The role of polar bear behavior in defining resiliency and sensitivity to sea ice loss

Karyn Rode, Research Wildlife Biologist

U.S. Department of the Interior
U.S. Geological Survey

Some of the information provided in these seminars is preliminary or provisional and is subject to revision. It is being provided to meet the need for timely best science. Some of the information has not received final approval by the U.S. Geological Survey (USGS) and is provided on the condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the information.

New paradigm in polar bear research

Previous work: population dynamics and habitat use

Current: new tools needed to project short and long-term responses to sea ice loss

- behavior
- energetics
- physiology

c/o US Fish and Wildlife Service

USGS
science for a changing world

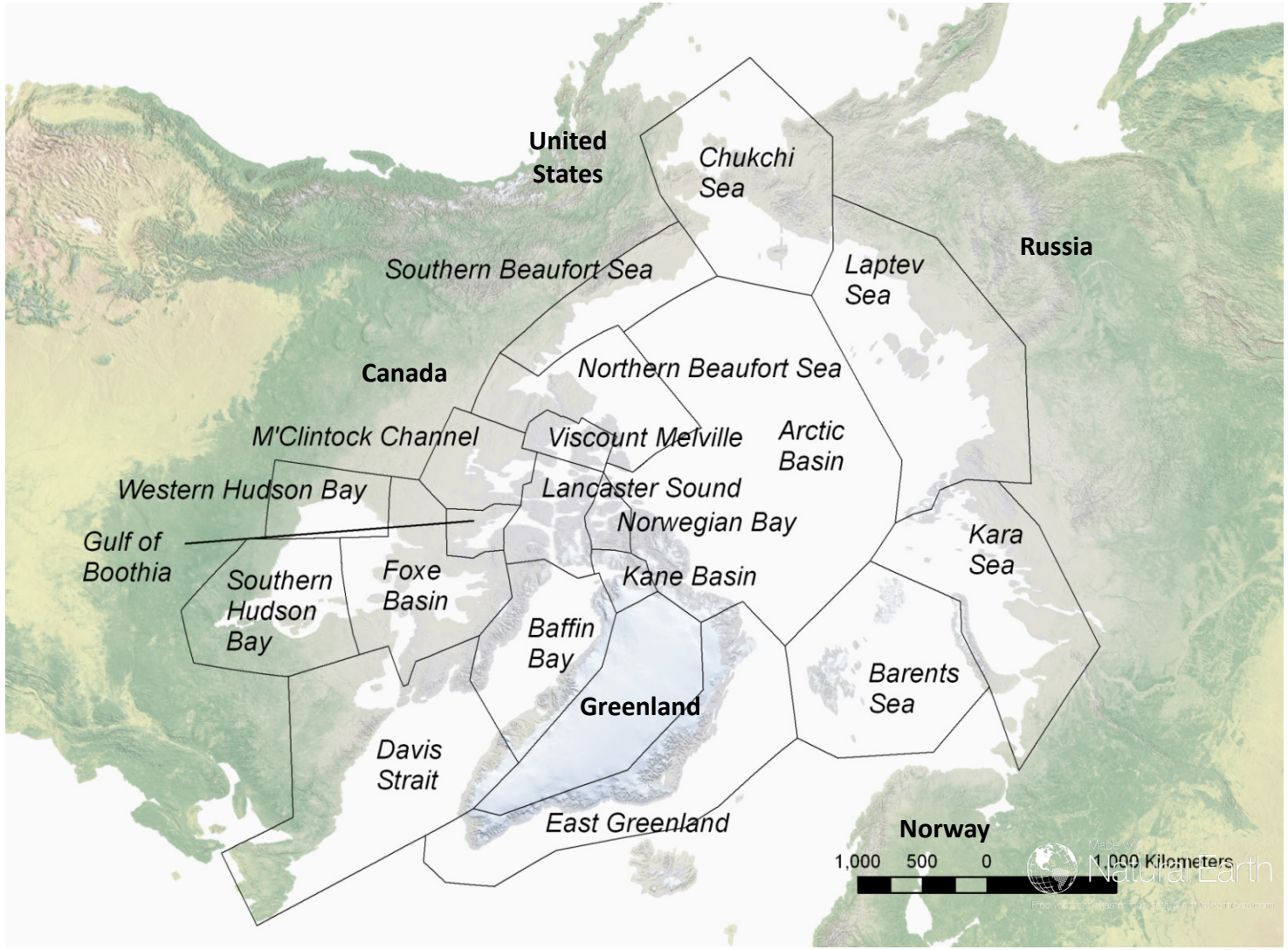
Questions to address:

- Are polar bears responding to sea ice loss and how does this vary throughout their range?
- If so, what is the primary way in which they are affected?
- How can we best manage other issues affecting polar bears, such as harvest, oil and gas development, disease, contaminants, & bear-human conflict?

c/o US Fish and Wildlife Service

USGS
science for a changing world

FROM BROAD SCALE:
Ecological and environmental variability across the 19 recognized polar bear subpopulations



USGS
science for a changing world

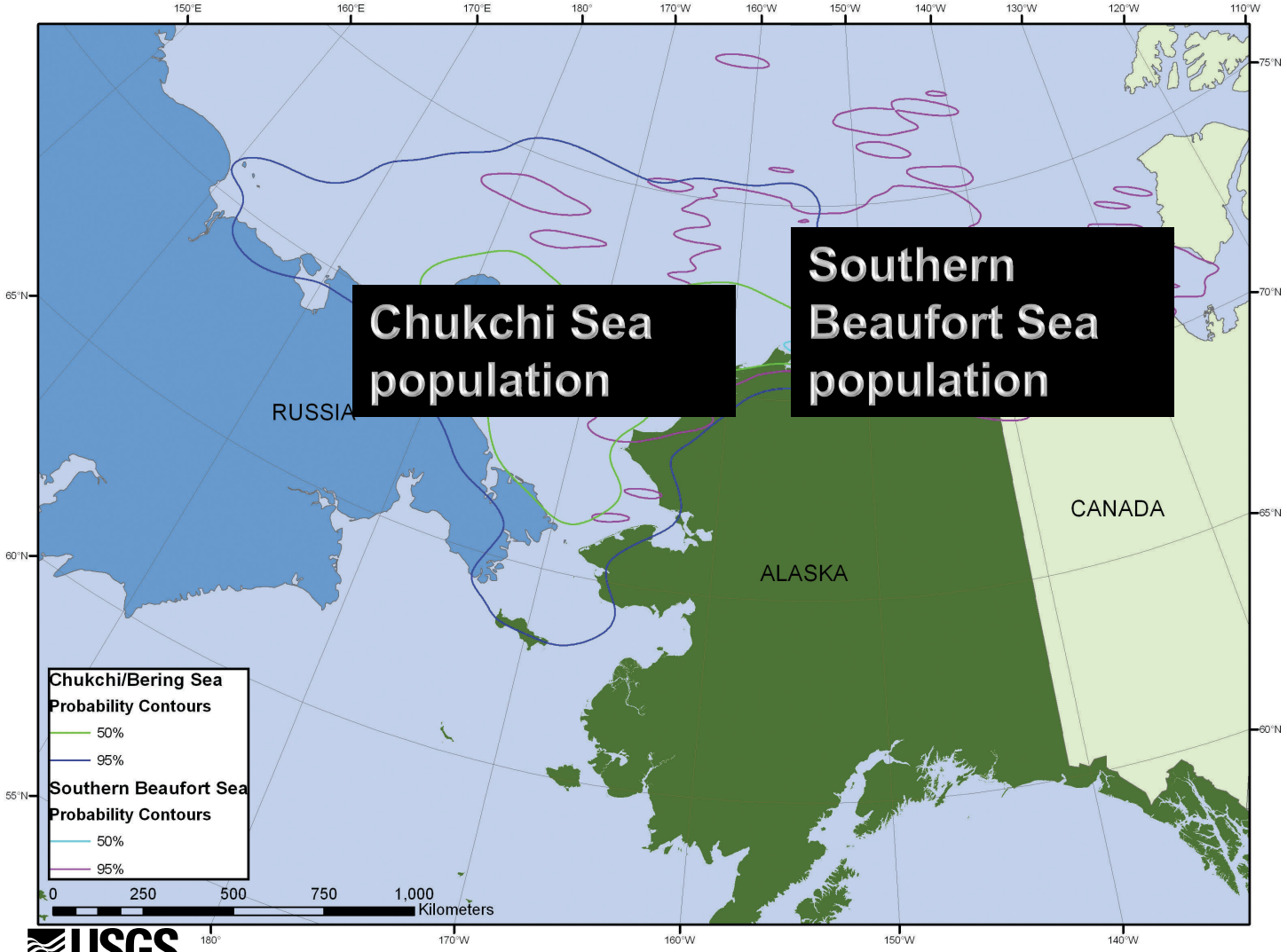
TO LOCAL SCALE: We also need to understand local, short-term responses to sea ice loss

c/o US Fish and Wildlife Service

Harvest management, bear-human conflict

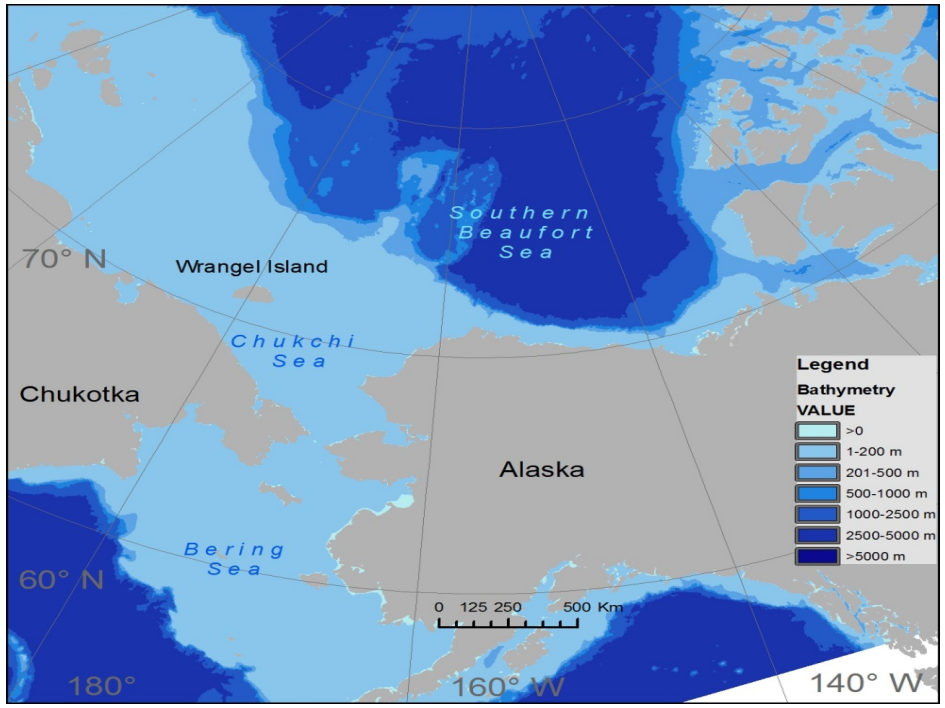
USGS
science for a changing world

Alaska's two subpopulations provide an opportunity to better understand long and short-term responses and spatial variation

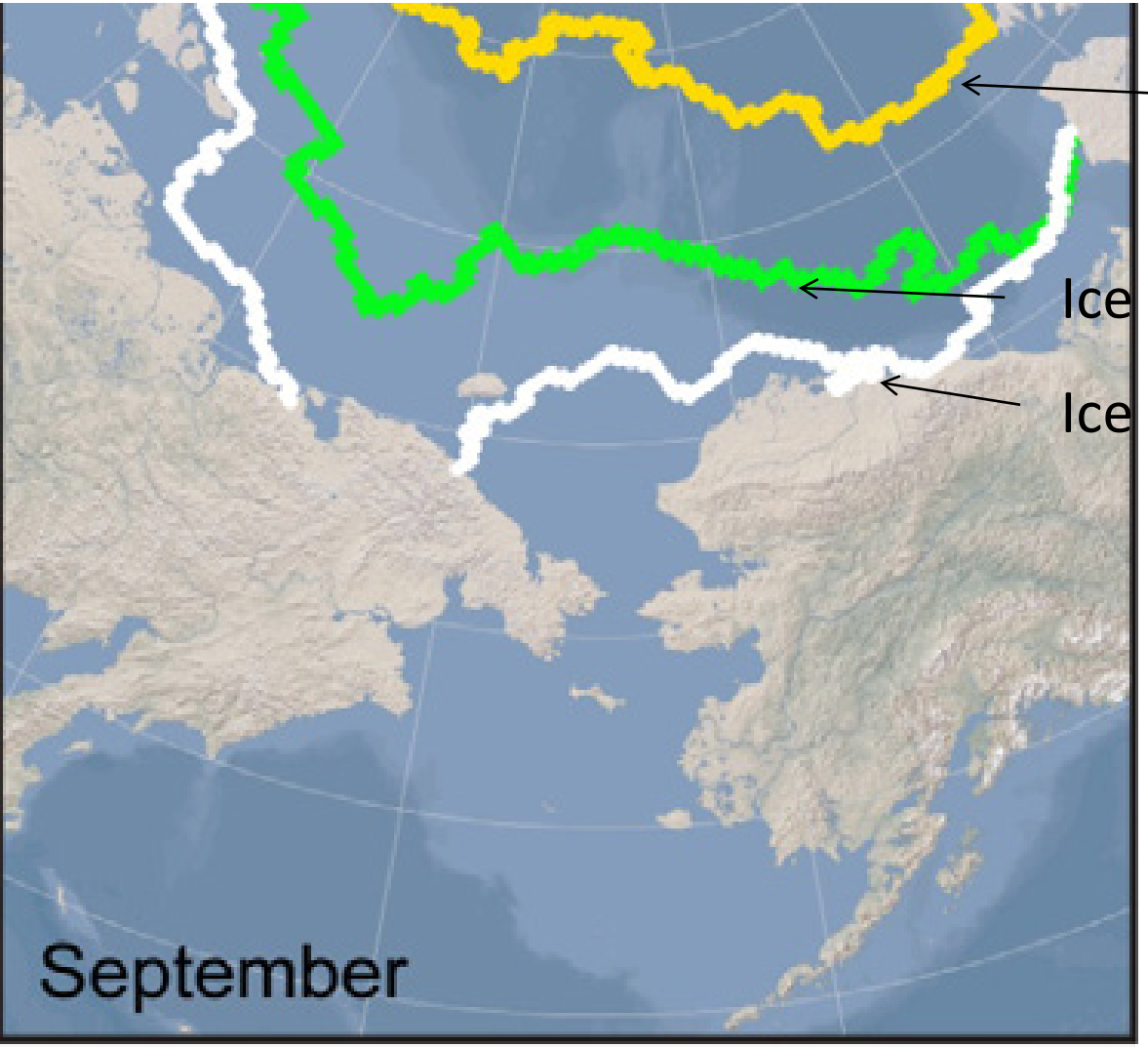


From Amstrup et al. 1994

Differences between subpopulations in bathymetry, ecological productivity



How will polar bears cope with continued sea ice loss?

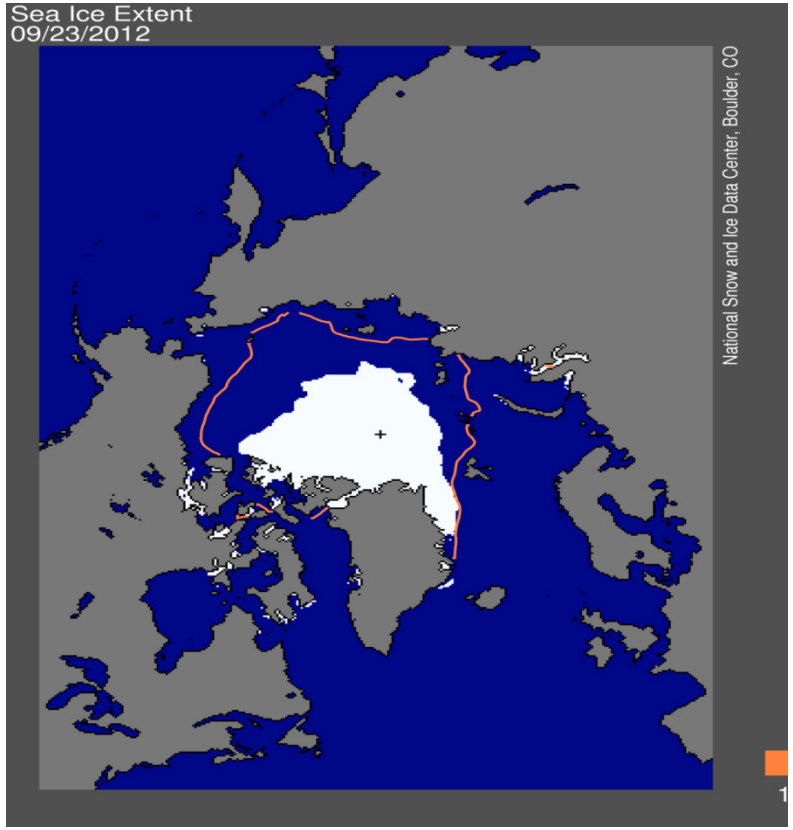


Projected ice extent 2045

Ice extent 1999-2008

Ice extent 1979-1988

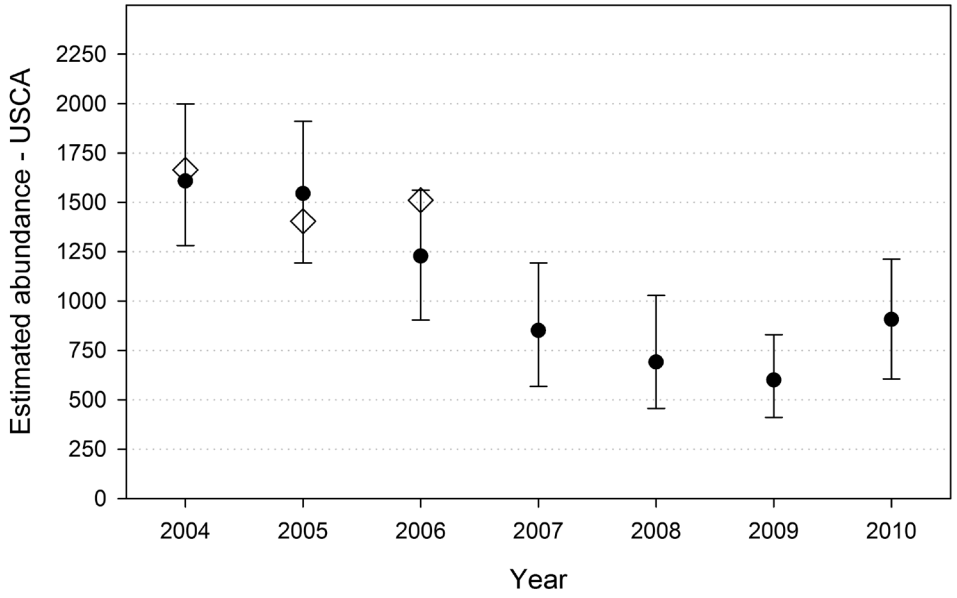
Douglas 2010



Importance of understanding mechanisms

- Challenge of obtaining population estimates & vital rates
- Identifying key behaviors to monitor as indicators of response to sea ice loss

Polar bears in the southern Beaufort Sea have exhibited declines



- Decline from 1500 to 900 polar bears 2004 to 2010 due to very low cub survival (Bromaghin et al. 2015)
- Declines in body condition (Rode et al. 2010)

USGS
science for a changing world

In the Chukchi Sea, body condition and cub survival appears stable

- No changes over time
- Indicators that bear condition & recruitment are better in Chukchi than Beaufort
- Cubs, yearlings & subadults weigh more which results in higher survival

Rode et al. (2014)

c/o US Fish and Wildlife Service

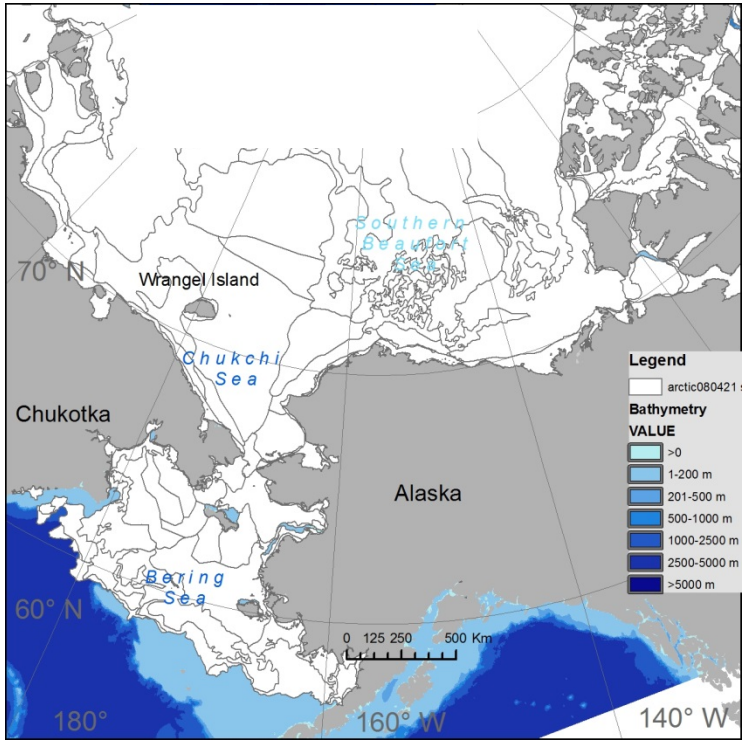
c/o US Fish and Wildlife Service

USGS
science for a changing world

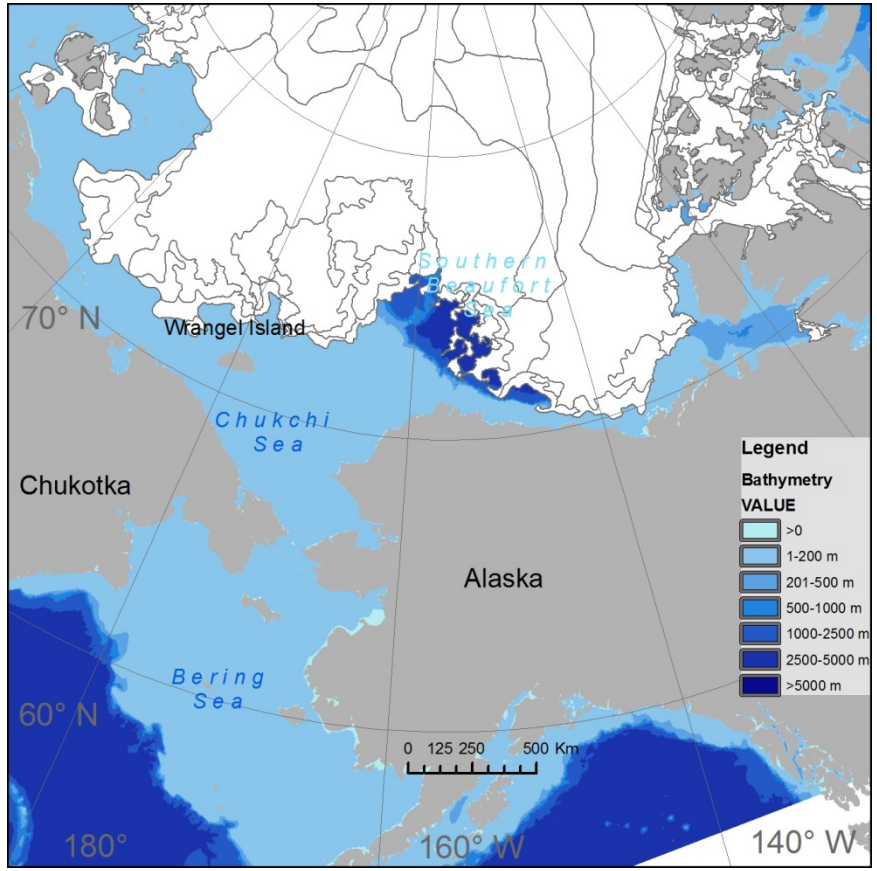
Behaviors across critical seasons

SPRING (March/April)– seals haulout – important feeding period, mating, energetics
SUMMER (Aug-Oct)– Minimal sea ice, changes in habitat use patterns (land use), activity/energetics, feeding?, exposure to disease
WINTER (Dec-March)– changes in denning habitat and phenology

SPRING ICE CONDITIONS



SUMMER ICE CONDITIONS



USGS
science for a changing world

SPRING-BASED CAPTURES

c/o US Fish and Wildlife Service

USGS
science for a changing world

SPRING: Lower frequency of spring fasting in Chukchi Sea than the southern Beaufort 2008-2016

- Fasting– can be identified by blood serum values of urea and creatinine
- N = 1034 samples from 801 bears; 1983-2016

Probability of fasting

Females:

Chukchi Sea: 12%

Southern Beaufort : 47%

Males

Chukchi Sea: 43%

Southern Beaufort Sea 73%

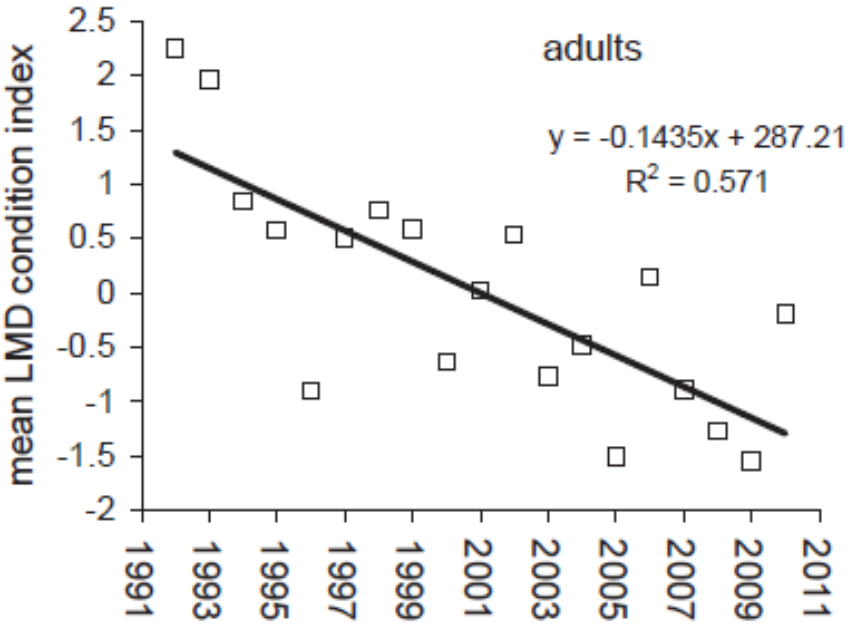
Rode KD, RR Wilson, DC Douglas,V Muhlenbruch, E. Peacock, T Atwood, E Regehr, G Durner, M St Martin, S Amstup A Pagano, K Simac, N Pilfold, A Derocher, I Stirling, E Richardson (In prep) Regional and temporal variation in spring fasting behavior of polar bears in relation to sea ice and seal availability.

USGS
science for a changing world

Why are polar bears fasting more in the southern Beaufort during the spring?

No declines in body condition of ringed and bearded seals in the Chukchi Sea
(Quakenbush et al. 2008)

Declines in ringed seal body condition in the Southern Beaufort

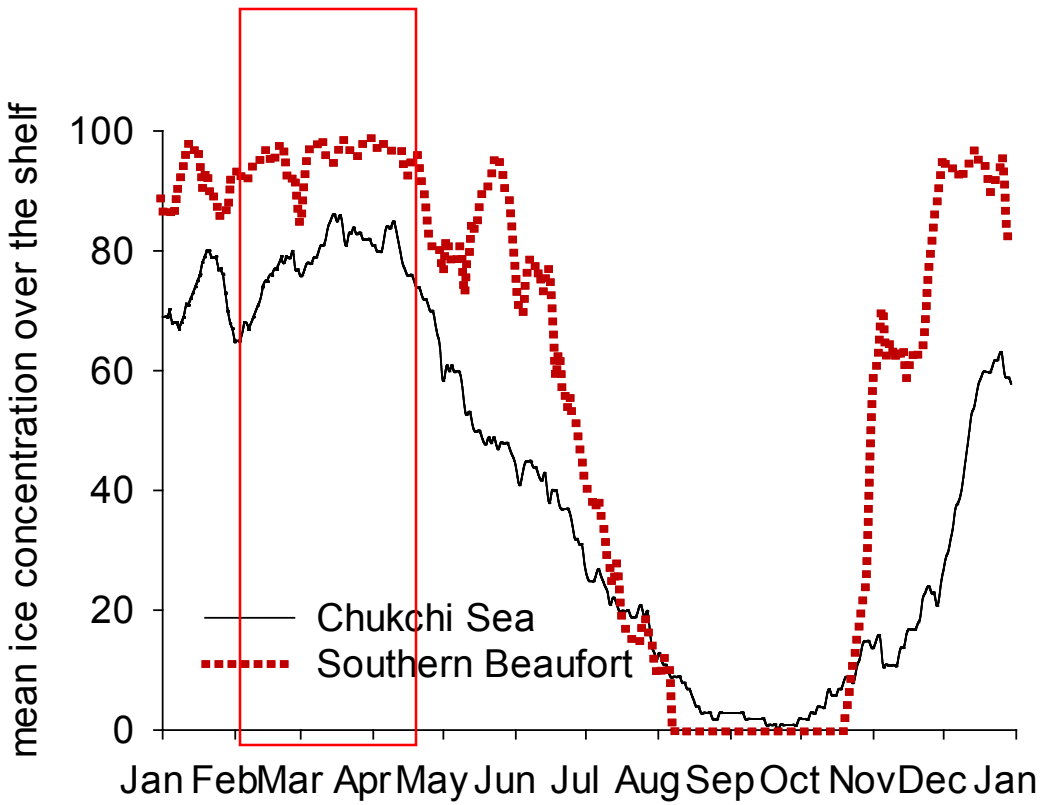


Harwood et al. 2012

In the southern Beaufort a bear's probability of fasting in the spring is related to indices of seal body condition

USGS
science for a changing world

Why are polar bears fasting more in the southern Beaufort during the spring?

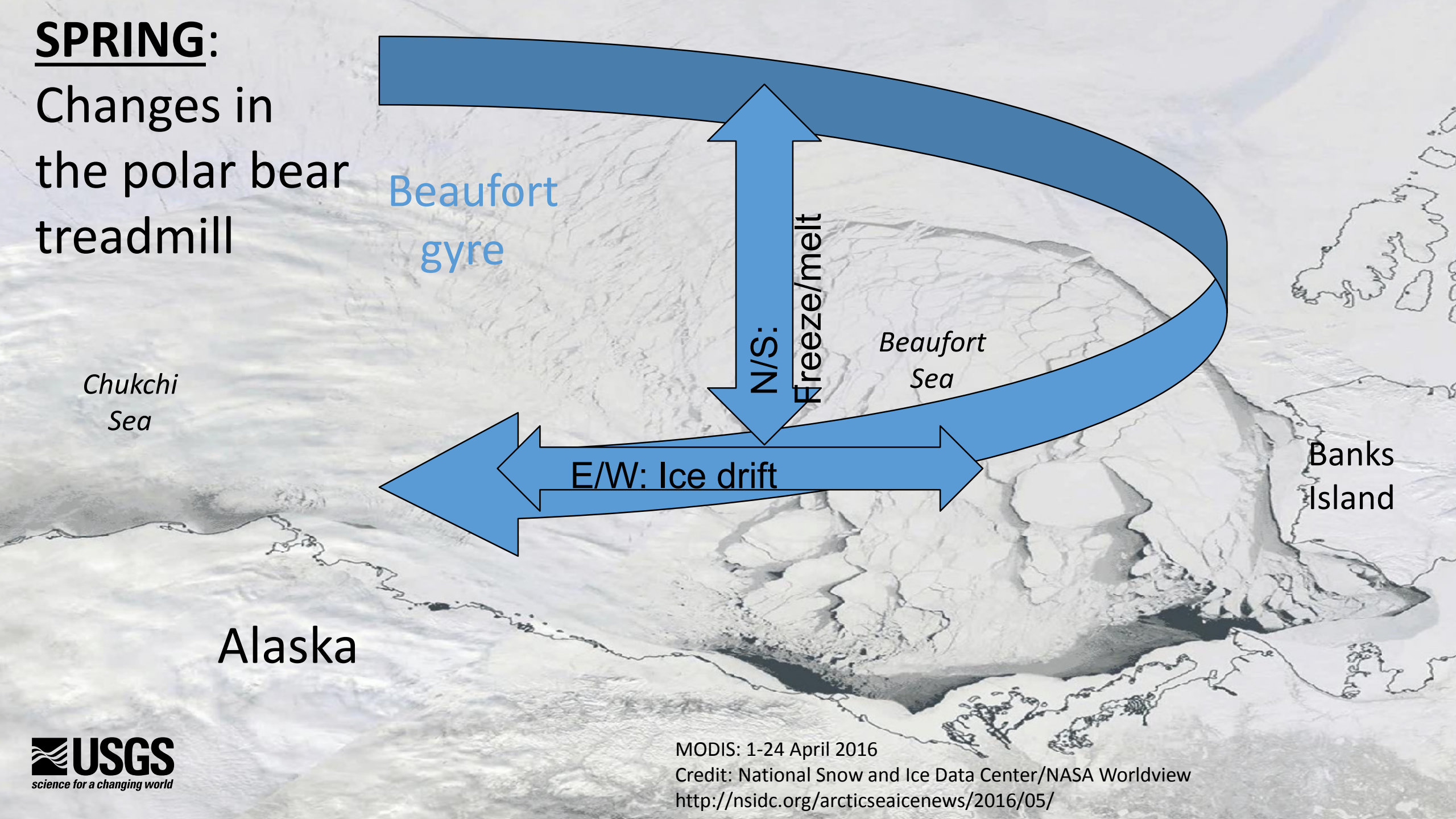


PREY ACCESSIBILITY VIA ICE CONDITIONS?

- Bears prefer 60-80% sea ice concentration
- Ice more concentrated in SB than CS in the spring
- Fasting behavior linked to variability in the spring sea ice conditions

USGS
science for a changing world

SPRING: Changes in the polar bear treadmill



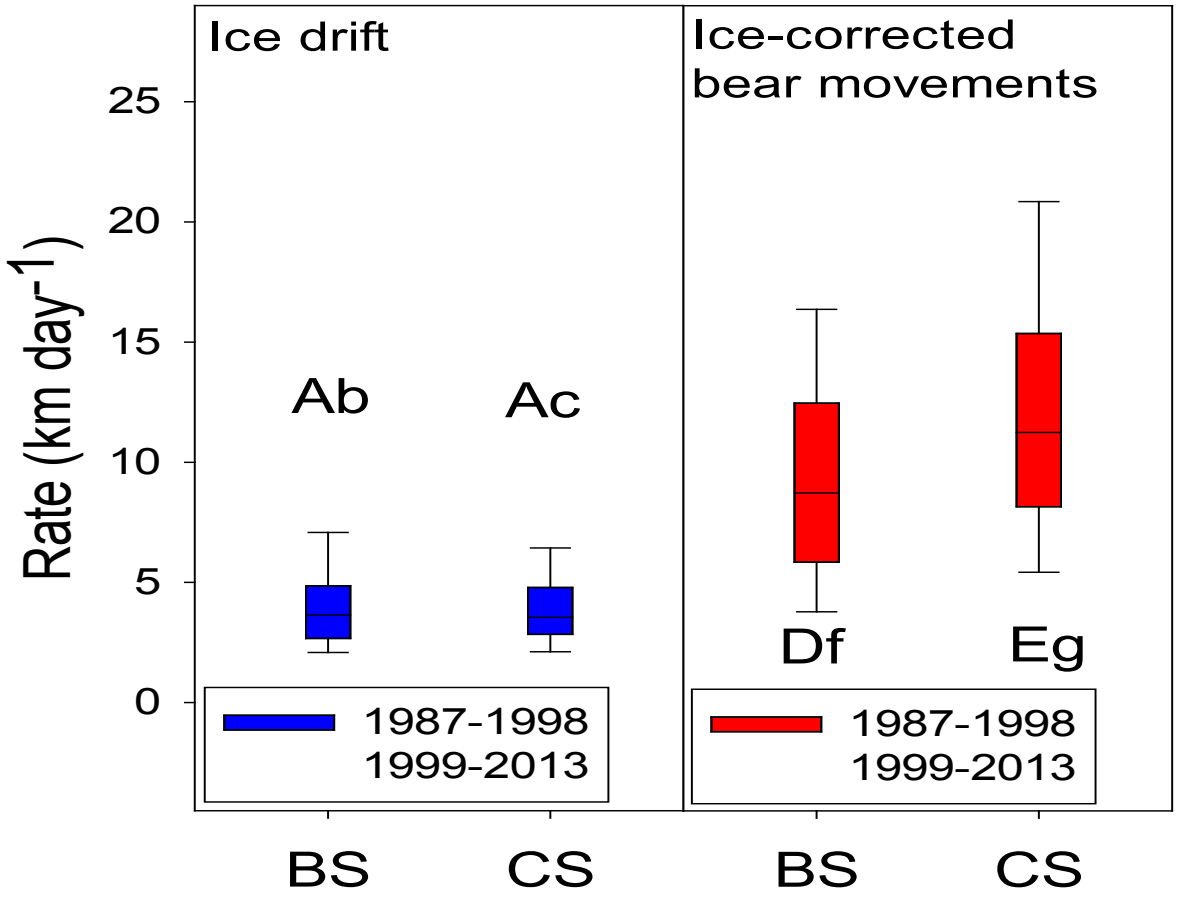
MODIS: 1-24 April 2016
Credit: National Snow and Ice Data Center/NASA Worldview
http://nsidc.org/arcticseaicenews/2016/05/

USGS
science for a changing world

Rates of Ice drift have increased between 1987-1998 and 1999-2013

Southern Beaufort increased 27.6% (4.1 to 5.2)

Chukchi Sea increased 49.6% (4.0 to 6.0)



Durner GM, SE Albeke, JP Whiteman, DC Douglas, SC Amstrup, ES Richardson, RR Wilson, M Ben-David. In review. Increased Arctic sea ice drift alters polar bear movements and energetics.

USGS
science for a changing world

Energetic consequences of increased ice drift

1999-2013

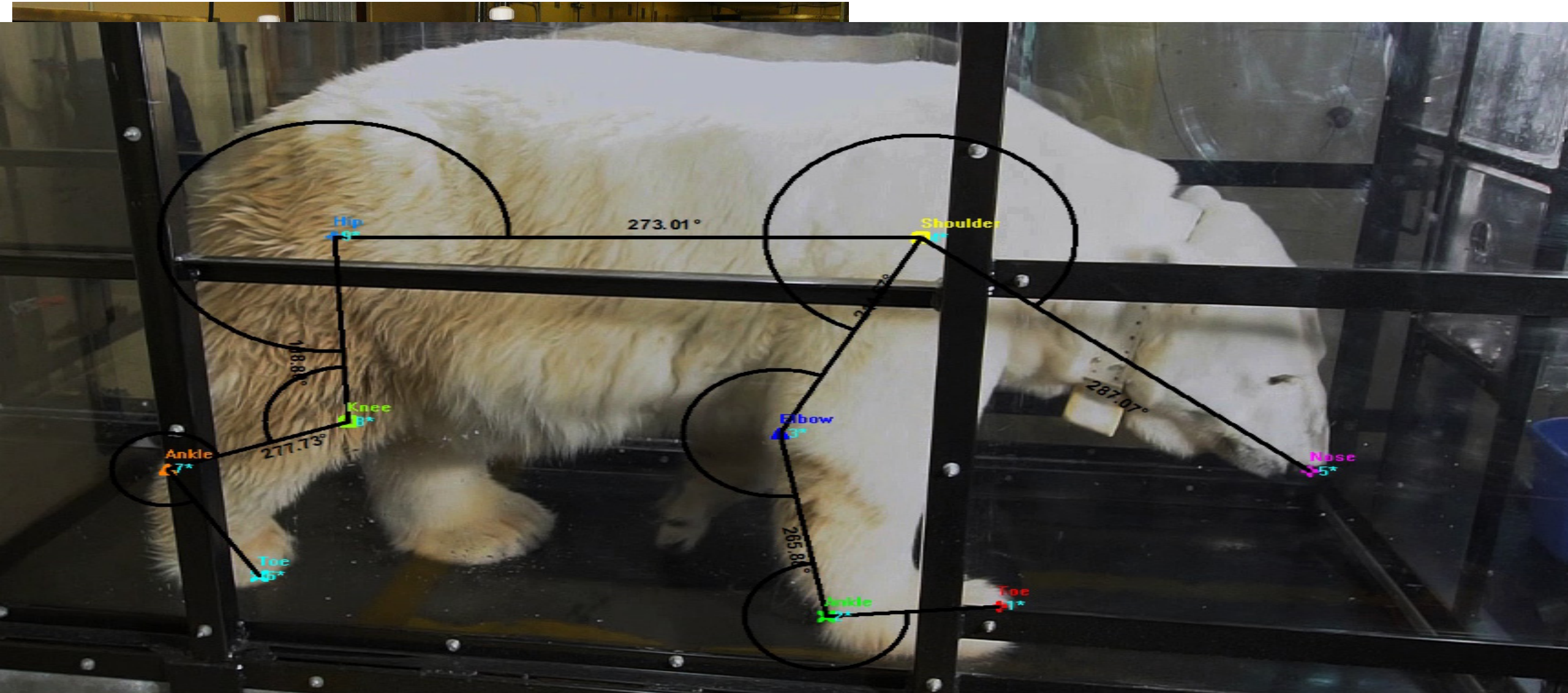
Bears either have to

Increase time spent or travel speed by 8-13%

Durner GM, SE Albeke, JP Whiteman, DC Douglas, SC Amstrup, ES Richardson, RR Wilson, M Ben-David. In review. Increased Arctic sea ice drift alters polar bear movements and energetics.

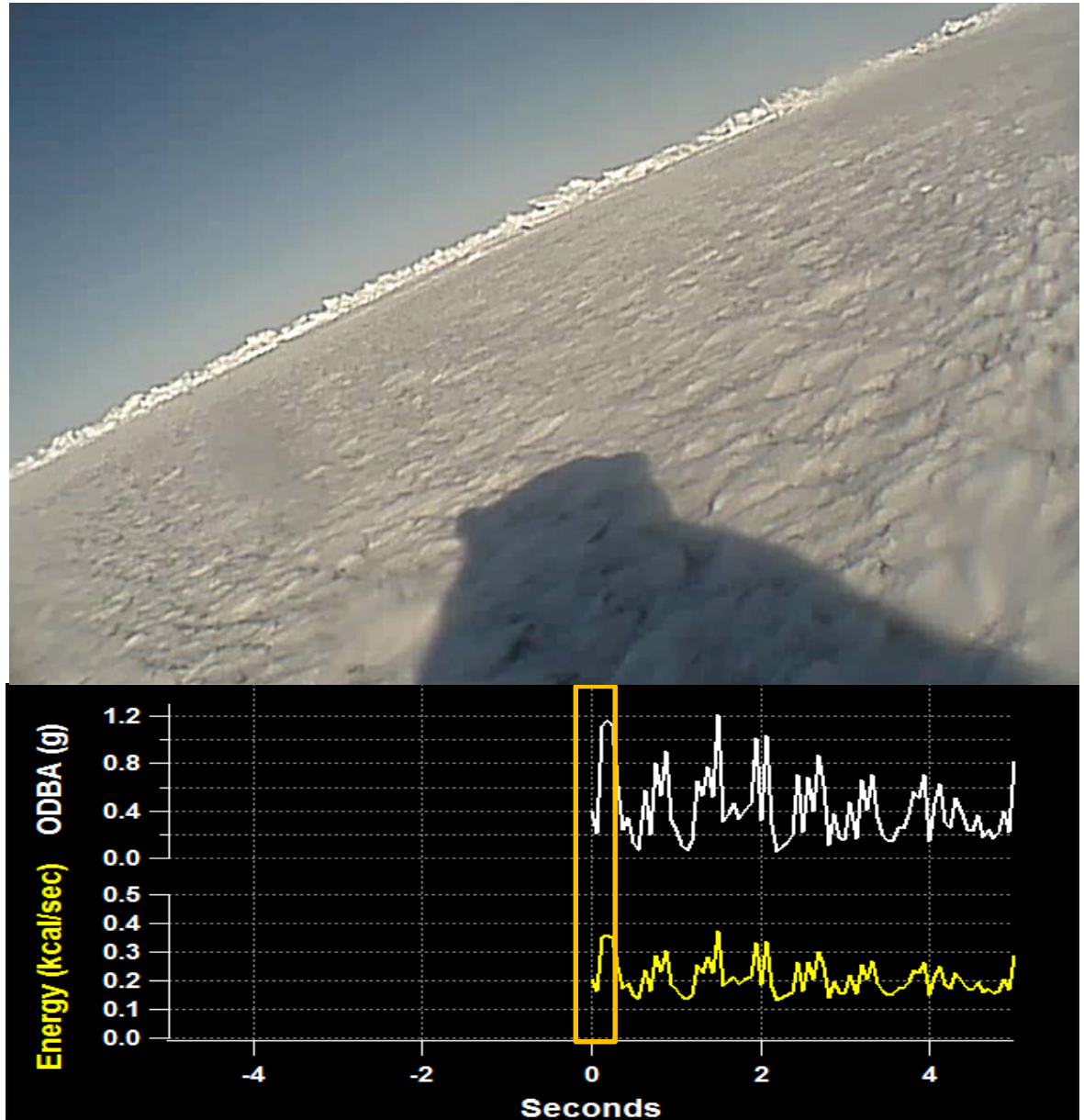
USGS
science for a changing world

Better understand polar bear energetic costs



Energy Expenditure estimated in the Wild

20 sec walking = 4.3 kcal



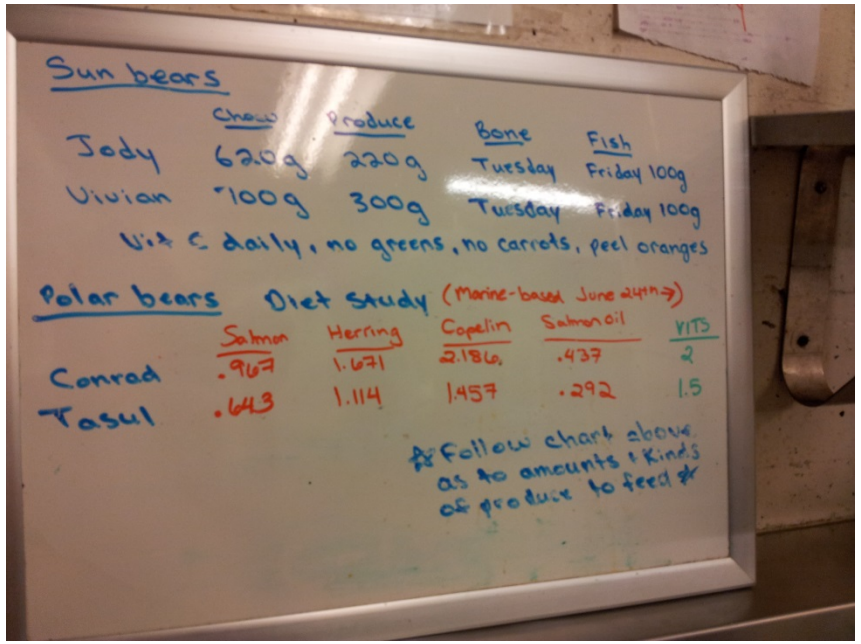
Pagano AM, KD Rode, A Cutting, MA Owen, S Jensen, JV Ware, CT Robbins, GM Durner, TC Atwood, ME Obbard, KR Middel, GW Thiemann, TM Williams. 2016. Using tri-axial accelerometers to identify wild polar bear behaviors remotely. Endangered Species Research: in press.

USGS
science for a changing world

SPRING: SB bears eating less, expending more energy

CS bears not eating less, but increasing energy expenditure

USGS
science for a changing world



Developing new techniques to estimate diet

- Stable isotopes in blood & hair
- Determine diet from archived samples collected since 1983

Rode KD, CA Stricker, J Erlenbach, CT Robbins, SG Cherry, SD Newsome, A Cutting, S Jensen, G Stenhouse, M Brooks, A Hash, N Nicassio. 2016. Isotopic incorporation and the effects of fasting and dietary lipid content on isotopic discrimination in large, carnivorous mammals. Phys Biochem Zool

Cumulative effects of disease, contaminants, and diet on body condition

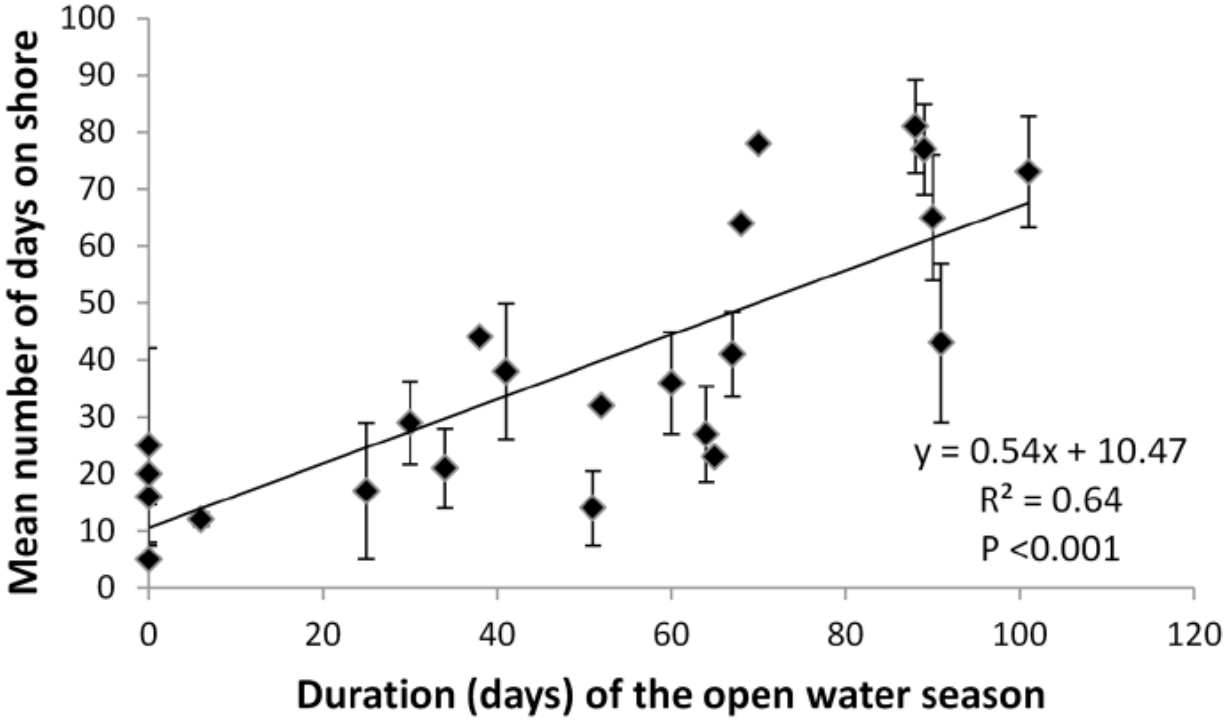
c/o US Fish and Wildlife Service

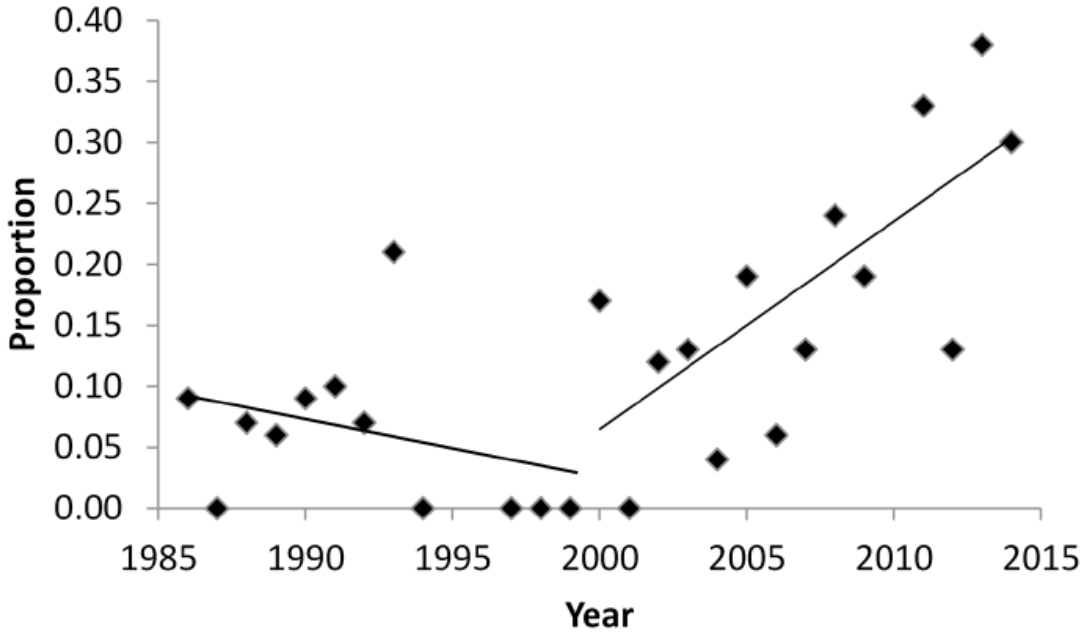
USGS
science for a changing world

SUMMER: Are polar bears increasing land use in response to sea ice loss?

USGS
science for a changing world

YES: Increased summer land use in the Southern Beaufort Sea





c/o US Fish and Wildlife Service

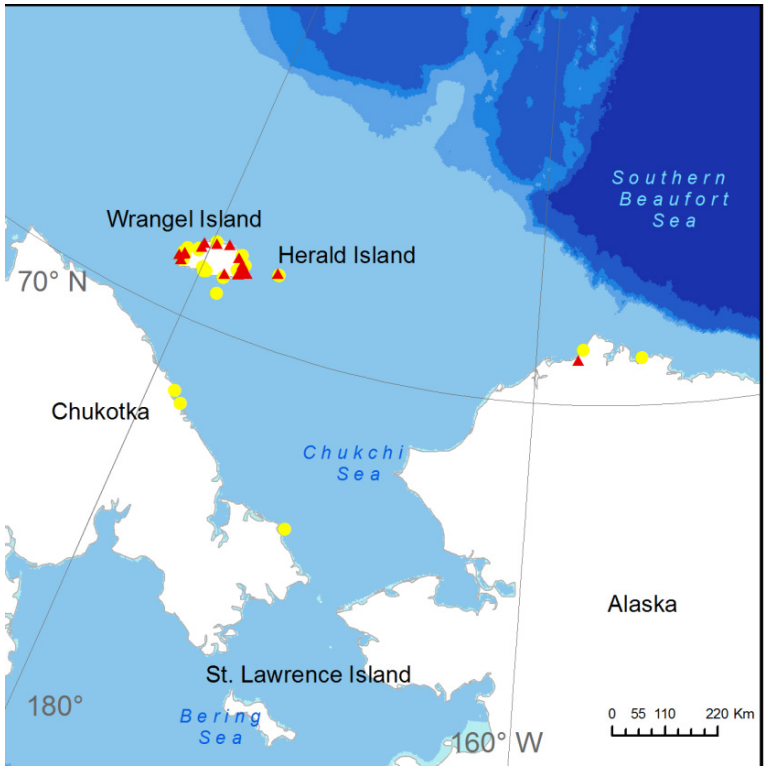
Atwood TC, E Peacock, MA McKinney, K Lillie, RR Wilson, DC Douglas, S Miller, P Terletzky (2016) Rapid environmental change drives increased land use by an Arctic marine predator. PLoS One 11:e0155932.

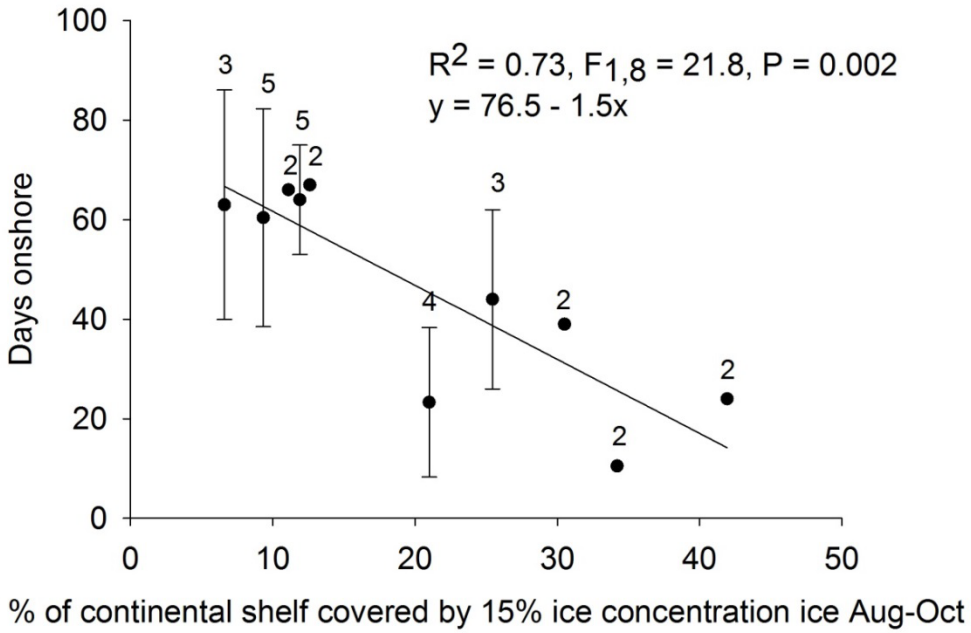
USGS
science for a changing world

YES: Increased land use in the Chukchi Sea

- Proportion of bears onshore increased from 20.0% to 38.9%

- 30 days more onshore
- 90% of bears summering on shore came to Wrangel Island



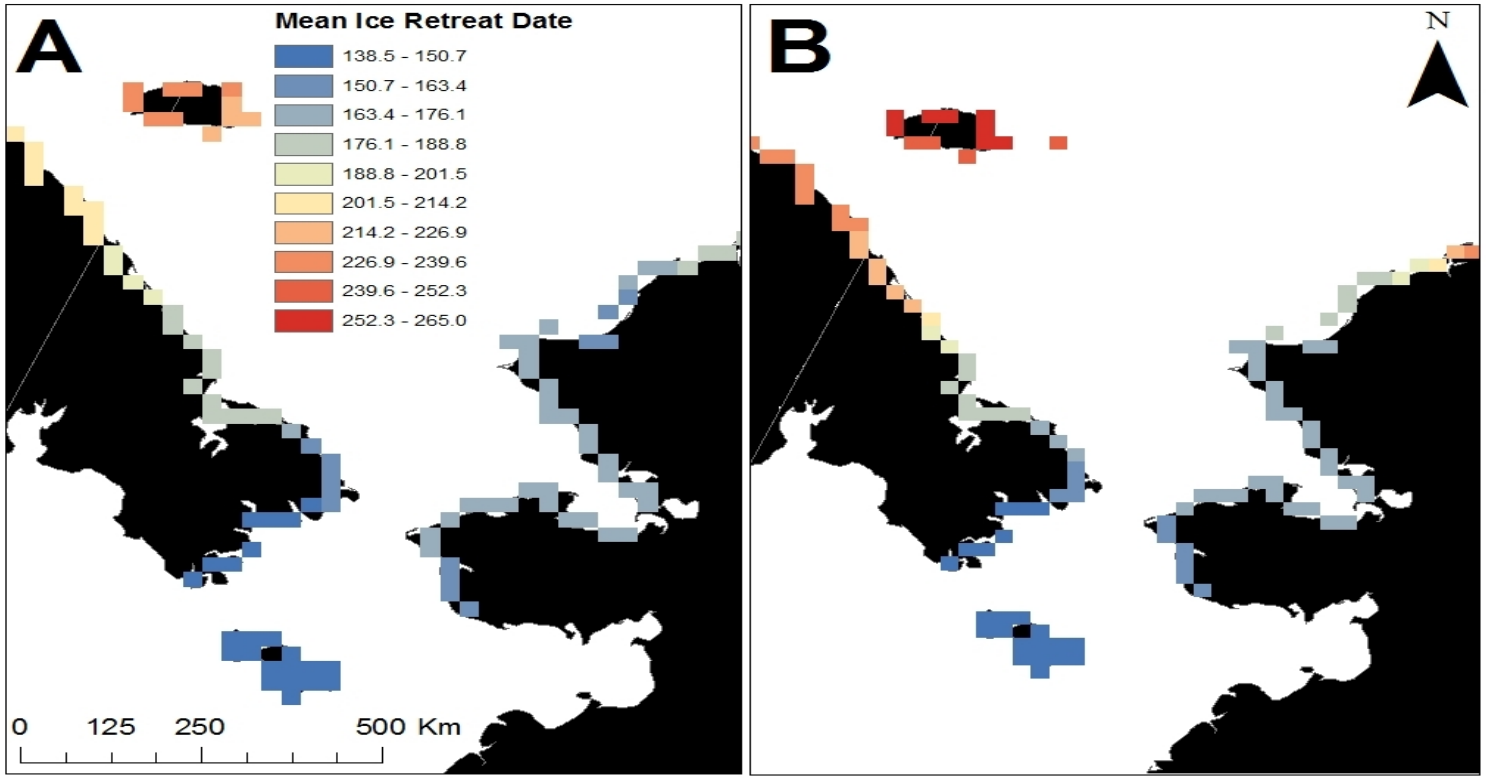


USGS
science for a changing world

Rode KD, RR Wilson, EV Regehr, M St Martin, DC Douglas, J Olson. 2015. Increased land use by Chukchi Sea polar bears in relation to changing sea ice conditions. PLoS One 10:e0142213.

Where summering occurred was related to timing of sea ice retreat

2008-2013 1986-1995



Rode KD, RR Wilson, EV Regehr, M St Martin, DC Douglas, J Olson. 2015. Increased land use by Chukchi Sea polar bears in relation to changing sea ice conditions. PLoS One 10:e0142213.

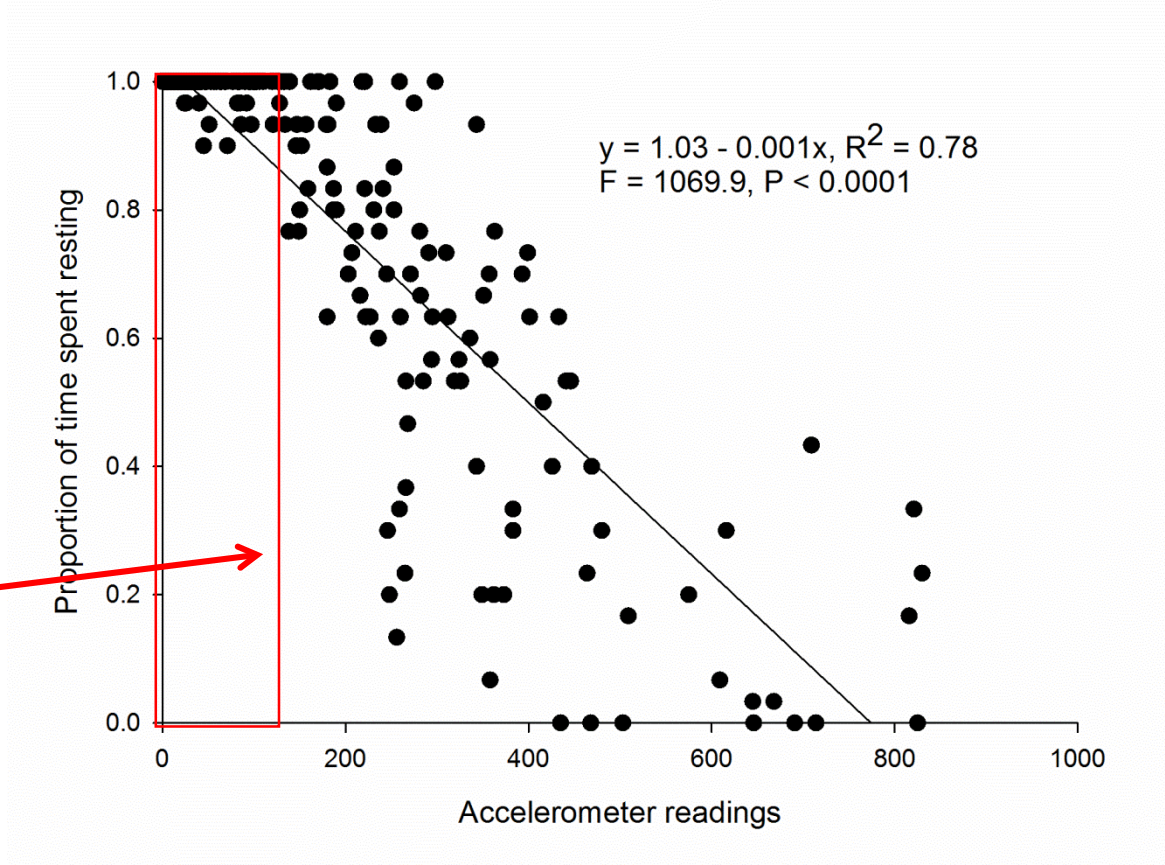
USGS
science for a changing world

What are the consequences of bears spending more time on land?

USGS
science for a changing world

Activity sensor data suggest Chukchi Sea bears onshore are spending >90% of their time resting

Aug-Oct all accelerometer readings < 150



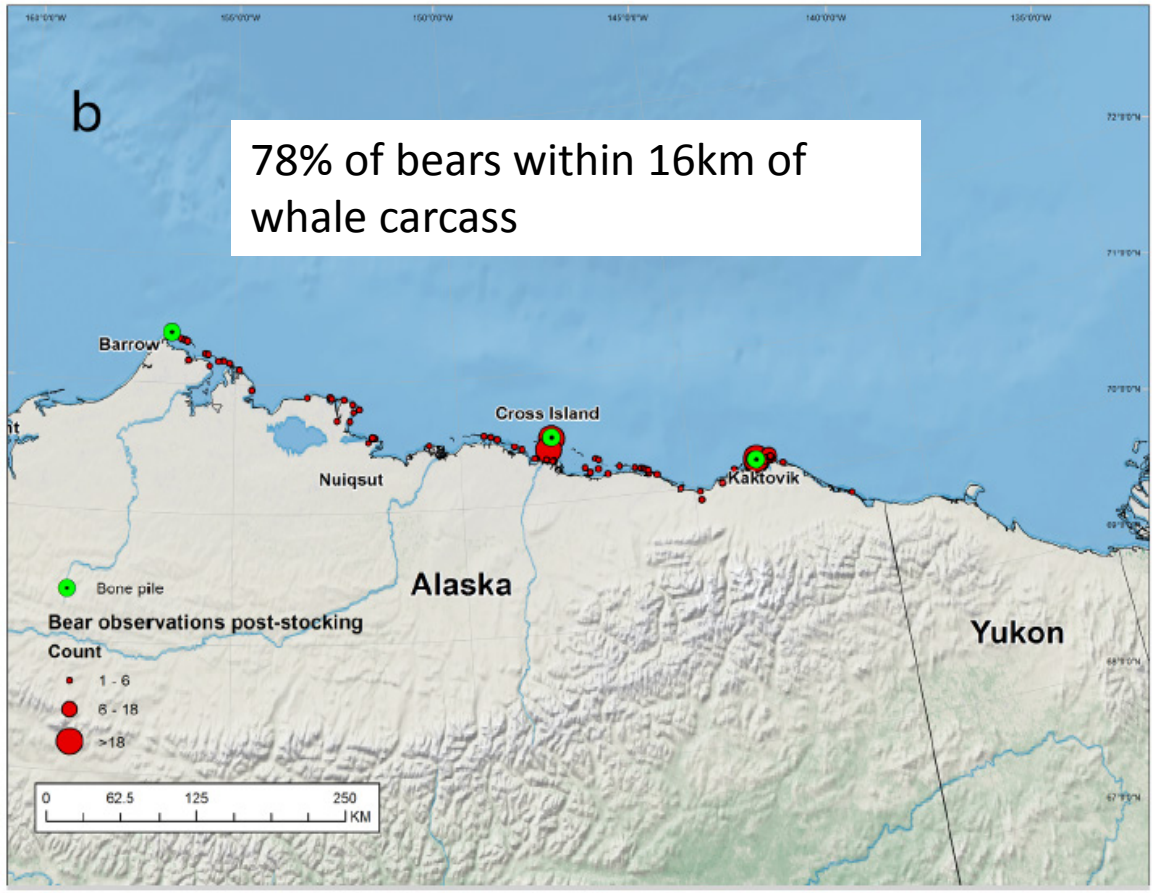
Ware JV, KD Rode, AM Pagano, JF Bromaghin, CT Robbins, JA Erlenbach, HT Jansen (2015) Validation of mercury tip-switch and accelerometer activity sensors for identifying resting and active behaviors in bears. Ursus 26:86-96.

USGS
science for a changing world

Whereas in the southern Beaufort bears are feeding on bowhead whale remains

c/o US Fish and Wildlife Service

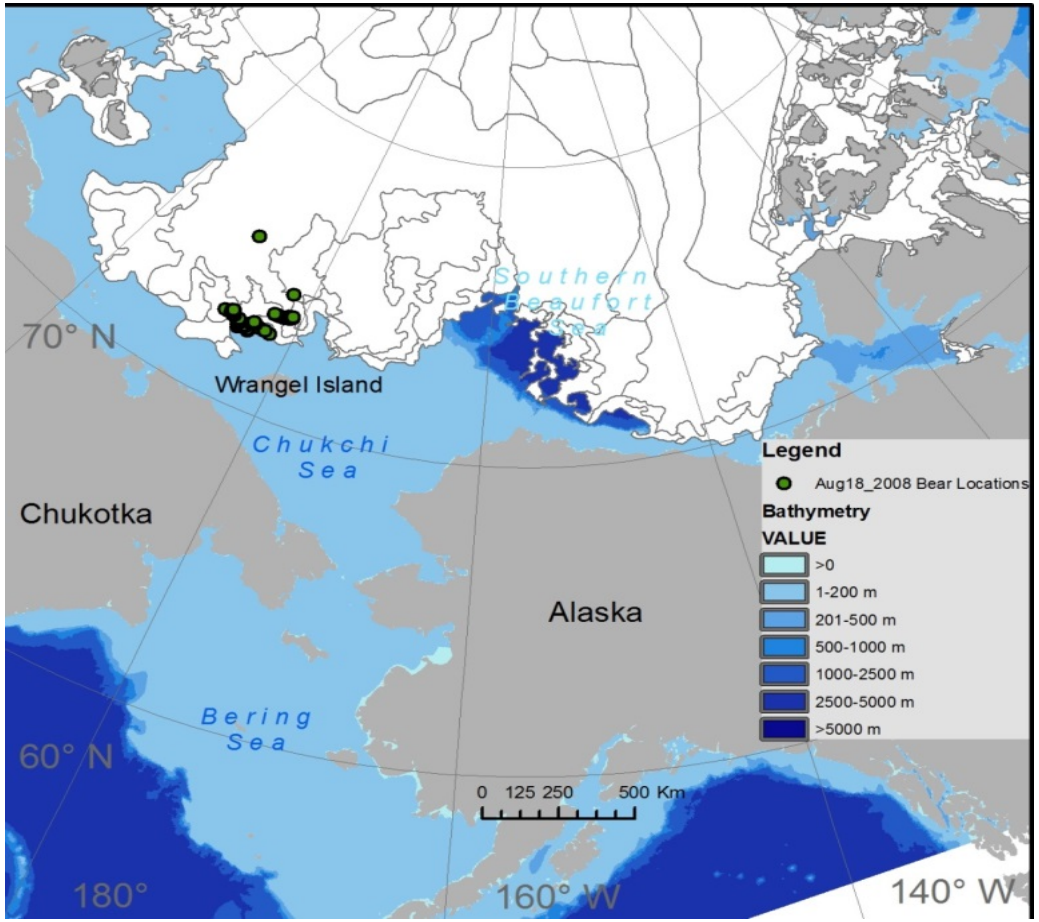
Atwood TC, E Peacock, MA McKinney, K Lillie, RR Wilson, DC Douglas, S Miller, P Terletzky (2016) Rapid environmental change drives increased land use by an Arctic marine predator. PLoS One 11:e0155932.

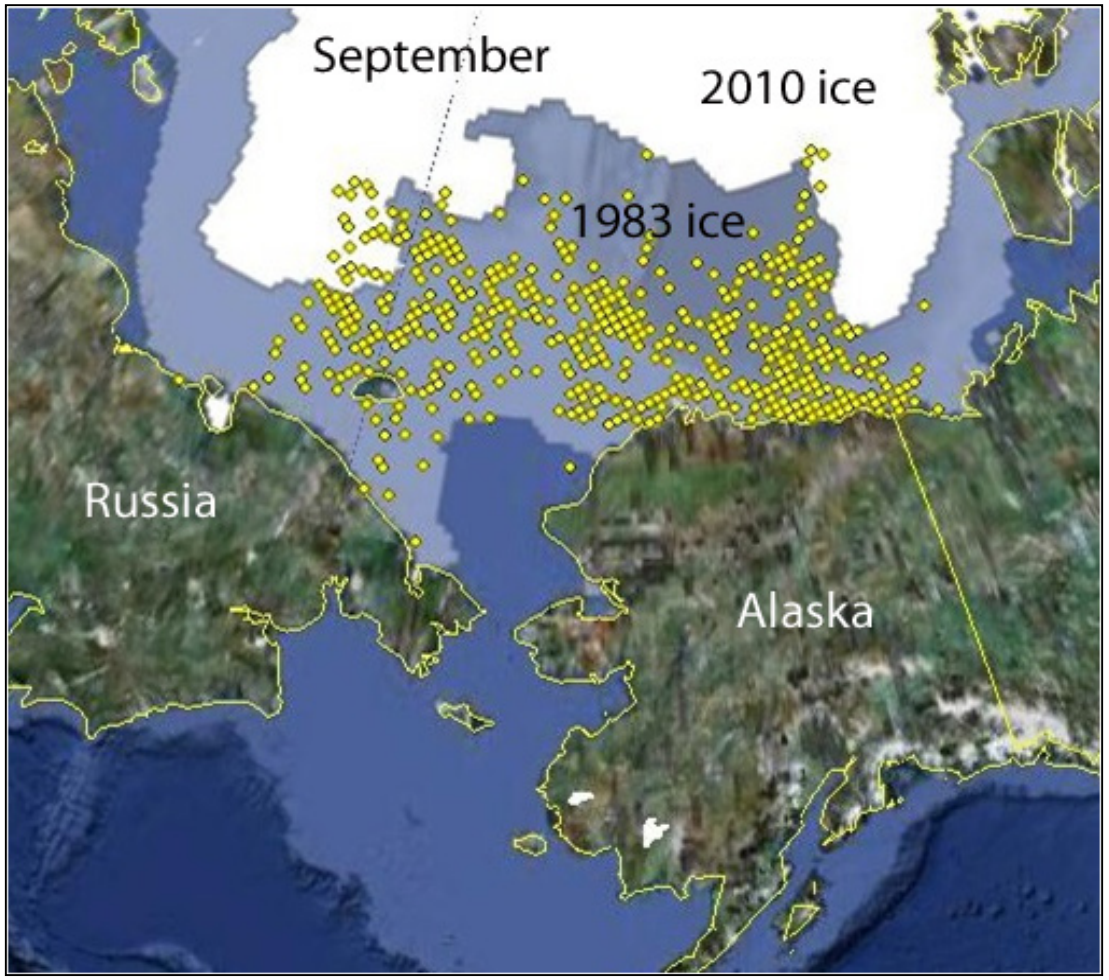


Represents 13% of the total population visiting whale carcasses

USGS
science for a changing world

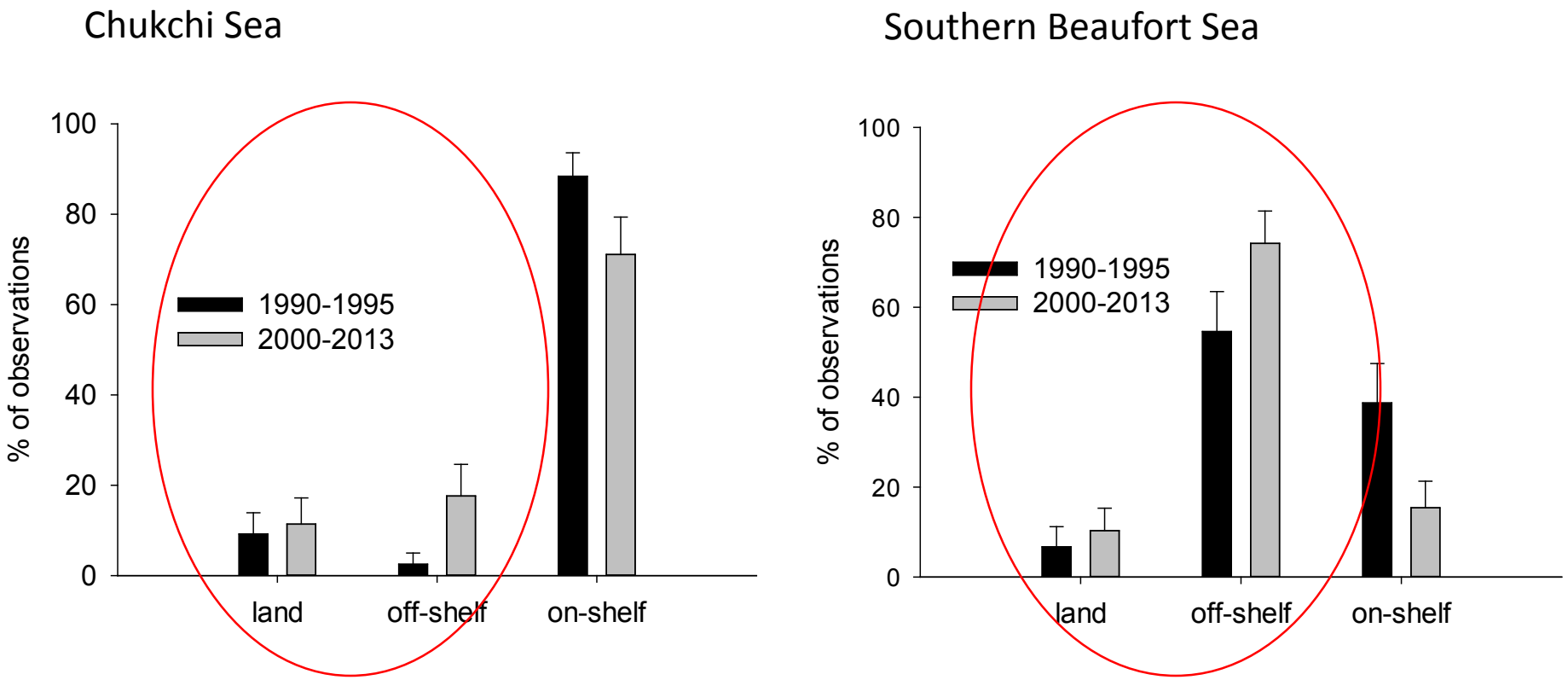
SUMMER: But the majority of bears in both subpopulations summer on the sea ice





USGS
science for a changing world

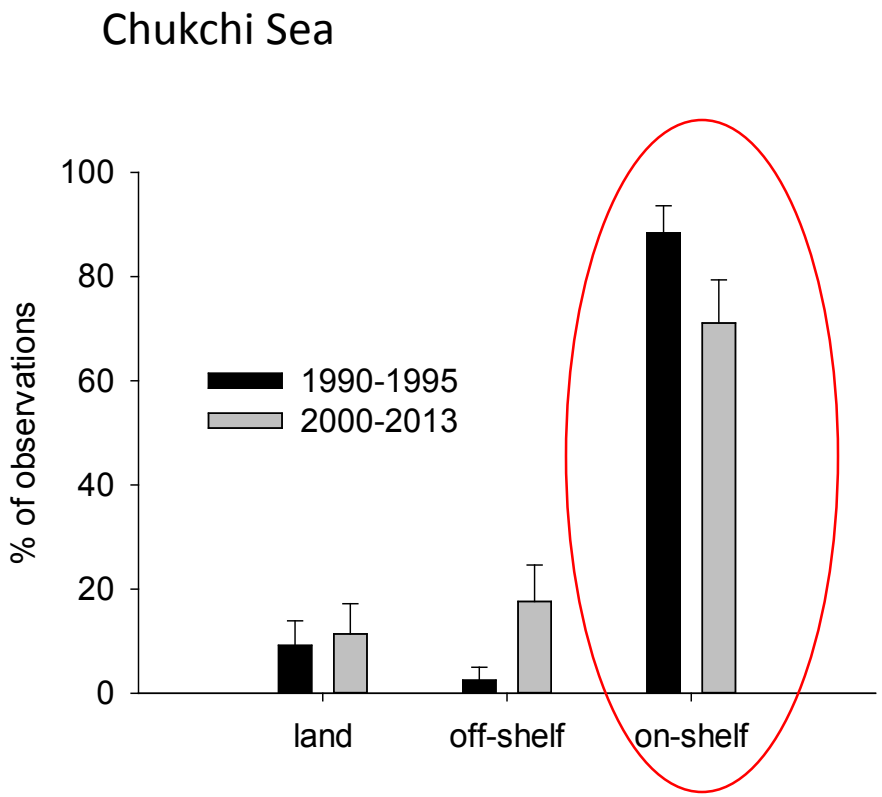
Both subpopulations have increased use of land and sea ice habitat off the continental shelf in recent years

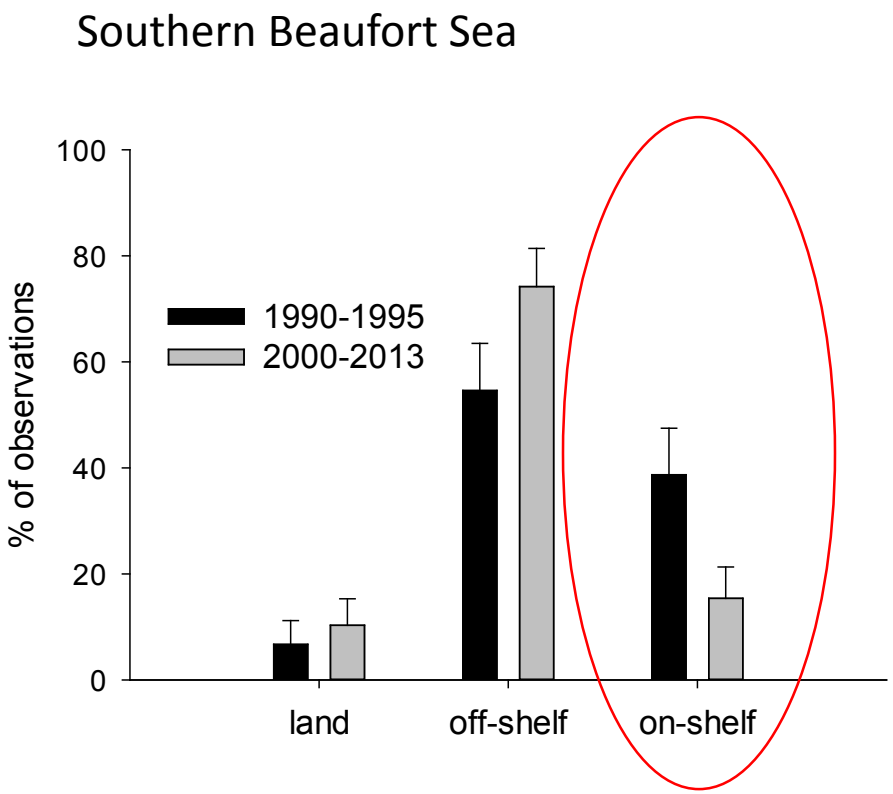


Ware JV, KD Rode, JF Bromaghin, DC Douglas, RR Wilson, EV Regehr, SC Amstrup, GM Durner, AM Pagano, J Olson CT Robbins, HT Jansen (2017) Summery activity in response to habitat degradation in the Chukchi and Beaufort Seas. Oecologia: in review.

USGS
science for a changing world

Chukchi Sea bears use ice habitats over the continental shelf much more frequently than Southern Beaufort bears during the summer



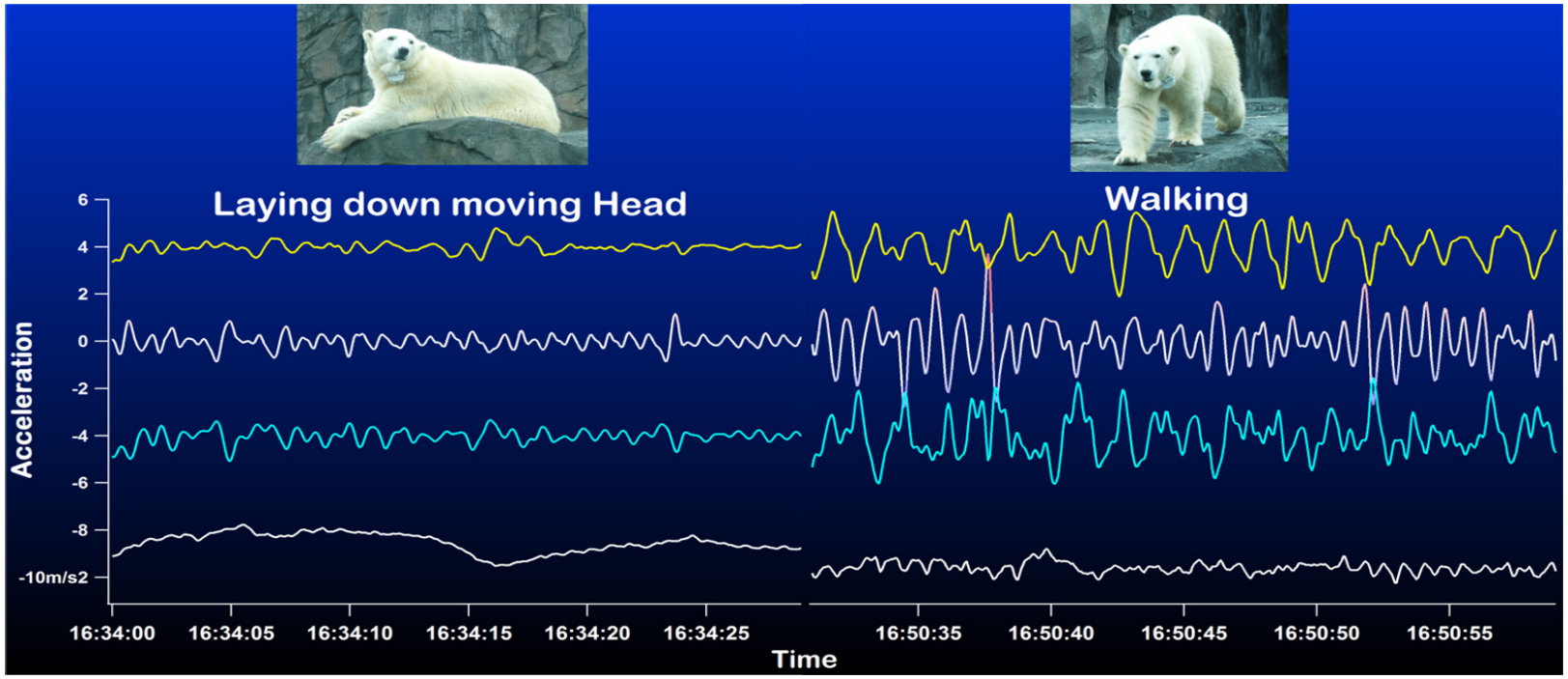


Ware JV, KD Rode, JF Bromaghin, DC Douglas, RR Wilson, EV Regehr, SC Amstrup, GM Durner, AM Pagano, J Olson CT Robbins, HT Jansen (2017) Summery activity in response to habitat degradation in the Chukchi and Beaufort Seas. Oecologia: in review.

USGS
science for a changing world

Developing new methods to determine bear behavior on the ice

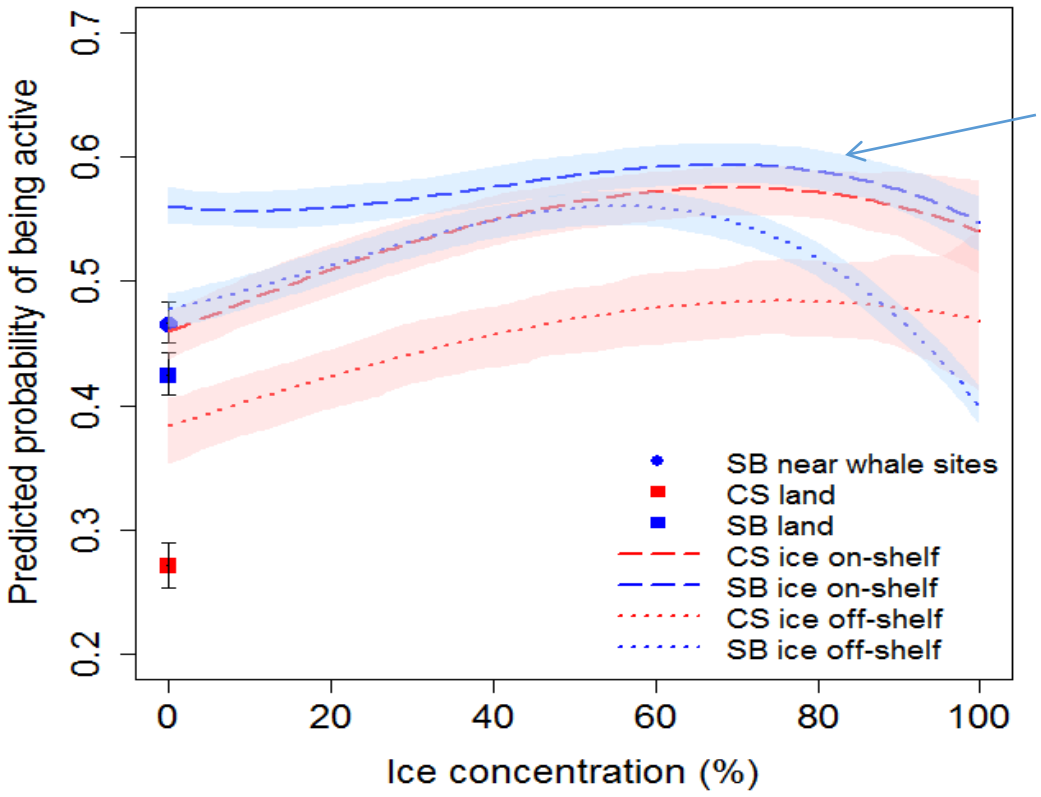
Validate new collar-based sensors



Ware et al. 2015; Pagano et al. in press

USGS
science for a changing world

Bears reduce their activity levels when on land and ice off the continental shelf



Bears MOST ACTIVE on Ice over productive continental shelf

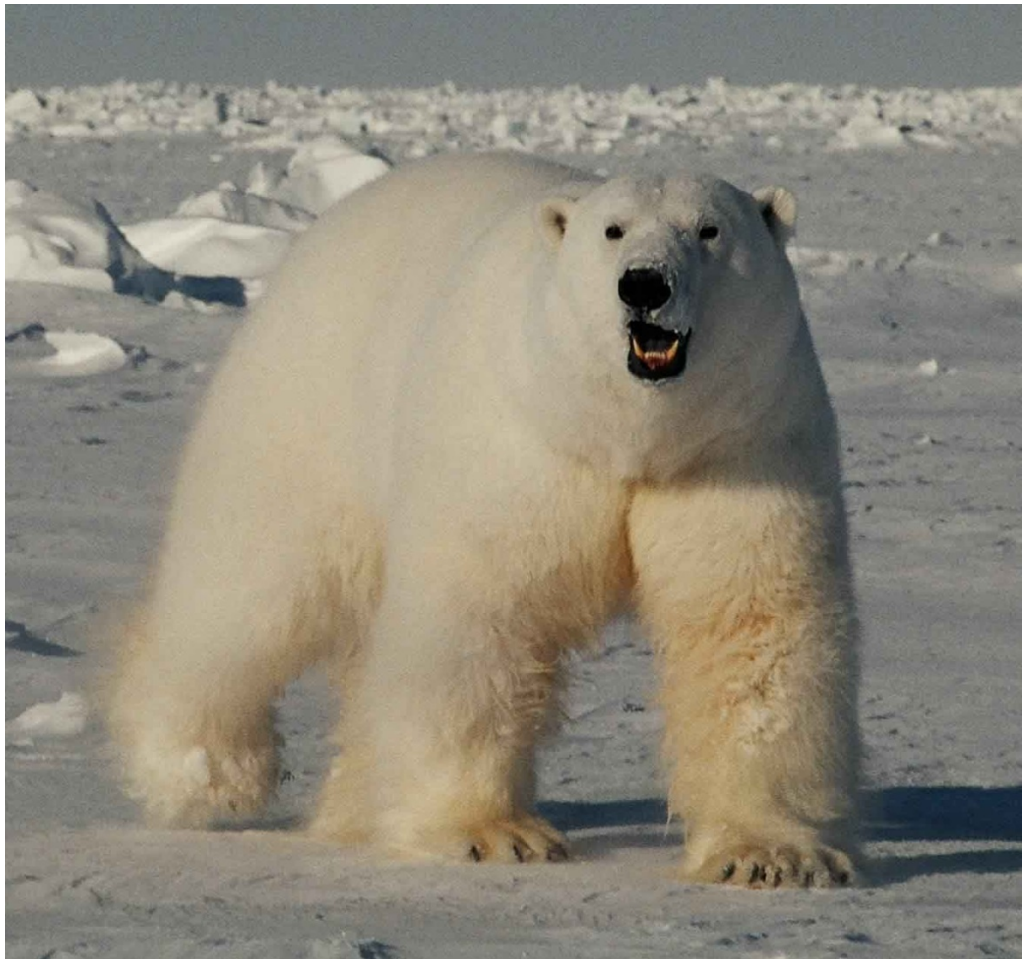
- CS polar bears decrease activity in suboptimal habitats
- SB bears maintain higher activity levels on ice off the shelf

Ware JV, KD Rode, JF Bromaghin, DC Douglas, RR Wilson, EV Regehr, SC Amstrup, GM Durner, AM Pagano, J Olson CT Robbins, HT Jansen (2017) Summery activity in response to habitat degradation in the Chukchi and Beaufort Seas. Oecologia: in review.

USGS
science for a changing world

Southern Beaufort bears are fasting during the summer on ice off the continental shelf

- >70% of SB bears remain with sea ice during the summer
- Time is spent largely over deep water



Whiteman JP, HJ Harlow, GM Durner, R Anderson-Sprecher, SE Albeke, EV Regehr, SC Amstrup, M Ben-David (2015) summer declines in activity and body temperature offer polar bears limited energy savings. Science 349:295-298.

SUMMER: Increased frequency of long distance swims

What are the energetic costs of swimming versus walking?

Are bears expending more energy in search of prey and good habitat?

Pagano AM, GM Durner, SC Amstrup, KS Simac, GS York (2012) Long-distance swimming by polar bears of the southern Beaufort Sea during years of extensive open water. Can Journal of Zoology 90:663-676.

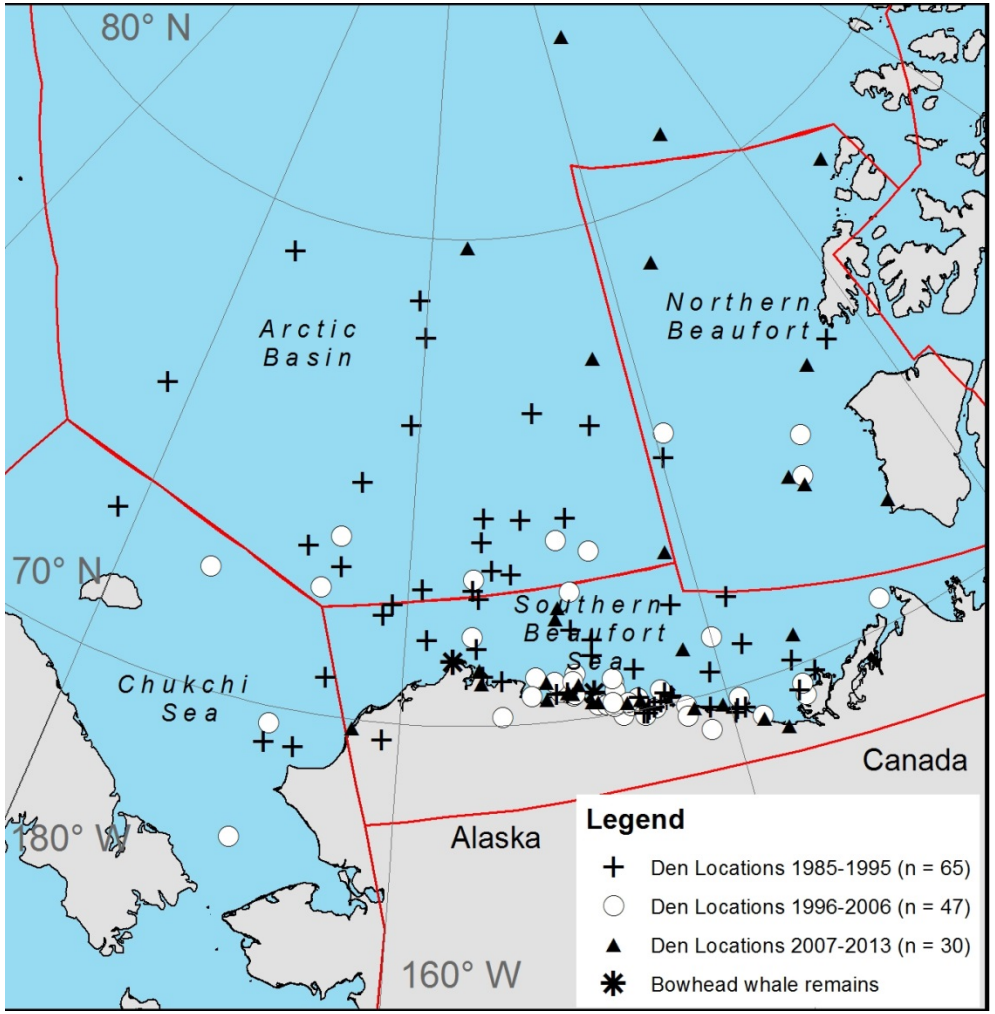
Energetic costs of swimming

USGS
science for a changing world

OREGON ZOO

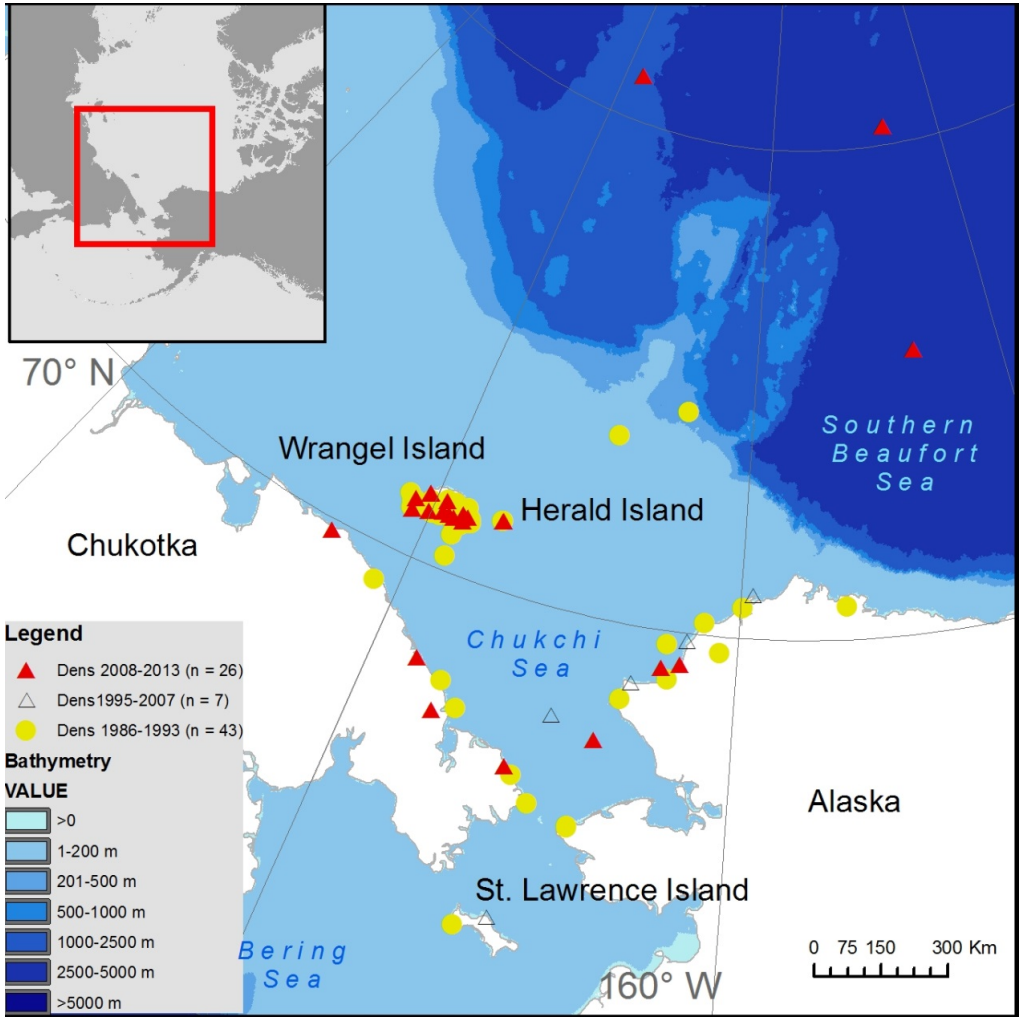
WINTER: Changes in denning habitat

Southern Beaufort Sea 55% den on land



Fischbach et al. 2007; Olson et al. in review

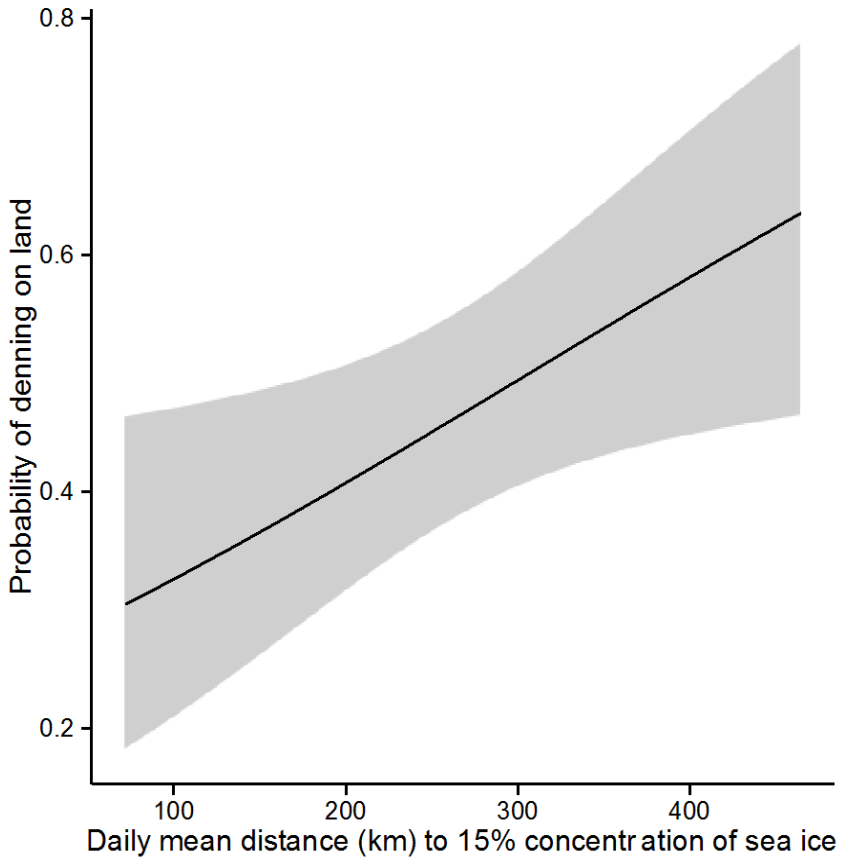
Chukchi Sea 84% den on land



Rode et al. 2015

Timing of sea ice retreat determines whether bears den on land and where they den

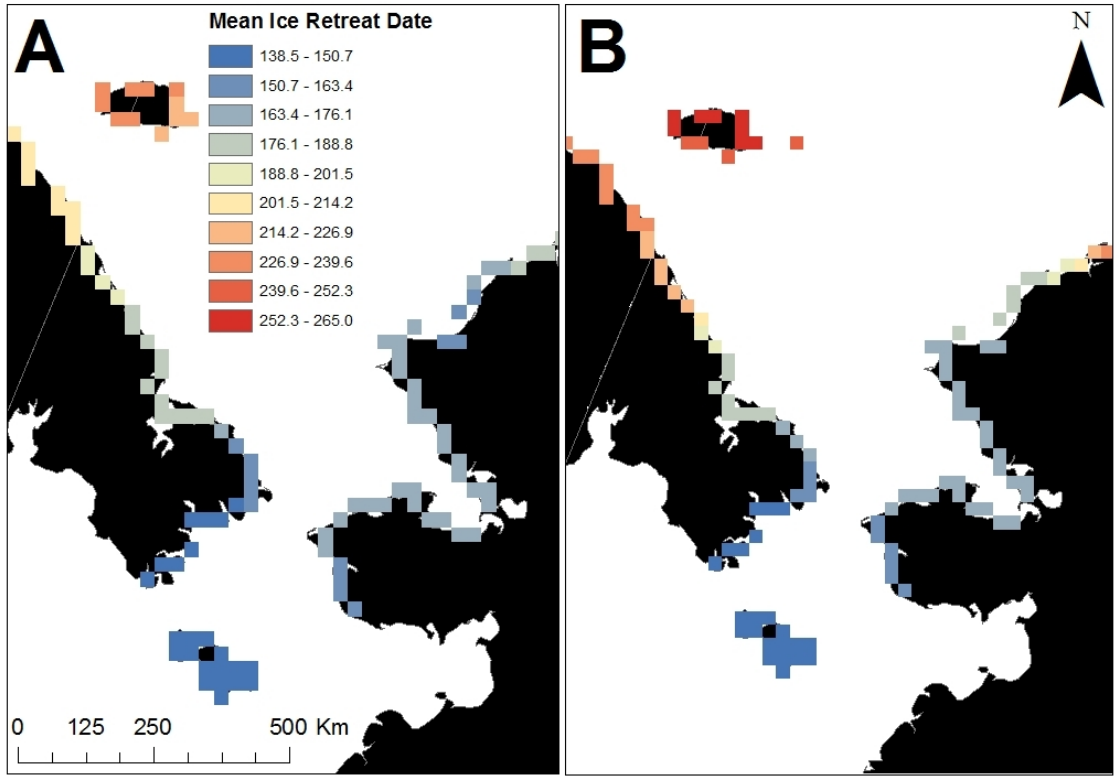
Southern Beaufort Sea



Olson et al. in review

Chukchi Sea

2008-2013 1986-1995



Rode et al. 2015

Land-based denning may be associated with increased cub survival

- Bears in land-based dens spent 13 days longer in the den than sea ice-based dens
- Emergence date linked to cub survival
  - Bears that denned and were later observed with cubs emerged 17 days later than bears that denned that were later observed without cubs.
- CS bears emerged from dens 10 days later than SB bears

USGS
science for a changing world

Olson J, KD Rode, D. Eggett, E Regehr, T Atwood, RR Wilson, M St Martin, G Durner (In prep) Polar bear denning phenology in the southern Beaufort and Chukchi Seas.

Denning substrate linked to summer substrate use

- Denning females also increasingly summered on land
- Spent 20 more days on land during the denning period

USGS
science for a changing world

What have we learned?

Both populations

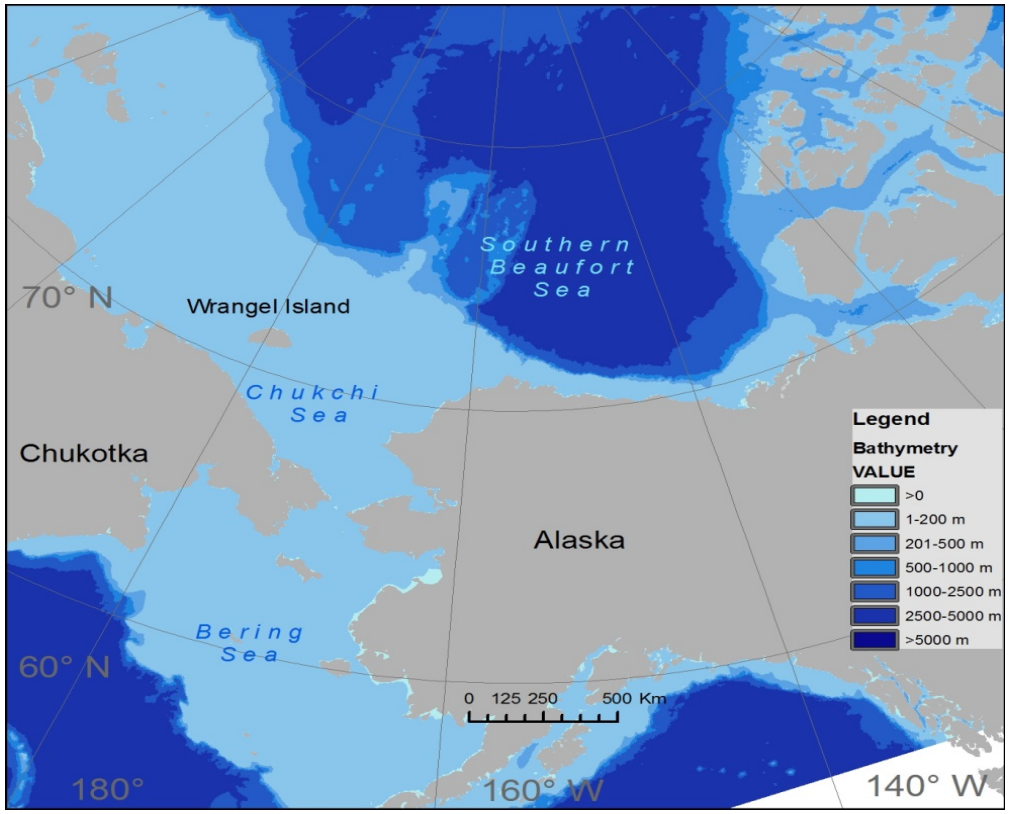
- Increased summer land use
- More movement to compensate for drift

Southern Beaufort

- More spring fasting
- More use of off-shelf habitats in the summer
- Earlier den emergence
- Increased swimming

Chukchi Sea

- Maintaining body condition & spring access to food
- Resting on land
- Lack of change in seal productivity
- Large, productive continental shelf



- Low productivity
- Narrow continental shelf
- Evidence of ecosystem change that may be affecting prey abundance

USGS
science for a changing world

What have we learned?

Management

SB ecosystem change simultaneous to sea ice loss
Less productive system to buffer SB population from effects of sea ice loss
SB Land use important for habitat protection and bear-human interactions
Wrangel Island as a key summering and denning habitat

Long-term projections

Importance of ecological productivity
Response of lower trophic levels
Bathymetry
New mechanisms into Bayesian projection model

Future research: Which behaviors are linked to vital rates?

USGS
science for a changing world

US Fish and Wildlife Service
North Pacific Research Board
North Slope Borough
State of Alaska – Coastal Impact Assessment Program Grant
Village of Point Hope
TeckAlaska, Inc
Selawik National Wildlife Refuge
Detroit Zoological Association
National Fish and Wildlife Foundation
Alaska, San Diego, and Oregon Zoos
Washington State University
Polar Bears International
International Bear Association