UNIVERSITY of HOUSTON

Polar Climate Intervention:

Possible Methods, Suggested Rules

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Climate Intervention Law
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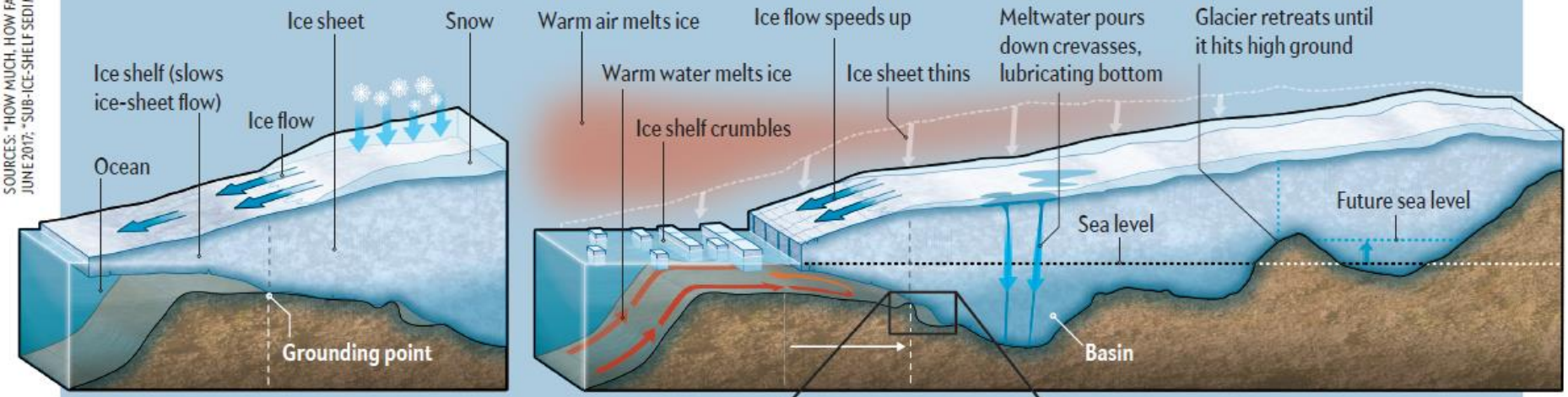
SOURCES: "HOW MUCH, HOW FAST?: A SCIENCE REVIEW AND OUTLOOK JUNE 2012"; "SUB-ICE-SHELF SEDIMENTS RECORD HISTORY OF TWENTIET

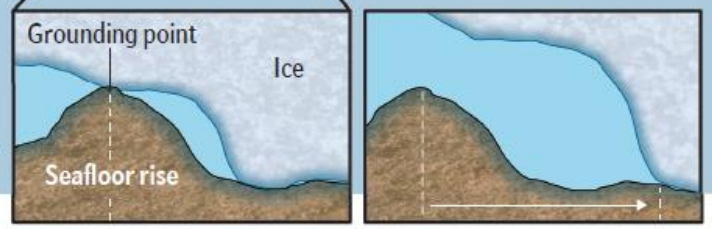
How to Unzip an Ice Sheet

New snow adds to an ice sheet, but the ice also flows under its own weight into the sea and melts (*short illustration*). Ice sheets in West Antarctica are losing slightly more mass than they gain, raising sea level. An ice shelf floating on the ocean at the front edge of the sheet slows the flow, but if warm air and water disintegrate the shelf, the sheet's flow quickens, and the sheet gets thinner (*long illustration*). The front edge recedes, and the grounding point where the ice contacts the seafloor recedes with it. If a deep basin exists behind that point, the retreat will continue unimpeded, raising sea level significantly, until the ice reaches the next high ground inland or gets hung up on a seafloor bump (*inset*).



Jumping the Bump

A receding ice sheet can catch on a seafloor rise, or bump, creating friction and blocking warm water from melting the underside. If the retreat clears the bump, friction drops, and the water has open access.



Carnegie Climate Governance Initiative

an initiative of

CARNEGIE COUNCIL *for Ethics in International Affairs*

Arctic Circle Assembly

10 October 2019, Reykjavík, Iceland

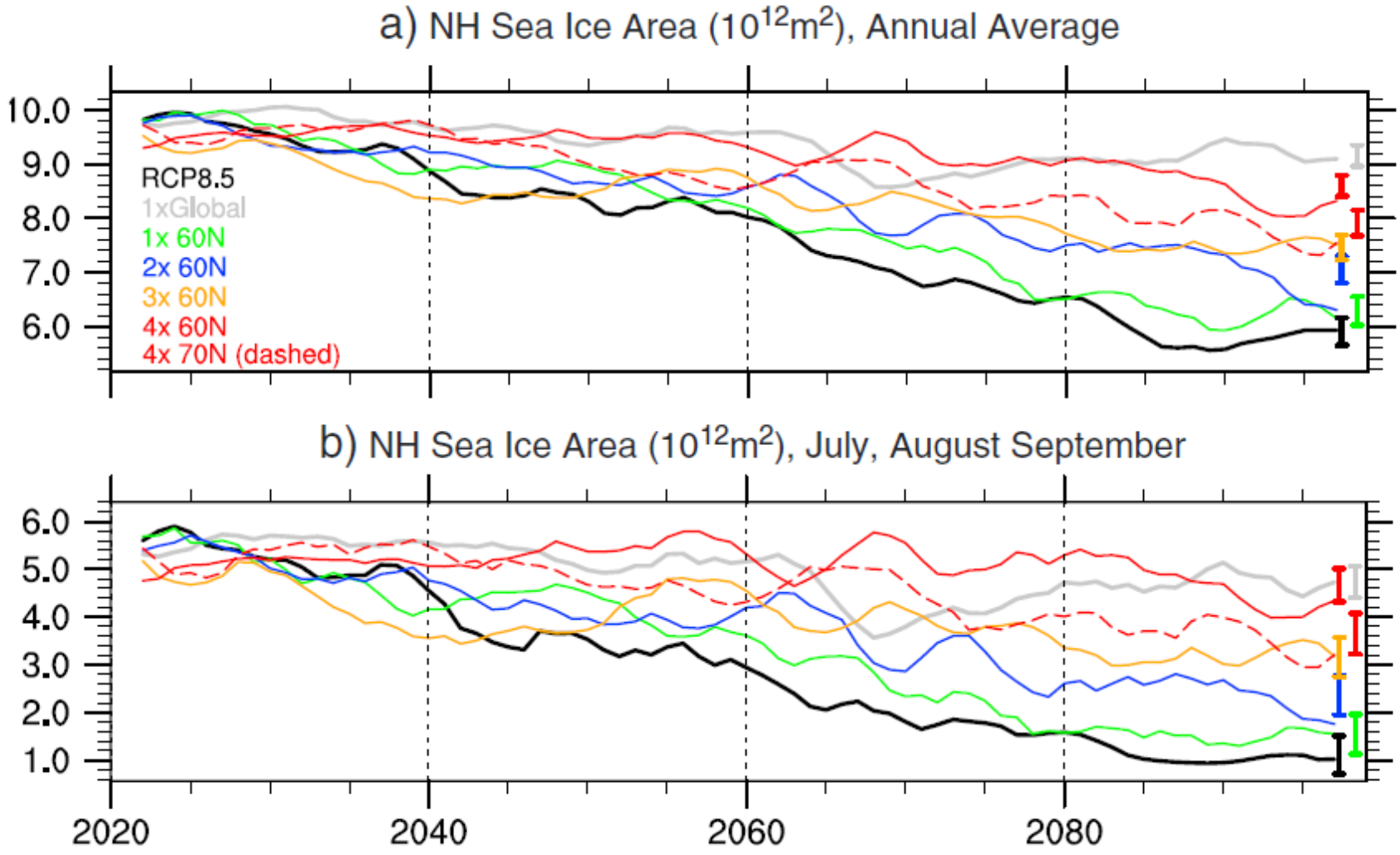
The Arctic plays a key role in the global climate system. This makes the region an area of special interest for those considering the viability of climate-altering technologies, including Solar Radiation Modification and large-scale Carbon Dioxide Removal. In addition, others are considering interventions to engineer or protect ice in order to slow or reverse ice melt. But is there adequate governance in place to protect people and ecosystems should these climate-altering technologies be tested or used?

Options: Air, Earth, Ice, Water

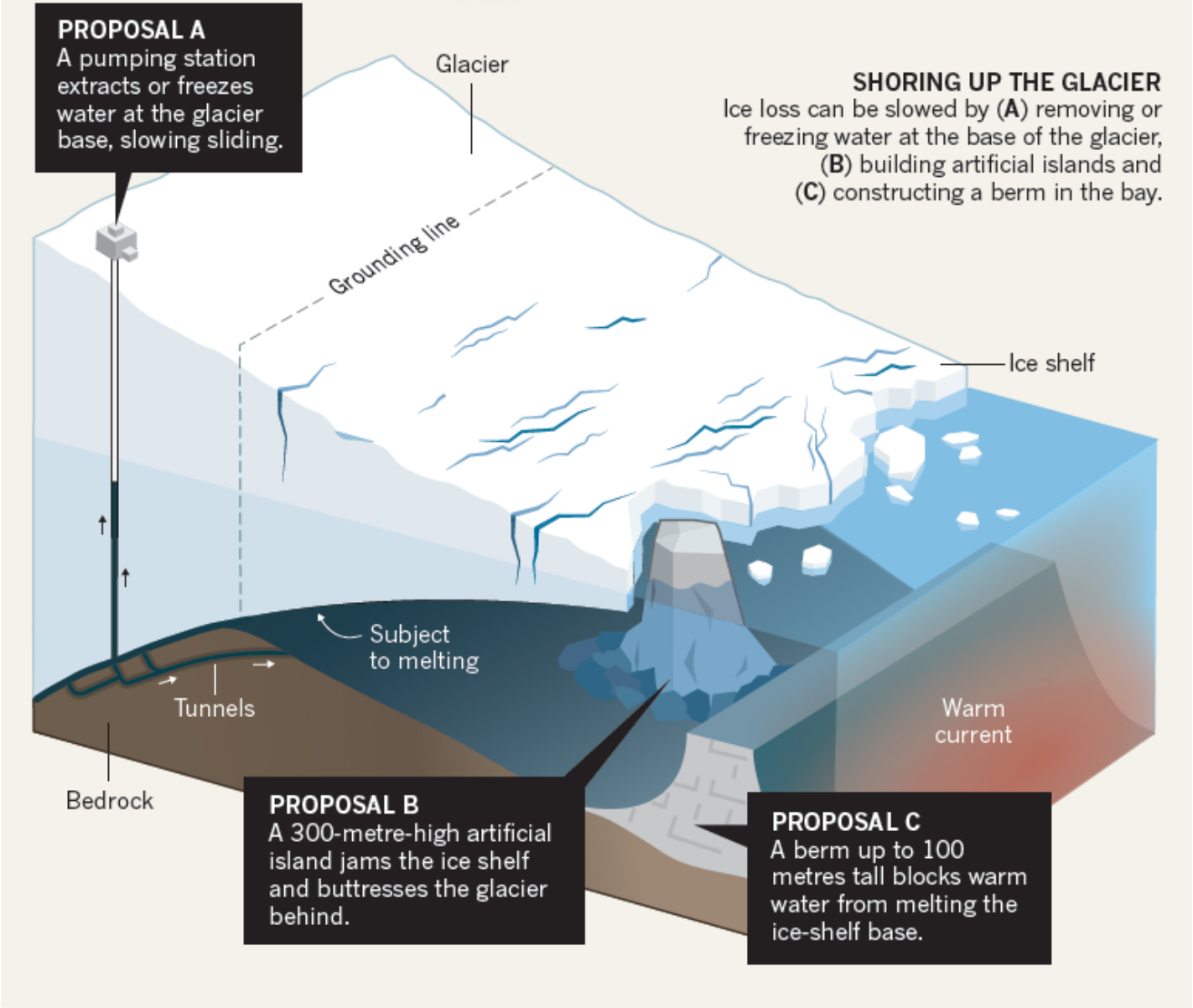
Technologies and the Arctic.

Proposed Technology	Technological Readiness	Specific Governance Challenges
Enhancing surface albedo Making surfaces brighter to reflect solar radiation.	• Small scale trials using silica spheres, bubbles and foams are underway. • Potential technical limitations to scale, scope and longevity of materials in situ.	• Regulatory and legal measures include customary international law, the LP, CBD and UNCLOS, but these may not be comprehensive and would apply to ocean-based activities only. • Regional variation in impacts (e.g., temperature and hydrological) are expected and will require governance. • Environmental protection and food safety regulations.
Marine cloud brightening Seeding and whitening clouds above ocean surfaces, most likely using sea salt spray, to reflect solar radiation back into space.	• Technology theoretical, based on natural analogues and computer models. • Some potential for small scale outdoor experiments by 2020.	• Regulation would likely be covered by customary international law. • The proposal to use sea salt may in due course be interpreted as a pollutant, and the technique would then be subject to the LP. • Regional variation in impacts (e.g., temperature and hydrological). • Social acceptability remains uncertain.
Stratospheric aerosol injection Reflective aerosols would be deployed in the stratosphere.	• Theoretical understandings of the technique only. Mechanisms not yet developed. • Modelling suggests planetary cooling is possible.	• Unresolved, as there is no clear fora or entity to consider SAI governance. Governance measures, however, may include state and customary law, UNEA, CBD, the UNFCCC and amended instruments which could include air pollution instruments, the Vienna Convention and others. • Evidence suggests potential security issues may arise.

Regional Solar Radiation Management



Glacier Engineering



Surface Ice Albedo Management

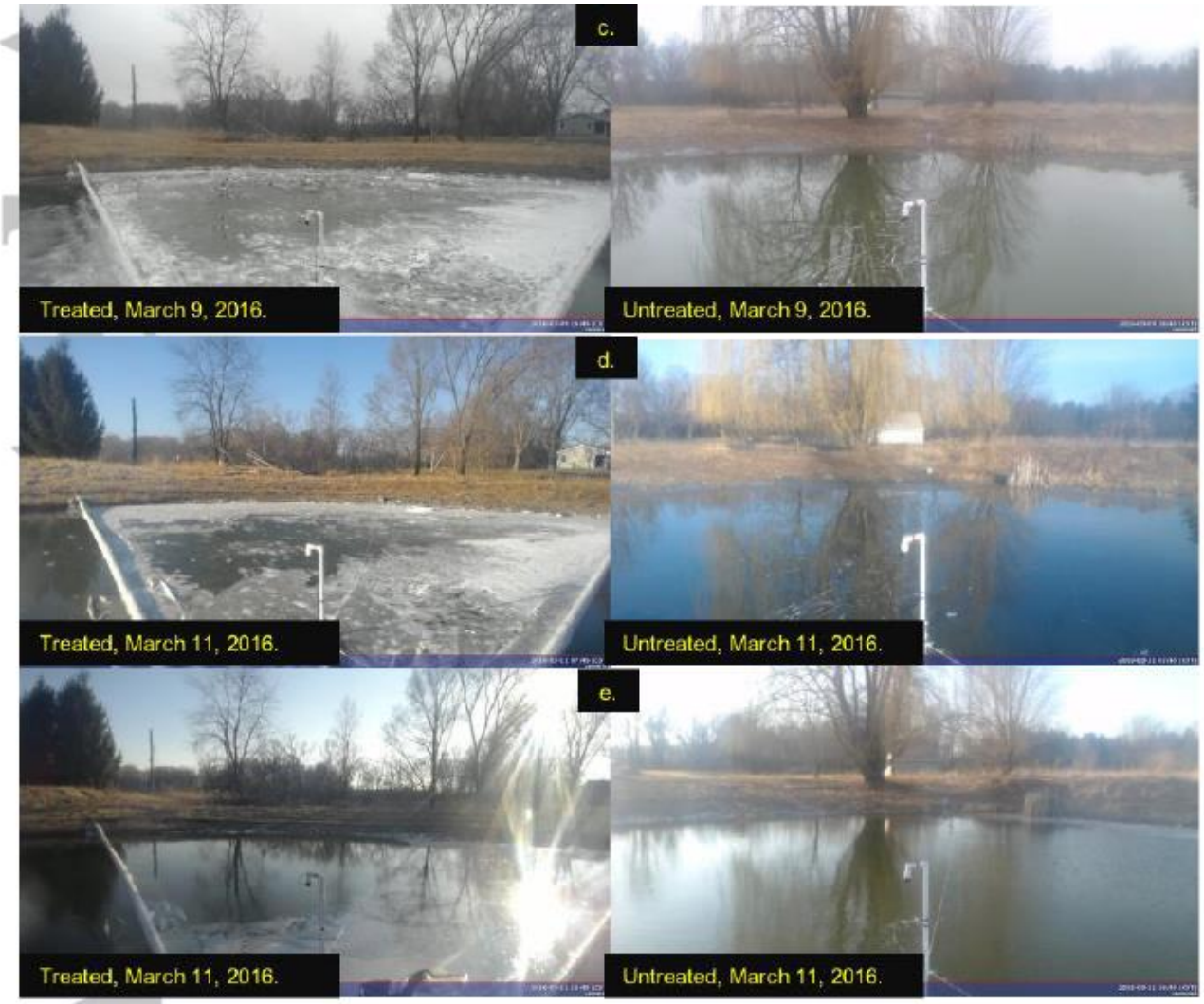


Figure 4. a.) K1-treated area (left) and one of the adjacent control areas (right), on March 5, 2016. b.). Same areas on March 8, when there was a trace of ice left on one section of the control area. c.) March 9, when all ice had melted from untreated control area (right). d.) March 11, and e.) later on March 11, when the ice, which had persisted

Polar Ocean Albedo Management

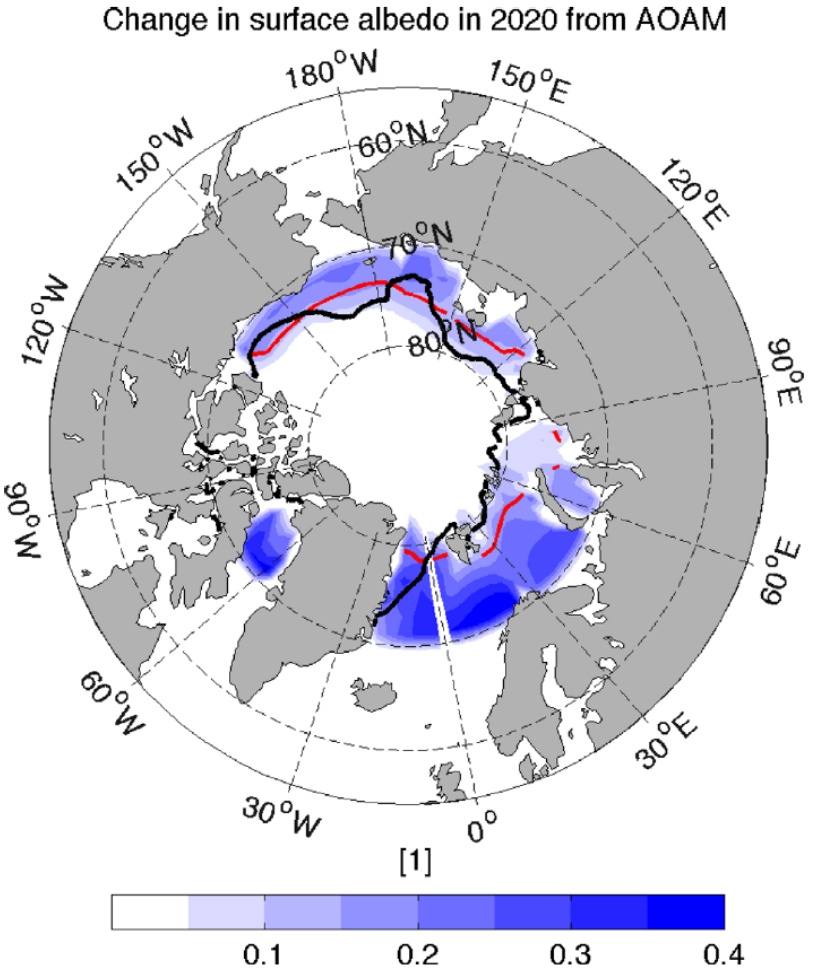


Figure 1. Annual mean changes in surface albedo in the Arctic due to the AOAM implementation in 2020 exemplarily in the RCP8.5 scenarios, i.e., RCP8.5 AOAM minus RCP8.5. As a reference the mean september sea ice edge defined as the 15% sea ice concentration contour line from observations (black line) and the UVic ESCM (red line) for the period of 2005–2014 is shown, where observations are taken from *Meier et al*. [2013].

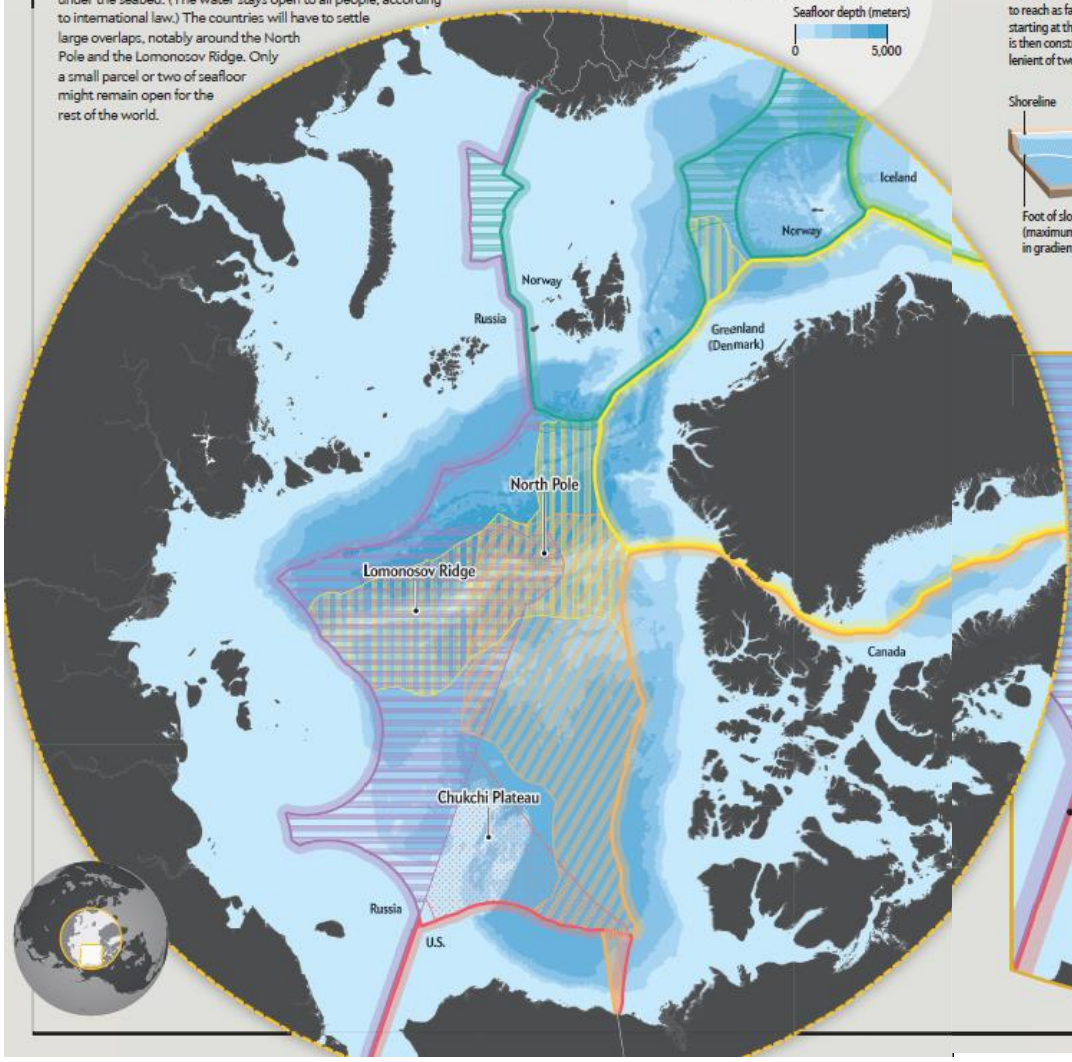
Legal Frameworks

- Same rules apply in most circumstances
- UNCLOS (interplay with Arctic Council)
- National jurisdiction over citizens and vessels
- Antarctic Treaty System
  - Madrid Protocol of 1991
    - Requirements: "limit adverse impacts", CEP, Comprehensive Environmental Evaluation, public review
    - Specifically includes "adverse effects on climate or weather patterns"

SETTING BOUNDARIES

Maps by Katie Peek, Text by Mark Fischetti

The five countries with coastlines along the Arctic Ocean are making a case to the Commission on the Limits of the Continental Shelf for "extended continental shelf"—seafloor beyond their exclusive economic zones—to gain rights to resources on and under the seabed. (The water stays open to all people, according to international law.) The countries will have to settle large overlaps, notably around the North Pole and the Lomonosov Ridge. Only a small parcel or two of seafloor might remain open for the rest of the world.



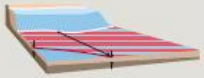
HOW COUNTRIES MAKE THEIR CASE

A country submits documents to the commission outlining the outer edge of its extended continental shelf. It uses one of two formulas (A, B) to reach as far out as they allow, starting at the foot of slope. That line is then constrained by the more lenient of two limits (C, D).

Formulas to delineate outer edge:

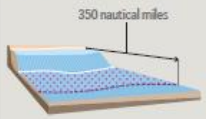
A A line 60 nautical miles from the foot of slope

B A line where the thickness of sedimentary rock is at least 1 percent of the shortest distance from the foot of slope

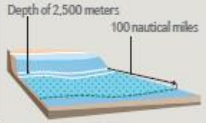


Limits to outer edge:

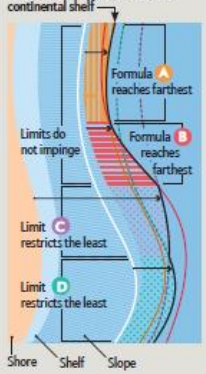
C A line 350 nautical miles from shore



D A line 100 nautical miles from a slope depth of 2,500 meters



Final outer edge of the extended continental shelf



CHUKCHI CONUNDRUM

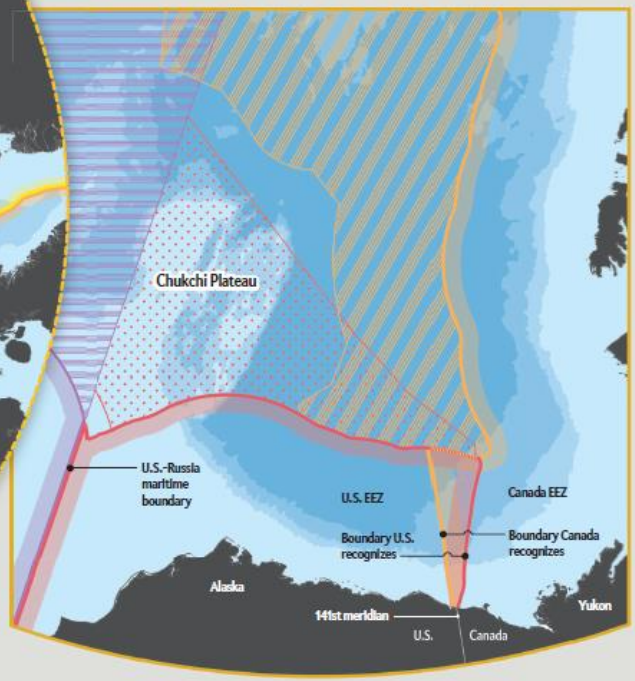
Resolving seafloor claims involves political and scientific trade-offs.

Pliable Plateau

Russia and the U.S. could say the Chukchi Plateau is a "natural prolongation" of their shelf, depending on how experts interpret the way continents have separated over millions of years. But in 1990 the former Soviet Union and the U.S. negotiated a maritime boundary between their exclusive economic zones (EEZs); Russia elongated that boundary in its submission for extended continental shelf and did not cross it. The U.S. says it will honor the boundary, too.

Economic Impasse

The U.S. and Canada disagree on their EEZ border. Canada extends the 141st meridian land boundary (*orange line*); the U.S. traces a line equidistant to the meandering coasts (*red*). The triangular seafloor in between holds an estimated 1.7 billion cubic meters of natural gas.



SOURCES: IBRU, DURHAM UNIVERSITY (claim areas); UNITED NATIONS CONVENTION ON THE LAW OF THE SEA (claim areas); MARINEREGIONS.ORG (EEZs); GLOBAL SELF-CONSISTENT, HIERARCHICAL, HIGH-RESOLUTION GEOGRAPHY DATABASE (coastlines); INTERNATIONAL BATHYMETRIC CHART OF THE ARCTIC OCEAN, VERSION 3.0 (seafloor depths)

Polar Regions as Platforms

Table 1 – Summary of CDR techniques

www.c2g2.net

Techniques	Readiness	Active research area	Governance	Social acceptability
Iron Ocean Fertilisation	Technically feasible and the industrial infrastructure required is well understood.	Yes. in particular environmental impacts and capacity to uptake CO_2.	Research addressed under the London Protocol and UN Convention on the Law of the Sea (UNCLOS).	Limited research suggests it is not welcomed
Micro-nutrients, Nitrogen and Phosphorus Ocean Fertilisation	Modelling studies only to date.	Very limited theoretical and modelling research.	Research addressed under the London Protocol.	Unlikely to be welcomed – see Iron Fertilisation.
Direct Air Capture and Carbon Storage (DACCS)	Small scale operations have been deployed and are demonstrating capacity to remove carbon.	Yes – seeking to improve efficiency and scale up plants.	Subject to nation state terms.	It is uncertain how publics would respond to this technique.
Placing Liquid CO_2 in the Mid/Deep Oceans	Minimal theoretical development of the method only to date.	None.	Would be subject to UNCLOS and the London Protocol.	It is uncertain how publics would respond to this technique.
Placing Liquid CO_2 on the Seabed	Minimal theoretical development of the method only to date.	None.	Would be subject to UNCLOS and the London Protocol.	It is uncertain how publics would respond to this technique.
Placing Liquid CO_2 in Deep-Sea Sediments	Minimal theoretical development of the method only to date.	None.	Would be subject to UNCLOS and the London Protocol.	It is uncertain how publics would respond to this technique.
Mineralisation of Injected CO_2 Within Geologic Structures	Technologies are not to hand. Work underway to develop the technologies to demonstration.	Research currently funded by the European Union (EU) and the United States (US) Department of Energy.	Would be subject to UNCLOS and the London Protocol.	There is no evidence to indicate the nature and scale of any responses.
Ocean Down Welling	Not currently practical, even in principle in engineering terms, to deliver cooling.	Very limited if any activity.	Unresolved.	Unknown.
Ocean Carbon Capture and Storage (OCSS)	The principles are well understood. chemical engineering research is required before a viable technology becomes available for testing.	Mainly technical and economic modelling.	If conducted in EEZ waters, OCSS would be subject to nation state terms. on the high seas, the storage of CO_2 beneath the seabed would be covered by the London Protocol.	There is no evidence to indicate the nature and scale of any responses.

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