INTERNATIONAL MARITIME ORGANIZATION

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FIRST MEETING OF THE
INTERSESSIONAL TECHNICAL
WORKING GROUP ON OCEAN
FERTILIZATION
9 – 13 February 2009
Agenda item 5

LC/SG-CO2 3/WP.1
12 February 2009
Original: ENGLISH

CONSIDERATION AND ADOPTION OF THE REPORT

Draft report of the 1st Meeting of the Intersessional Technical Working Group on Ocean Fertilization

1 INTRODUCTION

1.1 The 1st Meeting of the Intersessional Technical Working Group on Ocean Fertilization was convened at IMO Headquarters, London, from 9 to 13 February 2009 under the Chairmanship of Dr. Chris Vivian (United Kingdom).

1.2 Delegations from the following 19 Contracting Parties to the London Convention 1972 attended the Meeting:

ARGENTINA
AUSTRALIA
BRAZIL
CANADA
CHINA
DENMARK
FRANCE
GERMANY
IRELAND
ITALY
JAPAN
MEXICO
NEW ZEALAND
NORWAY
PERU
SOUTH AFRICA
UNITED KINGDOM
UNITED STATES]

1.3 Delegations from the following 15 Contracting Parties to the 1996 Protocol to the London Convention 1972 also attended the Meeting:

[AUSTRALIA
CANADA
CHINA
DENMARK
FRANCE
GERMANY
IRELAND
ITALY
JAPAN
MEXICO
NEW ZEALAND
NORWAY
SAUDI ARABIA
SOUTH AFRICA
UNITED KINGDOM]

1.4 An observer from the following State that is neither a Contracting Party to the London Convention 1972, nor to the 1996 Protocol also attended:

SYRIAN ARAB REPUBLIC

1.5 Representatives from the following United Nations organizations attended the meeting:

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION – INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (UNESCO-IOC)
UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP) – SECRETARIAT OF THE CONVENTION ON BIOLOGICAL DIVERSITY

1.6 Observers from the following intergovernmental organization attended the meeting:

NORTH PACIFIC MARINE SCIENCE ORGANIZATION (PICES)

1.7 Observers from the following three international non-governmental organizations also attended the meeting:

GREENPEACE INTERNATIONAL
ADVISORY COMMITTEE ON PROTECTION OF THE SEA (ACOPS
INTERNATIONAL EMISSIONS TRADING ASSOCIATION (IETA)

Opening of the Meeting

1.8 In opening the proceedings, the Chairman welcomed all participants to the 1st meeting of the Intersessional Technical Working Group on Ocean Fertilization.

TERMS OF REFERENCE

1.9 The governing bodies, convened in October 2008, adopted a non-binding resolution LC - LP.1(2008) on the regulation of ocean fertilization and identified, *inter alia*, the need for preparatory work in the intersessional period on technical/scientific issues related to ocean fertilization (LC 30/16, paragraph 4.15). Consequently, the Intersessional Technical Working Group on Ocean Fertilization was instructed to:

.1 commence the development of an assessment framework on ocean fertilization ensuring compatibility with Annex 2 to the London Protocol; and

.2 prepare, with the assistance of experts, as required, and in co-operation with relevant international organizations, as appropriate: a document, for the information of all Contracting Parties, summarizing the current state of knowledge on ocean fertilization, relevant to assessing impacts on the marine environment, taking into account the work done on this issue in other fora.

ADOPTION OF THE AGENDA AND ORGANIZATION OF THE WORK

1.10 The agenda for the meeting (LC/SG-/CO2 3/1) was structured in accordance with the terms of reference and was adopted, as shown at annex 1 to this report.

2 DEVELOPMENT OF AN ASSESSMENT FRAMEWORK ON OCEAN FERTILIZATION

2.1 Following the introduction by the delegation of the United States of it's list of considerations for ocean fertilization the Working Group agreed to model the assessment framework on ocean fertilization after the "Risk Assessment and Management Framework for CO_2 Sequestration in Sub-seabed Geological Structures (CS-SSGS), adopted in 2006.

2.2 The German delegation gave a brief presentation on the German/Indian LOHAFEX iron fertilization experiment which was currently being conducted in the Southern Atlantic Ocean and on the decision-making process within the German Government regarding this experiment.

2.3 Clarifications were given in a short question and answer session and the German delegation offered to request the Alfred Wegener Institute to present the first scientific results to the next session of the Scientific Groups in May 2009. The progress with the experiment can be followed by visiting http://www.awi.de.

2.4 The Australian delegation informed the meeting that government officials had been approached by a representative of a university in Australia who indicated that they intend to apply for approval to conduct a nitrogen/phosphorus addition experiment within Australia's exclusive economic zone. No formal application had yet been received but the delegation indicated that Australia intended to use the outcomes of the Technical Working Group session this week to aid the preparation of their application.

2.5 The representative of the Secretariat of the Convention on Biological Diversity informed the meeting about the "Voluntary Guidelines on biodiversity-inclusive impact assessment", as contained in the Annex of decision VIII/28, that where endorsed at the eighth meeting of the Conference of the Parties to the Convention.

2.6 The observer from Greenpeace International suggested that proposals for legitimate scientific research on ocean fertilization must meet, as a minimum, a set of seven principles or conditions (Justification; Consultation; Assessment; Regulation; Transparency; Liability and redress; and Non-commerciality).

2.7 In the ensuing discussion, the Group identified the following issues for further consideration and review by the Legal Working Group:

.1 the current definition of 'ocean fertilization' in resolution LC-LP.1(2008) does not cover *all* processes that might be explored through the addition of material to the marine environment, (e.g., – (1) the addition of iron to the ocean to study geochemical aspects; and (2) one could add materials that would cause materials to adhere to and sink). The following suggestions were offered for consideration:

.1 *ocean fertilization* is any human activity undertaken that results in the deliberate addition or redistribution to the photosynthetic layer of micro nutrients such as iron and macro nutrients such as nitrogen or phosphorus; or

.2 *ocean fertilization* is any human activity undertaken in full or in part to add or redistribute to the photosynthetic layer micro nutrients such as iron and macro nutrients such as nitrogen or phosphorus.

2.8 In case the definition of ocean fertilization would be amended, the current footnoted exceptions should be carefully reviewed in light of the following elements:

.1 "agriculture" should be added;

.2 ocean thermal energy conversion (OTEC), land-based agricultural run-off etc'; and

.3 the uncertainty about what forms of mariculture are excluded.

2.9 Furthermore, the following issues had not been addressed:

.1 what is “contrary to the aims of the Convention/Protocol”; and

.2 who would have the responsibility for carrying out risk assessments on ocean fertilization.

2.10 Based on the discussions the Working Group established several drafting groups to prepare text for the assessment framework on fertilization.

2.11 The Group subsequently agreed to a Draft Assessment and Management Framework as set out in Annex 2 to this report. The Group also agreed that the draft text was a ‘work in progress’ and required further consistency checks, additional explanatory notes and figures as well as a final edit. The Group further agreed that it be presented for consideration by the Scientific Groups, with a view to finalizing the Framework for adoption by the governing bodies in October 2009.

2.12 The Group also agreed to consider the feasibility of establishing of a repository of data on ocean fertilization experiments to allow easy access to data by the scientific community.

[MORE TO COME]

3 PREPARATION OF AN INITIAL DRAFT OF AN INFORMATION DOCUMENT SUMMARIZING THE CURRENT STATE OF KNOWLEDGE ON OCEAN FERTILIZATION

The Group noted that UNESCO/IOC is preparing, through SOLAS, a Summary for Policy Makers on Ocean Fertilization in the style of the documents developed for the IPCC. While it was ultimately destined for the IOC Assembly, the Scientific Groups could actively participate in the development and review of this document. The Group agreed that this document could serve the purposes of the current requirement requested by the governing bodies and suggested that a draft could be submitted to the meetings of the governing bodies in October 2009.

4 ANY OTHER BUSINESS

No issues were raised.

[MORE TO COME]

5 CONSIDERATION AND ADOPTION OF THE REPORT

[The 1st Meeting of the Intersessional Technical Working Group on Ocean Fertilization adopted its report on Friday, 13 February 2009.]

ANNEX 1

AGENDA FOR THE INTERSESSIONAL TECHNICAL WORKING GROUP ON OCEAN FERTILIZATION

1 Adoption of the agenda

LC/SG-CO2 3/1	Secretariat:	Provisional Agenda

2 Development of an assessment framework on ocean fertilization

No documents submitted under this item

3 Preparation of an initial draft of an information document summarizing the current state of knowledge on ocean fertilization

No documents submitted under this item

4 Any other business

No documents submitted under this item

5 Consideration and adoption of the report

LC/SG-CO2 3/WP.1	Secretariat:	Draft report
LC/SG-CO2 3/INF.1	Secretariat:	List of Participants

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ANNEX 2

DRAFT RISK ASSESSMENT AND MANAGEMENT FRAMEWORK FOR SCIENTIFIC RESEARCH [ON] OCEAN FERTILIZATION

Table of contents

[N.B. This document is based on the resolution LC - LP.1(2008) on ocean fertilization adopted by the governing bodies 31 October 2008 and may need revision in future in light of future decisions by the governing bodies]

1 INTRODUCTION AND SUMMARY

This framework is designed to evaluate proposals that fall within the following definition of ocean fertilization: [placeholder for definition of ocean fertilization]

1.1 The framework provides:

.1 A tool for assessing scientific research proposals on a case-by case basis to determine if proposed activity is contrary to the aims and objectives of the London Convention or Protocol and meets the requirements, as appropriate, of Annex 2 of the Protocol. [A listing of the aims and objectives may be useful here and could be added based on the deliberations of the legal group]

.2 Guidance to:

.1 Determine whether a project is legitimate scientific research;

.2 Characterize risks to the marine environment from ocean fertilization on a project-specific basis; and

.3 Collect the necessary information to develop a [risk] management strategy.

1.2 [placeholder for explanation of any unique aspects of this assessment activity.]

1.3 An overview of the [risk] assessment [and management] framework is given in Figure 1. It will be up to the national regulator to decide whether the initial assessment could be done as a separate step followed by the full assessment. The elements of the framework can be summarized as follows:

.1 ***Problem Formulation and Initial Assessment.*** The problem formulation defines the bounds of the assessment, including the scenarios and pathways to be considered. The initial assessment is a critical first step in determining whether a proposed activity can be considered legitimate scientific research;

.2 ***Site Selection and Description*** concerns the collection of data necessary for describing the physical, chemical, and biological conditions at the site. These data are used for both site selection and the analyses conducted in various other elements of the Framework;

.3 ***Exposure Assessment*** is concerned with describing the movement and fate of added substances within the marine environment;

.4 ***Effects Assessment*** assembles the information necessary to describe the response of receptors within the marine environment resulting from exposure to ocean fertilization. This section describes details required in the evaluation of the impact hypothesis;

.5 ***Risk Characterization*** integrates the exposure and effects information to provide an estimate of the likelihood for adverse impacts and the magnitude of those impacts. Impacts may range from low probability and low magnitude to high probability and high magnitude. Risk characterization should be considered using site-specific information. The risk characterization will include a description of the risks and uncertainties associated with conclusions made by the risk assessment. The sources and level of uncertainty associated with a risk estimate will be a function of the data and modelling assumptions used; and

.6 ***Risk Management*** procedures are necessary to ensure that, as far as practicable, environmental risks are minimized and the benefits maximized.

1.5 In general, national authorities should use this framework in an iterative manner to ensure that all steps receive full consideration before all decisions are made.

1.6 Uncertainties and/or data gaps need to be considered throughout the assessment framework, and in considering risk management steps. Such a consideration will include the significant/consequential assumptions, data gaps, and sources of variation in exposure and effect processes. This evaluation of the uncertainties should be sufficient to inform decision-makers of the relevant limitations and constraints. This treatment of uncertainty will also provide a source of input for identifying future monitoring and/or research activities through which uncertainties can be reduced and future risk assessments can be supported.

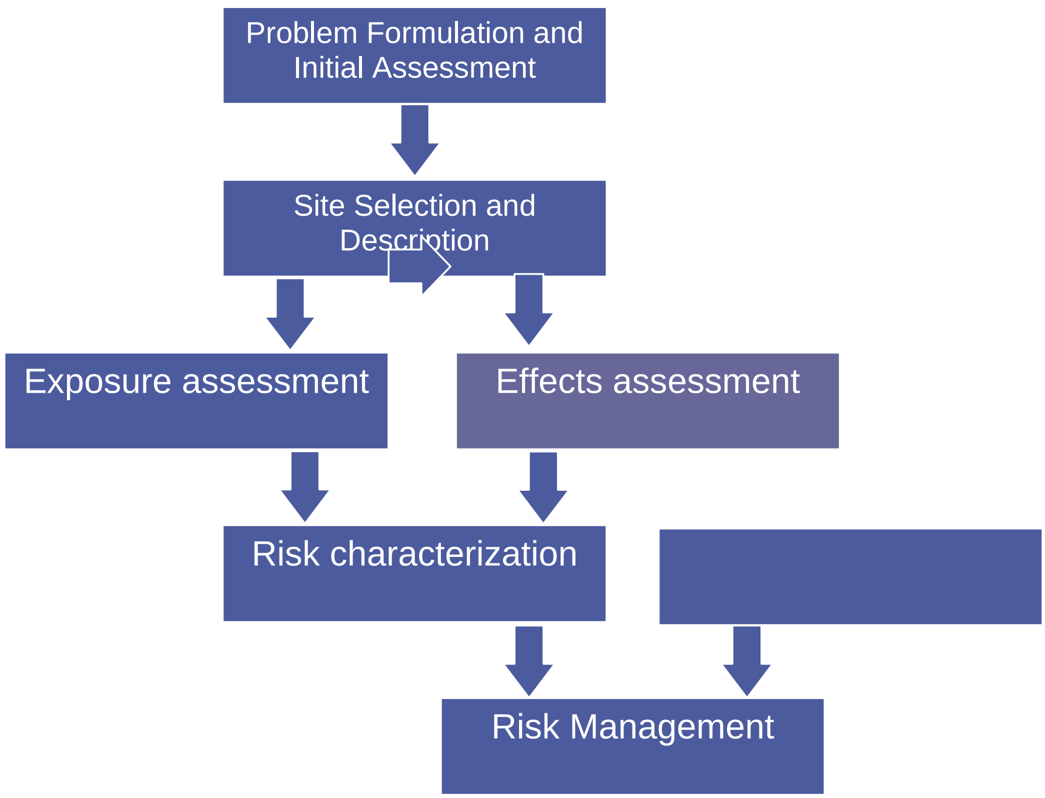
1.7 Evidence to support key assumptions and statements should be provided.

1.8 Approvals should only be issued for defined periods of time and defined areas. Reporting on the conduct of the experiment and compliance with approval conditions should be submitted to the regulator, the London Convention Secretariat and, where appropriate, to other Contracting Parties. The assessment and approval documentation should be publicly available.

1.9 [The regulatory authority could exempt a *de minimis* scale activity for educational purposes from a full risk assessment provided the regulatory authority is convinced there will be no environmental harm. – Advice from the Legal group may be needed]

1.10 [Text on iterative process needed here?]

Figure1 – **[Risk] Assessment [and Management] Framework**



2 PROBLEM FORMULATION AND INITIAL ASSESSMENT

2.1 The problem formulation defines the bounds of the assessment, including the scenarios and pathways to be considered. The initial assessment is a critical first step in determining whether a proposed activity can be considered legitimate scientific research as required under Paragraph 7 of Resolution LC-LP.1 (2008) on the Regulation of Ocean Fertilization.

2.2 Proposals should include:

.1 Information regarding the principal project team and their affiliations as well as identification of the proposed funding sources and any potential conflicts of interest.

.2 Information required for the characterization of planned fertilization project should include:

.1 Method, timing and duration of both addition of material and collection of data;

.2 Detailed description of the composition and form of substance(s) to be added or redistributed and the source of the material;

.3 Amount of substance(s) to be loaded and discharged, or amount to be redistributed in the ocean;

.4 The number, characteristics, and location of any structures located in the water column;

.5 Anticipated changes in concentration of substances introduced into the photosynthetic layer;

.6 Anticipated fate of added substances including where appropriate uptake and settling;

.7 Location of the proposed project;

.8 Area of treatment (size); and

.9 Flag State(s) of the vessel(s) involved and the Port State(s) where the substance will be loaded aboard the vessel(s).

.3 The conceptual assessment model

.1 The project proposal should include a project-specific conceptual model of potential environmental pathways and effects, including the key exposure and effects considerations.

.2 In view of site characteristics, the nature of the proposed operation, and relevant legal/regulatory objectives, the proposal should identify the specific assessment endpoints that will be the focus of the risk assessment.

.3 Risk should be described relative to the attributes in risk characterization.

.4 Gaps and uncertainties relative to the conceptual model, and any activities planned to address these gaps and uncertainties should be identified.

2.3 The proposal should meet the following criteria:

.1 The project should be designed to answer questions that will add to the body of scientific knowledge. Proposals should state their rationale, research goals, methods, scale, timings and locations with clear justification for [a field-based approach/why the expected outcomes cannot reasonably achieved by other methods].

.2 [The legal and policy meeting may wish to consider a need to mention commercial activities in this section];

.3 The proposal should follow the basic principles of the scientific method. There should be clearly defined experimental hypotheses and the project should be adequately designed to test those hypotheses;

.4 The proposal should be subject to scientific peer review that is taken into consideration by national regulators. The peer review methodology should be stated and the outcomes of the peer review of successful projects should be publicly available together with the details of the project. This peer review may be organized by national bodies but it would be beneficial to involve expert scientists from other countries where appropriate; and

.5 The project proponents should make a commitment to publish the results in peer reviewed scientific publications and to include a plan in the proposal to make the data and outcomes publicly available in a specified time-frame.

2.4 Proposals that meet the above criteria can proceed through subsequent stages of the framework.

Uncertainties

2.5 Risk assessment, in addition to describing and communicating the risks posed by the fertilization experiment, will also provide a description and summary of the uncertainties associated with the conclusions of the risk assessment. Such a description will include a listing of the significant/consequential assumptions, data gaps, and sources of variation in exposure and effect processes. Beyond a simple listing, this element of the risk assessment should provide an evaluation of the uncertainties that is sufficient to inform decision-makers regarding the limitation and constraints associated with the risk conclusions, including the means for decision-makers to inform themselves about the implications for decision-making posed by the identified uncertainties. This treatment of uncertainty will also provide a source of input for identifying future monitoring and/or research activities through which uncertainties can be reduced and future risk assessments can be supported.

3 SITE SELECTION AND DESCRIPTION

3.1 Section objective: This section concerns the collection of data necessary for describing the physical, geological, chemical, and biological conditions at the site, and uncertainties in these conditions. These data can be used for both site selection and the analyses conducted in various other elements of the Framework.

3.2 Definitions:

Proposed Region – the surface area of the ocean for which the permit will be issued and the Experimental Baseline established

Site(s) – the specific location(s) within the Proposed Region where the action will take place

Fertilized Volume – the volume in which nutrient levels have been deliberately elevated

Far-Field Area and Volume - meaning all areas and volumes affected outside of the Fertilized Volume

Region of Potential Impact - the region in which detectable effects may result as described by the Impact Hypothesis and for which the Risk Assessment Baseline is established. This Region encompasses the Fertilized Volume and the Far-Field.

3.3 Key goals of ocean fertilization site selection:

.1 suitable for testing hypothesis;

.2 suitable for minimizing undesirable effects; and

.3 avoiding proximity to sensitive regions & habitats eg. essential fish habitats, coral reefs.

3.4 Overall Rationale should be provided for the Proposed Region, including criteria for Experimental Site(s) in order of priority

3.5 Site description should include information for establishing both the Experimental Baseline and the Risk Assessment Baseline conditions and their variability. The following information should be included, as relevant:

.1 Coordinates of Proposed Region within which Experimental Site(s) will be selected,

.2 Coordinates of Region of Potential Impact

.3 Physical characteristics of Proposed Region and Region of Potential Impact:

.1 Water column attributes

.1 Depth of water

.2 Depth of light penetration

.3 Temperature and salinity distributions

.4 Depth of mixed layer

.2 Sediment and seabed considerations

.1 Characteristics of surficial sediments

.2 Existing bottom sediment transport to sensitive marine habitats or coastal zones and the potential for resuspension of added material

.3 Transport and mixing considerations

.1 intensity of vertical and horizontal mixing

.2 Currents - surface, mid-depth, and bottom water current direction and velocity

.4 Meteorology (where relevant to installed structures or dispersal systems)

.1 Temporal/seasonal conditions and wind variability that influences physical conditions of site

.2 Wave period and height

.4 Chemical characteristics:

.1 Dissolved oxygen

.2 Concentrations and composition of macro- (eg. N, P, Si) and micro-nutrients (eg. Fe, Zn).

.3 Carbonate system, pH, alkalinity etc., dissolved organic carbon

.4 Particulate loading and fluxes

.5 Contaminants

.5 Biological characteristics:

.1 Species expected in water column, in particular plankton community composition, and the presence of especially vulnerable, endemic, protected and/or migratory species (including marine mammals and seabirds).

.2 Benthic Species in particular the presence of especially vulnerable, endemic and protected species

.6 Other Considerations:

.1 Proximity to other uses of the ocean eg. recreational or commercial fishing grounds, shipping lanes

[.2 Identify countries that may be affected and a plan to explain the potential impacts and encourage their scientific cooperation] NOTE – THIS MAY BE MORE APPROPRIATE EARLIER IN THE DOCUMENT

4 EXPOSURE ASSESSMENT

4.1 Section objective: Exposure assessment is concerned with describing the movement and fate of added substances within the marine environment. The uncertainties associated with such an assessment also need to be identified.

4.2 Technical Considerations: Proposers should comment on the implications of limited knowledge of baseline conditions, and on experimental limitations such as replications of treatment and measurement.

.1 General category

- .1 Type (e.g. Artificial Upwelling, Nutrient Addition)

.2 Mode of application

- .1 Mechanical description / Method of delivery
- .2 Any hazards of ship operations (eg waste management, noise, exhaust gases)
- .3 Any hazards if the material reaches an unintended area.

.3 Chemical characterization of each substance (including solvents, chelators, tracers, etc) to be added or of artificially upwelled water.

- .1 Chemical composition of substance to be added
- .2 Toxicity of substance, including any impurities / contaminants

.4 Physical characterization

- .1 Form (e.g., solid, particle size, liquid solution, concentration)
- .2 Depth in water column of addition
- .3 Rate of addition
- .4 Surface Area of addition and intended volume
- .5 Intended initial concentration of substance in the Fertilized Volume
- .6 Total amount to be added
- .7 Duration (including number and interval between additions).
- .8 Other impacts or changes on the physical environment (including temperature and buoyancy effects as well as the effect of the physical apparatus) during fertilization.
- .9 Other information necessary to describe the spatial and temporal extent of exposure processes (e.g. advection to sensitive areas)

.5 Biological Characterization

- .1 Any intended or unintended transport of organisms

.6 Methodology used to estimate the Exposure processes and pathways –including movement and fate of all added materials (solvents, chelators, tracers, etc) and the sensitivity of the Exposure to underpinning assumptions, uncertainties and data gaps regarding :

.1 Physical processes (e.g. currents, wind patterns, seasonal influences, settling, dispersion, resuspension, subduction)

.2 Chemical processes (e.g. decomposition, transformation, coagulation)

.3 Biological processes (e.g. transformation, bioaccumulation, biomagnification)

.7 Other Considerations

.1 Other unintended impacts of delivery method

.2 Conflicts of delivery method with other human uses of the marine environment

.3 Cumulative exposure from repeated or other fertilizations, if relevant

[Because of the vast scope for far-field effects associated with fertilization experiments they may be best assessed through appropriate computer models.]

5 EFFECTS ASSESSMENT

5.1 Section objective: Short and long term effects assessment assembles the information necessary to describe the response of the marine environment resulting from exposure to ocean fertilization. This section considers details required for the evaluation of the impact hypothesis (defined in section X.X of this draft)

5.2 Technical Considerations:

.1 Fertilized Volume impacts, such as changes to marine ecosystem structure and dynamics including sensitivity of species, populations, communities, habitats, and processes within the Fertilized Volume. Elements of concern include physiological changes and changes in state and rate variables.

.1 Biogeochemical changes (e.g. nutrients, oxygen, pH, carbonate system, dissolved organics)

.2 Organism responses (e.g. Population responses)

.1 Response of primary producers.

.2 Potential response of other organisms (e.g. bacteria, planktonic species, fish, reptiles, seabirds, marine mammals, benthic species).

.3 Ecosystem considerations

.1 Community composition and biodiversity

.2 Foodweb interactions (e.g. grazing responses, predator/prey relationships)

.3 Potential for bioaccumulation and biomagnifications of any toxins and trace elements in organisms.

.4 Potential for acute or chronic effects from toxins or trace elements.

.5 Human health considerations, including food chain effects.

.2 Far-field impacts:

.1 Biogeochemical changes (e.g. nutrients, oxygen, pH, carbonate system, dissolved organics)

.2 Biogeochemical fluxes (e.g. nutrients, dissolved and particulate carbon, trace elements)

.3 Organism responses (e,g, Population responses)

.1 Response of primary producers.

.2 Potential response of other organisms (e.g. bacteria, planktonic species, fish, reptiles, seabirds, marine mammals, benthic species).

.4 Ecosystem considerations

.1 Community composition and biodiversity

.2 Foodweb interactions (e.g. grazing responses, predator/prey relationships)

.3 Changes to sediment and benthic habitat

.4 Potential for bioaccumulation and biomagnifications of any toxins and trace elements in organisms.

.5 Potential for acute or chronic effects from toxins or trace elements.

.6 Human health considerations, including food chain effects.

.3 In considering the effects in 5.2.1 and 5.2.2, the following potential adverse effects should be addressed.

.1 long-term primary production changes, leading to impacts to fisheries or protected species

.2 longterm ecosystem changes, such as changes in community structure and/or diversity

.3 Hypoxia/Anoxia

.4 Acidification

.5 Harmful algal blooms

.6 Production of climate-active gases (e.g. GHGs, halocarbons, DMS)

.7 Changes in the absorption of light and heat and associated buoyancy changes that affect oceanic circulation, air-sea exchange, and/or climate

.8 Cumulative Effects from repeated or other fertilizations in close proximity in space and time

.4 Methodologies (including models, pre-existing data, targeted measurements) for assessing Effects should be described, including the sensitivity to underpinning assumptions, uncertainties and data gaps such as:

.1 Limited information about initial or baseline conditions

.2 Natural variability within the Risk Assessment Baseline

.3 Longevity of the response.

.4 Lack of long-term monitoring in previous experiments

6 RISK CHARACTERIZATION

Section objective: This section integrates the exposure and effects information to provide an estimate of the likelihood for adverse impacts and the magnitude of those impacts. Impacts may range from low probability and low magnitude to high probability and high magnitude. Risk characterization should be considered using site-specific information. The risk characterization will include a description of the risks and uncertainties associated with conclusions made by the risk assessment. The sources and level of uncertainty associated with a risk estimate will be a function of the data and modelling assumptions used.

What are the risks?

6.1 The definition of risk is taken as "the likelihood for an adverse effect or outcome". Risks are characterized in terms of the assessments endpoints identified in problem formulation.

.1 Risks can be brought about through the following changes:

- Physical. Examples include:
  - The effects of permanent structures, such as pipes utilised to bring about upwelling of nutrient rich deep water to nutrient poor surface waters, include hazards to navigation and restriction of fishing grounds.
  - Vertical distribution of heat in the ocean is altered by the presence of phytoplankton blooms, which would absorb additional light and heat thus leading to increased surface water temperature.

- Chemical. Examples include:
  - Changes in pH resulting from iron (or other) fertilisation. Such changes of pH in surface waters can occur as a consequence of increased phytoplankton populations as CO_2 taken from the seawater to convert to organic matter. Conversely, the sinking and decomposition of the organic matter results in chemical changes to the carbonate ion balance, which may contribute to lowering of the pH of seawater (ocean acidification).
  - Changes in dissolved oxygen concentration are brought about by increased phytoplankton populations. This can result in increased oxygen in surface waters due to photosynthesis. Following the die-back of the bloom, the organic matter sinks through the water column. Decomposition of this organic matter at depth can result in depleted oxygen, possibly leading to anoxia in deep waters thus bringing about the die-off of benthic communities.
  - Generation of greenhouse gases e.g. N_2O and CH_4.

- Biological. Examples include:
  - Toxins can be produced as a result of harmful algal blooms (HABS). These toxins can have detrimental effects on shellfish and finfish, resulting in adverse effects on human health.
  - Enhanced primary productivity is the intention of many fertilisation activities and a side-effect of others. This enhanced productivity may lead to changes in diversity, i.e. numbers of individuals or species composition. This may lead to secondary effects including possibly enhanced fish populations or alternatively may enhance populations of less economically relevant species such as jellyfish.

- o Changes to the nutrient composition of seawater, as a result of fertilisation experiments, may bring about changes in composition of the lower trophic levels of the food web (e.g. bacteria, plankton) which will have secondary and possibly more intense effects further up the marine food chain.

6.2 The risks characterised should take into consideration their impingement upon other legitimate uses of the sea.

6.3 Cumulative impacts may be anticipated as a result of other activities or operations, e.g.

- Multiple activities in the same water body (spatial) e.g. aquaculture, offshore oil and gas exploration and other fertilisation experiments have potential to increase nutrient concentrations in receiving waters.
- Multiple fertilisation activities in the same water mass over a period of time have the potential to change iron (or other nutrient) cycling in a local area, which may lead to changes in diversity of the plankton and bacterial communities, and the associated changes to dependent communities.

The role of baseline – how will it be used?

6.4 The baseline can be defined as the state of the ecosystem (including natural variability) before the experiment. The description will draw upon the activities and results of site characterisation. The baseline represents the basis of comparison for the experiment and for the risk assessment. The baseline should include a description of environmental physical, chemical and biological conditions at the site, e.g.

- pH, temperature, salinity
- CO_2, O_2 and other gases if any (natural production of methane…)
- Contaminants
- Nature and number of species in and around the concerned area (and migratory species if any)
- Relative abundance of species
- Predator-prey dynamics (diatom, small/big)
- Exchange regime with the surrounding media (including atmosphere).

6.5 Data should be collected at different depths and at as many geographical points as necessary to be representative of the experimental area.

.1 Experimental baseline consists of a description of conditions specifically relevant to the experiment, and includes a description of those conditions over a short period of time directly preceding the experiment.

.2 Risk assessment baseline consists of a description of conditions collected over a longer period of time, which is used to draw conclusions about the potential for adverse impact resulting from the operation. This baseline should include data representative of natural variability e.g. diurnal, seasonal and interannual.

6.6 For both experimental and risk assessment baselines information can be drawn from;

- literature reviews
- existing data from other activities
- targeted surveys.

Evaluating the nature of the risks

6.7 For each assessment endpoint, integration of the magnitude of the effect and the probability, or likelihood, of the effect occurring will yield an estimation of risk. Both of these components are likely to be, at best, semi-quantitative so will represent judgments based on the available knowledge and experience.

6.8 Magnitude of effect
An estimation of the magnitude of the effect will need to consider the temporal and spatial scale of effects.

.1 Temporal scale
The duration of the effects could be transient, such as a phytoplankton bloom that is over in a matter of days or more sustained such as the introduction of structures into the marine environment causing physical barriers. Temporal responses may also involve time lags so that the effects may be delayed.
All else being equal, the longer the predicted duration of effect, the greater the risk.

2 Spatial scale
The geographical scale of the effect can be near-field (local) or far-field (remote) in relation to the operation. It should be taken into account that the water mass fertilised can and will move over time. For example, fertilization could cause depletion of nutrients in subducted waters that are later upwelled elsewhere. All else being equal, the larger the area over which effects are manifested, the greater the risk.

3 Number of effects
The number of effects (identified as *assessment endpoints* by Problem formulation) will vary on a case by case basis. All else being equal, the greater the number of effects predicted, the greater the overall risk.

6.9 Probability of effect – as part of the risk characterisation, an estimation of the likelihood of effects (of various magnitudes) will be made. This is discussed in section 6.x.x.

Reaching Conclusions About Risks

6.10 Weight of evidence approach: The information produced during the exposure and effects assessments is used to develop lines of evidence supporting specific conclusions about how the fertilization experiment operation could influence the assessment endpoints. Multiple lines of evidence will be used to describe the physical, chemical and biological processes relevant to changes in each assessment endpoint and conclusions regarding the magnitude of potential changes and the likelihood of those changes. For example, results from previous field observations, modelling results, and laboratory or mesocosm experiments could provide independent lines of evidence supporting a specific conclusion that relates some aspect of the proposed fertilization operation and the assessment endpoints.

.1 The strength of any conclusion will be a function of the 'weight' of evidence supporting it. Used in this sense, *weight* is the result of the degree to which independent lines of evidence support specific aspects of the conclusion and the amount of information, overall, supporting the conclusion. The greater number of independent lines of evidence and information supporting the conclusion, then the greater the weight of evidence.

6.11 Magnitude and likelihood: For each assessment endpoint, information relating magnitude of exposure and magnitude of effect will be used to describe the risk to that endpoint, as indicated in Figure X.

.1 A conventional risk assessment matrix (Figure Y) can be used to inform and provide a consistent approach to decision-making. Separate sets of criteria are defined for both the magnitude and the likelihood of effects according to the parameters of the assessment endpoint. These are then brought together in a matrix to identify relative degrees or categories of risk. The boundaries of the significance of the risk indicated on the matrix can be summarized using simple language terminology (e.g. 'high' 'medium' 'low') or on a numerical scale.

.2 Magnitude: In the risk assessment, it is necessary to distinguish conclusions about the magnitude of an effect from conclusions about the likelihood for an effect of a particular magnitude (Figure Y). This distinction acknowledges the uncertainty associated with the relationship between magnitude of exposure and magnitude of effect, and is depicted as the shaded area around the line representing the relationship in Figure X.

.3 In addition to the exposure-effect relationship, other factors contributing to conclusions about the magnitude of risk include the spatial extent over which the effect will occur as well as the duration of the effect. Evidence concerning magnitude, spatial extent and duration of the effect is used to reach conclusions about the magnitude of a change in the assessment endpoint, i.e., the relative positions along the horizontal axis in Figure Y.

.4 Likelihood: Conclusions regarding the likelihood for effects of a given magnitude are developed from evidence regarding the strength of relevant cause-and- effect relationships (e.g., between a specific exposure process and a given effect, as determined by the exposure and effects assessments), uncertainties associated with these relationships, and the role of natural variation in these processes in the environment.

[Example under development]

.5 Evidence-based conclusions regarding magnitude of effect and likelihood are used to identify the cells, in Figure Y, representing the risk conclusion for the assessment endpoint under consideration. Following this approach, a version of Figure Y would be prepared for each assessment endpoint evaluated in the risk assessment. [Example under development.] It should be acknowledged here that the presentation of risks in Figure Y is only one of several different approaches that could be used, depending on the needs and uses of the assessment.

6.12 Integrating across endpoints to produce an overall description of risk: Once conclusions are reached regarding the risk to each assessment endpoint, it will be necessary to develop an overall risk conclusion that integrates across all assessment endpoints. This integration step gives consideration to the nature of the risks and differences in emphasis, importance, or weight that may be attached to the risks under consideration. It is a useful part of decision-making under risk management to evaluate the sensitivity of the ultimate decision(s) to changes in key elements of the integration process.

[Example under development using equally weighted and differently weights samples]

1 Different logic frameworks may be used to accomplish this integration in the practice of environmental risk assessment. Obviously, the approach selected by a Contracting Party or Authority will be selected to satisfy both national and international requirements. Approaches can range from narrative presentation of arguments to more formal, quantitative frameworks such as the application of decision analysis methods (e.g., Kiker et al. 2008).

.2 Regardless of the approach taken, the purpose of the integration is to inform the decision-making processes of risk management.

6.13 Uncertainties: Risk characterization, in addition to describing and communicating the risks posed by the fertilization experiment, will also provide a description and summary of the uncertainties associated with the conclusions of the risk assessment. Such a description will include a listing of the significant/consequential assumptions, data gaps, and sources of variation in exposure and effect processes.

.1 Beyond a simple listing, this element of the risk characterization should provide an evaluation of the uncertainties that is sufficient to inform decision-makers regarding the limitation and constraints associated with the risk conclusions, including the means for decision-makers to inform themselves about the implications for decision-making posed by the identified uncertainties.

.2 This treatment of uncertainty will also provide a source of input for identifying future monitoring and/or research activities through which uncertainties can be reduced and future risk assessments can be supported.

6.14 While it should be considered that widespread, prolonged low-level effects may have greater potential for cumulative impact than contained, brief but high-level effect, in reaching conclusions about risks, a fundamental principle to consider is that:

- The greater the change in the endpoint (in relation to the risk assessment baseline),
- the larger the area over which the effect will occur, and
- the longer the duration of the effect,

then the greater the risk posed by the activity.

From prediction to planning:

6.15 The principal product of risk characterization is a series of evidence-supported predictions about the risks posed by a proposed ocean fertilization experiment. These predictions are developed to inform the decision-making processes comprising risk management. The risk assessment is conducted to fulfil the aims and objectives of the London Convention and Protocol. As such, how the risk information is used to support decision making should be consistent with those aims and objectives.

6.16 Because the risk management decisions are, by necessity, based on predictions, monitoring designs and investments should support refinements and improvements to future risk assessments and adaptive management of risks. As such, the predictions made by the risk assessment will be a source of input for developing impact hypotheses, which can be tested through monitoring or future research.

Figure X: Relationship between magnitude of effect and exposure

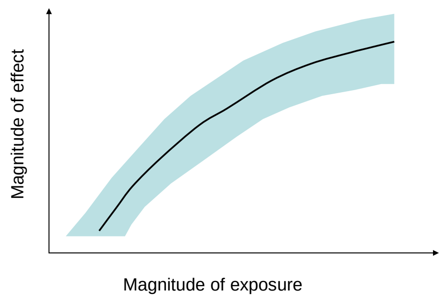
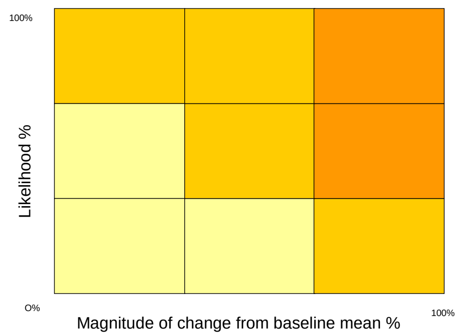


Figure Y: Risk assessment matrix



7 RISK MANAGEMENT

7.1 Objective: Risk management procedures are necessary to ensure that, as far as practicable, environmental risks are minimized and the benefits maximized.

7.2 Definition: Risk management is a structured process following risk characterization to minimize and manage risk and implement appropriate monitoring and intervention strategies to manage risk. In the context of ocean fertilization, risk management consists of careful site selection, monitoring to provide assurance that an experiment is proceeding as expected and to provide early warning of adverse consequences, effective regulatory oversight, and implementation of remedial measures, as required to limit the impacts of adverse consequences.

7.3 Compatibility with London Protocol Annex 2: Risk management includes the conduct of compliance and field monitoring as outlined in paragraph 16. Risk management also provides guidance on the process and feedback necessary for reaching approval decisions, as outlined in paragraphs 17 and 18.

7.4 Mitigation and Contingency Planning: Risks should be managed to reduce them to a low level. Strategies to manage or mitigate risks need to be appropriate for the risks under consideration. They may be imposed as approval conditions or included as an intrinsic part of the proposal. Such strategies may include:

- Temporal restrictions (e.g., during certain oceanographic conditions or biologically important times for species of concern);
- Spatial restrictions (e.g., proximity to ecological communities of concern); and
- Delivery restrictions (e.g., substances, tracers, amounts, repetition).

However, if the magnitudes of the risks remain so high as to be unacceptable, the operation should not proceed.

Contingency planning may also need to be considered to respond to monitoring in cases where the Impact Hypothesis (defined in Annex 2, Paragraph 12) is found to be incorrect. This may include cessation of fertilization (particularly in the case of multiple additions over time or artificial upwelling).

7.5 Monitoring:

.1 Monitoring is used to verify that approval conditions are met – compliance monitoring – and that the assumptions made during the approval review and site selection process were correct and sufficient to protect the environment and human health – field monitoring. It is essential that such monitoring programs have clearly defined objectives. The type, frequency and extent of monitoring will depend on the Impact Hypothesis and local and regional consequences. The monitoring program should be developed in accordance with Article 13 of the London Protocol and Article IX of the London Convention concerning technical cooperation and assistance.

.2 The Impact Hypothesis forms the basis for defining field monitoring. The measurement program should be designed to ascertain that changes in the receiving environment are within those predicted. The following questions must be answered:

- What testable hypotheses can be derived from the Impact Hypothesis?

- What measurements (type, location, frequency, performance requirements) are required to test these hypotheses?
- How should the data be managed and interpreted?

.3 It may usually be assumed that suitable specifications of existing (pre-experiment) conditions in the receiving area are already contained in the application for research including basic knowledge of the [receiving ecosystem]. If the information in the application is inadequate to formulate an Impact Hypothesis, the approving authority will require additional information before reaching a conclusion. If an Impact Hypothesis cannot be formulated the application will be rejected.

.4 The authorizing authority is encouraged to take account of relevant research and modelling information in evaluating the design and requesting modification of field monitoring programs. Where appropriate, the measurements may be divided into two types - those within the zone of predicted impact and those outside.

.5 Field monitoring programs should be designed to determine whether both the predicted zone of impact and the magnitude of impact support the Impact Hypothesis. The former can be answered by designing a sequence of measurements in space and time that ensures that the projected scale of change is not exceeded. The latter can be answered by measurements that provide information on the magnitude of impact that occurs both inside and outside the zone of impact as a result of the experiment.

.6 As new results become available; monitoring requirements should be reviewed at appropriate intervals in relation to the objectives and can provide a basis to:

- modify or terminate the field monitoring program;
- modify or revoke the authorization;
- redefine or close the approved site; and
- modify the basis on which applications to conduct ocean fertilization activities are assessed.

7.7 Approval and Compliance: Approvals should only be issued for defined periods of time and areas. Reporting on the conduct of the experiment and compliance with approval conditions should be submitted to the Organization and, where appropriate, to other Contracting Parties. The assessment and approval documentation should be publicly available [through the web site of the Organisation] [There may be considerations for liability]

APPENDIX 1

GLOSSARY

CONSISTENCY:

Technical terms relating to physical entities (areas, sites, etc)

NOTE: All areas on the ocean surface are defined as bounded by great circle arcs connecting a sequence of points defined by latitude and longitude. All volumes are defined by an area and a depth range (which may be uniform or variable depending on the experimental conditions).

Proposed Region: The area on the ocean surface in which the *Site* will be located.

Region of Potential Impact: The area on the ocean surface in which changes in concentrations could occur at at least the detection limit as a result of nutrient introductions taking place within the *Proposed Region*.

Site: The area on the ocean surface through which or above which nutrients are introduced.

Fertilized volume: The volume of ocean where the concentration of nutrients has been purposefully elevated (volume in which the experiment is attempting to achieve a desired perturbation or effect). This volume will change over time as nutrients are transported.

Fertilized area: The area of ocean surface above the fertilized volume. This area will change over time as nutrients are transported.

Volume of Impact: The volume ocean in which changes in concentrations would be expected to occur at least at the detection limit as a result of nutrient introductions taking place at the *Site*.

Area of Impact: The area on the ocean surface above the volume of impact.

Transport: Change in location of materials through natural processes such as advection, mixing, diffusion or sinking.

Mixed-layer: The oceanic layer in which active turbulence has largely homogenized physical properties; often operationally defined to be the layer above the depth where the potential density difference between the surface and that depth is less than 0.125 kg m^{-3}.

Euphotic zone: The layer of the ocean that receives sufficient sunlight to support photosynthesis. It usually extends to about 200 meters below the water surface. [NOTE: Replace all occurrences of "Photosynthetic layer" with "euphotic zone"]

Experimental baseline: A description of conditions specifically relevant to the experiment, and includes a description of those conditions over a short period of time directly preceding the experiment.

Risk assessment baseline: A description of conditions collected over a longer period of time, which is used to draw conclusions about the potential for adverse impact resulting from the operation. This baseline should include data representative of natural variability e.g. diurnal, seasonal and interannual.

Note: Since Far-field is used in only one place, we propose using the phrase "Area of impact beyond the fertilized area".

[**APPENDIX 2**

Notes from the Risk Characterization Group to the other Groups including text removed from section 6 of J/3

a. Compatibility with LP Annex 2: Risk characterization provides information necessary for dump-site selection as described in paragraph 11, provides input to satisfy requirements of an assessment of potential effects as described in paragraphs 12-15, and may provide the process and feedback necessary for reviewing the basis for permits as required in paragraphs 17 and 18. – Bearing in mind point 3 of the resolution, does this now apply??

Scoping: Ecologically relevant endpoints must be identified during problem formulation

How does pulsed vs. sustained iron supply/nutrient supply affect ecosystem dynamics and biogeochemistry?

Problem formulation or exposure??

Cumulative impacts: Problem formulation or effects group

i. Factors to consider include:

Chemical

.1 Mesoscale chemical considerations
   a. Ocean acidification
   b. Alteration of local/mesoscale chemistry which do not subside within a short period post-treatment (1-3 months)

.2 Potential for pooling of fertilization substance, lack of transport to sub-surface waters

Biological

.3 Potential for growth of harmful algal blooms leading to increased presence in coastal systems
.4 Permanent or long-term changes in trophic webs or plankton communities
.5 Temporary loss of forage fish
.6 Temporary or permanent loss of trophic structures which support commercial fisheries
.7 Temporary or permanent loss of commercial fisheries species or populations
.8 Loss of calcareous habitats/communities due to increased acidification
.9 Alteration of depositional habitats due to changes in phytoplankton community dynamics
.10 Changes to benthic structure

Uncertainties:

.11 Assessment of overall budget in water column and on the seabed of substance added (including any present prior to project), as well as assessment of amount of substance added taken up by phytoplankton – Problem formulation group
.12 Residence time of substance added vs. depth reached by substance added [do we also want to consider residence time of C sequestered?] – Exposure group

.13 How to measure at mixing zones amount/presence of substance added – Exposure group
.14 Does mode of substance supply/addition result in different impacts? – Exposure group
.15 What should be extent and duration of monitoring and odelling? - Risk management group
.16 Are impacts based on sinking rate, scavenging? – Effects group

For problem formulation group – Is the overall environmental cost important in the assessment?

- Extraction and other process for haematite/ iron sulphate?
- Energy budgets of experiment

Consistent scaling approach must be used throughout the assessment, and must be explicit.

Approach for decision making? To be included under Risk Management or Problem Formulation

i. Multiple agencies
ii. Public review & consultation
iii. National authorities
iv. Negotiation?

Evaluation of the impact : To be included under Risk Management
Sampling and analyses should be conducted during and after OF experiment at different time intervals, till a steady state is reached. The description of environmental conditions at this steady state will constitute the risk line.
Additional analyses should include:

- iron concentration
- Concentration of any other elements associated to iron and introduced in water during the experiment.
- Control and observation of new species if any

Moreover any change in the nature or composition of the sediments should be reported.

Impact evaluation should include data collected as well as modeling results (predictive). These results should be confirmed (for the steady state) by pertinent analyses and observation.]