

# Humpback whale foraging structures winter schooling behavior of Pacific herring

<sup>1</sup>K.M. Boswell, <sup>2</sup>J.J. Vollenweider, <sup>2</sup>J.M. Moran, <sup>2</sup>R.A. Heintz, <sup>3</sup>J.K. Blackburn and, <sup>2</sup>D.J. Csepp

<sup>1</sup>Florida International University, Marine Sciences Program, North Miami, FL 33181

<sup>2</sup>Auke Bay Laboratories, Alaska Fisheries Science Center, NMFS/NOAA, Juneau, AK 99801

<sup>3</sup>Department of Geography, University of Florida, Gainesville, FL 32611

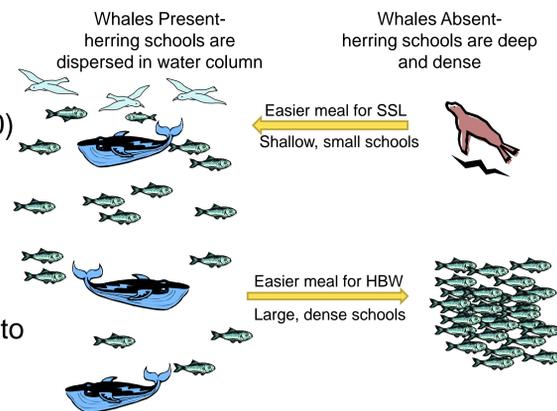
\*Email: kevin.boswell@fiu.edu



## Background

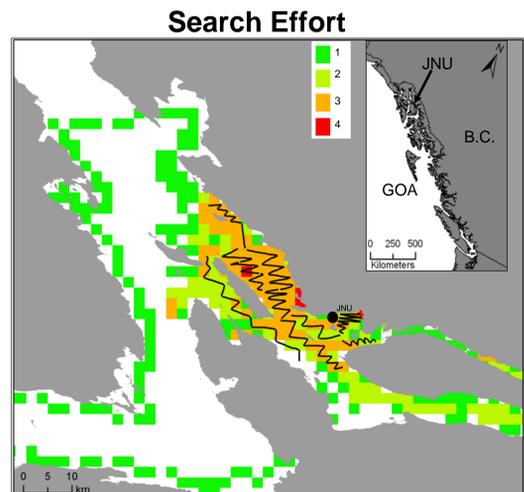
- Humpback whales are significant predators consuming  $\sim 0.4 \text{ T} \cdot \text{indiv}^{-1} \cdot \text{d}^{-1}$
- Increasing whale population size  $\sim 5\% \text{ yr}^{-1}$  (2004-2006: Population estimated at 20,000)
- Herring aggregate in massive schools while overwintering in predictable locations
- Humpback whales have been observed foraging on overwintering herring
- Increasing whale population may contribute to top-down control on herring populations

## Dilemma for Wintering Herring : Strategy for avoiding whales differs from sea lions



## Methods

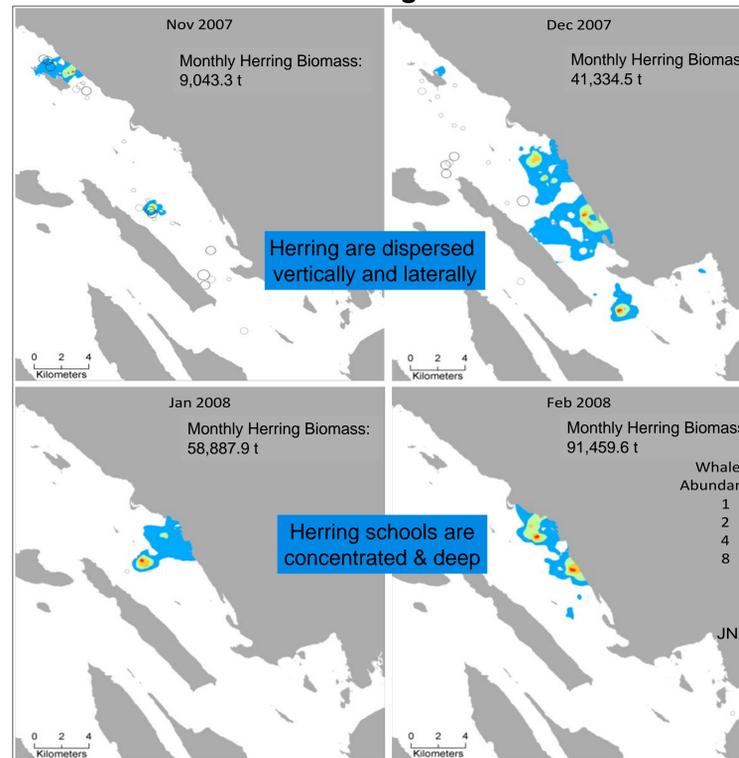
- Whale and acoustic surveys (38 kHz) were conducted monthly during winters of 2006-2007 and 2008-2009 (Nov–Feb)
- “Whale days” = cumulative whales present each day summed over each month



Cumulative maximum search effort (log minutes, color scale) for humpback whales in Lynn Canal, AK during the 2007-2008 and 2008-2009 winter months. Acoustic survey transect is represented by solid line.

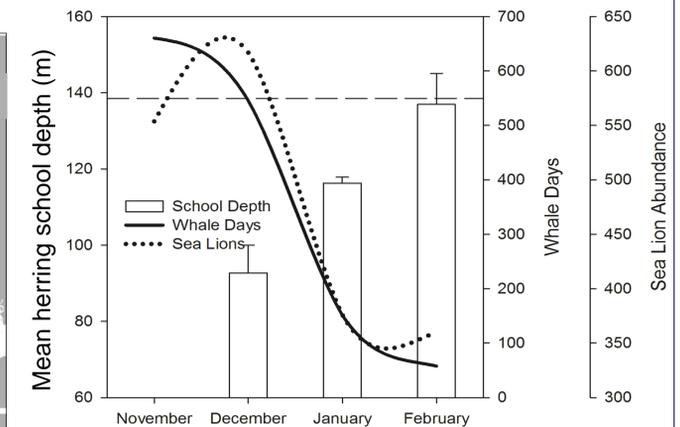
## Results

### Whale & Herring Distribution



Winter distribution of humpback whales (circles) and herring (color map). Spatial distribution of herring biomass derived from IDW analysis. Colormap represents the percentile distribution when herring are present (red=100%-75%, orange = 75%-50%, green=50%-25%, blue=25%-0%). Whale abundance from visual surveys are represented by graduated open circles. Note change in herring biomass.

### Herring Depth Relative to Predator Abundance

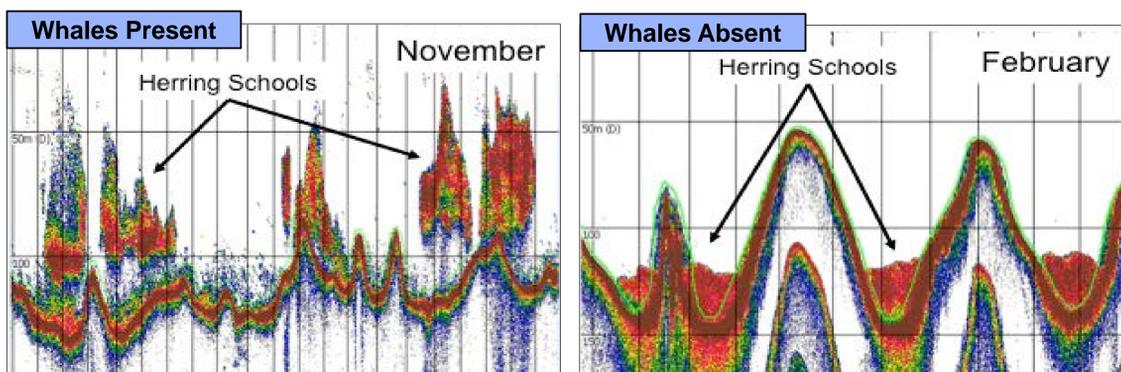


Monthly depth distribution ( $\pm$ se) of herring schools relative to whale days during 2007-2008 and 2008-2009, and historical sea lion abundance data from Womble et al. (2009). Broken line represents mean water depth where herring schools were observed.



As whale abundance decreases, sea lions synchronize dives with remaining whales.

### Influence of Whales on Winter Herring Schooling Behavior

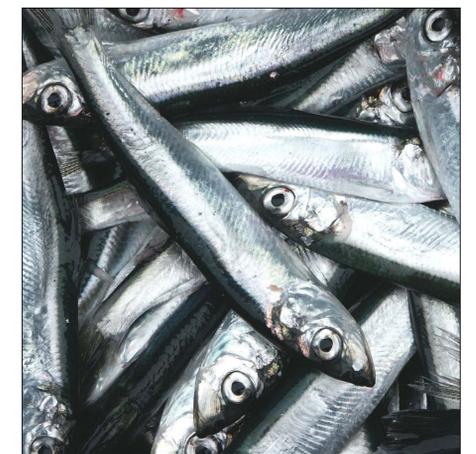


Example echograms of winter herring distribution. Herring schools are dispersed in the water column in the presence of whales, and consolidated in deep trenches in the absence of whales.

## Summary

- Humpback whales were strongly associated with herring school locations
- Pacific herring schooling behavior is measurably different in the presence of humpback whales
- In the presence of humpback whales, dispersed herring schools were more available to surface-oriented predators (sea lions, birds)
- As whales departed to breeding grounds or alternate feeding areas, herring rapidly settled into deep trench habitats

**Foraging whales interfere with the preferred behavior of herring and make herring available to other surface-oriented predators**



Pacific herring



The recommendations and general content presented in this poster do not necessarily represent the views or official position of the Department of Commerce, the National Oceanic and Atmospheric Administration, or the National Marine Fisheries Service.

**Acknowledgements:** Funding provided by the EVOS Trustee Council. We thank Alex DeRobertis for assistance with initial data quality checking, and Jan Straley (UAS).