POLICY BRIEF:

Ocean health dictates Europe's water security

KEY POLICY ASKS FOR THE EUROPEAN LEADERS

- Fund priority ecological research
- Integrate ocean water resilience to mCDR certification
- Modernise EU ocean restoration and coordinate mCDR governance

OCEANRY

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SUMMARY:

Europe's weather begins at the ocean. Much of its rain starts as water evaporated from the North Atlantic and the Mediterranean and carries the heat that shapes our climate. Plankton, the base of ocean life, help clouds form and remove CO_2 from the atmosphere through the biological carbon pump. But plankton need iron to grow, and as a side effect of commercial fishing, up to 30,000 tonnes of iron stored in the bodies of fish is removed from the ocean every year instead of being recycled back into the water. Ocean iron replenishment (OIR) returns trace amounts of iron to open ocean areas where its lack limits plankton growth, biomimicking natural dust and volcanic ash deposition. The role of iron has been studied for over 30 years, but key knowledge gaps remain. Europe should now establish a dedicated research framework for ocean trials and a regulatory pathway to govern mCDR safely at large scale.

Key policy asks for the European climate leaders:

1. Fund priority ecological research through controlled mesocosm trials.

Resolving the current knowledge gaps around ocean iron replenishment requires answering fundamental ecological questions about species response, downstream nutrient dynamics, and marine cloud formation. When properly managed, ocean iron replenishment provides a highly scalable, nature-positive restoration and carbon removal pathway. CarbonGap recommends €2.6 billion for early-stage carbon removal by ring-fencing dedicated funding within FP10 and the European Competitiveness Fund. This would enable safe, controlled mesocosm studies as the essential bridge from laboratory research to ocean trials.

2. Integrate ocean water resilience to mCDR certification under the CRCF.

European water security begins at sea, where marine biological systems drive the moisture and weather patterns that sustain the continent. Integrating ocean restoration into the European Water Resilience Strategy ensures a comprehensive approach to climate stability. To support this vision, the EU must establish dedicated, high-integrity monitoring, reporting, and verification (MRV) methodologies for mCDR within the Carbon Removal Certification Framework (CRCF). Standardized baselines and independent scientific guardrails are essential to guarantee ecological safety, maintain public trust, and certify durable ocean carbon removal.

3. Modernise EU ocean restoration and enable coordinated mCDR governance.

Existing EU policy, including the Nature Restoration Law and Biodiversity Strategy 2030, focuses on habitats and species rather than functional nutrient cycles. Establishing a clear regulatory framework for ocean iron replenishment fills this critical gap, modernising EU marine restoration. Integrating mCDR across biodiversity, climate and marine legislation alongside the upcoming Ocean Act will establish predictable permitting pathways, robust environmental safeguards, and essential links to European monitoring infrastructure like OceanEye.

Oceanry welcomes the opportunity to contribute to upcoming European Union policy discussions to help shape these frameworks.

BACKGROUND:

Why ocean health governs European water balance

Most of the rain that falls in Europe begins as ocean evaporation. The North Atlantic acts as both the source of moisture and the heat engine that makes northern Europe habitable. Two critical disruptions are threatening this balance:

- **Thermal and chemical stress**: The ocean has absorbed more than 90% of the excess heat trapped by greenhouse gases, and it is taking up CO_2 at a rate that is measurably acidifying surface water.
- **Circulation instability**: Alongside this, the strength of the Atlantic Meridional Overturning Circulation (AMOC) is a critical scientific question, and a weakening would directly reorganise European rainfall and temperature patterns.

THE ESSENTIAL ROLE OF PLANKTON

Half of all oxygen in the Earth's atmosphere is produced in the ocean. It is done by phytoplankton, tiny organisms too small to see with bare eyes. Through photosynthesis, they drive the biological carbon pump, the process that moves carbon from the surface into the deep ocean. This process explains to a large extent why the ocean holds more carbon than the atmosphere and every terrestrial plant combined.

The ways by which oceans sustain life on land reach well beyond carbon. Every oceanic fish stock in Europe is dependent on healthy oceans through balanced marine food webs and plankton serve as the base of the marine food web.

Oceans also play a critical role on how clouds form. Water vapour needs tiny particles to condense on - called cloud condensation nuclei. Without such particles there are no droplets to form clouds. Clouds not only provide steady rain but also effectively reflect sunlight back to space owing to their white color, thus providing a cooling effect compared to sunlight hitting the darker ocean surface.

Above the open ocean, there are intrinsically few particles, and consequently, droplets. Over terrestrial areas there are plenty of particles of dust, pollen, smoke and pollution, all of which can act as cloud condensation nuclei to form clouds. Above the open ocean, cloud formation relies substantially on plankton. As plankton are grazed and broken down, they release gases that feed into cloud formation.

In order for plankton to thrive, they need what any plant needs: light, carbon dioxide, and nutrients such as nitrogen and phosphorus. They also need iron, in trace amounts, as iron is part of the machinery that photosynthesis runs on.

Human activity has been removing iron from the natural system. Commercial fishing alone removes up to 30,000 tonnes of iron per year in the fish catch (*Moreno and Haffa 2014*). This is roughly the mass of four Eiffel

Towers annually. In essence, iron that stays in the ocean circulates through predation, through excretion, and through the sinking of dead organisms. Iron that gets removed due to fishing decreases the amount of iron in circulation by leaving the system.

THE SOLUTION:

Restoring plankton through Ocean Iron Replenishment

Ocean Iron Replenishment (OIR) biomimicks something that already happens in nature. Dust storms and volcanic ash all carry iron into the open ocean. OIR does the same thing deliberately, and on a scale that can be measured. Trace amounts of natural iron-rich mineral dust are released into iron-limited open water, more than 200 km from any coast, at concentrations of parts per trillion. The aim is to return a crucial nutrient back into circulation that human activity has been taking out. Iron replenishment is neither a substitute for cutting emissions, but provides an additional, nature-based method to remove carbon dioxide from the atmosphere.

More than a dozen controlled trials since 1993 have shown that very small additions of iron increase phytoplankton growth in iron limited water. In the most successful trials, at least half of the resulting bloom sank below 1,000 metres, allowing carbon to stay out of contact with the atmosphere for centuries (*Smetacek et al., Nature, 2012*). Location and timing are the most significant factors determining the success of the method.

There are still research gaps, including:

- How large a fraction of the fixed carbon sinks into the deep ocean, and how long does it stay there?
- Which plankton species are favoured and which are displaced, and how the possible community shifts cascade through the food web?
- How does iron replenishment affect oxygen and nutrient concentrations in the treated and surrounding marine areas?
- How large is the contribution of plankton to the release of cloud-forming nuclei?
- How to define and monitor success in OIR trials?

ExOIS, a U.S-based international coalition is planning the next generation trials and has set out to answer several of these questions. Oceanry supports the ExOIS governance framework and advocates for active European leadership in it.

About Oceanry

Oceanry is a Finnish non-profit organisation advancing OIR to restore marine ecosystems and strengthen natural climate solutions. Our science-based approach revitalises plankton, enhancing marine biodiversity, stimulating cloud-forming aerosols, and driving durable carbon removal. Oceanry integrates biological oceanography, atmospheric chemistry, and policy advocacy to build universally accepted, safe, and scalable frameworks for ocean restoration. Working alongside international research institutions, Oceanry provides the empirical data and ethical guardrails needed to revive the ocean's natural carbon cycle.

For more information: oceanry.org

Oceanry's research programme runs in three stages, with each stage gated on the one before:

1.
Modelling: plankton growth, carbon export, satellite measurement, aerosol production.

2.
Mesocosm experiments in fully enclosed systems, where effects can be measured against controls.

3.
Open ocean experimentation at high seas at the North Atlantic, conducted under the assessment framework of the London Convention and Protocol.

References and more reading:

Alldredge, A. L., & Silver, M. W. (1988). Characteristics, dynamics and significance of marine snow. Progress in Oceanography, 20(1), 41–82. https://doi.org/10.1016/0079-6611(88)90053-5

Boyce, D. G., Dowd, M., Lewis, M. R., & Worm, B. (2014). Estimating global chlorophyll changes over the past century. Progress in Oceanography, 120, 32–33.

Boyd, P. W., Jickells, T., Law, C. S., Blain, S., Boyle, E. A., Buesseler, K. O., … Turner, S. (2007). Mesoscale iron enrichment experiments 1993–2005: Synthesis and future directions. Science, 315(5812), 612–617. https://doi.org/10.1126/science.1131669

Boyd, P. W. et al (2019). Multifaceted particle pumps drive carbon sequestration in the ocean. Nature 568, 327–335

Bradshaw, H. (2024). Migratory fish species are in drastic decline, a new UN report details. Science News. https://www.sciencenews.org/article/migratory-fish-decline-un-report

Coale, K. H., Johnson, K. S., Fitzwater, S. E., Gordon, R. M., Tanner, S., Chavez, F. P., … Kudela, R. (1996). A massive phytoplankton bloom induced by an ecosystem-scale iron fertilization experiment in the equatorial Pacific Ocean. Nature, 383, 495–501. https://doi.org/10.1038/383495a0

De La Rocha, C. L., & Passow, U. (2007). Factors influencing the sinking of POC and the efficiency of the biological carbon pump. Deep-Sea Research Part II, 54(5–7), 639–658. https://doi.org/10.1016/j.dsr2.2006.11.004

Field et al. (1998). Primary Production of the Biosphere: Integrating Terrestrial and Oceanic Components. Science. https://www.science.org/doi/10.1126/science.281.5374.237

Hamme R., Webley P., Crawford W., F. Whitney (2010). Volcanic ash fuels anomalous plankton bloom in subarctic Northeast Pacific Geophysical Research Letters. DOI:10.1029/2010GL044629

Iversen, M. H., & Ploug, H. (2010). Ballast minerals and the sinking carbon flux in the ocean: carbon export mediated by mineral ballasting. Marine Ecology Progress Series, 416, 47–66. https://doi.org/10.3354/meps08788

Martiny AC, Ustick LJ, Westberry TK, Behrenfeld MJ. Genomic-to-space measurements reveal large-scale ocean nutrient stress. Sci Adv. 2026 Jun 5;12(23):eaed8089. doi: 10.1126/sciadv.aed8089. Epub 2026 Jun 5. PMID: 42247500; PMCID: PMC13240183.

Moreno, A. R., & Haffa, A. L. M. (2014). The impact of fish and the commercial marine harvest on the ocean iron cycle.PLoS ONE, 9(9), e107690. https://doi.org/10.1371/journal.pone.0107690

Moore, C. M., et al. (2013). Processes and patterns of oceanic nutrient limitation. Nature Geoscience, 6, 701 to 710.

NASEM (National Academies of Sciences, Engineering, and Medicine). 2021. A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration. Washington, DC: The National Academies Press. doi: 10.17226/26278

Quinn, P. K., and Bates, T. S. (2011). The case against climate regulation via oceanic phytoplanktonsulphur emissions. Nature, 480, 51 to 56.

Siegel, D. A., DeVries, T., Doney, S. C., and Bell, T. (2021). Assessing the sequestration time scales of some ocean-based carbon dioxide reduction strategies. Environmental Research Letters, 16(10), 104003.

Smetacek, V., Klaas, C., et al. (2012). Deep carbon export from a Southern Ocean iron-fertilized diatom bloom. Nature, 487, 313 to 319.

Ratnarajah, L., Lea, M.-A., & Law, R. (2014). The biogeochemical role of baleen whales and krill in the Southern Ocean.PLoS ONE, 9(9), e107210. https://doi.org/10.1371/journal.pone.0114067

Turner, J. T. (2015). Zooplankton fecal pellets, marine snow, phytodetritus and the ocean's biological pump. Progress in Oceanography, 130, 205–248. https://doi.org/10.1016/j.pocean.2014.08.005

Tagliabue, A., Bowie, A. R., Frew, R., Martin, A., & Strzepek, R. (2017). The integral role of iron in ocean biogeochemistry.

WHOI ExOIS Working Group (2023). Paths forward: Exploring ocean worlds with interdisciplinary science .Woods Hole Oceanographic Institution. https://gfd.whoi.edu/wp-content/uploads/sites/54/2023/10/PathsForward-ExOIS-Full.pdf