Reconstructing the Past via Data and Dynamics

Using archaeological data to mathematically model the Aleut

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The Aleut were indigenous to Sanak Island for thousands of years until nineteenth-century A.D.

As a predator species, they played an intricate role in the arctic and marine ecosystem.
Sanak Island
Data Found by Researchers

- Massive food web of interdependent species.
- What the most common foods eaten by the Aleut were (salmon, sea lions).
- Which species have a large amount of trophic links.
Our Project In a Nutshell

- The data we’re using has already been statistical analyzed, but...
- Mathematicians like using use dynamic models.
- We combine the two in a new way to model historic changes of the Aleut population of Sanak Island.
- This offers new perspectives in paleoecology and hunter-gatherer dynamics.
Types of Analysis
Data-Driven Analysis
Local Taxa Through Time

Time (years since 3,000 B.C.)

Individuals per 100 km²

- Humans
- Salmon
- Sealions
Applying Paleoecology to Dynamic Models

Paleoecological studies:

- Offer qualitative understanding of behaviors.
- Show a strong dependence on caloric availability.
Belovsky's Hunter-Gatherer Model

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

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

\[ I(t) = \beta P_L(t) + \alpha P_S(t) + \gamma \]

\[ M(t) = M_A + R \left( \frac{C(t-1)}{A(t-1)} \right) \]

\[ M_A = 2190 \text{ kcal, } R = 1312 \text{ kcal} \]
1. We implement Belovsky’s hunter-gatherer dynamic model.

2. We use archaeological population data for Stellar Sea Lions and Salmon over time as caloric input.

\[ I(t) = \beta P_L(t) + \alpha P_S(t) + \gamma \]

\[ P_L(t) = \text{Sea lion population}, \quad P_S(t) = \text{Salmon population} \]
Belovsky Prediction of Median Aleut Population

- Predicted
- Actual

Human individuals per 100 km²

Time (years since 3,000 B.C.)
Interesting Conclusions

- Our models generally fit most of the data.
- More sea lions and salmon may have had a *negative* impact on Aleut populations.
- Combining these methods of analysis provide further insights into the stories and dynamics of the past.
References

[1] Aleut in Festival Dress in Alaska, watercolor by Mikhail Tikhanov, 1818

