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Ocean-based Climate Actions Recommended by Academicians from Europe and China

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Along with global warming and anthropogenic impacts, ocean acidification deoxygenation and sea level rising have resulted in tremendous ecological losses at species, diversity and ecosystem levels, leading to serious consequences. This calls for a dramatic scaling up of efforts towards ambitious mitigation and adaptation. A joint working group from the Chinese Academy of Sciences (CAS) and the European Academy of Sciences (EurASc) on ocean-based measures for climate action is thus formed at the moment.

The CAS-EurASc Working Group evaluated 19 ocean-based measures grouped into four major categories: (1) Measures addressing the causes of climate change, including *Renewable energy*, such as offshore wind energy; *Restoration and conservation of coastal blue carbon ecosystems*, as well as seaweed cultivation; *Enhancing Open Ocean Productivity* by fertilization, such as iron fertilization; *Alkalinization* by intentional dissolution of calcium carbonate or other minerals such as olivine to enhance CO₂ removal and/or carbon storage, this is particular beneficial for areas with hypoxia and acidification; and *Hybrid methods* such as marine- or land-fueled biomass energy plus accelerated weathering of limestone; renewable energy based negative emissions electricity/H₂ with ocean alkalinity production; storage marine organic carbon and biochar and subsurface ocean or under seafloor storage of captured CO₂; (2) Measures supporting biological and ecological adaptation, including *Pollution reduction*, *Restoring hydrology*, *Eliminating over-exploitation* of living (including vegetation and fish stocks) and nonliving resources (e.g., sand, minerals), *Relocation, restoration, and protection* of marine habitats, such as coral and oyster reef, and *Assisted evolution* (human intervention to accelerate the rate of naturally occurring evolutionary processes); (3) Solar radiation management, e.g. *Marine cloud brightening*, which involves the spraying of seawater into the lower atmosphere to enhance the production, longevity and brightness of stratocumulus clouds, and *Albedo enhancement* by producing long-lived ocean foam or by artificially increasing sea-ice cover in polar regions; and (4) Measures to enhance societal adaption, such as *community-based adaptation*, *improving risk reduction policies*, *infrastructure-based adaptation*, *relocate people*, *relocate and diversify economic activities* and *early warning, precautionary approach, emergency response system*.

The working group clustered these ocean-related measures into four policy-relevant clusters: Decisive, Low Regret, Unproven and Risky measures. “*Decisive measures*” address the causes of climate change, such as *Marine renewable energy* and *Carbon Capture and Storage*. “*Low Regret measures*” provide both climatic and non-climatic benefits, with few disbenefits, such as *Conservation, Restoring and enhancing blue carbon ecosystems*. “*Unproven measures*” are illustrated by *marine bioenergy with carbon capture and storage*, and some forms of *Assisted evolution*. “*Risky measures*” are mostly defined based on their potentially high disbenefits: *Enhancing open-ocean productivity* through ocean fertilization; *Enhancing weathering and alkalization*, as well as solar radiation management measures *Marine cloud brightening* and *Surface albedo enhancement*, neither of which would ameliorate ocean acidification. Whilst all these actions have a very large theoretical potential to address climate change globally, most of them have not been tested. These risky measures may also have unintended adverse consequences and some are short-lived, implying a long-term commitment. Much more attention needs to be given to their international governance and public acceptability before they can be considered for implementation as climate policy responses.

Some of the measures reviewed by the CAS-EurASc Working Group are rapidly being implemented. Significant progress is being made on the deployment of marine renewable energy, and research on negative emission technologies is rising. These ocean-based solutions may provide major benefits to society. It is critical that their implementation is sustainable, and that they do not add further stress to the already severe consequences of climate change. The CAS-EurASc Working Group also emphasize that ocean-related measures should not be considered as a substitute for climate mitigation or non-ocean-based adaptation measures. Ocean-based climate mitigation should prioritise *Decisive* and *Low Regret* measures, improve knowledge on the *Unproven* measures, and very cautiously weigh the *Risky* ones.

Full report:

Gattuso J.-P., Jiao N., Chen F., Jouzel J., Le Quéré C., Lu Y., Tréguer P., von Schuckmann K., Wang Z. L. & Zang J., 2022. *Ocean-based climate action*. 12 p. Chinese Academy of Sciences and European Academy of Sciences. DOI: 10.5281/zenodo.6410659