ASSESSMENT FRAMEWORK FOR SCIENTIFIC RESEARCH INVOLVING OCEAN FERTILIZATION[1]

(Adopted on 14 October 2010 under Resolution LC-LP.2(2010))

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[1] This text is still subject to final editing.

1 INTRODUCTION AND SUMMARY

1.1 This "Assessment Framework for Scientific Research Involving Ocean Fertilization" (the Framework) is designed for Contracting Parties to evaluate proposed activities that fall within the scope of Resolution LC-LP.1(2008). Ocean fertilization is defined as any activity undertaken by humans with the principal intention of stimulating primary productivity in the oceans[2].

1.2 This Framework provides a tool for assessing proposed activities on a case-by-case basis to determine if the proposed activity constitutes legitimate scientific research that is not contrary to the aims of the London Convention or Protocol.[3]

1.3 An overview of this Framework is given in Figure 1. The elements of the Framework can be summarized as follows:

.1 The ***Initial Assessment*** determines whether a proposed activity falls within the definition of ocean fertilization and has proper scientific attributes, and thus is eligible to be considered and evaluated in this framework;

.2 ***Environmental Assessment***

.1 The ***Problem Formulation*** describes the proposed activity and sets the bounds for the assessment carried out in subsequent steps;

.2 The ***Site Selection and Description*** outlines the criteria used for site selection and data necessary for describing the physical, geological, chemical, and biological conditions at the Proposed Site;

.3 The ***Exposure Assessment*** describes the movement and fate of added/redistributed substances within the marine environment;

.4 The ***Effects Assessment*** assembles the information necessary to describe the response of the marine environment resulting from ocean fertilization activities, taking into account the short- and long-term effects. This section describes the factors to be considered for the evaluation of the Impact Hypothesis;

.5 The ***Risk Characterization*** integrates the exposure and effects information to provide an estimate of the likelihood for adverse impacts and the magnitude of those impacts. The risk characterization should include a description of the uncertainties associated with its conclusions; and

.6 The ***Risk Management*** is a structured process following risk characterization designed to minimize and manage risk and implement appropriate monitoring and intervention and remediation strategies to manage risks, including mitigation and contingency planning. Risk management procedures, based on a precautionary approach, are necessary to ensure minimization of environmental risks;

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2 Ocean fertilization does not include conventional aquaculture, or mariculture, or the creation of artificial reefs.

3 This Assessment Framework is to be interpreted and applied in conformity with the relevant rules of international law, including as reflected in the United Nations Convention on the Law of the Sea 1982 (UNCLOS). Nothing in this Framework prejudices the rights, jurisdiction and duties of States under international law including as reflected in UNCLOS.

.3 ***Decision Making***
The determination that a proposed activity is legitimate scientific research, and is not contrary to the aims of the London Convention and Protocol, should only be made upon completion of the entire assessment framework;

.4 ***Results of monitoring***
The collection and use of information resulting from monitoring informs future decision making and can improve future assessments.

1.4 There could be several Contracting Parties involved in an experiment depending on flag of the vessel/s used, where the matter is loaded, where the experiment occurs, the funding source/s and the scientific expertise involved. The Contracting Parties involved should consult each other to determine the most appropriate lead for the application of the Assessment Framework. In the case where an experiment is intended to take place within the jurisdiction of a Contracting Party, that Contracting Party should take the lead

1.5 In general, the Contracting Parties should ensure that this Framework is used in an iterative manner to ensure that all steps receive full consideration before decisions are made. Notwithstanding, the preceding sentence, where it is determined part way through the assessment of a proposal that unacceptable impacts are considered likely, the assessment may be terminated without completing all steps in the framework in order to avoid unnecessary work, i.e. the proposal is withdrawn.

1.6 Contracting Parties should verify that key assumptions and statements are supported by sufficient information on which to base a decision including all the issues covered in the framework. The level of detail required for each issue should be appropriate to the nature of the proposal.

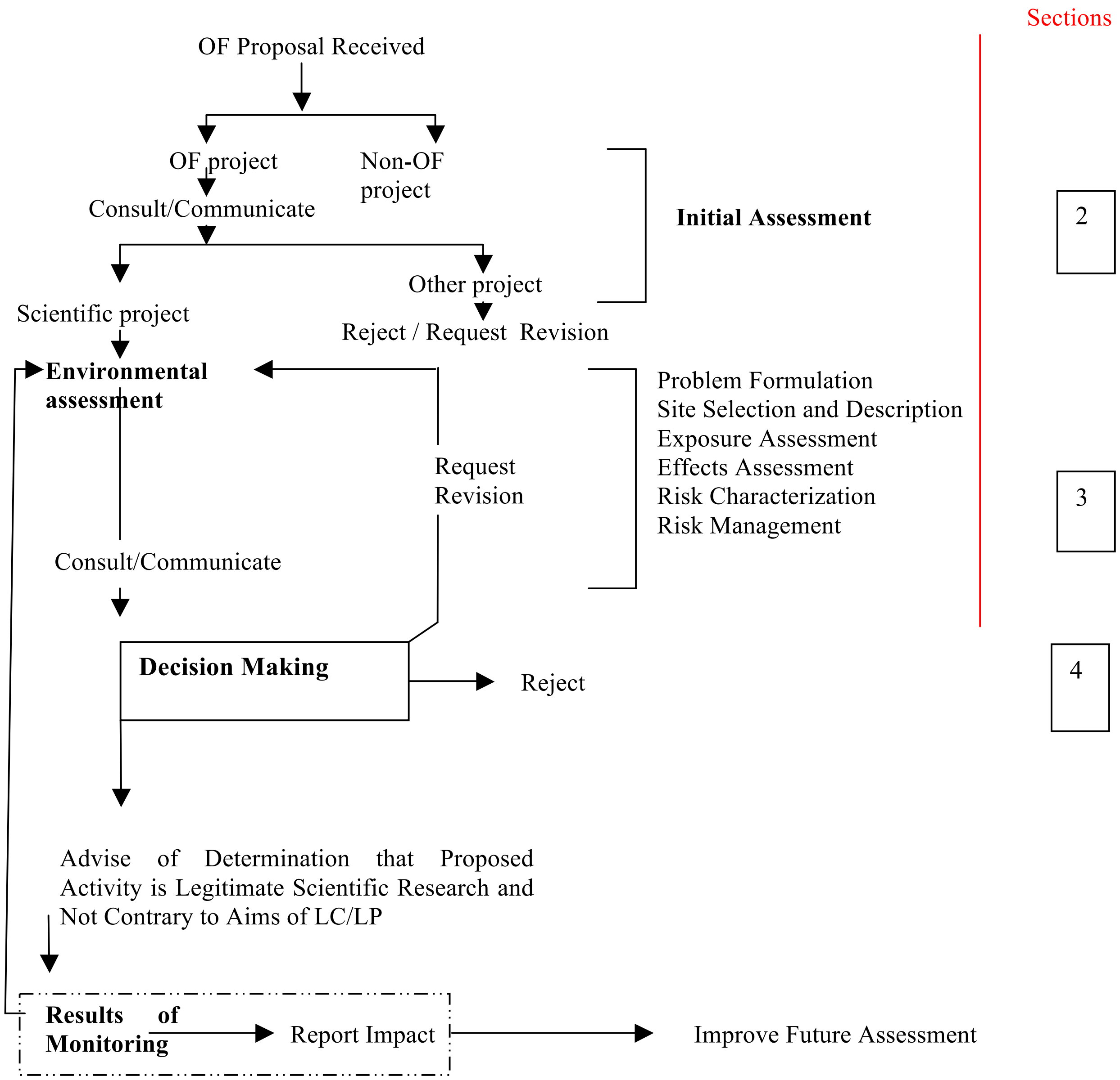
1.7 Upon completion of the ***Initial Assessment***, the Secretariat of the London Convention and Protocol should be informed. Contracting Parties may also inform the secretariat after receiving a proposal, prior to the completion of the Initial Assessment.

1.8 Contracting Parties should establish a consultation process with all stakeholders before a final decision is made. As part of this consultation process potentially affected countries should be identified and notified and a plan should be developed to explain the potential impacts, encourage scientific cooperation, and provide for ongoing consultation.

1.9 A determination that the proposed activity is not contrary to the aims of the Convention or Protocol should only be issued for defined periods of time and defined regions. The assessment and authorizing documentation should be publicly available at the time the decision is made.

1.10 It is recommended that relevant documents produced by Contracting Parties as part of their efforts to address the needs outlined in this Framework, should be catalogued by the Secretariat and maintained for use in future assessments. Contracting Parties should provide summaries of the assessment in English to the Secretariat.

Figure 1: Assessment Framework for Scientific Research Involving Ocean Fertilization



2 INITIAL ASSESSMENT

2.1 The received proposal should include a description of the activity falling within the definition of ocean fertilization in paragraph 1.1 above.

2.2 In order to determine if a proposed activity has proper scientific attributes, it should meet the following criteria:

.1 The proposed activity should be designed to answer questions that will add to the body of scientific knowledge. Proposals should state their rationale, research goals, scientific hypotheses and methods, scale, timings and locations with clear justification for why the expected outcomes cannot reasonably be achieved by other methods;

.2 Economic interests should not influence the design, conduct and/or outcomes of the proposed activity. There should not be any financial and/or economic gain arising directly from the experiment or its outcomes. This should not preclude payment for services rendered in support of the experiment or future financial impacts of patented technology;

.3 The proposed activity should be subject to scientific peer review at appropriate stages in the assessment process. The outcome of the scientific peer review should be taken into consideration by the Contracting Parties. The peer review methodology should be stated and the outcomes of the peer review of successful proposals should be made publicly available together with the details of the project. Where appropriate, it would be beneficial to involve expert scientists from other countries; and

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

2.3 Proposed activities that do not meet the above criteria cannot proceed through subsequent stages of the Framework without revision. Only proposed activities meeting these criteria should proceed through subsequent stages of assessment.

3 ENVIRONMENTAL ASSESSMENT

3.1 **Problem Formulation** defines the bounds of the assessment and characterization phase of the framework, i.e. steps 1.3.2.1 to 1.3.2.5. Proposals should include:

.1 information regarding the principal project team and their affiliations, as well as identification of the proposed funding sources and any financial and commercial interests;

.2 information required for the characterization of a proposed activity should include:

.1 the proposed activity location;

.2 the Fertilized Area (size);

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

.4 a detailed description of the composition and form of substance(s) to be added or redistributed and the source of the substance(s);

.5 the method, timing, and duration of both addition/redistribution of substance(s) and collection of data;

.6 the number, characteristics, and location of any structures to be located in the sea, if applicable;

.7 the anticipated fate of added/redistributed substances including, where appropriate, uptake and settling;

.8 the anticipated changes in concentration of substances introduced/redistributed into the ocean; and

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

.3 an activity-specific conceptual model should include:

.1 an Impact Hypothesis; and

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

.4 a formulation of Assessment Endpoints; and

.5 a plan for the monitoring of and reporting on observed impacts on the marine environment.

3.2 Site Selection and Description:

3.2.1 This section concerns the provision of data necessary for Contracting Parties to evaluate the physical, geological, chemical, and biological conditions at the Proposed Site, and the uncertainties in these conditions in relation to the proposed activity. These data can be used for both site selection and the analyses conducted in other elements of the Framework. These data are also necessary for the Experimental Baseline and the successful achievement of the scientific objectives of the proposed activity. Figure 2 depicts the planning and implementation stages of an ocean fertilization activity, including the Proposed Site.

3.2.2 An overall rationale for choosing the Proposed Region(s) should be provided based on the following key goals:

.1 suitability for testing the hypotheses;

.2 suitability for minimizing undesirable effects; and

.3 avoiding proximity to areas of special concern and value.

3.2.3 The rationale for site selection should take into consideration relevant criteria, including those listed below and should rank potential sites in order of priority.

3.2.4 Site description should include the following information for establishing both the Experimental Baseline and the Risk Assessment Baseline conditions and their variability:

.1 coordinates of the Proposed Region within which the site(s) will be selected;

.2 coordinates of the Region of Potential Impact;

.3 physical characteristics of the 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; and

.4 depth of mixed layer;

.2 sediment and seabed considerations:

.1 characteristics of sediments in the Region of Potential Impact; and

.2 bottom sediment transport to areas of special concern and value or coastal zones and the potential for re-suspension of added substances;

.3 transport and mixing considerations:

.1 intensity of vertical and horizontal mixing;

.2 currents – surface, mid-depth, and bottom water current direction and velocity; and

.3 exchange regime with the surrounding media, including the atmosphere;

Figure 2: Planning and Implementation Stages of an Ocean Fertilization Activity

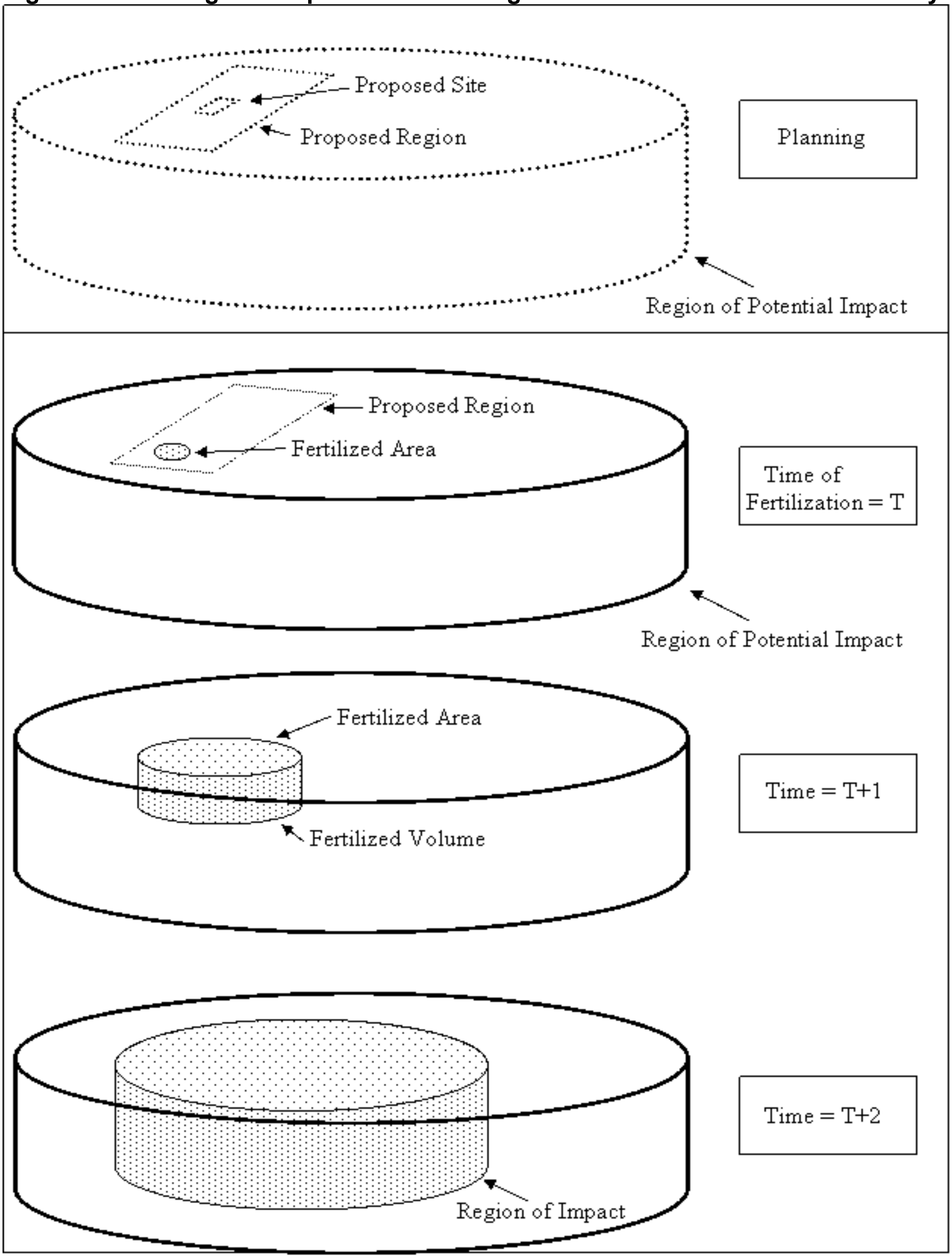


Figure 2: Planning and implementation stages of an ocean fertilization project. At the time of fertilization (time = T), the activity occurs at a location within the proposed region of the ocean (i.e. fertilized area). As time progresses the fertilized area and volume will change (shown as Time = T+1). The region of impact refers to the area of the ocean in which detectable changes (effects) occur as a result of ocean fertilization activity shown as (Time = T+2).

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

.1 temporal/seasonal conditions and wind variability that influences physical conditions at the proposed site; and

.2 wave period and height;

.4 chemical characteristics:

.1 dissolved oxygen and Climate-Active Gases;

.2 concentrations and composition of macro-nutrients (e.g., N, P, Si) and micro-nutrients (e.g., Fe, Zn);

.3 carbonate system, pH, alkalinity, etc., and dissolved organic carbon;

.4 particulate loading and fluxes; and

.5 contaminants;

.5 biological and ecological characteristics:

.1 benthic species and habitats in particular the presence of vulnerable ecosystems and protected species; as well as areas of special concern and value; and

.2 species expected in water column, in particular plankton community composition and dynamics, the presence of economically important species and vulnerable, endemic, protected and/or migratory species (including marine mammals and seabirds); and

.6 other considerations:

.1 proximity to other uses of the sea, e.g., fishing, navigation, engineering uses, areas of special concern and value, and traditional uses of the sea.

3.3 Exposure Assessment

3.3.1 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.

3.3.2 The proposal should discuss the implications of limited knowledge of Risk Assessment Baseline conditions.

3.3.3 Technical considerations should include:

.1 general category:

.1 type of ocean fertilization activity (e.g., artificial upwelling, nutrient addition);

.2 mode of application:

.1 mechanical description/method of delivery;

.2 any hazards due to ship operations or any structure to be located at sea (e.g., waste management, noise, exhaust gases); and

.3 any hazards if the substance 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; and

.2 hazardous properties of substance(s), including any impurities/ contaminants;

.4 physical characterization:

.1 form (e.g., solid, particle size, liquid solution, concentration);

.2 depth in water column of addition/redistribution;

.3 rate of addition/redistribution;

.4 Fertilized Area of ocean initially affected by the addition/redistribution of substance(s), and the intended Fertilized Volume;

.5 intended initial concentration of substance(s) in the Fertilized Volume;

.6 total amount of substance(s) to be added/redistributed;

.7 duration of the fertilizing process (including number of and interval between additions);

.8 other impacts on or changes to the physical environment (including temperature and buoyancy effects, as well as the effect of the physical apparatus) during the fertilization activity; and

.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/redistributed substances (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, re-suspension, subduction);

.2 chemical processes (e.g., decomposition, transformation, coagulation); and

.3 biological processes (e.g., transformation, bioaccumulation, bio-magnification);

.7 other considerations:

.1 other unintended impacts of the delivery method;

.2 conflicts of the delivery method with other legitimate uses of the sea; and

.3 cumulative exposure from repeated or other ocean fertilization activites, if relevant.

3.4 Effects Assessment

3.4.1 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.

3.4.2 Technical Considerations:

.1 Effects, such as changes to marine ecosystem structure and dynamics including sensitivity of species, populations, communities, habitats, and processes, within and outside 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; and

.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 food-web interactions (e.g., grazing responses, predator/prey relationships);

.3 potential for bioaccumulation and biomagnification of any toxins and contaminants in organisms;

.4 potential for acute or chronic effects from toxins or contaminants; and

.5 human health considerations, including food chain effects.

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

.2 In considering the effects listed in 3.4.2.1, the following potential adverse effects should be addressed:

.1 short- and long-term primary production changes, leading to impacts to fisheries or protected species, or other social impacts including visual amenity;

.2 short- and long-term 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;

.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 fertilization activities in close proximity in space and time;

.9 changes to sediment and benthic habitat; and

.10 downstream effects, such as nutrient robbing which may result in effects such as a decrease in production and/or a shift in species composition;

.3 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 Experimental Baseline conditions;

.2 natural variability within the Risk Assessment Baseline;

.3 longevity of the response; and

.4 lack of long-term monitoring in previous activities.

3.5 Risk Characterization

3.5.1 This section integrates the exposure and effects information to provide an estimate of the likelihood for adverse impacts and the magnitude of those impacts as indicated by the initial Impact Hypothesis. 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 should include a description of the risks and uncertainties associated with its conclusions.

3.5.2 *Identification of potential risks*: risk is a function of the magnitude of an adverse effect and its likelihood. Risks are characterized in terms of the assessment endpoints identified in Problem Formulation:

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

.1 physical: Examples include:

.1 the effects of permanent structures, such as pipes utilized to bring about upwelling of nutrient rich deep water to nutrient poor surface waters, include hazards to navigation and restriction of fishing grounds; and

.2 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.

.2 chemical: Examples include:

.1 changes in pH resulting from ocean fertilization. Ocean fertilization may lead to changes in the pH of seawater at the site of fertilization, depending on the type and chemical state of the fertilizing agents added. 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);

.2 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 decline 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 death of benthic communities; and

.3 generation of Climate-Active Gases, e.g., nitrous oxide (N_2O) and methane (CH_4).

.3 biological: Examples include:

.1 toxins can be produced as a result of harmful algal blooms. These toxins can have detrimental effects on shellfish and finfish, resulting in adverse effects on human health;

.2 enhanced primary productivity is the intention of many fertilization activities and a side-effect of others. This enhanced productivity may lead to changes in the community structure. This may lead to secondary effects including possibly enhanced fish populations or, alternatively, may enhance populations of less economically relevant species such as jellyfish; and

.3 changes to the nutrient composition of seawater, as a result of fertilization activities, 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.

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

3.5.4 *Cumulative impacts* may be anticipated as a result of other activities, e.g.:

.1 multiple activities in the same water body, e.g., aquaculture, offshore oil and gas exploration and other fertilization activities; and

.2 multiple fertilization activities in the same water mass over a period of time.

3.5.5 *Baseline*: baseline can be defined as the state of the ecosystem (including natural variability). The description will draw upon the activities and results of site characterization in section 3.2. There are two baselines of relevance to ocean fertilization operations: Experimental Baseline and Risk Assessment Baseline.

3.5.6 Data should be collected at different water depths and at as many geographical points as necessary to be representative of the Region of Potential Impact as defined in Figure 2 above.

3.5.7 For both Experimental and Risk Assessment Baselines information can be drawn from literature reviews, existing data from other activities, and targeted surveys.

3.5.8 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.

3.5.9 *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 occurs over in a matter of days or is more sustained; or the introduction of structures into the marine environment creating physical barriers and potentially causing long-term effects. 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 proposed operation. It should be taken into account that the Fertilized Volume can and will move over time in three dimensions. 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; and

.3 *Number of effects*: The number of effects identified as Assessment Endpoints by the 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.

3.5.10 *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 proposed fertilization activity 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 activity and the assessment endpoints. 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.

3.5.11 *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, such as exemplified in Figure 3A, and that together with the likelihood of effects, used to determine the risk conclusion through the following considerations:

.1 A conventional risk assessment matrix (Figure 3B) 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 in the matrix can be summarized using categories (e.g., "high" "medium" "low") or on a numerical scale;

.2 *Magnitude*: In the **Environmental 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 3B). 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 3A. Acute and chronic effects on human health or sensitive marine organisms should have the highest magnitude rating. National Action Lists could be used in this regard[4];

.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 3B;

.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; and

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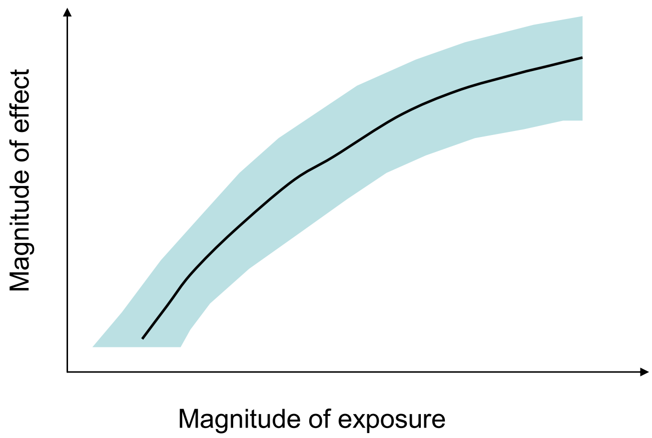
[4] See for instance document LC/SG 32/2.

.5 Evidence-based conclusions regarding magnitude of effect and likelihood are used to identify the cells, in Figure 3B, representing the risk conclusion for the Assessment Endpoint under consideration. Following this approach, a version of Figure 3B would be prepared for each Assessment Endpoint evaluated in the Environmental Assessment. It should be acknowledged here that the presentation of risks in Figure 3B is only one of several different approaches that could be used, depending on the needs and uses of the assessment.

A)



B)

Increasing acceptability ↘	Consequences			
	Severe	Moderate	Mild	Negligible
Probability				
High	High	High	Medium/Low	Very low
Medium	High	Medium	Low	Very low
Low	High/Medium	Medium/Low	Low	Very low
Negligible	High/Medium/Low	Medium/Low	Low	Very low

Figure 3 Relationship between magnitude of effect and exposure (A) and risk assessment matrix (B)

3.5.12 *Integrating across endpoints to produce an overall description of risk*: Once conclusions are reached regarding the risk to each Assessment Endpoint, an overall risk conclusion is to be developed 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:

.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 Parties 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; and

.2 regardless of the approach taken, the purpose of the integration is to inform the decision-making processes of Risk Management.

3.5.13 *Uncertainties*: In addition to describing and communicating the risks posed by the proposed fertilization activity, the Environmental Assessment is also to provide a description and summary of the uncertainties associated with its conclusions. Such a description is to include a listing of the significant/consequential assumptions, data gaps, and sources of variation in exposure and effect processes:

.1 this element of the the Environmental Assessment should go beyond a simple list and provide an evaluation of the uncertainties such that it is sufficient to inform decision-makers regarding the limitations and constraints associated with the risk conclusions, including the means for decision-makers to inform themselves about the implications for decision-making posed by those identified uncertainties; and

.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.

3.5.14 In general, risk increases with the magnitude of the effect, the size of the area over which it occurs, and the longer its duration. However, it should be considered that widespread, prolonged low-level effects may have greater potential for cumulative impact than contained, brief high-level effects.

3.5.15 The principal products of risk characterization are a series of evidence-supported predictions about the risks posed by a proposed ocean fertilization activity and a clear description of the uncertainties. These predictions are developed to inform the decision-making processes comprising Risk Management.

3.5.16 Because the Risk Management decisions are based on predictions, monitoring should seek to test these predictions, so that future Environmental Assessment can be improved.

3.6 Risk Management

3.6.1 Section objective: Risk Management procedures are necessary to ensure that, as far as practicable, environmental risks are minimized and the scientific benefits maximized and that a precautionary approach is followed.

3.6.2 The results from Risk Characterization will provide information for making Risk Management decisions.

3.6.3 The Risk Management process includes consultation with relevant countries to ensure that other activities in the Proposed Region are considered, and to allow for additional perspectives to be considered.

3.6.4 *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 additional conditions by the Contracting Parties or included as an intrinsic part of the proposal. Such strategies may include:

.1 temporal restrictions (e.g., during certain oceanographic conditions or biologically important times for species of concern);

.2 spatial restrictions (e.g., proximity to areas of special concern and value); and

.3 delivery restrictions (e.g., substances, tracers, amounts, repetition).

3.6.5 Contingency planning will also need to be considered to respond to monitoring in cases where the Impact Hypothesis is found to be incorrect. This may include the cessation of fertilization activities, particularly in the case of multiple additions over time or artificial upwelling.

3.6.6 *Monitoring*: A monitoring plan should be implemented in order to:

.1 verify that any conditions imposed by the Contracting Parties are met – *compliance monitoring* – and that the assumptions made during the assessment of the proposed activity review were correct and sufficient to protect the environment and human health – *impact monitoring*. It is essential that such monitoring programmes have clearly defined objectives. The type, frequency and extent of monitoring will depend on the Impact Hypothesis and local and regional consequences;

.2 determine the Region of Impact and to ascertain that changes are within the range of those predicted. The following questions should be answered:

  .1 what testable hypotheses can be derived from the Impact Hypothesis?

  .2 what measurements (type, location, frequency, performance requirements) are required to test these hypotheses?

  .3 how should the data be managed and interpreted?;

.3 take into account relevant research and modelling information in evaluating the design and requesting modification of impact monitoring programmes.

4 DECISION MAKING

4.1 A decision that a proposed activity is legitimate scientific research and is not contrary to the aims of the London Convention and Protocol should only be made if all earlier steps of the Framework, including the appropriate consultation and communication, have been satisfactorily completed and conditions are in place that ensure that, as far as practicable, environmental disturbance and detriment would be minimized and the scientific benefits maximized.

4.2 Consent should be sought from all countries with jurisdiction and/or in the Region of Potential Impact, without prejudice to international law including as reflected in the relevant provisions of UNCLOS.

4.3 If the risks and/or uncertainties are so high as to be deemed unacceptable, with respect to the protection of the marine environment, taking into account the precautionary approach, then a decision should be made to seek revision of or reject the proposal.

4.4 Authorization of the project includes the duration and location of the activity, the requirements for monitoring and reporting, and any other conditions required by Contracting Parties. This authorization should be communicated to the Secretariat and relevant countries.

5 RESULTS OF MONITORING

5.1 A report of any impacts of the ocean fertilization activities, including results of monitoring, should be communicated through the Secretariat.

5.2 Collection and use of information resulting from monitoring informs future decision making and can improve future assessments.

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

.1 modify or terminate the impact monitoring;

.2 modify or revoke the authorization;

.3 redefine or close the authorized site; and

.4 modify the basis on which proposals to conduct ocean fertilization activities are assessed.

6 GLOSSARY

Assessment Endpoint: The physical, biological or chemical attributes of the ecosystem to be protected, which may be adversely affected by the action of the experiment.

Climate-Active Gases: gases which affect the climate in some way, including, but not limited to greenhouse gases (CO_2, CH_4, N_2O), stratospheric ozone-depleting substances (CH_3Br, CH_3Cl, $CHBr_3$, etc.), aerosol-forming gases (DMS, NH_4) and volatile organic compounds which impact tropospheric photochemistry.

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

Fertilized Area: The surface area of the ocean into which substances are introduced. This area will change over time as substances are transported.

Fertilized Volume: The volume of the ocean in which substance concentrations have been purposefully elevated. This volume will change over time as substances are transported.

Impact Hypothesis: A concise statement of the expected consequences, as defined in Annex 2 paragraphs 12-15 to the London Protocol.

Marine Protected Areas (MPAs): any oceanic region which has been designated by national or international law to protect part or the entire enclosed environment.

Nutrient: a chemical element or compound found in the environment that organisms need to grow and survive. Nutrient requirements vary between organisms. Macro-nutrients are those nutrients that organisms require in relatively large amounts, and include nitrogen, phosphorus and silicate. Micro-nutrients are required in much smaller amounts but are nonetheless essential for growth and survival. Micro-nutrients include metals such as iron and zinc.

Nutrient Robbing: the depletion of essential nutrients downstream of the fertilized region as a result of the activity.

Proposed Region: The area of the ocean in which the Proposed Site is located.

Proposed Site: The surface area of the ocean into or through which substances are planned to be introduced.

Region of Potential Impact: The area of the ocean in which detectable changes would be expected to occur as a result of substance introductions.

Region of Impact: The area of the ocean in which detectable changes (effects) occur as a result of substance introductions.

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.

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