Humpback whale foraging structures winter schooling behavior of Pacific herring

**Background**

- Humpback whales are significant predators consuming ~0.4 T·indiv⁻¹·d⁻¹
- Increasing whale population size ~5% 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

**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

**Results**

**Dilemma for Wintering Herring:**

- Strategy for avoiding whales differs from sea lions
- Whales Present: herring schools are dispersed in water column
- Whales Absent: herring schools are deep and dense

**Search Effort**

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.

**Influence of Whales on Winter Herring Schooling Behavior**

- Whales Present: herring schools are dispersed
- Whales Absent: herring schools are deep and dense

**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 (+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.

**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

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