Seal Bones from the Beach Ridges:
Isotopic Values of Cape Krusenstern Archaeofauna

Cody Strathe, Environmental Archaeology Laboratory, University of Alaska Fairbanks, 311 Eielson, Fairbanks, AK, 99775, *ftcjs@uaf.edu.*

Abstract:

Seal bones associated with datable material were collected during the 2006 surveys at Cape Krusenstern for stable carbon and nitrogen isotope analysis. The examination of isotopic data from these archaeologically deposited seal remains provides a view of cultural and ecological change at large temporal scales. Datable material and seal bone samples were collected from shovel tests on beach ridges. These stable carbon and nitrogen values and associated radiocarbon dates have been used in reconstructing temporal changes in Chukchi and Bering Sea marine ecosystem productivity from approximately 2000 B.P. to present. This preliminary proxy of ecosystem change can then be compared to changes in cultural systems at Cape Krusenstern to test for possible causation.

Introduction:

Cape Krusenstern National Monument is composed of approximately 114 ancient beach ridges (Giddings & Anderson, 1986). Numerous cultural sites are located on these ridges with each known archaeological tradition in northwest Alaska found here. An atypical horizontal stratification exists with the oldest sites on beach ridges farther from the modern shoreline and youngest sites closer to the Chukchi Sea coast (Giddings & Anderson, 1986). It is widely known that prehistoric cultures residing on the beach ridges have subsisted largely on marine resources available from the Chukchi Sea (Giddings & Anderson, 1986). The faunal remains of these subsistence practices are well preserved within the cultural features throughout Cape Krusenstern National Monument.

Bone collagen from these faunal remains contains stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes (Schoeninger & Deniro, 1983) and offer a unique look at palaeoecological change in the Chukchi / Bering Sea marine food webs at large temporal scales. The analysis of $\delta^{15}N$ is used to investigate change in trophic level structure of an ecosystem (Fig. 2; Kelly, 2000). The $\delta^{13}C$ values are used for tracking changes in the primary productivity (Schell 2000) and sea ice cover (McRoy et al., 2004) of arctic marine ecosystems. Natural systems tend to discriminate against heavier isotopes taking up the lighter isotope. With each trophic level increase, $\delta^{13}C$ values become enriched by ~1 ‰ and $\delta^{15}N$ values by ~ 3 ‰ (Fig. 2; Deniro and Epstein, 1977, 1981). The collagen from phocid bone samples contains these stable isotopes in an enriched form (Schoeninger & Deniro, 1983). Recent studies on the differences in $\delta^{13}C$ and $\delta^{15}N$ values from ice seals demonstrate that no significant difference exists between species in Alaskan waters (Dehn et al. 2007). This makes identification to genus sufficient for a study of this resolution.

Using the phocid $\delta^{13}C$ values from dated layers within shovel test probes, a proxy of ecosystem change can be produced because the $\delta^{13}C$ of organic matter is associated with the fixation of carbon by phytoplankton (Bidigare et al., 1999; Hayes et al., 1990; Popp et al., 1998; Schell, 2000).

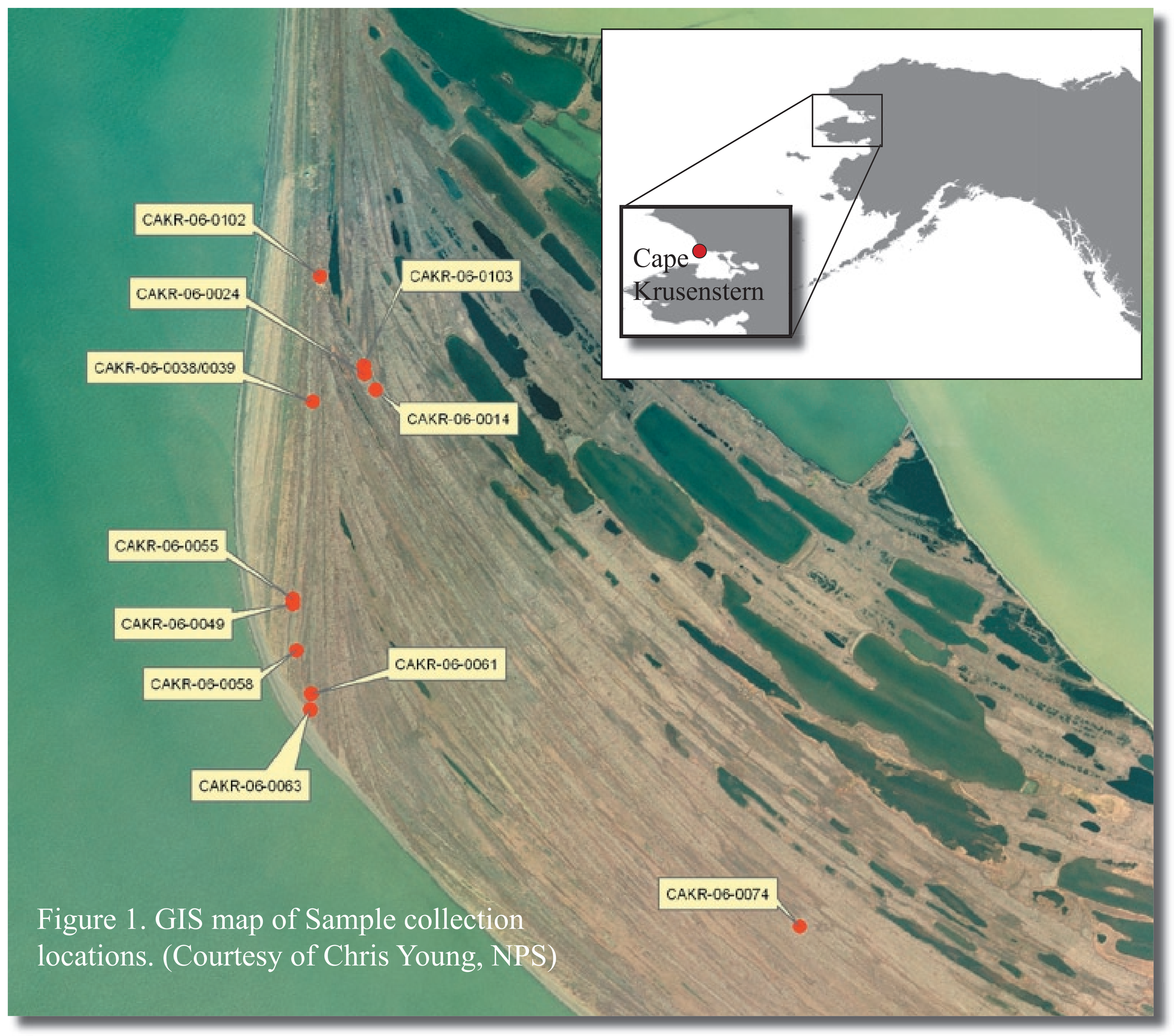

Figure 1. GIS map of Sample collection locations. (Courtesy of Chris Young, NPS)

Objectives:

1) Investigate temporal changes in productivity of prehistoric Chukchi Sea and Bering Sea marine food webs by analyzing $\delta^{13}C$ and $\delta^{15}N$ ratios from archaeologically deposited seal bone collagen.
2) Develop a proxy of marine productivity and marine ecosystem change from Cape Krusenstern archaeofuana for the periods of known human occupation (~4000 BP to present; Giddings & Anderson, 1986).
3) Identify if changes in ecosystem structure and function (isotope values) have any correlations with changes identified in archaeological cultural traditions (Giddings & Anderson, 1986).

Hypotheses:

1) Ecosystem structure and function has fluctuated over the past 2000 years in the Chukchi Sea/ Bering Sea and will be exhibited by increases and decreases in $\delta^{13}C$ and $\delta^{15}N$ values correlating with oceanographic and climatological changes.
2) Large scale ecosystem changes in the Chukchi Sea and Bering Sea may be partly responsible for changes in cultural chronology and settlement of Cape Krusenstern

Stable Isotopes in a Chukchi Food Web:

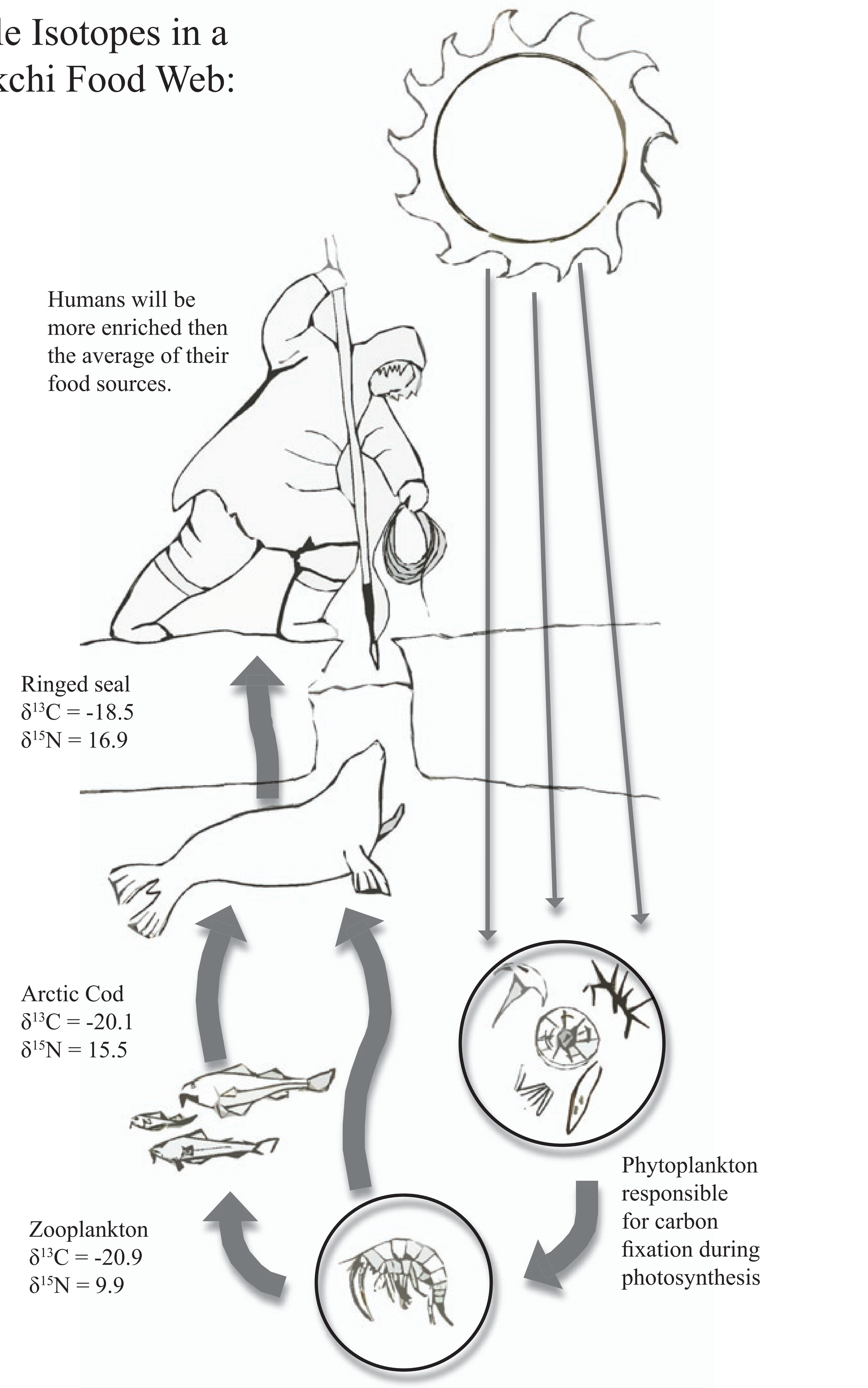

Figure 2. (Above) Diagram of simplified Chukchi Sea food web illustrating trophic fractionation of $\delta^{13}C$ and $\delta^{15}N$ using isotope values of modern muscle tissue from Dehn et al. (2007). These values do not match my modern ringed seal values due to different disrimination and different turnover rates of different tissues. (Illustration: Cody Strathe)

Methods:

1) Phocid bones were recovered for isotopic analysis from 13 shovel test probes containing associated datable charcoal during the 2006 survey at Cape Krusenstern (see fig. 1).
2) Associated charcoal from each shovel test probe was radiocarbon dated via Accelerated Mass Spectrometry (AMS) by Beta Analytic.
3) Modern Phocid samples (n=2) were collected from the high tide line for comparison.
4) Seal bones were identified using the UAF Environmental Archaeology Laboratory comparative collection to the genus of Phoca.
5) Collagen was extracted from seal bones (n = 15; fig. 3) using methods outlined by Matheus (1997) and Misarti (pers. comm., 2007).
6) Duplicate isotopic assays obtained using an EA – IRMS system, calibrated with the standards VPDB for ^{13}C and AIR for ^{15}N at the UAF Alaska Stable Isotope Facility.

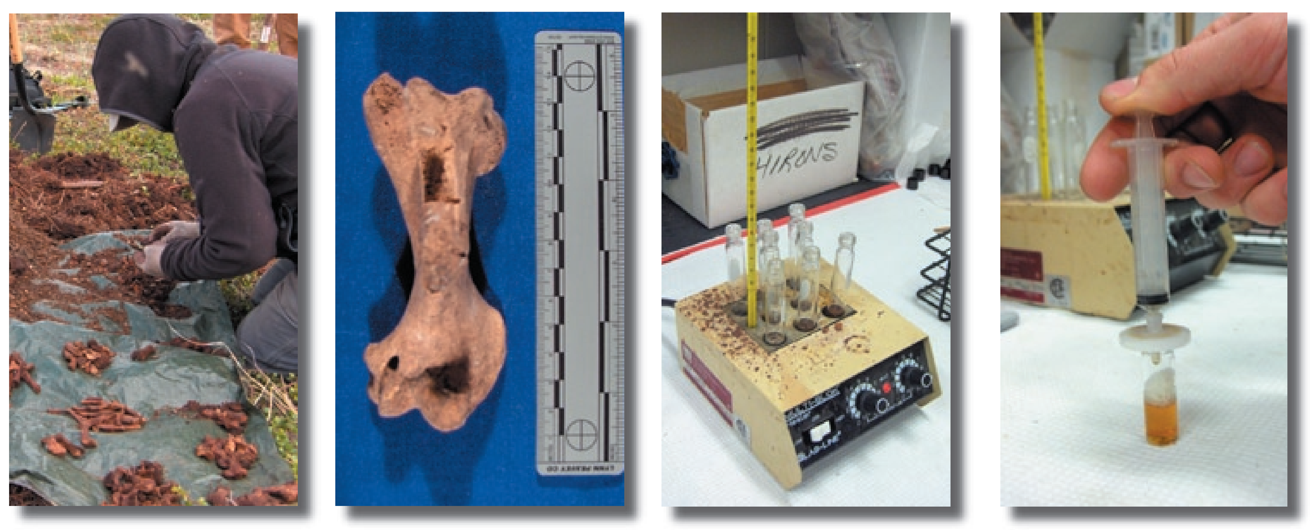

Figure 3. (Above) Steps from left to right. 1)Bones removed from shovel tests. 2) .5 grams of corticol bone removed. 3) Demineralizing and heating of bone to solution. 4) Filtering collagen from solution. (Photos: Cody Strathe)

Results:

$\delta^{13}C$ values exhibit a slight decline over time with most variation occurring in modern samples (fig. 4). $\delta^{15}N$ values exhibit an increase over time with lowest values being in oldest samples (fig. 4).

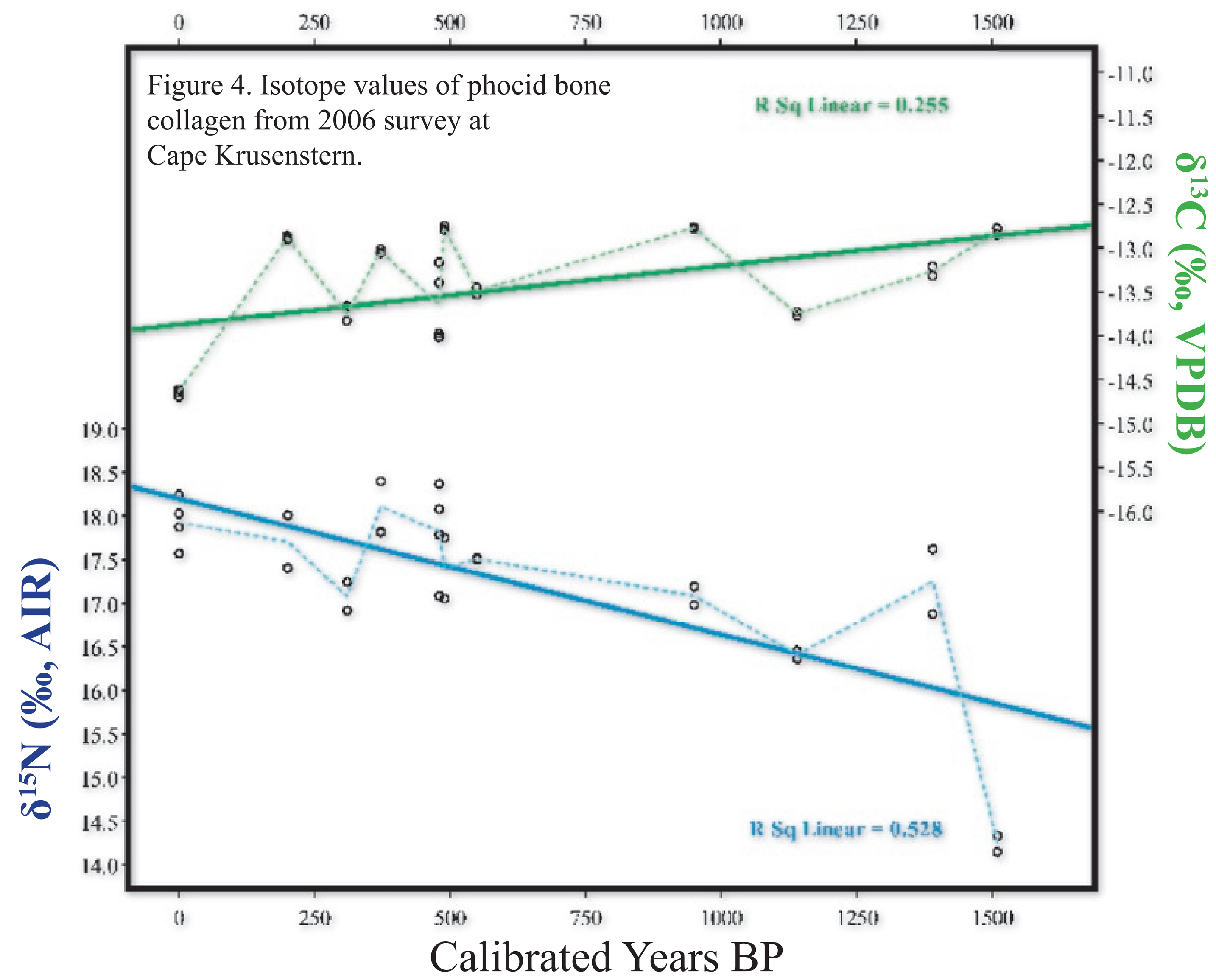

Figure 4. Isotope values of phocid bone collagen from 2006 survey at Cape Krusenstern.

Discussion:

A recent study by Schell (2000) produced a high resolution proxy of Bering and Chukchi ecosystem change using stable isotope values from bowhead whale baleen for the past 50 years. Isotope values were also taken from archaeologically deposited baleen (dated at 100 & 2200 years BP, Schell 2000). The archaeological samples exhibited higher $\delta^{13}C$ values than current levels and infers higher marine ecosystem productivity in prehistoric times (Schell, 2000).

In opposition to Schell's (2000) study, McRoy et al. (2004) illustrates evidence that the reduction in $\delta^{13}C$ is caused by a reduction in seasonal sea ice cover resulting in a change in the plankton structure of the ecosystem. A reduction in ice algal input is thought to be the cause of a decline over this period of time (McRoy et al., 2004).

The inverse relationship exhibited between the $\delta^{13}C$ and $\delta^{15}N$ in my Cape Krusenstern study is typical of changes in ecosystem productivity (fig. 4). As productivity declines, predators must widen their dietary preferences, raising their trophic level and resulting in higher $\delta^{15}N$ values. Regardless of the exact cause of these declining $\delta^{13}C$ values, the signature is a result of ecosystem change. Changes in productivity and sea ice can both have major effects on subsistence and settlement strategies. More samples from future field seasons will enhance the resolution and strengthen the findings of this preliminary study.

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