Brief Summary of Marine Geoengineering Techniques*

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Leaflet available on Cefas website at:
https://www.cefas.co.uk/publications/files/20120213-Brief-Summary-Marine-Geoeng-Techs.pdf

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Marine Geoengineering – What is it?

1. Climate-related geoengineering techniques are generally classified into ‘Solar Radiation Management’ (SRM) and ‘Carbon Dioxide Removal’ (CDR). Most of the marine geoengineering techniques fall into the CDR category.
2. For the purposes of the London Convention and Protocol, it is useful to classify marine geoengineering techniques into:
   - Those involving the deposit of wastes or other matter into the ocean, and
   - Those involving the deposit of structures or devices into the ocean, whether free floating, floating but tethered to the seabed or directly placed on the seabed.

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MARINE GEOENGINEERING – DEPOSITS OF WASTES OR OTHER MATTER - 1

- **Ocean fertilization** – Using iron, nitrogen or phosphorus intended to stimulate primary productivity and thus through the 'biological pump', increase the carbon flux into deep-ocean where the carbon will remain for a period of from hundreds to several thousand years.
  - Potentially could also be used to enhance fisheries e.g. with nitrogen compounds.
  - Ocean iron fertilization has been the subject of some dozen field experiments and many papers and reports.
  - Use of buoyant flakes with slow release of nutrients has been proposed to enhance primary productivity.

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MARINE GEOENGINEERING – DEPOSITS OF WASTES OR OTHER MATTER - 2

- **Use of Marine Macroalgae for Carbon Sequestration -** Including the use of marine macroalgae as a fuel.
- **Depositing crop wastes on the deep seabed –** likely to be covered by existing LC/LP waste categories.
- **Artificially Enhanced Downwelling** - injecting CO2 into suitable downwelling currents to dispose of CO2 in the deep ocean.
- **Increase sea ice thickness** – Pumping sweater on the ice to freeze and thicken the ice using e.g. wind turbines.
- **Increasing Ocean Albedo (Reflectivity):**
  - Microbubbles
  - Reflective foams or particles

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MARINE GEOENGINEERING – DEPOSITS OF WASTES OR OTHER MATTER - 3

- **Enhancing Ocean Alkalinity** – Sequestering CO2 from the atmosphere by increasing the alkalinity (and the pH) of the ocean. Can be done in a variety of ways:
  - Adding CaO, $Ca(OH)_2$ or $CACO_3$ directly to the ocean.
  - CO2 dissolved in seawater e.g. from power stations, to produce carbonic acid that is then reacted with a carbonate mineral to form calcium and bicarbonate ions that are released into the sea.
  - Electrochemical splitting of calcium carbonate with the bicarbonate ions produced released into the ocean.
  - Electrolysis of seawater with the release of the Ca and Mg Cl_2 into the ocean. The hydrogen and chloride ions produced are combined to form hydrochloric acid that is reacted with silicate rocks on land releasing bicarbonate ions into the ocean via rivers.

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MARINE GEOENGINEERING – DEPOSITS OF WASTES OR OTHER MATTER - 4

- **Enhancing Ocean Alkalinity (Continued)**
  - Coastal spreading of olivine or serpentine rock where its natural weathering consumes CO2 and releases bicarbonate ions
- **Mineralisation of Rocks in the Seabed** – Injection of CO2 into basalt/ peridotite rocks where it reacts with Ca and Mg in silicate minerals to form stable carbonate minerals. Probably considered a different form of CCS.
- **CO_2 Storage in Ocean Waters and Sediments**:
  - In mid to deep waters
  - On the seabed
  - Within deep sea sediments

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MARINE GEOENGINEERING – DEPOSIT OF STRUCTURES OR DEVICES

- **Artificial Upwelling** - This uses pipes suspended in the ocean that may use wave action to pump water from several hundred metres depth up to fertilise surface waters.
- **Placement of dams across straits either completely or partially** – e.g. proposal to dam the Bering Strait. The aim would be to reduce the inflow of warm, salty water into the Arctic, thus decreasing the temperature and salinity of Arctic seawater and helping to cool the Artic.

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OTHER TYPES OF GEOENGINEERING - DIRECT AND/OR INDIRECT EFFECTS ON THE OCEAN

- In principle, most types of geoengineering could have implications for the oceans, albeit some of the effects would take place over long periods of time through changes in the global cycles of the movement of carbon, nutrients, sediment, etc. For example:
  - Marine Cloud Brightening, a particular type of SRM technique, aims to seed low-level, maritime stratocumulus clouds – which cover about 30% of the oceanic surface – with micrometer-sized seawater particles, thereby creating additional droplets inside the clouds, and increasing their reflectivity. This could have some impacts on the ocean environment.

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Other Activities in the Ocean with Potentially Similar Side-effects to Marine Geoengineering

- **Ocean Thermal Energy Conversion (OTEC) -** This uses the temperature difference between cooler deep and warmer shallow or surface ocean waters to run a heat engine and produce electricity. However, that deep water will be rich in nutrients and so its discharge in surface waters will have a fertilizing effect.
- **Deep Water Source Cooling -** deep ocean water is being used to cool buildings in tropical areas particularly islands close to the deep ocean. It brings the same problems referred to above for OTEC.
- **Weakening Hurricanes** - using pipes in the ocean to carry warm water down to at least 100 metres thus cooling surface waters to drain hurricanes of some of their energy. .

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Thank you!