THE VALUE OF RESTORED UK SEAS

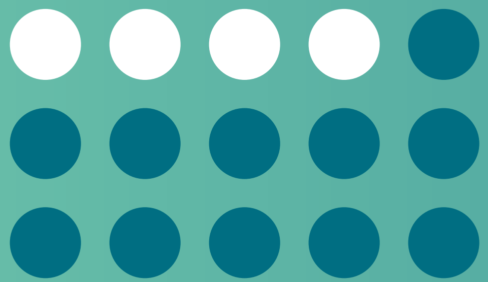
sky ocean rescue

WWF

OCEAN HERO

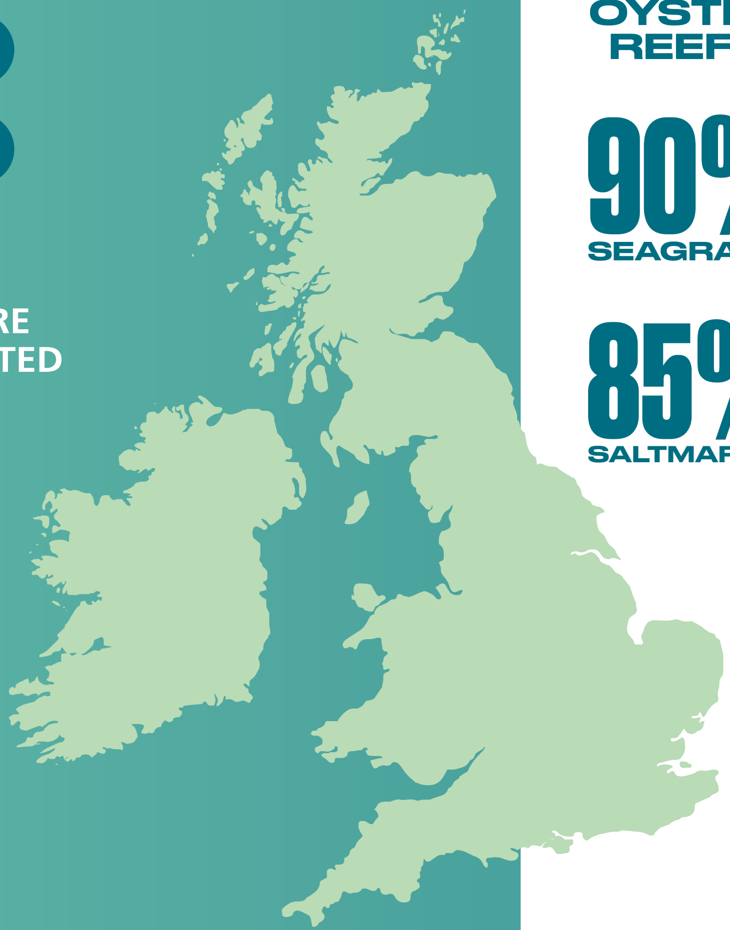
THE COST OF BUSINESS AS USUAL

ONLY 4 OF 15 INDICATORS OF HEALTH OF UK SEAS WERE IN 'GOOD' STATUS IN 2019



<1% OF UK SEAS ARE FULLY PROTECTED BY LAW

£15 BN LOSING COASTAL ECOSYSTEMS AND FISHERIES WOULD COST THE UK £15BN PER YEAR BY 2050



UK HABITAT LOSS

95% OYSTER REEFS

90% SEAGRASS

85% SALTMARSH

This report summarises the headline results and policy recommendations from the Value of Restored UK Seas project. A full description of the project objectives, methodology, results and conclusions is provided in the accompanying Technical Annex.

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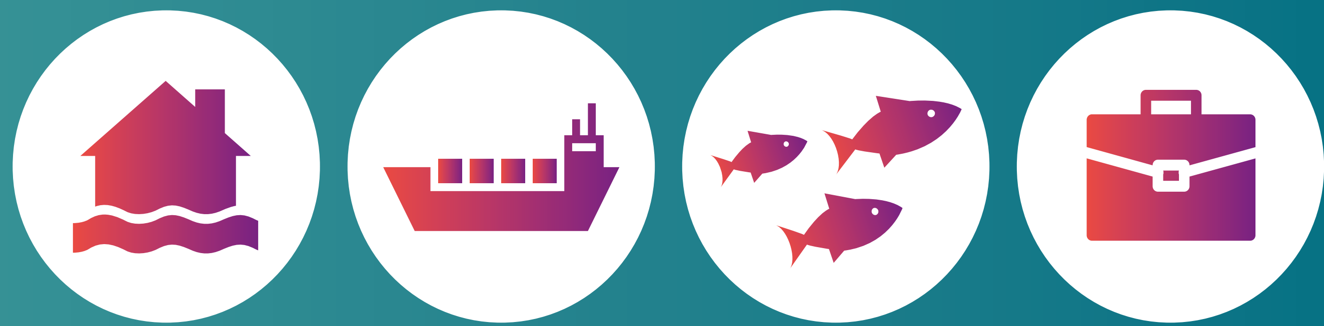
THE BENEFITS OF OCEAN RECOVERY

COASTAL ECOSYSTEMS CAN CAPTURE 33% OF THE UK'S 2018 EMISSIONS, WORTH £10.1BN

SUSTAINABLY DEPLOYING OFFSHORE RENEWABLES WILL BRING £26BN IN BENEFITS

BETTER MANAGEMENT OF MPAS CAN DELIVER UP TO £10.5BN OF RECREATIONAL AND OTHER BENEFITS



COASTAL ECOSYSTEMS CAN PROVIDE OVER £6BN WORTH OF FLOOD PROTECTION SERVICES

£9.8BN WORTH OF SHIPPING EMISSIONS REDUCTIONS BETWEEN 2020 AND 2050

CLIMATE CHANGE WILL COST THE UK FISHING SECTOR AT LEAST £1.5BN BY 2050 WITHOUT OCEAN RECOVERY

OCEAN RECOVERY HAS THE POTENTIAL TO CREATE UP TO 100,000 JOBS IN A GREEN RECOVERY

Science communication: Emma Cary, Jen Miller, Imogen Shapland

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CONTENTS

GLOSSARY

BAU scenario	Business as usual scenario: baseline reflecting the current policy situation where the ocean's health continues to decline and we continue to deplete the ocean's resources. MPAs are designated but not effectively managed and there is no resource available for large scale restoration of marine habitats
CBD	Convention on Biological Diversity
CFP	Common Fisheries Policy
CSR	Corporate social responsibility
ES	Ecosystem services
FMSY	Fishing Mortality in line with Maximum Sustainable Yield
FTE	Full Time Equivalent
GDP	Gross domestic product
GES	Good environmental status
GHG	Greenhouse gas
GVA	Gross value added
HAB	Harmful algal bloom
HPMA	Highly protected marine area
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
MPA	Marine protected area
MSFD	Marine Strategy Framework Directive
MSP	Marine spatial planning
MSY	Maximum sustainable yield
Mt	Megatonne
MtCO2e	Million tonnes of carbon dioxide equivalent
NDC	Nationally determined contribution
NTZ	No take zone
OA	Ocean acidification
OAW	Ocean acidification and warming
Ocean recovery scenario	A holistic ocean recovery framework of the UK seas is established and includes where the UK's seas are fully protected and restored, fisheries are reformed to operate sustainably and the ocean is able to provide a significant contribution to the delivery of the UK's net zero requirements. Traditional and innovative forms of finance are in place to support ocean recovery.
PES	Payment for ecosystem services
SSSI	Site of Special Scientific Interest
SST	Sea surface temperature
UKBI	UK Biodiversity Indicators
VMS	Vessel Monitoring System

EXECUTIVE SUMMARY

As an island nation, the UK's seas are part of our identify and our culture. Their natural beauty and amazing wildlife are a source of wonder, inspiration, recreation and wellbeing for millions. They also have huge economic value: the UK government estimates that maritime activities including tourism, shipping, fisheries and renewable energy contribute **£47 billion to the British economy** annually.

But our seas are in trouble. Fishing, pollution and climate change are putting increasing pressure on marine ecosystems, jeopardising their future. In 2019, **our seas failed to meet government standards on good environmental health against 11 out of 15 indicators**, including those relating to birds, fish and seabed habitats.

Sky Ocean Rescue and WWF are campaigning for a new 10-year vision and action plan for UK ocean recovery. Bringing our oceans back to life is crucial for our climate and biodiversity targets, but it's also a sound economic investment. Taking action now to put UK seas on a path to recovery will bring additional benefits worth **at least £50 billion by 2050**, against an estimated cost of £38 billion. It also has the potential to create **over 100,000 full-time job**s, mostly in renewable energy, as we seek to rebuild after the Covid-19 pandemic.

A HOLISTIC APPROACH

Rather than tackling issues in isolation, ocean recovery requires a holistic approach. We want to see action based on four key pillars:

- **Restoring lost coastal ecosystems**
- **Fully protecting a third of UK seas**
- **Making fisheries and seafood production nature and climate positive**
- **Supporting net-zero climate action.**

By taking action on these four pillars together, we can make the most of synergies and positive feedback loops: improving marine protection, for example, can help restore ecosystems, replenish fisheries and reduce carbon emissions.

Our study attempts to value the economic benefits of an "ocean recovery" scenario based on ambitious action in these four areas between now and 2050, compared to what would happen if current trends continue. But these values are an underestimate: we haven't attempted to model all the potential benefits, and of course it's impossible to assign an economic value to the joys and delights our seas give us.

These things are priceless.

Sky Ocean Rescue and WWF are working together to help protect and restore our ocean. Together we're campaigning for ocean recovery as the foundation for the next decade, inspiring millions to become Ocean Heroes and take real action to save our ocean.

By taking action for ocean recovery, we can restore life to UK seas for people, climate and nature with abundant marine wildlife, habitats healthy and recovering, and human pressures on our ocean reduced, from fishing to pollution. Join the fight at wwf.org.uk/oceanhero

PILLAR 1

RESTORING LOST COASTAL ECOSYSTEMS

Coastal habitats like seagrass meadows, saltmarshes and kelp forests store carbon, buffer us against floods and storms, and provide nursery grounds for commercially important fish species. But their continued loss and degradation undermines their ability to provide these vital services.

Marine habitats capture up to 20 times more carbon per hectare than forests on land. Fully restored, **our coastal ecosystems could capture a third of the UK's emissions** from 2018. **Restoring and stopping deterioration of coastal ecosystems** – tripling the area of seagrass and increasing the area of other habitats by 15% – **could prevent the loss of almost 40 million tonnes of carbon dioxide equivalent ($MtCO_2e$) and store a further 137 $MtCO_2e$ by 2050, equivalent to the emissions from 86,000 long-haul flights**. This would have a net economic benefit of **£10.1 billion by 2050** – which would increase further in the future as the protected and restored habitats continue to accumulate more carbon.

Protecting and restoring these habitats could **save an estimated £6.2 billion in spending on artificial flood defences** by 2050. It would also add value to fisheries, and provide jobs in the restoration work itself.

PILLAR 2

FULLY PROTECTING A THIRD OF UK SEAS THROUGH A WELL-MANAGED NETWORK OF MPAS

A well-designed and effectively managed network of marine protected areas (MPAs) isn't just important for wildlife: it supports key sectors like tourism and recreation, safeguards habitats that store carbon, and enables fish stocks to replenish. Today, MPAs cover about a quarter of UK seas, but many are little more than "paper parks", allowing even the most destructive types of fishing like bottom trawling.

Extending full protection to 30% of our seas would yield multiple benefits, yielding **net gains estimated at £10.5 billion and supporting up to 12,000 jobs in the tourism and recreation sector alone**. Reduced trawling in these areas would also allow habitats to recover and **capture carbon emissions worth an additional £459 million by 2050**. Growing the populations of large marine mammals also supports carbon capture.

Fully protected areas that exclude fishing (also called "no-take zones") are also, counterintuitively, good for the fishing industry: studies have shown they can increase fish biomass by 600% and species richness by over 20% compared to unprotected areas nearby, which benefits fisheries as shoals spill out into the wider marine environment.

PILLAR 3

NATURE AND CLIMATE POSITIVE FISHERIES AND SEAFOOD

Unsustainable fishing is one of the biggest threats to the marine environment – and the future of the fishing industry itself. Currently, **a third of UK stocks are overfished**, reducing their long-term economic value. Climate change is also having a major impact, and is expected to cost the sector an estimated **£1.5 billion by 2050**. Ocean recovery offers an opportunity to move towards fisheries that are good for climate and nature – including by reducing overfishing, improving fishing practices, and swapping diesel fuels for more efficient electric engines.

Today, the UK fishing industry has an estimated value of £989 million and supports around 12,000 full- and part-time fishers. Rebuilding fish stocks to their maximum sustainable yield could allow the UK to land **an extra 442,000 tonnes of fish every year, worth £440 million**, and support an additional **6,600 jobs**.

Rebuilding fish biomass has climate benefits too, as fish capture a surprising amount of carbon – this could be worth up to **£61.7 million by 2050**, while fuel efficiency gains in the UK fishing fleet could provide carbon savings worth **£98 million**.

PILLAR 4

SUPPORTING NET-ZERO ACTION

Our seas have a crucial role to play in bringing the UK's net carbon emissions down to zero. Stepping up marine renewable energy is particularly vital. Increasing offshore wind capacity by 40GW by 2030 and 75GW by 2050, in line with net-zero commitments, would deliver **savings in carbon emissions valued at £26 billion** compared with a business-as-usual scenario. This level of **offshore wind generation could also create 67,000 jobs** along with **16,200 jobs in tidal power and 12,000 jobs in wave power**. Careful planning and deployment is vital to ensure marine renewables don't undermine the other pillars of ocean recovery: habitat restoration, well managed marine protected areas and sustainable fishing.

Shipping is another area where we need to increase ambition to achieve net zero. In 2017, greenhouse gas emissions from UK shipping were 13.8MtCO2e – about 3% of total UK emissions. Halving emissions by 2050 through increased efficiency and alternative fuels would **deliver carbon savings worth £9.8 billion**.

1 INTRODUCTION

1.1 THE IMPORTANCE OF HEALTHY UK SEAS AND THE NEED FOR ACTION

UK seas are home to an amazing range of wildlife and support many important industries, but they are in crisis. True ocean recovery means bringing UK seas back to life for people, climate, and nature. Ocean recovery is a powerful message of hope.

Recent estimates by the UK Government[1] suggest that, in the UK, maritime activities are estimated to contribute £47 billion to the British economy annually. This value includes sectors heavily reliant on the UK seas, such as shipping, fishing, and renewables. Other crucial values are however currently not captured. For instance, seas not only produce oxygen but capture the majority of heat energy and a significant amount of the carbon dioxide that humans emit, and as such are essential in the fight against climate change. Fisheries also contribute significantly to the social and cultural fabric of many coastal communities in England, Scotland, Wales and Northern Ireland. UK seas offer many recreational opportunities for people to enjoy, alongside mental health and public health benefits[2], as well as the value gleaned from the sole knowledge of their existence.

However, the interactions between society, climate change and marine ecosystems are at a critical point, which could entail a significant loss if action is not taken. The Aichi 2020 targets have indicated that even with significant efforts to meet environmental goals, marine natural capital is degrading at a fast rate. Marine natural capital is an enabler of benefits, but is under increasing pressure from climate change, coastal squeeze, fishing, and pollution, including underwater noise. The impacts from acidification and heatwaves have devastating effects on the already fragile state of UK fisheries and aquaculture; on coastal areas, the impacts of flooding are now yearly noticeable in towns and cities. Yet, coastal habitats have the ability to offer a buffer zone around our shores to mitigate such effects, and resilient oceans offer refuges against the impacts of climate change. Ocean recovery is a tool to both mitigate and adapt to the impacts of climate change.

Traditionally however, the management of the seas has been sectoral, which has often missed the strategic importance of a healthy marine environment, with conflicts resulting from managing human uses separately from each other and from the environment. It is now more important than ever to develop a more strategic approach to the management of the UK seas to capitalise on the value. WWF is thus campaigning for an Ocean Recovery Framework for the new decade, which takes a holistic and ambitious approach to recovering UK seas rather than looking at the main issues individually. This aims to bring UK seas back to life for people, climate and nature, putting the seas on the pathway to recovery and in recognition of the contribution that recovered seas can make to the fight against climate change.

The Programme is built around four synergistic pillars:

- Restoration of lost coastal ecosystems, such as seagrass and saltmarshes;
- Fully protecting a third of UK oceans, through the effective management of marine protected areas (MPAs) and subsequent protection of significant carbon stores and sinks;
- Nature and climate positive fisheries and seafood: through the use of more selective practices, restriction of damaging gear from sensitive areas, setting and accounting for sustainable catch limits and minimising carbon emissions across seafood production; and
- Supporting net zero action: across all marine vessels through sustainably deployed renewables and initial efficiency gains, with moving away from use of fossil fuels being paramount in shipping.

BY 2030, THE BLUE ECONOMY COULD OUTPERFORM THE GROWTH OF THE GLOBAL ECONOMY.

GROWTH OF THE MARINE ENERGY, MARINE BIOTECHNOLOGY, COASTAL TOURISM, TRANSPORT AND FOOD PRODUCTION SECTORS COULD OFFER UNPRECEDENTED DEVELOPMENT, INVESTMENT AND EMPLOYMENT OPPORTUNITIES.

HOWEVER, LOSSES IN THE OCEAN'S NATURAL CAPITAL RESULTING FROM UNSUSTAINABLE ECONOMIC ACTIVITY IS ERODING THE RESOURCE BASE ON WHICH SUCH GROWTH DEPENDS.

THERE IS THEREFORE THE IMPERATIVE AND OPPORTUNITY TO TRANSFORM THE BLUE ECONOMY INTO A SUSTAINABLE MODEL THAT SUPPORTS THE ACHIEVEMENT OF THE COMBINED PILLARS OF OCEAN RECOVERY

PILLAR 1

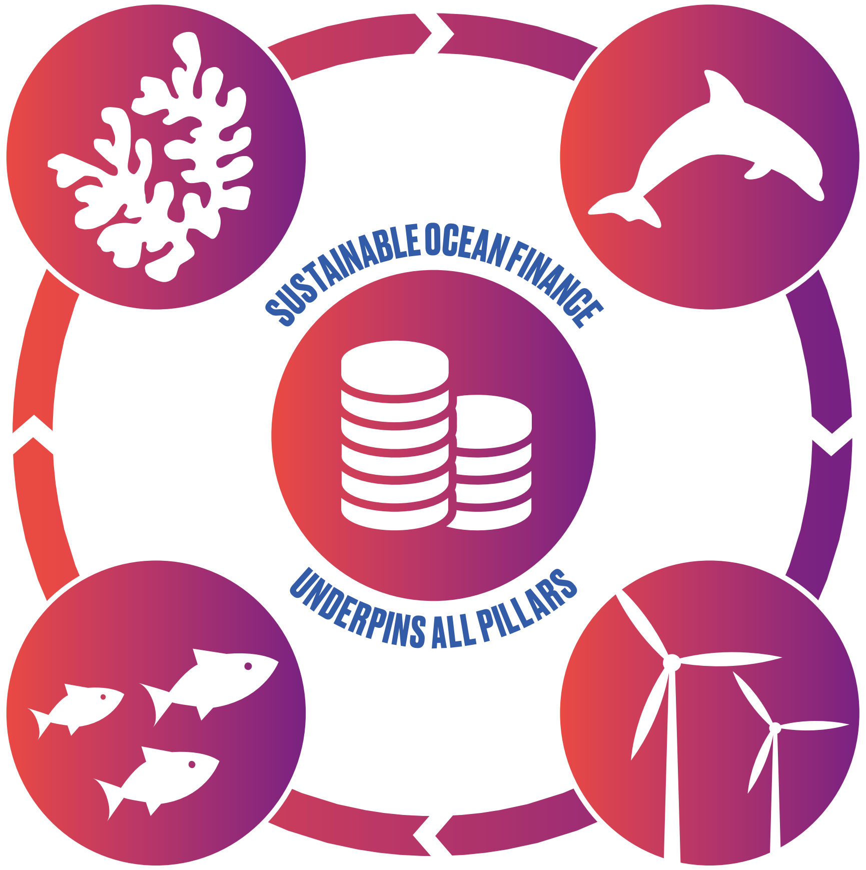
RESTORATION OF LOST COASTAL ECOSYSTEMS

Providing ecosystem services such as carbon capture, biomass health and wellbeing.

PILLAR 2

FULLY PROTECTING A THIRD OF UK SEAS THROUGH A WELL-MANAGED NETWORK OF MPAS

Protecting significant carbon stores and sinks and enhancing biodiversity.



PILLAR 3

NATURE AND CLIMATE POSITIVE FISHERIES AND SEAFOOD

Increasing stocks, improving wildlife and habitat health, helping tackle climate change and supporting coastal communities.

PILLAR 4

SUPPORTING NET ZERO ACTION

Increasing natural resilience and reducing climate risks.

These four pillars are interlinked; restorative action under one pillar will provide benefits in others, creating a loop of positive feedback. This study has been commissioned to identify and, where possible, quantify the benefits associated with bringing UK seas back to life by 2030 and 2050. This will assist WWF in the provision of evidence which highlights the urgent need for ocean recovery.

1.2 THE OBJECTIVES OF THIS STUDY

The specific objectives of this study are:

- To provide scientific evidence for UK seas to significantly contribute to the fight against climate change;
- To provide robust analysis on the economic case for investing in the recovery of the health of UK seas; and
- To support WWF advocacy for an Ocean Recovery Framework by providing scientific evidence to drive UK government action.

1.3 CONSIDERATIONS AND ENABLING FACTORS

Whilst not a specific objective of this study to identify the precise policy mechanisms to achieve ocean recovery, where these are commonly used, they have been referred to (e.g. networks of MPAs). Furthermore, it is acknowledged throughout this study that the development trajectory proposed must be fully sustainable and build environmental, social and economic resilience in the long-term. Due consideration is thus given to traditional and innovative forms of ocean finance that can facilitate ocean recovery as part of a sustainable blue economy but these are not the focus of this study.

1.4 OVERVIEW OF APPROACH

The approach has consisted of both a review of evidence and a modelling exercise. The review of evidence included a first RAPID assessment to gather the most robust information on the values and assumptions that could inform the development of the model. The model was aimed at assessing the benefit gained from moving from a baseline scenario to an ocean recovery scenario, described respectively as follows:

1. Business as usual (BAU) – baseline reflecting the current policy situation where the ocean's health continues to decline and we continue to deplete the ocean's resources. MPAs are designated but not effectively managed and there is no resource available for large scale restoration of marine habitats.
2. Ocean recovery – a holistic ocean recovery framework of the UK seas is established and includes where the UK's seas are fully protected and restored, fisheries are reformed to operate sustainably and the ocean is able to provide a significant contribution to the delivery of the UK's net zero requirements (particularly through renewable energy). An assumption here is that traditional and innovative forms of finance are in place to support ocean recovery.

The findings of the review and the specific assumptions for modelling the net gains from ocean recovery are given in a Technical Annex. The rest of the report is structured around the main pillars of ocean recovery. Noting that in some cases the benefits from their application will sit across different pillars, special care has been taken to avoid double-counting.

2 THE RESTORATION OF LOST COASTAL ECOSYSTEMS

2.1 INTRODUCTION

Coastal ecosystems provide habitat for a wide variety of marine plants and animals as well as providing resources and homes to people around the world. They also provide direct benefits for people including coastal defences, recreational and health benefits, and fisheries[3]. Coastal ecosystems also have a critical function in carbon sequestration, capturing and storing carbon from the atmosphere into sediments for many years.

Seagrasses in particular have the potential to bury a great amount of carbon per unit area on an annual scale, greater than other habitats; however, they cover a very small area which is, worryingly, decreasing yearly. Saltmarshes are also particularly effective in storing carbon. There are two main stressors that these habitats are facing currently:

- The natural response to changing conditions (e.g. temperature and sea level rise); and
- Habitat destruction, either for development or due to fishing or other seafloor activity.

This ocean recovery pillar aims to prevent further loss and actively restore lost coastal ecosystems such as seagrass, mudflats, salt marshes and macroalgae (kelp and other seaweeds). One of the most used mitigation actions for stopping further deterioration is the establishment of MPAs. Other approaches could include the removal of current stressors, such as excess nutrients or overuse.

Management and restoration activities need to be carefully planned as coastal habitats can also be a source of greenhouse gases such as methane (CH4) and nitrous oxide (N2O). There is not compelling evidence surrounding the level of such emissions however, and the long-term benefits of restoration are expected to outweigh any damaging emissions in the shorter term.

This section describes the status of these habitats and their capability to sequester carbon and provide ecosystems services. To do so, two main possible scenarios have been explored. The first scenario considers business-as-usual (BAU) activities that contribute to continued degradation. The approach utilises a range of values for carbon given the uncertainty surrounding the carbon value in appraisals. Values used as part of this modelling exercise with associated assumptions and uncertainties are reported in the Technical Annex. The BAU scenario has been used as a baseline or counterfactual against which an ocean recovery scenario can be assessed.

2.2 THE BENEFITS PROVIDED BY COASTAL ECOSYSTEMS

Coastal ecosystems can provide a number of ecosystem services. Direct ecosystem services linked to restored coastal ecosystems include:

- Carbon sequestration: seagrass beds, macroalgae, reefs and saltmarshes sequester and store carbon. The protection and restoration of coastal vegetation could make a valuable contribution to the UK's nationally determined contributions (NDC) target and provide coastal and island communities with important economic opportunities on the carbon offset market[4];
- Coastal defence: coastal ecosystems can stabilise sediment and provide a buffer against sea level rise and coastal flooding (e.g. saltmarshes);
- Recreation and tourism: recreation activities include bird watching, fishing, snorkelling, or diving, which can develop an economy of tourism with jobs in local communities;
- Improved water quality: seagrass and saltmarsh provide water filtration services and may help to reduce the effects of eutrophication within estuarine and coastal systems;
- Food supply, i.e. fisheries provision: restoration of coastal ecosystems provides refuge and protection for juvenile fish; and
- Health and wellbeing benefits: marine and coastal habitats provide important health and welfare benefits to coastal communities. Indeed, evidence collected by WWF has emphasised the value of seagrass restoration work in engaging communities with their coastal habitats and raising awareness of potential threats and climate change issues more generally.

Much research (see Technical Annex) has focused on the ability of coastal habitats to sequester carbon, particularly saltmarshes and seagrass due to their particularly intense carbon sink capability in temperate regions. The figure below depicts the carbon storage potential of the different habitats per year. Figure 2-2 depicts the carbon already stored in the habitats (carbon stocks), which, if disturbed, could be released into the atmosphere.

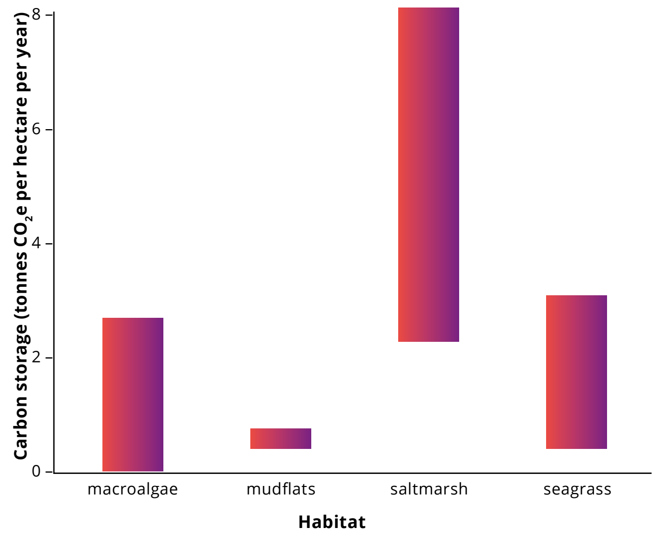


Figure 2-1
Carbon storage in different coastal habitats

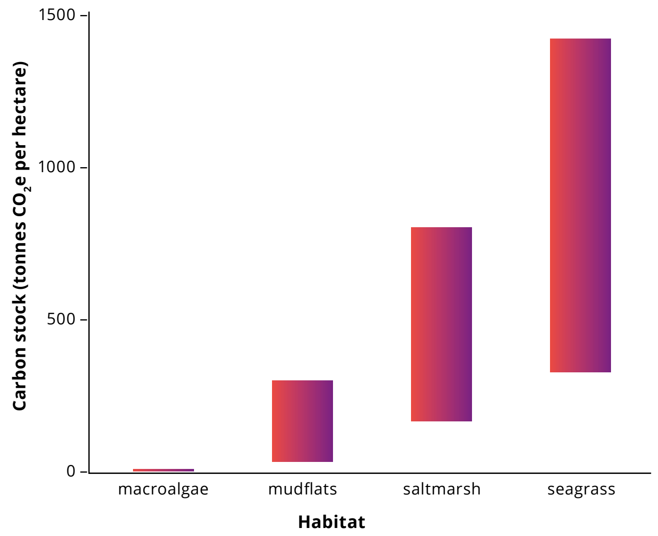


Figure 2-2
Carbon stock in different coastal habitats[a]

a: Source data provided by Legge, O., Johnson, M., Hicks, N., Jickells, T., Diesing, M., Aldridge, J., Andrews, J., Artioli, Y., Bakker, D.C., Burrows, M.T. and Carr, N., 2020. Carbon on the Northwest European Shelf: Contemporary Budget and Future Influences. Frontiers in Marine Science, 7, p.143

Moreover, restored coastal habitats can contribute towards achieving and maintaining Good Environmental Status (GES) under the current legal requirements set under EU and UK law and included in the Marine Strategy Framework Directive and Marine and Coastal Access Act 2009. Developing a clear understanding of the environmental status and condition of coastal ecosystems is critical to their long-term management.

KEY CARBON STORING COASTAL HABITATS IN THE UK:

- SALTMARSHES AND MUDFLATS
- SEAGRASS
- MACROALGAE (KELP AND OTHER SEAWEEDS)

2.3 THE CURRENT STATE OF UK COASTAL HABITATS AND ECOSYSTEMS

The picture for UK coastal habitats is worrying, as coastal habitats are being lost at a fast pace, despite attempts to revert such trends. The current rate of annual loss is estimated at 3%, which, should current trends continue, would be equivalent to more than half the current coverage being lost by 2050 (refer to the Technical Annex for detailed assumptions). The main habitats affected by such loss are saltmarshes and mudflats, seagrass, and macroalgae. These are described below. It is important to note however that much of this loss refers to their fragmentation and attrition of habitats (from sea level rise, disturbance, eutrophication and changing conditions and coastal squeeze) rather than them being stripped off due to development or extractive uses. Evidence suggests that in many cases habitat loss will not be easily recovered elsewhere without planned habitat creation, due to the limited ability of many of these habitats to adapt or move.

Saltmarshes

Saltmarshes in the UK cover an area of around 42,712 to 82,000 ha. They are however subject to a number of stressors, such as grazing, rising sea levels, coastal development and coastal squeeze. It is estimated that 57% of saltmarshes in the UK are in unfavourable condition and it is estimated that 100 ha of saltmarsh are lost in the UK per year[5]. This is of grave concern as they have capability to store more carbon per unit area than any other coastal habitats (see Figures 2-1 and 2-2). There have been, and still are, increasing attempts to restore saltmarshes[6]. In the past 50 years a significant effort has been made to restore degraded saltmarsh habitats and create new areas for saltmarsh plants to grow. However, the re-alignment schemes used for the restoration process are slow, with varying levels of success. Moreover, the current UK regulatory environment is unfavourable for large-scale restoration projects and the approval process tends to be quite long, requiring authorisation and gaining stakeholders' engagement and buy-in.

In the Forth Estuary, 51% of saltmarsh and mudflat area has been lost over a period of 400 years through land reclamation for agriculture and industry[7].

Seagrass

It is estimated that in the UK, seagrasses cover around 9,000 ha. Generally, however, there is a lack of data on seagrass areas as these are poorly mapped in the UK. It is crucial that the mapping of coastal habitats, including seagrasses, is improved, in order to aid plans for long-term management.

Seagrass meadows in the UK are also under increasing anthropogenic stresses (e.g. stressors associated with water quality, including light reduction, exposure of toxins, smothering by sediments and anthropogenic nutrient inputs[8,9]) and are declining in health across the UK. Research has indicated that UK seagrass beds are mostly in poor condition in comparison with global averages[10]. Of Britain's 155 estuaries, only 20 now contain seagrass. Although it is uncertain how many contained this habitat in the past, it has been estimated that there has been an 85% decline since the 1920s[11]. Seagrasses are declining with a rate equal to 3% per year[12]. Many of these seagrass beds are in sites of apparent conservation protection (e.g. within Special Areas of Conservation); thus, their protection could be enhanced by effectively managing the UK MPA network.

Macroalgae

Macroalgae (including kelp, seaweeds and maerl) play a key role in nutrient cycling in coastal marine ecosystems but they are currently affected by a range of anthropogenic stressors such as overfishing, increased temperature, storminess, the spread of invasive species, among others. UK kelp forests measure 480,000 – 770,000 ha[13]. Research suggests that ocean acidification and ocean warming will profoundly affect the UK's kelp forests in the future, with predictions that by 2100 warming will kill kelp forests in the south and ocean acidification will remove maerl beds in the north[14] which in turn, will have detrimental impacts on carbon sink capacities of the marine environment.

The evidence is less robust for maerl, as they are undergoing significant calcification and the area is considered to be relatively small and mostly covered by MPAs as a priority habitat. Mudflat and saltmarsh loss has impacted on ecosystem services upon which humans depend[15], e.g. the ability to support habitats and fisheries, and although there is enough evidence supporting this, there is not enough to model such impacts with any accuracy. Yet, it is worth highlighting that in stopping deterioration of coastal habitats the benefits under other pillars will become more tangible through the provision of other significant ecosystem services.

Trends and data on the carbon capture of the different type of habitats (as presented in the Technical Annex[16]) have been used to model the impacts until 2050. The impacts on the carbon losses under the current trends are summarised in Table 2-1 for years 2030 and 2050 (to reflect the uncertainty in trends and carbon capture potential, the results are presented as a range to give an indication of likely outcomes). The total carbon loss under the current baseline of continued deterioration is estimated to range from 7.53 to 39.7 MtCO2e.

Table 2-1: Carbon budgets for the different habitats under BAU scenario (Mt CO2e)

System	2030	2050
Saltmarsh (including mudflat)	-2.66 to -30.70	-6.07 to - 70
Seagrass	-0.42 to -3.39	-0.95 to -7.7
Macroalgae (kelp and seaweeds)	-0.22 to 16.60	-0.51 to 38
Total	**-3.3 to -17.49**	**-7.53 to -39.7**
Carbon budget expressed in MtCO2e. Positive number indicates carbon sequestration; negative number indicates carbon lost.		

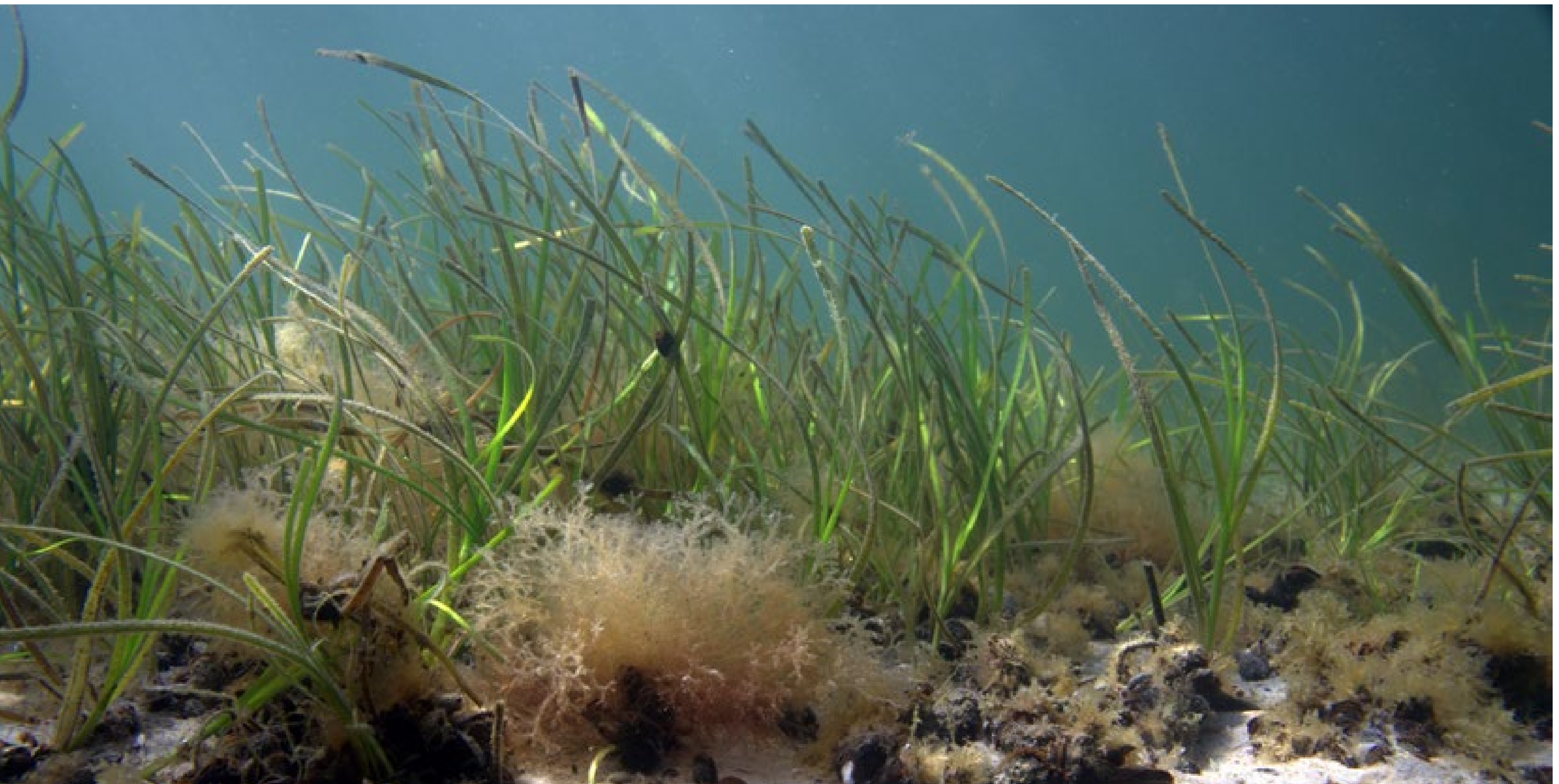
Under the current situation (BAU scenario), there is therefore a significant loss of carbon stocks which has been locked up in UK coastal habitats for many years, with particular regard to saltmarshes. This is depicted in Figure 2-3 (overleaf). Habitats will also stop storing further carbon on a yearly basis. The potential loss of carbon, both storage and stock loss, by current habitats under BAU scenario in the UK alone could reach c. 39.7MtCO2e by 2050.

These benefits could be significantly further compromised by ocean acidification and warming.

2.4 THE CARBON STORAGE VALUE OF STOPPING THE LOSS OF COASTAL HABITATS AND RESTORATION UNDER OCEAN RECOVERY

Following aspirational targets of the Environment Agency and other organisations to protect and restore such ecosystems, an ocean recovery scenario assumes the recovery of coastal habitats, although to different levels. Due to the small current coverage of seagrass area, an ocean recovery scenario assumes that this could be tripled by 2050. Other remaining coastal habitats, however, are projected to increase by 15% over the same period (full details of the model are given in the Technical Annex). The findings show that:

Under an ocean recovery scenario, seagrass, saltmarsh and macroalgae could protect and capture up to 137 MtCO2e, equivalent to 33% of total 2018 UK greenhouse gas emissions[17]. The economic benefits can be estimated to be c. £10.1 billion by 2050, compared to the BAU scenario.



The following table presents the summary of the model. The benefits from restoring coastal habitats by 2050 have been estimated at £9.4 billion[b] (or to range from £1 billion).

Table 2-2: Net carbon storage and associated economic benefit in restore vs BAU scenario

System	2030		2050	
	Carbon storage (Mt CO2e)	Carbon value (£Million)	Carbon storage (Mt CO2e)	Carbon value (£Million)
Saltmarsh (including mudflat)	4.4 to 39.6	305 to 2454	13.3 to 98.4	906 to 6661
Seagrass	0.44 to 3.8	27 to 236	1.08 to 9.7	73 to 661
Macroalgae (kelp and seaweeds)	0.22 to 4.6	14 to 275	0.51 to 29.3	34 to 2103
Total	**5.06 to 48**	**346 to 2965**	**14.89 to 137.4**	**1013 to 9425**

Most of the potential benefits are from stopping the loss of the habitats under an ocean recovery scenario, relative to the marginal benefits of increasing the area of coverage, with saltmarshes contributing to up 72% of the total carbon storage. Although macroalgae has significant capture potential, protecting saltmarshes will mean retaining the carbon stocks already locked in, with the result of a greater role as a carbon sink.

Recent years have seen a growing emphasis on conservation and restoration of saltmarsh environments, and these are likely to play a greater role in the net zero economy. Whilst seagrasses are excellent at sequestering carbon, their extent across the UK is limited due to substantial loss of habitat over the last one hundred years. Therefore, the overall impact of changes (both positive and negative) to seagrass has a marginal effect compared to the other coastal ecosystems. For instance, macroalgae also has a small stock, but a large carbon sequestration capacity.

The main benefits from restoring coastal habitats stem from stopping the loss of habitats which could lead to a significant reduction in the release of carbon which has been locked up in these habitats for many years.

Figure 2-3 – cumulative carbon storage by habitat

b: Using UK Government published values for non-traded carbon value and discount factors, applied at the time of carbon storage.

One tool to help stop the loss of habitats is through the designation and the effective protection of a network of MPAs (see pillar 2).

The management of fisheries (see pillar 3) either as part of MPA management measures or in their own right for managing ecosystem integrity is also expected to contribute to the protection of coastal habitats. For instance, reducing trawling in coastal ecosystems can reduce emissions (as disturbing sediments can result in carbon release, particularly in muddy sediments). This will also benefit coastal habitats and ecosystems (refer to pillar on MPAs for further discussion).

Applying carbon values as in UK Government guidance, the benefits from restoring coastal habitats by 2050 have been estimated to range from £1billion to £10.1 billion[c]. The broad range of possible values stems mainly from the uncertainty in both the best estimates of the current extent of coastal habitats in the UK and their carbon stock and storage rates.

Restoring and stopping deterioration of the coastal habitats in the UK could sequester the equivalent of up to 2,800 long-haul flights' carbon emissions per year (assumes flight from London-NY and 250 passengers per flight)[d].

The value of restoring habitats calculated above is focused on carbon sequestration, but other benefits are described below (notably fisheries and flood and coastal defence).

2.5 OTHER CRITICAL SERVICES PROVIDED BY COASTAL HABITATS

The UK National Ecosystem Assessment has also provided evidence on the savings that can be generated from restoration and protection of coastal habitats in terms of coastal protection. It has been estimated that coastal damages alone could costs the UK economy £12 billion a year by 2050 if action is not taken to combat climate change. The UK currently spends around £800 million per annum on flood and coastal defences and the average annual damage to properties and the cost of repairs alone is £1,400 million[18]. The National Infrastructure Commission estimates that, based on the level of resilience needed under a 4°C temperature rise, approximately £1 billion extra funding a year is required to support the Environment Agency with domestic adaptation[19].

Large-scale restoration of coastal habitats could significantly reduce both spend and cost of future damages. It estimated that in 2012, the value of coastal defences in England provided by salt marshes was £5.5-9.7 billion[20] (estimated as the savings from providing human-made defences instead to the same level of protection). It is uncertain the level to which these services could be lost under the baseline due to a lack of evidence, but applying the current rate of loss to the value of the services provided up to 2050 provides benefits of around £6.2 billion. These benefits do not include the damages, both tangible and intangible, of avoiding flood events however so they may be an underestimate.

Stopping the current level of loss of coastal habitats could ensure the continuation of flood alleviation services valued at over £6 billion up to 2050.

In addition, coastal habitats provide some valuable fisheries grounds but there is limited evidence to model the impacts on fisheries with accuracy. Thus, the above benefits are expected to underestimate the total benefits that could accrue from restoration.

The costs allocated to the establishment, monitoring and maintenance of coastal habitats have been estimated at £9 million over the next three years. The benefits are thus expected to exceed the costs. Such expenditure could generate 120 new jobs, to assist with post Covid-19 recovery.

c: Using UK Government published values for non-traded carbon value and discount factors, applied at the time of carbon storage.
d: Considering that the average passenger emits 0.904 tCO_2 per flight.

2.6 CONCLUSION

Under the BAU scenario, loss of coastal habitats could lead to a significant loss of the stock of carbon which has been locked up in these habitats for many years. The potential loss of carbon by current habitats under the BAU scenario could reach up 39.7 $MtCO_2e$ by 2050. Restoring coastal habitats in the UK under an ocean recovery scenario could store up to 147 $MtCO_2e$ with a value of c. £10.1 billion by 2050. The largest benefits stem from the protection of saltmarshes.

The majority of carbon benefit gained under an ocean recovery scenario for saltmarsh and seagrass habitats is due to the protection of stock which is otherwise vulnerable to loss under a BAU scenario. The difference in year-on-year accumulation of carbon between BAU and ocean recovery is relatively small by 2050. Over longer timescales the protected and restored habitats will accumulate more carbon and add significant additional value. However, it is needed to look to 2100 and beyond for this benefit to become significant relative to the carbon stock protection.

Additional benefits from the restoration include flood alleviation and fisheries provision and these benefits are not insignificant. Moreover, a particular value of seagrass restoration work has been engaging communities with their coastal habitats and raising awareness of potential threats and climate change issues more generally, which can only benefit moving towards net zero targets. The expenditure on restoration could support job creation but more importantly, the benefits, as valued, as expected to exceed the costs by a great margin.

THE PROTECTION AND LARGE SCALE RESTORATION OF COASTAL HABITATS IS TYPICALLY SUPPORTED BY GRANT FUNDING FROM BOTH PUBLIC SECTOR AND CORPORATE BODIES - THE LATTER OFTEN IN THE FORM OF PARTNERSHIPS SUCH AS THAT BETWEEN WWF AND SKY OCEAN RESCUE.

THERE IS POTENTIAL FOR FUNDING OF RESTORATION EFFORTS VIA A PAYMENT FOR ECOSYSTEM SERVICES (PES) APPROACH (WHEREBY ECOSYSTEM SERVICE PROVIDERS VOLUNTARILY ENTER INTO A PROGRAMME WHERE THEY RECEIVE PAYMENTS FROM USERS FOR RELEVANT OCEAN GOODS AND SERVICES).

FOR COASTAL ECOSYSTEMS, THIS MECHANISM COULD REVOLVE AROUND THE TRADING OF CARBON CAPTURE AND STORAGE.

3 FULLY PROTECTING A THIRD OF UK SEAS THROUGH A WELL-MANAGED NETWORK OF MPAS

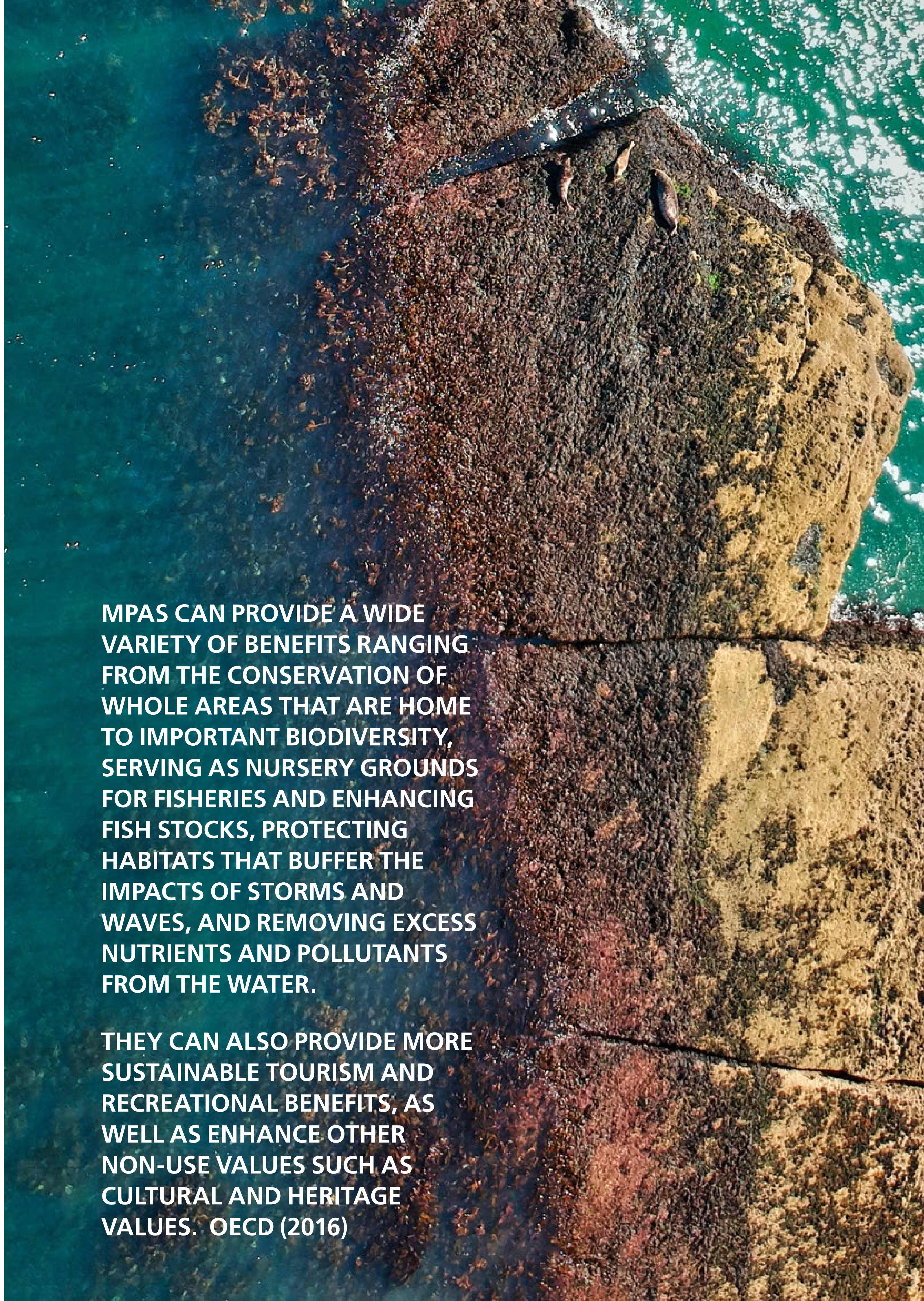
3.1 WHAT ARE MPAS?

The term MPA includes marine reserves, fully protected marine areas, no-take zones, marine sanctuaries, ocean sanctuaries, marine parks, and locally managed marine areas, to name a few (WWF, 2020)[21]. These are areas of sea and coast that are primarily managed to protect and recover the health of the ocean and its constituent habitats and species. A well designed and effectively managed network of MPAs is therefore crucial to ensure the health of marine biodiversity and ecosystems as part of a wider ocean recovery agenda. Although there are differing definitions of MPAs[22], all of them share conservation as their main purpose. MPAs can be conserved for a number of reasons including economic resources, biodiversity conservation, and species protection[23] and a classification system has been developed to this end.

MPAs are conceived to be a safe space for nature but can also support important ecosystem services, including fisheries provision. MPAs protect specific habitats and species and are a globally recognised tool that can help support the conservation of marine habitats and species whilst promoting sustainable use[24]. However, levels of protection afforded by, and types of activities allowed within, MPAs vary according to their designation[25]. Work by Lubchenco et al (2016) defines MPAs by level of protection: fully, highly, lightly and minimally protected[26]. Research indicates that the outcomes of an MPA depend on its protection level; lightly protected areas do not have the same ecological, social and economic outcomes as fully protected areas[27]. The UK Government recently engaged in evidence gathering on the introduction of Highly Protected Marine Areas (HPMA) in English waters; the independent review strongly recommended HPMAs be introduced for the multiple benefits they offer, including enabling marine protection and recovery.

The legislative and policy drivers for MPA monitoring, assessment and reporting are complex and include the Convention on Biological Diversity (CBD), EU Directives (Habitats, Birds, Water Framework, and Marine Strategy Framework), Convention on the Protection of the Marine Environment of the North East Atlantic (OSPAR Convention) and the Marine and Coastal Access Act 2009 (MCAA) (amongst others, see Marine Scotland, 2017)[28]. The Convention on Biological Diversity (CBD)'s Aichi targets include, as target 11, the "effective and equitable management" of protected areas, including coastal and marine areas. The Compass, a global tool adapted for use in the UK and implemented by WWF and Sky Ocean Rescue, supports the effective management of MPAs as part of pillar 2. Yet, recent assessments highlight that local challenges remain with regard to cross-sectoral working, funding and achievement of conservation goals[29]. Nationally, marine activities are commonly regulated on a sectoral basis and evidence suggests that adequate management plans and monitoring regimes are currently lacking[30]. Reporting on MPAs is legally required every 6 years, which is not necessarily the appropriate frequency to avoid harmful effects derived from lack of effective management. Other issues with MPAs have also been identified, especially with regard to long-term monitoring and enforcement[31,32].

This section assesses the value of UK seas in the context of an effectively managed network of MPAs including the introduction of fully protected areas (or HMPAs in England).



3.2 THE BENEFITS PROVIDED BY MPA NETWORKS

A global system of ecologically representative, effectively managed MPAs is required to contribute to sustainable development by providing integral benefits for marine conservation, building up resilience against climate change and also for activities such as fisheries and tourism. Habitats and species protected in MPAs will, for example, deliver increased robustness of ecosystems upon which commercial fish stocks depend. If managed effectively, they will provide shelter and food, and protect nursery areas and refuges for commercial fish and other species.

The constituent parts of the total economic value of an MPA can be separated into use (coastal defence, recreation and tourism, food supply, carbon sequestration) and non-use values (derived from the knowledge of existence). The value provided by MPAs are likely to vary based on location and how they are managed, as well as what they are being managed for. Different MPAs will have different effects on ecosystem services but these will mirror those of the habitats they protect (as described in section 2.2). For instance:

- Coastal defence: MPAs protect habitats that provide a buffer against the impacts of climate change and a level of insurance against natural disasters, e.g. saltmarshes;
- Recreation and tourism: among the recreation activities are bird watching, marine mammal and shark watching, scuba diving, sea angling etc. This, in turn, can provide jobs to local communities, depending on aspects such as accessibility and service provision;
- Carbon sequestration and storage: coastal habitats protected by MPAs such as seagrass and salt marshes store and sequester carbon; effective management and reduced trawling can safeguard offshore sediments preventing existing carbon sinks from being disturbed;
- Food supply, i.e. fisheries provision. MPAs have been shown to increase fish size, density, biomass and species richness. These increases are also seen beyond the boundaries of the protected area, through the spill-over effect[33]. Larger MPAs beyond coastal waters could contribute more significantly to the spill-over effect of fish biomass than coastal MPAs. This would support fisheries outside the sites, while protecting biodiversity inside[34];
- Ocean resilience and refuges against climate change: managed ecosystems, such as MPAs, may help marine ecosystems and people adapt to impacts of climate change including: acidification, sea-level rise, intensification of storms, shifts in species distribution, and decreased productivity and oxygen availability, as well as their cumulative effects[35].

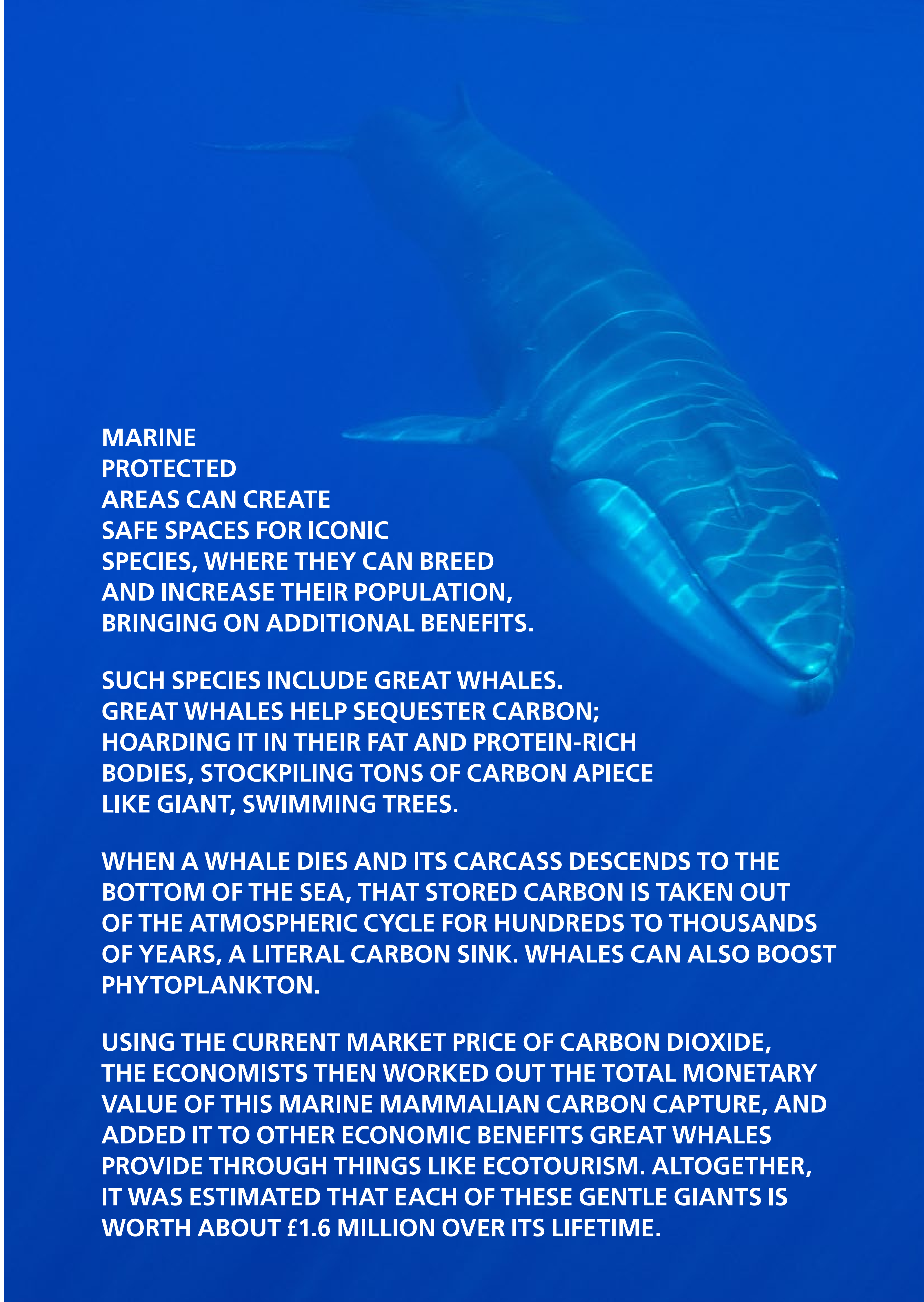
Research conducted in 2015 showed that expanding the coverage of MPAs to 30% globally could be expected to generate major economic benefits that significantly outweigh the costs. This was true under a range of scenarios for no-take MPAs to cover 10-30% of marine and coastal areas with varying degrees of biodiversity and human pressures. The net benefits to the global economy of increasing protection to 30% range from the most conservative estimate of US$490 billion and 150,000 full-time jobs in MPA management, to the most optimistic estimate of US$920 billion and over 180,000 jobs by 2050[36].

The designation of a No Take Zone (NTZ) can contribute to higher biodiversity values than partially protected areas, as they yield higher density of organisms[37]. Fully protected areas, commonly called 'marine reserves', can on average increase total fish biomass by over 600%, organism size by over 25%, and species richness by over 20% relative to unprotected areas nearby[38]. In contrast, MPAs that allow some or a lot of fishing (called 'lightly protected areas') typically do not even double fish biomass compared to unprotected areas. In addition, marine reserves help restore the interactions among species and the complexity of ecosystems through a chain of ecological effects, once the abundance of large animals and habitat-structuring species recovers sufficiently[39].

There is thus abundant evidence that NTZ are the most effective type of MPA for restoring and protecting biodiversity, but almost all MPAs in the UK are multiple use with lower level of biodiversity protection than NTZ. The UK Government is however aiming to step up protection and has recently published a review into the introduction of Highly Protected Marine Areas (HPMAs) in English and Secretary of State waters. The review recommends the introduction of HPMAs as essential for marine protection and recovery, as well as for the protection of 'blue carbon' habitats[40].

Evidence suggests that no-take fully protected areas are the most effective type of MPA for restoring and protecting biodiversity. The UK Government recognises that HPMAs can bring substantial benefits for conservation and biodiversity and commissioned a call for evidence to assist with designation. The resulting review recommends a process for establishing HPMAs, which could be part of the existing network, as well as criteria for ongoing enforcement and monitoring[41].

There is a growing body of literature that attempts to quantify the monetary value of recreational and tourism benefits provided by MPAs[42,43,44]. It has been reported that the protection of Lyme Bay in the UK has had a positive



MARINE PROTECTED AREAS CAN CREATE SAFE SPACES FOR ICONIC SPECIES, WHERE THEY CAN BREED AND INCREASE THEIR POPULATION, BRINGING ON ADDITIONAL BENEFITS.

SUCH SPECIES INCLUDE GREAT WHALES. GREAT WHALES HELP SEQUESTER CARBON; HOARDING IT IN THEIR FAT AND PROTEIN-RICH BODIES, STOCKPILING TONS OF CARBON APIECE LIKE GIANT, SWIMMING TREES.

WHEN A WHALE DIES AND ITS CARCASS DESCENDS TO THE BOTTOM OF THE SEA, THAT STORED CARBON IS TAKEN OUT OF THE ATMOSPHERIC CYCLE FOR HUNDREDS TO THOUSANDS OF YEARS, A LITERAL CARBON SINK. WHALES CAN ALSO BOOST PHYTOPLANKTON.

USING THE CURRENT MARKET PRICE OF CARBON DIOXIDE, THE ECONOMISTS THEN WORKED OUT THE TOTAL MONETARY VALUE OF THIS MARINE MAMMALIAN CARBON CAPTURE, AND ADDED IT TO OTHER ECONOMIC BENEFITS GREAT WHALES PROVIDE THROUGH THINGS LIKE ECOTOURISM. ALTOGETHER, IT WAS ESTIMATED THAT EACH OF THESE GENTLE GIANTS IS WORTH ABOUT £1.6 MILLION OVER ITS LIFETIME.

impact on local leisure and recreation, including scuba diving, sea angling and wildlife watching. The total monetary value of these recreational activities was estimated to be over £18 million (€23 million) per year, based on user expenditure and related businesses' turnover[45]. Designation of this MPA added around £2m to the total value of tourism and recreation[46]. RPA's study on the benefits of MCZ designation estimated the tourism and recreation benefits from the first round of designations (30 MCZs). These ranged from £40m to £83m for recreational benefits, and £5 to £10m for tourism annually.

More generally, benefits from conservation have been estimated in other UK studies although these are rather dated. For instance, a study in Cornwall, where seal damage to netted fish was costed at £100,000 per year, gave estimates of public willingness to pay to see grey seals between £8 and £9 with a conservative valuation of seal viewing at £526,000 per year[47]. Another 2012 report determined that the proposed network of MPAs in Scotland's waters could be worth up to £10 billion in economic benefits over 20 years, including both use and non-use related benefits and with recreation accounting for c. 80% of the total benefits[48]. MPAs can provide protection for the most important areas of whale and dolphin habitat[49], but there is a danger that poorly managed MPAs established for cetaceans may actually disturb populations. It is also vital that tourism's footprint on marine and coastal habitats and biodiversity is minimised. An ocean recovery scenario assumes that tourism and recreation is managed sustainably in line with conservation principles.

Through the protection of whales, well managed MPAs can ensure the continuity of £1.77 m in annual revenue for the Scottish tourism industry.

The most direct evidence that MPAs can protect and enhance ecosystem services comes from situations where habitats and species protected by MPAs are known to provide specific ecosystem services, whether in HPMAs or multiple-use MPAs[50] (see box below on the protection of whales). The benefits however will be different according to specific site and location and range from £2.5m to over £10m per MPA for tourism and recreation alone. Adding other benefits, including non-use could significantly increase the benefits (estimates from the literature range from £5m to £18 one-off). Other benefits include protection of carbon sequestration in coastal habitats (discussed under section 2) and shelf sediments, through protection from activities such as trawl fishing and dredging.

3.3 THE CURRENT STATE OF THE UK MPA NETWORK

There are in total 355 MPAs in the UK[51]. Approximately 25% of UK waters are currently within MPAs, with coverage higher in coastal waters than in offshore waters. Offshore MPAs will support different biodiversity features to inshore MPAs. As a result, although approaching ecological coherence, not all biodiversity features are equally represented in the MPA network, in particular deeper sea habitats. A wide diversity of seafloor habitats and geological features occurs in UK waters, including submarine canyons, seamounts, cold-water coral reefs and gardens, sponge aggregations and soft-sediment habitats[52].

Fully protected areas include no-take zones, areas where extractive practices such as fishing and mining are prohibited. In the UK, there are currently only three no take zones, one on the Isle of Arran in Scotland, one at Flamborough Head, and one around Lundy in Devon, England. Most of the UK's MPAs are of multiple use, with some areas closed to fishing activity, some on a seasonal basis, and others permanently. For areas that are not closed, the government has still to develop a management plan: permission must be granted, relevant licenses obtained, and proper authorities notified prior to any fishing or other activity, with some exemptions[53].

The establishment of a representative and coherent network of MPAs is one of the measures to achieving Good Environmental Status (GES) in UK seas in line with the Marine Strategy Framework Directive (MSFD)'s objectives. Indicators of good quality include certain marine species such as cetaceans, seal and seabirds, as well as seabed habitats. The most recent assessment shows the following[54]:

- For benthic (seafloor) habitats, GES has not yet been achieved for rock and biogenic habitats in either Greater North Sea or the Celtic Seas. The extent to which GES has been achieved in intertidal habitats is uncertain.
- The situation for coastal bottlenose dolphin and minke whale is uncertain, although is improving in the Greater North Sea;
- Seals have signs of recovery in certain parts, with a significant increase in the abundance of harbour seals in West Scotland. Their status in the Greater North Sea remains to be improved; and
- For breeding seabirds, the situation has been deteriorating since 2012.

Reduced availability of small fish on which the seabirds feed has been largely responsible for declines in seabird breeding abundance and the frequent, widespread breeding failures in some species. This highlights the importance of ensuring nature and climate positive fisheries and seafood, covered under current pillar 3. There is also a lack of understanding of how climate change is driving shifts in the food web that have led to these reductions in food availability[55]. Plankton communities are changing; some fish communities are recovering, but others are not. There is also uncertainty on how climatically driven changes in the plankton will affect the rest of the food web. The status of pelagic and benthic habitats is also not good, although the situation since 2012 is more stable.

Despite the UK having 25% of its waters designated as MPAs, to date, less than half of all English MCZs are achieving their objectives[56]. A 2019 assessment of the health of UK seas concluded that, despite this spatial MPA coverage, only four out of 15 indicators (to achieve GES) have been achieved (ibid). A focus on percentage targets alone risks prioritisation of 'political' over 'ecological' networks of protected areas, with so-called 'paper parks' the result[57]. The latest report on MPA progress has stated that MPAs are missing key components to meet protected area classification, including adequate management plans and monitoring. It is also noted that many MPAs allow fishing activity to take place, including the most damaging of fishing practices such scallop dredging. Trawling, which is one of the most damaging types of fishing, occurs widely in MPAs. A recent study found that the abundance of sensitive species (sharks, rays, and skates) can be significantly affected with high intensity trawling, with decreases of up to 69% in heavily trawled areas[58]. Effective monitoring and enforcement, coupled with holistic seascape management, is therefore central to MPAs achieving the desired effect to improve ecological status. In 2019, however, bottom trawling restrictions were only applicable in 1.7% of UK seas[59].

Failure to fully protect the current network of MPAs will result in failures to achieve biodiversity targets and jeopardise the achievement of targets for other biodiversity indicators, compromising food webs and the stability of large predator populations. This could in turn impact many sectors of the blue economy, including tourism and recreation, and miss out on the opportunity to increase resilience to climate change.

Under the current baseline the seas are not on a secure path to achieve GES. Though the proportion of UK waters within MPAs has greatly increased between 2012 and 2018, there is rising concern that this increase in designations is creating an illusion of effective marine conservation[60]. The BAU scenario assumes that under the current management the value of the MPA for tourism and recreation will decrease over time (refer to Technical Annex for summary of assumptions).

3.4 THE VALUE OF MANAGING MPAS AND DESIGNATION OF FULLY PROTECTED MPAS UNDER OCEAN RECOVERY

The United Nations' current target for global ocean protection is for at least 10% of the ocean to be within MPA networks by 2020, with growing consensus that at least 30% of the global ocean should be protected within MPA networks by 2030. However, currently only 3.6% of the ocean is in implemented MPAs, and only 2% is in strongly or fully protected areas[61].

The key to success is in ensuring that these MPAs are well managed. The findings from the literature review show that most benefits can be derived from improving the management and/or designation of more MPAs, particularly fully protected MPAs (or so-called HPMAs in England). The definition of HPMAs used in the recent Benyon[62] review is: "areas of the sea that allow the protection and recovery of marine ecosystems. They prohibit extractive, destructive and depositional uses and allow only non-damaging levels of other activities." Non-damaging activities can include recreational uses and tourism, but these need to be carefully managed. The recent evidence gathering on HPMAs concluded that these could be designated from the existing network. The ocean recovery scenario is based on the designation of fully protected areas from the existing network of MPAs, where "fully protected" areas include HMPAs in England and fully protected areas in Scotland and Wales as defined under the Lubchenko MPA guide and Category 1a of the IUCN's global categorisation of MPAs.

In order to estimate the value of UK ocean recovery a number of assumptions have been followed (refer to Technical Annex). This pillar considers two variations under the ocean recovery scenario, one where 10% of current MPAs (36 in total) could be designated as fully protected and a more ambitious scenario where 30% of current MPAs become fully protected (NB: note that the remaining 70% of the current designated MPA network would be effectively managed, addressing some of the current shortcomings, but some extractive uses will still be allowed. As a result, the use related values will not be lost over time but they will not be increased).

It is estimated that a £2.5m value for a multiple-use MPA is appropriate for modelling purposes, to account for the recreational and tourism benefits that may be sustained for an MPA should the network be properly managed following monitoring. Larger benefits may accrue from the designation and management of fully protected areas. The Benyon review[63] notes that there is evidence that fully protected MPAs provide additional recreational benefits compared with other types of MPAs in terms of biodiversity gains. This is to be expected due to the higher level of protection of the habitats and species. It is important to note that marine tourism and recreation (e.g. sailing, wildlife watching, sea angling, etc.) is estimated to contribute £4-£5 billion annually to the British economy (according to the Government Office for Science[64]). All this could be lost should effective management not be followed. The elevation of an MPA, or part of, to full protection could accrue additional value for already designated sites and values of £5m per site are not considered unreasonable (based on average values found across the literature that capture such biodiversity gains and non-use related benefits).

The net gains from restoring the seas through the effective management of a network of MPAs, including the designation of fully protected MPAs, can be estimated to range from £7.5 billion to £10.5 billion over the next 30 years for a 10% and 30% designation respectively. As the average salary in the tourism and hospitality sector is £29,000, this could support between 8,621 to 12,069 FTE.

Moreover, there will be additional jobs generation from the expansion, protection and management of the MPA network, including monitoring and enforcement costs. It has been estimated that there could be an additional 2,800 jobs from the protection of MPAs[65]. The costs of managing the MPA network over this timeframe have been estimated at £1.4bn, thus smaller than the benefits to tourism and recreation from improved biodiversity, showing that investing in nature pays off.

3.5 THE CARBON STORAGE VALUE OF PROTECTING SHELF SEDIMENTS AND REDUCING BOTTOM TRAWLING PRESSURE THROUGH MPAS

As well as their importance for biodiversity, tourism and recreation, coastal habitats and shelf seas are particularly important in terms of their amount and potential economic value of carbon stored. Integrated estimates for carbon exchanges and storage in the Northwest European shelf have been calculated to be in the range 8-22 billion tonnes, of which 0.1-0.2% is in the coastal system, 12-30% in the water column and 70-88% in the top 10cm layer of shelf sediments. Most of the carbon in shelf sediments is inorganic[66].

Although this report has not quantified the emission benefits of coastal shelf ecosystems to recover, the benefits of safeguarding include protection of biodiversity and carbon storage and sequestration from reduced seabed pressures, in particular bottom trawling, through fully protected MPAs is likely to be high. This should be considered along with the potential displacement impacts of such MPAs on fishing (and other) activities. Under an ocean recovery scenario, trawling (and other fishing) is prevented in protected areas, potentially leading to an intensification of trawling elsewhere. Where trawling is high intensity already this can have a significant effect on carbon stocks by protecting some parts of an area that is normally fully trawled. In less intensively trawled areas, protection can have little or no effect in carbon terms, because the trawling is simply intensified in adjacent non-protected areas.

For the purposes of this report, we therefore assume a 40% reduction of trawling activities from current baseline levels in both scenarios across the UK seas with no trawling in MPAs. The reduction in activity, including some redistribution of the remaining trawling outside of the MPAs, will lead to substantial carbon storage (refer to Technical Annex for more details). Enforcement is thus required to seek that unprotected sites are not over exploited. The Benyon review has further added that engagement and enforcement which will be critical to the success of fully protected areas, recognising the role of modern technology to this end for which sufficient funding should be allocated.

Coastal multi-use MPAs could sustain a tourism and recreational value of around £2.5m per MPA per year if properly managed under an ocean recovery scenario (but part of this value will be lost under a further deterioration baseline).

Fully protected areas could bring substantial benefits for conservation and biodiversity. An annual value of £5.5m per fully protected MPA could apply to include additional tourism and recreational benefits from the sites[67]. There will be additional benefits not associated to any use from fully protecting off-shore MPAs. The net gains from fully protecting 10% of the existing network have been estimated at £7 billion up to 2050. Designation of 30% of MPAs as fully protected could add another £3bn over the same time horizon, with the net benefits over the BAU estimated to total £10.5 billion.

In addition, there will benefits from carbon capture through improved management and enforcement and reduced trawling. The benefits of reduced trawling in both ocean recovery scenarios have been estimated at £422 million to £459 million to 2050.

3.6 CONCLUSION

The net gains from restoring the seas through the effective management of a network of MPAs, including the designation of fully protected MPAs, can be estimated to range from £7.5 billion to £10.5 billion over the next 30 years for a 10% and 30% designation respectively and could support between 8,621 to 12,069 FTE, related to tourism and recreation.

These benefits stem from more valuable recreational and tourism activities to users as a result of the effective management of currently designated MPAs, which are not yet effectively managed and monitored, non-use values and also carbon capture from better management. It is based on maintaining the current value of multi-use MPAs against diminishing the value of these activities under continued deterioration (the baseline), but also the added value of these activities in fully protected MPAs.

The present value of creating a well-protected network of MPAs is a conservative value since the impacts on fisheries is not being modelled in this section, and neither are the benefits that conservation of mammals can have on carbon sequestration. This is due to the lack of empirical data to model the impacts under the management scenarios (e.g. fisheries) or the lack of robust enough data (e.g. benefits such as carbon sequestration from whales have not been included as the study is still to be peer-reviewed). Assumptions and impacts could be thus revised as more information becomes available.

The value compares well against other findings in the literature (e.g. the Scottish proposed network of MPAs has been valued at £10 billion over the 20 years including use and non—use benefits and different management scenarios[68]). It is important to note that the value is related to effective management and enforcement and not additional designations (as the UK has already more than 25% of the seas under designations). Should more MPAs be designated and effectively managed, benefits could be expected to be larger. It is important that the process takes a holistic approach and enforcement and engagement will be critical to ensure that damaging activities are not displaced in detriment of these potential benefits.

Benefits are conditional to effective enforcement and monitoring as one infringement could undo years of recovery[69].

DESPITE THE UK HAVING 25% OF ITS WATERS DESIGNATED AS MPAS, THE LATEST REPORT ON PROGRESS ON MPAS HAS STATED THAT THEY ARE LACKING ADEQUATE MANAGEMENT PLANS AND MONITORING REGIMES, ALLOWING SOME OF THE MOST DAMAGING OF FISHING PRACTICES (E.G. TRAWLING)

MPA DESIGNATION ALONE, WITHOUT APPROPRIATE ENFORCEMENT, RISKS CREATING AN ILLUSION OF EFFECTIVE MARINE CONSERVATION

FAILURE TO FULLY PROTECT AND MANAGE THE CURRENT NETWORK OF MPAS WILL RESULT IN FAILURES TO ACHIEVE BIODIVERSITY TARGETS AND SUSTAIN THE ECOSYSTEM SERVICES, INCLUDING TOURISM AND RECREATION, FISHERIES AND CARBON SEQUESTRATION

4 NATURE AND CLIMATE POSITIVE FISHERIES AND SEAFOOD

4.1 WHAT ARE NATURE AND CLIMATE POSITIVE SEAFOOD AND FISHERIES?

Nature and climate positive seafood and fisheries means the harvesting and production of both wild caught fisheries and aquaculture in a way that is compatible with restoring ocean health, bringing benefits to people, climate and nature compared to business as usual. In this way, stocks can be increased, marine wildlife and habitat health improved, carbon sinks protected and coastal communities supported.

Ocean recovery would help sustain fisheries productivity and provide 'a positive vision of hope to allow the ocean to help us deliver food security, reduce seafood environmental footprint, improve livelihoods, support coastal communities, and reduce climate risks'[70].

This section assesses the impacts of delivering nature and climate positive seafood and fisheries against a BAU scenario that reflects the current state of UK fisheries up to 200 nautical miles, and current aquaculture practices. It also looks at the impacts that fisheries have on the ocean environment. The findings are compared against an ocean recovery scenario for fisheries.

4.2 FISHERIES AND SEAFOOD UNDER THE BUSINESS AS USUAL SCENARIO

4.2.1 Fisheries

Fishing under BAU

The UK fishing industry has an estimated value of £989 million value and currently support 11,961 full and part time fishers.

The impacts of climate change on maximum catch potential on capture fisheries for the UK could range from a reduction of 15.2% in the Celtic Seas to up to 34.6% reduction in the North Sea even in a low emissions scenario. This would have significant implications for the UK economy and local fishing communities unless action is taken to adapt.

Current global projections for climate change estimate an overall decrease in catch potential for both high and low emission scenarios (from 8.6–14.2% and 20.5–24.1% by the mid- and end- of the 21st century and 3.9–8.5% by 2041–2060 and 3.4–6.4% by 2081–2100 relative to 1986–2005). Furthermore, a potential catch loss of 3.4 million tonnes and decreases of 6.4% of catch potential of the exploited species per degree Celsius of atmospheric warming relative to 1951–1960 levels[71]. These projected oceanic changes already in motion in UK waters means the ability to harvest commercial fish sustainably in the coming decades will be increasingly challenging. And yet fishing activity has yet to be managed in a way that takes into account efforts to combat climate change. A goal of the Marine Strategy Framework Directive (MSFD) is to achieve Good Environmental Status (GES), part of which requires achieving biomass levels associated with Maximum Sustainable Yields (MSY) for all EU wide commercially important fish stocks. MSY, embedded into the UK's definition of GES, describes the maximum amount of fish that can be safely removed from the stock while maintaining its capacity to produce sustainable yields in the long-term and, hence, to ensure continuity of the sector. The UK has championed sustainable fisheries under this concept and progress has been made in terms of setting catch rates that are consistent with MSY. The percentage of fish stocks fished at or below MSY is reported to be 49% in 2017, with 33% of fish stocks overfished and 17% with no data. While there has been a marked increase since 1990 levels, since 2013 the trend has been stable[72].

There is growing awareness that MSY does not adequately cover the full range of aspects of ecosystem-based fisheries management within the wider context of seeking ocean recovery. With GES indicating the health of the seas, a key stressor on marine biodiversity is overexploitation of fish stocks and potential damage to ecosystems and seafloor integrity, including important carbon stores. The freedom to interpret and implement GES for commercial fisheries exclusively by attainment of MSY has therefore led to criticism that it should not be the only measure of successful ecosystem-based fisheries management. Diverse interpretations across the EU has also meant that the UK government has had autonomy over the implementation of GES standards within UK legislation. Despite this, the UK is not achieving GES for Descriptors[73] 1, 3, 4 and 6 which encompass both the state of fish stocks and the impact of fishing on natural ecosystems.

Furthermore, Defra's 25 Year Environment Plan sets out the ambition to secure clean, healthy, productive, and biologically diverse seas and oceans including an ecosystem approach to fisheries management. However, despite witnessing general improvements for many stocks from historically critical levels, there is a distance to travel to achieve this goal for almost half of the fish stocks.

The most recent reform of the Common Fisheries Policy (CFP) targeted eliminating the wasteful practice of discarding through the introduction of the landing obligation, or discard ban. The aim of the landing obligation was to incentivise measures that would reduce the amount of discarding across fleets by the adoption of more selective fishing behaviour and gear use. However, there has been general agreement that management of the landing obligation has been poorly implemented and enforced across European waters and the desired outcome not achieved. In February 2020, the UK House of Lords stated that the non-compliance of landing obligations and banning of discards are based on reluctance of industry and government to act[74]. The BAU scenario makes the case for government action, changes to fisher behaviour and fishing practice[75,76].

The UK ranks 6th in the EU overfishing league table, setting quotas an average of 21% above scientific advice[77].

MSY will be even more difficult to achieve in 2030 given the climatic impacts on UK ocean conditions affecting both the ability to catch fish and the likely changing location of key stocks in future. We anticipate that despite recent improvements in some stocks, the overall trend is for MSY not to be achieved in more UK stocks, particularly for highly mobile and temperature dependent species, unless action is taken to address this.

Seafood consumption under BAU

The degree of self-sufficiency of home production has been measured by the New Economics Foundation (NEF[78]) in the form of a 'fish dependence day', the date in a calendar year when a country would start to depend on fish from elsewhere because its own, domestic supplies have depleted. For example, cod and haddock which form part of the so called 'big five' most consumed species in the UK. Most cod and haddock consumed in the UK is sourced and imported from Norwegian, Icelandic and Russian waters. Imports of cod are significant at 103,000 tonnes and a value of just over £500 million in 2018. This high level of imports may pose a significant risk for food security, requiring a reduction in demand. In 2020, fish dependence day for the UK was 9th July 2020.

Almost one-third of fish consumed in the UK is beyond what could be supported nationally[79].

Biodiversity under BAU

The UK's efforts to reconcile biodiversity and fishing are captured in the UK Biodiversity Indicators[80] (UKBI). The UKBI qualitatively assesses long- and short-term changes to marine and terrestrial environments. The UKBI approach to evaluating stocks indicates the percentage of marine fish stocks that are harvested sustainably and the biomass of fish stocks at full reproductive capacity are improving. Furthermore, according to the UKBI, protected areas at sea are improving both in the short- and long-term. Although, some conditions of Sites of Special Scientific Interest (SSSI) suggest little or no change. The government's assessment of overall biodiversity suggests some improvement, yet UK waters are in a poor state with only 4 out of 15 official government indicators meeting GES[81].

The UK's approach to managing marine ecosystems while licensing destructive marine activities is increasingly impacting cetaceans[82,83]. For instance, noise created by marine traffic can mask 'calls' among cetaceans subsequently changing their behaviour. Gillnets although perceived low impact on seabeds still trap cetaceans and other non-target species[84]. For example, harbour porpoise entanglement estimates range from 587 to 2,615[85]. The UK government recently (2019[86]) commissioned a report to investigate how to reduce the accidental capture of cetaceans attributing conservation concerns to gaps in data, lack of policy integration and challenges to <10m fishing sector[87]. Therefore, under BAU, due to a lack of reporting of bycatch and effective monitoring of some sectors, and limitations of UK fisheries effort and landing data, deriving robust evidence based estimates is not possible[88].

Climate change impacts related to biodiversity include species re-distribution, trends of cold water species moving poleward or simply expanding fish abundance such as sea bass and red mullet; bringing earlier the breeding seasons for some species and reducing the number of cold-water species in other regions. In the UK, climate projections show increases of 1.5°C and 3.5°C by 2100[89] contributing to an overall decrease in primary production. Biomass projections for demersal fish species such as cod, haddock, plaice and other UK fisheries and shellfisheries show links to cooler waters[90]. Similar findings are observed for the UK recreational species seabass, with this moving to cooler waters (ibid). Climate fluctuations have led to cooler water herring and warmer water pilchard 'switches' in the English Channel[91].

A recent study[92] on the potential impacts of ocean acidification and warming (OAW) on future fisheries catches, revenue and employment in the UK fishing industry[93] found that projected standing stock biomasses could decrease by 6% to 10%; losses in revenue could decrease by 1% to 21%; and losses in relevant employment (fisheries and associated industries) could be between 3% and 20% during 2020–2050[14]. A total amounting to demersal, pelagic and shellfish catch to £87 million per annum to 2050. Other estimates report similar findings 1% and 21% in the short term (2020–2050)[94,95,96]. In Europe, a further analysis[97] suggested that annual economic losses resulting from OA effects by 2100 could amount to £74.7 million of shellfisheries, £0.77 million and £9.8 million in the UK, the Channel Islands and the Isle of Man respectively under a worst-case scenario, notably impacting scallop fisheries[98].

The physiological and biological effects of OA on individual species are broad yet under researched. The main effects on species subgroups show for:

- Marine invertebrates: Dissolution increase of carapace for the US Dungeness crab is attributed to atmospheric CO_2 in addition to detrimental impacts on larval crabs, growth and behavioural and sensory receptors[99]. Similar impacts have been reported on marine invertebrates in the EU, such as the European brown crab. This finding is significant to UK coastal communities as brown crab (i.e. the memorable Cromer crab) moved from fifth position to third (after mackerel and nephrops) in terms of annual catch value, as a result of a 32% rise in average price value to £2,280 per tonne in 2018. (£79 million in total landed value)[140].
- Finfish: Even a small change in pH can make differences in behaviour, physiology and survival. For instance, in humans, a drop in blood pH of 0.2-0.3 can cause seizures, comas, and even death[100,101]. Likewise, a fish is also sensitive to pH and has to put its body into overdrive to bring its chemistry back to normal. Larval mortality and tissue damage increases with OAW.
- Elasmobranchs: Increased mineralisation of the skeleton will reduce their capacity to migrate and potentially hinder biophysical development. Many elasmobranch species are classed by the International Council for the Exploration of the Sea (ICES) as data limited or lacking in thorough assessment protocols. Noting that the UK fleet landed 2,900 tonnes valued at £3.6 million in UK ports[102], these findings combined suggest significant implications to UK pertinent elasmobranch species.

These downward projections not only impact biodiversity significantly, they have wider consequences for coastal communities. Under BAU, social and economic impacts of OAW combined with government inaction amounts to annual losses in revenue for UK fishing fleets. Most impacts will be experienced by the >10m fishing fleets and associated businesses providing lifeblood to many coastal communities[103,104,105]. Levels of deprivation indices are used to assess the adaptive capacity of fishing communities. Morrissey (2014)[106] concluded that fishing and seafood processing are located in areas with higher than average deprivation in UK. The sensitivity and adaptability of regions containing fishery-dependent households will affect the ability of such communities to withstand any changes that may occur resulting from climate change and resulting OAW.

Seabed integrity under BAU

Closely tied into Descriptor 1 of GES, biodiversity is maintained, is Descriptor 6, related to seabed integrity. The true impacts of trawling on seabed integrity are difficult to thoroughly investigate. Several articles investigate the impact of bottom trawling on the seabed through spatially mapping fishing vessel activity through EU CFP stipulated Vessel Monitoring Systems (VMS). Eigaard et al. (2017)[107], Trouillet (2019)[108] and more recently Jac et al. (2020)[109], map ecosystem impacts to better inform ecosystem-based fisheries management. Aside from fishing intensity, the high intensity of trawling has higher fuel emissions. Moreover, as explored in more detail in pillar 1 and 2, intensive fishing pressure will have additional impacts on seabed ecosystems and coastal habitats.

Figure 4-2 also shows MPA locations which may raise concerns about the current management of the designated network. Current approaches visually present information on whether fishing on previously untrawled or trawled areas is more beneficial in reaching biodiversity targets, thereby facilitating the discussion on the usability of MPAs in the context of Marine Spatial Planning (MSP) policies.

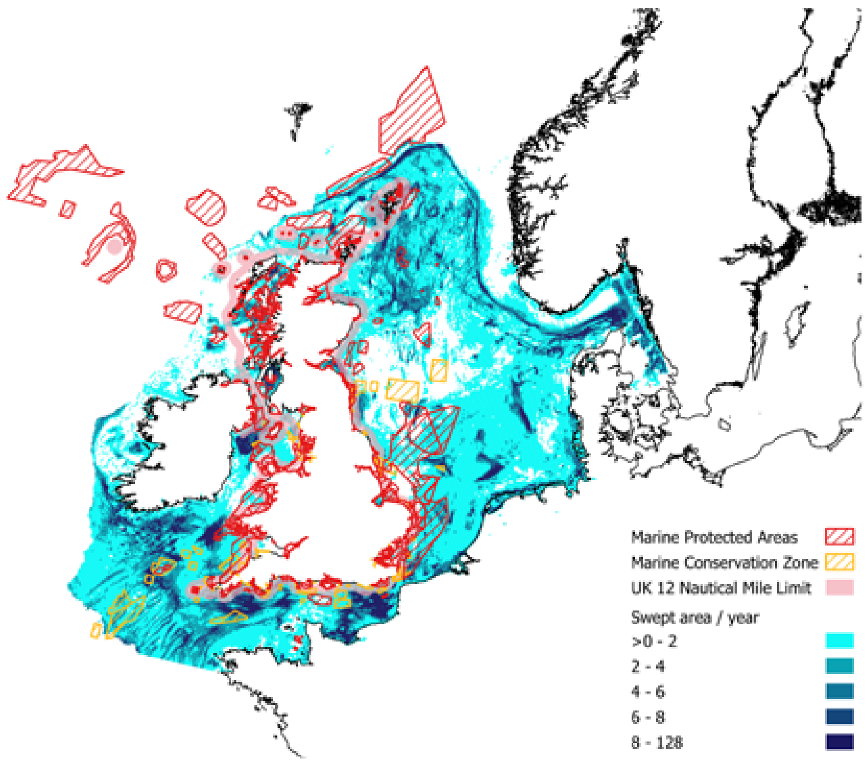


Figure 4-2: Distribution of trawling intensity overlayed with Marine Protected Areas and Marine Conservation Zones. Trawling intensity (shown in blue) indicates the estimated number of times per year that the seabed is fished by all bottom-contacting gears.

Sources: OSPAR (2018): OSPAR bottom fishing intensity – subsurface 2017.

Increasing Sea Surface Temperature, Ocean Acidification and Harmful Algal Blooms under BAU

The influences of OA on harmful algal blooms (HABs) have not been fully investigated yet increases are linked to rising sea surface temperature (SST) and HABs abundance[110]. Due to increased anthropogenic processes studies have reported HAB hazards increasing globally over the past 40 years, (i.e. through eutrophication, translocation of exotic species via global shipping routes, climate-driven range expansions, and altered physical oceanographic conditions[111]). Over this period, studies also report observations of red tides in Scottish waters[112], the influence of CO_2 of pH sensitive species altering the diversity within phytoplankton communities, and increased pH levels resulting in significant marine mortalities related to benthic and pelagic organisms.

Fisheries catches and their composition in many regions are already impacted by the effects of warming, salinity and circulation changing primary production, reproduction, and survival of fish stocks[113].

The annual costs of the tourism and fishing industries of HABs is estimated at more than €918 million per year across the EU[114]. Currently, sophisticated alert systems detecting water quality and HABs using European Space Agency and Copernicus satellite data are in development (S-3 EuroHAB) suggesting this is a growing concern for nature and climate positive fisheries.

Fishing vessel emissions under BAU

Throughout the 20th century the UK became highly dependent upon fossil fuels and they are a major source of greenhouse gas emissions and atmospheric pollutants[35]. The total number of active fishing vessels was 4,512 in 2018, which is a small fraction of the UK shipping fleet[116,117]. Taking the average quantity of fuel consumed as the basis for comparison: the average annual fuel consumption for years 2008–2010, calculated using the fuel-based methodology, is 251,270 tonnes[118]. Figure 4-3 shows the geographical distribution of CO_2 emissions. Areas of high emission intensity are generally clustered around ports. Although emissions are nominal in comparison to other marine activities, emissions from the cod trawler fleet are expected to increase in the future as boats travel further from port to find fish[119]. In addition, demersal gears targeting nephrops consume more fuel per kilogram than cod and sole targeted using demersal gears (such as Danish seines and bottom trawls).

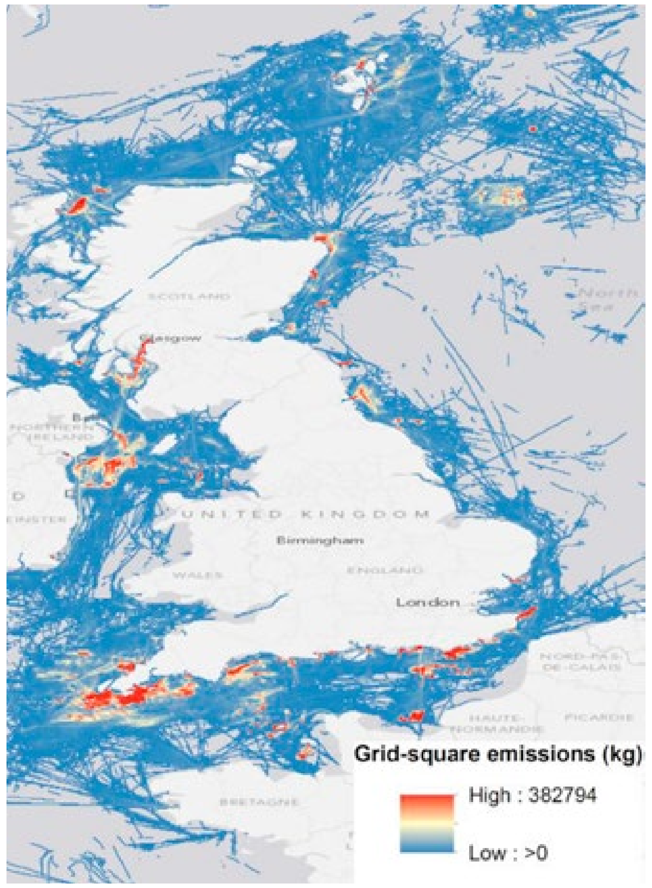


Figure 4-3: CO_2 emissions from the UK fishing fleet May 2012–May 2013 mapped in 0.2° x 0.2° grid-squares calculated using a bottom-up AIS activity-based methodology

Source: Coello et al., 2015. Atmospheric Environment

4.2.2 Aquaculture

Aquaculture under BAU

UK aquaculture directly supports approximately £3,230 full and part time jobs with average earnings £13,000 to £18,000 for fish farm workers and £38,000 for farm managers.

UK marine aquaculture can be broadly divided into the production of finfish and shellfish. The UK is a major aquaculture producer in the EU, with Scottish Atlantic salmon by far the most important product. The majority of aquaculture production in Scotland (in terms of weight and value) relates to the production of finfish at sea. Scotland is currently the largest producer of Atlantic salmon in the EU and the third largest globally with 162,817 tonnes produced in 2016[120,121]. For UK farmed salmon the main export markets are the USA (34%), France (23%) and China (12%)[122]. Shellfish farming is a growing aquaculture sector in the UK. Mussels are the main species produced (in terms of quantity and value)[123].

The UK aquaculture sector contributes a significant amount to the economy at almost £800 million in 2014[124]. It is estimated that around 3,230 people (2,700 FTEs) were directly employed in aquaculture across the UK in 2013[125]. The aquaculture sector also supports a diverse supply chain and it is estimated that the sector contributes as much as £1.8 billion turnover and 8,800 jobs to the whole of the UK[126]. Aquaculture provides sustainable employment, income generation and contributes to the development of skills and experience in rural areas of the UK that may otherwise lack alternative economic and development options[127]. Consolidation of businesses, increased automation and increasing site size have led to decreasing employment and increased productivity in UK aquaculture[131].

Climate change is likely to be the primary driver for change in the UK aquaculture industry over the next 50 years, with significant impacts due to extreme weather, disease, and harmful algal bloom. Species significantly affected include Atlantic salmon, mussels and oysters[128]. Even so, there are plans for UK salmon production to increase significantly. The UK is predicted to increase its share of the global farmed salmon market from 5.5% (in 2008) to 9% by 2030 (to reach 350,000 tonnes). It is assumed that Atlantic salmon will continue to dominate UK production[129,130], although there is also potential for aquaculture to develop in semi-contained recirculating aquaculture systems on both land and sea[131].

OA is also expected to have major impacts on mussels and oysters[132]. Peak sea temperatures in sheltered waters may exceed the preferred range of Atlantic salmon by 2070 so sites may have to relocate to more dynamic water bodies. Selective breeding could allow for some adaptation of farmed stocks to increases in temperature. It is estimated that a 1°C increase in temperature could see a 50% reduction in productivity of mussel aquaculture (ibid).

Climate change is likely to be the primary driver for change in the UK aquaculture industry over the next 50 years, with significant impacts due to extreme weather, disease, and harmful algal blooms. Species significantly affected include Atlantic salmon, mussels and oysters.

Impacts of aquaculture activities

Issues have been raised regarding the negative impacts of aquaculture. Impacts vary by type of aquaculture, production scale and management technique. Major impacts results from intensive systems which can result in discharge of suspended solids, nutrient and organic enrichment of waters, release of antibiotics and pharmaceuticals, introduction of diseases and escapees[133]. Environmental constraints such as parasitic sea lice and their potential effects on wild salmonids is a significant problem for the salmon sector[134].

Impacts of emissions from aquaculture activities

The carbon produced per tonne of edible protein through aquaculture products is 9.8 tonnes. This compares with 43.3 for chicken, 56.4 for pork and 337.2 for beef[135].

Most of the energy costs of aquaculture are embedded in feed, although recirculating aquaculture systems are highly energy dependent. Shellfish use about 3 to 4 MJ per kg of live weight produced, sea cage finfish use 28-48 MJ, on land finfish flow through uses 76-98 MJ and recirculating finfish 291-353 MJ[136].

The seafood carbon emissions tool, developed by Monterey Bay Aquarium Seafood Watch and Dalhousie University shows CO2e per kg of protein[137]:

- Atlantic salmon: 1.6 to 7.4 kg CO2e per kg of fish or 13-61 kg CO2e per kg protein: 94% of the emissions are associated with feed for marine net pens, this reduces to 58% for recirculating tanks (41% energy); and
- Blue mussel: 0.1 kg CO2e per kg of fish or 2.4 to 4.6 kg CO2e per kg protein.

4.3 SEAFOOD AND FISHERIES UNDER THE OCEAN RECOVERY SCENARIO

4.3.1 Fisheries[e,f]

Catch to sustainable levels for all UK pertinent fish stocks

Under ocean recovery rebuilding healthy fish stocks could achieve a potential (operating) profit of global fisheries could increase by $50 billion per year[138]. The potential contribution to food security of rebuilding stocks globally is between 83 to 99 million tonnes annually. Although slow progress is being made at fishing stocks at MSY there is potential for further benefits to be experienced by the UK economy. Recent findings suggest that globally, fishing fleets could improve on their current economic performance by $93 to $116 billion[139]. In other words, the UK fishing fleet is currently losing potential economic rents because many fish stocks are being exploited at rates that are not capable of delivering the MSY.

Based on these assumptions, under the ocean recovery scenario, our analysis shows that the value for two of the 'big five' (cod and haddock respectively) would produce an additional economic benefit of £4.2 million by 2030 and £11.9 million by 2050 if they were restored to sustainable levels.

The value of UK landed cod and haddock under an ocean recovery scenario would be £11.9 million if fished sustainably.

Restoring fisheries to FMSY, including other important species such as mackerel, could provide the UK with an additional 442,000 tonnes of fish landed every year, equivalent to an additional £440 million in earnings[g,140]. This could support an additional 6,600 jobs under ocean recovery.

Consumer behavioural shifts under ocean recovery

Under an ocean recovery scenario, there would be concerted effort for the UK to consume a diverse range of fish species, moving away from the big five towards species that the UK fleet are fishing. Such strategies include encouraging behavioural change such as Fish Dependence Day and reliance on fewer imported species. This would help the UK move to MSY on those stocks that are currently suffering from pressures.

This study did not examine in detail the changes in UK consumer demand needed to reduce the mutual dependence of the seafood sector on trade into and out of the UK, or the global footprint of the seafood that we import. Despite this, it appears safe to assume that consumer demands for UK caught fish and shellfish will not rise sufficiently to replace those species commonly imported from around the world. Therefore, while being critical to the recovery of UK marine ecosystems, taking action to restore UK seas will play a more limited role in addressing the overall biodiversity and climate footprint of the seafood eaten in the UK.

e: Marine Management Organisation and the New Economics Foundation BEMEF model provided the baseline data for fish stocks under the ocean recovery scenario. The landings value (£) is aggregated according to the BEMEF annual projections for UK economically important fish stocks for 2019.

f: Marine Management Organisation and Seafish data provided the baseline data for fuel emissions under the ocean recovery scenario. These data are from January 2018 to January 2019.

g: Annual exchange rate for 2017 at 0.876654 applied upon €500m and rounded.

Biodiversity and seabed integrity under ocean recovery

Although synonymous with sustainable fisheries, GES encompasses a stronger science-based remit on ecosystem-based fisheries management along with conservation strategies such as HPMAs. Improving localised fish stocks could provide economic benefits to the UK of £989 million worth of landings, or 698,000 tonnes of fish and shellfish[141]. Protecting the seabed will enable bottom feeding marine species to live longer that will eventually support the viability of fishing communities[142]. The previous pillar explained that HPMAs have proved to effectively restore and protect marine life and benefit fishing communities.

Some fish species are currently overfished, while others may be underutilised. The MSY concept can inform choices about quotas and maintenance of healthy stock levels of capture fisheries. For overfished species the stock level at MSY would be higher than at present, whereas for underfished species, the stock is greater than its MSY value. If fisheries are managed to maintain MSY stock levels then the carbon stored in fish biomass in the sea will change - with a carbon increase for currently overfished species such as cod and haddock and a carbon decrease for underfished species such as herring and mackerel. In total across 9 common fish species considered, we find that the total carbon stock in fish would increase by 0.8 Mtonnes CO2e, but with cod, haddock and plaice stocks accumulating an additional 3.2 Mtonnes CO2e and mackerel and herring carbon stocks decreasing by 2.4 Mtonnes CO2e. The remaining species considered (sole, nephrops, seabass and anglerfish) each increase stocks slightly under MSY, giving a total further carbon benefit of 0.02 Mt CO2e. Assuming this carbon stock change occurs by 2030, the net benefit of moving all fisheries to MSY stocks represents an economic benefit of between £39M and £62M depending on economic model applied (traded or non-traded value of carbon). Later action to achieve MSY provides less benefit under discounting.

Ocean recovery would also support recent government measures for the protection of cetaceans. These measures include supporting localising decision-making to local challenges faced by <10m fishing sector regarding bycatch solutions. Integrating monitoring and mitigation measures into a knowledge sharing platform to underpin bycatch solutions.

Sea surface temperature, ocean acidification and harmful algal blooms under ocean recovery

Ocean recovery would involve an intensive study that would better inform understanding of the interactions between SST, OA and HABs and the likely future implications on ecosystems. This understanding would inform UK management measures (for example, best practice guides, monitoring and observation programmes and rapid response strategies) to abate the negative implications to UK marine ecosystems.

Fishing vessel emissions under ocean recovery

Reducing carbon emissions on board vessels: with measures including using waste heat for refrigeration as seen in examples in the US[143] and Norwegian maritime vessels and transitioning from diesel to electric engines[144] show significant potential for emission reduction. Transitioning away from brown fuels and moving towards renewables, could generate a value of £98 million.

The value of carbon emissions saved from gains in fuel efficiency have been estimated to amount for £98m up to 2050. 30% of such savings are attributable to improvements in the nephrops fleet; 15% to haddock and 12% cod fisheries.

4.3.2 Aquaculture

Aquaculture under ocean recovery

Seafood systems management including clear linkages to ecosystem health and climate considerations will have significant benefits for both capture fisheries and aquaculture[145]. Like fisheries, aquaculture would benefit from study of the implications of increased temperature and ocean acidification on aquaculture to inform management measures that will help ensure that productivity and animal welfare are maintained.
The benefits of action to reduce sea temperature rises, ocean acidification and harmful algal blooms will also have direct benefits for aquaculture businesses.

Impacts of aquaculture activities

For consistent and continued growth of aquaculture under the ocean recovery scenario, there is a need for development of technologies to increase production without compromising the environment. Floating closed-containment systems are in development. These allow most waste to be captured and processed and should help make escapees and lice transmission controllable. Such systems offer many of the advantages of recirculating aquaculture systems, but at lower cost[146].

Impacts of emissions from aquaculture activities

There is interest in developing offshore production technologies that would increase the space available for expansion[147]. Technologies are also being developed that capture waste CO2 to create a protein source suitable for the aquaculture industry[148]. Investment in innovative seafood technologies could help ensure that aquaculture is able to expand so it can continue to provide a low-carbon source of protein without damaging the environment.

THE GAINS IN CHANGING FISHING GEARS

TAN ET AL. (2009) FOUND THAT PURSE SEINE FISHING GIVES THE LOWEST CARBON FOOTPRINT PER KG OF LANDED CATCH WHILE LONG LINE GEAR HAS THE LARGEST FOOTPRINT.

A STUDY IN NORWAY FOUND THE FUEL REQUIRED TO LAND ONE KILO OF NORWAY LOBSTER CAN BE REDUCED FROM 9 LITRES TO 2.2 LITRES BY SWITCHING FROM CONVENTIONAL TRAWL FISHERIES TO CREEL (TRAP) FISHERIES.

IN THE DANISH FLATLAND FISHERY, THE AMOUNT OF FUEL PER KG OF CAUGHT FISH COULD BE REDUCED BY A FACTOR OF 15 BY SWITCHING FROM BEAM TRAWLING TO THE DANISH SEINE (A SEMI-PASSIVE FISHERY).

IN SWEDEN, TRAWLING USES FOUR TIMES MORE FUEL PER KG LANDED COD THAN GILLNET FISHING

4.4 CONCLUSION

Ocean restoration will have many quantifiable impacts on fisheries and associated carbon emissions. We have demonstrated that achieving MSY would lead to greater carbon in wild fish stocks than current levels (valued at £39M to £62M). Healthier nursery grounds and reserves for fish stocks through restoring lost coastal ecosystems and better protection for MPAs will allow MSY stock levels to increase, whilst also increasing landings - leading to a greater accumulation of fish carbon and economic benefits of more landed fish (not to mention the carbon and health benefits of dietary change away from meat towards fish protein). Furthermore, as fish stocks increase, the fuel use per tonne of fish landed will likely decrease significantly, as fish become easier to find. Less area will need to be trawled and so less benthic carbon would be lost through disturbance, and greater areas of the seabed outside MPAs start to recover from years of trawling.

Such 'virtuous circles' can be identified across ocean restoration. Another example is the benefits of reduced trawling to increased water clarity (both directly through less resumed material and indirectly through the recovery of oyster grounds. Clearer water in turn would lead to better benthic cohesion due to benthic diatom populations being able to grow with increased light levels and therefore greater carbon storage. Whilst unquantifiable at current states of knowledge we can be quite sure that the co-benefits are significant, even after the first order effects quantified in this report have already returned many times the investment needed to kick-start ocean recovery.

The two-way impacts between climate change and fisheries suggest that a move to rebuilding UK fisheries and creating an integrated seafood production system is needed more than ever for environmental, social and economic reasons. Strong governance and management structures under an ocean recovery scenario will help establish catches that are at sustainable levels for UK fish stocks and will take account of the impact of fishing beyond the target species. Despite the short-term challenges faced by achieving GES targets, nature and climate positive fisheries provides greater scope for revisiting GES to provide MSY for both biomass and yields by 2050, as well as wider benefits to marine ecosystems. This will help ensure the viability of the fishing industry in the long-term, as well as helping to minimise loss of economic rents. These benefits are estimated at around £440 million per year.

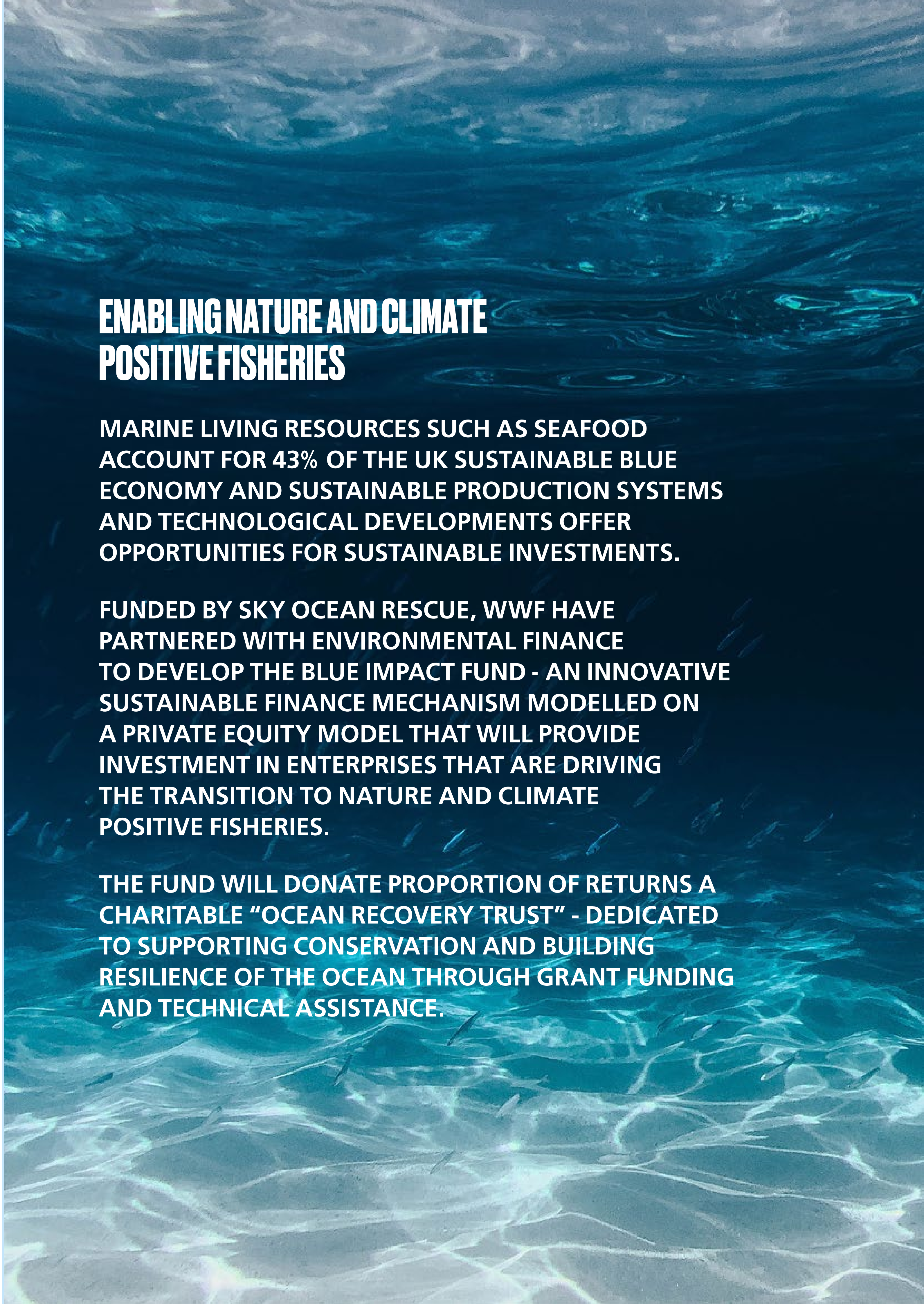
While the economic benefits under this pillar are lower than other pillars, the success of rebuilding UK fisheries and managing fisheries practices on an ecosystems based approach through an ocean recovery frame extends to, and heavily influences, the other pillars of ocean recovery. Protection of the seabed will improve viability of bottom feeding marine species, with this then expected to support the viability of fishers and fishing communities. Similarly, the designation and management of HPMAs will help to restore and protect marine life, again with potential knock-on benefits for fishers and fishing communities.

Achieving MSY for commercial species could also result in carbon sequestration benefits of £39 million to £62 million per year, while reducing emissions from fishing vessels could generate benefits from the reduction of carbon emissions of £98 million to 2050.

This pillar also shows that both wild-caught fisheries and the aquaculture industry will significantly benefit from wider net zero action, with industry costs of at least £1.5 billion from not meet net zero, based on projected future landed value of the species cod, haddock, mackerel, nephrops, scallops and crab. Encouraging consumers to diversify the fish species they consume will reduce pressure on certain stocks although the global nature of seafood means that these benefits will be limited.

Investment in new technologies for the aquaculture sector would reduce environmental impacts and potentially reduce carbon emissions. There is an opportunity for ocean finance to incentivise sustainable practices for aquaculture, but also for fishing in terms of engine replacement to reduce emissions and investment in less damaging gear.

Overall, ocean recovery is critical to ensure the future viability of fisheries and aquaculture in the face of climate impacts, to encourage investment in more sustainable, less environmentally-damaging practices and so maintain and grow fish and aquaculture as a low carbon source of protein. Embedding GES targets within future fisheries legislation and policy will underpin the role that climate positive fisheries could play in both restoring the seas and achieving zero emission targets.



ENABLING NATURE AND CLIMATE POSITIVE FISHERIES

MARINE LIVING RESOURCES SUCH AS SEAFOOD ACCOUNT FOR 43% OF THE UK SUSTAINABLE BLUE ECONOMY AND SUSTAINABLE PRODUCTION SYSTEMS AND TECHNOLOGICAL DEVELOPMENTS OFFER OPPORTUNITIES FOR SUSTAINABLE INVESTMENTS.

FUNDED BY SKY OCEAN RESCUE, WWF HAVE PARTNERED WITH ENVIRONMENTAL FINANCE TO DEVELOP THE BLUE IMPACT FUND - AN INNOVATIVE SUSTAINABLE FINANCE MECHANISM MODELLED ON A PRIVATE EQUITY MODEL THAT WILL PROVIDE INVESTMENT IN ENTERPRISES THAT ARE DRIVING THE TRANSITION TO NATURE AND CLIMATE POSITIVE FISHERIES.

THE FUND WILL DONATE PROPORTION OF RETURNS A CHARITABLE "OCEAN RECOVERY TRUST" - DEDICATED TO SUPPORTING CONSERVATION AND BUILDING RESILIENCE OF THE OCEAN THROUGH GRANT FUNDING AND TECHNICAL ASSISTANCE.

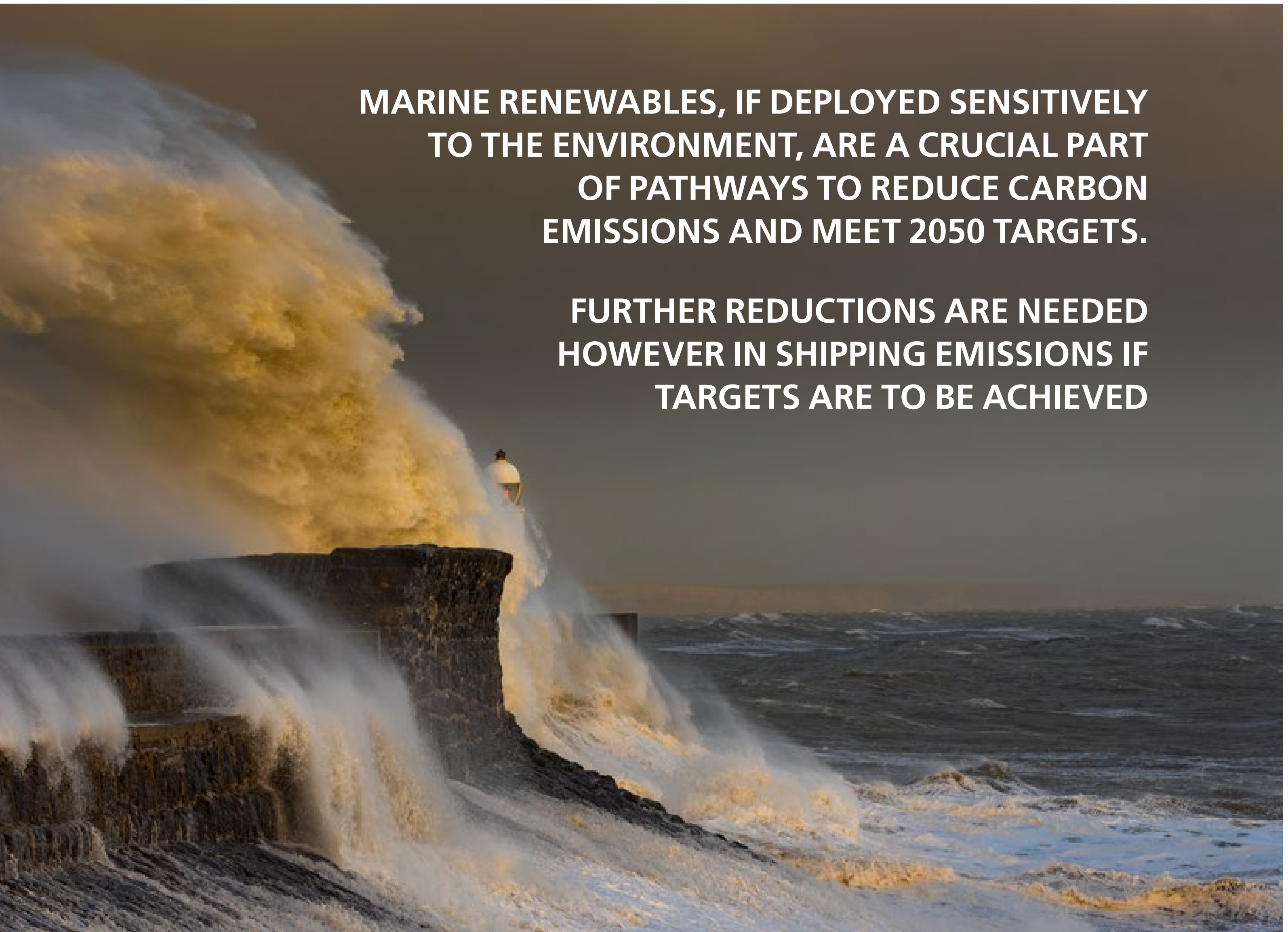
5 SUPPORTING NET ZERO ACTION

5.1 SUPPORTING NET ZERO THROUGH THE MARINE SECTOR

Supporting net zero action comprises the activities and actions being undertaken by marine sectors to reduce carbon emissions, as well as using ocean voices to support wider economic and social change to meet net zero as quickly as possible. This primarily includes emphasis on energy efficiency and carbon reduction through the sustainable expansion of renewable energy. Potential and existing marine renewable energy resources include offshore wind, tides, ocean currents, waves, thermal differences, salinity gradients and biomass[150].

The marine energy sector as a whole is a significant contributor to the UK economy, worth up to £6.1 billion. Developing technology, infrastructure and industrial capacity in the marine renewable energy sector would make the UK a global competitor, contributing £4 billion annually to the GDP by 2050[151]. Maritime shipping is a key component of the global economy, representing 80% of global trade by volume via seaborne transport[152]. There is potential for the UK to be a leader in achieving emissions reduction targets from shipping through the development of new technologies, contributing towards net zero action. Alongside discussion of marine renewable energy resources, this section also covers the impacts of shipping activities in the UK, including trends in the emissions produced by maritime transport and the potential of measures to achieve the IMO 50% emissions reduction target by 2050[153].

The baseline scenario is based on projected growth and agreed actions while an ocean recovery scenario is based on maximum effort to achieve net zero, whilst avoiding negative impacts on wildlife. This aligns with the Further Ambition scenario as set out by the Committee on Climate Change (2019)[154].



5.2 PLANNING FOR RENEWABLES: HARNESSING THE WIND

Under the BAU scenario, offshore wind could provide up to 78% of total energy demand by 2050, if investment in renewables continues at current pace, and save 1,800 million tonnes of carbon emissions between 2020 and 2050. The value of these carbon savings is estimated at £130 billion.

The Sector Deal agreed between the UK Government and the offshore wind industry in 2018 has implied increasing installed capacity of offshore wind to at least 30 GW by 2030[155] and the UK is on a good path to achieve this target, installing 1,764 MW in 2019[156]. Increasing installed offshore wind capacity to at least 30 GW by 2030 has the potential to support 27,000 jobs in the sector and generate £2.6 billion per year for exports[157]. Assuming a linear trend under BAU and continued growth to 66GW by 2050, an additional 59,000 jobs could be generated. Energy exports could increase to £5.7 billion per year (assumptions are provided in the Technical Annex), similar to those projected by Vivid Economics[158].

There is the potential to deliver additional benefits with smaller additional provisions for offshore renewables. An ocean recovery scenario however is more ambitious and aims for larger capacities of 40 GW by 2030 and 75GW by 2050, in order to ensure achieving the net zero targets. This will also have the potential to generate more significant job gains.

Under an ocean recovery scenario, it is assumed that the UK could generate 75 GW by 2050, deploying up to 7,500 turbines[159]. This equates to around 88% of the projected 75 GW of demand by 2050[160]. It is expected that this increase will be respectful of the marine environment, placed outside MPAs where possible and avoid other ecologically valuable areas through careful and effective ecosystem-based marine spatial planning (MSP)[161] and strategic environmental assessment (SEA), which both seek to reduce the cumulative impacts of this expansion.

Under an ocean recovery scenario, the carbon emissions saved over the period from 2020 to 2050 is estimated at almost 2.2 billion tonnes[162]. The value of these carbon savings is estimated at £156 billion (an additional £26 billion above the BAU).

In addition, the costs of offshore wind deployment are decreasing and continue to fall[163]. The cost reductions have been attributed to factors such as innovation in design, operation and maintenance, improvements in the supply chain but also subsidy-driven deployment and good policy and public-private partnerships[164]. New offshore wind farms are currently producing energy more cheaply than burning coal or nuclear energy and these cost savings can, and should, benefit consumers. There is scope for costs of technologies to fall further through learning-by-doing during deployment, which continues to increase globally and develop technical solutions to reduce the impacts of renewable projects on the marine environment. This includes the use of less invasive techniques to reduce impacts on marine species sensitive to noise, reduce collision risks for bats and migratory birds as well as overall displacement and barrier effects for seabirds[106]. These technical solutions could be supported by new ways of funding in ocean finance.

5.3 DELIVERING NET-ZERO THROUGH SHIPPING

Greenhouse gas emissions from UK flagged ships in 2017 were 13.8 MtCO2e (direct emissions from domestic and international shipping[165] and excluding embedded carbon in freight). This is equivalent to 3.4% of all UK domestic emissions[166].

The UK has a large maritime transport sector comprising of 51 major ports, accounting for 95% of UK imports and exports, including 25% and 48% of the UK's energy and food supplies respectively[167]. The maritime sector however has not yet been part of the mainstream discussion on climate change, nor the United Nations Framework Convention on Climate Change (UNFCCC). The 2019 Committee on Climate Change (CCC) report Net Zero[168] has however argued that shipping should not be ignored and sets a recommendation to reduce emissions from shipping. Under the BAU scenario, a 30% reduction in emissions is expected to be plausible through the generation of new vessels.

Assuming a 30% reduction in shipping emissions from current levels by 2050 amounts to a reduction in emissions of 1.6 MtCO2e from domestic shipping and 2.3 MtCO2e from international shipping. The benefits from emission reductions between 2020 and 2050 are estimated at £1.9 billion (domestic shipping) and £2.7 billion (international shipping)[169]. This gives total savings (discounted) over 2020 to 2050 of £4.6 billion.

The reductions under the BAU are insufficient to achieve the IMO greenhouse gas emission reduction target of 50% by 2050. An ocean recovery scenario explores the efforts involved in achieving national and international targets to significantly reduce GHG emissions from shipping in line with IMO's target. This is to reduce emissions from shipping to at least 50% below 2008 levels by 2050. The overall costs for shipping are expected to gradually rise as new technologies and fuels are introduced to new and existing fleets[170]. Fuel alternatives such as ammonia could increase the operating costs of a vessel by approximately £100 per tonne of CO2e abated but there will be significant savings in emissions and ocean finance could facilitate the transition. Shipping emissions could be reduced to less than 1 MtCO2e by 2050[71]. This is equivalent to a reduction of 6.8 MtCO2e for international shipping and 5.4 MtCO2e from domestic shipping compared with 2017 emission levels.

The total benefits from emission reductions between 2020 and 2050 are estimated at £14 billion[72] and the net benefits £9.8 billion

5.4 INVESTING IN NEW TECHNOLOGIES: SWIMMING WITH THE TIDE

The potential for wave and tidal stream to make a material contribution to the UK's energy mix is increasingly being recognised. Current energy generation from wave and tidal totals 20 MW[173]. Investment in wave and tidal stream has slowed, although there were 22 tidal devices and 23 wave devices active in the UK in 2018. Tidal stream has moved into first farm projects, but wave is still in the technology development phase[174].

Tidal stream energy has some advantages compared to offshore wind, e.g. higher predictability and consistency[175], but a key challenge remains lowering the costs of energy generation[176] as well as reducing the environmental impacts. Cost reductions for tidal stream could be expected as industry moves from pre-commercial arrays to commercial projects with the increasing support of funds such as the Marine Energy Accelerator[177]. A recent report by Vivid Economics[178] suggested Gross Value Added (GVA) from tidal stream could be around £800 million by 2050 (there is no reported contribution from wave). This is equivalent to 1.1GW of tidal stream by 2050.

Tidal stream could support emission reduction from fossils fuels, saving around 24 million tonnes of carbon between 2020 and 2050. The value of these carbon savings is estimated at £1.7 billion[179].

It has been estimated however that tidal power in the UK has the potential to meet 13% of the electricity demand. If energy policy provides additional support to tidal stream and wave, drawing on the drive for net zero, then an additional 1GW of tidal stream could be deployed by 2030 (100MW per year)[180] increasing to 3GW by 2050 and up to 1GW of wave energy by 2040 (100 MW per year from 2030)[181], increasing to 2GW by 2050. Under these assumptions, the tidal stream industry would generate an additional net £1.4 billion GVA by 2030 to the UK economy and support 4,000 jobs by 2030 supporting local communities (including £1.3 billion of revenue support)[182]. It is assumed that wave energy has a 10-year lag behind tidal stream, but that this could provide a net contribution to the UK of £4 billion GVA to the UK economy and support 8,100 jobs by 2040 (including £1.2 billion in revenue support)[183].

The increased capacity of these technologies under an ocean recovery scenario suggests that further reductions in costs could be possible. Further reductions in costs may be possible through focus on innovation and reductions in cost of capital. To meet this projected level of deployment, risk and cost management of R&D, obtaining investment for commercial deployment, including from public subsidy, development of supply chain infrastructure, planning and consenting must be prioritised.

Under an ocean recovery scenario, carbon emissions saved from an increase in capacity of wave and tidal energy between 2020 and 2050 is estimated at around 80 million tonnes. The value of these carbon savings is estimated at £6.1 billion. However, the trade-offs between these types of energy generation need careful consideration, as they may compromise the achievements of the benefits from restoring coastal habitats and/or the effective delivery of a coherent network of MPAs.

Throughout this report, the risks of a 'BAU' scenario to the integrity of marine ecosystems are made clear. By contrast, an ocean recovery scenario that prioritises positive outcomes for their long term health and future. Investment decisions compliant with the latter scenario can thus play a pivotal role in driving the ocean sustainability agenda in nurturing the growth of a sustainable blue economy.

To guide these decisions, WWF in partnership with the European Commission, the Prince of Wales's International Sustainability Unit and the European Investment Bank developed a set of voluntary Sustainable Blue Economy Finance Principles aimed at governing responsible investment that both contributes to the sustainable use of marine resources and furthers the implementation of the Sustainable Development goals.

Though voluntary, these principles are fundamental enablers for ensuring mainstream ocean finance and investment decisions are made a responsible basis as the blue economy grows over the next decade.

5.5 CONCLUSION

The marine energy sector as a whole is a significant contributor to the UK economy, worth up to £6.1 billion. Developing technology, infrastructure and industrial capacity in the marine renewable energy sector would make the UK a global competitor, contributing £4 billion annually to the GDP by 2050[184].

In the UK alone, over 500 companies engage in wind and marine energy related activities and activities in other countries are also growing in this area. Universities are developing specialist courses in marine and offshore renewable energy and many companies are developing apprenticeships and graduate training programmes[185].

The number of jobs under an ocean recovery scenario can be estimated by projecting upwards from the estimates identified for the business-as-usual scenario. For offshore wind, the number of jobs associated with deployment of 75 GW could be estimated at 67,000 with exports worth around £6,500 million per year in 2050. For tidal stream, the number of jobs is 2050 is estimated at 12,000 (3 GW) and for wave at 16,200 (2 GW) (efficiencies of scale may mean that job numbers do not rise linearly so this may be an over-estimate).

In looking across the other pillars of an ocean recovery scenario, it is important to ensure that the deployment of renewable energy at this scale does not hinder the recovery of ocean health as a whole. As with other types of development, these technologies, if inappropriately located, constructed and operated, have the potential to cause both short- and long-term adverse impacts on marine biodiversity. While we assume for the purposes of this study that such impacts can be avoided wherever possible, this will require significant strategic investment and coordination.

For shipping, the potential value of being the world leader in developing and exporting maritime emission abatement options is estimated to be worth £490 to £670 million per year by 2050, based on the UK maintaining its current export market share[186] (values converted to £2016[187]). The UK has a competitive advantage in a global market for alternative fuel technologies which is estimated to be around £8-11 million per year by 2050[188]. Under ocean recovery, the greater emphasis on reducing emissions may help to strengthen the UK's competitive position compared with the business as usual scenario, as long as this is not in detriment of the marine environment.

- **INCREASING THE CONTRIBUTION OF THE MARINE SECTOR TO NET ZERO TARGETS UNDER AN OCEAN RECOVERY SCENARIO COULD LEAD TO POTENTIAL SAVINGS IN CARBON EMISSIONS VALUED AT £26 BILLION FOR OFFSHORE WIND ALONE,**
- **OTHER MARINE RENEWABLES SUCH AS WAVE AND TIDAL COULD FURTHER CONTRIBUTE TO EMISSIONS REDUCTION TARGETS. HOWEVER, THE ENVIRONMENTAL IMPACTS NEED TO BE BETTER UNDERSTOOD TO BALANCE AGAINST THE BENEFITS FROM MEETING OTHER PILLARS OF OCEAN RECOVERY.**
- **SHIPPING EMISSIONS WILL HAVE TO BE REDUCE TO MEET INDUSTRY NET ZERO TARGETS. INCREASED REDUCTIONS UNDER AN OCEAN RECOVERY SCENARIO COULD SEE EMISSIONS BETWEEN 2020 AND 2050 REDUCING TO AT LEAST 50% BELOW 2008 LEVELS WITH NET BENEFITS ESTIMATED AT £9.8 BILLION**

6 DISCUSSION AND CONCLUSIONS

6.1 THE NEED TO TAKE ACTION

The above sections present compelling evidence on the benefits of restoring UK seas in line with the main pillars of ocean recovery. The report has been based on a review of the literature including the most recent publications on the ecosystem services and values that the UK seas have to offer.

The approach has also included some modelling with assumptions for both the Business as Usual and Ocean Recovery Scenarios, with limitations also bound to the current gaps in knowledge. These are explained further in the Technical Annex. Nevertheless, as a first attempt of its kind to explicitly seek define the benefits of UK ocean recovery, and given the limited ability to set quantified benefits on some aspects, the estimates provided through this report are likely to be an underestimate of the total benefits that the UK ocean recovery could provide.

UK seas remain in an alarming state of decline and are in breach of legislative requirements for Good Environmental Status (failing 11 of 15 key descriptors of a healthy marine environment). Yet taking action now to put UK seas on a path to recovery will have significant economic and climate benefits, in addition to simply helping nature to recover. For example, protecting coastal habitats through the creation of an effectively managed network of MPAs that incorporates HPMAs can help to mitigate the impacts of climate change.

Likewise, climate change is already having impacts on fisheries in the UK, and without action to reform and rebuild fish stocks in ways that contribute to wider ocean health, domestic food production and food security may be increasingly compromised. For instance, UK's reliance on imported seafood to meet demand and the heavy consumption of the big five species, of which two are in dangerous decline in UK waters (cod and haddock). In addition, decarbonisation of the UK's fishing fleet coupled with gear changes can contribute to national efforts to achieve net zero. Some authors such as Thomas et al. (2010)[189] have stressed the importance of energy audits of fishing vessels, similar to those systems for land-based industries to keep track of emissions and given the inefficiencies and age of a large proportion of vessels.

As this report shows, UK seas can, if recovered, be a true hero in both the fight against climate change and enabling a long-term green recovery. Coastal habitats such as saltmarshes have the ability to capture carbon and support populations of seabirds, which in turn can support jobs in local economies and provide recreational and wellbeing benefits to users. The seas also support many iconic species; activities such as whale watching can be important income generators. The status of iconic marine species such as cetaceans is however in doubt[190]. This is not only because their food systems have been affected by climate change, but also because of threats of bycatch. Moreover, marine mammals such as whales are increasingly being recognised for their carbon absorption potential. All these, if anything, highlight the importance of moving towards nature and climate positive fisheries and the need for ocean recovery more generally.

True ocean recovery means bringing UK seas back to life for people, climate and nature. It means delivering food security, improving livelihoods, supporting coastal communities, increasing natural resilience and reducing climate risks.

h: Calculated using New Economics Foundation BEMEF 2019 model estimates and scenario under Pillar 1.

6.2 THE BENEFITS OF MANAGING FISHERIES SUSTAINABLY

The economic cost of climate change impacts; arguably missed GES targets for descriptors 1, 3, 4 and 6; and failure to restore all fish stocks to FMSY on marine fisheries production are estimated at £1.5 billion by 2050.

Several large-scale impacts will influence success behind nature and climate positive fisheries. The key influence comes from the impacts of climate change on fisheries resulting in increasing sea surface temperature, ocean acidification and harmful algal blooms. These impacts also have serious environmental and socio-economic implications for the aquaculture supported livelihoods in Scotland. For the catch sector ocean recovery means immediately moving towards gear improvements and transitioning towards the use of cleaner fuels by 2035 (as witnessed in the US and Scandinavia) thus reducing the effects of brown fuel emissions. The savings in carbon emissions have been valued at £98m up to 2050. For the aquaculture sector, socio-economic benefits would mean to eliminate disease by improvements to recirculating aquaculture systems (RAS).

Carbon sequestration in coastal ecosystems is necessary to slow down the unintended consequences of climate change. The role that fisheries play in the health of coastal ecosystems is significant. For example, carbon sequestration benefits from moving to biomass MSY, and these could range from £38.7m to £61.7m by 2050[h]. Greater benefits may accrue for specific species currently overfished, such as cod. Although carbon sequestered by marine fish is arguably nominal, healthy coastal ecosystems offer protection for larval and juvenile fish species as well as many land and marine migratory species, including birds and cetaceans. Therefore, the importance of protecting fish stocks and their habitats is vital. Nature and climate positive fisheries require reformatting current approaches (such as Highly Marine Protected Areas) to ensure forward looking healthy and vibrant coastal and fisheries ecosystems for future generations. A forward looking and unified approach to ecosystem-based fisheries management could provide additional benefits of £440 million every year and support 6,600 new jobs.

Achieving nature and climate positive fisheries locally concerns the UK's reliance on the big five and impacts on food security. Tetley (2016)[191] explains that the notion of sustainable seafood is confusing to many consumers resulting in slower behavioural shifts to more sustainable seafoods sources. Currently, the UK is reliant on imports and although consumption of fish per capita is low, this is focused on a small variety of species. More sustainable localised fisheries have the dual benefit of reducing environmental impacts whilst offering alternatives to land use and meat provision, which is a significant contributor to climate change.

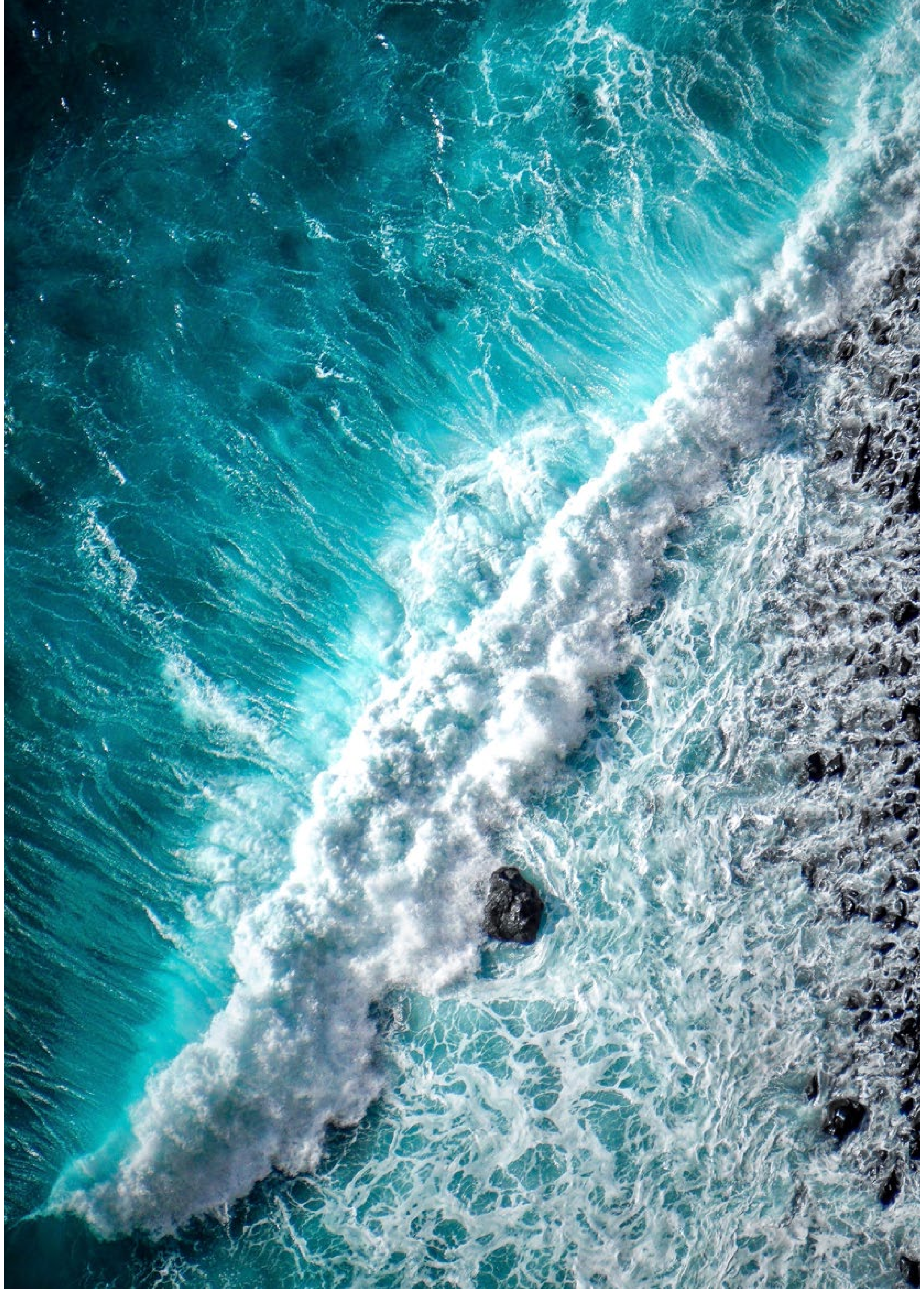
Underpinning large and local scale influences on achieving nature and climate positive fisheries requires a strong governance and management framework. For many decades, studies have negatively reported inconsistencies in legislative tools amounting to unsustainable fishing pressure. Cohesively tying nature and climate positive fisheries into a unified legislative tool that benefits ecosystem health, coastal communities and seafood consumers is a much-needed consideration for ocean recovery.

Nature and climate positive fisheries have the potential to deliver significant climate and environmental benefits but need sustainable ocean finance. There are substantial opportunities for novel and hybrid investment models to transition fisheries to sustainability. Established sectors will need to redirect existing capital flows towards sustainable practice and incorporate sustainability considerations into mainstream finance.

6.3 OTHER SERVICES BY THE SEAS AND THEIR VALUE

Other benefits included in the model are the tourism and recreational benefits from MPAs. The net gains from ocean recovery through the effective management of a network of MPAs, including the designation of fully protected areas, can be estimated at around £10 billion over the next 30 years (for a 30% designation). These quantified benefits stem from tourism and recreation and from the effective management of currently designated MPAs, which are not yet effectively managed and monitored, but other benefits in terms of 'spill over' fisheries effects and protection of offshore carbon shelf sediments mean that the total benefits are, in fact, much larger.

The UK National Ecosystem Assessment has also provided evidence on the savings that can be generated from restoration and protection of coastal habitats. It estimated that in 2012, England benefitted from salt marshes, shingle beaches and dunes in terms of providing coastal defence valued at £5.5-9.7 billion, £0.82 billion and £181-540 million respectively[192]. The UK currently spends around £800 million per annum on flood and coastal defences and the average damage is £1,400m[193]. Restoring coastal habitats could decrease such spend and reduce future damages. It has been estimated that the UK economy would face economic damages of up to £15 billion a year by 2050 from loss of coastal ecosystems alone if action is not taken to combat climate change[194]. The benefits from stopping the loss and/or restoring the habitats have been valued at £6.2 billion.



6.4 ENABLING OCEAN RECOVERY

Seas are of increasing importance to achieve net zero through the provision of renewable sources of energy. Without appropriate incentives, policies and an overarching political framework, the potential for significant emissions reductions will however be limited. Some renewables, such as offshore wind, have benefited from major scale-ups in global deployment, open global markets that have supported lower cost manufacturing and well-designed policy environments such as auctions of long-term contracts for renewable power. Subsequently, additional new policies will be required to meet the targets.

Additionally, the protection, restoration and effective management of coastal habitats have not been a traditional area of investment relative to other sectors, such as marine renewables, where government grants have been able to assist until the capacities have been developed to make them more financially viable.

Established sectors will need to redirect existing capital flows towards sustainable practice and incorporate sustainability considerations into mainstream finance. The Ocean Finance Handbook, developed by the Friends of Ocean Action, supports this pathway by providing an overview of the investment landscape in the blue economy, including both traditional and novel methods along with the suitability of different funding streams to different sectors. Lastly, the scale of investment in the blue economy has lagged behind that of terrestrial counterparts but by mainstreaming stronger governance and improving available data for existing investments, future risk profiles can be improved. Through these changes, along with capacity building and technological innovations that can positively impact the marine and coastal environment, some of the key enablers required to attract the sustainable ocean finance models needed to deliver the pillars of ocean recovery should become more prominent.

The benefits that may accrue from restoring the UK seas, in excess of £50 billion, would support the argument for the investigation of such investment models.

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SKY OCEAN RESCUE AND WWF ARE WORKING TOGETHER TO HELP PROTECT AND RESTORE OUR OCEAN. TOGETHER WE'RE CAMPAIGNING FOR OCEAN RECOVERY AS THE FOUNDATION FOR THE NEXT DECADE, INSPIRING MILLIONS TO BECOME OCEAN HEROES AND TAKE REAL ACTION TO SAVE OUR OCEAN.

BY TAKING ACTION FOR OCEAN RECOVERY, WE CAN RESTORE LIFE TO UK SEAS FOR PEOPLE, CLIMATE AND NATURE WITH ABUNDANT MARINE WILDLIFE, HABITATS HEALTHY AND RECOVERING, AND HUMAN PRESSURES ON OUR OCEAN REDUCED, FROM FISHING TO POLLUTION.

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