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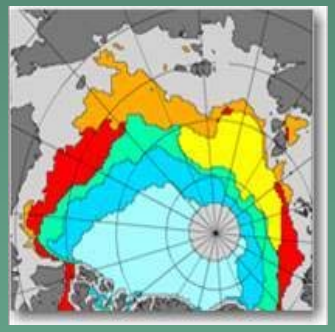
science for a changing world

Marine Mammals and Diminishing Sea Ice



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

Objectives of Presentation

- Overview of the most common sea ice-associated marine mammals of the U.S. Arctic
- Speculate on how diminishing sea ice may effect these species
- Focus in on Pacific walrus and polar bears

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Why are we interested in Arctic marine mammals?

- Arctic undergoing rapid change
- They are symbols of the Arctic and important subsistence resources
- They integrate change at lower trophic levels
- Many species associated with sea ice – proxies for the status of the arctic ecosystem
- Changing legal status

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Bearded Seal

Erignathus barbatus

Ringed Seal

Phoca hispida

Spotted Seal

Phoca largha

Ribbon Seal

Histriophoca fasciata

- **Effects of Climate Change on ice seals are unclear**
- **Potential sensitivities include:**
  - **Give birth, nurse pups, mate, and molt their coats on sea ice**
  - **Ringed seals create sub-nivean lairs to nurse pups, have relatively long lactation period, and tend to follow sea ice**
  - **Bearded seals are benthic feeders – access the sea floor from sea ice over continental shelf**
  - **Modifications to trophic pathways**

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NOAA

Beluga Whale

Delphinaptera leucas

Bowhead Whale

Balaena mysticetus

Photo by K. Laidre

- **Effects of Climate Change on “ice” whales are unclear**
- **Potential sensitivities include:**
  - **For bowhead whales potential competition with gray whales if they move into Beaufort Sea**
  - **Modifications to trophic pathways – competition for zooplankton with invading fish species?**
  - **Vessel strikes from large vessels in narrow leads?**

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NOAA

Status under U.S. Endangered Species Act

- Polar bears - listed rangewide as threatened
- Pacific walrus – petitioned to list; status review underway
- Ice seals – petitioned to list; ribbon seal – not warranted finding – 12/08; bearded, spotted and ringed seal – status reviews underway
- Beluga whale – Cook Inlet stock (outside the Arctic) listed as endangered
- Bowhead whale - endangered

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FOCUS ON PACIFIC WALRUS AND POLAR BEARS

Integrate benthic ecosystem

Integrate pelagic ecosystem

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Walrus Life History – Dependent on seafloor for feeding

- Feed on bottom invertebrates, mostly clams
- Forage on productive continental shelf in waters < 60 m depth
- Males up to ~2 tons
- Very gregarious
- Long-lived ~30 yrs
- Reproductive rate low – only half that of other pinnipeds

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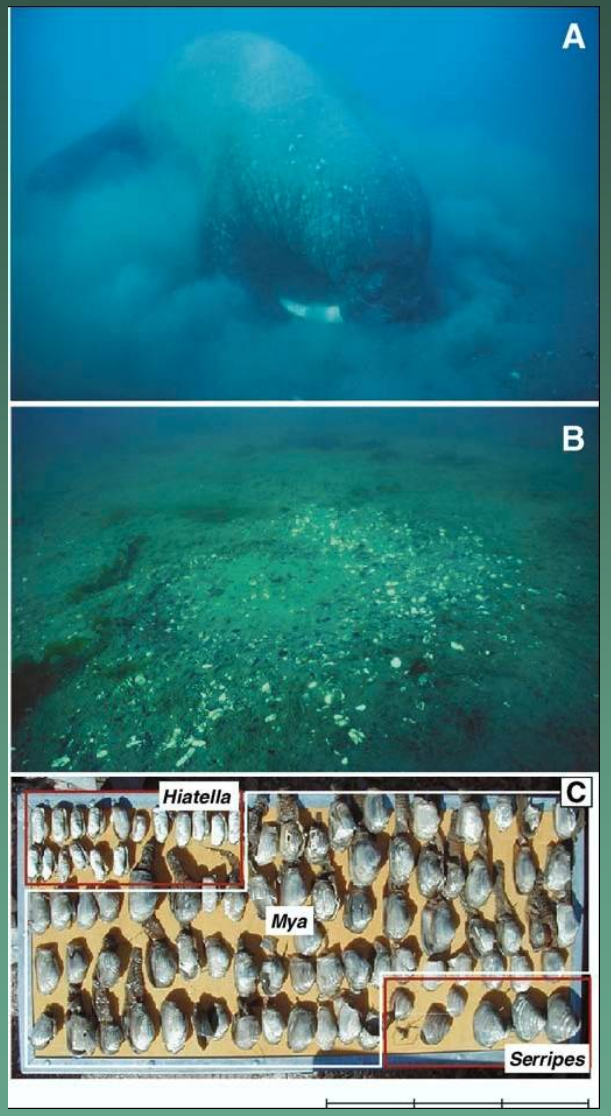
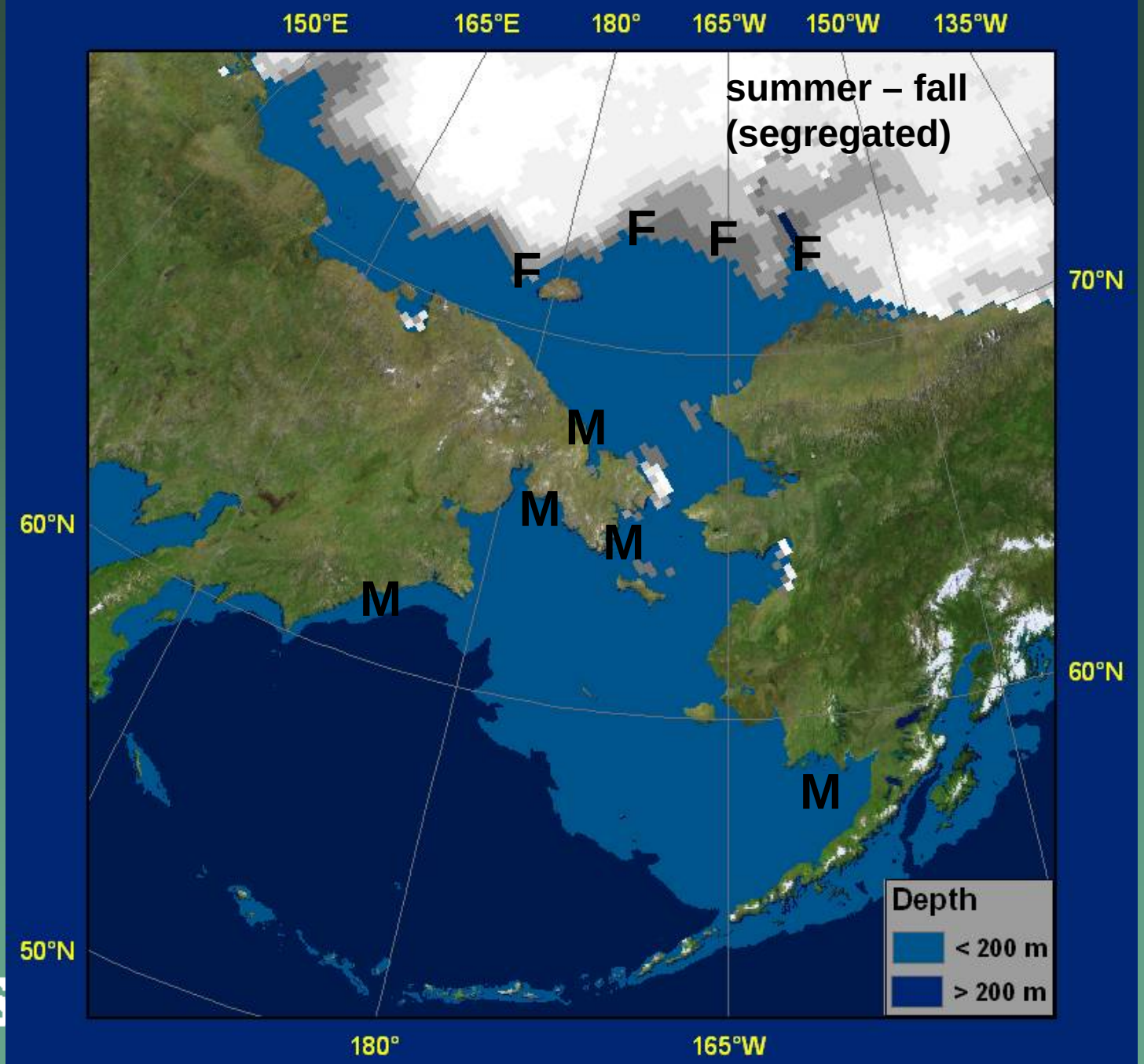
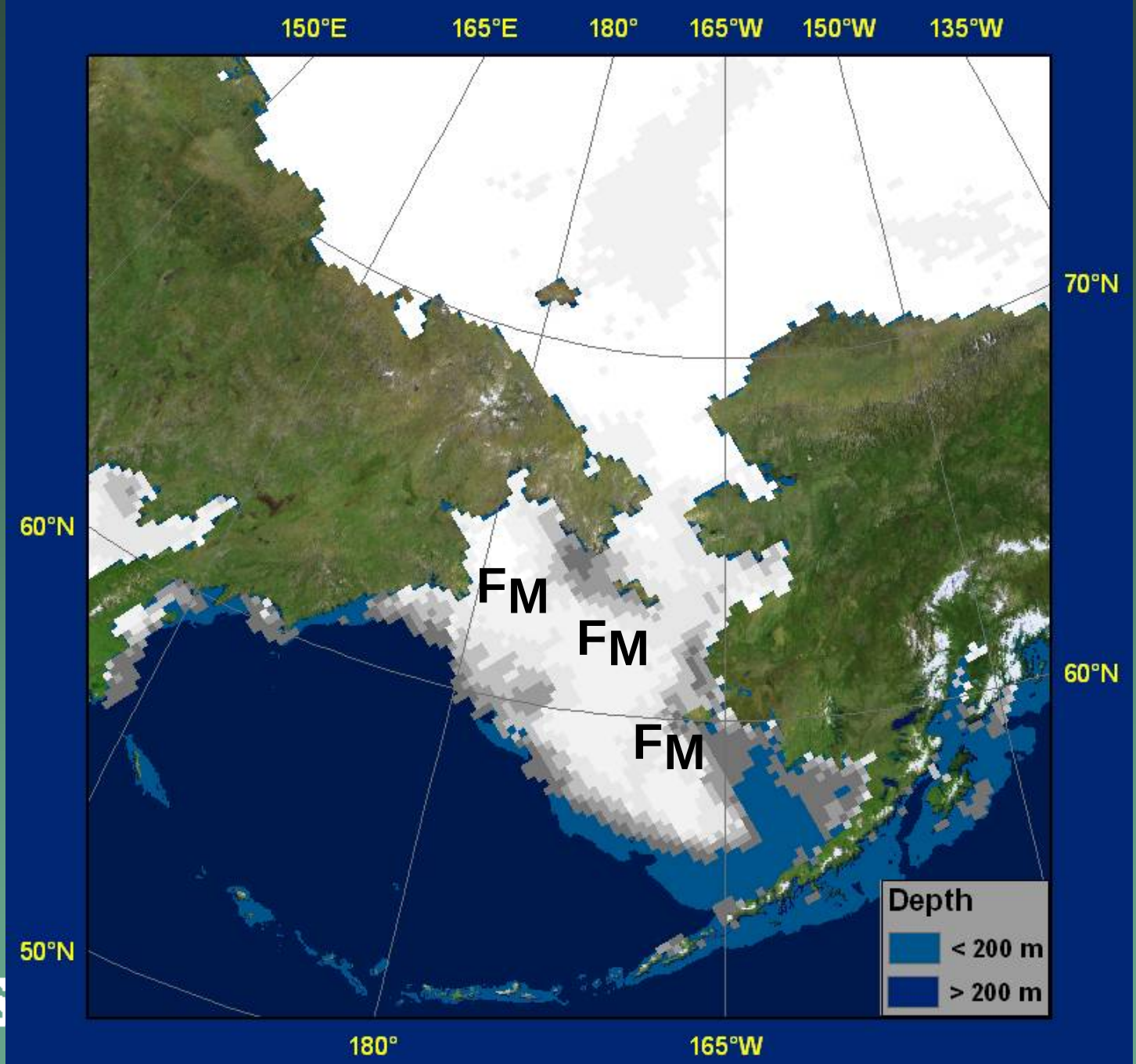


Born et al. 2003. Polar Biology 26:348-357


150°E
165°E
180°
165°W
150°W
135°W
summer – fall
(segregated)
F
F
F
F
70°N
M
M
M
M
60°N
60°N
M
50°N
Depth
< 200 m
> 200 m
180°
165°W


150°E
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FM
Depth
< 200 m
> 200 m
180°
165°W

Females with calves on beaches

A. Kochnev

Ongoing Research on Pacific walrus

- Foraging dynamics in the Bering and Chukchi seas
- Sea ice and walrus movement patterns in the Bering Sea using Radarsat imagery (with Ron Kwok, NASA)
- Population modeling
- Bayesian net modeling to help forecast response of Pacific walrus to environmental change
- and

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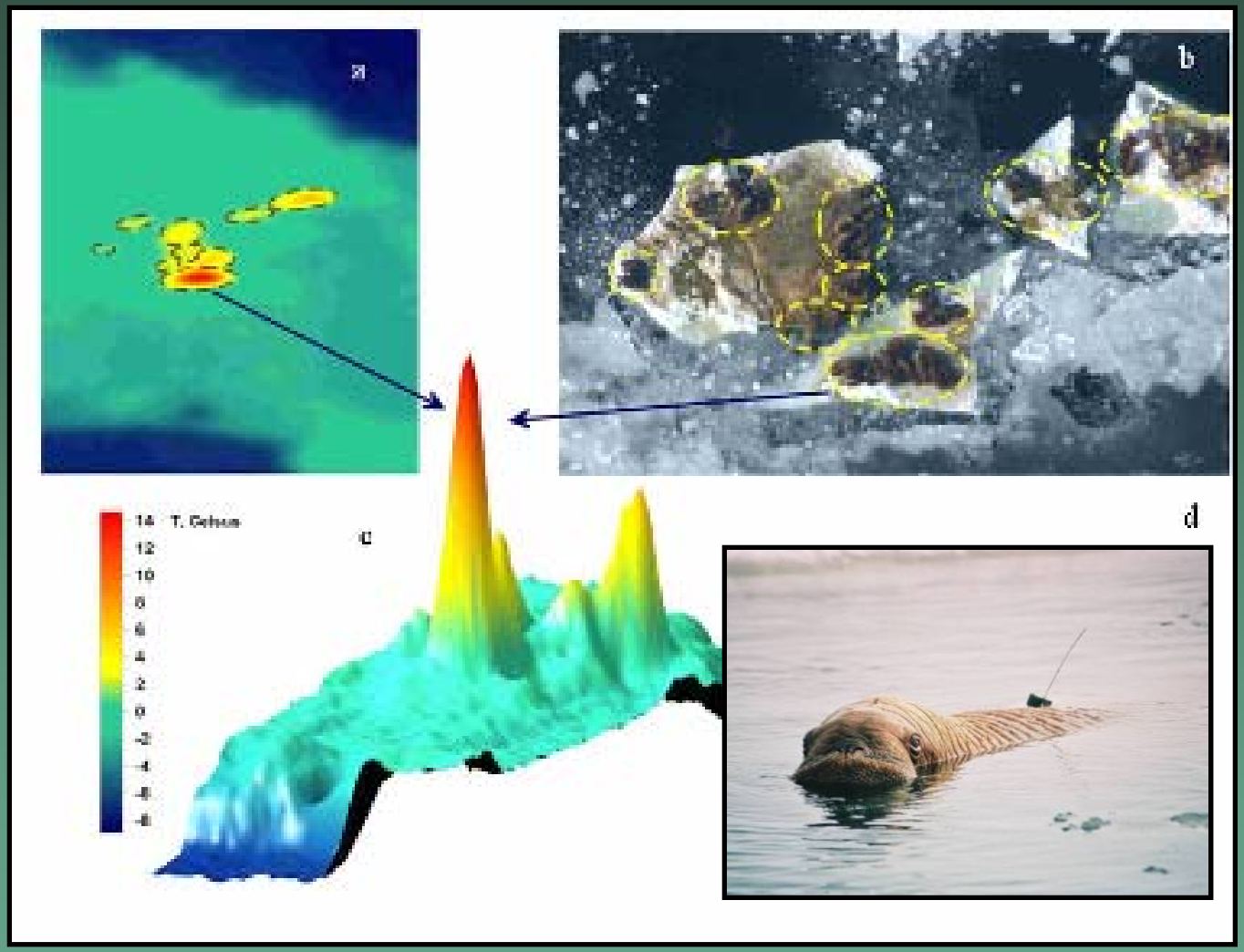
Completion of analysis of 2006 Survey



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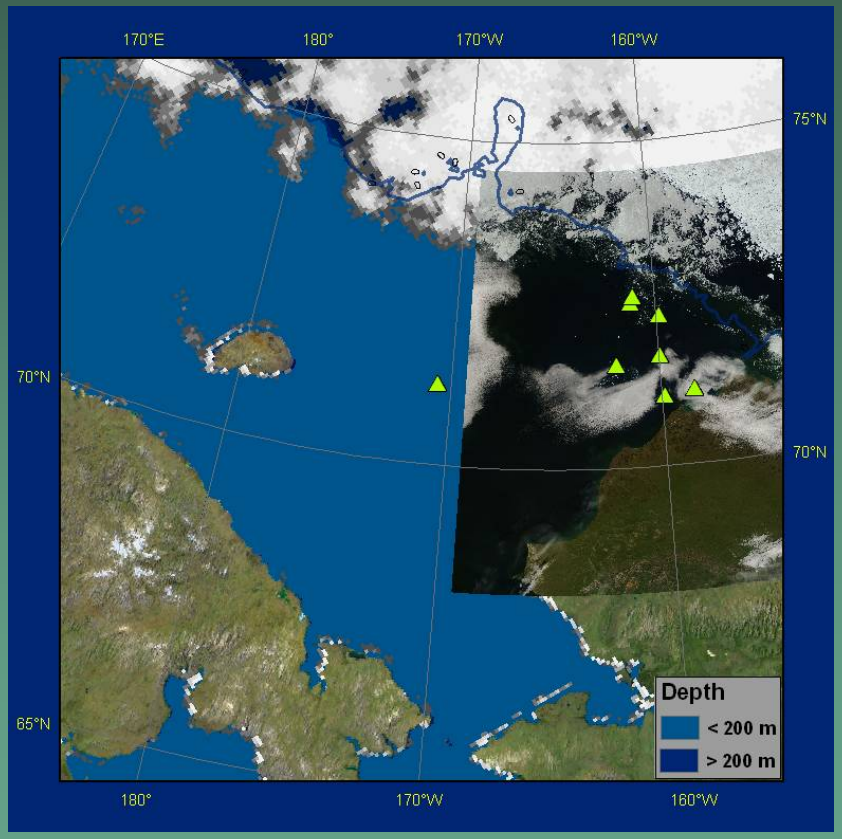
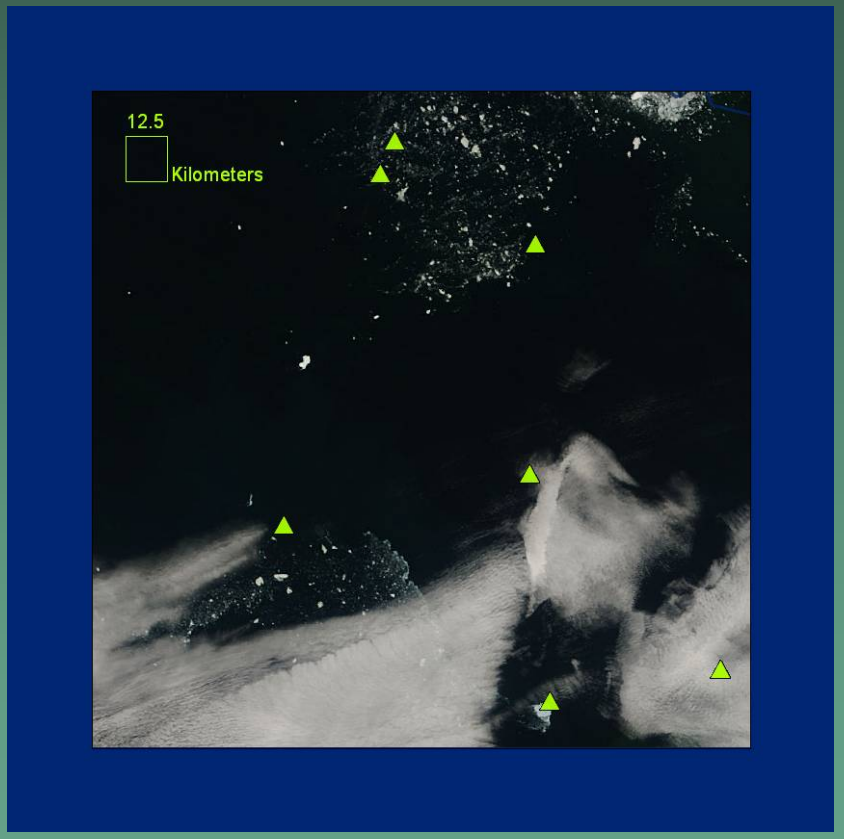
Walrus foraging dynamics in the Chukchi Sea

- And to study walrus foraging effort during summer ice minimum conditions
- Remnant ice over continental shelf important





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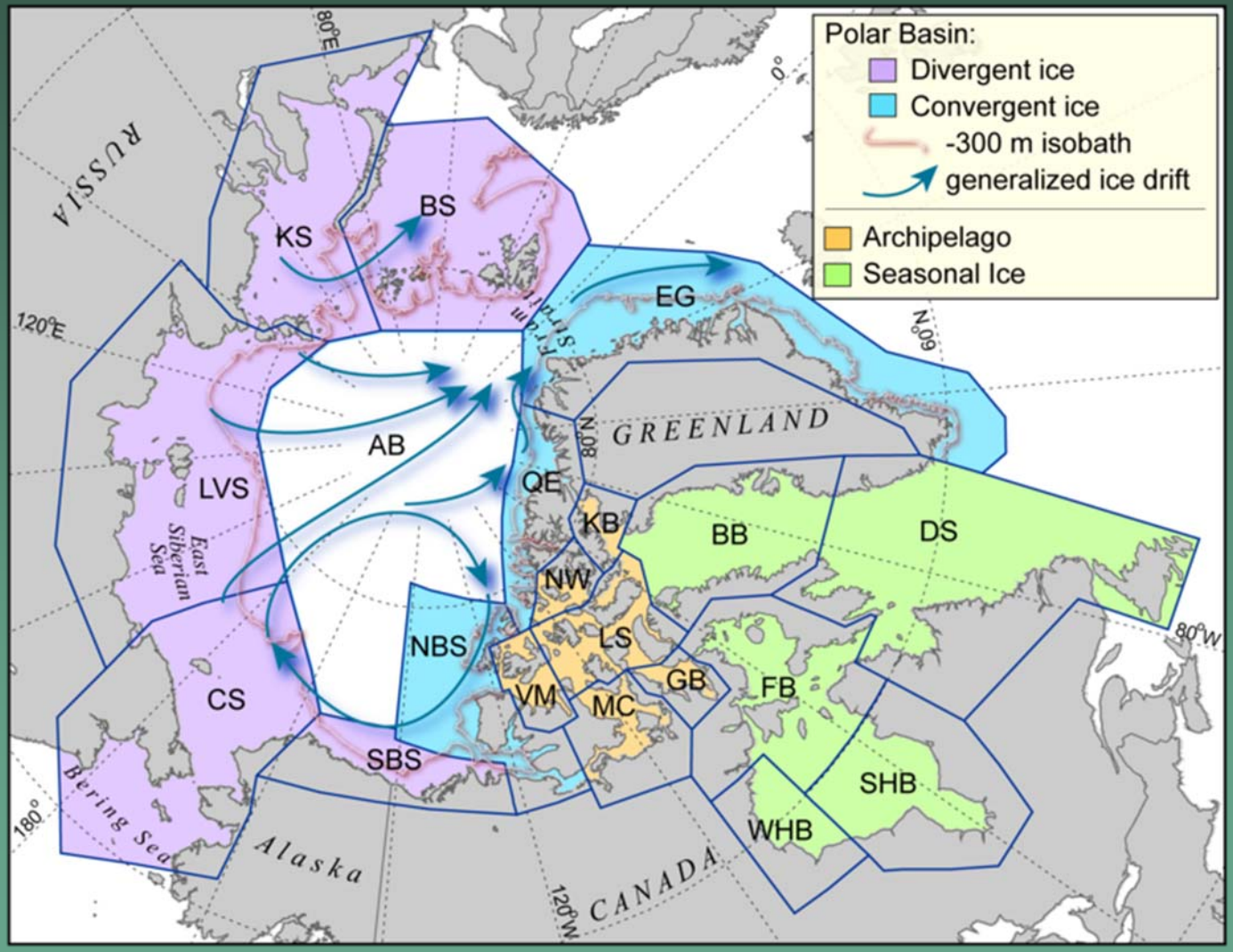
Polar Bear - Life history dependence on sea ice

- Foraging
- Reproduction

IUCN subpopulations, ice drift patterns, and ecoregions



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Life History – Highly Dependent on Sea Ice

- Long lived – up to 30 yrs
- Low reproductive rates
- Reproductive interval = 3 years
- Give birth in maternity dens on land and sea ice
- Feed almost exclusively on seals they catch on sea ice surface
- Top predator in a simple food chain

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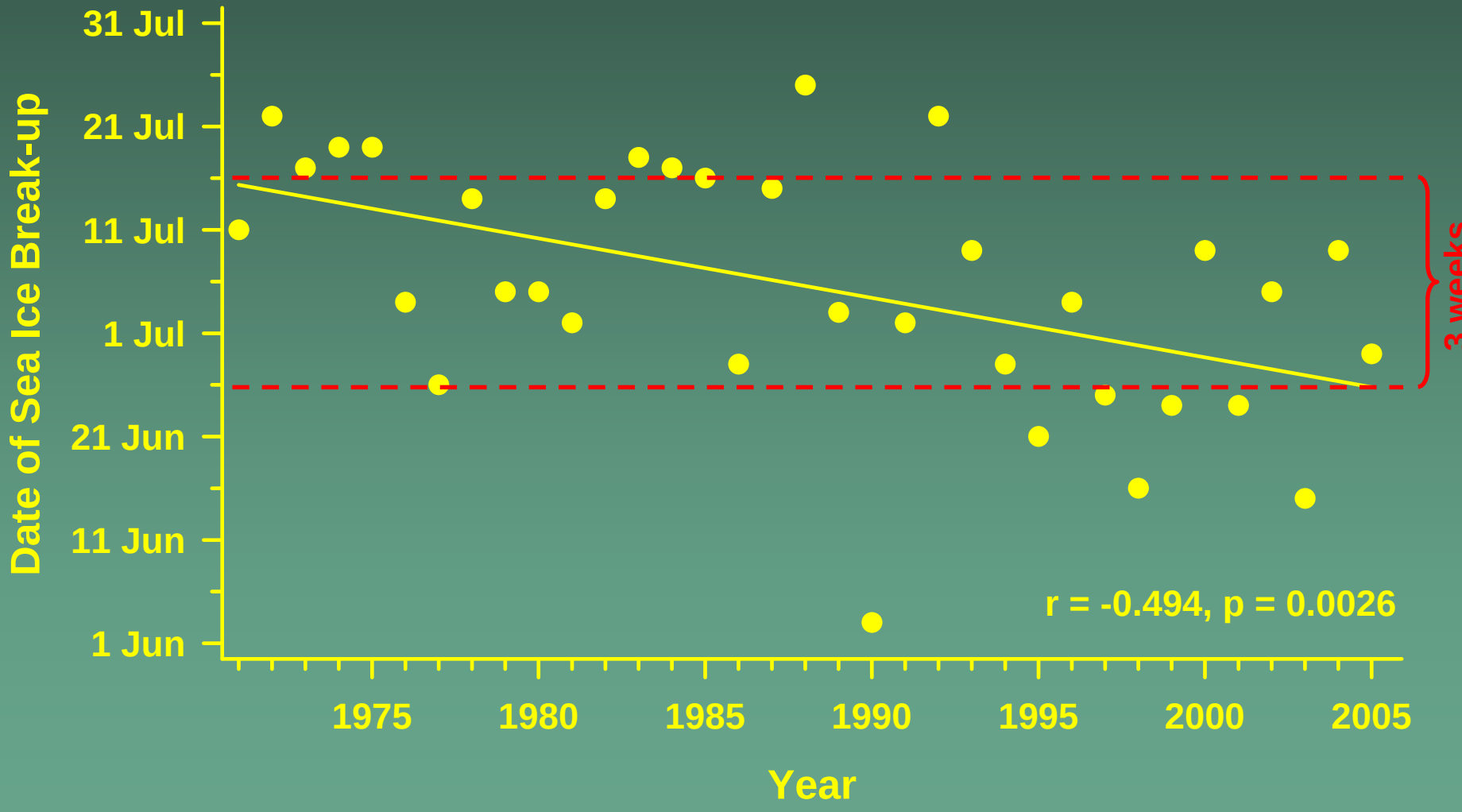
To see what changing ice means to bears let's first look at the southern most areas they occupy
Siberia
Arctic Ocean
(September 2005)
Record Minimum
Greenland
Mean
Summer
Minimum
North
Atlantic
Ocean
Pacific
Ocean
Alaska
Hudson
Bay
(http://NASA.GOV)

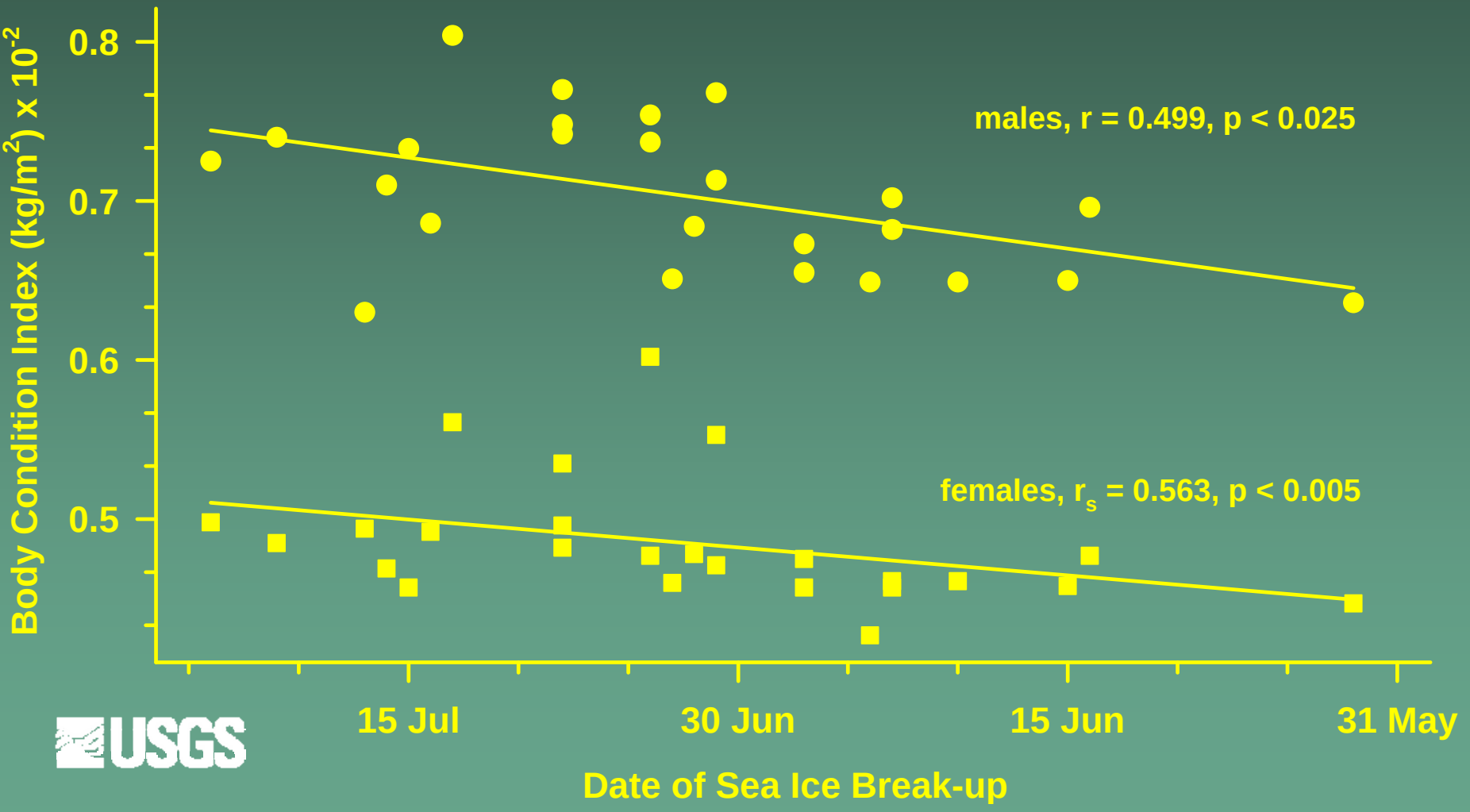
Timing of Break-up in Relation to Year, Western Hudson Bay, 1971-2005

(after Stirling et al. 1999, *Arctic* 52:294-306; Lunn & Stirling unpublished data)



Relationship between Date of Break-up and Body Condition Index, Western Hudson Bay, 1980-2004

(Stirling et al. 1999; Lunn & Stirling unpublished data)



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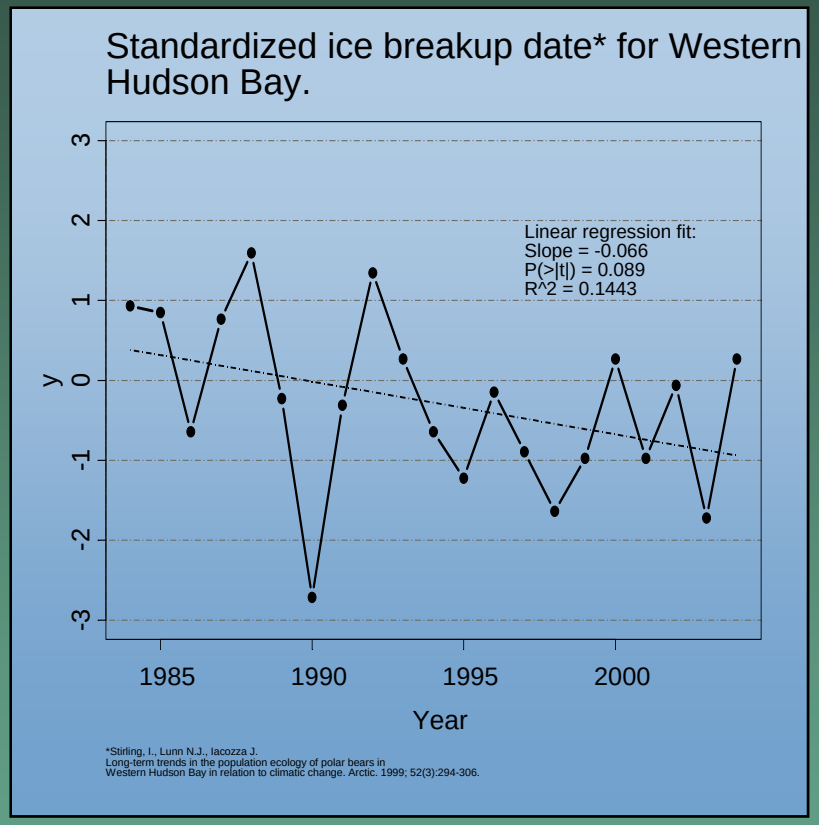
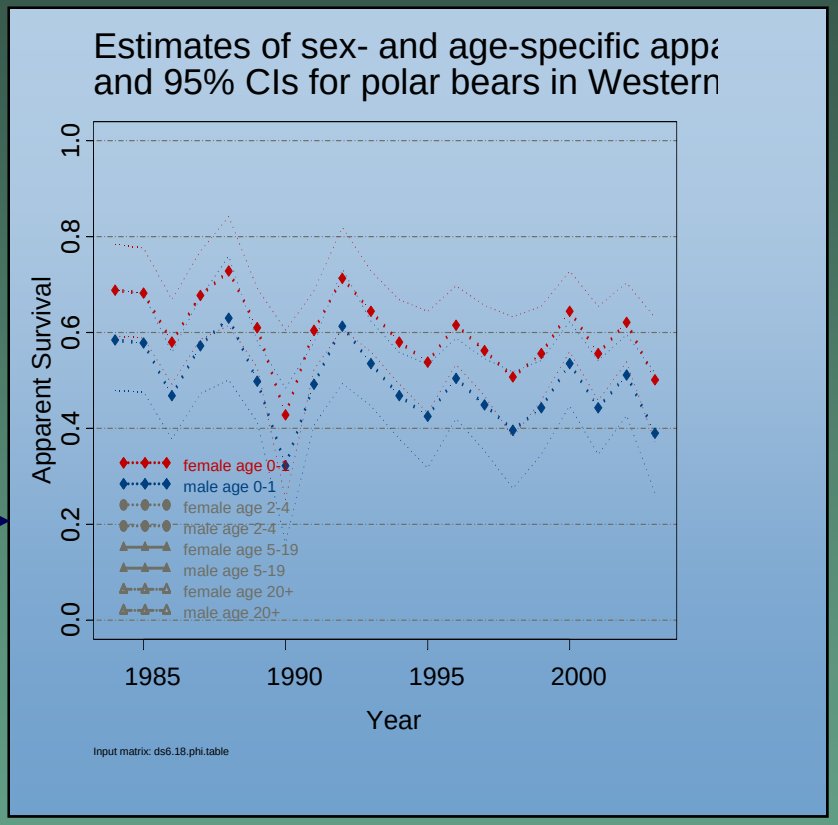
WHB population dynamics.

We found quantitative evidence for a correlation between early spring ice breakup and decreased polar bear survival.





$$\hat{\beta}_{ice} = 0.2977; 95\%\text{CI} = 0.1258, 0.4696$$

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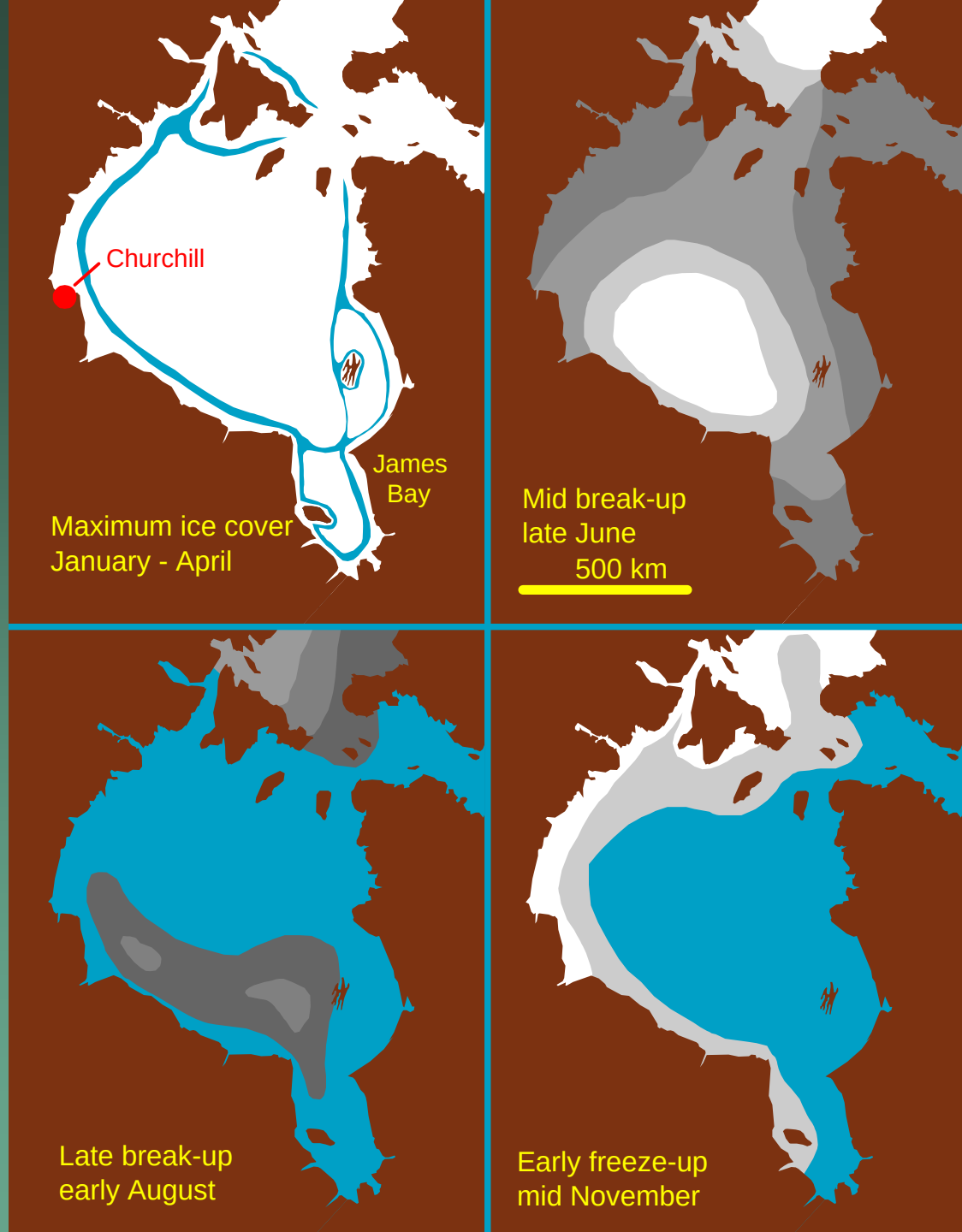
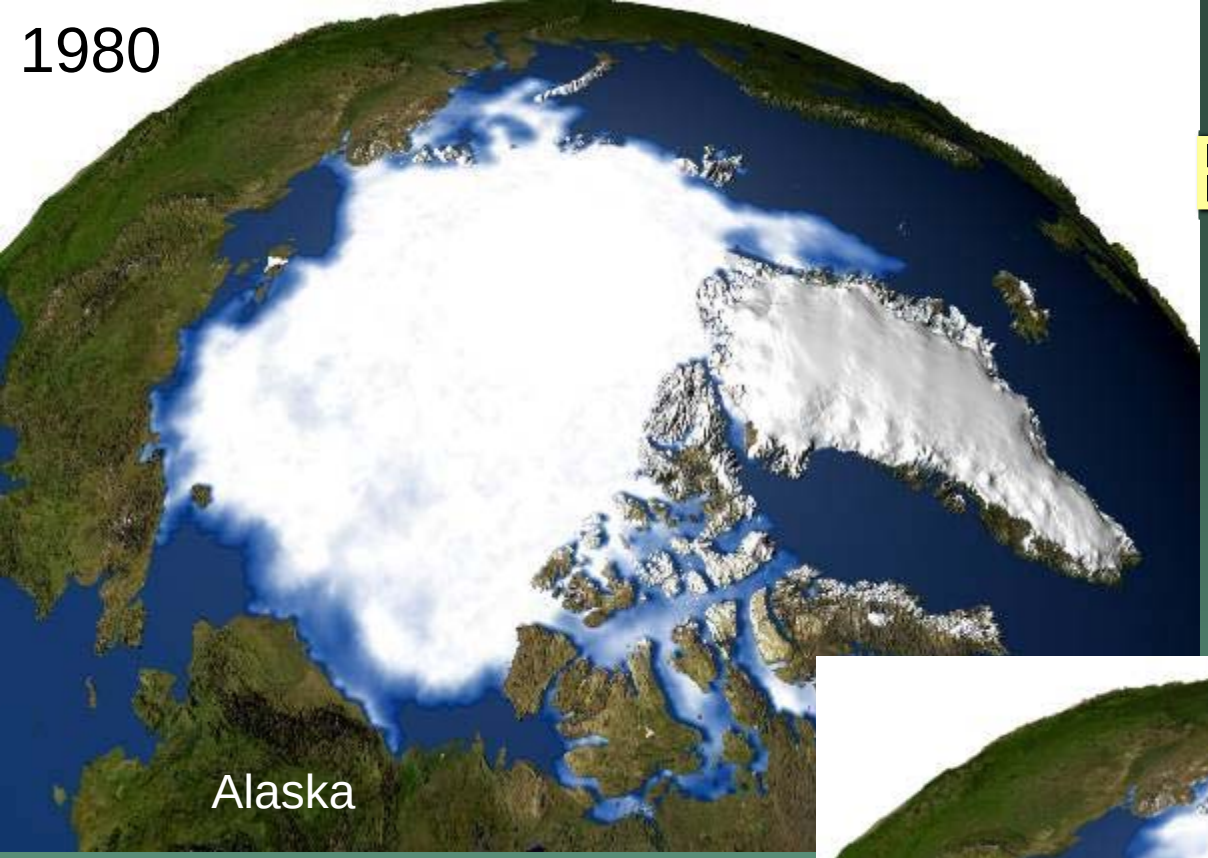
Breakup 1 week early $\approx$ 3 - 8% decrease in survival.

Earlier ice melt in Hudson Bay =

- bears come ashore earlier
- reduced weights
- poorer survival of young and old
- Declining population size



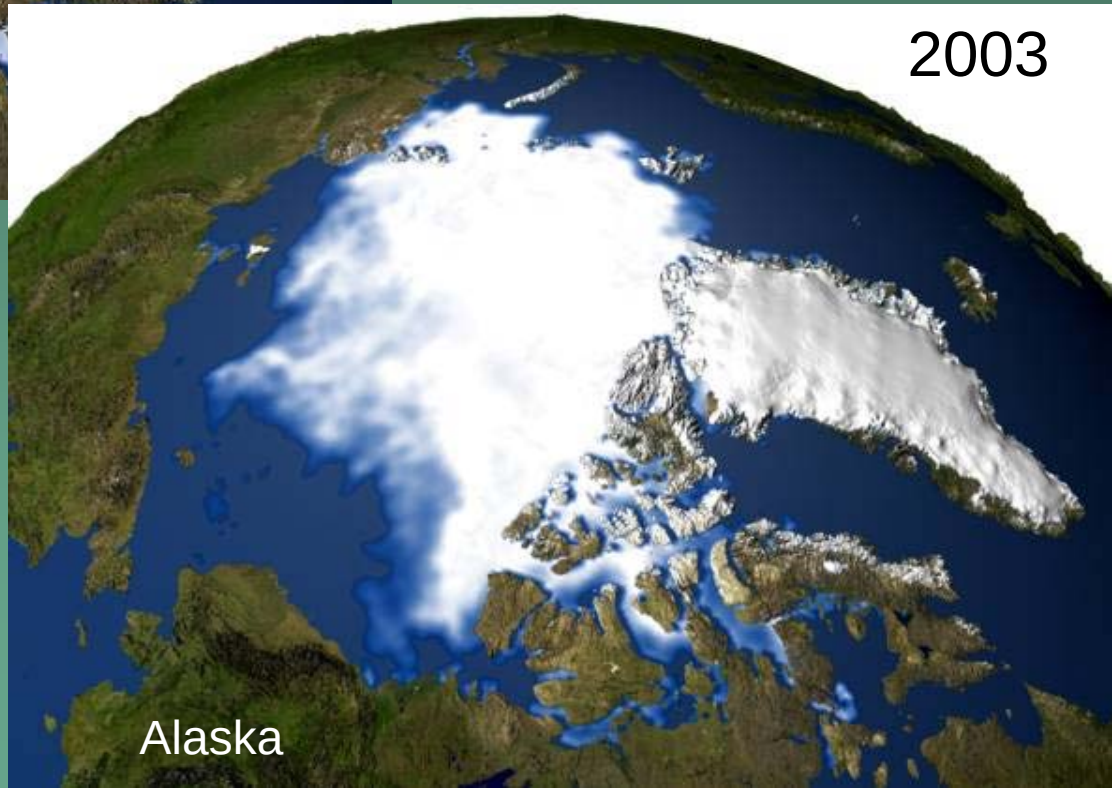
1980



Alaska

But what about higher latitudes?

2003



Alaska

Comiso, J. C.
NASA

Science to Inform Decision-making

- Increased knowledge of specific polar bear sub-populations, particularly Southern Beaufort Sea
- Examine spatial patterns of polar bear denning
- Develop a life history model and population projection for the SBS population
- Integrate sea ice projections and models of sea ice/polar bear relationships to forecast future polar bear distributions
- Synthesize available information into a model of the future status of polar bears worldwide

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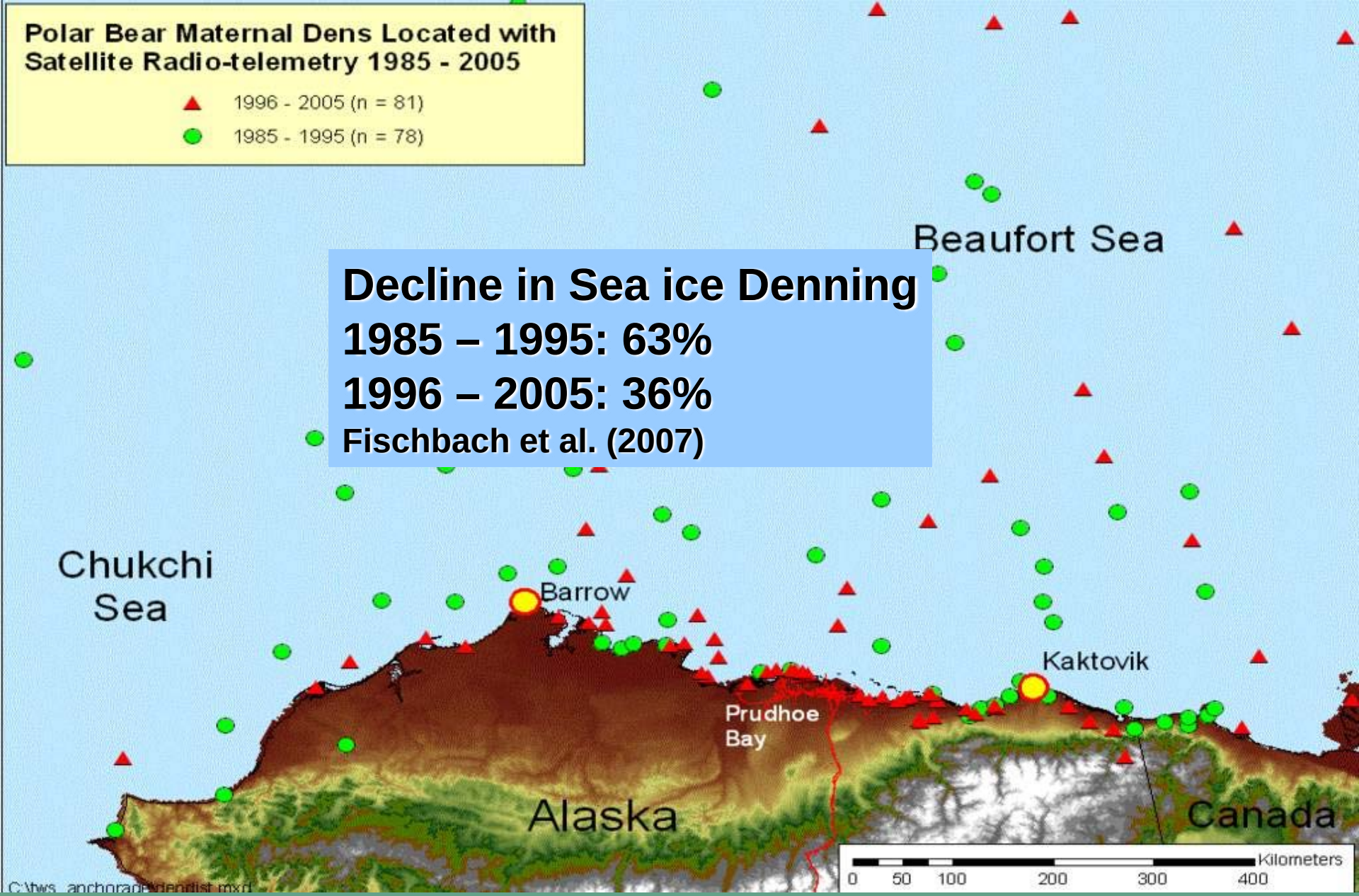

Decline in Sea ice Denning
1985 – 1995: 63%
1996 – 2005: 36%
Fischbach et al. (2007)

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Polar bear den distribution has changed

Reduced size in cubs- and adult males

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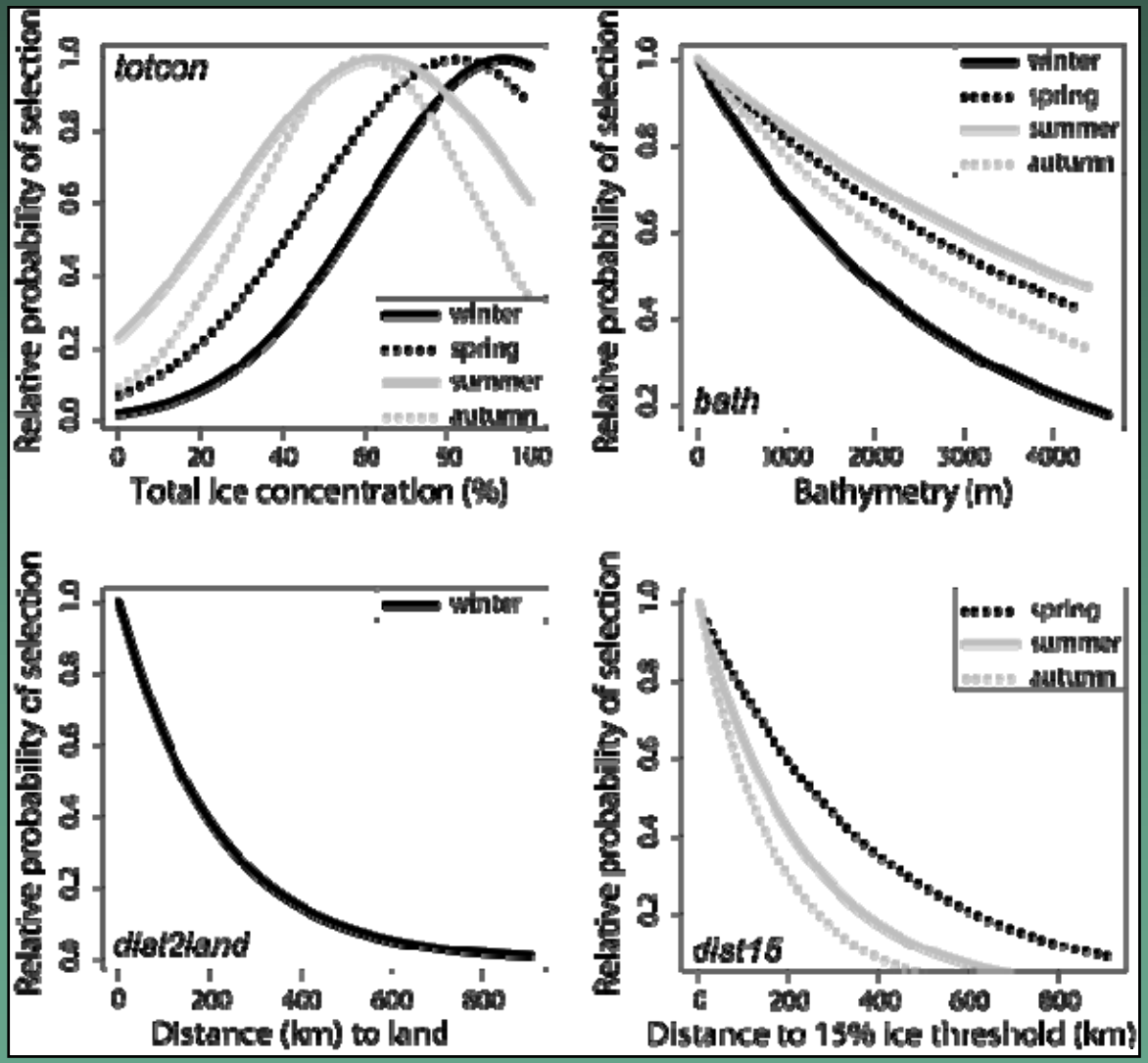
Final RSF model structure – Four seasonal RSFs Response to covariates

- Medium to high ice concentration
- Shallow waters
- Near the 15% ice threshold
- near land (winter)



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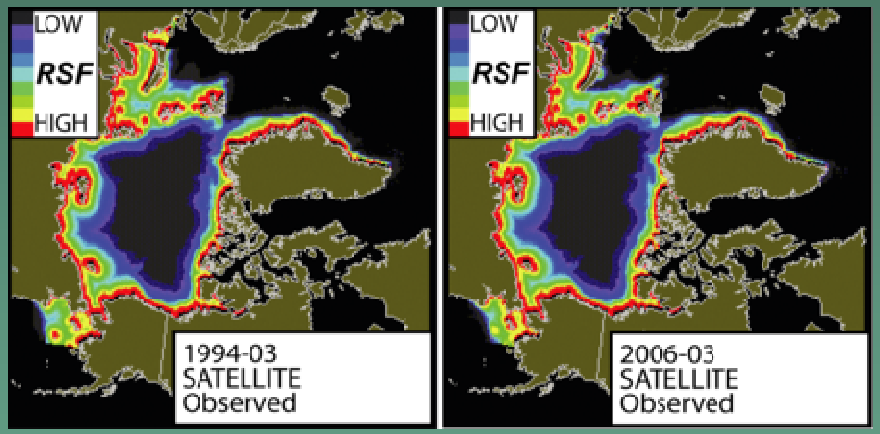
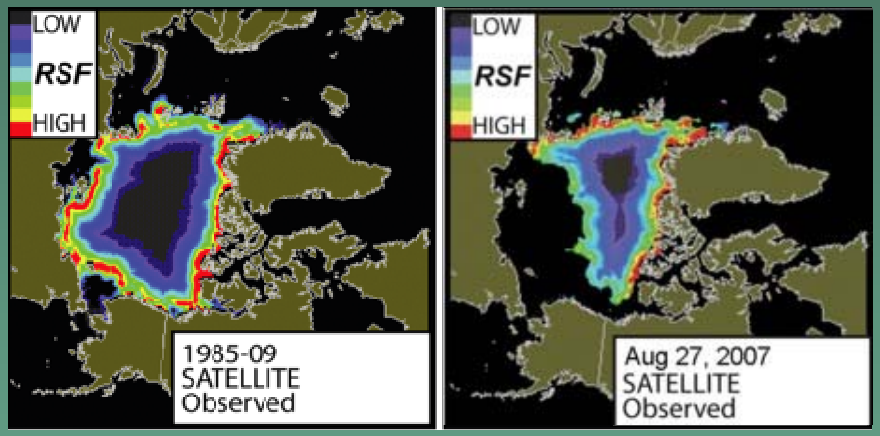
Examples:

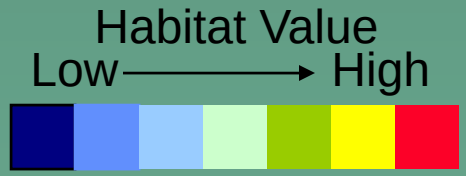
RSF models extrapolated to satellite-observed sea ice data

Winter (March)



Summer (September)





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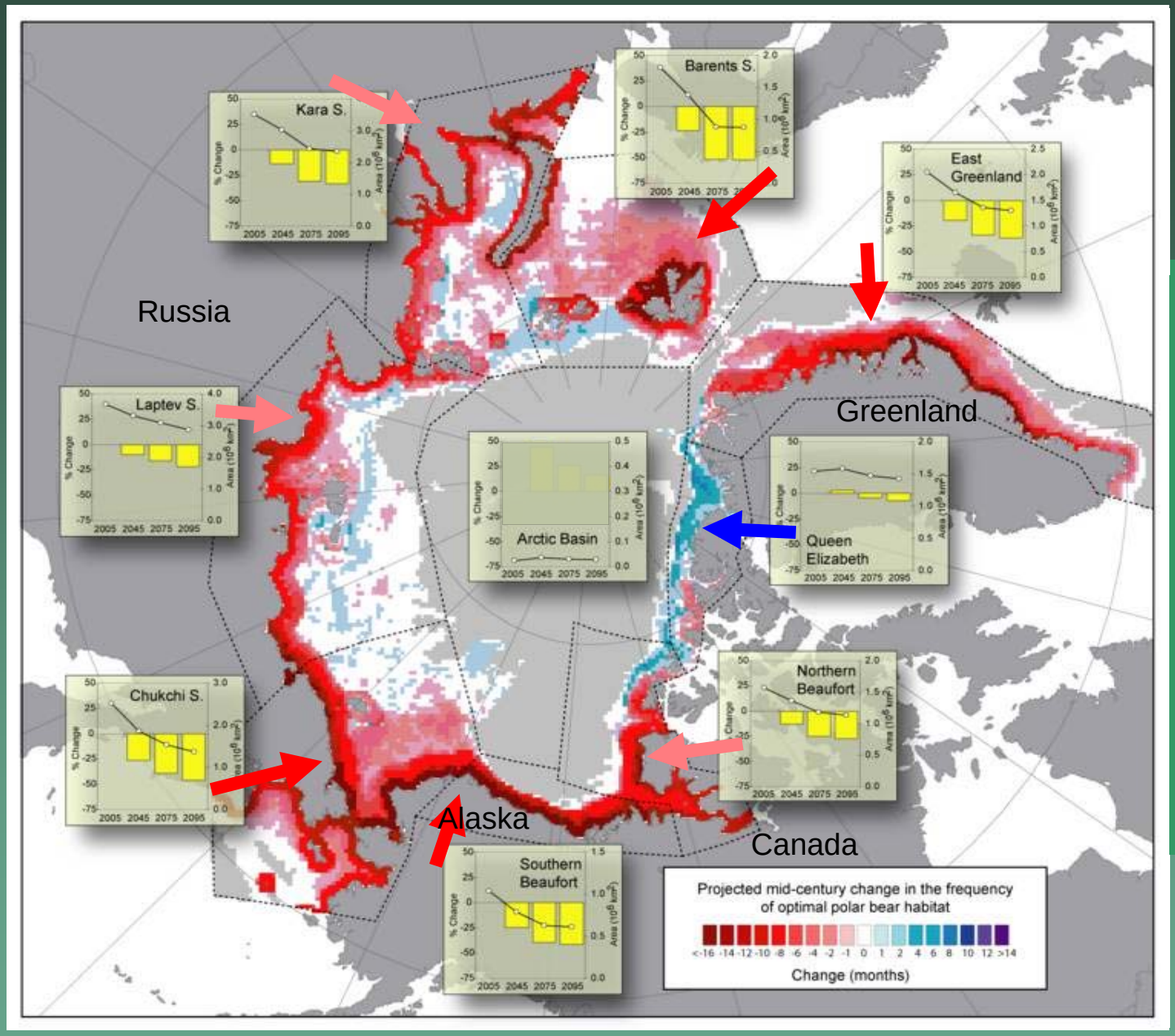
USGS Report: Durner et al. (2007)



Projection of Habitat change

Decade 2001-2010 To Decade 2041-2050

Capture-recapture study 2001-2006

Immobilization from helicopter.

Samples and measurements.

Application of ear tag.

Lip tattoo.

Tooth for age determination.

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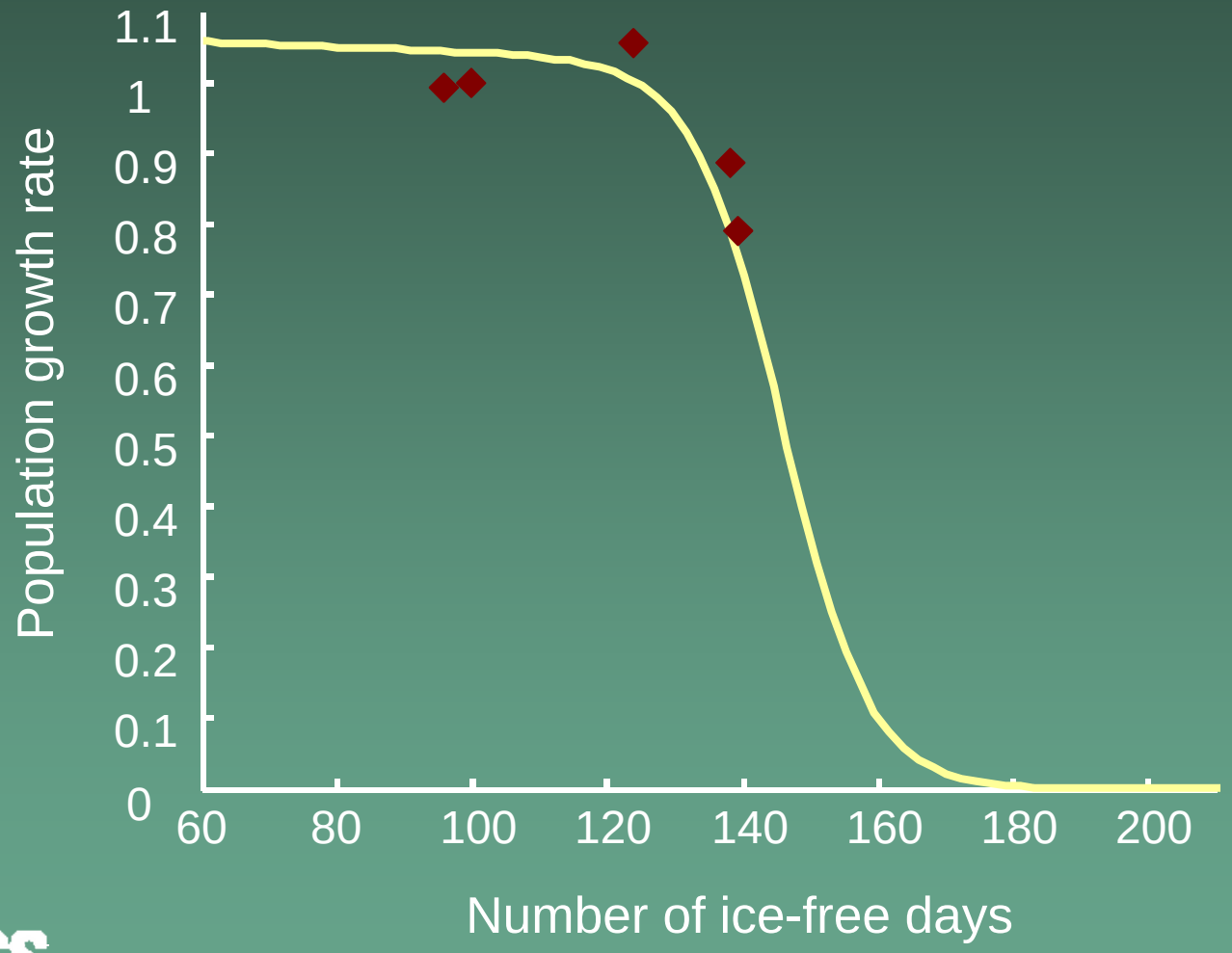
Deterministic growth rate vs ice-free days



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Southern Beaufort Sea deterministic population growth rates

	Year	population growth rate	growth per year	# ice-free days
Good	2001	1.06	+ 5.8%	90
Good	2002	1.06	+5.8%	94
Good	2003	1.04	+3.9%	119
Bad	2004	0.76	-27.0%	135
Bad	2005	0.80	-22.0%	134

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Summary: Stochastic demography in a variable environment

- **If the frequency of bad years > 0.17 the population will decline**
  - **average frequency of bad years 1979-2006 = 0.21**
  - **average frequency of bad years 2001-2005 = 0.40**
  - **predicted frequency of bad years by 2100 = 1.00**

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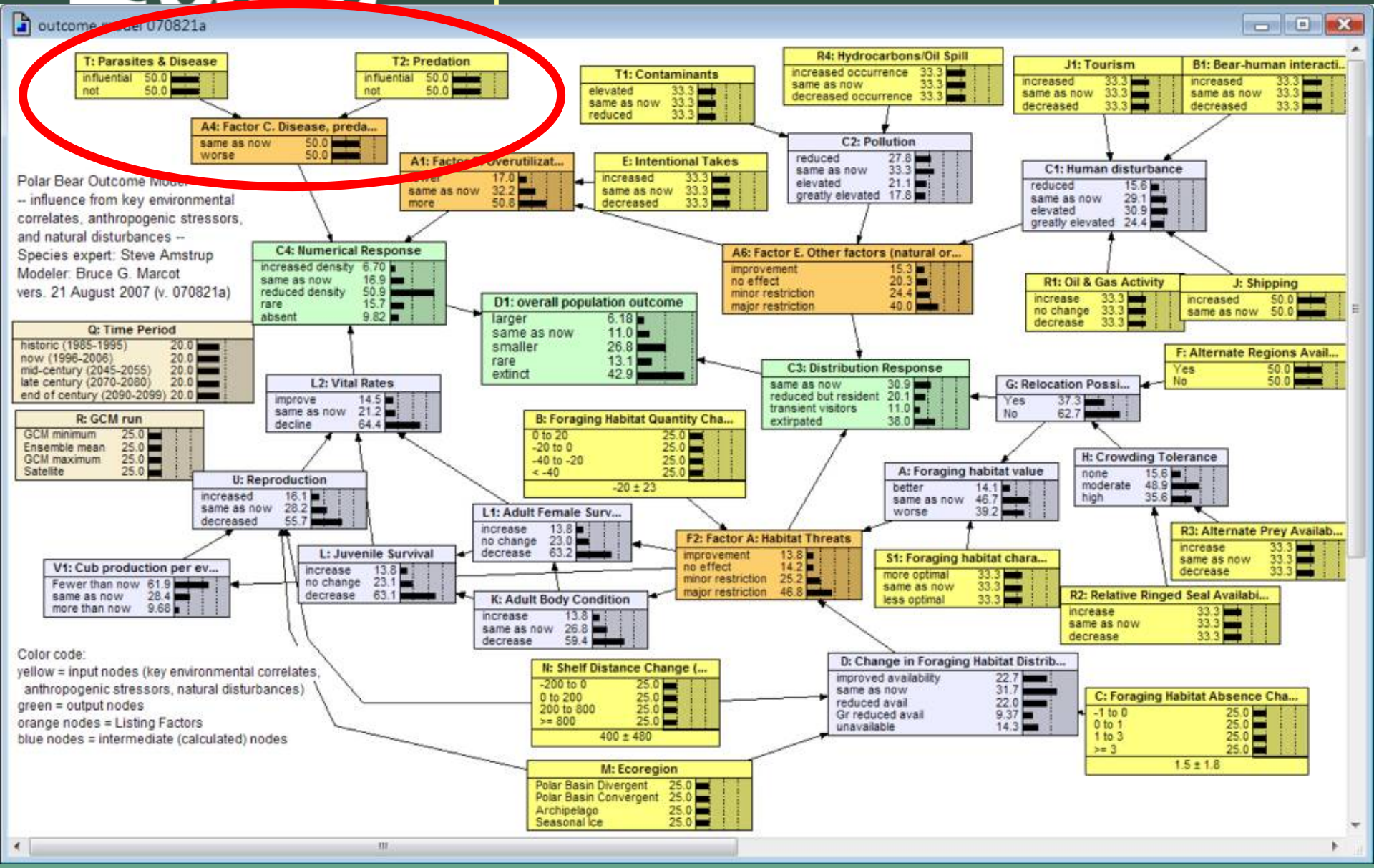
What does all of this mean to polar bears?

Forecasting the range-wide status of polar bears at selected times in the 21st century.

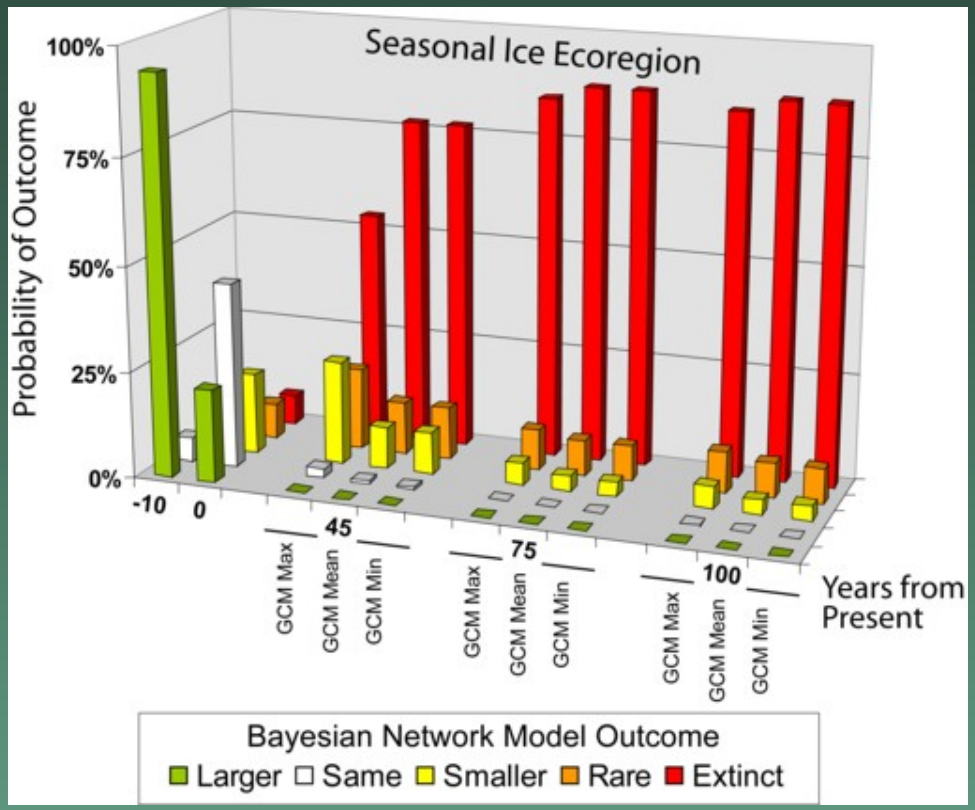
U.S. Department of Interior
U.S. Geological Survey

USGS Report: Amstrup et al (2007) with model inputs from previous USGS 2007 Administrative Reports.

Bayesian Network Polar Bear Population Stressor Model




RUSSIA
GREENLAND
Alaska
CANADA


Seasonal Ice Ecoregion
Probability of Outcome
100%
75%
50%
25%
0%
-10
0
45
75
100
GCM Max
GCM Mean
GCM Min
Years from Present
Bayesian Network Model Outcome
Larger
Same
Smaller
Rare
Extinct

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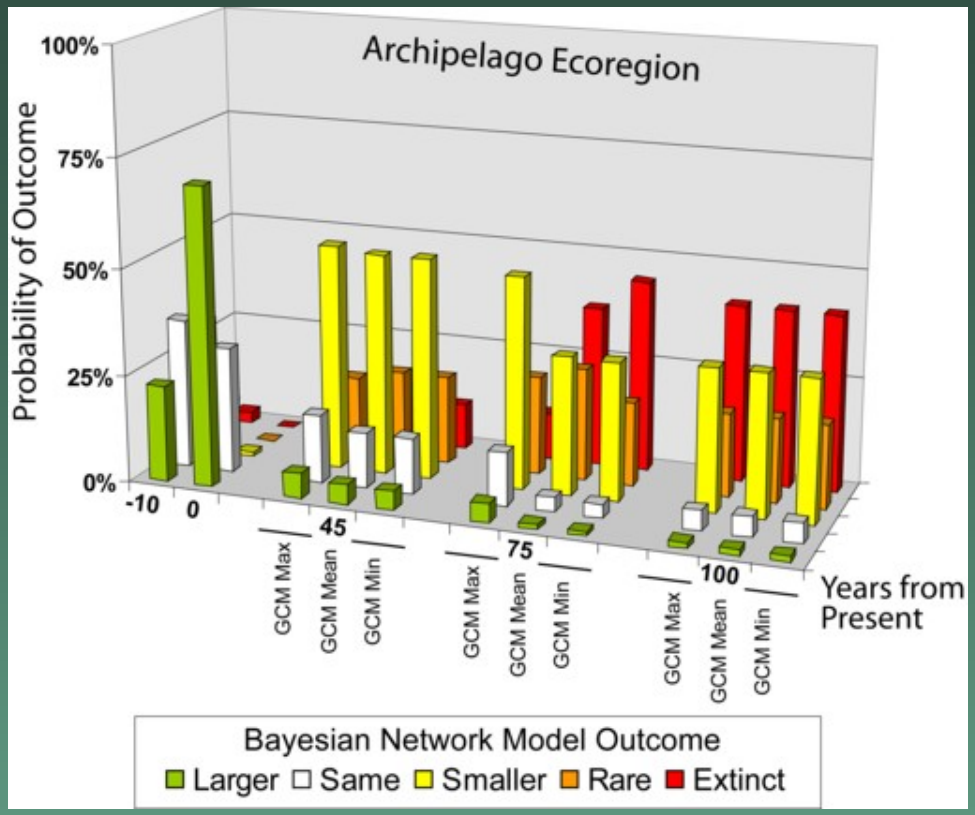
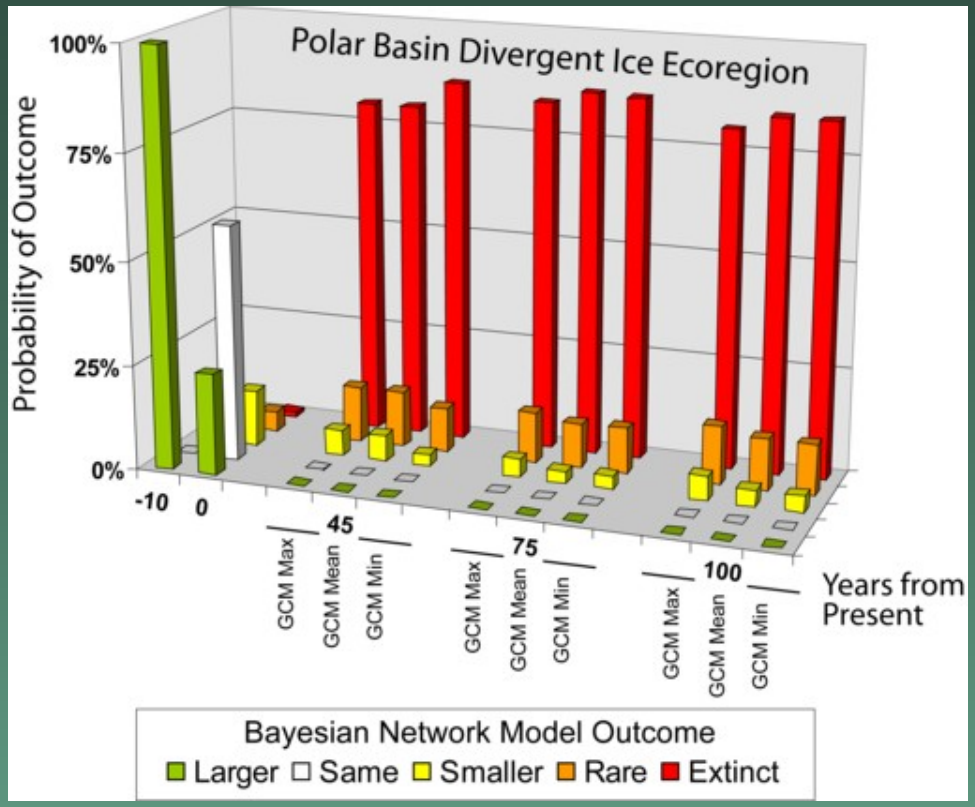
RUSSIA
GREENLAND
Alaska
CANADA


Archipelago Ecoregion
Probability of Outcome
100%
75%
50%
25%
0%
-10
0
45
75
100
GCM Max
GCM Mean
GCM Min
Years from Present
Bayesian Network Model Outcome
Larger
Same
Smaller
Rare
Extinct

USGS


RUSSIA
GREENLAND
Alaska
CANADA


Polar Basin Divergent Ice Ecoregion
Probability of Outcome
100%
75%
50%
25%
0%
-10
0
45
75
100
GCM Max
GCM Mean
GCM Min
Years from Present
Bayesian Network Model Outcome
Larger
Same
Smaller
Rare
Extinct

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Alaska
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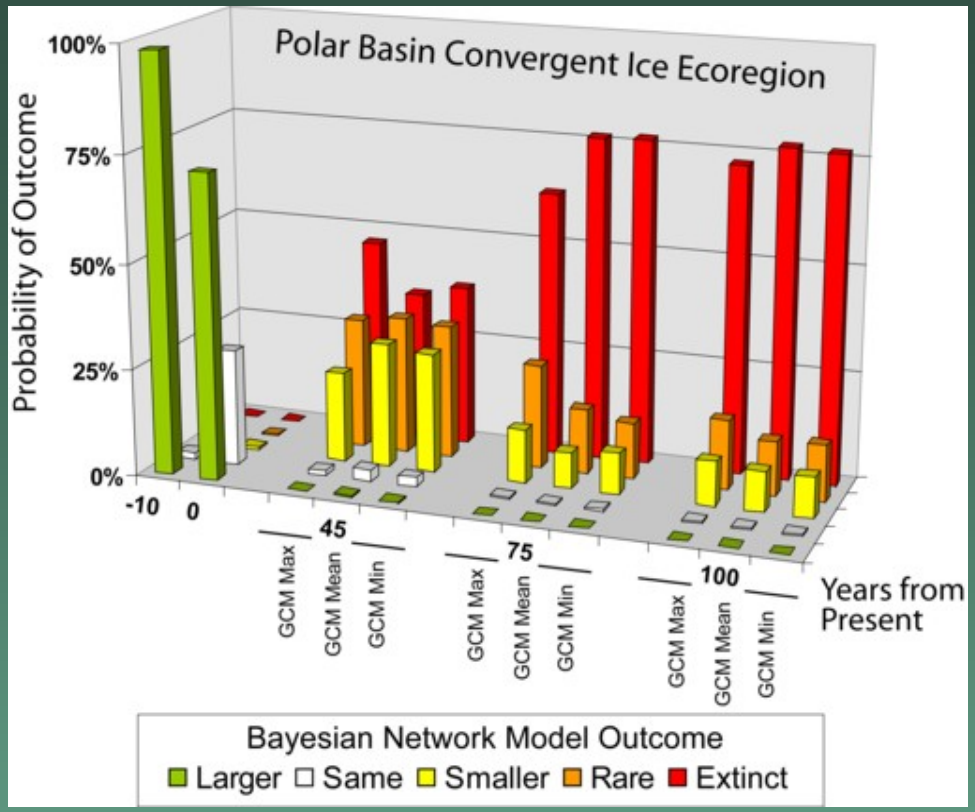
Polar Basin Convergent Ice Ecoregion
Probability of Outcome
100%
75%
50%
25%
0%
-10
0
45
75
100
GCM Max
GCM Mean
GCM Min
Years from Present
Bayesian Network Model Outcome
Larger
Same
Smaller
Rare
Extinct

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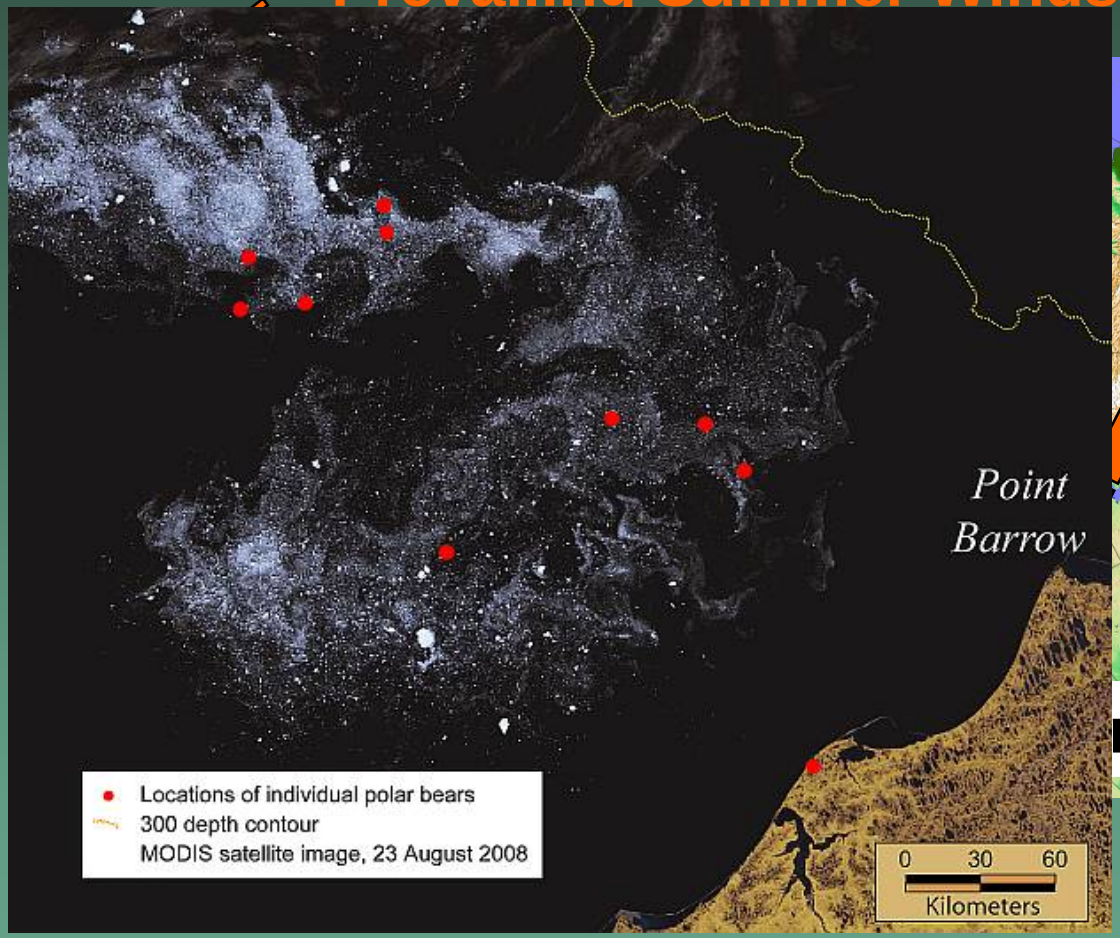
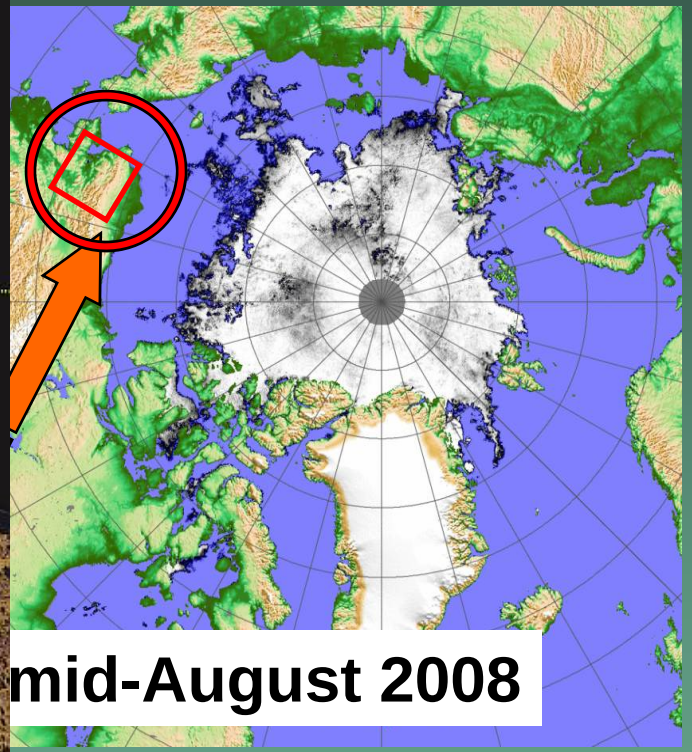
Wind-driven ice dynamics

Prevailing Summer Winds (Jun-Aug)





mid-August 2008

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Closing Thoughts

- Diminishing sea ice likely to have negative consequences to polar bears, walrus and some ice seals
- Less certain about impacts to other marine mammals
- Diminishing sea ice could result in increased ship traffic, development and tourism
- These in turn could impact marine mammals thru noise, disturbance and pollution
- Increasing legal complexity because of ESA listings and litigation

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