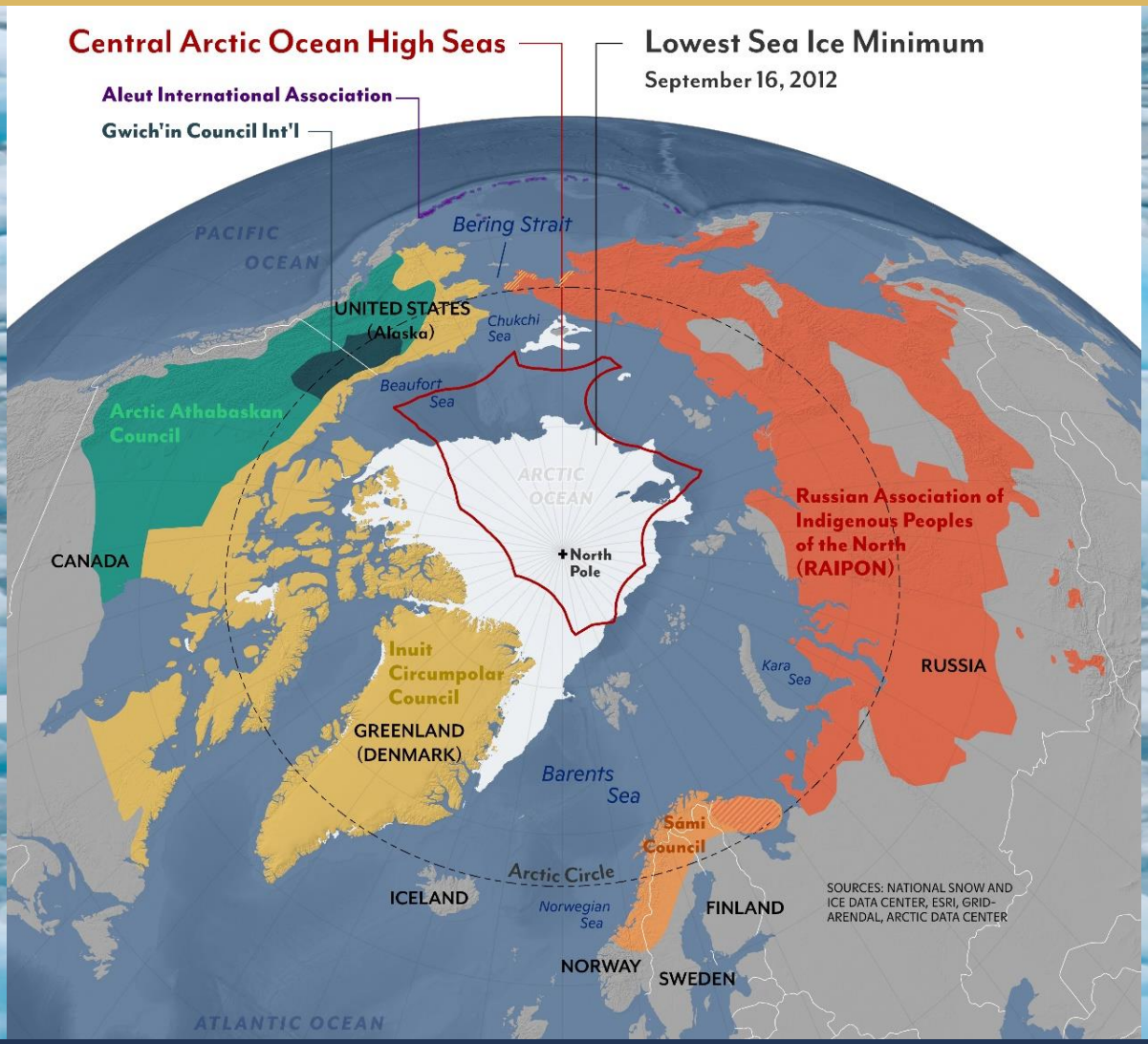
ARCTIC SATELLITE KNOWLEDGE (ASK):
INTEGRATING MARITIME SHIP TRAFFIC



Prof. Paul Arthur Berkman
Science Diplomacy Center™
United Nations Institute for Training and Research (UNITAR)
pab@scidiplo.org | paul.berkman@unitar.org

SCIENCE DIPLOMACY CENTER™
Education ▲ Research ▲ Leadership

unitar
United Nations Institute for Training and Research

Next-Generation Arctic Marine Shipping Assessments

TABLE 1: NEXT-GENERATION ARCTIC MARINE SHIPPING ASSESSMENTS[1]		
Attribute	**Arctic Marine Shipping Assessments (AMSA)**	
	AMSA (2009)	**Next-Generation**
Sampling Period	2004	2009-present
Data Sources	Arctic States Individually and with the Arctic Council	Diverse Government and Commercial Automatic Identification System (AIS) Sources
Observation Coverage	Point, Regional	Point, Regional and Pan-Arctic
Observation Scope	Ground-Based	Ground-Based and Satellite
Observation Frequency	Inconsistent over Space and Time	Synoptic and Continuous (from minutes to decades)
Ship-Type Designations	Variable National Designations	Standardized International Designations
Individual Ship Attributes	Inconsistent and Incomplete	Consistent and Comprehensive
Analytical Capacity	Limited Granularity and Questions	Open-Ended Granularity and Questions
Science-Diplomacy Contributions	Scenarios and Negotiated Recommendations	Holistic Evidence and Options (without advocacy)
Informed Decisionmaking[2]	Governance Mechanisms	Operations, Built Infrastructure and Governance Mechanisms

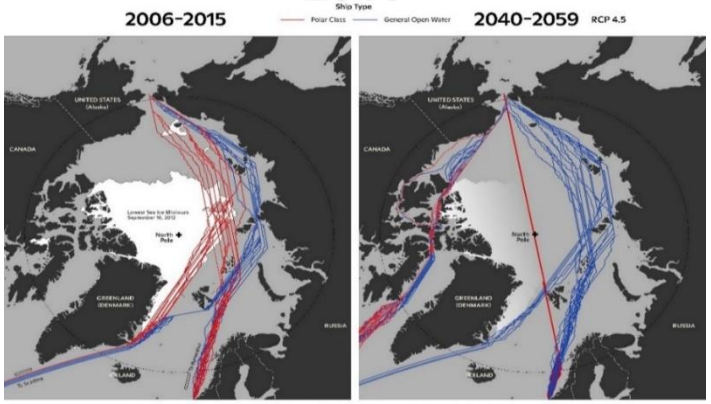
[1] Updated from Berkman et al. (2020a), involving Automatic Identification System (AIS) data collected by polar-orbiting satellites. [2] Informed decisions operate across a 'continuum of urgencies' short-to-long term (Berkman et al. 2020c), as elaborated subsequently (Berkman 2020a,b).

***Arctic Options / Pan-Arctic Options* Projects (2013-2022):**
Holistic Integration for Arctic Coastal-Marine Sustainability

(United States, Russia, Norway, France, China and Canada)

ASK – A Brief History

2013



Model of Arctic Maritime Ship Traffic

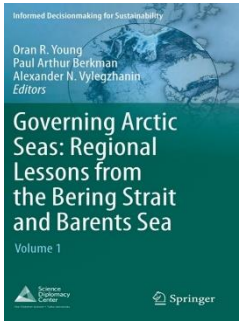
2013-2022

TABLE 1: Intertwined Projects Involving "*Holistic Integration for Arctic Coastal-Marine Sustainability*"[1]

ASPECTS	PROJECT NAME	
	Arctic Options	*Pan-Arctic Options*
Duration	2013-2019	2015-2021
Conceptual Scope	Decision-support process to integrate stakeholder perspectives, evidence and governance mechanisms to reveal options that contribute to informed decisionmaking for sustainable infrastructure development in the Arctic Ocean	
Geographic Scope	Arctic High Seas, Barents Sea Region (BaSR), Bering Strait Region (BeSR)	Pan-Arctic (defined as north of the Arctic Circle + Bering Strait Region)
Options	Governance Mechanisms	Governance Mechanisms and Built Infrastructure
Funding Nations	United States, France	United States, Russian Federation, Norway, France, China and Canada
Funding Program	**ArcSEES** *(Arctic Science, Engineering, and Education for Sustainability)* www.nsf.gov/pubs/2012/nsf12553/nsf12553.htm	**Belmont Forum** *(Arctic Observing and Research for Sustainability)* www.belmontforum.org/announcements/2015/belmont-forum-announces-collaborative-research-awards-arctic-observing
Funding	$2,000,000+	€1,000,000

[1] **Goal** Design, develop and demonstrate an holistic process to enhance the effectiveness of governance with build infrastructure for sustainable development in Arctic coastal-marine systems. **Objective 1** Aggregate Arctic coastal-marine data from the natural and social sciences in an efficient and flexible manner for diverse decision-making purposes. **Objective 2** Apply analytical tools and strategic planning concepts to reveal plausible scenarios about Arctic coastal-marine development over diverse spatial and temporal scales. **Objective 3** Generate infrastructure and policy options through international, interdisciplinary and inclusive dialogues responding to Arctic coastal-marine opportunities and risks. **Objective 4** Share the options resulting from Objectives 1-3 with members of the policy community in view of current Arctic governance issues.

Arctic Options / Pan-Arctic Options



NSF Arctic Data Center

SPRINGER NATURE

CLARK UNIVERSITY

Canada FISHERIES AND OCEANS

2023-2028

NORCE

HAVFORSKNINGS INSTITUTTET

Oregon State University

TRANSDISCIPLINARY CYCLE OF ASK PROJECT OBJECTIVES AND TASKS with the Arctic Observing Network (AON) and Arctic Research Coordination and Policy Support (ARCPS) Programs, NSF Office of Polar Programs.

International, Transdisciplinary and Inclusive

Satellite Record of Pan-Arctic Maritime Ship Traffic

P. A. Berkman[1,2,3], G. J. Fiske[4], D. Lorenzini[5], O. R. Young[6], K. Pletnikoff[7,8], J. M. Grebmeier[9], L. M. Fernandez[10], L. M. Divine[11], D. Causey[12], K. E. Kapsar[13] and L. L. Jørgensen[14]

[1]Science Diplomacy Center™, Falmouth, MA USA

[2]Program on Negotiation at Harvard Law School, Cambridge, MA USA

[3]United Nations Institute for Training and Research (UNITAR), Geneva, Switzerland

[4]Woodwell Climate Research Center, Falmouth, MA USA

[5]AAC SpaceQuest, Fairfax, VA USA

[6]Bren School of Environmental Science & Management, University of California, Santa Barbara, CA USA

[7]Aleutian Pribilof Islands Association, Anchorage, AK USA

[8]Aleut International Association, Anchorage, AK USA

[9]Chesapeake Biological Laboratory, Center for Environmental Science, University of Maryland, Solomons, MD USA

[10]Department of Economics, Center for Environmental Studies, Virginia Commonwealth University, Richmond, VA USA

[11]Aleut Community of St. Paul Island Tribal Government, St. Paul Island, AK USA

[12]Arctic Domain Awareness Center, University of Alaska, Anchorage, AK USA

[13]Center for Systems Integration & Sustainability, Department of Fisheries & Wildlife, Michigan State University, East Lansing, MI USA

[14]Institute of Marine Research, Hjalmar Johansens Gate 14, 9007 Tromsø, Norway

KNOWLEDGE DISCOVERY OVER SPACE AND TIME

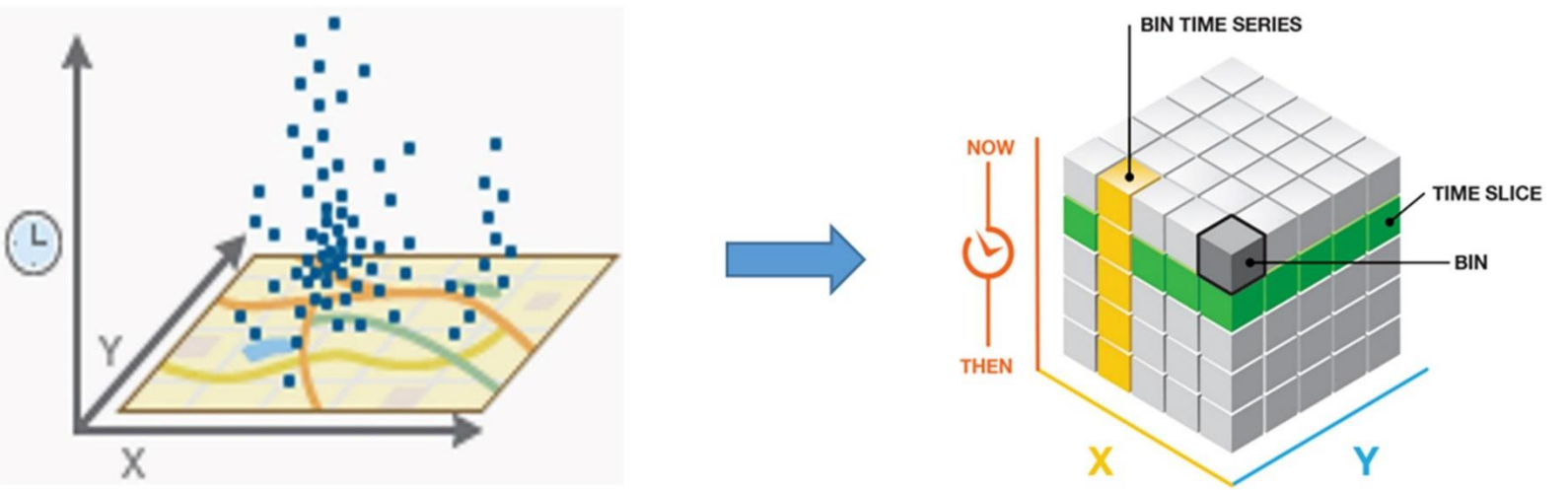


FIGURE 2: KNOWLEDGE DISCOVERY OVER SPACE AND TIME (Left) Three-dimensional system to analyze change in issues, impacts or resources that are measured over space (x-y, latitude-longitude) and time (past to future). **(Right)** The 'space-time cube' from ESRI (2017) is a geospatial approach that can be applied to 'big data' questions with vector-based analyses (points, lines and polygons) within and between 'bins.' From Berkman et al. (2020).

TABLE 3: MARITIME SHIP TRAFFIC ATTRIBUTES TO INTERPRET SOCIOECONOMIC DYNAMICS IN THE CENTRAL ARCTIC OCEAN (CAO) HIGH SEAS[1] WITH SURROUNDING EXCLUSIVE ECONOMIC ZONES (EEZ) SHOWN IN FIGURE 1

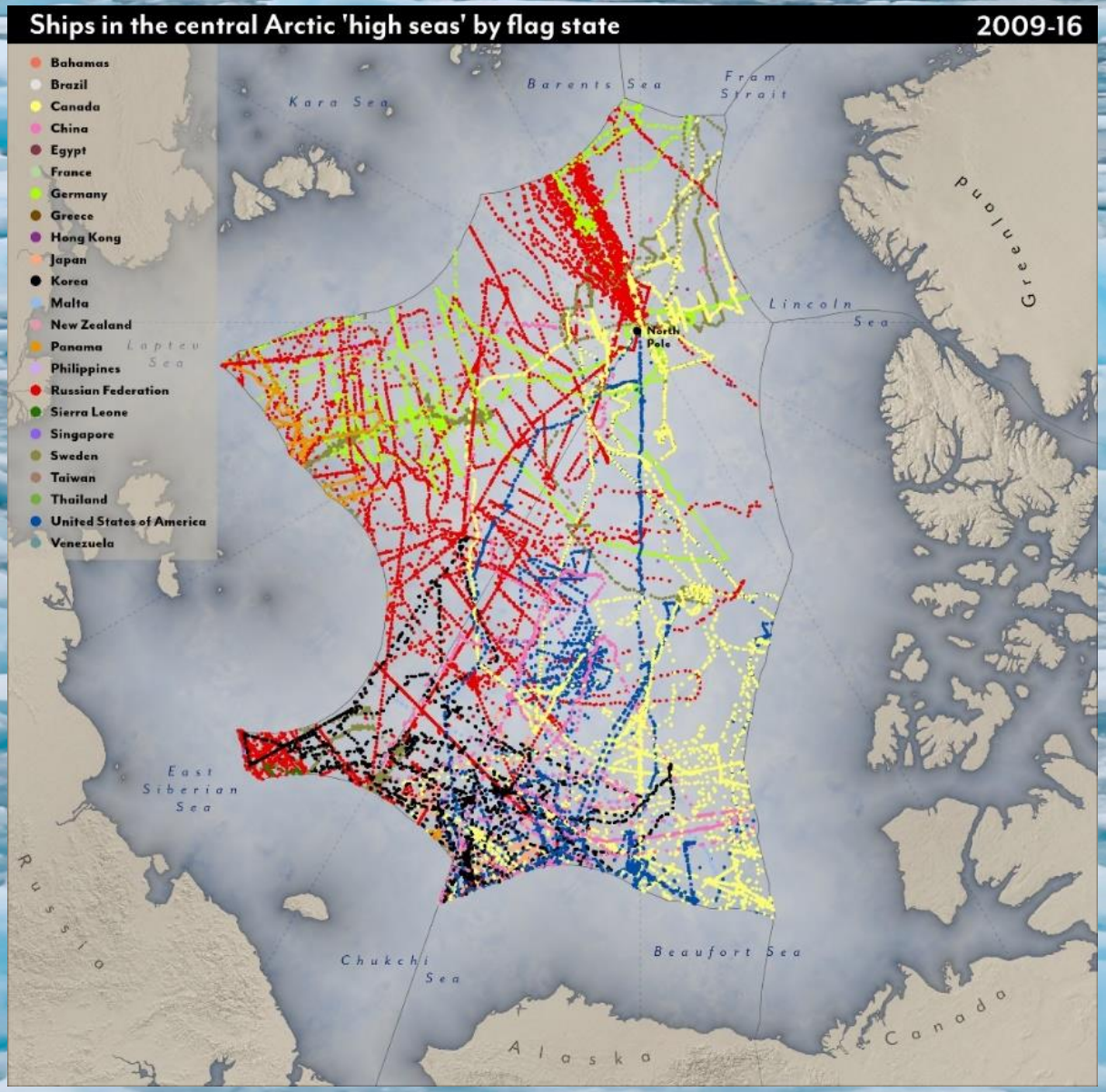
Unique Ship Designation[2]			Ship Metadata Attribute[3]			CAO High Seas Regional Visit	
MMSI[4]	Ship Name[5]	IMO[6]	Flag[7]	Type[8]	Size[9]	Dates in CAO[10]	Longitudinal Positions [12]

[1] Summary of the satellite Automatic Identification System (AIS) data for the CAO High Seas is available through the Arctic Data Center (https://arcticdata.io/) in conjunction with baseline dataset from September 1, 2009 through December 31, 2016 north of the Arctic Circle (Berkman et al. 2020a), derived from the from the Aprize satellite constellation launched by SpaceQuest Ltd. (Berkman et al. 2020b); [2]From AIS data file; [3]Selected AIS metadata attributes from among those available (NAVCEN 2019); [4]Mobile Maritime Service Identity (MMSI) as the unique ship identifier, which would be precluded with the Arctic Ship Traffic Database (ASTD) that anonymizes records with access Levels 2 and 3 (PAME 2020b); [5]Ship names (which may change) were noted, but MMSI (which remains with each ship) was used to identify unique ships; [6]International Maritime Organization (IMO) registered ships with Class-A transponders were used to validate the AIS record; [7]Nation (which may change) at time of each CAO visit; [8]Designation of ship type directly from the AIS data file (Marine Traffic 2018), recognizing there is a different IMO schema of ship types (IHS Markit 2017); [9]tonnage size-classes; [10]During period; [11]Longitudinal positions in the CAO High Seas.

173,000,000 AIS records with 21,005 unique ships during the 2009-2018

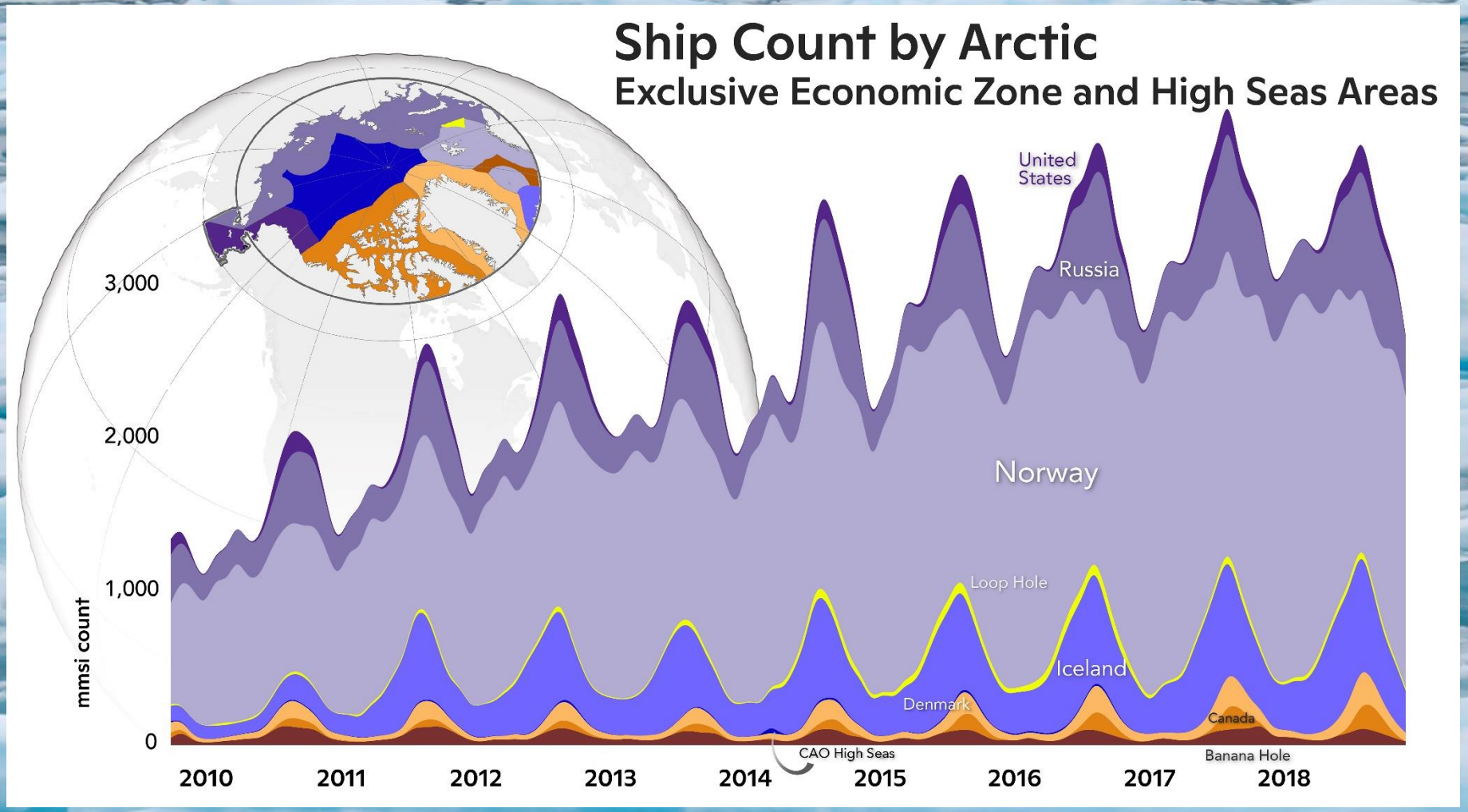
Arctic Maritime Ship Traffic Community by Nations

Central Arctic Ocean (CAO) High Seas



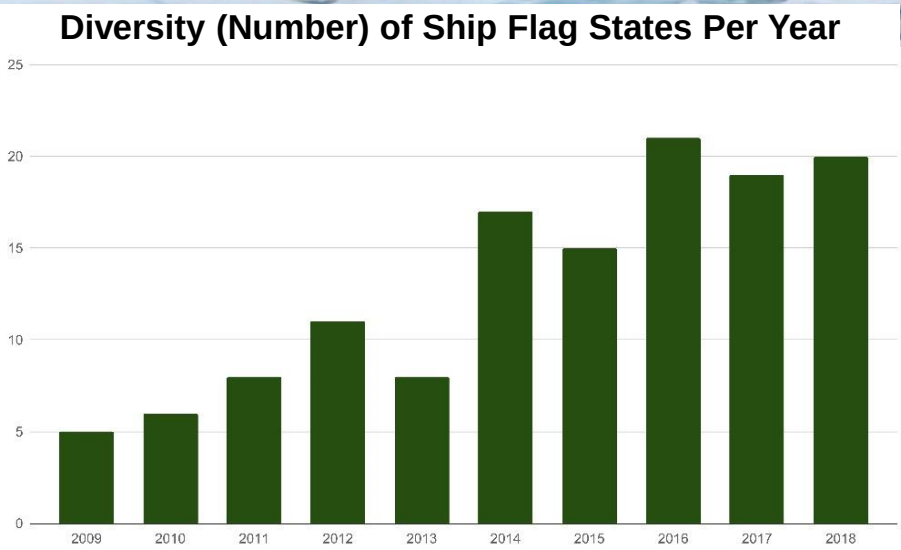
Circumpolar Distribution of Arctic Maritime Ship Traffic

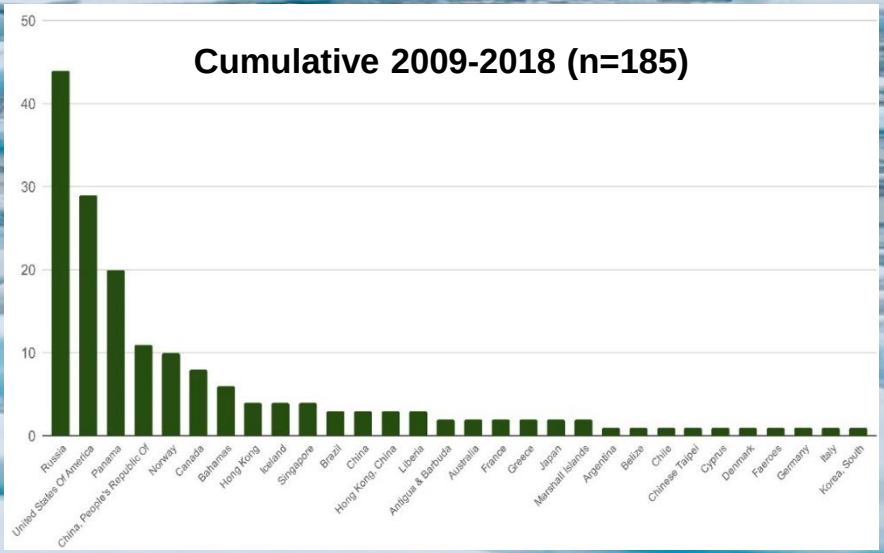
Biogeophysical

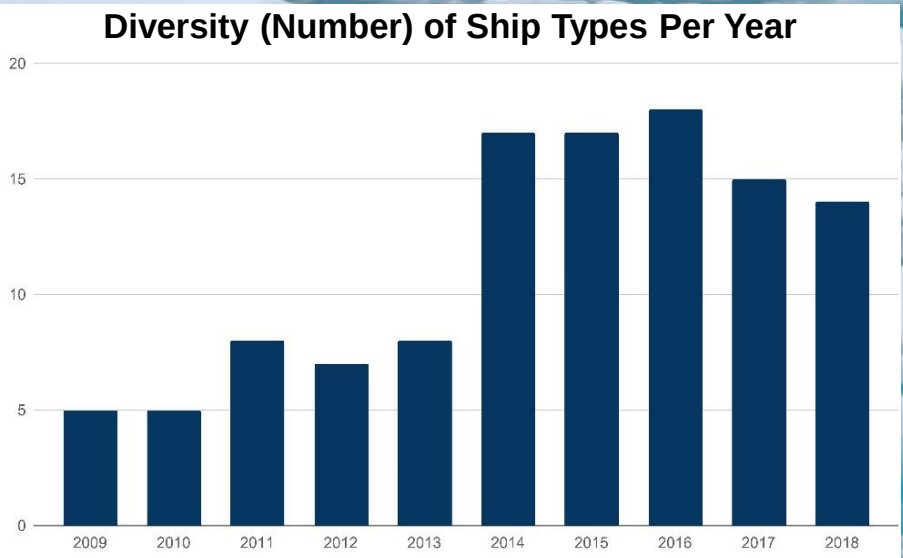


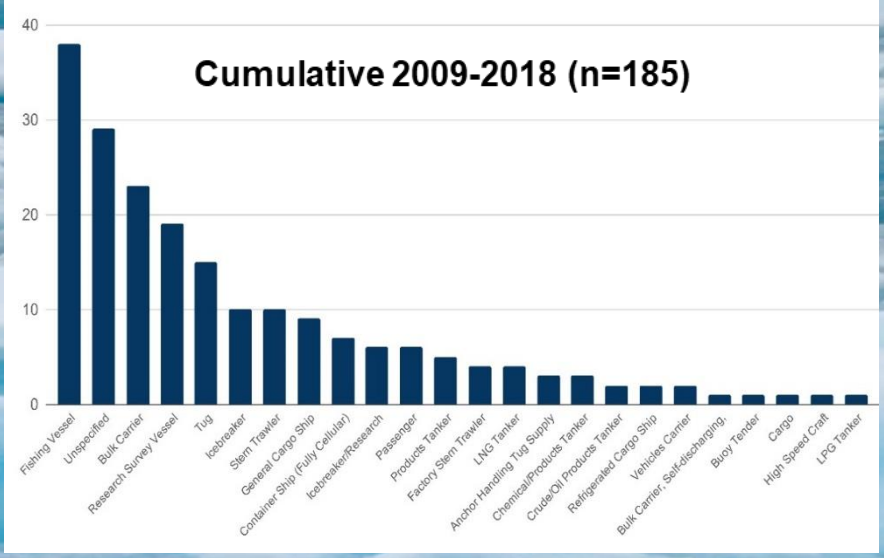
Socio-Economic

Ship Traffic Diversity Over Time in the CAO High Seas

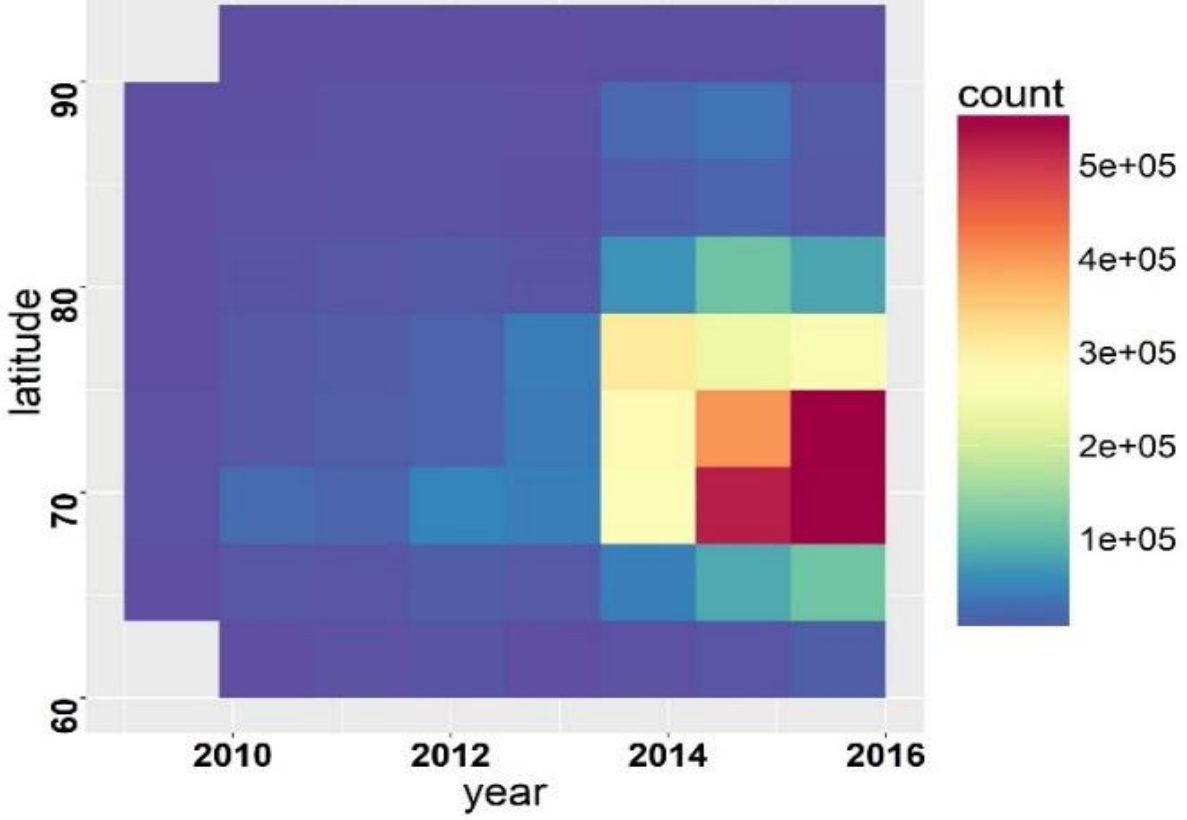








‘Ship-Ice Hypothesis’

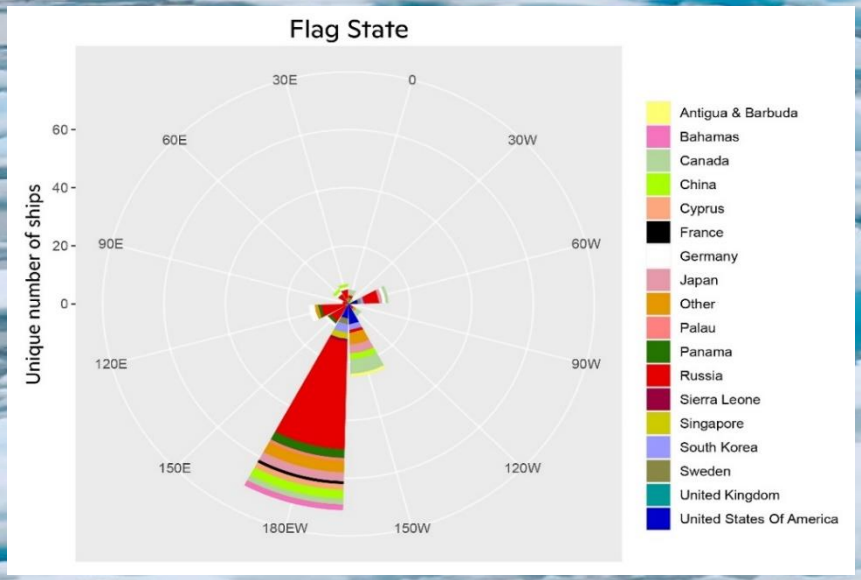


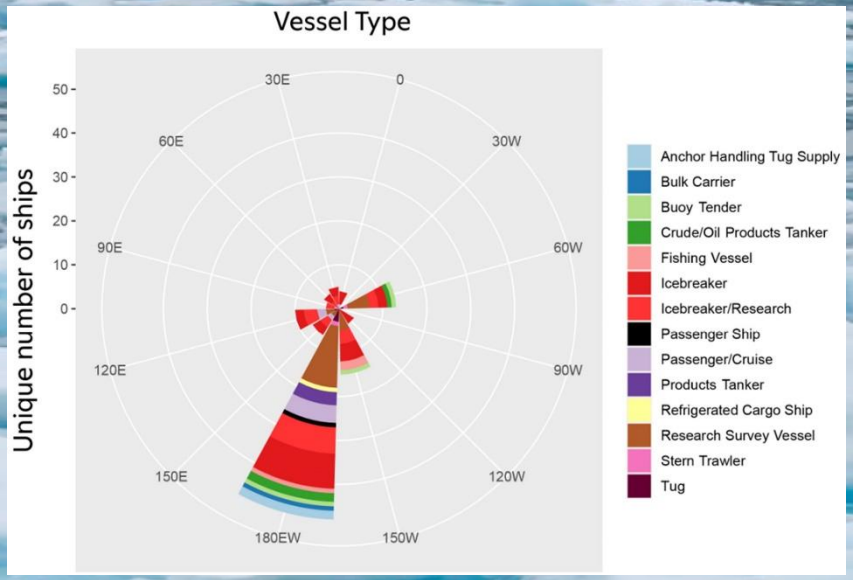
TESTING

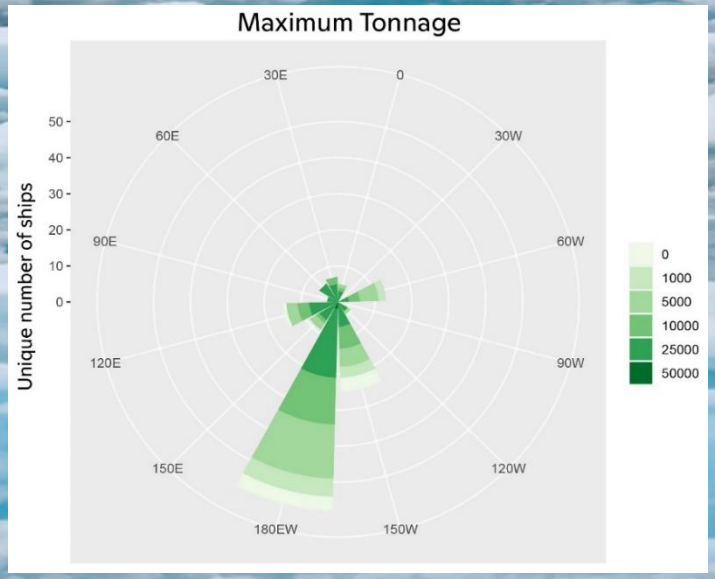
“Arctic ship traffic is increasing as sea-ice is diminishing”

(Berkman et al. 2020a, 2022a,b)

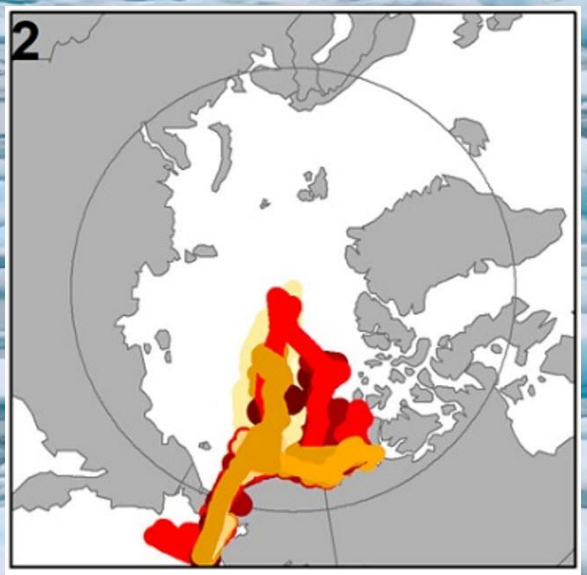
Pacific Sector Directionality of Ship Traffic Into the CAO High Seas (2009-2018)







What Questions do you want to ASK?



‘Healy’ – Arctic 2009-2016

Lydia Ames / Leonard Sussman