UNIVERSITÀ POLITECNICA DELLE MARCHE

European MARINE BOARD
Advancing Seas & Ocean Science

NATIONAL BIODIVERSITY FUTURE CENTER

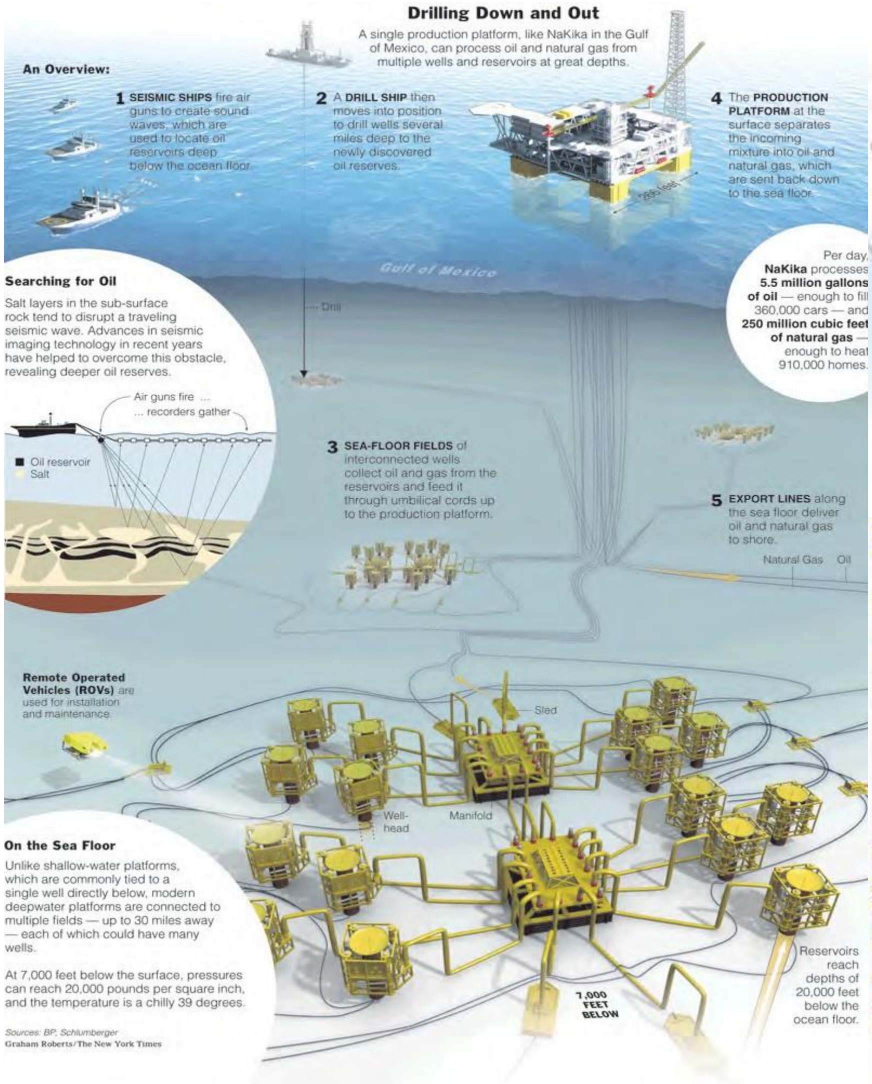
Restoration of deep-sea habitats to rebuild European Seas

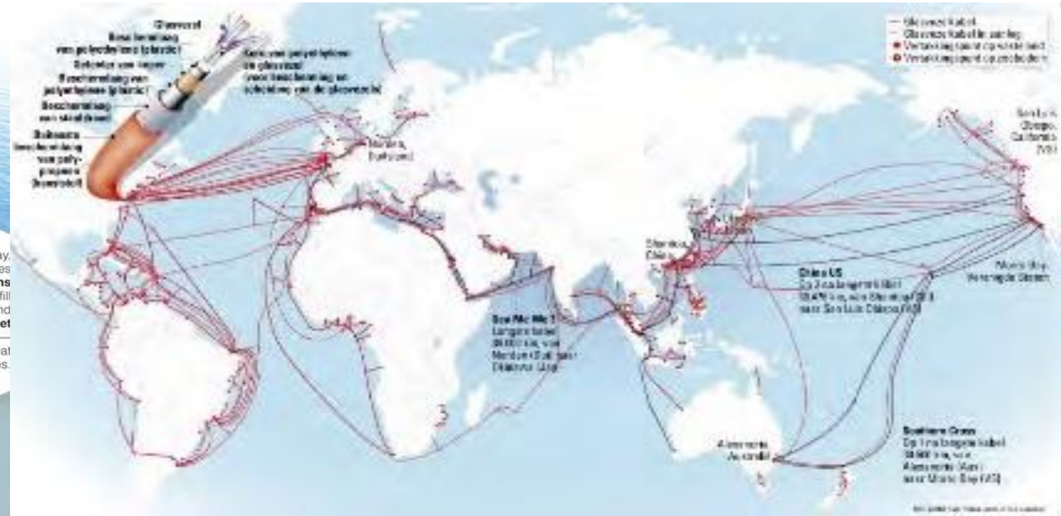
Roberto Danovaro

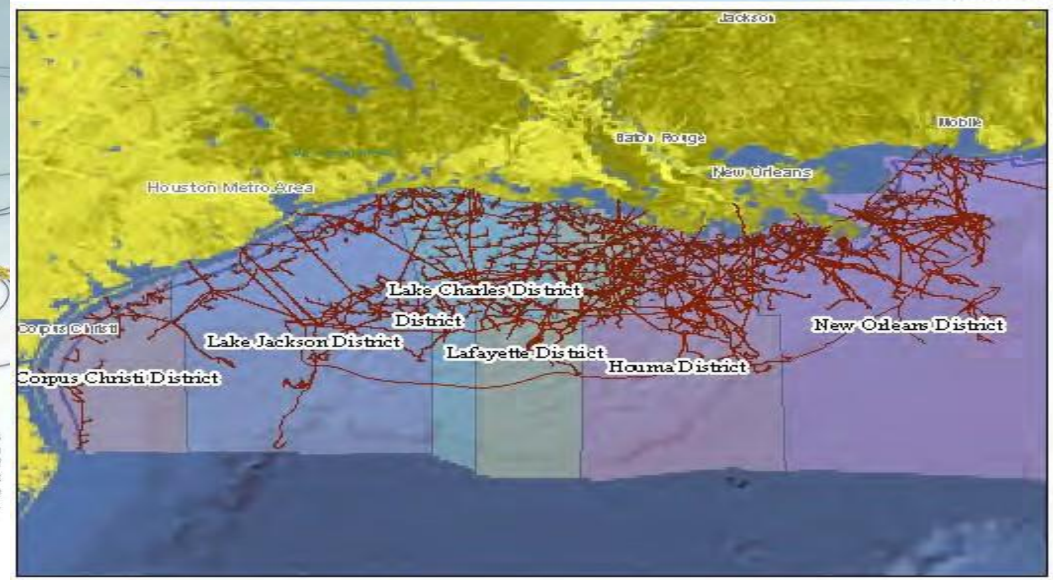
Polytechnic University of Marche

National Biodiversity Future Centre

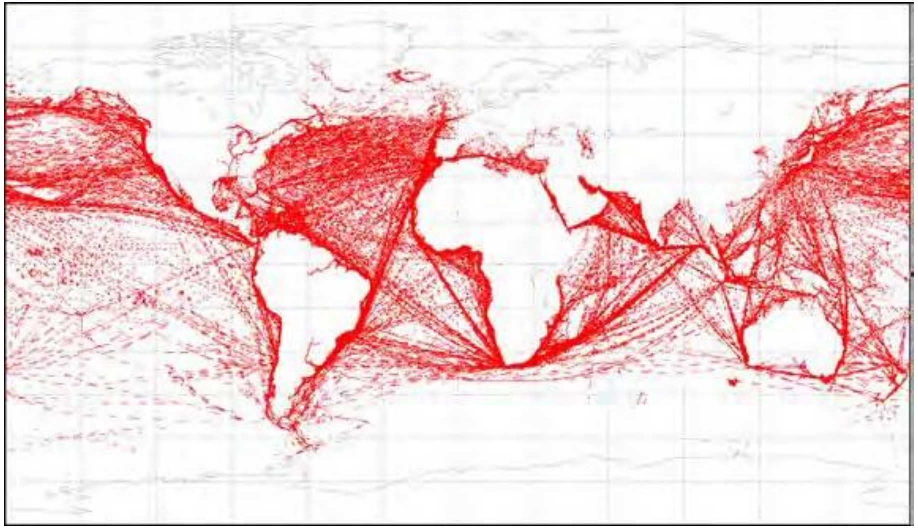
An increasingly crowded deep sea

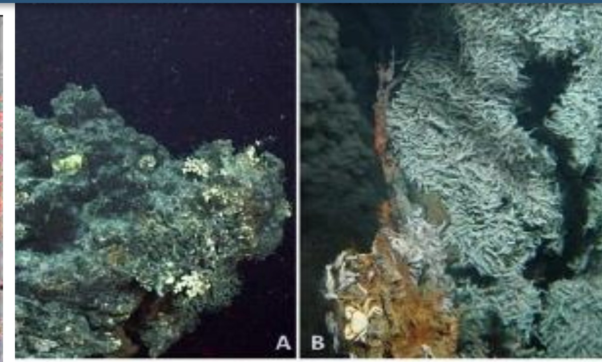




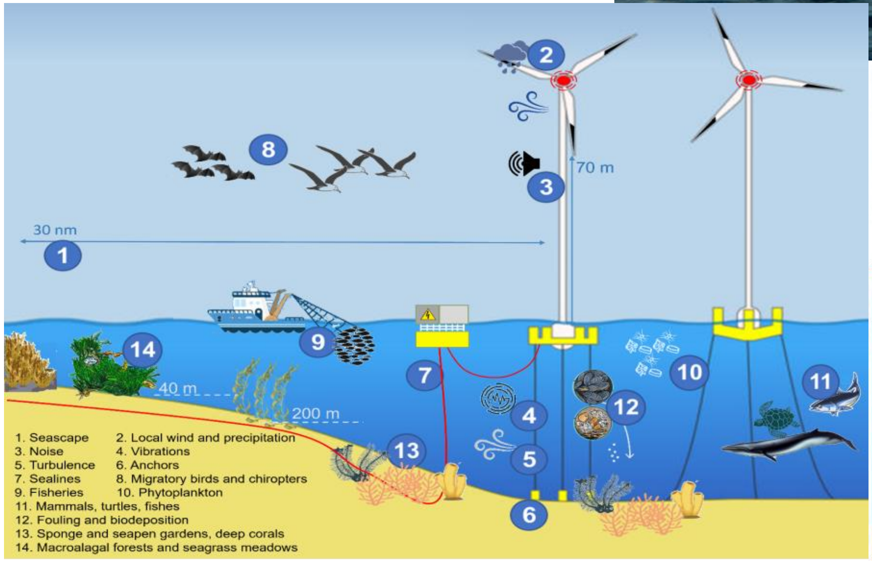


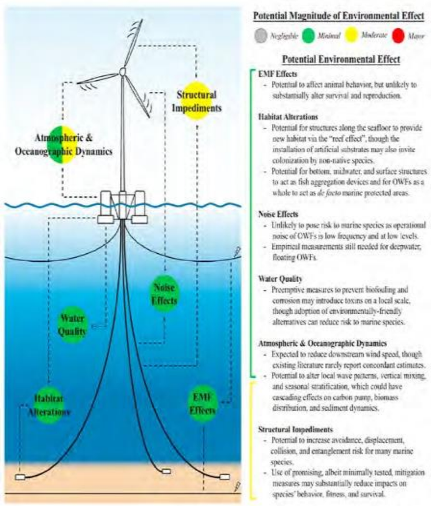
Sea lines, cables, pipelines

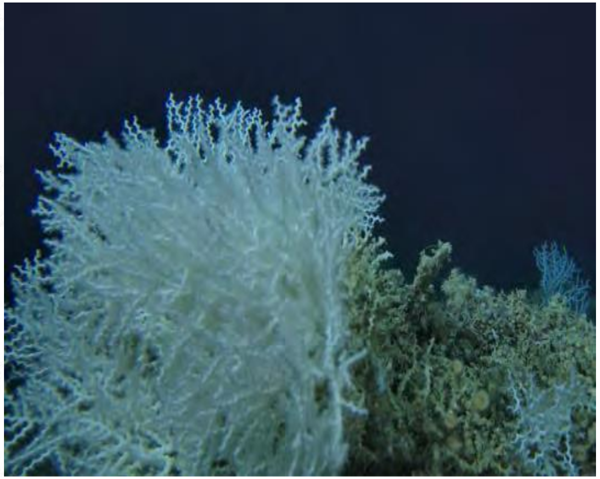




Floating offshore windfarms: the future of renewable energies





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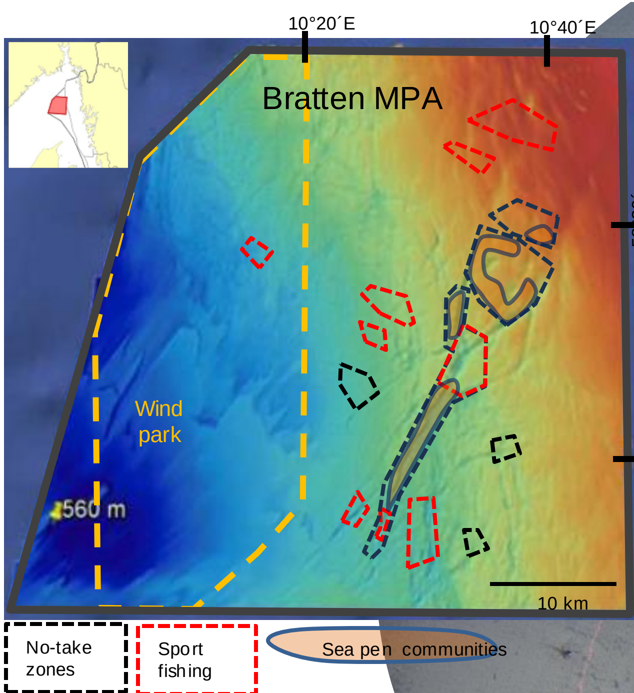
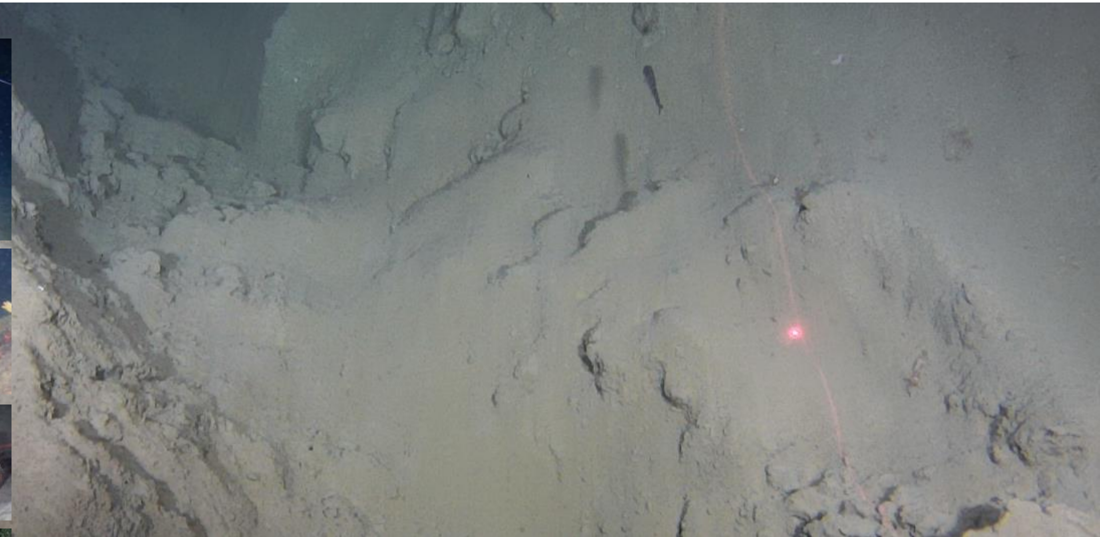
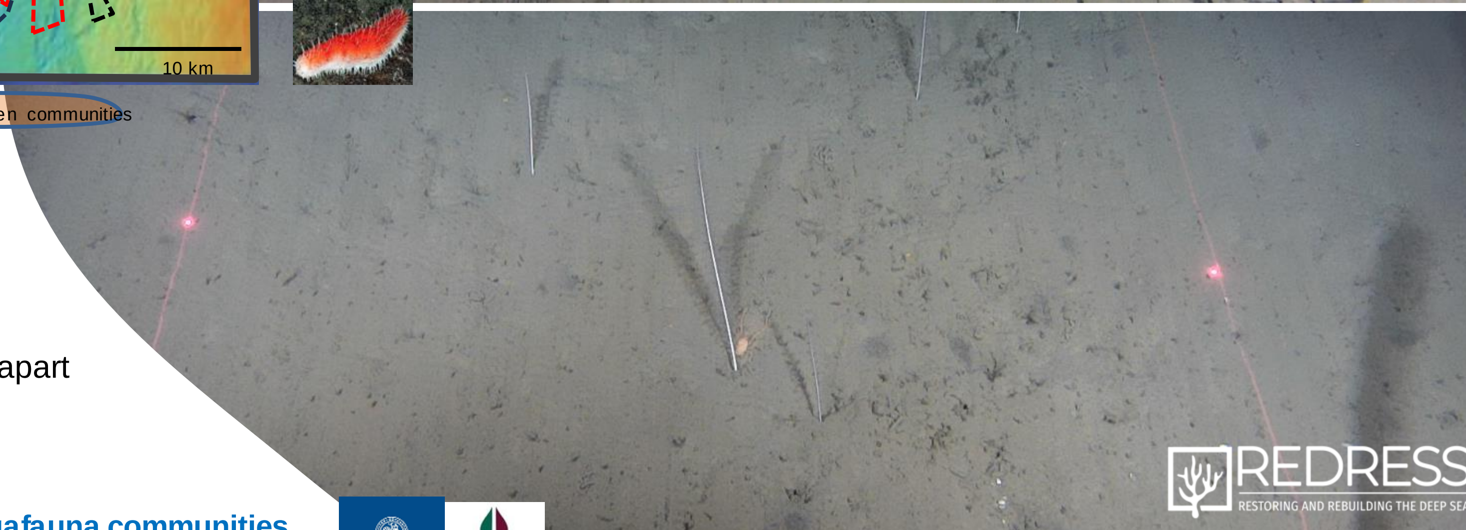






200 – 600 m

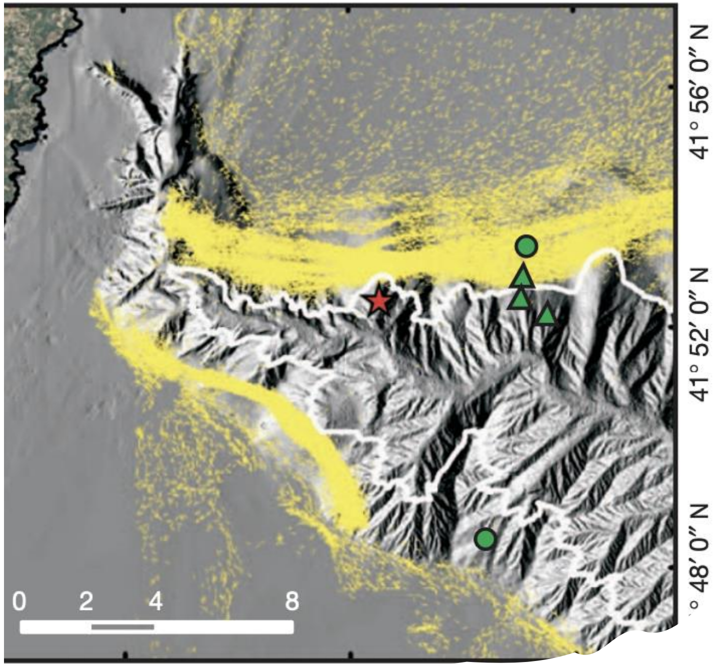
by SLU, Lyseskil, Sweden

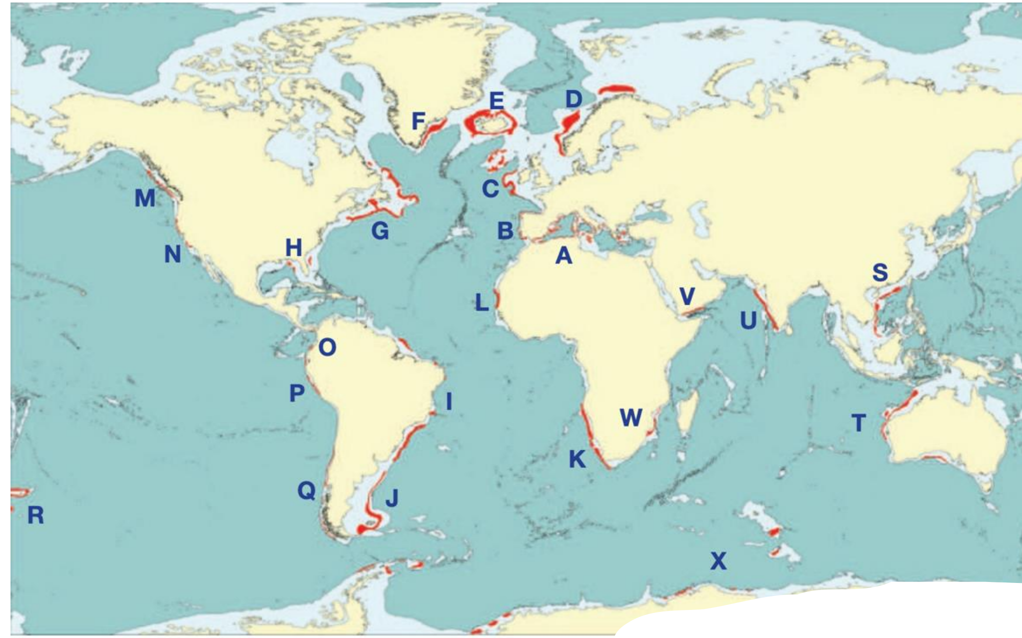
Laser markers are 80 cm apart

Sea pen and burrowing megafauna communities in the no-take zone in the "Bratten MPA" , Sweden

GÖTEBORGS UNIVERSITET

SLU





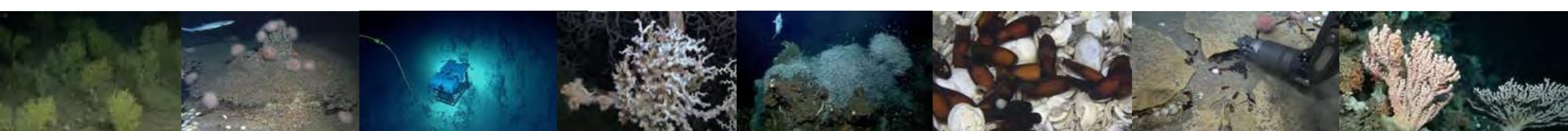
LETTER

doi:10.1038/nature11410

Ploughing the deep sea floor

Pere Puig[1], Miquel Canals[2], Joan B. Company[1], Jacobo Martín[1], David Amblas[2], Galderic Lastras[2], Albert Palanques[1] & Antoni M. Calafat[2]

Bottom-contact fisheries that rely on indiscriminate trawling physically damage ca. **4.9 million km²** (representing 1.3% of the global ocean) of the seafloor each year



Trawling causes the desertification of the deep seafloor

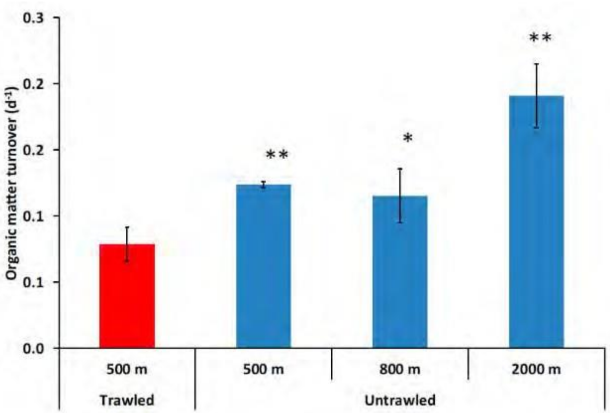
PNAS

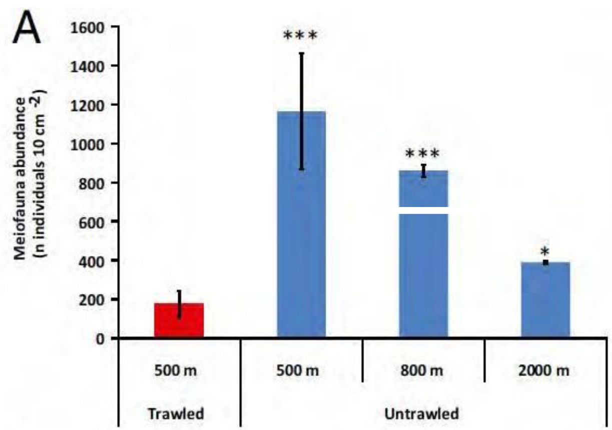
Chronic and intensive bottom trawling impairs deep-sea biodiversity and ecosystem functioning

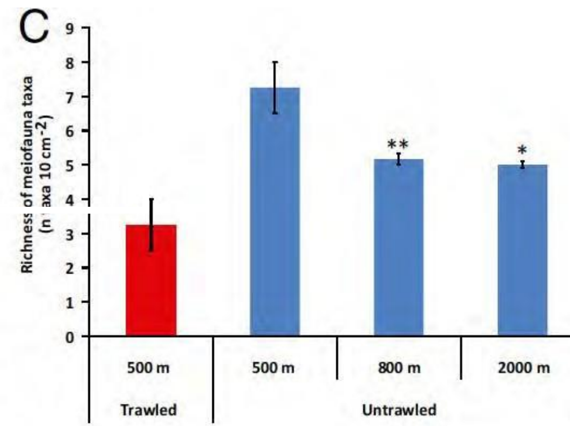
Antonio Pusceddu[a,1], Silvia Bianchelli[a], Jacobo Martín[b,c], Pere Puig[b], Albert Palanques[b], Pere Masqué[d], and Roberto Danovaro[a,e]

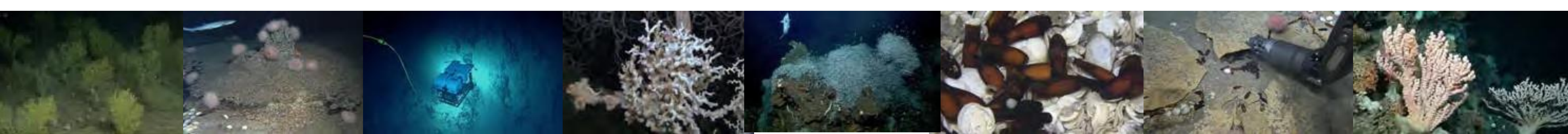
[a]Department of Life and Environmental Sciences, Polytechnic University of Marche, 60131 Ancona, Italy; [b]Department of Marine Geosciences, Institu de Ciències del Mar, Consejo Superior de Investigaciones Científicas, 08003 Barcelona, Spain; [c]Centro Austral de Investigaciones Científicas, 9410 Ushuai, Argentina; [d]Departament de Física and Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, 08193 Bellaterra, Spain; an [e]Stazione Zoologica Anton Dohrn, Villa Comunale, 80121 Naples, Italy

Edited by David M. Karl, University of Hawaii, Honolulu, HI, and approved April 17, 2014 (received for review March 26, 2014)









20 years ago…

SOBRE WWF ⌄ QUÉ HACEMOS ⌄ ¿DÓNDE TRABAJAMOS? ⌄ PUEDES AYUDAR ⌄ NOTICIAS Y PUBLICACIONES ⌄ CAMPAÑAS ⌄

Sea bed trawling, the greatest threat to deep-sea biodiversity

Posted on febrero, 10 2004

Bottom trawl fishing on the high seas is the single greatest threat to highly vulnerable deep-sea environments and the biodiversity they shelter, a new report released today by WWF, IUCN, and the Natural Resources Defense Council shows.

Deep-water coral Lophelia pertusa.
© WWF / Erling Svensen

Kuala Lumpur, Malaysia - Bottom trawl fishing on the high seas — which consists of dragging heavy chains, nets, and steel plates across the ocean floor — is the single greatest threat to highly vulnerable deep sea environments and the biodiversity they shelter, a new report released today by WWF, IUCN – The World Conservation Union, and the Natural Resources Defense Council (NRDC) shows.

The three organizations believe these fragile marine habitats could be protected with little significant economic impact on the global fishing industry.

Current Biology
Report

A Scientific Basis for Regulating Deep-Sea Fishing by Depth

Jo Clarke,[1,*] Rosanna J. Milligan,[1] David M. Bailey,[1,3] and Francis C. Neat[2,3]
[1]Institute of Biodiversity, Animal Health, and Comparative Medicine, University of Glasgow, Graham Kerr Building, Gl
[2]Marine Scotland Science, Marine Laboratory, 375 Victoria Road, Aberdeen AB11 9DB, UK
[3]Co-senior author
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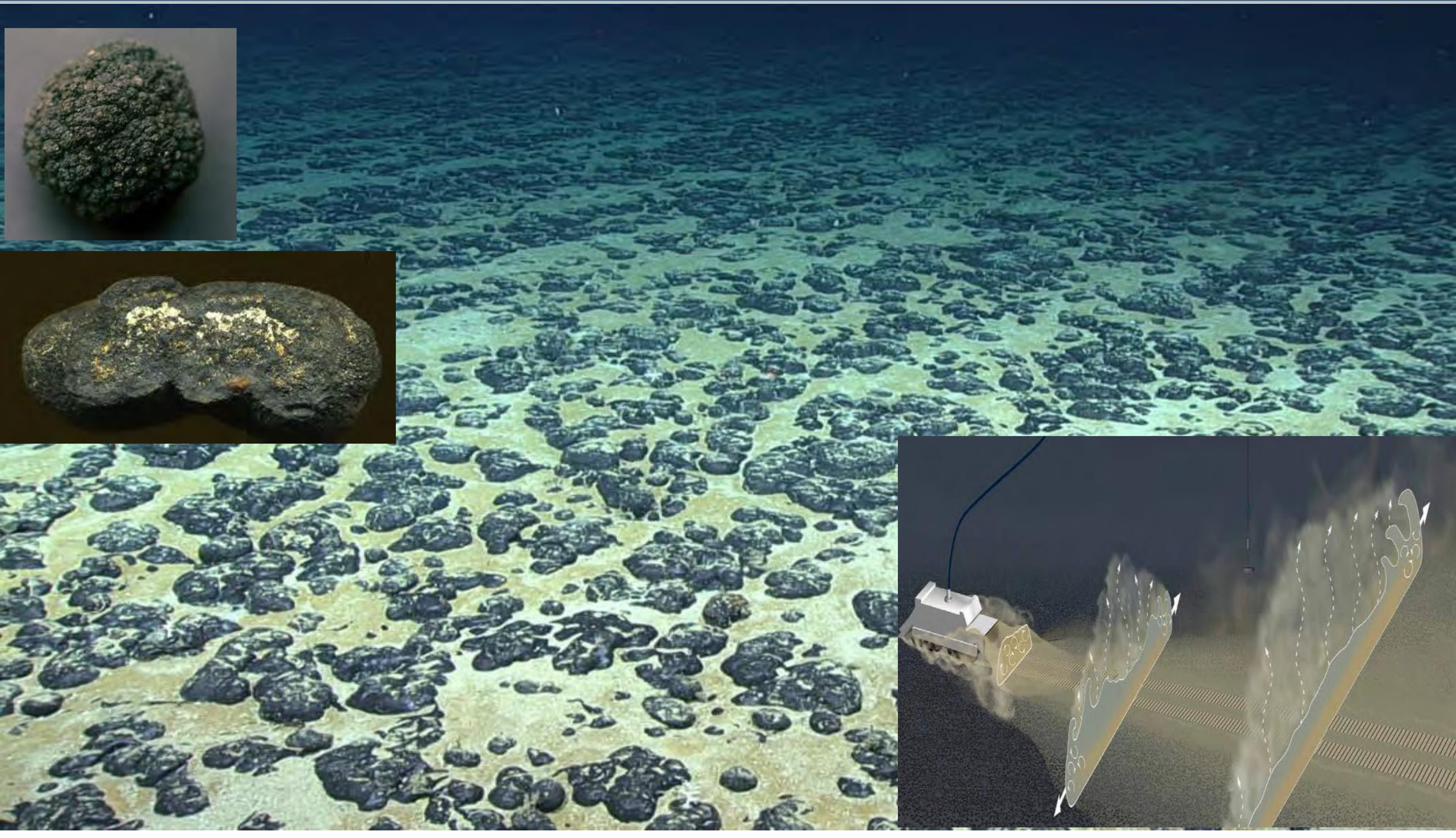
http://dx.doi.org/10.1016/j.cub.2015.07.070

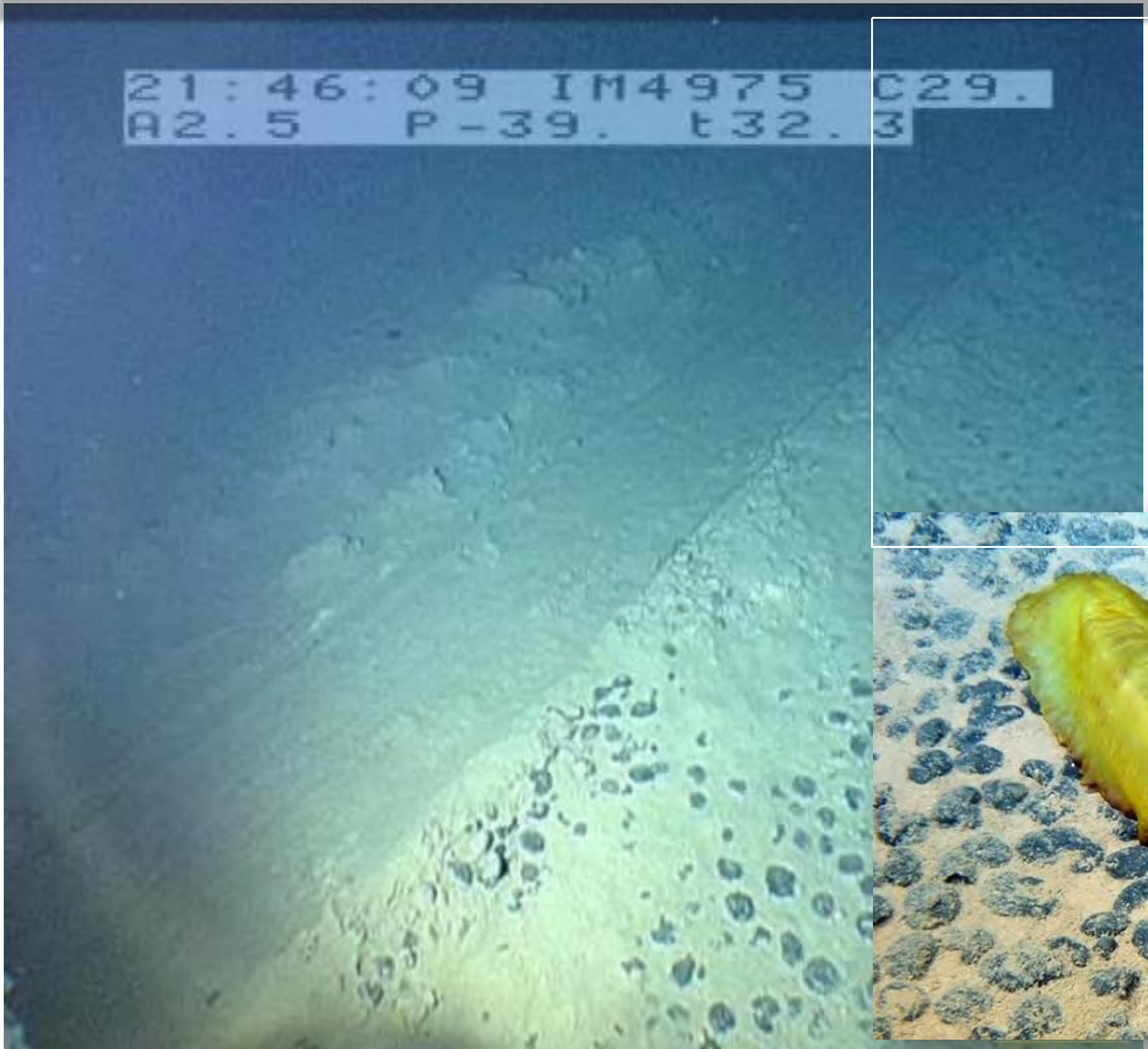
Mau

Trawling should be restricted below 600 metres, research suggests.

Yet (almost) nothing has been done so far

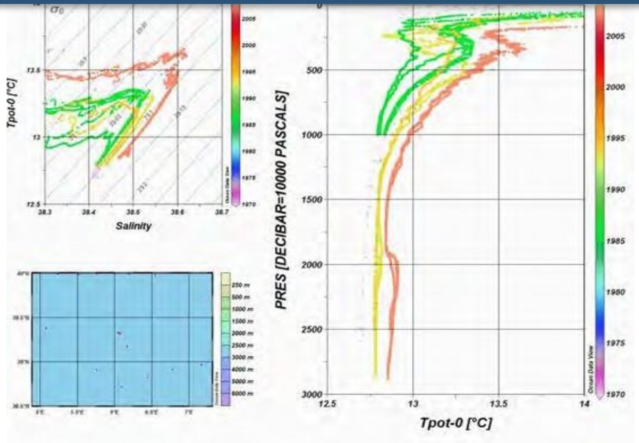
Polymetallic nodules



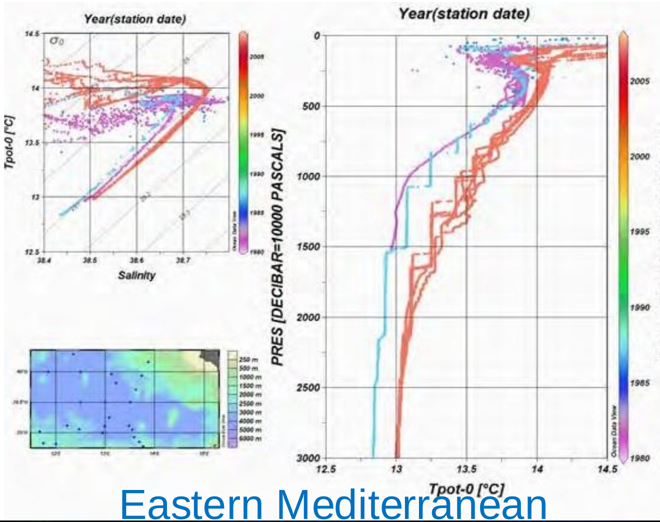


Deep-sea mining is targeting polymetallic-rich nodules on the Clarion Clipperton Zone of the Pacific Ocean abyssal plains, an area extending over 4.5 M km^2 from Hawaii to Mexico

Acceleration of deep-water warming



Western Mediterranean



Eastern Mediterranean

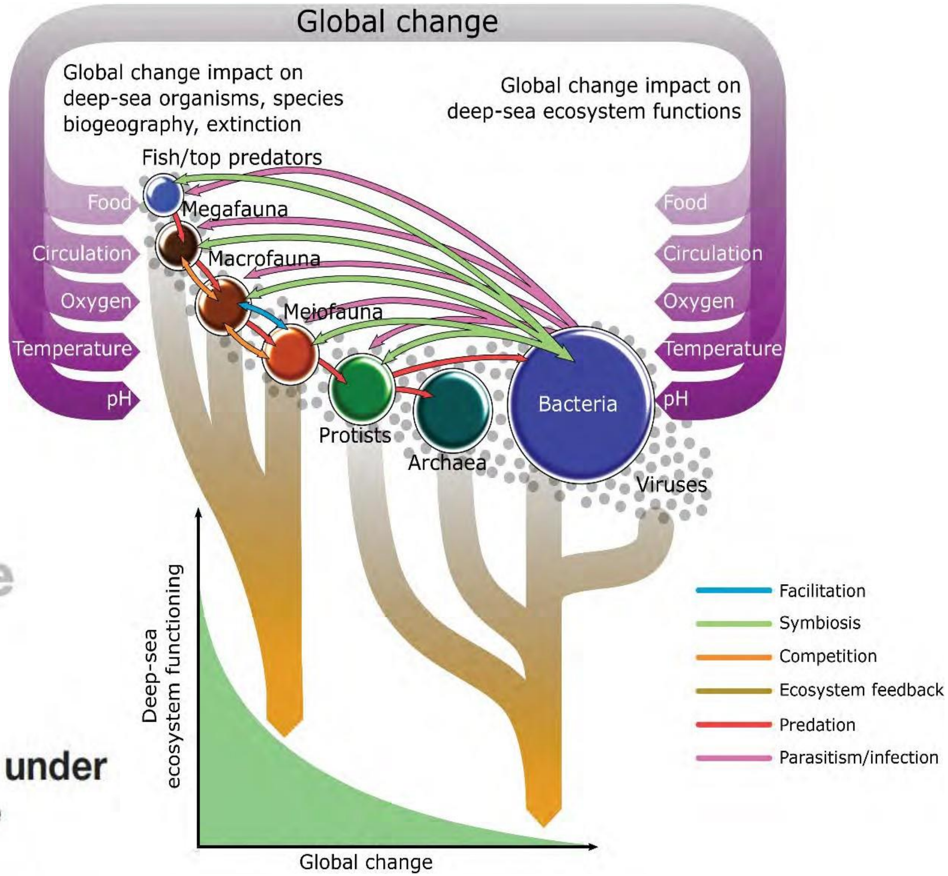

Current Biology

Magazine

Primer

The deep-sea under global change

Roberto Danovaro[1,2*], Cinzia Corinaldesi[1], Antonio Dell'Anno[1] and Paul V.R. Snelgrove[3]



Potential impacts of climate interventions

INSIGHTS

POLICY FORUM

MARINE SCIENCE

Deep-sea impacts of climate interventions

Ocean manipulation to mitigate climate change may harm deep-sea ecosystems

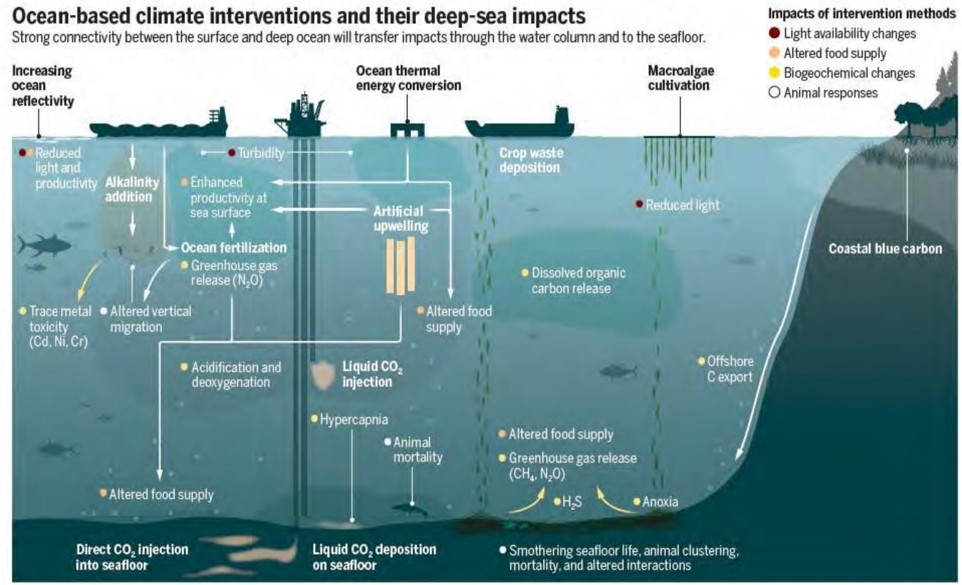
By Lisa A. Levin[1], Joan M. Alfaro-Lucas[2], Ana Colaço[3], Erik E. Cordes[4], Neil Craik[5], Roberto Danovaro[6], Henk-Jan Hoving[7], Jeroen Ingels[8], Nélia C. Mestre[9], Sarah Seabrook[10], Andrew R. Thurber[11], Chris Vivian[12], Moriaki Yasuhara[13,14]

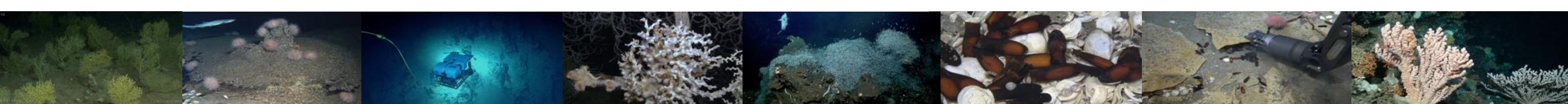
have been raised about OBCI costs, governance, impacts, and effectiveness at scale, but limited attention has been given to ocean biogeochemistry and ecosystems (1) and particularly to impacts on deep-sea ecosystems (>200-m water depth), an ocean region that is understudied but fun-

help centralize consideration of deep-sea impacts in mitigation planning.

Science and governance gaps have featured broadly in past discussions of ocean vulnerabilities to anthropogenic pressures including overfishing, biodiversity loss, plastic pollution, climate change, acidi-

INSTITUTE, CRUISE FK190106, ERIK CORDES CHIEF SCIENTIST



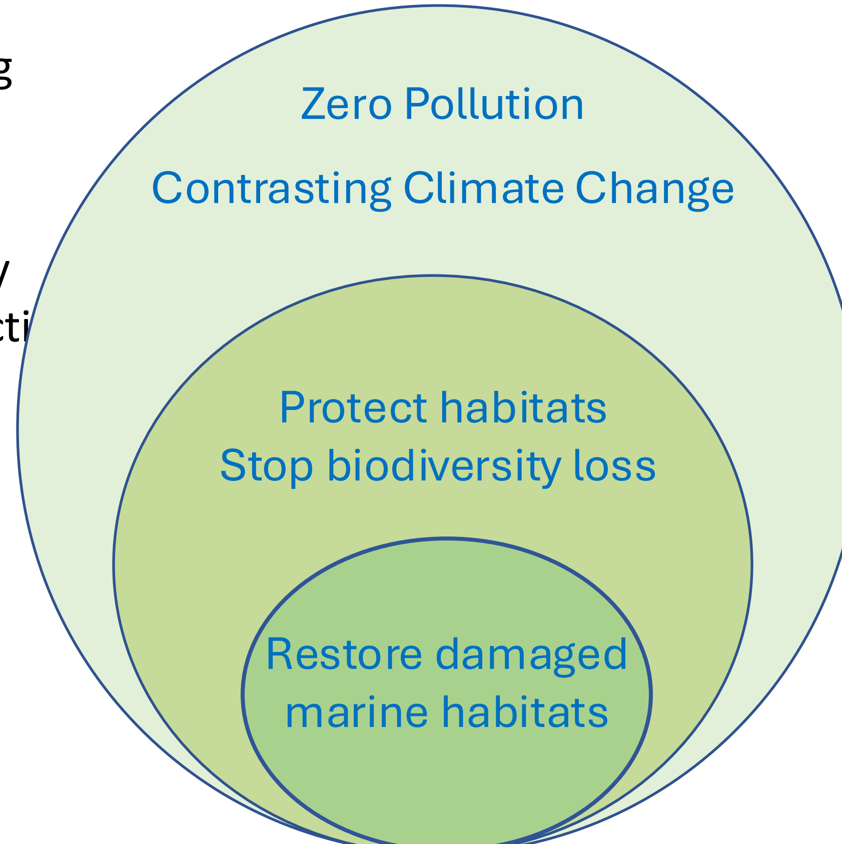


Do we need marine ecosystem restoration in the deep sea?

The full recovery of degraded habitats through "**passive restoration**" could require considerable time periods (up to 100-200 years)

Some ecosystems may have difficulty recovering once physically destroyed

Experience on damaged marine ecosystems indicates that an initial kickstart can significantly accelerate their recovery, along with ongoing acti restoration measures

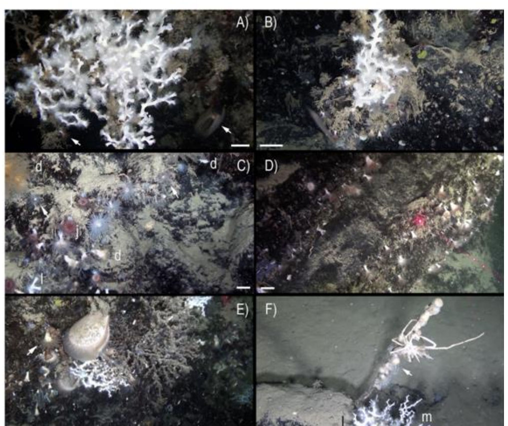


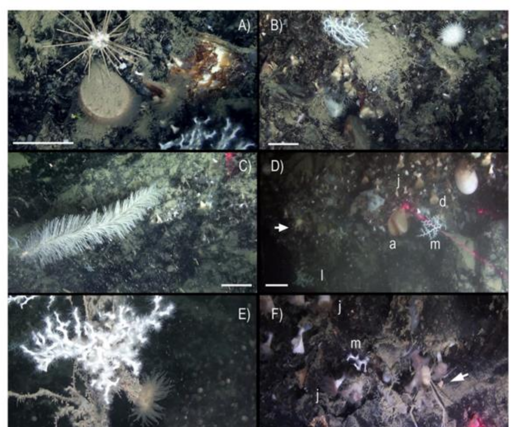
Can marine restoration be successful?

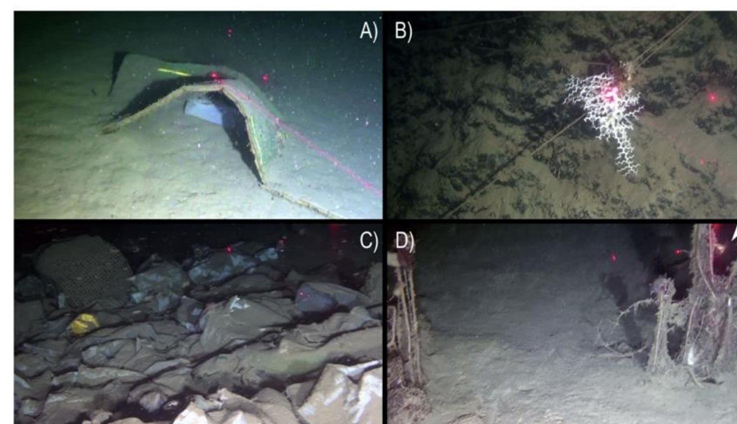
Marine ecosystem restoration **success stories are needed** to incentivize society and private enterprises to build capacity and stimulate investments.

Yet, we **still must demonstrate** that restoration efforts can effectively contribute to achieving the targets set by the UN Decade on Ecosystem Restoration.

Defining success: "*intervention that enables recovery of the biodiversity and ecosystem functions / services of a degraded ecosystem to values not significantly different than those in appropriate reference sites with relative intact, pre-disturbance structure, biodiversity, and functioning*"







REDRESS
RESTORING AND REBUILDING THE DEEP SEA

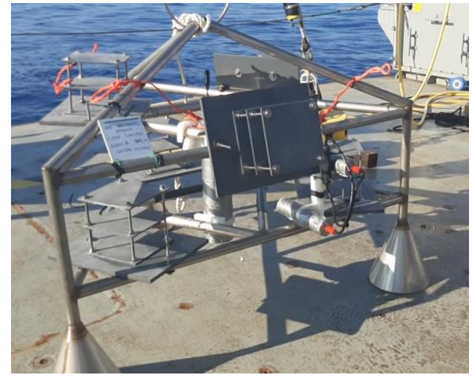
Can we carry on deep-sea ecosystem restoration?

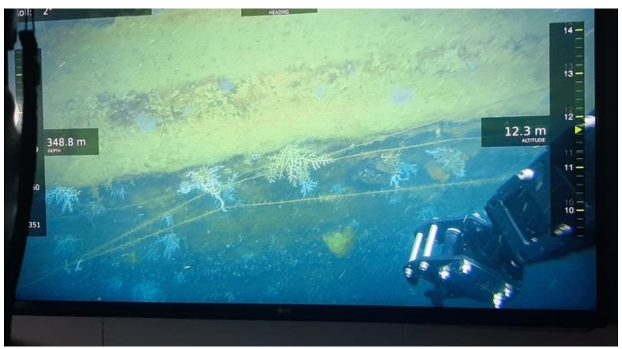
Restoration of deep-sea habitats to rebuild European Seas

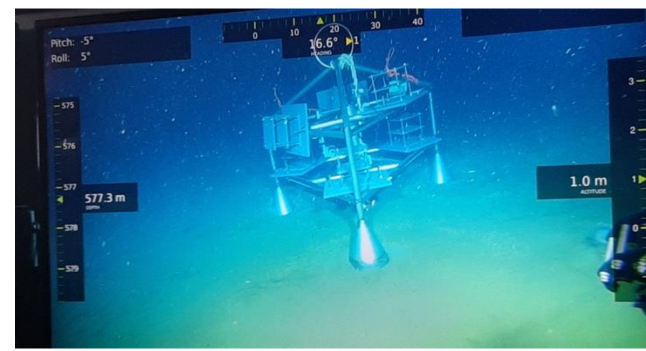
REDRESS technology:

REDRESS
Restoration of deep-sea habitats
to rebuild European Seas

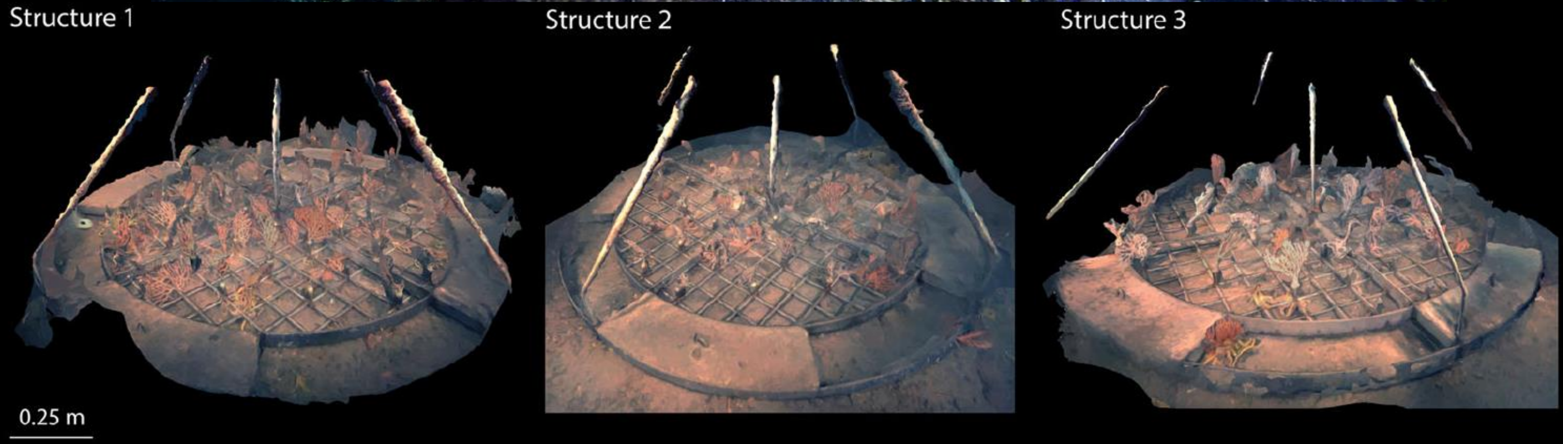
Eco-reefs & ASDERs deployment: ECO-REEF II cruise, 12-22 July 2024 – R/V Gaia Blu







Restoration of deep animal forests




REDRESS
RESTORING AND REBUILDING THE DEEP SEA

Is deep-sea ecosystem restoration more problematic than in other marine ecosystems?

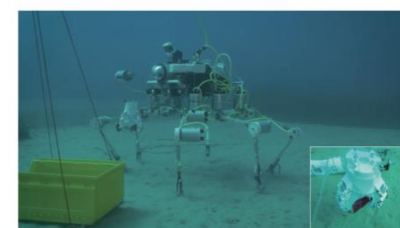
8 Habitats: seagrasses, macroalgal forests, saltmarshes, mangroves, oyster reefs, coral reefs, animal forests, deep-sea ecosystems (deep-water corals)

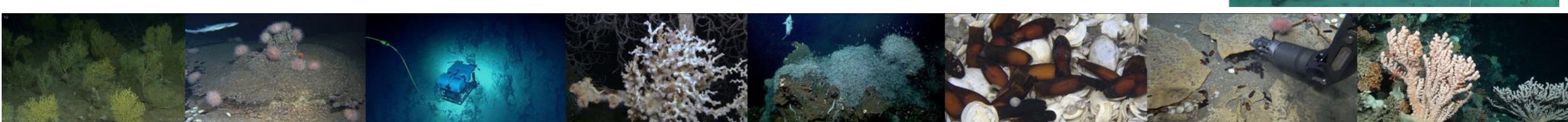
574 of marine restoration interventions, but only 10 in the deep sea (typically within the top 1000 m depth)

(a) (b)

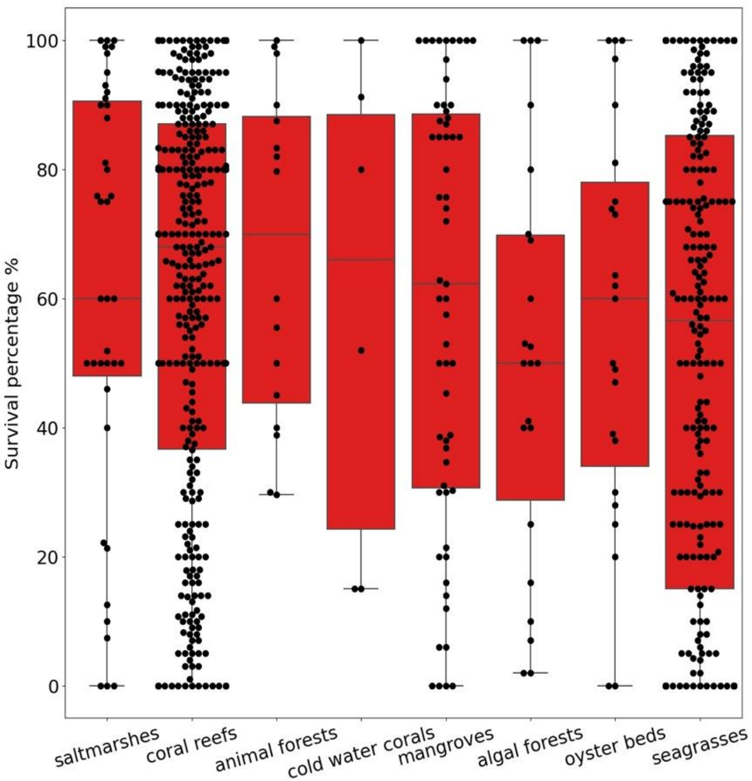
Success of ecological restoration assessed through:

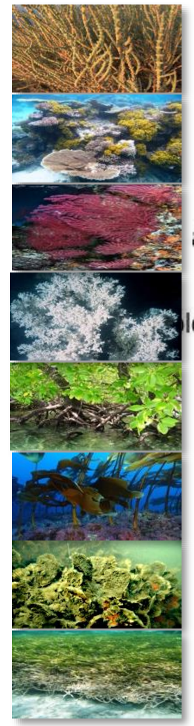
1) a descriptive statistical comparison
2) a formal meta-analysis
3) multilevel models conducted across the whole spectrum of "survival" data reported in the reviewed literature

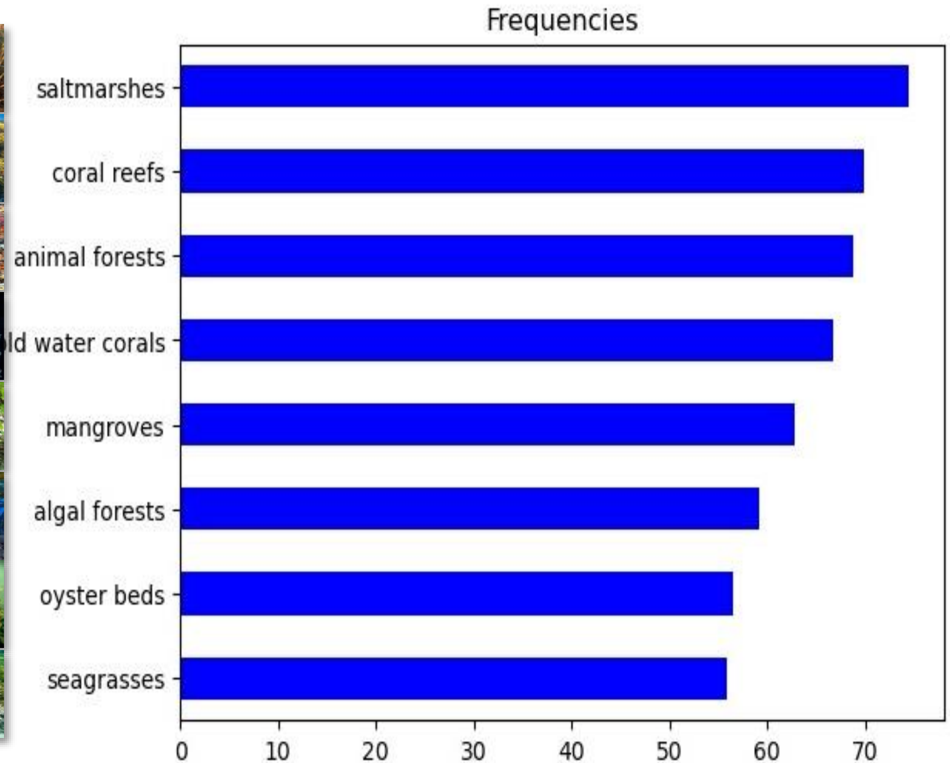




Average success of marine ecosystem restoration: 64%

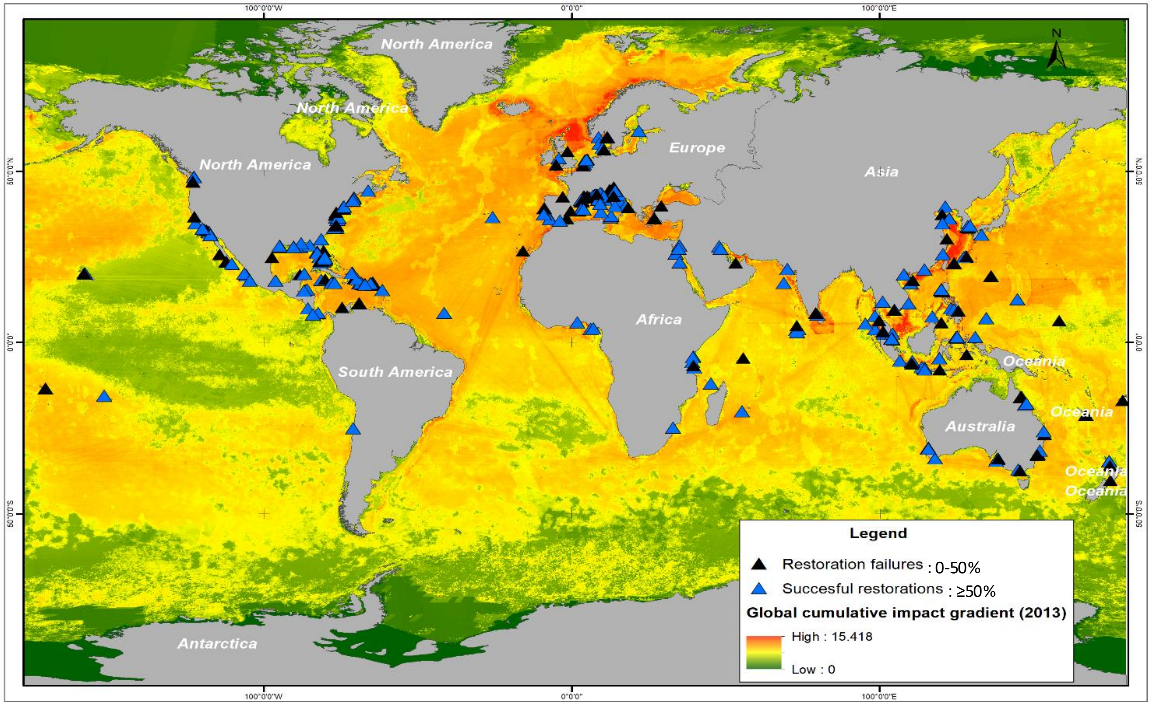


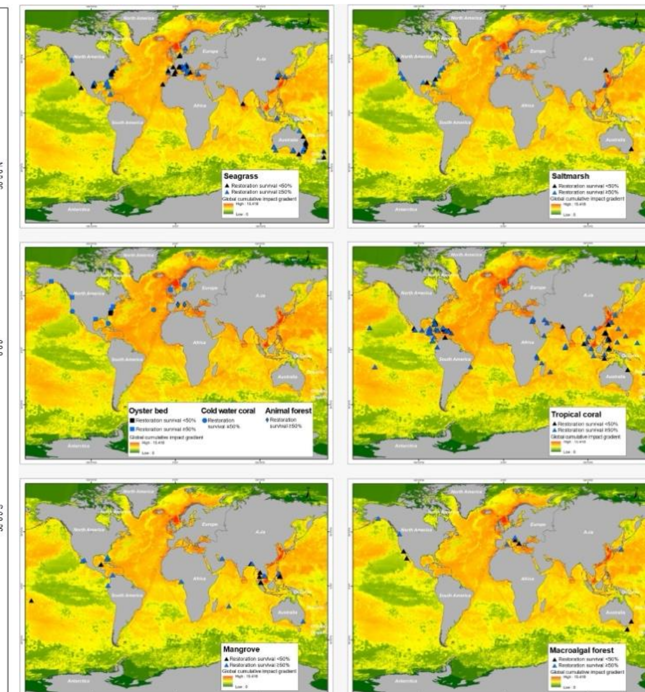




Success of deep-sea ecosystem restoration close to 70%

Restoration attempts on a global scale



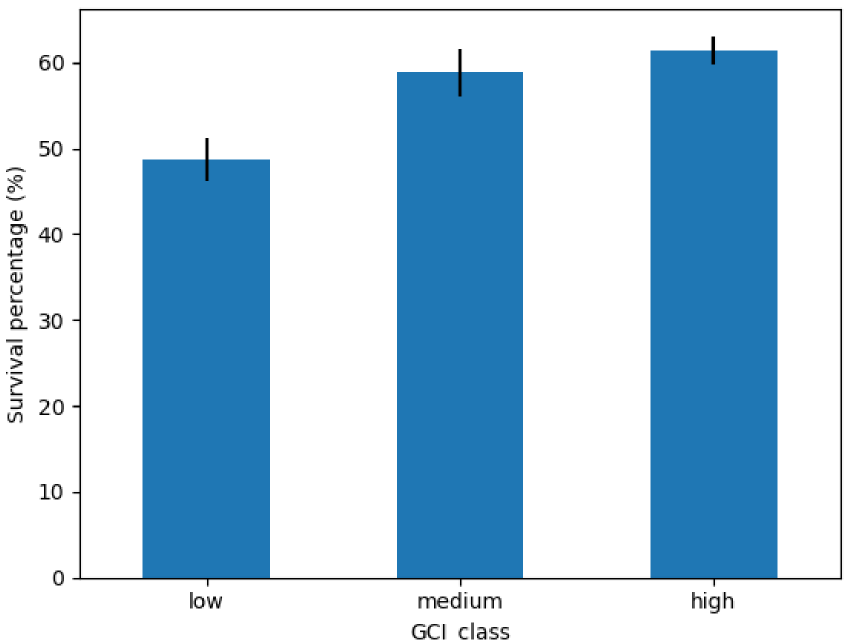


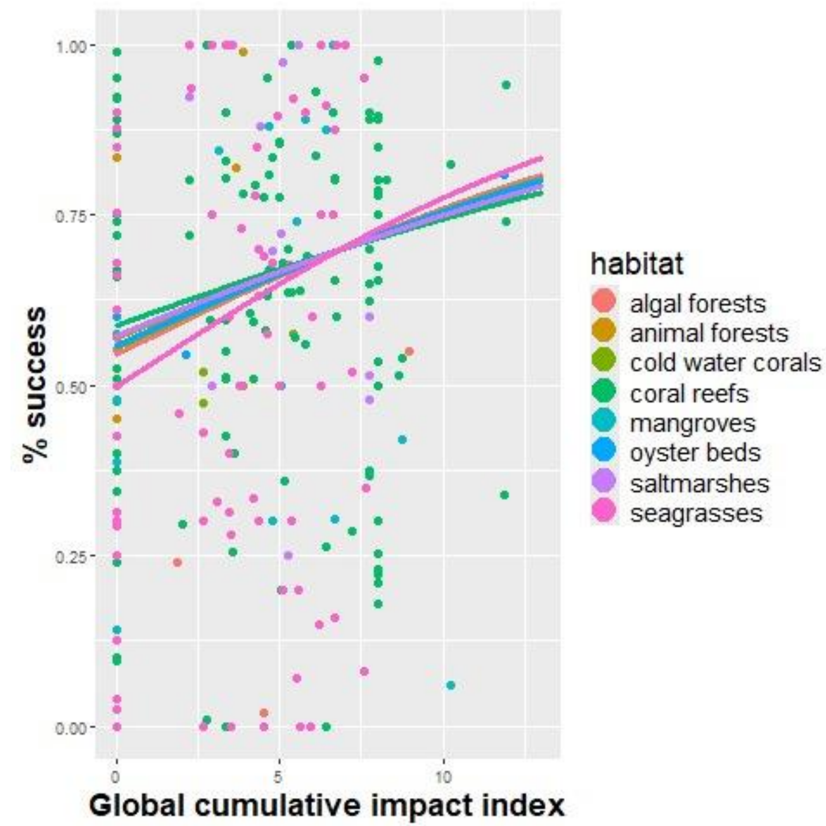
>50% of restoration interventions in impacted sites (cfr Halpern et al works)

Can we restore habitats without first removing the impacts?

Very high restoration success also in impacted areas

The Paradox of Marine Ecosystem restoration:





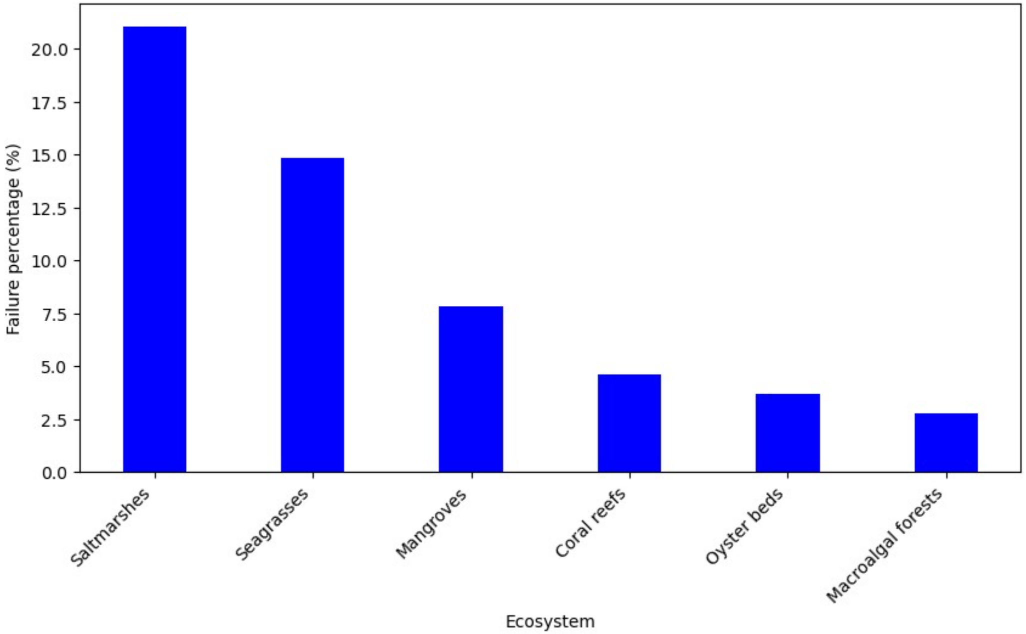
Only 1.5% sites undergone interventions to remove or mitigate the impacts

Is there a risk of failure?

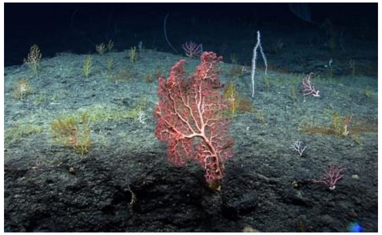
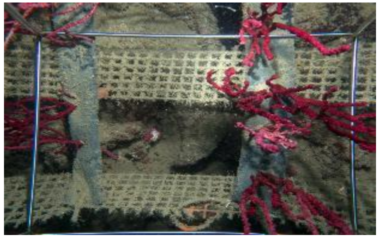
Risk of complete failure higher for **vegetated habitats** (e.g., saltmarshes, seagrasses, macroalgal forests up to 21%)

Very low risk (<5%) for most marine ecosystems

Negligible risk (on the basis of the currently available data) for **deep-sea habitats**





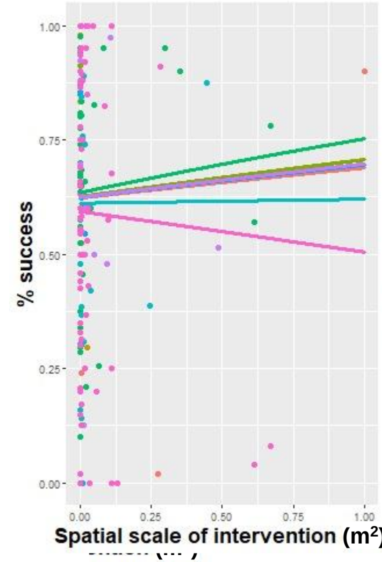
Is larger better?

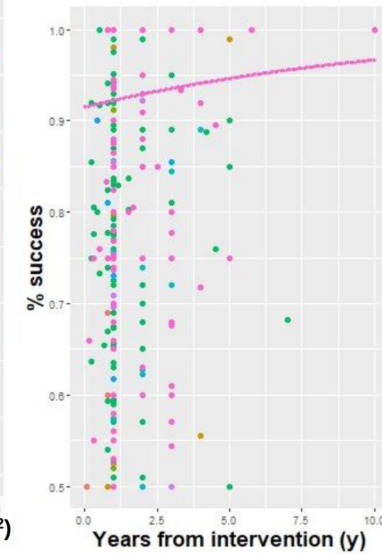
Non-statistically significant increase in success with increasing spatial scale of restoration

MEANS THAT: Small and large restoration interventions have an equally high expectancy of success

We can plan marine ecosystem <u>restoration on anlarge spatial scale using multiple interventions on a small spatial scale</u>

Opportunity: to better represent the natural variability and genetic diversity of the native populations in different areas

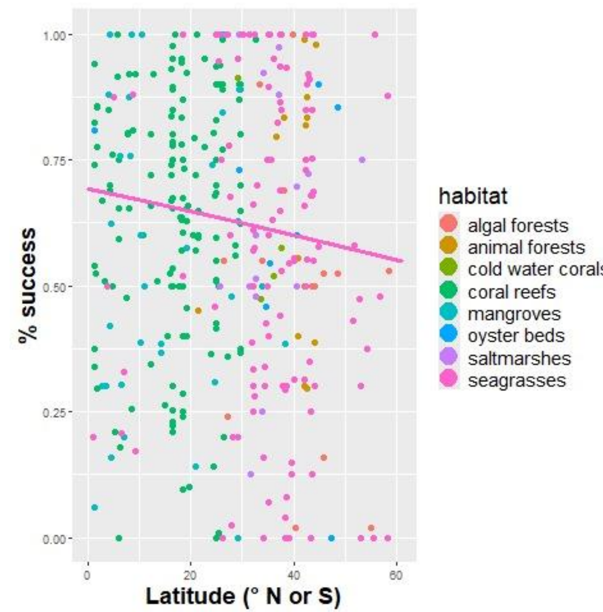




Latitudinal constraints?

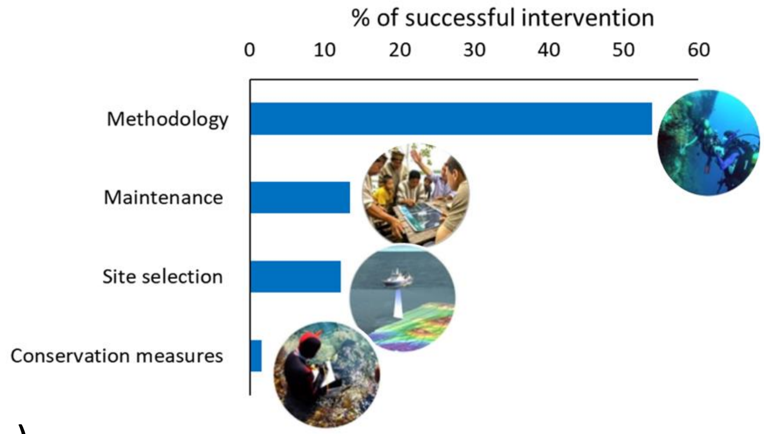
The success of restoration of the same typology of marine habitat doesn't change across latitudes

MEANS THAT: We can do it at all latitudes



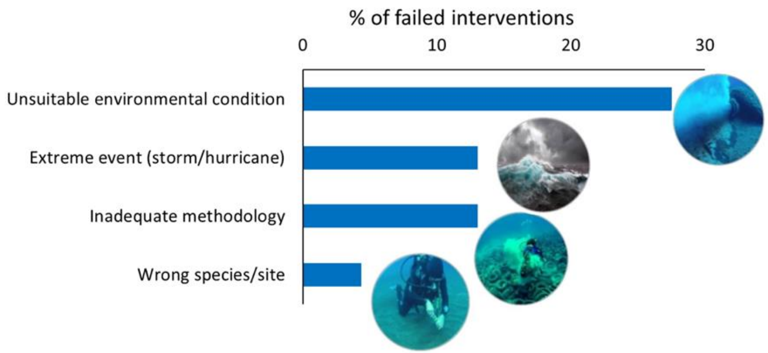
Drivers of restoration success:

Methodologies: i) habitat-forming species, ii) refined protocols; iii) combined species; "cultivation" *ex situ*, "reuse" of bycatch organisms; transplantation of entire portions of habitat
Maintenance: cooperation with local stakeholders (e.g., fishermen, diving centers); new technologies (drones, satellites, microchips and nano-sensors)
Site selection: a) high ecological connectivity; b) refugia c) sheltered sites
Conservation measures: creation of buffer areas



… and failure:

i) unsuitable environmental conditions; ii) the occurrence of extreme events; iii) the choice of inappropriate protocols or target species



Costs and benefits of marine ecosystem restoration

The cost of a restoration intervention may represent the greatest challenge as the costs of marine ecosystem restoration can be **1-2 orders** of magnitude higher than on land.

Return of Investments (ROI): Benefits can be valued in various ways (e.g., total economic value or using contingent valuation methods - discrete choice experiments and the willingness to pay), and even monetized (e.g., market values for increased billfish catch or increased blue tourism).

Existing economic assessments of coastal-ecosystem restoration report benefit-cost ratios typically between **0.05 and 1.7 up to 4 for coral reef restoration.**

Kelp Forests: 59 to 194,000 USD/ha/yr

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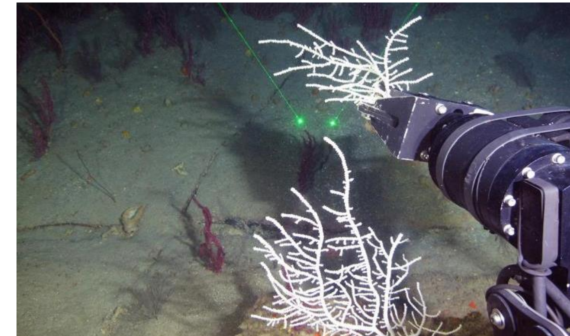
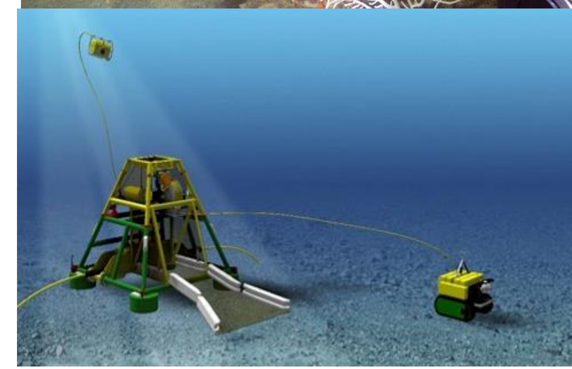
ELSEVIER

Ecosystem service benefits and costs of deep-sea ecosystem restoration

Wenting Chen [a,*], Philip Wallhead [a], Stephen Hynes [b], Rolf Groeneveld [c], Eamon O'Connor [b], Cristina Gambi [d], Roberto Danovaro [d,e], Rob Tinch [f], Nadia Papadopoulou [g], Chris Smith [g]

Investing in marine ecosystem restoration





Three main types of enablers:

1) **policy/regulatory enablers** to create the conditions and obligations to restore damaged marine habitats;
2) **economic enablers** (valuation of social-economic and cultural benefits to justify investments);
3) **technological enablers** (i.e., operating in all marine habitats and on a large spatial scale).

<u>Technological developments will offer important business and innovation opportunities in the near future for marine ecosystem restoration: **lower the costs**</u>

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New Technologies for Monitoring and Upscaling Marine Ecosystem Restoration in Deep-Sea Environments

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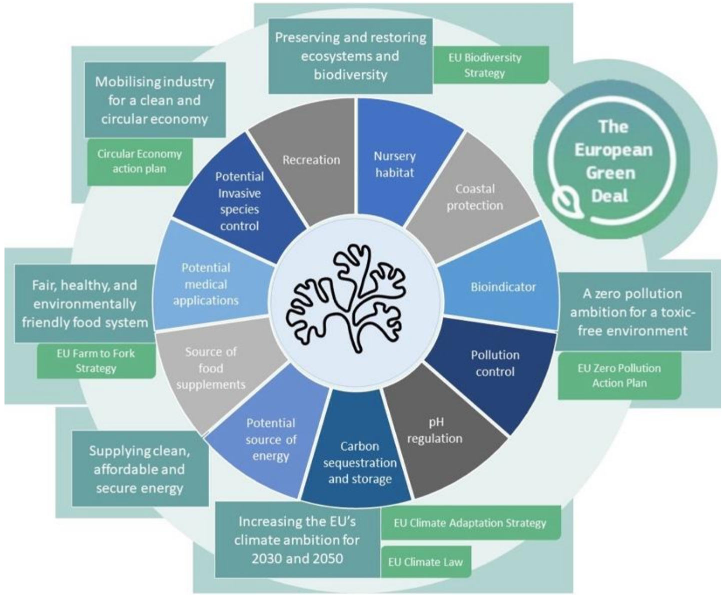
Management strategies supporting restoration

Governments and institutions must maximize the effectiveness of active restoration actions for **defending public interest**



We must establish active restoration as one of the recognised priority strategies and solutions for reversing past and ongoing marine habitat degradation that may be authorized, penalizing wilful corporate disrespect of regulations and recovering healthy and biodiverse marine seascapes.

Coupling "passive" and active restoration interventions could expand the areal extent of positive effects of active restoration, while providing an instrument to safeguard costly restoration interventions.

Best practices to maximize contributions of buffer areas to achieve these hoped-for multiple benefits will require specific assessments for different habitat types.

Conclusions

Evidence for **highly successful** marine ecosystem restoration also in deep-sea ecosystems

Parallel evidence of a **very low risk of complete failure**

Restoration can be **scalable upward** at all latitudes through existing regulations and financing instruments

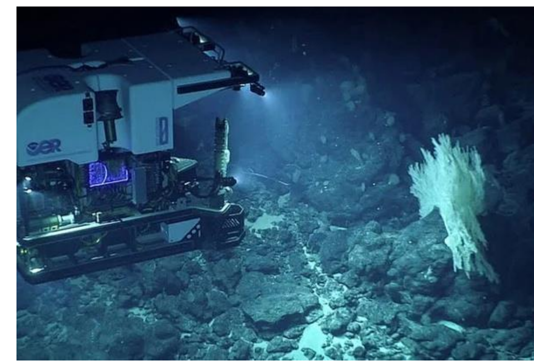
Marine ecosystems do not require large scale interventions as a pre-requisite oftheir success (if the physical disturbance is stopped)

High restoration success **even in impacted marine areas.** This supports the possibility of **immediate actions** to restore marine degraded habitats

Active restoration should be coupled with passive restoration to protect the recovery and to expand the effects of restoration on a wider spatial area.

Future perspectives

- **Considerable work remains in 2 main directions**:



- improved protocols for increasing success of restoration interventions on all degraded habitats including those for which we have limited or no experience yet (e.g., polymetallic nodules, hydrothermal vents, and cold-seeps);
- cost reduction to extend spatial scales of intervention
- engagement of the private sector.

Deep-sea ecosystem restoration will become soon "Wider and Deeper" but cannot be used to justify future impacts or deep-sea mining

nature ecology & evolution

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Microbes as marine habitat formers and ecosystem engineers

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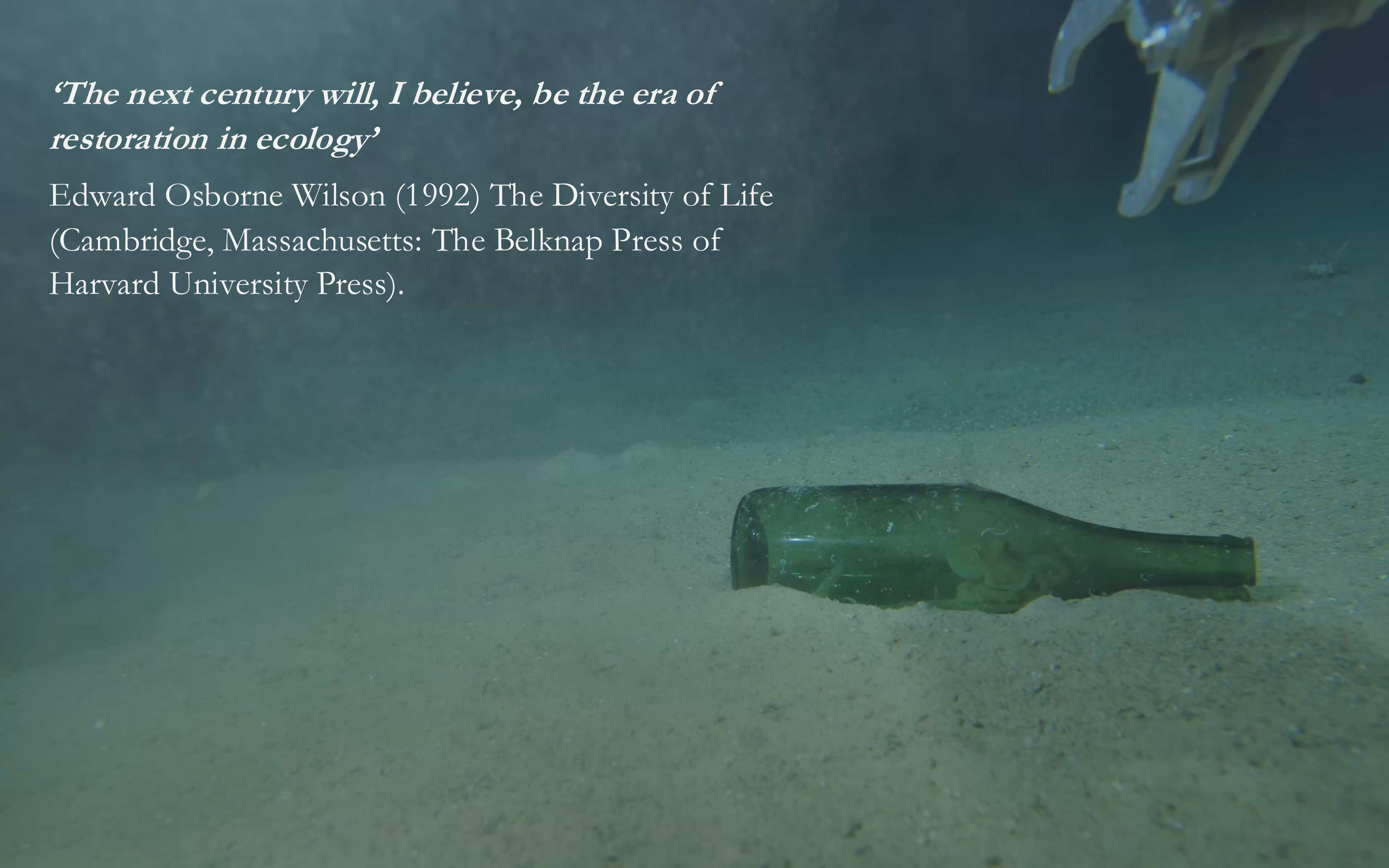
'The next century will, I believe, be the era of restoration in ecology'
Edward Osborne Wilson (1992) The Diversity of Life (Cambridge, Massachusetts: The Belknap Press of Harvard University Press).

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