Universal Journal of Hydraulics **9 (2021), 23-30**
www.papersciences.com **EU Academy of Sciences (EUAS) e-Symposium**

Ocean Science for Sustainable Development and Ecosystem Restoration: the way forward for the Next Decade

Roberto Danovaro[1,2] & Cristina Gambi[1]
[1] Università Politecnica delle Marche,
Dipartimento di Scienze della Vita e dell'Ambiente,
60131 Ancona, Italy
[2] Stazione Zoologica Anton Dohrn,
80121 Napoli, Italy
r.danovaro@univpm.it

Abstract
Seas and oceans, the largest biomes of the biosphere, show an increasing number of largely degraded habitats. The multiple human impacts on natural ecosystems are causing a widespread habitat loss, with consequent decline of biodiversity and ecosystem services. To address the dreadful state of the ocean, the United Nations proclaim in 2021-2030 Decades of "Ocean Science for Sustainable Development" and "Ecosystem Restoration". The Decades should turn the scientific knowledge and understanding into effective actions supporting improved ocean stewardship for sustainable development while the ecological restoration is the main tool to reverse the decline and recover the biodiversity, along with human health and wellbeing. This is a great challenge for scientists, stakeholders, politicians and civil society to recognize the need to massively accelerate a global sustainable development and restoration of degraded marine ecosystems, to fight the climate heating crisis, enhance food security, provide clean water and protect biodiversity on the planet.

Key Word and Phrases
Ocean, Sustainable Development, Restoration, Marine Ecosystems, UN Decades.

1. Ocean Science for Sustainable Development

Covering more than 70% of the planet's surface, the ocean is central to human well-being, providing valuable and vital ecosystem services such as climate regulation, food, energy, mineral and genetic resources, and cultural and recreational services [1]. The value of the ocean economy speaks to its importance: the Organization for Economic Cooperation and Development estimates that by 2030, $3 trillion USD will be generated annually from ocean sectors such as transportation, fishing, tourism, and energy [2]. Today, more than 40% of the global population lives in areas within 200 km of the ocean and 12 out of 15 mega cities are coastal [3]. Doubling of the world population over the last 50 years, rapid industrial development, and growing human affluence are exerting increasing pressure on the ocean [4].

Dailianis et al. [5] has provided a list of the major human activities acting on key European marine habitats: agriculture, carbon sequestration, coastal and marine infrastructure, defence and security, extraction of living resources, extraction of non-living resources, land-based industry, non-renewable energy generation, production of living resources, renewable energy generation, research and conservation, tourism/recreation and transport. All these activities exert multiple (endogenous and exogenous) pressures [5], which contribute to ongoing habitat degradation and loss (Table 1).

Table 1

Pressures (endogenous)	
Abrasion	Introduction of synthetic compounds
Aesthetic pollution	Introduction/translocations of non-indigenous species
Barrier to species movement	Litter

Change in wave exposure (local)	Nitrogen and phosphorus enrichment
Changes in siltation and light regime	Noise
Collision	pH changes (local)
Electromagnetic changes	Salinity regime change
Emergence regime change (local)	Selective extraction of non-living resources
Input of organic matter	Selective extraction of species
Introduction of microbial pathogens	Smothering
Introduction of non-synthetic compounds	Substratum loss
Introduction of other substances	Thermal regime change
Introduction of radionuclides	Water flow rate changes (local)
Pressures (exogenous)	
Change in wave exposure	Salinity regime change
Emergence regime change	Thermal regime change
Geomorphological changes	Water flow rate changes
pH changes	

Such changes reduce the capacity of marine ecosystems to deliver valuable ecosystem services and increase their sensitivity to future impacts such as those associated with climate change. The health of the ocean has now reached a critical point since most fish stocks are overexploited, climate change and increased dissolved carbon dioxide are changing ocean chemistry and disrupting species throughout food webs, and the fundamental capacity of the ocean to regulate the climate has been altered [1], [6]-[8].

To address the dreadful state of the ocean, the United Nations (UN) proclaim in 2021-2030 an international Decade of Ocean Science for Sustainable Development with aims to galvanize the international community to acquire and apply scientific knowledge of the ocean. This marks a major milestone in the Ocean Decade and reinforces the commitment of the Member States of the UN on the central role of ocean science in sustainable development, including its promise to "leave no one behind," which includes coastal least developed countries and small island developing states. The Ocean Decade will undoubtedly influence research agendas and financing well beyond 2030 and this focus is captured in the phrase "the science we need for the ocean we want" [9]. The Decade can mobilize the ocean community behind the ideas of sustainable development and serve to focus the research and technological development in oceanography on existentially important issues of protection and sustainable use of the ocean [10]. The idea of the Decade is to achieve a major change in the knowledge and management of the ocean.

The Decade runs from 2021 through 2030, which is also the deadline for the Sustainable Development Goals and the timeline scientists have identified as the last chance to prevent catastrophic climate change. It is reflected in the following two over-arching goals that provide the high-level motivation for the Decade: 1) to generate the scientific knowledge and underpinning infrastructure and partnerships needed for sustainable development of the ocean; and 2) to provide ocean science and data to inform policies for a well-functioning ocean in support of all Sustainable Development Goals of the 2030 Agenda. The design of the Decade should address both deep disciplinary understanding of ocean processes and solution-oriented research to generate the knowledge needed for reducing pressures on the ocean, preserving and restoring ocean ecosystems and safeguarding ocean-related prosperity for future generations [10], [11]. The Decade should turn the scientific knowledge and understanding into effective actions supporting improved ocean stewardship for sustainable development.

The Decade will aim to achieve considerable progress in a number of research and technology development areas with a view of generating the following six societal outcomes [10]: 1) a clean ocean, whereby sources of pollution are identified, quantified and reduced along with an efficient removal of pollutants from the ocean; 2) a healthy and resilient ocean, whereby marine ecosystems are mapped and protected while multiple impacts, including climate change, are quantified and

potentially reduced in order to conserve ocean ecosystem services; 3) a safe ocean, whereby human health is much better protected from ocean hazards including a major security for all operations at sea; 4) a predicted ocean, whereby society has an important role contributing to understand current and predict future ocean conditions, the human well-being and livelihoods; 5) a sustainably harvested and productive ocean, ensuring the provision of food supply and alternative livelihoods should create a better understanding of the interactions and interdependencies of the ocean ecosystem and environmental conditions and processes, the use of resources and the economy; and 6) a "transparent and accessible" ocean, whereby all nations, stakeholders and citizens have access to ocean data, information, technologies and the capacities to inform their decisions. Most of these societal outcomes of the Decade are holistic and to be achieved require actions supported by society, governments, and key (industrial) stakeholders.

Nevertheless, progress in several thematic areas of ocean science is either necessary or very useful to achieve them [3] but scientific papers should not be the sole measure of success of the Decade. Impact to society, appropriately measured against clear objectives, should also be a measure of success [10]-[12].

2. Ecosystem Restoration

Climate change, non-sustainable resource extraction, land-based pollution, and habitat degradation are threatening the productivity and health of the ocean in alarming ways [5], [13], [14]. Societal demands for resources often go hand in hand with massive alterations of marine habitats. Over recent decades to centuries, continued declines of coastal ecosystems have occurred worldwide such that the global coverage of saltmarshes, mangroves, seagrasses, oyster reefs, kelp beds and coral reefs has been reduced by 35-85% [15]-[21].

Indeed, the intensive exploitation of marine ecosystems and other effects of human usages [22], [23] are largely responsible for the alarming degradation and loss of marine ecosystems, including the deep sea [17], [19], [22], [24], [25]. Such environmental degradation results in drastic declines in the value of marine ecosystem services and, subsequently, increasing costs to society [26]-[28]. Solutions are urgently needed and will require leadership, trans-disciplinary approaches, international frameworks and national roadmaps, political and financial commitments, and strong governance [12]. At present, society is flooded with messages regarding the degradation of, and challenge of repairing, Earth's natural capital [29]. Thus, active marine restoration has been identified as a possible way forward to counteract some of these negative effects [30]. Such restoration could address for instance the recovery of ecosystem structure and function, which has been identified as one of eight "grand challenges" in marine ecosystems ecology [31].

On 1 March 2019, the UN General Assembly declared 2021-2030 the "UN Decade on Ecosystem Restoration." This call to action has the purpose of recognizing the need to massively accelerate global restoration of degraded ecosystems, to fight the climate heating crisis, enhance food security, provide clean water, and protect biodiversity on the planet [12]. Only with healthy ecosystems can we enhance people's livelihoods, counteract climate change, and stop the collapse of biodiversity. The UN Decade on Ecosystem Restoration is an opportunity to help turn the tide and give people and nature a sustainable future. This declaration also coincides with the UN Decade of Ocean Science for Sustainable Development. If both decades are executed in a coordinated manner, signatory nations could stand to deliver on both these UN calls to action [12]. To advance ongoing efforts in the (still emerging) field of marine restoration, different forms of knowledge must be combined: not only biological and technical aspects, but also social and cultural dimensions [11]. Yet, marine ecosystem restoration is a relatively new field and is proposed as a key strategy to rebuild the oceans [32], [33]. Relatively low implementation of restoration in marine compared with terrestrial or freshwater environments [34] is likely related to the greater challenge of working in the marine environment but is also likely influenced by low confidence in outcomes [35].

Examination of median values reported primarily in peer-reviewed literature suggests that marine coastal restoration projects are typically small scale (<1 ha), short duration (1-2 years), expensive (>US \$100,000s ha^{-1}), and have low item-based survival [36], [37]. Interest in the relatively young field of marine restoration is increasing rapidly as suggested by several initiatives

and project performed all around the world promoted by EU commission, national and international administrations, and governances.

The H2020 MERCES (Marine Ecosystem Restoration in Changing European Seas) project has explored the potential of restoration actions in shallow soft and hard bottoms (including mesophotic) and deep-sea habitats at pan-European scale, from Norway to Turkey. MERCES is giving a special attention on the most fragile and vulnerable habitats, including seagrass meadows, algal and kelp forests, coralligenous outcrops, cold-water corals, canyons, seamounts and fjords in 25 different pilot areas. More than 20 protocols (species translocation and transplanting, seedling and grazer removal, artificial biodegradable substrates) for restoration have been tested to increase restoration efficiency and to identify the criteria for the selection of target species and habitats. Within the frame of the MERCES project, pilot restoration actions have been successfully carried out on 4 species of seagrasses (*Zostera marina*, *Z. noltii*, *Cymodocea nodosa* and *Posidonia oceanica*), coupled with bivalves to activate ecological facilitations processes (e.g., *Mytilus edulis*, *Pinna nobilis* and *Macoma balthica*). Coral, gorgonians and sponge species (e.g., *Chondrilla nucula*, *Aplysina aerophoba*, *Spongia officinalis*, *Corallium rubrum*, *Paramuricea clavata*, *Eunicella singularis*, and *E. cavolini*) have been used to restore hard bottoms. Finally, a real challenge of the MERCES project has been the setup of restoration protocols for deep-sea habitats, including soft and hard bottoms and species of cold-water corals (e.g., *Callogorgia verticillata*, *Paracalyptrophora josephinae*, *Viminella flagellum*, and *Lophelia pertusa* - *Desmophyllum pertusum*).

Specific actions have been carried out to promote and inspire policy initiatives and to provide legal frameworks to support restoration in different EU countries in order to put restoration business at the heart of the Biodiversity Agenda. MERCES involved public, private and industrial stakeholders, for offering new blue-growth opportunities. Restoration accelerates the recovery of biological communities at local scales [38]-[45]. Although restored habitats remain vulnerable to subsequent disturbance events, their biodiversity has the potential to increase ecosystem resilience of larger areas by providing seed material for recovery [46]. Against a backdrop of environmental crisis, the UN Decade on Ecosystem Restoration is a chance to revive the natural world that supports us all. A decade may sound like a long time, but scientists say will count most in the fight to avert climate change and the loss of millions of species during these next ten years.

The Society for Ecological Restoration identifies ten actions and priorities in the strategy of the UN Decade that can build a #GenerationRestoration for both terrestrial and marine ecosystems: 1) empower a global movement; 2) finance restoration on the ground; 3) set the right incentives; 4) celebrate leadership; 5) shift behaviours; 6) invest in research; 7) build up capacity; 8) celebrate a culture of restoration; 9) build up the next generation and 10) listen and learn. A globally coordinated effort for the protection of the ocean for biodiversity, food and climate is a priority task [47] but researchers and managers increasingly recognize a need for ocean restoration actions to halt further decline.

3. Priorities for the implementation of the Marine Restoration

Marine ecosystem restoration is a very young branch of ecosystem restoration, although attempts have been made all over the world in the last decade [33], [48]. Major efforts of restoration actions have spent in key habitats such as coral and oyster reefs, seagrass, mangrove, saltmarsh and kelp forest for their spatial distribution and importance in terms of good and services they provide for human well-being. Restoration initiatives include large-scale projects, which receive high amounts of funding provided by international donors and projects financed by privates, which typically lack of appropriate monitoring programs. In addition, there are also small projects with low financial support from local or national government, often with a rudimentary monitoring plan.

Despite growing awareness and recognition that integrated approaches are needed to revert complex and interconnected socio-economic and environmental issues like land degradation, the socio-economic dimension remains underexposed in the majority of restoration projects, whereas monitoring is still regarded as an extra cost instead of a necessary investment [49]. When successful, restoration of marine-coastal systems can provide a myriad of benefits, relating to

climate, biodiversity, economic growth, and physical and mental well-being [50]. Decades of research on how science contributes to innovation and policy indicates that the most successful scientific programs are solution oriented and collaborative, with policymakers, industry, and communities helping to identify science that is directly applicable to the issues they face; that is, where demand for science among end-users - the knowledge needed for decision-making - influences science supply - research priorities and outputs [51]. The success of restoration actions depends upon the inherent ecology and biology of the species and habitats being restored [14]. Life history and population connectivity impact restoration success, while structural complexity typically is a feature that will affect the habitat's vulnerability against perturbations. This means that restoration actions should mainly undertake two different activities. The first step should be to protect and maintain structural complexity and diversity, the second should be devoted to enhancing the conditions crucial for those features that make the success uncertain (i.e., life history and population connectivity) [14].

A review on successful restoration efforts across a suite of metrics in coastal marine systems reports that similar to terrestrial systems, restoration interventions can be effective over large spatial expanses (1,000s-100,000s ha), persist for decades, rapidly expand in size, be cost-effective, and generate social and economic benefits [33]. The same authors provide also the list of priority factors that the greatest chances of success for restoration project cover multiple aspects on biophysical, technological and socio-economic factors: 1) context-specific requirements in relation to specific environment and ecology; 2) restoring habitats with sufficient connectivity to source populations; 3) mitigating multiple stressors using layered interventions; 4) adaptive management to provide additional, rapid responses when required; 5) optimizing regenerative capacity of systems though low-cost modifications in planting design; 6) use of low-cost technology that is cheap and scalable; 7) use of propagules; 8) partnerships; 9) legal or policy mandates and 10) sufficient financial investment and commitment to long-term monitoring and maintenance. The lack of knowledge of pre-disturbance baselines, which may have shifted along with climate change, is also a challenge. Ultimately, this hampers a proper evaluation of the impact of anthropogenic activities, the actual degree of degradation and therefore the choice of the restoration goals [14].

The MERCES project experience suggests that the ecological restoration requires adequate financing, relevant policy decisions, social awareness, and engagement with the private sector to be successful in marine ecosystems [52], [53]. Because restoration costs are high this should not be a reason not to include them through regulation or preclude activities. In addition, the experience acquired during the implementation and monitoring including the interaction with local stakeholders provided crucial lessons learned that can be capitalized in future restoration plans. Stakeholders, including local communities, funding organizations, governmental bodies, scientists, citizens and volunteers can play a key role in the upscaling restoration projects.

4. Conclusions

These global UN initiatives offer a great opportunity to restore marine ecosystems and could support the ecological transition to a sustainable future of our societies. However, the gaps between terrestrial and marine ecosystems restoration are still evident and require adequate support in terms of technological development and policy. A crucial point is the definition of the costs and the potential for scaling up of marine restoration, which are likely to be far more expensive than in terrestrial ecosystems. In addition, the technical challenges and high costs posed by the deep-sea restoration, make the exploitation of deep-sea resources difficult to compensate in the near future. The UN Decades on "Ocean Science for Sustainable Development" and "Ecosystem Restoration" are just at the beginning but are likely to provide an unprecedented opportunity for relaunching marine science in the next decade towards the sustainability targets.

References

1. *Claudet J. et al.,* 'A roadmap for using the un decade of ocean science for sustainable development in support of science, policy, and action', *One Earth, **2** (2020), 1.*
2. *OECD*, '*The Ocean Economy in 2030?*, OECD Paris, France, *2016, 2019.*

3. *Visbeck, M.,* 'Ocean science research is key for a sustainable future', *Nat. Commun., **9** (2018), 690.*
4. *He, Q., and Silliman, B.R.,* 'Climate change, human impacts, and coastal ecosystems in the Anthropocene', *Curr. Biol., **29** (2019), R1021-R1035.*
5. *Dailianis, T., Smith, C.J., Papadopoulou, N., Gerovasileiou, V., Sevastou, K., Bekkby T. et al.,* 'Human activities and resultant pressures on key European marine habitats: an analysis of mapped resources', *Mar. Policy, **98** (2018), 1-10.*
6. *Gattuso, J.-P., Magnan, A., Bille, R., Cheung, W.W.L., Howes, E.L., Joos, F., Allemand, D., Bopp, L., Cooley, S.R., Eakin, C.M., et al.,* 'Contrasting futures for ocean and society from different anthropogenic CO_2 emissions scenarios', *Science, **349** (2015), aac4722.*
7. *Breitburg, D., Levin, L.A., Oschlies, A., Gregoire, M., Chavez, F.P., Conley, D.J., Garcon, V., Gilbert, D., Gutierrez, D., Isensee, K., et al.,* 'Declining oxygen in the global ocean and coastal waters', *Science, **359** (2018), eaam 7240.*
8. *Smale, D.A., Wernberg, T., Oliver, E.C.J., Thomsen, M., Harvey, B.P., Straub, S.C., Burrows, M.T., Alexander, L.V., Benthuysen, J.A., Donat, M.G., et al.,* 'Marine heatwaves threaten global biodiversity and the provision of ecosystem services'. *Nat. Clim. Chang., **9** (2019), 306-312.*
9. *IOC*, '*United Nations Decade of Ocean Science for Sustainable Development 2021-2030 Implementation Plan Version 2.0*', Intergovernmental Oceanographic Commission, Paris, France, *2020.*
10. *Ryabinin, V., Barbière, J., Haugan, P., Kullenberg, G., Smith, N., McLean, C., Troisi, A., Fischer, A., Aricò, S., Aarup, T., Pissierssens, P., Visbeck, M., Enevoldsen, H.O., Rigaud, J.,* 'The UN Decade of Ocean Science for Sustainable Development', *Front. Mar. Sci., **6** (2019), 470.*
11. *Krause, G., Wolf, C., Happe, A.-K., Hauck, J., Buttigieg, P.L., Fuchs, N., Scheve, J., König, C., Wittmer, H., Raab, K.,* 'Lessons learnt from linking global recommendations with localized marine restoration schemes and policy options by using mixed methods', *Front. Mar. Sci., **7** (2020), 532.*
12. *Waltham, N.J., Elliott, M., Lee, S.Y., Lovelock, C., Duarte, C.M., Buelow, C., Simenstad, C., Nagelkerken, I., Claassens, L., Wen, C.K.-C., Barletta, M., Connolly, R.M., Gillies, C., Mitsch, W.J., Ogburn, M.B., Purandare, J., Possingham, H., Sheaves, M.,* 'UN Decade on Ecosystem Restoration 2021-2030 What chance for success in restoring coastal ecosystems?', *Front. Mar. Sci,. **7** (2020), 71.*
13. *Gerovasileiou, V., Smith, C.J., Sevastou, K., Papadopoulou, K.-N., Dailianis, T., Bekkby, T. et al.,* 'Habitat mapping in the European Seas - is it fit for purpose in the marine restoration agenda?', *Mar. Policy, **106** (2019), 103521.*
14. *Bekkby, T., Papadopoulou, N., Fiorentino, D., McOwen, C.J., Rinde, E., Boström, C., Carreiro-Silva, M., Linares, C., Andersen, G.S., Bengil, E.G.T., Bilan, M., Cebrian, E., Cerrano, C., Danovaro, R., Fagerli, C.W., Fraschetti, S., Gagnon, K., Gambi, C., Gundersen, H., Kipson, S., Kotta, J., Morato, T., Ojaveer, H., Ramirez-Llodra, E., Smith, C.J.,* 'Habitat features and their influence on the restoration potential of marine habitats in Europe', *Front. Mar. Sci., **7** (2020), 184.*
15. *Valiela, I., Bowen, J.L., and York, J.K.,* 'Mangrove forests: One of the world's threatened major tropical environments', *BioScience, **51** (2001), 807-815.*
16. *Lotze, H.K., Lenihan, H.S., Bourque, B.J., Bradbury, R.H., Cooke, R.G., Kay, M.C., Kidwell, S.M., Kirby, M.X., Peterson, C.H., Jackson, J.B.C.*, 'Depletion, degradation, and recovery potential of estuaries and coastal seas', *Science, **312** (2006), 1806-1809.*
17. *Waycott, M., Duarte, C.M., Carruthers, T.J., Orth, R.J., Dennison, W.C., Olyarnik, S., et al.,* 'Accelerating loss of seagrasses across the globe threatens coastal ecosystems', *Proc. Natl. Acad. Sci. U.S.A., **106** (2009), 12377-12381.*
18. *Silliman, B.R., Bertness, M.D., and Grosholz, E.D.,* '*Human Impacts on Salt Marshes: A Global Perspective'*, 1st Edition, University of California Press, *2009.*
19. *Beck, M.W., Brumbaugh, R.D., Airoldi, L., Carranza, A., Coen, L.D., Crawford, C., et al., '*Oyster reefs at risk and recommendations for conservation, restoration, and management', *BioScience, **61** (2011), 107-116.*
20. *Hughes, T.P., Anderson, K.D., Connolly, S.R., Heron, S.F., Kerry, J.T., Lough, J.M., Baird, A.H., Baum, J.K., Berumen, M.L., Bridge, T.C., et al.,* 'Spatial and temporal patterns of mass bleaching of corals in the Anthropocene', *Science, **359**, (2018), 80.*
21. *Wernberg, T., Bennett, S., Babcock, R.C., de Bettignies, T., Cure, K., Depczynski, M., Dufois, F., Fromont, J., Fulton, C.J., Hovey, R.K., et al.,* 'Climate-driven regime shift of a temperate marine ecosystem', *Science, **353** (2016), 169-172.*
22. *Burke, L.M., Reytar, K., Spalding, M., Perry, A.,* '*Reefs at Risk Revisited'*, Washington DC: World Resources Institute, *2011.*
23. *IPCC*, '*Climate Change 2013 - The Physical Science Basis*', Intergovernmental Panel on Climate Change, (Geneva), 203, *2013.*

24. *Gibson, R.B.,* 'Beyond the pillars: sustainability assessment as a framework for effective integration of social, economic and ecological considerations in significant decision-making', *J. Environ. Assess. Policy Manage., **8** (2006), 259-280.*
25. *Duke, N.C., Menecke, J.O., Dittmann, S., Ellison, A.M., Anger, K., Berger, U., et al.,* 'A world without mangroves?', *Science, **317** (2007), 41-42.*
26. *Cesar, H.S.J.* '*Coral reefs: their functions, threats and economic value*' in Collected Essays on the Economics of Coral Reefs, Kalmar University, (*2000), 14-39.*
27. *Barbier, E.B.,* 'Progress and challenges in valuing coastal and marine ecosystem services', *Rev. Environ. Econ. Pol., **6** (2012), 1-19.*
28. *Tadaki, M., Sinner, J., Chan, K.,* 'Making sense of environmental values: a typology of concepts', *Ecol. Soc., **22** (2017), 7.*
29. *Duarte, C.M.* 'Red ochre and shells: clues to human evolution', *Trends Ecol. Evol., **29** (2014), 560-565.*
30. *Abelson, A., Halpern, B.S., Reed, D.C., Orth, R.J., Kendrick, G.A., Beck, M.W., et al.,* 'Upgrading marine ecosystem restoration using ecological-social concepts', *BioScience, **66** (2016), 156-163.*
31. *Borja, A.,* 'Grand challenges in marine ecosystems ecology', *Front. Mar. Sci., **1** (2014), 1-6.*
32. *Duarte, C., Agusti, S., Barbier, E., Britten, G.L., Castilla, J.C., Gattuso, J.-P., Fulweiler, R.W., Hughes, T.P., Knowlton, N., Lovelock, C.E., et al.,* 'Rebuilding marine life', *Nature, **580** (2020), 39-51.*
33. *Saunders, M.I., Doropoulos, C., Bayraktarov, E., Babcock, R.C., Gorman, D., Eger, A.M., Vozzo, M.L., Gillies, C.L., Vanderklift, M.A., Steven, A.D.L., Bustamante, R.H., Silliman, B.R.,* 'Bright spots in coastal marine ecosystem restoration', *Curr. Biol., **30** (2020), R1500-R1510.*
34. *Blignaut, J., Esler, K.J., de Wit, M.P., Le Maitre, D., Milton, S.J., Aronson, J.,* 'Establishing the links between economic development and the restoration of natural capital', *Curr. Opin. Env. Sust., **5** (2013), 94-101.*
35. *Stewart-Sinclair, P.J., Purandare, J., Bayraktarov, E., Waltham, N., Reeves, S., Statton, J., Sinclair, E.A., Brown, B.M., Shribman, Z.I., Lovelock, C.E.,* 'Blue restoration - building confidence and overcoming barriers', *Front. Mar. Sci., **7** (2020), 748.*
36. *Bayraktarov, E., Saunders, M.I., Abdullah, S., Mills, M., Beher, J., Possingham, H.P., Mumby, P.J., Lovelock, C.E.,* 'The cost and feasibility of marine coastal restoration', *Ecol. Appl., **26** (2016), 1055-1074.*
37. *Bayraktarov, E., Stewart-Sinclair, P.J., Brisbane, S., Bostrom-Einarsson, L., Saunders, M.I., Lovelock, C.E., Possingham, H.P., Mumby, P.J., and Wilson, K.A.,* 'Motivations, success and cost of coral reef restoration', *Restor. Ecol., **27** (2019), 981-991.*
38. *Gordon, T.A.C., Radford, A.N., Simpson, S.D., Meekan, M.G.,* 'Marine restoration projects are undervalued', *Science, **367** (2020), 635-636.*
39. *Da Ros, Z., Corinaldesi, C., Dell'Anno, A., Gambi, C., Torsani, F., Danovaro, R.,* 'Restoration of *Cymodocea nodosa* seagrass meadows: efficiency and ecological implications'. *Restor. Ecol., (2021), in press.*
40. *Montero-Serra, I., Garrabou, J. Doak, D.F., Ledoux, J.-B., Linares, C.,* 'Marine protected areas enhance structural complexity but do not buffer the consequences of ocean warming for an overexploited precious coral', *J. Appl. Ecol., **56** (2019), 1063-1074.*
41. *Tamburello, L., Papa, L., Guarnieri, G., Basconi, L., Zampardi, S., Scipione, M.B., et al.,* 'Are we ready for scaling up restoration actions? An insight from Mediterranean macroalgal canopies', *PLoS ONE, **14** (2019), e0224477.*
42. *Verdura, J., Sales, M., Ballesteros, E., Cefalì, M.E., Cebrian, E.,* 'Restoration of a canopy-forming alga based on recruitment enhancement: methods and long-term success assessment', *Front. Plant Sci., **9** (2018), 1832.*
43. *Medrano, A., Hereu, B. Cleminson, M. Pagès-Escolà, M. Rovira, G. Solà, J. Linares, C.,* 'From marine deserts to algal beds: *Treptacantha elegans* revegetation to reverse stable degraded ecosystems inside and outside a No-Take marine reserve', *Restor. Ecol., **28** (2020), 632-644.*
44. *Meysick, L., Norkko, A., Gagnon, K., Gräfnings, M., Boström, C.,* 'Context-dependency of eelgrass-clam interactions: implications for coastal restoration', *Mar. Ecol. Progr. Ser., **647** (2020), 93-108.*
45. *Temmink, R.J.M., Christianen, M.J.A., Fivash, G.S., Angelini, C., Boström, C. et al.,* 'Mimicry of emergent traits amplifies coastal restoration success', *Nat. Commun., **11** (2020), 3668.*
46. *Darling E.S., and Côté I.M.* 'Seeking resilience in marine ecosystems', *Science, **359** (2018), 986-987.*
47. *Sala, E., Mayorga, J., Bradley, D., Cabral, R.B., Atwood, T.B., Auber, A., Cheung, W., Costello, C., Ferretti, F., Friedlander, A.M., Gaines, S.D., Garilao, C., Goodell, W., Halpern, B.S., Hinson, A., Kaschner, K., Kesner-Reyes, K., Leprieur, F., McGowan, J., Morgan, L.E., Mouillot, D., Palacios-Abrantes, J., Possingham, H.P., Rechberger, K.D., Worm, B., Lubchenco, J.,* 'Protecting the global ocean for biodiversity, food and climate', *Nature (2021).*

48. *Fraschetti, S., McOwen, C., Papa, L., Papadopoulou, N., Bilan, M., Boström, C., Capdevila, P., Carreiro-Silva, M., Carugati, L., Cebrian, E., Coll, M., Dailianis, T., Danovaro, R., De Leo, F., Fiorentino, D., Gagnon, K., Gambi, C., Garrabou, J., Gerovasileiou, V., Hereu, B., Kipson, S., Kotta, J., Ledoux, J., Linares, C., Martin, J., Medrano, A., Montero-Serra, I., Morato, T., Pusceddu, A., Sevastou, K., Smith, C., Verdura, J., Guarnieri, G.* (submitted) 'Where is more important than how: determinants of restoration success in coastal and marine ecosystems.', *Front. Mar. Sci., in press*
49. *Coppus, R., Romijn, J.E., Méndez-Toribio, M., Murcia, C., Thomas, E., Guariguata, M.R., Herold, M., Verchot, L.*, 'What is out there? A typology of land restoration projects in Latin America and the Caribbean', *Env. Res. Commun., **1** (2019), 041004.*
50. *Aronson, J., and Alexander, S.* 'Ecosystem restoration is now a global priority: time to roll up our sleeves', *Rest. Ecol., **21** (2013), 293-296.*
51. *McNie, E.C., Parris, A., Sarewitz, D.,* 'Improving the public value of science: A typology to inform discussion, design and implementation of research', *Res. Policy, **45** (2016), 884-895.*
52. *Da Ros, Z., Dell'Anno, A., Morato, T., Sweetman, A.K., Carreiro-Silva, M., Smith, C.J., Papadopoulou, N., Corinaldesi, C., Bianchelli, S., Gambi, C., Cimino, R., Snelgrove, P., Van Dover, C.L., Danovaro, R.* 'The deep sea: The new frontier for ecological restoration', *Mar. Policy, **108** (2019), 103642.*
53. *Danovaro, R., Fanelli, E., Aguzzi, J., Billett, D., Carugati, L., Corinaldesi, C., Dell'Anno, A., Gjerde, K., Jamieson, A.J., Kark, S., McClain, C., Levin, L., Levin, N., Ramirez-Llodra, E., Ruhl, H., Smith, C.R., Snelgrove, P.V.R., Thomsen, L., Van Dover, C.L., Yasuhara, M.*, 'Ecological variables for developing a global deep-ocean monitoring and conservation strategy', *Nat. Ecol. Evol., **4** (2020), 181-192.*