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Mathematically Predicting the Aleut Tribe Population Using Archaeological Data

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Introduction

Sanak Island, located off the southern Alaska Peninsula, was home to the native Aleut peoples for thousands of years. Their hunter-gatherer society depended heavily on the arctic and marine ecosystem for food resources.

In 2015, a team of archaeologists from Idaho State and Utah State universities went to the island and collected data about the Aleut population size and their diet.

This study constructed a dynamical model to mathematically predict the Aleut population over time in order to gain insights into how food resources affected the Aleut people's ability to survive.

Methods

Beginning with a hunter-gatherer predictive model pioneered by theoretical biologist Gary E. Belovsky (Figure 2) the model was modified to allow for the inclusion of real data sets.

Food intake parameters were fit to historic population data on two important animals in the typical Aleutian diet: salmon (family *Salmonidae*) and Steller sea lions (family *Otariidae*). Proportional calorie representations for these animals were found in order to best fit the Aleut data.

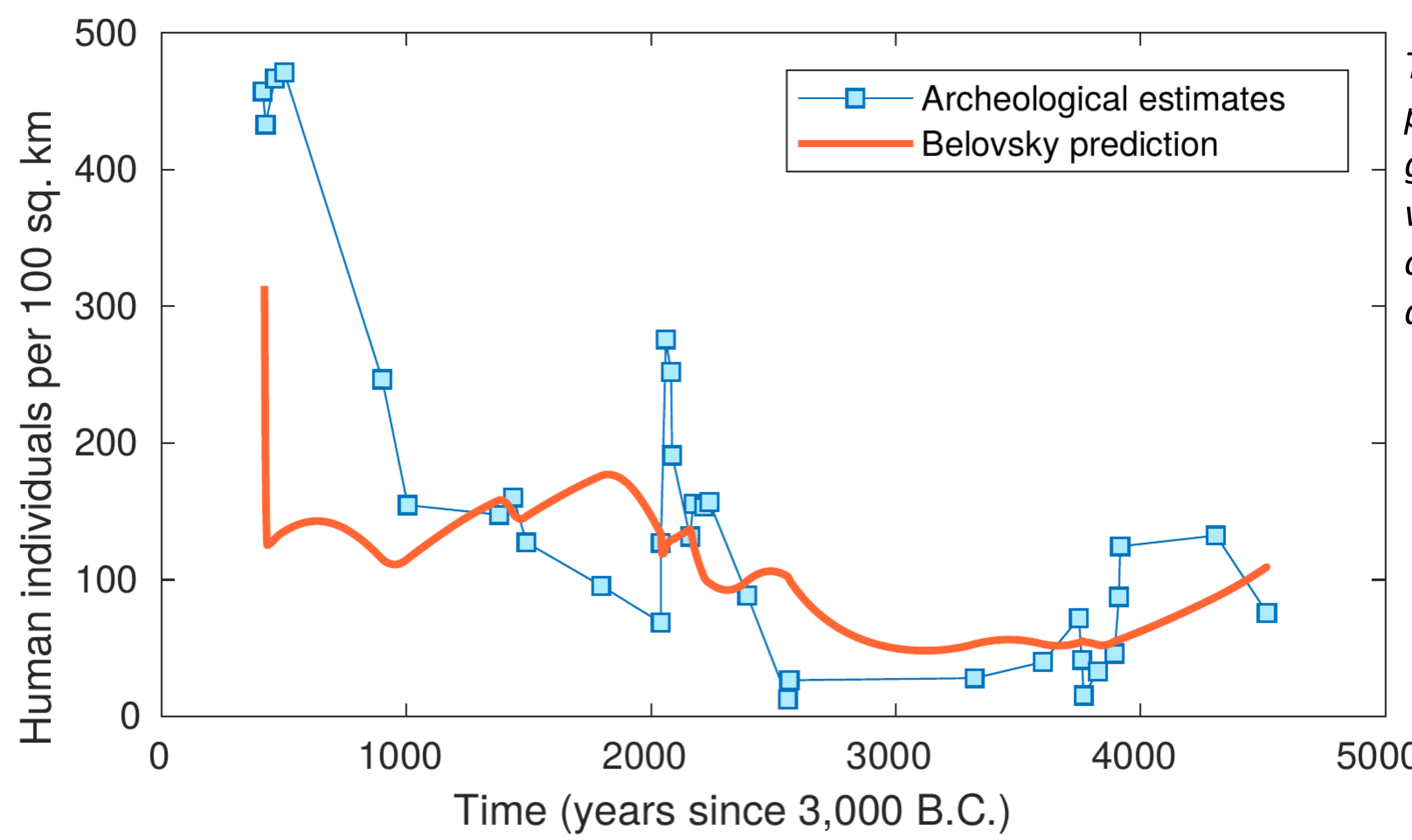
Results

This model's prediction is generally consistent with most of the dynamics of the archaeological data (Figure 1). However, there are certain time periods where the population is not well-accounted for by the model.

The fitted parameters were found as follows (expressed as calories per person per day):

Calories from salmon: *0.036 kcal*
Calories from sea lions: *-0.81 kcal*
Baseline caloric availability: *2566.8 kcal*

Figure 1 – Population prediction



This model's prediction is generally consistent with most dynamics of the archaeological data.

Figure 2 – The model

$$A(t) = \begin{cases} \left(\frac{1}{12}\right)C(t-1) + \left(1 - \frac{1}{60-12}\right)A(t-1) & \text{when } I(t) \geq M(t-1) \\ \left(\frac{I(t)}{M(t-1)}\right)\left(1 - \frac{1}{60-12}\right)A(t-1) & \text{when } I(t) < M(t-1) \end{cases}$$

$$C(t) = \begin{cases} \left(1 - \frac{1}{12}\right)C(t-1) + \left(\frac{I(t) - M(t-1)}{R}\right)A(t-1) & \text{when } I(t) \geq M(t-1) \\ \left(\frac{I(t)}{M(t-1)}\right)\left(1 - \frac{1}{12}\right)C(t-1) & \text{when } I(t) < M(t-1) \end{cases}$$

$$I(t) = \beta P_L(t) + \alpha P_S(t) + \gamma \qquad M(t) = M_A + R\left(\frac{C(t-1)}{A(t-1)}\right) \qquad M_A = 2190 \text{ kcal}, \quad R = 1312 \text{ kcal}$$

$$P_L(t) = \text{Sea lion population}, \quad P_S(t) = \text{Salmon population}$$

Adult pop. at year *t* =
- when caloric intake is *greater* than caloric need: (1/12 of children become adults) + (adults live to age 60 on average)
- when caloric intake is *less* than caloric need: fraction sustainable by intake of adults who are younger than 60

Child pop. at year *t* =
- when caloric intake is *greater* than caloric need: (1/12 of children become adults) + (adults bear children proportional to excess food)
- when caloric intake is *less* than caloric need: fraction sustainable by intake of children who are younger than 12

Caloric intake at year t = (calories from sea lions) + (calories from salmon) + (baseline caloric availability)

Caloric requirement at year t = (calories for adult's survival) + (calories for survival of that adult's dependents)

The Belovsky model with our modifications. Shown here alongside an analogous English explanation.

Conclusions

Early results suggest that local salmon population changes seem to be a positive factor in driving the size of the Aleut population through time. Additionally, there exists the theoretical possibility that a greater numbers of Steller sea lions have a *negative* impact on the Aleut peoples' ability to obtain sufficient amounts of food. We hope further research and analyses will provide additional insights into our findings.

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