Use of landfast sea ice as a platform for subsistence whaling in a changing environment

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1. Introduction

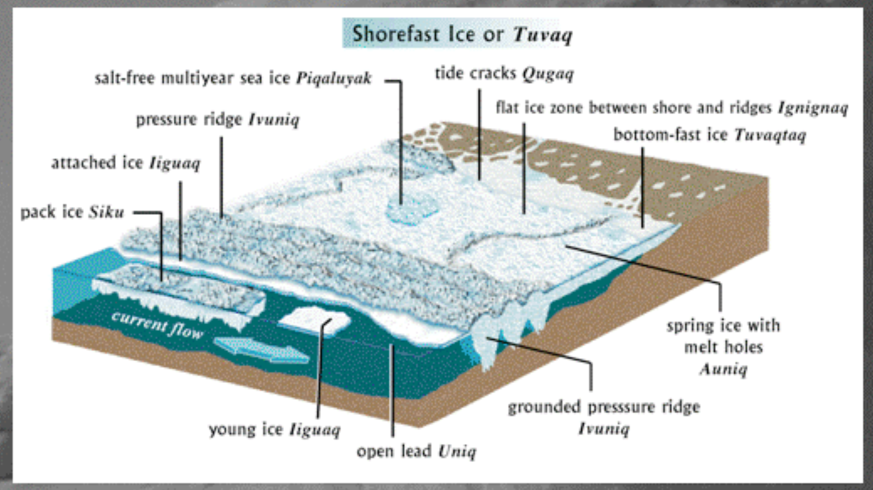
The spring whale harvest throughout Arctic Alaska is a prime example of the use of sea ice as a platform for human activities. Whaling trails are cleared through the highly deformed landfast ice (tuvaq) to allow whaling crews to position themselves along the open leads of the flaw zone (uiñiq) in wait for the migratory passage of bowhead whales—an important cultural and subsistence resource for many Iñupiat Eskimo communities. In Barrow, wildlife biologists with the North Slope Borough have geographically referenced whaling trails for most years from 2001–2006; however, a thorough collection of this data alongside detailed information about ice conditions has yet to be initiated. Such analysis holds promise for an increased understanding of how hunters use the ice in relation to the physical sea-ice properties and processes that we have the ability to monitor with remote sensing techniques, namely satellite imagery and coastal marine radar. Ultimately, these relationships may assist in the development of tools that help predict ice hazards during the periods when hunters are present on the ice. Furthermore, an understanding of how environmental conditions influence the decisions made by whalers may provide a basis for assessing how future sea-ice scenarios will affect Barrow's spring whaling season. As ice trends in the Chukchi and Beaufort Seas continue, we may expect decreasing summer minimum pack-ice, which may in turn have a large impact on the stability of the landfast ice since it depends on the presence of multi-year (MY) ice as a stabilizing component during grounding (Norton and Gaylord, 2004).

2. Hunters' Use of Changing Ice

- Barrow's whaling season may extend from mid-April to early June.
- Whaling camps are placed along open leads at the edge of the landfast ice, in locations where the probability of a whale surfacing is high and yet where the ice can offer a certain level of safety.
- Whalers assess the landfast ice three-dimensionally with a knowledge of the year's preceding ice events that may have contributed to the integrity of the landfast ice (Huntington et al., 2001; Norton et al., 2002; Norton and Gaylord, 2004).

The Marine Mammal Workshop in 2000 summarized that (Huntington, 2000):

- "sea ice patterns in the Bering and Chukchi Seas have changed over the last 50 years. Multi-year floes used to be blown south in fall, reaching the shore near Barrow and passing through the Bering Strait to St. Lawrence Island. Today these floes appear in November or December, after sea ice has already formed locally, " and
- "In spring, the ice goes out sooner, and whaling crews have had to adjust their usual patterns to prepare earlier, go farther out, and be ready to return to shore sooner. In Barrow, the sea ice now goes out before July 4, and sometimes has left in June."



Schematic representation of coastal sea ice in the Chukchi Sea off Barrow, with both English and Iñupiaq terms for ice structures (George et al., 2004). Illustration by Deb Coccia.

Optimal Environmental Conditions for Spring Whaling as Identified by Barrow Whalers (George et al., 1998)

Environmental Criteria	Optimal spring whaling conditions
Wind direction & speed	East wind (perhaps most important), < 40 km/h
Current	Northeast current (in the Chukchi sea)
Landfast ice stability	Grounded MY
Lead width	$\geq$ 1 km in width (wider than normal bowhead dive length)
Wave height	Approximately < 0.7 m
Temperature	Fairly unimportant, except for when leads freeze in low wind and very cold temperatures (<-20 C)

3. Coastal Sea-Ice Radar in Barrow - available at www.gi.alaska.edu/BRWICE/

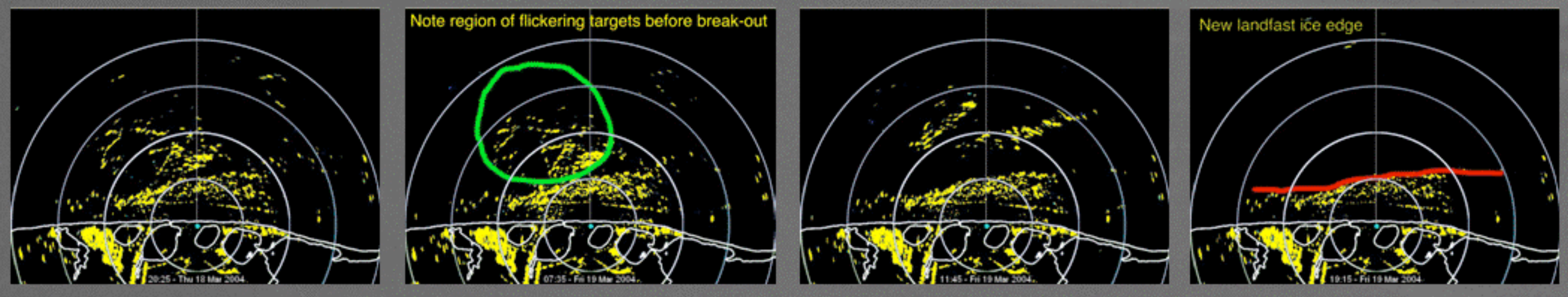
Andy Mahoney stands next to the radar and webcam of the Barrow Sea Ice Observatory (Photo by Patrick Cotter).

A 10 kW X-band (3 cm wavelength) coastal radar, which is located on a four-story building in Barrow, monitors landfast ice. A component of the Barrow Sea Ice Observatory, the radar provides data in near-real-time via the internet to the Barrow Community and serves as a resource for assessing local sea-ice conditions. The four images below represent a time series of radar images revealing a break-out event in the landfast ice off Barrow over the coarse of 23 hours during mid-March 2004 (Mahoney, 2006). Breakout events are a significant hazard to whaling crews and have been responsible for the marooning of large numbers of hunters throughout history. The yellow objects, referred to as targets, represent sea-ice features when north of the coastline. Note that the absence of targets does not necessarily represent the absence of sea ice but rather the lack of sea-ice features capable of providing a reflection.

The four radar images (below) depicting a break-out event may be interpreted as follows:

1. Targets indicate stationary landfast ice
2. The targets indicated by the green circle begin to "flicker".*
3. A break-out event begins as the previously "flickering" targets break off from the landfast ice.
4. The recently detached landfast ice drifts out of the radar's recorded range. A new landfast ice edge is indicated by the red line.

* Mahoney et al. (in press) have indicated that the "flickering" of landfast ice is a promising research area to pursue in working toward a landfast ice break-out warning system.

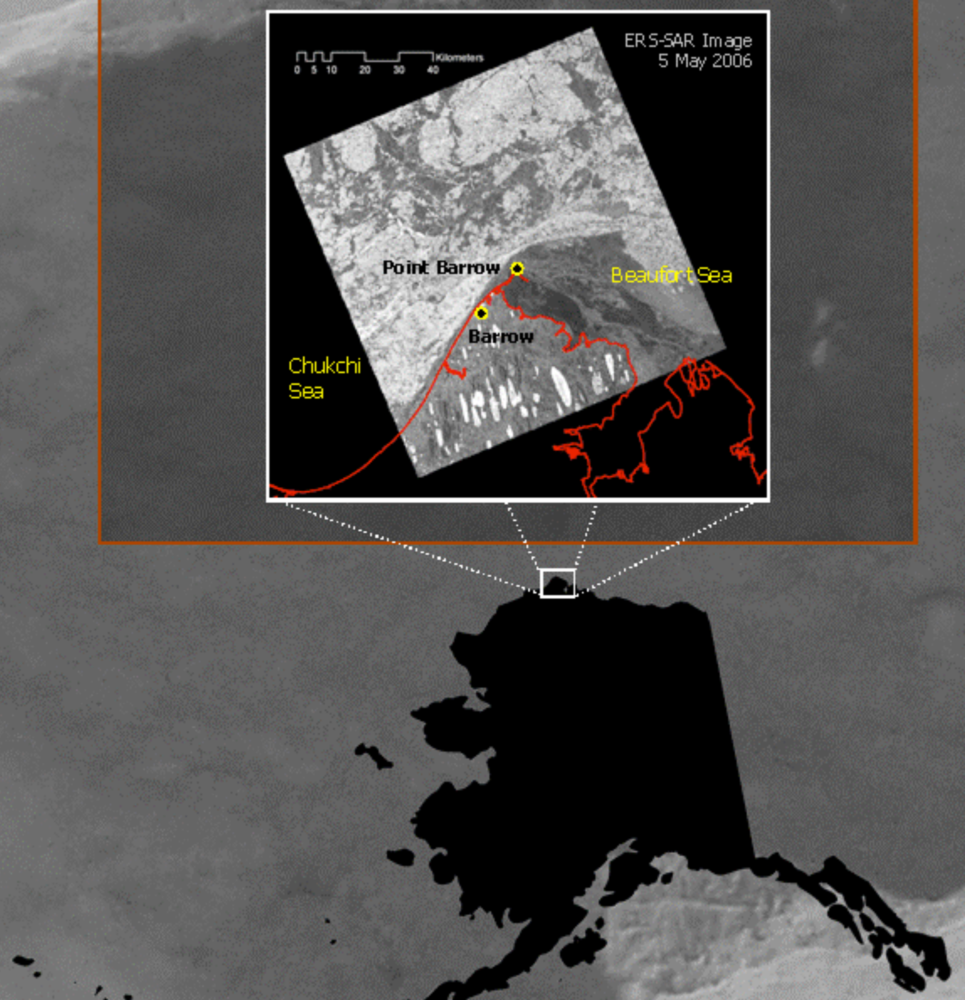


1. 2. 3. 4.

4. SAR Satellite Imagery

Synthetic Aperture Radar (SAR) sensors provide high-resolution satellite imagery of sea ice, independent of solar illumination and cloud cover. The following three SAR sensors provide coverage over the Arctic:

1. RADARSAT (3 day repeat cycle, 100 m resolution),
2. ERS-1 (24 day repeat cycle, 30 m resolution), and
3. ERS-2 (35 day repeat cycle, 30 m resolution)

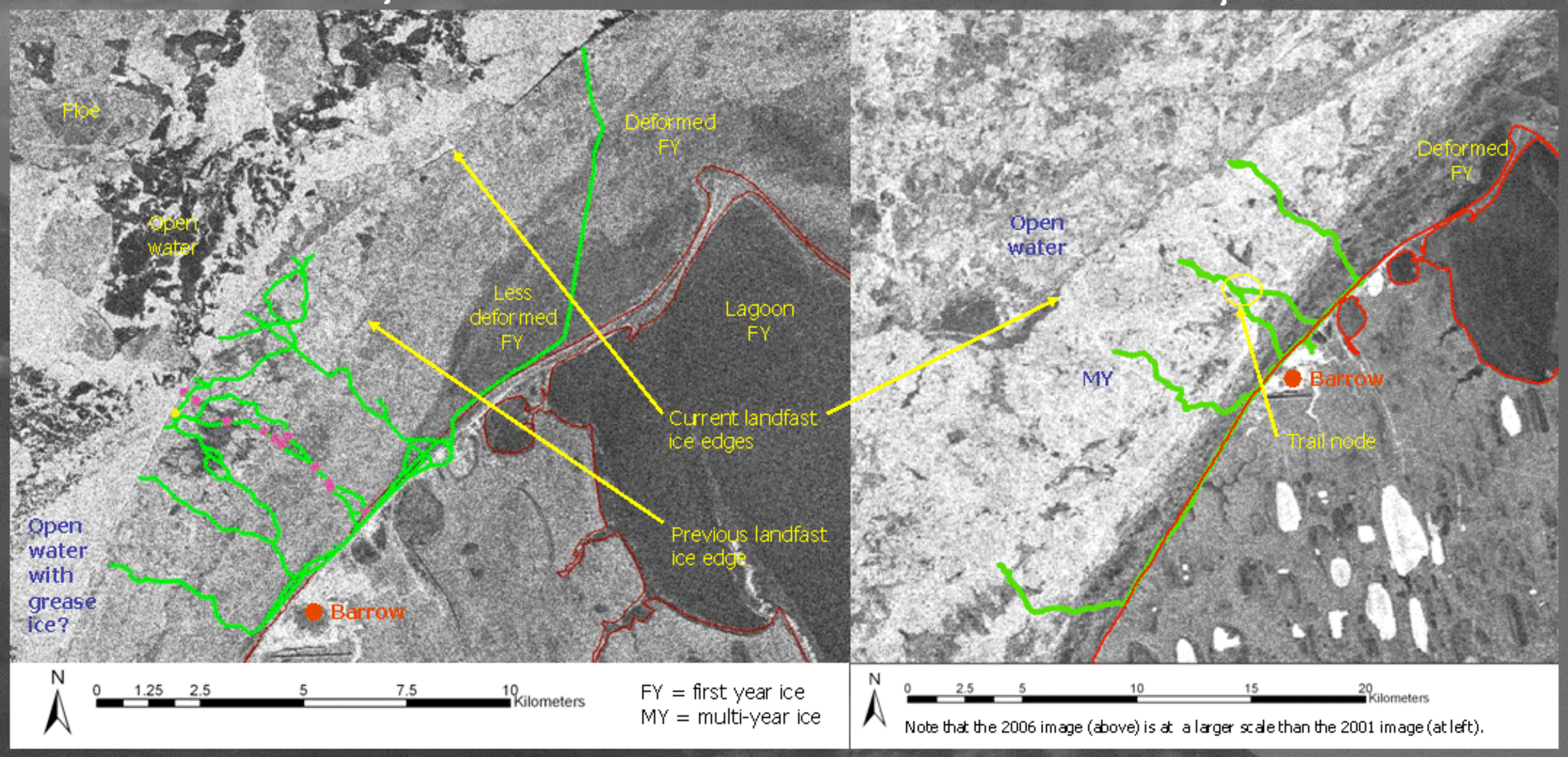


Barrow whalers harvesting a bowhead whale
(Photo by Craig George)

The whale harvest provides not only basic nutrition and sustenance but also serves as an activity that unites families and the community, and promotes efficient resource management and ethical and spiritual values. Subsistence hunting contributes greatly to the local economy – an economy intricately connected to Alaska's statewide economic and political forces.

The consumption of wildlife resources in Arctic Alaska averages about 650 pounds/person/year. The average US per capita consumption of fish, meat and poultry, not distinguishing between wild and farm-raised, is 222 pounds/person/year. (Callaway et al., 1998)

5. Case Studies for Preliminary Analysis: 2001 and 2006 Whaling Trails



In 2001, favorable whaling conditions (open leads, steady NE winds, and movement of floes to the SW) existed between early April and mid May. By 18 May, Barrow whalers had landed 20 whales. On 21 May, after whaling ceased, bad whaling conditions developed after ice movement reversed and shifted toward the Beaufort Sea (Norton and Gaylord, 2004).

In 2006, large amounts of MY ice mixed into the landfast ice and provided a very stable landfast ice zone. However, west winds and extensive heavy MY ice jammed into the Chukchi Sea seemed to prevent the leads from maturing as they usually do. These conditions were poor for spring whaling, and therefore Barrow landed only 3 whales. 2006 was the lowest spring whale harvest (5 whales total) for Alaska's ten whaling villages since at least 1974.

Some Important Questions to Answer:

1. How did the favorable conditions in 2001 contribute to trail construction, as opposed to 2006?
2. Which trail nodes are controlled by ice conditions and which are due to other factors?
3. Where are retreat camps located in relation to previous landfast ice edges?
4. How is the presence of MY ice in the landfast ice zone related to trail tortuosity (see equation above)? Hunters often note that it is easier to break trail through MY ice, as it shatters easily. How are trail location, tortuosity, and topology (nodes/branches) related to various other ice conditions (e.g., un-deformed FY ice), construction effort and expenses, and evacuation efficiency?

Trail Tortuosity (τ):
τ = (total trail length)/(trail vector length)
For example, in 2006 $\tau_{Avg} = 1.20$.

6. Expanding the Study

This preliminary work holds promise for a multi-year comprehensive documentation of trail data, such as trail location, density, tortuosity, and construction effort, in relation to sea-ice conditions (e.g., landfast ice stability, topography, and sea-ice concentration) and weather (e.g., seasonally dominant wind speeds and direction as well as ocean currents), thus providing insight into the factors that play a role in trail construction and hunting site selection. Data correlations may assist in assigning a relative importance factor to various types of local sea-ice knowledge that are employed during the spring whale harvest. Since various factors play a role in trail construction, interviews with sea-ice and whaling experts of the Barrow community will be important.

Key criteria and points assessed by hunters are also relevant in the broader context and are currently poorly monitored or understood; these include:

1. ice stability on the scale of the landfast ice extent (length of time during which ice does not move or deform),
2. ice stability on the scale of the ice thickness (degree to which ice flexes or fails when a load is imposed), and
3. trafficability of ice for access and potential evacuation

This future study may provide information on the temporal and spatial scale of sea-ice observations and predictions needed to inform the whole of a whaling community. Insight may be gained into how large-scale changes in sea ice impact subsistence hunting and other human activities on a regional or local scale.
In the event that this study is additionally expanded to a whaling village in the Bering Strait Region (e.g., Wales), one may:

1. compare and contrast the different ice conditions deemed suitable by hunters,
2. assess the differences in monitoring needs, and
3. discuss the effects caused by changes in sea ice and weather throughout different whaling communities in Alaska.

An up-thrusted ice floe at a grounded ridge in the landfast ice off Barrow (Photo by Craig George)

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*Clipart of whale at left provided by the Alaska Native Knowledge Network.

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Background Photo by Daniel Pringle, June 2006, Landfast ice off Barrow, AK