# Determining a Model for Harbor Seal Whisker Geometry Through Extensive Data Analysis

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**Overview :** Can harbor seal whisker geometry be predictably described by a mathematical model? We are collecting the necessary data to validate, refute, or replace existing models in the most comprehensive investigation into the matter to date, with over 500 whisker samples being analyzed.

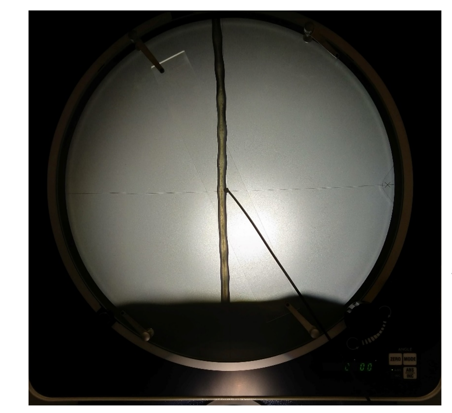
## Introduction

**Background**: Harbor seal whiskers exhibit a tapering elliptical geometry suited to detect ways in ways a regular, tapering, or elliptical cylinder cannot. Previous studies have gathered insufficient data to produce a biologically accurate model. Current models are only idealized representations of the rough geometry the whiskers seem to take on. A question arose to see if it is possible to model the seven varying parameters of seal whisker geometry: the periods of undulation or waves, the wide and narrow diameters of the major and minor axes, and the angles at which maxima and minima occur. Measuring base diameter and whisker lengths will also be useful in creating a model.

**Project Aims:** We aim to gather a large amount of data from our collection of harbor seal whiskers using flatbed and CT scans to develop a comprehensive mathematical model of seal whiskers with a high degree of certainty compared to previous approximations.

## Imaging Options

**Profile Projector:** This tool takes measurements with uncertainties that were too large, but it could be useful for viewing details in real time.



*Seal whisker viewed using profile projector*

**Leica DM6 Microscope and 7000T Camera:** This tool takes 40 minutes per scan, can only scan 1 whisker at a time, and produces a less clear image than CT scanning.

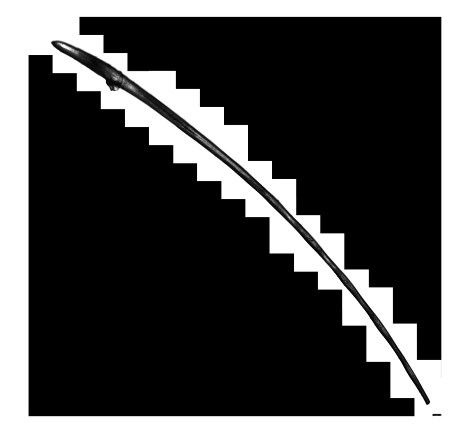
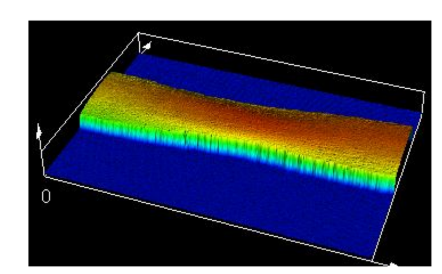


*Image of seal whisker taken on Leica 7000T Camera*

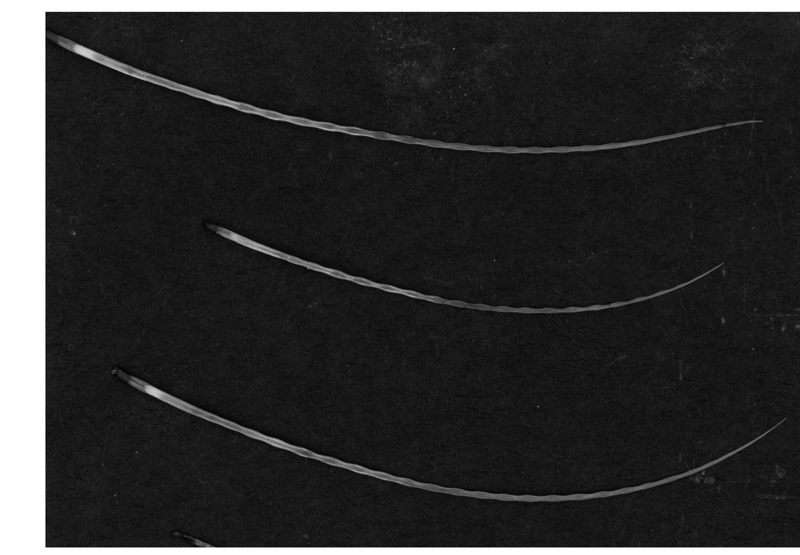
**Olympus LEXT OLS500:** This tool takes detailed measurements, but only results in the top view of the whisker.



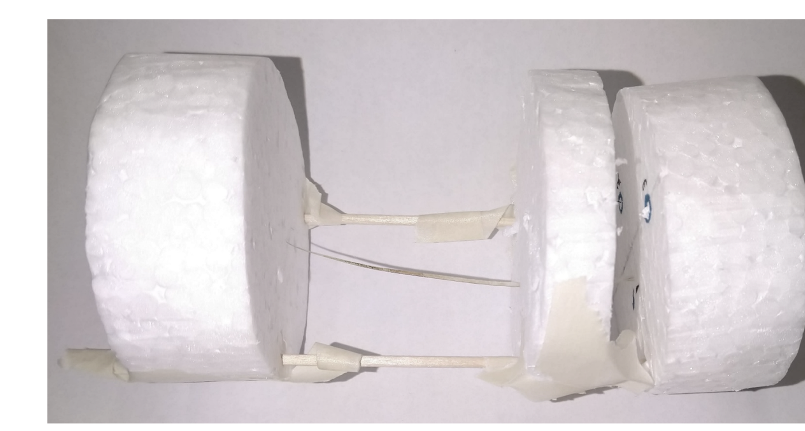
*Detailed view of seal whisker section taken by Olympus LEXT OLS500*

## CT Scanning Setup

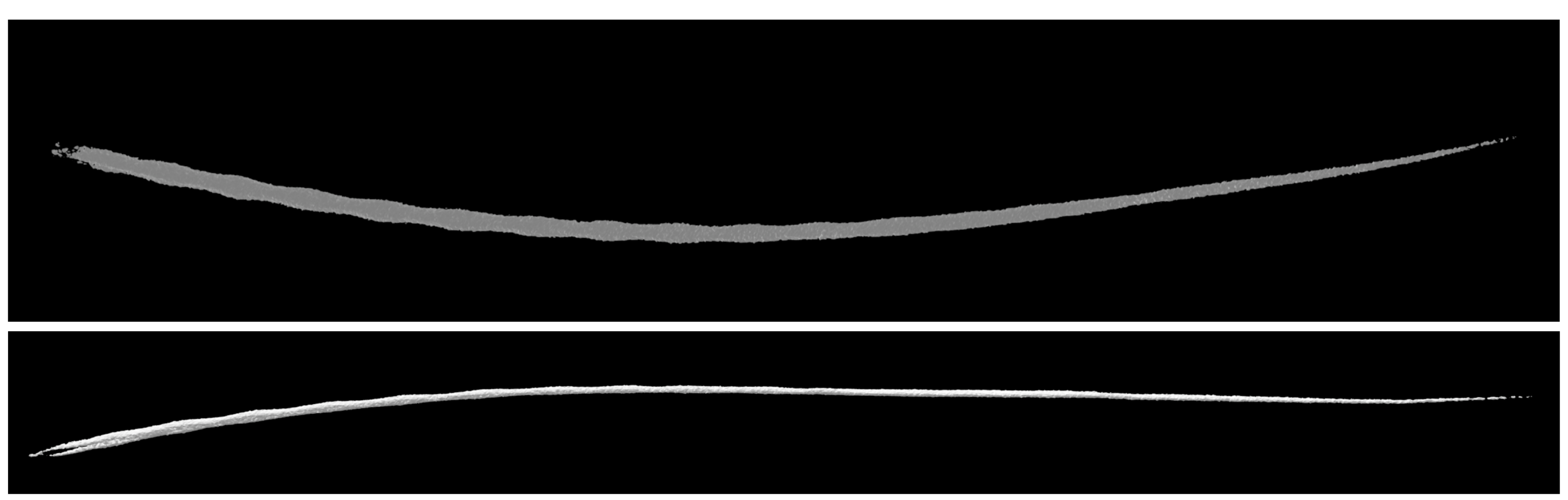
**Flatbed Scanning:** This method provides 2D data, including length measurements, and allows for easy sorting into groups by size for CT scanning.



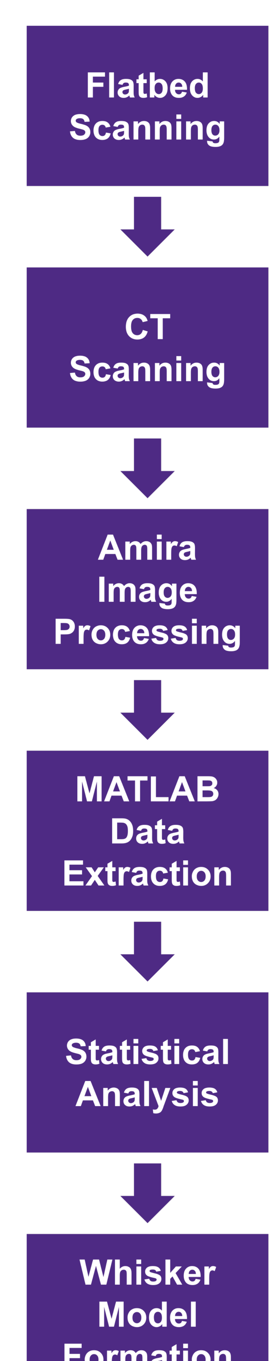
**Jigging System:** The construction used to house the whiskers is made of expanded polystyrene foam (a radio-translucent material). It provides a clear contrast with whiskers in a CT scan, makes segmenting easier in post-processing, keeps the original whisker curvature, and helps produce a clearer final image.



## Methods



*Orthogonal views from CT scan of one seal whisker showing out of plane curvature and undulations*




To convert the data from raw form into a 3D model, we use Amira, a software available to us at the Center for Advanced Molecular Imaging (CAMI) facilities at Northwestern. To generate this model, we first applied a non-local means filter to de-noise the data with minimal loss in detail. Then, we segmented the 2D slices by setting a threshold value, corrected errors in marking, smoothed the labels, and applied an arithmetic filter to separate the target whisker from the rest of the data. From this, we generated a surface, shown above.

## Discussion and Future Work

The project will continue its work with flatbed scanning followed by CT scanning over the summer of 2019. After the flatbed scans are run through the MATLAB code that will characterize the length of each whisker, the whiskers will be sorted by length for CT scanning. The CT scans will then be processed by Amira to produce 3D images of each whisker, images that will be inputted to a MATLAB code that can deduce the seven parameters of whisker geometry we are interested in. With this data, we will conduct statistical and then multiple regression statistical analysis to test how base diameter and/or length influence the outcome variables—the seven parameters of whisker geometry. Based on how base diameter and length affect these parameters, we aim to form a mathematical model that can predict seal whisker geometry.

**Conclusions:** Preliminary qualitative analysis has suggested the geometry may be highly dependent on array position, but more data is needed before any conclusions can be accurately drawn.

## References & Acknowledgements

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