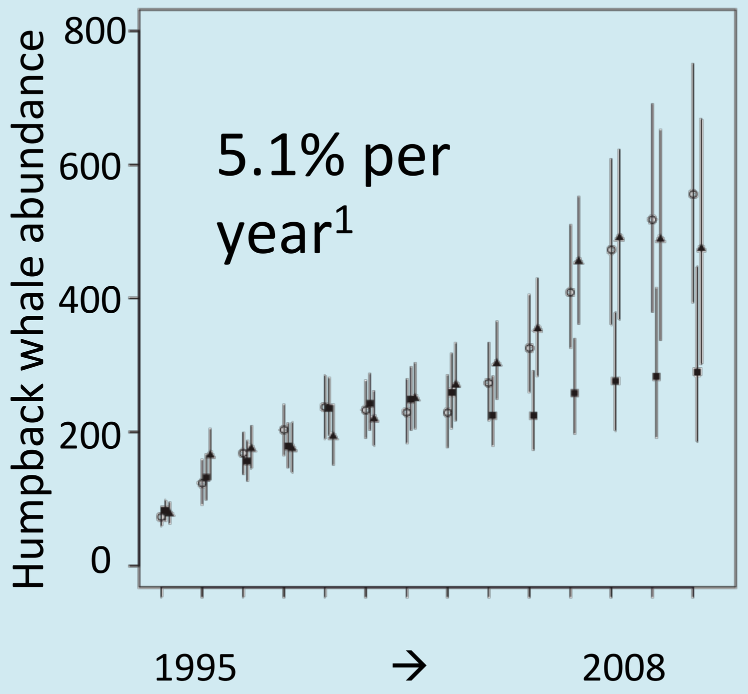
An Easy Meal: Predicting humpback whale foraging efficiency on wild and anthropogenic prey sources

Ellen M Chenoweth[1]*
Ari S. Friedlaender[2], Jan M. Straley[3,4] Julia Burrows[2], Lon Garrison[3], David W. Johnston[2], Doug Nowack[2]
[1] University of Alaska Fairbanks, [2] Duke University Nicholas School of the Environment, [3]Sitka Sound Science Center, [4]University of Alaska Southeast

Motivation

Humpback whales are increasing in Southeast Alaska

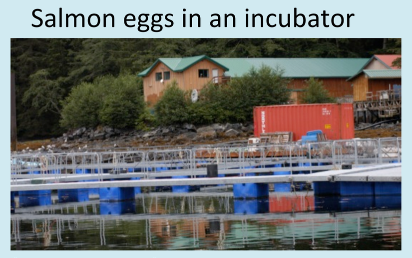


As generalist predators that switch between species of forage fish and krill, their future impact on ecosystems and fisheries is difficult to predict. However, each whale must consume about 338-370 kg/day[2] to accommodate its energetic requirements. Recently, humpback whales have begun feeding at hatchery release sites competing with salmon fisheries and exposing themselves to risk of entanglement.

What are hatcheries?

Whale surfaces in an open hatchery net pen

Salmon eggs in an incubator



Floating salt water net pens, where juvenile salmon are held directly prior to release

In Alaska, hatcheries are artificial nurseries operating as nonprofit organizations for fishery enhancement. Hatcheries rear salmon from eggs through the freshwater life stage because this early life stage is thought to limit cohort size of wild salmon due to predation and environmental extremes. These salmon are released into the salt water environment where they spend most of their lives and are subject to the same selection pressures as wild salmon. Hatchery fish comprise 30% of the ex-vessel value of Southeast Alaska's commercial salmon fishery, generate $171 million and create 971 jobs.[3,4]

Figure 1 Hatcheries in Chatham Strait that participated in Straley et al 2010[5]

A pilot study documented humpback whale feeding at hatcheries[5]

- Whales were present near the net pens at all five release sites
- At one hatchery, at least one whale was seen in the release area on ten days out of a two-week period.
- Whales were significantly more likely to be present on the day following a release than after a non-release day ($\chi 2=14$, df=1, $p=0.0002$).
- One individual whale was photographically identified as feeding in 2008, 2010, and 2013 at the same release site.

*emchenoweth@alaska.edu

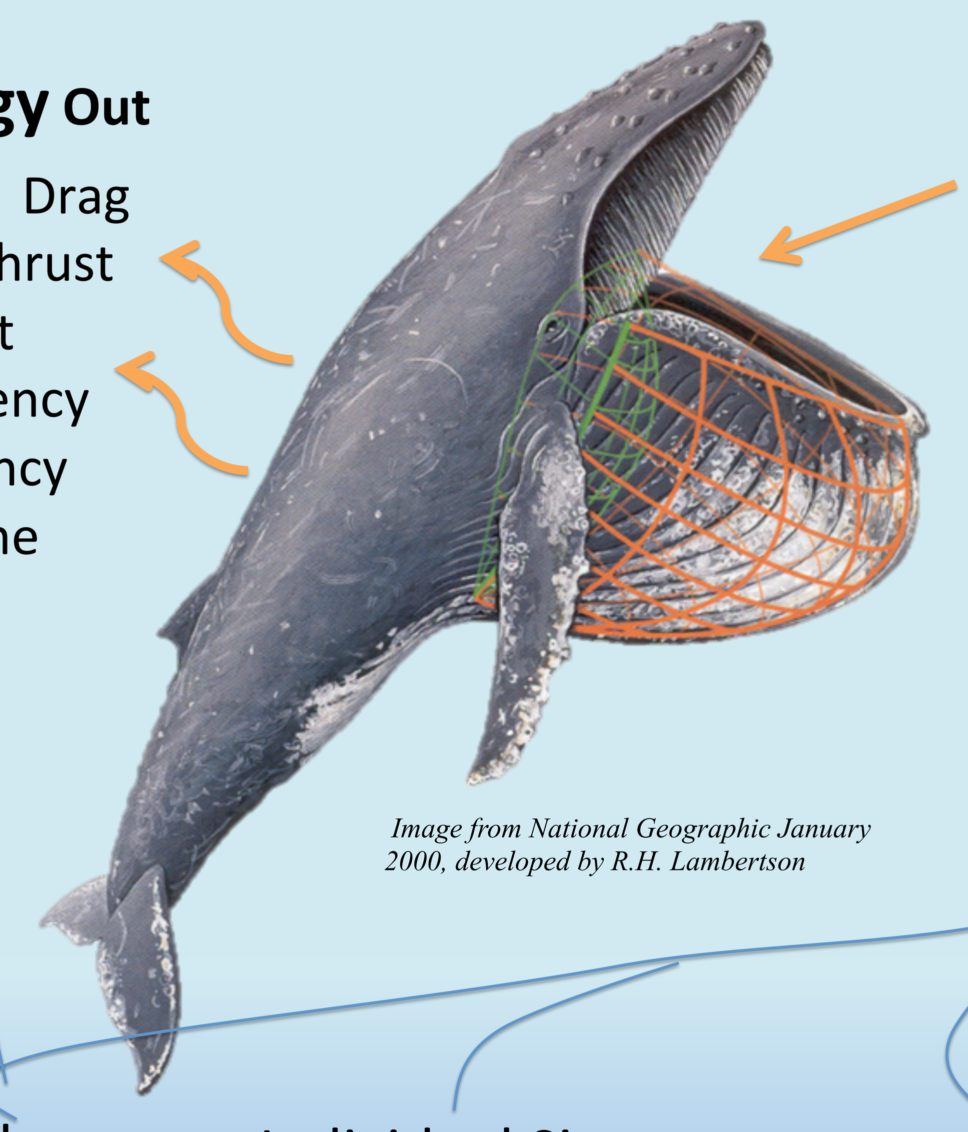
Objectives

1). Model how prey patch characteristics affect foraging efficiency
2). Compare foraging efficiency at hatcheries to wild prey sources
3). Apply this knowledge and economic considerations to suggest an optimal release strategy

Foraging efficiency is a balance between energy obtained and energy expended while feeding

Energy Out
Drag
Thrust
Weight
Assimilation efficiency
Conversion efficiency
Search Time

Energy In
Consuming Prey



Depth
Avoidance
Individual Size
Energy Content
Density

Prey patch characteristics affect both the amount of energy obtained and energy expended

Methods

Split-beam Simrad K-60 scientific echosounder at 38 kHz and 120 kHz.

Tagging

We used suction cups to attach biologging tags to the backs of foraging humpback whales. From these tags we can determine changes in orientation, depth, speed and ambient sound.

Prey Sampling

We used an echosounder to visualize prey patch characteristics density, and depth. For krill we used a 333 µm mesh bongo net for species, size and energetics. For small fish, we will sample fish with hook and line or cast nets. Bomb calorimetry will be used to determine energetics.

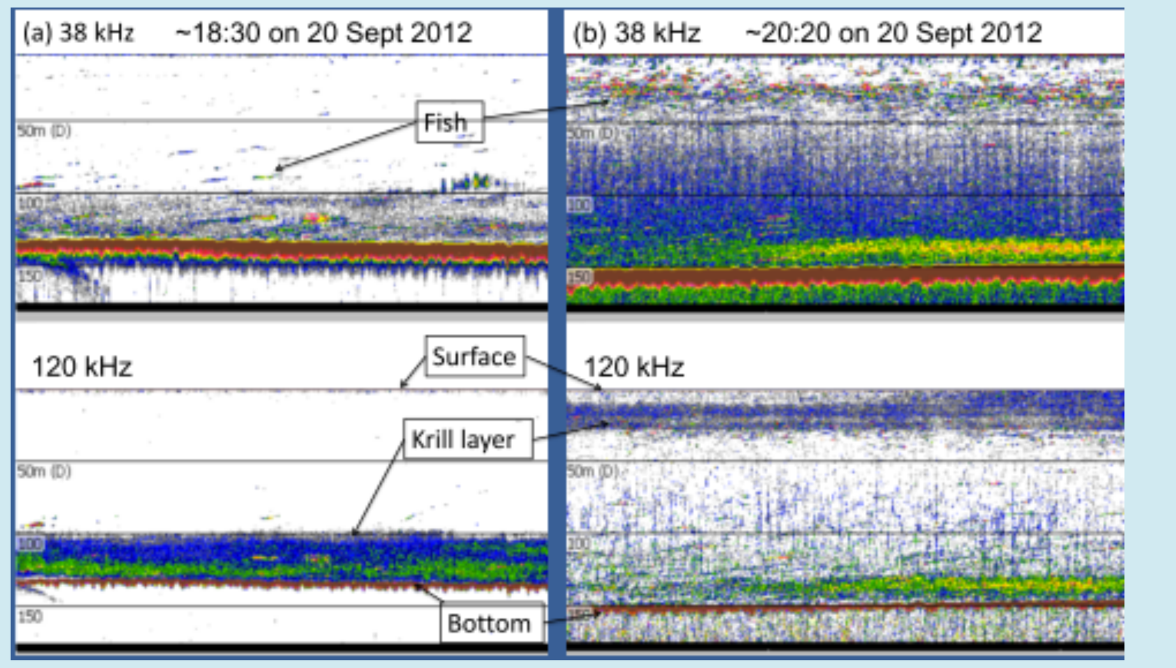
Energetic Modeling

We will use hydrodynamic and energetic modeling and optimal foraging theory to estimate the efficiency of each foraging dive based on tag and prey sampling data[6]. We will then use maximum likelihood estimation to determine the relative importance of the parameters corresponding to each prey patch characteristic tested.

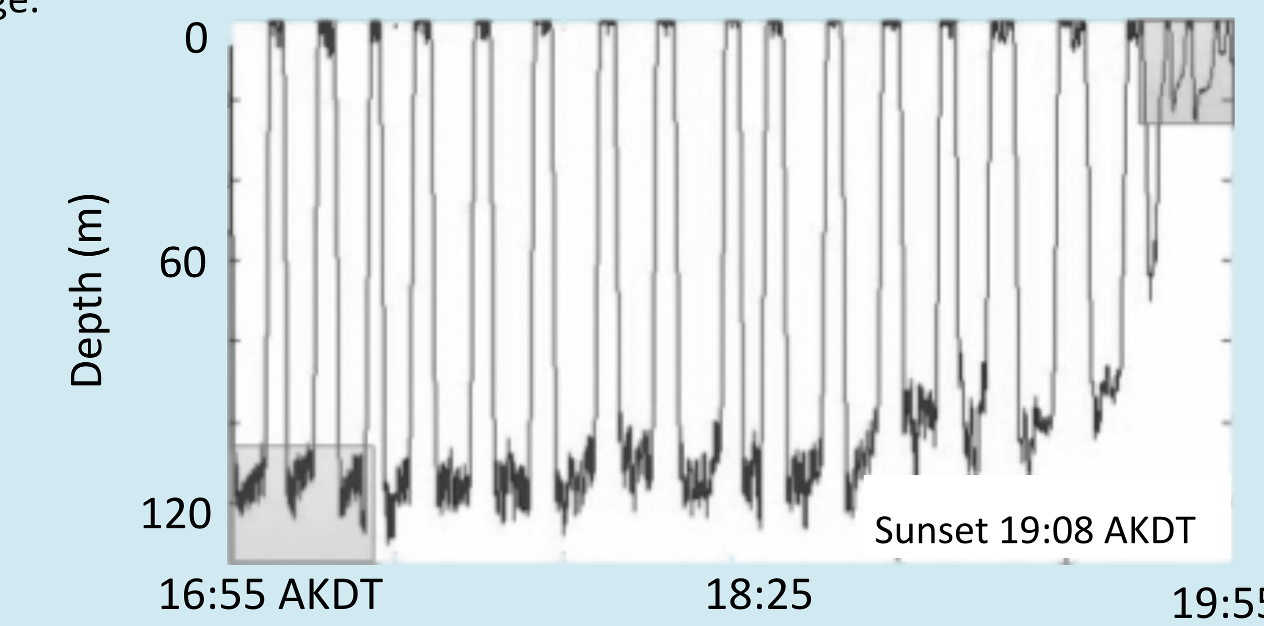
Results

These are preliminary results from 6 humpback whales tagged in Sept. 2012 in Sitka Sound, Alaska.

Whales were targeting *Euphausia pacifica*, a species of krill



(Above) This image is produced from the multi-beam echosounder and shows how prey rises during dusk causing a relatively rapid change in prey patch characteristics from deep dense prey (a) to shallow diffuse prey (b). (Below) a humpback whale's dive profiles retrieved from bio-logging tags shows the whale tracks these changes by shallowing the foraging dives and eventually ceasing to forage.



Because this method relies upon data collection from humpback whales feeding on a wide variety of prey types, in April 2013 we tagged 6 whales feeding on herring in Tenakee Inlet, Alaska. This included members of a cooperative lunge feeding group as well as individual feeders. When the effects of prey patch characteristics on foraging efficiency is more fully understood, release strategies that decrease humpback whale foraging efficiency at hatcheries can be developed to encourage whales to feed on wild prey sources. Finally, we will use economic models to determine the most cost-effective release strategy.

Acknowledgements

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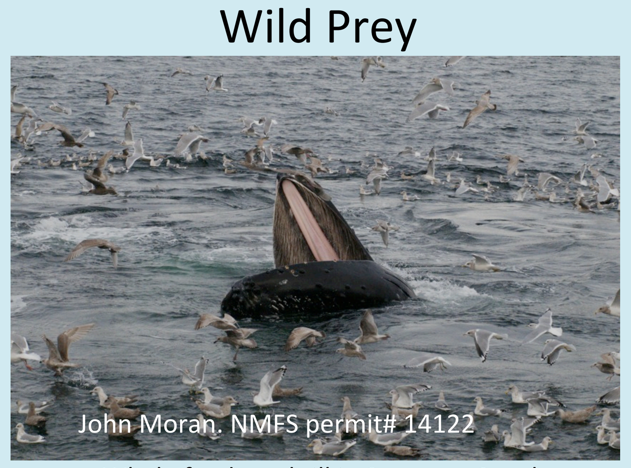
Wild Prey



Whale feeds on krill in Seymour Canal

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