Climate change, sea ice, and polar bears in Greenland

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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



Objectives

Evaluate change in polar bear sea ice habitat in the Arctic

Quantify and predict sea ice loss impacts for sub-populations of polar bears in Greenland

Work based on long-term time series of polar bear captures in Greenland (1993-2013)



Relevant to 1) conservation of polar bears and 2) management of marine resources in a changing ecosystem



Topics:

- 1. Models of male and female movement during the breeding season (Laidre et al. 2012)
- 2. Resource selection using historical and present satellite telemetry data for East Greenland and West Greenland (Laidre et al. 2015a, Laidre et al. In prep)
- 3. Circumpolar trends in sea ice habitat change for polar bears (and other marine mammals) (Laidre et al. 2015b, Stern and Laidre In review)
- 4. Sea ice metric for global IUCN Red List assessment of polar bears (Wiig et al. 2015)

Brief field methods: Polar bear capture and marking efforts







Females

Males only

10 cm



What is 'Pack ice'?

- Sea ice unattached to land
 Dynamic
 Moves >20 km/day in
 West Greenland, >70km/
- day in East Greenland
- •9-10% decrease/decade



AMSR-E



1. Male and female 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



Primary prey for polar bears is the ringed seal
In spring, ringed seals occupy lairs or sit at breathing holes
Sea ice is a critical platform for feeding



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

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 (SSMI and AMSR-E)



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 (km²) P<0.001 Adult females moved in significantly more linear paths and had significantly larger breeding ranges than adult males.

Significant in all years and for both populations.

Results independent of female reproductive availability



Year was not a significant covariate in explaining variation in linearity of movement.

Result of sex-specific habitat selection?



Explained by difference in sea ice regimes?

Sea ice -AMSR-E instrument on NASA's Aqua satellite

Linear mixed effects models of bear presence as a function of:

sea ice concentration (%) at 3 scales (at bear, and two buffers)
distance to sea ice edge (15% and 50% sea ice)
distance to shore



Strong preference by both sexes for high sea ice concentrations at several spatial scales.

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



Why – are differences related to encounter rates?

• Females –Linear movement maximizes probability of encountering sparsely distributed, low-probability prey (i.e. seals)

• Males – "semi -territorial" movement leads to sufficient probability of encounter with mobile females while minimizing probability of male-male competition

Laidre et al. 2012. Proceedings of the Royal Academy B.



2. Resource selection in East Greenland

No assessment of this population has even been conducted.

Telemetry data in NE Greenland from 1990s and 2007-08.

Quantify resource use and possible changes over decades.

Laidre et al. 2015a. Polar Biology



With assistance from Hyperwall team, AMSR-E

AMSR-E and SSMI sea ice habitat covariates

Habitat selection, maternity denning timing and selection

Only adult females with collars

Compare 1990s with 2000s



Availability of sea ice in East Greenland. 1979 - 2013



- In 2000s, adult females located significantly closer (100-150 km) to open water in all seasons than in 1990s.
- In 2000s, adult females used areas with <60% sea ice concentration two months longer than females in the 1990s.



1990s, 2000s





Laidre et al. 2015a. Polar Biology

SSM/I



West Greenland (Baffin Bay)

2009-2013

N=38 adult females with satellite radio collars



Annual cycle on sea ice foraging and on land fasting





Increasing time spent on land

56 paired arrival/departure dates from individual bears

Significant (p<0.001) increase in time on land in the 2000s

~30 days longer on last fasting since 1990s

Decade	n	min	max	Mean	stdv
				days on	
				land	
1990s	14	8	99	62.3	25.0
2000s	26	56	120	94.8	15.7

Swimming Events: <15% sea ice, 200 km from shore, antenna underwater so few locations, rapid movement direct to land at end of sea ice season



3. Circumpolar trends in polar bear habitat loss

Timing of sea ice formation and recession is critical.

Calculated dates of spring sea ice retreat and fall sea ice advance using SSM/I satellite data (1979-2013).

Encompasses change in the seasonal open-water period.



Partial support: NASA Climate Indicators Program

Timing of sea ice advance and retreat in 19 subpopulations





19 polar bear sub-populations

Data: Gridded daily sea-ice concentration (nominal cell size 25 x 25 km) from the National Snow and Ice Data Center, Boulder





Subpopulation specific trends





Spring and fall transition dates (50% coverage) all slopes significant (p<0.05)

Also used in **IUCN Red List Assessment** for Polar Bears (Wiig et al. 2015)

Sea ice metric used to project global population size under a set of assumptions

Assuming a one-to-one proportional relationship between sea ice and abundance, median percent change in global population size over three generations was -30% (95%CI = -35% to -25%).

Other relationships between sea ice metrics and estimates of abundance explored.



Also used in **IUCN Red List Assessment** for Polar Bears (Wiig et al. 2015)

Sea ice metric used to project global population size under a set of assumptions





Methods also adapted for CAFF regional assessments

CAFF Arctic Biodiversity Assessment (2014), included in report to the Arctic Council

Assessed habitat for all species of Arctic marine mammals (including polar bears)

Laidre et al. (2015) Conservation Biology 29(3): 724-737



Change in duration of the low sea-ice season (days per decade)



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