Abundance and species diversity hotspots of tracked marine predators across the North American Arctic

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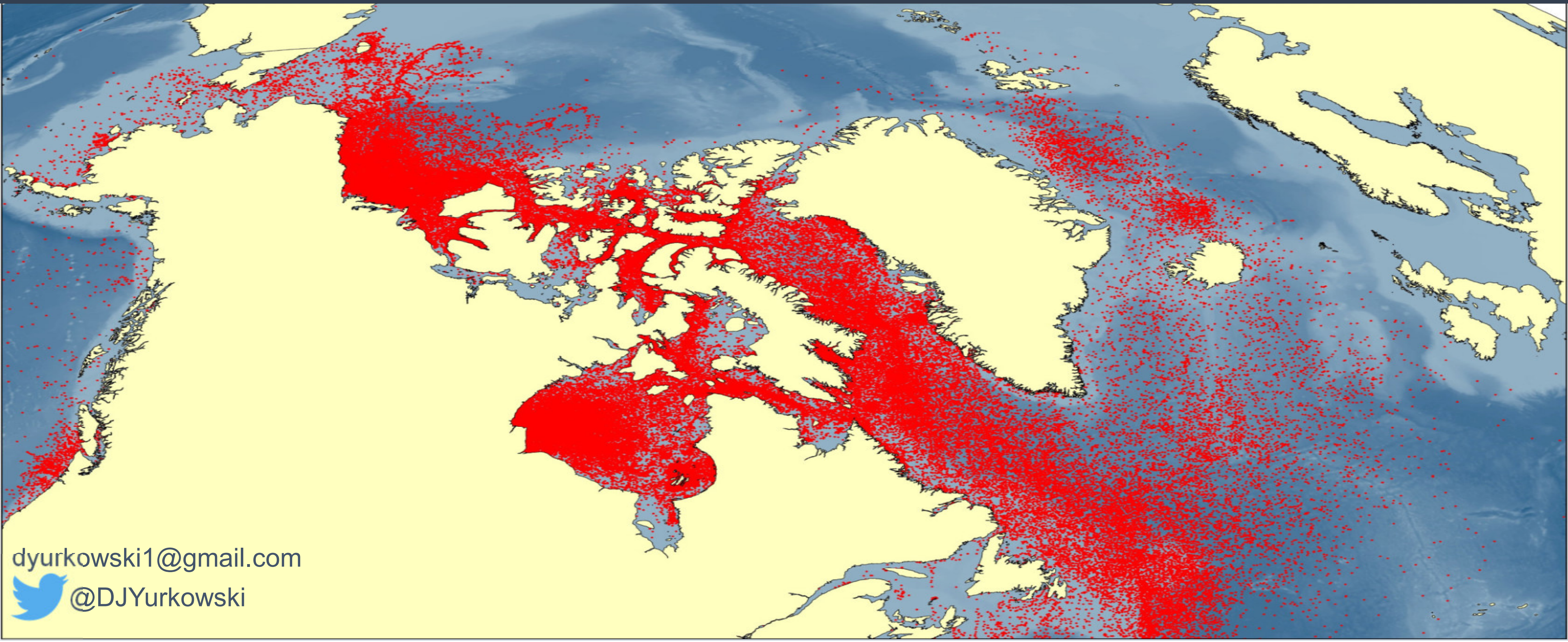

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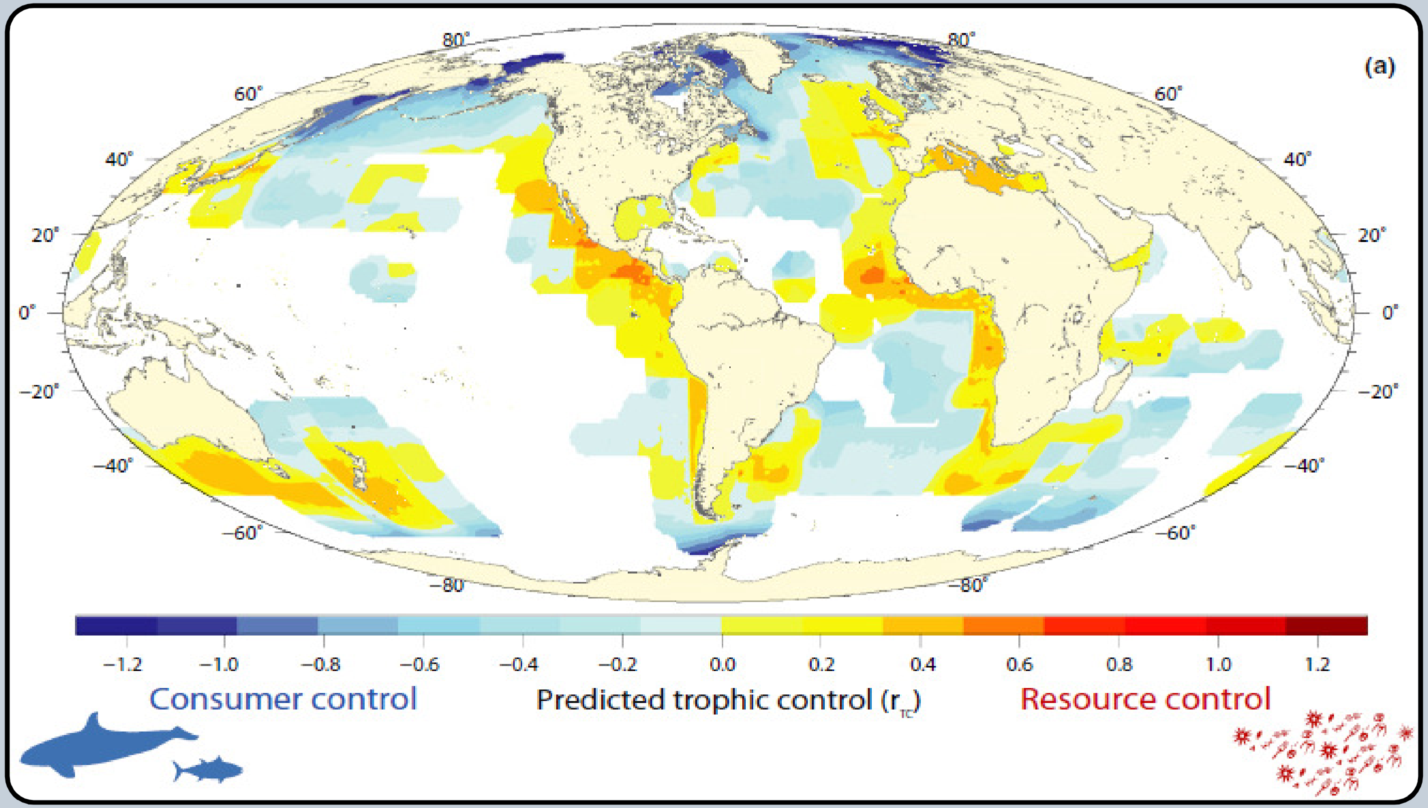
Near-apex and apex predators

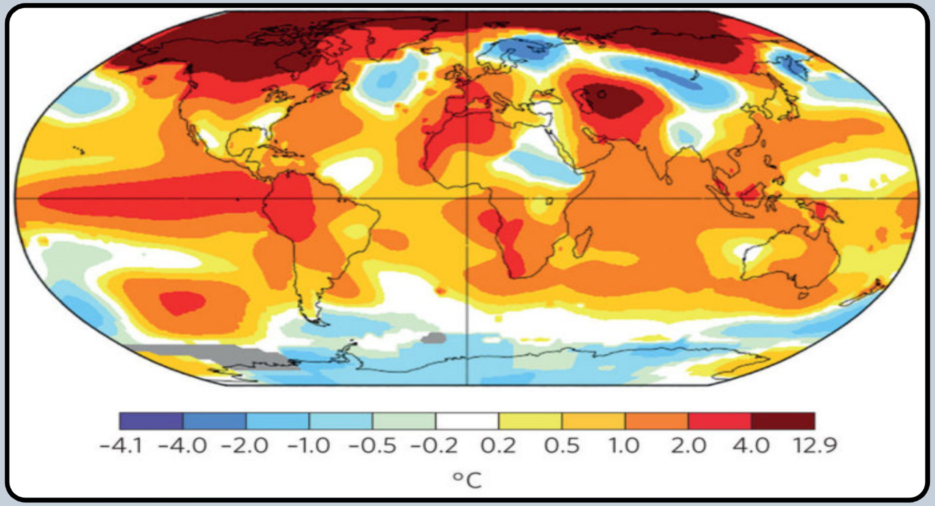
- Integrate resources across several spatial and temporal scales
  - Highly mobile
  - Sentinels to ecosystems
- Strong top-down trophic control



Boyce et al. 2015 – Ecology Letters 18: 1001-1011

Arctic ecosystem stressors

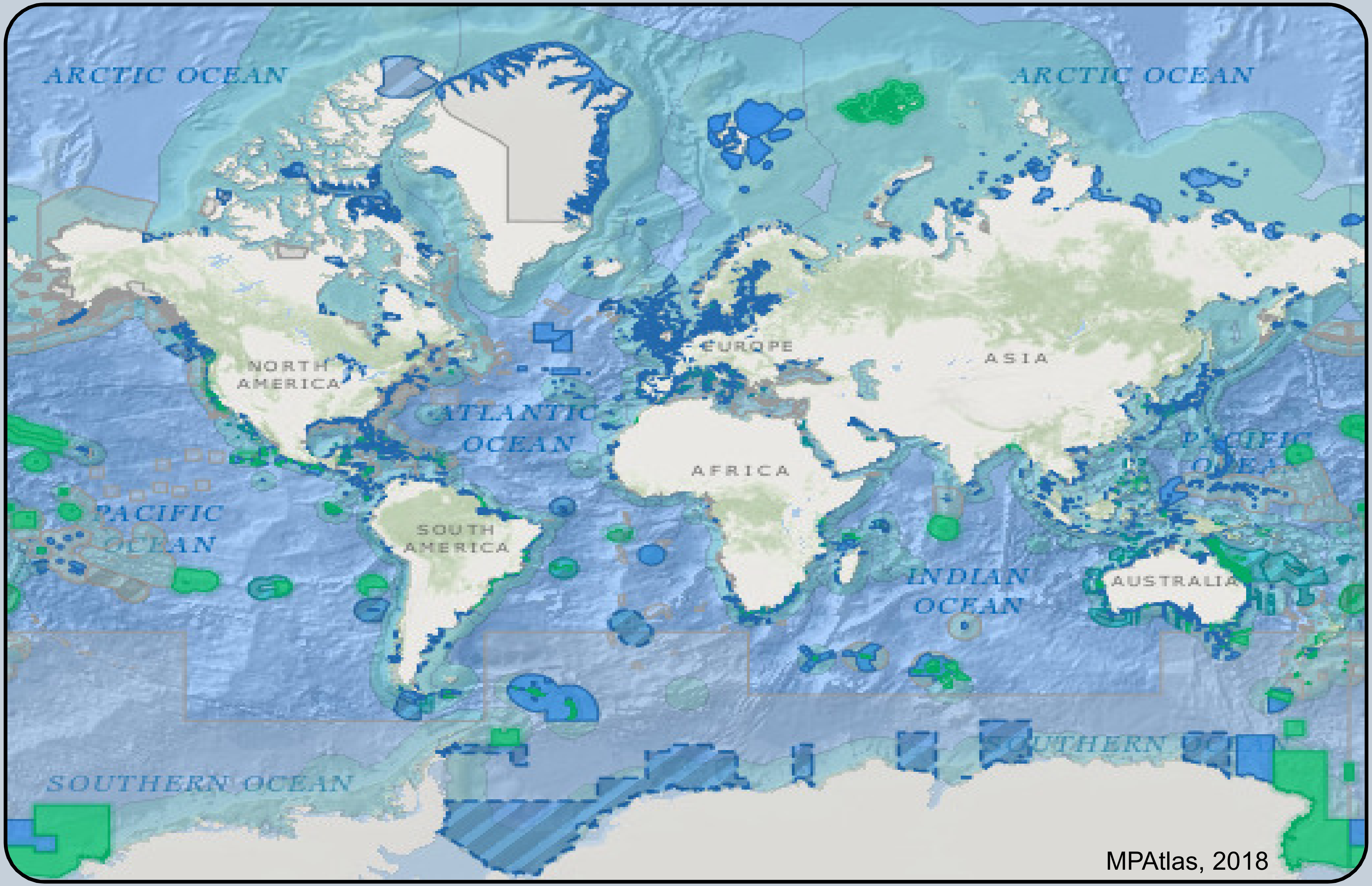
- Climate change
- Shipping
- Mining
- Fisheries potential
- Oil and gas exploration and exploitation



Overland et al. 2016 – Nat. Clim. Change 6:992-999

Important to identify areas that sustain higher levels of abundance and biodiversity for conservation and management measures

Protected areas

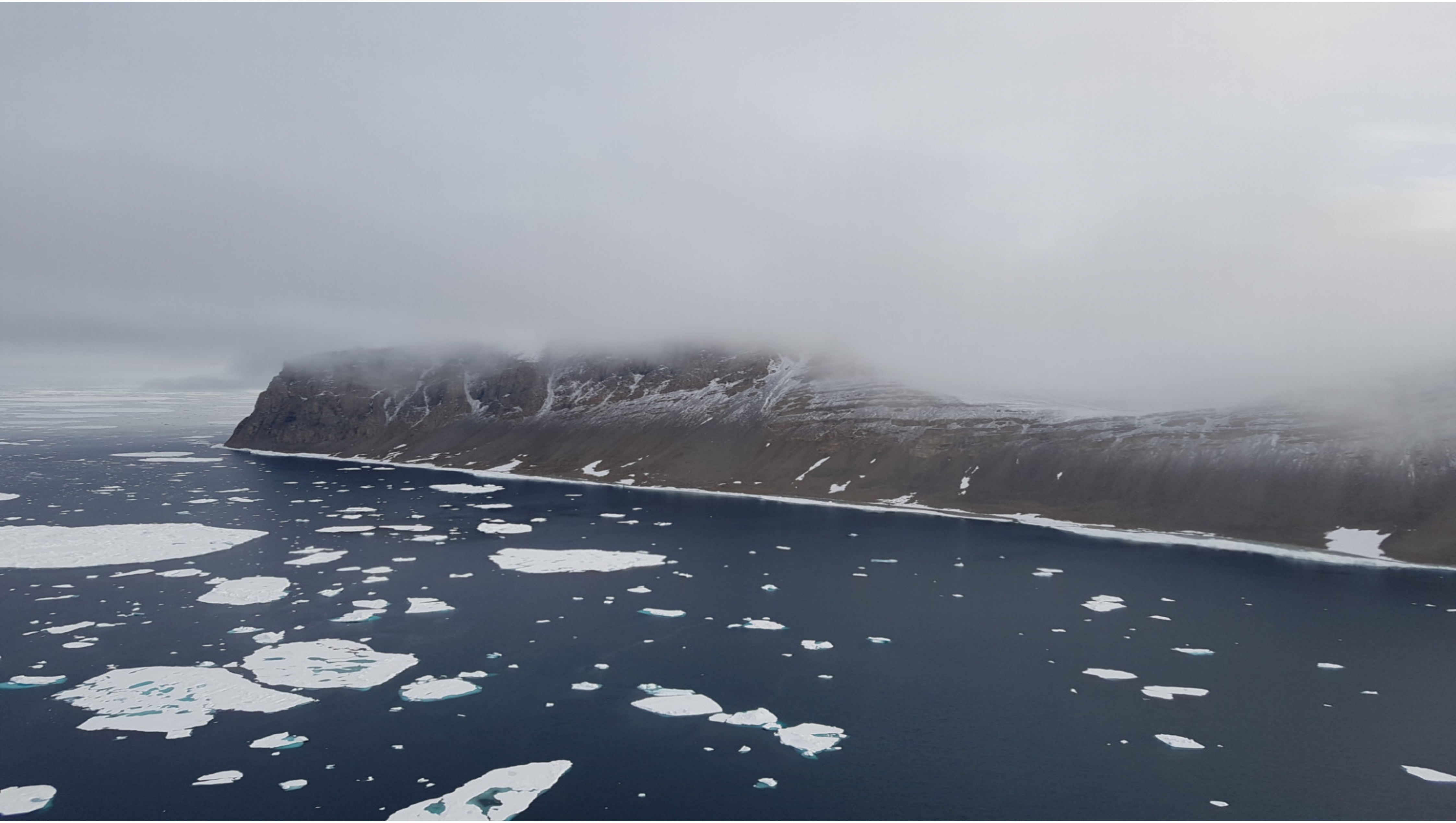


3.7% - implemented

1.8% - designated

2.0% - proposed

Global goal of 10% by 2020



Biotelemetry

Revolutionized study of animal movement ecology

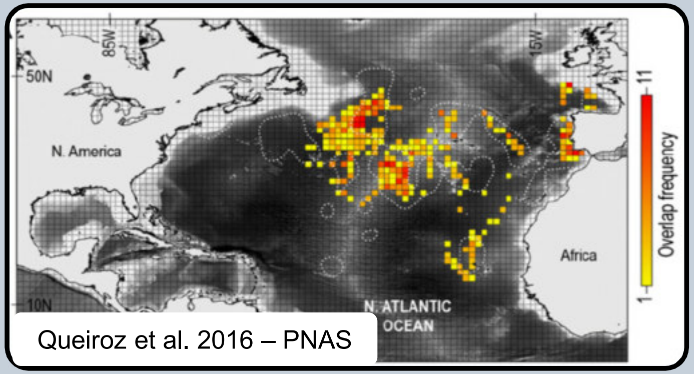
Provide insight into:

- Fish-fishing fleet interactions
- Environmental drivers of habitat use
- Species diversity hotspots
- Identify critical conservation areas

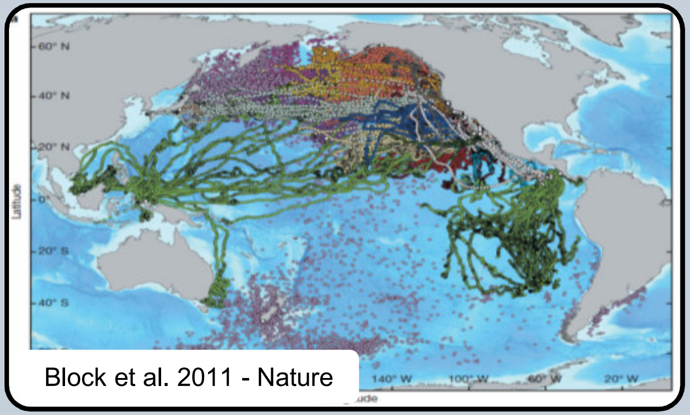
Generally been species-specific in Arctic



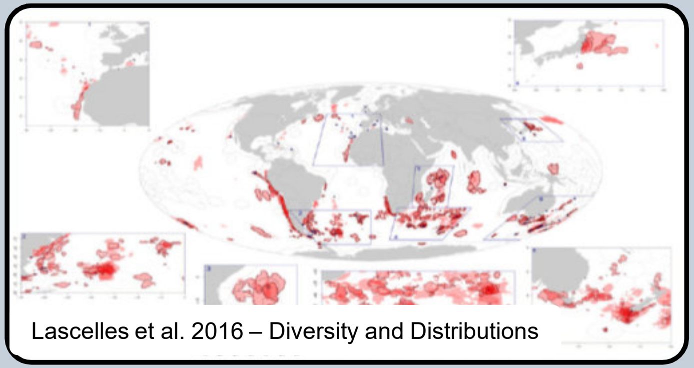




Queiroz et al. 2016 – PNAS



Block et al. 2011 - Nature



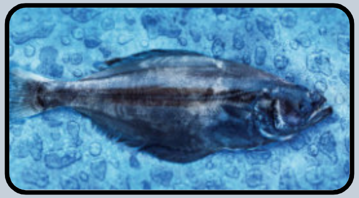
Lascelles et al. 2016 – Diversity and Distributions

Species







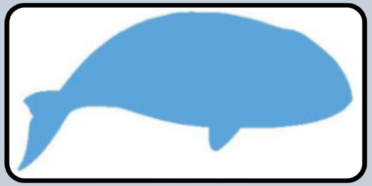



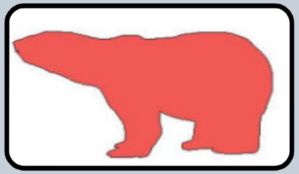
Species	N individuals	N days
Cetaceans and pinnipeds		
Beluga	115	8286
Bowhead	40	7267
Narwhal	76	7212
Ringed seal	130	16528
Harbour seal	19	4084
Walrus	38	1490
Polar bears	**312**	**65203**
Seabirds		
Common eider	134	16772
King eider	94	7173
Ivory gull	12	4739
Sabine's gull	26	6959
Ross's gull	2	735
Herring gull	28	4913
Long-tailed duck	44	2200
Dovekie	28	16455
Northern fulmar	5	852
Parasitic jaeger	3	757
Thick-billed murre	63	15094
Fishes		
Greenland shark	45	164
Greenland halibut	7	14
Arctic skate	3	6

Approach and objectives

Compiled data from **1283 individuals across 21 species** - 1989-2016

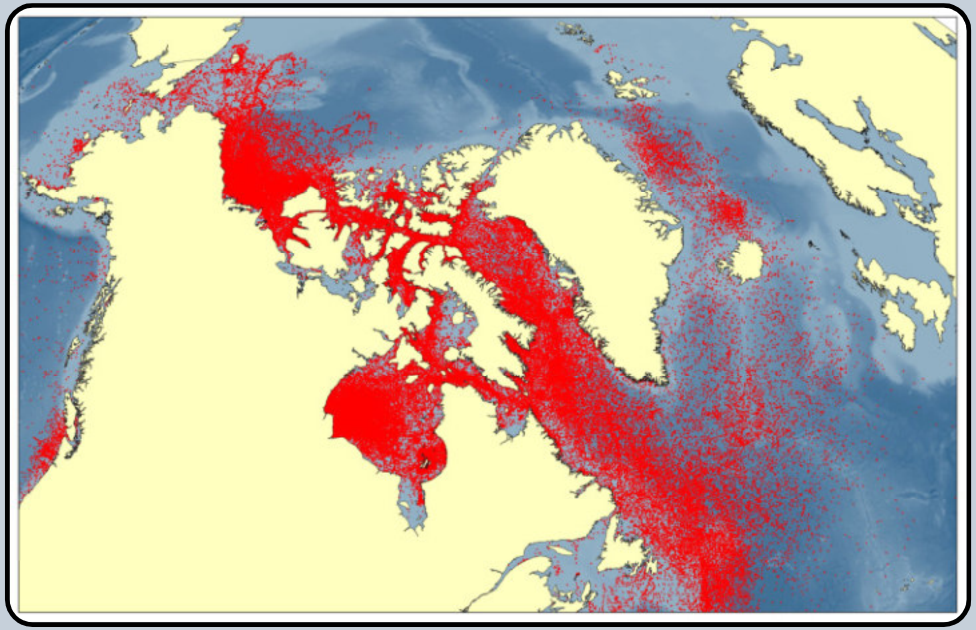
- Cetaceans and pinnipeds - ARGOS
- Polar bears – ARGOS and GPS
- Seabirds – ARGOS and GLS
- Fishes – Pop-off





- **Data processing**
- ARGOS and GLS
  - state-space model at 1d time-step
- GPS
  - 1 location per day
- **186,786 daily location estimates**

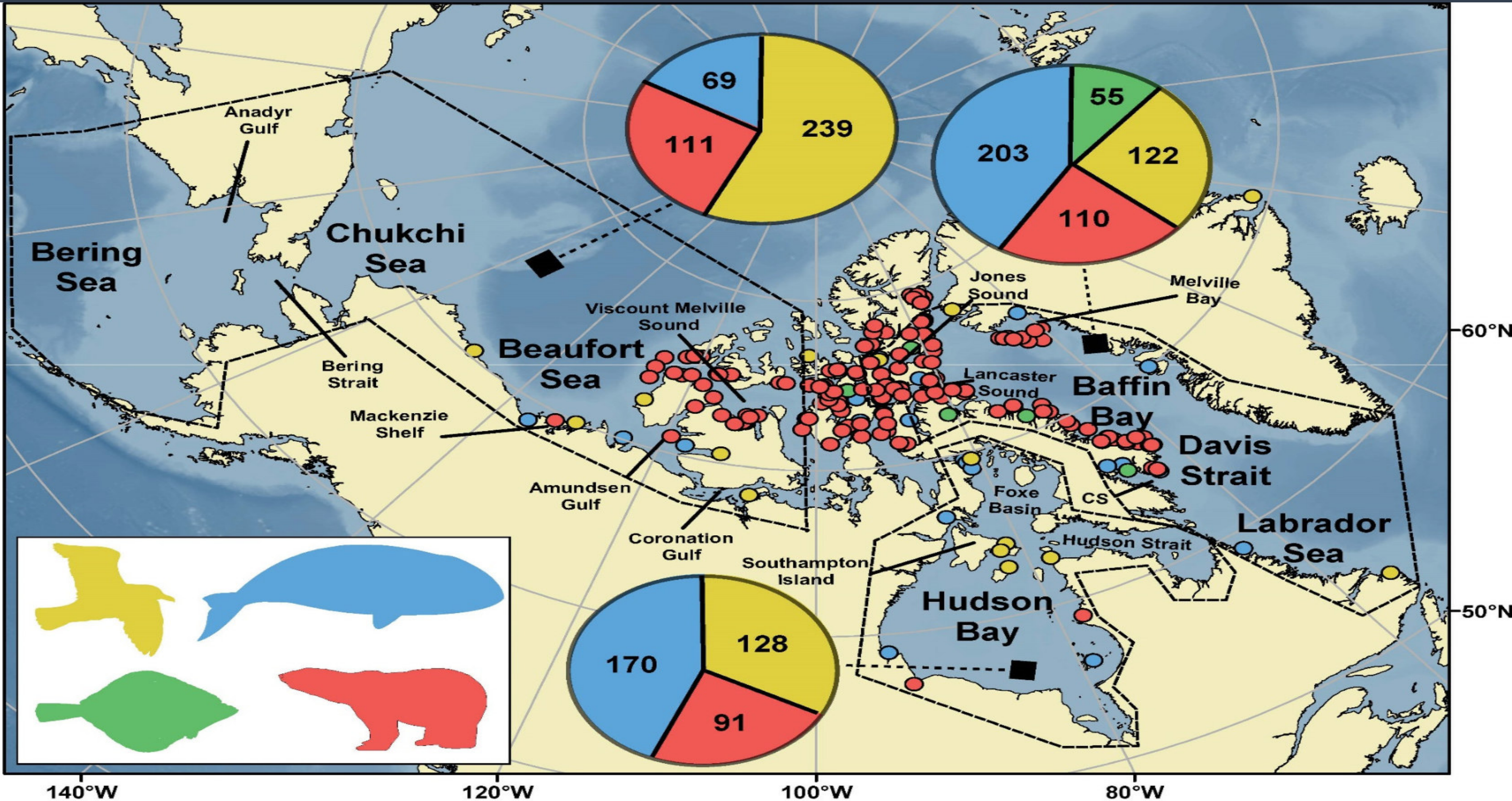
- Summer-autumn (June to December)
- Winter-spring (January to May)



Objectives:

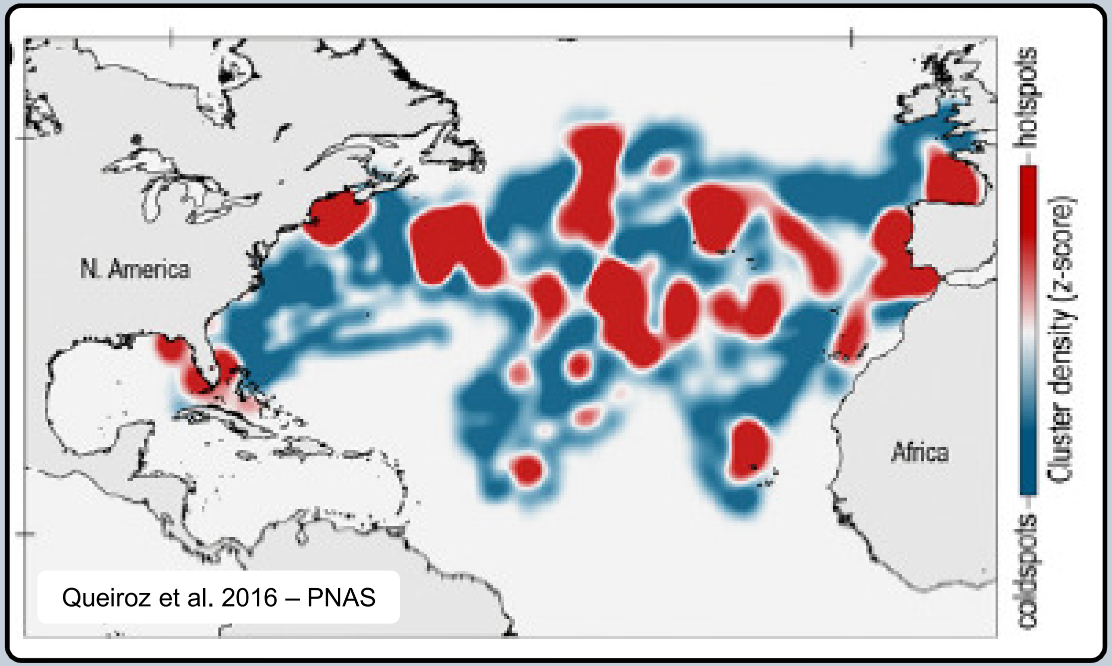
1) Map species diversity hotspots across the Arctic by season
2) Assess overlap of species diversity hotspots relative to protected areas and exclusive economic zones by season

Geographic areas

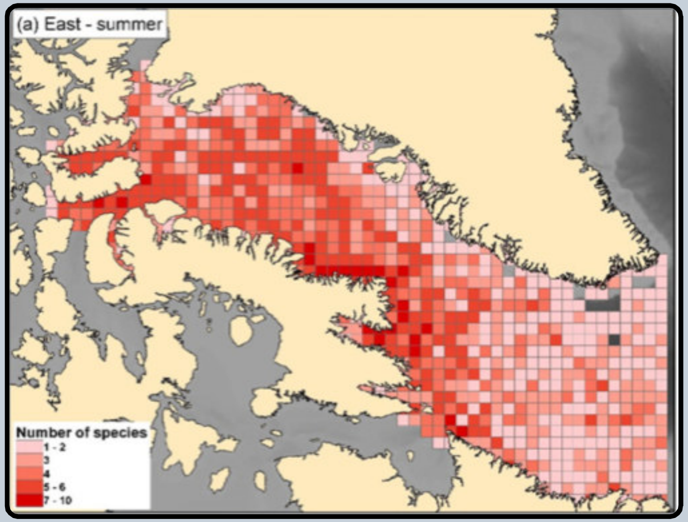


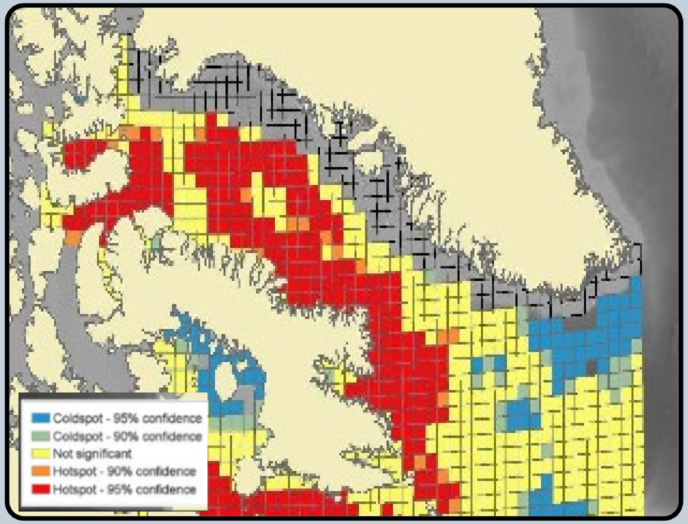
Hotspot analysis

- 50km x 50km grid cells
- Unique number of species per grid cell that season
- Getis-Ord Gi* statistic
  - Tests for significantly higher (“hotspots”) and lower (“coldspots”) spatial clustering among grid cells

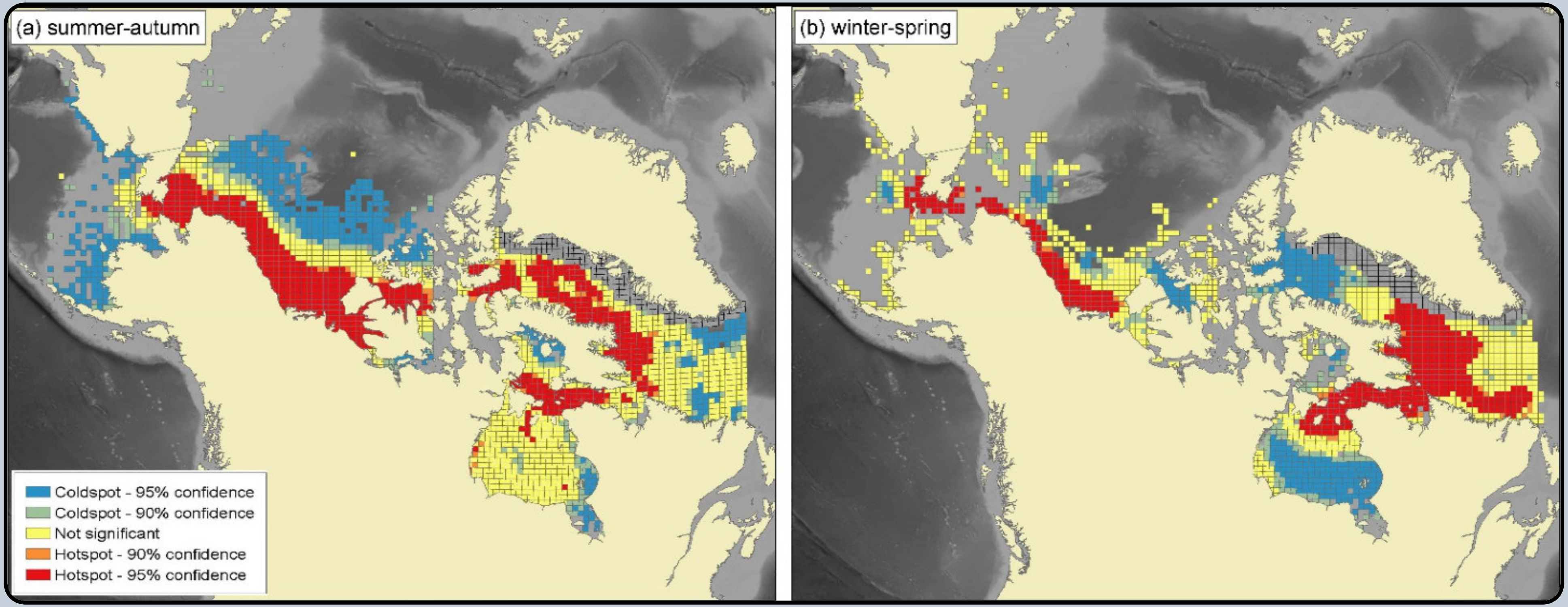


Queiroz et al. 2016 – PNAS





Objective 1 - species diversity hotspots



West – Along coastline and continental shelf (summer)

- Nutrient-rich Pacific water flowing eastward; Winter - Cape Bathurst Polynya

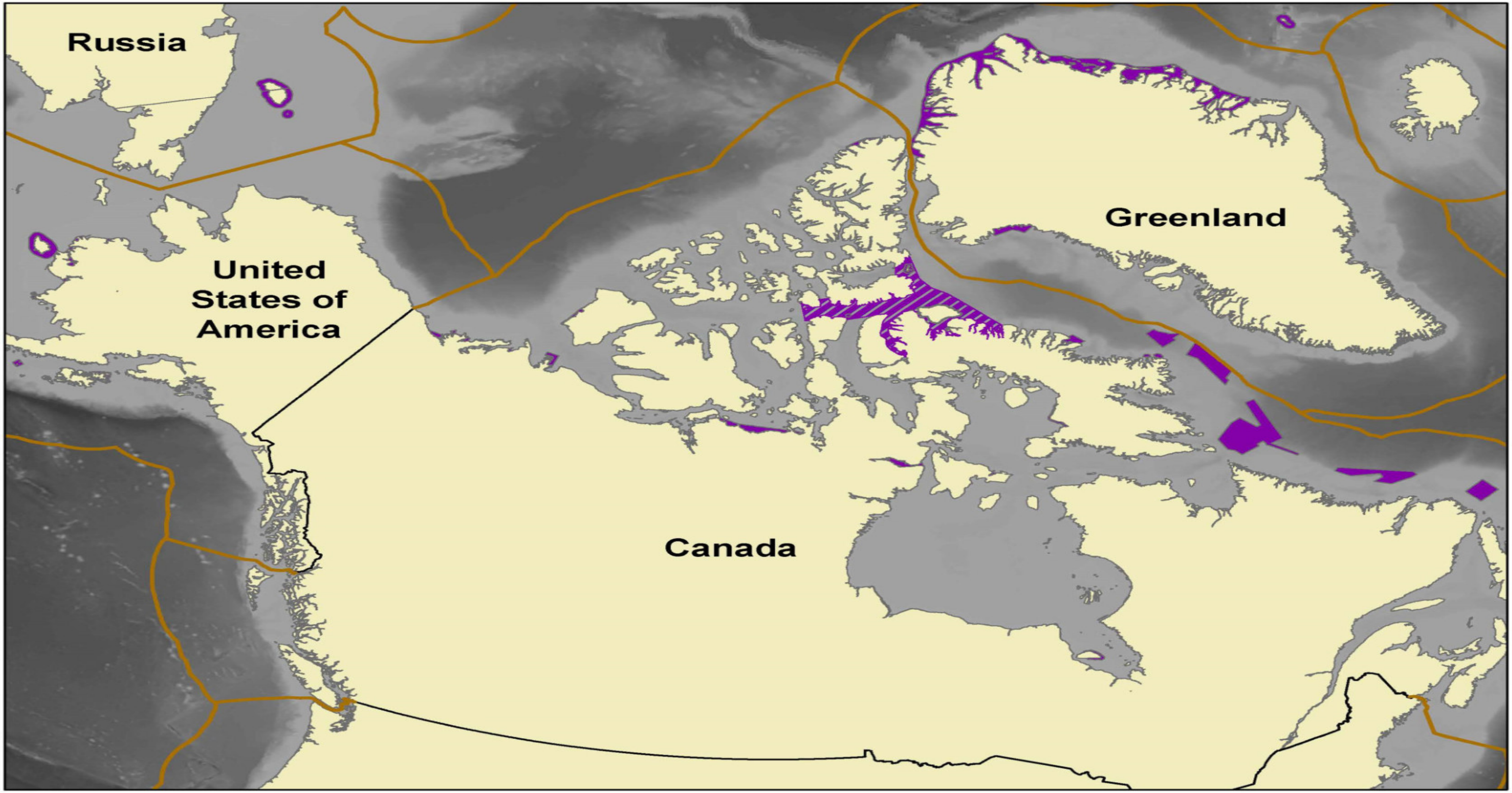
East – Lancaster Sound and along Baffin Island coastline (summer)

- Fjords have high organic carbon content; Winter - Mobile pack ice offshore

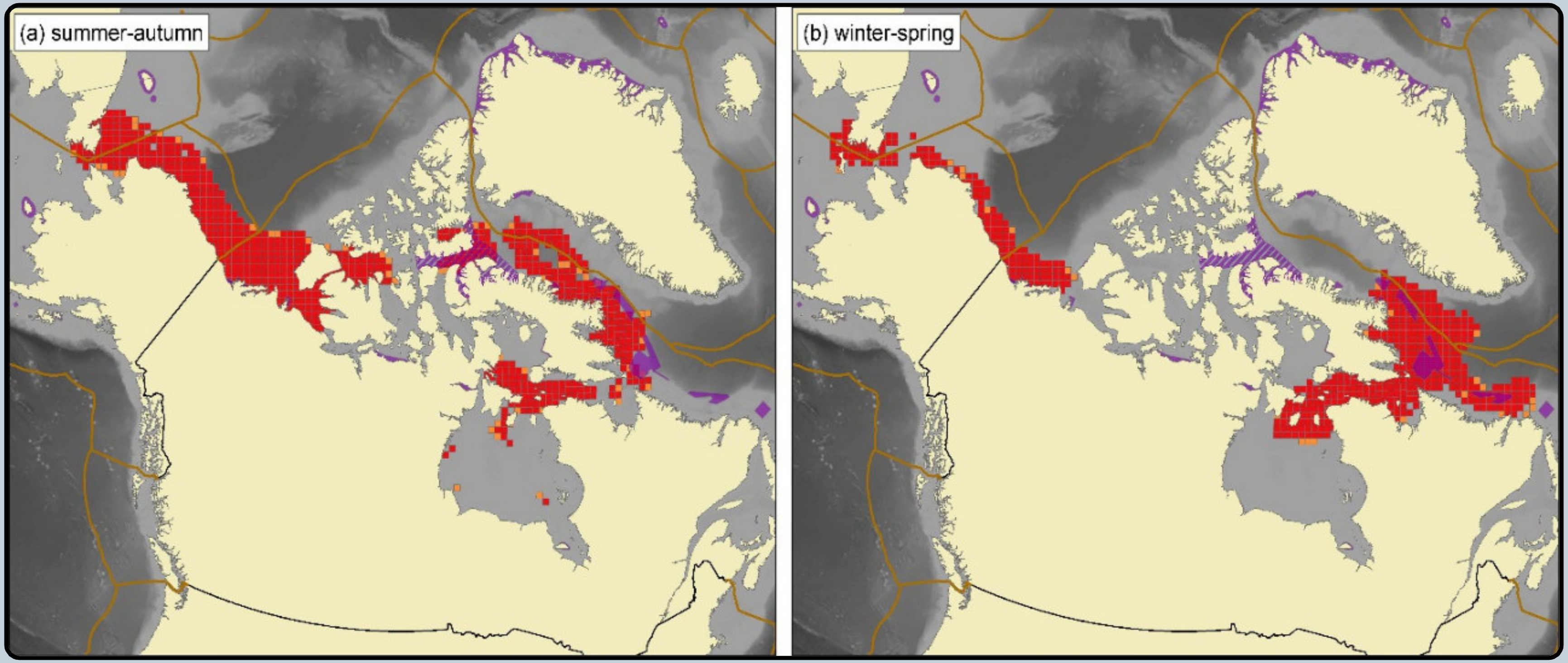
South – Waters around Southampton Island and Hudson Strait (summer)

- Higher primary productivity; Winter - Mobile pack ice

Objective 2 – hotspots relative to PAs and EEZs



Objective 2 – hotspots relative to PAs and EEZs



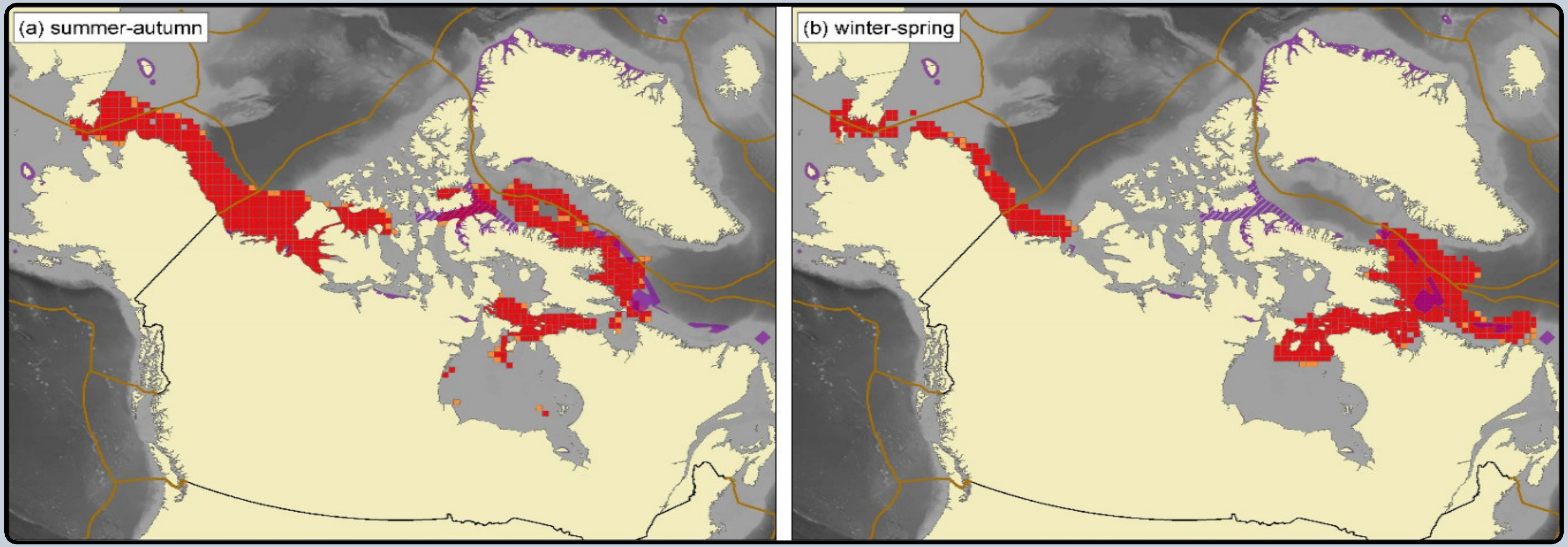
Level of conservation protection is very low across the North American Arctic

Total protected area overlap of 77,498 km^2 (5%) and 83,202 km^2 (7%)

- Summer: 15% in East, <1% in West and South
- Winter: 14% in East and <1% in West and South

Provide starting point to policy-makers to address deficiency in conservation protection

Objective 2 – hotspots relative to PAs and EEZs



		Spatial overlap (km²)	Percentage overlap (% area)
	EEZ		
Summer-autumn			
	Canada	992,766	65.17
	U.S.A.	332,251	21.81
	Greenland	90,582	5.95
	Russia	107,809	7.08
Winter-spring			
	Canada	798,429	66.92
	U.S.A.	173,204	14.52
	Greenland	163,811	13.73
	Russia	57,713	4.84

Most hotspots within national jurisdictions – likely easier to implement protection?

Highlights need for multi-national collaboration and data-sharing

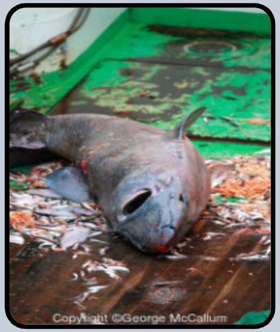
Conservation implications

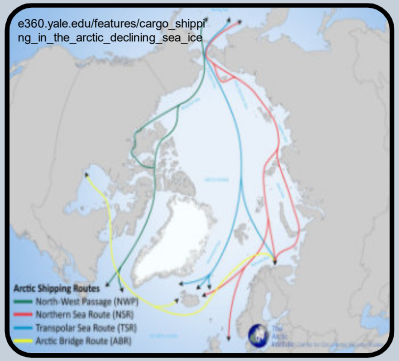
Climate change
- Associated with declines in body condition
- Species redistribution and ‘re-wiring’ of the food web

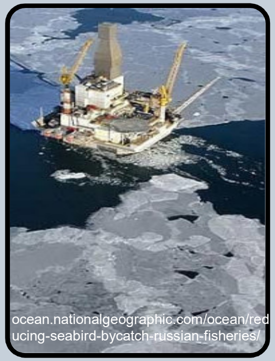
Fisheries exploitation
- Increase risk of bycatch mortality
    - Greenland shark and seabird

Shipping
- Increase risk of ship strikes, ice-breaking,
  Noise pollution

Oil and gas exploration and exploitation
- <u>Seismic surveys</u>
    - ecosystem disruption
    - Increase zooplankton mortality
    - Clyde River and Supreme Court of Canada







Future directions

- Large-scale retrospective analysis implemented by several other programs
  - Antarctica – RAATD
  - Pacific Ocean – GTOPP
  - Atlantic Ocean – SEATRACK
  - **No such programs for Arctic Ocean**

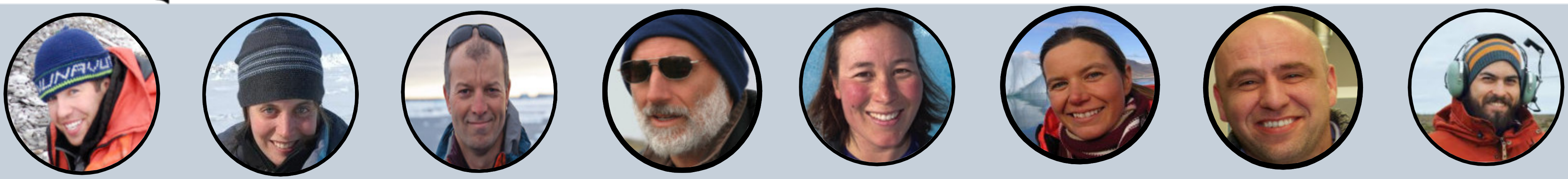
- Continue retrospective analysis of Arctic telemetry data
  - Incorporate:
    - more species data
    - environmental data
    - data types (i.e. acoustic telemetry, at-sea observations, TEK)

- Share telemetry resources amongst Arctic nations

- Implementation of appropriate multinational regulations and adaptive conservation strategies to protect the Arctic

ArcticTRAILS

Arctic TRAILS



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Nunavut Wildlife Management Board

Nunavut

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FJMC FISHERIES JOINT MANAGEMENT COMMITTEE

Parks Canada / Parcs Canada

ISDELL FAMILY FOUNDATION

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Quark Expeditions

earth rangers The Kids' Conservation Organization

care for the wild INTERNATIONAL

Marie Skłodowska-Curie Actions

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