Viral Emergence in Marine Mammals in the North Pacific linked to Arctic Sea Ice Reduction

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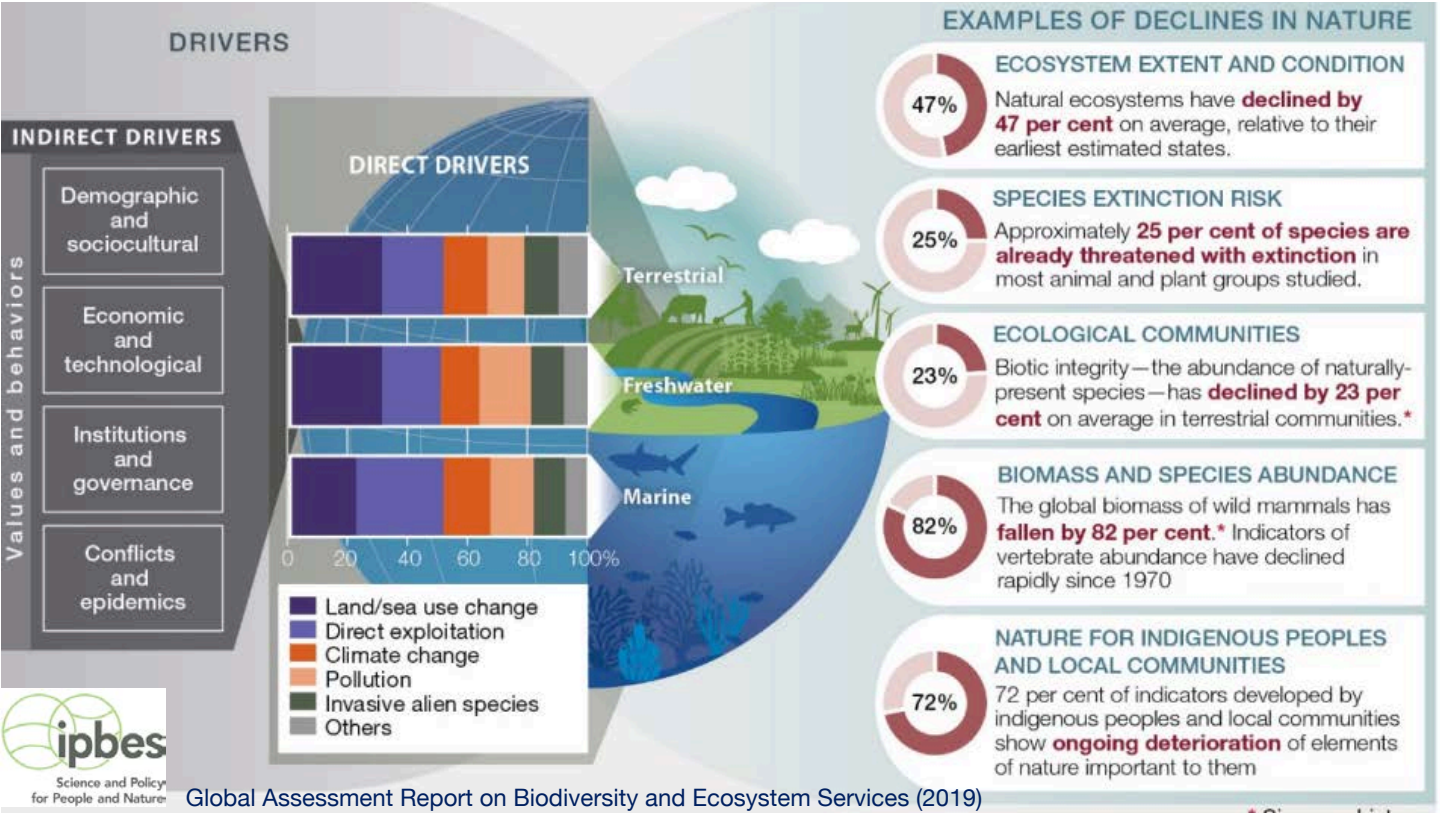
Climate Change and Pathogen Movement in the Arctic

Unprecedented Global Change



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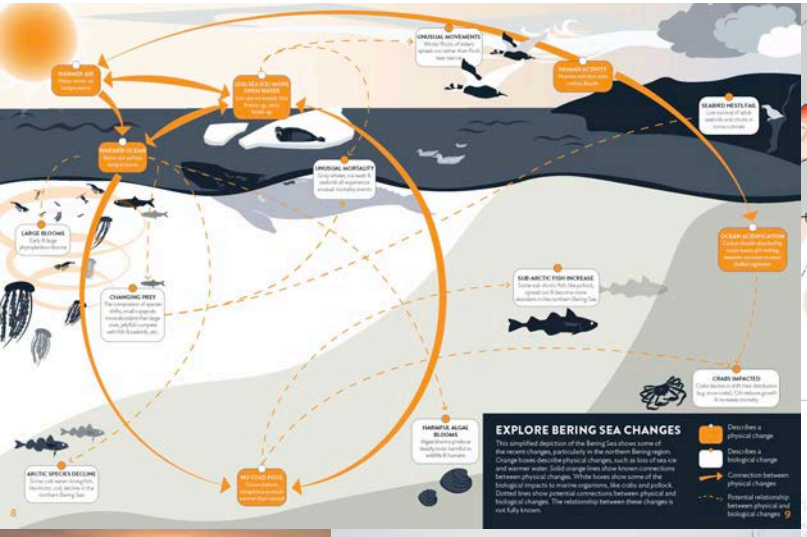
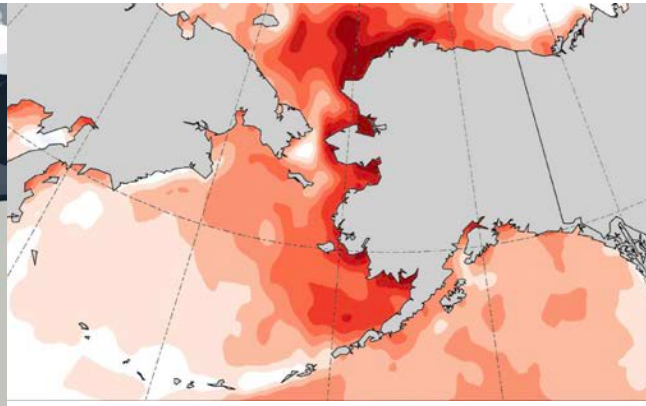
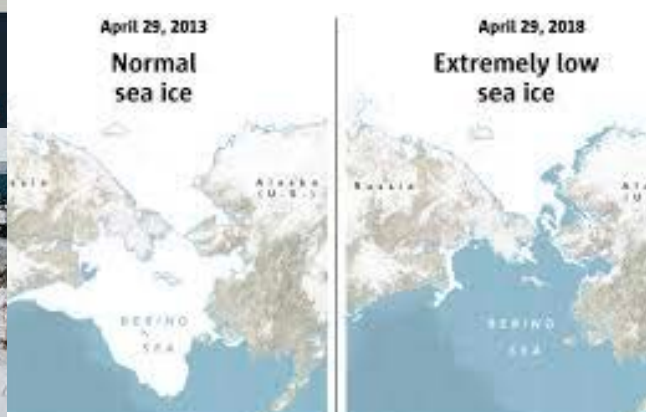
Science and Policy for People and Nature

Global Assessment Report on Biodiversity and Ecosystem Services (2019)

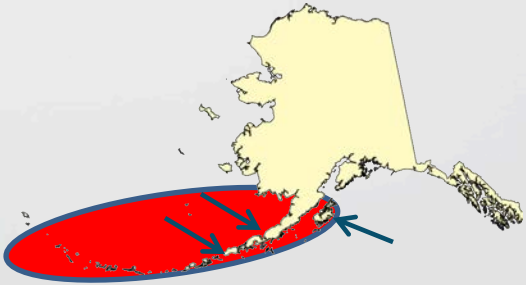
Extreme Arctic Change







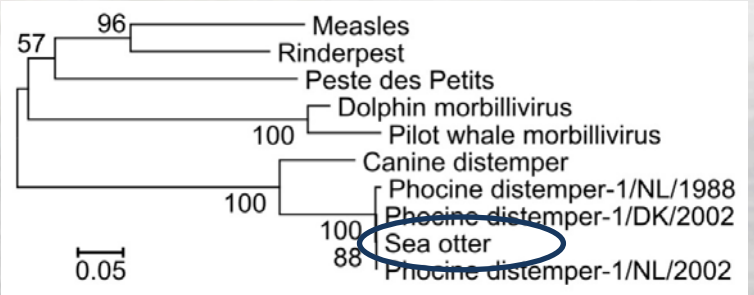
Northern sea otters



Serology

Pathogen	Alaska No. positive/No. tested (% positive)
Toxoplasma gondii	2/78 (2.6%)
Sarcosystis neurona	1/78 (2.6%)
Calicivirus (serotype 1)	0/69 (0%)
Canine Distemper virus	1/77 (1.3%)
Phocine Distemper virus	30/77 (38.9%)
Dolphin Morbillivirus	0/76 (0%)
Porpoise Morbillivirus	0/76 (0%)
Phocine Herpesvirus-1	11/76 (14.5%)
Leptospira spp.[a]	1/76 (1.3%)
Brucella marinus	1/76 (1.3%)

Relationship to morbilliviruses



Goldstein et al 2009, 2011

Transmission to the North Pacific?

- Arctic and sub-Arctic migrating seals suggested as carriers of PDV in Atlantic Ocean
- eg. gray seals vectors of disease to harbor seals, may provide contact between North Sea and Arctic Ocean
- PDV vector species largely unknown
- Intraspecies contact likely method of transmission through Arctic to Pacific Ocean



Phocine Distemper Virus

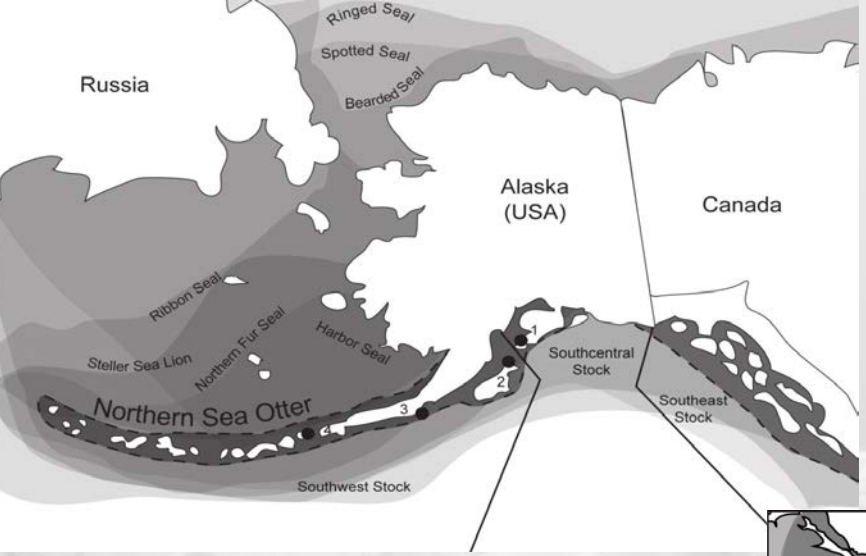
- Paramyxovirus, genus Morbillivirus: Measles, Canine distemper
- Highly infectious, high morbidity and mortality
- Outbreaks in Europe in 1988, 2002
  - 23,000 and 30,000 harbour seal deaths
  - Sympatric grey seals less affected
- Clinical signs: Respiratory, Fever, Neurologic
- Pathology: Pneumonia, Encephalitis, Lymphoid depletion
- Death often due to secondary bacterial infection, viral immunosuppression
- Disease susceptibility and severity varies

Phocine Distemper Virus in the US

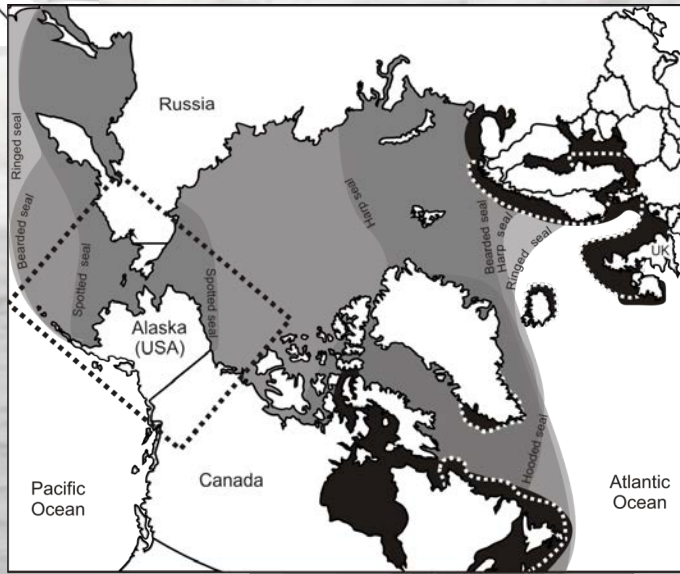
- Outbreaks in harbor seals on Atlantic Coast
- Endemic in Atlantic species?
  - Harp, hooded, gray, ringed Duignan et al 1997
- Exposure in Canada's Arctic Phillippa et al 2004
- Serologic surveys before 2000 no exposure in Pacific marine mammals

  Hanni et al 2003, Burek et al 2005, Zarnke et al 2006
- PDV never identified as cause of illness or death in the North Pacific Ocean

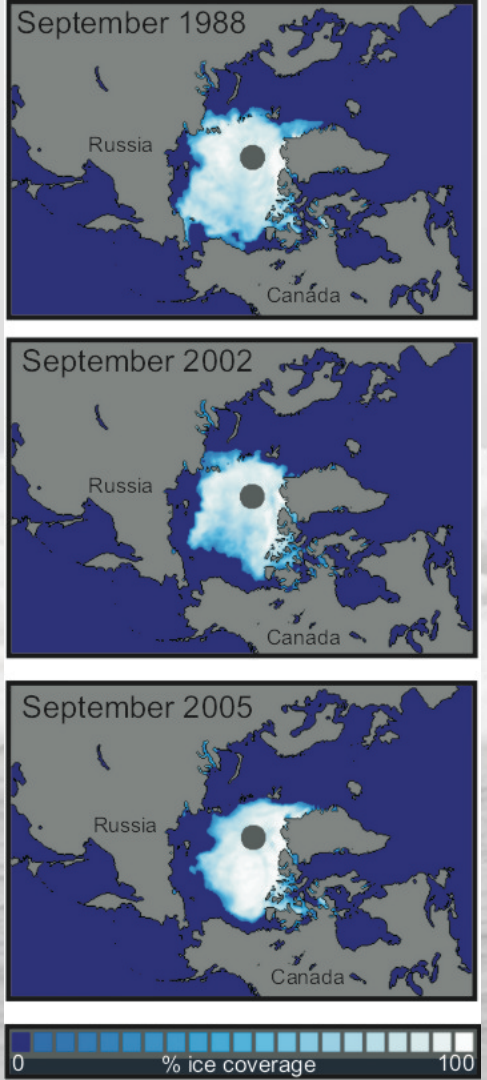
Species overlap in the North Pacific



Circumpolar Distribution



Sea Ice Coverage

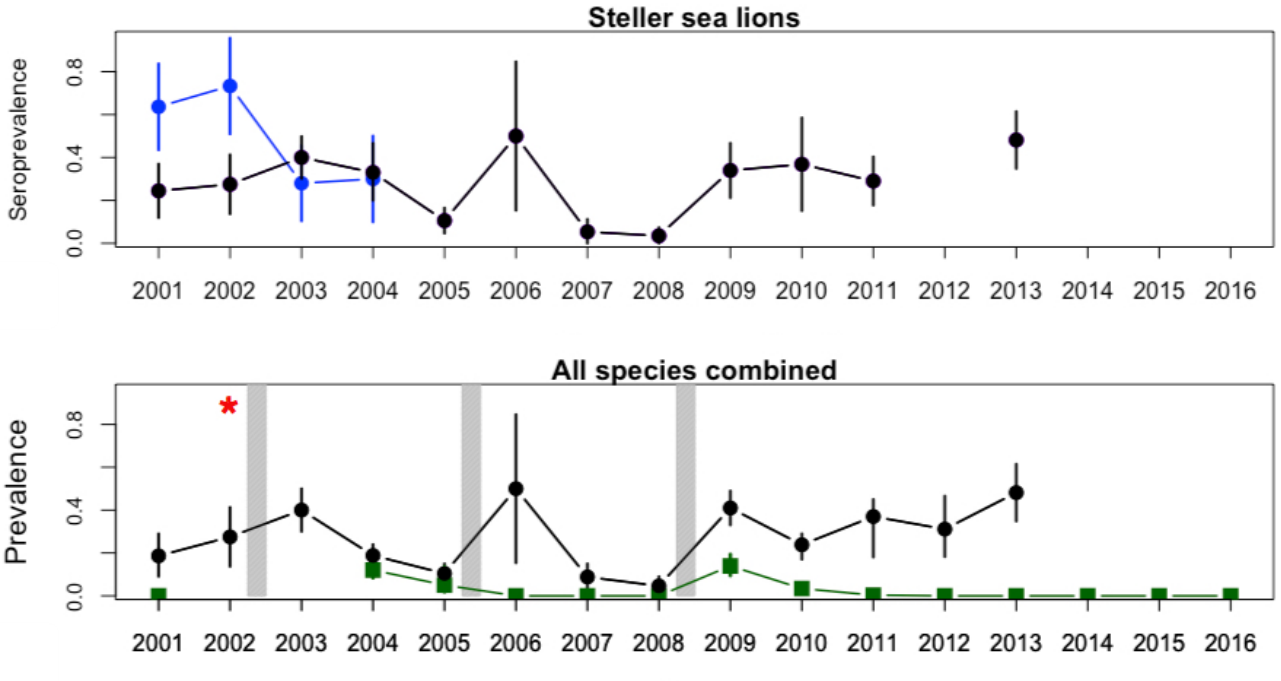


National Snow and Ice Data Center. Sea ice index [cited 2009 Mar 18].

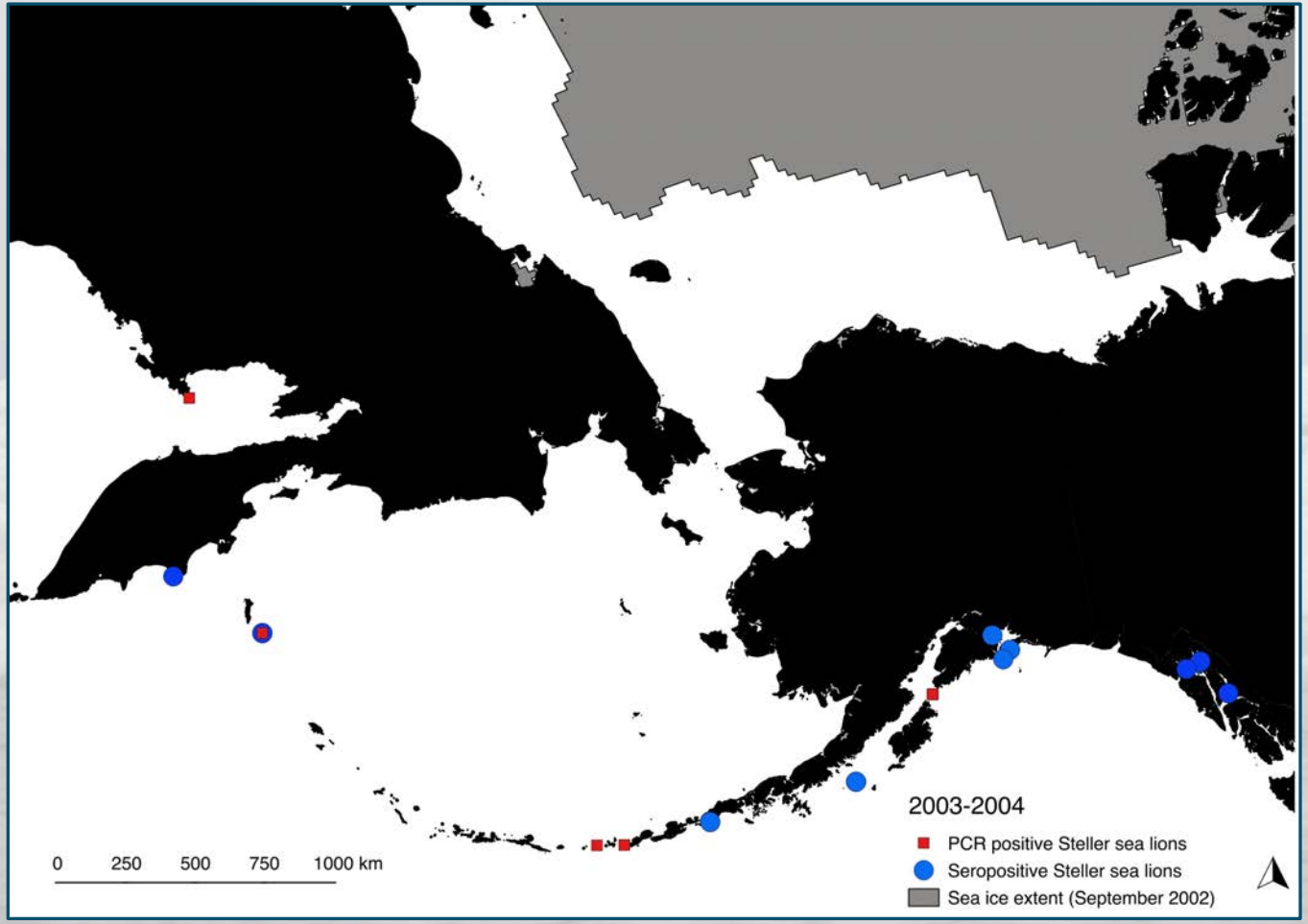
Transmission to the Pacific?

- Examine exposure and infection in sympatric species
  - Circumpolar: Ringed, Bearded
  - Arcticde : Spotted, Ribbon
  - Subarctic: Steller sea lion, Northern fur seal, Harbour seal
- Determine the timeline of exposure, geographic extent

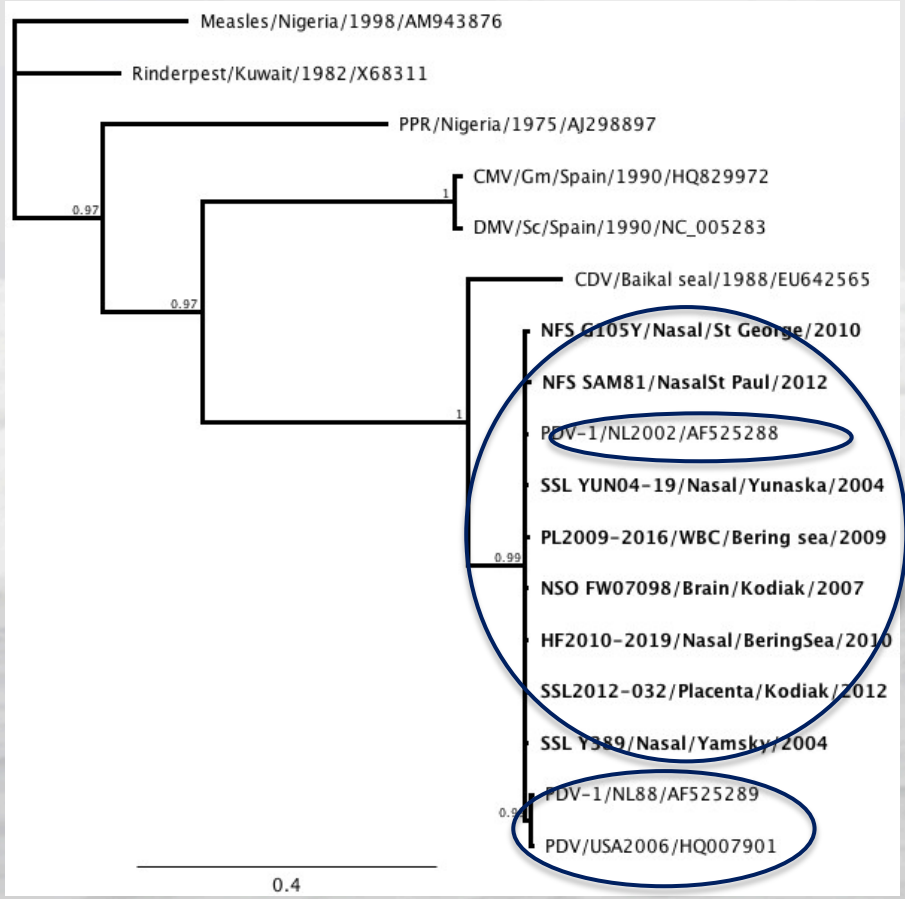
Timeline of Emergence



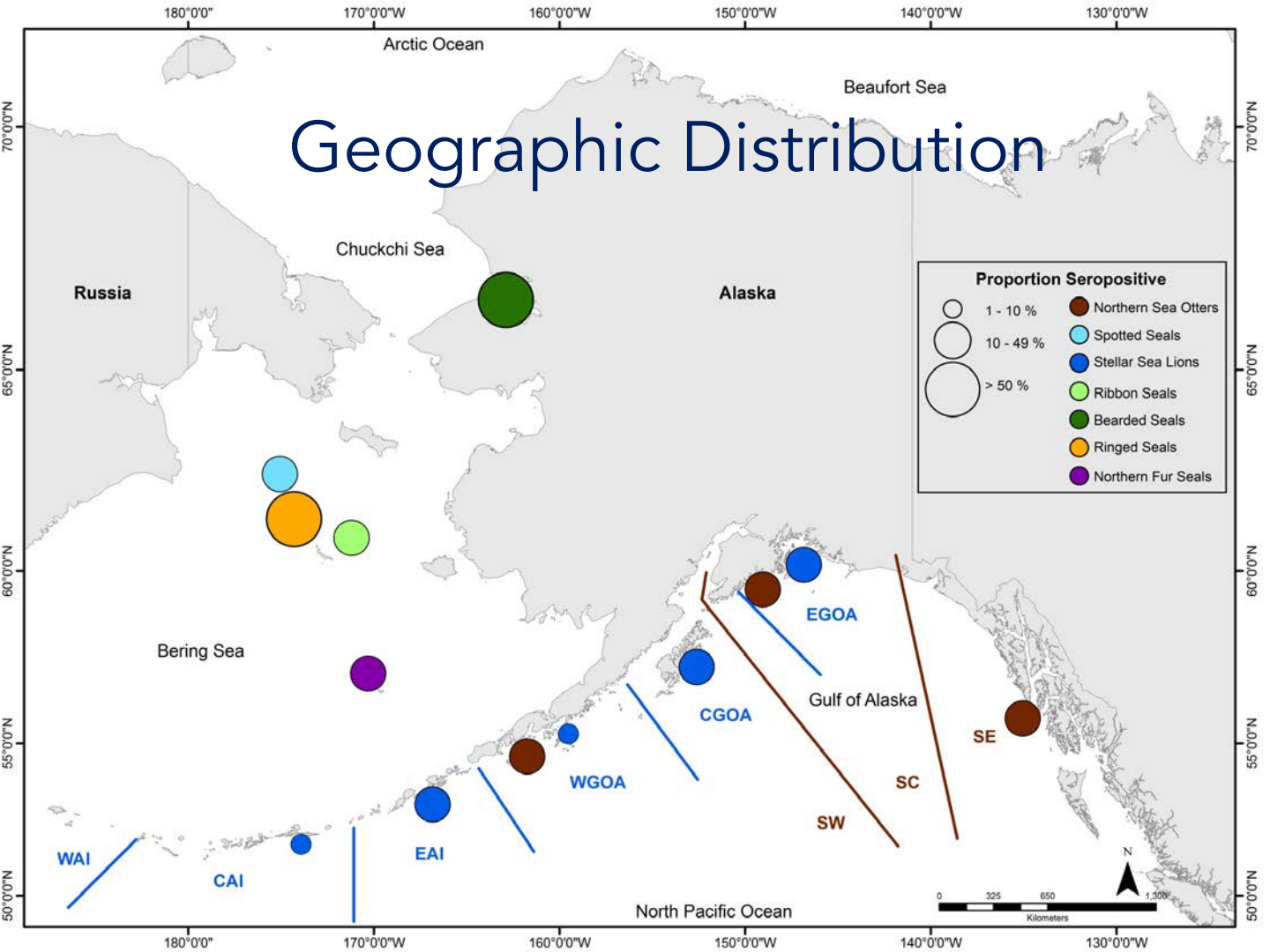
VanWormer et al 2019


2003-2004
PCR positive Steller sea lions
Seropositive Steller sea lions
Sea ice extent (September 2002)
0
250
500
750
1000 km

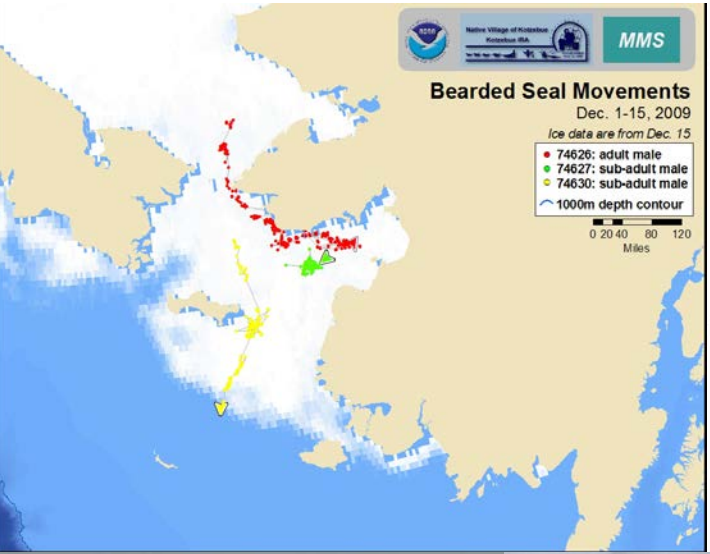
Relationship to other Morbilliviruses

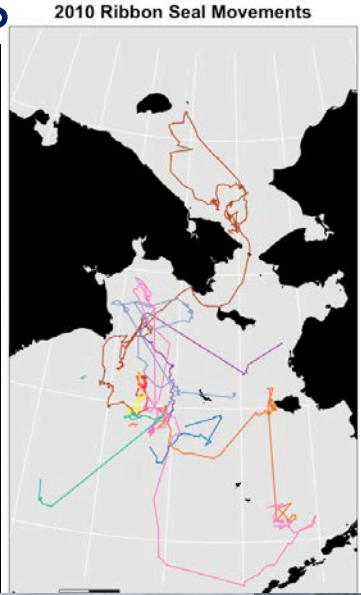


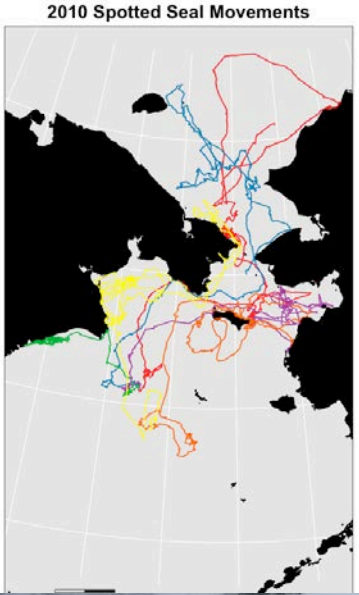
Geographic Distribution



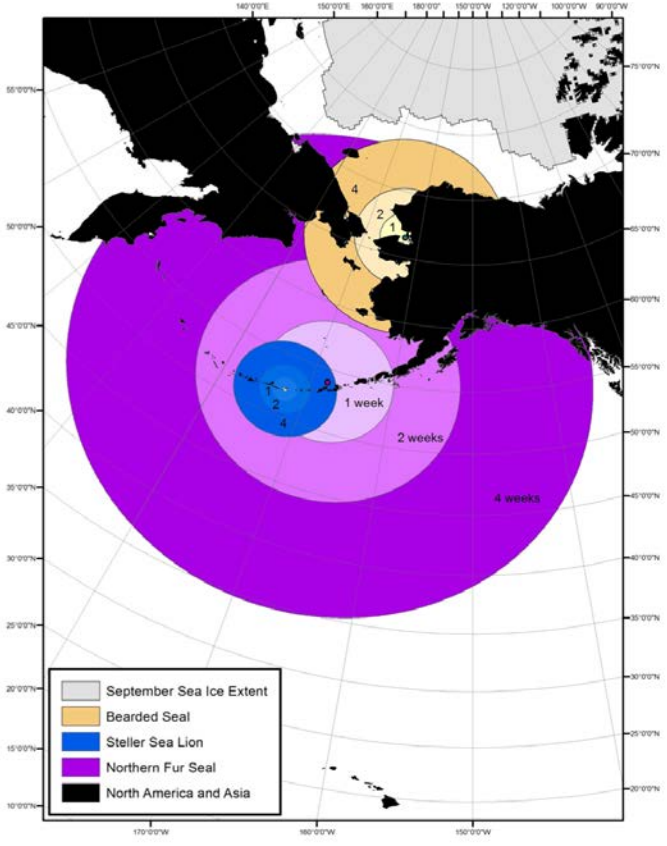
Animal Movements

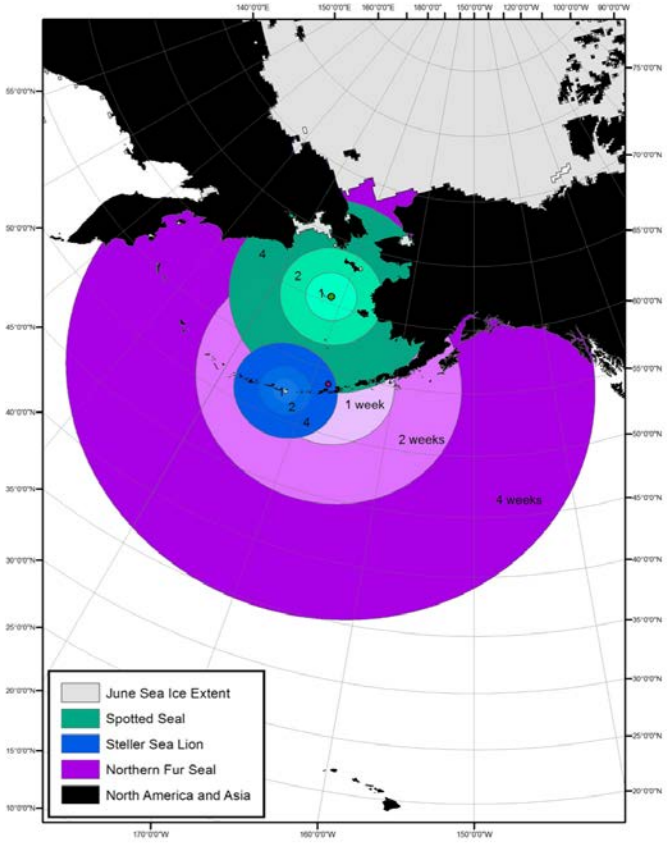




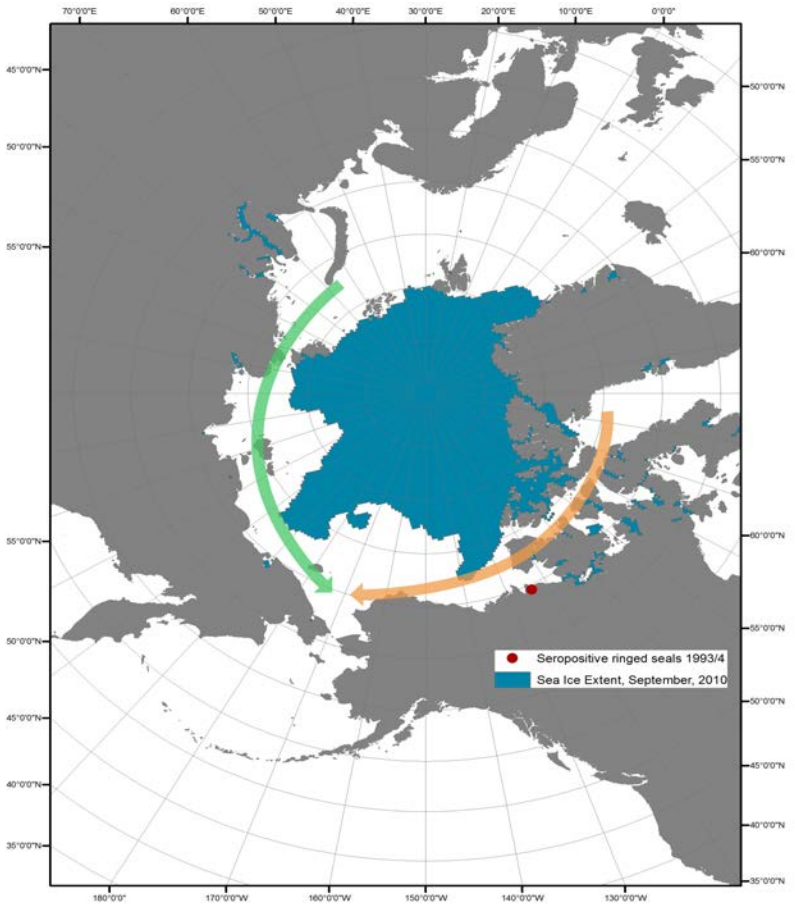


Virus Transmission and Animal Movement





Ice and Animal Movement

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Significance of Findings

- Widespread exposure to and infection across the North Pacific Ocean
- Introduction in 2003, second peak of exposure and infection in 2009
- Transmission across sympatric marine mammal species
- Change in Arctic sea ice extent and open water routes through sea ice suggest opportunities for introduction of other pathogens

Thank You!

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