



Fisheries and Oceans
Canada

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You can't always go back: bowhead whales, over-exploitation, global warming, and killer whale predation

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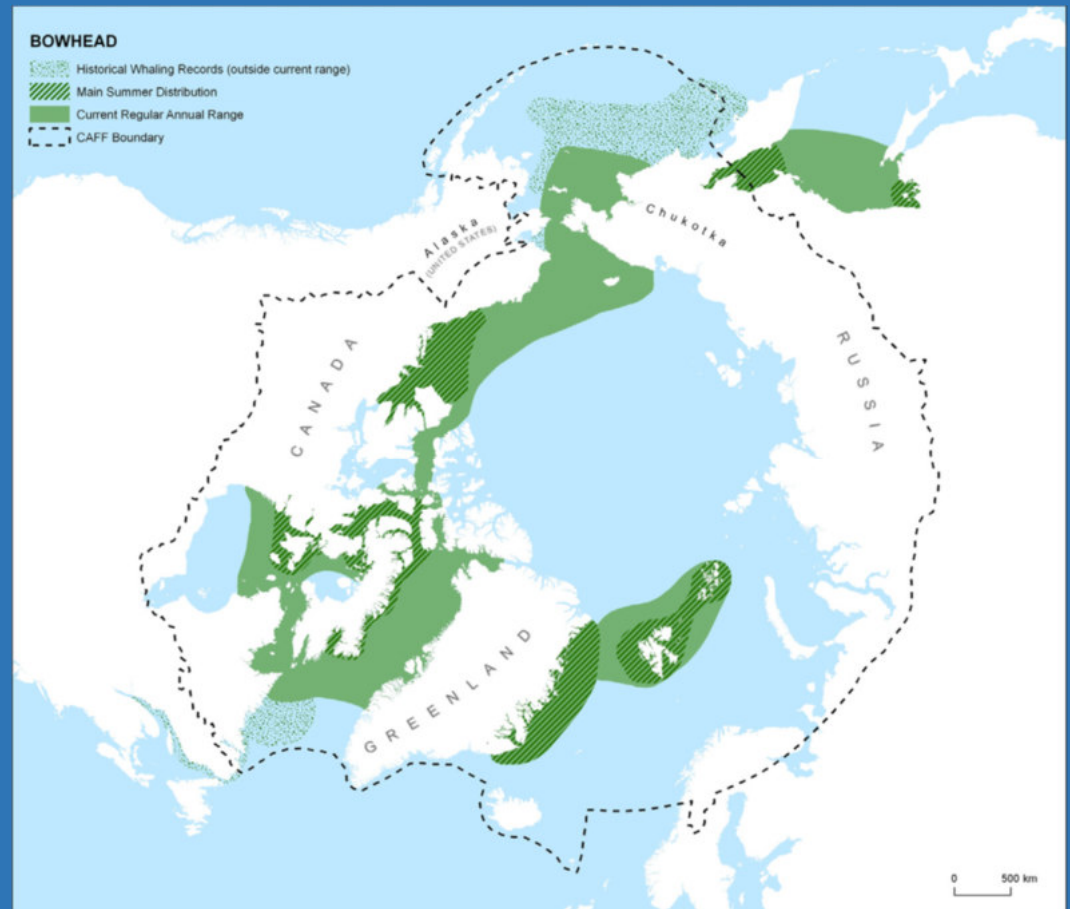
Outline

- History – fishing down the food web
- Why differences among populations?
- The Canadian example
- Three possible explanations for delayed recovery
- What does it mean for future conservation



World population was initially about 100,000 whales

Bowhead whales (*Balaena mysticetus*) have a distribution that has waxed and waned with geological changes in circumpolar sea ice extent

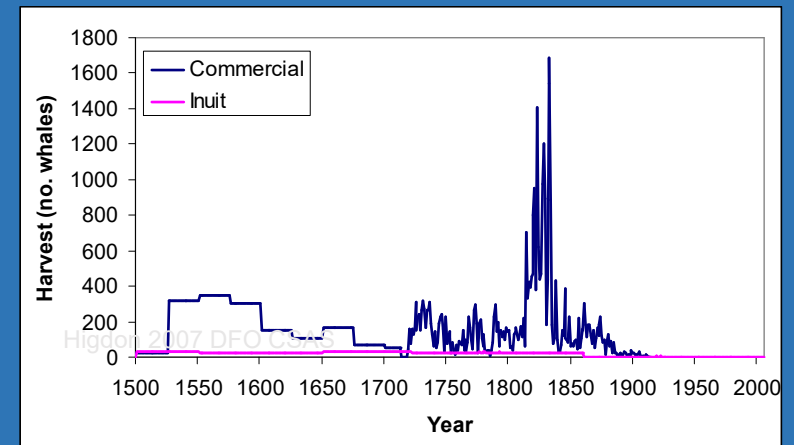
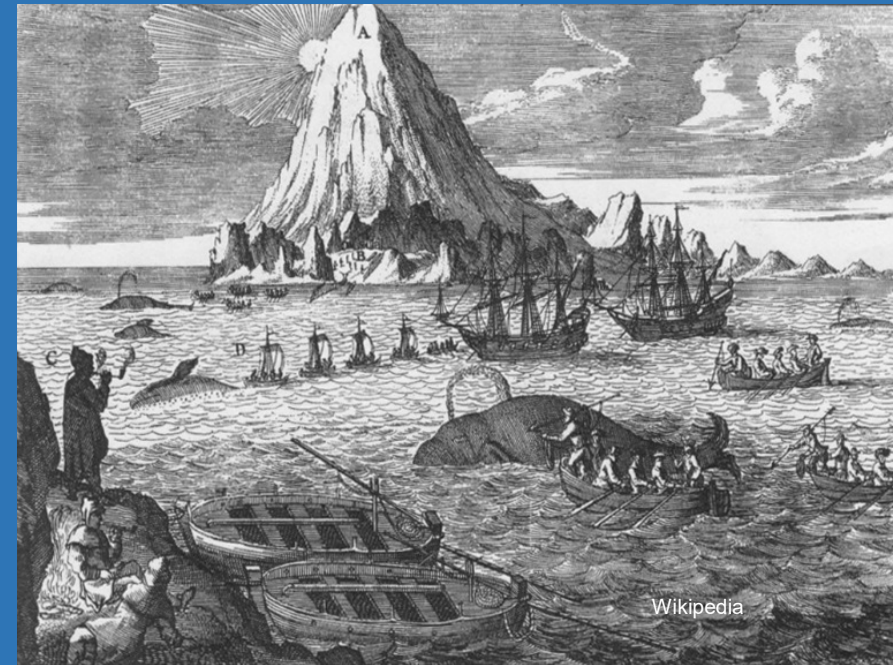


Inuit hunting for subsistence occurring at low levels for millennia



Commercial whaling

1500-1915



Whaling and crashes in bowhead numbers

- Greenland-Spitsbergen stock commercial whaling began 1500s coastal fishery and 1600s pelagic whaling. Moved from “east-ice” fishery Spitsbergen to Barents Sea and then towards the end of the 1600s to the “west-ice” fishery off Greenland. Fishery probably reached a low in the early 1700s



- In 1700s, European whalers sailed into Davis Strait and population depleted by mid-1700s. Fishery moved north into Baffin Bay and the stock had been exhausted by early 1800s

Commercial whaling for bowhead whales moved to Sea of Okhotsk in 1845 and Bering Sea in 1848. Both stocks were depleted by late 1800s

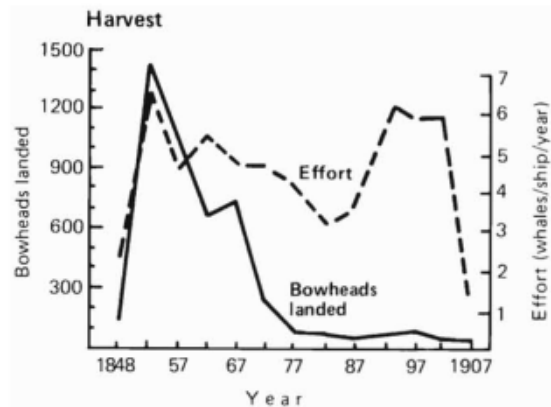


Figure 2—Most bowhead whales in the western Arctic stock were removed between 1850 and 1870, although whaling effort remained high into the 20th century (Braham et al., 1977).



Figure 3.—Commercial bowhead whaling principally occurred in the Sea of Okhotsk from 1845 to 1874, and in the Bering Sea from 1848 to 1917. Within 20 years of the start of the fishery, the stocks were depleted, and no bowheads were taken south of the dashed lines after the dates indicated. Data from Townsend (1935) and Bockstoe and Botkin (1983).

Recovery of the world's bowhead populations

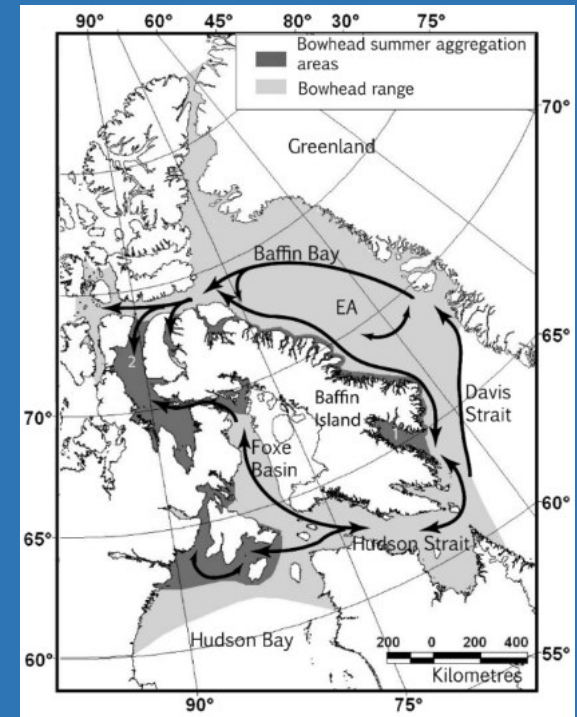
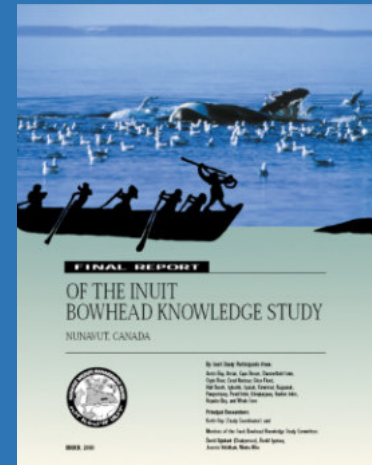
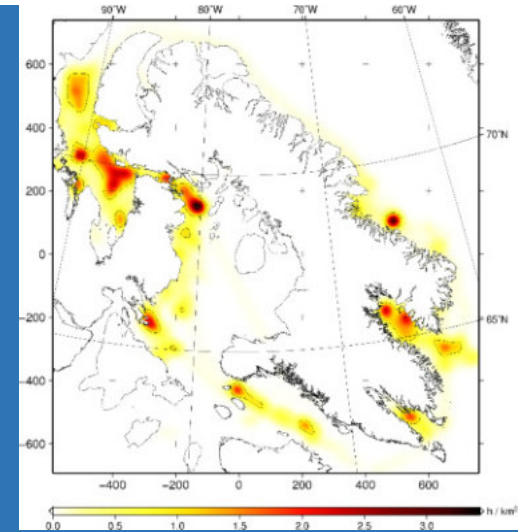
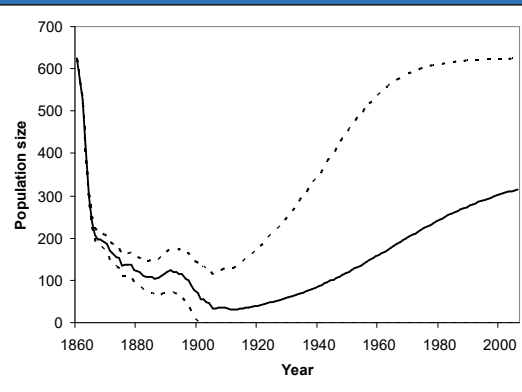
- Northeast Atlantic (East Greenland-Spitsbergen) stock estimated to have originally numbered about 50,000 reduced over centuries of whaling to few individuals that have grown in number since the cessation of whaling in the region to 100s currently
- Northwest Atlantic (Eastern Canada-West Greenland) population also harvested for centuries reduced to 100s in late 1800s has grown to about 10,000 from an estimated original population of about 20,000
- North Pacific (Sea of Okhotsk and Bering-Chukchi-Beaufort) population originally estimated to number about 20-40,000 reduced to 1000s by 1900 and has grown to a current estimate of 17,000

Divergent demographic scenarios

- All of the recognized bowhead populations declined to very low numbers following years of commercial harvesting from European and American whalers that ended in 1900s
- The Bering-Chukchi-Beaufort population has largely returned to historic numbers



The Canadian example – ECWG population



Plausible estimates of carrying capacity 18,000

Counts:

2003 = 6-14,000

2013 = 7-8,000

2016 = 10,000

A photograph of two humpback whales swimming in the ocean. The whales are dark grey with white markings on their heads and tails. They are moving from left to right, with their heads slightly above the water surface. The water is a deep blue color.

Date of estimate	Estimate	Method	Comments	Source
March 1981	1,349 (95% CI 402-4,529)	Aerial survey		Koski et al (2006)
2004	3,633 (1,382-9,550)	Above results projected forward		Koski et al (2006)
August 2002	7,309 (95% CI = 3,161-16,900)	Aerial survey	Analyzed multiple times	Cosens et al. (2006)
August 2002	14,400 (95% CI = 4,811-43,105)	Aerial survey	See above	Dueck et al. (2008)
August 2002	14,196 (95% CI = 5,935-33,956)	Aerial survey	See above	Heide-Jørgensen et al. (2008a)
August 2002	8,187 (95% CI = 3,835-17,480)	Aerial survey	See above	Heide-Jørgensen et al. (2008b)
August 2002	6,344 (95% CI = 3,119-12,906)	Aerial survey	See above	Givens et al. (2009)
August 2002	8,500 (90% CI = 3,900-17,000)	Aerial survey	See above	Witting (2011)
2013	7,660 (95% HDI 4,500-11,100)	Genetic CMR		Frasier et al. (2015)
August 2013	6,745 (CV 22%)	Aerial survey		DFO (2015); Doniol-Valcroze et al. (2015)

ECWG population growth appears stalled mid-way to its original pristine numbers

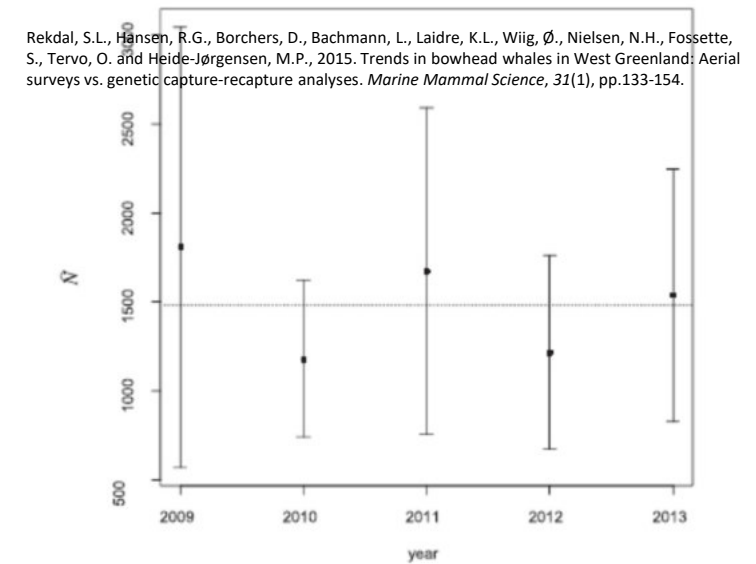
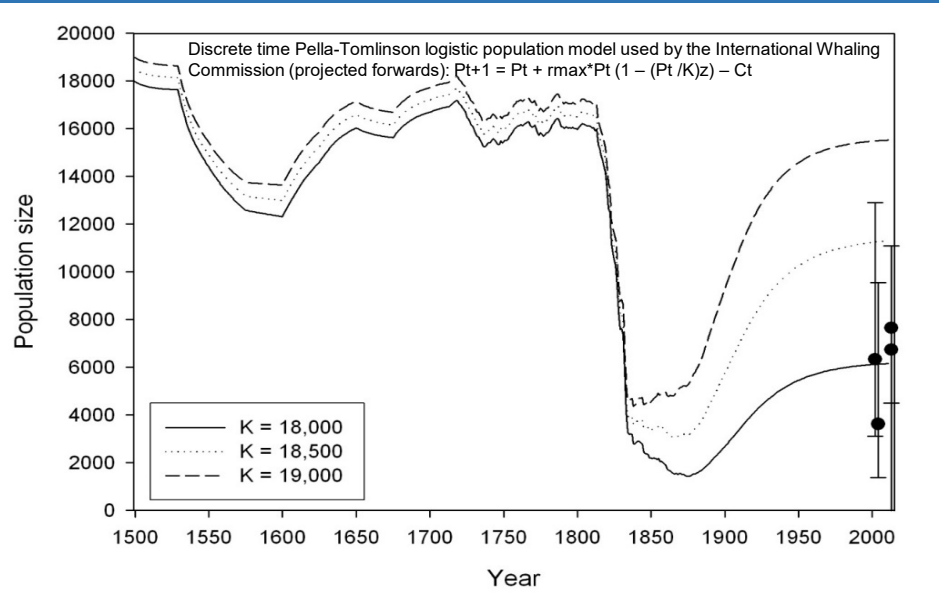
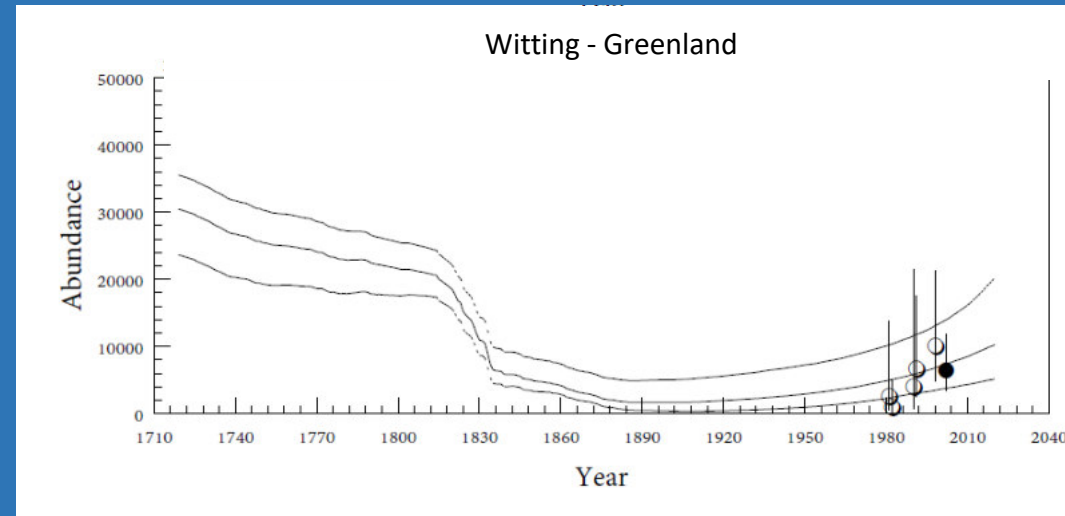


Figure 3. Population size of the source of the Disko Bay bowhead whale aggregation (\hat{N}), estimated for both sexes in each sampling year in the period 2009–2013 by a genetic capture-recapture approach, with 95% confidence intervals. Dotted line is mean value over these years.



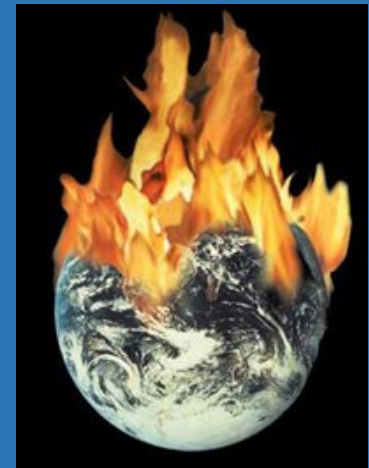
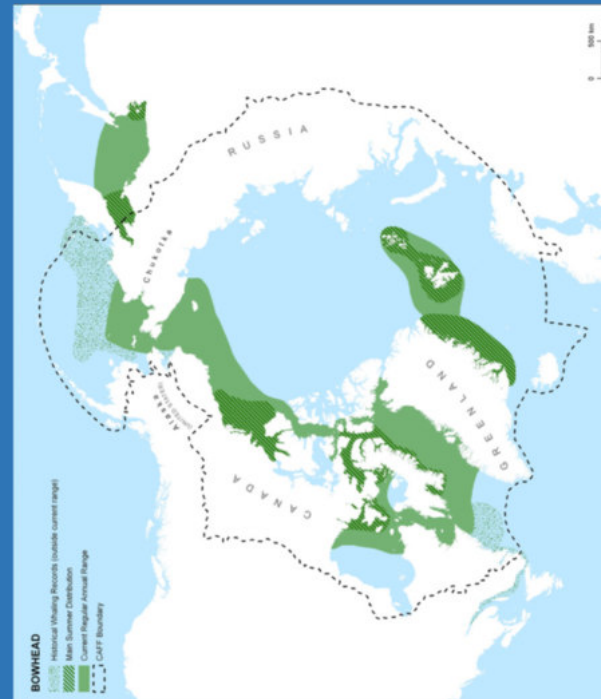
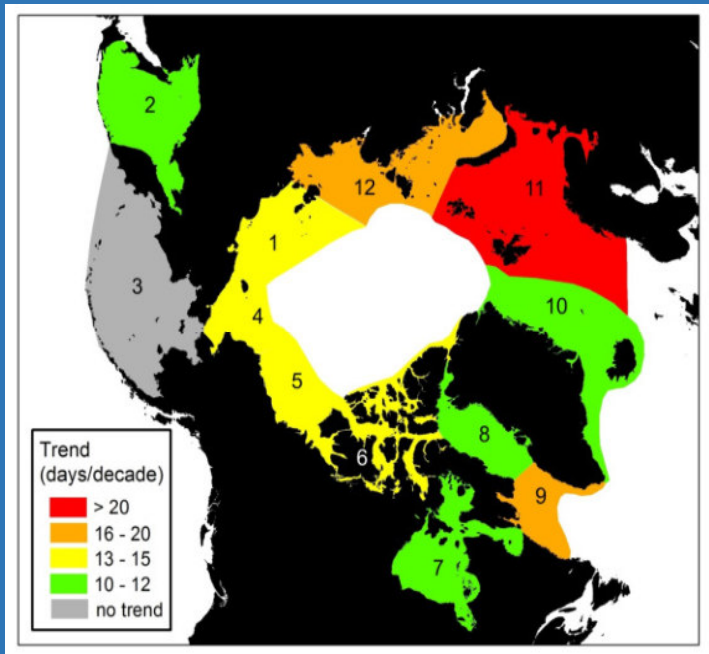
Why has this population not shown exponential growth

The ECWG population has a small co-managed subsistence harvest in Canada and Greenland that is not responsible for the stalled population growth

- (1) the carrying capacity has changed due to environmental effects of global warming;
- (1) killer whale predation is greatest in this region; and
- (2) the ecosystem has been severely altered due to anthropogenic commercial harvesting and cannot return to the original system equilibrium



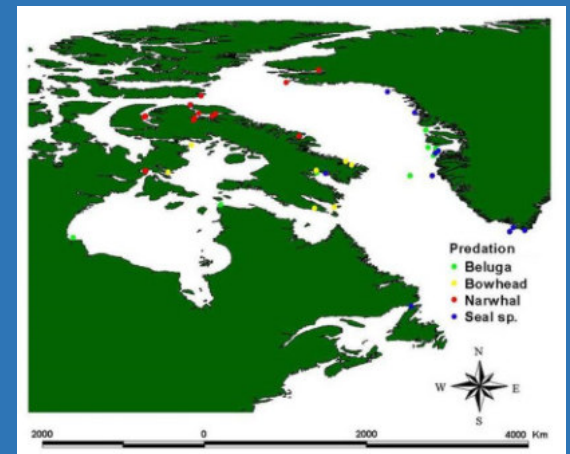
1. The carrying capacity has changed due to alterations of the Arctic marine ecosystem with global warming



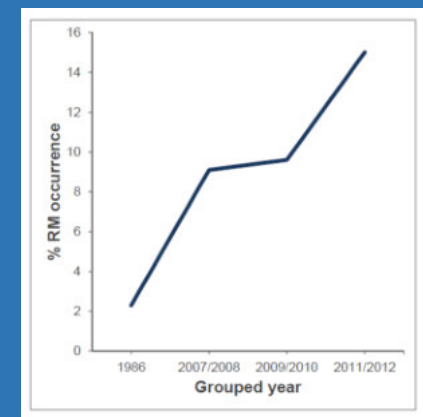
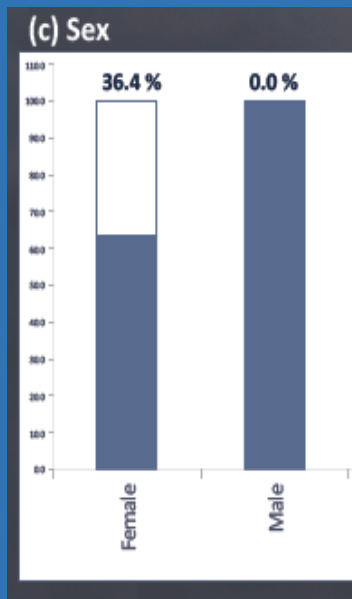
Laidre et al 2015



2. Density-dependent killer whale predation of bowhead whales as a plausible demographic cause of stalled population growth

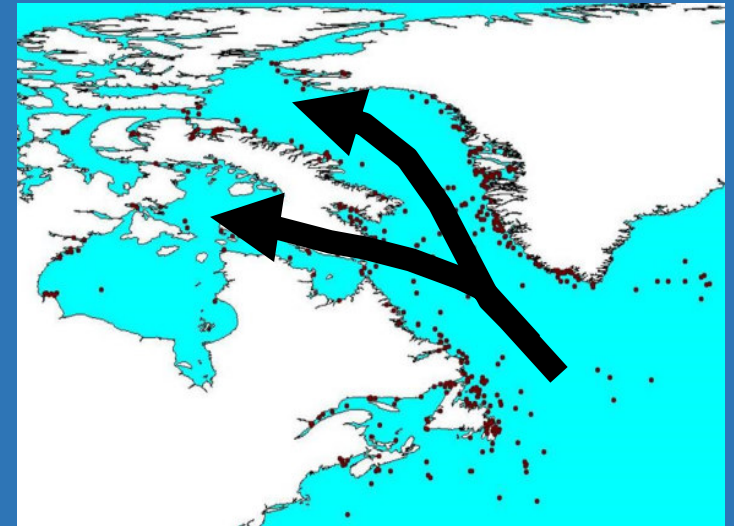
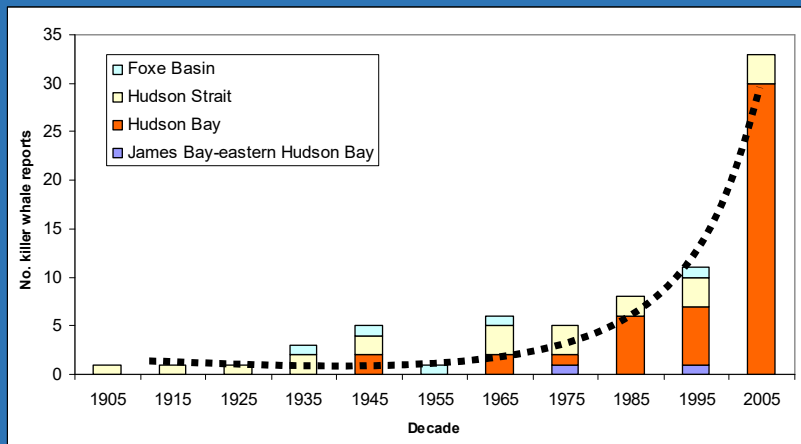


Approximately 10% of ECWG bowhead whales display rake marks from killer whale predation, a rate that is higher than found for other bowhead whale populations and higher than typical of mysticete whale populations generally



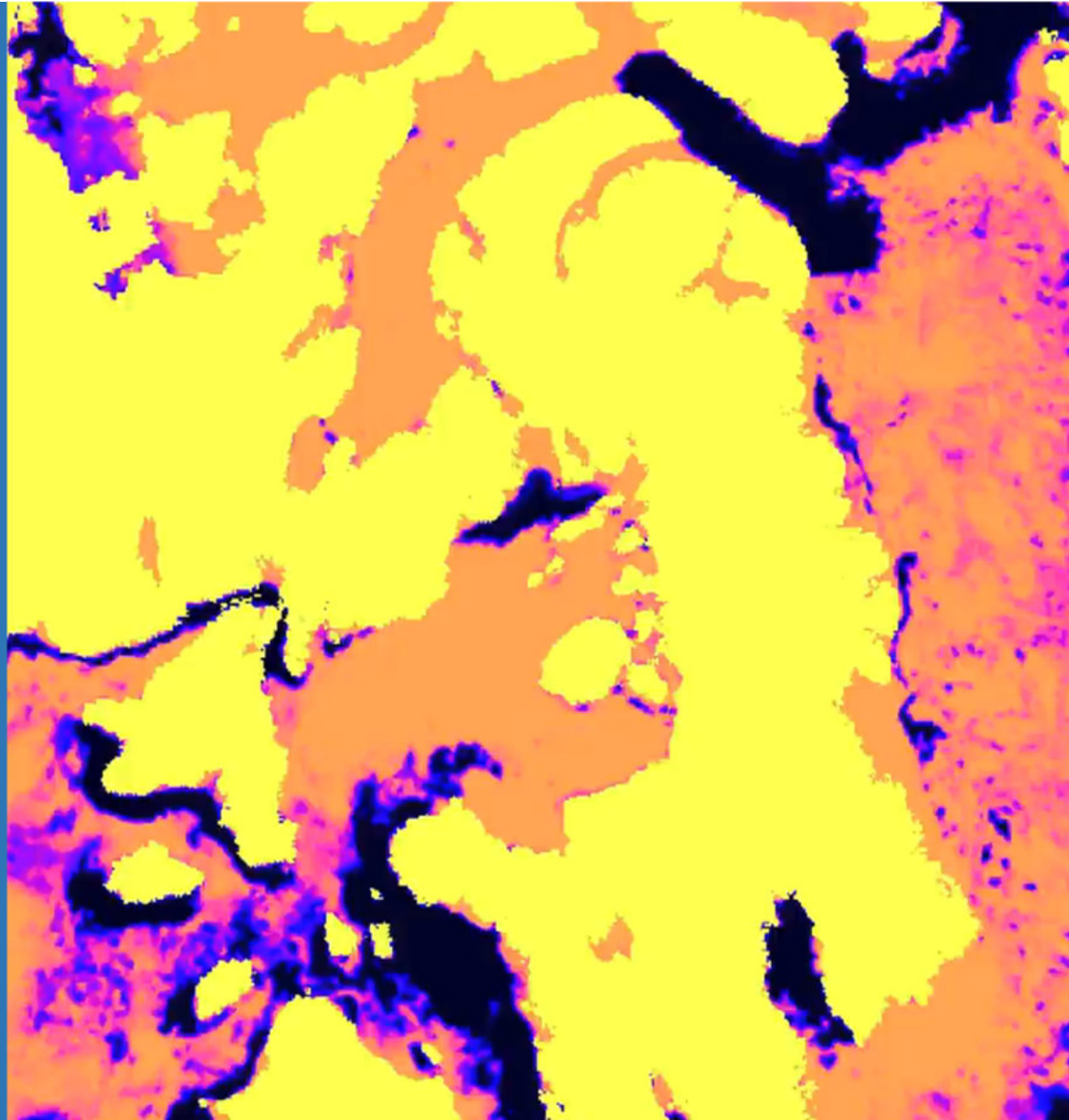


Arctic Invasion - traditional ecological knowledge and sighting records from the ECWG bowhead range have suggested that killer whale predation occurs frequently on bowhead whales – largely on vulnerable calves



Bowhead – Killer Whale Interactions from telemetry

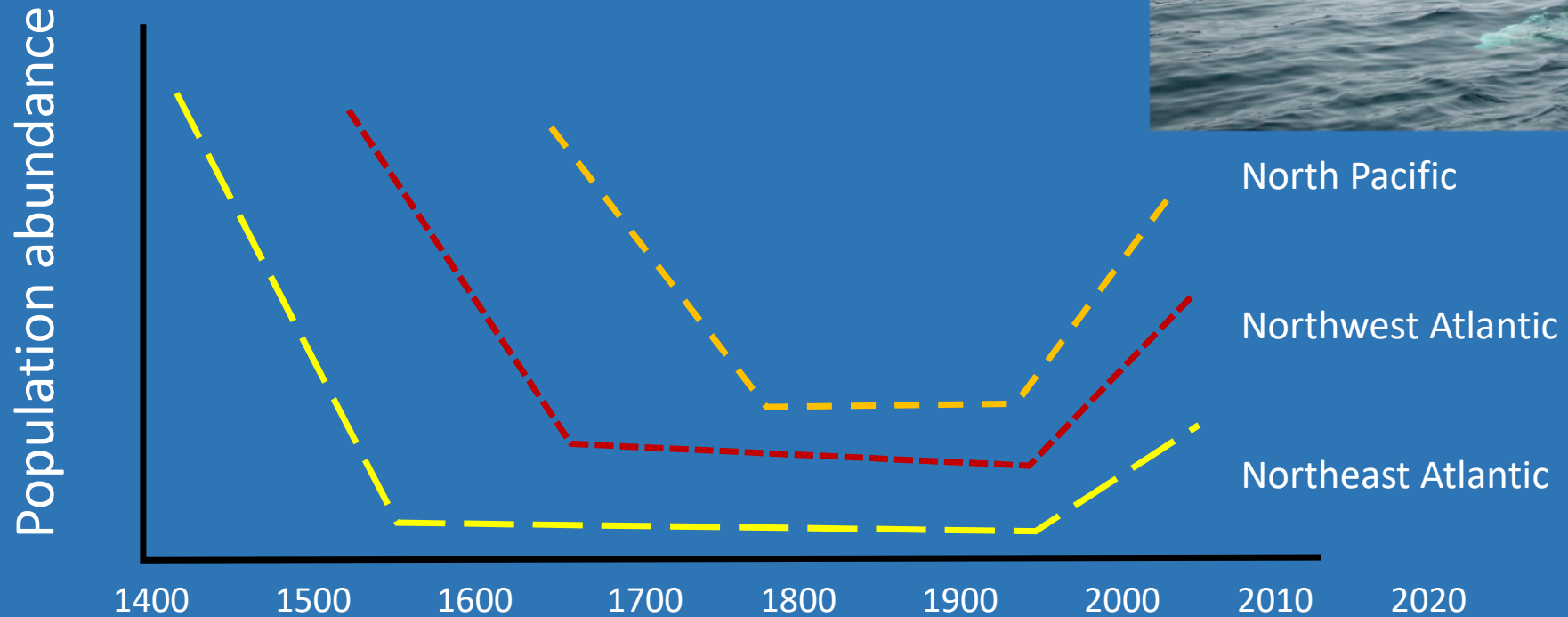
Bowhead whales have evolved successful tactics to minimize predation from killer whales, including seeking refuge in shallow inlets and fjords with summer sea ice



3. marine environment may have undergone a transformation due to novel species combinations and relative abundances that have not occurred previously

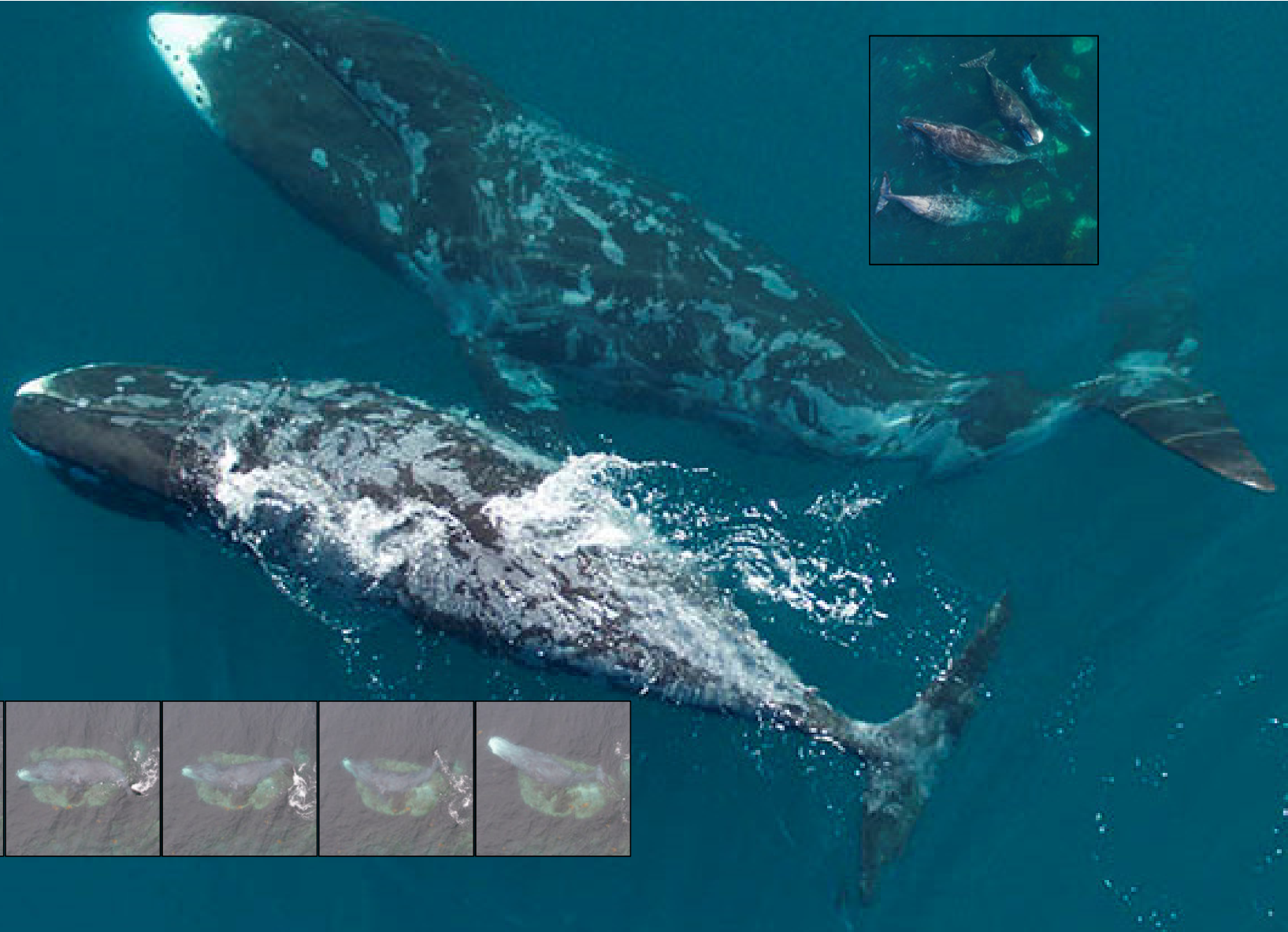
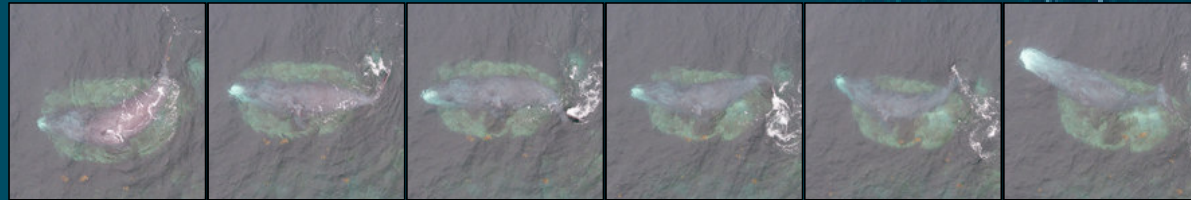
Key changes in ecosystem functioning due to human overharvesting may have inadvertently degraded the original native or 'wild' ecosystem making it very difficult to return the marine system to its previous state

How long and how much was the marine ecosystem messed up?



Although conclusions are elusive, the history of bowhead whales reminds us that over-exploitation can have large-scale, unintended, and sometimes irreversible consequences

Use of drone





Questions

