Defining Responsible Research and Innovation (RRI) for OceanNETs:

Conducting responsible research on ocean-based carbon dioxide removal

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OceanNETs seeks to improve our knowledge about the potential risks and benefits associated with different methods of ocean-based carbon dioxide removal (CDR), so that societies are better prepared to make informed choices about their further development or eventual deployment.

Although OceanNETs research is limited to computer modelling, laboratory, and mesocosm experimentation, we are assessing forms of carbon dioxide removal that would imply, were they to be adopted, interfering with Earth system properties at large scale. The OceanNETs mesocosm experiments in ocean alkalinity enhancement in particular involve manipulations of living organisms. They are also likely to be among the first of their kind anywhere in the world, thus presenting both a challenge and an opportunity for developing robust RRI principles.

1 A brief introduction to RRI

Responsible Research and Innovation (RRI) encompass a series of principles and good practice models intended to help researchers anticipate and reflect on the potential societal impacts of their work.

Von Schomber (2012) provides the following definition of RRI:

"A transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)."

This or similar definitions have since been incorporated in EU or national-level research funding frameworks, including our own Framework Programme, Horizon 2020.

Thematic foci of RRI in EU-sponsored R&D activities include public engagement, open access to scientific data, gender equality, research ethics, and a commitment to science education.

Further specifications of RRI principles have been developed in the context of research on 'climate engineering.' Those frameworks identified four dimensions that should be embedded in R&D projects: anticipation, reflexivity, inclusion and responsiveness (Stilgoe et al 2013).

Anticipation refers to a process of systematic thinking on the sorts of futures that might derive from the research and innovation being conducted. *Reflexivity* describes the activity of scrutinizing the broader value systems and social theories that shape research endeavours. *Inclusion* is a call to engage from the start those actors that might be affected by the research being conducted or its application, and *Responsiveness* describes the ability to adjust course in reaction to the views and priorities of the broader network of societal actors with a stake in the research process.

2 RRI at the intersection of public perceptions of marine CDR and their governance

As presently constituted, the field of ocean-based NETs or marine CDR includes a wide variety of potential interventions with very different governance implications. Each form of intervention is likely to require tailor-made governance arrangements, and raises slightly different questions from an RRI perspective. It remains to be seen whether generic categories such as ‘ocean-based NETs’ or ‘marine CDR’ will be robust enough to structure public debate once we advance in the assessment of individual options.

Research on public perceptions of ocean-based CDR suggests that its public acceptability will be guided by the distinction between ‘natural’ and ‘engineered’ approaches (Bertram and Merk 2020). This echoes earlier research on public perceptions of ‘climate engineering,’ which showed that describing hypothetical geoengineering technologies by analogy to natural processes (e.g. comparing chemical vents for DAC as ‘artificial trees,’ or describing stratospheric aerosol injection as ‘no different to the effects of a volcano eruption’) significantly increased levels of public support (Corner and Pidgeon 2015). Inversely, those interventions that appeared particularly artificial or involved active manipulations

It is important not note here that categories such as ‘natural’ and ‘engineered’ are not intrinsic to individual form of ocean-based CDR, but are entirely dependent on how the proposed intervention is framed, and how it is seen to impacts different communities and stakeholders. Social-scientific research into ‘blue carbon’ initiatives (and carbon sink conservation/restoration more generally) suggests, for example, that the local actors most directly affected by these efforts can perceive them as forms of social or environmental ‘engineering’ incompatible with existing livelihood strategies and cultural practices.

This is why the choice of terminology is critical. The use of a term such as ‘nature-based solutions,’ for example, tends to obviate the ‘engineering’ component of such interventions, while reinforcing the distinction with ‘artificial’ approaches that are by extension deemed ‘non-natural.’ Similarly, a term such as ‘negative emissions technologies’ implies a level of technical development that is not warranted for most of the interventions being considered by OceanNETs.

A second key insights from research into public perceptions of carbon dioxide removal is that judgments are also direcly influenced by whether respondents perceive the intervention in question to be compatible with a transition towards low-carbon societies or, rather, as contributing to entrenching GHG emissions (Cox et al 2020).

3 Ocean alkalinity enhancement

Ocean alkalinity enhancement is likely to be the type of ocean-based NET with the highest public prolife, given that OceanNETs and other consortia are planning physical experiments in marine environments, and that these will be the first of its kind. Given its ‘first-in-class’ character, OceanNETs will effectively need to invent a governance process for experiments in artificial ocean alkalinization.

There is little applicable guidance on how to define the responsible governance of such experiments, other than the standard criteria applied by national regulatory agencies to the conduct of scientific experiments, and extrapolations from principles governing other types of research in marine environments.

Previous research on public perceptions of ‘climate engineering’ suggests that the perceived controllability of experiments is key to their acceptability. Controllability is, however, a multidimensional category that includes 1) level of containment; 2) uncertainty of experimental outcomes; 3) reversibility of environmental impacts; and 4) scientific integrity (Bellamy, Lezaun and Palmer 2017). In other words, scale/location of the experiment and its degree of containment, while important, are not the only criteria that guide public perceptions of their acceptability.

These issues manifested themselves in the controversies that have surrounded ocean iron fertilization experiments since the early 2000s. Studies such as the Southern Ocean Iron Experiment (SOFeX), the European Iron Fertilization Experiment (EIFEX), and in particular the 2009 LOHAFEX study triggered expression of concern from key actors in international governance, including the United Nations Conference on Sustainable Development, the Conference of the Parties to the Convention on Biological Diversity and the Intergovernmental Oceanographic Commission of UNESCO.

The private fertilization activities carried out by the Haida Salmon Restoration Corporation (HSRC) in 2012 off the coast of British Columbia led to a resolution by contracting parties to the London Convention and London Protocol to amend the Protocol in order “to regulate the placement of matter for ocean fertilization *and other marine geoengineering activities*.” (This resolution is not yet in force.)

The essential point here is that ocean iron fertilization, construed as a form of “geoengineering,” is likely to be a relevant analogy in public debates over ocean alkalinisation experiments and their governance. This makes our approach to RRI particularly important, as it represents a key component in the governance model that OceanNETs proposes for marine CDR research.

4 OceanNETs RRI: process

Our proposal is that RRI remains a ‘live’ issue within OceanNETs as the project evolves, that it continues to be discussed throughout the evolution of the project, so that by the end we have generated a practical experience of RRI in the field of ocean carbon dioxide removal that is directly relevant to the specific research we are conducting and of value to similar projects in the future.

Internally, this means that the consortium will regularly debate the operational meaning of the four above listed RRI principles for its research practices (modelling, experimentation, scenario-development).

Externally, it means that we will treat our research, and particularly the mesocosm and scenario development for ocean alkalinity enhancement, as opportunities “to create engagements, reflect upon them, and tie the insights to concrete governance” (Low and Buck 2019).

We will continue to hold Knowledge Exchange meetings on this issue, focusing on different aspects of OceanNETs work as it evolves. These collective reflections will be synthesized into a public document that will be refined and discussed regularly with the project’s stakeholders.

5 OceanNETs RRI: principles

To initiate this discussion, we propose the following two principles/questions. We draw on ongoing attempts to translate RRI into guidelines for research on climate engineering (e.g. Hubert 2017; McDonald et al 2019; National Academies 2021):

- *Early and long-term engagement with scientific, economic, conservation stakeholders and the wider community in the regions where mesocosm experiments are planned*. In addition to mapping perceived risks and concerns, how can we help local stakeholders weigh potential local/regional benefits from the proposed interventions?

- *Explicit consideration in the different strands of work (modelling, scenario development, mesocosm studies) to how the proposed interventions may impact low-carbon transitions*. Given that they are a key input in any decision about advancing ocean-based NETs, how can we increase the reflexivity of the modelling and scenario work in relation to this question?

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