Estimating in-situ krill body tilt orientation, length, and abundance from stereo camera images

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Introduction

- Krill (euphausiids, largely *Thysanoessa spp.*) are a major prey species for walleye pollock in Alaska, leading to interest in improving acoustic krill population estimates.
- Converting acoustic backscatter to biomass or abundance estimates requires a model of krill acoustic scattering properties (i.e. target strength).

- Krill target strength can be measured in situ (difficult) or estimated with a scattering model that requires a number of parameters, including krill body length and body tilt orientation.
- While length composition can be measured from captured animals, estimating body orientation typically requires in situ camera observations.
- Acoustic estimates currently rely on krill tilt measurements from Antarctic (*Euphausia superba*) and North Atlantic (*Meganyctiphanes norvegica, Thysanoessa spp.*) krill. This is the first study to measure tilt in-situ in the Gulf of Alaska.

### Acknowledgements

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### Selected references


### Image collection and analysis

#### Image collection:

- We deployed a stereo camera system at 8 locations in the Gulf of Alaska. Images were captured at 1-second intervals from depths ranging from 10 m – 170 m.
- Camera deployments July-August 2015, all deployments during darkness.
- The system also collected depth, capture time, and camera tilt and roll measurements for each image.

#### Image analysis:

- We used SEBASTES, a stereo image analysis program created at the AFSC, to conduct a tiered image analysis that accounted for varying krill image quality.
- All observed krill were used as a measure of relative abundance, while high-quality subsets were judged for tilt, roll, and body position as well as body length.
- We excluded krill demonstrating escape responses (“L” or “C” curved body position, or upside-down postures) from tilt analysis.

### Results

- 10072 individual krill were identified. Of these, 1141 (11.3%) krill that were not demonstrating escape responses were included in tilt estimation and 565 (5.6%) krill with clearly defined eye and telson endpoints were used for length frequency analysis.

- Mean krill tilt was nearly horizontal with a wide distribution (1.74 ± 40.22° SD).
- Krill oriented more downward in a single deployment made just after midnight, suggesting that krill were migrating lower in the water column.

### Determining krill orientation and body length

#### Step 1. Removing rotation effect of camera

The true 3D coordinates of an individual krill (x, y, and z) are

\[
\begin{align*}
x' &= \cos(\alpha) \cos(\beta) - \sin(\beta) \\
y' &= \sin(\alpha) \\
z' &= \cos(\alpha) \sin(\beta)
\end{align*}
\]

where \(\alpha\) is roll angle and \(\beta\) is pitch angle of the camera, and \(x', y',\) and \(z'\) are the positions of head and tail in the camera coordinate system.

#### Step 2. Estimating tilt (slope) and yaw (movement around the vertical axis) of krill

\[
\begin{align*}
\theta &= \arctan\left(\frac{y'}{x'}\right) \\
\rho &= \arctan\left(\frac{x'}{\sqrt{x'^2 + y'^2}}\right)
\end{align*}
\]

where \(x', y',\) and \(z'\) are the coordinates of the krill head relative to the tail.

Theta (\(\theta\)) and Rho (\(\rho\)) are the corresponding body tilt and yaw.

### Conclusions

1. Stereo cameras can efficiently capture *in-situ* krill length, tilt, and relative abundance data
2. Further camera deployments during daylight survey conditions and in other seasons are needed to explore how krill tilt distribution varies spatially and temporally.
3. Collecting krill tilt data *in-situ* will lead to more accurate parameterization of acoustic scattering models for krill and acoustic estimates of krill abundance in Alaska.