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INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
(of UNESCO)

INFORMATION DOCUMENT

REPORT ON THE IMO LONDON CONVENTION SCIENTIFIC GROUP MEETING ON OCEAN FERTILIZATION

Summary. The IOC was invited to participate in discussions on ocean fertilization addressed by the 31st Session of the International Maritime Organization London Convention Scientific Group and the 2nd Session of the London Protocol Scientific Group, held from 19-23 May in Guayaquil, Ecuador. From its Terms of Reference adopted by the IOC Assembly in 2005, the International Ocean Carbon Coordination Project (IOCCP) has a mandate to provide ready expertise to the IOC on issues of ocean carbon sequestration. Under the authority of the IOC Executive Secretary, an informal Consultative Group of Experts was developed to respond to this request, consisting of the Chair of the IOCCP and four scientists currently active in ocean fertilization research. This group submitted input in response to a series of scientific and technical questions posed by the London Convention Scientific Group, and the chair of the group attended the meeting as an observer.

This report was prepared by the IOC Secretariat and presented to its Executive Council at its 41st Session (Paris, 24 June–1st July 2008).

I. Background

Ocean iron fertilization is a method proposed to sequester atmospheric CO_2 in the deep ocean by artificially stimulating growth and export flux of phytoplankton in the surface ocean through the addition of iron, an important micro-nutrient. Between 1993 and 2007, 12 iron enrichment experiments were carried out to examine phytoplankton response, changes in CO_2 and export flux, and impacts on local nutrient concentrations. Results showed that, while addition of iron did stimulate phytoplankton growth, this did not necessarily result in increased long-term storage of carbon. Further, changes in nutrients, oxygen concentrations, and production of other greenhouse gases resulting from this process led scientists to conclude that (a) this was a method with a limited capability to sequester carbon, (b) that it would be difficult if not impossible to verify the amount of carbon sequestered by this method, and (c) that large-scale implementation of this process may have negative consequences for chemistry and ecosystems, both in the locally fertilized area as well as zones beyond the intended target area.

II. International and Intergovernmental Statements

In 2005, the IPCC developed a special report on carbon capture and storage, which included a chapter on the use of the oceans for sequestering carbon. Owing to the speculative nature of iron fertilization as a method for sequestering carbon and the many environmental side effects that have not been adequately addressed, the IPCC agreed that it was premature to review ocean iron fertilization as a potential sequestration method. In 2007, the International Maritime Organization's Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other matter (1972) and its 1996 Protocol (e.g., "the London Convention") developed a Statement of Concern about ocean iron fertilization, and the Convention urged Contracting Parties to take into account these concerns when considering experimental or large-scale ocean iron fertilization to sequester CO_2. In 2008, the Scientific Committee on Oceanic Research (SCOR) and the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) published a joint position statement on Deliberate Nutrient Additions to the Ocean, in which they state that carbon credits for fertilization should not be allowed unless and until reliable methods have been developed to estimate and verify the amount of carbon actually sequestered, and side effects have been properly understood and taken into account. Also in 2008, the Global Carbon Project published a report on Carbon Reductions and Offsets in which they discuss ocean fertilization as a potential for sequestration. This report concluded that the likely large and unintended negative changes it produces in marine biodiversity and trophic interactions make this option ecologically and socially unacceptable, and the practice is not recommended by the Global Carbon Project.

On May 30, 2008, the 9th Conference of the Parties to the Convention on Biological Diversity adopted a decision on Ocean Fertilization as part of a larger decision on Biodiversity and Climate Change (UNEP/CBD/COP/9/L.36, Section C, Ocean Fertilization). Recognizing the on-going scientific and legal analysis occurring under the London Convention and Protocol, the Conference of the Parties requests Parties and urges other Governments to ensure that ocean fertilization activities do not take place until there is an adequate scientific basis on which to justify such activities, including assessing associated risks, and a global, transparent and effective control and regulatory mechanism is in place for these activities. (See Section IV.3 of this document for more information.)

III. Scientific and Legal Review by the London Convention

Despite the numerous international and intergovernmental scientific reviews on ocean fertilization that object to its use as a means of sequestering carbon, pressure from commercial groups has re-opened this issue. Commercial groups are proposing to fertilize the open ocean using proprietary techniques, to quantify the amount of carbon sequestered through this process, and to sell carbon offsets on the voluntary carbon market. These groups argue that research should be pursued to determine the efficiency and nature of the environmental impacts of large-scale fertilization ventures, investigating not only iron but also other nutrients such as nitrogen, or

pumping the ocean's naturally occurring nutrients from the deep to the surface waters. The London Convention has developed a Legal Intersessional Correspondence Group and a Scientific Working Group to examine the scientific and regulatory aspects of large-scale open-ocean fertilization experiments.

The IOC was invited to participate in discussions on ocean fertilization to be addressed by the 31st Session of the IMO London Convention Scientific Group and the 2nd Session of the London Protocol Scientific Group, held from 19 to 23 May 2008 in Guayaquil, Ecuador. From its Terms of Reference adopted by the IOC Assembly in 2005 (IOC-XXIII, Annex VI), the International Ocean Carbon Coordination Project (IOCCP) has a mandate to provide ready expertise to the IOC on issues of ocean carbon sequestration. Under the authority of the IOC Executive Secretary, an informal Consultative Group of Experts was developed to respond to this request, consisting of the Chair of the IOCCP and four scientists currently active in ocean fertilization research and modelling. This group developed a consensus statement in response to a series of scientific and technical questions posed by the London Convention Scientific Group, and the chair of the Consultative Group attended the London Convention Scientific Group meeting as an observer. The members of the ad hoc Consultative Group served in their personal capacity as experts, and the input provided to the IMO does not represent an official statement of the IOC.

IV. Statement of the UNESCO-IOC ad hoc Consultative Group on Ocean Fertilization[1]

1. General Comments

(i) The UNESCO-IOC ad hoc Consultative Group on Ocean Fertilization believes it is important to open a more complete and inclusive discussion about how ocean fertilization activities might be regulated under the London Convention. Here, we offer only a few broad initial comments.

(ii) Our goal is to safeguard the ocean against damaging ocean fertilization activities without impeding benign fertilization activities; however the scientific community must work to clearly determine what changes are damaging and which are benign.

(iii) We do not yet have the level of understanding of the marine environment needed to develop a set of specific regulations that would safeguard the ocean environment from fertilization-type activities.

(iv) The size of the activity is not the only factor to consider. An ocean fertilization activity might be damaging even if conducted over one square kilometre (for example, over a coral reef) just as another ocean fertilization activity might be benign even though conducted over many thousands of square kilometres.

(v) We should promote better scientific understanding of the ocean. Manipulative experiments, including ocean fertilization, are important tools that scientists use to develop a better understanding of the marine environment. Such scientific research should be promoted with a minimum of additional bureaucratic burden. For example, the scientists conducting the experiment should be free to decide which parameters (beyond those required to assure the detection of any significant environmental damage that might reasonably be anticipated to occur) need to be measured to address the questions motivating the experiment.

(vi) The UNESCO-IOC ad hoc Consultative Group on Ocean Fertilization is a group of scientists. We are not expert in international law or policy. Notwithstanding the lack of

[1] Ken Caldeira (Chair), Carnegie Institute of Washington, Stanford, USA; Philip Boyd, National Institute of Water and Atmospheric Research, New Zealand; Ulf Reibesell, Leibniz Institute of Marine Sciences, Germany; Christopher Sabine, National Oceanic and Atmospheric Administration, USA; Andrew Watson, University of East Anglia, UK.

specific expertise, members of the ad hoc committee offered two suggestions to help safeguard the ocean against damaging ocean fertilization activities while minimizing burden on benign fertilization activities:

(a) Under one suggestion, an independent but knowledgeable committee composed of scientists as well as representatives of policy, legal, and industry would assess each proposed fertilization activity on the basis of the risk it poses to the environment. The committee would allow activities to proceed which were assessed to fall below a clearly defined threshold of environmental damage.

(b) Under another suggestion, legitimate scientific experiments (those with defensible scientific goals and public disclosure of methods and results) would proceed but ocean fertilization activities designed to generate saleable carbon credits or other monetary gain would be delayed until appropriate environmental safeguards can be developed and enacted.

2. Response of the UNESCO-IOC ad hoc Consultative Group on Ocean Fertilization to specific questions raised by the London Convention and Protocol Scientific Group

(i) Existing Scientific Literature generated by, or available at, your organization on the topic:

- The Ocean in a High CO_2 World (2005). Proceedings from the International Symposium; Special Issue of the Journal of Geophysical Research-Oceans, v. 110, 2005.
- The Ocean in a High CO_2 World Meeting Report, Oceanography Magazine, Vol. 17, No. 3, Sept. 2004 (http://www.tos.org/oceanography/issues/issue_archive/issue_pdfs/17_3/17.3_scor_ioc.pdf)
- The Ocean in a High CO_2 World, EOS, American Geophysical Union, Vol. 85, No. 37, September 2004, p351-353.
- The Ocean in a High CO_2 World Research Priorities Report (http://iodeweb3.vliz.be/oanet/Symposium2004/Symp2004Docs/Research%20Priorities%20Report-Final.pdf)
- M. Hood and S. Schneegans, A carbon sink that can no longer cope?, A World of Science, Vol. 2, No. 4, Oct-Dec 2004, p 2-5. (http://unesdoc.unesco.org/images/0013/001372/137292e.pdf)
- The Ocean Acidification Network (www.ocean-acidification.net), which includes frequently-asked-questions, document lists, and powerpoint presentations on ocean carbon sequestration science.

(ii) Specific Submission to the Scientific Groups

A. What constitutes "large scale" in the ocean?

"Large scale" is a relative term. However, in this case we can relate the experiments to ocean physics scales where large scale motions are those significantly affected by apparent Coriolis forces, typically with length scales of tens of kilometres.

There is no well-established meaning to "large scale" that would allow it to usefully distinguish between activities that would and activities that would not damage the ocean environment (see item 4 above).

B. A clear justification of the need for experiments at scales of order 200 km by 200 km

Ocean waters are continuously stirred, with currents at different depths moving at different speeds and in different directions. Both the fertilized patch and any sinking carbon will be transported along with the currents. In the small-scale experiments (tens of kilometres) so far performed, the results are strongly influenced by dilution of unfertilized water into the patch, such that it is difficult to extrapolate the results to larger scales, or to longer times. In particular, estimates of amounts of carbon sequestered to depth from extrapolations of these experiments are very uncertain.

The effects on the fertilized patch of stirring and mixing with water that has not received the fertilization treatment becomes less important near the centre of the patch as patch size increases. This would provide incentive to develop experiments at scales of order 200 km by 200 km, this scale being larger than that of typical ocean eddies. For the same reason, it may be easier to assess the influence of surface manipulations on the sinking fluxes of particles when the experiments are at this scale.

Experiments designed to study the impact of ocean fertilization on the lifecycles of megafauna, such as fish, may require spatial scales of order 200 km by 200 km.

C. An assessment of the impacts on oceans of experiments at such scales

It is impossible to assess the impacts of experiments through information on spatial scale alone. A host of factors, including rates, amounts, concentration, duration and composition of chemical addition, location, time of year, and so on, could all jointly be determinative of ocean impacts.

3. ADDENDUM to the original submission to the London Convention Scientific Groups : Response of the UNESCO-IOC ad hoc Consultative Group on Ocean Fertilization to the Conference of the Parties of the Convention on Biological Diversity

The UNESCO Intergovernmental Oceanographic Commission (IOC) *ad hoc* Consultative Group on Ocean Fertilization is concerned that the statement on ocean fertilization activities issued by the Conference of the Parties to the Convention on Biodiversity in Bonn on 30 May 2008 places unnecessary and undue restriction on legitimate scientific activities.

The statement reads, in part, "*[The Conference of the Parties of the Convention on Biodiversity (COP of the CBD)] ... urges other Governments, in accordance with the precautionary approach, to ensure that ocean fertilization activities do not take place until there is an adequate scientific basis on which to justify such activities, including assessing associated risks, and a global transparent and effective control and regulatory mechanism is in place for these activities; with the exception of small scale research studies within coastal waters.*"

The UNESCO-IOC *ad hoc* Consultative Group on Ocean Fertilization notes that:

(1) The COP of the CBD recognizes "the ongoing scientific and legal analysis [of ocean fertilization] occurring under the auspices of the London Convention (1972) and the 1996 London Protocol."

(2) The CBD proposes 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.” The restriction of experiments to coastal waters appears to be a new, arbitrary, and counterproductive limitation. The most useful ocean fertilization experiments to date have been performed in open ocean environments, as this is where marine productivity is most commonly limited by

micronutrients. There is no scientific basis for limiting such experiments to coastal environments.

(3) There are good scientific reasons to do larger experiments, including diminishing dilution near the center of the experimental area and obtaining better data relating to vertical transport processes. "Small scale" is a relative term. A circle 200 km in diameter would cover less than one ten-thousandth of the ocean.

(4) We are concerned about the phrase in the CBD statement "global transparent and effective control and regulatory mechanism … for these activities". We assume that “these activities” refers to ocean fertilization activities for the purpose of introducing additional carbon dioxide into the ocean, as distinct from purposes such as legitimate scientific investigation. It would be helpful if this phrase were clarified to make this important distinction evident.

(5) Preservation of biodiversity in marine systems may require good scientific information from manipulative experiments in the open ocean. A careful science-based "assessment of associated risks" depends on knowledge that could be gained by further experimentation.

(6) It is essential for sound and unbiased scientific advice to be available to intergovernmental deliberations on the issue of ocean fertilization both to protect the marine environment and to ensure that marine scientific research is not unnecessarily hindered. The IOC should continue to provide scientific advice to the London Convention Scientific Group, as well as other international or intergovernmental deliberations, as requested.

V. Results from the London Convention Scientific Group Meeting

The 31st session of the London Convention Scientific Group and the 2nd session of the London Protocol Scientific Group met in Guayaquil, Ecuador from 19-23 May 2008. Both groups, at the request of their parent bodies, addressed a range of issues to better understand the implications for the protection of the marine environment of ocean fertilization proposals intended for climate change mitigation purposes, and to provide the scientific/technical basis for evaluating such activities. The IOC ad hoc Consultative Group on Ocean Fertilization provided scientific and technical input to these discussions and was represented at the meeting by the Chair of the Group, who attended as an observer (see Sections III and IV, above).

The Convention and Protocol Working Group on Ocean Fertilization reviewed input from the IOC and other international organizations with specific expertise in ocean fertilization issues and discussed how current scientific understanding of the consequences of ocean fertilization for the marine environment could be integrated into advice requested by the Legal Intersessional Correspondence Group, specifically highlighting if and how ocean fertilization may be contrary to the aims of the Convention / Protocol.

In its report (LC/SG 31/WP.3), the Working Group on Ocean Fertilization provided some general statements and recommendations on ocean fertilization activities. The Working Group took the view that if ocean fertilization activities are likely to result in harmful effects to living resources and marine ecosystems, the activity may be regarded as contrary to the aims of the Convention (para 4.2). An evaluation of whether an ocean fertilization activity is contrary to the aims of the convention should be based, *inter alia*, on the evaluation guidelines described in Annex 3 (para 4.3). (Note: Annex 3 is reproduced in Section VIII at the end of this document, INF-1247). Based on the studies conducted thus far, there is insufficient evidence to determine whether such activities would pose significant risks of harm to the marine environment. However, based on scientific projections, there is the potential for significant risks of harm, and there is still uncertainty regarding direct and indirect effects (para 4.4). Given the current scientific uncertainty and lack of data, a precautionary approach should be applied when evaluating proposal for ocean fertilization

activities (para 4.5). The Working Group established three recommendations for the Scientific and Legal Groups: (1) The Working Group requests advise from the Legal Intersessional Correspondence Group regarding the appropriateness to the phrase “contrary to the aims of the Convention / Protocol”; (2) The Working Group requests that the London Convention and Protocol consolidate new information on scientific research on ocean fertilization as it becomes available and make it available for use in assessing proposals; and (3) The Working Group recommends that Annex 3 be used as the list of considerations for evaluating ocean fertilization activities.

The Scientific and Legal Groups will review this report and summarize the scientific and legal views in a document for consideration by the next joint session of the governing bodies (27–31 October 2008) to determine what further action should be taken towards regulation of the issue of ocean fertilization under the London Convention and Protocol.

VI. IOC Mandate and Activities for Ocean Carbon Sequestration Issues

The IOC Assembly at its 21st Session (Paris, 3–13 July 2001), noted that the issue of ocean CO_2 sequestration was important for the IOC, and it cautioned about the implications of direct involvement of the IOC in matters that might be counter to the London Convention without further discussion among the Member States. The Assembly agreed that the IOC should continue monitoring developments in ocean CO_2 sequestration and to maintain a watching brief for the Member States on the environmental and scientific implications.

1. The IOC-SCOR Watching Brief on Ocean Carbon Sequestration

Through the IOC-SCOR Ocean CO_2 Advisory Panel (now the International Ocean Carbon Coordination Project, the IOCCP), the IOC developed the first Watching Brief on ocean carbon sequestration in 2001 and made it available on the IOC web-site and the CO_2 Panel site. In 2007, following the publication of the IPCC Special Report on Carbon Dioxide Capture and Storage, the Watching Brief was updated to include the ocean-relevant sections of that report. This report is now available on the IOCCP web-site, with links to the IPCC Special Report, available in Arabic, Chinese, English, French, Russian, and Spanish.

2. The Ocean in a High CO_2 World Symposium

In 2004, the IOC and SCOR developed the Ocean in a High CO_2 World symposium, which was the first international symposium to address the issue of ocean acidification. This symposium also addressed ocean carbon sequestration issues, where many of the environmental impacts are similar to impacts from ocean acidification. This symposium brought together over 120 scientists from physics, chemistry, and biology to assess what is known about the biological and biogeochemical consequences of increasing atmospheric and oceanic CO_2 levels as well as the possible benefits and impacts of proposed ocean sequestration strategies. Symposium participants did not address whether it would be a good policy choice to sequester carbon dioxide in the ocean, but did identify what scientific information is available, and what is still needed, to make informed policy decisions. This information was used by the IPCC Special Report on Carbon Dioxide Capture and Storage.

Following this symposium, several national and global research programs produced special reports on the issue of ocean acidification, and requested the IOC to keep this issue under review at the highest levels. The IOC Assembly at its 23rd Session (Paris, 21-30 June 2005) agreed that the IOCCP should make this symposium a regular event, and the IOC agreed to hold this symposium every 4 years in order to catalyze new peer-reviewed research on ocean acidification and ocean carbon sequestration for the IPCC assessment report, and to produce regular research priority reports for national and global research efforts. The next symposium will be held this October, under the patronage of His Serene Highness Albert II, Sovereign Prince of Monaco. The symposium will also be co-sponsored by SCOR, the International Atomic Energy Agency’s Marine Environmental Laboratory, and the International Geosphere-Biosphere Programme.

3. The Ocean Acidification Network

In partnership with the Scientific Committee on Oceanic Research (SCOR), the International Geosphere-Biosphere Programme (IGBP), and the Marine Environmental Laboratory of the International Atomic Energy Agency (MEL-IAEA), IOC has developed the Ocean Acidification Network, an information network for the international scientific community. This web-based resource serves as a directory and clearinghouse for ocean acidification and ocean carbon sequestration information from all sponsoring agencies as well as other groups. The site includes news and resources for the scientific community as well as "frequently asked questions" sections for the general public, including information on ocean carbon sequestration. All of IOC's information on sequestration and fertilization are available through this portal. (www.ocean-acidification.net)

4. The IOC ad hoc Consultative Group on Ocean Fertilization

This ad hoc group of experts, described in sections III and IV above, provides scientific and technical advice to the IOC on issues of ocean fertilization for the purposes of sequestering atmospheric CO_2.

5. The GEOHAB Scientific Steering Committee Advisory Bulletin on Urea Fertilization

In 2008, the Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB) network published a 57-author view point paper in the Marine Pollution Bulletin to provide scientific advice and warning in response to plans of a private cooperation to add thousands of tons of urea to the Sulu Sea, Philippines, in order to stimulate algal blooms and sequester carbon for commercial purposes (Gilbert et al., 2008. Ocean urea fertilization for carbon credits poses high ecological risks. Marine Pollution Bulletin, doi :10.1016/j.marpolbul.2008.03.010). The local scientists and scientists in the region working with GEOHAB conveyed their concerns to the Philippine authorities, who rejected the proposal of the private company to carry out the fertilization activity. The private company is currently seeking alternative areas in the region for their activities, and the GEOHAB Scientific Steering Committee has developed an Advisory Bulletin about urea fertilization to provide sound scientific and technical advice to decision-makers:

> *"GEOHAB, in agreement with the position of SCOR, GESAMP, and the IOC ad hoc Consultative Group on Ocean Fertilization on the deliberate nutrient additions to the oceans, expresses its concern about plans to fertilize the ocean with urea for both carbon trading and enhanced fish production. Such proposals raise important questions about the fate of massive quantities of nitrogen added to the ocean. The potential for the development of harmful algal blooms, as well as hypoxia, is great, and the negative impacts may last long after urea additions have been halted. GEOHAB not only urges caution, but strongly suggests that such efforts not be conducted."*

VII. Summary

The IOC provides scientific and technical guidance to national and global research organizations as well as to intergovernmental organizations, operating within the mandate provided by the 21st Assembly. This information contributes to the development of international and intergovernmental assessments, coordinated research strategies, and to decision-making. The IOC stands ready to provide further scientific and technical guidance within its area of competence to the London Convention and Protocol as they continue their deliberations on the issue of ocean fertilization.

VIII. Annex 3 of the Report of the IMO London Convention and Protocol Working Group on Ocean Fertilization (LC/SG 31/WP.3): Considerations for Evaluating Ocean Fertilisation Proposals (Version 22 May 2008)

1) Description of Project
   a) What will be added?
      i) Chemical composition of all substances (e.g. solvents, carrier, tracer)
      ii) Purity
      iii) Impurities (list & amounts)
   b) How will it be added?
      i) Form (e.g. solid, particle size, liquid solution (concentration))
      ii) Mode of application
      iii) Area and depth of addition
      iv) Rate of application (amount per metre squared per time)
   c) How much will be added? (e.g. total amount, volume)
   d) When will it be added?
      i) Date(s)
   e) Where will it be added? (site characterization)
      i) Physical characterization, for example:
         (1) Location of addition
         (2) Depth of water
         (3) Temperature
         (4) Circulation
      ii) Chemical characterization, for example:
         (1) pH
         (2) dissolved oxygen
         (3) nutrient concentrations
      iii) Biological characterization, for example:
         (1) Species expected in water column
         (2) Species expected on bottom
         (3) Predicted spread of advection and diffusion of additives and chla (response)
      iv) Proximity to “marine protected/reserve area” and/or “areas of special concern” including other sensitivities (e.g. fisheries, spawning grounds, ecologically sensitive areas).
   f) Purpose

2) Impacts
   a) The Proponent should address the following potential impacts to the marine environment:
      i) Direct effects of added substances (including pH)
      ii) Species of phytoplankton and their diversity
         (1) With consideration of species that might be harmful to the environment
      iii) Species microzooplankton and their diversity
      iv) Species of zooplankton and their diversity
      v) As or where appropriate: other marine organisms including mesopelagic, benthic organisms, fish, marine mammals, other invertebrates and vertebrates, spawning areas
      vi) Biogeochemical transformations and substances that may be produced or consumed as a result of the substance added, for example:
         (1) Gases produced and consumed
         (2) particulate carbon produced
         (3) Any change in pH
         (4) Toxins produced
      vii) Bacterial diversity and biomass

3) Contributions to Scientific Knowledge

4) Monitoring of substance addition

a) Must be appropriate to the scale of experiment
b) Data must be made publicly available as soon as possible.
c) Impact Hypotheses should form the basis of the monitoring.

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