

Climate Change and Baleen Whale Trophic Cascades in Greenland

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LONG-TERM GOALS

The primary goal of this study is to examine and contrast the foraging strategies of two baleen whale species in West Greenland. We use a multidisciplinary approach by combining observations of foraging ecology and phenology collected by satellite and archival telemetry with intensive and localized *in situ* sampling of ocean conditions and prey availability. These baseline trophic relationships are quantified using spatial and bioenergetic models.

OBJECTIVES

We are focusing on two species in Disko Bay, West Greenland and asking the following questions: 1) What is the spatial and temporal overlap between bowhead whales, phytoplankton, and zooplankton after the spring sea ice breakup in April and May?, and 2) What is the spatial and temporal overlap between humpback whales and capelin in June and July, and on what space and time scales do these two large whales overlap? Answering these questions will enable us to determine the spatial, temporal, and ecological overlap between these two top predators in West Greenland. Fluxes of organisms across ecosystem boundaries have major consequences for community dynamics and predation can create strong effects throughout food webs. This is one of the few studies conducted on the multi-species trophic coupling between whales and their prey. The simplicity of the food chains in West Greenland offer unique opportunities to gain insight into predator-prey dynamics also relevant to more complex ecosystems.

APPROACH

This portion of the study focused on the foraging ecology of bowhead whales in late-spring just after sea ice break-up. Annual sea ice conditions, including ice concentrations, timing of break-up and locations of the ice edge, are assessed using remotely sensed imagery (MODIS, SMMR/SSM/I) (See Laidre and Heide-Jørgensen 2004). Satellite-linked tags are deployed on bowhead whales to determine small-scale movements in Disko Bay, the timing of departure and movements during spring and summer. These tags are simple location-only transmitters (SPOT5, Wildlife Computers) with a longevity of 6-12 months that enable detection of alternative feeding areas in the high Arctic. Bowhead whales are also instrumented with high resolution retrievable GPS-based Argos data collection transmitters. The GPS tags receive signals from GPS satellites and acquire and process a small time-

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stamped snapshot of GPS constellation signals (4-16 msec) to obtain the satellite data needed for location calculation by an extremely fast acquisition processor (<40 msec acquisition time) during each surfacing. These data are transmitted through the Argos Data Collection and Location System. The calculation of GPS positions allows for location accuracy of +/- 55 meters (95%) where the whale was surfacing. The satellite transmitter also provides its own Argos based Doppler shift position as well as data on the diving. Collected data include dive depth, duration of dives, and time-at-depth sampled in 1 hour intervals.

These data are coupled to epibenthic zooplankton data to quantify the spatial and temporal variability in Disko Bay. Near-bottom zooplankton concentrations are investigated at 25 stations where bowhead whales feed. Data are collected with an epibenthic sled and the zooplankton biomass is determined by simple measurements of volumetric displacement. Further quantification of epibenthic zooplankton abundance is conducted by use of a 200 KHz submersible split-beam echo sounder, which estimates vertical gradients in zooplankton concentrations as well as patchiness between stations.

The portion of the study focused on the foraging ecology of humpback whales utilizes satellite telemetry (SPOT5 and SPLASH tags, Wildlife Computers) deployed on whales in spring when they arrive en route from the Caribbean to their feeding areas. The focus is on obtaining a large sample size of tagged whales so that spatial movement patterns and focal areas can be robustly calculated. Movement data are used to describe movement patterns and use of focal areas along the coast using probabilistic spatial techniques, including the time individuals spend feeding in each site and the phenology of the use of the focal areas. These data are related to long-term physical and biological monitoring program in Nuuk Fjord and on the coast of West Greenland, where long-term fishery data are collected to quantify seasonal and inter-annual variations in the biological and geophysical properties of the marine ecosystem.

WORK COMPLETED

Bowhead whales. Field work for the first component of the study was conducted on Disko Island, West Greenland between 14 April and 5 May 2008 based at Arctic Station (University of Copenhagen research station) in the town of Qeqertarsuaq. Our team has successfully instrumented twelve bowhead whales with satellite transmitters (SPOT5) using a modified pneumatic line Air Gun. All tags were deployed within 10 nmi of the town of Qeqertarsuaq. Instrumented whales were all >12 m in length. Two of the whales carrying satellite tags were re-sighted one week later, traveling with other whales and photos were taken. One bowhead was instrumented with a GPS archival dive and temperature recording tag using a 6 m long fiberglass pole and the instrument collected data for over one month while on the whale. 61 skin biopsies were collected by biologists and hunters using crossbows. Biopsies were also collected immediately after a whale was tagged whenever possible and 10 of the 12 tagged whales were biopsied. Concurrently, 33 stations in Disko Bay were sampled for zooplankton composition and density using the ship RV *Porsild* (Arctic Station's research vessel). Two methods were used to sample zooplankton at each station: a 10 minute bottom drag using an epi-benthic sledge targeting benthic zooplankton and a WP2 plankton net hauled through the water column targeting pelagic zooplankton. The epi-benthic sledge had a 70 cm wide mouth opening and the sledge was dragged at a speed of 1 kt over a 10 minute period, or for approximately 300 m at each station. Zooplankton samples were examined in the laboratory of Arctic Station: species from each station were counted, identified to the lowest taxonomic order, and weighed. Samples were sent to

Copenhagen for further analysis. Five fresh fecal samples were collected from feeding bowhead whales.

Humpback whales. The second component of the study was conducted on Disko Island, West Greenland between 26 May and 9 June 2008 based at Arctic Station (University of Copenhagen research station) in the town of Qeqertarsuaq. Our team successfully instrumented 10 humpback whales and four bowhead whales. All tags were deployed within 50 nmi of the town of Qeqertarsuaq with some tags deployed in the southern part of Disko Bay near Aassiaat. Instrumented whales were all >12 m in length. All humpback whales were sighted and tagged very close to shore, in some cases just a few hundred meters from the coast where they were foraging intensively on capelin. Data from satellite tags are still being collected.

RESULTS

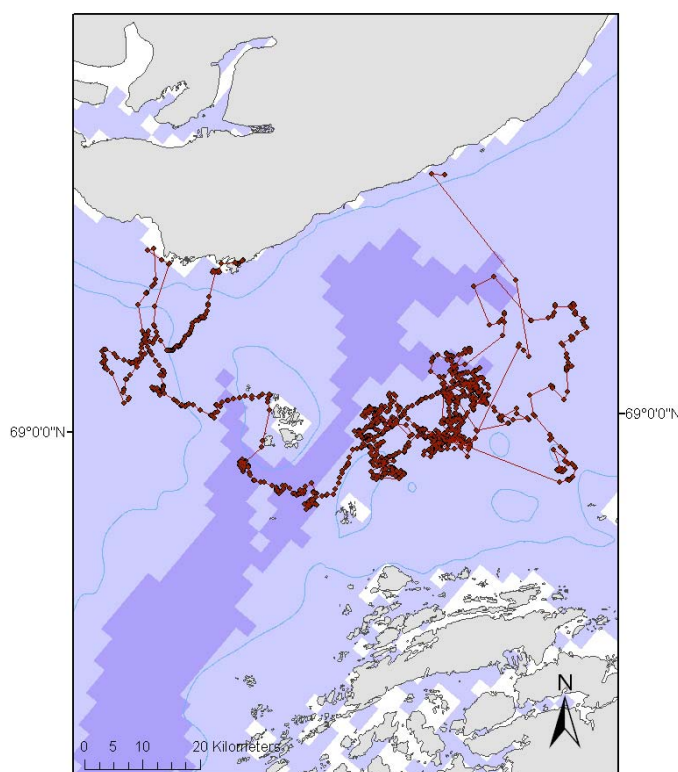


Figure 1. Map of a one-month detailed track of a bowhead whale instrumented in Disko Bay with a GPS transmitter. This instrument provided detailed dive and temperature data every second during this period.

Our primary accomplishment for the first year of the project was the instrumentation of 26 whales with satellite tags between April and June in Disko Bay, based on two field seasons, with one additional whale instrumented with a GPS dive tag that collected daily data for one month (Fig. 1). Based on the satellite tracking data we found a clear spatial overlap during a several week period of bowhead and humpback whales in Disko Bay during the last half of May and early June. Whales explore several

focal areas in the bay and during the period of temporal overlap, there is a clear spatial partitioning of the bay, with bowheads in northern coastal areas and humpback in southern coastal areas. Models will be developed quantifying this overlap. Furthermore, information on zooplankton resulted in the identification of over 50 species, several of which had never been described before in Disko Bay. Preliminary results suggest extremely high variability in epibenthic zooplankton species composition and densities in the area where whales are feeding.

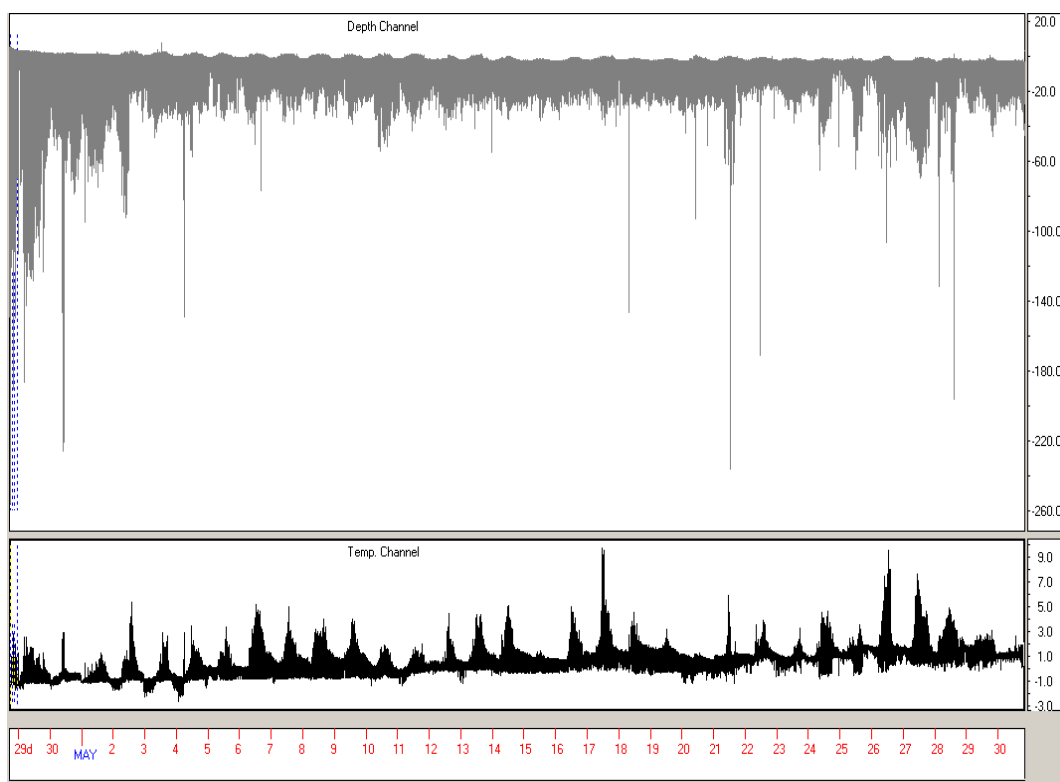


Figure 2. Graph of time series of dive and temperature data collected from a bowhead whale instrumented with a FastLoc GPS tag for one month in April in Disko Bay, West Greenland.

IMPACT/APPLICATIONS

1. A new perspective on the interaction between sub-Arctic and Arctic baleen whales in West Greenland. Few studies have been conducted on the trophic coupling between whales and their prey, given the dynamic nature of the marine environment and the difficulty in observing or quantifying feeding behavior. By instrumenting twenty-six individual bowhead and humpback whales in a defined region of West Greenland, we are enabled to examine the movements and space use patterns of each species, together with how the two species overlap in space and time and compete for resources.

Potential future impact for Science and/or Systems Applications

2. New techniques for ecological studies of large whales using telemetry. Our study develops technical and methodological advances which are of broad interest for applications in other regions for

whale tagging. We have developed a retrievable archival instrument that can be reliably deployed on a large whale and retrieved up to one month later, providing high resolution GPS location data together with dive data measured on a one-second temporal scale. Furthermore, design and deployment of satellite transmitters for large whales is continually being refined based on field efforts during this project to improve attachment.

RELATED PROJECTS

None.

PUBLICATIONS

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