		Y	
F816	M	7	6	2000	Warrior Rocks	5.1		Y	
F818	M	6	21	2000	White Sisters	5.1		N	
F818	M	6	21	2000	White Sisters	5.1		N	
F826	F	6	27	2000	North Rocks - Forrester	5.1		Y	Y
F826	F	7	6	2000	Warrior Rocks	5.1		Y	
F827	F	6	27	2000	North Rocks - Forrester	5.1		Y	Y

Table 30.

Brand	Sex	Month	Day	Year	Location	Age	Assoc	Photo	New2000
F854	F	6	26	2000	North Rocks - Forrester	5.1		Y	Y
F860	F	6	27	2000	North Rocks - Forrester	5.1		Y	
F875	F	6	25	2000	Cape Addington	5.1		Y	Y
F885	F	6	26	2000	North Rocks - Forrester	5.1		Y	
F885	F	6	28	2000	North Rocks - Forrester	5.1	w/pup	Y	
F910	F	6	26	2000	East Rock - Forrester Is.	5.1		Y	
F934	M	6	21	2000	White Sisters	5.1		Y	
F934	M	6	22	2000	White Sisters	5.1		N	
F937	M	7	1	2000	Garcin Rocks, B.C.	5.1		Y	Y
F941	F	6	27	2000	North Rocks - Forrester	5.1		Y	Y
F941	F	6	28	2000	North Rocks - Forrester	5.1		Y	
F943	M	6	24	2000	Hazy Is.	5.1		Y	
F947	F	6	25	2000	Cape Addington	5.1		Y	
F951	M	6	21	2000	White Sisters	5.1		Y	Y
F956	F	6	25	2000	Cape Addington	5.1		Y	Y
F956	F	7	1	2000	Cape St. James	5.1		Y	
F956	F	7	2	2000	Cape St. James	5.1		N	
F957	F	6	28	2000	Sea Lion Rocks - Forrester	5.1	w/pup	Y	
F958	F	6	28	2000	Sea Lion Rocks - Forrester	5.1	w/pup	Y	Y
F961	M	6	22	2000	White Sisters	5.1		N	
F966	F	7	6	2000	Warrior Rocks	5.1		Y	Y
F971	F	6	26	2000	Sea Lion Rocks - Forrester	5.1		Y	
F977	F	6	27	2000	Sea Lion Rocks - Forrester	5.1	w/pup	Y	
F977	F	6	28	2000	Sea Lion Rocks - Forrester	5.1		N	
F980	F	6	24	2000	Hazy Is.	5.1	w/pup	Y	
F981	M	6	20	2000	White Sisters	5.1		N	Y
F984	M	7	6	2000	Warrior Rocks	5.1		Y	Y
F988	F	6	27	2000	Lowrie Is.	5.1		Y	Y
F988	F	6	28	2000	Lowrie Is.	5.1		Y	
F996	F	6	27	2000	Cape Horn Rocks - Forrester	5.1		Y	

Table 31.--Steller sea lions observed during 19 June to 10 July with unreadable brands. Sex (F = female, M = male), date, location, age (in years), association with a pup (w/juv indicates female is nursing a juvenile; w/pup indicates female is nursing a pup), photo taken (Y = yes, N = no), and if the animal was observed for the first time since branding (U = unknown due to unreadable brand).

Brand	Sex	Month	Day	Year	Location	Age	Assoc	Photo	New2000
F__1?		7	1	2000	Reef I., B.C.			N	U
F???		6	21	2000	White Sisters			N	U
F211??		6	23	2000	Cape Ommaney	6.1		Y	U
F25?		6	22	2000	White Sisters	6.1		N	U
F3bowtie		6	25	2000	Cape Addington	6.1		Y	Y
FJTH	F	6	27	2000	North Rocks - Forrester		w/pup	Y	Y
FJTH	F	6	28	2000	North Rocks - Forrester			Y	
F4H		6	28	2000	North Rocks - Forrester	6.1		Y	U
F4M		6	22	2000	White Sisters	6.1	w/pup	Y	U
F4M?		6	26	2000	North Rocks - Forrester	6.1	w/pup	Y	U
F4M?		6	28	2000	North Rocks - Forrester	6.1		Y	U
F4??		6	24	2000	Hazy Is.	6.1		N	U
F4?4		6	27	2000	Cape Horn Rocks - Forrester	6.1		N	U
F5??		6	22	2000	White Sisters			N	
F5K	M	6	21	2000	White Sisters	6.1		Y	U
F506/536?		6	26	2000	Cape Horn Rocks - Forrester			N	U
F59boxX		7	9	2000	Southwest Brothers Island h-o			Y	Y
F6backwardK		6	28	2000	North Rocks - Forrester	5.1		Y	U
F610?		6	25	2000	Cape Addington	5.1		Y	U
F614?		6	25	2000	Cape Addington	5.1		Y	U
F677/699?		6	25	2000	Cape Addington	5.1		Y	N
F7(8or0)1		6	25	2000	Cape Addington	5.1		Y	U
F72rainbow	M	6	21	2000	White Sisters	5.1		Y	U
F744?		6	26	2000	North Rocks - Forrester	5.1	w/pup	Y	U
F744?		6	27	2000	North Rocks - Forrester	5.1		Y	U
F78?4		7	7	2000	West Rock Rookery	5.1		Y	U
F79(9?)		6	25	2000	Cape Addington	5.1		Y	U
F914/944?		7	4	2000	Virgin Is.	5.1		Y	U

TRIP REPORT: STELLER SEA LION CAPTURES IN PRINCE WILLIAM SOUND AND SOUTHEAST ALASKA DURING AUGUST-SEPTEMBER 2000[1]

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OBJECTIVE

The objective of this research is to understand what is currently limiting population growth of the western Alaskan population of Steller sea lions (*Eumetopias jubatus*). Major components of the research include: describing juvenile life history, comparisons of juvenile growth and body condition between eastern and western populations, disease, contaminants, immunology, movements, and diving behavior.

STUDY AREA

The vessel M/V *Pacific Star* was chartered for the Prince William Sound (PWS) portion of the capture trip. From 20-30 August 2000, we visited two haulouts (Glacier Island, The Needle) and two rookeries (Fish Island, Seal Rocks) in Prince William Sound and the Northeast Gulf of Alaska (Fig. 26). The Alaska Department of Fish and Game vessel R/V *Medeia* was chartered for the Southeast Alaska (SE) portion of the capture trip. From 5-14 September 2000, we visited two haulout sites in Frederick Sound (Southwest Brothers Island, Sail Island), Southeast Alaska (Fig. 27).

METHODS

Sea lions were captured using two different methods. One method involved divers capturing sea lions underwater using a noose and the other method involved capturing sea lions on land using hoop nets.

<u>Captures - Underwater</u>

Underwater captures were conducted in the following manner. Two divers entered the water near an active group of young sea lions adjacent to a rookery or haul-out site. The divers submerged to a depth of approximately 2-15 m until they reached the bottom. One diver carried a bait bucket full of frozen herring. He placed a herring between a fork at the end of a pole and

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[1]This research summary was taken from an ADF&G report of work conducted during 2000. Do not cite without permission of the authors, and contact them for additional information, final reports, or publications resulting from this work.

slowly moved the pole through the water to entice the sea lions closer. The second diver held a noose supported at one end by the tip of his pole. The noose was constructed from one end of a 15.2-m halibut ground line or floating line with two buoys attached to the opposite end, floating at the surface. These buoys rested at the surface until a sea lion was captured. The diver captured the sea lion by placing the noose around the neck of the sea lion and cinching the noose down as much as possible before the sea lion began to swim away, the drag of the buoys further cinched the noose around its neck.

Captures – Above Water

Once the noose was around a sea lion's neck, the two divers surfaced and waved to the capture skiff. The capture skiff then proceeded directly to the buoy attached to the sea lion, used a boat hook to pull the buoy to the skiff, then pulled the line in to the skiff. The line was fed through a small pipe in the bottom of a three-sided wooden capture box inside the skiff and held by one person. As the sea lion was brought alongside the skiff, the capture line was cleated off and a large Nomar blanket was lowered down below the sea lion in the water. The sea lion was pushed onto the blanket while in the water using shepherds hooks and the water current as the skiff was slowly driven in forward gear. Once the sea lion was inside the blanket, the front of the blanket was cinched tightly so the head of the sea lion was securely in the blanket. The capture line was removed from the cleat, and three people lifted the sea lion from the water directly into a three-sided capture box. The top of the blanket was held down firmly over the box as the lid to the box was placed over the blanket. The blanket was slowly worked out from under the lid and when completely free, the lid was secured to the rest of the box. Three web straps were secured around the box. Two hooked rods were then passed through small openings in the box to release the noose and remove it from the box.

When capturing pups, a similar method was used, but as the pup was pulled alongside the capture skiff, the pup was scooped into a salmon net, brought onboard the skiff, the noose removed, and the pup placed inside an extra large airline pet kennel.

Pups captured on shore were captured by running up to a pup, placing a hoop net around the pup, tying the hoop net closed with a line, carrying the pup in the hoop net to the water's edge and placing the pup in the capture skiff. Once the pup was in the capture skiff, the hoop net was removed and the pup was placed in a kennel.

Morphometric and Medical Procedures

Once the sea lions were secured in boxes or kennels, they were transported back to the charter vessel, lifted aboard, and weighed to the closest tenth of a kilogram using a load-cell scale. They were then placed onto a large table (in their capture boxes). The sea lions were masked using a cone, and administered isoflurane to sedate them. Once they were asleep, the rear of the box was opened, and blood was taken from either the hind flippers or the caudal gluteal vein. Blood was extracted for serology, hematology, immunology, toxicology, heavy metal, and fatty acid analyses. Once blood was taken, deuterium oxide (administered according to the sea lion's weight) was injected intramuscular (IM). After this injection, the sea lion was unmasked and allowed to wake up. The sea lion remained in the capture box for approximately 1 to 1.5 hours. The box was then rotated upside down so the sea lion now was lying on the inside lid of the box (now used as a stretcher). The sea lion was sedated again and once asleep, the three-sided box removed from above. The three webbed straps were then secured around the body and the sea lion was intubated using a soft plastic tube inserted into the trachea. Once intubated, the straps were removed, the respiration rate, pulse rate, and temperature were monitored by the anesthesiologists.

Procedures conducted on each sea lion included the following: bioelectrical impedance analysis (BIA) to compare with deuterium oxide results to determine total body water; ultrasound to determine blubber depth; length and girth measurements; photographs of foreflippers, whiskers, teeth, and any unusual injuries; nasal swabs for phocine herpes virus analysis; oral, ocular, rectal, and vaginal swabs for chlamydia and virology analyses; hair sample for heavy metal analysis; fecal samples for contaminant and parasite analyses; blubber biopsies for fatty acid and toxicology analyses; flipper punch for genetic analysis; a vibrissae for stable isotope analysis; an upper second premolar removed from yearlings and older for age analysis; and a stomach tube inserted to collect milk and gastric juices for fatty acid and enzyme analyses.

<u>Satellite Data Recorder (SDR) Deployments - Yearlings</u>

SDRs were glued to the pelage along the midline of the back with the leading edge of the SDR perpendicular to the leading edge of front flipper. We glued four SDRs using Titan Bird Epoxy and five SDRs using hand-mixed 10-minute Devcon epoxy. We applied SDRs to those animals with complete or nearly complete molted pelage. On one additional animal, we removed the old, loose fur from the dorsal shoulder and revealed a fresh patch of new fur suitable for SDR attachment. We did not apply SDRs to some molted animals because we reserved 1 SDR for possible pup attachment, one animal had molted but was in relatively poor body condition, and one molted animal appeared to be $\geq$ 2 years old. We attempted to extend the life of the SDRs by doubling the antenna diameter. Additional antenna weight appears to be offset by a more streamlined SDR design. We programmed the SDRs to allow a minimum 6-month battery life. We found no pups sufficiently molted to attach SDRs. One pup had begun molting in the attachment area, but old fur remained interspersed with new fur after several minutes of cleaning.

<u>Smart Position-Only Tags (SPOT) Flipper Tag Deployments - Pups</u>

We attached SPOT flipper tags to the trailing edge of the left front flipper on three pups in Prince William Sound. We mounted SPOT tags to large original cattle tags (Temple Tag, Inc.) using 5-minute Devcon epoxy. After disinfecting the tags, we slid the lower prong through small incisions made in the flipper approximately 6 cm from the animal's torso. The trailing edge of the tag projected from the flipper edge and was secured by a stainless steel screw. Two SPOT tags were mounted with antenna trailing the flipper, and one SPOT tag was mounted with antenna projecting about 30 degrees from vertical.

Dye Numbers

Numbers were dyed on the shoulders and hips of each sea lion so animals could be resighted once released. The dye was prepared by mixing Clairol developer with Clairol black hair dye. The dye was applied to the pelage using a toothbrush. We attempted to use blonde hair dye on the black pelage of the pups in September but the dye did not "take". Therefore, we used black dye on all pups and yearlings.

RESULTS

We captured 30 (17 juveniles, 13 pups) Steller sea lions in PWS during nine days of captures. Captures included 11 yearlings at Glacier Island haulout, six yearlings and three pups at The Needle haulout, six pups at Fish Island rookery and four pups at Seal Rocks rookery (Table 32). The divers were responsible for capturing 28 of the sea lions and the remaining two were pups captured using hoop nets on shore at Seal Rocks rookery. We attached four SDRs to the pelage of yearlings and three SPOT tags to the flippers of pups. We resighted 17 of the 30 sea lions captured in PWS including one yearling suckling (Table 32).

We captured 33 (20 juveniles, 13 pups) Steller sea lions in SE during seven days of captures. Captures included 11 yearlings and five pups at Southwest Brothers haulout and nine yearlings and eight pups at Sail Island haulout (Table 33). The divers were responsible for all captures during this trip. We attached five SDRs to the pelage of yearlings (Table 33), but did not attach any SPOT tags during this trip. We resighted 13 of the 33 sea lions captured in SE including one yearling suckling (Table 33).

Overall, the captures and processing of sea lions was very successful. With two anesthesiologists, we were able to sedate two pups at one time, therefore decreasing the overall holding time of the sea lion pups. We had a well-trained and efficient crew, and captures and processing went smoothly.

We did not plan to attach SDRs to all sea lions during these trips because sea lions begin molting in late summer and the molt continues through the fall. Previously, several SDRs deployed on juveniles in March 1998 collected data until molted off in late August or early September. Our August-September 2000 SDR deployments have picked up data collection where these 1998 deployments left off.

This was our first attempt at attaching SPOT tags to the pups. Unfortunately, we were unable to gather much data because the satellites stopped receiving transmission signals from the SPOT tags. We did receive signals from all SPOT tags with a shipboard radio receiver before and shortly after deployment. Satellites did receive signals from one SPOT four days post-deployment. Another SPOT tag signal was received four hours pre-deployment. Signals from one SPOT tag were never received by satellites, either pre-deployment, post-deployment, or during the manufacturer signal testing. We had planned for three more SPOT tag deployments in SE, but they failed during manufacturer testing. The manufacturer has now discontinued this particular version of the SPOT tag.

Table 32.--Steller sea lions captured in Prince William Sound and Northeast Gulf of Alaska from 20-30 August 2000. Included below are specimen number, dye number, date and location of capture, sex, age (years), weight (kg), if an SDR or SPOT tag was applied, and if the sea lion was resighted on a subsequent visit to the rookery or haulout.

SPEC_ID	Dye #	Date	Location	Sex	Age (yr)	Weight (kg)	SDR/ SPOT	Resight
SSL92PWS00	92	8/20/00	Glacier Island	M	1.2	116.5		Yes
SSL93PWS00	93	8/21/00	Glacier Island	M	1.2	107.0		Yes
SSL94PWS00	94	8/21/00	Glacier Island	M	1.2	87.5		
SSL95PWS00	95	8/21/00	Glacier Island	F	1.2	94.5	SDR	Yes
SSL96PWS00	96	8/21/00	Glacier Island	F	1.2	90.5		
SSL97PWS00	97	8/22/00	The Needle	F	1.2	113.5		Yes
SSL98PWS00	98	8/22/00	The Needle	M	1.2	127.0		Yes
SSL99PWS00	99	8/22/00	The Needle	F	1.2	135.0	SDR	
SSL100PWS00	0	8/23/00	The Needle	M	1.2	138.5	SDR	Yes**
SSL101PWS00	1	8/23/00	The Needle	F	1.2	122.5		Yes
SSL102PWS00	2	8/23/00	The Needle	F	1.2	133.5	SDR	Yes
SSL103PWS00	3	8/23/00	The Needle	M	0.2 (pup)	61.5	SPOT	Yes
SSL104PWS00	4	8/24/00	The Needle	F	0.2 (pup)	44.0	SPOT	Yes
SSL105PWS00	5	8/24/00	The Needle	F	0.2 (pup)	39.0		Yes
SSL106PWS00	6	8/25/00	Fish Island (Pinnacle)	F	0.2 (pup)	34.5		Yes
SSL107PWS00	7	8/25/00	Fish Island (Pinnacle)	M	0.2 (pup)	58.0	SPOT	Yes
SSL108PWS00	8	8/25/00	Fish Island (Pinnacle)	F	0.2 (pup)	47.0		Yes
SSL109PWS00	9	8/25/00	Fish Island (Pinnacle)	M	0.2 (pup)	47.5		Yes
SSL110PWS00	10	8/25/00	Fish Island (Pinnacle)	M	0.2 (pup)	43.5		
SSL111PWS00	11	8/26/00	Fish Island (Pinnacle)	M	0.2 (pup)	42.0		
SSL112PWS00	12	8/26/00	Seal Rocks	M	0.2 (pup)	40.0		
SSL113PWS00	13	8/26/00	Seal Rocks	F	0.2 (pup)	31.5		
SSL114PWS00	14	8/26/00	Seal Rocks	M	0.2 (pup)	47.0		
SSL115PWS00	15	8/26/00	Seal Rocks	M	0.2 (pup)	47.5		
SSL116PWS00	16	8/28/00	Glacier Island	M	1.2	111.0		
SSL117PWS00	17	8/28/00	Glacier Island	M	1.2	122.0		Yes
SSL118PWS00	18	8/28/00	Glacier Island	M	2.2*	152.5		Yes
SSL119PWS00	19	8/29/00	Glacier Island	M	1.2	96.5		
SSL120PWS00	20	8/29/00	Glacier Island	M	1.2	127.0		
SSL121PWS00	21	8/29/00	Glacier Island	M	1.2	80.5		

* Indicates unknown age, but we think animal is two years old.

** Indicates animal was observed suckling when resighted.

Table 33.--Steller sea lions captured in Southeast Alaska from 07-13 September 2000. Included below are: specimen number, dye number, date and location of capture, sex, age (years), weight (kg), if an SDR or SPOT tag was applied, and if the sea lion was resighted on a subsequent visit to the rookery or haulout.

SPEC_ID	Dye #	Date	Location	Sex	Age (yr)	Weight (kg)	SDR	Resight
SSL122SE00	22	09/07/00	SW Brothers Island	M	1.25	120.5		Yes
SSL123SE00	23	09/07/00	SW Brothers Island	F	1.25	89.5		Yes
SSL124SE00	24	09/07/00	SW Brothers Island	M	1.25	112.0		
SSL125SE00	25	09/07/00	SW Brothers Island	M	0.25 (pup)	59.0		
SSL126SE00	26	09/08/00	SW Brothers Island	M	1.25	84.0		Yes
SSL127SE00	27	09/08/00	SW Brothers Island	F	1.25	80.5		
SSL128SE00	28	09/08/00	SW Brothers Island	M	1.25	103.5	SDR	
SSL129SE00	29	09/08/00	SW Brothers Island	F	1.25	105.0	SDR	
SSL130SE00	30	09/08/00	SW Brothers Island	M	1.25	91.0		
SSL131SE00	31	09/08/00	SW Brothers Island	M	0.25 (pup)	56.5		
SSL132SE00	32	09/09/00	SW Brothers Island	M	1.25	103.0		
SSL133SE00	33	09/09/00	SW Brothers Island	F	0.25 (pup)	42.0		Yes
SSL134SE00	34	09/09/00	SW Brothers Island	M	0.25 (pup)	58.0		
SSL135SE00	35	09/09/00	SW Brothers Island	M	1.25	128.0		Yes
SSL136SE00	36	09/09/00	SW Brothers Island	F	0.25 (pup)	42.0		
SSL137SE00	37	09/09/00	SW Brothers Island	M	1.25	113.0		
SSL138SE00	38	09/10/00	Sail Island	M	1.25	124.5	SDR	Yes**
SSL139SE00	39	09/10/00	Sail Island	M	0.25 (pup)	54.5		Yes
SSL140SE00	40	09/10/00	Sail Island	F	1.25	83.0		Yes
SSL141SE00	41	09/10/00	Sail Island	M	0.25 (pup)	55.0		
SSL142SE00	42	09/10/00	Sail Island	F	1.25	90.0	SDR	Yes
SSL143SE00	43	09/11/00	SW Brothers Island	F	1.25	81.0		
SSL144SE00	44	09/11/00	SW Brothers Island	M	1.25	105.0	SDR	
SSL145SE00	45	09/12/00	Sail Island	F	1.25	96.0		Yes
SSL146SE00	46	09/12/00	Sail Island	F	1.25	94.5		Yes
SSL147SE00	47	09/12/00	Sail Island	F	0.25 (pup)	44.5		
SSL148SE00	48	09/12/00	Sail Island	M	0.25 (pup)	51.0		
SSL149SE00	49	09/12/00	Sail Island	M	0.25 (pup)	50.5		Yes
SSL150SE00	50	09/12/00	Sail Island	M	0.25 (pup)	39.0		Yes
SSL151SE00	51	09/13/00	Sail Island	M	1.25	107.0		
SSL152SE00	52	09/13/00	Sail Island	M	1.25	92.5		
SSL153SE00	53	09/13/00	Sail Island	F	0.25 (pup)	46.0		
SSL154SE00	54	09/13/00	Sail Island	F	0.25 (pup)	42.0		

** Indicates animal was observed suckling when resighted.

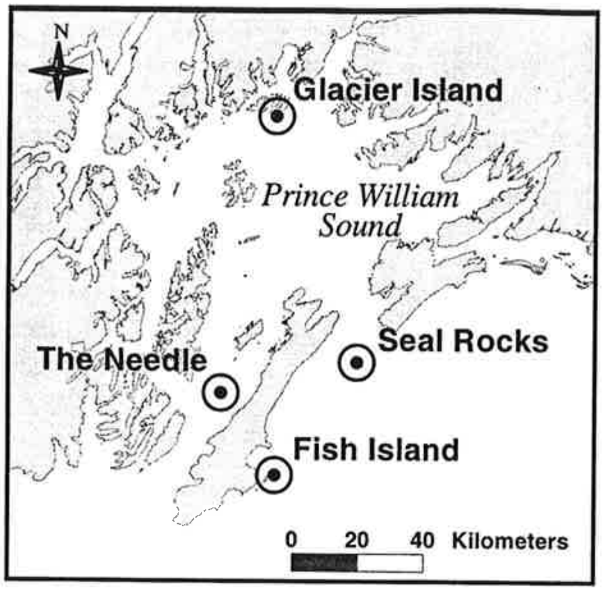

Figure 26.--Locations of Steller sea lion captures in Prince William Sound and Northeast Gulf of Alaska from 20-30 August 2000.

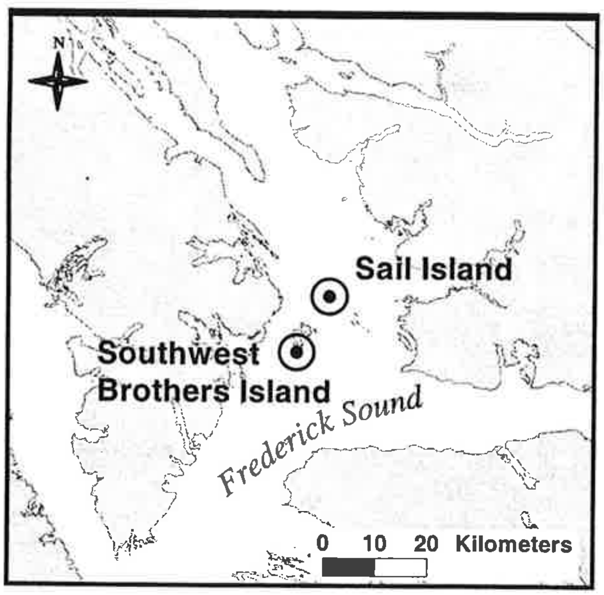

Figure 27.--Locations of Steller sea lion captures in Frederick Sound, Southeast Alaska from 5-14 September 2000.

Reports from the

Alaska SeaLife Center

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LONG-TERM MONITORING OF THE STELLER SEA LION ROOKERY ON CHISWELL ISLAND USING REMOTE CONTROLLED VIDEO CAMERAS[1]

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INTRODUCTION

Steller sea lion (*Eumetopias jubatus*) rookeries and haul out sites are usually located on offshore rocks and small, remote and inaccessible islands. These areas often make long term observations difficult or impossible. Access by researchers is limited by weather and sea conditions or a concern for disturbing the animals while attempting to gain access. Often sea lions occupy all available surfaces of the rocks. In order to avoid disturbance, counts or observations sometimes must be conducted from undesirable locations such as small boats or difficult to reach observation posts.

A clear understanding of the life history of Steller sea lions requires detailed analysis of utilization of both rookeries and haulouts by sea lions. It is important to understand how long individuals stay at the same geographic location, and what the daily and seasonal fluctuations in numbers, sex and age composition of sea lions are on a given area. This information is critical for realistic management of Steller sea lions. However, collection of this type of data is very difficult because it requires intensive, long term observations at the same site. Many sites are impossible to remain at for longer than a few hours.

The Alaska SeaLife Center (ASLC) contracted SeeMoreWildlife Inc. (mention of trade names does not constitute endorsement on the part of the Alaska SeaLife Center) to create and maintain a system that allows remote video observations at a nearby rookery. Images are transmitted directly to the ASLC via UHF signals and are received on video equipment located at the ASLC.

OBJECTIVES OF RESEARCH

The major goals of our first year of research were:

To develop a remote video monitoring capability for Steller sea lion research and test this system for:

- Estimation of daily/seasonal abundance including different age/sex classes of Steller sea lions on the rookery;

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[1]This paper, originally presented as an Annual Programmatic Research Report to the National Fish and Wildlife Foundation on December 31, 2000, was provided for inclusion in this report by the Alaska Sealife Center. Do not cite without permission. Please contact the authors for additional information or citation permission

- Remote monitoring of pupping success and survival of new born pups on the rookery during the first months of their life;
- Long term monitoring of individually recognizable animals with tags and/or brands or any natural markers (creating photo/video ID data base) and branded/tagged animals re-sighting data collection;
- Test the system for collection of other types of biological data on Steller sea lion rookeries year around.

METHODS AND DATA COLLECTION

The Chiswell Island Steller sea lion rookery was selected as the site for observations in April 1998. Chiswell Island is located 35 miles south of Seward, Alaska, on the southwest side of the entrance to Resurrection Bay (Figure 28). Teams composed of SeeMoreWildlife Systems personnel and ASLC personnel visited the site over the course of the summer and autumn, 1998, to evaluate the site and begin installation. The first camera and signal transmitting equipment was installed on Chiswell Island on October 28-29, 1998. A repeater station was installed on Caines Head approximately half way between Chiswell Island and the ASLC to facilitate "line of sight" transmission to the receiver station installed on the roof of the ASLC building (Figure 28).

Whenever the system was operational, daily observation of sea lions on the Chiswell Island Steller sea lion rookery were conducted using the remote video monitoring system and remote control terminal located at the ASLC in Seward (Figure 28). During the winter the system was turned on at daylight and shut off at dusk, when low light hampered observations. During the summer the system was generally active from 6 AM to 10 PM. A permanent video record was maintained on VHS tape. Standard commercially available videotapes were used with up to 6-8 hours recording in low speed mode (SLP). During winter and the first half of spring we recorded the video signal constantly 5-9 hours a day. From mid-May to early August video recording increased up to 16 hours a day.

From the start up date to the end of 1999 the video signal was available from 1 to 24 hours for a total of 349 of 428 days (82%). More than 350 videotapes were recorded with over 3200 hours of recording time. The data describing the technical operation of the system is presented in Table 34 and Appendix 1 [*please contact ASLC or authors for Appendix 1*-Ed.].

Counts of animals by age/sex on the rookery were conducted 1-6 times per day. By use of the remote control, the camera was panned, tilted and zoomed in or out during observations. After installation of additional cameras, we could switch from one camera to another and observe animals located on different parts of the rookery. Four cameras placed in different parts of the island allowed observation of almost all the animals hauled out on the rookery. Images of animals with tags, brands, or natural markers (scars, pigmented spots, target lesions, etc.) were recorded for future re-identification. Between counts or observations the camera was left to rest on the most advantageous angle and zoom to observe the most animals present on the rookery. This location was recorded constantly until the next time the camera was used. We were able to describe movements of sea lion in and out of the rookery in great detail using the recorded videotapes.

Video System Technical Description and Operations

Hardware

Visible light, commercially available video cameras (different models) with 12-18 power optical and 180-300 power digital zoom were mounted in fully weatherproof housings that included remote-controlled pan, tilt, zoom, and windshield wiper/washer assemblies. The camera housing was designed to function in high wind and marine conditions (Figure 29). Each camera had an on-board microprocessor that controlled camera movements and monitored power consumption and internal housing temperature.

A single microprocessor-based control center capable of operating up to seven cameras and microphones was used. The single control center directed user-selected control signals to the desired camera and routed the selected video and audio signals to the transmitter. Additionally, the control center collected and transmitted data from weather sensors. Temperature, air pressure, and wind speed and direction were monitored on Chiswell Island.

12-volt batteries recharged by solar panels (75 watts) and/or a 100-watt marine wind generator modified for high winds (Figure 29) provided power to the cameras, control center, and transmission equipment. The system was designed to use very little power and drew only 1 Amp at 12 volts DC (for one camera).

Principal technique of remote video system

The remote-controlled video system was operated from the ASLC in Seward. Camera control signals were transmitted on a UHF data link from the system operator to the camera site while remote sensing data was transmitted on the same link back to the operator. Concurrently, video and audio signals were transmitted via microwave to the operator. A Windows 98/NT desktop computer operated the remote system and received all remote data. Cameras were controlled with the click of a mouse or from a simple touch-screen interface. Real time video images and sounds were displayed on a standard television monitor, projected in large format, or streamed over the Internet.

RESULTS

1. Daily Operations and System Development

One camera and all signal transmitting equipment was set up on Chiswell Island during October 28-29, 1998. Since that time Steller sea lion observations and data collections were made constantly, except the days when technical difficulty or deteriorated quality of the signal prevented observations.

During October 1998 - March 1999 only one camera was functioning on Chiswell Island. In early March a second camera was set up near the rookery. Two cameras operated until early June, when two more cameras were added with coverage for most parts of the rookery used by sea lions. A total of four cameras operated on the rookery during the rest of the summer until early October. Two cameras were left on the rookery over the winter period only.

During the first half of the experiment, most operations (turn the system on/off, start/stop recording, etc.) were done manually. However, the hardware and software were upgraded and improved to the point where daily routine operations were executed automatically via computer.

In October-November 1999, automatic, preset positioning of the cameras was developed for up to 6 automatic scans of all parts of the rookery. At a preset time a camera was automatically selected and directed to pan, tilt and zoom to focus on a selected location (up to 8 locations for each camera). The windshield wiper was then automatically operated and the camera remained focused on the programmed location on the rookery for a programmed time of generally 2 - 3 min. Then that camera was automatically moved to another position and the sequence repeated or the program selected the next camera and repeated the sequence to focus on a new location. Video signals were continuously recorded on standard VHS tape. This provided a complete video record of the entire rookery for each scan sequence. This allowed long-term observation and recording of daily and seasonal presence and behavior of sea lions on the rookery.

2. Video System Maintenance and Reliability

During 1999 we considered this system to be in a development and testing stage for Steller sea lion remote video monitoring. The Chiswell Island system was visited twenty-one times for maintenance and repair from the time of installation to the end of 1999.

October-December 1998: On October 28-29 when the system was installed on Chiswell Island, a controllable signal was received at the ASLC. Shortly after the installation and startup, the wind generator malfunctioned and required two helicopter flights to troubleshoot and repair. During November the system functioned for 20 days, but the signal generally was unstable and the camera wasn't often controllable. During this time SeeMore technicians tested the equipment and developed software. In early December the signal was lost due to a power supply problem.

January-April 1999: One trip was made to the island in early January to repair the power supply problem and replace the camera with an upgraded model. Following this upgrade, the system operated for 23 days. Periodic problems were experienced with the remote control and the power supply. On mornings following frosty nights it was difficult to power the system up and operate it. On several days, system power was left on 24 hours a day to avoid this problem. On January 29, 1999 the system was shut off and another repair trip to Chiswell Island was necessary. On February 10, 1999 a new camera was installed and power was restored. The system functioned well through the remainder of February, but occasional fog spots appeared in the field of view. This was diagnosed as moisture temporarily condensing on the windshield inside the camera housing. On March 8, 1999 a second camera was installed and the first camera was again replaced. Both cameras were active and functioned on the rookery. For most of the rest of March they functioned satisfactorily although some problems with the remote control continued. Occasionally, remote control of the cameras temporarily failed. During March, a new version of the controlling software was developed and installed. At the end of March a power problem developed again due to a depleted battery. One trip on March 26 was necessary to repair this problem. During most of April the system functioned well except two days without wind when the battery bank was not charged. Windy weather during the following days allowed the wind generator to charge the batteries again and no additional maintenance trips were required for the period.

May-August 1999: In May one trip to Chiswell was necessary to solve the continuing low power problem. In this case, it was necessary to replace the batteries. Early in June, two additional cameras were installed on Chiswell Island bringing the total to four. Nearly all areas on the island where sea lions were present were now within view of a camera. Several solar panels were added to increase reliability and augment the wind generator. Near the end of June two fighting males damaged the transmitter. In mid-July additional improvements were made to allow independent control of two cameras simultaneously. Unfortunately, the additional equipment and signal caused more problems with the remote control and degraded the quality of the signal. Installation, tuning, and replacing equipment damaged by sea lions required two more trips to the island during June and three trips in July. During August the signal was available for 27 days and the system functioned satisfactorily, but solving the problem with interference between the two signals and continuous tuning needs took two more visits in August.

September - December 1999: Intensive improvements of hardware and upgrading computer software brought good results. During September the signal was reliable and stable, and all cameras remained controllable. One trip in September and one trip in early October were made in preparation for winter, replacing cameras and setting up a new wind generator. After Oct. 3, 1999, two controllable cameras remained on the rookery for the winter period. Two additional trips to the island in October were necessary due to an unstable power supply. The signal was available for observations on 23 days during October. New remote control software was installed on October 10 allowing preset cameras for automatic scans. During the month of November the system operated well although one visit was necessary for maintaining equipment. At the end of December a transmitting problem occurred due to a broken antenna resulting from a strong windstorm. This problem was solved in January 2000.

3. Seasonal Abundance of Steller Sea Lions on the Chiswell Island Rookery

Presence of sea lions on different rookeries or haul out sites changes dramatically by season (Calkins and Pitcher 1982). But each sea lion site has individual characteristics that make it unique. The remote video monitoring system we developed on Chiswell Island allowed us to monitor sea lion abundance throughout of the year (Figure 30).

November - December 1998: Only 9 counts were conducted during November (Table 35). The count remained from 10 to 35 individuals, averaging 23. In December counts were conducted on five days only. The numbers decreased to 15 to 25 animals, or an average of 17. During the first two months following installation of the system reliability was poor. Therefore, counts to describe age-sex structure of sea lions present were not possible. We did note the presence of animals of different ages (pups to adults) and sex.

January - April 1999: During these winter months we tracked the abundance of Steller sea lions on Chiswell Island rookery for 103 of 120 days (85%). The total number of sea lion was low and ranged between 0 to 16 animals. Sea lions seldom hauled out for very long. During January no sea lions were present for 42% of the time, in February 23%, March 72% and April 64% (Figure 31). The time animals stayed on the land also varied from a few seconds to over 12 hours a day. In average they were hauled out on the rookery from 9.2 to 16.6% of the total monitored time or an average of 13.7% during January to April (Table 36). Animals of all age-sex groups were present on the rookery during this period, although the proportion of each group changed over the period (Figure 35). It is interesting to note that few adult females were hauled out during March and April. There were mostly sub-adults and bulls.

May - August 1999: During May the number of sea lions increased rapidly. Mature bulls arrived on the rookery and established territories. The first bull arrived and occupied a territory on April 29. During May, the number of mature males increased to 10. Five of these bulls established territories within the breeding part of the rookery. The total number of sea lions on the rookery increased to 40 non-pup age animals. The number of sea lions continued to increase through June, due mostly to the arrival of pregnant females. By the end of June the maximum count reached 92 sea lions. During the following months the number of sea lions on the Chiswell rookery ranged between 40 and 140 animals older than pups. Unfortunately during this period numerous technical problems occurred so it wasn't possible to track the number of animals accurately enough to understand the reasons for short-term changes in abundance. However, the composition of the different age and sex groups was very clear. The proportion of mature females increased from 40% in May to almost 70% in July and remained so during August. The proportion of bulls and young animals decreased during this period and in August bulls comprised only 10%, and immature animals comprised about 20% of all sea lions present on the rookery.

September - December 1999: During this period the system was reasonably functional except during October. In September the number of sea lions was highly variable due to frequent adverse weather conditions. Total numbers decreased during this period, varying from 120 animals to 40 by the end of the month. In contrast during the first half of October, numbers increased to nearly 100 animals by mid-month, then dropped back down to 30 animals by the end of the month (Figure 30).

In early November the number of sea lions increased to over 70 animals for one day only. However, during most of the time the numbers held between 30-40 animals. Between November 23 and December 13 about 20 animals were present. Then the numbers dropped in the second half of December until there were often no animals on the rookery.

The sex-age structure of sea lions on Chiswell Island during this period was very stable: bulls - 7-11%, sub-adult males - 3-7%, females - 41-56% and young animals between 30-45% (Figure 33).

4. Weather conditions compared to Steller sea lion abundance on the rookery.

Weather conditions (air temperature, air pressure, wind speed and direction, and tides and current) were collected instrumentally or described visually during observations. No strict correlation was found between Steller sea lion abundance and weather parameters, but a decreasing number of animals on the rookery during strong rains was observed (Figure 34; July 18, September 12, 14, 18, etc.). Usually the number of sea lions was low on stormy days, especially in fall and winter (Figure 34; August 21-22 and 27-29, September 10-15, November 1-4, etc.). Weather conditions showed on a scale of 0 to 8 points where 0 is no rain or surf during the day and 8 is heavy rain or surf. The correlation between air temperature and air pressure has not been analyzed yet.

5. Breeding Success of Steller Sea Lion on Chiswell Island in 1999.

The first birth of the season occurred on May 27 in the morning and the last pup birth was registered on June 27. Unfortunately some parts of the breeding and pupping areas were out of view from any camera angle because they were hidden by rocks. This caused additional difficulty in collecting birthing data. The data we did collect allowed us to describe the length of the pupping season and estimate daily pup increment (Figures 35-37). In the 1999-breeding season we had two periods of high birth rate. The first was June 6 to 10 and the second occurred from June 20 to 23 (Figure 36). The number of females present during these periods also increased accordingly (Figure 37). Difficulty in viewing some areas also prevented a determination of the exact number of pups born on the rookery. Maximum pup counts during June indicated 43 live and 4 dead pups. But later counts in mid-July, when the cameras worked better for a short time, we often saw 46-48 pups during one count. This data allowed us to conclude that in 1999 on Chiswell rookery, 52 pups were born but four of them died during their first month. The average number of mature females on the rookery at the end of June also supports this conclusion (Figure 37).

From late June until the end of the year no additional dead pups were observed. Mortality was 4 of 52 pups born on Chiswell in 1999 (7.7%). This agrees with the average level of newborn pup mortality observed on other rookeries during the first months of the life (Perlov, 1970; Mamaev and Burkanov 1996).

The observed numbers of copulations on the rookery are shown in Figure 38. The first copulation occurred on June 9 and the last successful one was observed on July 3. The length of mating activity ranged between 8 and 26 minutes or 14.6 average. Late in July we observed several unsuccessful copulation attempts that lasted less than one minute. The last mating behavior was observed on July 20.

6. Other Steller Sea Lion Observations

6.1 Steller sea lion and killer whale interactions

During nearly continuous observation throughout the year, we observed killer whales near the Chiswell Island rookery on several occasions. The first time a whale was observed near the rookery was June 2 at 8 AM and was visible near shore for 2 minutes. Sea lions appeared to react to the whale, but for a short time only. On the next visit, two killer whales arrived near the rookery on July 20. They stayed near shore more than 3 hours in the morning (from 6:14 AM to almost 10:00 AM). The sea lions came out of the water and stayed on shore. Late that afternoon, (about 6:41 PM) many of the sea lions appeared to be simultaneously looking toward the sea but the camera was on automatic recording and we were not sure if killer whales were present or if there were other reasons for this behavior (tour or fishing boats).

Killer whales appeared near the rookery twice in September and stayed very close near shore for up to two hours each time. Many times they splashed water with their tails while swimming along the edge of the rookery. This behavior of killer whale cannot be considered as a hunting activity (Baird et al. 1998). No clear attacks on sea lions were observed during any visits of killer whales.

6.2 Data Collection on Marked Animals.

In contrast with some other marine mammals (spotted seal, killer whales, etc.) the Steller sea lion has a relatively uniform colored brownish skin and hair that is difficult if not impossible to use for individual recognition using distinctive colored spots or patches. However, Steller sea lions suffer many different injuries that result as scars, hairless spots, or scratches that are unique to the individual. These marks often remain unchanged (possibly life long)and can be used as natural markers for long term individual recognition (*contact authors for figure–Ed.*).

During summer 1999, images of different natural markers were identified on 21 bulls, 27 females and 10 sub-adult animals. Two young animals from Forrester Islands (southeast Alaska) with brands F452 and F753 were observed on the rookery in October and November 1999.

By comparing the daily counts of territorial sized bulls hauling out on Chiswell rookery (maximum daily count was 16 bulls) with the number of bulls observed with unique markers (21 animals), we can conclude that there was an active rotation of bulls on Chiswell rookery during the summer. Further analysis of our data will provide more details about the activities of individually identified sea lions and give more details of the life history of those individuals and the role of each age-sex group.

6.3 Human Related Disturbance of Steller Sea Lions

6.3.1. Boat activity near the Chiswell Island rookery

Chiswell Island is located on the route of the Kenai Fjords National Park tour boats and other small boats from Seward. Often these boats come close to the rookery in order to see the sea lions that were hauled out. On several occasions we observed small sport fishing boats pass near the rookery at a high rate of speed. Boats were observed near the rookery a total of 16 times during the summer season (May through August) 1999. Most boats stayed farther than 100 yards away and the sea lions did not react. At times the small fishing boats came very close to the shore (about 20 yards). On only one of these occasions did the animals raise their heads, but stayed on the rookery. None of the boats committed any other acts that could be considered harassment.

6.3.2. Disturbance from Remote Video Operations and Maintenance Trips

The system itself doesn't create any noise or other type of disturbance for the animals. Trips to the island required for setting up, maintenance and repair of the equipment resulted in some disturbance. A total of 21 trips were taken during the last part of 1998 and all of 1999 (Table

34). Three types of helicopters were used for transportation of people and equipment - Bell 206 Jet Ranger, Bell 206 Long Ranger and Coast Guard helicopter HH60 Jayhawk.

During 4 of 21 trips (January-March, 1999) there were no animals on the rookery or in the water near shore. Major disturbance during helicopter visits was noise during landing and taking off. The island is very small and there are no other places for landing except one spot about 120 yards from the rookery. Usually the helicopter dropped people off on the island and they continued work as long as necessary (sometimes up to few days) and returned back to pick up people after they had done the work. If it was a short visit for a few hours only, the helicopter stayed on island with the engine shut off. When possible, we recorded the strength of disturbance by tracking numbers of animals on the rookery before the arrival of the helicopter, during the presence of people on island, and after their departure.

It is clear the disturbance created by helicopter influenced short-term abundance of sea lions on the Chiswell rookery. Preliminary results showed the number of sea lions slightly decreased following nearly each visit (Figure 39). At the same time this influence lasted no more than one or two days, and usually after that the counts returned to the previous level. On one occasion (June 26) landing of helicopter had no apparent effect on sea lion presence. On two occasions of 10 analyzed the low number sea lions continued more than five days (May 13, and November 22, 1999). No serious long-term influence on sea lions resulting from human activity was observed on Chiswell Island in 1999.

Sea lion abundance on the rookery changed constantly and human related disturbance that interferes with natural cycles can extend the time some animals remain on the rookery (May 13 and November 22) or reduce the effect (June 26) depending on which stage of the natural cycle the disturbance occurred.

DISCUSSION

Marine mammals are generally more difficult to track long-term and conduct continuous observations than terrestrial animals. Steller sea lions breed on land and spend part of their life in close association with land. They occupy rookeries and haul out sites on remote, small islands and rocks or steep coasts that are very hard to access and dangerous to conduct long term observations. Mostly detailed observations on sea lion rookeries and haul outs are conducted during a few weeks in summer (Calkins and Pitcher 1982; Sandegren 1970; Gentry 1970, Burkanov et al., 1991, etc.). The serious problem of the unexplained decline of Steller sea lions in the western stock requires long-term monitoring of distribution and abundance and the collection of a wide variety of biological data on sea lion sites throughout the year. The remote video monitoring system developed under this project is a new and very useful scientific tool that provides almost unlimited access to Steller sea lion sites without serious disturbance of animals or weather limitations. During the project up to 4 video cameras were operated to observe the rookery and up to 2 independent signals were available for our work. Visual access on the rookery usually was available during day light hours. The major operational problems encountered were unstable or poor quality video signal, loss of camera control, and insufficient power. Throughout the year the hardware and software were under continuous development and were improved for better control and increasing quality of the signal and system reliability. Some very useful options were automated - preset positioning, auto start on/off of the system, wiping the windshield, preset zoom, etc.

Some limits were discovered during our work. Only one camera is available for control and recording information when only one signal is available. Therefore, at any given time we were able to see and record the picture from only one part of the rookery. If you switch the signal to another camera, you lose the first picture on the TV screen. This means that simultaneous observations of different parts of the rookery are not possible. Also it is difficult to count animals in large groups. It also limits the number of researchers that have access to the rookery at the same time to one researcher, and it limits the number of observations that can be done at the same time.

The first year of the project was a testing period to study the capabilities of remote video for long-term observations of Steller sea lions on rookeries and haul out sites. Even with the many technical difficulties and days when the signal did not allow observation of the animals we were able to collect and store important and comparable data in the form of the videotapes for future analyses.

Video observations of the Chiswell Island rookery will allow the most comprehensive description of the year around dynamics of a Steller sea lion rookery. This island is a breeding site for animals in the Central Gulf of Alaska where the population is in a severe, continuing decline. During most of the 1998-99 winter only a few sea lions hauled out on the rookery and for only a short time. Numbers began to increase on the island at the end of April with mature bulls arriving first. The mature bulls maintained their territories and were the most abundant age and sex group on the rookery until May 20. Females started to arrive after mid-May and the pupping season started around May 23-27. From that time until the end of June, the number of females increased constantly. The maximum count for mature females during the pupping season of 1999 was 61 animals. The last observed birth occurred on June 26. Fifty-two births were estimated on Chiswell Island in 1999. Four pups were found dead on the rookery during June and no more were observed subsequently. Observed juvenile mortality was 7.7%. The first copulation occurred on June 9 (13 days after the first birth) and the last successful copulation was observed on July 3, but mating behavior continued until July 20. Between July 15 and August 25 the maximum number of Steller sea lions counted on the rookery was 133 individuals. During this period the number of sea lions hauling out on the rookery was highly variable. It changed from a maximum of 133 to the minimum of 53 over only a few days. After the breeding season the adults began actively moving to and from the ocean. During this time age-sex structure on the rookery was 54% females, 26% pups, 10% 1-2 years old animals, 6% adult males and 4% were sub-adult males.

During September the number of sea lions decreased from about 100 animals in the beginning of the month to 40 at the end. During October and November about 40-60 animals were hauled out on the rookery. At the end of November the number decreased to 20 sea lions and after December 12, few animals were present on the rookery for a short time only.

CONCLUSIONS

- Remote controllable video system is new and valuable research instrument for long-term monitoring of Steller sea lions on rookeries and haul out sites.

- Placing several cameras along the rookery (or site where animals are present) you can view all animals present on the land.

- The system allows the collection of different types of biological information to characterize the present status of a group of animals on a research site and spatial changes the parameters on long-term basis:

  - Daily and seasonal population parameters - abundance, age-sex structure, breeding success and mortality level, etc.;
  - Collecting resighting data especially (brand/tags) or naturally marked animals on regular base;
  - Long-term tracking the life history (visual body conditions, copulation, pregnancy, birthing, etc.) of individually recognizable animals;
  - Different behavioral information (mother-pup interactions, any other age-sex group interactions on rookery, etc.;
  - Study effect of different type of disturbance sea lions occurred in research site area.

- Following limits of remote video method for collecting biological data on sea lion rookery discovered:

  - One camera available only for conducting observation with one transmitted video signal only. There is the ability to collect one type of data at particular time - conduct count animals, search for marked animals, or viewing general picture of the research site, etc.;
  - Data collection depends on the reliability of the system. Failure of the system or part of it stops all observations or any part of them.

- During the testing and developing period (1998-99), 82% of the days the system was active and allowed collection of biological information. Failure of the system during breeding season significantly reduced the amount of data that could be collected. The reliability of the system needs to be increased (especially during the most important seasons of the year, such as breeding).

- Steller sea lions are present on Chiswell I. year around (Fig. 32), but abundance and the time they stay on land varies highly by season:

  - During winter and first half of spring they visited the rookery 28-76% of days and stayed on land for a short time;

- During summer-fall they were present on the rookery every day and stayed on land constantly (24 hours a day), but their numbers changed constantly.

- Maximum seasonal counts in 1999 was 133 animals of age 1+ and 48 new born alive pups with following age-sex structure (Figure 40):

Bulls	6%
Sub adult males	4%
Young (age 1-4 years old)	10%
Females	54%
New born pups	26%

- Clear breeding groups of Steller sea liona are present on Chiswell Island. They use the island as rookery for pupping, mating and raising the new born pups

- In 1999:
  - Pupping season on the rookery lasted through period of May 27 to June 26;
  - 52 pups were born;
  - Juvenile mortality is 7.7%;
  - Mating period continued from June 9 to July 3 (or late due no observation due to failure the system during first half of July).
  - Many environmental and human related factors have influence on Steller sea lion abundance on Chiswell rookery:

- Rain and wind	some
- Tour and sport fishing boats	no
- Helicopter landings for system maintenance and repairing	short-term

ACKNOWLEDGMENTS

This work would not have been possible without the limitless hours Daniel Zatz and Rick Kleinleder (SeeMore Wildlife Inc.) spent creating and re-creating cameras and other system hardware, and writing computer programs to improve camera control. The US Coast Guard provided helicopter support with transportation, people and equipment to/from research site. Valya Burkanova and Mica O'Brein spent hundreds of personal hours recording the video signal and describing the information recorded on videotapes. Dr. Evgeny Mamaev (visiting scientist from Russia) helped to analyze the tapes throughout 1999 breeding season and describe the animals with different natural markers. Alaska SeaLife Center staff Michael Pendergast and Lynda Martin provided technical support, organized transportation and other project related activity. The authors are very appreciative to all of them for supporting our project.

CITATIONS

Baird, R. W., and P. J. Stacey. 1998. Foraging and feeding behavior of transient Killer Whales. Whalewatcher. Spring 1888. 11-15.

Burkanov, V., V. N. Bazarkin, E. G. Mammayev, A. R. Semenov, A. V. Tret'yakov, L. G. Shabanova, and O. B. Smolyaninov. 1992. The organization of monitoring and explanation of the reasons for the decline in sea lion population in the Kamchatka region. Unpubl. rep., 37 p. Russian Academy of Science, Far Eastern Division, Kamchatka Institute of Ecology and Natural Management. Available National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle WA 98115.

Calkins, D. G. and K. W. Pitcher. 1982. Population assessment, ecology and trophic relationships of Steller sea lions in the Gulf of Alaska. In Environmental Assessment of the Alaskan Continental Shelf. Final Reports 19:455-546.

Gentry, R. L. 1970. Social behavior of the Steller sea lion. Ph.D. Thesis, Univ. Calif. Santa Cruz, 113 p.

Perlov, A. S. 1970. Some information about new sea lion mortality on Kuril general harem areas in 1967. Izvestiya Nauchno-issledovatel'skii Institut Rybnogo Khozyalstva i Okeanografii (TNIRO) 74:345-346. (Translated by A. Y. Roppel, National Marine Mammal Laboratory, Seattle).

Mamaev, E. G. and V. N. Burkanov. 1996. Condition of reproductive group of Steller sea lions *Eumetopias jubatus* (Pinnipedia, Otariidae) on the South-Eastern rookery of Medny Island (Commander Islands). Izv. TNIRO, 121:163-175.

Sandegren, F. E. 1970. Breeding and maternal behavior of the Steller sea lion (*Eumetopias jubatus*) in Alaska. M.S. Thesis, Univ. Alaska Fairbanks, 138 p.

Table 34. Summary of remote video system operations on Chiswell Island during October 28, 1998 - December 31, 1999.

Month	Days system active	Hours system active	Hours data recorded on VCR	Visits to Chiswell
Oct-98	1	1:00:00	0:00:00	1
Nov-98	20	50:13:00	0:20:00	2
Dec-98	8	39:49:00	0:00:00	0
Jan-99	24	283:14:00	116:47:00	1
Feb-99	19	243:28:00	126:56:00	1
Mar-99	29	286:55:00	229:32:00	2
Apr-99	28	310:59:00	271:16:00	0
May-99	31	449:55:00	396:18:00	1
Jun-99	30	473:18:00	453:42:00	3*
Jul-99	22	345:35:00	310:57:00	3*
Aug-99	27	364:45:00	243:23:00	2*
Sep-99	30	360:00:00	304:00:00	1
Oct-99	23	276:00:00	176:00:00	3
Nov-99	30	270:00:00	232:00:00	1
Dec-99	27	243:00:00	192:00:00	0
Total	349	3998:11:00	3053:11:00	21

* - during these visits technicans stayed and worked on Chiswell Island longer than one day

Table 35. Seasonal changes in adundance of Steller sea lions on Chiswell Island rookery, 1998-99.

Month	Days with counts	AVG abundance of SSL on rookery	Standard Error	Min number of SSL on island	Max number of SSL on island
Nov-98	9	23	2.52	10	35
Dec-98	5	17	2.00	15	25
Jan-99	19	2	0.50	0	7
Feb-99	17	4	1.03	0	16
Mar-99	29	1	0.53	0	11
Apr-99	28	1	0.44	0	11
May-99	29	15	1.79	1	40
Jun-99	29	56	3.37	26	92
Jul-99	14	90	6.36	45	130
Aug-99	23	100	4.47	51	133
Sep-99	29	63	4.94	19	115
Oct-99	15	54	5.16	27	94
Nov-99	28	27	3.34	0	73
Dec-99	22	9	1.88	0	26
Total	296			0	133

Table 36. Presence of Steller sea lions on Chiswell Island rookery during winter

Month	Hours observations during daylight time	Hours Steller sea lion were present on rookery	Percent
Jan-99	116:47:00	17:07:00	14.7%
Feb-99	126:56:00	21:01:00	16.6%
Mar-99	229:32:00	21:12:00	9.2%
Apr-99	271:16:00	42:27:00	15.6%
Total	744:31:00	101:47:00	13.7%

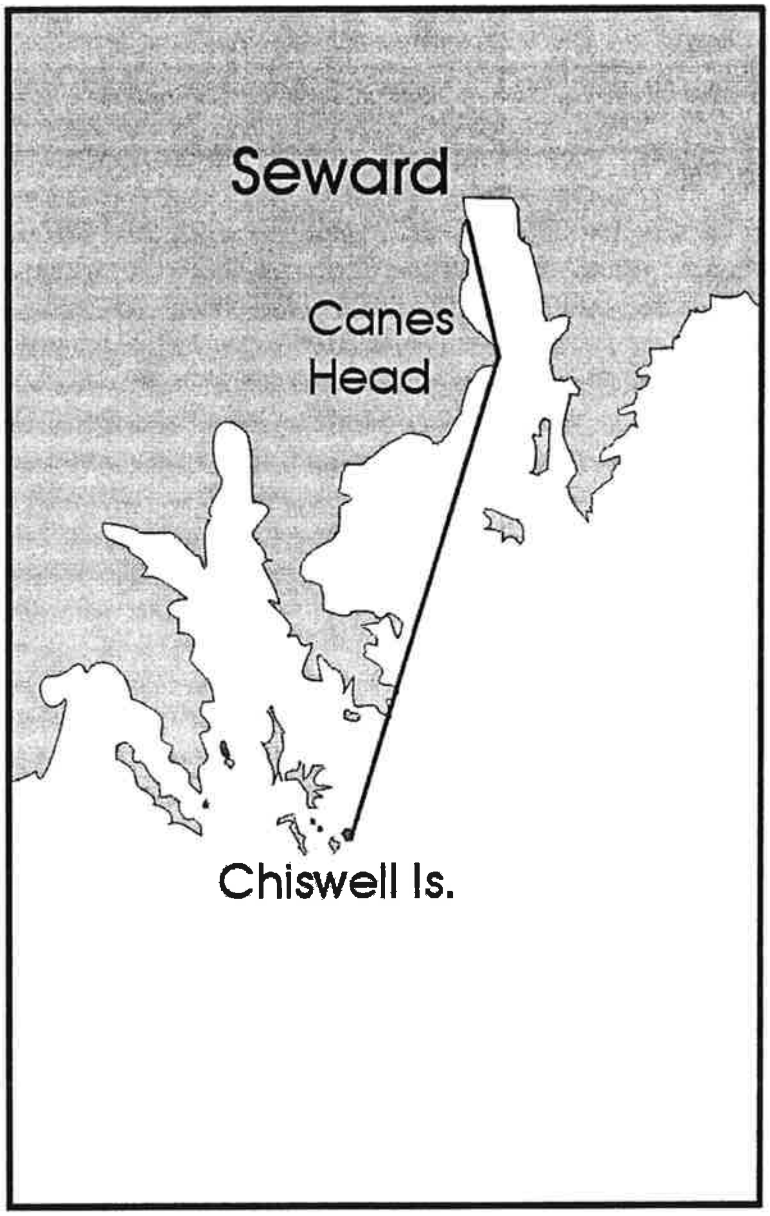
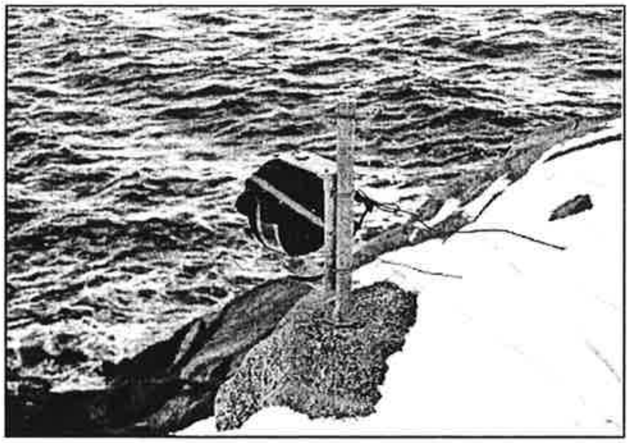


Figure 28.–Study area.

A.



B.

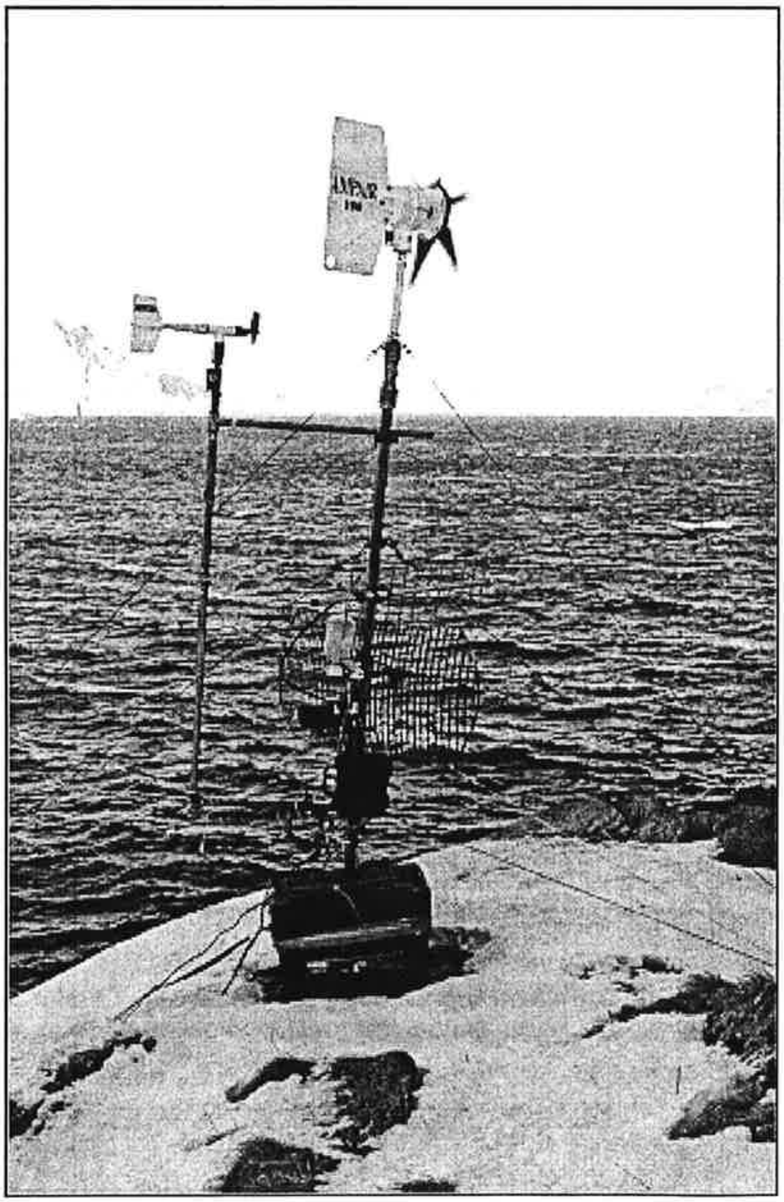


Figure 29.--Equipment for video monitoring of Steller sea lions on Chiswell Island: a) remote controllable video camera in weatherproof housing; and b) the wind generator and transmitting unit.

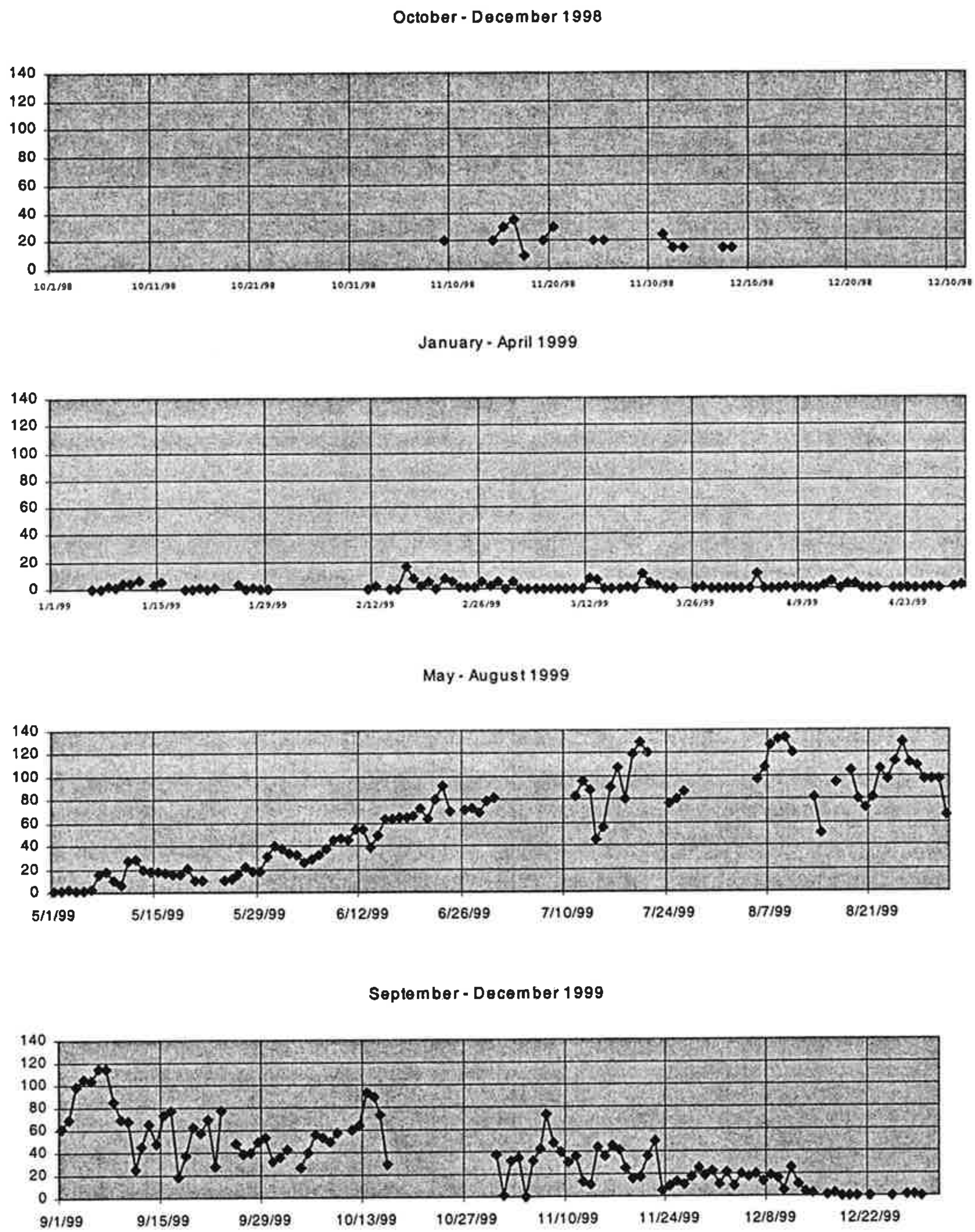


Figure 30.--Seasonal changes in abundance of Steller sea lion on Chiswell Island rookery, Oct-98 – Dec-99

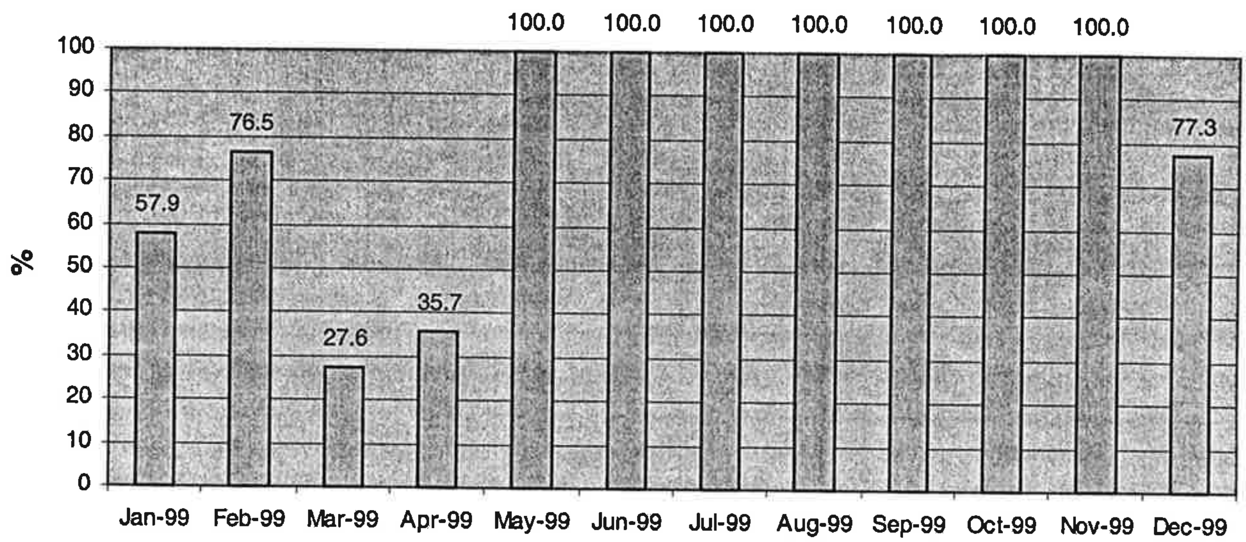


Figure 31.--Percent days/month when Steller sea lion hauled out on Chiswell Island.

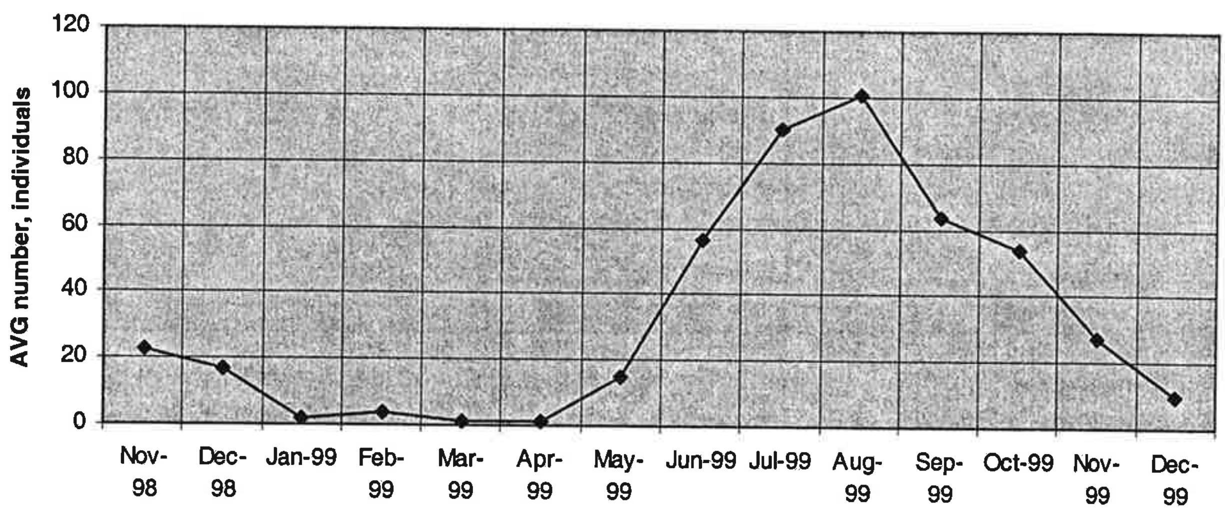


Figure 32.--Average monthly number of Steller sea lion hauled out on Chiswell Island.

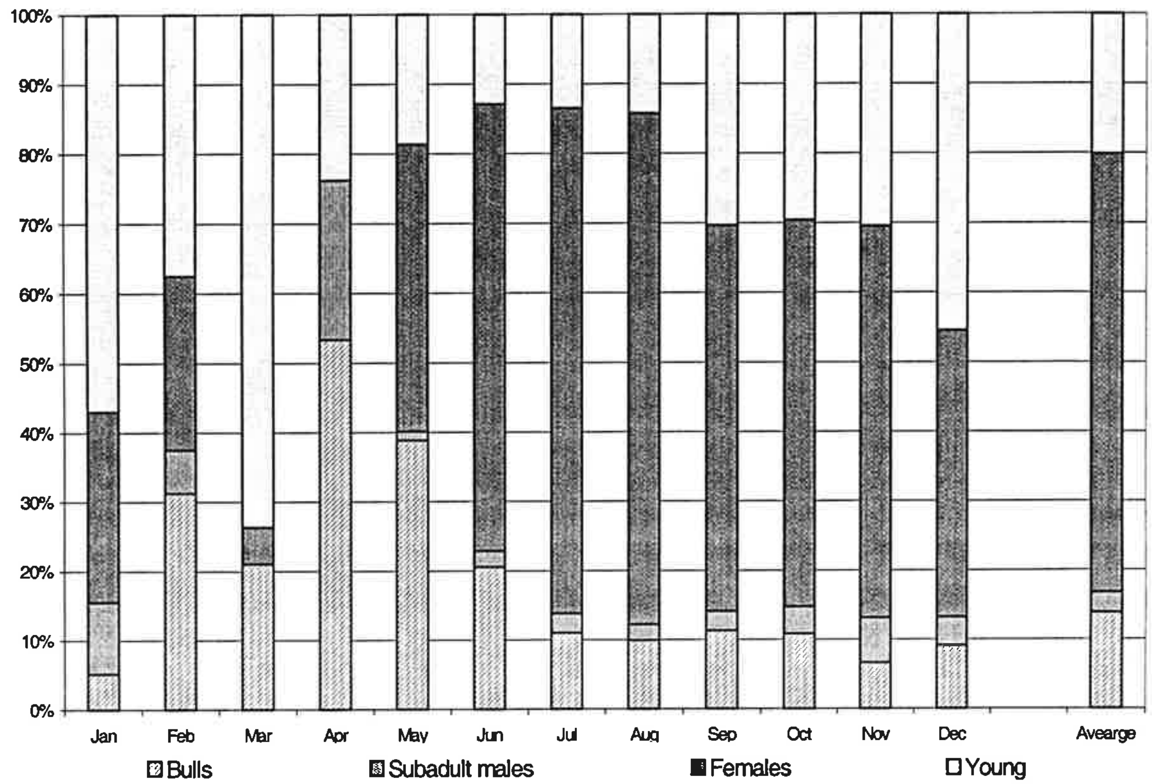

100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Avearge
Bulls
Subadult males
Females
Young

Figure 33.

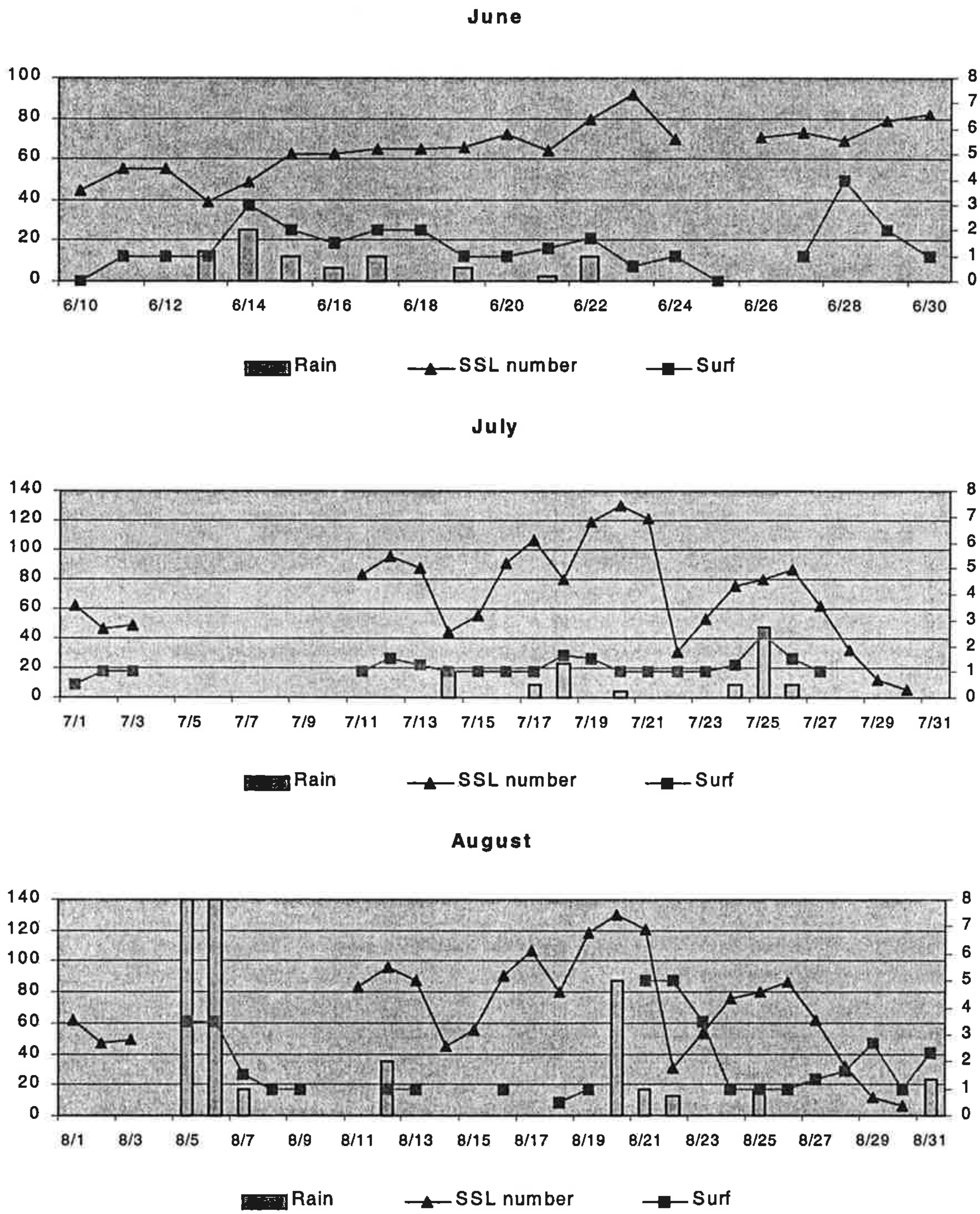


Figure 34.--Steller sea lion abundance on Chiswell rookery compared to some weather conditions.

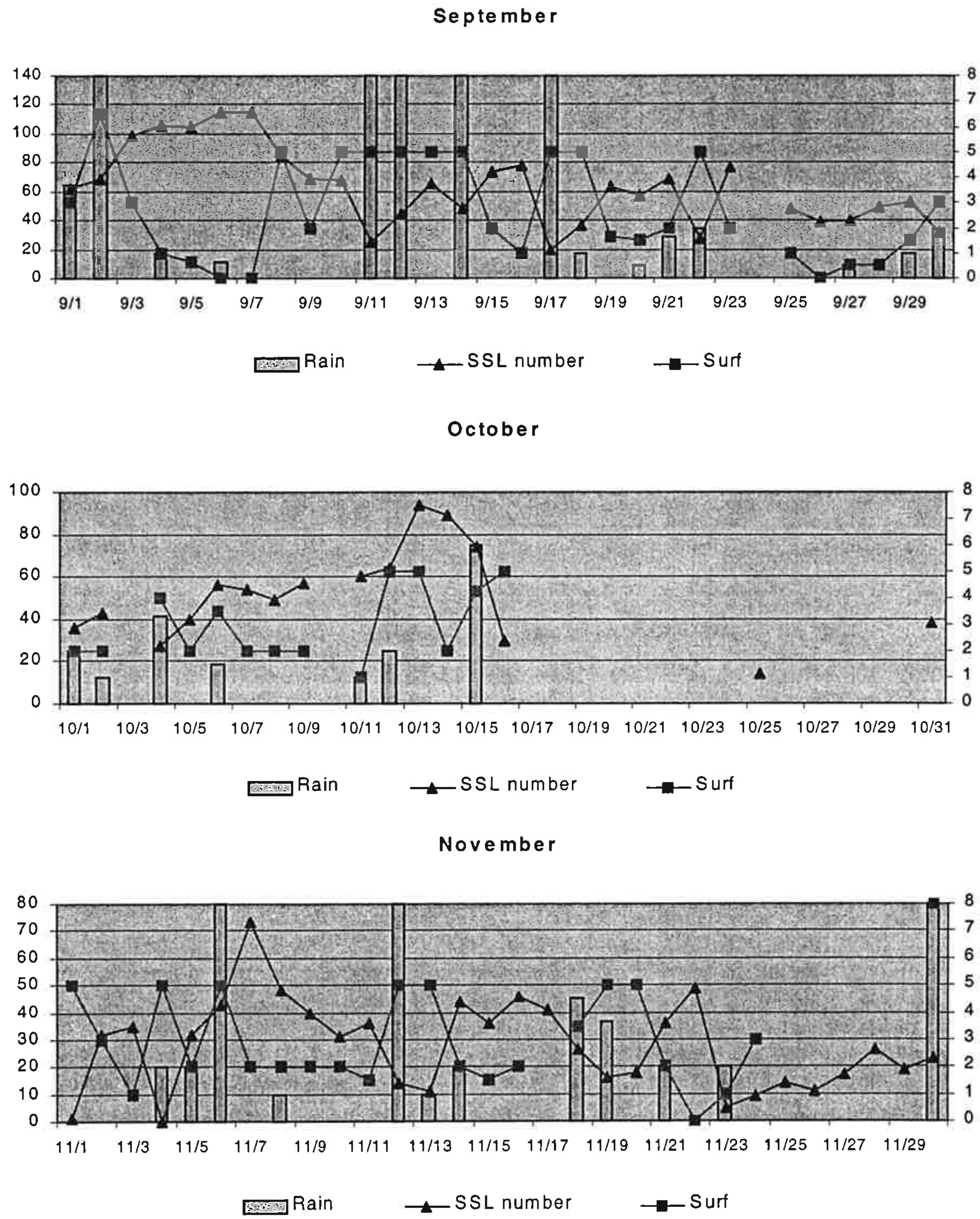


Figure 34.–continued.

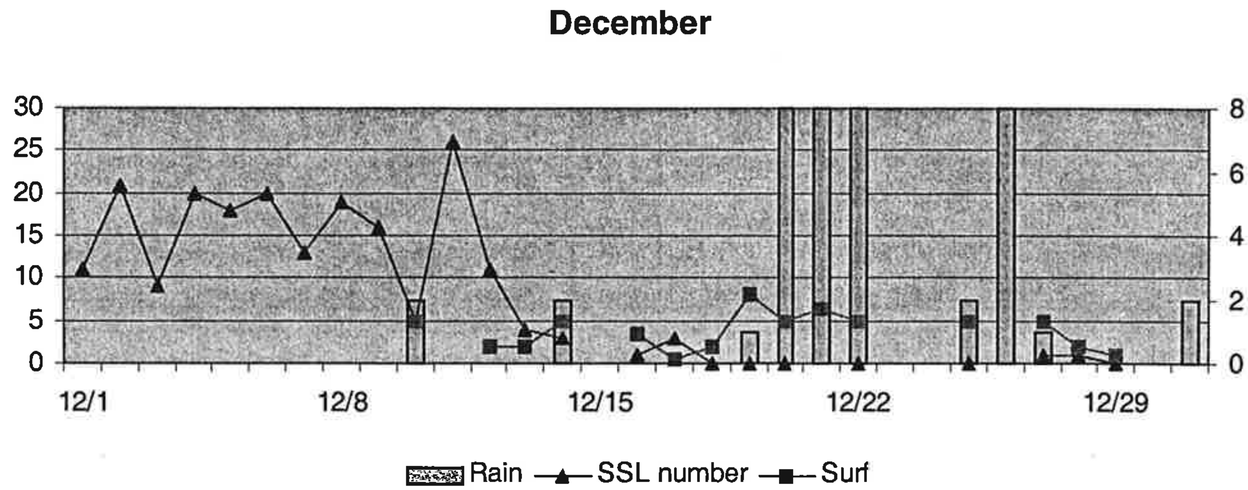


Figure 34.–Continued.

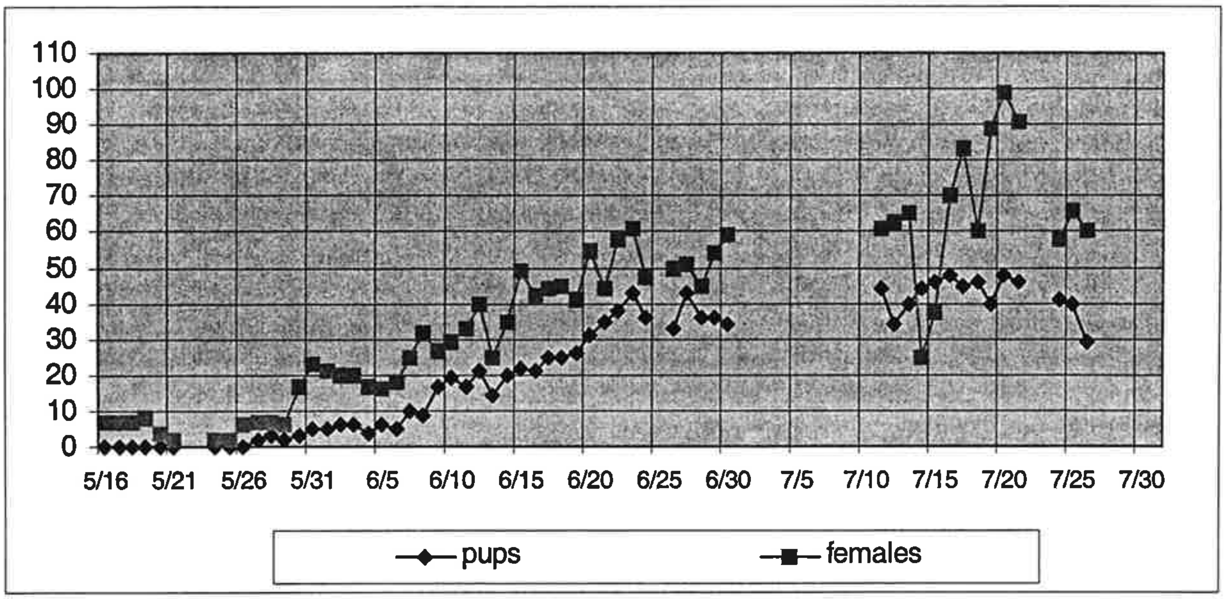


Figure 35.--Number of females and pups on Chiswell I. rookery during breeding season (direct counts).

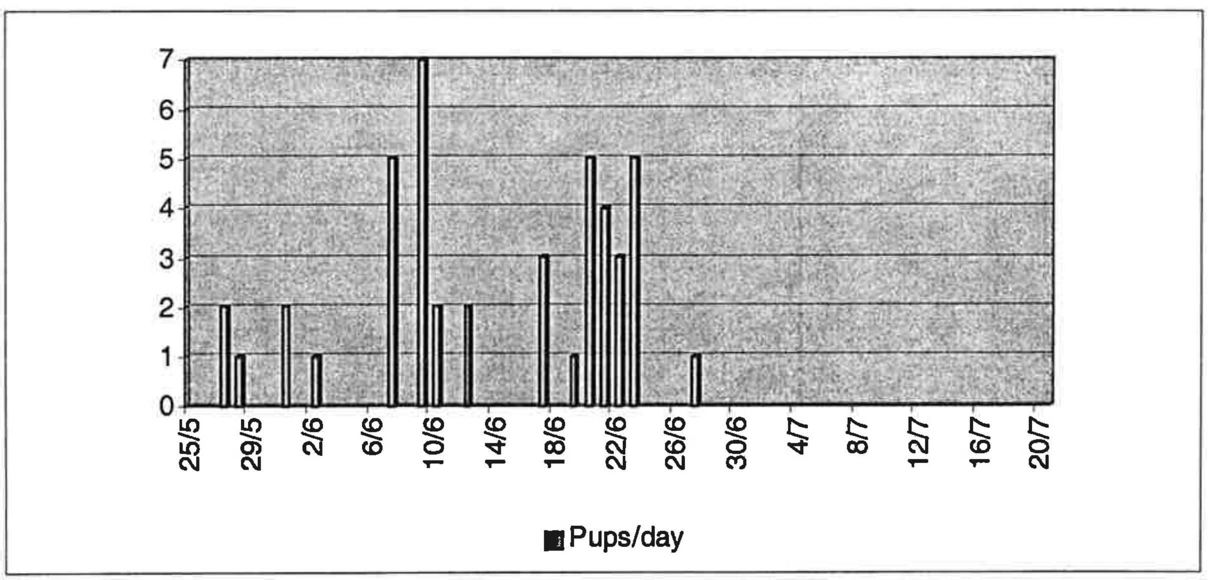


Figure 36.--Daily pup increment on Chiswell Island rookery during 1999 breeding season.

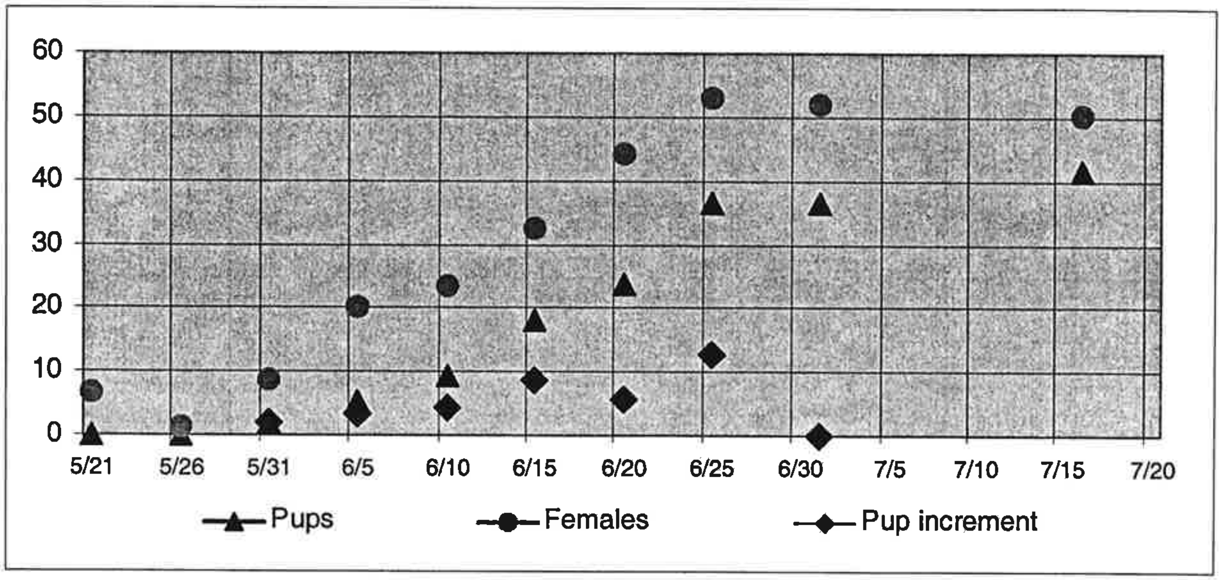


Figure 37.--Average number of females and pups by 5 days increments.

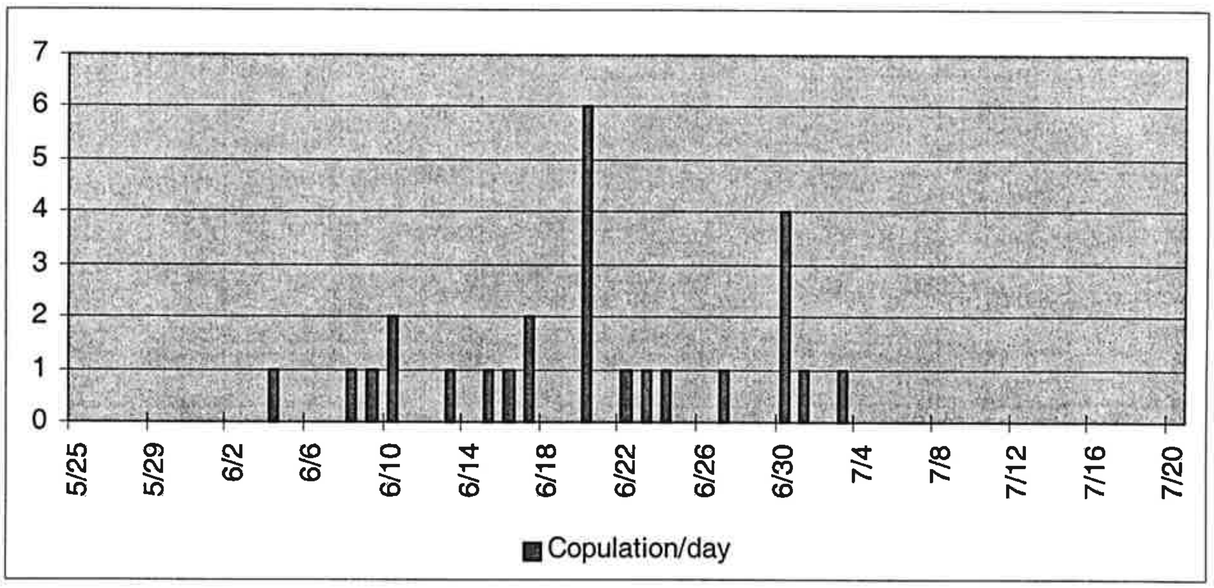


Figure 38.--Number copulation registered on Chiswell Island rookery in 1999.

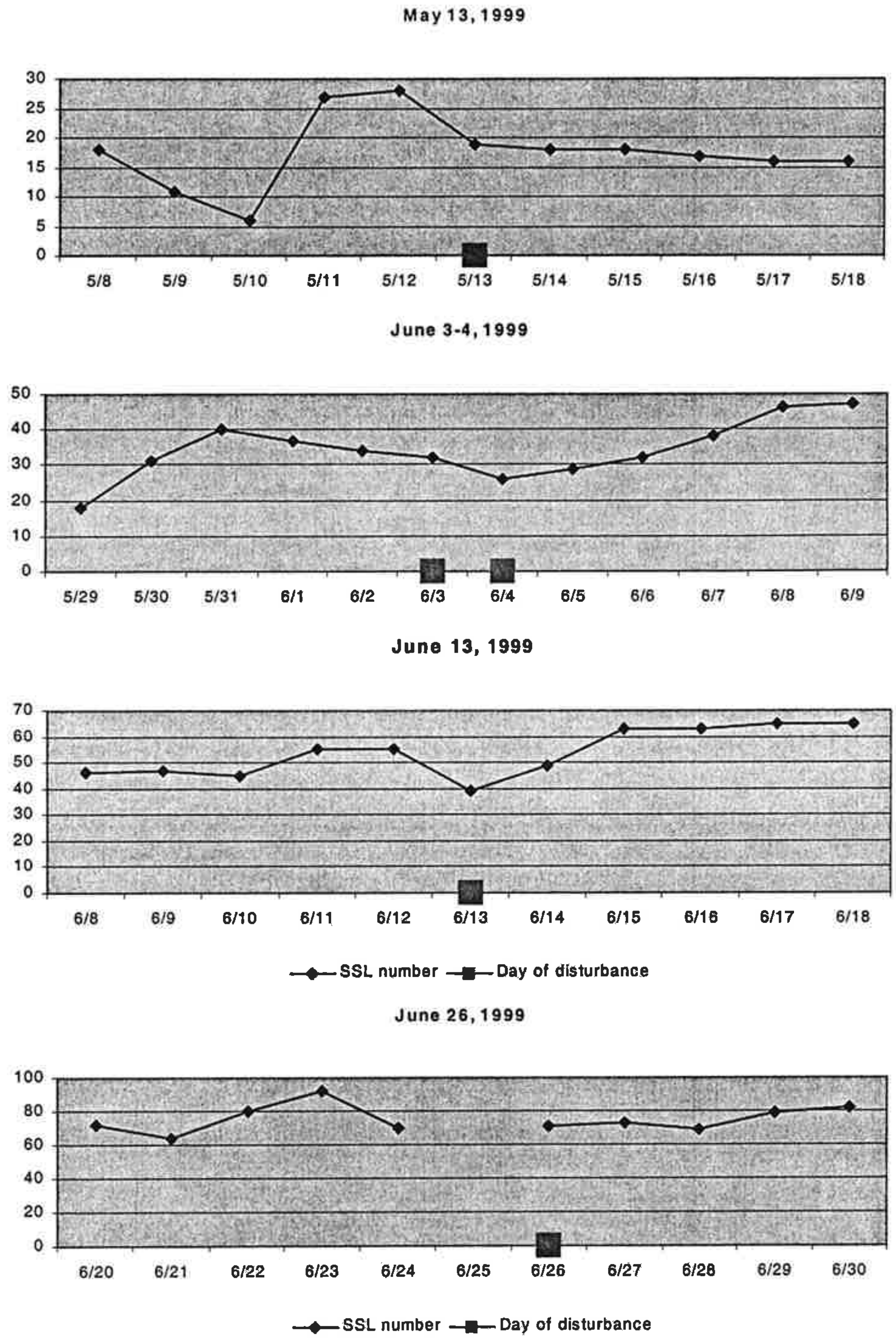


Figure 39.--Changing in abundance of Steller sea lion on Chiswell Island rookery beforeand after helicopters disturbance.

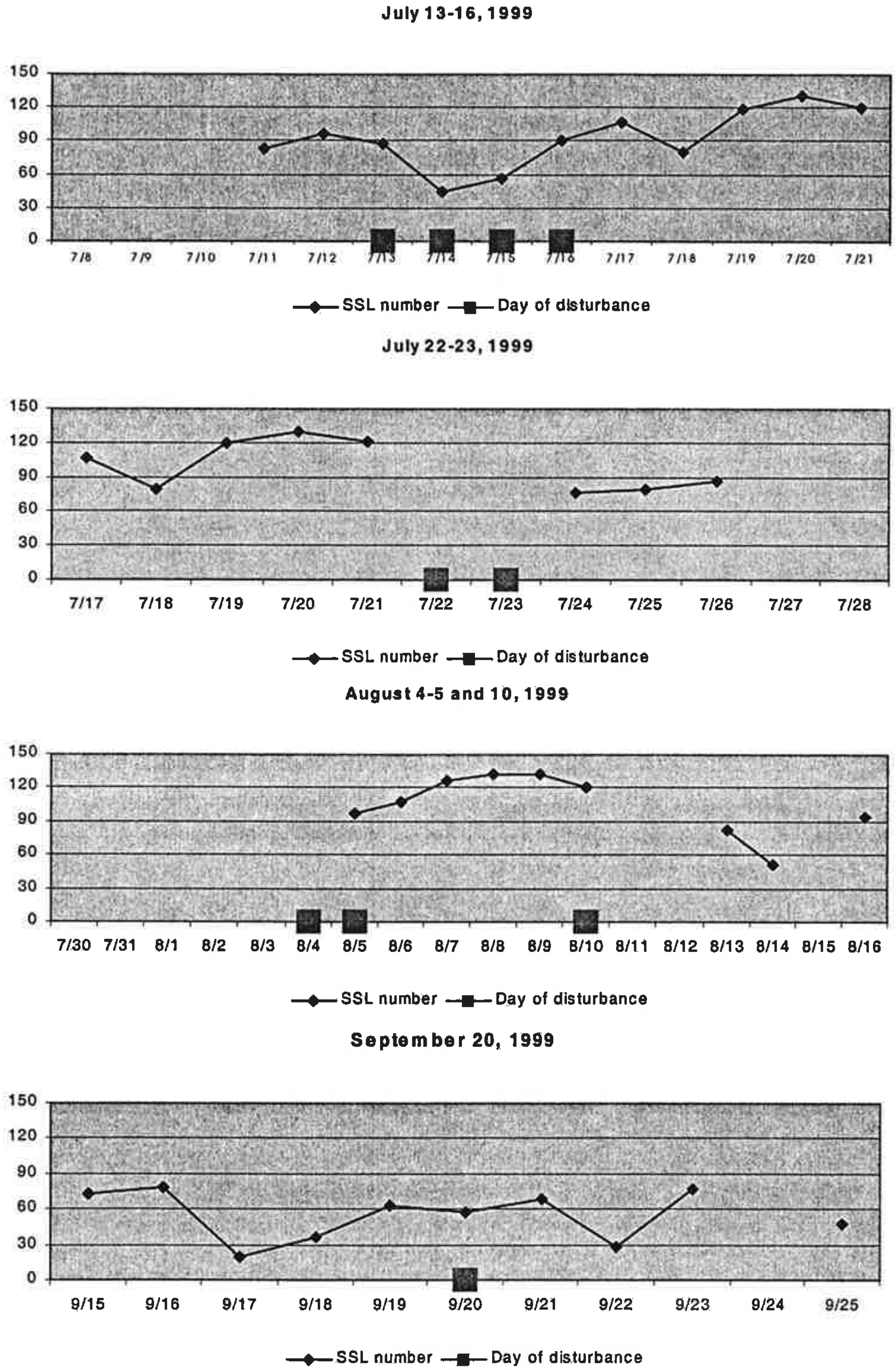
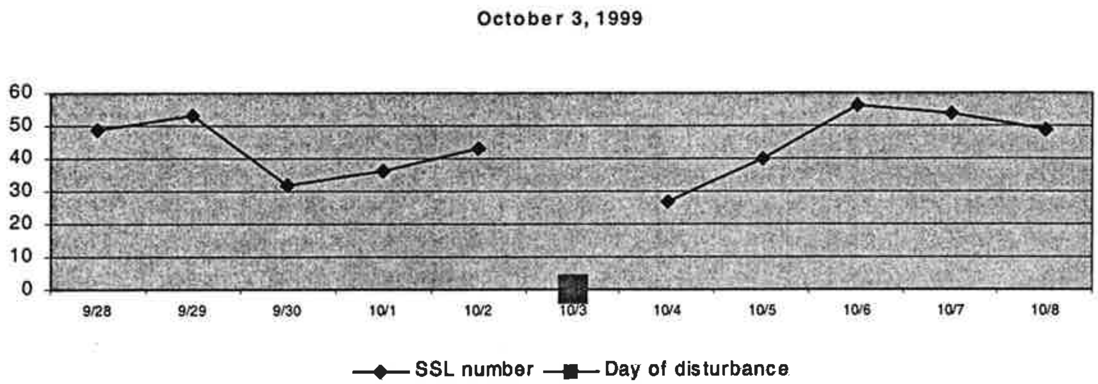


Figure 39.–continued.



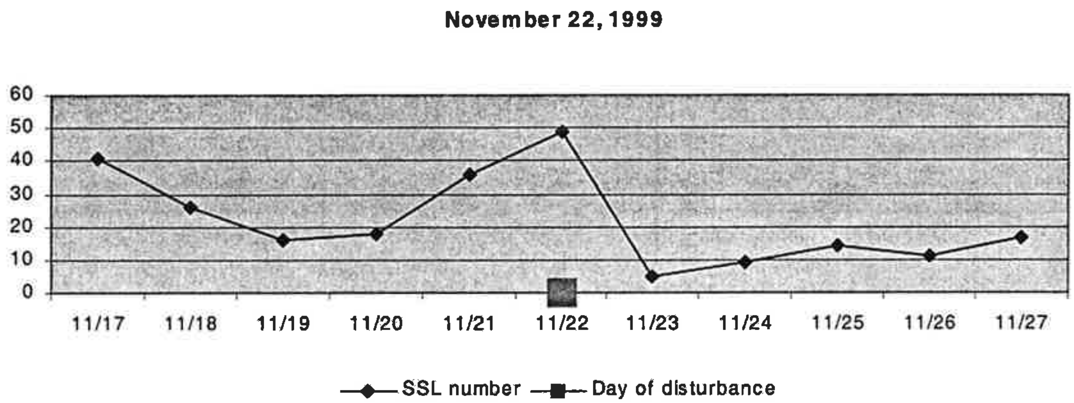


Figure 39.–continued.

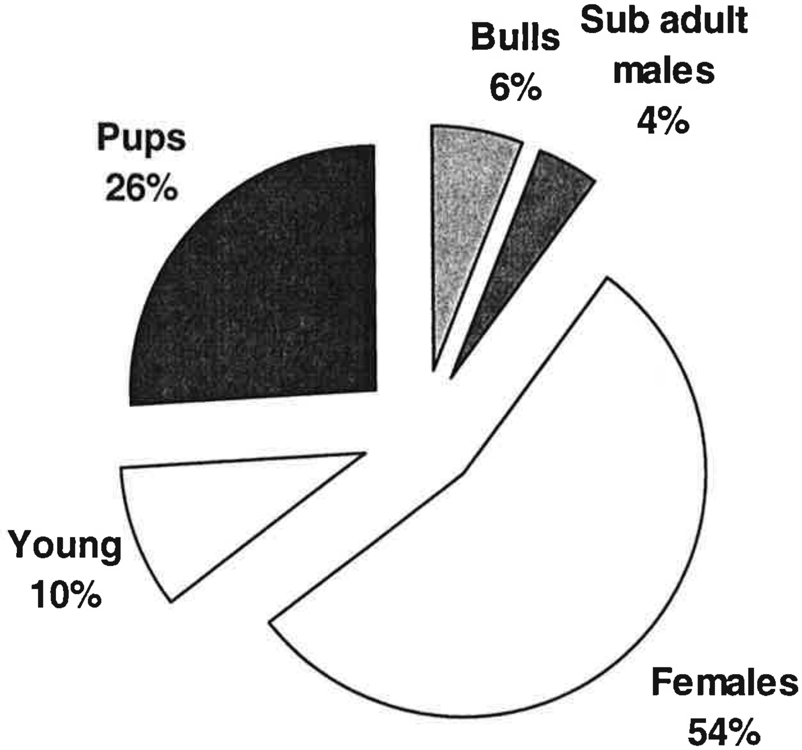


Figure 40.--Age-sex structure of Steller sea lions on Chiswell Island rookery in the day of maximum abundance.

STELLER SEA LION FEEDING REGIME STUDY[1]

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INTRODUCTION

Steller sea lions began declining in Alaska in the 1960's and have declined in a major portion of their range west of Cape Suckling in Alaska as well as in Russia (the western stock). In 1990 the entire population in the United States was listed under the US Endangered Species Act as threatened and in 1997 the western stock was listed as endangered. The National Marine Fisheries Service published the Steller Sea Lion Recovery Plan in 1992 (NMFS 1992), through the assistance of a Recovery Team. Since 1992 intensive studies have been conducted to attempt to determine necessary actions to assist in recovery of the species as called for in the Recovery Plan. To date, no concrete causes of the decline have been identified. A leading theory on one of the causes is that Steller sea lions were nutritionally stressed which has led to chronic high juvenile mortality and episodic adult mortality (Calkins and Goodwin 1988; York 1994; Merrick 1995; NMFS 1995; Calkins et al. 1998). Several studies have been conducted that address this hypothesis. Breeding adult females and pups have been intensively studied on rookeries. Comparisons have been attempted between the declining western stock and the stable eastern stock in Alaska. Very few conclusions can be drawn from the work but there does not appear to be nutritional problems in adult females at rookeries during the breeding season nor with the pups prior to weaning.

Experiments conducted on nutritional stress in captive animals have been of limited scope. Some feeding trial studies were conducted on captive sea lions but most involved single species diets and were conducted for short periods of time, often as little as two weeks (e.g. Rosen and Trites 1999). Fasting experiments have shown some very interesting and pertinent results. There is an indication that sea lions tend to adjust to fasting differently during the breeding season as opposed to the non-breeding seasons. This work has laid the groundwork for captive studies of nutritional stress in sea lions but much remains to be done. In order to determine the actual effect of changes in diet and how captive Steller sea lions relate to prey resources under different regimens observed in the wild, we began to conduct a feeding regime experiment at the Alaska SeaLife Center. The diet of the three captive Steller sea lions was manipulated according to diet parameters reflected in studies of wild Steller sea lions in the Kodiak, Alaska area pre and post decline, and the diet found in the stable Southeastern Alaska population (Calkins and Pitcher

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[1]This paper, originally presented as an Annual Programmatic Research Report to the National Fish and Wildlife Foundation on December 31, 2000, was provided for inclusion in this report by the Alaska Sealife Center. Do not cite without permission. Please contact the authors for additional information or citation permission.

1982, Calkins and Goodwin 1988, and Trites and Calkins *in press*).

The first regime is based on the food habits of Steller sea lions found in the Kodiak area from 1975 through 1977, prior to the beginning of the decline (Pitcher 1981 and Calkins and Pitcher 1982). Because this was seen in the pre-declining period, it is presumed to reflect a diet that sustained a healthy Steller sea lion population. The second regime was based on the diet found in the Kodiak area in 1985 and 1986, after the decline began in that area. The population in that area was considered to be declining by 1984 (Calkins 1985) and showed signs of nutritional stress (Calkins and Goodwin 1988 and Calkins et al. 1998). The third diet regime was modeled after the diet seen in Southeastern Alaska in the 1990's (Trites and Calkins *in press*) where the population has remained stable to slightly increasing.

OBJECTIVES

1. Test the hypothesis that sea lions can maintain good health status as indicated by maintaining or gaining weight, maintaining lean to fat body mass ratio and by physiological parameters measured in blood indices on a diet similar to that found in the Gulf of Alaska in the 1970's before the decline began there.
2. Test the hypothesis that sea lions can maintain good health status as indicated by maintaining or gaining weight, maintaining lean to fat body mass ratio and by physiological parameters measured in blood indices on a diet similar to that found in Southeastern Alaska in the 1990's where no decline has been seen since the 1960's.
3. Test the hypothesis that sea lions will not remain in good health status as indicated by not maintaining or losing weight, or reducing lean to fat body mass ratio or by physiological parameters measured in blood indices on a diet similar to that found in the Gulf of Alaska in the 1980's after the decline began there.
4. Provide a mixed species diet that is changed at set intervals to allow for a variety of additional physical and physiological measurements.

METHODS

Prior to this study the three sub-adult Steller sea lions at the Alaska SeaLife Center were maintained on a diet of Pacific herring (*Clupea harengus*). Three different diet regimes were fed over a period of 1 year, with each sea lion maintained on each regime for a period of 4 months. Each diet regime was estimated to follow as close as possible the diet found in wild sea lions under differing conditions. Wild sea lions have responded differently to each diet regime. At the beginning of this study and at the end of each 4-month regime, each sea lion was thoroughly tested for basic condition indices. Morphometric measurements including standard length, girth and weight were taken weekly. General health of the animals was monitored through monthly blood samples.

The three sea lions underwent a short fasting period preceding introduction to each diet shift. One of the females (Sugar) was used as the subject of a two-week fast conducted as a separate experiment. The other female (Kiska) and the male (Woody) were subjected to a fast for a shorter period and all three animals were switched to the first diet regime. The first diet regime was designed to mimic as close as possible the diet found by Calkins and Pitcher (1982) in the Kodiak area in the 1970's prior to what was generally accepted as the beginning of the decline in that area (Table 37). The animals remained on this diet for a period of 4 months. At the end of the period, the diet was switched to the species composition found in the Kodiak area after the decline began (Calkins and Goodwin 1988). This diet was also maintained for a period of 4 months. At 8 months into the experiment, the diet was switched to that found in Southeast Alaska where the population is stable to increasing (Calkins et al 1999; Trites and Calkins in press). During the second year the 4-month periods are to be repeated in different seasons. The experiment will continue for a third year so that each feeding regime will be fed to each animal through an entire year to eliminate seasonal effects.

At the beginning of the experiment and at the end of each 4-month regime, a complete physical work-up was conducted which included:

- Body measurements - Standard length, axillary girth, mass, blubber depth (portable Scanprobe Ultrasound)
- Total fat mass to lean body mass ratio estimate- deuterium dilution and BIA
- Standard blood chemistry

The physical parameters will then be compared to standard values and between regimes to determine the effects of each feeding regime.

The diet regime feeding schedules for each individual sea lion for the first year of the experiment is shown in Table 38. The period of feeding for all three regimes totaled 118 days each. Sugar began on her first diet regime approximately 11 weeks later than the others to accommodate a previous experiment.

Diet species were procured frozen whole from commercial sources for the experiment with the exception of pollock (*Theragra chalcogramma*). Much of the pollock were caught, frozen in the round, and donated to the ASLC by American Seafoods. Each day a weighed proportion by species was fed to the sea lions, usually in three to five separate feeding bouts depending on training requirements. In addition, fork length of pollock fed to sea lions was measured daily. Each food species was fed according to the proportions in Table 37 for each diet regime. Because food is used as a training incentive sea lions were fed until they were satiated or food was withheld for short periods. Adjustments were made by training staff periodically within weeks in order to maintain the proper proportions under these conditions. The sea lions were held in several different locations at the ASLC over the year and feedings took place wherever they happened to be at the time. The male was isolated from the females during approximately March through October to avoid the possibility of impregnation.

Body composition was estimated at the beginning and end of each feeding trial for each sea lion using the deuterium oxide dilution method. On the day of the measurements, a dose of 99.9 gm% sterile, deuterated water was prepared for injection. The dose mass was adjusted for the mass of the sea lion and varied between 9 to 15 gm. The dose was drawn into a sterile syringe and weighed. After injection, the syringe was weighed again to determine the actual mass of injected deuterium.

The sea lions were held either in a squeeze cage or were under general anesthesia for additional procedures. A pre-injection background blood sample was collected from the hip vein plexus using percutaneous venipuncture. Approximately 7 ml of blood was collected into a sterile Vacutainer© brand "tiger top" serum tube. Immediately afterwards, the deuterium dose was injected into the muscle near the hip. The animal either then remained on anesthesia for additional work, or was released from the squeeze cage for the equilibration time. The sea lion was weighed on a platform scale either before going into the squeeze cage or when it came out of the cage.

For some sea lions, samples were collected at 1 hr and 2 hr post injection to test for dose equilibration. Detailed tests of equilibration were carried out on the same animals by Dr. L.D. Rea and it was found that sufficient equilibration occurred between 2 to 2.5 hr. At 2 to 2.5 hr, another 7 ml of blood was collected using the same venipuncture methods. After clotting, the blood samples were spun in a clinical centrifuge to separate the serum. The serum was then stored in 1.0 ml aliquots in vapor tight Cryovials© at -80 °C.

For analysis, the samples and an aliquot of the dose were sent to a commercial laboratory (Metabolic Solutions, NH) for analysis of deuterium. The samples were analyzed in triplicate and results sent back for deuterium enrichment. The values for blood deuterium enrichment and dose enrichment were entered into a Quattro-Pro spreadsheet that calculated percent body water by simple dilution equations. Metabolic Solutions recommends that the percent Body Water (% BW) values be adjusted upwards by 4% to correct for known pool distribution limitations in calculating total body water using deuterium dilution. Therefore, % BW was multiplied by 1.04. Using equations defined by Bowen and Iverson (1998) and Arnould et al. (1996), calculations were then made for total body lipid, total body lean tissue, total body percent lipid and total body percent lean tissue.

RESULTS

Food consumption by all three sea lions for the three periods is shown in Table 39 through 47. Rockfish was planned as part of the third period diet but sufficient quantities of rockfish were not available to feed to all three animals during 1999 so we elected to not feed during the experiment. We plan to not feed rockfish to any of the sea lions in the next two years of the study. Although Kiska received 0.1 kg of herring and Sugar received 1.9-kg herring during the second period, no herring was planned to be fed to any of the three sea lions during the second period. The amounts they received were considered insignificant and therefore are not reported in Tables 43 and 46

The results of the deuterium dilution-body composition analysis are shown in Table 48. On diet 1, both Sugar and Woody showed no change in body composition. It is possible that Kiska may have decreased her body fat by 2%, but this could be considered within the accuracy and noise level of the experimental protocol. Therefore, diet 1 did not change the body composition of the animals. During that same time, Woody and Sugar gained mass, but Kiska remained constant. For Woody and Kiska, this experiment began in February of 1999 and concluded in June. For Sugar, the experiment began in April and ended in August. Woody gained mass on diet 2, Kiska appeared to drop a few percent of body fat (from 22 to 19%) while Sugar may have gained a few percent from 26 to 28%. Once again however, these changes are minimal. On this diet, in contrast to diet #1 Kiska lost about 7 kg and Sugar lost about 15 kg. On this diet, the females clearly lost body mass, but may not, on average, changed body composition. Woody gained mass but did not change in body composition.

On diet 3, Woody's body composition again remained constant and Kiska regained the body fat lost on diet #2. The body composition data for Sugar have not yet been analyzed by the ASLC. On this diet, all three sea lions gained mass.

Interestingly, the largest change in body composition for any of the animals came BETWEEN feeding trials. Woody lost considerable body fat from June to July 1999 in the transition stage from the end of diet 1 to the beginning of diet 2. By contrast, Sugar gained a significant amount of body fat between the end of 1 and the beginning of 2 from August to Sept. of 1999.

DISCUSSION

During the first diet period Woody initially increased consumption (Fig. 41) leveled off and then dropped in the eleventh week of the period. During the same time he initially lost mass until about the fourth week when he began gaining and continued to gain mass through the rest of the period. In the second period Woody steadily gained mass through the period while his consumption rate was considerably higher (Fig. 42). During the third period Woody maintained about the same mass with a considerably lower consumption rate than the second period (Fig. 43).

For Woody, both diets 2 and 3 did not impact body composition, but diet 2 stabilized his body growth. Body growth for Woody continued on diet 3. Therefore, none of the diets altered the body composition of the male SSL.

During the first period, Kiska's mass remained relatively constant while consumption rose then decreased somewhat (Fig. 44). In the second period Kiska lost mass (about 7 kg) in spite of substantially increased consumption. In the fifth and seventh weeks of the second diet regime, Kiska's weekly consumption exceeded her body mass (Fig. 45). In the third diet regime period Kiska increased mass, regaining the body fat lost in the second period although her consumption rate was substantially lower than the second period (Fig. 46).

For Kiska, diet 1 had no impact at any level. On diet 2 she may have lost both mass and body fat which she gained back on diet 3. Therefore, for this female SSL, diet 2 was not as nutritious as either 1 or 3. However, the largest gain in body mass was on diet 3.

Sugar showed no significant change in mass during period 1 but her consumption rate increased until the ninth week, dropped precipitously in the tenth week and rose in the eleventh and twelfth weeks, then declined slowly for the rest of the period (Fig. 47). In the second period Sugar's consumption immediately rose sharply through the seventh week, leveled off then dropped in the thirteenth and fourteenth weeks then rose in the fifteenth week, leveling off for the rest of the period (Fig. 48). During the second period Sugar's mass remained nearly the same.

Sugar's consumption dropped steadily from the beginning of the third period until the seventh week then rose and leveled off in the ninth week. Her mass fluctuated slightly over the period but did not change significantly (Fig. 49).

Figures 50-52 show the full first year of the feeding regime trials with the mass, food consumption and the deuterium dilution test dates. Deuterium dilution test dates did not always coincide with the projected start or end dates of the three feeding regime diet periods. Therefore, mass gain or loss may have appeared different between the mass recorded with the specific dates of the Deuterium dilution experiments and the average weekly mass shown in Figures 41 through 49.

At this point in the experiment we have finished the first year and compiled some of the data collected. It is important to avoid drawing broad conclusions based on this data. The sea lion's responses to shifting diet regimes cannot be conclusively explained until seasonal effects have been eliminated and the data are compiled for the entire experiment. For instance weight loss by Woody in June between the first and second diet regime period might reflect breeding season effects. It is impossible to fully determine or explain any differences in mass gain or loss or changes in body condition until the experiment is complete. The authors wish to caution users of this report to avoid drawing possible erroneous conclusions based on incomplete information in this report.

In year 1, the design of the experiment we tested three diets, but could not address seasonal impacts on sea lion food requirements and metabolism. By continuing the feeding trials in years 2 and 3, seasonal changes in metabolic responses to these different diets will be tested. On these limited bases, it appears that the sea lions responded to differing diets mostly by altering the amount of prey consumed. Body mass increased in some cases and decreased in others. Body composition remained remarkably stable throughout year one and may reflect defense of metabolic status by the animals despite differing diets.

In any case, it was clear that feeding trials must be long term and must compensate for differing seasons and sexes of the animals. Also, the animals remained clinically healthy and behaviorally normal on all diets.

CITATIONS

Arnould, J. P. Y., I. L. Boyd, and J. R. Speakman. 1996. Measuring the body composition of Antarctic fur seals (Arctpcephalus gazella): validation of hydrogen isotope dilution. Physiol. Zool. 69:93-116.

Bowen, W. D. and S. J. Iverson. 1998. Estimation of total body water in pinnipeds using hydrogen-isotope dilution. Physiol. Zool. 71:329-332

Calkins, D. G. 1985. Steller sea lion pup counts in and adjacent to Shelikof Strait. Final report submitted to North Pacific Fisheries Management Council, contract 84-1. Alaska Dept of Fish and Game, Anchorage. 13 pp.

Calkins, D. G. and K. W. Pitcher. 1982. Population assessment, ecology and trophic relationships of Steller sea Lions in the Gulf of Alaska. Pages

Calkins D. G. and E. Goodwin. 1988. Investigation of the declining sea lion population in the Gulf of Alaska. Unpublished Report, National Marine Mammal Laboratory contract NA-ABH-00029. Available from Alaska Dept. of Fish and Game, 333 Raspberry Road, Anchorage, AK 99518. 76pp.

Calkins, D. G., D. C. McAllister, K. W. Pitcher and G. W. Pendleton. 1999. Steller sea lion status and trend in southeastern Alaska. Mar. Mamm. Sci. 15(2):462-277

Calkins, D. G., E. F. Becker, and K. W. Pitcher. 1998. Reduced body size of female Steller sea lions from a declining population in the Gulf of Alaska. Mar. Mamm. Sci. 12(2):232-244.

Merrick, R. L. 1995. The relationship of the foraging ecology of Steller sea lions Eumetopias jubatus) to their population declining Alaska. Ph. D thesis, Univ. of Wash., Seattle WA. 175pp.

NMFS. 1992. Recovery plan for the Steller sea Lion (Eumetopias jubatus). Prepared by the Steller Sea Lion Recovery Team for the National Marine Fisheries Service, Silver Springs MD. 92pp.

NMFS. 1995. Status review of the United States Steller sea lion (Eumetopias jubatus) population. Prepared by National Marine Mammal Laboratory, NMFS, Seattle, WA. 92 pp.

Pitcher, K. W. 1981. Prey of the Steller sea lion Eumetopias jubatus, in the Gulf of Alaska. Fishery Bulletin. US. 79:467-472.

Rosen, D. A. S. and Andrew W. Trites. 1999. Metabolic effects of low-energy diet on Steller sea lions, Eumetopias jubatus. Physiol. and Biochem. Zool. 72(6).

York A. 1994. The population dynamics of northern sea lions, 1976 - 85. Mar Mamm. Sci. 10:38-51.

Table 37.--Annual feeding regime cycle for Steller sea lions at the Alaska SeaLife Center.

FEEDING REGIME 1		FEEDING REGIME 2		FEEDING REGIME 3	
SPECIES	%[a]	SPECIES	%[a]	SPECIES	%[c]
Pollock	56	Pollock	45	Pollock	28
Herring	14	Octopus	25	Pacific cod	15
Squid	12	Flatfish	25	Salmon	14
Capelin	8	Sand lance	5[b]	Flatfish	13
Pacific cod	6	Pacific cod		Herring	10
Salmon	4	Salmon		Rockfish	7
				Cephalopods	4

[a] Percentages of diet were estimated from Calkins and Pitcher (1982) for feeding regime 1 and Calkins and Goodwin (1988) for feeding regime 2. Percentages fed were by weight and were estimated by adding the percent volume and percent frequency of occurrence reported. The sum of all six percent weights and frequency of occurrences was then used to calculate the percent weight to be fed.

[b] Sand lance, Pacific cod and salmon comprised 5% of the diet in total to be fed at the discretion of the trainers but fed in equal portion over a week period.

[c] Feeding regime 3 was estimated from scat samples collected in Southeastern Alaska (Trites and Calkins in press).

Table 38.--Feeding schedule for diet regimes for three captive sea lions at the Alaska SeaLife Center, February 1, 1999 through April 23, 2000.

SEA LION	DIET 1	DIET 2	DIET 3
Woody (male)	Feb. 1, 1999 to May 30, 1999	Jul. 19, 1999 to Nov. 14, 1999	Nov. 22, 1999 to Mar. 18, 2000
Kiska (female)	Feb. 1, 1999 to May 30, 1999	Jul. 19, 1999 to Nov. 14, 1999	Nov 22, 1999 to Mar. 18, 1999
Sugar (female)	Apr. 22, 1999 to Aug 8, 1999	Aug 30, 1999 to Dec 26, 1999	Dec 27, 1999 to Apr 23, 2000

Table 39. Weekly totals of food in kilograms consumed by Woody during feeding regime diet 1 at the Alaska SeaLife Center, Feb. 1 through May 30, 1999.

Weeks		Amount consumed							Total Intake
Julian	Expt.	Pollock	Herring	Squids	Capelin	Pacific cod	Octopus	Rockfish	
5	1	99.5	24.3	2.7	5.7	0.0	0.0	0.0	132.2
6	2	149.6	0.0	10.3	0.0	0.0	0.0	0.0	159.9
7	3	149.1	0.0	15.0	0.0	0.0	0.0	0.0	164.1
8	4	152.6	14.7	0.0	0.0	0.0	0.0	0.0	167.3
9	5	155.5	16.3	0.0	0.0	0.0	0.0	0.0	171.8
10	6	153.7	16.1	0.0	0.0	0.0	0.0	0.0	169.8
11	7	151.6	13.9	0.0	0.0	0.0	0.0	0.0	165.5
12	8	153.3	15.7	0.0	0.0	0.0	0.0	0.0	169.0
13	9	152.1	14.0	0.0	0.0	0.0	0.0	0.0	166.1
14	10	152.8	13.6	0.0	0.0	0.0	0.0	0.0	166.4
15	11	86.5	17.9	8.9	28.5	23.6	0.0	0.0	165.4
16	12	0.0	7.0	20.1	106.5	0.0	0.0	0.0	133.6
17	13	0.0	0.0	22.4	98.0	0.0	0.0	0.0	120.4
18	14	0.0	0.0	20.0	60.0	0.0	40.2	115.0	235.2
19	15	4.1	15.3	7.8	0.0	0.0	99.6	0.0	126.8
20	16	0.0	95.5	0.0	1.0	1.0	15.0	0.0	112.5
21	17	0.0	101.7	0.0	0.0	0.0	0.0	0.0	101.7
Period Totals		1560.4	366.0	107.2	299.7	24.6	154.8	115.0	2627.6

Table 40. Weekly totals of food in kilograms consumed by Woody during feeding regime diet 2 at the Alaska SeaLife Center, July 19 through Nov. 14, 1999.

Weeks		Amount consumed								Total Intake
Julian	Expt. period	Pollock	Squids	Pacific cod	Salmon	Flatfish	Sandlance	Octopus	Rockfish	
29	1	88.5	1.6	8.8	0.0	44.5	0.0	77.3		220.7
30	2	117.8	1.4	8.9	0.0	66.0	0.0	58.0		252.0
31	3	96.3	0.0	6.8	0.0	58.7	0.0	54.7		216.5
32	4	94.3	2.0	11.3	0.0	52.8	0.0	60.3		220.7
33	5	103.1	0.0	11.3	0.0	55.7	0.0	65.5		235.6
34	6	106.1	0.0	11.7	0.0	56.1	0.0	55.7		229.6
35	7	125.0	0.0	14.4	0.0	57.9	0.0	60.4		257.7
36	8	121.6	0.0	15.5	0.0	58.1	0.0	63.6		258.9
37	9	117.2	0.0	14.3	0.0	59.5	0.0	63.0		254.0
38	10	74.3	0.0	0.0	0.0	68.0	15.3	87.5		245.1
39	11	173.1	0.0	0.0	0.0	0.0	14.2	48.6		235.9
40	12	98.2	0.0	0.0	0.0	56.7	16.5	56.5		227.9
41	13	99.5	0.0	0.0	0.0	54.1	16.0	75.0		244.6
42	14	166.4	0.0	0.0	0.0	0.0	16.0	65.5		247.9
43	15	160.8	0.0	0.0	0.0	0.0	17.0	54.0		231.8
44	16	96.9	0.0	0.0	20.4	0.0	21.0	59.5	12.1	197.8
45	17	89.6	0.0	0.0	60.7	25.4	0.0	59.5	12.1	235.6
Period Totals		1840.1	3.4	94.2	81.1	669.0	116.0	987.3	24.2	3791.5

Table 41. Weekly totals of food in kilograms consumed by Woody during feeding regime diet 3 at the Alaska SeaLife Center, Nov. 22, 1999 through Mar. 18, 2000.

Weeks		Amount consumed									Total
Julian	Expt.	Pollock	Herring	Squids	Pacific cod	Salmon	Flatfish	Sandlance	Octopus	Rockfish	Intake
47	1	58.4	27.6	0.0	25.6	1.5	24.7	10.3	16.5	0.0	164.6
48	2	51.0	26.7	0.0	29.2	8.6	24.8	15.6	17.0	0.0	172.9
49	3	54.2	28.8	0.0	26.6	8.8	26.3	18.5	20.0	0.0	183.2
50	4	45.9	23.3	7.5	18.2	11.5	28.3	17.4	24.5	0.0	176.6
51	5	44.4	24.3	6.5	36.8	9.1	27.9	23.1	22.5	0.0	194.6
52	6	58.2	26.7	7.5	27.4	10.9	17.8	18.3	21.0	0.0	187.8
1	7	33.8	14.8	0.8	20.0	18.8	32.5	4.1	0.0	0.0	124.8
2	8	48.8	31.9	0.0	0.0	66.5	2.2	0.0	0.0	0.0	149.4
3	9	39.5	30.5	0.0	0.0	45.3	3.0	0.0	0.0	0.0	118.3
4	10	23.9	26.0	0.0	25.5	49.6	2.9	0.0	0.0	0.0	127.9
5	11	37.8	10.2	0.0	30.8	50.6	2.8	0.0	0.0	0.0	132.2
6	12	38.2	19.5	0.0	25.2	21.3	22.0	0.0	12.0	0.0	138.2
7	13	33.7	14.0	0.0	23.8	15.1	25.4	12.5	0.0	0.0	124.5
8	14	45.8	14.7	3.8	23.3	14.2	20.5	24.2	0.0	0.0	146.4
9	15	44.6	17.4	0.0	20.5	12.2	19.9	26.5	0.0	0.0	141.1
10	16	58.5	15.5	0.0	27.8	15.0	20.7	26.4	0.0	0.0	163.9
11	17	60.4	8.5	0.0	24.2	14.0	28.4	15.1	0.0	0.0	150.6
Period Totals		777.1	360.4	26.1	384.9	373.0	330.1	211.9	133.5	0.0	2596.

Table 42. Weekly totals of food in kilograms consumed by Kiska during feeding regime diet 1 at the Alaska SeaLife Center, Feb. 1 through May 30, 1999.

Weeks		Amount consumed							Total
Julian	Expt.	Pollock	Herring	Squid	Capelin	Pacific	Octopus	Rockfish	Intake
6	2	69.2	5.8	0.0	0.0	0.0	0.0	0.0	75.0
7	3	73.5	10.0	0.0	0.0	0.0	0.0	0.0	83.4
8	4	79.2	9.9	0.0	0.0	0.0	0.0	0.0	89.1
9	5	77.4	10.4	0.0	0.0	0.0	0.0	0.0	87.8
10	6	78.4	10.8	0.0	0.0	0.0	0.0	0.0	89.2
11	7	78.6	10.6	0.0	0.0	0.0	0.0	0.0	89.2
12	8	84.1	10.7	0.0	0.0	0.0	0.0	0.0	94.8
13	9	76.8	9.3	0.0	0.0	0.0	0.0	0.0	86.1
14	10	79.4	9.0	0.0	0.0	0.0	0.0	0.0	88.4
15	11	27.9	8.2	4.6	18.5	13.6	0.0	0.0	72.8
16	12	0.0	4.8	13.4	37.4	0.0	0.0	0.0	55.5
17	13	0.0	0.0	17.0	57.2	0.0	0.0	0.0	74.2
18	14	0.0	0.1	11.5	26.3	0.0	9.0	0.0	46.9
19	15	0.0	13.5	1.5	0.0	0.0	66.1	0.0	81.1
20	16	0.0	48.2	0.0	0.0	0.0	10.3	0.0	58.5
21	17	5.0	41.7	0.0	0.0	0.0	0.0	0.0	46.7
Period Totals		729.5	202.9	48.0	139.4	13.6	85.4	0.0	1218.6

Table 43. Weekly totals of food in kilograms consumed by kiska during feeding regime diet 2 at the Alaska SeaLife Center, July 19, through Nov. 14, 1999.

Weeks		Amount consumed								Total
Julian	Expt.	Pollock	Squids	Pacific cod	Salmon	Flatfish	Sandlance	Octopus	Rockfish	Intake
31	3	57.7	0.8	5.2	0.0	32.2	0.0	34.1	0.0	130.1
32	4	62.7	1.2	6.5	0.0	32.0	0.0	50.4	0.0	152.8
33	5	68.6	0.0	8.2	0.0	42.4	0.0	43.1	0.0	162.3
34	6	81.3	0.0	8.9	0.0	38.9	0.0	40.2	0.0	170.7
35	7	69.3	0.0	3.6	0.0	40.7	0.0	38.6	0.0	152.2
36	8	77.9	0.0	11.6	0.0	42.4	0.0	46.4	0.0	178.3
37	9	76.1	0.0	12.4	0.0	36.9	0.0	29.8	0.0	155.2
38	10	60.3	0.0	0.0	0.0	23.0	10.0	15.1	0.0	108.4
39	11	90.0	0.0	0.0	0.0	0.0	9.6	26.8	0.0	126.4
40	12	47.5	0.0	11.5	0.0	3.2	4.6	17.7	0.0	84.5
41	13	56.1	0.0	0.0	0.0	27.5	6.7	30.0	0.0	120.3
42	14	82.0	0.0	0.0	0.0	0.0	6.4	42.0	0.0	130.4
43	15	86.3	0.0	0.0	0.0	0.0	7.2	39.7	0.0	133.2
44	16	65.9	0.0	0.0	11.8	0	17.5	37.5	0.0	132.7
Period Totals		981.6	2.0	67.9	11.8	319.2	62.0	491.4	0	1937.4

Table 44. Weekly totals of food in kilograms consumed by Kiska during feeding regime diet 3 at the Alaska Sealife Center,Nov. 22 through Mar. 18, 2000.

Weeks		Amount consumed									Total
Julian	Expt.	Pollock	Herring	Squid	Pacific	Salmon	Flatfish	Sandlance	Octopus	Rockfish	Intake
47	1	22.7	14.6	0.0	0.0	0.0	6.1	9.1	8.0	0.0	60.5
48	2	44.3	15.3	0.0	15.0	3.6	7.1	11.8	11.5	0.0	108.5
49	3	32.3	16.6	0.0	18.1	4.3	12.4	12.1	10.5	0.0	106.3
50	4	3.0	1.2	0.0	0.0	4.3	5.5	6.3	2.0	0.0	22.2
51	5	30.7	17.6	0.0	0.0	4.2	1.7	19.7	13.2	0.0	87.1
52	6	36.3	15.9	2.2	16.3	4.8	8.8	11.3	11.0	0.0	106.6
1	7	24.1	12.0	0.0	4.5	7.0	25.5	10.7	0.0	0.0	83.8
2	8	28.0	17.9	0.0	0.0	49.1	1.6	0.0	0.0	0.0	96.6
3	9	30.8	21.1	0.0	0.0	36.3	2.1	0.0	0.0	0.0	90.3
4	10	11.1	12.7	0.0	8.2	35.0	2.0	0.0	0.0	0.0	68.9
5	11	21.9	9.8	0.0	9.2	29.3	2.4	0.0	0.0	0.0	72.6
6	12	22.8	9.9	0.0	1.7	11.3	10.2	0.0	10.0	0.0	65.8
7	13	18.6	10.1	0.0	3.0	7.0	15.1	9.6	0.0	0.0	63.4
8	14	19.5	7.0	0.0	11.4	4.7	5.5	5.9	0.0	0.0	53.9
9	15	25.9	7.1	0.0	7.2	3.8	8.5	13.0	0.0	0.0	65.5
10	16	23.0	7.9	0.0	9.6	5.6	9.9	0.3	0.0	0.0	56.3
11	17	17.0	6.2	0.0	3.9	3.0	3.7	6.0	0.0	0.0	39.8
Period Totals		412.0	202.7	2.2	108.0	213.3	128.1	115.6	66.2	0	1247.9

Table 45. Weekly totals of food in kilograms consumed by Sugar during feeding regime diet 1 at the Alaska SeaLife Center, Apr. 22 through Aug. 8, 1999.

Weeks		Amount consumed							Total
Julian	Expt. period	Pollock	Herring	Squids	Capelin	Pacific cod	Octopus	Rockfish	Intake
16	1	55.4	7.3	0.0	0.0	0.0	0.0	0.0	62.7
17	2	54.3	0.0	0.0	0.0	0.0	0.0	0.0	54.3
18	3	53.1	11.7	0.0	0.0	0.0	0.0	0.0	64.8
19	4	57.6	11.0	0.0	0.0	0.0	0.0	0.0	68.6
20	5	65.3	10.5	0.0	0.0	0.0	1.5	0.0	77.3
21	6	67.1	10.5	0.0	0.0	0.0	0.0	0.0	77.6
22	7	73.4	10.5	0.0	0.0	0.0	0.0	0.0	83.9
23	8	73.6	10.0	0.0	0.0	0.0	0.0	0.0	83.6
24	9	73.6	17.5	0.0	0.0	0.0	0.0	0.0	91.1
25	10	34.4	6.5	0.0	0.0	0.0	0.0	0.0	40.9
26	11	46.5	14.3	0.0	0.0	0.0	0.0	0.0	60.8
27	12	40.8	8.6	2.5	27.7	3.7	0.0	0.0	83.3
28	13	4.0	1.5	7.1	58.7	6.4	0.0	0.0	77.7
29	14	0.3	8.7	24.6	32.6	1.6	17.2	0.0	85.0
30	15	0.4	6.3	22.1	2.2	0.0	45.6	0.0	76.6
31	16	0.0	47.1	10.6	0.0	0.0	11.1	0.0	68.8
32	17	2.7	53.7	7.6	0.0	0.0	0.0	0.0	64.0
Period Totals		702.5	235.6	74.5	121.2	11.7	75.4	0.0	1220.9

Table 46. Weekly totals of food in kilograms consumed by Sugar during feeding regime diet 2 at the Alaska SeaLife Center, Aug. 30 through Dec. 26, 1999.

Weeks		Amount consumed								Total
Julian	Expt. period	Pollock	Squids	Pacific cod	Salmon	Flatfish	Sandlance	Octopus	Rockish	Intake
35	1	30.4	0.3	2.6	0.0	9.9	0.0	9.5	0.0	52.7
36	2	39.1	1.0	5.9	0.0	18.6	0.0	28.7	0.0	93.3
37	3	52.1	1.0	4.2	0.0	19.6	0.0	25.6	0.0	102.5
38	4	42.9	1.1	7.7	0.0	27.1	0.0	33.3	0.0	112.1
39	5	81.5	1.4	4.5	0.0	0.0	0.0	20.7	0.0	108.1
40	6	57.0	1.1	6.4	0.0	28.6	0.0	29.0	0.0	122.1
41	7	58.5	0.0	5.1	0.0	34.7	0.0	38.0	0.0	136.3
42	8	91.1	0.0	6.2	0.0	0.0	0.0	37.2	0.0	134.5
43	9	89.8	6.2	0.0	0.0	0.0	0.0	31.6	0.0	127.6
44	10	82.8	0.0	0.0	0.0	0.0	9.0	33.5	0.0	125.3
45	11	93.6	0.0	0.0	0.0	11.4	3.7	17.6	0.0	126.3
46	12	61.1	0.0	2.1	0.0	26.6	8.4	32.4	0.0	130.6
47	13	45.1	0.0	1.5	0.0	16.5	4.3	16.5	0.0	83.8
48	14	32.6	0.0	0.0	0.0	16.4	3.5	20.0	0.0	72.5
49	15	44.0	0.0	0.0	0.0	18.6	6.0	29.0	0.0	97.6
50	16	40.4	0.0	0.0	5.7	17.8	2.7	30.0	0.0	96.6
51	17	41.3	0.0	0.0	19.1	12.3	0.0	25.0	0.0	97.7
Period Totals		983.2	12.1	46.2	24.8	258.1	37.6	457.6	0.0	1819.4

Table 47. Weekly totals of food in kilograms consumed by Sugar during feeding regime diet 3 at the Alaska Sealife Center, Dec. 27, 1999 through Apr. 23, 2000.

Weeks		Amount consumed									Total
Julian	Expt.	Pollock	Herring	Squids	Pacific cod	Salmon	Flatfish	Sandlance	Octopus	Rockfish	Intake
52	1	42.0	16.3	0.0	19.3	6.1	11.9	11.8	12.0	0.0	119.4
1	2	30.9	16.8	0.0	20.0	4.4	18.9	12.0	10.3	0.0	113.3
2	3	28.6	16.1	4.4	0.0	6.9	13.7	4.3	5.5	0.0	79.5
3	4	29.4	22.5	3.9	0.0	15.5	15.4	0.0	9.0	0.0	95.7
4	5	17.1	13.7	1.7	6.5	4.9	14.5	0.0	0.0	0.0	58.4
5	6	17.0	12.0	4.0	12.3	5.1	13.4	0.0	0.0	0.0	63.7
6	7	18.4	4.6	0.0	3.3	5.0	9.7	0.0	0.0	0.0	41.0
7	8	9.1	6.8	0.0	11.1	11.9	1.6	6.4	0.0	0.0	46.8
8	9	17.5	8.7	0.0	11.9	22.5	2.5	7.0	0.0	0.0	70.1
9	10	16.4	7.5	0.0	5.9	27.1	4.2	7.6	0.0	0.0	68.7
10	11	22.1	7.7	0.0	9.8	22.4	1.5	7.8	0.0	0.0	71.3
11	12	23.4	7.3	0.0	13.8	5.7	13.5	5.9	6.0	0.0	75.6
12	13	17.6	9.1	0.0	13.1	2.7	19.5	9.9	0.0	0.0	71.9
13	14	24.0	14.0	0.0	10.8	7.2	12.0	10.9	0.0	0.0	78.9
14	15	23.9	8.9	0.0	13.2	7.8	17.5	10.7	0.0	0.0	82.0
15	16	23.4	9.4	0.0	15.3	6.5	13.4	10.1	0.0	0.0	78.1
16	17	24.6	7.0	0.0	10.6	6.0	11.0	7.7	0.0	0.0	66.9
Period Totals		385.3	188.4	14.0	176.9	167.7	194.2	112.1	42.8	0.0	1281.1

Table 48. Deuterium dilution body composition analysis for three sea lions for the feeding regime diet study at the Alaska SeaLife Center 1999 -2000.

Woody	Pre-trial Nov. 98	Start 1 Feb, 99	End 1 Jun., 99	Start 2 Jul., 99	End 2 Nov., 99	Start 3 Nov, 99	End 3 Jul., 00
Body fat %	14	19	19	13	13	13	13
Lean fat%	86	82	81	87	87	87	87
Mass	285	285	329	304	327	327	349
Kiska	Pre-trial Nov. 98	Start 1 Feb., 99	End1 Jun., 99	Start 2 Jul., 99	End 2 Nov., 99	Start 3 Nov., 99	End 3 Jul., 00
Body fat %	22	27	25	22	19	19	22
Lean fat%	78	73	75	78	81	81	78
Mass	154	165	164	164	157	157	172
Sugar	Pre-trial Dec., 98	Start 1 Apr.,99	End 1 Aug., 99	Start 2 Sep.,99	End 2 Dec., 99	Start 3 Dec., 99	End 3 Apr. 00
Body fat %	19	18	17	26	28	28	*
Lean fat%	81	82	83	74	71	71	*
Mass	144	164	186	186	169	169	187

* data not available at time of report

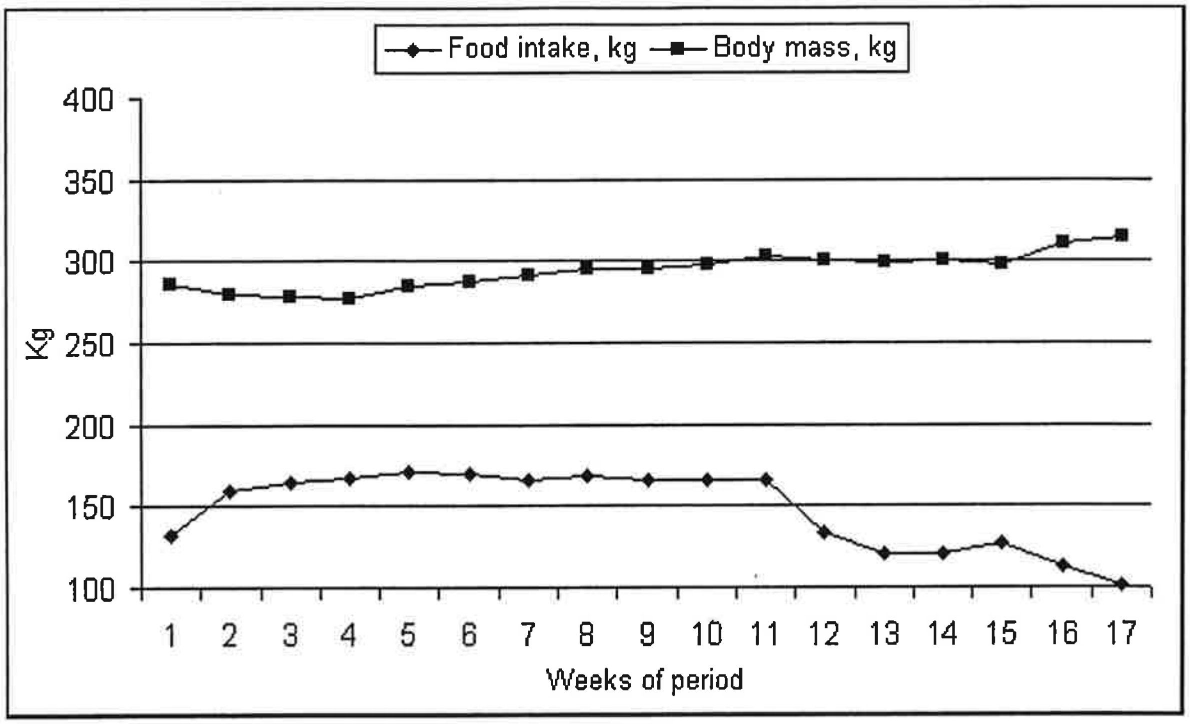

Figure 41. Mass and food consumption for Woody, feeding regime diet 1, Alaska SeaLife Center Feb.1 through May 30, 1999.

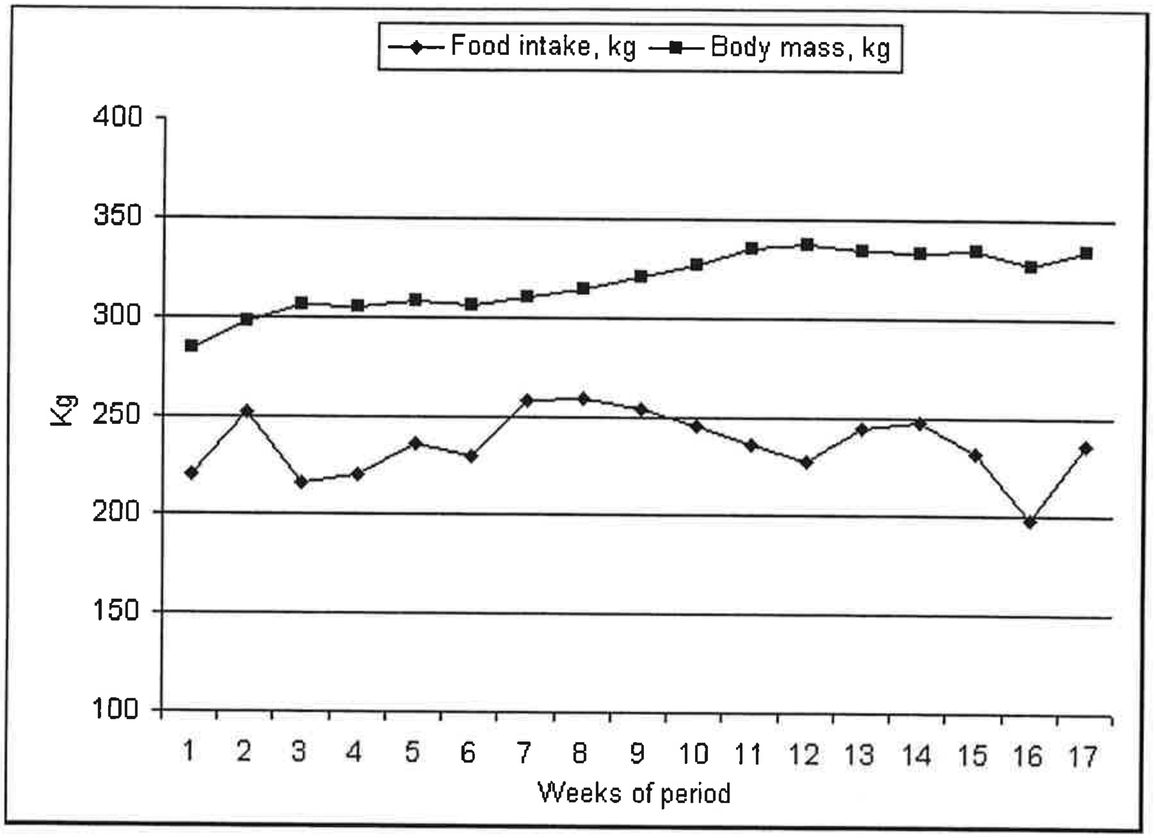

Figure 42. Mass and food consumption for Woody, feeding regime diet 2, Alaska SeaLife Center July 19 through Nov 14, 1999.

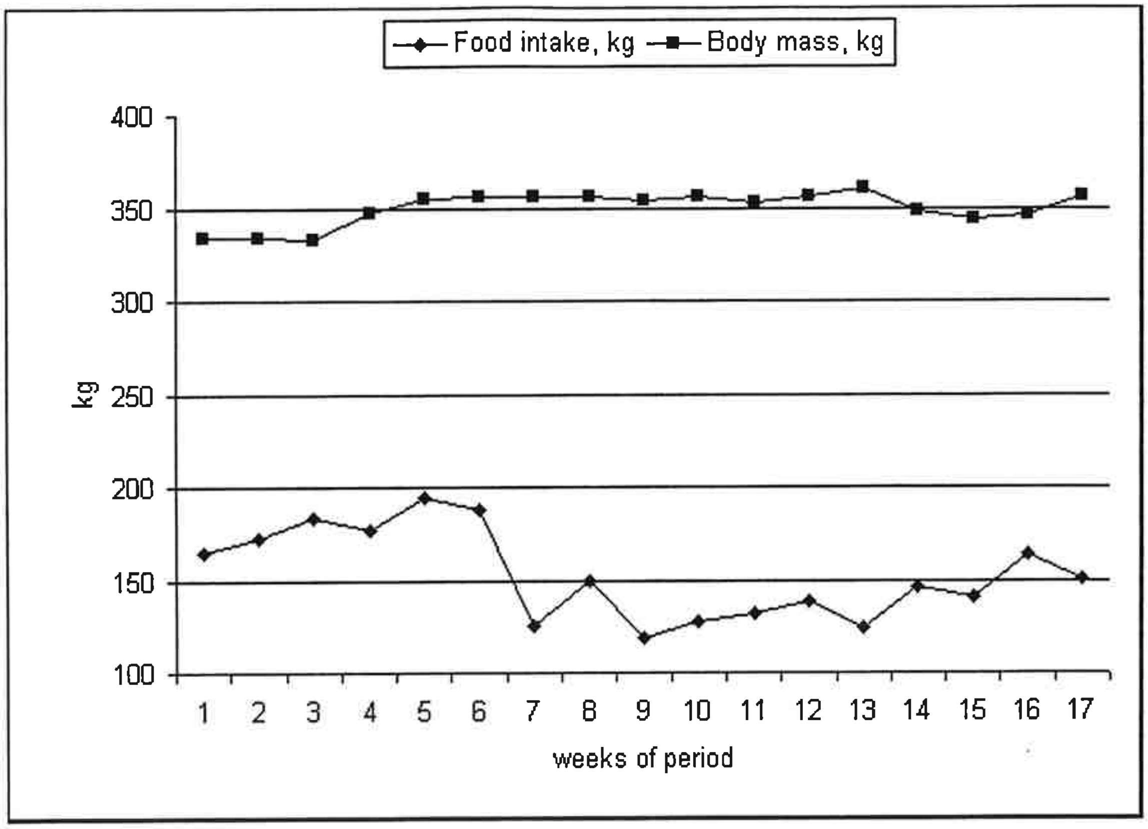

Figure 43. Mass and food consumption for Woody, feeding regime diet 3, Alaska SeaLife Center Nov. 22, 1999 through Mar. 18, 2000.

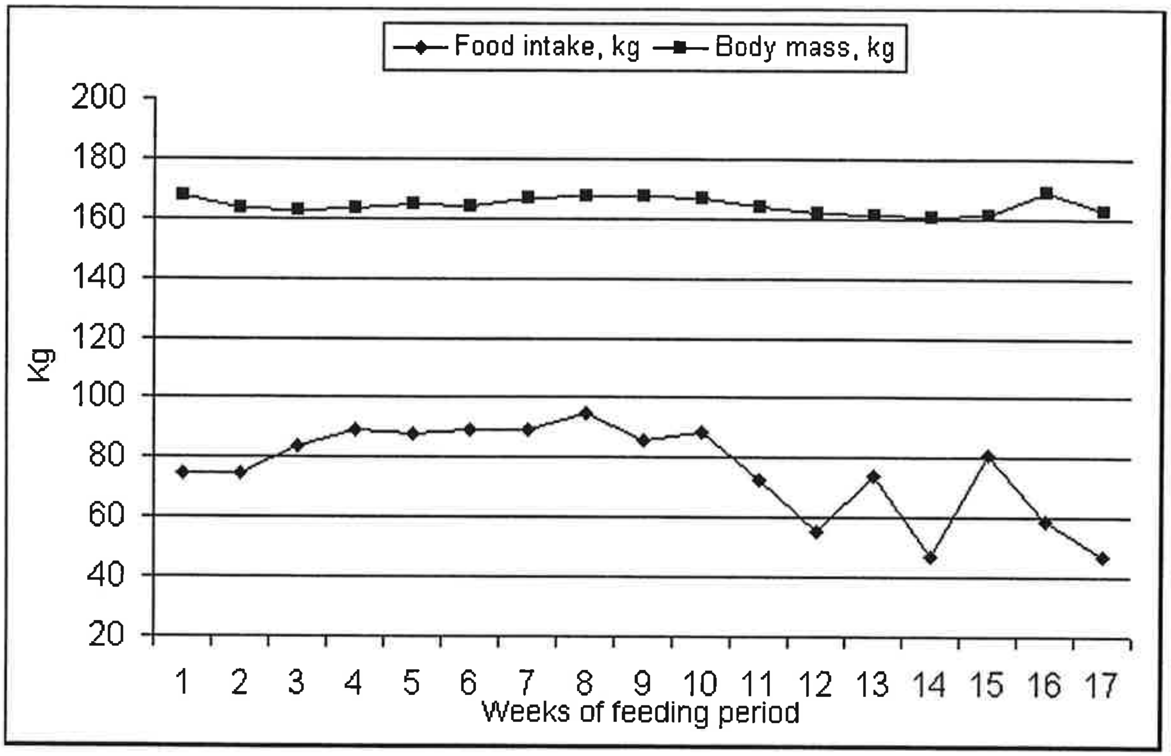

Figure 44. Mass and food consumption for Kiska feeding regime diet 1, Alaska SeaLife Center Feb.1 through May 30, 1999.

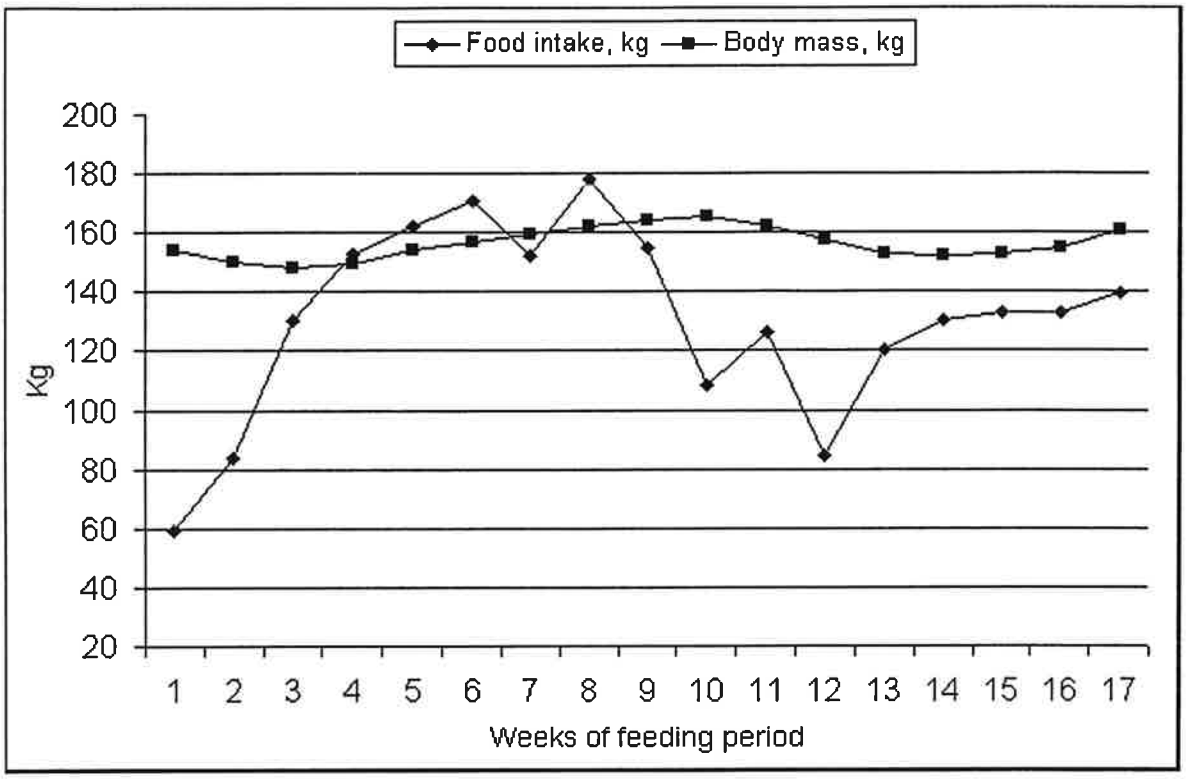

Figure 45. Mass and food consumption for Kiska, feeding regime diet 2, Alaska SeaLife Center July 19 through Nov 14, 1999

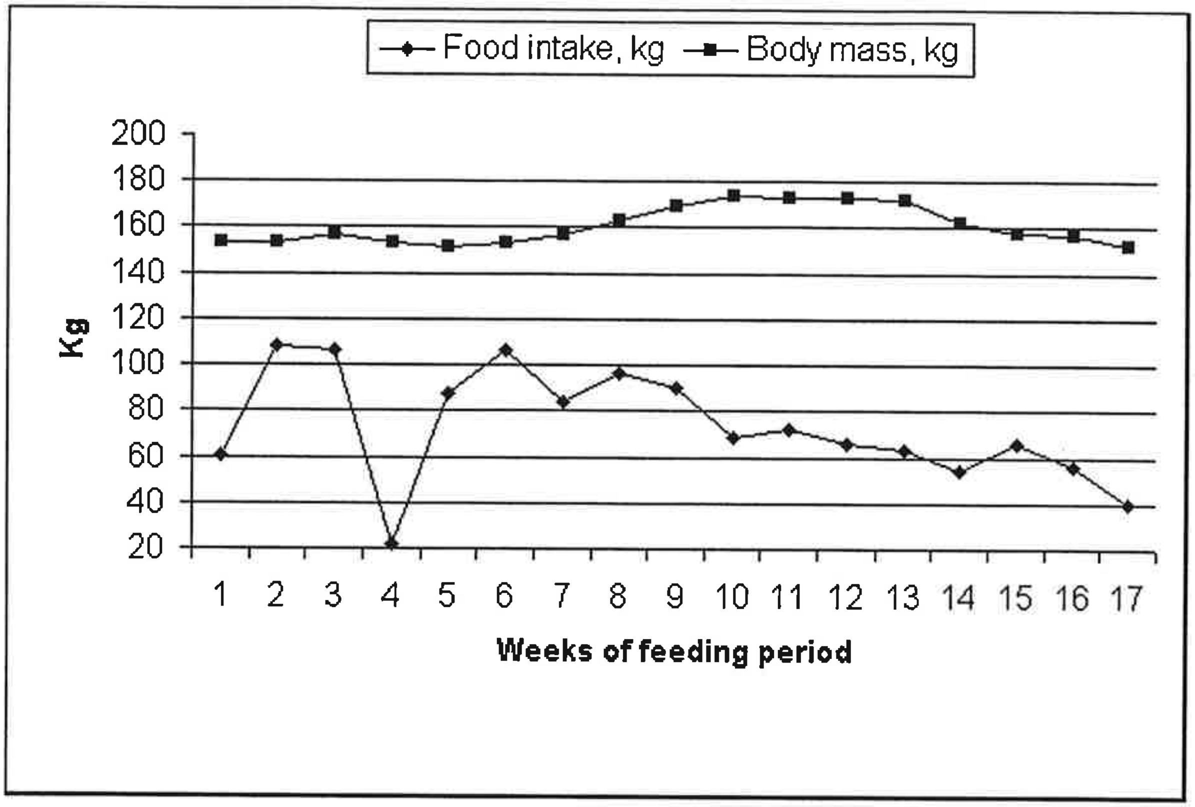

Figure 46. Mass and food consumption for Kiska, feeding regime diet 3, Alaska SeaLife Center Nov. 22,1999 through Mar. 18, 2000.

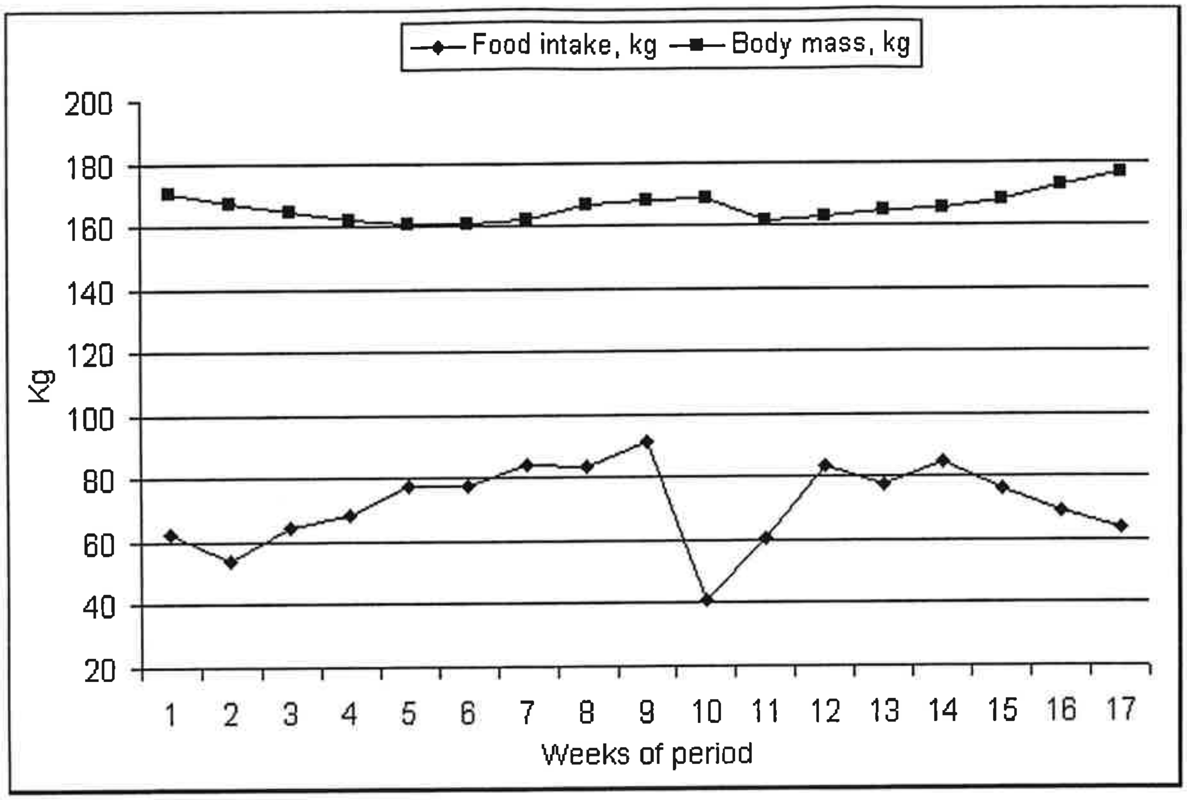

Figure 47. Mass and food consumption for Sugar, feeding regime diet 1, Alaska SeaLife Center Apr. 22 through Aug. 8, 1999.

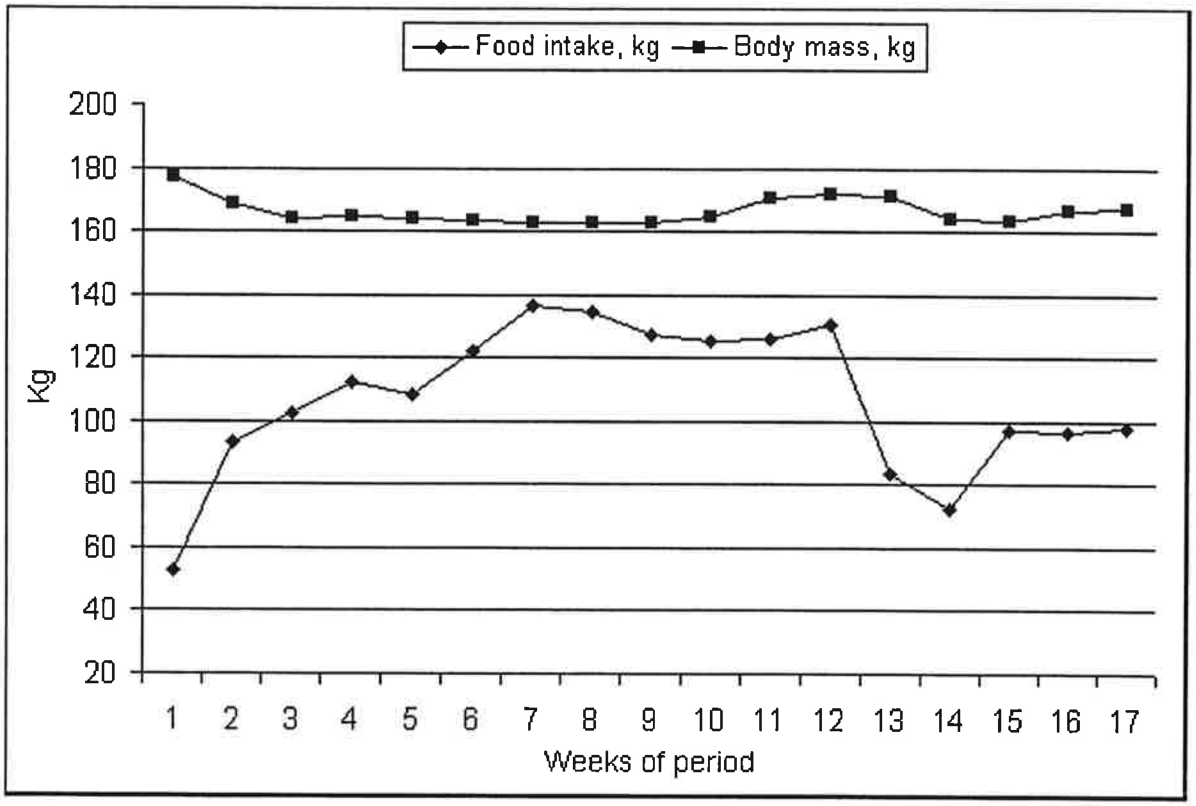

Figure 48. Mass and food consumption for Sugar, feeding regime diet 2, Alaska SeaLife Center Aug. 30, through Dec. 26, 1999.

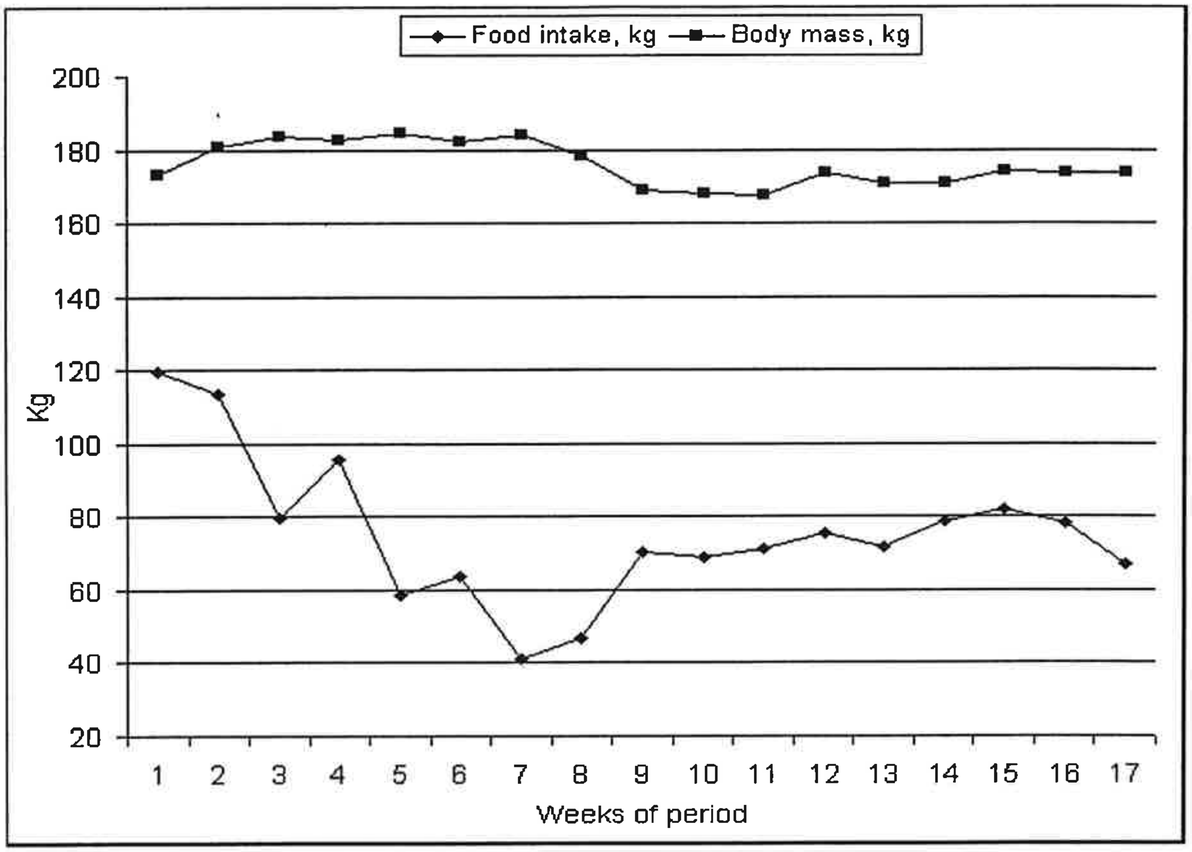

Figure 49. Mass and food consumption for Sugar, feeding regime diet 3, Alaska SeaLife Center Dec.27 1999 through Apr. 23, 2000.

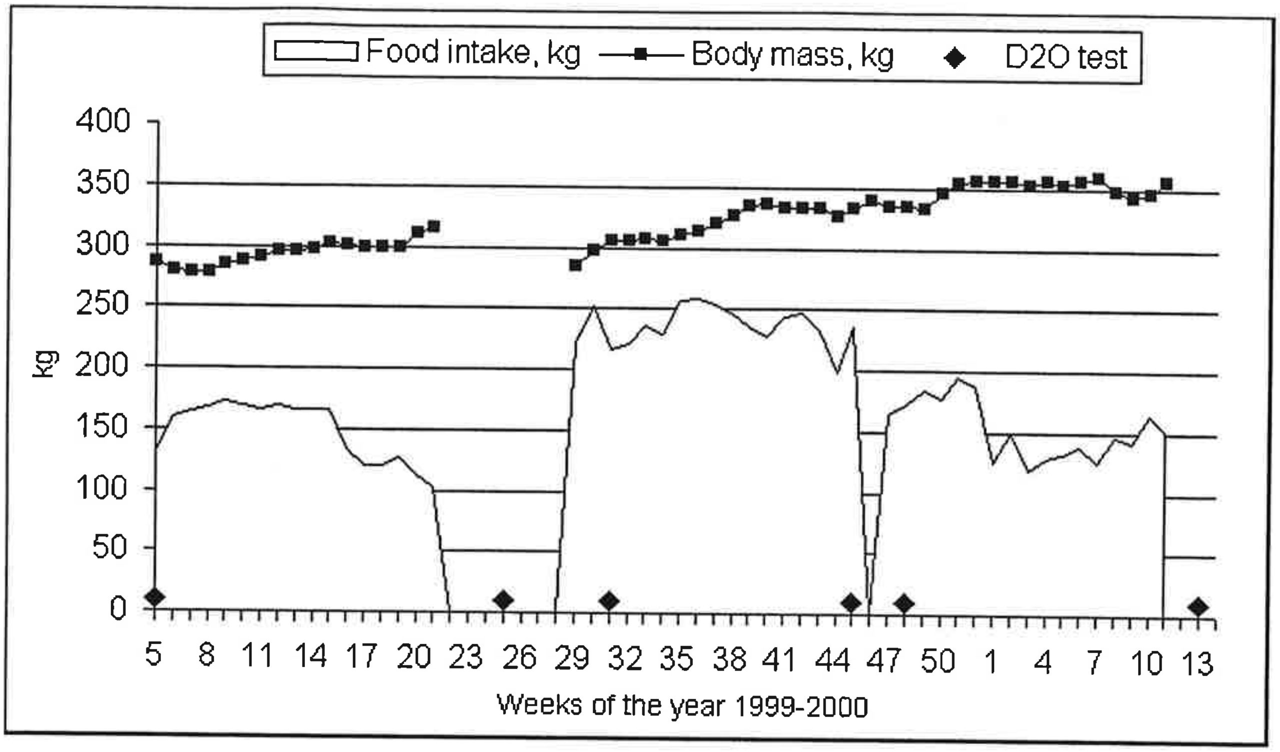

Figure 50. Consumption, mass and D2O test points for Woody for the Feeding Regime experiment at the Alaska Sea Life Center, Feb. 1, 1999 through Mar.18, 2000.

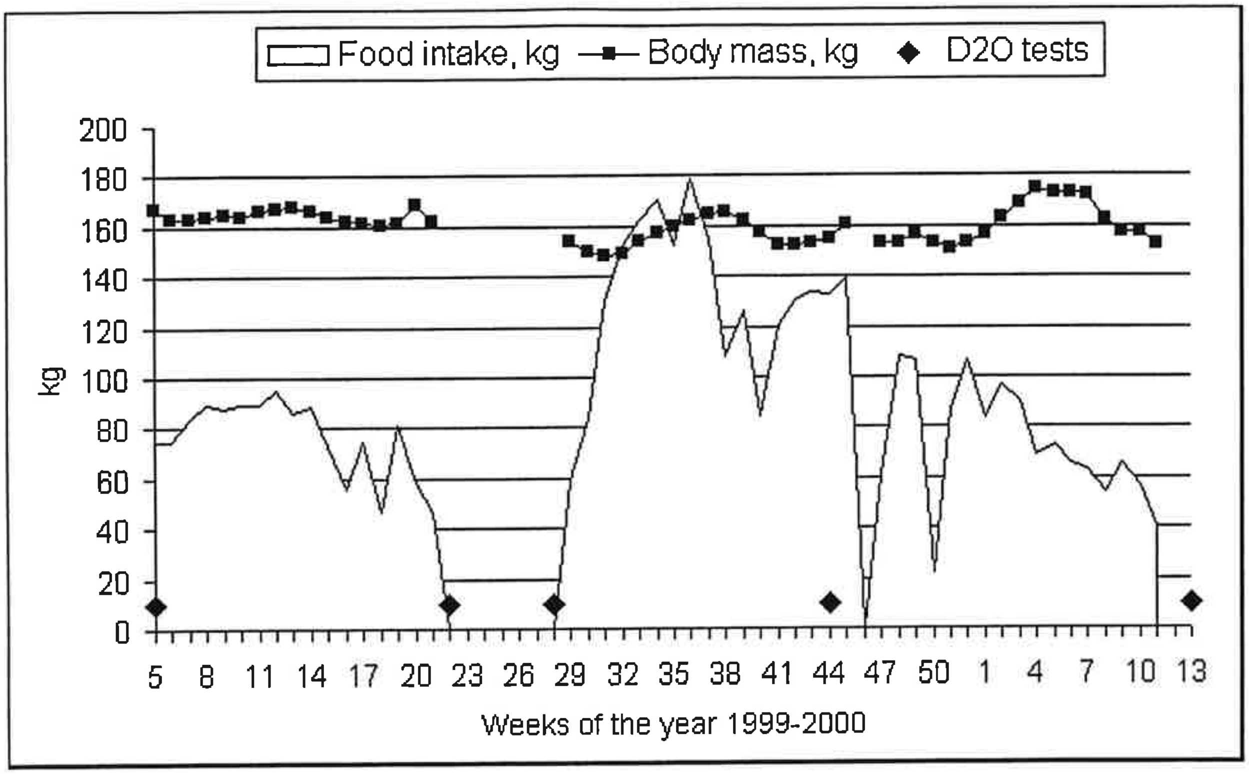

Figure 51. Consumption, mass and D2O test points for Kiska during the Feeding Regime experiment at the Alaska Sea Life Center, Feb. 1, 1999 through Mar.18, 2000.

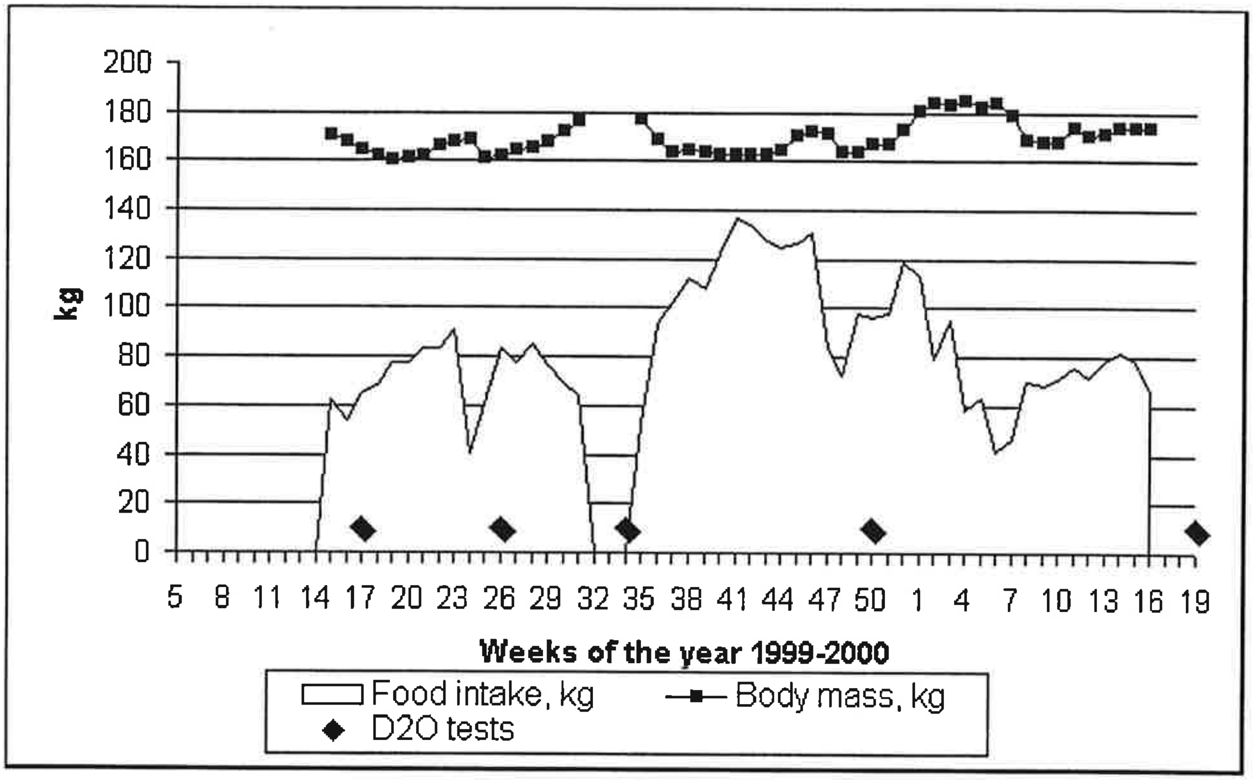

Figure 52. Consumption, mass and D2O test points for Sugar during the Feeding Regime experiment at the Alaska SeaLife Center, Apr. 22, 1999 through April 23, 2000.

APPENDIX I: CONTRIBUTOR PLACEMENT WITHIN ORGANIZATIONAL STRUCTURE OF THE ALASKA FISHERIES SCIENCE CENTER

Page numbers of contributed chapters indicated in parentheses

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- Kathryn Chumbley (31)
- Brian Fadely (1)
- Carolyn Kurle (67)
- Rolf Ream (65)
- John Sease (5, 49)
- Beth Sinclair (65)
- Rod Towell (45)
- Anne York (31, 43)
- Tonya Zeppelin (60)

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- Patience Browne (139)
- Vladimir Burkanov (107, 169, 199)
- Julie Harper (31)

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Resource Ecology and Fisheries Management (REFM) Division
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- Anne Hollowed (89)
- Michiyo Shima (89)
- Sandra Lowe (89)

APPENDIX II: MAP OF BERING SEA, GULF OF ALASKA, AND SEA OF OKHOTSK SHOWING SELECTED LOCATIONS REFERRED TO IN THIS VOLUME