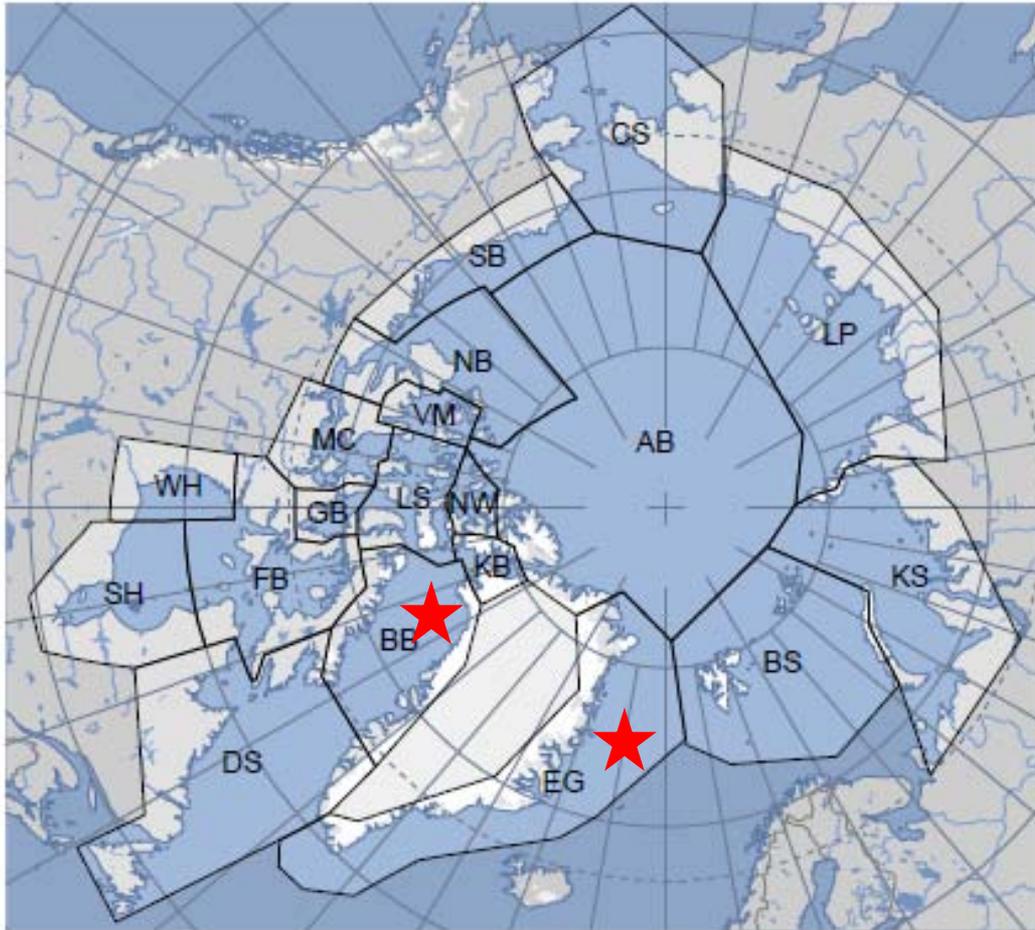


# Climate change, sea ice, and polar bears in Greenland

A polar bear is walking across a large, flat ice floe in the Arctic. The bear is moving from right to left, leaving a trail of snow behind it. The ice is a pale blue color, and the background shows more ice floes and a dark blue sea.

**Kristin L. Laidre, Harry Stern  
University of Washington**

**Erik W. Born  
Greenland Institute of Natural Resources**

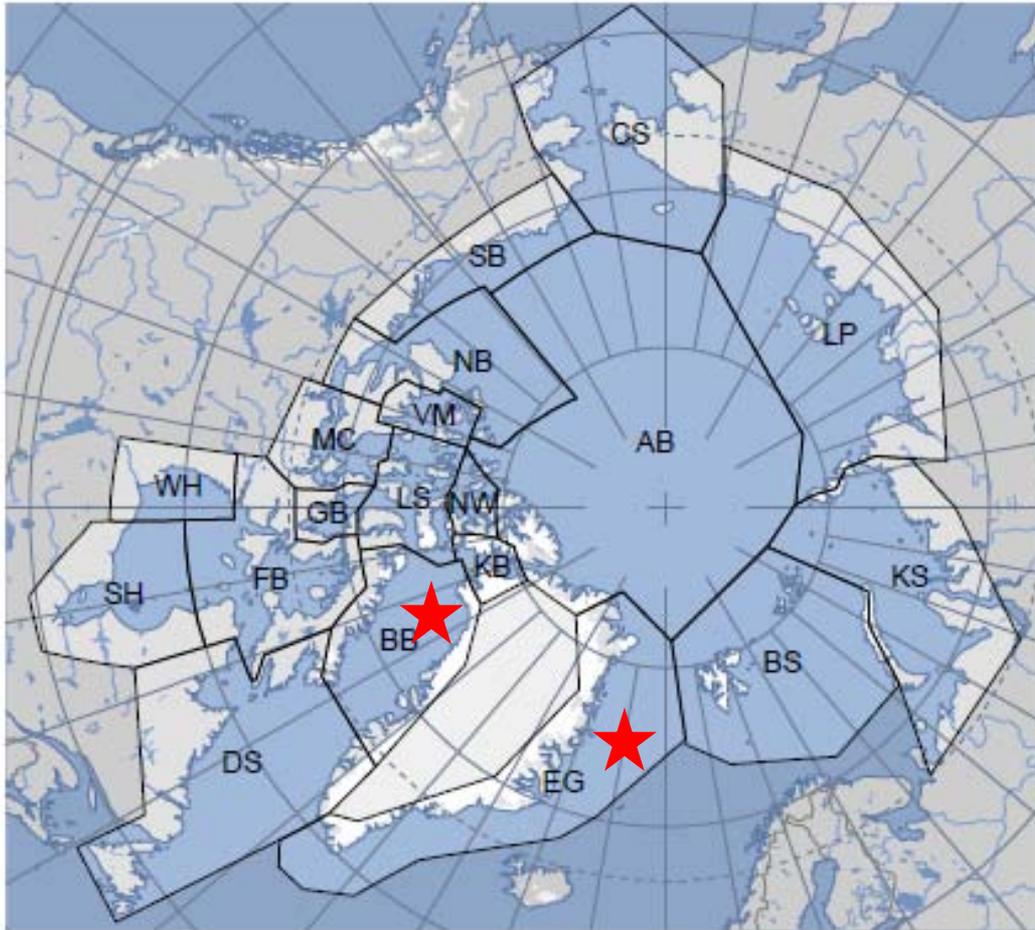


19 sub-populations of polar bears worldwide

3 in West Greenland (based on satellite telemetry + genetic studies)

- Kane Basin
- **Baffin Bay**
- Davis Strait

1 in **East Greenland**



Evaluate change in polar bear sea ice habitat

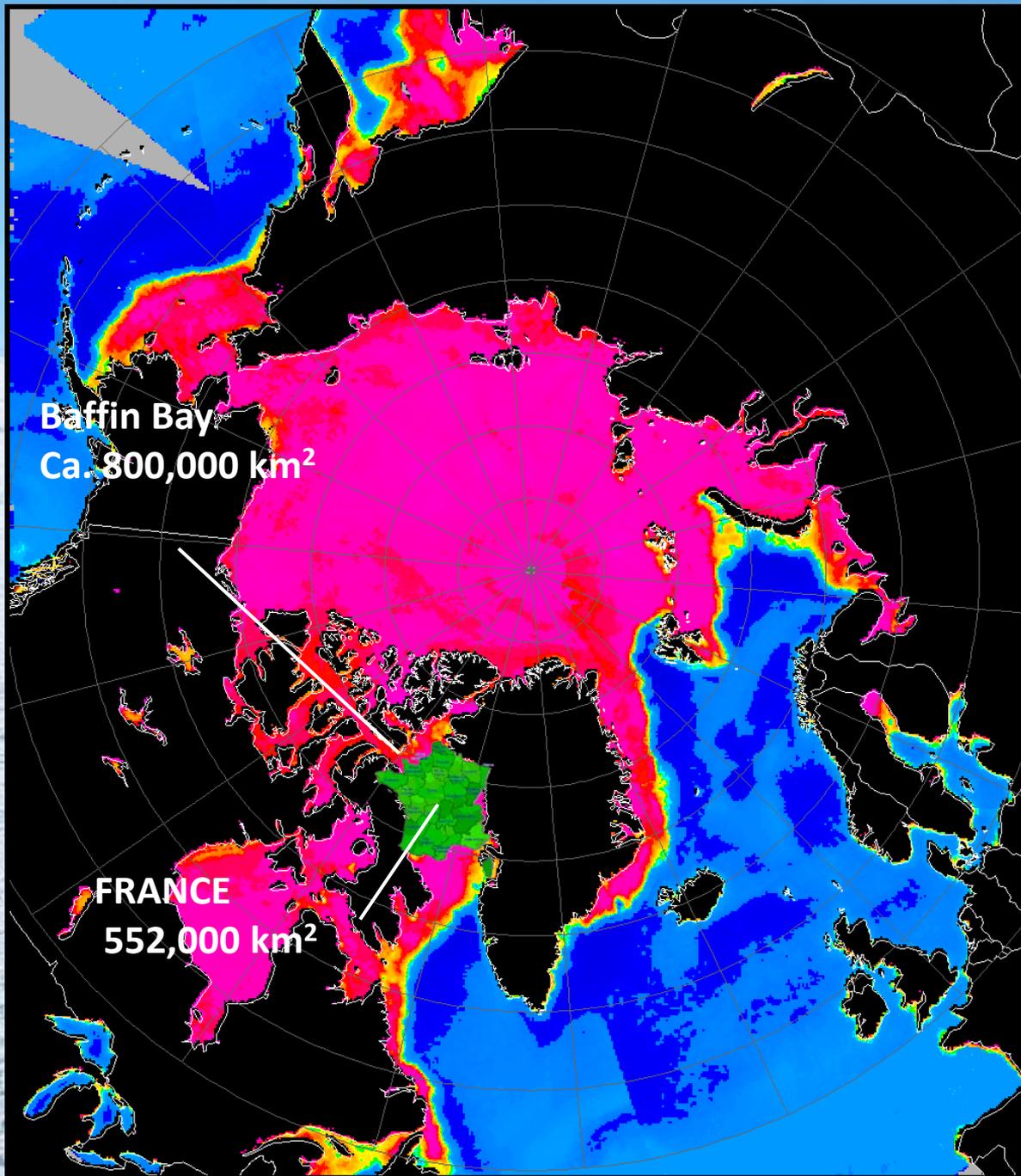
- Baffin Bay
- East Greenland

Quantify and predict sea ice loss impacts for ice dependent polar bears in Greenland at the population level

Year 1 of 4

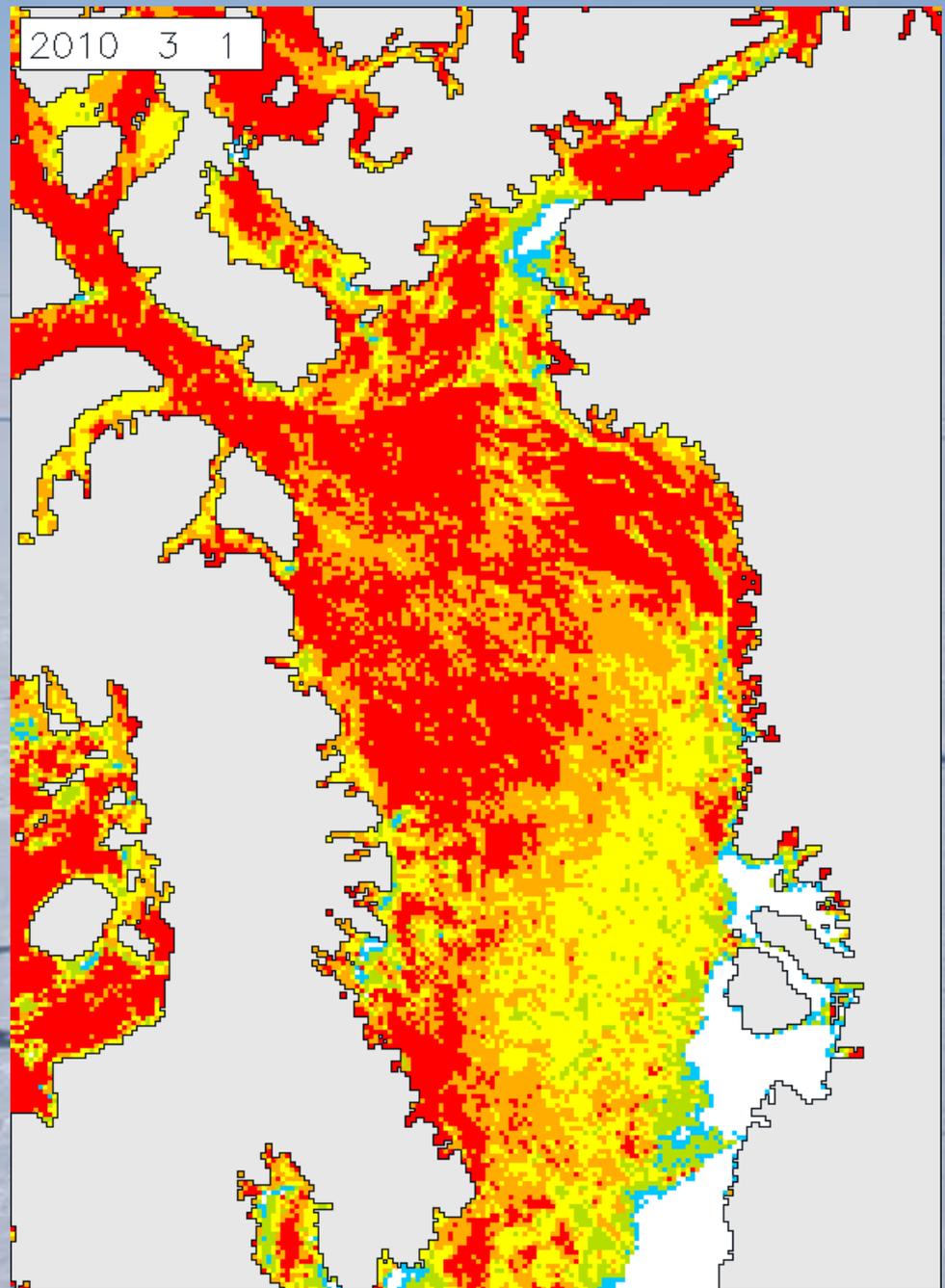
Update on 2012 Baffin Bay field work  
(externally funded), April 4-21, 2012

For some scale...



# Baffin Bay pack ice

[Click here to play 17M .avi format movie.](#)



# Polar bear capture and marking efforts

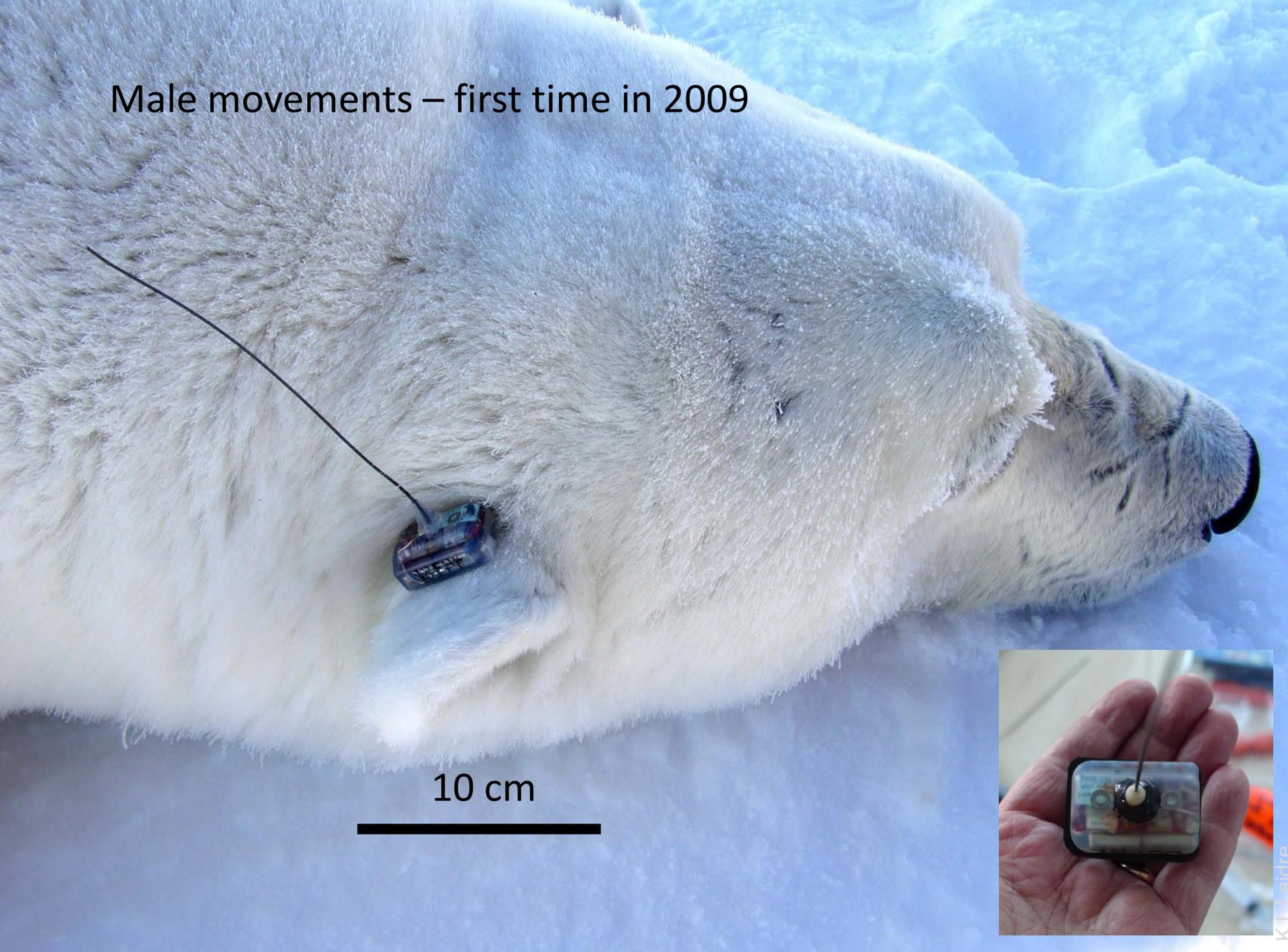




- Series of body condition measures
- Blood, fat, hair for pollution
- Marked w/ tattoo and plastic ear tags
- Satellite transmitter



# Male movements – first time in 2009



10 cm



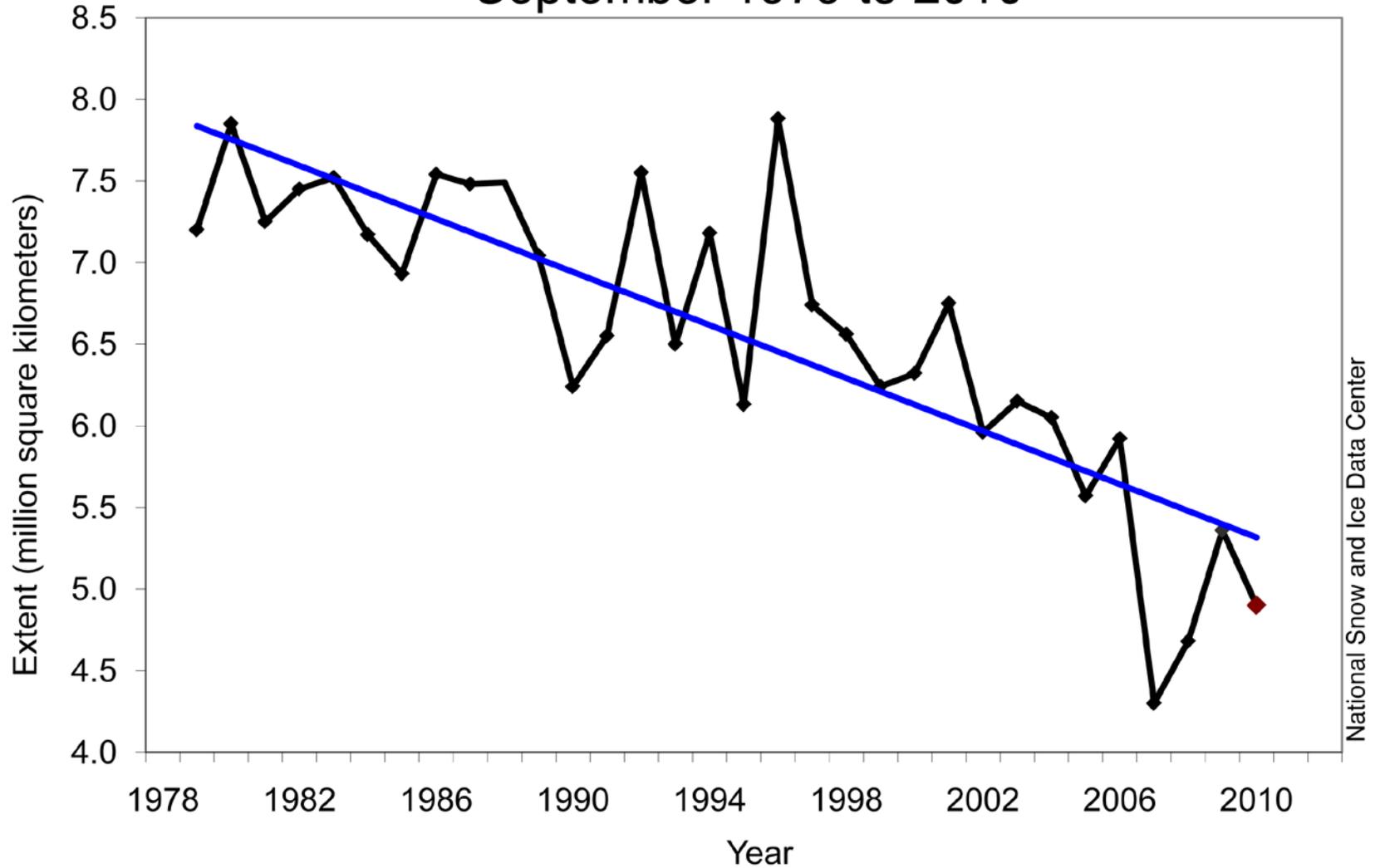
# 2012 field work

32 polar bears captured

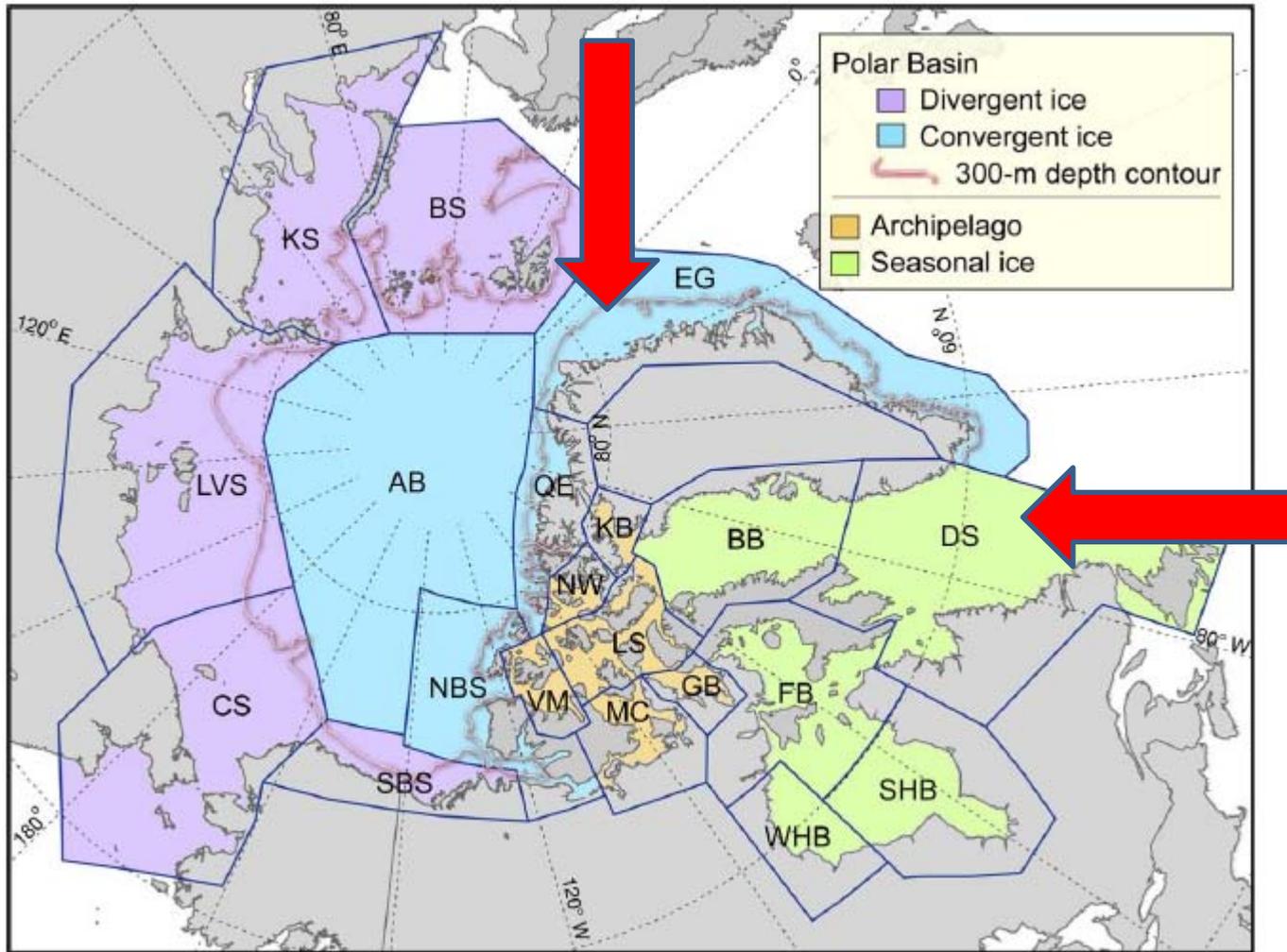
22 polar bears instrumented with transmitters (11 females with collars, 11 males with ear tags)

Add these data to Baffin Bay time series (1993-1997, and 2009-2012)

# Average Monthly Arctic Sea Ice Extent September 1979 to 2010

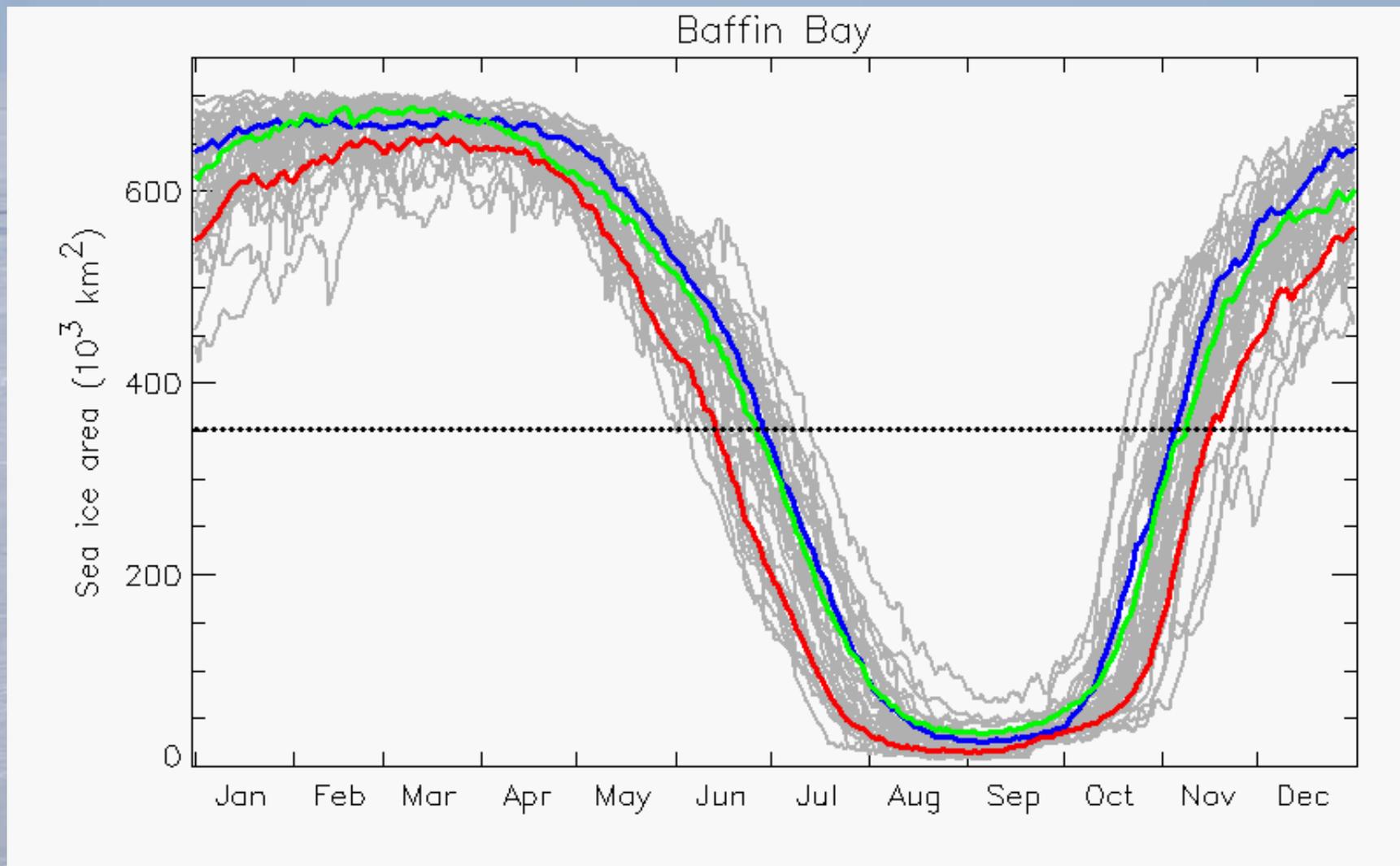


National Snow and Ice Data Center



Seasonal ecoregion polar bear populations considered the most likely to go extinct by the mid-21st century

# Decadal average of sea ice, 1979-2011

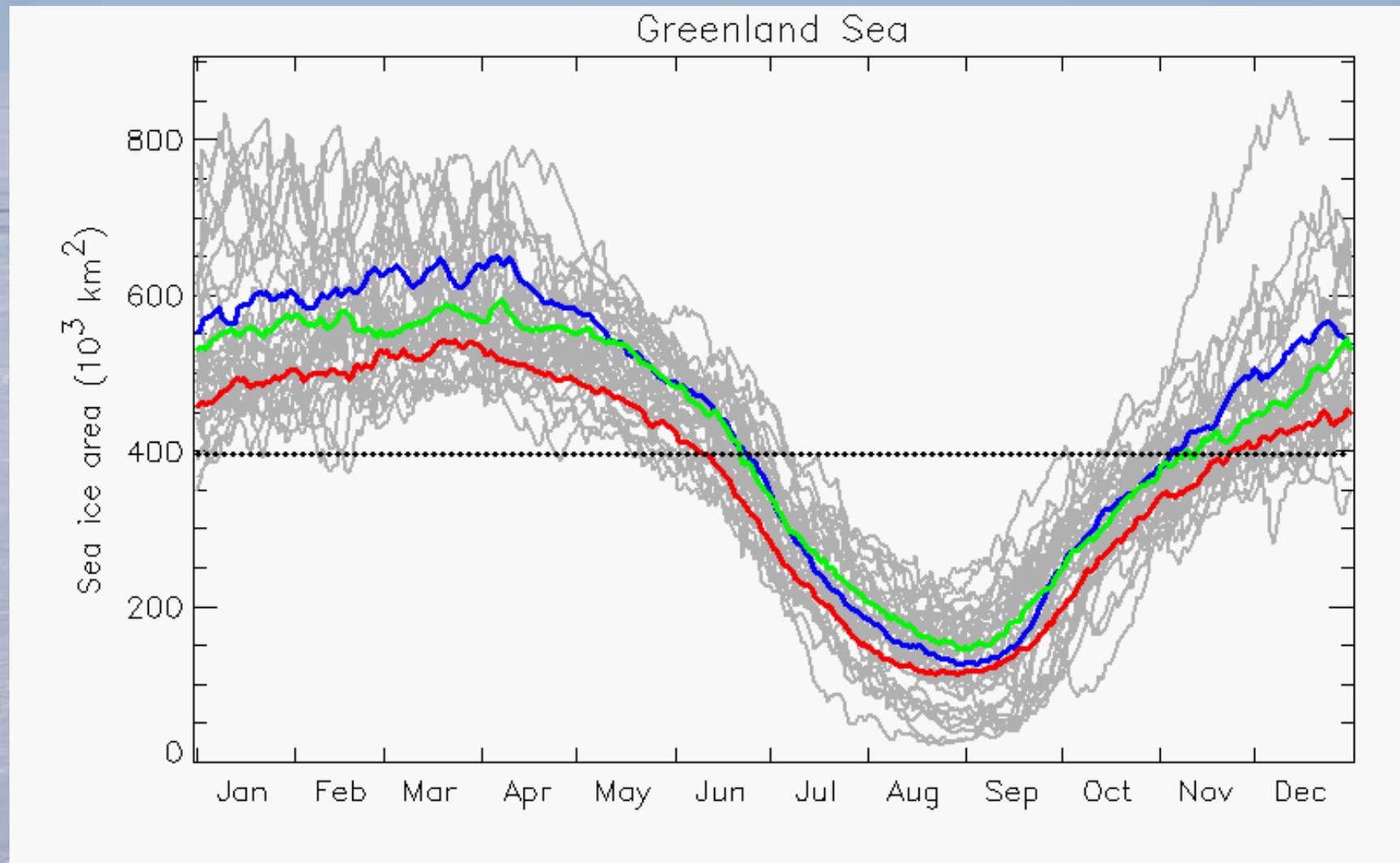


1982-1991

1992-2001

2002-2011

# Decadal average of sea ice, 1979-2011

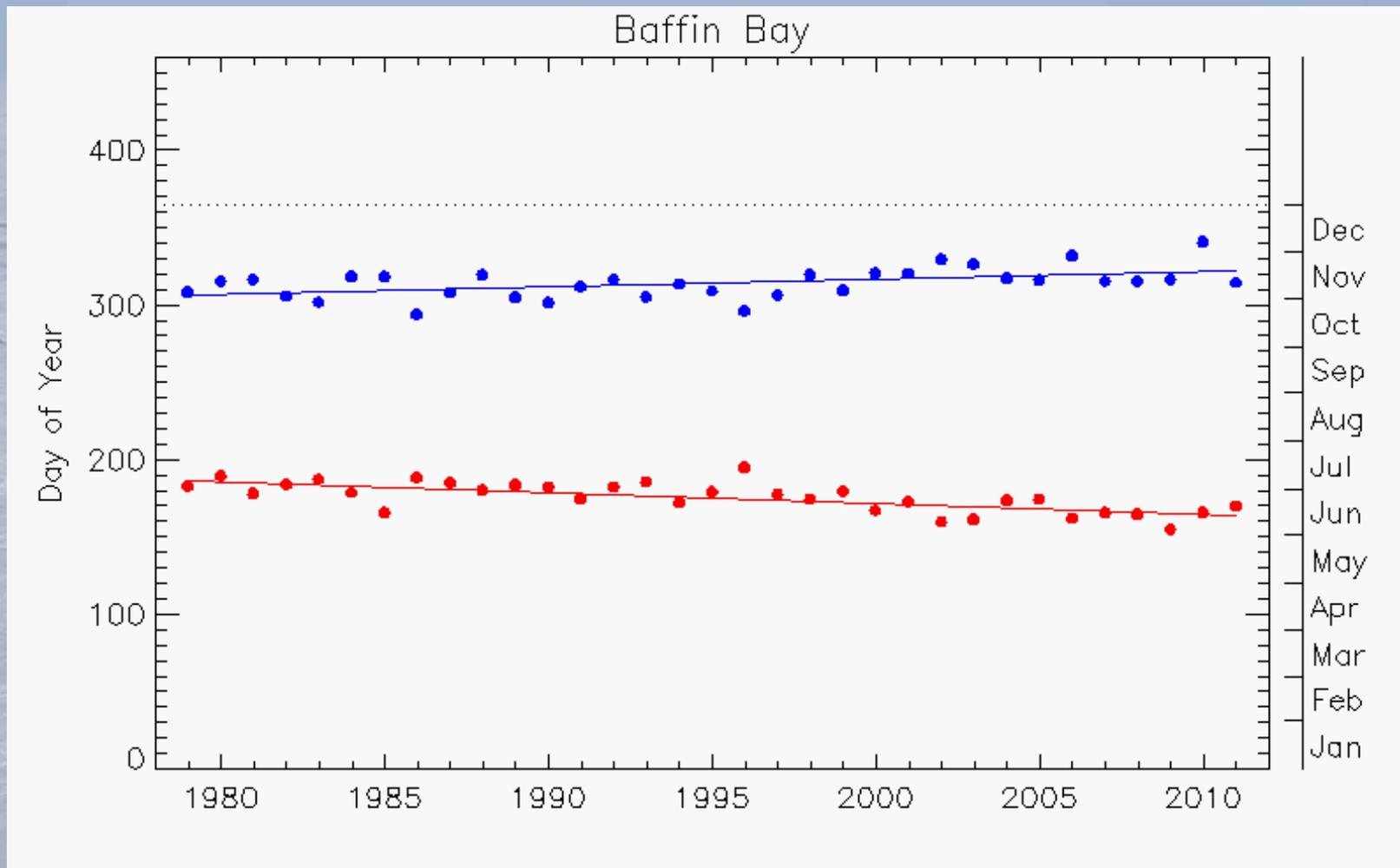


1982-1991

1992-2001

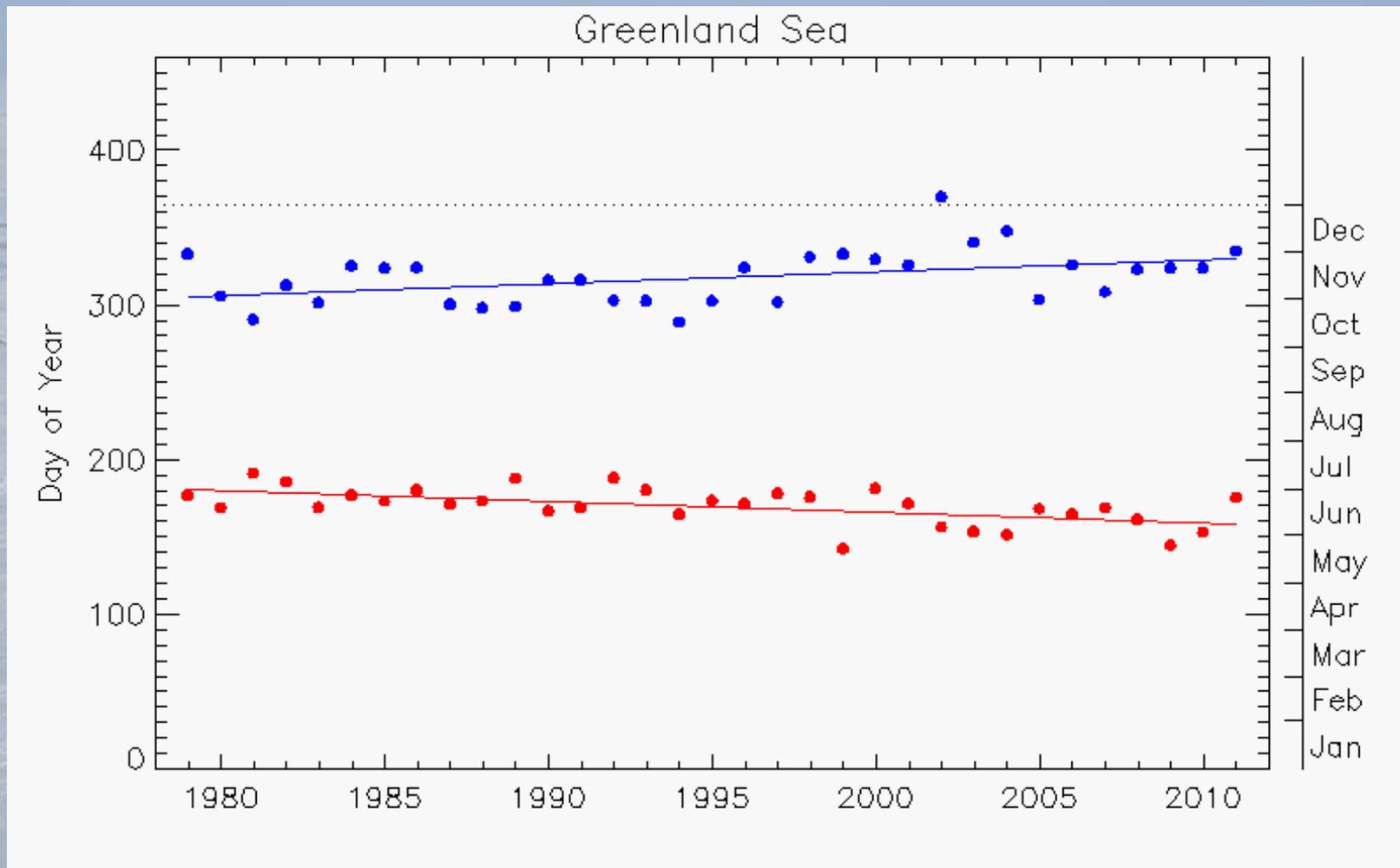
2002-2011

# Earlier spring and later fall transitions, 1979-2011



7 days/decade earlier in spring, 5 days/decade later in fall

# Earlier spring and later fall transitions, 1979-2011



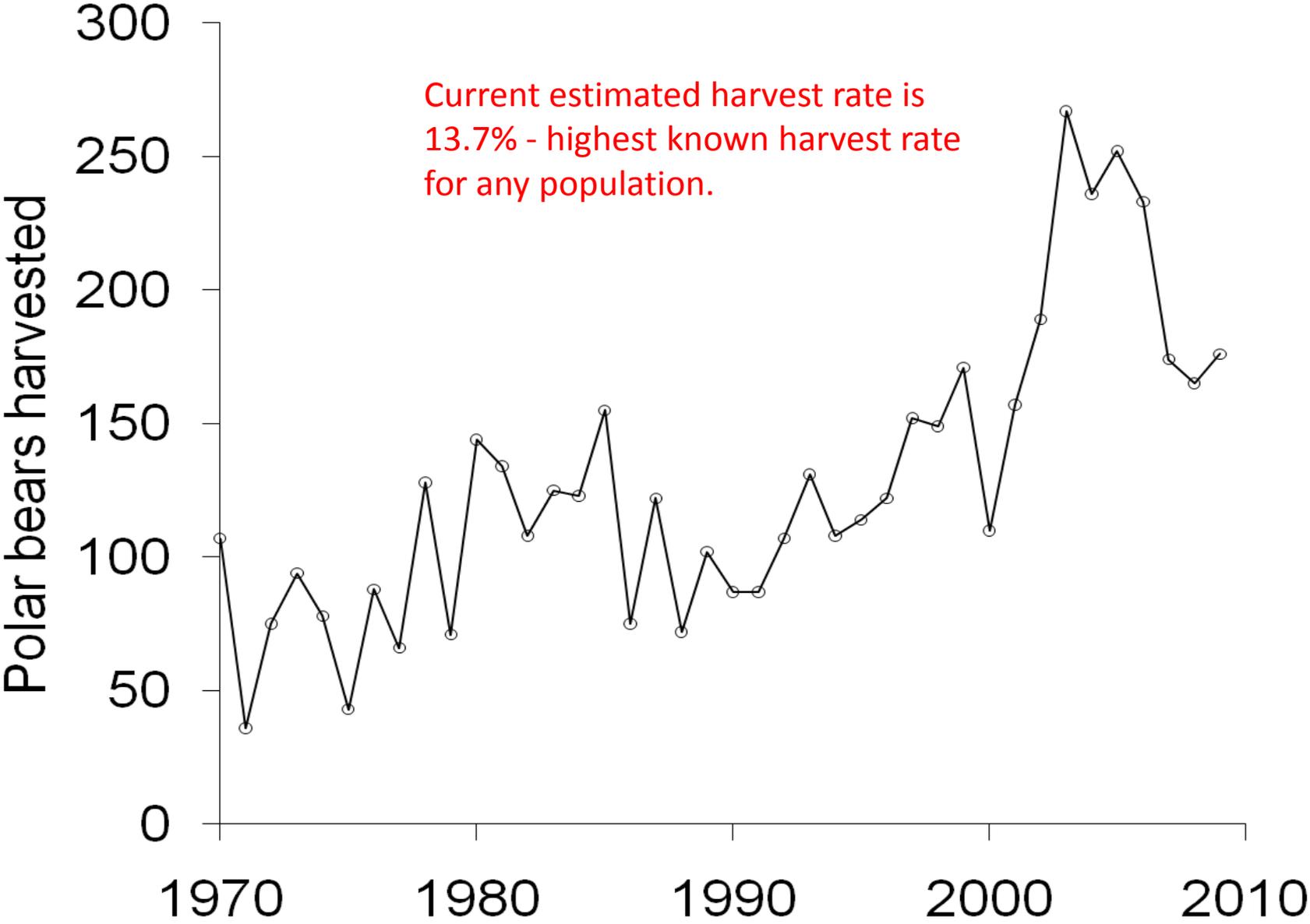
7 days/decade earlier in spring, 7 days/decade later in fall

Additional concern from impacts of large subsistence harvest  
or harvest on unknown population size



# Recorded Subsistence Harvest in Baffin Bay

Current estimated harvest rate is 13.7% - highest known harvest rate for any population.



- Primary prey is the ringed seal
- Occupy lairs with breathing holes in spring



- Bears search for lairs on the ice, break through, and feed on seals
- Spring is a critical feeding period for bears of all ages



Spring is also a critical period for breeding pair formation and mating



Males enter battles and compete for access to females in spring.



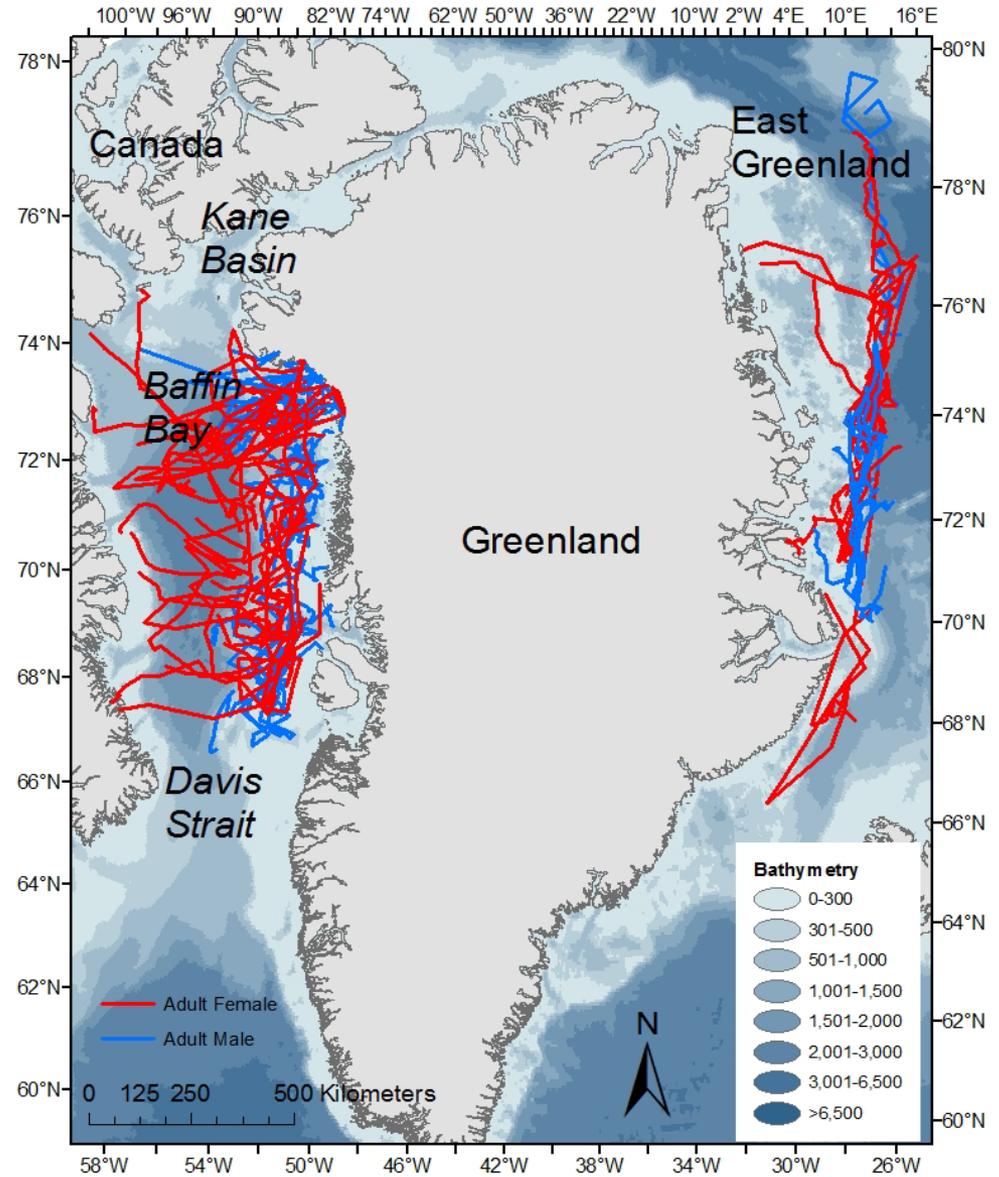
To date, it has been assumed male movement is similar to that of females and they are not territorial.

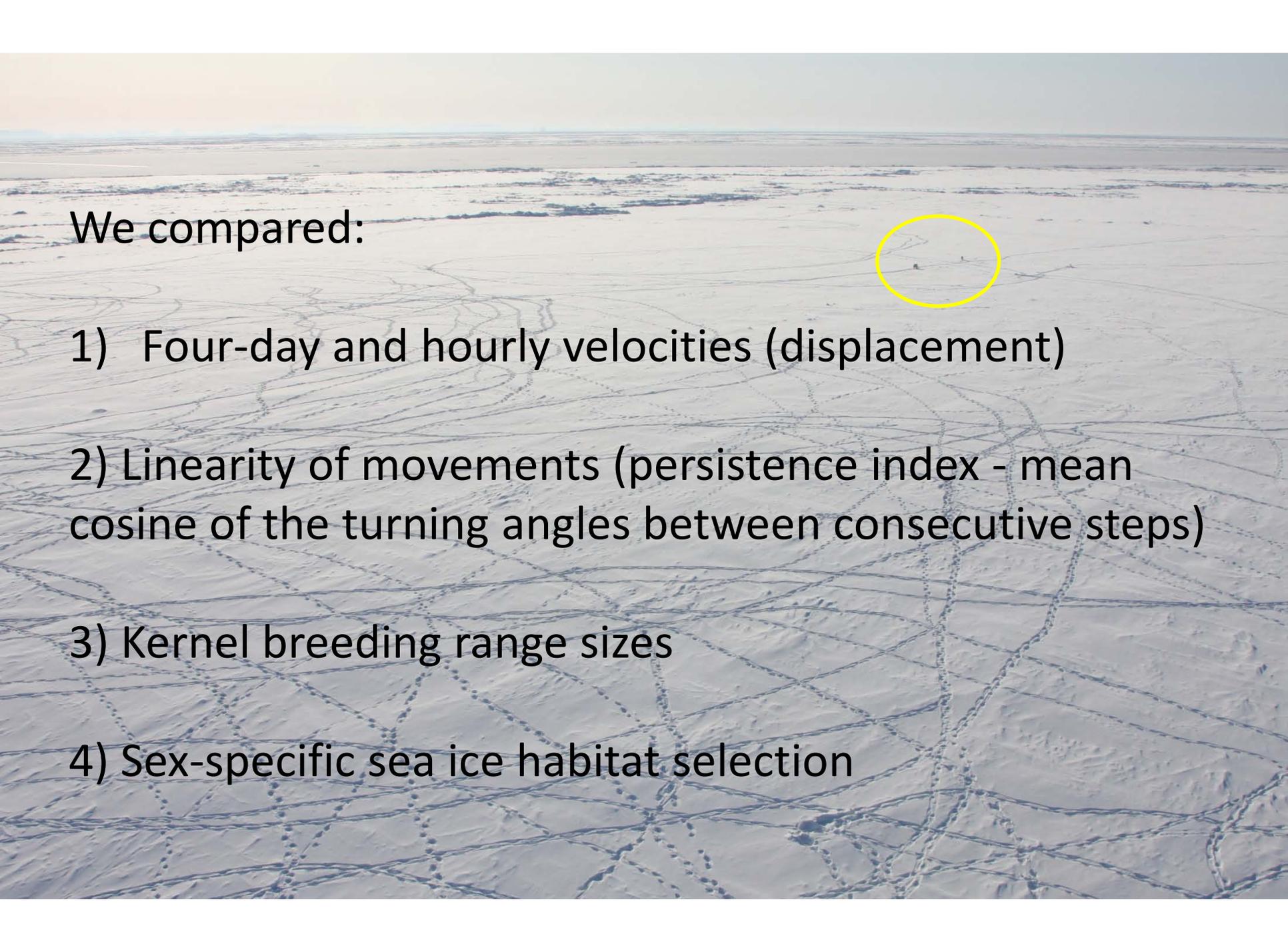


# Movement

Compare of adult males  
and adult females  
(n=23/26)

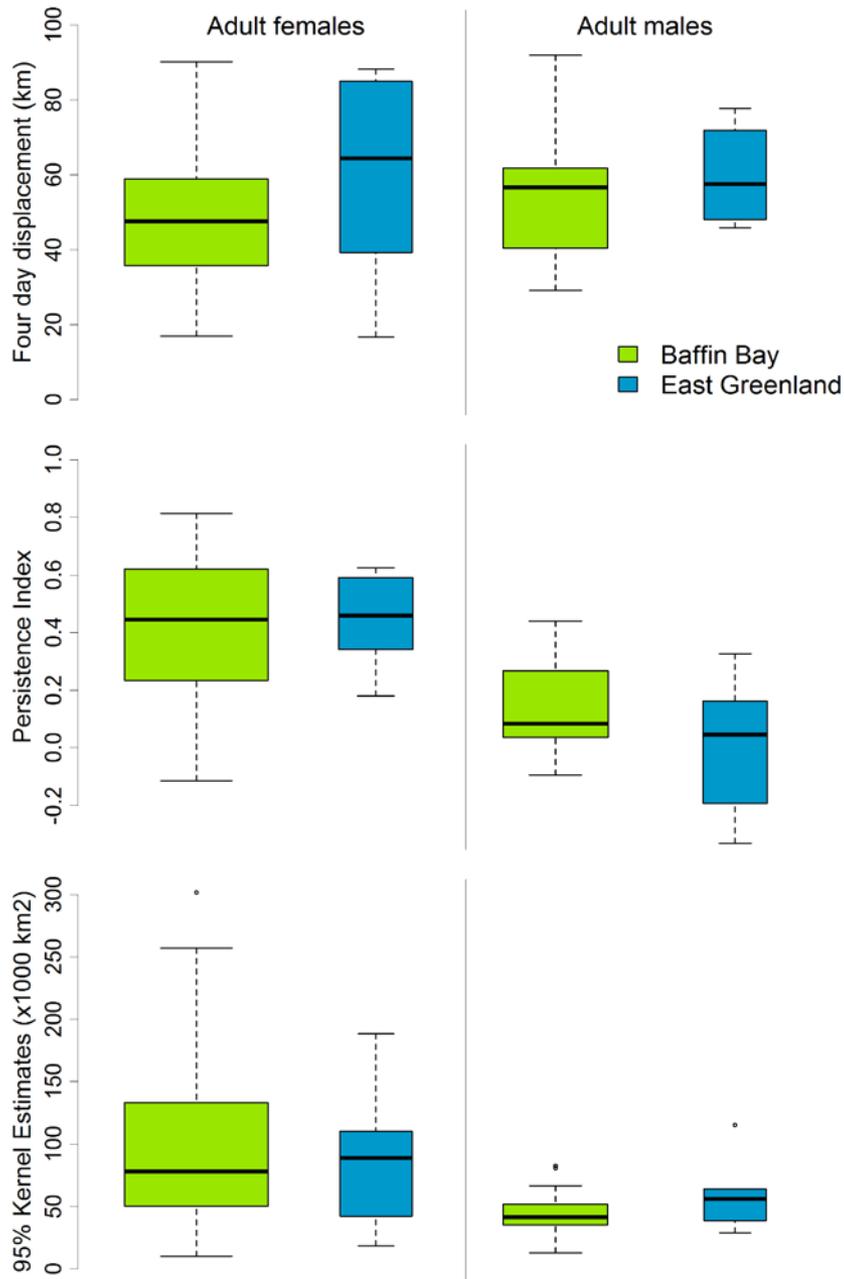
- Baffin Bay and East Greenland during the mating period
- April-May pack ice
- Data from 2007-2011





We compared:

- 1) Four-day and hourly velocities (displacement)
- 2) Linearity of movements (persistence index - mean cosine of the turning angles between consecutive steps)
- 3) Kernel breeding range sizes
- 4) Sex-specific sea ice habitat selection



Median value, 25% and 75% interquartile range for:

(a) 4-day displacement values in km,

**NOT SIGNIFICANT**

(b) Linearity of movement (persistence index)

**P<0.001**

(c) 95% kernel home range (km<sup>2</sup>)

**P<0.001**

Adult females move in significantly more linear paths (higher PI) and have significantly larger breeding ranges.

Significant in all years and for both populations.

Within each population, year was not a significant covariate in explaining variation in PI.

Result of differential habitat selection?





Pseudo-absence locations constructed by computing the distance and turning angle for 50 randomly selected movement steps, and adding those steps to the preceding location for each bear.

Conservative set reflects based entirely on the movement behavior of individual, accounting for autocorrelation.

**Strong** preference for high sea ice concentrations at several scales.

**Same** strength of preference for habitat covariates for both sexes.

**Females** – linear movement follows encounter theory where probability of encountering sparsely distributed, low-probability prey (i.e. seals) maximized by moving straight.

**Males** – tortuous “semi-territorial” movement leads to sufficient probability of encounter with mobile receptive females, but minimizes probability of male-male competition



# Pair formation rate important at low densities

## Modelling the mating system of polar bears: a mechanistic approach to the Allee effect

Péter K Molnár, Andrew E Derocher, Mark A Lewis and Mitchell K Taylor

*Proc. R. Soc. B* 2008 **275**, 217-226  
doi: 10.1098/rspb.2007.1307

$$\underbrace{\frac{dM}{dt}}_{\text{solitary available males}} = - \underbrace{\sigma MF}_{\text{pair formation}} + \underbrace{\alpha \mu P}_{\text{males available after pair separation}},$$

$$\underbrace{\frac{dF}{dt}}_{\text{unfertilized females}} = - \underbrace{\sigma MF}_{\text{pair formation}},$$

$$\underbrace{\frac{dP}{dt}}_{\text{breeding pairs}} = \underbrace{\sigma MF}_{\text{pair formation}} - \underbrace{\mu P}_{\text{pair separation}},$$

$$\underbrace{\frac{dM^*}{dt}}_{\text{solitary unavailable males}} = \underbrace{(1 - \alpha)\mu P}_{\text{males unavailable after pair separation}},$$

$$\underbrace{\frac{dF^*}{dt}}_{\text{fertilized females}} = \underbrace{\mu P}_{\text{pair separation}},$$



## Concluding thoughts:

- Direct observation of climate change impacts on abundances of polar bears is difficult
  - confounded by high harvest
  - high uncertainty around estimates
- Biological and behavioral data can provide insights into mechanisms behind population dynamics

# Acknowledgements

NASA ROSES (2011-2014)

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