



TREC – Traversing European Coastlines



Foreword

A scientific expedition to understand biodiversity and ecosystems along Europe's coastlines

Europe's coastlines are environments rich in life, industry, culture, and heritage. Forty percent of Europe's population lives within a coastal region, and many European societies have been, and still are, defined by their relationships with the sea.

Our seas and coasts host an extremely rich diversity of life and play critical roles in the stability and sustainability of wider ecosystems.

In recent decades, we have all become aware of the fragility of our coastal habitats, especially their extreme vulnerability to human impacts ranging from pollution and reduction of natural habitats to climate change. Governments, regulators, and communities have sought to best understand how to protect and preserve these areas.

At the same time, science has continued to provide an ever-increasing understanding of the role of the environment on human, animal, plant, and planetary health. This knowledge has made apparent how little we still know about the largely invisible biodiversity, mechanisms, and processes that underpin life as a whole where land and sea meet.

How do such different ecosystems interact? Why can antibiotic resistance spread from land to sea, if most microbial species can only thrive in one habitat? What are the effects of human impacts at the molecular and cellular level? How do species

adapt to changing environments? And how can we measure and mitigate biodiversity loss over time, especially when it comes to the microscopic organisms that form the basis of ecosystems? Our ocean and soils still hide a myriad of unanswered – but important – questions.

TREC – Traversing European Coastlines – will help to find answers. As a result of scientific and technological advances in recent years, we now have the tools and knowledge needed to document, examine, and probe the molecular and cellular states of life in our coastal areas in the field, in real time, across national borders, and at an unprecedented scale.

The TREC expedition is the first time researchers from across Europe will study life at all biological scales, from molecules to communities, along the entire European coast, to provide a richer and deeper understanding of how ecosystems respond to natural and human-made challenges. This will produce new knowledge and discoveries that will help to provide our societies, governments, and regulatory agencies with the ability to best predict the possible effects of environmental changes and impacts.

It is an ambitious – and essential – project, given the environmental challenges that our planet faces.



Professor Edith Heard FRS,
Director General, European Molecular
Biology Laboratory (EMBL)



Romain Troublé,
Director General, Tara Ocean Foundation

A new era for European molecular biology

EMBL is Europe's life sciences laboratory. Established in 1974 and under the guidance of its 28 member states, EMBL provides leadership and coordination for the life sciences across Europe.

With our current scientific programme 'Molecules to Ecosystems', we embarked on an exciting and ambitious new era for the life sciences in Europe. We seek to better understand the very processes of life itself – from the smallest to largest of scales – and in its natural context.

The TREC expedition is our flagship planetary biology project. We are taking the knowledge and technologies developed over the past 50 years out of the lab and into the field, so that we can understand how life itself is affected by changes in its environment.

EMBL has a long history of successfully working with its member states, partner organisations, and scientific and industrial collaborators to further knowledge, push technological boundaries, and drive skills development. With the pan-European, interdisciplinary TREC expedition, we are building on our connections and expertise to usher in a new era in life sciences research in Europe.

www.embl.org/programme



A mission for science and society

We live in an interconnected world.

While that phrase might, at first glance, conjure up thoughts of our global digital connectivity or transportation networks that take us to every corner of the world, it applies, first and foremost, to our natural world.

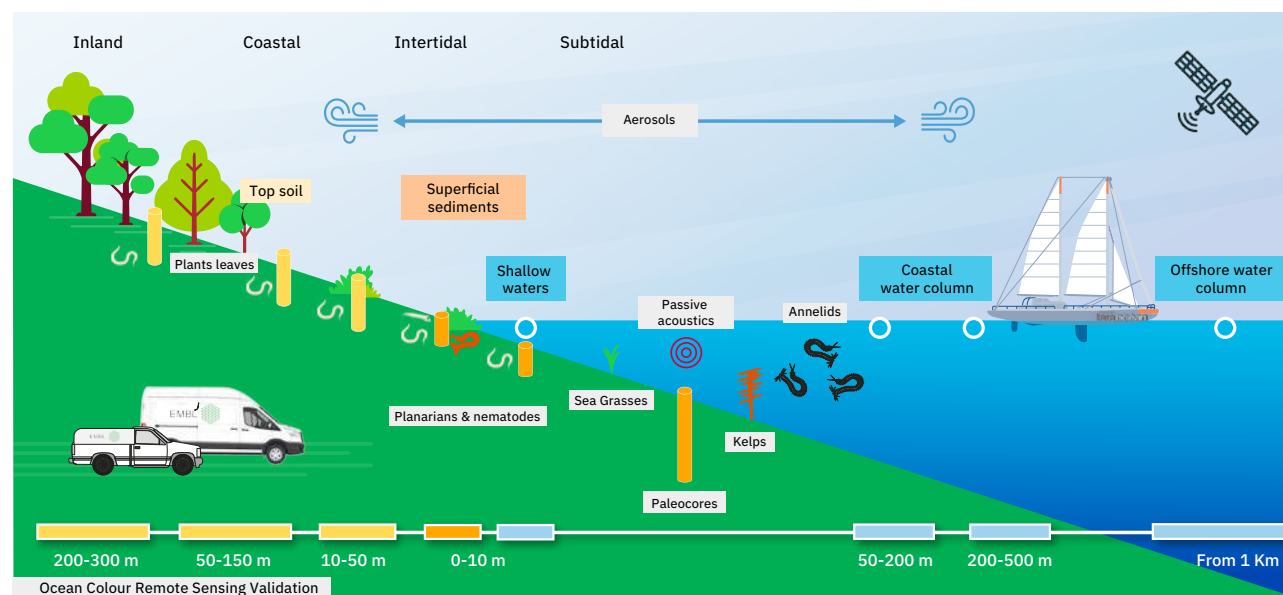
The ecosystems on land and at sea don't exist in isolation. They, and the organisms within them, influence each other, impact the overall health of our planet, and underpin the evolution of life on Earth.

Coastal regions are key functional ecosystems on which humans depend for their livelihoods and well-being. For centuries, ecologists, marine biologists, evolutionary and developmental biologists, and many others have studied organisms and the ecosystems they live in. The knowledge they created has already driven debate and decisions necessary to protect natural habitats.

However, in an ever faster changing world in which the impacts of humans have accelerated biodiversity loss and the rise of antimicrobial

resistance at high pace, we must not stop there. Scientists now have at hand the most advanced molecular and cell biology technologies that make it possible to study – in the field – the mechanisms of life on Earth at a scale and level of detail that was not possible before. From genomics and metabolomics to imaging and artificial intelligence – we can generate and integrate big data from the smallest microbes through to animals and plants in different ecosystems on land, in the water, and at their interface.

TREC (Traversing European Coastlines) is an international, highly collaborative scientific expedition led by Europe's life sciences laboratory EMBL that addresses fundamental biological questions at the core of environmental and societal challenges. TREC will explore the interactions within and between the two major ecosystems on our planet: ocean and land. It will bring molecular sciences to environmental research in a Europe-wide project at an unprecedented scale, to better understand how organisms – from viruses to animals – respond to natural and human-made environmental changes.



The TREC expedition will explore the interactions between the two major and highly divergent ecosystems on our planet: land and sea. By bringing molecular and cellular sciences to environmental research in a Europe-wide project, it enables the study of how organisms respond to natural and human-made environmental factors across different scales.

A mission for science and society

TREC brings together researchers across borders and scientific disciplines with a common goal of studying life in our coastal regions at all scales. During the TREC expedition, researchers from the European Molecular Biology Laboratory (EMBL) and the *Tara* OceanS consortium, together with the *Tara* Ocean Foundation, the European Marine Biological Resource Centre (EMBRC-ERIC), and more than 150 research teams from over 70 institutions in 29 European countries, will collect and analyse soil, sediment, aerosol, and water samples, as well as selected model organisms and environmental data along European coastlines. In doing so, they are pursuing three major goals with benefits for science and society.

1. Unveil the invisible biodiversity on land and at sea, and understand the effects of environmental changes on the interactions within and between ecosystems

Through the TREC expedition, we will:

- apply some of the most advanced biotechnologies for a unique, holistic exploration of ecosystems on the molecular and cellular level
- unveil new biodiversity and biological functions on land, at sea, and in the space where the two meet
- study these organisms, which are at the heart of healthy ecosystems
- use the knowledge acquired to drive the development of future technologies to assess ecosystem health and bioremediation

2. Understand the interactions between humans and the planet

The TREC expedition will:

- discover the inextricable and complex connections between planetary and human health (One Health at the interface between land and sea)
- contribute to understanding the impact of pollution and global climate change on biodiversity and coastal ecosystem functions

- help to understand other societal challenges such as antimicrobial resistance by exploring how the genes involved can spread between organisms and across ecosystems

3. Highlight the importance of collaboration, scientific training, and public engagement

The pan-European expedition will:

- create value for society by bringing together experts in different countries and disciplines for a joint initiative that aims to address many of the challenges our planet faces today
- deliver knowledge and advanced technologies for the benefit of the scientific community in Europe and worldwide
- engage the general public in debate and discussion to raise awareness of the role of science in society
- inspire the next generation of scientists by raising awareness of the importance of understanding life on this planet among pupils and teachers



The TREC expedition will begin in Roscoff, France, in spring 2023 and conclude in Malta in mid-2024. During this period, researchers from EMBL, the *Tara* OceanS consortium, together with the *Tara* Ocean Foundation, and numerous European collaborating institutes and organisations will work at 120 sampling sites across 46 regions.

An expedition where land meets sea



"TREC will explore the interactions of the two major ecosystems on our planet. We will bring molecular sciences to environmental research, and connect the European life science community across countries and disciplines, to better understand how these ecosystems interact, and how organisms within them respond to natural and human-made environmental changes."

Professor Peer Bork, Director EMBL Heidelberg and TREC Coordinator

Coastal ecosystems host some of the world's greatest biodiversity and are vital for global ecology and human societies. With TREC, we embark on a journey along European coastlines to explore the biodiversity and molecular adaptability of life and key selected species where land and sea meet.

EMBL and its collaborators will sample soil and shallow waters at 120 sites across 46 regions across Europe. In doing so, EMBL will bring modern technologies, from genomics and cell sorting to imaging and metabolomics, to the field with its new Advanced Mobile Service laboratories.

Throughout the expedition, we will gather information on organismal diversity on land and at sea along the European coastline. TREC covers all taxonomic scales, from viruses and bacteria to protists, algae, plants, and animals, to explore the organisms in communities and at the scale of populations, the molecular basis of their interactions, and their contribution to

shaping their environment. We will also collect data on environmental factors in a systematic and standardised way: researchers will record information on a broad range of anthropogenic and natural factors, such as the presence of pollutants, antibiotics, pesticides, or hormones, but also specific temperature, pH, salinity, oxygen levels, and geophysical parameters.

Researchers will then analyse these data to understand how organisms and ecosystems adapt to environmental changes on the molecular and cellular levels. At the same time, the information collected on this expedition will act as a comprehensive reference data set that can form the basis for studying changes in coastal ecosystems in years to come.

Individual scientific projects range from assessing microbial community interactions between land and sea to understanding how select species adapt to different environmental conditions and changes, and studying diversity and symbiosis in plankton.



An expedition at sea



"During her new Tara EUROPA expedition, which is the sea component of TREC, Tara will measure the invisible living majority in marine coastal ecosystems, which has been so important to shape diversity over the last 3.5 billion years, and is today sustaining human societies and planetary health. Importantly, the sea and land sampling will open new dimensions to explore and question ocean life as a whole, allowing us to image and measure the sub-cellular structures and molecules within the most important cells and holobionts at the core of marine ecosystems."

Dr Colombar de Vargas, Research Director CNRS & Sorbonne Université, Tara EUROPA Science Director

Marine biodiversity and ecosystems are changing at a faster rate than terrestrial ecosystems, arising from the cumulative impacts of human actions, including global ocean warming, deoxygenation, acidification, as well as pollutants and exploitation of natural resources.

Our knowledge of the extraordinary richness and functions of marine life is severely limited by the lack of field methods and biotechnologies to assess it as a whole. However, recent technological developments are changing this outlook. Combining cross-disciplinary tools allows consistent measurement of marine biodiversity from viruses to animals and from molecules to species along with all their interactions, across spatio-temporal scales and environmental gradients.

A core component of TREC is the expedition Tara EUROPA involving the Tara OceanS consortium, the Tara research schooner, and the Tara Ocean Foundation. In addition to TREC sampling of shallow waters at coasts and river estuaries, the schooner will enable sampling of deeper water along coastlines and offshore.

Tara has been travelling the world to discover the mysteries of the ocean since 2003. In 2009, the schooner set out on its major mission to unveil the invisible life that thrives in the sea: the expedition Tara Oceans. Over three years, Tara collected more than 35,000 plankton samples in the open ocean across the planet, revealing an outstanding diversity of genes and species at the core of the functioning of our blue planet. The expedition Mission Microbiome continued this endeavour between 2020 and 2022, sailing across the Pacific

Ocean along the Chilean coast, the Atlantic Ocean, and Antarctica.

Completing this big picture of life in the world ocean, Tara EUROPA will focus on the coastal waters and ecosystems, which are among the richest, most dynamic, and most complex parts of our biosphere. Throughout the TREC expedition, Tara will sample European coastal waters in synchronisation with land-based soil, sediment, and shallow water sampling.

This interconnected approach between land and sea will allow the researchers to build an extremely full picture across sites representing urban developments, agricultural areas, river estuaries, and pristine nature. The schooner will encounter extremely dynamic oceanic conditions with varying tides, depths, and gradients in salinity, temperature, and biodiversity. The sampling locations offer the best 'natural laboratory' to discover marine biodiversity adapted to highly variable and extreme conditions covering the range of predicted global change. In this way, the expedition will help to complete the planetary picture built by Tara over the last 15 years, while assessing the relative impact of local pollution and global change on marine biodiversity.

The Earth's biodiversity – including each of us – is connected with the ocean, whether we live near or far away from it. Overall, TREC and in it, Tara EUROPA, will greatly enhance our understanding of how coastal ocean life and ecosystems will adapt to both pollution and climate change, and thus predict the impact of such upheaval on human and planetary health.

An expedition for and with the European science community

Meeting the challenges of an expedition at land and on sea

An important new aspect of this scientific endeavour is combining land- and sea-based expeditions along the entire European coast. At each point where the EMBL team with the mobile laboratory and collaborators will sample soil, sediments, and shallow water, the schooner *Tara* will sample the associated marine ecosystems – on the same day and in the immediate vicinity.

This provides a logistical challenge for both the floating lab and the lab on wheels. Each will have its own constraints and challenges. While both land- and sea-based teams might need to contend with unpredictable weather, the land-based sampling teams must manage access to a range of different locations and terrains. On the other hand, the schooner will need to adapt to complex coastal navigation conditions due to tides, shallow depths and obstacles, and marine traffic.

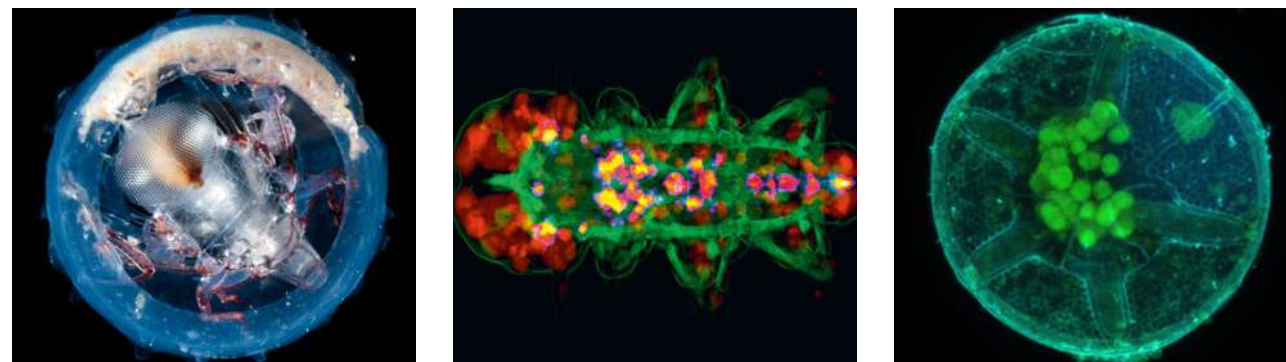
At the heart of TREC is the collaboration with numerous national and international partners, in particular, European marine stations in 46 regions from Portugal to Estonia and Finland to Malta.

Setting up this unique sampling strategy has relied on meticulous planning and communication between different scientific disciplines and institutions. In doing so, the expedition will create not only a uniquely full picture of coastal ecosystems, but also long-term links between researchers, disciplines, and countries across Europe.

Mobile biological services for Europe

Biological samples are fragile: as soon as a drop of water or crumb of soil is removed from its natural environment, the organisms within them begin to change. To maximise the integrity of organisms and to study them in the context of their natural environment, EMBL is bringing the lab to the samples, instead of samples to the lab.

The equipment and technologies which form part of EMBL's Advanced Mobile Services will enable scientists to perform leading subcellular research in direct proximity to the field. For decades, EMBL has used, developed, and made available for the scientific community cutting-edge tools and technologies in the molecular life



sciences. With the EMBL Mobile Service, we are bringing some of the most advanced technologies to laboratories across Europe. Working together with ecology and marine biology laboratories, we are able to provide services and training to an even wider scientific community, while also understanding how to continue to push the boundaries of such technologies to answer ever more complex questions.

The Mobile Service laboratories will include cutting-edge light microscopy, sample preparation for (cryo)-electron microscopy, and single-cell pheno-genomics. Additionally, advanced tools for environmental measurements from soil, air, sediment, and water samples will be part of the standard equipment.

By providing these technologies across Europe throughout the expedition, the EMBL Mobile Service will support the interdisciplinary approaches that underpin TREC. It will allow exceptional exploration of the molecular and sub-cellular processes underlying ecosystem functioning, while also enabling standardisation of experimental protocols on an unprecedented pan-European scale.

Underpinning research and knowledge sharing across Europe

TREC will bring some of the most advanced technologies available to life scientists to the field. In doing so, it will allow researchers to address entirely new questions about fundamental biological processes in ways that have never been done before.

Together with partner organisations and institutions, our scientists will offer scientific workshops on different topics and techniques, including hands-on training on the mobile laboratory equipment. This way, the technologies and approaches will be made available to a wider scientific community.

TREC's scientific efforts and data collection and analysis will also underpin other important European projects, and contribute to improved scientific, societal, and political understanding of the importance of maintaining the biological health of our seas and coastlines. Examples include the interdisciplinary European Commission-funded project BIOcean5D (www.biocean5D.org).

Supporting wider societal efforts

Science for the European public

Societal change needs society to act. This is why we will offer different public engagement and school education activities along the TREC route and beyond. Citizens will be able to experience first-hand the power of molecular and cell biology in tackling human and planetary health challenges. They can hear from researchers, or explore science themselves, to understand the connections between land and sea, humans, and the planet. Teachers and educators will be able to access training and resources to engage and inspire the next generation of scientists. In this way, we will stimulate public debate about the role that science plays in society and inspire the next generation. At the same time, we will raise awareness of the important role that each and every one of us plays in helping to secure the health of our planet, our ocean, and ourselves.

From science to policy

Our coasts are under high pressure: they are the most inhabited place on Earth and receive waters drained from our land, containing human-induced pollutants such as chemicals from drugs or pesticides. Functional coastal ecosystems are critical for human health and their destruction can

have diverse consequences on both agriculture and marine-dependent livelihoods.

Beyond plastic pollution, which has been at the centre of attention for over a decade, the human-induced chemical pollution of rivers and coasts must be at the core of our attention, because it has the potential to affect planetary and human health at a greater rate than climate change. For example, the increased rate of chemical pollutants flowing through water treatment plants is enabling the development of antibiotic resistance at an alarming pace. Another example of human impact is the effect of excess nitrogen on terrestrial ecosystems, and of nitrogen and phosphorus on rivers and the ocean, where this leads to algal blooms and eutrophication.

This collaborative scientific effort at the European scale aims to emphasise the vital importance of present and future European legislation on water and coastal ecological states. Through this international and multidisciplinary scientific approach, the expedition aims to provide knowledge and information that will help to clarify the priorities of the EU Green deal future investments to ensure healthy and functional ecosystems, and to work towards the urgent goal of improved European global health.

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TREC expedition stops 2023

Roscoff, France	Early April	Kristineberg Center, Sweden	End July
Baie de Vays, France	Mid-April	Bergen, Norway	Early August
Oostende, Belgium	Late April	Southampton, England	Mid-August
Texel, The Netherlands	End April	St Abbs, Scotland	Late August
Sylt, Germany	Early May	St Andrews, Scotland	Late August
Aarhus, Denmark	Mid-May	Galway, Ireland	Early September
Helsingør, Denmark	Late May	Lorient, France	Late September
Rostock, Germany	Early June	La Tremblade, France	Early October
Sopot, Poland	Mid-June	Bilbao, Spain	Early October
Klaipeda, Lithuania	Mid-June	Ferrol, Spain	Mid-October
Riga, Latvia	Late June	Porto, Portugal	Late October
Tallinn, Estonia	Early July	Cadiz, Spain	Early November
Turku, Finland	Mid-July		
Asko, Sweden	Mid-July		

For more information, please visit: embl.org/TREC



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For more information



About EMBL

The European Molecular Biology Laboratory (EMBL) is Europe's life sciences laboratory. We provide leadership and coordination for the life sciences across Europe, and our world-class fundamental research seeks collaborative and interdisciplinary solutions for some of society's biggest challenges. We provide training for students and scientists, drive the development of new technology and methods in the life sciences, and offer state-of-the-art research infrastructure for a wide range of experimental and data services.

EMBL is an intergovernmental organisation with 28 member states, one associate member, and one prospective member. At our six sites in Barcelona, Grenoble, Hamburg, Heidelberg, Hinxton near Cambridge, and Rome, we seek to better understand life in its natural context, from molecules to ecosystems.

About Tara Ocean Foundation

The Tara Ocean Foundation is the first public interest foundation in France dedicated to the Ocean. It's 2 main missions are to explore the Ocean to better understand it and share the relating scientific knowledge to raise citizen and collective awareness. For 19 years, the Foundation has developed a high-level Ocean science in collaboration with international research laboratories of excellence, to explore, understand and anticipate the upheavals related to climate and environmental risks, as well as the impacts of pollution. In order to make the Ocean a common responsibility and to preserve it, the Tara Ocean Foundation also works towards raising public awareness about ocean science and educating the younger generations. By studying and protecting the Ocean, we take care of our planet's global system.