Blue economy

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Turning the Tide: Systems thinking for a sustainable ocean

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About the Institution of Environmental Sciences

The Institution of Environmental Sciences (the IES) is at the forefront of uniting the environmental sciences around a shared goal: to work with speed, vision and expertise to solve the world's most pressing environmental challenges, together. As the global professional membership body for environmental scientists, we support a diverse network of professionals all over the world – and at every stage of their education and careers – to connect, develop, progress and inspire.

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Defining the blue economy

The concept of the blue economy is generally taken to cover all resource-focused activity taking place in the coastal and marine environment, including fisheries and aquaculture, maritime transport, renewable energy (such as offshore wind and tidal), tourism, seabed mining, marine biotechnology, and oil and gas. Given the range of activities, the term takes many forms and can describe resources that hold value outside of a financial perspective.

Ideally, there needs to be consensus on what constitutes the blue economy – and this needs to be sustainable. The UN Environment Programme[1] defines a sustainable blue economy as "the sustainable use of the ocean and coastal resources which generates equitable and inclusively distributed benefits for people, protects and restores healthy ocean ecosystems, and contributes to the delivery of global ambitions for a sustainable future". A sustainable blue economy would inherently recognise the ocean as a complex system, meaning any activities taking place would have to be considered in terms of the effects they produce across the system rather than just in their locale. This would favour regenerative practices over extractive or polluting ones. As such, a sustainable blue economy would rely on balance and follow a circular model.

Challenges facing the blue economy

Extractive activities taking place in the marine environment are often not conducive to a sustainable blue economy. However, not all definitions of the blue economy take into consideration the long-term effects on ecosystems, and instead include any activities that align with traditional economic principles of profit and loss. A key criticism of this outlook is that extractive activities cannot take place indefinitely, as resources will either be used up or degraded, often leaving irreparable damage to the areas they have taken place in.

Oil and gas extraction is a clear example of this. Not only does the use of these finite resources directly contribute to anthropogenic climate change, which has myriad impacts on the marine and coastal environment, there are also direct impacts on the marine environment during the scoping and extraction process. The construction, drilling and extraction process causes significant noise and light pollution, disrupting entire ecosystems. This can lead to direct habitat damage as well as changes to animal behaviour, for example the hunting and breeding patterns of marine species can be affected. Once a rig is constructed and extraction is in process, they emit volatile organic compounds (VOCs), which can have a range of negative impacts on marine life and human health.[2] In addition, there is a risk of oil spills, which can cause untold damage to life in the vicinity of the extraction site but also much further afield.

Deep-sea mining is an extractive activity used to obtain minerals like nickel, cobalt and manganese, and is generally employed because of declining levels of these minerals in terrestrial mines. As on land, mining at sea has many negative impacts on the ecosystems situated near drilling and blast zones, through noise, chemical and particulate pollution. Organisations such as WWF have called for a global moratorium on any deep-sea mining until the associated risks are fully understood and all alternatives have been considered, stating that “Without this knowledge base, we cannot possibly design adequate safeguards to protect the marine environment and human well-being”.[3]

However, there is tension between the damage caused and the need to procure these materials for use in transitioning to renewable energy. Electric cars, for example, require these minerals for use in

lithium-ion batteries, which are currently relied upon as the most viable alternative to internal combustion engines and the greenhouse gases they produce.

After controversially deciding in January 2024 to begin issuing permits for exploration of its seabed, with the view of permitting deep-sea mining, the Norwegian government paused the project in December 2024 without issuing a single permit. It would have been the first country in the world to embark on such a scheme, with many others imposing bans on similar projects in their own waters.

There are non-extractive options to source these minerals: in 2024 Mercedes-Benz opened the first battery recycling plant in Europe to enable it to extract and reuse them for its own electric vehicles. Part-funded by the German Federal Ministry for Economic Affairs and Climate Action, the plant will also host researchers from three German universities, who will aim to analyse the entire process and its potential for scaling.[4] This could represent a circular alternative to extractive practices, on land or at sea, currently used to source vital minerals.

To explore the topic of deep-sea mining in more detail, you can read our article 'Examining the impact of deep-sea mining',[5] published as part of Turning the Tide and based on research by the iAtlantic programme.

Developing a supportive regulatory environment

There are changes needed – starting with governance – to move from business-as-usual to a system aligned with the UN's definition of a sustainable blue economy. Central to this shift will be the adoption of specific plans for the marine and coastal environment at a national level: Scotland and Portugal have done this but many other countries, including the UK as a whole, are lagging behind.

This is especially pertinent to the UK given that it is an island with multiple devolved administrations who all interact with the ocean independently and together. The adoption of the principles in Scotland's Marine Plan by central Government would be a useful first step. The Plan explicitly "promotes an ecosystem approach, putting the marine environment at the heart of the planning process to promote ecosystem health, resilience to human induced change and the ability to support sustainable development and use" and "adopts the guiding principles of sustainable development, which also ensures that any individual policy, plan or activity is carried out within environmental limits".[6]

Centring an ecosystem approach and addressing the fact that the ocean's resources are finite sets a strong precedent for governance of Scottish waters and could be replicated more broadly across the UK.

Investing in the blue economy

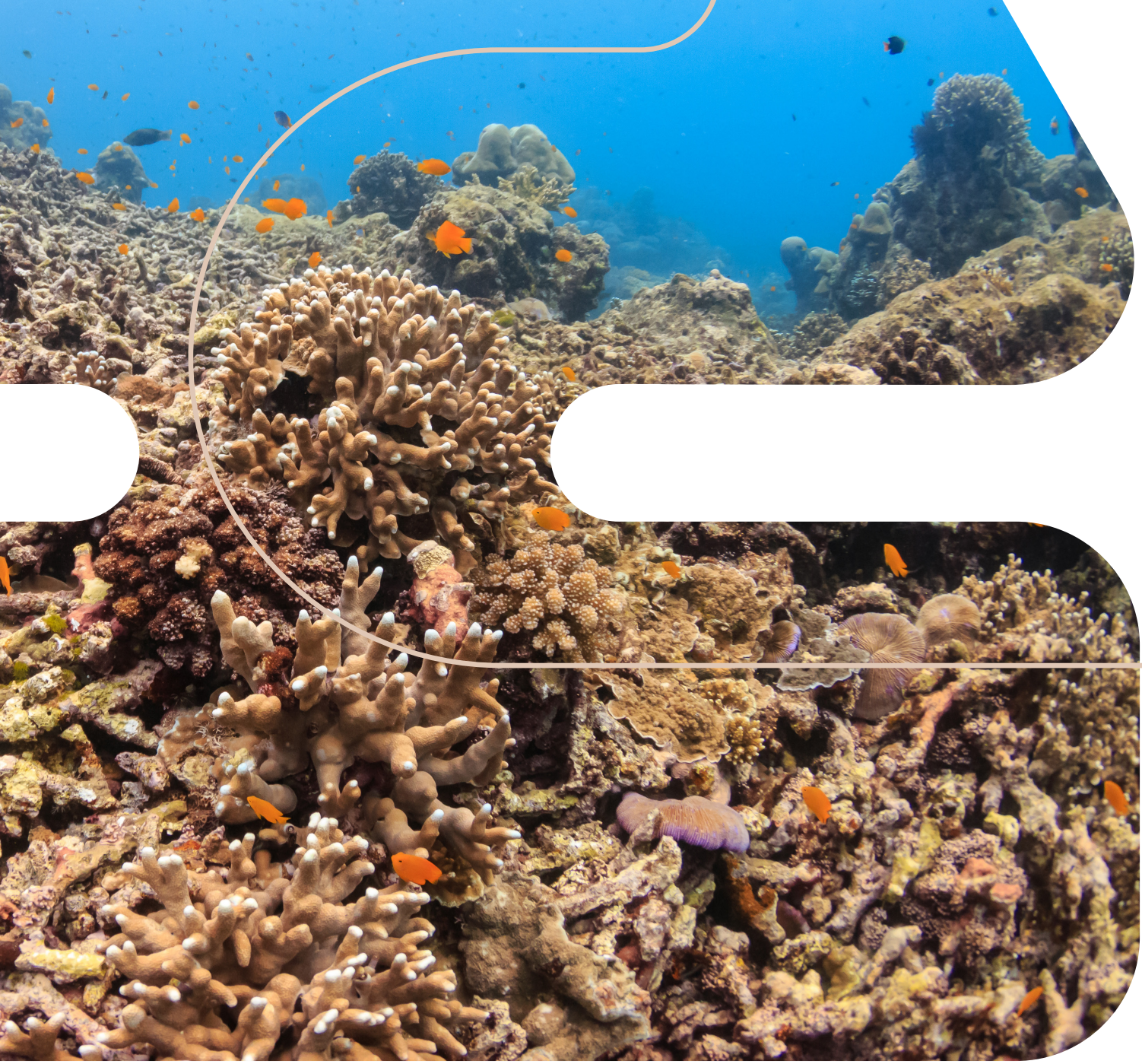
To drive the concept of a blue economy towards a sustainable definition, it is important to consider those who have so far profited from extractive practices, and how the activities causing damage can be transitioned to sustainable alternatives.

A sustainable and healthy marine environment is beneficial to a range of economic activities: for example, more people are likely to visit coastlines for tourism and leisure in areas with good water quality which are safe to swim in, and water free from pollutants benefits the species living in it supporting sustainable fish stocks. Reframing resources such as unpolluted seawater as valuable natural capital assets is key to driving an understanding of their value to those more familiar with financial sustainability than environmental. Considering how we value marine ecoysystems is important, and we should seek to identify the wider value that healthy marine ecosystems can provide beyond financial value.

Other types of theoretically infinite capital can be exchanged in and around the marine environment; knowledge is an example of this. Valuing these resources more holistically would support more regenerative and sustainable practices in marine and coastal environments. Emphasising that investment into the sustainability of the marine and coastal environment is an opportunity is crucial and can also support organisations to demonstrate progress towards both ESG goals and financial goals.

As well as presenting the opportunity associated with investment, it is essential to ensure that financiers understand the long-term risks associated with business-as-usual. Various coastal activities may become untenable in the future due to changes in legislation, rising sea levels and a changing landscape, or biodiversity loss resulting in fewer visitors for example. This is already becoming clear in some parts of the financial sector such as insurance, as companies are unable to cover the costs caused by the impacts of climate change such as extreme flooding. Other extreme events like Marine Heatwaves (MHW) are projected to increase, The incidence and severity of other extreme events, like Marine Heatwaves (MHW), are projected to increase. Globally these have already had negative consequences on marine ecosystems and associated economic activities.[7]

Should these happen more frequently in the UK as projected, we would stand to lose income from industries like fishing and incur longer-term costs associated with erosion and flooding should the protection afforded to our coastlines by blue carbon



ecosystems like saltmarshes and seagrass be diminished. The fact that much marine degradation cannot be easily observed from land is a barrier, as the risk is not currently as palpable as it might be in a terrestrial setting – so putting numbers to the costs potentially incurred by inaction will be useful. The scientific community can help through improved communication of challenges and solutions in the public domain.

If investment is made in a sustainable blue economy alongside climate mitigation measures, there will be far less risk to coastal and marine capital in the future. Supporting resilience of marine and coastal ecosystems will need to be a key part of the sustainable blue economy in the face of the interlinked crises of climate change, biodiversity loss and pollution.

Ultimately, it is important that financiers start to redirect mainstream finance towards more sustainable blue economy pathways and recognise the value of investing in the environment, which will not come at the expense of other socioeconomic goals, and instead will be beneficial to securing a sustainable blue economy that works for people and nature. Significant progress could be made simply by shifting investment away from destructive and extractive activities.

Innovation and technology

Innovation and technology are needed to support the transition to a sustainable blue economy in a number of key areas. Advancements in data collection and monitoring are needed to provide increased understanding of marine and coastal ecosystems as well as the impact of pressures on their functioning. Solutions are also needed to support practices that not only limit damage but actually support regeneration of marine and coastal environments. Innovate approaches that integrate technology and nature-based solutions are needed to build resilience and deliver multiple benefits. Given the breadth and depth of challenges facing these environments, it is essential that innovation and technology is scalable and that research is translated to practice rapidly and iteratively to support change at the timescales needed.

There are many ways in which innovation and technology can support more sustainable practice. For example, artificial Intelligence (AI) can help fishing trawlers to target species, reduce bycatch and minimise environmental impact. 'Smartrawl' is a robotic device that uses cameras to identify the size and species of anything caught in trawling nets, releasing anything it deems unintended.[8] Technology can also support a reduction in 'ghost fishing': researchers at the Scottish Association for Marine Science have demonstrated the efficacy of using a sonar scanning system to locate lost creels, a type of baited fishing pot, off the coast of Argyll.[9] This equipment can pose risks to marine species, who become trapped as nets and other items continue 'ghost fishing' unsupervised. Being able to locate lost creels means researchers can begin to work on techniques to remove them from the sea but also develop a greater understanding of currents and other factors that may influence where the equipment is deposited. This will allow for the identification of areas which are most highly impacted, and their subsequent monitoring. Once the long-term effects of lost creels are better understood, researchers may be able to develop techniques to remove them with minimal disruption to ecosystems.

It is likely that this research will be replicable in other locations, and similar initiatives are being trialled around the world, with organisations like the WWF encouraging the use of the 'GhostDiver' app to track sonar-identified ghost nets. Once located and logged in the app, WWF urge governments to embark on removal projects to protect marine life.[10] Though the exact amount of ghost fishing gear present

in marine environments globally is unknown, a 2020 report suggested that between 500,000 and 1,000,000 tonnes of fishing gear are lost in the ocean every year – meaning it makes up at least 10% of all marine litter.[11]

Case study: Sustainable shipping

Innovation and technology will also be key to supporting a sustainable blue economy in the shipping industry, which is currently estimated to be responsible for between 2-3% of all anthropogenic greenhouse gas emissions globally,[12] and is undoubtedly a lynchpin of the blue economy. In the EU, voyages are subject to an Emissions Trading System, meaning that carbon dioxide, methane and nitrous oxide emissions must be paid for by shipping companies operating within the EU – even if only for part of a journey.

Initially, the system will only apply to carbon dioxide, and only to a percentage of total emissions, but will be scaled up to include the full scope of carbon emissions, plus methane and nitrous oxide, by 2027. It is hoped that this will act as an incentive for shipping companies to invest in more sustainable fleets and thus reduce their emissions and responsibility to pay tariffs.

One approach recommended by the European Maritime Safety Agency (EMSA) is the use of Exhaust Gas Cleaning Systems (EGCSs) – often referred to as 'scrubbers'.[13] These systems remove sulphur dioxide from the exhaust gases emitted by ships along with some particulate matter. However, this strategy is more of a sticking plaster than a solution, as it simply filters out a known pollutant as fuel is burned rather than creating a less-polluting alternative. If it fails or operates inefficiently, sulphur dioxide will still end up in the ocean and atmosphere.

'Slow steaming', or a reduction in a ship's speed, is a straightforward way to reduce greenhouse gas emissions across a voyage by simply reducing fuel consumption – it has been reported that a 20% reduction in speed can reduce a ship's emissions by 24-34%.[14] Using traditional maritime knowledge to optimise routes based on ocean currents, weather conditions and wind speeds can support this approach. The required innovation associated with slow steaming is not the method itself but how it could be applied in a modern world reliant on fast, predictable shipping.

Innovation would need to focus on engineering a shift in expectations on how long shipping should reasonably take, challenging cognitive dissonance regarding the journey goods have to take to arrive from overseas. Investment would be necessary in this scenario to mitigate losses incurred by slower, reduced trade.

Wind-powered shipping has already seen an increase in investment, with the International Windship Association (IWSA)

designating 2020-30 the ‘Decade to Deliver’ on wind propulsion in shipping, with 48 large ocean-going vessels already sporting modern wind-assist systems to reduce their fuel reliance.[15] The UK Clean Maritime Plan forecasts that, by 2050, wind propulsion technologies will be worth over £2 billion annually – more than either hydrogen or battery power.[16] Such growth presents an enticing investment opportunity, as well as an opportunity to reduce the emissions associated with shipping.

Interdisciplinarity and stakeholder engagement

Interdisciplinary collaboration across environments scientists, social scientists, industry and policymakers will be key to unlocking a sustainable blue economy. Innovative approaches to marine and coastal management and restoration which embed interdisciplinarity must happen alongside technological innovation. Interdisciplinarity can lead to benefits for multiple stakeholders, therefore the potential of innovation should not be looked at solely from the perspective of marine industries.

Interdisciplinary collaboration in the marine and coastal sector has already yielded groundbreaking results in other fields. Medical researchers have been able to isolate the chemical trabectedin from *Ecteinascidia turibnata* (more commonly known as the mangrove turbinate). Since 2010, trabectedin has been approved in the EU for use in the treatment of soft tissue sarcoma and some ovarian cancers.[17] This innovation could not have happened without collaboration between the marine and medical sector, and along with the benefits of interdisciplinarity it highlights the importance of conserving marine ecosystems like mangroves to safeguard future researchers' abilities to make similar discoveries. Using interdisciplinary examples like this to emphasise the fact that the ocean provides essential ecosystem services, some of which may not yet be fully understood or even discovered – and that we are all consequently stakeholders in its wellbeing – is a useful tool to advocate for a sustainable blue economy.

Stakeholder engagement must reach outside of scientific disciplines, outside of industry and finance, and into communities. Those who live in coastal regions often have rich knowledge about their local area. When making plans for coastal areas, their views must be taken into account and solutions co-designed. In addition to their knowledge, coastal communities are also poised to suffer most from the effects of climate change with sea level rise, high incidence of extreme weather events and pollution among the risks they may be exposed to. Many communities self-organise to tackle problems they have not caused, cleaning beaches and lobbying against pollutants being pumped into the ocean. They are currently being made disproportionately responsible for a resource that impacts the whole planet without enough support, due only to their proximity – and connection – to the coast.

This is particularly true when it comes to Small Island Developing States (SIDS), who often have ways of life entirely reliant on the ocean and are significantly impacted by climate change and associated severe weather events. Protecting their continued

ability to access ocean ecosystem services, like seafood, is integral to SIDS local blue economies. Countries in the global north could learn from approaches used in SIDS where they have developed more sustainable approaches to blue economy activities

However, SIDS may not be well-equipped to deal with the effects of climate change. It is important to recognise that in many cases, the UK and other global powers have historically perpetuated this imbalance through colonialism. Much of the UK's power on the global stage has stemmed from its relationship with the ocean. Our blue economy has historically been extractive, and this is a model that has spread globally at the expense of many SIDS who now struggle to implement sustainable practices due to the declining health of the ocean.

In the context of the Commonwealth, a collection of countries formed through colonialism enacted over the ocean, the UK is uniquely placed to act as advocate, learning from and platforming sustainable practices, and taking the wellbeing of SIDS into account in its own interactions with the ocean system.

Additionally, research expertise based in the UK can – and should – be utilised to work urgently towards innovative solutions to the most pressing challenges facing the ocean, and investment must keep pace with the need for new technologies in the face of a changing climate. Collaboration and stakeholder engagement are therefore needed on a number of levels, spanning collaboration between disciplines, between coastal and marine stakeholders, and across regions.

Lessons can be learned from indigenous ocean stewardship that focuses on maintaining a balance of resources and treating humanity as part of the complex land-sea system rather than separate from it. Efforts have been made to recentre indigenous communities in planning for the marine environment, with the launch of Ocean Panel's 2024 Blue Paper, Co-producing Sustainable Ocean Plans with Indigenous and traditional knowledge holders, just one example. Launched at COP16, it provides insight into the ways in which policymakers can and should engage with indigenous communities to ensure their lived experiences and generations of knowledge are captured in marine management plans.

Systems thinking

Extractive industries and unsustainable practices in the marine and coastal environments have led to the widespread degradation of ecosystems, on both local and global scales. Viewing finite resources and delicately balanced ecosystems as individual entities which can be drawn from with no consequences outside of their own depletion is a dangerous practice. Degrading one component of the wider marine and coastal environment will have far-reaching impacts, whether in the short- or long-term.

Systems thinking approaches that recognise the interconnected nature of marine and coastal environments and their interaction with socioeconomic systems are needed to support a move towards practices that are aligned with a sustainable blue economy. Understanding the connections and dependencies across environmental, social and economic systems will support us in better understanding and quantifying the value that healthy marine and coastal ecosystems provide beyond traditional economic approaches and will support development of approaches that have multiple benefits across the systems involved.

What next?

The work done by the Marine and Coastal Community to develop and deliver Turning the Tide is reflected in the IES' updated Message to Government.[19] This document puts forward the key priorities identified by our Communities to ensure that the climate crisis is addressed with clear direction and urgency.

We will be releasing a summary publication for the final of the four themes covered in Turning the Tide, Marine conservation and restoration, which will cover the challenges and opportunities for conservation and restoration efforts in the context of the triple crisis of pollution, climate change and biodiversity loss. This will wrap up the project and explore what must be done to protect the marine and coastal environment for generations to come.

If you haven't already joined, why not become part of the IES' Marine and Coastal Sciences Community? You can also request to join our Marine and Coastal Science LinkedIn group to connect with likeminded peers working, or interested in, the sector.

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