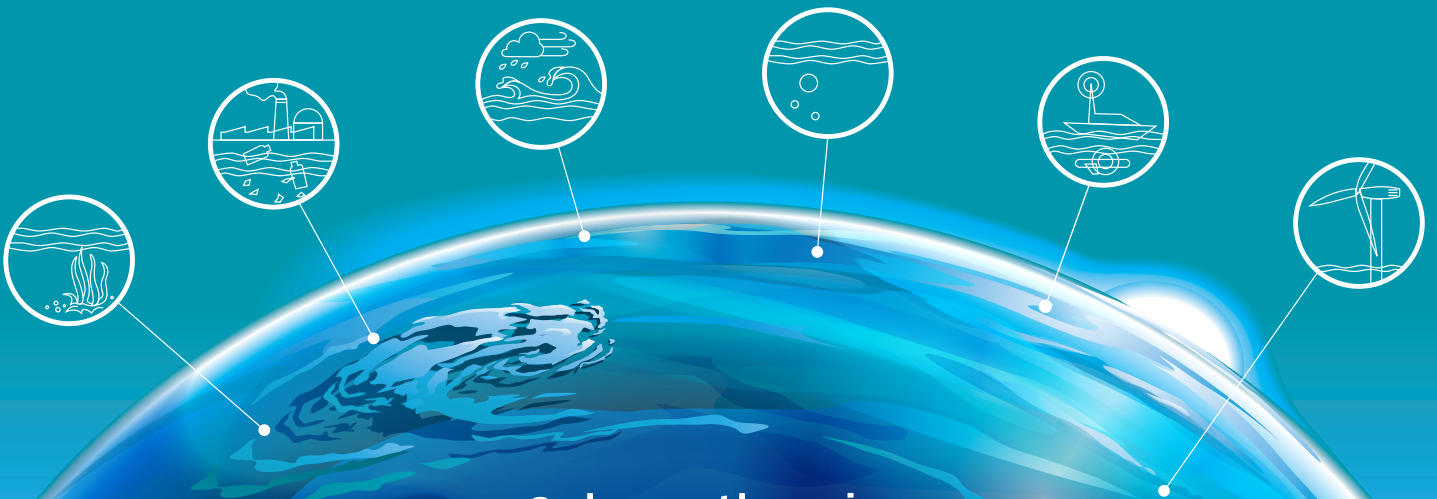


PML

Plymouth Marine
Laboratory

Pioneering science

to address critical ocean issues



@plymouthmarine
pml.ac.uk

INTRODUCING

Plymouth Marine Laboratory (PML) is a charity, undertaking innovative and impartial marine science in support of clean, productive, biologically-diverse seas, and a stable climate, now and for future generations.

Our research is consistently listed amongst the top 1% of the most cited environmental science papers in the world.

Thanks to our funders, we are advancing the frontiers of knowledge in marine science, training the next generation of marine scientists around the world, and using our expertise to help address global challenges such as climate change, biodiversity loss, pollution, public health and food security.

Through interdisciplinary science we aim to:

1. UNDERSTAND THE MARINE ENVIRONMENT

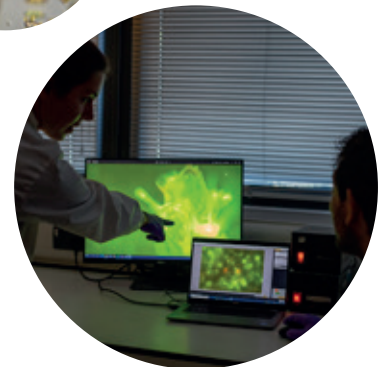
Increasing the understanding of how complex marine systems are fundamentally structured and how they function, including their interactions with terrestrial, atmospheric and freshwater systems.

2. UNDERSTAND THE STRESSORS

Identifying and quantifying how human activities impact upon the natural functioning of marine systems, biodiversity and the provision of ecosystem services.

3. IDENTIFY SOLUTIONS AND IMPROVEMENTS

Supporting the development of effective, evidence-based tools, strategies and policies for sustainably managing human activities in the ocean.



PML Applications

Through PML's trading subsidiary - PML Applications - we provide applied science for the blue economy. Experts in the fields of marine biology, biofouling, corrosion, coastal technologies, and remote sensing, PML Applications works with some of the world's biggest names in shipping, offshore energy, aquaculture, and environmental services, with all profits invested back into PML's research.



Climate Change, Ocean Acidification & Smart Planning

The ocean plays a critical role in regulating Earth's climate and has acted as a buffer for global warming caused by human activity.

But this has come at a cost - the ocean has warmed, become more acidic, and lost oxygen. Its circulation patterns are shifting, sea levels are on the rise, and ecosystems are changing.

PML has been studying climate change, its impacts on marine ecosystems and society for decades. We were among the first to discover ocean acidification and bring it to the world's attention. Our research informs decision-making at international and national levels and we are developing novel technologies and applications for climate change mitigation and adaptation.

Our areas of focus include:

- **Pioneering research into ocean acidification**, including as Co-Chair of the Global Ocean Acidification Observing Network (GOA-ON), Co-lead of the UN Ocean Decade program Ocean Acidification Research for Sustainability (OARS).
- **Using advanced Earth System Models** to provide crucial knowledge in support of UK and international efforts to combat climate change and ocean acidification.
- **Providing policymakers with the best available evidence and predictions** on which to base climate policy, including as Lead Authors of IPCC Assessment Reports and through participation in each UNFCCC COP since 2009.
- **Applying projections of how marine ecosystems will respond to climate change** to support adaptation planning (e.g. climate-smart marine spatial planning, marine protected area networks, and climate-smart fisheries).

- **Quantifying the fluxes of greenhouse gases** and other climatically important gases between the ocean and atmosphere, providing key data to improve climate change predictions.
- **Generating long-term datasets vital for understanding climate change, ocean acidification and their impacts.** Our Western Channel Observatory provides integrated long-term monitoring of the pelagic, benthic and atmospheric environments. We also lead the European Space Agency's Ocean Colour Climate Change Initiative providing unique insights into climate feedbacks and impacts.
- **Developing innovative digital tools to improve early-warning systems for climate-sensitive, water-associated infectious diseases** such as cholera.
- **Working towards a net zero ocean observing system** using an advanced fleet of autonomous platforms and vessels.



Ocean-Based Carbon Dioxide Removal (oCDR)

The ocean is the largest carbon store on Earth estimated to absorb over a quarter of the carbon dioxide (CO₂) emissions created by human activities each year.

While carbon emissions reduction remains paramount, ocean-based Carbon Dioxide Removal (oCDR) - which involves using the marine environment and its chemical and biological processes to remove CO₂ - is recognised as having a pivotal role to play in addressing climate change.

It is vital that the efficacy and wider environmental and social impacts of different approaches is robustly assessed in order realise the full potential of oCDR and prevent unintended negative consequences.

Examples of our work in this area include:

- **Rigorously evaluating and validating cutting-edge carbon removal technologies** including electro-dialytic removal of CO₂ from seawater and alkalinity enhancement of wastewater.
- **Conducting precise carbonate chemistry analysis and modelling.**
- **Developing robust monitoring, reporting and verification (MRV) protocols** for oCDR.
- **Carrying out thorough assessments of the environmental impacts** associated with carbon removal technologies.
- **Applying biogeochemical models** to offer valuable insights into carbon cycling and removal.
- **Analysing the potential consequences of carbon loss** from Carbon Capture and Storage (CCS) facilities.
- **Developing monitoring protocols** to assure the safety of CCS.
- **Carbon store assessments** covering the comprehensive evaluation of carbon storage potential.





Pollution & Plastics

Ocean health is threatened by a multitude of pollutants, including plastics and microplastics. Oil spills, chemicals and sewage can poison marine organisms and introduce harmful pathogens, while light pollution disrupts marine ecosystems in ways we are just beginning to fully understand.

These diverse pollutants collectively degrade water quality, threaten biodiversity, and disrupt ecological balance.

Examples of our work in this area include:

- **Investigating the key drivers of marine plastic risk and assessing its impact on marine ecosystems and organisms.** Our research has led to multiple government bans on the manufacture of microplastic beads and is now informing the Global Plastics Treaty.
- **Leading the development of tools that use satellite imagery to detect oil spills and plastic pollution.** The Malaysian Government successfully used our oil spill detection tool to contain an oil spill, preventing major impacts on fragile coastal ecosystems.
- **Assessing the environmental impacts of supposedly more sustainable plastic alternatives.**
- **Pioneering research into the impact of Artificial Light at Night (ALAN)** on marine organisms and ecosystems, including a global atlas development quantifying the extent of ALAN in the ocean.
- **Investigating the environmental transmission of the bacterium that causes cholera** to improve disease forecasting models and help prevent cholera outbreaks.

- **Addressing nutrient pollution in coastal waters** by researching the efficacy of land and ocean-based interventions (e.g. improved farming techniques, watershed management methods, seaweed farming).
- **Advancing environmental economics methods** for valuing nutrient sequestration by ecosystems and developing sustainable finance approaches.
- **Developing a low-cost system for monitoring ship emissions** of sulphur dioxide and nitrogen oxides to aid compliance with air quality regulations.



Blue Carbon, Policy & Finance

There is a huge demand for reliable blue carbon programs but uncertainty remains around the carbon sequestration and other benefits. This is one of the main barriers to blue carbon investment.

PML is conducting the natural science to understand and quantify the fluxes of greenhouse gases in a range of habitats from mangroves and saltmarshes to seagrass beds and kelp forests. We are a world leader in seaweed blue carbon. We are also conducting environmental economics research to generate more accurate values for blue carbon and its associated benefits, and to develop sustainable finance mechanisms.

Our findings will help guide investment companies, governments and NGOs on how best to finance and implement effective, equitable, and verifiable blue carbon programmes.



Examples of our work in this area include:

- **Uncovering the role of macroalgae (seaweeds) in global blue carbon.** We were the first to demonstrate that macroalgal ecosystems export large amounts of organic material to offshore sediments where the carbon is stored. We are conducting research to quantify carbon sequestration by macroalgae in natural ecosystems (e.g. in kelp forests in Orkney, Scotland) and in aquaculture systems.
- **Informing conservation and restoration plans for macroalgal habitats,** as well as the growing seaweed farming industry.
- **Providing the evidence base necessary for a more inclusive definition of blue carbon ecosystems,** including macroalgae and other habitats.
- **Investigating how human activities affect carbon storage** in marine sediments.
- **Quantifying fluxes of other greenhouse gases besides carbon dioxide** during saltmarsh regeneration to improve understanding of its global warming mitigation potential.
- **Quantifying the socio-economic values of carbon sequestration and co-benefits** stemming from blue carbon projects.
- **Assessing the value and feasibility of blue carbon initiatives** and their financial and societal implications.
- **Novel research into the demand and supply, and societal acceptability of different blue carbon finance mechanisms.**

PIONEERING SCIENCE



Autonomy, AI & Innovation

Critical to the ocean economy is the sustainability and productivity of the oceans which requires smarter monitoring, modelling and data-driven management.

PML scientists, modellers and technologists operate at the forefront of marine technology development, utilising our expertise in autonomy, AI and digital science to improve the management, sustainability and governance of marine and coastal environments.

We are advancing the capability of marine observing systems to provide radically improved measurements of the key environmental variables that are crucial for understanding and responding to our changing climate.

Through the development and adoption of new technologies, automation and citizen science we are also lowering the cost of environmental observation.

Our activities include:

- **Leading the UK National Centre for Coastal Autonomy (NCCA)** - the UK's first autonomous coastal observing system, operating a state-of-the-art fleet with surface autonomous vessels, sub-surface coastal platforms, and advanced scientific buoys.
- **Leading 'Smart Sound Plymouth'** - the UK's premier proving area for designing, testing and developing cutting edge products and services for the marine sector.

- **Chairing the Future Autonomous at Sea Technologies (FAST) cluster** - the largest marine autonomy cluster in the UK.
- **Radically improving the monitoring and analysis of plankton** through the development and application of state-of-the-art equipment and processes using AI capabilities.
- **Developing environmental 'digital twins'**, making ecosystem modelling capabilities more accessible for specific purposes such as within aquaculture, blue carbon initiatives and coastal development.
- **Training machine learning models to automatically detect invasive species**, such as Pacific oysters in UK waters.
- **Developing low-cost citizen science sensors for water quality monitoring.**

PML is home to the UK NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS) and the MAGEO supercomputer (MAssive GPU cluster for Earth Observation), applying AI and data science to Earth observation data.



Renewable Energy & Offshore Structures

The provision of clean energy is vital for sustaining prosperity whilst achieving net zero carbon emissions and avoiding catastrophic climate change. Globally, there is a huge development of renewable energy infrastructure, however this is leading to concerns about its cumulative impact on the ocean.

PML is investigating new approaches to monitor marine life and assess the socio-economic impacts of renewable

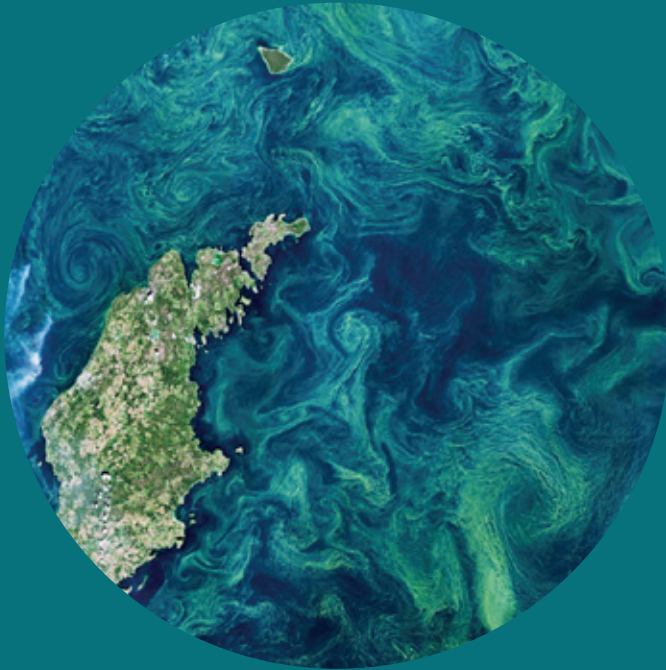
energy schemes and other offshore structures. We are applying our scientific expertise to understand the impacts of offshore energy production, maximise the sustainability of operations, and develop appropriate monitoring strategies.

Our work includes:

- **Creating a better understanding of the individual and cumulative effects of installations** using advanced monitoring and modelling systems.
- **Supporting evidence-based policy and marine management** through interdisciplinary research exploring the consequences of offshore wind development on marine environments, marine wildlife, and wider ecosystems, and by creating decision-support tools.
- **Quantifying the benefits and trade-offs of infrastructure projects**, including with regards to biodiversity and ecosystem services.
- **Examining how the benefits of offshore wind farms could be maximised** through co-location with commercial and recreational fishing activities.
- **Determining monetary values for the effects of these technologies** on habitats, species and the seascape.
- **Improving strategies for decommissioning structures**, informing decision-makers and stakeholders.
- **Examining public and industry perceptions**, the role of small-scale and community-led initiatives, and the implications of offshore development for regional economies.

FIND OUT MORE

“Understanding the ocean,
the stressors it faces, and
working towards solutions”



Registered charity number 1091222.
Plymouth Marine Laboratory (PML) is a
company limited by guarantee, registered in
England & Wales, company number 4178503.

Patron: James Cameron
(Explorer, environmentalist and filmmaker)

Plymouth Marine Laboratory

Prospect Place
Plymouth
PL1 3DH
United Kingdom

+44 (0)1752 633 100

forinfo@pml.ac.uk

www.pml.ac.uk

www.pml-applications.co.uk

@plymouthmarine

Or find us on:
Facebook // LinkedIn // Instagram

PRINTED ON 100% RECYCLED PAPER