Anthropological investigations on the decline of the Steller Sea Lion (*Eumetopias jubatus*) in the western Gulf of Alaska and southern Bering Sea

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ABSTRACT

25 The western Gulf of Alaska Steller sea lion (*Eumetopias jubatus*) population has declined dramatically
26 in recent decades, resulting in their addition to the Endangered Species List in 1997. The reasons for
27 the decline immediately became politicized and debated. Broad and sweeping restrictions on North
28 Pacific fisheries became the favored solutions of policymakers and environmental groups. Aleut
29 fishermen, who were fated to lose large portions of their traditional fishing grounds, were left in a
30 reactionary mode, having never been included in the regulatory or recovery processes. Here we
31 consider the wealth of knowledge of the North Pacific ecosystem that Aleut fishermen and their
32 heritage possess, which places humans squarely upon the landscape, and argue that the inclusion of
33 their traditional knowledge and history is crucial to understanding variations in the North Pacific
34 ecosystem. We show that the Steller sea lion has gone through at least three major declines in the
35 last 1000 years and that these collapses are closely tied to reported regime shifts in the north Pacific
36 ecosystem. The result is a refutation of the direct role of humans in the modern collapse of the
37 Steller sea lion population and extensive support for hypotheses encompassing climate change and
38 regime shifts. But the relationships between people and SSLs are complicated by historical factors
39 reaching back hundreds, if not thousands of years.
40
41 Key words: Steller sea lion, Aleut, archaeology, traditional knowledge, regime shifts

INTRODUCTION

Between 1977 and 1988, the western Gulf of Alaska Steller sea lion (*Eumetopias jubatus*) (hereafter SSL) population went through a catastrophic decline. Numbers of sea lions dropped from a high of nearly 250 000 individuals to below 100 000 (National Research Council 2003; Trites and Larkin 1996). The decline continued, although more slowly in the 1990s, and by 1995 there were fewer than 40 000 sea lions in this population. A number of hypotheses were put forward to explain the cause of the decline. They range from a reduction in SSL food sources to disease to climate change (National Research Council 2003:2-8), but the cause most often implicated, and one that became a major fundraising mantra for various environmental groups, was commercial harvesting of groundfish leading to Steller sea lion starvation (Demaster and Atkinson 2002; Trites and Donnelly 2003; Alverson 1992). In 1998, Judge Thomas Zilly found the National Marine Fisheries Service's (NMFS) Biological Opinion concerning the decline of the sea lion to be legally inadequate, the result of a lawsuit initiated by Greenpeace, the Sierra Club, and the American Oceans Campaign, and thus a decision not based upon ecological data (e.g. Bowen et al. 2001). The outcome was the prohibition of commercial groundfish harvesting in many areas of the western Gulf of Alaska, particularly around sea lion rookeries and haulouts, and resulted in a surge of research efforts in the region (Figure 1) (NRC 2003).

The impacts on local, indigenous fishermen were immediate and devastating. For more than 10 000 years, the Aleut, one of the least known or studied northern peoples, have occupied the eastern Aleutian Islands, Alaska Peninsula, and the Shumagin Islands, as well as the Pribilof Islands for the past 200 years. Unlike foraging peoples elsewhere in the world, the Aleut lived in large, permanent towns, had strong institutions of rank and status, owned slaves, and participated in long distance military campaigns (Black 1984; Maschner and Reedy-Maschner 1998; Townsend 1983; Venaiminov 1984). Importantly, the Aleut used marine resources such as gadids, salmon, and sea

66 mammals not just for subsistence, but as actual commodities that were sold for status and prestige,
67 power, rare goods, and other social, political and material products (Lantis 1970, 1984; Townsend
68 1983; Maschner and Hoffman 2003; Reedy-Maschner and Maschner 2004). With the arrival of the
69 Russian fur traders and then the American government, various aspects of this economic system
70 changed in emphasis, but never altered its basic form (Reedy-Maschner 2004, 2001). Today, the
71 approximately 3000 surviving Aleut, a small but vibrant population reduced from the perhaps 20
72 000-30 000 who lived in the region prior to European diseases and conflict (Lantis 1970, 1984), still
73 maintain this economic pattern of using the marine ecosystem to produce the necessary
74 commodities for maintaining families in the region. Their removal from many of their traditional
75 fishing grounds was, in many respects, the final indignity in a 250 year history of introduced diseases,
76 forced relocations, restrictions on access to traditional foods, policy unpredictability, and harassment
77 by environmental groups.

78 For government agencies and most research biologists, the problem of the endangered
79 Steller sea lion is largely considered a commercial fishery issue, not one of community or cultural
80 survival. With this in mind, the SSL protection plan, while perhaps being environmentally sensitive,
81 may be contributing to the collapse of Alaska Peninsula and Aleutian coastal communities (Reedy-
82 Maschner 2001). Ongoing research in these villages by the authors has found that local people have
83 felt disenfranchised from the process of regulating their fisheries for the protection of the SSL, and
84 local fishermen's knowledge of SSL ecology and behavior has not been sought.

85 With little access to the research concerning the Steller sea lion decline and given no voice in
86 the regulatory process, the Aleut of the western Alaska Peninsula invited us to conduct studies of
87 the decline that used anthropological and archaeological data - an area of inquiry lacking in all other
88 studies in the region. Two areas in which anthropology and archaeology can contribute were long-
89 term trends in the distribution of Steller sea lions from the archaeological data over the last 5000

90 years, and medium scale trends through ethnohistory, ethnography, and traditional knowledge over
91 the last 200 years. These data are important because NMFS has no population estimates or survey
92 data prior to 1956 (Mathisen and Lopp 1963), and no scientifically validated counts prior to the
93 1970s (National Research Council 2003:62). It was further unknown if the high numbers of Steller
94 sea lions on the north Pacific in the late 1960s were representative of 'normal' conditions, or if they
95 were, for example, experiencing unusual population growth.
96 Traditional knowledge and ethnohistoric accounts are critical to any management scenario
97 (e.g. Berkes 1999; Collings 1997; Huntington 1989, 1992). Repeatedly, conservationists and
98 biologists are finding that continuing detailed studies of endangered species is having little effect on
99 the sustainability of those species without a concomitant understanding of both historic and modern
100 interactions between those species and the people sharing the same landscape. This is the reason
101 that most major projects in the Amazon Basin, for example, now invest more time and funding on
102 studying human-landscape interactions as the primary means of saving indigenous species
103 threatened by human expansion or exploitation of the environment (e.g. papers in Western and
104 Wright 1994).
105 Recent implementations of community-based conservation programs have had considerable
106 success in many parts of the world because they have explicitly included local peoples in
107 management and scientific programs. Biologists often fail to recognize that humans have been an
108 integral part of the natural environment (except in Antarctica) for thousands of years. In fact, there
109 is no such thing as an arctic environment that does not directly include humans, at least for the last
110 12 000 years in the western Arctic. Most attempts to mitigate humanity's role in the environment
111 through the 'National Park' mentality that seeks to exclude all humans have had poorer results than
112 those which recognize the important roles that indigenous populations play in the management and
113 ecology of local species (Berkes 1999; Weber *et al* 2000). With this as a foundation and research

perspective, this analysis of our results will present information from ongoing research concerning the decline of the Steller sea lion on the north Pacific and southern Bering Sea (Figure 1).

INDIGENOUS, ETHNOHISTORIC AND ARCHAEOLOGICAL PERSPECTIVES ON THE SSL DECLINE

An area of anthropological research that is gaining prominence is the incorporation of local or traditional knowledge into our research agendas (Berkes 1999; Brush and Stabinsky 1996; Freeman 1992; Ortiz 1999), which has been an important part of Aleutian anthropology for many years. The research conducted by Veltre and Veltre (1987) with the residents of Atka Island provides one of the most comprehensive descriptions of historic and modern subsistence practices available. Similarly, ongoing studies by the Alaska Department of Fish & Game have documented subsistence practices within the northeast Pacific, permitting the identification of local differences and regional similarities (Fall *et al* 1993; Fall *et al* 1996; Veltre and Veltre 1983). More research still needs to be done. Studies of local place names, oral history, and subsistence contribute greatly to our understanding of human-landscape interactions (e.g. Kari 1986). These studies also provide a connection between the lives of those who reside in the Aleutians today and the people of the past.

The role of local peoples in the collection of population data for conservation and ecological studies has a long history (Colchester 1994; Weber *et al* 2000). Monkey counts in the Amazon have demonstrated that indigenous knowledge of the local environment plays an important role in the accuracy of any population estimates. Paule Gros found in her African research on cheetah ecology that there were no scientific methods that could even approximate the accuracy of local Maasai observers (Gros 1997; Gros *et al* 1996). Aleutian fishermen spend an extraordinary amount of time each year in their boats out on the water and have a detailed knowledge of the coastline, currents, weather, and the frequency and behavior of all species that inhabit the region. Reedy-Maschner has

spent many months in the Aleut community of King Cove during the salmon, cod, halibut and crab fishing seasons. In anticipation of the restricted cod and pollock season, many of these fishermen were concerned about their future and eager to discuss their own observations of SSLs, predator and prey relationships, and what they see as contributing to the decline of the SSL.

For example, Marine biologists investigating the modern distributions of SSLs have focused on rookeries and other areas of concentration in order to conduct population counts. While there is considerable evidence that the majority of SSLs are counted because of their attraction to these locations at particular times of the year (National Research Council 2003:62-66), local residents wonder who is counting all of the SSLs that do not congregate at the rookeries. Trites and Larkin (1996) estimate that 45% of the adult population does not return to rookeries during the summer based on a 1991 range wide survey of all rookeries and major haulouts. While other SSL biologists consider this number to be smaller (Tom Loughlin, personal communication), fishermen of the region disagree.

Traditional scientists appropriately point out that indigenous survey data that are collected ancillary to other subsistence or commercial activities may not be as robust as systematic surveys and will be difficult to incorporate into the larger data gathering efforts of current SSL studies. However, these observations will be spatially and temporally different from those same systematic surveys. Such data are important if we are to evaluate the effectiveness of haul-out and rookery-based observations. Certainly unsystematic but quite broad based, these observations will fill an important gap in the current data.

Interviews with fishermen and other local elders and residents of the villages of the Aleutians East Borough demonstrated a willingness to share their vast knowledge of their environment. The foci of these interviews were on their observations of SSLs throughout their lives, subsistence hunting and use in previous years, and data on predators and prey. Our work in these

Eastern Aleutian villages suggests that there is a considerable amount of traditional knowledge to be found on subjects ranging from plant use to sea lion ecology. Interviews with fishermen in the region have demonstrated an extensive and detailed understanding of the north Pacific – southern Bering Sea ecosystem, which should come as no surprise since some of the residents have been making natural science observations, in the context of subsistence and commercial harvesting, for over 50 years.

The ethnohistoric and early ethnographic literature is critical to this study. Traditionally, Aleuts hunted sea lions for meat, oil and blubber, bone and whiskers for tools and other needs, sinew for cordage, intestines and stomach for waterproof containers and clothing, and skin for *baidarkas* (kayaks) (Laughlin 1980; Veniaminov 1984). Until recently, annual subsistence harvests of sea lions occurred in most coastal communities in the geographic range of the species (Wolfe and Mishler 1993). In 1992, two years after the SSL was designated as a threatened species, many Alaska Native residents were under the mistaken impression that subsistence harvests were also banned, and of the 65 coastal communities surveyed by the Alaska Department of Fish & Game that year, sea lions were taken in only 23 (Wolfe and Mishler 1993). Wolfe and Mishler observed an overall decline in the subsistence harvest of SSLs over time with the concomitant decline in the population of the species (1993:73). Aleut harvest and use of sea lions in the village of King Cove was largely opportunistic and occurred within the context of other fishing activities (Braund *et al* 1986:7:29). Today, sea lions are only sporadically hunted, but are still observed closely by local residents and fishermen.

The archaeology of Aleut use of SSLs is also important here. Yesner (1980, 1981) has pointed out that the Aleutian region is one of the most productive and biologically diverse ecosystems in the northern hemisphere and the peoples of the area were poised and equipped to harvest those resources (cf. L. Black 1987; Veltre 1998). As Yesner (1980) and others have discussed

(Laughlin 1980; Maschner 1998; Savinetsky *et al* 2004; Siegel-Causey *et al* 1991; Simenstad *et al* 1978; Yesner 1987, 1988), the remains of mammals, birds, and fish found in archaeological sites are not only a good measure of relative abundance at the time of harvesting but also provide a measure of change in the ecological system should there be deviations from modern distributions. Long-term change in the distribution, range, and structure of specific populations will provide baseline data for any attempts to model change in human-environment interactions and for the investigation of macro-regional and micro-regional changes in the Bering Sea and Pacific Ocean marine ecosystems. In a seminal study using archaeological and modern data, Simenstad *et al* (1978) argued that there was a direct relationship between the over-exploitation of sea otters by the Aleut and the expansion of sea urchin and mussel communities, which in turn reduce kelp forests because kelp is the primary food source of these invertebrates. On the other hand, when there are large numbers of sea otter, there are few adult urchins and mussels because the otters prey them upon, and thus, there is an expansion of the kelp communities and the other species associated with them. But these types of studies, which now fall in the field of biocomplexity, have made little subsequent impacts on Aleutian studies until recently.

The implications of these kinds of research programs are substantial. The north Pacific is one of the world's last great fisheries. Any diachronic study of the long-term viability of, and the effects of human exploitation on, that fishery will provide data that are critical yet currently lacking for the management of the Bering Sea and north Pacific. By monitoring the effects of human harvesting as well as changes in the population systematics of species and ecosystems, we will be in a more informed position for management and policy. Long-term changes in the north Pacific and southern Bering Sea ecosystems have been the subject of intensive investigations using archaeological data. The archaeological data indicate that there have been significant variations in the distributions of key species over the last 5000 years that correlate closely with broad changes in

210 regional climatic regimes. The most notable is the Steller sea lion. While it is impossible to use
211 archaeological data to determine absolute abundances of individual species, the tens of thousands of
212 bones from archaeological sites allow the reconstruction of relative abundances because the ancient
213 Aleut were optimal foragers and species were harvested in numbers relative to their actual
214 abundance on the landscape (Yesner 1981). Thus, substantial changes in the proportions of phocid
215 and otariid bones, for example, should be indicators of actual changes in the proportions of these
216 animals on the natural landscape. Centennial scale changes in species abundance are a measure of
217 long-term and region-wide fluctuations in the marine environment.
218 The Lower Alaska Peninsula Project and the Sanak Island Projects have generated data over
219 12 field seasons in the western Gulf of Alaska and southern Bering Sea. Over 300 ancient village
220 sites spanning the last 6000 years have been documented. Nearly 100 000 sea mammal, bird and fish
221 bones have been collected resulting in the largest paleoecological data set in the southern Bering Sea
222 and north Pacific region. These data have been correlated and compared with paleoclimatic data
223 collected by the project, which includes several detailed pollen cores, studies of sea level changes and
224 coastal geomorphology, and changes in the near-shore environments (Jordan 2000; Jordan and
225 Maschner 2000; Jordan and Krumhardt 2003; Maschner 1998, 1999a, b), as well as extensive
226 regional data (Anderson et al. 2005; Anderson et al. 2001; Mann et al. 2002; Mann et al 1998).
227 We combined the archaeological and ethnohistoric data with over fifty interviews conducted
228 with fishermen, young and old, in the western Gulf communities of King Cove, Sand Point, False
229 Pass and Nelson Lagoon. These were unstructured interviews that allowed the participants to
230 express ideas, observations, and knowledge over a range of topics. The results of these interviews
231 are often quite different and certainly more informative than structured surveys or questionnaire
232 surveys done through the mail (e.g. Heise *et al* 2003). The regional survey conducted by Heise and
233 others to document orca-SSL interaction on the North Pacific was heavily biased by responses from

234 the eastern Gulf where the majority of fishermen is of European ancestry and very limited in the
235 western Gulf and Aleutians where the bulk of the fleet is Aleut owned. We have found that
236 indigenous observers are much more likely to recognize the importance of predator-prey
237 interactions and to maintain an oral history of traditional ecological knowledge.

238 From our interviews, a number of patterns were evident in local perceptions of the problem.
239 When the Aleut people are asked what they believe are the possible causes for the decline in the
240 Steller sea lions, they point out the fact that this is not the first time there have been major declines
241 in the numbers of sea mammals in the region. Aleut oral histories mention that significant declines
242 occurred a number of times in the past. General observations about SSLs are made in nearly every
243 interview and comments "During the 1960s and 70s, sea lions were seen everywhere", "great herds
244 of them," "1000s." Every offshore island was covered: "It looked like they were moving like a
245 kaleidoscope," according to one elder speaking of the islands around Sanak, Cherni, and the Pavlov
246 Islands. "Sea lions were on all of the small islands, used to be packed." All agree that there has been
247 a major decline in the numbers of SSL throughout the western Gulf of Alaska and eastern Aleutian
248 Islands. Some of the oldest fishermen also mentioned that in their fathers or grandfather's times,
249 there were periods with many fewer sea lions than were around after the 1940s.

250 But they also report that few carcasses have ever been seen. One 70-year-old elder, who
251 trapped and fished the entire Alaska Peninsula region for 55 years, has seen four his entire life. That
252 is more than anyone else has reported. Culprits were listed as: Orcas (primarily), overfishing and big
253 draggers taking the bottomfish (maybe) - "Draggers take the bottom fish. If you cut draggers down
254 the population would pop back up", and SSLs moving around (often). It is always mentioned that
255 the numbers of SSLs are underestimated because the biologists did not know where to look: "How
256 can they count all the sea lions in one day on a coastline of 1500 miles or more? Sea lions migrate to
257 follow their food just like a fisherman has to."

Within this suite of general commentary is a rich body of qualitative assessments and observations that, when combined with the ethnohistoric and the archaeological data, provide important contributions to nearly every major hypothesis that was proposed to explain the decline of the SSL.

Below we provide details of these ethnographic and archaeological observations in the context of six of the seven initial hypotheses (we have no data on containments): fisheries competition, environmental change, predation, anthropogenic effects, disease, and most importantly, the general category of synergies. As will be shown below, the SSL has gone through at least three major declines in the last 1000 years, and the ultimate cause has probably been climate, but climate change synergistically associated with anthropogenic effects, predation, fisheries, and other factors.

Fisheries Competition

When the residents of the region are asked whether they think over-fishing could have caused the SSL decline, they are quick to point out that the local levels of commercial harvest are trivial when compared to the massive international factory ships, or even those from the American west coast. But they also point out that gadids often disappear and this certainly has an effect on the mammals that eat them. The long-term population fluctuations in cod and pollock are poorly known, but Lydia Black states that, referring to a conversation held in Unalaska in 1978, "Fr. Paul Morculief [sic], a native of St. George Island and a resident of Nikolski, Umnak, pointed out that the Aleut term for codfish can be rendered into English 'the fish that stops,' meaning it disappears periodically,' (1981:332). This could have dramatic impacts on the entire ecosystem.

One King Cove Aleut fishermen stated, "Instead of chasing salmon and herring which are real oily and rich fish, they are chasing pollock and cod. We think- I think, and I'm not the only one, that they are starving with full bellies. No oil and no fat in cod and pollock, very little. They are

starving to death with full bellies. … Yeah, there were 100s and 100s and 1000s of sea lions [in the 1940s and 1960s] from here all the way to the Aleutians. They've only started to disappear after the cod and pollock came into being. It is all just a natural cycle and they can't blame fishermen for sea lions disappearing 'cause the salmon and herring are still there and the sea lions aren't eating them. The sea lions that are eating salmon are probably living."

Aleut fishermen spend extraordinary amounts of time on their boats at sea, making frequent observations of SSLs. SSLs are largely regarded as pests and very dangerous, following boats, picking fish out of nets, threatening and even succeeding in pulling fishermen off the decks of their boats. For example, in March 2004, Ray Dushkin, Jr. of King Cove was pulled from the deck of a boat while fishing by a 12-feet long sea lion. The 1200 to 1500 pound animal latched onto the seat of his pants and yanked him backwards into the water. Luckily he was able to break free (Porco 2004). Many have concluded that their aggressive behavior is due to starvation. Yet one man argued, "If they starved, we would have found them [their carcasses]. Look for the damned killer whale scat." Every Aleut elder interviewed stated they have either never seen an SSL carcass or they have only seen a few in their lifetime of fishing and beach combing, even at the rookeries and haulouts. Veniaminov observed in the 1830s that, "A sea lion which is killed in the water sinks at once. The body floats only when its insides begin to rot" (1984:354). Nearly all Aleut fishermen asked this one simple question: "the dead eventually float – where are the bodies?"

Environmental Change

Our data on climate change come from the archaeological and ethnohistoric literature. The majority of the archaeological data come from 12 sites on the western Alaska Peninsula, Unimak Island, and Sanak Island where major excavations have been conducted. Smaller but significant samples come from 20 other sites scattered around the region. One might expect that the number of

306 SSL elements in an assemblage would be related to the distance of a site from the nearest haulout or
307 rookery, since most SSL hunting was done at those locations. This is not the case ($r^2 = .0003$) as
308 there is no relationship between distance to the nearest haulout or rookery and percentage of SSLs
309 as a ratio of all seals and seal lions in the assemblage. More likely, every village had haulouts or
310 rookeries within its harvesting zone, and that the percentage of SSLs in the assemblage is a rough
311 measure of their actual density in the region at any one time – an assumption complicated by the
312 number of SSLs needed for kayak construction (discussed below).

313 The archaeology of Steller Sea lion harvesting tells us much about their natural history
314 (Figure 2), and taking a temporal perspective, an insidious pattern emerges. When we plot the
315 difference from the mean harvest of SSLs over 4000 years, we see that during cooler periods, the
316 harvest is equal to or greater than average, while during warmer periods the harvest is less than the
317 long-term average. While these climate indicators are general, there does appear to be a trend in the
318 data. After AD 1400, or well into the Little Ice Age, SSL harvests, and thus we suspect, populations,
319 rise to levels not seen in the previous 4000 years. The ratio of phocids to SSL in the archaeological
320 middens shifts from approximately 7:1 to approximately 1:1. These data also demonstrate that there
321 have been shifts in the abundance of other species as well.

322 The Little Ice Age pattern of 500 years ago is similar to the beginnings of the Neoglacial
323 4500 years ago when, again, SSLs make a much greater contribution to the diet. These are in
324 contrast to warmer periods. The most stark is the Medieval warm period, occurring between 900 and
325 700 years ago, but perhaps stretching back to 1200 years ago. The few samples we have been able to
326 collect form this time period have very few SSLs or other pinnipeds and have the greatest
327 proportion of sea otters. In fact, it has been exceedingly difficult to find preserved midden deposits
328 from this time period because most of the village sites are located away from the coast on small
329 salmon streams. Thus, the fact that there are few village sites on outer coasts, and the ones that exist

are dominated by sea otters, caribou, and salmon, indicate that that there was a major disruption in the north Pacific ecosystem causing the prehistoric inhabitants of the region to make a shift to lower ranked species during this period of oceanic warming and reduced primary productivity (Anderson et al. 2005; Finney et al. 2002).

In a similar study of bones from various archeological sites along the Bering Sea, Savinetsky *et al* (2004) concluded that most marine mammals maintained their geographic distributions during the past 2000 to 3000 years, but changed in abundance. For example, sea lions that were once numerous on Nunivak Island (located in the Bering Sea along southwestern Alaska) are now rare. Population changes of SSLs and other marine mammal species over this time were found to correlate with environmental conditions in relation to temperature, precipitation, ice cover and sea level changes, and not hunting. On the other hand, David Yesner has discussed the SSL faunal remains from the excavations conducted on Umnak Island in the 1960s and 1970s. While the data collection methods in these excavations makes comparisons with our data difficult (no fault of Yesner's), Yesner (1987) argues that there is a decline in the number of SSLs in these sites through time, from approximately 4000 to 1000 years ago. He believes that this is a product of the Aleut over-harvesting SSLs leading to a general decline in the regional population. A reanalysis of the timing of the occupations used in the Umnak sites shows that rather than a continuous occupation, the use of certain villages sites in Yesner's sample is punctuated and that there may be a climatic relationship with the numbers of SSLs on Umnak as well with dense populations during the early Neoglacial, and declining populations in the warmer periods of the first millennium AD.

Other species follow this trend. Our local sources stated that there was a north Pacific walrus haulout during the 19th century at the southern end of Isanotski Strait (False Pass) on Sankin Island, where today the remains of many dead walrus can be seen. It is interesting to note that the cooler periods where SSLs play an important role in the diet are also periods of increased walrus

abundance in the prehistoric village sites. Walruses are almost non-existent in village sites during warmer periods.

The fact that sea otters are notoriously absent from most of the middens except during periods of economic stress, and given the large literature on their economic importance prior to the arrival of the Russians, indicates that they were never very common in the region. But they also measure Aleut adaptive flexibility in that they were able to harvest large numbers of secondary food resources during periods of economic stress.

We continue to discuss climate, especially in regards to the 1870s collapse of the SSL, in sections below.

Predation

Orcas, or killer whales, have recently been investigated for predatory attacks on sea lions (Springer et al 2003; Heise *et al* 2003). The Aleut proposed this hypothesis to NMFS in the late 1980s, even providing video of orca attacks on SSL rookeries, but the video and local observations were, as reported by local informants, dismissed as piecemeal and anecdotal by both environmental organizations and NMFS. Fishermen report today that orcas have made a major expansion into Bristol Bay, a place that many have fished for 50 years, but only in the last ten years have orcas been seen there. Of course, the predation of orcas on Steller sea lions was noted by many early explorers including Nelson who stated "like the fur seal they have a dreaded enemy in the killer whale" (Nelson 1887:267), although for more than a century before this time, no Russian observers mention interactions between SSL and orcas. The fact that SSL were in deep decline in the 1870s (see below), and that orcas were heavily preying on them as well, may be more than coincidence as it may mirror the modern pattern quite well. We will return to this relationship below.

The ultimate cause of the SSL decline according to Aleut informants, as recorded in nearly every interview, is predation from orcas. Incidences of this predation, from the 1950s through the 1990s, are found throughout the region. This explanation was repeatedly given in public testimony to a number of federal agencies, and, according to our informants, representatives of several environmental groups refused to watch home videos of orcas attacking SSLs. In 2003, a giant pod of orcas was repeatedly spotted moving through False Pass. Estimated numbers by local fishermen ranged from 200-400 individuals. There was general consensus that there were no pinnipeds or sea otters in the area after they left.

Anthropogenic Effects

Historic Aleut interactions with SSLs comes in three forms. The first is direct hunting. The rookery southeast of Belkofski was the traditional hunting territory and harvesting location for the Aleut of Belkofski, a village now abandoned. The people of Sanak Island traditionally harvested sea lions at the haulouts south of Sanak, Clubbing Rocks, and Cherni Island. The peoples of Ikatan and False Pass hunted a number of haulouts around the Ikatan Peninsula. Those living on the north shore of the western Peninsula hunted at Amak. While the first three were harvested up until the 1960s, the Amak area has not been hunted for nearly a century.

The second type is passive interaction where the Aleut fished around SSL rookeries and haulouts. Here the Aleut were passive observers, especially in the last 50 years when SSL played little role in the subsistence economy. Fishing is now restricted in these areas.

The third type is active interaction, where the Aleut fish with SSLs continually lunging at their nets, trying to eat the caught salmon. It is ironic that most damage to SSLs from human interaction is out in open water with SSLs stalking and harassing boats, and where the animals actively seek out salmon fishermen.

Although subsistence harvests of SSLs are legal for Alaska Natives, many Aleut do not attempt the hunt. This is in part because there is a local perception that it is still illegal for them. In fact, some Aleut hunters learned from Reedy-Maschner and Maschner the actual laws regarding SSL harvesting, since Fish & Game's posters and advertising materials about the endangered species do not indicate any exceptions. Still others stated that the hunt was too contentious, and they did not want to risk bringing any controversy on themselves. One individual stated that he did in fact hunt a SSL annually but will never report it. Fish & Game reports that a mere 1.0% of Sand Point households and 1.3% of King Cove households used Steller sea lions in 1992, although none reported actually hunting them (Fall *et al* 1993: 32). Only one False Pass household reported harvesting a sea lion to Fish & Game in their 1987/88 study year, and none reported any SSL harvest or use in 1992-1995 (Fall *et al* 1996:63; Wolfe and Mishler 1996). The subsistence hunts that have been recorded indicate a small number of successful hunters in the villages, and through our fieldwork we have found that some hunters are known for taking SSLs and redistributing the meat to certain relatives and friends. Many Aleut state that they miss eating SSL meat, and that it "makes a nice roast." Some fishermen joked about writing a sea lion cookbook as a way saving the SSL, under the assumption that if it was to be saved, then one should create a market for it (we assume along the lines of saving ancient rare breeds of sheep, cattle, and fowl in the US and Europe).

Aleut knowledge of the spatial geography of SSLs is a by product of the kinds of interactions between Aleut and SSLs, but it is also a direct measure of the fact that the traditional harvesting geography of the Aleut is identical to the traditional harvesting geography of the SSL. Rookeries and haulouts listed by peninsula Aleuts are: Clubbing Rocks by Cherni Island; Bird Island on the other side of Cape Pankoff; Outer Cove on Unimak; Ugamak Island – "a huge rookery over there"; Amak Island, where there's a SSL rookery north of there; and also on Rock Island (south Unimak). Thousands were reported around Ikatan. One fisherman stated, "you make a set, and some days you

would get all sea lions." Belkofski people used to camp on Sushilnoi Island to hunt SSLs on Rose Island. There are two rookeries by Cherni: "Bob Jones [former Fish & Wildlife manager in Cold Bay] did a count of maybe 5000 [in the 1960s or 70s], now there are maybe 500. We can't go close enough to count them." The biggest herd was reported by Cherni. There are a few by East Anchor. Around Caton Island, "there's a few back there so they closed it off to us."

Fishermen described SSLs' spatial distributions today as the following. "We see very few sea lions anymore." When settnetting along Dolgoi (Pavlov Islands), some fishermen "saw a few." "On the bar east of Belkofski Point, there's always a batch of sea lions there in late July. In the summer, there are little bunches." "Cape Pankoff, there's two big rocks, haulouts. See them sunning themselves." "In the winter, sea lions are on the haulout around Caton and south of Sanak. Last January, there were young ones in Caton's harbor." "About eight sea lion adults come into the King Cove harbor each year; never see any little ones." "Big ones in King Cove harbor. They never do leave here. They're eating off the boats. Some leave the harbor in March." Occasionally there is "one sitting on the Cold Bay buoy." Many fishermen reported seeing groups of SSL moving on the open water, even in summer in areas where they have not been seen in the past.

Two important points can be taken from this discussion. The first is that the Aleut and the SSL share a common geography. The second is that over the last 40 years, the interactions between fishermen and the SSL have been quite limited.

Disease

One Aleut leader noted that when looking at the decline in populations between 1983 and 1987, it appears similar to the estimated decline in the Aleut population after being struck with Eurasian infectious diseases. This might be similar to an event that affected southern fur seals over

150 years ago (Black 1981:330). Captain Benjamin Morrell, Jr. wrote the following of his observations on September 20 and 24th 1828:

> 'On the surface of this island I saw the effects of a pestilence or plague, which had visited the amphibious inhabitants of the ocean with as much malignancy as the Asiatic cholera has the bipeds of the land. The whole island is literally covered with the carcasses of the fur seal with their skin still on them. They appeared to have been dead about five years, and it was evident they had all met their fate about the same period. I should judge, from the immense magnitude of bones and carcasses, that not less than half a million had perished here at once, and that they had fallen victims to some mysterious disease or plague' (1832:290).

In fact, the magnitude of population collapse exhibited in the population decline chart would be difficult to simulate through a natural, food-based die off, certainly among humans, and probably among other higher mammals. We would also anticipate that there would be considerable numbers of carcasses. This was not the case. Even at the rookeries, local informants have seen very few dead sea lions over the last 50 years. These sightings were rarely on beaches, but never anywhere else. Although dead SSLs are more likely to sink than most sea mammals, Elliot (1886:267) suggests that this is a summer phenomenon when they have less fat (and see the Veniaminov quote above). 200 000 sea lion carcasses would have left a considerable visual and olfactory impact on the landscape.

Synergies

Historical reductions in Steller sea lion populations, as well as other species, have occurred across the region, some ecosystem-wide mirroring modern developments, others more local.[1] Elliot recounted Aleuts' statements that the Russians drove sea lions off St. George Island so fur seals would colonize the island, noting that in the Pribilof Islands, St. George had been primarily covered in sea lions with fewer fur seals (Elliot 1896:48, 54). In 1873-74, however, Elliot observed 8000 to 10 000 sea lions breeding around the outer edge of the seal rookeries on St. Paul and said there was "no conflict" between them (1896:45, 48). He notes sea lion behavior in response to humans, abandoning their pups on the rocks while roaring at humans from the sea (Elliot 1881:87). St. Paul islanders annually captured about two or three hundred for skin, meat, intestines, fat and sinew (1881:89), with perhaps 30 to 40 sea lions caged at a time in a flimsy makeshift corral of stakes and flags (1881:90), where they are then slaughtered and butchered. There is no commercial value to sea lions, however the Chinese procured sea lion whiskers as pickers for their opium pipes (Elliot 1881:92).

Wrangell's 1839 observations of the sea lions and Aleut use of them found SSLs on "almost all Pacific coasts and islands from latitude 61° (and even farther north, since they have been seen, though rarely, on Stuart Island, at latitude 63½°) to undetermined southern latitudes " (1980:24-25). He added that only on St. George Island are they in high concentration and can be hunted like a fur seal, otherwise the SSL is "more dispersed, nor does he return to his birthplace with the fur seal's punctuality but comes and goes and, if disturbed, leaves his home; should he observe blood on the stones, he will never return" (1980:25). Since the Aleut use the cured skins for *baidarka* covering and

[1] Lydia Black provides the most comprehensive overview of marine mortality due to local tectonic and volcanic activity in the Aleutians, recounting mass fish kills following earthquakes (notably the 1964 earthquake), ashfalls and submarine volcanic activity. She reports the possibility of the decline in sea otters after earthquake activity in the northern Kuriles in 1780 (1981:323). Sea mammals are affected indirectly from lack of food (1981:324) after these events. Further, catastrophic environmental events such as earthquakes, volcanic eruptions and tsunamis, contributed to the loss of some breeding grounds, which in the Aleutians has been documented for Unalaska, the Sanak Islands, the Shumagin Islands, and the Attu area over the last 200 years (Black 1981)

489 intestines for *kamleis* (outer garments), 1500 skin pieces and 12 000 fathoms of intestines were
490 prepared annually on St. George alone in the early 19th century (1980:26).
491 Investigating the ethnohistoric literature as well as early American government reports (e.g.
492 Black 1981; Elliot 1881; Nelson 1887; U.S. Census 1890; Veniaminov 1840 [1984]) allows us to posit
493 at least one major disruption in SSL populations between AD 1800 and 1960. The 1870s saw the
494 near extinction of the SSL throughout the Aleutians Islands and Gulf of Alaska, perhaps
495 corresponding with the warming period identified in Sitka air temperatures (see Royer, personal
496 communication 2004, as cited in Trites *et al* 2005). The low numbers of animals lasted until at least
497 the 1920s, but perhaps to the early 1940s. By the late 1870s, sea lions were so rare in many areas of
498 the Bering Sea and north Pacific (Nelson 1887:267) that the total Aleut harvest did not meet basic
499 needs in the Pribilof Islands (Nelson 1887:267), and sometime before 1909 on Attu Island in the
500 western Aleutians, the local Aleut had to stop making kayaks because there were no sea lion skins to
501 cover them. Jochelson reports that by 1909 the large, ocean going boats built by the Aleut were no
502 longer constructed because of a lack of SSL skins (Jochelson 1933 [2002]:56-77). This resulted in
503 serious adaptive problems for the Aleut as they were no longer able to move families between
504 islands. It is not surprising that this lead to widespread subsistence problems throughout the region
505 (Maschner and Reedy-Maschner, unpublished field data). The collapse of the SSL populations in the
506 late 19th century were so serious that the U.S. Government started importing sea lion skins from
507 California so that kayak construction could continue and prevent widespread starvation (U.S. Census
508 1890:226).
509 Just 70 years earlier, several writers report that there were several hundred thousand sea lions
510 on the Pribilofs, and that SSL were found in large numbers throughout the Aleutian chain (Elliot
511 1881:88). Choris reports that in the early 19th century, SSLs outnumbered fur seals on the Pribilofs
512 (1822). Some early references imply that this crash was caused by excessive hunting, but most report

513 that the only killers of SSLs were Aleut meeting basic needs (Elliot 1881:91-92) and orcas (Nelson
514 1887).

515 In 1912, after wending through the entire Aleutian Chain and visiting the Pribilof
516 Islands, Jochelson wrote, "Sea mammals like the sea-lion, sea-bear, the fur seal, and the varieties of
517 the common seal, and of the whale, are now rare near the coasts, or have disappeared altogether
518 from some of the islands" (1912:335). Further, Collins, Clark, and Walker noted in 1945 (based on
519 data from Jochelson and other early 20th century observers) that, "Once abundant, this animal [SSL]
520 is now greatly reduced in numbers, and it has disappeared from many of its former haunts. It is still
521 numerous on Bogoslof Island" (1945:49).

522 By the mid 1940s, there were extraordinary numbers of SSL across the region. Numerous
523 informants watched or participated in Navy target practice exercises that used SSLs as targets during
524 WWII (Cheri Island, Clubbing Rocks, south Sanak). There was a local bounty on SSLs and many
525 Aleuts hunted them for the money. Thousands were killed to protect salmon stocks and fishing nets.
526 Yet despite these predations, the numbers of SSL in the western Gulf continued to rise (see data in
527 Trites and Larkin 1996). Aleut informants regularly reported large numbers of SSLs, but always after
528 the collapse of the cod stocks in the early 1940s. They also report that the SSL began to decline just
529 as the cod came back and became a viable commercial enterprise. These events correlate with
530 reported regime shifts in the north Pacific ecosystem (e.g. Anderson and Piatt 1999; Ebbesmeyer *et*
531 *al* 1991; Hare and Mantua 2000; Miller *et al* 1994; McGowen *et al* 2003; Benson and Trites 2002).

532 The role of regime shifts in the structure of the north Pacific ecosystem has become an
533 important aspect of the dialogue in attempting to understand fluctuations of various populations,
534 and the SSL is no exception. Trites *et al* (2005) make a strong case for climate being a critical factor
535 in the SSL decline. The 1977 regime shift is well documented scientifically, and by the local Aleut
536 community who instantly noticed the return of gadids and the decline of the SSL. The local

communities are also quite aware of a reverse regime shift that occurred in the early 1940s that saw the complete disappearance of cod in many areas of the Alaska Peninsula, and the expansion and success of SSL populations (Most informants became aware of a major change taking place between 1942 and 1945). We suspect that another major regime shift occurred in the 1870s that led to the collapse of the SSL population and started the Scandinavian migration to Alaska because of the expansion of the gadids, which lasted until the late 1930s. We find the following passage interesting in light of recent studies of the effects of some diets on SSL productivity. In 1961, after a stay on Adak, Miriam Weissinger wrote, "Cod were almost unknown until the sea lion herds diminished in 1873; now they are very common. The Atka mackerel was unknown on Attu before 1875, when it appeared unexpectedly. The natives say that it drove the sea lions away!" (1961:59). This is remarkably similar to events that occurred 100 years later (e.g. Merrick *et al* 1997; Alverson 1992, Trites and Donnelly 2003).

More Complex Synergies

When the ice sheets retreated off the continental shelf between 12 000 and 15 000 years ago, the shelf regions of the north Pacific along the Alaska Peninsula and as far west as Umnak Island were colonized by the ancestors of the Aleut and the ancestors to modern sea mammal populations at the same time. The island regions of the central and western Aleutians, which had little glacial activity, probably acted as a refuge for sea mammal populations during full glacial conditions, much like the Commander Islands acted as a refuge for the Steller sea cow until 1741.

By the time sea levels reached their near-modern equivalent approximately 9000 years ago, the ancient Aleut and the contemporaneous sea mammals of the region also reached most of their modern extent (although the Near Islands were not colonized until 5000 years ago). From the earliest periods of occupation, the Aleut harvested marine resources. Thus, there has never been a

561 period when the Aleut were not an intimate and critical part of the north Pacific ecosystem, much
562 like any other high trophic level consumer. Accordingly, humans and SSLs have been interacting for
563 more than 10 000 years (Lantis 1984; Laughlin 1958, 1963, 1974/75; 1980; Laughlin and Aigner
564 1975; McCartney 1988; McCartney and Veltre 1996, 1999).

565 However most modern biological and ecological research fails to consider, or even
566 recognize, this important facet of north Pacific ecology. Every study done to date regarding either
567 the SSL or its primary and secondary foods, starts with some nebulous 'baseline' that is defined as
568 'prior to fishing' or 'before human impacts'; an assumption that has no scientific basis. This is
569 epitomized in a recent *Science* article (Jackson *et al* 2001) that presented two categories, 'before
570 fishing' and 'after fishing.' For much of the north Pacific since deglaciation, there is no such period
571 as 'before fishing.'

572 So what kind of impact would a prehistoric Aleut population have had on the ecosystem?
573 The impact is perhaps not directly comparable to the modern condition, but one of significance
574 nonetheless. We have attempted to reconstruct the Aleut population for approximately 400 years
575 ago based on village and radiocarbon data for the Alaska Peninsula and Aleutian Islands. We then,
576 based on caloric needs, harvesting strategies, and preference, computed the numbers of SSLs and
577 phocids that would have been harvested on a yearly basis for subsistence needs (Denniston 1973;
578 Yesner 1977). While the numbers of fish the Aleut harvested would have been trivial given the
579 numbers harvested by non-Aleut on U.S. and international ships in the region today, the numbers of
580 sea mammals might have been quite high and maintained for several thousand years. For example,
581 we estimate that the approximately 25,000 Aleut living in the region 400 years ago probably required
582 between 5000 and 10000 Steller sea lions and nearly 15000-25000 phocids per year to meet basic
583 subsistence needs – a considerable impact and one that certainly conditioned the basic structure of
584 the north Pacific ecosystem.

But there is a larger force at work in this context beyond basic subsistence needs. Much like the sea otter, which was the center of the north Pacific market economy for nearly 200 years, the SSL harvest was also driven by market forces but in a completely different context. One of the authors of this article, Michael Livingston, is an Aleut and master kayak builder who has experimented widely with kayak construction in the Aleutians. He has found that the skin of the SSL is the only skin that works for covering bidarkas (kayaks). Historically, each adult male owned at least one kayak, which took five to six SSL skins to cover, and these needed to be replaced every year. Since the kayak was the only means for the Aleut to hunt and fish, SSLs amounted to a "fixed cost." This means that regardless of the number of SSL on the north Pacific, the Aleut harvest was ultimately dictated by the number of Aleut males owning kayaks, not the number of sea lions actually on the landscape. For example, we estimate that between AD 1400 and 1600, there were 3000 to 4500 adult males in the Aleutian region. To meet basic needs, the Aleut needed to harvest between 12,000 and 27,000 SSL each year just to cover their kayaks.

Returning to the historic sea lion collapse in the 1870s, we can elaborate on the problem. While there is certainly evidence for a major regime shift associated with regional warming, we were also 150 years into the commercial sea otter harvest. Why is this important? We think it critical because even though the Aleut population was at a point lower than it had been in 4000 years, the sea otter hunters were spending so much time on the north Pacific waters that we estimate that they needed to replace their kayak skins three or four times per year, thus equaling the harvest of SSL prior to human depopulation of the region. When the warming climatic conditions occurred, the SSL numbers were already under such stress that they could not recover. But this shift also ushered in the greatest commercial cod fishery of the 19th century, only rivaled by the cod fishery of the last 30 years.

608 Thus, humans have always been an integral part of the regional ecosystem and there is,
609 therefore, no *a priori* reason to assume that the north Pacific ecosystem can be understood without
610 reference to the role humans played (or now play) in that ecosystem. A scientifically more valid
611 research agenda is one that sees the southern Bering Sea and north Pacific as a complex system: an
612 ecological system that functioned for more than 10 000 years with the Aleut actively harvesting the
613 marine environment. The indigenous peoples of the region are not separate or disjointed from the
614 ecosystem; they are an integral part of it. There is no "coupled human-natural ecosystem" because
615 there is only one ecosystem. Thus, we need a new kind of northern science that goes beyond 'human
616 impacts' and treats humans as agents in the structure of northern ecosystems (e.g. Maschner *et al*
617 2003; 2004 [NSF proposal]). This situation is especially true for the north Pacific.
618 Anthropologists and archaeologists have assumed for many years that the reason the Steller
619 Sea Cow was found in the one Aleutian region never colonized by the Aleut is because early on they
620 were harvested to extinction by the initial colonists in the region. In fact, it comes as no real surprise
621 that the youngest dated sea cow remains were recently found on Buldir Island in the western
622 Aleutians, one of the remotest locations to be harvested by the Aleut (Debra Corbett, personal
623 communication), one of the last places to be colonized. Using this as an anecdotal measure of Aleut
624 – marine mammal relations, it should also come as no surprise then that SSLs, which are terrified of
625 humans, spend most of their time in inaccessible locations while fur seals, which have only had
626 direct contact with humans since the forced relocation of the Aleut to the Pribilof Islands 200 years
627 ago, have no natural fear of humans. Thus, 10 000 years of harvesting has likely created the
628 "natural" SSL behavioral ecology we see today.
629 It should also be noted that after 10 000 years of SSL harvesting on the north Pacific, the
630 1960s saw little human-caused mortality. SSLs were no longer being hunted for food and materials
631 except in a few communities and at very low numbers. The Navy was no longer using them for

target practice, and Aleut fishermen were learning to avoid them during the salmon runs. It should come as no surprise then that this decade saw the highest numbers of SSLs ever recorded. This leads us to a new hypothesis for the decline of the SSL, and one that takes into account this long-term relationship between the Aleut and the SSL.

We propose that after thousands of years of Aleut harvesting for food and kayak production, Steller sea lions had adapted to this predation by reproducing yearly at their highest possible level regardless of the availability of food resources. This allowed them to maintain their populations in the face of intensive harvesting pressures. In the 1960s and 70s, after 30 years with nearly zero predation pressure, the SSL population had reached a level not witnessed in the last several thousand years. This extremely high and un-natural population, when faced with the 1977 regime shift and the influx of less nutritious prey, resulted in a catastrophic population collapse. With the ecosystem dominance of gadids and Atka Mackerel, the high population levels could not be maintained. The 20 year decline and subsequent small increases might be best explained as a simple, if spectacular population adjustment. This argument also accounts for the rise in Orca populations and their effects on the region as well and may even apply to the sea otter decline. So in this scenario, it was the lack of predation by humans, in combination with a productive, mid-20th century ecosystem, which led to the eventual collapse of the SSL population along the north Pacific.

CONCLUSIONS

There is a growing body of evidence that major fluctuations have occurred in the marine ecosystem of the north Pacific and southern Bering Sea and the findings here show that the results reported in Trites et al. (in press) have probably occurred in the past as well. Archaeological data provide a glimpse of the structure of prehistoric ecosystems and the kinds of spatial and temporal

656 variation present in these systems. These data indicate that at least one major collapse of the north
657 Pacific ecosystem occurred approximately 1100-800 years ago, a period of hemispheric warming and
658 reduced oceanic productivity. More importantly, and in strong support of the climate hypotheses for
659 the Steller sea lion decline, the greatest densities of SSLs in archaeological deposits are during cool
660 periods, which also appear to have been favorable to walrus populations.

661 Decadal scale changes in the marine ecosystem spanning nearly 150 years are identifiable
662 using both ethnohistoric data and traditional ecological knowledge of local Aleut fishermen. Based
663 on Russian and early American accounts of the region, there has been at least one period in the last
664 200 years when there were few or no Steller Sea lions in many areas of the north Pacific, leading to
665 widespread starvation for the indigenous peoples who depended on them. These depressions in the
666 population levels appear to be a product of the interactions of climate change and the global
667 economy. We have also found that Steller sea lions have undergone local extinctions due to
668 catastrophic environmental events such as earthquakes, volcanic eruptions, and tsunami. A number
669 of these are documented for the Alaska Peninsula, Unalaska, Sanak Island, the Shumagin Islands,
670 and the Attu area over the last 200 years (Black 1981; Maschner 2000).

671 Traditional knowledge of local fishermen has demonstrated that the north Pacific ecosystem
672 has undergone a series of disruptions over the last 100 years. For example, the north Pacific was
673 heavily fished for cod between the 1870s and the mid 1930s, when the fishery collapsed. This is the
674 time period for which all sources document as having very few SSLs. Sea lions again became
675 common after the collapse of the cod fishery in the early 1940s. Further, there is some evidence that
676 the rapid rise in SSL populations in the 1960s may have been partly a product of it being the first
677 time in thousands of years that there was little to no predation by human agents. The collapse of the
678 cod stocks at the same time as the rise in Steller sea lion populations may also indicate that in the

679 absence of cod, SSLs will focus their harvesting energies on other species that happen to have higher
680 energy content.

681 A growing area of study using traditional knowledge and indigenous explanations to build
682 scientific models are only now being used to understand the Steller sea lion decline. One area in
683 which this strategy might be very productive is to refocus research from measuring human impacts
684 to investigating how the local inhabitants were integrated into the ecosystem over the last 12 000
685 years and why it appeared to function given the obvious natural cycles of both climate and key
686 species. Thus, archaeological and anthropological analyses have provided data for time scales that
687 are currently not available in any other form of analysis. They demonstrated that the north Pacific
688 and southern Bering seas have been dynamic, volatile, and subject to great fluctuations over the last
689 hundreds to thousands of years. This requires that we evaluate our current models in order to
690 determine where in one of these large cycles we are now positioned. We find it amusing that 20
691 years ago, the local fishermen were convinced, based on a century of observations, that orcas, along
692 with changing regimes with increased gadid populations, were the proximate cause of the SSL
693 decline. Despite repeated warnings to multiple agencies and to individual ecologists, it took 15 years
694 and $80 000 000 for the scientific community to take the hypothesis (Orcas) seriously (e.g. Springer
695 et al. 2003; Heise et al. 2003, Barrett-Lennard et al. 1995).

696 Yet the data presented here indicate that orcas are probably a symptom, rather than a cause
697 of the SSL decline. As we do not even remotely understand the cascading effects of even a small
698 reduction in productivity caused by oceanic warming, we do have sufficient data to argue that many
699 of these symptoms, whether discussing the Aleut shift to otters in 1000 years ago, or the orca shift
700 to otters in the last 10 years, are parts of the cumulative effects of changing climatic and
701 oceanographic conditions. We are still cataloging and summarizing the local knowledge data and
702 more interviews are scheduled, but the local people have clearly recognized the complexities of the

703 north Pacific, that these changes are caused by a multitude of causes, and that there have been
704 substantial shifts in the marine ecosystem over the last 200 years. These shifts appear a byproduct of
705 both non-human and human factors. But the effects of humans on the behavioral ecology of SSLs
706 have not been studied, at least from the point of human predation having adaptive consequences.
707 While at different spatial and temporal scales, the higher densities of SSLs during the
708 Neoglacial, the Little Ice Age, and the mid-20th century, the decline of SSL populations during the
709 Medieval Warm Period, the late 19th century, or the 1980s, are all associated with either major
710 climatic episodes or oceanic regime shifts – or both. It should be also clear that the massive
711 numbers of SSLs in the mid-twentieth century may have had more to do with a lack of human
712 harvesting, because from the scenario presented here, human harvesting of SSLs should be
713 considered part of the natural ecology of the SSL, while a lack of harvesting in the late 20th century
714 should be considered an abnormal shift in the history of the north pacific ecosystem, one in which
715 the Aleut played a critical role. It is only through archaeological and anthropological data that these
716 long-term patterns can be identified.

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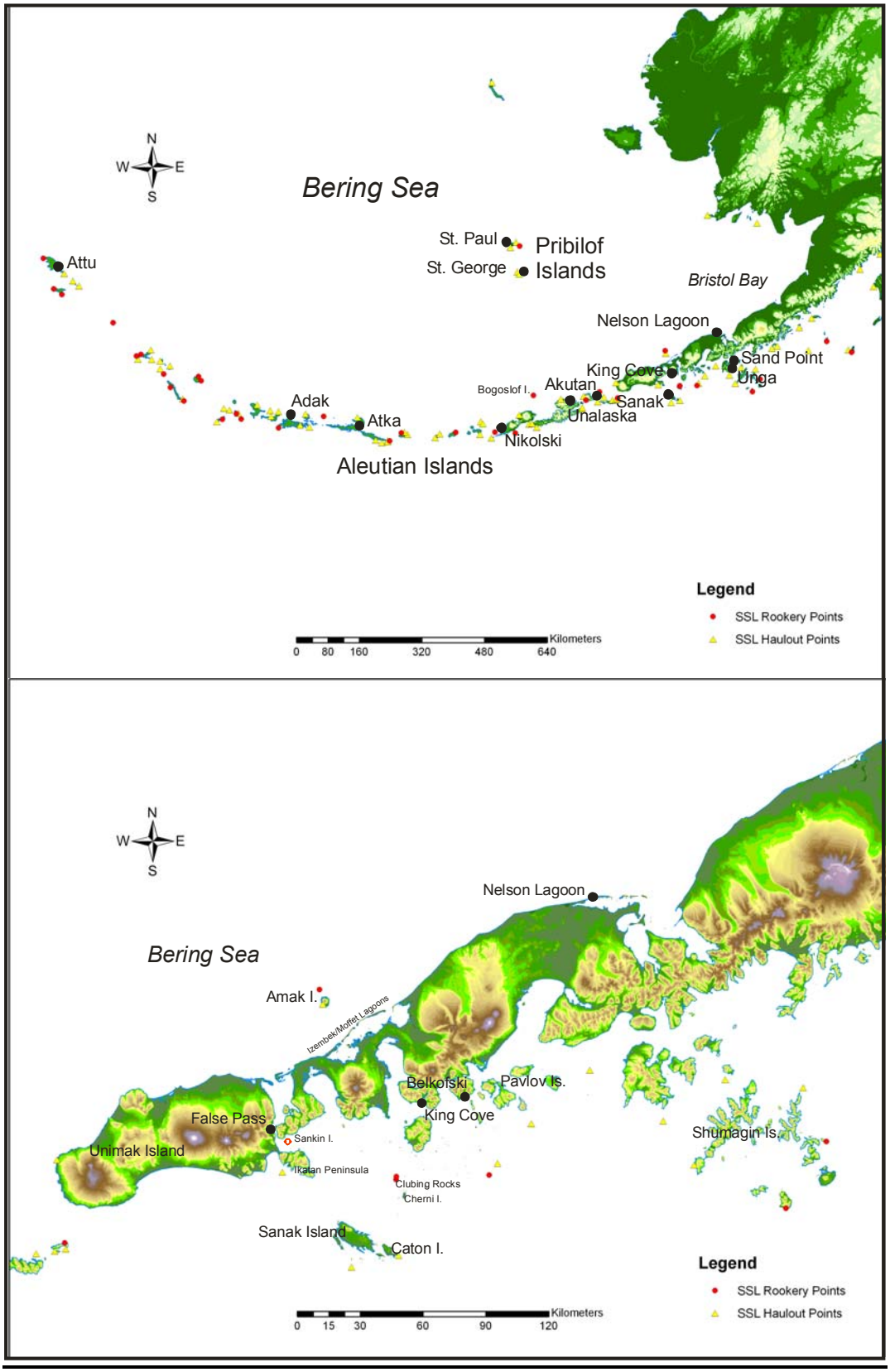
LIST OF FIGURES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Pavlov Is.
King Cove
False Pass
Sankin I.
Unimak Island
Ikatan Peninsula
Clubing Rocks
Cherni I.
Shumagin Is.
Sanak Island
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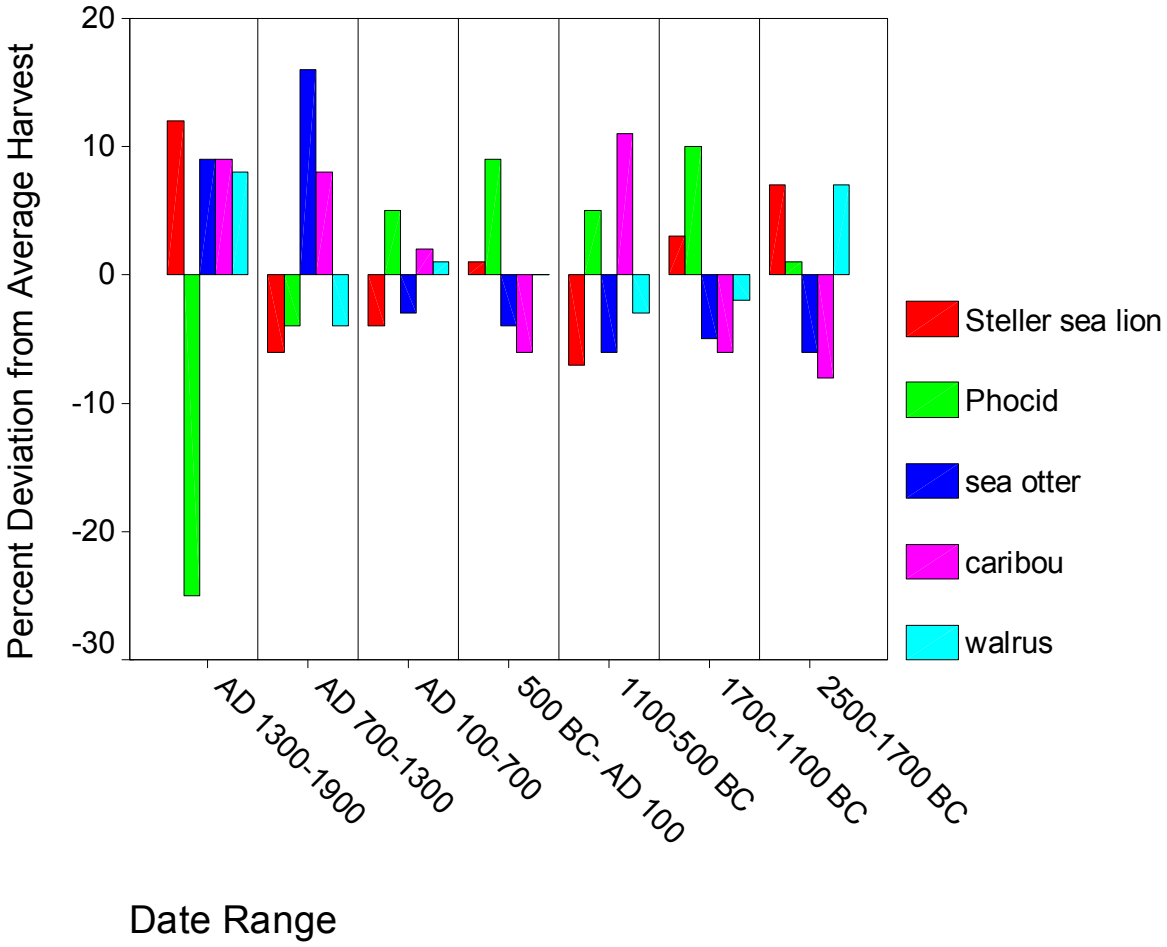
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Percent Deviation from Average Harvest
AD 1300-1900
AD 700-1300
AD 100-700
500 BC- AD 100
1100-500 BC
1700-1100 BC
2500-1700 BC
Date Range
Steller sea lion
Phocid
sea otter
caribou
walrus

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