European Commission

LIFE & the MARINE ENVIRONMENT

Environment

EUROPEAN COMMISSION
ENVIRONMENT DIRECTORATE-GENERAL

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The contents of the publication "LIFE and the Marine Environment" do not necessarily reflect the opinions of the institutions of the European Union.

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Foreword


Photo: EU/Inguin A. Mæhlum

Clean and healthy oceans are crucial to the wellbeing of our planet. That is why it has been one of the priorities of my mandate. That is why I was given the new portfolio that combined Environment, Maritime Affairs and Fisheries. When the Ocean makes up 70% of our planet it makes sense that we consider the blue and green of our planet together.

The **EU's Marine Strategy Framework Directive** looks at the pressures on the marine environment. How do we limit damage to marine biodiversity and ecosystems and restore their good environmental status? Millions make a living from the sea. We must ensure it is compatible with a healthy marine environment.

The EU has developed strong instruments to make this happen. For marine biodiversity in the EU, **the Birds and Habitats Directives and the Natura 2000 network** of marine protected areas play the major role. Having well-managed protected areas is key to the recovery of the marine environment. It increases productivity while respecting its rich biodiversity.

By taking a coordinated approach to biodiversity, marine, fisheries and maritime policy, the EU can be a global leader in marine conservation.

One of LIFE's strengths is to join different policies that have an impact on the health of our seas. The result? Good environmental status for EU marine waters.

LIFE projects are practical tools in the fight against marine litter or invasive alien species, among others. They help balance or reduce any negative impacts of fishing and aquaculture, underwater noise, marine contaminants and eutrophication:

- Fighting marine litter is one of the highest profile achievements of this Commission. To complement our flagship plastics strategy, we have developed projects that support clean-up schemes and prevention campaigns. I particularly liked the MERMAIDS project, which developed fabric treatments to stop microplastics from our clothes ending up in the sea.
- It's just as important to tackle the spread and impact of invasive alien species in coastal areas. LIFE projects such as RAPID in the UK are doing this in a comprehensive way.
- It's also great to see projects working with fishing communities to mainstream sustainable practices, such as precision methods that cut down on by-catch. This makes commercial sense, as well as being more resource efficient. LIFE's best practices can promote blue growth and job creation in the marine and maritime sectors.
- We have to find new ways to prevent and treat the causes of eutrophication. The Urban Oases project in Finland shows that vegetated swales for rainwater retention in cities are more attractive and more cost efficient than bigger stormwater pipes.
- We need to work together to make sure governance and transboundary management of marine pressures works. LIFE is at the forefront of such efforts. For instance, the BIAS project brought together partners from seven countries and worked closely with HELCOM to develop standards for measuring and mapping underwater noise in the Baltic Sea.
- Exceptional stakeholder engagement is a feature of the LIFE programme and it's pleasing to note that LIFE Integrated Projects have an even greater capacity to build bonds. This can help boost marine biodiversity through species conservation and support for marine protected areas across Europe, as the LIFE-IP INTEMARES project is showing.

Enjoy this brochure and join us in the fight to keep our oceans clean and the extraordinary biodiversity that lives within, thriving.

Karmenu Vella

European Commissioner for Environment, Maritime Affairs and Fisheries

Photo: LIFE12 NAT/MT/000845/OCEANA/Carlos Minguel

Cleaning up Europe's seas with the MSFD

The EU's Marine Strategy Framework Directive (MSFD) has helped swell our understanding of Europe's seas, says **Matjaž Malgaj,** Head of DG Environment's Marine Environment and Water Industry Unit. The next step is to turn this knowledge into more effective action.

Photo: European Commission

"The Marine Strategy Framework Directive is about ensuring the EU's seas are clean, healthy and productive."

"I've been working on the marine environment for the past three and a half years, both in the EU and helping colleagues worldwide to develop the oceans governance approach," says Mr Malgaj. "The Marine Strategy Framework Directive is about ensuring the EU's seas are clean, healthy and productive," he explains. "We already had legislation and policies on different aspects of the marine environment but the Directive looks at this environment as a whole. It also pushes back frontiers, introducing issues not covered by legislation before, such as marine litter, underwater noise and seabed integrity."

In its first cycle, the MSFD has already improved understanding of the EU's seas and brought more cooperation between Member States, reckons Mr Malgaj. "We had big knowledge gaps - and we still have some. But getting countries to work together to look at their seas over the past six years has really increased the amount of knowledge and tells us what we have to do to improve them." Lack of data and resources is still a big barrier to implementing the Directive, he thinks. "Seas are vast ecosystems, with complex interactions, which can be hard to reach and monitor. Countries often aren't sufficiently equipped with the people and the money to do this."

The MSFD's overarching goal is for EU marine waters to have 'good environmental status' by 2020. To achieve this, "the first challenge is to be sure what constitutes good environmental status," says Mr Malgaj. "We're making headway on this. In areas where we have a better understanding it's already clear that it'll be very difficult to reach this status for some descriptors. But that's something we should take as a trigger for more action - and more focused action," he explains.

"The main pressure on the EU's seas is still overfishing," points out Mr Malgaj. "There are also big problems with pollution, marine litter and in many places with the integrity of seabed habitats." Underwater noise is another issue: "We are making really good progress with understanding the impacts, but we simply don't know enough about what needs to be done to mitigate them."

Photo: European Commission

The focus on marine biodiversity

"EU nature legislation - the Birds and Habitats Directives - is vital for reaching the Marine Strategy Framework Directive's targets. The Natura 2000 network contains more than 3 100 marine sites, covering 7% of EU seas, that must be properly managed to protect threatened habitats and species. In addition, Member States have to enforce strict protection measures for certain marine species. These conservation efforts, and other key actions under the EU's Biodiversity Strategy – namely those related to invasive alien species - will help Member States reach 'good environmental status' for the MSFD's descriptors. In turn, the MSFD's comprehensive marine protection supports the work done in Natura 2000 sites and beyond.

"The LIFE programme plays a pivotal role in marine conservation: its innovative projects serve common policy goals and showcase the synergies between marine nature conservation and protection of the wider marine environment. These efforts must now be scaled up across Europe. The EU can lead by example in global marine conservation and respond decisively to the mounting challenges. We can achieve this if we work together - authorities, stakeholders and all users of the sea - to implement EU biodiversity, marine, fisheries and maritime policies in full."

Humberto Delgado Rosa
Director for Natural Capital
DG Environment, European Commission

Photo: LIFE12 NAT/MT/000845/OCEANA/Carlos Minguel

What next?

In the MSFD's second cycle, establishing exactly what constitutes good environmental status is vital, reckons Mr Malgaj. "We've adopted new rules that explain this more clearly and we're developing threshold values - a way of using quantification, or in exceptional cases, trends - to determine this in relevant parts of the sea. This will show us where we are furthest from our targets. At the moment, it's difficult for us to assess whether the actions taken are achieving what they are supposed to. The next generation of measures must be clearly linked to the pressures [on the EU's seas] and monitored appropriately to see if they are effective."

Mr Malgaj explains that "one of the big added values of this Directive is getting those who have to work together to deal with problems at the appropriate scale. Some are global, like climate change and marine litter." Others can be dealt with at a smaller scale. "Member States are already working together at regional and sub-regional level. But more of this cooperation is needed."

LIFE projects have a role to play here, he thinks. "Their biggest strength is their ability to bring different people together to work towards a common goal. They can have a very positive impact." For instance, a traditional LIFE project helped Spanish authorities and scientists to establish the requirements for effective marine protected areas. Now a LIFE Integrated Project is pulling together different resources to set up a coherent and effective chain of marine protected areas around Spain (see pp. 18-20).

Europe leads the way on marine protection

Deep-sea biologist **Roberto Danovaro** says EU legislation on the marine environment is the best in the world, but more work is needed to hit the demanding targets for Europe's seas, especially in neglected areas.

Photo Giandomenico Papa

"I specialise in deep-sea biology, exploring the biodiversity and secrets of life in the dark part of the ocean," says Roberto Danovaro, professor of marine biology and marine ecology at Marche Polytechnic University in Ancona, Italy.

"Globally, we are failing to protect marine areas of particular natural interest," he says. "Also, 50% of the ocean is beyond national jurisdictions so we need international cooperation programmes to develop protected areas there." At the European level, Prof Danovaro says: "More progress has been made in protecting the terrestrial environment." When it comes to the sea, the focus has generally been closer to shore and on shallower waters, neglecting the open ocean and deep-sea regions. As a result, the EU is closer to reaching its environmental targets on land than in the marine environment: "We tend to protect what we can see."

The Marine Strategy Framework Directive (MSFD) is already helping improve understanding of the marine environment in the EU and the state it's in. "It's the best Directive ever conceived for the protection of the marine environment - the most visionary, complete and advanced in terms of scientific tools," says Prof Danovaro. "It puts ecosystems and biodiversity at the centre of protection. There are no comparable tools or legislation, or such complete ones, in any other part of the world."

He adds, "We need a baseline and data to build up true protection of the whole ecosystem." The MSFD provides the tools to obtain this information, through its 'descriptors'. EU Member States will use these descriptors to determine whether their marine waters have 'good environmental status'. "There is a certain degree of redundancy in some of the descriptors, as a result of overlaps between different descriptors. But scientists are trying to pull these together, to concentrate the indicators into some main pillars."

Protecting deep and shallow

Prof Danovaro thinks it will be a challenge to achieve good environmental status for Europe's seas by 2020. "To do this, we need to know the oceans better. We still haven't mapped most of the oceans, or identified the biodiversity or ecosystem functions of these parts of the oceans." For him, going deeper is key: "Very little is known of the deep sea, certainly not enough to fully exploit the potential of the marine strategy. Most of the species fished on the continental shelf spawn in deeper waters, so protecting the deep means protecting the shallow."

Knowing more about the interaction between shallower and deeper waters is also vital. "Shallow ecosystems don't work without upwelling of deep waters, or injections of life, food, propagules, larvae and so forth. So it's less than halfway protection if we don't consider also the deeper habitats. We need to consider the whole marine system in a three-dimensional perspective." Changing attitudes is important as well, he believes. "People have to understand that protection is not about restricting their freedom to use the marine environment, but about guaranteeing its preservation and sustainable use," explains Prof Danovaro.

To achieve good environmental status of Europe's seas, more work needs to be done on implementing the legislation, says Prof Danovaro. "Making the marine strategy successful means enforcing marine protection." This is made harder by differences in approach across Member States: "Every country uses different models to implement the descriptors, in some cases based on species that have limited distribution or sensitivity to pollution." More should be done to harmonise the methods used, he believes. "We need consistent approaches over wide spatial scales in order to develop standardised protocols and joint actions. This should be coordinated at EU level, based on the biogeographical units or regional seas, and using the most advanced technologies that are needed to work on larger spatial and temporal scales." This is in line with the EU Decision on good environmental status adopted in May 2017.

Prof Danovaro reckons LIFE projects have been important so far in helping protect the marine environment. "These projects really produce something concrete, visible and hopefully long lasting." He hopes future projects will focus on some of the more neglected marine areas: "On the open ocean and deep sea; on new habitats. Widening the approach is important. We need to start protecting vulnerable deep-sea ecosystems, such as canyons, seamounts, hydrothermal vents and cold seeps that are becoming the main target for industrial exploitation of minerals, oil and gas."

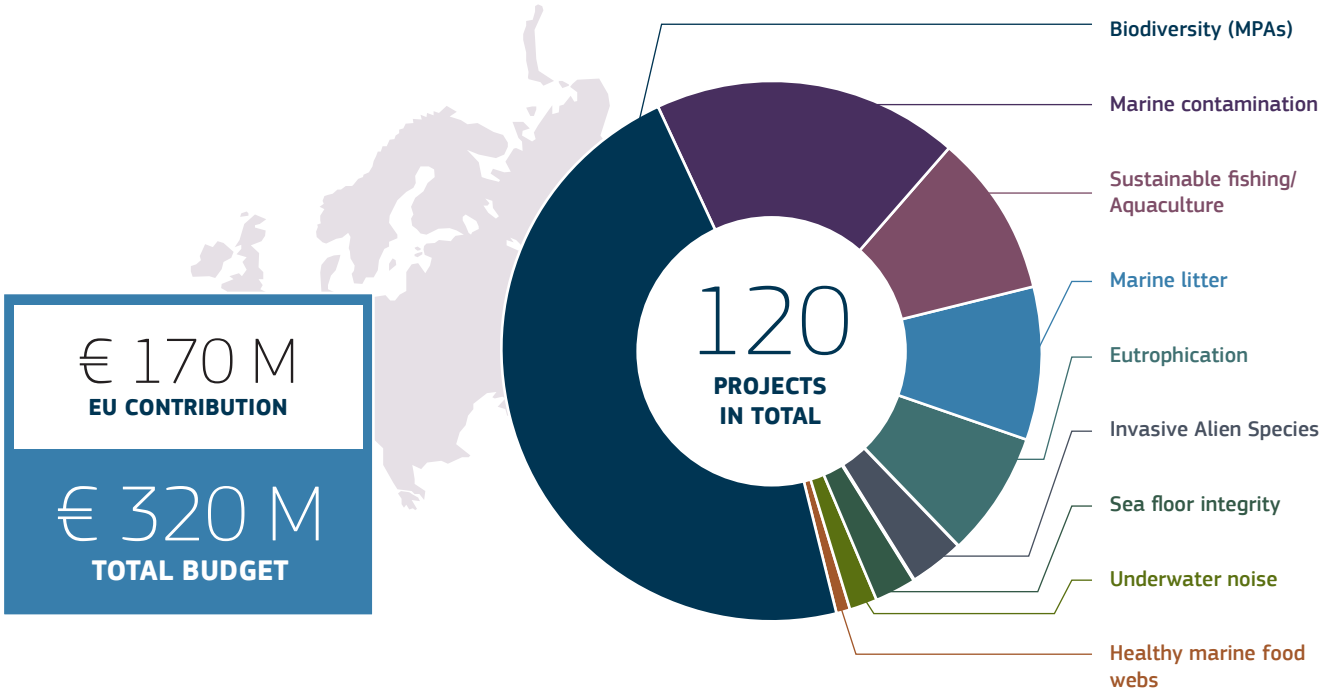
Globally, he believes the EU can lead the way when it comes to protecting the marine environment. "Developing countries have major problems and would benefit from cooperation programmes with the EU. The marine strategy is a revolutionary approach for protecting and managing the seas and oceans. We need to enforce it and make efforts to widen the approach at global level."

"People have to understand that protection is not about restricting their freedom to use the marine environment, but about guaranteeing its preservation and sustainable use."

Photo: LIFE12 NAT/IT/000845/OCEANA/Carlos Minguel

LIFE and the marine environment: introduction

The LIFE programme plays an important role in safeguarding the health of our seas and oceans. LIFE has co-funded some 120 projects that have mobilised some €320 million, including an EU contribution of €170 million. The solutions developed by these projects are widely transferable and replicable across the EU.



LIFE projects have taken an integrated approach to protecting the marine environment. This has created important synergies, especially between the Marine Strategy Framework Directive (MSFD), the Birds and Habitats Directives, the Circular Economy Action Plan, the Water Framework Directive, and the Plastics Strategy. This policy-integration role is now being reinforced through LIFE Integrated Projects, such as LIFE-IP INTEMARES (see pages 18-24).

To date, LIFE projects have addressed nine of the eleven qualitative descriptors of the MSFD, which describe what the marine environment will look like when 'good environmental status' has been achieved.

The first descriptor, biodiversity, has been addressed by over 55 projects funded under the LIFE Nature strand. The second big area is marine pollution, encompassing the descriptors of marine litter, marine contamination and eutrophication; these three together account for 42 projects and a total of €85 million (€37 million of EU contribution).

To maintain marine biodiversity, LIFE projects have established and proposed management measures for more than 150 offshore and coastal Natura 2000 sites. Thanks to major efforts through LIFE, this network now forms the core of marine protected areas (MPAs) in the EU. By improving the 'conservation status' of marine species and habitats across the Natura 2000 network, LIFE has taken a big step towards achieving 'good environmental status' of marine waters under the MSFD. LIFE projects have also greatly improved knowledge of marine offshore habitats, such as reefs, and improved the conservation status of numerous species, especially seabirds (73% of projects), cetaceans (17%) and sea turtles (9%).

Successful MSFD implementation relies on effective stakeholder participation at all levels. LIFE projects have also consistently highlighted the necessity of working together to manage marine Natura 2000 sites, and successful collaborations have been established with fishermen, tourist operators and local authorities.

Invasive alien species, food webs, contaminants in seafood, sea floor integrity and underwater noise have been targeted to a lesser extent by LIFE projects. However, these projects have made significant contributions, such as developing early warning systems for marine invasive species (see page 36) and standards for measuring underwater noise (see page 56). This work can be built upon, to complete the scientific knowledge needed to define the state of the marine environment, and the means to achieve good environmental status with respect to these pressures.

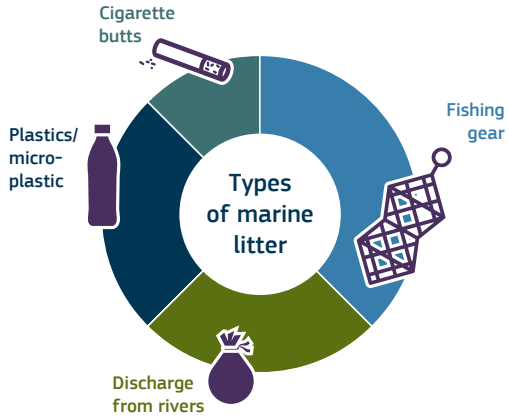
LIFE projects concerning marine litter have helped in implementing EU policy in areas such as the circular economy, single-use plastics, urban waste and wastewater management, all of which prevent litter entering the marine environment. Most of these projects have devised actions to tackle the problem at source through preventive measures, such as using "litter traps" in rivers (see page 40) or reducing microplastics released during laundry processes (see pages 45-46). The remainder have involved awareness campaigns and clean-up operations on beaches or at sea, with the active participation of citizens, fishermen, divers and other stakeholders. These have helped to retrieve waste for reuse and upcycling in line with a resource efficient economy. LIFE solutions have targeted land-based and sea-based litter indistinctly. The main types of litter recovered are discarded fishing gear, plastics and other floating marine litter, which are potential resources if effectively managed, for example, according to the Port Reception Facility Directive.

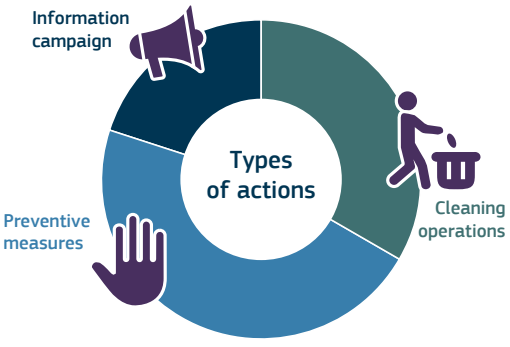
Regarding the MSFD descriptor on healthy populations of commercial fish species, LIFE projects have developed technologies for precision fishing, mapping fish stocks, and making aquaculture more sustainable. Campaigns have also been organised to encourage consumers to eat alternative fish considered as discards, to reduce pressure on overexploited species.

In terms of contaminants, the LIFE programme has funded hundreds of projects that have helped prevent pollutants from industrial and agricultural sources entering the marine environment, or projects that have improved water quality in freshwater bodies. The projects featured in this publication have directly reduced contamination in marine waters, for example, by demonstrating sediment treatments for different types of pollutants. These techniques have reduced contamination both on the seabed and in the open water column, thus improving marine water quality. The complete removal of contaminants also facilitates the reuse of sediments in diverse applications.

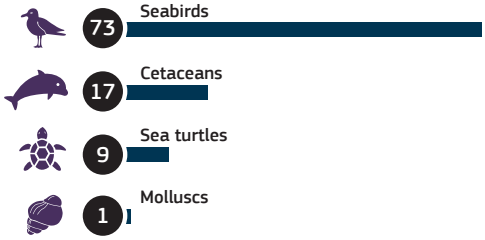
The LIFE programme has provided multiple solutions for tackling eutrophication at source, such as reducing nitrogen use and run-off in agriculture and identifying new agri-environmental measures to optimise resource use, or improving wastewater treatment. Furthermore, LIFE projects featured in this publication have developed tools to forecast algal blooms (see page 64), and test water protection measures such as constructed wetlands that reduce nutrient run-off into the Baltic Sea (see page 65).

LIFE & marine litter

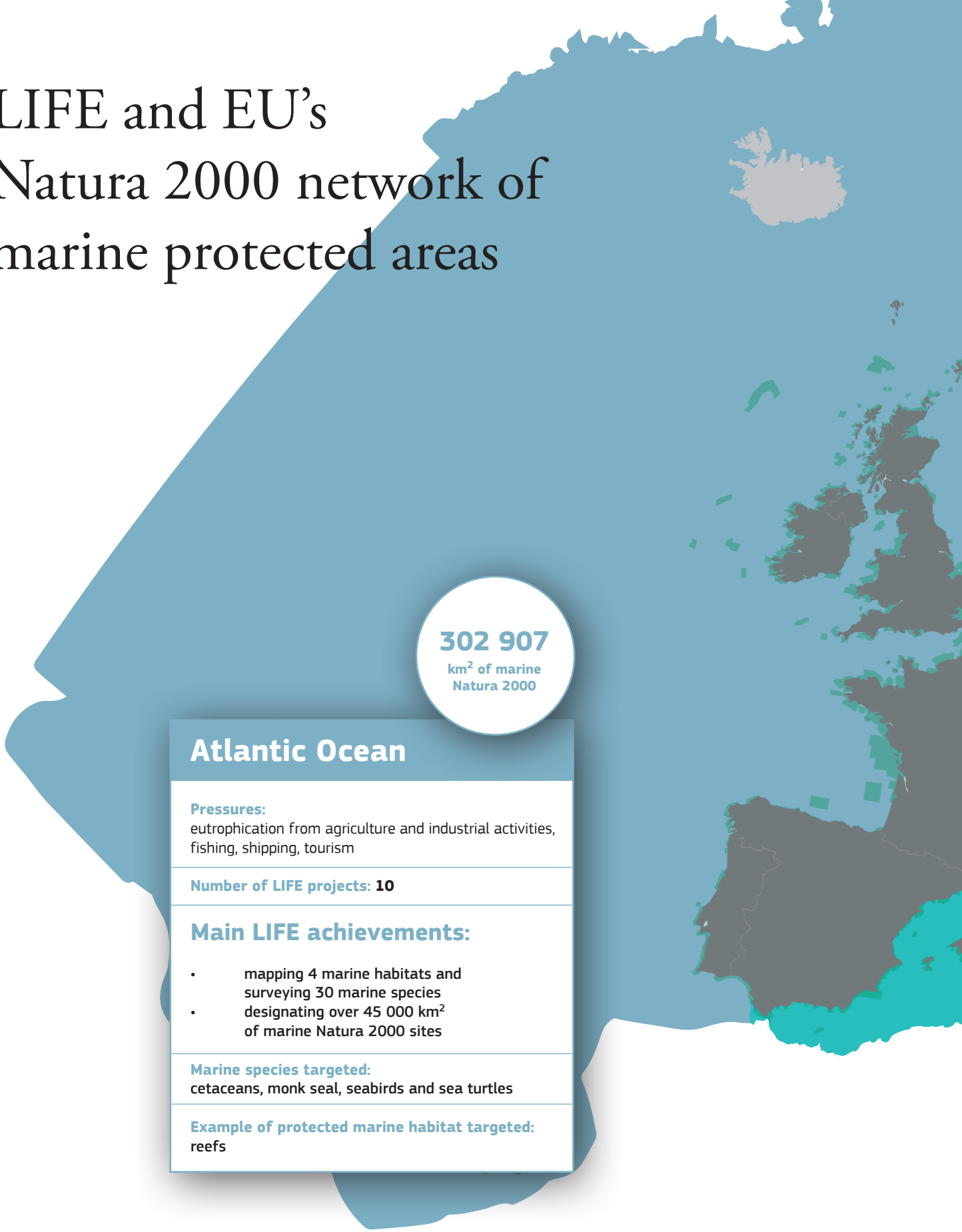




Number of projects per species group



LIFE and EU's Natura 2000 network of marine protected areas



302 907
km² of marine Natura 2000

Atlantic Ocean

Pressures:
eutrophication from agriculture and industrial activities, fishing, shipping, tourism

Number of LIFE projects: 10

Main LIFE achievements:

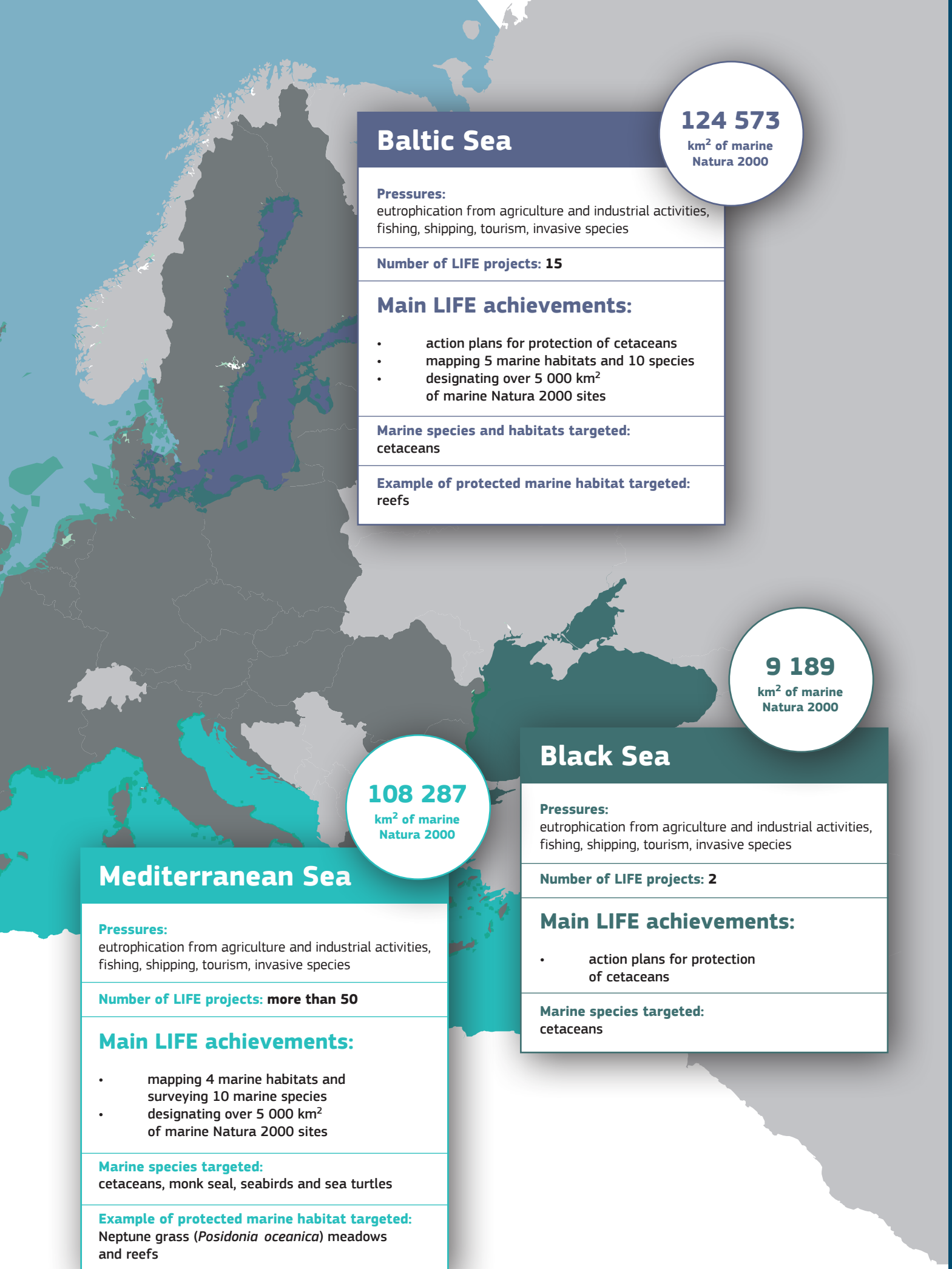
- mapping 4 marine habitats and surveying 30 marine species
- designating over 45 000 km² of marine Natura 2000 sites

Marine species targeted:
cetaceans, monk seal, seabirds and sea turtles

Example of protected marine habitat targeted:
reefs

NATURA 2000

532.417 Km²*
of marine Natura 2000 network
*(*up to May 2018)*



Baltic Sea

124 573 km² of marine Natura 2000

Pressures:
eutrophication from agriculture and industrial activities, fishing, shipping, tourism, invasive species

Number of LIFE projects: 15

Main LIFE achievements:

- action plans for protection of cetaceans
- mapping 5 marine habitats and 10 species
- designating over 5 000 km² of marine Natura 2000 sites

Marine species and habitats targeted:
cetaceans

Example of protected marine habitat targeted:
reefs

Black Sea

9 189 km² of marine Natura 2000

Pressures:
eutrophication from agriculture and industrial activities, fishing, shipping, tourism, invasive species

Number of LIFE projects: 2

Main LIFE achievements:

- action plans for protection of cetaceans

Marine species targeted:
cetaceans

Mediterranean Sea

108 287 km² of marine Natura 2000

Pressures:
eutrophication from agriculture and industrial activities, fishing, shipping, tourism, invasive species

Number of LIFE projects: more than 50

Main LIFE achievements:

- mapping 4 marine habitats and surveying 10 marine species
- designating over 5 000 km² of marine Natura 2000 sites

Marine species targeted:
cetaceans, monk seal, seabirds and sea turtles

Example of protected marine habitat targeted:
Neptune grass (*Posidonia oceanica*) meadows and reefs

Photo: NEEMO EEIG/Robin Salter

1

Safeguarding biodiversity in marine protected areas

LIFE projects have proposed the designation of many marine Natura 2000 sites to protect threatened habitats and species. These sites, established under the Birds and Habitats Directives, form the core of the network of marine protected areas (MPAs) in EU waters, providing conservation, ecosystem services and socio-economic benefits.

What has LIFE done?

Played a major role in establishing the marine Natura 2000 network and therefore in establishing marine protected areas in the EU.

Extensively mapped marine habitats and the distribution of target species.

Established important synergies between policies, in particular between the Birds and Habitats Directives and the MSFD.

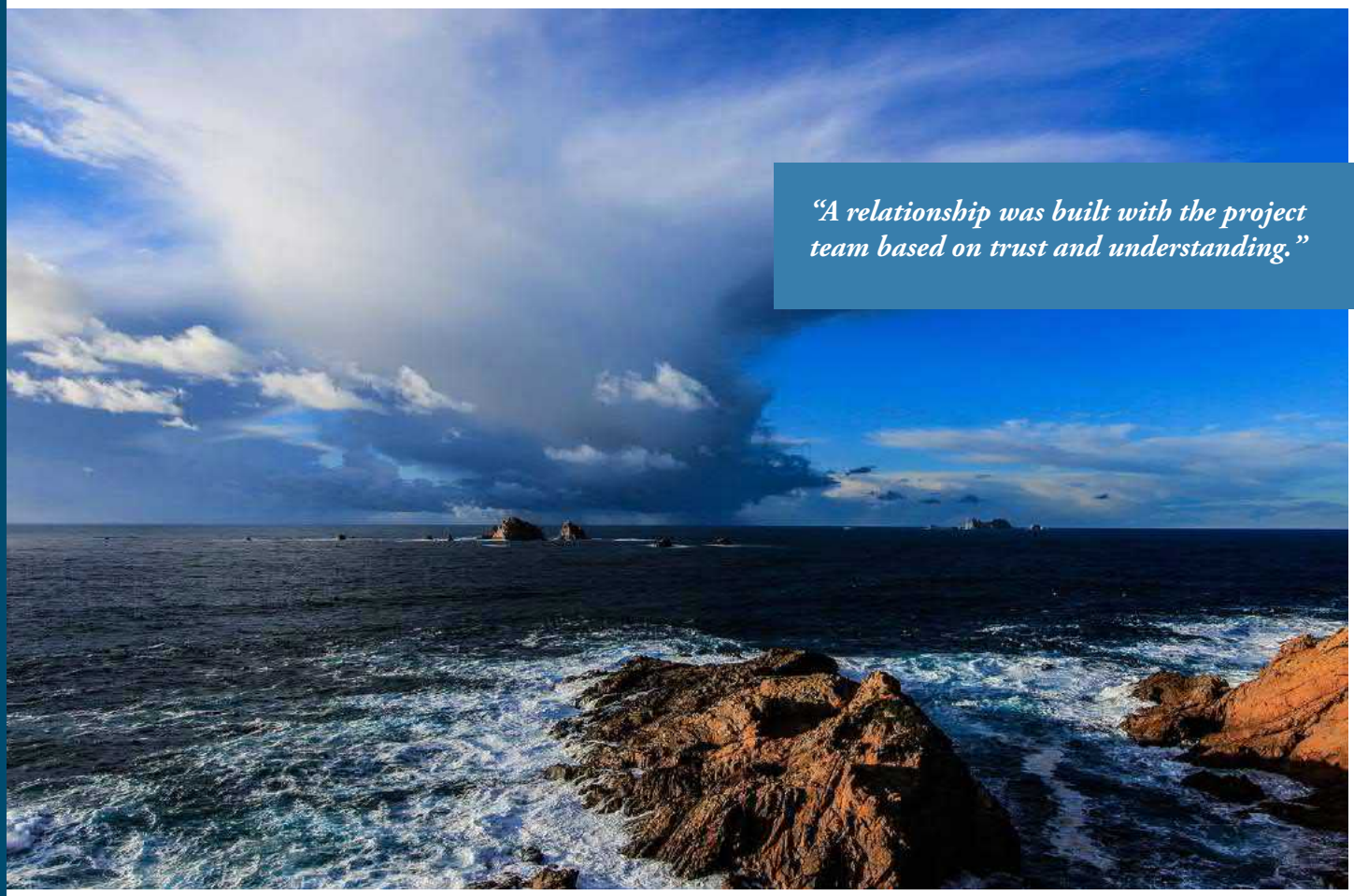
By improving the 'conservation status' of species and habitats in marine Natura 2000 sites, LIFE has taken a large step towards achieving the 'good environmental status' of marine waters.

Through the adoption of the Marine Strategy Framework Directive (MSFD) in 2008, the EU established a framework to protect and use sustainably its seas and oceans, requiring the implementation of marine strategies. It established 11 descriptors for EU Member States to determine whether they had achieved Good Environmental Status (GES) of their marine waters. The first of these descriptors is the maintenance of biodiversity.

The EU Biodiversity Strategy aims to halt the loss of biodiversity and ecosystem services in the EU and help stop global biodiversity loss by 2020. It contains important targets and actions related to the protection of marine biodiversity.

Marine protected areas (MPAs) are globally-recognised as conservation tools with the main aim of protecting marine biodiversity. In the EU, most of the MPAs belong to the Natura 2000 network established under the Birds and Habitats Directives. At the same time, these or additional MPAs are designated under the Regional Sea Conventions, the MSFD, international agreements (e.g. Ramsar) or national protection schemes.

Atlantic Ocean



"A relationship was built with the project team based on trust and understanding."

Photo: LIFE13 NAT/PT/000458/Mauro Hilário

The MSFD divides the European waters of the north-east Atlantic Ocean into four sub-regions: the Greater North Sea, the Celtic Seas, the Bay of Biscay and Iberian coast, and Macaronesia.

LIFE has been involved in designating marine Natura 2000 sites in continental Portuguese waters and in implementing the MSFD process in the Celtic Seas.

The Portuguese MarPro project was responsible for proposing two new marine Natura 2000 sites and enlarging two existing ones. These four sites cover nearly half a million hectares in total. "We also proposed Sites of Community Interest for the protection of cetaceans, particularly the harbour porpoise (*Phocoena phocoena*), and we expect they will soon be legally approved by the Portuguese government," says project manager Catarina Eira. These would cover a further 800 000 ha.

Marine Natura 2000 sites were selected based on the presence of species listed in Annex I of the Birds Directive, such as birds particularly threatened in the EU or where a considerable percentage of the European migratory population concentrates seasonally. The sites for the protection of cetaceans were based on the criteria defined in the Habitats Directive.

MarPro's fisheries mitigation measures are contributing to a drop in incidental by-catch of protected species. And improvements it made to the marine animal stranding network are critical for evaluating by-catch mortality, while improved rehabilitation centre facilities "continue to be crucial for rescued marine animals," says Dr Eira.

Management of the marine Natura 2000 sites needs the involvement of marine stakeholders.

"In the future, it will be very important that the different marine stakeholders are involved during the implementation of sites' management plans," stresses Dr Eira. MarPro's survey work was facilitated by good relations with the Portuguese fishing fleet. "Captains allowed observers aboard, filled in voluntary logbooks, responded to enquiries and permitted electronic surveillance cameras in their boats," explains Dr Eira. "The remarkable collaboration with fishermen was possible because a relationship was built with the project team based on trust and understanding, instead of accusations and punishment."

Celtic Seas Partnership

"The PISCES project produced a set of principles on how to engage with marine sectors in support of EU marine policy. The follow-on Celtic Seas Partnership (CSP) project applied those recommendations to start the MSFD process in the Celtic Seas," says CSP project manager Jenny Oates of WWF.

"PISCES found fishermen to be the most difficult sector to engage, so we designed specific activities directly aimed at them," says Dr Oates. "We had Stakeholder Engagement Officers in all six Celtic Seas countries. Our Scottish Stakeholder Engagement Officer set up a fisheries project, drawing on her background in conflict mediation in Northern Ireland. She found out why conflicts exist and ran

Photo: LIFE07 ENV/UK/000943/naturepl.com/Toby Roxburgh/2020Vision/WWF Canon

workshops to improve relationships between different sectors. At the end of the project there was a lot more willingness for those groups to work together."

"CSP had lots of different products. One of the key things was to develop those tools with stakeholders, because at the end of the project they were more likely to buy into those tools if they had co-developed them," Dr Oates explains.

A key challenge, according to Dr Oates, was to integrate land and marine planning, as environmental issues on land like pollution can easily spread to the sea. "Our partner, the University of Liverpool, produced guidelines so terrestrial planners could look through their work and see where they should be making considerations for the marine environment. They called this 'marine proofing', and it links directly to the MSFD process."

The project's Future Trend study predicted the impacts of different marine sectors on the environment and the economy in the Celtic Seas over the next 20 years under alternative future growth scenarios (futuretrends.celticseaspartnership.eu). "This was a really innovative piece of work, involving a long process of stakeholder engagement," says Dr Oates. "We created an interactive website which displays these results in a way that is easy to understand. People can click on different scenarios to see graphs of impacts on the MSFD descriptors or jobs in different sectors."

"The way I look at the MSFD is that it is an overarching policy, which brings together work covered by other directives too," explains Dr Oates. "So anything we did in terms of habitats and species would certainly help deliver the Habitats and Birds Directives, and our work engaging with fisheries would connect with legislation like the common fisheries policy."

CSP developed initiatives with marine sectors for three MSFD descriptors: biodiversity, non-indigenous species, and marine litter. "For the biodiversity descriptor, we worked with the fishing industry to establish how fishermen could best collect data on marine biodiversity," says Dr Oates. "That was a good example of how we wanted the ownership of those initiatives to be with stakeholders, rather than be with a project that had a finite end."

CSP created "a trans-boundary, trans-sectoral forum. That had not been done before – a forum that brings people together from the whole of the Celtic Seas from all different sectors," she says.

Mediterranean Sea

The MSFD subdivided the Mediterranean Sea into four sub-regions: Western Mediterranean Sea, Adriatic Sea, Ionian Sea and the Central Mediterranean Sea, and the Aegean-Levantine Sea.

This enclosed sea of 2.5 million square kilometres is subject to many pressures from human activities. The MALTA SEABIRD PROJECT and the MIGRATE project surveyed seabirds, turtles and cetaceans, leading to the designation of nine new Natura 2000 sites in Malta's marine waters. Building on this, LIFE BaĦAR for N2K has created inventories of habitats and species to fill existing knowledge gaps, and to extend marine protection in Maltese waters.

LIFE BaĦAR for N2K has focused on three habitat types under-represented in Maltese Natura 2000 sites - sandbanks, reefs, and sea caves.

The project team identified a priority list of areas that could potentially host the target habitats, and carried out detailed surveys in these areas in the summers of 2015 and 2016. "These two expeditions entailed more than 100 days at sea, during which underwater footage and photos on benthic habitats and species of interest was collected," says project manager Marie Thérèse Gambin. Survey methods involved scuba divers in coastal areas, remotely operated vehicles (underwater drones) in deeper offshore areas and a bathymetric survey of the seabed by means of a multibeam echo-sounder and sediment sampling.

The project team analysed the data to identify the most suitable areas for protection. As a result, it proposed the extension of six marine Natura 2000 sites and the creation of two brand new sites.

Photo: LIFE12 NAT/MT/000845/OCEANA

Black Sea

The Black Sea has suffered from severe ecological degradation since the 1970s due to intense eutrophication, overfishing, changes in marine living resources, chemical pollution and biodiversity/habitat changes.

There have been few LIFE projects helping to designate protected areas in the Black Sea. However, the project 'Conservation of the Dolphins from the Romanian Black Sea waters' began to establish the technical and legal basis for the conservation of three Odontoceti (toothed whale) species found in the Black Sea: the harbour porpoise, bottle-nosed dolphin (*Tursiops truncatus*) and the common dolphin (*Delphinus delphis*).

Among the main threats to these species are entrapment in large fishing nets, habitat degradation, urban development and coastal industrialisation, increased pollution levels, and disease. The project established a collaboration network, including fishermen, coastguards, frontier police, the national water company, and volunteers. Its surveys of sightings, strandings and by-catch greatly improved knowledge of populations of the three dolphin species along the Romanian Black Sea coast.

Baltic Sea

The Baltic Sea is heavily affected by eutrophication, overfishing, contamination from industries and transportation. These pressures have resulted in 4% of species and 27% of habitats in the Baltic Sea to be threatened with extinction.

Several LIFE projects have contributed to the designation of Natura 2000 sites in the Baltic Sea.

The Baltic MPAs project conducted surveys of seabirds, marine mammals and fish, leading to proposals for seven Natura 2000 sites in Latvia and one in Lithuania, and modifications to existing areas in Lithuania and Estonia. Following this, the MARMONI project developed a set of biodiversity indicators to support MSFD goals and the designation of protected marine areas throughout the Baltic Sea region (*see box*).

DENOFLIT and FINMARINET conducted surveys of marine habitat types and species in Lithuania and Finland, respectively. In the case of the Finnish project these were used to produce maps that enable the extension of the Natura 2000 network in the northern Baltic Sea. DENOFLIT meanwhile designated two open sea Natura 2000 sites covering more than 50 000 ha, half of which was priority reef habitat, and including important sites for seabirds. The project's work expanded Lithuania's marine protected area to 35% of coastal waters.

Photo: LIFE07 NAT/FIN/000151/Juho Lappalainen

Marine biodiversity indicators

MARMONI developed and tested innovative marine biodiversity indicators for four species groups: fish, seabirds, benthic, and pelagic species[1].

"We began by evaluating existing indicators used by HELCOM. We found that most were not true biodiversity indicators, but were mostly eutrophication or other pressure indicators for water quality," says project manager Heidrun Fammler, of Latvia's Baltic Environment Forum.

To develop new indicators that could be used for policymaking in the Baltic Sea, the MARMONI team tested 17 monitoring methods in demonstration areas, including new automated methods. "These were all used alongside existing methods to collect data for indicator development," explains Georg Martin of the Estonian Marine Institute, the LIFE project's action leader for indicator development.

For the indicator part, MARMONI used novel approaches, such as measuring the length of mature female fish, high-resolution aerial imaging and thermal imaging for seabirds, a seabed spectral variability index for benthic biodiversity, and an index for phytoplankton taxonomic diversity.

The project has made its 49 true marine biodiversity indicators and a MARMONI Biodiversity Assessment Tool available online (marmoni.balticseaportal.net). Many of these have been used to support national marine monitoring programmes, the regional HELCOM Baltic Sea Action Plan, and for assessing good environmental status under the MSFD.

"In Estonia, many of these indicators are included in our national process of reporting of the MSFD, and several indicators are used in the HELCOM core set," says Dr Martin. The LIFE project also made recommendations for the national marine monitoring programmes of Finland, Latvia and Sweden.

"MARMONI biodiversity indicators continue to be taken up, while work is ongoing on testing and further developing them," says Anda Ruskule, the project's action leader for policy recommendations "There is a new assessment of the status of the MSFD, so this work continues and new indicators are under consideration."

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1. Benthic species live at the bottom of the sea and pelagic species live in the open sea.

PROJECT FEATURE

Protecting Spanish marine waters

LIFE-IP INTEMARES is developing innovative, integrated and participatory management approaches for the marine Natura 2000 network. It builds upon the work of two earlier Spanish LIFE projects.

"We have a big responsibility to protect the marine environment, and LIFE-IP INTEMARES allows us to be more participative and innovative, and to make sure that decisions are based upon scientific criteria."

Spain is a biodiversity hotspot, thanks to its geographical position, 8 000 km of coastline, different seas, and its two groups of islands. Spanish LIFE projects have gathered information, identified funding and capacity building needs, and designated sites for the Natura 2000 network. LIFE-IP INTEMARES is continuing to build on their knowledge and is creating the network of Spanish marine Natura 2000 sites, and hence marine protected areas (MPAs). By implementing the Marine Strategy Framework Directive (MSFD) these projects are protecting biodiversity and ecosystem services, and safeguarding long-term economic benefits.

"The marine environment is very important for Spain. We have the second largest marine waters in the EU, covering one million square kilometres in diverse regions with fantastic biodiversity," says Itziar Martin, Technical Director of the Division for the Protection of the Sea within the Spanish Ministry of Agriculture and Fisheries, Food and Environment (MAPAMA). "We have a big responsibility to protect the marine environment, and LIFE-IP INTEMARES allows us to be more participative and innovative, and to make sure that decisions are based upon scientific criteria."

LIFE-IP INTEMARES is developing management plans for Natura 2000 sites in Spanish waters in the North-east Atlantic, Mediterranean and Macaronesian regions, and ensuring that the plans are adopted by 2023. The project covers 10% of all Spanish marine waters, which is an area comparable in size to Austria.

This LIFE Integrated Project is building on the legacy of two earlier projects (see box).

INDEMARES and PAF NATURA 2000 SPAIN

INDEMARES (2009-2014) collected the necessary data on habitats and species to complete the designation of Natura 2000 sites in the North-east Atlantic, Mediterranean and Macaronesian regions of Spain. It developed standard methodologies to assess marine areas in terms of their diverse features, habitats and biodiversity. The project's oceanographic campaigns mapped 112 habitats across 1.5 million ha; identified 10 000 species (50 new to science); and collected valuable information on over 80 cetacean and seabird species. Thanks to the project, the area under Natura 2000 was increased by 7.3 million ha.

Using INDEMARES data, the PAF NATURA 2000 SPAIN project (2012-2014) developed seven pilot actions to demonstrate the application of the prioritised action framework (PAF), a strategic planning tool for financing Natura 2000, in Spain. This showed how different EU funding programmes can be integrated and how to develop a participatory management model for marine protected areas. These measures are being used in the LIFE-IP INTEMARES project.

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INDEMARES: discovering species new to science

The 50 newly discovered species included a soft coral from the deep waters of the Menorca Channel, which was named *Nidalia indemares* after the project. The team encountered a new species of crab, *Uroptychus cartesi*, at 1 400 m in the underwater mountains off the Galician coast, an area where they also found a new deep-sea carnivorous sponge, *Chondrocladia robertballardi*.

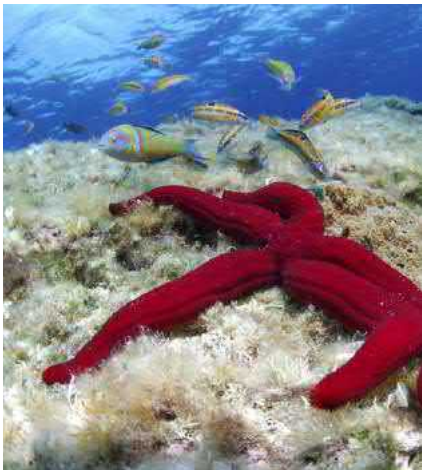

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Photo: LIFE07 NAT/E/000732/OCEANA/Iñaki Relanzón

"INDEMARES was a milestone in the development of the Natura 2000 network in Spain and also in terms of how oceanographic research is carried out. We produced protocols on how to do research in a uniform way. We collected data to a depth of 200 m in the marine protected areas. There is still a lack of knowledge about species and habitats below 200 m. The next stage is to collect data to a depth of 2 km," says Víctor Gutiérrez, coordinator of projects at the Biodiversity Foundation of MAPAMA.

Mobilising complementary funding

To achieve its ambitious goals, LIFE-IP INTEMARES draws on different funding for different purposes. "In particular, two EU funds, the European Maritime and Fisheries Fund (EMFF) and the European Social Fund (ESF). There are also funds from Fundación Biodiversidad, on top of the LIFE project funding," explains Ignacio Torres, LIFE-IP INTEMARES project manager and Deputy Director of the Biodiversity Foundation.

"The EMFF provides funds for increasing the sustainability of the fisheries sector, and for measures to improve collaboration between fishermen and scientists," Mr Torres says. "The ESF supports training and capacity building among sea users, the creation of employment, and the promotion of entrepreneurship in the context of a blue and sustainable economy."

"We have used the ESF for economic diversification," Mr Gutiérrez adds, "so in areas with fishing limitations to protect biodiversity, other types of activity can be carried out such as fishing tourism, marine litter fishing or value-added sustainable fishing."

The value of Integrated Projects

"I think that this Integrated Project helps Spain to change the model of how we implement the Natura 2000 network. Before, the methodology was not working so well, but now local, regional and national governments are on board, collaborating and supporting our work, thanks to LIFE and the other funds," says Mr Torres.

"The European dimension of funding is a big weapon allowing political backing whatever the political turnover," he concludes. "With this project we will have all of the management plans adopted and, very importantly, with a consensus that enables secure implementation. This was not imaginable just 10 years ago, when trying to get political support was one of the biggest barriers."

2

Engaging people in marine species conservation

LIFE repeatedly shows the value for the marine environment of working with stakeholders.

What has LIFE done?

Consistently highlighted the value, indeed the necessity, of working with stakeholders to achieve favourable conservation status of species and achieve good environmental status (GES) of the ocean.

Developed best practice methodologies for addressing conflicts between users of the sea, requirements for species conservation and GES of marine areas.

Shown that stakeholders can play an important role in the implementation of the Marine Strategy Framework Directive and Birds and Habitats directives.

Shown how EU marine, nature and fisheries policy can be integrated at different levels for marine areas.

EU Member States need to take the necessary conservation measures for species protected under the Habitats and Birds Directives and to report on their conservation status every six years. They must also update their marine strategies under the Marine Strategy Framework Directive (MSFD), including the assessment of pressures and status, monitoring programmes and programmes of measures. Many of the marine species listed in the annexes of the nature directives are reported to be in an 'unfavourable' conservation status, mostly as a consequence of human activities. This is why it is important to ensure that different economic activities are done in a sustainable way that enables strictly protected species to reach a 'favourable' conservation status.

The Marine Directive requires EU countries to "apply an ecosystem-based approach to the management of human activities". This is a way of taking decisions that allow us to manage our activities at sea sustainably. It recognises that humans are part of the ecosystem and that our activities both affect the ecosystem and depend upon it. Stakeholder engagement is at the heart of the ecosystem approach. Successful implementation of the MSFD relies on enhanced participation of stakeholders at all levels: national, regional, European and international.

Photo: Solvin Zankl

Data with a 'porpoise'

Stakeholders played a leading role in helping to conserve the endangered Baltic Sea subpopulation of the harbour porpoise (*Phocoena phocoena*), a strictly protected species under the Habitats Directive, for which appropriate Natura 2000 sites need to be designated and effectively managed.

The SAMBAH project primarily gathered much-needed data about the distribution of this rare cetacean ahead of designating key marine sites for protection to reverse its declining numbers. This involved Kolmardens Djurpark wildlife park hiring two trawlers in Sweden for this important acoustic monitoring work in order to foster acceptance among fishermen. The Finnish navy was involved in logging porpoises and the good relationships this created led to military operations being scheduled to take into account the needs of the threatened subpopulation. The Swedish navy was given advice on the development of a planning tool. "It helps them minimise negative impacts on wildlife, including porpoises," says project leader Mats Amundin.

Sweden's county administrations are responsible for managing the waters of its Exclusive Economic Zone. The SAMBAH team kept them up to speed with its work and, shortly after the publication of its final report, two administrations produced a proposal for a new, extensive marine Natura 2000 site, based entirely on the LIFE project's results. This site, which covers the harbour porpoise's mating and breeding area, has now been confirmed by the Swedish Government and a management plan is being drawn up. "This will be extremely important for the survival of the Baltic harbour porpoise population," believes Mr Amundin.

Local concerns inform management plan

"One of our goals was to engage with stakeholders to establish sustainable practices for the management of the Berlengas archipelagos marine Natura 2000 site in Portugal," says Joana Andrade of SPEA, the coordinating beneficiary of LIFE Berlengas. The project aims to reduce the impact of fisheries and tourism on seabirds, such as the Madeiran storm petrel (*Oceanodroma castro*) and mitigate the mortality related to interactions with fishing gears. The Portuguese BirdLife partner held workshops, meetings and one-to-one interviews to gather local fishermen views and concerns about the protected site.

This feedback helped SPEA to draw up the first management plan for the site, which was then further revised in consultation with a wide range of stakeholders, from tour operators and fishermen to governmental officials, researchers and representatives of local organisations.

"Thanks to this valuable engagement process, they are all on board with the proposed measures to be implemented over the next five years," says Ms Andrade.

Project goals will be achieved through the use of tailored versions of archipelago management methodologies. Outcomes will be ready to apply at local, regional, national and international levels.

Photo: LIFE13 NAT/PT/000458/Ben Metzger

Tackling threats to sea turtles

Photo: F.Bertolino

Commercial fishing has unintended negative consequences for sea turtles. The Italian Marine Science Institute led a project called TARTALIFE to tackle unnecessary turtle deaths. This involved showing fishermen what to do in case of accidental capture and how to use devices to prevent such by-catch occurring.

The project team encouraged the use of LED visual deterrents, circular hooks for line fishing, which are less damaging to turtles, and exclusion grids for bottom trawling. “It is essential to train fishermen because they are the first actors in the species conservation process,” explains project leader Alessandro Lucchetti. “Protection of sea turtles mainly depends on the procedures implemented in the immediate aftermath of capture.”

TARTALIFE’s efforts were not in vain. “The fishermen showed interest in the various activities and great cooperation during sea trials,” says Mr Lucchetti. Some 500 of them took part in those trials, with around 1 500 fishermen in total reached by the project through ‘infodays’.

Results showed that TARTALIFE’s procedures can help reduce incidental catches of sea turtles, and the team says that most fishermen are now aware of what needs to be done. Furthermore, the project reached out to around one million visitors to the rescue centres that are benefiting from LIFE funding.

PROJECT FEATURE

Building partnerships for healthier seas

Two LIFE projects have built partnerships for the management of marine Natura 2000 sites in Spanish waters, particularly with fishermen, ship owners and tourism businesses.

Sea users are closely involved in developing plans that will help tackle threats ranging from land-based pollution and climate change, to unsustainable fishing practices, commercial shipping, marine litter and invasive species. Some of these plans were produced by the LIFE+ INDEMARES project. Now, LIFE-IP INTEMARES is building on the participatory approach as it seeks to develop more than 50 management plans for Natura 2000 sites over the next few years.

"New methods of collaboration are being explored, such as participatory workshops to draft management plans," says project manager Ignacio Torres. "These represent a step forward from basic consultation to more complex participation processes, with the involvement of more stakeholders," he explains.

In 2018, the project is busy organising a huge number of these innovative workshops throughout Spain, involving all marine sectors and organisations. The aim is to get everyone working towards common goals, to facilitate the co-management of MPAs.

"Stakeholders have different and sometimes conflicting interests. It is important to get them to agree on measures that will be adopted in the management plans, and to create consensus among them to enable widespread and correct implementation of such measures," believes Mr Torres. The management plans also guarantee a common methodology for Natura 2000 sites and marine protected areas.

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Whale-watching in the Canaries

The Canary Islands are a unique area for marine biodiversity. "We have 30 species of cetaceans of seven different families. This does not happen anywhere else in the world," says Érika Urquiola, technician of the Biodiversity Service of the Canary Islands Government.

Tourism is the main economic activity, but this also puts pressure on biodiversity. "We have 10 million tourists and one million of them go whale watching," says Ms Urquiola.

Antonio Sampedro is a marine biologist and the Director of Atlantic Eco Experience, a company offering tours off the south-west coast of Tenerife. "The main impacts of whale watching are due to incorrect approaches, acoustic and physical stress," he says. "Our aim is to have the most neutral interaction possible with the animal. Creating an emotional impact on the visitor will generate more benefit than exploitation without consideration for nature. Our hope is that projects such as LIFE-IP INTEMARES enable administrations to solve such problems of environmental conservation."

The project's participatory workshops will play a key role in building consensus on which regulatory measures aimed at nautical and recreational activities can be implemented in the Natura 2000 sites.

Fishing and shipping partners

Overfishing, abandoned fishing gear and other waste at sea, and maritime traffic are major pressures on marine biodiversity. This makes it doubly important to actively involve fishermen and ship owners in planning how to manage protected areas, as LIFE-IP INTEMARES is doing.

One practical example is to present maps produced in collaboration with the Spanish Oceanographic Institute showing the impact of the fishing industry on protected areas. "In collaboration with fishermen, within the participatory workshops, this information will be used to decide what type of fishing will be allowed in the designated sites," says Mr Torres. It is important to note that "the Natura 2000 sites are not strict reserves so the fishermen can continue to fish, but with limitations and different techniques in certain areas such as where we find reefs or seagrass beds," he explains.

There is trust among the fishing community in the oceanography institute's data, "which has provided a basis for a fruitful collaboration," says Mr Torres. Indeed, the Spanish Fishing Confederation (CEPESCA) is part of the project consortium (*see box*).

Maritime traffic has an impact on marine organisms, for instance, on marine mammals. "We have a big issue with sperm whales colliding with ferries," reveals Mr Torres. LIFE-IP INTEMARES is working with the ship owners to solve this problem. "We are comparing whale movement patterns with ferry routes and are testing technologies to avoid collisions, such as the use of thermal cameras on ferry boats to identify where the cetaceans are so they can be avoided."

Alleviating tourism pressures

Participatory workshops are also being used to address specific impacts on the marine environment caused by tourism, for instance in the Canary Islands. This has led to a voluntary agreement with Jet Ski hire companies, who now instruct tourists to reduce speeds or avoid areas where green turtles and dolphins are present.

"Tourism businesses do not want to harm marine species, and through the workshops they receive ecological information in a visual way that they can explain to tourists. Codes of conduct and more concrete measures originating in the workshops will be implemented as of 2019," says Mr Torres.

LIFE IP-INTEMARES is also working with local and regional authorities to help protect nesting sites of green turtles, for example, by placing information boards on beaches.

Collaborative monitoring

"After we have finished the participatory workshops, and defined the conservation measures in the management plans, we will apply the measures in the MPAs from 2019," says Mr Torres. To monitor implementation in the vast and sometimes remote Spanish marine waters requires the latest technologies, such as drones and surveillance ships. The support of stakeholders is essential, which is why the LIFE Integrated Project is developing a capacity building programme for marine organisations, including the Spanish navy. Already 1 000 naval officers have been briefed on the marine Natura 2000 network.

CEPESCA and marine protected areas

"The establishment of MPAs is only effective when the commercial sectors working in the marine environment participate and make a clear commitment to sustainability in its three dimensions: environmental, economic and social.

Ensuring that our voice and experience is considered in the design of new management instruments is a guarantee of success."

PROJECT FEATURE

‘Smart’ engagement protects sea turtles

LIFE Euroturtles is showing how simple technology can be a cost effective tool for stakeholder engagement, generating crucial data as well as building trust.

Croatian fisherman, Aldo Šilovinac, receives his smartphone from the marine conservation organisation Blue World Institute (BWI) with a smile of appreciation. Although this is an ordinary-looking phone, it comes preloaded with an ‘extraordinary’ app. The app is designed to be easily used by fishermen like Aldo to record the location of sighted and caught sea turtles via the phone’s GPS function and to readily send a photo of the animal back to BWI for monitoring purposes. This citizen science app also lets users answer simple questions about the turtle’s condition, providing valuable data worth much more than the outlay on the phone.

Indeed, Dr Peter Mackelworth of the BWI says that the financial cost of getting himself on board a fishing boat as an observer – getting in the way and creating inevitable suspicion – would be far higher. “And that’s just for one day,” he adds. For the user, Aldo emphasises that the device will make his life easier. “I won’t have to spend time calling in from out at sea, trying to get a signal.”

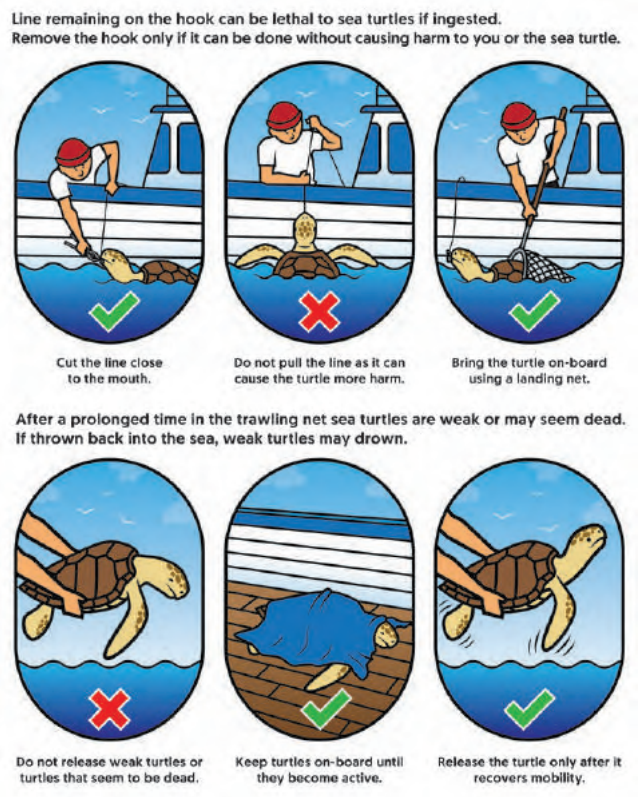
Around a hundred smartphones will be distributed to fishermen and boat users in the Adriatic Sea region, under the cross-border LIFE Euroturtles project. “You have to give them something to show some commitment,” explains Dr Bojan Lazar of the University of Primoska. The Adriatic is a key summer foraging ground for the most common sea turtle, the loggerhead (*Caretta caretta*), but it is also a hotspot for by-catch, affecting several thousand turtles each year. Each fishing boat, however, may only catch around a dozen individuals, so the burden of recording the incidents isn’t too prohibitive.

Bottom trawlers are particularly hazardous to turtles in wintertime when the animals become lethargic and rest on the seafloor. If they are brought on-board in this comatose state, then the fisherman may assume that they are dead and throw them straight back into the sea. This is an action fatal for the sea turtle in this condition. The project, which is being co-ordinated by the Croatia Natural History Museum, has already launched a successful awareness campaign, producing simple posters and stickers to be placed on fishing boats explaining what to do if a comatose turtle is captured. In fact, it can take a few hours for the lethargic turtle to wake from this condition.

“In the Adriatic area, there is a positive attitude towards the turtle. Fishermen are willing to help but not in a way that would interfere with their catch too much,” says Dr Lazar. “The way to incentivise stakeholders is to work with them and show that you care,” emphasises project leader Dr Draško Holcer.

Around 40% of sea turtles that are caught as by-catch are thought to be comatose or dead. Analysis suggests that at least one in four of these turtles will turn out not to be dead and thus able to be saved if correctly treated. The project team is eager to highlight that preventing this type of mortality would already be a major conservation measure saving hundreds of turtles.

"The way to incentivise stakeholders is to work with them and show that you care."



LED the way?

Set nets that are left on the seafloor for a day represent another major threat to sea turtles, trapping individuals so that they can't resurface for air. In the summer months, turtles need to surface every half hour. This problem is amplified by the use of synthetic materials that are less visible for the turtle. Though the scale of the threat is difficult to determine, it is the deadliest with mortality rates greater than 70%. The project is addressing this problem by trialling the use of LED lights to warn the turtles of the danger.

"We need to see if it really works for loggerheads before we really invest in it," says Dr Lazar, "but studies have shown that LED lights don't affect the target fish catch."

Nevertheless, Dr Holcer cautions that encouraging the use of the lights will be a challenge. "They are heavy, need to be placed every few metres and will require a change to fishing protocols."

Avoiding collisions

Turtles are also prone to collisions with speedboats and other vessels when they are basking in the summer. At BWI's research centre, Dr Mackelworth says that more than half of the turtles that they see – the institute runs a small rescue unit – have markings indicating that they have been hit at some point in their life.

Such collisions can be fatal, and the citizen science initiated by the project will be able to give a clearer picture. "The results could show that the extent of the problem is much greater than we might have thought," he says. Indeed, many boat owners aren't aware of the presence of sea turtles in the region, and the institute is working with stakeholders, such as boat clubs and marinas, to raise their profile.

Socio-economic data that the project is collecting during the monitoring phase also raises the possibility of eco-tourism. "We can identify areas where you are most likely to spot a turtle, which opens up the opportunity of developing regulated 'diving-with-turtles' tourism, for example," says Dr Mackelworth.

The partners are also carrying out structured interviews with tourists and visitors to gauge their willingness to pay extra for fish that has been caught in a turtle-friendly way. Affirmative replies will be used to drum up support for more ecological fishing techniques.

BWI also runs a small exhibition centre featuring turtles and bottlenose dolphins that regularly attracts schoolchildren "All the best results come when you work with the little ones. They are the decision-makers of tomorrow," says Jelena Basta of BWI.

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3

Assessing and improving marine food webs

Food webs are a measurable indicator of the health of marine ecosystems. A LIFE project in the Mediterranean has shown how to make key species more abundant and to monitor the impact on juvenile fish.

What has LIFE done?

Shown it is possible to improve reproduction and abundance of fish species and in particular prevent the decline of stocks of protected and fisheries-exploited species.

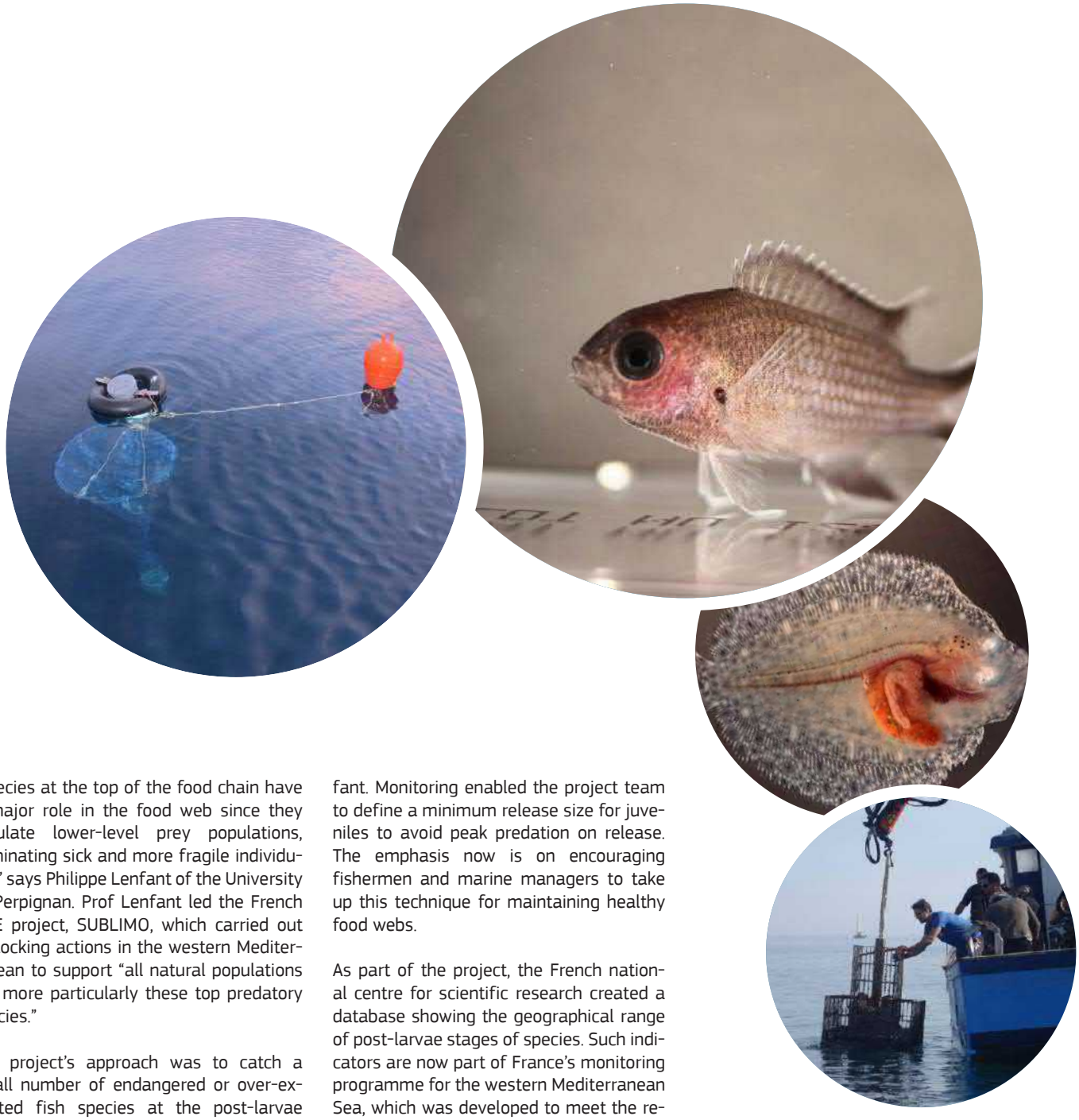
Provided an alternative to standard control of fishing activities by boosting heavily exploited species early in their lifecycle. This has a direct impact on the productivity of the food web.

Set up post-larvae fish indicators that have been incorporated into an MSFD monitoring programme for the western Mediterranean.

A food web shows how different food chains are linked. Healthy food webs are one of the main regulators of ecosystem dynamics. They play a role in the way ecosystems respond to natural and human-induced changes. This is why the Marine Strategy Framework Directive (MSFD) requires that all elements (guilds) of marine food webs occur at normal abundance and diversity, so that species can reproduce and ensure abundance in the long term.

Reliable data about the interactions among marine species is essential for assessing this MSFD descriptor. Signs of healthy food webs include the pervasiveness of species groups that respond quickly to change, such as plankton and bacteria, as well as species targeted by fishing. Because interactions between species are complex, more research is needed to better understand the connections and the impact of pressures on food webs as a whole.

Boosting Mediterranean food webs



"Species at the top of the food chain have a major role in the food web since they regulate lower-level prey populations, eliminating sick and more fragile individuals," says Philippe Lenfant of the University of Perpignan. Prof Lenfant led the French LIFE project, SUBLIMO, which carried out restocking actions in the western Mediterranean to support "all natural populations but more particularly these top predatory species."

The project's approach was to catch a small number of endangered or over-exploited fish species at the post-larvae stage of their lifecycle when they are vulnerable to predation. These specimens were then reared in tanks at two research centres before being reintroduced as juveniles into the sea a few months later.

Monitoring showed that this practice can help arrest the decline of stocks of protected and exploited species, especially the common two-banded seabream (*Diplodus vulgaris*) and white seabream (*Diplodus sargus*). "The survival rate of juveniles who have spent part of their life in the aquarium is as good as or better than that of individuals in the wild," explains Prof Lenfant. Monitoring enabled the project team to define a minimum release size for juveniles to avoid peak predation on release. The emphasis now is on encouraging fishermen and marine managers to take up this technique for maintaining healthy food webs.

As part of the project, the French national centre for scientific research created a database showing the geographical range of post-larvae stages of species. Such indicators are now part of France's monitoring programme for the western Mediterranean Sea, which was developed to meet the requirements of the MSFD.

4

Restoring the integrity of the seabed

Seabed habitats support a wealth of marine species, especially in shallow waters. LIFE's efforts to conserve the integrity of Europe's sea floor are safeguarding the rich abundance of marine life that depends upon these habitats.

What has LIFE done?

Addressed pressures from a range of human activities, including coastal infrastructure, dredging, aquaculture, industrial effluents and fishing practices.

Restored reefs and other seabed habitats. These efforts have improved ecosystem structures and functions at the bottom of the seas.

Commercial and leisure activities often have an adverse impact on the sea floor. Major disruptions such as dredging and offshore mining and sand extraction must take into account environmental effects. Wind turbines and defences against coastal erosion can have negative impacts in the same way as more obvious threats such as pollution, mooring of ships and trawling for fish.

The Marine Strategy Framework Directive says that sea-floor integrity should be at a level that ensures "that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected." In addition, the Habitats Directive protects certain habitat types such as reefs, sandbanks or *Posidonia* meadows.

LIFE builds reefs

Photo: Danish Nature Agency

Boulder reefs not only look spectacular, this protected rocky reef habitat provides valuable spawning and feeding grounds for fish and marine mammals that support reef biodiversity.

The boulder reefs in the shallow waters of the Kattegat, the sea off the east coast of Denmark, have been repeatedly plundered to build sea defences and harbour jetties.

To restore this important habitat, protected under the Habitats Directive, the BLUEREEF project relocated more than 100 000 large stones from a quarry in southern Norway. The impact of restoring more than 5 ha of boulder reef was a six- to-eightfold increase in biomass. The LIFE project increased marine life, including the restoration of 6 tonnes of macroalgal vegetation and 3 tonnes of bottom-living fauna, and a three- to six-fold increase in cod in the reef area.

The BLUEREEF team drew up guidelines on restoring boulder reefs that are applicable to other sites in northern Europe and proposed a ban on harmful bottom trawling at protected boulder reef sites.

Protecting sea meadows

Uncontrolled trawling has also harmed underwater seagrass meadows of Neptune grass (*Posidonia oceanica*) in Andalusia. The Spanish LIFE project Posidonia sought to eliminate this practice in marine protected areas, while also drastically reducing the threat to the habitat from ships' anchors. Trawling is in fact forbidden above seagrass meadow. The project thus focused on greater surveillance of trawling, while installing two artificial reefs to act as a protective barrier to prevent this illegal practice. In addition, the project team restored habitat by re-planting Neptune grass.

A major achievement of the project was to draw up a management plan for the seagrass meadows and a regulatory framework at regional level. The project engaged local communities, building up volunteer groups and working with the fishing and tourism industries to ensure the sustainability of the local economy. "The best option for the fisheries sector is to provide training," says project manager Rosa Maria Mendoza Castellón.

Photo: Consejería de Medio Ambiente de la Junta de Andalucía

Photo: Aula del Mar/IUCN

Restoring marine forests

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Brown algae, which makes up the marine algal forest in the Mediterranean, plays a key role in preserving the integrity of the seabed. Marine algal forests are "ecosystem engineers" that maintain the diversity of habitats, support food webs and absorb large amounts of carbon dioxide, explains Annalisa Falace from the Life Sciences Department at the University of Trieste. These underwater forests are made up of brown algae of the genus *Cystoseira,* which is in decline because of urbanisation, overfishing and climate change. "The loss of such habitat-forming species can alter the biotic and abiotic structure and functions of the sea bed," explains Ms Falace.

Conservation efforts to date have not reversed the decline. That is why the ROCPOP-LIFE project was launched last year to pioneer an ecologically-sustainable approach to marine restoration. This will see brown algae germlings grown in the lab before being transplanted to the seabed.

The project is implementing a restoration protocol designed "to maximise zygote settlement, minimise embryo development time and generate a dense coverage of healthy germlings for outplanting," she says. Trials will take place in the Gulf of Trieste, the Ligurian Sea and the Apulian coast, where the biggest threat to the success of the project could be hungry molluscs and crabs eating the algae. To avoid this, "we are building on our observations and improving support for the transplanted algae to reduce the pressure from herbivores," says Ms Falace.

She explains that interest in restoring populations is increasing thanks to the EU's 2020 Biodiversity Strategy which recommends the reintroduction of relevant species into areas where they were historically present and where the factors that led to their loss have been removed.

"Marine algal forests are "ecosystem engineers" that maintain the diversity of habitats."

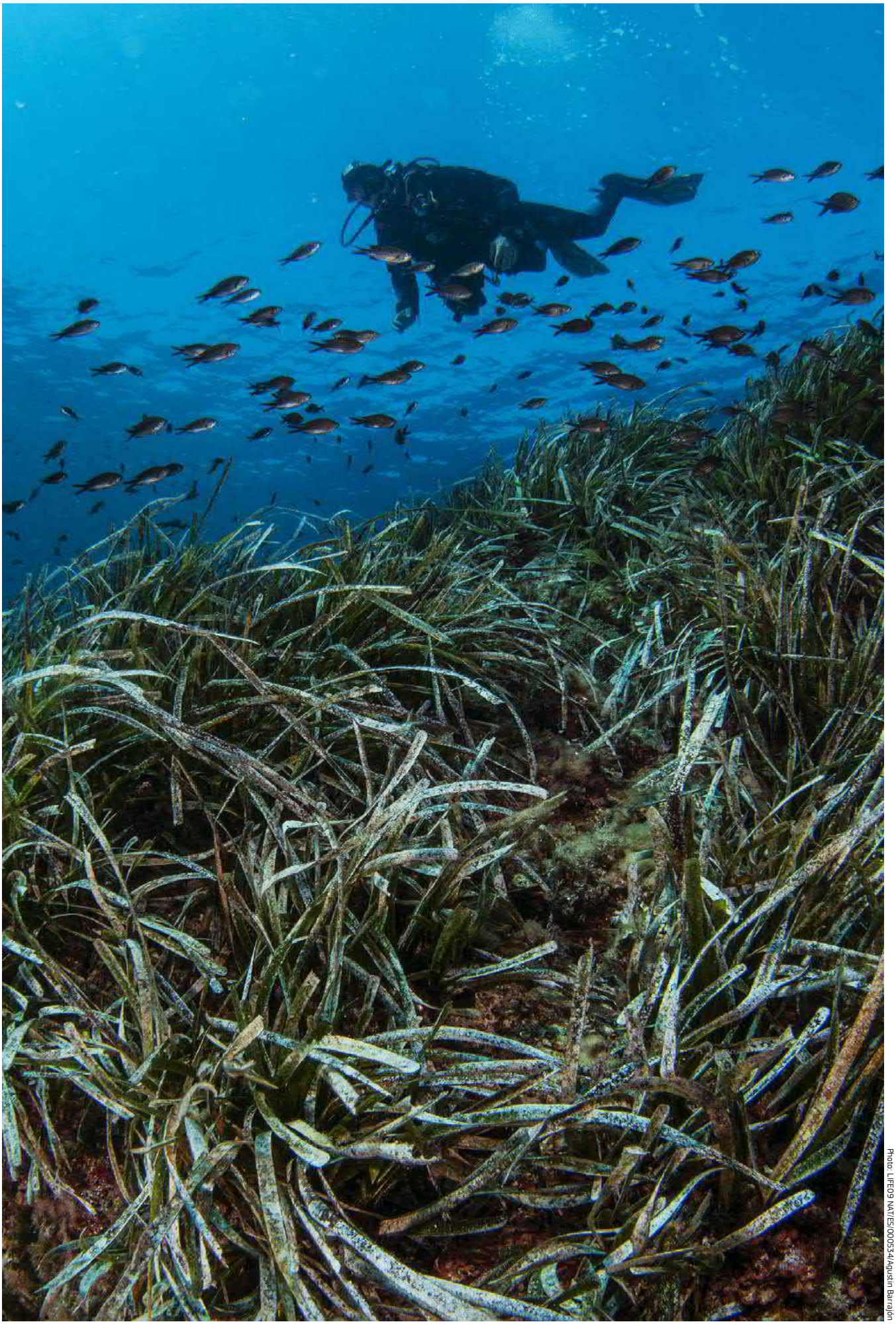

Photo LIFE09 NAT/ES/000534/Agustín Barrajón

5

Showing how to prevent marine invasives spreading

Invasive species can wreak havoc on our marine environment. LIFE is helping to warn against and eradicate this threat.

What has LIFE done?

Set up early warning systems for some marine invasive species, involving stakeholder groups such as divers and fish-farmers.

Removed invasive seaweed that is damaging seagrass meadows in Spain and Sardinia.

Helped establish a framework for prevention and control at national level in England.

Non-indigenous species that are introduced to marine areas through human activities such as shipping can become “invasive” species. They can have enormous and long-lasting impacts on marine areas. Non-indigenous species can also introduce diseases that affect native species and reduce ecosystems’ resilience to major pressures such as climate change.

The Marine Strategy Framework Directive (MSFD) recognises the threat posed by non-indigenous species, stating that “non-indigenous species should be at levels that do not adversely alter the ecosystem.” In 2014, the EU also introduced a Regulation on Invasive Alien Species, which listed invasive species of concern and focused on preventing them entering EU territory and on creating early warning systems to eradicate them or manage their spread if present (http://ec.europa.eu/environment/nature/invasivealien/list/index_en.htm).

Beware of the lionfish

An early warning system for the colourful but invasive lionfish (*Pterois miles*) – the species is native to the Indian Ocean and Red Sea – is central to the ongoing RELIONMED-LIFE project. The lionfish is thought to be entering European waters via the Suez Canal, and it is particularly prevalent on the eastern side of Cyprus where it preys on small native species. Identifying the Mediterranean Sea as a 'hot spot' of marine non-indigenous species, the project wants to make Cyprus the first line of defence against the spread of this type of invasive species.

Teams on the island will remove lionfish whenever they are found, with coordinated campaigns to clear them from protected areas where they are known to congregate. To get more people involved, the project plans to hold 'removal competitions' for divers. "We receive many phone calls from concerned divers. Many of them want to assist removal efforts," says Yianna Samuel-Rhoads from the University of Cyprus, who is leading the project. RELIONMED-LIFE will also develop tools for site managers, including a guide to effective management of the species and a risk analysis and modelling tool, which will be able to "predict the effectiveness of removals".

Dr Samuel-Rhoads says that more than 150 fish have already been removed in the first months of the project, putting it well on track to exceed its target of 400. These numbers may sound low, but the project calculated that 100 million lionfish eggs per year would not be laid as a result. This would save more than a tonne of fish and crustacean species, representing a significant boost to local food chains.

To make the lionfish removal pay for itself, Dr Samuel-Rhoads and her team are exploring whether there is a local market as a healthy seafood. On a wider scale, the removal work will also inform risk assessments of the threat to native biodiversity posed by this species, a body of evidence that could support efforts to include the species in the European list of invasive alien species.

Photo: Area Marina Protetta Capo Carbonara

Invaders of the seagrass meadows

Caulerpa cylindracea is an invasive seaweed native to Australia. It is damaging the marine biodiversity, including Neptune grass (*Posidonia oceanica*) meadows across the Mediterranean Sea. The LIFE RES MARIS project set out to reduce the presence of this invasive seaweed off the coast of Sardinia. However, as project manager Laura Lentini explains: "Manual removal proved to be rather ineffective because of the rapid recolonisation of the species just a month after taking action."

This led the team to test an alternative method that involved installing 'blackout curtains' for 30 days. Initial observations suggest this is an effective means of removal and further observations are ongoing.

Caulerpa cylindracea was first observed in Andalusia in Spain in 2008, having spread from neighbouring Murcia. The regional environment ministry used a LIFE project called Posidonia Andalucia to address this threat. The invasive seaweed was eradicated from two small areas of Cabo de Gata-Níjar Natural Park, but soon reinvaded the areas, highlighting the difficulty of controlling its dispersal.

Project manager Rosa Maria Mendoza Castellón says the lesson from this experience is that efforts should be directed towards "preventing new invasive seaweed arriving in the area". To this end, the project team got local volunteers to monitor the health of the underwater meadows and report the presence of any invasives. "Citizen Science can be a useful tool for early detection," she says.

Photo: LIFE09 NAT/ES/000534/Consejería de Medio Ambiente de la Junta de Andalucía

Networks to control invasives

Photo: Crown copyright 2009/CCW/Stephen Mowat

Photo: LIFE16 NAT/UK/000582/Bristol Zoological Society

The UK project RAPID LIFE is carrying out measures to reduce the impact and spread of non-indigenous species in a range of aquatic environments across England, including marine environments. The project beneficiary, the Animal and Plant Health Agency, has drawn up a list of marine invasive species likely to have the most adverse impact, such as the carpet sea squirt (*Didemnum vexillum*). This invertebrate has become established in marinas along the southern coast of England and can smother shellfish beds and affect underwater pipes and other surfaces.

One of RAPID LIFE's main tasks is to establish a regional framework for managing invasive non-indigenous species. It is bringing together operators of marinas, ports, harbours and aquaculture sites, along with project partners, such as Natural England, through workshops on biosecurity – i.e. safeguarding ecosystems from non-indigenous species. These events are designed to facilitate the development of management plans. The project is also promoting biosecurity by creating online toolkits and training packages to encourage good practice among those working in marine and coastal environments.

"The toolkits will help advise local groups to control populations in specific areas where it may be feasible and cost effective to do so," says Jan Maclennan, Natural England senior marine specialist on the project.

6

Tackling the blight of marine litter

Whether on land or sea, sources of marine litter are in LIFE's sights. Projects are delivering multiple EU policy goals in the fight against a sea of rubbish.

What has LIFE done?

Co-funded many projects supporting EU policies aimed at preventing or reducing marine litter, including indirectly (e.g. projects on waste-water treatment or landfilling).

Worked with fishermen to raise awareness of the impact of discarded fishing gear.

Involved fishermen in clean-up campaigns and in rescuing turtles and marine mammals injured by marine litter.

Modelled accumulations of marine litter.

Taken action to stop land-based sources of marine litter.

Tested new technologies to stop microplastics in textiles being released in the wash.

Begun recycling marine litter into secondary raw materials, in line with circular economy goals.

Marine litter is an increasingly serious threat to the environment, ecosystems, wildlife, coastal economies, and human health. In the EU, 150 000 to 500 000 tonnes of plastic waste enter the oceans every year. This represents a small proportion of global marine litter (5 to 13 million tonnes of plastics), but plastic waste from European sources ends up in particularly vulnerable marine areas, such as the Mediterranean Sea and parts of the Arctic Ocean[1]. Marine litter has economic costs for coastal communities and for the tourism, shipping and fishing industries. The European Commission estimates that potential costs for coastal and beach cleaning across the EU could be some €630 million per year[2].

One approach is to deploy innovative strategies to clean up the marine environment. A more cost-effective method is to tackle the problem at source, requiring knowledge of where marine litter originates so solutions can be applied to prevent it.

Land-based sources derive from inefficient solid waste and wastewater management; insecure landfills; items carried by rivers and the wind; and littering in coastal areas. The fishing industry is the main sea-based litter source, followed by commercial shipping and offshore mining.

Descriptor 10 of the MSFD states that good environmental status is achieved when marine litter no longer harms the coastal and marine environment. Prevention rather than cure is the key to bringing this about. That requires better waste management, including for plastics, avoidance of single-use products, eco-design of products (e.g. to minimise release of microplastics in the marine environment), and intensive education and awareness campaigns.

1. A European Strategy for Plastics in a Circular Economy". COM(2018) 28 final.

2. Impact Assessment accompanying the Commission's Circular Economy Communication, July 2014.

What is marine litter made of?

Plastic accounts for 60-90% of marine litter; the remainder consisting of wood, paper, metals, glass, rubber, textiles, ceramics and other materials[1]. Marine litter can be anything from large discarded fishing nets down to microplastic particles invisible to the naked eye. It can float or be suspended just below the surface, but the vast majority sinks to the seabed.

Marine litter is a sign of inefficient use of resources and the Circular Economy Package targets a 30% reduction in beach litter and discarded fishing gear by 2020. The most effective way of tackling marine litter is therefore through the coordinated application of marine and terrestrial policy.

1. UN Environmental Programme. November 2017 (https://europa.eu/capacity4dev/unep/discussions/marine-litter-ingredients-oceans-plastic-soup)

From land to sea

"We managed to reduce marine litter in the project area by 30%, waste abandoned on the beach by 67%, and increased recycling by 15% through the management of urban waste."

"Land-based sources account for around 80% of marine litter, so preventing that litter at source achieves the objectives of both the Waste and Marine Strategy Framework Directives," explains Ilaria Fasce, project manager of LIFE SMILE. This Italian initiative developed an integrated district-level waste management system and applied it in four municipalities in Liguria, three inland and one on the coast. "Improvements in the management of land-based solid waste can prevent it from reaching the Mediterranean Sea. This required joint actions between municipalities on the coast and those inland," she adds.

Preventive measures included more checks to stop fly tipping, riverbed clearances, daily beach cleaning in the summer, more frequently-emptied bins near the sea, early interventions during storms, and awareness campaigns.

LIFE SMILE also developed a novel means of catching litter in rivers when storms and heavy rainfall inland bring more downstream – nets positioned across the mouth of the river. As well as trapping - mostly plastic - waste, the nets gave the project a means to analyse types of waste, information that can be used to direct further preventive actions.

"We managed to reduce marine litter in the project area by 30%, waste abandoned on the beach by 67%, and increased recycling by 15% through the management of urban waste," says Ms Fasce. The project's wider legacy is a tool called the SMILE Photo Guide, which can be used by experts across Europe to identify different waste types.

Photo: © — 2018 — LIFE14 GIE/GR/001127/University of Patras/Stavroula Kordella.
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"Plastic bags show a significant decrease of more than 65%."

Bags for LIFE

As part of the EU's Plastics Strategy[1], the European Commission is gathering evidence to determine the scope of legislation on single-use plastics and fishing gear at EU level. Moreover, EU funding will be used to understand and combat the rise of marine litter, and to work with Member States to cut consumption of plastic bags under the Plastic Bags Directive.

"Plastic bags account for almost 5% of litter found on beaches, but 30% of the litter found on the seabed around the European coastline," says George Papatheodorou from the University of Patras. He led LIFE DEBAG's campaign to encourage Greek consumers to stop taking their shopping home in single-use plastic bags because of their impact on the marine environment.

"Greece is among the Member States with the highest per capita consumption of single-use plastic carrier bags, and there was no legislation about them until 2018," says Prof Papatheodorou. "LIFE DEBAG is filling this gap, by reducing plastic bag use in Greece through an integrated awareness-raising campaign for the prevention and reduction of plastic bag use."

As well as a comprehensive national information campaign, "on the island of Syros we engaged people through a door-to-door campaign and distributed 10 000 reusable shopping bags," he explains. As a result of the project, 10 shops in Syros are also producing their own re-usable bags. The level of awareness among citizens of Syros has risen, according to the project's surveys outside supermarkets, and by the end of 2017 half of those questioned said they agreed with the imposition of a plastic bag fee as a disincentive to their use.

One of the biggest achievements of the project was its contribution to Greek legislation on plastic bags, which has been enacted since January 2018. The project made recommendations and proposed measures for reducing the use of lightweight plastic bags that helped shape the national legislation.

"A very important finding is that while all non-plastic bag litter items seem to have an almost constant accumulation on beaches, plastic bags show a significant decrease of more than 65% from the start of the project to October 2017," says Prof Papatheodorou. He believes that the campaigns show that "citizens can be inspired enough to contribute to the achievement of Good Environmental Status."

The project team monitored levels of marine litter with drones and underwater cameras. Using spatial analysis methods it was able "to draw conclusions about seabed features that trap specific types of litter, especially plastic bags and bottles, such as bathymetric depressions and seagrass patches," says Prof Papatheodorou.

1. A European Strategy for Plastics in a Circular Economy COM(2018) 28 final (http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1516265440535&uri=COM:2018:28:FIN)

Photo: ISMAR-CNR

Ghost fishing

In shallow coastal waters, abandoned fishing gear is a major threat to marine biodiversity because nets continue to catch fish (ghost fishing) and indiscriminately entrap wildlife. LIFE Ghost mapped and removed the abandoned, lost or otherwise discarded fishing gear (ALDFG) from underwater rocky outcrops along Italy's Venetian coast.

"We mapped ALDFG with echo-sounding techniques and underwater observations. Lost nets and other fishing litter were located with extreme accuracy, even on a rough seabed under turbid coastal waters," says project manager Luisa Da Ros. LIFE Ghost worked with 37 diving associations, whose members helped with the preliminary mapping of ALDFG.

Fishing crews and fish-farmers also provided important information about the location of fishing gear. Their involvement in the management process "was a necessary step for the long-term prevention of ALDFG," believes Ms Da Ros. "In doing so, not only do they contribute to the definition of operational solutions, but they also become more willing to use newly-implemented systems for responsible fishing."

The project evaluated the impact of getting rid of ALDFG and this was only carried out if future environmental benefits outweighed the disturbance caused by removal operations. It removed more than half a tonne of gear from rocky habitats, and monitored over 2 000 ha of marine seabed. "The total benefits for the environmental services of Venetian rocky outcrops have been calculated as €41 million. These findings provide relevant information for the design of suitable environmental policy," says Ms Da Ros.

'Fishing for litter'

"Coral fishermen have used their remotely-operated vehicles (ROVs) to retrieve marine litter at depths beyond the capability of scuba divers."

Clean Sea LIFE worked with fishermen and divers in Italy on clean-up operations for fishing gear and other marine litter. Sixty diving centres took part in the project in its first year. As well as organising clean-ups, "they teach their students that it is normal to pick up stuff from the sea floor," says project manager Eleonora de Sabata.

Divers and beach-clean volunteers collected three tonnes of rubbish in one year. "Most of it was plastic," says Ms de Sabata, "but divers have found mopeds, and computers and hairdryers have been collected on beaches. There is always a surprise!"

Fishermen have trawled for marine litter during 'fishing for litter' activities and coral fishermen have used their remotely-operated vehicles (ROVs) to retrieve marine litter at depths beyond the capability of scuba divers. These underwater drones don't just locate nets; they can also hook them and bring them to the surface. "We believe this is the very first time this has been demonstrated," says the project manager.

A key outcome of Clean Sea LIFE will be a map of marine litter. "This map will be compared with known areas of biodiversity value, so we can focus clean-ups in sensitive areas such as turtle-laying beaches," explains Ms de Sabata. "At the end of the project the map will be delivered to Italian and EU authorities, as our contribution to the knowledge of marine litter in the Mediterranean Sea."

Litter forecast

Huge accumulations of floating marine litter have been found in the large global gyres.

In European waters such concentrations are a major hazard to fish, seabirds and animals, through entanglement or ingestion. LIFE LEMA is testing ways to cost-effectively detect, monitor and predict accumulations of floating marine litter along the Bay of Biscay off France and Spain.

The project has already collected considerable amounts of floating marine litter, during demonstrations of its innovative methods for locating and retrieving it. This includes the use of fishing vessels to retrieve litter for local authorities, as a supplementary source of income. For example, in May 2018, on one trip a single French fishing boat fished 4 000 kg of accumulated floating marine litter and returned it to harbour.

"Our technology includes drones with visible light and infrared cameras; meteorological-ocean models and high-frequency radar to identify litter accumulation hotspots; vessels for collecting marine litter; barriers to prevent it flowing from river to sea; and computer tools for predicting marine litter accumulations days in advance and for managing specific litter types," says project manager Iker Azurmendi Sierra. At the half-way stage of the project, "the accuracy of these forecasting techniques is between 50% and 70%. Hence we must continue to improve the numerical models," he stresses.

Fishermen and volunteers are helping to deliver the project, which is now preparing to replicate its methods elsewhere. "The city of Marseille is installing two infrared cameras by the end of 2018 to monitor waterborne litter entering the marine environment via a canal and a river mouth," says Mr Azurmendi Sierra. "The prototype and the software for the forecasting tool could be installed in any boat, with only a little customisation needed."

The project's innovative clean-up approach could enable marine litter to be collected in more places and "boost local industries to start working with marine litter as a raw material," he concludes. The project team, for instance, is collaborating with a clothing company interested in recycling marine litter.

Photo: NEEMO EEIG/Audrey Thénard

Circular economy in port waste

The Port Reception Facility Directive introduced rules to ensure solid waste generated at sea is effectively managed when boats return to port, to discourage dumping. Discarded fishing nets damage the seabed, ghost fish and ensnare turtles and seabirds, for example, while batteries leak toxic metals into the water.

3-R FISH focused on three types of solid waste on fishing boats: batteries, nets and other fishing gear and expanded polystyrene fish boxes. Vessels, skippers and crews from four ports in Galicia collected more than 30 tonnes of batteries, with local fishing associations acting as a go-between with the project and distributing battery bins and handling protocols. Metals were subsequently recycled on shore.

The project also collected tonnes of damaged fishing nets, which were handled by waste managers, and sent to different companies for different uses, among them, recycling of specific types of fibre. "Two types of marketable plastic were obtained from broken-down nets," says CETMAR, the project beneficiary.

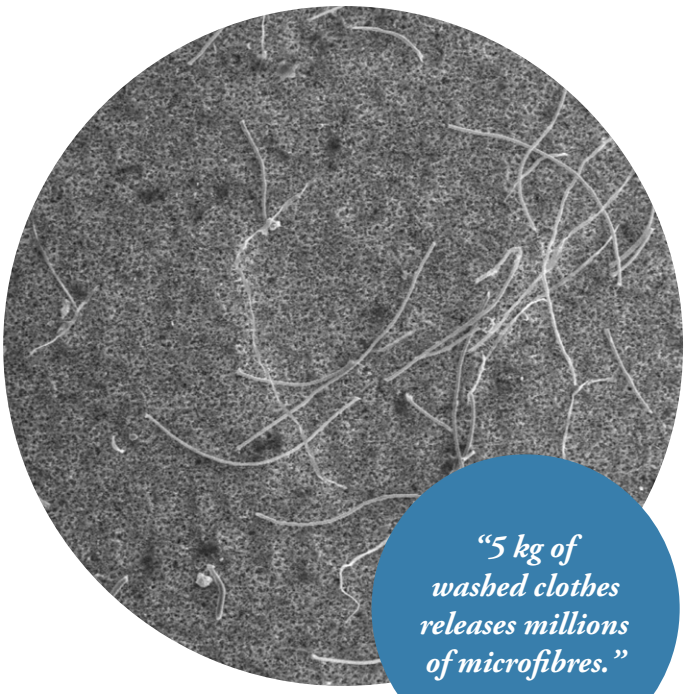
Polystyrene boxes are used for fish auctions. Odours and residues make them hard to recycle. 3-R FISH turned the expanded polystyrene into an ingredient in construction material.

"By informing the fishing sector of the management scheme and the amount of waste collected during the project, they felt involved and proud of preventing those materials entering the sea," says CETMAR. Seven years after the project ended, these activities continue and have been extended to other Galician ports.

CETMAR believes that its integrated waste management model can support a circular economy if the logistic costs are favourable. The more waste that is collected, and the better the links between ports, transport companies and recyclers, the more viable the model becomes.

Stopping microplastics from clothes washing into the sea

Washing synthetic garments is now recognised as a major source of microplastics in the marine environment. The MERMAIDS project pioneered new methods for reducing microfibre loss during the laundry process.



"5 kg of washed clothes releases millions of microfibres."

Synthetic clothing is made from polymers (plastics) with fibres that do not biodegrade. Every time we wash our clothes, microfibres (filament-shaped microplastics) are released into the drainage water.

Many microfibres are too small to be recovered by wastewater treatment plants, so they flow down rivers and accumulate in the marine environment, where they pass through food chains, and eventually end up on our plates in fish and seafood.

LIFE's MERMAIDS project set out to find solutions to this serious problem that could be applied by households and industry. This involved simulating laundry processes, under controlled conditions with a range of different synthetic fabrics, to determine microfibre loss.

In a laboratory of the Italian National Research Council (CNR) in Pozzuoli, Francesca De Falco demonstrates how fabric squares are placed in small-volume canisters, along with water, detergent and additives, and steel balls to simulate mechanical wear. Eight canisters at a time rotate in a water bath, after which wastewater is passed through filters. These are put under a scanning electron microscope, where a procedure developed by the project is used to count microfibres.

"We calculated that 5 kg of washed clothes releases millions of microfibres, which is much more than previously thought," says Dr De Falco.

One polyester fleece jacket sheds almost a million fibres per wash

- *An acrylic scarf: 300 000 fibres*
- *A pair of nylon socks: 136 000 fibres*

Source: Mermaids good practice guide.

Washing instructions

"Our results indicate there is an effect from the detergent used, washing conditions such as temperature, water hardness, mechanical action, and washing time," says Mariacristina Cocca of CNR. The experiments were scaled up to domestic and industrial washing machines. Results showed that polyester garments lost the most microfibres, but nylon and acrylic also shed large amounts.

From these results, the project produced guidelines for consumers and industry for reducing microfibre release. At home, you should use liquid rather than powdered detergent, lower temperatures, full loads, and less intense spin-drying cycles.

The technical report for industry focused on fibre geometry, as longer filaments in the fabric yarn contribute less to fibre loss. This is the key for eco-designing synthetic fabrics that shed fewer microfibres.

"We then started mitigation approaches to reduce the amount of microfibres released,

"We found a reduction of nearly 90% in microfibre release using pectin-treated fabric."

Photo: NEEMO EEIG/Stephen Nottingham

by modifying the surface of fabrics using finishing agents," explains Dr Cocca. "Our project partner Polysistec produces textile auxiliaries so we tested those, in particular silicon emulsion." A very thin coating of silicon emulsion formed on the fabric and reduced microfibre loss by about 30%. Importantly, this did not make the fabric less comfortable for the wearer.

Natural agents for coating fabrics

However, this is not the whole solution, as project manager Maurizio Avella explains: "If silicon detaches during washing it is just another microplastic introduced in the wastewater. So we started developing new finishing agents, but using natural products such as pectin and chitosan." Although pectin and chitosan are already in commercial use, this is the first time they have been used to treat textiles in this way.

Dr De Falco conducted the natural products research at CNR for her PhD. "We found a reduction of nearly 90% in microfibre release using pectin-treated fabric compared to untreated fabric. The pectin coating was still present after the washing process, so now we are performing more tests," she says.

The project team, including the Spanish technological institute LEITAT, developed new washing detergent formulations with innovative additives. The promising results of washing resistance trials performed using these detergent formulations suggested further research activities in this field.

Following on from MERMAIDS, a new project is developing a filter that can be fitted to the wastewater pipe of washing machines to trap microfibres. Dr Avella says CNR is now working with an industrial partner to market this filter.

"For manufacturing clothes we have looked at alternative polymers that biodegrade in soil, but in the sea it is different because of the presence of salt, a preservation agent," says Dr Avella. The team are now using their expertise in polymers to design novel synthetic polymers that degrade in seawater like natural fibres.

The project produced a series of policy recommendations. It highlighted the need for fitting wastewater treatment plants with membrane filters to trap more microplastics, for example, and suggested updating the textile industry BREF and EU Ecolab criteria to include information on microplastics.

MERMAIDS has made a major contribution to the objective of achieving good environmental status of marine waters by tackling this type of marine litter. It has shown that there are new opportunities in focusing on the synergies between the MSFD, the EU's Plastics Strategy and the Circular Economy Action Plan.

Project partner, the Plastic Soup Foundation, led a campaign to raise public awareness about the scale of the microplastics problem, and the things that people can do to reduce it. Their message is clear: it is important for everyone to work together to find solutions as quickly as possible.

LIFE13 ENV/IT/001069
Title: LIFE - MERMAIDS
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Website: http://life-mermaids.eu/en/

7

Introducing sustainable fisheries and aquaculture

LIFE is helping to ensure that the fish and shellfish we eat are sustainably fished from the seas and oceans, and sustainably produced in aquaculture.

What has LIFE done?

Tested ways to reduce discards from fishing vessels, with technologies for more precise fishing and mapping of fish stocks.

Organised campaigns to encourage consumers to eat discards, reducing the pressure on overexploited species of fish.

Reduced pressures on marine protected areas caused by recreational fishing from the shore.

Most of the EU's fish stocks have been overexploited as a result of excess fishing capacity. Overfishing depletes fish and shellfish stocks and can lead to fisheries collapse. It also limits the ability of species to adapt to environmental changes. Fish populations could be larger - and their exploitation more profitable - if fishing pressure were reduced.

63% of EU stocks are fished beyond maximum sustainable yield, 30% of stocks are outside safe biological limits, meaning they are at high risk of depletion.

Source: European Commission

EU law requires fish stocks to be maintained within safe biological limits to avoid depletion. With the Marine Strategy Framework Directive (MSFD), management of fisheries is even more ambitious, aiming for sustainability at higher long-term yields. More sustainable fishing will allow fish populations to grow at the same time as bringing higher economic output.

The MSFD and the common fisheries policy (CFP) are working hand-in-hand to reduce the pressures of overexploitation. The MSFD requires all commercially exploited fish and shellfish stocks to be in a healthy state, while the CFP ensures that their exploitation is sustainable by setting restrictions on the size of fishing fleets and how much time they can spend at sea, as well as how much can be caught.

"I was like other consumers, eating just a few species. Then after starting the project, I tried another - one of our sustainable fish - and it was fabulous!"

Sustainability on a plate

Consumers tend to eat a small number of fish species, meaning many of those harvested are thrown back into the sea. The FISH SCALE project reduced this waste - and the pressure on more exploited species - by helping edible discards reach your plate.

The commercial fish market is concentrated on a small number of species preferred by consumers. Others are classed as by-catch and often thrown back dead into the sea. Yet many of these are edible. With expert help, FISH SCALE drew up a list of 18 sustainable fish species normally ignored by consumers, but which are as tasty and versatile for food preparation as those usually eaten. The project set up a network of 'fish providers' - including fishermen, fishmongers, supermarkets, restaurants and hotels - which helped promote the use and consumption of these under-exploited species.

"We used a positive approach," says coordinator Bruna Valettini, "creating a 'green' list of species to be promoted, rather than a 'red' list of those to be avoided. This way we avoided possible conflict with retailers and fishermen." For the general public, there were theatrical shows, games for children and families, show cooking and tasting events, filleting and salting workshops, and so on. "Allowing people to taste the sustainable species was most effective because they realised these fish were very good," she explains. "I was like other consumers, eating just a few species. Then after starting the project, I tried another - one of our sustainable fish - and it was fabulous!"

Persuading consumers to eat fish that are usually discarded reduces the pressure on overexploited and overfished species, as well as cutting the amount of fish waste and its treatment. "In one year alone, sales of sustainable fish increased by up to 53%. We assume that people are substituting these species for overfished ones, which prevents overexploitation," says Ms Valettini.

The supermarket chain Coop, which was a partner to the project, has made 10 of the species promoted by FISH SCALE available in-store in Liguria, while a catering company in the region is also now serving sustainable fish.

Towards sustainable aquaculture

What has LIFE done?

Made aquaculture more sustainable by using new bioremediators[1] and developing technology to improve the water quality of fish farms.

Developed criteria for certifying aquaculture as 'organic' or eco-friendly, enabling the production of higher-quality seafood with a better public image.

Shown that sustainable aquaculture can be more profitable and can promote blue growth and job creation.

Around half of the fish and seafood consumed worldwide comes from aquaculture. But it can pollute and put pressure on marine ecosystems, for example through increased concentrations of nutrients, faecal matter and uneaten feed as well as pesticides, cleaning agents and medicines. There are also risks from the introduction of alien species and the possibility for escape of farmed fish, which can negatively impact biodiversity.

The MSFD will help ensure that aquaculture is environmentally sustainable in the long term, while the EU's blue growth policy envisages an increase in aquaculture, including farming new species or moving further offshore. The spatial scale of likely environmental impacts from aquaculture is a key issue in the MSFD, as is the cumulative effects of fish farming and other anthropogenic pressures. These must be assessed for the different MSFD descriptors, at the relevant scales.

More sustainable aquaculture will help achieve the 'good environmental status' needed under the MSFD for the EU's marine waters. More farmed fish results in reduced pressure on wild fish stocks provided the feed source is ecologically sustainable, while the natural filtration feeding of shellfish helps improve water clarity, as shown by mussel farms in the Baltic. In turn, the MSFD benefits aquaculture by improving water quality, reducing contaminant levels in fish and tackling problems caused by marine litter.

1. Bioremediators are biological agents, such as bacteria, plants or molluscs, that remove or neutralise contaminants in polluted soil or water.

Cleaner fish farms

REMEDIA Life is using biological organisms to clear pollutants from the water of a pilot fish farm. Its approach could help make aquaculture more sustainable in the future.

"Conventional aquaculture is a monoculture-based system," says Adriana Giangrande, project manager of REMEDIA Life. Waste from marine fish farms is often untreated and discharged straight to sea (including food, faecal matter and medicinal residue, such as antibiotics). This affects the quality of the surrounding water and sediment, and could help diseases emerge in farmed fish, posing a risk to human health and marine biodiversity.

At a pilot sea bass farm in Puglia, REMEDIA Life aims at developing a polyculture system to mitigate these effects. Mussels and microalgae are commonly used to clean fish farms, but the team in Italy wants to find out if polychaetes and sponges are better at the job. "These new bioremediators can break down a large amount of bacteria and organic particles and convert them into valuable biomass," says Ms Giangrande.

Short to medium term, the system is expected to clean the environment surrounding the fish farm. The reduction of bacteria may also help cut the use of antibiotics and improve the quality of fish reared. REMEDIA Life is upscaling the process from smaller trials to a pre-industrial application. "If successful, the project's methods could enable the number of aquaculture facilities to increase without a similar rise in their environmental impact," she says.

This sustainable approach may prove to be more profitable than conventional aquaculture as well. A farm using this method will produce more biomass than a conventional system. "This extra biomass has commercial value and could be sold," notes Ms Giangrande. Uses include as bait, ornamentation in aquariums, pharmaceuticals and fertilisers.

Sustainable fish farming in Andalusia

"Aquaculture, far from producing an environmental impact, can provide added value to the ecosystem that surrounds it. Purification by microalgae in estuaries is an excellent way to improve water quality naturally and at low cost," explains Maribel Rodríguez, manager of the AQUASEF project. This theory was put to the test as AQUASEF harnessed technology and nature to improve the water quality of a pilot fish farm for sea bream and sea bass at the mouth of the Guadiana River, a special protection zone close to Doñana National Park in Spain, which is part of the Natura 2000 network.

"We developed the first electrolyser unit to produce oxygen for an aquaculture plant," says Ms Rodriguez. This extracts oxygen from water by electrolysis and the leftover hydrogen is used for additional power generation. The oxygen is used to aerate the plant's nursery tanks for fish fry and fattening ponds, reducing the nutrient load in the water and so cutting pollution and eutrophication. Two other project prototypes improve oxygen diffusion in the water tanks. This resulted in up to 16 t/year less oxygen being purchased, at a cost saving of 30 000 €/year.

By introducing microalgae to the sea bream fattening tanks, AQUASEF was able to cut the concentrations of nitrogen and phosphorous by 40% and 60%, respectively, compared to tanks where no microalgae were added. "No effect was seen on the growth of the fish," Ms Rodríguez points out. Nor was there an impact on nesting birds in the neighbouring conservation area.

Most of the pilot techniques "are easily replicable in about 95% of the aquaculture facilities on land and inshore in Europe," she adds. "We believe more sustainable aquaculture will produce higher quality seafood with a better public image. It could also be more profitable than conventional aquaculture and mean more jobs for sustainable producers and the companies supplying technology to them."

Certifying organic aquaculture

ECOSMA developed criteria enabling sustainable marine aquaculture to qualify for ecological certification. Its methods can help others make the switch to eco-friendly aquaculture.

“A main goal of the project was the modification of the EU eco-regulation to make it possible for aquaculture to be certified with a label for eco-friendly production,” says Stefan Rehm of the German project beneficiary CRM (Coastal Research & Management) in Kiel. CRM has pioneered polyculture aquaculture systems, starting with algae and integrating mussels, and wanted to promote its sustainable products with an ecolabel. With eco-certification successfully obtained, the project developed procedures so others could convert conventional aquaculture operations into ecologically-sustainable marine systems.

Aquaculture operators can show they have high-quality, eco-friendly products by becoming certified. “The market for ‘bio’ or ecologically-sustainable products has been increasing for years,” says Dr Rehm. Consumers want more organic products and are willing to pay for them. Eco-friendly aquaculture is rare at industrial scale and still quite regional, so there’s room for growth. “And it doesn’t automatically mean higher production costs,” he points out. Other aquaculture operators have taken up the sustainable baton from ECOSMA: “We know that friends and colleagues are following the same principles in Denmark, Iceland, Ireland and Brittany. Some fish farms are also ecologically certified.”

Sustainable aquaculture can bring more employment, too. There is significant scope for new research jobs in organic aquaculture. It also helps the pharmaceutical and cosmetics industries increase their capacity to use marine resources. CRM has taken on new staff cultivating algae to obtain extracts and compounds, such as fucoidan. “There are important opportunities for polyculture aquaculture, and we are seeking internationally for companies looking into new ingredients for cosmetics and for medicinal purposes.”

The beneficiary is cultivating algae to obtain extracts and ingredients for cosmetics and for medicinal purposes

Photo: Markus Reisenberger

Using real-time data to cut fishing discards

A LIFE project in Spain developed ways to map in real time fishing areas with higher levels of discards. Its methods could help make fishing more sustainable, avoid overfishing and reduce waste.

Photo: Luis Taboada Antelo

"Discards can be reduced substantially using our tools and fishing activity made more sustainable and profitable."

"Before 2015 fishermen were allowed to discard some species caught accidentally - those below the minimum legal size, without quota, of no commercial interest or in need of conservation," says Luis Taboada Antelo, Technical Coordinator at the Spanish National Research Council's Marine Research Institute (IIM-CSIC) in Vigo. "Generally they were dumped overboard."

A measure in the common fisheries policy is putting a stop to this - the 'landing obligation', being phased in between 2015 and 2019. "It means that all specimens of species subject to TAC [total allowable catch] and quotas must be kept on board and brought to shore, where they're counted against their quotas or, once these are used up, against the quotas for other species," he explains. "It's a big problem for fishing fleets because they have to manage and keep a lot of new biomass on board, and it's a risk for their sustainability and future viability."

Discards can make up a large proportion of fishing hauls, especially in bottom trawling where they can reach as much as 90%. "With LIFE iSEAS, we're trying to obtain data from fishing vessels in real time to determine where there are higher rates of discards or juveniles present," says IIM-CSIC's Ricardo Pérez-Martín, who is coordinating the project. "Then fishing vessels can use the data to avoid those areas."

Precision fishing

The project used LIFE funding to develop a prototype that can identify and quantify all fish caught, turning the information into maps that clearly show which areas are better for fishing and which are less suitable.

The process starts with the iObserver. "It's a small box with a camera and computer inside, fixed above the conveyor belt where fishermen sort the catch on the fishing boat," explains Dr Antelo. The camera photographs the fish as they pass by, while the computer processes the images in real time - identifying the species and estimating the weight - and quantifies the haul.

"We can identify 20 fish species at the moment, with 80-85% accuracy." And fisher-

Photo: Luis Taboada Antelo

Photo: Luis Taboada Antelo

Photo: Luis Taboada Antelo

men can easily train the iObserver to recognise other species. "This makes it more transferable. We think our technology can be used by any fishing fleet anywhere in Europe and around the world." The team have some ideas for improvements after the project ends, such as "introducing a vibrating device to the conveyor belt or different speeds to help separate the fish, improving the iObserver's accuracy."

The RedBox software developed by LIFE iSEAS processes the iObserver data and information about the vessel's location, speed and the fishing depth. This is sent (via satellite or mobile device) to a geoportal in Galicia where it can be used to create individual maps for the 20 species. The maps are colour-coded to show where discards are low, medium or high, where fish are having problems reproducing, or areas with lots of juveniles present - all useful information for fishing fleets.

"Discards can be reduced substantially using our tools and fishing activity made more sustainable and profitable," reckons Dr Pérez-Martín. "In some cases, we could reduce discards by 50% or more," he says. The information gathered can also be used to help manage fish stocks and populations better, to reach their maximum sustainable yield. "If the data show that lots of juveniles or individual fish smaller than the legal catch size are appearing in a certain area, the authorities could decide to stop people fishing there. If you're catching these, you're risking the sustainability of the stock."

This LIFE project shows that technology can reduce overfishing: "Direct people more precisely where to fish and the fishing itself will be more sustainable," says Dr Antelo. "We think the ideas of LIFE iSEAS could help define a strategy to ensure the sustainability of both the fish themselves and the fishing sector in Galicia - and the results could be transferable to other areas as well."

Making the most of discards

Fish brought to shore in Galicia that aren't sold at auction are generally sent for processing into fish oil and fish meal. "But these producers only pay a few cents per kg," says Dr Pérez-Martín. LIFE iSEAS developed some new ways of using the biomass at a pilot plant in Marin.

Prototypes convert commercial fish species into mince, separating the flesh from the other parts. "This is pressed into large slabs which are frozen and can be used to make restructured food products like fish fingers, burgers and nuggets." He sees a potential market for this mince locally: "There's a broker in Barcelona who buys these blocks from China!"

The leftover parts and fish under the minimum legal size (which can't be used for direct human consumption) are converted into other products, such as collagen, gelatine, mineral supplements, nutraceuticals, peptones and fish hydrolysates. "We sent these products to several companies in Europe that might be interested and we've had a good response about their quality," adds Dr Antelo. The marine research institute is also trying to develop regeneration materials for teeth using hydroxyapatite from fish bones.

Adding value to discards is "a way for ship owners to cut the costs of complying with the landing obligation," says Dr Pérez-Martín. He sees an opportunity for local owners to club together and invest in similar processing equipment, perhaps with support from the regional government. "From our data, the level of discards is high enough to have a plant in each major port where fish are landed in Galicia."

LIFE13 ENV/ES/000131
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8

Helping to silence underwater noise

LIFE is at the forefront of efforts to measure and mitigate the impact of underwater noise.

What has LIFE done?

Established standards for measuring underwater noise in the Baltic Sea. This has greatly increased the capacity of Member States to understand this pressure and in the long term to take appropriate actions to achieve good environmental status.

Developed a system for tracking marine mammals and a protocol for ships in their vicinity in the Ligurian Sea.

In both cases, LIFE has successfully pursued a regional approach that could be a template for action in other seas.

What could LIFE do next?

Test more technologies to reduce underwater noise.

Assess the impact of noise on species' breeding cycles, ability to detect food and communicate.

Marine mammals and certain fish species are known to be sensitive to underwater noise. For instance, research has shown that beaked whales have become stranded as a result of sound from subaquatic military activities.

While it is a known pressure, the precise impact of underwater noise is less well-known. We need to know more about its effect on species' breeding cycles, their ability to detect food and to communicate in order to achieve a good environmental status for underwater noise.

The Baltic Sea is designated as a 'particularly sensitive sea area' by the International Maritime Organisation. Noise levels are increasing. Major sources of noise include shipping, seismic surveys for oil and gas exploration, offshore construction such as marine wind farms, military and mapping sonars, offshore industrial activities, and the use of acoustic deterrent devices.

The largest contributor to human-induced underwater noise in the Baltic Sea is commercial shipping. The number of ships is set to double by 2030.

BIAS: Baltic Sea Information on the Acoustic Soundscape

The LIFE project BIAS set out to ensure that underwater noise levels do not adversely affect the marine environment of the Baltic Sea.

"The background to the project was really the Marine Strategy Framework Directive. I was also a member of the MSFD Technical Group on Noise, which was the expert group that was formed by the Commission and Member States to help interpret the 11th descriptor," explains project manager Peter Sigray.

"The Baltic Sea is well suited to a regional approach, because, apart from Russia, we are all Member States around it. We applied to LIFE+, really pushing hard this regional approach," recalls Mr Sigray. Led by the Swedish Defence Research Agency (FOI), the project team consisted of seven partner organisations from six EU countries: Sweden, Finland, Estonia, Poland, Germany and Denmark. The aim was to establish standard guidelines to measure continuous noise. Without common standards, joint management would not be possible.

The project partners spoke to the managing authorities responsible for underwater noise. "We realised one or two years into the project that no manager will take any big decision unless HELCOM is involved, because HELCOM is the coordinating body in the Baltic Sea. HELCOM grabbed onto this, they understood that this is something that has to be coordinated, and that has to be done by HELCOM. And then the Member States became aware that this is important, that they have to contribute. We started to really have a good, coordinated communication with the Member States through HELCOM," says Mr Sigray.

Setting the standard

To create standards for noise measurement and signal processing, it was first necessary to establish a baseline of the prevailing ambient noise. The project placed hydrophone loggers at 36 selected locations across the Baltic Sea to measure continuous noise levels for 12 months.

The data analysis focused on sound pressure levels of the sound energy in frequency bands around 63 Hz and 125 Hz, where ship noise is concentrated, as well as high-pitched frequencies (2 kHz) that are known to be audible to seals, harbour porpoise and herring.

The BIAS team then used advanced acoustic modelling to produce soundscape maps for each of the chosen frequency bands at three depth ranges. The maps took the natural noise of wind and waves into account. The interactive maps allow changes in the soundscape to be tracked, understood and interpreted. They provide a GIS-based planning tool for continuous underwater noise in the Baltic Sea that can be updated with new monitoring data. "This tool is taking the recommendation from the European Union of Descriptor 11 and going closer to good environmental status," says Mr Sigray.

Bridging the gap

"We went further than our aims," he believes. "The BIAS project somehow became the pilot project that bridged the gap between the TSG Noise Group's work and implementation."

The BIAS standards for noise measurement have been adopted by the TSG Noise Group. "This year an INTERREG project called JOMOPANS has started (http://northsearegion.eu/jomopans/). It is very much like the BIAS project but for the North Sea. They are taking BIAS and building on it," says Mr Sigray. "The BIAS standards are part of the JOMOPANS project and will be reused now. They have to be tweaked a bit, because the North Sea is not the Baltic Sea – in the Baltic Sea you can have a sensor standing on the sea bed very easily, but in the North Sea it will be trawled away."

BIAS has built capacity among the partner beneficiaries. "They are now the national experts, and they were not in the beginning," explains Mr Sigray. "Awareness has grown about underwater noise through the descriptor and this has become an issue. All Member States are obliged to measure this pressure. They say 'How do we measure it?' We have the BIAS standard. And 'who are the national experts?' They come from BIAS."

When it comes to ongoing noise measurement, "HELCOM is very much into cost efficiency. The solution that BIAS developed was a kind of minimum way of doing it; I think it is cost efficient. Managing authorities are starting to look at different kinds of pressure in the Baltic Sea, such as the impact of sound relative to eutrophication," says Mr Sigray. This helps determine "where to put the money in the future."

The BIAS team is now working with HELCOM to establish the protocols for a continuous monitoring and observation programme across the Baltic Sea region. "The other thing that we are working on is to establish a regional standard. We are using the BIAS standard and reworking it backwards to take a little bit of the detail out," explains Mr Sigray. "The next step is to bridge the last gap between what we have done in the BIAS project and the impact. You always start with pressure first, then you address the impact, and when you have understood the impact it is time for mitigation measures," he adds. "I think we are on our way and especially now JOMOPANS is established. We are so many now in the EU that we will be able to decide how to interpret Good Environmental Status in a coherent way."

Global noise

Peter Sigray: "I have been invited to NOAA in the US to give a presentation of the BIAS project and its results. There is also interest from Australia and South Korea."

Photo: Solvin Zankl

Saving whales from noise stress

Photo: Acquario di Genova/Delfini Metropolitani/Laura Frigerio

A new collision and traffic prevention system will reduce noise stress for sperm whales caused by shipping. The LIFE WHALESAFE project is taking place in the Pelagos Sanctuary for Mediterranean marine mammals, a special marine protected area located between Liguria, France and Sardinia. The sanctuary is the most important breeding and feeding site for cetacean populations living in the Mediterranean Sea.

"We introduced a Protocol of Conduct, agreed with the stakeholders, that foresees a speed reduction in proximity to the animals (distances of less than 500 m). The tracking system helps to determine the correct position of the animal and to inform ships in the area," explains project manager Mauro Taiuti. "The coastguard guarantees the application of the Protocol."

The system was first tested in 2016. "We successfully proved that cetaceans could be identified and tracked," says Professor Taiuti.

A similar system has been deployed in the United States, but in the much shallower waters of the Boston Bay (www.whalealert.org). LIFE WHALESAFE is breaking new ground by deploying a whale tracking system in the deep waters of the Ligurian Sea.

9

Dealing with marine contamination

LIFE projects in Italy and Sweden have pioneered new approaches to dealing with contaminants in the marine environment.

What has LIFE done?

Funded hundreds of projects that have reduced sources of contaminants from land-based activities. These have indirectly had a positive effect on the status of the marine environment. Actions have included using natural water retention measures to treat storm water or agricultural run-off.

Reduced pesticide and fertiliser use through sustainable farming practices, thus improving water quality.

Decontaminated sediments to directly improve the marine environment, reducing contamination of the seabed and the water columns above.

Developed techniques that enable sediments to be reused, creating a circular economy resource.

Contaminants are substances that are toxic, persistent and liable to bio-accumulate in the marine environment. These include pesticides, anti-foulants, pharmaceuticals and heavy metals. Their presence can affect the quality of marine waters and the functioning of organisms or biological processes. For instance, female dog whelks (*Nucella lapillus*) exposed to a biocide called TBT developed male sex organs. One of the goals of the Marine Strategy Framework Directive (MSFD) is to ensure that levels of contaminants in the marine environment do not give rise to pollution effects.

Natural oceanographic and geological factors can sometimes lead to elevated levels of certain contaminants. However, human activities - including industrial and agricultural effluents, pollution from shipping, and oil, gas and mineral exploitation - are the main sources of marine contamination.

The simplest way to address this is to reduce the sources of contamination. The MSFD is part of a suite of EU legislation working towards this goal, including the REACH Regulation on chemical substances, the Water Framework Directive, which covers the status of rivers, streams and lakes, and the Environmental Quality Standard Directive, which defines the maximum allowable concentration of a contaminant not causing harm.

The MSFD also sets out the requirement that contaminants in fish and other seafood for human consumption do not exceed established safety levels.

Decontaminating dredged sediment

Photo: Cristiano Frasca

Between 100 and 200 million m^3 of sediment is dredged each year in Europe. Up to 20% of this material is contaminated by organic compounds or heavy metals. Treatment typically involves transfer to large fill-in basins, with the polluted water drained into wastewater systems, while polluted sediments are usually sent to landfill sites.

For the SEDI.PORT.SIL project, the Italian engineering consultancy MED INGEGNERIA built a pilot plant in the port of Ravenna to demonstrate a circular approach to sediment decontamination. Using a three-stage treatment process - soil washing, land farming and plasma fusion – the plant successfully recycled 99% of the dredged sediment. The recovered material can be reused in construction and environmental engineering. An important outcome was to demonstrate that the plasma treatment stage could separate silicon – in particular, valuable ferrosilicon – from the sediment.

The project team explored potential replicability by drawing up plans for an industrial scale treatment plant in Ravenna. This was calculated to have a positive economic balance over a 20-year lifecycle. SEDI.PORT.SIL also determined that the treatment process could be applied at the port of Midia in Romania, as an example of its suitability in other European contexts.

In Porto Marghera, Venice, the company Alles SpA tested a prototype for the fast decontamination of marine and river sediments contaminated by hydrocarbons and other organic substances, a LIFE project known as GREEN SITE. Its mobile technology exploits the special solvent properties of carbon dioxide in supercritical state during the extraction phase. This is followed by an oxidation phase. The project showed that sediments that would normally go to landfill on Tresse Island can be reused to make mudflats and salt marshes. These are of fundamental importance to the environmental balance of the Venice Lagoon: they facilitate water exchange, moderate wave action and limit the dispersion of sediments in the lagoon and their loss at sea.

The project's lifecycle assessment showed that the new technology operated at 90% efficiency with a 90% reduction in wastewater volumes.

Purification technologies for blue growth

Photo: CC BY-SA 2.0/mafe de baggis

"It is very efficient and not invasive for the fragile marine ecosystem of Mar Piccolo."

Mar Piccolo is an intensively industrialised coastal basin north of Taranto in southern Italy. Both its seawaters and seabed are contaminated by heavy metals, and carcinogenic compounds (PAHs and PCBs). These contaminants have had a harmful effect on the basin's biodiversity and its aquaculture industry. "The accumulation of PCBs in the mussels farmed in the first inlet of Mar Piccolo has led to a prohibition on their sale, causing considerable economic damage to local communities, since aquaculture is an important source of income for them," explains project manager Gaetano Perrotta.

LIFE is trialling a purification pilot plant that will restore around 3 km^2 of the Mar Piccolo basin using membrane microfiltration. The pilot plant consists of a mobile system and a ground system: "The mobile unit takes care of re-suspending the seabed in an area while it sucks the decanted water column in a previously suspended neighbouring area. Over time the mobile part sweeps the entire work area sending the collected liquid to the ground plant which separates the pollutants concentrating them and returning the purified water inside the bounded work area," says Mr Perrotta.

This technology should reduce contamination both on the seabed and in the water column above. "It is very efficient and not invasive for the fragile marine ecosystem of Mar Piccolo, unlike other seabed remediation approaches, such as dredging or capping," notes Mr Perrotta. "This should help create an environment of extraordinary beauty, highly attractive both for nature tourism and for economic activities such as quality mussel farming," he says.

Alongside proof of the pilot technology's effectiveness, the goal of Life4MarPiccolo is to develop an intervention protocol for use by authorities in Italy and other parts of Europe that face similar pollution challenges in coastal areas. Tools for the sustainable management of marine areas will include "a molecular kit for a rapid and multi-determinative diagnosis of water quality," says Mr Perrotta. The kit will be "low cost" as it is "able to simultaneously investigate several selected molecular probes, indicative of different types of contamination."

Treating and commercialising dredged sediments

The Baltic Sea is predisposed to harmful contamination effects. Its sediments can contain hazardous substances and high levels of nutrients, leading to eutrophication.

Sustainable dredging methods are available but are too expensive to employ on a large scale. LIFE SURE is tackling this problem by developing a cost-effective and ecologically-sustainable process for dredging sediments in shallow eutrophic waters and reusing the valuable nutrients and metals they contain. "The system has been mainly adapted to the physical conditions of the target dredging site, Malmfjärden," says project manager Fabio Kaczala, of Kalmar municipality in Sweden. He explains that the main characteristics of this semi-enclosed bay within the coastal city of Kalmar are "high population density, use as a recreational area for boats and canoes, and constant discharge of stormwater runoff from drainage systems with a higher degree of pollutants, such as nitrogen, phosphorous, lead and cadmium."

LIFE SURE's continuous dredging system is designed to move slowly (1 cm/s) and therefore avoid any re-suspension of sediments. Using built-in sensors, it can be controlled remotely as well as locally, without expert knowledge. "It can be used in any accumulation seabed application as long as site-specific conditions are taken into account," says Dr Kaczala.

Once sediments have been dredged, they will pass through a land-based treatment and dewatering system, which removes water and pollutants via settling/sedimentation and mechanical dewatering with a centrifuge. Sediments are separated into three fractions: water, organic sediments and mineral sediments. The project's goal is to recover and find commercial uses for more than 70% of dredged sediments. According to Eurostat, only 12% of dredged sediments are currently recycled.

Markets for recycled sediments

"There are major discussions with potential end users," says Dr Kaczala. Four market opportunities have been identified: "Civil engineering purposes, waste to energy via biogas production, nutrients and minerals recovery via production of fertilisers, and silt for use in 3D printing," he reveals.

10

Solutions to minimise eutrophication

Unsightly algal blooms on seas and lakes are the most visible sign human activities have enriched water with too much nitrogen and phosphorous. LIFE is showing new ways to prevent and treat the causes of eutrophication.

What has LIFE done?

Provided multiple solutions for tackling eutrophication at source.

Funded projects to reduce nitrogen use and run off in agriculture.

Supported sustainable aquaculture (see pages 49-52).

Improved the efficiency of industrial and urban wastewater treatment (nearly 250 projects).

Used blue and green infrastructure for stormwater management and depollution.

Nitrogen and phosphorous are the primary inorganic nutrients responsible for the eutrophication of marine waters. Human inputs – including from farming, industrial and domestic waste water, aquaculture and ships' effluents – have increased the load of nitrogen and phosphorous to our seas and oceans. This can lead to eutrophication, which causes biodiversity loss, degraded ecosystems, harmful algal blooms and oxygen deficiency in bottom waters. Descriptor 5 of the Marine Strategy Framework Directive requires EU Member States to reduce nitrogen and phosphorous loads to the marine environment.

The nutrient load can be reduced through changes in agricultural practices, or through mitigation measures on land or at sea. The LIFE programme is at the forefront of introducing such measures.

The projects in this chapter have devised tools to forecast algal blooms and identify appropriate agri-environmental measures, and tested water protection measures that reduce nutrients in run-off water, ultimately benefitting the Baltic Sea.

Bad for society, bad for the economy

Negative socio-economic impacts of eutrophication include:

- Reduced fish and shellfish stocks caused by oxygen depletion.
- Toxins from algal blooms. These are a danger to people (through shellfish poisoning) as well as to livestock in coastal areas.
- Foul odours and unsightly foam from algal blooms are a problem for tourism.

Blooming forecast

Photo: CC BY-SA 3.0 IGO/European Space Agency

"In order to tackle algal blooms, it is essential to know exactly when and where they will happen. The GISBLOOM project created a tool for forecasting algal blooming in Finland's rivers and lakes in real-time. The tool combines data from satellites, automatic measuring stations and field observations by the public. This is fed into a model that simulates hydrology, land-use changes and nutrient loads.

"Based on the real-time forecasts it is possible to warn swimmers and water intake plants beforehand. Accuracy of forecasts is relatively good despite the inherent randomness of algal blooms and predictions can be updated as new observations are obtained," says project manager Olli Malve.

As agriculture is the main contributor to eutrophication in many areas, especially in coastal regions, it is important to be able to assess the potential impact of cultivation measures on nutrient loading," he explains. "Correct targeting of agri-environmental measures requires precise, site-specific information on each field or plot. Agri-environmental management measures are nowadays much better targeted and dimensioned based on the site-specific information created and on the participatory operations model demonstrated in the project."

Since GISBLOOM concluded in 2013, the forecasting service has been commercialised by a Finnish company (http://www.vesinetti.fi/login). "The tools are used in Finland and Russia to monitor and to exchange data about water quality in rivers flowing across the border," notes Mr Malve.

Reducing run-off through Urban Oases

Photo: Outi Wahlroos


Photo: Outi Wahlroos


Photo: Outi Wahlroos


Photo: Outi Wahlroos


Photo: Outi Wahlroos

Also in Finland, the Urban Oases project tested whether specially-constructed wetlands and vegetated swales in urban watersheds could reduce run-off of nutrients and pollutants to receiving rivers and lakes and ultimately improve the water quality of the Baltic Sea. "We targeted ecosystem services relating to stormwater management landscapes, such as: flood control, water pollution control, increasing biodiversity, and recreational amenities," explains project manager Outi Wahlroos.

"A constructed wetland typically consists of an inflow pond for solids settling, a wetland vegetation covered shallow area for dissolved pollutants control, and an outflow pond for settling plant debris from the vegetated area. Stormwater wetlands need all three of these parts," she says.

The project monitored water quality through the wetlands every 10 minutes. "We were able to demonstrate that once the vegetation was established in the shallow area of the wetland, water quality treatment increased every year," says Ms Wahlroos. "By the fifth year after construction this relatively small yet already lushly-vegetated wetland was removing 21% of incoming phosphorus on an annual scale," she adds.

Urban Oases calculated that in areas such as southern Finland functional wetlands would need to cover at least 1% of the surface area of the contributing watershed. "Then ideally upstream of such wetlands one would need our pilot swales to trap severe pollutants (e.g. heavy metals) before they reach the wetlands," says Ms Wahlroos.

Is this feasible? The Urban Oases team believes it is. The project's surveys showed that people are willing to pay more for stormwater management by nature-based solutions than municipalities currently pay for conventional treatment.

"One wetland takes away 20% of the phosphorous load it receives, but to have a big impact on the Baltic Sea you would need lots of them," she explains. "Our contribution is to show that water environment management parks and structures are a joy and cost efficient. People are willing to pay for them and have them in their backyard. They also have the indirect effect of improving biodiversity and providing ecosystem services."

Photo: City of Helsinki/Kajsa Rosqvist

Best practice toolbox

The CITYWATER project benchmarked water protection measures for cities on the Baltic Sea coast, including Helsinki and Tallinn. It gathered best practice case studies and advice into a toolbox for politicians, planners and civil contractors (www.waterprotection-tools.net).

"Local actors have a crucial role to play in protecting the Baltic Sea," says project manager Kajsa Rosqvist. "Remarkable nutrient load reductions have been achieved in Finland by investments in wastewater treatment plants in Pori and Liepaja, as well as port reception facilities in Helsinki. Natural solutions such as a stormwater wetland in Lahti and agricultural buffer zones in Turku were estimated to reduce the nutrient load rather efficiently," she explains. With results indicating substantial positive net benefits for the Baltic Sea, the measures are good for society too.

"The protection of the Baltic Sea should be seen as an entirety and every single measure is an important part of it," believes Ms Rosqvist. CITYWATER's results encourage "implementing diverse water protection measures both by the coast and elsewhere in the catchment area and to prefer measures that provide multiple benefits." More effort should go into water protection research to take local impacts into account in decision-making, even at Baltic Sea level. "Cost-benefit analysis and the Baltic Sea Challenge network are tools that can support the implementation of new water protection measures," she adds.

"The toolbox is in active use and new actions are included all the time by the Baltic Sea Challenge Initiative," says Ms Rosqvist. "There are several new storm water projects based on CITYWATER's results, and especially on the solutions implemented in Helsinki and Tallinn."

The Baltic Sea Challenge

Following the initiative of the Cities of Helsinki and Turku, more than 270 organisations are taking part in the Baltic Sea Challenge. They are committed to going beyond the minimal legal requirements by taking concrete actions locally to protect the waters of the Baltic from problems such as eutrophication. Read more at: http://www.itamerihaaste.net/en/about_us/communique

Beware of the sea wasps

Spanish marine habitats have been adversely affected recently by increased populations of the sea wasp (*Carybdea marsupialis*), a predatory and mildly venomous jellyfish.

LIFE's CUBOMED project investigated the links between water quality and sea wasp outbreaks. "Water quality (in terms of nutrient content, mainly nitrogen and phosphorus) may increase the amount of plankton, hence the food available for jellyfish (not only for *Carybdea marsupialis*). The more food there is, the higher the reproduction rate and growth rate would be," explains project manager Cesar Bordehore.

Although wastewater treatment plants can remove more than 95% of pollutants in the incoming waste (mainly phosphorous), sometimes the 5% remaining can be enough to generate disturbances in sensitive aquatic ecosystems. The CUBOMED team developed prediction models for the presence of sea wasps in the Mediterranean Sea. Based on simulations, reducing food availability was shown to be the most effective strategy for curbing the population of the species.

Based on their findings, Dr Bordehore and his colleagues at the Multidisciplinary Institute for the Study of the Environment in Alicante are drafting recommendations for amending the EU's Nitrates, Urban Wastewater and Groundwater Directives, to improve water quality in coastal areas.

PROJECT FEATURE

Simulating storms to restore dead sea bottoms

A Swedish LIFE project used wave power to pump oxygen-rich surface water to the depths of the sea. The WEBAP system could be a way of mitigating oxygen depletion caused by eutrophication.

"Why not simulate the storm? Isn't that smarter?"

"The Baltic Sea around here is in a very bad shape. You have huge areas totally dead. Why? The reason is for many, many years we let out nutrients to the sea without treatment. And then you have algal blooms and then algae goes to the bottom and consumes all the oxygen. And when this happens life cannot survive at the bottom," explains Östen Ekengren, Executive Vice President at IVL - Swedish Environmental Research Institute.

"When you have anaerobic conditions, phosphorous will be released from the bottom - much more than is coming from all the rivers going into the lakes," he points out. "If you want to see a change in the Baltic Sea you must do something to stop the release of phosphorous from the bottom sediments."

Nature's solution is a storm, which sends oxygen-rich surface water to the lower depths of the sea. Researchers at the Royal Institute of Technology in Stockholm (KTH) had an ingenious idea, as Mr Ekengren recalls: "Why not simulate the storm? Isn't that smarter?"

Wave goodbye to hypoxia

IVL secured funding through LIFE to build and test a prototype of the 'Wave Energised Baltic Aeration Pump' (WEBAP). This uses wave energy to pump oxygen-rich surface waters down to oxygen-poor bottom layers. "Water depth doesn't matter, although it will be more costly the deeper you go," he explains.

Tests took place for around 18 months in the Stockholm archipelago and nearly two years in open seas off the coast of Simrishamn in southern Sweden. "The bay at Simrishamn is large so the testing there was mainly to see that you could pump down to the bottom and that you could withstand a winter storm. Here in Stockholm we could really study what was happening," says Mr Ekengren.

Pumping was accompanied by active sampling of marine and biological data around the test areas. "Our specialists on the marine environment could not see any negative toxic effects," he says. Monitoring and evaluation of the marine environment, water, biota and bottom sediments also showed that there was no negative effect on the salt barrier in the sea where cod lay their eggs. "Some marine biologists said it would be destroyed; that does not happen," adds Mr Ekengren. "Oxygen came back; we could even find cod swimming after some weeks. You could say it is similar to after a storm," he explains.

The WEBAP team calculated environmental impact and lifecycle cost for the new technology in comparison with alternative solutions for removing phosphorous from the sea, such as oxygenation using electric pumps powered by diesel (off shore) or electricity (near shore), or chemical treatment (using PAX or PIX) to bind the phosphorous. "The lifecycle cost per kg of phosphorous removed is much lower for WEBAP," says Mr Ekengren. "We have a very low impact on the global warming potential, which is also important," he adds.

Photo: IVL Swedish Environmental Research institute

Beyond the pilot

The LIFE project also modelled regional large-scale impacts. Modelling for the Gotland Deep based on field data showed it is possible to oxygenate the whole area down to the seafloor within five years using an array of 40 pumping units. "The technology has the potential to bind up to 100 000 tonnes of phosphorous," says Mr Ekengren. This would make WEBAP a valuable complement to efforts to reduce the run-off of fertiliser and wastewater effluents and to meet the objectives of EU marine policy and the Water Framework Directive.

Mr Ekengren believes that while the LIFE project proved the concept, there is scope to improve the technology. "The price to build [the platform] was 1.5 million Swedish Crowns (circa 150 000 euros). After we published our conclusions some people contacted us and had better ideas how to build it. One guy built something the size of a buoy; it could pump down five times the amount (of water) with lower energy at a lower wave height. If more people are engaged you can develop this and also lower the price."

As well as his role at IVL, Mr Ekengren is Senior Advisor at Smart City Sweden, the national export and investment platform for smart and sustainable city solutions. "I have engaged a new employee to take WEBAP further: to start a new full-scale project," he says. "We have interest mainly from the tourism industry, someone having a hotel or something in a place where it smells due to algae, and they are willing to pay to do something. A foundation in Finland contacted me and they have 10 different actors willing to install it because they want to refresh the bay right next to their hotel where people go fishing."

He believes that WEBAP is "something that can also be used in other places." Smart City Sweden has been developing links with stakeholders in Chesapeake Bay in the US and the Bohai Sea in China, two semi-enclosed marine areas that face similar challenges to the Baltic Sea in terms of eutrophication.

According to the latest HELCOM assessment on eutrophication[1], in 2011-2015 over 95% of the Baltic Sea area suffers from eutrophication due to inputs of nitrogen and phosphorus. Although signs of improvement are seen in some areas, the effects of past and current nutrient inputs still predominate the overall status.

1. http://stateofthebalticsea.helcom.fi/pressures-and-their-status/eutrophication/

LIFE08 ENV/S/000271
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LIFE & the Marine Environment project list

Here is a complete list of LIFE projects that are featured in LIFE and the Marine Environment publication.
Arranged by theme, the list highlights 45 projects relevant to the marine environment. For more information on individual projects, visit the online database at: http://ec.europa.eu/environment/life/project/Projects/index.cfm

A number of LIFE publications are available on the LIFE website: *http://ec.europa.eu/environment/life/publications/lifepublications/index.htm*
A number of printed copies of certain LIFE publications are available and can be ordered free-of-charge at:
http://ec.europa.eu/environment/life/publications/order.htm

Photo: LIFE13 BIO/FR/000075/M. Riethmuller

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LIFE "L'Instrument Financier pour l'Environnement" / The financial instrument for the environment

The LIFE programme is the EU's funding instrument for the environment and climate action

Period covered 2014-2020

EU funding available approximately €3.46 billion

Allocation of funds

Of the €3.46 billion allocated to LIFE, €2.59 billion are for the Environment sub-programme, and €0.86 billion are for the Climate Action sub-programme. At least €2.8 billion (81% of the total budget) are earmarked for LIFE projects financed through action grants or innovative financial instruments. About €0.7 billion will go to integrated projects. At least 55% of the budgetary resources allocated to projects supported through action grants under the sub-programme for Environment will be used for projects supporting the conservation of nature and biodiversity. A maximum of €0.62 billion will be used directly by DG Environment and DG Climate Action for policy development and operating grants.

Types of projects

Action Grants for the Environment and Climate Action sub-programmes are available for the following:

- "Traditional" projects – these may be best-practice, demonstration, pilot or information, awareness and dissemination projects in any of the following priority areas: LIFE Nature & Biodiversity; LIFE Environment & Resource Efficiency; LIFE Environmental Governance & Information; LIFE Climate Change Mitigation; LIFE Climate Change Adaptation; LIFE Climate Governance and Information.
- Preparatory projects – these address specific needs for the development and implementation of Union environmental or climate policy and legislation.
- Integrated projects – these implement on a large territorial scale environmental or climate plans or strategies required by specific Union environmental or climate legislation.
- Technical assistance projects – these provide financial support to help applicants prepare integrated projects.
- Capacity building projects – these provide financial support to activities required to build the capacity of Member States, including LIFE national or regional contact points, with a view to enabling Member States to participate more effectively in the LIFE programme.

Further information

More information on LIFE is available at http://ec.europa.eu/life.

How to apply for LIFE funding

The European Commission organises annual calls for proposals.
Full details are available at http://ec.europa.eu/environment/life/funding/life.htm

Contact

European Commission – Directorate-General for the Environment – B-1049 Brussels (env-life@ec.europa.eu).
European Commission – Directorate-General for Climate Action – B-1049 Brussels (clima-life@ec.europa.eu).
European Commission – EASME – B-1049 Brussels (easme-life@ec.europa.eu).

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LIFE Publication / LIFE and the Marine Environment

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