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Old Sea, New Ice: sea ice geoengineering and indigenous rights in Arctic Ocean governance

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ABSTRACT

This comprehensive paper explores the complex interplay between Arctic sea ice governance, geoengineering, and the rights of Indigenous peoples. It raises critical questions about the feasibility of regulating potential sea ice geoengineering initiatives while upholding Indigenous rights. Employing a multidisciplinary approach, the paper investigates diverse perspectives on Arctic sea ice encompassing its roles in climate science, international law, and for Arctic Indigenous peoples, contributing to ongoing discussions on implementing Indigenous rights within Arctic governance and emerging climate technologies. As climate interventions are becoming a likely reality, the paper emphasises the imperative of integrating marine geoengineering responses to climate change into global ocean law and governance, with a specific focus on climate justice and the active involvement of Indigenous and local communities in the decision-making. Using analogies of resource exploitation, this paper also explores whether the conceptualisation of geo-engineered sea ice as a resource and looking at existing international legal frameworks governing resource extraction could enhance the effective implementation of Indigenous rights. The paper contends that there is an urgent need to develop an oceanic ethics component that considers Indigenous rights in the context of geoengineering, and advocates for nature-centric visions, Indigenous-led climate actions, and community-level marine resource management within international legal frameworks to strike a balance between the rights-based approach and emerging climate intervention technologies.

KEYWORDS

Ice; Ocean governance; UNCLOS; Indigenous rights; Arctic

1. Introduction

As a carbon sink, and as part of the cryosphere, the Arctic makes a significant contribution to planetary albedo (the reflectivity of the planet's surface) and climate regulation.[1] Based on current climate projections, changes to the stability of this system are set to

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[1]US Department of Commerce, 'What Is the Cryosphere?'.

continue, and the Arctic Ocean may become seasonally ice-free as early as 2050.[2] The result is that the Arctic environment is now destabilised. Older, thicker sea ice is being rapidly replaced by thinner, weaker ice types that are more susceptible to break-up and melting.[3] The unprecedented scale and rate of change has generated much concern among scientists, policymakers, and the general public over the potential implications of sea-ice loss in the cryosphere, at large. While considering these concerns within the context of warnings that the current climate change strategies are not being implemented at the speed required to save critical ecosystems like those in the Arctic,[4] it is now emerging as an area for concentrated efforts for geoengineering – researchers and venture capital investors have been exploring methods of maintaining and even growing the sea-ice, through ice geoengineering.[5] As a result, commercial enterprises to 'refreeze the Arctic' have started to emerge over the past few years.

In addition to its significance to climate change, the changing sea-ice characteristics present fundamentally different environments for species reliant on the peculiar conditions of the cryosphere. This threatens the stability of the Arctic's rich marine ecosystem, which relies upon sea ice as a habitat, a shelter, a hunting ground, and a place for reproduction.[6] Not only does this threaten global food security from the effects on fish stocks,[7] for example, these changes have knock-on effects for Indigenous communities living in the Arctic, undermining the security of their culture, livelihoods, and well-being.[8] At the same time, receding ice cover offers new economic and political opportunities around the growing viability of trans-Arctic sea routes and prospects for increased commercial access to natural resources.[9] Given this set of factors, the introduction of ice-geoengineering as a climate solution poses challenges for the existing regulatory framework and knock-on effects for Indigenous peoples.[10]

In the context of this emerging situation, this paper explores the intricate relationship between Arctic sea ice governance, geoengineering, and the rights of Indigenous peoples. In the process, we raise fundamental questions about whether it is feasible to regulate potential sea ice geoengineering interventions while also respecting Indigenous rights. The paper employs a multidisciplinary approach to delve into various perspectives on Arctic sea ice, examining its roles in climate science, international law, and for Arctic Indigenous peoples. Our argument is fourfold. First, ice is an elusive physical and legal concept and is important to Indigenous peoples of the Arctic. Second, the way ice is currently monitored presents challenges for incorporating Indigenous knowledge. Third, the potential geoengineering of sea ice creates issues for international law, potentially infringing on Indigenous rights. Fourth, international law needs development to conceptually define and situate (geoengineered) sea ice within governance frameworks and determine its material position, for example, as a resource, scientific activity or intervention. As such this comprehensive paper adds to current literature on the implementation of the rights of Indigenous peoples in decision-making on Arctic governance in relation

[2]IPCC, 'Findlater et al. (2021)'.
[3]Kwok, 'Arctic Sea Ice Thickness'.
[4]Rogelj et al., 'Paris Agreement Climate Proposals'; McCaulley, et al., 'Which States Will Lead a Just Transition for the Arctic?'; Wood-Donnelly, 'Evaluating Normative Capacity through Arctic Environmental Governance'.
[5]NASEM (National Academies of Sciences, Engineering and Medicine), *Reflecting Sunlight*.
[6]Meltofte et al., *Arctic Biodiversity Assessment*.
[7]Campana et al., 'Shifting Fish Distributions in Warming Sub-Arctic Oceans'.
[8]Durkalec et al., 'Climate Change Influences on Environment'.
[9]Bird et al., 'Circum-Arctic Resource Appraisal'.
[10]'Resource Rush in the Arctic?'.

to development of new technologies and to the literature examining Arctic ice within international legal frameworks.

2. Perspectives of arctic sea ice and climate change monitoring

Current scientific discourses about Arctic sea ice are dominated by stories of change, loss and transformation.[11] With the role of climate and weather in the Arctic providing a major theme for Arctic science diplomacy and along with the implications of Arctic sea-ice decline already being felt both within and beyond the region, the observation and monitoring of sea ice has become a major focus of climate science in recent decades. This collection of information now underpins scientific knowledge of historical, current, and future changes. It is used to assess the potential implications and risks and provides the empirical basis for decision-making and policy responses. Finally, it informs public awareness of climate change using the Arctic as a 'warning region' for what will follow elsewhere.

Within this sea-ice monitoring, the use of satellites has significantly shaped our understanding of the Arctic Ocean environment and the melting of Arctic sea ice, allowing us to visualise complex changes, inform policies, and prepare for future scenarios. Since the late 1970s, satellite observations have provided near-complete coverage of the Arctic Ocean on a 24-hour basis – except for a small gap at the North Pole – creating one of the longest and most consistent climate data records available with year-on-year observation of maximum and minimum ice extent now showing an alarming decline.[12] These scientific observations on sea ice influence climate governance and responses like geoengineering. While they have advanced sea ice knowledge, they reflect a particular Western perspective of what ought to exist in the Arctic maritime space. They classify the ocean environment into distinct variables and parameters, treating sea ice as a separate geophysical entity that can be explained and predicted through science. These distinctions are not solely based on natural entities but are influenced by environmental conditions, technology, and scientific interests and may be influenced by logic of national interest.[13]

The comprehensive view these satellites offer transformed scientific knowledge of Arctic sea ice, including the challenges and opportunities related to future change and how these might be addressed.[14] Satellite observations have come to be seen as part of a global response to the problem of sea-ice decline by enabling real-time monitoring of current conditions, which may in time include geoengineering interventions. Against a backdrop of increasing scientific, political, and public concern, areal parameters have become ubiquitous in climate change discourse and have come to dominate the broader understanding of sea-ice variability, despite the partial, two-dimensional perspective they provide.[15] However, these satellite-derived sea-ice data are not direct observations of sea-ice environments but are rather measurements of electromagnetic signals that are retrieved, processed, and transformed into meaningful information about sea ice

[11]Stroeve et al., 'The Arctic's Rapidly Shrinking Sea Ice Cover'.
[12]NASA, Arctic Sea Ice.
[13]Wood-Donnelly and Bartels, 'Science diplomacy in the Arctic'.
[14]Kuhn, *The Structure of Scientific Revolutions*; see also Wormbs, 'Eyes on the Ice'.
[15]Parkinson et al., 'Arctic Sea Ice Extents'; Comiso, Meier, and Gersten, 'Variability and Trends in the Arctic Sea Ice Cover'.

according to the logic of geophysics and the constraints of satellite technologies. While such transformation processes make sea ice more amenable to scientific study, the complex materiality of sea ice, small-scale dynamics, and localised features are inevitably lost and abstracted. Recent social science research highlights the need for critical examination of how science and technology shape our understanding of climate change, emphasising that focusing solely on technical and geophysical aspects may limit our comprehension of its broader socio-political and ecological implications.[16] This approach risks neglecting diverse perspectives and local experiences that exist beyond the dominant norms of knowledge production.[17]

One perspective that is often excluded from cryosphere observations and corresponding climate adaptation and mitigation strategies is the perspective of Arctic Indigenous peoples. Mainstream science does not traditionally include Indigenous knowledge, and, in addition, nation-states have been reluctant to recognise the role of and use of ice for Indigenous peoples beyond the shoreline. Sea ice governance and science unfortunately follow this trend. Both national and international governance tend to draw jurisdictional and regulatory boundaries between land and sea, which only conceives of sea ice as a liminal space, and does not reflect how coastal Indigenous nations have traditionally engaged with the land-sea continuum.[18]

For coastal communities in the Arctic, sea ice has always been a source of knowledge, culture, spirituality, and a critical component of health and food security.[19] Sea ice facilitates human interactions with the natural world and allows for more traditional activities, such as hunting and fishing, to take place. There is no boundary, no divide. For the Inuit, for instance, sea ice is road, infrastructure, territory, land and sea all at once. In wintertime, sea ice is a highway, in summertime, it is the open sea. As such there is a fundamental distinction between land and sea.[20] Sea ice is an integral component of life in the Arctic. As stated in a report by the Inuit Circumpolar Council, '[l]and is anywhere our feet, dog teams, or snowmobiles can take us'.[21] From a regulatory perspective, not only does this understanding of ice as more than water allows to avoid the colonial legal fiction of '*mare nullius*', but it also gives the conceptual tools to look at the interplay of governing ice geoengineering as a resource extractive activity with ocean governance and the rights of Indigenous peoples.

3. Arctic sea ice law and governance

In international ocean governance, scholars have already called for a greater appreciation of ice,[22] not least for its role in climate regulation, but also related to its significance as a source of potable water.[23] Although not the case in current international law, some earlier scholars[24] argued for the expansion of legal practices to develop the legal bases to

[16]Jasanoff, 'Heaven and Earth'; Findlater et al., 'Climate Services Promise Better Decisions'.
[17]Jasanoff and Martello, *Earthly Politics*; Lahsen and Turnhout, 'How Norms, Needs, and Power in Science Obstruct Transformations towards Sustainability'.
[18]Mulrennan and Scott, 'Mare Nullius'.
[19]See Huntington et al., 'Sea Ice Is Our Beautiful Garden'; see also Durkalec et al., 'Climate Change Influences on Environment'.
[20]Inuit Circumpolar Council, *The Sea Ice Is Our Highway*.
[21]Ibid., 2.
[22]Cinelli, 'Legal Status and Environmental Protection of the Arctic Sea Ice'.
[23]Wood-Donnelly, 'Iceberg Sovereignty'.
[24]See Lakhtine, 'Rights Over the Arctic'; see also Joyner, 'Ice-Covered Regions in International Law'.

territorialise sea ice through the exercise of sovereignty – *i.e.* establishing jurisdiction and valid claims to ice-covered areas – or to facilitate its exploitation and commodification as a valuable natural resource with ideas such as harvesting icebergs.[25] Within debates on the perspectives of ice, it is also suggested to approach ice, and in particular, sea ice as one coherent whole can serve a dual purpose. It both strengthens the need to rethink 'surfaces, volumes, structures, and movements of and in ocean-space that are inherent to Western conceptions of mobility, time, and territory' and, even more importantly perhaps, it reinforces Indigenous peoples' self-determination over their landscapes and seascapes.[26]

However, its changing physical properties, sizes, shapes, and the different types of ice have made it difficult to regulate it in the same manner as other mineral resources or living resources.[27] As a result, international law only really understands sea ice as a nuisance rather than as a critical material or as an asset. As it gets in the way of frictionless transportation for commercial purposes and the exercise of sovereignty, ocean governance consciously 'breaks' the ice. Often described as a constitution for the oceans, the 1982 United Nations Convention on the Law of the Sea (UNCLOS) applies to the entirety of Arctic waters. Under UNCLOS, ice either breaks and causes hazards (Art. 234) or is perceived as a hindrance to navigation (i.e. a naturally occurring obstacle that needs to be broken up for ships to navigate through) under the customary principle of freedom of navigation (Art. 87(1)a). Sea ice's structural coherence is rarely valued intrinsically beyond its role in climate regulation or ecosystem services.[28] There is, however, a longer historical debate on the legal status of sea ice used as land that demonstrates 'Western' logic for perspectives on ice.

In its form as sea ice, ice enters Western legal conversations about its role as liminal material and its capacity to be used as land by explorers still making discoveries of unclaimed land in using established procedures for imperial territorial expansion in the early 20th century. Given the rudimentary understanding of Arctic geographies by explorers, it was sometimes believed that an undiscovered continent could be found in the Far North.[29] With potential possession of the North Pole waived by U.S. authorities after Peary's claim to the first reach of the pole, it had the effect of positioning sea ice, although used as land, within the law of the sea and apparently under the principle of the freedom of the seas. Scholars of the period were certain that sovereign titles could not be applied to frozen seas with the freedom of the sea forming the backbone for the governance of ocean spaces.[30] However, the concept of the sector principle was soon introduced and posed a challenge to this order.

Although not specifically for ice, the sector principle, levied first by Russia and then Canada, provided a potentially significant alteration to the territorial order that formed the division of sovereignty between land and sea prevailing for hundreds of years. First, the sector principle had the effect of removing the patchwork of sovereignty claims from the various nations who had sent explorers to the Arctic, making redundant claims of

[25]Joyner, ibid.
[26]Steinberg et al., 'Navigating the Structural Coherence of Sea Ice', 166.
[27]Wood-Donnelly, 'Iceberg Sovereignty'.
[28]Steinberg et al., 'Navigating the Structural Coherence of Sea Ice'.
[29]Humphreys and Hosey, *Romance of the Airman*; Welky, *A Wretched and Precarious Situation*.
[30]Scott, 'Arctic Exploration and International Law'.

discovery over Arctic islands within sectoral slices. Second, the sector principle provided the framework for thinking about the sovereignty of sea ice used as ice islands for semi-permanent habitation. With ice and the sea itself in a constant state of rotation, thanks to the Beaufort gyre, the movement and precarity of ice islands of no fixed coordinates made it difficult to establish good title.[31] The predominant perception was that if ice islands with semi-permanent habitation, a form of effective occupation, drifted from the sector of one state to the next this would form a crisis of sovereignty.

A number of propositions were floated around conceptualising ice island sovereignty. Some of these were positioned in the concept of permanent sovereignty.[32] However, if the sovereign property of one state happenstance came to be floating in the sovereignty territory of another state, this could present a condition where title should transfer, an unfeasible situation given that sovereign transfer of territory is not ordinarily organised in this way. Next, it was proposed that ice islands could have a similar legal status to ships and could have a designated flag state, however this was both legally and technologically problematic given their lack of navigational capabilities.[33] Later, as the insecurities of the Cold War developed, concerns of migrating sovereign territory became a security concern should the ice islands be used as assault platforms.[34] The debate only took some practical form when a murder forced the question of jurisdiction to the fore, where the state who could claim sovereignty over the island, by virtue of position, deferred action to the state whose citizen had committed the crime.[35] Through all of these discussions, Indigenous use of land as ice and questions of self-determination and Indigenous rights were absent from the debate.

In contemporary legal frameworks, sea ice appears in two contexts. One is UNCLOS Art. 234, which allocates special provisions to states for environmental protection of ice-covered waters within their exclusive economic zones. The second is in land claims, such as the Nunavut Land Claims Agreement, where land-fast ice is recognised as a harvesting area for Indigenous tradition use but is not included specifically within discussions of territory. The history of debates for the legal status of ice, varying perspectives on the use and practices around ice and ice islands and the limited variation of sea ice inclusion within legal frameworks makes it difficult to determine long-standing precedent for sea ice that could be useful for a conversation of how geo-engineered sea ice should be handled within governance frameworks. While legally awkward, this in fact presents the opportunity to frame discussions around the handling of geo-engineered sea ice within practices that respect Indigenous self-determination and bring procedural justice to the foreground.

3. Arctic sea ice and geoengineering

As a place with a long history of legal and social transformations, environmental understanding of the Arctic is deeply colonial. From the 19th and early 20th-century intensive whaling to the discovery of fossil fuel reserves in the decades following the Cold War to

[31]Balch, 'The Arctic and Antarctic Regions and the Law of Nations'.
[32]Joyner, 'Ice-Covered Regions in International Law'.
[33]Pharand, *The Law of the Sea of the Arctic*.
[34]Auburn, 'The White Desert'.
[35]Pharand, 'State Jurisdiction over Ice Island *T*-3'.

the creation of intergovernmental forums, changes in regulatory spaces and regimes regulate, and prioritise, Arctic resource activity. Western imaginaries have always pictured the Arctic as an empty resource frontier; a frontier to be conquered – an environmental, economic, and human challenge[36] – and a space that needed to be transformed to fit the developmental needs of the modern state. As climate change accelerates another period of change for the Arctic, the melting sea ice presents further economic opportunities in the shape of resource extraction and shipping, the Arctic States have adopted several strategies to protect this vulnerable ecosystem with geoengineering the sea ice as a possible additional strategy.

Defined as ' . . . the deliberate large-scale manipulation of the planet's climate system for a specific benefit . . . ',[37] there are two broad categories of geoengineering. The first category, greenhouse gas removal (GGR) focuses on the removal and capture of gasses with high global warming potential by using methods such as carbon dioxide removal (CDR),[38] and the second category (and more pertinent to the subject of this paper) includes solar radiation management (SRM). While GGR ideas have been proposed to enhance the Arctic as a carbon sink,[39] it is within SRM and surface albedo modification, *i.e.*, modifying the reflectivity of the planet, that ice geoengineering emerged as a potential method to protect the Arctic given the doubts that conventional emissions reductions will not be enough lead to a cascade of consequences in the global tipping points. Of the various methods that have been proposed, there are two that have been a focus for research, Marine Cloud Brightening (MCB) using seawater and salt crystals, and Stratospheric Aerosol Injection (SAI) using the injection of aerosol particles into the upper stratosphere. Both methods, in principle, would recreate conditions similar to that found after large-scale volcanic eruptions. Thus, if this could be replicated in a controlled manner, it would provide the benefit of a decrease in atmospheric temperature where it is likely that lower temperatures would provide a benefit to the ice.

From a more practical perspective, it is thought that methods such as this could decrease atmospheric temperatures providing a benefit in potentially maintaining the Arctic ice. MCB and SAI could provide an additional option for climate mitigation (supplementing decarbonisation). They each have different methods of implementation. In theory, the injection of aerosol particles could provide an increase in atmospheric reflectivity, which would result in a cooling of global temperatures.[40] However, research has not advanced much further than laboratory modelling, as there have been few field tests owing to the high degree of uncertainty and difficulty in robustly governing these forms of geoengineering.[41] While the technical challenges may be relatively easier to overcome, using SRM, and MCB poses challenges for the law. These endeavours can be carried out within national jurisdictions subject to adherence to the necessary environmental law, however there are still questions over the risk of transboundary harm and how much precaution should be exercised. Furthermore, testing in the Arctic has been criticised by some NGOs and the Sami Council.[42]

[36]Cooper, 'Energy Development in the Russian Arctic'.
[37]'Royal Geographical Society – Geoengineering'.
[38]National Academies of Sciences, Engineering and Medicine (NASEM), *Reflecting Sunlight*.
[39]For example, 'Climeworks', a CO_2 removal operation in Iceland.
[40]NASEM, *Reflecting Sunlight*.
[41]US National Aeronautics and Space Administration (NASA), 'Global Effects of Mount Pinatubo'.
[42]Cooper, 'FPIC and Geoengineering in the Future of Scandinavia'.

From the broader portfolio of geoengineering, there have been some specific small-scale ice-geoengineering tests in the Arctic. The Arctic Ice Project (formally Ice911) has carried out some preliminary testing in north-western Alaska, attempting to increase the surface albedo and thickness of the ice using silica crystals.[43] However, while such experiments can be modelled over the short term, the long-term results of introducing these silica crystals are presently difficult to accurately map. In addition, these crystals could then be ingested by marine life with unknown impacts. Some researchers have tried more eco-friendly methods, by using a wool and corn starch blend sheet to increase surface albedo with results showing a positive increase in the volume of the glacier.[44] Yet however successful the technical or scientific stages of the processes might be, it is pertinent to note that each stage of development presents different governance issues based on area of jurisdiction and carries varying degrees of risk and questions of ethics.

Ice geoengineering involves novel technologies that are transboundary and global in their nature. However, there is still polarised debate over its viability. On the one hand, a technological intervention would alleviate the 'symptoms' of climate change and protect vulnerable ecosystems like the Arctic. On the other hand, there is still uncertainty over the negative effects of geoengineering and crucially, how to appropriately govern such a complex undertaking and its broader effects. Regardless of whether geoengineering is viewed as an inevitability, fundamentally it is not an exceptional concept in law. However, ice and the legal status of sea ice are unclear in international law. Despite this, there are key principles within customary international law that are relevant to ice geoengineering and can offer guidance for regulating such activity.

The first principle is that of preventing transboundary harm, and the second is the precautionary principle. The obligations they create are by no means absolute, but they could provide a foundation for sea ice geoengineering if the sea ice is considered a resource with broadly defined exploitation potential. These principles are an accepted part of customary international law, reflected in Principle 21 of the 1972 Stockholm Declaration on the Human Environment, and in Principle 2 of the 1992 Rio Declaration on the Environment and Development. Broadly the no harm principle places an obligation of conduct upon the state, to take all reasonable measures to minimise any transboundary harm that may occur.[45] Still, as with many geoengineering proposals there is a degree of uncertainty involved. The precautionary principle appeals for caution in the absence of adequate scientific data to map out what measures can be taken to minimise harm. In these instances, once a risk is established, the question becomes one of the appropriate courses of action. Given the background of the climate crisis and the uncertainty associated with geoengineering, this is often unclear. However, these fundamentals apply to public and private actors, which in the context of geoengineering is vital as there is a view that private actors will be more inclined to 'act-profit' in their potential geoengineering endeavours.

However, beyond the existing legal and scientific ethics norms that provide guidance for minimum standards of conduct in exploitation or scientific context, a lack of clarity on the legal status of sea ice does present a governance challenge, as especially as these

[43]'Arctic Geoengineering Experiment Is Dangerous'.
[44]DeGeorge, 'A Cloth Sheet Helped Protect a Swedish Glacier from Global Warming'.
[45]Chuffart and Jabour, 'Environmental Impact Assessment in the Polar Regions'.

questions of geoengineering, 'sovereignty over the ice' and Indigenous Peoples pose problems for ocean governance when exploitation is not strictly within usual ocean resource exploitation practices such as harvesting or transit. UNCLOS Article 234 makes a brief mention of ice-covered areas, but this is only in reference to the option placed upon coastal states to exercise environmental and pollution prevention measures in these waters. However, under UNCLOS, states have a general obligation to protect and preserve the marine environment (Art. 192), a general duty to prevent, reduce and control pollution of the marine environment (Art. 194) and, more specifically, pollution resulting from the introduction of new technologies (Art. 196). Under the recent BBNJ agreement, the precautionary approach and environmental obligations also extend for activities with the potential to negatively impact areas beyond national jurisdiction.[46]

Further, although it is currently not in force, Article 5 of the 2013 Marine Geoengineering Protocol to the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter is a promising avenue because it is sufficiently broad in scope and crucially it covers deleterious effects where they may be 'widespread, 'long lasting', 'severe' or detrimental effects to vulnerable parties. However, in a complex geopolitical landscape this framework may do little to properly inform decision-making moving forward as the different stages of geoengineering (research, testing and implementation) will need different levels of regulation, finding synergy between treaty regimes and governance considerations may prove a challenge.

For the Arctic region in particular, there is another regulatory framework that may support synergies between legal frameworks in the 2017 Agreement on Enhancing Arctic Scientific Cooperation. The agreement may be sufficient to ensure that there is at least a general governance framework in place that includes guarantees of consultation with other stakeholders including Indigenous peoples. For instance, the consultation provision of Article 9 provides a preliminary framework to ensure that at the early phases of geoengineering research, planning and potential testing, Indigenous peoples are adequately consulted, and Indigenous traditional knowledge is taken into consideration. Given the nature of the conditions in the Arctic, it would dictate more stringent provisions concerning consultation, preventing transboundary harm, and ensuring accountability should be included.[47] The principles of environmental law should underpin existing scientific practice. However, generally, it is implicit within international governance that there is a duty to facilitate international cooperation, and that all reasonable, informed steps should be taken to avoid serious environmental harm. This would include consultation, undertaking an EIA and engaging in the appropriate dialogue with relevant stakeholders and rights-holders.[48]

In multilateral environmental agreements, there is only one more notable decision more specifically relating to geoengineering, adopted under the auspices of the 1992 Convention on Biological Diversity (CBD). In 2010, Decision X/33 and Decision XIII/14 called for a degree of precaution to be exercised in geoengineering research – stopping short of an outright moratorium in the absence of an 'adequate scientific basis', given the

[46]BBNJ Agreement, 19 June 2023.
[47]Hopster, 'Climate Uncertainty, Real Possibilities and the Precautionary Principle'.
[48]Chuffart and Jabour, 'Environmental Impact Assessment in the Polar Regions'.

potential effects of geoengineering on biodiversity. However, the details of what endeavours were intended to be covered were unclear.

Ocean spaces have a long history of human subsistence, and scientific and commercial uses of marine and non-living resources. In international law, interactions with natural resources played a key role in the development of the law of the sea as known today. One example of such a trend is the (re)discovery of polymetallic nodules on the seabed in the mid-twentieth century. This spurred new extractive imaginaries and plans for their extraction on a commercial scale. The need to regulate the ocean floor and areas beyond national jurisdiction thus became a necessity. Famously, Maltese UN Ambassador Arvid Pardo called for 'an effective international regime over the seabed and the ocean floor beyond a clearly defined national jurisdiction'.[49] This necessity brought about the third law of the sea conference (1973–82 UNCLOS III) which led to UNCLOS.

However, the law is slow to respond to the regulation of new activities in the law of the sea and ocean governance. From narratives of shared resources with fishing and petroleum exploitation to innovative ideas of the seabed as common heritage of (hu)mankind, the ocean is narrated as a resource to be exploited. For instance, the growth of oil and gas as alternatives to coal and the recent need to develop renewable energy from the sea to accelerate the transition out of fossil fuels have come to define the legal landscape of the 20th and 21st centuries.[50] In addition, the fisheries regime was a late but regarded as necessary addition to UNCLOS in the mid-1990s to allow for the management, conservation and utilisation of fish stocks within and beyond the exclusive economic zone.[51] As it reifies nature through the regulation and allocation of natural resources, UNCLOS reinforces the status quo of ocean governance which is to codify states' exploitation of nature.[52] For example, current legal norms do provide the flexibility to incorporate and regulate geoengineering as a resource exploitation activity. Using SRM and ice-geoengineering to preserve and protect the Arctic environment could therefore be an option, but only where interaction with sea ice is thought of as an exploitation activity. In terms of regulation, for the ice-covered areas there are few specific provisions – even fewer that explicitly refer to geoengineering.

4. Sea ice geoengineering, ocean governance, and indigenous rights

The development of marine geoengineering as a result of climate change needs to be incorporated into global ocean law and governance, not only to prevent environmental harm in transboundary contexts, but also with respect to Arctic Indigenous peoples. Current international law already seems to provide a legal framework for geoengineering from a *stricto sensu* state perspective. However, whether there is a legal framework flexible enough to incorporate and regulate new activities will not matter if this legal framework is not responsive enough and does not include some level of environmental or climate justice. Such an approach requires going beyond state's anxieties of control and involving Indigenous people(s) and local communities in any legal measures that try to address climate change – whether this is climate mitigation or adaptation – and its

[49]United Nations, UN DOC A/C.1/PV.1515".
[50]Jones, 'Commodifying the Ocean'.
[51]United Nations Fish Stock Agreement, UN Doc A/CONF.164/37.
[52]Enyew, Poto, and Tsiouvalas, 'Beyond Borders and States'.

harmful effects, especially (but not only) when such measures will affect their traditional spaces and practices.[53]

From a human rights perspective, this issue of geoengineering is of particular interest to the UN Human Rights Council (HRC) which provides the most comprehensive legal guidance for sea-ice geoengineering and Arctic Indigenous Peoples. For example, in its Resolution 48/14 in 2021 the HRC requested the Advisory Committee (AC) to conduct a study and to prepare a report on the 'impact of new technologies for climate protection on the enjoyment of human rights'. The premise of the report is that geoengineering is not compatible with human rights. The precautionary approach and States' human rights obligations entail a duty not to deploy or develop geoengineering technologies, 'given the associated high risks and uncertainties for the rights of present and future generations . . . and the availability of proven low-risk alternatives to prevent climate harm'.[54]

By considering New Technologies for Climate Protection (NTCP), the HRC AC emphasised that decisions and impacts of NTCPs could significantly impact the ability of marginalised socio-economic groups to exercise and fulfil their human rights, [55] suggesting that 'Indigenous Peoples and other frontline communities may be particularly exposed to the negative impacts of NTCPs'.[56] Since 'Indigenous lands and territories are particularly exposed and at risk of experimental use', the report argues for the implementation of UN Declaration on the Rights of Indigenous Peoples (UNDRIP) standards such as their free, prior and informed consent 'before adopting and implementing any legislative or administrative measure that may affect them' (UNDRIP Art. 19). The HRC report also draws from the ScoPEx project that had been planned without respecting FPIC requirements as well as the Alaska Native opposition to the Arctic Ice project.[57] The latter drew on the right of Indigenous peoples not to have the storage or disposal of hazardous materials on their lands or territories without their free, prior and informed consent (UNDRIP Art. 29). The report's approach to the implementation of human rights standards illustrates why in the context of geoengineering it is vital to have consultation. Each state has the obligation to implement appropriate measures, and this includes the inherent duty to consult with those who may be affected to ensure they are aware of the risks and can consent (or withhold consent). Otherwise, the report argues, 'it risks compromising the progress on Indigenous self-determination and increasing existing divisions on geoengineering research'.[58]

However, the conceptualisation of the development of human rights in NTCPs in the HRC Report still lacks an oceanic component in relation to Indigenous peoples. Whereas it is alluded to in the case of the opposition from Alaska Iñupiaq communities to the Arctic Ice Project, there is still a paucity of thinking about the ocean spaces in light of both Indigenous rights and geoengineering. This is critical given that Indigenous peoples rely on the use of oceans, seabed and their associated environments to ensure their food, health, economic, and cultural securities and practices. This relationship with ocean-space that goes beyond 'usage' and 'possession' as traditionally reflected in international

[53]See Papanicolopulu and Rocha, 'Oceans, Climate Change and Non-State Actors'.
[54]CIEL, '30th Session'
[55]UN HRC, 'Impact of New Technologies'.
[56]Ibid., para 53.
[57]Ibid., para 55.
[58]Cooper, 'Sámi Council Resistance'.

law, is little developed in UNDRIP. In fact, only Art. 25 textually mentions wet non-land spaces providing 'the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used [...] *waters and coastal seas* [...]'. Equally, there is no mention of ocean-space in the 1989 International Labour Convention 169 on Indigenous and Tribal Peoples Convention (ILO 169), the only legally binding instrument that applies specifically to Indigenous issues and rights. However, ILO 169 Article 13(2) suggests that Indigenous 'land' in international law is not limited to *terra firma* but extends to 'the total environment of the areas which the peoples concerned occupy or otherwise use'.[59] In effect, international human rights standards that limit state sovereignty can also apply to the rights of Indigenous peoples and especially in relation to the land and resource rights of Indigenous peoples.[60] Since the use of ocean space and access to marine living resources remain at the core of continued existence of coastal Indigenous peoples as culturally distinct peoples,[61] it is worth considering the implementation of Indigenous rights in the marine Arctic, not least for recognition of their status as rightsholders in the region.

Consultation and prior consent underpin state-to-state relations at the international stage and can be used to limit state sovereignty.[62] States are bound to provide for effective means of consultation with Indigenous communities in the development of projects that may affect Indigenous traditional territories, which includes either scientific or commercial geoengineering activities. While at least some Arctic states, for instance, have developed robust consultations and impact assessment mechanisms to fulfil their obligation to consult with other states on potential transboundary impacts. However, the application of the right of Indigenous Peoples to FPIC still lags behind and is seldom implemented within a domestic context,[63] let alone in a potentially more complex scenario of transboundary and transnational issues such sea ice use by Indigenous communities in multiple Arctic states.

In the Arctic, the introduction of geoengineering policies would therefore represent yet another complex chapter in state-Indigenous colonial relationships. Even after the formal UN Decolonization process took place, through the 1960 UN General Assembly resolution 1514 (XV) on the Declaration on the Granting of Independence to Colonial Countries and Peoples Indigenous Peoples across the world have found themselves trapped within sovereign states with only limited possibilities for internal self-determination. As a result of colonial policies, they were either marginalised or forcefully assimilated[64] and post-cold war Arctic governance has seen Indigenous Peoples' rights and claims for more autonomy gain greater recognition.[65] There is still significant asymmetry in Arctic governance between States and Indigenous peoples.[66] While broad generalities are often the characteristic of colonisers and should be avoided, in many Indigenous cosmologies, the relationship to the environment carries a legal, cultural and spiritual significance.[67] Given that traditional activities rely on the

[59]See also Johnstone, 'Indigenous Rights in the Marine Arctic', 126.
[60]Bankes, 'International Human Rights Law'.
[61]Enyew, 'International Human Rights Law'.
[62]Anaya and Puig, 'Mitigating State Sovereignty'.
[63]Human Rights Committee, 'Communication No. 1457/2006'.
[64]Newcomb, 'Domination in Relation to Indigenous ("Dominated") Peoples in International Law'.
[65]Koivurova and Heinämäki, 'The Participation of Indigenous Peoples'.
[66]Wood-Donnelly, '2: Responsibility of and for Structural (In)Justice in Arctic Governance'.
[67]See Watson, *Aboriginal Peoples, Colonialism and International Law*.

environment and have unique ties to Indigenous cultural heritage and identity, especially as they relate to traditional use of nature,[68] this makes Indigenous rights and culture more vulnerable to environmental degradation.[69]

As discussed above, the frozen state of ocean space and their traditional uses have more than mere cultural significance for Arctic Indigenous peoples, they are an integral component of life of coastal communities across the region[70] and beyond the structural integrity of sea ice, its lack of interaction with other ecosystems could lead to dramatic consequences for traditional activities. However, the urgency of the issue also requires including Indigenous perspective and rights in ocean governance, ordinarily seen as a space for international relations between states only. Although marine protection, the rights-based approach to environmental and marine protection in the UNDRIP and the ILO 169 is broad enough and might even be sufficient to apply to traditional use of ocean space, if seen as a space for protection or common heritage. For instance, the right to Indigenous-led conservation and environmental protection as well as to the productive capacity of their lands or territories and resources in UNDRIP Art. 29 should be read in conjunction with general international environmental law.[71] Environmental obligations could therefore be used as means to bridge the gap between ocean governance and Indigenous rights as both the UNDRIP and ILO 169 provide 'specific rules for the protection, conservation and sustainable use of the environment in the interest of an identified group of beneficiaries'[72] which need to be understood as part of the corpus of international environmental law that informs the application of marine environment protection and preservation provisions, such as UNCLOS Art. 192.[73]

However, questions remain. How can the potential effects of ocean-based technological climate solutions be regulated in a way that includes Indigenous rights and Indigenous perspectives within ocean governance when these solutions would be done in the name of global environmental protection? New marine activities often have a disruptive potential. For instance, deep-sea mining, which is already governed by the UNCLOS (Part XI), has already been flagged by the UN as having the potential to disrupt Indigenous traditional livelihoods. The development of such activities under the principle of sustainable development therefore requires Indigenous peoples to engage in the governance of oceans and the seabed. However, how does the urgency of dealing with climate change globally materialise with local climate solutions that deal with specific traditional sea ice use and the services coastal Indigenous communities derive from the ice cover? The governance of sea ice through UNCLOS Art. 234 may not adequately provide a framework to include both the temporal urgency of climate change and the need for consultation at local scales.

This therefore prompts the question of how ice and not ice-covered areas would be regulated with the emergence of a technology that produces ice to cover marine areas. Ice as a resource to be exploited and whose production and (re)production through technological means need to be regulated does not come as a shock or a novelty to the

[68]Daes, 'Indigenous People and Their Relationship to Land'.
[69]Knox, 'The United Nations Mandate on Human Rights and the Environment'.
[70]Inuit Circumpolar Council, *The Sea Ice Is Our Highway*.
[71]Chircop, Koivurova, and Singh, 'Is There a Relationship between UNDRIP and UNCLOS?'.
[72]Ibid.
[73]Ibid.

international legal mind. The exploitation of living and non-living resources has come to define the law of the sea and negotiations to codify the sea and its resources have also often offered alternative models to collective extractive imaginaries.[74] If understanding the production of new sea ice as a resource-intensive activity could lead to the inclusion of state obligations regarding consultation and consent with Indigenous communities, it still relies on legal interpretations of physical environment-human realities as exploitative. It finds roots in the translation of nature into the language of international law. In the context of oil and gas development in the marine Arctic, for example, scholars such as Johnstone have argued that it needs to be and can be made compatible with international Indigenous rights standards. For this work, such enterprises need to implement the right of Indigenous peoples to self-determination and land rights, including rights to traditionally used coastal and marine areas.[75]

As an exploitable resource, ice loses its identity as a physical space where humans and non-humans interact and as a biota that supports a rich diversity of species. It omits the intrinsic nature of sea ice as sustaining life. Ocean connectivities have always had a social component. Even in western ontologies, the ocean as space to be navigated and crossed allowed the development of capitalism.[76] Beyond Western legal realities, thus far, local and Indigenous perspectives have rarely been included in ocean management. As a result, the social component of ice is completely ignored. To address our new climate reality with fairness, Indigenous stewardship and self-determination over ice-covered ocean-space need to be brought to the fore of global ocean governance. However, as posited above, the type of marine geoengineering we cover in this paper will be exploitative in nature. Even if sea ice cannot be conceived of as a resource, marine geoengineering as a commercial activity is set to *exploit* ocean space to *produce* ice. Therefore, a slight ontological shift is needed. Because marine geoengineering is and will be an activity that involves the transformation of a specific part of nature into a resource, we argue that it should be treated as other resource extractive activities in ocean governance.

The protection of the environmental integrity of ecosystems is crucial for Indigenous peoples' cultural wellbeing and to fulfil their right to self-determination.[77] Protecting marine spaces also is a matter of decolonisation. As calls to decolonise ocean governance have been advanced, law of the sea scholars have posited the need to provide a counter-narrative to the law of the sea's exclusiveness. Ranganathan argues that while we need to understand that the law of the sea consolidated an extractive imaginary of the ocean and global prosperity, two concepts firmly in the same semantic field as global capitalism, the making of ocean governance nevertheless 'offers insights into the contingencies and countercurrents of the decolonization moment . . . and . . . reveals fluid political geographies, alternative models *within* extractivism, and divergent understandings of epistemic community' .[78] In this respect, the development of another form of extraction and exploitation activity in the form of sea ice geoengineering could build up a new ius generative momentum and create room for more inclusion of Indigenous views on ocean and ice connectivities.

[74]Ranganathan, 'Ocean Floor Grab'.
[75]Johnstone, 'Indigenous Rights in the Marine Arctic'.
[76]See Steinberg, *The Social Construction of the Ocean*.
[77]Heinämäki, 'The Protection of the Environmental Integrity of Indigenous Peoples in Human Rights Law'.
[78]Ranganathan, 'Decolonization and International Law'.

There are nonetheless obvious ontological limits to this argument as it would effectively commodify sea ice as a resource and would demonstrate yet again the inherent nature of international law to enable and facilitate the circulation of capital. At its core, the Anthropocene's climate crisis, which spurs a desperate need for *deus ex machina* solutions such as geoengineering, has been enabled by the flow of capital. Currently arguments within international law cannot escape this. However, as Enyew *et al*. argue, it might be possible to counterbalance anthropocentrism in international law by favouring the implementation of nature-centred visions, Indigenous-driven and -regulated climate actions as well as by 'prioritizing and reporting the voices of Indigenous representatives'.[79] In resource governance, this also means considering local and community-level conceptions of marine resource management.[80] However, one missing piece of this legal puzzle remains to be found. How does one link ice geoengineering and ocean governance with a right-based approach? Derived from both general international human rights law and from the rights of Indigenous peoples, norms of international Indigenous rights have already been able to shape the development of environmental protection on land and conservation policies at sea.[81] Moreover, Indigenous peoples have often been a driving force behind the development of environmental protection.[82]

5. Conclusion

This paper considered the potential synergies between Arctic sea ice governance and geoengineering in relation to the rights of Indigenous peoples, taking into consideration a broader landscape of ice ontologies. It asked whether it is possible to regulate such interventions while including Indigenous rights. As such it developed a multi-layered approach to explore different understandings of Arctic sea ice in climate science, international law, and Arctic Indigenous cultures. The paper first highlighted the role of sea ice monitoring in climate governance and the role the production of such data plays in climate policies. What becomes clear is that Indigenous perspectives are not fully included in the monitoring and governance of sea ice. While Arctic sea ice disappearance will have dramatic consequences for the Earth system, it will also have socio-cultural consequences for right-holders in the region. These socio-cultural consequences are not adequately reflected within current scientific understandings of sea ice monitoring.

In the realm of international ocean governance, scholars have emphasised the importance of ice, both as a consumable and useful resource for commercial gain or scientific activities. While current international law does not address ice in a comprehensive manner, earlier scholars argued for its inclusion in legal frameworks to establish territorial claims and facilitate its exploitation as a valuable natural resource. However, the unique physical properties and diverse forms of ice have made regulation challenging, with international law largely viewing sea ice as a hindrance to commercial transportation and sovereignty. The intrinsic value of use beyond its role in climate regulation or

[79]Enyew, Poto, and Tsiouvalas, 'Beyond Borders and States'.
[80]Tsiouvalas, 'Mare Nullius or Mare Suum?'.
[81]Anaya and Grossman, 'The Case of Awas Tingni v. Nicaragua'; Tramontana, 'The Contribution of the Inter-American Human Rights Bodies to Evolving International Law on Indigenous Rights'.
[82]Koivurova and Heinämäki, 'The Participation of Indigenous Peoples in International Norm-Making in the Arctic'.

ecosystem services has often been overlooked. Throughout time, various propositions were explored regarding the sovereignty of ice, but none provided a satisfactory solution. In contemporary law of the sea, sea ice is mentioned in UNCLOS Art. 234, which provides specific regulations for environmental protection in ice-covered waters within exclusive economic zones of states. The historical debates surrounding the legal status of ice, diverse perspectives on its use, and the limited incorporation of sea ice into legal frameworks make it challenging to establish clear precedents for handling climate intervention such as the geoengineering of sea ice. However, this complexity offers an opportunity to shape discussions on geoengineered sea ice governance that prioritise Indigenous self-determination and procedural justice.

The Arctic region, historically perceived as a colonial frontier for resource exploitation, faces new challenges due to climate change, particularly the melting sea ice. To counter this, some propose geoengineering as a solution to restore and maintain the Arctic ice cover. Geoengineering involves deliberate large-scale interventions in the climate system. However, the lack of regulatory frameworks and concerns over its environmental and social impact, especially on Indigenous communities, hinder its implementation. International law offers some guidance but lacks explicit provisions for geoengineering, especially in the context of protecting Indigenous rights. Still, principles like the precautionary principle and no harm principle can inform potential legal frameworks although ultimately, the governance of geoengineering in the Arctic remains complex, involving a delicate balance between environmental preservation, Indigenous rights, and international cooperation.

The development of marine geoengineering in response to climate change needs integration into global ocean law and governance, with a focus on environmental or climate justice and the involvement of Indigenous and local communities. The UN HRC has recognised the potential impact of new climate protection technologies on human rights, especially for Indigenous peoples. However, there is a need to further incorporate an oceanic component in relation to Indigenous rights and geoengineering, as Indigenous cultures depend on oceans and associated environments for food, health, economics, and culture. While international human rights standards can limit state sovereignty and apply to Indigenous rights, the urgency of addressing climate change and geoengineering poses challenges in including Indigenous perspectives in ocean governance. The concept of sea ice as a resource and marine geoengineering's commercial nature should be treated similarly to other resource exploitation activities in ocean governance. However, it's crucial to avoid commodifying sea ice and to prioritise nature-centred visions, Indigenous-led climate actions, and community-level marine resource management within international law to balance anthropocentrism and promote a rights-based approach.

To address new climate realities with fairness, Indigenous stewardship and self-determination over ice covered ocean-space need to be brought to the fore of global ocean governance. However, as posited above, the type of marine geoengineering covered in this paper will be inherently exploitative in nature. Even if sea ice cannot be conceived of as a resource, marine geoengineering as a commercial activity is set to *exploit* ocean space to *produce* ice. Therefore, an ontological shift is needed in thinking about the role of ice and the impact of 'ice' manipulation and manufacturing in the cryosphere. Because marine geoengineering is and will be an activity that

involves the transformation of a specific part of nature into a resource, we argue that it should be treated as other resource exploitation or scientific activities in ocean governance and before venture capital or well-meaning scientific experiments step over the point of no return.

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