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The recovery of the European seas

12 ideas for marine restoration actions

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AUTHOR

Biljana Aljinovic, Consultant, BirdLife Europe and Central Asia
biljana.aljinovic@gmail.com

CONTACT

Anouk Puymartin, Policy Officer, BirdLife Europe and Central Asia
anouk.puymartin@birdlife.org

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Introduction

The marine environment provides up to two-thirds of the ecosystem services supplied by the planet's natural capital but is particularly vulnerable to the climate and biodiversity crises. The pandemic has not put these crises on hold, and they continue to need urgent attention and action. The European seas are in dire straits: currently, 65% of protected seabed habitats in Europe are in unfavorable conservation status. In the Mediterranean, 80% of the assessed fish stocks are overexploited and at risk of being depleted[1]. In Europe, 200,000 seabirds are estimated to be bycaught in fishing gear every year[2].Destructive fishing techniques have contributed to the vanishing of most of our seafloor and continental shelf's rich biodiversity, as well as biodiversity in the water column. In response to global warming, distribution ranges of seagrass meadows and kelp forests are shifting, and in some areas, episodic losses occur following heatwaves.

There is a pressing need to halt the decline in biodiversity and restore lost ecosystem functioning and services at sea. The EU has established key legislation to ensure this happens, including the Birds Directive, the Habitats Directive and the Marine Strategy Framework Directive. The updated EU Biodiversity Strategy will further include legislation to set legally binding restoration targets and these must reflect the urgency to restore degraded marine ecosystems Also, with the new EU Recovery and Resilience Facility in place, now is a good time to consider options for building back better in the European seas and ensure that national Recovery and Resilience Plans (RRPs) financing delivers restoration of habitats at sea. Decisions taken now will have long-lasting impacts and will determine whether we will be able to secure a healthy, safe and resilient future.

There is growing evidence of the benefits that marine restoration of seabeds and water columns can bring both for biodiversity and climate action. Marine restoration ensures the continuation and improved provision of marine ecosystem services, preserves the sea's natural function as a climate regulator and supports the basis and conditions for blue economy in a sustainable manner.

Active restoration of seabeds should be implemented where carbon rich ecosystems were historically abundant (i.e. seagrass beds, shellfish reefs, etc.). This would emphasise the carbon sequestration benefits that marine restoration of such ecosystems can deliver, especially compared to terrestrial habitat restoration. A concrete pathway for restoration is needed and banning destructive activities in fish recovery grounds, nursery areas and carbon sinks should be a priority.

Research has shown that restoration and conservation efforts can lead to significant employment generation in various sectors - for active restoration of marine ecosystems this can mean increased economic activity in sectors such as marine construction while boosting fish production, improving water quality, and recovering threatened ecosystems[3]. Further long-term opportunities can also be created for tourism, which is among the sectors hit hardest by the COVID-19 crisis. Restoration and conservation efforts also help rebalance the interests of coastal areas, creating employment and lasting assets while increasing the resilience of coastal areas against future challenges such as climate change.

The recovery of the original state of the ecosystem can be done through active manipulation or passive natural recovery that allows the ecosystem to recover by limiting human pressure. Different forms of restoration will often need to complement each other to give best results.

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1. FAO/GFCM (2019) Report of the twenty-first session of the Scientific Advisory Committee on Fisheries, Cairo, Egypt, 24-27 June 2019.

2. https://www.birdlife.org/europe-and-central-asia/news/whats-catch-fate-europes-seabirds

3. https://www.birdlife.org/sites/default/files/turning_the_tide_june2020_1.pdf

PROJECT EXAMPLES

1 RESTORATION OF CORALLIGENOUS HABITATS

WHY Coralligenous bioconstructions in the Mediterranean Sea represent key coastal habitats due to their structural and functional importance. They also have high aesthetic value. A study[4] in the Adriatic and Ionian Seas showed that coralligenous habitats in these areas generate an economic contribution of 4.7 million euros/year. At the same time, it was found that conservation alone is not sufficient for the preservation of these habitats and that concrete actions dedicated to their restoration are critically needed.

HOW Transplanting asexually produced units (i.e. coral fragments) is a common tool for recovering habitats by avoiding sensitive early life stages of corals. Existing restoration protocols in the Mediterranean are based on fragments/transplants from donor organisms and recruitment-enhancing devices[5].

SOCIO-ECONOMIC GAINS Coral restoration can create jobs for scientists, divers and diving operators, technicians, biologists, fishermen, administrative staff, and the transport sector. In the long run, it can boost employment in tourism and recreation.

EXAMPLE Several coralligenous habitat restoration activities have been carried out in the framework of the MERCES project. They include the restoration of gorgonians in Spain's Parc Natural del Montgrí i les Illes Medes i Baix Ter and the restoration of sponges and gorgonians in Portofino MPA, in Italy, with actions such as the transplantation of 400 red gorgonian Paramuricea clavata explants over an area that was affected by mortality events. Two methods were used: use of transplanted corals (by transplantation of fragments) and use of recruited corals (grown on suitable recruitment plates attached to the roof of caves supporting dense coral colonies, for larvae to settle and grow). This also included transplanting red coral fragments intercepted/confiscated by local authorities from illegal fishers and poachers in an MPA (Marine Protected Area). The project efforts resulted in the publication of the 'Criteria and protocols for restoration of shallow hard bottoms and mesophotic habitats'[6].

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4. http://www.merces-project.eu/?q=content/importance-restoration-actions-coastal-marine-habitats-coralligenous-habitats

5. Cerrano C. et al. (2018): Restoring biodiversity in the Mediterranean coralligenous - the MERCES project, PeerJ Preprints 6:e26813v1.

6. https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5cb491cde&appId=PPGMS

REBUILDING OYSTER REEFS

WHY Oyster reefs are important biodiversity hotspots in European waters as they build ecosystems. Oysters, including the European Flat Oyster / Native Oyster *Ostrea edulis*, build reef habitats and increase species richness and multidimensional biogenic structures, which play a role in disaster risk reduction by buffering coastlines from the impacts of storms and other climate-induced meteorological events[7]. The construction of oyster reefs stabilises the shoreline and promotes oyster colonisation.

HOW Construction of reef using shell and rock. The whole native oyster restoration programme would include several steps such as selecting the site to be restored, identifying the site connectivity, recommending technologies for reef design and seed oyster production, and monitoring and managing, which would employ highly skilled workers with experience in such restoration methods.

SOCIO-ECONOMIC GAINS Estimates from NOAA in the US show that, for every 1 million USD invested in oyster reef restoration, 16.6 jobs have been created[8]. It can create direct jobs on the ground such as loading crews, fishers, scientists, technicians, biologists, divers, mining and quarry workers, and truck drivers. It would also support indirect jobs in industries that supply materials (e.g. nurseries, lumber, steel, concrete and cement products). It would further induce jobs by boosting employment benefiting from the restoration of the oyster reef such as tourism and recreational activities.

EXAMPLE The Native Oyster Restoration Alliance (NORA) works towards the responsible ecological restoration of the native European oyster and its habitat in areas of its current or historical distribution, in line with biosecurity and sustainability principles. Through the NORA network, the University of Dubrovnik in Croatia is coordinating Mediterranean efforts involved in native oyster restoration. For instance, Mali Ston Bay in Croatia has the largest native oyster aquaculture production in the Mediterranean and pristine water quality, high levels of natural spat (the name for oyster larvae once they permanently attach to a surface) recruitment and a longstanding experience with suspended oyster culture technologies. Native oyster restoration projects are also being carried out in Ireland, France, Germany, Sweden, France, and the UK.

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7. https://www.birdlife.org/sites/default/files/turning_the_tide_june2020_1.pdf

8. Edwards P.E.T. (2013) Investing in nature: Restoring coastal habitat blue infrastructure and green job creation. Marine Policy, Vol. 38, pp. 65-71.

RESTORATION OF BOULDER REEFS

WHY Boulder reefs are reefs where animal and plant communities develop on rock or stable boulders and cobbles, characterised by communities of attached algae and invertebrates and a range of associated mobile animals. They provide refuge for fish, including commercial fish species, and hard substrate for benthic fauna and macroalgal forests. They may also contribute towards improved water quality through the macroalgal production of oxygen, as well as minimise the effect of expected future loss in seaweed production caused by increasing water levels due to climate change.

HOW The restoration of boulder reefs is carried out by depositing new boulders on previously devastated areas of the reef by creating piles of reef forming structures or inserting them among the existing boulders with the aim to provide a physically stable substrate for the development of macroalgae.

SOCIO-ECONOMIC GAINS The restoration of boulder reefs can enhance these highly productive and species rich habitats which in turn provide a series of socio-economic benefits. Locally, leisure fishery will have better conditions for their activity and a positive effect is expected for the local tourist industry based on sightseeing boat trips and divers. Some commercial fish species have been observed to increase in abundance as a result of restoration actions[9]. The actions themselves can create jobs for scientists, divers and diving operators, technicians, biologists, fishermen, administrative staff, and the transport sector.

EXAMPLE Boulders from reef areas have been exploited as a resource for construction of harbours and other marine construction for centuries, especially in the south western part of the Baltic Sea, where boulders are exposed on the seabed. This led to habitat degradation for local fish populations through the destruction of cavernous reefs and changes in macroalgal cover resulting from a loss of substrate. The temperate reef at Læsø Trindel in Kattegat, Denmark, was restored in 2008[10]. Approximately 100,000 tons of large boulders were shipped on a barge from a Norwegian quarry and deposited at three predefined areas at Læsø Trindel during eight trips. The large boulders restored the former water depth of 1.5 m below the surface and in total approximately 27,400 m2 of seabed was covered by new boulders. In the following years, several positive effects of restoration actions on fish species were observed: commercially important species such as cod *Gadus morhua*, and saithe *Pollachius virens*, occurred infrequently in the catches in 2007 but were significantly more abundant in the catches in 2012. Cods were especially attracted to the shallow part of the reef that was restored by adding stones. For some species, such as the Ballan wrasse *Labrus bergylta*, and the cod, the proportion of larger individuals increased after the restoration. The restoration of the reef has so far resulted in an overall increase in biomasses of almost 6-8 folds per m2 seabed at the two depth intervals of 5-6 m and 9-10 m.

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9. Støttrup J.G. et al. (2014) Restoration of a Temperate Reef: Effects on the Fish Community. Open Journal of Ecology 4(4), pp.1045-1059.

10. Stenberg C. et al. (2013) Ecological benefits from restoring a marine cavernous boulder reef in Kattegat, Denmark. Final report to the European Commission, 47 pp.

4 SEAGRASS MEADOW RESTORATION

WHY Seagrass meadows play an important ecological role in the marine environment and provide ecosystem services of great value for the well-being of coastal communities and beyond, such as protection against coastal erosion, contribution to fishery by supporting food webs, carbon sequestration or absorption of pollutants by filtrating water.

HOW Seagrass beds can be restored using a range of techniques that are based either on collecting and transplanting plants or on obtaining and planting seeds[11]. When transplanting adult plants, core plugs, or adult plants are collected from healthy beds, mature plants with rhizomes and adhered substrate, or shoots without adhered substrate, and subsequently transplanted into degraded areas. Unfortunately, this method results in high mortality rates of transplanted plants. Planting seeds seems to be more effective - once the seeds are collected, they may be planted directly in the area to be restored or maintained and treated in a laboratory to promote or even induce germination before being taken to sea. Mechanical planting methods have been developed to reduce time engagement and costs. For large scale seagrass habitats, methods like planting seeds and sediment using natural fiber hessian bags deployed along strings anchored onto the seabed (also called Bags of Seagrass Seeds Line or BoSSLine) were tested successfully[12]. Over the years, numerous analysis[13] and guidelines[14] were published in order to facilitate better success in seagrass restoration actions.

SOCIO-ECONOMIC GAINS Seagrass restoration can create jobs for scientists, divers and diving operators, technicians, administrative staff, and the transport sector. Seagrass beds have an enormous potential for carbon sequestration, providing for effective climate change mitigation strategies. In the longer term, restoring seagrass meadows enhances their provision of numerous ecosystem services (up to 25 ES were identified for *Posidonia oceanica* meadows), with direct benefits to the diving, fishing and tourism industries. The value of *P.oceanica* meadows was estimated between 25.3 million and 45.9 million euros/year which means 283–513 €/ha/year[15] in goods and benefits.

EXAMPLE Long-term Common Eelgrass (*Zostera marina*) restoration efforts have been carried out in a number of areas in the Dutch Wadden Sea, a shallow estuarine area consisting of tidal flats and wetlands, with a combination of passive measures (e.g. decreasing pressures on the ecosystem and improving the biotic and abiotic conditions) and active small-scale seagrass transplantation already initiated in the 1980s. Several techniques for transplantation and for promoting plant growth and increasing stability, including the construction of artificial mussel banks, have been tested. Also, methods to treat infected seeds and to store them in winter have been developed. Recently, additional testing was done through the MERCES project, with a number of field experiments and modelling work, aimed at finding suitable sites and optimal conditions for seeding[16]. A vast number of *Posidonia oceanica* transplanting experiments have been carried out in the Mediterranean in the last decades, with mixed results. Some of the efforts in Italian waters have been summarised in the framework of the LIFE SEPOSSO project.

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11. https://www.saveposidoniaproject.org/formentera/wp-content/uploads/2017/03/OCEANA_Restoration_of_seagrass_meadows.pdf

12. Unsworth R.K.F. et al. (2019) Sowing the Seeds of Seagrass Recovery Using Hessian Bags. Frontiers in Ecology and Evolution vol. 5, p. 311

13. Van Katwijk M.M. et al. (2015) Global analysis of seagrass restoration: the importance of large-scale planting. Journal of Applied Ecology, vol. 53(2), pp. 567-578.

14. Bacci T. et al. (2014) Il trapianto delle praterie di Posidonia oceanica. Manuale e Linee Guida ISPRA 106, 97 pp.

15. Campagne C.S. et al. (2015) The seagrass Posidonia oceanica: Ecosystem services identification and economic evaluation of goods and benefits. Marine Pollution Bulletin, vol. 97 (1-2), pp. 391-400.

16. Carballo-Cárdenas E. et al. (2018) Review on restoration, conservation and recovery of marine ecosystems in the four regional EU seas. MERCES project. 113 pp.

5 MACROALGAL FOREST RESTORATION

WHY Macroalgal forests such as fucoids and kelps are the main habitat-forming species in rocky intertidal and subtidal habitats around the European coasts. They enhance coastal primary productivity and represent diversity hot spots that provide biogenic structure, food and habitat to species assemblages that live within and under the forests. The fucoid algae *Cystoseira* forms dense canopies along the Mediterranean coasts that give shade and reduce physical stress from aerial exposure for rich assemblages of invertebrates and smaller-sized algae[17].

HOW Macroalgae forest restoration can be generally performed through transplantation of juvenile or adult individuals, release of a suspension of gametes/ zygotes or instalment of fertile receptacles in the target area for enhancement of the recruitment potential, or through artificial recruitment (culture of embryos/ juveniles in laboratory).

SOCIO-ECONOMIC GAINS Marine forest restoration can create jobs for scientists, divers and diving operators, technicians, administrative staff, the transport sector, and loading crews. In the long run, it can lead to an increase in commercial species stocks, contribute to the attractiveness of the area, boost employment in fisheries, tourism, as well as mitigate climate change effects and decrease associated costs.

EXAMPLE A few studies explored the reforestation potential of Mediterranean rocky shores through different techniques involving Cystoseira species, such as the transplantation of *C. barbata* in the Northern Adriatic Sea and in the south of France, with a high success rate[18]. This included transplantations to artificial structures, such as breakwaters. A broad-scale experiment was carried out on Marseille harbour dikes where concrete structures were tested to transplant fertile *Cystoseira amentacea var. stricta*. A Cystoseira forests restoration and conservation project in Catalonia and the Balearic islands of Spain worked on developing innovative and non-destructive restoration techniques without adult manipulation of the natural population to restore the damaged populations by incorporating new juvenile individuals bred in laboratory conditions. A recent study in Norway developed and tested a new, cost-effective approach to kelp forest restoration called the "green gravel"[19]- kelp was seeded with small rocks and reared in the laboratory until reaching 2–3cm in size. These were then planted in the field, with high survival and growth over nine months, even when dropped from the surface.

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17. http://www.merces-project.eu/?q=content/importance-restoration-actions-coastal-marine-habitats-coralligenous-habitats

18. Gianni F. et al. (2013) Conservation and restoration of marine forests in the Mediterranean Sea and the potential role of Marine Protected Areas. Advances in Oceanography and Limnology, vol. 4(2), pp. 83-101.

19. Fredriksen S. et al. (2020) Green gravel: a novel restoration tool to combat kelp forest decline. Scientific Reports, vol. 10, art. 3983.

RESTORATION OF THE NOBLE PEN SHELL (PINNA NOBILIS) POPULATIONS

WHY A mass mortality event has been affecting *Pinna nobilis* populations in the Mediterranean since 2016. The outbreak is caused by a pathogen (*Haplosporidium pinnae*), causing very high mortality rates (80-100%) across the region. Restoration actions are among recommended conservation measures to be undertaken in order to ensure the recovery of this endemic and emblematic species.

HOW Restoration actions can be undertaken with juveniles obtained from larval collectors and from ex situ breeding, although the latter still requires more research to close the biological cycle. The actions should be adequately assessed before the implementation, keeping in mind the critical status of the species and the narrow margin for errors. Enhancing larval recruitment is essential, as well as following up on whether the larvae coming from unaffected sites or resistant individuals are reaching the impacted areas, as this would potentially contribute to recovery. Specific guidelines to construct and install *Pinna nobilis* larval collectors are available[20].

SOCIO-ECONOMIC GAINS Restoration of *Pinna nobilis* would create direct jobs on the ground and in the laboratories such as specialised scientists, technicians, biologists, and divers, as well jobs in the transport sector. It would further induce jobs by boosting employment benefiting from the restoration of this emblematic species such as tourism and recreational activities.

EXAMPLES Several Mediterranean countries have already implemented or started implementing different conservation actions to ensure the survival of more resistant *P.nobilis* populations, including restoration. In Spain, a national rescue program has been implemented[21], successfully preserving some individual specimens in aquariums for later translocation in more adequate sites - it seems that coastal lagoons can be considered as "nursery ecosystems," aiding in the recruitment of the species. In the North Adriatic Sea in Croatia activities of translocation of *P. nobilis* from Pula Harbour to a nearby MPA, the Brijuni National Park, have been carried out in 2017 in the context of an Environmental Impact Assessment[22] - it was determined that a planned construction of a new nautical centre would endanger the local *P. nobilis* population and its translocation was prescribed. Recently, larvae collectors were placed among the translocated population and over a dozen larvae were successfully collected and transported to an aquarium.

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20. Kersting D.K. & Hendriks I.E. (2019) Short guidance for the construction, installation and removal of Pinna nobilis larval collectors. IUCN., 6 pp.

21. https://intemares.es/actualidad/noticias/se-ponen-en-marcha-medidas-de-emergencia-para-rescatar-la-nacra

22. Bakran-Petricioli T. et al. (2019) Transplantation of endangered Mediterranean habitat-forming bivalve Pinna nobilis as a prescribed conservation measure: a case study. Proceedings of the 6th Mediterranean Symposium on Marine on Marine Vegetation (Langar H. & Oureghi A. eds.), Tunisia, RAC/SPA, pp. 115-116.

7 COASTAL SAND DUNES RESTORATION

WHY Coastal habitats such as dunes and beaches with *Posidonia oceanica* banquettes play an important role as nature-based defences since they can act as physical barriers to waves and protect the coast from flooding and erosion. They can self-repair after strong storms and have much lower maintenance costs than artificial infrastructures. Additionally, they often host rare and endemic species in need of protection.

HOW Restoration strategies for coastal dune systems are complex because sandy dunes are exposed to multiple dynamic processes that operate on different temporal and spatial scales. These range from the re-establishment of vegetation to the removal of vegetation and eliminating invasive species, including the introduction of grasses and nourishment in order to enhance flood protection and wave erosion defences and promote dune fixation[23].

SOCIO-ECONOMIC GAINS The restoration of sand dunes and beaches with *Posidonia oceanica* banquettes can create jobs in coastal safety, marine and terrestrial ecology, hydrology, geochemistry, engineering, governance, and maintenance. Indirect jobs in the tourism industry would also be boosted from such restoration projects as healthy coastlines provide valuable ecosystem services such as recreation and cultural values.

EXAMPLE A dune ecosystems restoration project in Sardinia[24] implemented anti-erosive, stabilising and consolidation actions for the protection and restoration of dune ecosystems through naturalistic engineering interventions. Restoration actions were performed ensuring the manual removal of invasive alien plant species and the subsequent planting of native ones, with the aim of contributing to the preservation of indigenous plant communities and their genetic diversity. The activities included different interventions (positioning of cane structures for sand retention and consequent recovery of the dune profile, positioning of coconut fibre bionets to avoid erosion, particularly after the eradication), as well as plantation and sowing of plant species.

Sand dunes,
Uwe Jelting / Unsplash

23. Bird T.L.F. et al. (2020) Can Vegetation Removal Successfully Restore Coastal Dune Biodiversity? Applied Sciences vol. 10, art. 2310.

24. https://ser-insr.org/news/2018/10/8/seed-based-restoration-of-damaged-mediterranean-coastal-habitats-the-sardinia-case

8 PASSIVE RESTORATION IN MARINE PROTECTED AREAS

WHY Marine protected areas have a range of protection mechanisms and measures in place that can allow the damaged ecosystems to restore and thrive. The concept of "no-take zones" as a form of passive restoration has been widely effective in Marine Protected Areas[25]. An effective implementation of these mechanisms through improved surveillance and enforcement is an opportunity to allow for these restoration processes to unravel.

HOW Different approaches can be explored depending on local and national conditions and the context of each MPA. These can include, but are not limited to, setting up co-management committees for rules enforcement, setting up an effective surveillance system through equipment modernisation, building and strengthening MPA capacities for surveillance and enforcement (trainings, workshops, exchange visits), and enhancing collaboration with local authorities (coast guard, inspectors, maritime police).

SOCIO-ECONOMIC GAINS Maintaining effective limited-activity zones or "no-take zones" in MPAs create jobs for scientific researchers, field surveyors and monitors as well as enforcement officers. The restoration effects of such zones, with an improved aesthetic value of the area, can boost jobs in the tourism and fisheries sectors. For example, in six no-take zones in parts of Gökova Bay, Turkey, trawling and purse seine activities were restricted, which led to a 400% increase in the income of fishers[26].

EXAMPLE The Torre Guaceto MPA in Italy includes a multi-use area for small-scale fishing. Its fishery regulation was set up together with resident fishers, resulting in a protocol that gave them exclusive access rights inside the MPA, while limiting their activity to one day per week and with large mesh nets only, in order to avoid capturing juveniles. Thanks to this regulation, the income generated inside the MPA doubled with respect to the surrounding waters, and fishers themselves decided to use large-mesh nets also outside the MPA. The tourism sector joined the process as well through an innovative management strategy that involved combining a system of parking fees and high-quality services. This resulted in a significant improvement of the tourism services and led a transition towards low-volume, high-value tourism, with livelihood opportunities for residents and a lower environmental impact[27].

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25. https://www.birdlife.org/sites/default/files/turning_the_tide_june2020_1.pdf

26. Haines R. et al. (2018) Study on Economic Benefits of MPAs. European Commission, 93 pp.

27. Russi D. (2020) Chapter 17 - The Torre Guaceto marine protected area - what can we learn from this success story? Marine Protected Areas, pp. 329-342.

9 PASSIVE RESTORATION THROUGH FISHERIES MEASURES

WHY The negative impact of fisheries on the balance of marine ecosystems in European waters is well-documented and addressed through several policies, but the efforts on the ground have so far been largely insufficient. More actions must be carried out to ensure the recovery of depleted fish populations and degraded habitats. While several measures prescribed through the European Maritime and Fisheries Fund (EMFF) directly, or indirectly, address the protection of the marine environment, additional measures can be implemented to ensure that the recovery of the fisheries sector does not lead to further degradation of marine ecosystems.

HOW Examples of measures that can contribute to passive restoration of marine ecosystems include, but are not limited to: investing in technologies that can help monitor oceans more efficiently and effectively, such as systems that can help analyse and interpret remote monitoring, design intelligent harvest-yield protocols that can maximize the long-term benefits of sustainable management practices; establishing best practice mentoring to deliver improved environmental performance from fishing vessels; establishing a fisher wellbeing programme to build resilience in the fishing industry; developing a programme to trial low-impact methods of fishing that eliminate bycatch and prevent sea floor damage; establishing diversification schemes for alternative job opportunities for fishers.

SOCIO-ECONOMIC GAINS By rebuilding fish populations, the EU could feed an extra 89 million citizens, gain an extra €1.6 billion in annual revenue and create over 20,000 new jobs[28]. Training would include skills training for fishers with new technologies, and increased opportunities for apprenticeships in trades, as well as job opportunities for former fishers as mentors. Increased skills for sustainable fishing can lead to an improved social wellbeing for fishers and stronger social licence, with the potential to attract more people to be employed in sustainable fishing. It would also contribute to a better resilience of the sector itself.

EXAMPLE A study from 2008[29] established that changing gear type from conventional trawl fisheries to more passive creel (basket) fisheries to catch Norway lobster would reduce the impact on the seafloor area from 33,000 m2 to 1.8 m2 per kilo of lobster. It would also cut down the amount of unwanted catches from 4.5 to 0.36 kg and the need for fuel from 9 to 2.2 litres. The lobster caught by creel is generally of better quality and thus better priced. In the American oyster fishery, changing from dredging and tonging to diver harvesting produced 25-32% more oysters for the same amount of time-spent fishing[30].

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28. https://neweconomics.org/2020/03/landing-the-blame-overfishing-in-the-northeast-atlantic-2020

29. Ziegler F. & Valentinsson D. (2008) Environmental life-cycle assessment of Norway lobster (Nephrops norvegicus) caught along the Swedish west coast by creels and conventional trawls - LCA methodology with case study. The International Journal of Life Cycle Assessment, vol. 13, art. 487.

30. Lenihan H.S.& Peterson C.H. (2004) Conserving oyster reef habitat by switching from dredging and tonging to diver-harvesting. Fishery Bulletin - NOAA, vol. 102(2).

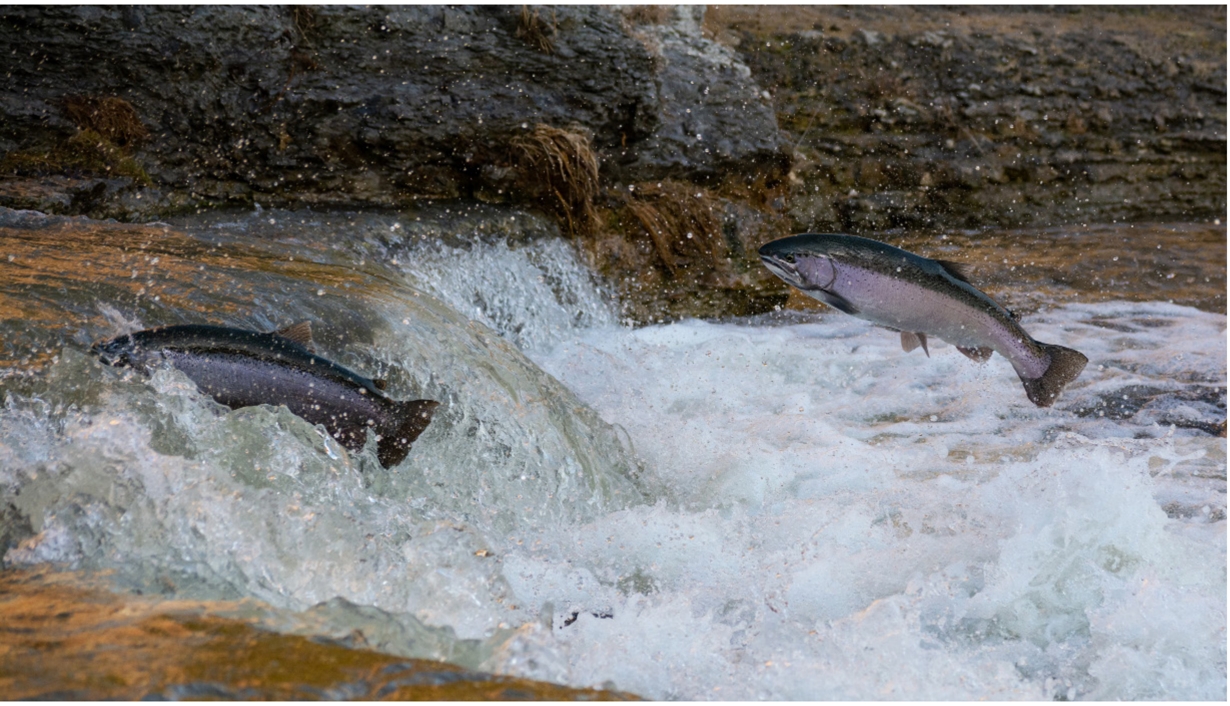
10 RESTORING FISH MIGRATION PATHS

WHY In the last decades, fish worldwide have been increasingly limited in their ability to swim from seawater to fresh water or vice versa due to the construction of dams, dikes and other obstacles in rivers and delta areas. Restoring such fish passages is an active method of reestablishing their access to spawning grounds, which in turn helps restore wild fish populations.

HOW Fish migration paths can be restored by building permanent entrances in existing dams and other structures, as well as by removing dams that are obsolete.

SOCIO-ECONOMIC GAINS Depending on the size of the project, this type of activity can create jobs in the construction, tourism, fishing, and conservation sectors, for roles such as engineers, construction professionals, environmental consultants, horticulturists, landscapers, lawyers, scientists, administrative positions, recreational angling and commercial fishers, and researchers. A report[31] from Nature Conservancy states that "the Sea Trout Funen Project in Denmark generates an estimated 5.8 million EUR/year in angling tourism for a 5 million EUR/year initial investment in river restoration through dam removal."

EXAMPLE To restore the connection between the Wadden Sea and Lake Ijsselmeer, Netherlands, a permanent entrance will be built in the Afsluitdijk dam ("fish migration river") by 2023. This should allow for the passage of different fish species, such as the Sea Trout, the River Lamprey, the European Eel, the European Flounder, and the critically endangered Atlantic Salmon.



Salmons migrating,
Brandon / Unsplash

31. https://www.nature.org/en-us/about-us/where-we-work/europe/stories-in-europe/restoring-free-flowing-rivers-in-europe/

11 RESTORING SEABIRD NESTING SITES

WHY Seabirds are the world's most threatened bird group and are in high risk by human activities. Seabirds tend to be long-lived, mature late, lay few eggs, and invest a lot of time in their offspring. Their nesting sites are often exposed to a variety of threats, such as invasive species, habitat degradation, and disturbance. Active seabird restoration supports the expansion of existing colonies, restoration of historical populations and protection against further threats[32].

HOW One approach consists in creating artificial nests to increase the use of certain coastal areas by seabirds. Habitats for seabird nesting can include vegetation, trees, burrows, crevices, and ground-surface. Depending on the target seabird species, artificial or enhanced habitat may be necessary for establishing a colony - for example, an active intervention in form planting low-growing vegetation for certain ground-nesting seabird species. This approach often needs to be complemented by other methods, such as the removal of invasive mammals (e.g. rodents, mongoose). If this is not possible, predator-proof nesting structures or areas may be needed to protect breeding seabirds.

SOCIO-ECONOMIC GAINS This type of activities may involve jobs for different types of specialists, such as biologists, small boat operators, hunters, and open up administrative positions. It would further induce jobs by boosting employment benefiting from the presence of emblematic seabird species, such as tourism and recreational activities, as well as the IT sector (e.g. installation and maintenance of cameras for seasonal live streaming of nests with chicks).

EXAMPLE In the framework of the Life Berlengas project in Portugal, artificial nests were built for Cory's Shearwaters and Band-rumped Storm-Petrels, and the removal of mammals introduced by humans (black rats and rabbits) was carried out with a high success rate. Biosecurity measures were established to prevent new rodents from entering the island. The artificial nests mimic the crevices the birds would normally nest in. The nest occupancy rates at the end of the project (2019) were around 36% for Cory's Shearwater and 10% for Band-rumped Storm-Petrels, tending to increase. The nests also contributed to the breeding success of both species.

32. Jones H.P. and Kress S.W. (2012) A Review of the World's Active Seabird Restoration Projects. The Journal of Wildlife Management, vol. 7681), pp. 2-9.

12 DEEP SEA RESTORATION

WHY Deep-sea ecosystems are the most extensive ecosystems on Earth, essential for human well-being as they provide key ecosystems services such as genetic resources and climate regulation. They are currently facing major changes related to human and climate-induced impacts and their protection is important for the maintenance of the sustainable functioning of the global biosphere as a whole. Given the level of habitat degradation in the deep-sea, in some cases the protection alone can often be insufficient and restoration actions should be taken into consideration.

HOW Scientifically, deep-sea restoration actions are feasible, but limited data availability and often prohibitive costs represent a major obstacle for such actions. To minimise those obstacles, it is best to implement such projects through actions of international cooperation and through collaboration of different types of institutions (governments, academia, industries). Researchers have proposed several methods for deep-sea habitat restoration, many of which still require testing and evaluation[33]. These include electrified artificial reefs to enhance survival/growth/recruitment rate of cold-water corals; recruitment of larvae in shallow depths and translocation in deeper areas and increasing of the rugosity of mined substrata to promote larval settlement. Deep-sea restoration can also be passive, allowing for an unassisted natural recovery of ecosystems following cessation of an activity, mainly using protected area protection mechanisms.

SOCIO-ECONOMIC GAINS Given the large-scale aspect and the complexity of deep-sea restoration actions, these could represent an important business opportunity for technological development and application and an investment in natural capital for a new and competitive blue-growth sector. Involvement of governments, research institutions, academia, industries, and non-governmental organisations for monitoring activities aiming to assess the natural recovery of the investigated ecosystems, including funding for ship time, personnel involved and sampling activities, are just some of the examples. A recent research[34] estimated the benefit value to society of the restoration of the deep-water Dohrn canyon ecosystem in the Bay of Naples, Italy, and obtained the aggregate value of restoration of approximately €127 million/annually. Taking into account available estimates for the cost of restoration, this value indicates a positive net benefit to society from the potential restoration of the canyon.

EXAMPLE The MERCES project aims to provide additional evidence that deep-sea restoration is feasible, either using coral nubbins transplantation techniques or using artificial habitats enabling a better recruitment of the larvae of some deep-sea species.

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33. Da Ros Z. et al. (2019) The deep sea: The new frontier for ecological restoration. Marine Policy, vol.108, art. 103642.

34. http://whitakerinstitute.ie/wp-content/uploads/2020/09/Policy-Brief_no-67_Eamonn-OConnor.pdf