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Scientific Review of the Alfred Wegener Institute's Internal Risk Assessment for LOHAFEX

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Purpose of the Review

The AWI has prepared an internal scientific assessment of the proposed Indo-German iron fertilization experiment LOHAFEX. The assessment focuses on the potential for negative environmental impacts of the experiment. Our review examines the scientific quality of this assessment and the validity of its conclusions, in light of two recent international agreements concerning scientific research into iron fertilization (decision IX/16 of the Convention on Biodiversity of May 2008 and the subsequent resolution LC-LP.1 (2008) of the London Convention and London Protocol from October 2008). We pay particular attention to the COP-CBD declaration's mentioning of "*small scale scientific research studies within coastal waters*" as well as to the critical issues reported under LC-LP.1 (2008):

> ***4.*** *that scientific research proposals should be assessed on a case-by-case basis using an assessment framework to be developed by the Scientific Groups under the London Convention and Protocol;*
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> ***6.*** *that until specific guidance is available, Contracting Parties should be urged to use utmost caution and the best available guidance to evaluate the scientific research proposals to ensure protection of the marine environment consistent with the Convention and Protocol;*
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> ***7.*** *that for the purposes of this resolution, legitimate scientific research should be defined as those proposals that have been assessed and found acceptable under the assessment framework;*
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> ***8.*** *that, given the present state of knowledge, ocean fertilization activities other than legitimate scientific research should not be allowed.*

Our review therefore examines whether LOHAFEX represents "legitimate", appropriate, and responsible scientific research, whether it is a small scale experiment in coastal waters, and whether AWI's internal assessment has been conducted with "utmost caution" and represents "best available guidance" concerning the potential for risks to the marine environment.

In addition we make comments concerning our own assessment of the potential for risks or negative consequences for biodiversity and the marine environment associated with this experiment.

Is the experiment legitimate and appropriate?

The LOHAFEX experiment is aimed at a better understanding of how iron impacts marine ecosystem dynamics and consequently, the global carbon cycle. It addresses important, unresolved scientific questions concerning productivity and biodiversity changes during the growth and demise of natural, iron-induced plankton blooms. Most of the stated goals and aims of the LOHAFEX experiment address the past and future effects of natural Fe-fertilization on the marine ecosystem and the marine carbon cycle. Natural Fe-fertilization has varied strongly, on large geographical scales, throughout earth history in connection with changes in climate. It is possible, in response to anthropogenic climate change, that the future delivery of iron via atmospheric dust, or via the melting of icebergs, or changes in ocean circulation, will change dramatically with as yet poorly understood consequences for marine ecosystems and the carbon cycle. Because of the complexity and scale of the processes involved, it is not possible to obtain the required information from experiments in artificial settings in the lab. Experiments such as LOHAFEX are therefore appropriate and essential for collecting data needed to parameterize the impact of natural and climate-driven changes in iron supply to the Southern Ocean. These climate-related hypotheses are effectively presented and justified in the internal assessment and **address legitimate and important areas of basic science concerning the functioning of marine ecosystems and the carbon cycle.**

The experiment will collect some data (e.g. production of trace gases; fate of carbon; changes in species composition) to address hypotheses that are relevant to assessing either risks or effectiveness of deliberate CO_2 sequestration. Both the CBD text and the LC text recognise the need for more data of this sort, and both advocate such research in order to provide a better scientific base for regulation. It is legitimate and appropriate to use the experimental data to address these issues.

Location and scale of the proposed experiment

Location:

The experiment will be carried out in the Atlantic sector of the Antarctic Circumpolar Current (ACC), downstream of the Antarctic Peninsula. Water masses passing through this area can show signs of coastal influences due to contact with land and the shelf, generating an intermittent natural supply of iron. This leads to enhanced primary productivity relative to the rest of the ACC and the occurrence of coastal phytoplankton species. Artificial iron fertilization in this area therefore can be expected to mimic events of naturally enhanced iron concentration.

AWI's internal risk assessment makes clear that the location and experimental design involves adding iron within a region that is known to be significantly influenced by coastal waters (e.g. it is a region where the sediments contain spores of coastal phytoplankton species). The goal of the experiment is to fertilize an eddy that contains typical coastal phytoplankton species. The experiment will not take place in a marine conservation area.

The Convention on Biological Diversity text specifically allows small scale scientific research studies within coastal waters. There has been criticism of the restriction to "coastal waters" including very strong criticism by an advisory group appointed by the UNESCO Intergovernmental Oceanographic Commission (IOC). The restriction was noted but not repeated in the more recent London Convention resolutions (see above). Scientific definitions

of the term “coastal waters” in relation to marine biodiversity and measures to protect marine ecosystems reflect the fact that planktonic organisms (by definition) move around due to the action of wind, tides and ocean circulation. The chemical and physical characteristics of their habitat, and hence the coastal water ecosystem itself, is mobile for the same reason. Accordingly, The “European Community Biodiversity Clearing House Mechanism” defines “coastal waters” not on the basis of geography, water depth or location but rather on the basis of ecosystem characteristics. It defines “coastal waters” as being “marine benthic and pelagic ecosystems having substantial influence from the land”. The presence of coastal plankton species is such an ecosystem characteristic and **hence the LOHAFEX design, as presented in AWI’s internal assessment, is consistent with a scientific interpretation of the CBD text**. Nevertheless, we recommend that this arbitrary and unnecessary restriction to coastal waters be removed from all future regulations concerning this activity.

Scales

Spatial. The final size of the fertilized patch (300 km^2) is extremely small (0.0006%) in respect to the biogeographical province of the Antarctic Circumpolar current within which the experiment is planned to take place. The size of the proposed experiment is appropriate and responsible in that it is as small as possible for the attainment of the goals and testing of the hypotheses. Fertilization of an eddy is required to allow the fertilized patch to be monitored over the full duration of the experiment without the signal being diluted below detection limit via lateral mixing already during the experiment.

Temporal. The duration of the iron-induced stimulation of phytoplankton growth, if successful, will likely resemble that of phytoplankton blooms typical in the study area, i.e. several days. This is followed by a demise of the bloom within days to a few weeks. A temporary shift in the species composition observed in previous iron fertilization experiments did not cause a loss of species diversity. Previous iron fertilization in the Southern Ocean has not been found to stimulate toxic algae or enhance toxin production. While scientists tried hard to evaluate the long-term impacts of iron fertilization during previous experiments, in no case were any measureable environmental effects found a few weeks after the fertilization.

Magnitude of the Perturbation. The scale of the perturbation of seawater chemistry (e.g. iron concentrations) is fully evaluated in the internal assessment. Estimates based on the results of previous iron fertilization experiments show that the induced changes in chemistry, including nutrient and oxygen concentrations, are small compared to the natural variability in the surrounding region, and will not be detectable once waters within the eddy are diluted by lateral mixing within weeks after the end of the experiment.

Is the experiment responsible?

AWI’s internal assessment of effects

The assessment provided by the AWI presents a very detailed analysis of the known possible risks to the environment. The quality of the analysis benefits from the research team’s extensive knowledge of marine ecosystem and biogeochemical processes, marine biodiversity, trace gas chemistry and the region proposed for the experimental site. This depth of knowledge is evident from the assessment, which also benefits from information collected during 6 previous fertilization experiments conducted in the Southern Ocean, including 2 experiments led by Prof. Smetacek. The database on oceanographic and ecosystem conditions in the region is extensive, due to decades of prior study by AWI

scientists and other groups. **Our judgment is that this analysis has indeed been conducted according to the best available scientific guidance**.

Reviewers' assessment of potential risks for the marine environment

Iron fertilization in the proposed study area is expected to stimulate phytoplankton growth, potentially leading to an increase in algal biomass. A temporary shift in the species composition observed in previous iron fertilization experiments did not cause a loss of species diversity. Iron fertilization in the Southern Ocean has not been found to stimulate toxic algae or enhance toxin production. Previous experiments also did not show a net effect on the production of climate relevant gases. An exception may be N_2O, although previous results are conflicting. In any case, the potential for extra N_2O production is negligible in a climate-related sense given the small scale and limited duration of the iron fertilization. Any possible impurities of the iron sulphate ($FeSO_4$) used as the iron source will be expected to have no side effects on the marine biota due to their low concentrations compared to background levels in seawater. For the purpose of tracking the fate of the iron-enriched water, fertilization is accompanied by the injection of approximately 600 grams of sulphur hexafluoride (SF_6). SF_6 is an inert and non-toxic gas (it is safe to breathe for humans, for example in a mixture of 80% SF_6 - 20% oxygen). Over a period of one to two months most will escape from the surface water to the atmosphere. The amount is completely trivial compared to the c. 5000 tonnes per year emitted to the atmosphere by industry.

Estimates based on previous fertilization experiments in the Southern Ocean show that the induced changes in oxygen concentrations due to primary production in the surface layer and respiration in deeper waters are at least a factor 10 to 100 smaller than the natural variability in the study area. At the spatial and temporal scales of the planned LOHAFEX experiment there is no reason to expect any detectable downstream effects on deep water oxygen or nutrient concentrations.

Summary and Recommendations

We view the proposed LOHAFEX experiment as **legitimate, appropriate and responsible basic scientific research** that is timely and should help to improve our understanding of past and likely future impacts of changing natural iron supplies on marine ecosystems and carbon fluxes in the Southern Ocean. AWIs internal assessment of risk is thorough and competent and based on the best scientific guidance available: it shows that there is no evidence for, or reason to suspect, negative environmental impacts from this experiment. The experiment itself is of the smallest scale possible consistent with a chance to address its scientific goals. **For these reasons we consider that LOHAFEX has been planned with the utmost caution.**

The experimental design of LOHAFEX is therefore consistent with the requirements of the Convention on Biodiversity and the London Convention and London Protocol.

Finally we recognize that a large amount of monitoring data are to be collected during the experiment and we encourage the responsible scientists to make these data publicly available as quickly as possible after the experiment in order to support further development of international standards for the evaluation of such activities.