Approaches and considerations for understanding connectivity for marine mammals using various techniques

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Arctic Council/PAME Workshop, September 22-23, 2016

Outline

- Marine mammals in the Arctic
- Design principles for MPA networks for marine mammals
- Modes of connectivity for marine mammals
- Tools and approaches for understanding marine mammal connectivity
- Marine mammal connectivity in a changing Arctic
- Key considerations and ongoing policy processes

WCS Oceans 2020 Strategy

WHERE? Our local waters and 8 Coastal Regions with Low Capacity:

- Highest **biodiversity,** Most **productivity** and Greatest **threat,**

WHY?: 90% Coral Diversity, 75% S&R Diversity, > 60% MM Diversity

Marine mammals in the Arctic

Design principles for marine mammal MPA networks

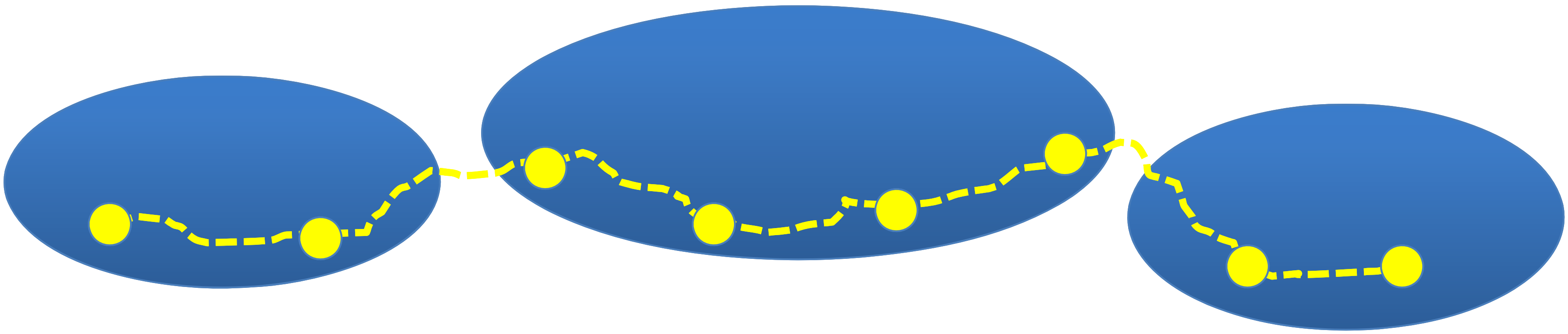
Hooker *et al*. 2011 *Endangered Species Research*:

Ecologically centered MPA networks for marine top predators need to be capable of incorporating the:

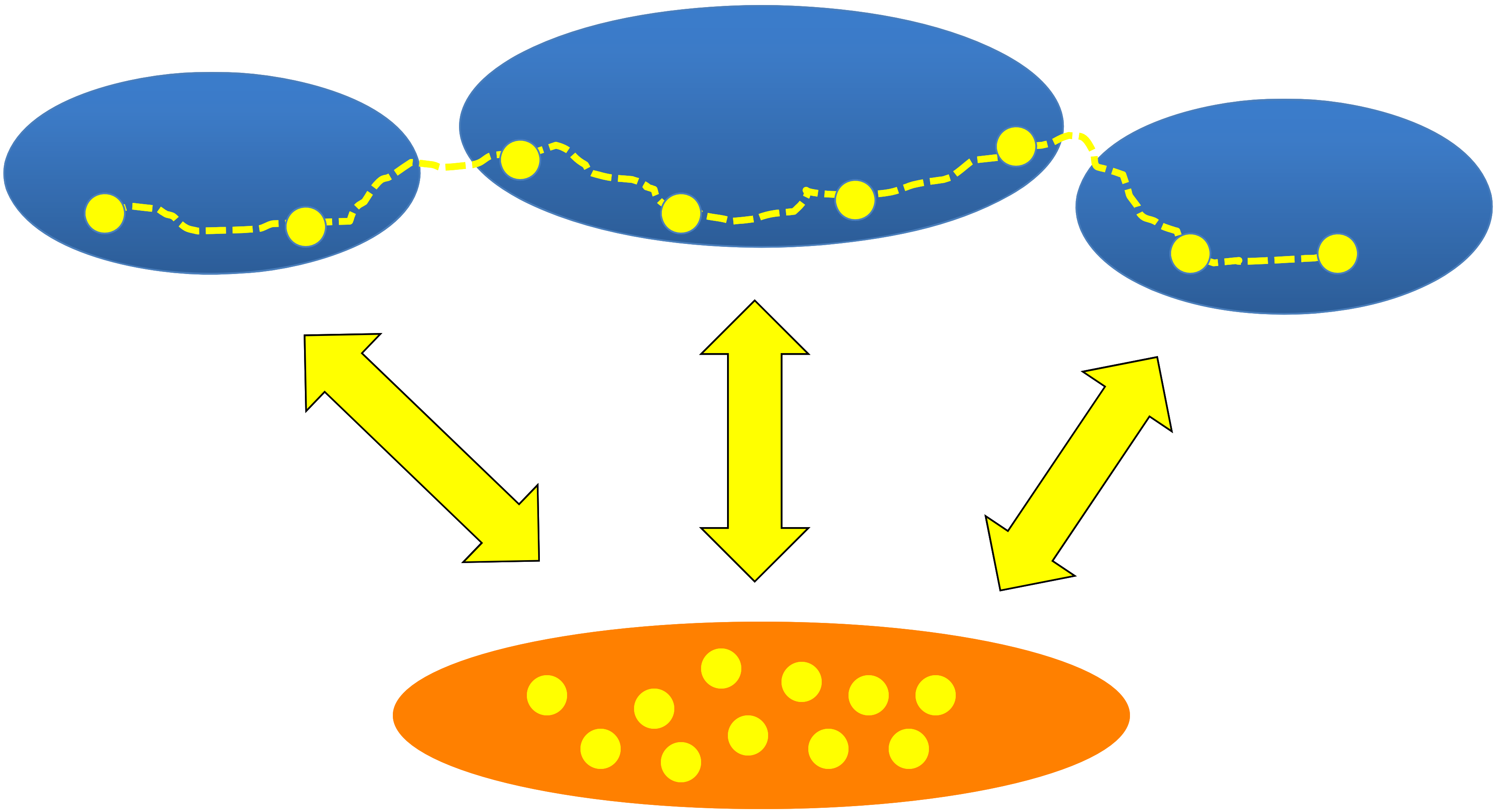
- complex life history characteristics of these species
- dynamics of their ocean habitats
- vast scope of detrimental activities

"Networks should promote species survival by maximizing adequacy and connectivity, through inclusion of multiple life-history stages and the maintenance of site specific (e.g. local abundance; pop-age structure) and network wide (e.g. genetic structure, pop range, pop abundance) characteristics of the focal species."

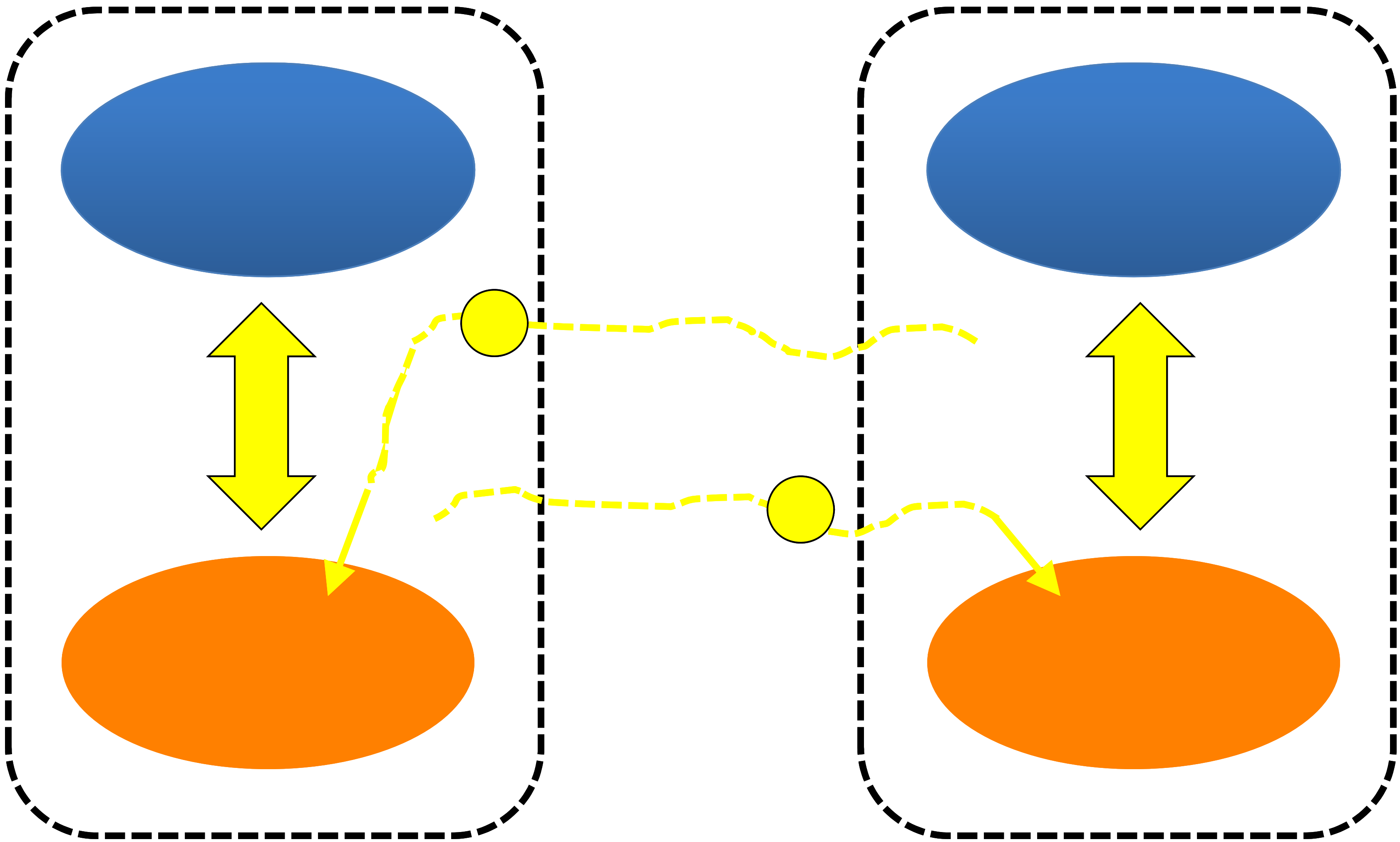
Modes of connectivity: Habitat connectivity



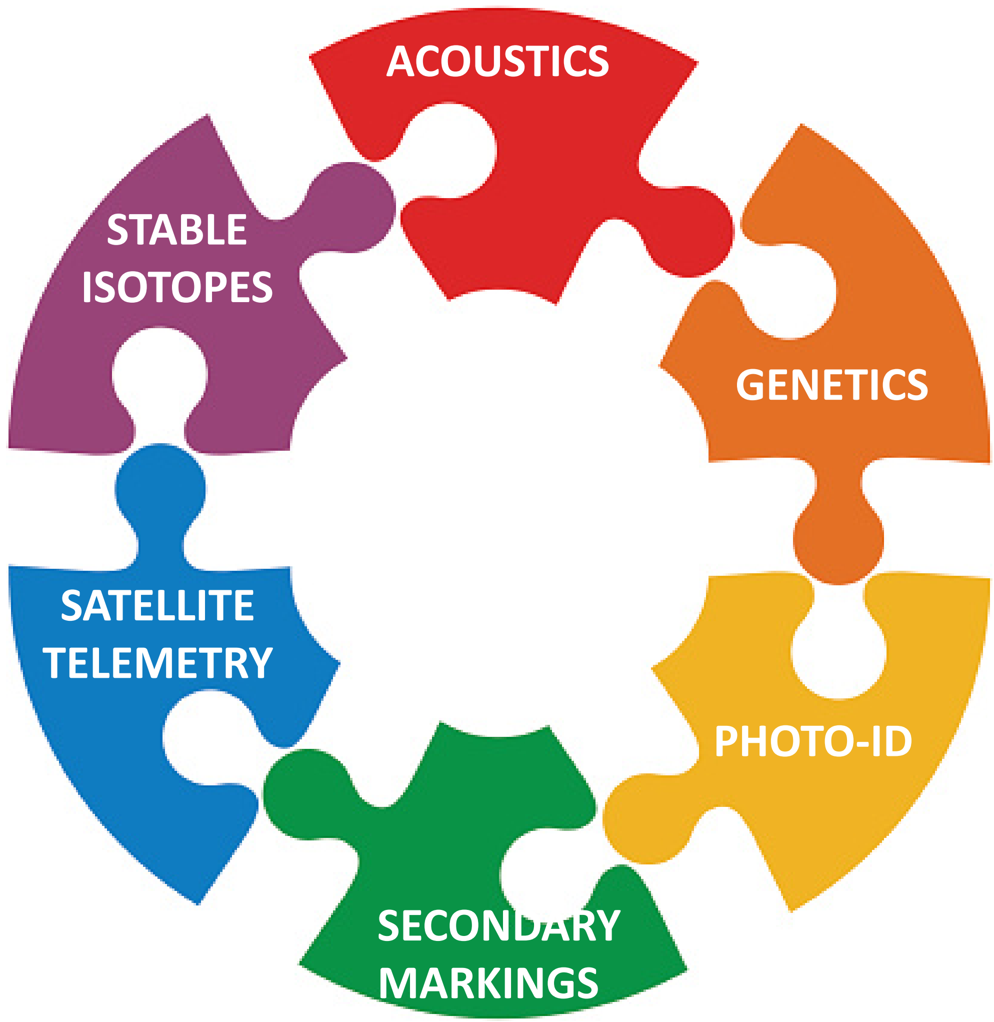
Modes of connectivity: Migratory connectivity



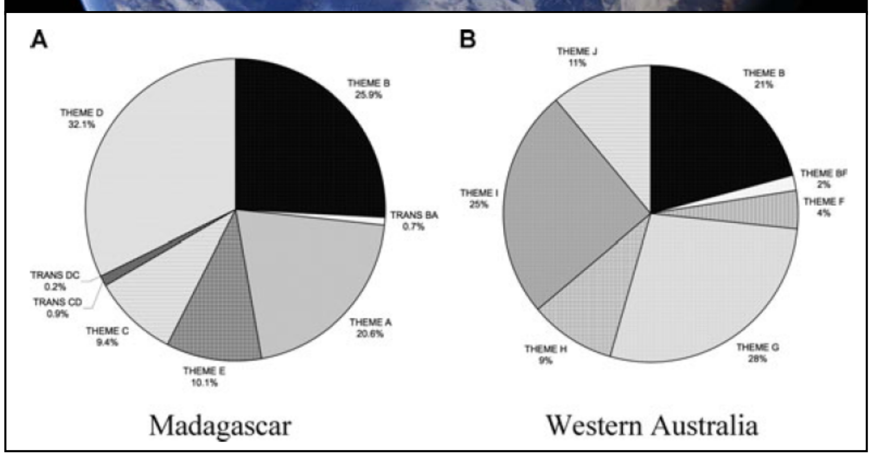
Modes of connectivity: Population-level connectivity



The marine mammal connectivity toolbox



Acoustics – contact between humpback whale breeding populations in the Indian Ocean

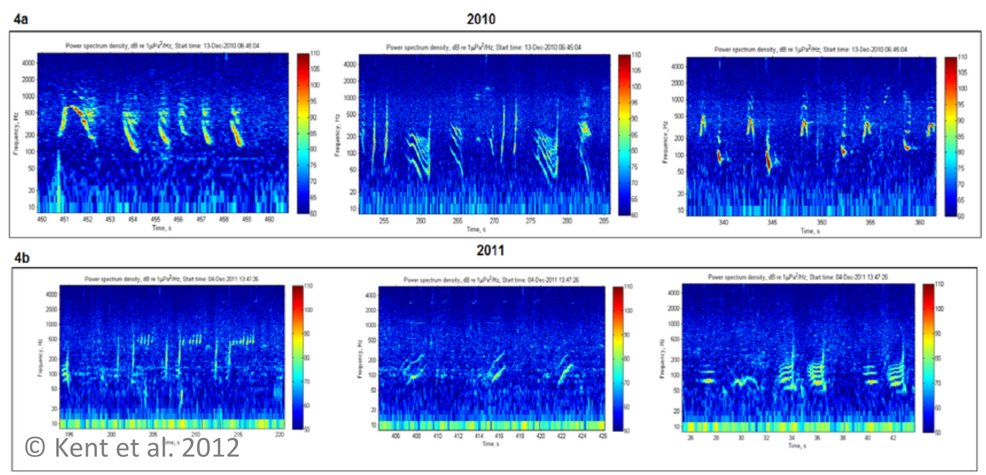


Advantages

- Data collection in remote environments
- Recent contact between populations

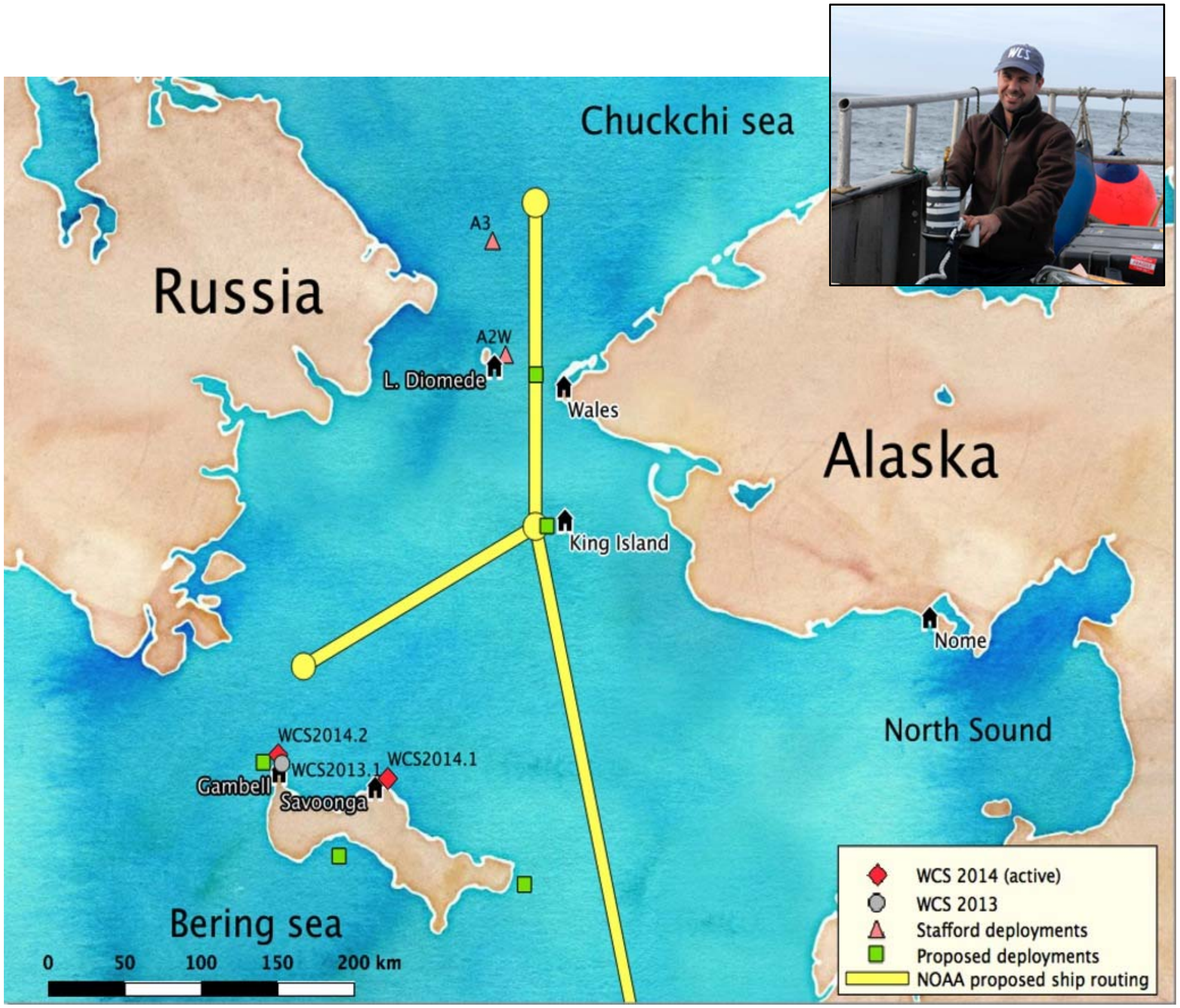
Disadvantages

- Low resolution data
- Suitable for a vocalizing species

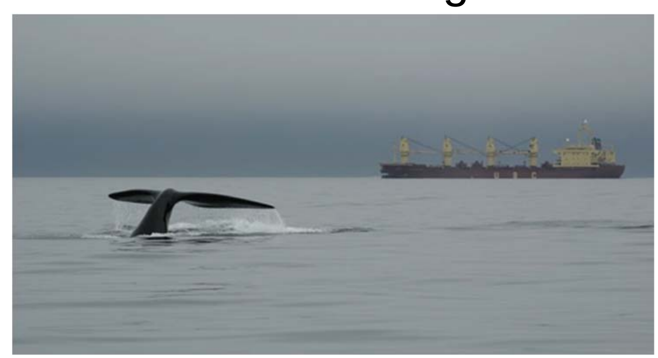


Murray et al. 2012 *Marine Mammal Science*

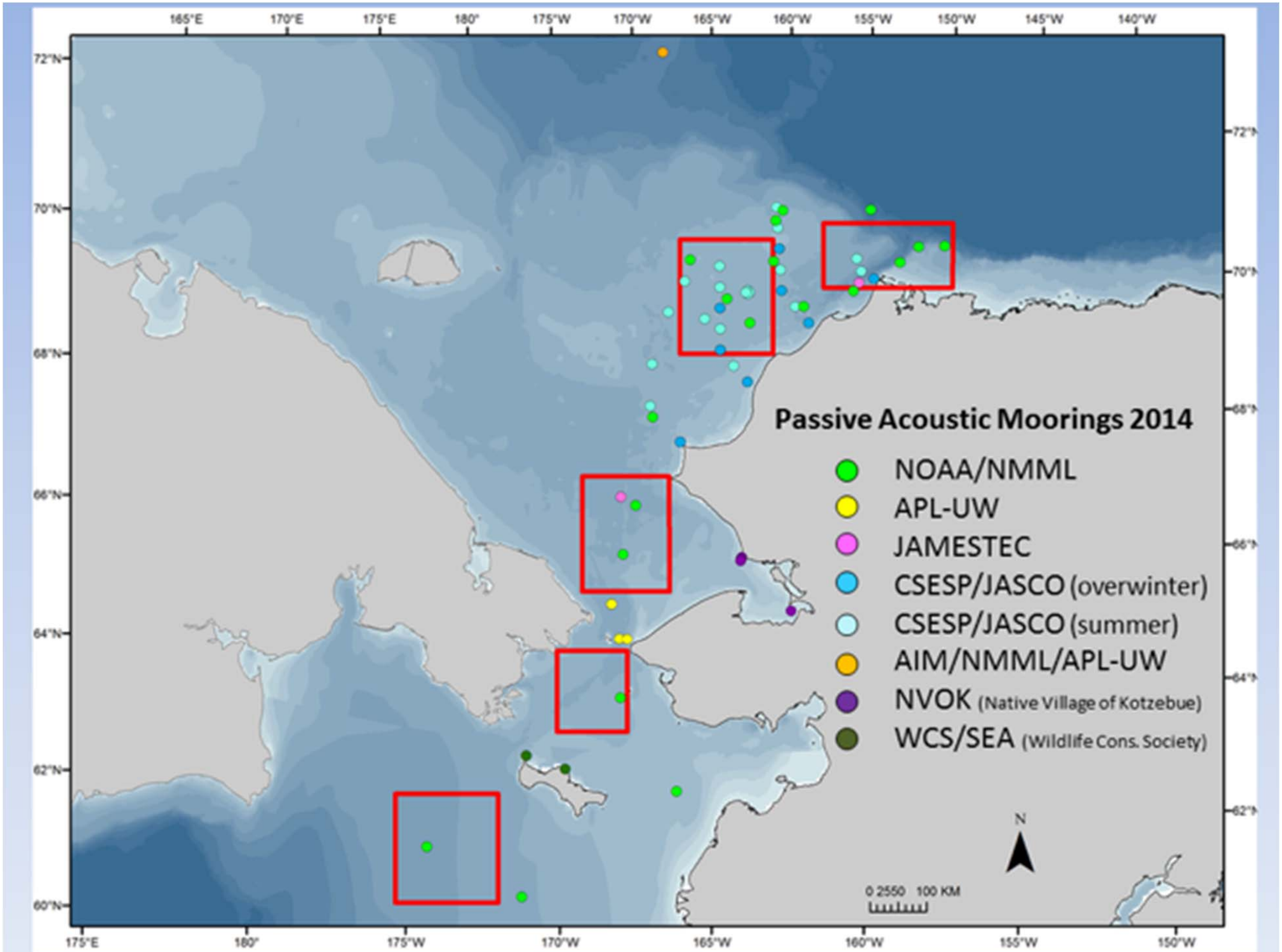
PROVIDING SAFE PASSAGE



- Detect marine mammal sounds
- Timing of migration/habitat-use
- Measuring Noise
- Guide Safe Passage



Rosenbaum, Antunes, Robards, Southall, Stafford: Funded



Passive Acoustic Moorings 2014
NOAA/NMML
APL-UW
JAMESTEC
CSESP/JASCO (overwinter)
CSESP/JASCO (summer)
AIM/NMML/APL-UW
NVOK (Native Village of Kotzebue)
WCS/SEA (Wildlife Cons. Society)
N
0 2550 100 KM

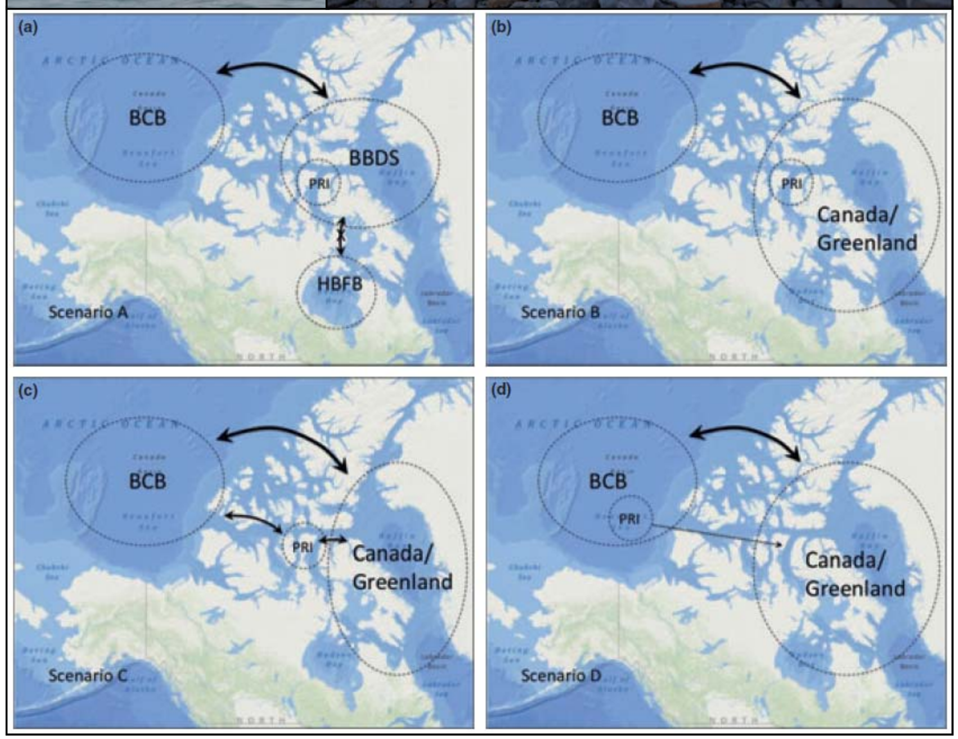
Genetics – exploring historic scenarios of bowhead whale genetic connectivity in the Arctic

Advantages

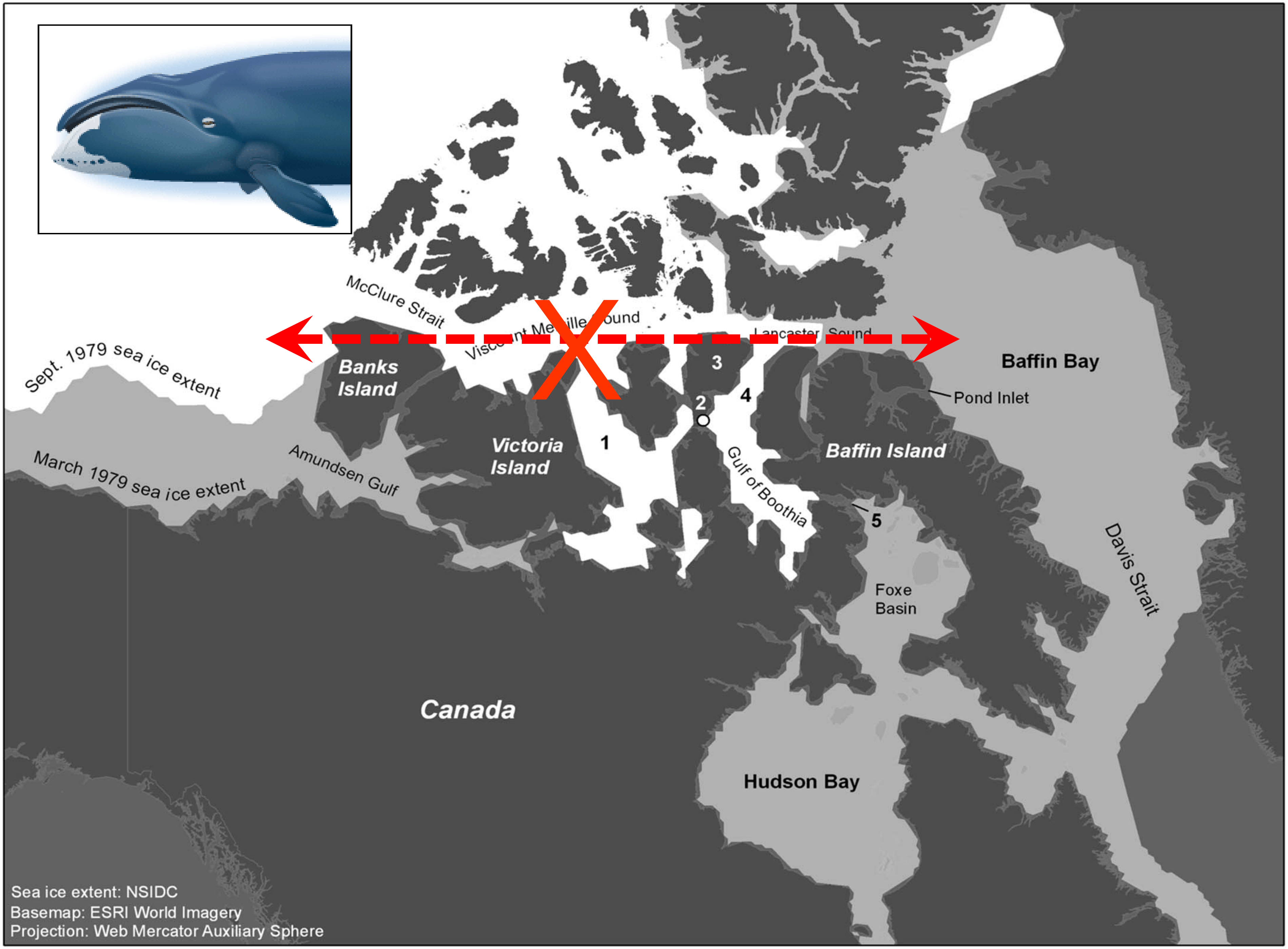
- Provides data on individual-level and population-level connectivity (required for long-term species persistence)
- Can provide a historic perspective on population size and connectivity

Disadvantages

- Sampling can be logistically challenging and costly in remote environments
- Data generation requires technical expertise and can be costly



Alter et al. 2012 *Ecology & Evolution*

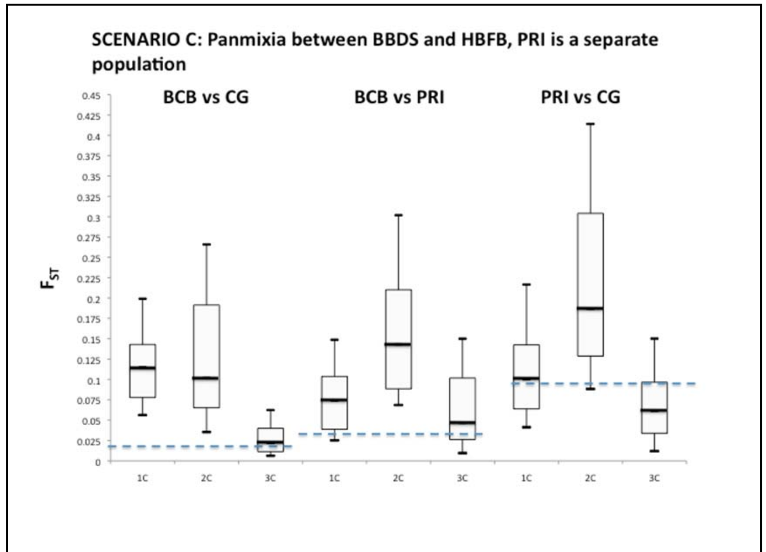

McClure Strait
Viscount Melville Sound
Lancaster Sound
Baffin Bay
Pond Inlet
Sept. 1979 sea ice extent
Banks Island
Victoria Island
1
2
3
4
5
Baffin Island
Gulf of Boothia
March 1979 sea ice extent
Amundsen Gulf
Foxe Basin
Davis Strait
Canada
Hudson Bay
Sea ice extent: NSIDC
Basemap: ESRI World Imagery
Projection: Web Mercator Auxiliary Sphere

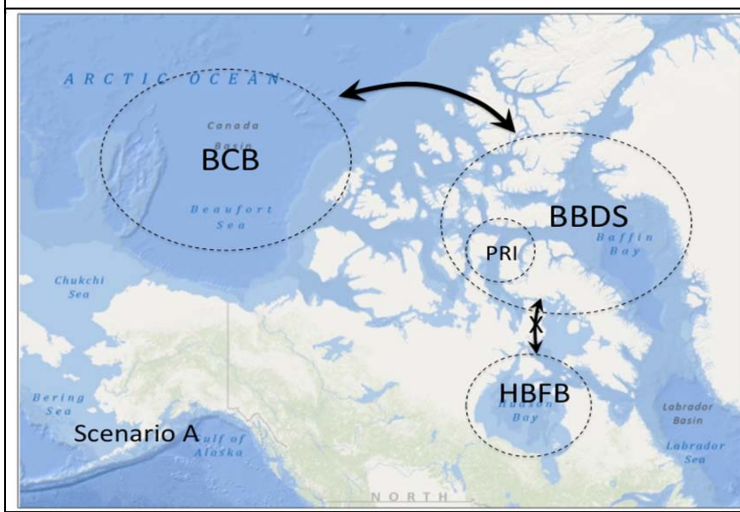
For bowhead whales, Atlantic-Pacific migration was even more recent (<100 years)

- Demographic simulations: recent to contemporary gene flow most likely

- Diversity and structure are incompatible with cessation of gene flow, even when whaling is taken into account

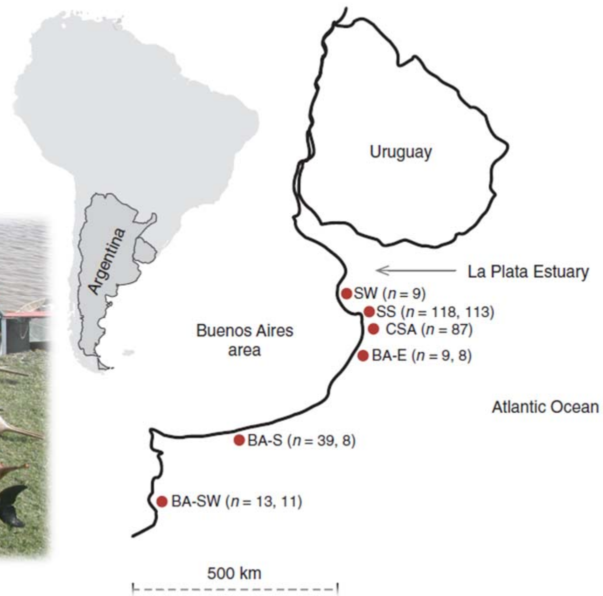
- Atlantic-Pacific divergence time much lower than other baleen whales





Alter et al. 2012 *Ecology & Evolution*

Seascape genetics – environmental variables correlate with Franciscana dolphin genetic structure in Argentina

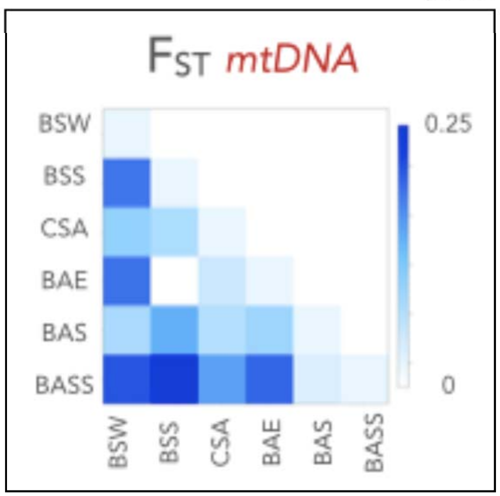


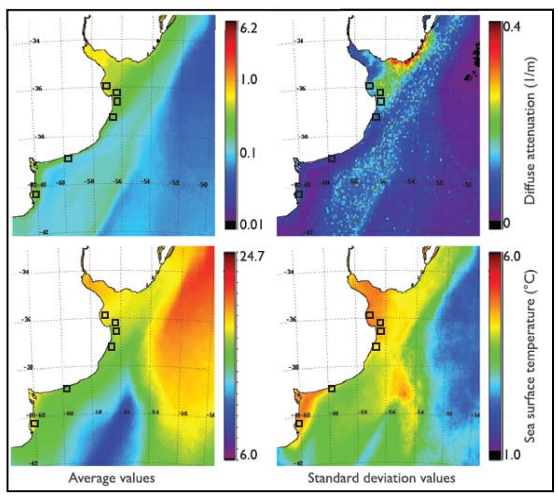
Advantages

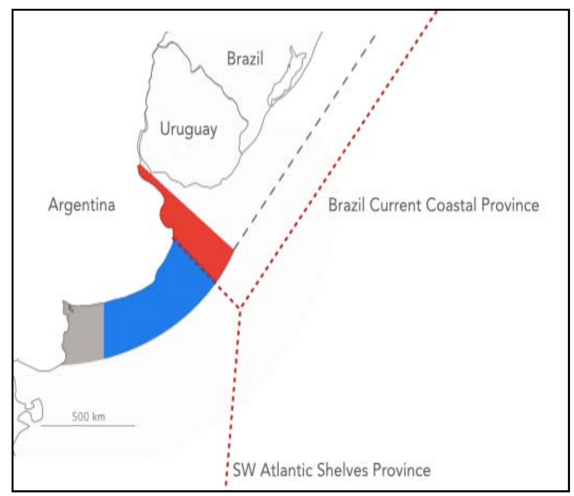
- Provides a proxy for management units and connectivity
- Remote sensing data is available at multiple spatial and temporal scales

Disadvantages

- Not suitable for all species
- Behavioral information not easily incorporated





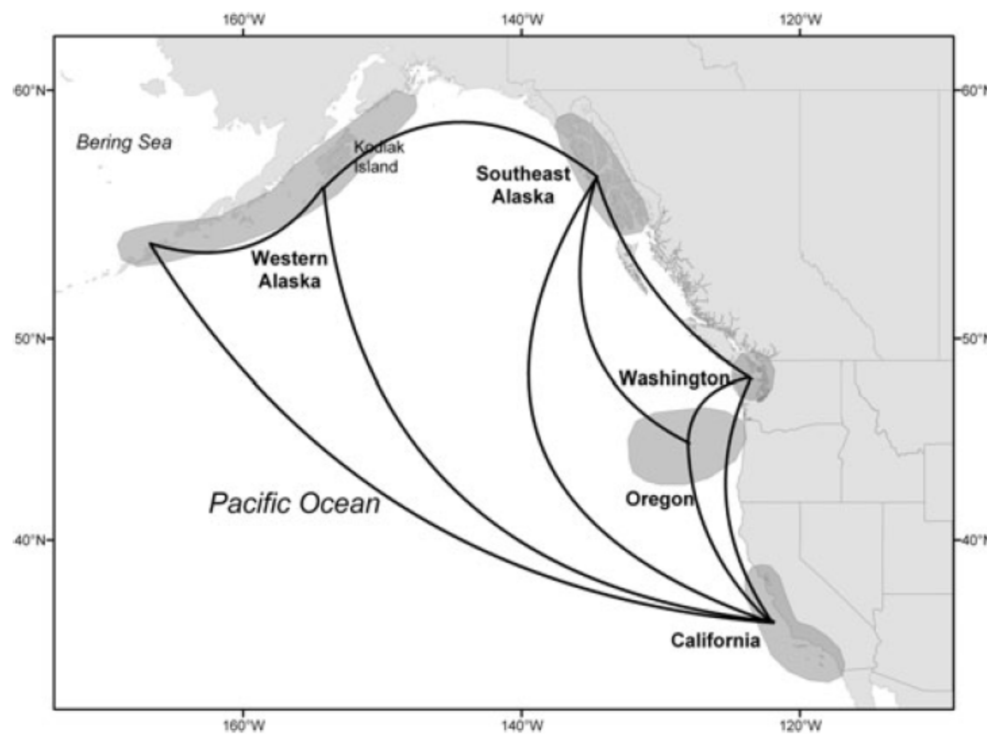


Adapted from Mendez et al. 2010 *Molecular Ecology*

Photo-ID– photographic matches reveal large-scale movements of offshore killer whales in the ENP

Advantages
- High resolution data on individual movements
- Relatively low ‘cost’ (aided by long-term development of large catalogs)

Disadvantages
- Only information on ‘end-points’ not connectivity
- Time/Effort to population level. Only applicable to some species



Dalheim et al. 2008 *Marine Mammal Science*

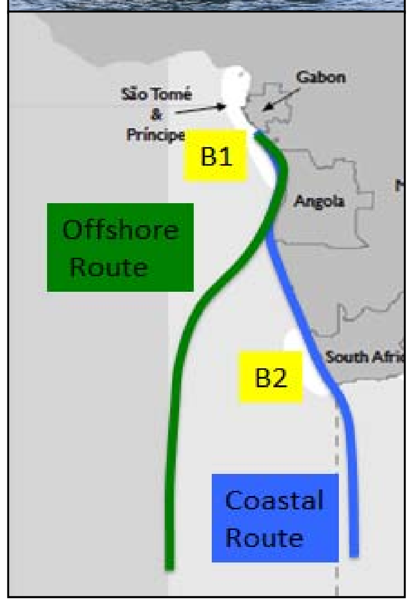
Secondary markings – cookie cutter shark bites reveal different migration routes for humpbacks off West Africa

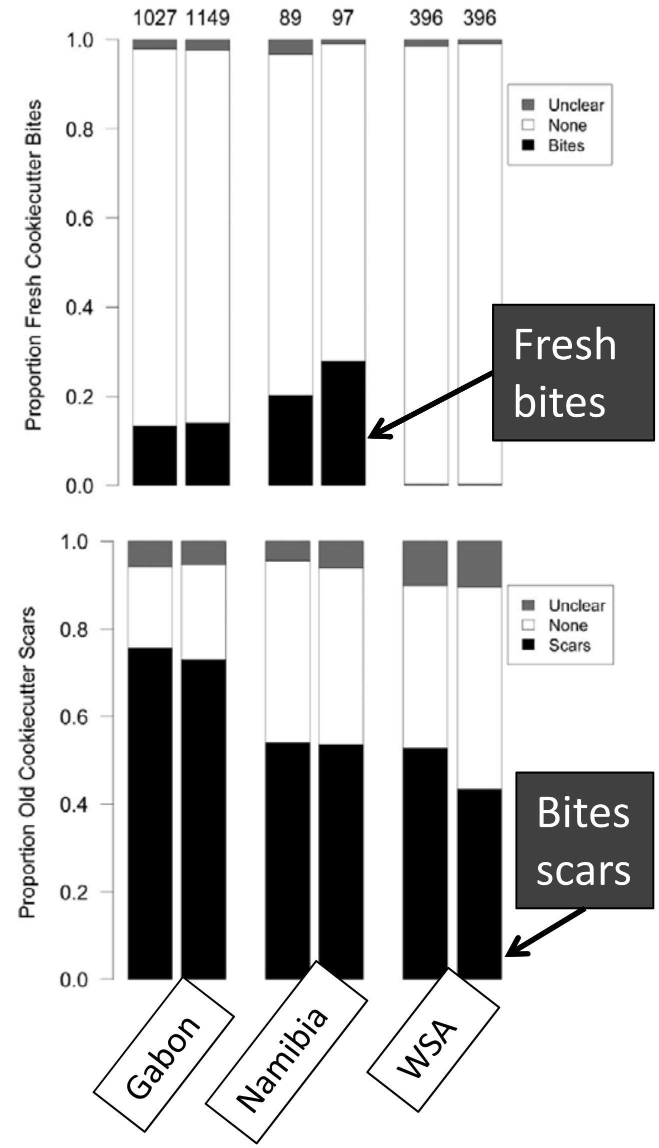
Advantages

- Easily opportunistically collected as part of photo-ID/survey efforts
- Proven to be useful across multiple species

Disadvantages

- Low resolution data
- May be misleading if distribution of secondary species not fully understood





Elwen et al. 2014 *Journal of Mammalogy*

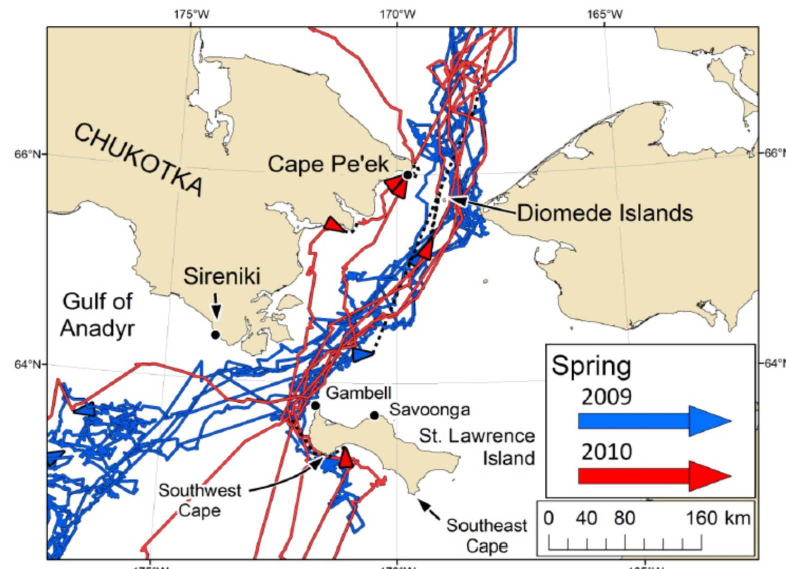
Satellite telemetry – seasonal connectivity of bowhead whales between the Bering Strait into the Chukchi Sea

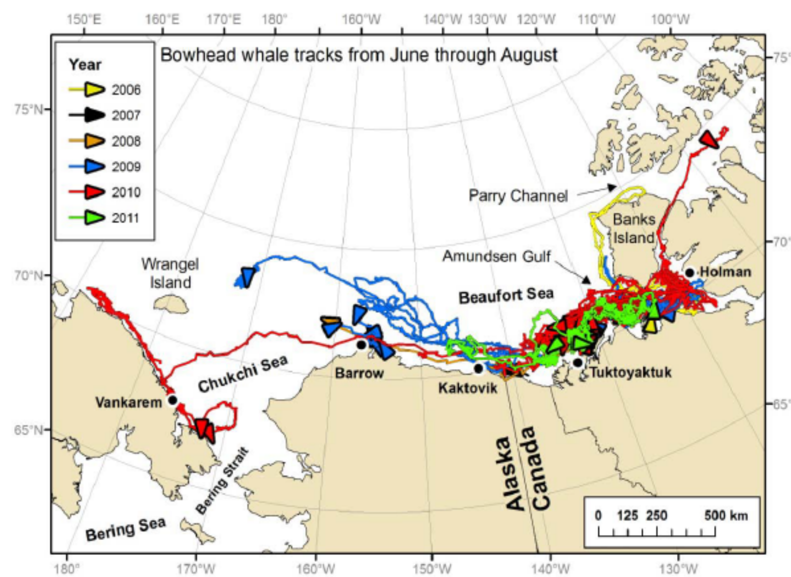
Advantages

- High resolution data of individual movement and connectivity, including offshore
- Can be used to identify high-use areas such as migratory corridors

Disadvantages

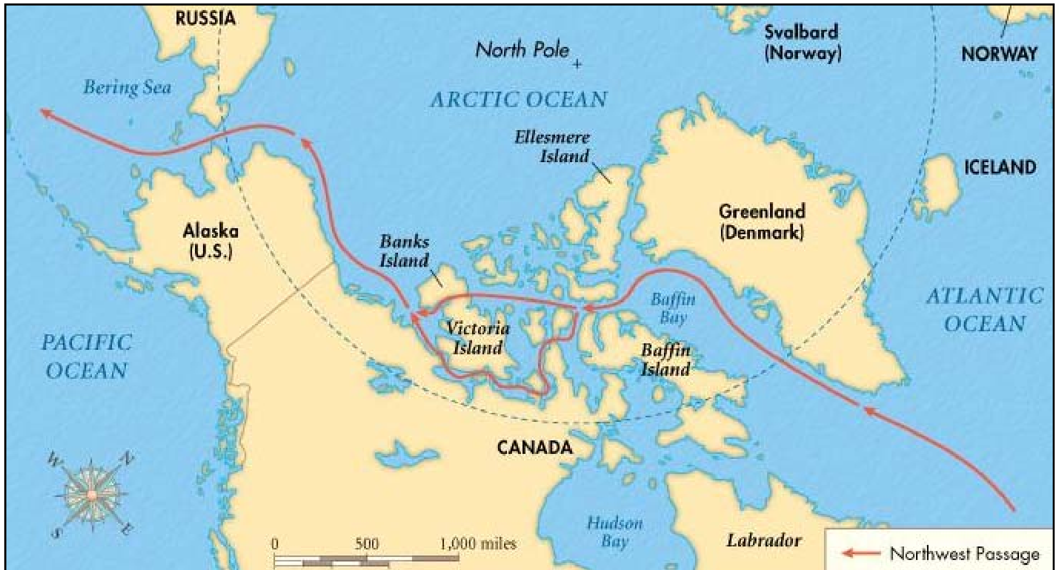
- Costly, resulting in generally low sample sizes
- Time/Effort to scale up to population-level

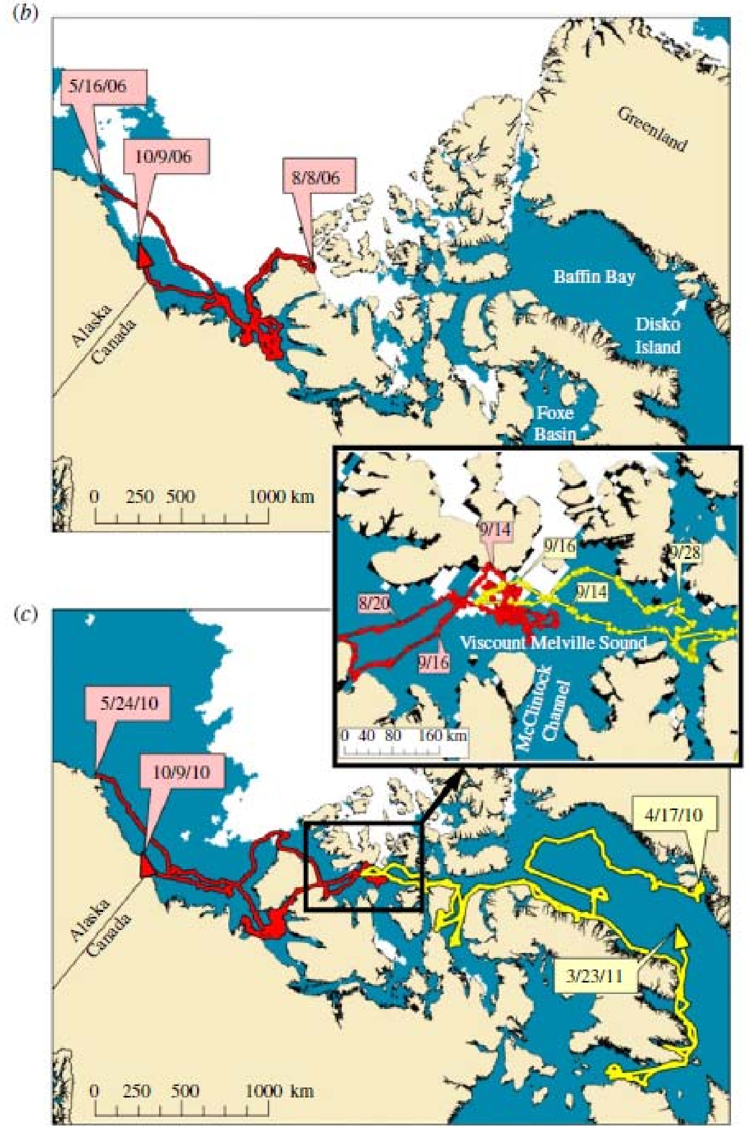




Quakenbush et al. 2012 *IWC Report SC/64/BRG1*

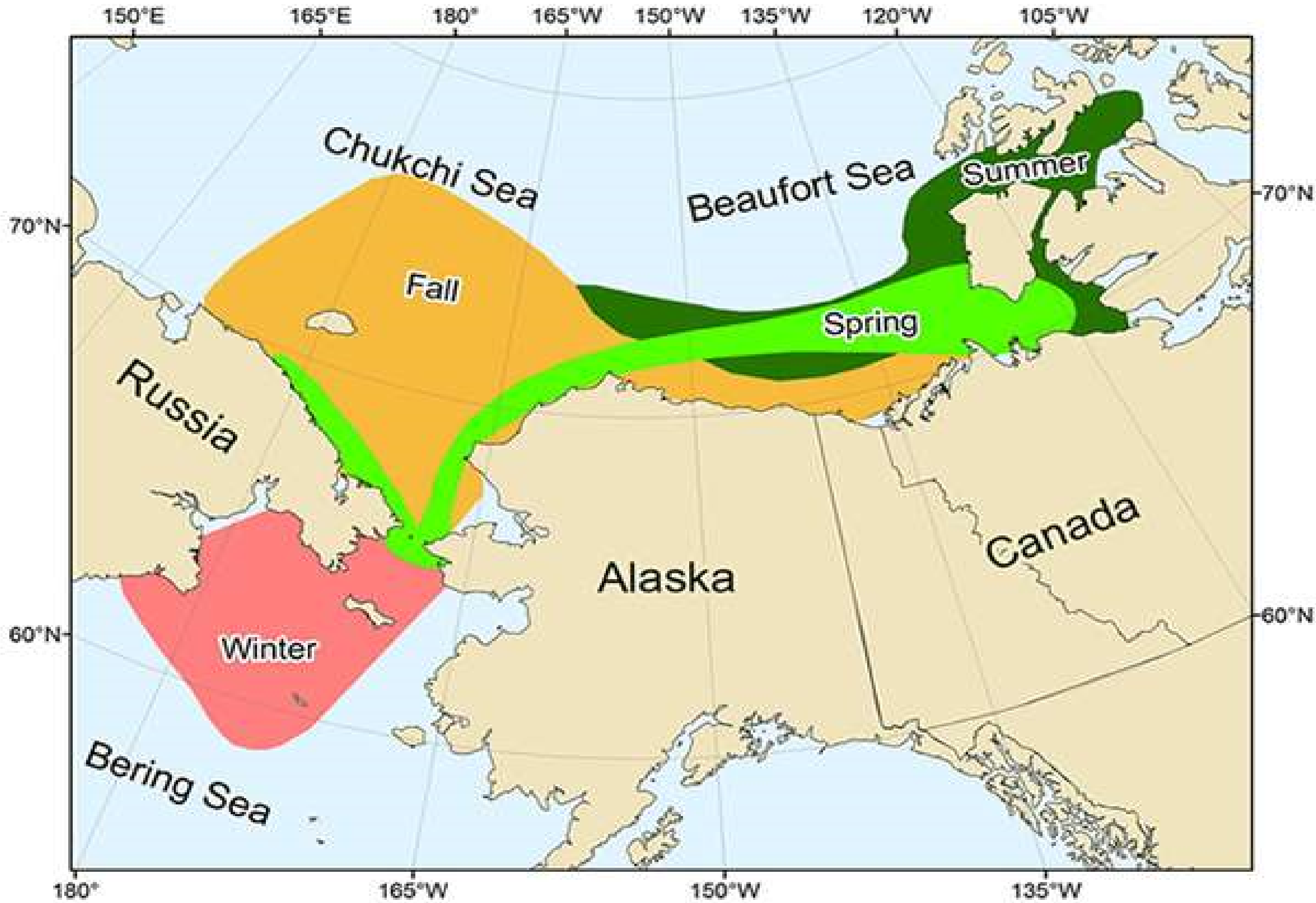
Satellite telemetry – the northwest passage connects bowhead whales from West Greenland and Alaska





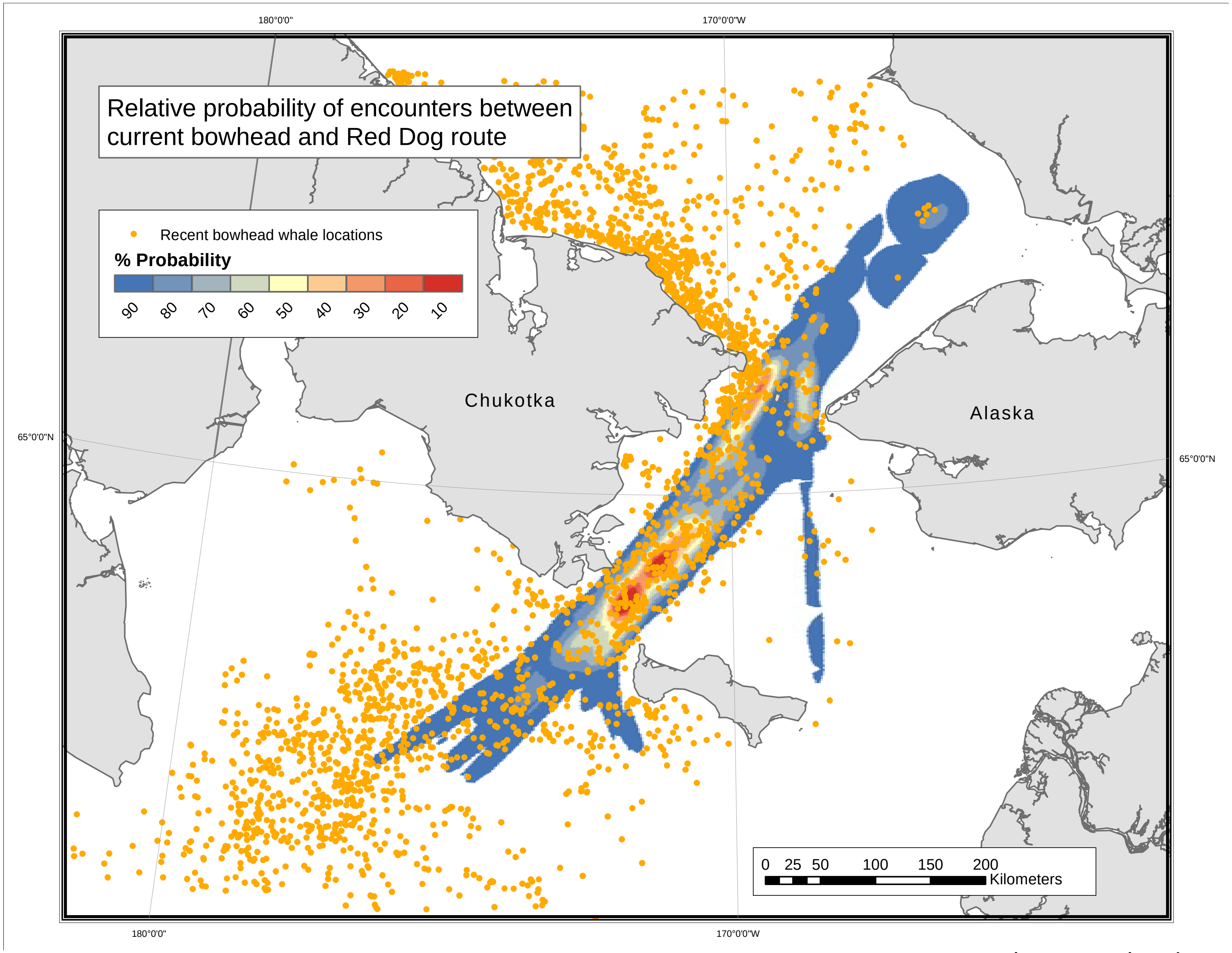
Heide-Jorgenson et al. 2012 *Biology Letters*

Satellite telemetry – seasonal connectivity of bowhead whales between the Bering Strait into the Chukchi Sea



Alaska Department of Fish & Game

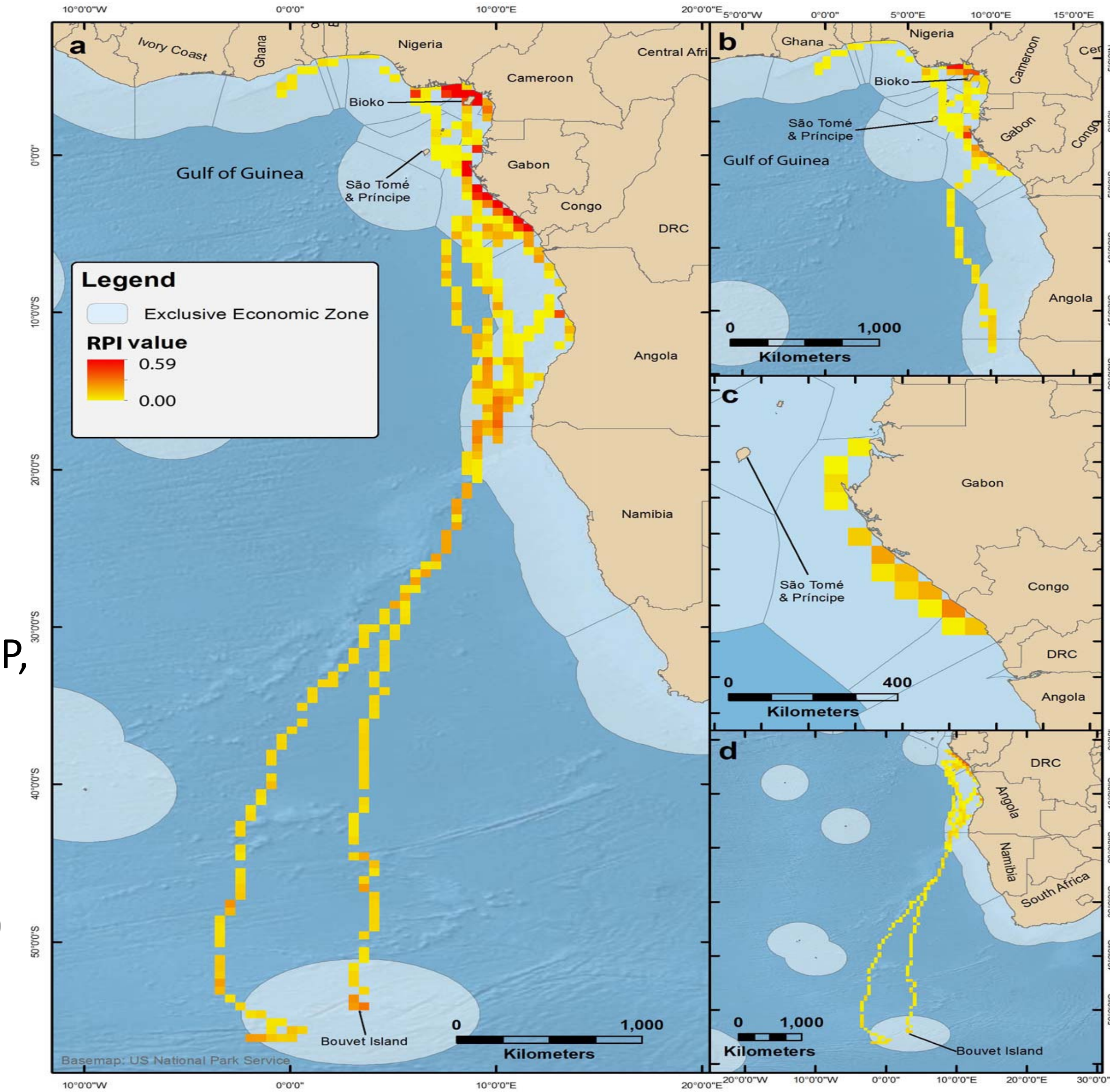
Satellite telemetry –Overlays with Anthropogenic Effects



Rosenbaum, Robards et al. *in prep*

Satellite telemetry – Looking at Relative Potential Impacts

- Humpback whales in eastern South Atlantic
- Within and Beyond EEZ movements
  - Occupancy
  - Habitat use
  - Behavior state
  - Migratory movements
  - Degree of overlap with anthropogenic activity (E&P, Shipping, Pollution)
- Interaction with anthropogenic features (RPI = relative potential impact**)**



Rosenbaum *et al*. 2014, *Conservation Biology*

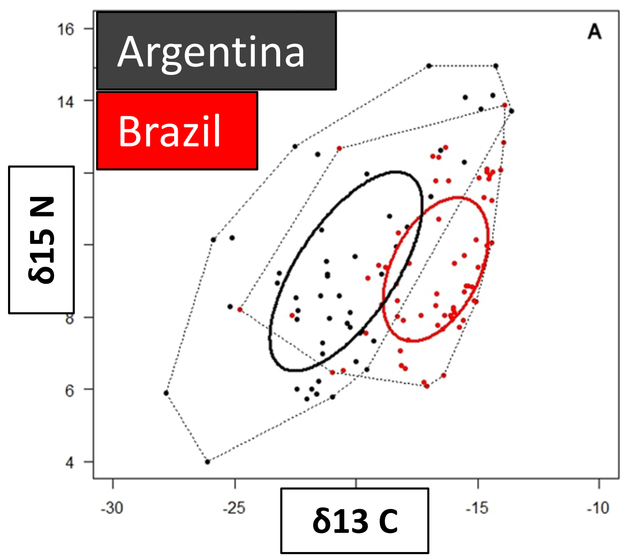
Stable isotopes – differences in feeding habitat between and within populations of southern right whales

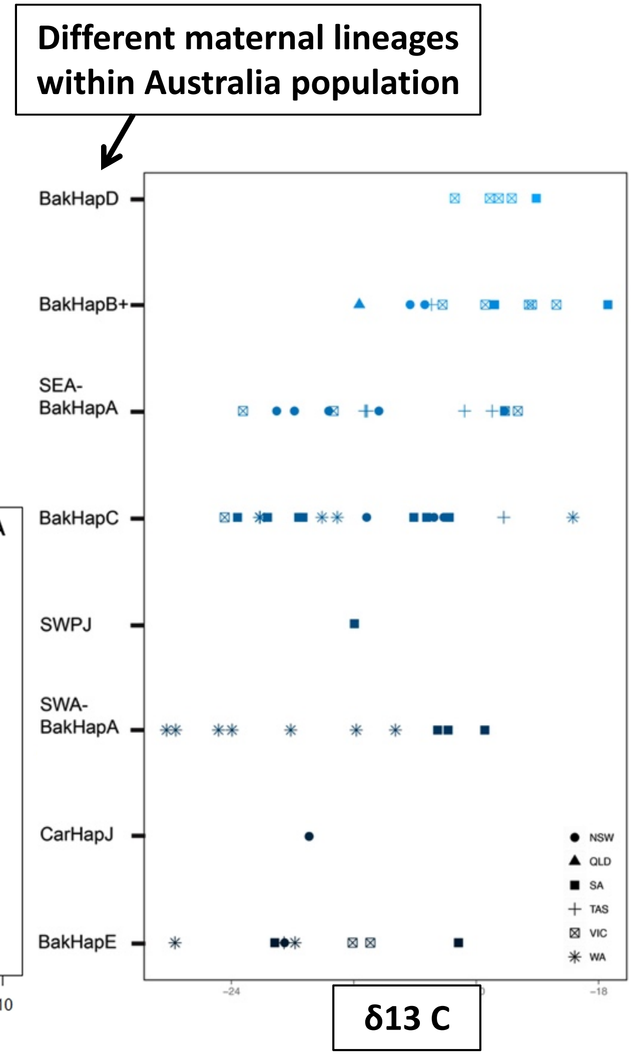
Advantages

- Can provide insights into distribution on feeding areas, which are often logistically inaccessible to sampling
- Data generation is relatively low cost

Disadvantages

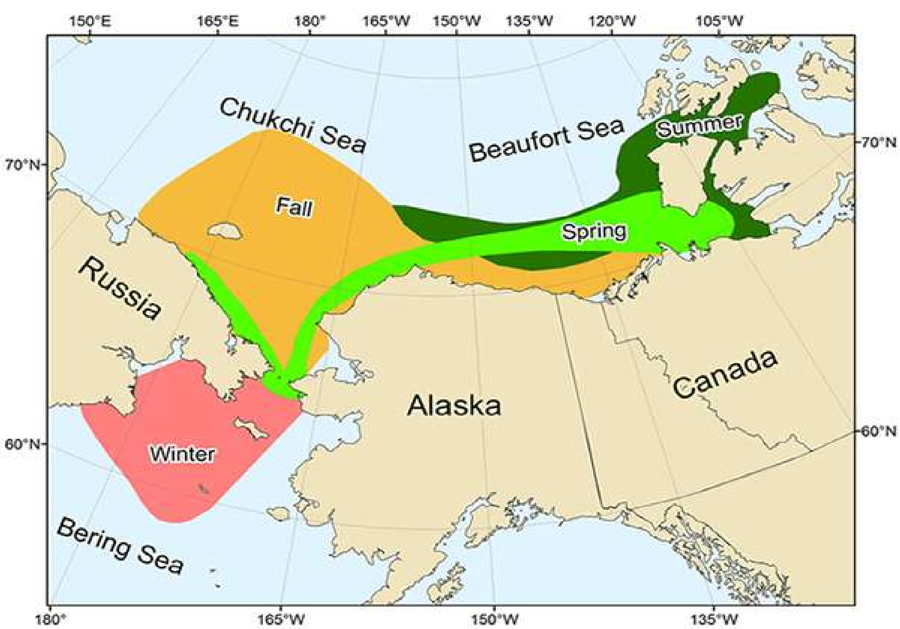
- Relatively low resolution data as ‘isoscapes’ are not well-mapped
- Data may be confounded by unknown feeding behaviors

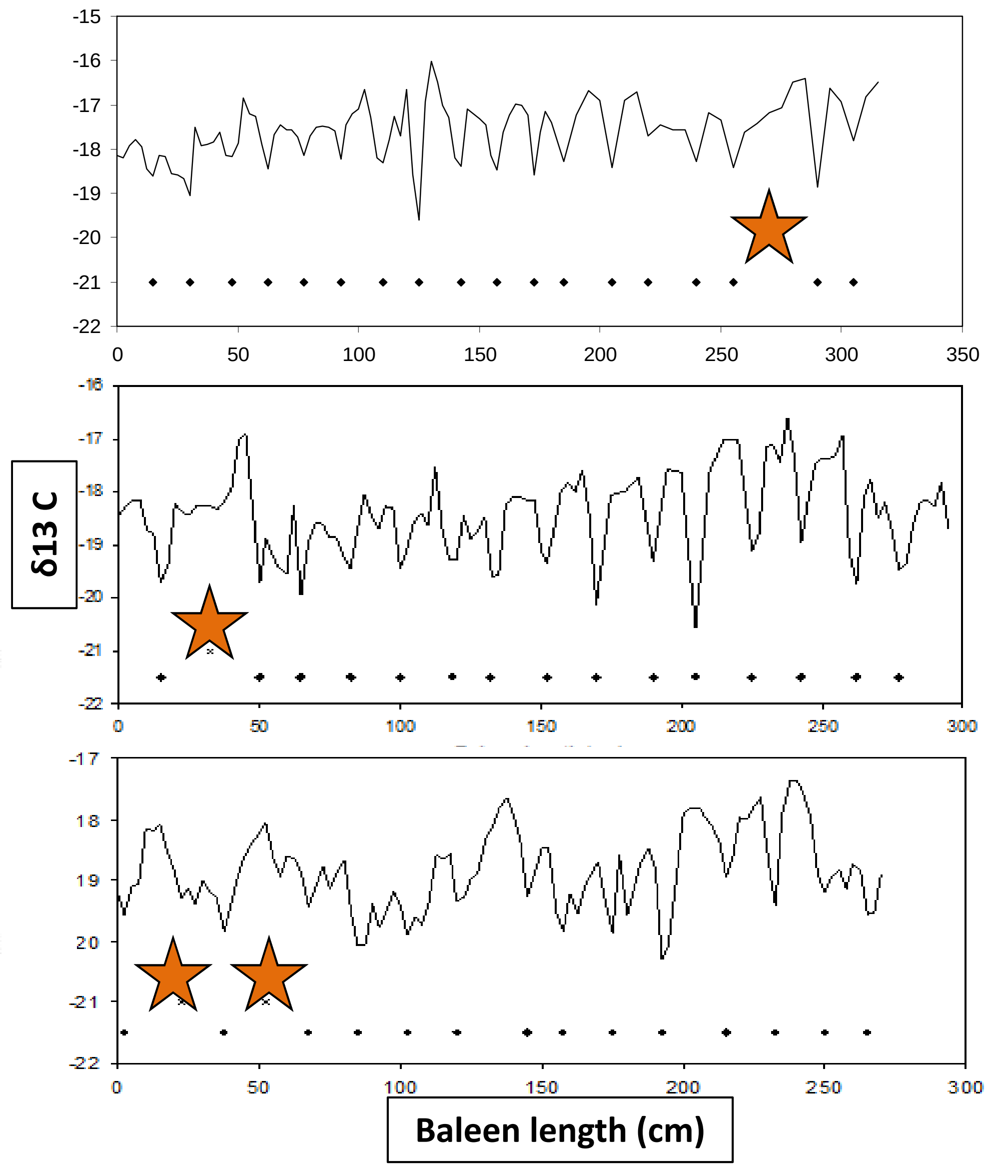




Vighi et al. 2014 *PLoS ONE*; Carroll et al. 2015 *Scientific Reports*

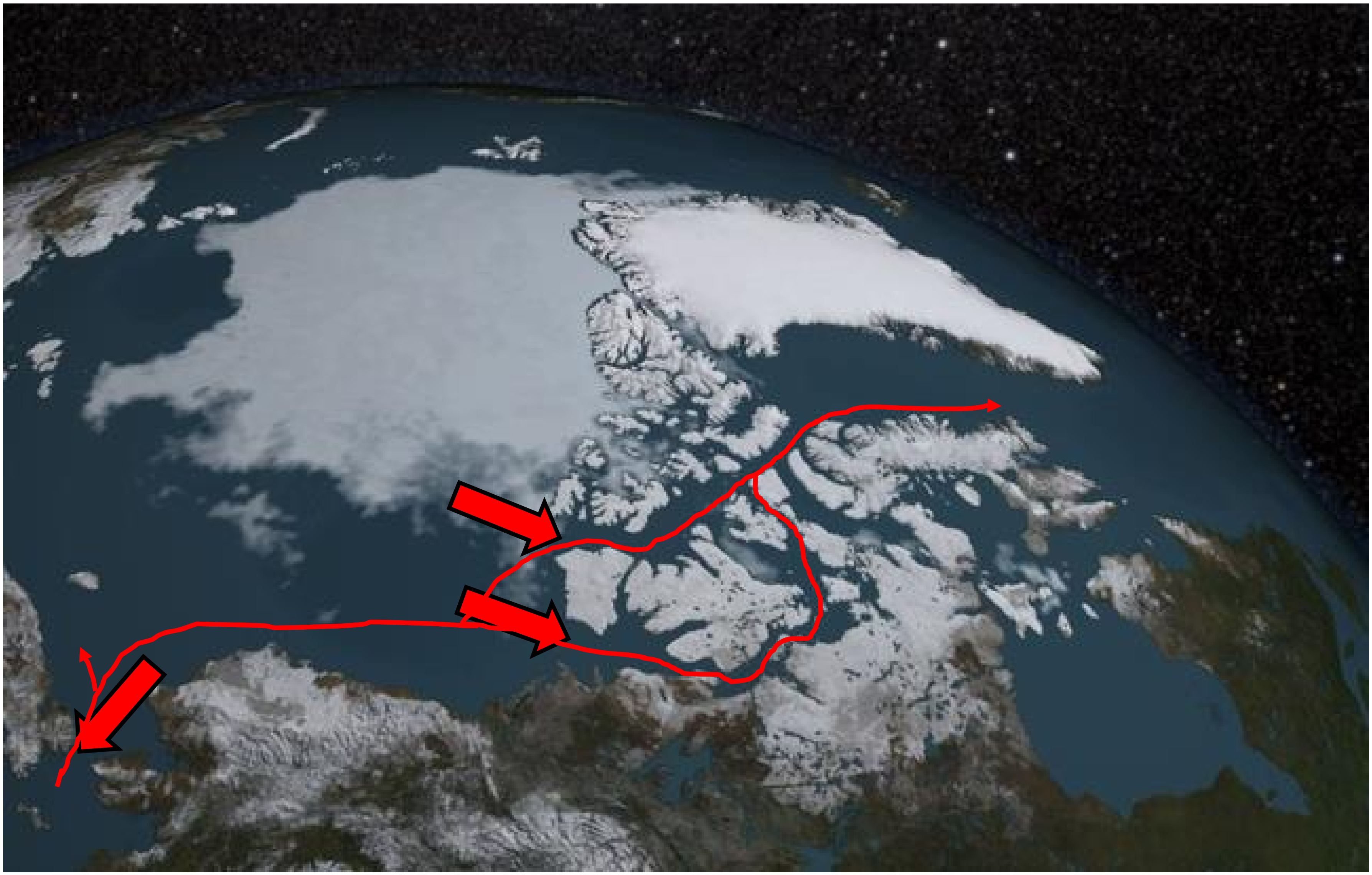
Stable isotopes – fluctuations in δ^{13}C patterns may indicate ‘missed’ migrations in bowhead whales



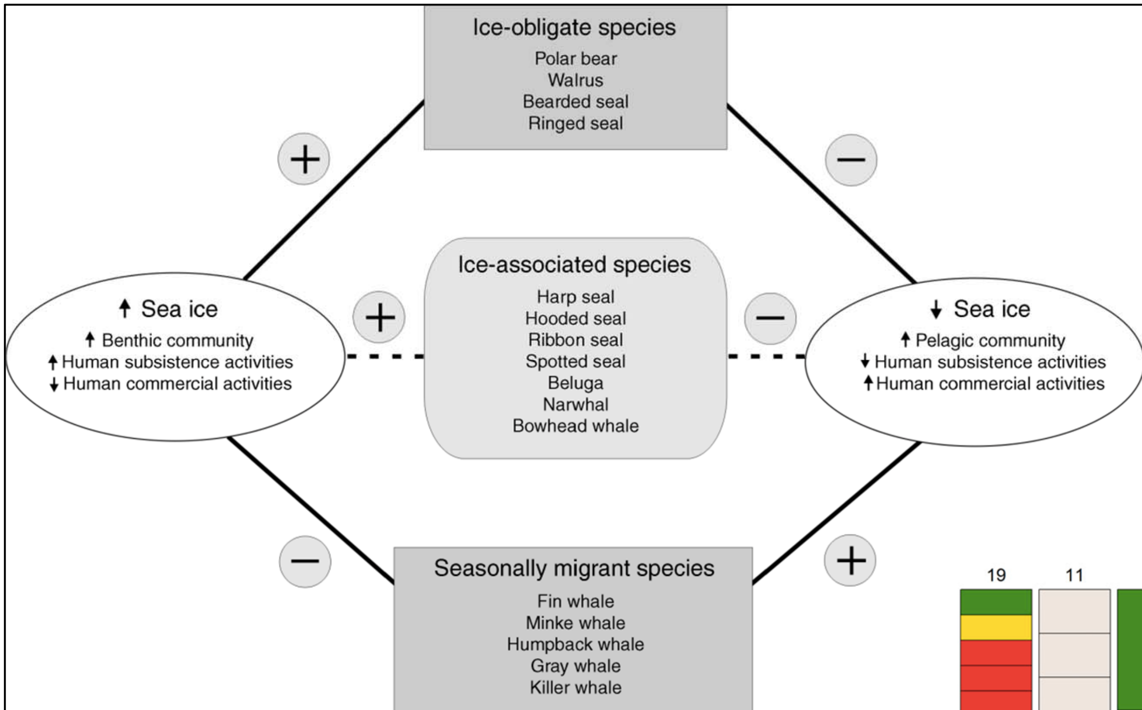


Lubetkin 2008 PhD Thesis

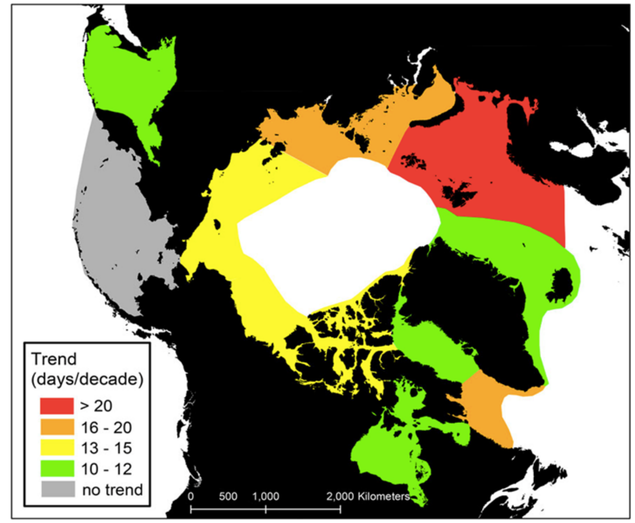
What loss of sea ice really means for marine mammals

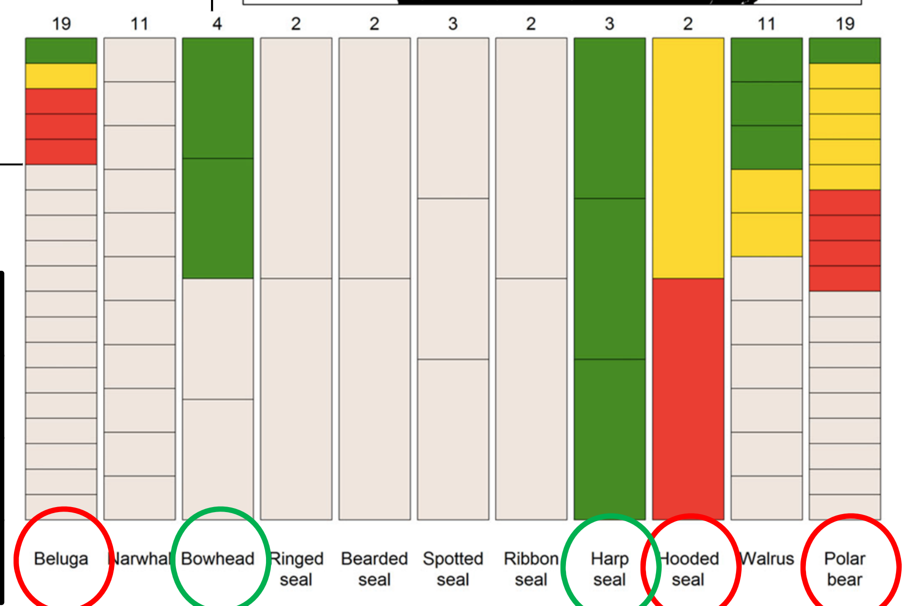


Marine mammal connectivity in a changing Arctic – a case of winners and losers



Trend in length of summer season
(spring ice retreat to fall ice advance)





Current trend in abundance

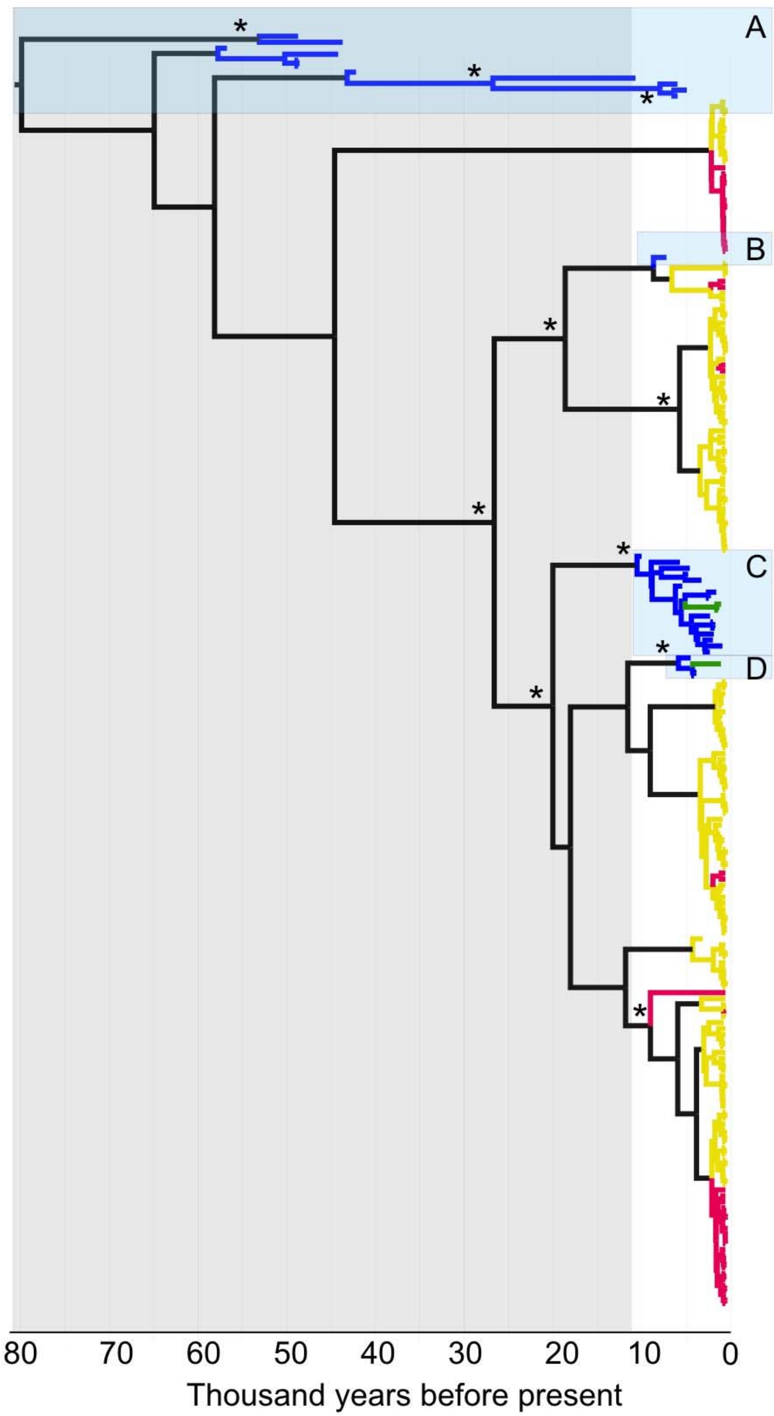
Increasing
Stable
Declining
Unknown

Moore & Huntingdon 2008 *Ecological Applications*; Laidre et al. 2015 *Conservation Biology*

Climate impacts on transocean dispersal and habitat in gray whales from the Pleistocene to 2100

S. ELIZABETH ALTER,*†‡ MATTHIAS MEYER,§ KLAAS POST,¶ PAUL CZECHOWSKI,‡** PETER GRAVLUND,†† CORK GAINES,‡ HOWARD C. ROSENBAUM,‡‡‡ KRISTIN KASCHNER,§§ SAMUEL T. TURVEY,¶¶ JOHANNES VAN DER PLICHT,***††† BETH SHAPIRO‡‡‡ and MICHAEL HOFREITER§§§¶¶¶

Alter et al. 2015 *Molecular Ecology*



MRCA of oldest Atlantic lineage: 63-102 ka ago (median=79)

MRCA: 6.6-13.5 ka ago (median=9)

MRCA: 9.4-13.2 ka ago (median=10.4)

MRCA: 3.9-9 ka ago (median=5.8)

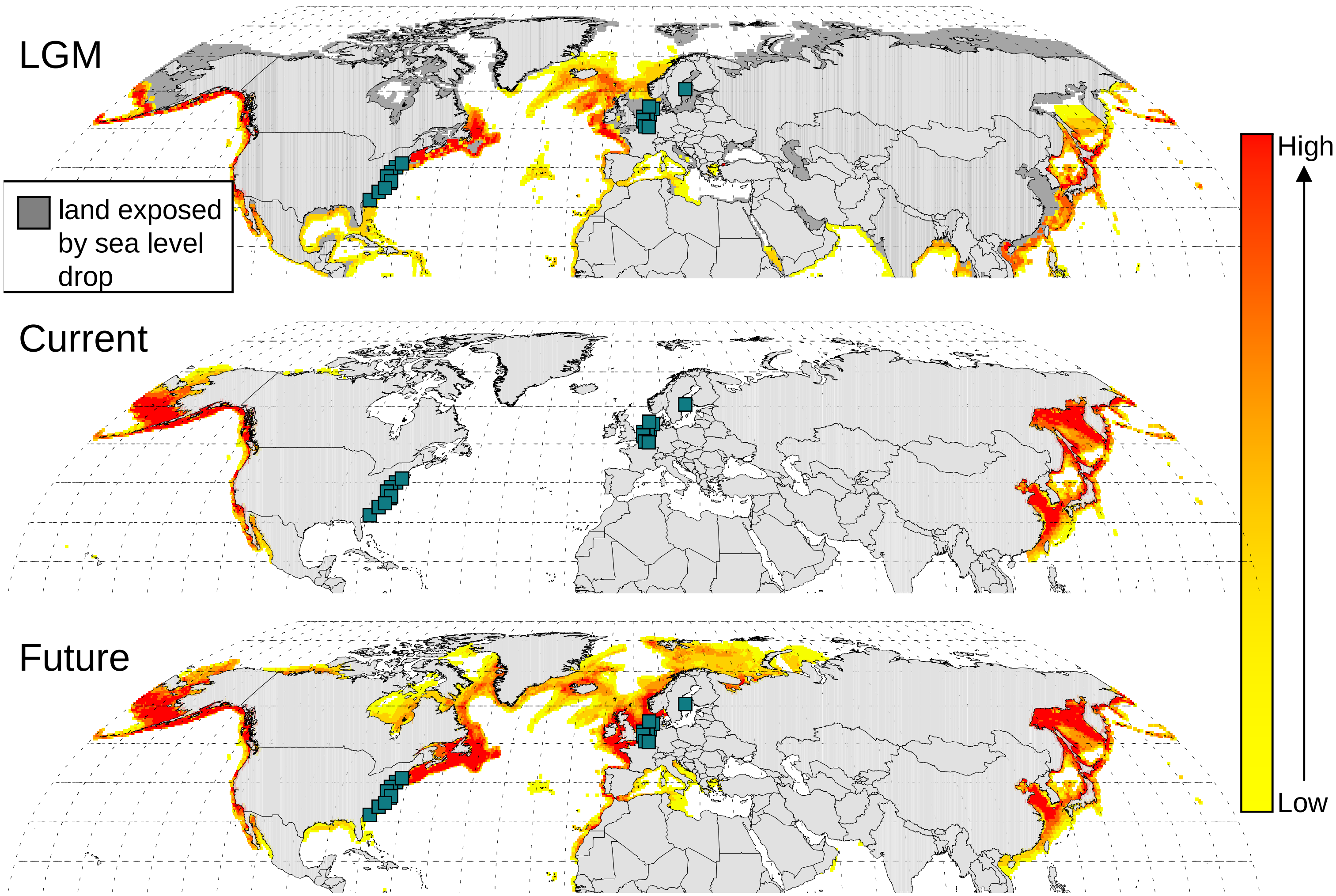
Atlantic

Eastern North Pacific

Western North Pacific

Alter et al. 2015 *Molecular Ecology*

Predicted suitable habitat for gray whales across different time periods



Alter et al. 2015 *Molecular Ecology*

Summary of key considerations

- **Protecting connectivity at multiple scales**
  - Spatial , temporal, individual-level, population-level. **Significant data gaps for many species within their Arctic range (and beyond)**
  - Cross-institutional collaboration between researchers and experts will be needed
- **Limited understanding of how many species interact with their current environment presents challenges when predicting impacts of climate change**
  - Long-term, dedicated research program required
  - Use best available science to make management decisions, and plan for adaptive management
- **Development of approaches to integrate different data types to provide a synthetic understanding of connectivity should be an active area of research**
- **Accounting for multiple species, with different habitat preferences and connectivity patterns, in a MPA network is not a simple exercise**
  - Species prioritization may be needed
  - Holistic approach to prioritize habitat and ecosystem resilience

Good news! Science-led policy processes are currently underway

- Important Marine Mammal Areas (IMMAs)
  - Guidelines to be presented at the 4th ICMMPA
  - Regional workshops planned to identify IMMAs
  - Protection policies to be developed in parallel

- Scientists are collaborating to integrate their data into MPA network design; build out from single species approach
  - E.g. Geospatial genetics (informing IMMAs)

- Local, regional and national efforts to identify and protect important habitat connections for marine mammals, especially including local community engagement (next 2 talks)

Engagement with IWC-Some interest is there; 2014 workshop and 2016 Scientific Committee

Recommendation 1. Progress towards a summary of present knowledge is being made via peer-reviewed publications, reports to the Committee (e.g. via the BRG sub-committee and HIM working group), and reports from various workshops and working groups, especially the Arctic Council Conservation of Arctic Flora and Fauna (CAFF) and Protection of the Arctic Marine Environment (PAME) Working Groups. However, a fully comprehensive list of current literature on Arctic cetaceans is not available, and would take considerable effort to compile.

Recommendation 2. Plans for co-hosted workshops should be undertaken with other Scientific Committee subcommittees and working groups and, where possible, with Arctic Council Working Groups, relevant NGOs and other stakeholders. See the examples listed below.

(a) Data and analytical requirements (both for cetaceans and human activities) for identifying high risk areas to cetaceans at the correct geographical and temporal scales: *this should be coordinated with the HIM working group, the Arctic Council's PAME working group, NGOs and other stakeholders.*

(b) Evaluation of non-direct threats to cetaceans at the population level including chemical pollution, noise, climate change, HABs, etc. (*for noise, see SC/66b/Rep10 and relevant background documents). Workshops could be coordinated with the Arctic Council CAFF, PAME and Arctic Monitoring and Assessment Program (AMAP), and also the Western Gray Whale Advisory Panel (WGWAP) Noise Task Force.*

(c) Methods to examine synergistic and cumulative effects of a range of actual and potential threats at the population level. *For this issue, see SC/66b/Rep10 and relevant background documents; build on work on health*

IWC/65/Rep07.Rev1 ; IWC SC 2016

Alter et al. 2012. Gene flow on ice: the role of sea ice and whaling in shaping Holarctic genetic diversity and population differentiation in bowhead whales (*Balaena mysticetus*). *Ecology and Evolution*, 2(11), 2895-2911.

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