COMPENDIUM OF STELLER SEA LION RELATED RESEARCH, 2000-2006

Final Report

Prepared by:

Thomas R. Loughlin, Ph.D
TRL Wildlife Consulting
17341 NE 34th Street
Redmond, WA 98052
trlwc@comcast.net

and,

Jack V. Tagart, Ph.D.
Tagart Consulting
7247 105th Ave. SW
Olympia, WA 98512
jtagart@aol.com

On behalf of

Chris Oliver, Executive Director
North Pacific Fishery Management Council
605 W. 4th Ave., Suite 306
Anchorage, AK 99501-2817

Contract # 2005-02

June 21, 2006

(This page intentionally left blank)

TABLE OF CONTENTS

I. Introduction

On November 29, 2005, Chris Oliver, on behalf of the North Pacific Fishery Management Council, entered into a contract with Thomas R. Loughlin, TRL Wildlife Consulting, and Jack V. Tagart, Tagart Consulting, for the purpose of constructing a compendium of Steller sea lion (SSL) related research in the North Pacific. The objectives of the project were to: 1) identify all relevant SSL related research conducted from the year 2000 to 2006, including gray literature; 2) compile brief (one to two page) summaries of each research project; and 3) synthesize these various research findings into major (thematic) categories with attendant summary results.

II. Methods

A working bibliography of SSL related research papers published between 2000 and 2006 was compiled from existing summaries of SSL research, through literature search, and by means of personal interviews and correspondence with sea lion researchers. We contacted researchers known to have received SSL funding and solicited copies of papers that were either completed and published, in press or in review. In most cases we obtained a pdf file or paper copy of the published report.

The working bibliography was partitioned into 11 thematic categories (borrowed from the NMFS/AFSC):

1. **Life History -** Investigations of the life history of SSLs, including all aspects of ontogeny (e.g., weaning process, molt, growth) and reproduction. Studies of behavior are included as a sub-theme since the age and sex of the studied individuals are central to their behavior.

2. **Foraging -** Studies of the foraging ecology of juvenile and adult SSLs. This includes all aspects of foraging, including what is eaten (food habits and diet), the costs incurred in locating and obtaining prey (bioenergetics), and differences in habitat use by juveniles and adults (habitat use).

3. **Vital Rates -** All studies related to population assessment (both counting of animals and assessment of their condition), reproductive rates, and survival/mortality rates (e.g. branding studies). Modeling studies, such as the creation of a new life table, would also fall under this theme. Many of these studies supply baseline information necessary to address all of the hypotheses/questions.

4. **Fish Assessment and Fisheries -** Prey or fish surveys, along with any studies of the impacts of fisheries on either large scales (ecosystem-wide) or small spatial/temporal scales.

5. **Ecosystems -** Any study dealing with bottom-up processes in the ocean and how changes in them might affect the prey field for SSLs. There are two sub-themes: large scale (ecosystem-wide) studies and those addressing ecosystem processes at small spatial/temporal scales.

6. **Other Anthropogenic Effects -** Any studies of the effects or quantification of subsistence hunting, intentional shooting, incidental take, or the residual effect of harvests and bounties on the SSL population..

7. **Predation** - Killer whale and shark predation are sub-themes under this general research theme. These would include all studies whose primary focus is addressing questions pertaining to predation as well as killer whale and shark assessment and ecology in Alaska.

8. **Disease** - Studies of sea lion diseases (including parasites) are included in one of two sub-themes, which evaluate the impacts of disease on: 1) individual sea lion health, and 2) the population of sea lions as a whole (population-level assessment).

9. **Contaminants** - Similar to sea lion disease studies, contaminant studies were also placed into one of two sub-themes depending on the scale at which contaminant effects were analyzed: 1) assessment of the effects of contaminants on the health of individuals (individual health assessment), and 2) assessment of the effects of contaminants on sea lion habitats (environmental-level effects), and how this could reduce sea lion survival or births.

10. **Management** - Projects under this theme involve funding for meetings to implement regulations (e.g., NPFMC), for independent reviews of actions, and for analysis of economic impacts of actions. Reviews address the scientific and legal information available and required to answer some or all of the questions posed, while other projects inform decisions made by managers.

11. **Communications** - Communication of ideas and information both among researchers (coordination) and between researchers and the interested public (outreach) are the principal goals of projects under this theme. Forms of communication considered include symposia, publishing of scientific literature, and web-based content.

We classified each referenced citation into one or more of the above thematic categories. For Theme's 1-9, the classified references were annotated and a summary of findings was prepared. For Themes 10 and 11, we provide a list of references but no annotations or summaries.

III. Results

Our list of references includes 756 primary citations, and 59 citations in a separate appendix (Appendix 3). Included in the list are journal articles, progress and technical reports, contract reports, proceedings of conferences and symposia including conference abstracts and posters, books, thesis and other manuscripts. Given the types of articles included in this compendium, readers should be circumspect when evaluating the scientific content of the information. Journal articles and theses typically receive the highest level of peer scrutiny and the scientific merit of the article can be judged accordingly; books and technical reports may also be peer reviewed , while contract reports, abstracts and posters typically receive litte or no peer review. More than 50% of the articles were written since 2004 (Table 1, Figure 1). The majority of the citations are classified in three themes: Life History, Foraging, and Vital Rates (Table 2). With the inclusion of abstracts, posters, and unpublished manuscripts there is substantial redundancy among the citations. Our citation list is attached as Appendix 2 of this report.

Due to the number of citations and range of content in the Life History and Foraging themes we divided the content into sub-themes and prepared separate summaries for each. Life history is divided into four sub-themes: Physiology/Anatomy, Genetics, Reproduction and Behavior, and "Sundry" (a catch all category). Foraging is broken into three sub-themes: Diet, Searching, and Models.

The annotated citations and thematic summaries are presented in Appendix 1. Annotated citations may occur in more than one theme dependent upon the breadth of discussion in the paper. Readers are cautioned that where the citation is repeated an annotation may be carried over from theme to theme or could be customized for the specific theme. As annotators, we attempted to report the content of the published paper without interpretation of the results, i.e., to the extent practicable we avoid commenting on the merit of the arguments presented in the papers. By necessity we do limit our discussion of content in the thematic summaries and in so doing may be guilty of some interpretation.

To facilitate an inspection of the citation list, a companion Excel spreadsheet is included. For each citation, the spreadsheet provides a classification by theme, literature type, and archive format (pdf or paper), year published, and first author for the paper. The spreadsheet is built to take advangage of the Excel Auto Filter utility. Policy makers and researchers may find this tool useful as a quick reference guide. A companion CD containing collected pdfs is also included with this report. A set of paper copies of published reports was provided to the Council.

IV. Acknowledgements

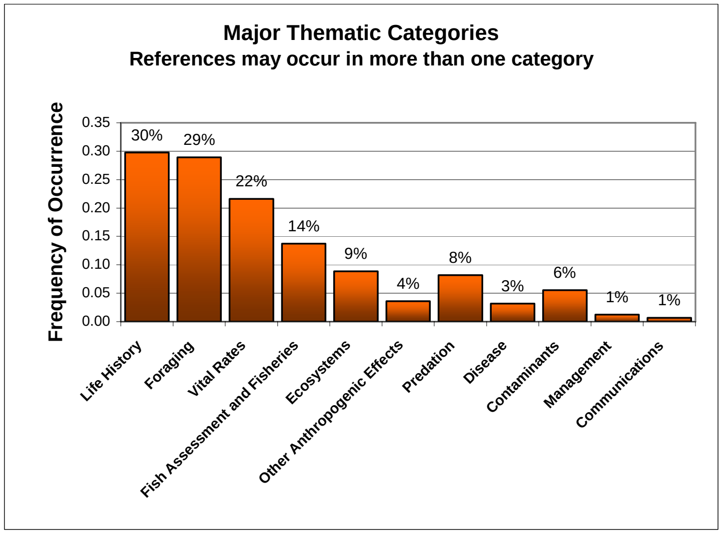
For help in guiding this project or for providing citations we acknowledge Douglas DeMaster, Tom Gelatt, Heather Higgins, Sonja Kromann, Chris Oliver, Lorrie Rea, Robert Small, Andrew Trites, Bill Wilson, and Kate Wynne.

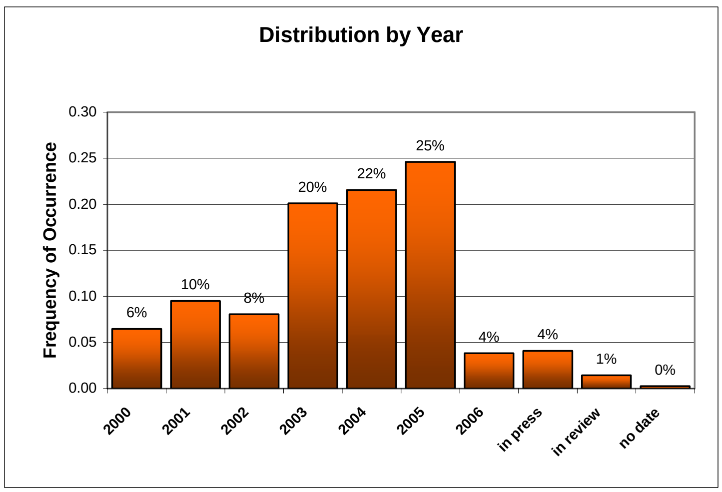
Table 1. Distribution of Steller sea lion cited literature, 2000-2006, by reference type and year published.

	Year										
Reference Type	2000	2001	2002	2003	2004	2005	2006	in press	in review	no date	Total
Journal Article	27	18	23	18	24	35	6	18	11		180
Technical Report	2	5	5	4	2	5					23
Theses	4	6	5	4	6	8	1				34
Contract Reports	1		5	6	4	9				1	26
Books		1	2	3	2	37		12			57
Symposia/Conference Proceedings	7	1	1	8	3	5		1			26
Abstracts		28	16	106	61	28	19				258
Posters					55	44	1				100
Other Manuscripts	8	13	4	3	6	15	2			1	52
Total	49	72	61	152	163	186	29	31	11	2	756

Table 2. Distribution of Steller sea lion cited literature, 2000-2006, by major thematic category.

	Thematic Classification										
Reference Type	Life History	Foraging	Vital Rates	Fish Assessment and Fisheries	Ecosystems	Other Anthropogenic Effects	Predation	Disease	Contaminants	Management	Communications
Journal Article	55	43	23	31	33	1	21	5	5		
Technical Report		2	13	3	1	4	6				2
Theses	13	10	7	5	2	1		1		1	
Contract Reports	1	7	8	6	2	5	4	1	1		
Books	18	15	11	6	5	1	6	2	5	1	1
Symposia/Conference Proceedings	6	5	1	3	1		1	2	10		1
Abstracts	82	83	60	23	8	6	16	8	14	4	
Posters	33	36	23	7	3	6		3	3	1	
Other Manuscripts	7	8	10	15	9	2	5	1	2	2	1
Total	215	209	156	99	64	26	59	23	40	9	5





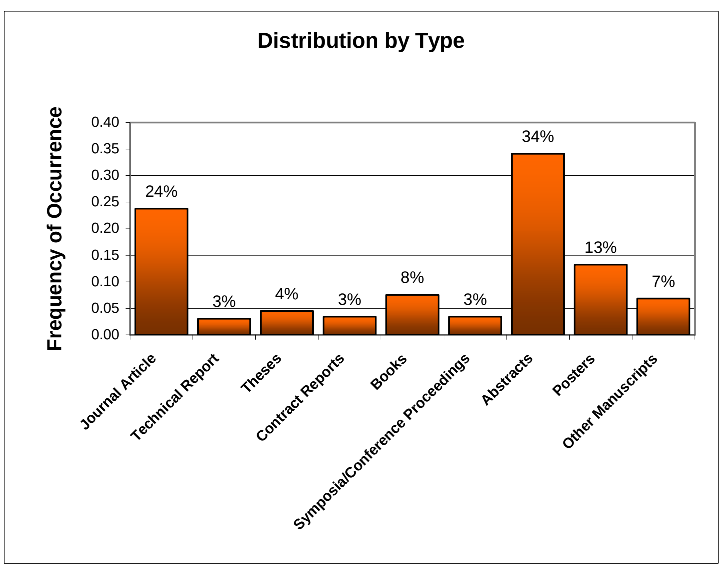


Figure 1. Distribution of Steller sea lion publications by type, time, and category.

(This page intentionally left blank)

APPENDIX I. ANNOTATED BIBLIOGRAPHY WITH THEMATIC SUMMARY

THEME 1 (a) – LIFE HISTORY – PHYSIOLOGY/ANATOMY

SUMMARY:

This theme contains 101 articles including 49 presentations at scientific meetings, six theses, one dissertation, two unpublished reports, and 43 papers in peer-reviewed journals or book chapters.

General physiology and metabolism were studied by many researchers during the review period. The physiological constraints associated with lactation and pup weaning were addressed by Burns and colleagues (2004) and indices of pup weaning were summarized by Rea et al. (2005). Percent total lipid content in pups was measured throughout the first year as a measure of weaning status and condition (Rea et al., 2003). They found that total body lipid stores increased 9-27% throughout the year and that there was no evidence of poor body condition in SSL pups during the first year of development. In an innovative research protocol, some of the captive animals at the Vancouver Aquarium were trained to perform in the open ocean with subsequent oxygen consumption and other metabolic costs of swimming and diving measured. These studies were summarized by Hastie and colleagues (2004, 2005, and two papers in press) including the physiological results and a general linear model to predict oxygen consumption of SSLs diving in the wild. Resting metabolic rates in captive and wild SSLs under different water temperature and water flow rates were measured by Hoopes et al. (2004) who found no evidence for metabolic depression in SSLs from the western stock. Basal metabolic rate (BMR) and feeding rates based on maximum body length measurements were calculated based on published values for most marine mammals with the conclusion that BMRs of marine mammals were the same as those for terrestrial mammals (Hunter et al., 2000). Rivera et al. (2005) and Rosen et al. (2004) presented sundry blood parameters as indices of stress, health, and condition in young SSLs in wild and captive situations under different environmental and feeding regimes.

The physiology of diving and ontogeny of body oxygen stores was studied by Richmond (2004) for her Master's degree (2004) and subsequent papers and presentations with colleagues (2003, 2004, 2006). Numerous blood oxygen parameters were presented including the ontogeny of occurrence of the hormone erythropoietin which is responsible for the production of red blood cells. One conclusion states that at around 2 years of age, juveniles attained mass specific body oxygen stores similar to adult females but their aerobic dive limit remained less than adults.

The physiological implications of food deprivation were studied by Berman and Rea (2000) and Rea et al. (2000) by measuring sera lipid levels and blood parameters in captive and wild SSLs. Various measures during different levels of fasting were presented and pups showed blood chemistry consistent with metabolic adaptation to fasting within 16 hours, but were unable to sustain a protein-sparing metabolism; pups revert to protein catabolism after only 2.5 days of fasting. Mellish and Horning (2005, in press) used the transient juvenile holding facility at the ASLC to measure fasting effects on mass, morphometrics, body composition, blubber thickness, and blood chemistry. They found that the site of greatest blubber mobilization was immediately posterior to the fore-flippers and mass gain in the recovery period (up to 12 days) was 0.7% body mass/day. Kumagai (2004) in his thesis and subsequent papers and presentations (2003 to 2005 with Rosen and Trites) focused on the physiological and metabolic changes in captive SSLs fed herring and pollock diets. One of his conclusions was that restricted energy intake at different times of the year differentially affects SSLs, and the diet type (herring or pollock) may have seasonally-specific effects on body mass and composition. Castellini (2004) and Castellini et al. (2001) described the on-going study at the ASLC to assess changes in SSL (and harbor seal) physiology and condition on different diets. He also made a presentation (2004) summarizing physiological research on SSLs during the 1990s. Noren (2003) presented her model of fasting capabilities for weaned SSL juveniles which suggested that lean juvenile SSLs may be especially susceptible to short-term reductions in prey availability. Williams (2005) reported in two papers the reproductive energetics, feeding bioenergetics, and related intestinal length (measured from dead sea lions) of SSLs based on measures of oxygen consumption in captive SSLs and California sea lions.

Thyroid and cortisol hormone detection and assessment were investigated in numerous studies. In some studies feces were examined to assess the utility of using scat to detect the hormone and thus levels of stress in the defecator (Hunt et al., 2004; Mashburn et al., 2003, 2004; Trites et al., 2003, 2004), and in other studies blood levels were monitored (Atkinson et al., 2001; Mashburn et al., 2003; Myers et al., 2003; Petrauskas et al., 2005.). Leptin, a peptide hormone secreted by adipocytes and used as a measure of energy metabolism, was the focus of studies by Rea et al. (2000) and Myers et al. (2001) with indecisive results. Harmon in a thesis (2001) and presentation discussed reproductive endocrinology in SSLs and found that saliva was useful to determine circulating progesterone levels but not estrogen. Litz et al. (2005, 2006) gave two presentations on their work to investigate testosterone levels in sera and feces in the captive male SSL at the ASLC. Browne complete her dissertation (2004) and subsequent publication (Browne et al., 2006) on sex steroid concentrations and enzyme expression in SSLs and northern fur seals. One important recommendation from her dissertation was that caution be exercised when using scat to monitor male and female sex hormones.

Growth and condition was the focus of numerous presentations and publications. Winship et al. (2001) used the extensive data set from ADFG on morphometrics of SSLs collected by them in the 1970s and 1980s to describe and compare growth by age and sex. Pitcher et al. (2000) used the same data set to define condition indices based on % SCULP and other morphometric relationships. They concluded that SSLs were relatively lean pinnipeds based on estimated blubber and total body lipids that ranged from 5% to 17% of total body mass. Fadely et al. in three presentations (2002, 2004, and 2004) discussed growth and growth rates as an indicator of health and condition in pups and juveniles in Alaska and Russia and as indicators of population and environmental trends (2001). Body condition was also estimated in pups and juveniles as a measure of % body fat by using deuterium oxide dilution methods (Dunlap-Harding et al., 2001). The maximum percent body fat in a juvenile was ~34% and the minimum was ~3%.

An assortment of papers pertaining to anatomical topics was published during this period. McPhee (2001 and McPhee et al., 2003) successfully used heart rate as an indirect measure of oxygen consumption to measure metabolic rate in free-ranging and captive SSLs. Cheneval (2005) detailed the biomechanics of turning maneuvers in SSLs for a Masters study and Steele et al. (2000) calculated the hydrodynamic drag of SSLs as they move through the water. Rosen et al. (2002) measured the cost of swimming in three captive juvenile SSLs in the Vancouver Aquarium and found that locomotor costs were proportional to body mass. Daniel (2003) described the ontogeny of the molt for both wild and captive SSLs for a Masters degree. Vibrissae growth rates were measured using stable isotopes revealing that SSL vibrissae exhibit multi-year records while harbor seals tend to shed the vibrissae annually (Hirons et al. (2001). Skin-fold calipers were used in the 1990s to measure blubber thickness in SSL pups but the resulting values were equivocal. Jonkers and Trites (2000) measured the reliability of skin-fold calipers and found the average error of measurement of skin and blubber was an acceptable 5.4% but that blubber was too compressible and thus not amenable to measure by calipers. They then used their measurements to compare relative body condition of healthy and starved pups (Trites and Jonkers 2000). Underwater hearing sensitivities were detailed for captive animals by Kastelein et al. (2003 and 2005) and proved to be typically mammalian. Olawalee et al. (2005) measured the dielectric properties of SSL skin as part of the development of antennae design for a subcutaneous transmitter. Trace elements (e.g., calcium, zinc, lead, and copper) were described in SSL teeth from Japan and Alaska (Ando et al., 2005).

The presence and health benefits of vitamins were investigated in two studies. Hu et al. (2004, 2005) discussed the advantages of supplementing vitamin E to protect from oxidative stress. Mazzaro et al. (2003) measured vitamins A and E levels in sera from wild SSLs in Alaska and found them to be within normal range.

One paper suggested that pinniped brain size was within relatively narrow limits and that the SSL brain weight to body mass ratio was 0.07% for males and 0.20% for females (Bininda-Edmonds , 2000). Bunner (2002) published a paper on geographic variation in SSL skulls and found that Alaskan skulls were typically longer and less robust than those from other areas. She then published a paper in 2003 comparing skull dimensions within the Otariidae and found no support to divide the family into sub-families. Wiig et al (2004) in a presentation then Miller et al. (2005) in a report summarized a survey of repositories where SSL skulls are housed, and Miller et al. (2000) described SSL bacula. Perlov and Zadalsky (2001) in two papers and Zadalsky and Perlov (2002) compared changes by sex in SSL organ size with ontogeny. SSL and northern fur seal sleep patterns were described in a presentation by Lyamin (2004).

In an indirect approach at the anatomy of animals that may be nutritionally stressed, Stegall et al. (2005) examined fast and slow-twitch muscle fiber diameter; smaller diameters suggest nutritional stress. The study was in progress when reported. A new approach for measuring heat flux and details of where SSLs dump heat was described by Willis and Horning in a number of publications. Heat flux from the shoulders and hips was consistently greater than from mid-trunk and axillary areas.

ANNOTATED BIBLIOGRAPHY – LIFE HISTORY -- PHYSIOLOGY/ANATOMY

Ando, N., T. Isono, and Y. Sakurai. 2005. Trace elements in the teeth of Steller sea lions (*Eumetopias jubatus*) from the North Pacific. Ecol Res. 20:415–423.

> The occurrence of trace elements in the teeth of SSLs collected from the North Pacific from 1968 to 1999 was examined. The authors used particle-induced X-ray emission analysis and detected eight trace elements: Ca, Mn, Fe, Cu, Zn, Br, Sr and Pb. Pb were detected in 39% of the samples from Hokkaido (Japan) and 22% of those from Alaska. The high levels of Pb recorded in 1975 were thought to be related to the use of leaded gasoline during the 1970s. The authors proposed that their results indicate that the levels of trace elements in the teeth of SSLs can be used as indicators of temporal and spatial variations of trace element pollution.

Atkinson, S., M. Meyers and L. Rea. 2001. Thyroid and cortisol hormone concentrations in Steller sea lions (*Eumetopias jubatus*). p. 11 i*n*: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

> The authors measured free and total thyroid hormones and cortisol as a measure of metabolic regulations in captive and wild SSLs in pups and adults to 7-years of age. Free thyroxines

(T4) and free triiodothyronine (T3) values were presented for each age group. Their results indicated that the metabolism of SSLs is regulated ontogenetically and is suppressed as a function of fasting. Cortisol concentration of the wild animals 4-12 months old suggested these animals were more challenged (stressed) than were neonatal or captive SSLs.

Atkinson, S., T.M. Williams, K. Mashburn, D. Greig, and D. Christen. 2004. Physiology of homeostasis in sea lions: The link between hormones and metabolism. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors report two instances where weight gain was achieved without increasing the mass of food intake. In one case a male SSL gained >30% (from 560 to 900 kg) each spring with a relatively constant food intake of 35-40 kg. Seasonal rate of mass gain or loss is highly influenced by testosterone. Likewise in pregnant California sea lions progesterone appeared to be the causal factor influencing the rate of weight gain throughout gestation, as opposed to the level of dietary intake.

Berman, M. L. and L. D. Rea. 2000. The effects of food deprivation on serum lipid concentration and content in Steller sea lions (*Eumetopias jubatus*). Third Biennial symposium of the Comparative Nutrition Society, Pacific Grove, California. August 4-9, 2000.

This study addressed the physiological implications of food deprivation by analyzing the effects of fasting on serum lipid composition and content. The breeding and non-breeding seasons were compared to determine if seasonality affects serum lipid composition and content. Nine SSLs, four juveniles and five sub-adults, were used in 13 different fasting experiments lasting from 7 to 14 days. Eight of the fasts were conducted during the breeding season (May-July) and five were conducted throughout the rest of the year. The length of the fast was dependent upon body size and fasting was discontinued once the animal lost 15% body mass. Non-esterified fatty acid (NEFA) concentration was quantified using a spectrophotometric assay. NEFA concentrations did not differ significantly between the breeding and non-breeding season, however, NEFA concentrations did increase in juveniles during the breeding season but not during their non-breeding season fasts. Although the NEFA concentrations appeared to increase during the breeding and non-breeding seasons fasts in sub-adults, this trend was not significant. The results suggested differences in lipid metabolism between seasons in some age classes. Although no difference of NEFA concentration was found between the breeding and nonbreeding season, NEFA concentration did significantly increase during the breeding season of the juveniles and not during the non-breeding season.

Bininda-Edmonds, O.R.P. 2000. Pinniped brain sizes. Marine Mammal Science 16(2):469-481.

This 13 page note is composed of two large tables providing the absolute brain weight and brain weight as a proportion of body mass for all pinnipeds. To provide an initial estimate of brain size for most pinniped species the author measured the cranial capacity of specimens (generally one male, one female) housed at the Natural History Museum, London. The volume of cleaned, undamaged skulls was determined using 2.0 mm plastic beads and this value was used to directly estimate brain weight assuming 1 ml = 1 g. Relative brain size ranges from 0.03% of body weight in-male southern elephant seals to 1.02% of body weight in female Galapagos fur seals; relative brain size tends to be smaller in heavier species and strongly sexually dimorphic species (i.e., the smaller females have relatively larger brains). This suggests that brain size in pinnipeds is bounded within relatively narrow limits, possibly due to functional constraints on skull size. For SSLs, absolute brain weight and brain weight as a proportion of body mass were 747.5 g and 0.07% for males and 575 g and 0.20% for females.

Browne, P. 2004. Some aspects of the reproductive physiology of otariid pinnipeds. Ph.D. Dissertation. University of California, Davis. 130 p.

This Ph.D. dissertation included the measure of progesterone in blood and feces of SSLs and northern fur seals to evaluate the potential of using non-invasive methods to monitor pregnancy. Excreted levels were correlated with circulating progesterone concentrations. The identification of a variety of immunoreactive steroid metabolites in samples collected from male and female SSLs illustrated the need for rigorous validation of fecal assays. Examination of circulating sex steroid metabolites of NFS indicated very low estrogen levels and substantial androgen levels in peripheral circulation in females near the end of embryonic delay. When contrasted with male and female fur seals sampled during late summer, decreases in levels of specific serum androgens were implicated as possible regulators of uterine implantation. Additional results regarding hormonal levels and their influence on ontogeny of pregnancy and placental circulation were discussed.

Browne, P. A.J. Conley, T. Spraker, R.R. Ream, and B.L. Lasley. 2006. Sex steroid concentrations and localization of steroidogenic enzyme expression in free-ranging female northern fur seals (*Callorhinus ursinus*). General and Comparative Endocrinology.

This work is part of Browne's Ph.D. dissertation funded with SSLRI funds. This portion pertains to circulating sex steroid concentrations in northern fur seals as a proxy for SSLs and is the journal form of the information presented above (Browne 2004) regarding circulating sex hormones in northern fur seals.

Brunner, S. 2002. Geographic variation in skull morphology of adult Steller sea lions *(Eumetopias jubatus*). Marine Mammal Science, 18:206-222.

The author measured SSL skulls from numerous institutions to compare intraspecific morphology in SSLs. Males and females were grouped separately due to sexual dimorphism. Sample sizes were small but she reported geographic variations males suggesting three groups (Alaska, California, and Japan/Russia) with those from Japan being most divergent. Skulls from Alaska possessed a typically longer, less robust skull whereas those from Japan appeared smaller yet most robust. Skulls from California were intermediate.

Brunner, S. 2003. Fur seals and sea lions (Otariidae): identification of species and taxonomic review. Systematics and Biodiversity 1 (3):339-439.

This journal paper is a study of skull morphology for all otariids in a re-appraisal of species limits in the family. She examined 2,345 specimens representing all otariid species in museums and other institutions world-wide. The 53 page appendix lists in table form all specimens examined. Her results did not support a subfamily separation of otariid seals. There was a suggestion to reconfigure some genera, species, and subspecies, but these dealt principally with fur seals (*Arctocephalus*). Taxonomy of Steller sea lions was not altered outside the recommendation not to consider subfamily separations within the family.

Burns, J.M., C. A. Clark, J.P Richmond. 2004. The impact of lactation strategy on physiological development of juvenile marine mammals: implications for the transition to independent foraging. Comparative Physiology and Biochemistry, International Congress Series, 1275: 341-350.

> The authors present a general paper using results of their studies on harbor seals and SSLs to assess physiological constraints as pups begin to wean. Sample sizes were large based on their own work in conjunction with ADFG and NMML. Total body oxygen stores were determined by an initial blood sample from which hematocrit (HCT) and hemoglobin were determined. Plasma volume was measured and blood volume was determined by dividing plasma volume by the measured HCT. Other methods were described. They report that phocid pups, which grow rapidly during their brief nursing period, undergo a strong post-parturition anemia and are weaned with relatively immature oxygen stores, possibly due to limited iron intake. Otariid pups, which grow at a slower pace over a longer period, are weaned with body oxygen stores that are significantly more mature. This suggests that newly independent phocid pups must quickly develop foraging skills in order to acquire the nutrients necessary to mature physiologically. In contrast, newly weaned otariids have more mature oxygen stores, and may have previous foraging experience, which may allow for increased behavioral flexibility.

Burns, J.M.. T.M. Williams, S.M. Secor, N. Owen-Smith, N.A. Bargmann, M.A. Castellini. In press. New insights into the physiology of natural foraging. Physiological and Biochemical Zoology.

> This paper was not seen for review in this synopsis.

Castellini. M. 2004. A Decade of adult Steller physiology in the field: Where are we now? Presented paper. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> This presentation is a summary of what was known regarding SSL physiology through the 1990s and its relationship to observed declines. Most of the work was conducted on adult females. The data supported the concept that no clear biochemical, metabolic, or physiological systems appeared compromised in adult females that would have been serious enough to cause animals to die from nutritional impacts. While that work focused primarily on nutrition (a caloric perspective), there were hints that other control systems (immune function, metabolic regulation) were unusual. Current research (at the time of the presentation) was to test some of those control systems in captive animals.

Castellini, M., D. Calkins, V. Burkanov, J. M. Castellini, S. Trumble and T. Mau. 2001. Long-term feeding trials with harbor seals and Steller sea lions: Impact of differential diets on health and nutrition. p. 40 *in*: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

> The authors describe their 2-3 year feeding studies at the ASLC on harbor seals and SSLs to assess the changes in body mass and physiology under different diet regimes by season. Diets were changed every four months. The results from both studies suggested significant seasonal and male/female responses to dietary shifts. Animals put on mass and body fat under all diets depending on season, or they could lose mass and body fat or some combination of those parameters. They concluded that significant changes in the seasonal metabolic status of pinnipeds and sex based differences must be assessed in any model of diet and prey interactions.

Castellini, M.A., L. Zhao, and S. Inglis. 2005. Metabolic demands of Steller sea lion survival. Chapter 8, pages 68-76, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

> The focus of this project was to examine several of the major metabolic demands that are involved in the energetic requirements of SSLs. They examined four areas of which three were presented, metabolism, ASLC fish, and hydrodynamics. Results from the metabolism study showed that adding herring to the diet and decreasing the amount of pollock impacted the turnover of protein in captive sea lions. In all cases (both sea lions and for all three time components), replacing half the pollock with herring increased the metabolic turnover (decreased the half-life) of protein by 30-50%. The rate at which the sea lions processed protein increased when fed both herring and pollock simultaneously. In the ASLC fish study, preliminary results on moisture content indicated that there were seasonal differences between the prey samples, with the largest variability found in herring. There was also a significant difference between age classes of walleye pollock, with 0 and 1 age classes having significantly higher moisture content than older animals. Preliminary results from the hydrodynamics study indicated that active swimming dominated foraging activities. Subsequently, an entire suite of measurements needs to be calculated for drag to distinguish the gliding from the stroking and turning sea lion.

Cheneval, O. 2005. Biomechanics of turning maneuvers in Steller sea lions (*Eumetopias jubatus*). M.S. Thesis, University of British Columbia, Vancouver, Canada. 64 p.

> In this Master's degree study the author measured three captive SSLs held at the Vancouver aquarium to gather detailed information about the turning techniques employed by SSLs. He analyzed kinematic and kinetic parameters measured from video recordings. Centripetal force and thrust production were determined by examining body movements throughout a series of turns. Results showed that most of the thrust was produced during the power phase of the stroke cycle of the pectoral flippers; very little or no thrust was generated during initial abduction of the pectoral flippers and during the final drag-based paddling style of the stroke cycle. Peak of the thrust force was reached halfway through the power phase. The degree of dorsal flexion of the body changed with the turning radius and the degree of flipper abduction varied with swimming speed. However, the general maneuvering technique and turning sequence remained the same in all the recorded maneuvers. Comparison of reported maneuvers to a model was also reported.

Daniel, R.G. 2003. The timing of moulting in wild and captive Steller sea lions (*Eumetopias jubatus*). M.S. Thesis, University of British Columbia, Vancouver, B.C. 64 p.

> This Master's degree study documented the timing and progression of the molt by sex and age class in free ranging SSLs on Lowrie Island (July-November 2001) and from captive animals at the Vancouver Aquarium (1993-2000). In the wild, ages 1-2 years were the first to molt followed by adult females, bulls and pups. The mean date when juveniles started their molt was June 21 which was significantly different from the mean start date of August 7 for adult females, and differed from the mean start date for pups of September 1. Mean completion dates were also about one month apart (September 19 for juveniles, October 26 for adult females and November 17 for pups). Duration of the molt was about 45 days for each age group (pups and adult females). However, duration of the molt for captive sea lions

was longer (averaging 83.5 days) and differed among years and within age classes. Patterns of hair loss in the wild (i.e., the progression of the molt over the body surface) differed among pups, juveniles and early molting adult females, and bulls and later molting adult females.

Daniel, R., and A.W. Trites. 2003. Timing of moulting in Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

Similar information without much detail as in Daniel's (2003) Master's degree study above.

Dunlap-Harding, W. S., L. D. Rea, K. W. Pitcher and S. D. Farley. 2001. Body condition of free-ranging Steller sea lions estimated by deuterium isotope dilution. P. 63, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

These authors present their summaries of data collected over four years using deuterium isotope dilution to estimate percent body fat (%BF) as an index of body condition in 132 SSLs ranging from 2 to 26 months of age from both stocks in Alaska. Preliminary results showed that there was no significant difference in %BF between male and females up to 15 months of age. %BF increased significantly from ~9.1% to ~27.4% between 2 and 10.5 months of age. Two month old pups from the western stock had a significantly higher %BF than pups in the eastern stock, but this difference disappeared by 15 months of age. The maximum %BF measured in a juvenile was 33.7% and the minimum was 4.3%.

Fadely, B.S., V.N. Burkanov, and T. Loughlin. 2002. Analysis of Steller sea lion pup condition in Russia and Alaska. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

This report summarizes morphometric data from pups branded in Russia and Alaska during 1987-2001. A condition index (CI) was calculated based on mass and body length (L). For 4,438 pups, mass was found to be $L^{2.43}$ for males and $L^{2.30}$ for females. CI measured at <1week and 2-3 weeks of age was unrelated to growth rate, but CI measured at 3-4 weeks was significantly related to growth rate. CI was insensitive to sampling date effects during 4-6 week age period, but was sensitive to sample size, stomach fill, and suckling bout intervals. In 2001, CI of pups from Russia was significantly greater than for pups from Alaska and in Alaska CI declines from Southeast Alaska west.

Fadely, B.S., T.S. Gelatt, L.D. Rea, J.C. King, and T.R. Loughlin. 2004. Geographic differences among juvenile Steller sea lions (*Eumetopias jubatus*) growth rates in Alaska. Pages 567-568, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

These authors report their studies comparing growth rates of Alaskan SSLs between 1 and 40 months of age during 2000-2003. In total, 3,221 pups and 460 juveniles were captured, weighed, and measured providing cross-sectional data. Longitudinal growth data were available from 29 SSL re-captured 2-3 times during their first 2 years. Mean pup mass declined regionally from the western Aleutians to Southeast Alaska, consistent with earlier studies. SSL from Southeast Alaska remained smaller than those from other regions up through 2 years of age. Growth slowed between 1 and 2 years, presumably related to weaning. Growth rates were slower in Southeast Alaska.

Fadely, B.S., T.S. Gelatt, L.D. Rea, J.C. King, and T.R. Loughlin. 2004. Regional variation of juvenile Steller sea lion (*Eumetopias jubatus*) growth rates in Alaska . Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> The author report their comparison of growth rates for 3,221 pup and 460 juvenile SSLs between the ages of 1 and 40 months captured in Alaska during 2000-2003. mean pup mass declined regionally from the western Aleutians (mean 35.8 kg males; 29.9 kg females) to Southeast Alaska (29.9 kg males, 25.8 kg females). SSLs from Southeast Alaska were smaller at all age groups up to 2 years of age; growth slowed for all regions between 1 and 2 years of age.

Fadely, B. and T. R. Loughlin. 2001. Weak association between Steller sea lion pup condition and population and environmental trends in western Alaska. P. 68, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

> Same information as in Fadely et al. (2002) above, but here there is a focus on pups in the Aleutian Islands. No trends were evident between pup count and CI which was relatively poorer in the western Aleutians in 1997 and 1998. Ugamak Is. had poor CI during 1995-98. There was a weak association between CI and the Aleutian Low. Condition was poorest during weak depression of the Low (1996-98), but increased linearly as the Low intensified. Positive NPI anomalies were associated with better pup condition.

Harmon, H.L. 2001. Seasonal reproductive endocrinology and anatomy of Steller sea lions. M.S. thesis, University of Alaska, Fairbanks.

> Following is an abbreviated version of the thesis abstract. The objectives of this study were to determine if saliva samples were a valid alternative to plasma samples for measurement of peripheral progesterone and testosterone, to describe annual cycles of steroid concentrations, and to provide anatomical verification of reproductive endocrinology. Samples were collected from adult, captive, and wild SSLs. Progesterone and testosterone concentrations in paired plasma and saliva samples were highly correlated (96% and 84%, respectively). Captive SSLs had seasonal variations in these steroids that did not follow typical pinniped patterns, suggesting that reproductive activity is sensitive to social cues. The wild SSLs exhibited steroid patterns similar to other seasonal breeders. Vaginal cytology could not be evaluated for detecting estrous because no samples were obtained during estrous. Testes volume was correlated to plasma testosterone concentrations (71%).

Harmon, H.L., M.A. Castellini, J. Rowell and S. Atkinson. 2000. The use of saliva, vaginal cytology and testicular size to determine reproductive status in Steller sea lions. FASEB Journal. 14(4): A46.

> This presentation is a summary of Harmon's Master's degree study above. Three captive SSLs at the ASLC were monitored for peripheral reproductive hormone concentrations using blood sera, saliva, vaginal swabs, morphometrics, and anatomy. Results showed that there was high correlation between plasma and saliva for progesterone and testosterone but poor correlation between sera and saliva for estrogen. Vaginal cytology was a useful tool for determining reproductive status.

Hastie, G.D., D.A.S. Rosen, D.V. Gummeson, T. VanLeeuwen, R. Marshall, R.S. MacVicar, and A.W. Trites. 2005. The influence of depth on a breath-hold diver: Predicting the diving metabolism of Steller sea lions. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Same information as in the detailed account in Hastie et al. (in press b) below.

Hastie, G.D., D. A.S. Rosen, G.E. Wallace, and A.W. Trites. 2004. Diving physiology of Steller sea lions: Insights from trained animals in the open ocean. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Same information as in the detailed account in Hastie et al. (in press a) below.

Hastie, G, D.A.S. Rosen, and A.W. Trites. In press a. Studying trained Steller sea lions in the open ocean. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

This book chapter is the published version of a talk given at the Sea Lions of the World Symposium in 2004. Here the authors give a detailed description of the logistics and methods of working with SSLs in an open ocean test facility. They conducted diving metabolism studies with two captive-reared SSLs housed in a holding pen and transported by boat to a diving trial area. The animals were trained to dive to predetermined depths for controlled periods of time using an underwater light targeting system and a video system to monitor behavior. At the end of each dive the sea lions returned to a respirometry dome on the surface where oxygen consumption was measured to estimate diving metabolism. This paper describes the experimental setup used to evaluate diving metabolism, discusses the logistical challenges of the study and the advantages of using such an approach to carry out physiological experiments with sea lions, and provides preliminary data on the diving energetics of SSLs.

Hastie, G.D., D.A.S. Rosen, and A.W. Trites. In press b. The influence of depth on a breath-hold diver: predicting the dive metabolism of Steller sea lions (*Eumetopias jubatus*). Journal of Experimental Marine Biology and Ecology.

In this published paper the authors measured metabolic rates of SSLs trained to dive to depth in the open ocean to investigate the relationships between diving behavior and the energetic costs of diving. They also constructed a general linear model to predict the oxygen consumption of sea lions diving in the wild. The resultant model suggested that mean swimming distance and depth of dives significantly influence the oxygen consumption of diving SSLs. The predictive power of the model was tested using a cross-validation approach, whereby models reconstructed using data from pairs of sea lions were found to accurately predict the oxygen consumption of the third diving animal. Predicted oxygen consumption during dives to depth ranged from 3.37 L/ min at 10 meters, to 1.40 L/min at 300 meters over a standardized swimming distance of 600 meters. This equated to an estimated metabolic rate of 97.54 and 40.52 MJ/day, and an estimated daily feeding requirement of 18.92 and 7.96 kg/ day for dives between 10 and 300 meters, respectively.

Hirons, A.C., D.M. Schell and D.J. St. Aubin. 2001. Growth rates of vibrissae of harbor seals (*Phoca vitulina*) and Steller sea lions (*Eumetopias jubatus*). Canadian Journal of Zoology 79:1053-1061.

> Growth rates of vibrissae, which act as a temporal record of feeding in harbor seals and SSLs, were estimated using 13C- and 15N-labeled glycine followed by stable-isotope analysis. The labeled glycine was incorporated into keratin and served as a temporal marker for growth rate calculation. One captive harbor seal received two doses 147 days apart, while a second seal received one dose; vibrissae were analyzed after 86 and 154 days. The peak positions indicated that growth began in the fall, continued into spring, but ceased in June, with active growth rates of 0.33 mm/day. Two adult female captive SSLs held at Mystic Aquarium each received two labeled doses during a 308-day period. After 427 days vibrissae in both sea lions showed two peaks corresponding to the markers; growth rates were calculated as 0.05–0.07 mm/day. Growth rates in captive juvenile and wild adult SSLs, 0.10–0.17 mm/day, supported the assumption that major isotopic oscillations in vibrissae of wild sea lions were annual. The multi-year records imply that SSLs retain their vibrissae; harbor seal vibrissae, in contrast, have periods of rapid growth and appear to be shed annually.

Hoopes, L.A., L.D Rea, D.A.S Rosen, and G.A.J Worthy. 2004. Effects of body condition on resting metabolism in captive and free-ranging Steller sea lions (*Eumetopias jubatus*). Symposia of the Comparative Nutrition Society 2004. No. 5, Pp 79-82.

> These authors measured oxygen consumption on captive SSLs at the Vancouver Aquarium and from wild sea lions to compare resting metabolic rate (RMR) from animals in the eastern and western populations to discern any evidence for nutritional stress. Oxygen consumption rates were measured for pups and sub-adults in water using open flow respirometry with a seawater filled swim flume. All sub-adult sea lions began the study in a state of reduced body condition after being subjected to a sub-maintenance diet of varying length (9 days or 31 days). In water, RMR ranged from 33.3 to 56.7 MJ/day for sub-adult animals (109-158 kg, 2.9-4.6 times predicted for an adult animal) and from 20.0 to 26.6 MJ/day for pups (57-59 kg, 3.3-4.3 times predicted) at 2°C. RMR, generally decreased with increasing water temperature, but the relationship was not statistically significant. Reduced body condition had a noticeable impact on RMR in juvenile sea lions at colder water temperatures. The results suggested that young sea lions would be subject to even greater thermoregulatory demands if their body condition were reduced

Hoopes, L.A., L.D. Rea, and G.A.J. Worthy. 2004. Resting metabolic rate in free-ranging juvenile Steller sea lions (*Eumetopias jubatus*): Life on the edge. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> Similar information as in Hoopes et al. (2004) above.

Hoopes, L., L.D. Rea, and G.A.J. Worthy. 2005 Resting metabolic rate in free-ranging juvenile Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

> Similar information as in Hoopes et al. (2004) above, with the added conclusion that RMR was not significantly different for similar aged pups and yearlings from Prince William Sound and Southeast Alaska. There was no evidence of metabolic depression in animals from the western stock.

Hoshino,H., T. Takeomi,T. Takayama, Y. Goto, K. Hattori, M. Ishizuka, A. Wada, Y., Orio, Y. Yasunori, and F. Shouichi. 2005. Differentiation of adipocyte collected from Steller sea lion *Eumetopias jubatus*. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

> This presentation discusses an experiment to culture adipocyte (fat cells) from the blubber of SSLs killed in the Japanese controlled harvest near Hokkaido. Apparently, experiments on rodents and humans showed that various hormones excreted from adipocyte had an affect on energy stores, the immune system, and reproduction. Blubber from the breast area of killed animals was removed and cultured within 24 hours of death and treated chemically for preservation and to enhance the culture process. Results showed that a small part of the cultured cells differentiated into adipocyte but no cell differentiation was observed.

Hu, C., L. Mazzaro, D. A. Rosen, A.W. Trites, and D. D. Kitts. 2004. Vitamin supplementation maintains plasma 8-isoprostane levels in captive Steller sea lions. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> This poster summarizes a study to evaluate vitamin supplements to captive SSLs by measuring plasma vitamin E levels and plasma 8-isoprostane, useful markers of oxidative stress. Their results suggest that vitamin E containing supplements were important for maintaining health and protection against oxidative stress for the captive SSLs.

Hu, C., S. Wise, A.W. Trites, J. Wise, D.D. Kitts. 2005. Vitamin E protects Steller sea lion cells from reactive oxygen radical induced damage. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

> Captive studies showed that SSLs had lower levels of plasma vitamin E when consuming pollock compared to herring; poor vitamin E absorption is associated with increased levels of oxidative stress. This study cultured SSL skin and liver cells and exposed them to different conditions. Results showed that by adding supplemental vitamin E to the cell cultures increased survival of the cells when exposed to sub-lethal concentrations of hydrogen peroxide which the authors contend is in-depth evidence of the importance and benefit of antioxidant vitamin to marine mammal health and wellness.

Hunt, K.E., A.W. Trites, and S.K. Wasser. 2004. Validation of a fecal glucocorticoid assay for Steller sea lions (*Eumetopias jubatus*). Physiology and Behavior 80: 595-601.

> The authors validated a fecal glucocorticoid assay for SSLs with an adrenocorticotropic hormone (ACTH) challenge. Feces were collected from captive SSLs (two males and two females) for 2 days before injection with ACTH, and for 4 or more days post-injection. Feces were freeze-dried, extracted with a methanol vortex method, and assayed for glucocorticoids. All animals showed the expected peak of fecal glucocorticoid excretion after ACTH injection. However, the two males had higher baselines, higher peaks, and more delayed peaks than the females. Peak glucocorticoid excretion occurred at 5 and 28 hours post-injection for the two females, and at 71 and 98 hours for the two males. Correction for recoveries by the addition of tritiated hormones produced ACTH profiles that were virtually identical in pattern to uncorrected data, but with higher within-sample coefficients of variation. Based on these results, they concluded that this fecal glucocorticoid assay accurately reflected endogenous adrenal activity of SSLs, and that recovery corrections were not necessary when using the methanol vortex extraction method.

Hunter, A.M.J., A.W. Trites, and D. Pauly. 2000. Estimates of basal metabolic and feeding rates for marine mammals from measurements of maximum body length. *In* C.L.K. Baer (ed.), Proceedings of the Third Comparative Nutrition Society Symposium, No. 3, Pages 103-106. Pacific Grove, California, August 4-9, 2000.

> The authors reviewed published data to investigate whether basal metabolic and feeding rates of marine mammals were similar to those predicted for terrestrial mammals and whether the relationships between taxa could be used to predict basal metabolic rates of species of marine mammals not previously studied. They augmented previous reviews by expanding the number of species, eliminating repeated measures, and implementing maximum body length, a more accurate independent variable than body weight. Experimental measurements of basal metabolic rate (BMR) of marine mammals with known growth curves were extracted from the literature and expressed as kilocalories per day. Mean weights of both males and females of each species at physical maturity were determined from existing growth curves or extrapolated from the literature.. They were unable to reject the null hypothesis that the BMRs of marine mammals were the same as those of terrestrial mammals of similar body size and concluded that marine mammals have similar BMRs as terrestrial mammals of similar body size. They also suggest that feeding rates of marine mammals are within the range stated for terrestrial mammals provides more evidence that the energy consumption of marine mammals is not disproportionate compared to terrestrial mammals of similar body size.

Ishinazaka, T., M. Suzuki, Y. Yamamoto, T. Isono, N. Harada, J. I. Mason, M. Watabe, M. Tsunokawa, and N. Ohtaishi. 2001. Immunohistochemical localization of steroidogenic enzymes in the corpus luteum and the placenta of the ribbon seal (*Phoca fasciata*) and Steller sea lion (*Eumetopias jubatus*). Journal of Veterinary Medical Science 63:955-959.

> This study analyzed the localization of steroidogenic enzymes to assess luteal and placental function in SSLs and ribbon seals. Samples were from 8 SSLs shot as part of the nuisance control program near Hokkaido, Japan (similar for the ribbon seals). The article provides specifics on enzymes of interest and there presence or absence in the luteal cells and placenta. They conclude that corpora lutea of both species synthesize pregnenolone, progesterone, and estrogen during the entire pregnancy and that the placenta of both species do not have the capability for synthesizing progesterone in the latter half of the pregnancy.

Jonker, R.A.H., and A.W. Trites. 2000. The reliability of skinfold-calipers for measuring blubber thickness of Steller sea lion pups (Eumetopias jubatus). Marine Mammal Science 16:757-766.

> The authors tested the utility of using skin-fold calibers to measure blubber thickness and overall condition of SSL pups. They measured 12 dead SSL pups aged 3-14 days old which had a wide range of body size and condition. Average error of measurement for skin and blubber thickness was an acceptable 5.4%, but the skin and blubber were highly compressible. They concluded that skin-fold thickness predicted body size better than it predicts blubber thickness.

Kastelein, R., R. van Schie, and D. de Haan. 2003. Underwater hearing sensitivity of Steller sea lions (*Eumetopias jubatus*): Potential sexual differences. P. 82, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

A 9-year old male and a 7-year old female SSL in captivity were measured for underwater hearing sensitivity by producing a known signal and measuring behavioral response. The article provides upper and lower sensitivity levels for each animal by frequency and db levels and provides the typical mammalian U-shaped audiogram. Hearing thresholds of the male were significantly higher than those for the female, perhaps due to individual differences or to sexual dimorphism in hearing.

Kastelein, R., R. van Schie, W.C. Verboom, and D. de Haan. 2005. Underwater hearing sensitivity of Steller sea lions (*Eumetopias jubatus*): Potential sexual differences. Acoustical Society of America 118(3):1820-1829.

Similar information as in Kastelein et al. (2003) above but in journal form with more detail.

Kumagai, S. 2004. Seasonal differences in physiology of captive Steller sea lions (*Eumetopias jubatus*) in response to short-term low energy intake. M.Sc. thesis, University of British Columbia. 112 p.

This Master's degree study concerned changes in body mass and physiology in captive SSLs given different diets. The study was presented at numerous symposia and results were incorporated into papers by Rosen and Trites regarding the testing of the junk-food hypothesis. The animals were fed restricted isocaloric amounts of Pacific herring or walleye pollock for 8-9 days, four times a year. At these levels, the sea lions lost an average of 10.1% of their initial body mass while on both experimental diets for up to nine days, but at a significantly higher rate in winter and at a lower rate in summer. Decreases in body fat mass and standard metabolic rates during the trials were similar throughout the seasons and for both diets. Metabolic depression was not always observed during the trials despite the constant loss of body mass. Changes in blood chemistry were also reported. The author concluded that his results support the hypothesis that restricted energy intake at different times of the year differentially affects SSLs, and that diet type (herring or pollock) may have seasonally-specific effects on body mass and composition. SSLs may be more severely impacted by reduced energy intake in winter than at other times of the year. Changes in iron binding capacity were significantly greater in the herring-fed group than in the pollock- fed group, and a significantly greater decrease occurred in winter and spring compared to summer and fall. Iron saturation increased in the herring- fed group and decreased in the group fed pollock. These results suggested a potential anemia from a reduced diet of pollock in SSLs. Serum iron, phosphorus, hematocrit and gamma glutamyltransferase showed consistent changes during food restriction, suggesting that these may serve as indicators of nutritional stress in SSLs.

Kumagai, S., D.A.S. Rosen, and A.W. Trites. 2003. Seasonal changes in defended energy state in Steller sea lions. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

This abstract is a general summary of the study described in Kumagai's (2004) Master's degree study above. No data were provided.

Kumagai, S., D.A.S. Rosen, and A.WQ. Trites. 2003. Seasonal differences in body composition and energy balance in response to low energy intake in Steller sea lions (*Eumetopias jubatus*). P 89, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

This is an early presentation of the work by the senior author (Kumagai 2004, above) in his Master's degree thesis. Here he concludes that sea lions have natural fluctuations of body composition, that they respond differently to low energy intake in winter and spring, and that they use different energy sources at different times of the year.

Kumagai, S., D.A.S. Rosen, and A. Trites. 2004. Potential iron deficiency induced by pollock diet in captive Steller sea lions (*Eumetopias jubatus*). Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Similar information as in Kumagai (2004) above concerning the aspect of his thesis on iron-binding capacity. Here the authors conclude that diets inadequate in iron could result in decreased body size and reproductive failure.

Kumagai, S., D.A.S. Rosen, and A.W. Trites. 2005. Physiological responses to short-term low energy intake are seasonally dependent in Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Similar information as in Kumagai (2004) above and other earlier presentations on the same topic.

Litz, B.S., K.L. Mashburn, L. Petranskas, and S. Atkinson. 2005. Non-invasive monitoring of testosterone in an endangered species, the Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This study monitored fecal and serum testosterone levels in scat of an adult male SSL at the ASLC using a commercially available radioimmunoassay kit. Fecal concentrations were significantly higher during the breeding season than the non-breeding season. The study supported the use of feces as a reliable medium for non-invasive monitoring of testosterone.

Litz, B., K. Mashburn, L. Petrauskas, and S. Atkinson. 2006. Non-invasive monitoring of testosterone in an endangered species, the Steller sea lion (*Eumetopias jubatus*). *In* Marine Science in Alaska, January 22-25, 2006, Hilton Hotel, Anchorage, AK.

An adult captive SSL at the ASLC was monitored for fecal and serum testosterone concentrations from May 2002 to June 2003 to determine if feces could be used to monitor testosterone levels. Data were provided that support the use of feces as a reliable medium for non-invasive monitoring of testosterone.

Lyamin, O.I. 2004. Sleep in young Steller sea lions and northern fur seals: A comparative study. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The author conducted an electrophysiological study of sleep in four 3-5 month old SSLs and three 2-3 month old northern fur seals. While on land the SSLs spent ~24% of each 24 hours in slow wave sleep (SWS) and 9.8% in rapid eye sleep (REM); fur seals spent 33% and 7%, respectively. Average REM sleep lasted ~6 minutes in SSLs and ~4 minutes in the fur seals.

Both species were able to sleep in water and while asleep the SSL kept swimming slowly at the surface. Fur seals slept on their sides in the 'jug-bottle' position. REM sleep nearly disappeared while in water and SWS sleep was reduced.

Mashburn, K.L., and S. Atkinson. 2002. Sex differences in corticoid metabolism measured in Steller sea lion feces. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

This study developed extraction and assay methods to evaluate sex differences in corticoid metabolism in SSLs using scat. The abstract contains detailed information on the chemical assay and the results of the analysis which appeared to be equivocal. Apparently the sex of the defecating animal needs to be known but it was difficult to discern whether this was the case on not based on the abstract.

Mashburn, K., and S. Atkinson. 2003. Evaluation of adrenal activity in Steller sea lion serum and feces. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

Similar information as that provided in Mashburn and Atkinson above and below (2002, 2004, and 2005).

Mashburn, K.L. and S. Atkinson. 2004. Evaluation of adrenal function in serum and feces of Steller sea lions (*Eumetopias jubatus*): influences of molt, gender, sample storage, and age of glucocorticoid metabolism. General and Comparative Endocrinology, 136:371-381.

Fecal corticosterone concentrations using radioimmunoassay (RIA) were validated as a method to monitor adrenal function in SSL physiology. Quantification of adrenal response to an acute stressor and relevance of data produced by developed methodologies was determined through physiological challenge with exogenous administration of adrenocorticotropic hormone (ACTH) to captive adult, reproductively intact, SSLs of both sexes during seasonal molt. Following ACTH administration, serial blood and fecal samples were collected and analyzed by RIA to determine adrenal response. ACTH challenges produced >3-fold increases in serum cortisol concentrations which were reflected in >18-fold increases in fecal corticosterone concentrations post-injection at 3.25 and 32 h, respectively, and fecal corticosterone concentrations returned to baseline 52 h post-injection. Neither outdoor exposure to weather nor variation in duration and temperature of freezer storage impacted fecal corticosterone concentrations.

Mashburn, K., and S. Atkinson. 2004. Survey of Steller sea lion corticosteroid concentrations in scat. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Similar information as in Mashburn and Atkinson (2004) above.

Mashburn, K.L., and S. Atkinson. 2005. Evaluation of adrenal function in serum and feces of Steller sea lions. Chapter 17, pages 159-176, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Similar information to Mashburn and Atkinson (2004) above.

Mashburn, K., and S. Atkinson. 2005. The price of puberty: Evaluation of adrenal function in juvenile Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

> Similar information to Mashburn and Atkinson (2004) above but with a slightly different emphasis. Six male and two female juvenile SSLs held in the temporary facility at the ASLC were physiologically challenged through the administration of adrenocorticotropic hormone (ACTH) through summer and winter to assess adrenal function under duress. Serial blood and fecal samples were analyzed. Radioimmunoassay indicated a 3-fold increase in serum cortisol 90 minutes post injection in both seasons and 10-17-fold increases in fecal corticosterone at 28 hours in summer and winter. Acute response in juvenile's adrenal glands was detectable in feces 24 hours after injection. These and additional results suggested that adrenal output of corticosterone in juvenile sea lions was strong during winter; winter may pose a greater environmental challenge.

Mazzaro, L.M., D.J. St. Aubin, R.M. Clark, and H.C. Furr. 2003. Comparison of serum retinol, tocopheral and lipid levels in free-ranging Steller sea lions and their prey from the eastern and western stocks. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

> This study assessed the levels of vitamin A and E in eastern and western stocks of SSLs and their prey as a measure of the role that the vitamins play in SSL reproductive success. Statistical differences in vitamin levels were found between the two stocks but they were opposite expected values. Vitamin levels were within normal ranges for captive and wild animals and pollock contained as much or more of the two vitamins as do other prey. They conclude that neither vitamin A nor E deficiency appeared to be a problem.

McPhee, C.P. 2001. Heart rate as a monitor for metabolic rate in captive juvenile Steller sea lions (*Eumetopias jubatus*). M.S. thesis. University of British Columbia. 86p.

> The potential use of heart rate to monitor energy expenditure in free-ranging SSLs was investigated by establishing whether a relationship exists between heart rate and oxygen consumption in captive sea lions while swimming and resting. Four trained SSLs (2 males and 2 females; mass 87.4 -194.4 kg; ages 16 months-3 years) were equipped with a data-logger and two dorsal electrodes to record ECG. The resulting relationship differed significantly from the relationship derived while the animal was fasted, indicating that digestion may alter the relationship between heart rate and oxygen consumption. Fasting and feeding intervals must therefore be taken into account when considering the use heart rate to oxygen consumption relationships to estimate energy expenditure from heart rate of free-ranging sea lions. The study did demonstrate that heart rate can potentially be used to monitor energy consumption in free-ranging Steller sea lions.

McPhee, J.M., D.A.S. Rosen, R.D. Andrews, and A.W. Trites. 2003. Predicting metabolic rate from heart rate for juvenile Steller sea lions *Eumetopias jubatus*. Journal of Experimental Biology 206: 1941-1951.

> Same information as in McPhee (2001) but in journal form.

Mellish, J.-A., E., and M. Horning. 2005. Fuel selection in fasting juvenile Steller sea lions (*Eumetopias jubatus*): Are leaner animals the losers? *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

> Four wild juvenile SSLs were fasted and re-fed in the temporary captive facility at the ASLC in spring 2004. Mass, morphometrics, body composition, hematology, blood chemistry, and blubber thickness were monitored. Animals lost 0.5% body mass/day while fasting up to 13 days; the two smallest animals metabolized protein while the two largest metabolized fat. Ultrasound measures indicated the site of greatest blubber mobilization to be immediately posterior to the fore-flippers in all animals. Mass gain in the recovery period (up to 12 days) was 0.7% body mass/day.

Mellish J.E., and M. Horning. In review. Differential fuel selection in fasting juvenile Steller sea lions (*Eumetopias jubatus*): are leaner animals the losers? Comparative Biochemistry and Physiology A.

> This paper is in manuscript form and being reviewed for publication at the journal; it was not available to be summarized for this review.

Miller, E.H., K. W. Pitcher, and T.R. Loughlin. 2000. Bacular size, growth, and allometry in the largest extant otariid, the Steller sea lion (*Eumetopias jubatus*). Journal of Mammalogy 81 (1):134-144.

> The authors studied bacular size and relative growth in SSLs. Bacula roughly tripled in length and increased 30-fold in mass between 1 and 8 years of age. Allometric relationships changed over development; bacular length and mass changed from being initially positively allometric to body length to negatively allometric and isometric, respectively; bacular mass and thickness were positively allometric to body length throughout life, and apical growth was isometric then was positively allometric to bacular length. The baculum of SSLs is about the same length relative to body length as in other adult male otariids but is about twice the density, presumably to increase strength.

Miller, E. H., Ø. Wiig and A. W. Trites. 2005. International survey of scientific collections of Steller sea lions. Fisheries Centre Research Reports 13 (6), 68 pp.

> The authors report on their survey to examine or obtain information on specimens of SSLs in museums and other collections, including 1740 specimens (complete or partial skulls) in 44 collections in Canada, Germany, Japan, the Netherlands, Russia, the United Kingdom, and the United States. At least several hundred other specimens exist, mainly in Japan and Russia. Collection dates range from 1842 to the present. Geographically, specimens are well represented in both western and eastern regions: 509 and 956, respectively. Collection localities within Alaskan regions 2 (eastern Gulf of Alaska) to 8 (eastern Bering Sea) are represented by 290 specimens; another 566 specimens are from Japan and Russia and 462 from Alaska region 1 (Southeastern Alaska) southwards.

Myers, M., S. Atkinson, and L. Rea. 2001. Development of an index for metabolic condition in Steller sea lions (*Eumetopias jubatus*) utilizing leptin hormone concentrations. Page 153, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

The objective of this study was to develop and investigate the suitability of using blood samples and the subsequent analysis of leptin hormone concentrations as a correlate to fitness in wild SSLs. Some results were presented which validate their conclusion that leptin may be a useful indicator of body size and condition.

Myers, M. J., L.D. Rea, K.L. Mashburn, and S. Atkinson. 2003. Thyroid and cortisol hormones as an indication of metabolic function and well-being in Steller sea lions (*Eumetopis jubatus*). *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

The purpose of this study was to investigate serum thyroid and cortisol concentrations in captive and wild SSLs. The information provided is similar to studies described above by Atkinson et al. and Mashburn et al.

Noren, D. P. 2003. Fasting capabilities in weaned juvenile Steller sea lions: influence of body condition and activity. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

The author developed a dynamic state variable model to explain how protein and lipid reserve allocation and maximum fasting duration are influenced by body condition and activity. Different model scenarios were discussed. Maximum fasting duration for juveniles with <10 % fat of total body mass had limited fasting capabilities (<10 days) when 70% of each day is spent in water. The results suggested that lean juvenile SSLs may be especially susceptible to relatively short term reductions in prey availability due to their limited fasting capabilities.

Noren, D.P., L. Rea, and T.R. Loughlin. Fasting capabilities of unsuccessfully foraging weaned juvenile Steller sea lions: Influence of body condition and environment. Draft ms ready for submission in December 2005.

Similar to Noren (2003) above, this draft manuscript is an effort to explain how protein and fat reserve allocation and maximum fasting duration are influenced by body condition and activity. A dynamic state variable model was developed which incorporated the independent effects of body mass and protein mass (the two state variables) on juvenile SSL survival and accounts for fitness consequences of utilizing either fat or protein during the fast. Predictions of fat and protein allocation by the model were not significantly different from body composition changes measured in fasting captive juvenile and sub-adult Steller sea lions. The results predicted that maximum fasting duration decreases with increased time spent in the water. Furthermore, animals with lower percentage fat of total body mass (%TBF) had limited fasting abilities. Fat and protein allocation were also influenced by %TBF, with leaner sea lions catabolizing higher levels of protein. The results suggested that lean juvenile SSLs may be especially susceptible to relatively short term reductions in prey availability due to their limited fasting abilities.

Olawale, K.O., R.J. Petrell, D.G. Michelson, A.W. Trites. 2005. The dielectric properties of the cranial skin of five young captive Steller sea lions (*Eumetopias jubatus*) and a similar number of young domestic pigs (*Sus scrofa*) and sheep (*Ovis aries*) between 0.1 and 10 GHz. Physiological Measurement 26: 627-637.

> To aid in the development of a long-range subcutaneous radio frequency identification tag to monitor the fate of sea lion pups (see Dunford et al., 2003 in the Life History—Sundry Theme), the dielectric properties of the cranial skin of young female otariids, and possible test subjects of similar size and age, or pigs and sheep, were obtained over a frequency range of 0.1–10 GHz at the base of their heads where the tag will be implanted. The resulting curves were similar in shape to adult human skin data, but the values were generally lower. Between subjects, variations were noted in all the species. Circuitry for the RF-ID tag is being designed to account for antenna de-tuning as a result of the skin and the variation in dielectric properties.

Perlov, A. S. and S. V. Zadal'skiy. 2001. Age difference of the morphological indicators and features of sexual dimorphism of Steller sea lions during postnatal ontogenesis. Izvestiya TINRO 128(3):940-962. In Russian with English abstract.

> This is a short abstract in Russian with an English translation which is difficult to follow. Apparently 20 morphological indices were measured in male and female SSLs of different ages (pups to >10 years of age). Growth of female organs occurred from birth to about 4 years of age and for males they increased to about 5-6 years of age, slowed, then increased again to 7-9 years of age and stopped at 10. Sexual dimorphism is obvious after 4 years of age in males.

Perlov, A. S. and S. V. Zadal'skiy. 2001. Morpho-ecological aspects of the postnatal ontogeny of Steller sea lions (*Eumetopias jubatus* Schreb., 1776). Izvestiya TINRO 128(3):970-981. In Russian with English abstract.

> This too is a short abstract in Russian with an English translation which is difficult to follow. The abstract deals generally with the trend in growth of organ systems in male and female SSLs with age. Some systems decreased with age, others increased, were stable, or 'pulsed.' For example they state that for males most systems decrease with age but the index for the diaphragm increases and the spleen is stable. Not much else useful is provided.

Petrauskas, L. 2005. Variation of fecal corticosterone concentrations in captive Steller sea lions (*Eumetopias jubatus*) in relation to season, social status, and behavior. In: Marine science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

> The study was designed to monitor fecal corticosterone concentrations in the two female and one male captive SSL at the ASLC through scat analysis over three years. There was a significant difference between summer and winter corticosterone concentration in the two females. Higher concentrations correlated significantly with less attentive behavior during training for the male.

Petrauskas, L., M. Horning, P. Tuomi, and S. Atkinson. 2005. Non-invasive monitoring of rehabilitation procedures in California and Steller sea lions. Chapter 18, pages 177-186, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

> This study validated existing methods of steroid hormone analysis in marine mammals to enable the quantification of stress in rehabilitated California and SSLs. Four experimental categories were opportunistically selected from existing procedures on California sea lions during rehabilitation at The Marine Mammal Center, Sausalito, CA: (Group A: restraint blood draw, Group B: anesthesia, no surgery, Group C: anesthesia, minor surgery, Group D: anesthesia, major invasive surgery. Feces were collected opportunistically up to 72 hours prior and 72 hours post procedure for corticosterone analysis. Group C had a significant difference between fecal corticosterone concentrations before and after surgical procedures, suggesting that fecal corticosterone concentrations may be used as a non-invasive tool for the assessment of stress in rehabilitated sea lions subjected to minor surgical procedures.

Petrauskas, L., P. Tuomi, and S. Atkinson. 2004. Noninvasive monitoring of stress hormone levels of a female Steller sea lion (*Eumetopias jubatus*) pup undergoing rehabilitation. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> Similar information as in Petrauskas et al. (2005) above with emphasis on one rehabilitated SSL held at the ASLC..

Pitcher, K. W., D. G. Calkins, and G. W. Pendleton. 2000. Steller sea lion body condition indices. Marine Mammal Science 16:427-436.

> The authors evaluated various measurements of mass, morphology, and blubber thickness from 523 SSLs collected in Alaska between 1979-1989 by ADFG as indices of fatness by correlation with the percentage of total body mass comprised by the sculp (%SCULP). They concluded that length/mass/dorsal blubber thickness (LMD-index) was the best index evaluated because it had a relatively high correlation coefficient, had a linear relationship with %SCULP, and the intercept term was not different from 0. They suggested the development of a LMD-index for otariids would likely reduce the unexplained variation in the index. They also developed a multiple regression model for predicting %SCULP with LMD-index and functions of sex, age, and season as predictor variables. SSLs <5 yr of age had higher %SCULP values than those 25 years old. %SCULP declined with age for sea lions <5 yr. Both younger and older males were fatter during the winter/spring period than during summer/ fall. Females of both age classes had similar %SCULP values throughout the year. They conclude that SSLs are relatively lean pinnipeds based on estimates of blubber and total body lipids that ranged from 5% to 17% of total body mass.

Rea, L.D., C.A. Beck, V.K. Stegall, S.D. Farley, K.B. Beckmen, and K.W. Pitcher. 2005. Got milk? –assembling physiological indices of weaning for Steller sea lions. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

> This presentation summarized numerous indices to try and determine when SSLs wean. The indices included presence of milk in the stomach, presence of specific parasites which have a fish intermediary, high blubber or serum levels of certain fatty acids, and changes in levels of stable isotopes. In combination with all the indices, the authors suggest that a higher

proportion of pups are nursed into their second year in the eastern population compared to the western.

Rea, L.D., and T.R. Nagy 2000. Changes in serum leptin levels during fasting and food limitation in Steller sea lions (*Eumetopias jubatus*). Pages 171-175, *in* C.L.K. Baer (ed.), Proceedings of the Third Comparative Nutrition Society Symposium, No. 3, Pacific Grove, California, August 4-9, 2000.

Leptin, also commonly known as the *ob* protein, is a peptide hormone secreted by adipocytes which has been shown to have a role in energy metabolism and food intake in rodents and man. Although the specific molecular and biochemical pathways of action of this hormone are still the-focus of intensive study, it is thought that leptin acts as a negative feedback signal to satiety centers in the hypothalamus to regulate body energy stores. When adipose reserves are abundant, high levels of leptin are secreted and signal the brain to regulate energy balance (i.e. decrease food intake). These authors investigated how serum leptin concentrations change in response to food deprivation in SSLs which undergo periods of voluntary natural fasting in the wild. Female SSLs fast for 1 to 2 weeks during the breeding season in order to give birth and nurse their young. Males fast while defending territory during the breeding season. Blood samples were collected during experimental food limitation and complete fasting trials conducted on subadult SSLs held at the Vancouver Aquarium. Leptin concentrations were determined by radio-immunoassay and body fat content was determined by the dilution of deuterium oxide. Males and females showed significantly different patterns of change in serum leptin concentration during fasting experiments. The-three male sea lions showed a consistent decrease in serum leptin levels during the 9 to 14 day fasting period, while the two female sea lions shown progressive increase in serum leptin concentrations over the same period of fasting. Animals with greater body fat mass did not circulate higher levels of leptin as would be expected if leptin was produced strictly in proportion to the number and volume of adipocytes.

Rea, L.D., K.W. Pitcher, S.D. Farley. 2003. Percent total body lipid content increases in Steller sea lion (*Eumetopias jubatus*) pups throughout the first year of life in a similar pattern to other otariid pups. P. 135, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

This abstract discusses a study to estimate percent total body lipid content (TBL) of SSL pups 2-11 month old using deuterium dilution technique. Samples were from Southeast Alaska (98), Prince William Sound (72), Gulf of Alaska (14) and the Aleutian Islands (39). Mean TBL increased during the first year of development from ~9% to ~27% in late lactation. Values at early and mid-lactation were similar to reported values for other otariids. The authors concluded that there was no evidence of poor body condition in SSL pups during the first year of development.

Rea, L.D., D.A.S. Rosen and A.W. Trites. 2000. Metabolic response to fasting in 6-week-old Steller sea lion pups (*Eumetopias jubatus*). Canadian Journal of Zoology 78:890-894.

Four SSLs aged 6 weeks were fasted for 2.5 days to determine how young pups mobilize energy reserves during short periods of fasting similar to those experienced in the wild. At 6 weeks of age, the pups lost ~5.1% of their body mass during 2 days of fasting, with an average daily mass loss of 0.7 kg/d. Plasma blood urea nitrogen (BUN) concentration increased significantly after 2.5 days of fasting. Plasma ketone body (b-HBA) concentrations of the 6-week-old pups increased significantly between 0.5 and 1.5 days of fasting. There was no significant change in mean plasma concentration beyond 1.5 d, owing to variable individual responses to extended fasting. Six-week-old SSL pups showed blood chemistry consistent with metabolic adaptation to fasting within 16 hours but were unable to sustain a protein-sparing metabolism for a prolonged period. The pups appeared to revert to protein catabolism after only 2.5 days of fasting. This infers a decrease in lipid catabolism that might be due to the depletion of available lipid resources.

Richmond, J.P. 2004. Ontogeny of total body oxygen stores and aerobic dive potential in the Steller sea lion (*Eumetopias jubatus*). M.S. thesis, University of Alaska, Anchorage. 126 pp.

This Master's degree study examined the physiological development of 235 free-ranging juvenile SSLs (1 - 29 months) by measuring blood and muscle oxygen stores, and calculating aerobic dive limits. The hormone erythropoietin (EPO) is responsible for the increased production of red blood cells in response to tissue hypoxia. The author states that while the role of EPO in hematological development has been established in humans and terrestrial mammals, this relationship has never been examined in marine mammals that rely heavily on stored oxygen to maintain aerobic metabolism while diving. Hematocrit (Hct), hemoglobin (Hb), and red blood cell (RBC) counts were also measured, and mean corpuscular hemoglobin content (MCHC), mean corpuscular volume (MCV), and mean corpuscular hemoglobin (MCV) values determined. Erythropoietin and most hematological parameters varied with age. Hematocrit, Hb, RBC, and MCHC decreased after birth, reached their lowest values at two to three months of age, and then increased to values similar to those of adults by five months of age. While all oxygen stores increased with age, blood developed faster than muscle, perhaps as a result of enhanced EPO production early in year-one. Mass specific total body oxygen stores did not reach adult female values until juveniles were 21 months of age, and never attained adult male values. As a result, juvenile aerobic dive limits remained significantly lower than those of adults, suggesting that the physiology of juvenile SSLs is immature and may constrain dive behavior well beyond 2 years of age.

Richmond, J.P., J.M. Burns, and L.D. Rea. 2003. Developmental trends in erythropoietin: The diving force behind blood oxygen store expansion. P. 137, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p .

Similar information as in Richmond's (2004) Master's degree study above.

Richmond, J.P., J. M. Burns, and L. D. Rea. 2004. Examination of blood and muscle development in the Steller sea lion (*Eumetopias jubatus*): Implications for diving and foraging ability. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Similar information as in Richmond's (2004) Master's degree study above.

Richmond, J.P., J. M. Burns, and L. D. Rea. 2006. Ontogeny of total oxygen stores and aerobic dive potential in Steller sea lions (*Eumetopias jubatus*). Journal of Comparative Physiology B: (early on-line source: DOI 10.1007/s00360-006-0076-9.).

Much of the information here is part of Richmond's Master's thesis (2004) and appears in the presentations and thesis above. This study examined the development of dive physiology in SSLs by measuring total body oxygen stores in animals from 1 to 29 months of age and used these measurements to estimate aerobic dive limit (ADL). Blood oxygen stores were determined by measuring hematocrit, hemoglobin, and plasma volume, while muscle oxygen stores were determined by measuring myoglobin concentration and total muscle mass. Around 2 years of age, juveniles attained mass specific total body oxygen stores that were similar to those of adult females; however, their estimated ADL remained less than that of adults, most likely due to their smaller size and higher mass specific metabolic rates. The results indicated that juvenile SSL oxygen stores remain immature for more than a year, and therefore may constrain dive behavior during the transition to nutritional independence.

Richmond, J.P., J.M. Burns, L.D. Rea, K. Mashburn. 2005. Postnatal ontogeny of erythropoietin and hematology in free-ranging Steller sea lions (*Eumetopias jubatus*). General and Comparative Endocrinology. 141:240-247.

Same information as in Richmond (2004) above but in journal form.

Richmond, J. P. and L. D. Rea. 2001. Nutritional blood chemistry provides clues to the feeding status of young of the year and juvenile Steller sea lions (*Eumetopias jubatus*). P. 179, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

The authors used plasma ketone body concentrations in conjunction with blood urea nitrogen (BUN) values from captive and wild SSL pups to 12 months of age and juveniles as an indicator of fasting. Plasma values for these parameters were provided in the abstract. Contrasting values for eastern and western stock animals suggested that juveniles in the west were relying on mobilization of body protein stores for energy as seen during fasting.

Rivera, P.M., L.D. Rea, P. Richmond, and V.K. Stegall. 2005. Nutritional indices of young Steller sea lions in Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

The authors analyzed 307 blood samples collected during July 1998 to April 2005 throughout the SSL range in Alaska for blood concentration of ketone bodies, blood urea nitrogen (BUN), and non-esterified fatty acids (NEFA) to monitor health and condition. Values for each parameter were provided in the abstract by region and age. Their results led the authors to conclude that these indicators of increased fasting did not appear to result in poor body condition and were consistent with previous findings that pups from western stocks were larger and maintained greater fat reserves.

Rosen, D.A.S., G.D. Hastie, and A.W. Trites. 2004. Searching for stress: Hematological indicators of nutritional inadequacies in Steller sea lions. Symposia of the Comparative Nutrition Society 2004. No. 5, Pp 145-149.

This experiment examined the response of a suite of blood parameters to experimentally induced nutritional stress in a group of captive SSLs. The goal was to identify a suite of parameters that could be used to diagnose comparable conditions among wild sea lions. The experiments were conducted with four captive female SSLs that were alternated between isocaloric diets of Atka mackerel and herring. The level of food intake was set at a level estimated to produce a 10-15% loss of initial body mass over the 29-day trials. Body mass was measured daily and body composition was determined at the start and end of each trial by deuterium dilution technique. Blood samples were also obtained at the beginning and end of each trial for clinical analyses. Nine of the blood parameters measured showed consistent changes over the 29-day period of induced nutritional stress. White blood cell counts, platelet counts, phosphorous levels, alkaline phosphatase levels, and serum Fe levels all showed consistent decreases, whilst red blood cell counts, hemoglobin levels, hematocrit levels, and gamma GT levels, showed consistent increases. Only blood urea nitrogen (BUN) showed a significantly different response in relation to diet levels; a consistent increase on the Atka mackerel diet and a consistent decrease on the herring diet. The study identified consistent changes in certain blood parameters over this type of simulated nutritional stress, including differences related to prey species. Although the majority of blood parameters measured in this study showed little consistency in changes over the 29-day period of simulated nutritional stress, nine of the parameters did show consistent changes across the trials.

Rosen, D.A.S. and A.W. Trites. 2002. Cost of transport in Steller sea lions, *Eumetopias jubatus*. Marine Mammal Science 18(2):513-524.

This study measured the oxygen consumption of three juvenile SSLs swimming in a flume tank at velocities up to 2.2 m/sec. Minimum measured cost of transport ranged from 3.5-5.3 J/kg/ m, and was reached at swimming speeds of 1.7-2.1 m/s. These cost-of-transport values were higher than those reported for other marine mammals. However, once differences in stationary metabolic rate were accounted for, the locomotor costs for the SSLs were commensurate with those of other marine mammals. Locomotor costs appeared to be directly proportional to body mass.

Rosen, D.A.S. and A.W. Trites. 2003. No evidence for bioenergetic interaction between digestion and thermoregulation in Steller sea lions, *Eumetopias jubatus*. Physiological and Biochemical Zoology. 76:899-906.

The increase in metabolism during digestion—the heat increment of feeding—is often regarded as an energetic waste product. However, it has been suggested that this energy could offset thermoregulatory costs in cold environments. This study investigated this possibility by measuring the rate of oxygen consumption of four juvenile SSLs before and after they ingested a meal in water temperatures of 2– 8 degrees C. Rates of oxygen consumption of fasted and fed animals increased in parallel with decreasing water temperature, such that the apparent heat increment of feeding did not change with water temperature. These results suggested that SSLs did not use the heat released during digestion to offset thermoregulatory costs

Rosen, DAS, A.J. Winship, and L. Hoopes. In press. Thermal and digestive constraints to foraging in marine mammals. Special proceedings publication "Environmental Constraints upon the Locomotion and Energetics of Aquatic Organisms". Springer-Verlag.

This paper was not seen for review in this synopsis.

Stegall, V.K., L.D. Rea, and M.A. Castellini. 2005. Pectoral muscle development in free-ranging Steller sea lion (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Existing data show that fast and slow twitch muscle fiber diameters of nutritionally deprived porpoises is smaller than in robust animals. This study aimed to provide baseline measurements for future determination of similar differences in muscle fibers in nutritionally stressed SSLs. Pectoral muscle biopsies were collected from wild SSL pups and juveniles in both stocks in Alaska. Results of the analysis were provided in the abstract from which subsequent comparisons can be made.

Stelle, L.L., R.W. Blake and A.W. Trites. 2000. Hydrodynamic drag in Steller sea lions (*Eumetopias jubatus*). Journal of Experimental Biology 203:1915-1923.

Drag forces acting on SSLs were investigated from 'deceleration during glide' measurements. A total of 66 glides from six juvenile sea lions yielded a mean drag coefficient of 0.0056 at a mean Reynolds number of 5.5 $x10^6$. The drag values indicated that the boundary layer is largely turbulent for SSLs swimming at these Reynolds numbers, which are past the point of expected transition from laminar to turbulent flow. The position of maximum thickness (at 34 % of the body length measured from the tip of the nose) was more anterior than for a 'laminar' profile, supporting the idea that there is little laminar flow. SSLs' streamlined shape helps to delay flow separation, reducing total drag. In addition, turbulent boundary layers are more stable than laminar ones.

Trites, A.W., K. Hunt, S.K. Wasser, and K.M. Wynne. 2003. Assessing the physiological stress of Steller sea lions in Alaska using fecal hormone analysis. Final Report to the North Pacific Marine research program, Grant #00-0045. School of Fisheries and Ocean Sciences, Univ. of Alaska Fairbanks 24 pp.

This contract report summarized work aimed to validate a fecal glucocorticoid assay for SSLs and to estimate stress hormone concentrations from fecal samples collected from sea lions in different regions of Alaska. Validation was undertaken with an adrenocorticotropic hormone (ACTH) challenge. Feces were collected from captive SSLs (two males and two females) for two days prior to injection with ACTH, and for four or more days post-injection. Feces were freeze-dried, extracted with a methanol vortex method, and assayed for glucocorticoids. Fecal samples were also collected in the wild from three separate groups of animals during summer: mature females, mature males and immature animals. In addition, scats were collected in winter (Dec-Mar) and summer (May-Sep) from Southeast Alaska and the Gulf of Alaska. Diets and stress hormone concentrations were compared by season and region to test whether there was a relationship between diet and stress. The captive study showed that fecal glucocorticoid concentrations can be reliably measured in SSL scats. From the summer field study, they found that bulls had higher summer concentrations of stress hormones on average than mature females, which were in turn higher than those of immature sea lions. In general, mean consumption of prey (all sites combined) was higher in winter than in summer, as were mean stress hormone concentrations. Similarly, consumption was higher in Southeast Alaska than in the Gulf of Alaska, as too were stress hormone concentrations. The lower levels of stress hormones detected in the Gulf of Alaska and the relatively high energy content of their diets in 2000 is inconsistent with the nutritional stress hypothesis.

Trites, A.W., K.E. Hunt, K.M. Wynne, and S.K. Wasser. 2004. Non-invasive assessment of possible nutritional stress in Steller sea lions (*Eumetopias jubatus*) using fecal glucocorticoid and dietary analyses. Society of Integrative and Comparative Biologists. New Orleans, LA. January 2004.

This is a small poster at a symposium presenting part of the information in Final Report by Trites et al. (2003) above.

Trites, A.W. and R.A.H. Jonker. 2000. Morphometric measurements and body conditions of healthy and starveling Steller sea lion pups (*Eumetopias jubatus*). Aquatic Mammals 26: 151-157.

> The thickness and weight of skin, blubber, and body core were measured from 12 dead SSL pups with a wide range of body sizes and condition to compare relative body condition of healthy and starved pups. Skin and blubber were not uniformly thick over the body surface; skin was thinnest on the head and around the flippers and thicker towards the rump. Blubber was thickest in the ventral side increasing from snout to mid-truck. Starvlings lost an estimated 43% of their body mass before dying. Girth was found not to be a good predictor of body condition for SSL pups.

Wiig, Ø., E.H. Miller, and A.W. Trites. 2004. International survey of scientific skull collections of Steller sea lions (*Eumetopias jubatus*). Pages 149 – 150, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

> Same information as in Miller et al. (2005) above.

Williams, T.M. 2005. The bioenergetics of Steller sea lions: a marine predator built to eat. Chapter 9, pages 77-82, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

> The author measured maintenance energetic demands and gastrointestinal tract morphology of adult SSLs. Two captive adult, female SSLs (210 kg) were trained to breathe into a metabolic hood while resting quietly on the water surface of a pool. The results showed that the metabolic rate of adult SSLs did not change with season; average metabolic rate for SL1 was ~6.69 mlO_2./kg/min and for SL2 was ~8.23 $mlO_{2/}$.kg/.min. This translated into an average maintenance caloric requirement of 10,570 kcal/day, a value that was 2.7 times that predicted for a terrestrial mammal of similar size. Small intestine length of Steller sea lions averaged 66.8 ± 6.4 m (n = 3 adult females) and was 2.5 times the length predicted for other marine mammals. Carnivory, decreased assimilation during periods of submergence, as well as diet composition likely contributed to the development of a comparatively long gastrointestinal tract in marine mammals in general and Steller sea lions in particular.

Williams, T.M. 2005. Reproductive energetics of sea lions: implications for the size of protected areas around Steller sea lion rookeries. Chapter 10, pages 83-89, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

> The author compared energetic demands of adult California sea lions during non-reproductive (n = 3 females), and reproductive (n = 2 sea lions) periods. Monthly measurements included metabolic rate, blood hormone levels, body condition (blubber thickness and girths), and caloric intake. The results showed that metabolic rate was positively correlated with blood progesterone concentration in non-pregnant/non-lactating sea lions. Resting metabolic rate of California sea lions varied little with pregnancy and lactation. Maintenance caloric demand remained stable throughout the period of lactation and post-weaning. In contrast, caloric intake based on daily fish consumption showed marked changes during the reproductive cycle, particularly during lactation and post-weaning when caloric intake increased to 3.6 times baseline levels. Using the resting metabolic rate of the SSLs as a baseline, the impact of these otariids on local prey resources may change by a factor of 4 during the period of

lactation, thereby affecting the estimated size of protected marine areas required around rookeries.

Willis, K., M. Horning, D.A.S. Rosen and A.W. Trites. 2005. Spatial variation of heat flux in Steller sea lions: evidence for consistent avenues of heat exchange along the body trunk. Journal of Experimental Marine Biology and Ecology 315:163-175.

Similar information as in Willis and Horning (2005) below but in journal form.

Willis, K., and M. Horning. 2005. A novel approach to measuring heat flux in swimming animals. Journal of Experimental Marine Biology and Ecology 315: 147-162.

This paper is the techniques presentation for the Willis publications below. They described a design for long-term or removable attachment of heat flux sensors (HFSs) to stationary or swimming animals in water that enables collection of heat flux data on both captive and free-ranging pinnipeds. HFSs were modified to allow for independent, continuous, and long-term or removable attachment to study animals. Effects were insulative and consistent across water temperatures and flow speeds, resulting in a correction factor of 3.42. This correction factor was applied to all measurements of heat flux from animal experiments to account for the thermal resistance of HFSs and insulative effects of the attachment mechanism.

Willis, K., and M. Horning. 2005. Thermoregulation in swimming Steller sea lions. Chapter 11, pages 90-100, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Heat flux and skin temperature data were collected from two captive SSLs using heat flux sensors (HFSs) with embedded thermistors. Optimal sensor placement was established using infrared thermography to locate the major areas of heat flux along the surface of the animals. Experiments were conducted on swimming animals at the ASLC with and without a drag harness. All heat flux measurements were corrected by a previously determined correction factor of 3.42 to account for insulative effects of the HFSs and attachment mechanism. Heat flux from shoulders and hips was consistently greater than from mid-trunk and axillary areas, suggesting that certain areas of the body are preferentially used to offload excess heat. Mean heat flux for animals swimming with a drag harness was significantly greater than for unencumbered animals, indicating a likely increase in heat production beyond minimum heat loss. Thus, thermal stress may not constitute significant costs for SSLs swimming under conditions of increased drag at speeds of approximately 1 m/s in water temperatures of approximately 8.0 °C.

Winship, A.J., A.W. Trites and D.G. Calkins. 2001. Growth in body size of Steller sea lions (*Eumetopias jubatus*). Journal of Mammalogy 82:500-519.

Growth models (mass and length) were constructed for male, female, and pregnant female SSLs shot on rookeries or haulouts, or in coastal waters of southeastern Alaska, the Gulf of Alaska, or the Bering Sea ice edge between 1976 and 1989. The Richards model best described growth in body length and mass. Females with fetuses were 3 cm longer and 28 kg heavier on average than females of the same age without fetuses. Males grew in length over a longer period than did females and exhibited a growth spurt in mass that coincided with sexual maturity between 5 and 7 years of age. Average predicted standard lengths of males

and females greater than 12 years of age were 3.04 and 2.32 m, respectively, and average predicted masses were 681 and 273 kg, respectively. Maximum recorded mass was 910 kg for an adult male. Males achieved 90% of their asymptotic length and mass by 8 and 9 years of age, respectively, compared with 4 and 13 years, respectively, for females. Residuals of the size-at age models indicated seasonal changes in growth rates. Young animals (<6 years old) and adult males grew little during the breeding season (May–July), and adult males did not resume growth until sometime after November.

Zadalskiy, S.V., and A.S. Perlov. 2002. Age variability properties of Steller sea lions interior characteristics. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

The author measured variability in morphology of individual SSLs by sex and age. Various organs were measured as well as whole animals. Numerous sexual and age-related differences were reported. They concluded that the species in general is distinguished by a decline in variability of all characters with increasing age and that population aspects of variability should be studied in sexually mature individuals.

(This page intentionally left blank)

THEME 1 (b) – LIFE HISTORY – GENETICS

SUMMARY:

This theme contains 23 articles including 11 presentations at scientific meetings, four theses or dissertations, and 8 papers in peer-reviewed journals or book chapters. There were major advancements in this theme during the period 2000-2005 including continuation of population genetics and gene flow between stocks using nuclear and mitochondrial (mt) DNA in Bickham's laboratory at Texas A&M University and at the NMFS Southwest Fisheries Science Center (SWFSC). Bickham's group produced 2 thesis, 3 published papers, and numerous presentations at symposia. The SWFSC produced three talks and one draft manuscript submitted for publication in early 2006. Russian work on population genetics using electrophoresis to distinguish allelic frequencies of serum haptoglobin had mixed results which are equivocal and may not be instructive. Scats were used in two studies to identify prey (Deagle et al., 2005) and sea lion haplotype seasonal movements in Alaska (Ream, 2002). An assortment of other studies added to the general understanding of the use of genetics in SSL biology and conservation.

1. Bickham's group studied variations in the three-stock hypothesis. Trujillo's graduate work and subsequent analyses used nuclear DNA to define a third stock suggesting the Commander Islands were part of the new Asian stock (which then was a subdivision of the western stock). Baker used the control region of the mtDNA and a greater sample size from the Commander Islands and other Russian sites and determined that the Asian stock did not include the Commander Islands; they were part of the western stock and were a continuation of Aleutian Islands haplotypes. Bickham's annual report to NMFS and Lambert's honors thesis analyzed the cytochrome b sequence of the mtDNA chain and confirmed the three stock hypothesis but showed that cytochrome b had less heterozygosity than the control region. Harlin-Cognato et al. (2006) used these control-region sequences to investigate the evolutionary history of SSLs and found a series of independent population expansions, contractions and isolations that had analogous results on SSL and other marine and terrestrial species with evidence of four glacial refugia in which populations of SSLs diverged (North America, Alaska, Aleutians, and Eurasia). These events occurred from approximately 60 000 to 180 000 years BP and thus preceded the last glacial maximum. Wynen et al. (2001) examined the historic biogeography of the family Otariidae (which includes SSLs) using cytochrome b and the control region of the mtDNA molecule and found that the family likely originated about 6 million years ago with northern fur seals diverging from the line leading to the remaining fur seals and sea lions.

2. The NMFS SWFSC examined control region mtDNA to estimate dispersal rates between SSL rookeries. One draft paper was submitted for publication in May 2006 on this 5-year study (O'Corry-Crowe et al., in review); in their two presentations (same abstract) they estimated annual dispersal among eastern stock rookeries was 0.1% to 1.0% corresponding to 5- 50 females dispersing each year. Conversely, dispersal rates for the western stock were about 0.01% corresponding to < 1 female per year, suggesting that neighboring rookeries are, in effect, demographically separate entities (O'Corry-Crowe et al., 2003). In another presentation they report mixed-stock origins for one of the new rookeries in Southeast Alaska (O'Corry-Crowe et al., 2005).

3. Additional work using mt and nuclear DNA was contracted by the NMML to Dr. W. Amos of Cambridge University, England, to investigate the importance of inbreeding depression by analyzing genetic material to assess the level and magnitude of inbreeding coefficients based on the possible link between these coefficients and fitness. A manuscript is in press (Hoffman et al., in press) summarizing part of this work which concludes that the designation of a third Asian stock is equivocal.

4. Scats were used in two studies to identify prey (Deagle et al., 2005) and sea lion haplotype seasonal movements in Alaska (Ream, 2002). Ream showed that during winter 98.6% of the SSLs residing in the geographic region of the western stock originated from that stock and that females were the predominate gender identified from summer (72.5%) and winter (61.2%) scat samples.

5. Bowen et al (in press) examined nuclear genetic material as indicators of environmental health. Bowen et al. analyzed the major histocompatibility complex (MHC) and found selective suppression of MHC DRB genes could be indicative of geographically disparate environmental pressures, thereby serving as an immediate and sensitive indicator of population and ecosystem health.   Bozza and Atkinson (2003) used cytokines as a tool in their development of an immunoassay to determine exposure to contaminants.

ANNOTATED BIBLIOGRAPHY – LIFE HISTORY – GENETICS

Baker, A. R. 2003. Variation of mitochondrial control region sequences of Steller sea lions, *Eumetopias jubatus*: the three-stock hypothesis. M.S. thesis, Texas A&M University, College Station, Texas. 55 p.

> The results from this Master's thesis were presented in a scientific journal (Baker et al., 2005) below. The abstract from the thesis reads: Sequence variation of a 238 base pair (bp) segment of the mitochondrial control region was analyzed for 1,568 SSLs (2.8% of the estimated species population) sampled from 50 rookeries representing nearly every locality at which SSLs are known to breed in significant numbers. Haplotype diversity ($H = 0.9164 \pm 0.0035$) was high and nucleotide diversity ($\pi = 0.00967 \pm 0.00586$) was moderate. No evidence was observed for significant genetic bottleneck effects. Rookeries were grouped into regions and stocks to examine structure at different spatial scales. F- and Φ-statistics were computed for all pair-wise comparisons of rookeries, regions and stocks. Significant ($P \leq 0.05$) divergence of eastern stock (southeastern Alaska to California) animals from western stock animals was supported in analyses at all spatial scales. Likewise, rookeries and regions from Asia were found to be significantly different from all other western stock rookeries. This was most clearly demonstrated using Φ-statistics at the regional level. The Commander Islands clearly associate with Alaskan western stock rookeries, not with the Asian rookeries. Within each of the three stocks there is significant isolation by distance among rookeries. This relationship does not hold for inter-stock comparisons indicating that there are important barriers to gene flow among stocks. Mitochondrial DNA analysis supports the recognition of three stocks for appropriate conservation of the species. The currently recognized eastern stock is unaffected, but the western stock is now partitioned west of the Commander Islands yielding a western stock which ranges from Prince William Sound west to the Commander Islands, and an Asian stock including rookeries from the Kamchatka Peninsula, Kuril Islands, and Sea of Okhotsk.

Baker, A.R., T.R. Loughlin, V. Burkanov, C.W. Matson, R.G. Trujillo, D.G. Calkins, J.K. Wickliffe, and J.W. Bickham. 2005. Variation of mitochondrial control region sequences of Steller sea lions: The three-stock hypothesis. Journal of Mammalogy 86 (6): 1075-1084.

Similar information as in Baker (2003) above and gives peer review validity in a journal for the three-stock hypothesis.

Bickham, J.W. 2005. Variation in mitochondrial DNA of Steller sea lions: Cytochrome b and control region sequences from juveniles and pups from western stock rookeries. Annual report to National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115. 27 pp.

This is an annual report for a contract to Dr. Bickham from NMFS. Here he presents mtDNA control region sequences for 173 Steller sea lions from Alaskan western stock rookeries, cytochrome *b* (cyt *b*) sequences from 161 Steller sea lions from western stock rookeries, and control region sequences from 105 juvenile Steller sea lions from unknown rookeries. The objectives of the study were to build upon the existing database of control region sequences from pups to further increase the capability to understand population structure in the species, to build upon the existing database of cyt b sequences from pups in order to compare this more conservative mtDNA gene to the faster evolving control region, and to look for evidence of dispersal patterns among juveniles in the early years of their lives. Dr. Bickham's group now has complete cytochrome b sequences for 901 Steller sea lions including 878 pups from rookeries and has identified a total of 34 haplotypes, far fewer than the 151 haplotypes observed from the 2,071 animals examined for the control region. There are three common cytochrome b haplotypes: haplotype 1 (N = 355), haplotype 2 (N = 125) and haplotype 3 (N = 295). There are few low frequency haplotypes, which is quite different from the control region dataset in which a large number of low frequency haplotypes occur. Of interest with regard to the cytochrome b dataset is many non-synonymous changes have occurred during the evolution of this molecule.

Bickham, J. R. Trujillo, and T. Loughlin. 2002. Genetic variability and population structure in an endangered marine mammal (*Eumetopias jubatus*. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Abstract of a paper presented at a conference which summarized studies on the population genetics of Steller sea lions through 2001. Mitochondrial DNA control region sequences for more than 1,000 pups were sampled and found to exhibit a distinct phylogeographic break between the western populations from Prince William Sound to Russia, and the eastern populations from Southeast Alaska to California. A second but weaker phylogeographic break occurred between the central populations of the western stock from PWS to the western Aleutian Islands and the Asian populations from the Commander Islands to the Sea of Okhotsk. They refer to these as the Asian and central groups of the western stock. But see Baker et al. (2005, above) for more recent demarcation line of the Asian and central populations.

Bickham, J.W., and T. R. Loughlin. 2003. Genetic variability and population structure in an endangered marine mammal (Steller sea lion, *Eumetopias jubatus).* In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

Same summary information as Bickham et al (2002) above.

Bowen, L., B. Aldridge, T. Gelatt, L. Rea, K. Burek, K. Beckmen, and J.L. Stott. In press. Differential expression of immune response genes in Steller sea lions: a tool for timely identification of alterations in ecosystem health? J. Ecosystem Health.

Characterization of the polygenic and polymorphic features of the Steller sea lion major histocompatibility complex (MHC) provides an ideal window for evaluating immunologic vigor of the population and identifying emergence of new genotypes that reflect ecosystem pressures. MHC genotyping can be used to measure the potential immunologic vigor of a population. However, since ecosystem-induced changes to MHC genotype can be slow to emerge, measurement of differential expression of these genes can potentially provide real-time evidence of immunologic perturbations. MHC DRB genes were cloned and sequenced using peripheral blood mononuclear leukocytes derived from ten Steller sea lions from Southeast Alaska, Prince William Sound and the Aleutian Islands. Nine unique DRB gene sequences were represented in each of ten animals. MHC DRB gene expression was measured in a subset of 6 sea lions. Although DRB in genomic DNA was identical in all individuals, relative levels of 2 expressed DRB mRNA was highly variable. Selective suppression of MHC DRB genes could be indicative of geographically disparate environmental pressures, thereby serving as an immediate and sensitive indicator of population and ecosystem health.

Bozza, M., and S. Atkinson. 2003. Molecular cloning of Steller sea lion (*Eumetopias jubatus*) interleukin-1 beta (IL-1beta) from a LPS-stimulated mononuclear cell cDNA library. P. 22, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p

The authors describe an on-going study to develop species-specific immunoassays using cytokines, which are immune modulators produced in response to infection or inflammation, as a measure of exposure of SSLs to contaminants. The methods include use of total RNA and polymerase chain reaction (PCR) to produce various cytokines whose genetic similarities to other mammalian cytokines suggest immune expression and possible exposure to certain contaminants.

Deagle, B.E., D.J. Tollit, S.N. Jarman, M.A. Hindell, A.W. Trites and N.J. Gales. 2005. Molecular scatology as a tool to study diet: analysis of prey DNA in scats from captive Steller sea lions. Molecular Ecology 14: 1831-1842.

The authors conducted a captive feeding trial to test whether prey DNA could be reliably detected in scat samples from Steller sea lions. Two sea lions were fed a diet of fish (five species) and squid (one species), and DNA was extracted from the soft component of collected scats. Most of the DNA obtained came from the predator, but prey DNA could be amplified using prey-specific primers. The four prey species fed in consistent daily proportions throughout the trial were detected in more than 90% of the scat DNA extractions. Squid and sockeye salmon, which were fed as a relatively small percentage of the daily diet, were detected as reliably as the more abundant diet items. Prey detection was erratic in scats collected when the daily diet was fed in two meals that differed in prey composition, suggesting that prey DNA is passed in meal specific pulses. Prey items that were removed from the diet following one day of feeding were only detected in scats collected within 48 hours of ingestion. Proportions of fish DNA present in eight scat samples (evaluated through the screening of clone libraries) were roughly proportional to the mass of prey items consumed raising the possibility that DNA quantification methods could provide semi-quantitative diet composition data.

Harlin-Cognato, A., J.W. Bickham, T.R. Loughlin, and R.L. Honeycutt. 2006. Glacial refugia and the phylogeography of Steller's sea lion (*Eumetopias jubatus*) in the North Pacific. Journal of Evolutionary Biology 19:955-969.

Mitochondrial DNA sequence data were used to examine the phylogeographic history of SSLs in relation to the presence of Plio-Pleistocene insular refugia. Cytochrome b and control region sequences from 336 SSLs revealed phylogenetic lineages associated with continental refugia south of the ice sheets in North America and Eurasia. Phylogenetic analysis suggested the SSL genetic structure was the result of Pleistocene glacial geology, which caused the elimination and subsequent reappearance of suitable rookery habitat during glacial and interglacial periods. The cyclic nature of geological change produced a series of independent population expansions, contractions and isolations that had analogous results on SSL and other marine and terrestrial species. Their data showed evidence of four glacial refugia in which populations of SSLs diverged. These events occurred from approximately 60 000 to 180 000 years BP and thus preceded the last glacial maximum.

Hoffman, J.I., C. Matson, W. Amos, T. R. Loughlin, and J. W. Bickham. In press. Deep genetic subdivision within a continuously distributed and highly vagile marine mammal, the Steller's sea lion *Eumetopias jubatus*. Molecular Ecology.

Studies using mitochondrial DNA (mtDNA) have shown that an apparently continuous population includes a strong division, yielding two discrete stocks, western and eastern. Based on a weaker split within the western stock, a third Asian stock has also been defined. While these findings indicate strong female philopatry, a recent study using nuclear microsatellite markers found little evidence of any genetic structure, implying extensive paternal gene flow. However, this result was at odds with mark–recapture data, and both sample sizes and genetic resolution were limited. To address these concerns, the authors increased analytical power by genotyping over 700 individuals from across the species' range at 13 highly polymorphic microsatellite loci. They found a clear phylogenetic break between populations of the eastern stock and those of the western and Asian stocks. However, their data provide little support for the classification of a separate Asian stock. These findings show that mtDNA structuring is not due simply to female philopatry, but instead reflects a genuine discontinuity within the range, with implications for both the phylogeography and conservation of SSLs.

Lambert, M. M. 2005. Genetic variation and population structure: using the control region and cytochrome *b* regions to study the phylogeographic distribution of Steller sea lions (*Eumetopias jubatus*). Senior Honors thesis, Texas A&M University, College Station, Texas, ix + 28 pp.

This is a senior honors thesis of a student working in Dr. J. Bickham's laboratory. She used samples and data presented elsewhere by Bickham and his students. The basic core of the study supported the three-stock hypothesis. The primary purpose of this study was to examine the overall population structure of Steller sea lions for wildlife management purposes as well as to compare the effectiveness of cytochrome b to control region in phylogeographic studies. They found that the population structure in cytochrome b mirrored that found in the control region sequences with a delineation of three stocks. However, the resolution in cytochrome b is much lower than in control region. This suggests that the concern regarding homoplasies (a character shared by a set of species but not present in their common ancestor) in control region affecting phylogeographic studies could be unfounded.

O'Corry -Crowe, G., B.L. Taylor, M. Basterretche, T.R. Loughlin, T. Gelatt, and J.W. Bickham. 2003. Using molecular genetics to estimate dispersal rates between Steller sea lion rookeries. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

As the title states, this talk summarized a study using mitochondrial DNA sequence data to estimate dispersal rates between SSL rookeries. A case-specific simulation technique was developed using the genetic data (more base pairs in the mtDNA control region then used by Bickham and his group). Estimates of annual dispersal among eastern stock rookeries were 0.1% to 1.0% corresponding to 5- 50 females dispersing each year. Conversely, dispersal rates for the western stock were about 0.01% corresponding to < 1 female per year, suggesting that neighboring rookeries are, in effect, demographically separate entities.

O'Corry-Crowe, G., T. Gelatt, K. Pitcher, and B Taylor. 2005. Crossing significant boundaries: Evidence of mixed-stock origins of new Steller sea lion, Eumetopias jubatus, rookeries in Southeast A;asla. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This presentation discussed the mtDNA analysis of tissue samples from Southeast Alaska and provided evidence that the new rookeries at Graves Rock (founded in 1998) and White Sisters (founded in 1990) were formed by both western and eastern stock females. The rookery at nearby Hazy Island is likely from eastern stock females.

O'Corry-Crowe, G., B.L. Taylor, T/ Gelatt, T.R. Loughlin, J. Bickham, M. Basterretche, K. Pitcher, and D.P. DeMaster. In review. Demographic independence along ecosystem boundaries in Steller sea lions revealed by mDNA analysis: implications for management of an endangered species. Canadian Journal of Zoology.

This paper is in manuscript form and being reviewed for publication at the journal; it was not available to be summarized for this review.

Ream, R. R. 2002. Molecular ecology of North Pacific otariids: Genetic assessment of northern fur seal and Steller sea lion distributions. Ph.D. dissertation, University of Washington, Seattle, WA, 135 p.

Ream studied molecular markers to determine population distribution, seasonal distribution, and gender distribution among sites and seasons for northern fur seals and Steller sea lions. He found little evidence of genetic differentiation among breeding islands for NFSs. For SSLs, he used mtDNA haplotypes determined from fecal samples (DNA in epithelial cells from the sea lion that are passed in the scat during defecation) and found that during winter 98.6% of the SSLs residing in the geographic region of the western stock originated from that stock and that females were the predominate gender identified from summer (72.5%) and winter (61.2%) scat samples. This last finding suggests that terrestrial sites may be more important to females than to males. He also found that seasonal movement by females among sites is extensive and possibly reflects changes in prey availability or environmental conditions.

Taylor, B., G. O'Corry Crowe, M. Basterretche, T. Loughlin, T. Gellat, J. Bickham, and K. Pitcher. 2003. Using molecular genetics to estimate dispersal rates between Steller sea lion rookeries, p. 160-161 *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Same abstract with only a few word changes as in O'Corry-Crow et al. (2003) above.

Teramitsu, I., Y. Yamamoto, I. Chiba, H. Iwata, S. Tanabe, Y. Fujise, A. Kazusaka, F. Akahori and S. Fujita. 2000. Identification of novel cytochrome P450 1A genes from five marine mammal species. Aquatic Toxicology 51:145-153.

The cytochrome P450 enzymes (CYPs) comprise a unique superfamily of heme-containing proteins that are bound to the membranes of endoplasmic reticulum. This system is involved in the oxidative metabolism of a wide variety of xenobiotics such as drugs, carcinogens, and environmental chemicals, as well as endogenous substrates such as steroids and fatty acids. The CYPs are known to exist in a wide range of organisms, from bacteria to mammals, and their genes show an extraordinary diversity. In this study, the authors report the identification of novel CYP1A genes from the livers of marine mammals, including Steller sea lions, by using reverse- transcription polymerase chain reaction and present the molecular cloning of CYP1A genes in marine mammals with the establishment of a molecular phylogeny which covers CYP1A genes of various species, ranging widely from terrestrial to marine vertebrates.

Trujillo, R. G. 2001. Macrogeographic variation of nuclear microsatellite loci in an endangered species, *Eumetopias jubatus*. M.S. thesis, Texas A&M Univ., College Station, TX. 56 p.

This is one of the early studies by one of Bickham's graduate students analyzing nuclear microsatellite loci samples from Steller sea lion pups and then comparing the results to earlier studies using mtDNA from Steller sea lion pups. Results were presented at symposia and in journal form (below). Six polymorphic microsatellite loci were analyzed for samples from the Sea of Okhotsk to northern California. Microsatellite diversity was high but levels of subdivision were not as striking as those from mtDNA; no macrogeographic variation was revealed with the microsatellites. He proposed that male-biased gene flow in Steller sea lions may be important in maintaining high levels of genetic diversity.

Trujillo, R.G., J.W. Bickham, and T.R. Loughlin. 2002. Macrogeographic variation of nuclear microsatellite loci in an endangered species, *Eumetopias jubatus*. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Same information as in published paper at Trujillo et al. (2004) below.

Trujillo, R.G., T.R. Loughlin, N.J. Gemmell, J.C. Patton, and J.W. Bickham. 2004. Variation in microsatellite and mtDNA across the range of the Steller sea lion, *Eumetopias jubatus*. Journal of Mammalogy, 85 (2):338-346.

Genetic variation at 6 nuclear microsatellite loci with biparental inheritance and the maternally inherited mitochondrial DNA (mtDNA) was studied at 3 geographic scales (rookeries, regions, and stocks) in SSLs. Genetic variation was high in both nuclear and mtDNA markers as revealed by a near range-wide survey of 21 rookeries. However, population structure was not well defined, and there was no obvious phylogeographic pattern to the distribution of microsatellite alleles. This contrasts with a clear phylogeographic pattern revealed by control-region sequences of mtDNA in which 2 well-differentiated stocks, eastern and western, are defined as well as 2 distinct groups, Asian and central, in the western stock. Effective migration estimates are consistently higher for the nuclear loci than for mtDNA. The difference in patterns between the biparentally and maternally inherited genetic markers can be explained by relatively high male dispersal rates and female philopatry, or else there has been insufficient time since populations have been isolated for the nuclear loci to have diverged. It was recommended that the presently accepted stock structure be retained for management purposes. (See Baker et al., 2005, above for more recent determination of SSL stock structure).

Watanabe, Y., M. Onuma, T. Kariya, T. Ishinazaka, T. Isono, and N. Ohtaishi. 2003. The genetic structure of Steller sea lion which have migrated to Hokkaido. P. 172, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201 p.

This study analyzed mitochondrial DNA (as in Bickham et al. studies) to determine the possible birth islands of SSLs killed in Japan. They obtained 122 samples from which 25 haplotypes were identified, most of which were reported previously by Bickham et al. (1999) as originating from the Kuril Islands. New haplotypes were reported for samples from Hokkaido and they assumed these animals originated at Sakhalin Island

Wynen, L. P., S. D. Goldsworthy, S. J. Insley, M. Adams, J. W. Bickham, J. Francis, J. P. Gallo, A. R. Hoelzel, P. Majluf, R. W. G. White, and R. Slade. 2001. Phylogenetic relationships within the eared seals (Otariid: Carnivora): Implications for the historical biogeography of the family. Molecular Phylogenetics and Evolution 21(2): 270-284.

These authors pooled existing genetic samples and published information to describe the phylogenetic relationships within the Family Otaria which contains sea lions and fur seals. Both the cytochrome b region and the control region of the mtDNA segments were used for comparisons. Results suggest that the traditional classification of the family into two subfamilies for fur seals and sea lions was not supported, with the northern fur seal having a basal relationship relative to the rest of the family; this is consistent with the fossil record which suggests that the genus *Callorhinus* diverged from the line leading to the remaining fur seals and sea lions about 6 million years ago. These groups underwent rapid radiations at about the time they diverged from each other.

Zasypkin, M. Yu., E.M. Krainova, V.N. Burkanov, D.G. Calkins, and P. Browne. 2002. Allozyme variability in Steller sea lion assessed through the combination of biochemical genetic markers in blood. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

These authors studied variability in Steller sea lions using plasma and red blood cells from 253 sea lion pups. The samples were analyzed using 16 plasma loci and 24 cell loci by polyacrylamide gel electrophoresis. Parameters of allozymic variability (PAV) were surprisingly low compared to other pinnipeds, but significant differences occurred between sites sufficient to distinguish the Iony Island samples from those of the Kuril Islands.

Zasypkin, M. Yu., E.M. Kraynova, V.N. Burkanov, and D.G. Calkins. 2004. Allozymic variability in serum of Steller sea lion (*Eumetopias jubatus*) and its use for the study of population structure. Pages 215-220, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

The authors summarize their studies in 2002 and 2003 which were a continuation of those reported above (Zasypkin et al., 2002). In this report they found that the allelic frequency of the serum haptoglobin Hp locus was almost identical between Iony Island and the Kuril Islands, opposite to their 2001 findings. Confounding results from other Okhotsk Sea islands and the Kuril Islands were explained based on migration between the different sites. However, additional sampling in the Kuril Islands in 2003 suggested that the haptoglobin locus was not a reliable marker for use in population genetics based on its high heterogeneity.

(This page intentionally left blank)

THEME 1 (c) – LIFE HISTORY-- REPRODUCTION AND BEHAVIOR (not foraging)

SUMMARY:

This theme contains 39 articles including 27 presentations at scientific meetings, one dissertation, and 11 papers in peer-reviewed journals or book chapters. It contains primarily studies pertaining to maternal care, attendance patterns, and behavior at rookeries and haulout sites during and after the breeding season. There were descriptions of the birth process and its duration, one study on vocalization, one on dispersal, and a couple on growth. Most of the information in these presentations and papers on reproductive and maternal behavior was not new. Reproductive behavior was described and quantified in the 1970s and 1980s (e.g., Gentry, Gisiner, Sandegren, and others[1]). The novel information presented here was the breath of the geographic range of the studies allowing for regional comparisons in attendance behavior, maternal investments, and efforts to define the age at weaning. There was some effort to use attendance behavior and maternal investment as an indirect measure of foraging effort, but its utility for that purpose is equivocal (Kuzin 2004).

Attendance patterns, nursing duration, and estimates of weaning age were contained in no less than 14 papers and presentations, all of which provide estimates of time on shore and time at sea by lactating females at sites from the Kuril Islands to Oregon. Most behavior data were obtained by observation and a few by following animals equipped with radio transmitters (Call, Brandon, and Davis) or remote cameras (e.g., Teate et al., 2005). Five reports were from Russian rookeries. The detail and variation provided in these studies is difficult to summarize, but in generality, lactating SSLs spent about half the day on land nursing their pups then left in the evening on foraging bouts returning the next morning. As the season progresses and as the pup grows, foraging trips tend to become longer in duration. Overall, average foraging trip duration among rookeries decreased and pup growth rate increased in an east-to-west direction from the area of stable to declining population. There was no evidence that female sea lions and pups were nutritionally stressed during the first six weeks postpartum in the area of population decline. There is variation by region, likely determined by the distance that the female needs to travel to acquire adequate nutrition. None of this is new information; these studies reiterate with more detail those data published prior to 2000 and with a much larger sample size over a greater range.

One study reported a 4-year old female SSL nursing its own pup while nursing on its mother (Mamaev and Burkanov. 2004). Alloparental care was studied at Chiswell Island (Harris et al. (2005) and in Southeast Alaska (Porter and Trites 2004).

In regards to growth, Brandon (2000) and subsequent papers (including Davis et al., 2004 and 2006) measured pup growth in the western and eastern stocks. Part of their findings show that male and female pups grew at the same rate (in mass, standard length, and axillary girth). Body mass and standard length increased at a faster rate for pups in the Aleutian Islands and the western GOA than in Southeast Alaska. The results indicated a greater maternal investment in male pups during gestation but not during lactation. Christen et al. (2003) measured a captive adult male at the ASLC and reported changes in mass and testosterone levels with the onset of sexual maturity.

[1] Gentry, R. L. (1970). "Social behavior of the Steller sea lion," Ph.D., University of California, Santa Cruz.
Gisiner, R. C. (1985). "Male territorial and reproductive behavior in the Steller sea lion, (*Eumetopias jubatus*)," Ph. D., University of California, Santa Cruz.
Sandegren, F. E. 1970. Breeding and maternal behavior of the Steller sea lion (*Eumetopias jubata*) in Alaska. M.S. Thesis, Univ. Alaska, Fairbanks. 138 pp.

Raum-Suryan et al. (2002) used 24 years of branding data on >8,500 pups to define dispersal and rookery fidelity of SSLs in Alaska and found that pups usually remained within 55 km of their natal rookery and that juveniles dispersed widely and were resighted up to 1,785 km from their natal rookery. No interchange of breeding adults was documented between the eastern and western stocks. Natal fidelity was prevalent but some adult females were observed with pups at sites other than their natal rookery. Parker et al. (2005) also dealt with pupping site fidelity at a single site (Chiswell Island) and report that fifteen females that gave birth every year of the study period exhibited 73 % site fidelity.

Bogdanova discussed the successful breeding of SSLs in captivity at an aquarium in Russia. Minor presentations were made on SSL vocalizations associated with behavior (Park et al., 2004).

ANNOTATED BIBLIOGRAPHY – LIFE HISTORY -- REPRODUCTION AND BEHAVIOR (not foraging)

Bogdanova, L.N. 2004. Breeding of Steller sea lions (*Eumetopias jubatus*) and their functional control in captivity. Pages 82-85, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

> The abstract discusses the successful breeding of SSLs in captivity at an aquarium in Russia based on 2 females and 2 males captured in 1980. Specific information on food requirements, physiology, gestation period, timing and duration of parturition, nursing, and copulation were provided, some in tabular form. Of interest was that copulation occurred in the water (pools) and not on land. The animals consumed at least 16-20 kg of food daily, mating occurred in June or July, gestation was over 11 months and occurred on land. Note the summary below by Trukhin (2004) regarding the similar information from a Russian rookery.

Brandon, E. A. A. 2000. Maternal investment in Steller sea lions in Alaska. Ph.D. dissertation, Texas A&M Univ., Galveston, TX. 136 p.

> This Ph.D. dissertation dealt with the growth rate of SSL pups in Southeast Alaska, the Gulf of Alaska, and the Aleutian Islands during the first six weeks after birth. Male pups (~ 22.6 kg) were significantly heavier than females (~19.6 kg) at 1-5 days but there were no significant differences among rookeries. Male and female pups grew at the same rate (in mass, standard length, and axillary girth). Body mass and standard length increased at a faster rate for pups in the Aleutian Islands and the western GOA than in Southeast Alaska. Adult females showed a cline in length of time spent at sea (7.1-25.6 hours) with females in the stable population making the longest trips. The results indicate a greater maternal investment in male pups during gestation but not during lactation. There was no evidence that female SSLs and their pups were nutritionally stressed in the are of decline (similar information in Davis et at. 2006 below).

Brandon, E.A.A., D.G. Calkins, T.R. Loughlin, and R.W. Davis. 2005. Neonatal growth of Steller sea lion pups in Alaska. Fishery Bulletin, U.S. 103:246-257.

> This paper is the journal form of Brandon's (2000) Ph.D. dissertation.

Call, K.A., B.S. Fadely, and A. Greig. 2004. Attendance patterns of juvenile Steller sea lions (*Eumetopias jubatus*) in the Gulf of Alaska and Aleutian Islands derived from satellite dive recorders (SDRs). Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> The authors determined attendance patterns of juvenile SSLs to assess changes in behavior potentially related to weaning and development of diving behavior. Data were collected from satellite-linked dive recorders; one data set from these transmitters is called 'timeline data' which were used to determine time on land (dry) and in the water (wet). They developed an algorithm to deal with the large mount of data (>252,000 records) which provided arrival and departure times for each wet and dry period. Results showed that SSLs tended to haul out just after sunrise and depart at dusk. The mean duration of time on shore was 9.2 hours and did not differ among sex, region, year, or age. Time spent at sea was variable and was significantly longer in the eastern Aleutian Islands and central GOA

Christen, D., K. Mashburn, and C. Stephens. 2003. Monitoring a male Steller sea lion into adulthood. P. 32, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p

> This abstract described the physical and physiological changes in an adult male SSL housed at the ASLC. The changes occurred during mid December 2002 through June 2003 when he displayed a dramatic increase in body mass (519 kg to 835.5 kg) in the absence of an accompanying increase in diet (~218 kg/week) or diet composition. In previous years appetite declined in March but not during this study period. Monthly serum testosterone levels exhibited a linear increase over the same period and were nearly triple the concentration from June 2002; lean body mass and fat mass increased 15% and 64%, respectively.

Coombs, A.P., and A.W. Trites. 2005. Steller sea lion haulouts: breeding locations for non-pregnant females? *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

> The authors observed reproductive behavior at two haulout sites in Alaska (not provided) during spring and summer 1996-1998 and compared these observations with those at a rookery. Mature males held territories at the haulout sites and engaged in courtships and copulations with non-pregnant females; breeding occurred 1-2 weeks earlier than on the rookery. Births were observed at the haulouts but no pups survived. Subadult males were not tolerated at the haulout by mature males until after the breeding season. The authors contend that haulouts should be considered in a broader context where some breeding occurs.

Davis, R.W., A.A. Brandon, D. Calkins, and T.R. Loughlin. 2004. Indices of reproductive effort and nutritional health in lactating Steller sea lions and pups in areas of declining and stable population . Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> Same information as in Davis et al. (2006) below.

Davis, R.W., A.A. Brandon, D. Calkins, and T.R. Loughlin. 2006. Female attendance and neonatal pup growth in Steller sea lions (*Eumetopias jubatus*). Pages ___, *in* A. Trites, S. Atkinson, D. DeMaster, L. Fritz, T. Gelatt, L. Rea, and K. Wynne (eds.). Sea lions of the world. Alaska Sea Grant College Program, University of Alaska Fairbanks.

These authors studied attendance behavior of lactating SSLs and the growth rates of pups in Southeast Alaska, the Gulf of Alaska, and the Aleutian Islands from 1990 to 1997; the growth data are part of Brandon's dissertation (above). The presence and absence of SSLs on the rookeries was monitored using radio transmitters for the first four to six weeks postpartum. Newborn pups were weighed and measured every two weeks over the same period. The time spent onshore (~22.5 hours) by females did not differ significantly among rookeries. Average foraging trip duration was significantly different among rookeries and ranged from ~25.6 hours in the area of stable population to ~9.4 hours in the area of declining population. The average percentage of time spent at sea was significantly different among rookeries and ranged from ~51% in the area of stable population to ~24% for the declining population. Male pups (~22.6 kg) were significantly heavier than female pups (~19.6 kg) at 1-5 days of age, but there were no significant differences among rookeries. Male and female pups on the same rookery grew at the same rate during the first 4-6 weeks. Body mass and standard length increased at a faster rate for pups in the Aleutian Islands and the western Gulf of Alaska (0.45-0.48 kg /day and 0.47-0.53 cm/day, respectively) than in Southeast Alaska (0.23 kg/day and 0.20 cm/day). Overall, average foraging trip duration among rookeries decreased and pup growth rate increased in an east-to-west direction from the area of stable to declining population. There was no evidence that female sea lions and pups were nutritionally stressed during the first six weeks postpartum in the area of population decline.

Gurarie, E., V.N. Burkanov, E. Mamaev, and S. Purtov. 2005. Comparison of maternal attendance patterns on two Steller sea lion (*Eumetopias jubatus*) rookeries in Russia. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This study is similar to Milette and Trites (2003) below in that they compare adult female behavior from an area of stable population to one of decreasing population, both in Russia. They monitored branded and tagged females at Antsiferov Island, Kuril Islands (stable) and Medney Island, Commander Islands (declining) from late May to late July; the year was not provided. SSLs from Medney tended to depart earlier in the day, to take shorter trips to sea, and have less variability then at Antsiferov. Females at Medney spent 19% of their time away from the rookery and those at Antsiferov 35%, opposite of what was expected given the population trends (as in Milette and Trites 2003).

Hamblen, E.E., J.J. Scordino, and S.S. Heppell. 2005. Nursing duration and frequency in determining Steller sea lion weaning. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Nursing duration and frequency were observed at Sea Lion Caves, Oregon, through winter, spring, and summer 2005 for pups and juveniles using scan sampling and focused observations. Results indicated that neither sex, time of day, or month had any effect on duration of nursing which were ~ 16.3 minutes and ~14.4 minutes for males and females, respectively. Peaks in nursing frequency occurred at 9:00, 12:00, and 16:00 and the percent of the population observed nursing peaked in January and March, and then declined. They concluded that weaning occurs in late spring.

Harris, K., J. Maniscalco, S. Atkinson, and P. Parker. 2005. Observations of alloparental care. Chapter 29, pages 284-289, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

This book chapter contains the authors observations of alloparental care. Alloparental care occurs when an individual provides nourishment, protection, or other forms of care to unrelated offspring. They observed 23 allosuckling events and one case of adoption at Chiswell Island. During allosuckling events, non-filial individuals nursed significantly longer than filial pups. Multiparous and primiparous females were observed nursing non-filial individuals with equal frequency but primiparous females spent significantly more time nursing and less time vocalizing aggressively toward non-filial individuals. This suggests that primiparous (presumably younger) females nurse non-filial pups due to inexperience; whereas multiparous (presumably older) females are victims of milk stealing during times of inattentiveness. Starveling pups were not cared for by any female but two were attended by a single bull during separate fall seasons.

Iida, K., T.-G. Park, T. Mukai, and S. Kotani. 2004. Acoustic characteristics and morphological observation of roar sound of Steller sea lion (*Eumetopias jubatus*) migrating to the west coast of Hokkaido, northern Japan. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Similar information as in Park et al. (2004) below.

Kuzin, A.E. 2004. Attendance patterns of Steller sea lion (*Eumetopias jubatus*) on Tuleny Island during the breeding season. Pages 303-305, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

Attendance behavior of SSLs was observed on Tuleny Island during June through July 2000-2003 using marked individuals (45-96 individuals/season with a total of 274 individuals including 154 males and 120 females); most were non-breeding but 3 were nursing females and 6 were non-nursing adult females. The animals were monitored at least 6-8 hours /day. Percent of time on shore by males was 41-53% and time at sea was 47-59%; females spent ~32-62% of their time on shore and 38-68% at sea. On average SSLs spent ~1.8 days on land and ~2.5 days at sea. Time on shore and at sea did not differ between non-breeding males and females (which showed more variability in time at sea). However, nursing females spent more time on shore (55.6%) than at sea (44.3%). Non breeding females spent less time on shore compared to nursing females. Suckling juveniles spent ~76% of their time on shore. Other data on attendance were provided. Of interest was the conclusion that attendance patterns of SSLs "did not provide enough suitable information for assessing the state and accessibility of food resources. Presumably this is due to the low power of the methodology employed." (Compare this to assertions of the use of attendance data to assess the nutritional stress hypothesis in Brandon, Davis, Milette other authors in the eastern Pacific).

Mamaev, E.G. 2004. Steller sea lions (*Eumetopias jubatus*) subadult males behavior in the on (sic) a rookery. Pages 352-356, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

This long abstract provides extensive detail on the movements and interactions of sub-adult male SSLs at the rookery on Medney Island during June-August 1998. He provided data on the duration of interactions with males the same age, with females, territorial males, and other con-specifics by age (4 through 7 years of age) based on branded and naturally marked individuals. Duration was measured to the minute and second and distance to the meter. Four tables are provided as well as ample data in text form (e.g., the mean duration of contact with a female by 4 year old males was 15.5 seconds).

Mamaev, E.G., and V.N. Burkanov. 2004. Some cases of long suckling bouts in the Steller sea lion (*Eumetopias jubatus*). Pages 359-361, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

This abstracts documents two four-year old female SSLs still nursing on their mothers observed at Medney Island, Commander Islands. It is not unusual to observe 2 year olds, and sometimes 3-year old SSLs still nursing, but in this case the unusual observation of two 4-year old animals is documented. In one of these, the 4-year old was observed giving birth to its own pup; she subsequently nursed her own new pup and also continued to nurse on her mother. Details of the observations are provided for both sets of observation.

Mamaev, E.G., and V. N. Burkanov. 2004. How long do Steller sea lions drink milk? Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Similar information as in Mamaev and Burkanov (2004) above but with more information on the ratio of females nursing pups and the proportion of pups older than one year still nursing, 4.1% of which were 3 years old and 3.1% were four years old.

Maniscalco, J. 2005. Reproductive performance in Steller sea lions at Chiswell Island, Gulf of Alaska. *In* Marine Science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

This poster discusses reproductive rates for adult female SSLs observced at Chiswell Island during 2001-2004 using the remote video system and identifiable females with at least a two-year history at the island. Reproductive rates decreased from 89.7% in 2001 to 75.0% in 2004; the number of live pups born increased from 52 to 78 over the same period. Females who did not pup or whose pup died during the first two months of life were less likely to pup the subsequent year than females whose pup lived at least two months; those in the first category that did have a pup the next year tended to pup earlier the next year (7 June versus 11 June).

Maniscalco, J, and S. Atkinson. 2003. Characteristics of parturition and neonatal behavior in Steller sea lions (*Eumetopias jubatus*). P. 101, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

The authors video-taped 59 SSL births at Chiswell Island during May-June 2001-2003. They reported that parturition was independent of time of day, and that in 2003 births of 10 identifiable females were earlier than in 2002 (but not 2001). Parturition was more rapid with cephalic births and 70% of known females gave birth in opposite directions in different years. Times and durations of other specifics of the birth process were provided in the abstract.

Maniscalco, J., S. Atkinson, and P. Armato. 2002. Early maternal care and pup survival in Steller sea lions: A remote video monitoring project in the Northern Gulf of Alaska. Arctic Research 16: 36-41.

This is a popular article for the lay public describing the remote video system first installed at Chiswell Island in 1998 and some of the results pertaining to maternal care and pup survival gained from the system. Birthdates of SSL pups ranged consistently from about May 23 to July during 1999-2002 (they were slightly earlier in 2001 vs. 2002). Females that gave birth later in the season tended to forage sooner than females that gave birth early (shorter perinatal period). Foraging trip duration decreased slightly from ~14 hours to 10 hours in the first month after birth. Lactating females spent ~9.6% of their time nursing in the morning versus 7.1% in the afternoon and 4.2% in the evening. Early pup mortality was caused by killer whales or storms.

Maniscalco, J., S. Atkinson, A. Burdin, and D. Calkins. 2003. Population dynamics, maternal investment, and early pup mortality in Steller sea lions at Chiswell Island. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

The authors discuss a biennial cycle of population numbers and births at Chiswell Island during 1999-2002. Greater numbers of non-pups and pups occurred there in even numbered years and maternal investment parameters measured in 2001 and 2002 also suggest this trend. 2002 was better in terms of pup parental care with tighter synchrony of births, longer perinatal periods, shorter foraging trips, and greater amount of time spent on shore. They estimated that 54% of mature females gave birth in both 2001 and 2002, 37% gave birth in only one of these years, and 9% did not give birth in either year. Early pup losses in 2001 were attributed to killer whale predation but considered a factor in early pup declines

Maniscalco, J.M., P. Parker, and S. Atkinson. 2005. Use of remote monitoring equipment to study maternal care. Chapter 32, pages 308-320, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.,

These authors used the remote video system at Chiswell Island to study maternal care during four summers, 2001-2004 and three fall seasons, 2002-2004 using remotely operated video cameras. Perinatal periods were ≥10.0 days and varied between years. Timing of parturition was earlier and perinatal periods longer for multiparous females compared to females considered to be primiparous. Summer foraging trip durations were short ($\bar{x}$ = 15.4 hr), increased during August, then did not change significantly during fall ($\bar{x}$ = 52.9 hr). Individual lactating females spent a greater proportion of their time on shore during summer and a greater proportion of their time at sea during fall. The amount of time that females nursed their pups also increased significantly from the summer to fall. Long perinatal periods and short foraging trips suggested that sea lions at the Chiswell Islands were likely to find sufficient food nearby and that SSLs reach an upper plateau in foraging cycle durations by the end of August.

Marcotte, M.L., and A.W. Trites. 2004. A comparison of maternal attendance among the world's sea lions. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors present their review of the literature concerning maternal attendance among the five species of sea lions. They found that overall patterns of maternal attendance were similar with variations caused by stochastic changes in food availability. Females of all species remain with their pup 7-10 days post-partum before undertaking foraging trips of variable duration until weaning; lactation in 4 species is about one year and for Australian sea lions it is about 17.5 months. Time spent on shore between foraging trips is about 1-2 days (see specific measures for SSLs in other citations in this section). All sea lions had sexually dimorphic offspring but they report no differential allocation of resources or increased effort (but see Brandon et al., 2005).

Marcotte, M.L., and A.W. Trites. 2005. Shifts in the timing of weaning in an increasing population of Steller sea lions in Southeast Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

The authors report their observations of SSLs at a haulout site in Southeast Alaska (Southwest Brothers Island) over 12 months during 2004-2005. Their observations revealed high numbers (not provided) of one and two-year old juvenile SSLs continuing to nurse, and a number (not provided) of late-term abortions. These observations led the authors to speculate that weaning has increased to two years and that some females give birth biennially which would result in a curtailment of population growth.

Milette, L.L., and A.W. Trites. 2003. Maternal attendance patterns of Steller sea lions (*Eumetopias jubatus*) from stable and declining populations in Alaska. Canadian Journal of Zoology 81:340-348.

This published paper is part of Milette's Master's degree study at UBC. She measured behavioural parameters based on observations; no transmitters were used in this study. An edited version of the paper's abstract follows. Maternal attendance patterns of Alaskan SSLs were compared during the summer breeding seasons in 1994 and 1995 at Sugarloaf Island (a declining population) and Lowrie Island (a stable population). The goal was to determine whether there were differences in maternal attendance between the two populations that were consistent with the hypothesis that lactating Steller sea lions in the area of decline were food-limited during summer. They found that foraging trips were significantly shorter in the area of population decline. The mean length of foraging trips in the declining area was 19.5 hours compared with 24.9 hours in the stable area. In contrast, the mean perinatal period (time between parturition and first feeding trip) was significantly longer in the area of decline (9.9 versus 7.9 days). The mean length of shore visits for the declining population was also significantly longer (27.0 hours compared with 22.6 hours where the population was stable). For both populations, the mean time that mothers foraged increased as pups grew older, whereas the time that they spent on shore with their pups became shorter. Behavioral observations of maternal attendance patterns were inconsistent with the hypothesis that lactating Steller sea lions from the declining population had difficulty obtaining prey during summer.

Ono, K., T. R. Loughlin, and R. Merrick. 2001. Behavior and ecology of juvenile Steller sea lions (*Eumetopias jubatus*) during the breeding season. Page 163, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

The abstract reported observations of associations between juvenile and adult SSLs at Marmot and Lowrie islands during 1993-1998. Most (51%) juveniles on both islands were associated with their mother and appeared to be nursing; 28% appeared to be alone or with other juveniles, and 21% were seen nursing along with a neonatal sibling. Once a female gave birth to a new pup, the juvenile disappeared within a few days in 54% of the cases. Females nursed both a juvenile and the new pup in 32% of the time, and rejected the juvenile while continuing to nurse the pup in 16% of the cases.

Park, T.-G., K. Iida, T. Mukai, and S. Kotani. 2004. Relationship between roar sound and behavior of Steller sea lion (*Eumetopias jubatus*) migrating to the west coast of Hokkaido, northern Japan. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors report their audio and video recordings of SSL vocalizations for wild animals off Hokkaido and captive animals in a Japanese aquarium. They found that roar sounds were at a maximum after sunrise and before sunset and decreased at nighttime; for captive animals vocalizations were dependent on feeding time. In wild SSLs females emitted sounds four times more frequently than males and 1.3 times more in captivity. They classified the vocalizations into four categories: communication, threat, wheedleling, and acknowledgement. Each was characterized by a sonogram but not presented in the abstract. Sounds by males were typically lower in frequency than females and wild animals were lower than captive.

Parker, P., J.M. Maniscalco, and S. Atkinson. 2005. Pupping site fidelity among individual Steller sea lions at Chiswell Island, Alaska. Chapter 33, pages 321-330, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

An edited version of the published abstract states that pupping site fidelity in Steller sea lions was studied at Chiswell Island during the breeding seasons of 2001 to 2004. Fifteen females that gave birth every year of the study period exhibited 73% site fidelity. Breeding season storms and timing of birth within 24 hours significantly increased the distance females moved between pupping locations between years. Approximately 45% of all births took place in 20% of the pupping locations. Locations of births were not randomly distributed and preliminary results suggested that pups were born more frequently in proximity to rock walls, with easy access to water for thermoregulation, and greater than 5 m from high water level. Multiparous females that exhibited pupping site fidelity generally give birth in the most common (or preferred) pupping locations with physical attributes that may increase pup survival. Primiparous females frequently gave birth in pupping locations with fewer positive physical attributes.

Parker, P., J. Maniscalco, S. Atkinson, K. Harris, and R. Baptista. 2003. Summer to autumn increases in maternal investment for individual Steller sea lions (*Eumetopias jubatus*) in the northern Gulf of Alaska. Page 127, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

This abstract summarizes maternal behavior at Chiswell Island from 15 May through 1 November 2002. Forage trip duration was significantly longer in fall (51.2 hours) than summer (11.3 hours) for ten identifiable females. Time on shore increased from 19.5 hours to 32.4 hours. Trip durations peaked by late September. Females nursed their pups in fall 8.5% of their time versus summer (3.0%).

Parker, P., J.M. Maniscalco, J.T. Harvey, and S. Atkinson. 2005. Pupping site fidelity among individual Steller sea lions (*Eumetopias jubatus*) in the northern Gulf of Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Same information as in Parker et al. (2005) above).

Pitcher, K.W., G. W. Pendleton, and T. S. Gelatt. 2004. Estimation of weaning status of juvenile Steller sea lions using mark-resight models. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors used multiple resightings of branded (known-aged) juvenile SSLs on haulout sites in Southeast Alaska in a modified Cormack-Jolly-Seber model to estimate sighting probability and the probability of sighting them if not weaned. This allowed the estimation of the proportion of each juvenile by age that was weaned or independent and provided insights into population productivity. No results were provided in the abstract.

Porter, B.T. and A.W. Trites. 2004. Suckling attempts during winter by two non-filial Steller sea lion pups. Mammalia 68:23-26.

From January to March 1996, the authors observed two non-filial pups repeatedly suckling lactating females at a winter haulout site at Timbered Island in southeast Alaska. The first case of milk stealing involved a branded female pup never seen with her own mother and was considered to be a starveling due to her poor and deteriorating condition. They observed this pup for 15 continuous days during which time it made several successful attempts to steal milk from sleeping mother-pup pairs. The second case was a mother providing care to an alien pup that was still with its own mother (allomaternal care). It involved a healthy looking pup identifiable by natural markings that regularly suckled its own mother. This pup stole milk from one resident mother-pup pair on several occasions, but the pair allowed suckling to continue without incident and with no sign of aggression.

Raum-Suryan, K. L., K. W. Pitcher, D. G. Calkins, J. L. Sease, and T. R. Loughlin. 2002. Dispersal, rookery fidelity and metapopulation structure of Steller sea lions (*Eumetopias jubatus*) in an increasing and a decreasing population in Alaska. Marine Mammal Science 18:746-764.

These authors used 24 years of branding data on >8,500 pups to define dispersal and rookery fidelity of SSLs in Alaska. They found that pups usually remained within 55 km of their natal rookery and that juveniles dispersed widely and resighted up to 1,785 km from their natal rookery. Adults generally remained within 55 km of the natal site. No interchange of breeding adults was documented between the eastern and western stocks. Natal fidelity was prevalent but some adult females were observed with pups at sites other than their natal rookery

Suzuki, N. and V. Veljankin. 2001. A successive and social phenomenon recorded at Steller sea lion (*Eumetopias jubatus*) rookery in Commander Islands, Russia, summer 1994. P. 208, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

This is a somewhat meaningless abstract describing an adult female SSL 'stealing' a placenta from a female that had just given birth. The first female carried the placenta through a rookery at which point a territorial male took the placenta from her and sat on it.

Teate, E., P. Parker, J.M. Maniscalco, and K. Harris. 2005. Tenure and reproductive success of Steller sea lions (*Eumetopias jubatus*) males at Chiswell Island, Gulf of Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This abstract summarized a study using the Chiswell Island remote video system to determine if territory features influenced male SSL copulation success. Nineteen identifiable males copulated at least once (average 5.4/year) over the 6-year study period with tenure ranging from 1 to 4 years (average 2.4 years and copulation success increased over the first 3 years of tenure. Territory sizes were 36-225 m^2 and copulating males held territory 9-62 days. Territory size and pup births were the best predictors of a male's copulation success but not number of days on territory.

Trites, A.W. and B.T. Porter. 2002. Attendance patterns of Steller sea lions (*Eumetopias jubatus*) and their young during winter. Journal of Zoology, London 256:547-556.

This published account is part of Boyd Porter's Master's degree study at UBC. He monitored marked and unmarked SSLs at the Brother's Islands in Southeast Alaska during the winter of 1996. The edited text of the abstract follows. Winter attendance patterns of lactating SSLs and their offspring were recorded during the late stages of nursing when the young were expected to move from milk to independent foraging. Trip duration and nursing visits to shore by 24 mothers with pups (7±9 months old) and six mothers with yearlings (19±21 months old) were noted during 600 hours of observations (from 22 January to 1 April 1996). Pups and yearlings tended to stay on or near the haulout while their mothers were away and showed no signs of weaning during winter. Their average trips to sea were 43% shorter in duration than those of lactating females, suggesting that pups and yearlings make independent trips away from the haulout while their mothers forage. The winter attendance cycle of lactating females averaged about 3 days, with the mothers of pups spending an average of 15 hours of this time onshore with their offspring. The winter attendance cycle of pups and yearlings averaged just over 2 days, with the immature sea lions spending an average of 22 hours on shore. Foraging trips by mothers of yearlings were significantly longer than those by mothers of pups. However, there was no significant difference in the foraging times of mothers of male and female pups. Lactating females spent more time at sea during winter than during summer. The probability of sighting an individual on the winter haulout during daylight hours was 15% for lactating females and 40% for immature animals.

Trites, A.W., B.P. Porter, V.B. Deecke, A.P. Coombs, M.L. Marcotte, and D.A.S. Rosen. In press. Behavioral insights into the timing of weaning and the attendance patterns of lactating Steller sea lions (*Eumetopias jubatus*) in Alaska during winter, spring, and summer. Aquatic Mammals.

Similar to Trites and Porter (above), this published paper relies on behavioural observations to detect time of weaning for SSLs in Alaska. An edited version of the abstract follows. Observations of lactating SSLs and their offspring were recorded at 4 haulout sites in Alaska to determine: 1) whether sea lions wean during winter while they are 7-9 months old, and 2) whether sea lions using sites in the Gulf of Alaska made longer foraging trips than sea lions in Southeast Alaska. Eight sets of behavioral observations were made using focal and scan sampling techniques at haulouts over 4 years (1995-1998) during winter, spring and summer. They found no significant differences between the duration that lactating SSLs spent at sea or on shore, suggesting to them that sea lions did not have more difficulty capturing prey from winter through summer in the area of decline compared to where sea lion numbers increased. Lactating SSLs in both regions made longer foraging trips in winter than they did in spring and summer. These changes in foraging patterns between seasons were consistent among all years and sites. The proportion of time that immature sea lions suckled declined through the spring to early summer, suggesting that sea lions began supplementing their milk diet with solid food in the spring. We did not observe any sea lions weaning during winter. Rather, most appeared to wean at the start of the breeding season when they were 1 or 2 years old. Sea lions observed in Southeast Alaska during the late 1990s while population growth was slowing suggest that most males weaned at 2 years, and that about 50% of females weaned at 1 year and the remainder at 2 years.

Trukhin, A.M. 2004. Preliminary period and delivery in Steller sea lion (*Eumetopias jubatus*) under natural conditions. Pages 554-557, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

This long abstract provides a lengthy and thorough description of birth in SSLs at Raikoke Island, Kuril Islands during 110 days of observation in 2001-2003. Many of the observations were of animals branded at that site in previous years. Specific information of note was that females occurred at the rookeries 0-17 days prior to parturition (4.9 days on average) and the duration between mating and parturition was 340-359 days (n=10), based on marked animals; average gestation period was 352.3 days. Cephalic and pelvic deliveries occurred about evenly and had similar durations. One marked female had a cephalic delivery one year and a pelvic the next. Other pertinent and interesting observations were provided. (this summary is repeated in the Life History-Sundry theme).

Trukhin, A.M., and V.N. Burkanov. 2004. Breeding patterns of Steller sea lion *Eumetopias jubatus* on Raykoke Island (Kuril Islands), 2001-2003. Pages 546-550, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

The authors provide a detailed summary of breeding patterns at Raykoke Island, Kuril Islands, during 2001-2003. Three figures accompany the abstract. Parturition began on May 27 in 2003 and ended on July 11 in 2001; 78% of pups were born before June 20 with >200 pups born/year. Pup mortality was greatest at 5.8% in 2002. Dates of observed copulations were provided. Marked SSLs and their origins were provided with animals seen from Yamsky Island, Kozlova Cape, and other Kuril Islands. Survival rates of older females were asserted to be high based on sightings of marked individuals. They also reported that 12% of 4 year old females gave birth, 64% of 5 year olds gave birth, and 75% of 7 year olds gave birth.

Trukhin, A.M., and A.A. Sychenko. 2004. Daily time budget of lactating Steller seal (sic) lion (*Eumetopias jubatus*) females. Pages 550-554, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

The authors monitored the daily time budget of two branded adult females at Raykoke Island during 2003. Both had been branded at Raykoke as pups. One gave birth in the center of the rookery and the other at the edge. The location had influence on the subsequent time budget regarding time spent sleeping, nursing, etc. They found that energy expenditure of lactating females that use the edge of the rookery is lower compared to the center. Those in the center were more apt to be disturbed by territorial males pursuing females, by other females moving through the rookery, and by sub-adult males attempting to gain access to a territory or females. One figure and two tables were provided to substantiate the time differences and frequency of nursing periods.

THEME 1 (d) – LIFE HISTORY – SUNDRY

SUMMARY:

This theme contains 50 articles including 33 presentations at scientific meetings, one thesis, one report, one unpublished report, and 15 papers in peer-reviewed journals or book chapters. It contains an assortment of topics including rookery characterization, behavior, new techniques, electronics, and distribution.

Ban completed a Master's degree and gave numerous presentations on the characterization of SSL rookeries and haulout sites and found that haulouts and rookeries were preferentially located on exposed rocky shorelines and wave-cut platforms. Call and Loughlin (2005) provided an ecological classification of rookeries using data on habitat (bathymetry, sea surface temperature, substrate type, and orientation), population trends, and diet from available literature. Lander et al. (2005) are attempting to define habitat as part of Lander's Ph.D. studies by using remote-sensed environmental data and sea lion movements and dive behavior from satellite transmitters attached to the animals. That work is still in progress.

Many new techniques and equipment were in use or in development during 2000-2005. King et al. (2003) reported that canine tooth length and tooth eruption state were reliable indices for pup age to within 2-3 months. A remote video system was used in many locations and discussed in papers and presentation by Burdin et al. (2002) at Kozlova Cape, Russia, and by Maniscalco et al. (2005) at Chiswell Island, Gulf of Alaska. Numerous reports on SSL biology were gleaned from the information gathered by these systems and reported in other themes in this report. In this section the hardware and advantages of the system were discussed. Dunford et al. (2003) reported on the status of a new implantable transmitter, about the size of a credit card, which had not been used to date, and Nelson et al. (2003) reported on their efforts to develop a surgical pouch derived from skin folds to house a radio transmitter; sheep are being used as the surrogate test animals. This later technique along with a new transmitter design was presented by Andrews et al. in 2003; Andrews et al. (2005) discuss efforts to remotely determine prey ingestion including stomach temperature measurement, jaw opening (inter-mandibular angle), and animal-borne video camera recording. T. Horning and Hill (2005) have developed and are testing a satellite tag that is implanted in a pinniped and collects data while in the animal. Once the host animal dies, the tag is extruded, and, while floating on the ocean or lying on a beach, transmits previously stored data to orbiting satellites. Plankis et al. (in press) are testing a remote system to conduct shore-based, close-range three-dimensional imaging in remote areas (SLiDAP). Mellish et al. (2004) tested portable ultrasound imaging as a noninvasive measure of skin including blubber thickness in captive subadult Steller sea lions and adult harbor seals. And last, McAllister et al. (2001) reported on the development of the underwater capture technique for juvenile sea lions developed by the ADF&G.

As important as the underwater capture technique was to allow researchers access to young animals, so was the construction and use of the transient juvenile facility at the ASLC. Mellish et al. (2005a, b; 2006) provide overviews of the facility and results obtained from the some of the juveniles that had gone through their system; many more have been processed since these reports. Schrader et al. (2005) reported on the post-release movements of these juvenile animals once released back to the wild. In a similar study, Lander and Gulland (2003) reported on the movements and dive behavior of young SSLs released from rehabilitation at the California Marine Mammal Center.

Presentations on the general distribution and occurrence of SSLs were reported by many authors. SSL abundance, population trends, and diet in Oregon were provided by Reimer et al. (2001), and

Scordino et al. (2005) reported on movements of SSLs in the California Current ecosystem. A new rookery in Glacier Bay, Alaska was reported by Mathews and Dzinich (2001) and Hoshino et al. (2005) discuss occurrence of SSLs of in the Sea of Japan in winter. Six presentations were made on the occurrence and distribution of SSLs in Russian waters by Burkanov, Nevedomskaya (2 presentations), Vazhenina, Zadalskiy, and Zagrebin. None of the papers and presentations regarding distribution and occurrence added much new information on this topic.

Similarly, a few presentations and papers were provided on SSL behavior while on the rookery, but aside from providing insight into the dynamics of a specific location, none add much new information to this topic. The exception is Burdin et al. (2002) who report observations that document the movement of two adult females from Medney Island to Kozlova Cape and that bred at both sites. Reports are summarized below by Altukhov, Kruchenkova, Kuzin, Lisitsyna, and Trukhin.

There were three papers in book chapters and encyclopedia that were of the general type that provided background information and overviews of SSL biology (Calkins et al., 2005; Loughlin 2000, 2002). Willoya et al. (2005) summarizes efforts by the Alaska Sea Otter and Steller Sea Lion Commission to develop protocols whereby Alaskan tribes can gather and provide information on SSL population trends and distribution using cultural knowledge and scientific methods. Trites et al. (2002) summarize the asserted consequences to SSLs feeding on low-quality prey including health and condition, and susceptibility to predation and disease. They stress the importance of captive studies, field studies, and modeling to understand population dynamics and the cause(s) of the SSL decline. Last is the NPFMC requested review by the NRC (2003) that included review of (1) the status of current knowledge about the decline in Alaska, (2) the relative importance of food competition and other cause of the decline and impediments to recovery, (3) critical information gaps in understanding interactions between SSLs and fisheries, (4) the type of research program needed to identify and assess human and natural causes of the decline, and (5) the components of an effective monitoring program and efficacy of the management regime.

ANNOTATED BIBLIOGRAPHY – LIFE HISTORY - SUNDRY

Altukhov, A.V., and V.N. Burkanov. 2005. Spatial distribution of Steller sea lions (*Eumetopias jubatus*) males on a non-reproductive section of rookery. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

> The authors studied male sea lion behavior at non-breeding sites adjacent to rookeries after the breeding season and when females began to move onto the area. They found that young males (4-5 years old) tended to interact with similarly-aged animals, 6-7 year old males interacted with females, and their territorial behavior was expressed primarily in the presence of these females; territorial behavior of adult males was independent of female presence.

Andrews, R. D., A.W. Nelson, R.B. Heath, R.D. Hill, R.E. Davis, and D.G. Calkins. 2003. Novel transmitter and antenna design and surgical techniques for monitoring pinnipeds with satellite telemetry. P. 6, In: 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

> The authors described the development of the marsupial pouch for transmitter inclusion (see Nelson et al. below), subcutaneous antenna exit, and a new satellite transmitter with a quarter

wave whip antennae for use on SSLs. The project was ongoing at the time of the presentation and no results were reported.

Andrews, R.D., A.W. Nelson, R. B. Heath, S.E. Norberg, and D. G. Calkins. 2005. Innovations in remote monitoring techniques for Steller sea lions. Chapter 25, pages 249-259, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

The authors examined methods of remotely determining prey ingestion including stomach temperature measurement, jaw opening (inter-mandibular angle), and animal-borne video camera recording. The measurement of inter-mandibular angle is advantageous in that all ingestion events will be recorded, but it is difficult to separate prey ingestion from breathing, vocalization and aggression towards conspecifics (biting), and quantification is complicated when prey handling involves multiple openings of the jaw before successful swallowing occurs. Video recording holds great promise, but for predators such as SSLs that often feed on loosely schooled or solitary prey in water with limited visibility, images should be taken at rates greater than 1 Hz, which requires a larger capacity to store images than is currently possible with commercially available systems. In order to obtain a better long-term attachment method, they pursued two avenues of research and development: a subcutaneously-implanted transmitter with either a percutaneous antenna or a flat, completely implanted antenna. There was no discussion as to the progress on these last techniques in this chapter.

Ban, S. 2005. Modelling and characterization of Steller sea lion haulouts and rookeries using oceanographic and shoreline type data. M.S. Thesis, University of British Columbia, Vancouver, Canada. 103 p.

In this Master's degree study the author used GIS techniques and models to determine the oceanographic characteristics that define the locations of SSL rookeries and haulout sites in British Columbia and Alaska. Spatial models were constructed to determine which oceanographic factors were associated with haulouts and rookeries, and how conditions near sites might differ from conditions elsewhere. The two modeling techniques employed (logistic regression and supervised classification) were evaluated using the kappa statistic, and receiver-operating characteristic plots. Supervised classification was found to produce better-fitting models than logistic regression. In general, SSLs showed preferences for sites associated with waters that were relatively shallow, well-mixed, had higher average tidal speeds and less-steep bottom slopes. Conditions within one nautical mile of land were better predictors of haulout and rookery locations than were conditions within 10, 20, and 50 nautical miles. No consistent differences were found in the physical characteristics of waters surrounding sites in the eastern and western populations of Steller sea lions, or between haulouts and rookeries. Locations of haulouts and rookeries were then compared against a coastline type database to identify the shoreline preferences of Steller sea lions and to look for other spatial trends in site characteristics. Haulouts and rookeries were preferentially located on exposed rocky shorelines and wave-cut platforms. No relationship was found between either latitude or longitude of a site and its average non-pup count. The results indicated that there are differences in both the oceanographic and terrestrial characteristics of sites used by SSLs versus areas of coastline where they are not found.

Ban, S.S., and A.W. Trites. 2005. Terrestrial characteristics of Steller sea lion haulouts and rookeries. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

As in Ban (2005) above, the terrestrial component.

Ban, S., J. Porter, A. Trites, and M. Foreman. 2001. Using geographic information systems to analyze and predict Steller sea lion (*Eumetopias jubatus*) haulouts and rookeries. P. 15, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

As in Ban (2005) above, the oceanographic component.

Ban, S., J. Porter, A. Trites, and M. Foreman. 2003. Oceanographic characteristics of Steller sea lion haulouts and rookeries. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

As in Ban (2005), above, the oceanographic component for six SSL rookeries and haulout sites in British Columbia.

Ban, S. A.W. Trites, M. Foreman, and J. Porter. 2003. Steller sea lion haulouts and rookeries: Why are they where they are? P. 11, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

As in Ban (2005), above, the oceanographic component for six SSL rookeries and haulout sites in British Columbia

Burdin, A.M., T. Yu. Lisitsina, V.N. Burkanov, D. Calkins, S. Atkinson, and D. Zats. 2002. Application of remote video system for biological research on Steller sea lion (*Eumetopias jubatus*) at Cape Kozlova (Kronotskiy State Reserve, Kamchatka). *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

The authors describe the utility of the remote video system to monitor SSL behavior at Kozlova Cape, Kamchatka Peninsula, Russia, which was developed by Zats and colleagues and used extensively to observe SSLs at the Chiswell Island rookery in Alaska. The video system is briefly described and some results provided validating the utility of the system to remotely monitor SSL behavior and to re-sight brands.

Burdin, A.M., T. Yu. Lisitsina, and V.S. Nikulin. 2002. How conservative are Steller sea lion (*Eumetopias jubatus*) females choosing reproductive grounds? *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

The authors used the remote video system described above (Burdin et al. (2002) to monitor branded SSLs at Kozlova Cape, Russia. Of importance was their observation that in 2002, two female sea lions were seen at Kozlova Cape that were each nursing a one-year old pup; both pups had been branded in 2001 at Medney Island, Commander Islands. These two females subsequently were seen at Kozlova Cape with pups of the year such that each was nursing a one year old pup and a new pup. These observations document the movement of two adult females from Medney Island to Kozlova Cape and that they bred at both sites. It also documents two female SSLs nursing pups from consecutive breeding seasons.

Burkanov, V.N. 2006. Steller sea lion and northern fur seal surveys in Kuril Islands (Russia), 2005. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

This poster presentation reviewed results of ship and land surveys of rookeries in June-July 2005 for SSLs and in August for northern fur seals in the Kuril Islands, Russia. SSL counts totaled 5,725 non pups and 2,366 pups, and increase over 2003 counts of 7.1% and 10.5%, respectively. Fur seal counts at Lovushki and Srednego islands totaled 28, 692 pups, 108% higher than the last count in 1988. Three new fur seal haulout sites were discovered.

Calkins, D.G., and S. Atkinson. 2005. Introduction. Chapter 1, pages 1-5, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

The introductory chapter to this volume summarizes recent SSL biology and the scope and intent of the research program at the Alaska SeaLife Center, which is reported in the book chapters that follow the introduction. It contends that the synopsis provides a cross sectional look at the breadth of Steller sea lion research conducted by the ASLC Steller sea lion program, primarily since 2001. This introductory chapter explains that a reasonable effort was made by ASLC to coordinate all of their work with both NMFS and ADF&G research programs, particularly in investigations conducted in the Russian Far East. Sub-awards were made available to researchers from Universities and non-governmental organizations whose expertise was needed to assist the Steller sea lion program in evaluating the potential causes of the decline.

Call, K.A., and T.R. Loughlin. 2005. An ecological classification of Alaskan Steller sea lion (*Eumetopias jubatus*) rookeries: A tool for conservation management. Fisheries Oceanography 14 (Suppl. 1):212-222.

These authors provide a broad ecological characterization of rookeries for the western stock of SSLs by gathering data on habitat (bathymetry, sea surface temperature, substrate type, and orientation), population trends, and diet from available literature and NMFS databases (1990 - 1998). They used Geographical Information System resources to group sea lion rookeries into ecologically related regions. Ecological attributes were assigned to rookeries within a 10 nm radius of land, using GIS resources. Regions were determined using cluster analysis. Five distinct classes of rookeries (i.e. potential management regions) were identified based on their relatedness to the ecological factors. Several of the regional breaks occurred at major oceanic passes including Amchitka, Samalga, and Unimak passes and are associated with oceanographic currents.

Curgus, C. S., D. McAllister, K. Raum-Suryan, K. Pitcher and W. Cunningham. 2001. Live-capture method for Steller sea lions using SCUBA. P. 51, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Same information but more condensed as in McAllister et al. (2001) below.

Dunford, B., S. McKinley, R. Petrell, A.W. Trites, M. Yedlin, and R. Virtue. 2003. An implantable radio identification tag for Steller sea lions. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

This poster presentation describes work in progress to develop an implantable UHF transmitter for use on SSLs. This particular poster dealt with the problems associated with antennae design and various antenna configurations being explored. The entire transmitter and antennae are expected to be about the size of a credit card and will be suitable for implanting below the SSLs skin.

Harington, C.R., R.L.M. Ross, R.W. Mathewes, K.M. Stewart, and O. Beattie. 2004. A late Pleistocene Steller sea lion (*Eumetopias jubatus*) from Courtenay, British Columbia: its death, associated biota, and paleoenvironment. Can. J. Earth Sci. 41:1285–1297.

This journal paper describes a partial juvenile SSL skeleton from near-shore marine sands at Courtenay, Vancouver Island, British Columbia radiocarbon dated to 12 570 ± 70 BP. This date was supported by both stratigraphic and regional sea-level emergence data and was similar to radiocarbon dates on a SSL humerus from Bowen Island, just north of Vancouver. The juvenile apparently died from a blow to the braincase, most likely caused by a SSL bull. The authors state that the Courtenay specimen is significant since very few Pleistocene otariid fossils are complete enough to be assigned to modern taxa. Associated mollusk remains indicated that the marine paleoclimate of the fossil locality was considerably colder than now — close to that along the northern reaches of Cook Inlet and Prince William Sound, Alaska. Fish remains (mainly Pacific cod and walleye pollock, with some salmon) from this site probably reflect selection by adult sea lions at a rookery.

Horning, M., and R.L. Hill. 2005. Designing an archival satellite transmitter for long-life deployments on oceanic vertebrates: The life history transmitter. IEEE Journal of Oceanic Engineering 30 (4): 807-817.

These authors discuss their development of the first telemetry transmitter specifically designed for collecting vital data over extended periods, up to a decade. The implantable Life History Transmitter records data throughout the life of a host animal. After the host animal dies, the tag is extruded, and, while floating on the ocean or lying on a beach, transmits previously stored data to orbiting satellites. The article discusses the technical features of the transmitter and the testing procedures used to validate transmitter identification and data interpretation.

Hoshino, H., T. Isono, T. Takayama, T. Ishinazaka, A. Wada, and Y. Sakurai. 2004. Wintering of Steller sea lion (*Eumetopias jubatus*) along the northern coast of the Sea of Japan. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Aerial and land SSL counts were conducted from December 2002 to May 2003 of the haulout sites between Rishiri-Rebun Islands and Tsugaru Strait, Japan. Aerial surveys confirmed 135-390 SSLs in the area between January and early March; Cape Kamui was used by more SSLs than other sites. SSLs were also seen at other sites and the general trend in abundance provided. The appearance of SSL was consistent with the appearance of arabesque greenling and walleye pollock breeding aggregations.

King, J.C., T.S. Gelatt, and K.W. Pitcher . 2004. A field-based method for estimating age in free-ranging juvenile Steller sea lions (*Eumetopias jubatus*). Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors report their use of canine tooth length and tooth eruption state as a reliable estimator of pup age, to within 2-3 months. The results were based on known aged animals 3-23 months of age. Length of body, whisker, and diastema were not reliable indices.

Kruchenkova, E., N. Lobacheva, and M. Goltsman. 2001. Does the duration of shore visits depend on food availability in lactating Steller sea lions? P. 118, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

The authors measured the duration of time at sea and on land for adult female SSLs at Medney Island, Commander Islands, and found that the time females spent in each area was rigid and less than published accounts. On Medny the females spent about 12.6 hours at sea at night (on foraging trips) and 11.6 hours on shore, a total of about one day. Published accounts for females in Alaska are much longer and less rigid. The authors contend that this difference is based on food availability and that the abundance of nearby food at the Commander Islands allows for this difference. No measures of prey abundance or availability were provided.

Kuzin, A.E. 2002. Abundance and some biological features of Steller sea lions of the Tyuleniy Island. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

The author provides SSL counts and ratios of females to males at the Tyuleny Island (Robben Island) rookery for 2001. Also given are counts of animals with marine debris (17) and brands (45) seen at the island that originated in the Kuril Islands rookeries. Individual animals were monitored and their time spent on shore and away from the rookery was provided. Females spent about half their time on shore and at sea with increasing time on shore as the season progressed. Immigration was an important factor in the population dynamics of the rookery and marine pollution likely has a negative effect on population trends.

Kuzin, A.E. 2004. Results of biological studies of northern sea lions (*Eumetopias jubatus*) on the Tyuleny Island (the Sea of Okhotsk) in 2003. Pages 300-303, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

This abstract reports studies during 2003 on Tyuleniy Island, including structure of the rookery, abundance, injuries from marine debris, sources of mortality, observations of marked animals, survival, and time on shore. Storms and disturbance in early 2003 reduced the amount of space available to SSLs; when the fur seal harvest ended SSLs moved into areas occupied by fur seals. Over 700 breeding females and >40 territorial males were present with abundance increasing by almost seven times in the past 14 years. Only 6 animals were seen entangled and no dead adults were seen; 15 dead pups were counted. Ninety six marked SSLs were observed most of which were from the Kuril Islands and 11 from Yamsky Island. Survival rate for pups marked at Jonah Island in 1997 was 27% for males and 31% for females.

Kuzin, A.E., V.N. Burkanov, and N.N. Pavlov. 2002. To the problem of dispersion, homing and phylopatry of juvenile Steller sea lions. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

This abstract documents observations of marked SSLs on Tyuleny Island that were marked elsewhere. Most of these marked animals were subsequently resighted at the island where they were marked, their birth islands. Only one female marked in the Kuril Islands gave birth at Tyuleny Island. Their observations show that juvenile SSLs range widely but at maturity most return to their natal rookeries for reproduction.

Lander, M.E., and F.M.D. Gulland. 2003. Rehabilitation and post-release monitoring of Steller sea lion pups raised in captivity. Wildlife Society Bulletin 31(4): 1047-1053.

This article discusses the movements of two male and one female SSL that were admitted for rehabilitation to the Marine Mammal Center, California. They were released at Southeast Farallon Island and Año Nuevo Island after about 10 months and followed with satellite-linked time-depth recorders attached to their dorsal fur. One animal was sighted near Coos Bay, Oregon while the others stayed within the central California coast area. Figure 1 of the article provides a depiction of movements. Transmissions were received for up to 1, 3, and 4 months respectively for each sea lion. Overall, mean dive depth was 22.6 m and mean duration was 1.13 minutes, similar to values in the literature

Lander, M.E., T.R. Loughlin, M.L. Logsdon, G.R. VanBlaricom, B.S. Fadely, and L.W. Fritz. 2005. Environmental composition of habitat used by juvenile Steller sea lion (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Similar information as in Lander et al. (2003, 2005) in the Foraging-Searching theme. Habitat was assessed by deploying satellite-depth recorders and satellite relay data loggers on juvenile SSLs (n=50) during 2000-2004 within four regions of the western stock. Areas used by SSLs during June-August were demarcated using telemetry data and characterized by environmental variables (SST and chlorophyll-a) which serve as proxies for environmental processes or prey. Shannon's Diversity Index (shows how evenly the proportions of environmental patch types are distributed) was quantified for each area using a spatial pattern analysis computer program. There was considerable inter annual variability within and among all areas, however indices of diversity of SST for the eastern and central Aleutian Islands (both stable or increasing) were consistently greater than indices for the western Aleutians or the central Gulf of Alaska, both of which are in decline.

Lisitsyna, T. Yu., and A.M. Burdin. 2002. Structure peculiarities of rookery population and behavior adaptations in Steller sea lions (*Eumetopias jubatus*) at Cape Kozlova (Kamchatka Peninsula). *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

The authors document movement of females with pups after birth to parts of the Kozlova Cape rookery that were' unsafe' for pups. Subsequent storms washed some of these pups off the rookery and placed them on the male haulout site where they likely died from starvation. Older pups that were capable of swimming were observed interacting with the males but no aggressive or sexual behavior was observed toward the pups by the males. Males without territories were observed trying to enter the rookery and interfered with female/pup nursing; the pups were protected from the males by the mother. Last, branded sea lions from the Commander Islands, the Kuril Islands, and Iony Island were observed on Kozlova Cape during the 2001 breeding season.

Loughlin, T. R. 2000. Steller sea lions. Alaska Geographic 27 (2):60-73.

This is a non-technical article written for the lay public and includes discussion of SSL distribution, feeding habits, reproduction and life cycle, and management. It includes numerous color photographs of SSLs in the wild. The information was obtained from published accounts and the authors studies with the federal government's National Marine Mammal Laboratory.

Loughlin, T. R. 2002. Steller sea lion. Pages 1181-1185, *in* W.F. Perrin, B. Wursig, and H.G.M. Thewissen, editors, Encyclopedia of Marine Mammals, Academic Press, San Diego.

> Similar to Loughlin (2000) above but in a more technical format. The article provided a summary of SSL distribution, geographical variation, ecology, notable behavior (primarily breeding and foraging behaviors), anatomy, physiology, fossil record, and interactions with humans.

Maniscalco, J.M., S. Atkinson, D.G. Calkins, P. Parker, E. Teate, and D. Zatz. 2005. The usefulness of remote-operated video cameras for long-term tracking of individual Steller sea lions. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

> This abstract summarized the utility of the remote video camera at Chiswell Island, Gulf of Alaska. The abstract is similar to that of Burdin et al. (2002) above that was used at the Russian Kozlova Cape rookery. Summary information was presented that was obtained using the video system including daily, seasonal, and annual population changes, maternal care, reproductive performance, pup production, predation, and other information.

Mathews, E.A., and L. Dzinich. 2001. A new Steller sea lion rookery in Glacier Bay National Park and Preserve. Final Report to Glacier Bay National Park and Preserve, Gustavus, AK, 99826. Available at National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115. 15 pp.

> This short report provides a history of the Graves Rock SSL haulout site in Glacier Bay National Park and its transition to a rookery. SSLs were not observed there during boat surveys between 1962 and 1984; its regular use as a haulout site likely began in the mid 1980s. Several hundred sea lions used the site in the 1990s. Breeding activities likely began there in 1995 or 1996 but were not documented until 2000. Pup births there are in the 20s. This is the 5th rookery in Southeast Alaska.

McAllister, D. C., D. G. Calkins, and K.W. Pitcher. 2001. Underwater capture of juvenile Steller sea lions with Scuba: a narrated video presentation. Pages 53-56, *in* Cold Water Diving for Science, University of Alaska Sea Grant Publication AK-SG-01-06.

> This brief article summarizes the history and developments in the ADFG underwater capture technique to capture and handle juvenile SSLs. Originally suggested by Shane Moore, an underwater photographer, the ADFG began development of the technique by use of a noosing technique. The article describes the technique and a summary of captures through May 2001 (171 captures). Many hundreds have been safely captured by them since. The NMFS and ASLC are now using the technique to capture juvenile sea lions in their studies.

Mellish, J.-A., S. Atkinson, and M. Castellini. 2004. Capture and holding of juvenile Steller sea lions: the transient project. *In*: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK

> As in Mellish et al. (2005) below.

Mellish, J.-A, E., D.G. Calkins, and S. Atkinson. 2005a. The transient juvenile Steller sea lion project. Chapter 19, pages 187-192, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

This book chapter describes the rationale and purpose of the subject project. In a workshop held at the ASLC in November 2000, short term captive holding of juvenile SSLs was identified as a new and innovative method for learning more about young SSLs in the wild. The Transient Juvenile Steller Sea Lion Project would allow for longitudinal study of multiple individuals for numerous complementary research programs which would not otherwise be feasible with either pure field work or captive approaches. As of the writing of this chapter twelve animals had successfully completed the program since August 2003 (many more have completed the program since then). The ASLC has facilitated and participated in the data collection for more than a dozen projects with multiple investigators from government, educational, non-profit and private institutions

Mellish, J.-A. E.. D.G. Calkins, D.R. Christen, M. Horning, and S. Atkinson. 2005b. Temporary captivity as a research tool: a novel approach to the comprehensive study of wild mammals. Chapter 21, pages 200-211, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

In this book chapter, the authors provide more detail of the juvenile transient program at the ASLC briefly described above (Mellish et al., 2005). Rotating groups of up to four endangered western stock SSLs were held in temporary quarantine captivity for periods of up to 3 months. Comprehensive collaborative research allowed collection of a maximum of information with minimal impact. Analysis of blood, body condition, and post-release monitoring data show that temporarily captive animals did not differ overall from free-ranging individuals. Of fifteen blood parameters measured, only four changed significantly during captivity (white blood cells, albumin, hematocrit, and total protein). Only albumin levels fell outside of control values for wild sea lions at exit. Decreased white blood cells during the captive study period suggested a decrease in overall stress. Increased body fat, albumin, hematocrit and total protein in captive animals over time were likely a function of a regular diet schedule and low-impact nutritional studies.

Mellish, J.E., D.G. Calkins, D. Christen, M. Horning, and S. K. Atkinson. 2006. Temporary captivity as a research tool: a comprehensive study of wild pinnipeds under controlled conditions. Aquatic Mammals 32(1):58-65.

This is a journal article with the same information as the two above (Mellish et al., 2005a and b). Here they discuss four groups of four animals (16 total) that had been held for up to 3 months. Hematological and blood chemistry parameters were collected at the beginning and end of captivity and compared to free-ranging juvenile controls to determine if animals in temporary captivity can provide accurate physiological data representative of their wild counterparts. Free-ranging pups and juveniles were compared for hematological differences related to developmental stage. As stated in the articles above, temporarily captive animals did not differ from free-ranging juveniles. Seven of 17 blood parameters measured changed significantly during captivity, likely as a function of a regular schedule and low-impact nutritional studies (e.g., increased mass, cholesterol, total protein, and globulins). A decrease in white blood cells during the study period (~10.4 to ~7.9 m/mm ^{3}) to levels lower than that of free-ranging animals (~10.7 m/mm ^{3}) indicated a drop in overall stress during captivity despite research and handling procedures. Calcium increased with captivity duration, suggesting that physiological changes can begin in even limited time frames. Eight parameters related to immune status and diet differed significantly between juveniles and pups from the same geographical region.

Mellish, J.E., P.A. Tuomi, and M.Horning, 2004. Assessment of ultrasound imaging as a noninvasive measure of blubber thickness in pinnipeds. Journal of Zoo and Wildlife Medicine 35(1): 116–118.

Portable ultrasound imaging was examined as a noninvasive measure of skin including blubber thickness in captive subadult Steller sea lions and adult harbor seals. This method was validated through comparison with blubber biopsy. Ultrasound images provided depth measurements that were accurate to 99.8% of the actual. This method allowed clear images of the epidermis, dermis, and blubber layer to be rapidly obtained, with minimal animal restraint, and allowed differentiation of phocid and otariid blubber structure.

National Research Council (NRC). 2003. Decline of the Steller sea lion in Alaskan waters; untangling food webs and fishing nets. National Academy Press, Washington, D.C. 184 pp.

In November 2000 the ESA Section 7 consultation by NMFS concluded that the Alaska groundfish fishery posed a threat to the recovery of SSLs and imposed more restrictive management measures on the management of the fishery. Concern that the new regulations would bring significant social and economic disruption prompted Congress to direct the North Pacific Fisheries Management Council to sponsor an independent scientific review by the National Academy of Sciences on the causes of the SSL decline and the potential efficacy of the new management measures. This book represents the published results of that review. The focus of the review included (1) the status of current knowledge about the decline in Alaska, (2) the relative importance of food competition and other cause of the decline and impediments to recovery, (3) critical information gaps in understanding interactions between SSLs and fisheries, (4) the type of research program needed to identify and assess human and natural causes of the decline, and (5) the components of an effective monitoring program and efficacy of the management regime. A summary of part of the results is in the vital rates theme.

Nelson, A.W., and R.B. Heath. 2003. A study to evaluate transmitter implant methodology. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

This paper provides an overview of efforts to develop techniques for implanting radio transmitters in SSLs. In this presentation, the authors developed a surgical pouch derived from skin folds; sheep are being used as the surrogate test animals. The authors provide details on the progress of pouch skin healing after surgical construction of the pouch in 12 sheep. Based on possible necrosis of the pouch from stretch and compression of the transmitter, the transmitter's design was modified to provide a lower profile

Nevedomskaya, I.A. 2004. Unusual encounter with Steller sea lion (*Eumetopias jubatus*) in a vicinity of Yuzhno-Kurilsk settlement (Kunashir Is. of the Kuril Islands). Pages 425-426, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

This abstract summarizes a rare sighting of an adult female SSL near an inland village on Kunashir Island, one of the northern Kuril Islands. The animal was alive and was herded back to the water, some 2 km away. It is not known how or why it was so far inland but the authors speculate that it swam up a nearby river to escape from ice on the Okhotsk Sea side of the island and came ashore far inland.

Nevedomskaya, I.A. 2004. Localization of rookeries and haulouts of marine mammals on the Kuril Islands. Pages 422 – 425, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

This abstract is a generalized summary of pinniped use of the Kuril Islands. It deals mostly with phocid seals but dwells briefly on some rookeries used by fur seals and SSLs in an historical context. There are no data presented and the article concludes that each species has its own peculiarities that determine which sites will be used.

Plankis, B.J., M. Horning, N. Ponto, and L.K. Brown. In press. Designing a dependable and fault tolerant semi-autonomous distributed control data collection network with opportunistic hierarchy. IEEE Journal of Oceanic Engineering.

This paper presents the Satellite-Linked Data Acquisition and Photogrammetry (SLiDAP) network, designed to conduct shore-based, close-range three-dimensional imaging in remote areas. The system uses 4-5 or more imaging stations (cameras) to collect the images which are sent to an orbiting satellite then to the home laboratory. The imaging stations on site are linked with a wireless LAN. The article with drawings provides the technical details of the system. The system has been tested but not deployed as of April 2006.

Riemer, S. D., R. F. Brown and B. E. Wright. 2001. The Steller sea lion in Oregon. P. 180, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

This is a generalized presentation discussing the overall research program in Oregon on SSLs from 1976 to 2001. The program includes aerial and land surveys, scat collection, pup counts, pup branding, morphological measurements, and tissue collection for viral screening, genetics, and other topics. They report some survey data and note that the SSL population increased from 1976 to 2000 at an annual rate of 3.9%; 3,786 non pups and 600-800 pups were counted in 2000. The most common prey identified from scats was Pacific hake (whiting), Pacific lamprey, salmonids, herring, cephalopods, skate, and smelts.

Schrader, W., M. Horning, and J.-A. Mellish. 2005. Post-release monitoring of juvenile Steller sea lions. Chapter 20, pages 193-199, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Juvenile SSLs in the transient program at the ASLC were monitored upon release to assess any effects of temporary captivity on diving and ranging behavior. Twelve transient and five free-ranging juveniles were monitored using satellite dive recorders. Most juveniles remained within 80 km of their capture location. Two transient juveniles made transit trips of >500 km upon release. Mean depths and durations for transient juveniles per-6 hr period were ~30.3 m and ~91.7 seconds. The mean daily maximum dive depth for juveniles was 84 m. Ranging and diving behavior for transient juveniles was consistent with values reported for juvenile SSLs from other studies. Mean dive depths and durations exceeded previously reported mean values for juveniles from the western stock by 13.7 m and 24.7 s. Mean daily maximum dive depth also exceeded previously reported values by 20.6 m. Diving and ranging behavior of transient juveniles collected in the first months after release do not show any effects of temporary captivity on diving and ranging ability.

Scordino, J., R. Brown, B. Wright, J. Jennings, and S. Heppell. 2005. Juvenile Steller sea lion movements of the California Current ecosystem. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This abstract summarizes monthly observation of marked juvenile SSLs since 2001 in the California Current ecosystem resulting in over 3,500 individual sightings. Juvenile SSLs from northern California and southern Oregon were seen most commonly at Sea Lion Caves, Oregon and in haulout sites of northern Puget Sound and the Straight of Juan de Fuca. No data were provided.

Trites, A.W., D.A.S. Rosen, and A.J. Winship. 2002. Unravelling the mysterious disappearance of Steller sea lions in Alaska: insights from fieldwork, captive studies, and mathematical models. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

This generalized abstract discusses results of studies by the authors at the Univ. of British Columbia (see Foraging—Models theme). Here they discuss the asserted consequences to SSLs feeding on low-quality prey including health and condition, and susceptibility to predation and disease. They then stress the importance of captive studies, field studies, and modeling to understand population dynamics and the cause(s) of the SSL decline.

Trukhin, A.M. 2004. Preliminary period and delivery in Steller sea lion (*Eumetopias jubatus*) under natural conditions. Pages 554-557, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

This long abstract provides a lengthy and thorough description of birth in SSLs at Raikoke Island, Kuril Islands during 110 days of observation in 2001-2003. Many of the observations were of animals branded at that site in previous years. Specific information of note was that females occurred at the rookeries 0-17 days prior to parturition (4.9 days on average) and the duration between mating and parturition was 340-359 days (n=10), based on marked animals; average gestation period was 352.3 days. Cephalic and pelvic deliveries occurred about evenly and had similar durations. One marked female had a cephalic delivery one year and a pelvic the next. Other pertinent and interesting observations were provided.

Trukhin, A.M., and V.N. Burkanov. 2002. Observations of marked Steller sea lions on Raykoke Island (Kuril Islands) in 2001. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

This study summarizes observations of tagged and branded SSLs at Raykoke Rookery, Kuril Islands in 2001. Marking began there in 1989, 1991, and 1995-1999. Sightings of marked animals by sex and age are provided along with reproductive status of marked animals and their natal rookeries. The abstract concludes that females on Raykoke Island start breeding at 5 years of age and that migration from other sites is not uncommon.

Vazhenina, V.B. 2004. Steller sea lion (*Eumetopias jubatus*) sightings in Chukotka. Pages 116-117, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

This abstract lists five haulout sites in Chukotka where SSLs are observed in the non-breeding season. Latitude and longitude of the sites is provided as well as the number of animals seen and the person reporting the information. Additional sightings of SSLs seen in the water are provided.

Willoya, D., L. Jack, and M. King. 2005. Steller sea lion photographic monitoring and brand resights of local, seasonal haulouts in Prince William Sound, Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

The abstract summarizes efforts by the Alaska Sea Otter and Steller Sea Lion Commission to develop protocols whereby Alaskan tribes can gather and provide information on SSL population trends and distribution using cultural knowledge and scientific methods. An overview of surveys and methods used in Prince William Sound was provided but no data was included.

Zadalskiy, S.V. 2002. Population status and migrations of Steller sea lions in the northern part of the Sea of Okhotsk. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

The abstract contains information of the distribution and abundance of SSLs on three sites in the northern Sea of Okhotsk, two rookeries and one haulout site. On the Yamsky Island rookery abundance was stable at about 800-900 animals with and additional 200 pups through the year 2000 when abundance quickly increased to 1314 animals and 427 pups. Migration from the Kuril Islands was the principal cause of the increase. Counts at Lisyanski Peninsula remained stable during this period and the haulout site at Zavyalova Island had about 128 animals in 2001. Branding and brand resight information from these sites was provided

Zagrebin, I.A., and D.I. Litovka. 2004. Distribution of Steller sea lions (*Eumetopias jubatus*) in north-western Anadyr Gulf and western Bering Strait in 1994-2003. Pages 331-335, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

The authors provide their observations of SSLs obtained while conducting bowhead whale and other marine mammal surveys in northwestern Anadyr Gulf and western Bering Strait during 1994-2003. A map and table of sightings was provided. The earliest sighting was in the middle of June at Cape Chukotsky with increasing numbers by October-November. Both single animals and groups of up to 25-30 animals were seen. Sightings since 1998 increased on average at 52%/year and occur in this area5-6 months per year, from June to the end of December if conditions allow. The greatest number of animals seen was 386 in 2003.

THEME 2A – FORAGING – DIET

SUMMARY:

This theme had major effort during the review period and contains 91 articles including 58 presentations at scientific meetings, four reports, two unpublished reports, two theses and one dissertation, and 24 papers in peer-reviewed journals or book chapters. The major focus of research dealt with efforts to (1) describe SSL prey items through analysis of scat, stable isotopes, and fatty acids, (2) relate diet to available prey fields, (3) define the energetic value or quality of various prey items, and (4) general themes dealing with prey and SSLs.

1. As in years past, SSL diet was studied using scat collected throughout most of Alaska and Russia. Published studies by Sinclair, Tollit, Waite, B. Wilson, and Zeppelin confirm earlier published accounts of SSL diet in that the common prey of 61+ species identified was pollock, Pacific cod, Atka mackerel, herring, sandlance, salmon, arrowtooth flounder, rockfish, skates, and cephalopods with proportions of prey varying depending on location, season, and age. Use of remains other than otoliths was explored (Tollit, Zeppelin) and found to be useful in identifying prey and prey size.

Changes in stable isotope ratios obtained from various SSL tissue was used by a few researchers to determine if SSL trophic level had changed over time (deHart, Farley, Hirons, Hobson) with suggestions that the carbon and nitrogen isotope values varied greatly according to the location and year of each sample. The lower values found in some samples from western areas suggested that SSLs were consuming lower trophic level fish species or could be an indication of a reduced carrying capacity in the North Pacific Ocean.

Use of fatty acids to define consumed prey was a major topic during the review period. Originally used by Iverson on Atlantic phocid seals, it has become a useful technique in combination with scat analysis to describe SSL diet. Efforts by Beck, Hoberecht, Rea, Tollit, L. Wilson and others contributed to these efforts. No new prey items were added to the diet list using this technique, but its utility as a meaningful tool was confirmed. Samples must be obtained from blubber which may be problematic. Hoberecht described the use of a darting technique to obtain samples, but most studies used samples obtained from animals captured for other studies (e.g., telemetry) and the animals were in-hand for sample acquisition.

2. Relate diet to available prey fields:

Some very useful studies focused on the seasonal availability and quality of different prey, principally in Southeast Alaska (Gende, Sigler, and Womble), Kodiak area (Foy, Logerwell, and Wynne). These studies were often linked with telemetry studies (see Foraging—Searching For Prey theme) and provide insight into the seasonal abundance and location of principle prey available to SSLs. Notable results were those in Southeast Alaska where Womble, Sigler, and others found the spatial distribution of SSLs during spring reflected the distribution of spawning eulachon in northern Southeast Alaska, particularly in Lynn Canal and along the Yakutat forelands. Haulouts with peak numbers of SSLs in spring were located significantly closer to eulachon spawning sites than haulouts that peaked at other times of year. Some haulouts were occupied only during the eulachon spawning period. The maximum number of SSLs at haulouts in spring was inversely correlated with the distance to the closest eulachon aggregation and was positively associated with the number of eulachon within 20 km. And in the Kodiak area, Wynne and colleagues reported seasonal and regional patterns of prey use. Capelin and herring were significantly more common in scats collected from northern sites while pollock were seasonally more prevalent on eastern sites.

3. Energetic value or quality of various prey items:

The quality and value of prey has received special attention in the past few years as the debate continues over the utility of the 'junk food' hypothesis and other issues related to prey quality and quantity. Most of that research is discussed in the Foraging-Models theme. However in this section, analyses were conducted by some researchers to get at the issue of variability in energetic content of prey and prey quality by prey age and by season and location. Studies by Bando, Ingles, Kitts, and Schauflerer address this topic. Bando's Master degree study suggested diet composition for the Southeast Alaska SSL population provided a higher caloric density per gram than western populations of SSLs. In the Bering Sea, Aleutian Islands, Gulf of Alaska, and Southeast Alaska, Ingles et al., Kitts et al. and Schaufler et al. report the proximate analysis of over 1,200 fish representing species identified as SSL prey and calculated mean energy densities based on lipid and protein content. Comparison of the energy densities between Aleutian Islands and Southeast Alaska fish on a species basis revealed significant differences in energetic prey content where those in Southeast Alaska generally had a higher energy contend; fish size may have confounded these comparisons. Vollenweider and colleagues combined scat data with energetic content of prey to estimate species-specific energy contribution to SSL diets at Benjamin Island. Rosen and colleagues report on dry-matter digestibility and energy digestive efficiency in six captive juvenile SSLs at the Vancouver Aquarium fed three diets each consisting of a single species: herring, pollock, and squid.

4. General themes dealing with prey and SSLs:

Reports in this category summarize sea lion diet by region (Brown) and species (Trites), or other topics pertaining to diet that do not fit in the categories above (e.g., Carpenter et al; Harvey et al.).

ANNOTATED BIBLIOGRAPHY – FORAGING – DIET

Bando, M. 2002. Proximate compositions of Steller sea lion prey items. M.S. thesis, Alaska SeaLife Center, Seward, AK, and University of Alaska, Fairbanks, AK.

> This Master's thesis focused on the quality of SSL prey during different feeding regimes applied to captive animals. The author states that nutritional stress may be attributable to reduced preferred prey availability and/or prey quality and could be the result of commercial fisheries removals or, alternately, environmental changes such as climatic regime shifts. At the Alaska SeaLife Center, researchers have formulated three different feeding regimes representative of SSL diets: prior to their population decline (Gulf of Alaska, 1970s), during their decline (Gulf of Alaska, 1980s), and from a stable or growing population (southeast Alaska, 1990s). The purpose of this project was to compare the nutritional quality of these three diets that differ in prey species composition. Proximate composition and bomb calorimetry were used to determine energy density of prey species. Variations in the proximate composition of prey species, such as high energy herring and low energy octopus, affected the overall energy densities of the different diets. While the pre-decline and stable diets were composed of more high fat fish such as herring, capelin and pink salmon, the decline diet contained more lower fat prey items, such as octopus, Dover sole and rock sole.

The resulting overall energy densities provided by the pre-decline and stable diets are similar to one another and significantly higher in energy density than the decline diet. Assuming that the ten prey species analyzed for this study adequately represent the bulk of prey consumed by SSLs and that these formulated diets are representative of SSL diets prior to and during their population decline and in stable populations, results from this study are consistent with the possibility that nutritional stress was a cause of the Steller sea lion decline.

Bando, M. and B. Norcross. 2001. Comparing the nutritional quality of Steller sea lion diets. P.15 *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

A presentation at a conference and is the same as information in Bando (2002) above.

Barrick, R., D.J. Tollit, S. Heaslip, J. Beblow, and A.W. Trites. 2005. Digestion and recovery rates of otoliths, bones, and beaks: Assessing biases in using fecal samples to determine the diet of the Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This abstract summarizes a study comparing the digestion and passage of fish otoliths and squid beaks with that of other hard parts recovered from scat of four captive SSLs. Enumerating other bones in addition to otoliths increased estimated prey recovery by two-fold on average. Bones were distributed over more scats per meal than otoliths and pollock occurred over more scat than other prey tested. Prey recovery was significantly correlated with otolith robustness. Squid beak recovery exceeded otolith recovery. The application of numerical correction factors which aim to account for lack of recovery due to complete digestion of otoliths and bones, improved biomass reconstruction diet estimates, especially those based on otoliths alone.

Beck, C.A., L. D. Rea, S. J. Iverson, J. Kennish, K.W. Pitcher, and D. J. Tollit. 2004. Using fatty acids to investigate dietary changes in young Steller sea lions (*Eumetopias jubatus*) in Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Fatty acids (FA) were extracted from SSL blubber samples obtained from pups and juvenile throughout Alaska. 68 fatty acids were identified and significant regional differences in the FA profiles of both pups and yearlings were found. Within Prince William Sound, FA signatures varied by season and age.

Beck, C.A., L.D. Rea, S.J. Iverson, J.M. Kennish, D. Tollit, and K.W. Pitcher. 2005. Estimating diet of young Steller sea lions using quantitative fatty acid signature analysis (QFASA). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

QFASA is an established method to identify prey using fatty acid signature analysis. This study sought to determine if it could also be used to differentiate milk samples from prey species. Results showed that milk samples could be clearly distinguished from all prey with 93% accuracy. The authors also constructed 4 mixed-prey diets, each differing in the proportion of milk (0-100%). These and additional tests described in the abstract suggested to the authors that QFASA can be used to determine the importance of milk with age in SSLs.

Beck, C., L.D. Rea, S.J. Iverson, J.M. Kennish, D. Tollit, and K.W. Pitcher. 2006. Using quantitative fatty acid signature analysis (QFASA) to estimate diet in young Steller sea lions (SSL) in Prince William Sound, Alaska. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

> Same abstract information as presented above (Beck et al., 2005) and below (Beck et al., 2003) but with a sample size of 207 blubber samples (was 179).

Beck, C., L. Rea, J. Kennish, and S. Iverson. 2003. Diet differences in Steller sea lions by age and location based on fatty acid signatures. P. 14, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p

> This abstract summarizes a study comparing fatty acid signatures in young animals to adult females and juvenile diets. The authors used 179 blubber biopsy samples from SSLs ranging in age from 2 to 23 months and encompassing numerous seasons from Prince William Sound, Kodiak area, and the Aleutian Islands. Fatty acids were extracted using typical methods and 68 were identified using gas chromatography. Fatty acid signatures differed for 9-10 month old pups between locations but not by sex. For those pups that were still nursing the fatty acid signatures reflected that of the mother's diet suggesting that these females consumed different diets at each location and by season. The diet of yearlings remained relatively constant suggesting that adult females respond to changes in prey availability while yearlings do not.

Beck, C., L. Rea, J. Kennish, and S. Iverson. 2003. Location and age class differences in the dietary fatty acids of young Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

> Similar to the abstract above, the authors used fatty acid signatures from blubber samples to determine diet in 13 pups and 16 yearlings from Prince William Sound and 13 pups and 20 yearlings from Southeast Alaska. An overview of methods and results is provided and the results suggested that SSLs in the two areas were consuming different prey.

Bleakney, K., J.R. Carpenter, and S. Atkinson. 2005. Rate of passage and assimilation efficiency of herring diets containing different fat levels in harbor seals. Chapter 5, pages 31-42, in Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

> This study determined the effect of dietary fat content on assimilation efficiency (AE). They used harbor seals as a surrogate species for SSLs to validate assimilation efficiency techniques on captive pinnipeds at the ASLC. Rate of passage (ROP) and initial defecation times (IDT) were first measured in five harbor seals on a high-fat herring diet. Intake and nutrient digestibility of both high- and low-fat herring diets were determined over 72 hours using chromic oxide (Cr_2O_3) as an inert marker. All diet and fecal samples were analyzed for their nutrient content. Initial defecation times were 13.0 ± 7.5 hours. Percent Cr_2O_3 recovery was high at 85.33 ± 11.36%. Recovery of Cr_2O_3 followed a bell-shaped curve with peak recovery at ~24 hours after feeding. Assimilation efficiency of dry matter was significantly higher for the high-fat herring, but AE's of crude protein, crude fat, and energy were similar between the two diets. This study showed that fat content of herring does not affect AE substantially, but does have a significant impact on both the quantity of protein and fat consumed daily. The similarity of AE values found in this study suggests that AE may be

more dependent on prey species and level of intake, and less dependent on actual nutrient composition of any particular type of prey.

Brown, R. F., S. D. Riemer, and B. E. Wright. 2002. Population status and food habits of Steller sea lions in Oregon. Report from Oregon Department of Fish and Wildlife to Oregon State Univ. Contract F0225A-01. 17 pp.

This unpublished contract report includes results of aerial surveys and examination of scat from rookeries and haulout sites in Oregon during 2000-2001. A total of 408 scats were collected from which North Pacific hake was the most frequently occurring prey item (and the largest biomass of any single species in the region). Other frequently occurring prey was Pacific lamprey, salmonids, skates, Pacific herring, and rockfishes. No significant variation in prey utilization was seen by year or area. The report includes 3 tables and 4 figures of which Figure 4 details frequency of occurrence of most prey found in the scat samples.

Carpenter, J.R., C. L. Morishige, and B. Rasco. 2005. Utilization of near infrared spectroscopy (nirs) and dry matter to predict the nutrient composition of Pacific herring. Chapter 6, pages 43-58, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

In this book chapter the authors describe the use of Short-Wave Near Infrared Reflectance (SW-NIR) Spectroscopy as a technique to analyze diet based on its speed, efficiency and cost effectiveness. The abstract states that the objective of this project was to develop SW-NIR spectroscopy calibration equations for moisture, fat, protein and ash (total mineral) content for whole homogenized Pacific herring. Eighty-six samples were homogenized and analyzed with standard methods of proximate analyses. There were significant differences between all analytes (except carbohydrate) and location of catch. These samples were then scanned using visible and short-wavelength near-infrared (SW-NIR) reflectance spectroscopy to develop models for the chemometric prediction and calibrations equations developed for both the individual lots and overall sample pool for moisture, fat, protein and ash. Calibration models for each location were fairly comparable: Alaska (Lot D) R^2=0.66-0.91 and Canada (Lots A through C) R^2=0.47-0.81. Using cross-validation, the NIRs equations were repeatable and accurate in predicting nutrient composition of Pacific herring. In addition, it was also determined that the moisture or dry matter of the fish can also be successfully used to predict the energy density and nutrient composition of herring.

Cottrell, P.E. and A.W. Trites. 2002. Classifying prey hard part structures recovered from fecal remains of captive Steller sea lions (*Eumetopias jubatus*). Marine Mammal Science 18:525-539.

The authors conducted a captive study on SSLs to determine the numbers and types of taxon-specific hard parts that pass through the digestive tract and to develop correction factors for certain abundantly occurring structures from the prey. Atka mackerel, salmon, Pacific herring, pollock, and squid were used as test prey. Of over 20,000 prey consumed, the branchiocranium, axial skeleton, and dermocranium accounted for the greatest number of hard parts recovered. Over 70% of all recovered hard parts were represented by one to six taxon specific structures.

deHart, P.A.P., and M.J. Wooller. 2004. Shouldn't we ask where? Stable isotopic evidence of geographical variations in Steller sea lion (*Eumetopias jubatus*) diets. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This abstract summarizes a study using stable carbon and nitrogen isotopes in SSL bone and tooth collagen from across the range to determine if the trophic level for SSLs changed during the decline. Their results showed that the carbon and nitrogen isotope values varied greatly according to the location and year of each sample. The authors suggest that lower values found in samples from western areas were likely the result of SSLs consuming lower trophic level fish species.

deHart, P.A.P., and M.J. Wooller. 2005. A temporal perspective on pinniped foraging ecology: stable isotope variations in the teeth and bones of Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Basically the same abstract as the one above. The signature differences and trends isolated from tooth samples suggested to the authors that there may have been a change in the carbon isotope around a regime shift period (~1976), and that this jump may be due to alterations in local primary production.

Farley, S.D., V.K. Stegall, L.D. Rea, and W.I. Ridley. 2003. Application of laser ablation ICP-MS to elemental fingerprinting and isotope analysis to evaluate nutritional history and diet of Steller sea lions. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

A brief abstract outlining the merits of using laser ablation inductively coupled mass spectrometry as a means of sampling tissues at scales ranging from 10 to 300 microns. Additional explanations of process are presented in 2005 (abstract below) but no results are presented here

Farley, S.D., V.K. Stegall, L.D. Rea, A. Koening, I. Ridley, and P.J. LaMotte. 2005. Trace element composition in vibrissae, milk, and serum of Alaska Steller sea lion (*Eumetopias jubatus*): Identification of weaning and dietary shifts. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This abstract provides no results but summarizes an interesting study of SSL vibrissae to determine relative age at weaning and dietary shifts using keratin and mineralized deposits that vary with age in the vibrissae. Data were collected on over 25 trace elements, and consistent trends were identified. Significant increases from vibrissae tip to the root were measured for many elements (e.g., copper, zinc, cadmium). Information to determine time of weaning and dietary changes was not provided.

Foy, R.J., and K.M. Wynne. 2003. Availability and use of prey by Steller sea lions in Kodiak, Alaska in 2000. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

The authors determined seasonal SSL abundance, distribution and diet at two haulout sites near Kodiak. They also conducted thirteen monthly surveys at 12 haulouts near Kodiak in 2000 and collected 819 scats. Seasonal species composition, biomass, and distribution of pelagic and demersal fish species within 20 nm of Long Island in March, May, and

November was determined using hydroacoustic, bottom trawl, and midwater trawl surveys. Specific results were not provided but see abstract below by Wynne for results from this study.

Gende, S., and M. Sigler. 2004. Persistence of prey "Hot Spots" for Steller sea lions in Southeast Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This abstract summarizes the authors' examination of the quantity and location of pelagic fish species (Pacific herring and pollock) available to SSLs in Southeast Alaska by determining the density of prey hot spots over a 24-month period and whether these hot spots persisted over several months or across seasons. They found that the density of hot spots varied by season and months. Large schools of herring determined the location and density of these hot spots, some of which persisted over winter months (November-February).

Gende, S., and M. Sigler. 2006. Persistence of forage "hot spots" and its association with foraging Steller sea lions in Southeast Alaska. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Similar information as presented above in Gende and Sigler (2004). They also included here a foraging model that included a random Bayesian forager to estimate foraging effort in varying prey densities.

Gende, S., and M. Sigler. In press. Predictability of prey available to Steller sea lions in Southeast Alaska. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

This is the published version of the abstract at the Sea Lions of the World Symposium summarized above (Gende and Sigler 2004). The authors examined the predictability of pelagic fish distributions during 24 months of surveys in Lynn Canal, Southeast Alaska. The spatial distribution of available prey (measured as energy density) during a given month was examined to determine if it was an accurate indicator of prey distribution during the following month (monthly time scale) or during the same month the following year (annual time scale). They also examined how predictability varied among seasons and across several spatial scales. Pacific herring dominated the prey energy available to SSLs often occurring at densities several orders of magnitude greater than walleye pollock, particularly during the winter months. Prey distribution in one month was a good indicator of prey distribution the same month the following year, but mostly during the winter months. The distribution of prey in one winter month was also a good indicator of the distribution of prey the following month. However, significant month-to-month correlations were less frequent than at annual time scales due to a southerly movement of herring aggregations as the winter progressed.

Harvey, J. T., T. R. Loughlin, M. A. Perez, and D. Oxman. 2000. Relationship between fish size and otolith length for 63 species of fishes from the eastern North Pacific Ocean. U.S. Dep. Commerce, NOAA Technical Report NMFS 150. 36 p.

The relationships between fish length and fish weight, and between otolith length and fish length, were developed for 63 species of fishes caught in the eastern North Pacific Ocean, many of which are known prey of SSLs. The authors summarized similar relationships for 46 eastern North Pacific fish species reported in the literature. The relationship between fish length and otolith length was linear, and most of the variability was explained by a simple least-squares regression. The relationship between otolith length and fish length was not significantly different between left and right otoliths for all but one fish species. Images of otoliths from 77 taxa were included to assist in the identification of species.

Heaslip, S. G., D. J. Tollit, T. Zepplin, R. Joy, K. Call, and A. W. Ttites. 2003. Prey size selection of walleye pollock by Steller sea lions in Southeast Alaska (1994-99) assessed from skeletal remains and the application of size correction factors. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

Size selection by SSLs of walleye pollock was evaluated by applying fork length-skeletal structure regressions to seven selected structures recovered from 531 of 1,987 scats collected in Southeast Alaska in 1994-1999. The information provided in the abstract is the same as that provided in the journal publications of this study by Tollit et al. (2003, 2004) and Zeppelin et al. (2004) below.

Hirons, A.C. 2001. Trophic dynamics of pinniped populations in Alaska using stable carbon and nitrogen isotope rations. PhD dissertation, University of Alaska, Fairbanks AK. 143p.

Trophic changes in SSLs, northern fur seals, and harbor seals were studied using stable isotope analysis. Stable carbon and nitrogen isotope ratios were analyzed in the vibrissae and body tissues from 1993-1998 and compared to muscle tissue from prey species during the same time period to determine pinniped trophic dynamics. Results showed that harbor seal vibrissae are retained for only one year then replaced, while SSL maintain their vibrissae for several years. Isotopic data from all three species were consistent with diets composed of pollock at various times and locations throughout the year. SSL and fur seal vibrissae revealed regular oscillations along their lengths in both carbon and nitrogen isotope ratios that likely correspond to regional isotopic differences. Since these animals move or migrate from one region to another during the year, they methodically incorporated the different regional isotopes through their prey. Because they return to rookeries to pup, breed, and molt each year, the isotope ratios in the vibrissae showed a regular pattern of enrichment and depletion. Harbor seals have relatively static isotope ratios in their vibrissae while seals that moved into offshore waters had fluctuating isotope ratios that corresponded to regional differences. No trophic shifts, as evidenced by major changes in nitrogen isotope ratios, were present in any tissues from the three species over the period 1975-1998. Stable isotope ratios of bone collagen for all three species from 1950-1997 indicted no change in trophic level but did reveal a decline in the carbon isotope ratios, which supports the contention that a decreased carrying capacity in the North pacific Ocean.

Hirons, A. C., D. M. Schell, and B. P. Finney. 2001. Temporal records $\delta^{13}C$ and $\delta^{15}N$ in North Pacific pinnipeds: inferences regarding environmental change and diet. Oecologia 129:591-601.

This is the journal publication of Hirons' Ph.D. dissertation. The stable carbon (13C/12C) and nitrogen (15N/14N) isotope ratios in bone collagen from SSLs, northern fur seals, and harbor seals from the Bering Sea and Gulf of Alaska were measured for the period 1951–1997 to test the hypothesis that a change in trophic level may have occurred during this interval and contributed to the population declines. A significant change in 15N in pinniped tissues over time would imply a marked change in trophic level. No significant change in bone collagen 15N was found for any of the three species during the past 47 years in either the Bering Sea or the Gulf of Alaska. However, the 15N in SSL collagen was significantly higher than both northern fur seals and harbor seals. A significant decline in 13C (almost 2 ‰ over the 47 years) was evident in SSLs, while a declining trend, though not significant, was evident in harbor seals and northern fur seals. Changes in foraging location, in combination with a trophic shift, may offer one possible explanation. Nevertheless, a decrease in 13C over time with no accompanying change in 15N suggests an environmental change affecting the base of the food web rather than a trophic level change due to prey switching. A decline in the seasonal primary production in the region, possibly resulting from decreased phytoplankton growth rates, would exhibit itself as a decline in δ13C. The authors speculate that declining production could be an indication of a reduced carrying capacity in the North Pacific Ocean. Sufficient quantities of optimal prey species may have fallen below threshold sustaining densities for these pinnipeds, particularly for yearlings and subadults who have not yet developed adequate foraging skills.

Hirons, A.C., and K.M. Wynne. 2003. Seasonal forage patterns of Steller sea lions. Marine Science for the Northeast Pacific: Science for resource-dependent communities. Joint Scientific Symposium, Anchorage, AK 13-17 January 2003.

(Not found in abstract book)

Hoberecht, L.K., G. R. VanBlaricom, and B. J. Prazen. 2004. Comparisons of blubber fatty acids between sexes of adult Steller sea lions. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This abstract discusses a study near Kodiak in 2002 and 2003 using fatty acid analysis to determine diet in adult SSL blubber samples collected by use of a remote biopsy sampling system. The study was on-going at the time of the presentation and no results were provided.

Hoberecht, L., G.R. VanBlaricom, and B.J. Prazen. 2005. Comparisons of blubber fatty acids between sexes of adult Steller sea lions (*Eumetopias jubatus*). *In* 16^{th} Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This abstract summarizes a study using fatty acid analysis between adult male (n=33) and female (n=14) SSLs near Kodiak in 2004. Biopsy darts yielded 68 blubber samples for FA analysis. Those FA with highest prevalence were identified in the abstract based on Principle Component Analysis (PCA). The first PCA showed some differences between males and females but no distinct separation was seen between sites where the samples were collected. A second PCA on a subset of 31 FA showed differences which the authors interpreted as indications that between individuals, female diet is less varied than male diet

Hoberecht, L., D.J. Vos, and G.R. VanBlaricom. 2003. Sampling Steller sea lion blubber using a remote biopsy system. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

The abstract provides the methods and tools used to collect blubber samples from free-ranging SSLs by use of a crossbow and three-part biopsy dart. During 2002, 25 animals were struck with biopsy darts, 23 strikes yielded tissue samples, 20 samples contained blubber, and 3 samples contained full-depth cores

Hoberecht, L.K. D.J. Vos, and. G. R. VanBlaricom. In press. A remote biopsy system used to sample Steller sea lion (*Eumetopias jubatus*) blubber. Marine Mammal Science.

This is a methods paper and is the journal presentation and extension of the abstract above. The same information is provided but in more detail and with more explanation. A total of

296 biopsy darts struck animals of which 20 were not recovered and only four of those recovered did not contain a sample. The system worked well on all age and sex classes sampled but nursing females and pups were not sampled.

Hobson, K., Sinclair, E., York, A., Thomason, J. and Merrick, R. 2004. Retrospective isotopic analyses of Steller's sea lion tooth annuli and seabird feathers: A cross-taxa approach to investigating regime and dietary shifts in the Gulf of Alaska. Marine Mammal Science, 20 (3):621-638.

Stable isotope values for nitrogen and carbon of individual tooth annuli of 120 female SSLs collected from the 1960s through the 1980s were used for retrospective analyses of temporal changes in food webs in the Gulf of Alaska and North Pacific Ocean. The authors examined seabird feathers to test for broader isotopic changes. SSLs decreased slightly in C13 and increased in N15 values, suggesting an increasing trophic level in foraging location or oceanographic isotopic signature. SSL first and second tooth annuli were enriched in N15 and depleted in C13 with subsequent annuli indicating the effects of maternal influence through weaning. The observed increasing values of the nitrogen isotope in SSLs supported previous conclusions regarding a reduction or redistribution of forage fishes and an increase of demersal or semi-demersal species in the North Pacific ecosystem.

Ingles, S.D., M.A. Castellini, and C.F. Adams. 2005. Seasonal patterns in nutritional quality of pelagic prey at a Steller sea lion rookery in Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

The authors collected SSL prey samples near Chiswell Island during the sea lion breeding and molting periods and assessed nutritional quality of the prey through energy density, proximate analysis, amino acid profile, and mineral and vitamin content. Pollock were the major component of the prey base in the surveys, but also included herring, eulachon, sable fish, and surf smelt. Mineral, amino acid, and vitamin content did not vary between surveys. Energy density did show temporal variability: adult fish sampled in April had a lower energy density than in November. The energy density of juvenile fish varied temporally and with age class.

Kitts, D.D., M.D. Huynh, C. Hu, and A.W. Trites. 2004. Seasonal variation in nutrient composition of Alaskan pollock (*Theragra chalcogramma*). Canadian Journal of Zoology 82:1408-1415.

This study examined the seasonal changes in proximate nutrients of pollock collected in the Bering Sea. Mean energy density (dry mass) of pollock peaked in October then declined and remained low throughout winter. Energy recovery occurred in summer months with strong recovery observed in female fish caught in July. Contrary to whole fish carcass energy contents, both total protein and moisture contents were at their highest levels in winter (January) when total crude lipid content was at its lowest. This trend gradually declined to its lowest levels in the fall when lipid content was high. The decline in total lipids during winter seasons appeared to parallel gonad development during the prespawning period. Sex differences in energy densities were not found. Proximate analysis data for moisture, protein, ash, and lipid content also did not show any significant variation between males and females. Protein digestibility of pollock was higher in the summer than in the spring, but not different for winter or fall. The authors concluded that the nutrient content of walleye pollock may have some impact on SSLs that feed on them, particularly the energetic value that appears to be low during important feeding periods for this marine mammal.

Logerwell, E.A. 2004. The Fishery Interaction Team: Investigating the potential for commercial fishing to compete with endangered Steller sea lions for shared prey. *In* Marine Science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK.

> This is a summary abstract describing the Fisheries Interaction Team at the Alaska Fisheries Science Center and the goals of the team. There are no studies presented or results provided. The general goals of the team are to (1) test the hypothesis that commercial fishing results in depletion or disruption of prey fields and (2) to evaluate the efficacy of management measures designed to mitigate competition between commercial fisheries and SSLs.

Logerwell, E.A., and Schaufler, L.E. 2005. New data on proximate composition and energy density of Steller sea lion (*Eumetopias jubatus*) prey fills seasonal and geographic gaps in existing information. Aquatic Mammals 31:62-82.

> This study provided proximate composition and energy density information for SLL prey species where there were seasonal and/or geographic gaps in the existing data. Opportunistic collections were made in the Aleutian Islands, eastern Bering Sea, and Gulf of Alaska, targeting particular species of interest. Proximate analyses and energy density were calculated from lipid and protein content. Pacific herring, sand lance, and rockfish were found to contain the highest amount of lipid and provide the most energy. Atka mackerel, surf smelt, capelin, salmon, sandfish, pollock, yellow Irish lords, Pacific cod, squid, skates, and rock sole had intermediate energy densities. Smooth lumpsucker and snailfish were found to contain the least amount of energy. The authors contend that this study was the first to provide proximate composition data for adult pollock during the non-spawning seasons in the Gulf of Alaska and Aleutian Islands region, to provide the first proximate composition data for juvenile pollock in the Aleutian Islands region and eastern Bering Sea, and for Pacific cod in the eastern Bering Sea. The study also provided information on proximate composition of adult Atka mackerel, an important prey of SSLs in the Aleutian Islands.

Loughlin, T., and E. Sinclair. 2001. Fatty acid profiles of Steller sea lions and North Pacific Ocean forage fishes, a pilot study using northern fur seals Pages 113-115, *in* Anita L. Lopez and Robyn P. Angliss (eds.) Marine Mammal Protection Act and Endangered Species Act implementation program 2000. U.S. Department of Commerce, AFSC Processed Report 2001-06.

> This is a progress report summarizing work between the NMML and the NMFS Auke Bay Laboratory to develop fatty acid signatures for North Pacific Ocean fish commonly consumed by SSLs and northern fur seals and to determine variability in fatty acid in pinniped blubber. Northern fur seals were used for blubber samples; no SSLs were sampled in this 3-year project which concluded in early 2000. Results indicated that non-polar lipid content was highly variable among individuals, between sexes, and with body location; there were no differences between inner and outer blubber layers. Analysis was underway for 95 fish species collected from the Bering Sea but results were not available.

Rea, L.D. 2003. Differences in blubber levels of fatty acid 20:1n-11 suggest free-ranging Steller sea lions (*Eumetopias jubatus*) ingest prey at a younger age in Prince William Sound than sea lions captured in southeast Alaska. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

> The fatty acid 20:1n-11 tends to be under-represented in SSL milk compared to marine fish. The author used this difference to analyze juvenile SSL blubber to try and determine if weaning (reduced milk intake) could be determined. She found that 100% of SSLs 10

months old or older in Prince William Sound had eaten fish but that only 1 of 69 2-19 months old in Southeast Alaska had consumed fish. However, three animals in PWS had body fat content that confounded the results such that the high 20:1n-11 did not definitively separate weaned animals.

Rosen, D.A.S. and A.W. Trites. 2000b. Digestive efficiency and dry-matter digestibility of Steller sea lions fed herring, pollock, salmon and squid. Canadian Journal of Zoology 78: 234-239.

Dry-matter digestibility and energy digestive efficiency were measured in six captive juvenile SSLs at the Vancouver Aquarium fed three diets each consisting of a single species: herring, pollock, and squid. Two of the animals were also fed pink salmon. Dry-matter digestibility (DMD) and digestive efficiency (DE) were measured using the energy and manganese concentration in fecal and food samples. DE values were high for all prey species (herring: 95.4 ± 0.7% (mean ± SD), pollock: 93.9 ± 1.4%, salmon: 93.4 ± 0.5%, squid: 90.4 ± 1.3%). SSLs appeared to digest prey of high energy density more efficiently than prey of low energy density. DMD values were also high for all prey species (herring: 90.1 ± 1.8%, pollock: 86.5 ± 3.4%, salmon: 87.3% ± 2.6, squid: 90.5 ± 1.2%). The low DMD value for pollock compared with herring and squid was due to the high proportion of bony material in pollock. There was a strong linear relationship between DE and DMD for each prey type, but the terms cannot be used interchangeably. DE measures were more meaningful than DMD in conveying the energetic benefits derived by sea lions from different types of prey

Schauflerer, L., E. Logerwell, and J. Vollenweider . 2004. Variation in the quality of Steller sea lion prey from the Aleutian Islands and Southeastern Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors report their proximate analysis of over 1,200 fish representing species identified as SSL prey and calculated mean energy densities based on lipid and protein content. Comparison of the energy densities between Aleutian Islands and Southeast Alaska fish on a species basis revealed significant differences in energetic prey content where those in Southeast Alaska generally had a higher energy contend; fish size may have confounded these comparisons.

Sigler, M., J. Vollenweider, and D. Csepp. 2003. Southeast Alaska Steller sea lion prey study. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK

This abstract provides an overview and brief results of a study to measure seasonal SSL prey abundance and nutritional quality in Southeast Alaska. Specific questions studied include what are the characteristics of the available prey field, what are the characteristics of the areas where SSL are diving, and what prey field is represented in SSL scat. Preliminary conclusions were that prey abundance was concentrated in specific areas (principally Frederick Sound), over wintering herring concentrations there and in Lynn Canal may be important winter forage for SSLs, and spawning aggregations of eulachon appeared to be important energy sources for SSL in spring.

Sigler, M., J. Vollenweider, and J. Womble. 2003. Availability to Steller sea lions (*Eumetopias jubatus*) of a seasonal prey resource: A prespawning aggregation of eulachon (*Thaleichthys pacificus*). P. 150, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

> The authors describe the occurrence of SSLs in Berners Bay, Southeast Alaska, during the pre-spawning aggregation of eulachon during April-May 2002. SSL abundance peaked as eulachon abundance peaked and decreased as the fish moved up the river to spawn. The authors estimate that SSLs consumed 20% of the eulachon which provided an energy rich, predictable prey source. They speculated that the eulachon pulse likely contributes to SSL breeding success because breeding occurs just after the pulse.

Sigler, M. and J.N. Womble. 2006. Ecological significance of seasonal aggregations of marine forage species for Steller sea lions. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

> A general discussion about the selective advantage of SSLs taking advantage of predictable intermittent prey availability. The discussion is an extension of the authors work during 200-2004 in Southeast Alaska reported in numerous abstracts and papers by Sigler, Gende, Womble, and others.

Sigler, M.F., J.N. Womble, and J.J. Vollenweider. 2004. Availability to Steller sea lions (*Eumetopias jubatus*) of a seasonable prey resource: a spawning aggregation of eulachon (*Thaleichthys pacificus*). Can. J. Fish. Aquat. Science 61:1475-1484.

> This is the journal presentation of the earlier abstracts detailing SSLs in Berners Bay (near Juneau) where they are attracted to a prespawning aggregation of eulachon during April-May, 2002 and 2003. SSL abundance increased as eulachon gathered in the bay, peaked as eulachon abundance peaked, and decreased as the eulachon moved up-river. As SSL abundance increased in the bay it decreased at the nearby Benjamin Island haulout site. The authors feel that the eulachon pulse may be critical to SSLs during a period of high energetic demands.

Sinclair, E., and T. Zeppelin. 2002. Seasonal and spatial differences in diet in the western stock of Steller sea lions (*Eumetopias jubatus*). J. Mammal. 83(4):973-990.

> The authors identified prey remains from 3,762 SSL scats collected from 1990-1998 throughout most of Alaska. Pollock and Atka mackerel were the two most common species of prey, followed by salmon and Pacific cod. An additional 16 other fish and unidentified cephalopods were considered primary in the diet. Regions of diet similarity suggest area-specific foraging strategies, with strong seasonal patterns in consumption of most species of prey. Patterns in prey consumption and characteristics of prey indicate that Steller sea lions target prey that was densely schooled in spawning or migratory aggregations at the continental shelf or along oceanographic boundary zones.

Stegall, V.K., S.D. Farley, L.D. Rea, and K. Pitcher. 2003. Stable isotope fluctuations in Steller sea lion (*Eumetopias jubatus*) vibrissae indicating weaning events. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

This study examined the fluctuations in stable isotope ratios in serum, milk, and longitudinally in vibrissae collected from free-ranging SSLs 1 month to 2 years old. Results indicated that vibrissae isotope ratios changed *in utero* versus *ex utero* suggesting the occurrence of nursing; with age these values change along the length of the vibrissae suggesting a diet shift from nursing. The nitrogen isotope values at the base of the vibrissae did not differ from blood.

Stegall, V., S. Farley, L.Rea, K. Pitcher, R. Rye, and C. Kester. 2003. Stable isotope comparisons of Alaska Steller sea lion (*Eumetopias jubatus*) populations using milk, serum, and vibrissae. P. 155, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

As in Stegall et al. (2003) above

Stegall, V.K., S.D. Farley, L. D. Rea, K. W. Pitcher, R. O. Rye, C. L. Kester, and C.R. Bern. 2004. Use of carbon and nitrogen stable isotope ratios in vibrissae to detect weaning in Alaska Steller sea lions (*Eumetopias jubatus*). Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

As in Stegall et al. (2003) above.

Tollit, D.J., S.G. Heaslip, B.E. Deagle, S.J. Iverson, R. Joy, D.A.S. Rosen, and A.W. Trites. In press. Estimating diet composition in sea lions: which technique to choose? Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

This is the published version of a paper presented at the Sea Lions of the World symposium (see below). In it the authors propose that accurate estimates of diets are vital to monitor impacts of sea lion populations on their ecosystems and their interactions with fisheries, and to understand the role of food to animal nutrition and health. Approaches include using (1) prey remnants in stomach contents, spews and scats; (2) prey DNA in scats; (3) fatty acid signatures in blubber; and (4) stable isotope ratios in predator tissue. Each methodology has particular advantages and limitations, many of which can be assessed and improved through controlled captive feeding trials. Analysis of prey remnants from captive sea lion scats have shown significant variability in digestion between and within prey species, which, coupled with preferential regurgitation and enumeration biases, can confound accurate diet quantification, but does not prevent spatial or temporal comparisons. Correction for partial digestion and use of additional structures besides otoliths can provide accurate prey size estimates. Prey DNA can be reliably isolated from soft remains in scats from captive sea lions, and with further development this approach may allow quantification of diet. Genetic methods can be expensive and representative of only one to two days foraging (like prey remnant analysis), but may be less affected by differential digestion and can identify prey in scats that could not be identified through structural remnants. Validation of fatty acid signature analysis to quantify diet at longer temporal scales in sea lions is ongoing. This new technique promises to be particularly useful to assess biases in traditional methods, identify the onset of weaning, and highlight the prey that most contribute to lipid reserves. Stable isotope analysis of predator tissues gives only trophic level data, but can provide data on diet changes on many temporal scales. Remote video monitoring of foraging events and lavage/enema techniques can provide valuable diet information, but, like many newer techniques, animal capture is required. Ideally a suite of techniques should be used to study diet. While methods and correction factors developed for Steller sea lions can likely be applied to the other five sea lion species, they should be verified experimentally.

Tollit, D.J., S. Heaslip, S. Iverson, D.A. Rosen, and A.W. Trites. 2003. Diet quantification of Steller sea lions- scat and fat. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

The authors describe a multi-faceted approach to studying SSL diet. Controlled captive feeding experiments with numerous SSL prey were undertaken to assess inter- and intra-specific variability in passage rates and recovery of hard parts in scat. Pollock occurred in relatively more scats/meal leading to significantly higher overall recovery levels. QFASA was tested as a complementary technique to assess SSL diet and data were collected to provide SSL calibration coefficients (CCs) required for QFASA. Preliminary results showed that the SSL CCs were comparable to those obtained for phocids.

Tollit, D., S. Heaslip, R. Joy, and A. W. Trites. 2004. Estimating diet composition in sea lions: What technique to choose? Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors discuss the various methods used to determine diet in SSLs and conclude that scat examination coupled with fatty acids is optimal but that all methods provide useful information. The other methods include stomach contents, DNA analysis of stomach contents, and stable isotopes.

Tollit, D.J., S.G. Heaslip, and A.W. Trites. 2004. Sizes of walleye pollock consumed by the eastern stock of Steller sea lions in Southeast Alaska from 1994-1999. Fishery Bulletin 102(3): 522-532.

Lengths of walleye pollock consumed by SSLs were estimated by using allometric regressions applied to seven diagnostic cranial structures recovered from 531 scats collected in Southeast Alaska between 1994 and 1999. Only elements in good and fair condition were selected. Selected structural measurements were corrected for loss of size due to erosion by using experimentally derived condition-specific digestion correction factors. Correcting for digestion increased the estimated length of fish consumed by 23%, and the average mass of fish consumed by 88%. Mean corrected fork length (FL) of pollock consumed was ~42.4 cm (range=10.0−78.1 cm, n=909). Adult pollock (FL>45.0 cm) occurred more frequently in scats collected from rookeries along the open ocean coastline of Southeast Alaska during June and July (74% adults, mean FL=48.4 cm) than they did in scats from haul-outs located in inside waters between October and May (51% adults, mean FL=38.4 cm). Overall, the contribution of juvenile pollock (≤20 cm) to the sea lion diet was insignificant; whereas adults contributed 44% to the diet by number and 74% by mass. On average, larger pollock were eaten in summer at rookeries throughout Southeast Alaska than at rookeries in the Gulf of Alaska and the Bering Sea. Overall it appears that Steller sea lions are capable of consuming a wide size range of pollock, and the bulk of fish fall between 20 and 60 cm. The use of cranial hard parts other than otoliths and the application of digestion correction factors are fundamental to correctly estimating the sizes of prey consumed by sea lions and determining the extent that these sizes overlap with the sizes of pollock caught by commercial fisheries.

Tollit, D.J., Heaslip, S.G., Zeppelin, T.K., Joy, R., Call, K.A., and A.W. Trites. 2004. A method to improve size estimates of walleye pollock (*Theragra chalcogramma*) Atka mackerel (*Pleurogrammus monopterygius*) consumed by pinnipeds: digestion correction factors applied to bones and otoliths recovered in scats. Fishery Bulletin 102(3):498-508.

This study developed a method (using defined criteria and photo-reference material) to assign the degree of digestion for key cranial structures of two prey species, walleye pollock and Atka mackerel. The method graded each structure into one of three condition categories; good, fair or poor. The authors also conducted feeding trials with captive SSLs, feeding both fish species to determine the extent of erosion of each structure and to derive condition-specific digestion correction factors to reconstruct the original sizes of the structures consumed. In general, larger structures were relatively more digested than smaller ones. Mean size reduction varied between different types of structures (3.3−26.3%), but was not influenced by the size of the prey consumed. Results from the observations and experiments were combined to be able to reconstruct the size of prey consumed by sea lions and other pinnipeds. The proposed method has four steps: 1) measure the recovered structures and grade the extent of digestion by using defined criteria and photo-reference collection; 2) exclude structures graded in poor condition; 3) multiply measurements of structures in good and fair condition by their appropriate digestion correction factors to derive their original size; and 4) calculate the size of prey from allometric regressions relating corrected structure measurements to body lengths.

Tollit, D., S. Iverson, S. Heaslip, D.A.S. Rosen, M.J. Walton, and A.W. Trites. 2005. Validation studies of blubber quantitative fatty acid signature analysis (QFASA) with captive Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

QFASA was developed to estimate species composition of marine mammal diets from fatty acid signature analysis of the blubber and that of potential prey. This abstract summarizes captive feeding trials (1-20 months each) on full-depth blubber samples taken from the flank of seven juvenile female SSLs following periods of controlled diet. Fish FA signatures varied among the 12 prey species tested but was most confounding in diets where herring diets exceeded 200 days. Using additional trials, prediction of short-term and multi-species diet switches correctly identified herring as a major diet contributor, and also certain new diet items, but results were inconsistent, particularly in discerning between herring and small shoaling prey (e.g., capelin, pollock, and squid).

Tollit, D., S. Iverson, S. Heaslip, D.A.S. Rosen, M.J. Walton, and A.W. Trites. 2006. Validation studies of blubber quantitative fatty acid signature analysis (QFASA) with captive Steller sea lions (*Eumetopias jubatus*). *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Same information as in Tollit et al. (2005) above.

Tollit, D., A. W. Trites, M. Wong, D. Rosen and R. Barrick. 2001. Addressing biases associated with quantifying diet consumption from the scat of pinnipeds. P. 215, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

This abstract summarizes the authors' study on captive SSLs at the Vancouver Aquarium to quantify variability in passage and recovery rates of hard remains (salmon, herring, pollock, and sandlance) depending on SSL activity and other parameters. Passage rates varied greatly, particularly between prey species. Minimum and maximum transit times were found for sandlance (2 hours) and pollock (121 hours); plastic beads exceeded 260 hours). Recovery rates varied significantly, not only between species, but also between identical experiments. However, most bones were found after 20-50 hours. In general, active SSLs had faster passage and higher recovery rates than inactive animals

Tollit, D.J., M. Wong, A.J. Winship, D.A.S. Rosen, and A.W. Trites. 2003. Quantifying errors associated with using prey skeletal structures from fecal samples to determine the diet of Steller's sea lion (*Eumetopias jubatus*). Marine Mammal Science 19(4):724-744.

> The authors examined the digestion and passage times of bones and other hard parts from pollock, herring, salmon, and sandlance recovered from two juvenile captive SSLs subjected to varying activity levels. Key bones that could be identified to species were distributed over an average of 3.2 scats (range 1–6) following a single meal, with pollock remains occurring in significantly more scats than other species. Relying on otoliths alone to determine the presence of prey resulted in significantly fewer prey being identified than if other structures were also used (such as vertebrae, jaw bones, and teeth), particularly for salmon. Using either technique, there were significant differences in the likelihood that bones would be recovered from the series of scats produced following a meal, with pollock recovery exceeding herring (by three-fold) and sandlance (by eight-fold). Differences between species were reduced when recovery was calculated on a per scat basis rather than over multiple scats. Active animals passed greater numbers of bones, but the overall effect on prey recovery estimates was not significant. Defecation times of prey structures from a meal were variable and ranged from an initial 2–56 h to a final 28–148 h. The time interval to pass 95% of recovered structures varied by a factor of two among prey species, and was highest for pollock due to retention beyond 65 h.

Trites, A.W. 2001. Marine mammal trophic levels and interactions. Pages. 1628-1633, *in* J. Steele, S. Thorpe, and K. Turekian (eds.) Encyclopedia of Ocean Sciences. Academic Press, London.

> This is a general article in an encyclopedia discussing marine mammal trophic levels in the marine ecosystems. The author reviews food webs, trophic levels, stable isotopes and other dietary information, and trophic interactions of marine mammals with their ecosystem. The article concludes by stating that calculating trophic levels is a necessary first step to quantifying and understanding trophic interactions between marine mammals and other species in marine ecosystems. This can be achieved using dietary information collected from stomachs, scats, and other sources. These data indicate that marine mammals occupy a wide range of trophic levels beginning with dugongs and manatees and ending in polar bears; SSLs and near the top but below polar bears

Trites, A.W. 2003. Food webs in the ocean: who eats whom, and how much? Pages 125-143, *in* M. Sinclair and G. Valdimarsson (eds.), Responsible Fisheries in the Marine Ecosystem. FAO, Rome and CABI Publishing, Wallingford.

> The author reviews published food webs and reports that the lengths of the chains that form food webs are typically short (3–4 links), and that ecosystems with long food chains may be less stable than those with shorter food chains. Consumption of marine organisms, expressed as a percentage of an individual's body weight per day, ranges from about 4–15% for zooplankton, to 1–4% for cephalopods, 1–2% for fish, 3–5% for marine mammals and 15–20% for sea birds. Immature age classes consume about twice as much (per unit of body weight) as do mature individuals. Furthermore, consumption is not constant throughout the

year, but varies with seasonal periods of growth and reproduction. Most groups of species consume 3–10 times more than they produce, and export or pass up the food web about 70–95% of their production. Marine organisms tend to be larger at successive trophic levels and are limited in the sizes of food they can consume. Humans are one of the few species that can prey upon almost any level of the food chain and any size of prey.

Trites, A.W., E.L. Bredesen, R. Joy, and A.J. Winship. 2005. A range-wide review of Steller sea lion diets and the evidence for dietary change in the North Pacific. *In* Marine Science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

The authors evaluated the assertion that SSL diets changed from a high energy fish diet to one of low energy fish by compiling all available dietary information on SSL throughout their North Pacific range. Data from 31 reports published since 1901 from California to Japan were reviewed. The review led the authors to conclude that available data were consistent with the hypothesis that dietary shifts occurred over time and that there was a link between high-energy species and high sea lion abundance numbers. The data also suggested some correspondence between oceanographic regime shifts and the dominance of certain species of prey in SSL diets.

Trites, A.W., and D.G. Calkins. 2006. Do breeding age male and female Steller sea lions eat the same things? Unpublished Manuscript. Marine Mammal Research Consortium.

Diets of SSLs were determined from 734 of 780 scats collected from 1 male haulout (264 scat) and 3 female (470 scat) dominated rookeries at Forrester Island in Southeast Alaska from 1994 to 1999. Female diets were fairly evenly distributed between gadids, forage fish and salmon, and contained lesser amounts of rockfish, flatfish, cephalopods and other fishes. Female diet did not differ significantly between the 3 rookeries, but did differ significantly from that of males. Males consumed significantly fewer salmon, and more pollock and rockfish compared to females. The males also consumed larger pollock compared to females. These dietary differences may reflect a difference in hunting abilities related to the physical size differences of the two sexes (mature males are 2.5 times larger than mature females). They may also reflect a difference in where male and female Steller sea lions seek prey. The similarity of the female diets between rookeries suggests that female diets can be determined from samples collected at a single site within a rookery complex. Unfortunately, summer diets of females cannot be ascertained from hard parts contained in the scats of male Steller sea lions.

Trites, A.W., D.G. Calkins, and A.J. Winship. 2006. Diets of Steller sea lions (*Eumetopias jubatus*) in Southeast Alaska from 1993 to 1999. Unpublished Manuscript. Marine Mammal Research Consortium.

This unpublished ms. is similar to the information presented at a symposium in 2003 (see below) but with more detail. The authors determined diet of SSLs 1,494 scats collected at rookeries and haulout sites in Southeast Alaska from 1993 to 1999. The most common prey of 61 species identified were walleye pollock, Pacific herring, sandlance, salmon, arrowtooth flounder, rockfish, skates, squid and octopus. SSL diets at the 3 Southeast Alaska rookeries differed significantly from one another. SSLs consumed the most diverse range of prey categories during summer, and the least diverse during fall. Diet was more diverse and energy-dense in Southeast Alaska during the 1990s than in any other region of Alaska (Gulf of Alaska and Aleutian Islands). Dietary differences (diversity and energy content) between increasing and declining populations of sea lions in Alaska correlate with rates of population change, and add credence to the view that diet may have played a role in the decline of sea lions in the Gulf of Alaska and Aleutian Islands.

Trites, A.W., D.G. Calkins, and A.J. Winship. 2003. Diets of Steller sea lions in Southeast Alaska *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

Diet of SSL in Southeast Alaska was determined from 1,565 scats collected from 1993 to 1999. The most common prey of 61 species identified was pollock herring, sandlance, salmon, arrowtooth flounder, rockfish, skates, and cephalopods. Gadids dominated the diet throughout SEA. Diets at three SEA rookeries differed. SSLs in SEA consumed the greatest diversity of prey during summer and the least in fall.

Trites, A.W., and R. Joy. 2003. Dietary analysis from fecal remains of pinnipeds: How many scats is enough? *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

Same as in Trites and Joy (2005) below.

Trites, A.W. and R. Joy. 2005. Dietary analysis from fecal samples: how many scats are enough? Journal of Mammalogy 86: 704-712.

This is the journal presentation of the abstract above and discusses the use of a Monte Carlo simulation to analytically determine the consequence of sample size on the dietary analysis of scat using frequency of occurrence models. The authors proposed two questions: how is the statistical power affected by sample size and what is the likelihood of not identifying a prey species. The results suggest that a minimum of 60 scats is necessary to distinguish two populations with biologically significant differences in scat remains or that no important diet species are missed.

Trites, A.W., and K.H. Soto. 2004. A global comparative analysis of sea lion diets. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Dietary information based on stomach and scat contents were compiles from published sources for all five sea lion species. They indicate that sea lions are generalists in terms of the large numbers of species that each consumes (>40 species), but have preferences based on the dominance of a small number of key species that are repeatedly reported in scats and stomach contents (~3-8% species). The authors concluded that many species consumed by sea lions are also targeted by commercial fisheries, but competition has not been demonstrated for any of the sea lion species,

Vollenweider, J.J., and R.A. Heintz. 2003. Seasonal and spatial variability of Steller sea lion (*Eumetopias jubatus*) prey quality. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

This abstract summarizes the systematic examination of the quality of SSL prey near two haulout sites (names not given) in Southeast Alaska. Marked seasonal variation in lipid content was observed for all species, with as much as a two-fold increase between seasons. Lipid content of eulachon was most variable. Results indicated that fish acquire maximum energy stores prior to winter and subsequently metabolize these stores reaching a minimum in spring as animals undergo gamete recrudescence. Protein content peaked in December as well for all sizes of pollock and capelin; however it peaked in spring for other species.

Vollenweider, J., and R. Heintz. 2003. Magnitude and sources of variability in Steller sea lion (*Eumetopias jubatus*) prey quality. P 170, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Proximate composition and energy density of several SSL prey (pollock, herring, eulachon, capelin, and hake) were evaluated through a systematic experimental design (not provided in abstract). For a given species, proximate composition varied significantly, particularly lipid content which varied by an average of 35-fold, with over 100-fold differences among individual mature pollock. Seasonal effects accounted for variability within species. A general cyclical trend of body composition was observed with increasing lipid stores throughout summer coincident with intense feeding activity, peaking in fall or winter, and subsequently declining in spring. Shifts in peak condition among species caused the relative ranking of prey to alternate depending upon season, with no one species remaining a superior source of lipid or energy content.

Vollenweider, J., and R. Heintz. 2004. Magnitude and sources of variability in Steller sea lion (*Eumetopias jubatus*) prey quality. In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK.

As in Vollenweider and Heintz (2003) above.

Vollenweider, J.J., J. N. Womble, R. Heintz, and M. Sigler. 2004. Prey contributions to energetic content of Steller sea lion diets. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors combined scat data with energetic content of prey to estimate species-specific energy contribution to SSL diets at Benjamin Island (near Juneau) during 2001-2002. Quarterly scat samples and prey surveys occurred from nearby waters (method not provided) and then analyzed for proximate composition and energy content. Results from these analyses were used to develop biomasses for each prey species from which the authors calculated the biomass of ingested prey species. Prey biomass was then multiplied by energy density resulting in the energy content contributed per prey species per scat. Results showed that mean energy content remained stable between seasons but the species changed. During winter three species of prey made up more than 80% of the energy content and in spring six prey species were required for the same amount of energy content.

Waite, J. and V. Burkanov. 2003. Summer feeding habits of Steller sea lions (*Eumetopias jubatus*) in the Russian far-east. P. 171, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p

This abstract summarizes the summer diet of SSLs determined from 1045 scat during 2000-2002 from 23 rookery and haulout sites in the Kuril Islands, Kamchatka Peninsula, and Okhotsk Sea. The top ten prey items were Atka mackerel, pollock, sculpins, salmon, sandlance, herring, capelin, northern smoothtongue, and snailfish. Diets in each major area differed from one another, along with the rate of SSL population change in those areas. Rookeries and haulout sites in close proximity to large land masses had, on average, higher diet diversity indices (more diet diversity) than off-shore haulout sites.

Waite, J.N., and V.N. Burkanov. 2004. Steller sea lion (*Eumetopias jubatus*) feeding habits in the Russian Far-East, 2000-2003. Pages 150-153, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

> This abstract is basically the same as that described above (Waite and Burkanov, 2003) except that it includes results from scat collections in 2003 plus 93 scat collected in fall 2003. The same ten species were found in the scat.

Waite, J.N., and V.N. Burkanov. 2004. Steller Sea Lion (*Eumetopias jubatus*) feeding habits in the Russian Far East. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> Same information as two abstracts above.

Waite, J.N., V.N. Burkanov, and T.R. Loughlin. 2005. Steller sea lion diet in the Russian far east. Chapter 3, pages 19-26, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

> The authors report their examination of 1,821 (out of 2,254 collected) scat from SSLs in the Russian Far East, similar to the abstract above. During the 2000 – 2004 SLL seasons, they collected scats from 7 rookeries and 19 haulout sites on the Kamchatka Peninsula and in the Kuril Islands, Okhotsk Sea, and Commander Islands to analyze the diet of Steller sea lions in the Russian Far East. The most frequently occurring prey items were Atka mackerel, walleye pollock, salmon, sculpins, cephalopods, Pacific sand lance, Pacific herring, northern smoothtongue, snailfish, and Pacific cod. Spatial differences were analyzed by comparing frequency of occurrence (FO) values on a site-by-site basis for each year and all years combined. Breeding-season collection sites were grouped into seven geographic regions based on FO similarities using cluster analysis. Diet diversity was calculated for each of these geographic regions. No significant relationship was found between diet diversity and population trend. Significant differences in diet composition were found between geographic regions. Significant seasonal differences were also detected at two haulouts on the Kamchatka Peninsula from which an additional 93 scats were collected during the fall molt.

Waite, J.M., and K.L. Mashburn. 2005. Dietary differences between sex and age classes of Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

> This abstract describes a study to quantify the dietary differences between gender and age classes using a combination of hormone assays and hard part analysis. Hard parts were used to identify prey and fecal glucocorticoid immunoreactivity profiles were used to determine if scats were from an adult male, adult female, or juvenile of unknown sex. Samples from one haulout site and one rookery had been analyzed for this abstract. Adult female scat contained primarily prey associated with open water while those from adult males were associated with shallower, near-shore waters (but salmon and Atka mackerel were present). Additional results of prey type were provided. The authors suggest that combining hard-part analysis with hormone analysis allows for a greater depth of understanding in prey selection.

Wilson, B., A.W. Trites, and A.J. Winship. 2003. Optimal foraging or focused prey selection: Can individual scat samples provide information on Steller sea lion feeding strategies? *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

> The authors analyzed scat collected during 1993-1999 (see Trites et al., 2003, above) to statistically test whether SSL foraging strategies could be detected based on the occurrence of different prey in scat. Preliminary resulted suggested that individual SSLs do not pursue a simple optimal diet but instead specialize on prey and foraging strategies

Wilson, L.J., D. Tollit, D.A.S. Rosen, C.A. Beck, L.D. Rea, D.V. Gummeson, and A.W. Trites. 2005. Variation in fatty acid composition of sea lion blubber by body site and tissue depth: Consequences for biopsy sampling in the wild. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

> This abstract summarizes a study to assess variation in fatty acid composition in SSL blubber based on six body site locations and depth of the sample. Full samples were cut into three depth layers prior to FA analysis. Significant variation in hind end and neck samples was detected; depth stratification was observed in many FA concentrations with differences in concentration between layers sometimes exceeding 100%. They also tested a remote biopsy dart (see also Hoberecht) and obtained 30 blubber samples using this technique. About one fourth of the samples were 'whole' (contained blubber and muscle) and the rest 'partial' of which the partial may be inadequate samples for optimal fatty acid profiles.

Womble, J.N. 2003. Seasonal distribution of Steller sea lions (*Eumetopias jubatus*) in relation to high-quality ephemeral prey species in Southeastern Alaska. M.S. thesis, Univ. Alaska, Fairbanks.54 p.

> This is the Master's thesis from which most of the following papers derive their information. For her thesis work she conducted monthly aerial surveys at 23 SSL haulout sites in Southeast Alaska and reported that use by SSLs was seasonally dynamic. Some sites were used only during spring and other increased in use during certain seasons. Those with peak numbers in spring were significantly closer to forage fish aggregations than haulout sites with peak numbers at other times of the year.

Womble, J. N., B. P. Kelly, M. F. Willson and M. Sigler. 2001. Spatial ecology of Steller sea lions (*Eumetopias jubatus*) and forage fish aggregations in Southeastern Alaska. P. 236, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

> This abstract reports the abundance and distribution of SSLs in Southeast Alaska and their apparent relationship to seasonally occurring prey. The authors used a spatial database using a geographical information system (GIS) which included SSL sites and eulachon and herring spawning aggregations. Distances were calculated between haulouts and forage fish aggregations. Monthly aerial surveys were conducted at 23 SSL haulout sites and results showed that some sites were occupied only during times when ephemeral prey was nearby. Haulouts with peak abundance were significantly closer to forage fish aggregations than haulouts with peak numbers at other times of the year. (see Womble M.S. thesis above).

Womble, J.N., and M. F. Sigler. 2004. Importance of seasonally available prey for Steller sea lions (*Eumetopias jubatus*) at Benjamin Island, Southeastern Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Similar information as in abstract above but with a greater focus on the prey of SSLs near Benjamin Island and prey found in scat during 2001-2003. Pacific herring made up 70% of the total prey biomass observed around the island with peaks in biomass during November and February. Pollock made up 28% of the biomass but did not exhibit as much seasonal variation. Herring and pollock were the two most frequently occurring prey items in scat, followed by skate, salmon, cod, capelin, and others. Peaks in number of sea lions at Benjamin Island corresponded with periods of high herring biomass.

Womble, J.N., M.F. Willson, M.F. Sigler, and B.P. Kelly. 2003. Seasonal distribution of Steller sea lions (*Eumetopias jubatus*) in relation to high-quality ephemeral prey species in Southeastern Alaska. P. 179, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

As in Womble et al. (2001) above but includes 2002 results (which concurred with those in 2001).

Womble, J. N., M. F. Willson, M. F. Sigler, B. P. Kelly, and G. R. VanBlaricom. 2003. Spring-spawning fish aggregations: A seasonal feast for Steller sea lions. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK

As in Womble et al. (2001) above.

Womble, J. N., M. F. Wilson, M. F. Sigler, B. P. Kelly, and G. R. VanBlaricom. 2003. Spring-spawning fish aggregations: A seasonal feast for Steller sea lions. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

As in Womble et al. (2001) above.

Womble, J. N., M. F. Willson, M. F. Sigler, B. P. Kelly, and G. R. VanBlaricom. 2005. Distribution of Steller sea lions *Eumetopias jubatus* in relation to spring-spawning fish species in southeastern Alaska. Marine Ecology Progress Series 294:271-282.

This is the journal article that was part of Womble's thesis work and was presented in numerous conferences by Womble and Sigler. In this article they predicted that the distribution of SSLs in SE Alaska in spring would be influenced by the distribution of spring spawning aggregations of high-energy prey species such as Pacific herring and eulachon. The spatial distribution of SSLs during spring reflected the distribution of spawning eulachon in northern Southeast Alaska, particularly in Lynn Canal and along the Yakutat forelands. Haulouts with peak numbers of SSLs in spring were located significantly closer to eulachon spawning sites than haulouts that peaked at other times of year. Some haulouts were occupied only during the eulachon spawning period. The maximum number of SSLs at haulouts in spring was inversely correlated with the distance to the closest eulachon aggregation and was positively associated with the number of eulachon within 20 km. Aerial surveys conducted every 7 to 10 days during March through May in 2002 and 2003 revealed large numbers of SSLs in the water at herring spawning sites in 2002 and 2003; however, there were no significant relationships between the number of herring spawning sites and number of SSLs (except at distances >60 km). The number of SSLs was greater at herring spawning sites in 2003, corresponding to higher herring biomass. Seasonally aggregated, high-energy prey species influence the seasonal distribution of sea lions and may be critical to their reproductive success.

Wynne, K.M. 2003. Seasonal prey use by Steller sea lions near Kodiak, Alaska. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

The frequency of occurrence of prey remains found in SSL scat was used to assess and monitor the use and relative importance of fish species to SSL near Kodiak. Scats were collected monthly. Six dominate prey groups were found in more than 20% of scat: Pacific sandlance (47.8%), arrowtooth flounder (41.1%), Pacific cod (35.6%), pollock (31.6%), salmonids (28.9%), and cottids (22.6%). Seasonal and regional patterns of prey use were found. Capelin and herring were significantly more common in scats collected from northern sites while pollock were seasonally more prevalent on eastern sites.

Wynne, K.M. 2005. Preliminary assessment of the diet of Steller sea lions in the Kodiak Area, 1999-2003.pages 70-79, *in* Wynne, KM, RJ Foy, and CL Buck (eds). Gulf Apex Predator-prey Study (GAP) Final Rept. NOAA Grant NA16FX1270, University of Alaska Fairbanks, Kodiak, AK. 241pp.

This chapter in the large report of the GAP program contains information on SSL diet obtained by scat analysis during 1999-2003 at rookeries and haulout sites at or near Kodiak Island. Nine prey species (or families) were found in greater than 10% of the scats containing identifiable remains (% frequency of occurrence, FOC) in preliminary analyses. The five most frequently occurring prey species each occurred in greater than 25% of scats containing identifiable remains: Pacific sandlance (42.0 FOC), arrowtooth flounder (37.0 FOC), walleye pollock (30.1 FOC), Pacific cod (29.2 FOC), and salmon. (28.5 FOC). Pacific herring, capelin and Irish Lord were found in close to 15% of scats and sole in 10% of scats with identifiable remains. Hexagrammids represented primarily by greenling were found in >5% of scats examined and would therefore have qualified as a tenth significant prey item using standards used in other studies. Only 37 of 1168 (3.7%) scats analyzed to date contained no identifiable remains and were classified as 'empty'. More empty scats were collected on North Kodiak sites than others. Cephalopods (primarily octopus) and rockfish were found in >5% of some seasonal samples but were not found to be significant prey overall.

Wynne, K. and R. J. Foy. 2001. Steller sea lion prey use vs availability near Kodiak Island. P. 237, *in*: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Seasonal prey use by SSLs was compared to fish species availability within critical habitat near Kodiak Island. Fish species composition, distribution, and relative abundance were documented near Long Island through hydroacoustic and trawl surveys in March, May, and November 2000. SSL diet was determined from 142 scats. Up to nine prey species were found in >10%of the scat. Sandlance, arrowtooth flounder, and salmon ranked first in different collections.

Wynne, K.M., R.J. Foy, B.L. Norcross, C.L. Buck, and S. Hills. 2003. Availability and use of prey by Steller sea lions in the eastern Kodiak area, 1999-2000. Final Report to the North Pacific Marine Research Program, School of Fisheries and Ocean Sciences, Univ. of Alaska Fairbanks, 23 pp.

This report summarizes a study near Kodiak Island during 2000 to determine seasonal use by SSLs of designated critical haulouts in Kodiak area using aerial surveys, to determine seasonal differences in prey species composition and abundance within 10 nm and 20 nm of a critical SSL haulout by analyzing scat, to relate fish composition to oceanographic parameters (water temperature, salinity, depth), to determine seasonal pattern of prey consumption, and to compare SSL diet to prey availability within 10 nm and 20 nm of the Long Island SSL haulout using bottom and mid-water trawls and echo-integration surveys. Results were provided for each goal and included in nine tables and eight figures. SSL counts peaked from June to September and were lowest from December through May; the primary source of seasonal fluctuation was increases in breeding adults on Marmot Island during summer. SSLs consumed a diverse prey base including 31 species of which 11 were significant prey (in > 5% of scats), six of which occurred in greater than 20% of the scats: pollock, arrowtooth flounder, sandlance, Pacific cod, salmon, and Irish lords. Snailfish and sandfish are among significant dietary items not reported as significant in previous sea lion studies. The recovery of species such as greenlings, pricklebacks, sticklebacks, poachers, etc. suggested that some animals (perhaps pups) forage successfully in nearshore and subtidal waters. Flatfish and gadids were the dominant prey groups used by sea lions and were also found to dominate the biomass of fish within waters of the study area. Five of the seven most frequently occurring prey species found in scat samples were also found to be most abundant in waters within 20 nm of Long Island: arrowtooth flounder, rock sole, walleye pollock, Pacific cod, and Irish lords.

Zeppelin, T. K., K. A. Call and T. J. Orchard. 2001. Using fish bones to estimate length of prey consumed by Steller sea lions (*Eumetopias jubatus*) in the Bering Sea and Gulf of Alaska. P. 242, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

This abstract discusses the use of bones other than otoliths that are found in SSL scat to identify prey species and their length. The authors developed regressions to estimate fish length using six diagnostic bones from pollock, Pacific cod, and Atka mackerel. They used a broad size range (20 cm -55 cm) of fish specimens of each species for generation of regression formulae. A high degree of correlation (>85%) was found between the size of the element and fork length of prey.

Zeppelin, T.K., K. A. Call, D. J. Tollit, T.J. Orchard, and C.J. Gudmundson. 2003. Estimating the size of walleye pollock and Atka mackerel consumed by the western stock of Steller sea lions. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

Same information as in Zeppelin et al. (2001, above) then they applied the regressions to samples collected in scat from 1998 to 2000. Estimated fork length of pollock ranged from 3.7 to 70.8 cm and for Atka mackerel length ranged from 15.3 to 49.6 cm.

Zeppelin, T. K., D. J. Tollit, K. A. Call, T. J. Orchard, and C. J. Gudmundson. 2004. Sizes of walleye pollock (*Theragra chalcogramma*) and Atka mackerel (*Pleurogrammus monopterygius*) consumed by the Western stock of Steller sea lions (*Eumetopias jubatus*) in Alaska from 1998-2000. Fishery Bulletin 102(3):509-521.

This is the formal presentation in a journal of the two presentations discussed above. In summary, the authors developed regression formulae to estimate fish length from seven diagnostic cranial structures of walleye pollock and Atka mackerel. For both species, all structure measurements were related with fork length (FL) of prey. FL of walleye pollock and Atka mackerel consumed by Steller sea lions was estimated by applying these regression models to cranial structures recovered from scats collected between 1998 and 2000 across the range of the Alaskan western stock of Steller sea lions. FL of walleye pollock consumed by SSLs ranged from 3.7 to 70.8 cm (mean=39.3 cm, SD=14.3 cm, n=666) and Atka mackerel ranged from 15.3 to 49.6 cm (mean=32.3 cm, SD=5.9 cm, n=1685). Although sample sizes were limited, a greater proportion of juvenile (≤20 cm) walleye pollock were found in samples collected during the summer (June − September) on haul-out sites (64% juveniles, n=11 scats) than on summer rookeries (9% juveniles, n=132 scats) or winter (February − March) haul-out sites (3% juveniles, n=69 scats). Annual changes in the size of Atka mackerel consumed by Steller sea lions corresponded to changes in the length distribution of Atka mackerel resulting from exceptionally strong year classes. Considerable overlap (>51%) in the size of walleye pollock and Atka mackerel taken by Steller sea lions and the sizes of these species caught by the commercial trawl fishery were demonstrated.

THEME 2B – FORAGING – SEARCHING FOR PREY

SUMMARY:

This theme had major effort during the review period and contains 51 articles including 33 presentations at scientific meetings, four reports, one thesis and one dissertation, and 12 papers in peer-reviewed journals or book chapters. Three major areas of research by numerous groups contributed meaningful results that enhanced the overall understanding of SSL foraging ecology. The three areas include a focus on younger animals, technological improvements in instruments including analysis of dive data, and linking of sea lion dive behavior and foraging activity to habitat features and available prey fields. Additional to these research efforts was a report provided to the North Pacific Fishery Management Council's SSL Mitigation Committee summarizing SSL telemetric techniques, analytical methods, and results up to the year 2000 (see ADFG and NMFS, 2001) and an independent review of the federal government's telemetry research program (see summaries of review by Boyd, Hindell, and McConnell).

1. Focus on younger animals:

Prior to the mid 1990s all telemetry work was conducted on adult female (or rarely adult male) SSLs due to problems associated with immobilization of younger animals and working outside the breeding season. The dissertation by Adams (2000) provides an overview of telemetry research on these older animals and discusses differences in foraging patterns for adult females at different rookeries. Underwater capture techniques developed by ADFG and on-land net captures developed by NMFS in the late 1990s allowed access to younger animals. Focus on these animals was crucial since most population data and models suggested that high mortality of pre-recruit animals could be responsible for the decline. Studies by Loughlin et al. (2003), Pitcher et al. (2005), and Raum-Suryan (2004) portrayed the ontogeny of dive performance by juveniles, the dependence of juvenile sea lions on the near-shore environment, and their variable movement patterns between haulout sites and trip distances while foraging. Numerous presentations at meetings provided overviews of these papers and other studies (e.g., Briggs et al., 2004; Davis et al., 2004) while others (e.g., Andrews 2003) provided an overview of various techniques available for use on these younger animals.

2. Technological improvements:

Many telemetry studies prior to 2000 used Wildlife Computers satellite transmitters to transmit binned dive data, but their physical size was such that only larger animals could accommodate them without hindering dive performance. Over time the manufacturer improved the instruments by reducing size (thus allowing attachment to smaller animals) and improving the type and quality of data transmitted and its analysis (see Loughlin et al., 2003 and Pitcher et al., 2005). However, specific dive data that are attainable with time-depth-recorders was not available since the amount of electronic storage space on the units was too small; recapture is required for TDRs. A new instrument developed at the Sea Mammal Research Unit in Scotland provided some dive-type data and began to be used by NMFS (by Lander, a Ph.D. student at the University of Washington and an NMML employee) and by ADFG and Burns at UAA (by Rehberg, a Masters student at the University of Alaska, Anchorage, and an employee of ADFG). Adding to the understanding of sea lion foraging was the analysis of dive data showing different dive profiles and dive patterns (see presentations by Burns, Rehberg, and others). At the same time, alternative types of electronic instrumentation was being used in Southeast Alaska by Lea, Wilson, and others as part of the University of British Columbia's efforts to detail dive behavior and prey fields. The use of sonic transmitters had been attempted in the late 1980s by NMFS (Merrick) but the results were equivocal;

the technology available at present allowed these researchers to follow SSLs with attached sonic transmitters during foraging bouts.

3. Linking foraging ecology to habitat and prey:

An important component missing from studies prior to 2000 was the link between dive information and the environment in which the SSLs were foraging. With access to remote satellite data and improved satellite instruments attached to sea lions, new efforts to link habitat, prey fields, and sea lions occurred. Linking sea lion dive performance to bathymetry and remote environmental data was accomplished (see publication by Fadely et al., 2003, 2005; presentations by Lander and Sterling); others were able to link sea lion movements and habitat (Briggs et al., 2005 and presentations by her). Efforts to show relationships between sea lion movements, dive behavior, and prey fields were successful in the Kodiak area (presentations by Fadely et al., 2003 and Shima et al., 2003) and in Southeast Alaska (publications and presentations by Bredesen; publications presentations by Gende, Sigler, and Womble; presentations by Thedinga et al.; and publications and presentations by Lea and Wilson). Sterling et al. utilized remote sensing information from satellites to monitor SSL movements and foraging behavior in and around surface eddies in the Bering Sea and North Pacific.

ANNOTATED BIBLIOGRAPHY – FORAGING -- SEARCHING FOR PREY

Adams, T.C. 2000. Foraging differences and early maternal investment in adult female Alaskan Steller sea lions (*Eumetopias jubatus*). Ph.D. dissertation, Texas A&M University. 150 p.

> This dissertation compared the proximate composition of milk, and milk energy intake rates, of SSL pups during the first month after birth between stable and declining populations. Feeding preferences of adult females were examined using fatty acids profiles of their milk and blubber. The proximate composition of milk did not differ significantly among regions, except for total protein. Milk averaged 61.8% water, 21.6% lipid, 9.3% protein, and 2.2% ash. The difference in total protein did not significantly affect energy content. Energy intake rates of pups did not differ among regions, averaging 733.2kJ/day. Estimated maintenance requirements for milk energy of pups in the region of stable population were over twice that of pups in the region of decline. Daily growth rates of pups in stable regions were slower than those in the decline region. Fatty acid profiles analyses indicated both spatial and temporal differences in diets of lactating females that may reflect the abundance and diversity of prey. The results also suggested that winter and summer foraging ranges of prey preferences of adult females were sufficiently distinct between metapopulations to allow determination of geographic region from either milk or blubber fatty acids.

ADFG and NMFS. 2001. Satellite telemetry & Steller sea lion research. A 'white paper' prepared for the North Pacific Fisheries Management Council. 16 pp. Available, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

> This 2001 unpublished paper was an overview of the use of satellite telemetry on SSLs in Alaska by the Alaska Department of Fish and Game and the National Marine Mammal Laboratory. This 'white paper' was originally prepared for use by the North Pacific Fishery Management Council's Sea Lion Mitigation Committee (previously called the Reasonable and Prudent Alternative—RPA- Committee). The primary intent was to provide information on the basic operation of satellite telemetry devices deployed on SSLs, the type of data

obtained, how the data were processed and analyzed, a brief summary of available results through 2000 and analyses, and how inferences from satellite telemetry data have been used in developing conservation and management strategies. Since this paper was written, additional groups have used telemetry to study SSLs, some of the devices have been modified and new and different ones deployed (e.g., satellite relay data loggers).

The conclusion states that the use of satellite telemetry in SSL research in Alaska has expanded substantially since the initial deployments by the NMML in the mid 1980s. Advances in telemetry technology and SSL capture techniques have allowed satellite dive recorders (SDRs) to be deployed on a relatively large number of animals from which a significant amount of information can be obtained. Knowledge of SSL movements, dive behavior, and site fidelity will continue to increase as data from recent deployments are analyzed. Integrating dive behavior and at-sea locations to estimate the extent and location of key SSL foraging areas was a primary focus of research at that time.

Andrews, R.D. 2003. Foraging behavior of Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

This abstract discusses in general terms the utility of various instruments to elucidate SSL foraging behavior, including stomach transmitters and instruments that record swim speed, dive depth, etc., and when combined with local bathymetry, provide information on prey ingestion and foraging time budgets. No data or results were provided.

Baba, N., H. Nitto, and A. Nitta. 2000. Satellite tracking of young Steller sea lion off the coast of northern Hokkaido. Fisheries Science, 66:180-181.

This 2-page journal article summarizes the movements of a single juvenile SSL captured in 1993 and held in captivity for 5 months in Japan before attachment of two ToyoCom PTTs (one on the back, one on the head) in late 1993. The animal was followed for 52 days; 41 transmissions were received from which 18 locations were derived from only one of the two PTTs. The animal moved between northern Hokkaido, Sakhalin Island, and haulout sites in the Sea of Japan and Okhotsk Sea.

Boyd, I.L. 2004. Steller sea lion telemetry studies: A review conducted for the Center for Independent Experts. Manuscript Rpt, Center for Independent Experts. 14p.

In 2003 the NMML requested that the Center for Independent Experts (University of Miami) conduct a review of their telemetry program with the goals (1) to determine the appropriateness of the methods used to retrieve and manage telemetry data from Service Argos, (2) the appropriateness of the stage-based filtering algorithm used by NMML to detect haul-out patterns and evaluate movements at sea, (3) assess the appropriateness of the programming and deployment strategy of SDRs on juvenile Steller sea lions, and (4) determine if potential biases had been adequately identified and whether potential measurements of statistical uncertainty had been identified. The CIE provided three experts for this review which occurred at the NMML in June 2004. The following is the review by Boyd. Those of Hindell and McConnell are below.

A review of satellite telemetry studies was carried out between 1 and 18 June 2004. This found that the team responsible for Steller sea lion research at the NMML has been at the leading edge of new innovations in the field of marine mammal tracking. The program had been responsible for stimulating early developments in satellite transmitter technology and continues to innovate with the development of new sampling methods. The program is generally using the most up-to-date technology and statistical methods. Areas where new techniques could be applied include: (i) path analysis as a means of smoothing the tracks of sea lions; (ii) simulations to assess the effects of likely sampling biases; (iii) state-space modeling as a way of capturing all the uncertainties about movements into a single analytical framework and; (iv) the integration of movement and behavior data with data about the population distribution to develop a population-wide estimate of space usage by Steller sea lions. Data from satellite telemetry could also be used to calibrate both mark-recapture studies to estimate vital rates and surveys of the population.

Bredesen, E.L., A. P. Coombs, and A. W. Trites. 2004. Assessing overlap between Steller sea lion diets and fish distributions in the North Pacific. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors compared distributions of fish species with SSL diet information to assess the level of correspondence between prey availability and SSL feeding habits. Fish distributions were based on published accounts of distribution and habitat preferences. Their results suggested that there was a reasonable correlation between fish distribution and SSL diet obtained from scats and stomachs collected in the 1990s, supporting the view that SSLs are generalist feeders preying on the dominant fish species in the area.

Bredesen, E.L., A.P. Coombs, and A.W. Trites. In press. Relationship between Steller sea lion diets and fish distributions in the eastern North Pacific. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

This paper is the published and longer version of the presentation above. The authors summarize their work by comparing fish species distribution with diet information for SSLs to assess the level of correspondence between potential prey availability and SSL feeding habits. Fish distributions were compiled as part of the Sea Around Us Project at the UBC Fisheries Centre, and were based on published distributions and habitat preferences (e.g., latitude, depth). Sea lion scat samples were collected during the 1990s from seven geographic regions from Oregon to the western and central Aleutian Islands. The frequencies of occurrence of four prevalent species (walleye pollock, Pacific herring, Pacific cod, and North Pacific hake) in the SSL diet were compared to their distributions in the North Pacific Ocean. The data suggested that SSL diets broadly reflect the distributions of these major prey species. However, some of the fish species that were regionally predicted to be present in high abundance were not proportionally reflected in the Steller sea lion diet, suggesting that other factors in addition to fish abundance influence their diets.

Briggs, H.B., D. Calkins, and R.W. Davis. 2004. Movements and diving behavior of juvenile Steller sea lions (*Eumetopias jubatus*) during the winter and spring in southcentral Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The objective of the study was to characterize subadult SSL diving patterns and habitat use along the Kenai Peninsula and Prince William Sound from winter to spring to enhance the understanding of SSL critical habitat. Fifteen juvenile SSLs were equipped with Spot 2 satellite transmitters and SDR-T16 time depth recorders which transmitted for an average of 110 days. Dive characteristics and locations were summarized. Dives were generally < 1 minute and shallow (mean = 11 m) with maximum dive depth at about 193 m. In January and February most dives were in daytime but by April-May this changed to nighttime, perhaps a reflection of variation in prey availability. They concluded that shallow, near-coastal waters may provide important habitat for juvenile SSLs during the transition to nutritional dependency. (see also Briggs et al., 2005 and Davis et al., 2004).

Briggs, H.B., D.G. Calkins, and R. W. Davis. 2005. Habitat associations and diving patterns of juvenile Steller sea lions in the north-central Gulf of Alaska. Chapter 7, pages 59-67, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

This is a book-chapter version of the presentations by Briggs and Davis at various conferences noted above and below this summary. Fifteen juvenile SSLs lions were captured and equipped with satellite telemeters at five haulout sites in Prince William Sound and Resurrection Bay, Alaska. Telemeters transmitted for an average of 122 days (range 38-181 days). A total of 11,692 locations were received and 217,419 dives recorded. All sea lions exhibited localized movements near shore. Most dives were short (mean duration = 1 min) and shallow (mean depth = 11 m), with animals diving to an average maximum depth of 193 m. During winter (January and February), most dives (> 40%) occurred during the daytime (0900-1500 LT). However, by April and May this pattern changed and the animals made most of their dives (> 40%) during night (2100-0300 LT). This relationship was more pronounced for dives deeper than 20 m and coincided with the seasonal increase in photoperiod. Shallow, near-coastal waters provide important habitat for juvenile sea lions during the transition to nutritional independence. The current 20 nm buffer zones encompassed more than 95% of the locations recorded for juvenile Steller sea lions in this study.

Briggs, H.B., D.G. Calkins, R.W. Davis, and R. Thorne. 2005. Habitat associations and diving activity of subadult Steller sea lion (*Eumetopias jubatus*) during the winter and spring in north-central Gulf of Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Similar information as in Briggs et al. (2005) above.

Burns, J.M., M.J. Rehberg, and J.P. Richmond. 2003. Diving behavior and physiology in juvenile Steller sea lions: What are the links? In: Marine science in the Northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

This study focused on determining whether juvenile SSL foraging patterns might be constrained by their physiological status. Their methods included collection of data on body oxygen stores and calculated age-related changes in dive capacity. In comparison to adults, 1-month old pups have significantly lower oxygen stores in blood and muscle resulting in pup diving capacity being less than a third of the adults. The authors suggest that juveniles may be constrained in their diving ability. However, their results from following seven juveniles show that older sea lions do not always dive deeper and longer than younger animals, and the vast majority of dives are well within estimated aerobic capacity.

Burns, J.M., M. J. Rehberg, and J. P. Richmond. 2004. Juvenile Steller sea lion (*Eumetopias jubatus*) dive patterns during long and short trips to sea. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> The authors examine the temporal patterning of dives made by 17 juvenile SSLs and correlate observed differences with dive capacity, age, and season in an attempt to discern foraging. Trips were classified by cluster analysis as type 1 (longer with deeper and longer dives, and type 2 trips which were the opposite. Dive depth, duration, and post-dive surface intervals were less variable between sequential dives in type 1 versus type 2 trips, suggesting that dive activity was more directed during type 1 trips. Type 1 trips were a larger proportion of older juvenile trips and the length of the trips increased as animals aged. The mean and median duration of dives made during type 1 trips were longer than the aerobic dive limit, and dive duration increased in concert with age-related changes in aerobic capacity. This was opposite the type 2 trips. (Compare with the three movements patterns defined by Loughlin et al., 2003).

Burns, J., M.J. Rehberg, and J.P. Richmond. 2006. Working in the dark: Winter diving and foraging patterns in juvenile Steller sea lions. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

> To assess whether winter foraging poses a physiological challenge to foraging juvenile SSLs, the authors determined the proportion of anaerobic dives during bouts of diving activity for 32 young SSLs for which they had measured the aerobic dive limit. Overall, 53% of dives made by juvenile SSLs during long trips away from haulout sites during winter were anaerobic, as compared to 26% of dives during the remainder of the year (April-July). Juveniles dove more frequently and spent an increased amount of time at sea diving during winter months. Together these findings led the authors to suggest that juvenile SSLs are working harder to obtain prey during winter which may be the time of year that this age class is most vulnerable to reductions in prey availability.

Burns, J., J. Richmond, and M. Rehberg. 2003. Linking diving behavior and physiology in juvenile Steller sea lions. P. 26, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

> As above, this abstract summarized efforts to determine whether foraging patterns of juvenile SSLs might be constrained by their physiological status. The authors collected data on body oxygen stores and calculated age-related changes in dive capacity. In comparison to adults, one-month old pups had significantly lower oxygen stores in both the blood and muscle resulting in pup diving capacity being less than a third of the adults. However, whether or not reduced dive capacity affects foraging success was equivocal. Data from older animals showed that older sea lions did not always dive deeper and longer than older animals, and the vast majority of dives were within estimated aerobic capacity suggesting that physiological status may play a smaller role in determining diving patterns.

Davis, R., H. Briggs, and D. Calkins. 2004. Winter movements and diving behavior of juvenile Steller sea lions (*Eumetopias jubatus*) in south-central Alaska. Page 188, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

> Fifteen SSLs of both sexes were equipped with location-only satellite transmitters from five sites along the Kenai Peninsula during 2003 and 2004 (see Briggs et al., 2005 above).. Young of the year (YOY) exhibited high site fidelity to sites where they were captured while

animals 1-3 years of age traveled greater distances (ca. 240 km); all exhibited localized movements parallel or close to shore. Most dives were 1-3 minutes, shallow (ca. 20 m), and were concentrated at night (additional information as in Briggs et al., 2005). Juveniles remained within the 37 km coastal zone during winter and spring but many hauled out at sites where buffer zones do not presently exist; these zones may need to be expanded to include localities used during winter and spring.

Fadely, B., R. Foy, K. Call, K. Wynne, A. Greig, and J. Sterling. 2003. Behavior of juvenile Steller sea lions in relation to available prey distribution in eastern Kodiak Island waters. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

The authors investigated relationships between behavior of sea lions and distribution of available prey by capturing 12 juvenile Steller sea lions underwater near haulouts in Chiniak Bay (near Kodiak), and instrumented them with satellite-linked depth recorders during March of 2001 and 2002. (This study was conducted by Univ. of Alaska scientists as the GAP program and utilized NMFS telemetry data. See Shima et al. (2003) below for a similar study using NMFS trawl data.) Corresponding hydroacoustic and trawl biomass surveys were conducted in March and May. A significantly greater proportion of dives (41%) were made during nighttime than during other periods. In 2001, one of the four animals still transmitting left the area by May, dispersing northward. In March, most dives (95%) were to less than 10 m, but deepened to less than 34 m for animals remaining in May, with time at sea and number of dives increasing. In 2002, three of the five animals still transmitting moved southerly out of the area by May. Animals remaining in the area spent less time at sea but made more dives than in March, and most were to less than 20 m. Sea temperatures were coldest throughout the water column in March, but by May thermal stratification set up frontal structures accumulating food in the upper surface waters, and juvenile pollock and capelin were present at depths of 20-30 m from the gully areas to shore. All pelagic fish species rose and dispersed throughout the water column at night, thus foraging sea lions would have closer access to prey but in much less dense aggregations.

Fadely, B., B. Robson, J. Sterling, A. Grieg, and K. Call. 2003. Defining marine habitat use of immature Steller sea lions through the use of satellite telemetry and GIS. P. 49, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Similar information as in the journal article below (Fadely et al., 2005).

Fadely, B.S., B.W. Robson, J.T. Sterling, A. Grieg, and K.A. Call. 2005. Immature Steller sea lion (*Eumetopias jubatus*) dive activity in relation to habitat features of the eastern Aleutian Islands. Fisheries Oceanography 14 (Suppl. 1):243-258.

In this full-length journal article the authors explored whether oceanographic features and bathymetry influenced the diving activity of 30 immature sea lions (ages 5–21 months) equipped with satellite linked depth recorders in the eastern Aleutian Islands during 2000–2002. SST and chlorophyll a concentrations were obtained from remote sensing satellite imagery and associated with locations where sea lion diving was recorded. Most locations associated with diving to >4 m were within 10 nm of shore and associated with on-shelf waters <100 m deep. Use of offshore and deeper waters in the Bering Sea increased during May, as did trip durations. General movements were northwesterly from the North Pacific Ocean to the Bering Sea. Diving activity varied coincidently with increases in SST and chlorophyll a concentrations, but also with sea lion age. Associations with habitat features did not consistently explain variability in dive count, time at depth, dive focus or focal depth. Near-shore diving tended to be influenced by distance from shore or seafloor depth, whereas increased SST coincided with activity of sea lions diving >30 nm offshore. Immature sea lions developing into independent foragers in the relatively shallow pass areas of the EAI do so at a time of rapid changes in oceanography and prey availability.

Gende, S., M., J. N. Womble, M. F. Willson, and B. H. Marston. 2001. Cooperative foraging by Steller sea lions, *Eumetopias jubatus*. Canadian Field-Naturalist 115:355-356.

The authors report their observations of 75-300 SSLs exhibiting cooperative foraging behavior during 1996-1999 in Berners Bay, Southeast Alaska. The SSLs entered the bay in pursuit of eulachon that were entering the bay and then the rivers to spawn in spring. The sea lions were observed moving synchronously in a 0.75 km line of porpoising sea lions perpendicular to shore, a few meters apart. All porpoised for 8-20 seconds before diving simultaneously for 4-9 minutes before simultaneous emergence in a different section of the bay; the sequence was repeated on numerous occasions. The SSLs then formed large rafts of 10-80 sea lions sleeping on the surface. The forage species could not be confirmed but is was assumed that they were feeding on eulachon.

Hindell, M.A. 2004. Review of the National Marine Mammal Laboratories Steller Sea Lion Telemetry Program. Manuscript Rpt, Center for Independent Experts. 23p.

As noted above under Boyd (2004), a review of the NMML telemetry program was held in June 2004. Following is Mark Hindell's conclusions from that review.

The NMML telemetry program has been a driving force in the development of satellite telemetry in the past 20 years, and many of the innovations made by this team have been of considerable benefit to the discipline in general. The end point of their research efforts is to provide the best possible information to aid in the conservation and management of this endangered species, and the team is well placed to continue as a leader in the field. After the meeting held with NMML scientists in Seattle June 2-3, 2004, I found that:

1. With respect to Scope Item i (SDR programming and deployment strategies), I felt that the team has done an excellent job developing the appropriate sampling and transmission protocols to be used on the SDRs. However, the devices used in the past have in-built limitations, largely due to the use of "binned" summaries of behavioral data. To date these limitations have not been a problem and the information collected has been sufficient to answer most of the important questions (such as identification of critical habitat). The team will however need to obtain better data on foraging behavior to address emerging questions of habitat use, and this will require the use of better on-board summaries and data transmission. The deployment strategies used so far have to large extent been driven by the requirement to study juveniles. Access to this age group has been difficult, but adopting the SCUBA capture technique and developing the new "raft traps" has greatly increased the team's ability to conduct properly stratified designs. Another difficulty is the remote location of the seal's haul-outs, particularly in the Gulf of Alaska. However the team, in conjunction with the Alaska Department of Fish and Game, has managed to sample a large number of regions. There are now sufficient data to assess the appropriateness of the sample sizes in each region and to attempt some state-based "population" level spatial usage analyses.

2. The system developed for retrieval, storage, linkage to other data sources and access to analytical packages was excellent, and is likely to be of use to others working in similar fields. However, there was a clear need to coordinate all of the other sources of telemetry data

for this species. The NNML database is an obvious repository for these data. Management of this species can only be better informed if complete information is used to address the key issues. While issues of intellectual property may hamper this, I feel every attempt should be made to improve data sharing between research labs.

3. The stage–based filter developed by NMML (Scope Item iii) was a sophisticated version of other “destructive” filters that are widely used in the marine mammal community. However, adopting the newly emerging “path analysis” models of animal movements will enable maximum use of the complete data set, while also incorporating uncertainty information.

4. The team has recognized most of the potential biases in the data (Scope Item iv), and has worked to minimize them. Adopting the emerging SDR technology and data analysis approaches outlined above will further reduce biases and improve the quality of information available.

Lander, M.E., T.R. Loughlin, M.L. Logsdon, G.R. VanBlaricom, B.S. Fadely, and L.W. Fritz. 2006. Environmental composition of habitat used by juvenile Steller sea lions (*Eumetopias jubatus*). *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

The objective of this study was to examine diversity of habitat used by SSLs with respect to population trajectories. Habitat was assessed by deploying satellite-depth recorders and satellite relay data loggers on juvenile SSLs (n=50) during 2000-2004 within four regions of the western stock. Areas used by SSLs during June-August were demarcated using telemetry data and characterized by environmental variables (SST and chlorophyll-a) which serve as proxies for environmental processes or prey. Shannon’s Diversity Index (shows how evenly the proportions of environmental patch types are distributed) was quantified for each area using a spatial pattern analysis computer program. There was considerable inter annual variability within and among all areas, however indices of diversity of SST for the eastern and central Aleutian Islands (both stable or increasing) were consistently greater than indices for the western Aleutians or the central Gulf of Alaska, both of which are in decline.

Lander, M. E., T. R. Loughlin, G. R. VanBlaricom, M. Logsdon, and J. T. Sterling. 2003. Spatially explicit foraging ecology of juvenile Steller sea lions (*Eumetopias jubatus*). P. 90, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

This study utilizes satellite telemetry data from 81 SSLs (used by NMML to define movements and dive characteristics) to examine how SSLs alter their foraging strategies in response to seasonal or annual changes in oceanographic features, which ultimately affect distribution of prey. The study examines SSL distribution and movements, along with selected diving behaviors with respect to oceanic conditions (bathymetry, temperature at depth, SST, etc.) within the context of a spatially explicit model. The study of part of Lander’s Ph.D. dissertation and was ongoing at the time of the presentation. No results were provided in the abstract.

Lander, M.E., T.R. Loughlin, G.R. VanBlaricom, and M.L. Logsdon. 2004 Spatially explicit foraging ecology of juvenile Steller sea lions (*Eumetopias jubatus*). Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

As in Lander et al (2003) above.

Lea, M.A., and B. Wilson. In press. Techniques for real-time, active tracking of sea lions. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

This paper is a book chapter summarizing details of techniques to follow SSLs using three telemetry techniques. The paper was given at a symposium (below) prior to publication. The authors describe an alternative technique using boat-based active tracking of individuals by very high frequency (VHF) or acoustic telemetry. By following an individual equipped with transmitters, detailed observations of habitat use, predator occurrence, social context, behavioral state, and prey availability may be integrated to provide a real-time context in which to place the animals' movements. Twenty-one juvenile SSLs were captured in Southeast Alaska during October 2003 and February 2004 and were fitted with a variety of VHF, satellite, and/or acoustic tags and tracked through the winter and spring of 2003-2004. The use of ship-based VHF telemetry in conjunction with real time navigation plotting software was highly successful and provided 37 fine-scale tracks of coastal and pelagic sea lion movements covering a total distance of 482 km. Acoustic telemetry techniques were less successful because of the suspected overlap in tag transmission frequency and sea lion hearing.

Lea, M.-A., B. Wilson, and A.W. Trites. 2003. A marine predator's pursuit of happiness- Linking fine-scale Steller sea lion movements to prey distribution and behavior at sea. P. 93, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

As above, this study examined the fine-scale spatial aspects of juvenile SSL foraging behavior, particularly how their behavior is modified by the abundance and distribution of prey. They fitted juvenile SSLs with VHF, satellite, and acoustic transmitters to follow animals on foraging trips in Lynn Canal, Southeast Alaska, an area dominated by over-wintering herring and pollock. This study was on-going at the time of the presentation and no results were provided.

Lea, M.-L., B. Wilson, A. Trites, M. Sigler, and D. Csepp. 2004. Bridging the gap—linking real-time foraging: Movements of sea lions to prey availability. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

As in Lea et al (2003) above but with some additions and details. Included is an additional prey item, eulachon, in the assessment of prey availability. They summarized tracking of individual SSLs for two 58-hour periods revealed a variety of solo and group foraging strategies. Detailed dive characteristics (not provided in abstract) were correlated with prey distribution, habitat characteristics, and behavior at sea. SSL foraging behavior varied considerably in relation to prey type and availability throughout winter and spring.

Loughlin, T. R., J. T. Sterling, R. L. Merrick, J. L. Sease, and A.E. York. 2003. Immature Steller sea lion diving behavior. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

A short version of the abstract presented below that was from the published journal article.

Loughlin, T.R., J.T. Sterling, R.L. Merrick, J.L. Sease, and A.E. York. 2003. Diving behavior of immature Steller sea lions (*Eumetopias jubatus)*. Fishery Bulletin 101 (3):567-582.

This journal article provided information to help understand the ontogenetic relationship between juvenile SSLs and their foraging habitat. The authors summarized dive and movement data from 13 young-of-the-year (YOY) and 12 yearling SSLs equipped with satellite dive recorders in the Gulf of Alaska and Aleutian Islands and Washington from 1994 to 2000. A total of 1413 days of transmission (0=56.5 days, range: 14.5−104.1 days) were received. They recorded 222,073 dives, which had a mean depth of 18.4 m (range of means: 5.8−67.9 m). Alaska YOY dived for shorter periods and at shallower depths (mean depth=7.7 m, mean duration=0.8 min, mean maximum depth=25.7 m, and maximum depth=252 m) than Alaska yearlings (0=16.6 m, 0=1.1 min, 0=63.4 m, 288 m), whereas Washington yearlings dived the longest and deepest (mean depth=39.4 m, mean duration=1.8 min, mean maximum depth=144.5 m, and maximum depth=328 m). Mean distance for 564 measured trips was 16.6 km; for sea lions 10 months of age, trip distance (7.0 km) was significantly less than for those >10 months of age (24.6 km). Mean trip duration for 10 of the 25 sea lions was 12.1 h; for sea lions #10 months of age, trip duration was 7.5 h and 18.1 h for those >10 months of age. Three movement types were identified: long-range trips (>15 km and >20 h), short-range trips (<15 km and <20 h) during which the animals left and returned to the same site, and transits to other haul-out sites. Long-range trips started around 9 months of age and occurred most frequently around the assumed time of weaning while short-range trips happened almost daily. Transits began as early as 7 months of age, occurred more often after 9 months of age, and ranged between 6.5 and 454 km. The change in dive characteristics coincided with the assumed onset of weaning. These yearling sea lion movement patterns and dive characteristics suggest that immature Steller sea lions are as capable of making the same types of movements as adults.

Marston, B. H., M. F. Willson and S. M. Gende. 2002. Predator aggregations during eulachon *Thaleichthys pacificus* spawning runs. Marine Ecology Progress Series 231:229-236.

This article is linked with Gende et al. (2001) above but here the authors discuss seabird, pinniped, and cetacean abundance increases in Berners Bay coincident with the eulachon spawning run. In 1996 and 1997 gulls, bald eagles, Steller sea lions, harbor seals, and humpback whales increased in abundance as eulachon entered the bay. They report that eulachon are unusually high in lipid content, and many of the runs occur in spring when energetic demands are high.

McConnell, B. 2004. Review of National Marine Mammal Laboratory Stellar Sea Lion Satellite Telemetry Program. Manuscript Rpt, Center for Independent Experts. 11p.

This is the third of three reviews of the 2004 NMML telemetry program discussed above under Boyd (2004) and Hindell (2004). Here McConnell discusses material presented during the review and provides recommendations to the NMML to augment their telemetry program and to enhance SSL recovery. Those pertaining to this topical theme are provided here. The NMML team should keep abreast of the latest developments in telemetry systems and should use its expertise and financial buying power to foster new technological developments that would further increase their understanding of SSLs ecology in an oceanographic context. The NMML team should explore the recent literature in track ‘smoothers’ and should interact with colleagues in other institutes who are developing such algorithms. It is essential that efforts be made to incorporate all SSL telemetry data (from whatever agency or institute) into the NMML database for central analysis. While this may require considerable political tact to achieve, the status quo does not allow the full potential of the combined data sets to be realized. Public funding agencies should be lobbied to stipulate that copies of SSL telemetry data that are funded from the public purse should be made available to the NMML database. The practical and political ramifications are real and numerous – but none should be insurmountable. The NMML team should explore the recent literature in spatial usage estimation and should confer with colleagues in other institutes who are developing such techniques. The NMML team should immediately appoint a locally based statistical modeler / biometrician who can routinely interact with the other members of the team and who can develop the necessary analytical techniques.

Pitcher, K.W., M.J. Rehberg, G.W. Pendleton, K.L. Raum-Suryan, T.S. Gelatt, U.G. Swain, and M.F. Sigler. 2005. Ontogeny of dive performance in pup and juvenile Steller sea lions in Alaska. Can. J. Zool., 83:1214-1231.

In this full length journal article the authors report their study of diving performance in 75 pup and 36 juvenile SSLs using satellite data recorders. In general, dives by SSLs were brief and shallow. Overall, 82.3% of dives were <2 min long and 86.9% of dives were <10 m deep. Long (>5 min) and deep dives (>100 m) constituted only 2.49% and 0.77%, respectively, of total dives. They then used linear mixed-effects models to investigate the relationships between the response variables maximum daily depth, time at depth, mean dive duration, dive rate, and time at sea and the predictor variables age, sex, population (eastern and western Alaska populations), time of day, and month of year. All response variables except dive rate were positively related to age. Dive rate declined with age. Time of day, month, population, sex, and some first-order interactions were all significantly related to some measure of diving performance. With large samples they were able to identify significant relationships between the response variables and the predictor variables, even though the total amount of variation explained by the models was low, because most dives were short and shallow regardless of age, sex, population, time-of-day, or month-of-year. Depths and durations of dives by juvenile animals increased throughout the range of ages studied and were similar to or greater than those previously reported for juveniles and adult females. The authors expected maximum depths and durations to continue to increase with age until body mass plateaus at about 10 years of age. Therefore, the authors conclude that older animals will be more efficient foragers because they would have greater aerobic dive limits as well as more experience locating and capturing prey.

Raum-Suryan, K.L., M.J. Rehberg, G.W. Pendleton, K.W. Pitcher, and T.S. Gelatt. 2004. Development of dispersal, movement patterns, and haul-out use by pup and juvenile Steller sea lions (*Eumetopias jubatus*) in Alaska. Marine Mammal Science 20:823-850.

In this journal article the authors present their extensive use of satellite telemetry to study SSL distribution at sea and movement patterns of pups (1.6 - 11.9 months old) and juveniles (12.0 - 35.1 months old). They studied trip distance, duration, and inter haul-out movements of sea lions in relation to age, sex, and month of year in the decreasing western population (Prince William Sound, Kodiak, and the Aleutian Islands) and the increasing eastern population (Southeast Alaska). They deployed 103 satellite transmitters (29 in the west and 74 in the east) between 1998 and 2001. Round trip distance and duration increased with age, trip distance was greater in the western population than the eastern population, trip duration was greater for females than males, and haul-out use was clustered. Changes in round trip distance and duration occurred from April to June for all age classes studied indicating that the annual timing of weaning may be less variable than the age of weaning. Overall, 90% of round trips were 15 km from haul-outs and 84% were <20 hours in duration, indicating near-shore areas adjacent to haul-outs are critical to the developing juvenile.

Raum-Suryan, K., M. Rehberg, K. Pitcher, G. Pendleton, and T. Gelatt. 2003. Dispersal and movement patterns of juvenile Steller sea lions in Alaska. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

Same information as above in the journal article.

Rehberg, M.J. 2005. Pattern matters: Changes in the organization of swimming and diving behavior by Steller sea lion juveniles in coastal Alaska waters. M.S. Thesis, University of Alaska, Anchorage, AK. 92 p.

This is a 4-chapter thesis summarizing Rehberg's studies of SSL foraging ecology which had been presented at various conferences (see below). Among 11 young-of-year (pup) sea lions, a significant increase in the amount of time spent at sea and spent diving, and mean dive depth and duration was observed. This increase was driven by a significant shift of swimming and diving behavior from evenly spread by time-of-day to mainly focused at night, suggesting that young sea lions began to pursue vertically migrating prey. These behavioral transitions suggest that some pups begin foraging by the end of their first year. Furthermore, by the middle of the second year, juvenile (n=12) diving behavior is comparable to that of known foraging adults. Therefore, the data indicate that young SSL juveniles depend, at least in part, upon prey capture and may therefore be vulnerable to prey limitations. However, indices of diving performance suggest that by the end of their second year they are sufficiently competent to adjust to local prey depletion. A model incorporating information on both the temporal organization of behavior and magnitude of diving successfully assigned individual sea lions to all 3 age/season categories, while a model ignoring temporal organization could not. Juvenile and pup organization clearly reflected different foraging strategies. Compared to pups, juvenile trips were longer in duration, the diving within trips was more highly organized into temporal bout structure, these bouts were characterized by longer and deeper diving and the greater proportion of these dives were flat-bottomed (square) in shape. Because SSL lactation is long and variable in duration, these results suggest that pups were not foraging as actively as the older juveniles, even within the same season.

Rehberg, M.J., and J.M. Burns. 2003. Developing methods to describe Steller sea lion (*Eumetopias jubatus*) juvenile habitat usage at varying temporal scales. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

This abstract describes the use of satellite relay data loggers on juvenile SSLs to test the hypothesis that SSLs utilize their habitat in a spatially and temporally non-random fashion, and that diving behaviors differ among habitats used. Four temporal scales were investigated: central place haulout, trip to sea, diving bout, and individual dive. Results from juveniles tagged in November 2001 and February 2002 suggest that SSLs moving along different habitats alter their behavior. A female yearling reduced her maximum dive depth from 225 to 68 m, from 328 to 264 seconds, and proportion of day spent diving after moving 40 km. A male remaining in the same location showed little change in these behaviors

Rehberg, M.J., and J. M. Burns. 2004. Objective classification of trips-to-sea made by juvenile Steller sea lions (*Eumetopias jubatus*) in Alaska. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> The authors examined juvenile SSL trips to sea to determine whether differences in behavior may be considered the basic unit of foraging effort. Among 748 trips to sea by 17 juveniles they identified two types (see Burns et al., 2004 above for similar information). 83% of trips were short in duration (0.25 days) and had shallow (~14 m) and brief (~1 min) diving. The remainder of trips were long in duration (>1 day) and exhibited deep (60 m) and longer (~3 min) dives. Most juveniles were observed making both types of trips.

Rehberg, M. J. and J.M. Burns. 2005. Objective classification of dive shapes from satellite relay data recorders. 3rd Annual Biologging Conference, St. Andrews, Scotland, UK. June 2005.

> This is a poster presented at the subject conference. The authors describe their use of statistical clustering techniques to define SSL dive profiles. The poster contained numerous graphics to illustrate the technique. The abstract states that shape of individual dives should be determined objectively, to avoid bias, improve reproducibility, and to permit comparisons among different studies. Previous objective analyses of dive shape have been made using data from archival time-depth recorders (TDR), which must be recovered from study animals in order to retrieve the data collected. Because recovery of instruments is not feasible in all cases, shape classification techniques that can be applied to data from satellite tags would be useful. The authors report on an adaptation to the multivariate K-means clustering method, an approach frequently used in the classification of dive shape from archival TDR data, that allows it to be used with the discrete, generalized dive profiles reported by satellite-relayed data recorders (SRDL). They then apply the results to understand the foraging behavior of SSLs in Alaska. They monitored the diving behavior of 32 SSL: 19 pups (1 year of age) and 13 juveniles (2-4 years of age) captured and released in the central Aleutian Islands, Kodiak Island and Prince William Sound. Objective classification of 40,359 dives yielded 5 distinct dive shapes, which were classified with 91% accuracy.

Rehberg, M.J., and J.M. Burns. 2005. Organization of diving behavior discriminates among general predators: example in Steller sea lion (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

> Similar to the poster presentation described above, this abstract reports use of data from the same 40,300 dives obtained from 32 SSLs with satellite-relayed data loggers to test for organization of dive behavior at three temporal scales. They objectively determined individual dive shape, reflecting vertical prey patch structure, dive bout organization, reflecting horizontal patch structure, and the organization of trips to sea, reflecting prey distribution across the seascape. Results showed that 52% of dives were square in shape, 60% fell within bouts, 63% were non-random over time, and the results were variable with individuals. They then integrated all dive measures into linear discriminant models to determine the features necessary to assign SSLs to their age categories. Only models using temporal organization and traditional metrics properly classified SSL by age.

Rehberg, M. J. Burns, and T. Gelatt. 2003. Diving and activity patterns of juvenile Steller sea lions (*Eumetopias jubatus*). P. 136, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

> The authors examined diving and activity budget information from 11 young of the year and 4 yearling SSLs and deployed SMRU Satellite Relay Data Loggers between November 2001 and March 2003 in the central Aleutian Islands and Gulf of Alaska. Five of six YOY SSLs in the Aleutians and one of five in the Gulf showed no increasing trends in proportion of time at sea spent diving. Yearlings generally dove deeper and longer than YOY but there was little effect of age on dive behavior suggesting that age is not the primary factor influencing dive patterns of all young SSLs. Diurnal patterns revealed that most juveniles dove deeper, longer, and more frequently at night but some yearlings did not exhibit this pattern.

Richmond, J.P., J.M. Burns, and L.D. Rea. 2003. Steller sea lion foraging ecology is an important factor in juvenile survival. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

> The authors monitored changes in blood oxygen stores, muscle oxygen stores, and muscle enzyme concentrations using numerous blood and chemical parameters discussed in the abstract. They found that numerous values indicated that nursing SSLs had decreased oxygen storage capacity in comparison to adults and that physiology in young SSLs is immature and may constrain dive behavior.

Schrader, W.J., M. Horning, and J.-A. E. Mellish. 2005. Where do they spend their time? A focus on water column use by juvenile Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

> These authors report their study of 12 temporarily captive and 5 free-ranging juvenile SSLs using satellite telemetry to assess time spent at depth during dives. The expected time spent in each depth bin (provided by the transmitter) based on width of bins and depth. This calculation was then modified to reflect water column use and dive duration from published values for juveniles. Randomized dives were simulated using these parameters to estimate expected time spent in each time-at-depth bib per 6-hour period. Results showed that water column use differed significantly between winter and summer with increased focus in shallow portions of the water column (9-33 m) in summer and deeper (41-150 m) in winter. Focus did not differ between males and females although there was a correlation of mass with focus at 61-150 m.

Shima, M., A. Hollowed, B. Fadely, C. Wilson, J. Sterling, and K. Call. 2003. Comparison of Steller sea lion diving behavior relative to spatial distribution of walleye pollock and capelin. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

> This study is similar to that in Fadely et al. (2003) above except this study utilizes trawl data in Chiniak and Barnabas troughs near Kodiak collected in a NMFS predator/prey study during August 2001 and 2002. Field observations were used to map the vertical distribution of pollock and capelin. The study was partitioned into six sub-regions with a day and night vertical distribution within each partition. Fish were not evenly distributed throughout the study regions and exhibited marked diurnal shifts in vertical distribution. Juvenile SSLs captured near Cape Chiniak traveled within the Chiniak trough study area with most dives

shallower than 34 m made during 2100-0900 hour period. SSLs instrumented near the Barnabas trough did not use the trawl survey areas.

Sigler, M.F., S. M. Gende, and D. J. Csepp. 2004. Predictability of prey available to free-ranging Steller sea lions at varying spatial scales. In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK.

The authors examined the characteristics of fish species at three spatial scales that may facilitate efficient foraging for free-ranging SSLs in Southeast Alaska, and used observations of foraging sea lions to examine their effectiveness in locating high-energy prey patches. Herring and pollock were the dominant prey in the area. At the largest spatial scale, prey energy was variable across months, peaking in December and January principally due to the presence of herring. Combining all prey species, predictability varied among months but was highest from November to February regardless of spatial scale. Predictability of herring peaked at a spatial scale of 11 km whereas pollock were most predictable at a scale of 2.1 km, reflecting a more uniform distribution. SSLs were able to locate prey patches that were highest in energy density during most months.

Sigler, M.F., S. M. Gende, and D. J. Csepp. 2004. Predictability of prey available to free-ranging Steller sea lions at varying spatial scales. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Same information as in Sigler et al (2004) above.

Sinclair, E.H., S.E. Moore, N.A. Friday, T.K. Zeppelin, and J.M. Waite. 2005. Do patterns of Steller sea lion (*Eumetopias jubatus*) diet, population trend and cetacean occurrence reflect oceanographic domains from the Alaska Peninsula to the central Aleutian Islands? Fisheries Oceanography 14 (Suppl. 1):223-242.

Shipboard surveys were conducted along the Aleutian Islands in 2001 and 2002 to assess the influence of a suite of biophysical parameters on regional patterns in the distribution of cetaceans and SSLs. Distributions of four large whale species: fin, humpback, minke, and sperm aligned with proposed metapopulation breaks in diet and population trend of SSLs. Dalls porpoise and killer whales were widely distributed throughout the study area, and killer whales were particularly prevalent along the north Aleutian Island coastlines between Unimak Pass and Samalga Pass. Biopsies determined that most killer whales (92%) were of the piscivorous (resident) ecotype as opposed to the mammal-eating (transient) ecotype observed in 2002 only. Generalized additive models (GAMs) were used to explore relationships between these multispecies patterns in distribution, oceanographic variables (salinity, temperature, fluorescence and depth) and proximity to six Aleutian passes. The GAMs indicated the best-fit models and most significant correlations as determined by the Akaike function and Cp-statistics were: depth and proximity to the nearest measured pass for SSLs and all cetaceans, respectively; frequencies of herring and salmon in SSL diet with population trend; fluorescence in the top 50 m with occurrence of humpback, minke, and killer whales; and surface temperature with occurrence of humpback, killer, and sperm whales. Results of the GAM analyses suggest foci for future investigation of relationships between physical variables and interspecific patterns of marine mammal distribution.

Sterling, J.T., B.S. Fadely, and T.R. Loughlin. 2004. Movement and dive behavior of foraging juvenile Steller sea lions (*Eumetopias jubatus*) associated with pelagic eddies. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> Movements and dive behavior of three juvenile SSLs were examined in relation to satellite derived sea surface height (SSH), geostrophic vectors, and surface chlorophyll a concentrations. Each animal encountered eddies of 150-200 km in diameter identified by SSH and geostrophic vectors. Their movements were in the edge of an anticyclonic eddy or directly through the middle. Dive performance while in the eddies is provided. The eddie features appeared to concentrate primary production, detected as higher chlorophyll a, which likely influenced the distribution and abundance of prey species for SSLs. SSL diving in and around the eddies occurred in the first half of the evening to depths associated with vertical migrating prey.

Thedinga, J.F., S.W. Johnson, and D.J. Csepp. 2003. Seasonal availability of nearshore prey to Steller sea lions at two haulouts in Southeast Alaska. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

> This study examined the seasonal availability of SSL prey in near-shore waters <100 m deep near two haulout sites in Southeast Alaska in summer and winter from 2001 to 2004. Prey was inventoried by beach seine, jig, and ROV within 7 km of the Benjamin Island and Brothers haulout sites. Regardless of sampling method, total catch was always greater at the Brothers than at Benjamin Island. Total fish and species count for each sampling method are presented for each area. Sixteen of the species they captured had been identified in SSL scat and more prey was available to SSLs in summer than in winter in near-shore areas.

Thedinga, J.F., S. W. Johnson, and D.J. Csepp. 2004. Seasonal availability of nearshore prey to Steller sea lions near two haul-outs in Southeastern Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> Same information as in Thedinga et al. (2004) above.

Thomas, G. L. and R. E. Thorne. 2001. Night-time predation by Steller sea lions: New insight into the feeding habits of these mammals will help conservation attempts. Nature 11(6841):1013.

> The authors estimated herring biomass in Prince William Sound using sonar surveys in March 2000 was 7,281 metric tons. The estimate of pollock biomass was 28,277 metric tons. Despite the much greater abundance of pollock, their use of an infrared system to observe SSLs at night revealed that foraging by Steller sea lions was exclusively on herring and was conducted only at night. Foraging activity was intense on dense herring schools. SSLs were often observed swimming side by side in a row of 50 or more individuals along the edges of a school, suggesting that they were herding the herring. The sonar records revealed herring schools at depths of 10–35 m at night, but deeper during the day. Walleye pollock, on the other hand, remained at depths of over 100 m during both day and night. Pollock schools were also found in less protected regions and were further offshore. Although SSLs are capable of dives exceeding 250 m, the more accessible distribution of herring at night may be the primary factor in the foraging behavior of the sea lions.

Thomas, G. L., and R. E. Thorne. 2001. Night-time predation by Steller sea lions (vol. 411, pg 1013, 2001) - Correction. Nature 414(6865):710.

This is just a short correction statement in the journal in follow-up to the article above. It states: We stated that our acoustic surveys in Prince William Sound since 1993 and infrared surveys since 2000 suggested that these sea lions “feed exclusively” on herring. However, it has been drawn to our attention that this statement is misleading. In clarification, the sea lions were selectively targeting the relatively shallow (0–50-m depth) schools of Pacific herring at night as a source of winter forage to the exclusion of relatively larger and deeper (150–250 m) concentrations of walleye pollock

Wilson, B., M.-A. Lea, and A. W. Trites. 2004. Following in the wake of sea lions: Fine-scale boat-based tracking of juvenile Steller sea lions reveals distinct habitat preferences for shorelines. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This study used the same animals as in Lea et al. (2003, 2004) above but this study details the movements of 21 juvenile SSLs 5-29 months of age equipped with satellite, VHF, and acoustic transmitters. Tracking was conducted day and night over 10 weeks in fall and spring 2003-2004 on 35 occasions lasting up to 58 hours. Substantial portions of all tracks occurred within close proximity (10s of meters) of the shoreline and during movements they frequently paused or spent prolonged periods at promontories at the tips of islands; open water crossings were infrequent and they took the shortest straight-line route.

THEME 2C – FORAGING -- MODELS AND HYPOTHESES

SUMMARY:

This theme had major effort during the review period and contains 71 articles including 31 presentations at scientific meetings, seven reports, four theses, one dissertation, and 28 papers in peer-reviewed journals or book chapters. The significant contributions were those pertaining to testing the 'junk food' hypothesis through captive studies and modeling. Results in the early 2000s from captive studies by Rosen and associates were the driving force for much of the research from 2000 to 2006 related to prey quality and its effect on SSL health and condition.

Rosen and Trites (2000a) was the pivotal paper that set much of the research in motion. In that paper the authors asserted that eating pollock is 'bad' for sea lions resulting in loss of body mass. The loss of body mass while eating pollock was due to the lower gross energy content of pollock versus herring, the higher cost of digesting pollock, and the increased energy loss from digesting the larger quantity of fish needed to compensate for the lower energy content of pollock. Results from their captive-feeding studies were consistent with the junk-food hypothesis which they asserted has serious implications for SSLs that have been eating primarily pollock in the Gulf of Alaska and the Aleutian Islands. This study was followed by other studies by them pertaining to SSL health and condition, effects of prey quality, prey passage rates, physiological indicators for assessing compromised health (principally using blood parameters), and other studies. Their findings indicated that body composition (fat to total mass ratio) changes with season (when animals are fed constant, maintenance level, isocaloric diets of high or low-lipid prey), but that body composition is not affected by whether the prey are high or low-lipid. In contrast, sea lions lose body mass when they experience short-term shortages of prey, but lose a greater portion of their mass from lipid reserves when eating low lipid prey compared to eating high lipid prey. These experiments suggested that juvenile sea lions were physiologically living 'on the edge.' A variation on this theme was the Masters study at UBC by Donnelly (2001) who used the Norwegian rat to test whether changes in physical size and reproductive performance could be caused by a switch in the quality of prey consumed. Interestingly, some models validated this assertion when varying food distribution was examined. Thomson et al. (2003) and Matthiopoulos et al. (2005) suggest that recently weaned SSL pups may be unable to meet their metabolic requirements in prey densities that adults can exploit effectively, and Burns et al. (2006; in 'Searching for prey' theme) suggest that juvenile SSLs are working harder to obtain prey during winter which may be the time of year that this age class is most vulnerable to reductions in prey availability.

The Rosen et al. studies precipitated numerous studies to validate their findings. Captive studies at the ASLC (Calkins et al., 2005) using study periods of longer duration and more varied diets than those at UBC were unable to validate the results from those at UBC. These later studies have not been published in journals but at presentations, meetings, and elsewhere the authors contend that their results differ from the UBC studies because SSLs are opportunistic predators that are capable of compensating for low quality prey. Changing seasonal physiology of Steller sea lions is likely to have more impact on body condition than quality of prey, provided sufficient quantity of prey is available. The authors suggest that the negative health effects that may have been detected in previous studies were artifacts of permanent captivity of the test animals. Calkins et al. (2006) studied juvenile sea lions held captive for a short period fed an exclusive pollock diet for an average of 54 days. Eight additional animals were fed a mixed diet consisting of several species of fish and cephalopods. All animals increased in mass on both diets.

The validity of the junk-food hypothesis was challenged by Fritz and Hinckley (2005) who reviewed available data and found little support for the hypothesis that increases in the availability and consumption of gadids following the regime shift are primarily responsible for the decline of the western population of SSLs. Trites and Donnelly (2003) in their review found that the data collected in Alaska were consistent with the hypothesis that SSLs in the declining regions were nutritionally compromised because of the relative quality of prey available to them (chronic nutritional stress), rather than because of the overall quantity of fish per se (acute nutritional stress). This is further supported by captive studies by Rosen et al. which indicate the overall quality of prey that has been available to SSLs in the declining population could compromise the SSL health and hinder their recovery.

Results from the captive studies precipitated interest in developing models to validate field and captive studies and to explore additional parameter variations. Work by Matthiopoulos et al (2005, mentioned above), Alvarez-Flores, Hinckley, Testa, and Winship provided such models to test a broad array of foraging, survival, growth, and physiological parameters. Winship's Master's thesis and subsequent publications included development of a bioenergetic model to predict the food requirements of SSLs. The model provided both a quantitative estimate of the Alaskan SSL population's food requirements and direction for future research.

Efforts to assess the energetic cost of foraging in high and low density prey fields, and for high and low energetic prey, was studied by Cornick (2005) in her Ph.D. dissertation (and published papers from that work) on animals at the ASLC and by Cheneval et al. (2001). The work by Cornick found that dive duration and relative foraging efficiency decreased with reduced simulated reduced prey accessibility (RPA) and were consistent with previous findings. The effects of varying food availability were further explored by Soto, Thorne, Thomas, and Wynne. Soto studied prey availability on the survival of South American sea lions pups during and after El Niño events and found high pup mortality when prey are low (El Niño event). Other results were similar to those documented for California sea lions at San Miguel Island, California, during and after El Niño events chronicled by R. DeLong at the NMML. Malavear (2002) constructed a model to assess changes in prey availability in Oregon and found that the model predictions were consistent with observations on the declining population of SSLs in Alaska.

The junk-food hypothesis asserts that certain prey is inferior to others. Following the Rosen and Trites study, Azana, Jeanniard Du Dot, and Joy measured nutrient composition, energetic properties, and conducted computer simulations to determine possible effects of different prey quality on SSL growth and fitness. Their findings suggest that consumption of predominantly pollock has nutritional consequences for SSLs. Beck and Rea investigated the spatial and temporal variability in the diet of juvenile SSLs in Alaska using both qualitative and quantitative fatty acid signature (FAS) analysis.

ANNOTATED BIBLIOGRAPHY –FORAGING -- MODELS AND HYPOTHESES

Alvarez-Flores, C., and S. Hinckley. 2004. A model of diving behavior applied to Steller sea lion foraging. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> The authors discuss a theoretical model they found in the literature and developed from it a model for diving behavior. Their study was designed to analyze the foraging success of SSLs by optimizing time spent at the surface and diving time using net energy gain from ingested

fish. It also considers the quality of the prey patch and distribution of fish in the water column. The model proved to be internally consistent and versatile under different distributions of fish and was flexible to accommodate individual differences in behavior.

Andrews, R.D. 2004. The population decline of Steller sea lions: testing the nutritional stress hypothesis. Pages132-146, *in,* M. Gordon and S. Bartol (eds.), Experimental approaches to conservation biology, University of California Press, Berkeley, CA.

This is a paper derived from a talk discussing the general biology of SSL, the observed declines, and information relevant to explaining the cause(s) of the decline. It then goes on to discuss field and laboratory experiments pertaining to testing the nutritional stress hypothesis. It is a thorough, succinct review, and along with Fritz and Hinckley (2005) and Trites and Donnelly (2003) below, provides a good overview of the hypotheses and pertinent information.

Atkinson, S., D. Calkins, M. Castellini, V. Burkanov, S. Ingles, and D. Hennen. 2005. Impact of changing diet regimes on Steller sea lion body condition. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This abstract describes a study discussed in more detail in Calkins et al. (2005) below and contains the same information as the abstract in that book chapter.

Azana, C.D.P. 2002. Seasonal variation in nutrient composition of Alaskan walleye pollock (*Theragra chalcogramma*) and its effect on the nutritional status of Steller sea lions (*Eumetopias jubatus*). M.S. thesis, University of British Columbia. 104 p.

In this Masters degree study the author compared the nutritional value of herring with pollock and explored seasonal changes in the nutrient content of pollock. She also compared the nutritional status of three captive Steller sea lions fed pollock and herring. Herring was more concentrated in dietary lipid and energy source than pollock. The protein of herring was also higher in digestibility than pollock protein, which could indicate that even if ingested energy was equal in both diets, absorbed energy for body functions may be reduced when pollock was eaten. There was little difference in the protein quality of pollock and herring with the exception that valine was more abundant in herring. The energy content of pollock changed seasonally, with the peak in energy concentration occurring in the summer and fall (July to November) and then declining over the winter prior to spawning. Captive SSLs lost mass or increased mass at a slower rate on a pollock diet than when they consumed herring at which time they all increased in mass. The sea lions had lower levels of plasma cholesterol when fed pollock. Their red blood cells were also more susceptible to oxidation, which corresponded with lower plasma vitamin E levels. Their findings suggest that consumption of predominantly pollock has nutritional consequences for SSLs.

Beck, C., L. Rea, and J. Kennish. 2004. Modeling diet composition of free-ranging Steller sea lions using quantitative fatty acid signature analysis. Final report to North Pacific Marine Research Institute (NPMRI) at the Alaska SeaLife Center. 25p

This final report contains studies designed to investigate the spatial and temporal variability in the diet of juvenile SSLs in Alaska using both qualitative and quantitative fatty acid signature (FAS) analysis. They used a qualitative approach to examine differences in the FAS, and thus diet, of juvenile SSLs from four different regions (Prince William Sound (PWS), Southeast Alaska (SEA), Kodiak and the Aleutian Islands). Within PWS and SEA, they also examined seasonal and age-class differences to better understand how juveniles transition to independent foraging. For the report they determined FAS of blubber tissue from 521 individuals (1-35 months old) representing all four regions. FAS were found to differ significantly by region and by season and age class within region, indicating that the diet consumed by juvenile SSLs differs by location, time of year, and age. They also report on-going studies using quantitative fatty acid signature analysis (QFASA) to estimate the diet of juveniles (> 10 months) within PWS (n=88) and to develop a library of FAS for SSL prey species within PWS and elsewhere. They have also investigated the comparability of various lipid extraction and gas-chromatography methodologies commonly used in fatty acid analysis.

Calkins, D.G., M. Castellini, V. Burkanov, S. Atkinson, S. Inglis, and D. Hennen. 2005. Impact of changing diet regimes on Steller sea lion body condition. Chapter 2, pages 6-18, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

This book chapter summarizes work at the Alaska SeaLife Center addressing whether the cause of the SSL decline was nutritional stress, which led to chronic high juvenile mortality and possibly episodic adult mortality. The objective of this study was to determine whether or not shifting diet (toward lower quality prey) could predict shifts in body condition (i.e., body mass or body fat content) over different seasons. Captive SSLs (n = 3) were fed three different diet regimes, where Diet 1 approximated the diet in the Kodiak area in the 1970's prior to the decline in that area, Diet 2 approximated the species composition in the Kodiak area after the decline had begun, and Diet 3 approximated the diet in Southeast Alaska where the population is stable to increasing. Although all of the SSLs were still growing during the 3-year study, changes in body mass were not significantly different on the three diet regimes. Body fat (%) varied between 13% and 28%, but was not consistently high or low for any diet regime or season. Mean intake (in kg) of Diet 2 was significantly greater for all sea lions during all seasons. Mean weekly intake (in kcal) showed significant interactions between diet and season. Animals tended to lose body mass on Diets 2 and 3, as well as during the breeding and post-breeding seasons; they tended to gain mass during the winter and on Diet 1. They conclude that SSLs are opportunistic predators that are capable of compensating for low quality prey. Changing seasonal physiology of Steller sea lions is likely to have more impact on body condition than quality of prey, provided sufficient quantity of prey is available.

Calkins, D.G., J.-A. Mellish, S. Atkinson, and D. Hennen. 2005. Does consuming pollock truly have negative impacts on free-ranging Steller sea lions? *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

The authors report that some captive studies supported the theory that consuming pollock resulted in negative impacts on juvenile SSLs. The objective of this work was to test the hypothesis that free-ranging SSLs suffer negative consequences from a pollock diet. Seven free-ranging juveniles (1 and 2 years old) were temporarily held in captivity and fed an exclusive pollock diet for an average of 54 days. Eight additional animals were fed a mixed diet consisting of several species of fish and cephalopods. All animals increased in mass on both diets. There was a significant increase in mean body fat (8.2%) between capture and release for the 7 animals in the treatment group; there was no significant difference in mass change between diet types. No negative consequences to free-ranging SSLs were detected from consuming an exclusive pollock diet. The authors suggest that the negative health effects that may have been detected in previous studies were artifacts of permanent captivity of the test animals.

Cheneval, O., D. A. S. Rosen, R. D. Andrews and A. W. Trites. 2001. Foraging behavior and energetics of captive Steller sea lions. P. 42, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

This abstract reviews an experiment to measure the metabolic costs involved in foraging and to observe foraging behavior by use of four underwater video cameras while a respirometer system measured oxygen consumption. Their preliminary results indicated a substantial increase in activity and metabolism during foraging. Predatory behavior was described. Their estimation of foraging costs were intended to help refine bioenergetic models for SSLs.

Cornick, L.A. 2001. Optimal forging theory as a model to examine the relationship between relative prey accessibility and forging energetics in Steller sea lions (*Eumetopias jubatus*) in the Gulf of Alaska and Bering Sea. Ph.D. dissertation, Texas A&M University.

This is the dissertation from which the presentations and published papers listed below are derived. The following is an abbreviated version of the dissertation's abstract. Optimal foraging theory predicts that predators should change their dive behavior (foraging strategy) as prey availability changes. Relative prey accessibility (RPA, the ability of an individual SSL to access prey during a dive cycle) is likely a crucial causal link between hypothesized reduced prey biomass resulting from commercial fishing activity and depressed foraging efficiency of SSLs. The author employed a combined approach of predictive model development and controlled experiments. Testable predictions were determined by developing a bioenergetics-based model of individual dive behavior for aerobic dives of otariids. To determine the relationship between RPA and dive behavior, she examined how dive duration, foraging time, surface interval, percent time foraging, submerged: surface time, dive efficiency, and foraging efficiency varied with changes in simulated RPA in optimal foraging experiments performed with three seven-year-old SSL (two females, one male) held captive at the Alaska Sea Life Center. RPA had a significant positive effect on dive duration, foraging time, percent time foraging, and relative foraging efficiency. The dive model accurately predicted the observed effect of changing RPA on dive behavior and foraging efficiency. A population-based model was also developed in order to predict the effects of varying regimes of commercial fisheries activity on SSL population trends, based upon an estimate of annual SSL energetic requirements. The model accurately portrayed SSL abundance trends predicted by published projections, but failed to implicate competition with the commercial groundfish fishery in Alaska as a cause of the decline of SSL.

Cornick, L.A. 2005. Examining the relationship between prey availability, behavior, and energetic gain in captive Steller sea lions. Chapter 4, pages 27-30, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

This book chapter reviews published and unpublished papers by the author pertaining to the response of marine predators to changes in fine-scale prey distribution. Precipitous declines in many marine apex predators necessitate a better understanding of the magnitude of fluctuations in prey availability that is within the limits of compensatory behavioral plasticity of predators. This report summarizes the results of two optimal foraging experiments conducted with three captive Steller sea lions at the ASLC from 1999 – 2002. The first examined the relationship between prey encounter rate and dive behavior and efficiency

(Cornick and Horning 2003). The second examined this relationship in the face of increased swimming costs (Cornick unpublished data).

Cornick, L. A. and M. Horning. 2000. Simulated foraging experiments on captive diving mammals: A feasibility study with Steller sea lions (*Eumetopias jubatus*). Federation of American Societies for Experimental Biology Journal 14(4):440.

This is an abstract from a presentation at a conference and includes discussion of research; see Cornick (2005) above and Cornick and Horning (2003) below. The authors conducted a study at the Alaska SeaLife Center to assess the feasibility of using feeding dives of trained captive animals to simulate different prey density and distribution scenarios. Steller sea lions were trained to target to a lighted pole for a fish reward. After two months of training, sea lions were transitioned to lit targets attached to two fish feeders mounted in their habitat. Each time a sea lion chose the correct lit target, a prey item was released. Sea lions were tasked to swim to and between lit targets for varying durations, with prey released at intervals throughout the dive. Sea lions were solicited to perform extended dives by alternating lit targets and randomizing prey release location and frequency. Sea lions were fitted with time-depth recorders (TDR) and dives were recorded on video. During three months of testing, sea lions chose unlit targets in <20% of dives, and broke off during extended dives in <30% of dives. Break-off frequency increased with decreasing prey release rates. They concluded that it is feasible to conduct foraging experiments with pinnipeds under controlled conditions, in which prey accessibility can be varied by varying the frequency and amount of prey release.

Cornick, L.A. and M. Horning. 2001. Simulating pinniped foraging in captivity: Experimental validation of foraging theory predictions. P. 47, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

This abstract is a presentation as part of Cornick's Ph.D. research at Texas A&M. Here the authors describe their experimental manipulation of relative prey accessibility (RPA) in a controlled, captive setting, using a remotely controlled fish feeder then observing changes in SSL dive behavior (see summary above). Results show that dive duration and relative foraging efficiency decrease significantly with reduced simulated RPA.

Cornick, L. A. and M. Horning. 2001. Examining the relationship between relative prey accessibility and sea lion dive behavior: An experimental approach. Federation of American Societies for Experimental Biology Journal 15(4):90.

This is an abstract from a presentation at a conference and includes discussion of research with no specific results provided. See Cornick (2005) above and Cornick and Horning (2003) below. A key problem in testing adverse effects on SSL foraging efficiency from reduced prey biomass is the difficulty in assessing relative prey accessibility (RPA) for individual animals. Here the authors experimentally manipulating RPA in a controlled setting, and observing changes in dive behavior with each simulated prey density scenario, the authors quantified the relationship between RPA and observed dive behavior. Results indicate that dive duration and relative foraging efficiency decrease with reduced simulated RPA, and are consistent with findings from the sole extant study relating otariid dive behavior to natural cyclic changes in RPA.

Cornick, L., and M. Horning. 2003. A test of hypotheses based on optimal foraging considerations for a diving mammal using a novel experimental approach. Can. J. Zool. 81(11) 1799-1807.

This published article is derived from Cornick's Ph.D. dissertation and as above they experimentally manipulated the fine-scale prey field for a marine carnivore in a controlled, captive setting and examined changes in SSL behavior and efficiency with changes in prey encounter rate. They hypothesized (*i*) a minimum prey encounter rate below which the cost of foraging always exceeds the benefit, (*ii*) foraging effort should increase with increasing prey encounter rates, and (*iii*) a maximum threshold prey encounter rate at which foraging efficiency is optimized. Dive duration, foraging time, and dive and foraging efficiency increased significantly with increasing prey encounter rate up to an asymptote of ~13 fish per dive cycle, supporting two of the three hypotheses. The results also support predicted responses to changing prey encounter rates derived from an optimal foraging model for diving animals and validated optimal foraging model predictions in a marine mammal

Cornick, L.A., S.D. Inglis, K. Willis, and M. Horning. In press. Effects of increased swimming costs on foraging behavior and efficiency of captive Steller sea lions: evidence for behavioral plasticity in the recovery phase of dives. Journal of Experimental Marine Biology and Ecology.

The authors tested the hypothesis that an increased cost of swimming, brought on by increased hydrodynamic drag, has the same effect on dive behavior and efficiency as reduced prey availability under standard locomotion. They conducted experiments on the two adult female SSLs at the ASLC using the same animals and general experimental design previously used to test the effects of reduced prey encounter rate on dive behavior and efficiency. Animals were fitted with a drag inducing harness for half of the 500 simulated foraging dives in order to increase the cost of swimming. Individual dive duration and foraging time were significantly reduced in all cost-increased dives, comparable to the effects of reduced prey encounter rate. However, on a bout-by-bout basis, dive and foraging efficiency were only slightly reduced, which is likely due to an average 50% reduction in post-dive surface recovery duration during cost-increased dives. Increased heat flux across the body surface measured in a parallel study confirmed a significant increase in work during drag-increased dives. The authors suggest that sea lions were able to compensate for changes in the cost of foraging and maintain their foraging efficiency by altering their dive strategy over an entire bout of dives when operating well within their aerobic scope.

Donnelly, C.P. 2001. Possible effects of pollock and herring on the growth and reproductive success of Steller sea lions: insights from feeding experiments using an alternative animal model, *Rattus novegicus.* M.S. thesis, University of British Columbia. 76 p.

This Master's study used the Norwegian rat, *Rattus nowegicus*, to test whether changes in physical size and reproductive performance could be caused by a switch in the quality of prey consumed. The abstract states that she fed five groups of 12 female, weanling rats diets composed of herring (H), pollock (P), pollock supplemented with herring oil (PH), pollock supplemented with pollock oil (PP), or a semi-purified diet (ICN). Mean body weights were greatest for H, followed by PH, P, PP and finally ICN, although ICN was the only group significantly different from the others. Food intakes prior to mating were 10% higher for groups on the lower fat diets (P and ICN), resulting in similar caloric intakes in all groups. Efficiency of energy utilization was also similar for all fish diets. However, this efficiency was slightly reduced when pollock was supplemented with oil (PP and PH) compared to pollock alone. The protein efficiency ratio (PER) was highest for the H diet, slightly lower for all pollock diets, and significantly lower for ICN. Rats fed the low energy P and ICN meals did not compensate by consuming more during gestation. The fetal weights for mothers fed pollock (P) were significantly reduced. This study showed that the caloric content was a major limiting factor in the nutritional quality of pollock. If food intake was adjusted to meet energetic requirements, there were no detrimental consequences to eating pollock. However, supplementation of pollock meal with additional pollock oil may reduce growth and reproductive performance, although the reasons for this were not apparent.

Donnelly, C.P., and A.W. Trites. 2000. The nutritional stress hypothesis as it relates to Alaskan pinnipeds. Unpublished manuscript, Marine Mammal Research Unit, Fisheries Centre, University of British Columbia, 2204 Main mall, Vancouver, B.C. V6T 1Z4 26 p.

This report is an early form of the journal article published later (Trites and Donnelly 2003). It summarizes published literature in three sections pertaining to an overview of the nutritional stress hypothesis, evidence for nutritional stress in Alaskan SSLs, and the question of quality versus quantity of prey, including the junk food hypothesis. They conclude that data collected in Alaska suggest that SSLs in the declining region were nutritionally compromised due to the relative quality of prey available to them, rather than due to the overall quantity of fish per se.

Donnelly, C., A. W. Trites, and D. D. Kitts. 2000. Alternative models for assessing the role of nutrition in the population dynamics of marine mammals. Pages 41-45, *in* C.L.K. Baer, editor, Proceedings of the Third Comparative Nutrition Society Symposium, No. 3, Pacific Grove, California, August 4-9, 2000.

This is a summary paper of Donnelly's Master's thesis above which advocates use of rats to test nutrition-related theories for SSLs. Here, her and coauthors state that alternative animal models are desirable to assess the role of nutrition on the population dynamics of marine mammals. If an appropriate model could be found, it might be possible to identify population consequences and risks that face sea otters forced to eat fish after depleting local invertebrates, or for sea lions which switch from a fatty fish to a lean fish. The rat appears to be a feasible model for studying marine mammal nutrition. A preliminary study exploring the effects of nutrition on population dynamics via parameters of growth and reproductive success is feasible. Although mink and harbor seal models are superior in their similarity to other marine mammals, the difficulty and time involved in breeding them is either extremely labor intensive or prohibitive. Again, the regular, five day cycle of the rat and shorter generation time allow for parameters of fertility and offspring viability in response to different diets to be examined in a cost effective and economic way. Additionally, because of the extensive use of rats in other nutritional studies, many signs and symptoms of specific nutritional shortcomings are known and easily detected If a reliable model can be implemented in the study of marine mammal population dynamics, research can explore aspects of physiology not available when using captive marine mammals or mammals in the wild. Development of a model also has the potential to reduce the number of mammals taken from the wild for scientific study, thereby helping to preserve many threatened species.

Donnelly, C.P., A.W. Trites, and D.D. Kitts. 2003. Possible effects of pollock and herring on the growth and reproductive success of Steller sea lions: insights from feeding experiments using an alternative animal model, *Rattus novegicus*. British Journal of Nutrition 89:71-82.

This is the journal publication of the Master's degree study by Donnelly. From the abstract the following was extracted. The authors used the general mammalian model, the laboratory rat (*Rattus norvegicus*), to test whether changing the quality of prey consumed could cause

changes in body size and reproductive performance. Five groups of twelve female, weanling rats were fed diets composed of herring (H), pollock (P), pollock supplemented with herring oil (PH), pollock supplemented with pollock oil (PP), or a semi-purified diet (ICN). Mean body weights were greatest for H, followed by PH, P, PP and finally ICN, although ICN was the only group significantly different from the others. Food intakes before mating were 10% higher for groups on the lower-fat diets (P and ICN), resulting In similar energy intakes in all groups. The protein efficiency ratio was highest for the H diet, slightly lower for all pollock diets, and significantly lower for ICN. The fetal weights for mothers fed P were significantly reduced. The study showed that the energy content was a major limiting factor in the nutritional quality of pollock. When food intake was adjusted to meet energetic requirements, there were no detrimental consequences from eating pollock.

Fritz, L.W., and S. Hinckley. 2003. A critical review of the ‘Regime shift/junk food’ hypothesis for the Steller sea lion decline. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

This is the first of two presentations on this topic that was later published as a journal article with the same information as in Fritz and Hinckley (2005) below.

Fritz, L., and S. Hinckley. 2004. A critical review of the regime shift–“junk food” hypothesis for the decline of the western stock of Steller sea lion. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This is the second of two presentations on this topic that was later published as a journal article with the same information as in Fritz and Hinckley (2005) below.

Fritz, L.W., and S. Hinckley. 2005. A critical review of the regime shift-"junk food"-nutritional stress hypothesis for the decline of the western stock of Steller sea lion. Marine Mammal Science 21:476-518.

This is a full length journal article discussing the utility of the junk food hypothesis and provides alternatives explanations to refute the hypothesis. The abstract states that one hypothesis for the decline in this western population is that a climate regime shift in 1976–1977 changed the species composition of the fish community and reduced the nutritional quality (energy density) of the sea lion prey field. This in turn led to nutritional stress and reduced individual fitness, survival, and reproduction of sea lions. Implications of this regime shift–“junk food” hypothesis are that (1) the recruitment and abundance of supposed high quality species (e.g., Pacific herring), decreased while those of supposed low quality (e.g., species in the family Gadidae) increased following the regime shift, (2) Steller sea lion diets shifted in response to this change in fish community structure, and (3) a diet composed principally of gadids (e.g., walleye pollock) was detrimental to sea lion fitness and survival. They examine data relating to each of these implications and find little support for the hypothesis that increases in the availability and consumption of gadids following the regime shift are primarily responsible for the decline of the western population of Steller sea lion

Hinckley, S., C. Alvarez-Flores, J. Horne, J. Burgos, and M. Dorn. 2004. Individually based modeling of Steller sea lion foraging behavior. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This abstracts discusses an individual-based model for SSLs which was in development at the time of the presentation. The specific goal of the project was to investigate foraging behavior, and the effect localized deletion caused by the pollock fishery could have on overall physical condition of individual animals. Their model contained four main components: a module representing travel to foraging areas; a module for dive behavior; a module for bioenergetic budget; and an independent model for the behavior of the fishing fleet. Preliminary results were provided in the presentation but not included in the abstract.

Hunt, G. L., et al., 2002. Foraging habitats of Steller sea lions in the Aleutian Islands: bottom-up controls of prey availability and the presence of killer whales. Cruise Report - *Alpha Helix* cruise 259, 16 May to 19 June 2002. University of California, Irvine, Irvine, CA. 151p.

Unable to locate and read this report.

Hunt, G. L., Jr. 2001. Foraging habits of Steller sea lions in the Aleutian Islands: bottom-up controls of prey availability and the presence of killer whales. Cruise report - *Alpha Helix* cruise 245, 4 June 2001 to 25 June 2001. University of California, Irvine, Irvine, CA. 26p. +figures.

Unable to locate and read this report.

Jeanniard Du Dot,T., D.A.S. Rosen, and A.W. Trites. 2005. Steller sea lion energetic priorities during and after a nutritional stress: Are proteins the key? *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This abstract discusses a study to investigate the pattern of energetic priorities and fuel utilization in eight captive SSLs during a one-month food restriction followed by a one-month recovery period fed two different diets. They measured bioenergetic costs of growth, daily metabolism, thermoregulation, and exercise capacity biweekly. Blood parameters and metabolic hormones were also measured to assess physiological mechanisms during nutritional stress and recovery. No results were provided but the authors contend that they will lead to refinement of bioenergetic models.

Joy, R., J., D.J. Tollit, J.L. Laake, and A. W. Trites. 2004. Using feeding trials and computer simulations to reconstruct sea lion diet from scat. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors describe a study to develop correction factors for remains of consumed prey using captive animals fed under controlled conditions. Computer simulations were then used to investigate levels of error and bias in reconstructing diet from hard parts with and without correction factors. The complete study with results was presented in a book chapter at Joy et al. (in press) below.

Joy, R., D.J. Tollit, J.L. Laake, and A.W. Trites. In press. Using simulations to evaluate reconstructions of sea lion diet from scat. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

The authors used a computer simulation model that aimed to replicate captive feeding studies. They performed computer simulations using data from captive feeding studies to investigate levels and sources of error in reconstructing simulated mixed species diets. The simulations used different combinations of hard remains, were conducted both with and without the application of numerical correction factors, and compared four different diet indices (1. modified frequency of occurrence, 2. split sample frequency of occurrence, 3. variable biomass reconstruction, and 4. fixed biomass reconstruction). Simulations indicated that levels of error were related to the minimum number of individuals (MNI) method of inferring fish numbers from prey remains, prey size, the number of identifiable prey structures used, and the robustness of the remains to digestive processes (recovery rate). The fewer fish fed, the higher the relative probability of counting the fish, particularly when a multiple element structure or all structure techniques are used. If recovery rates were assumed to be consistent across species, then large fish (particularly when fed in small amounts) were overestimated relative to smaller sized prey in all models, but particularly biomass reconstruction models and when using more than one paired structure. When recovery rates of a paired structure (otoliths) were varied across species (as observed in captive feeding studies) then biomass models tended to overestimate the species with high recovery rates. In contrast, frequency of occurrence models overestimated the contribution of smaller prey (particularly when fed in small amounts). Simulations also indicated correction factors could reduce levels of error in biomass reconstruction models, but could not solve problems related to counting fish using MNI.

Malavear, M.Y.G. 2002. Modeling the energetics of Steller sea lions (*Eumetopias jubatus*) along the Oregon coast. M.S. thesis, Oregon State University, Newport, OR. 114p.

A dynamic bioenergetic model for SSLs was built using the STELLA simulation modeling system. The model is intended as an aid for the exploration of ecological questions regarding growth and survival of immature Steller sea lions (ages 1-3) living along the Oregon coast under different nutritional scenarios. The ultimate goals were: 1) to identify features of the Oregon ecosystem that could contribute to the growth of the Steller sea lion population in contrast to the declining population in Alaska and 2) to provide a basis for examining the various hypotheses that have been put forward regarding the causes of the decline in Alaska. The dynamic energetic model was composed of coupled submodels, created or adapted from the literature, that describe the energetic inputs and outputs of the animal. It is a mechanistic model based on biological principles that attempts to describe the connections and feedbacks between the different components and the allocation of energy to them under suboptimal nutrition. The model predicted that both changes in prey abundance and quality would have a more pronounced effect in one-year-old animals than in two- and three-year-old sea lions. A reduction in prey density could delay the attainment of sexual maturity, and this could have a significant negative effect on the population rate of increase. The seasonal migration of Pacific whiting was shown to be very important as a biomass influx into the system. In general, the model predictions were consistent with observations on the declining population of SSLs in Alaska.

Malavear, M.Y.G., and D.B. Sampson. 2003. Modeling the energetics of Steller sea lions (*Eumetopias jubatus*) along the Oregon coast. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

Same information as in the Master’s thesis above (Malavear 2002).

Matthiopoulos, J., D. Thompson and I. Boyd. (**YEAR**?). Implications of varying food distributions for fitness in Steller sea lions. Final Contract Report (Contract No. NA17FX1431), Sea Mammal Research Unit, Gatty Marine Laboratory, St Andrews University, St Andrews, Fife KY16 8LB, U.K. 92p.

The project had two principal objectives: (1) To synthesize within a modeling framework most of the biological information (particularly energetics, reproductive rates, mortality/survival rates, growth and life-history variables) about SSLs; and (2) to use this as a

tool for management by allowing assessment of the consequences of different management/policy scenarios within the boundaries of uncertainty known to exist for current empirical measurements. The goals were achieved by linking models of sea lion behavior at different scales to examine how changes in prey encounter rates during individual dives and bouts of foraging were scaled up to influence individual fitness and, in turn, how this was translated into the population trajectory. The model was fitted to the trajectories of pup production from sites in SE Alaska and on Kodiak Island because they showed opposite trends and because they would be challenging test for the assumptions underlying the model. Appropriate fits to the pup production trajectories were obtained. An emergent property of the model was that good fits were obtained to the trajectories of the survey data for the non-pup portions of these populations, suggesting that the model was providing a realistic representation of the way in which energy density and distribution is translated into population dynamics. Although preliminary, these results suggested that sea lions are likely to be most sensitive to factors that change the quality and depth distribution of prey, such as might be found in association with major shifts in the structure of food chains. However, an important caveat to this conclusion is that these results rely heavily upon the estimates of mass-specific metabolic rate which need further investigation.

Matthiopoulos, M., D. Thompson, and I. Boyd. 2005. Implications of varying food distributions for fitness in Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This abstract provides a summary of information found in the contract report by Matthiopoulos et al. (above).

Rea, L., J. Kennish, and C. Beck. 2003. Modeling diet composition of free-ranging Steller sea lions using quantitative fatty acid signature analysis. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

This abstract discusses the utility of quantitative fatty acid analysis in SSL diet studies and efforts by ADFG and NMML to model diet composition from QFASA and scat diet data. She reviews efforts to facilitate collaborative analysis using QFASA and other appropriate models (not discussed).

Rosen, D. 2005. Physiological answers to ecosystem questions: What we have learned from laboratory studies about the decline of Steller sea lions in Alaska. *In* Marine Science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

This abstract discusses the breath of experiments conducted by the authors on captive SSLs. They conducted a series of studies to test several potential links between prey quality and sea lion health. Their findings indicate that body composition (fat to total mass ratio) changes with season (when animals are fed constant, maintenance level, isocaloric diets of high or low-lipid prey), but that body composition is not affected by whether the prey are high or low-lipid. In contrast, sea lions lose body mass when they experience short-term shortages of prey, but lose a greater portion of their mass from lipid reserves when eating low lipid prey compared to eating high lipid prey. Additional studies are discussed. Their experiments suggested that juvenile sea lions are physiologically living ‘on the edge.’

Rosen, D.A.S., G.D. Hastie, and A.W. Trites. 2004. Searching for stress: Hematological indicators of nutritional inadequacies in Steller sea lions. Symposia of the Comparative Nutrition Society 2004. No. 5:145-149.

This experiment examined the response of a suite of blood parameters to experimentally induced nutritional stress in a group of four captive female SSLs. The goal was to identify a suite of parameters that could be used to diagnose comparable conditions among wild SSLs. The experiments were alternated between isocaloric diets of Atka mackerel and herring. The level of food intake (-35.6 kJ/day) was set at a level estimated to produce a 10-15% loss of initial body mass over the 29-day trials. Body mass was measured daily and body composition was determined at the start and end of each trial by deuterium dilution technique. Blood samples were also obtained at the beginning and end of each trial for clinical analyses. A standard suite of 39 clinical parameters was measured. The consistency in blood parameter changes was determined by comparing the direction of change between of pre- and post-experimental samples for each of the 39 tested parameters. Nine blood parameters showed consistent changes over the 29-day period of induced nutritional stress. White blood cell counts, platelet counts, phosphorous levels, alkaline phosphatase levels, and serum Fe levels all showed consistent decreases, whilst red blood cell counts, hemoglobin levels, hematocrit levels, and gamma GT levels, showed consistent increases. Only one of the blood parameters showed a significantly different response in relation to diet; blood urea-nitrogen (BUN) levels showed a consistent increase on the Atka mackerel diet and a consistent decrease on the herring diet. Sea lions on the Atka mackerel diet showed a mean percentage increase in BUN level of 9.2%, and a mean percentage decrease of 4.9% on the herring diet.

Rosen, D.A.S., S. Kumagai, G.D. Hastie, R. Barrick, C.A. Nordstrom, and A.W. Trites. 2005. Blood barometers: Indicators of nutritional stress in captive Steller sea lions. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This study examined changes in blood profiles in captive SSLs exposed to differing time courses of nutritional stress to determine which parameters changed consistently. During the experiments SSLs consistently lost 10-15% of their body mass but the loss was achieved over 9 -29 day periods. Numerous blood parameters were measured during the experiment which was detailed in the abstract. Sample size was reported as an important factor to detect differences between populations and that some measures required <100 samples while others were more prohibitive.

Rosen, D.A.S., D. J. Tollit, A.J. Winship, and A.W. Trites. 2004. Potential effects of short-term prey changes on sea lion physiology. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK

This abstract contains the same information as the published version (below) of this talk at the conference.

Rosen, D.A., D.J. Tollit, A.J. Winship, and A.W. Trites. In press. Potential effects of short-term prey changes on sea lion physiology. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

This is the published version of the presentation above. The authors discuss how otariids react physiologically to short-term changes in prey quality and availability. A series of studies with young captive SSLs tested several potential links between prey quality and sea lion health. Body composition (fat to total mass ratio) of animals fed constant, maintenance-level, isocaloric diets of high- or low-lipid prey changed with season, but overall was not affected by prey composition. The sea lions appeared to prioritize maintaining core growth rates even when energy was limited, electing to deplete lipid reserves to fulfill energy deficits, resulting in changes in relative body condition. In contrast, sea lions subject to short-term, sub-maintenance diets of high- or low-lipid prey utilized a greater portion of their lipid reserves when losing body mass on low lipid prey. Experiments with different *ad libitum* feeding regimes indicated that sea lions were readily able to alter food intake levels to compensate for differences in prey energy content and, to a lesser degree, prey availability. However, the results also suggested that decreases in prey quality or foraging opportunities can combine to require food intake levels that are greater than the digestive capacity of the individual. This is particularly true for young animals that may already be living "on the edge" energetically.

Rosen, D.A.S. and A.W. Trites. 2000a. Pollock and the decline of Steller sea lions: testing the junk-food hypothesis. Canadian Journal of Zoology 78:1243-1258.

This is the primary paper validating the 'junk-food' hypothesis and from which many of the studies in this theme evolved. The important conclusion of this abstract precipitated studies in the field and in captivity to validate the assertion that eating pollock is 'bad' for sea lions. A modified form of the abstract follows. The decline of Steller sea lions in the Gulf of Alaska and the Aleutian Islands may be the result of them eating too much pollock (a gadid fish) instead of a more balanced and diverse diet containing fattier fishes, such as herring or sandlance. They sought to test this junk-food hypothesis by feeding six captive Steller sea lions (ages 0.9–4.5 years) only pollock or herring. All sea lions gained mass while eating herring. However, eating only pollock for short periods (11–23 days) caused the study animals to lose an average of 6.5% of their initial body mass (0.6 kg/day) over an average feeding trial of 16 days (initial mass averaged 125 kg). The animals were allowed to eat as much pollock as they wanted but did not increase their food intake to compensate for the low energy they were receiving. The sea lions showed progressive metabolic depression while losing body mass on a pollock-only diet. The loss of body mass while eating pollock was due to the lower gross energy content of pollock versus herring, the higher cost of digesting pollock, and the increased energy loss from digesting the larger quantity of fish needed to compensate for the lower energy content of pollock. Thus, the sea lions would have had to eat 35–80% more pollock than herring to maintain similar net energy intakes. Results from the captive-feeding studies were consistent with the junk-food hypothesis and have serious implications for Steller sea lions that have been eating primarily pollock in the Gulf of Alaska and the Aleutian Islands.

Rosen, D.A.S. and A.W. Trites. 2000c. Assessing the role of nutritional stress in the decline of wild populations: a Steller case of scientific sleuthing. Pages 182-186, *in* C.L.K. Baer (ed.). Proceedings of the Third Comparative Nutrition Society Symposium, No. 3, Pacific Grove, California, August 4-9, 2000.

This is a review paper where the authors summarize studies on captive animals pertaining to nutritional stress. They state that there are essentially three fundamental questions that need to be addressed to resolve whether a population is nutritionally stressed. These can be generalized as concerns of: 1) food intake (i.e., prey identity, quantity, and foraging location), 2) food quality (i.e., energetic and specific nutritional components), and 3) the ultimate impact of diet on the individual and the population (i.e., energy budgets, overall health, life history parameters). All three questions require a combination of field and captive studies to be properly addressed. Since 1995, they have been studying whether the decline of SSLs in the North Pacific Ocean has been caused by nutritional stress. They then provide an overview of some of the research they are actively undertaking to address the aforementioned 3 questions that are fundamental to evaluating the role of nutritional stress in wild populations. Most of these studies are detailed in the papers above and below by Rosen and others.

Rosen, D.A.S., Trites, A.W. 2001. Effect of diet composition and feeding regime on body mass and composition in captive Steller sea lions. P. 183, *in* 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, BC, Nov 28-Dec 3, 2001.

This is a symposium presentation of published research by Rosen and associates investigating whether a low fat pollock diet induced decreases in body mass or condition compared to high fat herring diet. Three captive SSLs (3 years old) were alternately maintained on isocaloric diets of herring or pollock fed on either an even (equal kg/day) or uneven schedule for 6 weeks. Although substantial changes in body mass occurred, they were not due to differences in food type as predicted. The occurrence of seasonal changes in body mass despite constant energy intake indicated substantial shifts in the animals' energy budgets. Those on an uneven feeding schedule gained or lost mass faster than those on even feeding schedules. Animals were likely to lose fat mass when fed an uneven pollock diet. Their work suggested that a low fat diet may have significant impacts on fat stores at critical times of the year and that changes in percent fat may not accurately reflect changes in absolute energy stores.

Rosen, D.A.S. and A.W. Trites. 2002. Changes in metabolism in response to fasting and food restriction in the Steller sea lion (*Eumetopias jubatus*). Comparative Biochemistry and Physiology B 132(2): 389-399.

This paper, together with Rosen and Trites (2000a) above, forms the basis for subsequent studies attempting to assess the impact of diet of SSL health and condition. The authors state that many animals lower their resting metabolism when fasting or consuming inadequate food. The authors sought to document this response by subjecting five SSLs to periods of complete fasting or restricting them to 50% of their normal herring diet. The sea lions lost an average of 1.5% of their initial body mass per day during the 9–14-day fast, and their resting metabolic rates decreased 31%, which is typical of a 'fasting response.' However, metabolic depression did not occur during the 28-day food restriction trials, despite the loss of 0.30% of body mass per day. This difference in response suggests that under-nutrition caused by reduced food intake may stimulate a 'hunger response', which in turn might lead to increased foraging effort. The progressive changes in metabolism they observed during the fasts were related to, but were not directly caused by, changes in body mass from control levels. Combining these results with data collected from experiments when Steller sea lions were losing mass on low energy squid and pollock diets reveals a strong relationship between relative changes in body mass and relative changes in resting metabolism across experimental conditions. While metabolic depression caused by fasting or consuming large amounts of low energy food reduced the direct costs from resting metabolism, it was insufficient to completely overcome the incurred energy deficit.

Rosen, D.A.S. and A.W. Trites. 2002. Cost of transport in Steller sea lions, *Eumetopias jubatus*. Marine Mammal Science 18(2):513-524.

This study measured the oxygen consumption of three juvenile SSLs swimming in a flume tank at velocities up to 2.2 m/ second. Minimum measured cost of transport ranged from 3.5-5.3 J kg/ m, and was reached at swimming speeds of 1.7-2.1 m/ second. These cost-of-transport values are higher than those reported for other marine mammals. However, once differences in stationary metabolic rate were accounted for, the locomotor costs for the SSLs were commensurate with those of other marine mammals. Locomotor costs appeared to be directly proportional to body mass. The authors propose that these estimates for the cost of locomotion can be incorporated into bioenergetic models and used to determine the energetic consequences of observed swimming behavior in wild marine mammals.

Rosen, D.A.S. and A.W. Trites. 2003. No evidence for bioenergetic interaction between digestion and thermoregulation in Steller sea lions, *Eumetopias jubatus*. Physiological and Biochemical Zoology. 76:899-906.

The increase in metabolism during digestion—the heat increment of feeding—is often regarded as an energetic waste product. However, it has been suggested that this energy could offset thermoregulatory costs in cold environments. The authors investigated this possibility by measuring the rate of oxygen consumption of four captive juvenile SSLs before and after they ingested a meal in water temperatures of 2– 8^{o} C. Rates of oxygen consumption of fasted and fed animals increased in parallel with decreasing water temperature, such that the apparent heat increment of feeding did not change with water temperature. These results suggest that SSLs did not use the heat released during digestion to offset thermoregulatory costs.

Rosen, D.A.S. and A.W. Trites. 2004. Satiation and compensation for short-term changes in food quality and availability in young Steller sea lions (*Eumetopias jubatus*). Canadian Journal of Zoology 82:1061-1069.

The authors tested the ability of SSLs to compensate for short-term changes in prey energy density and availability, and quantified the maximum amount of food a young sea lion could consume. Five 1–2-year-old captive Steller sea lions were offered either herring (high energy) or capelin (low energy) each day or every second day. When prey were available on a daily basis, the sea lions compensated for differences in the energy content of herring and capelin by consuming sufficient quantities of each (8.3 vs. 14.0 kg/day, respectively) to maintain equivalent gross energy intakes. When herring was available only on alternate days, the sea lions increased their consumption by 52% to 11.5 kg/day, which was not sufficient to maintain an average gross intake equal to that maintained when herring was available every day. When capelin was available only on alternate days, some animals increased their intake for a few days, but average intake (15.2 kg/day) was far below levels observed during daily feeding. Generally, the sea lions appeared to reach their digestive limit at a level equivalent to 14%–16% of their body mass. These findings suggested that SSLs can alter their food intake in response to short-term changes in prey quality or availability, but that these variables can quickly combine to necessitate food intake levels that exceed the physiological digestive capacities of young animals.

Rosen, D. A. S. and Trites, A. W. 2005. Examining the potential for nutritional stress in young Steller sea lions: physiological effects of prey composition. Journal of Comparative Physiology B 175: 265-273.

This is a study in the continuation of those by the authors to assess the effect of diet on SSL physiology. Here they examined the effects of high and low-lipid prey on body mass, body condition, and metabolic rates of captive juvenile SSLs. Results of three feeding experiments suggested that prey lipid content did not significantly affect body mass or relative body condition when the animals could consume sufficient prey to meet their energy demands.

When energy intake was insufficient to meet daily requirements, they lost more lipid mass consuming low-lipid prey compared with eating high-lipid prey. They also lost lipid mass while consuming oil-supplemented pollock at maintenance energy levels but gained mass while consuming identical energetic levels of herring. The results suggested that prey composition can have additional effects on sea lion energy stores beyond direct effects of insufficient energy intake.

Rosen, D.A.S., L. Williams, and A.W. Trites. 2000. Effect of ration size and meal frequency on digestive and assimilation efficiency in yearling Steller sea lions, *Eumetopias jubatus*. Aquatic Mammals 26:76-82.

The authors measured assimilation and digestive efficiencies in four juvenile SSLs fed three ration sizes of herring (3%, 6%, or 9% of body mass) at three frequencies (2, 3, or 4 times daily). Assimilation efficiency (dry matter digestive efficiency) was about 90% and digestive efficiency (efficiency of energy digestion) was about 95.5%. There was a strong linear relationship between digestive and assimilation efficiency, but no significant differences in either assimilation or digestive efficiency with changes in feeding frequency or changes in daily food intake within the ranges offered. This study found that Steller sea lions exhibit digestive and assimilation efficiencies typical of most carnivorous mammals. This high level of efficiency did not seem to be affected by either the frequency or size of meals within the range offered.

Rosen, D.A.S., A.J. Winship, R.L. Barrick, C.A. Nordstrom, D.J. Tollit, and A.W. Trites. 2003. Limitations to food intake and potential physiological consequences. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK

This abstract discusses two completed experiments by the authors on captive SSLs. One set of experiments examined the effect of short-term high-fat (herring) and low-fat (Atka mackerel) sub-maintenance diets on the health and condition of 2 juvenile females. For isocaloric diets, rates of body mass loss were equal for the two diets. However, the animals lost a greater proportion of mass from lipid reserves when they were on a low-fat diet. Some blood parameters also changed that may be useful as biomarkers in the field. In another experiment they investigated the maximum ingestion capacity of young sea lions and compared actual ingestion rates with those predicted from bioenergetic models. Four juveniles consumed more capelin (~15% body mass) than herring (~9% body mass) when they were given unrestricted assess to food; different proportions and capacities were reported under differing diets. They suggest that younger sea lions may have difficulty consuming sufficient quantities of lower energy prey, particularly when prey is not available on a daily basis (see abstract above).

Rosen, DAS, A.J. Winship, and L. Hoopes. In press. Thermal and digestive constraints to foraging in marine mammals. Special proceedings publication Environmental Constraints upon the Locomotion and Energetics of Aquatic Organisms. Springer-Verlag.

Not able to locate or read this paper for this synopsis.

Soto, K., A.W. Trites, and M. Arias-Schreiber. 2004. The effects of prey availability on pup mortality and the timing of birth of South American sea lions *(Otaria flavescens*) in Peru. Journal of Zoology London 264: 419-428.

This is a study dealing with another sea lion species but has relevance since it investigates the effect of prey deprivation on population dynamics. Pup mortality and the timing of birth of South American sea lions *Otaria flavescens* were investigated to determine the possible relationship between fluctuations in prey availability in the Peruvian up-welling ecosystem and current and future reproductive success of sea lions during six consecutive breeding seasons. The study from 1997 to 2002 encompassed the strongest El Niño on record and one La Niña event. Pup mortality ranged from 13% before El Niño to 100% during El Niño, and was negatively correlated with prey availability. Abortions were also more frequent when prey availability was low. However, pup mortality remained high following El Niño due to the punctuated short-term effects it had on population dynamics and subsequent maternal behavior. Births occurred later in the season after years of low food availability and earlier following years of high food availability. The peak of pupping occurred around the peak of mortality in all years, and may have been the product of intensive competition between bulls at the peak of the breeding season. The stronger and more frequent El Niños that appear to be occurring along the Peruvian coast may produce significant stochastic changes in future births and pup mortality, which may place the vulnerable South American sea lion population in Peru at greater risk.

Soto, K., A.W. Trites, and M. Arias-Schreiber. In press. Changes in diet and maternal attendance of South American sea lions indicate changes in the marine environment and the abundance of prey. Marine Ecology Progress Series 0: 000-000.

As above, this study pertains to another sea lion species but has relevance to SSL by the effect of food deprivation on behavior. Behavioral observations were made of South American sea lions (*Otaria flavescens*) in Peru to determine whether changes in their diet and maternal attendance patterns reflected physical changes in the marine environment and alterations in the abundance and distribution of prey. The study was undertaken during breeding seasons (1998-2002) that encompassed a strong El Niño (1997-1998) and a moderate La Niña (1999- 2001). Observations revealed strong linkages between maternal attendance patterns and the abundance of prey and oceanographic features close to the rookeries. Acute prey shortage during El Niño resulted in females increasing the length of their foraging trips and decreasing the time they spent onshore with their pups. In contrast, shorter times at sea and longer times onshore were observed during the favorable conditions of La Niña when their preferred prey (anchovy and squat lobster) were more abundant near the rookeries. Pup mortalities increased when females spent more time at sea searching for prey and did not return frequently enough to nurse their pups. Greater numbers of species (particularly demersal fishes) were consumed during El Niño when anchovy and lobster were less available. Females appeared to adjust their diets and maternal attendance patterns in response to annual changes in the abundance and distribution of their prey. These observations suggest that diet and maternal responses reflect inter-annual fluctuations of the unpredictable Peruvian up-welling ecosystem, and imply that South American sea lions may be good indicators of relative changes in the distribution and abundance of marine resources.

Testa, J.W., and J.M. Burns. 2005. Optimal foraging predictions of an index to patch quality applied to juvenile Steller sea lions in Prince William Sound. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

The authors report their use of the Index to Patch Quality (IPQ) as it relates to SSL transit, foraging and recovery times of a dive cycle to the variation in the expected net energetic gain obtained while foraging at the bottom of the dive. They used 17 SSLs in Prince William Sound equipped with satellite dive recorders in 2003-2005. Results were consistent with their predictions that IPQ would decline during dive bouts due to prey depletion and dispersion caused by foraging in a prey patch, and that there would be seasonal shifts in IPQ reflecting the changing depth distributions and behavior of target species.

Testa, J.W., and J.M. Burns. 2006. Optimal foraging predictions of an index to patch quality applied to juvenile Steller sea lions in Prince William Sound. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hotel, Anchorage, AK.

Same as in Testa and Burns (2005) above.

Thomas, G.L., and R.E. Thorne. 2003. Density and accessibility as factors in the foraging behavior of Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

These authors examined prey depth, school density, overall abundance, location and time of year as potential factors in SSL foraging behavior to understand why they targeted herring rather than pollock during winter in Prince William Sound. They found that the number of SSLs associated with herring concentrations was positively correlated with herring abundance and negatively correlated with depth of peak school density. Highest numbers of SSLs were associated with more near-surface conditions. Juvenile pollock were distributed slightly deeper than herring during night and considerably deeper during day. They conclude that accessibility is a crucial factor in SSL foraging behavior, and that the energetics of capture is probably at least as important as the caloric value of the prey.

Thomas, G.L., and R. E. Thorne. 2004. Implications of the Prince William Sound herring population crash: Did it impact Steller sea lions? Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors report declines in herring biomass in Prince William Sound concomitant with declining SSL abundance at nearby rookeries and haulout sites. Over the period 1989-2000 herring stocks declined by 88% and nearby SSL numbers dropped by a similar order of magnitude. Both SSL counts and herring biomass in PWS have increased since 2000 suggesting an abundance-dependent foraging behavior.

Thompson, D., J. Matthiopoulos, and I. L. Boyd . 2004. Effects of water temperature on swimming metabolic rates and foraging efficiency in sea lions. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

These authors discuss a model they developed incorporating water temperature on swimming metabolic rates (SMR) and foraging efficiency. They state that mass specific differences in SMR may lead to different foraging efficiencies and influence profitability of different prey distributions for different SSL size classes. They used a simple model of swimming incorporating the mechanical costs of overcoming drag and incorporating passive and forced convection heat loss to reconcile disparate experimental data relating swim speed to metabolic rate. They showed that apparent differences can be accounted for by differences in water temperature and that simple equations can predict metabolic rates over a wide range of SSL body masses and water temperatures. At low temperatures mass specific MR scales at mass to the 0.67 power which holds over a wide range of swim speeds. They also showed that the almost linear MR swim speed curve suggests that there is no achievable minimum cost of transport speed. Last, recently weaned SSL pups may be unable to meet their metabolic requirements in prey densities that adults can exploit effectively.

Thompson, D., J. Matthiopoulos, and I.L. Boyd. 2005. Effects of water temperature on swimming metabolic rate and foraging efficiency in sea lions. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Same information as in Thompson et al. (2004) above.

Thompson, D., J. Matthiopoulos, C. Letteri, and I. Boyd. 2003. Implications of varying food distribution for fitness in Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

The authors describe in general terms their models relating mass specific energetic costs to diving and foraging behavior. The information is part of a large report presented above by Matthiopoulos et al. (2005)

Thorne, R.E. and G.L. Thomas 2002. Evaluation of changes in the foraging behavior of Steller sea lions in response to precipitous declines of the herring population in Prince William Sound. Final Report to NMFS, SSLRI Project # 31, 32p.

This final report was not seen but interim reports by the authors available on the web dated 2001 and 2002 provide sufficient information to believe that the final report is similar to the interim report. The data and information in these interim reports are the same as those in the presentations above by Thomas and Thorne and the presentations below by Thorne and Thomas (2003) and Thorne et al. (2003). Published versions of this study can be found in Thorne and Thomas (2001) in the Foraging—Searching For Prey theme.

Thorne, R. E., G. L. Thomas and J, J. Goering. 2002. Interactions among Steller sea lions, pollock and herring and an examination of variability associated with acoustic surveys of pollock. Final Project Report to the Pollock Conservation Cooperative, University of Alaska, Fairbanks, Prince William Sound Science Center, Cordova, AK. 18 p.

The authors report finding Steller sea lions coincident with and actively foraging upon all major herring concentrations in Prince William Sound. They report no similar interactions with pollock despite extensive aerial survey and intensive, day and night boat surveys that included the use of infrared scanners. Further, they report that the population of Steller sea lions has varied in near direct proportion to the changes in abundance of herring in Prince William Sound..

Thorne, R.E., and G.L. Thomas. 2003. Spatial and numerical relationships between Steller sea lions and Pacific herring in Prince William Sound, Alaska. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

The abstract describes a 12-week acoustic survey with associated midwater and purse-seine sampling of fish stocks, and 14 aerial and vessel censuses of SSLs in Prince William Sound. They found nearly 100% spatial coincidence of SSLs with over-wintering herring concentrations, and 0% spatial coincidence with over-winter pollock. SSLs began targeting herring in November. They conclude that the availability of energetically efficient over-winter forage is a critical factor governing the abundance of SSLs in PWS.

Thorne, R.E., G.L. Thomas, and M. Foster. 2003. Associations between Steller sea lions and Pacific herring around Kodiak. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK

A general overview of surveys conducted in the northwestern quarter of Kodiak Island during 2002. Casual observations of SSLs and examination of spatial associations between SSLs and over-winter herring concentrations were reported.

Trites, A.W., D.G. Calkins, and A.J. Winship. 2003. Diet and the decline of Steller sea lions in Alaska. P. 165, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p

This abstract reports a study testing the hypothesis that SSL populations consuming a diet of low diversity experience high rates of decline by examining scat from Southeast Alaska where the population was stable or increasing. They collected and examined 1565 scat from 1993-1999 and the most common prey of 61 species was pollock, Pacific herring, sandlance, salmon, and other prey. They describe the dominant prey by season and sex. They report that the highest diversity of consumption was during summer and the least during fall. The summer diet was more diverse than any reported for the Gulf of Alaska and Aleutian Islands and was consistent with the relationship of diversity and population trend.

Trites, A.W. and C.P. Donnelly. 2003. The decline of Steller sea lions in Alaska: a review of the nutritional stress hypothesis. Mammal Review 33: 3-28.

The authors review available information pertaining to the nutritional stress hypothesis. Their abstract states that the decline of Steller sea lions in the Gulf of Alaska and Aleutian Islands between the late 1970s and 1990s may have been related to reduced availability of suitable prey. Many studies have shown that pinnipeds and other mammals suffering from nutritional stress typically exhibit reduced body size, reduced productivity, high mortality of pups and juveniles, altered blood chemistry and specific behavioral modifications. Morphometric measurements of Steller sea lions through the 1970s and 1980s in Alaska indicate reduced body size. Reduced numbers of pups born and an apparent increase in juvenile mortality rates also appear to be nutritionally based. Blood chemistry analyses have further shown that Steller sea lions in the Gulf of Alaska and Aleutian Islands area exhibited signs of an acute phase reaction, or immune reaction, in response to unidentified physical and/or environmental stress. Behavioral studies during the 1990s have not noted any changes that are indicative of an overall shortage in the quantity of prey available to lactating female sea lions. The data collected in Alaska are consistent with the hypothesis that Steller sea lions in the declining regions were nutritionally compromised because of the relative quality of prey available to them (chronic nutritional stress), rather than because of the overall quantity of fish per se (acute nutritional stress). This is further supported by captive studies that indicate the overall quality of prey that has been available to Steller sea lions in the declining population could compromise the health of Steller sea lions and hinder their recovery.

Winship, A. J. 2000. Growth and bioenergetic models for Steller sea lions (*Eumetopias jubatus*) in Alaska. M.S. Thesis, University of British Columbia. 160 p.

The goal of this graduate study was to develop a bioenergetic model to predict the food requirements of SSLs. Growth models were constructed using morphometric measurements of males (> 1 year old), females (> 1 year old), and pregnant females with a fetus that had been shot on rookeries, haulouts, and in the coastal waters of southeastern Alaska, the Gulf of Alaska and along the Bering Sea ice edge between 1976 and 1989. A Richards model best described age related growth in body length and mass. Males grew (in length) over a longer period than females and exhibited a growth spurt in mass which coincided with sexual maturity. Sexual dimorphism in both body length and mass was significant by 3 years of age. A bioenergetic model was used to estimate the food requirements of the Alaskan SSL population in the 1990's and to examine how these food requirements varied seasonally and spatially. Input included age/sex-specific energy requirements, population size/composition, and diet composition/energy content by date and region of Alaska. Error in model predictions was calculated using uncertainty in parameter values and Monte Carlo simulation methods. Food requirements were generally lowest in the summer and highest in the winter and spring mainly due to changes in activity budgets and the energy content of the diet. The mean daily food requirement of pregnant females was only marginally greater than the mean daily food requirement of non-pregnant females of the same age, but the mean daily food requirement of females nursing pups was about 70% greater than females of the same age without pups. Per capita population food requirements differed by up to 12% among regions of Alaska due to differences in the energy content of the diet. Steller sea lion predation was small relative to total walleye pollock natural mortality, but accounted for a large part of total Atka mackerel natural mortality. Of the bioenergetic, population, and diet parameters, uncertainty in bioenergetic parameters resulted in the largest error in model predictions. The model provided both a quantitative estimate of the Alaskan Steller sea lion population's food requirements and direction for future research.

Winship, A.J., A.M.J. Hunter, D. A.S. Rosen, and A. W. Trites. 2004. Food consumption of sea lions: Data gaps and direction for future research. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This is the same information as in Winship et al. (in press) below.

Winship, A.J., A.M.J. Hunter, D.A.S. Rosen, and A.W. Trites. In press. Food consumption by sea lions: existing data and techniques. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

This is the published version of the presentation above. The authors reviewed data on the quantity of food consumed by sea lions in captivity, and examined how consumption varied by species, body size, and season. They also reviewed and quantified available information on the energetics of sea lions and assessed the potential application of these data to parameterize an existing bioenergetic model that was developed to estimate the food requirements of SSLs. The paper includes two tables and five figures showing summary data and relationships of such data amongst sea lions. This study provided ranges of estimates of food consumption for sea lions that can be used in various modeling strategies to assess the impact of sea lions on prey populations, including commercially exploited fish species. This modeling exercise identified the major uncertainties involved in estimating the food requirements of each sea lion species using an energetics approach.

Winship, A.J, and A.W. Trites. 2003. Prey consumption of Steller sea lions (*Eumetopias jubatus*) off Alaska: how much prey do they require? Fishery Bulletin 101:147-167.

This is the journal publication of Winship's Master's thesis. Here the authors present the core of the bioenergetics model. An abbreviated form of the abstract follows. The effects of seasonal and regional differences in diet composition on the food requirements of SSLs were estimated by using a bioenergetic model. The model considered differences in the energy density of the prey, and differences in digestive efficiency and the heat increment of feeding of different diets. The model predicted that SSLs in Southeast Alaska required 45–60% more food per day in early spring (March) than after the breeding season in late summer (August) because of seasonal changes in the energy density of the diets (along with seasonal changes in energy requirements). The southeast Alaska population, at ~23,000 animals (all ages), consumed an estimated 140,000 t of prey in 1998. In contrast, they estimated that the ~51,000 animals making up the western Alaska population in the Gulf of Alaska and Aleutian Islands consumed just over twice this amount (~303,000 t). In terms of biomass removed in 1998 from Alaskan waters, the authors estimated that SSALs accounted for about 5% of the natural mortality of gadids (pollock and cod) and up to 75% of the natural mortality of hexagrammids (adult Atka mackerel). These two groups of species were consumed in higher amounts than any other. The predicted average daily food requirement per individual ranged from ~16 to ~20 kg (all ages combined). Per capita food requirements differed by as much as 24% between regions of Alaska depending on the relative amounts of low–energy-density prey (e.g., gadids) versus high–energy density prey (e.g. forage fish and salmon) consumed. Estimated requirements were highest in regions where SSLs consumed higher proportions of low–energy-density prey and experienced the highest rates of population decline.

Winship, A., A.W. Trites, and D. Rosen. 2001. Towards a dynamic bioenergetic model for the Steller sea lion (*Eumetopias jubatus*). P. 235, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Similar information as in Winship (2000) above and Winship et al. (2002) below.

Winship, A.J, A.W. Trites, and D.A.S. Rosen. 2002. A bioenergetic model for estimating the food requirements of Steller sea lions (*Eumetopias jubatus*) in Alaska, USA. Marine Ecology Progress Series 229:291-312.

Similar to Winship and Trites (2003) above, these authors developed a generalized bioenergetic model to estimate the food requirements of SSLs in Alaska. Inputs included age- and sex-specific energy requirements by date, population size and composition, and diet composition and energy content. Error in model predictions was calculated using uncertainty in parameter values and Monte Carlo simulation methods. Their model suggested that energy requirements of individuals were generally lowest in the summer breeding season (June to August) and highest in the winter (December to February) and spring (March to May) mainly due to changes in activity budgets. Predicted relative daily food requirements were highest for young animals (12 ± 3% SD and 13 ± 3% of body mass for 1 year old males and females respectively) and decreased with age (5 ± 1% and 6 ± 1% of body mass for 14 year old males and 22 year old females respectively). The mean daily food requirement of pregnant females predicted by the model was only marginally greater than the predicted mean daily food requirement of non-pregnant females of the same age. However, the model suggested that the mean daily food requirement of females nursing pups was about 70% greater than females of the same age without pups. Of the 3 sets of model parameters (diet, population, and bioenergetic), uncertainty in diet and bioenergetic parameters resulted in the largest variation in model predictions. The model provides a quantitative estimate of the SSL population's food requirements and also suggests directions for future research.

Wynne, K.M., R. J. Foy, B. Knoth, and C. L. Buck. 2004. Are Steller sea lions prey-limited? Ask their neighbors! Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

These authors summarize diet data for SSLs, arrowtooth flounder, black-legged kittiwakes, harbor seals, and commercial fishermen in the Kodiak area. They also summarized the trends in population abundance or condition of these consumers whose diets overlap with SSLs. They then use these findings to discuss the likelihood that prey availability or quality was limiting recovery of SSLs near Kodiak. No conclusions or data were provided.

THEME 3: VITAL RATES

There are 23 journal articles, 13 technical reports, 7 theses, 11 book articles, 8 contract reports, 10 manuscript reports, and 84 symposia presentations, abstracts and posters represented in this section.

SUMMARY

Abundance and Population Trends: After declining dramatically during the mid-1980s, the decline in the western stock of Steller sea lions persisted in the 1990s at a somewhat slower rate of 4-5% y^{-1} depending on the trend site index used (Fritz and Stinchcomb, 2005). Despite the modest abatement from the rate of decline experienced in the 1980s, there was considerable uncertainty about the projected trends in abundance. Surveys conducted since 2000 (Sease et al., 2001;Sease and Gudmundson, 2002; and, Sease and Stinchcomb, 2003) have shown an increase in abundance for the western stock. The estimated rate of population change for the western stock since 2000 is an increase of 2.6-3.7% y^{-1}. Despite the reversal in the direction of the rate of change, minimum estimated population size has not changed substantially: 34,600 animals in 2000 (Anglis and Lodge, 2001) and 34,799 in 2002 (Anglis and Lodge, 2004) . Meanwhile, the eastern stock continues its growth at 2.5-3% per year, with a stock wide (SE Alaska, British Columbia and Washington-Oregon-California) minimum population size estimate of 31,028 animals (Angliss and Lodge, 2004). Pitcher et al (2003) report that the eastern population numbers over 40,000 animals and represents 55% of the North American population of Steller sea lions.

In addition to the survey estimates for the eastern and western stocks, considerable information has been gathered on the trends and abundance of Steller sea lion stocks in the Russian Far East (Burkanov 2000, 2006; Burkanov, Calkins and Loughlin 2003b, 2004, 2005; Cupakhina et al., 2004; Kuzin, 2002; Permyakov and Burkanov, 2004a, 2004b; Purtov and Burkanov, 2005; Vzhenia, 2004; Zadalskiy, 2002; and Zagrebin and Litovka, 2004). Steller sea lions in this area experienced sharp declines from the early 1900s to the 1990s dropping from 115,000 animals to 15,000; much of the population loss is due to anthropogenic causes with natural causes a lesser component (Burkanov and Loughlin, 2004). A portion of the losses can be attributed to active hunting pressure to mitigate sea lion damage to fishing gear. Calkins (2000) reports official Japanese estimates of 4,600 sea lions killed by sanctioned hunting around Hokkaido between 1977 and 1996 but he also notes independent Japanese scientist estimates that as many as 22,725 sea lions may have been killed. All these deaths are animals that presumptively stem from Kuril Islands stock.

Movement: The western stock of Steller sea lions is considered a metapopulation, i.e., one made up of multiple regional aggregations that maintain a level of independence one from the other. Movement between and among rookeries can mitigate and/or explain increases or decreases in local abundance; however, rates of migration are not well measured. There are some contradictory indicators of the extent of movement, for example, analysis of mtDNA dispersion rates (maternally transmitted genetic markers) suggest that the eastern Steller sea lion rookeries are genetically connected while the western population rookeries are essentially isolated (O'Corry Crowe et al., 2003 and Taylor et al., 2003). By contrast, branding studies indicate that 33% of western stock females pup at non-natal rookeries while 19% do so in the eastern stock (Raum-Suryan et al., 2002). Higher rates of site fidelity for eastern stock females would be more consistent with rookery isolation than connectivity and vise versa for the western stock. Branding studies in the Russian Far East have noted similar rates of site fidelity for females pupping there. Fourteen percent of branded animals pupping at Raykoke Island (Kuril Islands) in 2001 were of non-natal origin (Trukhim and Burkanov, 2002); while the proportion was 37% for sea lions pupping at Antsiferov Island (Kuril Islands) in 2003.

Survival Rates: Three papers provide new information on survival rates (Hastings and Gellat, 2004; Kaplan, 2005; and Pendleton et al., in review). The first two deal with neo-natal survival. Kaplan estimates pup survival during the first 3 weeks of life from observations at two sites on Lowrie Island (SE Alaska) in 2002-2003. Kaplan's two sites had dramatically different survival rates 0.588 and 0.967. Hastings and Gellat estimated Lowrie Island pup survival during the first 3 months of life in 2001 and 2002; their estimated survival rate for the 3 m period was 0.88 and 0.77. The estimated daily survival rate was 0.955 for the first 14 d and 0.985 thereafter. Pendleton et al. provide a comprehensive analysis of brand resighting data in SE Alaska. They use the Cormak-Jolly-Seber mark/recapture model to estimate survival rates for sea lions at Forrester (eastern stock) and Marmot (western stock) Islands. Survival rates differed by sex at Forrester Island with estimated cumulative survival rates to age 9 of 0.123 for males, and 0.284 for females. At Marmot Island the cumulative survival rate to age 9 was 0.094 for both males and females. The lower overall survival estimates at Marrmot Island appear to reflect a higher age-specific rate of loss for ages 1-4 compared to Forrester Island.

Birth Rates: The proportion of sea lions giving birth in the Russian Far East was monitored from 2002-2004 at 5 major rookeries (Burkanov and Calkins, 2005). Branded animals of known age were observed and the fraction at each age giving birth was noted. Observations were recorded for 646 branded and tagged female sea lions age 1-15 years. No females less than 4 y of age produced pups. The birth rate was low for 4 y olds only 2.9% producing pups. Birth rates for 5-15 year old females appear to vary substantially. For 41 females (age 5-15) resighted in each of the 3 years of this study 3 (7.3%) did not pup in any year, 5 (12.2%) pupped in one year only, 19 (46.3%) pupped two out of three years and 14 (34.1%) pupped in all three years.

Chiswell Island (Central Gulf of Alaska) is home to a small rookery. The rookery is monitored by video camera. (Maniscalco et al., 2005c). Birth rates were estimated from video observations conducted between 2001 and 2004. Mean birth-rate (proportion with pups) for females with at least a two-year history on the island was 82.5% (Maniscalco et al., 2005b). Females had a lower expectation of pupping following years of early pup loss or years where no pup was born. Early pup mortality (first 2 months) ranged from 20.8% to 22.2% from 2001-2003, and then dropped dramatically in 2004 to 3.8%. Killer whale predation and loss due to storm surge accounted for a large fraction of mortality in 2001 and 2002. Marcotte and Trites (2004) report an increased incidence of biennial weaning among branded sea lions observed in an intensive 12 m study in SE Alaska. Sea lions nursing a pup into its second year are not reproductively active while nursing (Pitcher et al., 2004); thus prolonged nursing would lower the effect reproductive rate of the population.

Models: Models were constructed to look at population trends and/or project population viability; to simulate population declines and evaluate alternative hypotheses for those declines; and to estimate survival and growth. There are two population viability models (Gerber and VanBlaricom, 2001; and Winship and Trites, 2006). Gerber and VanBlaricom estimate the number of years to extinction and contrast their own model estimates with others completed by York et al. (1996). They estimate a higher likelihood of extinction than York et al. but note considerable variability among models. Winship and Trites estimate a low probability of extinction. They note that the probability declines further if the populations adapt density dependent compensations to lowered carrying capacity. Eberhart et al. (2005) estimate current trends in abundance of the western population within 6 geographic regions. They project mixed results with population increases in one area, equilibrium or static populations in others, and two areas that continue to show declines.

A number of researchers use their models to evaluate alternative hypotheses to explain the Steller sea lion decline (Fay, 2004; Holmes and York, 2003; Malavear, 2002; Punt and Fay 2002 and 2003; and Wolfe and Mangel, 2005). Typically, they are attempting to distinguish whether population decline was caused by a change in survival rate, pregnancy rate or both. The outcomes are mostly familiar; population decline is explained by a decrease in juvenile survival with and without simultaneous decreases in reproductive rate. Multiple modelers identify distinct periods of transitioning survival rates; but Holmes and York are more emphatic with their results: survival was estimated to be low in the 1980s with adult fecundity dropping in the 1990s. Wolfe and Mangel believe that there is strong evidence that acute nutritional stress effects fecundity and chronic nutritional stress impacts recruitment. In almost all cases the model outcomes are highly conditioned on the imbedded assumptions, and considerable uncertainty remains prevalent.

ANNOTATED BIBLIOGRAPHY – VITAL RATES

Altukhov, A.V., and V.N. Burkanov. 2005. Spatial distribution of Steller sea lions (*Eumetopias jubatus*) males on a non-reproductive section of rookery. In 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

> In this abstract, the author describes behavioral differences among age specific groupings of male Steller sea lions on a non-breeding section of a rookery. Adult males, 8 years and older, i.e., bulls, tended to lay together in groups with a small fraction (5%) lying alone. A greater fraction (25%) of males 6-7 years of age lay alone, and males 4-5 years of age were always in groups of the same age class. Once females arrived on the rookery, younger males continued to interact with like age males; 6-7 year old males showed more interaction with females, expressing territorial behavior in their presence. Adult bulls exhibited territorial behavior independent of the female's presence.

Altukhov, A.V., and V.N. Burkanov. 2004. Seasonal changes in Steller sea lion (Eumetopias jubatus) population on Dolgaya Rock Island, Lovushki Island. Pages 25-26 , in Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

> This abstract provides a description of the 2001 and 2002 sequential changes in Steller sea lion abundance on Dolgaya Rock Island, a rookery with apparent high densities of sea lions. The number of hauled out animals on the island increased between May 20 until June 17 when it peaked. In this interval the number of territorial males doubled (from 73-148). Within 10 days of the peak count, the number of territorial males began to decline. At peak population densities, 77% of territorial males were with females. Active pupping occurred between May 30 and June 25th. Peak female count was 576, peak pup count 416 for a pup/female ratio of 0.72. The authors attribute the high ratio of harem bulls with females to the restricted breeding area and high density of animals on this rookery.

Andrews, R.D. 2004. The population decline of Steller sea lions: testing the nutritional stress hypothesis. Pages133-146, in, M. Gordon and S. Bartol (eds.), Experimental approaches to conservation biology, University of California Press, Berkeley, CA.

> In this paper the author reviews the hypotheses used to explain the decline in the western population of Steller sea lions, and goes into greater detail to examine the arguments for and against the nutritional stress hypothesis. With respect to vital rates, there is a brief review of sea lion life history including an interpretation of evidence for changes in pregnancy rates associated with the decline (i.e., the observation of Pitcher et al., 1998[2] that pregnancy rates dropped from 67% in the 1970s to 55% in 1980s). Ultimately, the author points out that the pregnancy rates are not significantly different. [This paper is probably more relevant to Life History and/or Foraging, than it is to Vital Rates].

Angliss, R. P., Lopez, A., and D.P. DeMaster. 2001. Draft Alaska Marine Mammal Stock Assessments, 2001. National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115. p. 181.

> This technical report is written to comply with provisions of the Marine Mammal Protection Act (MMPA) and provides estimates of the minimum population size, population trends, maximum net productivity rates (R_{max}) and optimum sustainable population (OSP) levels for marine mammal populations in Alaskan waters. This report updates Steller sea lion population numbers as of 2000. The minimum population size of the western stock of Steller sea lions is estimated at 34,600 animals (25,277 non-pups; 9,373 pups). Non-pup counts are based on aerial surveys in 2000. Pup counts are based on surveys from 1998. Population trends are inferred from counts at index sites; counts from 1990-2000 were declining at a rate of approximately 5% per year. The maximum theoretical net productivity rate for the stock is 0.12 (or 12% per year). The western stock of Steller sea lions is listed as endangered. There is no indication of OSP levels for this stock. This report also provides estimates of total human induced mortality from incidental takes in fisheries, subsistence harvest and other sources. Estimates of total removals was 381 animals (28 by fisheries; 353 by subsistence), and exceeded the potential biological removal (PBR) allowance of 283 animals.
>
> The minimum population size for the eastern stock of Steller sea lions was estimated to be 31,005 animals based on combined 1996 counts from Washington, Oregon, California (WOC), the 1994 counts from British Columbia (BC) and the 1998 counts from Southeast Alaska (SEAK). The SEAK segment of the eastern population was increasing at approximately 1.4% per year, compared to 2.8% per year for the entire stock. The R_{max} value is the same for both stocks, 12%. Total human caused mortality was estimated at 46 animals and did not exceed the PBR of 1395 animals. The OSP level was listed as unknown.

Angliss, R. P., and K. L. Lodge. 2002. Alaska marine mammal stock assessments, 2002. U.S. Dep. Commer., NOAA Tech. Memo. NMFS -AFSC-133, 224 pp.

> This technical report is written to comply with provisions of the Marine Mammal Protection Act (MMPA) and provides estimates of the minimum population size, population trends, maximum net productivity rates (R_{max}) and optimum sustainable population (OSP) levels for

---

[2] Pitcher, K.W., D.G. Calkins, and G.W. Pendleton. 1998. Reproductive performances of female Steller sea lions from the Gulf of Alaska: Indications of nutritional stress? Can. J. Zool. 76: 2075-2083.

marine mammal populations in Alaskan waters. This report updates Steller sea lion population numbers as of 2000. The minimum population size of the western stock of Steller sea lions is estimated at 34,595 animals (25,384 non-pups; 9,211 pups). Non-pup counts are based on aerial surveys in 2000. Pup counts are based on surveys from 1998 (note these numbers are slightly different than reported in Anglis et al., 2001). Population trends are inferred from counts at index sites; counts from 1990-2002 were declining at a rate of approximately 5.0 % per year. The maximum theoretical net productivity rate for the stock is 0.12 (or 12% per year). The western stock of Steller sea lions is listed as endangered. There is no indication of OSP levels for this stock. This report also provides estimates of total human induced motality from incidental takes in fisheries, subsistence harvest and other sources. Estimates of total removals was 197 animals (29 by fisheries; 168 by subsistence), and do not exceeded the potential biological removal (PBR) allowance of 208 animals.

The minimum population size for the eastern stock of Steller sea lions was estimated to be 31,028 animals based on combined 1996 counts from Washington, Oregon, California (WOC), the 1994 counts from British Columbia (BC) and the 1998 counts from Southeast Alaska (SEAK). The SEAK segment of the eastern population was increasing at approximately 2.4% per year, compared to 2.8% per year for the entire stock. The R_{max} value is the same for both stocks, 12%. Total human caused mortality was estimated at 46 animals and did not exceed the PBR of 1396 animals. The OSP level was listed as unknown.

Angliss, R.P., and K.L. Lodge. 2004. Alaska marine mammal stock assessments, 2003. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-AFSC-144. 230 p.

This technical report is written to comply with provisions of the Marine Mammal Protection Act (MMPA) and provides estimates of the minimum population size, population trends, maximum net productivity rates (R_{max}) and optimum sustainable population (OSP) levels for marine mammal populations in Alaskan waters. This report updates Steller sea lion population numbers as of 2002. The minimum population size of the western stock of Steller sea lions is estimated at 34,779 animals (26,602 non-pups; 8,177 pups). Non-pup counts are based on aerial surveys in 2002. Pup counts are based on surveys from 2001 and 2002. Population trends are inferred from counts at index sites; counts from 1990-2000 were declining at rate of approximately 4.4 % per year. The maximum theoretical net productivity rate for the stock is 0.12 (or 12% per year). The western stock of Steller sea lions is listed as endangered. There is no indication of OSP levels for this stock. This report also provides estimates of total human induced mortality from incidental takes in fisheries, subsistence harvest and other sources. Estimates of total removals was 208 animals (32 by fisheries; 176 by subsistence), and do not exceeded the potential biological removal (PBR) allowance of 209 animals.

The minimum population size for the eastern stock of Steller sea lions was estimated to be 31,028 animals based on combined 1996 counts from Washington, Oregon, California (WOC), the 1994 counts from British Columbia (BC) and the 1998 counts from Southeast Alaska (SEAK) which is unchanged from Anglis and Lodge (2002). The SEAK segment of the eastern population was increasing at approximately 2.4% per year, compared to 2.8% per year for the entire stock. The R_{max} value is the same for both stocks, 12%. Total human caused mortality was estimated at 46 animals and did not exceed the PBR of 1396 animals. The OSP level was listed as unknown.

Ban, S., J. Porter, A. Trites and M. Foreman. 2001. Using Geographic Information Systems to Analyze and Predict Steller Sea Lion (Eumetopias jubatus) Haulouts and Rookeries. 2001. p. 15 In: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

In this abstract the authors describe the analysis of habitat features associated with the presence of Steller sea lions on haulouts and rookeries in British Columbia. Using a GIS approach, the British Columbia coast was stratified into a 500 sq m grid. Four variables were classed for each grid cell: average bathymetry, tidal speed, summer salinity, and Summer Sea surface temperature. The grid cells were also classed by distance from known Steller sea lion haulouts and rookeries. Logistic regression was used to predict presence and absence of sea lions. Apparently, correlation of habitat features and sea lion distribution was strongest for grid cells within 10 nm of the haulouts and rookeries. The authors suggest, sea lions were more attracted to habitats with higher tidal speed, higher salinity, lower sea surface temperatures and shallower water. With respect to vital rates, it is the reviewer's opinion that the abstract identifies a method that could lead to improved predictability of habitat utilization and perhaps more precise enumeration of Steller sea lion population size by attracting attention to locales that may otherwise be overlooked when surveying for abundance.

Brown, R. F., S. D. Riemer, and B. E. Wright. 2002. Population status and food habits of Steller sea lions in Oregon. Rep. from Oregon Dept. of Fish and Wildlife to Oregon State Univ. Contract F0225A-01. 17 pp.

Steller sea lion aerial surveys of rookery and haulout sites on the Oregon coast have been conducted for 25 years. This report provides information on surveys conducted in July 2000 and April 2001. Counts reported increased from 1,500 animals in the mid-1970s to ~4,000 animals in 1998, representing an estimated rate of increase of 3.7% y^{-1}. The 2001 abundance estimate was 3,648 adults and juveniles (non-pups).

Bryant, J., M. Riedel, and J. Fall. 2006. Community-based harvest monitoring of subsistence harvest of harbor seals and Steller sea lions. In Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

This poster describes an Alaska Native Harbor Seal Commission and Alaska Department of Fish and Game cooperative harbor seal and Steller sea lion subsistence monitoring program. Annual harvest data are collected through interviews with subsistence hunters. Collected data includes total number of animals harvested, sex and approximate age of harvested animals, and timing of the hunt. Harvesters are also asked to record their perception of the trend in abundance of harvested seals over the past 5-years. Data are available to the public.

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). Marine Mammals of the Holarctic Regions: Materials from international Conference, Archangelsk, Russia, 21-23 September, 2000. Archangelsk. Pages. 56-65. (in Russian).

The abstract of this paper is reprinted here: "The study analyses data from three large-scale Steller's sea lion surveys of 52 rookeries and Haulout sites in the Russian Far East in 1989, 1994(95) and 1999. The surveys were conducted during reproductive seasons from ships or boats, aircraft and from shore. The animals were grouped into two age categories: newborn

pups and animals 1 or more years old (1+). Considerable differences in population dynamics were observed in different areas and on different sites. During the ten years there was a decrease in abundance on non-reproductive haulouts, whereas on reproductive rookeries the number of animals increased, remained stable or fluctuated slightly. The total number of pups increased by 32% during the overall period of observations (i.e. increased at the rate of 3.2% per year). However pup numbers dynamics also varied by area and by year. The total Steller's sea lion population in Russian waters is currently estimated at 14.8 thousand."

Burkanov, V. N., D. Calkins, and T. R. Loughlin. 2003a. Steller sea lion survey in the western Bering Sea and the Kamchatka Peninsula in 2002. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

In this abstract the authors note steep declines in Steller sea lion abundance between 1999 and 2002 as recorded by a survey of 27 sites in the Western Bering Sea and Kamchatka Peninsula. Total population abundance was 1050 non-pups and 295 pups. Sea lion counts in sites of the Western Bering Sea dropped 93% between 1999 and 2002. Numbers dropped 31% in Eastern Kamchatka. In the Commander Islands numbers dropped only 6% since the prior survey in 1994.

Burkanov, V., D. Calkins, and T. Loughlin. 2003b. Steller sea lion survey in the western Bering Sea and the Kamchatka Peninsula in 2002, p. 26, in 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

This abstract repeats the information reported in Burkanov, Calkins and Loughlin, 2003a.

Burkanov, V., J. M. Maniscalco and E. G. Mamaev. 2001. Identification and Tracking of Individual Steller Sea Lions at Chiswell Island Rookery (Alaska) with the Use of a Remote Control Video System. p. 35 In: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

This abstract describes a method used to record individual Steller sea lion identification utilizing natural scars and injuries. Scars are reported to appear in the first 3-years of life and remain visible and essentially unaltered thereafter. The method has proven effective in identifying individuals for up to 7 years for males and 10 years for females. Researchers employed a remote control video camera at Chiswell, Island (GOA) to record and identify individual animals. They identified 50 mature animals in 2000 (33 males and 19 females) only 5 of these were observed at the same rookery a year earlier. Males were observed at the rookery (period between the first and last meeting) for 2-215 days (mean=64.6, SE=10); females for 2-104 days (mean=32.1, SE=8.2).

Burkanov, V.N. 2006. Steller sea lion and northern fur seal surveys in Kuril Islands (Russia), 2005. In Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

This poster describes results of a 2005 Steller sea lion survey conducted in the Kuril Islands. Counts were conducted between June and July, with pup counts July 4-July 10. Total counts were 5,725 non-pups, 2,366 pups. Non pup counts increased 7.1% from counts made in 2003, while pup counts increase 10.5%. The 5-year trends indicated a 3.5% y^{-1} increase in non-pups, and a 6.1% y^{-1} increase in pups. Five main rookeries accounted for 97.5% of all pups and 66% of the non-pups.

Burkanov, V.N., and D.G. Calkins. 2005. Breeding performance of marked Steller sea lion (*Eumetopias jubatus*) in Russian waters. In 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This abstract provides summaries of Steller sea lion birth rates observed on 5 major rookeries in the Russian Far East between 2002 and 2004. Observations were recorded for 646 branded and tagged female sea lions age 1-15 years. No females less than 4 y of age produced pups. The birth rate was low for 4 y olds only 2.9% producing pups. Birth rates for 5-15 year old females appear to vary substantially. For 41 females (age 5-15) resighted in each of the 3 years of this study 3 (7.3%) did not pup in any year, 5 (12.2%) pupped in one year only, 19 (46.3%) pupped two out of three years and 14 (34.1%) pupped in all three years.

Burkanov, V.N., and E.G. Mamaey. 2004. Effect of marking operations on pup survival at Medny Island (Russia), 1991-2001. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

In this poster, the authors report pup mortalities for 857 pups marked over an 11-year period, 1991-2001. More than a third of pups present were marked annually, pup mortality ranged from 3.6-13.3% (mean 6.7%). Tagging operations accounted for 0.4 to 4.4% of the annual mortality (mean 1.5%). Mortality from tagging operations was minimal when tagging occurred after June 25 (following pup/female bonding), and when pups were not overheated and stressed due to crowding.

Burkanov, V.N., and T.R. Loughlin. 2004. Historic distribution and abundance of Steller sea lion (Eumetopias jubatus) in the northwestern Pacific, 1700s-2000s. Pages 111-112, in Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

In this article, the authors describe the distribution and abundance of Steller sea lions along the Asian coast from the Bering Strait to the Korean Peninsula. The area is discussed in 5 regional classifications: Commander Islands, Kamchatka, Kuril Islands, Sea of Okhotsk, and Sakhalin Islands. Overall population abundance is estimated to have declined from 115,000 to 15,000 animals (drop of 87%) between 1890 and 1990. Regional differences were noted. Declines were not necessarily continuous, some areas experience increases during an otherwise extended period of decline. The authors attribute losses to human activities including: harvest and direct killing, interactions with fisheries, disturbance, and mortality due to military activities. The authors report that natural causes (disease or environmental effects) were a lesser source of loss.

Burkanov, V.N., and T.R. Loughlin. 2004. Historic changes in distribution and abundance of Steller sea lions in the western Pacific, 1700s–2002. Presented paper. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

See Burkanov and Loughlin (2004) Holarctic 3rd International Conference.

Burkanov, V.N., and T.R. Loughlin. In review. Historical distribution and abundance of Steller sea lions on the Asian coast. Marine Fisheries Review.

See Burkanov and Loughlin (2004) Holarctic 3rd International Conference.

Burkanov, V.N., D.G. Calkins, and T.R. Loughlin. 2005. Steller sea lion abundance in Russia in 2004. In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK.

This abstract describes results of a survey of Steller sea lion abundance conducted in Russian waters from June 13 to July 22, 2004. The survey visited 41 of 45 known haulouts and rookeries. Population numbers were up in all locales compared with surveys conducted in 2002. Non-pup counts increased from 11.1% to 750% between 2002 and 2004 depending on location. Pup counts increased 0-79.2% over the same interval. The largest increases occurred in the northern Sea of Okhotsk. Despite the recent increases, population numbers remain a fraction of the abundance observed in the 1980s.

Burkanov, V.N., T.R. Loughlin, , and D.G. Calkins. 2004. Unusual mortality of female Steller sea lions. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This abstract reports that the aggressive mating behavior of 2 territorial bulls on Lovushki Island (Kuril Islands) resulted in the deaths of 11 female Steller sea lions. Fatal wounds were apparently inflicted during copulation. Authors report that the females killed tended to be younger inexperienced sea lions. Older seasoned females tended to avoid the aggressive males.

Burkanov, V.N., U.B. Artukhin, P. Browne, A. Wada, D. Wate, M.U. Zasypkin, D. Calkins, I.A. Nevedomskaya, N.N. Pavlov, A.M. Trukhin, and H. Hoshino. 2002. Brief results of survey of Steller sea lion rookeries and haulouts in the waters of the Russian Far East in 2001. In Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

In this article the authors report on a 2002 Steller sea lion survey of the Russian Far East including southeast Kamchatka, Kuril Islands, and Iona Island. They visited 5 known sites in Kamchatka finding sea lions at only 1 locale; they surveyed 40 of 53 sites in the Kuril Islands, missing known haulouts but no rookeries. Finally, the surveyed the entirety of Iona Island. Greatest abundance was in the Kuril Islands with 5033 non-pups and 1898 pups. Counts at a Iona Island were 1509 non-pups and 952 pups. They saw only 119 non-pups in SE Kamchatka. [Annotator’s note-these counts don’t reconcile with the 2004 survey results reported above]

Calkins, D. G. 2000. Investigation of the intentional killing of Steller sea lions in Japan's commercial fisheries. Calkins Wildlife Consulting, 12600 Elmore Road, Anchorage, AK, 99516-2904, Revised by Bohan, January 2000, 71p.

The author provides an account of the number of Steller sea lion killed by hunters around Hokkaido, Japan. These sea lions are presumptively of Kuril Island stock origin. The time series of kill data presented extends from 1977 to 1996. Sea lion takes were recorded as 1) killed and recovered and 2) struck and lost. Official government records report 3,527 sea lions killed and recovered between 1977 and 1996 another 4,165 are reported struck and lost. The author speculates that this is an underestimate of actual deliberate mortality, citing independent Japanese scientist’s estimates of 22,725 sea lions killed between 1958 and 1993. Additional information is provided on restrictions imposed on hunters, or lack thereof.

Calkins, D.G., and S. Atkinson. 2005. Introduction. Chapter 1, pages 1-5, in Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

> This paper presents a very brief recount of historic trends in Steller sea lion abundance. It goes on to discuss funding and research priorities of the Alaska Sea Life Center over the period 2001-2004.

Campbell, G. S., R. C. Gisiner, D. A. Helweg, and L. L. Milette. 2002. Acoustic identification of female Steller sea lions (*Eumetopias jubatus*). Journal of the Acoustical Society of America 111(6):2920-2928.

> In this paper the authors describe a neural network that they employed to decipher acoustic data and identify unique female Steller sea lion call patterns. This work represents advancement in the recognition of individual sea lions improving upon prior efforts. Using their neural network, they achieved 100% recognition of individuals in a training data set and 71% accuracy for separation of individuals in novel data sets. Acoustic signal recognition could be used as a "marking tool". The authors speculate on applications which may allow evaluation of maternal care/energy transfer during the critical development stage of pups.

Catterson, N. and B. Lucey. 2002. Seasonal abundance of Steller sea lions at Dry Bay, Alaska. Unpublished Report, USDA Forest Service, Tongass National Forest, Yakutat Ranger District, May 2002, 7p.

> This paper contains a brief note regarding a 2002 aerial survey of a Steller sea lion haulout site. The haulout is located in Dry Bay at the mouth of the Alsek River. Sea lions congregate at this haulout concurrent with annual run of eulachon (*Thaleichthys pacificus*). The survey consisted of 4 flights conducted from March 20 to April 15. Peak counts were 1357 sea lions on March 29. By the end of April all sea lions have left the area.

Chelnokov, F.G. 2004. Marking and survival of Steller sea lion pups (*Eumetopias jubatus*) in Medny Island in 2002. Pages 573-575, in Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

> Eighty-five pups were corralled and branded on Medny Island July 2, 2002. Observations over the following 29 days revealed no apparent deaths as a result of branding. Marked pups were resighted more than 1200 times. Of the 85 marked pups, the maximum number resighted in any interval was 69, the minimum number was 35. Pups separated from their mothers during branding and driven more than 100m from their nursery site had re-established themselves with their mothers within two days.

Christen, D., K. Mashburn, and C. Stephens. 2003. Monitoring a male Steller sea lion into adulthood. P. 32, in 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p

> This abstract contains a brief note on reproductive age of male Steller sea lions. Males are capable of breeding at age 3, but not physically mature until age 10. Observations from a single captive male noted that the onset of puberty was associated with a dramatic increase in body mass over a seven month interval from December to June.

Coombs, A.P., and A.W. Trites. 2005. Steller sea lion haulouts: breeding locations for non-pregnant females? In 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

In this abstract the authors report that Steller sea lions are known to occupy 88 rookeries and 600 haulouts throughout their range. They report that 45% of the population does not return to rookeries during the summer. The authors observed breeding behavior by territorial bulls at two haulouts during summer. The behavior was exhibited 2 weeks earlier than the onset of breeding at rookeries. Females bred by bulls on these haulouts were "unencumbered" or nursing pups from the previous year. None of the pups born at the haulouts survived.

Cupakhina, T.I., O.I. Ponteleeva, and V.N. Burkanov. 2004. Distribution and abundance of Steller sea lion (*Eumetopias jubatus*) on haul out sites of Sakhalin Island. Pages 581-585, in Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

In addition to the rookery on Tuleny Island, only four Steller sea lion haulouts currently exist off the coasts of Sakhalin, where the animals are most abundant during late winter and spring. Animals of different age classes haul-out there, including adult males and females; however, no births were reported on either of the haulouts. The authors present a brief account of irregular observations of sea lion counts on these four haulouts between 1960 and 2004.

Curgus, C. S., D. McAllister, K. Raum-Suryan, K. Pitcher and W. Cunningham. 2001. Live-Capture Method for Steller Sea Lions Using SCUBA. p. 51 In: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

This brief abstract reports on the success of a SCUBA live capture technique used to secure juvenile Steller sea lions for marking and physiological studies. The authors report 179 seals, age 2 months to 5 years, had been captured and released with no apparent injuries or deaths.

Dunford, B., S. McKinley, R. Petrell, A.W. Trites, M. Yedlin, and R. Virtue. 2003. An implantable radio identification tag for Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

In this abstract the authors describe concepts for a small implantable radio tag that could have a battery life of 3 years. Such a tag would be monitored through receivers placed at haulouts and rookeries. No indication of any implementation trials.

Dunlap-Harding, W. S., L. D. Rea, K. W. Pitcher and S. D. Farley. 2001. Body Condition of Free-Ranging Steller Sea Lions Estimated by Deuterium Isotope Dilution. p. 63 In: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Mean percent body fat (%BF) was monitored in juvenile Steller sea lions age 2 months to 19 months. Males and females 2-10.5 months showed no difference in mean %BF which increased dramatically from 4.2 to 27.4% with age. By 14-15 months of age, western and eastern stock sea lions showed a significant difference in %BF (17.1% versus 19.0% respectively). The authors speculate that wide variations in observed %BF for animals 9-19 months may reflect weaning status.

Eberhardt, L.L., J.L. Sease, and D.P. Demaster. 2005. Projecting the trend of Steller sea lion populations in western Alaska. Marine Mammal Science 21(4)728-738

Projected populations trends are provided for 6 regional subdivisions of the western stock of Steller sea lions. Utilizing count data from 1989-2002, the authors fit linear and quadratic models to the data, and use the fitted models to predict population abundance in 2004. They generate multiple confidence interval estimates for the 2004 projected population size. Confidence intervals are developed using two bootstrapping techniques as well as standard regression methods. Populations in 3 regions (EGOA, CGOA, CAI) are projected to be "leveling off". Counts from the WGOA indicate a low level of decline, while those from the WAI indicate a continued substantive decline of 10% y^{-1}. Trends in the EAI are reported to be static. The authors use life table data from the 1980s to evaluate the possibility that the population decline was associated with a sudden short-term loss of age 3+ animals. Calculating the rate of population change following such a loss, the authors report that they would have expected at best a 3-year lag before the population returned to the equilibrium rate of change. Thus, their results imply that the observed long-term declines in abundance can not be accounted for by a dramatic change in age structure.

Fadely, B. and T. R. Loughlin. 2001. Weak Association between Steller Sea Lion Pup Condition and Population and Environmental Trends in Western Alaska. p. 68 In: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

In this abstract the author notes that pup condition is related to pup survival. In an attempt to interpret apparent variability in survival among regions of the western Steller sea lion population, the authors standardized measures of pup condition and correlated those measures to local trends in abundance. There were no trends between pup count and condition or the magnitude of population decline and condition. Pup condition was weakly correlated with the North Pacific Index (NPI) implying a possible environmental link.

Fadely, B.S., editor. 2001. Steller sea lion investigations, 2000. U.S. Department of Commerce, Seattle, WA. (AFSC Processed Report 2001-05) 226 p.

This is a compendium of papers. (see Appendix 3.)

Fadely, B.S., T.S. Gelatt, L.D. Rea, J.C. King, and T.R. Loughlin. 2004. Regional variation of juvenile Steller sea lion (*Eumetopias jubatus*) growth rates in Alaska . Presented paper, in Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Growth rates of Steller sea lions age 1-40 months sampled in 2002 and 2003 were measured in seven regions with variable population trends since 1998 (SEAK, EGOA, CGOA, and EAI are all increasing; WGOA, CAI are stable, and WAI decreasing). Pup mass declined from west to east. Growth rate slowed between age 1 and 2 likely as a response to weaning.

Fall, J.A. 2003. The subsistence harvest of Steller sea lions by Alaska natives in 2001. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. (6)

See Wolfe et al., 2001; Lestenkof et al 2003.

Fay, G. 2004. A Bayesian-stochastic metapopulation model for Steller sea lions in Alaska. M.S. Thesis, School of Aquatic and Fishery Sciences, Univ. of Washington, Seattle. 253 p.

From the thesis abstract, “A stochastic-, age- and sex-structured metapopulation population dynamics model was developed for the western stock, which explicitly allowed for geographical differences in factors affecting sea lion vital rates, and could be parameterised to represent a wide range of hypotheses for the decline in Steller sea lion abundance.

The western stock was divided into six regions, which formed the subpopulations within the metapopulation. The data for the western stock of Steller sea lions include pup and non-pup count data, in addition to age-structure samples, and estimates of survival rates. Nine impact scenarios, representing different functional forms for the nature of the cause of the decline, were developed. These scenarios included impacts on survival (juveniles, pups, and adults), pregnancy rate and carrying capacity, and combinations of the different survival and pregnancy rate impacts.

The population dynamics model was fitted to the data for each region separately using maximum likelihood methods and by applying the SIR algorithm to obtain Bayesian posteriors. Inferences from model selection criteria demonstrated spatial variation in the models deemed the most parsimonious representations of the data, both with respect to the types of impact responsible for the decline, and the nature in which that impact was expressed in the population. The pup data were mimicked well, with pup production generally being estimated consistently among scenarios. This was not the case for other population components, specifically the total number of animals. Examination of posterior distributions for model quantities indicated correlations among the values for the parameters of the various impact functions, and that a wide range of combinations of parameter values were able to provide adequate fits to the available data.

The results of model selection were sensitive to the choice of data set for the Central Gulf of Alaska, with removal of survival estimates from the likelihood function resulting in models assuming a reduction in survival rate losing support in favour of those implying a reduction in pregnancy rate. Model predictions were insensitive to demographic variability, even for regions with a small 2001 population size. Models which included varying degrees of environmental stochasticity in birth and death rates inferred greater uncertainty in the trends and magnitude of population size prior to the decline. Trajectories of population size were however well defined during the decline, as these were driven by the impact functions and fitted to the data, resulting in estimates of current population size from the Bayesian analyses that were consistent with those from the deterministic analyses.

Linking of regions within the metapopulation through mixing enabled sea lions belonging to one region to experience the impacts on survival in other regions. Model estimates indicated that the degree of mixing among regions is likely relatively low, and this is corroborated by the distinct spatial differences in regional trends. However, mixing was found to be confounded with the parameterisation of the impact functions. “ [also see Punt and Fay, 2002 and 2003].

Fay, G., and A.E. Punt. 2004. A Bayesian Stochastic Metapopulation Model for Steller Sea Lions (Eumetopias jubatus): Evaluating Changes in Model Fits with Different Assumptions about the Causes for Population Decline. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This poster provides an overview of modeling efforts to evaluate alternative hypotheses for the decline in Steller sea lions. No specific outcomes are discussed. (see Fay, 2004)

Fay, G., and A.E. Punt. 2003.A Bayesian stochastic metapopulation model for Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

See Fay, 2004

Ferrero, R. C., D. P. DeMaster, P. S. Hill, M. M. Muto, and A. L. Lopez. 2000. Alaska marine mammal stock assessments. NOAA Tech. Memo. NMFS-AFSC-119. 191 pp.

This technical report is written to comply with provisions of the Marine Mammal Protection Act (MMPA) and provides estimates of the minimum population size, population trends, maximum net productivity rates (R_{max}) and optimum sustainable population (OSP) levels for marine mammal populations in Alaskan waters. This report updates Steller sea lion population numbers as of 1998. The minimum population size of the western stock of Steller sea lions is estimated at 39,031 animals (28,658 non-pups; 9,373 pups). All counts are based on surveys in 1998. Population trends are inferred from counts at index sites; counts from 1990-1998 were declining at a rate of approximately 4% per year. The maximum theoretical net productivity rate for the stock is 0.12 (or 12% per year). The western stock of Steller sea lions is listed as endangered. There is no indication of OSP levels for this stock. This report also provides estimates of total human induced mortality from incidental takes in fisheries, subsistence harvest and other sources. Estimates of total removals was 442 animals (30 by fisheries; 412 by subsistence), and exceeded the potential biological removal (PBR) allowance of 234 animals.

The minimum population size for the eastern stock of Steller sea lions was estimated to be 30,403 animals based on 1996 counts from Washington, Oregon, California (WOC) and Southeast Alaska (SEAK), the 1994 counts from British Columbia (BC). The SEAK segment of the eastern population was increasing at approximately 1.4% per year, compared to 2.8% per year for the entire stock. The R_{max} value is the same for both stocks, 12%. Total human caused mortality was estimated at 19 animals and did not exceed the PBR of 1368 animals. The OSP level was listed as unknown.

Fritz, L, T. Gelatt, W. Perryman, R. Ream, C. Stinchcomb, and R. Towell. 2005. Differences in recent trends in the populations of western Steller sea lions and northern fur seals in Alaska. In: Marine science in Alaska: joint scientific symposium. January 24-26, 2005 Hilton Hotel, Anchorage, AK.

In this abstract, the authors report a 23% y^{-1} increase in the Steller sea lion western population trend site counts (adult and juvenile) between 2000 and 2004. [The reviewer checked with the primary author and finds that this number is in error and should have been 2%-3% y^{-1}.] The authors note that this increase followed a 30 y period of decline with losses as great as 15% y^{-1} [Maximum losses occurred in the 1985-1989 time period]. Regional differences in trend counts were observed with counts in the EAI and WGOA generally stable from 1991-2004; counts in the EAI and EGOA are more recently stable, and counts from the WAI and CGOA continue to decline.

Fritz, L., C. Stinchcomb, T. Loughlin, and W. Perryman. 2004. Status of the Western Steller Sea Lion (*Eumetopias jubatus*) Population in 2004. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This poster provides a brief account of Steller sea lion aerial survey methods. Surveys are conducted in 2-year intervals. The authors report a 70% decline is sea lion abundance between 1970 and 1990, another 38% decline from 1990-2000, but signs of improvement in 2002.

Fritz, L.W., and C. Stinchcomb. 2005. Aerial, ship, and land-based surveys of Steller sea lions (*Eumetopias jubatus*) in the western stock in Alaska, June and July 2003 and 2004. NOAA Technical Memorandum NMFS-AFSC-153. 56p.

This technical memorandum reports the results of 2003 and 2004 surveys of Steller sea lion abundance. Aerial surveys for non-pups utilized medium-format photography in 2004. Comparison of traditional counts from slides with those from the MF photos indicated greater resolution and higher counts for the MF photos. Adjustments were made to standardize the long-term trend site count index. Non-pup counts for the western stock increased 11-12% (depending on trend site grouping) from 2000 to 2004. Pup counts in the EAI and EGOA have increased since 1998, been relatively stable since 1994 in the WGOA and have continued to decline in the CGOA.

Gerber, L.R. and G.R. VanBlaricom 2001. Implications of three viability models for the conservation status of the western population of Steller sea lions (*Eumetopias jubatus*). Biological Conservation 102: 261-269.

In this paper the authors test two different population viability assessments (PVAs) and contrast their results with prior models developed by York et al., 1996[3]. The new PVA models were developed using abundance data for 1965-1997. Estimated time to extinction ranged from ~50 to 160 y with a median value of 62 y. The average maximum difference in estimated time to extinction was 15.0 years within models (third quartile minus first quartile) and 37.7 years among models. The comparison of PVAs implied that estimated risk of extinction was comparable among models (with the exception of the York et al. rookery model). However, there greater between model variability in estimated time to extinction compared to the within model variability implied that a thorough viability analysis should incorporate more than one modeling approach. Among the limiting factors in the PVA analysis was a meaningful estimate of the risk of catastrophic population declines. In addition to conducting the PVA, the authors review the decision to list Steller sea lions as endangered against a set of standards developed by the IUCN [4]. The authors report that the western population of SSL meets the IUCN criteria of endangered.

[3] York, A.E., Merrick, R.L., Loughlin, T.R., 1996. An analysis of the Steller sea lion metapopulation in Alaska. In: McCullough, D.R. (Ed.), Metapopulations and Wildlife Conservation. Island Press, Covelo, CA, pp. 259–292

[4] http://www.iucn.org/

Gerber, L.R. and Hilborn, R. (2001). Catastrophic events and recovery from low densities in populations of otariids: implications for risk of extinction. Mammal Rev. 31: 131-150.

An excerpt from the paper's abstract: "We examined the literature on population dynamics of otariids (fur seals and sea lions), to determine how frequently populations are subjected to major population declines, and to what extent depleted populations recover from low population size. We present frequency distributions for percentage declines for otariid life-stages (pup, juvenile, adult female and male), and describe eight examples of events leading to a population decline of 50% or greater among otariids. We found that numerous otariid populations have been reduced to very low densities by exploitation (low enough to be thought extinct) and have recovered to levels where they are no longer at risk of extinction. This suggests that the reduction in population rate of increase at low densities in otariid populations may not be strong."

Harke, V. L. and W. G. Williams. 2000. Seasonal abundance of Steller sea lions at Dry Bay, Alaska. Unpublished Report. Project completed under the authority of the MMPA and ESA permit no. 965 issued by the National Marine Fisheries Service to the Alaska Department of Fish and Game, 9 p.

This paper was unavailable.

Hastings, K. K., and W. J. Sydeman. 2002. Population status, seasonal variation in abundance, and long-term population trends of Steller sea lions (*Eumetopias jubatus*) at the South Farallon Islands, California. Fishery Bulletin 100:51-62.

An excerpt from the paper's abstract: "From 1977 to 1996, numbers present during the breeding season decreased by 5.9% per year for adult females and increased by 1.9% per year for subadult males. No trend in numbers of adult males was detected. Numbers of immature individuals also declined by 4.5% per year during the breeding season but increased by 5.0% per year from late fall through early winter. Maximum number of pups counted declined significantly through time, although few pups were produced at the South Farallon Islands. The ratio of adult females to adult males averaged 5.2:1 and declined significantly with each year, whereas no trend in the ratio of pups to adult females was discernible. Further studies are needed to determine if reduced numbers of adult females in recent years have resulted from reduced survival of juvenile or adult females or from changes in the geographic distribution of females."

Hastings, K., and T. Gelatt. 2004. Survival of Steller sea lion pups from branding to three months after branding at Lowrie Island, Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK. (**3)**

Four hundred and twenty seven Steller sea lion pups were branded at Lowrie Island and Cape Horn rocks in June 2001 and 2002. Branded animals were resighted more than 4000 times. Apparent survival of pups from branding to three months of age varied among sights from 0.88 to 0.77 [presumably this is the proportion surviving the 3 month interval]. Estimated weekly survival rates were 0.955 in the first two weeks after branding and 0.985 thereafter. Resighting continued from 2002-2004, although annual survival rates are not reported. [also see Kaplan, 2005]

Hastings, K., and T. Gelatt. 2003. Mark-recapture studies of branded sea liuon pups at Lowrie Island, Alaska. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

This abstract provides initial results from the branding experiments discussed above in Hastings and Gelatt (2004).

Hillman, G.R. 2005. Photo-identification of Steller sea lions. Chapter 28, pages 275-283, in Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

This is a methods paper evaluating the utility of photographic identification of individual Steller sea lions using distinctive markings on flippers. Test to date indicate a better than 50% recognition rate but not a lot better. Further testing and refinement of the method is anticipated but ultimate utilization will be up to individual researchers.

Holley, D.K., P. K. Parker, J.M. Maniscalco, and R. D. Andrews. 2005. Chiswell Island research platform: implementation and assessment. Chapter 26, pages 260-270, in Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

This paper describes the placement of an observation platform on Chiswell Island. The platform was constructed to facilitate close observation and capture of pups on this rookery. It was also used as a platform for night-time viewing of mating and puping activities. There is no discussion of vital rates, but capture of pups through utilization of the platform could lead to collection of improved demographic data.

Holmes, E., and A.E. York. 2003. Using age structure to detect impacts on threatened populations: a case study using Steller sea lions. Conservation Biology 17 (6):1794-1806.

This is a significant paper addressing estimates of time varying changes in Steller sea lion vital rates. Utilizing CGOA count data from 1976 to 1998, The authors develop an age-structured model by inferring demographic properties of the population from ratios of adult to juvenile animals on haulouts in the CGOA. They then create a set of nested models to test for temporal changes in juvenile and adult survivorship and fecundity. Their models indicate that the data are best fit by assuming multiple periods of changing vital rates: 1983-1987, 1988-1992, and 1992-1998, with respective population wide survival rates of 0.80, 0.87, and 0.92. Juvenile mortality was severe during the first period, then improved to levels near those experienced in 1976; adult survivorship was lowest in the 1988-1992 time period, but was typically much nearer to the rates experienced in the 1970s than that of juveniles. Fecundity was lower throughout the time period 1983-1998 than it was in 1976; however, the rates were stable between 1983-1992, dropping substantially in the 1993-1998 time period. Among the implications of these findings is the realization that factors which appear to have provoked the rapid decline in the 1980s are not the same as that affecting population recovery in the 1990s. Moreover, the population is sensitive to impacts on adult and juvenile survivorship, and even small depressions can have significant effects on current decline.

Holmes, E.E., L.W. Fritz, A.E. York, and K. Sweeney. 2005. Evidence of continuing declines in fecundity of Steller sea lions in the central Gulf of Alaska. In 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

In this abstract the authors note that "a demographic model based on counts of pups and non-pups and the proportion of juvenile sea lions on haul-outs sites in the central Gulf of Alaska indicated that the steep decline in …the 1980s was caused primarily by a large drop in the survival rate of juvenile sea lions, but smaller decreases in the rates of adult survival and female fecundity occurred as well. As the rate of population decline slowed through 1998, juvenile and adult survival rates increased, but the decline in fecundity persisted." The authors add that, "these trends continued through 2004."

Holmes, E.E., L.W. Fritz, A.E. York, and K. Sweeney. 2006. Evidence of continuing declines in fecundity of Steller sea lions in the central Gulf of Alaska. In Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Same information as Holmes et al., 2005 above.

Hoshino, H., T. Isono, T. Takayama, T. Ishinazaka, A. Wada, and Y. Sakurai. 2004. Wintering of Steller Sea Lion (Eumetopias jubatus) along the Northern Coast of the Sea of Japan. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors report on aerial and land surveys conducted at Rishiri-Rebun Islands (45°29 N) and Tsugaru Strait (41°30 N) in the Sea of Japan, 2001-2003. During winter surveys from December – May 2002 and 2003, Steller sea lions were observed using two main winter haulouts: Cape Ofuyu (43°41 N) and Cape Kamui (43°20 N). The maximum number of sea lions observed at these haulouts was 90. Overall survey counts ranged from 135-390 sea lions in winter (late Jan – early March). Winter aggregations in Tsugaru Strait coincided with the presence of arabesque greenling (*Pleurogrammus azonus*) and spawning populations of walleye pollock (*Theragra chalcogramma*).

Iida, K., T.-G. Park, T. Mukai, and S. Kotani. 2004. Acoustic Characteristics and Morphological Observation of Roar Sound of Steller Sea Lion (*Eumetopias jubatus*) Migrating to the West Coast of Hokkaido, Northern Japan. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Investigators studied "roar sounds" emitted by 300 wild and 180 captive Steller sea lions classifying dominant frequency, formant frequency and pulse repetition rate. They observed that roar sounds differed among size classes and between sexes of sea lions. The authors correlated dominant frequency and formant frequency with size and sex of captive animals. They applied the regression equations to sounds from wild animals and found a "rough" agreement with length distributions estimated from photographs.

Isono, T., H. Hoshino, T. Takayama, T. Ishinazaka, V. Burkanov, and Y. Sakurai. 2004. Changes in Abundance and Sightings of Marked Steller Sea Lion in Hokkaido. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors report results from Steller sea lion surveys of Iturup Island (northwest of Hokkaido and southeast of the Kuril Islands) conducted between 2000 to 2004. Sea lion populations declined from 1516 animals in 1963 to 122 in 2003. Cause of the decline is

unknown, although sea lion harvest has been authorized in Hokkaido since 1958 as a measure to protect fishing gear. Sea lions are reported to have been absent from Hokkaido since 1954. Of 4,516 Steller sea lion pups branded in the Kuril Islands and Sea of Okhostk; 58 had been resighted around Hokkaido during winter months over the period 1989-2004.

Jeffries, S. J., P. J. Gearin, H. R. Huber, D. L. Saul, and D. A. Pruett. 2000. Atlas of seal and sea lion haulout sites in Washington. Washington Dep. Fish Wildlife, Wildlife Sci. Div., 600 Capitol Way North, Olympia WA, 150 p.

Jeffries et al report no Steller sea lion rookeries in Washington State coastal waters but sea lions due use haulouts along the Washington and Vancouver Island coasts. Peak counts are reported to be 1100 animals typically seen during fall and winter months.

Jeffries, S., P. Olesiuk, P. Gearin, D. Lambourn, and A. Trites. 2004. Techniques for Capture and Handling of Steller and California Sea Lions. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors describe a transportable platform used to attract sea lions to haulout. The platform was fitted with a cyclone fence and guillotine drop gate to facilitate capture. Twenty-six sea lions, ranging in size up to 600kg, were captured and outfitted with various tags and instruments.

Jemison, L., K. Raum-Suryan, K. Pitcher, G. Pendleton, J. King, and T. Gelatt. 2003. Preliminary report on Steller sea lion brand-resighting results in Southeast Alaska. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

In SE Alaska 1615 Steller sea lion pups were branded in June between 1994 and 2002. Another 94 older age sea lions branded in the 2001-2002 time period. Since, 1999, ADFG has conducted dedicated brand resighting cruises. In June 2002, 315 unique brands were resighted from a population of approximately 10,700 sea lions observed. There were 1,373 brands in the marked population at the time. Additional resighting surveys in August that same year produced 90 unique brands a third of which had not been seen in June. During the August cruise, observers resighted 39% of the 318 pups branded that summer.

Jemison, L.A., T. S. Gelatt, K. W. Pitcher, K.L. Raum-Suryan. 2004. Steller Sea Lion Movements Based on Brand-Resighting Observations in Southeast Alaska: An Alternative to Satellite Telemetry. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This abstract updates brand resighting information provided in Jemison et al 2003. Total number of branded sea lions is 2,144, of which 2007 were pups. During brand resighting cruises in 2003, 524 unique brands were observed: 13% from releases in 1994-1995, 27% from releases in 2001, and 40% from releases in 2002.

Jonker, R.A.H. and A.W. Trites. 2000. The reliability of skinfold-calipers for measuring blubber thickness of Steller sea lion pups (*Eumetopias jubatus*). Marine Mammal Science 16:757-766.

The authors report on correlations between skin-fold thickness, blubber thickness and body size. Skin-fold thickness calipers were used to measure skin-fold thickness on 12 dead 3-14d old Steller sea lion pups. Skin-fold thickness was better correlated with body mass than blubber thickness. The authors suggest these calipers are not useful for indexing sea lion body condition or percent body fat.

Kaplan, C. Curgis. 2005. Neonatal survival of Steller sea lions (*Eumetopias jubatus*). M.S. thesis, Colorado State Univ., Fort Collins, CO. 72 p.

This study took advantage of natural markings of adult female Steller sea lions to generate mark-recapture estimates of pup survival at two sites on Lowrie Island in Southeast Alaska, 2002-2003. Survival was monitored from birth to 3-weeks of age. Neonatal survival varied greatly by site: 0.588 at site 5 and 0.967 at site 1. Highest rates of mortality occurred on the first day of life, leveling out thereafter. [also see Hastings and Gellat, 2004].

King, J., T. Gelatt, and K. Pitcher. 2003. A field-based method for estimating age in wild juvenile Steller sea lions (Eumetopias jubatus). P. 84, in 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p

These authors report that Steller sea lions less than 2 years of age can be accurately aged by the eruption pattern and length of their canine teeth. Diastema length and whisker length were least correlated with age, with body length doing slightly better, but less well than canine length.

King, J.C., T.S. Gelatt, and K.W. Pitcher . 2004. A Field-Based Method for Estimating Age in Free-Ranging Juvenile Steller Sea Lions (Eumetopias jubatus) . Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This poster discusses the same results as reported in King et al 2003. A slightly improved description of tooth eruption patterns are provided.

Kuzin. A.E. 2002. Abundance and some biological features of Steller sea lions of the Tyuleniy Island. In Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

The author reports 857 Steller sea lions on Tyuleny Island (Sea of Okhotsk) in 2001. There were 4.1 females per male, 9.5 females per harem male. Between 1989 and 2001 sea lion population increased 20% y^{-1}, with birth rate increasing 17% y^{-1}. Forty-five marked sea lions were observed, 40% of which had immigrated from elsewhere.

Lestenkof, A.D., P.A. Zavadil, and M.T. Williams. 2003. The subsistence harvest of Steller sea lions on St. Paul Island in 2001. Annual Report provided to the National Marine Fisheries Service under contract NA16FX1420. 10 pp. Available, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

Upon review of past reports by ADFG Subsistence Division (see Wolf et al., 2001, 2002), the Ecosystem Conservation Office of the Tribal Government of St, Paul felt that there was considerable uncertainty on the part of sea lion hunters and the local community on the reported results, specifically in regard to the accuracy of the data collected by retrospective survey and the presentation of results. The ECO since has managed the SSL harvest on the island and provides to NMFS (and others) an annual summary of subsistence takes based on real time harvest information. “The reported subsistence harvest of Steller sea lions on St. Paul Island in 2001 was 24. Twelve sea lions were retrieved and 12 were reported struck and lost. Of the 24 sea lion harvested five sets of [biological] samples were collected. Of the active Steller sea lion hunters on St. Paul Island in 2001 100% hunter participation was achieved with real-time harvest monitoring."

Lisitsyna, T. Yu., and A.M. Burdin. 2002. Structure peculiarities of rookery population and behavior adaptations in Steller sea lions (*Eumetopias jubatus*) at Cape Kozlova (Kamchatka Peninsula). In Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

This paper describes observations of maternal nurturing for new born pups. There is no information on survival rates.

Loughlin, T. and J. L. Sease. 2001. Steller sea lion research cruise in the Aleutian Islands and Gulf of Alaska, February-March 2000, p. 103-112 In: Anita L. Lopez and Robyn P. Angliss, editors, Marine Mammal Protection Act and Endangered Species Act implementation program 2000. U.S. Department of Commerce, Seattle, WA. (AFSC Processed Report 2001-06).

The authors report the number of Steller sea lions observed on haulouts in the Gulf of Alaska and Aleutian Islands during a winter cruise from 24 February to 15 March 2001. Some 1950 sea lions were counted at 30 locations. Highest concentration was 350 animals at Adak/Lake Point. There were 7 sites with more than 100 sea lions, and 6 with no sea lions. The focus of the cruise was to conduct scat sampling and live capture to facilitate telemetry studies and other physiology studies.

Loughlin, T. R., and A. E. York. 2000. An accounting of the sources of Steller sea lion, *Eumetopias jubatus*, mortality. Mar. Fish. Rev. 62(4):40-45

Excerpt from the paper's abstract: "We estimated the total non-pup population size in Alaska of the western stock of Steller sea lions to be about 33,000 animals. Based on a published life table and the current rate of decline, we estimate that the total number of mortalities of non-pup Steller sea lions during 1991-2000 was about 6,383 animals; of those, 4,718 (74%) are mortalities that would have occurred if the population were stable, and 1,666 (26%) are additional mortalities that fueled the decline. We tabulated the levels of reported anthropogenic sources of mortality (subsistence, incidental take in the fisheries, and research), estimated another (illegal shooting), then approximated the levels of predation (killer whales and sharks). We attempted to partition the various sources of "additional" mortalities as anthropogenic and as additional mortality including some predation. We classified 436 anthropogenic mortalities and 769 anthropogenic plus some predation mortalities as "mortality above replacement"; this accounted for 26% and 46% of the estimated total level of "mortality above replacement", respectively. The remaining mortality (74% and 54%, respectively) was not attributed to a specific cause and may be the result of nutritional stress."

Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.). 2005. Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

This report represents a compilation of work completed in association with the Alaska Sea Life Center. Chapters relating to Steller sea lion abundance and/or vital rates include Ch. 12: "Steller sea lion research in the Russian Far East" (Waite and Burkanov, 2005); Ch. 22:

Steller Sea Lion Predation by Killer Whales in Kenai Fjords/Prince William Sound (see Matkin, 2005 under Theme 3: Predation of this report); Ch. 30: "Reproductive performance and pup mortality in Steller sea lions" (Maniscalco et al., 2005).

MacDonald, R, and M. McClaran. 2000. Abundance and distribution of marine mammals in Bristol Bay and southern Kuskokwim Bay, Alaska, 1999. Manuscript Rpt., U.S. Fish and Wildlife Service, Togiak National Wildlife Refuge, P.O. Box 270 Dillingham, Alaska 99576. 29p.

A status report of the 1999 marine mammal monitoring effort at Togiak National Wildlife Refuge. Two sea lion surveys were performed at Cape Newenham with 116 and 157 sea lions documented at Sentry Beach. Other incidental observations of sea lions were recorded at Cape Newenham and Cape Peirce. Sea lions at Round Island were documented by other offices from 17 May to 2 August and counts ranged from 12 to 138 animals.

Malavear, M.Y.G. 2002. Modeling the energetics of Steller sea lions (Eumetopias jubatus) along the Oregon coast. M.S. thesis, Oregon State University, Newport, OR. 114p.

Thesis abstract: "A dynamic bioenergetic model for Steller sea lions (*Eumetopias jubatus*) was built using the STELLA simulation modeling system. The model is intended as an aid for the exploration of ecological questions regarding growth and survival of immature Steller sea lions (ages 1-3) living along the Oregon coast under different nutritional scenarios. The ultimate goals were: 1) to identify features of the Oregon ecosystem that could contribute to the growth of the Steller sea lion population in contrast to the declining population in Alaska and 2) to provide a basis for examining the various hypotheses that have been put forward regarding the causes of the Steller sea lion decline in Alaska.

The dynamic energetic model was composed of coupled submodels, created or adapted from the literature, that describe the energetic inputs and outputs of the animal. It is a mechanistic model based on biological principles that attempts to describe the connections and feedbacks between the different components and the allocation of energy to them under suboptimal nutrition.

The model predicted that both changes in prey abundance and quality would have a more pronounced effect in one-year-old animals than in two- and three-year-old sea lions. A reduction in prey density could delay the attainment of sexual maturity, and this could have a significant negative effect on the population rate of increase. The seasonal migration of Pacific whiting was shown to be very important as a biomass influx into the system. In general, the model predictions were consistent with observations on the declining population of Steller sea lions in Alaska."

Maniscalco, J., and S. Atkinson. 2004. Causes of early pup mortality at a Steller sea lion rookery (*Eumetopias jubatus*) in the northern Gulf of Alaska. In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK

A small Gulf of Alaska rookery [Chiswell Island] was monitored for pup mortality during the "first few months of life" for three years, 2001-2003. Pup mortality ranged from 19.2% to 20.3%. Cause of mortality included killer whale predation, deaths due to storm surge, and an unknown factor (possibly disease). The principle cause of death varied from year to year.

Maniscalco, J., S. Atkinson, A. Burdin, and D. Calkins. 2003. Population dynamics, maternal investment, and early pup mortality in Steller sea lions at Chiswell Island. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

A Steller sea lion rookery at Chiswell Island was monitored for four years, 1999-2002. Births fluctuated from 52 to 65 pups with higher counts in alternate years. Approximately half the females gave birth in 2001 and 2002; 37% gave birth in only one those two years, and 9% did not pup at all. Maternal care varied between higher and lower birth years with better maternal care (“tighter synchrony of births, longer perinatal periods, shorter foraging trips, and a greater percentage of time spent on shore”) in years with higher numbers of births.

Maniscalco, J., S. Atkinson, and P. Armato. 2002. Early maternal care and pup survival in Steller sea lions: A remote video monitoring project in the Northern Gulf of Alaska. Arctic Research 16: 36-41.

This is a more detailed and earlier description of the studies reported in Maniscalco et al., 2003. The rookery at Chiswell Island is monitored via video camera. The article describes the camera set up and placement. More detailed reports of female nurturing behaviors are provided. More synoptic report of results are obtained from Maniscalco et al., 2005a, and 2005b.

Maniscalco, J.M., P. Parker, and S. Atkinson. 2005a. Use of remote monitoring equipment to study maternal care. Chapter 32, pages 308-320, in Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

In this article the authors summarize results of 4 years of video camera observation of a Gulf of Alaska Steller sea lion rookery at Chiswell Island. Information is provided on the duration of perinatal care, and the duration of foraging trips by nursing mothers. Perinatal periods averaged 10.7 d (range 1.3-17.1 d). Summer foraging duration averaged 15.4 h (±0.6 h). Fall foraging trips averaged 52.9 h (±4.1 h). Females spent 40% of their time at sea during summer and 60% of their time at sea during fall. The perinatal period for Chiswell Island females is longer than reported elsewhere, and suggests that a sufficient food supply is available. Female foraging duration increased nearly linearly between late July and late August, leveling off in September and October. Pup counts and pup survival was also noted (see Maniscalco et al., 2005b).

Maniscalco, J.M., R. Taylor, D. G. Calkins, and S. Atkinson. 2005b. Reproductive performance and pup mortality in Steller sea lions . Chapter 30, pages 290-301, in Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

This paper provides evidence of annual variability in pup survival from a longitudinal sample of known females on the Gulf of Alaska rookery at Chiswell Island. Video monitoring and classification of individual animals allowed researchers to track pup survival for females from 2001 to 2004. Reproductive rates are estimated as the ratio of females giving birth to those not giving birth. The denominator in this ratio includes all females observed without pups, and half the females of uncertain status, i.e., either too young to give birth or observed previously on the island but not observed in the current pupping year. Pup births increased from 52 in 2001 to 80 in 2004. Mean birth-rate for females with at least a two-year history on the island was 82.5%, annual variability is noted with reproductive-rate decreasing from 2002-2005 and inversely correlated with the number of pups born. Females had a lower expectation of pupping following years of early pup loss or years where no pup was born. Early pup mortality (first 2 months) ranged from 20.8% to 22.2% from 2001-2003, then dropped dramatically in 2004 to 3.8%. Killer whale predation and loss due to storm surge accounted for a large fraction of mortality in 2001 and 2002.

Maniscalco, J.M., S. Atkinson, D.G. Calkins, P. Parker, E. Teate, and D. Zatz. 2005c. The usefulness of remote-operated video cameras for long-term tracking of individual Steller sea lions. In 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This abstract briefly details results from the video camera observations at the Gulf of Alaska Steller sea lion rookery on Chiswell Island. See Maniscalco et al 2005a, and 2005b for more detailed reporting of findings.

Marcotte, M.L., and A.W. Trites. 2004. A Comparison of maternal attendance among the world's sea lions. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

These researchers report a shift in the age of weaning observed from monitoring branded Steller sea lions in Southeast Alaska. During the 1990s weaning was expected to occur annually; however, observations during a 12 m continuous period in 2004-2005 of sea lions branded in 2000-2004 suggest an increased occurrence of biennial weaning. Implications for expectations of population reproductive rates are obvious.

Miller, E. H., Ø. Wiig and A. W. Trites. 2005. International survey of scientific collections of Steller sea lions. Fisheries Centre Research Reports 13 (6), 68 pp.

This paper reviews the location and number of Steller sea lion museum specimens (skulls) in numerous international collections. The specimens are classified by locality of collection, year, season, sex, age, institution housing the collection and collection catalog number. These museum collections could be used to construct historic age distributions, or for qualitative appraisal of foraging trends via stable-isotope analysis. The summary is extensive but not exhaustive, other specimens may be available particularly in Asia, or the Russian Far East.

National Research Council (NRC). 2003. Decline of the Steller sea lion in Alaskan waters; untangling food webs and fishing nets. National Academy press, Washington, D.C. 184 pp.

This National Research Council report provides a review of Steller sea lion population trends and vital rates as understood through 2002. There is an additional review of population models. The report summarizes count data from 1959 to 2000 in tabular formats and figures. Early count data is qualified as less precise than current data due to variability in survey techniques. Regardless, counts are recognized as very high in the 1960s and 1970s and declining substantially thereafter. The most rapid rate of decline occurred in the 1985-1989 time period.

Vital rates (measures of fecundity, age, maturity, and growth) all came from studies at Marmot Island in the Gulf of Alaska, from specimens collected in 1975-1978 and 1985-1986.

Fecundity data was derived from animals intentionally shot for collection, age was inferred from inspection of the cross-sectional banding patterns on upper premolars. Additional observations of body mass, length, blubber thickness, pregnancy rates and lactation status were also collected for many specimens used in analysis of vital rates. Reproductive parameters were based on 46 and 62 females collected in the 1970s and 1980s; age and growth on 80 and 102 animals in the same respective time periods.

Population models address population viability (projected survival at current rates of increase or decrease) typically through deterministic age structured models; population elasticity or the dynamic range in population change as a result of changes in vital rates through stochastic simulation models. Typical model outcomes point to either significant declines in young sea lion survival rates, and/or substantial changes in fecundity or reproductive rate to explain the dramatic decline in sea lion abundance. Modeling conducted through 2002 could account for only about a quarter to a third of the total mortality occurring during the period of rapid population decline, the remaining unexplained mortality is attributed to nutritional stress but may also be linked to underestimates of predation and directed mortality due to human interaction and shooting.

Nikulin, V. S., and V. N. Burkanov. 2000. Species composition of marine mammal by-catch during Japanese driftnet salmon fishery in southwestern Bering Sea. Unpubl. manuscript, National Marine Mammal Laboratory, AFSC, 7600 Sand Point Way, NE, Seattle, WA 98115. 2 pp.

Unable to locate this paper.

Noren, D. P. 2003. Fasting capabilities in weaned juvenile Steller sea lions: influence of body condition and activity. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

Using a dynamic state variable model, the author estimated that the maximum fasting duration for sea lions with <10 %TBF (total body fat) is <10 days when 70% of each day is spent in water. Lipid and protein allocation are also influenced by %TBF, with leaner sea lions catabolizing higher levels of protein. The results suggest that lean juvenile Steller sea lions may be especially susceptible to relatively short term reductions in prey availability due to their limited fasting abilities.

O'Corry Crowe, G., B.L. Taylor, M. Basterretche, T.R. Loughlin, T. Gelatt, and J.W. Bickham. 2003. Using molecular genetics to estimate dispersal rates between Steller sea lion rookeries. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

Analysis of mtDNA from 60-106 Steller sea lions from three adjacent western stock rookeries and 2 eastern stock rookeries was used to assess dispersal rates among rookeries. Dispersal rates were an order of magnitude higher in the eastern stock than in the western stock and sufficient to imply mixing between the eastern stock rookeries. By contrast the western stock rookeries were estimated to be essentially isolated one from the other.

Olesiuk, P. F. 2001. Recent trends in abundance of Steller sea lions (*Eumetopias jubatus*) in British Columbia. Working Paper 2001-10, Dept. Fisheries and Oceans, Canada, National Marine Mammal Review Committee Meeting, 27 February- 1 March 2001, Winnipeg, Manitoba, Canada. 29 pp.

Unable to locate this paper.

Olesiuk, P.F. 2004. Population biology and status of Steller and California sea lions (*Eumetopias jubatus* and *Zalophus californianus*) in Canadian waters. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This abstract describes counts and trends in Steller sea lion abundance at 3 active rookeries in British Columbia. Current population size was reported a 9400 animals, increasing at an annual rate of 3.2% y^{-1} from a population low of 3400 animals in the 1970s. Population recovery resulted as a consequence of the elimination of predator control programs and imposition of government protection in the1970s. The author speculates that sympatric population of Steller and California sea lions may be competing with each other around Vancouver Island and the recent declines in California sea lion abundance may be caused by increased competition with Steller's in recent years.

Parker, P., J. Maniscalco, S. Atkinson, K. Harris, and R. Baptista. 2003. Summer to autumn increases in maternal investment for individual Steller sea lions (Eumetopias jubatus) in the northern Gulf of Alaska. P. 127, in 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

This abstract provides a summary of observations regarding the nurturing behavior of females Steller sea lions on Chiswell Island, Gulf of Alaska. Seasonal differences in behavior were observed. Females spent more time on rookeries nursing pups during summer and less time during fall. See Maniscalco 2005a and Parker et al 2005 for additional information.

Parker, P., J.M. Maniscalco, and S. Atkinson. 2005. Pupping site fidelity among individual Steller sea lions at Chiswell Island, Alaska. Chapter 33, pages 321-330, in Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

There were 15 females that pupped annually at Chiswell Island, Gulf of Alaska from 2001 to 2004. Birthing locations were not randomly distributed. Females preferentially selected locations near rock walls with easy access to water, and more than 5 m above sea level. Multiparous females were more likely to secure preferential birthing locations than primiparous females.

Pendleton, G.W, K.W. Pitcher, L.W. Fritz, K.L. Raum-Suryan, T.R. Loughlin, D.G. Calkins, A.E. York, K.K. Hastings, and T.S. Gelatt. In review. Steller sea lion survival probabilities in Alaska: A comparison of increasing and decreasing populations. Canadian Journal of Zoology.

In this paper the authors utilize Cormak-Jolly-Seber (CJS) model to estimate survival probabilities for Steller sea lions branded at Marmot (western stock) and Forrester (eastern stock) Islands. At Marmot Island (MI) 751 pups were branded in 1987-1988; 799 pups were branded at Forrester Island (FI) in 1994-95. Major resighting effort occurred at MI between November 1987 and March 1988; June-July 1988, 1991-1996, 1998-2003; and opportunistically else where. In addition, resighting effort was also carried out at Surgarloaf

Island, and Fish Island in the CGOA. Resighting effort was somewhat more synoptic at FI covering more rookeries and haulouts utilized by the eastern population. Major resighting effort occurred at FI from July-February 1994-1995; May-June, 1995, June-July 1996-1998 and 2000; June-October 2001, and June-August 2002-2003. Additionally, 21 rookeries and haulouts in Southeast Alaska were visited from June-July 1999 and 42 rookeries and haulouts in SEA and British Columbia were visited from Jun-July 2000-2003. Multiple models were evaluated and compared using the AIC criteria with the more parsimonious model chosen as the preferred model. The overall male sea lion survival estimate through age 9 at FI was 0.123; the female estimate for FI was 0.284. At MI, overall male and female survival was similar and estimated to be 0.094. The lower overall survival estimates at MI appear to reflect a higher age-specific rate of loss for ages 1-4 compared to FI. The distinct dichotomy between FI males and females was expected, whereas the similarity of estimates for both sexes at MI was not.

Pendleton, G.W., K. W. Pitcher, L. W. Fritz, and T. S. Gelatt. 2004. Survival Rates of Steller Sea Lions in Southcentral and Southeastern Alaska. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

In this abstract, the authors report estimates of juvenile and young-of-the-year Steller sea lion survival rates based on mark-recapture of 800 sea lions. Annual survival rates for sea lions less than 3 years of age is 70%; survival for sea lions more than 3 years of age is 83% for males, 96% for females.

Perez. M.A. 2003. Compilation of marine mammal incidental take data from the domestic and joint-venture groundfish fisheries in the US EEZ of the north Pacific, 1989-2001. NOAA Tech Memo NMFS-AFSC-138, 145 p.

The author provides tabular reports on the estimated number of Steller sea lions taken incidentally in the domestic groundfish fishery of the Bering Sea and Gulf of Alaska from 1989-2001. Total estimated incidental take ranged from 6 to 48 sea lions annually. The domestic trawl fishery of the Bering sea accounted for the majority of the estimated Steller sea lion incidental catch. Steller sea lion incidental catch dropped sharply after 1992. The mean estimated annual incidental catch from 2000-2001 was 15.5 Steller sea lions compared to 19.9 from 1989-1999.

Permyakov, P.A., and V.N. Burkanov. 2004a. Age and sex structure of branded Steller sea lion (*Eumetopias jubatus*) on Brat Chirpoev I. (Kuril Island) in 2002-2003. Pages 449-451, in Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

Six-hundred and seventy six Steller sea lion pups were branded at Brat Chirpoev Island in 6 separate years: 1989, 1999-1996 and 2001. Branded animals were resighted at the rookery between May and July in 2002 and 2003. One-hundred forty branded animals were resighted in 2002 (33 males, and 71 females); 86 were resighted in 2003 (24 males and 62 females). Tabular data is provided of the number of animals resighted by cohort.

Permyakov, P.A., and V.N. Burkanov. 2004b. Seasonal changes in abundance of Steller sea lion (*Eumetopias jubatus*) on Brat Chirpoev Island (Kuril Island) during the breeding season 2002-2003. Pages 446-449, in Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

The authors conducted counts of Steller sea lions on Brat Chirpoev Island (Kuril Island) in 2002-2003. Counting began in on June 6, 2002, and May 25, 2003 ending on July 11, 2002 and July 13, 2003. Counts of sea lion at least 1-y and older stabilized at approximately 700 animals in 2002 and 600 animals in 2003. The majority of sea lions on the island were mature females. There were 372 pups born in 2002, and 352 in 2003. Pup mortality was 3.2% in 2002, 6.5% in 2003. Graphs are provided showing increase in seasonal population numbers by sex and age group.

Pitcher, K. and J. Sease. 2003. Equivocal indicators of Steller sea lion population trend in Prince William Sound, Alaska. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

This abstract is presented here in its entirety. "The Steller sea lion population in Prince William Sound, Alaska has been portrayed as one of the most rapidly declining segments of the western U.S. population during recent years. This appears to be supported when examining counts of nonpups on rookeries and haulouts in the region. However counts of pups on Seal Rocks, the major rookery in the Prince William Sound area, show little or no decline since the 1970s unlike nearly all other rookeries in the western population. These data suggest little decline in the "resident" Steller sea lion population and we hypothesize the large decline observed in nonpup numbers is largely a result of a reduction in the presence of immature and nonbreeding animals from the adjacent Central Gulf of Alaska where numbers of pups born on rookeries ha ve declined by about 90%. There is also limited support for the hypothesis of immigration of breeding animals to the Prince William Sound area."

Pitcher, K. W., V. D. Burkanov, D. G. Calkins, B. J. LeBoeuf, E. G. Mamaev, R. L. Merrick, and G. W. Pendleton. 2001. Spatial and temporal variation in timing of births of Steller sea lions. Journal of Mammalogy 82:1047-1053.

Pup births are nearly synchronous throughout the range of the Steller sea lion typically occurring between 15 May and 15 July annually. The authors report findings for regional variation in seasonal birthing dates based on pup counts from 1968-1998. Earliest birth dates are typically observed in Southeast Alaska at Forrester Island, and grow progressively later as you move south and north. The authors "hypothesize that timing of births at rookeries is determined through selection for time periods when weather conditions are generally favorable for pup survival and when adequate prey items are predictably available near rookeries for lactating females."

Pitcher, K., R. Brown, S. Jeffries, L. Lowry, M. Lowry, P. Olesiuk, W. Perryman, J. Sease, and J. Stinchcomb. 2003. Status of the eastern Steller sea lion population. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

An excerpt from the abstract: "The total eastern population [of Steller sea lions] now numbers over 40,000 animals and comprises about 55% of the North American population whereas in the 1970s it made up only about 10% of the total. The three largest rookeries in North America; the Forrester Island complex, Hazy Islands, and the Scott Islands complex are all in the eastern population."

Pitcher, K.W., G. W. Pendleton, and T. S. Gelatt. 2004. Estimation of Weaning Status of Juvenile Steller Sea Lions Using Mark-Resight Models. Presented paper. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

In this abstract, the authors note the incidence of extended nursing of Steller sea lions beyond the first and even second year of age. Females nursing one and two-year-old sea lions do not engage in reproduction during the nursing period. This effectively reduces the population of reproductive females and thus impacts demographic modeling of the stock. The authors followed branded animals and employed a mark-recapture model to estimate the probability of extended nursing. There are no results of the mark-recapture analysis presented. [The reviewer contacted the primary author who reported that research is on-going and a final paper has not yet been written.]

Punt, A.E. and G. Fay. 2002. Methods for determining extinction risk and recovery probability of Steller Sea Lion populations subject to harvesting, demographic and environmental stochasticity, and catastrophic events. Final report submitted to NMML, NMFS, NOAA. 54 pp

Adapted from the paper abstract: "Data on counts of pups and non-pups, information on survival rates from tagging, and information on the age-structure of the population are used to fit a population dynamics model to seven areas encompassing southeastern Alaska to the western Aleutian Islands. The population dynamics model allows for meta-population features, demographic and environmental stochasticity and catastrophic events although there are few data to parameterize the magnitudes of such processes. The model is fitted to the data using likelihood and Bayesian methods. The model is able to mimic the existing data for the seven areas with varying degrees of success. The best fits occur for central Gulf of Alaska area." Difficulty in fitting other areas implies inconsistent data or modeling process errors. "The model in unable to mimic the increasing trend in pup numbers in southeastern Alaska and there appear to be contradictory trends in pup and non-pup counts in the eastern Gulf of Alaska and the eastern Aleutian Islands. Results for the central Gulf of Alaska area are reasonably precise and suggest that the reduction in Steller sea lion population size in this area can be explained by lower survival rates (by 12.6% for adults, 30.8% for juveniles and 4.5% for pups at its maximum in 1984) as well as lower fecundity (by 22.1% at its maximum in 1990). The reductions in survival are estimated to have started fairly abruptly in about 1982 and peaked in about 1984. Survival for this area is estimated not to have recovered to its pre-impact level yet (the survival rate for juveniles for 2001 is predicted to be 89% of the pre-1980 level). In contrast, the impacts on fecundity are estimated to have ceased. Allowing for impacts on both fecundity and survival leads to better fits to the data. The probability of extinction depends critically on the extent of environmental stochasticity in survival. However, the magnitude of this source of variability cannot be estimated from the existing data."

Punt, A.E. and G. Fay. 2003. Estimation of Steller sea lion population dynamics Parameters. Report to the North Pacific Universities Marine Mammal Research Consortium. 48 pp.

The authors develop a spatially-structured individual based Steller sea lion population dynamics model to evaluate two objectives: 1) Examine the scientific value of data to be collected to reduce the variances of the estimates of key population model outputs by means of Monte Carlo simulation. 2) Examine whether experimental management based on spatial replication of treatments can be used to discriminate among the various possible hypotheses for the decline in Steller sea lion population size. The model can generate the types of

demographic data typically available for Steller sea lions (pup counts, counts at haul-outs, estimates of survival rate from mark-recapture studies, and age-composition data). Monte Carlo simulation is used to evaluate the ability of different data collection schemes to distinguish whether population decline was caused by a change in survival rate, pregnancy rate or both. The model was successful in discriminating population trends when changes were gradual (smooth population decline) but had low success when population changes were abrupt. Simulation modeling was also used to evaluate the utility of spatial zoning (open and closed fishing areas) to determine fishery impacts on sea lion abundance. Movement of sea lions between open and closed areas confounded interpretation of the simulated impact of controlled fishing. More empirical data is required to improve model parameter estimates of sea lion movement between rookeries.

Punt, A.E., and G. Fay. 2004. Can experimental manipulation be used to determine the cause of the decline of the western stock of Steller sea lions (*Eumetopias jubatus*)? Presented paper, in Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

See Punt and Fay, 2002, 2004; Fay and Punt 2003, 2004; and Fay, 2004.

Purtov, S.Y., and V.N. Burkanov. 2004. Observation of marked Steller sea lion (*Eumetopias jubatus*) on Antsiferov I. (Kuril Islands) in 2003. Pages 465-467, in Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

The authors report counts of branded Steller sea lions at Antiserov Island (Kuril Islands) in 2003. Approximately two thirds of the 94 resighted animals (62.7%) were originally branded on Antiserov Island, the remainder migrated to Antiserov Island from 7 other locales throughout the Russian Far East. The most distant migrants were from the Yamskie Islands. Migrants also originated from Iony Island in the Sea of Okhotsk and Cape Kozlov on the Kamchatka peninsula. The oldest branded sea lions were 14 years of age and from Lovushki and Raykoke Island. Forty-one of 59 sexually mature sea lions (27 females, 14 males) were of local origin (maximum age 7-years). None of the 14 local origin males was involved in breeding. Overall, there were 35 mature branded females (age 4-14 year); only, 19 (54.3%) of these had pups; 6 (17.1%) had dependent juveniles, and 10 (28.6%) did not participate in breeding. Immigrant females accounted for 15.8% of the total pup production in 2003.

Purtov, S.Y., and V.N. Burkanov. 2005. Changes in winter abundance and distribution of Steller sea lions (*Eumetopias jubatus*) in Commander Islands, Russia. In 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

The authors provide a brief account of the changes in the number of Steller sea lions observed on the Commander Islands. Qualitative estimates of numbers in the mid-19th century were low compared with initial observations in the mid-18th century. Small groups were reported on the island at the turn of the 20th century. By the 1920s numbers had increased, with the species was regarded as common during summer. A survey conducted in 1965 estimated 10,000 sea lions on the Islands at seven predominant sites. By 1978, spring survey counts were a third of the 1965 spring counts. In 2005, the spring survey counted 500 animals, compared to 800 the previous year.

Raum-Suryan, K. L., K. W. Pitcher, D. G. Calkins, J. L. Sease, and T. R. Loughlin. 2002. Dispersal, rookery fidelity and metapopulation structure of Steller sea lions (*Eumetopias jubatus*) in an increasing and a decreasing population in Alaska. Marine Mammal Science 18:746-764.

In this paper the authors examine 25 years of brand resighting data for western and eastern stock Steller sea lions. Just over 7000 brands were placed on pups at 7 rookeries in the Gulf of Alaska in 1975-76. Brands were location and cohort specific, but not specific to individuals. In 1987-88, another 751 individually coded brands were placed on pups at Marmot Island in the GOA, and in 1994-95, 799 individually coded brands were placed on pups at Forrester Island (eastern stock). Resighting efforts varied by year and location, and results from resighting are largely but not exclusively qualitative. Resighting effort in the range of the western stock was distributed among 5 primary locations in the GOA (Sugarloaf Island, Marmot Island, Cape Saint Elias, Otter Island haulout, and Fish Island). Observations were seldom synchronous among locales. Additional opportunistic sampling occurred. In the range of the eastern stock, resighting was concentrated at Forrester Island immediately following branding and continued there through 2000. Additional resighting effort in 1999 and 2000 included most rookery and haulout sites in SE Alaska. Branding was intended to provide information on survival rates, fecundity, movement and site fidelity. Results indicate that pups typically remained within 500 km of their natal rookery, but individuals were widely distributed with minimum distances traveled as great at 1,785 km. There was no observed interchange of animals between the eastern and western Steller sea lion stocks. In the western stock 33% of females were observed pupping at non-natal rookeries compared to 19% of females in the eastern stock.

Raum-Suryan, K.L., M.J. Rehberg, G.W. Pendleton, K.W. Pitcher, and T.S. Gelatt. 2004. Development of dispersal, movement patterns, and haul-out use by pup and juvenile Steller sea lions (*Eumetopias jubatus*) in Alaska. Marine Mammal Science 20:823-850

The authors used satellite telemetry to study the at-sea distribution and movement patterns of pup (1.6–11.9 mo) and juvenile (12.0–35.1 mo) Steller sea lions in the eastern and western populations. Twenty-nine tags were released in the western stock (predominantly in Prince William Sound, but also at Long Island near Kodiak Is), and, 74 tags were released in the SE Alaska range of the eastern stock in 1998 and 2001. Tags were retained by the sea lions for 10-144 d for western stock releases and 3-190 d for eastern stock. Telemetry fixes were filtered through a 3-stage process to eliminate errors and outliers. Round trip distance and duration increased with age, trip distance was greater in the WP than the EP, trip duration was greater for females than males, and haul-out use was clustered. Overall, 90% of round trips were ≤ 15 km from haul-outs and 84% were ≤20 h duration, indicating nearshore areas adjacent to haulouts are critical to the developing juvenile Steller sea lion. One tagged sea lion migrated more than 1100 km from the range of the eastern population into the range of the western population; a second western population animal made an easterly migration of 500 km before the satellite tag was lost. Over half the tagged sea lions utilized multiple haulouts. All movements >500 km were conducted by males.

Riemer, S. D., R. F. Brown and B. E. Wright. 2001.The Steller Sea Lion in Oregon. p. 180 In: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

In this abstract the authors recount studies of eastern stock Steller sea lions along the Orgeon coast from the 1980s through 2001. Trend counts in Oregon indicated 3.9% annual growth rate (i.e., increase in abundance) in the Steller sea lion population from 1,486 animals in 1976 to 3,786 in 2000. Six to eight-hundred pups are reported to be produced annually in the most

recent years. Marked sea lions from Oregon rookeries have been resighted from Northern California to Alaska.

Sease, J. L. and C. Stinchcomb. 2003. 2002 surveys of Steller sea lions in Alaska. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

In this abstract, the authors report on Steller sea lion surveys conducted by The National Marine Mammal Laboratory (NMML) and the Southwest Fisheries Science Center (SWFSC) across Alaska during June and July 2002. Numbers of non-pup Steller sea lions at the 84 western-stock rookery and haulout trend sites increased by 5.5% from 2000 to 2002. Numbers of non-pups in Southeast Alaska increased by 1% from 2000 to 2002. The composite 2001/2002 pup count for the western-stock showed continuing decline in pup production. Pup numbers were down 8% from 1998 and 42% from 1990/1991. Numbers of pups in Southeast Alaska increased by about 11% from 1998 to 2002.

Sease, J. L., and A. E. York. 2003. Seasonal distribution of Steller's sea lions at rookeries and haul-out sites in Alaska. Marine Mammal Science 19(4):745-763.

In this paper the authors contrast the distribution and abundance of Steller sea lions during winter and summer. The authors present data on Steller sea lion abundance surveys conducted during the breeding season, mid-June to early July 1992, 1994, and 1998 and compare those numbers with the winter distribution of sea lions as indicated by surveys conducted during March 1993, November–December 1994, and March 1999. They counted about one-half as many sea lions during winter surveys compared to the breeding-season surveys. Numbers of sea lions at rookery sites dropped off considerably during winter, whereas numbers at haul-out sites did not. The authors found little evidence of large-scale, seasonal movement, at least for the western stock of sea lions. Rather, differences between summer and winter distribution were primarily a function of sea lions dispersing to local haul-out sites during the winter. Terrestrial sites, both rookeries and haul-outs, were important to Steller's sea lions during the entire year. Individual sites may be occupied year-round or only during particular times of year.

Sease, J. L., and C. J. Gudmundson. 2002. Aerial and land-based surveys of Steller sea lions (*Eumetopias jubatus*) from the western stock in Alaska, June and July 2001 and 2002. NOAA Tech. Memo. NMFS-AFSC-131. 45 pp.

This report provides results from The National Marine Fisheries Service (NMFS) aerial and land-based surveys of the western stock of Steller sea lions (Eumetopias jubatus) in Alaska during June and July of 2001 and 2002 at all sites from 144° W to 172° E, the westernmost point in the Aleutian Islands. Survey effort in 2001 was restricted to pup counts at selected sites in the Aleutian Islands and the Gulf of Alaska. The 2002 survey included the entire western stock: aerial surveys of non-pups at all sites and pup counts at all rookeries except those counted in 2001. In June 2002, a total of 26,602 non-pups were counted on all surveyed sites ($n = 259$). These counts represent an increase of 5.5% for all trend sites and 6.8% for trend rookeries from June 2000, the first region-wide increase observed since standardized aerial surveys began in the 1970s. Counts were still down compared to 1998 (-5.4% for all trend sites and -1.2% for trend rookeries) and down more than 30% since 1990. From 1991 to 2002, the population declined by an average of 4.1% per year ($P < 0.001$: 95% C.I.= -2.8% to

-5.5%) for all trend sites and 3.9% per year (P = 0.002: 95% C.I.= -2.3% to -5.6%) at the trend rookeries.

Region-wide pup counts are on a 4-year schedule (including 2002), with counts at selected sites during intervening years. During June and July 2001, NMFS personnel counted 3,837 live pups at 11 rookeries and 90 live pups at five haul-out sites in Alaska. During June and July 2002, NMFS counted 5,472 live pups at 27 rookeries and 178 live pups at six haul-out sites. Pups were counted in both years at Marmot, Ugamak, and Semisopochnoi Island rookeries and at the Seguam Island, Turf Point haul-out site. Using a composite of 2001 and 2002 pup counts, the total pup count for the western stock was 8,345 live pups at 35 rookeries and 244 live pups at 10 haul-out sites. This represented a decline of 11.2% since 1998 for the western stock in Alaska.

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. noaa Tech. Memo. NMFS-AFSC-122. 52 pp.

The National Marine Fisheries Service (NMFS) and the Alaska Department of Fish and Game (ADF&G) conducted aerial and land-based surveys of Steller sea lions (*Eumetopias jubatus*) in Alaska during July 1999 and June 2000. The 1999 aerial survey was restricted to the eastern Gulf of Alaska, where we counted 2,072 non-pup Steller sea lions on 23 rookery and haul-out sites. In June 2000, we counted a total of 37,801 non-pups on 289 rookery and haul-out sites from Southeast Alaska through the western Aleutian Islands. Of these non-pups Alaska-wide, 28,187 were on the 94 trend rookery and haul-out sites, which was a decline of 3.2% from 1998 and 26.1% from 1990. The 33 trend rookeries Alaska-wide included 20,298 non-pups, indicating declines of 3.8% from the 1998 count and 26.4% from 1990. Estimated average annual rates of decline from 1990 to 2000 were 3.2% (P < 0.001: 95% C.I.= 2.5% to 3.9%) for all trend sites and 3.3% (P < 0.001: 95% C.I.= 2.7% to 3.9%) for the 33 trend rookeries.

The eastern stock is represented in Alaska only by Southeast Alaska, where we counted 12,417 non-pups at all 25 sites in June 2000. The count of 9,862 non-pups at 12 trend sites represented increases of 13.4% from 1998 and 29.3% from 1990. At the three trend rookeries in Southeast Alaska, we counted 6,896 non-pups, which represented increases of 4.4% from 1998 and 25.6% from 1990. Estimated annual increases from 1990 to 2000 in Southeast Alaska were 1.9% (P = 0.058: 95% C.I.= 3.8% to -0.1%) for all trend sites and 1.6% for trend rookeries (P = 0.041: 95% C.I.= 3.0% to 0.1%).

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. Marine Mammal Science. 17:136-146.

The authors evaluated counts made from medium-format, color, aerial photographs as an alternative to drive counts and peripheral counts. Neither the peripheral counts nor the aerial photographic counts disturbed animals on the rookeries. There were strong 1:1 linear relationships between photographic counts and drive counts ($r2$ = 0.966, P < 0.001) and between photographic counts and peripheral counts ($r2$ = 0.999, P < 0.001). Precision was similar for all three methods of counting.

Soto, K., A.W. Trites, and M. Arias-Schreiber. 2004. The effects of prey availability on pup mortality and the timing of birth of South American sea lions (*Otaria flavescens*) in Peru. Journal of Zoology London 264: 419-428.

> "Pup mortality and the timing of birth of South American sea lions *Otaria flavescens* were investigated to determine the possible relationship between fluctuations in prey availability in the Peruvian upwelling ecosystem and current and future reproductive success of sea lions during six consecutive breeding seasons. This study conducted from 1997 to 2002 encompassed the strongest El Niño on record and one La Niña event. Pup mortality ranged from13% before El Niño to 100% during El Niño, and was negatively correlated with prey availability. Abortions were also more frequent when prey availability was low. However, pup mortality remained high following El Niño due to the punctuated short-term effects it had on population dynamics and subsequent maternal behaviour. Births occurred later in the season after years of low food availability and earlier following years of high food availability. The peak of pupping occurred around the peak of mortality in all years, and may have been the product of intensive competition between bulls at the peak of the breeding season. The stronger and more frequent El Niños that appear to be occurring along the Peruvian coast may produce significant stochastic changes in future births and pup mortality, which may place the vulnerable South American sea lion population in Peru at greater risk."

Soto, K., A.W. Trites, and M. Arias-Schreiber. in press. Changes in diet and maternal attendance of South American sea lions indicate changes in the marine environment and the abundance of prey. Marine Ecology Progress Series 0: 000-000.

> "Behavioural observations were made of South American sea lions (*Otaria flavescens*) in Peru to determine whether changes in their diet and maternal attendance patterns reflected physical changes in the marine environment and alterations in the abundance and distribution of prey. The study was undertaken during breeding seasons (1998-2002) that encompassed a strong El Niño (1997-1998) and a moderate La Niña (1999-2001). Observations revealed strong linkages between maternal attendance patterns and the abundance of prey and oceanographic features close to the rookeries. Acute prey shortage during El Niño resulted in females increasing the length of their foraging trips and decreasing the time they spent onshore with their pups. In contrast, shorter times at sea and longer times onshore were observed during the favourable conditions of La Niña when their preferred prey (anchovy and squat lobster) were more abundant near the rookeries. Pup mortalities increased when females spent more time at sea searching for prey and did not return frequently enough to nurse their pups. Greater numbers of species (particularly demersal fishes) were consumed during El Niño when anchovy and lobster were less available. Females appeared to adjust their diets and maternal attendance patterns in response to annual changes in the abundance and distribution of their prey. These observations suggest that diet and maternal responses reflect interannual fluctuations of the unpredictable Peruvian upwelling ecosystem, and imply that South American sea lions may be good indicators of relative changes in the distribution and abundance of marine resources."

Taylor, B., G. O'Corry Crowe, M. Basterretche, T. Loughlin, T. Gellat, J. Bickham, and K. Pitcher. 2003. Using molecular genetics to estimate dispersal rates between Steller sea lion rookeries, p. 160-161 in 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p. (1)

In this abstract the authors report on analysis of long sequences (532 bp) of mtDNA from 60-150 individuals per rookery used to estimate mixing rates among rookeries. Estimated dispersal rates among eastern stock Steller sea lions ranged from 0.1 to 1% y^{-1} (5-50 females), implying rookeries are connected. By contrast, estimated dispersal rates for western stock Steller sea lions were about 0.01% y^{-1} (<< 1 female), implying the rookeries were essentially isolated.

Taylor, R.L. 2005. Assessing reproductive rates in branded Steller sea lion (*Eumetopias jubatus*). Poster. In 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This abstract is present in its entirety, "The Alaska Department of Fish and Game branded 362 female pups at the eastern stock's Forrester Island Rookery Complex in 1994-1995. From 2000-2004, 17777 sightings have been made of 114 branded females with and without pups. These data are being use to estimate current reproductive rates for the eastern stock. Steller sea lion reproductive status and location fare highly associated. Females who reproduce spend the first few post-partum weeks on land and return to the same rookery throughout much of the summer to nurse their pups. Females who do not pup usually frequent haulouts. Only one of the 167 pups sighted was at a haulout. Due to practical necessities there is also an association between location and resighting effort. Resighting effort and number of cow sightings is higher at rookeries (1963 hours, 1636 sightings) than haulouts (412 hours, 139 sightings). Thus resighting effort and reproductive status are associated with each other, because they are both location specific. As a result, apparent reproductive rates (27-68% per cohort per year) are expected to overestimate actual reproductive rates. I designed a multinomial model to describe the complex interaction among reproduction, location and sightability in branded Steller sea lions. Data were simulated according to this model and were analyzed using Markov chain Monte Carlo methods. I evaluate the performance of a series of models of increasing complexity to determine the best method to disentangle this interaction given the sample size constraint of the actual data."

Teate, E., P. Parker, J.M. Maniscalco, and K. Harris. 2005. Tenure and reproductive success of Steller sea lions (*Eumetopias jubatus*) males at Chiswell Island, Gulf of Alaska. In 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Breeding season tenure (1999-2004) and reproductive success (2001-2004) of Steller sea lion males was examined using remote cameras at Chiswell Island (GOA). Nineteen individually recognized males copulated at least once (average 5.4 per year) over the 6-year study period (24 May to 15 July annually). Inter-annual tenure lasted 1-4 years with copulation success increasing during the first 3 years. Territories ranged in size from 36-225 m^2 (mean, 144 m^2); and males held territories 9-62 days. Females appeared to prefer territory over specific males as indicated by copulation success within different territories. Eighty-five percent of copulations produced a pup the following year, with no significant variation between years.

Testa, J. W., J.L. Sease, C.E. Stinchcomb, K. W. Pitcher, T. S. Gelatt, W. L. Perryman, and T. R. Loughlin. 2003. Calibrating different counting methods and modeling recent trends in the western stock of Steller's sea lions. P. 162, in 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p

In this abstract the authors describe the application of Bayesian methods to test the effectiveness of new Medium Format (MF) photography as an aid to improved aerial counts of Steller sea lions. MF photos provided a slight improvement [presumably better precision] over the older 35 mm oblique photographs typically used for aerial surveys.

Testa, J.W., R.R. Ream, R. Hobbs, and P.R. Wade. 2004. Status and trend of selected marine mammals in Alaska: Steller sea lions, northern fur seals, Cook Inlet beluga whales, and North Pacific right whales. In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK .

In a very brief comment within this abstract, the authors report that, "The western stock of Steller sea lions…showed some evidence of arrested decline, or even slight recovery in parts of its range in the most recent surveys (2002), but continued decline I the far west."

Trites, A.W. and B.T. Porter. 2002. Attendance patterns of Steller sea lions (*Eumetopias jubatus*) and their young during winter. Journal of Zoology, London 256:547-556.

The authors of this paper describe the duration of on-shore stays and offshore foraging trips by lactating female Steller sea lions and nursing pups and juvenile on a Southeast Alaska haulout during winter. Of interest with respect to vital rates, in this instance the ability to count animals, is their note on the probability of sighting an individual on a winter haulout during daylight hours. The authors estimate a 15% probability of sighting a lactating female and a 40% probability of sighting an immature animal.

Trukhin, A.M., and V.N. Burkanov. 2002. Observations of marked Steller sea lions on Raykoke Island (Kuril Islands) in 2001. In Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

The authors report on Steller sea lion marking studies conducted in the Kuril Islands from 1989 to 1999 and specific monitoring efforts to resight marked animals in 2001. Marks were applied in 1989, 1991 and annually from 1995-1999. In 1989 marks were a combination of brands and flipper tags, in 1991 and 1995, only flipper tags were applied, and from 1996-1999 branding was the only mark used. Sea lions were marked at 5 rookeries: Brat Chirpoev, Srednego, Lovushki, Raykoke and Antsiferov Islands. In total, 3070 pups were marked. Resighting observations were gathered at Raykoke Island in 2001. Seventy marked animals were observed; 86% were of local origin, 9% were from Lovushki Island, 4% from Srednego and 1% from Antsiferov Island. Most of the resighted animals were 3-years old or older. Males and females were resighted in near equal numbers.

Vazhenina, V.B. 2004. Steller sea lion (*Eumetopias jubatus*) sightings in Chukotka. Pages 116-117, in Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

The author reports on sightings of Steller sea lions in far northerly reaches of the Bering Strait north of latitude 64°08' and west of 171°10' W longitude.

Waite, J.N. 2000. Three-dimensional photogrammetry as a tool for assessing morphometrics and estimating body mass of Steller sea lions. M.S. thesis, Texas A&M University.

The thesis abstract is presented in it's entirety: "A technique was developed to indirectly assess morphometrics and to estimate body mass of Steller sea lions (Eumetopias jubatus) using three-dimensional (3D) photogrammetry. 3D computer wireframes of thirty-five Steller sea lions of various age classes were generated from multiple time-synchronous digital photos. Overall average estimates of standard length and axillary girth were within ±2.8% and ±4.2% of physically measured dimensions, respectively. Average estimates of standard length and axillary girth from wireframes based on ideal body postures were within ±1.7% and ±3.1% of physically measured dimensions, respectively. These measurements were used to estimate body mass by applying previously existing regression equations. Regressions of physically measured mass on photogrammetrically estimated body volume yielded a predictive model. Body mass estimates using this model were on average within 10.5% (with a 95% confidence interval of ±2.35%) of the physically measured mass. The use of 3D photogrammetry decreases many of the problems associated with camera and body position encountered with two-dimensional photogrammetric techniques. This technique can be used to estimate the body mass of free-ranging, active sea lions, eliminating the need for sedation, heavy weighing equipment, and animal disturbance."

Waite, J. N. and M. Horning. 2001. Three-Dimensional Photogrammetry as a Tool for Assessing Morphometrics and Estimating Body Mass of Steller Sea Lions. p. 227 In: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver,

Same information as provide in the Master's Thesis above [see Waite, 2000].

Waite, J.N., and V.N. Burkanov. 2005. Steller sea lion research in the Russian Far East. Chapter 12, pages 101-106, in Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

In this paper, the authors provide a brief description of research studies and data collected during Steller sea lion investigations of rookeries and haulouts in the Russian Far East between 2001 and 2004. There is no information on counts or survival rates. Tabular data are provided on the number of sea lions branded by year and region. In total, 2031 sea lions were marked over the four year interval at nine different rookeries.

Willoya, L. Jack, and M. King. 2005. Steller sea lion photographic monitoring and brand resights of local, seasonal haulouts in Prince William Sound, Alaska. In 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

In this abstract, the authors briefly describe a program to gather traditional ecological knowledge from members of native communities in Prince William Sound. Community members are monitoring areas outside of typical aerial survey sites. Natives report specific sea lion usage of sites by juveniles and pups and separate site usage by adult males. In addition, natives have documented 130 brand resightings.

Winship, A. J. 2000. Growth and bioenergetic models for Steller sea lions (*Eumetopias jubatus*) in Alaska. Masters Thesis, University of British Columbia. 160 p.

In this thesis the author constructs a bioenergetic model to predict the food requirements of Steller sea lions. Within the thesis, Steller sea lion abundance estimates, age specific survival rates and maturity schedules are used as inputs to the model. Abundance indices were derived from Sease and Loughlin (1999) and survival data from Trites and Larkin (1992) and York (1994). Maturity schedules were adapted from Pitcher and Calkins (1981).[5] Thesis findings are more related to the Foraging Theme and/or Life History than they are to Vital Rates.

Winship, A, and A.W. Trites. 2003. The probabilities of extinction of Steller sea lion populations in Alaska. P. 178, in 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

In this abstract, the authors describe population viability analyses conducted at the level of individual Steller sea lion rookeries in Alaska. Results are presented in greater detail in Winship and Trites (2006) below.

Winship, A.J., and A.W. Trites. 2003. Population viability analysis of the Steller sea lion: a Bayesian approach. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

In this abstract, the authors describe population viability analyses conducted at the level of individual Steller sea lion rookeries in Alaska. Results are presented in greater detail in Winship and Trites (2006) below.

Winship, A., and A. Trites. 2005. Risk of extirpation of the Steller sea lion in the Gulf of Alaska and Aleutian Islands. In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK.

In this abstract, the authors describe population viability analyses conducted at the level of individual Steller sea lion rookeries in Alaska. Results are presented in greater detail in Winship and Trites (2006) below.

[5] Pitcher, K. W., and D. G. Calkins. 1981. Reproductive biology of Steller sea lions in the Gulf of Alaska. J. Mammal. 62:599-605.

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.

Trites, A. W., and P. A. Larkin. 1992. The status of Steller sea lion populations and the development of fisheries in the Gulf of Alaska and Aleutian Islands. Fisheries Centre, University of British Columbia, 134 p.

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

Winship, A.J. and A.W. Trites. 2006. Risk of extirpation of Steller sea lions in the Gulf of Alaska and Aleutian Islands: A population viability analysis based on alternative hypotheses for why sea lions declined in western Alaska. Mar. Mamml. Sci. 22(1)124-155.

The paper's abstract is presented in its entirety, "We estimated the risk that the Steller sea lion will be extirpated in western Alaska using a population viability analysis (PVA) that combined simulations with statistically fitted models of historical population dynamics. Our analysis considered the roles that density-dependent and density-independent factors may have played in the past, and how they might influence future population dynamics. It also established functional relationships between population size, population growth rate and the risk of extinction under alternative hypotheses about population regulation and environmental variability. These functional relationships can be used to develop recovery criteria and guide research and management decisions. Life table parameters (e.g., birth and survival rates) operating during the population decline (1978–2002) were estimated by fitting simple age-structured models to time-series of pup and non-pup counts from 33 rookeries (subpopulations). The PVA was carried out by projecting all 33 subpopulations into the future using these estimated site-specific life tables (with associated uncertainties) and different assumptions about carrying capacities and the presence or absence of density-dependent population regulation. Results suggest that the overall predicted risk of extirpation of Steller sea lions as a species in western Alaska was low in the next 100 yr under all scenarios explored. However, most subpopulations of Steller sea lions had high probabilities of going extinct within the next 100 yr if trends observed during the 1990s were to continue. Two clusters of contiguous subpopulations occurring in the Unimak Pass area in the western Gulf of Alaska/eastern Aleutian Islands and the Seguam–Adak region in the central Aleutian Islands had relatively lower risks of extinction. Risks of extinction for a number of subpopulations in the Gulf of Alaska were reduced if the increases observed since the late 1990s continue into the future. The risks of subpopulations going extinct were small when density-dependent compensation in birth and survival rates was assumed, even when random stochasticity in these vital rates was introduced."

Winship, A.J., A.W. Trites and D.G. Calkins. 2001. Growth in body size of Steller sea lions (*Eumetopias jubatus*). Journal of Mammalogy 82:500-519.

Growth models (length/weight and weight-at-age) were developed from measurements of Steller sea lions sampled throughout Alaska. Separate weigth-at-age models were fit for pregnant and non-pregnant females. Pregnant females were longer and heavier than non-pregnant females of the same age. Males achieved 90% of their asymptotic length and mass by 8 and 9 years of age, respectively, compared with 4 and 13 years, respectively, for females. Average predicted standard lengths of males and females ≥12 years of age were 3.04 and 2.32 m, respectively, and average predicted masses were 681 and 273 kg, respectively.

Wolf, N., and M. Mangel. 2005. Understanding the decline of the western Alaskan Steller sea lion: Assessing the evidence concerning multiple hypotheses. Final report for contract AB133F-02-CN-0085 to the National Marine Fisheries Service. 91 text pages and 84 figure pages. Available at the National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

These authors use a modeling approach to systematically and objectively test 10 competing hypotheses covering the decline in Steller sea lion abundance. Three hypotheses deal with acute nutritional stress and its effect on Steller sea lion fecundity, pup survival and non-pup survival. Similarly, another three hypotheses deal with chronic nutritional stress and its impact on fecundity and survival. There are two hypotheses relating to direct fishery induced mortality and two more hypotheses that relate to predation upon Steller sea lions. Data are arrayed at the spatial scale of the rookery. Functional relationships in the model are constructed to represent each hypothesis by a separate single parameter. Test for each hypothesis is classed in a 3x3 array representing strong, weak or no evidence (based on estimated parameter values and confidence intervals) versus strong, moderate and weak effects (based on the parameter contribution to the overall model likelihood). The authors conclude that there is strong evidence that local prey availability (acute nutritional stress) has a strong effect on sea lion fecundity; additionally, they conclude that there is strong evidence that chronic nutritional stress has a strong effect on sea lion recruitment. The authors also indicate that there is strong evidence of a moderate effect of predation on pup survival. The remaining 7 hypotheses are classed as showing weak or no evidence of a weak effect on sea lion fecundity, recruitment and survival.

Wolf, N., J. Melbourne, and M. Mangel. 2004. The method of multiple (spatial) hypotheses and the decline of Steller sea lions in western Alaska. Presented paper. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This is a very brief abstract describing models under construction. See Wolf and Mangel, 2005 above.

Wolfe, R.J. 2001. The subsistence harvest of harbor seals and sea lions by Alaska natives. 2000. ADFG, Division of Subsistence, Technical Paper No. 266. 241 p.

This paper presents results from an annual in-person survey of seal and sea lion subsistence hunters in 62 coastal communities throughout Alaska. Surveys were conducted in January 2001 asking respondents to recount monthly harvests of seal and sea lions between January and December 2000. The survey provides data on total take (numbers killed and recovered plus numbers struck and lost). Sex of the harvested animal is ascertained as is crude demographic data (pups, juvenile, adult). In addition the survey provides demographic information on the participation level of hunters in the community and hunter success rate among other ancillary data. Total estimated Steller sea lion subsistence harvest in 2000 was 205 animals (95% CI 147-306). Harvest occurred in 18 of 62 communities. The report also provides a time series of recent harvest from 1995 to 2000.

Wolfe, R.J., J. Fall, and R.T. Stanek. 2002. The subsistence harvest of harbor seals and sea lions by Alaska natives. 2001. ADFG, Division of Subsistence, Technical Paper No. 273. 250 p.

This paper is a continuation of annual reports on subsistence seal and sea lion harvests. Steller sea lion subsistence harvest in 2001 was estimated to be 198 animals (95% CI 162-282). Harvest occurred in 19 of 62 surveyed communities. The 2000 subsistence harvest seems to be revised downward from the estimate reported in Wolfe 2001. This paper lists the 2000 harvest as 164 sea lions.

Wolfe, R.J., J. Fall, and R.T. Stanek. 2003. The subsistence harvest of harbor seals and sea lions by Alaska natives. 2002. ADFG, Division of Subsistence, Technical Paper No. 277. 249p.

This paper is a continuation of annual reports on subsistence seal and sea lion harvests. Steller sea lion subsistence harvest in 2002 was estimated to be 185 animals (95% CI 140-236). Harvest occurred in 16 of 62 surveyed communities. The 2000 subsistence harvest seems to be revised again from the estimate reported in Wolfe 2001. This paper lists the 2000 harvest as 171 sea lions.

Wolfe, R.J., J. Fall, and R.T. Stanek. 2004. The subsistence harvest of harbor seals and sea lions by Alaska natives. 2003. ADFG, Division of Subsistence, Technical Paper No. 291. 253 p.

This paper is a continuation of annual reports on subsistence seal and sea lion harvests. Steller sea lion subsistence harvest in 2003 was estimated to be 212 animals (95% CI 149-303). Harvest occurred in 17of 62 surveyed communities.

Womble, J. N., B. P. Kelly, M. F. Willson and M. Sigler. 2001. Spatial Ecology of Steller Sea Lions (*Eumetopias jubatus*) and Forage Fish Aggregations in Southeastern Alaska. p. 236 In: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

In this abstract the authors describe aerial surveys conducted to enumerate Steller sea lions occupying seasonal haulouts in Southeast Alaska. The motive for these surveys was to correlate seasonal distribution at haulouts with seasonal aggregations of forage fish (eulachon and herring). The authors did find a correlation between sea lion abundance and the abundance of forage fish. No abundance information is provided in the abstract.

Wynne, K. and D. Mercy (eds). 2005. Alaska's Steller sea lions boom to bust - and back? In, Alaska Seas and Coasts, Vol. 1(May): 12p Alaska Sea Grant/Marine Advisory Program.

This is a journalism style article, written more for mass communication than for a technical audience. The authors recount the status of Steller sea lions, provide a description of abundance trends and population rate of change, review sea lion protection measures and discuss ecosystem interactions.

York, A. E., and E. E. Holmes. 2003. Using age structure to detect impacts on threatened populations: a case study using Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

This abstract describes the development of a model to evaluate time-varying changes in the demographic characteristics of the CGOA Steller sea lion population. The results are reported in greater detail in published paper by Holmes and York, 2003.

York, A.E., J. Thomason, and E. Sinclair. 2002. Stable isotopes in teeth of Steller sea lions: do they tell us the age at weaning? In Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

In this brief article, the authors present evidence regarding changes in the concentrations of $\delta^{13}C$ and $\delta^{15}N$ in the dentine of teeth collected from 113 male Steller sea lions. The carbon and nitrogen concentrations are measured for the growth layer group (GLG) 1- 4. The sampled teeth were collected from sea lions aged 3-17 years and represent cohorts from the 1960 to the 1983. Distinct differences were observed between isotope concentration in GLG 1 and GLG4. These differences were attributed to reliance on mothers milk in the first years of growth. Temporal differences in the rate of change in isotope concentrations were also noted with distinct changes detected around 1976. The authors noted that the number of nursing 2-y old animals increased from 35-50% between 1960 and 1980, except for the

period around 1975-76. There was a strong deviance from the expected value of nursing 2-y old sea lions at that time. The authors speculate that the 1975-76 regime shift made it more difficult for females to nurse their pups into the second year, and that a greater proportion of surviving pups were weaned by the end of their first year during this period.

York, A.E., J. Thomason, and E. Sinclair. 2005. Stable isotopes in the teeth of Steller sea lions: Do they tell us the age of weaning? In 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

This abstract updates statistical analyses applied to data collected and discussed in York, Thomason and Sinclair (2002, above). The authors used a linear discriminant function (LDF) to discriminate between growth layer groups one and four (GLG-1, GLG-4), then evaluated the carbon and nitrogen isotope levels in GLG-2 and GLG-3 to determine if they were more similar to GLG-1 or GLG-4. The LDF classified 60% of the animals as weaned by the end of their first year, another 30% in their second year, and another 10% in their third year. The proportion of 2-year old animals, classified as nursing, increased during 1960-1980 (expect for 1975-1976 regime shift) from about 35-50%; however, the observed proportion of nursing animals for the time of the regime shift was only 23% , less than predicted value of 45% based on the increasing trend. The authors conjecture, that at the beginning of the regime shift, it was mere difficult for females to nurse their pups into the second year and that a greater proportion of pups that survived (to have their teeth sampled for this study) were weaned by the end of their first year.

Zadalskiy, S.V. 2002. Population status and migrations of Steller sea lions in the northern part of the Sea of Okhotsk. In Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

The author provides an account of sea lion population numbers at 2 Sea of Okhotsk rookeries and 1 haulout: Lisyanski Peninsula, Yamkie Islands, and Zavyalova Island respectively. Surveys conducted in 2000 recorded 1314 sea lions (including 427 pups) at Yamskie Is. And 225 sea lions (including 20 pups) ast Lisyanksi. In 2001, 1335 sea lions (including 360 pups) were counted at Yamskie, there was no count available for Lisyanki. At Zavyalova Is, 128 bachelor males were observed in 2001. One-hundred and seventy pups were marked at Matykil Is, 90 in 2000, and 80 more in 2001. Nine of the pups marked in 2000 were seen on the island in 2001, another was observed at Tuyleni Is. In addition, while marking animals on Matykil Is., the author observed branded animals from Antsiferova, Sredneva, Rayoke, Lovushki, and Jonah Is.

Zagrebin, I.A., and D.I. Litovka. 2004. Distribution of Steller sea lions (*Eumetopias jubatus*) in north-western Anadyr Gulf and western Bering Strait in 1994-2003. Pages 331-335, in Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.

The author provides a brief account of surveys conducted from shore and sea in the 3 predominant sites in the northwestern Anadyr Gulf and 2 sites in the western Bering Strait from July through November 1995 to 2003. Counts increased annually from a low of 16 animals in 1996 to 386 sea lions in 2003. The highest numbers were observed around the village of Sireniki in the northwestern Anadyr Gulf. Sea lions were considerably more rare in the western Bering Strait.

Zavadil, P.A., A.D. Lestenkof, M.T. Williams, and S.A. MacLean. 2003. The subsistence harvest of Steller sea lions on St. Paul Island in 2002. Annual Report provided to the National Marine Fisheries Service under contract NA16FX1420. 17 pp. Available, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

See Zavadil et al., 2005

Zavadil, P.A., A.D. Lestenkof, D. Jones, P.G. Tetoff, and M.T. Williams. 2004. The subsistence harvest of Steller sea lions on St. Paul Island in 2003. Annual Report provided to the National Marine Fisheries Service under contract NA16FX1420. 17 pp. Available, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

See Zavadil et al., 2005

Zavadil, P.A., D. Jones, A.D. Lestenkof, P.G. Tetoff, and B.W. Robson. 2005. The subsistence harvest of Steller sea lions on St. Paul Island in 2004. Annual Report provided to the National Marine Fisheries Service under contract NA16FX1420 and AB133F05RP1163. Available, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

Upon review of past reports by ADFG Subsistence Division (see Wolf et al., 2001, 2002), the Ecosystem Conservation Office of the Tribal Government of St, Paul felt that there was considerable uncertainty on the part of sea lion hunters and the local community with respect to the ADFG reported results, specifically in regard to the accuracy of the data collected by retrospective survey and the presentation of results. Since 2001, The ECO has managed the SSL harvest on the island and provides NMFS (and others) an annual summary of subsistence takes based on real time (in-season) harvest information. (See Lestenkof et al., 2003, Zavadil et al., 2003 and 2004).

For 2004, the ECO reports 18 SSLs were taken of which nine were harvested and nine were struck and lost. Age and sex information are provided for each take, when known. A table is provided that summarizes take for 2001-2004. Twenty four sea lions were taken in 2001, 36 in 2002, and 18 in 2003. Of the 96 animals taken over this period, 55% were struck and lost.

(This page intentionally left blank)

THEME 4: FISH ASSESSMENTS AND FISHERIES

There are 31 journal articles, 3 technical reports, 5 theses, 6 book articles, 6 contract reports, 15 manuscript reports, and 33 symposia presentations, abstracts and posters represented in this section.

SUMMARY

<u>Principle Prey Species – Abundance Trends</u>
In the Gulf of Alaska, Eastern Bering Sea and Aleutian Islands pollock, Pacific cod, and Atka mackerel, three commercially exploited groundfish species, are recognized as principle prey of Steller sea lions. Sea lions consume pollock and Atka mackerel year round while they seem to show a stronger seasonal preference for Pacific cod. Stock status for these three groundfish species is evaluated annually and reported in the NMFS Stock Assessment and Fishery Evaluation (SAFE) reports. Independent reports are written for each management plan: Gulf of Alaska (GOA) and Bering Sea/Aleutian Islands (BSAI). There are separate reports for each species including three regional pollock assessments for the BSAI: Eastern Bering Sea (EBS), Aleutian Islands (AI) and Bogoslof.

<u>BSAI</u>: The largest pollock stock is in the EBS. Model estimated stock biomass has remained stable at 10 mmt since the 1980s (Ianelli et al., 2005a). Mean annual catch increased from 1.2 mmt in the 1990s to 1.4 mmt since 2000. Catch is consistently less than the Acceptable Biological Catch (ABC); and annual percent utilization (Catch/Biomass) has averaged 14% since 2000. In 2005, the proportion of catch from the sea lion conservation area (SCA) was 44% in the January-June time period, 17% from July-December, and 29% overall.

In the Aleutian Islands, pollock stock abundance was traditionally estimated from trawl surveys; in 2003 a demographic population model was introduced, and that model was updated in 2005 (Barbeaux et al., 2005). Compared to the EBS, there is considerably less data and greater uncertainty in the model estimated abundance of pollock in the AI. Nevertheless, the population trend since 2000 is estimated to be increasing. Dependent upon the model used, 2005 stock biomass is estimated to be 218 to 469 kmt. Estimated allowable catch ranges between 29,000 and 102,900 mt. Annual catch averaged 49,000 mt in the 1990s and dropped to 1200 mt since 2000.

The Bogoslof stock of pollock is considered a part of the Aleutian Basin stock, which includes the international waters known as the Donut Hole (Ianelli et al., 2005b). The Bogoslof area is thought to contain 60% of the Aleutian Basin stock. Directed fishing in the area has been closed since 1992. Since 2000, incidental catch has ranged from 29 to 1042 mt, but has typically been less than 100 mt. Model estimated biomass was 3.0 mmt in the 1980s, 833 kmt in the 1990s and has averaged 454 kmt since 2000.

Pacific cod are a seasonally important prey item for Steller sea lions particularly during the winter and early spring. Furthermore, the size ranges of Pacific cod harvested by the fisheries and consumed by Steller sea lions overlap, and the fishery operates to some extent in the same geographic areas used by Steller sea lion as foraging grounds. Model estimated Pacific cod stock biomass has been declining since the 1970s (Thompson and Dorn, 2005a). It averaged 1.5 mmt in the 1980s, 1.1 mmt in the 1990s, and 960 kmt since 2000. At the same time, mean annual catch increased from 126 kmt in the 1980s to 207 kmt in the 1990s and has declined to 192 kmt since 2000. The annual utilization rate has averaged 17% since 2000.

The catch of Aleutian Island Atka mackerel has averaged 55,000 mt since 2000, compared with 60,000 mt in the 1990s and 25,000 mt in the 1980s (Lowe et al., 2005a). Mean model estimated biomass was 381, 508, and 479 thousand mt in the 1980s, 1990s and since 2000 respectively. The fishery exploitation rate has been steady since the 1980s at just over 12% per year.

GOA: GOA pollock estimated annual biomass had been declining in the 1990s, but showed an upward trend in the early 2000s (Dorn et al., 2005). Model estimated population biomass (age 3+) averaged ~1.1 mmt in the 1990s (range 0.6-1.7 mmt) and declined to an average 732 kmt since 2000. Catch has declined from a peak of 307 kmt in 1984 to 63.9 kmt in 2004. Annual fishery exploitation rate ranged from 1-15% from 1969-2005, with the median value since 2000 being 8%.

In the GOA, Pacific cod model estimated stock biomass reflects an increasing population from the late 1970s through the 1980s and a subsequent decline from the 1990s to present (Thompson and Dorn, 2005b). The stock assessment author's preferred model mean annual estimated biomass was 609 kmt in the 1980s, 736 kmt in the 1990s and 562 kmt since 2000. The NPFMC GOA Plan Team preferred an alternate model which estimated a lower biomass but with similar trends (Anonymous, 2005). Gulf of Alaska area catch of Pacific cod has averaged 54 kmt y^{-1} since 2000, compared to an average annual catch of 31 kmt in the 1980s and 70 kmt in the 1990s. Average annual utilization rate has been 9% since 2000.

Atka mackerel seem to be at the eastern end of their range and are prevalent predominantly in the western portion of the Gulf of Alaska,. While abundant in the early 1980s, the GOA population declined following a short pulsed foreign fishery. There are insufficient data to construct an Atka mackerel demographic model in the GOA. Furthermore, due to the sparse and patchy distribution of the biomass, trawl survey estimates of stock abundance are also highly variable (Lowe, et al., 2005b). Survey estimated biomass in 2005 was 97 kmt with coefficient of variation of 51%. The stock is managed based on the average catch over time. Since 2000 the catch has average 435 mt.

Fishery/Steller sea lion Interactions

There have been three controlled experiments to evaluate fishery effects on Steller sea lions (Wilson et al., 2003; Connors et al., 2004; McDermott et al., 2005). Wilson et al., (2003) studied the GOA pollock fishery around Kodiak Island. Opened and closed fishing areas were established at Barnabus and Chiniak Troughs. Surveys were conducted prior, during and after fishing, in treatment and control areas. Results did not indicate a significant link between fishing activities and changes in juvenile and adult pollock geographic distribution. Connors et al. (2004) conducted controlled experiments to monitor potential local depletion of Pacific cod in the intensive winter fishery near Unimak Island. Again there were designated open and closed fishing areas and Pacific cod catch rates were monitored with survey gear (pots) simultaneously in treatment and control areas. There was no evidence of fishery induced local depletion in their experiment. Connor's findings contradict Fritz and Brown (2005) who estimated a potentially large local depletion effect in 2001 using Leslie models to interpret commercial fishery catch rates. McDermott et al. (2005) report the results of 1999 and 2000 Atka mackerel tagging studies in the Aleutian Islands near Seguam Pass. Fish were tagged inside and outside the 20 nm Steller sea lion trawl fishery exclusion zones. Researches detected little movement of fish between the protected and unprotected zones. Logerwell (2004) and Logerwell and McDermott (2004) report that results are mixed elsewhere in the Aleutian Islands.

Competition for Prey

Competition for prey between commercial fisheries and pinniped populations is evaluated by Baraff and Loughlin (2000), Shima, Hollowed and VanBlaricom (2000) and Trites, Christiansen and Pauly (in press). The pinniped populations in Alaska and elsewhere shared common experiences, for example the predominant prey of the pinnipeds is often the target of commercial fishing. Yet, the Gulf of Alaska sea lion population seems unique with respect to the declines in population abundance coincident with the co-occurrence of commercial fisheries. In ecosystems outside of Alaska, healthy pinniped populations were noted despite the presence of intense commercial fisheries. Baraff and Loughlin report that “concerns over pinnipeds impacting fisheries are more prevalent than concerns over fisheries’ impacts on pinnipeds.” Nevertheless, the potential for significant pinniped/fishery interaction remains, and as Trites et al observe, “the effects of fisheries go well beyond those of other apex predators, due in large part to their capacity to remove large amounts of biomass from the world’s oceans and the lack of biological controls or feedback to limit what and how much they take.”

Muter and Norcross (2000a) and Wynne et al (2003) conducted surveys to measure the seasonal availability of pelagic and benthic fishes and coincidentally Steller sea lion prey. Muter and Norcross looked at benthic fish communities around 6 specific rookeries from Akutan to Sugarloaf Islands. Results showed significant differences in species composition among rookeries with the differences attributed to variability in topography, substrate composition, temperature, and salinity. Wynne et al evaluated seasonal availability of prey at three haulouts and one rookery along the coast of Kodiak Island. They used the Marmot Island rookery, and haulouts at Long Island, Chiniak and Ugak Island. The area centered on Long Island is bounded by 10 nm and 20 nm strata to evaluate differences within and outside different Steller sea lion protection zones. These authors report that Steller sea lions in the Kodiak study area were using a diverse prey base as evidenced by the occurrence of 31 species identified in scats. Eleven species were found to be significant prey, six of which occurred in greater than 20% of the scats: pollock, arrowtooth flounder, sandlance, Pacific cod, salmon, and Irish lords. Flatfish and gadids were the dominant prey groups used by sea lions and were also found to dominate the biomass of fish within waters of the study area. Five of the seven most frequently occurring prey species found in scat samples were also found to be most abundant in waters within 20nm of Long Island: arrowtooth flounder, rock sole, walleye pollock, Pacific cod, and Irish lords. Salmon and sandlance were significant primary prey items that were not found to be prevalent in the prey surveys. Eulachon, a smelt frequently sampled in the deep water trawls, was found in less than 5% of scat samples.

Fishery and Steller sea lion Correlation Studies

Four studies looked at the correlation between commercial fishery catch and/or effort and the abundance of Steller sea lions (Dillingham, Skalsi and Ryding, 2006; Gregr and Trites 2003, 2004, 2005a, 2005b; Hennen, 2006; and Soboleff, 2006.) In each instance, attempts were made to partition commercial fishery catch data and/or survey data by fine regional scales grouping sea lion haulouts and rookeries into lowest spatial scale of statistically similar aggregations. Soboleff looked at the interaction between sea lions and “State managed” fisheries; where, Dillingham et al., Hennen and Trites and Gregr were focused on the interactions with federally managed fisheries. All tended to find some correlations between trends in fishery catch and effort and sea lion abundance, but most led to equivocal conclusions. Hennen identified “significant” correlations between sea lion declines and fishing effort prior to 1991 and attributed the weaker association after 1991 to success in regulatory measures separating fisheries and sea lions. Soboleff noted positive correlations between sea lion abundance and fishing but found few statistically significant relationships. Dillingham et al reported that “neither commercial groundfish abundance nor commercial fishing effort could explain the large historical declines in the rate of Steller sea lion population change observed.” The work by Gregr and Trites is incomplete, however, in there approach they attempted to quantitatively describe the breadth of the niche overlap between sea lions and fisheries, thus providing a framework for focused studies of interactions.

Seasonal Prey Use

There are two regional studies of the seasonal concentration of Steller sea lion predation; these include studies in Prince William Sound (PWS) and Southeast Alaska (Gende and Sigler, in press; Sigler et al 2004a; Thomas and Thorne, 2001b, 2003; and Womble et al., 2005). In Prince William Sound, Thomas and Thorne report on sea lion seasonal preferential predation on herring despite availability of abundant pollock. Sea lion counts at haulouts in PWS appeared to be correlated with the interannual abundance of herring populations. Feeding was predominately at night. In Southeast Alaska, sea lions appear to capitalize on the predicable prespawning aggregations of eulachon and herring (Sigler et al., 2004a, Gende and Sigler, in press; and Womble et al., 2005). Sea lion haulout counts peaked sharply around the annual timing of the anadromous eulachon runs. Most of these authors speculate that the timing of this select predation activity correlates with the reproductive season and may be important for reproductive success.

ANNOTATED BIBLIOGRAPHY – FISH ASSESSMENTS AND FISHERIES

Adams, C.F. 2005. Physical and biological effects on the diel vertical migration of walleye pollock. Chapter 34, pages 331-336, in Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

> This chapter describes progress in the acquisition of data for research in support of a Ph.D. dissertation. The author lists for objectives for this research, 1) assess the crepuscular [twilight] and nocturnal distribution of pollock within 10 nm of Chiswell Island; 2) determine the effect of downwelling irradiance, upwelling radiance and temperature on the diel vertical migration (DVM) of age-1, age-2 and adult pollock; 3) determine the effect of invertebrate prey availability on the DVM of age-1, age-2 and adult pollock; and 4) determine the effect of cannibalism on the DVM of age-1 pollock. Four acoustic surveys were completed in July-August 2002, April 2003, August 2003 and November 2003. Opportunistic midwater tows were taken to determine the species composition of the acoustic targets. Radiometric data, conductivity and temperature were collected during each survey. Pollock stomachs were sampled to evaluate seasonal differences in diet. The pollock diet analysis was complete, there was an apparent seasonal shift from spring to fall from euphausids and copepods in spring/summer to shrimp during fall. The dissertation was expected to be completed in July 2006.

Anonymous. 2005. Introduction. In: Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pac. Fish. Mgmt. Council, Anchorage, AK, pp 1-40.

> The Introduction to the December 2005 Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska provides an overview of the stock status for all managed groundfish species. Of particular interest with respect to sea lions is the status of three key prey species: pollock, Pacific cod and Atka mackerel (although Atka mackerel is a lesser prey species within the Gulf of Alaska). Pollock stock biomass is estimated to have declined over the past 2 years and is projected to continue to do so as a result of weaker recruitment following a strong 1999 and 2000 year class. Exploitable stock biomass is estimated to be 635,700 mt in 2006. The proposed allowable biological catch is 86,500 mt.

Pacific cod stock biomass was also estimated to be declining. Estimated exploitable biomass in 2006 was 453,000. Projected 2006 acceptable biological catch was 79,600 with allowable catch expected to drop to 49,500 mt in 2007. Atka mackerel are a minor species within the Gulf of Alaska; there is no reliable estimate of stock biomass and allowable harvest is based on historic catch. Recommended allowable harvest for 2006 is set at 4,700 mt although the Plan Teams recommend holding total allowable catch to 1500 mt. Review of trawl survey data indicate that Atka mackerel populations were increasing in abundance in the GOA, but the increase was predominately the result of a strong 1999 year class. This Introduction also provides a brief overview of ecosystem considerations for the groundfish fisheries. The Ecopath model showed that pollock abundance is positively correlated with the abundance of Steller sea lions arrowtooth flounder, halibut, and Pacific cod. Although arrowtooth flounder is responsible for more than one third of pollock mortality, this positive relationship between arrowtooth and pollock is not as strong as that between Steller sea lions and pollock. It was noted that Steller sea lion abundance is negatively correlated to arrowtooth flounder and halibut.

Baraff, L. S., and T. R. Loughlin. 2000. Trends and potential interactions between pinnipeds and fisheries of New England and the U.S. west coast. Marine Fisheries Review 62(4):1-39.

The following represents a compilation of excerpts from the Abstract and body of the text of this article: “Long-term trends in the abundance and distribution of 6 pinniped species and 8 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. Most of these pinniped populations have grown exponentially since passage of the U.S. Marine Mammal Protection Act in 1972. 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. Pinniped populations in New England are healthy and expanding. Resident species are increasing, and the extralimital ranges of higher latitude species are extending into the Gulf of Maine and southern New England. Food availability is apparently not a limiting factor. There may be greater concern over the potential impact of expanding pinniped populations on commercial fisheries, rather than the reverse. The potential for pinniped-fisheries interactions appears greater and more complex along the U.S. west coast than in New England. This is related to the size of the region, the number of pinniped species, the extensive seasonal migrations undertaken by different sex and age classes of pinnipeds, tremendous variation in prey preferences, and numerous state and federally managed fisheries. Periodic El Niño events may further complicate matters by altering the abundance and distribution of prey and fisheries resources. The U.S. west coast component of the eastern stock of Steller sea lions increased more gradually and less conspicuously. The population is relatively stable from at least northern California northward, but is declining from central California southward.”

Barbeaux, S.J. Ianelli, and E. Brown. Stock assessment of Aleutian Islands Region Pollock. 2005. In: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Fish. Mgmt. Council, Anchorage, AK. Section 1:125-180

Pollock is a primary prey species for the western stock of Steller sea lions. The abundance of the Aleutian Island (AI) population of pollock has traditionally been assessed via trawl survey. Separate AI age-structured stock assessments were introduced in 2003. There is considerable uncertainty regarding the physical boundary between Eastern Bering Sea (EBS) and AI pollock stocks. Overlap between the two stocks is likely between 174°W and 170° W longitude. The 2005 assessment continues development of the age-structured models introduced earlier. Two models are evaluated that include (Model 2) and exclude (Model 1) the eastern AI area between 170° W and 170° W. The models rely on regional partitioning of available data, and abundance estimates vary dependent on input data used. Spatial analyses of fishery, survey, and bycatch data using GIS methods reveal that pollock concentrations are highly variable and likely evolve quickly within seasons. Both models show high peaks in exploitation in the late 1990's. Recruitment is estimated to be more resilient under Model 2 than it is under Model 1. The estimated trend in stock biomass since 2000 is increasing. Estimated stock biomass in 2005 is 218,000 mt for Model 1, and 468,900 mt for Model 2. The most recent (2004) trawl survey abundance estimates are 19,201 mt for the area west of 174 W longitude, and 130,451 mt for the area west of 170 W longitude. Annual catch averaged 49,000 mt in the 1990s and has averaged 1,200 mt since 2000. The analyst's recommended acceptable biological catch in 2006 ranges between 29,350 mt and 102,900 mt dependent on Model and tier system selected.

Battaile, Brian C. 2005. A Walleye Pollock (*Theragra chalcogramma*) Depletion Estimator for the Eastern Bering Sea. PhD Dissertation, University of Alaska Fairbanks, Fairbanks, Alaska. 180 pp.

This paper's abstract is presented in its entirety: "The decline of the Steller Sea lion in the eastern Bering Sea over the last 25 years has resulted in increased management of the pollock fishery due to requirements of the Endangered Species Act, as food competition was hypothesized to contribute to the decline. Our research focused on determining if the pollock fishery was causing significant depletion in the eastern Bering Sea, particularly in Steller sea lion critical habitat. DeLury depletion models were fitted to catch and effort data from 1995 to 1999, from the observer program, which required considerable processing to obtain a database at a temporal and spatial scale that is much finer than that used for stock assessment in the eastern Bering Sea. The catch per unit effort (CPUE) data were standardized in a unique way in that the data were stratified in space and time and standardized using separate general linear models for each stratum. A significant amount of depletion was detected in the pollock fishery from 1995-1999. Depletion estimates of fishery mortality tended to be an order of magnitude smaller than those found in traditional stock assessments. Post hoc analyses indicated that depletion is detected more easily in areas of low abundance due to the hyperstable relationship between CPUE and biomass, possibly exacerbated by a lack of search time in the model. Evidence further suggested that dispersing exploitation pressure decreases local depletion, and pollock may repopulate a depleted area within weeks. Finally, a hierarchical spatial Bayesian analysis with a conditional autoregressive model was constructed to unify the analysis. Because the data were relatively clean of outliers and not over dispersed, significant changes in the results between the frequentist and Bayesian based analyses were not found as was little evidence of spatial autocorrelation in the estimates of catchability."

Battaile, B.C., and T.J. Quinn, II. in press. A DeLury depletion estimator for walleye pollock (*Theragra chalcogramma*) in the eastern Bering Sea. Natural Resource Modeling.

> This paper's abstract is presented in its entirety: "Concerns about local depletion of fish populations are intensifying, as interest becomes focused on finer spatial and temporal scales. We used the DeLury model to investigate local depletion of the eastern Bering Sea walleye pollock population by its fishery by using spatial and temporal scales thought to meet assumptions about closure and applicability. Local depletion is estimated as the slope of logarithmic catch-per-unit-effort (CPUE) from the fishery versus cumulative effort, with data from 1995-1999 stratified by small areas, short seasons and years. Of 237 depletion estimators, 172 had negative slopes, 94 of which were significant, a greater number than would be expected by chance alone. Of the 65 positive slopes, 19 were significantly positive, which is also more than would be expected. Cumulative depletion over a season was inversely related to estimated initial biomass, total catch, and total effort, indicating that depletion is detected more easily in areas of low abundance and consequently lower catch and effort. Our fine-scale estimates of depletion are much smaller than the overall depletion from annual stock assessments, showing that commercial data alone can be at best a relative index of depletion. This hyperstable relationship may result from the lack of search time in the measure of effort, fish finding technology and schooling behavior of pollock. Evidence also suggests that measures that were taken starting in 1999 to disperse the exploitation pressure in space and time may decrease local depletion, and that pollock may repopulate an exploited area in a relatively short time period (weeks)."

Berman, M. 2005. Modeling effects of habitat closures in ocean fisheries. Prepared for North American Association of Fisheries Economists, third biennial forum. PDF available thru NPFMC.

> This is essentially a methods paper where the author extends an existing economics model to develop one which accommodates estimation of costs associated with the relocation of fishing operations due to regulatory constraints on area fished. The model is innovative in that it allows estimation of costs associated with the redistribution of fishing effort at fine spatial scales. The author demonstrates that estimates of discrete choice models with the new approach provide nearly identical results to what would be achieved by estimating a standard RUM model, were it feasible to do so. The ability of the new approach to accommodate detailed spatial modeling greatly enhances the utility of discrete choice methods for addressing management issues. In particular, it provides a scientifically defensible method of quantifying the economic cost of relatively small habitat closures and other conservation measures that involve incremental time and area closures to fisheries. Because the method can flexibly evaluate incremental changes in the spatial extent of habitat closures, it can help managers adjust closure boundaries in ways that minimize costs to fisheries while meeting conservation objectives. Application of the new approach to the North Pacific groundfish fisheries produced a map showing detailed spatial distribution of economic value estimated over a large region, illustrating the potential contribution to management decisions about marine protected areas. Future research can identify values on an even finer scale in order to answer specific questions about adjustment to individual protected area boundaries.

Bodtker, K.M., E.S. Gregr, E. Carruthers, D.L. Musgrave, and A.W. Trites. 2005. Predicting the spatial distribution of Steller sea lion prey based on modeled physical oceanography. In 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

In the abstract the authors describe a model constructed to predict the distribution of pollock in the Gulf of Alaska based on fine to coarse scale spatial/temporal habitat features. Working under the hypothesis that pollock would be more prevalent in the vicinity of converging water masses, they used output from a coastal ocean circulation model to locate areas of high variability and abrupt change; then linked these areas to georeferenced pollock assessment data. They then evaluated the predictive ability of their model using commercial catch data. As they moved from fine to coarse spatial/temporal data there were fewer predictable areas of abrupt circulation change, and consequently decreased predictive power of the model.

Bowen, W. D., H. Harwood, D. Goodman, and G. L. Swartzman. 2001. Review of the November 2000 Biological Opinion and Incidental Take Statement with respect to the western stock of the Steller sea lion. Final Report to the North Pacific Fisheries Management Council, May, 2001. 19 p.

This is a study specifically commissioned by the NPFMC. The authors note “that there is great uncertainty about the effects of the groundfish fisheries on SSL, but it is possible that these effects could be negative. However, the evidence presented in the Nov2000BiOp is almost entirely circumstantial. With respect to many of the key hypotheses (e.g., local depletion of prey by fishing, effects of local depletion on SSL) there are essentially no direct data bearing on the specific mechanisms for the effects of fishing on SSL. For the most part, the arguments in the November 2000 BiOp are constructed on the basis that such effects are possible, biologically imaginable, and are not contradicted by the available data.” The authors are dubious about the rationale for mitigation measures put forward in the draft August 2001 Biological Opinion, citing the high degree of uncertainty in the interpretation of telemetry data. The authors conduct a reasonable review of the evidence supporting the nutritional stress hypothesis for declines in sea lion abundance and the links between fisheries and prey availability. They recommend field experiments that might be conducted to address the pressing questions of fishery interaction more directly, and provide other recommendations for further research.

Bredesen, E.L., A. P. Coombs, and A. W. Trites. 2004. Assessing overlap between Steller sea lion diets and fish distributions in the North Pacific. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

See Bredesen et al., in press, below

Bredesen, E.L., A.P. Coombs, and A.W. Trites. in press. Relationship between Steller sea lion diets and fish distributions in the eastern North Pacific. Pages 000-000 in Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

This paper reports on correlations between the distribution of primary Steller sea lion prey species (expressed as a proportion of the world population) in large regional blocks (e.g, W, C, and E Gulf of Alaska) with the frequency of occurrence of these species in Steller sea lion diets. Results indicate a positive association between abundance and frequency of occurrence with some exceptions. The authors interpret the outcomes of their analysis to be corroborative of the notion that Steller sea lions are opportunistic feeders who occasionally demonstrate preferences for specific prey.

Conners, M. E., A. B. Hollowed and E. Brown. 2002. Retrospective analysis of Bering Sea bottom trawl surveys: regime shift and ecosystem reorganization. Progress in Oceanography 55:209-222.

> In this paper the authors evaluate spatial/temporal patterns in the distributions of 22 species groupings across three domains of the Bering Sea: inner, middle, and outer shelf. Using data from trawl surveys, the authors construct standardized filtered data sets spanning the period 1963 to 2000. Catch is standardized to catch per unit area. The spatial/temporal distributions are evaluated to look for major change points (shifts in location and/or abundance) with a focus on synchrony of events across species groups. The authors report that their "results indicate that wide-ranging changes have occurred in demersal and benthic food webs of the eastern Bering Sea, which have affected taxa ranging from large pelagic and benthic predators to sessile benthic filter feeders. This type of systemic change suggests that a non-linear ecosystem shift occurred sometime in the early 1980s." The authors go on to say, "Our data do not show evidence of effects either from contemporary commercial harvests or short-term changes in climate conditions. The system-level changes evident in our data are very consistent with recent interdisciplinary research that indicates the timing and duration of primary and secondary production in the southeastern Bering Sea has been altered by changing sea-ice extent. Our data are strongly inconsistent with hypotheses that declines of top-level predators in the system are a result of any overall reduction in productivity."

Conners, M.E., E. A. Logerwell, and P. Munro. 2004. Fishery effects: Testing the local depletion hypothesis. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK

> This poster provides preliminary information on a study to evaluate fishery effects on the local depletion of Pacific cod near Cape Sarichef in the Bering Sea. Conners et al., 2004 below.

Conners, M.E., P. Monro, E.A. Logerwell, and S. Neidetcher. 2006. Results of the Pacific cod local depletion study. 2006. In Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

> This abstract provides a brief summary of results from an experiment conducted to test for fishery effects on local depletion of Pacific cod stocks (See Connors et al., 2004). It adds information from tests conducted in 2004-2005. Over a three year period, deliberate test were conducted with treatments and controls to measure fishery impacts on Pacific cod catch rates. The researchers found no difference between the fished treatment areas and the unfished controls during any year of the study. The experimental design was sufficiently sensitive to detect 20-30% reduction in Pacific cod catch should it occur; no such reduction was measured. Concurrent tagging effort indicated that Pacific cod were highly mobile in the study area such that the fishery was operating on a dynamic rather than static population. There was no evidence of local depletion of Pacific cod stocks in this area during the time period studied.

Conners, M.E., P. Munro, S. Neidecheter. 2004. Pacific cod pot studies 2002-2003. NOAA NMFS-AFSC-Proc. Rpt 2004-04. 131p.

> This technical report provides detailed descriptions of the Pacific cod local depletion studies summarized in the Connors et al 2006 abstract. Research began in 2002. The study area is

on the Bering Sea shelf immediately north of Unimak Pass and Unimak Island. The study area included areas open and closed to fishing. Pots were used by researchers to catch Pacific cod in each area so they could measure the change in catch rate over time. The null hypothesis assumed no difference in the rate of change between fished and unfished areas. The experiment was conducted annually during the Pacific cod "A" season. Pacific cod are known to aggregate at high density in the study area during winter. There was no evidence of fishery induced local depletion although the researchers warned readers to treat the results cautiously due to low sample sizes. [Reviewers note: subsequent studies in 2004-2005 improved sample size and again found no indication of local depletion due to fishing (see Connors et al., 2006)]

DeMaster, D. and S. Atkinson. 2002. Steller Sea Lion Decline: Is It Food II. University of Alaska Sea Grant, AK-SG-02-02, Fairbanks. 80 pp. (Numerous papers were presented at this workshop that have individual authorship but are NOT included in this citation list—see appendix 1)

Twenty-four scientists participated in a 2-day workshop to discuss evidence for and against hypotheses put forward to explain the decline in Steller sea lion abundance. Attendees concluded that there was insufficient evidence to rule out nutritional stress as a cause for the Steller sea lion decline. In the Gulf of Alaska and Bering Sea, pollock are a primary component of the diet of SSLs year round; in the Aleutian Islands, Atka mackerel and cephalopods are primary components year round; and around Kodiak Island in the GOA, sandlance are an important prey item. In the North Pacific, groundfish stocks had increased in abundance since the 1980s. Commercial fishery removals are not evenly dispersed throughout the range of the fished population, thus, local effects of fishing result in higher rates of exploitation on the local population than prescribed for the "global fishery". More data were needed to evaluate the role of predation (killer whales and sharks) as a controlling mechanism on SSL production. At least one attendee speculated that growing spiny dogfish population may be competing with SSLs for prey.

DeMaster, D.P. 2001. Evaluating the Impact of Reasonable and Prudent Alternatives for the Management of the BSAI and GOA groundfish fisheries on the western Stock of Steller sea lion. Unpublished NMFS White paper

This white paper presents NMFS's case for acceptance of the management measures proposed by the NPFMC's RPA committee to mitigate the presumptive adverse impacts of the groundfish fishery on the recovery of the western stock of Steller sea lions, and thus avoid "jeopardy" as defined and utilized under the Endangered Species Act. Management measures place restrictions on fishing at distances up to 20 nm from Steller sea lion haulouts and rookeries. The predominant constraints are on trawl fisheries with lesser constraints on fixed gears. The exclusion zones were based at least in part on preliminary analysis of Steller sea lion spatial distributions as ascertained from telemetry data.

Dillingham, P. K. Ryding and J.R. Skalski. 2004. Assessment of fine-scaled interaction between Steller sea lion abundance and trends of local fisheries. Manuscript Rept., NOAA/NMFS/AFSC SSLRI Program, Juneau, Ak. 147 p.

See Dillingham et al., 2006

Dillingham, P.K., J.R. Skalski, and P.K. Ryding. 2006. Fine-scale geographic interactions between Steller sea lion (Eumetopias jubatus) trends and local fisheries. Can. J. Fish. Aquat. Sci. 63:107-119.

> Fine-scale geographic interactions between Steller sea lion (*Eumetopias jubatus*) abundance trends and the abundance of local fisheries and commercial fishing efforts from Southeast Alaska to the Aleutian Islands were assessed. Census counts of Steller sea lions from 1976 to 2002 at 53 different trend sites and rookeries were grouped into 33 locales with similar population trends. Trawl survey biomass estimates, from 1983 to 2002 for pollock, Pacific cod, Atka mackerel and Arrowtooth flounder were matched to the 33 locales; as was fishing effort from 1990 to 2002. Neither commercial groundfish abundance nor commercial fishing effort could explain the large historical declines in the rate of Steller sea lion population change observed.

Dorn, M., K. Aydin, S. Barbeaux, M. Guttormsen, B. Megrey, K. Spalinger, and M. Wilkins. 2005. Assessment of walleye pollock in the Gulf of Alaska. In: Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pac. Fish. Mgmt. Council, Anchorage, AK, 1:41-153.

> Gulf of Alaska (GOA) pollock population abundance estimates are based on a 45 year time series of demographic data (1961-2005) evaluated by means of statistical age-structured model. The exploitable population is age 3 years and older. Estimated annual biomass had been declining in the 1990s, but showed a upward trend in the early 2000s. Bottom trawl survey estimated biomass (which accounts for only a portion of total biomass) peaked in 1990 at 825,000 mt and has declined to a low of 217,000 mt in 2001 recovering to 355,000 mt in 2005. Estimated biomass in 2005 was 709,000 mt. Annual catch has dropped from a peak of 307,400 mt in 1984 to 63,900 mt in 2004. Annual fishery exploitation rate ranged from 1-15% from 1969-2005, with a median value since 2000 of 8% (range 6-12%). [The authors provide additional information on pollock ecosystem interactions which is presented under Theme 5—Ecosystems of this report.]

Foy, C.L., B. Konar, K.M. Wynne, and S. Hills. No date. Seasonal habitat use by nearshore fishes around Steller sea lion haulouts of Kodiak Island. Unpublished manuscript.

> During 2001 and 2002, five SCUBA-based surveys were conducted in the nearshore waters adjacent to two Steller sea lion haulouts at multiple depths to quantify seasonal fish abundance and species composition. Habitat information including macroalgal cover, substrate, and benthic invertebrate faunal composition was recorded concurrent with fish surveys to determine similarity of fish habitat between sites. Control surveys were conducted at two similar rocky headland areas that were not historical haulouts of Steller sea lions. Significant differences in fish community composition and abundance existed between Steller haulouts and control sites, primarily due to an absence of rockfish and an abundance of greenling at the haulout sites. Fish assemblage patterns varied with depth and season, with higher abundances at 9 m, 15 m and 21 m depths during summer. Lower abundance of fishes and more even distribution patterns were seen in winter. Overall differences in the fish assemblages do not appear to be driven by algal habitat differences, but substrate may be playing a role.

Fritz, L.W., and E. S. Brown. 2005. Survey and fishery-derived estimates of Pacific cod (Gadus macrocephalus) biomass: implications managing Steller sea lion (Eumetopias jubatus) and groundfish fishery interactions. Fishery Bulletin 103:501-515.

> Fritz and Brown utilize a Leslie depletion model to estimate Pacific cod abundance from 2001 commercial groundfish fishery catch and effort data collected in the BSAI in the vicinity of Unimak Island. They compare the abundance estimates derived from the Leslie model with independent estimates obtained from a NMFS winter trawl survey conducted specifically to estimate Pacific cod abundance. Observer data were gathered from all fisheries with any Pacific cod catch. Fisheries were divided into three sectors: trawl, longline and pot; and two catching modes: catcher processor and catcher vessel. Trawl catches were further stratified based on the level of Pacific cod targeting (20, 40, or 60% Pacific cod in the haul or set). Catch and effort data were aggregated into daily catches by sector, mode and targeting level. Catch and effort data were compiled from 1 Jan to 30 Apr 2001. Select data subsets from this time-series are utilized in the Leslie analysis. The authors report that the fishery may have exploited 26% to 80% of initial population over the period 1 Jan 2001 to 24 Mar 2001. The author's findings imply that estimated local rates of harvest are substantially higher than the stock wide management exploitation rate and may cause localized depletions that impact Steller sea lion foraging.

Gauthier, S. and J.K. Horne. 2004. Acoustic characteristics of forage fish species in the Gulf of Alaska and Bering Sea based on Kirchoff-approximation models. Can. J. Fish. Aquat. Sci. 61: 1839-1850

> This is a methods paper, the article's abstract follows in its entirety, "Acoustic surveys are routinely used to assess fish abundance. To ensure accurate population estimates, the characteristics of echoes from constituent species must be quantified. Kirchhoff-ray mode (KRM) backscatter models were used to quantify acoustic characteristics of Bering Sea and Gulf of Alaska pelagic fish species: capelin *(Mallotus villosus)*, Pacific herring *(Clupea pallasii)*, walleye pollock *(Theragra chalcogramma)*, Atka mackerel *(Pleurogrammus monopterygius)*, and eulachon *(Thaleichthys pacificus)*. Atka mackerel and eulachon do not have swimbladders. Acoustic backscatter was estimated as a function of insonifying frequency, fish length, and body orientation relative to the incident wave front. Backscatter intensity and variance estimates were compared to examine the potential to discriminate among species. Based on relative intensity differences, species could be separated in two major groups: fish with gas-filled swimbladders and fish without swimbladders. The effects of length and tilt angle on echo intensity depended on frequency. Variability in target strength (TS) resulting from morphometric differences was high for species without swimbladders. Based on our model predictions, a series of TS to length equations were developed for each species at the common frequencies used by fisheries acousticians."

Gauthier, S. and J.K. Horne. 2004. Potential acoustic discrimination within boreal fish assemblages. ICES J. of Mar. Sci. 61: 836-845.

> This is a methods paper, the article's abstract follows in its entirety, "Differences in the acoustic characteristics of forage fish species in the Gulf of Alaska and the Bering Sea were examined using Kirchhoff ray-mode (KRM) backscatter models. Our goal was to identify species-specific characteristics and metrics that facilitate the discrimination of species using acoustic techniques. Five fish species were analyzed: capelin (*Mallotus villosus*), Pacific herring (*Clupea pallasii*), walleye pollock (*Theragra chalcogramma*), Atka mackerel

(Pleurogrammus monopterygius), and eulachon (*Thaleichthys pacificus*). Backscatter amplitude differences exist among these species, especially between swimbladdered and non-swimbladdered fish. Echo intensities were variable within and among species. The effect of morphological variability was indexed using the ratio of the Reduced scattering length (RSL) standard deviation over its mean. Morphological variability was low only at fish length to acoustic wavelength ratios less than eight. Target strength differences between pairs of carrier frequencies (ranging from 12 kHz to 200 kHz) differed among species, and were dependent on fish size and body orientation. Frequency differencing successfully discriminated between fish species but the choice of frequency to maximize target strength differences was not consistent among species pairs. Frequency dependent, backscatter model predictions facilitate comparison of target strength differences prior to acoustic data collection."

Gende, S., and M. Sigler. 2004. Persistence of prey "Hot Spots" for Steller sea lions in Southeast Alaska. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This abstract summarizes the authors' examination of the quantity and location of pelagic fish species (Pacific herring and pollock) available to SSLs in Southeast Alaska by determining the density of prey hot spots over a 24-month period and whether these hot spots persisted over several months or across seasons. They found that the density of hot spots varied by season and months. Large schools of herring determined the location and density of these hot spots, some of which persisted over winter months (November-February).

Gende, S., and M. Sigler. 2006. Persistence of forage "hot spots" and its association with foraging Steller sea lions in Southeast Alaska. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

The abstract summarizes 36 months of observations on the location, density and persistence of Steller sea lion prey hot spots. Prey density varied by month and season, with persistent high density aggregations in some seasons (mostly winter). Herring were the principle prey. The authors describe a foraging model that attempts to evaluate the utility of predictable prey access for both random search behavior and "Bayesian" search behavior. Bayesian foragers minimize search effort when prey access is predictable.

Gende, S., and M. Sigler. In press. Predictability of prey available to Steller sea lions in Southeast Alaska. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

The authors examined the predictability of pelagic fish distributions (predominately herring and pollock) during 24 months of surveys (June 2001-May 2003) in Lynn Canal, Southeast Alaska. The spatial distribution of available prey (measured as energy density) during a given month was examined to determine if it was an accurate indicator of prey distribution during the following month (monthly time scale) or during the same month the following year (annual time scale). Prey distribution in one month was a good indicator of prey distribution the same month the following year, but mostly during the winter months. This was due to the formation of large schools of herring in consistent locations during both winters. The distribution of prey in one winter month was also a good indicator of the distribution of prey the following month. However, significant month-to-month correlations were less frequent than at annual time scales due to a southerly movement of herring aggregations as the winter progressed.

Gregr, E. and A.W. Trites. In review. Assessing the distributional overlap between Steller sea lions and commercial trawl fisheries in Alaska. Ecological Applications.

This paper is under review and not available for inspection at this time.

Gregr, E.J., and A.W. Trites. 2004. Estimating Ecological Niche Overlap between Steller Sea Lions **and** Commercial Trawl Fisheries in Alaska. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

In this abstract the authors describe construction of a model to predict the spatial distribution of Steller sea lions in summer and winter. They then overlap the predicted sea lion distribution with that of the commercial trawl fishery effort, and calculate MacArthur and Levin's niche overlap index. Sea lions are more dispersed in winter and have a higher niche overlap with the trawl fishery during this time although the overlap was relatively low in both seasons.

Gregr, E.J., and A.W. Trites. 2005a. Evaluating ecological niche overlap between Steller sea lions and commercial trawl fisheries in Alaska. In: Marine science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

Repeats the findings reported in Gregr and Trites, 2004.

Gregr, E.J., and A.W. Trites. 2003. Probability of distributional overlap between Steller sea lions and commercial trawl fisheries in Alaska. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

See Gregr and Trites, 2004

Gregr, E.S., and A.W. Trites. 2005b. Using overlap indices to assess the efficacy of regulations designed to reduce competition between fisheries and Steller sea lions. In 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

In this abstract the authors build on the findings reported under Gregr and Trites (2004) by incorporating telemetry data into their sea lion habitat model. Additionally, they evaluate niche overlap with the trawl fishery for a set of management periods with differing regulatory regimes with respect to sea lion protection. Niche overlap was low overall; reduction in niche overlap was only detected in the late 1990s when fishery constraints near sea lion habitats were most restrictive.

Guénette, S., and V. Christensen. 2005. Food web models and data for studying fisheries and environmental impacts on Eastern Pacific ecosystems. Univ. British Columbia, Fisheries Centre Research Reports Vol 13(1) pp. 237

This is a compilation of 7 papers edited by Guénette and Christensen. Three deal with ecosystem models in Alaskan waters: two represent models for the Aleutian Islands, one for SE Alaska. The models are complex, the discussions long, and results limited.

Harvey, J. T., T. R. Loughlin, M. A. Perez, and D. Oxman. 2000. Relationship between fish size and otolith length for 63 species of fishes from the eastern North Pacific Ocean. U.S. Dep. Commer., NOAA Technical Report NMFS 150. 36 p.

> The paper's abstract is presented in it's entirety: "Otoliths commonly are used to determine the taxon, age, and size of fishes. This information is useful for population management, predator-prey studies, and archaeological research. The relationship between the length of a fish and the length of its otoliths remains unknown for many species of marine fishes in the Pacific Ocean. Therefore, the relationships between fish length and fish weight, and between otolith length and fish length, were developed for 63 species of fishes caught in the eastern North Pacific Ocean. We also summarized similar relationships for 46 eastern North Pacific fish species reported in the literature. The relationship between fish length and otolith length was linear, and most of the variability was explained by a simple least-squares regression ($r^2 > 0.700$ for 45 of 63 species). The relationship between otolith length and fish length was not significantly different between left and right otoliths for all but one fish species. Images of otoliths from 77 taxa are included to assist in the identification of species."

Hegwer, C.L. 2003. Seasonal abundance and diversity of nearshore fishes around Steller sea lion haulouts of Kodiak Island. M.S. Thesis, University of Alaska, Fairbanks. 77p.

> Nearshore fishes around haulouts are potential prey for Steller sea lions, especially pups, as they learn to forage and supplement their milk diets during weaning. Visual surveys in July and November 2001, and March, May and July 2002 were used to quantify spatial and temporal variation in fish diversity and abundance around two Steller sea lion haulouts and two control sites. SCUBA divers sampled depths of 9, 15, 21, 27, and 33 m. Concurrent habitat surveys were used to quantify substrate, macroalga and benthic invertebrate cover. Steller sea lion haulout sites had fewer fish than control sites, but similar species richness and species composition at the 9, 15 and 21 m depths during the summer sampling periods. In winter, fish were fewer but more evenly distributed. Habitats were not significantly different between haulouts and control sites. All sites had seasonal cover of canopy forming kelp, and overstory algal cover was heavy down to 21 m. At approximately 27 m the habitat changed abruptly from kelp-covered bedrock to bare gravel and shell hash. While nearshore fish are an important component of Steller sea lion diets, results from this study do not indicate that fish assemblages at haulouts are substantially different from other headland sites.

Hennen, D. 2003.Spatial coherence and density dependence in the decline of the Steller sea lion. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

> This abstract is reprinted here in its entirety. "The National Marine Fisheries Service time series of adult counts of Western Alaska Steller sea lions was analyzed to estimate population growth rates and population sizes at 31 individual rookeries. The results show evidence of density dependence in the decline during the 1981-1991 period. Principal components analysis based on estimated growth rates show spatial coherence on the scales of 0 - 225 km, motivating a subdivision of the Western Alaska stock into 9 spatial groupings. This arrangement was compared with others in order to determine the "best fit", using Mahalanobis' distance, from each groups center, with cross validation, as a fitting criteria."

Hennen, D. R. 2004. The Steller sea lion (*Eumetopias jubatus*) decline and the Gulf of Alaska/Bering Sea commercial fishery. Ph.D. dissertation, Montana State Univ., Bozeman, MT. 207 p.

Excerpt from the dissertation abstract: "Fisheries data from 1976 – 2000 were analyzed in relation to SSL population counts from 1956 – 2001, at 32 rookeries from the endangered Western Stock. Linear regression on the principal components of the fisheries data show that a positive correlation exists between several metrics of historical fishing activity and SSL population decline. The relationship is less consistent after 1991, supporting a hypothesis that fishing closures around some of the rookeries have been effective in moderating the localized effects of fishing activity on SSL."

Hennen, D.R. 2004. Correlations between the Steller Sea Lion Decline and the Bering Sea/Gulf of Alaska Commercial Fishery. Presented paper. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

"Linear regression on the principal components of the fisheries data show that a positive correlation exists between several metrics of historical fishing activity and SSL population decline. The relationship is less consistent after 1991, supporting a hypothesis that fishing closures around s some of the rockeries have been effective in moderating the localized effects of fishing activity on SSL."

Hennen, D.R. 2006. Correlations between the Alaska Steller Sea Lion Decline and Commercial Fisheries. Ecological Applications 16(2) 704-717.

In an effort to determine whether or not fisheries management measures have helped the SSL population to recover, estimates of the fishing activity of the Bering Sea/Gulf of Alaska commercial fisheries in the vicinity of individual SSL rookeries and SSL population trends at those rookeries were made using data from the National Marine Fisheries Service (NMFS) Fisheries Observer Program and Steller Sea Lion Adult Count Database. Fisheries data from 1976–2000 were analyzed in relation to SSL population counts from 1956–2001 at 32 rookeries from the endangered western stock. Linear regression on the principal components of the fisheries data show that a positive correlation exists between several metrics of historical fishing activity and the SSL population decline. The relationship is less consistent after 1991, supporting a hypothesis that management measures around some of the rookeries have been effective in moderating the localized effects of fishing activity on SSL.

Holladay, B.A., B.L Norcross, and F. Mueter. 2000. Forage fish abundance and distribution at Forrester Island, Alaska. Unpub. Manuscript, Final Contract Rpt NA66FX045, Institute of Marine Science, University of Alaska, Fairbanks, Alaska. pp. 75 + appendices

The objective of this study was to assess the distribution and abundance of juvenile and subadult stages of fishes within a 15 nm radius of the Forrester Island Steller sea lion rookery. To give perspective on how forage fishes in Southeast Alaska compare with forage fishes in other Alaskan regions, the authors also report results of analogous collections made during June-July 1997 in the Aleutian and Pribilof Islands. Bottom trawl sites were selected within 15 km of shore from among suitable depths on trawlable bottom topography and substrates. Bottom trawl samples were collected with 3.05 m plumb staff beam trawl; mid-water trawl samples were gathered with a modified 30m herring trawl. Large predatory fish were sampled with longline gear and their stomachs preserved for subsequent analysis of the

contents. Fish species diversity, composition, abundance, and size differed between Southeast Alaska and western locations. There were higher species diversity, different species, and fewer individuals in Southeast Alaska than in the Aleutians and Pribilofs. There were also considerable differences between sampling sites in Southeast Alaska and the Aleutian and Pribilof Islands. Trawlable areas within Southeast Alaska were significantly deeper than in the other regions, and were all of sand substrate. Bottom temperatures at bottom trawl tow sites in Southeast Alaska and in the East Aleutian Islands were warmer than in the Pribilofs, Central Aleutians and West Aleutian Islands.

Hollowed, A., J. N. Ianelli, and P. Livingston. 2000a. Including predation mortality in stock assessments: A case study for Gulf of Alaska pollock. ICES J. Mar. Sci. 57:279-293.

The paper's abstract is presented in its entirety: "A separable catch-age stock assessment model that accommodates predation mortality is applied to the Gulf of Alaska walleye pollock assessment. Three predators are incorporated in the model: arrowtooth flounder, Pacific halibut, and Steller sea lions. The effect of these predators is examined by defining the predation mortality as a type of fishery. The model is used to quantify changes in the relative fit to the survey, fishery, and predator data when the assumption of constant natural mortality is relaxed. Specifically, we examine the effect of assumptions regarding the functional feeding response, residual natural mortality, and uncertainty in predator biomass on stock assessment. Total natural mortality rates (including predation) tended to be higher than estimated from life history characteristics of the stock. Models that did not account for uncertainty in natural mortality underestimated uncertainty in current stock biomass by as much as 20%. Our results indicate that independent estimates of survey selectivity, additional food habits data, and estimates of the feeding responses of predators to different prey densities are all needed to improve our ability to develop stock assessment models that address ecosystem concerns."

Hollowed, A.B., N. Bax, R. Beamish, J. Collie, M. Fogarty, P. Livingston, J. Pope, and J.C. Rice. 2000b. Are multispecies models an improvement on single-species models for measuring fishing impacts on marine ecosystems? ICES J. Mar. Sci. 57:707-719.

In this paper the authors "consider whether multispecies models are better than single-species models for predicting the consequences of direct mortality, and whether they provide useful measurements of indirect effects", i.e, are they better at evaluating the effects of fishing. The authors identify two ways that multispecies models could improve understanding of stock dynamics: "(1) through a more realistic treatment of uncertainty and variability in population parameters (e.g. natural mortality) of the target species; or (2) by representing additional non-target species and ecological linkages among species, either of which could be altered through fishing." The authors conclude through comparison of single-species and multispecies models "that the latter have the distinct advantage of allowing the user to more realistically model natural mortality and growth rates." However, their support for multispecies models appears to weaken when these models are used for short-term stock projections. When multispecies models don't include dynamic processes for interactions among species the stock projections become less certain. The implication seem to be that multispecies models have been very useful in helping to improve understanding of the dynamics driving single species models, but are not as useful in making short term projections of stock abundance and thus allowable catch.

Hollowed, A.B., Wilson, C.D., Stabeno, P. and Salo, S. In press. Effect of ocean conditions on the cross-shelf distribution of walleye pollock (*Theragra chalcogramma*) and capelin (*Mallotus villosus*). Fisheries Oceanography

This paper compliments findings reported in Wilson et al (2003). Wilson reports on the effects of commercial fishing on distribution of pollock and capelin in Chiniak and Barnabus Troughs on the east side of Kodiak Island. Inferences were gained through a controlled fishing experiment in 2000 and 2001. The current paper describes the potential role of biophysical factors in the regulation of the spatial distribution of pollock and capelin. "Results suggest that habitat selection of walleye pollock and capelin are controlled by different processes. Capelin distribution appears to be limited by oceanographic conditions while other factors appear to be more important for pollock."

Ianelli, J.N., S. Barbeaux, T. Honkalehto, B. Lauth and N. Williamson. 2005a. Bering Sea-Aleutian Islands Walleye Pollock Assessment for 2005. In: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Fish. Mgmt. Council, Anchorage, AK, section 1:31-124.

Pollock catch in the Eastern Bering Sea has averaged 1.4 million mt since 2000, up from a mean of 1.2 million mt in the 1990s and 1.0 million mt in the 1980s. Mean Acceptable Biological Catch (ABC) over the same intervals was 1.3, 1.3 and 2.0 million mt respectively. Since 2000, catch has averaged 71% of the ABC and 96% of the annual TAC (Total Allowable Catch). Population abundance is indexed through bottom trawl and Echo Integration trawl surveys, and absolute abundance is estimated via statistical age-structured models. Bottom trawl (BT) survey abundance estimates have increased since 2000 compared to the 1980s and 1990s. Mean annual BT survey estimates are 5.4, 4.4 and 4.5 million mt for the period since 2000, 1990s and 1980s respectively. Echo Integration surveys were conducted triennially from 1977 to 1996, and approximately biennially since 1997. Mean EIT survey abundance since 2000 has been 3.3 million mt, up from 2.5 million mt in the 1990s but down from an average 4.8 million mt in the 1980s. The mean model estimated stock abundance (age 3+) has remained very stable at approximately 10 million mt since the 1980s. It was 3.2 million mt in the 1960s, 4.6 million mt in the 1970s, 10.0 million mt in the 1980s, 10.1 million mt in the 1990s, and 10.1 million mt since 2000. Since 1980 the annual Catch to Biomass ratio has ranged from 7% to 22%, averaging 14% since 2000.

Since 2000, the Bering Sea pollock fishery has undergone a number of regulatory changes that facilitated mitigation measures imposed to protect Steller sea lions. The advent of the AFA in 1999 resulted in the formation of cooperatives that led to lower fishing effort. The imposition of no-trawl zones around Steller sea lion rookeries and haulouts reduced the fraction of catch removed for sea lion conservation areas (SCA). Seasonal apportionment of TAC dispersed the catch temporally as well as spatially. This stock assessment provides a review of the management measures and the impact on pollock catch in the SCA. The proportion of catch in the SCA varies seasonally, estimated distribution in 2005 was 44% in the January-June time period, 17% from July-December, and 29% overall.

The stock assessment authors report on independent studies to evaluate potential for localized depletion of pollock resources by the fishery. The independent investigator used the slope of log-CPUE versus cumulative effort to generate an index of local abundance, for data from 1995-1999 stratified by small areas, short seasons and years. He found that of 237 depletion estimators, 172 had negative slopes while 65 had positive slopes. Each group had subsets that were statistically significant (more than expected based on chance alone). Depletion was most easily detected in areas of low abundance and consequently lower catch and effort. Overall, his estimates of depletion were smaller than the overall depletion expected from the estimates of exploitation rates. As noted in Barbeaux et al. (2005) estimators involving CPUE data from a pollock fishery are likely to be problematic due to hyperstability. Nonetheless, there is evidence that pollock can repopulate areas rapidly.

Ianelli, J.N., T. Honkalehto, and N. Williamson. 2005b. An age-structured assessment of pollock (*Theragra chalcogramma*) from the Bogoslof Island Region. In: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Fish. Mgmt. Council, Anchorage, AK, section 1:181-218.

The Bogoslof management district (INPFC area 518) was established in 1992 in response to fisheries and surveys conducted during the late 1980s, which consistently found a discrete aggregation of spawning pollock in this area during the winter. The degree to which this aggregation represents a unique, self-recruiting stock is unknown but the persistence of this aggregation suggests some spawning site fidelity that called for management. Collectively, pollock found in the Donut Hole and in the Bogoslof region are considered a single stock, the Aleutian Basin stock. Currently, 60% of the Aleutian Basin pollock population is thought to spawn in the Bogoslof region. The actual distribution of Aleutian Basin pollock likely varies depending on environmental conditions and the age-structure of the stock. The Aleutian Islands, Eastern Bering Sea and Aleutian Basin stocks probably intermingle, but the exchange rate and magnitude are unknown.

Directed fishing for pollock in the Bogoslof area has been closed since 1992; since 2000 pollock catch in non-targeted fisheries has typically been <100 mt annually (range 29-1,042 mt). With minor exceptions, the NMFS has conducted annual echo-integration-trawl (EIT) surveys for Aleutian Basin pollock spawning in the Bogoslof Island area since 1988. EIT survey abundance declined between 1988 and 1994, was stable and variable, then dropped again to the level it has maintained since 2000. Mean EIT survey abundance estimates were 2.2 million mt in the 1980s, 670 thousand mt in the 1990s and 250 thousand mt since 2000. There is no bottom trawl survey estimate for this area. A statistical age structured model is also used to estimate stock abundance. Model estimated mean biomass (age 5+) was 3.0 million mt in the 1980s, 833 thousand mt in the 1990s and 454 thousand mt in since 2000.

Joy, R., D.J. Tollit, J.L. Laake, and A.W. Trites. in press. Using simulations to evaluate reconstructions of sea lion diet from scat. Pages 000-000 in Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

Excerpt of this papers abstract, “We performed computer simulations using data from captive feeding studies to investigate levels and sources of error in reconstructing simulated mixed species diets. Our simulations used different combinations of hard remains, were conducted both with and without the application of numerical correction factors, and compared four different diet indices (1. Modified frequency of occurrence, 2. Split sample frequency of occurrence, 3. Variable biomass reconstruction, 4. Fixed biomass reconstruction). Simulations indicated that levels of error were related to the MNI [Minimum Number of Individuals] method of inferring fish numbers from prey remains, prey size, the number of identifiable prey structures used, and the robustness of the remains to digestive processes (recovery rate). The fewer fish fed, the higher the relative probability of counting the fish, particularly when a multiple element structure or all structure techniques are used. If recovery rates were assumed to be consistent across species, then large fish (particularly when fed in small amounts) were overestimated relative to smaller sized prey in all models, but particularly biomass reconstruction models and when using more than one paired structure. When recovery rates of a paired structure (otoliths) were varied across species (as observed in captive feeding studies) then biomass models tended to overestimate the species with high recovery rates. In contrast, frequency of occurrence models overestimated the contribution of smaller prey (particularly when fed in small amounts). Simulations also indicated correction factors can reduce levels of error in biomass reconstruction models, but cannot solve problems related to counting fish using MNI."

Jurado-Molina, J. and P.A. Livingston. 2002. Multispecies perspectives on the Bering Sea groundfish fisheries management regime. N. Amer. J. Fish. Management 22:1164-1175.

In this article the authors evaluate the effects that different exploitation rates may have on eastern Bering Sea groundfish using a multispecies simulation context that incorporates predator–prey relationships. The authors contrast multispecies virtual population analysis (MSVPA) outcomes with single species virtual population analysis (SSVPA) for eight species in the Bering Sea, including pollock and Pacific cod. After conducting the virtual population analysis they project populations forward in time 40 years to a point of "equilibrium" and compare changes in the population abundance. The species modeled represent different rates of current exploitation from fully utilized to partially utilized. The authors are interested in determining the population effects of these differential rates of harvest when compared with full utilization across all species or no utilization at all. They use three different fishing mortality rates in their forward projections: 1) the average F over the most recent 4 years as measured in the MSVPA model; 2) the estimate F_{ABC} as determined in routine annual SAFE documents; and 3) F=0. With minor exception, the MSVPA and SSVPA models produced population estimates similar to those generated in the current statistical models (i.e., stock assessment SAFEs). Forward population projections produced predicable results; populations whose fishing mortality was reduced tended to increase in abundance and those whose fishing mortality was increased declined in abundance. The magnitude of change differed between SSVPA and MSVPA with differences attributable to the multispecies interactions built into MSVPA. The multispecies simulations that included predation interactions predicted much lower equilibrium population sizes for prey species populations under conditions of no fishing than did single-species simulations that did not take predator–prey relationships into account.

Jurado-Molina, J. P.A. Livingston, and V.F. Gallucci. 2005. Testing the stability of the suitability coefficients from an eastern Bering Sea multispecies virtual population analysis. ICES J. Mar. Sci. 62:915-924.

Suitability coefficients are estimated within an MSVPA model based in part on the stomach contents data integrated in the model. In this paper the authors evaluate the stability of the suitability estimates by comparing outcomes using different stomach contents data sets. In general, results suggested that the predator preferences and prey vulnerabilities remained stable over the time period studied. Therefore, MSFOR (multispecies forecasting model) could be considered as a tool to advice fisheries managers within a multispecies context.

Jurado-Molina, J., P.A. Livingston, and J.N. Ianelli. 2005. Incorporating predation interactions in a statistical catch-at-age model for a predator-prey system in the eastern Bering Sea. Can. J. Fish. Sci. Aquat. 62:1-9.

In this paper the authors use a two-species system, walleye pollock and Pacific cod, to incorporate the predation equations from MSVPA into an age-structured multispecies statistical model (MSM). Results suggest that both models produced similar estimates of suitability coefficients and predation mortalities. The advantage of MSM is the availability of variance estimates for parameters, providing a measure of model uncertainty not available in MSVPA.

Konar, B., C. Hegwer, S. Hills, and K. Wynne. 2004. Shallow water nearshore fish assemblages around Steller sea lion haulouts near Kodiak, Alaska. In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK .

See Hegwer, 2003.

Kruse, G. H., F. C. Fritz, H. J. Geiger, K. R. Mabry, H. M. Savikko and M Shareef. 2000. Overview of state managed marine fisheries in the central and western Gulf of Alaska, Aleutian Islands, and southeastern Bering Sea, with reference to Steller sea lions. (Regional Information Report no. 5J00 - 10 (Division of Commercial Fisheries, Alaska Department of Fish and Game).) Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, AK. 173 pages

In this report the authors provide information on what , when and where fisheries occur within State of Alaska managed marine waters of the Gulf of Alaska west of 144° W longitude and the southeastern Bering Sea. Additionally they provide data on the status of managed stocks, catch, gear types, monitoring methods and any recognized interactions between state managed fisheries and Steller sea lions. GIS maps are provided showing the spatial distribution of fisheries in four categories: herring, salmon, invertebrates and groundfish. Summaries are based on observations in 1999.

Livingston, P.A. and J-J. Jurado-Molina. 2000. A multispecies virtual population analysis of the eastern Bering Sea. ICES J. Mar. Sci. 57:294-299.

In this paper, the authors develop a multispecies virtual population analysis model (MSVPA) for the eastern Bering Sea covering the period 1979–1995. The model includes the following species as predators: walleye pollock, Pacific cod, Greenland turbot, yellowfin sole, arrowtooth flounder, and northern fur seal. Prey species are walleye pollock, Pacific cod, Greenland turbot, yellowfin sole, rock sole, and Pacific herring. Results show that large numbers of walleye pollock, particularly age-0 and age-1 fish are consumed and cannibalism by adult pollock and their predation constitutes the largest source of predation mortality for age-0 fish. Predation plays an important role in explaining the recruitment dynamics of pollock.

Logerwell, E.A. 2004. The Fishery Interaction Team: Investigating the potential for commercial fishing to compete with endangered Steller sea lions for shared prey. In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK.

This abstract describes ongoing experiments to test the whether commercial fishing operations directly or indirectly impact the foraging success of sea lions. Two types of

studies are noted: 1) tests of hypotheses regarding fishing impacts on depletion or disruption of sea lion prey fields, and 2) evaluation of the efficacy of mitigation measures to limit the potential for fishery competition with sea lions. The abstract reports that studies of fish movement between open and closed fishing zones around sea lion rookeries in the Aleutian Islands show mixed results with some protected zones showing high fish abundance and low fish movement while the opposite conditions are observed at other zones.

Logerwell, E.A., and S. F. McDermott. 2004. Are Trawl Exclusion Zones Effective at Mitigating Competition between Commercial Fisheries and Steller Sea Lions? Presented paper. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

This abstract briefly expands on the 2003 presentation at the Marine Science Symposium. A tagging model was developed to evaluate movement rates of Atka mackerel tagged in [the Aleutian Islands] during early summer 2000-2003. Results are as reported above, some protected zones show high abundance and low movement, while others display the opposite conditions.

Logerwell, E.A., K. Aydin, S. Barbeaux, E. Brown, M.E. Conners, S. Lowe, J.W. Orr, I. Ortiz, R. Reuter, and P. Spencer. 2005. Geographic patterns in the demersal ichthyofauna of the Aleutian Islands. Fisheries Oceanography 14 (Suppl. 1): 93-112

Using all or filtered subsets of trawl survey data collected in the Aleutian Islands from 1980-2002 the authors conducted a number of investigations to evaluate distribution and abundance, food habits, and growth studies of demersal species in this area. A number of analyses required pooling sample data across years. Regional delineations were made at six Aleutian Island passes: Unimak, Samalga, Amukta, Tanaga, Amchitka, and Buldir. In addition, data were stratified by finer and coarser scale geographic regions as well as depth zones for different analyses. For example, distribution and abundance of four commercial species (pollock, Pacific cod, Atka mackerel and Pacific ocean perch) was evaluated at a fine spatial scale using ¼ degree longitude blocks and 100 m depth ranges. Food habits were evaluated for the same four commercial species but at larger spatial scale (2° longitude blocks). Functional growth relationships were estimated for a number of rockfish species for each Aleutian Island management area (541, 542 and 543). There were “step-changes” in species occurrence, diversity, population distribution and food habits at Samalga Pass and sites further west indicating physical and biological changes along the length of the Aleutian Island chain. Depth related variability in demersal fish distributions were equally common. The biological changes were consistent with changes in the physical oceanography observed in the vicinity of Samalga Pass.

Lowe S., J. Ianelli, H. Zenger, K. Aydin, and R. Lauth. 2005a. Stock Assessment of Aleutian Islands Atka Mackerel In: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Fish. Mgmt. Council, Anchorage, AK, section 15:757-820.

The catch of Atka mackerel has averaged 55,000 mt since 2000, compared with 60,000 mt in the 1990s and 25,000 mt in the 1980s. Mean ABC over the same intervals was 73,800, 77,600 and 27,000 mt respectively. Since 2000 catch has averaged 79% of the ABC and 89% of the TAC. Population abundance is indexed by trawl surveys (conducted triennial from 1977-1999 and biennially since 1999) and absolute abundance is estimated from statistical age-structured models. Trawl survey abundance has been increasing since the late 1970s.

Model estimated absolute abundance has been somewhat more cyclical than the index from the trawl survey but it has also shown a steady increasing trend since the late 1970s. Mean model estimated age 3+ population biomass was 381, 508, and 479 thousand mt in the 1980s, 1990s and since 2000 respectively. The fishery exploitation rate has been steady since the 1980s at just over 12% y^{-1}.

Lowe, S. A., M. Wilkins, and R. Lauth. 2005b. Assessment Of Gulf Of Alaska Atka Mackerel. In: Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pac. Fish. Mgmt. Council, Anchorage, AK, 15: 861-880

An Atka mackerel population existed in the Gulf of Alaska (GOA) primarily in the Kodiak, Chirikof, and Shumagin areas, and supported a large foreign fishery through the early 1980s. By the mid-1980s, this fishery, and presumably the population, had all but disappeared. Evidence of low population levels was supported by Atka mackerel bycatch in other fisheries of less than 5 mt prior to 1988. The decline of the GOA Atka mackerel fishery suggests that the area may be the edge of the species' range. During periods of high recruitment in the Aleutian Islands, it is thought that juvenile Atka mackerel may move into the Gulf of Alaska under favorable conditions. Recently, Atka mackerel have been detected by the summer trawl surveys primarily in the Shumagin (Western) area of the Gulf of Alaska. Catch has averaged 435 mt annually since 2000. The population is difficult to assess by bottom trawl survey in the Gulf of Alaska. Atka mackerel are highly gregarious patchily distributed population. Consequently survey abundance estimates have shown substantial variability. Most of the GOA Atka mackerel biomass (91% and 96% in 2003 and 2005, respectively) is distributed within the Shumagin area of the Western GOA (Area 610). Atka mackerel were encountered in 29% of the survey hauls conducted in the Shumagin area in the 2005. The 2005 estimate of Atka mackerel biomass in the Shumagin area is 97,200 mt, with a coefficient of variation (*CV*) of 51% (reflecting a variance of 2.5 million), and a 95% confidence interval ranging from 0-198,285 mt.

Marston, B. H., M. F. Willson and S. M. Gende. 2002. Predator aggregations during eulachon *Thaleichthys pacificus* spawning runs. Marine Ecology Progress Series 231:229-236.

In this paper the authors note the seasonal concentration of predatory birds and mammals, including Steller sea lions, during the annual eulachon run. Eulachon abundance is indexed by dip net catch per unit effort and via trap. Marine mammal counts were reasonably synchronous with the short duration (10-12 d) eulachon run. Peak marine mammal counts reached 450 animals, principally Steller sea lion and harbor seals. (see also Gende and Sigler, 2006 above and Gende, et al., 2001 under the Foraging Theme).

McDermott, S.F., L.W. Fritz, and V. Haist. 2005. Estimating movement and abundance of Atka mackerel (Pleurogrammus monopterygius) with tag-release-recapture data. Fisheries Oceanography 14 (Suppl. 1): 113-130

This article addresses the results of Atka mackerel tagging studies conducted in the vicinity of Seguam Pass in the Aleutian Islands, in 1999 and 2000. The study area was divided into two zones: one within the 20 nm trawl exclusion zone, the other outside that zone. During 1999 Atka mackerel were tagged exclusively in areas outside the 20 nm trawl exclusion zone. In 2000, fish were caught and tagged in both zones. Thirteen hundred and seventy-five fish were tagged and released in 1999; 8773 fish were tagged and released in 2000. A greater number of tags were released within the exclusion zone to compensate for lower tag recovery fishing effort and to assure a sufficient probability of recapture. Tag recovery within the 20 nm trawl exclusion zone was accomplished via chartered research vessel; recovery outside the zone was via the charter vessel and the commercial fishery. There was a single tag recovery event in 1999, and 3 tag recovery events in 2000. Fifty tags were recovered in 1999, 104 in 2000. The researchers noted little movement from the exclusion zone to the open zone; but did observe movement from the open zone to the closed zone. The rate of movement was low, the absolute number of tagged fish that moved and were recovered was small (4 fish), the confidence bounds on estimated movement rates are large. The authors report that Atka mackerel do not appear to move substantially outside their local aggregations (<70 km), and show strong habitat preferences within their home range.

Mueter, F. J. and B. L. Norcross. 2000a. Species composition and abundance of juvenile groundfishes around Steller sea lion (*Eumetopias jubatus*) rookeries in the Gulf of Alaska. Alaska Fisheries Research Bulletin 7:33-43.

The authors conducted bottom trawl surveys from late June through July 1994 to 1996 to determine species composition and abundance of juvenile groundfish communities around 6 Steller sea lion rookeries: Akutan, Ugamak, Atkins, Chowiet, Marmot and Sugarloaf Islands. Surveys were conducted coincident with NMML Steller sea lion pup and prey distribution surveys. Temperature, salinity and sediment samples were also gathered at most sites. Sampling did not occur around all rookeries each year. Principle survey gear was a 3.05 m plumb staff beam trawl. Survey samples were stratified in 3 depth zones: 15-40 m, 40-70 m and > 70 m. Overall, the most abundant species in their collections were rock sole *Pleuronectes bilineatus*, walleye pollock *Theragra chalcogramma*, Pacific halibut *Hippoglossus stenolepis*, northern sculpin *Icelinus borealis*, *Triglops* spp., *Gymnocanthus* spp., Pacific cod *Gadus macrocephalus*, slim sculpin *Radulinus asprellus*, and arrowtooth flounder *Atheresthes stomias*. Results showed significant differences in species composition among rookeries within each of 3 depth strata and a greater abundance of juvenile groundfishes in the western part of the study area. Gadid and flatfish species were more abundant and had a higher probability of occurrence in the vicinity of sea lion rookeries on Akun, Ugamak, Atkins, and Chowiet Islands, compared to rookeries on Marmot and Sugarloaf Islands. The observed differences in species composition coincided with differences in topography, substrate composition, temperature, and salinity. A potential relationship between the abundance of juvenile groundfishes and sea lion survival is discussed.

Mueter, F., and B. L. Norcross. 2000b. Spatial and temporal patterns in the demersal fish community on the shelf and upper slope regions of the Gulf of Alaska. Fishery Bulletin 100:559-581.

The authors analyzed data from National Marine Fisheries Service bottom trawl surveys carried out triennially from 1984 to 1996 in the Gulf of Alaska (GOA). The continental shelf and upper slope (0–500 m) of the GOA supported a rich demersal fish fauna dominated by arrowtooth flounder, walleye pollock, Pacific cod, Pacific halibut, and Pacific Ocean perch. Average catch per unit of effort (CPUE) of all groundfish species combined increased with depth and had a significant peak near the shelf break at 150–200 m. Species richness and diversity had significant peaks at 200–300 m. The western GOA was characterized by higher CPUEs and lower species richness and diversity than the eastern GOA. Highest CPUEs were observed in Shelikof Strait, along the shelf break and upper slope south of Kodiak Island, and on the banks and in the gullies northeast of Kodiak Island. Significant differences in total

CPUE among surveys suggest a 40% increase in total groundfish biomass between 1984 and 1996. A multivariate analysis of the CPUE of 72 groundfish taxa revealed strong gradients in species composition with depth and from east to west, and a weak but significant trend in species composition over time. The trend over time was associated with increases in the frequency of occurrence and CPUE of at least eight taxa, including skates, capelin, three flatfish species, and Pacific Ocean perch, and decreases in frequency of occurrence and CPUE of several sculpin species. Results are discussed in terms of spatial and temporal patterns in productivity and in the context of their ecological and management implications.

National Research Council (NRC). 2003. Decline of the Steller sea lion in Alaskan waters; untangling food webs and fishing nets. National Academy press, Washington, D.C. 184 pp.

Within this comprehensive report there are separate reviews of the federal and state managed fisheries in the Gulf of Alaska, Bering Sea and Aleutian Islands. The review provides catch summaries for the groundfish fishery from 1955-2001 and for the state managed herring, crab and salmon fisheries from the early 1900s to 2000. There is additional information on the level of participation in the fisheries, fishery exploitation rates, and population trends for key Steller sea lion prey species. Finally there is a brief appraisal of fishery and sea lion interactions.

Otis, E.O. and M. Spahn. 2003. Improving Access to ADF&G's Lower Cook Inlet Pacific Herring Stock Assessment and Commercial Fishery Databases, Including Observations of Steller Sea Lions (SSLRI Project 12). Final Report (Contract Number NA16FX1411), Alaska Department of Fish and Game, Division of Commercial Fisheries, 3298 Douglas Place, Homer, AK 99603. 7p.

The Alaska Department of Fish and Game has conducted aerial and vessel surveys in Kamishak Bay, Lower Cook Inlet for Pacific herring (*Clupea pallasi*) stock assessment and fishery management since 1978. Surveys occur from approximately April 18 through June 10th of each year. Observations made during these surveys have been digitized for the purpose of improving public access to, and facilitating analysis of, this relatively long-term dataset. The data include over 6,300 individual biological observations including: herring schools, herring spawn events, and incidental observations of marine mammals and seabirds. Other data provided include fishery management areas, age-weight-length sample data, hyper-linked photographs of the area's geography, fauna, and fishery, and commercial harvest effort and catch records.

Ryding, K.E., J.R. Skalski, P.Dillingham, and T.J. Miller. 2003. Empirical relationships between localized fisheries trends and Steller sea lion abundance. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

This abstract presents preliminary findings from research to correlate sea lion declines and local fishery abundance and effort. See Dillingham, et al., 2006 for a comprehensive report on the research.

Shima, M., A. B. Hollowed, and G. R. VanBlaricom. 2000. Response of pinniped populations to directed harvest, climate variability, and commercial fishery activity: a comparative analysis. Rev. Fish. Sci. 8(2):89-124.

In this paper the authors explore hypotheses addressing the decline of the Steller sea lion (*Eumetopias jubatus*) population in the Gulf of Alaska (GOA) through comparative analysis of fisheries and pinniped populations in three other ecosystems: Barents Sea, Benguela Current, and California Current. The authors focus on examining the effects of commercial pinniped harvest, commercial fisheries, and environmental changes. Of the four pinniped species included in this study, only the Steller sea lion population has exhibited a sharp decline in population number. Comparative analysis indicated that the Gulf of Alaska pinniped population has not experienced any unique large-scale perturbations compared to the other ecosystems. Commercial fisheries played a major part in all four ecosystems. The main species in pinniped diets were often the target of commercial fishing activity leading to potential conflicts between the 2 types of predators (i.e., pinnipeds and commercial fisheries). Exploitation rates in the GOA were comparable to or less than rates in the other ecosystems. Statistical analysis showed that GOA pollock exploitation rates were significantly different from the rates of most other species. Healthy pinniped populations were present in all the ecosystems in this study except for the GOA despite the presence of much commercial fishing activity. This suggests the need for more detailed analysis of the possible role of commercial fisheries in the GOA ecosystem and the management actions taken to alleviate its effects.

Shima, M., A. B. Hollowed, and G. R. VanBlaricom. 2002. Changes over time in the spatial distribution of walleye pollock (*Theragra chalcogramma*) in the Gulf of Alaska, 1984-1996. Fish. Bull., 100:3-7-323.

Triennial bottom trawl survey data from 1984 to 1996 were used to evaluate changes in the summer distribution of walleye pollock in the western and central Gulf of Alaska. Differences between several age groups of pollock were evaluated. Distribution was examined in relation to several physical characteristics, including bottom depth and distance from land. Interspecies associations were also analyzed with the Bray-Curtis clustering technique to better understand community structure. Our results indicated that although the population numbers decreased, high concentrations of pollock remained in the same areas during 1984–96. However, there was an increase in the number of stations where low-density pollock concentrations of all ages were observed, which resulted in a decrease in mean population density of pollock within the GOA region. Patterns emerging from our data suggested an alternative to Mac-Call's "basin hypothesis" which states that as population numbers decrease, there should be a contraction of the population range to optimal habitats. During 1984–96 there was a concurrent precipitous decline in Steller sea lions in the Gulf of Alaska. The results of our study suggest that decreases in the mean density of adult pollock, the main food in the Steller sea lion diet, combined with slight changes in the distribution of pollock (age-1 pollock in particular) in the mid-1980s, may have contributed to decreased foraging efficiency in Steller sea lions. Our results support the prevailing conceptual model for pollock ontogeny, although there is evidence that substantial spawning may also occur outside of Shelikof Strait.

Shima, M., A. Hollowed, B. Fadely, C. Wilson, J. Sterling, and K. Call. 2003. Comparison of Steller sea lion diving behavior relative to spatial distribution of walleye pollock and capelin. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AKl

> This abstract is provided in its entirety. "Because the relationships between foraging behavior and prey availability are poorly understood for Steller sea lions, ecosystem modelers must base parameters on theoretical relationships. To improve understanding of these relationships, and to explore the potential for commercial fisheries effects on local fish abundance we compared Steller sea lion dive behavior to potential prey fields derived from acoustic mid-water trawl surveys in Chiniak and Barnabas troughs on the east side of Kodiak Island, Alaska. Field observations during August 2001 and 2002 were used to map the vertical and spatial distribution of two species of potential sea lion prey, walleye pollock (*Theragra chalcogramma*) and capelin (*Mallotus villosus*). To compensate for spatial and temporal differences in the fish fields the study region was partitioned into six sub-regions with a day and night vertical distribution within each partition. Fish were not evenly distributed throughout the study regions and exhibited marked diurnal shifts in vertical distribution. Juvenile sea lions captured and instrumented at Cape Chiniak (2001 n=1, 2002 n=2) traveled within the Chiniak trough study area, with most dives shallower than 34 m and made during the 2100-0900 h period. Examination of dive behavior during unique trips, however, showed that sea lions occasionally targeted depths much deeper (50-100 m) than average. Juvenile sea lions instrumented near the Barnabas trough (2001 n=2, 2002 n=5) did not utilize the trawl survey areas. Analyses of location-matched dive behavior with fish distribution are being conducted, and implications for modeling foraging behavior explored."

Sigler, M., J. Vollenweider, and D. Csepp. 2003a. Southeast Alaska Steller sea lion prey study. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK

> The authors conducted seasonal measurements of prey abundance and nutritional quality in southeast Alaska. They attempted to determine: 1) the characteristics of the *available* prey field (prey, bathymetry, oceanography) within the study area; 2) the characteristics of the areas where sea lions were diving, the *utilized* prey field; and 3) which prey field was better represented by sea lion scats They used data collected via acoustic and midwater trawl surveys, ROV and beach seine surveys, chemical analyses of prey energy density and nutritional quality, scat collections (UBC & UA), aerial surveys of sea lion haulouts (UA), and satellite tagging of sea lions (ADFG, NMML). Three preliminary conclusions are: 1) Prey abundance is concentrated: 45-75% of prey were concentrated in 10% of Frederick Sound during May, September, and December 2001. 2) Overwintering herring aggregations in Frederick Sound and lower Lynn Canal may be important energy sources for Steller sea lions during winter. Herring were concentrated and found throughout winter 2001/2002 at certain, known locations (e.g. on the east side of Benjamin Island; a seasonal Steller sea lion haulout is located on the west side) and were at their highest energy density of the year. 3) Spawning aggregations of eulachon appear to be important energy sources for Steller sea lions during spring. Peak sea lion abundance at Berners Bay, the site of an eulachon prespawning aggregation, was 949 animals. Sea lion abundance increased as eulachon began concentrating in Berners Bay, peaked as eulachon abundance peaked, and decreased as the eulachon moved upriver. Eulachon energy density was greatest during the period of highest sea lion abundance. [See also, Sigler et al., 2004a]

Sigler, M., J. Vollenweider, and J. Womble. 2003b. Availability to Steller sea lions (*Eumetopias jubatus*) of a seasonal prey resource: A prespawning aggregation of eulachon (*Thaleichthys pacificus*). P. 150, in 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

In this abstract the authors provide additional results from the studies outlined in Sigler et al., 2003a (above). Sea lions reported consumed 20% of the eulachon aggregated in Berners Bay. Energy density of eulachon was 2.21 kcal g^{-1}. They estimated that at least 81 daily energy rations per sea lion were available while eulachon were present. The eulachon run lasted from late April to early May.

Sigler, M.F., J.N. Womble, and J.J. Vollenweider. 2004a. Availability to Steller sea lions (*Eumetopias jubatus*) of a seasonable prey resource: a spawning aggregation of eulachon (*Thaleichthys pacificus*). Can. J. Fish. Aquat. Science 61:1475-1484.

The availability of seasonally abundant energy-rich prey can be a significant factor for the survival and reproductive success of predator populations. Large numbers of Steller sea lions (*Eumetopias jubatus*) were attracted to a prespawning aggregation of eulachon (*Thaleichthys pacificus*) in Berners Bay in southeast Alaska during April–May in 2002 and 2003. Sea lion abundance increased as eulachon gathered in Berners Bay, peaked as eulachon abundance peaked, and decreased as the eulachon moved up-river. As sea lion abundance increased in Berners Bay, sea lion abundance decreased at Benjamin Island, a sea lion haulout located 22 km away. The eulachon provided an abundant, energy-rich, predictable prey source for the Steller sea lions: (*i*) eulachon energy density was 9.70 ± 0.24 kJ·g–1, much higher than that of any forage species reported in the North Pacific Ocean except northern lampfish (*Stenobrachius leucopsarus*); (*ii*) a large surplus of prey was available per sea lion while the eulachon aggregation was present; and (*iii*) the spawning run usually begins between late April and early May. The eulachon pulse may be critical to Steller sea lions during a period of high energetic demands.

Sigler, M.F., S. M. Gende, and D. J. Csepp. 2004b. Predictability of prey available to free-ranging Steller sea lions at varying spatial scales. Presented paper. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors looked for characteristics of Southeast Alaska fish species at several spatial scales that may facilitate efficient foraging by free-ranging Steller sea lions. Herring and pollock were the dominant prey species in the study area. Predictability of herring was generally asymptotic, peaking at a spatial scale of 11 km^2, whereas pollock were more predictable a much smaller spatial scale of 2.1 km^2 (reflecting a more uniform population distribution). Sea lions were able to locate prey patches that were highest in energy density during most months. The authors speculate that the ability to predictably locate high energy prey may play a central role in the nutritional health for stable or increasing sea lion populations.

Soboleff, N.J. 2006. Potential interactions between state-managed fisheries and Steller sea lions (*Eumetopias jubatus*). M.S. Thesis, University of Alaska, Fairbanks. 124 p.

> This study attempts to determine if the Steller sea lion decline in abundance between 1976 and 2002 was “consistent with development of certain state-managed commercial fisheries.” Using sea lion count data and Alaska Department of Fish and Game’s (ADF&G) Fish Ticket data, Steller sea lion population counts were grouped based on patterns of population decline and commercial fishery catch, from state managed fisheries, within 50 nm of each rookery grouping was correlated with sea lion population trends. Negative correlations between state-managed fisheries for groundfish and salmon fisheries were found but few were statistically significant. Low statistical power constrained some of these tests. Many state-managed fisheries for shellfish (shrimp, king, and Tanner crab) were positively correlated with Steller sea lion declines, but again few were statistically significant. Rather than suggesting that somehow sea lions benefit from these fisheries, positive correlations are more likely to be indicative of covariation of sea lions and fisheries with common environmental factors.

Soboleff, N.J., and G. H. Kruse. 2004. Potential interactions between state-managed fisheries and Steller sea lions (Eumetopias jubatus). Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> In this poster the author presents a sketch of the research supporting his MS Thesis. [See Soboleff, 2006.]

Soboleff, N.J., and G.H. Kruse. 2005. Potential interactions between state-managed fisheries and Steller sea lions, Eumetopias jubatus. In: Marine science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

> [See Soboleff, 2006.]

Thedinga, J.F., S. W. Johnson, and D.J. Csepp. 2004. Seasonal availability of nearshore prey to Steller sea lions near two haul-outs in Southeastern Alaska. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> [See Thedinga et al., 2003 below.]

Thedinga, J.F., S.W. Johnson, and D.J. Csepp. 2003. Seasonal availability of nearshore prey to Steller sea lions at two haulouts in Southeast Alaska. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

> This study examined the seasonal availability of SSL prey in near-shore waters <100 m deep near two haulout sites in Southeast Alaska in summer and winter from 2001 to 2004. Prey was inventoried by beach seine, jig, and ROV within 7 km of the Benjamin Island and Brothers haulout sites. Regardless of sampling method, total catch was always greater at the Brothers than at Benjamin Island. Total fish and species count for each sampling method are presented for each area. Sixteen of the species they captured had been identified in SSL scat and more prey was available to SSLs in summer than in winter in near-shore areas.

Thomas, G. L. and R. E. Thorne. 2001a. Night time predation by Steller sea lions (vol 411, pg 1013, 2001) - Correction. Nature 414(6865):710.

This note contains a minor correction to the article summarized below. In the original article, the authors implied that sea lions were feeding exclusively on herring. In the correction they note that sea lions were "selectively targeting the relatively shallow (0-50 m depth) schools of Pacific herring at night to the exclusion of relatively large and deeper (150-250 m) concentrations of walleye pollock."

Thomas, G. L. and R. E. Thorne. 2001b. Night-time predation by Steller sea lions: New insight into the feeding habits of these mammals will help conservation attempts. Nature 411(6841):1013.

In Prince William Sound, Steller sea lions are observed feeding selectively on herring. Infrared technology allowed the authors to observe sea lions feeding at night. Acoustic assessments of herring and pollock revealed a herring biomass of 7,300 mt and a pollock biomass of 28,300. These two biomasses were bathymetrically separated during night-time hours. Pollock although more abundant than herring remained in deeper water (>100 m) both day and night and were not the apparent preferred prey of sea lions at this time. The authors detected no sea lion predation on herring during the daylight hours, but did observe active sea lion predation on herring at night as the fish rose in the water column forming dense schools in 10-35 m of water.

Thomas, G.L. and R.E. Thorne 2003. Acoustical-optical assessment of Pacific herring and their predator assemblage in Prince William Sound, Alaska. Aquatic Living Resources 16:247-253.

In this paper the authors recount the development of an acoustic sampling methodology to estimate biomass of herring in Prince William Sound. The acoustic sampling techniques evolved into one which surveyed spring time aggregations of pre-spawning herring. Purse seine sampling was used in combination with the acoustic sampling to verify size, age and species composition of the acoustic targets. Acoustic sampling proved comparable to traditional methods of indexing population abundance. Acoustic surveys estimated an abundance of 16,082 mt in the fall of 1993 and 12,555 mt in fall 1994. With a moratorium on fishing, the population rebuilt to 23,203 mt and 37,498 mt in the spring of 1995 and 1996, respectively. However, after reopening the commercial fishery, the acoustic surveys in the springs of 1998 and 1999 showed a decline to about 17,000 mt. After test fishing in the spring of 1999, management cancelled the fishery. The spring survey of 2000 and 2001 showed the population to have fallen to new, all-time lows of 7,281 and 6,384 mt, respectively. Over a three-year period, the authors found strong correlations (R^2 =0.88 to 0.98) between acoustic estimates of biomass and synoptic counts of Steller sea lions at various locations of overwintering herring (Thorne and Thomas 2002). Subsequent comparisons between our annual estimates of herring in PWS and the long-term census data on Steller sea lion abundance in PWS taken at The Needle, which is the major haul-out within PWS (Kruse et al., 2000; Sease et al., 2001) also show a very strong correlation. The herring population declined by 88% between 1989 and 2000, while the Steller sea lion count declined 86% (Fig. 4). Further, the Steller count in 1973 was 25% of the peak count in 1990, while the herring miles of spawn the first year it was measured, 1974 was 22% of its peak value measured in 1988. Steller sea lion counts also declined after 1989 at sites adjacent to PWS. The average decline between 1989 and 2000 for the three major adjacent sites, Wooded Island, Seal Rocks and Point Elhrington, was 72%.

Thomas, G.L., and R. E. Thorne. 2004. Implications of the Prince William Sound Herring Population Crash: Did It Impact Steller Sea Lions? Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors report declines in herring biomass in Prince William Sound concomitant with declining SSL abundance at nearby rookeries and haulout sites. Over the period 1989-2000 herring stocks declined by 88% and nearby SSL numbers dropped by a similar order of magnitude. Both SSL counts and herring biomass in PWS have increased since 2000 suggesting an abundance-dependent foraging behavior.

Thompson, G. G. and M.W. Dorn. 2005a. Assessment of the Pacific Cod Stock in the Eastern Bering Sea and Aleutian Islands Area.

Pacific cod are a seasonally important prey item for Steller sea lions, particularly during winter in the western Gulf of Alaska and eastern Aleutian Islands. Furthermore, the size ranges of Pacific cod harvested by the fisheries and consumed by Steller sea lions overlap, and the fishery operates to some extent in the same geographic areas used by Steller sea lion as foraging grounds. The Bering Sea and Aleutian Islands area catch of Pacific cod has averaged 192,000 mt y^{-1} since 2000, compared to an average annual catch of 126,300 mt in the 1980s and 207,900 mt in the 1990s. Mean ABC was 281.8 kmt in the 1980s, 250.9 kmt in the 1990s, and 209.3 kmt since 2000. TAC has routinely been set lower than ABC. The average annual rate of utilization (Catch/Biomass) has been 17% since 2000 (Model 3 of the current assessment). Survey estimated stock biomass has shown a decline in abundance over the past 27 years. Mean survey estimated biomass was high in the 1970s at 1.030 mmt declining to 746 kmt in the 1980s and declining further to 631 kmt since 2000. Since 2002, survey estimated biomass has remained stable. A new model was introduced in the current assessment and the authors preferred version of the new model is Model 3. Model population biomass estimates reflect a change in biomass over time that is slightly less severe than that shown in the survey estimated biomass. The model estimated age 3+ population biomass averaged 1.5 mmt in the 1980s, 1.1 mmt in the 1990s and 960 kmt since 2000. The Plan Team disagreed with the stock assessment authors regarding the preferred model parameterization; they selected Model 2 which estimates a slightly different biomass trace than Model 3; biomass was estimated to be a little higher in the 1980s (1.520 mmt) and a little bit lower since 2000 (930 kmt) [6].

Thompson, G. G. and M. W. Dorn. 2005b. Assessment of the Pacific Cod Stock in the Gulf of Alaska. In: Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pac. Fish. Mgmt. Council, Anchorage, AK, 2:155-244

Pacific cod are a seasonally important prey item for Steller sea lions, particularly during winter in the western Gulf of Alaska and eastern Aleutian Islands. Furthermore, the size ranges of Pacific cod harvested by the fisheries and consumed by Steller sea lions overlap, and the fishery operates to some extent in the same geographic areas used by Steller sea lion as foraging grounds. The Gulf of Alaska area catch of Pacific cod has averaged 54 kmt y^{-1} since 2000, compared to an average annual catch of 31 kmt in the 1980s and 70 kmt in the 1990s. Mean ABC was 108 kmt in the 1980s, 72 kmt in the 1990s, and 63 kmt since 2000. TAC has routinely been set much lower than ABC averaging 65 kmt, 66 kmt, and 48 kmt in

[6] See the 2005 North Pacific Groundfish Stock Assessment and Fishery Evaluation Reports for 2006: BSAI Introduction at http://www.afsc.noaa.gov/refm/stocks/assessments.htm

the 1980s, 1990s, and 2000s respectively. The average annual rate of utilization (Catch/Biomass) has been 9% since 2000 (Model 3 of the current assessment). Survey estimated stock biomass has shown a decline since the 1980s. Mean survey estimated biomass was 473 kmt in the 1980s declining to 418 kmt in the 1990s and declining further to 288 kmt since 2000. Survey estimated biomass has remained fairly stable since 1999. A new model was introduced in the current assessment and the authors preferred version of the new model is Model 3. Model population biomass estimates paint a very different picture of the change in biomass over time when compared with the trawl survey. The model indicates that stock abundance was relatively low in the late 1970s increased substantially through the 1980s and has been declining since the 1990s. The model estimated age 3+ population biomass averaged 609 kmt in the 1980s, 736 kmt in the 1990s and 562 kmt since 2000. The Plan Team disagreed with the stock assessment authors regarding the preferred model parameterization; they selected Model 2 which estimates a lower biomass than Model 3; biomass was estimated to be 450 kmt in 1980s, 550 kmt in the 1990s and 411 kmt since 2000 (see Anonymous, 2005 above).

Thorne, R. E., G. L. Thomas and J, J. Goering. 2002. Interactions among Steller Sea Lions, Pollock and Herring and an Examination of Variability Associated with Acoustic Surveys of Pollock. Final Project Report to the Pollock Conservation Cooperative, University of Alaska, Fairbanks, Prince William Sound Science Center, Cordova, AK. 18 p

The authors report finding Steller sea lions coincident with and actively foraging upon all major herring concentrations in Prince William Sound. They report no similar interactions with pollock despite extensive aerial survey and intensive, day and night boat surveys that included the use of infrared scanners. Further, they report that the population of Steller sea lions has varied in near direct proportion to the changes in abundance of herring in Prince William Sound. [see also, Thomas and Thorne, 2001a, 2001b, 2003, and 2004 above]

Thorne, R.E. and G.L. Thomas 2002. Evaluation of Changes in the Foraging Behavior of Steller Sea Lions in Response to Precipitous Declines of the Herring Population in Prince William Sound. Final Report to NMFS, SSLRI Project # 31, 32p.

This final report was not seen but interim reports by the authors available on the web dated 2001 and 2002 provide sufficient information to believe that the final report is similar to the interim report. The data and information in these interim reports are the same as those in the presentations above by Thomas and Thorne and the presentations below by Thorne and Thomas (2003) and Thorne et al. (2003). Published versions of this study can be found in Thorne and Thomas (2001) in the Foraging—Searching For Prey theme

Thorne, R.E., and G.L. Thomas. 2003. Spatial and numerical relationships between Steller sea lions and Pacific herring in Prince William Sound, Alaska. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

In the abstract the authors report that they found nearly 100% spatial coincidence of Steller sea lions with overwintering herring concentrations, and 0% spatial coincidence of Steller sea lions with overwintering pollock concentrations in Prince William Sound (PWS). They also reported that Steller sea lions began to target herring concentrations in early November. The foraging activity peaked in early March. An examination of historic databases showed that Steller sea lion counts in PWS declined 86% between 1989 and 2000, while herring declined

88%. The authors concluded that the availability of energetically efficient overwinter forage is a critical factor governing the abundance of Steller sea lions in PWS.

Thorne, R.E., G.L. Thomas and M. Foster 2003. Application of combined optical and acoustic technologies for fisheries and marine mammal research in Prince William Sound and Kodiak, Alaska. Proceedings Ocean 2003 MTS/IEEE (Electronic), Holland Publications, Escondido, CA.

This paper describes the use infrared scanners in association with acoustic technologies to monitor the abundance of pollock and herring in Prince William Sound and the coincidental association of Steller sea lions with the fish aggregations. (see Thorne et al., 2002).

Thorne, R.E., G.L. Thomas, and M. Foster. 2003. Associations between Steller sea lions and Pacific herring around Kodiak. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

In this abstract the authors extend their observations from Prince William Sound into waters around NW Kodiak Island, and Uganik Inlet. Here they conducted acoustic survey estimates of herring abundance in January and March, 2002. Abundance estimates were 13, 071 mt and 8,179 mt respectively. Seventy Steller sea lions were observed via aerial survey in the vicinity of the herring aggregation in January, with that number increasing to 300 in March. Foraging activity was still primarily at night, but daytime foraging was also observed on shallower herring schools at the head of the inlet.

Tollit, D.J., S.G. Heaslip, and A.W. Trites. 2004. Sizes of walleye pollock consumed by the eastern stock of Steller sea lions in Southeast Alaska from 1994-1999. Fishery Bulletin 102(3): 522-532.

In this paper the authors describe a method for estimating the size frequency of Steller sea lion prey based on allometric relationships between bone size and fish size. The ingested bones of prey items are segregated from scat samples and stratified based on the degree of digestion. The actual size of the bones at the time of consumption is back calculated from formulae associating the change in bone size due to digestion. Application of the method demonstrates that the size frequency of ingested prey is larger than might otherwise be surmised. [see additional summary comments for this article under Theme 2a-Foraging-Diet.]

Trites, A. W., V. Christensen, and D. Pauly. In press. Effects of fisheries on ecosystems: just another top predator? Pp. 000-000 in Top predators in marine ecosystems: their role in monitoring and management (I.L. Boyd, K. Camphuysen and S. Wanless, eds.). Cambridge University Press, Cambridge.

In this article the authors recount changes in world populations of fishes and the apparent effect of commercial fishing on the ecosystems where they occur. In particular they contrast fisheries with other apex predators and note the differences in ecological mechanisms constraining exploitation of prey resources by these predators. Thus, the authors report, it appears that fisheries have the potential to disrupt the biological structure of food webs, particularly in ecosystems comprised primarily of long food chains. While there are undoubtedly parallels between the effects of fisheries and those of marine mammals on food chains, there are at least three important differences. One is that mammals and all other species that make up food webs are generally limited by the size of prey they can consume. In addition, they tend to be specialized feeders and hence, draw their energy from a very limited range of trophic levels; in contrast, humans can feed on any size of organism at any trophic level. A second major difference between fisheries and apex predators is that predator populations in naturally occurring systems are regulated through density-dependent processes that limit reproduction and survival as prey populations decline; however, there is little to regulate the rate of fishery catches apart from economic incentives, which normally increase (rather than decline) as the species becomes rarer. The third, and perhaps most significant, difference between the two is that stable marine food webs are the result of a long period of natural selection and co-evolution between predators and prey, whereas fisheries represent an abrupt, knife-edged selective force that has potentially destabilizing consequences. Overall, it appears that predator–prey interactions have shaped each others life-history strategies, and potentially those of their competitors as well. None of these selected characteristics are likely to be effective at maintaining populations targeted by fisheries. In fact, many of the features that have allowed prey to flourish in the face of apex predators now make fish more vulnerable to being caught by fisheries. On many levels, fisheries have a lot in common with apex predators in that they can reduce the abundance of their prey and can influence the rates of growth and maturity of the species they target. Fisheries can also influence rates of turnover and nutrient cycling. However, the effects of fisheries go well beyond those of other apex predators, due in large part to their capacity to remove large amounts of biomass from the world's oceans and the lack of biological controls or feedback to limit what and how much they take.

Trites, A.W. 2002. Predator-prey relationships, pages 994-997. In: W.F. Perrin, B. Wursig, and H.G.M. Thewissen, editors, Encyclopedia of Marine Mammals. Academic Press, San Diego.

This paper presents a very generic overview of predator-prey ecological relationships.

Wespestad, V. G., L. W. Fritz, W. J. Ingraham, and B. A. Megrey. 2000. On relationships between cannibalism, climate variability, physical transport, and recruitment success of Bering Sea walleye pollock (*Theragra chalcogramma*). ICES J. Mar. Sci. 57: 272-278.

This paper's abstract is presented in its entirety: "Walleye pollock (*Theragra chalcogramma*) is the single most abundant fish species in the Bering Sea and comprises the bulk of the commercial catch. Juvenile pollock are an important forage fish for older pollock, other fish, marine mammals, and birds. We examine the interaction between cannibalism, climate variability, and related patterns in physical transport. Our analysis of adult and juvenile pollock abundance and distribution time series, ocean current modeling studies, and information on climate variability indicates that cannibalism is a major determinant of interannual recruitment variability. In turn, the intensity of cannibalism appears to be dependent on the degree of spatial separation of adults and juveniles. Strong year classes occur when juvenile pollock are transported inshore and away from adults in spring – conditions typical of warm years. In cold years, transport is reduced and juveniles remain on the outer shelf in proximity to adults. Co-occurring distribution patterns of adults and juveniles resulting from these conditions lead to potentially increased cannibalism and subsequent weak year classes."

Wilson, C. D., A. B. Hollowed, M. Shima, P. Walline, and S. Stienessen. 2003. Interactions between commercial fishing and walleye pollock. Alaska Fishery Research Bulletin 10(1):61-77.

This paper presents the results from the first two years (2000-2001) of a study of fishery effects on local population density of pollock along the southeast coast of Kodiak Island, Gulf of Alaska. Barnabas Trough served as a treatment site where commercial fishing was allowed and nearby Chiniak Trough served as a control site where fishing was prohibited. The study area is adjacent to six Steller sea lion haulouts, occupied by 508 animals in 2000. During 2000, there was no fishing in either the treatment or control site; fishing occurred in the treatment site in 2001. Acoustic surveys were conducted in August of each year to estimate the distribution and abundance of pollock and other pelagic forage fish in the study area. Survey timing was selected to coincide with the initial weeks of foraging for recently weaned sea lions. The surveys consisted of a series of uniformly-spaced (3 nmi) parallel transects. Multiple surveys were conducted in each year. The biomass and distribution of walleye pollock were stable over periods of days to weeks although during the 2001 an unusual, extremely dense, small-scale walleye pollock aggregation was detected during one of several survey passes. Several morphological descriptors of the walleye pollock echosign layers were evaluated to better understand whether differences at the scale of the fish aggregations occurred in response to fishing. Variography was used to quantify walleye pollock spatial patterns. Results from 2001 do not suggest a significant link between fishing activities and changes in estimates of juvenile and adult walleye pollock geographical distribution, biomass, or vertical distribution. Additional research is suggested to monitor the persistence of the observed trends.

Womble, J. N., B. P. Kelly, M. F. Willson and M. Sigler. 2001. Spatial ecology of Steller sea lions (*Eumetopias jubatus*) and forage fish aggregations in Southeastern Alaska. P. 236, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

[See Sigler, Womble and Vollenweider, 2004a above, and Womble et al., 2005 below]

Womble, J. N., M. F. Willson, M. F. Sigler, B. P. Kelly, and G. R. VanBlaricom. 2003. Spring-spawning fish aggregations: A seasonal feast for Steller sea lions. In Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK

[See Sigler, Womble and Vollenweider, 2004a above, and Womble et al., 2005 below]

Womble, J. N., M. F. Willson, M. F. Sigler, B. P. Kelly, and G. R. VanBlaricom. 2005. Distribution of Steller sea lions Eumetopias jubatus in relation to spring-spawning fish species in southeastern Alaska. Mar. Ecol. Prog. Ser. 294:271-282

The paper's abstract is presented in its entirety: "Energetic demands are high for Steller sea lions, *Eumetopias jubatus*, during spring, when females are pregnant and lactating and males are preparing for extended fasts on breeding territories. Therefore, we predicted that the distribution of sea lions in SE Alaska in spring would be influenced by the distribution of spring spawning aggregations of high-energy prey species (Pacific herring *Clupea pallasii* and eulachon *Thaleichthys pacificus*). The spatial distribution of sea lions during spring reflected the distribution of spawning eulachon in northern Southeast Alaska, particularly in Lynn Canal and along the Yakutat forelands. Haulouts with peak numbers of sea lions in spring were located significantly closer to eulachon spawning sites than haulouts that peaked at other times of year. Some haulouts were occupied only during the eulachon spawning period. The maximum number of sea lions at haulouts in spring was inversely correlated with the distance to the closest eulachon aggregation and was positively associated with the number of eulachon within 20 km. Aerial surveys conducted every 7 to 10 d during March through May in 2002 and 2003 revealed large numbers of sea lions in the water at herring spawning sites in 2002 and 2003; however, there were no significant relationships between the number of herring spawning sites and number of sea lions (except at distances >60 km). The number of sea lions was greater at herring spawning sites in 2003, corresponding to higher herring biomass. Seasonally aggregated, high-energy prey species influence the seasonal distribution of sea lions and may be critical to their reproductive success."

Womble, J.N. 2003. Seasonal distribution of Steller sea lions (*Eumetopias jubatus*) in relation to high-quality ephemeral prey species in Southeastern Alaska. M.S. thesis, Univ. Alaska, Fairbanks.54 p.

Monthly aerial surveys at 23 Southeast Alaska Steller sea lion haulouts revealed that they were being used only during spring. These haulouts were significantly closer to forage fish aggregations (herring and eulachon) than haulouts occupied throughout a wider range of seasons and located elsewhere. The author speculates that seasonal use of the 23 Southeast Alaska haulouts may be critical to Steller sea lion reproductive success.

Wynne, K. and R. J. Foy. 2001. Steller sea lion prey use vs availability near Kodiak Island. P. 237, in: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada

In this abstract, the authors report on the seasonal distribution of prey species within Steller sea lion critical habitat near Kodiak Island and the coincidental use of prey by Steller sea lions. Using bottom trawl, mid-water trawl and acoustic surveys, they determined the species composition, distribution and relative abundance of fish species surrounding Long Island in March, May and November 2000. Scat samples were gathered from November 1999 through April 2000. Benthic fish density was seasonally variable. Predominant species included arrowtooth flounder, flathead sole, pollock and rock sole, with halibut, Pacific cod and spiny dogfish seasonally important. Dominant pelagic species included pollock, eulachon and capelin. Sea lion diet based on frequency of occurrence of prey items was diverse. Prey dominance varied seasonally with sandlance, arrowtooth flounder and salmon ranking first in different collections.

Wynne, K.M., R.J. Foy, B.L. Norcross, C.L. Buck, and S. Hills. 2003. Availability and use of prey by Steller sea lions in the eastern Kodiak area, 1999-2000. Final Report to the North Pacific Marine Research Program, School of Fisheries and Ocean Sciences, Univ. of Alaska Fairbanks, 23 pp.

The specific objectives of this study were to 1) determine seasonal use by Steller sea lions of designated critical haulouts in Kodiak area; 2) determine the seasonal differences in prey species composition and abundance within 10 nm and 20 nm of a critical SSL haulout; 3) relate fish composition to oceanographic parameters (water temperature, salinity, depth; 4) determine the seasonal pattern of prey consumption by Steller sea lions in Kodiak area, including frequency of occurrence, diversity, and relative size by species or species groupings; and 5) compare diet of Steller sea lions to prey availability within 10 nmi and 20 nmi of Long Island haulout. The study area encompassed Critical Habitat for Steller sea lions and included a Marmot Island rookery and three haulouts at Ugak Island, Cape Chiniak, and Long Island as well as the waters within 20nm of the Long Island haulout. From September 1999 to December 2000, aerial surveys were used to count sea lions monthly and a synchronous collection of scats were gathered from haulouts only. To minimize sea lion disturbance alternate haulouts were sampled monthly resulting in bimonthly visits to the same location. Prey availability was assessed via trawl and acoustic surveys in March, May and November 2000. Survey areas were stratified to allow estimation of fish density within 10 and 20 nm radius of the sea lion haulouts and rookery. The authors report that Steller sea lions in the Kodiak study area were using a diverse prey base as evidenced by the occurrence of 31 species identified in scats. Eleven species were found to be significant prey, six of which occurred in greater than 20% of the scats: pollock, arrowtooth flounder, sandlance, Pacific cod, salmon, and Irish lords. Flatfish and gadids were the dominant prey groups used by sea lions and were also found to dominate the biomass of fish within waters of the study area. Five of the seven most frequently occurring prey species found in scat samples were also found to be most abundant in waters within 20nm of Long Island: arrowtooth flounder, rock sole, walleye pollock, Pacific cod, and Irish lords. Salmon and sandlance were significant primary prey items that were not found to be prevalent in the prey surveys. Eulachon, a smelt frequently sampled in the deep water trawls, was found in less than 5% of scat samples.

Wynne. K.M. 2005. Alaska's Steller sea lions: boom to bust- and back? Alaska Seas and Coasts, Vol. 1. May 2005. Univ. of Alaska Sea Grant Marine Advisory Program, Anchorage, AK 12pp.

This article appears to be written as a public education piece. In the article the author provides an overview of Steller sea lion status, management, research, and prognosis for recovery.

Yang, M-S., K. Aydin, A. Greig, G. Lang, and P. Livingston. 2005. Historical review of capelin (*Mallotus villosus*) consumption in the Gulf of Alaska and eastern Bering Sea. NOAA Tech. Memo. NMFS-AFSC-155. 89p.

This study reviews the consumption of capelin by marine fishes in the eastern Bering Sea and Gulf of Alaska. Bering Sea data from 1970 to 2001 and Gulf of Alaska data from 1981 to 2001 are used to describe the spatial distribution of capelin reflected in the stomach contents of various predators. Capelin was a key diet item for groundfish in the inner domain (wates < 50 m deep) of the eastern Bering Sea, and shelf area (waters less than 100 m deep) of the Gulf of Alaska. Principal predators included arrowtooth flounder, Pacific cod, halibut, and pollock . Estimated volume of consumption in the Gulf of Alaska ranged from 21 kmt to 221 kmt; by contrast, consumption in the eastern Bering Sea ranged from 19 to 48 kmt.

(This page intentionally left blank)

THEME 5: ECOSYSTEMS

There are 33 journal articles, 1 technical report, 2 theses, 5 book articles, 2 contract reports, 9 manuscript reports, and 12 symposia presentations, abstracts and posters represented in this section.

SUMMARY

In 2003, the National Research Council published their review, "Decline of the Steller Sea Lion in Alaskan Waters." The review panel identified eight hypotheses to explain the decline; two were classified as "bottom-up", five as "top-down" and one as either bottom-up or top-down. Bottom-up hypotheses relate to controls on sea lion food supply, e.g., through competition with fisheries for prey resources or via impacts of climate on ecosystem productivity. Top-down hypotheses deal with direct impacts on sea lion survival, e.g., predation on sea lions by killer whales and/or sharks; shooting by humans either legally through subsistence harvest or illegal shooting; incidental mortality through interaction with fishing gear (entanglement); or losses due to disease. A number of researchers have explored these hypotheses.

Top-down Hypotheses

Springer et al (2003) is the principle proponent of top-down predation controls on Steller sea lion declines and recovery. Springer formulated the "sequential megafaunal collapse" hypothesis asserting that industrial commercial whaling in the 1950s-1960s depleted an import prey for mammal eating killer whales forcing them to shift prey preferences. The resultant "sequential decline" in harbor seals, fur seals, Steller sea lions and sea otters is assumed to reflect the changing diet of killer whales following the large whale decline. They are supported in part by Whitehead and Reeves (2005) who defend the notion of killer whale prey switching, but don't necessarily support the mechanism suggested by Springer. Hunt et al (2002) put forward another hypothesis, the "oscillating control hypothesis" (OCH) which predicts that pelagic ecosystem function in the southeastern Bering Sea will alternate between primarily bottom-up control in cold regimes and primarily top-down control in warm regimes.

Springer's hypothesis was controversial to say the least. Trites, Breedsen and Coombs (2004), DeMaster et al (in press), and Trites et al (in press.c.) each refute the Springer hypothesis. Trites, Breedsen and Coombs, using Ecopath modeling, argue that environmental effects are the apparent forcing variable on sea lion abundance. DeMaster et al., dispute the timing of the megafaunal collapse as determined by Srpinger and argue further that killer whales were never really dependent upon the large whales removed during commercial whaling as Springer asserts. Trites et al. argue that if Springer's hypothesis were correct similar effects should have manifested themselves in British Columbia waters; since they did not, Springer's hypothesis must not be correct.

Bottom-up Hypotheses

Arguments for and against bottom-up ecosystem controls depend in part on the recognition of distinct regime shifts effecting primary productivity in Alaskan marine ecosystems. Hare and Mantua (2000) describe a suite of environmental indices that support the notion of an ecosystem regime shift in Bering Sea occurring in 1977, and subsequent weaker regime shift in 1989. Benson and Trites (2002) review multiple environmental indices and conclude that recognizable regime shifts occurred in the north Pacific in 1925, 1947, 1977, 1989 and possibly 1998. Conners et al (2002) evaluating the spatial/temporal patterns of species diversity in trawl survey records from 1963-2000 conclude that systemic changes affecting taxa ranging from large pelagic and benthic predators to sessile benthic filter feeders suggests that a non-linear ecosystem shift occurred sometime in the early 1980s. Miller et al (2005) describe a physical mechanism that they speculate may be responsible for changes in ecosystem dynamics in the Gulf of Alaska.

The impact of regime shifts on primary productivity is in greater dispute than the existence of regime shifts. Schell (2000) using stable isotope ratios of C and N in whale baleen, and Hobson et al (2004) looking at stable isotopes in sea lion tooth dentin each conclude that productivity in Alaskan marine ecosystems declined after 1977. Hirons et al (2001) looking at similar isotope ratios in marine mammal bone collagen acknowledge a continuous productivity decline from 1950-1997; but, they note no trend in the nitrogen isotope ratios implying no trophic level shifting among foraging pinnipeds.

Trites and Donnelly (2003) present evidence in support of the so called "junk food" hypothesis which asserts that Steller sea lions abundance declined as a consequence of "chronic nutritional stress" brought about by a change is diet quality. The junk food hypothesis depends on a shift in Steller sea lion prey consumption from energy rich prey prior to the regime shift to lower energy prey subsequent to the regime shift. Hirons' et al (2001) isotope study appears to contradict the notion of a change in trophic level which might be expected if pinnipeds shifted from phytoplankton grassers like capelin and smelt to zooplankton and piscivorus consumers like pollock. Fritz and Hinckley (2005) present additional arguments to refute the junk food hypothesis.

Competition among species other than man may also be controlling sea lion abundance and/or recovery. Livingston and Jurado-Molina (2000) using MSVPA showed that predation played an important role in explaining the recruitment dynamics of pollock. Steller sea lions and other fishes consume pollock and are competing with each other for that resource. Aydin (2002) used Ecosim modeling to evaluate the impact of changes in pinniped food supply on their abundance (e.g., by manipulating the availability of pollock) and concluded that there was little gain without commensurate control of interspecific competition (namely arrowtooth flounder abundance). Similarly, Dorn et al (2005) using Ecopath modeling, noted that of the top five predators on GOA pollock were arrowtooth flounder first, Pacific halibut second, Pacific cod third, Steller sea lions forth and the commercial fishery fifth. Dorn et al concluded that the effects of arrowtooth predation on pollock, and therefore indirectly on sea lions was under appreciated.

Other Ecosystem Observations

A series of papers were published on the ecosystem dynamics of the Aleutian Islands (Hunt and Stabeno, 2005; Loggerwell et al., 2005; Rodinov et al., 2005; Sinclair et al., 2005). Each of these papers provides information on the physical and biological diversity experienced along the Aleutian Island chain. All point to a major break-point in the vicinity of Samalga Pass where not only physical oceanography changes but biological diversity changes as well. Moreover, the changes noted are consistent with observation which divide the western population of Steller sea lions into discrete eco-regions (Call and Loughlin, 2005).

Overall ecosystem health is monitored annually and reported in the NMFS Stock Assessment and Fishery Evaluation (SAFE) Report Ecosystem Chapter (Livingston 2000, 2001, 2002; Boldt 2003, 2004, 2005). Livingston et al (2005) present a framework for ecosystem impacts assessment using an indicator approach. Witherall et al (2000) describe the ecosystem management approach evolving the NPFMC.

ANNOTATED BIBLIOGRAPHY—ECOSYSTEMS

Anonymous. 2005. Introduction. In: Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pac. Fish. Mgmt. Council, Anchorage, AK, pp 1-40.

> The November 2005 Gulf of Alaska (GOA) groundfish fishery Stock Assessment and Fishery Evaluation Report (SAFE) contains a brief two-page account of "Ecosystem Considerations" in the GOA. This represents an encapsulated version of reports contained in the annual Ecosystem Chapter of the SAFE, and/or comments embedded in the various single species stock assessment chapters. For example, it was reported that, "groundfish species richness and diversity increased on average"; although, "it was unclear whether existing levels of precaution implemented at the single-species level will be sufficient to deal with declines in overall system productivity when trying to meet multispeciess or ecosystem objectives." Pollock abundance is reported to be "positively correlated to abundances of Steller sea lions, arrowtooth flounder, halibut, and Pacific cod. Although arrowtooth flounder is responsible for more than one third of pollock mortality, this positive relationship between arrowtooth and pollock is not as strong as that between Steller sea lions and pollock." It was further noted that "Steller sea lion abundance is negatively correlated to arrowtooth flounder and halibut."

Aydin, K. 2002. The Eastern Bering Sea. In, T. Pitcher and K. Cochrane (Eds.), The use of ecosystem models to investigate multispecies management strategies for capture fisheries. Fisheries Center Research Report 10(2) 33-38

> The paper's abstract is copied in its entirety: "Ecosim policy maximization routines were used to examine fishing policies for a mid-1980s model of the eastern Bering Sea shelf/slope ecosystem containing 38 functional groups and including catch and bycatch. In addition to yield maximization, the simulations explored "ecological" maximization (using the 1/PB index discussed in the workshop as a criterion) and examined mechanisms for increasing pinniped biomass through selective prey manipulation, especially with respect to the endangered Steller Sea Lion (*Eumetopias jubatus*).
>
> Maximizing to the 1/PB criterion resulted in recommendations for complete ecosystem removal of higher trophic level fish species (specifically Pacific cod; *Gadus macrocephalus*). This removal reduced food competition for slower-lived marine mammals. There is no evidence that such a strategy provides ecological benefits, especially in light of the unpredictability that such a drastic manipulation would entail.
>
> Manipulating pinniped food supply to increase their biomass showed that, without the removal of large fish predators such as arrowtooth flounder (*Atheresthes stomias*), pinniped gains would be modest if fishing policies were set at the scale of the entire shelf and not targeted to local pinniped foraging habitat. Pinniped results were sensitive to the initial apportionment of their diet between juvenile walleye pollock (*Theragra chalcogramma*) and 'other' pelagic forage species."

Ban, S. 2005. Modelling and characterization of Steller sea lion haulouts and rookeries using oceanographic and shoreline type data. M.S. Thesis, University of British Columbia, Vancouver, Canada. 103 p.

In this thesis the author attempts to evaluate differences between habitats selected by Steller sea lions as haulouts and rookeries and adjacent unselected habitats. In general, SSLs showed preferences for sites associated with waters that were relatively shallow, well-mixed, had higher average tidal speeds and less-steep bottom slopes. Conditions within one nautical mile of land were better predictors of haulout and rookery locations than were conditions within 10, 20, and 50 nautical miles. No consistent differences were found in the physical characteristics of waters surrounding sites in the eastern and western populations of Steller sea lions, or between haulouts and rookeries. Locations of haulouts and rookeries were then compared against a coastline type database to identify the shoreline preferences of Steller sea lions and to look for other spatial trends in site characteristics. Haulouts and rookeries were preferentially located on exposed rocky shorelines and wave-cut platforms. No relationship was found between either latitude or longitude of a site and its average non-pup count. The results indicated that there are differences in both the oceanographic and terrestrial characteristics of sites used by SSLs versus areas of coastline where they are not found.

Benson, A.J. and A.W. Trites. 2002. Ecological effects of regime shifts in the Bering Sea and eastern North Pacific Ocean. Fish and Fisheries 3:95-113.

The paper's abstract is copied in its entirety: "Large-scale shifts occurred in climatic and oceanic conditions in 1925, 1947, 1977, 1989 and possibly 1998. These shifts affected the mix and abundance of suites of coexisting species during each period of relative environmental stability; from primary producers to apex predators. However, the1989 regime shift was not a simple reversal of the 1977 shift. The regime shifts occurred abruptly and were neither random variations nor simple reversals to the previous conditions. Timing of these anomalous environmental events in the North Pacific Ocean appears to be linked to physical and biological responses in other oceanic regions of the world. Changes in the atmospheric pressure can alter wind patterns that affect oceanic circulation and physical properties such as salinity and depth of the thermocline. This, in turn, affects primary and secondary production. Data from the North Pacific indicate that regime shifts can have opposite effects on species living in different domains, or can affect similar species living within a single domain in opposite ways. Climatic forcing appears to indirectly affect fish and marine mammal populations through changes in the distribution and abundance of their predators and prey. Effects of regime shifts on marine ecosystems are also manifested faster at lower trophic levels. Natural variability in the productivity of fish stocks in association with regime shifts indicates that new approaches to managing fisheries should incorporate climatic as well as fisheries effects."

Boldt, J. (Editor). 2003. Ecosystem considerations for 2004. Appendix: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the EBS/AI and GOA. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. 336p.

Note this is one of series of NMFS SAFE Ecosystem Chapters. The Ecosystem Chapter is produced annually as a part of the BSAI and GOA Groundfish Fishery SAFE. The report has evolved over time, adding new topical areas of discussion as required. The Chapter typically partitions its content among three broad areas of information: 1) a brief overview of recently acquired results; 2) a section on "Ecosystem Status Indicators"; and, 3) a section on

"Ecosystem Based Management Indices and Information". Ecosystem Status Indicators include descriptions of the physical environment and habitat, biological trends in prey resources, fish and mammal populations, and benthic communities. Ecosystem Management evaluates indicators addressing management goals that include maintenance of diversity and habitat, sustainability of resources, and control of anthropogenic interactions [fishing capacity]. [See also, Livingston 2000, 2001, 2002; and Boldt 2004, 2005]

Boldt, J. (Editor). 2004. Ecosystem considerations for 2005. Appendix: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the EBS/AI and GOA. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. 260p.

One of a series of Ecosystem Chapters in the annual NMFS SAFE reports.
[See also, Livingston 2000, 2001, 2002; and Boldt 2003, 2005]

Boldt, J. (Editor). 2005. Ecosystem considerations for 2006. Appendix: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the EBS/AI and GOA. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. 314p.

This is the most recent Ecosystem Chapter from the annual NMFS Groundfish Fishery SAFE report. The following is an excerpt of portions of the Executive Summary of that report:

"It has been shown that the North Pacific atmosphere-ocean system included anomalies during the winter of 2004-05 that were unlike those associated with the primary modes of past variability. This result suggests a combination of two factors: (1) that the nature of North Pacific variability is actually richer in variability than appreciated previously, and (2), that there is the potential for significant evolution in the patterns of variability due to both random, stochastic effects and systematic trends such as global warming. Notably, at the time of this writing, it cannot be determined whether the North Pacific is heading into a positive PDO-like condition or some other state. The Bering Sea (BS) shows three multidecadal regimes in surface air temperatures (SAT) fluctuations: 1921-1939 (warm), 1940-1976 (cold), and 1977-2005 (warm). … In the current warm regime, the magnitude of SAT fluctuations has been steadily increasing since the mid-1980s, and the Bering Sea may become even warmer before it will switch to a new cold regime. … Physical data collected on the NMFS Gulf of Alaska (GOA) bottom trawl survey indicate that summer temperatures in 2005 were the warmest on record. There has been a general warming of depths less than 50 m in the GOA.

Summer zooplankton biomass has been anomalously low in the past five years (2000-2004) in all four geographic domains [of the EBS]. … New analyses conducted on the GOA small mesh survey data, to account for spatial and temporal variability in the survey samples, confirm that the GOA biological community shifted after the 1977 climate regime shift. Observed changes include a trend towards increased catches of jellyfish, arrowtooth flounder, walleye pollock, flathead sole and decreased catches of Pandalid shrimp, capelin, Pacific sandfish red king crab, and sculpins. … The number of northern fur seal pups born on the Pribilof Islands continued to decline. However, increases in Steller sea lion non-pup counts were observed in 2004 in all areas except the central GOA (slight decline) and the eastern GOA (similar counts as 2002).

Average species richness and diversity of the groundfish community in the Gulf of Alaska increased from 1990 to 1999 with both indices peaking in 1999 and sharply decreasing

thereafter. The spatial distribution of individual species appears to drive changes in species richness. Local species diversity is a function of the number of species and their relative abundance in each haul. Changes in local species richness and diversity are strongly confounded with natural variability in spatial distribution and relative abundance.

Annual surplus production (ASP) indices, the sum of new growth and recruitment minus deaths from natural mortality, suggest high variability in groundfish production in the EBS and a decrease in production between 1978 and 2004. Production in the GOA was much lower on average, less variable, and decreased slightly from 1978 to 2004. … These trends reflect decreases across many species and are not driven by the next dominant species alone. These declining trends suggest that substantial reductions in total catches may be necessary in the near future.

The bycatch of "other salmon" and herring increased markedly in 2003 and 2004. Between 2002 and 2003, herring bycatch increased by over 600% and "other salmon" bycatch more than doubled. After the dramatic increase in 2003, the herring bycatch increased again by about 42% and "other salmon" bycatch almost doubled in 2004." Herring bycatch increased with an increase in fishing effort in the northwest portion of the fleets range. Salmon bycatch was highest in areas outside designated salmon savings area; the NPFMC is considering alternative management approaches to alleviate this problem. [See also, Livingston 2000, 2001, 2002; and Boldt 2003, 2004].

Buck, C. L., S. D. Kildaw, K. A. Murra, J. B. Gamble, and B. Fadely. 2003. Seabird component of the GAP project: indicators of marine conditions and potential competitors of Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

A brief abstract regarding the 2001 and 2002 results of sea bird feeding studies conducted in the Gulf Apex Predator-prey Program. Summer foraging areas of kittiwakes in Chiniak Bay overlapped in time and space with Steller sea lions tagged in Chiniak Bay, 2001. The authors monitored a total of 2071 and 2193 nests of black legged kittiwakes in 2001 and 2002, respectively. Productivity (total chicks fledged/nest attempt) of kittiwakes in 2001 (71%) exceeded that of 2002 (48%) and was greater than in any year on record. Likewise, for glaucous-winged gulls we monitored 150 nests in 2001 and 147 nests in 2002. Productivity (hatchlings/nest attempt) of glaucous-winged gulls was greater in 2001 (79%) than in 2002 (60%). The high productivity observed for kittiwakes and glaucous-winged gulls is suggestive of high forage availability in 2001.

Call, K.A., and T.R. Loughlin. 2005. An ecological classification of Alaskan Steller sea lion (*Eumetopias jubatus*) rookeries: A tool for conservation management. Fisheries Oceanography 14 (Suppl. 1):212-222.

In this paper the authors classify the western population of Steller sea lions into 5 ecological regions. Classifications are based on trends in sea lion abundance, habitat features and diet at known rookeries. The Aleutian Islands are cleanly divided westward of Amchitka Pass and Samalga Pass. Ecological separation of rookeries east of Samalga Pass is more complex and like ecotypes are not necessarily contiguous.

Conners, M. E., A. B. Hollowed and E. Brown. 2002. Retrospective analysis of Bering Sea bottom trawl surveys: regime shift and ecosystem reorganization. Progress in Oceanography 55:209-222.

In this paper the authors evaluate spatial/temporal patterns in the distributions of 22 species groupings across three domains of the Bering Sea: inner, middle, and outer shelf. Using data from trawl surveys, the authors construct standardized filtered data sets spanning the period 1963 to 2000. Catch is standardized to catch per unit area. The spatial/temporal distributions are evaluated to look for major change points (shifts in location and/or abundance) with a focus on synchrony of events across species groups. The authors report that their “results indicate that wide-ranging changes have occurred in demersal and benthic food webs of the eastern Bering Sea, which have affected taxa ranging from large pelagic and benthic predators to sessile benthic filter feeders. This type of systemic change suggests that a non-linear ecosystem shift occurred sometime in the early 1980s.” The authors go on to say, “Our data do not show evidence of effects either from contemporary commercial harvests or short-term changes in climate conditions. The system-level changes evident in our data are very consistent with recent interdisciplinary research that indicates the timing and duration of primary and secondary production in the southeastern Bering Sea has been altered by changing sea-ice extent. Our data are strongly inconsistent with hypotheses that declines of top-level predators in the system are a result of any overall reduction in productivity.

DeMaster, D. P., A.W. Trites, P. Clapham, S. Mizroch, P. Wade, and R.J. Small. in press. The sequential megafaunal collapse hypothesis: testing with existing data. Progress in Oceanography.

These authors challenge the sequential megafaunal collapse hypothesis put forward by Springer et al. (2003). The Springer hypothesis suggests that industrial commercial whaling in the 1950s-1960s depleted an import prey for mammal eating killer whales forcing them to shift prey preferences. The resultant “sequential decline” in harbor seals, fur seals, Steller sea lions and sea otters is assumed to reflect the changing diet of killer whales following the large whale decline. DeMaster et al. argue that the declines in harbor seal and northern fur seal populations were concurrent rather than sequential, and were followed by declines in Steller sea lions. Further, they argue that all pinniped declines had their steepest decent after the “regime shift” of 1977. In addition, they dispute the conclusion of Springer et al. that there was a collapse of large whale biomass in the Bering Sea; and argue that under any circumstances, killer whales were unlikely to have preyed upon those components of the large whale population that experienced the greatest decline. Overall, they conclude that available data do not support the sequential megafaunal collapse hypothesis.

Dorn, M., K. Aydin, S. Barbeaux, M. Guttormsen, B. Megrey, K. Spalinger, and M. Wilkins. 2005. Assessment of walleye pollock in the Gulf of Alaska. In: Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pac. Fish. Mgmt. Council, Anchorage, AK, 1:41-153.

Included in the annual status of stocks assessment of Gulf of Alaska pollock is an ECOPATH model (see pp 71-75 of the assessment) that was assembled to characterize food web structure in Gulf of Alaska using diet data and population estimates during 1990-93. The authors focus in this model is primarily on first-order trophic interactions: prey of pollock and the predators of pollock. Pollock trophic interactions occur primarily in the pelagic pathway in the food web, which leads from phytoplankton through various categories of zooplankton to planktivorous fish species such as capelin and sandlance. Initial ECOPATH model results show that the top five predators on pollock >20 cm by relative importance are arrowtooth flounder, Pacific halibut, Pacific cod, Steller sea lion (SSL), and the directed pollock fishery. For pollock less than 20cm, arrowtooth flounder represent close to 50% of total mortality. All major predators show some diet specialization, and none depend on pollock for more than 50% of their total consumption. Pacific halibut is most dependent on pollock (48%), followed by SSL (39%), then arrowtooth flounder (24% for juvenile and adult pollock combined), and lastly Pacific cod (18%). Predation mortality, as estimated by ECOPATH, is extremely high for GOA pollock >20cm. Estimates for the 1990-1993 time period indicate that known sources of predation sum to 90%-120% of the total production of walleye pollock calculated from 2004 stock assessment growth and mortality rates. These high rates in consumption may be due in part to errors in estimates of pollock natural mortality rates, particularly at young age. Results suggest that recruitment remains bottom-up controlled even under the current estimates of high predation mortality, and may lead to strong year classes. However, top-down control seems to have increased on age 3+ pollock in recent years, perhaps as predators have attempted to maintain constant pollock consumption during a period of declining abundance. It is possible that natural mortality on adult pollock will remain high in the ecosystem in spite of decreasing pollock abundance. It is apparent that the potential for competition between Steller sea lions and arrowtooth flounder is underappreciated. Arrowtooth flounder consume both the primary prey of Steller sea lions (pollock), and alternate pelagic prey also utilized by Steller sea lions (capelin, herring, sandlance, salmon). Arrowtooth predation on pollock occurs at a smaller size than pollock targeted by Steller sea lions. The arrowtooth flounder population is nearly unexploited, is increasing in abundance, may be increasing its per unit consumption of pollock, and shows no evidence of density-dependent growth. And lastly, since 1976 there has been a strong inverse correlation between arrowtooth flounder and Steller sea lion abundance that is at least consistent with competition between these species.

Fadely, B. and T. R. Loughlin. 2001. Weak Association between Steller Sea Lion Pup Condition and Population and Environmental Trends in Western Alaska. p. 68 In: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Pup condition, which is correlated with survival, was weakly correlated with the North Pacific Index (NPI) implying a possible environmental link. [Note the NPI is an area weighted mean sea level pressure index; see Benson and Trites, 2002 for a review of different indices]

Fritz, L.W., and S. Hinckley. 2005. A critical review of the regime shift-"junk food"-nutritional stress hypothesis for the decline of the western stock of Steller sea lion. Marine Mammal Science 21:476-518.

This is a full length journal article discussing the utility of the junk food hypothesis and provides alternatives explanations to refute the hypothesis. The abstract states that one hypothesis for the decline in this western population is that a climate regime shift in 1976–1977 changed the species composition of the fish community and reduced the nutritional quality (energy density) of the sea lion prey field. This in turn led to nutritional stress and reduced individual fitness, survival, and reproduction of sea lions. Implications of this regime shift–"junk food" hypothesis are that (1) the recruitment and abundance of supposed high quality species (e.g., Pacific herring), decreased while those of supposed low quality (e.g., species in the family Gadidae) increased following the regime shift, (2) Steller sea lion diets shifted in response to this change in fish community structure, and (3) a diet composed principally of gadids (e.g., walleye pollock) was detrimental to sea lion fitness and survival. They examine data relating to each of these implications and find little support for the hypothesis that increases in the availability and consumption of gadids following the regime shift are primarily responsible for the decline of the western population of Steller sea lion. The authors conclude that, while western Steller sea lions may have been subjected to chronic nutritional stress it does not appear to be the result of regime-shift mediated increases in the proportion of low-energy prey species in their diet because: (1) gadid sea lion prey species fluctuate in abundance, and changes in the 1970s and 1980s in the North Pacific Ocean and Bering Sea were neither abnormal in their magnitude, nor were they particularly linked with the regime shift of 1976-77 or cycles that are multiple decades in length. In particular, neither the Bering Sea nor the North Pacific Ocean was likely dominated by 'forage' fish prior to the regime shift, and by gadids and flatfish after [the regime shift]; (2) evidence supporting significant changes in sea lion diets coincident with the 1976-77 regime shift is weak or non-existent; (3) prey energy density varies seasonally and is only one of many factors in the energy budget of a sea lion. Reliance on "average" energy densities ignores the seasonal and spatial differences in energy content and the costs associated with foraging; (4) detrimental health effects associated with high gadid diets in captivity may have resulted from biochemical changes occurring in frozen/thawed fish, and have not been observed with certainty in the wild; and (5) extrapolation of the results of captive feeding experiments directly to sea lions in the wild may not be appropriate. Finally, and perhaps most importantly, gadid fish species have been and continue to be principal components of the diets of other pinnipeds in the North Pacific and elsewhere.

Gelatt, T.S. and M.J. Rehberg. Coastal Bathymetry within the Range of Steller Sea Lions in Alaska Steller Sea Lion Research Initiative Project 01-SSL-065. Alaska Department of Fish and Game, 525 West 67th Ave., Anchorage AK 99518 10p.

An important, basic habitat feature, which provides context to Steller sea lion behavior, is seafloor topography, which is derived from bathymetry. Seafloor topography describes the limits to sea lion dives, influences forage fish distribution and is an important factor in the flow of energy in the system Detailed public domain digital bathymetry of the continental shelf – particularly within nearshore water bodies - are sparse. Alternative digital bathymetry layers, which do cover the entire range of Steller sea lions in Alaska, are of low horizontal resolution and provide rather generalized depth measures. Therefore, the authors exhausted public-domain sources for these data, identified gaps in the existing coverage, acquired additional data from private vendors, documented and integrated these data into a common database format and used the data to build depth models to support their marine mammal research.

Gregr, E. and A.W. Trites. In review. Assessing the distributional overlap between Steller sea lions and commercial trawl fisheries in Alaska. Ecological Applications.

This paper is under review and not available for inspection at this time.

Gregr, E.J., and A.W. Trites. 2004. Estimating Ecological Niche Overlap between Steller Sea Lions and Commercial Trawl Fisheries in Alaska. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

In this abstract the authors describe construction of a model to predict the spatial distribution of Steller sea lions in summer and winter. They then overlap the predicted sea lion distribution with that of the commercial trawl fishery effort, and calculate MacArthur and Levin's niche overlap index. Sea lions are more dispersed in winter and have a higher niche overlap with the trawl fishery during this time although the overlap was relatively low in both seasons.

Guénette, S., and V. Christensen. 2005. Food web models and data for studying fisheries and environmental impacts on Eastern Pacific ecosystems. Univ. British Columbia, Fisheries Centre Research Reports Vol 13(1) pp. 237

This is a compilation of 7 papers edited by Guénette and Christensen. Three deal with ecosystem models in Alaskan waters: two represent models for the Aleutian Islands, one for SE Alaska. The models are complex, the discussions long, and results limited.

Guénette, S., S.J.J. Heymans, V. Christensen, and A.W. Trites. 2004. The decline of Steller sea lions and the ecosystem of the Gulf of Alaska. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

In this abstract, the authors claim to test four hypotheses explaining the decline in Steller sea lion abundance: 1) the "junk-food" hypothesis which suggests that food consumed by sea lions in the western GOA does not contain enough energy to sustain the population; 2) increased predation by transient killer whales in the western GOA and farther east has reduced sea lion abundance; 3) primary production has dropped in the western GOA lowering sea lion carrying capacity; and 4) large-scale fisheries have modified the GOA ecosystem structure and function to the detriment of sea lions. These hypotheses are said to be tested using "Ecopath with Ecosim" models for the Aleutian Islands, central GOA and SE Alaska. The authors provide no model results. [see Guénette and Christensen. 2005]

Guénette, S., S.J.J. Heymans, V. Christensen, and A.W. Trites. 2005. Ecosystem analysis of Steller sea lions dynamics, their prey and predators. In: Marine science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

This abstract reports limited results from ecosystem simulation modeling for Southeast Alaska, the Central Gulf of Alaska and the western Aleutian Islands. Fishing and environmental variation was reported to be sufficient to explain increases in Steller sea lion abundance in SE Alaska, with more equivocal results for the CGOA and WAI. The authors note that declines in Steller sea lion abundance in the late 1980's could be the result of predation by transient killer whales given three constraining assumptions.

Hare, S. R., and N. J. Mantua. 2000. Empirical evidence for North Pacific regime shifts in 1977 and 1989. Prog. Oceanogr. 47:103-146.

The authors assembled 100 environmental time series, 31 climatic and 69 biological, to determine if there is evidence for common regime signals in the 1965–1997 period of record. Their analysis reproduces previously documented features of the 1977 regime shift, and identifies a further shift in 1989 in some components of the North Pacific ecosystem. The 1989 changes were neither as pervasive as the 1977 changes nor did they signal a simple return to pre-1977 conditions. The authors conclude that the large marine ecosystems of the North Pacific and Bering Sea appear to filter climate variability strongly, and respond nonlinearly to environmental forcing. They suggest that monitoring North Pacific and Bering Sea ecosystems may allow for an earlier identification of regime shifts than is possible from monitoring climate data alone.

Hirons, A. C., D. M. Schell, and B. P. Finney. 2001. Temporal records $\delta^{13}C$ and $\delta^{15}N$ in North Pacific pinnipeds: inferences regarding environmental change and diet. Oecologia 129:591-601.

This is the journal publication of Hirons' Ph.D. dissertation. This paper's abstract is presented in its entirety: "Sea lion and seal populations in Alaskan waters underwent various degrees of decline during the latter half of the twentieth century and the cause(s) for the declines remain uncertain. The stable carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) isotope ratios in bone collagen from wild Steller sea lions (*Eumetopias jubatus*), northern fur seals (*Callorhinus ursinus*) and harbor seals (*Phoca vitulina*) from the Bering Sea and Gulf of Alaska were measured for the period 1951–1997 to test the hypothesis that a change in trophic level may have occurred during this interval and contributed to the population declines. A significant change in $\delta^{15}N$ in pinniped tissues over time would imply a marked change in trophic level. No significant change in bone collagen $\delta^{15}N$ was found for any of the three species during the past 47 years in either the Bering Sea or the Gulf of Alaska. However, the $\delta^{15}N$ in the Steller sea lion collagen was significantly higher than both northern fur seals and harbor seals. A significant decline in $\delta^{13}C$ (almost 2 ‰ over the 47 years) was evident in Steller sea lions, while a declining trend, though not significant, was evident in harbor seals and northern fur seals. Changes in foraging location, in combination with a trophic shift, may offer one possible explanation. Nevertheless, a decrease in $\delta^{13}C$ over time with no accompanying change in $\delta^{15}N$ suggests an environmental change affecting the base of the foodweb rather than a trophic level change due to prey switching. A decline in the seasonal primary production in the region, possibly resulting from decreased phytoplankton growth rates, would exhibit itself as a decline in $\delta^{13}C$. Declining production could be an indication of a reduced carrying capacity in the North Pacific Ocean. Sufficient quantities of optimal prey species may have fallen below threshold sustaining densities for these pinnipeds, particularly for yearlings and subadults who have not yet developed adequate foraging skills."

From the body of the text, "A total of 31Steller sea lions, 13 northern fur seals and 63 harbor seals from regions throughout the Gulf of Alaska and the Bering Sea were analyzed. The specimens span the period 1951–1997 and range from coastal areas of southeast Alaska westward through the Gulf of Alaska and into the central Bering Sea"

Hirons, A.C. 2001. Trophic dynamics of pinniped populations in Alaska using stable carbon and nitrogen isotope rations. PhD dissertation, University of Alaska, Fairbanks AK. 143p.

See Hirons, 2001 in Theme 2-Foraging-Diet, see also, Hirons et al 2001 above.

Hobson, K., Sinclair, E., York, A., Thomason, J. and Merrick, R. 2004. Retrospective isotopic analyses of Steller's sea lion tooth annuli and seabird feathers: A cross-taxa approach to investigating regime and dietary shifts in the Gulf of Alaska. Marine Mammal Science 20(3):621-638.

Stable isotope values for nitrogen and carbon of individual tooth annuli of 120 female SSLs collected from the 1960s through the 1980s were used for retrospective analyses of temporal changes in food webs in the Gulf of Alaska and North Pacific Ocean. The authors examined seabird feathers to test for broader isotopic changes. SSLs decreased slightly in $\delta^{13}C$ and increased in $\delta^{15}N$ values, suggesting an increasing trophic level in foraging location or oceanographic isotopic signature. SSL first and second tooth annuli were enriched in $\delta^{15}N$ and depleted in $\delta^{13}C$ with subsequent annuli indicating the effects of maternal influence through weaning. The observed increasing values of the nitrogen isotope in SSLs supported previous conclusions regarding a reduction or redistribution of forage fishes and an increase of demersal or semi-demersal species in the North Pacific ecosystem.

Hollowed, A.B., Wilson, C.D., Stabeno, P. and Salo, S. Effect of ocean conditions on the cross-shelf distribution of walleye pollock (Theragra chalcogramma) and capelin (Mallotus villosus). in press. Fisheries Oceanography

This paper compliments findings reported in Wilson et al (2003). Wilson reports on the effects of commercial fishing on distribution of pollock and capelin in Chiniak and Barnabus Troughs on the east side of Kodiak Island. Inferences were gained through a controlled fishing experiment in 2000 and 2001. The current paper describes the potential role of biophysical factors in the regulation of the spatial distribution of pollock and capelin. "Results suggest that habitat selection of walleye pollock and capelin are controlled by different processes. Capelin distribution appears to be limited by oceanographic conditions while other factors appear to be more important for pollock."

Hunt, G.L. and P.J. Stabeno. 2005. Oceanography and ecology of the Aleutian Archipelago: spatial and temporal variation. Fisheries Oceanography 14 (Suppl. 1): 292-306

This paper summarizes a supplemental edition of Fisheries Oceanography where the focus of the collected papers was processes controlling variability in the productivity and ecosystem structure of the Aleutian Archipelago. The supplement contains 19 papers in total and covers physical oceanography, biological oceanography, ichthyofauna, birds, and mammals. The authors report that the marine ecosystem of the Aleutian Archipelago has a strong discontinuity at Samalga Pass where cold-water corals, zooplankton, fish, marine mammals and foraging sea birds show a step change in species composition. Diets of groundfish, Steller sea lions, and some sea birds also change in this area. The differences appear to be driven by changes in the physical oceanography with the area east of Samalga Pass bathed by the Alaska coastal current, and that west fed by the Alaska stream. All passes east of Samalga Pass are shallow whereas those west are increasingly deeper as you move out the chain. Lower growth rates of some fish species and stable isotope data indicate that productivity declines westward along the archipelago. Available data demonstrate considerable ecosystem variability over time scales from decades to millennia. The authors conclude that the marine waters of the Aleutian Archipelago are divided into at least two different ecological regions, with potential for a concomitant separation of some fishery resources.

Hunt, G.L., P.J. Stabeno, G.E. Walters, E.H. Sinclair, R. Brodeur, J. Napp, and N. Bond. 2002. Climate change and control of the southeastern Bering Sea pelagic ecosystem. Deep Sea Research Part II: Topical Studies in Oceanography 49(26):5821-5853.

> These authors propose a new hypothesis, the Oscillating Control Hypothesis (OCH), which predicts that pelagic ecosystem function in the southeastern Bering Sea will alternate between primarily bottom-up control in cold regimes and primarily top-down control in warm regimes. The timing of spring primary production is determined predominately by the timing of ice retreat. Late ice retreat (late March or later) leads to an early, ice-associated bloom in cold water (e.g., 1995, 1997, 1999), whereas no ice, or early ice retreat before mid-March, leads to an open-water bloom in May or June in warm water (e.g., 1996, 1998, 2000). In years when the spring bloom occurs in cold water, low temperatures limit the production of zooplankton, the survival of larval/juvenile fish, and their recruitment into the populations of species of large piscivorous fish. When continued over decadal scales, this will lead to bottom-up limitation and a decreased biomass of piscivorous fish. When the bloom occurs in warm water, zooplankton populations should grow rapidly, providing plentiful prey for larval and juvenile fish. Abundant zooplankton will support strong recruitment of fish and will lead to abundant predatory fish that control forage fish. Birds and pinnipeds may do better in cold regimes. The OCH predicts that the ability of large predatory fish populations to sustain fishing pressure will vary between warm and cold regimes. In the southeastern Bering Sea, important changes in the biota since the mid-1970s include a marked increase in the biomass of large piscivorous fish and a concurrent decline in the biomass of forage fish, including age-1 walleye pollock, particularly over the southern portion of the shelf. Populations of northern fur seals (*Callorhinus ursinus*) and seabirds such as kittiwakes (*Rissa* spp.) at the Pribilof Islands have declined, most probably in response to a diminished prey base. The available evidence suggests that these changes are unlikely the result of a decrease in total annual new primary production, though the possibility of reduced post-bloom production during summer remains. The authors assert that an ecosystem approach to management of the Bering Sea and its fisheries is of great importance if all of the ecosystem components valued by society are to thrive.

Jurado-Molina, J. and P. A. Livingston. 2002a. Climate-forcing effects on trophically linked groundfish populations: implications for fisheries management. Can. J. Fish. Aquat. Sci. 59:1941-1951.

> The authors simulate the effects of fishing mortality on eight trophically linked Bering Sea species (including pollock and Pacific Cod) under two scenarios of climate regimes using the multispecies virtual population analysis (MSVPA) model and the multispecies forecasting model (MSFOR). Species respond differently to climate change assumptions and fishing mortality depending on their position in the food web. Results suggest that the assumptions regarding climate regime shifts on mean recruitment may produce effects comparable to the ones produced by fishing and predation interactions. Therefore, accurate models for fisheries management would require considering these factors and their potential interactions.

Jurado-Molina, J. and P.A. Livingston. 2002b. Multispecies perspectives on the Bering Sea groundfish fisheries management regime. N. Amer. J. Fish. Management 22:1164-1175.

> In this article the authors evaluate the effects that different exploitation rates may have on eastern Bering Sea groundfish using a multispecies simulation context that incorporates predator–prey relationships. The authors contrast multispecies virtual population analysis

(MSVPA) outcomes with single species virtual population analysis (SSVPA) for eight species in the Bering Sea, including pollock and Pacific cod. After conducting the virtual population analysis they project populations forward in time 40 years to a point of "equilibrium" and compare changes in the population abundance. The species modeled represent different rates of current exploitation from fully utilized to partially utilized. The authors are interested in determining the population effects of these differential rates of harvest when compared with full utilization across all species or no utilization at all. They use three different fishing mortality rates in their forward projections: 1) the average F over the most recent 4 years as measured in the MSVPA model; 2) the estimate F_{ABC} as determined in routine annual SAFE documents; and 3) F=0. With minor exception, the MSVPA and SSVPA models produced population estimates similar to those generated in the current statistical models (i.e., stock assessment SAFEs). Forward population projections produced predicable results; populations whose fishing mortality was reduced tended to increase in abundance and those whose fishing mortality was increased declined in abundance. The magnitude of change differed between SSVPA and MSVPA with differences attributable to the multispecies interactions built into MSVPA. The multispecies simulations that included predation interactions predicted much lower equilibrium population sizes for prey species populations under conditions of no fishing than did single-species simulations that did not take predator–prey relationships into account.

Jurado-Molina, J. P.A. Livingston, and V.F. Gallucci. 2005a. Testing the stability of the suitability coefficients from an eastern Bering Sea multispecies virtual population analysis. ICES J. Mar. Sci. 62:915-924.

Suitability coefficients are estimated within an MSVPA model based in part on the stomach contents data integrated in the model. In this paper the authors evaluate the stability of the suitability estimates by comparing outcomes using different stomach contents data sets. In general, results suggested that the predator preferences and prey vulnerabilities remained stable over the time period studied. Therefore, MSFOR (multispecies forecasting model) could be considered as a tool to advice fisheries managers within a multispecies context.

Jurado-Molina, J., P.A. Livingston, and J.N. Ianelli. 2005b. Incorporating predation interactions in a statistical catch-at-age model for a predator-prey system in the eastern Bering Sea. Can. J. Fish. Sci. Aquat. 62:1-9.

In this paper the authors use a two-species system, walleye pollock and Pacific cod, to incorporate the predation equations from MSVPA into an age-structured multispecies statistical model (MSM). Results suggest that both models produced similar estimates of suitability coefficients and predation mortalities. The advantage of MSM is the availability of variance estimates for parameters, providing a measure of model uncertainty not available in MSVPA.

Lander, M.E., T.R. Loughlin, M.L. Logsdon, G.R. VanBlaricom, B.S. Fadely, and L.W. Fritz. 2005. Environmental composition of habitat used by juvenile Steller sea lion (Eumetopias jubatus). In 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Habitat was assessed by deploying satellite-depth recorders and satellite relay data loggers on juvenile SSLs (n=50) during 2000-2004 within four regions of the western stock. Areas used by SSLs during June-August were demarcated using telemetry data and characterized by

environmental variables (SST and chlorophyll-a) which serve as proxies for environmental processes or prey. Shannon's Diversity Index (shows how evenly the proportions of environmental patch types are distributed) was quantified for each area using a spatial pattern analysis computer program. There was considerable inter annual variability within and among all areas, however indices of diversity of SST for the eastern and central Aleutian Islands (both stable or increasing) were consistently greater than indices for the western Aleutians or the central Gulf of Alaska, both of which are in decline.

Livingston, P.A. (Editor). 2000. Ecosystem considerations for 2001. Appendix: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the EBS/AI and GOA. North Pacific Fishery Management Council, 605 W. 4th Ave, Suite 306, Anchorage, AK 99501. 119p.

One of a series of Ecosystem Chapters in the annual NMFS SAFE reports.
[See also, Livingston 2001, 2002; and Boldt 2003, 2004, 2005]

Livingston, P.A. (Editor). 2001. Ecosystem considerations for 2002. Appendix: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the EBS/AI and GOA. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. 180p.

One of a series of Ecosystem Chapters in the annual NMFS SAFE reports.
[See also, Livingston 2000, 2002; and Boldt 2003, 2004, 2005]

Livingston, P.A. (Editor). 2002. Ecosystem considerations for 2003. Appendix: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the EBS/AI and GOA. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. 230p.

One of a series of Ecosystem Chapters in the annual NMFS SAFE reports.
[See also, Livingston 2000, 2001; and Boldt 2003, 2004, 2005]

Livingston, P.A. and J-J. Jurado-Molina. 2000. A multispecies virtual population analysis of the eastern Bering Sea. ICES J. Mar. Sci. 57:294-299.

In this paper, the authors develop a multispecies virtual population analysis model (MSVPA) for the eastern Bering Sea covering the period 1979–1995. The model includes the following species as predators: walleye pollock, Pacific cod, Greenland turbot, yellowfin sole, arrowtooth flounder, and northern fur seal. Prey species are walleye pollock, Pacific cod, Greenland turbot, yellowfin sole, rock sole, and Pacific herring. Results show that large numbers of walleye pollock, particularly age-0 and age-1 fish are consumed and cannibalism by adult pollock and their predation constitutes the largest source of predation mortality for age-0 fish. Predation plays an important role in explaining the recruitment dynamics of pollock.

Livingston, P.A. and S. Tjelmeland. 2000. Fisheries in boreal ecosystems. ICES J. Mar. Sci. 57:619-627.

Four ecosystems – the Barents Sea/Norwegian Sea, the Bering Sea, the Iceland/Jan Mayen area, and the Newfoundland Shelf area – are compared and the impacts of climate and fishing are discussed on the basis of the recent literature. There is a brief, one page summary of physical and biological attributes of the Bering Sea. In general, the authors note that northern boreal shelf ecosystems are characterized by relatively few dominant species with strong

interactions. The environment is highly dynamic, with strong impacts from oceanographic events that have major influences on fish stocks by altering recruitment, growth, and migration patterns.

Livingston, P.A., K. Aydin, J. Boldt, J. Ianelli, and J. Jurado-Molina. 2005. A framework for ecosystem impacts assessment using an indicator approach. ICES J. Mar. Sci. 62:592-597.

In this paper the authors discuss an indicator approach employed for the Bering Sea/Aleutian Islands and Gulf of Alaska groundfish fisheries that describes ecosystem status, and trends and measures of human and climate influence developed to provide advice to fishery managers. This approach is now being expanded to utilize a variety of models to predict possible future trends in various ecosystem indicators. Future implementation challenges include the refinement of these predictive models, and the inclusion of climate into the models. Identification of sensitive and meaningful ecosystem indicators is also required before a more formalized decision making process, one that includes ecosystem considerations, can be developed.

Logerwell, E.A., K. Aydin, S. Barbeaux, E. Brown, M.E. Conners, S. Lowe, J.W. Orr, I. Ortiz, R. Reuter, and P. Spencer. 2005. Geographic patterns in the demersal ichthyofauna of the Aleutian Islands. Fisheries Oceanography 14 (Suppl. 1): 93-112

Using all or filtered subsets of trawl survey data collected in the Aleutian Islands from 1980-2002 the authors conducted a number of investigations to evaluate distribution and abundance, food habits, and growth studies of demersal species in this area. A number of analyses required pooling sample data across years. Regional delineations were made at six Aleutian Island passes: Unimak, Samalga, Amukta, Tanaga, Amchitka, and Buldir. In addition, data were stratified by finer and coarser scale geographic regions as well as depth zones for different analyses. For example, distribution and abundance of four commercial species (pollock, Pacific cod, Atka mackerel and Pacific ocean perch) was evaluated at a fine spatial scale using ¼ degree longitude blocks and 100 m depth ranges. Food habits were evaluated for the same four commercial species but at larger spatial scale (2° longitude blocks). Functional growth relationships were estimated for a number of rockfish species for each Aleutian Island management area (541, 542 and 543). There were "step-changes" in species occurrence, diversity, population distribution and food habits at Samalga Pass and sites further west indicating physical and biological changes along the length of the Aleutian Island chain. Depth related variability in demersal fish distributions were equally common. The biological changes were consistent with changes in the physical oceanography observed in the vicinity of Samalga Pass.

Miller, A.J., E. Di Lorenzo, D. J. Neilson, H. Kim, A. Capotondi, M. A. Alexander, S. J. Bograd, F. B. Schwing, R. Mendelssohn, K. Hedstrom and D.L. Musgrave. 2005. Interdecadal changes in mesoscale eddy variance in the Gulf of Alaska circulation: possible implications for the Steller sea lion decline. Atmosphere-Ocean 43(3) 231–240.

"A distinct change in the ocean circulation of the Gulf of Alaska after the 1976–77 climate shift is studied in an eddy-permitting primitive equation model forced by observed wind stresses from 1951–99. When the Aleutian Low strengthens after 1976–77, strong changes occur in the mean velocity of the Alaskan Stream and in its associated mesoscale eddy field. In contrast, the Alaska Current and the eddy flows in the eastern Gulf remain relatively unchanged after the shift. Since mesoscale eddies provide a possible mechanism for transporting nutrient-rich open-ocean waters to the productive shelf region, the flow of energy through the food web may have been altered by this physical oceanographic change. This climate-driven mechanism, which has a characteristic east-west spatial asymmetry, may potentially help to explain changes in forage fish quality in diet diversity of Steller sea lions whose populations have declined precipitously since the mid-1970s in the western Gulf while remaining stable in the eastern Gulf."

Musgrave, D., and H. Statscewich. 2005. Environmental monitoring of oceanographic conditions near the Chiswell Island Steller sea lion rookery. Chapter 35, pages 337-344, in Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

As a part of the Alaska Sea Life Center research program these authors attempt to assess temporal variability of the oceanographic environment in the vicinity of the Chiswell Island sea lion rookery using biophysical moorings to measure current velocity, temperature, salinity, photosynthetically active radiation (PAR), backscatter and fluorescence. They placed two oceanographic moorings (buoys with attached instruments) one GAK4 biological mooring was subsequently dislodged and lost, the physical mooring was recovered. Another, Chiswell I, biophysical mooring was recovered with damaged instruments (Seacat CTDs). This mooring was subsequently moved nearer to the Chiswell Island rookery. Salinity and temperature at Chiswell Island varied in a pattern similar to that observed at GAK1, summer heating at the surface with temperatures beginning to increase in April. During summer most of the heat is trapped above 70 m due to seasonal stratification. In October, winter mixing warms the water below 70 m and the water column becomes isothermal by the end of November. April salinity is lower at the surface with the weakest vertical gradient at this time. In May the surface freshens while salinity at depth gets saltier. Salinity lessens in November and by February the profile resembles that from April. The area experiences occasional abrupt freshenings lasting 5-7 d and impacting the entire water column. The authors report that these are anticyclonic meanders formed in the Alaska Coastal Current (ACC) upstream of Chiswell Island. Four such events were observed from April to June, 2004.

National Research Council (NRC). 2003. Decline of the Steller sea lion in Alaskan waters; untangling food webs and fishing nets. National Academy press, Washington, D.C. 184 pp.

This report is a comprehensive review of the interactions between Steller sea lions and Alaskan groundfish fisheries, and the role the fisheries play in sea lion demographics. Among the tasks undertaken is a review of hypotheses put forward to explain the dramatic decline in Steller sea lion abundance. The report lists eight hypotheses, two classified as "bottom-up", five as "top-down" and one as either bottom-up or top-down. Bottom-up hypotheses relate to controls on sea lion food supply, e.g., competition with fisheries for prey resources or impacts of climate on ecosystem productivity. Top-down hypotheses deal with direct impacts on sea lion survival, e.g., predation on sea lions by killer whales and/or sharks; shooting by humans either legally through subsistence harvest or illegal shooting; incidental mortality through interaction with fishing gear (entanglement); or losses due to disease. Finally, pollution could have adversely impacted sea lions manifested as either a top-down or bottom-up effect. The report evaluates the available evidence for each of these hypotheses. The authors of this report noted that, "In the existing body of information on Steller sea lions, there is no conclusive evidence supporting either the bottom-up or top-down hypotheses." The authors believe that bottom-up forces imposing nutritional stress on the sea lion population may have contributed to the rapid decline in the 1980s but that the mechanism appeared to impact the population range-wide, implying a environmental or climate effect. On the other hand, they note that "Existing data on the more recent period of decline (1990-present) with regard to bottom-up and top-down hypotheses indicate that bottom-up hypotheses invoking nutritional stress are unlikely to represent the primary threat to recovery." Rather, this scientific review panel wrote that, "Although no hypothesis can be excluded based on existing data, top-down sources of mortality appear to pose the greatest threat to the current population."

O'Corry Crowe, G., B.L. Taylor, M. Basterretche, T.R. Loughlin, T. Gelatt, and J.W. Bickham. 2003. Using molecular genetics to estimate dispersal rates between Steller sea lion rookeries. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

The authors employed used mitochondrial DNA (mtDNA) data to estimate dispersal rates of Steller sea lions. They sequenced 532 bp of mtDNA's control region for 60-106 individuals per rookery from 3 adjacent rookeries in the Western stock that have witnessed some of the most dramatic declines and 2 rookeries in the Eastern stock, where numbers are increasing. Estimated annual dispersal among eastern rookeries ranged from 0.1% to 1% corresponding to 5 to 50 females dispersing each year among rookeries on the order of 2,500 females, indicating that rookeries in Southeast Alaska are demographically connected. This agrees with independent evidence of the close historical relationships and evidence from branding studies of continued connectivity between rookeries in this region. Conversely, dispersal rates between rookeries in the Western stock were about 0.01% corresponding to << 1 female per year among rookeries that historically comprised 4,000 to 15,000 females. Such low levels of dispersal were surprising and indicate that neighboring rookeries are, in effect, demographically separate entities.

O'Corry-Crowe, G., B.L. Taylor, T/ Gelatt, T.R. Loughlin, J. Bickham, M. Basterretche, K. Pitcher, and D.P. DeMaster. In review. Demographic independence along ecosystem boundaries in Steller sea lions revealed by mtDNA analysis: implications for management of an endangered species. Canadian Journal of Zoology.

This paper is in manuscript form and being reviewed for publication at the journal; it was not available to be summarized for this review.

Piatt, J.F., G.V. Byrd, K.Pitcher, and S.R. Hare. 2003. Inverse production regimes and inverse population dynamics of three high trophic-level consumers in the North Pacific. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

In this abstract the authors report that, "Evidence suggests that Coho salmon (SAL), Steller's sea lion (SSL) and tufted puffin (TUPU) populations in northern (Gulf of Alaska, Aleutians) and southern (CA, OR, WA, BC) regions exhibit inverse population trends: When northern populations increase, southern populations decrease, and vice versa. This effect may be moderated in transitional areas (SE Alaska or BC) and there are some local exceptions (e.g., SSL populations in s. CA). One hypothesis for this large-scale geographic pattern is that overall ocean productivity reflects climate forcing of primary production in the Subarctic and Subtropical Gyres - which respond in opposite directions to changes in strength of the Aleutian Low pressure system. An assumption is that ocean productivity exerts significant

bottom- up control over the productivity of higher trophic level consumers such as SAL, TUPU and SSL. If so, and since these species have broadly overlapping distributions, centers of abundance and diets, we should not be surprised that they all exhibit similar inverse patterns among regions. Curiously, however, they also exhibit inverse trends within regions: While SSL declined dramatically during the 1980s and 1990s in most of Alaska, TUPU and SAL increased dramatically (there is a strong negative correlation between TUPU and SSL population trends throughout their range). Several hypotheses can be advanced to explain the inverse pattern among species: 1) All species are subject to over-riding anthropogenic effects which generate artificial 'pattern'; 2) Population trends are driven mostly by juvenile, adult survival in wintering areas (n. central Pacific for TUPU, SAL; continental shelf for SSL); 3) Dramatic decline of SSL has resulted in surplus food for TUPU in breeding areas (density dependent, competitive interaction); 4) Ocean conditions favor different prey bases for TUPU and SSL— small differences adequate to favor one species over another. We will consider evidence for and against these different hypotheses."
[Annotator's note: the authors have not published this research.]

Rodionov, S.N., J.E. Overland, and N.A. Bond. 2005. Spatial and temporal variability of the Aleutian climate. Fisheries Oceanography 14 (Suppl. 1):3-21.

In this paper the authors provides an account of the characteristics of climate variability in the Aleutian Islands. Focusing on surface air temperature (SAT) anomalies, the authors show that interannual and inter decadal variations in SAT are quite different between the eastern and western Aleutians, with the transition area in the vicinity of 170° W longitude. The eastern Aleutians experienced a regime shift with warming temperatures in 1977 that was coincident with a shift in the Pacific Decadal Oscillation (PDO). The western Aleutians, on the other hand, show a steady decline in winter SAT that began in the 1950s. With the cooling trend in the western Aleutians came a trend of increasing variability in SAT attributed to a seasonal warming trend in November and cooling trend in January which more than doubled the annual rate of cooling from November to January. The authors hypothesize that the increasing variability in SAT in the western Aleutians may have added to environmental stress placed on the western stock of Steller sea lions.

Schell, D. M. 2000. Declining carrying capacity in the Bering Sea: Isotopic evidence from whale baleen. Limnology and Oceanography 45:459-462.

The author assessed the hypothesis that major declines of marine mammal and bird populations were driven by bottom up processes, namely climate change effects. Using the inverse relationship between phytoplankton cell-growth rates and carbon isotope fractionation the author compares seasonal rates of primary productivity. The isotope ratios in the long baleen plates from bowhead whales (*Balaena mysticetus*) laid down while the whales fed in the Bering and Chukchi seas were used as a proxy for the average annual isotope ratios in their zooplankton prey and, by extension, phytoplankton. Plates from 37 whales produced a continuous isotopic record from 1947–1997 and indicate that seasonal productivity was higher in 1947–1976, peaking in 1966. Since that time, average $\delta^{13}C$ values have declined by over 2.7‰ until 1997, inferring a drop in seasonal carbon fixation of ~30–40%. Alternatively, lowered isotope ratios could arise if phytoplankton stocks significantly increased over time while cell-growth rates declined. However, long-term literature estimates for phytoplankton in the Western and Eastern Pacific Ocean and Eastern Bering Sea show either no trend or a decrease over time. Archaeological samples of baleen from ca. 100 and 2,200 yr. B.P.

showed average $\delta^{13}C$ values higher than any in the last five decades, implying still higher productivity in the past. The lowered carrying capacity is a likely contributor to the decline of top consumers in the region.

Schumacher, J.D., N. A. Bond, R. D. Brodeur, P. A. Livingston, J. M. Napp and P. J. Stabeno. 2003. Climate Change in the Southeastern Bering Sea and Some Consequences for Biota. pp17-40. In: Large Marine Ecosystems of the World: Trends in Exploitation, Protection, and Research. G. Hempel, K. Sherman, editors. Amsterdam: Elsevier Science. 440 pp.

In this paper the authors review the literature describing changes in the biophyisical environment of the Bering Sea and examine recent environmental anomalies and the biotic response to those changes. They then comment on management concerns, and speculate on the types and direction of changes that may be expected given the current understanding of ecosystem controls.

Shima, M., A. B. Hollowed, and G. R. VanBlaricom. 2000. Response of pinniped populations to directed harvest, climate variability, and commercial fishery activity: a comparative analysis. Rev. Fish. Sci. 8(2):89-124.

In this paper the authors explore hypotheses addressing the decline of the Steller sea lion (*Eumetopias jubatus*) population in the Gulf of Alaska (GOA) through comparative analysis of fisheries and pinniped populations in three other ecosystems: Barents Sea, Benguela Current, and California Current. The authors focus on examining the effects of commercial pinniped harvest, commercial fisheries, and environmental changes. Of the four pinniped species included in this study, only the Steller sea lion population has exhibited a sharp decline in population number. Comparative analysis indicated that the Gulf of Alaska pinniped population has not experienced any unique large-scale perturbations compared to the other ecosystems. Commercial fisheries played a major part in all four ecosystems. The main species in pinniped diets were often the target of commercial fishing activity leading to potential conflicts between the 2 types of predators (i.e., pinnipeds and commercial fisheries). Exploitation rates in the GOA were comparable to or less than rates in the other ecosystems while the rates were highest in the Barents Sea. Statistical analysis showed that GOA pollock exploitation rates were significantly different from the rates of most other species. Healthy pinniped populations were present in all the ecosystems in this study except for the GOA despite the presence of much commercial fishing activity. This suggests the need for more detailed analysis of the possible role of commercial fisheries in the GOA ecosystem and the management actions taken to alleviate its effects.

Sigler, M. and J.N. Womble. 2006. Ecological significance of seasonal aggregations of marine forage species for Steller sea lions. In Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

A general discussion about the selective advantage of SSLs taking advantage of predictable intermittent prey availability. The discussion is an extension of the authors work during 2000-2004 in Southeast Alaska reported in numerous abstracts and papers by Sigler, Gende, Womble, and others.

Sinclair, E.H. and P.J. Stabeno. 2002. Mesopelagic nekton and associated physics of the southeastern Bering Sea. Deep Sea Research, Part II.: Topical Studies in Oceanography 49(26):6127-6145.

This paper reports the results of surveys of the mesopelagic nekton (fish and invertebrate species in the water column at 250 to 1000 m depth) of the southeastern Bering sea. The fish and invertebrate species themselves occupy habitat predominately beyond the diving depth of foraging sea lions. Relative to sea lion ecology is the physical description of the major current regimes of the eastern Bering sea.

Sinclair, E.H., S.E. Moore, N.A. Friday, T.K. Zeppelin, and J.M. Waite. 2005. Do patterns of Steller sea lion (*Eumetopias jubatus*) diet, population trend and cetacean occurrence reflect oceanographic domains from the Alaska Peninsula to the central Aleutian Islands? Fisheries Oceanography 14 (Suppl. 1):223-242.

In this paper the authors are attempting to determine whether biophysical properties of the passes along the Aleutian Islands broadly influence distribution patterns of marine mammals. To do so, the authors evaluate the distribution of Steller sea lions, four large whales (fin, humpback, minke and sperm whales), Dahl's porpoise and killer whales in the Unimak Pass to Tanaga Pass region. They use general additive models (GAM) to discriminate associations with a variety of physical and biological factors (Steller sea lion diet diversity, rookery population trends, cetacean abundance, and physical oceanographic properties). Steller sea lions formed three recognizable clusters with the least amount of overlap between clusters at Samalga Pass. Rookeries near Unimak pass exhibited the highest diet diversity. The cetacean distribution generally aligned with that of Steller sea lions. The large temporal variability between data sets across these studies suggest that the regional physical characteristics of hydrography and current flow influenced by the passes along the eastern and central Aleutian Islands are predictable and comprise a series of eco-boundaries, with the most pronounced break at Samalga Pass. The similarity in spatial patterns demonstrated between species across the trophic scale provides strong inference for physical forcing or bottom–up structuring of the marine environment in the central and eastern Aleutian Islands.

Springer, A.M. , J. A. Estes , G. B. van Vliet , T. M. Williams, D. F. Doak, E. M. Danner, K. A. Forney, and B. Pfister. 2003. Sequential megafaunal collapse in the North Pacific Ocean: An ongoing legacy of industrial whaling? Proceedings of the National Academy of Sciences of the United States of America 100:12223-12228.

In this paper, the authors propose a hypothesis that asserts that industrial commercial whaling in the 1950s-1960s depleted an import prey for mammal eating killer whales forcing them to shift prey preferences. The resultant "sequential decline" in harbor seals, fur seals, Steller sea lions and sea otters is assumed to reflect the changing diet of killer whales following the large whale decline. The authors model energetic demand to demonstrate that capacity for killer whales to accommodate the losses in pinniped populations as a consequence of increased killer whale predation. They argue against bottom up controlling mechanisms on pinniped populations based on consistency of $\delta^{15}N$ concentrations in bone collagen (see Hirons et al 2001 above).

Trites, A. W., V. Christensen, and D. Pauly. in press.a. Effects of fisheries on ecosystems: just another top predator? Pp. 000-000 in Top predators in marine ecosystems: their role in monitoring and management (I.L. Boyd, K. Camphuysen and S. Wanless, eds.). Cambridge University Press, Cambridge.

> In this article the authors recount changes in world populations of fishes and the apparent effect of commercial fishing on the ecosystems where they occur. In particular they contrast fisheries with other apex predators and note the differences in ecological mechanisms constraining exploitation of prey resources by these predators. The authors note that on many levels, fisheries have a lot in common with apex predators in that they can reduce the abundance of their prey and can influence the rates of growth and maturity of the species they target. Fisheries can also influence rates of turnover and nutrient cycling. However, the effects of fisheries go well beyond those of other apex predators, due in large part to their capacity to remove large amounts of biomass from the world's oceans and the lack of biological controls or feedback to limit what and how much they take. [see also Trites, Christensen and Pauly, in press, under Theme 4-Fish Assessments and Fisheries]

Trites, A.W. and C.P. Donnelly. 2003. The decline of Steller sea lions in Alaska: a review of the nutritional stress hypothesis. Mammal Review 33: 3-28.

> The authors review available information pertaining to the nutritional stress hypothesis. Their abstract states that the decline of Steller sea lions in the Gulf of Alaska and Aleutian Islands between the late 1970s and 1990s may have been related to reduced availability of suitable prey. Many studies have shown that pinnipeds and other mammals suffering from nutritional stress typically exhibit reduced body size, reduced productivity, high mortality of pups and juveniles, altered blood chemistry and specific behavioral modifications. Morphometric measurements of Steller sea lions through the 1970s and 1980s in Alaska indicate reduced body size. Reduced numbers of pups born and an apparent increase in juvenile mortality rates also appear to be nutritionally based. Blood chemistry analyses have further shown that Steller sea lions in the Gulf of Alaska and Aleutian Islands area exhibited signs of an acute phase reaction, or immune reaction, in response to unidentified physical and/or environmental stress. Behavioral studies during the 1990s have not noted any changes that are indicative of an overall shortage in the quantity of prey available to lactating female sea lions. The data collected in Alaska are consistent with the hypothesis that Steller sea lions in the declining regions were nutritionally compromised because of the relative quality of prey available to them (chronic nutritional stress), rather than because of the overall quantity of fish per se (acute nutritional stress). This is further supported by captive studies that indicate the overall quality of prey that has been available to Steller sea lions in the declining population could compromise the health of Steller sea lions and hinder their recovery.

Trites, A.W., and K.H. Soto. 2004. A Global Comparative Analysis of Sea Lion Diets. Presented paper. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> Dietary information based on stomach and scat contents were compiled from published sources for all five sea lion species. They indicate that sea lions are generalists in terms of the large numbers of species that each consumes (>40 species), but have preferences based on the dominance of a small number of key species that are repeatedly reported in scats and stomach contents (~3-8% species). The authors concluded that many species consumed by sea lions are also targeted by commercial fisheries, but competition has not been demonstrated for any of the sea lion species.

Trites, A.W., A.J. Miller, H.D.G. Maschner, M.A. Alexander, S.J. Bograd, J.A. Calder, A. Capotondi, K.O. Coyle, E.D. Lorenzo, B.P. Finney, E.J. Gregr, C.E. Grosch, S.R. Hare, G.L. Hunt, J. Jahncke, N.B. Kachel, H.-J. Kim, C. Ladd, N.J. Mantua, C. Marzban, W. Maslowski, R. Mendelssohn, D.J. Neilson, S.R. Okkonen, J.E. Overland, K.L. Reedy-Maschner, T.C. Royer, F.B. Schwing, J.X.L. Wang, and A.J. Winship. in press.b. Bottom-up forcing and the decline of Steller sea lions in Alaska: assessing the ocean climate hypothesis. Fisheries Oceanography 0: 000-000.

This paper's abstract is copied in its entirety: "Declines of Steller sea lion (*Eumetopias jubatus*) populations in the Aleutian Islands and Gulf of Alaska could be a consequence of physical oceanographic changes associated with the 1976-77 climate regime shift. Changes in ocean climate are hypothesized to have affected the quantity, quality and accessibility of prey, which in turn may have affected the rates of birth and death of sea lions. Recent studies of the spatial and temporal variations in the ocean climate system of the North Pacific support this hypothesis. Ocean climate changes appear to have created adaptive opportunities for various species that are preyed upon by Steller sea lions at mid-trophic levels. The east-west asymmetry of the oceanic response to climate forcing after 1976-77 is consistent with both the temporal aspect (populations decreased after the late 1970's) and the spatial aspect of the decline (western, but not eastern, sea lion populations decreased). These broad-scale climate variations appear to be modulated by regionally sensitive biogeographic structures along the Aleutian Islands and Gulf of Alaska, which include a transition point from coastal to open-ocean conditions at Samalga Pass westward along the Aleutian Islands. These transition points delineate distinct clusterings of different combinations of prey species, which are in turn correlated with differential population sizes and trajectories of Steller sea lions. Archaeological records spanning 4000 years further indicate that sea lion populations have experienced major shifts in abundance in the past. Shifts in ocean climate are the most parsimonious underlying explanation for the broad suite of ecosystem changes that have been observed in the North Pacific Ocean in recent decades."

Trites, A.W., E.L. Bredesen, and A.P Coombs,. 2004. Whales, whaling and ecosystem change in the Antarctic and Eastern Bering Sea: insights from ecosystem models. In, Investigating the roles of cetaceans in marine ecosystems. Monaco: CIESM Workshop Monographs pp. 85-92.

This paper reviews the findings of the recent Bering Sea and Antarctic ecosystem models to better understand the role that cetaceans play in marine ecosystems. In the Bering Sea, Ecopath models were constructed for the shelf and slope regions covered by the Alaska Fisheries Science Center's bottom trawl surveys encompassing two periods: (a) the '1950s' covering the years 1955 to 1960, before large-scale commercial fisheries were underway, and (b) the '1980s' covering the period 1979-1985, after many marine mammal populations had declined. Niche overlaps were calculated between pollock, large flatfish and marine mammals in the 1980s model using two approaches. One determined the extent to which any two groups sought the same prey (referred to as prey overlap). The other approach determined to what extent they were subject to predation by the same predators (predator overlap). Baleen whales and pollock (both adult and juvenile) had the greatest dietary overlaps (68-83%). There was also substantial overlap between seals and adult pollock, and between seals, sea lions and flatfish. The largest potential competitors of sea lions appeared to be seals, toothed whales and large flatfish. Commercial whaling and fishing activities had little effect on the simulated ecosystem. Fishing (i.e., killing whales and catching fish) failed to account for the large abundance of pollock and the decreased population sizes of seals and sea lions observed in the 1980s. It therefore seems unlikely that whaling could have unleashed the ecosystem-wide changes purported by Springer et al. (2003).

Within the limitations that are inherent to simulations, the Bering Sea and Arctic ecosystem models suggest that removal of large whales had little measurable effect on lower trophic levels or on the dynamics of other species in their polar ecosystems. Trophic interactions failed to explain the magnitude of changes in the biomass of the major species groups in the Antarctic and Bering Sea. Nor did fin-fisheries appear to have had a significant effect on the abundance of non-targeted species. This may mean that environmental effects (which were not modeled) play an important role in influencing the dynamics of marine ecosystems.

Trites, A.W., V.B. Deecke, E.J. Gregr, J.K.B. Ford, and P.F. Olesiuk. In press.c. Killer whales, whaling and sequential megafaunal collapse in the North Pacific: a comparative analysis of the dynamics of marine mammals in Alaska and British Columbia following commercial whaling. Marine Mammal Science.

In this paper the authors challenge the hypothesis put forward by Springer et al. (2003) that transient killer whales were forced to alter their diet to include increasingly smaller pinnipeds and other marine mammals following the commercial depletion of large whale populations in the 1940s-1960s. By presenting evidence of large whale declines and smaller mammal population trends in British Columbia waters over a similar time period, the authors demonstrate that sequential collapse of these megafauna did not occur in British Columbia waters. Consequently, they dispute the inference put forward in the Springer et al paper.

Wade, P., L. Barrett-Lennard, N. Black, R. Brownell Jr. , V. Burkanov, A. Burdin, J. Calambokidis, S. Cerchio, P. Clapham, M. Dahlheim, J. Ford, N. Friday, L. Fritz, J. Jacobsen, T. Loughlin, M. Lowry, C. Matkin, D. Matkin, A. Mehta, S. Mizroch, M. Muto, D. Rice, D. Siniff, Robert Small1, G. Steiger, J. Straley, and G. Van Blaricom. 2003. Commercial whaling and "whale killers": A reanalysis of evidence for sequential megafaunal collapse in the North Pacific. Fifteenth Biennial Conference on the Biology of Marine Mammals. Society for Marine Mammalogy. Greensboro, North Carolina, USA, Dec. 15, 2003. (7)

This abstract addresses issues discussed in detail in the article by DeMaster et al (2006) reviewed above.

Wade, P., L. Barrett-Lennard, N. Black, R. Brownell, V. Burkanov, A. Burdin, J. Calambokidis, S. Cerchio, M. Dahlheim, J. Ford, N. Friday, L. Fritz, J. Jacobsen, T. Loughlin, M.Lowry, C. Matkin, D. Matkin, S. McCluskey, A. Mehta, S. Mizroch, M. Muto, D. Rice,D. Siniff, R. Small, G. Steiger, J. Straley, G. Van Blaricom and P. Clapham. in review. Marine mammal abundance, biomass, and trends in the North Pacific – a re-examination of evidence for sequential megafauna collapse. Marine Mammal Science (7)

This paper is not yet available for review.

Whitehead, H. and R. Reeves. 2005. Killer whales and whaling: the scavenging hypothesis. Biol. Lett. (2005) 1, 415–418

In this paper, the authors present an idea in support of the notion that killer whales may have made an abrupt shift from foraging on large whales to smaller mammals including pinnipeds and sea otters. Unlike Springer et al. they do not address the megafauna cascade hypothesis,

rather they argue that in the 1980s killer whales previously adapted to foraging on large whale carcasses provided by commercial whaling were suddenly deprived and forced to adopt new predation strategies that resulted in a shift to small mammals.

Witherell, D., Pautzke, C., and Fluharty, D. 2000. An ecosystem-based approach for Alaska groundfish fisheries. ICES Journal of Marine Science, 57: 771-777

This paper's abstract is presented in its entirety: "An ecosystem-based approach is being developed for the management of groundfish fisheries in the North Pacific Ocean off Alaska, USA. The approach involves public participation, reliance on scientific research and advice, conservative catch quotas, comprehensive monitoring and enforcement, by-catch controls, gear restrictions, temporal and spatial distribution of fisheries, habitat conservation areas, and other biological and socioeconomic considerations. The basic ecosystem consideration employed is a precautionary approach to extraction of fish resources. Off Alaska, all groundfish stocks are considered healthy, while providing sustained yields of about 2 million tonnes annually. Management measures are also taken to minimize potential impacts of fishing on seafloor habitat and other ecosystem components such as marine mammals and seabirds."

Wynne, K.M., R. Foy, and L. Buck. 2005. Gulf Apex Predator-prey Study (GAP) Final Report FY2001-2003. NOAA Grant NA16FX1270, University of Alaska Fairbanks, School of Fisheries and Ocean Sciences. 249p.

The following accounts are excerpted from the Executive Summary of this report: "The Gulf Apex Predator-prey (GAP) program represents a multidisciplinary effort to assess the status, environment, prey, and potential competitors of Steller sea lions in waters near Kodiak, Alaska. GAP's distinct but interrelated studies broadly assess the diets, distribution, and status of Kodiak's sympatric apex predators while exploring the processes that drive populations of their prey within a dynamic marine environment. These studies were designed to overlap spatially and temporally to allow synchronous collection of predator and prey data and a synoptic assessment of their seasonal interactions. By limiting the geographic breadth of its integrated studies to waters near Kodiak, GAP has been able to collect data with both temporal and taxonomic depth.

We used repeated aerial surveys of haulouts in the Kodiak Archipelago to monitor the seasonal abundance and distribution of Steller sea lion and to explore inter- and intra-annual patterns reflective of changing prey availability and reproductive needs of sea lions. Use of terrestrial habitat peaked in late summer and a negative trend in Steller sea lion numbers was seen in the area over four survey years. Seasonal patterns of use varied on each site, including shifts in overall attendance numbers and use of within-haulout microhabitat.

Preliminary findings indicate that Kodiak's Steller sea lions are currently preying on a diverse diet, including a remarkable nine dominant prey species. Relative use varied both seasonally and regionally but Pacific sandlance (42.0 FOC), arrowtooth flounder (37.0 FOC), walleye pollock (30.1 FOC), Pacific cod (29.2 FOC), and salmon spp. (28.5 FOC) were found to be the five dominant prey of Steller sea lion in the samples examined to date.

Prey distributions were found to vary spatially and seasonally between 2001 and 2003. Pelagic fish distribution was correlated to the presence of oceanographic features on the

northeast side of Kodiak Island and surveys were expanded to accommodate these features. Specifically, horizontal features of the water column off Portlock Bank, Marmot Gully and Chiniak Gully appear to affect the distributions of capelin and walleye pollock. As such, a large amount of variability was found in the energy density of prey available to upper trophic levels. Demersal fish distributions were highly variable among seasons and between years. However, distributions were associated with specific strata, such as distance to shore and depth.

Steller sea lions share Kodiak waters and prey resources with a variety of apex predators, including marine fish, birds, and mammals, whose numbers increased during the Steller sea lion's decline.

Large whales are apex predators found in Kodiak waters designated as Steller sea lion Critical Habitat. We documented the year-round presence and distribution of large whales in the Kodiak Archipelago and assessed their abundance, distribution, and habitat use in northeast Kodiak waters. We initiated studies to assess the foraging ecology of humpback whales in Kodiak waters, a consumer whose numbers are rebounding and whose diet includes fish consumed by Steller sea lions and zooplankton that feed those fish species.

We monitored dietary, reproductive, physiological and behavioral parameters of black-legged kittiwakes, glaucous-winged gulls and tufted puffins across their breeding season in 2001-2003. Seabirds exhibited remarkable similarity in the trends of predator-insensitive reproductive parameters thus allowing us to draw some general conclusions about marine foraging conditions in Chiniak Bay from 2001-2003."

THEME 6 – OTHER ANTHROPOGENIC EFFECTS

SUMMARY:

This theme contains 26 articles including 12 presentations at scientific meetings, 11 reports, one thesis, and two papers in peer-reviewed journals or book chapters. It includes summaries of anthropogenic sources of Steller sea lion kills, injuries, and harassment. There was one review of sanctioned SSL kills in Japan, annual reports of subsistence kills in Alaska, and one study on possible injury from fishing gear, and indirect impacts from harassment due to research activities. Major contributions include:

1. A report by Calkins (2000) regarding the Japanese government's sanctioned kill of Steller sea lions that interact with commercial fisheries off Hokkaido. The kill level presently is likely <100 animals/year and is probably not having population level effects. However, prior to 1994, the kill and struck-and-loss levels were reported to have been large enough sufficient to contribute to declines in abundance in the Kuril Islands.

2. The ADFG Subsistence Division reported about 200 SSLs killed each year during the period 2000 -2003 (range 198 – 212 sea lions/year) most of which were taken in Aleutian Islands villages and the two villages on the Pribilof Islands. But prior to 2000 there were large differences in Alaska Native subsistence kill levels as reported to the Subsistence Division, ADF&G, and reports by the St. Paul Tribal Government ECO. Recently, however, the take level in these reports are similar.. The Ecological Conservation Office on St. Paul believes that their reporting system was superior to the ADFG retrospective surveys from about 1998 to 2002, but in 2004 both reported the same take level (ADFG reported 18 takes of which 13 were harvested and 5 S/L; ECO reported 18 takes of which 9 were harvested and 9 S/L). The advantage to the ECO system is that a bio-sampling program was implemented and that real-time harvest monitoring occurs for more accurate age and sex information of harvested animals.

3. The Bristol Bay Native Association (Anonymous, 2004) conducted a thorough study in the Perryville area of SSL occurrence at haulout sites and rookeries and provided valid counts of SSLs at each site by age and sex. Of significance in their study was the accumulation of TKW through interviews with local elders and hunters, the summation of important information gathered during these interviews, and inclusion of transcripts from these interviews in the report.

4. Previously known but undocumented levels of injury to SSLs resulting from swallowing hooks and other gear associated with commercial line fisheries (salmon fishers, etc.) were summarized by ADFG. Entanglement in marine debris had been documented in the 1980s and early 1990s, but the study by ADF&G suggests that the level of injury may be greater than previously thought and that mortality may occur in some cases.

5. Kucey documented measurable short-term effects of human disturbance on the numbers of SSLs using terrestrial sites. She found that variation in the numbers of animals using haulout sites increased following the disturbances, but rates of change in daily numbers did not differ significantly between periods. Six of ten sites reached full recovery on average 4.3 days after the research disturbance.

ANNOTATED BIBLIOGRAPHY-- OTHER ANTHROPOGENIC EFFECTS

Anonymous. 2004. Steller Sea Lion Research Initiative, Native Village of Perryville, Traditional ecological knowledge of subsistence uses of Steller sea lions and identifying Steller sea lion haulouts and rookeries in the Perryville, Alaska area. Final Contract Report. Bristol Bay Native Association P.O. Box 310 Dillingham, Alaska 99576. 68p.

> This thorough report summarizes a project by the Native Village of Perryville (Gulf of Alaska, Shumagin Islands area) to document TKW and to provide local expertise in gathering SSL survey data at the rookery and haulout sites in the Perryville area. Phase 1 was gathering important traditional ecological knowledge (TEK) information on subsistence uses of SSLs from elders and subsistence users in the Perryville community. Phase 2 was conducting a population assessment using accepted small boat survey techniques and the identification of SSL haulouts and rookeries. The underlying reasons for conducting this project were to document TKW regarding subsistence uses of SSLs, to assess the SSL population in the area, to identify haulouts and rookeries, and to increase the local research capacity of Perryville residents through training and use of modern research techniques. The report contains accounts from interviews and maps and descriptions of SSL haulout locations, predation events, and other information gleaned from interviews. It also provides results of counts of juveniles and non pups by age and sex and location.

Bryant, J., M. Riedel, and J. Fall. 2006. Community-based harvest monitoring of subsistence harvest of harbor seals and Steller sea lions. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

> The authors describe the Alaska Native Harbor Seal Commission's 12 year involvement with the ADFG Subsistence Division (see Wolf below) to collect subsistence harvest information for harbor seals and SSLs through questionnaires and interviews. The information is then used by NMFS in stock assessment reports and to assess mortality levels of different stocks. Recently the questionnaires have included a question regarding the respondents' perception of pinniped population trends.

Calkins, D. G. 2000. Investigation of the intentional killing of Steller sea lions in Japan=s commercial fisheries. Calkins Wildlife Consulting, 12600 Elmore Road, Anchorage, AK, 99516-2904, Revised by Bohan, January 2000, 71p.

> This report summarizes contract work performed by Calkins in 1999 to investigate the intentional killing of SSL that were near actively fishing gear and caused damage to gear and catch, or were taken incidental to Japan's commercial fishing activities near Hokkaido. The information in this report was informally reported to NMFS at meetings in Japan in 1997; the purpose of the contract to Calkins was to confirm the estimated kill levels and their impact on SSL populations. The report summarized information from pertinent literature and from meetings between Calkins and Japanese authorities. Calkins reported that the level of kill was not large but models suggested that it was sufficient to contribute to declines in SSL abundance in the Kuril Islands, where most of the animals killed in Japan originate. The annual kill limit since 1994 was set at 116 animals. However, the actual kill level during 1994, 1995, and 1996, the last years that data are provided in the report, are 89, 84, and 99 sea lions, respectively. Prior to 1994, kill levels ranged from 49 (1977) to 411 (1984) with struck and loss levels often exceeding the kill levels (662 sea lions in 1977). Calkins reported that the Japanese intent to reduce mortality levels in the future.

Fall, J.A. 2003. The subsistence harvest of Steller sea lions by Alaska natives in 2001. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

> This is a public presentation of the ADFG Subsistence Division report of the subsistence take of Steller sea lions by Alaska Natives in 2001. The full report and summary is reported below at Wolfe et al. (2002).

Hough, K. R., T. R. Loughlin, and J. W. Testa. 2003. Interactions between Steller sea lions and groundfish fisheries in the largest Alaskan fishing port. P. 75, in 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

> This abstract provides an account of observations of Steller sea lion interactions with fishing vessels in the port of Kodiak. The authors note that sea lions haul out on vessels and docks, and scavange catches from vessels making landings. In general, sea lion abundance in port followed the season distribution of landed catch. Scat samples collected from docks indicated that sea lions fed on pollock (97% FO) and flatfish (50% FO).

Iida, K., T.-G. Park, T. Mukai, and S. Kotani. 2004. Avoidance behavior of Steller sea lion (*Eumetopias jubatus*) to artificial sound stimuli. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> This is a data-lacking generalized report of efforts by Japanese scientists to deter Steller sea lions from commercial fishing gear by the use of aerial and underwater sound stimuli and flashing lights. It is not clear if the test animals were captive or free-ranging. It is difficult to understand the results presented due to language problems but seemingly the researchers believe the results were equivocal; aerial sound proved more effective than underwater sound, with flashing lights the least effective.

Jack, L., D. Willoya, D. Garza, and M. Roberts. 2004. TASSC: Sea Lion Co-management in Alaska. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

> The presentation summarized involvement of the Alaska Sea Otter and Steller Sea Lion Commission in the co-management of Steller sea lions in Alaska. No data on take levels are presented.

Kucey, L. 2005. Human disturbance and the haulout out behaviour of Steller sea lions (*Eumetopias jubatus*). M.S. Thesis, University of British Columbia, Vancouver, Canada. 75 p.

> The purpose of this study was to determine if there were measurable short-term effects of human disturbance on the numbers of SSLs using terrestrial sites. Numbers and composition of SSLs were documented for 2-3 week periods in Southeast Alaska and British Columbia during summer and winter. Hauling out trends were examined for pre- and post disturbance (typically during scat collections by researchers) across multiple sites over two seasons. Disturbances resulted in significantly fewer SSLs using haulout sites during the post-disturbance period. Variation in the numbers of animals using haulout sites increased following the disturbances, but rates of change in daily numbers did not differ significantly between periods. Six of ten sites reached full recovery on average 4.3 days after the research disturbance. Behavior of individual SSLs was different following disturbance.

Kucey, L., and A.W. Trites. 2003. Assessing the effect of human disturbance on Steller sea lions. P. 88, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Abbreviated information as contained in Kucey (2005) above.

Kucey, L., and A.W. Trites. 2004. Is Human Disturbance Affecting Steller Sea Lions? Presented paper. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Abbreviated information as contained in Kucey (2005) above.

Kucey, L., and A.W. Trites. 2005. Human disturbance and the hauling out behavior of Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Abbreviated information as contained in Kucey (2005) above.

Kucey, L., and A.W. Trites. In press. A review of the potential effects of disturbance on sea lions: assessing response and recovery. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

Abbreviated information as contained in Kucey (2005) above.

Lestenkof, A.D., P.A. Zavadil, and M.T. Williams. 2003. The subsistence harvest of Steller sea lions on St. Paul Island in 2001. Annual Report provided to the National Marine Fisheries Service under contract NA16FX1420. 10 pp. Available, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

The information provided here for 2001 is also provided in the 2005 report below by Zavadil et al. (2005).

Loughlin, T. R., and A. E. York. 2000. An accounting of the sources of Steller sea lion, *Eumetopias jubatus*, mortality. Mar. Fish. Rev. 62(4):40-45.

The authors summarized the nature and magnitude of mortality to Steller sea lions between 1991 and 2000 and concluded that about 1,666 mortalities above replacement fueled the decline during the study period. Anthropogenic mortality in the form of subsistence kills, incidental take, illegal shooting, and research mortalities could account for up to 26% of the mortality above replacement.

Mathews, E.A. 2000. Reactions of Steller sea lions (*Eumetopias jubatus*) to vessels at a haulout in Glacier Bay. Unpublished progress report to Glacier Bay National Park and Reserve, Resource Management Div., National Parks Service, PO Box 140, Gustavus, Alaska. January 2000. 32 p.

Private and commercial vessels visiting Glacier Bay National Park commonly approach South Marble Island to observe SSLs. To minimize disturbance of wildlife, National Park Service (NPS) regulations require that boaters remain more than 100 yards from haulouts. This study was designed to determine if the distance limit prevents disturbance and if visitors comply with the regulation. On 23 days the researchers recorded resting and non-resting behavioral states and the number of animals in the water at 2 or 3 minute intervals throughout

the day and measured vessel distances. Ninety cases involving paired control (before approach) and 'experimental' (during approach) observations were analyzed. Nineteen (21%) vessels approached closer than 100 yards; 2 of these were commercial tour boats, others were private motorized vessels or kayaks. Sixteen (18%) vessel operators caused disturbance of sea lions, defined as a >20% increase in activity or >10% increase in the number of sea lions in the water. Compared to tour boats and private boats, kayaks were significantly more likely to approach the haulout closer than 100 yards and more likely to cause disturbances. Disturbances occurred at distances of 42 – 345 yards. Disturbances of sea lions by vessels could be reduced by increasing the 100 yard distance and improving compliance with regulations through visitor education and increased enforcement, but it is likely that other factors in addition to distance affect sea lion behavior.

Raum-Suryan, K., L. Jemison, and K.W. Pitcher. 2005. Entanglement of Steller sea lions in marine debris: Identifying causes and finding solutions. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

The authors report the nature and magnitude of entanglement in marine debris on SSLs by recording count, sex, age class, and number and type of entanglement. Entanglement rates varied from 0.07% to 0.26% affecting juveniles (19.4%), adult males (21%), adult females (12.9%), and undetermined (47%). Observed entanglements were primarily fishing net, line, or packing bands around the neck or fishing line and lures protruding from the mouth, indicating a swallowed hook.

Raum-Suryan, K.L., F. Gulland, T. S. Gelatt, and L. Jemison. 2004. Entanglements of North American sea lions in marine debris: Do we know enough? Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Same information as in Raum-Suryan et al (2005) above.

Szaniszlo, W. 2001. California Sea Lion (*Zalophus californianus*) and Steller sea lion *Eumetopias jubatus*) interactions with vessels in Pacific Rim National Park Reserve: Implications for marine mammal viewing management. p. 209 In: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

This report summarizes a planned study to determine the effect of disturbance by marine mammal viewing on pinnipeds in the Reserve. Preliminary results suggest that vessels do elicit disturbed behavior reactions.

Szaniszlo, W., and P. Dearden. 2005. Steller sea lion (*Eumetopias jubatus*) and California sea lions (Zalophus californianus) interactions with vessels in Pacific Rim National Park Reserve: implications for marine viewing management. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p

The object of this study was to evaluate the effectiveness of the Reserve's pinniped viewing guidelines in preventing sea lion disturbance from vessels. Thirty nine (24%) vessel interactions resulted in disturbance. Variance in behaviors was significant for vessel approaches within 0-25 m; vessels approaching fast, for motorized vessels > 5 tons; and for 1-vessel and 2-vessel interactions. The results suggest that the Park's guidelines were effective in preventing sea lion disturbance.

Wolfe, R.J. 2001. The subsistence harvest of harbor seals and sea lions by Alaska natives. 2000. ADFG, Division of Subsistence, Technical Paper No. 266. 241 p.

> The report describes the subsistence harvest of Steller sea lions (and harbor seals) by Alaska Natives in 2000, including quantity, seasons, geographic distribution, and age and sex of the harvest. Information was summarized at the state, region, and community levels and was compared with annual takes since 1992. The study was funded by NMFS-Juneau. Information was derived by interviews with hunters in 1,560 households and 62 communities. In 2000, 205 SSLs were taken (range 147-306) of which 35 (17.1%) were struck and lost (S/L) and 170 (82.8%) were harvested. Males outnumbered females by about 4:1 and adults and juveniles over pups. The 2000 take was the largest since 1995 when 339 were taken. Recent levels of take were: 549 in 1992, 487 in 1993, 416 in 1994, 339 in 1995, 186 in 1996, 164 in 997, and 178 in 1998. The greatest harvests were in the Aleutian Islands villages (71 takes, 5 S/L) and the Pribilof Islands (29 takes, 14 struck and lost), with the largest Pribilof Islands takes at St. Paul (17 takes and 12 S/L).

Wolfe, R.J., J. Fall, and R.T. Stanek. 2002. The subsistence harvest of harbor seals and sea lions by Alaska natives. 2001. ADFG, Division of Subsistence, Technical Paper No. 273. 250 p.

> As in Wolfe et al. (2001) above but with 1,461 households surveyed. In 2001, 198 SSLs were taken (range 162-282) of which 42 (21.3%) were S/L and 156 (78.7%) were harvested. Males outnumbered females by about 3:1 and adults and juveniles over pups. The greatest harvests were in the Aleutian Islands villages (78 takes, 20 S/L) and the Pribilof Islands (19 takes, 19 S/L), with the largest Pribilof Islands takes at St. Paul (12 takes and 12 S/L).

Wolfe, R.J., J. Fall, and R.T. Stanek. 2003. The subsistence harvest of harbor seals and sea lions by Alaska natives. 2002. ADFG, Division of Subsistence, Technical Paper No. 277. 249p.

> As in Wolfe et al. (2001) above but with 1,367 households surveyed. In 2002, 185 SSLs were taken (range 140-236) of which 41 (22.2%) were S/L and 144 (77.8%) were harvested. Males outnumbered females by about 5:1 and adults and juveniles over pups. The greatest harvests were in the Aleutian Islands villages (87 takes, 18 S/L) and the Pribilof Islands (24 takes, 19 S/L), with the largest Pribilof Islands takes at St. Paul (18 takes and 18 S/L).

Wolfe, R.J., J. Fall, and R.T. Stanek. 2004. The subsistence harvest of harbor seals and sea lions by Alaska natives. 2003. ADFG, Division of Subsistence, Technical Paper No. 291. 253 p.

> As in Wolfe et al. (2001) above but with 1,310 households surveyed. In 2003, 212 SSLs were taken (range 149-303) of which 47 (22%) were S/L and 165 (78%) were harvested. Males outnumbered females by about 1.5:1 and adults and juveniles over pups. The greatest harvests were in the Aleutian Islands villages (88 takes, 19 S/L) and the Pribilof Islands (22 takes, 10 S/L), with the largest Pribilof Islands takes at St. Paul (13 takes and 5 S/L).

Zavadil, P.A., D. Jones, A.D. Lestenkof, P.G. Tetoff, and B.W. Robson. 2005. The subsistence harvest of Steller sea lions on St. Paul Island in 2004. Annual Report provided to the National Marine Fisheries Service under contract NA16FX1420 and AB133F05RP1163. Available, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

> Upon review of past reports by ADFG Subsistence Division (Wolf et al., above), the Ecosystem Conservation Office of the Tribal Government of St, Paul felt that there was considerable uncertainty on the part of sea lion hunters and the local community on the

reported results, specifically in regard to the accuracy of the data collected by retrospective survey and the presentation of results. The ECO since has managed the SSL harvest on the island and provides to NMFS (and others) an annual summary of subsistence takes based on real time harvest information. The ECO has also implemented a bio-sampling protocol whereby samples from taken animals are provided to researchers upon request. The resultant reported take levels by the ECO have typically been much lower than reported by ADFG. For 2004, the ECO reports 18 SSLs were taken of which nine were harvested and nine were struck and lost. Age and sex information are provided for each take, when known. A table is provided that summarizes take for 2001-2004. Twenty four were taken in 2001, 36 in 2002, and 18 in 2003. Of the 96 animals taken over this period, 55% were S/L.

Zavadil, P.A., A.D. Lestenkof, M.T. Williams, and S.A. MacLean. 2003. The subsistence harvest of Steller sea lions on St. Paul Island in 2002. Annual Report provided to the National Marine Fisheries Service under contract NA16FX1420. 17 pp. Available, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

The information provided here for 2002 is also provided in the 2005 report above.

Zavadil, P.A., A.D. Lestenkof, D. Jones, P.G. Tetoff, and M.T. Williams. 2004. The subsistence harvest of Steller sea lions on St. Paul Island in 2003. Annual Report provided to the National Marine Fisheries Service under contract NA16FX1420. 17 pp. Available, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

The information provided here for 2003 is also provided in the 2005 report above.

(This page intentionally left blank)

THEME 7 – PREDATION

There are 21 journal articles, 6 technical reports, 0 theses, 6 book articles,4 contract reports,5 manuscript reports, and 17 symposia presentations, abstracts and posters represented in this section

SUMMARY

In the 2001 Biological Opinion[7]authorizing Alaska groundfish fisheries, NMFS reports that there is little evidence of predation on Steller sea lions by sharks but sufficient evidence "*..that killer whale predation on the current population of Steller sea lions in western Alaska is potentially significant and should be investigated further.*" The National Academy of Science, through the National Research Council (NRC, 2003) acknowledges the potential for sea lion declines to have been provoked by predation; and, the opportunity for predation to constrain recovery of the currently depleted stock. Since 2000 a number of reports have addressed these issues.

Predation by Sharks: Sleeper sharks (*Somnious pacificus*) are suspected predators of Steller sea lions (NRC, 2003). These are large sharks reaching lengths of up to 7 m. Their life history and habitat preferences are minimally known in Alaskan waters. Population estimates of sleeper sharks began to show increases in the late 1980s and have persisted to date (Mueter and Norcross, 2002; Courtney and Sigler, 2003; Courtney et al 2005). In the EBS, sleeper shark are most abundant along the continental slope where they are taken as bycatch in the Pacific cod and Greenland turbot longline fisheries. In the Gulf of Alaska, these sharks are concentrated around Shelikof trough (canyon along the continental slope) Tagging studies indicate that sleeper sharks make diel vertical movements, residing predominantly on bottom at 150-450 m depth during daylight hours and rising to near surface depths (within a few meters) at night (Hulbert et al., *in review*; Skomal and Benz, 2004; Stokesbury et al., 2005). In the Gulf of Alaska, sleeper shark tags were typically recovered within 100 km of their point of release (median distance 36 km) after being at liberty for 2 to 11 months (Hulbert et al., *in review*). Sleeper sharks are recognized scavengers feeding significantly on whale carrion among other things (Sigler et al., *in press*; Schaufler et al., 2005; Smith and Baco, 2003; Smith, 2005). No Steller sea lion remains have been identified in any of the recent studies of stomachs contents (Hulbert, 2001; Hulbert et al., 2003; Sigler et al., *in press*; Wynne et al., 2005). Fatty acid analysis also failed to identify Steller sea lions as likely prey of sleeper sharks (Schaufler et al., 2005).

Killer Whale Predation: Killer whales are known predators of Steller sea lions. Information on their absolute abundance and predilection for predation on sea lions was somewhat weak as reported in the 2001 Biological Opinion. Since 2000, a number of studies have been undertaken to examine these issues. Killer whales are divided into three recognized ecotypes: residents, known to prey only on fish; transients, known to prey on a variety of marine mammals and birds; and "offshore", assumed to prey predominantly on fish but which may also prey on marine mammals.

Abundance: There is no routine synoptic survey of killer whale abundance in Alaska. Killer whales are long lived and widely distributed at low density over a long coastline. Abundance estimates are pieced together from regional surveys and a database of unique photographic identifiers. A time series of population abundance is not available. Anglis and Lodge (2002, 2004) provide a brief report on killer whale abundance as of the year 2000 for the Eastern North Pacific transient killer whale population estimating 346 killer whales. This population includes whales from California to Alaska; they identify 251 of these whales as from "Alaskan" waters. More recently Matkin et al (2003), Matkin et al (2005) , Matkin et al (in press) and Zerbini et al (in press) have looked more closely at the Alaskan population of transient killer whales. Matkin et al (in press)

[7] http://www.fakr.noaa.gov/protectedresources/stellers/biop2002/final.htm

report killer whale counts in the Eastern Aleutian Islands from Unimak Pass to Samalga Pass. Some 1124 whales were enumerated, but only 15% were identified as transients (165 animals); 54 animals were classed as "offshores", but 44 of these had been seen elsewhere, the remainder (903) were resident whales. In the Gulf of Alaska, Straley et al (2004), Matkin et al (2003) and Matkin et al (2005) identify 23-38 Gulf of Alaska transients and another 8+ AT1 transients (Prince William Sound). In addition, Straley et al note 123 west coast transients that frequent Southeast Alaska. Zerbini et al (in press) report results from repeated line-transect surveys conducted throughout the range of the western stock of Steller sea lions from 2001 to 2003. They estimated 991 resident killer whales (95% CI 379-2585) and 251 (95% CI 97-644) transient killer whales between Prince William Sound and Samalga Pass in the Aleutian Islands. Another 700 killer whales have been counted in the Russian Far East (Burdin et al., 2005) but only about 4% of these are reported to be transient killer whales.

Diet Preferences: In the Gulf of Alaska, transient killer whales are grouped into two subpopulations: AT1 and Gulf of Alaska or GAT. The GAT killer whales are recognized as predominantly but not exclusively feeding on Steller sea lions. AT1 killer whales, predominant in Prince William Sound, feed mostly on harbor seal and Dall's porpoise. West coast killer whales, which frequent Southeast Alaska, feed on harbor seal, porpoise and Steller sea lions. Straley et al 2003, reports about 18% of predation events in Southeast Alaska are on Steller sea lions. In the Eastern Aleutian Islands, Matkin et al (in press) and Barrett-Lennard et al (2006) note significant predation on gray whales, particularly in the vicinity of False Pass. Predominant prey in the EAI was gray whales and fur seals with Steller sea lions representing less than 10% of the observed predation events. Herman et al (in press) confirm these EAI findings using fatty acid analysis.

Effects of Predation on Steller sea lions: NRC (2003) and Heise et al (2001) argued that it was possible for killer whale predation to account for the steep decline in the Western population of Steller sea lions during the 1980s and 1990s and the continued slow rate of recovery. Since then, Maniscalso et al (2006) and Williams et al (2004) have confirmed the plausibility that predation could control Steller sea lion abundance or at least inhibit recovery. Wolfe and Mangel (2005) using simulation modeling attempt to test this notion through the simultaneous evaluation of 10 competing hypotheses and conclude that there is strong evidence and a moderate effect of predation on non-pup [Steller sea lion] survival; but no evidence and a weak effect of predation on pup recruitment. All the arguments that support the plausibility of killer whale predation controlling Steller sea lion abundance are dependent on critical assumptions on consumption rates, and number of predatory animals in the population, and the proportion of their diet attributable to Steller sea lions. Despite these constrains, Williams et al (2004) assert their conclusions are conservative.

Ecosystem considerations: Springer et al (2003) put forward a hypothesis that asserts that industrial commercial whaling in Alaskan waters put in motion a sequential megafaunal collapse provoked by the transition of killer whales from predators on large whales to predators on smaller whales and other mammals (pinnipeds and sea otters). They support the notion by display of timing of collapsing marine mammal populations and their apparent connection to predation by killer whales. Whitehead and Reeves (2005) support the contention of sequential megafaunal collapse but don't necessarily link it to the declines in large whale populations. DeMaster et al 2006), Trites et al (in press) and Mizroch and Rice (*in press*) all dispute the Springer hypothesis. Trites argues that the events noted in Alaska were coincidental to the loss of large whales and supports his argument by showing trends for similar populations in British Columbia waters. Mizroch and Rice, challenge Springer's view of the timing of commercial whaling in the Alaskan waters north of 50° N latitude, pointing out that commercial whaling ceased for all intents and purposes years earlier than Springer reports. DeMaster et al argue that the events portrayed by Springer were 1) not in fact sequential, 2) that it was unlikely that killer whales were ever dependent on the large whales depleted by commercial whaling, and 3) that the numbers of smaller whales, not part of the commercial whaling operations, were significant and could have supported killer whale predation whether the large whales were present or not.

Killer whale summary: Well over 1500 killer whales have now been enumerated in Alaskan waters, roughly 15% of which are transient killer whales. These whales hunt in smaller pods (1-9 animals), do not target their prey acoustically, and appear to specialize in particular prey types at least seasonally if not persistently. Within the transient killer whale populations, Steller sea lions are typically a lesser preferred prey item; although some population subgroups appear to specialize on this prey. Despite the low incidence of predation, it is estimated to be theoretically possible for as few as 40 killer whales to account for the losses of Steller sea lions in the 1980s and as few as 5 killer whales to inhibit Steller sea lion recovery in the Aleutian Islands population.

ANNOTATED BIBLIOGRAPHY - PREDATION

Andrews, R.D., L. Mazzuca, and C.O. Matkin. 2005. Satellite tracking of killer whales. Chapter 24, pages 238-248, in Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

> These authors report on work to develop a procedure for attachment of a satellite tag on killer whales. This research is motivated to place satellite tracking devises on transient killer whales in an effort to measure their home range. Initial experiments have been conducted on resident killer whales which are more abundant and more accessible for this phase of the research. Thus far, there has been one "successful" 6-day deployment of a satellite tracking device. Researchers are refining their choice of attachment target area on the animal, and tag construction to improve the probability for successful attachment.

Angliss, R. P., and K. L. Lodge. 2002. Alaska marine mammal stock assessments, 2002. U.S. Dep. Commer., NOAA Tech. Memo. NMFS -AFSC-133, 224 pp.

> See Angliss and Lodge (2004)

Angliss, R.P., and K.L. Lodge. 2004. Alaska marine mammal stock assessments, 2003. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-AFSC-144. 230 p.

> This report contains an assessment of the total population size of Eastern North Pacific Transient Killer whale stock. The last update of this assessment was December 15, 2000. The report was first presented in Angliss and Lodge (2002) and repeated here. There are additional assessments of resident killer whales, which we are not reviewing as they are not pertinent to killer whale predation on sea lions. The Eastern North Pacific transient killer whale stock extends from Alaska through California, and includes whales observed in waters of British Columbia. The estimated minimum population size is 346 animals: 219 in British Columbia/Southeast Alaska, 21 in the Gulf of Alaska, 11 in Prince William Sound/Kenai Fjords, and 95 in California.

Barrett-Lennard, L, C.O. Matkin, and D.K. Ellifrit. 2006. The role of transient killer whales in structuring marine mammal communities in the Aleutian Islands: Insights from predation hotspots. In Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

In this abstract, the authors report findings on killer whale predation on gray whales in the vicinity of False Pass during three years of observation. The authors maintain that "hot spot" observations improve the opportunity to record predation behavior and identify predation targets and rates. There were no observations of Steller sea lion predation in the False Pass hot spot. The authors recommend utilizing sea lion and fur seal killer whale predation hot spots as observation areas for estimation of minimum predation rates on those species.

Barrett-Lennard, L.G., K. Heise, S. Martell, D.P DeMaster, and A.W. Trites. In review. The impact of killer whale predation on the decline of Steller sea lions in western Alaska: a simulation study. Ecological Applications.

This article is unavailable for review.

Burdin, A.M., D. G. Calkins, S. Atkinson, and D. Maldini. 2005. Killer whale surveys in the Russian Far East.: 2002-2004. Chapter 23, pages 227-237, in Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

This paper provides limited results from three years of survey sampling for killer whales in the Russian Far East. All surveys were conducted in mid-summer, July-August, 2002-2004. Some 700 whales in 51 groups were estimated to be present. Most (91%) were classed as resident whales, 4% as transients and with the remainder of unknown origin. Resident groups ranged in size from 1-68 animals with a median best estimate of 13 whales. Transient groups ranged from 1-9 animals with a median best estimate of 4 whales. Biopsies were obtained for a small subset of whales (64 samples), tissue analysis is ongoing.

Carretta, J. V., M. M. Muto, J. Barlow, J. Baker, K. A. Forney, and M. Lowry. 2002. U.S. Pacific Marine Mammal Stock Assessments: 2002. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-346. 290 p.

Offshore killer whale population along the U.S. west coast (Washington-Oregon-California coast line) is estimated to have a minimum population size of 211 animals.

Carretta, J.V., K.A. Forney, M.M. Muto, J. Barlow, J. Baker, B. Hanson, and M.S. Lowry. 2005. U.S. Pacific marine mammal stock assessments: 2005. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-375. 316p.

Offshore killer whale population along the U.S. west coast (Washington-Oregon-California coast line) is estimated to have a minimum population size of 361 animals.

Cherel, Y. and G. Duhamel. 2004. Antarctic jaws: cephalopod prey of sharks in Kerguelen waters Deep-Sea Research I 51(2004) 17–31.

This paper is written about a Pacific sleeper shark conspecific, *Somniosus microcephalus*, sampled from the southern Indian Ocean in waters of the Kerguelen Archipelago. The authors report that this species preyed upon large-sized cephalopods (*Kondakovia longimana* and *Taningia danae*) and giant squids (*Mesonychoteuthis hamiltoni* and *Architeuthis dux*). It is a fish with sperm whale-like feeding habits and, hence, the second top predator known to science to rely significantly on giant squids. The authors describe sleeper sharks as mainly benthic top predators and scavengers.

Courtney, D.L. and M.F. Sigler. 2003. Analysis of Pacific Sleeper Shark (*Somniosus pacificus*) Abundance Trends from Sablefish Longline Surveys 1979 – 2003. *In*. Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska as projected for 2004. Ecosystem considerations for 2004. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501. p155-169

These authors use the US/Japan (Cooperative) and domestic sablefish longline surveys to evaluate trends in sleeper shark abundance in the Gulf of Alaska from 1979-2003. Rather than absolute abundance, the longline survey provides a relative index of abundance, with the metric Relative Population Numbers or RPN. Overall, the incidence of sleeper sharks in this survey is low (typically less than one shark per standard station), nevertheless the RPNs showed a significant increase that began in the late 1980s and has persisted although peaking in 2001. The 2003 RPN was similar to the abundance index of the late 1990s, and is roughly half the peak value.

Courtney, D.L., C. Tribuzio, S. Gaichas, and K. J. Goldman. 2005. BSAI Sharks. *In*. Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea and Aleutian Islands as projected for 2006. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501. p881-924.

This paper represents the most current stock assessment for sharks in the Bering Sea and Aleutian Islands. Sleeper sharks are a large fish that may have the capacity to avoid capture in routine trawl surveys. Nevertheless, there is an obvious increase in sleeper shark abundance that is detectable beginning in the late 1980s. The species is more strongly associated with the continental slope (depths > 200m) than the shelf environs. Eastern Bering Sea shelf trawl survey indicates low abundance between 1979 and 1991, with a marked increase typified by highly variable annual estimates thereafter. Biomass was estimated to range from 0 to 5000 t annually since 1992. In the Bering Sea slope survey, biomass showed an anomalous peak in 2002, estimated at 25,000 t; the 2004 estimate was approximately 2000 t. The Aleutian Island trawl survey shows a peak in abundance in 1991 at 3000 t dropping to a current (2002) estimate of 500 t. Bycatch increased during the late 1990s and continued high through 2002. Analysts speculate that biomass for this species has been increasing.

Dahlheim, M.E., D.K. Ellifrit, and P.A. White. 2004. Kill rates and prey preferences of Southeast Alaska transient killer whales (*Orcinus orca*). In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK

This abstract presents estimates of killer whale predation kill rates (prey items/24 h/whale) derived from 13 years of observation (1991-2003) in Southeast Alaska inland waters. Authors report kill rates of 0.78 prey items/24h/whale. There is no description of prey items consumed.

Deecke, V.B., J.K.B. Ford, and P.J.B. Slater. 2006. Studying killer whale predation in the field: a sound approach to detecting kills. In Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK

> In this abstract the authors report on a 5-year study in South-east Alaska to utilize acoustic monitoring as a device to detect killer whale attacks on marine mammals. They observed that compared to their fish eating counterparts, mammal eating killer whales traveled in silence most of the time. Vocalizations among mammal eating killer whales typically occurred when the whales were "surface-active" or immediately after a kill. The authors assert that their findings indicate that acoustic monitoring should be incorporated into field studies attempting to assess prey capture rates of mammal eating killer whales. The authors imply that predation rates may be underestimated without utilization of acoustic monitoring.

Deecke, V. B., Ford, J.K.B., Slater, P.J.B. 2005. The vocal behaviour of mammal-eating killer whales (Orcinus orca): communicating with costly calls. Animal Behaviour 69:395-405.

> In this paper, the authors report on 25 groups of transient and 10 groups of resident killer whales tracked between June and December, 1999-2003. Protocols were established to standardize recording of acoustic communications among whales and test for differences in communication type during different classes of activity. Transient killer whales were found to vocalize significantly less frequently than resident killer whales. Transient killer whales were vocally more active after a successful kill than they were before or during a kill. The authors hypothesize that the vocalization behavior patterns of transient killer whales are an adaptation to improve predation success given the acute hearing of their typical prey targets.

DeMaster, D. P., A.W. Trites, P. Clapham, S. Mizroch, P. Wade, and R.J. Small. 2006. The sequential megafaunal collapse hypothesis: testing with existing data. Progress in Oceanography 68: 329-342.

> These authors dispute the sequential megafaunal collapse hypothesis put forward by Springer et al. (2003). They argue that the declines in harbor seal and northern fur seal populations were concurrent rather than sequential, and were followed by declines in Steller sea lions. Further, they argue that all pinniped declines had their steepest decent after the "regime shift" of 1977. In addition, they dispute the conclusion of Springer et al. that there was a collapse of large whale biomass in the Bering Sea; and argue that under any circumstances, killer whales were unlikely to have preyed upon those components of the large whale population that experienced the greatest decline. Overall, they conclude that available data do not support the sequential megafaunal collapse hypothesis.

Gallucci, V., I. Taylor, and J. Rice. 2003. Competitive interactions: Steller sea lions and sharks. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

> This abstract presents an overview of the author's modeling efforts on the interaction of Steller sea lions and salmon sharks. No results are presented.

Guénette, S., S.J.J. Heymans, V. Christensen, and A.W. Trites. 2005. Ecosystem analysis of Steller sea lions dynamics, their prey and predators. In: Marine science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK

> This abstract reports limited results from ecosystem simulation modeling for Southeast Alaska, the Central Gulf of Alaska and the western Aleutian Islands. Fishing and environmental variation was reported to be sufficient to explain increases in Steller sea lion abundance in SE Alaska, with more equivocal results for the CGOA and WAI. The authors note that declines in Steller sea lion abundance in the late 1980's could be the result of predation by transient killer whales given three constraining assumptions.

Heise, K,. L.G. Barrett-Lennard, E. Saulitis, C. O. Matkin, and D. Bain. 2003. Examining the evidence for killer whale predation on Steller sea lions in British Columbia and Alaska. Aquatic Mammals 29:325-334.

> In this paper, the authors report the findings from examination of the stomach contents of 12 stranded killer whales collected between 1990 and 2001, seven of which contained marine mammal remains. In addition, they report results from the return of 126 1993-1994 surveys of 250 British Columbia and Alaskan mariners. Mariners were asked to report details of witnessed killer whale attacks, including number of animals involved, the age class of the sea lions, the locations where interactions were observed, and the length of time the interactions lasted. Two of the 12 stomach contained Steller sea lion remains; 4 of the 12 stomachs were determined to belong to transient killer whales; those containing Steller sea lion remains were from transient whales. Harbor seal remains were found in all seven stomachs containing marine mammal remains. Dall's porpoise remains were found in one stomach. The survey of mariners noted that only 10% of the observed killer whale- Steller sea lion interactions were predatory attacks with 60% of these leading to confirmed kills.

Heise, K., L. G. Barrett-Lennard, S. Martell, and A. Trites. 2001. Are transient killer whales the culprits: the decline of Steller sea lions in western Alaska: a simulation study. Abstracts of the 14th Biennial Conference on the Biology of Marine Mammals. Page 97.

> This abstract reports findings from a simulation study of Steller sea lion population dynamics and the link to killer whale predation. The authors test whether it is plausible that killer whale predation could account for declines in Steller sea lion abundance, and/or constraints on Steller sea lion recovery. In both cases, the authors confirm that it is plausible that killer whale predation could account for the losses and lack of recovery. Their findings are contingent on assumptions of the proportion of Steller sea lions in the diet of killer whales and the numbers of actively feeding transient killer whales.

Herman, D.P., D.G. Burrows, P.R. Wade, J.W. Durban, C.O. Matkin, R.G. Leduc, L.G. Barrett-Lennard And M.M. Krahn. In press. Feeding ecology of eastern North Pacific killer whales from fatty acid, stable isotope and organochlorine analyses of blubber biopsies. Marine Ecology Progress Series

> This is a significant paper regarding the application of a variety of chemical analyses that can be used to discriminate killer whale ecotype (resident, transient, or offshore), genetic haplotypes; regional groupings and diet composition. The authors report that ecotype is readily differentiable using fatty acid and organochlorine chemical signatures. Stable isotopes were unsuccessful in separating ecotypes. The authors report that "…*quantitative assessments of killer whale prey preferences will not be possible from fatty acid signature*

analysis of blubber …unless calibration factors are applied." However, broad qualitative analyses are possible; toward that end, the authors note that fatty acid signatures within ecotypes were consistent with recognized diet composition (fish for resident and mammals for transients). Killer whales of the offshore ecotype appeared to be more closely aligned with fish consumers but also represented consumers of mammal species.

Herman, D.P., P. Wade, A. Hirons, P. Krahn. 2005. Investigations into dietary specialization of Killer Whales in the Bering Sea and Aleutian Islands. N. Pacific Res. Board, Prog. Rpt., Proj No. F0411, Jan 1-Jun 30, 2005., 2p.

This brief contract report notes preliminary findings of the work to utilize chemical analyses to discriminate killer whale ecotype, haplotype, and diet. See Herman et al (in press) immediately above.

Hulbert, L. 2001. Do Pacific sleeper sharks prey on Steller sea lions? AFSC Quarterly Report October-November-December:13.

This brief account reports the results of stomach analysis of 99 sleeper sharks (*Somniosus pacificus*) collected in 21 longline sets near 4 Steller sea lion rookeries in the Gulf of Alaska during August 2001. No Steller sea lion remains were found in any of the stomachs examined.

Hulbert, L., M. Sigler and C. Lunsford. 2002. Pacific sleeper shark predation on Steller sea lions, p. 67-69 In: Douglas DeMaster and Shannon Atkinson, editors, Steller sea lion decline: Is it food II. Alaska Sea Grant College Program, Fairbanks, AK.

This paper describes studies planned to investigate the role of sleeper sharks as predators of Steller sea lions. The results of this work is reported in Schaufler et al (2005), Sigler et al (in press) and Hulbert et al (in review).

Hulbert, L., M. Sigler, and C. Lunsford. 2003. Pacific sleeper shark predation of Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

In this abstract the authors report additional results from analysis of sleeper shark stomach contents (see Hulbert, 2001 above). Sampling in August 2002 added, another 99 sleeper shark stomachs to previous collections (total 198). There was "*no direct evidence of sea lion parts* [in any of the stomachs examined]." Additional tests using DNA, and fatty acid analysis were pending. Fatty acids were being analyzed to infer presence of fish versus marine mammal prey; DNA was being evaluated to identify the marine mammal species.

Hulbert, L.B., M.F. Sigler and C.R. Lunsford. (in review) Depth and movement behaviour of the Pacific sleeper shark in the northeast Pacific Ocean. J. Fish. Biol. xx: xxx-xxx 51p.

This paper reports on the movements of 24 sleeper sharks tagged with pop-up archival tags (PAT) and 12 sleeper sharks tagged with satellite depth recorder tags (SDR) in the Gulf of Alaska in August, 2001 and May, 2002. PAT tags were programmed to detach 3-11 months after placement. Most sharks were recovered with 100 km of their release point. The sharks made significant vertical migrations, typically traveling below the photic zone during daylight and to the surface at night. They spent 60% of their time between 150 and 450 m depth. Although recent research reveals no evidence of sleeper shark predation on Steller sea lions (see Sigler et al., 2005), their bathymetric range overlaps signifying an opportunity for shark predation.

Hunt, G. L., Chief Scientist., et al., 2002. Foraging habitats of Steller sea lions in the Aleutian Islands: bottom-up controls of prey availability and the presence of killer whales. Cruise Report - Alpha Helix cruise 259, 16 May to 19 June 2002. University of California, Irvine, Irvine, CA. 151p.

This paper is unavailable for review.

Hunt, G. L., Jr. 2001. Foraging habits of Steller sea lions in the Aleutian Islands:bottom-up controls of prey availability and the presence of killer whales. Cruise report - Alpha Helix cruise 245, 4 June 2001 to 25 June 2001. University of California, Irvine, Irvine, CA. 26p. +figures.

This paper is unavailable for review.

Kastelein, R., R. van Schie, and D. de Haan. 2003. Underwater hearing sensitivity of Steller sea lions (Eumetopias jubatus): Potential sexual differences. P. 82, in 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p

This abstract describes results of experiments to test the auditory range of Steller sea lions. A thorough description of those experiments is described below in Kastelein et al., 2005.

Kastelein, R., R. van Schie, W.C. Verboom and D. de Haan. 2005. Underwater hearing sensitivity of Steller sea lions (Eumetopias jubatus): Potential sexual differences. Acoustical Society of America 118(3) 1820-1829.

In this paper the authors describe the auditory range of male and female captive Steller sea lions. Sea lion detectable audible frequencies overlap the range of acoustical sounds transmitted by killer whales. (See Deeke et al 2005, 2006 above)

Krahn, M. M., D. P. Herman, D. G. Burrows, P. R. Wade, J. W. Durban, M. E. Dahlheim, R. G. Leduc, L. Barrett-Lennard and C. O. Matkin. 2005. Use of chemical profiles in assessing the feeding ecology of eastern North Pacific killer whales. International Whaling Comm. SC-57-E7, 17p.

This paper is a precursor to the paper by Herman et al (in press), reviewed above. The input data is essentially the same; statistical analysis is not as developed as that used in Herman et al.

Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.). 2005. Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

This report represents a compilation of work completed in association with the Alaska Sea Life Center. Chapters relating to killer whales and their potential for predation on Steller sea lions include Ch. 22: Steller Sea Lion Predation by Killer Whales in Kenai Fjords/Prince William Sound (see Matkin, 2005); Ch. 23: Killer Whale Surveys in the Russian Far East (see Burdin et al., 2005); and Ch. 24: Satellite Tracking of Killer Whales (see Andrews, et al., 2005).

Maniscalso, J., C.O. Matkin, D. Maldini, S. Atkinson, D.G. Calkins, and R. Andrews. 2006. Are killer whales affecting the recovery of Steller sea lions? Assessing evidence in Kenai Fjords, Alaska. In Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

In this poster, authors report on predatory patterns of Gulf of Alaska transient (GAT) killer whales. Studies were undertaken from 2000-2005 near Chiswell Island and in Kenai Fjords. During 118 days of observation, 9 predatory events were witnessed and 16 more inferred from remote video studies; all events involved Steller sea lions. Annual predation mortality is estimated to represent 4%-8% of available sea lion population. The authors note that GAT killer whale predation could be partially responsible for inhibiting recovery of GOA Steller sea lions.

Matkin, C. O., L. Barrett Lennard and G. Ellis. 2002. Killer whales and predation on Steller sea lions, p. 61-66 In: Douglas DeMaster and Shannon Atkinson, editors, Steller sea lion decline: Is it food II. Alaska Sea Grant College Program, Fairbanks, AK.

In this paper the authors provide a summary of killer whale numbers and their propensity for predation on Steller sea lions. Killer whales were divided into two ecotypes: residents and transients. Within each ecotype, killer whales are genetically distinguishable by haplotype. Residents are divided into Northern and Southern haplotypes. Transients into three haplotypes: AT1, Gulf of Alaska (GAT) and West Coast (WC). Killer whale abundance was estimated at 1301 whales in the Washington State to Alaska region of which 306 were classed transients the remainder being residents. Western Alaska counts were considered preliminary. The estimated number of transient killer whales in the range of the western population of Steller sea lions was 125 animals. Steller sea lions were estimated to represent 5-20% of the killer whale diet, with a point estimate of 12.5%

Matkin, C., L. Barrett-Lennard, D. Maldini, and E. Saulitis. 2003. Northern Gulf of Alaska killer whales: Status, population structure, and feeding habitat (Prince William Sound/Kenai Fjords/Kodiak). Abstracts from the Symposium on Marine Science in the Northeast Pacific: Science for Resource Dependent Communities. January 13-17, Anchorage, AK.

In this abstract, the authors describe 4 known populations of killer whales observed in the Gulf of Alaska: 1) Alaska residents (consume only fish); 2) AT1 transients (consume harbor seals and Dall's porpoise, no record of Steller sea lion consumption); 3) Gulf of Alaska transients (GAT) (some are known Steller sea lion consumers); and 4) offshores (no record of consumption preferences). GAT killer whales numbers are low, approximately 28, and are observed infrequently. More observation is required to ascertain the extent of predation on Steller sea lions.

Matkin, C.O., E. Saulitis, D. Maldini, J. Maniscalco, and L. Mazzuca. 2005. Steller sea lion predation by killer whales in Kenai Fjords/Prince William Sound, Alaska. Chapter 22, pages 212-226, in Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

In this paper, the authors report on the counts and feeding behavior of killer whales in Kenai Fjords/Prince William Sound between 2000 and 2004. They provide a brief overview of similar counts and observations in Southeast Alaska. Killer whales are identified in 3 ecotypes: 1) resident, 2) transient, and 3) offshore. They identified 568 unique resident whales, 23 transients and more than 50 offshore killer whales. Transient killer whales were

further classified as belonging to two populations: AT1, and GAT. The only killer whales preying on Steller sea lions were from the GAT population. Estimated minimum killer whale predation rates on Steller sea lions (annual fraction of sea lions killed) ranged from 3.1% to 5.6%. These estimates exclude predation on pups. Observed pup predation mortality at Chiswell Island ranged from 0 to 19% dependent on year and period. The higher rates of mortality were associated with predation by a single female killer whale (AT109) with occasional appearance of an additional female and calf. The authors regarded the predation behavior of AT109 as atypical of the larger GAT population. While providing insight to killer whale behavior, the authors note that "*Considerable additional data are needed to quantify predation rates by transient killer whales across the range of the western stock of Steller sea lions.*"

Matkin, C.O., L. Barret-Lennard, and D. Ellifrit. 2006. Ecotype variation and predatory behavior of killer whales in the eastern Aleutian Islands. In Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

In this abstract the authors report findings presented in greater detail in Matkin et al (in press) reviewed below.

Matkin, C.O., L.G. Barrett-Lennard, H. Yurk, D.Ellifrit and A.W. Trites. in press. Ecotypic Variation and Predatory Behavior of Killer Whales (*Orcinus orca*) in the Eastern Aleutian Islands, Alaska. Fisheries Bulletin.

In this paper, the authors report on extensive late spring and summer surveys (May-September) to count, type and determine diet of Eastern Aleutian Island killer whales. Surveys were undertaken from 2002-2004. Spring surveys were predominantly around Unimak Island and False Pass; summer surveys ranged from Unimak Pass to Samalga Pass. Just over 1100 killer whales were observed, approximately 80% resident, 15% transient, and 5% offshore ecotypes. There were 31 observations of predation events. The transient population preyed predominantly upon gray whales during spring and northern fur seals (42% of predation encounters observed) during summer. Steller sea lions made up less than 10% of the observed predation events during the summer period. The authors estimated that Steller sea lions comprised 14% of the prey taken by killer whales during the summer; but caution that rates could not be considered as annual rates and would be lower if spring predation rates were included.

Mizroch, S. A., & Rice, D. W. *in press*. Have North Pacific killer whales switched prey species in response to depletion of the great whale populations? Marine Ecology Progress Series. 47p.

In this paper, the authors dispute the sequential megafaunal collapse hypothesis put forward by Springer et al 2003. They provide data showing the spatial-temporal distribution of commercial whaling north of 50°N latitude indicating that the harvest of large whales cited in Springer et al had been complete in this area by 1968, years earlier than indicated in Springer. Furthermore, they review historical accounts of killer whale predation on large whales which indicate that less than 3% of the mammal eating whales were observed with large whale remains in their stomachs.

Mueter, F. J., and B. L. Norcross. 2002. Spatial and temporal patterns in the demersal fish community on the shelf on upper slope regions of the Gulf of Alaska. Fisheries Bulletin. 100(3):559-581.

In this paper the authors provide information on the trends in Gulf of Alaska sleeper shark abundance as determined from NMFS triennial trawl surveys over the period 1984-1996. Estimated biomass was near zero in the 1980s but began to increase in the 1990s reaching a maximum in 1996 (the end of this time series). Biomass apparently showed greater increases in abundance in the Chirikof and Kodiak areas than it did elsewhere.

National Research Council (NRC). 2003. Decline of the Steller sea lion in Alaskan waters; untangling food webs and fishing nets. National Academy press, Washington, D.C. 184 pp.

This report is a comprehensive review of the interactions between Steller sea lions and Alaskan groundfish fisheries, and the role the fisheries play in sea lion demographics. Among the tasks undertaken is a review of hypotheses put forward to explain the dramatic decline in Steller sea lion abundance. In that endeavor, the authors evaluate top down forcing and the potential effects of predation on sea lion abundance. The report acknowledges the potential for sea lion declines to have been provoked by predation; and, the opportunity for predation to constrain recovery of the currently depleted stock. The primary suspected predators were salmon sharks, sleeper sharks and killer whales. They report little to no evidence of shark predation and limited evidence of killer whale predation. Killer whale population sizes were estimated at fewer than 400 animals, but their diet preferences were not well known. The report notes that there was "*…no direct evidence that increased predation since* [the 1970s] *was the primary cause of Steller sea lion decline in the 1980s*." Ultimately, they conclude that the "*..role of killer whale predation in the historical decline is indeterminate."*

Petras, E. 2003. A review of marine mammal deterrents and their possible applications to limit killer whale (Orcinus orca) predation on Steller sea lions (Eumetopias jubatus). U.S. Department of Commerce, Seattle. (AFSC Processed Report 2003-02) 49p.

This report provides a review of various marine mammal deterrents, used primarily in fisheries, to either prevent marine mammal entanglement or predation. Deterrent methods are evaluated based upon various factors including effectiveness, particularly with killer whales, potential impacts on non-target species, including Steller sea lions, and feasibility of use in the western Aleutian Islands. Based upon a thorough review of the literature, lack of previous long-term success and high degrees of uncertainty, it is unlikely that deterrents would be successful in this application.

Saulitas, E., Matkin, C., Barrett-Lennard, L. G., Heise, K., and Ellis, G. 2000. Foraging strategies of sympatric killer whale (Orcinus orca) populations in Prince William Sound, Alaska. Marine Mammal Science, 16:94-109.

This paper was cited in the 2001 Biological Opinion for authorization of Alaska groundfish fisheries. The authors identify two distinct foraging behaviors exhibited by killer whales in Prince William Sound: resident, fish eating whales and transient, mammal eating whales. Observations were made from March-October, 1984-1996. Transient killer whales were observed in 30% of the researcher's encounters, the vast majority of encounters were with resident killer whales. Two subpopulations of transients were identified: AT1, and Gulf of Alaska (GAT). AT1 transients were observed to feed predominantly on harbor seals and

Dall's porpoise. There was no evidence of Steller sea lion predation by AT1 transients. GAT killer whales were observed to harass Steller sea lions but there were no observations of a confirmed kill. Authors speculate based on the killer whale's behavior that GATs specialize in preying on Steller sea lions.

Schaufler, L, R. Heintz, M. Sigler and L. Hulbert. 2005. Fatty acid composition of sleeper shark (*Somniousus pacificus*) liver an dmuscle reveals nutritional dependence on planktivores. ICES Annual Science Conference, Aberdeen, UK., ICES CM 2005/N:05, 19P.

In this paper the authors examine the fatty acid signatures of liver and muscle tissue from 27 sleeper sharks collected during longline surveys between Prince William Sound and Marmot Island at the east end of Kodiak Island. Fatty acids found in these tissues were compared via multivariate analysis with signatures of known prey types. The predominant prey items of these sharks included "*six fish species, octopus, unidentified teuthoid squids, and cetacean blubber.*" The majority of the energy source was found to be whale blubber, presumably from baleen whales as indicated by similarity to calanoid copepod fatty acid signatures. There was no significant indication of predation on Steller sea lions.

Scheel, D., C.O. Matkin, and E. Saulitis. 2001: Distribution of killer whale pods in Prince William Sound, Alaska 1984–1996**.** Marine Mammal Science 17(3)555–569.

Excerpted segments of the article abstract: "Thirteen years of encounter data (1984–1996) were used to examine killer whale distribution within Prince William Sound, Alaska. Four patterns of area use were found. Resident pods frequented large open passages, while transient groups used the narrow passages and bays in the southwest. …Use of the Sound by the AT1 transient whales declined in the latter part of the study. Nearshore foraging for pinniped prey by the AT1 transient whales was more common in areas where these whales spend a disproportionate amount of time, suggesting that these areas were critical foraging habitat for them. No similar pattern emerged for Open-water Foraging for cetaceans by AT1 whales, nor for foraging by the resident whales."

Sigler, M, Hulbert, L, Lunsford, C, Thompson, M, Burek, K, Hirons, A, O'Corry-Crowe, G. (*in press*). Diet of Pacific Sleeper Sharks in the Northeast Pacific Ocean. J. Fish Biol., Submitted manuscript.

In this paper, the authors report the diet preferences of 198 sleeper sharks collected between May and August 2001 and 2002 in the Gulf of Alaska between Prince William Sound and Marmot Island. Sampling locations were adjacent to Steller sea lion rookeries and coincided with Steller sea lion pupping. Marine mammal tissues were found in 15% of the stomachs. Whale tissue made up the predominant marine mammal prey. There was no indication of predation on Steller sea lions.

Skomal, G.B., and G.W. Benz. 2004. Ultrasonic tracking of Greenland sharks, *Somniosus microcephalus*, under Arctic ice. Marine Biology (2004) 145: 489–498.

This paper describes movement of Greenland sleeper sharks, *Somnious microcephalus*, a species related to the Pacific sleeper shark. The movement patterns are similar to those described by Hulbert et al (in review) above. Typically, benthic by day, with significant vertical migrations to within a few meters of the surface by night. Greenland sleeper sharks are reputed to be occasional consumers of seals. The authors speculate on the potential for active predation on ringed seals.

Smith, C.R. and A. R. Baco. 2003. The ecology of whale falls at the deep-sea floor. Oceanography and Marine Biology Annual Review**,** 41: 311-354.

A precursor to the more recent paper of Smith (in press, reviewed below), this paper discusses the diverse community of organisms associated with whale falls (i.e., deceased whales): a special form of detrital energy. Of note is the predation of Pacific sleeper shark on this form of carrion; particularly the long duration of utilization of a single carcass. Feeding by a succession of scavengers can extend from months to years. Relevance to Steller sea lions is the linkage between sleeper sharks and their prey sources and the opportunity to concentrate sleeper sharks, potential sea lion predators, in areas where there may be a high occurrence of dead whales.

Smith, C. R. *in press*. Bigger is better: The role of whales as detritus in marine ecosystems. In: Whales, Whaling and Ocean Ecosystems. J. Estes, editor, University of California Press, in press. 46p

The paper may be more appropriate in the discussion of Steller sea lion ecosystem considerations. It deals with the fate of large whale detritus and its specialized role in ecosystem diversity. The author reports that Pacific sleeper sharks are significant users of whale carrion and help to distribute the detrital carbon during a four stage process of decay. Of some note is the fact that whale detritus from a single individual may provide energy resources for detrital feeders for years. Relevance to Steller sea lions is the linkage between sleeper sharks and their prey sources and the opportunity to concentrate sleeper sharks, potential sea lion predators, in areas where there may be a high occurrence of dead whales.

Springer, A.M. , J. A. Estes , G. B. van Vliet , T. M. Williams, D. F. Doak, E. M. Danner, K. A. Forney, and B. Pfister. 2003. Sequential megafaunal collapse in the North Pacific Ocean: An ongoing legacy of industrial whaling? Proceedings of the National Academy of Sciences of the United States of America 100:12223-12228

In this paper, the authors propose a hypothesis that asserts that industrial commercial whaling in the 1950s-1960s depleted an import prey for mammal eating killer whales forcing them to shift prey preferences. The resultant "sequential decline" in harbor seals, fur seals, Steller sea lions and sea otters is assumed to reflect the changing diet of killer whales following the large whale decline. The authors model energetic demand to demonstrate that capacity for killer whales to accommodate the losses in pinniped populations as a consequence of increased killer whale predation. They argue against bottom up controlling mechanisms on pinniped populations based on consistency of $\delta^{15}N$ concentrations in bone collagen (see Hirons et al 2001 in THEME 5-ECOSYSTEMS).

Stokesbury, M.J.W, C. Harvey-Clark, J. Gallant, B.A. Block and R.A. Myers. 2005. Movement and environmental preferences of Greenland sharks (*Somniosus microcephalus*) electronically tagged in the St. Lawrence Estuary, Canada. Marine Biology 148: 159–165
Submitted manuscript. 33p.

Greenland sharks are conspecifics of the Pacific sleeper shark. Since there are limited studies on the behavior of Pacific sleeper sharks, review of the conspecific may shed light on this sharks habits. In this paper the author reports on the migrations of three Greenland sharks tagged with pop-up satellite archival tags in the St. Lawrence Estuary. Of note were the diel habits of the sharks, remaining near bottom during the day and rising to the surface or near

surface at night. Two of the three sharks exhibited this behavior, the other remained on bottom. The diel vertical migration demonstrates an overlap in bathymetric distribution with seals providing the potential for predatory interactions.

Straley, J., C. Matkin, D. Matkin, L. Barrett-Lennard, and C. Gabriele. 2004. Feeding ecology of transient killer whales in the northern and eastern Gulf of Alaska. In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK.

This abstracts reviews the proportion of transient killer whale encounters in the Eastern Gulf of Alaska (EGOA) and contrasts it with similar observation in the Northern Gulf (NGOA). The NGOA contains two populations of transients, AT1 and Gulf of Alaska; while, the EGOA shares the Gulf of Alaska transient population and also includes a "west coast" (WC) population. The NGOA AT1 population was reported to have declined in number from 22 whales in the 1980s to 8 whales. The Gulf of Alaska population reportedly consisted of 38 whales. In the EGOA, the WC population numbered 123 whales and the Gulf of Alaska population, 19 whales. In the NGOA transients were encountered about 10% of the time, while in the EGOA the rate was 57%. GOA transients were observed killing Steller sea lions on 5 occasions. In the observed predation events of the EGOA transient killer whales, Steller sea lions made up 18% of the observations.

Straley, J.M., D.R. Matkin, C.M. Gabriele, G.M. Ellis, L.G. Barrett-Lennard. 2003. Transient killer whales in Southeast Alaska: Who are they? What are they eating? In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

In this abstract, the authors report on the observations of transient killer whales in Southeast Alaska over the period 1984-2001. Steller sea lions are reported to have made up 15% of observed kills in this period.

Straley, J.M.. 2005. Investigations of Steller sea lion predation by killer whales in Southeastern Alaska. NOAA Contract report, Contract No. NA16FX1413 University of Alaska Southeast, Sitka, Alaska

This paper was unavailable for review.

Taggart, S.J., A.G. Andrews, J. Mondragon, and E.A. Mathews. 2005. Co-occurrence of Pacific Sleeper Sharks *Somniosus pacificus* and Harbor Seals *Phoca vitulina* in Glacier Bay. Alaska Fishery Research Bulletin 11(2):xxx–xxx.

In this paper the authors evaluate the probability of a non-random distribution of sleeper sharks in Glacier Bay. While conducting a pot survey for king crab in Glacier Bay, three sleeper sharks (ranging in size from 1.6-3.0 m) were captured as bycatch in the survey. All sharks were captured near the mouth of Johns Hopkins Inlet, a fjord with the largest concentration of harbor seals in Glacier Bay. Statistical analysis demonstrated that the capture rate in this area was not random. The authors speculate that the non-random occurrence implies an ecological connection between sleeper sharks and harbor seals.

Trites, A.W., V.B. Deecke, E.J. Gregr, J.K.B. Ford, and P.F. Olesiuk. *in press*. Killer whales, whaling and sequential megafaunal collapse in the North Pacific: a comparative analysis of the dynamics of marine mammals in Alaska and British Columbia following commercial whaling. Marine Mammal Science.

In this paper the authors challenge the hypothesis put forward by Springer et al. (2003) that transient killer whales were forced to alter their diet to include increasingly smaller pinnipeds and other marine mammals following the commercial depletion of large whale populations in the 1940s-1960s. By presenting evidence of large whale declines and smaller mammal population trends in British Columbia waters over a similar time period, the authors demonstrate that sequential collapse of these megafauna did not occur in British Columbia waters. Consequently, they dispute the inference put forward in the Springer et al paper.

Wade, P. R., J. M. Waite, S. E. Moore, L. L. Mazzuca, and A. N. Zerbibi. 2003. Distribution and ecotype of killer whales in southwestern Alaska, with a discussion of abundance estimation methods. Abstracts from the Symposium on Marine Science in the Northeast Pacific: Science for Resource Dependent Communities. January 13-17, Anchorage, AK.

In this abstract, the authors provide results from systematic killer whale abundance surveys conducted in 2001 and 2002 in the Kenai Fjords to central Aleutian Islands region. Over the two-year study, 123 encounters were documented. Whales were classed by ecotype: 84% resident, 9% transient, 3% offshore and 4% unknown.

Wade, P., M.M. Krahn, D.P. Herman, C.O. Matkin, J.W. Durbin, L. Barrett-Lennard, D.G. Burrows, M.E. Dahlheim, N. Black, and R.G. LeDuc. 2006. Use of chemical profiles in assessing the feeding ecology of Alaskan killer whales. In Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK

This abstract reports results which are provided in greater detail in Herman et al (in press) and Krahn et al (2005) reviewed above.

Wade, P., L. Barrett-Lennard, N. Black, R. Brownell Jr. , V. Burkanov, A. Burdin, J. Calambokidis, S. Cerchio, P. Clapham, M. Dahlheim, J. Ford, N. Friday, L. Fritz, J. Jacobsen, T. Loughlin, M. Lowry, C. Matkin, D. Matkin, A. Mehta, S. Mizroch, M. Muto, D. Rice, D. Siniff, Robert Small1, G. Steiger, J. Straley, and G. Van Blaricom. 2003. Commercial whaling and "whale killers": A reanalysis of evidence for sequential megafaunal collapse in the North Pacific. Fifteenth Biennial Conference on the Biology of Marine Mammals. Society for Marine Mammalogy. Greensboro, North Carolina, USA, Dec. 15, 2003.

This abstract addresses issues discussed in detail in the article by DeMaster et al (2006) reviewed above.

Wade, P., L. Barrett-Lennard, N. Black, R. Brownell, V. Burkanov, A. Burdin, J. Calambokidis, S. Cerchio, M. Dahlheim, J. Ford, N. Friday, L. Fritz, J. Jacobsen, T. Loughlin, M.Lowry, C. Matkin, D. Matkin, S. McCluskey, A. Mehta, S. Mizroch, M. Muto, D. Rice,D. Siniff, R. Small, G. Steiger, J. Straley, G. Van Blaricom and P. Clapham. *in review.* Marine mammal abundance, biomass, and trends in the North Pacific – a re-examination of evidence for sequential megafauna collapse. Marine Mammal Science

This paper is unavailable for review.

Whitehead, H. and R. Reeves. 2005. Killer whales and whaling: the scavenging hypothesis. Biol. Lett. (2005) 1, 415–418

In this paper, the authors present an idea in support of the notion that killer whales may have made an abrupt shift from foraging on large whales to smaller mammals including pinnipeds and sea otters. Unlike Springer et al. they do not address the megafauna cascade hypothesis, rather they argue that in the 1980s killer whales previously adapted to foraging on large whale carcasses provided by commercial whaling were suddenly deprived and forced to adopt new predation strategies that resulted in a shift to small mammals.

Williams, T.M., J.A. Estes, D.F. Doak, and A.M. Springer. 2004. Killer appetites: Assessing the role of predators in ecological communities. Ecology 85(12): 3373-3384.

In this paper, the authors argue that it is theoretically possible for a small number of killer whales (<40) specializing in Steller sea lion predation to have caused the observed declines in the Aleutian Island sea lion population. Using estimates of killer whale caloric requirements, caloric content of prey, and demographic models of sea lions and killer whales, the authors estimate that a single pod of 5 killer whales could consume 1200-1900 sea lions per year dependent upon the age specific prey selectivity. The authors note that a single pod of killer whales has the potential to prevent Steller sea lion population recovery. These authors argue in support of the sequential megafauna collapse hypothesis presented in Springer et al (2003).

Williams, T.M., and L. Yeates. 2004. The energetics of foraging in large mammals: a comparison of marine and terrestrial predators. International Congress Series 1275 (2004):351– 358.

The abstract for this article is provided in its entirety, “The combination of large body size, carnivory and endothermic costs leads to high caloric demands in many mammalian predators. Tactics used to capture prey to meet these demands vary among mammals, and ranges from prolonged tracking to high-speed chases. Furthermore, accessibility to air differs for species that hunt in water or on land. To determine the behavioral and energetic consequences of these different foraging methods and habitats, we measured the energetic cost of hunting, energy acquired from ingested prey, and patterns of energy acquisition in free-ranging Weddell seals (body mass=461 kg) and sea otters (mass=25 kg). The values were then compared to terrestrial predators ranging in mass from 25 to 170 kg. We found that foraging dive duration was 2.4F0.4 min for otters and 16.3F0.6 min for seals, and that dives were interspersed with short to moderate duration rest periods. In contrast, large terrestrial mammals hunted in one to two sessions per day that lasted several hours. The efficiency of an individual hunting event ranged from 3.8 in the sea otter to 10.2 for Weddell seals. This compared to 2.2 for African wild dogs and 3.8 for African lions feeding on ungulates. In general, adaptations for marine living including elevated basal metabolic rates and the dive response represent major influences on hunting efficiency that is further modified by the energetic cost of specific hunting tactics. D 2004 Elsevier B.V. All rights reserved.”

Wolf, N., and M. Mangel. 2005. Understanding the decline of the western Alaskan Steller sea lion: Assessing the evidence concerning multiple hypotheses. Final report for contract AB133F-02-CN-0085 to the National Marine Fisheries Service. 91 text pages and 84 figure pages. Available at the National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

These authors use a modeling approach to systematically and objectively test 10 competing hypotheses covering the decline in Steller sea lion abundance. Data are arrayed at the spatial scale of the rookery. Functional relationships in the model are constructed to represent each

hypothesis by a separate single parameter. Test for each hypothesis is classed in a 3x3 array representing strong, weak or no evidence (based on estimated parameter values and confidence intervals) versus strong, moderate and weak effects (based on the parameter contribution to the overall model likelihood). Harbor seal abundance is used as a proxy for killer whale predation in the model. This is done under the notion that killer whale predation at any given rookery is likely to be higher in the absence of harbor seals than it would be in their presence. The model predicts that there is strong evidence and a moderate effect of predation on non-pup [Steller sea lion] survival; but no evidence and a weak effect of predation on pup recruitment. The authors note that the predation effect is most expected in areas of low harbor seal abundance, but is not likely to provoke a large reduction in Steller sea lion survival.

Wynne, K.M. 2005. A summary of sleeper shark stomach contents collected in the Kodiak Area, spring 2001. pp 64-68. *In*, Wynne, K.M., R.J. Foy, and C.L. Buck (eds). 2005. Gulf Apex Predator-prey Study (GAP) Final Report NOAA Grant NA16FX1270, University of Alaska Fairbanks, Kodiak, AK. 241 pp.

This article presents findings from an examination of 22 sleeper shark and 3 salmon shark stomachs collected opportunistically in the Shelikof Strait pollock trawl fishery in 2001. None of the stomachs examined contained identifiable Steller sea lion remains. Only one sleeper shark stomach contained mammalian remains; these were partially digested whale tissue.

Zerbini, A.N., and J. M. Waite, J.W. Durban, R. LeDuc, M. E. Dahlheim, and Paul R. Wade. In press. Estimating abundance of killer whales in the nearshore waters of the Gulf of Alaska and Aleutian Islands using line transect sampling. Marine Biology.

Killer whale (*Orcinus orca* Linnaeus, 1758) line transects ship surveys were conducted in July and August of 2001-2003 in coastal waters of the western Gulf of Alaska and the Aleutian Islands. Conventional (CDS) and Multiple Covariate Distance Sampling (MCDS) methods were used to estimate abundance of different killer whale ecotypes, which were distinguished based upon morphological and genetic data. Abundance was calculated separately for two datasets that differed in the method by which killer whale group size data were obtained. Initial group size (IGS) data corresponded to estimates of group size at the time of first sighting and post-encounter group size (PEGS) corresponded to estimates made after closely approaching sighted groups. 'Resident'-type (fish-eating) killer whales were more abundant than the 'transient'-type (mammal-eating). Abundance estimates of resident killer whales (991 [95% CI = 379-2585] [IGS] and 1587 [95% CI = 608-4140] [PEGS], were at least four times greater than those of transient killer whales (200 [95% CI = 81-488] [IGS] and 251 [95% CI = 97-644] whales [PEGS]). The IGS estimate of abundance is preferred for resident killer whales because the estimate based on PEGS data may show an upward bias. The PEGS estimate of abundance is likely more accurate for transients. Residents were most abundant near Kodiak Island in the northern Gulf of Alaska, around Umnak and Unalaska Islands in the eastern Aleutians, and in Seguam Pass in the central Aleutians. This ecotype was not observed between 156 and 164° W, south of the Alaska Peninsula. In contrast, transient killer whale sightings were found at higher densities south of the Alaska Peninsula between the Shumagin Islands and the eastern Aleutians. Only two sightings of 'offshore'-type killer whales were recorded during the surveys, one northeast of Unalaska Island and the other south of Kodiak Island. These are the first estimates of abundance of killer whale ecotypes in the Aleutian Islands and Alaska Peninsula area and provide a baseline for quantifying the role of these top predators in their ecosystem.

THEME 8 -- DISEASE

SUMMARY:

This theme contains 22 articles including 11 presentations at scientific meetings, three reports, one dissertation, and 7 papers in peer-reviewed journals or book chapters. It contains studies primarily of the monitoring type. Little new information on the effects of disease on SSLs was provided; nor were there descriptions of new diseases present to which sea lions may have been exposed. One methodological study (seen in four papers by Colcoveresses and Middlebrooks) adds to the science but does not contribute to understanding the role of disease in the SSL decline.

Studies relating to disease since 2000 that have provided significant findings include:

1. Investigators have identified hookworms in SSLs of the same genus (*Uncinaria*) found in California sea lions. The effect of this parasite on SSLs is minimal, if any, at present but the parasite has had devastating effects on California sea lions on San Miguel Island. High infestation and passage between individuals is dependent upon rookery substrate type and population density (high). As SSL populations recover and densities at rookeries increases, prevalence of this parasite should be monitored.

2. The review funded by the NPUMMC and conducted by Burek and colleagues provided a good summary of the prevalence and exposure of SSLs to disease over the past three decades. Their conclusions support earlier statements and assertions that disease was not the principle cause of SSL declines in the 1970s through the 1990s. SSLs were exposed to some disease agents that may have contributed to the decline but such assertions are still equivocal. Samples collected from 1997 through 2000 confirm these findings for recent population trends. The summary of a workshop in 2004 (Goldstein 2005) provides a useful guide to investigators for future SSL disease studies and techniques for sample collection and analysis.

ANNOTATED BIBLIOGRAPHY – DISEASE

Beckmen, K.B., K.A. Burek, T. Gelatt, F. Morado, S. Nadler, and E.T. Lyons. 2005. Hookworms in Steller sea lions (*Eumetopias jubatus*) in Alaska. Poster at the 16th biennial meeting of the Society for Marine Mammalogy.

> Investigators examined SSL pups in the eastern stock to determine hookworm prevalence, pathology, and to identify the worm to species. Results suggest that the worm is *Uncinaria lucasi*, the same worm that infects California sea lions. Parasitic L3 stages were recovered from the ventral abdominal blubber of pups. Population effects are not known.

Beckmen, K.B., K. A. Burek, L. D. Rea, and T. S. Gelatt. 2004. A health assessment approach to Steller sea lion research in Alaska. Presented paper. Sea Lions of the World.

> The authors report their studies sponsored by the ADFG to incorporate health assessment in the agencies studies. Over 400 pups were examined for heavy metals, disease and population effects. They found no evidence of exposure to known marine mammal epidemic agents including morbilliviruses, leptospirosa, influenza A, and Brucella sp. Exposure to known

agents identified in disease studies during the 1980s and 1990s was confirmed but no population effects were presented.

Beckmen, K.B., J.L. Stott, K.A. Burke, and K.W. Pitcher. 2002. Studies of immune function in Steller sea lions. Final Report to the National Fish and Wildlife Foundation and the Alaska SeaLife Center, 67 p.

This study is part of the broad ADFG study on effects of disease and contaminants on SSLs. This component of the study investigated the immune function of captive SSLs at the Alaska SeaLife Center and Vancouver Aquarium and for free-ranging pups and juveniles. They validated multiple immune function assays for use in SSLs and then used these assays to define each of the components of the immune system. They established reference ranges for normal leukocytes for different age groups of free-ranging juveniles.

Bracht, A,J,, R.L. Brudek, R.Y. Ewing, C.A. Manire, K.A. Burek, C. Rosa, K.B. Beckmen, J.E. Maruniak, and C.H. Romero. 2005. Genetic identification of novel poxviruses of cetaceans and pinnipeds. Archives of Virology, published on line November 21, 2005, Springer-Velag.

Novel poxviruses were identified in skin lesions of several species of cetaceans and pinnipeds, including SSLs. Polymerase chain reaction (PCR) was used to target DNA polymerase and DNA topoisomerase I genes of the virus subfamily Chordopoxvirae. Novel species-specific poxvirus and parapoxviruses were identified in skin lesions of SSL

Burek, K.A. K. B. Beckmen, T. Gelatt, F. Morado, and S. Nadler. 2004. Hookworms in Steller sea lions (*Eumetopias jubatus*) in Alaska. Presented paper, Sea Lions of the World.

The authors provide the same information presented by Beckmen et al (2005) above but provide more detailed information on methods and sample sizes.

Burek, K.A., F.M.D. Gulland, G. Sheffield, D. Calkins, E. Keyes, T.R. Spraker, A.W. Smith, D.E. Skilling, J. Evermann, J.L. Stott and A.W. Trites. 2003. Disease agents in Steller sea lions in Alaska: A review and analysis of serology data from 1975-2000. Fisheries Centre Reports 11 (4), 26 pages.

The NPUMMC (Consortium) funded K. Burek and K. Beckmen to summarize past efforts by ADFG and NMFS to determine the role that disease may have had in the decline of SSL in the 1970s to the 1990s. Many of the studies had not been reported, were incomplete, or were scattered. The disposition, number, and quality of many of the collected samples were also unknown. This report, and later the formal presentation of the report in journal form (Burek et al., 2005, below), do not represent data and samples collected after 2000. The authors reviewed past data and analyses, performed analyses on archived sera samples to assess the chronological and spatial patterns of exposure to disease agents, and assessed the role that infectious disease may have played in the SSL decline. They concluded that it was unlikely that the disease agents that they examined caused the population decline of SSLs by epidemic mortality. The sample size for morbillivirus was too low to include in the conclusion.

Burek, K.A., F.M.D. Gulland, G. Sheffield, K.B. Beckman, E. Keyes, T.R. Spraker, A.W. Smith, D.E. Skilling, J.E. Evermann, J.L. Stott, J.T. Saliki and A.W. Trites. 2005. Infectious disease and the decline of Steller sea lions (*Eumetopias jubatus*) in Alaska: insights from serology data. Journal of Wildlife Diseases 41: 512-524.

The authors present results from their study as described above but also include samples from 1997-2000. The results are similar except that the new study provided no convincing evidence of significant exposure of SSLs to morbillivirus and other disease agents. They have been exposed to phocid herpesvirus, caliciviruses, and other agents but the authors believe that such exposure likely did not cause the decline. It is possible they may have contributed to the decline or hampered recovery.

Burek, K. B., R. Zarnke, T. Spraker and A. Trites. 2001. Historical and current serology in Steller sea lions in Alaska. p. 35 In: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

The authors present an early summary of the information later presented in Burek et al., 2005, J. Wildl. Dis. (above).

Colvocoresses, J.A. 2004. Characterization of the humoral immune system of the Steller sea lion, *Eumetopias jubatus*, and development of reagents and assays for quantitative measure of humoral immunity. Ph.D. Dissertation, The University of Southern Mississippi, 163 pp.

This is a dissertation dealing with complex chemical processes somewhat out of the sphere of SSL biology. It contains methods and analyses specific to laboratory processes to develop cell lines for testing effects of metals (see Wise report below). A shortened version of the abstract follows. A deterioration of the immune function manifests as reduced immune responsiveness to infectious agents and disease by decreasing the function of crucial cellular components of the immune system. To investigate impaired immune response, the author identified, purified, and developed reagents used in immunoassays. Methods were described to purify immunoglobulins of various classes which were eventually used for the production of polyclonal and monoclonal antibodies which were in turn characterized with regard to other mammalian isotypes.

Colvocoresses, J., B. Middlebrooks, and R. Patterson. 2003. Production and characterization of monoclonal antibodies against Steller sea lion immunoglobulins. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

The authors report the methods to develop reagents for use in assays for SSL immune response. They purified species-specific immunoglobulins using an enzyme-linked immunosorbent assay (ELISA) to identify cells producing antibodies. The technique may be useful when assessing exposure to disease or other perturbations.

Colvocoresses, J., R. A. Patterson and B. L. Middlebrooks. 2000. Purification of immunoglobulin isotypes G, A, and M from the serum of the Steller sea lion (*Eumetopias jubatus*), pages 477-478. Annual Conference - American Association of Zoo Veterinarians.

This abstract was not seen but we assume it contains similar information as in the Colvocoresses (2004) dissertation and the Wise (2005) final report in the contaminants theme.

Dailey, M. D., R. S. Demaree, and R. L. Critchfield. 2002. *Galactosomum stelleri* sp. n. (Trematoda: Heterophydae) from Northern sea-lion, *Eumetopias jubatus* (Schreber, 1776) (Carnivora: Otariidae). Comparative Parasitology 69(1): 58-61.

The authors describe a new trematode worm (*Galactosomum stelleri*) from the small intestine of a Steller sea lion found in Oregon. The genus is common in pinnipeds and marine birds. No pathology or detrimental effects on sea lions was reported.

Denisenko, T., O. Sokolovca, and V.N. Burkanov. 2005. Microflora of Steller sea lion pups (*Eumetopias jubatus*) of the Kamchatka and Commander Islands. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

The authors collected 230 swabs from 46 pups at several Russian rookeries during June-July 2004 and report nine species of bacteria found. Bacterial genera included *Staphylococcus*, *Streptococcus*, *Escherichia Bacillus*, and a few others. They also examined blood sera for leptospirosis and *Brucella* of which titers for leptospirosis were positive.

Goldstein, T. 2005. Report on the workshop to assess the effects of disease on Steller sea lion (*Eumetopias jubatus*) populations. Report of a workshop held at the ASLC, 20-21 January 2004, S. Atkinson, D. Calkins, and F. Gulland (eds.). Available ASLC, 301 Railway Ave., Seward, AK 99664.

This is a report of a workshop held at the Alaska SeaLife Center in January 2004 with the goal to develop a comprehensive collaborative epidemiologic research plan to assess the effects disease may be having on SSL populations and whether disease may play a role in their failure to recover. The participants reviewed past disease studies on SSL and other pinnipeds and reviewed present efforts (see Beckmen 2004 above). A summary of research priorities for health assessment was provided.

Goldstein, T., D. G. Calkins, and S. Atkinson. 2005. Workshop to asses the effects of disease on Steller sea lion populations. Chapter 31, pages 302-307, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

This paper is a condensed version of the report of the workshop described above (Goldstein 2005).

Lyons, E.T. 2005. Historic importance of some aspects of research by O. Wilford Olsen on hookworms (*Uncinaria lucasi*) in northern fur seals (*Callorhinus ursinus*) and Steller sea lions (*Eumetopias jubatus*) in 1951 on St. Paul Island, Alaska. Parasitol Res (2005) 95: 353–357.

The purpose of this short paper by Lyons is to disseminate more widely research by Olsen on hookworms in northern fur seals and Steller sea lions conducted by Olsen on St. Paul in 1951. This report includes detailed measurement of the worm's infective third stage larvae (provided in a report by Olsen) plus photographs of the worms. Of importance is the conclusion that the worm species (*U. lucasi*) probably infects both pinniped species.

Marcogliese, D. J. 2001. Implications of climate change for parasitism of animals in the aquatic environment. Can J. Zool. 79:1331-1352.

> The author provides his views that parasites in aquatic systems will respond directly to climate change that may ultimately be mediated indirectly through changes in the distribution and abundance of their hosts. In the long term, climate change may influence selection of different life-history traits, affecting parasite transmission and, potentially, virulence.

Middlebrooks, B.L., J. A. Colvocoresses, and R. A. Patterson. 2005. Evaluation of immunoglobulin isotype levels of the Steller sea lion. Chapter 15, pages 135-146, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

> This is a full-length paper similar to the three papers above by Colvocoresses (2004), Colvocoresses et al. (2003) and Colvocoresses et al. (2000). The present paper includes samples from the western (including Russia now considered the Asian stock) and eastern DPSs. Comparison of the three population mean immunoglobulins levels indicated significant differences by one way analysis of variance ($p<0.001$) between the eastern and Russian populations, and the western and Russian populations, but not between the eastern and western populations. Purified Steller sea lion immunoglobulins were also used as immunogens for the production of monoclonal antibodies with specificities for Steller sea lion light chains, IgG, IgM and gamma heavy chains.
>
> This is a techniques paper; it does not imply any population level effects on SSLs.

Moore, M., and J. F. Morado. 2003 Evaluation of the effects of parasites on Steller sea lions in Alaska. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

> The authors report preliminary findings of their study to identify and assess detrimental parasites in SSLs, and to compare parasite fauna between rookeries. Examination of scat revealed hookworms (*Uncinaria*) and lungworms (*Parafilaroides*). The effect of these infections was reported as not known.

Sokolova, O.V., T.E. Denisenko, and V.N. Burkanov. 2005. Immuno-microbiological correlates in Steller sea lions (*Eumetopias jubatus*) pups from Kamchatka Peninsula and Commander Islands. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

> The authors conducted an immuno-microbiological study in June/July 2004 in Kamchatka and the Commander islands on 26 SSL pups to identify indices of phagocytic activity of leukocytes using a strain of *Staphylococcus aureus*. Results showed that phagocytic activity decreased . Six additional species of microflora were isolated from the samples and the genera and species provided.

Stephens, C.A., T. Goldstein, J.-A. Mellish, and S. Jang. 2005. Disease and health monitoring in juvenile Steller sea lions (*Eumetopias jubatus*) held in temporary captivity.
16th Society of Marine Mammalogy biennial meeting.

> The authors report their monitoring study of the health and exposure to diseases of juvenile SLLs held in captivity for short periods at the Alaska SeaLife Center. As of the report, 20

juvenile sea lions (age 1-2 years) had completed temporary captivity and another 34 free-ranging juveniles were tested. A broad spectrum of disease assays were performed on sera and no animals tested showed evidence of exposure to any pathogens tested.

Stephens, C., T. Goldstein, J.E. Mellish, S. Jang, and M. Gray. 2006. Disease and health monitoring in juvenile Steller sea lions (*Eumetopias jubatus*) held in temporary captivity. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

As in Stephens et al. (2005) above.

THEME 9 – CONTAMINANTS

SUMMARY:

This theme contains 41 articles including 29 presentations at scientific meetings, four reports, and eight papers in peer-reviewed journals or book chapters. The theme contains new studies and reviews addressing the possible effect of contaminants on Steller sea lions. The contaminants included organochlorines (OCs) such as PCBs and DDTs, polychlorinated hydrocarbons, and heavy metals. Most studies conclude that these pollutants could have had a role in the decline of SSLs but none provide a link between the decline and pollutant levels. All conclusions regarding population level effects were based on supposition and recommend additional monitoring studies. The underlying theme in all the studies was that various forms of contaminants and heavy metals occur in SSL tissues, some at high levels. What is lacking is the next step as to what these high levels (or presence in most cases) mean biologically to individual SSL survival or reproduction; none address effects at the population level.

Interestingly, none of the studies consider that the pup and juvenile samples they analyzed were from the western and eastern DPSs in Alaska where abundance was either increasing or stable during the duration of their studies.

Four groups made major contributions to this theme. They include the Alaska SeaLife Center, ADFG, University of Southern Maine (J.P. Wise and associates), and NMFS's Auke Bay Laboratory.

The significant findings of these groups include:

1. The Alaska SeaLife Center published four papers and gave numerous presentations at conferences summarizing their work on organochlorine contaminant toxicity and effects on immune function, primarily in pups and juveniles. They also conducted organochlorine and heavy metal monitoring studies on all animals that they handle for other studies.

2. ADFG monitored some metals (principally mercury) and organochlorines in scat and in tissues from free-ranging SSL pups and juveniles (and some adults) that they handle during capture operations (see summary at Krahn et al., 2001). Significant correlations were found between OC exposure and impaired immune function at several levels; their findings suggest that adverse effects of OCs must be considered as contributing factors in the decline of the western DPS in Alaska.

3. J.P. Wise, University of Southern Maine, his associates, and graduates students received SSLRI funding for a study to investigates the toxicity of metals in the major organ systems of SSLs by establishing cell lines from organ systems and determining the effects of metals in these lines. They made about 13 presentations (with numerous authors) at conferences and provided a detailed final report to NMFS in 2005 on the study (Wise, 2005). They found that toxicity level varied based on metal type, tissue, and amount of exposure. Their most significant result was that exposure to chromium and arsenic posed a significant risk factor for the health of SSLs and both metals are likely contributing to their decline and inability to recover. Whether or not these levels of toxicity occur in free ranging SSLs was not presented.

4. The NMFS Auke Bay Laboratory analyzed fish that are documented as part of the SSL diet and found arrowtooth flounder presented the greatest risk of exposure to PCBs, followed by Pacific cod, Atka mackerel, and walleye pollock. They convened a workshop to review studies on contaminants in marine mammals and to gauge exposure risks to SSLs from prey and other environmental sources.

They produced a workshop report, made three presentations and one formal publication (Barron et al., 2003) that concluded that there are insufficient data to reject the hypothesis that contaminants played a role in the continued decline of SSLs, and they suggest that a coordinated monitoring program be developed.

Additional to these are studies by Hoshino et al. (2004) showing high levels of OCs in western Pacific SSLs, and studies by Saeke et al. (2001) showing high levels of silver in SSL liver and other tissues. The review and recommendations in AMAP were useful though not specific to Steller sea lions.

ANNOTATED BIBLIOGRAPHY – CONTAMINANTS

Albers, P. H., and T. R. Loughlin. 2003. Effects of PAHs on marine birds, mammals, and reptiles. Pages 243-261, in P. E. T. Douben (ed.) PAHs: An ecotoxicological perspective. John Wiley and sons, London.

> The authors summarized effects of polycyclic aromatic hydrocarbons (PAHs), typically found in petroleum, on marine birds, mammals, and reptiles. Target organs for PAH toxic action are skin, small intestine, kidney, and mammary glands; tissues of the hematopoietic, lymphoid, and immune systems; and gametic tissue. Non-alkylated PAHs are rapidly oxidized and less likely to be accumulated than alkylated PAHs. PAH toxicity occurs at levels that can also induce DNA alterations and cancer. No efforts have been made to relate PAHs to effects on populations or communities, although attempts to relate petroleum spills to these levels (especially for birds) is common in the literature. The research related to the effects of *Exxon Valdez* oil spill on marine mammals was the most current.

AMAP. 2004. AMAP assessment 2002: Persistent organic pollutants in the Arctic. Arctic Monitoring and Assessment Programme, PO Box 8100 Dep., N-0032 Oslo Norway.

> The Arctic Monitoring and Assessment Programme was established in 1991 to monitor identified pollution risks and their impacts on Arctic Ecosystems. After the first assessment in 1997, AMAP was asked to continue its activities and provide updates on persistent organic pollutants (POPs), heavy metals, radioactivity, human health, and pathways in 2002. The 2002 report concluded that certain Arctic species, particularly those at the upper end of the marine food chains as well as birds of prey, carry high levels of POPs. Fur seals and harbor seals were mentioned, as well as some cetaceans occurring in the Arctic, but Steller sea lions were not specifically named. Mercury and cadmium were noted metals present throughout the food chain and biologically available. Concern was expressed as to the possible impact of these metals in the marine environment as run-off from snow melt.

Atkinson, S. 2005. Introduction to the contaminant, immune and endocrine studies. Pages 107-109, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

> This paper is introductory to six contaminant studies funded by the ASLC that appear in the ASLC volume on SSLs (Loughlin et al., 2005). The overall goal of the studies was to determine whether or not organochlorine contaminants may have either caused the SSL decline, or may be a factor in the failure of the SSL population to recover. The objectives of

these studies addressed the question "Is it contaminants?" by surveying the potential contaminants in subpopulations across the geographic range of the endangered western stock of SSLs, and then to identify or test mechanisms that may provide insight into how contaminants may be expected to influence the physiology of SSLs.

Atkinson, S., S.M. Hong, S. Campell, M. Myers, A. Springer, and Q. Li. 2003. Organic contaminants in tissue from two subarctic pinnipeds. P.8, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Similar information as in Hong et al. (2005) below, but here some harbor seal results are included.

Atkinson, S., S.-M. Hong, A. Springer, and Q. Li. Comparison of PCB concentrations in different Steller sea lions tissues. 2003. In: *Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.*

This abstract is an early description of the analysis of SSL samples for PCB concentration. The full report of the study is in Hong et al. (2005) summarized below.

Atkinson, S., M. Myers, and G. Ylitalo. 2005. Contaminants in North Pacific basin marine mammals. In: Marine science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

The authors present data on the analysis of tissue samples from three cetacean and three pinniped species, including SSLs, for PCBs and DDTs. Range of contaminants in SSL blubber for PCBs was 990 ± 5,700 ng/g wet weight and for DDTs the range was 590 – 4,100 ng/g wet weight. Compared to the other species in the study, SSL blubber levels were highest. Since they feed at the same or lower trophic levels as the other species examined, the authors suggest that SSLs forage in areas with higher levels of contaminants or that they are not able to metabolize organochlorines as well as other marine mammals.

Barron, M. G., R. A. Heintz, And M. M. Krahn. 2003. Contaminant exposure and effects in pinnipeds: Implications for Steller sea lion declines in Alaska. Sci. Total Environ. 311:111-133.

This paper is the published version of the workshop proceedings described below (Heintz and Barron 2001). The objectives of this paper (and the workshop) were to review and synthesize existing information on contaminants measured in SSLs and their prey (see Heintz et al., 2004, below), and evaluate any associations between contaminant exposures and impacts. The authors concluded that there were insufficient data to reject the hypothesis that contaminants play a role in the continued decline of SSLs, and they suggest that a coordinated monitoring program be developed.

Beckmen, K.B., K.A. Burek, K.W. Pitcher, G.M. Ylitalo, M.M. Krahn, and J.L. Stott. 2003. An investigation of the potential effects of environmental contaminants on immune function and health in free-ranging Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK

This abstract summarizes field studies by ADFG to investigate organochlorine contaminant and mercury exposure, the general health, and development of immune function in juvenile SSLs. No data were presented but the abstract stated that significant correlations were found between OC exposures and impaired immune function at several levels (not given in

abstract). The results of the study on mercury were stated in general terms. A journal article (Beckmen et al., 2002; above) resulted from this study.

Beckmen, K. B., K. A. Burek, K. W. Pitcher, G. M. Ylitalo and L. K. Lawrence. 2001. Organochlorine contaminants in live Steller sea lions, *Eumetopias jubatus*. p. 20 In: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

The authors studied levels of exposure to organochlorine contaminants (dioxin-like PCBs, DDTs) in matched sets of scat, blood sera, and blubber from pups, juveniles, and some captive adult SSLs in the eastern and western stocks of Alaska. Blood levels of individual PCBs congeners and DDT metabolites were highly correlated with blubber levels, but levels in feces were not correlated with either blood or blubber levels, likely because feces represents recent exposure. The authors stated that their findings indicate that adverse effects of OCs must be considered as contributing factors in the decline of the western stock in Alaska. (see also Beckmen et al., 2003. Population survey...)

Beckmen, K., K. Burek, K. Pitcher, G. Ylitalo, and J. Short. 2003. The potential effects of environmental contaminants on immune function and health in free-ranging pinnipeds in Alaska. P. 14, In: 15th biennial conference on the biology of marine mammals, Greensboro, NC, USA. 14-19 December 2003. Society for Marine Mammalogy. 201p.

This abstract summarizes recent studies by ADFG to investigate organochlorine contaminants, mercury, and the immune system in northern fur seals and Steller sea lions. Results of these studies are presented in numerous presentations by Beckmen and Burek in this list. No new information is provided in this abstract.

Beckmen, K. B., L. K. Duffy, X. Zhang, and K. W. Pitcher. 2002. Mercury concentrations in the fur of Steller sea lions and northern fur seals from Alaska. Marine Pollution Bulletin 44 (10):1130-1135.

This study compared total mercury concentrations in the fur of northern fur seals and SSLs from Prince William Sound and Southeast Alaska during 1998 and 2000. Relatively low wet weight concentrations were found in SSL pups and juveniles compared to NFSs. Mercury could not be linked directly to the declines of either species but additional monitoring was recommended.

Beckmen, K.B., K.W. Pitcher, K.A. Burek, G.M. Ylitalo, and M.M. Krahn. 2003. Population survey of organochlorine contaminant exposure in Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

Scats from SSLs were collected on 21 rookeries over 4 years to assess exposure to organochlorine contaminants (dioxin-like PCBs, DDTs) in the eastern and western stocks of Alaska. OCs were found to be present in the food web used by SSLs as far west as the eastern Aleutian Islands with the EAI>SE>GOA. The authors then speculate on the role that these contaminants may have had or are having on the SSL decline and propose that scat be used as a non-invasive indicator of contaminant exposure.

Bozza, M., and S. Atkinson. 2005. Steller sea lion cytokine immunoassay development. Chapter 14, pages 121-134, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on

Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

Environmental contaminants including PCBs, organochlorines, and heavy metals are known to suppress immunity in mammalian species, increasing susceptibility to viral, bacterial, parasitic or autoimmune disease. Cytokines are immune modulators produced in response to infection or inflammation and are important indicators of immune function in humans, experimental and domestic animals, and increasingly in wildlife species. The authors are developing species-specific assays to measure concentrations of cytokines including interleukin-1 beta (IL-1β) and interleukin-6 (IL-6) in SSL serum and *in vitro* mononuclear cell cultures. IL-1β and IL-6 regulate inflammation and interact with the endocrine system. Cytokine assays may be valuable in further characterizing the SSL immune system to better understand the potential effects of environmental stressors, including contaminants, on immune function.

Goertz, C.E.C., Wise, S.S., Dunn, J.L., Gulland, F., Morin, A.T., Jayasundara, N., Bozza, M., Atkinson, S., Wise Sr. J.P. 2003. Sodium Chromate and Cadmium Chloride Toxicity in Steller Sea Lion Dermal, Renal, Bronchial, and Testicular Cells. Presented at the Northeast Society of Toxicology (NESOT) Annual Meeting, November 2003.

Information presented here is contained in the contract final report at Wise (2005) below.

Goertz, C.E.C., Wise, S.S., Dunn, J.L., Gulland, F, Morin, A., Jayasundara, N., Bozza, M., Atkinson, S., and Wise, Sr. J.P. 2004. Sodium chromate and cadmium chloride toxicity in Steller sea lion cells. The Toxicologist, 78 (S-1): no. 756.

Information presented here is contained in the contract final report at Wise (2005) below.

Goertz, C.E.C., Wise, S.S., Dunn, J.L., Bozza, M., Atkinson, S., Gulland, F.M.D., Taylor, R.J., and Wise, Sr. J.P. 2004. *In Vitro* metal toxicity in Steller sea lion (*Eumetopias jubatus*) fibroblasts with an emphasis on hexavalent chromium. Proceedings of the Annual Meeting of the International Association of Aquatic Animal Medicine, 35: 74-75 2004.

Information presented here is contained in the contract final report at Wise (2005) below.

Goertz, C.E.C., Wise, S.S., Dunn, J.L., Gulland, F.M.D., Morin, A., Jayasundra, N., Bozza, M., Atkinson, S., and Wise, Sr. J.P. 2004. Sodium chromate toxicity and uptake in Steller sea lion cells. Proceedings of the 22nd Wakefield Fisheries Symposium: Sea Lions of the World Conservation and Research in the 21st Century. September, 2004.

Using clonogenic assays (cell cultures), the authors found that chromium (Cr) induced a concentration-dependent toxicity in testicular cells of SSLs. Ovarian, bronchial, and renal cells showed moderate toxicity and dermal cells the least. Samples from wild pups had undetectable levels of CR; however in those pups where CR was detected its concentration was similar to that causing 50% cytotoxicity in cultures.

Heintz, R., and M. Barron. 2001. Workshop to assess contaminant impacts on Steller sea lions in Alaska, September 5 -6, 2001, Anchorage, Alaska. Sponsored by: the Alaska Fisheries Science Center, Auke Bay Laboratory. [U.S. Department of Commerce], NOAA, NMFS, Alaska Fisheries Science Center, Auke Bay Laboratory, Juneau, AK.

This report summarizes a workshop held September 5 and 6, 2001, in Anchorage, Alaska, to assess the role that contaminants may have on the decline of SSLs and to develop future research directions and needs. Fourteen papers were presented discussing present and historical studies on the impact of contaminants on pinnipeds, summaries of which are part of the report. A two-page summary provides consensus statements and future research directions and needs.

Heintz, R., M. Barron, and M.M. Krahn. 2003. A science plan for evaluating the role of contaminants in the decline of Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.

This abstract is a preliminary presentation of the authors' summary of contaminants that SSLs contact through their prey or environment. The study is presented as a published journal article in Barron et al. (2003) above.

Heintz, R., M. M. Krahn, G.M. Ylitalo, and F. Morado. 2004. Organochlorine levels in Steller sea lion prey from the Aleutian Islands and Southeastern Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors report their analysis of 180 samples from seven fish species from the Aleutian Islands, eastern Bering Sea, and Southeast Alaska. In the SSL western stock region, arrowtooth flounder presented the greatest risk of exposure to PCBs, averaging 22,000 ng PCBs per fish. Pacific cod was the next highest risk level, followed by Atka mackerel and walleye pollock. There were no detectable differences in risk among prey from Southeast Alaska. For most species, exposure risk increased linearly with fish size (bigger fish carry more contaminants).

Holmes, A.L., S.S. Wise, J.A. Little, H. Xie, M. Bozza, M. Moreland, D. J. St. Aubin, J.L. Dunn, S. Atkinson, F. Gulland, S. Bursian, and J.P. Wise Jr. 2003. Hexavalent chromium cytotoxicity is organ and species specific for Steller sea lion and mink cells. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK

The abstract describes a study examining the toxicity of a range of metals to cell lines established from major organ systems in SSLs and the use of mink cells as surrogates to SSL cells. They found that mink cells were a suboptimal model for studying the effects of metals on SSL. The abstract presents preliminary results of a larger study with SSLRI funding that is summarized below at Wise (2005, contract report).

Holmes, A.L., S.S. Wise, A.T. Morin, C.E.C. Goertz, S. Atkinson, J.L. Dunn, F.M.D. Gulland, and J.P. Wise, Sr. 2005. Sodium chromate toxicity in Steller sea lion cells. Proceedings of the Annual Meeting of the North Atlantic Chapter of the Society for Environmental Toxicology and Chemistry, June 2005.

Title suggests that the content of this presentation is similar to the paper above at Holmes et al. (2003). This abstract was not obtained or read. See final contract report by Wise (2005).

Hong, S.-M., S. Atkinson, K. Hülck, and Q. X. Li. 2005. PCB concentrations and profiles in tissues of Steller sea lions from Alaska and the Bering Sea. Chapter 13, pages 110-120, *in* Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Concentrations of 145 individual PCBs were determined in the tissues of 19 Steller sea lions stranded along St. Paul Island, in the Bering Sea, and Tatitlek in Prince William Sound. The total PCB concentrations were 860, 905, 1355 and 2821 ng/g lipid weight (lw) in the placenta, kidney, blubber, and liver samples, respectively. Penta-and hexa-chlorobiphenyls were prevalent in the placenta, kidney, blubber, and liver samples. PCBs 90/101, 118 and 153 (32% of total PCBs) were the most abundant congeners in the placenta samples. The total PCB concentrations in SSL tissue samples were below the immunotoxic threshold of 17 µg/g lw in the blubber, and the physiological toxic threshold of 6.6-11 µg/g lw in the liver of marine mammals. The mean total 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) equivalent of two to four coplanar PCBs detected were 0.5, 0.8, 2.7, and 9.1 pg/g dw in the kidney, placenta, liver, and blubber samples, respectively.

Hoshino, H., H., S. Fujita, Y. Goto, T. Isono, T. Ishinazaka, V. N. Burkanov, and Y. Sakurai. 2004. Organochlorine contaminants in Steller sea lions (*Eumetopias jubatus*) of the Northwestern Pacific. Presented paper. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

The authors analyzed blubber obtained from SSLs from Hokkaido, the Kuril Islands, and the Bering Sea in Russia (abstract does not give exact locations). Blubber was examined for organochlorines and results showed that DDT and its metabolites were the dominant compounds accumulated in the blubber. Levels in males were similar to levels observed in phocid seals. The authors suggested that organochlorine contaminants in SSLs in Asia may be at levels that cause some physiological effects.

Hülck, K., D. Wang, S. Atkinson, Q.T. Li. 2005. Persistent organic pollutants in the blubber of male Steller sea lion (*Eumetopias jubatus*) from different locations in the North Pacific Ocean. Poster at the 16th biennial meeting of the Society for Marine Mammalogy.

This abstract proposes that persistent organic pollutants (POPs) in the form of PCBs and other contaminants may have had a role in the SSL decline. Blubber from male sea lions from Tatitlek, St. Paul Island, and Olutorsky Gulf (Russia) was analyzed and the method described. No results or conclusions were presented but see Hong above.

Kelly, R., Holmes, A.L., Wise, S.S., Morin, A.T., Goertz, C.E.C., Atkinson, S., Dunn, J.L., Gulland, F.M.D., and Wise Sr., J.P. Sodium chromate toxicity in Steller sea lion cells. Proceedings of the Biennial Meeting of the Chromium and Human Health Workshop, August 2005.

Information presented here is contained in the contract final report at Wise (2005) below.

Krahn, M. M., K. B. Beckmen, K. W. Pitcher, and K. A. Burek. 2001. Population survey of organochlorine contaminants in Alaskan Steller sea lions. Final Programmatic Report for the National Fish and Wildlife Foundation, October 2, 2001. 22 p.

This is a final report of work performed during 1998-2001 results of which were reported at conferences by Beckmen et al. (2001) and elsewhere. A shortened version of their abstract contains the following. SSL scats were collected on rookeries to compare relative levels of selected organochlorine (OC) contaminants between the eastern stock (ES) in Southeast

Alaska (SEA) and the western stock in Gulf of Alaska (GOA) and eastern Aleutian Islands (EAI). Matched sets of feces, blood, and blubber samples were collected from pups and juveniles captured during ADFG capture operations in SEA and Prince William Sound (GOA) as well as from captive adults at the Alaska SeaLife Center. These sets were used to evaluate relationships of organochlorine levels [i.e., polychlorinated biphenyls (PCBs), DDTs] and composition in the three media. In addition, they examined porphyrin profiles in feces as a biomarker of environmental contaminant exposure in both individual sea lion feces and from rookery scats. Blood levels of individual PCBs congeners and DDT metabolites were highly correlated with blubber levels. In contrast, congener concentrations in feces were not well correlated with blubber or blood concentrations although the same congeners were present in these samples. This result was expected since fecal OC levels reflect excretion of PCBs congeners not metabolized or retained in the body in addition to recent dietary intake. Therefore, fecal OCs were used as a rough indicator of recent exposure levels, not as a reflection of the individual congeners in body depot stores. We determined that OC contamination in Steller sea lions from portions (EAI) of the western stock (WS) have significantly higher OC levels excreted in feces compared to the GOA and SEA. Additionally, the mean ratios of porphyrins in scats from rookeries were correlated with OC levels in these samples. Therefore, adverse effects of environmental contaminants may be a contributing factor in the continuing decline of some portions of the western stock of SSL. They conclude dthat additional, extensive, effects-based contaminant research on Steller sea lions is warranted.

Morin, A.T., C.E.C. Goertz, S.S. Wise, J.L. Dunn, F. Gulland, N. Jayasundara, M. Bozza, S. Atkinson, and J.P. Wise, Sr.2003. Comparative cytotoxicity of hexavalent chromium in humans and Steller sea lions. Presented at the Northeast Society of Toxicology (NESOT) Annual Meeting, November 2003.

Information presented here is contained in the contract final report at Wise (2005) below.

Morin, A.T., C.E.C. Goertz., S.S. Wise, J.L. Dunn, F. Gulland, N. Jayasundara, M. Bozza, S. Atkinson, and J.P. Wise, Sr. 2004. Metal toxicity of sodium chromate in Steller sea lion bronchus and dermis compared to humans. The Toxicologist, 78 (S-1): no. 757.

Information presented here is contained in the contract final report at Wise (2005) below.

Myers, M. 2005. Organochlorine contamination in Steller sea lion pups from four Russian rookeries. In: Marine science in Alaska: joint scientific symposium. January 24-26, 2005,Hilton Hotel, Anchorage, AK.

The author compared organochlorine contaminants from four SSL rookeries in Russia by analyzing blood sera from pups. He provided mean values and the range for sampled islands. Average contaminant levels were consistently higher in females than males for PCBs and DDTs, but the differences were not significant. The author suggested that contaminant exposure and potential effects may vary between areas for SSL pups in Russia.

Myers, M., and S. Atkinson. 2004. Chemical contamination levels in Steller's sea lion pups from southwest Alaska and the Russian Far East. *In*, 22nd Wakefield Fisheries Symposium: Sea lions of the World, 30 September – 3 October 2004. Anchorage, Alaska.

Blood sera from 65 SSL pups from southwest Alaska and Russia were analyzed for polychlorinated biphenyls (PCBs) and DDT. Values were provided for all samples that

suggest that contaminant exposure and potential effects may be more pronounced in SSL pups in Russia.

Myers, M., and S. Atkinson. 2005a. Contaminants in Steller sea lion (*Eumetopias jubatus*) and other marine mammals from the North Pacific. Poster at the 16th biennial meeting of the Society for Marine Mammalogy.

Same information as presented in Atkinson et al. (2005), Myers (2005), and Myers and Atkinson (2005b).

Myers, M.J., and S. Atkinson. 2005b. Thyroid and cortisol hormones and contaminants in Steller sea lions. Chapter 16, pages 147-158, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

Myers has presented numerous posters and presentations at symposia as part of his Ph.D, studies with Atkinson at the Alaska SeaLife Center. This paper is the first formal presentation of his studies and involves analysis of toxicity caused by the accumulation of organochlorines (OCs). OCs, such as polychlorinated biphenyls (PCBs), 1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane, or dichlorodiphenyltrichloroethane (DDT), have been shown to effect marine mammal populations and were considered by the authors as a possible factor in the sea lion decline or the failure to recover. The chemical structure of OCs may account for disturbances at the cellular level including thyroid suppression. Thyroid hormones function primarily to control basal metabolic rate and regulate lipid metabolism. Cortisol is released by the adrenal glands in response to an acute or chronic change in the environment and varies on a diurnal cycle that tends to peak in relation to activity. Data presented were inadequate for comparison between contaminants and hormones but the full analysis has not been completed.

Myers, M., and S. Atkinson. 2006. Variability in organochlorine contaminants in both blood and blubber over time in captive Steller sea lions (Eumetopias jubatus). *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Similar presentation to other Myers symposia presentations. Blood and blubber samples from three adult captive SSLs (two female and one male) housed at the Alaska SeaLife Center were temporarily sampled for OCs over about two years. Values for PCBs, DDTs, and their derivatives are provided. Concentrations in blood for all three animals were similar and followed seasonal patterns with levels higher in late fall and lower in early spring. Blubber concentrations in females showed similar trends as in blood except the male which had considerably low levels and which declined over the study period.

Saeki, K., M. Nakajima, T.R. Loughlin, D.G. Calkins, N. Baba, M. Kiyota, R. Tatsukawa. 2001. Accumulation of silver in the liver of three species of pinnipeds. Environmental Pollution 112:19-25.

Samples from SSLs, northern fur seals, and harbor seals from the North Pacific were analyzed to assess distribution and accumulation of silver in pinnipeds. The SSL samples were subsamples of ADFG collections in the Gulf of Alaska in the 1970s and 1980s. Principle concentration site was the liver and concentrations were significantly correlated with age (higher with increasing age). Silver concentration for all pinnipeds was significantly correlated with mercury and selenium. Increase in silver accumulation in the liver was caused by the retention in nuclei and mitochondria.

Wise, J.P. 2005. Metal toxicity in Steller sea lion (*Eumetopias jubatus*) tissues and cell lines. Final Contract Report (Contract number NA16FX1412). University of Southern Maine. 24 p.

This project was funded through the SSLRI and investigates the toxicity of metals in major organ systems of SSLs by establishing cell lines from organ systems and determining the effects of metals in these lines, so that a priority list could be developed for intervention measures. Results outlined in the final report include:

1. Exposure to chromium and arsenic is a significant risk factor for the health of SSLs and both metals are likely contributing to their decline and inability to recover.

2. Exposure to mercury, cadmium, silver, selenium and copper is a moderate risk factor for the health of SSLs and may also be contributing to the decline and inability to recover.

3. Exposure to lead, nickel, aluminum, iron, manganese and vanadium are unlikely to be a risk factor for the health of SSLs and may not be contributing to the decline.

4. The specific sensitivity of each organ depends on the specific metal and cannot be generalized. Thus merely measuring blubber levels will not predict toxicity as each organ system responds differently. Their data are based on the organs considered. Care must be taken with interpretation as some organs not tested (e.g. heart, spleen, thyroid etc.) which may be more sensitive to some metals than those studied. Thus those metals that were relatively nontoxic in this study may still exert some toxicity in other organ systems.

Wise, S.S., Little, J.E., Bozza, M., Atkinson, S., ST. Aubin, D.J., J.A., Dunn, J.L., Gulland, F., Wise, Sr. J.P. 2003. Metal Toxicity in cultured Steller sea lion fibroblasts. Presented at the International Association for Aquatic Animal Medicine (IAAAM) Annual Meeting, May 2003.

Information presented here is contained in the contract final report at Wise (2005) above.

Wise, Sr. J.P., Wise, S.S., Goertz, C.E.C., Bozza, M., Atkinson, S., St Aubin, D.J., Dunn, J.L., Gulland, F. 2003. Toxicity of heavy metals in cultured Steller sea lion cells. Presented at the Society of Environmental Toxicology and Chemistry (SETAC) Annual Meeting, November 2003

Information presented here is contained in the contract final report at Wise (2005) above.

Wise, Sr., J.P., S.S. Wise, C.E.C. Goertz, M. Bozza, D.K. St. Aubin, J.L. Dunn, S. Atkinson, and F. Gulland. 2003. Toxicity of heavy metals in cultured Steller sea lion cells. Presented at the Society of Environmental Toxicology and Chemistry, November, 2003.

Information presented here is contained in the contract final report at Wise (2005) above.

Wise, S.S., A.T. Morin, C.E.C. Goertz, J.L. Dunn, F.M.D. Gulland, M. Bozza, S. Atkinson, and J.P. Wise, Sr. 2005. Metal toxicity of sodium chromate in Steller sea lion bronchus and dermis compared to humans. Presented at the Biennial meeting of PRIMO (Pollution Research in Marine Organisms), June 2005.

Information presented here is contained in the contract final report at Wise (2005) above.

THEME 10 – MANAGEMENT

Alaska Steller Sea Lion Restoration Team (ASSLRT). 2001. Minutes of the fifth meeting of the Alaska Steller Sea Lion Restoration Team, June 28-29, 2001. Kruse, G. chair.

Bishop, A. 2006. Designation of critical habitat under the Endangered Species Act for marine mammals in the US EEZ: Evolution of designation criteria based on recent litigation. In Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK

Brown, M.N., B. L. Gerke, and W.J. Wilson. 2004. Steller sea lion protection measures in the Alaska groundfish fisheries: Spatial and temporal harvest control. Poster, in Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Capron, S., and L. Fritz. 2004. How uncertainties about competition between Steller sea lions and U.S. groundfish fisheries off Alaska have been addressed in fisheries regulations. Presented paper, in Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Kruse, G. H., M. Crow, E.E. Krygier, D.S. Lloyd, K.W. Pitcher, L.D. Rea, M. Ridgway, R.J. Small, J. Stinson, and K.M. Wynne. 2001. A review of proposed fishery management actions and the decline of Steller sea lions *Eumetopias jubatus* in Alaska: a report by the Alaska Steller Sea Lion Restoration Team. Regional Information Report Number 5J01-04, Alaska Department of Fish and Game, Juneau, AK. 106 p

Robson, B. W., L. W. Fritz and T. R. Loughlin. 2001. Conflicts in conservation: the impact of habitat protection measures for Steller sea lions on the distribution of fisheries in northern fur seal foraging habitat. P. 180, in 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Rusin, Jeremy D. 2002. Management of the western Alaska Steller sea lion, *Eumetopias jubatus*, under the Endangered Species Act: evolution of interagency consultation and impacts on Alaska groundfish fisheries. M.M.A. thesis, University of Washington. 117p.

Small, R.J., and D.P. DeMaster. 2004. Uncertain management or management of uncertainty: Steller sea lion—a case study. Presented paper, in Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Small, R.J., and D.P. DeMaster. In press. Uncertain management or management of uncertainty: Steller sea lion—a case study. Pages 000-000 in Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

(This page intentionally left blank)

THEME 11 -- COMMUNICATIONS

Scientific meetings, symposia, and edited volumes:

Abstracts and posters from the Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK. Some of the titles may appear in a volume to be published in 2006 by University of Alaska Alaska Sea Grant.

Abstracts from the January 13-17, 2003, Marine Science in the Northeast Pacific symposium at the Captain Cook, Anchorage

Abstracts from the January 12-14, 2004, Marine Science in Alaska symposium at the Captain Cook, Anchorage

Abstracts from the January 24-26, 2005, Marine Science in Alaska symposium at the Hilton Hotel, Anchorage

Abstracts from the January 22-25, 2006, Marine Science in Alaska symposium at the Hilton Hotel, Anchorage.

Abstracts from the 14th Marine Mammal Society biennial meeting, Vancouver, B.C. November 28 – December 3, 2001

Abstracts from the 15th Marine Mammal Society biennial meeting, Greensboro, N.C., December 14-19, 2003

Abstracts from the 16th Marine Mammal Society biennial meeting, San Diego, CA, December 12-16, 2005.

Abstracts from the Marine Mammals of the Holarctic, 2nd International Conference, Baikal, Russia, September 10-15, 2002.

Abstracts from the Marine Mammals of the Holarctic, 3rd International Conference, Koktebel, Crimea, Ukraine, October 11-17, 2004.

Alaska Fisheries Science Center Steller sea lion research project reports fiscal year 2002. 2003. AFSC Processed Report 2003-08 (L. Fritz, compiler). NOAA Fisheries, Alaska Fisheries Science Center, 7600 Sand Point Way, NE, Seattle, WA, 98115. 145 p.

DeMaster, D. and S. Atkinson, editors. 2002. Steller sea lion decline: Is it food II. Proceedings of the workshop, Is it food II, Alaska SeaLife Center, Seward, Alaska May 2001. University of Alaska Sea Grant College Program, Fairbanks, AK. (AK-SG-02-02). 78 p. (see Appendix 3)

Fadely, B.S., editor. 2001. Steller sea lion investigations, 2000. U.S. Department of Commerce, Seattle, WA. (AFSC Processed Report 2001-05). 226 p. (see Appendix 3)

Ferrero, R. C. and L. W. Fritz 2002. Steller sea lion research and coordination: a brief history and summary of recent progress. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-129. 34 p.

Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Web pages:

Alaska Department of Fish and Game, Marine Mammal Program:
http://www.wildlife.alaska.gov/management/mm/mm_home.cfm

Alaska Fisheries Development Foundation:
http://www.afdf.org/home.html

Alaska SeaLife Center:
http://www.alaskasealife.org/

Marine Conservation Alliance
http://www.marineconservationalliance.org/

NOAA, NMFS, publication page:
http://www.afsc.noaa.gov/Publications/

NOAA, NMFS, Alaska Fisheries Science Center, Coordinated Steller sea lion page:
http://www.afsc.noaa.gov/Stellers/coordinatedresearch.htm

NOAA, NMFS, National Marine Mammal Laboratory:
http://nmml.afsc.noaa.gov/AlaskaEcosystems/sslhome/stellerhome.html

NOAA, NMFS, Alaska Region, Office of Protected Species:
http://www.fakr.noaa.gov/protectedresources/stellers/

NOAA, NMFS, Alaska Region Steller sea lion:
http://stellersealions.noaa.gov/

NOAA, NMFS, Steller Sea Lion Recovery Team:
http://www.fakr.noaa.gov/protectedresources/stellers/recovery_team.htm

NOAA, PMEL, Steller sea lion page:
http://www.pmel.noaa.gov/steller/steller.shtml

NOAA, NOS. See University of Alaska, CIFAR.

NOAA, Steller Sea Lion Research Initiative (2001)
http://www.fakr.noaa.gov/omi/grants/sslri/default.htm

North Pacific Universities Marine Mammal Research Consortium:
http://www.marinemammal.org/

North Pacific Fisheries Management Council:
http://www.fakr.noaa.gov/npfmc/

North Pacific Research Board:
http://www.nprb.org/

Pollock Conservation Cooperative Research Center:
http://www.sfos.uaf.edu/pcc/

Prince William Sound Science Center:
http://www.pwssc.gen.ak.us/pwssc/pwssc.html

Sea Mammal Research Unit, St. Andrews, Scotland
http://www.smru.st-and.ac.uk/

University of Alaska, Marine Advisory Program, GAP Project:
http://www.uaf.edu/map/mammals/index.html

University of Alaska Sea Grant program:
http://www.uaf.edu/seagrant/Conferences/sealions/program.pdf

University of Alaska, Cooperative Institute for Arctic Research:
http://www.cifar.uaf.edu/research/ssl.php

(This page intentionally left blank)

APPENDIX 2 – CITATION LIST

ALPHABETICAL CITATION LIST
FOR THE
NORTH PACIFIC FISHERIES MANANAGEMENT COUNCIL'S
"COMPENDIUM OF STELLER SEA LION RESEARCH, 2000-2006"

Adams, C.F. 2005. Physical and biological effects on the diel vertical migration of walleye pollock. Chapter 34, pages 331-336, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Adams, T.C. 2000. Foraging differences and early maternal investment in adult female Alaskan Steller sea lions (*Eumetopias jubatus*). Ph.D. dissertation, Texas A&M University. 150 p.

ADFG and NMFS. 2001. Satellite telemetry & Steller sea lion research. A 'white paper' prepared for the North Pacific Fisheries Management Council. 16 pp. Available, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

Alaska Steller Sea Lion Restoration Team (ASSLRT). 2001. Minutes of the fifth meeting of the Alaska Steller Sea Lion Restoration Team, June 28-29, 2001. Kruse, G. chair. [6]

Albers, P.H., and T.R. Loughlin. 2003. Effects of PAHs on marine birds, mammals, and reptiles. Pages 243-261, in P. E. T. Douben (ed.) PAHs: An ecotoxicological perspective. John Wiley and sons, London.

Altukhov, A.V., and V.N. Burkanov. 2004. Seasonal changes in Steller sea lion (*Eumetopias jubatus*) population on Dolgaya Rock Island, Lovushki Island. Pages 25-26 , *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.[1]

Altukhov, A.V., and V.N. Burkanov. 2005. Spatial distribution of Steller sea lions (*Eumetopias jubatus*) males on a non-reproductive section of rookery. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Alvarez-Flores, C., and S. Hinckley. 2004. A model of diving behavior applied to Steller sea lion foraging. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

AMAP. 2004. AMAP assessment 2002: Persistent organic pollutants in the Arctic. Arctic Monitoring and Assessment Programme, PO Box 8100 Dep., N-0032 Oslo Norway.

Ando, N., T. Isono, and Y. Sakurai. 2005. Trace elements in the teeth of Steller sea lions (*Eumetopias jubatus*) from the North Pacific. Ecol Res. 20:415–423.

Angliss, R. P., Lopez, A., and D.P. DeMaster. 2001. Draft Alaska Marine Mammal Stock Assessments, 2001. National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115. p. 181.

Angliss, R. P., and K. L. Lodge. 2002. Alaska marine mammal stock assessments, 2002. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS –AFSC-133, 224 pp.

Angliss, R.P., and K.L. Lodge. 2004. Alaska marine mammal stock assessments, 2003. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-AFSC-144. 230 p.

Andrews, R.D. 2003. Foraging behavior of Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Andrews, R.D. 2004. The population decline of Steller sea lions: testing the nutritional stress hypothesis. Pages133-146, *in,* M. Gordon and S. Bartol (eds.), Experimental approaches to conservation biology, University of California Press, Berkeley, CA.

Andrews, R.D., L. Mazzuca, and C.O. Matkin. 2005. Satellite tracking of killer whales. Chapter 24, pages 238-248, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

Andrews, R. D., A.W. Nelson, R.B. Heath, R.D. Hill, R.E. Davis, and D.G. Calkins. 2003. Novel transmitter and antenna design and surgical techniques for monitoring pinnipeds with satellite telemetry. P. 6, In: 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Andrews, R.D., A.W. Nelson, R. B. Heath, S.E. Norberg, and D. G. Calkins. 2005. Innovations in remote monitoring techniques for Steller sea lions. Chapter 25, pages 249-259, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Anonymous. 2004. Steller Sea Lion Research Initiative, Native Village of Perryville, Traditional ecological knowledge of subsistence uses of Steller sea lions and identifying Steller sea lion haulouts and rookeries in the Perryville, Alaska area. Final Contract Report. Bristol Bay Native Association P.O. Box 310 Dillingham, Alaska 99576. 68p.

Anonymous. 2005. Introduction. In: Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fisheries Management Council, Anchorage, AK, pp 1-40.

Atkinson, S. 2005. Introduction to the contaminant, immune and endocrine studies. Pages 107-109, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.)

Atkinson, S., D. Calkins, M. Castellini, V. Burkanov, S. Ingles, and D. Hennen. 2005. Impact of changing diet regimes on Steller sea lion body condition. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Atkinson, S., S.M. Hong, S. Campell, M. Myers, A. Springer, and Q. Li. 2003. Organic contaminants in tissue from two subarctic pinnipeds. P.8, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Atkinson, S., S.-M. Hong, A. Springer, and Q. Li. 2003. Comparison of PCB concentrations in different Steller sea lions tissues. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.[2]

Atkinson, S., M. Meyers and L. Rea. 2001. Thyroid and cortisol hormone concentrations in Steller sea lions (*Eumetopias jubatus*). Page 11 i*n*: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Atkinson, S., M. Myers, and G. Ylitalo. 2005. Contaminants in North Pacific basin marine mammals. In: Marine science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

Atkinson, S., T.M. Williams, K. Mashburn, D. Greig, and D. Christen. 2004. Physiology of homeostasis in sea lions: The link between hormones and metabolism. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Aydin, K. 2002. The eastern Bering Sea. *In* T. Pitcher and K. Cochrane (eds.), The use of ecosystem models to investigate multispecies management strategies for capture fisheries. Fisheries Center Research Report 10(2) 33-38. [3]

Azana, C.D.P. 2002. Seasonal variation in nutrient composition of Alaskan walleye pollock (*Theragra chalcogramma*) and its effect on the nutritional status of Steller sea lions (*Eumetopias jubatus*). M.S. thesis, University of British Columbia. 104 p.

Baba, N., H. Nitto, and A. Nitta. 2000. Satellite tracking of young Steller sea lion off the coast of northern Hokkaido. Fisheries Science, 66:180-181.

Baker, A. R. 2003. Variation of mitochondrial control region sequences of Steller sea lions, *Eumetopias jubatus*: the three-stock hypothesis. M.S. thesis, Texas A&M University, College Station, Texas. 55 p.

Baker, A.R., T.R. Loughlin, V. Burkanov, C.W. Matson, R.G. Trujillo, D.G. Calkins, J.K. Wickliffe, and J.W. Bickham. 2005. Variation of mitochondrial control region sequences of Steller sea lions: The three-stock hypothesis. Journal of Mammalogy 86 (6): 1075-1084.

Ban, S. 2005. Modelling and characterization of Steller sea lion haulouts and rookeries using oceanographic and shoreline type data. M.S. Thesis, University of British Columbia, Vancouver, Canada. 103 p.

Ban, S.S., and A.W. Trites. 2005. Terrestrial characteristics of Steller sea lion haulouts and rookeries. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Ban, S., J. Porter, A. Trites, and M. Foreman. 2001. Using geographic information systems to analyze and predict Steller sea lion (*Eumetopias jubatus*) haulouts and rookeries. P. 15, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Ban, S., J. Porter, A. Trites, and M. Foreman. 2003. Oceanographic characteristics of Steller sea lion haulouts and rookeries. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.[2]

Ban, S. A.W. Trites, M. Foreman, and J. Porter. 2003. Steller sea lion haulouts and rookeries: Why are they where they are? P. 11, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Bando, M. 2002. Proximate compositions of Steller sea lion prey items. M.S. thesis, Alaska SeaLife Center, Seward, AK., and University of Alaska, Fairbanks, AK.

Bando, M. and B. Norcross. 2001. Comparing the nutritional quality of Steller sea lion diets. P.15 *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Baraff, L. S., and T. R. Loughlin. 2000. Trends and potential interactions between pinnipeds and fisheries of New England and the U.S. west coast. Marine Fisheries Review 62(4):1-39.

Barbeaux, S., J. Ianelli, and E. Brown. Stock assessment of Aleutian Islands region pollock. 2005. *In*: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pacific Fisheries Management Council, Anchorage, AK. Section 1:125-180

Barrett-Lennard, L, C.O. Matkin, and D.K. Ellifrit. 2006. The role of transient killer whales in structuring marine mammal communities in the Aleutian Islands: Insights from predation hotspots. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Barrett-Lennard, L.G., K. Heise, S. Martell, D.P DeMaster, and A.W. Trites. *In review.* The impact of killer whale predation on the decline of Steller sea lions in western Alaska: a simulation study. *Ecological Applications.*

Barrick, R., D.J. Tollit, S. Heaslip, J. Beblow, and A.W. Trites. 2005. Digestion and recovery rates of otoliths, bones, and beaks: Assessing biases in using fecal samples to determine the diet of the Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Barron, M. G., R. A. Heintz, and M. M. Krahn. 2003. Contaminant exposure and effects in pinnipeds: Implications for Steller sea lion declines in Alaska. Sci. Total Environ. 311:111-133.

Battaile, Brian C. 2005. A Walleye Pollock (*Theragra chalcogramma*) Depletion Estimator for the Eastern Bering Sea. PhD Dissertation, University of Alaska Fairbanks, Fairbanks, Alaska. 180 pp.

Battaile, B.C., and T.J. Quinn, II. in press. A DeLury depletion estimator for walleye pollock (*Theragra chalcogramma*) in the eastern Bering Sea. Natural Resource Modeling.

Beck, C.A., L. D. Rea, S. J. Iverson, J. Kennish, K.W. Pitcher, and D. J. Tollit. 2004. Using fatty acids to investigate dietary changes in young Steller sea lions (*Eumetopias jubatus*) in Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Beck, C.A., L.D. Rea, S.J. Iverson, J.M. Kennish, D. Tollit, and K.W. Pitcher. 2005. Estimating diet of young Steller sea lions using quantitative fatty acid signature analysis (QFASA). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Beck, C., L.D. Rea, S.J. Iverson, J.M. Kennish, D. Tollit, and K.W. Pitcher. 2006. Using quantitative fatty acid signature analysis (QFASA) to estimate diet in young Steller sea lions (SSL) in Prince William Sound, Alaska. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Beck, C., L. Rea, J. Kennish, and S. Iverson. 2003. Diet differences in Steller sea lions by age and location based on fatty acid signatures. P. 14, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Beck, C., L. Rea, J. Kennish, and S. Iverson. 2003. Location and age class differences in the dietary fatty acids of young Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK[2]

Beck, C., L. Rea, and J. Kennish. 2004. Modeling diet composition of free-ranging Steller sea lions using quantitative fatty acid signature analysis. Final report to North Pacific Marine Research Institute (NPMRI) at the Alaska SeaLife Center. 25p.

Beckmen, K.B., K.A. Burek, T. Gelatt, F. Morado, S. Nadler, and E.T. Lyons. 2005. Hookworms in Steller sea lions (*Eumetopias jubatus*) in Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Beckmen, K. B., K. A. Burek, K. W. Pitcher, G. M. Ylitalo and L. K. Lawrence. 2001. Organochlorine contaminants in live Steller sea lions, *Eumetopias jubatus*. P. 20, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Beckmen, K.B., K.A. Burek, K.W. Pitcher, G.M. Ylitalo, M.M. Krahn, and J.L. Stott. 2003. An investigation of the potential effects of environmental contaminants on immune function and health in free-ranging Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK[2].

Beckmen, K., K. Burek, K. Pitcher, G. Ylitalo, and J. Short. 2003. The potential effects of environmental contaminants on immune function and health in free-ranging pinnipeds in Alaska. P. 14, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Beckmen, K.B., K. A. Burek, L. D. Rea, and T. S. Gelatt. 2004. A health assessment approach to Steller sea lion research in Alaska. Presented paper. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Beckmen, K. B., L. K. Duffy, X. Zhang, and K. W. Pitcher. 2002. Mercury concentrations in the fur of Steller sea lions and northern fur seals from Alaska. Marine Pollution Bulletin 44 (10):1130-1135.

Beckmen, K.B., K.W. Pitcher, K.A. Burek, G.M. Ylitalo, and M.M. Krahn. 2003. Population survey of organochlorine contaminant exposure in Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.[2]

Beckmen, K.B., J.L. Stott, K.A. Burke, and K.W. Pitcher. 2002. Studies of immune function in Steller sea lions. Final report to the National Fish and Wildlife Foundation and the Alaska SeaLife Center, 67 p.

Benson, A.J. and A.W. Trites. 2002. Ecological effects of regime shifts in the Bering Sea and eastern North Pacific Ocean. Fish and Fisheries 3:95-113.

Berman, M. 2005. Modeling effects of habitat closures in ocean fisheries. Prepared for North American Association of Fisheries Economists, third biennial forum. PDF available thru NPFMC.

Berman, M. L. and L. D. Rea. 2000. The effects of food deprivation on serum lipid concentration and content in Steller sea lions (*Eumetopias jubatus*). Third Biennial symposium of the Comparative Nutrition Society, Pacific Grove, California. August 4-9, 2000.

Bickham, J.W. 2005. Variation in mitochondrial DNA of Steller sea lions: Cytochrome b and control region sequences from juveniles and pups from western stock rookeries. Annual report to National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115. 27 pp.

Bickham, J. R. Trujillo, and T. Loughlin. 2002. Genetic variability and population structure in an endangered marine mammal (*Eumetopias jubatus*). *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Bickham, J.W., and T. R. Loughlin. 2003. Genetic variability and population structure in an endangered marine mammal (Steller sea lion, *Eumetopias jubatus).* In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.[2]

Bininda-Edmonds, O.R.P. 2000. Pinniped brain sizes. Marine Mammal Sci. 16(2):469-481.

Bishop, A. 2006. Designation of critical habitat under the Endangered Species Act for marine mammals in the US EEZ: Evolution of designation criteria based on recent litigation. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK [6]

Bleakney, K., J.R. Carpenter, and S. Atkinson. 2005. Rate of passage and assimilation efficiency of herring diets containing different fat levels in harbor seals. Chapter 5, pages 31-42, in Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Bodtker, K.M., E.S. Gregr, E. Carruthers, D.L. Musgrave, and A.W. Trites. 2005. Predicting the spatial distribution of Steller sea lion prey based on modeled physical oceanography. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Bogdanova, L.N. 2004. Breeding of Steller sea lions (*Eumetopias jubatus*) and their functional control in captivity. Pages 82-85, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.[1]

Boldt, J. (Editor). 2003. Ecosystem considerations for 2004. Appendix: Stock assessment and fishery evaluation report for the groundfish resources of the EBS/AI and GOA. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. 336p.

Boldt, J. (Editor). 2004. Ecosystem considerations for 2005. Appendix: Stock assessment and fishery evaluation report for the groundfish resources of the EBS/AI and GOA. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. 260p.

Boldt, J. (Editor). 2005. Ecosystem considerations for 2006. Appendix: Stock assessment and fishery evaluation report for the groundfish resources of the EBS/AI and GOA. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. 314p.

Bowen, L., B. Aldridge, T. Gelatt, L. Rea, K. Burek, K. Beckmen, and J.L. Stott. In press. Differential expression of immune response genes in Steller sea lions: a tool for timely identification of alterations in ecosystem health? J. Ecosystem Health.

Bowen, W. D., H. Harwood, D. Goodman, and G. L. Swartzman. 2001. Review of the November 2000 Biological Opinion and Incidental Take Statement with respect to the western stock of the Steller sea lion. Final Report to the North Pacific Fisheries Management Council, May, 2001. 19 p.

Boyd, I.L. 2004. Steller sea lion telemetry studies: A review conducted for the Center for Independent Experts. Manuscript Rpt, Center for Independent Experts. 14p.

Bozza, M., and S. Atkinson. 2003. Molecular cloning of Steller sea lion (*Eumetopias jubatus*) interleukin-1 beta (IL-1beta) from a LPS-stimulated mononuclear cell cDNA library. P. 22, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Bozza, M., and S. Atkinson. 2005. Steller sea lion cytokine immunoassay development . Chapter 14, pages 121-134, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Bracht, A,J,, R.L. Brudek, R.Y. Ewing, C.A. Manire, K.A. Burek, C. Rosa, K.B. Beckmen, J.E. Maruniak, and C.H. Romero. 2005. Genetic identification of novel poxviruses of cetaceans and pinnipeds. Archives of Virology, published on line November 21, 2005, Springer-Velag.

Brandon, E. A. A. 2000. Maternal investment in Steller sea lions in Alaska. Ph.D. dissertation, Texas A&M Univ., Galveston, TX. 136 p.

Brandon, E.A.A., D.G. Calkins, T.R. Loughlin, and R.W. Davis. 2005. Neonatal growth of Steller sea lion pups in Alaska. Fishery Bulletin, U.S. 103:246-257.

Bredesen, E.L., A. P. Coombs, and A. W. Trites. 2004. Assessing overlap between Steller sea lion diets and fish distributions in the North Pacific. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Bredesen, E.L., A.P. Coombs, and A.W. Trites. In press. Relationship between Steller sea lion diets and fish distributions in the eastern North Pacific. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

Briggs, H.B., D. Calkins, and R.W. Davis. 2004. Movements and diving behavior of juvenile Steller sea lions (*Eumetopias jubatus*) during the winter and spring in southcentral Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Briggs, H.B., D.G. Calkins, and R. W. Davis. 2005. Habitat associations and diving patterns of juvenile Steller sea lions in the north-central Gulf of Alaska. Chapter 7, pages 59-67, *in* Loughlin, T.

R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Briggs, H.B., D.G. Calkins, R.W. Davis, and R. Thorne. 2005. Habitat associations and diving activity of subadult Steller sea lion (*Eumetopias jubatus*) during the winter and spring in north-central Gulf of Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Brown, M.N., B. L. Gerke, and W.J. Wilson. 2004. Steller sea lion protection measures in the Alaska groundfish fisheries: Spatial and temporal harvest control. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK. [6]

Brown, R. F., S. D. Riemer, and B. E. Wright. 2002. Population status and food habits of Steller sea lions in Oregon. Report from Oregon Department of Fish and Wildlife to Oregon State Univ. Contract F0225A-01. 17 pp.

Browne, P. 2004. Some aspects of the reproductive physiology of otariid pinnipeds. Ph.D. Dissertation. University of California, Davis. 130 p.

Browne, P. A.J. Conley, T. Spraker, R.R. Ream, and B.L. Lasley. 2006. Sex steroid concentrations and localization of steroidogenic enzyme expression in free-ranging female northern fur seals (*Callorhinus ursinus*). General and Comparative Endocrinology. Article in press, PDF of galley provided by author.

Brunner, S. 2002. Geographic variation in skull morphology of adult Steller sea lions *(Eumetopias jubatus*). Marine Mammal Science, 18:206-222.

Brunner, S. 2003. Fur seals and sea lions (Otariidae): identification of species and taxonomic review. Systematics and Biodiversity 1 (3):339-439.

Bryant, J., M. Riedel, and J. Fall. 2006. Community-based harvest monitoring of subsistence harvest of harbor seals and Steller sea lions. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Buck, C. L., S. D. Kildaw, K. A. Murra, J. B. Gamble, and B. Fadely. 2003. Seabird component of the GAP project: indicators of marine conditions and potential competitors of Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.[2]

Burdin, A.M., T. Yu. Lisitsina, V.N. Burkanov, D. Calkins, S. Atkinson, and D. Zats. 2002. Application of remote video system for biological research on Steller sea lion (*Eumetopias jubatus*) at Cape Kozlova (Kronotskiy State Reserve, Kamchatka). *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Burdin, A.M., T. Yu. Lisitsina, and V.S. Nikulin. 2002. How conservative are Steller sea lion (*Eumetopias jubatus*) females choosing reproductive grounds? *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Burdin, A.M., D. G. Calkins, S. Atkinson, and D. Maldini. 2005. Killer whale surveys in the Russian Far East.: 2002-2004. Chapter 23, pages 227-237, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

Burek, K.A. K. B. Beckmen, T. Gelatt, F. Morado, and S. Nadler. 2004. Hookworms in Steller sea lions (*Eumetopias jubatus*) in Alaska. Presented paper. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Burek, K.A., F.M.D. Gulland, G. Sheffield, D. Calkins, E. Keyes, T.R. Spraker, A.W. Smith, D.E. Skilling, J. Evermann, J.L. Stott and A.W. Trites. 2003. Disease agents in Steller sea lions in Alaska: A review and analysis of serology data from 1975-2000. Fisheries Centre Reports 11 (4), 26 pages.

Burek, K.A., F.M.D. Gulland, G. Sheffield, K.B. Beckman, E. Keyes, T.R. Spraker, A.W. Smith, D.E. Skilling, J.E. Evermann, J.L. Stott, J.T. Saliki and A.W. Trites. 2005. Infectious disease and the decline of Steller sea lions (*Eumetopias jubatus*) in Alaska: insights from serology data. Journal of Wildlife Diseases 41: 512-524.

Burek, K. B., R. Zarnke, T. Spraker and A. Trites. 2001. Historical and current serology in Steller sea lions in Alaska. P. 35, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

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). Marine Mammals of the Holarctic Regions: Materials from international Conference, Archangelsk, Russia, 21-23 September, 2000. Archangelsk. Pages. 56-65. (in Russian).

Burkanov, V.N. 2006. Steller sea lion and northern fur seal surveys in Kuril Islands (Russia), 2005. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Burkanov, V.N., U.B. Artukhin, P. Browne, A. Wada, D. Wate, M.U. Zasypkin, D. Calkins, I.A. Nevedomskaya, N.N. Pavlov, A.M. Trukhin, and H. Hoshino. 2002. Brief results of survey of Steller sea lion rookeries and haulouts in the waters of the Russian Far East in 2001. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Burkanov, V.N., and D.G. Calkins. 2005. Breeding performance of marked Steller sea lion (*Eumetopias jubatus*) in Russian waters. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Burkanov, V. N**.**, D. Calkins, and T. R. Loughlin. 2003a. Steller sea lion survey in the western Bering Sea and the Kamchatka Peninsula in 2002. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Burkanov, V., D. Calkins, and T. Loughlin. 2003b. Steller sea lion survey in the western Bering Sea and the Kamchatka Peninsula in 2002. P. 26**, i***n* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Burkanov, V.N., D.G. Calkins, and T.R. Loughlin. 2005. Steller sea lion abundance in Russia in 2004. In: Marine science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK. (**3**)

Burkanov, V.N., and T.R. Loughlin. 2004. Historic distribution and abundance of Steller sea lion (*Eumetopias jubatus*) in the northwestern Pacific, 1700s-200s. Pages 111-112, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.[1]

Burkanov, V.N., and T.R. Loughlin. 2004. Historic changes in distribution and abundance of Steller sea lions in the western Pacific, 1700s–2002. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Burkanov, V.N., and T.R. Loughlin. In review. Distribution and abundance of Steller sea lions on the Asian coast, 1720s – 2005. Marine Fishery Review.

Burkanov, V.N., T.R. Loughlin, , and D.G. Calkins. 2004. Unusual mortality of female Steller sea lions. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Burkanov, V.N., and E.G. Mamaey. 2004. Effect of marking operations on pup survival at Medny Island (Russia), 1991-2001. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Burkanov, V., J. M. Maniscalco and E. G. Mamaev. 2001. Identification and tracking of individual Steller sea lions at Chiswell Island rookery (Alaska) with the use of a remote control video system. P. 35, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Burns, J.M., C. A. Clark, J.P Richmond. 2004. The impact of lactation strategy on physiological development of juvenile marine mammals: implications for the transition to independent foraging. Comparative Physiology and Biochemistry, International Congress Series, 1275: 341-350.

Burns, J.M., M.J. Rehberg, and J.P. Richmond. 2003. Diving behavior and physiology in juvenile Steller sea lions: What are the links? In: Marine science in the Northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.[1]

Burns, J.M., M. J. Rehberg, and J. P. Richmond. 2004. Juvenile Steller sea lion (*Eumetopias jubatus*) dive patterns during long and short trips to sea. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Burns, J., M.J. Rehberg, and J.P. Richmond. 2006. Working in the dark: Winter diving and foraging patterns in juvenile Steller sea lions. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Burns, J., J. Richmond, and M. Rehberg. 2003. Linking diving behavior and physiology in juvenile Steller sea lions. P. 26, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Burns, J.M.. T.M. Williams, S.M. Secor, N. Owen-Smith, N.A. Bargmann, M.A. Castellini. In press. New insights into the physiology of natural foraging. Physiological and Biochemical Zoology.

Calkins, D. G. 2000. Investigation of the intentional killing of Steller sea lions in Japan=s commercial fisheries. Calkins Wildlife Consulting, 12600 Elmore Road, Anchorage, AK, 99516-2904, Revised by Bohan, January 2000, 17p. Available, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

Calkins, D.G., and S. Atkinson. 2005. Introduction. Chapter 1, pages 1-5, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Calkins, D.G., M. Castellini, V. Burkanov, S. Atkinson, S. Inglis, and D. Hennen. 2005. Impact of changing diet regimes on Steller sea lion body condition. Chapter 2, pages 6-18, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Calkins, D.G., J.-A. Mellish, S. Atkinson, and D. Hennen. 2005. Does consuming pollock truly have negative impacts on free-ranging Steller sea lions? *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Call, K.A., B.S. Fadely, and A. Greig. 2004. Attendance patterns of juvenile Steller sea lions (*Eumetopias jubatus*) in the Gulf of Alaska and Aleutian Islands derived from satellite dive recorders (SDRs). Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Call, K.A., and T.R. Loughlin. 2005. An ecological classification of Alaskan Steller sea lion (*Eumetopias jubatus*) rookeries: A tool for conservation management. Fisheries Oceanography 14 (Suppl. 1):212-222.

Campbell, G. S., R. C. Gisiner, D. A. Helweg, and L. L. Milette. 2002. Acoustic identification of female Steller sea lions (*Eumetopias jubatus*). Journal of the Acoustical Society of America 111(6):2920-2928.

Capron, S., and L. Fritz. 2004. How uncertainties about competition between Steller sea lions and U.S. groundfish fisheries off Alaska have been addressed in fisheries regulations. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK. [6]

Carpenter, J.R., C. L. Morishige, and B. Rasco. 2005. Utilization of near infrared spectroscopy (nirs) and dry matter to predict the nutrient composition of Pacific herring. Chapter 6, pages 43-58, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Carretta, J. V., M. M. Muto, J. Barlow, J. Baker, K. A. Forney, and M. Lowry. 2002. U.S. Pacific Marine Mammal Stock Assessments: 2002. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-346. 290 p.

Carretta, J. V., M. M. Muto, J. Barlow, J. Baker, K. A. Forney, and M. Lowry. 2005. U.S. Pacific Marine Mammal Stock Assessments: 2002. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-. 320 p.

Castellini, M.A. 2001. Using bio-electrical impedance to measure the body composition of seals and sea lions. FASEB Journal. 15(1): A90.

Castellini. M. 2004. A decade of adult Steller physiology in the field: Where are we now? Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Castellini, M., D. Calkins, V. Burkanov, J. M. Castellini, S. Trumble and T. Mau. 2001. Long-term feeding trials with harbor seals and Steller sea lions: Impact of differential diets on health and nutrition. P. 40 *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Castellini, M.A., L. Zhao, and S. Inglis. 2005. Metabolic demands of Steller sea lion survival. Chapter 8, pages 68-76, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Catterson, N. and B. Lucey. 2002. Seasonal abundance of Steller sea lions at Dry Bay, Alaska. Unpublished Report, USDA Forest Service, Tongass National Forest, Yakutat Ranger District, May 2002, 7p.

Chelnokov, F.G. 2004. Marking and survival of Steller sea lion pups (*Eumetopias jubatus*) in Medny Island in 2002. Pages 573-575, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.[1]

Cheneval, O. 2005. Biomechanics of turning maneuvers in Steller sea lions (*Eumetopias jubatus*). M.S. Thesis, University of British Columbia, Vancouver, Canada. 64 p.

Cheneval, O., D. A. S. Rosen, R. D. Andrews and A. W. Trites. 2001. Foraging behavior and energetics of captive Steller sea lions. P. 42, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Cherel, Y., and G. Duhamel. 2004. Antarctic jaws: cephalopod prey of sharks in Kerguelen waters Deep-Sea Research I 51:17–31.

Christen, D., K. Mashburn, and C. Stephens. 2003. Monitoring a male Steller sea lion into adulthood. P. 32, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p

Colvocoresses, J.A. 2004. Characterization of the humoral immune system of the Steller sea lion, *Eumetopias jubatus*, and development of reagents and assays for quantitative measure of humoral immunity. Ph.D. Dissertation, The University of Southern Mississippi, 163 pp.

Colvocoresses, J., B. Middlebrooks, and R. Patterson. 2003. Production and characterization of monoclonal antibodies against Steller sea lion immunoglobulins. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.[2]

Colvocoresses, J., R. A. Patterson and B. L. Middlebrooks. 2000. Purification of immunoglobulin isotypes G, A, and M from the serum of the Steller sea lion (*Eumetopias jubatus*). Pages 477-478, Annual Conference - American Association of Zoo Veterinarians.

Conners, M. E., A. B. Hollowed and E. Brown. 2002. Retrospective analysis of Bering Sea bottom trawl surveys: regime shift and ecosystem reorganization. *Progress in Oceanography* 55:209-222.

Conners, M.E., E. A. Logerwell, and P. Munro. 2004. Fishery effects: Testing the local depletion hypothesis. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Conners, M.E., P. Monro, E.A. Logerwell, and S. Neidetcher. 2006. Results of the Pacific cod local depletion study. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Conners, M.E., P. Munro, S. Neidecheter. 2004. Pacific cod pot studies 2002-2003. NOAA NMFS-AFSC-Processed Report 2004-04. 131p.

Coombs, A.P., and A.W. Trites. 2005. Steller sea lion haulouts: breeding locations for non-pregnant females? *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Cornick, L.A. 2001. Optimal forging theory as a model to examine the relationship between relative prey accessibility and forging energetics in Steller sea lions (*Eumetopias jubatus*) in the Gulf of Alaska and Bering Sea. Ph.D. dissertation, Texas A&M University.

Cornick, L.A. 2005. Examining the relationship between prey availability, behavior, and energetic gain in captive Steller sea lions. Chapter 4, pages 27-30, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Cornick, L. A. and M. Horning. 2000. Simulated foraging experiments on captive diving mammals: A feasibility study with Steller sea lions (*Eumetopias jubatus*). Federation of American Societies for Experimental Biology Journal 14(4):440.

Cornick, L.A. and M. Horning. 2001. Simulating pinniped foraging in captivity: Experimental validation of foraging theory predictions. P. 47, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Cornick, L. A. and M. Horning. 2001. Examining the relationship between relative prey accessibility and sea lion dive behavior: An experimental approach. Federation of American Societies for Experimental Biology Journal 15(4):90.

Cornick, L., and M. Horning. 2003. A test of hypotheses based on optimal foraging considerations for a diving mammal using a novel experimental approach. Can. J. Zool. 81(11): 1799-1807.

Cornick, L.A., S.D. Inglis, K. Willis, and M. Horning. In press. Effects of increased swimming costs on foraging behavior and efficiency of captive Steller sea lions: evidence for behavioral plasticity in the recovery phase of dives. Journal of Experimental Marine Biology and Ecology.

Cottrell, P.E. and A.W. Trites. 2002. Classifying prey hard part structures recovered from fecal remains of captive Steller sea lions (*Eumetopias jubatus*). Marine Mammal Science 18:525-539.

Courtney, D.L. and M.F. Sigler. 2003. Analysis of Pacific sleeper shark (*Somniosus pacificus*) abundance trends from sablefish longline surveys 1979 – 2003. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska as projected for 2004. Ecosystem considerations for 2004. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501. p155-169

Courtney, D.L., C. Tribuzio, S. Gaichas, and K. J. Goldman. 2005. BSAI sharks. Pages 881-924, *in* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea and

Aleutian Islands as projected for 2006. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Cupakhina, T.I., O.I. Ponteleeva, and V.N. Burkanov. 2004. Distribution and abundance of Steller sea lion (*Eumetopias jubatus*) on haul out sites of Sakhalin Island. Pages 581-585, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.[1]

Curgus, C.S. M.S. thesis. See Kaplan, C.C. 2005.

Curgus, C. S., D. McAllister, K. Raum-Suryan, K. Pitcher and W. Cunningham. 2001. Live-capture method for Steller sea lions using SCUBA. P. 51, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Dahlheim, M.E., D.K. Ellifrit, and P.A. White. 2004. Kill rates and prey preferences of Southeast Alaska transient killer whales (*Orcinus orca*). In: Marine Science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK

Dailey, M. D., R. S. Demaree, and R. L. Critchfield. 2002. *Galactosomum stelleri* sp. n. (Trematoda: Heterophydae) from northern sea-lion, *Eumetopias jubatus* (Schreber, 1776) (Carnivora: Otariidae). Comparative Parasitology 69(1): 58-61.

Daniel, R.G. 2003. The timing of moulting in wild and captive Steller sea lions (*Eumetopias jubatus*). M.S. Thesis, University of British Columbia, Vancouver, B.C. 64 p.

Daniel, R., and A.W. Trites. 2003. Timing of moulting in Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.[2]

Davis, R.W., A.A. Brandon, D. Calkins, and T.R. Loughlin. 2004. Indices of reproductive effort and nutritional health in lactating Steller sea lions and pups in areas of declining and stable population . Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Davis, R.W., A.A. Brandon, D. Calkins, and T.R. Loughlin. 2006. Female attendance and neonatal pup growth in Steller sea lions (*Eumetopias jubatus*). Pages ___, *in* A. Trites, S. Atkinson, D. DeMaster, L. Fritz, T. Gelatt, L. Rea, and K. Wynne (eds.). Sea lions of the world. Alaska Sea Grant College Program, University of Alaska Fairbanks.

Davis, R., H. Briggs, and D. Calkins. 2004. Winter movements and diving behavior of juvenile Steller sea lions (*Eumetopias jubatus*) in south-central Alaska. Page 188, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.[1]

Deagle, B.E., D.J. Tollit, S.N. Jarman, M.A. Hindell, A.W. Trites and N.J.Gales. 2005. Molecular scatology as a tool to study diet: analysis of prey DNA in scats from captive Steller sea lions. Molecular Ecology 14: 1831-1842.

Deecke, V. B., Ford, J.K.B., Slater, P.J.B. 2005. The vocal behaviour of mammal-eating killer whales (*Orcinus orca*): communicating with costly calls. Animal Behaviour 69:395-405.

Deecke, V.B., J.K.B. Ford, and P.J.B. Slater. 2006. Studying killer whale predation in the field: a sound approach to detecting kills. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

deHart, P.A.P., and M.J. Wooller. 2004. Shouldn't we ask where? Stable isotopic evidence of geographical variations in Steller sea lion (*Eumetopias jubatus*) diets. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

deHart, P.A.P., and M.J. Wooller. 2005. A temporal perspective on pinniped foraging ecology: stable isotope variations in the teeth and bones of Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

DeMaster, D.P. 2001. Evaluating the impact of reasonable and prudent alternatives for the management of the BSAI and GOA groundfish fisheries on the western Stock of Steller sea lion. Unpublished NMFS White paper.

DeMaster, D. and S. Atkinson. 2002. Steller Sea Lion Decline: Is It Food II. University of Alaska Sea Grant, AK-SG-02-02, Fairbanks. 80 pp. *(Numerous papers were presented at this workshop that have individual authorship but are NOT included in this citation list—see appendix 3).*

DeMaster, D. P., A.W. Trites, P. Clapham, S. Mizroch, P. Wade, and R.J. Small. 2006. The sequential megafaunal collapse hypothesis: testing with existing data. Progress in Oceanography 68: 329-342.

Denisenko, T., O. Sokolovca, and V.N. Burkanov. 2005. Microflora of Steller sea lion pups (*Eumetopias jubatus*) of the Kamchatka and Commander Islands. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Dillingham, P. K. Ryding and J.R. Skalski. 2004. Assessment of fine-scaled interaction between Steller sea lion abundance and trends of local fisheries. Manuscript Rept., NOAA/NMFS/AFSC SSLRI Program, Juneau, AK. 147 p.

Dillingham, P.K., J.R. Skalski, and P.K. Ryding. 2006. Fine-scale geographic interactions between Steller sea lion (*Eumetopias jubatus*) trends and local fisheries. Can. J. Fish. Aquat. Sci. 63:107-119.

Donnelly, C.P. 2001. Possible effects of pollock and herring on the growth and reproductive success of Steller sea lions: insights from feeding experiments using an alternative animal model, *Rattus novegicus.* M.S. thesis, University of British Columbia. 76 p.

Donnelly, C.P., and A.W. Trites. 2000. The nutritional stress hypothesis as it relates to Alaskan pinnipeds. Unpublished manuscript, Marine Mammal Research Unit, Fisheries Centre, University of British Columbia, 2204 Main mall, Vancouver, B.C. V6T 1Z4 26 p.

Donnelly, C., A. W. Trites, and D. D. Kitts. 2000. Alternative models for assessing the role of nutrition in the population dynamics of marine mammals. Pages 41-45, *in* C.L.K. Baer, editor, Proceedings of the Third Comparative Nutrition Society Symposium, No. 3, Pacific Grove, California, August 4-9, 2000.

Donnelly, C.P., A.W. Trites, and D.D. Kitts. 2003. Possible effects of pollock and herring on the growth and reproductive success of Steller sea lions: insights from feeding experiments using an alternative animal model, *Rattus novegicus*. British Journal of Nutrition 89:71-82.

Dorn, M., K. Aydin, S. Barbeaux, M. Guttormsen, B. Megrey, K. Spalinger, and M. Wilkins. 2005. Assessment of walleye pollock in the Gulf of Alaska. *In*: Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pac. Fish. Mgmt. Council, Anchorage, AK, 1:41-153.

Dunford, B., S. McKinley, R. Petrell, A.W. Trites, M. Yedlin, and R. Virtue. 2003. An implantable radio identification tag for Steller sea lions. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.[2]

Dunlap-Harding, W. S., L. D. Rea, K. W. Pitcher and S. D. Farley. 2001. Body condition of free-ranging Steller sea lions estimated by deuterium isotope dilution. P. 63, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Eberhardt, L.L., J.L. Sease, and D.P. DeMaster. 2005. Projecting the trend of Steller sea lion populations in western Alaska. Marine Mammal Science 21(4):728-738 .

Fadely, B.S., editor. 2001. Steller sea lion investigations, 2000. U.S. Department of Commerce, Seattle, WA. (AFSC Processed Report 2001-05) 226 p. (see appendix 3.)

Fadely, B.S., V.N. Burkanov, and T. Loughlin. 2002. Analysis of Steller sea lion pup condition in Russia and Alaska. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Fadely, B., R. Foy, K. Call, K. Wynne, A. Greig, and J. Sterling. 2003. Behavior of juvenile Steller sea lions in relation to available prey distribution in eastern Kodiak Island waters. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Fadely, B.S., T.S. Gelatt, L.D. Rea, J.C. King, and T.R. Loughlin. 2004. Geographic differences among juvenile Steller sea lions (*Eumetopias jubatus*) growth rates in Alaska. Pages 567-568, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine.[1]

Fadely, B.S., T.S. Gelatt, L.D. Rea, J.C. King, and T.R. Loughlin. 2004. Regional variation of juvenile Steller sea lion (*Eumetopias jubatus*) growth rates in Alaska . Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Fadely, B. and T. R. Loughlin. 2001. Weak association between Steller sea lion pup condition and population and environmental trends in western Alaska. P. 68, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Fadely, B., B. Robson, J. Sterling, A. Grieg, and K. Call. 2003. Defining marine habitat use of immature Steller sea lions through the use of satellite telemetry and GIS. P. 49, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Fadely, B.S., B.W. Robson, J.T. Sterling, A. Grieg, and K.A. Call. 2005. Immature Steller sea lion (*Eumetopias jubatus*) dive activity in relation to habitat features of the eastern Aleutian Islands. Fisheries Oceanography 14 (Suppl. 1):243-258.

Fall, J.A. 2003. The subsistence harvest of Steller sea lions by Alaska natives in 2001. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Farley, S.D., V.K. Stegall. L.D. Rea, and W.I. Ridley. 2003. Application of laser ablation ICP-MS to elemental fingerprinting and isotope analysis to evaluate nutritional history and diet of Steller sea lions. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Farley, S.D., V.K. Stegall, L.D. Rea, A. Koening, I. Ridley, and P.J. LaMotte. 2005. Trace element composition in vibrissae, milk, and serum of Alaska Steller sea lion (*Eumetopias jubatus*): Identification of weaning and dietary shifts. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Fay, G. 2004. A Bayesian-stochastic metapopulation model for Steller sea lions in Alaska. M.S. Thesis, School of Aquatic and Fishery Sciences, Univ. of Washington, Seattle. 253 p.

Fay, G., and A.E. Punt. 2003. A Bayesean stochastic metapopulation model for Steller sea lions. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Fay, G., and A.E. Punt. 2004. A Bayesian stochastic metapopulation model for Steller sea lions (*Eumetopias jubatus*): Evaluating changes in model fits with different assumptions about the causes for population decline. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Ferrero, R. C., D. P. DeMaster, P. S. Hill, M. M. Muto, and A. L. Lopez. 2000. Alaska marine mammal stock assessments. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-AFSC-119. 191 pp.

Ferrero, R. C. and L. W. Fritz 2002. Steller sea lion research and coordination: a brief history and summary of recent progress. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-129. 34 p.

Foy, C.L., B. Konar, K.M. Wynne, and S. Hills. No date. Seasonal habitat use by nearshore fishes around Steller sea lion haulouts of Kodiak Island. Unpublished manuscript.

Foy, R.J., and K.M. Wynne. 2003. Availability and use of prey by Steller sea lions in Kodiak, Alaska in 2000. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Fritz, L., compiler. 2003. Alaska Fisheries Science Center Steller sea lion research project reports fiscal year 2002. U.S. Department of Commerce, NOAA, AFSC Processed Report 2003-08. 145 p.

Fritz, L.W., and E. S. Brown. 2005. Survey and fishery-derived estimates of Pacific cod (*Gadus macrocephalus*) biomass: implications managing Steller sea lion (*Eumetopias jubatus*) and groundfish fishery interactions. Fishery Bulletin 103:501-515.

Fritz, L, T. Gelatt, W. Perryman, R. Ream, C. Stinchcomb, and R. Towell. 2005. Differences in recent trends in the populations of western Steller sea lions and northern fur seals in Alaska. *In* Marine Science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

Fritz, L.W., and S. Hinckley. 2003. A critical review of the 'Regime shift/junk food' hypothesis for the Steller sea lion decline. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Fritz, L., and S. Hinckley. 2004. A critical review of the regime shift–"junk food" hypothesis for the decline of the western stock of Steller sea lion. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Fritz, L.W., and S. Hinckley. 2005. A critical review of the regime shift-"junk food"-nutritional stress hypothesis for the decline of the western stock of Steller sea lion. Marine Mammal Science 21:476-518.

Fritz, L.W., and C. Stinchcomb. 2005. Aerial, ship, and land-based surveys of Steller sea lions (*Eumetopias jubatus*) in the western stock in Alaska, June and July 2003 and 2004. NOAA Technical Memorandum NMFS-AFSC-153. 56p.

Fritz, L., C. Stinchcomb, T. Loughlin, and W. Perryman. 2004. Status of the western Steller sea lion (*Eumetopias jubatus*) population in 2004. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Gallucci, V., I. Taylor, and J. Rice. 2003. Competitive interactions: Steller sea lions and sharks. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Gauthier, S., and J.K. Horne. 2004. Acoustic characteristics of forage fish species in the Gulf of Alaska and Bering Sea based on Kirchoff-approximation models. Can. J. Fish. Aquat. Sci. 61: 1839-1850.

Gauthier, S. and J.K. Horne. 2004. Potential acoustic discrimination within boreal fish assemblages. ICES J. of Mar. Sci. 61: 836-845.

Gelatt, T.S., and M.J. Rehberg. Coastal bathymetry within the range of Steller sea lions in Alaska Steller Sea Lion Research Initiative Project 01-SSL-065. Alaska Department of Fish and Game, 525 West 67th Ave., Anchorage AK 99518 10p.

Gende, S., and M. Sigler. 2004. Persistence of prey "Hot Spots" for Steller sea lions in Southeast Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Gende, S., and M. Sigler. 2006. Persistence of forage "hot spots" and its association with foraging Steller sea lions in Southeast Alaska. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Gende, S., and M. Sigler. In press. Predictability of prey available to Steller sea lions in Southeast Alaska. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

Gende, S., M., J. N. Womble, M. F. Willson, and B. H. Marston. 2001. Cooperative foraging by Steller sea lions, *Eumetopias jubatus*. Canadian Field-Naturalist 115:355-356.

Gerber, L.R., and G.R. VanBlaricom 2001. Implications of three viability models for the conservation status of the western population of Steller sea lions (*Eumetopias jubatus*). Biological Conservation 102: 261-269.

Gerber, L.R., and R. Hilborn. 2001. Catastrophic events and recovery from low densities in populations of otariids: implications for risk of extinction. Mammal Rev. 31: 131-150. (**3**)

Goertz, C.E.C., S.S. Wise, J.L. Dunn, F. Gulland, A.T. Morin., N. Jayasundara, M. Bozza, S. Atkinson, and J.P. Wise Sr. 2003. Sodium Chromate and Cadmium Chloride Toxicity in Steller Sea Lion Dermal, Renal, Bronchial, and Testicular Cells. Presented at the Northeast Society of Toxicology (NESOT) Annual Meeting, November 2003.

Goertz, C.E.C., S.S. Wise, J.L. Dunn, F. Gulland, A.Morin, N. Jayasundara, M. Bozza, S. Atkinson, and J.P. Wise, Sr. 2004. Sodium chromate and cadmium chloride toxicity in Steller sea lion cells. The Toxicologist, 78 (S-1): no. 756.

Goertz, C.E.C., S.S.Wise, J.L. Dunn, M. Bozza, S. Atkinson, F. M.D. Gulland, R.J.Taylor, and J.P. Wise, Sr. 2004. In vitro metal toxicity in Steller sea lion (*Eumetopias jubatus*) fibroblasts with an emphasis on hexavalent chromium. Proceedings of the Annual Meeting of the International Association of Aquatic Animal Medicine, 35: 74-75 2004.

Goertz, C.E.C., S.S. Wise, J.L. Dunn, F.M.D. Gulland, A. Morin, N. Jayasundra, M. Bozza, S. Atkinson, and J.P. Wise, Sr. 2004. Sodium chromate toxicity and uptake in Steller sea lion cells. Proceedings of the 22nd Wakefield Fisheries Symposium: Sea Lions of the World Conservation and Research in the 21st Century. September, 2004.

Goldstein, T. 2005. Report on the workshop to assess the effects of disease on Steller sea lion (*Eumetopias jubatus*) populations. Report of a workshop held at the ASLC, 20-21 January 2004, S. Atkinson, D. Calkins, and F. Gulland (eds.). Available ASLC, 301 Railway Ave., Seward, AK 99664.

Goldstein, T., D. G. Calkins, and S. Atkinson. 2005. Workshop to asses the effects of disease on Steller sea lion populations. Chapter 31, pages 302-307, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Gregr, E.J., and A.W. Trites. 2003. Probability of distributional overlap between Steller sea lions and commercial trawl fisheries in Alaska. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.[2]

Gregr, E.J., and A.W. Trites. 2004. Estimating ecological niche overlap between Steller sea lions and commercial trawl fisheries in Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Gregr, E.J., and A.W. Trites. 2005. Evaluating ecological niche overlap between Steller sea lions and commercial trawl fisheries in Alaska. *In* Marine science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

Gregr, E.S., and A.W. Trites. 2005. Using overlap indices to assess the efficacy of regulations designed to reduce competition between fisheries and Steller sea lions. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Gregr, E. and A.W. Trites. In review. Assessing the distributional overlap between Steller sea lions and commercial trawl fisheries in Alaska. Ecological Applications.

Guénette, S., and V. Christensen. 2005. Food web models and data for studying fisheries and environmental impacts on Eastern Pacific ecosystems. Univ. British Columbia, Fisheries Centre Research Reports Vol. 13(1) pp. 237

Guénette, S., S.J.J. Heymans, V. Christensen, and A.W. Trites. 2005. Ecosystem analysis of Steller sea lions dynamics, their prey and predators. *In* Marine science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

Guénette, S., S.J.J. Heymans, V. Christensen, and A.W. Trites. 2004. The decline of Steller sea lions and the ecosystem of the Gulf of Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Gurarie, E., V.N. Burkanov, E. Mamaev, and S. Purtov. 2005. Comparison of maternal attendance patterns on two Steller sea lion (*Eumetopias jubatus*) rookeries in Russia. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Hamblen, E.E., J.J. Scordino, and S.S. Heppell. 2005. Nursing duration and frequency in determining Steller sea lion weaning. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Hare, S. R., and N. J. Mantua. 2000. Empirical evidence for North Pacific regime shifts in 1977 and 1989. Prog. Oceanogr. 47:103-146.

Harington, C.R., R.L.M. Ross, R.W. Mathewes, K.M. Stewart, and O. Beattie. 2004. A late Pleistocene Steller sea lion (*Eumetopias jubatus*) from Courtenay, British Columbia: its death, associated biota, and paleoenvironment. Can. J. Earth Sci. 41:1285–1297.

Harke, V. L. and W. G. Williams. 2000. Seasonal abundance of Steller sea lions at Dry Bay, Alaska. Unpublished Report. Project completed under the authority of the MMPA and ESA permit no. 965 issued by the National Marine Fisheries Service to the Alaska Department of Fish and Game, 9 p.

Harlin-Cognato, A., J.W. Bickham, T.R. Loughlin, and R.L. Honeycutt. 2006. Glacial refugia and the phylogeography of Steller's sea lion (*Eumetopias jubatus*) in the North Pacific. Journal of Evolutionary Biology 19:955-969.

Harmon, H.L. 2001. Seasonal reproductive endocrinology and anatomy of Steller sea lions. M.S. thesis, University of Alaska, Fairbanks.

Harmon, H.L., M.A. Castellini, J. Rowell and S. Atkinson. 2000. The use of saliva, vaginal cytology and testicular size to determine reproductive status in Steller sea lions. FASEB Journal. 14(4): A46.

Harris, K., J. Maniscalco, S. Atkinson, and P. Parker. 2005. Observations of alloparental care. Chapter 29, pages 284-289, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

Harvey, J. T., T. R. Loughlin, M. A. Perez, and D. Oxman. 2000. Relationship between fish size and otolith length for 63 species of fishes from the eastern North Pacific Ocean. U.S. Dep. Commerce, NOAA Technical Report NMFS 150. 36 p.

Hastie, G.D., D.A.S. Rosen, D.V. Gummeson, T. VanLeeuwen, R. Marshall, R.S. MacVicar, and A.W. Trites. 2005. The influence of depth on a breath-hold diver: Predicting the diving metabolism of Steller sea lions. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Hastie, G.D., D. A.S. Rosen, G.E. Wallace, and A.W. Trites. 2004. Diving physiology of Steller sea lions: Insights from trained animals in the open ocean. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Hastie, G, D.A.S. Rosen, and A.W. Trites. In press. Studying trained Steller sea lions in the open ocean. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

Hastie, G.D., D.A.S. Rosen, and A.W. Trites. In press. The influence of depth on a breath-hold diver: predicting the dive metabolism of Steller sea lions (*Eumetopias jubatus*). Journal of Experimental Marine Biology and Ecology.

Hastings, K., and T. Gelatt. 2003. Mark-recapture studies of branded sea lion pups at Lowrie Island, Alaska. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Hastings, K., and T. Gelatt. 2004. Survival of Steller sea lion pups from branding to three months after branding at Lowrie Island, Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Hastings, K. K., and W. J. Sydeman. 2002. Population status, seasonal variation in abundance, and long-term population trends of Steller sea lions (*Eumetopias jubatus*) at the South Farallon Islands, California. Fishery Bulletin 100:51-62.

Heaslip, S. G., D. J. Tollit, T. Zepplin, R. Joy, K. Call, and A. W. Ttites. 2003. Prey size selection of walleye pollock by Steller sea lions in Southeast Alaska (1994-99) assessed from skeletal remains and the application of size correction factors. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Hegwer, C.L. 2003. Seasonal abundance and diversity of nearshore fishes around Steller sea lion haulouts of Kodiak Island. M.S. Thesis, University of Alaska, Fairbanks. 77p.

Heintz, R., and M. Barron. 2001. Workshop to assess contaminant impacts on Steller sea lions in Alaska, September 5 -6, 2001, Anchorage, Alaska. Sponsored by: the Alaska Fisheries Science Center, Auke Bay Laboratory. [U.S. Department of Commerce], NOAA, NMFS, Alaska Fisheries Science Center, Auke Bay Laboratory, Juneau, AK. v.p.

Heintz, R., M. Barron, and M.M. Krahn. 2003. A science plan for evaluating the role of contaminants in the decline of Steller sea lions. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Heintz, R., M. M. Krahn, G.M. Ylitalo, and F. Morado. 2004. Organochlorine levels in Steller sea lion prey from the Aleutian Islands and Southeastern Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Heise, K., L. G. Barrett-Lennard, S. Martell, and A. Trites. 2001. Are transient killer whales the culprits: the decline of Steller sea lions in western Alaska: a simulation study. Abstracts of the 14th Biennial Conference on the Biology of Marine Mammals. Page 97.

Heise, K,. L.G. Barrett-Lennard, E. Saulitis, C. O. Matkin, and D. Bain. 2003. Examining the evidence for killer whale predation on Steller sea lions in British Columbia and Alaska. Aquatic Mammals 29:325-334.

Hennen, D. 2003. Spatial coherence and density dependence in the decline of the Steller sea lion. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Hennen, D.R. 2004. Correlations between the Steller sea lion decline and the Bering Sea/Gulf of Alaska commercial fishery. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Hennen, D. R. 2004. The Steller sea lion (*Eumetopias jubatus*) decline and the Gulf of Alaska/Bering Sea commercial fishery. Ph.D. dissertation, Montana State Univ., Bozeman, MT. 207 p.

Hennen, D. 2006. Associations between the Alaska Steller sea lion decline and commercial fisheries. Ecological Applications 16 (2):704-717.

Herman, D.P., D.G. Burrows, P.R. Wade, J. Durban, C.O. Matkin, R.G. LeDuc, L. Barrett-Lennard and M.M. Krahn. In press. Feeding ecology of eastern North Pacific killer whales from fatty acid, stable isotope and organochlorine analyses of blubber biopsies. Marine Ecology Progress Series.

Herman, D.P., P. Wade, A. Hirons, P. Krahn. 2005. Investigations into dietary specialization of killer whales in the Bering Sea and Aleutian Islands. N. Pacific Res. Board, Prog. Rpt., Proj No. F0411, Jan 1-Jun 30, 2005, 2p.

Hillman, G.R. 2005. Photo-identification of Steller sea lions. Chapter 28, pages 275-283, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Hinckley, S., C. Alvarez-Flores, J. Horne, J. Burgos, and M. Dorn. 2004. Individually based modeling of Steller sea lion foraging behavior. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Hindell, M.A. 2004. Review of the National Marine Mammal Laboratories Steller Sea Lion Telemetry Program. Manuscipt Rpt, Center for Independent Experts. 23p.

Hirons, A.C. 2001. Trophic dynamics of pinniped populations in Alaska using stable carbon and nitrogen isotope rations. PhD dissertation, University of Alaska, Fairbanks AK. 143p.

Hirons, A. C., D. M. Schell, and B. P. Finney. 2001. Temporal records δ^{13}C and δ^{15}N in North Pacific pinnipeds: inferences regarding environmental change and diet. Oecologia 129:591-601.

Hirons, A.C., D.M. Schell and D.J. St. Aubin. 2001. Growth rates of vibrissae of harbor seals (*Phoca vitulina*) and Steller sea lions (*Eumetopias jubatus*). Canadian Journal of Zoology 79:1053-1061.

Hirons, A.C., and K.M. Wynne. 2003. Seasonal forage patterns of Steller sea lions. Marine Science for the Northeast Pacific: Science for resource-dependent communities. Joint Scientific Symposium, Anchorage, AK 13-17 January 2003.

Hoberecht, L.K., G. R. VanBlaricom, and B. J. Prazen. 2004. Comparisons of blubber fatty acids between sexes of adult Steller sea lions. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Hoberecht, L., G.R. VanBlaricom, and B.J. Prazen. 2005. Comparisons of blubber fatty acids between sexes of adult Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Hoberecht, L., D.J. Vos, and G.R. VanBlaricom. 2003. Sampling Steller sea lion blubber using a remote biopsy system. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Hoberecht, L.K. D.J. Vos, and. G. R. VanBlaricom. In press. A remote biopsy system used to sample Steller sea lion (*Eumetopias jubatus*) blubber. Marine Mammal Science.

Hobson, K., Sinclair, E., York, A., Thomason, J. and Merrick, R. 2004. Retrospective isotopic analyses of Steller's sea lion tooth annuli and seabird feathers: A cross-taxa approach to investigating regime and dietary shifts in the Gulf of Alaska. Marine Mammal Science, 20 (3):621-638.

Hoffman, J.I., C. Matson, W. Amos, T. R. Loughlin, and J. W. Bickham. In press. Deep genetic subdivision within a continuously distributed and highly vagile marine mammal, the Steller's sea lion *Eumetopias jubatus*. Molecular Ecology.

Holladay, B.A., B.L Norcross, and F. Mueter. 2000. Forage fish abundance and distribution at Forrester Island, Alaska. Unpub. Manuscript, Final Contract Rpt NA66FX045, Institute of Marine Science, University of Alaska, Fairbanks, Alaska. pp. 75 + appendices

Holley, D.K., P. K. Parker, J.M. Maniscalco, and R. D. Andrews. 2005. Chiswell Island research platform: implementation and assessment. Chapter 26, pages 260-270, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

Hollowed, A. B., J. N. Ianelli, and P. Livingston. 2000. Including predation mortality in stock assessments: a case study for Gulf of Alaska pollock. ICES J. Mar. Sci. 57: 279-293.

Hollowed, A.B., N. Bax, R. Beamish, J. Collie, M. Fogarty, P. Livingston, J. Pope, and J.C. Rice. 2000. Are multispecies models an improvement on single-species models for measuring fishing impacts on marine ecosystems? ICES J. Mar. Sci. 57:707-719.

Hollowed, A.B., Wilson, C.D., Stabeno, P. and Salo, S. In press. Effect of ocean conditions on the cross-shelf distribution of walleye pollock (*Theragra chalcogramma*) and capelin (*Mallotus villosus*). Fisheries Oceanography

Holmes, A.L., S.S. Wise, J.A. Little, H. Xie, M. Bozza, M. Moreland, D. J. St. Aubin, J.L. Dunn, S. Atkinson, F. Gulland, S. Bursian, and J.P. Wise Jr. 2003. Hexavalent chromium cytotoxicity is organ and species specific for Steller sea lion and mink cells. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Holmes, A.L., S.S. Wise, A.T. Morin, C.E.C. Goertz, S. Atkinson, J.L. Dunn, F.M.D. Gulland, and J.P. Wise, Sr. 2005. Sodium chromate toxicity in Steller sea lion cells. Proceedings of the Annual Meeting of the North Atlantic Chapter of the Society for Environmental Toxicology and Chemistry, June 2005.

Holmes, E.E., L.W. Fritz, A.E. York, and K. Sweeney. 2005. Evidence of continuing declines in fecundity of Steller sea lions in the central Gulf of Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Holmes, E.E., L.W. Fritz, A.E. York, and K. Sweeney. 2006. Evidence of continuing declines in fecundity of Steller sea lions in the central Gulf of Alaska. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Holmes, E., and A.E. York. 2003. Using age structure to detect impacts on threatened populations: a case study using Steller sea lions. Conservation Biology 17 (6):1794-1806.

Hong, S.-M., S. Atkinson, K. Hülck, and Q. X. Li. 2005. PCB concentrations and profiles in tissues of Steller sea lions from Alaska and the Bering Sea. Chapter 13, pages 110-120, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Hoopes, L.A., L.D Rea, D.A.S Rosen, and G.A.J Worthy. 2004. Effects of body condition on resting metabolism in captive and free-ranging Steller sea lions (*Eumetopias jubatus*). Symposia of the Comparative Nutrition Society 2004. No. 5, Pp 79-82.

Hoopes, L.A., L.D. Rea, and G.A.J. Worthy. 2004. Resting metabolic rate in free-ranging juvenile Steller sea lions (*Eumetopias jubatus*): Life on the edge. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Hoopes, L., L.D. Rea, and G.A.J. Worthy. 2005 Resting metabolic rate in free-ranging juvenile Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Horning, M., and R.L. Hill. 2005. Designing an archival satellite transmitter for long-life deployments on oceanic vertebrates: The life history transmitter. IEEE Journal of Oceanic Engineering 30 (4): 807-817.

Hoshino, H., H., S. Fujita, Y. Goto, T. Isono, T. Ishinazaka, V. N. Burkanov, and Y. Sakurai. 2004. Organochlorine contaminants in Steller sea lions (*Eumetopias jubatus*) of the Northwestern Pacific. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Hoshino, H., T. Isono, T. Takayama, T. Ishinazaka, A. Wada, and Y. Sakurai. 2004. Wintering of Steller sea lion (*Eumetopias jubatus*) along the northern coast of the Sea of Japan. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Hoshino,H., T. Takeomi,T. Takayama, Y. Goto, K. Hattori, M. Ishizuka, A. Wada, Y., Orio, Y. Yasunori, and F. Shouichi. 2005. Differentiation of adipocyte collected from Steller sea lion *Eumetopias jubatus*. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Hough, K. R., T. R. Loughlin, and J. W. Testa. 2003. Interactions between Steller sea lions and groundfish fisheries in the largest Alaskan fishing port. P. 75, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Hu, C., L. Mazzaro, D. A. Rosen, A.W. Trites, and D. D. Kitts. 2004. Vitamin supplementation maintains plasma 8-isoprostane levels in captive Steller sea lions. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Hu, C., S. Wise, A.W. Trites, J. Wise, D.D. Kitts. 2005. Vitamin E protects Steller sea lion cells from reactive oxygen radical induced damage. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Hulbert, L. 2001. Do Pacific sleeper sharks prey on Steller sea lions*? AFSC Quarterly Report* October-November-December: 13.

Hulbert, L., M. Sigler, and C. Lunsford. 2003. Pacific sleeper shark predation of Steller sea lions. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Hulbert, L.B., M.F. Sigler, and C.R. Lunsford. In review. Depth and movement behaviour of the Pacific sleeper shark in the northeast Pacific Ocean. J. Fish. Biol. xx: xxx-xxx 51p.

Hülck, K., D. Wang, S. Atkinson, Q.T. Li. 2005. Persistent organic pollutants in the blubber of male Steller sea lion (*Eumetopias jubatus*) from different locations in the North Pacific Ocean. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Hunt, G. L., et al. (other authors??). 2002. Foraging habitats of Steller sea lions in the Aleutian Islands: bottom-up controls of prey availability and the presence of killer whales. Cruise Report - *Alpha Helix* cruise 259, 16 May to 19 June 2002. University of California, Irvine, Irvine, CA. 151p.

Hunt, G. L., Jr. 2001. Foraging habits of Steller sea lions in the Aleutian Islands: bottom-up controls of prey availability and the presence of killer whales. Cruise report - *Alpha Helix* cruise 245, 4 June 2001 to 25 June 2001. University of California, Irvine, Irvine, CA. 26p. +figures.

Hunt, G.L., P.J. Stabeno, G.E. Walters, E.H. Sinclair, R. Brodeur, J. Napp, and N. Bond. 2002. Climate change and control of the southeastern Bering Sea pelagic ecosystem. Deep Sea Research Part II: Topical Studies in Oceanography 49(26):5821-5853.

Hunt, G.L., and P.J. Stabeno. 2005. Oceanography and ecology of the Aleutian Archipelago: spatial and temporal variation. Fisheries Oceanography 14 (Suppl. 1): 292-306

Hunt, K.E., A.W. Trites, and S.K. Wasser. 2004. Validation of a fecal glucocorticoid assay for Steller sea lions (*Eumetopias jubatus*). Physiology and Behavior 80: 595-601.

Hunter, A.M.J., A.W. Trites, and D. Pauly. 2000. Estimates of basal metabolic and feeding rates for marine mammals from measurements of maximum body length. *In* C.L.K. Baer (ed.), Proceedings of the Third Comparative Nutrition Society Symposium, No. 3, Pages 103-106. Pacific Grove, California, August 4-9, 2000.

Ianelli, J.N., S. Barbeaux, T. Honkalehto, B. Lauth and N. Williamson. 2005. Bering Sea-Aleutian Islands walleye pollock assessment for 2005. *In*: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Fish. Mgmt. Council, Anchorage, AK, section 1:31-124.

Ianelli, J.N., T. Honkalehto, and N. Williamson. 2005. An age-structured assessment of pollock (*Theragra chalcogramma*) from the Bogoslof Island Region. *In*: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Fish. Mgmt. Council, Anchorage, AK, section 1:181-218.

Ingles, S.D., M.A. Castellini, and C.F. Adams. 2005. Seasonal patterns in nutritional quality of pelagic prey at a Steller sea lion rookery in Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Iida, K., T.-G. Park, T. Mukai, and S. Kotani. 2004. Acoustic characteristics and morphological observation of roar sound of Steller sea lion (*Eumetopias jubatus*) migrating to the west coast of Hokkaido, northern Japan. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Iida, K., T.-G. Park, T. Mukai, and S. Kotani. 2004. Avoidance behavior of Steller sea lion (*Eumetopias jubatus*) to artificial sound stimuli. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Ishinazaka, T., M. Suzuki, Y. Yamamoto, T. Isono, N. Harada, J. I. Mason, M. Watabe, M. Tsunokawa, and N. Ohtaishi. 2001. Immunohistochemical localization of steroidogenic enzymes in the corpus luteum and the placenta of the ribbon seal (*Phoca fasciata*) and Steller sea lion (*Eumetopias jubatus*). Journal of Veterinary Medical Science 63:955-959.

Isono, T., H. Hoshino, T. Takayama, T. Ishinazaka, V. Burkanov, and Y. Sakurai. 2004. Changes in abundance and sightings of marked Steller sea lion in Hokkaido. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Jack, L., D. Willoya, D. Garza, and M. Roberts. 2004. TASSC: Sea lion co-management in Alaska. Poster. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Jeanniard Du Dot,T., D.A.S. Rosen, and A.W. Trites. 2005. Steller sea lion energetic priorities during and after a nutritional stress: Are proteins the key? *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Jeffries, S. J., P. J. Gearin, H. R. Huber, D. L. Saul, and D. A. Pruett. 2000. Atlas of seal and sea lion haulout sites in Washington. Washington Department of Fish Wildlife, Wildlife Sci. Div., 600 Capitol Way North, Olympia WA, 150 p.

Jeffries, S., P. Olesiuk, P. Gearin, D. Lambourn, and A. Trites. 2004. Techniques for capture and handling of Steller and California sea lions. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Jemison, L.A., T. S. Gelatt, K. W. Pitcher, K.L. Raum-Suryan. 2004. Steller sea lion movements based on brand-resighting observations in Southeast Alaska: An alternative to satellite telemetry. Poster. *In* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Jemison, L., K. Raum-Suryan, K. Pitcher, G. Pendleton, J. King, and T. Gelatt. 2003. Preliminary report on Steller sea lion brand-resighting results in Southeast Alaska. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Jonker, R.A.H., and A.W. Trites. 2000. The reliability of skinfold-calipers for measuring blubber thickness of Steller sea lion pups (Eumetopias jubatus). Marine Mammal Science 16:757-766.

Joy, R., D.J. Tollit, J.L. Laake, and A. W. Trites. 2004. Using feeding trials and computer simulations to reconstruct sea lion diet from scat. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Joy, R., D.J. Tollit, J.L. Laake, and A.W. Trites. In press. Using simulations to evaluate reconstructions of sea lion diet from scat. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

Jurado-Molina, J., and P.A. Livingston. 2002. Multispecies perspectives on the Bering Sea groundfish fisheries management regime. N. Amer. J. Fish. Management 22:1164-1175.

Jurado-Molina, J. and P. A. Livingston. 2002. Climate-forcing effects on trophically linked groundfish populations: implications for fisheries management. Can. J. Fish. Aquat. Sci. 59:1941-1951.

Jurado-Molina, J. P.A. Livingston, and V.F. Gallucci. 2005. Testing the stability of the suitability coefficients from an eastern Bering Sea multispecies virtual population analysis. ICES J. Mar. Sci. 62:915-924.

Jurado-Molina, J., P.A. Livingston, and J.N. Ianelli. 2005. Incorporating predation interactions in a statistical catch-at-age model for a predator-prey system in the eastern Bering Sea. Can. J. Fish. Sci. Aquat. 62:1-9.

Kaplan, C. Curgis. 2005. Neonatal survival of Steller sea lions (*Eumetopias jubatus*). M.S. thesis, Colorado State Univ., Fort Collins, CO. 72 p.

Kastelein, R., R. van Schie, and D. de Haan. 2003. Underwater hearing sensitivity of Steller sea lions (*Eumetopias jubatus*): Potential sexual differences. P. 82, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Kastelein, R., R. van Schie, W.C. Verboom, and D. de Haan. 2005. Underwater hearing sensitivity of Steller sea lions (*Eumetopias jubatus*): Potential sexual differences. Acoustical Society of America 118(3):1820-1829.

Kelly, R., A.L. Holmes, S.S. Wise, A.T. Morin, C.E.C. Goertz, S. Atkinson, J.L. Dunn, F.M.D. Gulland, and JP. Wise Sr. 2005. Sodium chromate toxicity in Steller sea lion cells. Proceedings of the Biennial Meeting of the Chromium and Human Health Workshop, August 2005.

King, J., T. Gelatt, and K. Pitcher. 2003. A field-based method for estimating age in wild juvenile Steller sea lions (*Eumetopias jubatus*). P. 84, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p

King, J.C., T.S. Gelatt, and K.W. Pitcher . 2004. A field-based method for estimating age in free-ranging juvenile Steller sea lions (*Eumetopias jubatus*). Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Kitts, D.D., M.D. Huynh, C. Hu, and A.W. Trites. 2004. Seasonal variation in nutrient composition of Alaskan pollock (*Theragra chalcogramma*). Canadian Journal of Zoology 82:1408-1415.

Konar, B., C. Hegwer, S. Hills, and K. Wynne. 2004. Shallow water nearshore fish assemblages around Steller sea lion haulouts near Kodiak, Alaska. In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK .

Krahn, M. M., K. B. Beckmen, K. W. Pitcher, and K. A. Burek. 2001. Population survey of organochlorine contaminants in Alaskan Steller sea lions. Final Programmatic Report for the National Fish and Wildlife Foundation, October 2, 2001. 22 p.

Krahn, M. M., D. P. Herman, D. G. Burrows, P. R. Wade, J. W. Durban, M. E. Dahlheim, R. G. Leduc, L. Barrett-Lennard and C. O. Matkin. 2005. Use of chemical profiles in assessing the feeding ecology of eastern North Pacific killer whales. International Whaling Comm. SC-57-E7, 17p.

Kruchenkova, E., N. Lobacheva, and M. Goltsman. 2001. Does the duration of shore visits depend on food availability in lactating Steller sea lions? P. 118, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Kruse, G. H., F. C. Fritz, H. J. Geiger, K. R. Mabry, H. M. Savikko, and M Shareef. 2000. Overview of state managed marine fisheries in the central and western Gulf of Alaska, Aleutian Islands, and southeastern Bering Sea, with reference to Steller sea lions. Regional Information Report Number 5J00 -10, Division of Commercial Fisheries, Alaska Department of Fish and Game, Juneau, AK. 173 p.

Kruse, G. H., M. Crow, E.E. Krygier, D.S. Lloyd, K.W. Pitcher, L.D. Rea, M. Ridgway, R.J. Small, J. Stinson, and K.M. Wynne. 2001. A review of proposed fishery management actions and the decline of Steller sea lions *Eumetopias jubatus* in Alaska: a report by the Alaska Steller Sea Lion Restoration Team. Regional Information Report Number 5J01-04, Alaska Department of Fish and Game, Juneau, AK. 106 p. [6]

Kucey, L. 2005. Human disturbance and the haulout out behaviour of Steller sea lions (*Eumetopias jubatus*). M.S. Thesis, University of British Columbia, Vancouver, Canada. 75 p.

Kucey, L., and A.W. Trites. 2003. Assessing the effect of human disturbance on Steller sea lions. P. 88, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Kucey, L., and A.W. Trites. 2004. Is human disturbance affecting Steller sea lions? Presented paper. In, Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Kucey, L., and A.W. Trites. 2005. Human disturbance and the hauling out behavior of Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Kucey, L., and A.W. Trites. In press. A review of the potential effects of disturbance on sea lions: assessing response and recovery. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

Kumagai, S. 2004. Seasonal differences in physiology of captive Steller sea lions (*Eumetopias jubatus*) in response to short-term low energy intake. M.Sc. thesis, University of British Columbia. 112 p.

Kumagai, S., D.A.S. Rosen, and A.W. Trites. 2003. Seasonal changes in defended energy state in Steller sea lions. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Kumagai, S., D.A.S. Rosen, and A.W. Trites. 2003. Seasonal differences in body composition and energy balance in response to low energy intake in Steller sea lions (*Eumetopias jubatus*). P 89, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Kumagai, S., D.A.S. Rosen, and A. Trites. 2004. Potential iron deficiency induced by pollock diet in captive Steller sea lions (*Eumetopias jubatus*). Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Kumagai, S., D.A.S. Rosen, and A.W. Trites. 2005. Physiological responses to short-term low energy intake are seasonally dependent in Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Kuzin, A.E. 2002. Abundance and some biological features of Steller sea lions of the Tyuleniy Island. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Kuzin, A.E. 2004. Attendance patterns of Steller sea lion (*Eumetopias jubatus*) on Tuleny Island during the breeding season. Pages 303-305, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Kuzin, A.E. 2004. Results of biological studies of northern sea lions (*Eumetopias jubatus*) on the Tyuleny Island (the Sea of Okhotsk) in 2003. Pages 300-303, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Kuzin, A.E., V.N. Burkanov, and N.N. Pavlov. 2002. To the problem of dispersion, homing and phylopatry of juvenile Steller sea lions. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Lambert, M. M. 2005. Genetic variation and population structure: using the control region and cytochrome *b* regions to study the phylogeographic distribution of Steller sea lions (*Eumetopias jubatus*). Senior Honors thesis, Texas A&M University, College Station, Texas, ix + 28 pp.

Lander, M.E., and F.M.D. Gulland. 2003. Rehabilitation and post-release monitoring of Steller sea lion pups raised in captivity. Wildlife Society Bulletin 31(4): 1047-1053.

Lander, M.E., T.R. Loughlin, M.L. Logsdon, G.R. VanBlaricom, B.S. Fadely, and L.W. Fritz. 2005. Environmental composition of habitat used by juvenile Steller sea lion (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Lander, M.E., T.R. Loughlin, M.L. Logsdon, G.R. VanBlaricom, B.S. Fadely, and L.W. Fritz. 2006. Environmental composition of habitat used by juvenile Steller sea lions (*Eumetopias jubatus*). *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Lander, M. E., T. R. Loughlin, G. R. VanBlaricom, M. Logsdon, and J. T. Sterling. 2003. Spatially explicit foraging ecology of juvenile Steller sea lions (*Eumetopias jubatus*). P. 90, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Lander, M.E., T.R. Loughlin, G.R. VanBlaricom, and M.L. Logsdon. 2004 Spatially explicit foraging ecology of juvenile Steller sea lions (*Eumetopias jubatus*). Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Lea, M.A., and B. Wilson. In press. Techniques for real-time, active tracking of sea lions. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

Lea, M.-A., B. Wilson, and A.W. Trites. 2003. A marine predator's pursuit of happiness- Linking fine-scale Steller sea lion movements to prey distribution and behavior at sea. P. 93, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Lea, M.-L., B. Wilson, A. Trites, M. Sigler, and D. Csepp. 2004. Bridging the gap—linking real-time foraging: Movements of sea lions to prey availability. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Lestenkof, A.D., P.A. Zavadil, and M.T. Williams. 2003. The subsistence harvest of Steller sea lions on St. Paul Island in 2001. Annual Report provided to the National Marine Fisheries Service under contract NA16FX1420. 10 pp. Available, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

Lisitsyna, T. Yu., and A.M. Burdin. 2002. Structure peculiarities of rookery population and behavior adaptations in Steller sea lions (*Eumetopias jubatus*) at Cape Kozlova (Kamchatka Peninsula). *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Litz, B.S., K.L. Mashburn, L. Petranskas, and S. Atkinson. 2005. Non-invasive monitoring of testosterone in an endangered species, the Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Litz, B., K. Mashburn, L. Petrauskas, and S. Atkinson. 2006. Non-invasive monitoring of testosterone in an endangered species, the Steller sea lion (*Eumetopias jubatus*). *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Livingston, P.A. (ed.). 2000. Ecosystem considerations for 2001. Appendix: Stock assessment and fishery evaluation report for the groundfish resources of the EBS/AI and GOA. North Pacific Fishery Management Council, 605 W. 4th Ave, Suite 306, Anchorage, AK 99501. 119p.

Livingston, P.A. (ed.). 2001. Ecosystem considerations for 2002. Appendix: Stock assessment and fishery evaluation report for the groundfish resources of the EBS/AI and GOA. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. 180p.

Livingston, P.A. (ed.). 2002. Ecosystem considerations for 2003. Appendix: Stock assessment and fishery evaluation report for the groundfish resources of the EBS/AI and GOA. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. 230p.

Livingston, P.A., K. Aydin, J. Boldt, J. Ianelli, and J. Jurado-Molina. 2005. A framework for ecosystem impacts assessment using an indicator approach. ICES J. Mar. Sci. 62:592-597.

Livingston, P.A., and J-J. Jurado-Molina. 2000. A multispecies virtual population analysis of the eastern Bering Sea. ICES J. Mar. Sci. 57:294-299.

Livingston, P.A., and S. Tjelmeland. 2000. Fisheries in boreal ecosystems. ICES J. Mar. Sci. 57:619-627.

Logerwell, E.A. 2004. The Fishery Interaction Team: Investigating the potential for commercial fishing to compete with endangered Steller sea lions for shared prey. *In* Marine Science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK.

Logerwell, E.A., K. Aydin, S. Barbeaux, E. Brown, M.E. Conners, S. Lowe, J.W. Orr, I. Ortiz, R. Reuter, and P. Spencer. 2005. Geographic patterns in the demersal ichthyofauna of the Aleutian Islands. Fisheries Oceanography 14 (Suppl. 1): 93-112

Logerwell, E.A., and S. F. McDermott. 2004. Are trawl exclusion zones effective at mitigating competition between commercial fisheries and Steller sea lions? Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Logerwell, E.A., and Schaufler, L.E. 2005. New data on proximate composition and energy density of Steller sea lion (*Eumetopias jubatus*) prey fills seasonal and geographic gaps in existing information. Aquatic Mammals 31:62-82.

Loughlin, T. R. 2000. Steller sea lions. Alaska Geographic 27 (2):60-73.

Loughlin, T. R. 2002. Steller sea lion. Pages 1181-1185, *in* W.F. Perrin, B. Wursig, and H.G.M. Thewissen, editors, Encyclopedia of Marine Mammals, Academic Press, San Diego.

Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.). 2005. Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

Loughlin, T., and J. L. Sease. 2001. Steller sea lion research cruise in the Aleutian Islands and Gulf of Alaska, February-March 2000. Pages 103-112, i*n* Anita L. Lopez and Robyn P. Angliss (eds.) Marine Mammal Protection Act and Endangered Species Act implementation program 2000. U.S. Department of Commerce, AFSC Processed Report 2001-06.

Loughlin, T., and E. Sinclair. 2001. Fatty acid profiles of Steller sea lions and North Pacific Ocean forage fishes, a pilot study using northern fur seals Pages 113-115, *in* Anita L. Lopez and Robyn P. Angliss (eds.) Marine Mammal Protection Act and Endangered Species Act implementation program 2000. U.S. Department of Commerce, AFSC Processed Report 2001-06.

Loughlin, T. R., J. T. Sterling, R. L. Merrick, J. L. Sease, and A.E. York. 2003. Immature Steller sea lion diving behavior. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Loughlin, T.R., J.T. Sterling, R.L. Merrick, J.L. Sease, and A.E. York. 2003. Diving behavior of immature Steller sea lions (*Eumetopias jubatus)*. Fishery Bulletin 101 (3):567-582.

Loughlin, T. R., and A. E. York. 2000. An accounting of the sources of Steller sea lion, *Eumetopias jubatus*, mortality. Marine Fish. Review 62(4):40-45.

Lowe S., J. Ianelli, H. Zenger, K. Aydin, and R. Lauth. 2005. Stock assessment of Aleutian Islands Atka mackerel. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Fish. Mgmt. Council, Anchorage, AK, section 15:757-820.

Lowe, S. A., M. Wilkins, and R. Lauth. 2005. Assessment of Gulf of Alaska Atka mackerel. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pac. Fish. Mgmt. Council, Anchorage, AK, 15: 861-880.

Lyamin, O.I. 2004. Sleep in young Steller sea lions and northern fur seals: A comparative study. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Lyons, E.T. 2005. Historic importance of some aspects of research by O. Wilford Olsen on hookworms (*Uncinaria lucasi*) in northern fur seals (*Callorhinus ursinus*) and Steller sea lions (*Eumetopias jubatus*) in 1951 on St. Paul Island, Alaska. Parasitol. Res. 95: 353–357.

MacDonald, R, and M. McClaran. 2000. Abundance and distribution of marine mammals in Bristol Bay and southern Kuskokwim Bay, Alaska, 1999. Manuscript Rpt., U.S. Fish and Wildlife Service, Togiak National Wildlife Refuge, P.O. Box 270 Dillingham, Alaska 99576. 29p.

Malavear, M.Y.G. 2002. Modeling the energetics of Steller sea lions (*Eumetopias jubatus*) along the Oregon coast. M.S. thesis, Oregon State University, Newport, OR. 114p.

Malavear, M.Y.G., and D.B. Sampson. 2003. Modeling the energetics of Steller sea lions (*Eumetopias jubatus*) along the Oregon coast. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK.[2]

Mamaev, E.G. 2004. Steller sea lions (*Eumetopias jubatus*) subadult males behavior in the on (sic) a rookery. Pages 352-356, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Mamaev, E.G., and V.N. Burkanov. 2004. Some cases of long suckling bouts in the Steller sea lion (*Eumetopias jubatus*). Pages 359-361, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Mamaev, E.G., and V. N. Burkanov. 2004. How long do Steller sea lions drink milk? Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Maniscalco, J. 2005. Reproductive performance in Steller sea lions at Chiswell Island, Gulf of Alaska. *In* Marine Science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

Maniscalco, J, and S. Atkinson. 2003. Characteristics of parturition and neonatal behavior in Steller sea lions (*Eumetopias jubatus*). P. 101, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Maniscalco, J., and S. Atkinson. 2004. Causes of early pup mortality at a Steller sea lion rookery (*Eumetopias jubatus*) in the northern Gulf of Alaska. In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK

Maniscalco, J., S. Atkinson, and P. Armato. 2002. Early maternal care and pup survival in Steller sea lions: A remote video monitoring project in the Northern Gulf of Alaska. Arctic Research 16: 36-41.

Maniscalco, J., S. Atkinson, A. Burdin, and D. Calkins. 2003. Population dynamics, maternal investment, and early pup mortality in Steller sea lions at Chiswell Island. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Maniscalco, J.M., S. Atkinson, D.G. Calkins, P. Parker, E. Teate, and D. Zatz. 2005. The usefulness of remote-operated video cameras for long-term tracking of individual Steller sea lions. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Maniscalco, J.M., P. Parker, and S. Atkinson. 2005. Use of remote monitoring equipment to study maternal care. Chapter 32, pages 308-320, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

Maniscalso, J., C.O. Matkin, D. Maldini, S. Atkinson, D.G. Calkins, and R. Andrews. 2006. Are killer whales affecting the recovery of Steller sea lions? Assessing evidence in Kenai Fjords, Alaska. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Maniscalco, J.M., R. Taylor, D. G. Calkins, and S. Atkinson. 2005. Reproductive performance and pup mortality in Steller sea lions. Chapter 30, pages 290-301, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Marcogliese, D. J. 2001. Implications of climate change for parasitism of animals in the aquatic environment. Can J. Zoology 79:1331-1352.

Marcotte, M.L., and A.W. Trites. 2004. A comparison of maternal attendance among the world's sea lions. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Marcotte, M.L., and A.W. Trites. 2005. Shifts in the timing of weaning in an increasing population of Steller sea lions in Southeast Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Marston, B. H., M. F. Willson and S. M. Gende. 2002. Predator aggregations during eulachon *Thaleichthys pacificus* spawning runs. Marine Ecology Progress Series 231:229-236.

Mashburn, K.L., and S. Atkinson. 2002. Sex differences in corticoid metabolism measured in Steller sea lion feces. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Mashburn, K., and S. Atkinson. 2003. Evaluation of adrenal activity in Steller sea lion serum and feces. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Mashburn, K.L. and S. Atkinson. 2004. Evaluation of adrenal function in serum and feces of Steller sea lions (*Eumetopias jubatus*): influences of molt, gender, sample storage, and age of glucocorticoid metabolism. General and Comparative Endocrinology, 136:371-381.

Mashburn, K., and S. Atkinson. 2004. Survey of Steller sea lion corticosteroid concentrations in scat. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Mashburn, K.L., and S. Atkinson. 2005. Evaluation of adrenal function in serum and feces of Steller sea lions. Chapter 17, pages 159-176, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Mashburn, K., and S. Atkinson. 2005. The price of puberty: Evaluation of adrenal function in juvenile Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Mathews, E.A. 2000. Reactions of Steller sea lions (*Eumetopias jubatus*) to vessels at a haulout in Glacier Bay. Unpublished progress report to Glacier Bay National Park and Reserve, Resource Management Div., National Parks Service, PO Box 140, Gustavus, Alaska. January 2000. 32 p.

Mathews, E.A., and L. Dzinich. 2001. A new Steller sea lion rookery in Glacier Bay National Park and Preserve. Final Report to Glacier Bay National Park and Preserve, Gustavus, AK, 99826. Available at National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115. 15 Pp.

Matkin, C.O., L. Barret-Lennard, and D. Ellifrit. 2006. Ecotype variation and predatory behavior of killer whales in the eastern Aleutian Islands. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Matkin, C.O., L. Barret-Lennard, H. Yurk, D. Ellifrit, and A.W. Trites. In press. Ecotype variation and predatory behavior of killer whales (*Orcinus orca*) in the eastern Aleutian Islands, Alaska. Fisheries Bulletin.

Matkin, C., L. Barrett-Lennard, D. Maldini, and E. Saulitis. 2003. Northern Gulf of Alaska killer whales: Status, population structure, and feeding habitat (Prince William Sound/Kenai Fjords/Kodiak). Abstracts from the Symposium on Marine Science in the Northeast Pacific: Science for Resource Dependent Communities. January 13-17, Anchorage, AK. [2]

Matkin, C.O., E. Saulitis, D. Maldini, J. Maniscalco, and L. Mazzuca. 2005. Steller sea lion predation by killer whales in Kenai Fjords/Prince William Sound, Alaska. Chapter 22, pages 212-226, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

Matthiopoulos, J., D. Thompson and I. Boyd. 2005. Implications of varying food distributions for fitness in Steller sea lions. Final Contract Report (Contract No. NA17FX1431), Sea Mammal Research Unit, Gatty Marine Laboratory, St Andrews University, St Andrews, Fife KY16 8LB, U.K. 92p.

Matthiopoulos, M., D. Thompson, and I. Boyd. 2005. Implications of varying food distributions for fitness in Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Mazzaro, L.M., D.J. St. Aubin, R.M. Clark, and H.C. Furr. 2003. Comparison of serum retinol, tocopheral and lipid levels in free-ranging Steller sea lions and their prey from the eastern and western stocks. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

McAllister, D. C., D. G. Calkins, and K.W. Pitcher. 2001. Underwater capture of juvenile Steller sea lions with Scuba: a narrated video presentation. Pages 53-56, *in* Cold Water Diving for Science, University of Alaska Sea Grant Publication AK-SG-01-06.

McConnell, B. 2004. Review of National Marine Mammal Laboratory Stellar Sea Lion Satellite Telemetry Program. Manuscipt Rpt, Center for Independent Experts. 11p.

McDermott, S.F., L.W. Fritz, and V. Haist. 2005. Estimating movement and abundance of Atka mackerel (*Pleurogrammus monopterygius*) with tag-release-recapture data. Fisheries Oceanography 14 (Suppl. 1): 113-130.

McPhee, C.P. 2001. Heart rate as a monitor for metabolic rate in captive juvenile Steller sea lions (*Eumetopias jubatus*). M.S. thesis. University of British Columbia. 86p.

McPhee, J.M., D.A.S. Rosen, R.D. Andrews, and A.W. Trites. 2003. Predicting metabolic rate from heart rate for juvenile Steller sea lions *Eumetopias jubatus*. Journal of Experimental Biology 206: 1941-1951.

Mellish, J.-A., S. Atkinson, and M. Castellini. 2004. Capture and holding of juvenile Steller sea lions: the transient project. *In*: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK

Mellish, J.-A, E., D.G. Calkins, and S. Atkinson. 2005a. The transient juvenile Steller sea lion project. Chapter 19, pages 187-192, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

Mellish, J.-A. E.. D.G. Calkins, D.R. Christen, M. Horning, and S. Atkinson. 2005b. Temporary captivity as a research tool: a novel approach to the comprehensive study of wild mammals. Chapter 21, pages 200-211, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

Mellish, J.E., D.G. Calkins, D. Christen, M. Horning, and S. K. Atkinson. 2006. Temporary captivity as a research tool: a comprehensive study of wild pinnipeds under controlled conditions. Aquatic Mammals 32(1):58-65.

Mellish, J.-A., E., and M. Horning. 2005. Fuel selection in fasting juvenile Steller sea lions (*Eumetopias jubatus*): Are leaner animals the losers? *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Mellish J.E., and M. Horning. In review. Differential fuel selection in fasting juvenile Steller sea lions (*Eumetopias jubatus*): are leaner animals the losers? Comparative Biochemistry and Physiology A.

Mellish, J.E., P.A. Tuomi, and M.Horning, 2004. Assessment of ultrasound imaging as a noninvasive measure of blubber thickness in pinnipeds. Journal of Zoo and Wildlife Medicine 35(1): 116–118.

Middlebrooks, B.L., J. A. Colvocoresses, and R. A. Patterson. 2005. Evaluation of immunoglobulin isotype levels of the Steller sea lion. Chapter 15, pages 135-146, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001- 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Milette, L.L., and A.W. Trites. 2003. Maternal attendance patterns of Steller sea lions (*Eumetopias jubatus*) from stable and declining populations in Alaska. Canadian Journal of Zoology 81:340-348.

Miller, A.J., E. Di Lorenzo, D. J. Neilson, H. Kim, A. Capotondi, M. A. Alexander, S. J. Bograd, F. B. Schwing, R. Mendelssohn, K. Hedstrom and D.L. Musgrave. 2005. Interdecadal changes in mesoscale eddy variance in the Gulf of Alaska circulation: possible implications for the Steller sea lion decline. Atmosphere-Ocean 43(3):231–240.

Miller, E.H., K. W. Pitcher, and T.R. Loughlin. 2000. Bacular size, growth, and allometry in the largest extant otariid, the Steller sea lion (*Eumetopias jubatus*). Journal of Mammalogy 81 (1):134-144.

Miller, E. H., Ø. Wiig and A. W. Trites. 2005. International survey of scientific collections of Steller sea lions. Fisheries Centre Research Reports 13 (6), 68 pp.

Mizroch, S. A., and D.W. Rice. In press. Have North Pacific killer whales switched prey species in response to depletion of the great whale populations? Marine Ecology Progress Series.

Moore, M., and J. F. Morado. 2003. Evaluation of the effects of parasites on Steller sea lions in Alaska. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Morin, A.T., C.E.C. Goertz, S.S. Wise, J.L. Dunn, F. Gulland, N. Jayasundara, M. Bozza, S. Atkinson, and J.P. Wise, Sr. 2003. Comparative cytotoxicity of hexavalent chromium in humans and Steller sea lions. Presented at the Northeast Society of Toxicology (NESOT) Annual Meeting, November 2003.

Morin, A.T., C.E.C. Goertz., S.S. Wise, J.L. Dunn, F. Gulland, N. Jayasundara, M. Bozza, S. Atkinson, and J.P. Wise, Sr. 2004. Metal toxicity of sodium chromate in Steller sea lion bronchus and dermis compared to humans. The Toxicologist, 78 (S-1): no. 757.

Mueter, F., and B. L. Norcross. 2002. Spatial and temporal patterns in the demersal fish community on the shelf and upper slope regions of the Gulf of Alaska. Fishery Bulletin 100 (3):559-581.

Mueter, F. J., and B. L. Norcross. 2002. Species composition and abundance of juvenile groundfishes around Steller sea lion (*Eumetopias jubatus*) rookeries in the Gulf of Alaska. Alaska Fisheries Research Bulletin 7:33-43.

Musgrave, D., and H. Statscewich. 2005. Environmental monitoring of oceanographic conditions near the Chiswell Island Steller sea lion rookery. Chapter 35, pages 37-344, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

Myers, M. 2005. Organochlorine contamination in Steller sea lion pups from four Russian rookeries. *In* Marine Science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

Myers, M., and S. Atkinson. 2004. Chemical contamination levels in Steller's sea lion pups from southwest Alaska and the Russian Far East. *In*, 22nd Wakefield Fisheries Symposium: Sea lions of the World, 30 September – 3 October 2004. Anchorage, Alaska.

Myers, M., and S. Atkinson. 2005a. Contaminants in Steller sea lion (*Eumetopias jubatus*) and other marine mammals from the North Pacific. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Myers, M.J., and S. Atkinson. 2005b. Thyroid and cortisol hormones and contaminants in Steller sea lions. Chapter 16, pages 147-158, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Myers, M., and S. Atkinson. 2006. Variability in organochlorine contaminants in both blood and blubber over time in captive Steller sea lions (*Eumetopias jubatus*). *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Myers, M., S. Atkinson, and L. Rea. 2001. Development of an index for metabolic condition in Steller sea lions (*Eumetopias jubatus*) utilizing leptin hormone concentrations. Page 153, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Myers, M. J., L.D. Rea, K.L. Mashburn, and S. Atkinson. 2003. Thyroid and cortisol hormones as an indication of metabolic function and well-being in Steller sea lions (*Eumetopis jubatus*). *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

National Research Council (NRC). 2003. Decline of the Steller sea lion in Alaskan waters; untangling food webs and fishing nets. National Academy Press, Washington, D.C. 184 pp.

Nelson, A.W., and R.B. Heath. 2003. A study to evaluate transmitter implant methodology. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Nevedomskaya, I.A. 2004. Unusual encounter with Steller sea lion (*Eumetopias jubatus*) in a vicinity of Yuzhno-Kurilsk settlement (Kunashir Is. of the Kuril Islands). Pages 425-426, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Nevedomskaya, I.A. 2004. Localization of rookeries and haulouts of marine mammals on the Kuril Islands. Pages 422 – 425, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Nikulin, V. S., and V. N. Burkanov. 2000. Species composition of marine mammal by-catch during Japanese driftnet salmon fishery in southwestern Bering Sea. Unpubl. manuscript, 2 pp. Available, National Marine Mammal Laboratory, AFSC, 7600 Sand Point Way, NE, Seattle, WA 98115.

Noren, D. P. 2003. Fasting capabilities in weaned juvenile Steller sea lions: influence of body condition and activity. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Noren, D.P., L. Rea, and T.R. Loughlin. Fasting capabilities of unsuccessfully foraging weaned juvenile Steller sea lions: Influence of body condition and environment. Draft ms ready for submission in December 2005.

O'Corry Crowe, G., B.L. Taylor, M. Basterretche, T.R. Loughlin, T. Gelatt, and J.W. Bickham. 2003. Using molecular genetics to estimate dispersal rates between Steller sea lion rookeries. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

O'Corry-Crowe, G., T. Gelatt, K. Pitcher, and B Taylor. 2005. Crossing significant boundaries: Evidence of mixed-stock origins of new Steller sea lion, Eumetopias jubatus, rookeries in Southeast A;asla. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

O'Corry-Crowe, G., B.L. Taylor, T/ Gelatt, T.R. Loughlin, J. Bickham, M. Basterretche, K. Pitcher, and D.P. DeMaster. In review. Demographic independence along ecosystem boundaries in Steller sea lions revealed by mDNA analysis: implications for management of an endangered species. Canadian Journal of Zoology.

Olawale, K.O., R.J. Petrell, D.G. Michelson, A.W. Trites. 2005. The dielectric properties of the cranial skin of five young captive Steller sea lions (*Eumetopias jubatus*) and a similar number of young domestic pigs (*Sus scrofa*) and sheep (*Ovis aries*) between 0.1 and 10 GHz. Physiological Measurement 26: 627-637.

Olesiuk, P. F. 2001. Recent trends in abundance of Steller sea lions (*Eumetopias jubatus*) in British Columbia. Working Paper 2001-10, Dept. Fisheries and Oceans, Canada, National Marine Mammal Review Committee Meeting, 27 February- 1 March 2001, Winnipeg, Manitoba, Canada. 29 pp.

Olesiuk, P.F. 2004. Population biology and status of Steller and California sea lions (*Eumetopias jubatus* and *Zalophus californianus*) in Canadian waters. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Ono, K., T. R. Loughlin, and R. Merrick. 2001. Behavior and ecology of juvenile Steller sea lions (*Eumetopias jubatus*) during the breeding season. Page 163, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Otis, E.O., and M. Spahn. 2003. Improving access to ADF&Gs lower Cook Inlet Pacific herring stock assessment and commercial fishery databases, including observations of Steller sea lions (SSLRI Project 12). Final report submitted to NOAA, NMFS, NOAA award NA16FX1411. 7 pp.

Park, T.-G., K. Iida, T. Mukai, and S. Kotani. 2004. Relationship between roar sound and behavior of Steller sea lion (*Eumetopias jubatus*) migrating to the west coast of Hokkaido, northern Japan. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Parker, P., J.M. Maniscalco, and S. Atkinson. 2005. Pupping site fidelity among individual Steller sea lions at Chiswell Island, Alaska. Chapter 33, pages 321-330, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

Parker, P., J. Maniscalco, S. Atkinson, K. Harris, and R. Baptista. 2003. Summer to autumn increases in maternal investment for individual Steller sea lions (*Eumetopias jubatus*) in the northern Gulf of Alaska. Page 127, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Parker, P., J.M. Maniscalco, J.T. Harvey, and S. Atkinson. 2005. Pupping site fidelity among individual Steller sea lions (*Eumetopias jubatus*) in the northern Gulf of Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Pendleton, G.W., K. W. Pitcher, L. W. Fritz, and T. S. Gelatt. 2004. Survival rates of Steller sea lions in southcentral and southeastern Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Pendleton, G.W, K.W. Pitcher, L.W. Fritz, K.L. Raum-Suryan, T.R. Loughlin, D.G. Calkins, A.E. York, K.K. Hastings, and T.S. Gelatt. In review. Steller sea lion survival probabilities in Alaska: A comparison of increasing and decreasing populations. Canadian Journal of Zoology.

Perez. M.A. 2003. Compilation of marine mammal incidental take data from the domestic and joint-venture groundfish fisheries in the US EEZ of the north Pacific, 1989-2001. US Department of Commerce, NOAA Technical Memorandum, NMFS-AFSC-138. 145 p.

Perlov, A. S. and S. V. Zadal'skiy. 2001. Age difference of the morphological indicators and features of sexual dimorphism of Steller sea lions during postnatal ontogenesis. Izvestiya TINRO 128(3):940-962. In Russian with English abstract.

Perlov, A. S. and S. V. Zadal'skiy. 2001. Morpho-ecological aspects of the postnatal ontogeny of Steller sea lions (*Eumetopias jubatus* Schreb., 1776). Izvestiya TINRO 128(3):970-981. In Russian with English abstract.

Permyakov, P.A., and V.N. Burkanov. 2004. Seasonal changes in abundance of Steller sea lion (*Eumetopias jubatus*) on Brat Chirpoev Island (Kuril Island) during the breeding season 2002-2003. Pages 446-449, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Permyakov, P.A., and V.N. Burkanov. 2004. Age and sex structure of branded Steller sea lion (*Eumetopias jubatus*) on Brat Chirpoev I. (Kuril Island) in 2002-2003. Pages 449-451, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Petras, E. 2003. A review of marine mammal deterrents and their possible applications to limit killer whale (*Orcinus orca*) predation on Steller sea lions (*Eumetopias jubatus*). U.S. Department of Commerce, AFSC Processed Report 2003-02. 49 p.

Petrauskas, L. 2005. Variation of fecal corticosterone concentrations in captive Steller sea lions (*Eumetopias jubatus*) in relation to season, social status, and behavior. In: Marine science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

Petrauskas, L., M. Horning, P. Tuomi, and S. Atkinson. 2005. Non-invasive monitoring of rehabilitation procedures in California and Steller sea lions. Chapter 18, pages 177-186, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Petrauskas, L., P. Tuomi, and S. Atkinson. 2004. Noninvasive monitoring of stress hormone levels of a female Steller sea lion (*Eumetopias jubatus*) pup undergoing rehabilitation. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Piatt, J.F., G.V. Byrd, K.Pitcher, and S.R. Hare. 2003. Inverse production regimes and inverse population dynamics of three high trophic-level consumers in the North Pacific. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Pitcher, K., R. Brown, S. Jeffries, L. Lowry, M. Lowry, P. Olesiuk, W. Perryman, J. Sease, and J. Stinchcomb. 2003. Status of the eastern Steller sea lion population. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Pitcher, K. W., V. D. Burkanov, D. G. Calkins, B. J. LeBoeuf, E. G. Mamaev, R. L. Merrick, and G. W. Pendleton. 2001. Spatial and temporal variation in timing of births of Steller sea lions. Journal of Mammalogy 82:1047-1053.

Pitcher, K. W., D. G. Calkins, and G. W. Pendleton. 2000. Steller sea lion body condition indices. Marine Mammal Science 16:427-436.

Pitcher, K.W., G. W. Pendleton, and T. S. Gelatt. 2004. Estimation of weaning status of juvenile Steller sea lions using mark-resight models. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Pitcher, K.W., M.J. Rehberg, G.W. Pendleton, K.L. Raum-Suryan, T.S. Gelatt, U.G. Swain, and M.F. Sigler. 2005. Ontogeny of dive performance in pup and juvenile Steller sea lions in Alaska. Can. J. Zool., 83:1214-1231.

Pitcher, K., and J. Sease. 2003. Equivocal indicators of Steller sea lion population trend in Prince William Sound, Alaska. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Plankis, B.J., M. Horning, N. Ponto, and L.K. Brown. In press. Designing a dependable and fault tolerant semi-autonomous distributed control data collection network with opportunistic hierarchy. IEEE Journal of Oceanic Engineering.

Porter, B.T. and A.W. Trites. 2004. Suckling attempts during winter by two non-filial Steller sea lion pups. Mammalia 68:23-26.

Punt, A.E. and G. Fay. 2002. Methods for determining extinction risk and recovery probability of Steller Sea Lion populations subject to harvesting, demographic and environmental stochasticity, and catastrophic events. Final report submitted to NMML, NMFS, NOAA. 54 pp

Punt, A.E. and G. Fay. 2003. Estimation of Steller sea lion population dynamics Parameters. Report to the North Pacific Universities Marine Mammal Research Consortium. 48 pp.

Punt, A.E., and G. Fay. 2004. Can experimental manipulation be used to determine the cause of the decline of the western stock of Steller sea lions (*Eumetopias jubatus*)? Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Purtov, S.Y., and V.N. Burkanov. 2004. Observation of marked Steller sea lion (*Eumetopias jubatus*) on Antsiferov I. (Kuril Islands) in 2003. Pages 465-467, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Purtov, S.Y., and V.N. Burkanov. 2005. Changes in winter abundance and distribution of Steller sea lions (*Eumetopias jubatus*) in Commander Islands, Russia. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Raum-Suryan, K., L. Jemison, and K.W. Pitcher. 2005. Entanglement of Steller sea lions in marine debris: Identifying causes and finding solutions. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Raum-Suryan, K.L., F. Gulland, T. S. Gelatt, and L. Jemison. 2004. Entanglements of North American sea lions in marine debris: Do we know enough? Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Raum-Suryan, K. L., K. W. Pitcher, D. G. Calkins, J. L. Sease, and T. R. Loughlin. 2002. Dispersal, rookery fidelity and metapopulation structure of Steller sea lions (*Eumetopias jubatus*) in an increasing and a decreasing population in Alaska. Marine Mammal Science 18:746-764.

Raum-Suryan, K.L., M.J. Rehberg, G.W. Pendleton, K.W. Pitcher, and T.S. Gelatt. 2004. Development of dispersal, movement patterns, and haul-out use by pup and juvenile Steller sea lions (*Eumetopias jubatus*) in Alaska. Marine Mammal Science 20:823-850.

Raum-Suryan, K., M. Rehberg, K. Pitcher, G. Pendleton, and T. Gelatt. 2003. Dispersal and movement patterns of juvenile Steller sea lions in Alaska. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Rea, L.D. 2003. Differences in blubber levels of fatty acid 20:1n-11 suggest free-ranging Steller sea lions (*Eumetopias jubatus*) ingest prey at a younger age in Prince William Sound than sea lions captured in southeast Alaska. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Rea, L.D., C.A. Beck, V.K. Stegall, S.D. Farley, K.B. Beckmen, and K.W. Pitcher. 2005. Got milk? –assembling physiological indices of weaning for Steller sea lions. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Rea, L., J. Kennish, and C. Beck. 2003. Modeling diet composition of free-ranging Steller sea lions using quantitative fatty acid signature analysis. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Rea, L.D., and T.R. Nagy 2000. Changes in serum leptin levels during fasting and food limitation in Steller sea lions (*Eumetopias jubatus*). Pages 171-175, *in* C.L.K. Baer (ed.), Proceedings of the Third Comparative Nutrition Society Symposium, No. 3, Pacific Grove, California, August 4-9, 2000.

Rea, L.D., K.W. Pitcher, S.D. Farley. 2003. Percent total body lipid content increases in Steller sea lion (*Eumetopias jubatus*) pups throughout the first year of life in a similar pattern to other otariid pups. P. 135, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Rea, L.D., D.A.S. Rosen and A.W. Trites. 2000. Metabolic response to fasting in 6-week-old Steller sea lion pups (*Eumetopias jubatus*). Canadian Journal of Zoology 78:890-894.

Ream, R. R. 2002. Molecular ecology of North Pacific otariids: Genetic assessment of northern fur seal and Steller sea lion distributions. Ph.D. dissert., Univ. Washington, Seattle, WA 135 p.

Rehberg, M.J. 2005. Pattern matters: changes in the organization of swimming and diving behavior by Steller sea lion juveniles in coastal Alaska waters. M.S.. Thesis, University of Alaska, Anchorage, AK. 92p.

Rehberg, M.J., and J.M. Burns. 2003. Developing methods to describe Steller sea lion (*Eumetopias jubatus*) juvenile habitat usage at varying temporal scales. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Rehberg, M.J., and J. M. Burns. 2004. Objective classification of trips-to-sea made by juvenile Steller sea lions (*Eumetopias jubatus*) in Alaska. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Rehberg, M. J. and J.M. Burns. 2005. Objective classification of dive shapes from Satellite relay data recorders. 3rd Annual Biologging Conference, St. Andrews, Scotland, UK. June 2005.

Rehberg, M.J., and J.M. Burns. 2005. Organization of diving behavior discriminates among general predators: example in Steller sea lion (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Rehberg, M. J. Burns, and T. Gelatt. 2003. Diving and activity patterns of juvenile Steller sea lions (*Eumetopias jubatus*). P. 136, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Richmond, J.P. 2004. Ontogeny of total body oxygen stores and aerobic dive potential in the Steller sea lion (*Eumetopias jubatus*). M.S. thesis, University of Alaska, Anchorage. 126 pp.

Richmond, J.P., J.M. Burns, and L.D. Rea. 2003. Developmental trends in erythropoietin: The diving force behind blood oxygen store expansion. P. 137, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p

Richmond, J.P., J.M. Burns, and L.D. Rea. 2003. Steller sea lion foraging ecology is an important factor in juvenile survival. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Richmond, J.P., J. M. Burns, and L. D. Rea. 2004. Examination of blood and muscle development in the Steller sea lion (*Eumetopias jubatus*): Implications for diving and foraging ability. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Richmond, J.P., J. M. Burns, and L. D. Rea. 2006. Ontogeny of total oxygen stores and aerobic dive potential in Steller sea lions (Eumetopias jubatus). Journal of Comparative Physiology B: (early on-line source: DOI 10.1007/s00360-006-0076-9.)

Richmond, J.P., J.M. Burns, L.D. Rea, K. Mashburn. 2005. Postnatal ontogeny of erythropoietin and hematology in free-ranging Steller sea lions (*Eumetopias jubatus*). General and Comparative Endocrinology. 141:240-247.

Richmond, J. P. and L. D. Rea. 2001. Nutritional blood chemistry provides clues to the feeding status of young of the year and juvenile Steller sea lions (*Eumetopias jubatus*). P. 179, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Riemer, S. D., R. F. Brown and B. E. Wright. 2001. The Steller sea lion in Oregon. P. 180, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Rivera, P.M., L.D. Rea, P. Richmond, and V.K. Stegall. 2005. Nutritional indices of young Steller sea lions in Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Robson, B. W., L. W. Fritz and T. R. Loughlin. 2001. Conflicts in conservation: the impact of habitat protection measures for Steller sea lions on the distribution of fisheries in northern fur seal foraging habitat. P. 180, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada. [6]

Rodionov, S.N., J.E. Overland, and N.A. Bond. 2005. Spatial and temporal variability of the Aleutian climate. Fisheries Oceanography 14 (Suppl. 1):3-21.

Rosen, D. 2005. Physiological answers to ecosystem questions: What we have learned from laboratory studies about the decline of Steller sea lions in Alaska. *In* Marine Science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

Rosen, D.A.S., G.D. Hastie, and A.W. Trites. 2004. Searching for stress: Hematological indicators of nutritional inadequacies in Steller sea lions. Symposia of the Comparative Nutrition Society 2004. No. 5:145-149.

Rosen, D.A.S., S. Kumagai, G.D. Hastie, R. Barrick, C.A. Nordstrom, and A.W. Trites. 2005. Blood barometers: Indicators of nutritional stress in captive Steller sea lions. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Rosen, D.A.S., D. J. Tollit, A.J. Winship, and A.W. Trites. 2004. Potential effects of short-term prey changes on sea lion physiology. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Rosen, D.A., D.J. Tollit, A.J. Winship, and A.W. Trites. In press. Potential effects of short-term prey changes on sea lion physiology. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

Rosen, D.A.S. and A.W. Trites. 2000a. Pollock and the decline of Steller sea lions: testing the junk-food hypothesis. Canadian Journal of Zoology 78:1243-1258.

Rosen, D.A.S. and A.W. Trites. 2000b. Digestive efficiency and dry-matter digestibility of Steller sea lions fed herring, pollock, salmon and squid. Canadian Journal of Zoology 78: 234-239.

Rosen, D.A.S. and A.W. Trites. 2000c. Assessing the role of nutritional stress in the decline of wild populations: a Steller case of scientific sleuthing. Pages 182-186, *in* C.L.K. Baer (ed.). Proceedings of the Third Comparative Nutrition Society Symposium, No. 3, Pacific Grove, California, August 4-9, 2000.

Rosen, D.A.S., and A.W. Trites. 2001. Effect of diet composition and feeding regime on body mass and composition in captive Steller sea lions. P. 183, *in* 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, BC, Nov 28-Dec 3, 2001.

Rosen, D.A.S. and A.W. Trites. 2002. Changes in metabolism in response to fasting and food restriction in the Steller sea lion (*Eumetopias jubatus*). Comparative Biochemistry and Physiology B 132(2): 389-399.

Rosen, D.A.S. and A.W. Trites. 2002. Cost of transport in Steller sea lions, *Eumetopias jubatus*. Marine Mammal Science 18(2):513-524.

Rosen, D.A.S. and A.W. Trites. 2003. No evidence for bioenergetic interaction between digestion and thermoregulation in Steller sea lions, *Eumetopias jubatus*. Physiological and Biochemical Zoology. 76:899-906.

Rosen, D.A.S. and A.W. Trites. 2004. Satiation and compensation for short-term changes in food quality and availability in young Steller sea lions (*Eumetopias jubatus*). Canadian Journal of Zoology 82:1061-1069.

Rosen, D. A. S., and A.W. Trites. 2005. Examining the potential for nutritional stress in young Steller sea lions: physiological effects of prey composition. Journal of Comparative Physiology B 175: 265-273.

Rosen, D.A.S., L. Williams, and A.W. Trites. 2000. Effect of ration size and meal frequency on digestive and assimilation efficiency in yearling Steller sea lions, *Eumetopias jubatus*. Aquatic Mammals 26:76-82.

Rosen, D.A.S., A.J. Winship, R.L. Barrick, C.A. Nordstrom, D.J. Tollit, and A.W. Trites. 2003. Limitations to food intake and potential physiological consequences. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Rosen, DAS, A.J. Winship, and L. Hoopes. In press. Thermal and digestive constraints to foraging in marine mammals. Special proceedings publication Environmental Constraints upon the Locomotion and Energetics of Aquatic Organisms. Springer-Verlag.

Rusin, Jeremy D. 2002. Management of the western Alaska Steller sea lion, *Eumetopias jubatus*, under the Endangered Species Act: evolution of interagency consultation and impacts on Alaska groundfish fisheries. M.M.A. thesis, University of Washington. 117p. [6]

Ryding, K.E., J.R. Skalski, P.Dillingham, and T.J. Miller. 2003. Empirical relationships between localized fisheries trends and Steller sea lion abundance. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Saulitas, E., Matkin, C., Barrett-Lennard, L. G., Heise, K., and Ellis, G. 2000. Foraging strategies of sympatric killer whale (*Orcinus orca*) populations in Prince William Sound, Alaska. Marine Mammal Science, 16:94-109.

Saeki, K., M. Nakajima, T.R. Loughlin, D.G. Calkins, N. Baba, M. Kiyota, R. Tatsukawa. 2001. Accumulation of silver in the liver of three species of pinnipeds. Environmental Pollution 112:19-25.

Schauflerer, L., E. Logerwell, and J. Vollenweider . 2004. Variation in the quality of Steller sea lion prey from the Aleutian Islands and Southeastern Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK. (

Scheel, D., C.O. Matkin, and E. Saulitis. 2001. Distribution of killer whale pods in Prince William Sound, Alaska 1984–1996**.** Marine Mammal Science 17(3):555–569.

Schell, D. M. 2000. Declining carrying capacity in the Bering Sea: Isotopic evidence from whale baleen. Limnology and Oceanography 45:459-462.

Schrader, W., M. Horning, and J.-A. Mellish. 2005. Post-release monitoring of juvenile Steller sea lions. Chapter 20, pages 193-199, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p

Schrader, W.J., M. Horning, and J.-A. E. Mellish. 2005. Where do they spend their time? A focus on water column use by juvenile Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Schumacher, J.D., N. A. Bond, R. D. Brodeur, P. A. Livingston, J. M. Napp and P. J. Stabeno. 2003. Climate Change in the Southeastern Bering Sea and Some Consequences for Biota. Pp 17-40. In: Large Marine Ecosystems of the World: Trends in Exploitation, Protection, and Research. G. Hempel, K. Sherman, editors. Amsterdam: Elsevier Science. 440 pp.

Scordino, J., R. Brown, B. Wright, J. Jennings, and S. Heppell. 2005. Juvenile Steller sea lion movements of the California Current ecosystem. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Sease, J. L., and C. J. Gudmundson. 2002. Aerial and land-based surveys of Steller sea lions (*Eumetopias jubatus*) from the western stock in Alaska, June and July 2001 and 2002. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-AFSC-131. 45 pp.

Sease, J. L. and C. Stinchcomb. 2003. 2002 surveys of Steller sea lions in Alaska. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

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. Department of Commerce, NOAA Technical Memorandum, NMFS-AFSC-122. 52 pp.

Sease, J. L., and A. E. York. 2003. Seasonal distribution of Steller's sea lions at rookeries and haul-out sites in Alaska. Marine Mammal Science 19(4):745-763.

Shima, M., A. Hollowed, B. Fadely, C. Wilson, J. Sterling, and K. Call. 2003. Comparison of Steller sea lion diving behavior relative to spatial distribution of walleye pollock and capelin. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Shima, M., A. B. Hollowed, and G. R. VanBlaricom. 2000. Response of pinniped populations to directed harvest, climate variability, and commercial fishery activity: a comparative analysis. Rev. Fish. Sci. 8(2):89-124.

Shima, M., A. B. Hollowed, and G. R. VanBlaricom. 2002. Changes over time in the spatial distribution of walleye pollock (*Theragra chalcogramma*) in the Gulf of Alaska, 1984-1996. Fish. Bull., 100:3-7-323.

Sigler, M.F., S. M. Gende, and D. J. Csepp. 2004. Predictability of prey available to free-ranging Steller sea lions at varying spatial scales. In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK.

Sigler, M.F., S. M. Gende, and D. J. Csepp. 2004. Predictability of prey available to free-ranging Steller sea lions at varying spatial scales. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Sigler, M., J. Vollenweider, and D. Csepp. 2003. Southeast Alaska Steller sea lion prey study. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Sigler, M., J. Vollenweider, and J. Womble. 2003. Availability to Steller sea lions (*Eumetopias jubatus*) of a seasonal prey resource: A prespawning aggregation of eulachon (*Thaleichthys pacificus*). P. 150, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Sigler, M. and J.N. Womble. 2006. Ecological significance of seasonal aggregations of marine forage species for Steller sea lions. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK. (**2a**)

Sigler, M.F., J.N. Womble, and J.J. Vollenweider. 2004. Availability to Steller sea lions (*Eumetopias jubatus*) of a seasonable prey resource: a spawning aggregation of eulachon (*Thaleichthys pacificus*). Can. J. Fish. Aquat. Science 61:1475-1484.

Sinclair, E.H. and P.J. Stabeno. 2002. Mesopelagic nekton and associated physics of the southeastern Bering Sea. Deep Sea Research, Part II.: Topical Studies in Oceanography 49(26):6127-6145.

Sinclair, E., and T. Zeppelin. 2002. Seasonal and spatial differences in diet in the western stock of Steller sea lions (*Eumetopias jubatus*). J. Mammal. 83(4):973-990.

Sinclair, E.H., S.E. Moore, N.A. Friday, T.K. Zeppelin, and J.M. Waite. 2005. Do patterns of Steller sea lion (*Eumetopias jubatus*) diet, population trend and cetacean occurrence reflect oceanographic domains from the Alaska Peninsula to the central Aleutian Islands? Fisheries Oceanography 14 (Suppl. 1):223-242.

Skomal, G.B., and G.W. Benz. 2004. Ultrasonic tracking of Greenland sharks, *Somniosus microcephalus*, under Arctic ice. Marine Biology 145: 489–498.

Small, R.J., and D.P. DeMaster. 2004. Uncertain management or management of uncertainty: Steller sea lion—a case study. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK. [6]

Small, R.J., and D.P. DeMaster. In press. Uncertain management or management of uncertainty: Steller sea lion—a case study. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant. [6]

Smith, C. R. 2005. Bigger is better: The role of whales as detritus in marine ecosystems. *In* Whales, Whaling and Ocean Ecosystems. J. Estes, editor, University of California Press, in press. 46p

Smith, C.R., and A. R. Baco. 2003. The ecology of whale falls at the deep-sea floor. Oceanography and Marine Biology Annual Review 41: 311-354.

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. Marine Mammal Science. 17:136-146.

Soboleff, N.J. 2006.. Potential interactions between state-managed fisheries and Steller sea lions (*Eumetopias jubatus*). M.S. Thesis, University of Alaska, Fairbanks. 124 p.

Soboleff, N.J., and G. H. Kruse. 2004. Potential interactions between state-managed fisheries and Steller sea lions (*Eumetopias jubatus*). Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Soboleff, N.J., and G.H. Kruse. 2005. Potential interactions between state-managed fisheries and Steller sea lions, *Eumetopias jubatus*. In: Marine science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

Sokolova, O.V., T.E. Denisenko, and V.N. Burkanov. 2005. Immuno-microbiological correlates in Steller sea lions (*Eumetopias jubatus*) pups from Kamchatka Peninsula and Commander Islands. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Soto, K., A.W. Trites, and M. Arias-Schreiber. In press. Changes in diet and maternal attendance of South American sea lions indicate changes in the marine environment and the abundance of prey. Marine Ecology Progress Series 0: 000-000.

Soto, K., A.W. Trites, and M. Arias-Schreiber. 2004. The effects of prey availability on pup mortality and the timing of birth of South American sea lions *(Otaria flavescen*s) in Peru. Journal of Zoology London 264: 419-428.

Springer, A.M., J. A. Estes , G. B. van Vliet , T. M. Williams, D. F. Doak, E. M. Danner, K. A. Forney, and B. Pfister. 2003. Sequential megafaunal collapse in the North Pacific Ocean: An ongoing legacy of industrial whaling? Proceedings of the National Academy of Sciences of the United States of America 100:12223-12228.

Stegall, V.K., S.D. Farley, L.D. Rea, and K. Pitcher. 2003. Stable isotope fluctuations in Steller sea lion (*Eumetopias jubatus*) vibrissae indicating weaning events. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Stegall, V., S. Farley, L.Rea, K. Pitcher, R. Rye, and C. Kester. 2003. Stable isotope comparisons of Alaska Steller sea lion (*Eumetopias jubatus*) populations using milk, serum, and vibrissae. P. 155, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Stegall, V.K., S.D. Farley, L. D. Rea, K. W. Pitcher, R. O. Rye, C. L. Kester, and C.R. Bern. 2004. Use of carbon and nitrogen stable isotope ratios in vibrissae to detect weaning in Alaska Steller sea lions (*Eumetopias jubatus*). Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Stegall, V.K., L.D. Rea, and M.A. Castellini. 2005. Pectoral muscle development in free-ranging Steller sea lion (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Stelle, L.L., R.W. Blake and A.W. Trites. 2000. Hydrodynamic drag in Steller sea lions (*Eumetopias jubatus*). Journal of Experimental Biology 203:1915-1923.

Stephens, C.A., T. Goldstein, J.-A. Mellish, and S. Jang. 2005. Disease and health monitoring in juvenile Steller sea lions (*Eumetopias jubatus*) held in temporary captivity. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Stephens, C., T. Goldstein, J.E. Mellish, S. Jang, and M. Gray. 2006. Disease and health monitoring in juvenile Steller sea lions (*Eumetopias jubatus*) held in temporary captivity. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Sterling, J.T., B.S. Fadely, and T.R. Loughlin. 2004. Movement and dive behavior of foraging juvenile Steller sea lions (*Eumetopias jubatus*) associated with pelagic eddies. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Stokesbury, M.J.W, C. Harvey-Clark, J. Gallant, B.A. Block, and R.A. Myers. 2005. Movement and environmental preferences of Greenland sharks (*Somniosus microcephalus*) electronically tagged in the St. Lawrence Estuary, Canada. Marine Biology 148: 159–165.

Straley, J.M.. 2005. Investigations of Steller sea lion predation by killer whales in Southeastern Alaska. NOAA Contract report, Contract No. NA16FX1413 University of Alaska Southeast, Sitka, Alaska

Straley, J.M., D.R. Matkin, C.M. Gabriele, G.M. Ellis, L.G. Barrett-Lennard. 2003. Transient killer whales in Southeast Alaska: Who are they? What are they eating? *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Straley, J., C. Matkin, D. Matkin, L. Barrett-Lennard, and C. Gabriele. 2004. Feeding ecology of transient killer whales in the northern and eastern Gulf of Alaska. In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK**.**

Suzuki, N. and V. Veljankin. 2001. A successive and social phenomenon recorded at Steller sea lion (*Eumetopias jubatus*) rookery in Commander Islands, Russia, summer 1994. P. 208, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Szaniszlo, W. 2001. California Sea Lion (*Zalophus californianus*) and Steller sea lion *Eumetopias jubatus*) interactions with vessels in Pacific Rim National Park Reserve: Implications for marine mammal viewing management. P. 209, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Szaniszlo, W., and P. Dearden. 2005. Steller sea lion (*Eumetopias jubatus*) and California sea lions (Zalophus californianus) interactions with vessels in Pacific Rim National Park Reserve: implications for marine viewing management. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Taggart, S.J., A.G. Andrews, J. Mondragon, and E.A. Mathews. 2005. Co-occurrence of Pacific sleeper sharks *Somniosus pacificus* and harbor seals *Phoca vitulina* in Glacier Bay. Alaska Fishery Research Bulletin 11(2):xxx–xxx.

Taylor, B., G. O'Corry Crowe, M. Basterretche, T. Loughlin, T. Gellat, J. Bickham, and K. Pitcher. 2003. Using molecular genetics to estimate dispersal rates between Steller sea lion rookeries. Pages 160-161, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Taylor, R.L. 2005. Assessing reproductive rates in branded Steller sea lion (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Teate, E., P. Parker, J.M. Maniscalco, and K. Harris. 2005. Tenure and reproductive success of Steller sea lions (*Eumetopias jubatus*) males at Chiswell Island, Gulf of Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Teramitsu, I., Y. Yamamoto, I. Chiba, H. Iwata, S. Tanabe, Y. Fujise, A. Kazusaka, F. Akahori and S. Fujita. 2000. Identification of novel cytochrome P450 1A genes from five marine mammal species. Aquatic Toxicology 51:145-153.

Testa, J.W., abd J.M. Burns. 2005. Optimal foraging predictions of an index to patch quality applied to juvenile Steller sea lions in Prince William Sound. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Testa, J.W., and J.M. Burns. 2006. Optimal foraging predictions of an index to patch quality applied to juvenile Steller sea lions in Prince William Sound. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Testa, J.W., R.R. Ream, R. Hobbs, and P.R. Wade. 2004. Status and trend of selected marine mammals in Alaska: Steller sea lions, northern fur seals, Cook Inlet beluga whales, and North Pacific right whales. In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK .

Testa, J. W., J.L. Sease**,** C.E. Stinchcomb, K. W. Pitcher, T. S. Gelatt, W. L. Perryman, and T. R. Loughlin. 2003. Calibrating different counting methods and modeling recent trends in the western stock of Steller's sea lions. P. 162, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Thedinga, J.F., S.W. Johnson, and D.J. Csepp. 2003. Seasonal availability of nearshore prey to Steller sea lions at two haulouts in Southeast Alaska. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Thedinga, J.F., S. W. Johnson, and D.J. Csepp. 2004. Seasonal availability of nearshore prey to Steller sea lions near two haul-outs in Southeastern Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Thomas, G. L. and R. E. Thorne. 2001. Night-time predation by Steller sea lions: New insight into the feeding habits of these mammals will help conservation attempts. Nature 411(6841):1013.

Thomas, G. L., and R. E. Thorne. 2001. Night-time predation by Steller sea lions (vol. 411, pg 1013, 2001) - Correction. Nature 414(6865):710.

Thomas, G.L. and R.E. Thorne 2003. Acoustical-optical assessment of Pacific herring and their predator assemblage in Prince William Sound, Alaska. Aquatic Living Resources 16:247-253.

Thomas, G.L., and R.E. Thorne. 2003. Density and accessibility as factors in the foraging behavior of Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Thomas, G.L., and R. E. Thorne. 2004. Implications of the Prince William Sound herring population crash: Did it impact Steller sea lions? Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Thompson, D., J. Matthiopoulos, and I. L. Boyd . 2004. Effects of water temperature on swimming metabolic rates and foraging efficiency in sea lions. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Thompson, D., J. Matthiopoulos, and I.L. Boyd. 2005. Effects of water temperature on swimming metabolic rate and foraging efficiency in sea lions. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Thompson, D., J. Matthiopoulos, C. Letteri, and I. Boyd. 2003. Implications of varying food distribution for fitness in Steller sea lions. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Thompson, G. G. and M.W. Dorn. 2005. Assessment of the Pacific cod stock in the Eastern Bering Sea and Aleutian Islands area. *In*: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Fish. Mgmt. Council, Anchorage, AK, section 2:220-330.

Thompson, G. G. and M. W. Dorn. 2005. Assessment of the Pacific cod stock in the Gulf of Alaska. *In*: Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pac. Fish. Mgmt. Council, Anchorage, AK, 2:155-244

Thorne, R.E. and G.L. Thomas 2002. Evaluation of changes in the foraging behavior of Steller sea lions in response to precipitous declines of the herring population in Prince William Sound. Final Report to NMFS, SSLRI Project # 31, 32p.

Thorne, R. E., G. L. Thomas and J, J. Goering. 2002. Interactions among Steller sea lions, pollock and herring and an examination of variability associated with acoustic surveys of pollock. Final Project Report to the Pollock Conservation Cooperative, University of Alaska, Fairbanks, Prince William Sound Science Center, Cordova, AK. 18 p.

Thorne, R.E., and G.L. Thomas. 2003. Spatial and numerical relationships between Steller sea lions and Pacific herring in Prince William Sound, Alaska. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Thorne, R.E., G.L. Thomas, and M. Foster. 2003. Associations between Steller sea lions and Pacific herring around Kodiak. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Thorne, R.E., G.L. Thomas and M. Foster 2003. Application of combined optical and acoustic technologies for fisheries and marine mammal research in Prince William Sound and Kodiak, Alaska. Proceedings Ocean 2003 MTS/IEEE (Electronic), Holland Publications, Escondido, CA.

Tollit, D.J., S.G. Heaslip, B.E. Deagle, S.J. Iverson, R. Joy, D.A.S. Rosen, and A.W. Trites. In press. Estimating diet composition in sea lions: which technique to choose? Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

Tollit, D.J., S. Heaslip, S. Iverson, D.A. Rosen, and A.W. Trites. 2003. Diet quantification of Steller sea lions- scat and fat. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Tollit, D., S. Heaslip, R. Joy, and A. W. Trites. 2004. Estimating diet composition in sea lions: What technique to choose? Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Tollit, D.J., S.G. Heaslip, and A.W. Trites. 2004. Sizes of walleye pollock consumed by the eastern stock of Steller sea lions in Southeast Alaska from 1994-1999. Fishery Bulletin 102(3): 522-532.

Tollit, D.J., Heaslip, S.G., Zeppelin, T.K., Joy, R., Call, K.A., and A.W. Trites. 2004. A method to improve size estimates of walleye pollock (*Theragra chalcogramma*) Atka mackerel (*Pleurogrammus monopterygius*) consumed by pinnipeds: digestion correction factors applied to bones and otoliths recovered in scats. . Fishery Bulletin 102(3):498-508.

Tollit, D., S. Iverson, S. Heaslip, D.A.S. Rosen, M.J. Walton, and A.W. Trites. 2005. Validation studies of blubber quantitative fatty acid signature analysis (QFASA) with captive Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Tollit, D., S. Iverson, S. Heaslip, D.A.S. Rosen, M.J. Walton, and A.W. Trites. 2006. Validation studies of blubber quantitative fatty acid signature analysis (QFASA) with captive Steller sea lions (*Eumetopias jubatus*). *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK.

Tollit, D., A. W. Trites, M. Wong, D. Rosen and R. Barrick. 2001. Addressing biases associated with quantifying diet consumption from the scat of pinnipeds. P. 215, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Tollit, D.J., M. Wong, A.J. Winship, D.A.S. Rosen, and A.W. Trites. 2003. Quantifying errors associated with using prey skeletal structures from fecal samples to determine the diet of Steller's sea lion (*Eumetopias jubatus*). Marine Mammal Science 19(4):724-744.

Trites, A.W. 2001. Marine mammal trophic levels and interactions. Pages. 1628-1633, *in* J. Steele, S. Thorpe, and K. Turekian (eds.) Encyclopedia of Ocean Sciences. Academic Press, London.

Trites, A.W. 2002. Predator-prey relationships. Pages 994-997, *in* W.F. Perrin, B. Wursig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals. Academic Press, San Diego. (**7**)

Trites, A.W. 2003. Food webs in the ocean: who eats whom, and how much? Pages 125-143, *in* M. Sinclair and G. Valdimarsson (eds.), Responsible Fisheries in the Marine Ecosystem. FAO, Rome and CABI Publishing, Wallingford.

Trites, A.W., E.L. Bredesen, and A.P Coombs,. 2004. Whales, whaling and ecosystem change in the Antarctic and Eastern Bering Sea: insights from ecosystem models. Pages 85-92, *in* Investigating the roles of cetaceans in marine ecosystems. Monaco: CIESM Workshop Monographs.

Trites, A.W., E.L. Bredesen, R. Joy, and A.J. Winship. 2005. A range-wide review of Steller sea lion diets and the evidence for dietary change in the North Pacific. *In* Marine Science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

Trites, A.W., and D.G. Calkins. 2006. Do breeding age male and female Steller sea lions eat the same things? Unpublished Manuscript. Marine Mammal Research Consortium.

Trites, A.W., D.G. Calkins, and A.J. Winship. 2006. Diets of Steller sea lions (*Eumetopias jubatus*) in Southeast Alaska from 1993 to 1999. Unpublished Manuscript. Marine Mammal Research Consortium.

Trites, A.W., D.G. Calkins, and A.J. Winship. 2003. Diet and the decline of Steller sea lions in Alaska. P. 165, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201 p.

Trites, A.W., D.G. Calkins, and A.J. Winship. 2003. Diets of Steller sea lions in Southeast Alaska *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Trites, A. W., V. Christensen, and D. Pauly. In press. Effects of fisheries on ecosystems: just another top predator? Pp. 000-000 *in* I.L. Boyd, K. Camphuysen and S. Wanless (eds.), Top predators in marine ecosystems: their role in monitoring and management (.). Cambridge University Press, Cambridge.

Trites, A.W., V.B. Deecke, E.J. Gregr, J.K.B. Ford, and P.F. Olesiuk. In press. Killer whales, whaling and sequential megafaunal collapse in the North Pacific: a comparative analysis of the dynamics of marine mammals in Alaska and British Columbia following commercial whaling. Marine Mammal Science.

Trites, A.W. and C.P. Donnelly. 2003. The decline of Steller sea lions in Alaska: a review of the nutritional stress hypothesis. Mammal Review 33: 3-28.

Trites, A.W., K. Hunt, S.K. Wasser, and K.M. Wynne. 2003. Assessing the physiological stress of Steller sea lions in Alaska using fecal hormone analysis. Final Report to the North Pacific Marine research program, Grant #00-0045. School of Fisheries and Ocean Sciences, Univ. of Alaska Fairbanks 24 pp.

Trites, A.W., K.E. Hunt, K.M. Wynne, and S.K. Wasser. 2004. Non-invasive assessment of possible nutritional stress in Steller sea lions (*Eumetopias jubatus*) using fecal glucocorticoid and dietary analyses. Society of Integrative and Comparative Biologists. New Orleans, LA. January 2004.

Trites, A.W. and R.A.H. Jonker. 2000. Morphometric measurements and body conditions of healthy and starveling Steller sea lion pups (*Eumetopias jubatus*). Aquatic Mammals 26: 151-157.

Trites, A.W., and R. Joy. 2003. Dietary analysis from fecal remains of pinnipeds: How many scats is enough? *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Trites, A.W. and R. Joy. 2005. Dietary analysis from fecal samples: how many scats are enough? Journal of Mammalogy 86: 704-712.

Trites, A.W., A.J. Miller, H.D.G. Maschner, M.A. Alexander, S.J. Bograd, J.A. Calder, A. Capotondi, K.O. Coyle, E.D. Lorenzo, B.P. Finney, E.J. Gregr, C.E. Grosch, S.R. Hare, G.L. Hunt, J. Jahncke, N.B. Kachel, H.-J. Kim, C. Ladd, N.J. Mantua, C. Marzban, W. Maslowski, R. Mendelssohn, D.J.

Neilson, S.R. Okkonen, J.E. Overland, K.L. Reedy-Maschner, T.C. Royer, F.B. Schwing, J.X.L. Wang, and A.J. Winship. In press. Bottom-up forcing and the decline of Steller sea lions in Alaska: assessing the ocean climate hypothesis. Fisheries Oceanography 0: 000-000.

Trites, A.W. and B.T. Porter. 2002. Attendance patterns of Steller sea lions (*Eumetopias jubatus*) and their young during winter. Journal of Zoology, London 256:547-556.

Trites, A.W., B.P. Porter, V.B. Deecke, A.P. Coombs, M.L. Marcotte, and D.A.S. Rosen. In press. Behavioral insights into the timing of weaning and the attendance patterns of lactating Steller sea lions (*Eumetopias jubatus*) in Alaska during winter, spring, and summer. Aquatic Mammals.

Trites, A.W., D.A.S. Rosen, and A.J. Winship. 2002. Unravelling the mysterious disappearance of Steller sea lions in Alaska: insights from fieldwork, captive studies, and mathematical models. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Trites, A.W., and K.H. Soto. 2004. A global comparative analysis of sea lion diets. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Trujillo, R. G. 2001. Macrogeographiuc variation of nuclear satellite loci in an endangered species, *Eumetopias jubatus*. M.S. thesis, Texas A&M Univ., College Station, TX. 56 p.

Trujillo, R.G., J.W. Bickham, and T.R. Loughlin. 2002. Macrogeographic variation of nuclear microsatellite loci in an endangered species, *Eumetopias jubatus*. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Trujillo, R.G., T.R. Loughlin, N.J. Gemmell, J.C. Patton, and J.W. Bickham. 2004. Variation in microsatellite and mtDNA across the range of the Steller sea lion, *Eumetopias jubatus*. Journal of Mammalogy, 85 (2):338-346.

Trukhin, A.M. 2004. Preliminary period and delivery in Steller sea lion (*Eumetopias jubatus*) under natural conditions. Pages 554-557, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Trukhin, A.M., and V.N. Burkanov. 2002. Observations of marked Steller sea lions on Raykoke Island (Kuril Islands) in 2001. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Trukhin, A.M., and V.N. Burkanov. 2004. Breeding patterns of Steller sea lion *Eumetopias jubatus* on Raykoke Island (Kuril Islands), 2001-2003. Pages 546-550, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Trukhin, A.M., and A.A. Sychenko. 2004. Daily time budget of lactating Steller seal (sic) lion (*Eumetopias jubatus*) females. Pages 550-554, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Vazhenina, V.B. 2004. Steller sea lion (*Eumetopias jubatus*) sightings in Chukotka. Pages 116-117, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Vollenweider, J.J., and R.A. Heintz. 2003. Seasonal and spatial variability of Steller sea lion (*Eumetopias jubatus*) prey quality. In: Marine science in the northeast Pacific: science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Vollenweider, J., and R. Heintz. 2003. Magnitude and sources of variability in Steller sea lion (*Eumetopias jubatus*) prey quality. P 170, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Vollenweider, J., and R. Heintz. 2004. Magnitude and sources of variability in Steller sea lion (*Eumetopias jubatus*) prey quality. In: Marine science in Alaska: joint scientific symposium. January 12-14, 2004, Hotel Captain Cook, Anchorage, AK.

Vollenweider, J.J., J. N. Womble, R. Heintz, and M. Sigler. 2004. Prey contributions to energetic content of Steller sea lion diets. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Wade,P, L. Barrett-Lennard, N. Black, R. Brownell, Jr., S. Cerchio, P. Clapham, M. Dahlheim, N. Friday, L. Fritz, J. Jacobsen, T. Loughlin, C. Matkin, D. Matkin, A. Mehta, S. Mizroch, M. Muto, D. Rice, D. Siniff, R. Small, J. Straley, G. Van Blaricom. 2003. Commercial whaling and "whale killers": A reanalysis of evidence for sequential megafaunal collapse in the North Pacific. I*n* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201 p.

Wade, P., L. Barrett-Lennard, N. Black, R. Brownell, V. Burkanov, A. Burdin, J. Calambokidis, S. Cerchio, M. Dahlheim, J. Ford, N. Friday, L. Fritz, J. Jacobsen, T. Loughlin, M.Lowry, C. Matkin, D. Matkin, S. McCluskey, A. Mehta, S. Mizroch, M. Muto, D. Rice,D. Siniff, R. Small, G. Steiger, J. Straley, G. Van Blaricom and P. Clapham. In review. Marine mammal abundance, biomass, and trends in the North Pacific – a re-examination of evidence for sequential megafauna collapse. Marine Mammal Science.

Wade, P., M.M. Krahn, D.P. Herman, C.O. Matkin, J.W. Durbin, L. Barrett-Lennard, D.G. Burrows, M.E. Dahlheim, N. Black, and R.G. LeDuc. 2006. Use of chemical profiles in assessing the feeding ecology of Alaskan killer whales. *In* Marine Science in Alaska, January 22-25, 2006, Anchorage Hilton Hotel, Anchorage, AK

Wade, P. R., J. M. Waite, S. E. Moore, L. L. Mazzuca, and A. N. Zerbini. 2003. Distribution and ecotype of killer whales in southwestern Alaska, with a discussion of abundance estimation methods. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Waite, J.N. 2000. Three-dimensional photogrammetry as a tool for assessing morphometrics and estimating body mass of Steller sea lions. M.S. thesis, Texas A&M University.

Waite, J. and V. Burkanov. 2003. Summer feeding habits of Steller sea lions (*Eumetopias jubatus*) in the Russian far-east. P. 171, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Waite, J.N., and V.N. Burkanov. 2004. Steller sea lion (*Eumetopias jubatus*) feeding habits in the Russian Far-East, 2000-2003. Pages 150-153, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Waite, J.N., and V.N. Burkanov. 2004. Steller Sea Lion (*Eumetopias jubatus*) feeding habits in the Russian Far East. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Waite, J.N., and V.N. Burkanov. 2005. Steller sea lion research in the Russian Far East. Chapter 12, pages 101-106, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Waite, J.N., V.N. Burkanov, and T.R. Loughlin. 2005. Steller sea lion diet in the Russian far east. Chapter 3, pages 19-26, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Waite, J. N. and M. Horning. 2001. Three-dimensional photogrammetry as a tool for assessing morphometrics and estimating body mass of Steller sea lions. P. 227, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver,

Waite, J.M., and K.L. Mashburn. 2005. Dietary differences between sex and age classes of Steller sea lions (*Eumetopias jubatus*). *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Watanabe, Y., M. Onuma, T. Kariya, T. Ishinazaka, T. Isono, and N. Ohtaishi. 2003. The genetic structure of Steller sea lion which have migrated to Hokkaido. P. 172, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Wespestad, V. G., L. W. Fritz, W. J. Ingraham, and B. A. Megrey. 2000. On relationships between cannibalism, climate variability, physical transport, and recruitment success of Bering Sea walleye pollock (*Theragra chalcogramma*). ICES J. Mar. Sci. 57: 272-278.

Whitehead, H. and R. Reeves. 2005. Killer whales and whaling: the scavenging hypothesis. Biol. Lett. (2005) 1, 415–418

Wiig, Ø., E.H. Miller, and A.W. Trites. 2004. International survey of scientific skull collections of Steller sea lions (*Eumetopias jubatus*). Pages 149 – 150, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Williams, T.M. 2005. The bioenergetics of Steller sea lions: a marine predator built to eat. Chapter 9, pages 77-82, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Williams, T.M. 2005. Reproductive energetics of sea lions: implications for the size of protected areas around Steller sea lion rookeries. Chapter 10, pages 83-89, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Williams, T.M., J.A. Estes, D.F. Doak, and A.M. Springer. 2004. Killer appetites: Assessing the role of predators in ecological communities. Ecology 85(12): 3373-3384.

Williams, T.M., and L. Yeates. 2004. The energetics of foraging in large mammals: a comparison of marine and terrestrial predators. International Congress Series 1275 (2004):351– 358.

Willis, K., M. Horning, D.A.S. Rosen and A.W. Trites. 2005. Spatial variation of heat flux in Steller sea lions: evidence for consistent avenues of heat exchange along the body trunk. Journal of Experimental Marine Biology and Ecology 315:163-175.

Willis, K., and M. Horning. 2005. A novel approach to measuring heat flux in swimming animals. Journal of Experimental Marine Biology and Ecology 315: 147-162.

Willis, K., and M. Horning. 2005. Thermoregulation in swimming Steller sea lions. Chapter 11, pages 90-100, *in* Loughlin, T. R., S. Atkinson, and D. G. Calkins (eds.), Synopsis of research on Steller sea lions: 2001 - 2005. Alaska SeaLife Center's Steller Sea Lion Program. Sea Script Company, Seattle, WA. 344 p.

Willoya, D., L. Jack, and M. King. 2005. Steller sea lion photographic monitoring and brand resights of local, seasonal haulouts in Prince William Sound, Alaska. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Wilson, B., M.-A. Lea, and A. W. Trites. 2004. Following in the wake of sea lions: Fine-scale boat-based tracking of juvenile Steller sea lions reveals distinct habitat preferences for shorelines. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Wilson, B., A.W. Trites, and A.J. Winship. 2003. Optimal foraging or focused prey selection: Can individual scat samples provide information on Steller sea lion feeding strategies? *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Wilson, C. D., A. B. Hollowed, M. Shima, P. Walline, and S. Stienessen. 2003. Interactions between commercial fishing and walleye pollock. Alaska Fishery Research Bulletin 10(1):61–77.

Wilson, L.J., D. Tollit, D.A.S. Rosen, C.A. Beck, L.D. Rea, D.V. Gummeson, and A.W. Trites. 2005. Variation in fatty acid composition of sea lion blubber by body site and tissue depth: Consequences for biopsy sampling in the wild. *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Winship, A. J. 2000. Growth and bioenergetic models for Steller sea lions (*Eumetopias jubatus*) in Alaska. M.S. Thesis, University of British Columbia. 160 p.

Winship, A.J., A.M.J. Hunter, D. A.S. Rosen, and A. W. Trites. 2004. Food consumption of sea lions: Data gaps and direction for future research. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Winship, A.J., A.M.J. Hunter, D.A.S. Rosen, and A.W. Trites. In press. Food consumption by sea lions: existing data and techniques. Pages 000-000 *in* Sea lions of the world: conservation and research in the 21st century, Alaska Sea Grant.

Winship, A.J., and A.W. Trites. 2003. Population viability analysis of the Steller sea lion: a Bayesian approach. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Winship, A, and A.W. Trites. 2003. The probabilities of extinction of Steller sea lion populations in Alaska. P. 178, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Winship, A.J, and A.W. Trites. 2003. Prey consumption of Steller sea lions (*Eumetopias jubatus*) off Alaska: how much prey do they require? Fishery Bulletin 101:147-167.

Winship, A., and A. Trites. 2005. Risk of extirpation of the Steller sea lion in the Gulf of Alaska and Aleutian Islands. In: Marine science in Alaska: joint scientific symposium. January 24-26, 2005, Hilton Hotel, Anchorage, AK.

Winship, A.J., and A.W. Trites. 2006. Risk of extirpation of Steller sea lions in the Gulf of Alaska and Aleutian Islands: A population viability analysis based on alternative hypotheses for why sea lions declined in western Alaska. Marine Mammal Science 22(1):124-155.

Winship, A.J., A.W. Trites and D.G. Calkins. 2001. Growth in body size of Steller sea lions (*Eumetopias jubatus*). Journal of Mammalogy 82:500-519.

Winship, A., A.W. Trites, and D. Rosen. 2001. Towards a dynamic bioenergetic model for the Steller sea lion (*Eumetopias jubatus*). P. 235, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Winship, A.J, A.W. Trites, and D.A.S. Rosen. 2002. A bioenergetic model for estimating the food requirements of Steller sea lions (*Eumetopias jubatus*) in Alaska, USA. Marine Ecology Progress Series 229:291-312.

Wise, J.P. 2005. Metal toxicity in Steller sea lion (*Eumetopias jubatus*) tissues and cell lines. Final Contract Report (Contract number NA16FX1412). University of Southern Maine. 24 p.

Wise, S.S., Little, J.E., Bozza, M., Atkinson, S., ST. Aubin, D.J., J.A., Dunn, J.L., Gulland, F., Wise, Sr. J.P. 2003. Metal toxicity in cultured Steller sea lion fibroblasts. Presented at the International Association for Aquatic Animal Medicine (IAAAM) Annual Meeting, May 2003.

Wise, Sr. J.P., Wise, S.S., Goertz, C.E.C., Bozza, M., Atkinson, S., St Aubin, D.J., Dunn, J.L., Gulland, F. 2003. Toxicity of heavy metals in cultured Steller sea lion cells. Presented at the Society of Environmental Toxicology and Chemistry (SETAC) Annual Meeting, November 2003.

Wise, Sr., J.P., S.S. Wise, C.E.C. Goertz, M. Bozza, D.K. St. Aubin, J.L. Dunn, S. Atkinson, and F. Gulland. 2003. Toxicity of heavy metals in cultured Steller sea lion cells. Presented at the Society of Environmental Toxicology and Chemistry, November, 2003.

Wise, S.S., A.T. Morin, C.E.C. Goertz, J.L. Dunn, F.M.D. Gulland, M. Bozza, S. Atkinson, and J.P. Wise, Sr. 2005. Metal toxicity of sodium chromate in Steller sea lion bronchus and dermis compared to humans. Presented at the Biennial meeting of PRIMO (Pollution Research in Marine Organisms), June 2005.

Witherell, D., Pautzke, C., and Fluharty, D. 2000. An ecosystem-based approach for Alaska groundfish fisheries. ICES Journal of Marine Science, 57: 771-777

Wolf, N., and M. Mangel. 2005. Understanding the decline of the western Alaskan Steller sea lion: Assessing the evidence concerning multiple hypotheses. Final report for contract AB133F-02-CN-0085 to the National Marine Fisheries Service. 91 text pages and 84 figure pages. Available at the National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

Wolf, N., J. Melbourne, and M. Mangel. 2004. The method of multiple (spatial) hypotheses and the decline of Steller sea lions in western Alaska. Presented paper, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Wolfe, R.J. 2001. The subsistence harvest of harbor seals and sea lions by Alaska natives. 2000. ADFG, Division of Subsistence, Technical Paper No. 266. 241 p.

Wolfe, R.J., J. Fall, and R.T. Stanek. 2002. The subsistence harvest of harbor seals and sea lions by Alaska natives. 2001. ADFG, Division of Subsistence, Technical Paper No. 273. 250 p.

Wolfe, R.J., J. Fall, and R.T. Stanek. 2003. The subsistence harvest of harbor seals and sea lions by Alaska natives. 2002. ADFG, Division of Subsistence, Technical Paper No. 277. 249p.

Wolfe, R.J., J. Fall, and R.T. Stanek. 2004. The subsistence harvest of harbor seals and sea lions by Alaska natives. 2003. ADFG, Division of Subsistence, Technical Paper No. 291. 253 p.

Womble, J.N. 2003. Seasonal distribution of Steller sea lions (*Eumetopias jubatus*) in relation to high-quality ephemeral prey species in Southeastern Alaska. M.S. thesis, Univ. Alaska, Fairbanks.54 p.

Womble, J. N., B. P. Kelly, M. F. Willson and M. Sigler. 2001. Spatial ecology of Steller sea lions (*Eumetopias jubatus*) and forage fish aggregations in Southeastern Alaska. P. 236, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Womble, J.N., and M. F. Sigler. 2004. Importance of seasonally available prey for Steller sea lions (*Eumetopias jubatus*) at Benjamin Island, Southeastern Alaska. Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Womble, J.N., M.F. Willson, M.F. Sigler, and B.P. Kelly. 2003. Seasonal distribution of Steller sea lions (*Eumetopias jubatus*) in relation to high-quality ephemeral prey species in Southeastern Alaska. P. 179, *in* 15th Biennial Conference on the Biology of Marine Mammals, December 14-19, 2003, Greensboro, NC. 201p.

Womble, J. N., M. F. Willson, M. F. Sigler, B. P. Kelly, and G. R. VanBlaricom. 2003. Spring-spawning fish aggregations: A seasonal feast for Steller sea lions. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Womble, J. N., M. F. Willson, M. F. Sigler, B. P. Kelly, and G. R. VanBlaricom. 2005. Distribution of Steller sea lions *Eumetopias jubatus* in relation to spring-spawning fish species in southeastern Alaska. Mar. Ecol. Prog. Ser. 294:271-282.

Wynen, L. P., S. D. Goldsworthy, S. J. Insley, M. Adams, J. W. Bickham, J. Francis, J. P. Gallo, A. R. Hoelzel, P. Majluf, R. W. G. White, and R. Slade. 2001. Phylogenetic relationships within the eared seals (Otariid: Carnivora): Implications for the historical biogeography of the family. Molecular Phylogenetics and Evolution 21(2): 270-284.

Wynne, K.M. 2003. Seasonal prey use by Steller sea lions near Kodiak, Alaska. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Wynne. K.M. 2005. Alaska's Steller sea lions: boom to bust- and back? Alaska Seas and Coasts, Vol. 1. May 2005. Univ. of Alaska Sea Grant Marine Advisory Program, Anchorage, AK 12pp.

Wynne, K.M. 2005. Preliminary assessment of the diet of Steller sea lions in the Kodiak Area, 1999-2003.pages 70-79, *in* Wynne, KM, RJ Foy, and CL Buck (eds). Gulf Apex Predator-prey Study (GAP) Final Rept. NOAA Grant NA16FX1270, University of Alaska Fairbanks, Kodiak, AK. 241pp. [4]

Wynne, K.M. 2005. A summary of sleeper shark stomach contents collected in the Kodiak Area, spring 2001. Pages 64-68, *in* Wynne, K.M., R.J. Foy, and C.L. Buck (eds). 2005. Gulf Apex Predator-prey Study (GAP) Final Report NOAA Grant NA16FX1270, University of Alaska Fairbanks, Kodiak, AK. 241 pp. [4]

Wynne, K. and R. J. Foy. 2001. Steller sea lion prey use vs availability near Kodiak Island. P. 237, *in*: 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Wynne, K.M., R.J. Foy, B.L. Norcross, C.L. Buck, and S. Hills. 2003. Availability and use of prey by Steller sea lions in the eastern Kodiak area, 1999-2000. Final Report to the North Pacific Marine Research Program, School of Fisheries and Ocean Sciences, Univ. of Alaska Fairbanks, 23 pp.

Wynne, K.M., R. J. Foy, B. Knoth, and C. L. Buck. 2004. Are Steller sea lions prey-limited? Ask their neighbors! Poster, *in* Sea Lions of the World Symposium, September 30-October 3, 2004, Anchorage, AK.

Wynne, K.M., R. Foy, and L. Buck. 2005. Gulf Apex Predator-prey Study (GAP) Final Report FY2001-2003. NOAA Grant NA16FX1270, University of Alaska Fairbanks, School of Fisheries and Ocean Sciences. 249p. [4]

Wynne, K. and D. Mercy (eds). 2005. Alaska's Steller sea lions boom to bust - and back? *In*, Alaska Seas and Coasts, Vol. 1(May): 12p Alaska Sea Grant/Marine Advisory Program.

Yang, M-S., K. Aydin, A. Greig, G. Lang, and P. Livingston. 2005. Historical review of capelin (*Mallotus villosus*) consumption in the Gulf of Alaska and eastern Bering Sea. US Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-155. 89p.

York, A. E., and E. E. Holmes. 2003. Using age structure to detect impacts on threatened populations: a case study using Steller sea lions. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

York, A.E., J. Thomason, and E. Sinclair. 2002. Stable isotopes in teeth of Steller sea lions: do they tell us the age at weaning? *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

York, A.E., J. Thomason, and E. Sinclair. 2005. Stable isotopes in the teeth of Steller sea lions: Do they tell us the age of weaning? *In* 16th Biennial Conference on the Biology of Marine Mammals, December 12-16, 2005, San Diego, CA. 330 p.

Zadalskiy, S.V. 2002. Population status and migrations of Steller sea lions in the northern part of the Sea of Okhotsk. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Zadalskiy, S.V., and A.S. Perlov. 2002. Age variability properties of Steller sea lions interior characteristics. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.`

Zagrebin, I.A., and D.I. Litovka. 2004. Distribution of Steller sea lions (*Eumetopias jubatus*) in north-western Anadyr Gulf and western Bering Strait in 1994-2003. Pages 331-335, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Zasypkin, M. Yu., E.M. Krainova, V.N. Burkanov, D.G. Calkins, and P. Browne. 2002. Allozyme variability in Steller sea lion assessed through the combination of biochemical genetic markers in blood. *In* Marine Mammals of the Holarctic, 2nd International Conference, 10-15 September 2002, Baikal, Russia.

Zasypkin, M. Yu., E.M. Kraynova, V.N. Burkanov, and D.G. Calkins. 2004. Allozymic variability in serum of Steller sea lion (*Eumetopias jubatus*) and its use for the study of population structure. Pages 215-220, *in* Marine Mammals of the Holarctic, 3rd International Conference, 11-17 October 2004. Koktebel, Crimea, Ukraine. [1]

Zavadil, P.A., D. Jones, A.D. Lestenkof, P.G. Tetoff, and B.W. Robson. 2005. The subsistence harvest of Steller sea lions on St. Paul Island in 2004. Annual Report provided to the National Marine Fisheries Service under contract NA16FX1420 and AB133F05RP1163. Available, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

Zavadil, P.A., A.D. Lestenkof, M.T. Williams, and S.A. MacLean. 2003. The subsistence harvest of Steller sea lions on St. Paul Island in 2002. Annual Report provided to the National Marine Fisheries Service under contract NA16FX1420. 17 pp. Available, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

Zavadil, P.A., A.D. Lestenkof, D. Jones, P.G. Tetoff, and M.T. Williams. 2004. The subsistence harvest of Steller sea lions on St. Paul Island in 2003. Annual Report provided to the National Marine Fisheries Service under contract NA16FX1420. 17 pp. Available, National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

Zeppelin, T. K., K. A. Call and T. J. Orchard. 2001. Using fish bones to estimate length of prey consumed by Steller sea lions (*Eumetopias jubatus*) in the Bering Sea and Gulf of Alaska. P. 242, *in* 14th Biennial Conference on the Biology of Marine Mammals, November 28 - December 3, 2001, Vancouver, Canada.

Zeppelin, T.K., K. A. Call, D. J. Tollit, T.J. Orchard, and C.J. Gudmundson. 2003. Estimating the size of walleye pollock and Atka mackerel consumed by the western stock of Steller sea lions. *In* Marine Science in the Northeast Pacific: Science for resource dependent communities. January 13-17, 2003, Hotel Captain Cook, Anchorage, AK. [2]

Zeppelin, T. K., D. J. Tollit, K. A. Call, T. J. Orchard, and C. J. Gudmundson. 2004. Sizes of walleye pollock (*Theragra chalcogramma*) and Atka mackerel (*Pleurogrammus monopterygius*) consumed by the Western stock of Steller sea lions (*Eumetopias jubatus*) in Alaska from 1998-2000. Fishery Bulletin 102(3):509-521.

Zerbini, A.N., J. M. Waite, J.W. Durban, R. LeDuc, M. E. Dahlheim, and P.R. Wade. In press. Estimating abundance of killer whales in the nearshore waters of the Gulf of Alaska and Aleutian Islands using line transect sampling. Marine Biology.

----

[1]Available at: http://2mn.org/ru/bookself/mmh3_book.htm

[2]Available at: http://www.afsc.noaa.gov/Stellers/MarSciSymp2003_Abstract-Bok.pdf

[3]Available at: http://www.fisheries.ubc.ca/publications/reports/report10_2.php

[4]Available at: http://www.sfos.uaf.edu/gap

[5]Available at: http://www.amap.no/

[6] This citation pertains to Steller sea lion or fisheries management and was not included in our annotated themes. It is included here to alert the reader of its existence.

APPENDIX 3 - GRAY LITERATURE SUMMARIES AND MAGAZINE/NEWSPAPER ACCOUNTS

Fadely, B.S., editor. 2001. Steller sea lion investigations, 2000. U.S. Department of Commerce, AFSC Processed Report 2001-05. 226 p.

This AFSC Processed Report summarized research on Steller sea lions during 2000 in 21 short articles and two appendices. The volume was originally intended to be a biennial publication, alternating with the Fur Seal Investigations published biennially by NMFS. But circumstances changed after 2000 and SSL research and publications took on a broader scale such that this publication became redundant with other efforts (principally the annual marine science meetings held in Anchorage). The Introduction for this volume states that it included summaries of research on SSLs during 2000 by the NMML and its contractors plus other congressionally funded parties (e.g., ADFG, Alaska SeaLife Center; the Consortium chose not to submit articles for this volume). The volume contained abstracts or short chapters separated by agency with the Alaska Fisheries Science Center contributing 11 articles, contractors to the AFSC contributing five articles, ADFG contributing three articles, and the ASLC contributing two articles. The purpose of the volume was to provide a medium through which current research, and preliminary results if appropriate, could be rapidly communicated. In almost every case, abstracts/articles included in this volume are redundant with abstracts, posters, or published articles appearing in the bibliography and accompanying annotated themes of our review. For that reason we did not annotate the abstracts/chapters included in this volume but recommend that the reader refer to the full citation list by author or coauthor of the listed citations below. A list of abstracts and articles in the volume follows.

> Baraff, L. S. and T. R. Loughlin. Trends and potential interactions between pinnipeds and fisheries of New England and the U.S. west coast, p. 137.
>
> Bickham, J. W., R. G. Trujillo and T. R. Loughlin. Population genetic analysis across the distributional range of an endangered marine mammal (Steller sea lion, *Eumetopias jubatus*), p. 117-131.
>
> Browne, P., and T.R. Loughlin. Interannual and regional differences in clinical blood parameters as an indication of Alaskan Steller sea lion condition, p 139.
>
> Burkanov, V. N. Summary of Steller sea lion studies in Russia, 2000, p. 107-116.
>
> Burkanov, V. N. and D. G. Calkins. Long-term monitoring of the Steller sea lion rookery on Chiswell Island using remote controlled video cameras, p. 169-197.
>
> Calkins, D., V. Burkanov, and M. Castellini. Steller sea lion feeding regime study, p.199-223.
>
> Chumbley, K., A. E. York and J. Harper. Steller sea lion (*Eumetopias jubatus*) demographic studies at Marmot Island, Alaska June-July 2000, p. 31-42.
>
> Fadely, B. S. Introduction, p. 1.
>
> Fritz, L. W., S. F. McDermott and S. A. Lowe. 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, p. 75-88.

Hennen, D. Towards estimating the efficacy of fisheries restrictions around Steller sea lion critical habitat, p. 133-135.

Hollowed, A. B., et al. Study to determine the effect of commercial fishing on walleye pollock distribution and abundance, p. 89-104.

Holmes, E. E. and A. E. York. Using age-structure to detect impacts on threatened populations: a case study using Steller sea lions, p. 43

Kurle, C. and T. R. Loughlin. The use of fatty acid signature profiles to obtain dietary and other information from otariids, p. 67-69.

Loughlin, T. R. Steller sea lion pup counts, tagging, and branding: Yunaska Island to Fish Island, 20 June-6 July 2000, p. 15-29.

Pitcher, K. W. Alaska Department of Fish and Game Steller sea lion research project summary, p. 143-147.

Raum-Suryan, K. and K. W. Pitcher. Trip report: brand resights of Steller sea lions within Southeast Alaska and northern British Columbia from 19 June to 10 July 2000, p. 149-158.

Raum-Suryan, K., K. Pitcher and M. Rehberg. Trip report: Steller sea lion captures in Prince William Sound and Southeast Alaska during August-September 2000, p. 159-165

Ream, R. Methods to determine gender and mitochondrial DNA haplotypes of Steller sea lions from fecal samples, p. 71-73

Sease, J. L. 2001. Capture and instrumentation of pup and juvenile Steller sea lions in the Aleutian Islands and Gulf of Alaska, February-March 2000, p. 49-64.

Sease, J. L. and W. P. Taylor. Aerial survey of adult and juvenile Steller sea lions in Alaska, June 2000, pp. 5-13.

Sinclair, E. H. and T. K. Zeppelin. Seasonal diet trends among the western stock of Steller sea lions (*Eumetopias jubatus*), pp. 65-66.

Towell, R. G. Simulated brand reading test, pp. 45-48

DeMaster, D. and S. Atkinson. 2002. Steller Sea Lion Decline: Is It Food II. University of Alaska Sea Grant, AK-SG-02-02, Fairbanks. 80 pp.

This published volume represents the proceedings of a workshop held at the Alaska SeaLife Center May 30-31, 2001, which included 14 talks followed by a discussion regarding the existence of evidence for and against various hypotheses concerning factors that could have been contributing to the decline of western stock SSLs. Each of the 14 speakers provided an abstract (or extended abstract) of their talk which was included in the volume; each is listed below. As above, we chose not to annotate each talk since they represented work in progress or were represented by more formal presentations at scientific meetings or publications that are included in our bibliography and annotated in the attached themes.

The volume did contain a brief summary statement regarding the conclusions reached by the participants. A shortened summary of the conclusions follows.

1. The suite of causes for the steep decline in the 1980s were likely different than those causing the decline in the 1990s.

2. There is considerable evidence from the 1970s and 1980s that support the hypothesis that SSLs in the western stock were nutritionally stressed, likely resulting in reduced recruitment or reproductive rates.

3. Fifty to 75% of mortality above recruitment was unexplained.

4. There were inadequate data to support or refute the nutritional stress hypothesis, particularly from data obtained in behavior and physiological studies in the 1990s.

5. Condition indices were inadequate to assess SSL health and condition.

6. Captive feeding studies showed that develop and gender cause marked differences in the way animals respond to changes in diet, that there were strong seasonal effects, fasting animals reduced their metabolic rate, and caloric density and prey quality seemed to be important in predicting and animal's response to a specific dietary regime.

7. Diet varied by region and season and prey nutritional value varied by region and season.

8. There were summaries of fish take by commercial fisheries and exploitable biomass by region, plus a discussion of the apparent changes in species composition of the near-shore marine community since the 1970s.

9. More data were needed to evaluate the impact of killer whales and sharks on SSL population dynamics. However, shark predation was not and presently is not considered a factor in SSL population dynamics.

A list of the talks presented at the workshop and abstracts in the volume follows.

Anderson, P. J. and J. E. Blackburn. Status of demersal and epibenthic species in the Kodiak Island and Gulf of Alaska region, p. 57-60

Andrews, R. D., D. G. Calkins, R.W. Davis, B.L. Norcross, K. Peijnenberg, and A.W. Trites. Foraging behavior and energetics of adult female Steller sea lions, p. 19-22.

Castellini, M. Captive studies with Steller sea lions at the Alaska SeaLife Center, p. 41-44 .

Davis, R. W., T.A. Adams, E.A. Brandon, D.G. Calkins, and T.R. Loughlin. Female attendance, lactation, and pup growth in Steller sea lions, p. 23-27.

Hulbert, L., M. Sigler and C. Lunsford. Pacific sleeper shark predation on Steller sea lions, p. 67-69.

Loughlin, T. R. and A. E. York. An accounting of the sources of Steller sea lion mortality, p. 9-13.

Matkin, C. O., L. Barrett Lennard and G. Ellis. Killer whales and predation on Steller sea lions, p. 61-66.

Pitcher, K. W. Nutritional limitation? An alternative hypothesis, p. 15-18.

Rea, L. D. Indices of condition in Steller sea lions (*Eumetopias jubatus*), p. 29-33.

Rehberg, M., K. L. Raum-Suryan, and J. Sterling. Overview of recent Steller sea lion telemetry work in Alaska, p. 35-39.

Rosen, D. A. S. and A. W. Trites. What is it about food? Examining possible mechanisms with captive Steller sea lions, p. 45-48

Sinclair, E. and T. Zeppelin. Seasonal diet trends among the western stock of Steller sea lions (*Eumetopias jubatus*), p. 53-55

Wynne, K. and R. Foy. Is it food now? Gulf apex predator-prey study, p. 49-51.

Other non-refereed SSL reports and newspaper articles, most of which are available at the library, National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, Seattle WA 98052

Burkanov, V. N. 2001. Steller sea lion survey on Kuril and Iony Islands, Russia. *AFSC Quarterly Report* Oct.-Dec.:1-8.

Cyr, C. 2001. New Steller BiOp to shed light on groundfishing's future. *Pacific Fishing* 22(8):20-21.

Daerr, E. G. 2001. Fishing for answers: Glacier Bay provides new birthing ground for Steller sea lions, whose overall numbers are down. *National Parks* 75(9-10):40.

Ess, C. 2001. Forage-fish issue deliver knockout to Alaska pollock, groundfish boat (Steller sea lions). *National Fisherman* 81(12):27-28.

Ess, C. 2002. Steller studies offer hope to pollock trawl fishery: suggest widespread closures unnecessary. *National Fisherman* 83(1):10.

Harper, J. L. 2001. Bibliography: Steller sea lion (*Eumetopias jubatus*). Unpublished bibliography, National Marine Mammal Laboratory, February 21, 2001, 57p. Updates Strick,J.M. 1993. AFSC Processed Report 93-12.

Hrynyshyn, J. 2001. What's on the menu? [Steller sea lion diet]. *New Scientist* 172(2321):17.

Hunter, A.M.J. and A.W. Trites. 2001. An annotated bibliography of scientific literature (1751-2000) pertaining to Steller sea lions (*Eumetopias jubatus*) in Alaska. (Fisheries Centre Research Reports, Vol 9 (1)). 45p.

Loy, W. 2001. Groundfish industry pins its hopes on Steller rider: legislation would overturn court injunction. *National Fisherman* 81(9):9.

Loy, W. 2001. High-tech Steller BiOp finds no jeopardy. *Pacific Fishing* 22(10):14.

Loy, W. 2001. NMFS flips Alaska fleet out of frying pan, into fire: Biological opinion could broaden impact of federal measures to protect Steller sea lion. *National Fisherman* 81(10):16-17.

Loy, W. 2001. Sea lion research bottleneck: with $43 million to spend, can Steller studies start soon enough to help fisheries? *Pacific Fishing* 22(3):19-20.

Loy, W. 2001. Stevens draws budget line in sand, gets Steller rider. *National Fisherman* 81(11):14.

Sease, J. L. 2001. Steller sea lion brand-resight cruise in the Gulf of Alaska 19-29 May 2001. Unpublished cruise report, 9p.

Sease, J. L. 2001. Steller sea lion research cruise in the Gulf of Alaska and eastern Aleutian Islands 2-16 November 2001. Unpublished report, 13p.

Sease, J. L. 2002. Aerial survey of western-stock Steller sea lions Cape St. Elias to Attu Island: 14-25 June 2002 - trip report. Unpublished paper, National Marine Mammal Laboratory, Seattle, WA, 7p. +appendix.

Sease, J. L. and C. Jenkins. 2002. Steller sea lion research cruise in the central Gulf of Alaska, 18-31 May 2002 - cruise summary. Unpublished paper, National Marine Mammal Laboratory, Seattle, WA, 6p. + tables.

van Amerongen, J. 2001. Playing with Tag: its more than fooling around [Vancouver Aquarium Steller sea lion research]. *Alaska Fisherman's Journal* 24(4):18-22.

Van Amerongen, J. 2001. State fisheries and Steller sea lions. *Alaska Fisherman's Journal* 24(1):12,82.

van Amerongen, J. 2001. Steller BiOp-4 says enough is enough: new report has kinder, gentler view of fisheries. *Alaska Fisherman's Journal* 24(10):10, 23.

van Amerongen, J. 2003. Zilly rejects Steller BiOp: but NMFS moves closer to compliance. *Alaska Fisherman's Journal* 26(2):20.

Vollenweider, J. 2002. Southeast Alaska Steller sea lion prey study. *AFSC Quarterly Report* July-August-September:19.

Warren, B. 2001. NMFS BiOp widens Steller crisis. *Pacific Fishing* 22(1):14-15.