

Vulnerability of Arctic marine mammals to vessel traffic in the Northwest Passage and Northern Sea Route

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Photo: K Laidre



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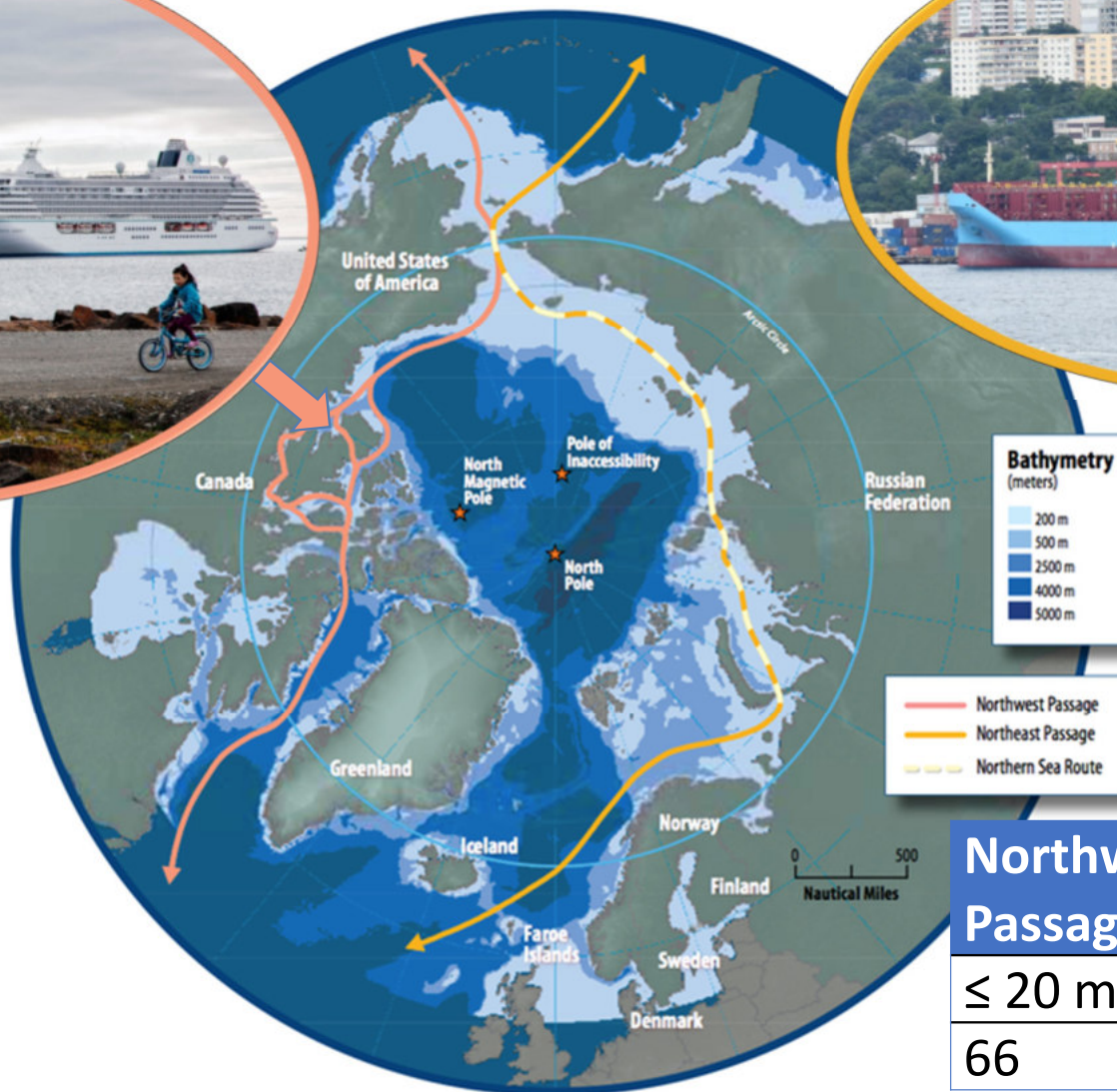
No longer Amundsen's Northwest Passage



Roald Amundsen, first to traverse Northwest Passage during 1903-1906 aboard 21 m wooden *Gjøa*



250 m, 1700 person
Crystal Serenity in
Ulukhaktok, Canada
August 2016



200 m container ship
Venta Maersk in
Vladivostok, Russia
August 2018

2011-2016 transits

Northwest Passage		Northern Sea Route	
≤ 20 m	> 20 m	≤ 20 m	> 20 m
66	39	0	247

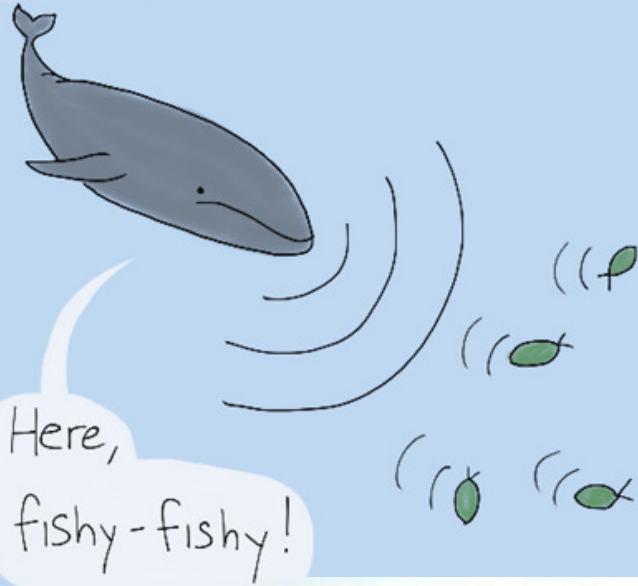
Sources: Headland 2017, CHNL 2017



Right whale and ship

Photo: Florida Fish & Wildlife Conservation Commission

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Arctic marine mammals: sentinel, ice-adapted, culturally and ecologically critical species



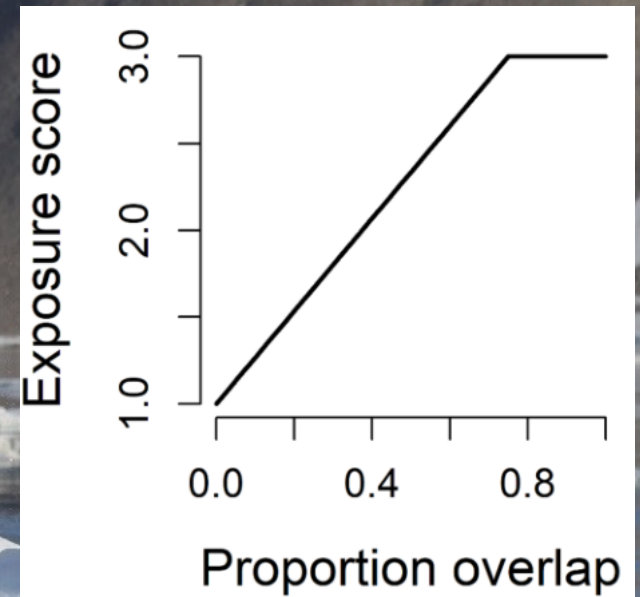
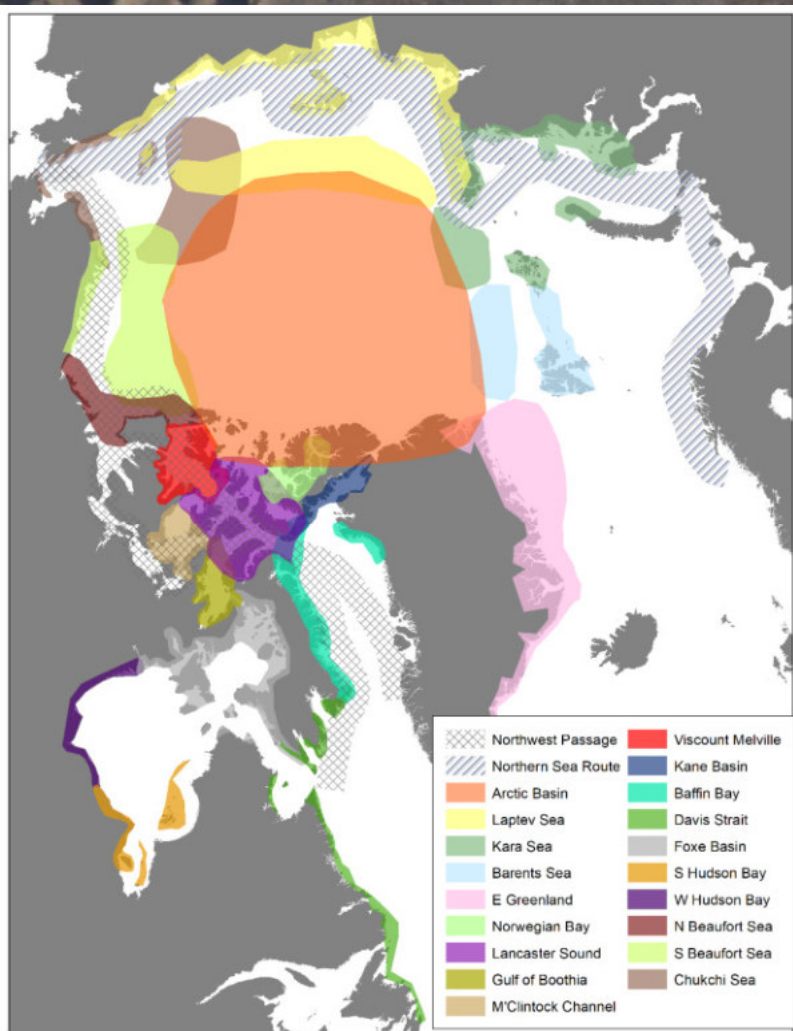
Photos: K Laidre, J Ross, P Nicklen, K Stafford, J Lindsay

An aerial photograph showing a whale breaching the surface of dark water in a narrow channel between large, white ice floes. The whale's dark body and tail are visible as it moves through the water. The ice floes are jagged and textured, surrounding the dark water.

Vulnerability measures the risk of a population to impact, often defined as the combined effect of **exposure** and **sensitivity** (i.e. consequence of exposure) to a particular hazard

$$\text{Vulnerability} = \text{Exposure} \times \text{Sensitivity}$$

Population-specific exposure



Spatial overlap of NWP & NSR and the September range for each of the 80 populations

Photo: K Laidre

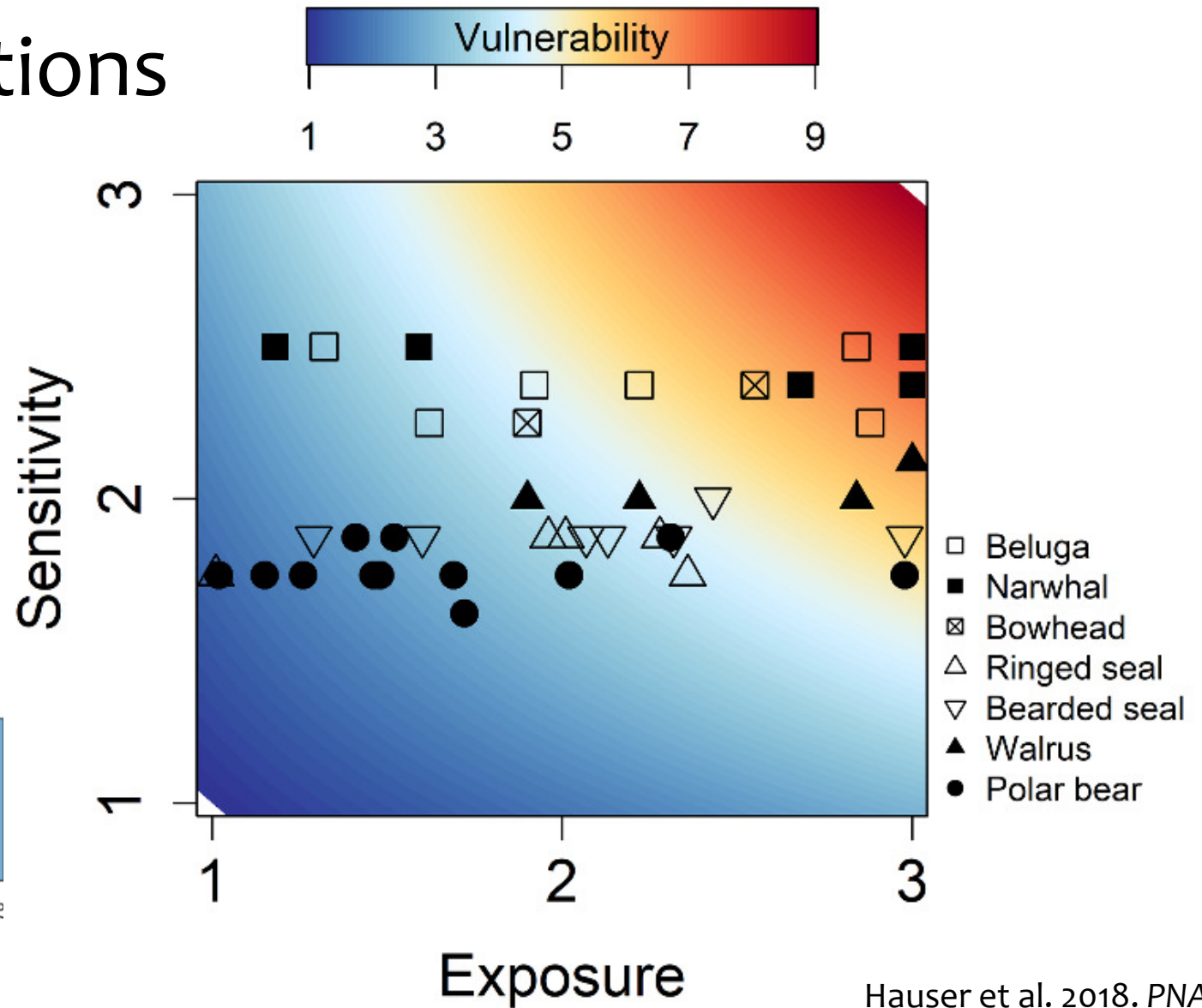
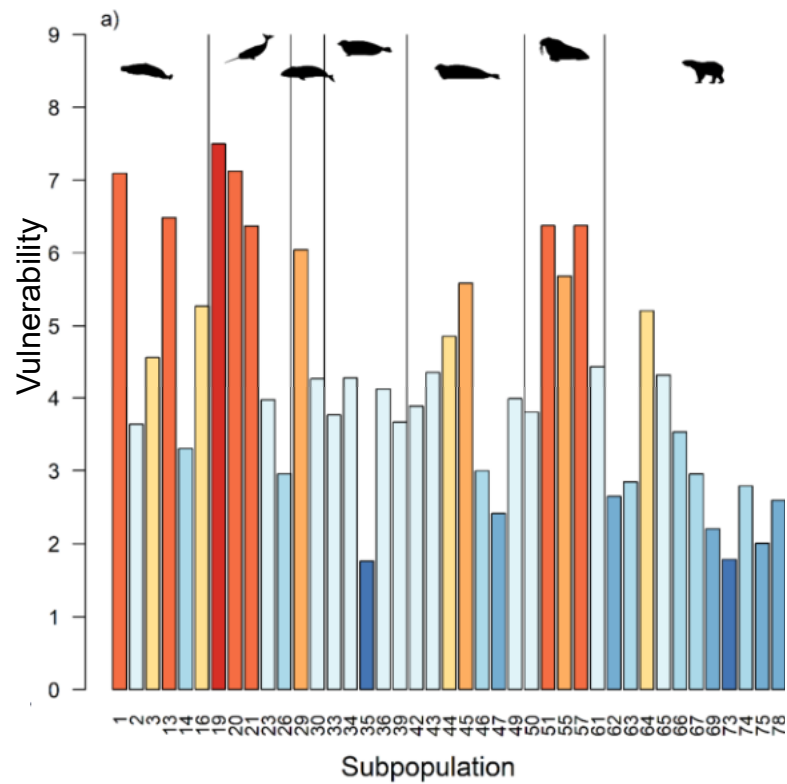


Population-specific sensitivity

- Seven variables that consider:
 - Vessel effects
 - Frequency of exposure
 - Ecological factors that affect population responses to vessels

Sensitivity variables	Score for Beaufort Sea belugas
Effect of behavioral disturbance	3
Effect of vessel collision	3
Acoustic impacts	3
Frequency of vessel exposure (2011-2016)	2.5
Susceptibility to ice loss (Laidre et al. 2008)	2
Relative abundance (Laidre et al. 2015)	1
Population trend (Laidre et al. 2015)	2
Mean Sensitivity Score	2.38

53% of populations exposed



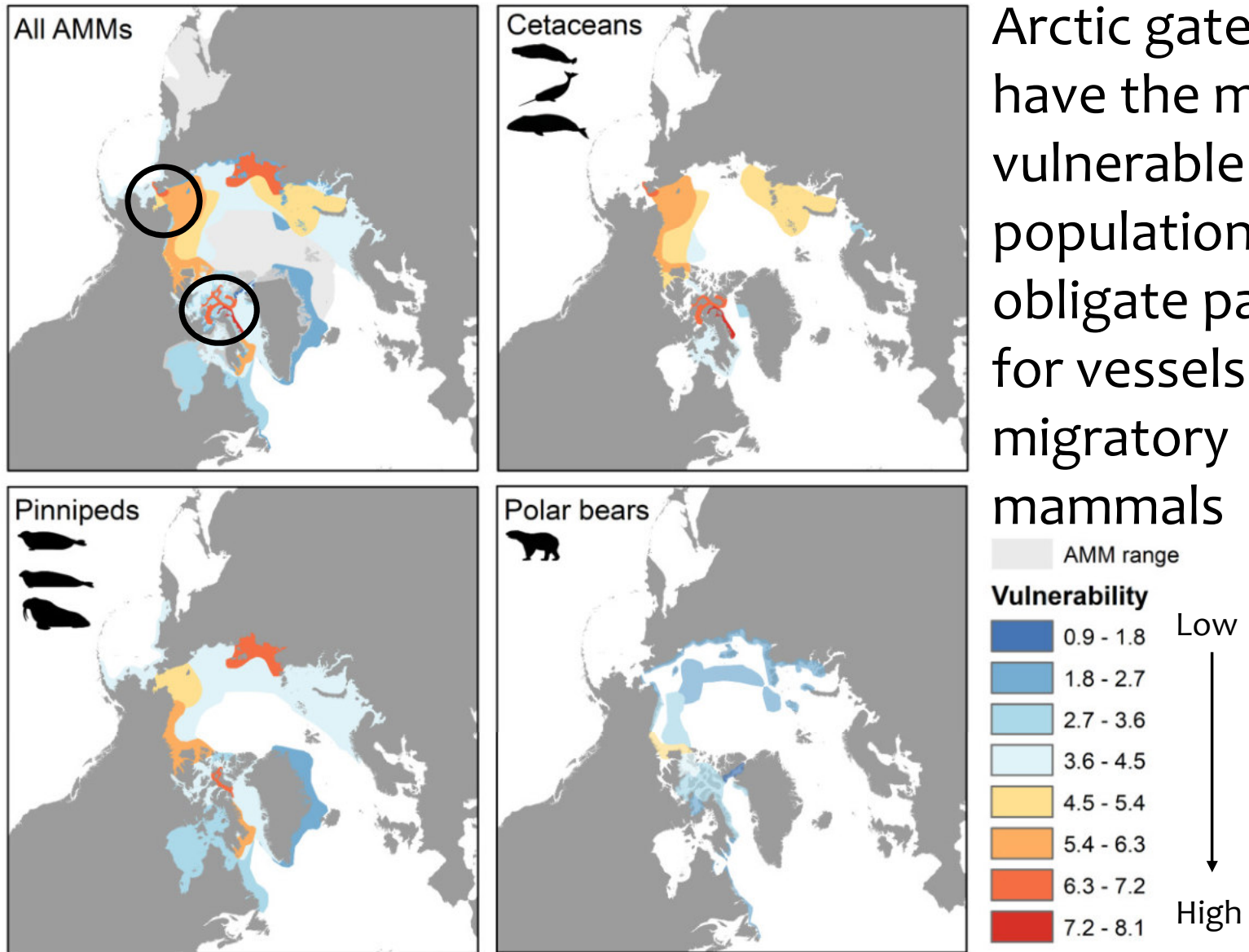
Hauser et al. 2018. PNAS

Table 1. Mean vulnerability assessment scores of AMMs to vessel traffic during the open-water period, averaged across subpopulations exposed to either or both the NWP or NSR

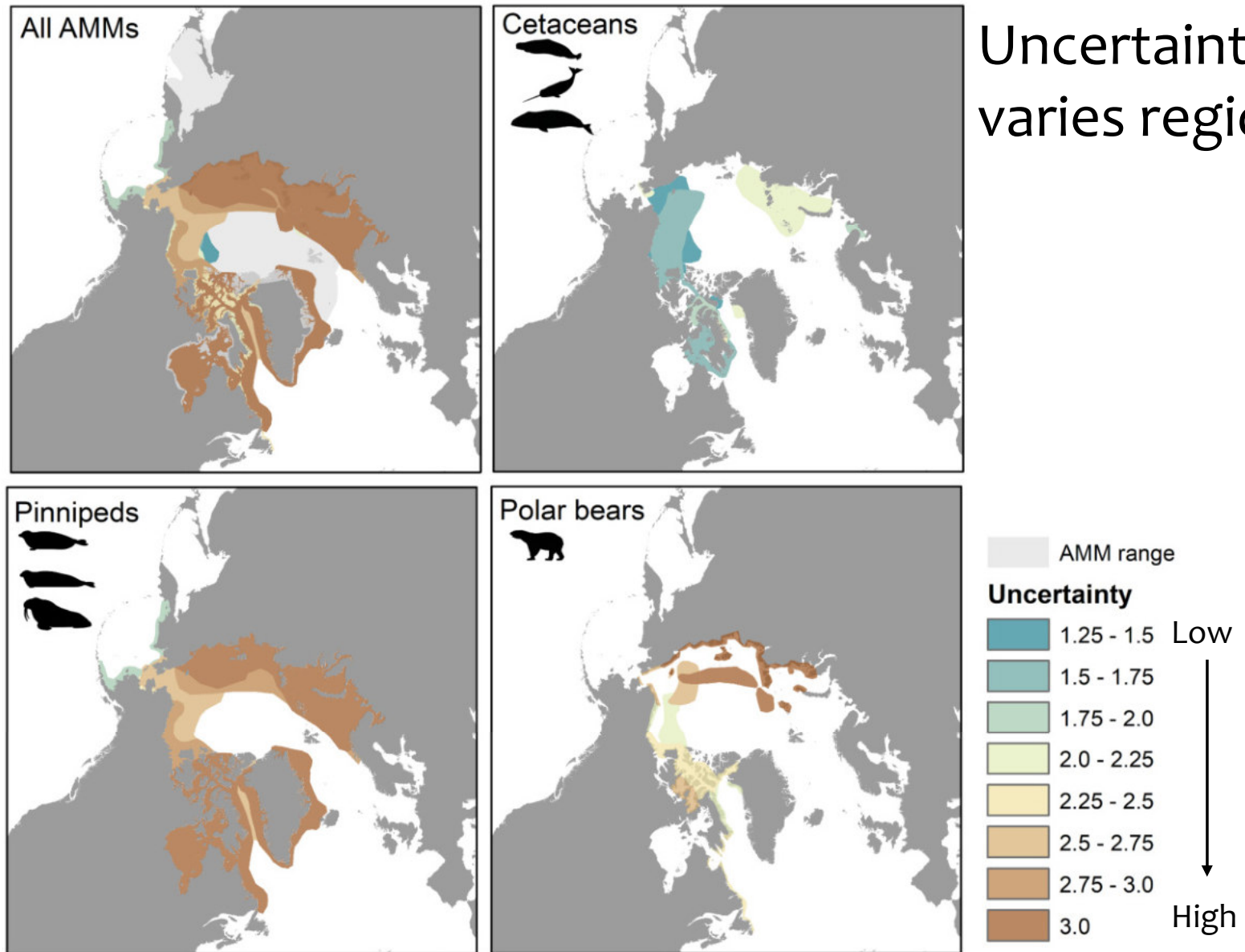
Species	Proportion of subpopulations exposed	Exposure	Sensitivity	Vulnerability	Uncertainty
Beluga	0.33	2.13	2.38	5.06	1.77
Narwhal	0.50	2.29	2.45	5.59	2.12
Bowhead	0.50	2.22	2.31	5.16	1.50
Ringed seal	0.63	1.92	1.83	3.52	2.64
Bearded seal	0.78	2.12	1.89	4.01	2.80
Walrus	0.42	2.59	2.05	5.34	2.04
Polar bear	0.63	1.67	1.77	2.95	2.52
All AMMs	0.53	2.05	2.02	4.20	2.32



Photo: K Laidre



Arctic gateways have the most vulnerable populations – obligate pathways for vessels and migratory mammals



Uncertainty also varies by species



Photo: J Lindsay

The Arctic is & will be increasingly navigable

- Detailed case studies
- Examine broader regions and seasons
- Transparent, accessible vessel data
- Learn from vessel measures elsewhere

A photograph of two walrus resting on a large, white ice floe in the Arctic. The walrus in the foreground is larger and has prominent white tusks. The background shows a vast, icy landscape under a pale sky.

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