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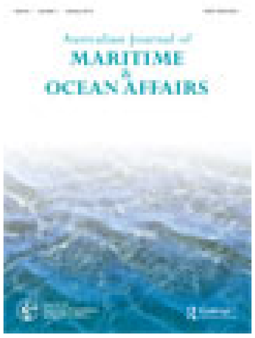

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Geoengineering the oceans: an emerging frontier in international climate change governance

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ABSTRACT

International climate change policy is increasingly reliant upon future large-scale removal and sequestration of greenhouse gases from the atmosphere. Assumptions on the development of 'negative emissions' technologies are built into recent IPCC emissions modelling and the 2015 *Paris Agreement*. Terrestrial proposals, such as bioenergy with carbon capture and storage, may be of limited benefit as the estimated land required would be vast and may negatively impact upon food security. The world's oceans could play an important role in meeting international climate change targets. 'Marine geoengineering' is being proposed to enhance the oceans capacity to sequester emissions and enhance the Earth's albedo. This article draws on discussions at a recent Marine Geoengineering Symposium held at the University of Tasmania to highlight prominent marine geoengineering proposals and raise questions about the readiness of the international law system to govern further research and implementation of these ideas.

1. Introduction

Climate geoengineering, defined by the UK's Royal Society as 'the deliberate large-scale manipulation of the planetary environment to counteract anthropogenic climate change' (The Royal Society 2009) is now at least implicitly embedded in key assumptions of international climate change policy. The 2015 *Paris Agreement* aims to limit human induced climate change to well below 2°C above pre-industrial levels and undertakes to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels.[1] However, limiting climate change to this range is unlikely to occur solely by reducing the amount of greenhouse gas emissions going into the atmosphere. The Intergovernmental Panel on Climate Change's Fifth Assessment Report (2014a) included 204 separate scenarios which in integrated assessment model runs held atmospheric temperature increases to less than 2°C above pre-industrial averages by 2100. Of those 204 scenarios, 184 contemplated large-scale deployment of one form of climate geoengineering, so-called carbon dioxide removal (CDR) or 'negative emissions' technologies, which seek to

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remove and sequester carbon dioxide from the atmosphere through biological, geochemical or chemical means. (IPCC 2014a; Moreira et al. 2016). The IPCC is also currently preparing a report that will include modelling on the 1.5°C stabilisation goal.[2] This report will also likely rely on significant assumptions regarding future use of negative emissions technologies, particularly terrestrial negative emissions such as bioenergy with carbon capture and storage (BECCS).

The climate science and policy communities have also discussed the potentially important role of negative emission technologies in responding to 'overshoot scenarios' (Boucher, Lowe, and Jones 2009). Overshoot of the Paris temperature goals is increasingly likely, given that the current nationally determined commitments of the *Paris Agreement* provide a pathway to a 2.3°C–3.5°C temperature increase above pre-industrial levels and the ambition of current policy settings is pointing to 2.6°–4.9° of warming (Climate Action Tracker 2017).

The oceans have been proposed as a potentially key locus for CDR geoengineering through early scientific work on an option known as ocean iron fertilization (OIF) (Buesseler and Boyd 2003). OIF would entail seeding iron-deficient areas of the world's oceans to stimulate carbon-sequestering phytoplankton production (Hubbard 2016). OIF is one of few geoengineering proposals that has progressed to field testing (Smetacek and Naqvi 2008; Martin et al. 2013). There have also been proposals for other processes to stimulate phytoplankton production in the oceans, including with macronutrients such as nitrogen and phosphorous (Harrison 2017).

In addition to carbon dioxide removal options of this nature, there has also been research on so-called solar radiation management (SRM) geoengineering approaches. SRM geoengineering approaches focus on reducing the amount of solar radiation absorbed by the Earth (estimated at approximately 235 W m^{-2} currently) by an amount sufficient to offset some, or all, of the increased trapping of infrared radiation by rising levels of greenhouse gases, thereby exerting a cooling impact (MacCracken 2009). The oceans are proposed as potential sites for implementation of SRM techniques such as marine cloud brightening and enhanced ocean bubbles (NRC SRM Report 2015b), both approaches of which are described in more detail below.

A national Marine Geoengineering Symposium was held in Hobart, Tasmania on 25 November 2016 hosted by the Institute for Marine and Antarctic Studies (IMAS) and supported by the Antarctic Climate & Ecosystems Cooperative Research Centre (ACE-CRC) and the Faculty of Law at the University of Tasmania. This symposium provided a venue for interdisciplinary discussion and analysis of emerging marine geoengineering technologies and governance issues. The papers delivered at this symposium explored key scientific questions including the rationale behind ocean fertilization and how it might provide a means to enhance the Earth's system in terms of sequestering higher levels of carbon dioxide in the oceans (Bowie 2016) and the role of modelling in understanding CDR geoengineering proposals (Lenton 2016). Papers also discussed the complex nature of existing international and Australian domestic law frameworks that are potentially applicable to ocean fertilization and other marine geoengineering proposals (Jabour 2016) (Brent and McGee 2016) (McDonald and Gogarty 2016). Broader socio-legal questions were also discussed in terms of the intersection between ocean fertilization and the rights of indigenous people, including a high profile 2012 attempt at OIF off the Western coast of Canada (Abate 2016). Suggestions were provided for furthering

geoengineering governance: one paper proposed that ocean fertilization might provide a test-bed for the development of more robust geoengineering governance mechanisms at an international and domestic level (Boyd 2016). Another paper considered how scenarios might be used by policymakers to gauge public attitudes on geoengineering that can inform future decision-making on governance (Talberg 2016). Finally, the symposium concluded with a sobering reminder of the consequences of inaction on climate change (i.e. large-scale negative impacts) and the potential importance of geoengineering technologies in avoiding the worst of these (Rohling 2016).

The following discussion of marine geoengineering draws inspiration from the papers and discussion generated from this symposium. The purpose of this discussion is not to advocate for, or against, marine geoengineering as a part of the human response to climate change. Instead, we simply seek to point to the assumptions that are gathering around geoengineering in international climate change policy and the fact that the oceans are increasingly being viewed as a potential site for geoengineering activity. However, any research on marine geoengineering technologies outside the laboratory setting, or potential deployment, will trigger consideration of the adequacy of existing governance frameworks at both a domestic and international level. This article sketches the more prominent marine CDR and SRM proposals and flags the key issues they raise for international governance.

In section 2, we provide a short history of ocean fertilization and how such experiments led to international law rules for the governance of marine geoengineering. In section 3, we provide an update on the more prominent proposals for future marine CDR and SRM technologies. In section 4, we flag some key issues for the international law system in managing research and potential implementation of marine CDR and SRM technologies. In section 5, we conclude by pointing out the importance of expediting an interdisciplinary and international research program on marine geoengineering governance.

2. Ocean fertilization: experimentation and development of governance

The world's oceans have taken up a large share of the increased energy in the climate system (IPCC 2014b) caused by anthropogenic climate change. The oceans have also absorbed thirty percent of atmospheric carbon dioxide from human activities, helping to reduce potential warming associated with greenhouse gas emissions, but also causing ocean acidification (IPCC 2014b). However, the world's oceans also have significant further potential for enhanced large-scale capture and storage of carbon dioxide. One such enhancement option that has gained prominence over the past fifteen years is ocean fertilization. Since 1993, there have been 15 ocean fertilization field-experiments (ACE CRC Report 2016).[3] However, most of these early experiments were for non-geoengineering purposes (i.e. to 'understand changes in ocean productivity and atmospheric CO_2 concentrations over glacial-interglacial cycles' (Strutton 2012)). Later experiments, such as the 2009 LOHAFEX experiment, examined the potential of ocean fertilization to sequester carbon dioxide (Schiermeier 2009). Additionally, in 2012 there was a controversial ocean fertilization experiment off the West Coast of Canada on behalf of the Haida Salmon Restoration Corporation that was ostensibly aimed at improving the yield of fisheries in the area (Lukacs 2012).

Since 2007 there has been significant activity on geoengineering governance within international regimes on biodiversity protection (*Convention on Biological Diversity*)[4] and ocean dumping (*London Convention* and *London Protocol*).[5] As mentioned above, ocean fertilization field tests have been conducted since the early 1990's. However, in the mid 2000's, corporations began proposing the development of ocean fertilization for the purpose of sequestering carbon dioxide from the atmosphere and generating carbon credits for sale on domestic and/or international carbon markets (Fuentes-George 2017). In May 2007, the US-based corporation Planktos Corp planned to conduct an *in-situ* ocean fertilization experiment in a high seas area off the Galapagos Islands in South America. Planktos proposed dissolving 100 tons of iron dust over a 10,000-square-kilometre area of the ocean to facilitate a phytoplankton bloom.[6] Environmental NGO's Greenpeace International and the IUCN brought this proposal to the attention of the ocean dumping regime. The NGOs highlighted potential for ocean fertilization to harm the marine environment and a high level of scientific uncertainty surrounding the proposals.[7]

This NGO lobbying prompted the ocean dumping regime and biological diversity regime to consider what steps might be needed to regulate ocean fertilization (Fuentes-George 2017).

There have been a number of developments within the ocean dumping and biological diversity regimes that have been detailed elsewhere (Scott 2013; Ginzky and Frost 2014). Here, we instead sketch the broad contours of these early attempts at regulating marine geoengineering.

The initial focus of both regimes was on the issue of ocean fertilization. In 2007, following the reports issued by the IUCN and Greenpeace International, the Scientific Group to the ocean dumping regime issued a statement of concern on ocean fertilization requesting the regime consider regulating ocean fertilization.[8] In May 2008, the *Convention on Biological Diversity* acknowledged this statement and adopted a non-binding decision that requested states 'ensure that ocean fertilization activities do not take place until there is an adequate scientific basis on which to justify such activities … with the exception of small scale scientific research studies within coastal waters.'[9] In October 2008, the ocean dumping regime similarly adopted a non-binding resolution noting that 'knowledge on the effectiveness and potential environmental impacts of ocean fertilization is currently insufficient to justify activities other than legitimate scientific research'.[10] This resolution stated that ocean fertilization activities other than 'legitimate scientific research' should not be allowed, and recommended developing a framework to assess whether proposed activities qualify as legitimate scientific research. These early decisions of the ocean dumping regime and the biological diversity regime therefore reinforced one another and essentially pursued the same governance aims of: (1) prohibiting ocean fertilization for commercial purposes; (2) seeking to prevent environmental harm from ocean fertilization; (3) creating limited exceptions for scientific research in line with a precautionary approach.

In 2010, the focus of these regimes began to broaden in relation to marine geoengineering. In October of that year, the ocean dumping regime adopted an assessment framework for states to employ to determine whether proposed ocean fertilization experiments qualify as legitimate scientific research.[11] This framework first involves evaluating the scientific attributes of proposed ocean fertilization experiments and excludes

proposals that directly give rise to economic gains. The framework also establishes processes for risk assessment and management. At the same time as developing this assessment framework, the ocean dumping regime also started to consider developing binding (i.e. legally enforceable) rules, not just for ocean fertilization, but for marine geoengineering activities more broadly.[12] Australia and New Zealand had previously suggested that the ocean dumping regime broaden its scope to consider other marine geoengineering proposals, as it was reasonable to assume that they will similarly fall within the scope of the ocean dumping regime and attract international concern.[13] In October 2010, the parties to the *Convention on Biological Diversity* adopted decision X/33, which similarly broadened its scope from ocean fertilization to 'climate-related geo-engineering activities'.[14] Decision X/33 provides a non-binding ban on all geoengineering activities (both CDR and SRM) that may negatively affect biodiversity. Once again, this decision created an exception for small-scale scientific research carried out in a controlled setting.

In 2013, parties to the ocean dumping regime adopted a further resolution, amending the 1996 *London Protocol* to create binding rules for regulating marine geoengineering.[15] Resolution LP.4(8) defines marine geoengineering broadly. It includes marine geoengineering for climate purposes, as well as marine geoengineering activities intended to improve marine productivity, such as the 2012 Haida incident off Canada. At present, the rules only provide detailed regulation of ocean fertilization, which is prohibited unless it qualifies as legitimate scientific research.[16] LP.4(8) also provides a general assessment framework, similar to the framework adopted for ocean fertilization in 2010, which can be used by states to assess whether other marine geoengineering proposals may qualify for a permit. LP.4(8) therefore establishes a regulatory framework that could be adapted to govern future field testing and deployment of other marine geoengineering technologies. However, these rules will only become binding once the amendment enters into force. This requires a two-third's majority of Contracting Parties accepting the amendment.[17] At present, only the United Kingdom has accepted the amendment. Thus, while LP.4(8) may provide a useful guide for the regulation of ocean fertilization and other marine geoengineering research, states (and their scientists and policymakers) are not yet bound under international law to comply with LP.4(8).

Several additional field tests of ocean fertilization may take place in the near future. A team of scientists from South Korea, funded by the Korean Ministry of Oceans and Fisheries, propose conducting ocean fertilization field tests in the Southern Ocean in 2018 (Yoon et al. 2016). A private company is also proposing to conduct a similar ocean fertilization activity off the coast of Chile in 2018 (Tollefson 2017). These are the first field tests proposed since amendment LP.4(8) was adopted in 2013. South Korea and Chile are both Parties to the London Protocol, but have not as yet accepted the LP.4(8) amendments. The assessment framework for ocean fertilization that was finalised in 2010 would nevertheless be relevant to both proposals. It will be interesting to ascertain the extent to which these rules influence the manner in which ocean fertilization activities are planned and conducted. These proposed field tests will therefore be more than mere physical science experiments – they will also test the first formal attempts to regulate geoengineering under international law.

3. Proposals for other types of marine geoengineering

As the international law system has made early efforts to regulate ocean fertilization activities, marine scientists have formulated additional CDR and SRM proposals involving the oceans. Most of these proposals have not yet moved beyond the drawing board or laboratory stage. However, the following list provides an indication of some of the marine geoengineering proposals that have been introduced in peer-reviewed scientific literature in recent years:

(1) Enhanced weathering and mineral carbonation techniques

'Weathering' refers to natural processes by which rocks (i.e. silicate and carbonate rocks) break down (Taylor et al.). As part of this process, carbon dioxide reacts with these rocks and is thereby removed from the atmosphere for thousands of years (The Royal Society 2009; NRC CDR Report 2015a). According to Hartmann et al. (2013), this reaction between carbon dioxide and silicate rocks has regulated the Earth's carbon cycle and climate for several eons. In the oceans, dissolved carbon dioxide from the atmosphere reacts with powdered minerals (Hartmann et al. 2013; NRC CDR Report 2015a). Such reactions can form sediments that settle on the ocean floor (NRC CDR Report 2015a). However, this naturally occurring weathering process is slow. One geoengineering proposal is to accelerate this process by adding powdered minerals to the ocean to increase the rate of carbon dioxide removed from the atmosphere. This could also counteract ocean acidification from elevated atmospheric concentrations of carbon dioxide (The Royal Society 2009; Hartmann et al. 2013).

(2) Enhanced kelp farming

A further marine geoengineering proposal involves cultivating kelp (seaweed). Growth of kelp removes carbon dioxide from the oceans through photosynthesis (Duarte et al. 2017). There are doubts on the extent to which kelp can act as a long term carbon sink, as it eventually decomposes and the carbon may thereby re-enter the atmosphere (Duarte et al. 2017). However, kelp might be used as a biomass to replace fossil fuels in energy production and therefore contribute to the production of BECCS (Chung et al. 2013; Duarte et al. 2017).

(3) Ocean up-welling and/or down-welling

Ocean upwelling proposals involve using large-scale vertical pipes in the oceans to bring nutrient-rich water from the deep ocean to the surface (The Royal Society 2009). This method is an alternative to ocean fertilization. Instead of adding nutrients to stimulate phytoplankton growth, nutrients would instead be transferred from the deep ocean (Lovelock and Rapley 2007). Similar pipes could also be used to enhance the down-welling of carbon-rich cold water for storage in the deep ocean (Zhou and Flynn 2005; The Royal Society 2009).

(4) Ocean alkalisation for coral reef recovery/restoration

Increased concentration of greenhouse gases in the atmosphere makes the oceans more acidic (IGBP, IOC, SCOR 2013). Ocean acidification reduces coral reef growth and the associated carbon sequestration provided by coral reefs. This geoengineering proposal therefore attempts to offset reductions in coral reef growth by mixing alkaline substances (such as calcium carbonate) into seawater (Feng et al. 2016). Whilst there are practical concerns about the ability of this approach to protect whole reefs, it might be useable at a smaller scale.

(5) Marine cloud brightening

Clouds reflect a percentage of incoming solar radiation (sunlight) into space, preventing it from warming the earth's surface. Low clouds over dark ocean surfaces are especially effective at influencing the earth's reflectivity or 'albedo' (NRC SRM Report 2015b). Marine cloud brightening proposes to increase the longevity and whiteness of ocean clouds (Latham et al. 2012). This technique would involve 'seeding' existing marine ocean clouds with microscopic sea water particles, increasing the amount of droplets within the cloud to enhance the amount of incoming sunlight it reflects (Jones and Haywood 2012; Latham et al. 2012).

(6) Microbubbles to enhance ocean albedo

Microbubbles dispersed in water have similar reflective properties to water droplets found in in clouds (Seitz 2011). A further proposal to enhance the earth's albedo is to create microbubbles to brighten the surface of the ocean. Microbubbles could be generated at strategic locations to have a localised cooling effect (i.e. the tropics) and could also be generated from ships to enhance the brightness of their wakes that can be kilometres long (Seitz 2011).

4. Marine geoengineering: key issues for the international law system

Proposals to develop geoengineering technologies pose significant challenges for the international law system. The concept of geoengineering automatically gives rise to consideration of international law as geoengineering technologies are broadly intended to manipulate the atmosphere and/or global climate system (The Royal Society 2009). As a class of geoengineering activities, CDR proposals are generally perceived to involve less perturbation in the Earth's system compared to SRM proposals, such as use of stratospheric aerosols (NRC CDR Report 2015a). However, proposals to use the oceans as a site for geoengineering raises questions about their impact on the marine environment. As discussed above, risk of harm to the marine environment and human health from placing large amounts of iron particles into the oceans was a key driver behind the 2013 amendments to the *London Protocol*. Enhanced weathering and other marine geoengineering proposals that involve placing large quantities of minerals or other matter into the oceans raise similar concerns (NRC CDR Report 2015a). A key challenge for the international law system is therefore how to govern risks of harm to the marine environment from marine geoengineering, and how to respond to such harm should it eventuate. This may include developing rules and institutions to provide mechanisms for environmental

impact and risk assessment, systems for monitoring results of geoengineering, mechanisms for civil society consultation and/or participation, plus rules for responsibility/liability for transboundary harm to the territory of other states and harm to the oceans as a global commons.

A further challenge is to understand how existing rules of international law might apply to different marine geoengineering proposals. As stated above, the 2013 amendments to the *London Protocol* establish a framework that could be used to govern marine geoengineering proposals (including scientific research) in addition to ocean fertilization. However, in addition, there are a number of other regimes for ocean governance that may be relevant to marine geoengineering proposals. These regimes include the 1982 *United Nations Convention on the Law of the Sea*,[18] 1995 *United Nations Fish Stocks Agreement*,[19] 1980 *Convention on the Conservation of Antarctic Marine Living Resources,* [20] 1972 *Convention Concerning the Protection of World Culture and Natural Heritage*,[21] and the 2015 *Paris Agreement*. In addition to international agreements, rules of customary international law are also likely to be relevant, including the obligation on states to prevent significant transboundary harm and harm to the global commons, as well as the precautionary principle/approach. Finally, it is also important to understand the interplay between these existing rules and regimes in the context of marine geoengineering. That is, how they might overlap and interact to form an existing governance structure for marine geoengineering.

The initial governance efforts to respond to ocean fertilization in the ocean dumping regime and biological diversity regime largely followed a preventative and/or precautionary approach. As noted above, governance efforts within these regimes have primarily been directed at minimising the risk of harm to the marine environment and biodiversity. We do not question the need to address the risks of environmental harm from ocean fertilization and other marine geoengineering proposals. However, protecting the marine environment from harm might no longer be appropriate as the primary goal of marine geoengineering governance. The targets set under the 2015 *Paris Agreement* (and the IPCC emission pathways informing these targets) present a new challenge for international law and geoengineering governance. As stated above, the *Paris Agreement* implicitly relies on large-scale negative emissions in the second half of this century in order to limit global temperature rise to 2 degrees Celsius. The international governance of geoengineering technologies therefore now needs to develop in such a way as to support and eventually realise the assumptions built into the *Paris Agreement*. It is no longer enough for international law and governance to be driven by the risks of developing negative emissions technologies. Consideration must also be given to the risks of *not* developing negative emissions technologies (Larkin et al. 2017). In the case of marine geoengineering governance, it may be necessary to revise the preventative/precautionary approach that has developed around ocean fertilization and consider whether this approach complements expectations about the development of negative emissions technologies in the *Paris Agreement*. In the context of BECCS, Peters and Geden (2017) suggest that a more facilitative approach to governance and policy may be necessary, including the development of carbon accounting systems and incentivizing the research and development of BECCS. This raises the question as to whether a similar approach may be appropriate in the context of marine geoengineering.

5. Conclusion

International climate change policy has already moved into a period in which assumptions about negative emissions are playing a significant role in modelling for future temperature stabilisation pathways. If these assumptions are to be realised, research into the science, governance, social acceptability and ethics of terrestrial and marine-based CDR will need to be accelerated by the research community. Presently, there are many formative ideas for marine geoengineering, which have not progressed beyond the journal article or laboratory stage. This lack of progress is in part unsurprising, given the initial highly precautionary approach to the governance of marine geoengineering put in place by the ocean dumping and biodiversity regimes. This precautionary approach is also understandable, given the heavy emphasis upon mitigation of greenhouse gases within the *UNFCCC* process in the lead up to the 2009 Copenhagen COP15 meeting. However, the reality now facing the global climate regime is that regardless of the ambition of emission reductions, there will need to be very significant negative emissions later this century to get close to the 1.5°C–2.0°C temperature stabilisation goals of the *Paris Agreement*. The threats posed by temperature increases of 3°C or more in this century and beyond may also necessitate contemplation of the use of SRM approaches that could buy us time on the path to decarbonization and help us avoid exceeding critical climatic thresholds.

This new reality for international climate change policy calls for an urgent rethinking of the current international governance regimes for both terrestrial and marine based geoengineering. For marine geoengineering, the 2013 LP.4(8) amendments of the *London Protocol* provide an existing template that might guide initial efforts to govern marine geoengineering proposals other than ocean fertilization, especially scientific research. However, governance frameworks for marine geoengineering research and deployment will be of limited use unless accompanied by parallel societal agreement around the social acceptability and ethical desirability of marine geoengineering. Any future research into marine geoengineering will therefore need to be carried out thorough a genuinely interdisciplinary program of scientists, lawyers, social scientists and ethicists. This interdisciplinary research program will offer the best prospects of properly informing societal deliberation into research of marine geoengineering and the democratic legitimacy of any wider application of these techniques.

Notes

1. *Paris Agreement*, opened for signature 12 December 2016 (entered into force 4 November 2016) art 2(1)(a).
2. IPCC (2017).
3. Prominent examples include: the IronEx-I experiment conducted near the Galapagos Islands in 1993(Coale et al. 1998); the 1999 'Southern Ocean Iron Release Experiment' (SOIREE) conducted in the Australasian-Pacific sector of the Southern Ocean (http://www.bco-dmo.org/project/2051); and the 'Subarctic Ecosystem Response to Iron Enrichment Study' (SERIES) conducted in the Gulf of Alaska in 2002 (Boyd et al. 2004).
4. *Convention on Biological Diversity*, opened for signature 5 June 1992, 1760 UNTS 79 (entered into force 29 December 1993)
5. *Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter*, opened for signature 29 December 1972, 1046 UNTS 138 (entered into force 30 August 1975) ('*London Convention*'); *1996 Protocol to the 1972 Convention on the Prevention of*

Marine Pollution by Dumping of Wastes and Other Matter, opened for signature 7 November 1996, [2006] ATS 11 (entered into force 24 March 2006) ('*London Protocol*').

6. World Conservation Union (IUCN) 'Regulation of CO_2 sequestration' Scientific Group of the London Convention, 30th mtg, Agenda Item 12, LC/SG 30/12 (8 May 2007); United States, 'Planktos, Inc., Large-scale Ocean Iron Addition Projects' Scientific Group of the London Convention, 30th mtg, Agenda Item 12, LC/SG 30/INF.28 (1 June 2007).
7. Greenpeace International, 'Challenging "geo-engineering solutions" to climate change: The urgent need for detailed scientific scrutiny and international regulations to protect the oceans from large-scale iron fertilization programs', Scientific Group of the London Convention, 30th mtg, Agenda Item 12, LC/SG 30/12/1 (8 May 2017) and World Conservation Union (IUCN) 'Regulation of CO_2 sequestration' Scientific Group of the London Convention, 30th mtg, Agenda Item 12, LC/SG 30/12 (8 May 2007).
8. *Statement of concern regarding iron fertilization of the oceans to sequester CO_2*, LC-LP.1/Circ.14 (13 July 2007).
9. *Decision adopted by the Conference of the Parties to the Convention on Biological Diversity at its Ninth Meeting: IX/16. Biodiversity and climate change*, 9th mtg, Agenda Item 4.5, UNEP/CBD/COP/DEC/IX/16 (9 October 2008) Section C.
10. *Resolution LC-LP.1 (2008) on the Regulation of Ocean Fertilization (adopted 31 October 2008)*, Report of the Thirtieth Meeting of the Contracting Parties to the London Convention and the Third Meeting of the Contracting Parties to the London Protocol, 30th and 3rd mtgs, Agenda Item 16, Annex 6, LC 30/16 (9 December 2008).
11. *Assessment Framework for Scientific Research Involving Ocean Fertilization (adopted 14 October 2010)*, Report of the Thirty-Second Consultative Meeting and the Fifth Meeting of Contracting Parties, 32nd and 5th mtgs, Agenda Item 15, Annex 6, LC 32/15 (9 November 2010).
12. See, eg, Australia and New Zealand, 'Examination of each of the legally binding options (options 4 to 8 developed in 2009) according to the criteria in the terms of reference, and of any additional options or criteria received under item 2 & further development of any of the legally binding options, as necessary: Regulating Ocean Fertilization Experiments under the London Protocol and Convention', LP CO2 3/3/1 (8 February 2010); Canada, 'Discussion of an Additional Option to Achieve the Regulation of Legitimate Scientific Research Involving Ocean Fertilization under the London Protocol', LC 32/4/1 (3 August 2010).
13. Australia and New Zealand, 'Regulating Ocean Fertilization Experiments under the London Protocol and Convention', LC 31/4/1 (4 September 2009).
14. *Decision Adopted by the Conference of the Parties to the Convention on Biological Diversity at its Tenth Meeting: X/33. Biodiversity and climate change*, 10th mtg, Agenda Item 5.6, UNEP/CBD/COP/DEC/X/33 (29 October 2010) paragraph 8(w).
15. *Resolution LP.4(8) on the Amendment to the London Protocol to Regulate the Placement of Matter for Ocean Fertilization and Other Marine Geoengineering Activities (adopted on 18 October 2013)*, Report of the Thirty-Fifth Consultative Meeting and the Eight Meeting of Contracting Parties, 35th and 8th mtgs, Agenda Item 15, Annex 4, LC 35/15 (21 October 2013).
16. *Resolution LP.4(8)* Art 6*bis*(1); Annex 4 (1.2)–(1.3).
17. *London Protocol*, art 21(3).
18. *United Nations Convention on the Law of the Sea*, opened for signature 10 December 1982, 1833 UNTS 3 (entered into force 16 November 1994)
19. *Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks*, opened for signature 4 August 1995, 2167 UNTS 3 (entered into force 11 December 2001).
20. *Convention on the Conservation of Antarctic Marine Living Resources*, opened for signature 20 May 1980, [1982] ATS 9 (entered into force 7 April 1982).
21. *Convention Concerning the Protection of the World Cultural and Natural Heritage*, opened for signature 23 November 1972, 1037 UNTS 151 (entered into force 15 December 1975).

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