Written evidence submitted by the University of Plymouth Marine Institute

Overview

- We agree with government in the belief that the sustainable seas are critical for the future of people and our planet. It is now time to act.

- Along with government we, recognise that the UK has a world-leading global offer and potential contribution to the sustainable use of the oceans. The University of Plymouth can play a key role in delivering this offer across multiple sectors.

- A national focus is required to integrate and prioritise UK effort, lead collaboration between science, industry and NGOs to drive successful outcomes. There is a great potential to share and benefit from our learning and experiences.

1. The Marine Institute

1.1. The Marine Institute provides access to one of the broadest portfolios of marine and maritime expertise in the UK, bringing together academics from marine science, engineering, social sciences, law, maritime business and culture at the University of Plymouth. We collaborate with industry, NGOs and governments to ensure that our expertise delivers real-world impact.

1.2. The University of Plymouth is leading projects that are providing effective solutions in marine renewable energy, ocean litter, marine protected areas and coastal zone dynamics.

1.3. This submission was prepared by Dr Nicholas Higgs (Deputy Director of the Marine Institute) with substantial contributions from the following experts at the University of Plymouth:

- Prof Richard Thompson - Professor of Marine Biology, Director of the Marine Institute
- Prof Tom Hutchinson - Professor in Environment & Health Sciences
- Prof Jason Hall-Spencer - Professor of Marine Biology
- Dr Abigail McQuatters-Gollop - Lecturer in Marine Conservation
- Dr Clare Embling - Lecturer in Marine Ecology
- Dr Siân Rees - Senior Research Fellow in Marine Conservation
- Dr Emma Sheehan - Senior Research Fellow in Marine Conservation
- Dr Ian Selby - Director of Sustainable Geoscience

2. The impact of environmental changes and the legal framework protecting ocean biodiversity

2.1. What forms of pollution are most prevalent in the ocean, and what impact are they having?

2.1.1. Contaminants are now found throughout the oceans but not all are causing environmental damage. In terms of the amounts of pollutants entering the oceans, most come from land based discharge, followed by atmospheric inputs, maritime transport and dumping with oil exploration and production accounting for the lowest amount of pollution of all these categories. In many parts of the world organic enrichment from sewage is a major problem, causing anoxia and disease in coastal waters. In most parts of the world agriculture is a major source of coastal eutrophication due to excess nutrients such as phosphorus and nitrogen.

2.1.2. Some materials are not subject to bacterial attack and have been steadily building up in coastal waters, sediment and biota such as heavy metals, pesticides, flame retardants, plastics, radioactivity, and drugs such as antibiotics, hormones and birth control chemicals. The impacts of these pollutants are wide ranging, from visual degradation of bathing beaches, increased prevalence of disease (to humans and to wildlife such as reef forming corals), chronic or acute build up of toxins in seafood and up the food chain to top predators, whole ecosystem shifts in eutrophic waters with spreading 'dead zones'.

2.1.3. An extensive review of '**Hazardous Chemicals and Physical Contaminants in the Marine Environment**' was recently authored by Prof Tom Hutchinson and published as part of the UK government's Foresight Future of the Sea evidence review[1]. The key conclusions are that:

i. Pollutants and their impacts are generally driven by three external factors: economic activity (the use and disposal of chemicals in society), geography (run-off from land) and climate change (affecting pollutant behaviour and toxicity).

ii. There has been some recent success in reducing chemical pollution. For example, inputs of lindane, a persistent organic pollutant historically used as an agricultural insecticide, reduced by approximately 80 per cent from 1990 to 2008. While there is evidence of ongoing risks from pollutants, the Ospar Convention (1992) and the Stockholm Convention (2001) have been successful overall in reducing the impacts of Persistent, Bioaccumulative and Toxic (PBT) chemicals.

iii. Seafood contamination is a key concern for monitoring PBTs. Recent research has highlighted the presence of persistent perfluorinated chemicals and brominated flame retardants in organisms used for food. Although there is no conclusive evidence of risks for human health from seafood, there are implications of pollutants for the industry. For example, cadmium is a toxic metal and cadmium levels in crabs have led to restrictions on UK exports to global seafood markets (e.g. China).

iv. A lack of data is a challenge for measuring marine pollutants and their impact. There is a growing body of evidence on contaminants that are not commonly monitored entering the marine environment. These include nanomaterials, personal care products and pharmaceuticals. Based on the limited data, some of these may have developmental and reproductive impacts in marine life, but more information is needed to understand their long-term impacts.

v. Evidence suggests the risks to the UK marine environment from radioactivity are low. Although levels of certain radionuclides discharged from Sellafield increased during the mid-1990s, they have since declined by >90 per cent.

vi. While there is growing scientific concern regarding the long-term impacts of light and noise pollution on marine life, more information is needed to assess these impacts.

vii. Emerging technologies offer new tools to monitor the complex range of chemical and physical hazards in the sea, enabling innovative marine monitoring which also capitalises on citizen science in both the UK and the Overseas Territories. This has the potential to strengthen our capacity to monitor contaminants and their drivers.

2.1.4. Prof Richard Thompson, Head of the International Marine Litter Research Unit at the University of Plymouth, also authored a review on the causes and potential solutions to **plastic pollution and how it impacts the UK's marine life**[2], marine industries and human health for the Foresight Future of the Sea evidence review. The conclusions were:

[1] Hutchinson, T. (2017) *Future of the Sea: Hazardous Chemicals and Physical Contaminants.* Foresight, Government Office for Science, 31 pp.
[2] Thompson, R. C. (2017) *Future of the Sea: Plastic Pollution.* Foresight, Government Office for Science, 39 pp.

i. Around 70 per cent of all the litter in the oceans is made of plastic. Globally, production of plastics exceeds 300 million tonnes per annum and it is likely that a similar quantity of plastics will be produced in the next eight years as was produced in the whole of the 20th century.

ii. Plastic pollution results from a highly heterogeneous mixture of litter types differing in origin, size, shape and polymer type. Some of the most numerous items are discarded single-use packaging together with rope, netting and sewage-related debris. The majority of this litter originates from the land with rivers providing an important pathway to the sea.

iii. Plastic pollution can be harmful to wildlife, human well-being and to the economy in the UK, its Overseas Territories (OTs) and internationally. There is extensive evidence that entanglement in, or ingestion of, plastics can cause injury and death to a wide range of marine organisms, including commercially important fish and shellfish.

iv. Plastic pollution is also hazardous for mariners and reduces the amenity value of coastlines necessitating costly ongoing clean-up operations.

v. In addition, there are emerging concerns of potential negative consequences for human well-being, but currently there is a lack of evidence on which to base firm conclusions here. The effects of small particles of micro and nano-sized plastic debris are not fully understood, but these particles could present different types of impact to those described for larger items.

vi. Plastics are persistent contaminants and while there is uncertainty about the absolute quantity currently in the environment, it is clear that in the absence of any actions both the quantity and the associated impacts will increase.

vii. Plastic pollution in the sea is a symptom of a more systemic issue originating on land and related to the design, the use and the disposal of plastic items, particularly single-use packaging. To reduce it, a key priority is to focus on interventions and stewardship to help reduce the quantity of plastic waste generated by society and the associated release of litter to the ocean.

2.1.5. One further concern regarding plastics and other types of anthropogenic marine debris is the "ghost-fishing effect" on protected reef building species, such as pink sea fans. Dr Emma Sheehan and her team at the University of Plymouth have been working with citizen scientists to investigate this problem. In their paper **Strandings of NE Atlantic gorgonians[3],** mass strandings of protected pink sea fans following winter storms across the south west UK were reported washed up on beaches entangled in fishing gear and domestic debris "sea fangles". This ongoing issue, It is thought that while marine protected areas can prevent active fishing from trawling these species, that marine debris can still catch, accumulate and in storms, eventually rip off these important long lived slow growing animals. This study provides further evidence of why domestic waste disposal and fishing practices need further refinement.

2.1.6. A non-chemical but pervasive pollutant in the marine environment is noise. There is a growing body of work evidencing the negative impacts of anthropogenic noise on marine life from invertebrate through to fish and marine mammals. Impulsive noise such as military sonar has been linked to the death of deep diving whales through strandings and the bends. But more pervasive chronic (long term continuous) noise sources such as shipping, have been linked to stress and changes in behaviour of animals with potential fitness consequences. So far this is

[3] E.V. Sheehan, A. Rees, D. Bridger, T. Williams, J.M. Hall-Spencer (2017) Strandings of NE Atlantic gorgonians. Biological Conservation, 209:482-487

a small but growing area of research, **and there is an urgent need to understand the level of noise pollution in the sea, and how it impacts marine life[4,5].**

2.2. *What impact is climate change having on the ocean? What are the effects of ocean acidification now and in the future?*

2.2.1. Phytoplankton primary production is at the base of the marine food web and changes in primary production have direct or indirect effects on higher trophic levels, from zooplankton organisms to marine mammals and seabirds. **A significant, climate-driven decline in North Sea primary productivity has been observed from 1988-2013**[6]. Decreasing primary productivity has been correlated with declines in higher trophic levels such as copepods (zooplankton) and commercial fish recruitment, suggesting that if primary production continues to decline fisheries productivity is expected to decrease unless North Sea fisheries are effectively managed.

2.2.2. Extensive evidence on the impact of ocean acidification, based on the world-leading research led by Prof Jason Hall-Spencer[7] and Prof John Spicer[8], has previously been submitted to the recent Science and Technology Committee inquiry on ocean acidification[9], and concluded:

i. Whilst we know with certainty that the chemistry of waters around Britain and her overseas territories is changing rapidly due to rising CO_2 levels this situation is not being monitored. As UKOA has now ended, it is important that impetus is not lost.

ii. There is a real need to focus on the biological consequences resulting from ocean acidification effects with: (1) other stressors, (2) overall repercussion for ecosystems (including fisheries and aquaculture) and (3) end-users.

iii. It is also imperative that a monitoring system is put in place, preferably in collaboration with the aquaculture and fisheries industries that may need to adapt to changes in ocean chemistry and alterations in marine habitats in order to remain profitable.

iv. Work in areas with naturally high levels of CO_2 in the Baltic Sea and the Mediterranean has shown that the impact of ocean acidification will vary regionally, we recommend that similar work is undertaken in the NE Atlantic.

2.2.3. In addition to the effects of ocean acidification, increasing storminess is another effect to result from climate change**. Increased magnitude and frequency of storms coupled with destructive fishing activities have the potential to maintain marine ecosystems in a degraded condition**. Dr Emma Sheehan, Professor Martin Attrill and colleagues have found

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[4] Chen, F., Shapiro, G., Bennett, K.A., Ingram, S.N., Thompson, D., Vincent, C., Russell, D.J.F., & Embling, C.B. (2017) 'Shipping noise in a dynamic sea: seasonal changes in shipping noise exposure experienced by diving seals'. Marine Pollution Bulletin, 114: 372-383.

[5] Trigg, L.E., Chen, F., Shapiro, G.I., Ingram, S.N., Embling, C.B. (2018) 'An adaptive grid to improve the efficiency and accuracy of modelling underwater noise from shipping'. Marine Pollution Bulletin, 131:589-601.

[6] Capuzzo, E., Lynam, C.P., Barry, J., Stephens, D., Forster, R.M., Greenwood, N., McQuatters-Gollop, A., Silva, T., Sonja M. van Leeuwen and Engelhard, G.H., (2018). A decline in primary production in the North Sea over twenty-five years, associated with reductions in zooplankton abundance and fish stock recruitment. Global Change Biology, 24: e352-e364.

[7] e.g. Hall-Spencer JM, Rodolfo-Metalpa R, Martin S, Ransome E, Fine M, Turner SM, Rowley SJ, Tedesco D, Buia M-C (2008) Volcanic carbon dioxide vents reveal ecosystem effects of ocean acidification. *Nature* 454, 96-99.

[8] e.g. Ellis RP, Widdicombe S, Parry H, Hutchinson TH & Spicer JI (2015) Pathogenic challenge reveals immune trade-off in mussels exposed to reduced seawater pH and increased temperature. *Journal of Experimental Marine Biology and Ecology,* 462:83-89.

[9] University of Plymouth - written evidence to Science and Technology Committee ocean acidification inquiry (OAC0016) 01 February 2017.

that extreme winter storms can reverse ecosystem recovery trends following protection from scallop dredging, and have attributed the damage to the scouring effect of unconsolidated sediments resulting from destructive fishing activity, that surround MPAs (where recovering communities of sea bed organisms create biogenic habitats that bind sediments together). The positive news resulting from this work, is that these communities bounce back far more rapidly than reported recovery from destructive fishing. This work, demonstrates the need to appropriately manage all areas of the sea bed, especially all habitats within MPAs, not just the prioritised features of interest[10,11].

2.3. What more should the Government do to hasten progress towards Aichi targets?

2.3.1. Dr Siân Rees has worked with the Global Ocean Biodiversity Initiative and the Convention of Biological Diversity to define the qualitative elements of Aichi Biodiversity Target 11 and track global progress[12].

2.3.2. In terms of global progress towards the 10% spatial protection target defined in Aichi Target 11, national waters represent 39% of the global ocean and at present, 16.03% of these waters are designated as protected areas. In contrast, only 1.18% of Areas Beyond National Jurisdiction (ABNJ), which makes up the remaining 61% of the global ocean, has been established as protected areas (UNEP-ECMC 2017)[13]. Despite great achievements in increasing the spatial extent of MPAs it is well recorded that there is persistent degradation and loss of marine species and populations, which has the potential to critically impair the ability of marine systems to continue to provide ecosystem services that underpin human wellbeing. There is a high level of functional and spatial connectivity within marine ecosystems. **It must be considered that policy led by quantitative area-based targets (the 10%) alone will not be adequate to safeguard the important ecosystem processes and services that marine ecosystems underpin** (Rees et al 2017). There is a need to mainstream the qualitative aspects of Aichi Target 11 "areas of particular importance for biodiversity and ecosystem services", "effectively and equitably managed", "ecologically representative", well-connected, integrated into the wider landscapes and seascapes”[5].

2.3.3. In terms "ecologically representative" there is a need to address the key challenges faced by countries at national or regional levels in the incorporation of “ecological representativity in conservation planning (e.g. data needs, capacity etc.). **At a global level, there is a need to improve understanding of marine biogeography in support of ecological representativity, particularly for Areas Beyond National Jurisdiction (ABNJ)**. Also, to decide what functions representativity should deliver (e.g. propagule stock function, ensuring the potential for restoration). In light of the recent trend in the designation of large MPAs there is also a need to understand how and if these sites contribute to ecological representativity[5].

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[10] E.V. Sheehan, S.L. Cousens, S.J. Nancollas, C. Stauss, J. Royle, M.J. Attrill (2013) Drawing lines at the sand: Evidence for functional vs. visual reef boundaries in temperate Marine Protected Areas. Marine Pollution Bulletin, 76:194-202.

[11] Sheehan EV, Stevens TF, Gall SC, Cousens SL, Attrill MJ (2013) Recovery of a Temperate Reef Assemblage in a Marine Protected Area following the Exclusion of Towed Demersal Fishing. PLoS ONE 8(12): e83883.

[12] Rees S.E., Foster N.L., Langmead O., Pittman S., Johnson D.E. (2016) Defining the qualitative elements of Aichi Biodiversity Target 11 with regard to the marine and coastal environment. A report to the Convention on Biological Diversity expert meeting complied by the Marine Institute at Plymouth University, UK. pp. 55

[13] Rees, S.E., Foster, N.L., Langmead, O., Pittman, S., Johnson, D. (2017) Defining the qualitative elements of Aichi Biodiversity Target 11 with regard to the marine and coastal environment in order to strengthen global efforts for marine biodiversity conservation outlined in the United Nations Sustainable Development Goal 14. (In Press Marine Policy Special Issue SDG Synergies for Sustainable Fisheries and Poverty Alleviation).

2.3.4. Like "ecologically representative", **a "well-connected" system of protected areas is a prerequisite for biodiversity conservation**. Connectivity forms a central tenant of "ecological coherence", where a network of MPAs is designed to interact and support the wider environment in order to underpin the resilience of the ecological system. Through resilience, the risk of permanent loss of ecosystem functions and ecosystem service benefits is reduced. Significant progress has been made in both empirical and modelling studies of connectivity in the past decade; however, challenges remain in understanding how best to include connectivity in conservation management. These include how to define minimum and optimal information needs for an assessment of connectivity to inform network design and management when considering a diverse set of phyla, families and species with many different modes and domains of dispersal. There is additionally an issue of scale; at what scale should connectivity be assessed in order for the assessment to be meaningful for MPA managers and planners[5].

2.3.5. **Include Ecologically or Biologically Significant Marine Areas as "areas important for biodiversity and ecosystem services" (EBSAs).** The EBSA process provides a set of scientific criteria to further the process of integrated marine management through the identification of sites that support broad scale ecological functions e.g. climate and nutrient regulation. EBSAs are not part of the current MPA process and therefore their spatial area does not currently contribute to the Aichi 11 and Sustainable Development Goal (SDG) 14 goal of 10% spatial protection. There is complementarity between EBSA criteria and the CBD criteria for ecological representivity[5]. The scope for EBSAs features to be managed using a variety of means to improve the status of biodiversity confers that they may be considered as another effective means of conservation" (OECM)[7]. Although OECMs are yet to be formally recognized by the CBD there is potential for such sites to contribute to ecologically representative and well-connected MPA networks. **The incorporation of EBSAs into the global marine governance framework offers potential for a broader range of tools to manage marine biodiversity for both ecological and human wellbeing benefits[7].**

2.3.6. **There is a need to establish a "gold standard" for assessing MPA management effectiveness and equity** with clear objectives to: set measurable ecological, include social and economic objectives; to build performance assessments metrics into the long-term management of the site rather than relying on ad-hoc opportunities and; design management objectives that can be assessed at a regional scale to understand the overall performance of the system rather than a focus on isolated sites.

2.4. What outcomes and protections should the UK Government be pushing for at the forthcoming UN negotiations on the conservation and sustainable use of marine biological diversity in the world's oceans?

2.4.1. **The UK Government must accelerate progress towards achieving Aichi Target 11 and develop post 2020 targets to achieve spatial management measures via MPAs and OECMs for 30% of marine areas as recommended by the IUCN[14,15].**

2.4.2. The potential for OECMs aside from statutory MPAs to contribute to ecologically representative and well-connected MPA networks is increasingly receiving attention. Potential OECMs may include some of the spatial management measures of Regional Fisheries

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[14] Diz, D., Johnson, D., Ridell, M., Rees, S., Battle, J., Gjerde, K., Hennige,S., Roberts, M. (2017) Mainstreaming Marine Biodiversity into the SDGs: The Role of Other Effective Area-Based Conservation Measures (SDG 14.5). (In Press, Marine Policy Special Issue SDG Synergies for Sustainable Fisheries and Poverty Alleviation).

[15] Rees, S.E., Foster, N.L., Langmead, O., Griffiths, C., Fletcher, S., Pittman, S., Johnson, D. Attrill, M.J. (2018) Bridging the divide: A framework for social-ecological coherence in Marine Protected Area network design (In Press, Aquatic Conservation).

Management Organizations (RMFOs) some of which, such as Vulnerable Marine Ecosystems (VMEs), are coincidental or overlap with Ecologically or Biologically Significant Areas (EBSAs) described by CBD Regional Workshops. **UK Government must work with States and competent international organizations to collaborate to join up and recognize areas of ecological significance and to coordinate protective measures though multi sectoral planning to achieve this end[15].**

2.4.3. **UK Government must to commit to a programme of work to designate and implement the IUCN recommended 30% of national waters as MPAs and OECMs; to engage in the process of establishing MPAs in areas beyond national jurisdiction (ABNJ) and to develop a new legally-binding instrument under the United Nations Law of the Sea for the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction.** A new instrument for ABNJ must contain a robust mechanism for establishing effectively and equitably managed, ecologically representative and well connected systems of marine protected areas, including reserves. Additionally, IUCN member States are urged to accelerate progress towards achieving Aichi Target 11 and all Parties to the CBD are encouraged to develop post 2020 targets to achieve spatial management measures via MPAs for 30% of marine areas[15].

2.5. What is the UK's record on meeting existing obligations under international law and the UN Sustainable Development Goal 14 (Life Below the Sea) in respect of biodiversity?

2.5.1. The CBD has made concerted efforts to support and encourage States to designate MPAs. Aichi Target 11 and SDG 14.5 both provide a focus for collective efforts. However, global coverage of MPAs is likely to fall short of expected targets. Several national MPA portfolios, such as that of the UK, significantly exceed the 10% target but the level of protection afforded is debatable. **Other efforts to strengthen the conservation and sustainable use of marine biodiversity must be considered, including giving more attention to qualitative aspects of the Aichi Biodiversity targets; recognising the value of OECMs; using EBSAs as a focus of attention to consider further protective measures; and evaluating governance priorities. Implementation of management measures and site condition monitoring to assess progress towards achieving conservation objectives is key[5].**

2.5.2. Transformation and exploitation of the marine environment since the 1850s provides a strong rationale as to why MPAs have to be highly protected. For example, historical records demonstrate clearly that as fishing intensity has increased, profound changes have resulted in marine food webs. Significant protection is required to reverse the decline in vulnerable species and restore their populations. **Leadership and political will is now needed more than ever to reverse marine biodiversity loss and ensure MPAs are nested within sustainable seas.** Conservation objectives to maintain existing ecological status of MPAs are insufficient, as they lack the ambition to build back and recover representative marine ecosystems. Thus, whilst the UK has made exceptional progress with quantitative MPA coverage, it is imperative to substantiate that these areas offer effective protection and allow for the improvement of marine biodiversity. Meaningful progress requires a focus from quantity to quality of MPAs[16].

2.6. Is the UK's current legal and regulatory framework adequate to protect biodiversity given the growing demands which are likely to be placed on marine resources?

[16] Johnson, D.E., Rees, S.E., Diz, D., Jones,P.J.S., Roberts, C., Barrio Froján, C. (2018) Securing effective and equitable coverage of Marine Protected Areas: an overview of global efforts by the Convention on Biological Diversity and analysis of national efforts on behalf of the United Kingdom" Submitted to Aquatic Conservation: Marine and Freshwater Ecosystems.

2.6.1. Without the legal enforcement of the EU through the MSFD there is a real danger that the UK will not deliver its current environmental protection and sustainable use objectives for biodiversity[17]. Right now we are managing our marine biodiversity proactively – with clear environmental targets and objectives which must be (in the future) regionally coherent with our EU neighbours. EU exit might come with a reduced ambition for biodiversity targets, however, particularly if priorities shift from marine conservation to economic interests such as commercial fishing and coastal development[17]. Without the legal impetus of the EU to proactively and meaningfully manage marine biodiversity, there is a risk that our management strategy may transition to a disaster-based method, where we only respond to environmental emergencies. The UK can should increase the effectiveness of its marine management by **no longer treating marine environmental protection as separate from the issue of fisheries management and legislation**. A new system can incorporate both aspects along with strong links to independent science advice and an increased focus on regionalisation. This will mean close collaboration with the devolved administrations to ensure our seas and coasts are managed in a coordinated manner. **Greater coordination and better integration between all stakeholders, scientists and government should provide an opportunity for greater flexibility and speed in decision-making**.

2.6.2. Long-term biological time-series data are crucial for informing management and policy, particularly in supporting the new generation of marine legislative drivers, such as the Marine Strategy Framework Directive, which take an ecosystem approach to management[18]. Reductions in national capability have resulted in the degradation or loss of key biological monitoring programmes[18]. If funding continues to be moved away from marine biodiversity management and monitoring, which is a real threat due to economic considerations, our ability to provide evidence for decision making will be damaged. Monitoring data are needed to detect changes in the marine environment, inform indicators, and determine whether we are meeting environmental targets. Detection of change is the first step to effectively managing our marine environment, but is dependent on the collection and analysis of robust scientific data. The UK has led the development and operationalisation of MSFD biodiversity indicators, but further work remains, particularly around linking state changes to pressures and determining the drivers of change. This information is required to help decision makers decide if and where to implement management measures, and knowledge and data gaps weaken our ability to sustainably manage the marine environment. It is therefore important that **monitoring, management and enforcement is adequately resourced and carried out by Government and the DAs**.

2.6.3. There is little point having good marine environmental legislation if there is inadequate enforcement and oversight. Being a member of the EU meant strong disincentives in failing to meet environmental standards (specifically infraction and the role of the European Court of Justice). **Equivalent enforcement mechanisms to ensure compliance must be put in place after EU exit.** This should also include useful reporting mechanisms so that marine environmental assessments are a meaningful tool for informing management.

2.6.4. At a UK level, legal provisions needs to be made for a 'whole site approach' for MPA management. The government's new 25 year plan for the environment promotes a 'net gain' principle for development. Research from the University of Plymouth pioneered the first model of integrated ecological and socio-economic research on Marine Protected Areas. This research has demonstrated that a 'net gain' for biodiversity can be achieved in marine

[17] This section is based on: (1) A. McQuatters-Gollop: Plankton and Policy website; (2) British Ecological Society workshop: Marine Environment After Brexit: the future for science and policy.

[18] McQuatters-Gollop, A., Edwards, M., Helaouët, P., Johns, D.G., Owens, N.J.P., Raitsos, D.E., Schroeder, D., Skinner, J. and Stern, R.F., (2015). The Continuous Plankton Recorder survey: how can long-term phytoplankton datasets deliver Good Environmental Status? Estuarine, Coastal and Shelf Science, 162: 88-97.

systems though the adaption of management approaches that support the maintenance of ecological processes and functions across a whole site rather than on select features of conservation importance. Whole site approaches to management can support conservation outcomes along with supporting economic and social objectives. The “whole site approach” for MPA management has been promoted in the new 25-year plan for the environment as part of a more ambitious approach to marine biodiversity conservation that will underpin natural capital-led economic growth.

3. A sustainable blue economy

3.1. How effective are the Marine Stewardship Council’s ecolabel and fishery certification scheme at ensuring fisheries are sustainable?

3.1.1 Prof Jason Hall-Spencer carried out an MSC assessment for Atlantic Scallop *Placopecten magellanicus* in the USA[19]. The problem, as he saw it, was that this fishery was certified as sustainable by virtue of being well managed and having healthy stocks of scallops, despite the fact that this gear type (New Bedford Dredge) is one of the most damaging and carbon intensive ways in catching seafood. The carbon footprint of fisheries is not factored in to MCS certification, and should be. The environmental damage caused by gear types can be outweighed in the MSC scoring system by management and stock levels (this should also be fixed). The MSC system also considers each fishery separately without considering the cumulative impacts of several fisheries acting together. So, for example in a certain region a scallop fishery and a herring fishery may each be sustainable individually, but together might not be (e.g. if scallop dredges destroy herring spawning areas).

3.2. Does aquaculture cause less harm to marine biodiversity than fishing? Is aquaculture in the UK adequately regulated to protect biodiversity

3.2.1. Overall, yes it causes less harm and is well regulated. However, some forms of aquaculture are less damaging that others, and some forms of fishing are less damaging than others. The lower down the food chain the farmed species is, the less impact farming it generally has – so seaweed farms and mussel farms are relatively benign (although places such as the Ria De Vigo have been damaged by too much mussel farming – i.e. too intensive). The higher up the food chain the farmed species is, the greater impact, particularly with top predators as in order to feed fish such as salmon, tuna, bream and bass you need to have wild caught fisheries to support them.

3.2.2. Another level of complexity is that it all depends on when and where such activities take place. For example, a bottom trawl fishery may be sustainable at certain times of year, but not when fish are laying eggs to spawn on the seabed. A fish farm may have very little impact on open coasts but may cause seabed anoxia or loss of long-lived habitats in sheltered waters

3.2.3. In some cases, regulation has not kept pace with aquaculture developments, e.g. a proposed doubling of production in Scotland in the next 5 years, and the capture of wild wrasse to combat sea lice infestations. There are significant concerns that wild wrasse harvesting has not been managed appropriately in the past in areas of Scotland and Norway. As a result of diminishing wrasse populations in these areas, Scottish salmon farms are now sourcing wrasse from the south west. To enable evidence based management, Dr Emma Sheehan is working with Devon and Severn IFCA undertaking studies about wrasse territory size and population structures

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[19] Aldous, D, Brand, AR, Hall-Spencer JM (2013) MSC Assessment Report for USA Sea Scallop Fishery Ref: 82517/v5

3.2.4. Hall-Spencer and colleagues published the first study of salmon farm impacts on maerl beds in 2006[20], at a time when increasing numbers of farms were being relocated to sites with strong tidal flows to combat problems with organic waste build up underneath cages.

3.2.5. Prior to these studies strong tidal flows on maerl beds that were assumed to flush away organic waste. Surveys around salmon farms located above maerl beds found significant reductions in live maerl cover and faunal biodiversity[12,21]. These negative impacts are the result of organic enrichment[12] and toxic chemicals in fish feed used to combat sea lice[13].

3.2.6. In addition to Salmon farms, mussel aquaculture in Scotland was also reported to having deleterious impacts to seabed habitats. The UKs first offshore mussel farm located in Lyme Bay appears to have avoided these issues. Dr Emma Sheehan, Professor Martin Attrill and colleagues are working with farmers to understand the effect of this new aquaculture development. The farm, located on previously, degraded fishing grounds is introducing new biogenic habitat in the form of mussel shell on the sea bed and hanging ropes, which provide refuge, nursey and feeding habitats for other commercial species, such as crab, lobster, cuttlefish and fishes (unpublished data). It is important to continue to monitor these developments to understand how they can contribute to the MPA networks and at what spatial scales are sustainable in the wider ecosystem.

3.3. What could the UK do to promote a sustainable marine economy and achieve sustainable marine and coastal ecosystems management in the Overseas Territories?

3.3.1. The UK should develop a model to develop a sustainable marine economy and communities which includes use of the sea bed and overlying waters. This will require integrating ambition for infrastructure (eg cables), energy (eg wind and tidal power), resources (eg sands), fisheries and conservation aims into an expert marine bureau that is charged with facilitating delivery of a sustainable marine zone.

3.3.2. There is a need to understand the relationship between marine conservation, marine management measures and the social and economic benefits generated by the marine and coastal ecosystems in the OTs. This can be achieved though the development of natural capital accounting tools, the development of MPA performance metrics and the develop sectoral sustainability strategies that place natural captial at the heart of decision making[22,23].

4. The impact of marine industries, science and innovation, and blue finance

4.1. What is the environmental impact of marine industries, such as deep sea mining, and how effectively does the Government and the International Seabed Authority regulate them to mitigate their environmental impact?

4.1.1. The oceans are largely unmapped in detail and our knowledge of resources and environments is commonly limited. The value of a strategic approach to basic mapping was established in the UK in the 1970-80s and has resulted in the successful development of our seas over the past few decades. Currently there is a variable understanding of marine development and

[20] Hall-Spencer *et al.* (2006) Impact of fish farms on maerl beds in strongly tidal areas. *Marine Ecology Progress Series*, 326:1-9.
[21] Hall-Spencer and Bamber (2007) Effects of salmon farming on benthic Crustacea. *Ciencias Marinas,* 33:353–366.
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environmental risks. For example, on a global scale impact of sea bed dredging to extract resources from the shallow seas are locally concentrated and variably managed. Global standards require development and application.

4.2. How is the deep sea mining industry likely to grow in the years ahead? What environmental risks will this bring? What legal protections are in place to mitigate these risks? Are additional legal protections needed?

4.2.1. On the basis that demand for renewable energy continues to grow and competition and constraints in the supply of key minerals it is likely that growth in deep sea mining will occur. The environmental risks, economic and social benefits are poorly understood and the legal framework is immature. Currently the governance structure is not fit for purpose and a revised approach is required to give confidence to operators, mineral owners and regulators[24]. Transparency is required to engage and provide stakeholders with clear terms for acceptable development reflecting the common benefit to mankind.

4.3. How well has Government supported UK marine science and innovation? What more could the Government do to promote a sustainable blue economy?

4.3.1. To date there has been limited government intervention in the marine sector which has been dominated by ‘traditional’ offshore activities including oil and gas and fisheries. This has not been assisted by responsibilities for our seas being split between a range of government departments (eg BEIS, DEFRA, DfT) with no overriding strategic leadership, ownership championing marine interests – there are clear benefits to integrate and consolidate benefits[24].

4.3.2. Within the marine biodiversity science community there has historically been concerns over the lack of government support for taxonomic science, with several inquiries by the House of Lords[25]. Taxonomic information provides a crucial understanding of the most basic component of biodiversity – which organisms are present in a region or ecosystem. Taxonomy, however, is a discipline in decline, at times perceived as ‘obsolete’ due to technical advances in science, and with fewer trained taxonomists and analysts emerging each year to replace the previous generation as it retires. Sensitive indicators derived from taxonomic data, however, are instrumental to the successful delivery of ecosystem-based management efforts which are needed to manage and protect biodiversity[26]. The UK Government should support central investment in taxonomy, taxonomic skills training, and taxonomic analysis under national capability programming.

4.4. What national or international measures could the UK pursue to minimise the impact of marine resource extraction, such as sand mining, aggregate dredging and deep-sea mining?

4.4.1. In the future marine sand and gravel, resources will become increasingly important across the world for use in construction, land reclamation and coastal protection for communities as sea level rises. The UK has a highly evolved resource management, regulatory and operational management regime which already minimizes impacts within its regulatory jurisdiction.

4.4.2. The incorporation of EBSAs into the global marine governance framework offers potential for a broader range of tools to manage marine biodiversity for both ecological and human wellbeing benefits[15]. UK Government should consider the overlaps between EBSAs and Vulnerable Marine Ecosystems (VME) an incorporate biodiversity management into plans and processes for marine resource extraction.

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4.4.3. UK Government must engage in the process of establishing MPAs in areas beyond national jurisdiction (ABNJ) and to develop a new legally-binding instrument under the United Nations Law of the Sea for the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction.

4.4.4. Dr Kerry Howell and her team in the Deep Sea Conservation Research Unit are currently investigating the application of predictive modelling to marine spatial planning associated with deep-sea mining[27]. These models will determine if current Areas of Particular Environmental Interest set aside as protected in the Clarion Clipperton mining zone are actually representative of mining areas and therefore capable of sustaining biological populations and ecosystem functions.

4.5. Is private sector finance available to support sustainable blue industries? What could the Government do to promote 'blue finance' and investment in a sustainable marine economy?

4.5.1. Marine activities and initiatives are typically high cost (exploration and plant) and high risk (immature sectors and technologies) so benefit from strategic early investment to reduce business and technical risk and improve confidence. The government can support development directly through partnering innovation and indirectly by providing generic information on resource and environmental characterisation. The Aggregate Levy Sustainability Fund was a successful funding model which contributed to business efficiency and improved environmental performance of a range of sectors across the UK sea bed. A more radical position is to create a self-supporting governance model by replicating the UK model of sea bed and resources ownership and re-investing revenues acquired by the sea bed owner.

4.5.2. The UK is a world leader in marine renewable energy, however, investment is lacking for Wave and Tidal energy. It is vital that the effects of Wave and Tidal are fully understood in order to be appropriately managed, however, appropriate monitoring is often considered a burden on the developer that results in poor small scale environmental impact studies which are not fit for purpose. Dr Emma Sheehan and Prof Martin Attrill have worked with a wide networker of developers and researchers to call for appropriate monitoring[28] and are working on collaborative monitoring at sites in the Cornwall[29] and in Orkney as part of a EC H2020 project Clean Energy From Ocean Waves[30]. Monitoring to date suggests that as these developments add structure and exclude destructive fishing activity that they can provide refuge for marine life and could contribute to the MPA network. With funded coordinated monitoring, and appropriate management these potential benefits could be realised.

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